GENIE 2.0.0 Validation - Comparisons with NEUGEN/daikon+

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In this note we present the extensive GENIE/NEUGEN comparisons that enabled us to validate the GENIE physics models to be included in the default configuration of its first production-quality version (2.0.0).

1. Introduction

GENIE-2.0.0 is the first physics production release of the GENIE Neutrino MC Generator. The neutrino interaction physics of that version is identical to the physics of NEUGEN/daikon+. The daikon+ is a bug fix revision of the NEUGEN/daikon MC used for the 2007 MINOS ν_μ CC Dissapearance Analysis. The daikon version has been documented extensively elsewhere [2]. The daikon+ revision includes:

- an update of resonance widths and masses in CC and NC resonance cross section code,
- an update of the AGKY [3] Hadronization model to a) ommit final state nucleons from the p_T reweighting scheme, and b) skip reselection of the final state nucleon after each rejected remnant hadronic system decay
- bug fixes in INTRANUKE [4] Hadron Transport model addressing problems with particle stepping and the creation of inelastic final states
- a bug fix in the coherent event kinematical selection affecting the lower end of the x distribution and the final stape primary lepton momentum component in the plane perpendicular to the incoming neutrino direction.

2. Validation Plots

Four sets of plots are shown in this document:

- GENIE-2.0.0 cross section comparisons with external data and NEUGEN/daikon+ cross sections.
- GENIE-2.0.0 AGKY hadronization model comparisons with external data and the NEUGEN/daikon+ version of AGKY.
- GENIE-2.0.0 and NEUGEN/daikon+ INTRANUKE-based hadron+nucleus event sample comparisons
- GENIE-2.0.0 and NEUGEN/daikon+ comparisons of many high-statistics neutrino event samples.

REFERENCES

1. GENIE, http://www.genie-mc.org

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2. H.Gallagher et al., docdb-1977;2137;2423 (MINOS Internal)
3. C.Andreopoulos, H.Gallagher, P.Kehayias, T.Yang, http://pubs.genie-mc.org; See also T.Yang's talk at NuINT-07
4. S.Dytman, docdb-2761,2816,2990,3111 (MINOS Internal); AIP Conference Proceedings, Vol 896, pp 178-184

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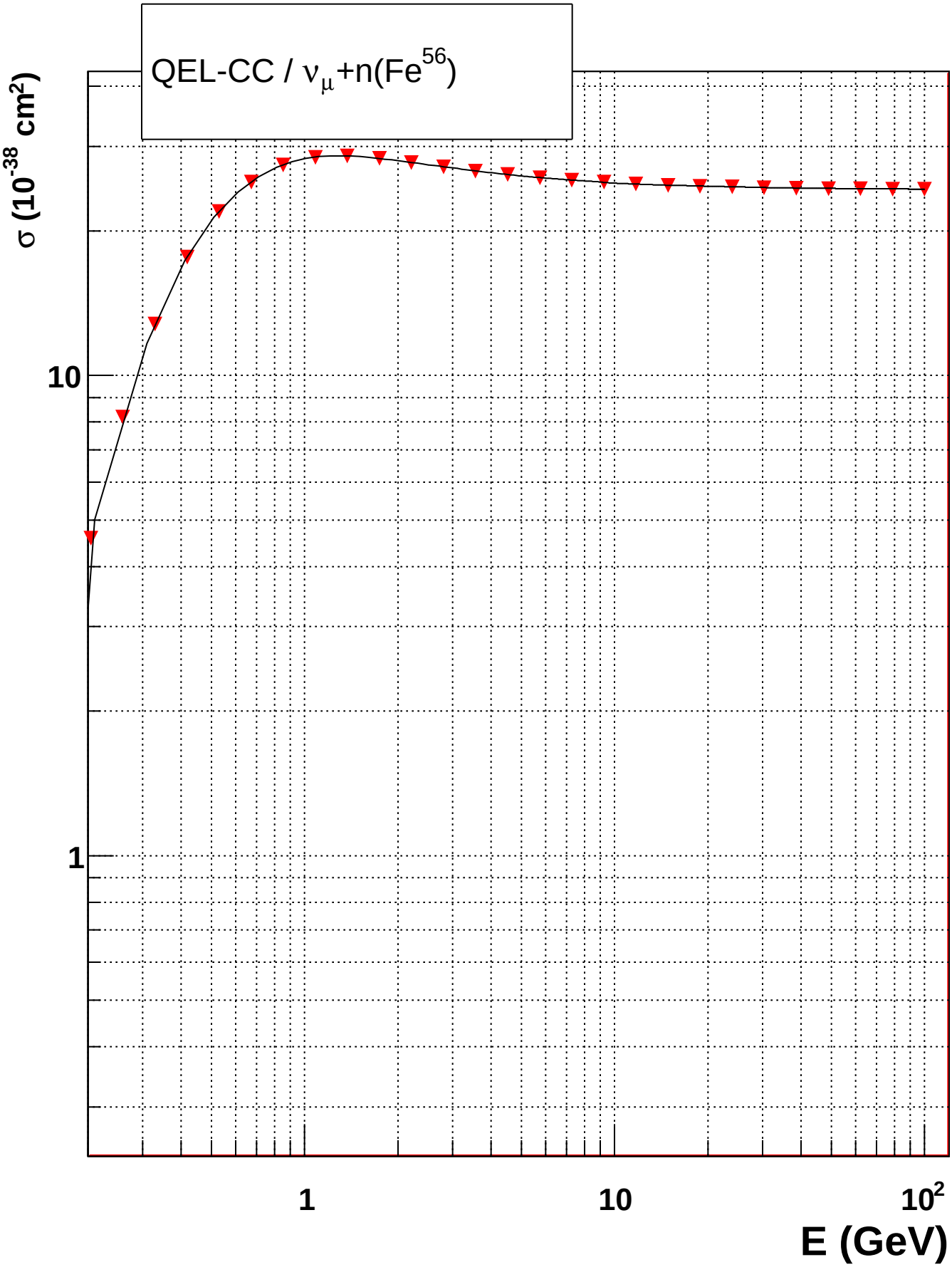
GENIE-2.0.0 vs NEUGEN/Daikon+ comparison

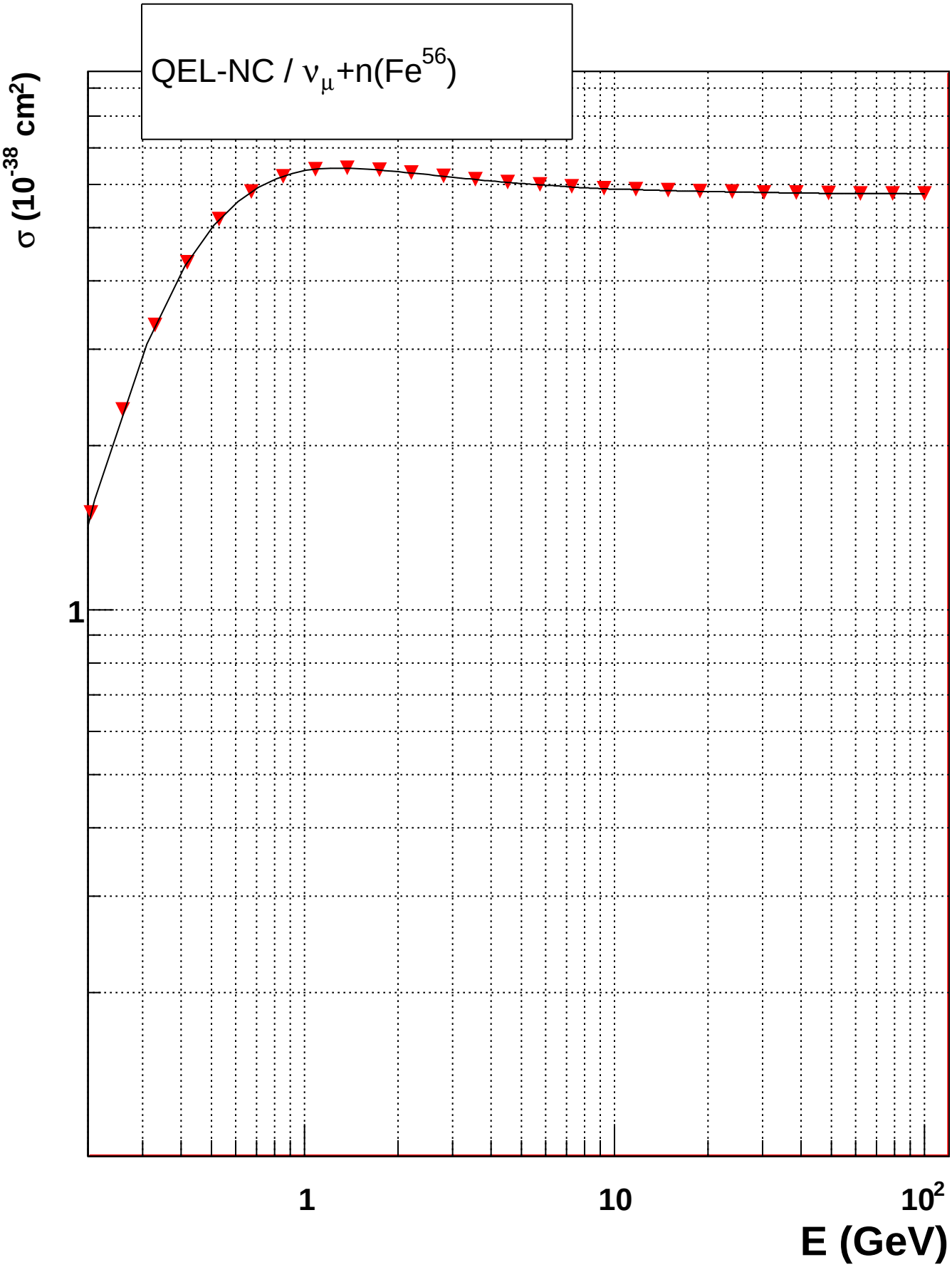
nu_mu, bar{nu_mu} + Fe56

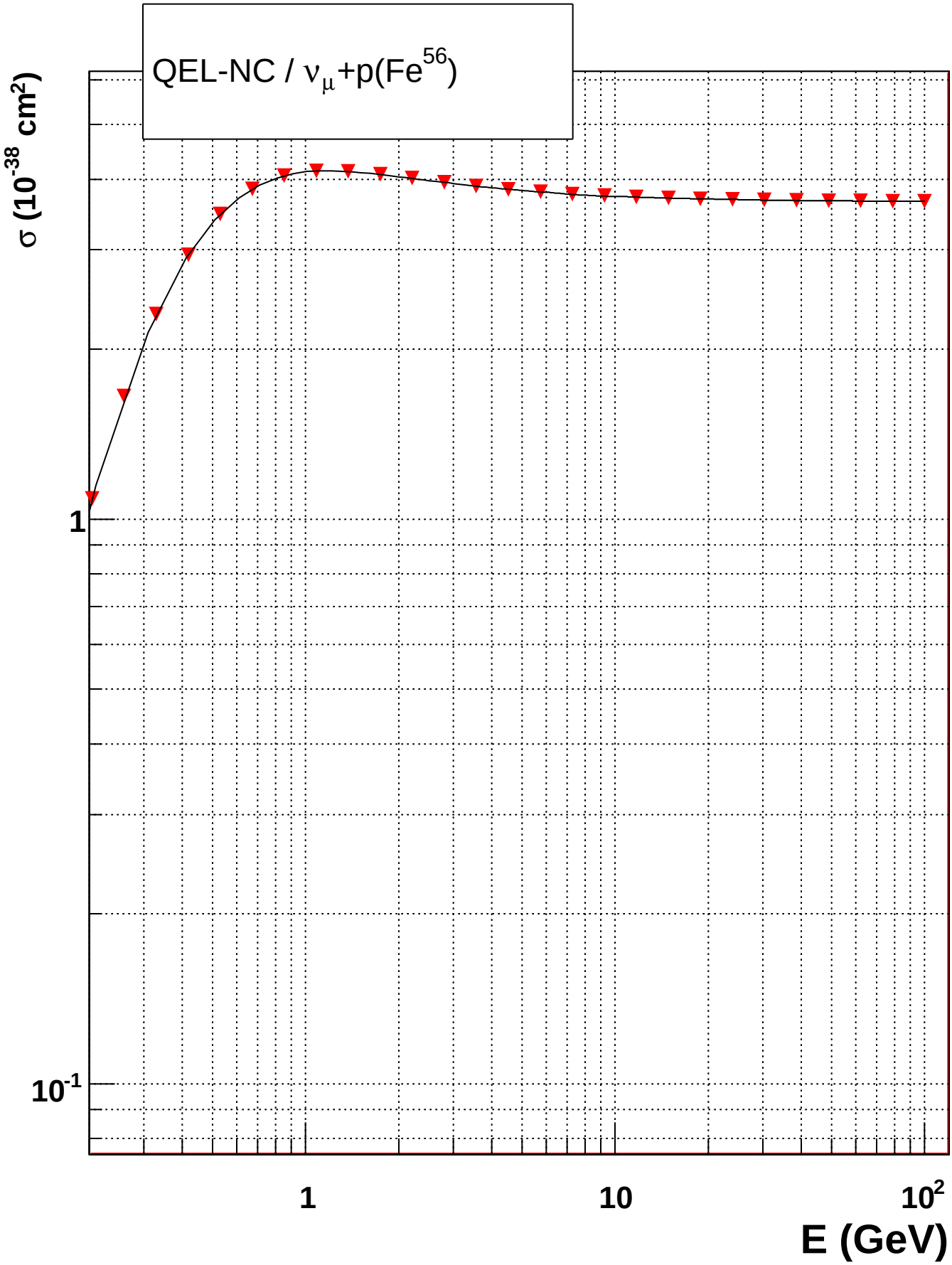
Notes:

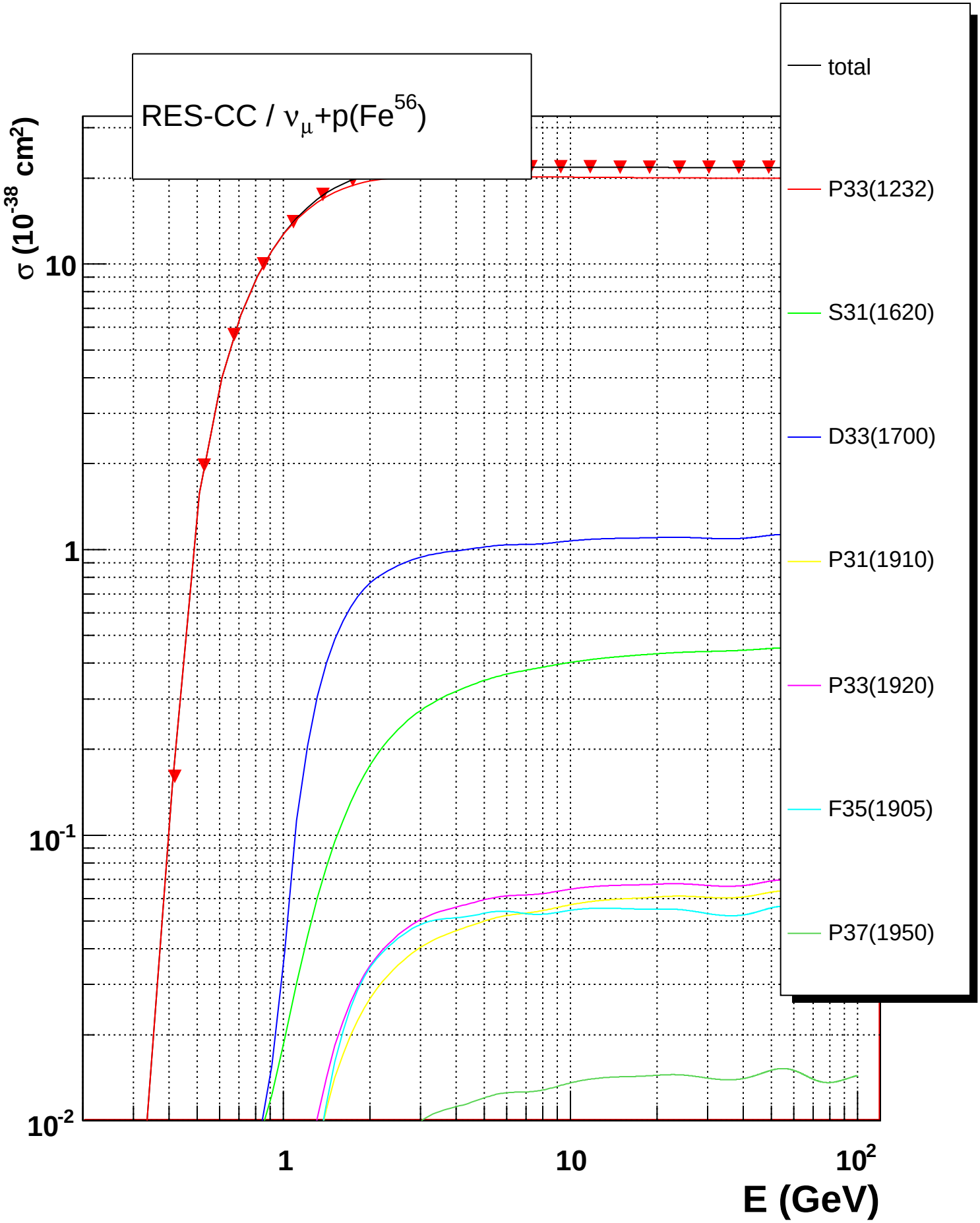
Daikon+ is a NEUGEN Daikon revision version

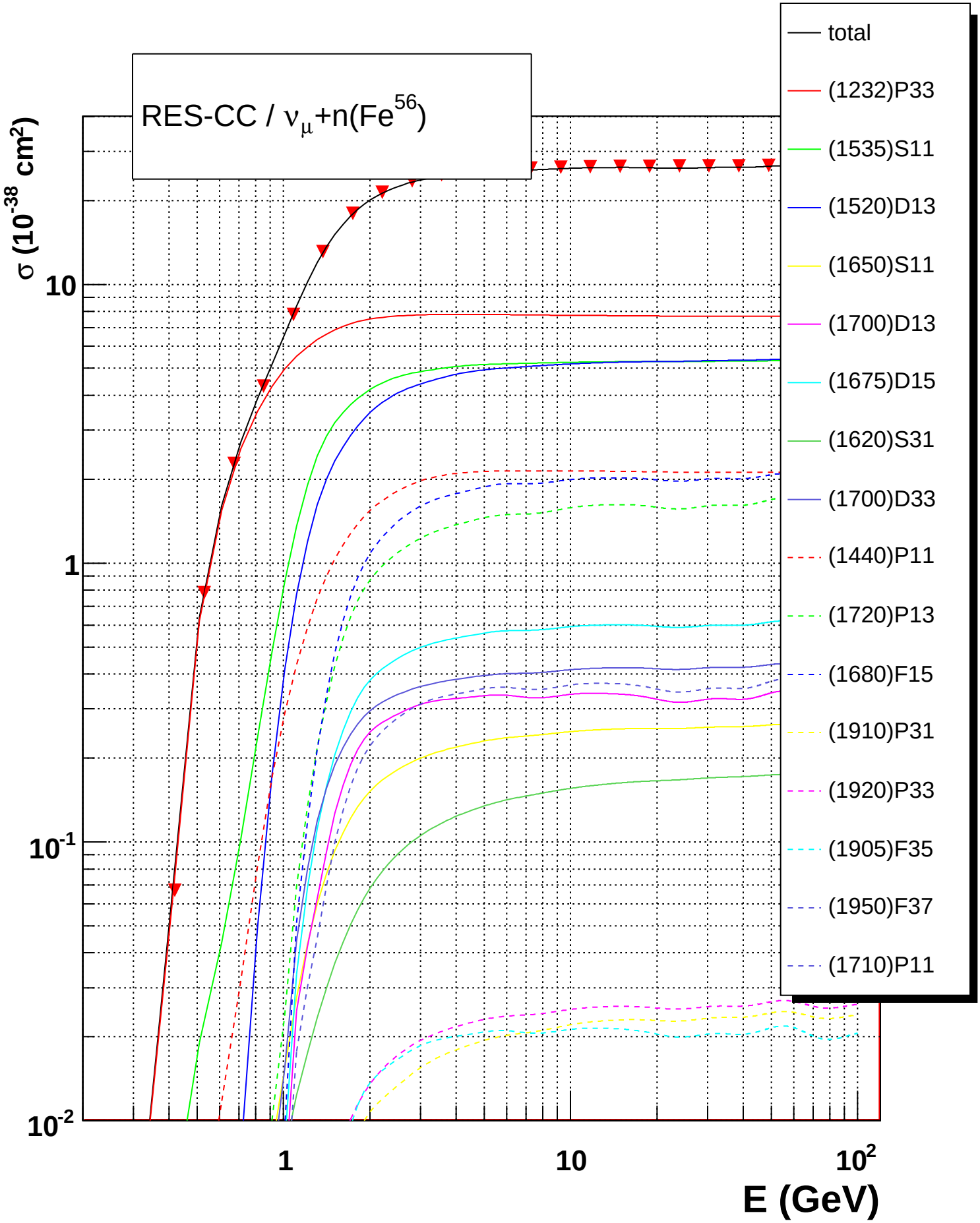
GENIE predictions shown with lines / NEUGEN's with markers

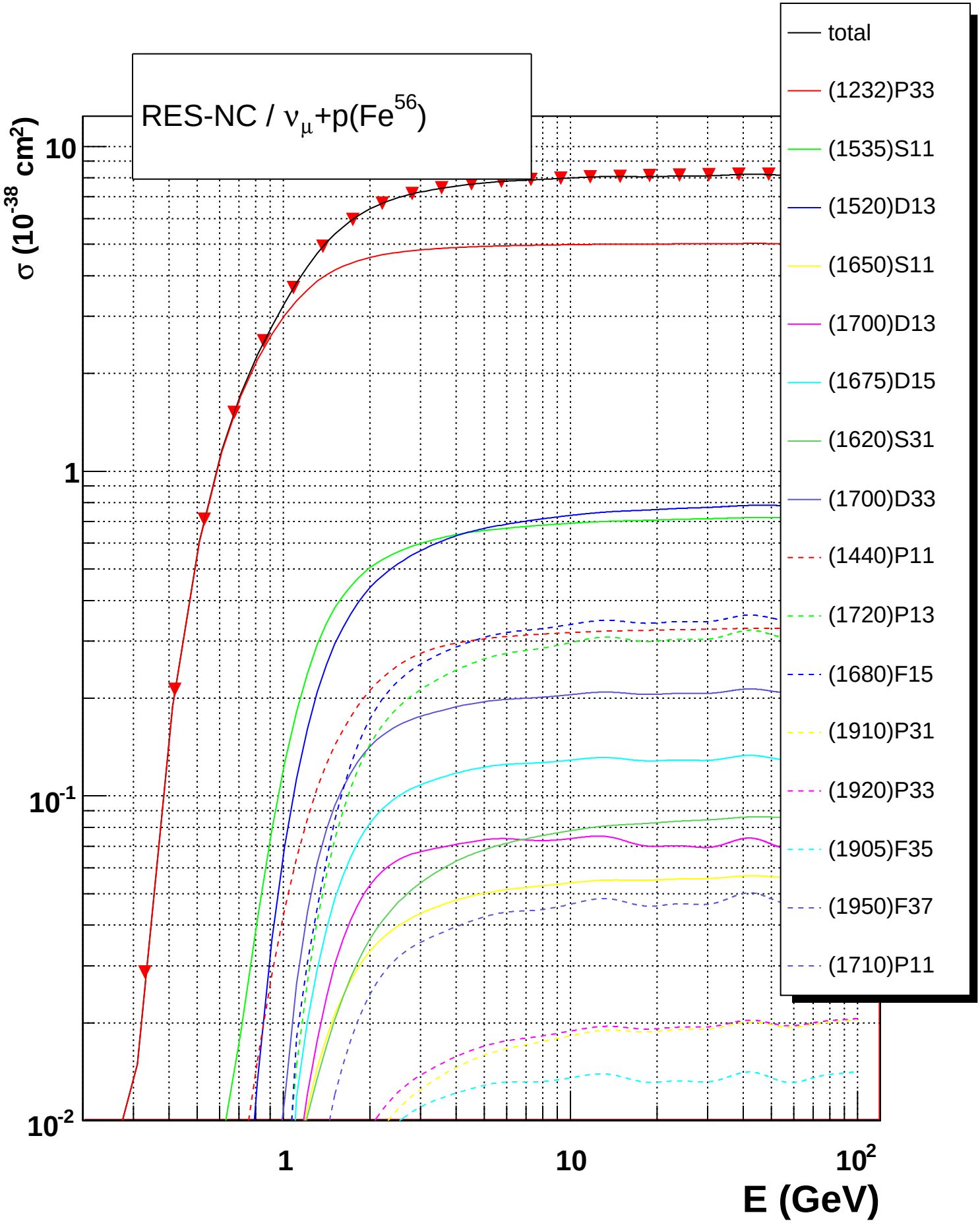

QEL-CC / ν_μ+n(Fe^{56})
σ (10^{-38} cm^2)
10
1
1
10
10^2
E (GeV)


QEL-NC / ν_μ+n(Fe^{56})
σ (10^{-38} cm^2)
1
1
10
10^2
E (GeV)


QEL-NC / ν_μ+p(Fe^{56})
σ (10^{-38} cm^2)
1
10^{-1}
1
10
10^2
E (GeV)


RES-CC / ν_μ+p(Fe^{56})
σ (10^{-38} cm^2)
10
1
10^{-1}
10^{-2}
1
10
10^2
E (GeV)
total
P33(1232)
S31(1620)
D33(1700)
P31(1910)
P33(1920)
F35(1905)
P37(1950)


RES-CC / ν_μ+n(Fe^{56})
σ (10^{-38} cm^2)
10
1
10^{-1}
10^{-2}
1
10
10^2
E (GeV)
total
(1232)P33
(1535)S11
(1520)D13
(1650)S11
(1700)D13
(1675)D15
(1620)S31
(1700)D33
(1440)P11
(1720)P13
(1680)F15
(1910)P31
(1920)P33
(1905)F35
(1950)F37
(1710)P11


RES-NC / ν_μ+p(Fe^{56})
σ (10^{-38} cm^2)
10
1
10^{-1}
10^{-2}
1
10
10^2
E (GeV)
total
(1232)P33
(1535)S11
(1520)D13
(1650)S11
(1700)D13
(1675)D15
(1620)S31
(1700)D33
(1440)P11
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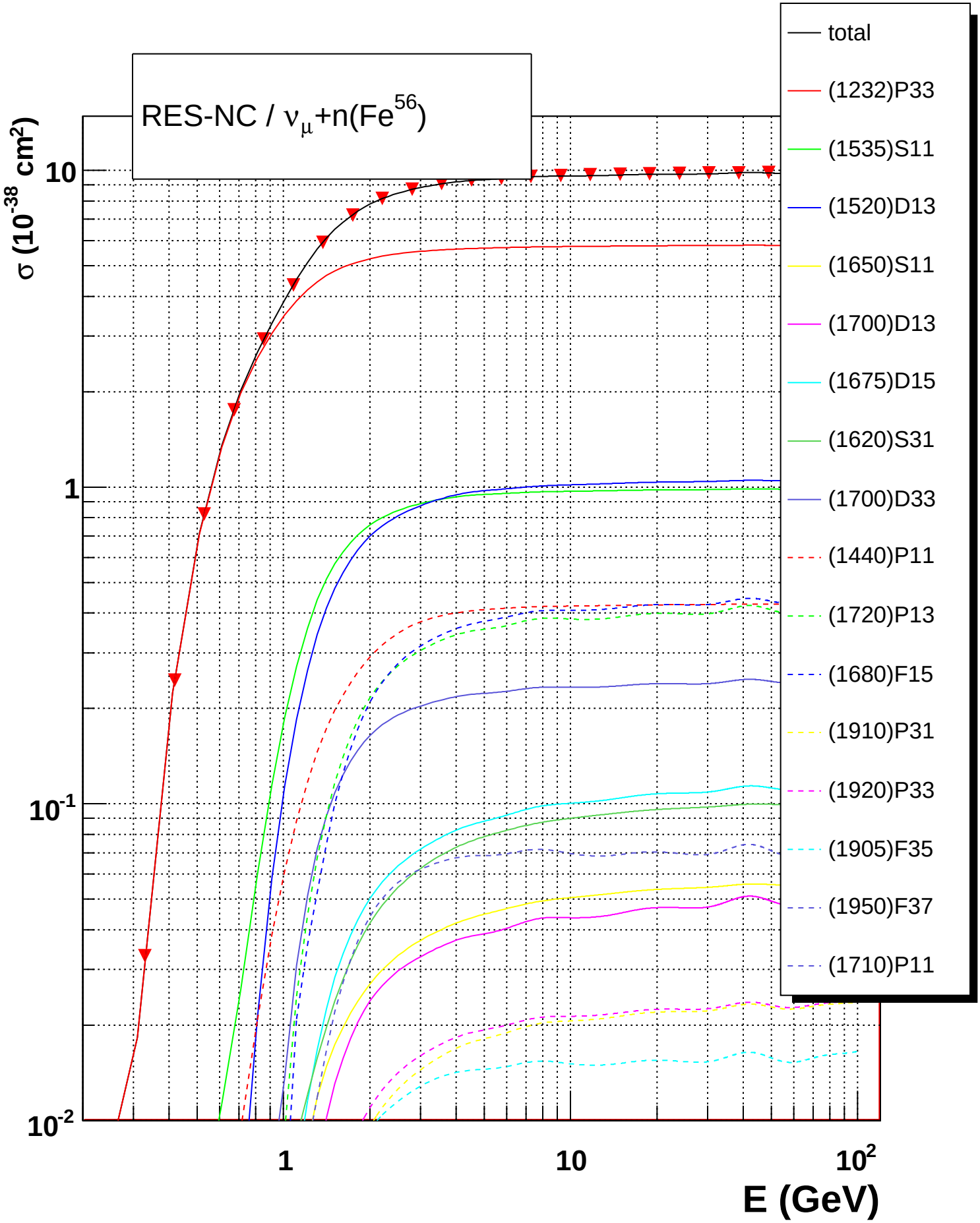
(1680)F15
(1910)P31
(1920)P33
(1905)F35
(1950)F37
(1710)P11


RES-NC / ν_μ+n(Fe^{56})
σ (10^{-38} cm^2)
10
1
10^{-1}
10^{-2}
1
10
10^2
E (GeV)
total
(1232)P33
(1535)S11
(1520)D13
(1650)S11
(1700)D13
(1675)D15
(1620)S31
(1700)D33
(1440)P11
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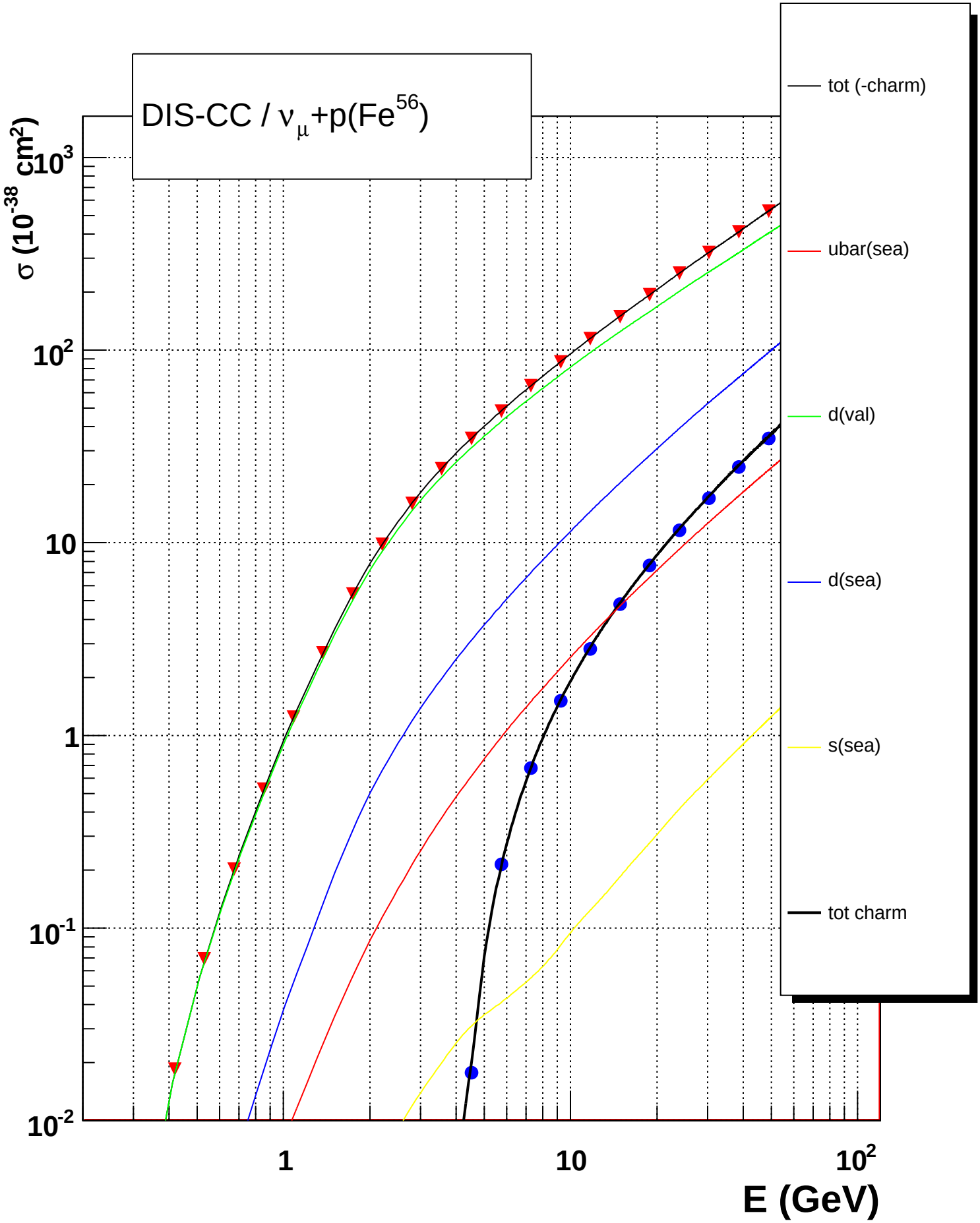
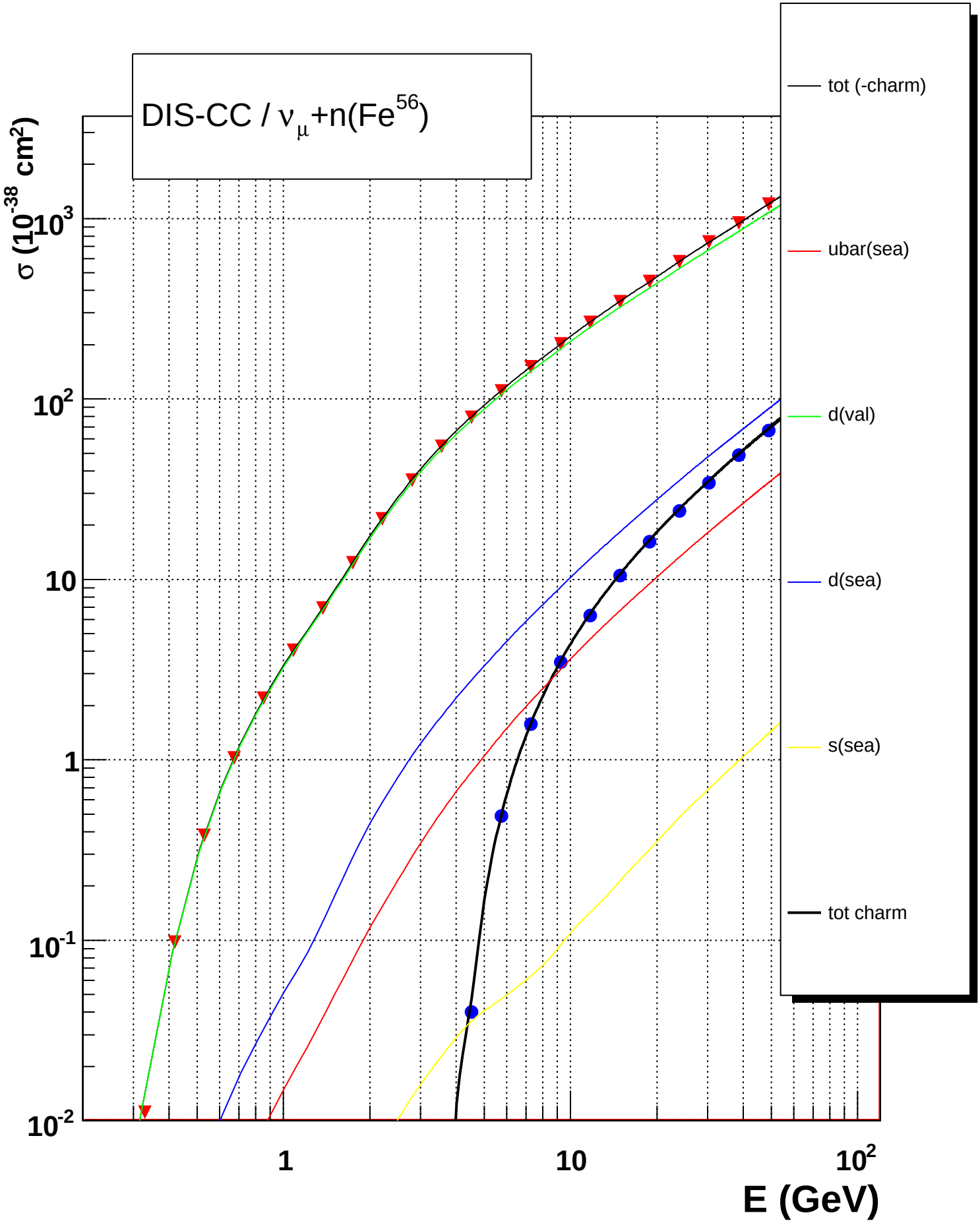
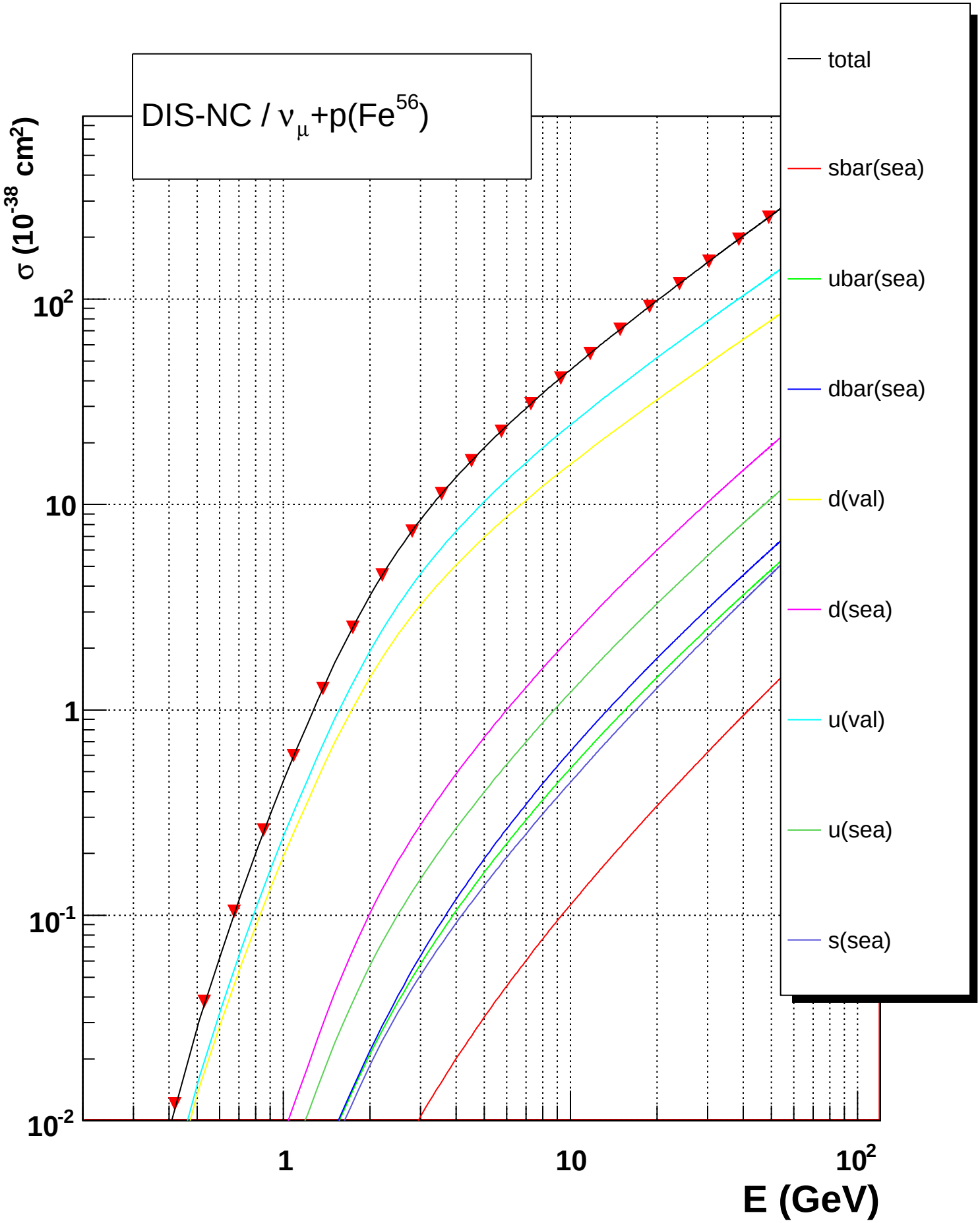
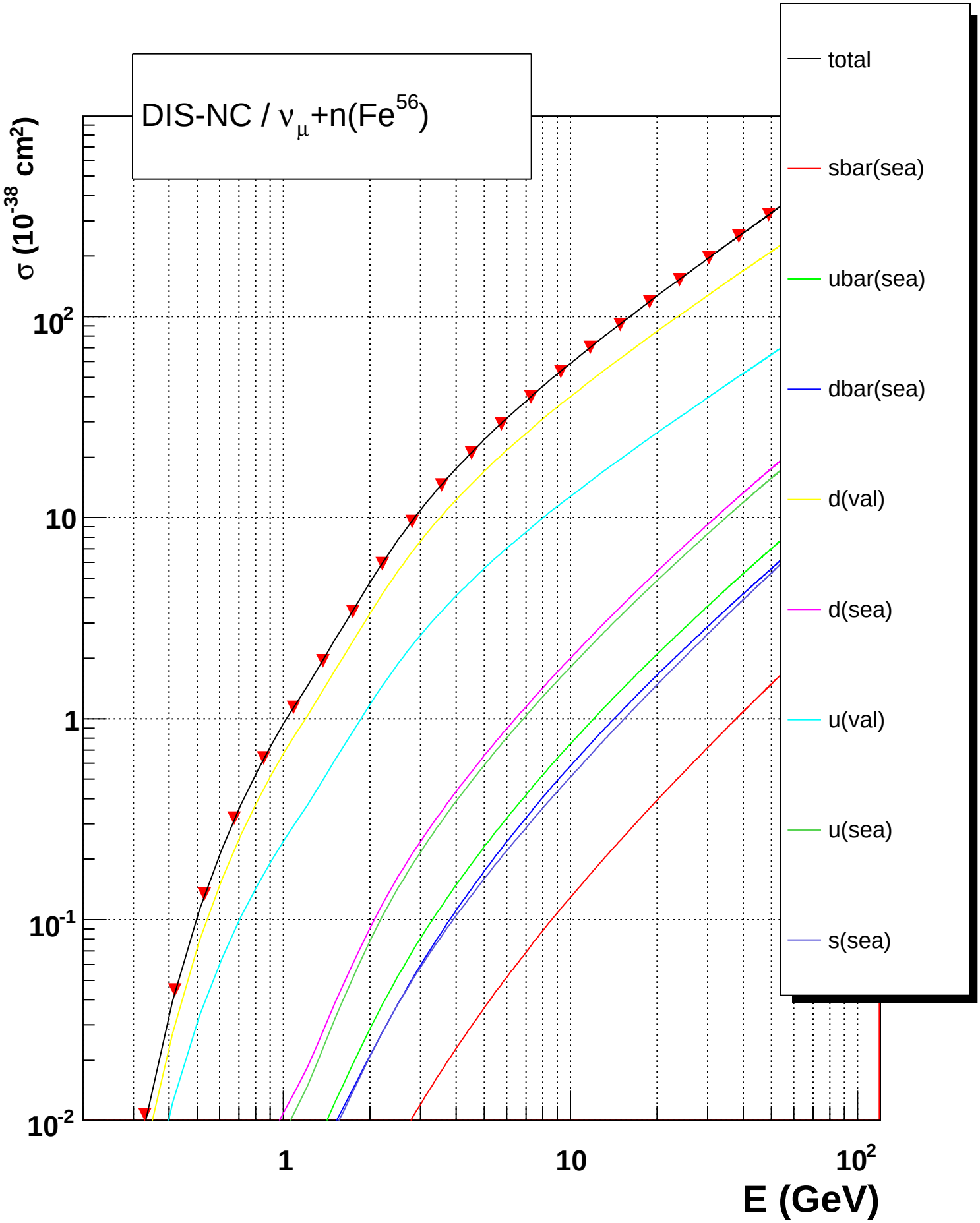
(1950)F37
(1710)P11


DIS-CC / ν_μ+p(Fe^{56})
σ (10^{-38} cm^2)
10^3
10^2
10
1
10^{-1}
10^{-2}
1
10
10^2
E (GeV)
tot (-charm)
ubar(sea)
d(val)
d(sea)
s(sea)
tot charm


DIS-CC / ν_μ+n(Fe^{56})
σ (10^{-38} cm^2)
10^3
10^2
10
1
10^{-1}
10^{-2}
1
10
10^2
E (GeV)
tot (-charm)
ubar(sea)
d(val)
d(sea)
s(sea)
tot charm


DIS-NC / ν_μ+p(Fe^{56})
σ (10^{-38} cm^2)
10^2
10
1
10^{-1}
10^{-2}
1
10
10^2
E (GeV)
total
sbar(sea)
ubar(sea)
dbar(sea)
d(val)
d(sea)
u(val)
u(sea)
s(sea)


DIS-NC / ν_μ+n(Fe^{56})
σ (10^{-38} cm^2)
10^2
10
1
10^{-1}
10^{-2}
1
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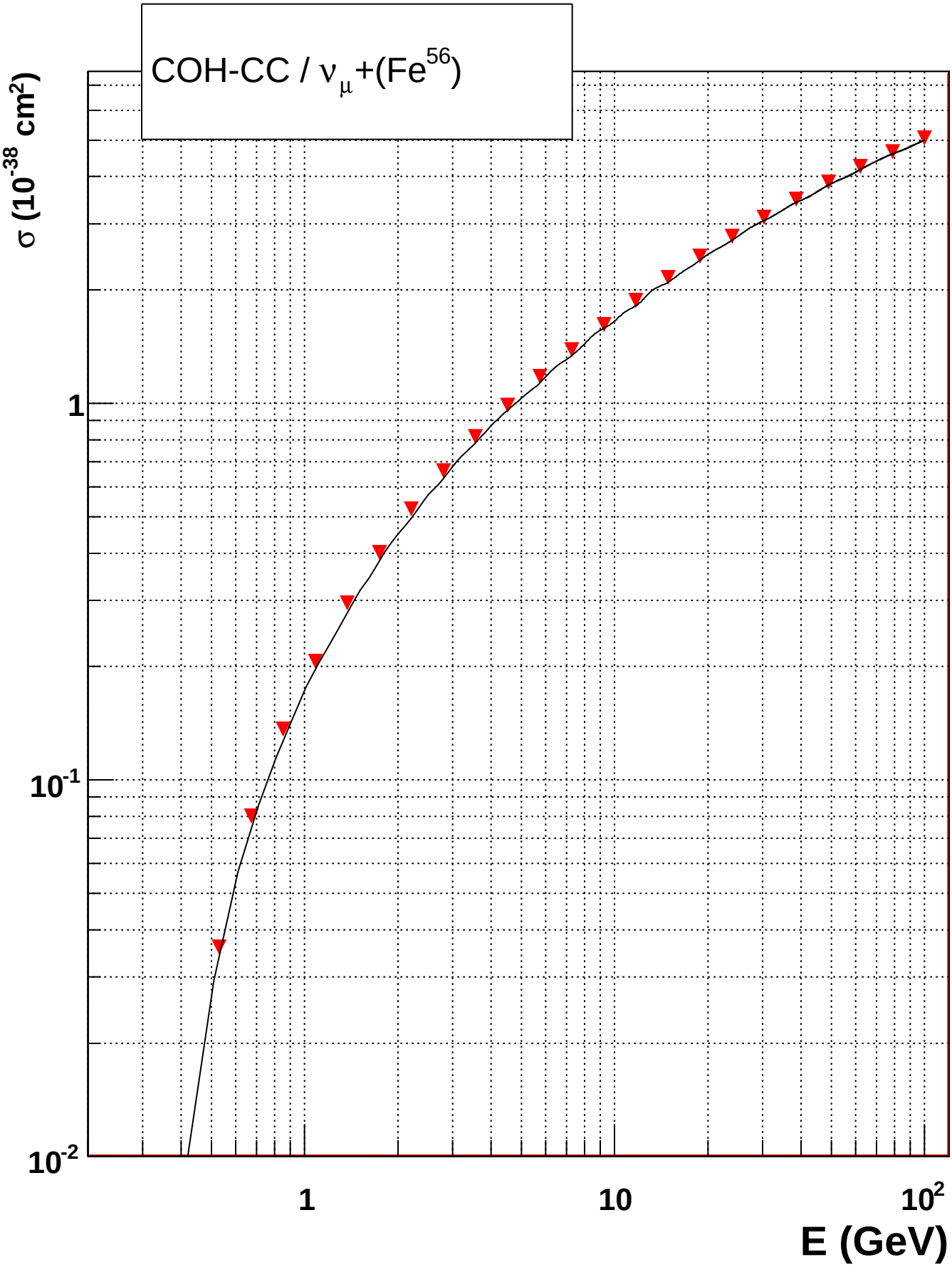
10^2
E (GeV)
total
sbar(sea)
ubar(sea)
dbar(sea)
d(val)
d(sea)
u(val)
u(sea)
s(sea)


COH-CC / ν_μ+(Fe^{56})
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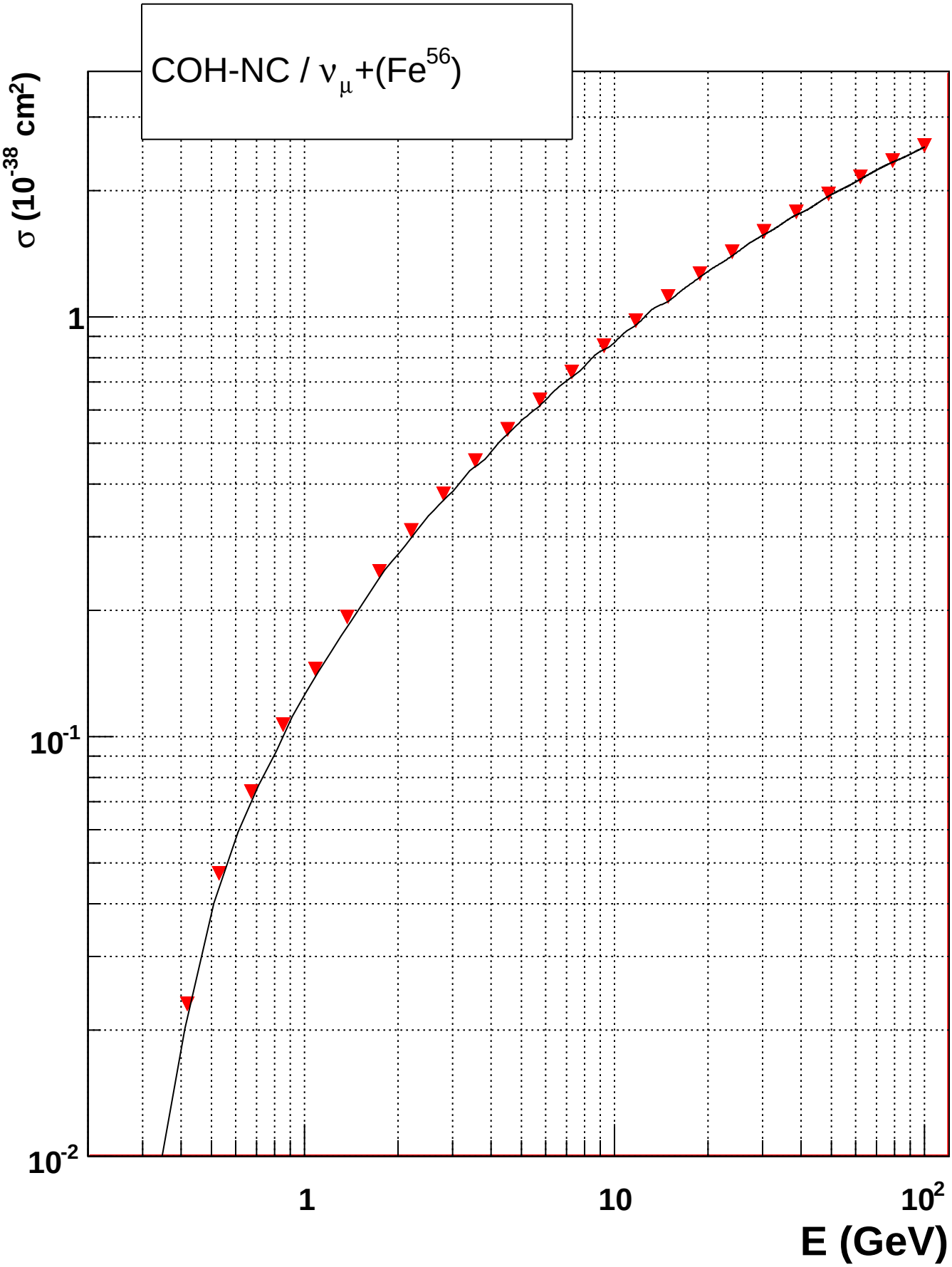
10^{-2}
1
10
10^2
E (GeV)


COH-NC / ν_μ+(Fe^{56})
σ (10^{-38} cm^2)
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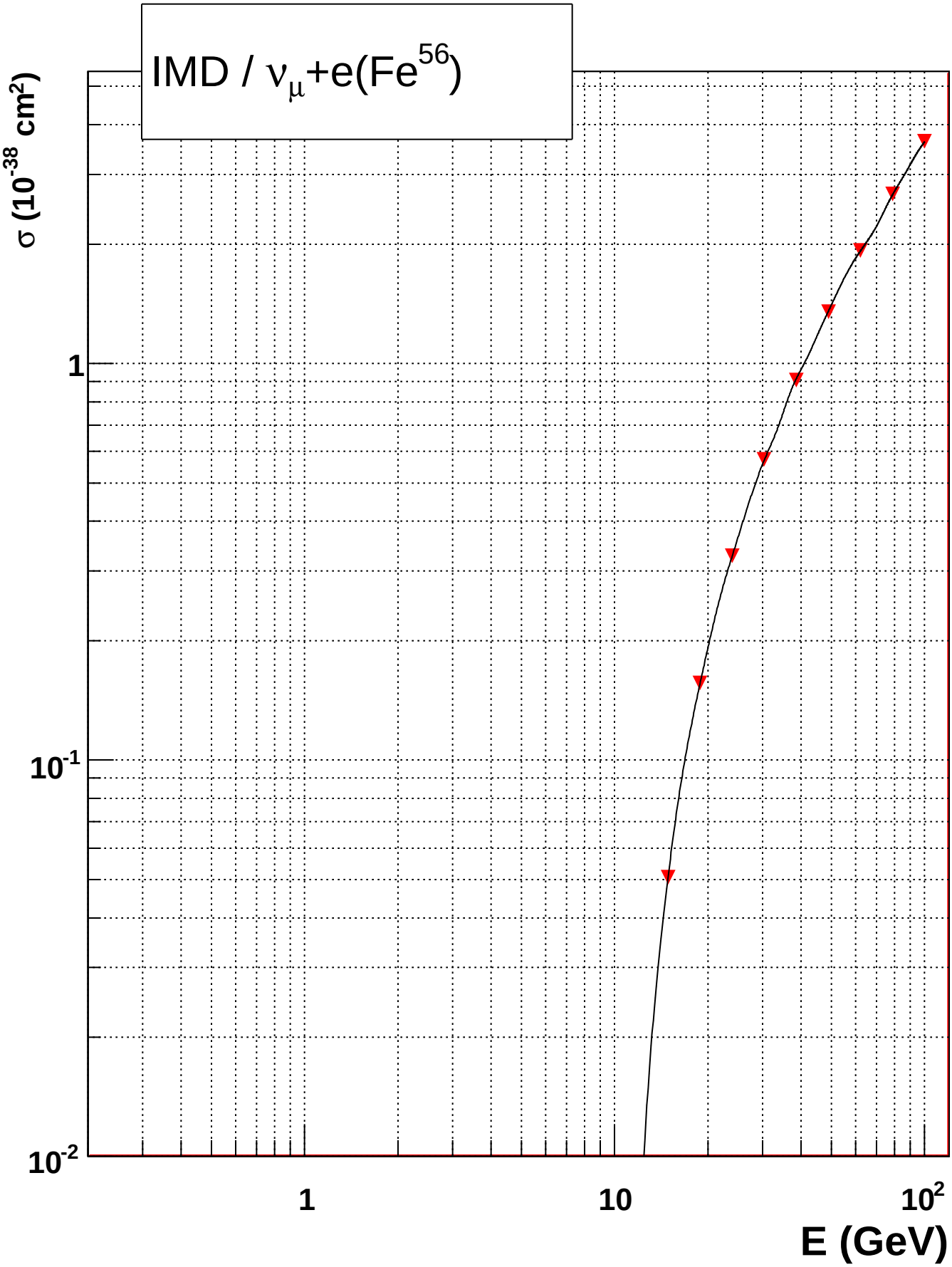
10^{-2}
1
10
10^2
E (GeV)


IMD / ν_μ+e(Fe^{56})
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10^{-2}
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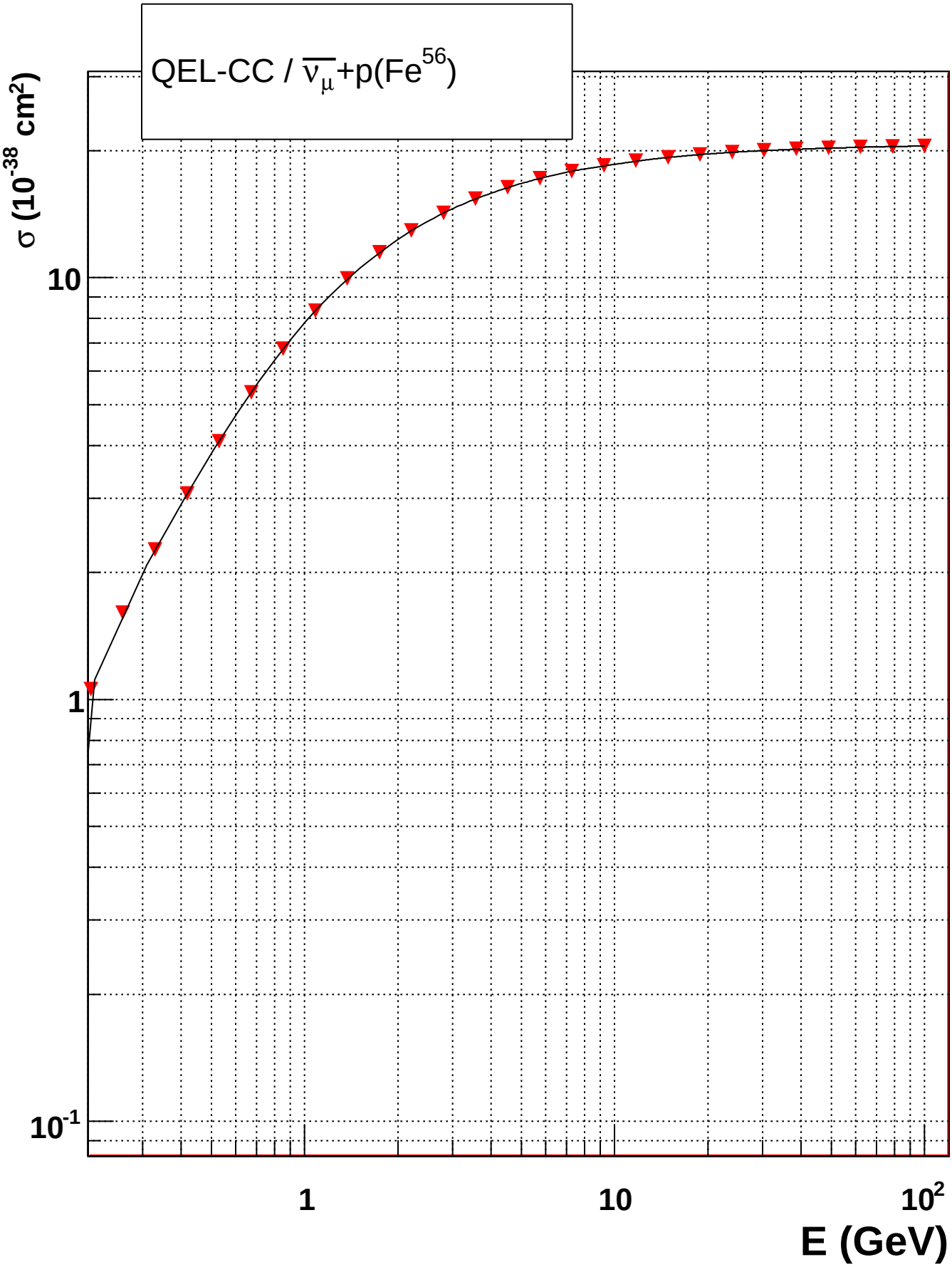
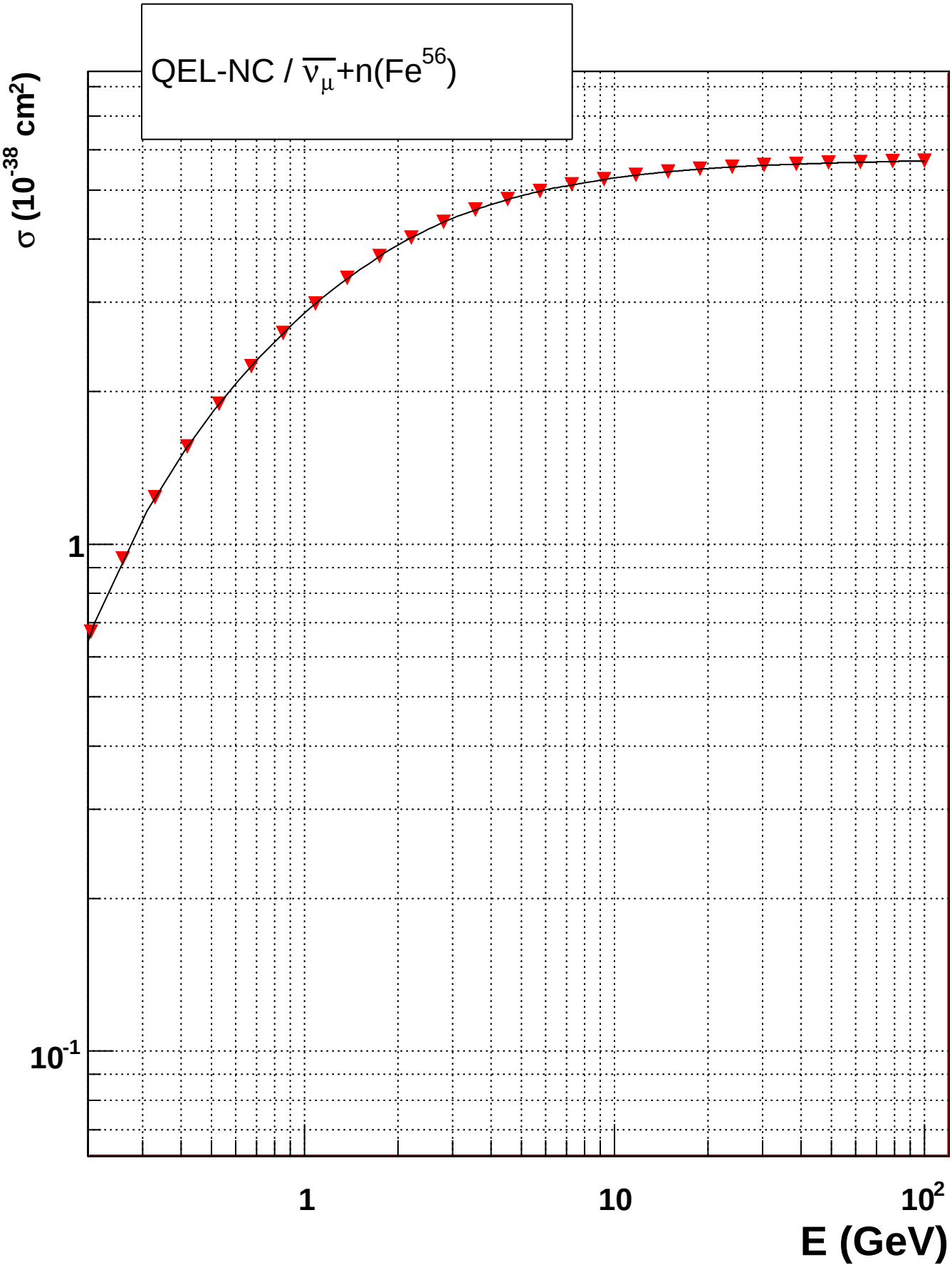
10
10^2
E (GeV)


QEL-CC / $\overline{\nu}_\mu$+p(Fe^{56})
σ (10^{-38} cm^2)
10
1
10^{-1}
1
10
10^2
E (GeV)


QEL-NC / $\overline{\nu}_\mu$+n(Fe^{56})
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10^{-1}
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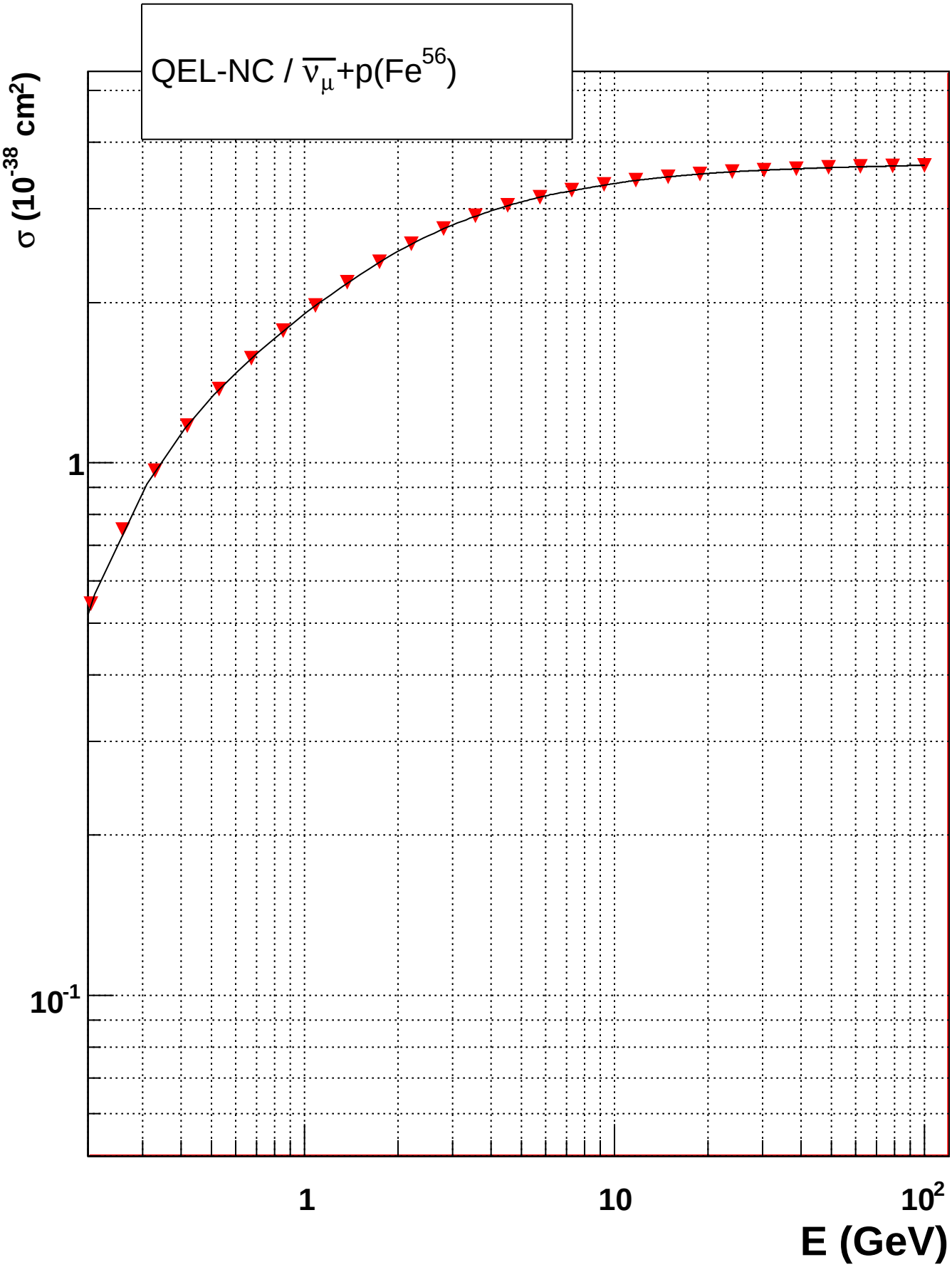
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10^{-1}
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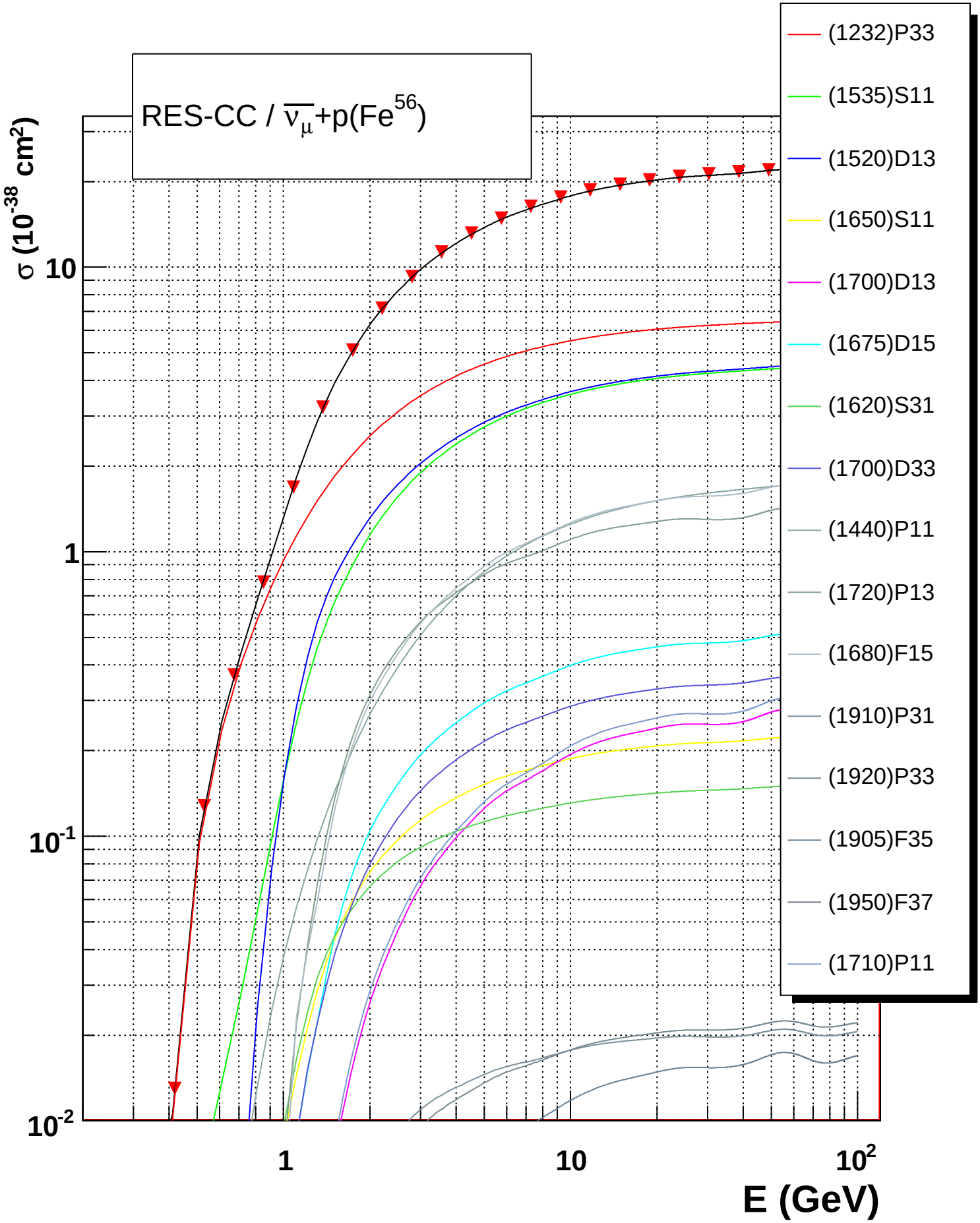
RES-CC / $\overline{\nu}_\mu$+p(Fe^{56})
σ (10^{-38} cm^2)
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10^{-1}
10^{-2}
1
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10^2
E (GeV)
(1232)P33
(1535)S11
(1520)D13
(1650)S11
(1700)D13
(1675)D15
(1620)S31
(1700)D33
(1440)P11
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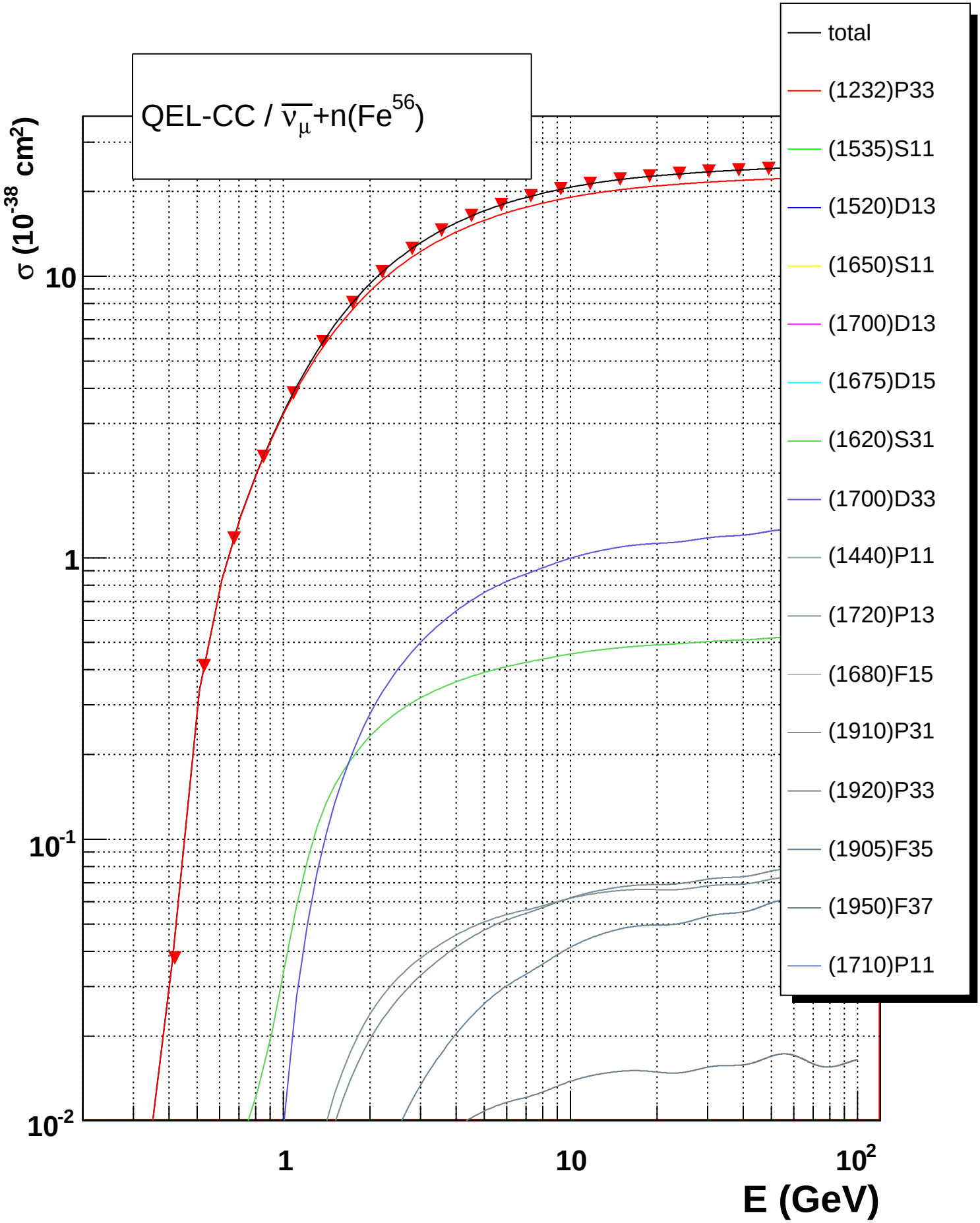
(1910)P31
(1920)P33
(1905)F35
(1950)F37
(1710)P11


QEL-CC / $\overline{\nu}_\mu$+n(Fe^{56})
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10
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10^{-1}
10^{-2}
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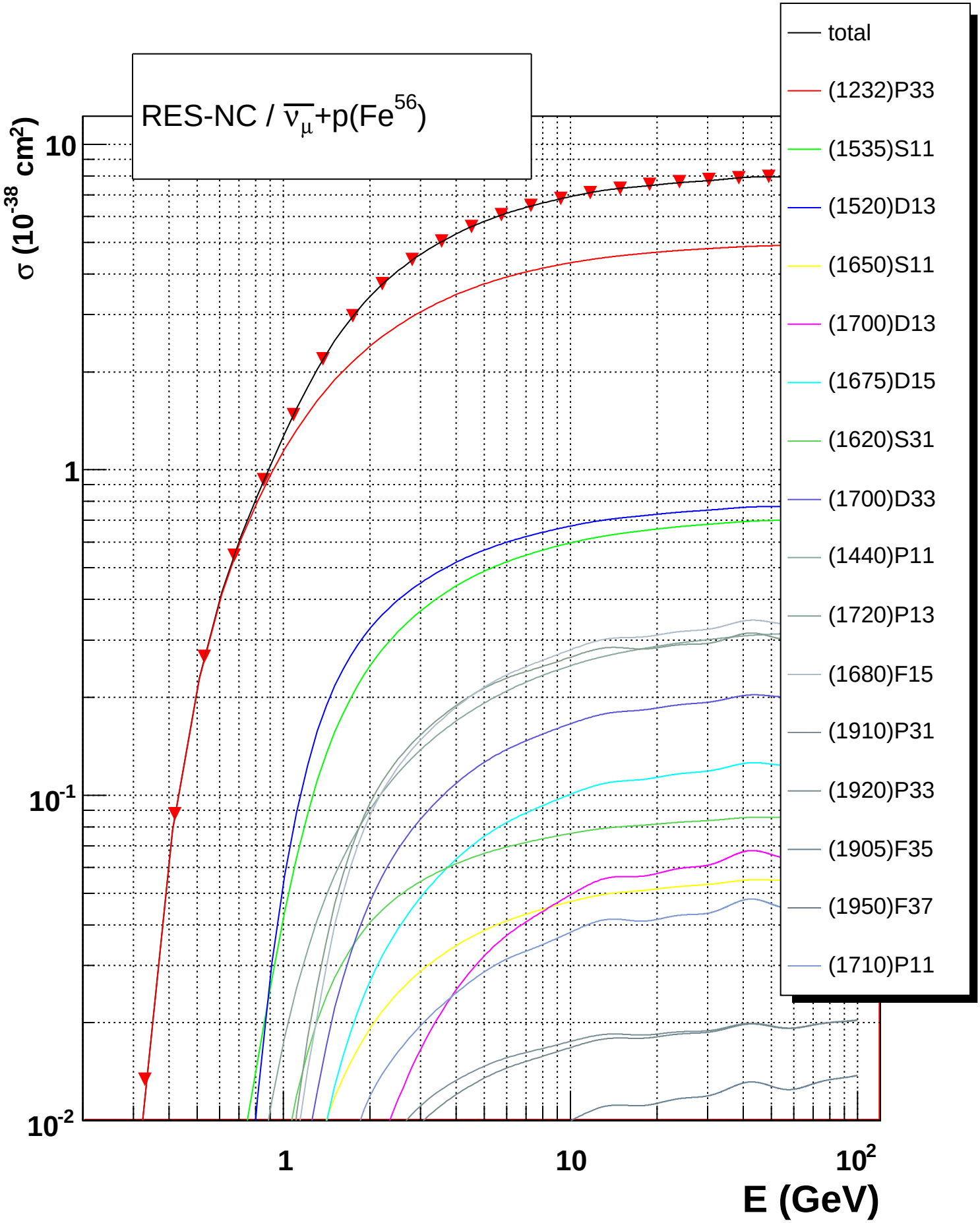
RES-NC / $\overline{\nu}_\mu$+p(Fe^{56})
σ (10^{-38} cm^2)
10
1
10^{-1}
10^{-2}
1
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10^2
E (GeV)
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(1232)P33
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(1650)S11
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(1620)S31
(1700)D33
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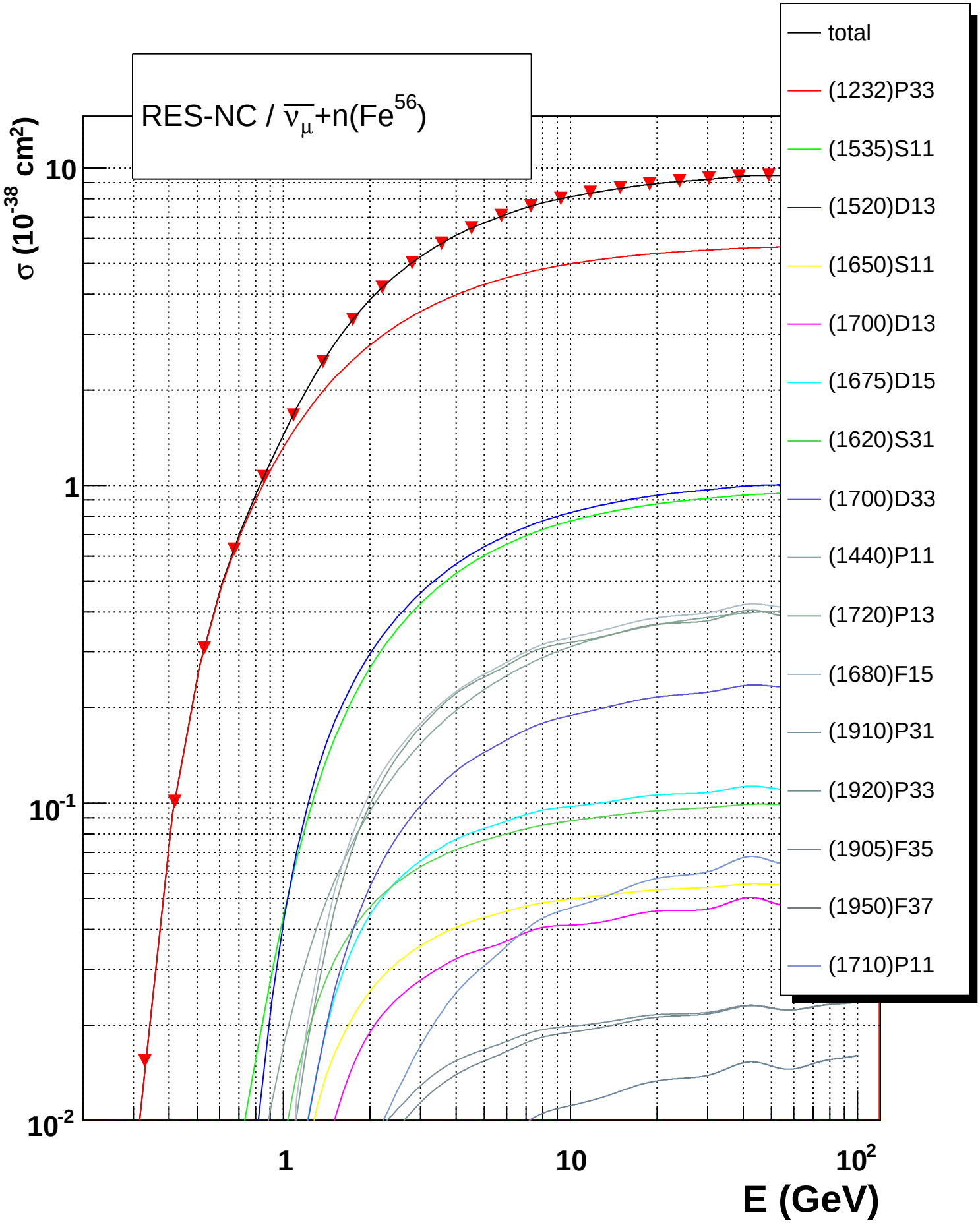
RES-NC / $\overline{\nu}_\mu$+n(Fe^{56})
σ (10^{-38} cm^2)
10
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10^{-1}
10^{-2}
1
10
10^2
E (GeV)
total
(1232)P33
(1535)S11
(1520)D13
(1650)S11
(1700)D13
(1675)D15
(1620)S31
(1700)D33
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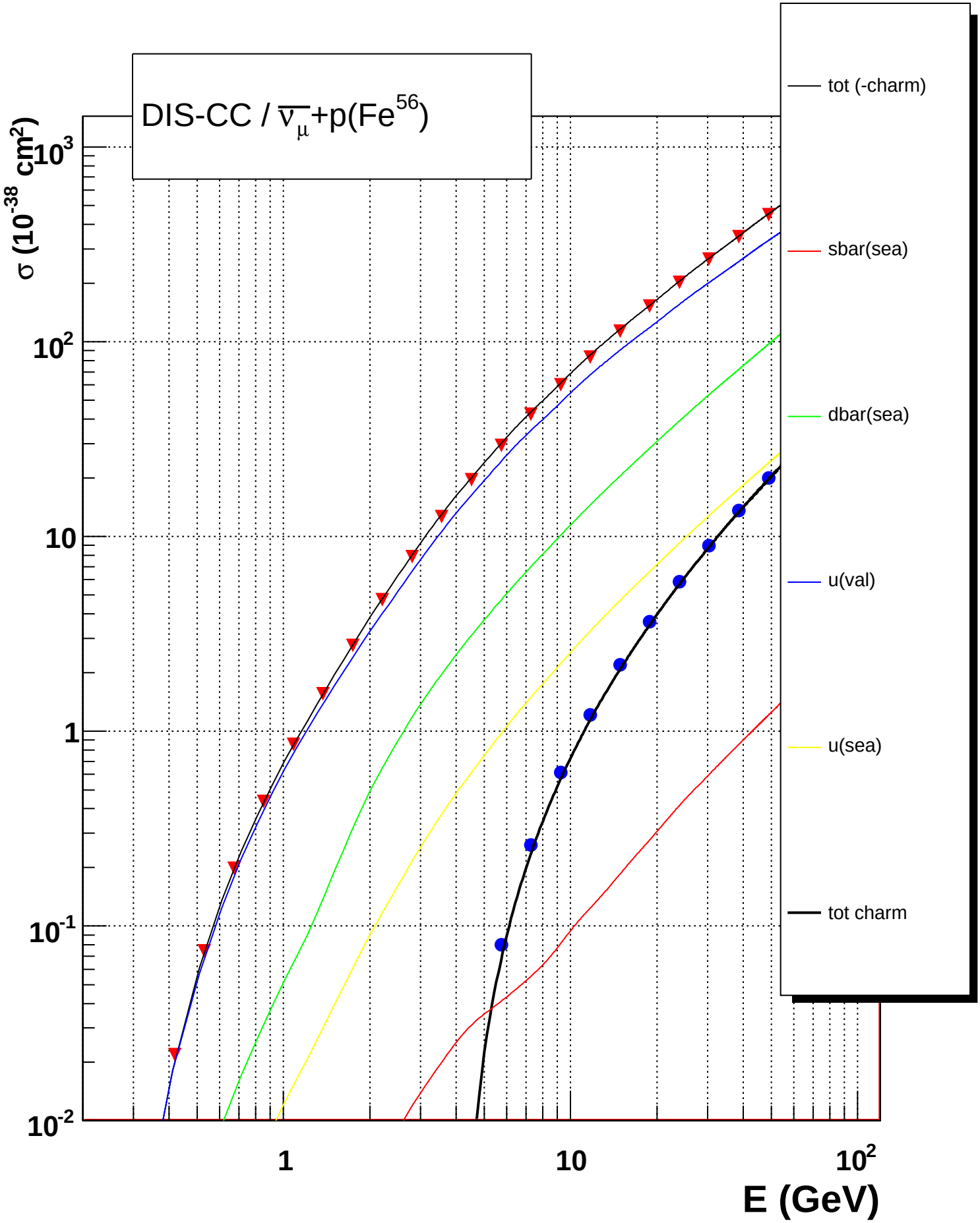
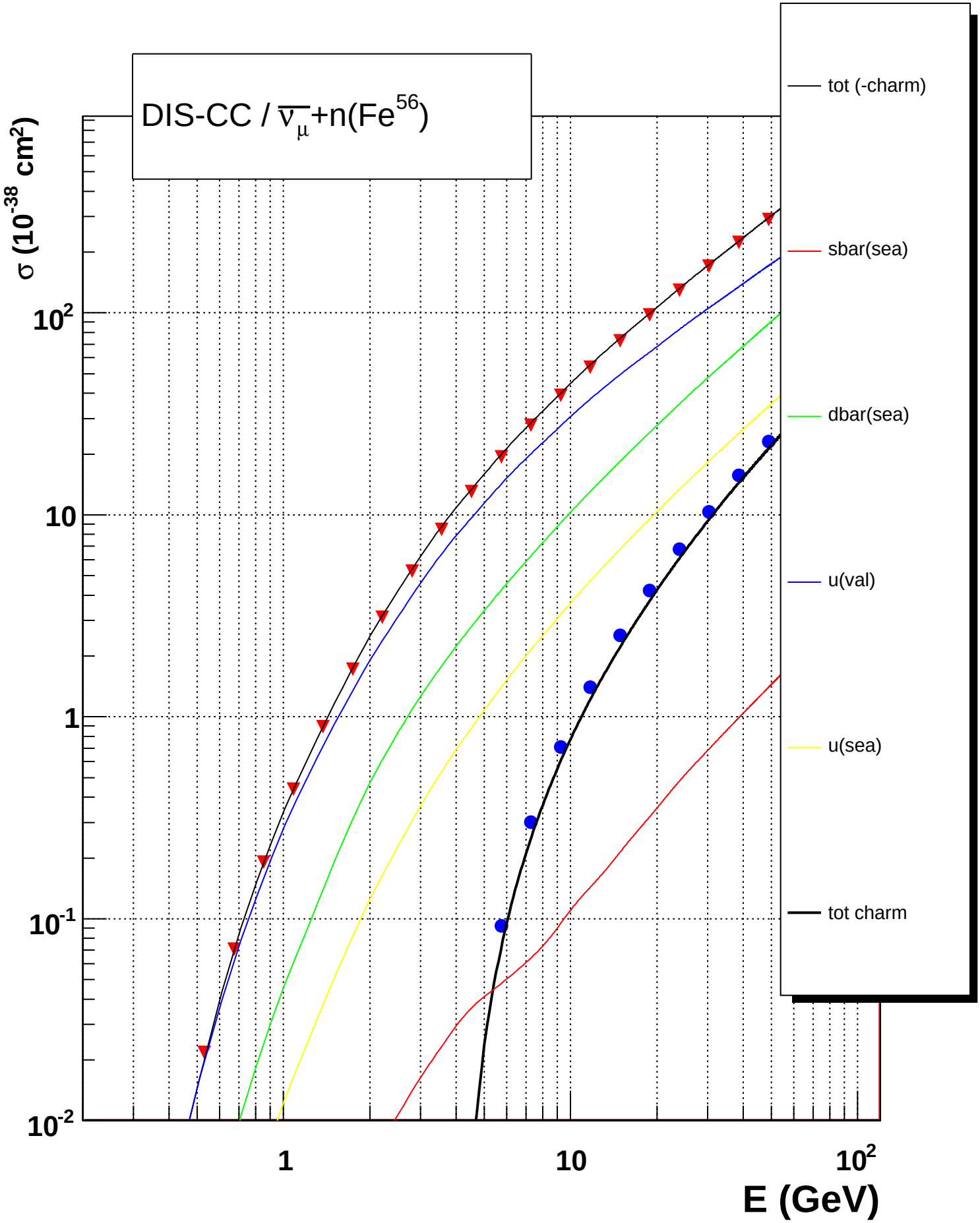
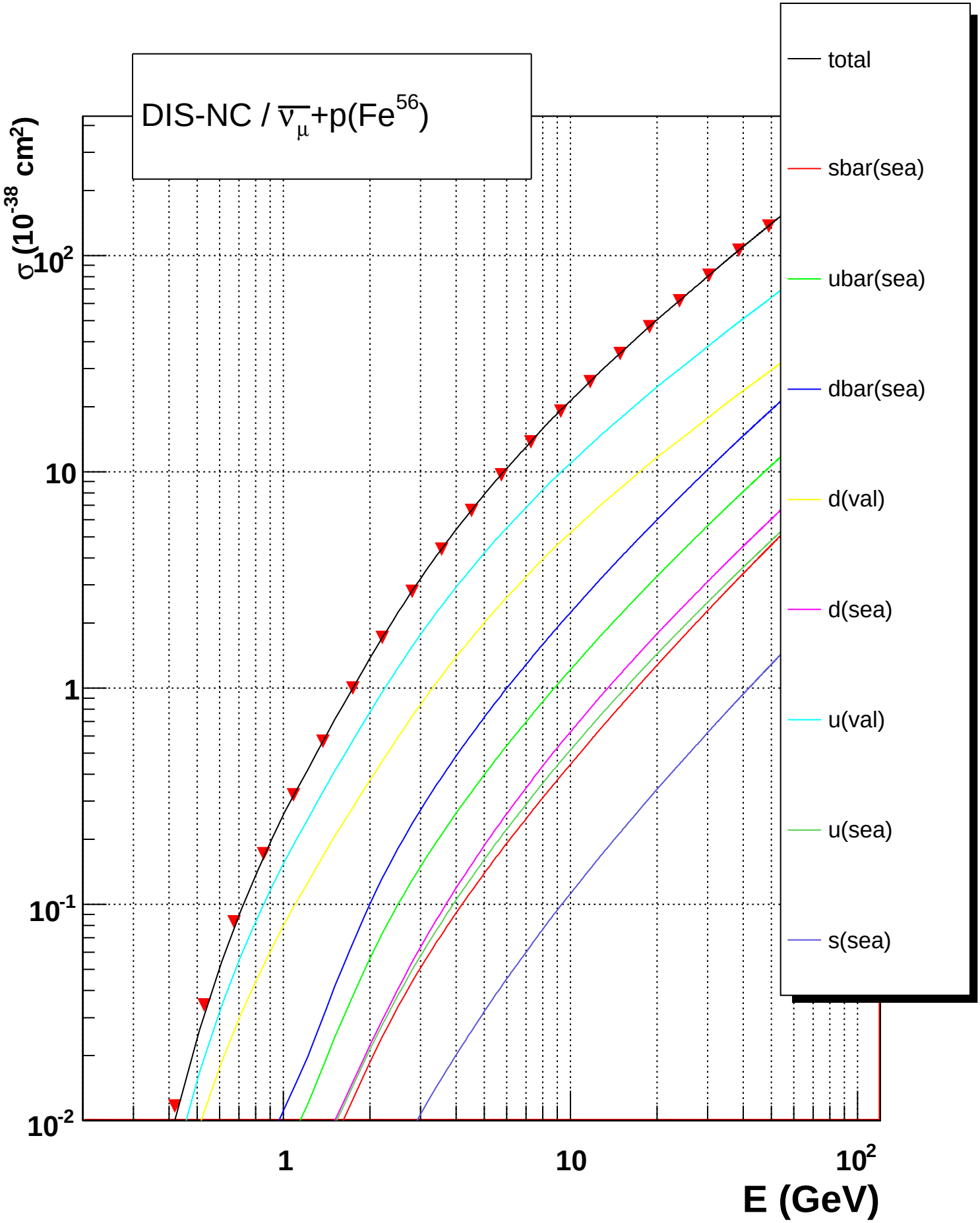

DIS-CC / $\overline{\nu}_\mu$+p(Fe^{56})
σ (10^{-38} cm^2)
10^3
10^2
10
1
10^{-1}
10^{-2}
1
10
10^2
E (GeV)
tot (-charm)
sbar(sea)
dbar(sea)
u(val)
u(sea)
tot charm


DIS-CC / $\overline{\nu}_\mu$+n(Fe^{56})
σ (10^{-38} cm^2)
10^2
10
1
10^{-1}
10^{-2}
1
10
10^2
E (GeV)
tot (-charm)
sbar(sea)
dbar(sea)
u(val)
u(sea)
tot charm


DIS-NC / $\bar{\nu}_\mu$+p(Fe^{56})
σ (10^{-38} cm^2)
10^2
10
1
10^{-1}
10^{-2}
1
10
10^2
E (GeV)
total
sbar(sea)
ubar(sea)
dbar(sea)
d(val)
d(sea)
u(val)
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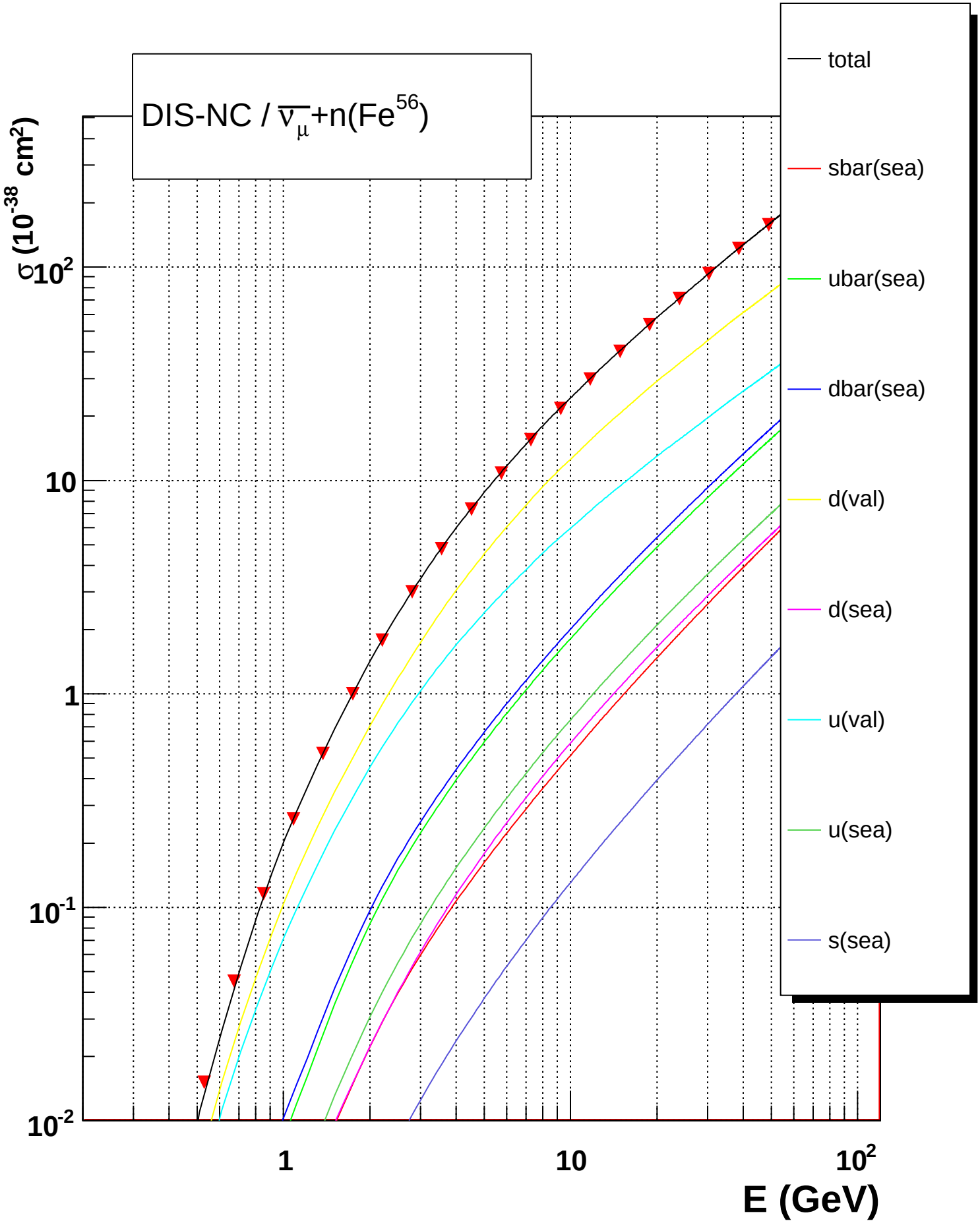
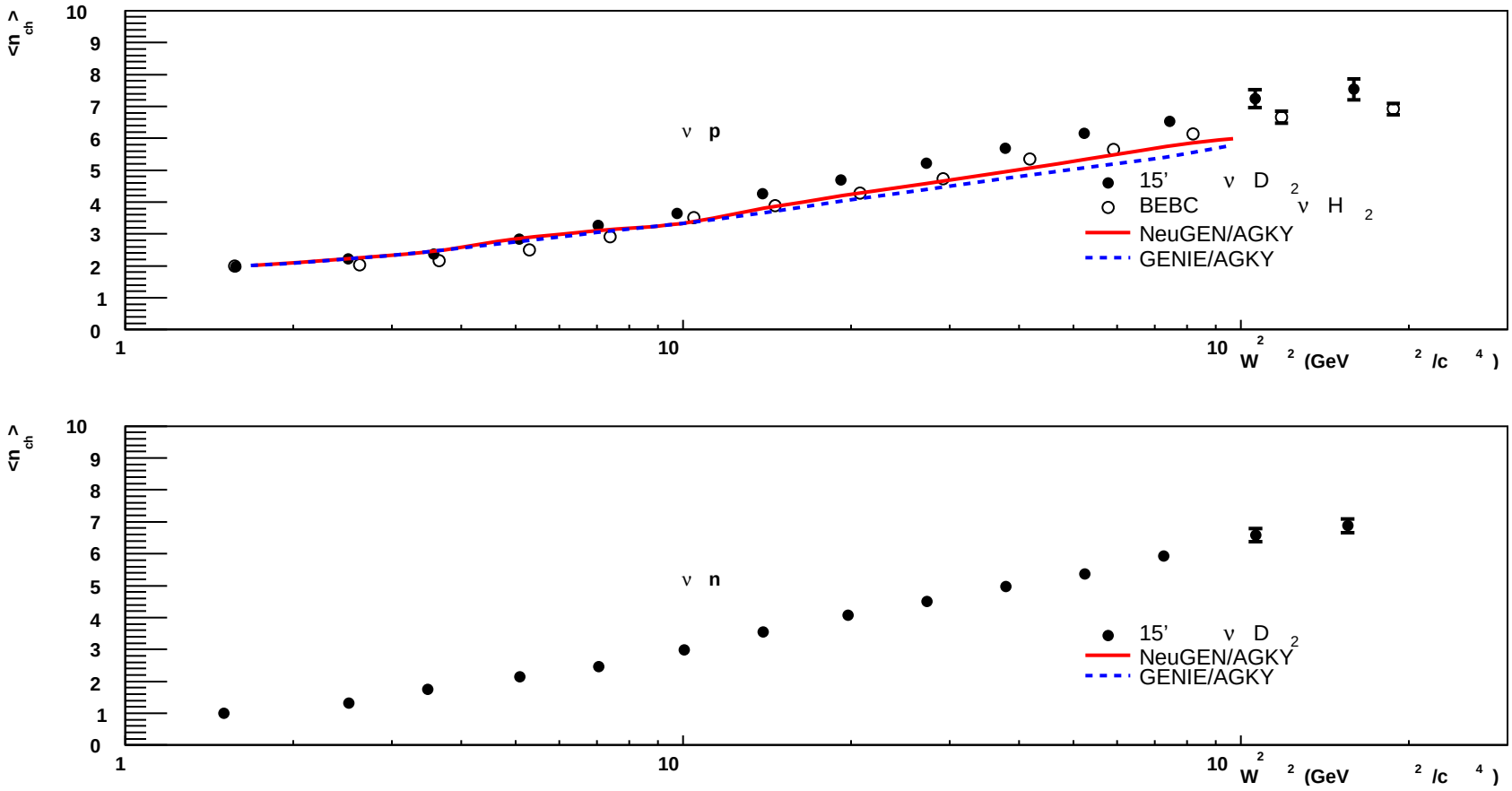
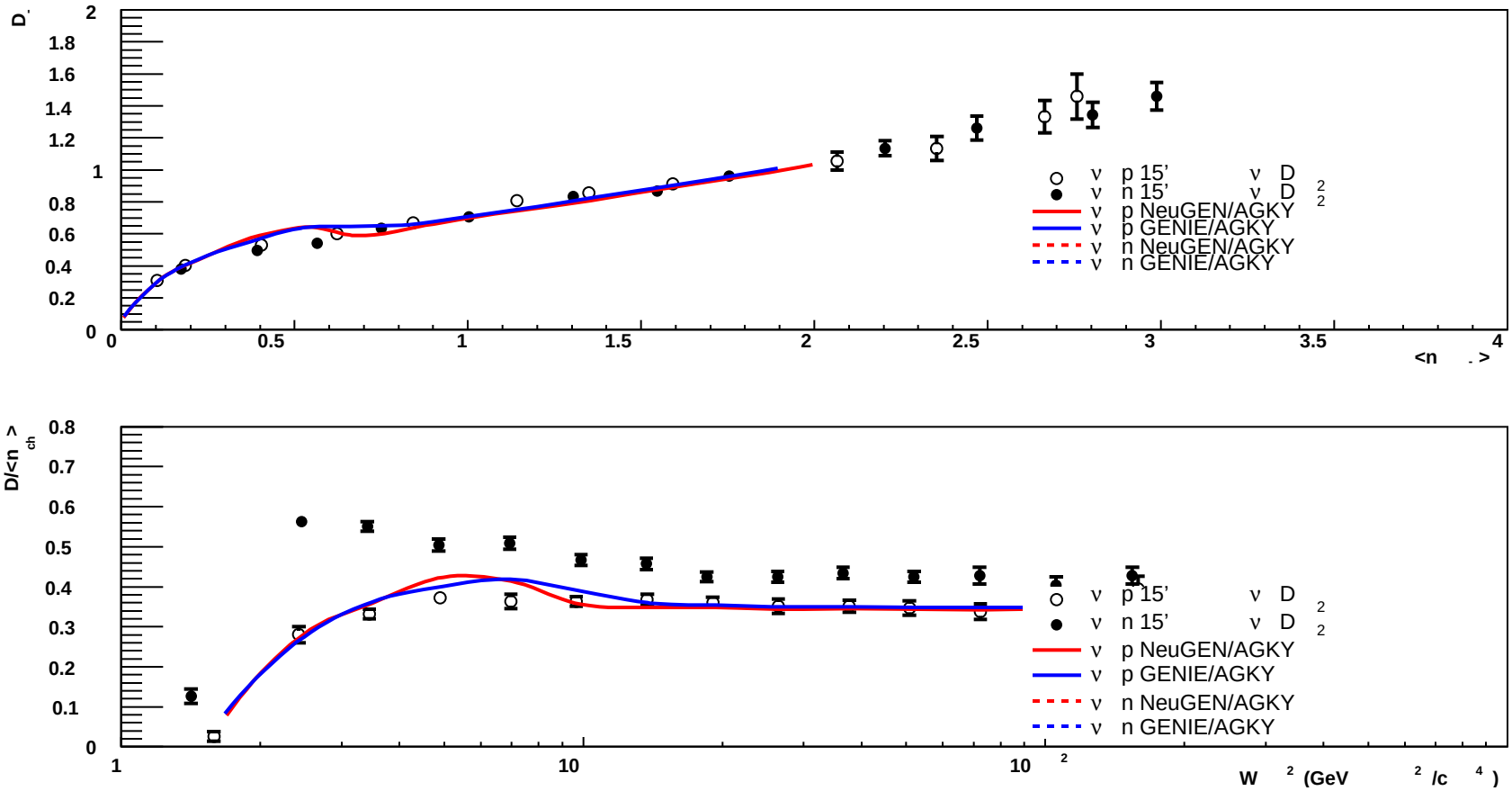
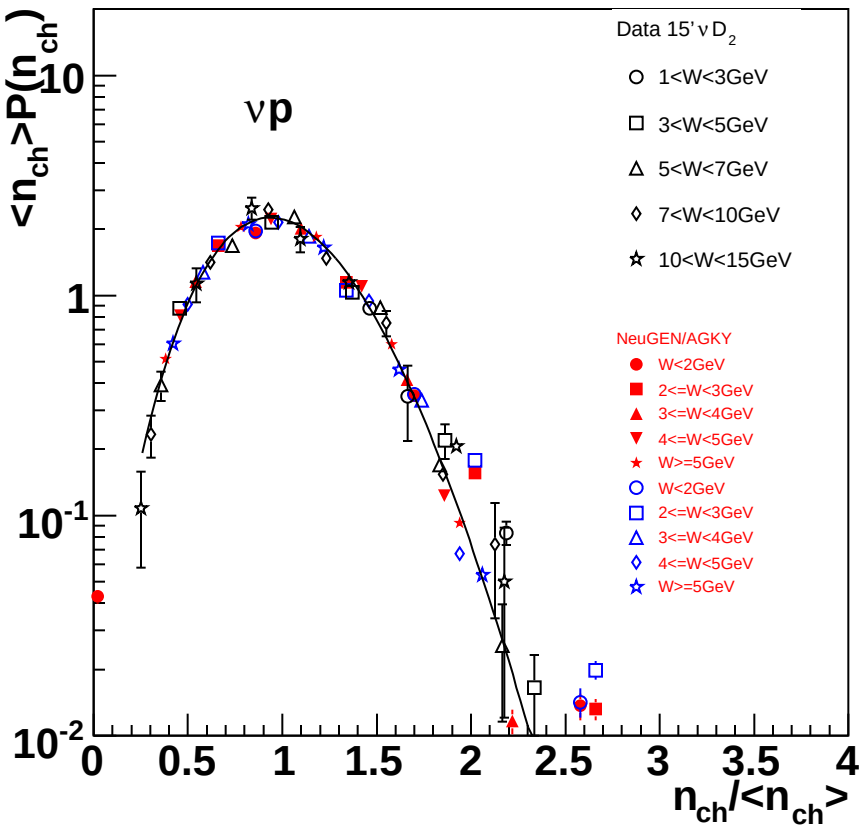
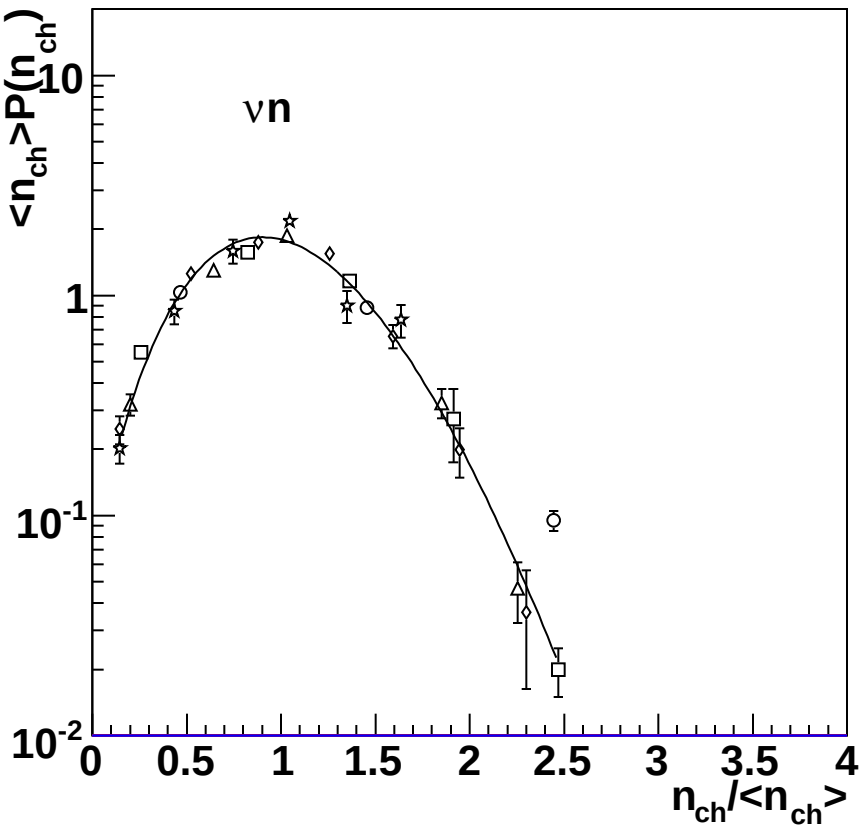
s(sea)

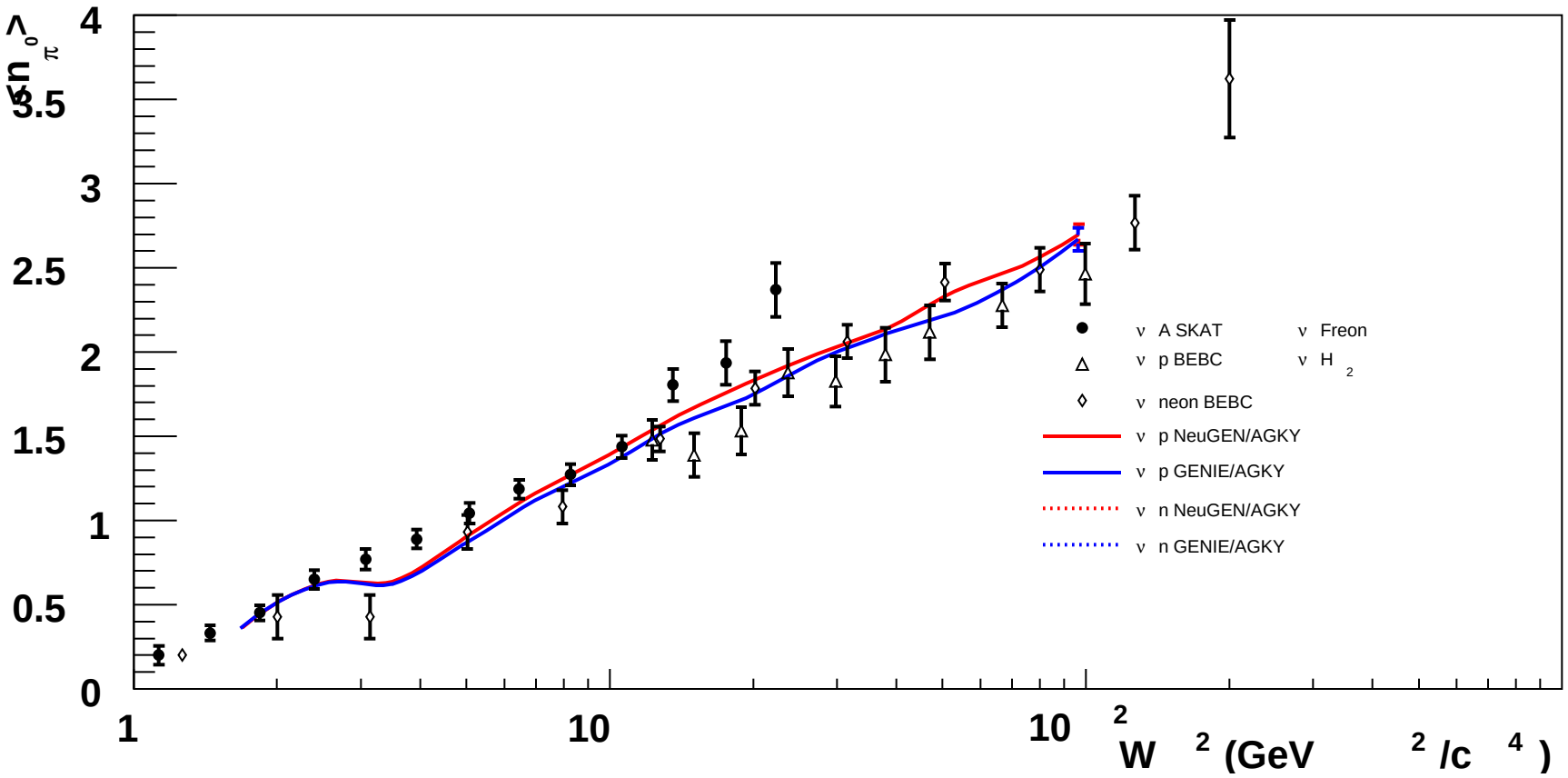

DIS-NC / $\bar{\nu}_\mu$+n(Fe^{56})
σ (10^{-38} cm^2)
10^2
10
1
10^{-1}
10^{-2}
1
10
10^2
E (GeV)
total
sbar(sea)
ubar(sea)
dbar(sea)
d(val)
d(sea)
u(val)
u(sea)
s(sea)

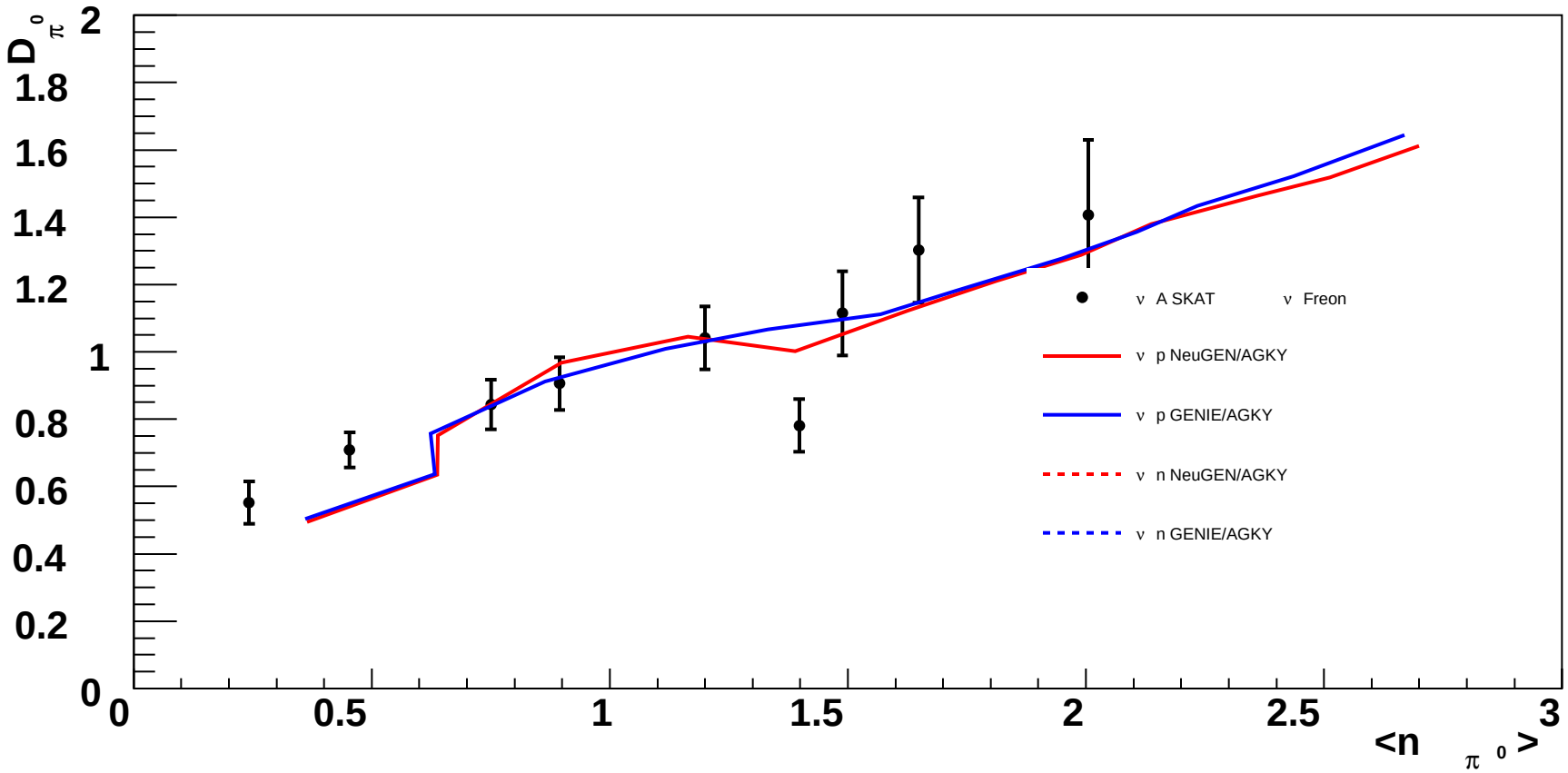

$\langle n_{ch} \rangle$
ν p
15' ν D 2
BEBC ν H 2
NeuGEN/AGKY
GENIE/AGKY
W 2 (GeV 2 /c 4)
ν n
15' ν D 2
NeuGEN/AGKY
GENIE/AGKY
W 2 (GeV 2 /c 4)

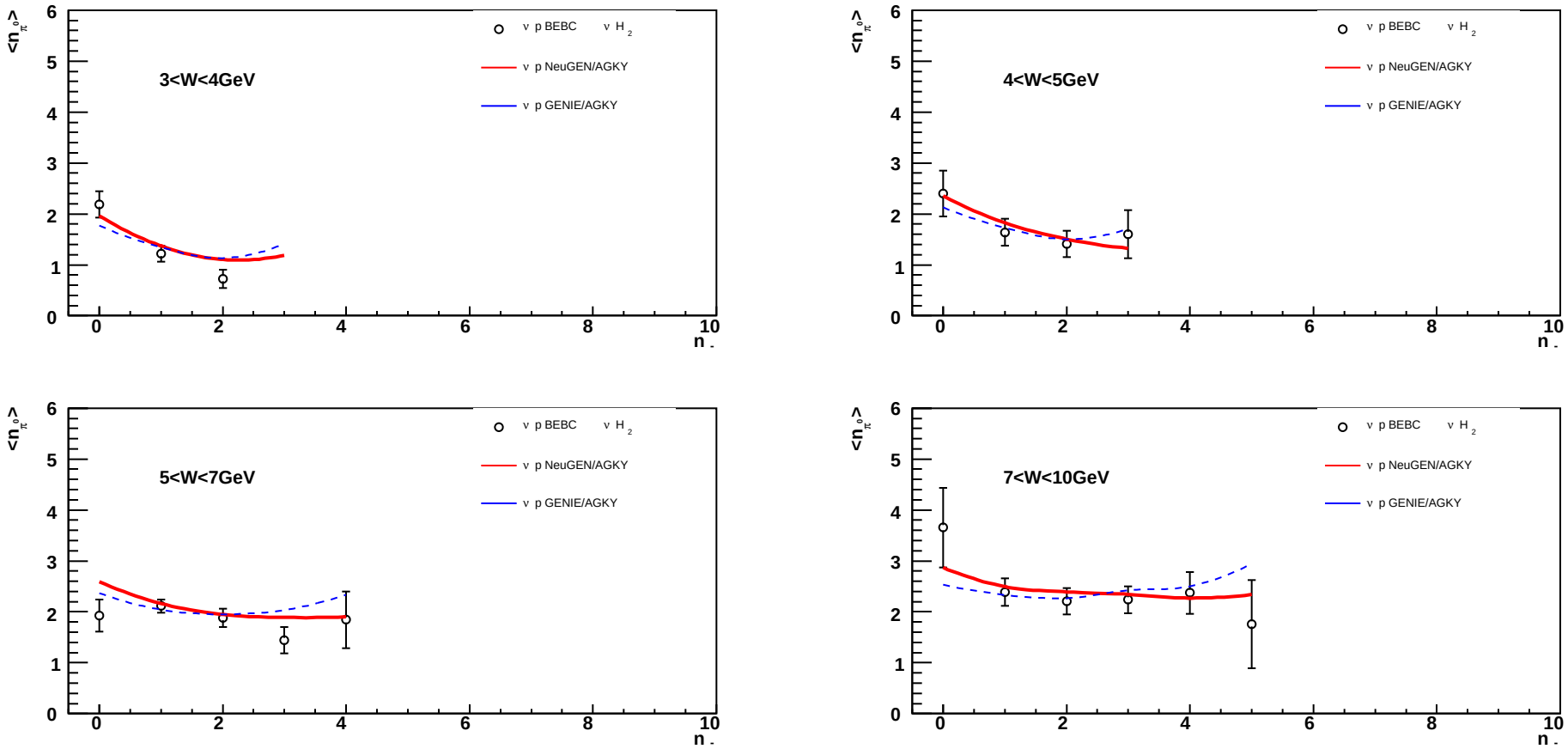

D
<n >
ν p 15'
ν n 15'
ν D
ν p NeuGEN/AGKY
ν p GENIE/AGKY
ν n NeuGEN/AGKY
ν n GENIE/AGKY
D/<n >ch
W 2 (GeV 2 /c 4)

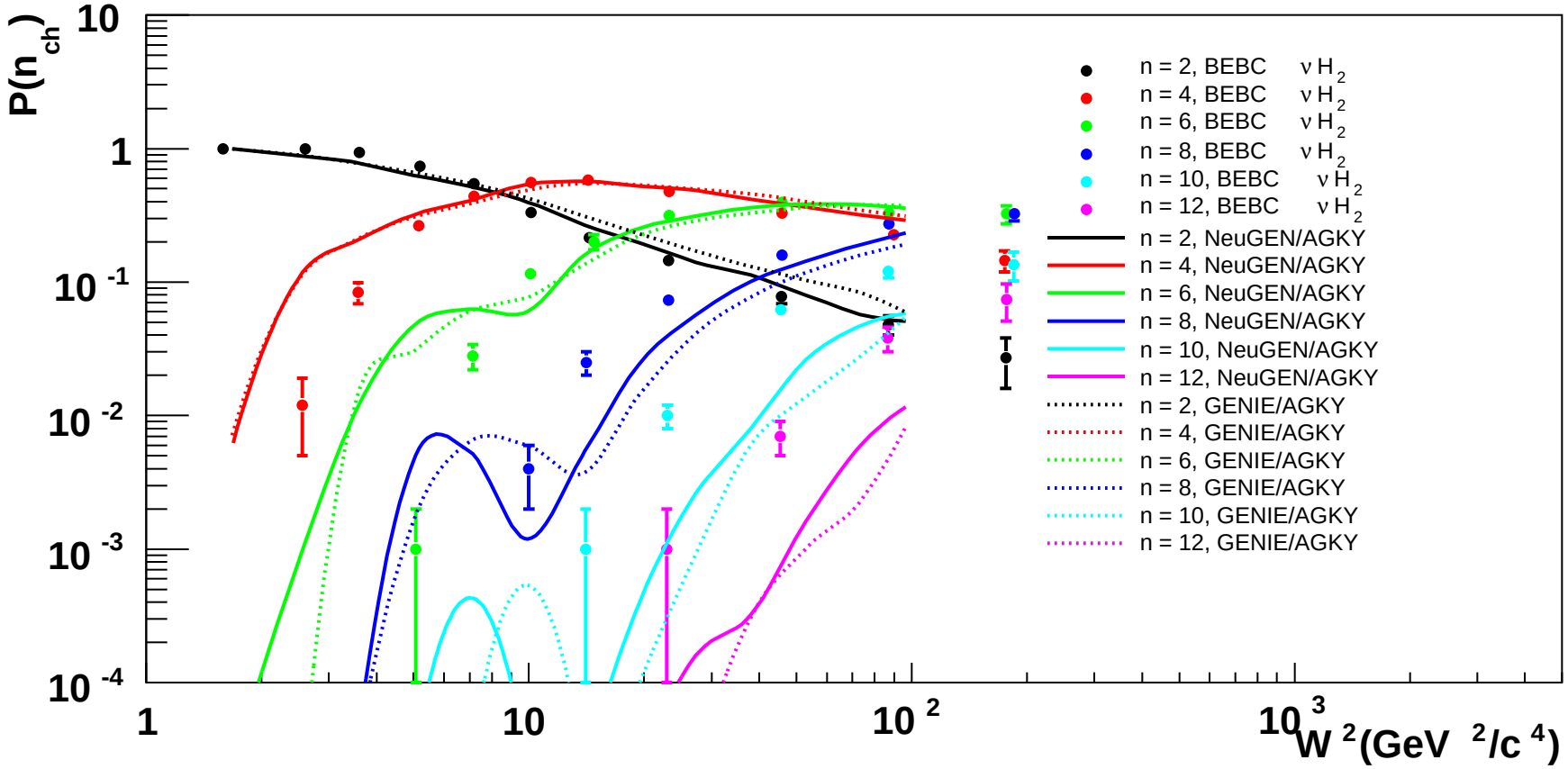

Data 15' ν D2
1<W<3GeV
3<W<5GeV
5<W<7GeV
7<W<10GeV
10<W<15GeV
NeuGEN/AGKY
W<2GeV
2<=W<3GeV
3<=W<4GeV
4<=W<5GeV
W>=5GeV
W<2GeV
2<=W<3GeV
3<=W<4GeV
4<=W<5GeV
W>=5GeV
νp
<nch>P(nch)
nch/<nch>
10
1
10-1
10-2
0
0.5
1
1.5
2
2.5
3
3.5
4

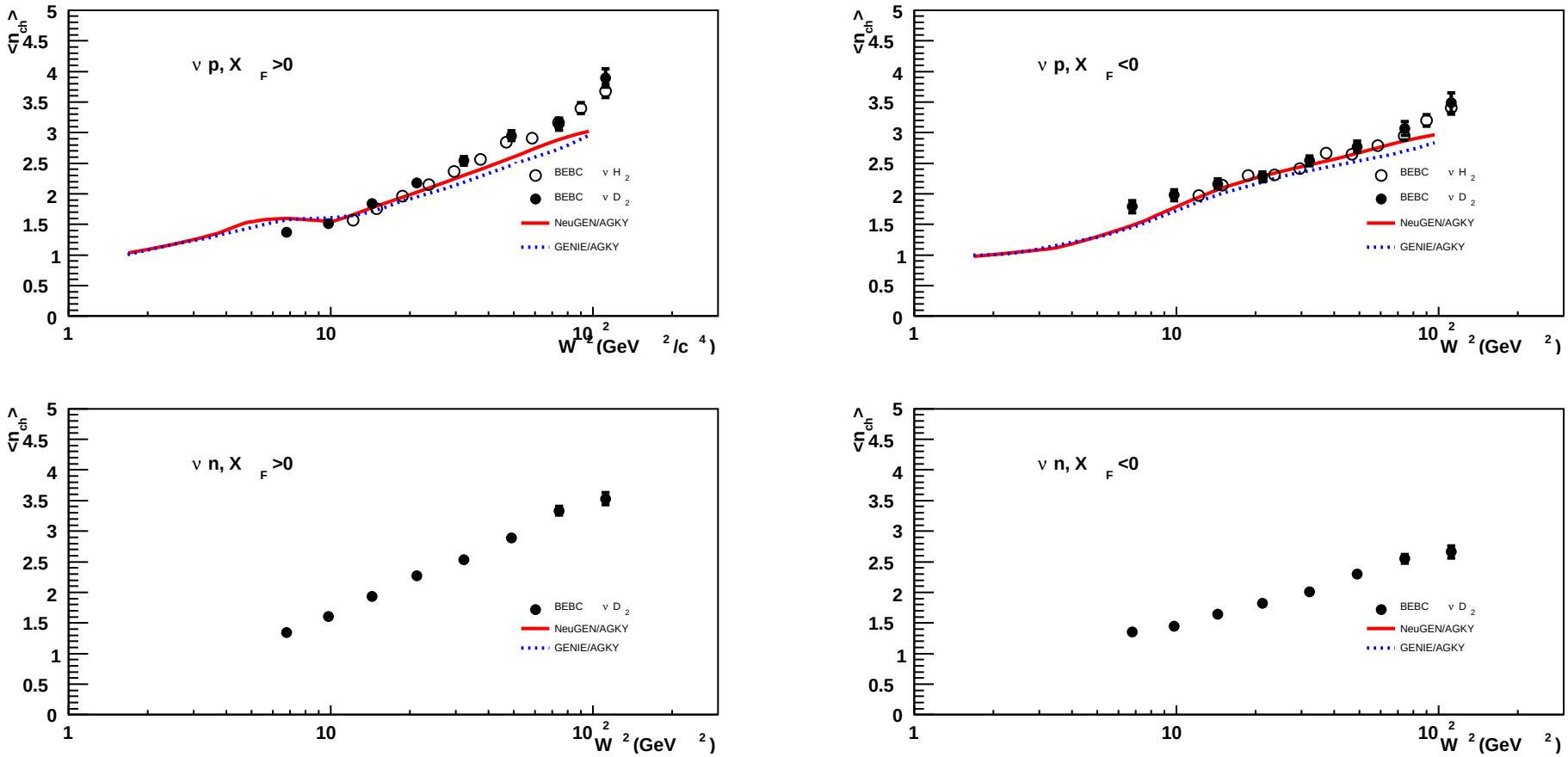

νn
<nch>P(nch)
nch/<nch>
10
1
10-1
10-2
0
0.5
1
1.5
2
2.5
3
3.5
4

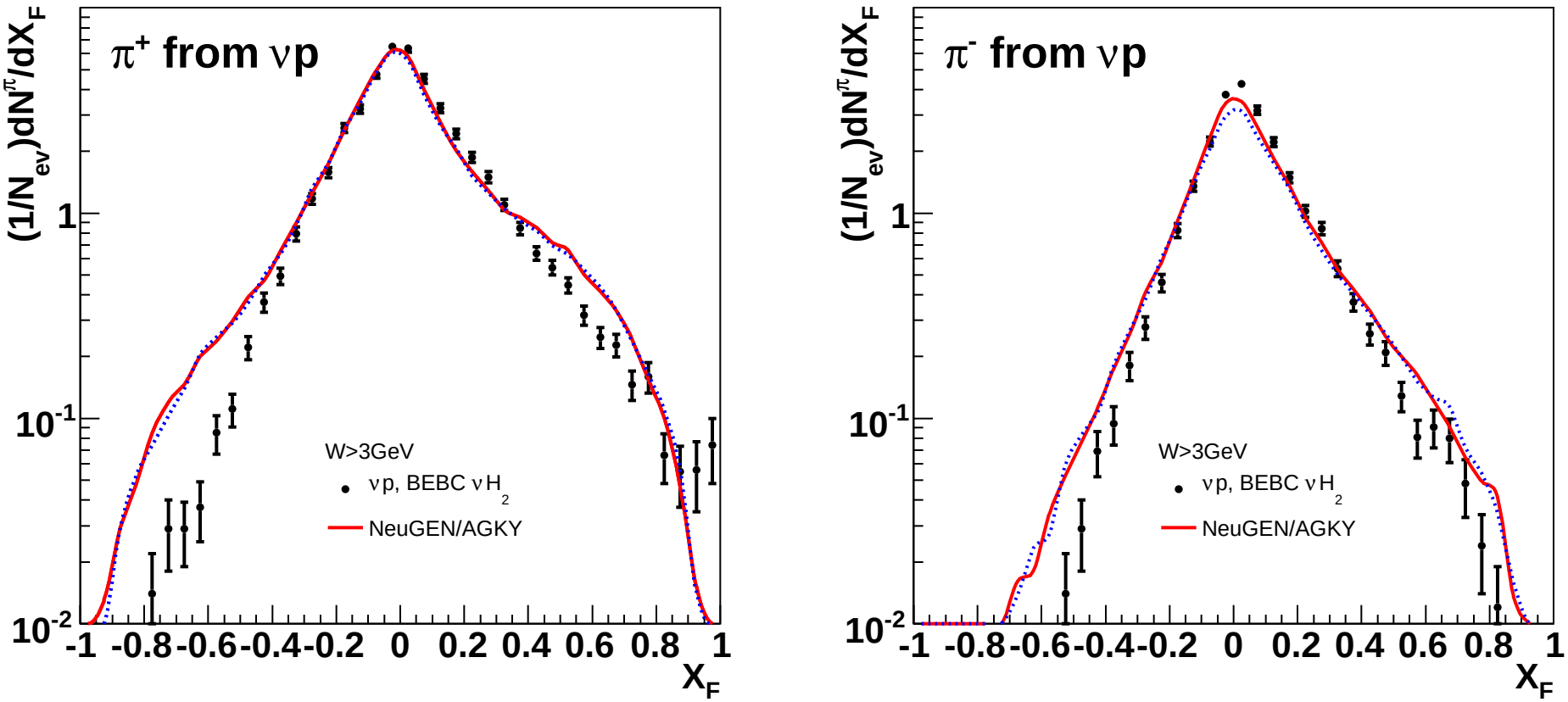

$\langle n_{\pi^0} \rangle$
4
3.5
3
2.5
2
1.5
1
0.5
0
1
10
10^2
W^2 (GeV^2/c^4)
ν A SKAT
ν p BEBC
ν neon BEBC
ν Freon
ν H_2
ν p NeuGEN/AGKY
ν p GENIE/AGKY
ν n NeuGEN/AGKY
ν n GENIE/AGKY

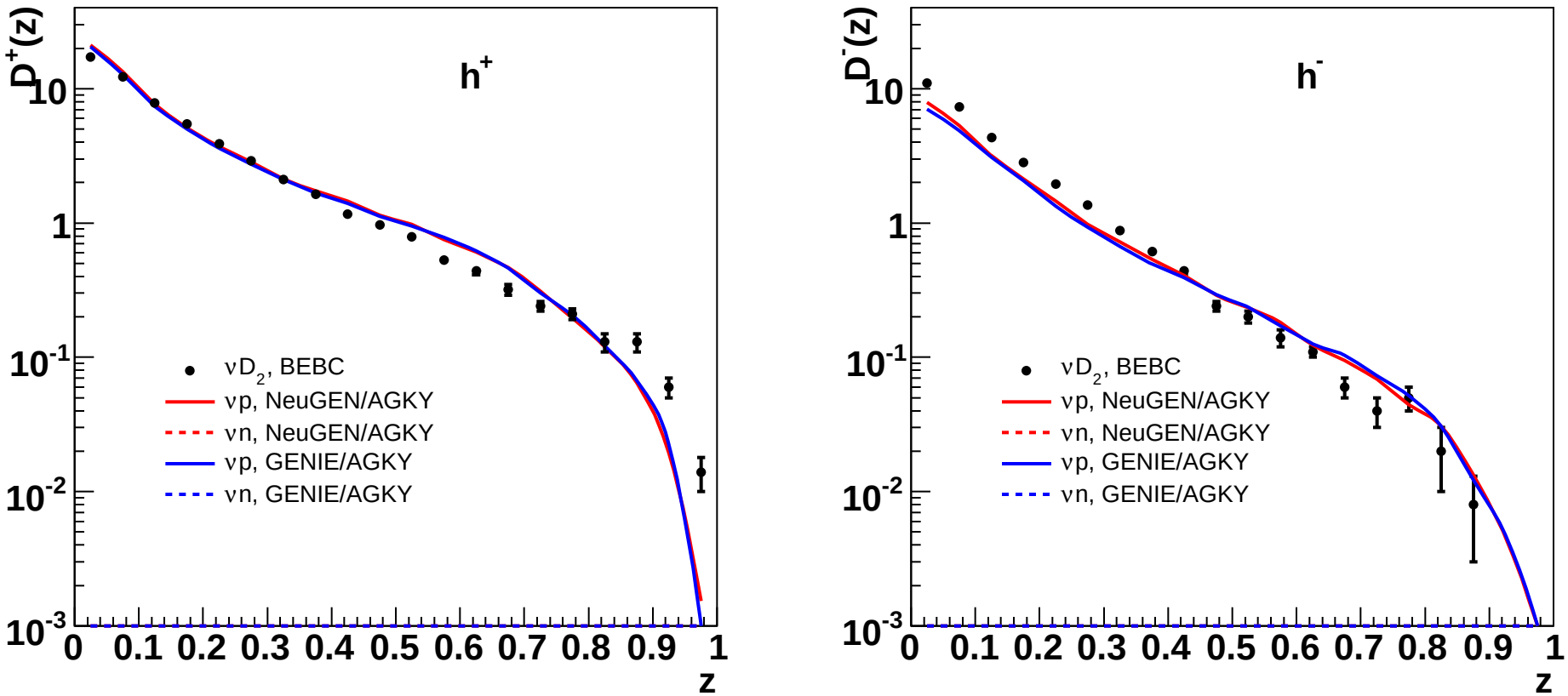

D_{π^0}
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
0.5
1
1.5
2
2.5
3
$\langle n_{\pi^0} \rangle$
ν A SKAT
ν Freon
ν p NeuGEN/AGKY
ν p GENIE/AGKY
ν n NeuGEN/AGKY
ν n GENIE/AGKY

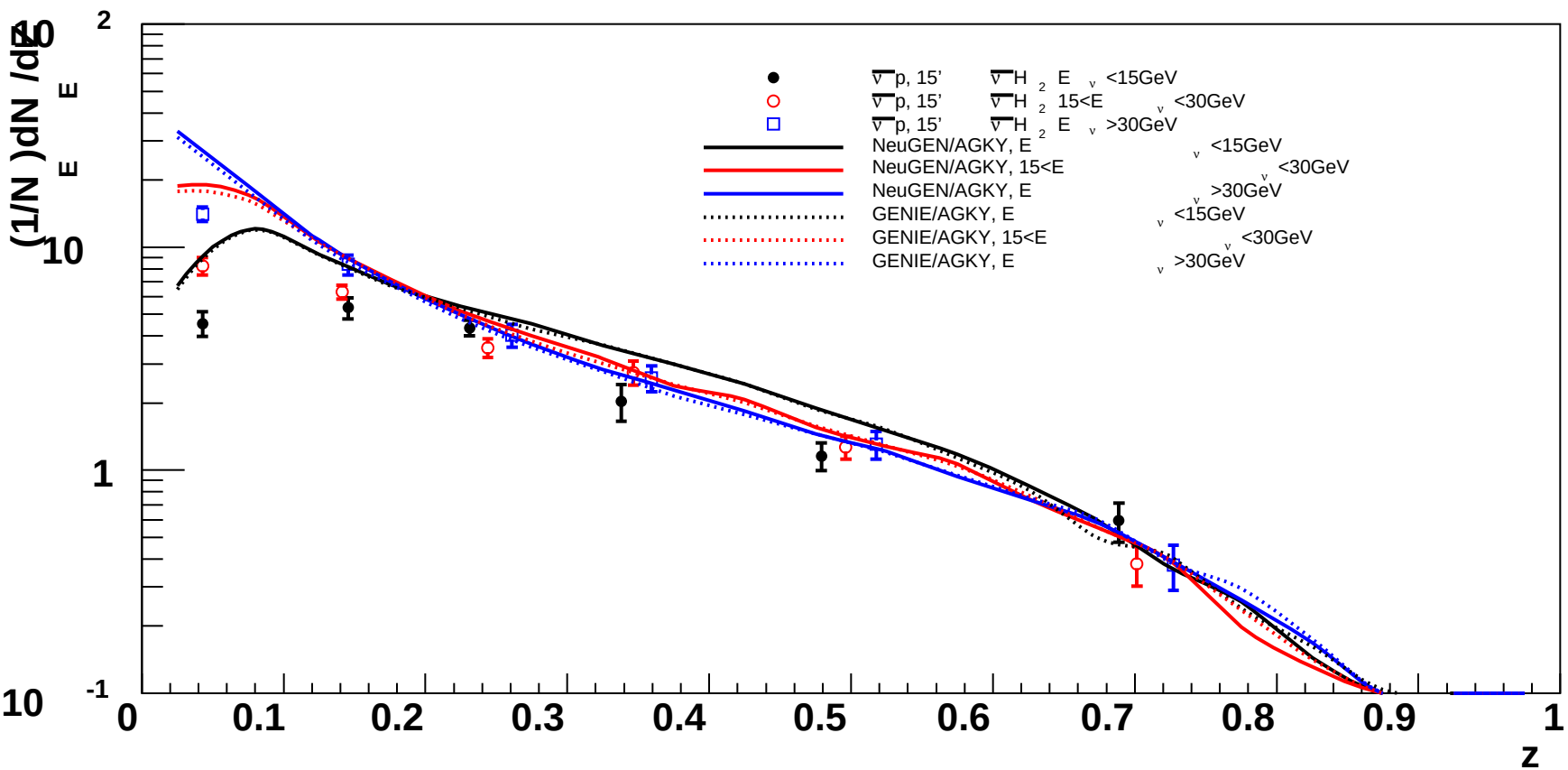

3<W<4GeV
4<W<5GeV
5<W<7GeV
7<W<10GeV
ν p BEBC ν H 2
ν p NeuGEN/AGKY
ν p GENIE/AGKY
<n π0>
n -

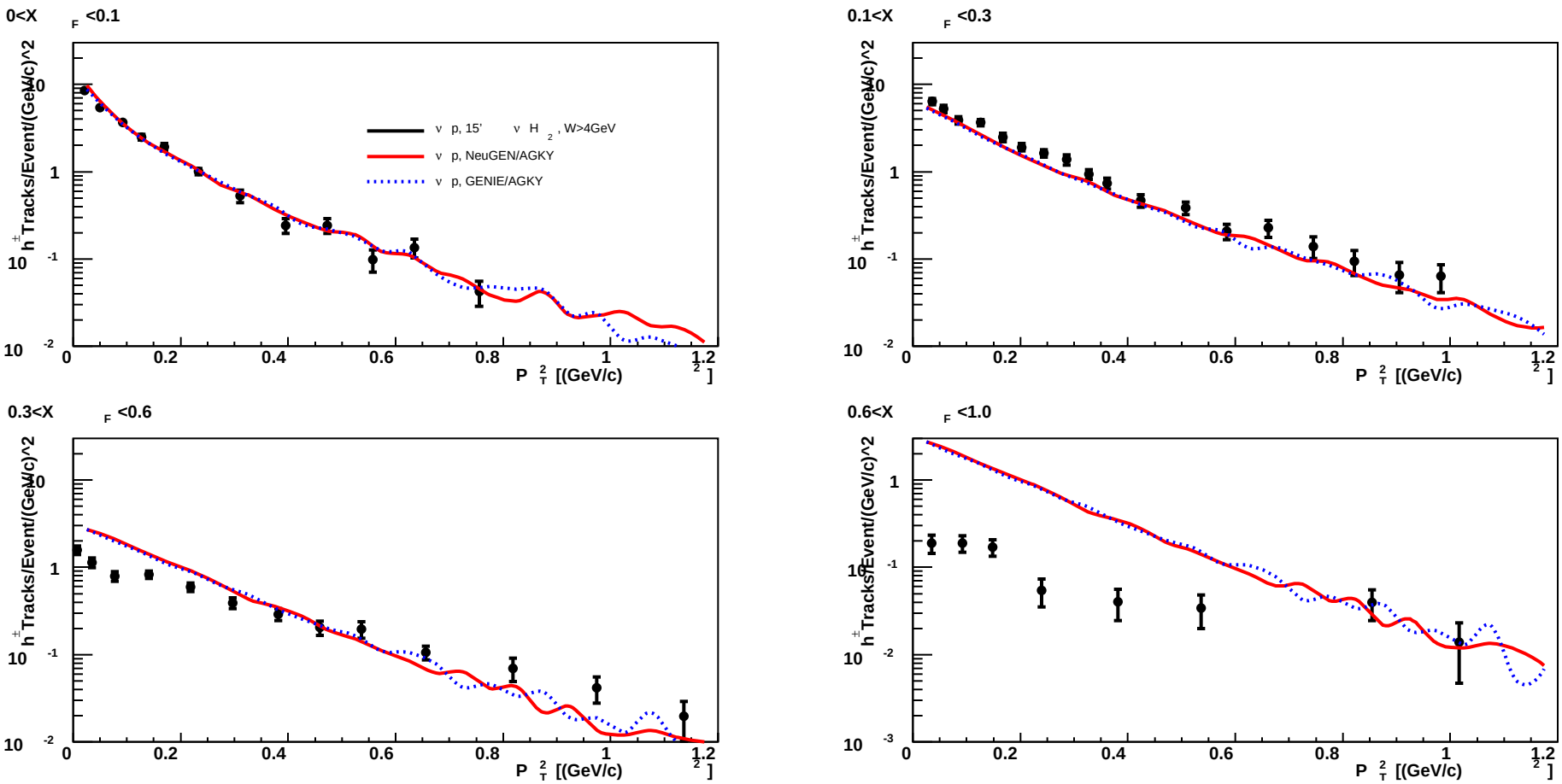

P(n_ch)
10
1
10 -1
10 -2
10 -3
10 -4
1
10
10 2
10 3
W 2(GeV 2/c 4)
n = 2, BEBC νH2
n = 4, BEBC νH2
n = 6, BEBC νH2
n = 8, BEBC νH2
n = 10, BEBC νH2
n = 12, BEBC νH2
n = 2, NeuGEN/AGKY
n = 4, NeuGEN/AGKY
n = 6, NeuGEN/AGKY
n = 8, NeuGEN/AGKY
n = 10, NeuGEN/AGKY
n = 12, NeuGEN/AGKY
n = 2, GENIE/AGKY
n = 4, GENIE/AGKY
n = 6, GENIE/AGKY
n = 8, GENIE/AGKY
n = 10, GENIE/AGKY
n = 12, GENIE/AGKY

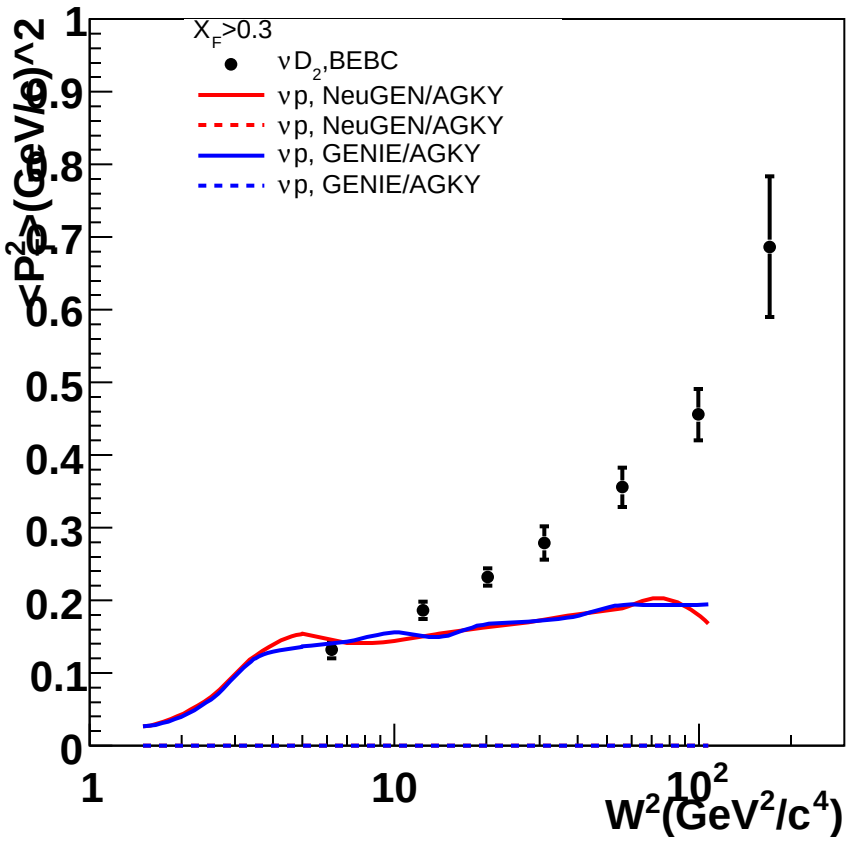

ν p, X F >0
ν p, X F <0
ν n, X F >0
ν n, X F <0
<n ch>
W 2 (GeV 2/c 4)
W 2 (GeV 2)
BEBC ν H 2
BEBC ν D 2
NeuGEN/AGKY
GENIE/AGKY

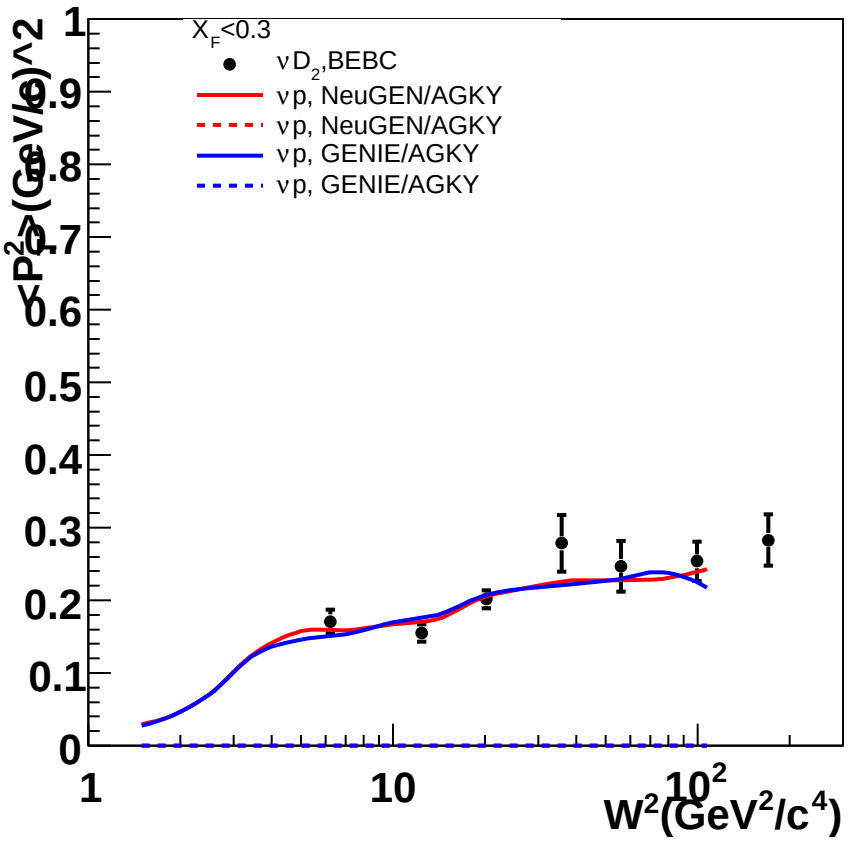

π+ from νp
(1/Nev)dNπ/dXF
W>3GeV
νp, BEBC νH2
NeuGEN/AGKY
XF
π- from νp
(1/Nev)dNπ/dXF
W>3GeV
νp, BEBC νH2
NeuGEN/AGKY
XF

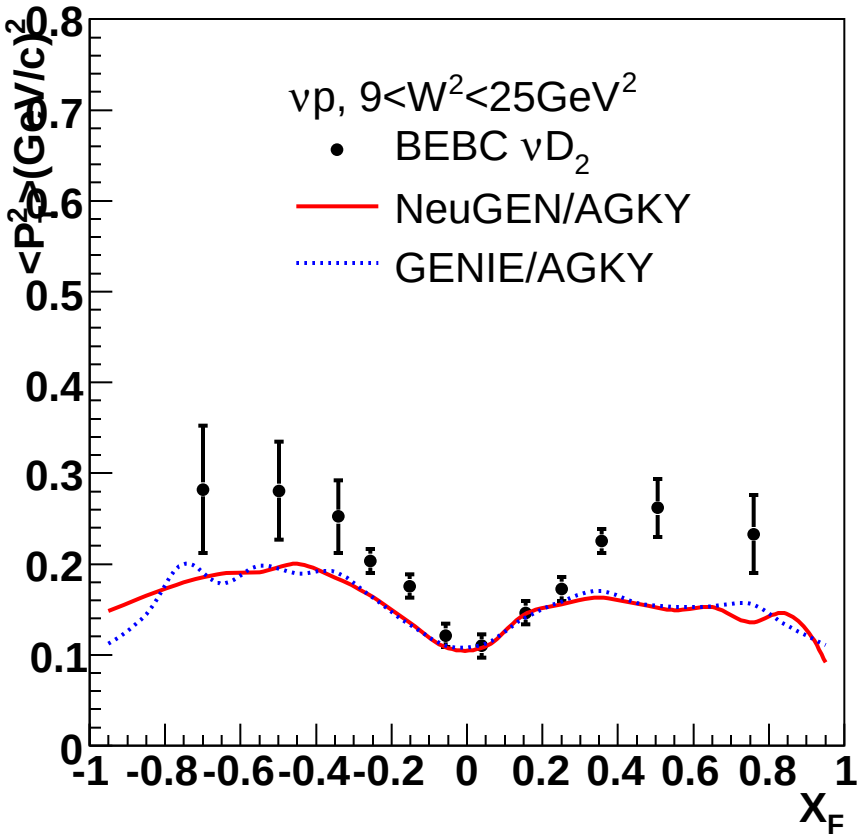

$D^+(z)$
h^+
νD_2, BEBC
νp, NeuGEN/AGKY
νn, NeuGEN/AGKY
νp, GENIE/AGKY
νn, GENIE/AGKY
z
$D^-(z)$
h^-
νD_2, BEBC
νp, NeuGEN/AGKY
νn, NeuGEN/AGKY
νp, GENIE/AGKY
νn, GENIE/AGKY
z

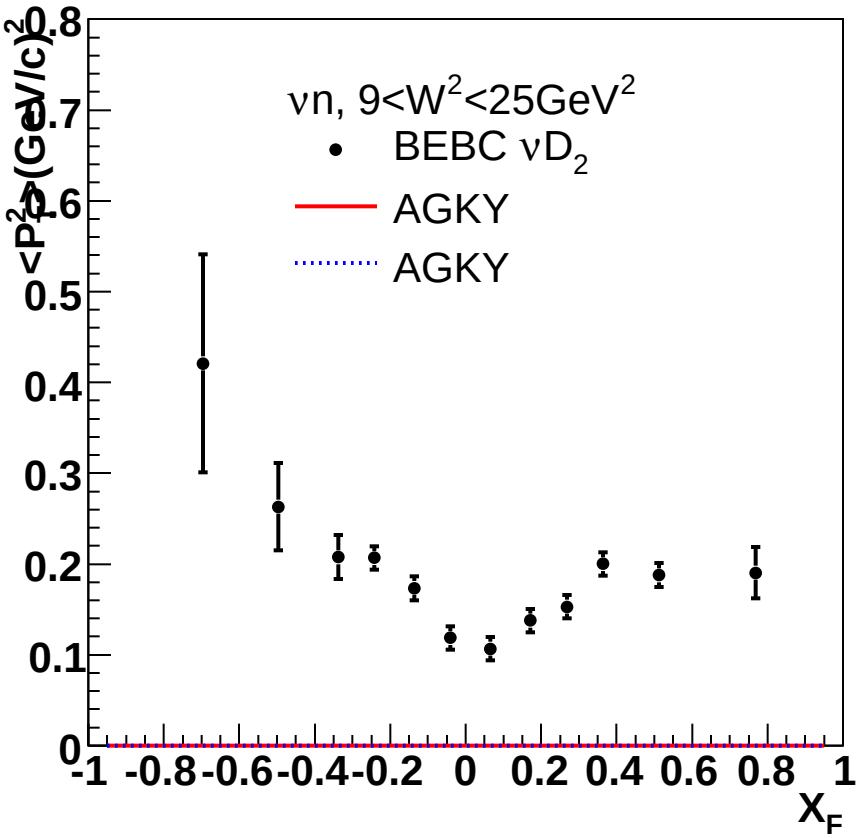

(1/N)dN /dz
z
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
10^2
10
1
10^-1
NeuGEN/AGKY, E ν <15GeV
NeuGEN/AGKY, 15<E ν <30GeV
NeuGEN/AGKY, E ν >30GeV
GENIE/AGKY, E ν <15GeV
GENIE/AGKY, 15<E ν <30GeV
GENIE/AGKY, E ν >30GeV


0<X F <0.1
0.1<X F <0.3
0.3<X F <0.6
0.6<X F <1.0
h± Tracks/Event/(GeV/c)^2
P T 2 [(GeV/c)2]
ν p, 15' ν H 2 , W>4GeV
ν p, NeuGEN/AGKY
ν p, GENIE/AGKY


X_F>0.3
νD$_2$,BEBC
νp, NeuGEN/AGKY
νp, NeuGEN/AGKY
νp, GENIE/AGKY
νp, GENIE/AGKY
<P^2>(GeV/c)^2
W^2(GeV^2/c^4)


X_F<0.3
νD$_2$,BEBC
νp, NeuGEN/AGKY
νp, NeuGEN/AGKY
νp, GENIE/AGKY
νp, GENIE/AGKY
<P^2>(GeV/c)^2
W^2(GeV^2/c^4)


νp, 9<W²<25GeV²
BEBC νD₂
NeuGEN/AGKY
GENIE/AGKY
<P²T>(GeV/c)²
X_F
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1


νn, 9<W²<25GeV²
BEBC νD₂
AGKY
AGKY
<P²T>(GeV/c)²
X_F
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1

GENIE-2.0.0 vs NEUGEN/Daikon+ Event Sample Comparisons

Event Sample:

100k events, numu+n, 0.5GeV, all processes

Notes:

Daikon+ is a NEUGEN Daikon revision version

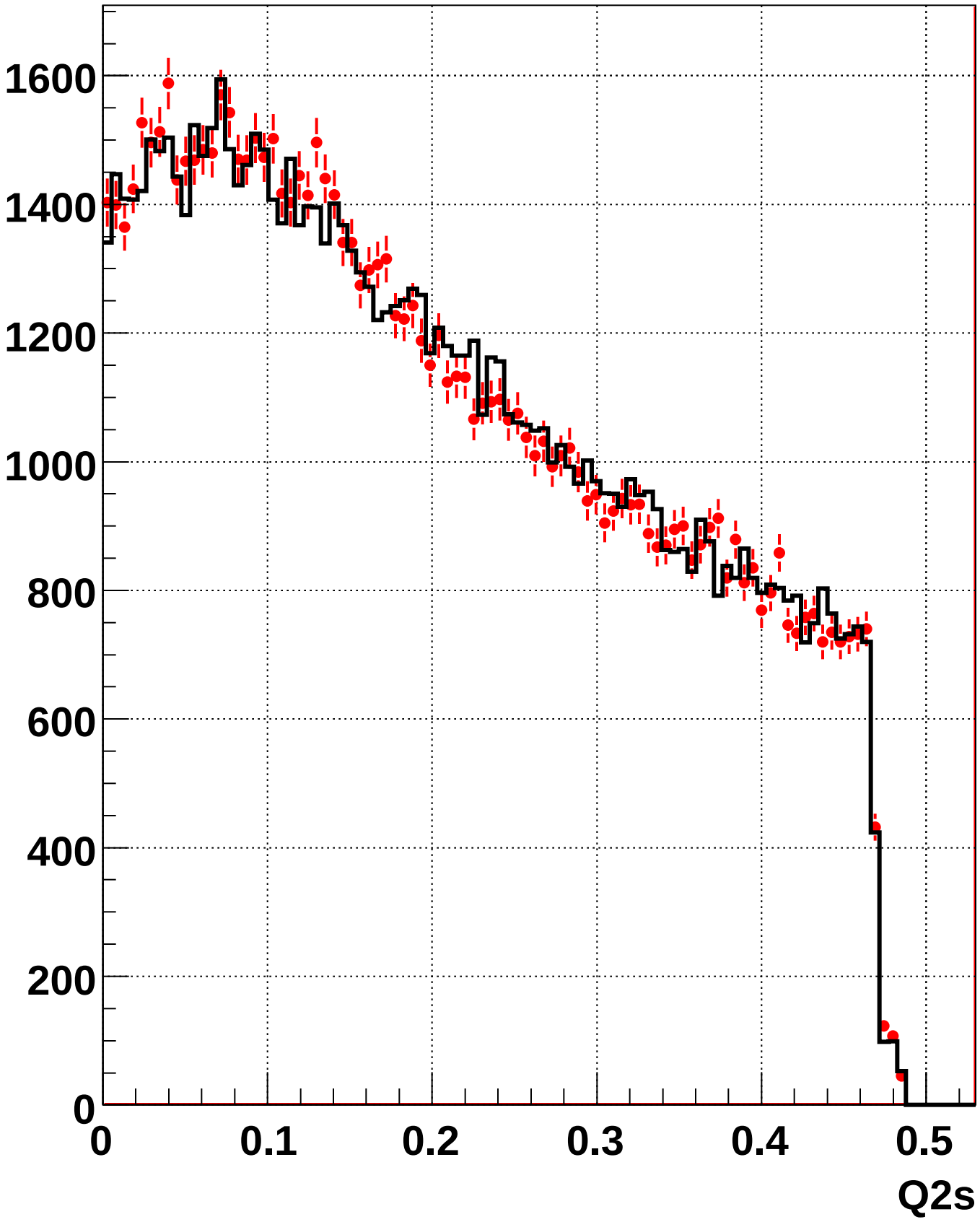
GENIE predictions shown with lines / NEUGEN's with markers

Event Numbers:

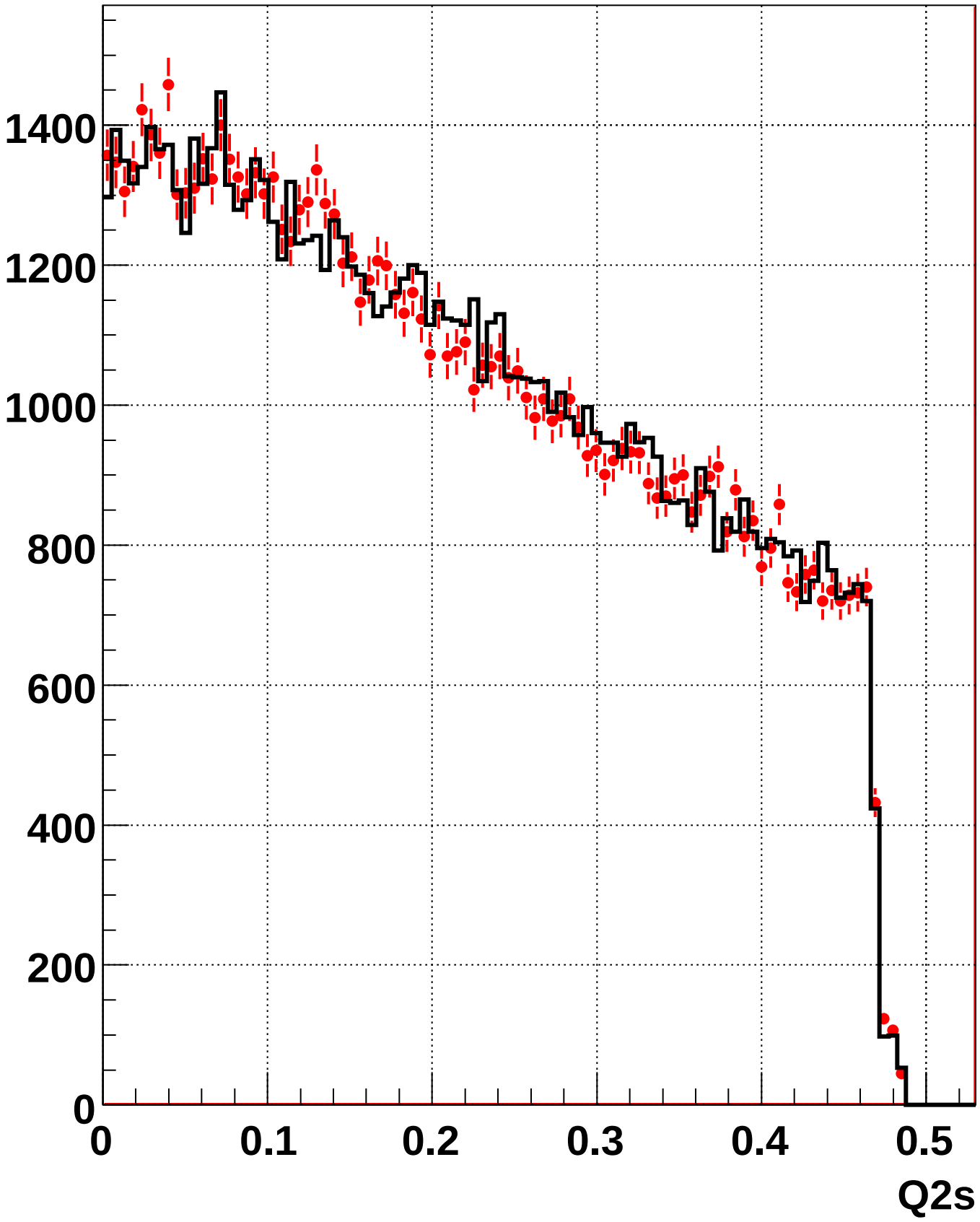
ALL :	100000 [NeuGEN],	100000 [GENIE]
QEL :	94544 [NeuGEN],	94907 [GENIE]
QEL-CC :	75749 [NeuGEN],	76200 [GENIE]
QEL-NC :	18795 [NeuGEN],	18707 [GENIE]
RES :	4084 [NeuGEN],	3818 [GENIE]
RES-CC :	1964 [NeuGEN],	1725 [GENIE]
RES-NC :	2120 [NeuGEN],	2093 [GENIE]
DIS :	1372 [NeuGEN],	1275 [GENIE]
DIS-CC :	976 [NeuGEN],	936 [GENIE]
(charm):	0 [NeuGEN],	0 [GENIE]
DIS-NC :	396 [NeuGEN],	339 [GENIE]
COH :	0 [NeuGEN],	0 [GENIE]
COH-CC :	0 [NeuGEN],	0 [GENIE]
COH-NC :	0 [NeuGEN],	0 [GENIE]
IMD :	0 [NeuGEN],	0 [GENIE]

Selected Kinematical Quantities

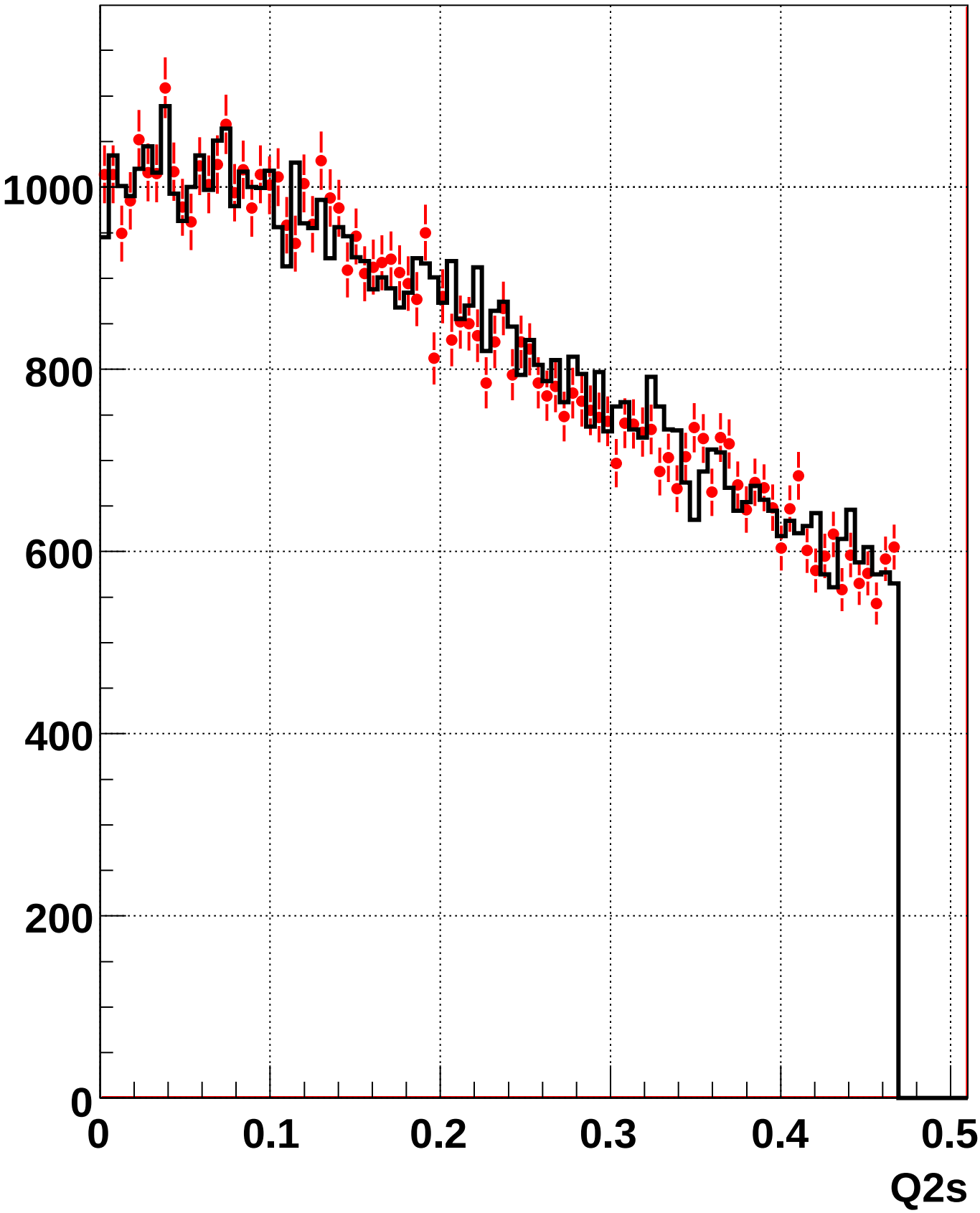
selected Q2 for all events



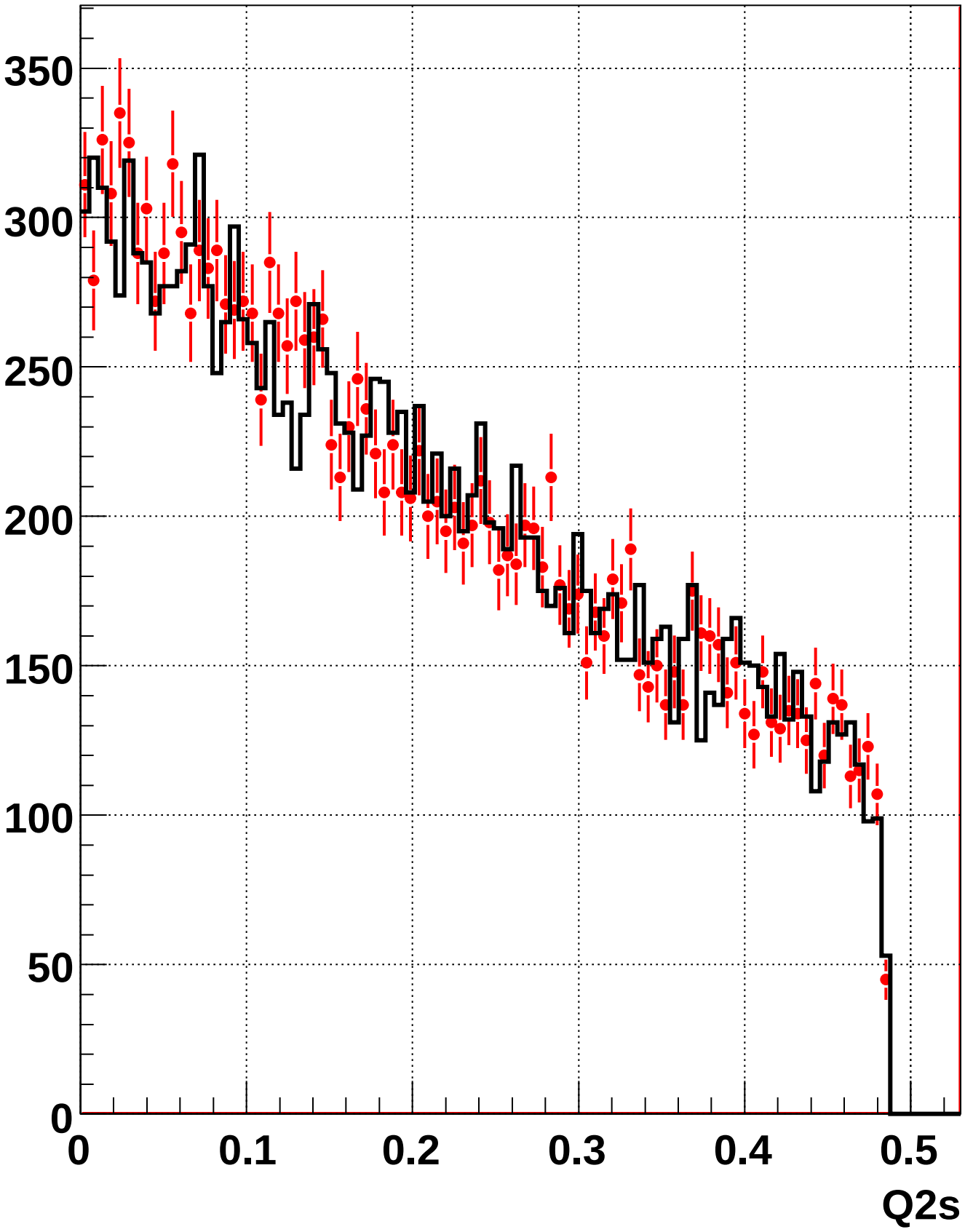
selected Q2 for QEL events



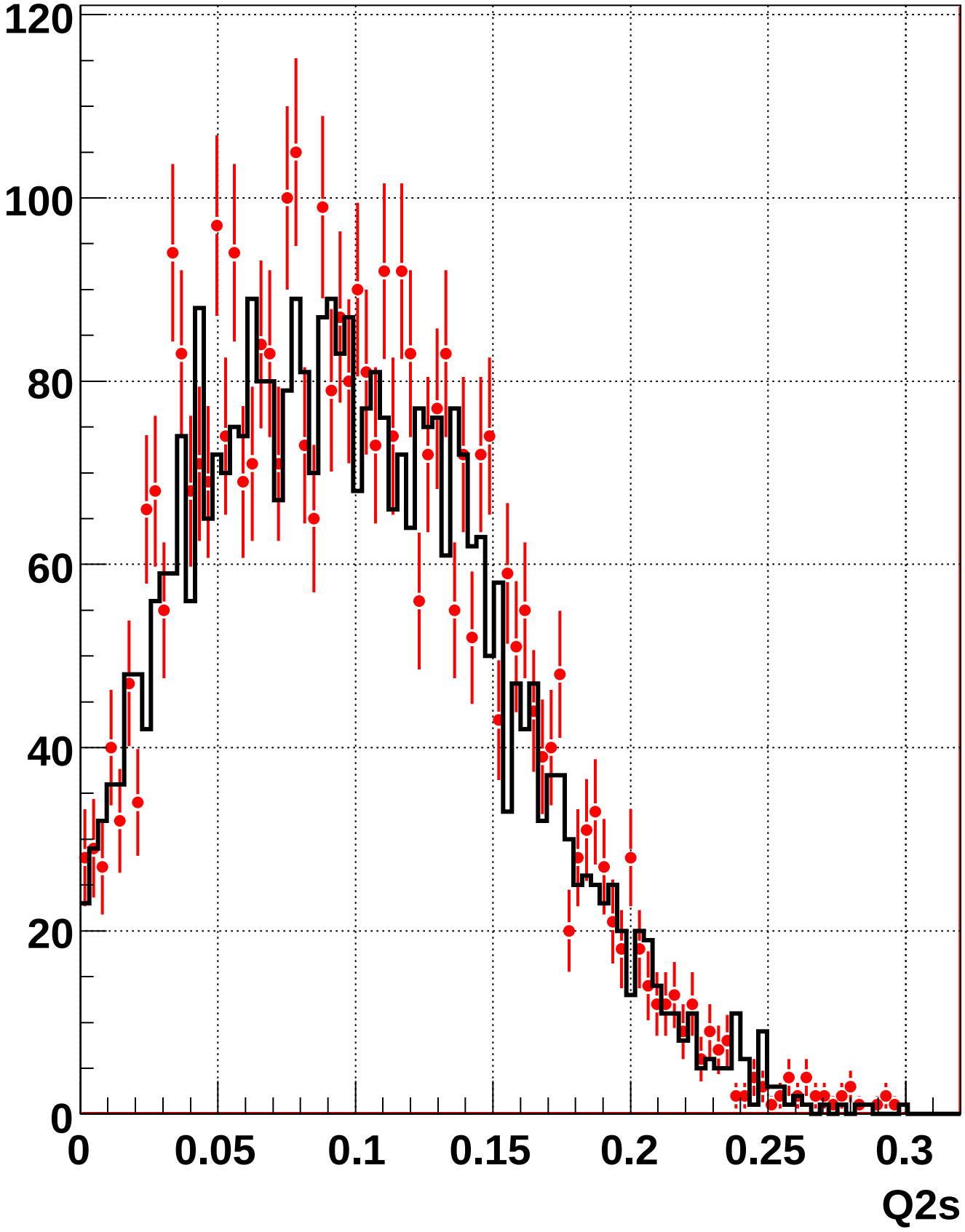
selected Q2 for QEL CC events



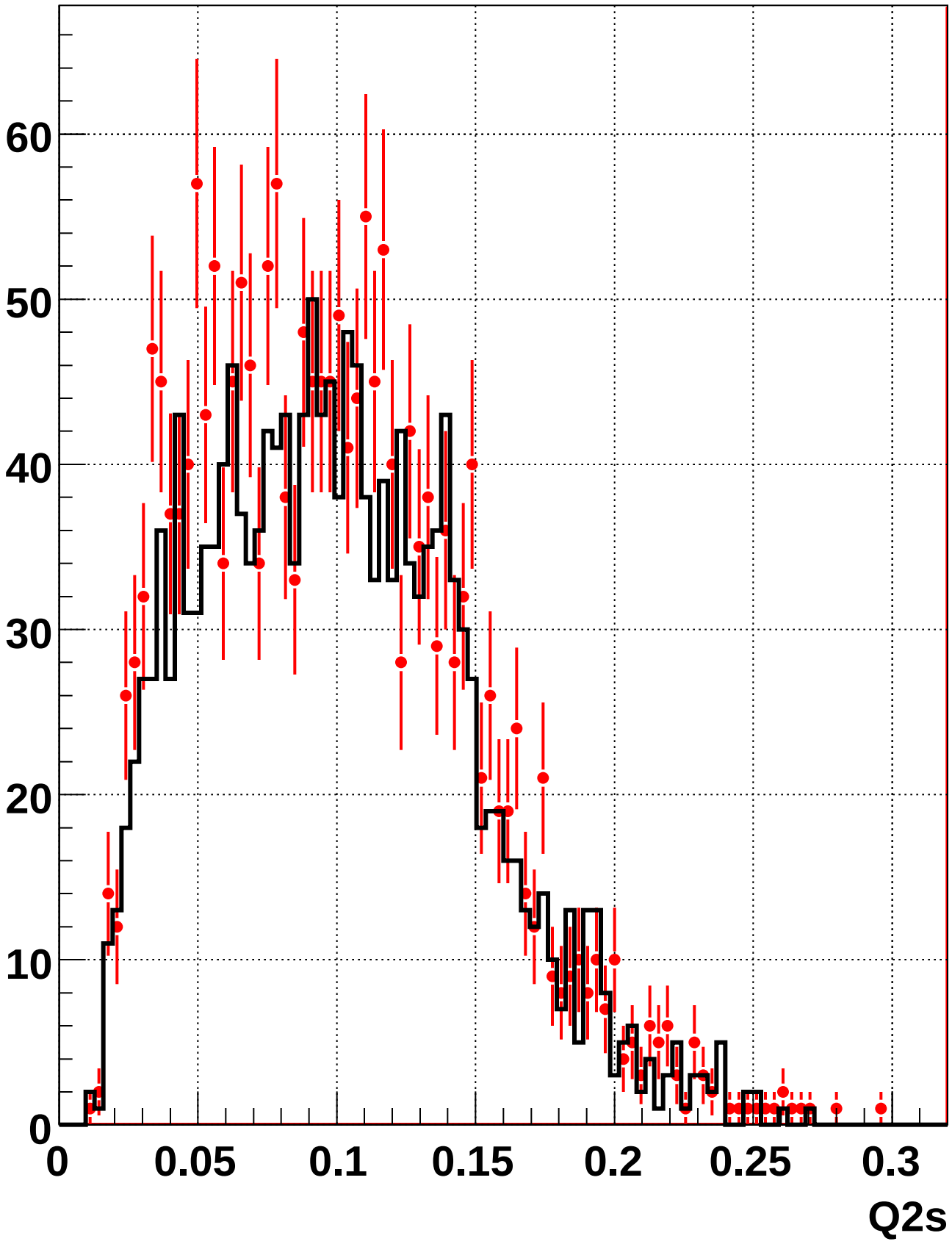
selected Q2 for QEL NC events



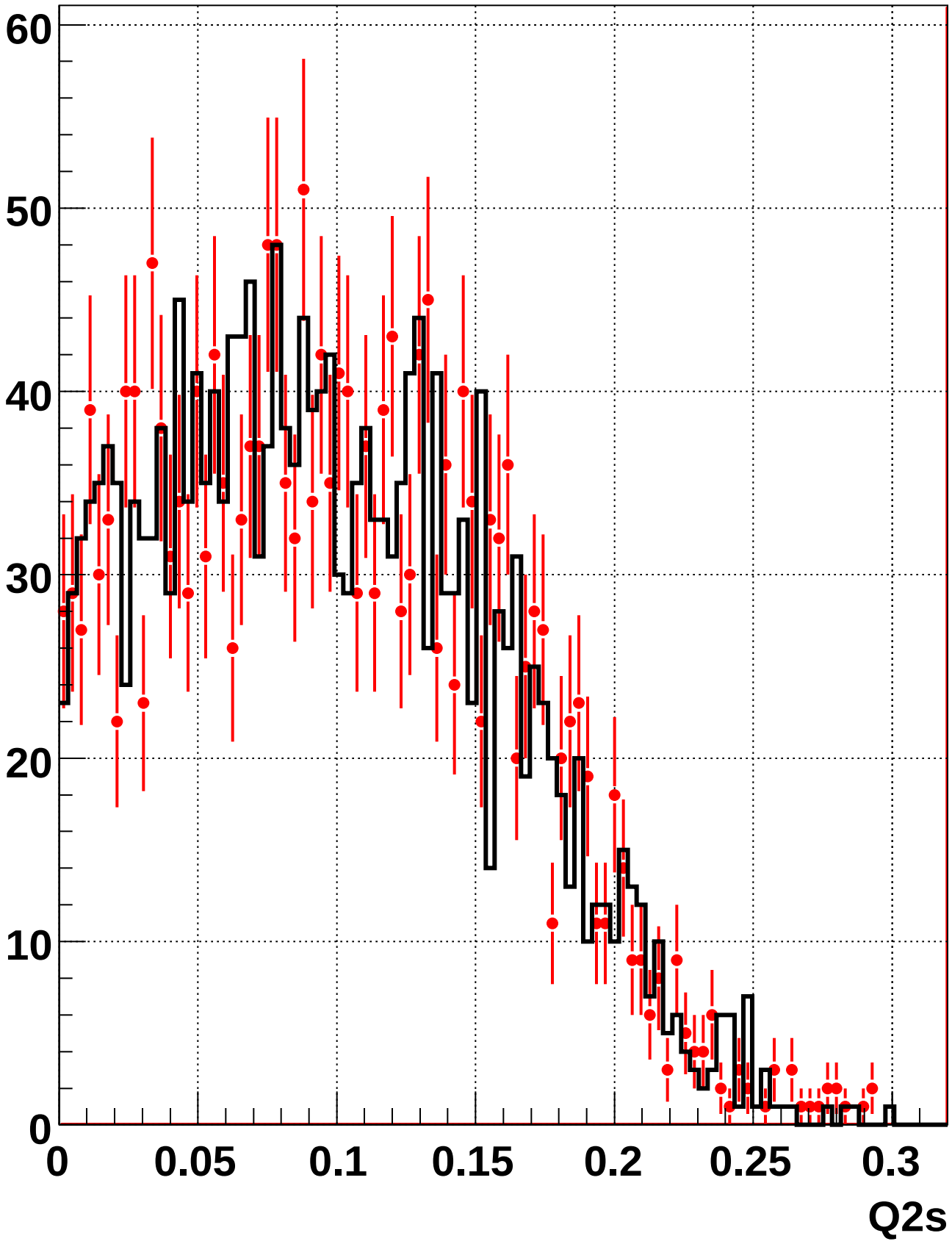
selected Q2 for RES events



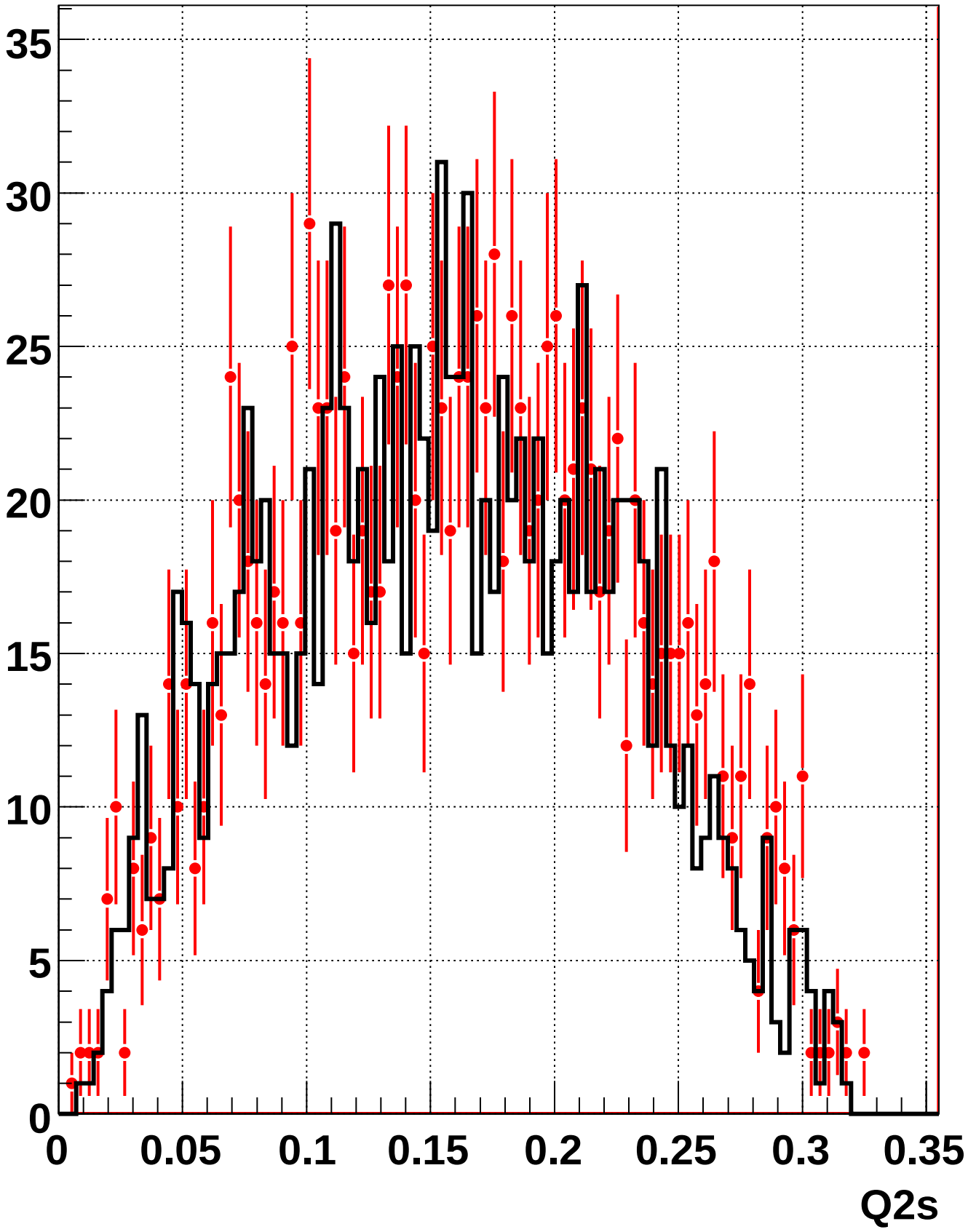
selected Q2 for RES CC events



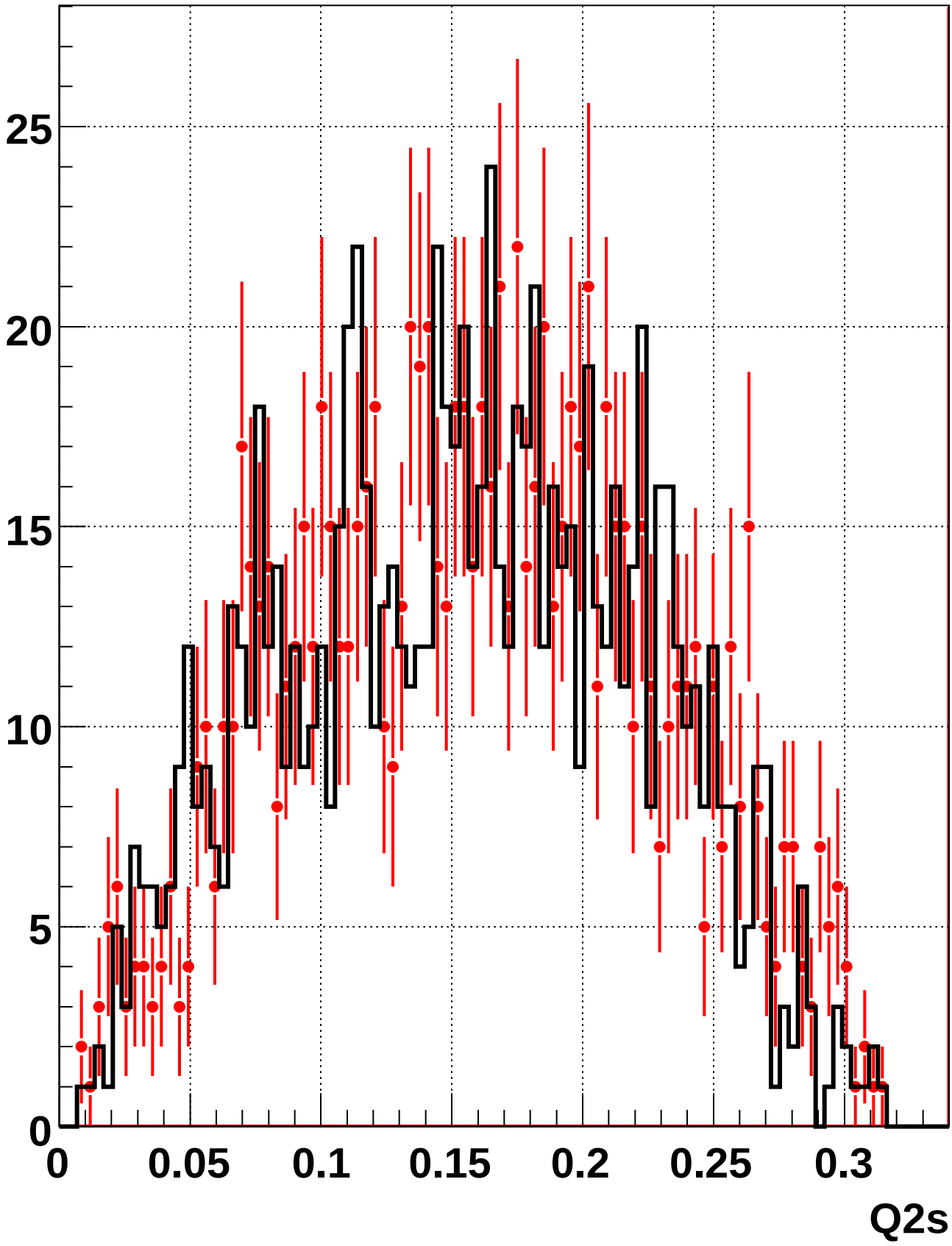
selected Q2 for RES NC events



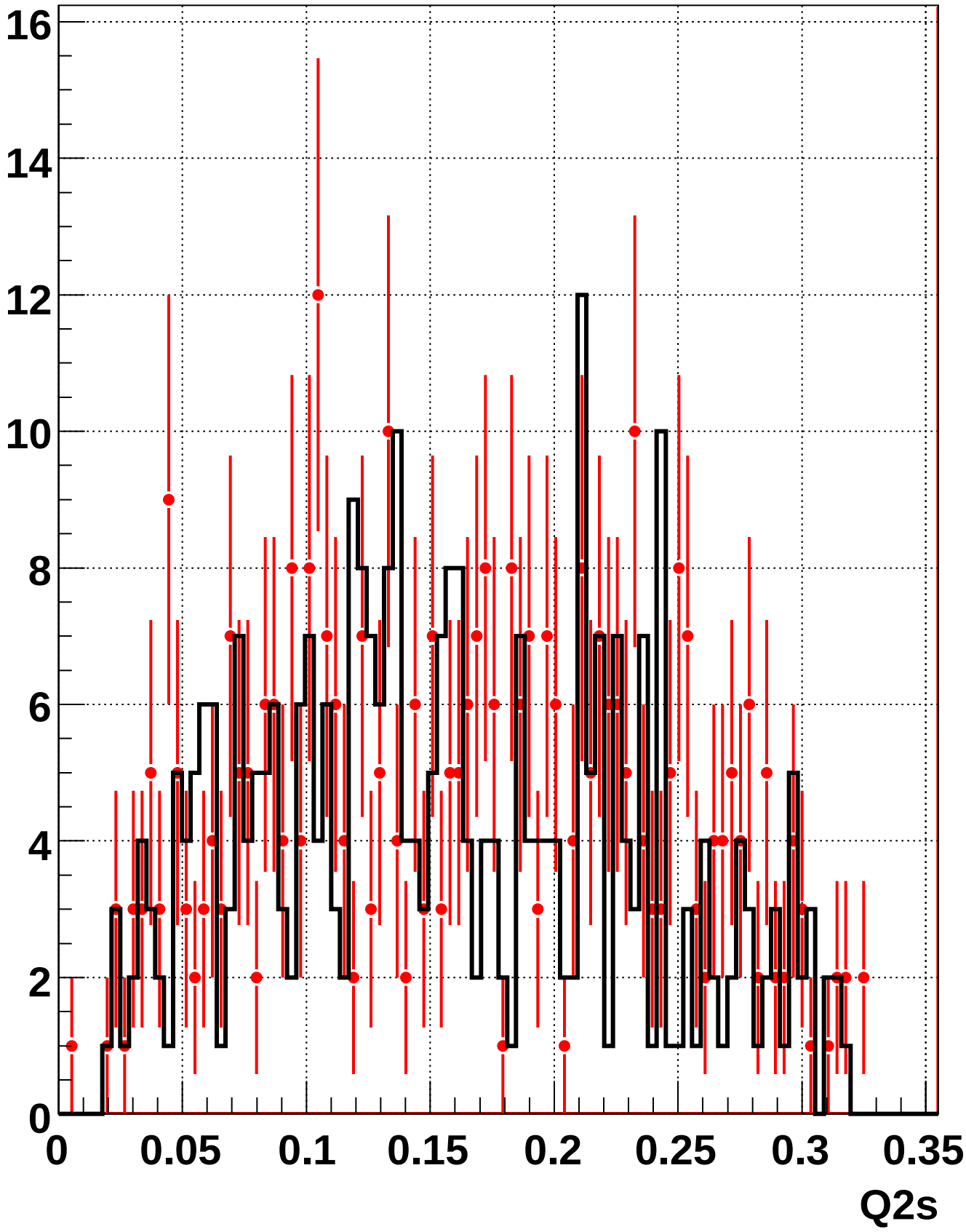
selected Q2 for DIS events



selected Q2 for DIS CC events

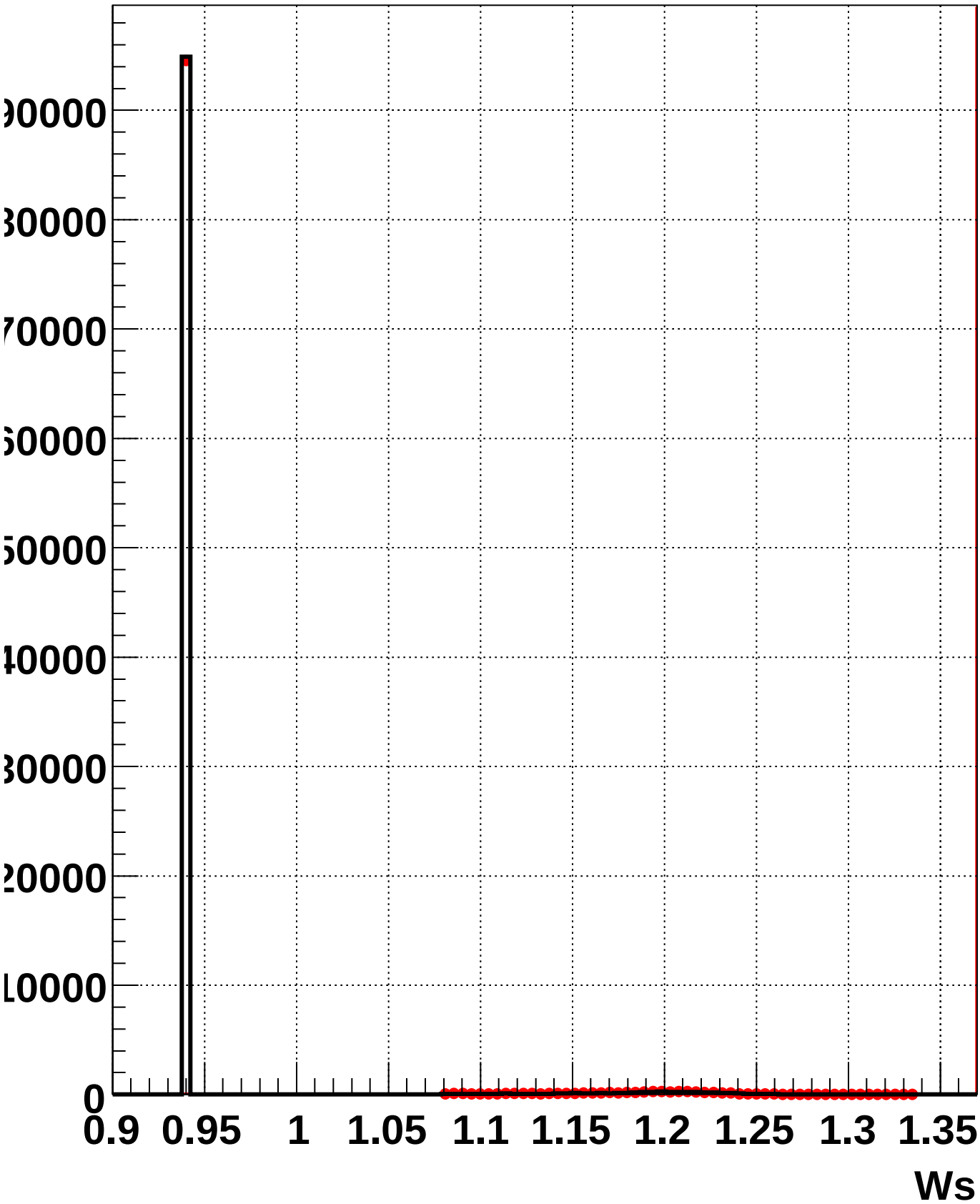


selected Q2 for DIS NC events

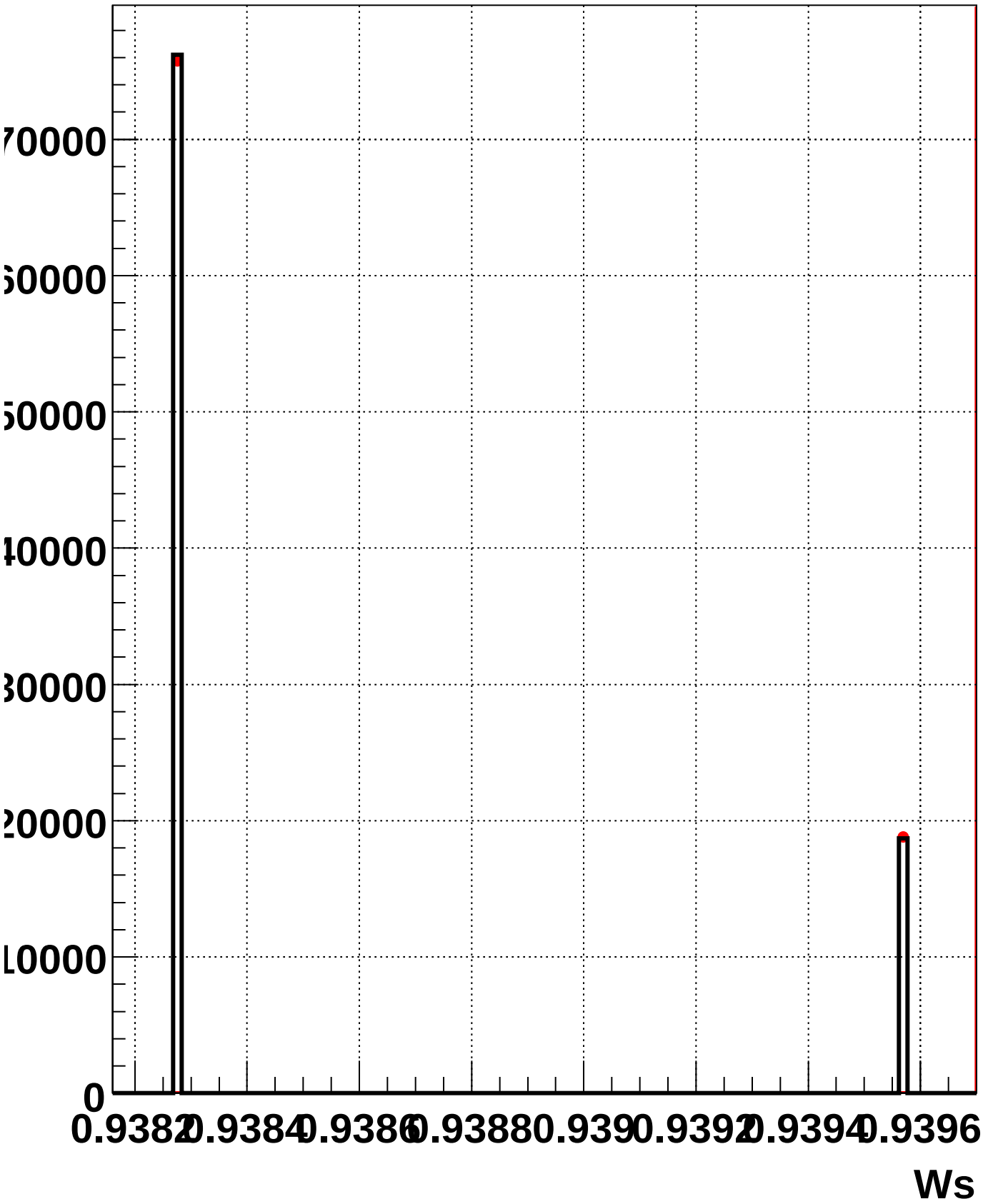


selected Q2 for Charm/DIS events

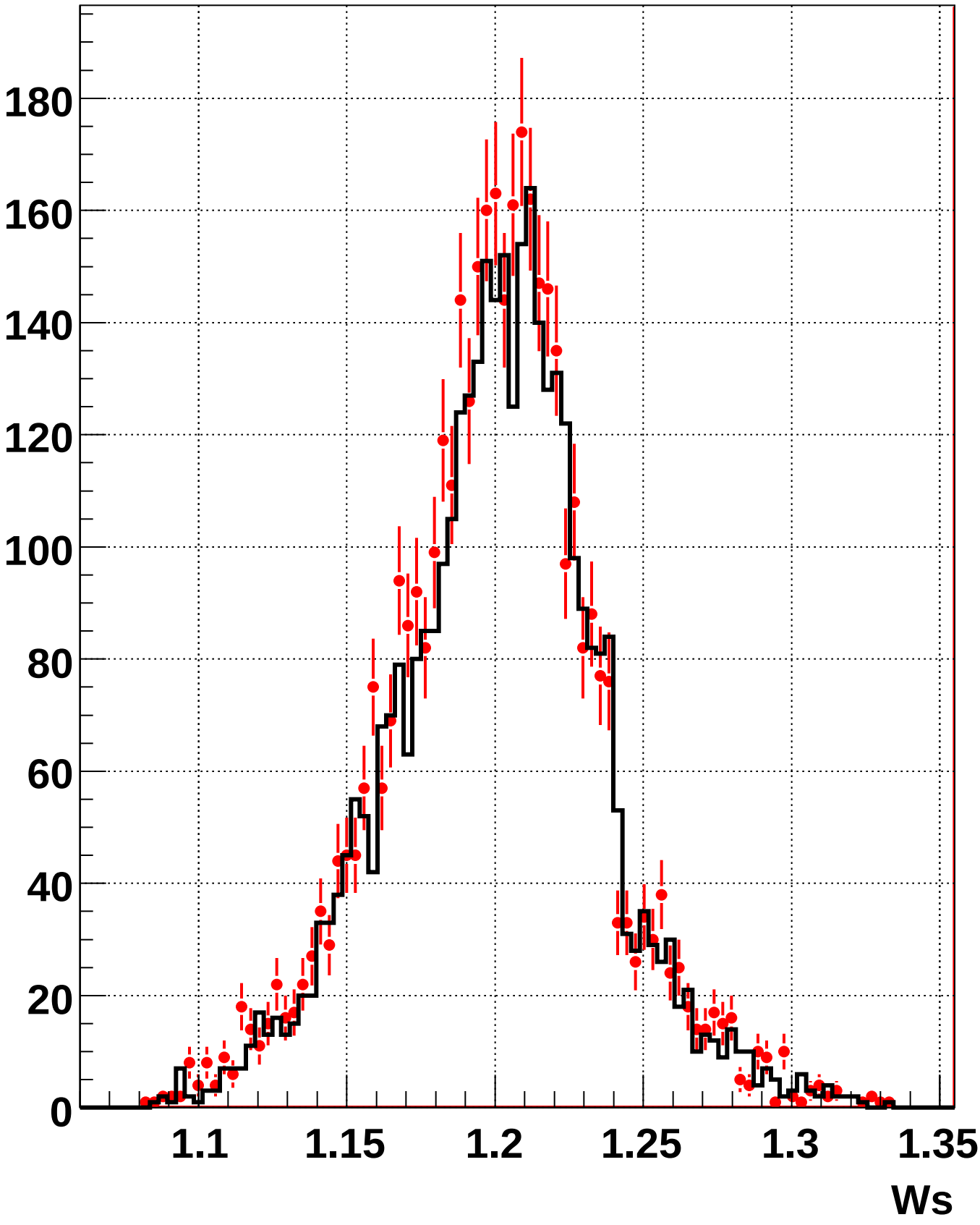
selected W for all events



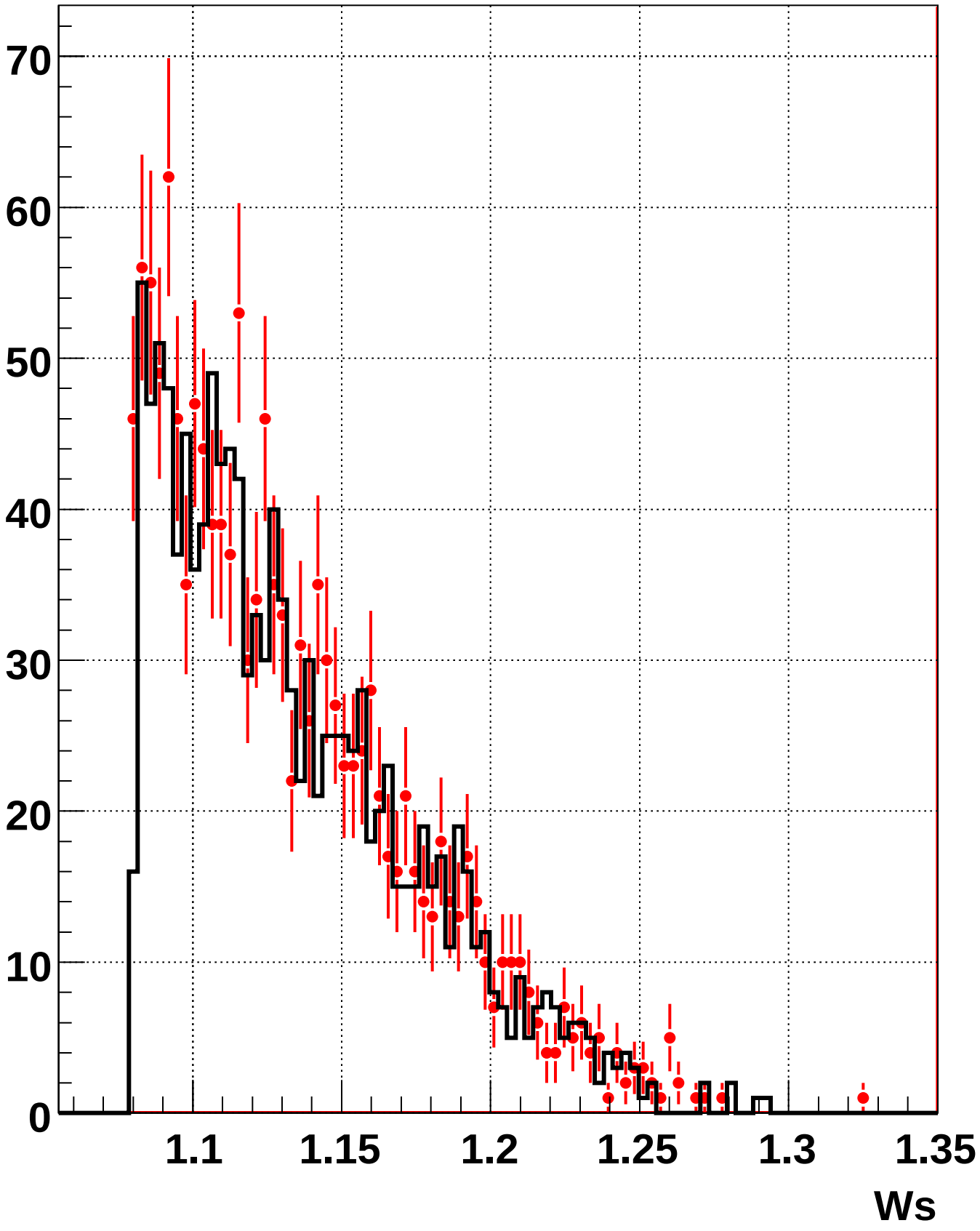
selected W for QEL events



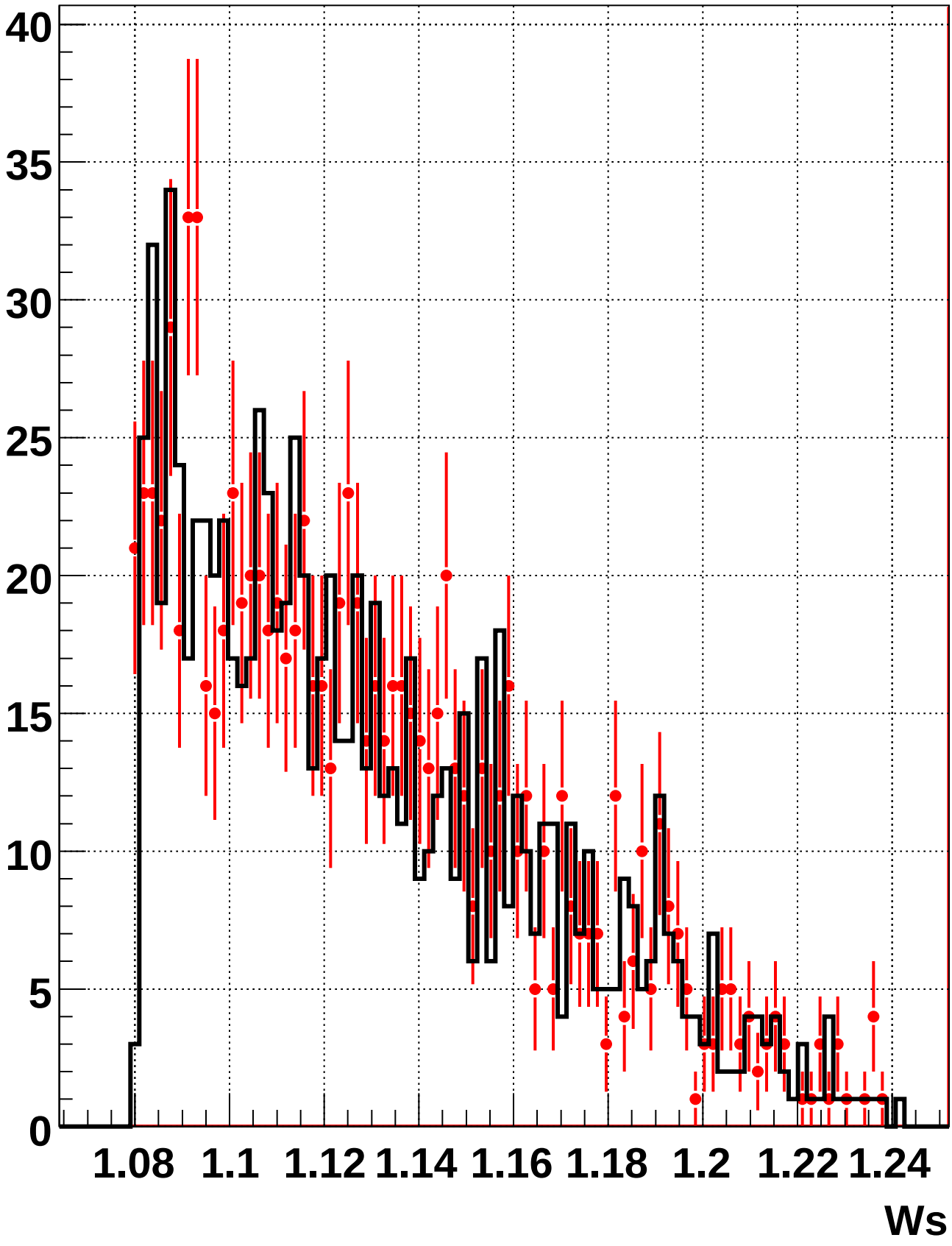
selected W for RES events



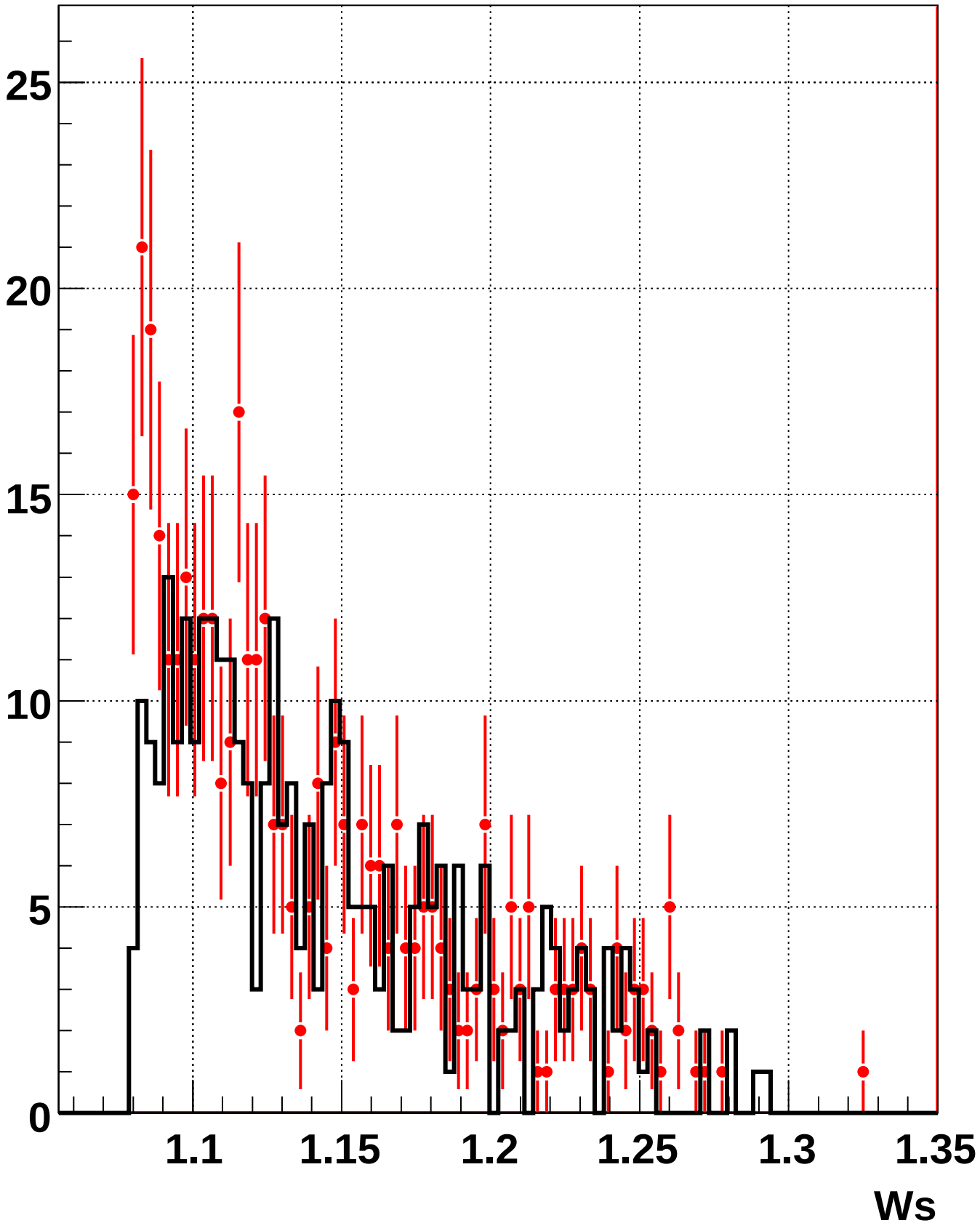
selected W for DIS events

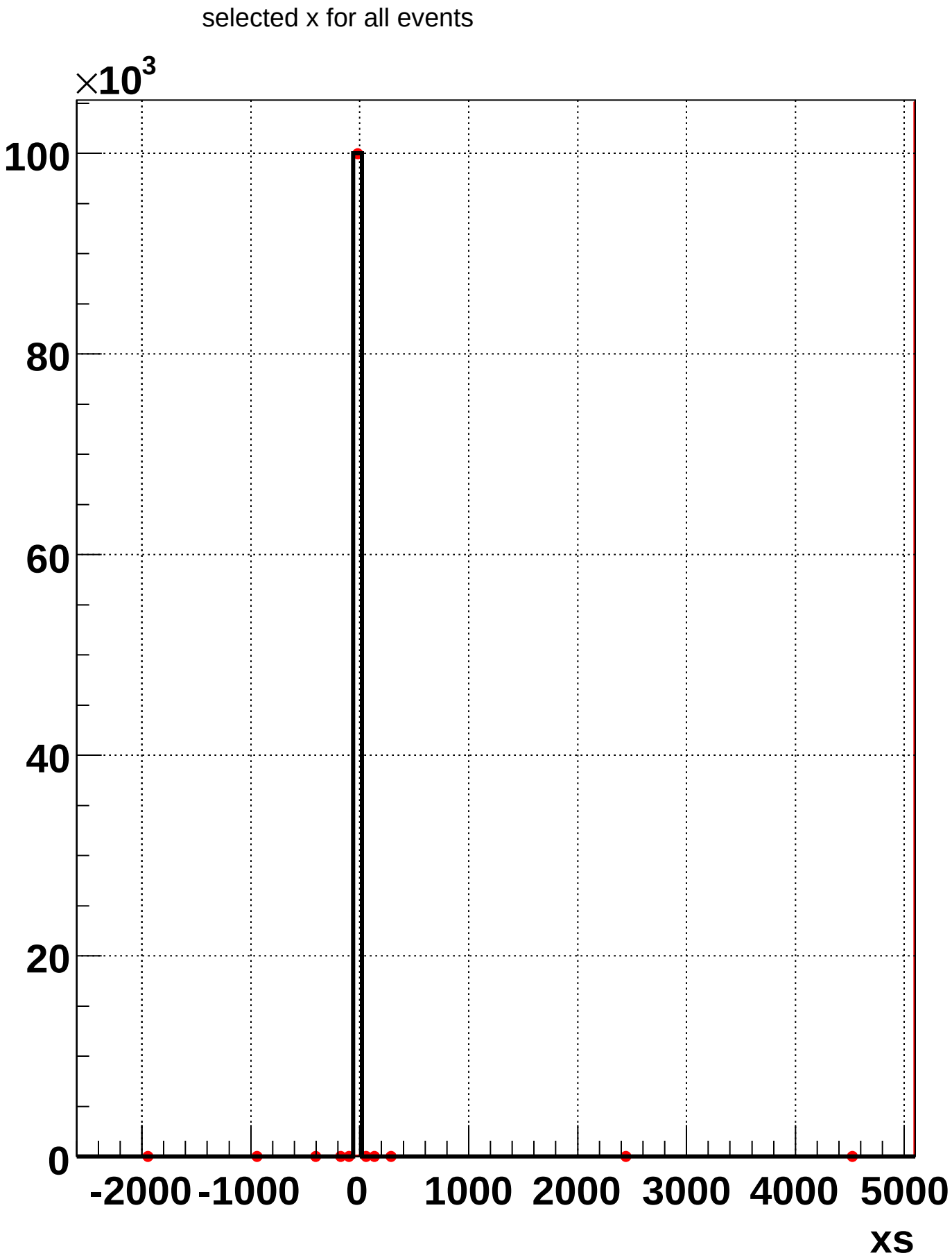


selected W for DIS CC events

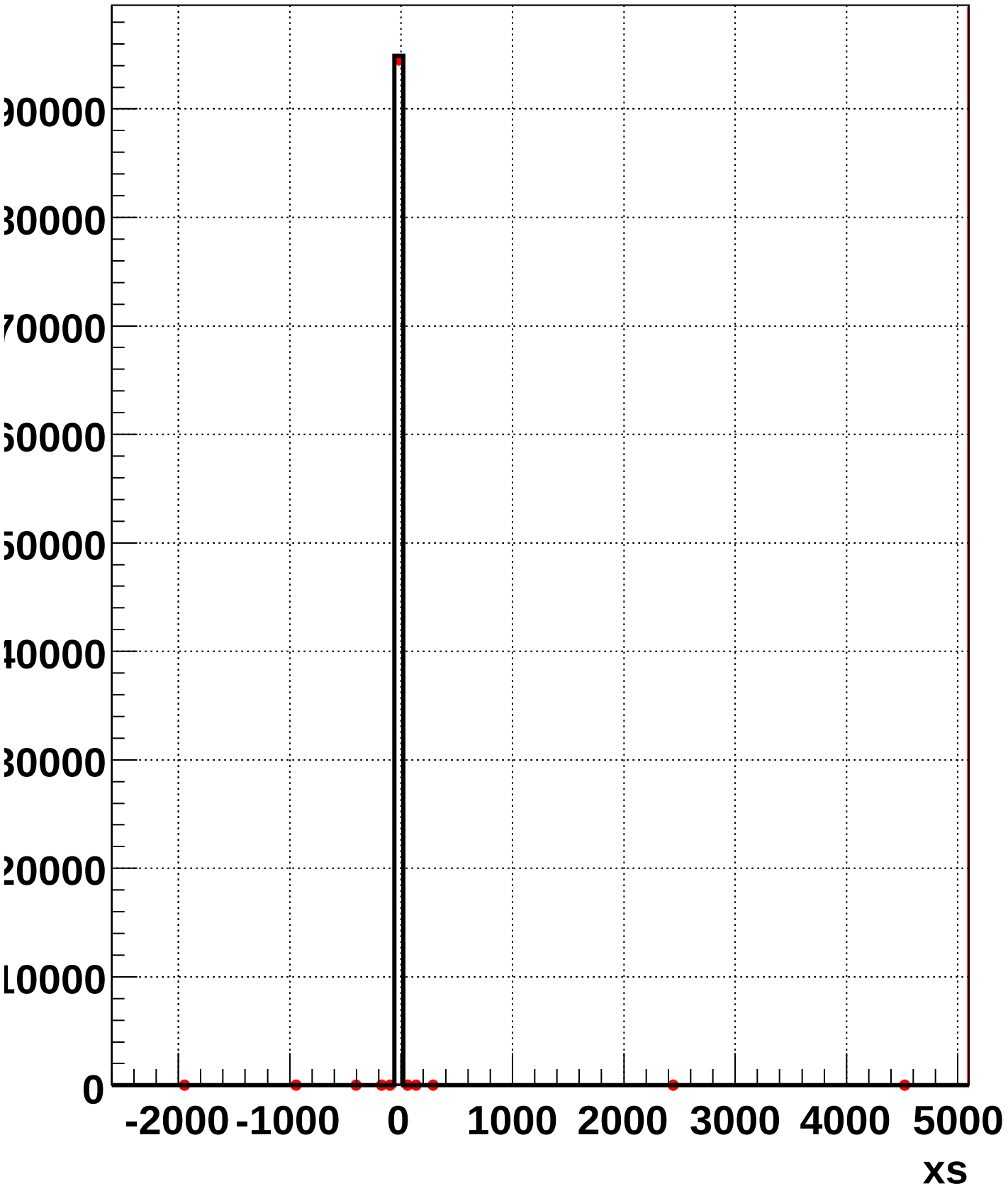


selected W for DIS NC events

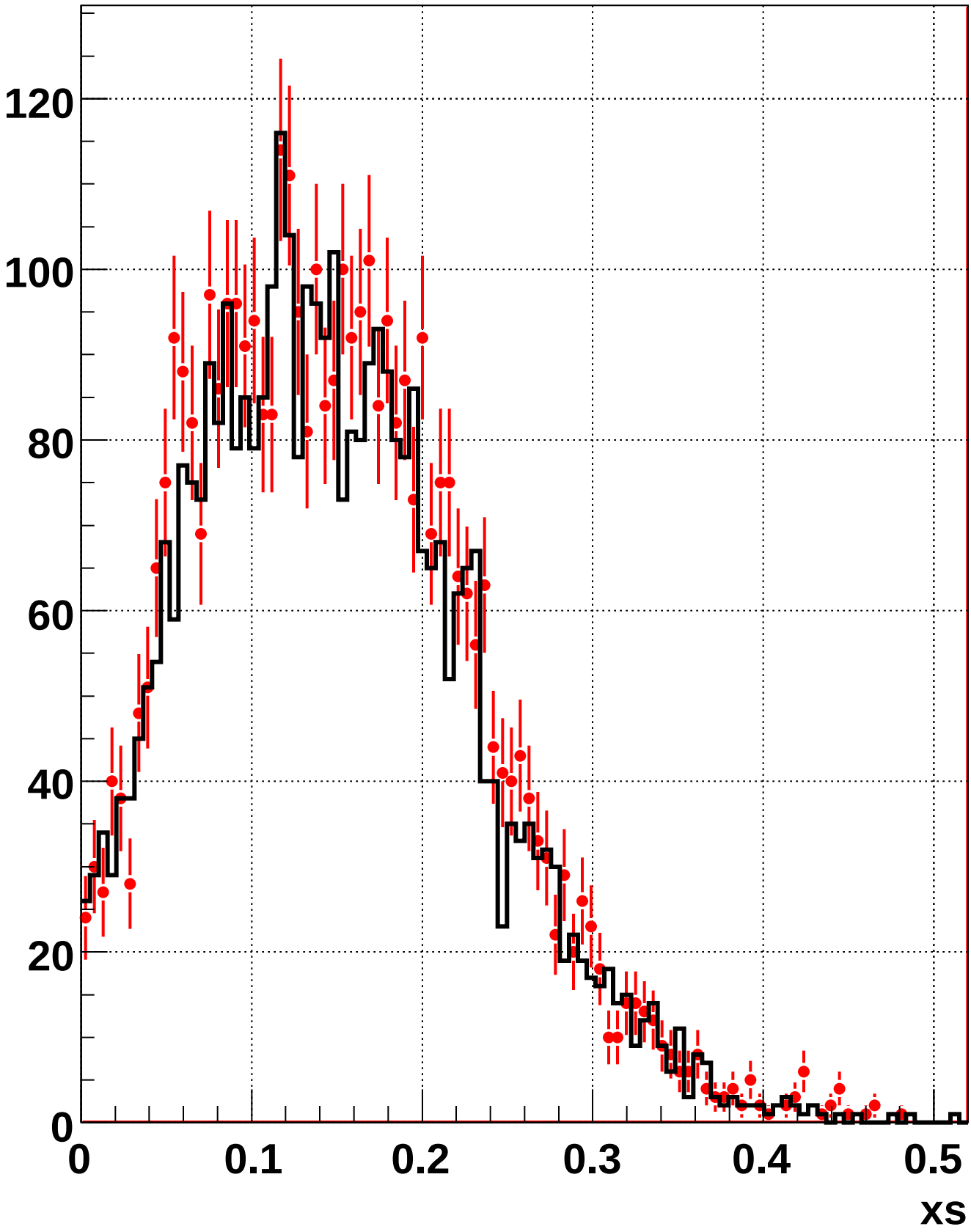



selected x for all events
×10^3
100
80
60
40
20
0
-2000
-1000
0
1000
2000
3000
4000
5000
xs

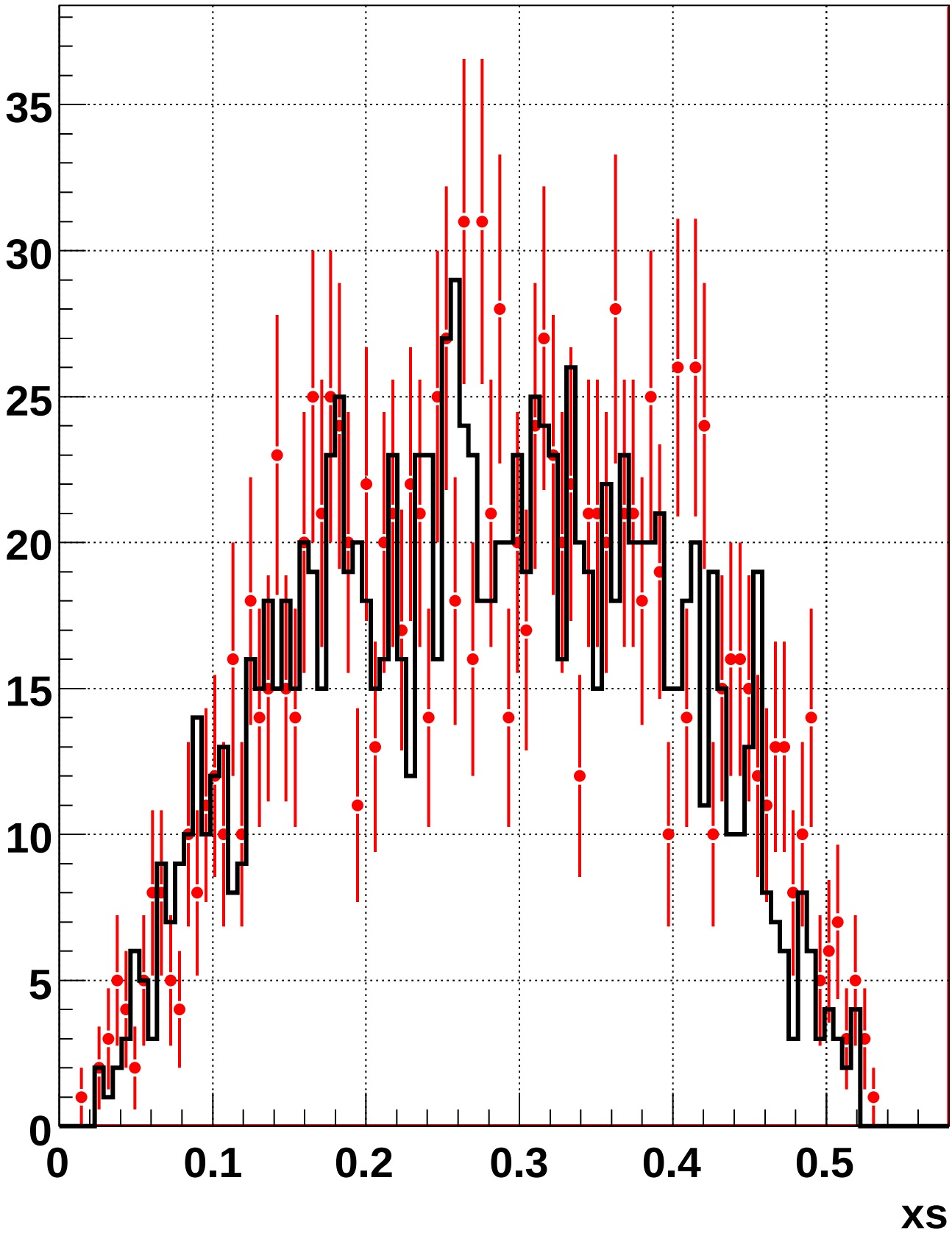
selected x for QEL events



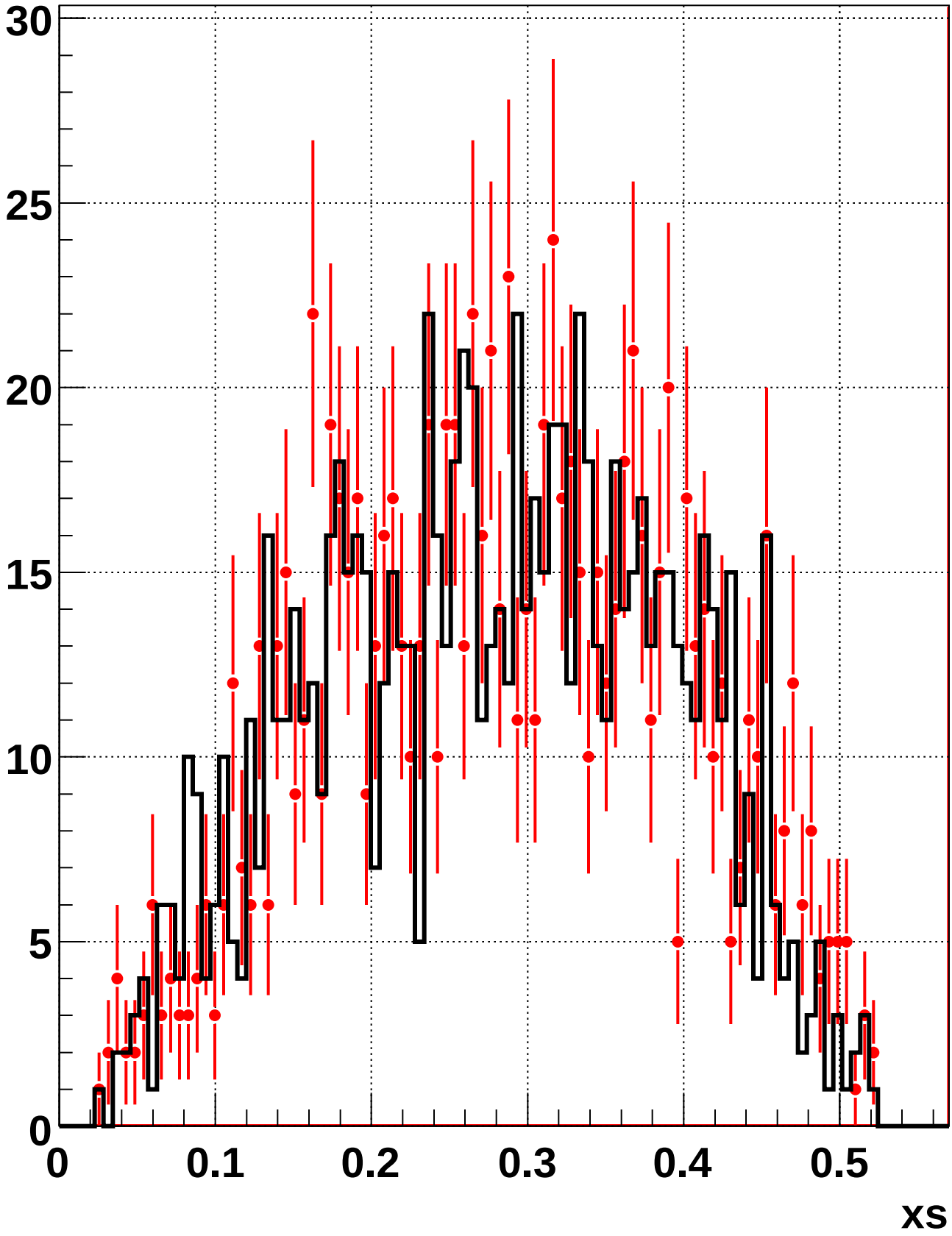
selected x for RES events



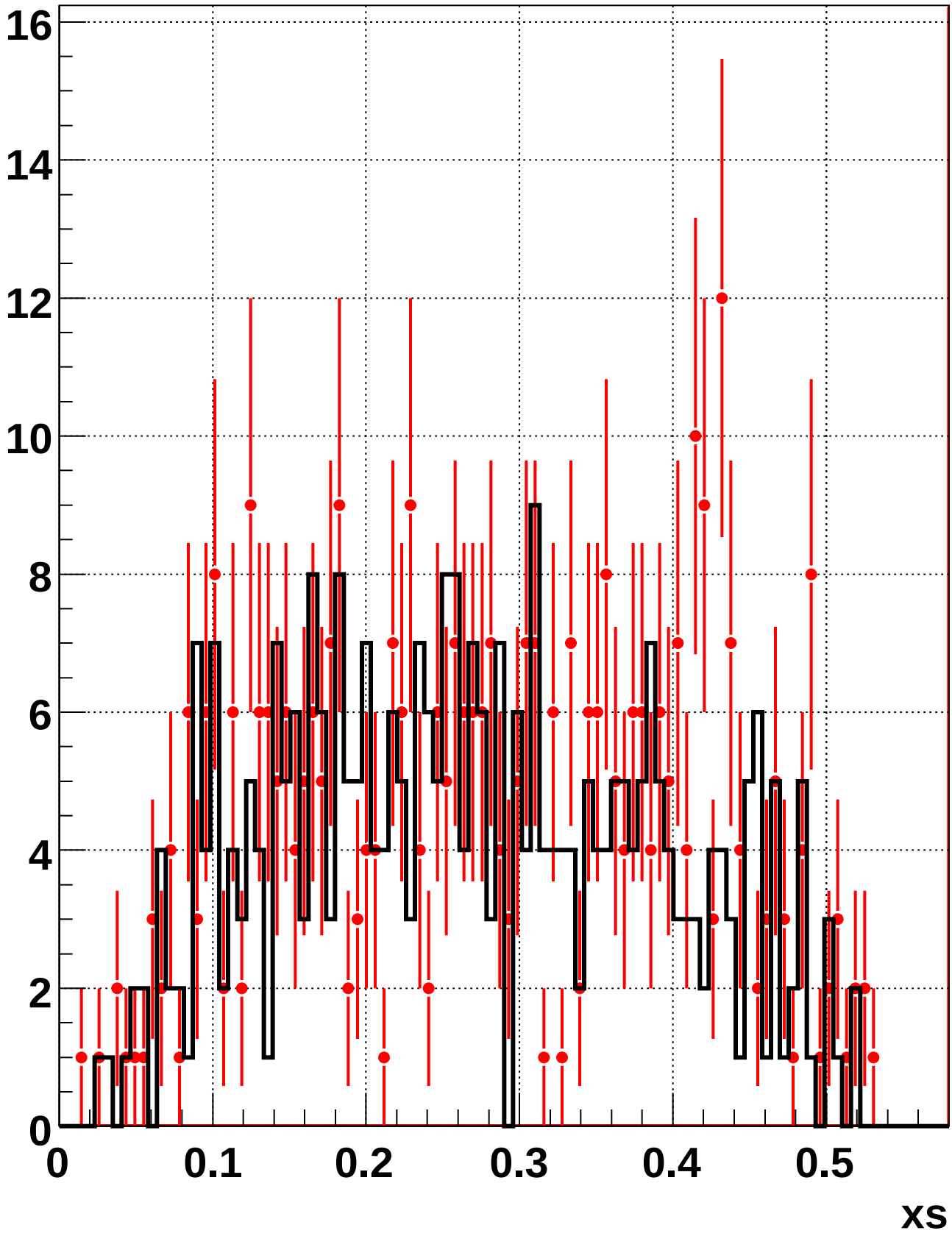
selected x for DIS events



selected x for DIS CC events

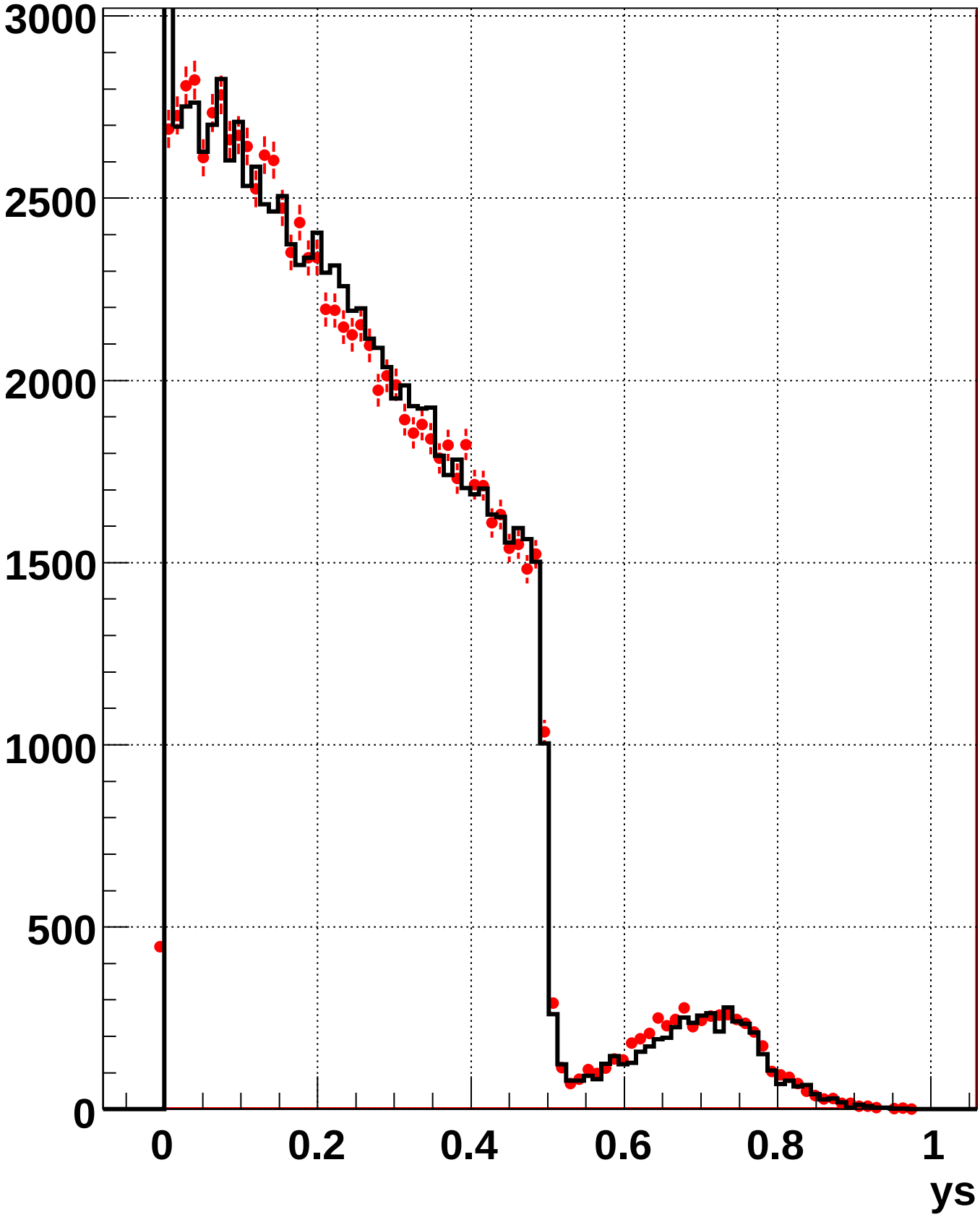


selected x for DIS NC events

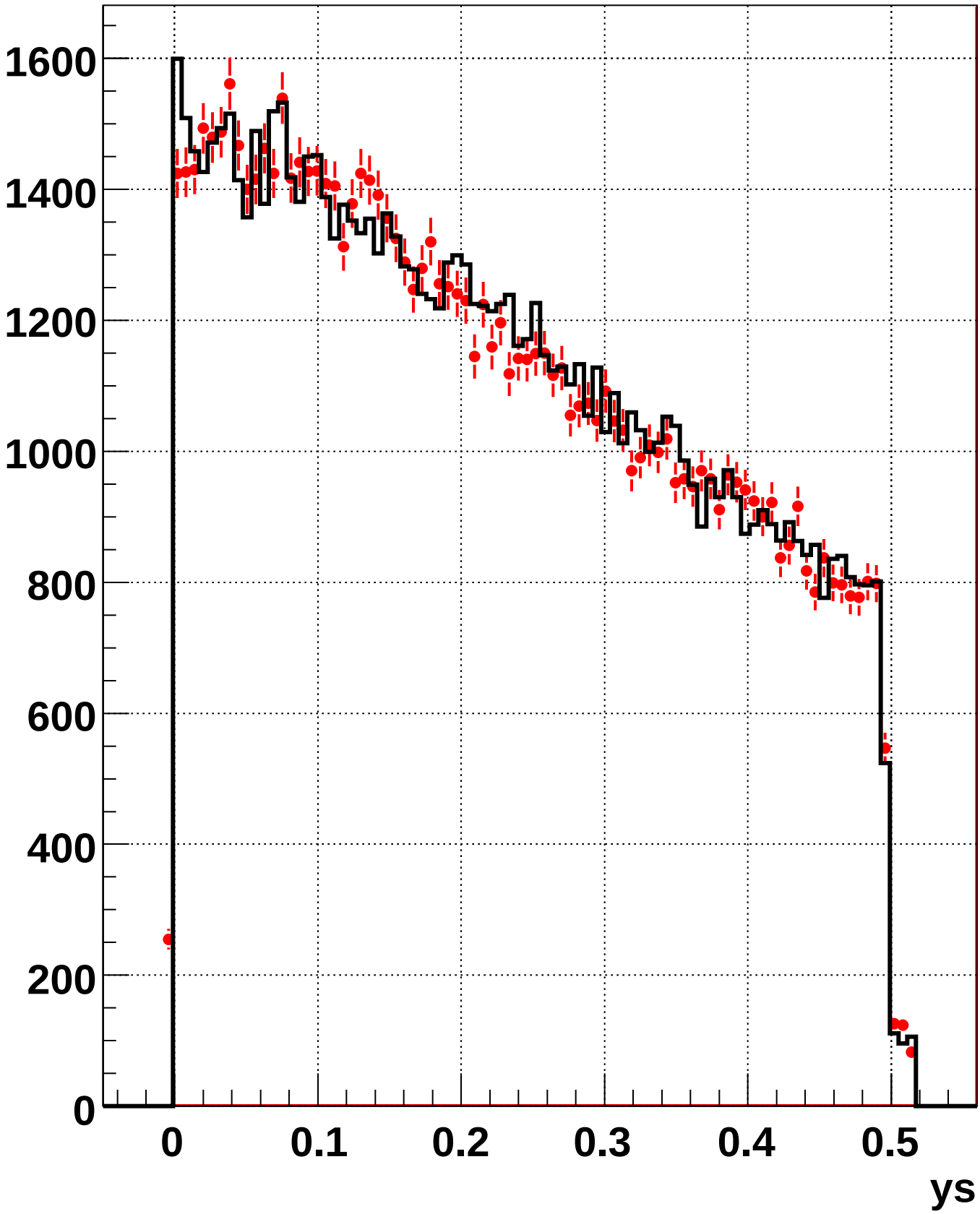


selected x for Charm/DIS events

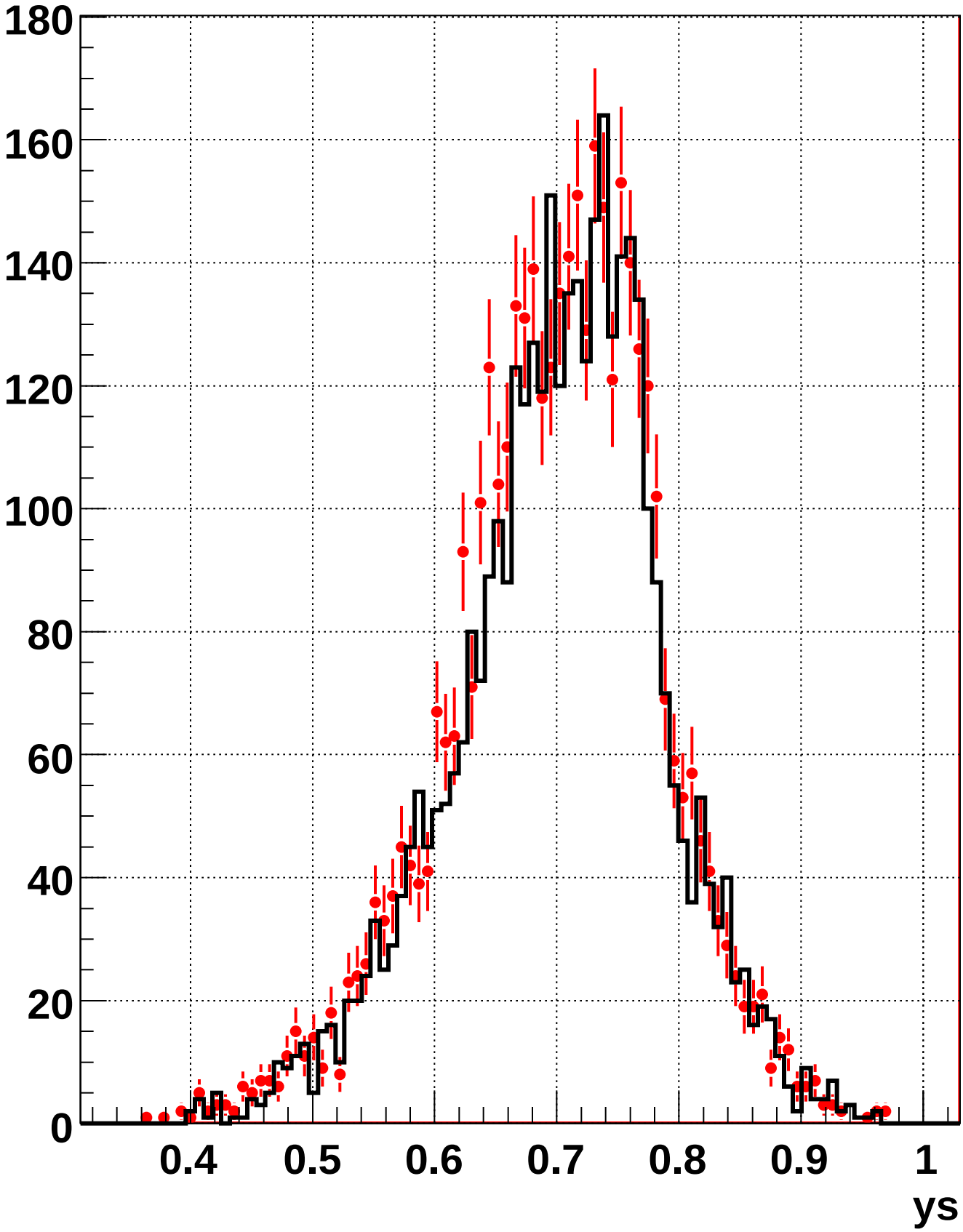
selected y for all events



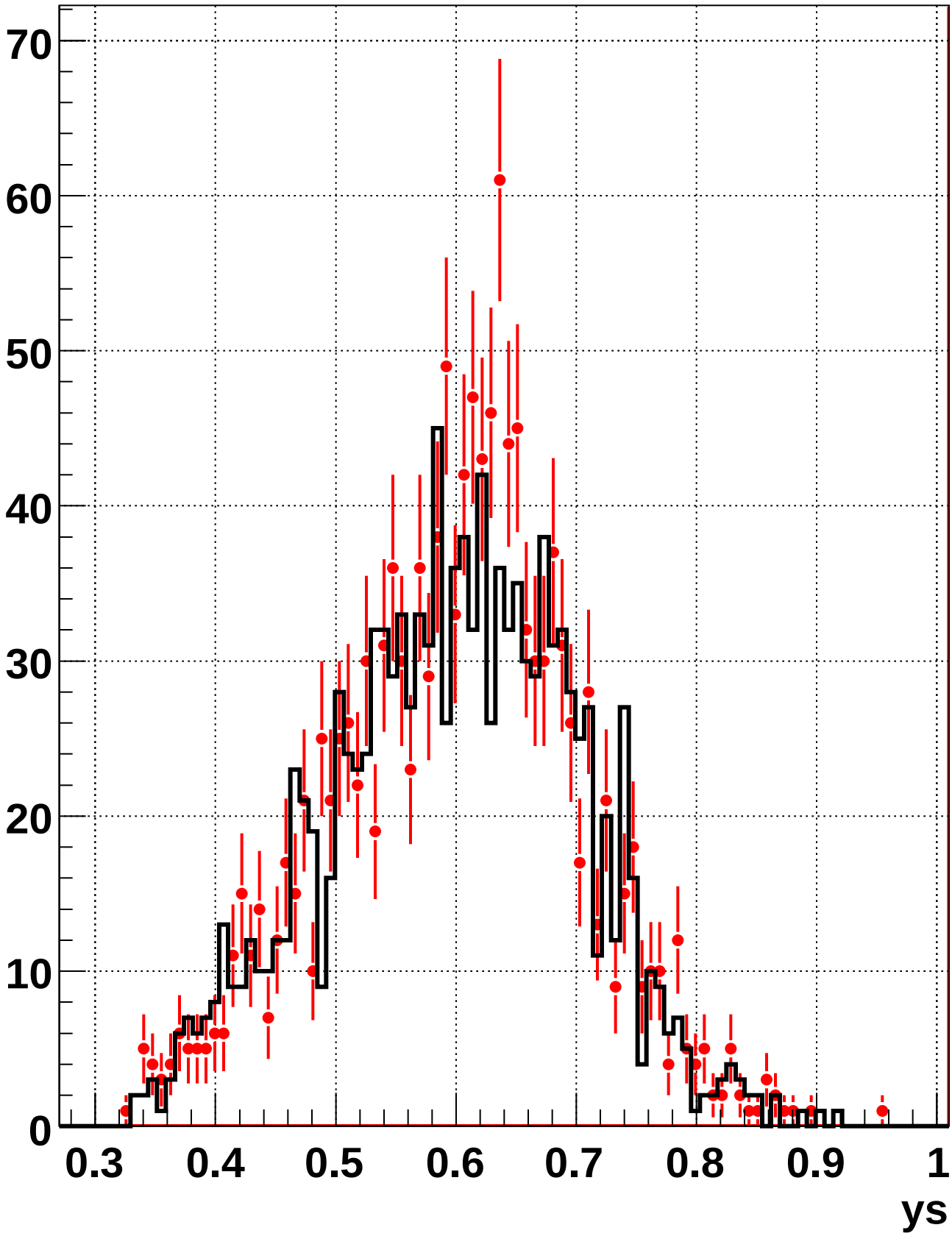
selected y for QEL events



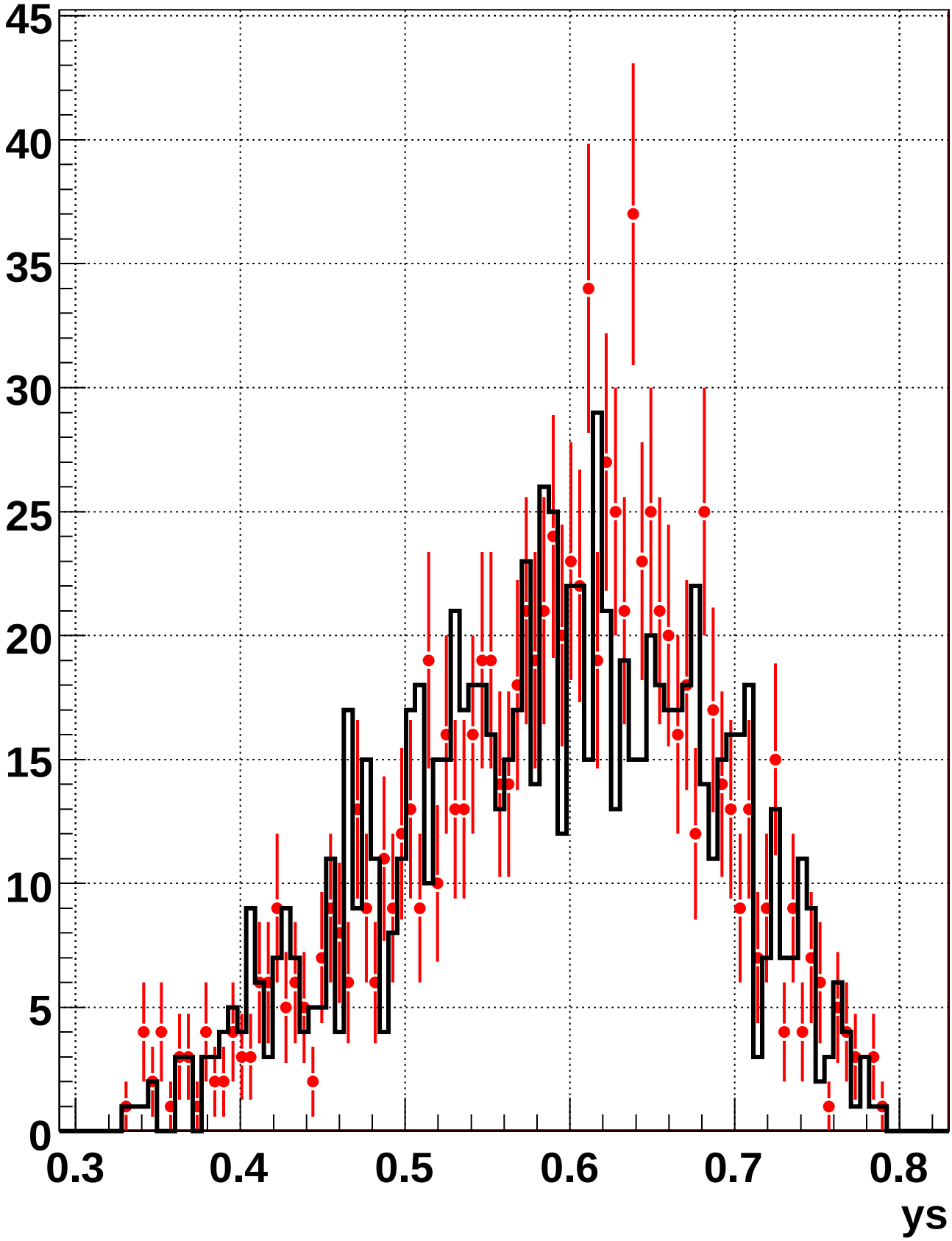
selected y for RES events



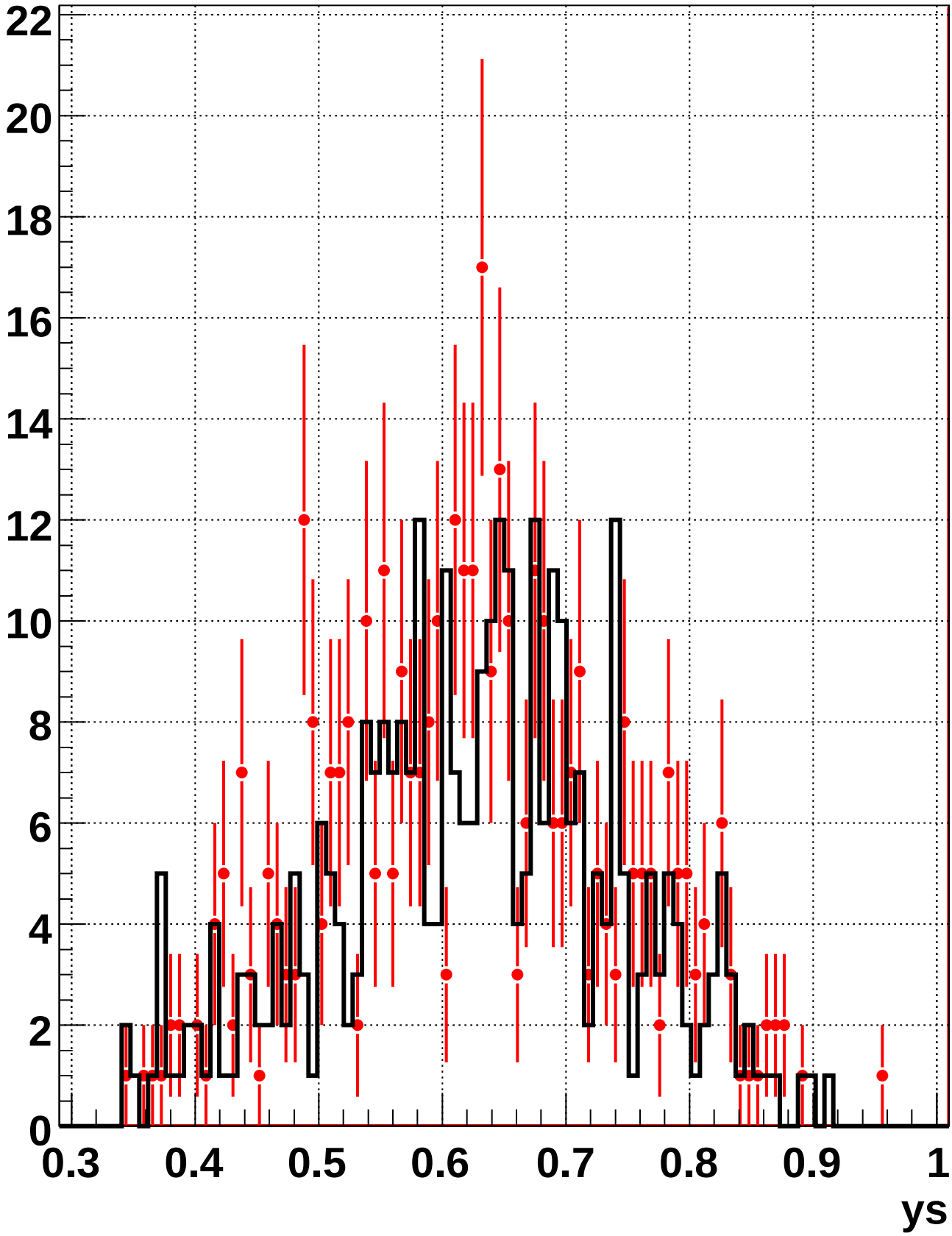
selected y for DIS events



selected y for DIS CC events



selected y for DIS NC events



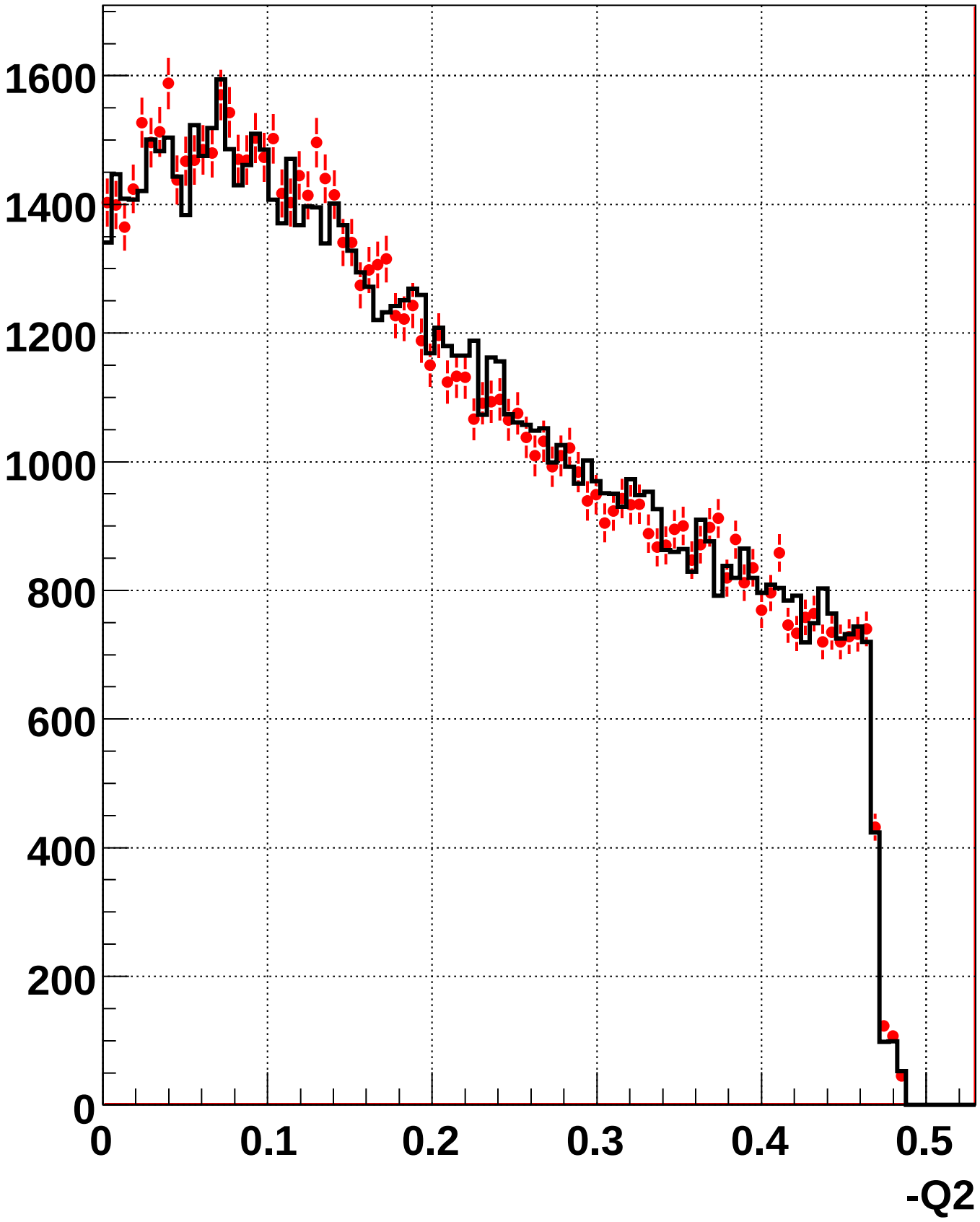
selected y for Charm/DIS events

Kinematical Quantities

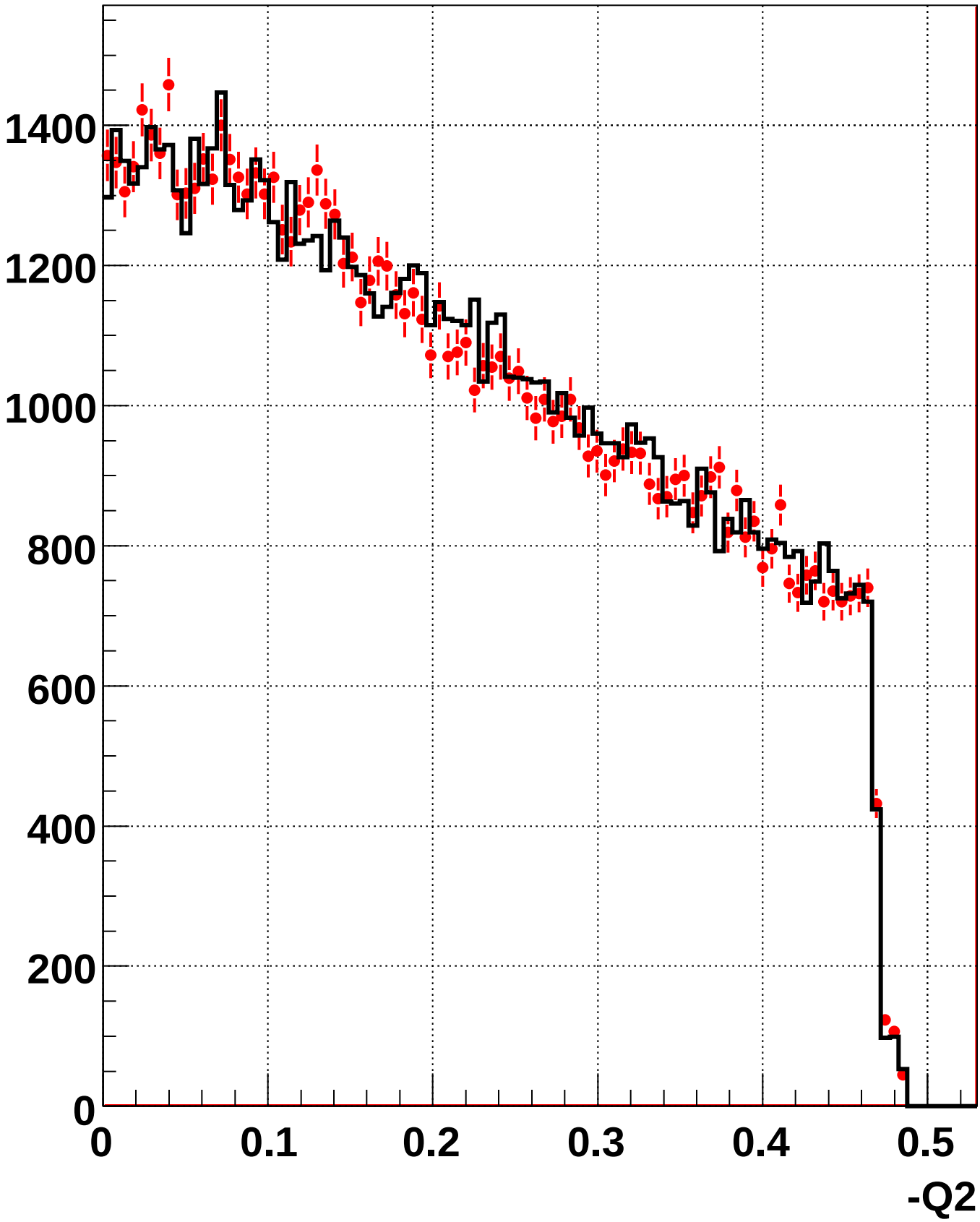
Similar to the previous set of plots but

showing ’computed’ rathen than ’selected’ variables

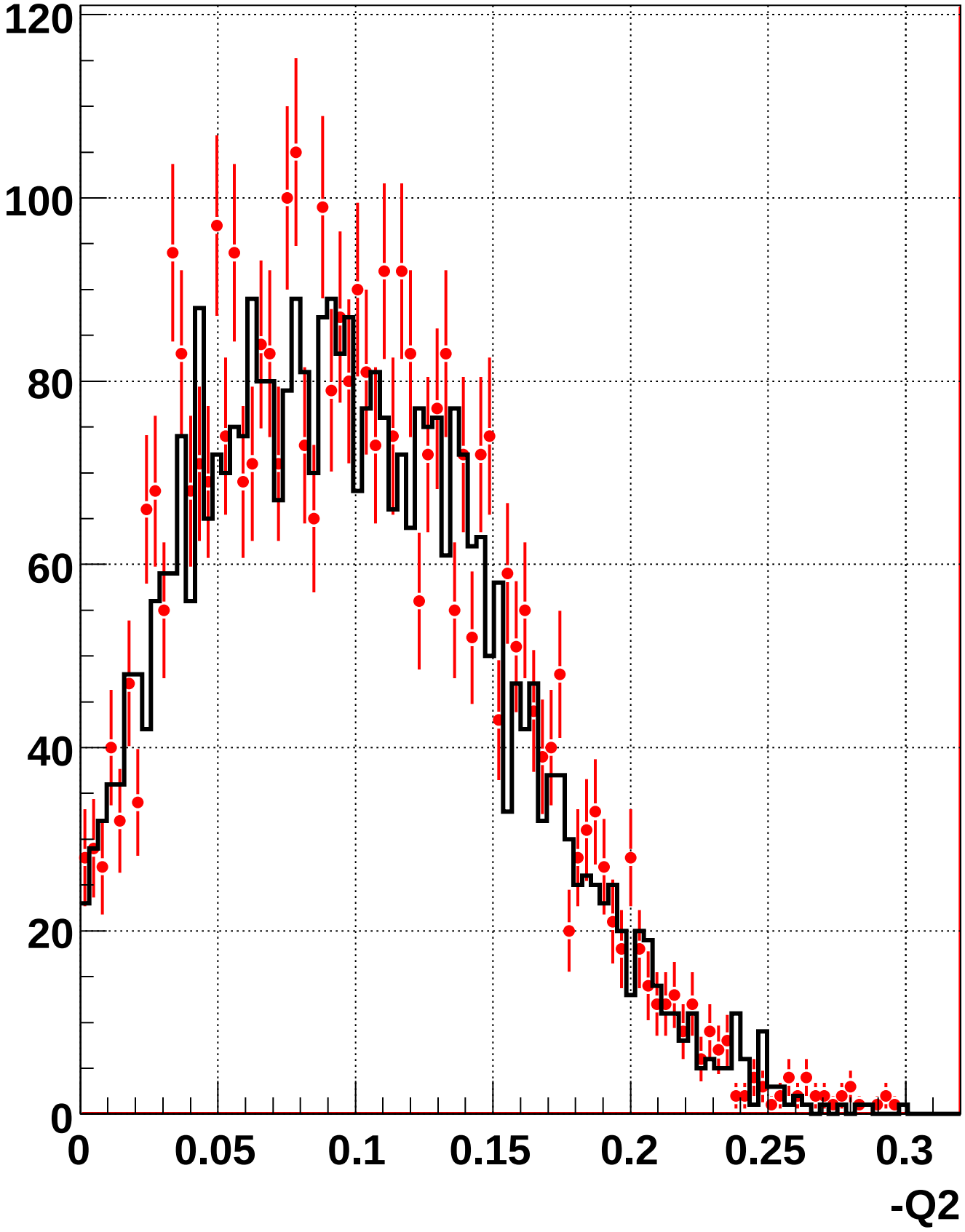
computed Q2 for all events



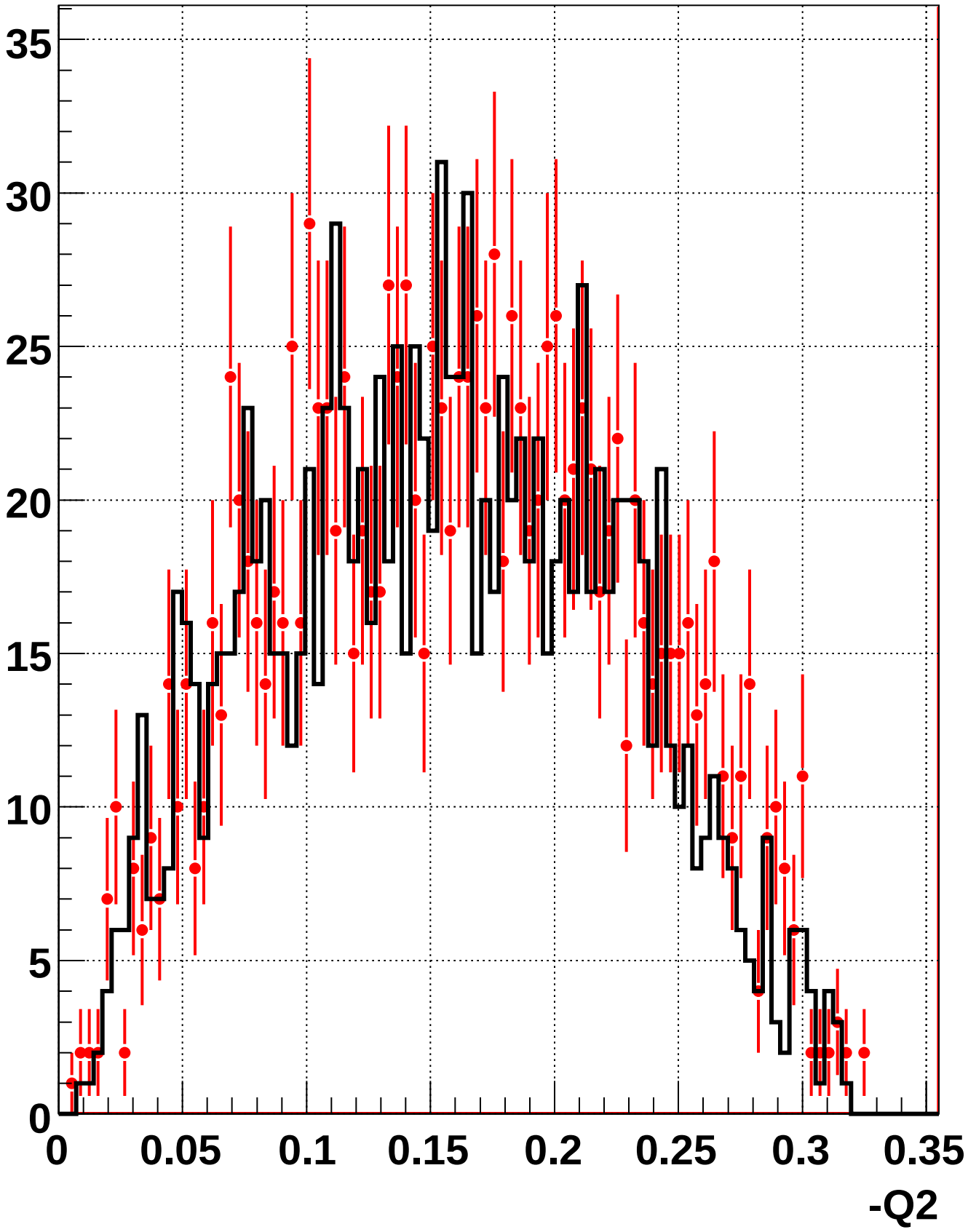
computed Q2 for QEL events

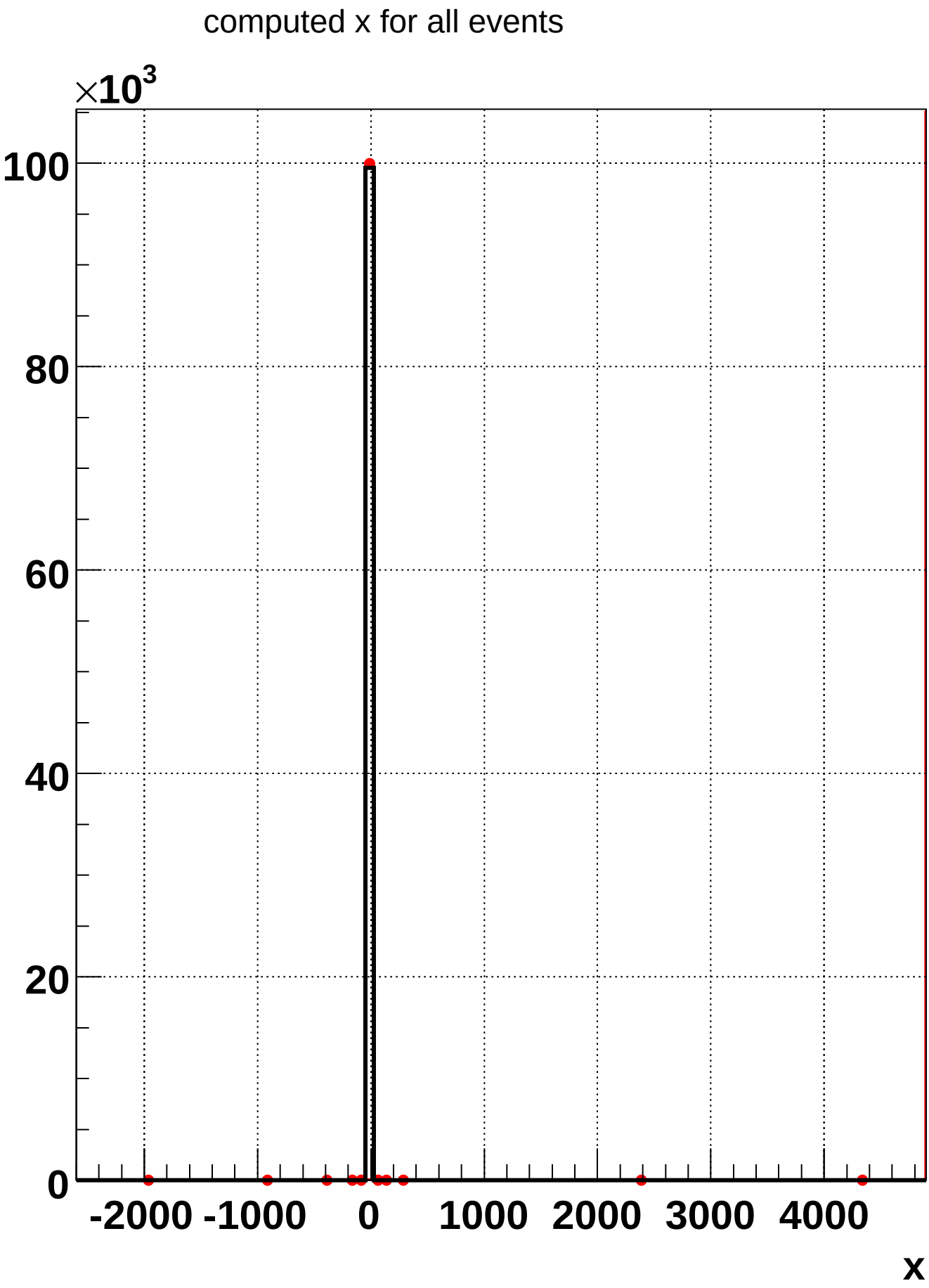


computed Q2 for RES events

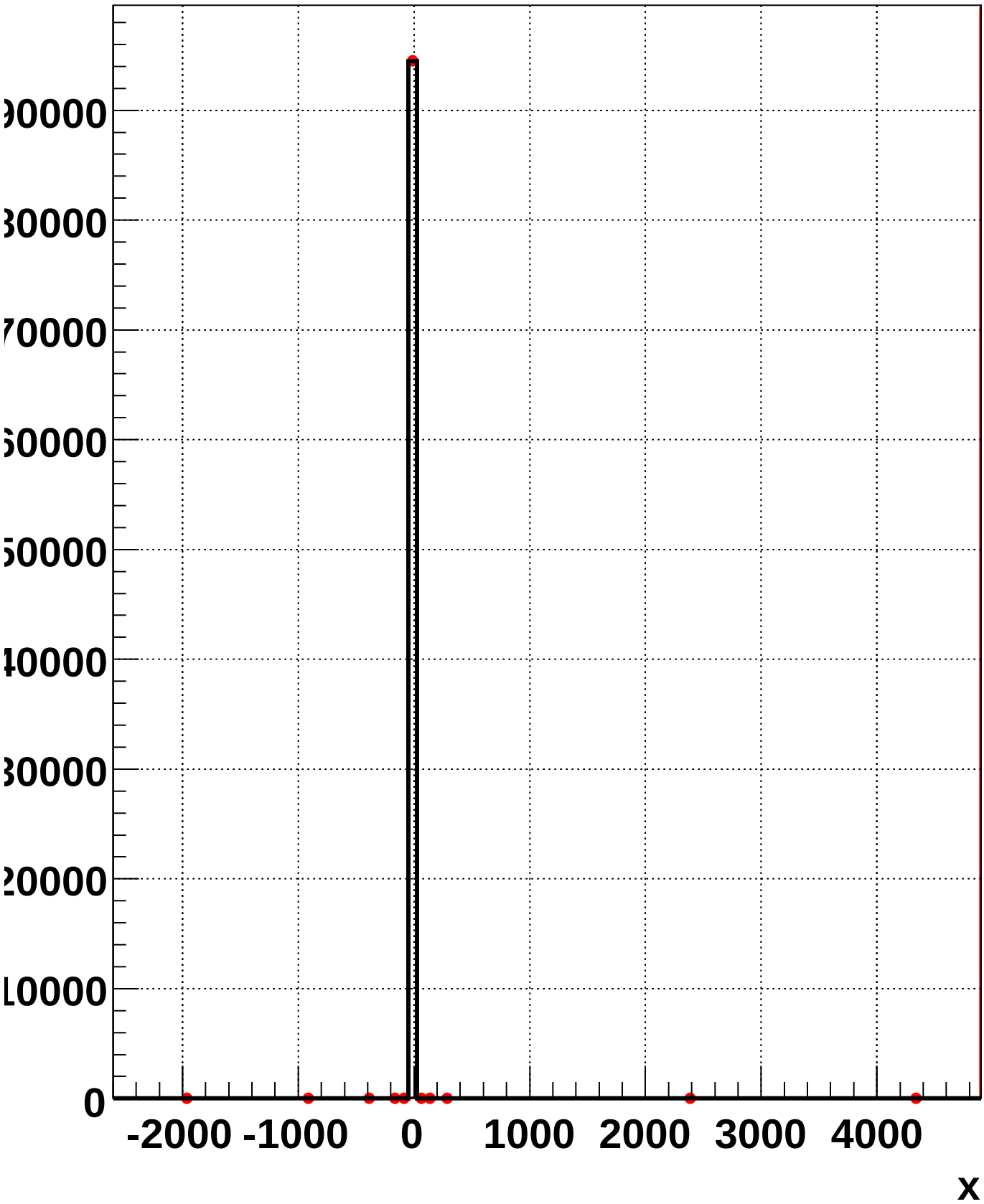


computed Q2 for DIS events

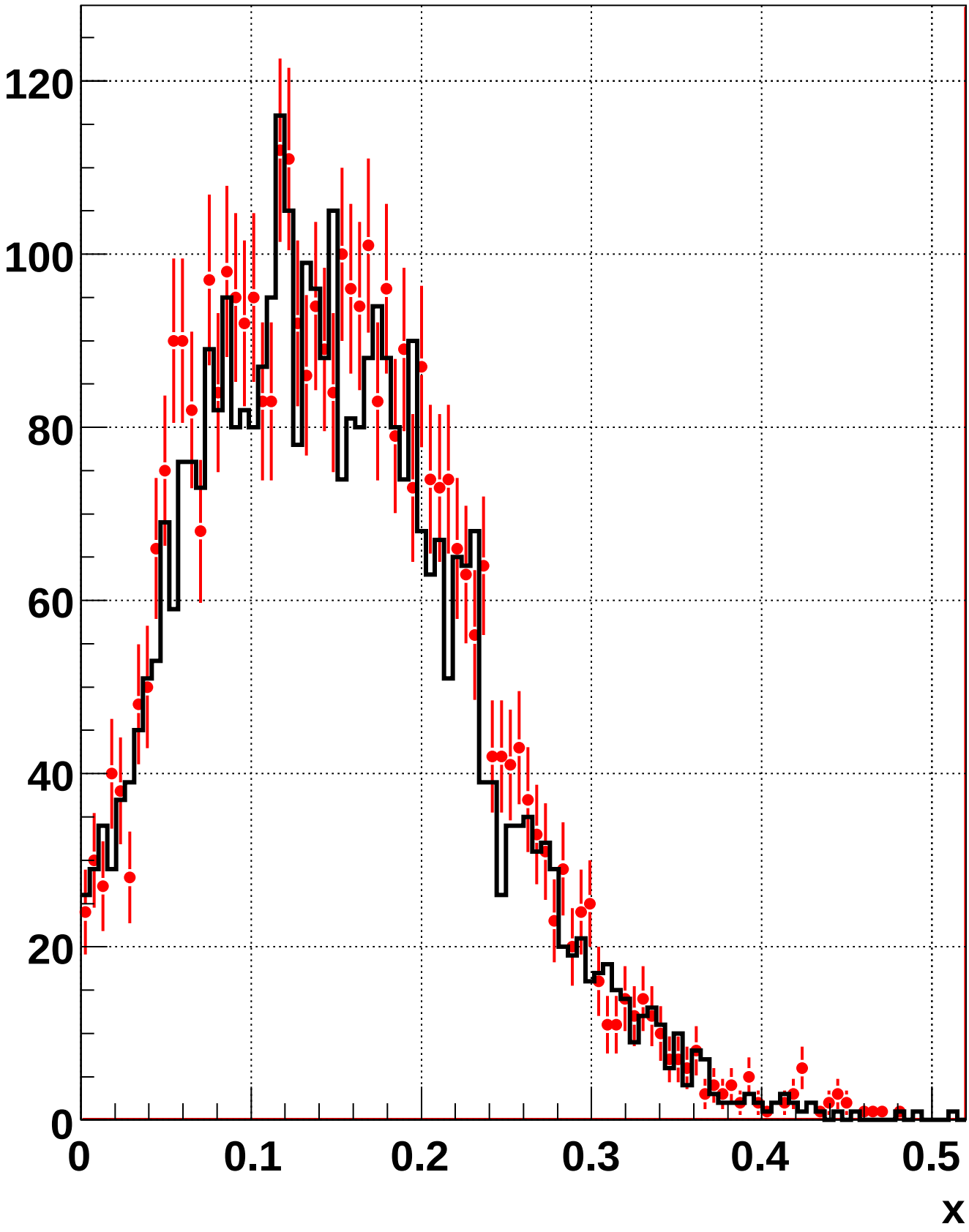



computed x for all events
×10^3
100
80
60
40
20
0
-2000
-1000
0
1000
2000
3000
4000
x

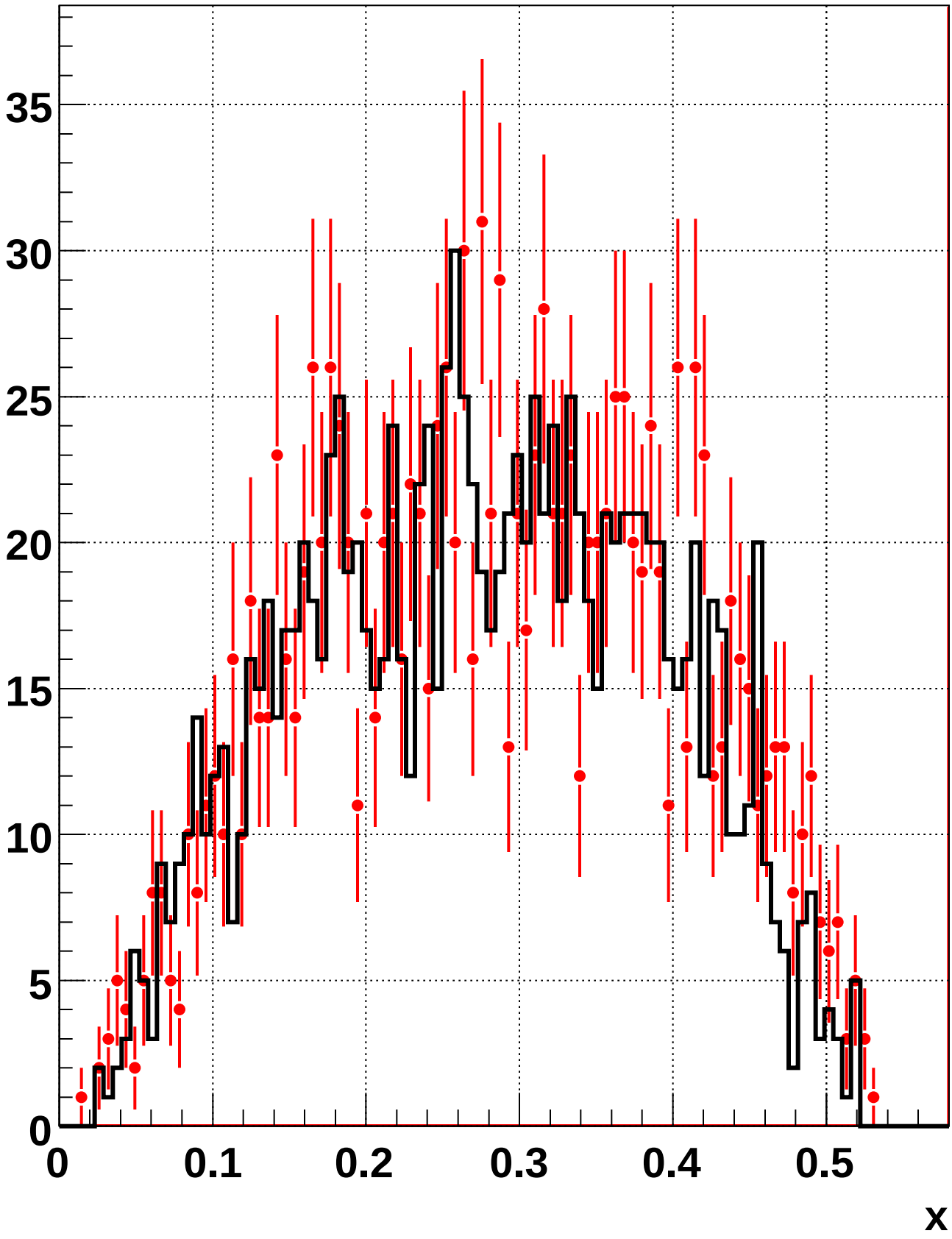
computed x for QEL events

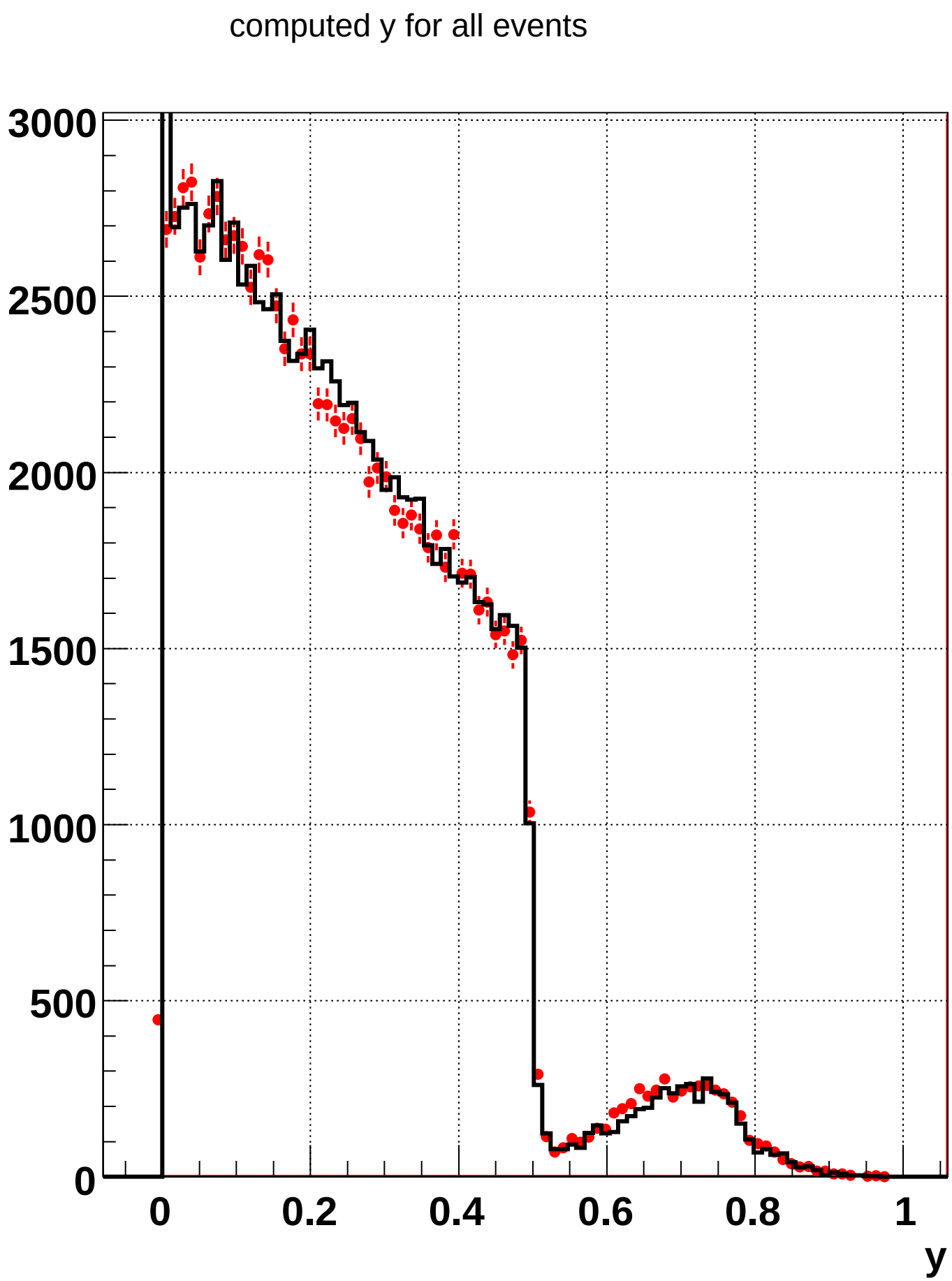


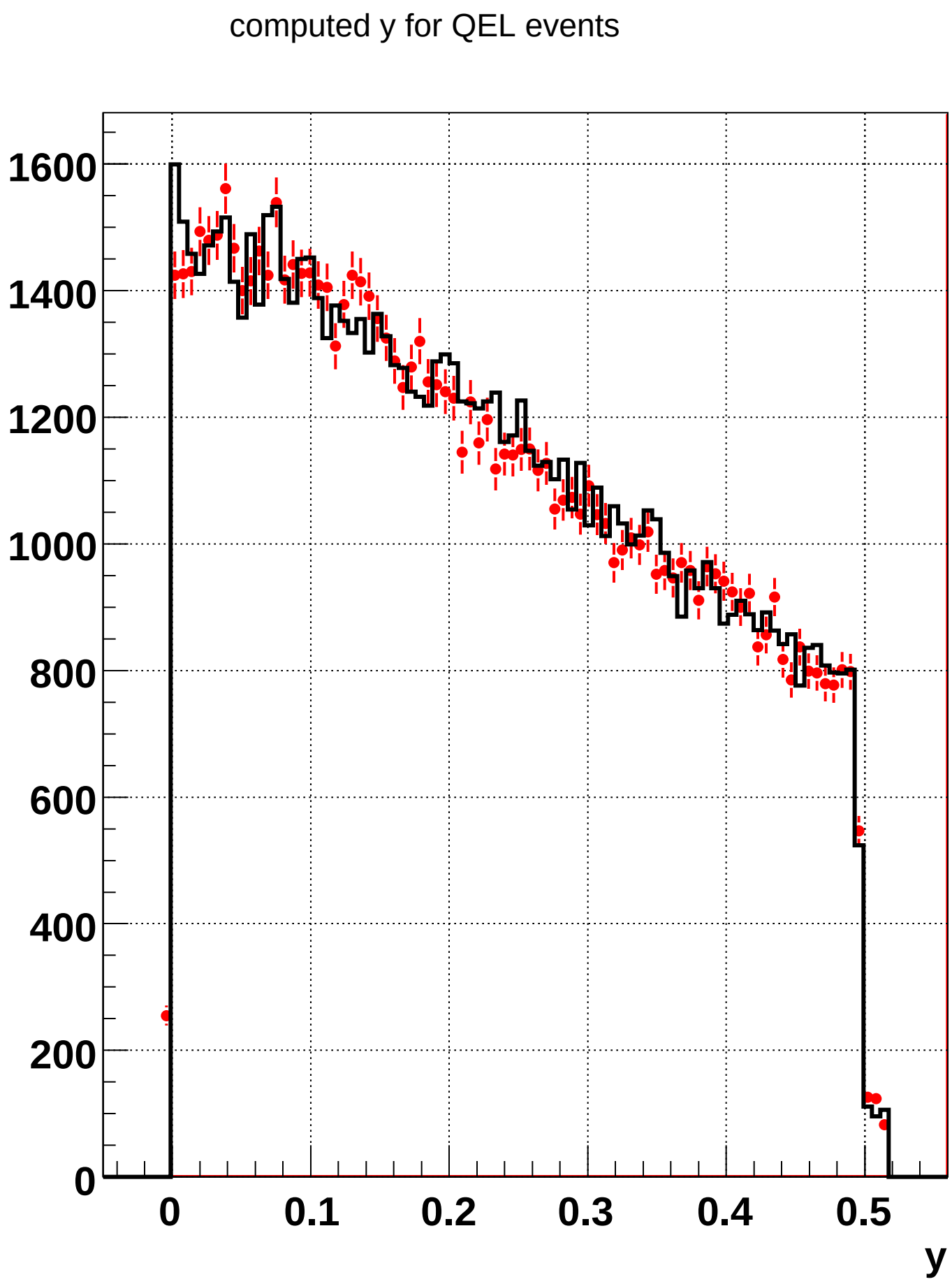
computed x for RES events



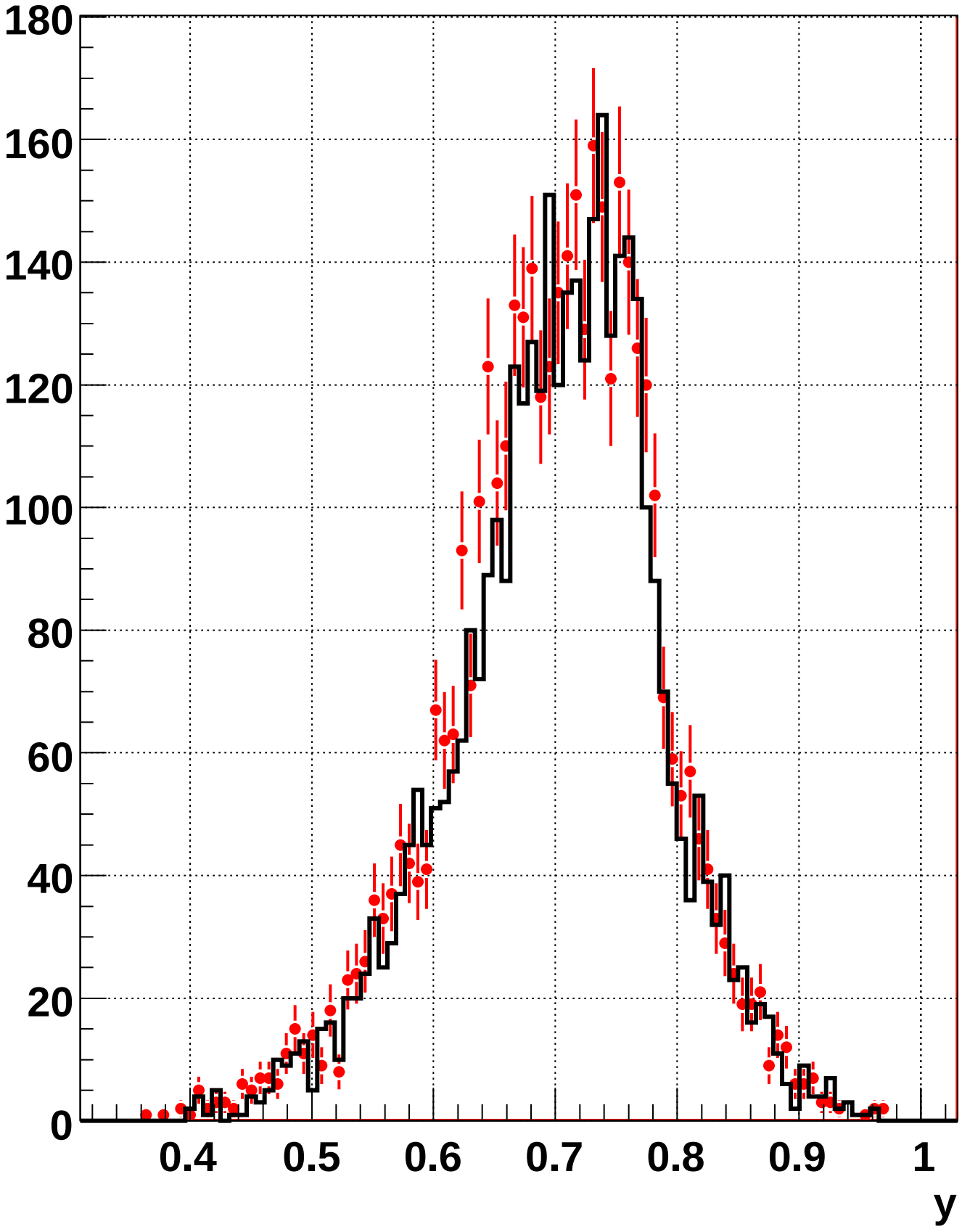
computed x for DIS events



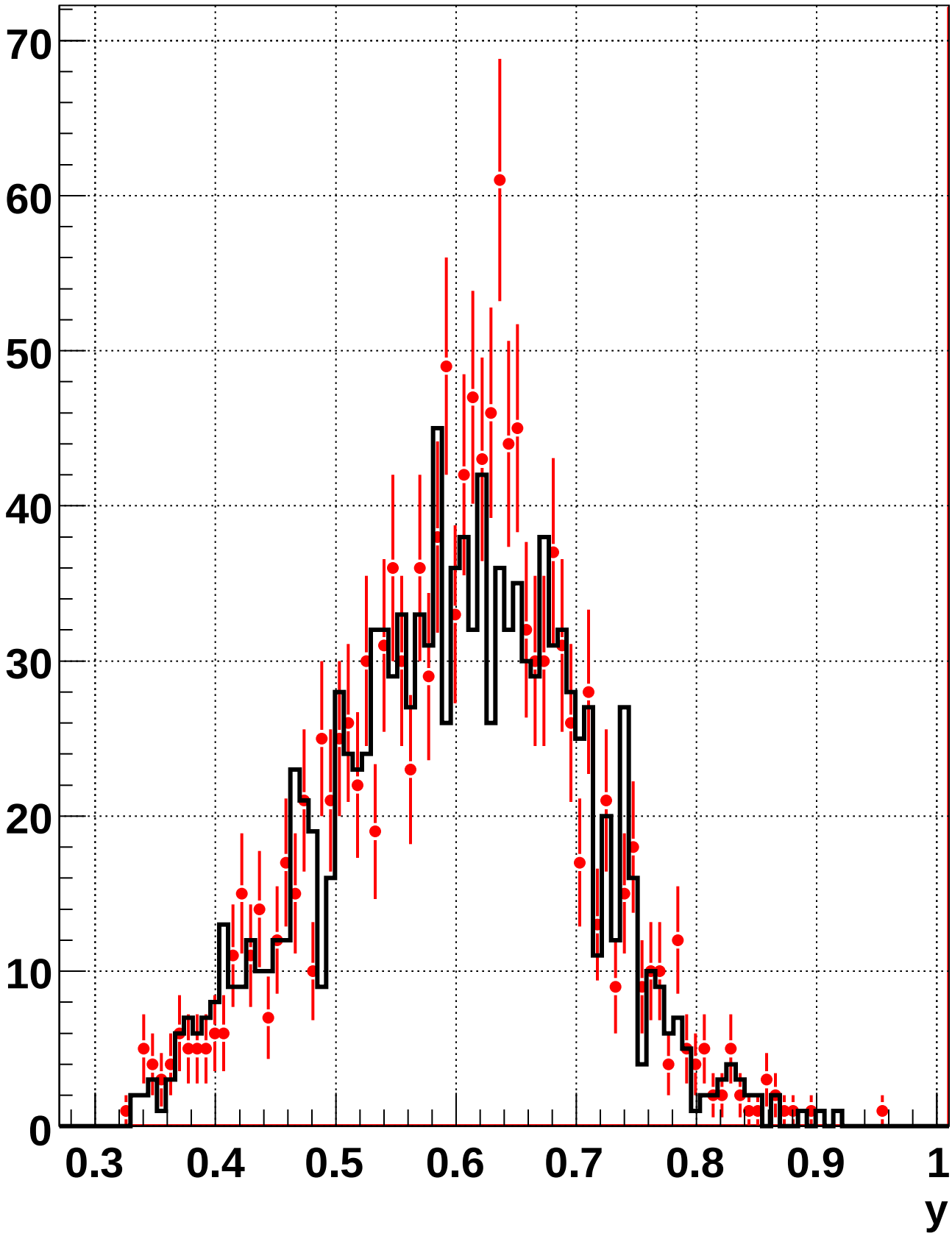

computed y for all events
3000
2500
2000
1500
1000
500
0
0
0.2
0.4
0.6
0.8
1
y


computed y for QEL events
1600
1400
1200
1000
800
600
400
200
0
0
0.1
0.2
0.3
0.4
0.5
y

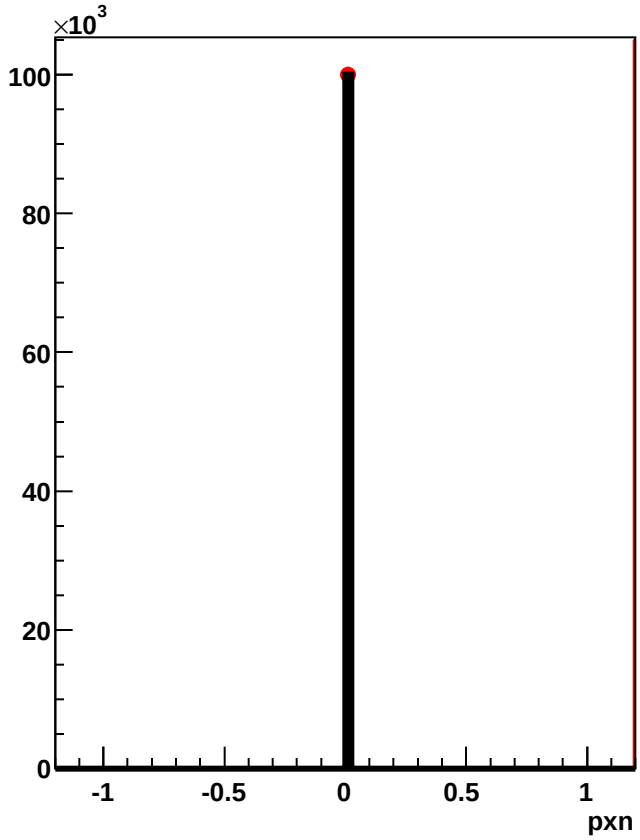
computed y for RES events

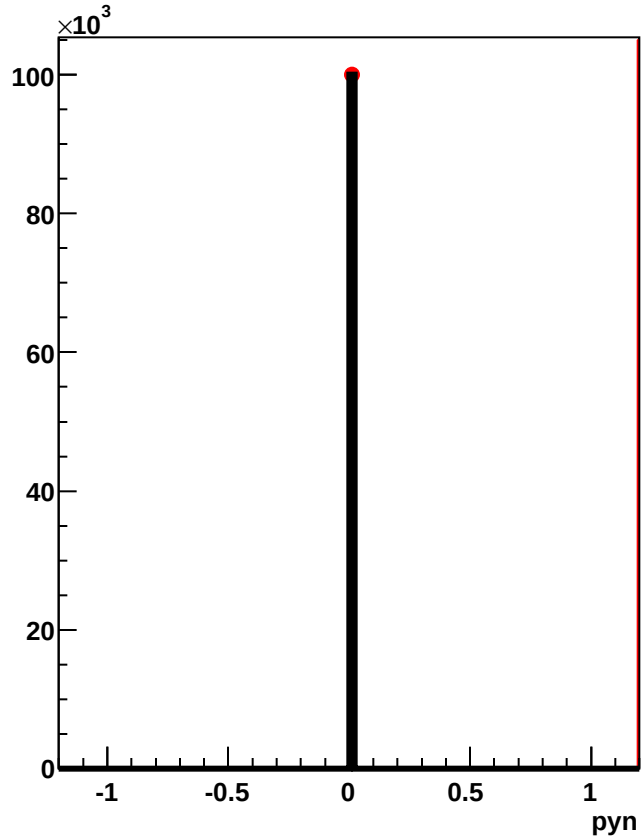


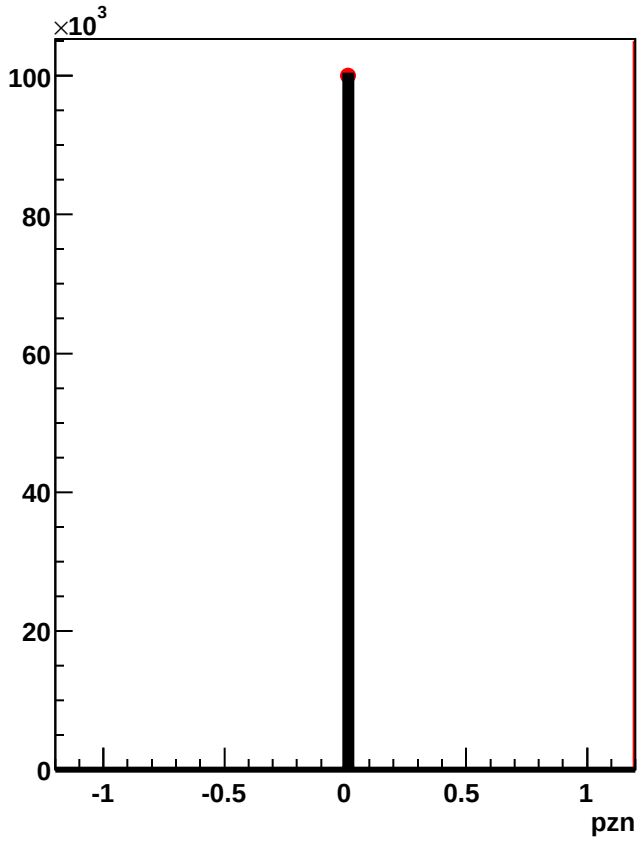
computed y for DIS events

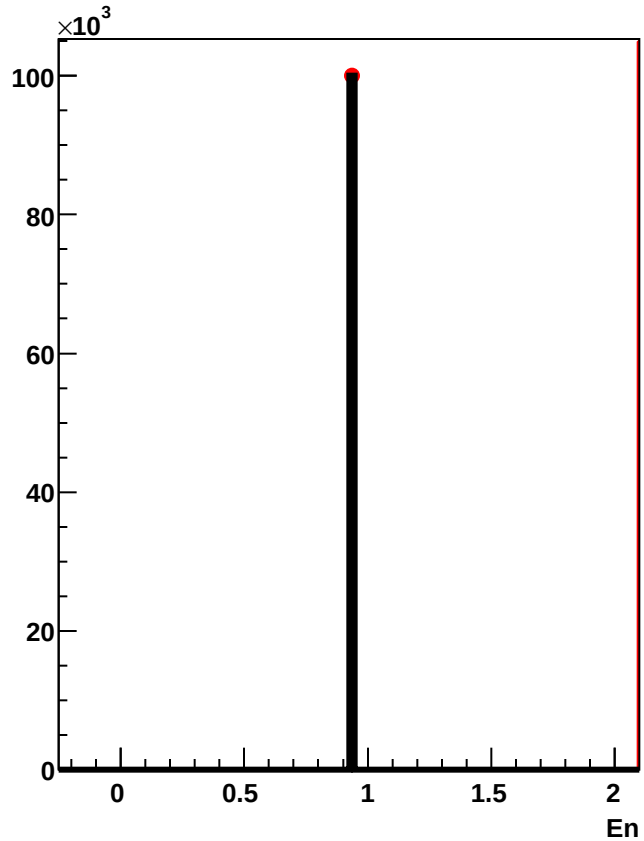


Initial state nucleon 4-Momentum


×10^3
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pxn

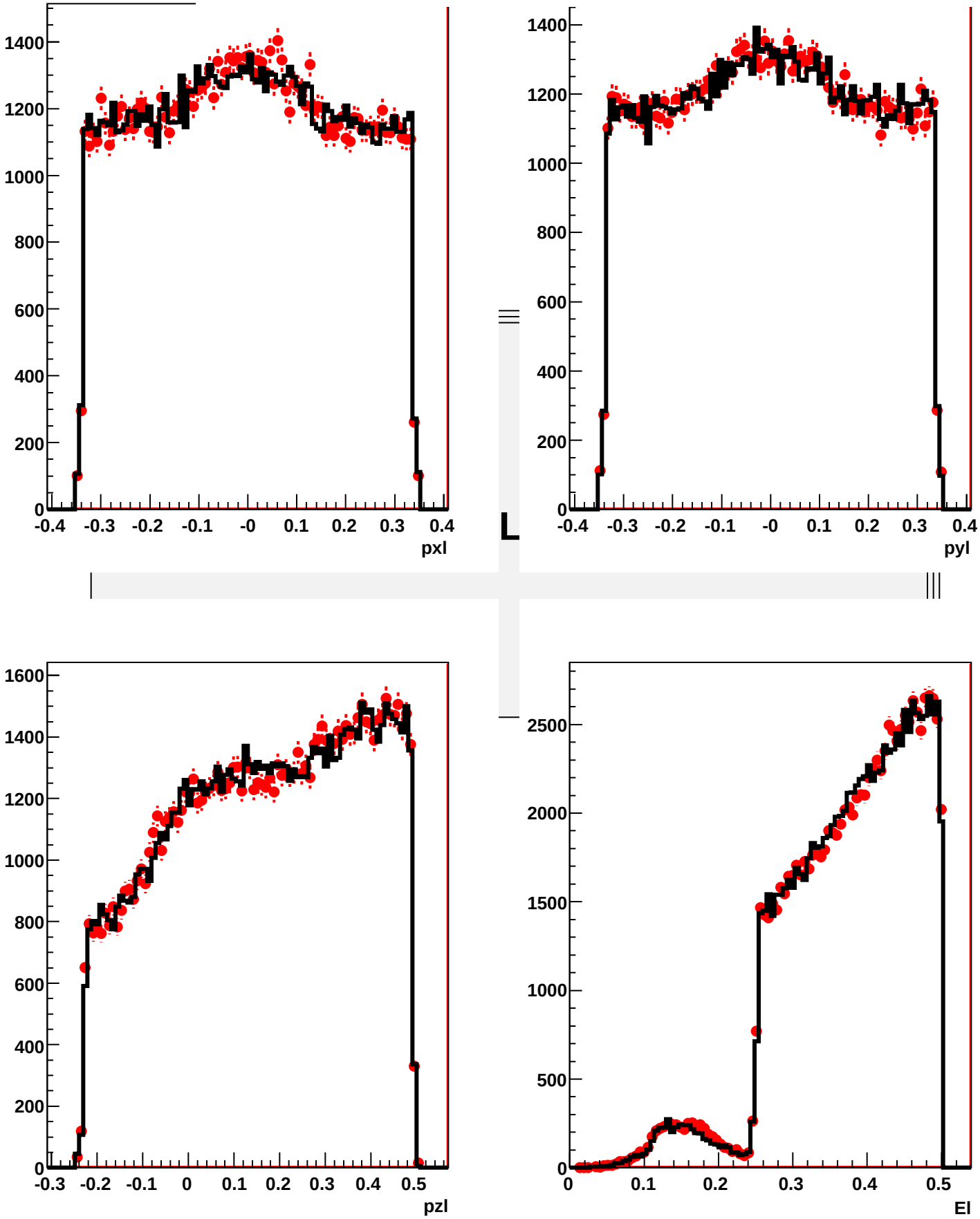

×10^3
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pyn


×10^3
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pzn

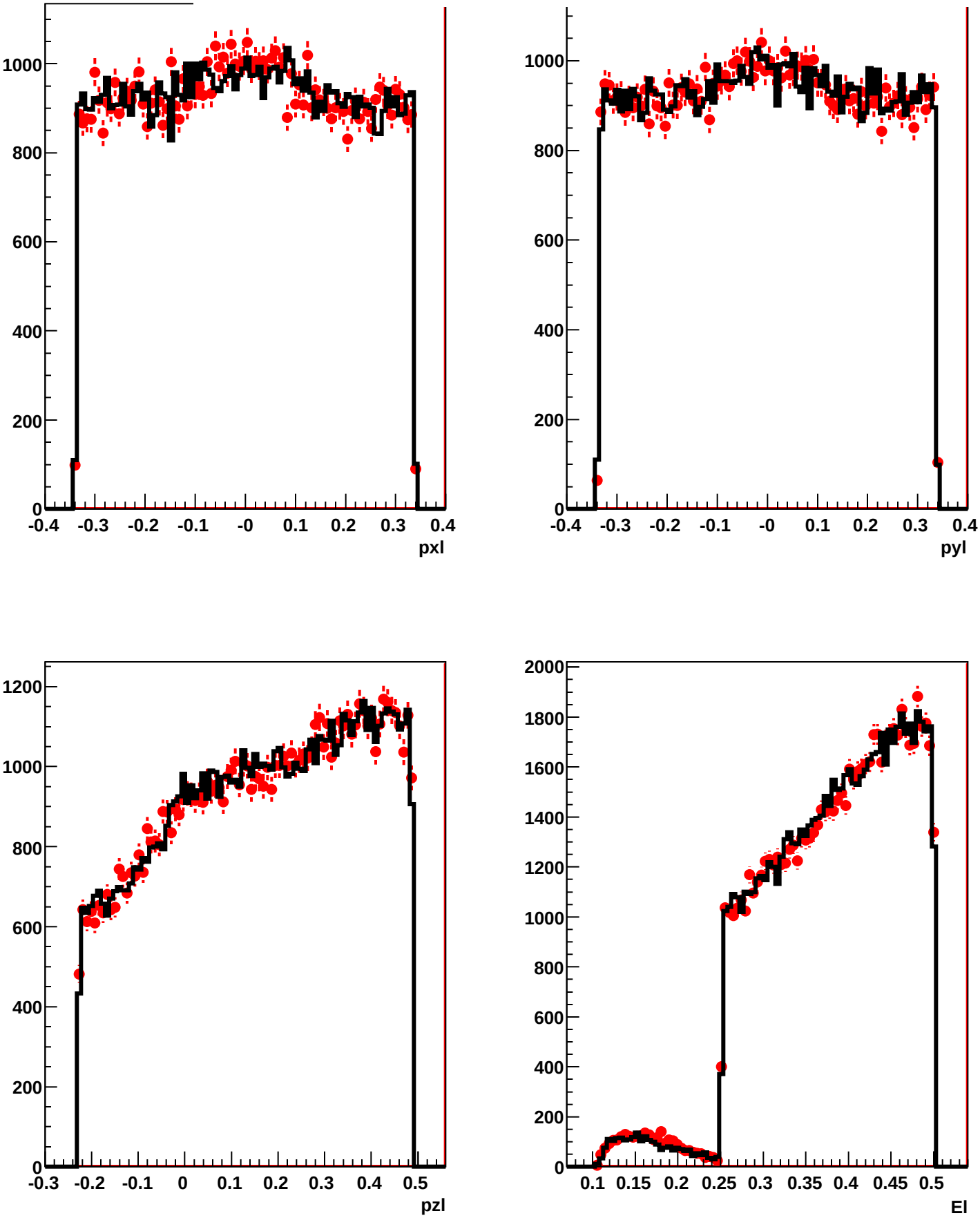

×10^3
100
80
60
40
20
0
0
0.5
1
1.5
2
En

Final State Primary Lepton 4-Momentum

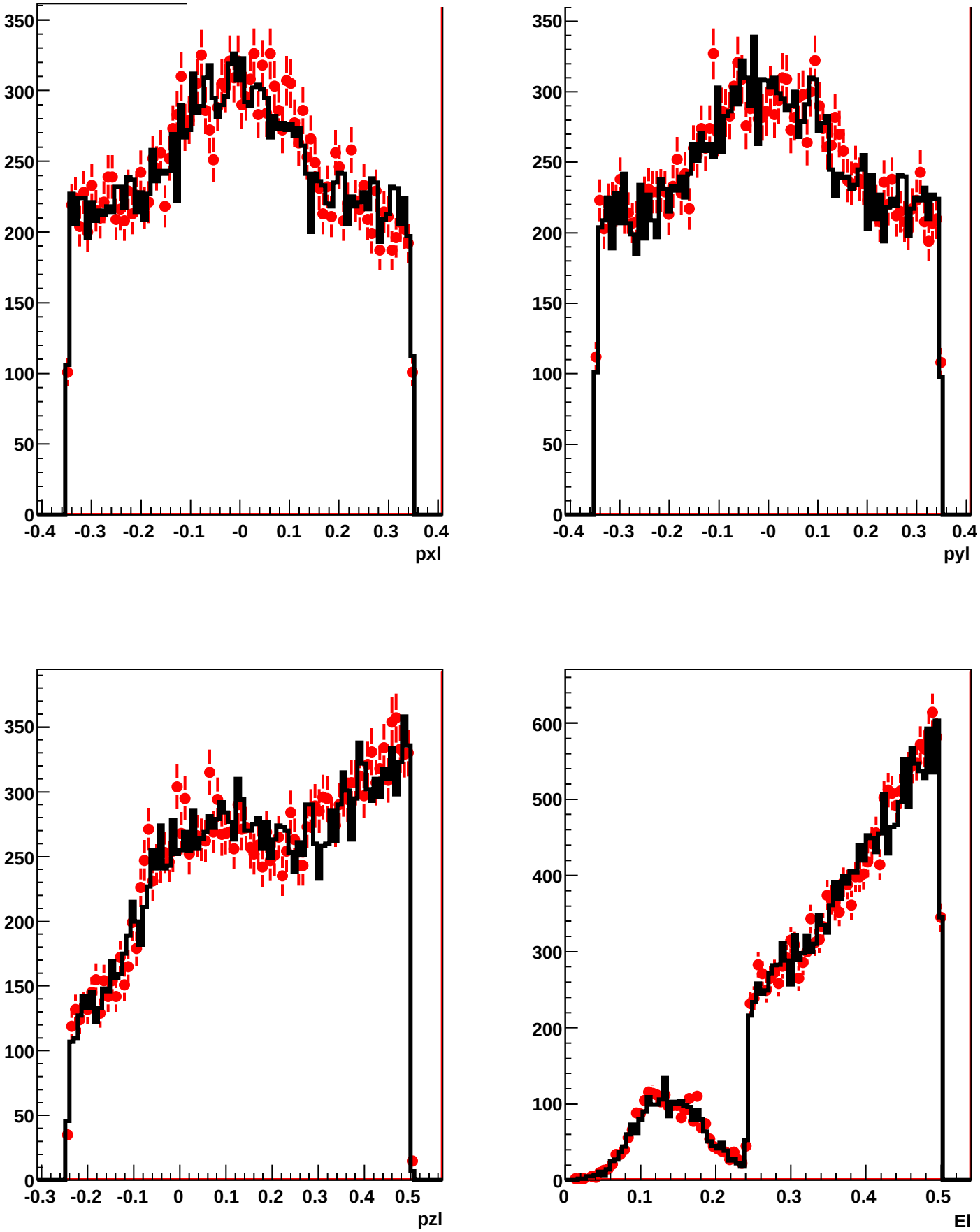
Final state primary lepton 4-p: All events



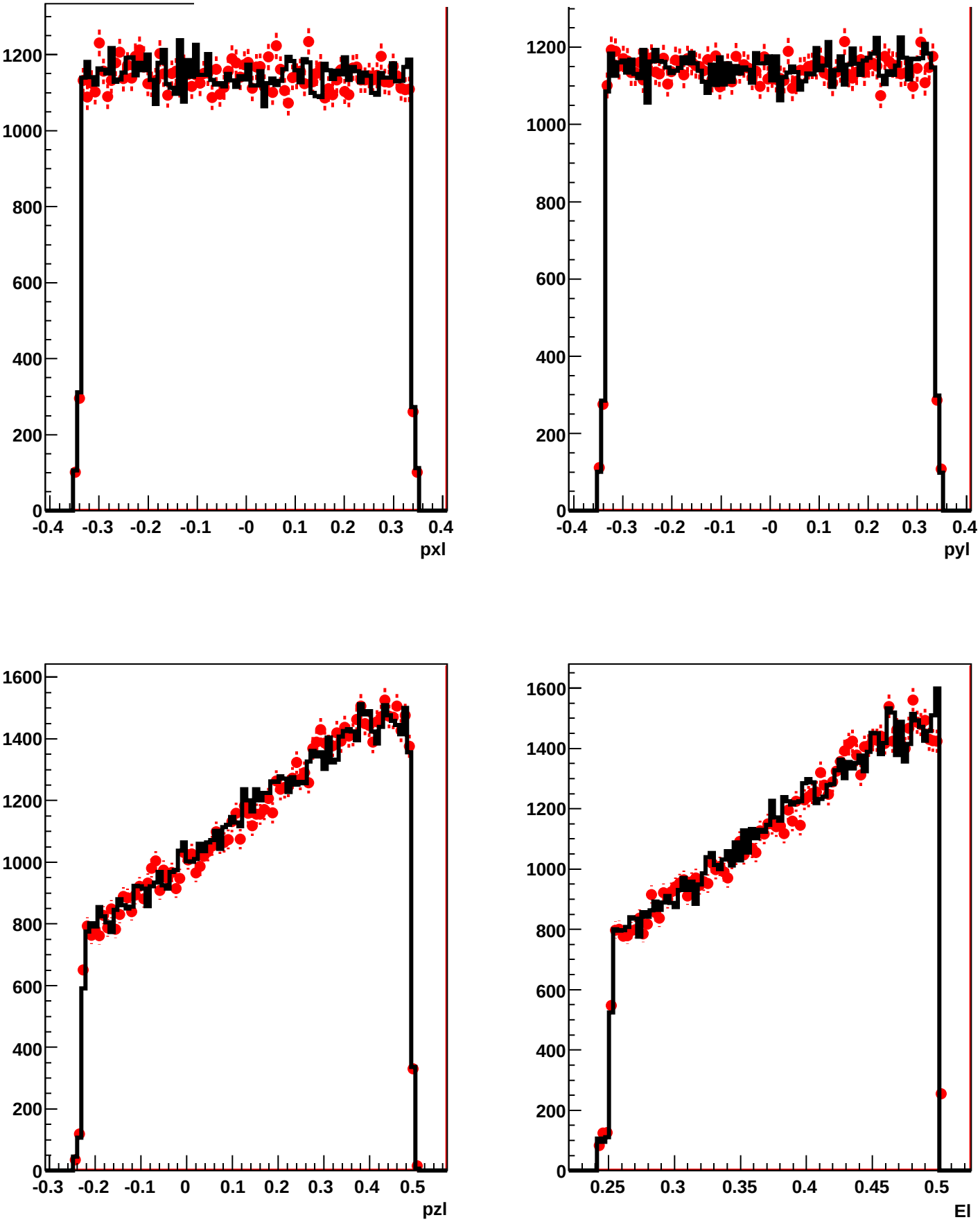
Final state primary lepton 4-p: All CC events



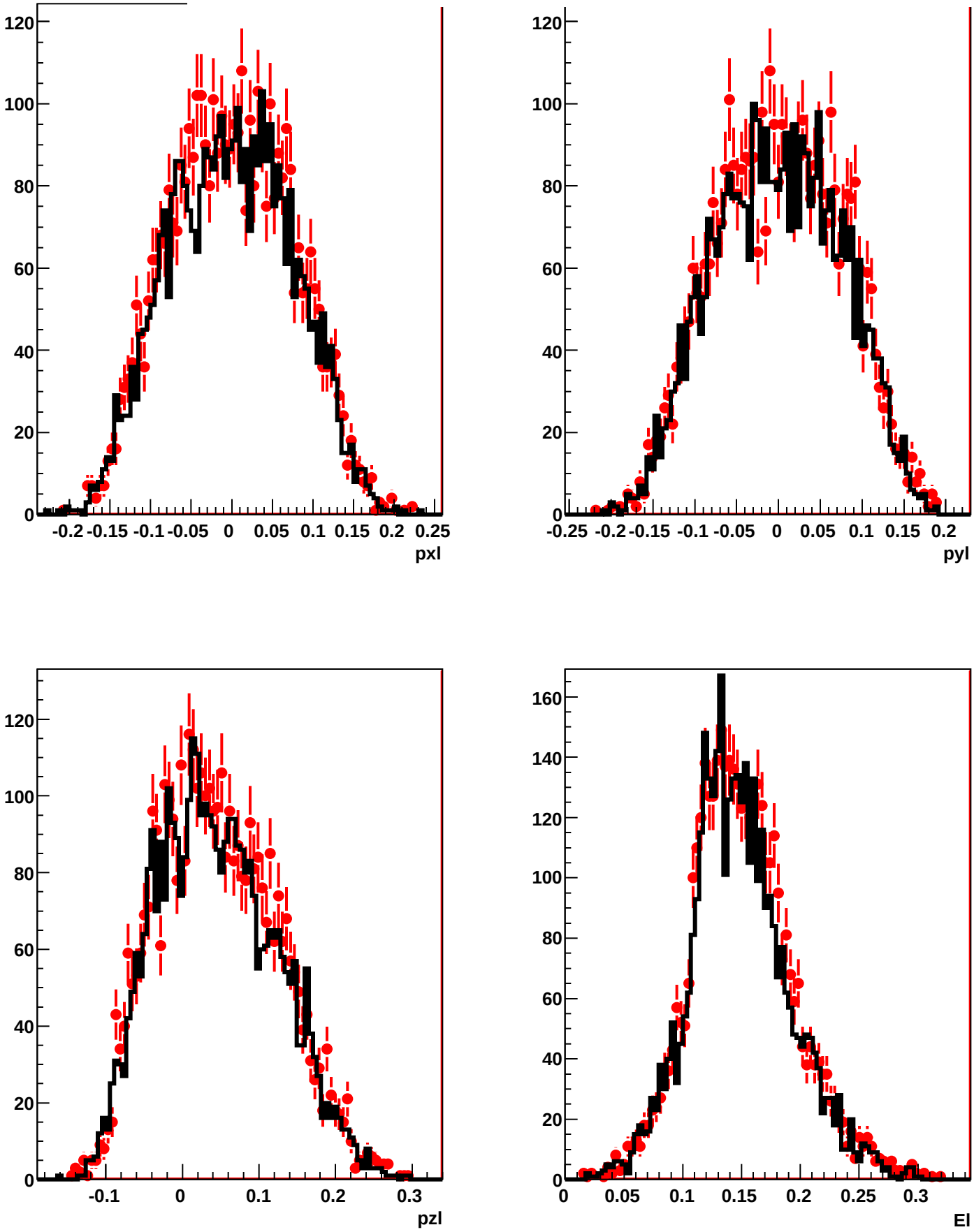
Final state primary lepton 4-p: All NC events



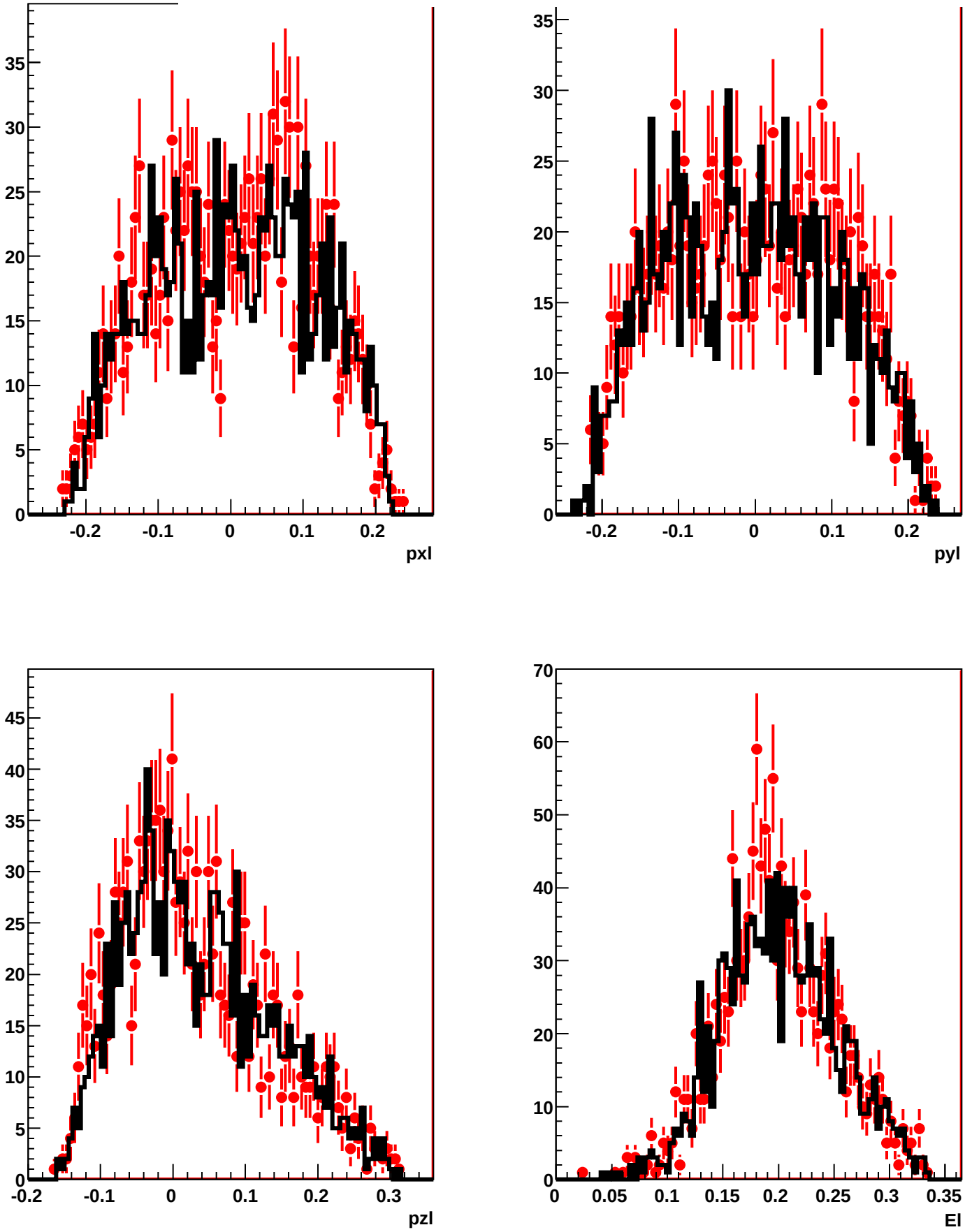
Final state primary lepton 4-p: QEL events



Final state primary lepton 4-p: RES events



Final state primary lepton 4-p: All DIS events



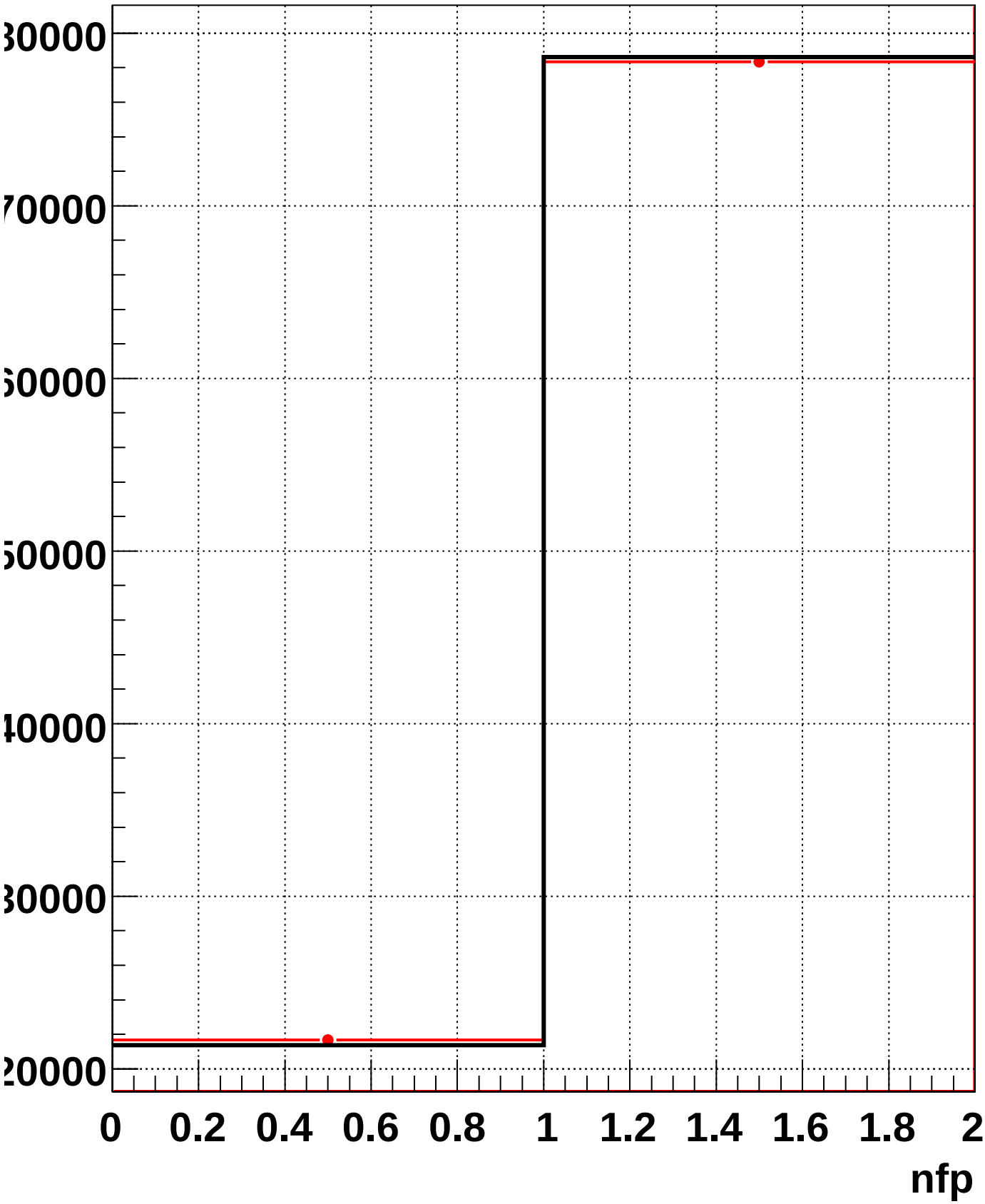
Final State Hadronic System

Multiplicities and 4-Momenta

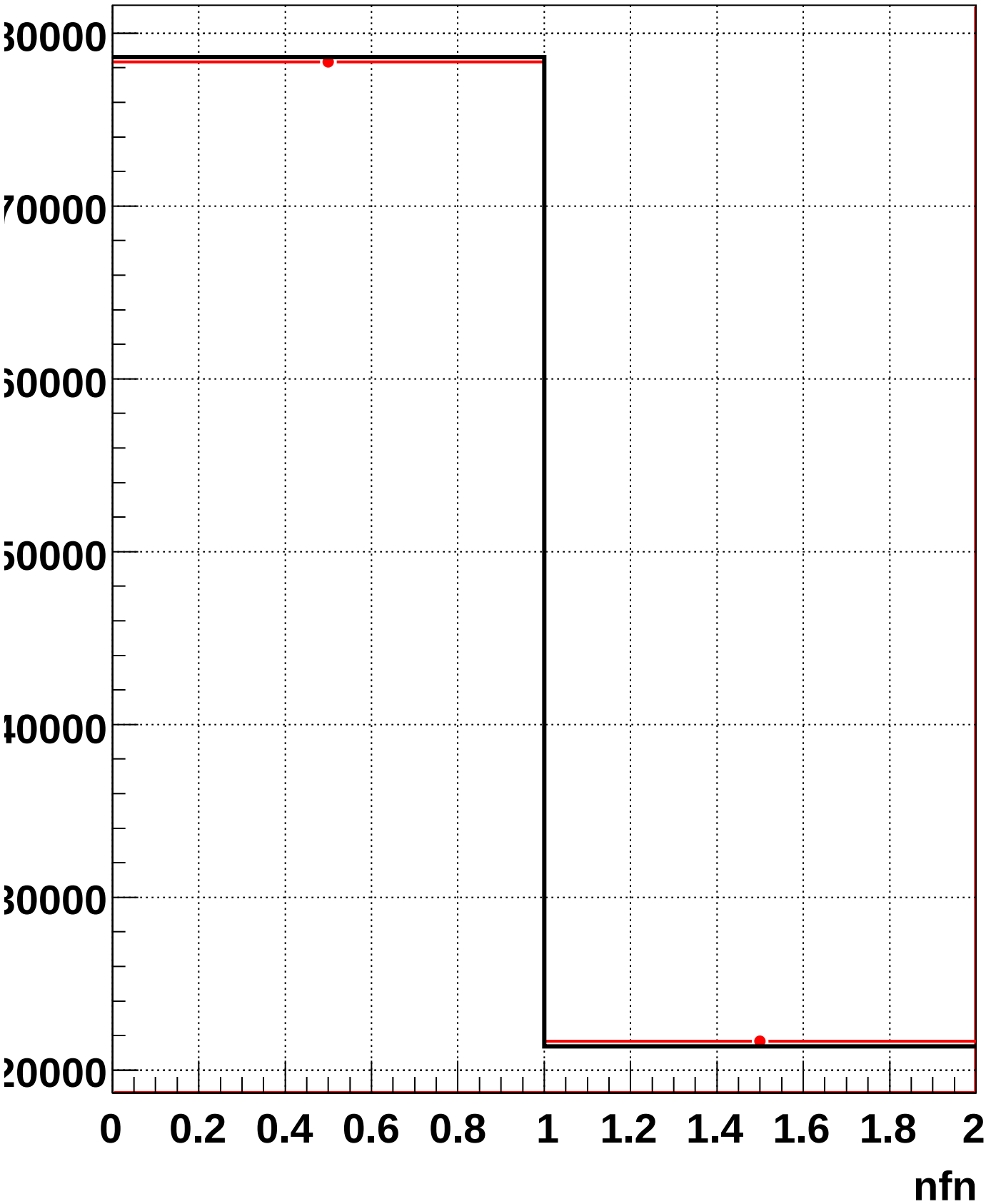
Note:

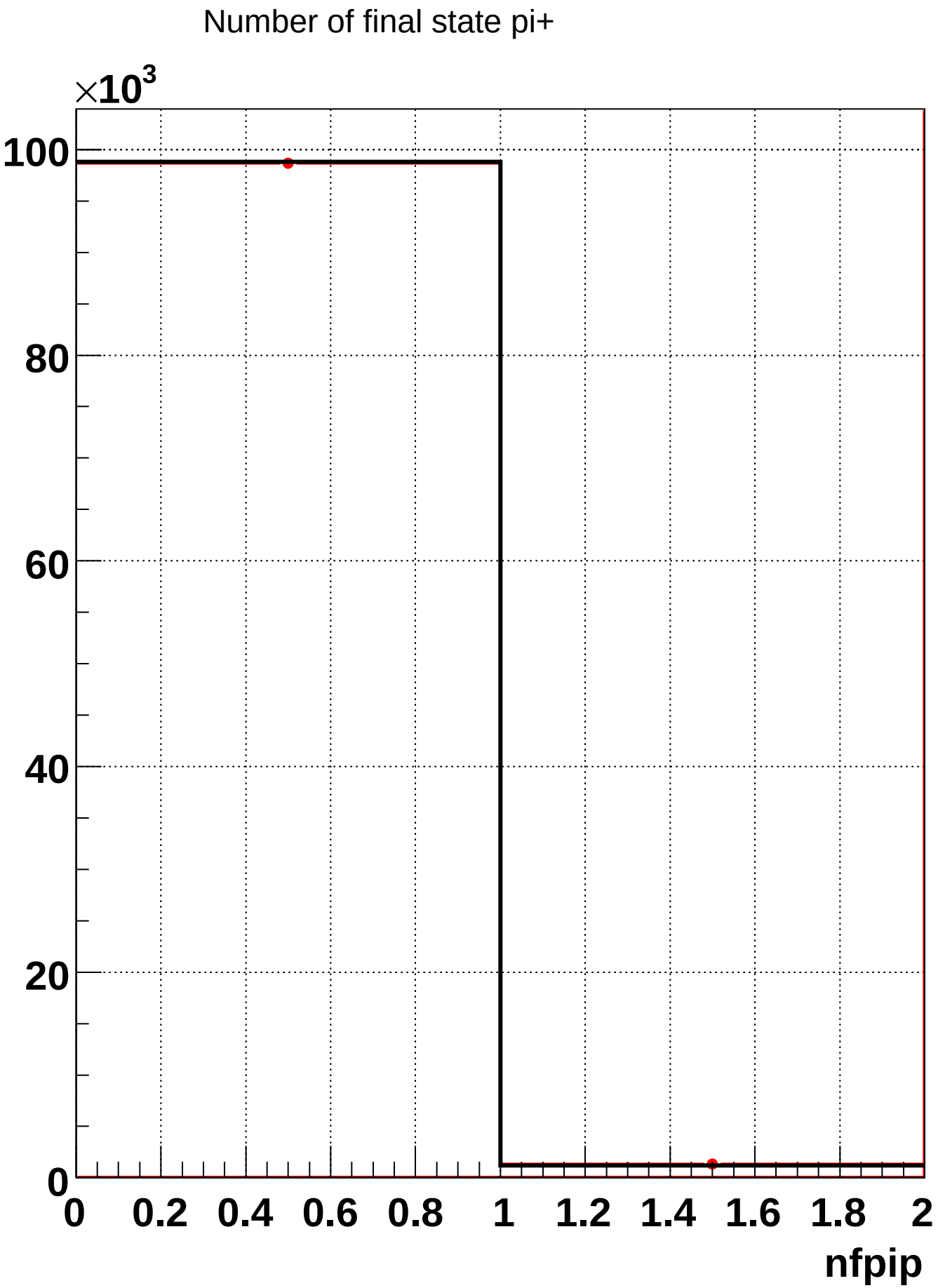
For nuclear targets these plots include the effect of intranuclear hadron transport / rescattering

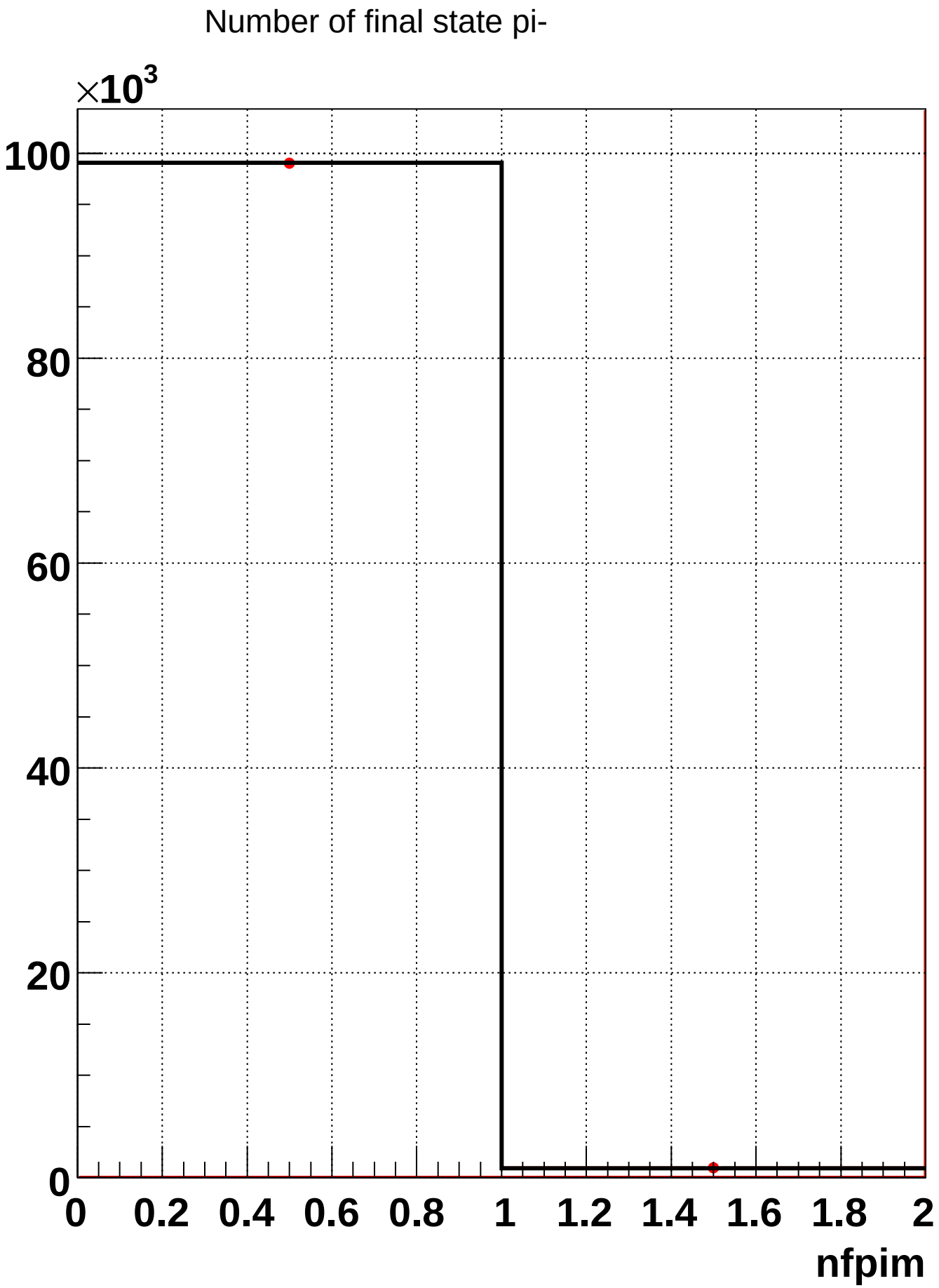
Number of final state protons

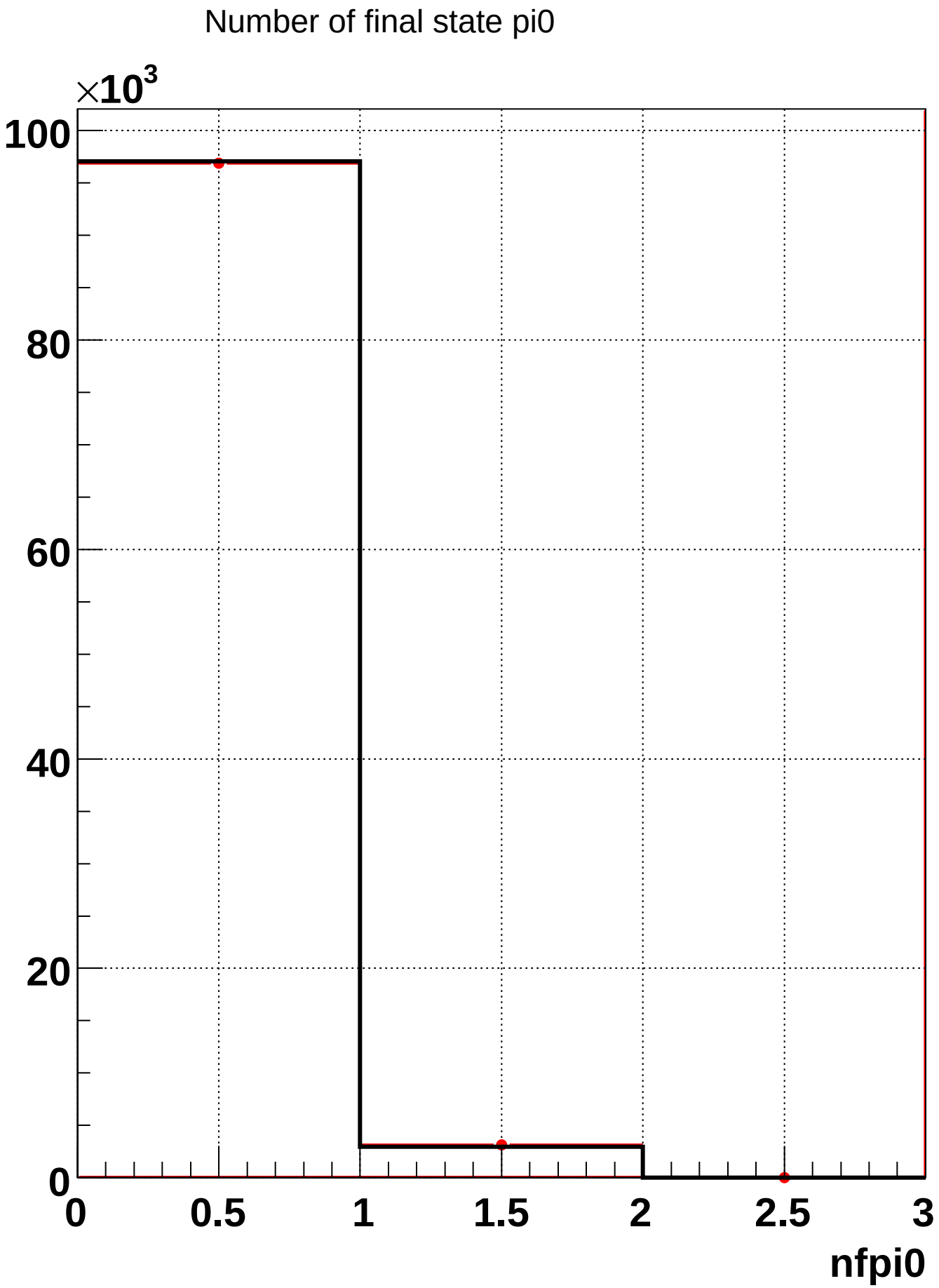


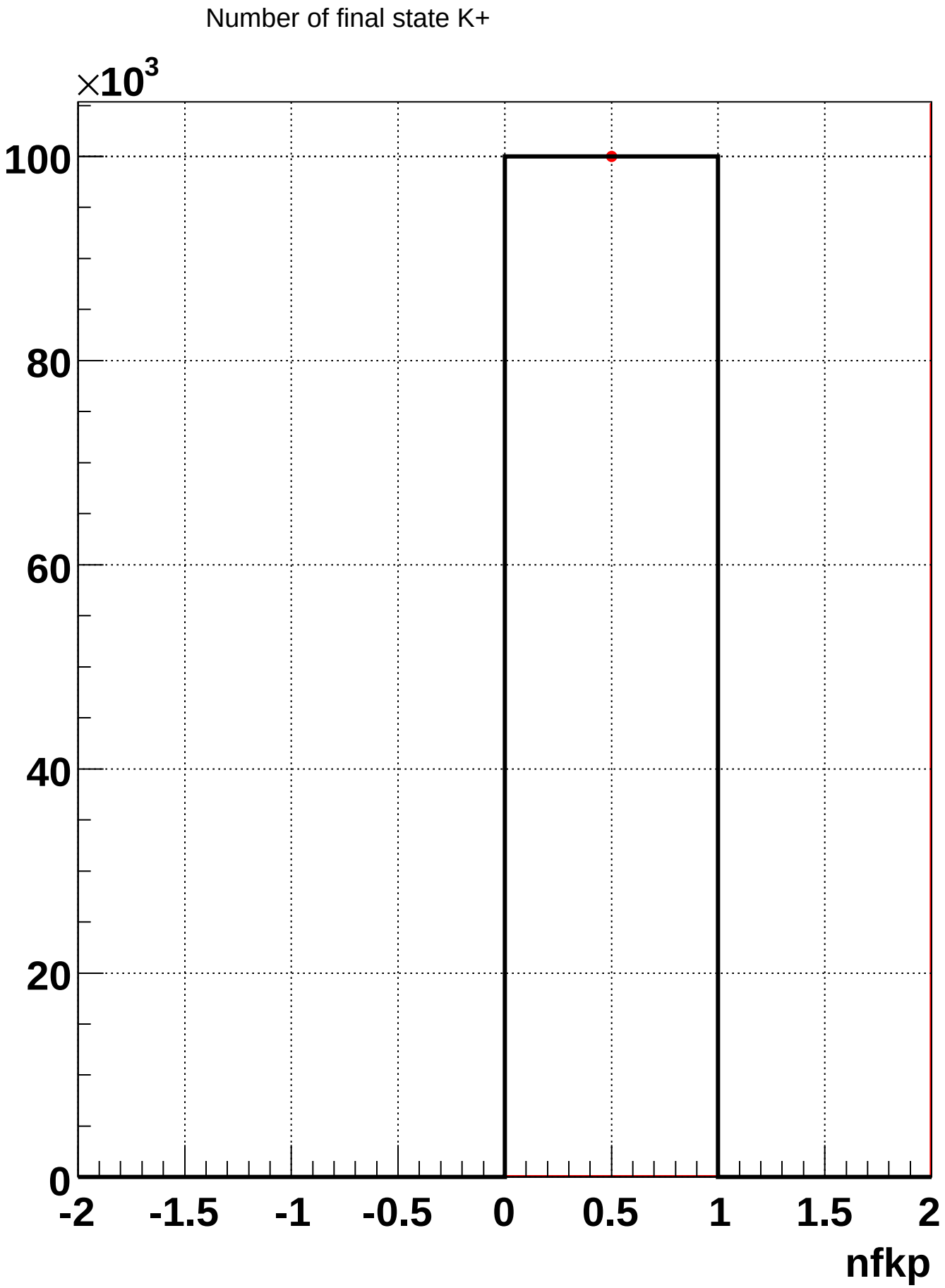
Number of final state neutrons

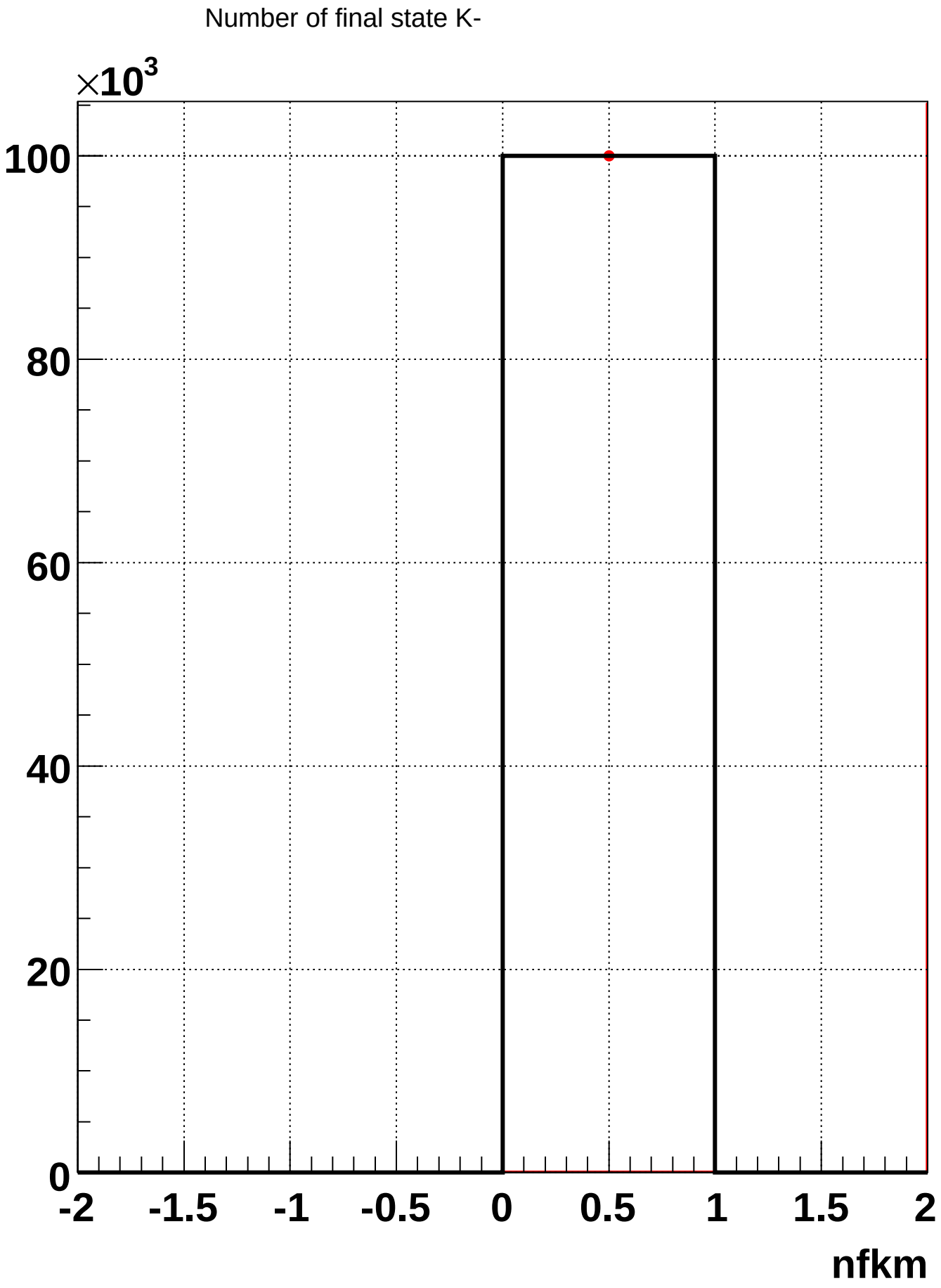


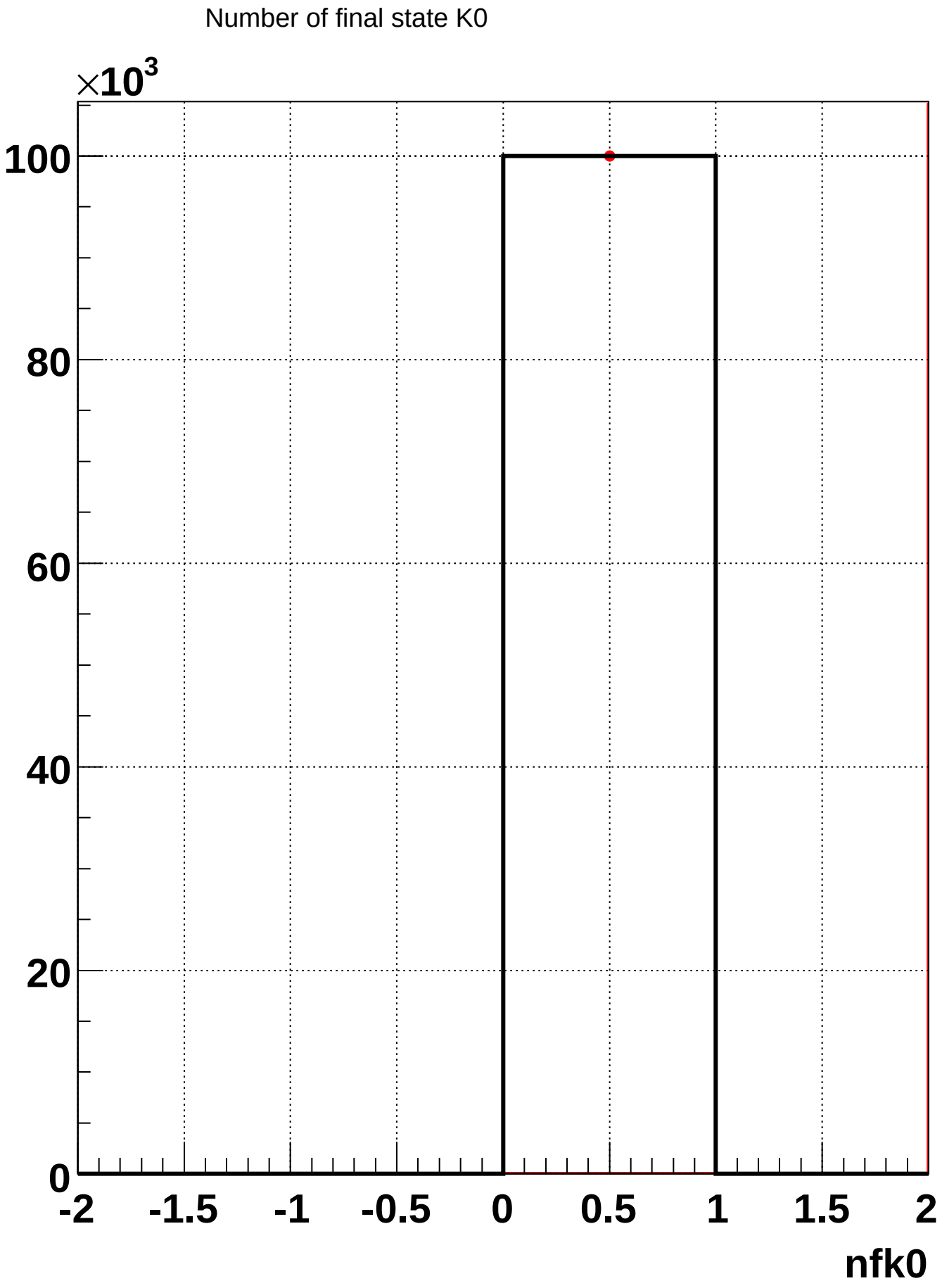

Number of final state pi+
×10^3
100
80
60
40
20
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
nfpip


Number of final state pi-
×10^3
100
80
60
40
20
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
nfpim

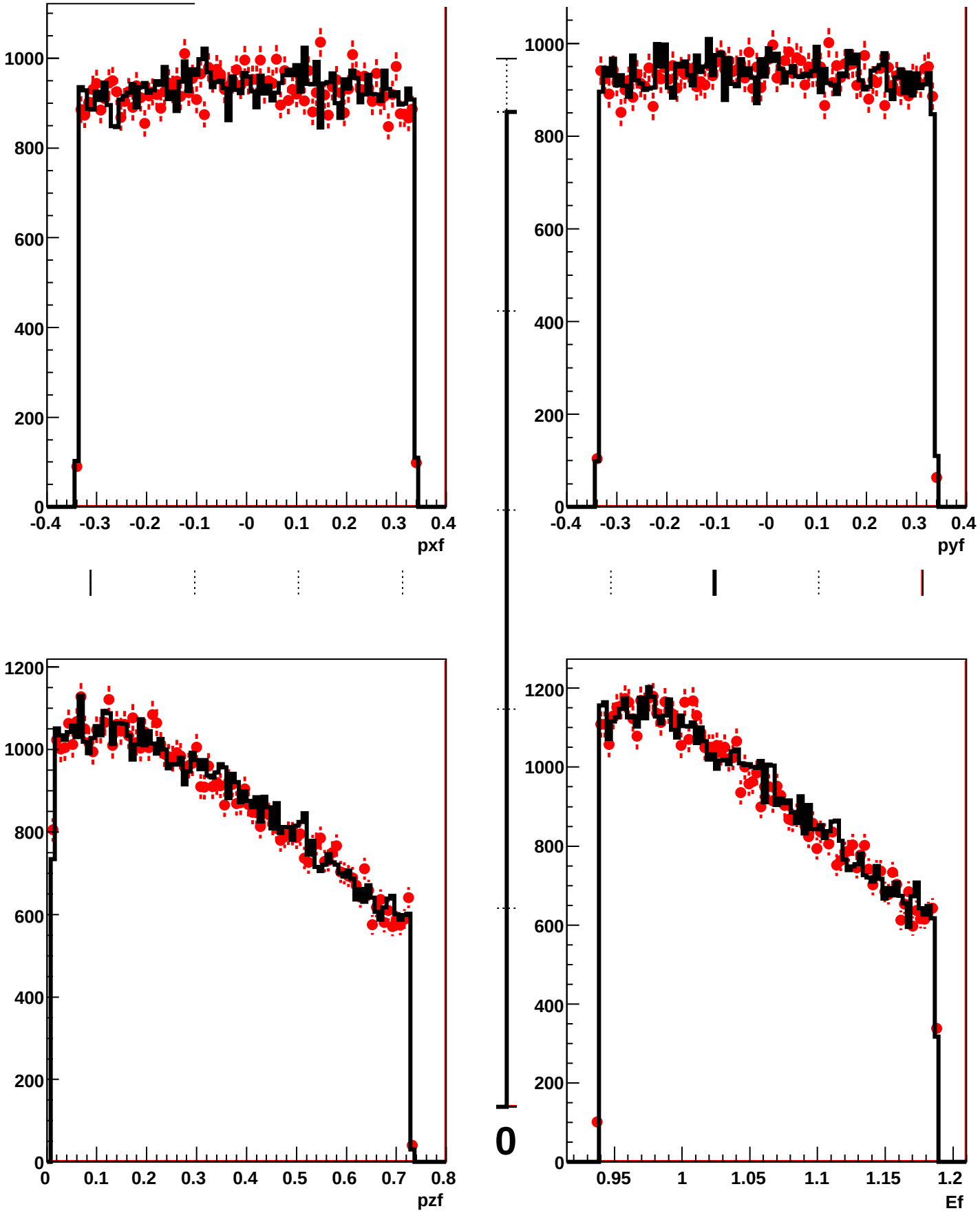

Number of final state pi0
×10^3
100
80
60
40
20
0
0
0.5
1
1.5
2
2.5
3
nfpi0


Number of final state K+
×10^3
100
80
60
40
20
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
nfkp


Number of final state K-
×10^3
100
80
60
40
20
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
nfkm

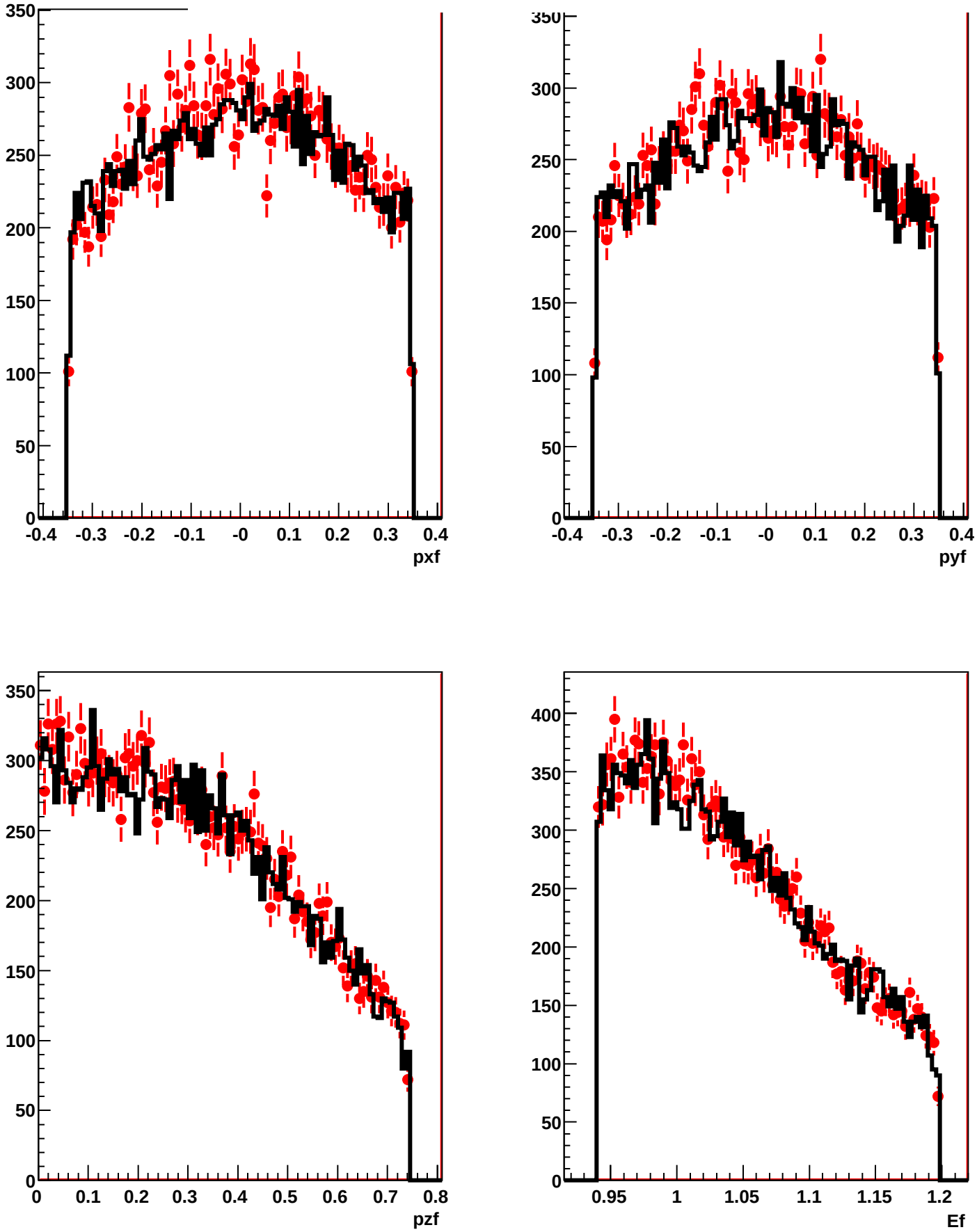

Number of final state K0
×10^3
100
80
60
40
20
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
nfk0

Final state protons 4-momentum

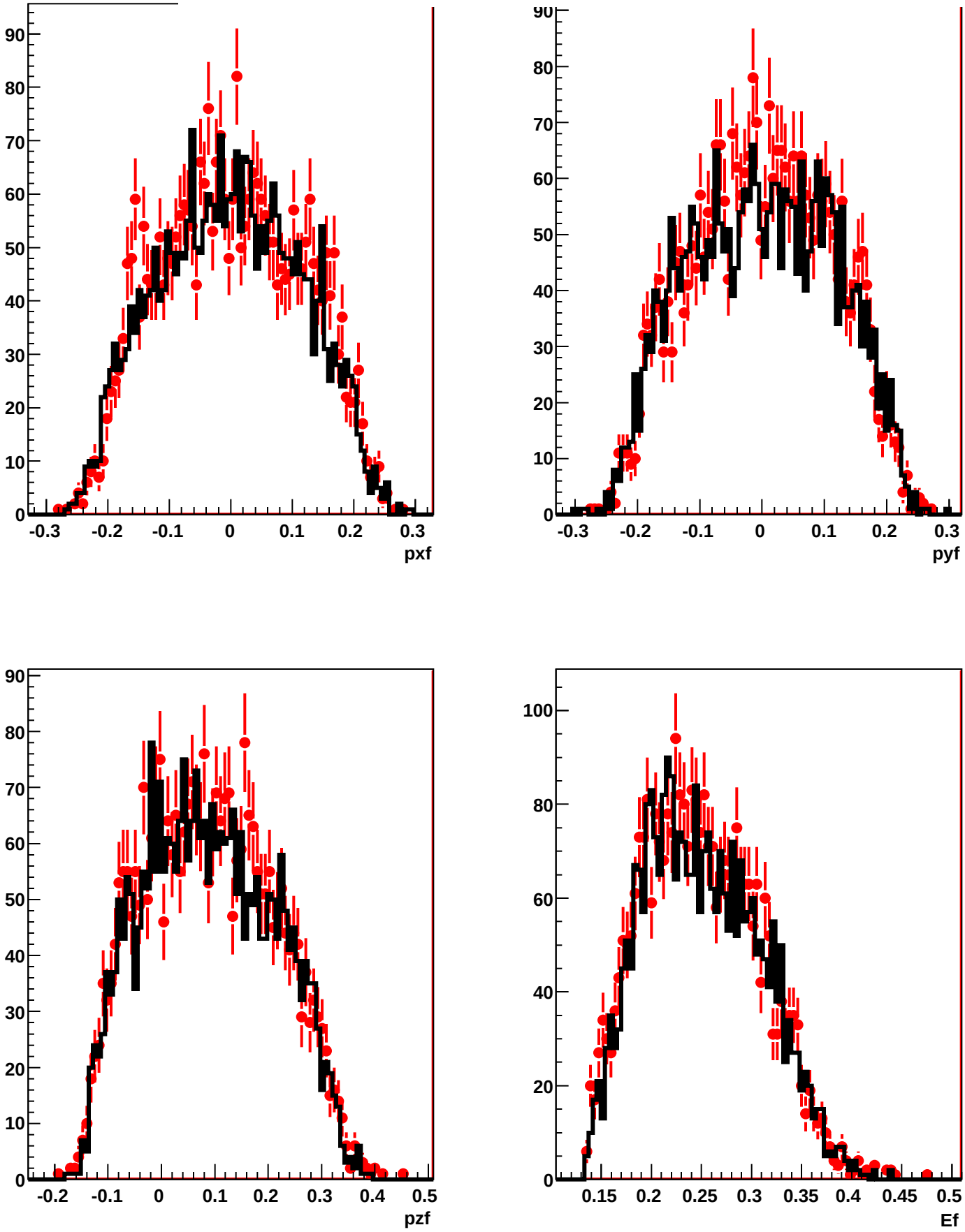


0

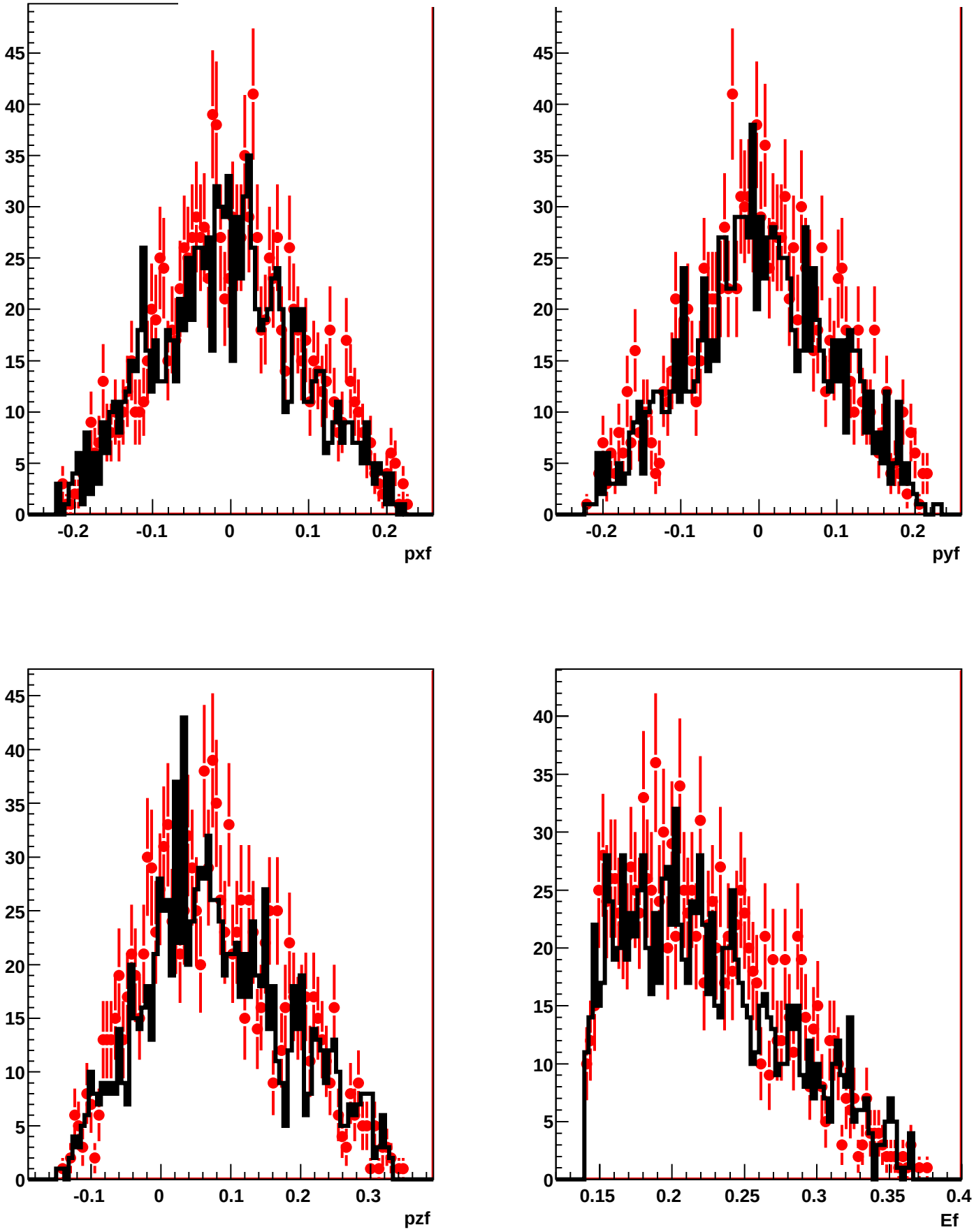
Final state neutrons 4-momentum



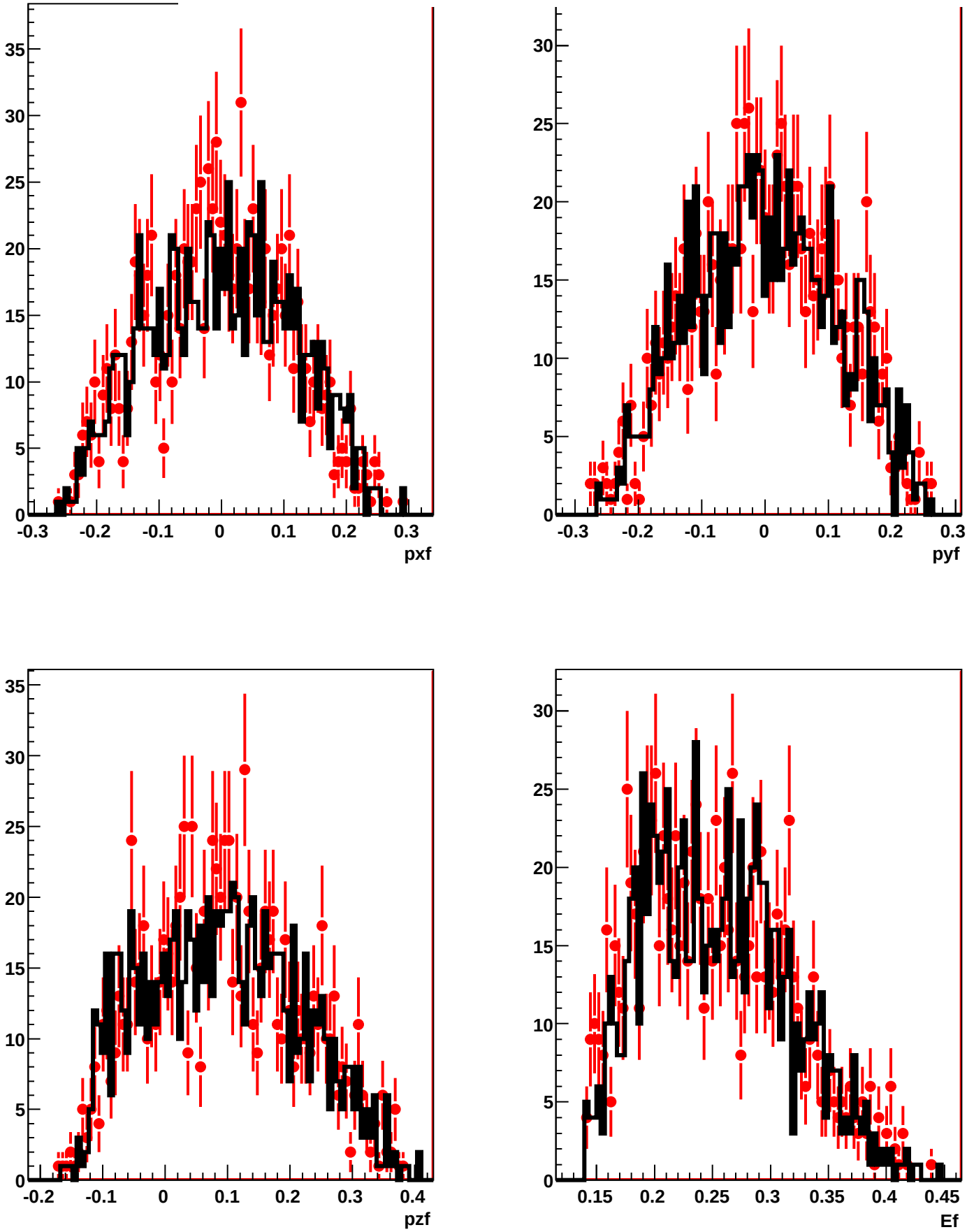
Final state pi0's 4-momentum



Final state pi+’s 4-momentum



Final state pi-'s 4-momentum



GENIE-2.0.0 vs NEUGEN/Daikon+ Event Sample Comparisons

Event Sample:

100k events, numu+n, 1GeV, all processes

Notes:

Daikon+ is a NEUGEN Daikon revision version

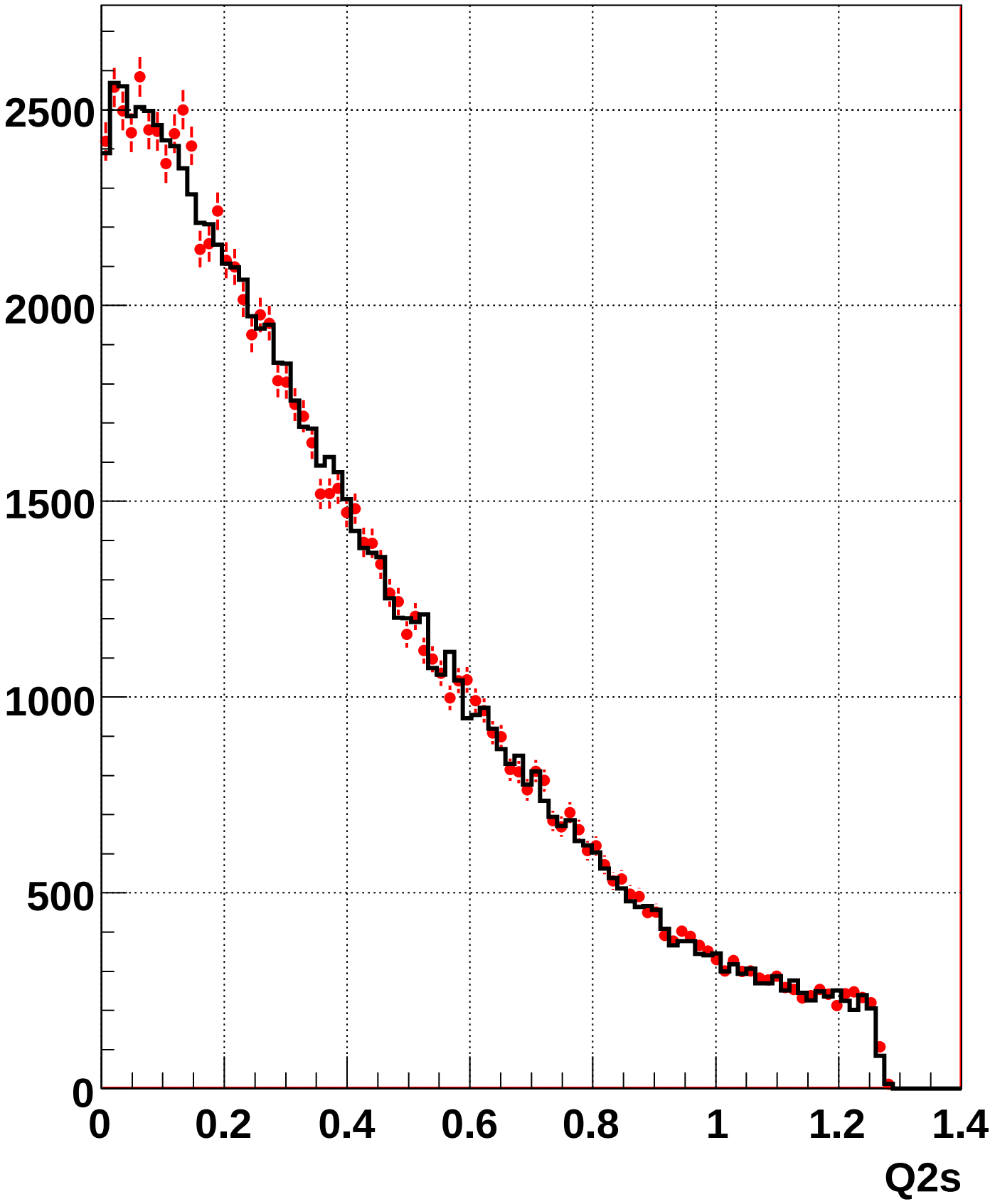
GENIE predictions shown with lines / NEUGEN's with markers

Event Numbers:

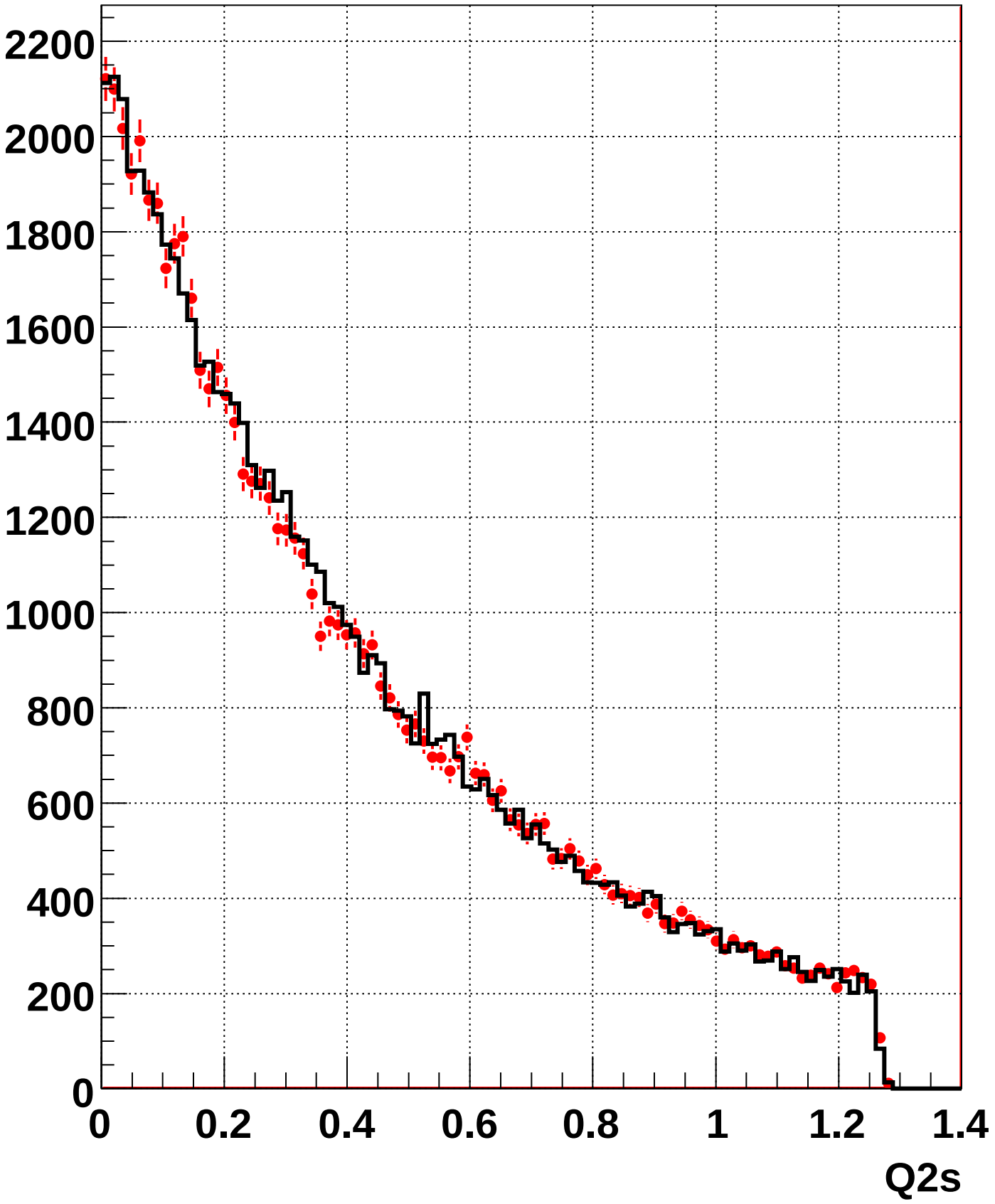
ALL :	100000 [NeuGEN],	100000 [GENIE]
QEL :	71974 [NeuGEN],	72404 [GENIE]
QEL-CC :	58220 [NeuGEN],	58952 [GENIE]
QEL-NC :	13754 [NeuGEN],	13452 [GENIE]
RES :	19745 [NeuGEN],	19501 [GENIE]
RES-CC :	12535 [NeuGEN],	12280 [GENIE]
RES-NC :	7210 [NeuGEN],	7221 [GENIE]
DIS :	8281 [NeuGEN],	8095 [GENIE]
DIS-CC :	6490 [NeuGEN],	6355 [GENIE]
(charm):	0 [NeuGEN],	0 [GENIE]
DIS-NC :	1791 [NeuGEN],	1740 [GENIE]
COH :	0 [NeuGEN],	0 [GENIE]
COH-CC :	0 [NeuGEN],	0 [GENIE]
COH-NC :	0 [NeuGEN],	0 [GENIE]
IMD :	0 [NeuGEN],	0 [GENIE]

Selected Kinematical Quantities

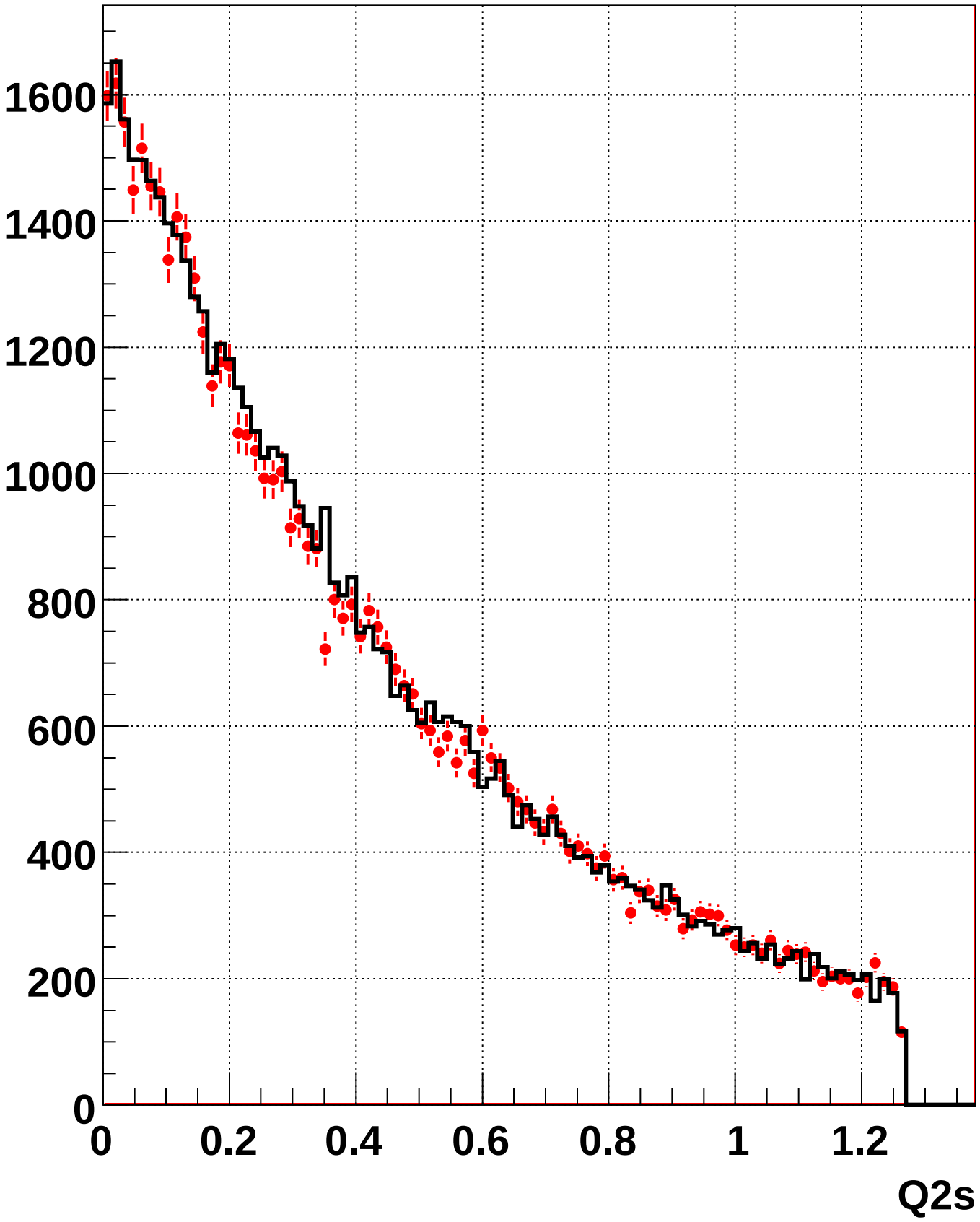
selected Q2 for all events



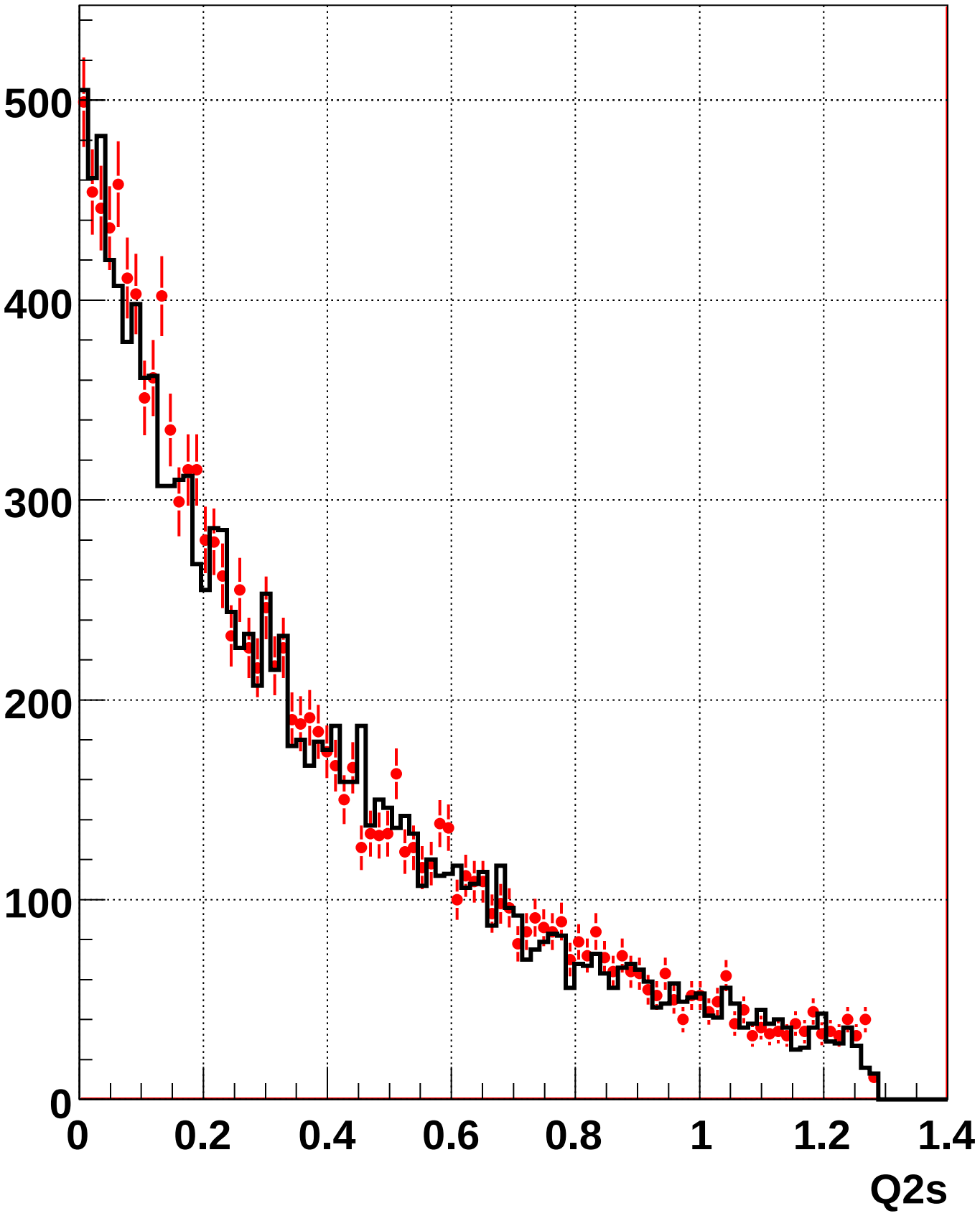
selected Q2 for QEL events



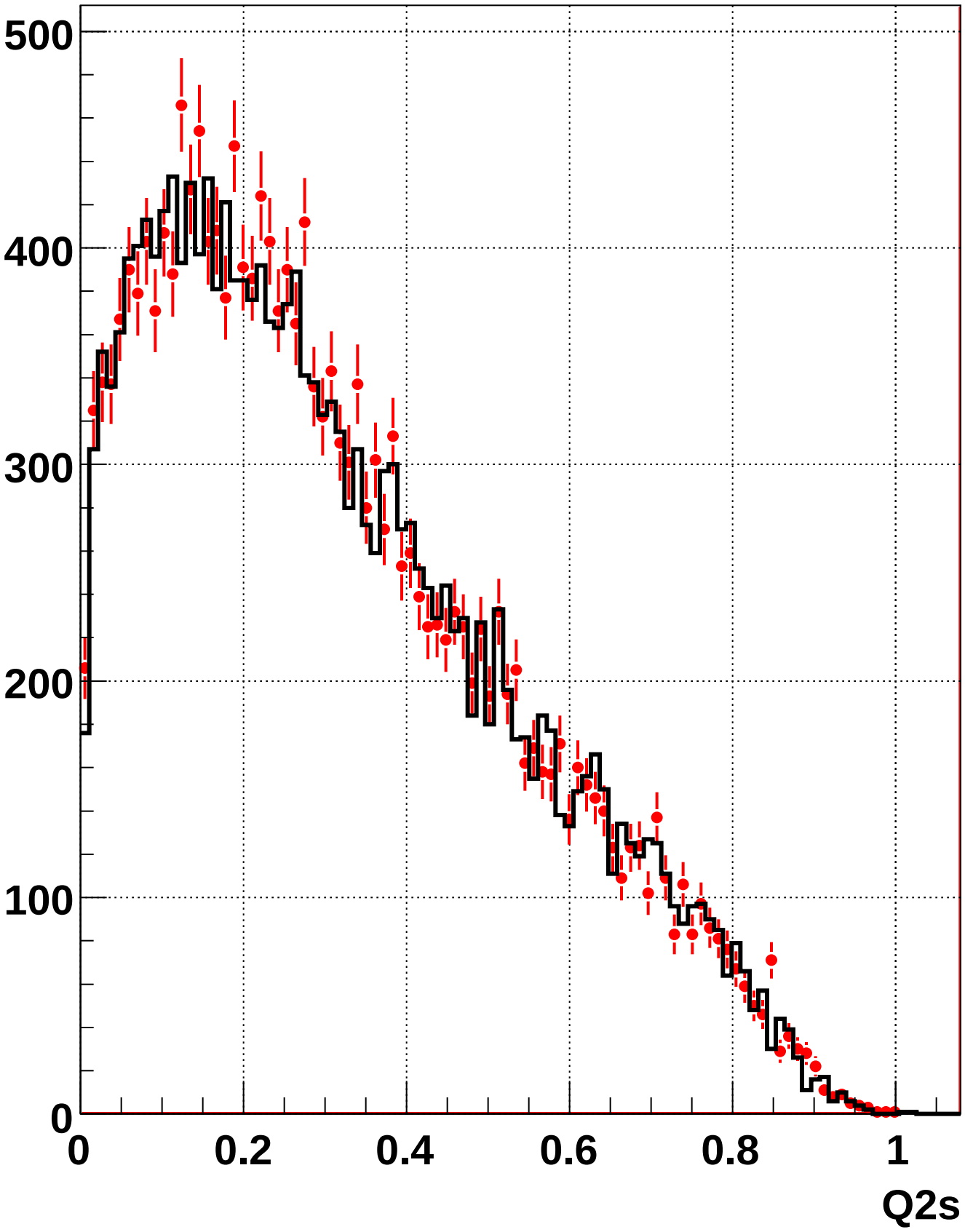
selected Q2 for QEL CC events



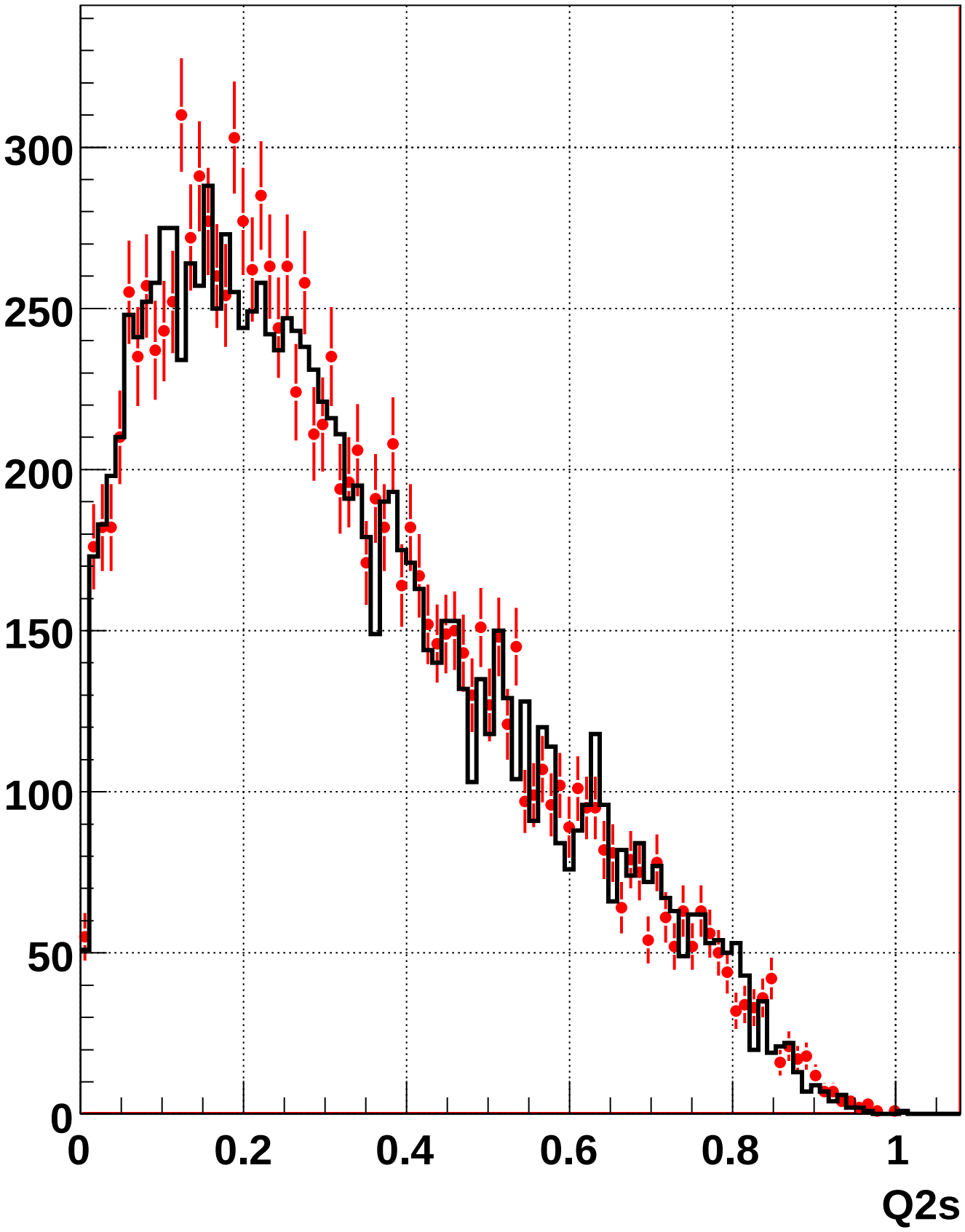
selected Q2 for QEL NC events



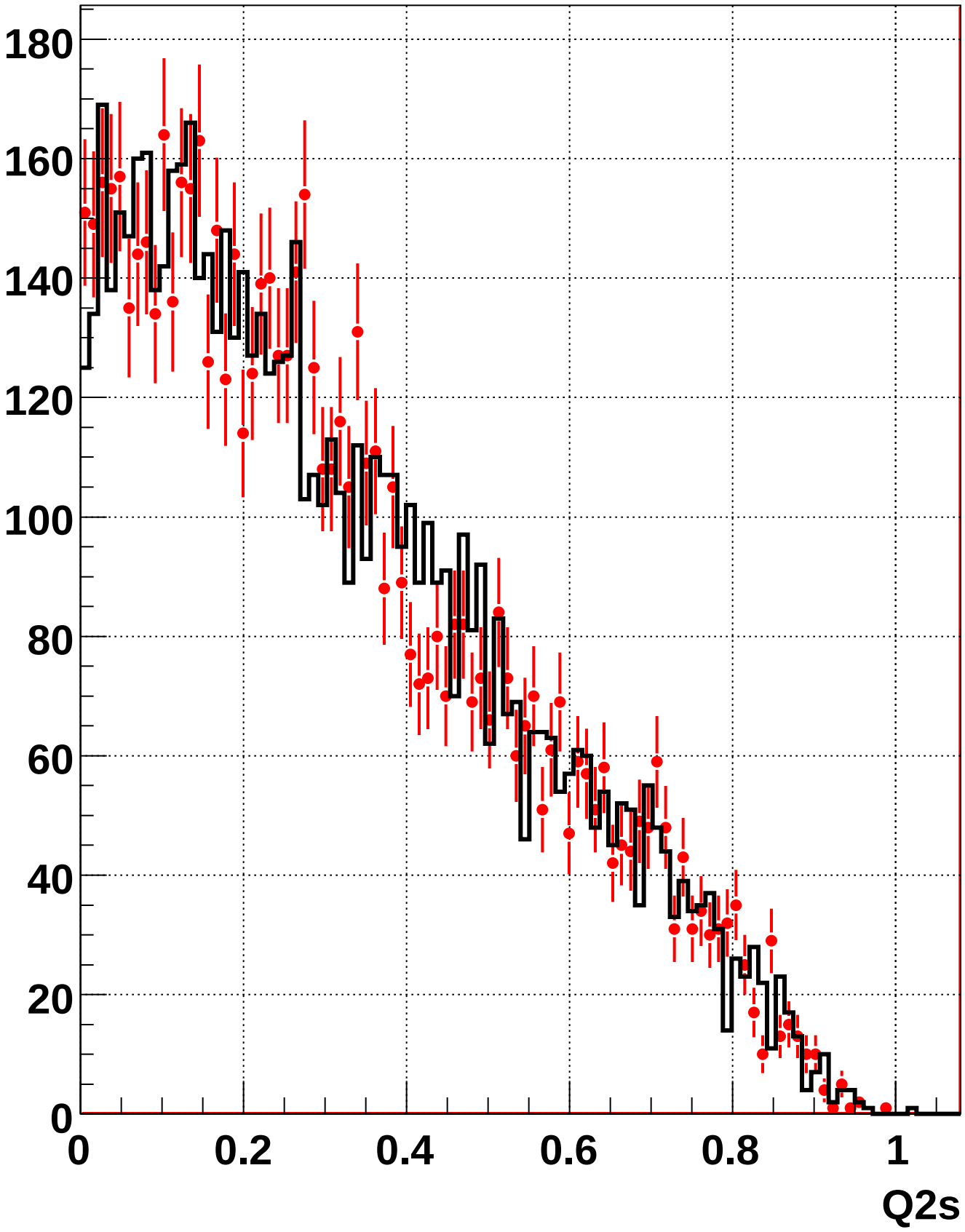
selected Q2 for RES events



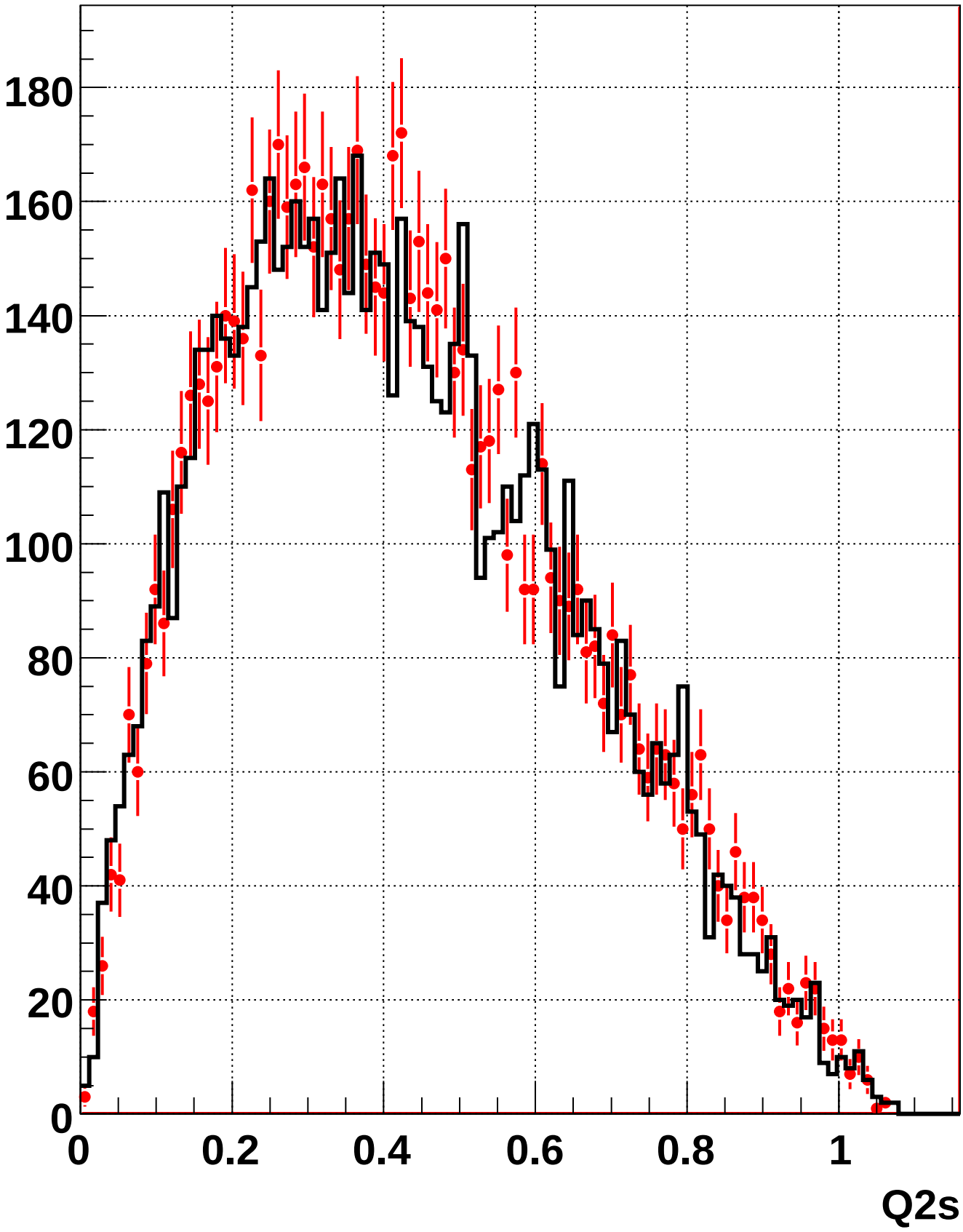
selected Q2 for RES CC events



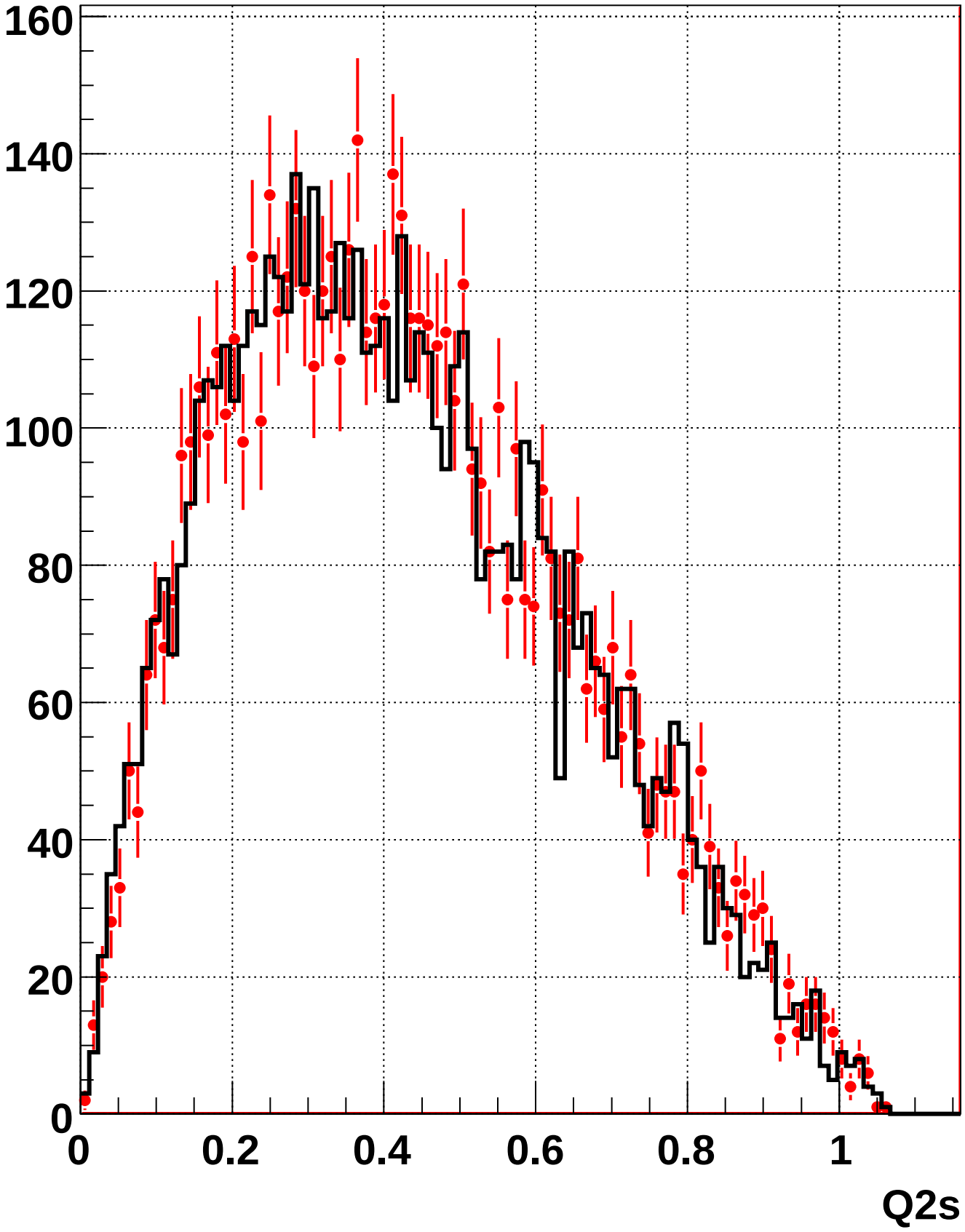
selected Q2 for RES NC events



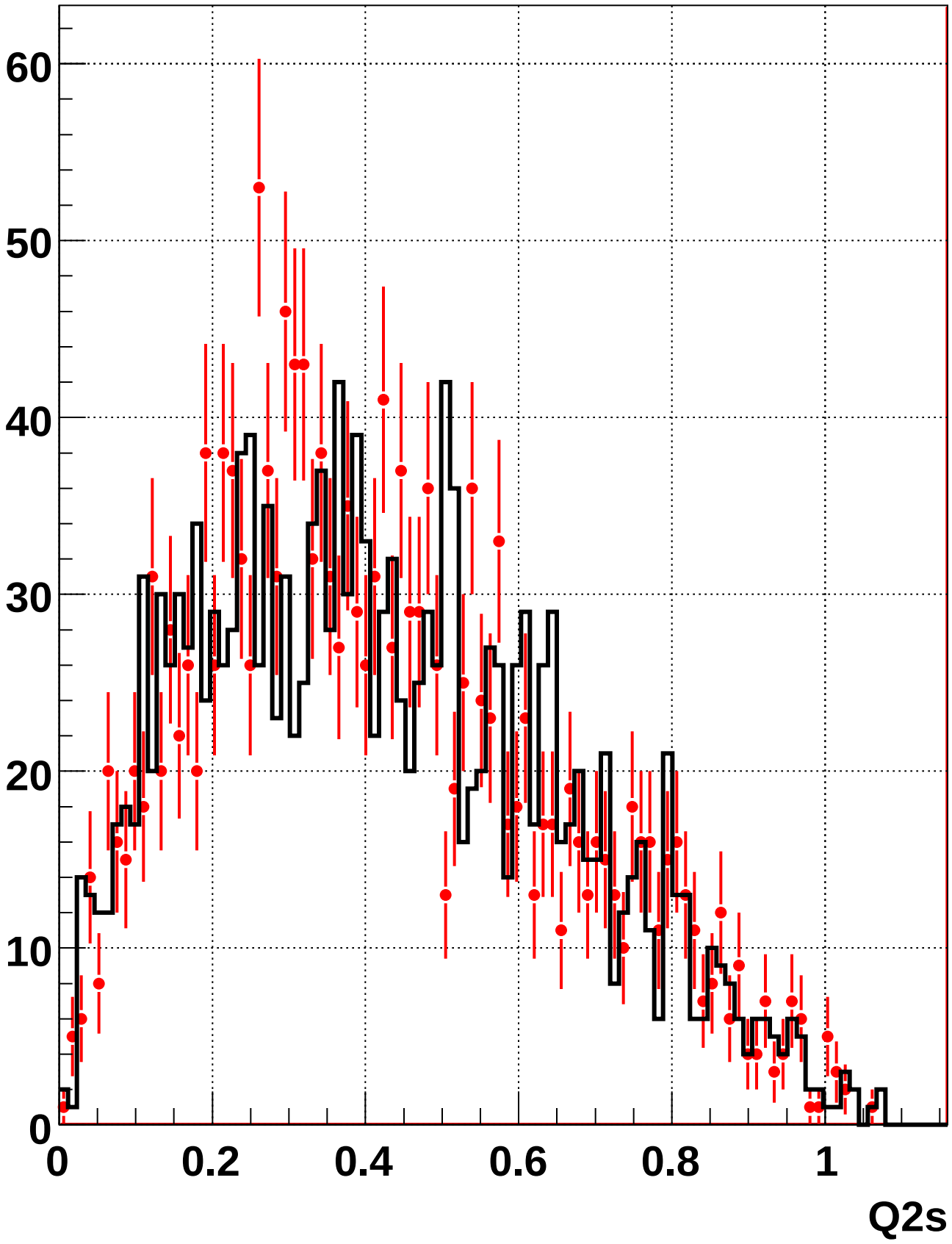
selected Q2 for DIS events



selected Q2 for DIS CC events

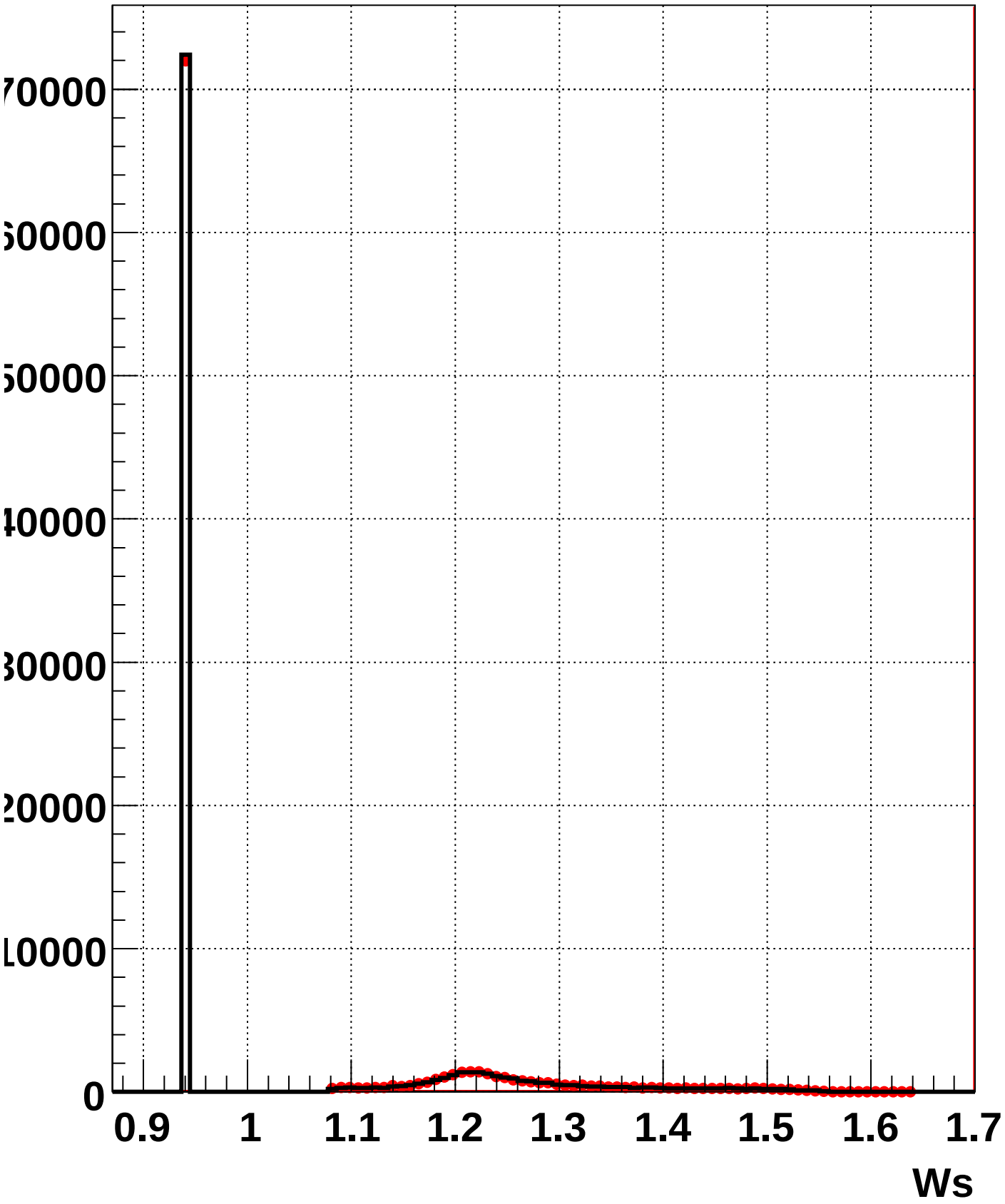


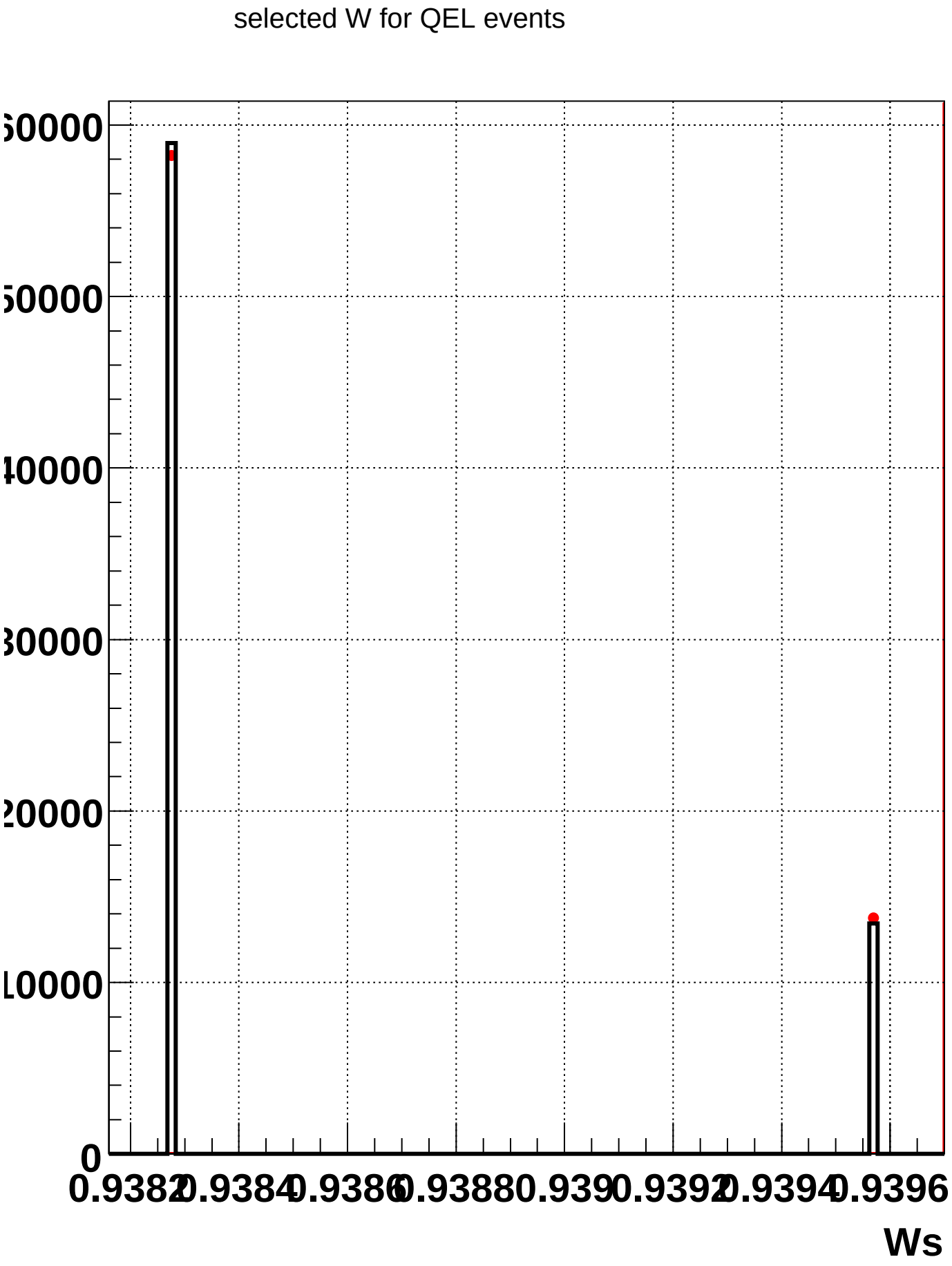
selected Q2 for DIS NC events



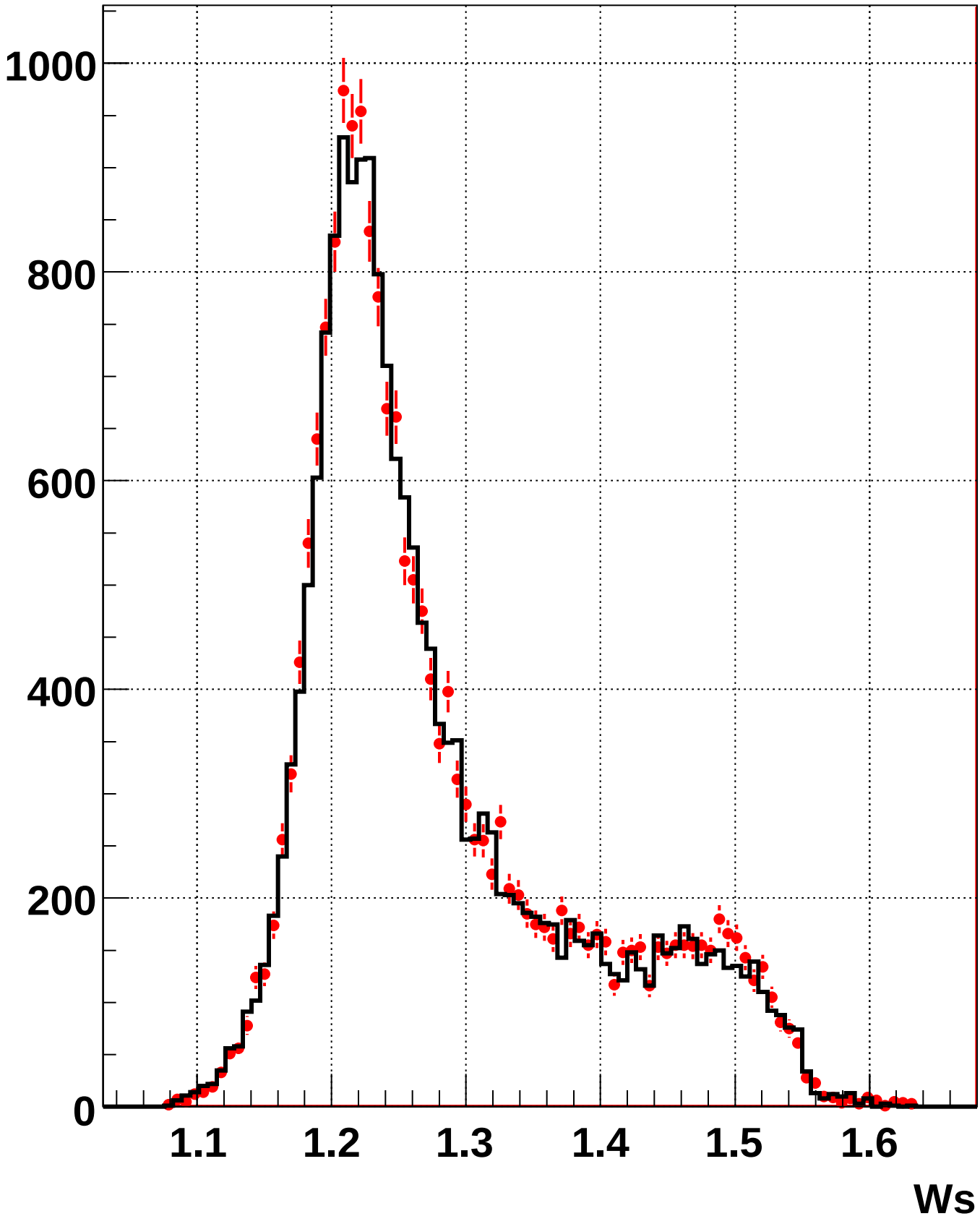
selected Q2 for Charm/DIS events

selected W for all events

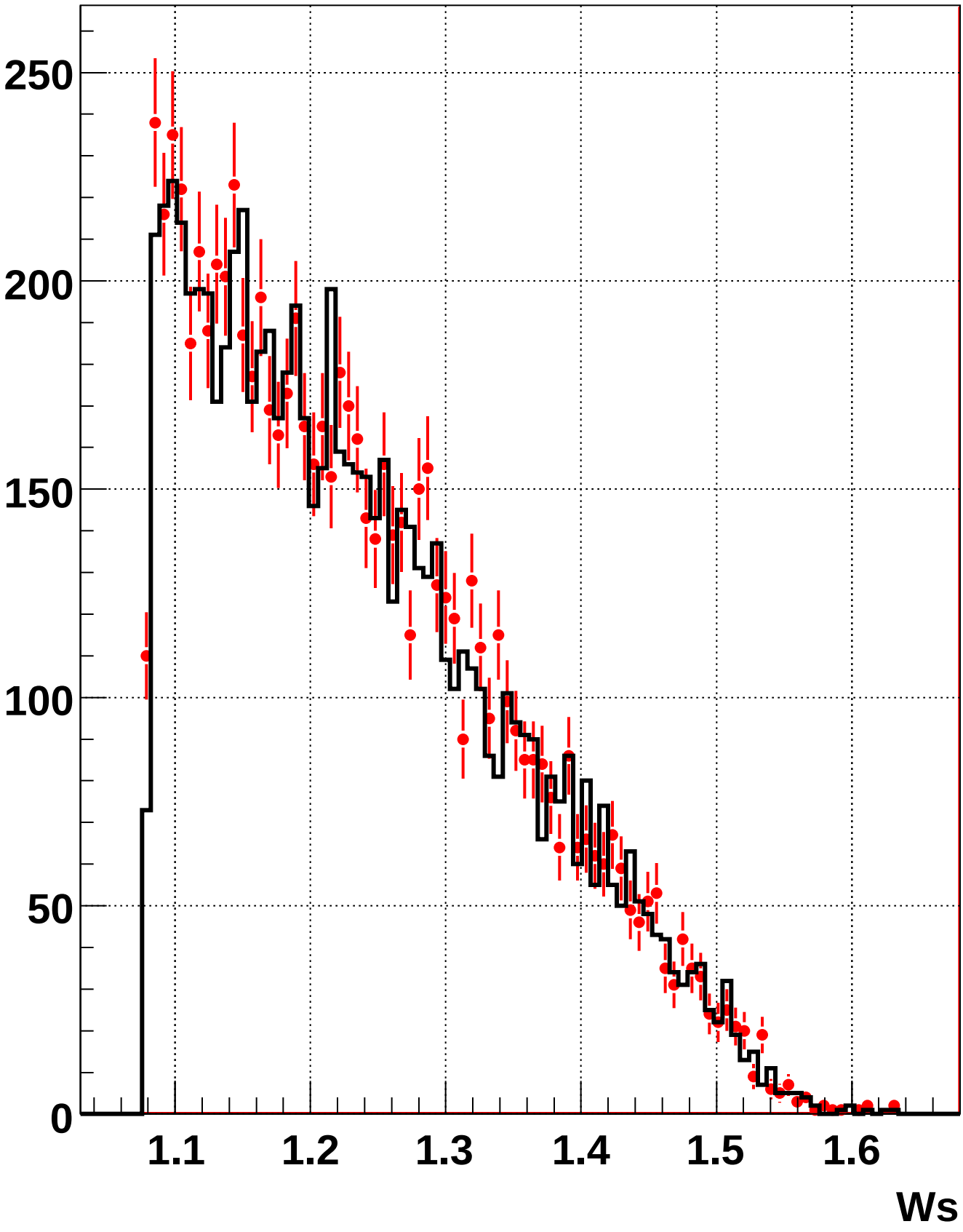



selected W for QEL events
60000
50000
40000
30000
20000
10000
0
0.9382
0.9384
0.9386
0.9388
0.939
0.9392
0.9394
0.9396
Ws

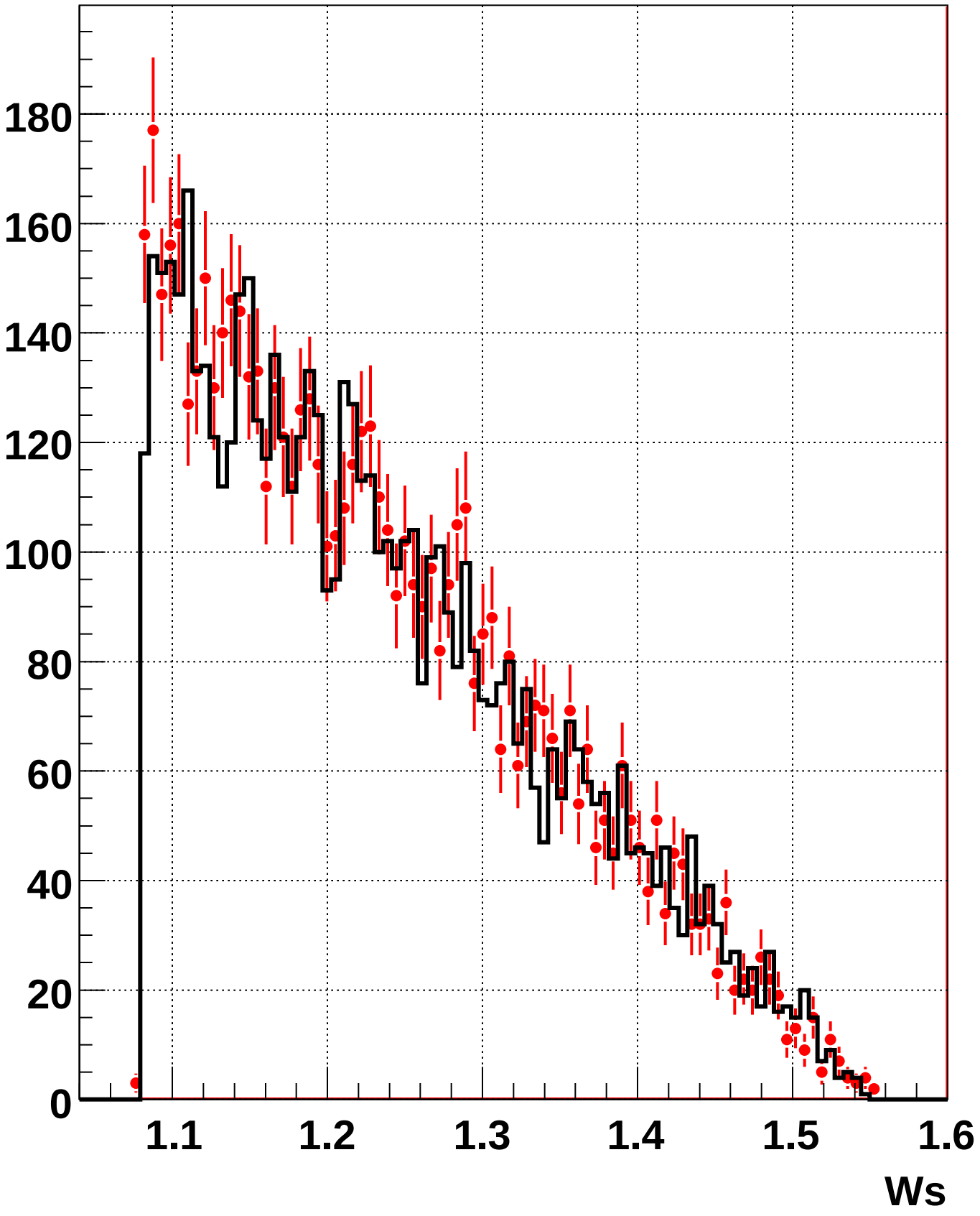
selected W for RES events



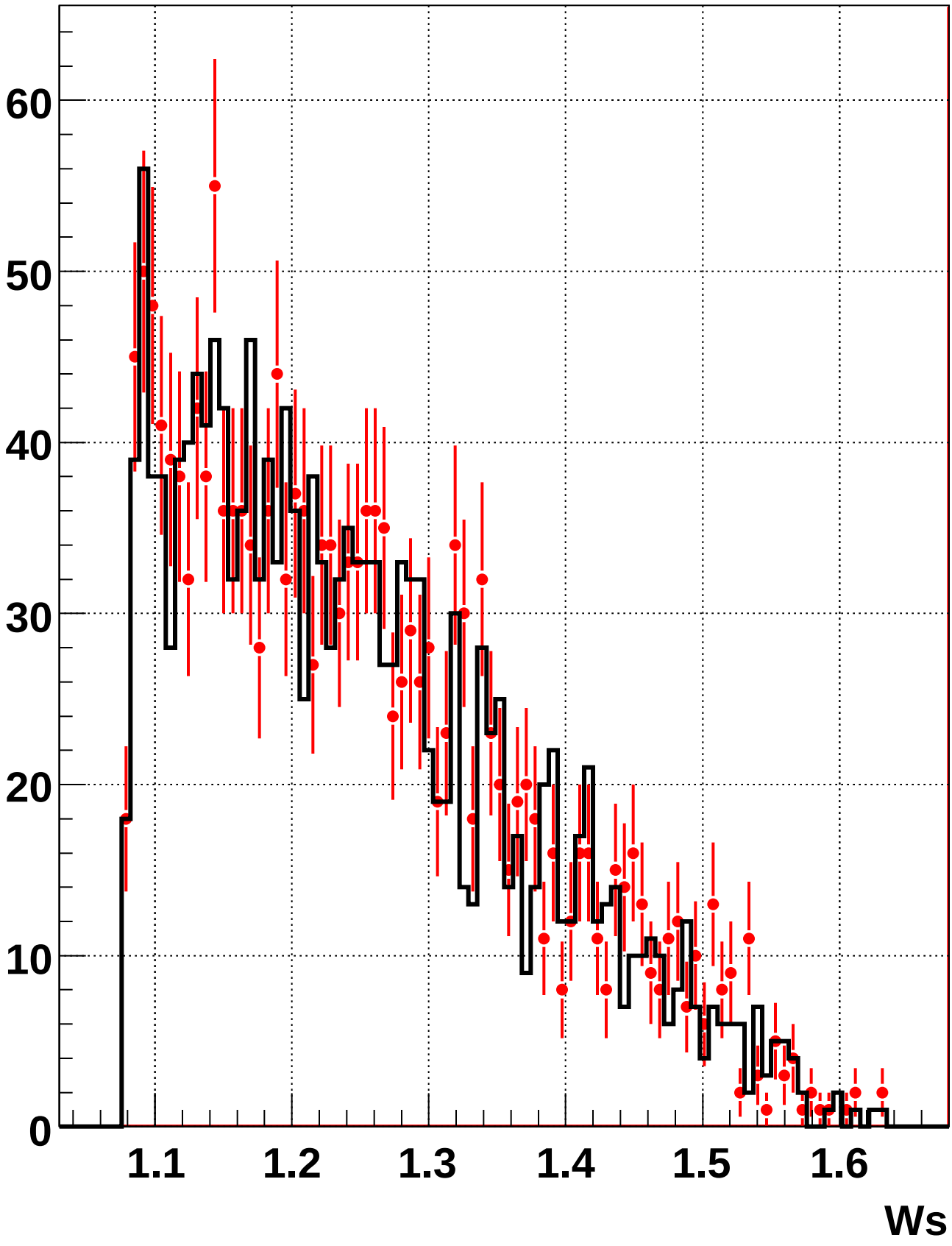
selected W for DIS events

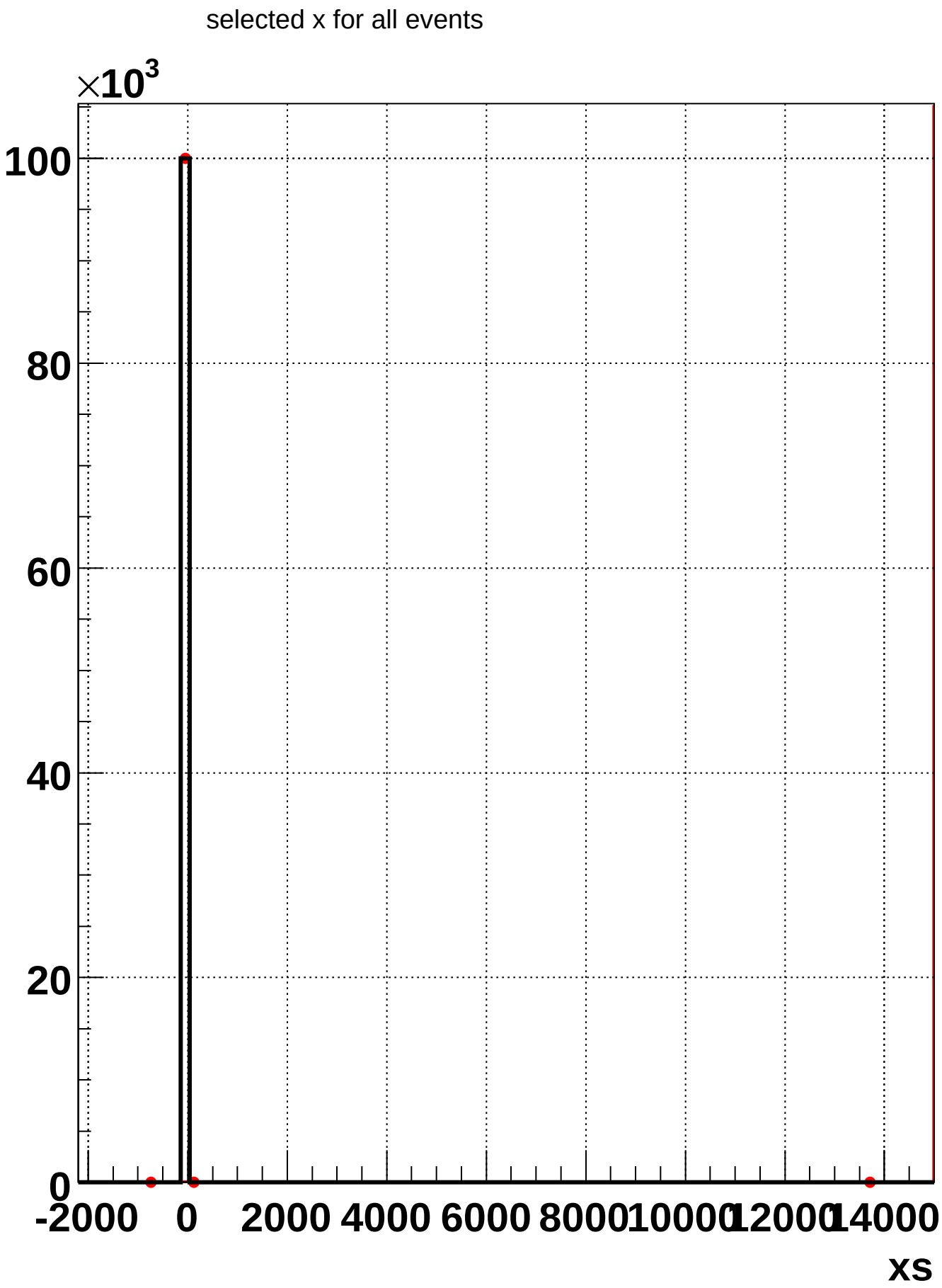


selected W for DIS CC events

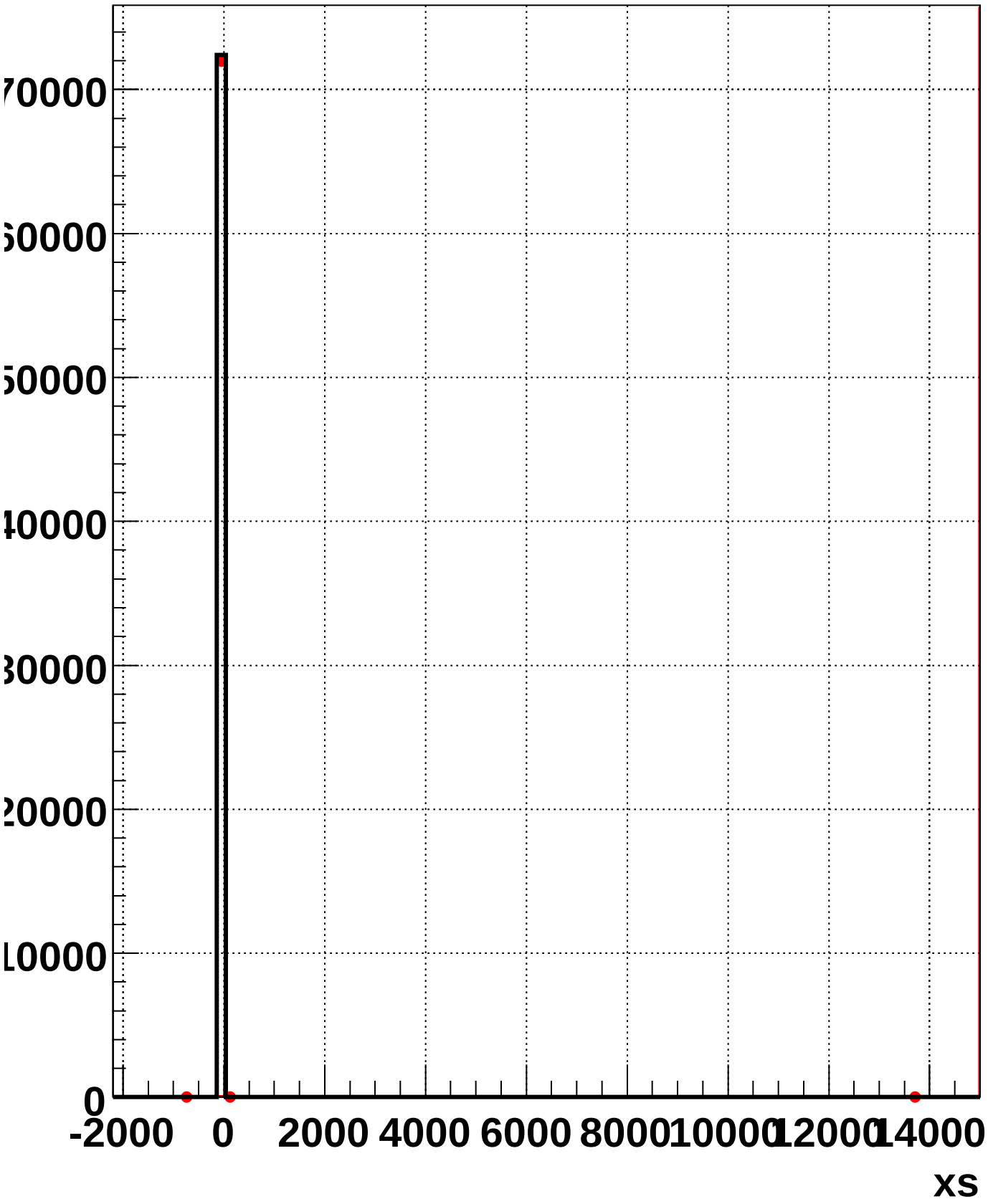


selected W for DIS NC events

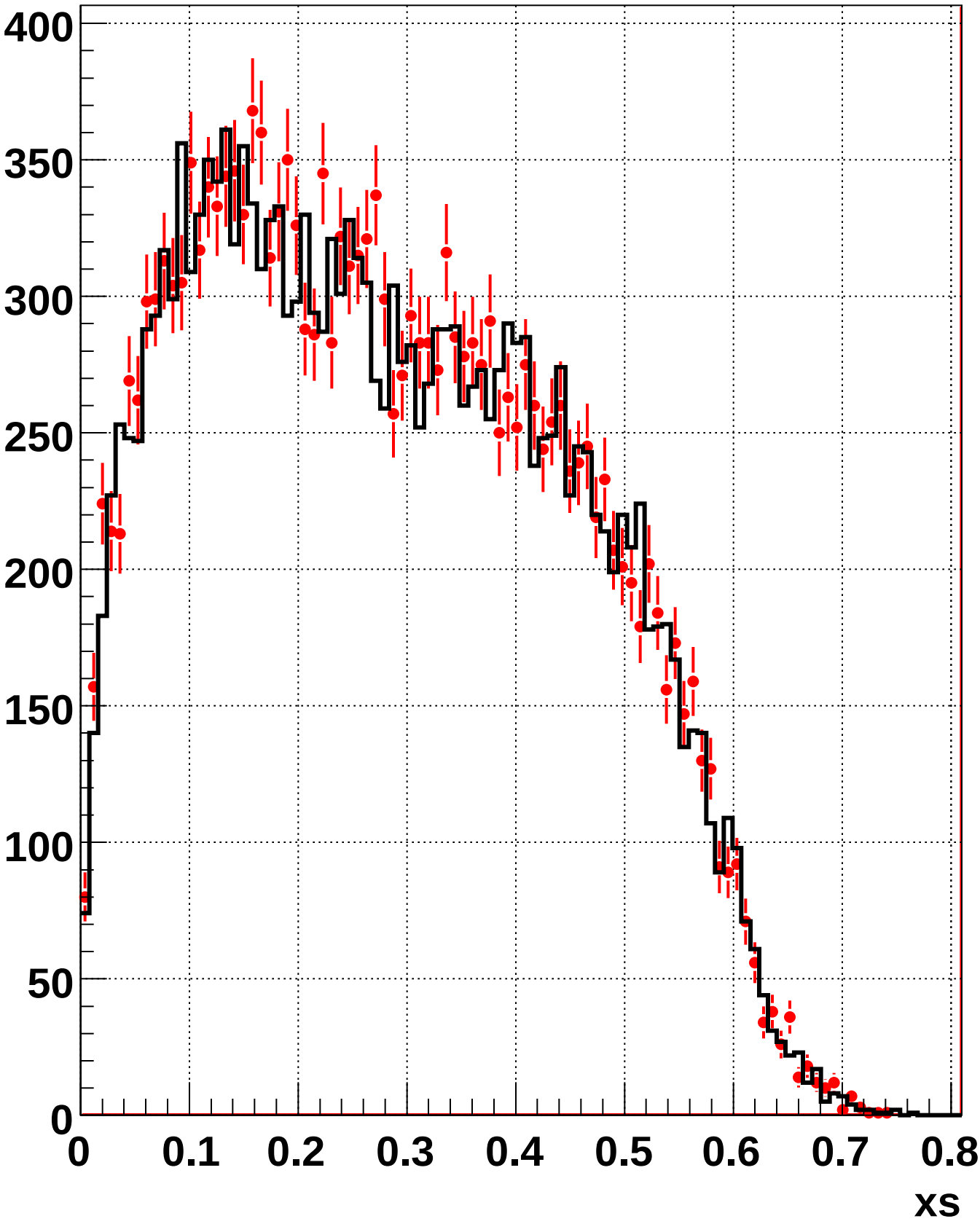



selected x for all events
×10^3
100
80
60
40
20
0
-2000
0
2000
4000
6000
8000
10000
12000
14000
xs

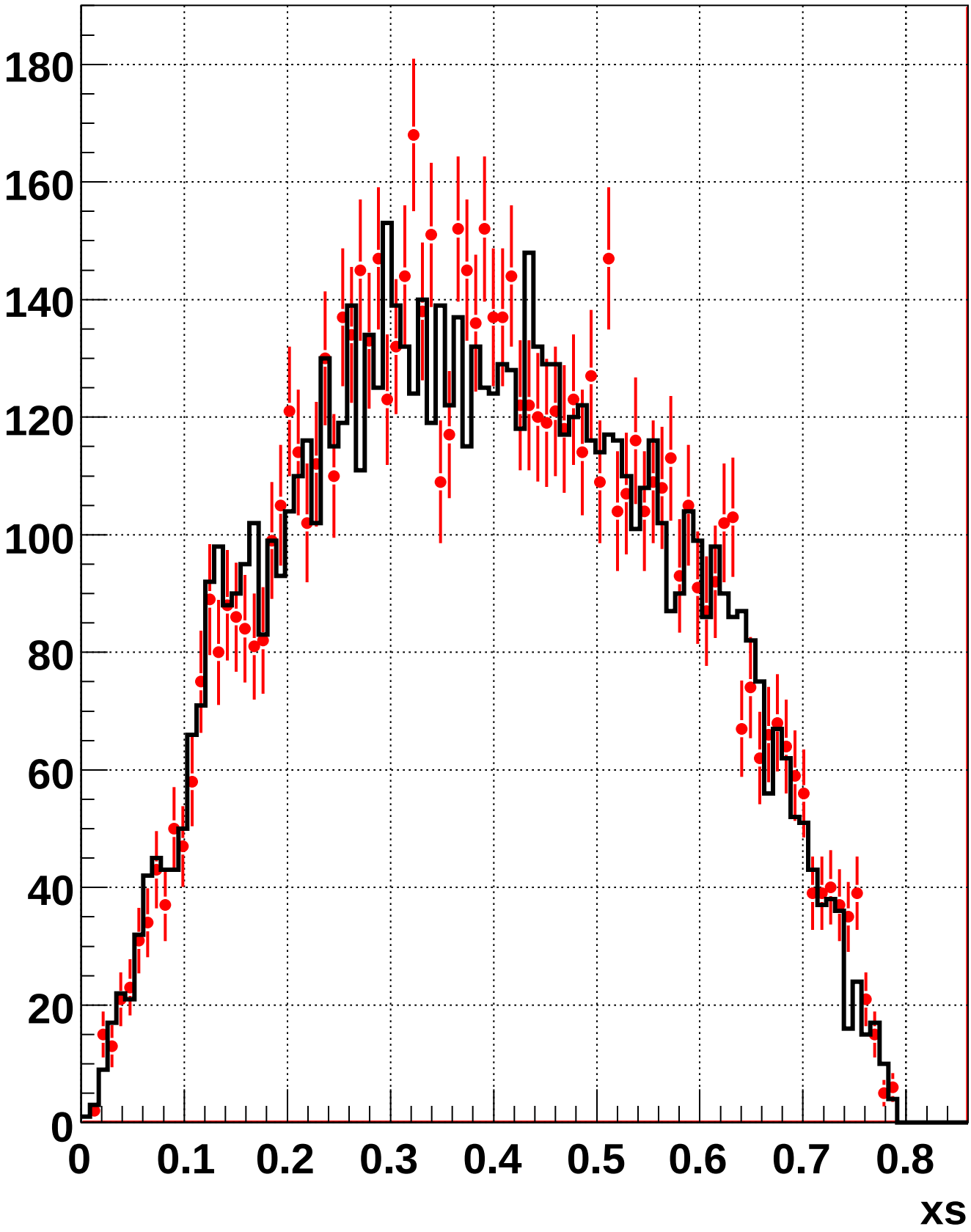
selected x for QEL events



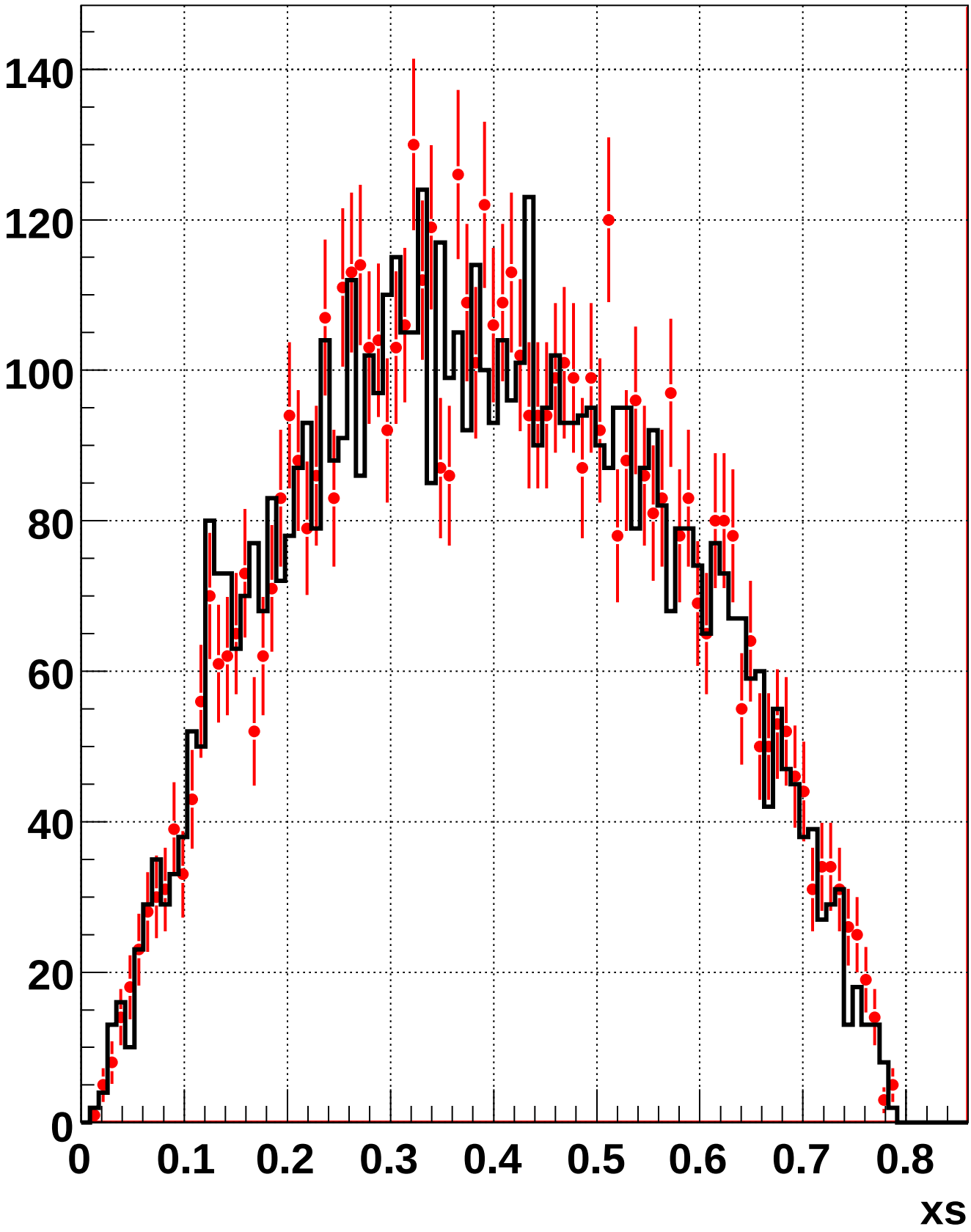
selected x for RES events



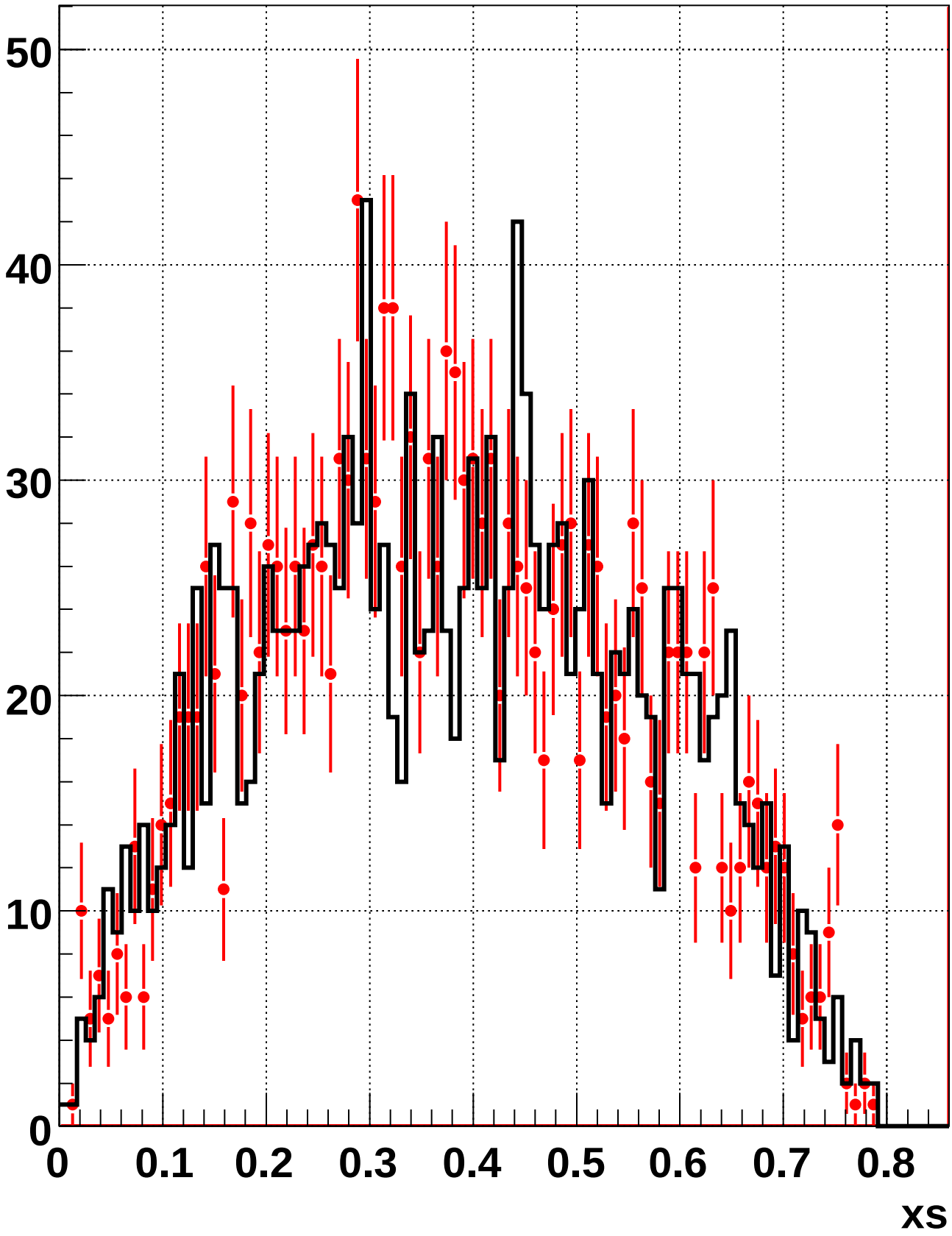
selected x for DIS events



selected x for DIS CC events

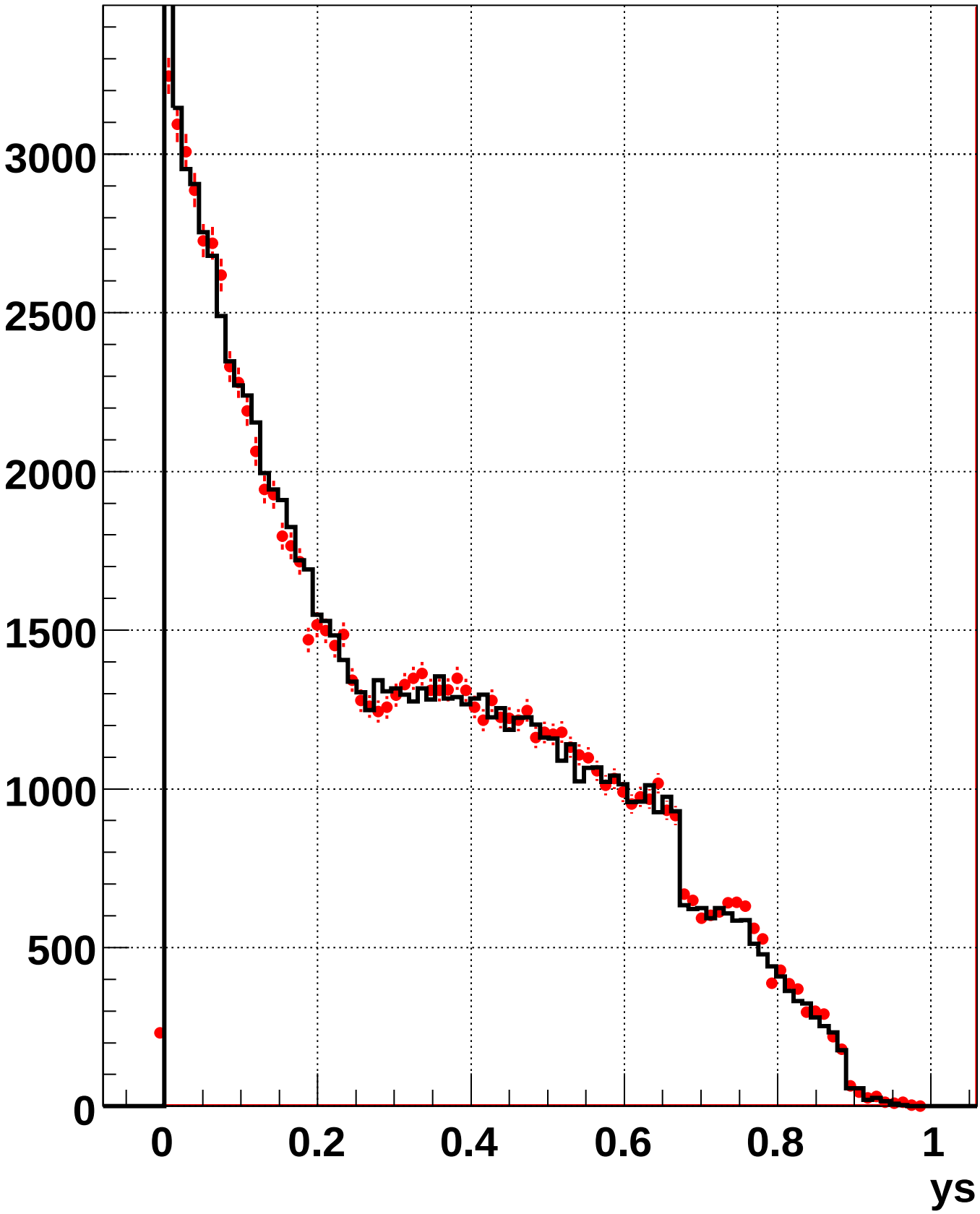


selected x for DIS NC events

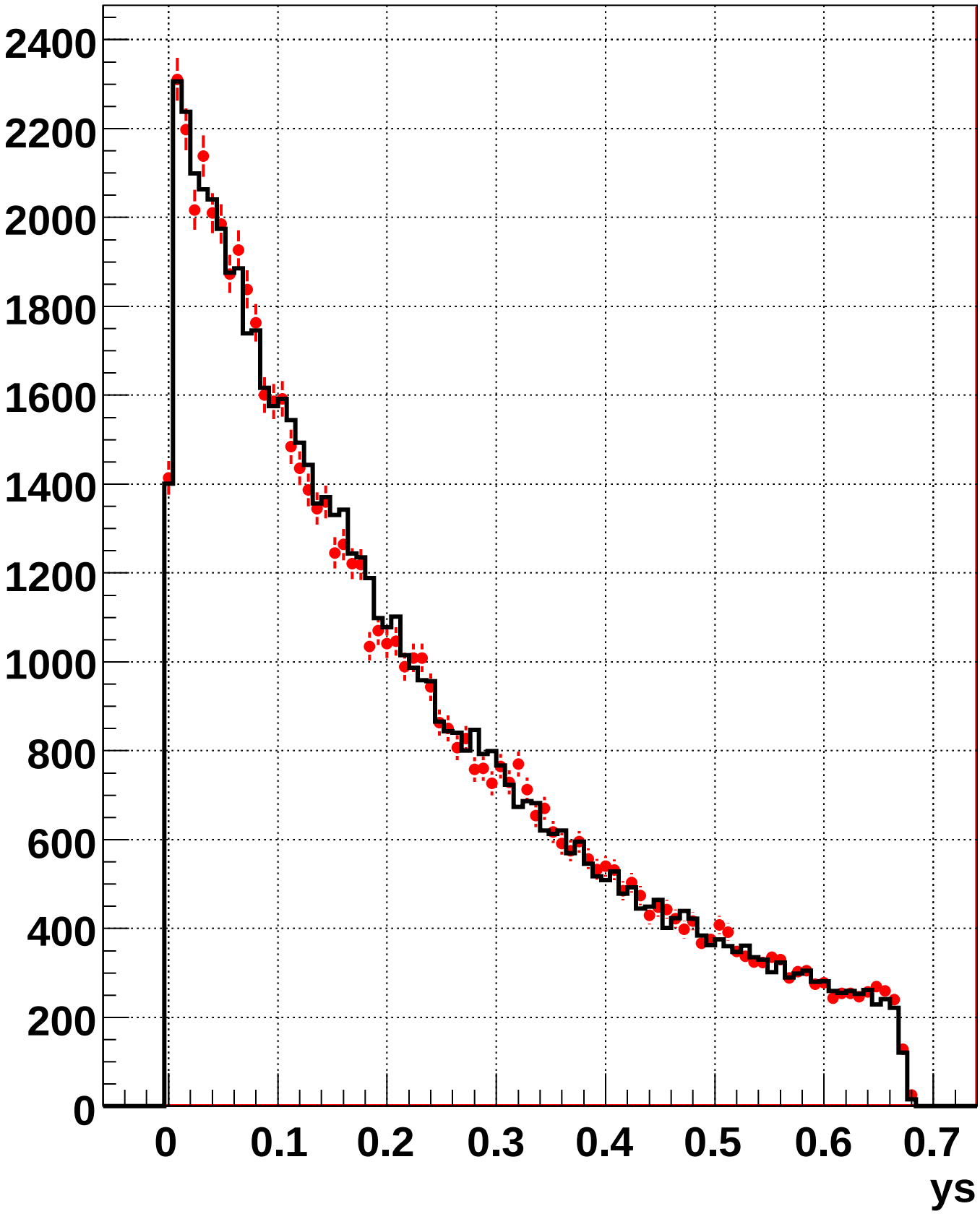


selected x for Charm/DIS events

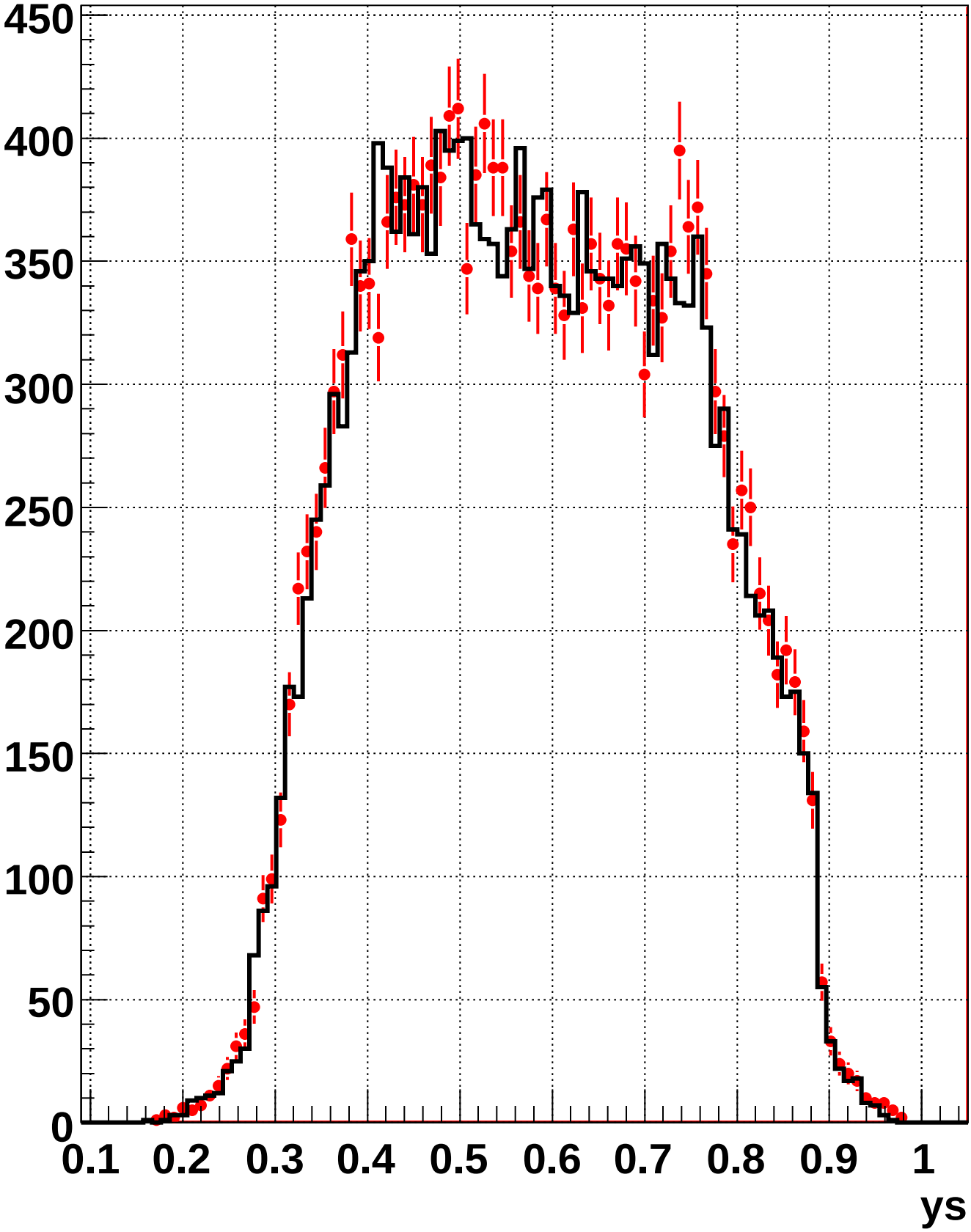
selected y for all events



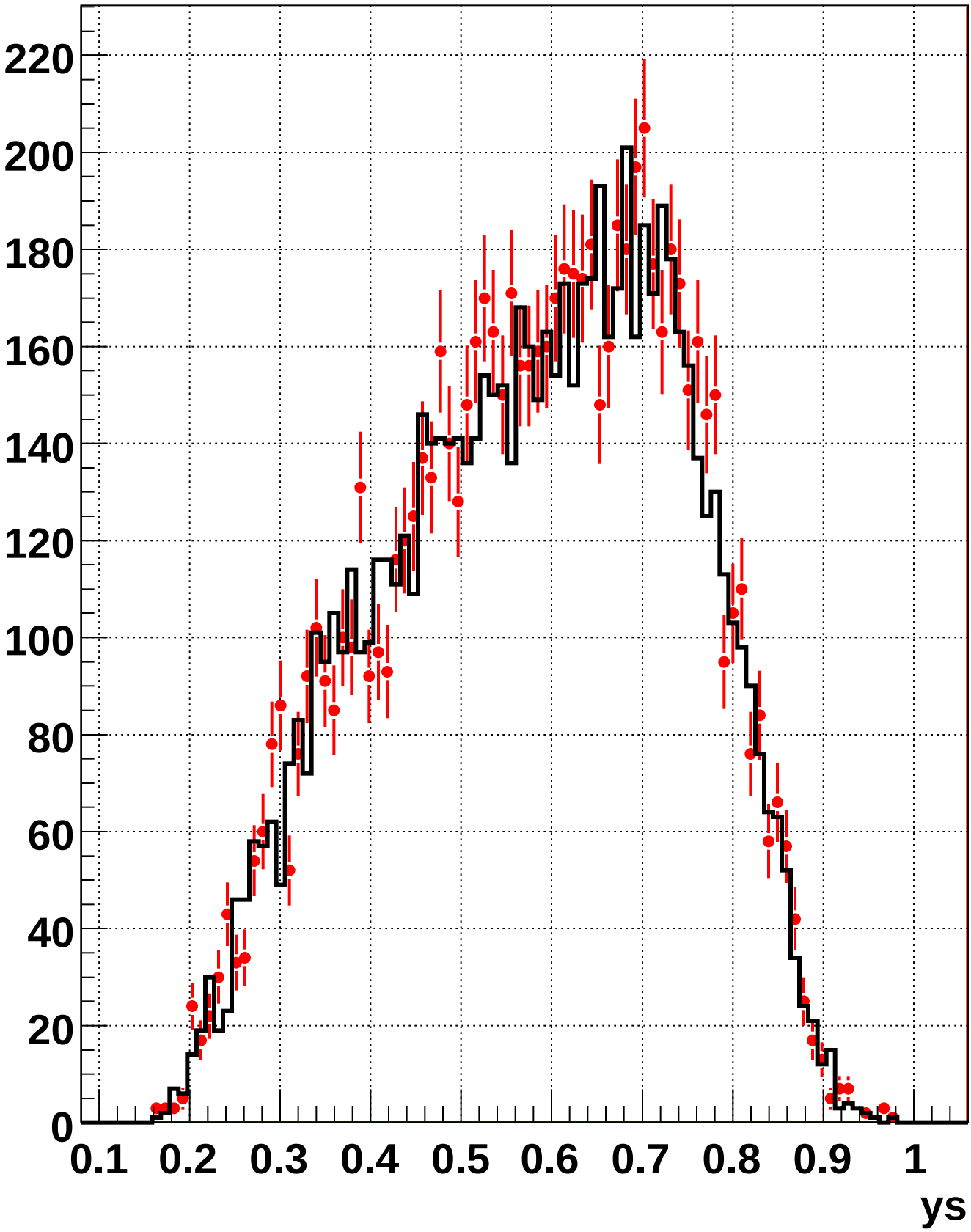
selected y for QEL events



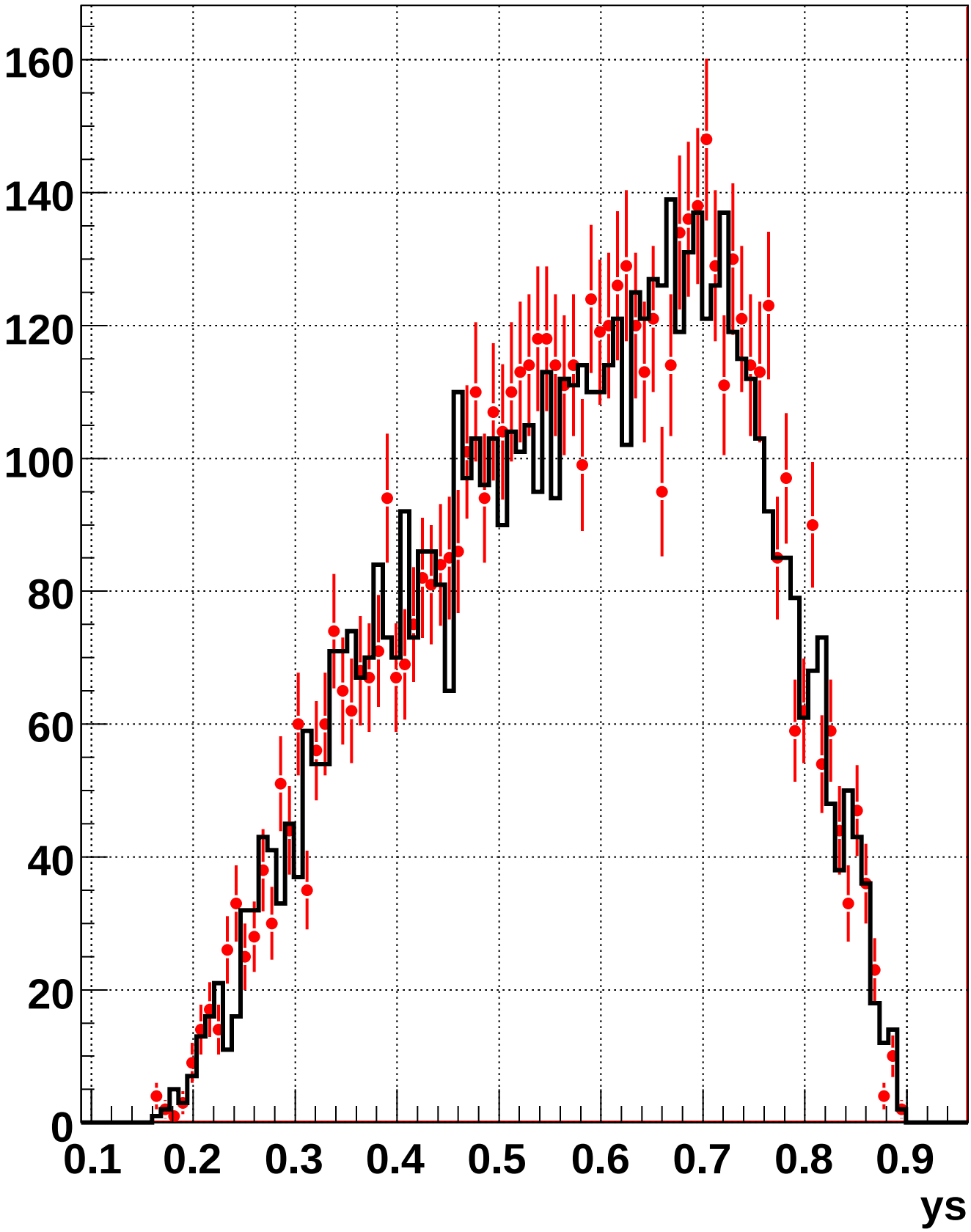
selected y for RES events



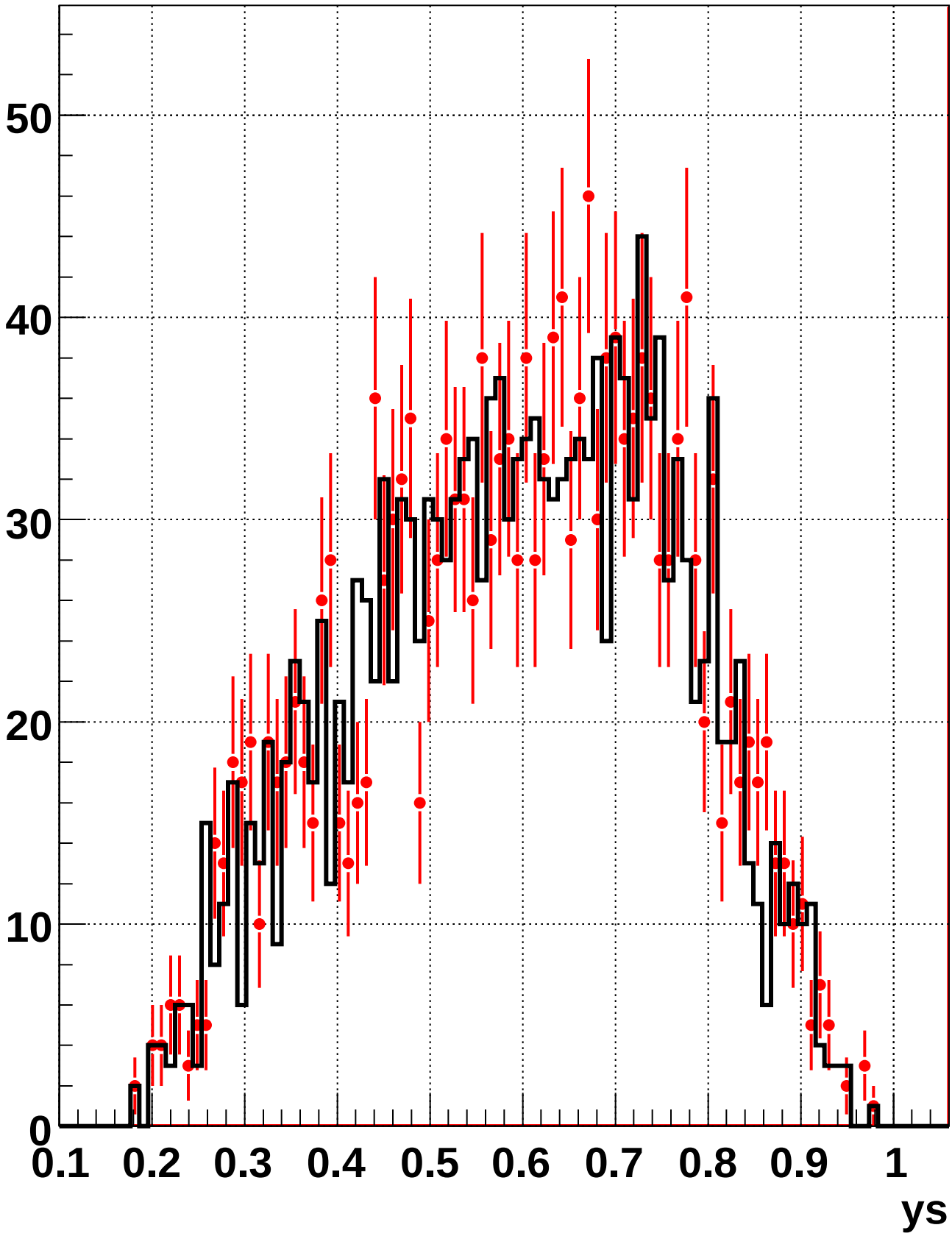
selected y for DIS events



selected y for DIS CC events



selected y for DIS NC events



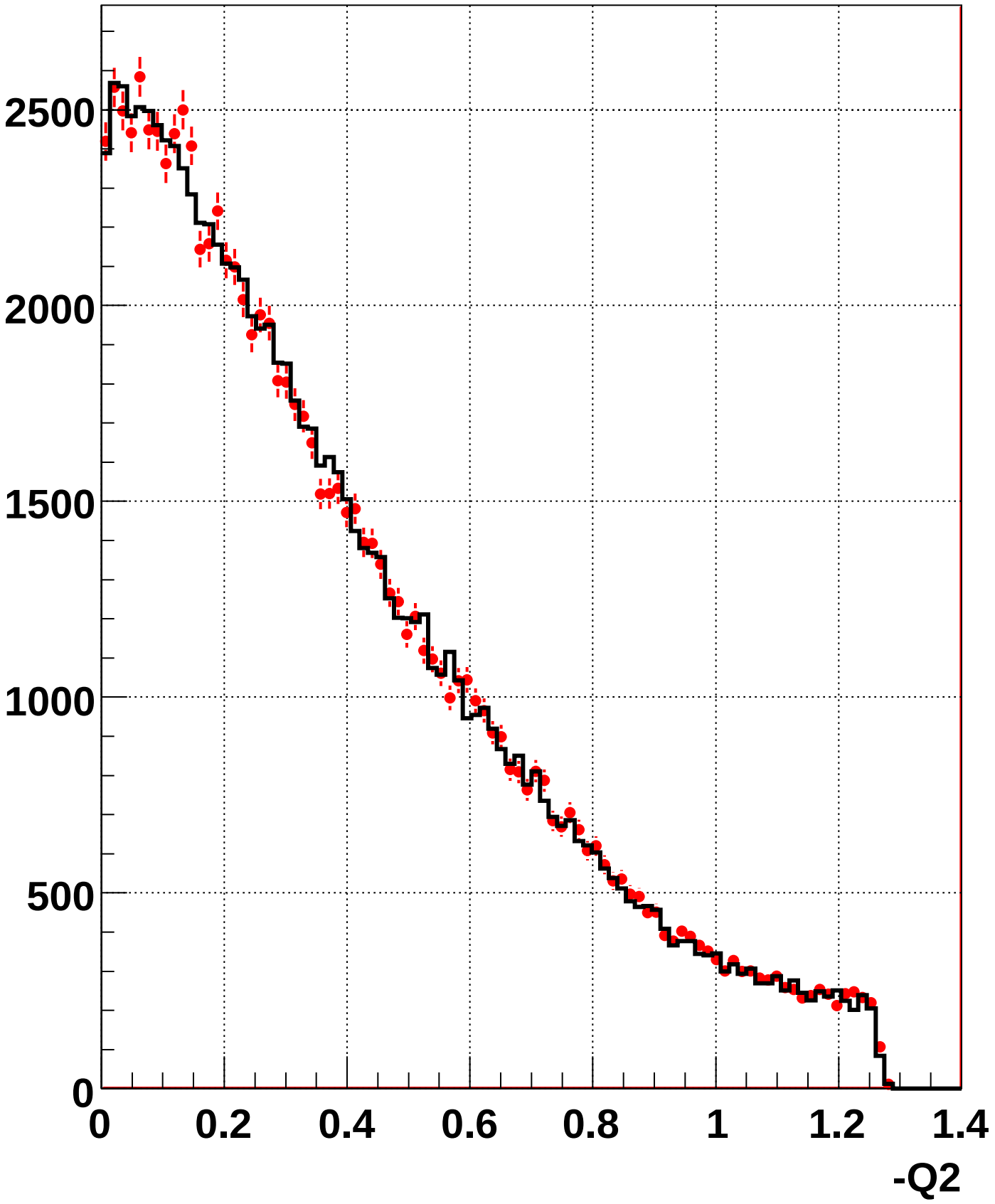
selected y for Charm/DIS events

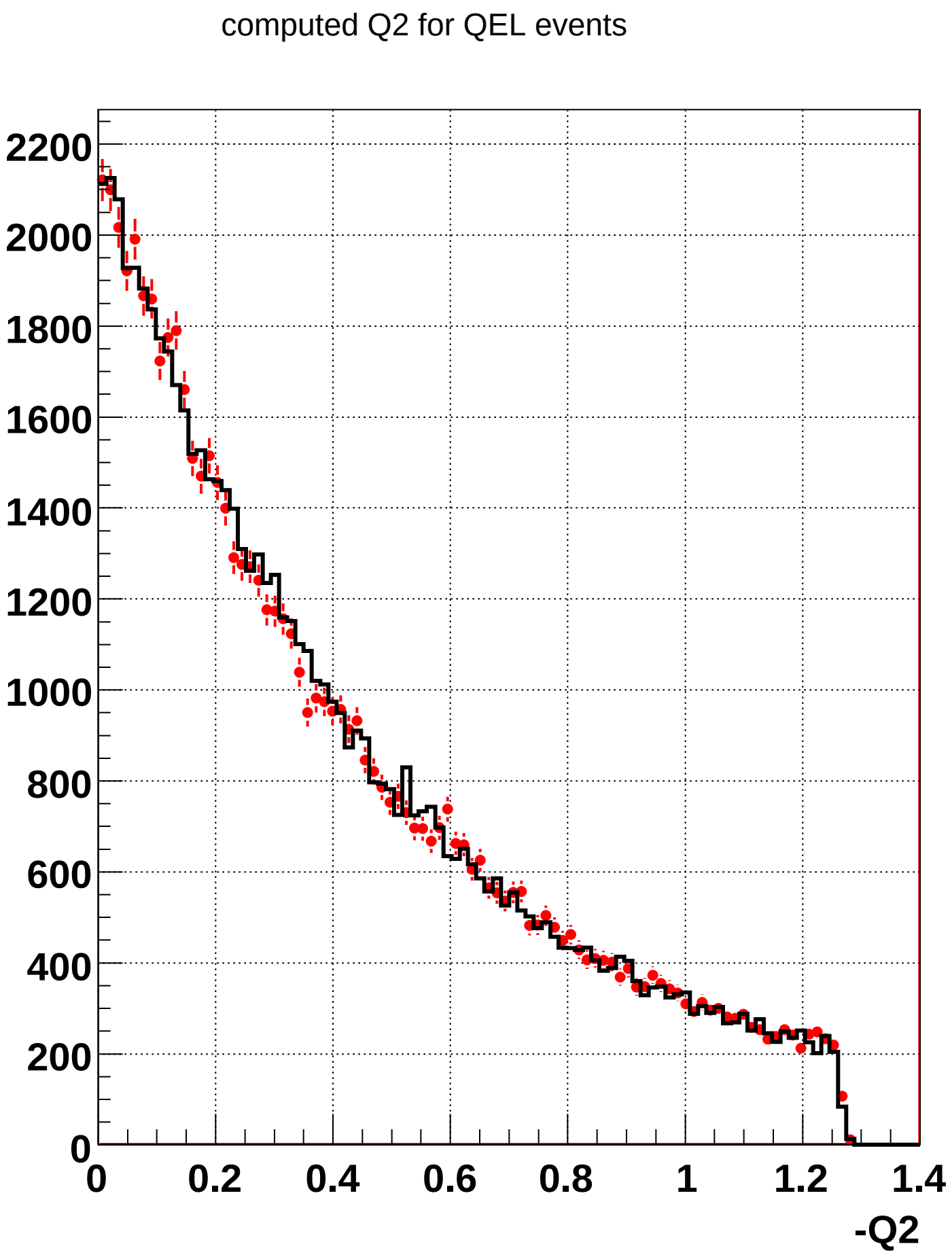
Kinematical Quantities

Similar to the previous set of plots but

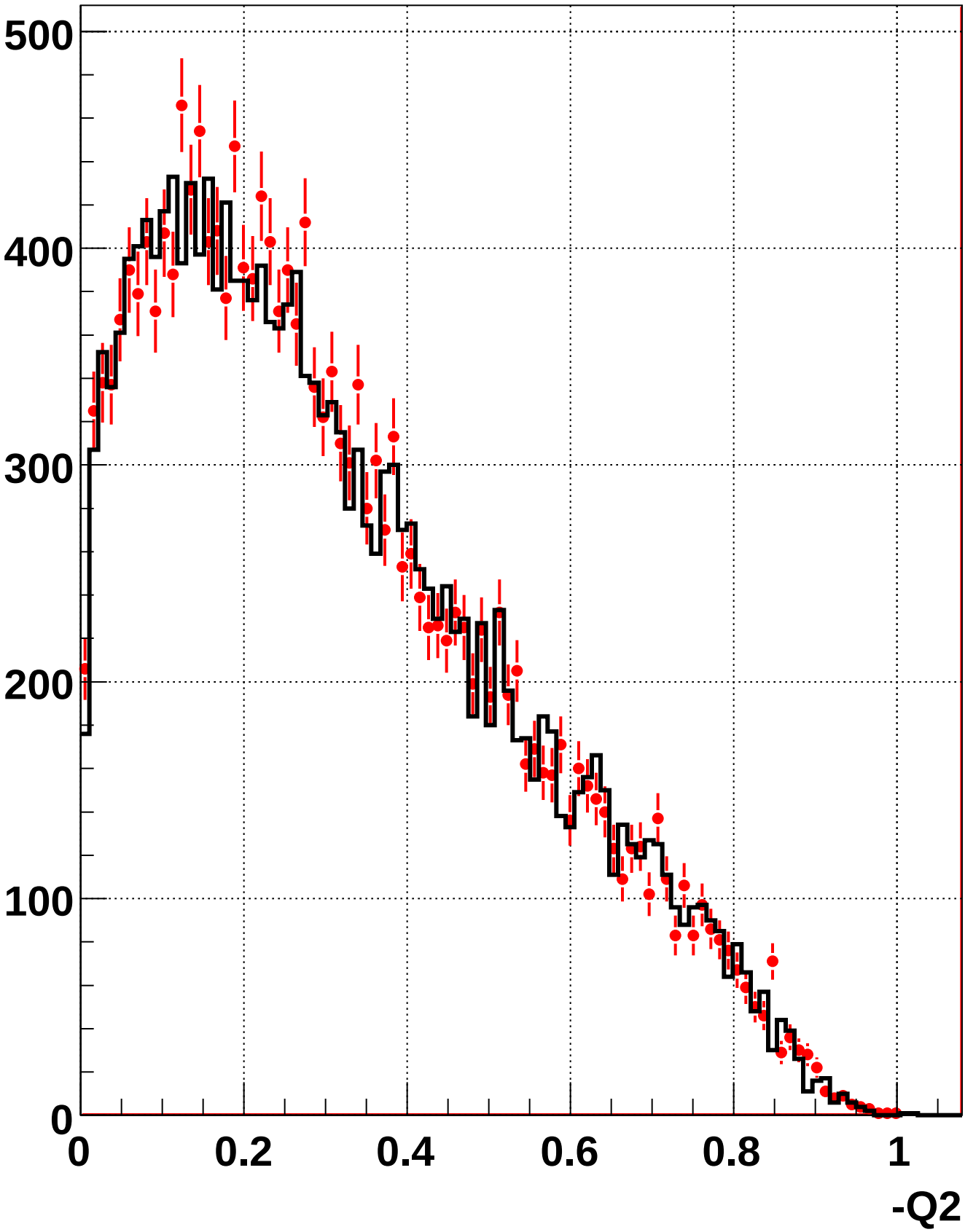
showing ’computed’ rathen than ’selected’ variables

computed Q2 for all events

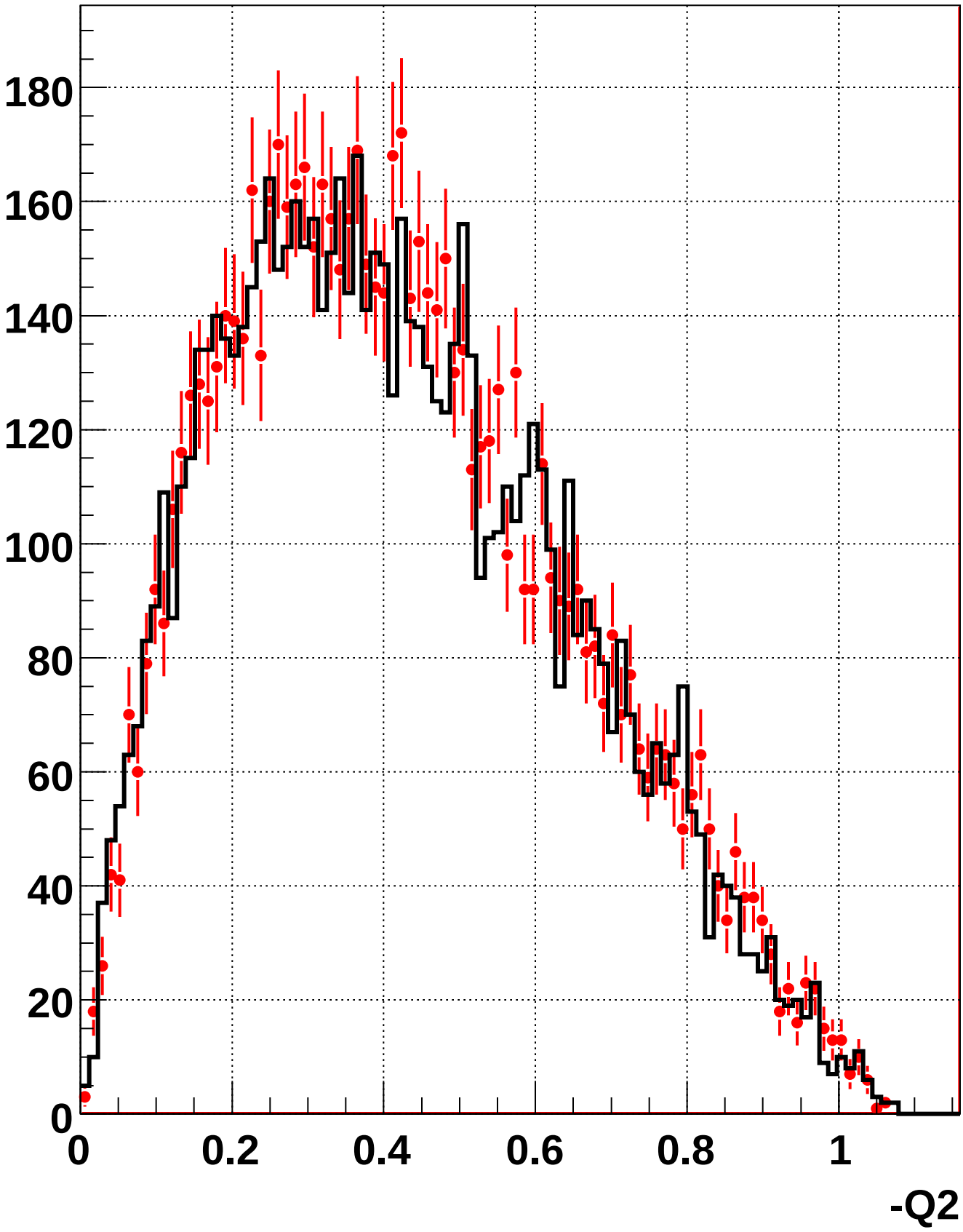


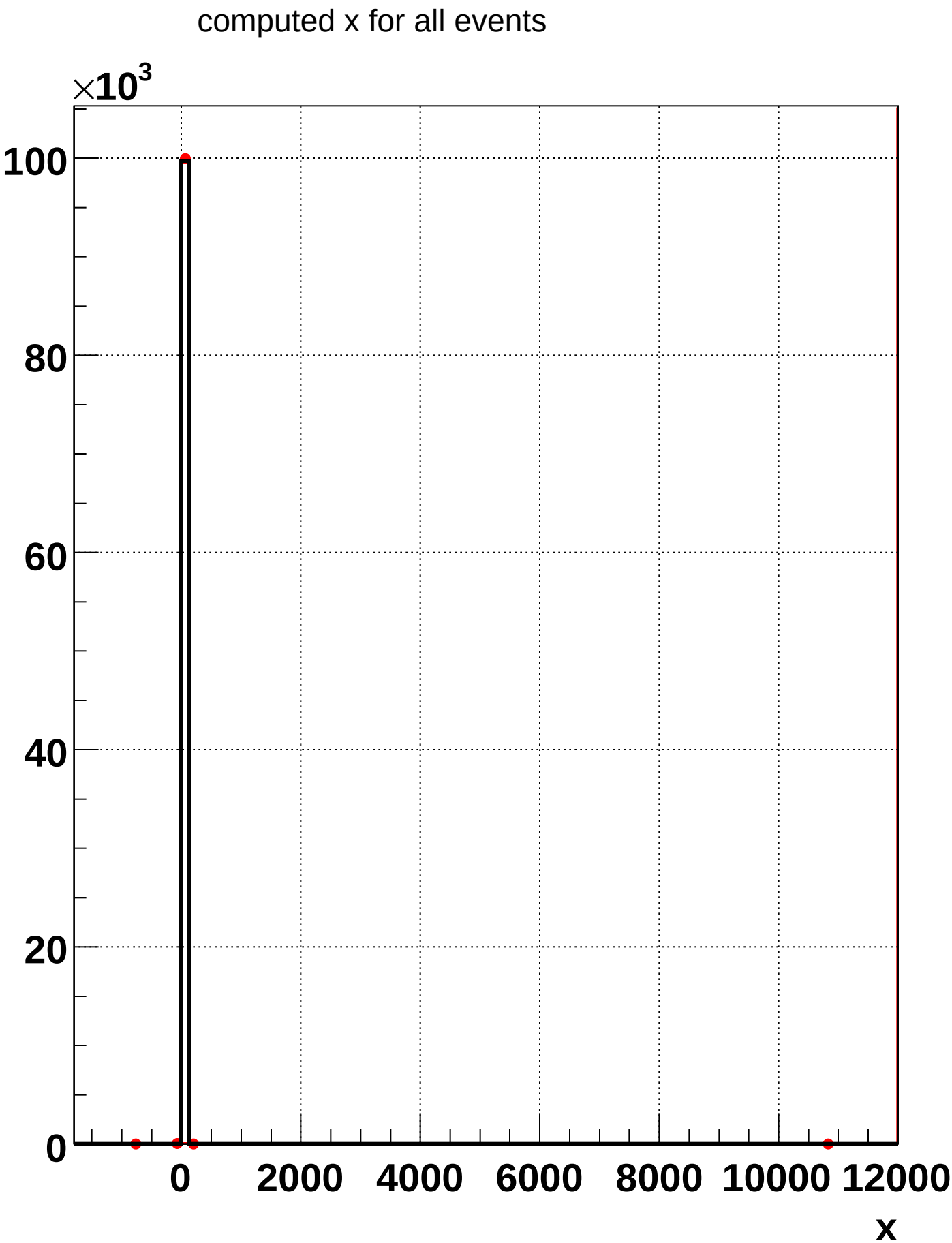

computed Q2 for QEL events
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
-Q2

computed Q2 for RES events

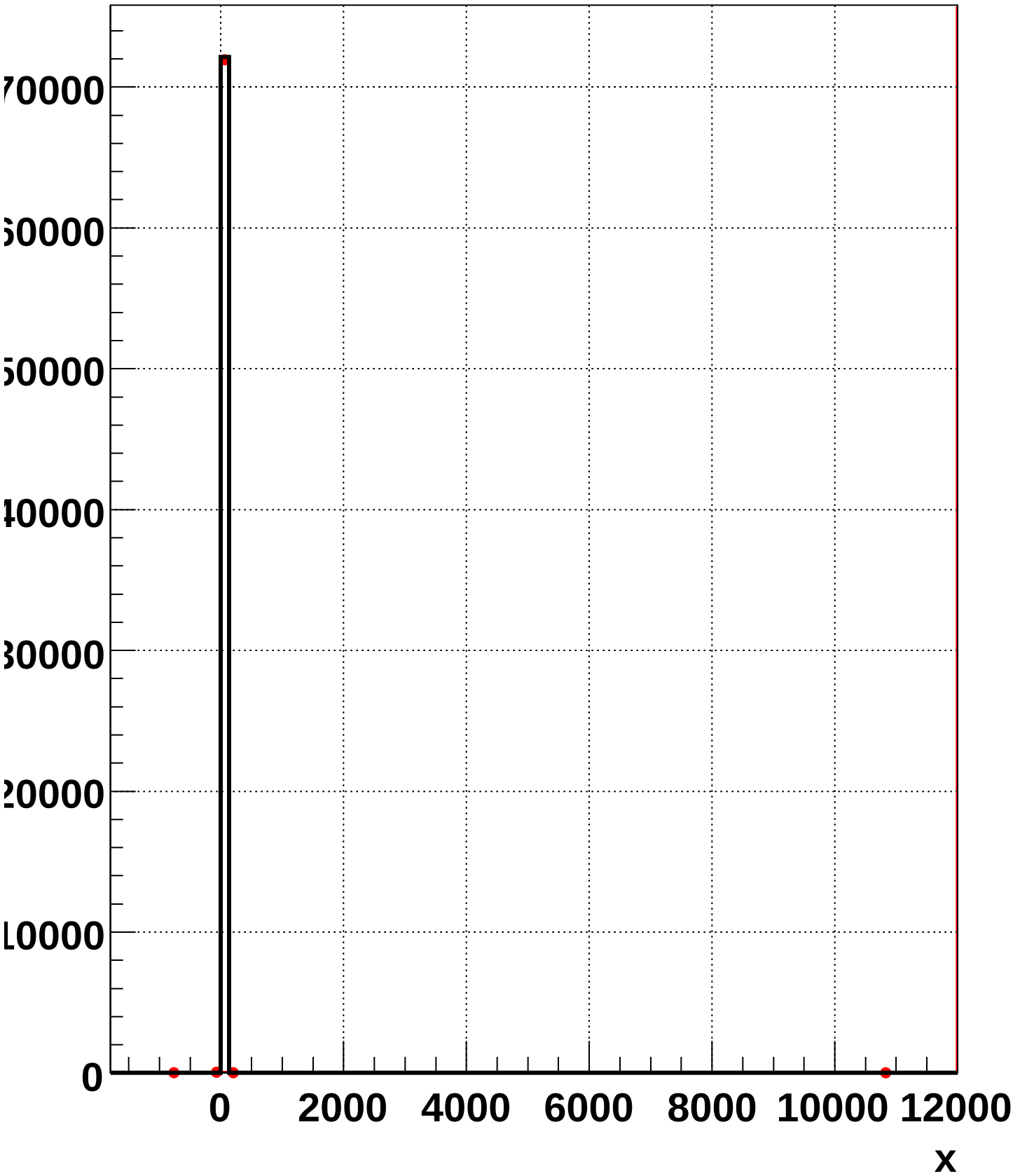


computed Q2 for DIS events

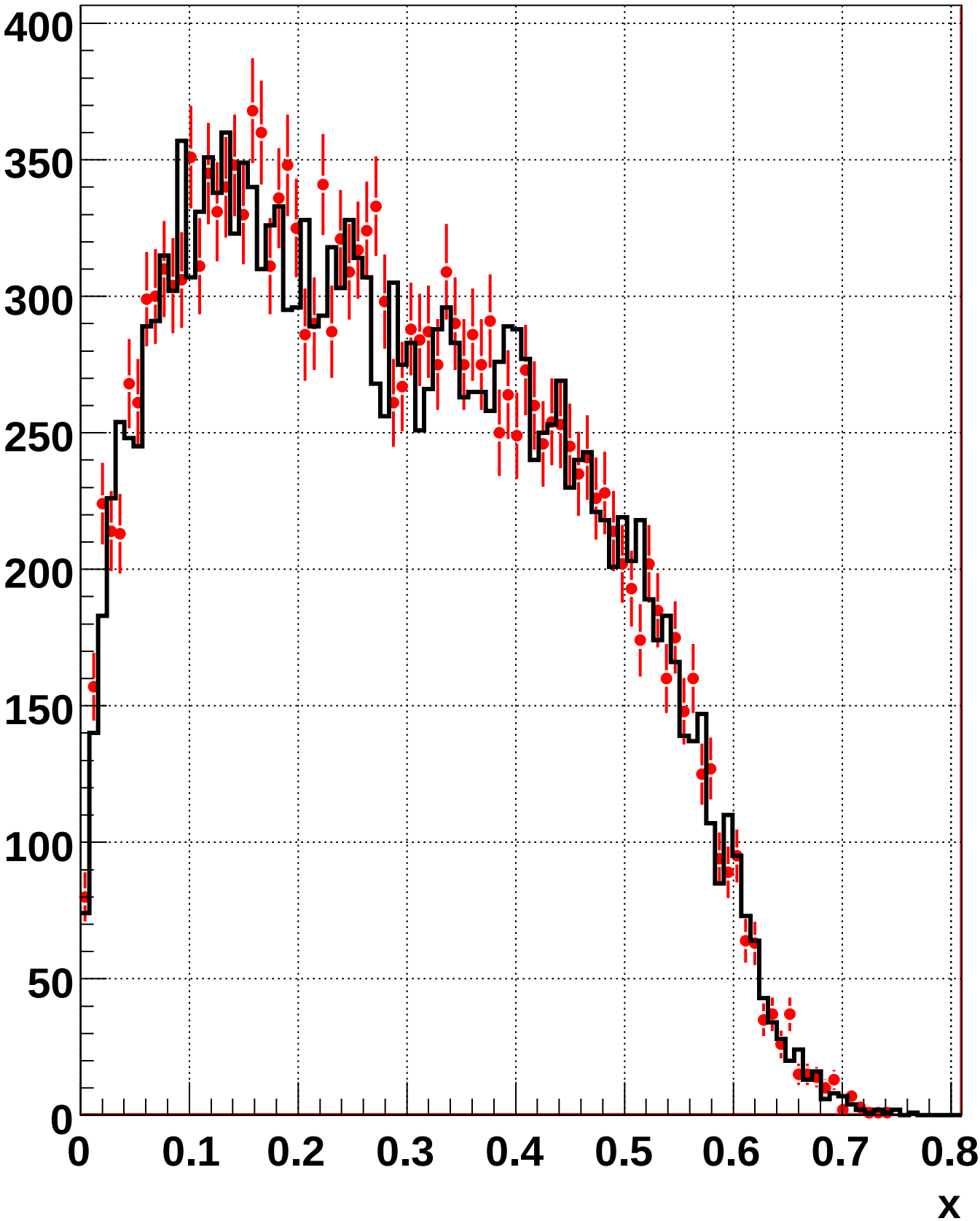



computed x for all events
×10^3
100
80
60
40
20
0
0
2000
4000
6000
8000
10000
12000
x

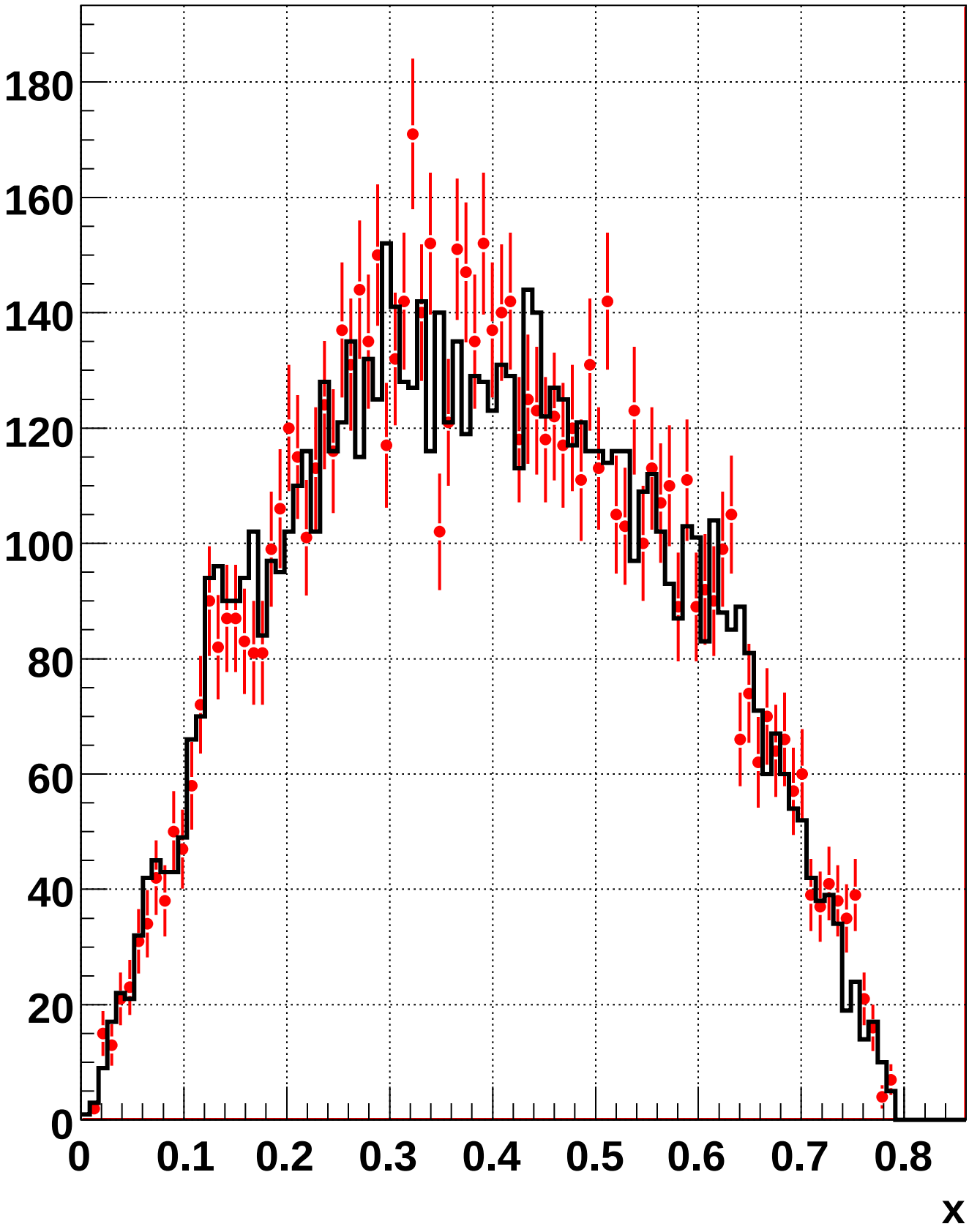
computed x for QEL events



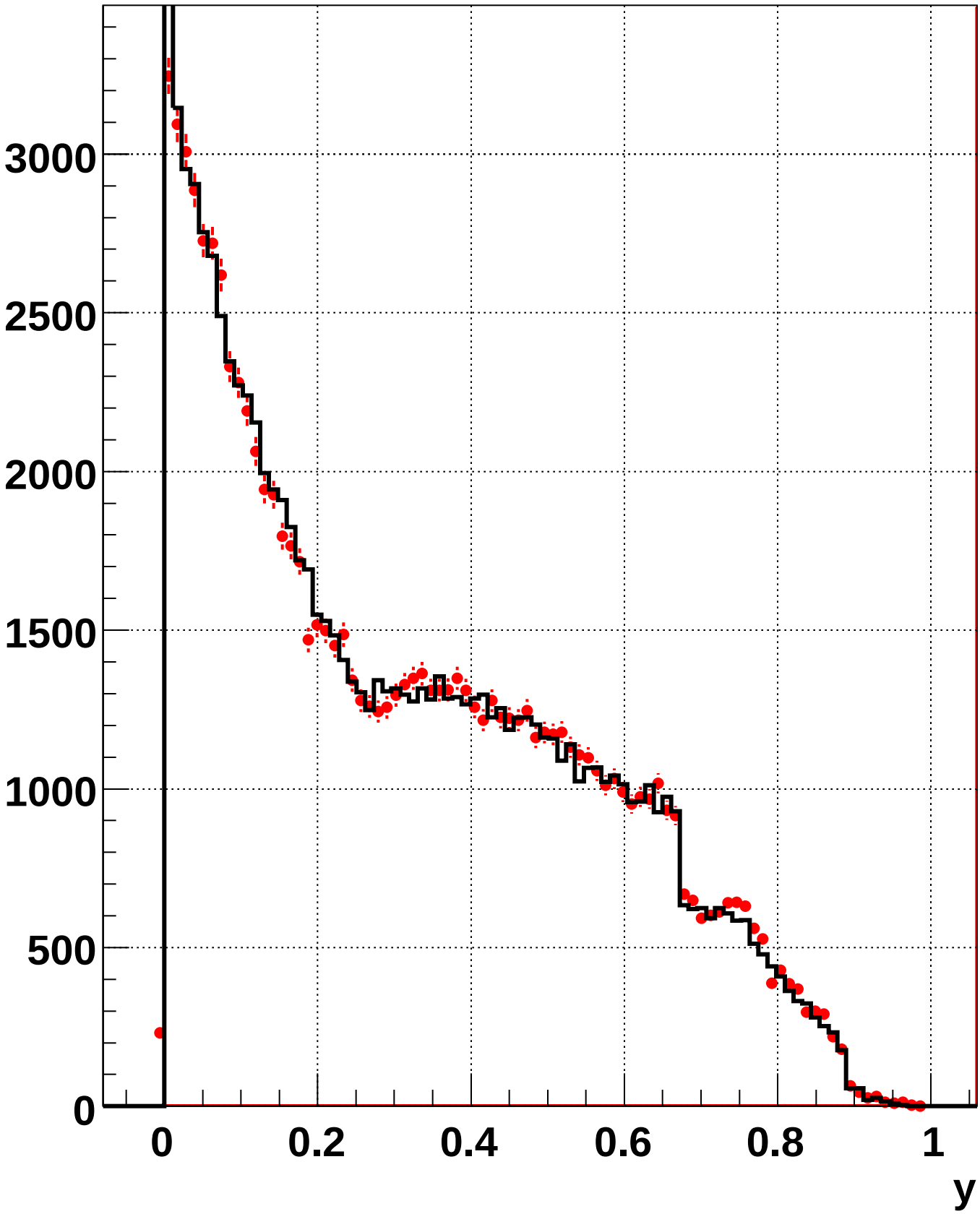
computed x for RES events

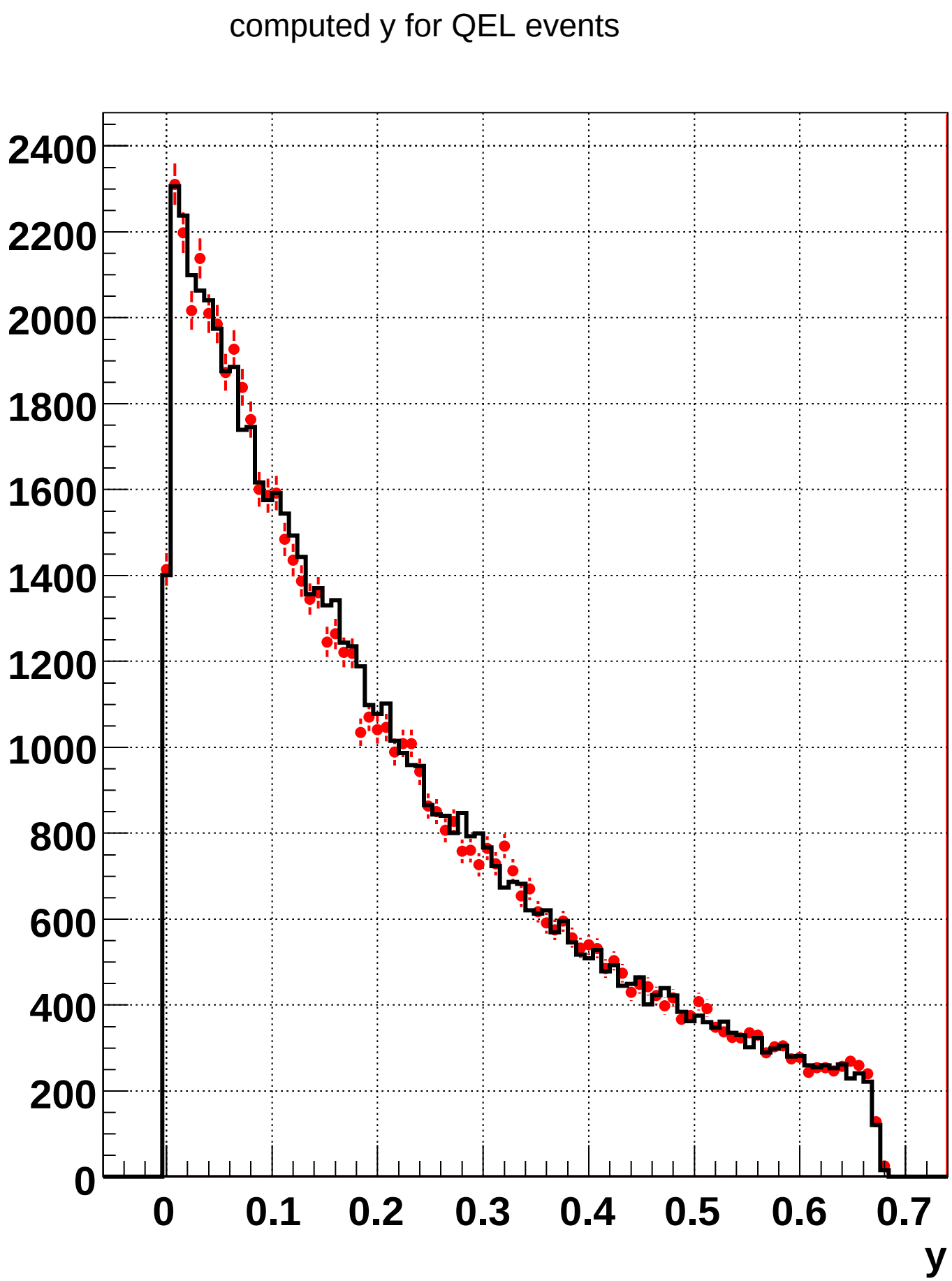


computed x for DIS events

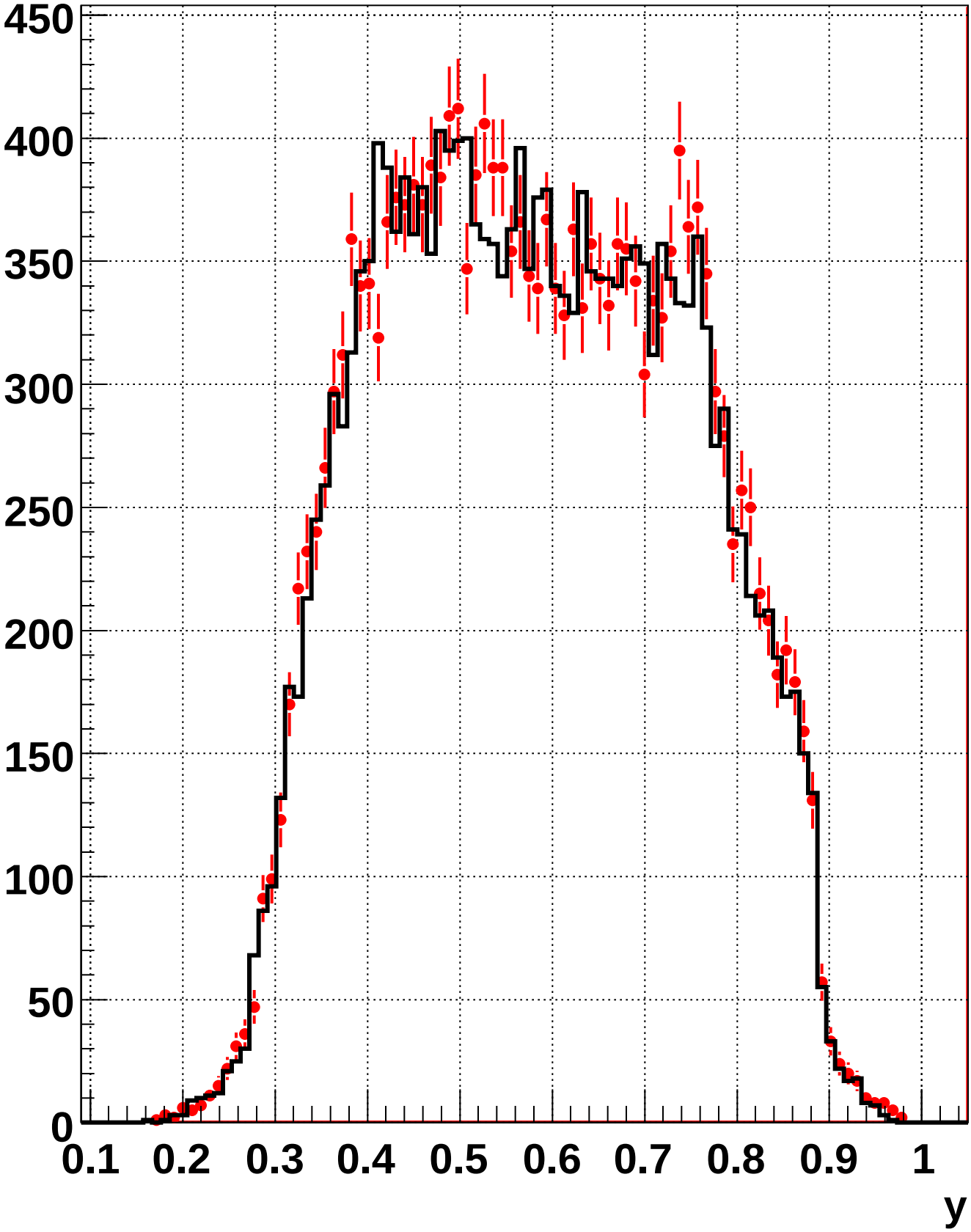


computed y for all events

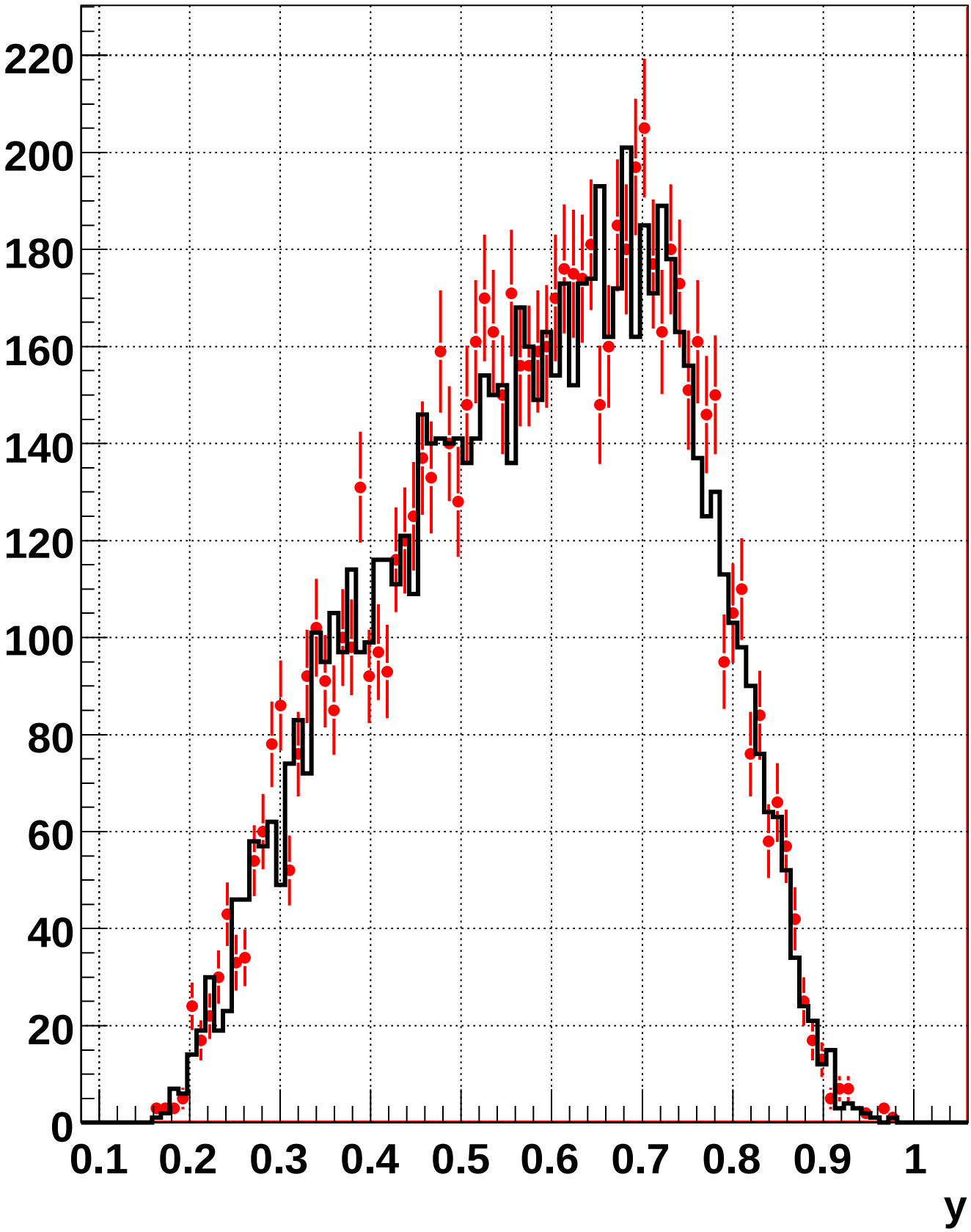



computed y for QEL events
2400
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
y

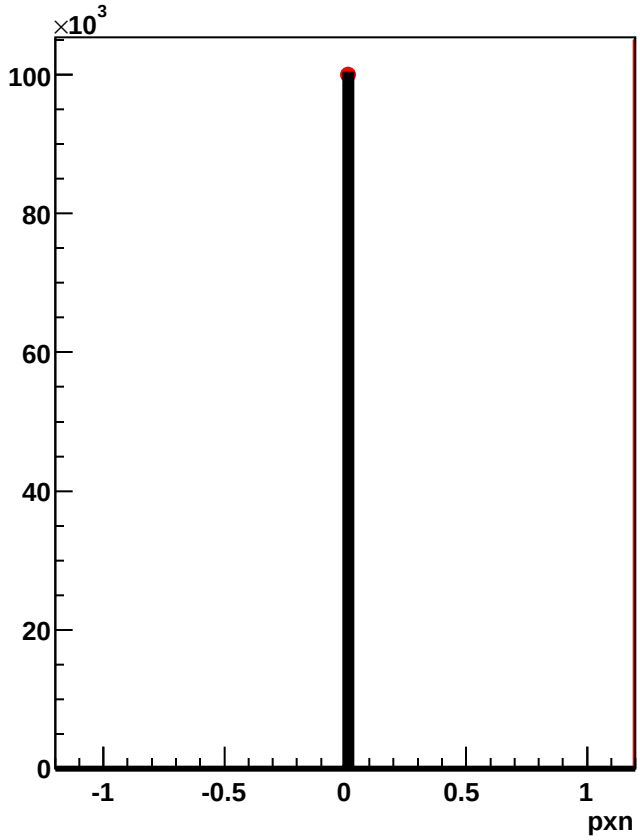
computed y for RES events

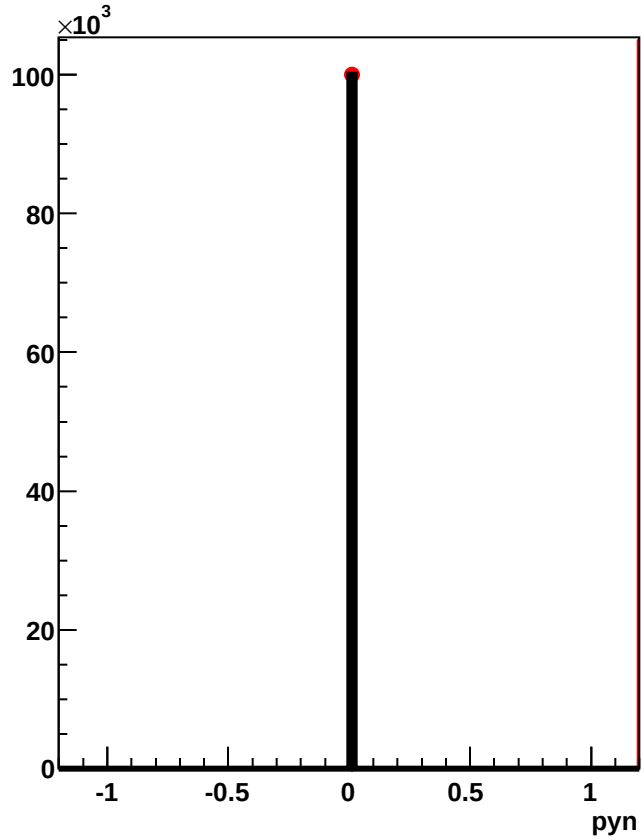


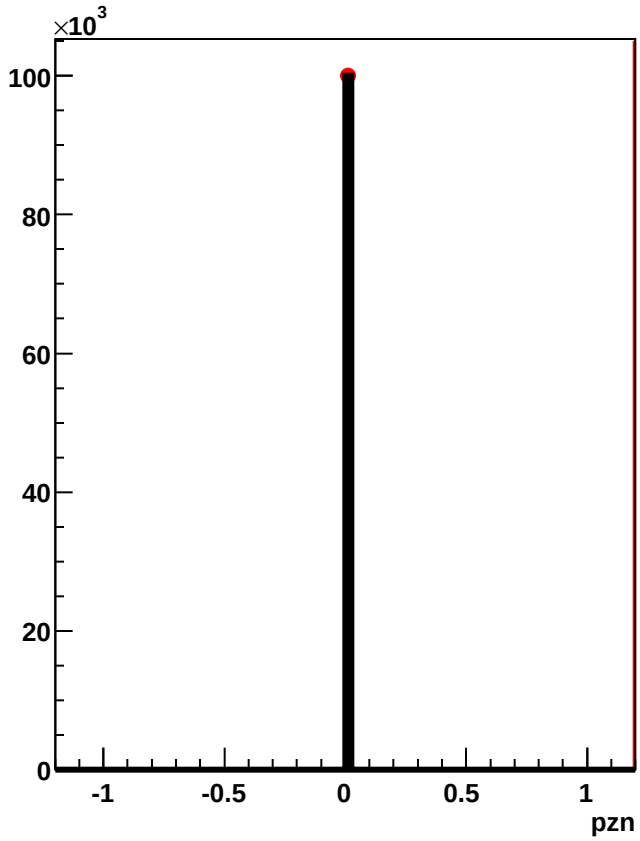
computed y for DIS events

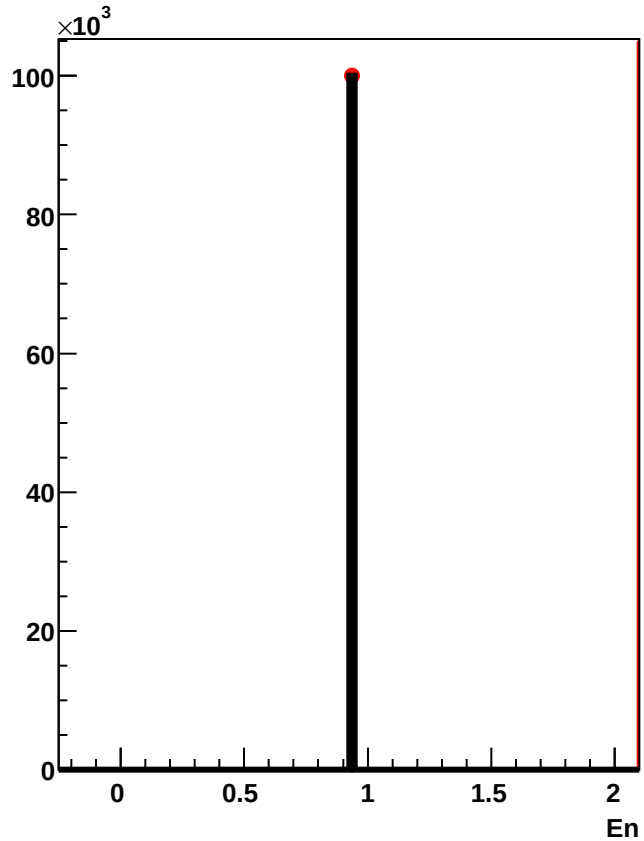


Initial state nucleon 4-Momentum


×10^3
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pxn

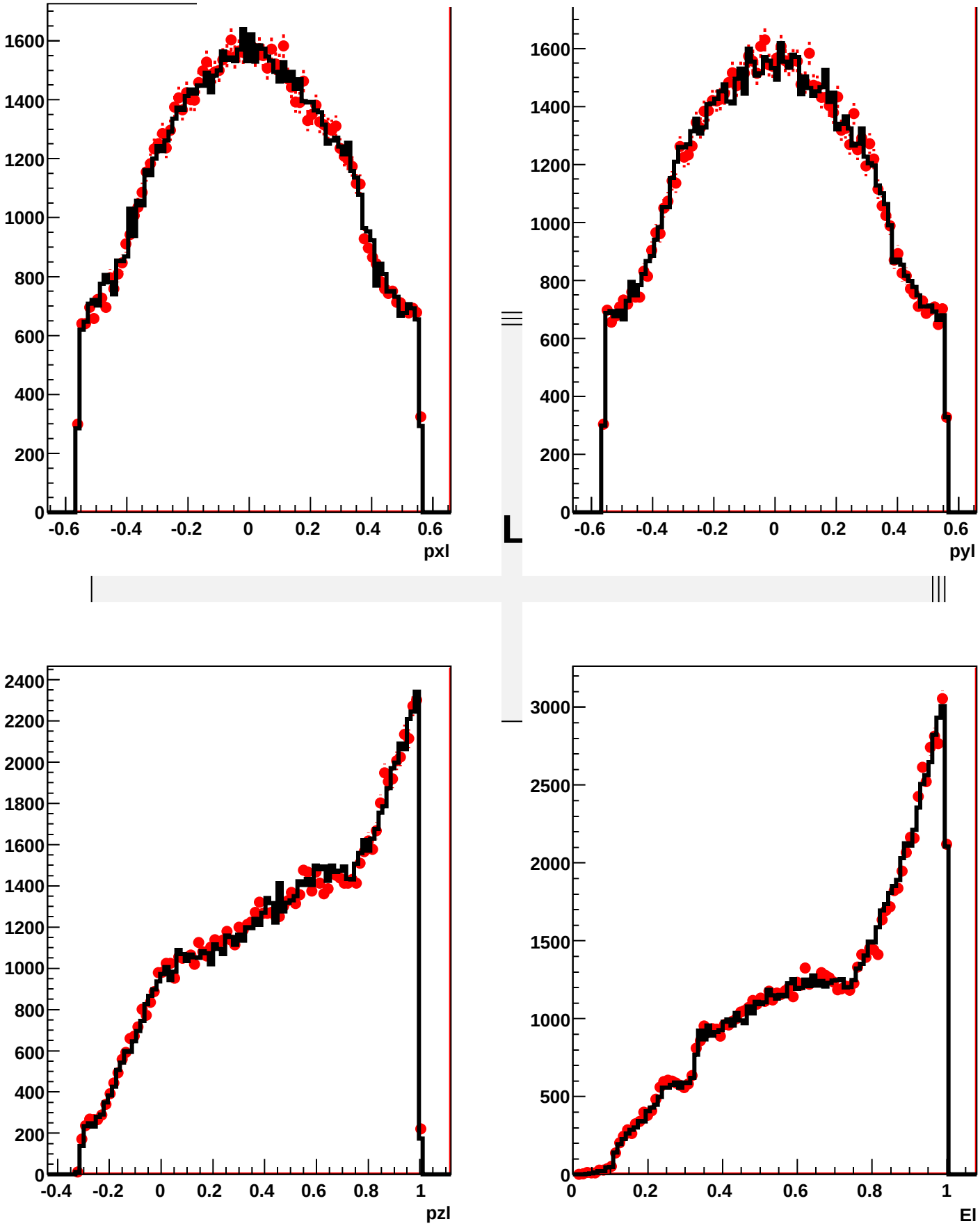

×10^3
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pyn


×10^3
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pzn

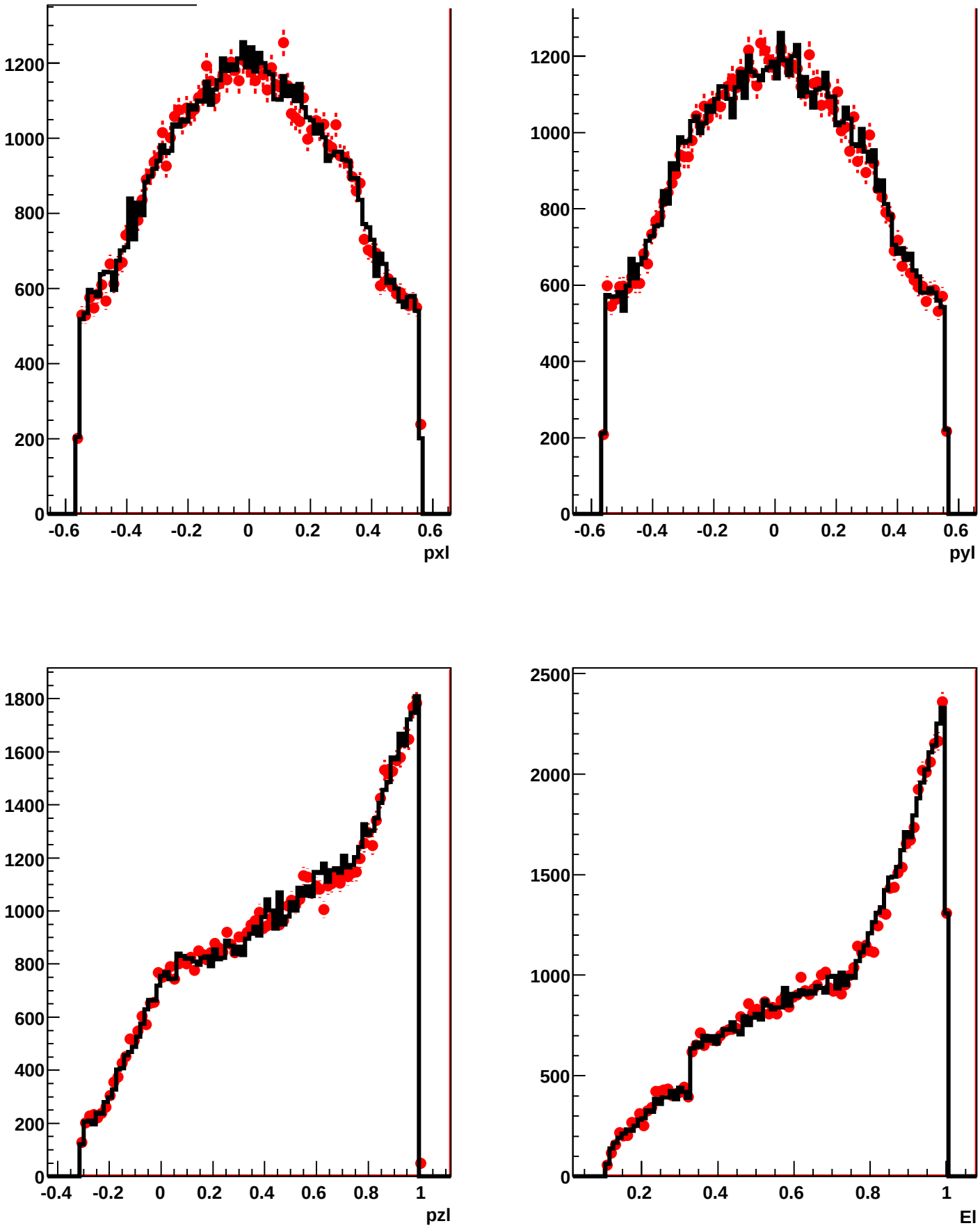

×10^3
100
80
60
40
20
0
0
0.5
1
1.5
2
En

Final State Primary Lepton 4-Momentum

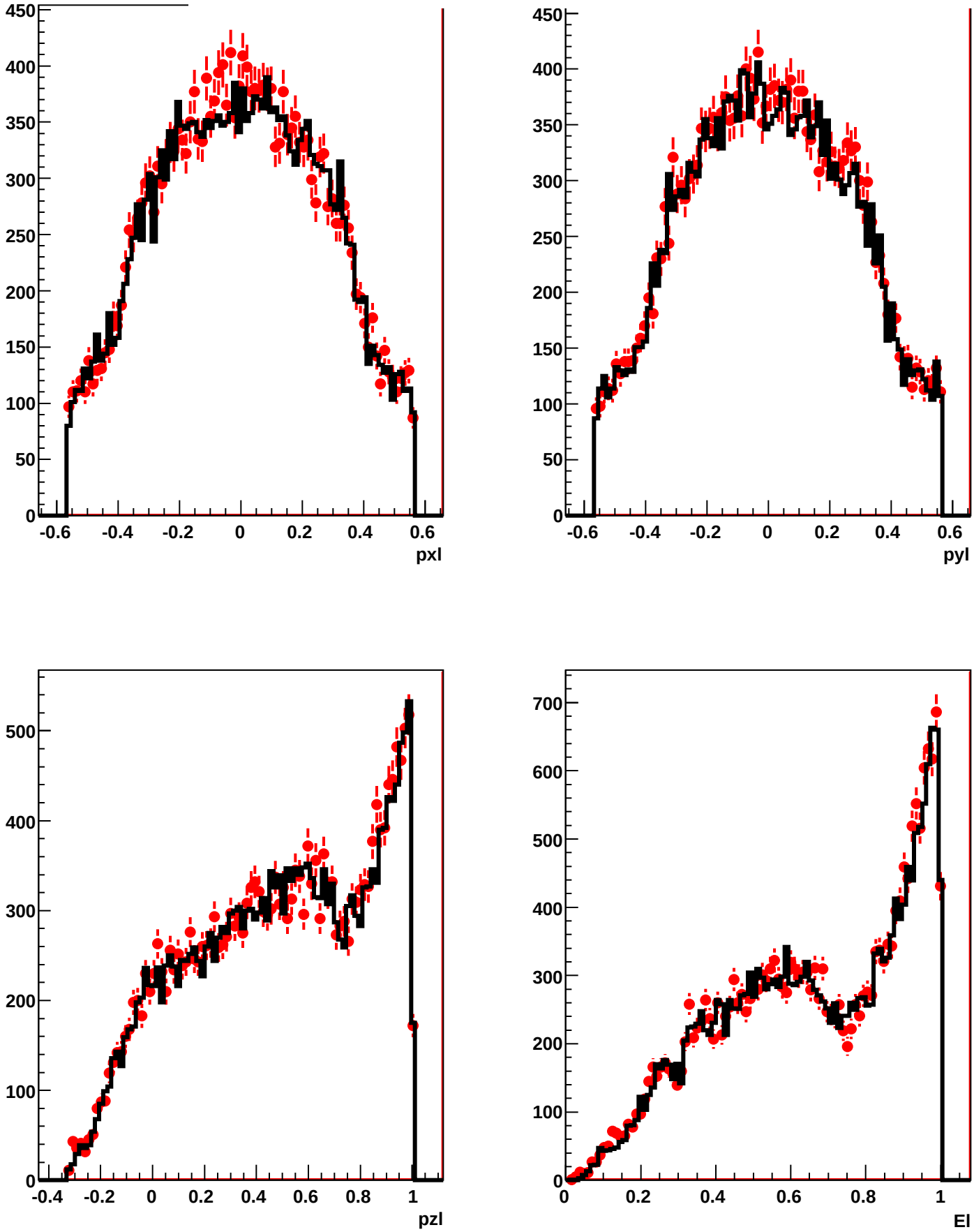
Final state primary lepton 4-p: All events



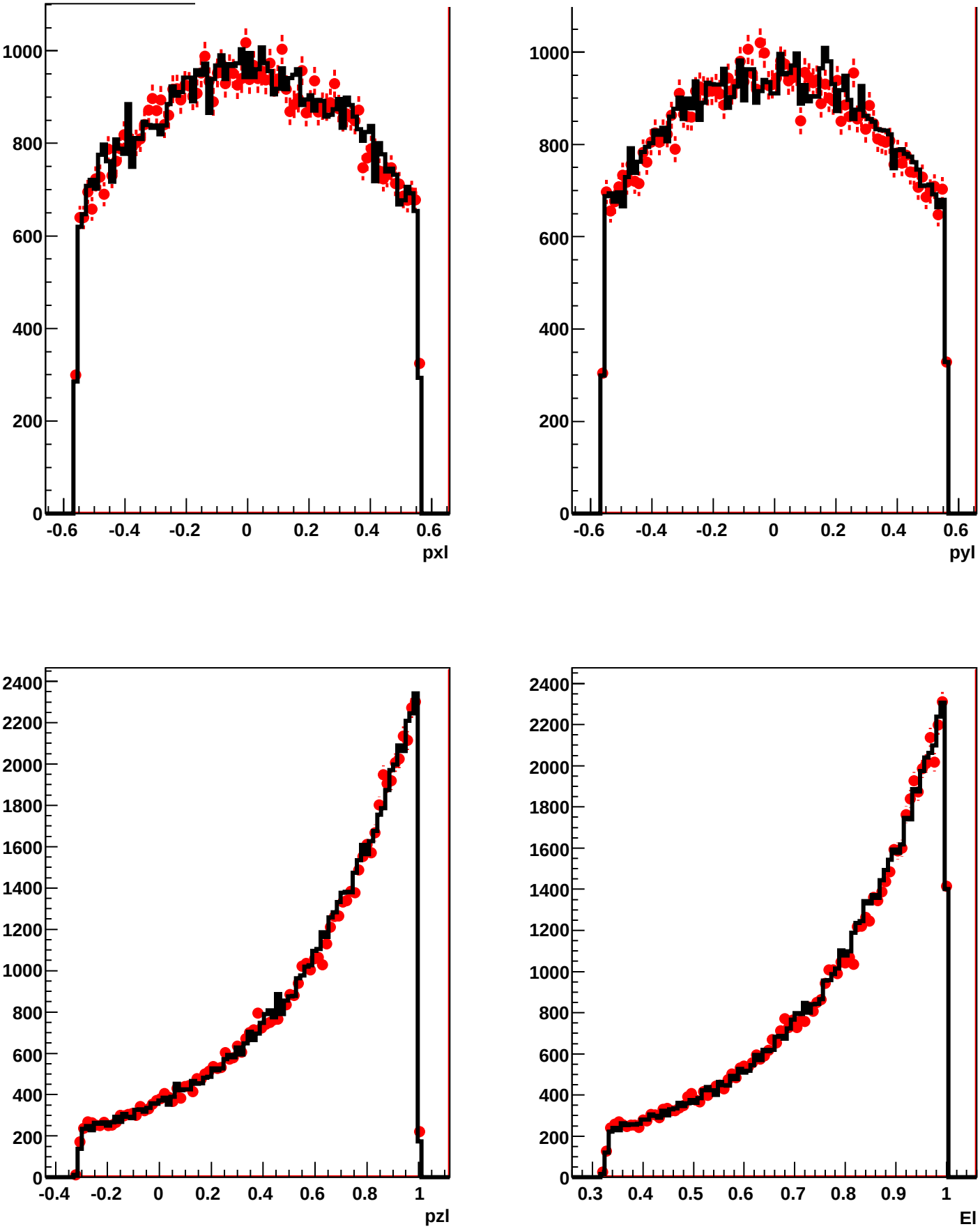
Final state primary lepton 4-p: All CC events



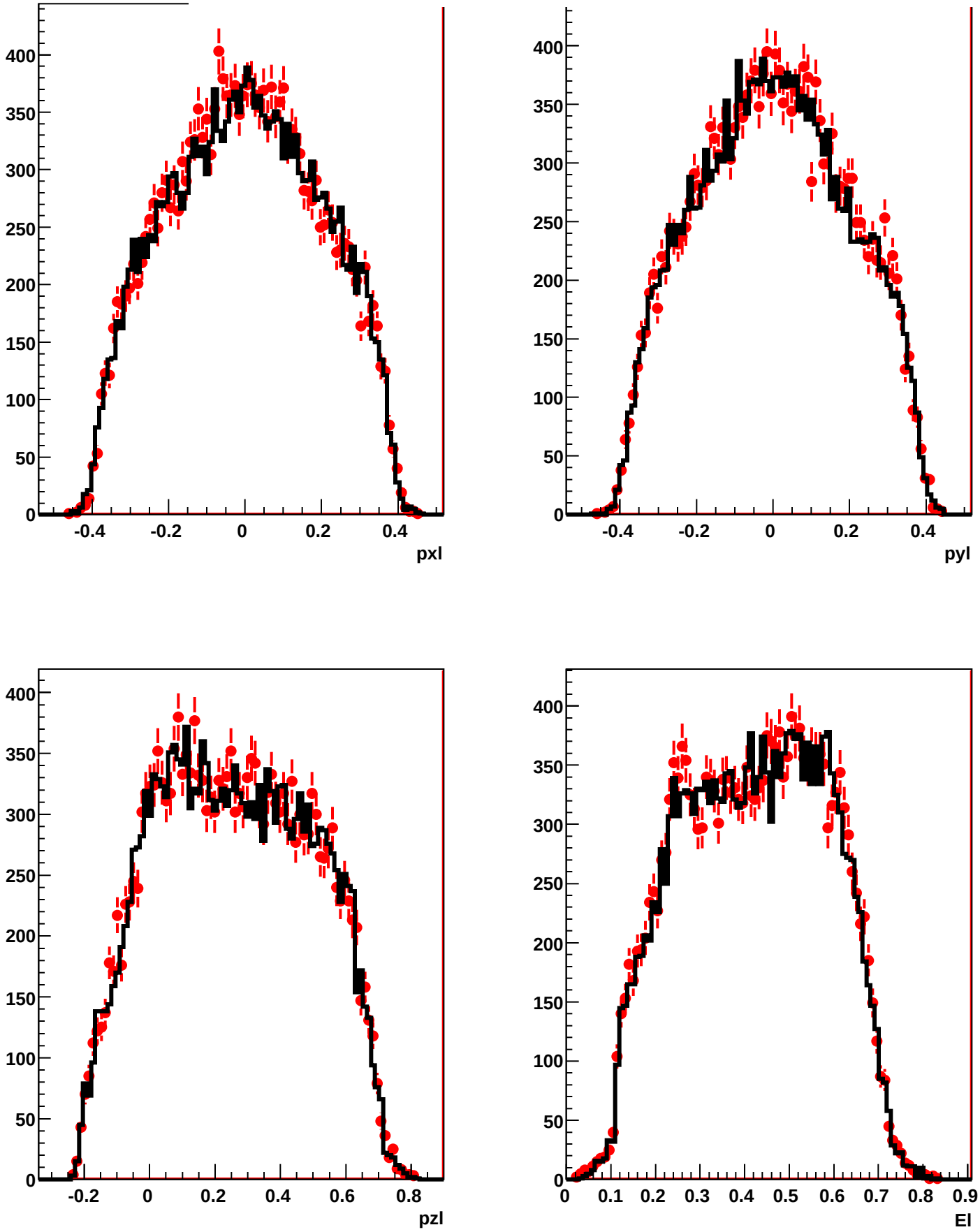
Final state primary lepton 4-p: All NC events



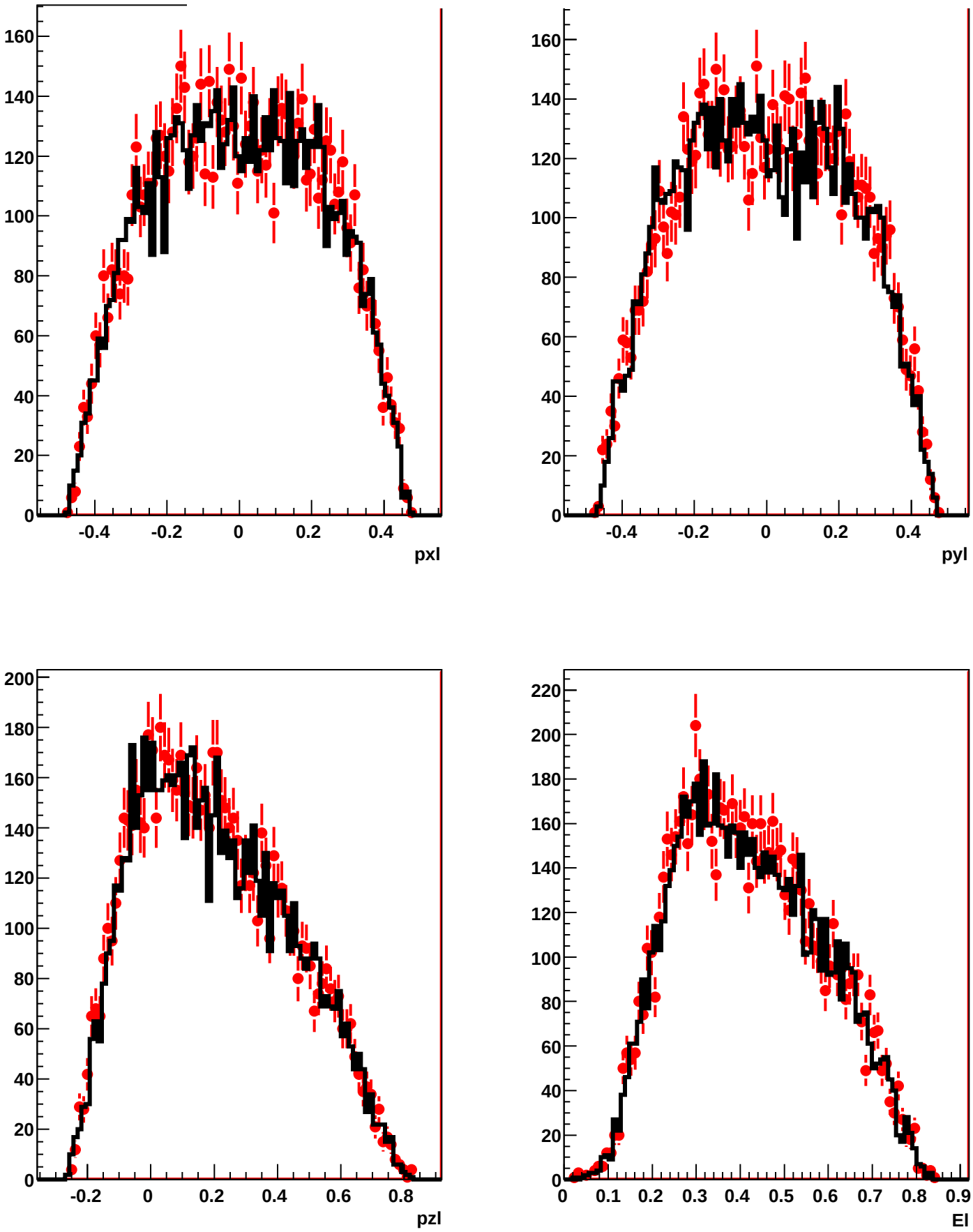
Final state primary lepton 4-p: QEL events



Final state primary lepton 4-p: RES events



Final state primary lepton 4-p: All DIS events



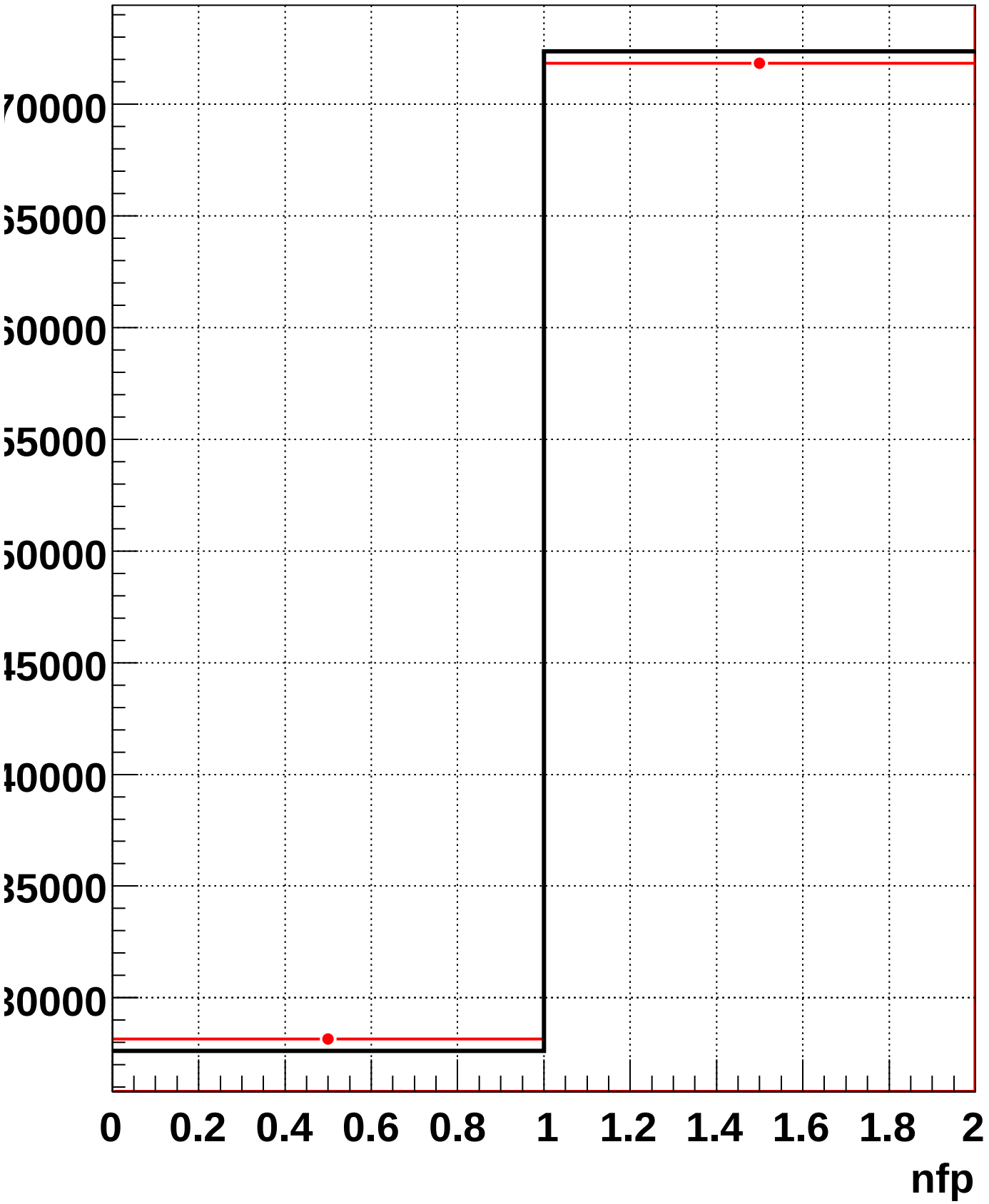
Final State Hadronic System

Multiplicities and 4-Momenta

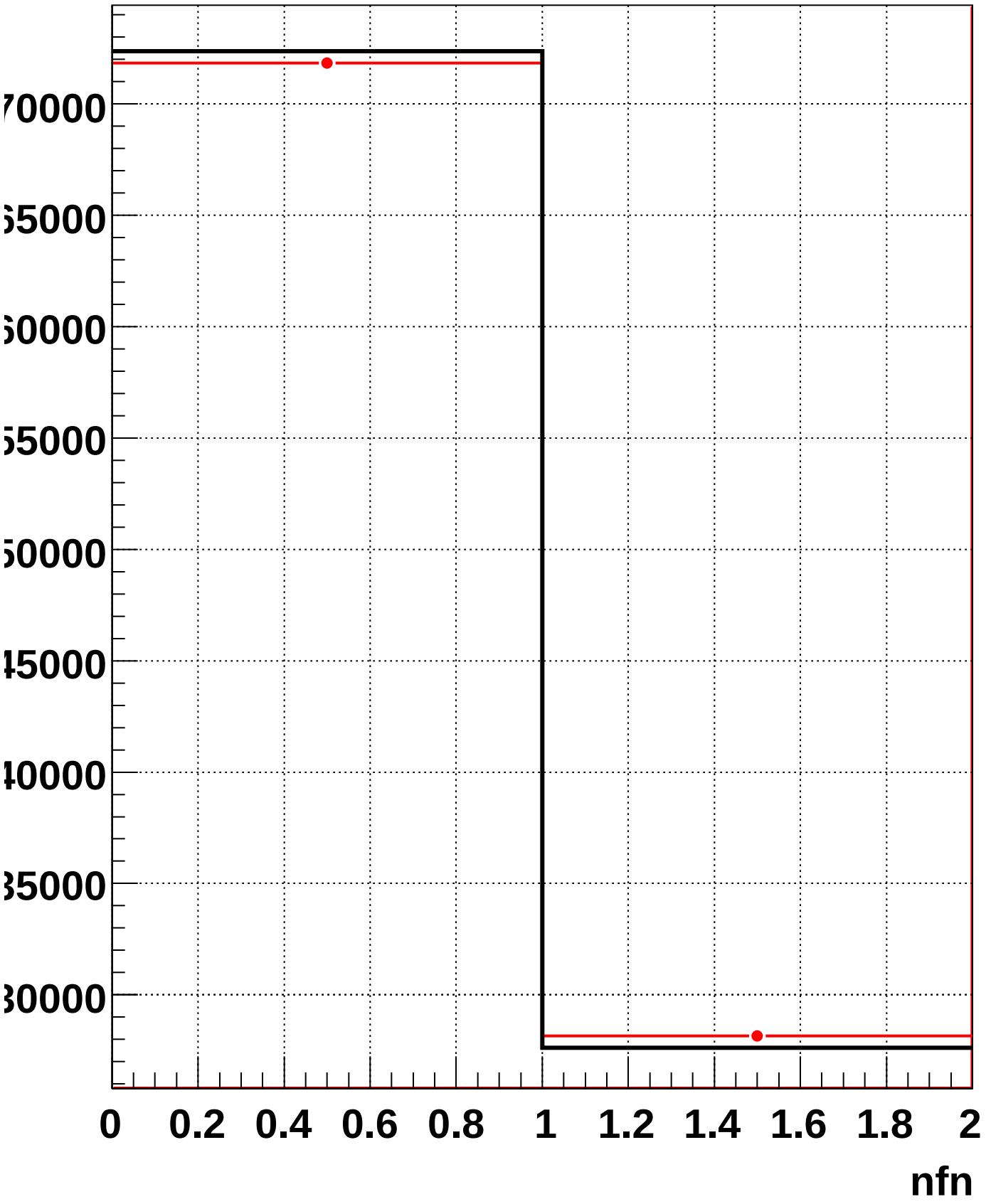
Note:

For nuclear targets these plots include the effect of intranuclear hadron transport / rescattering

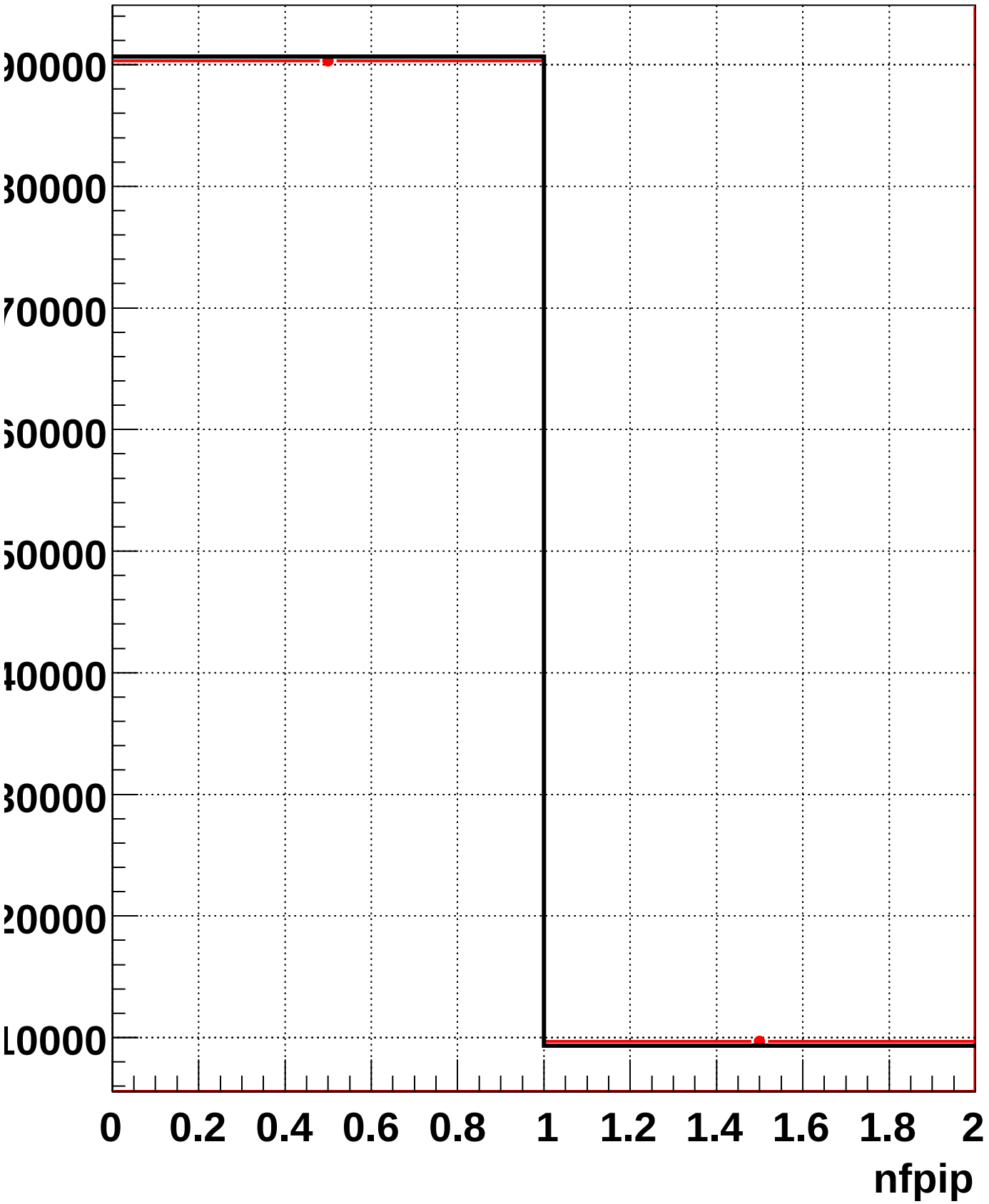
Number of final state protons

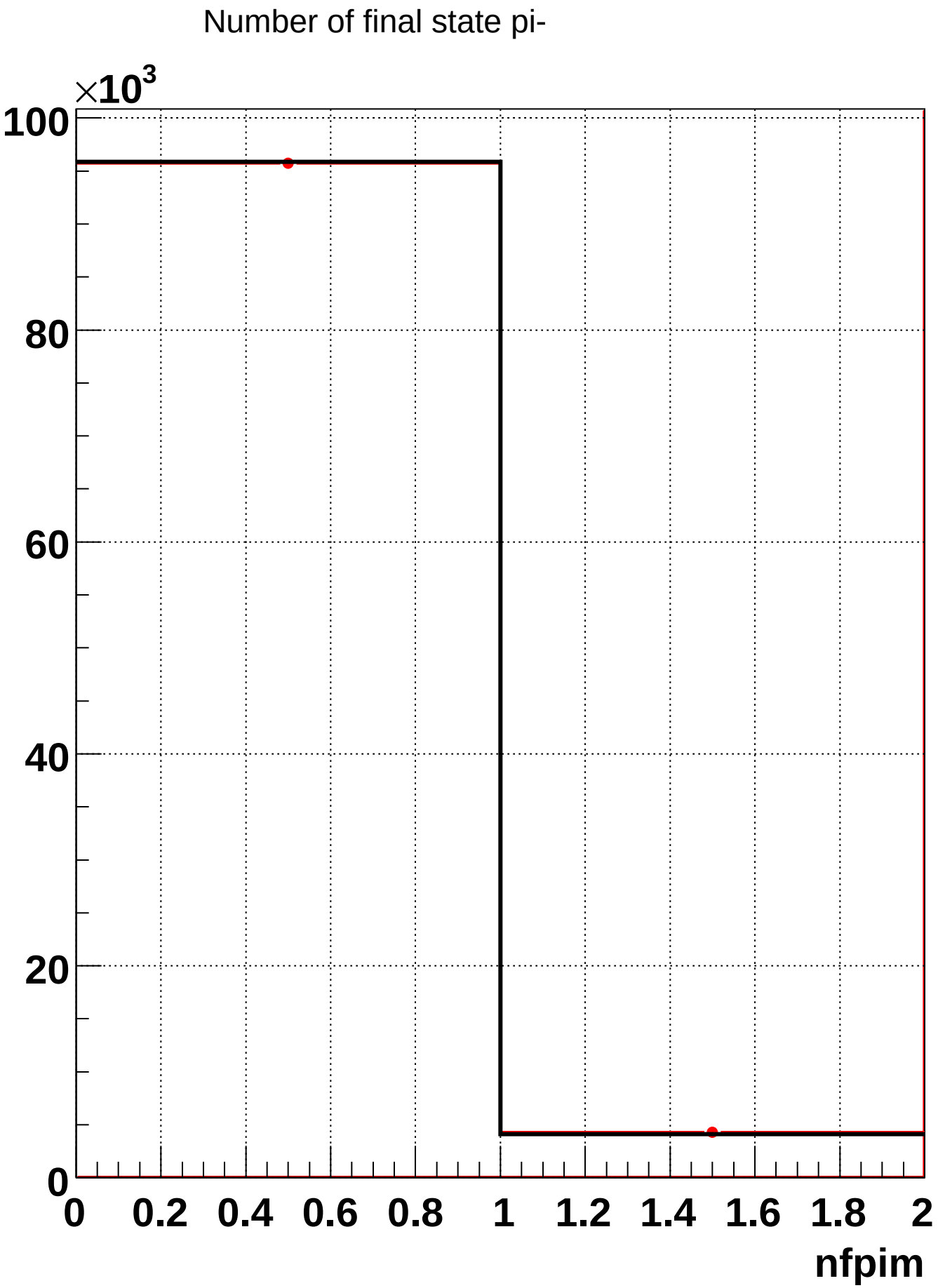


Number of final state neutrons

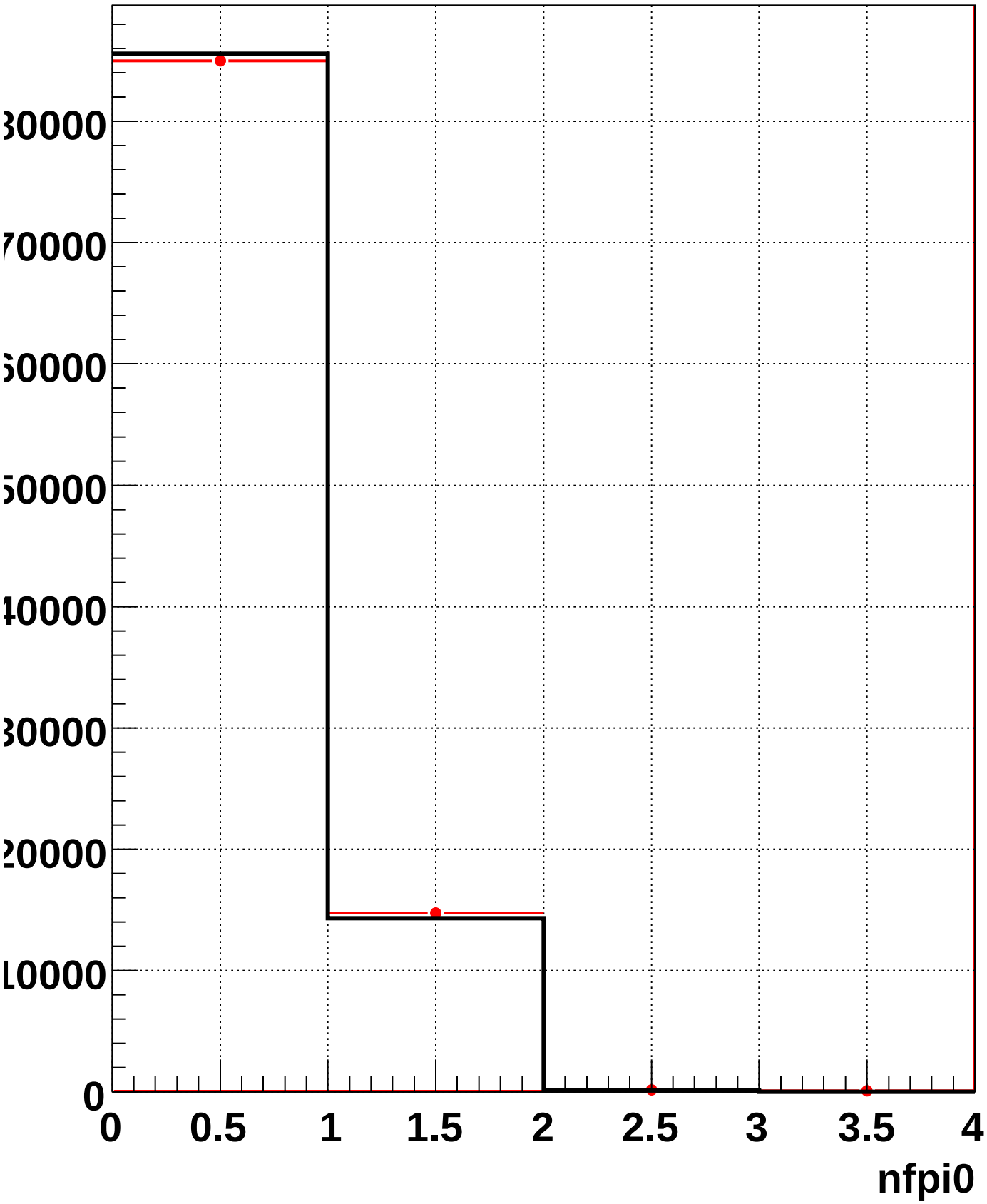


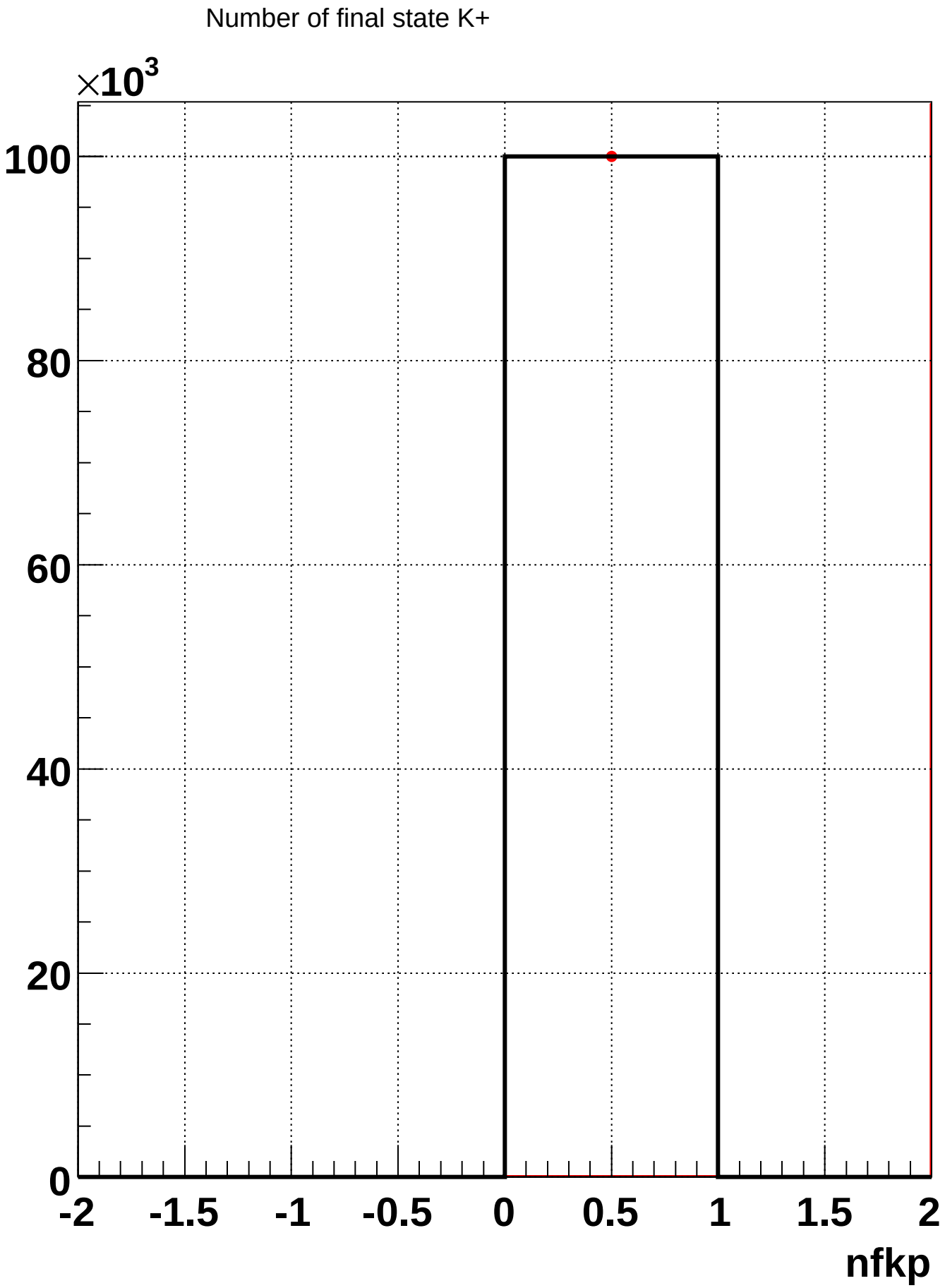
Number of final state pi+

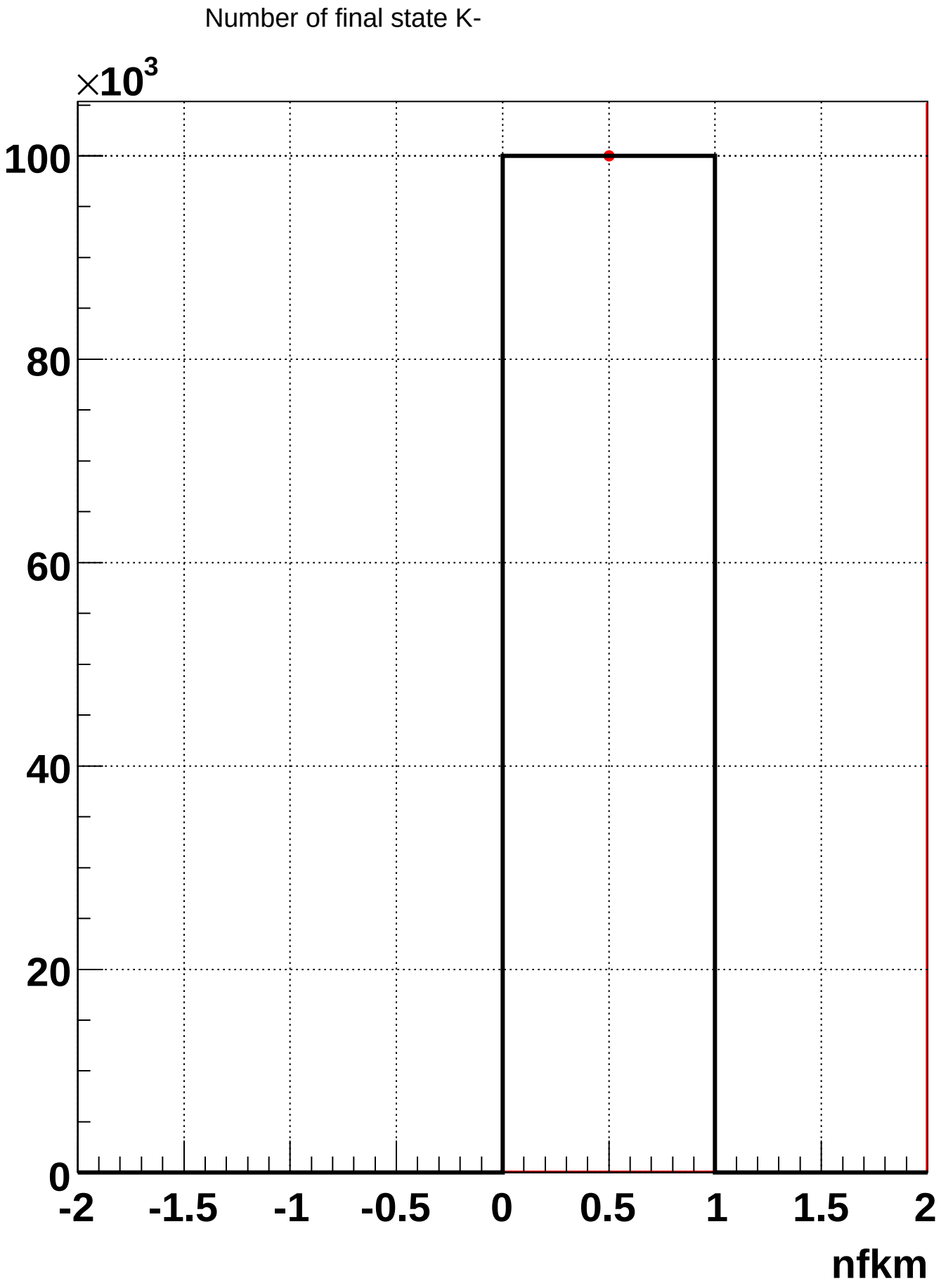


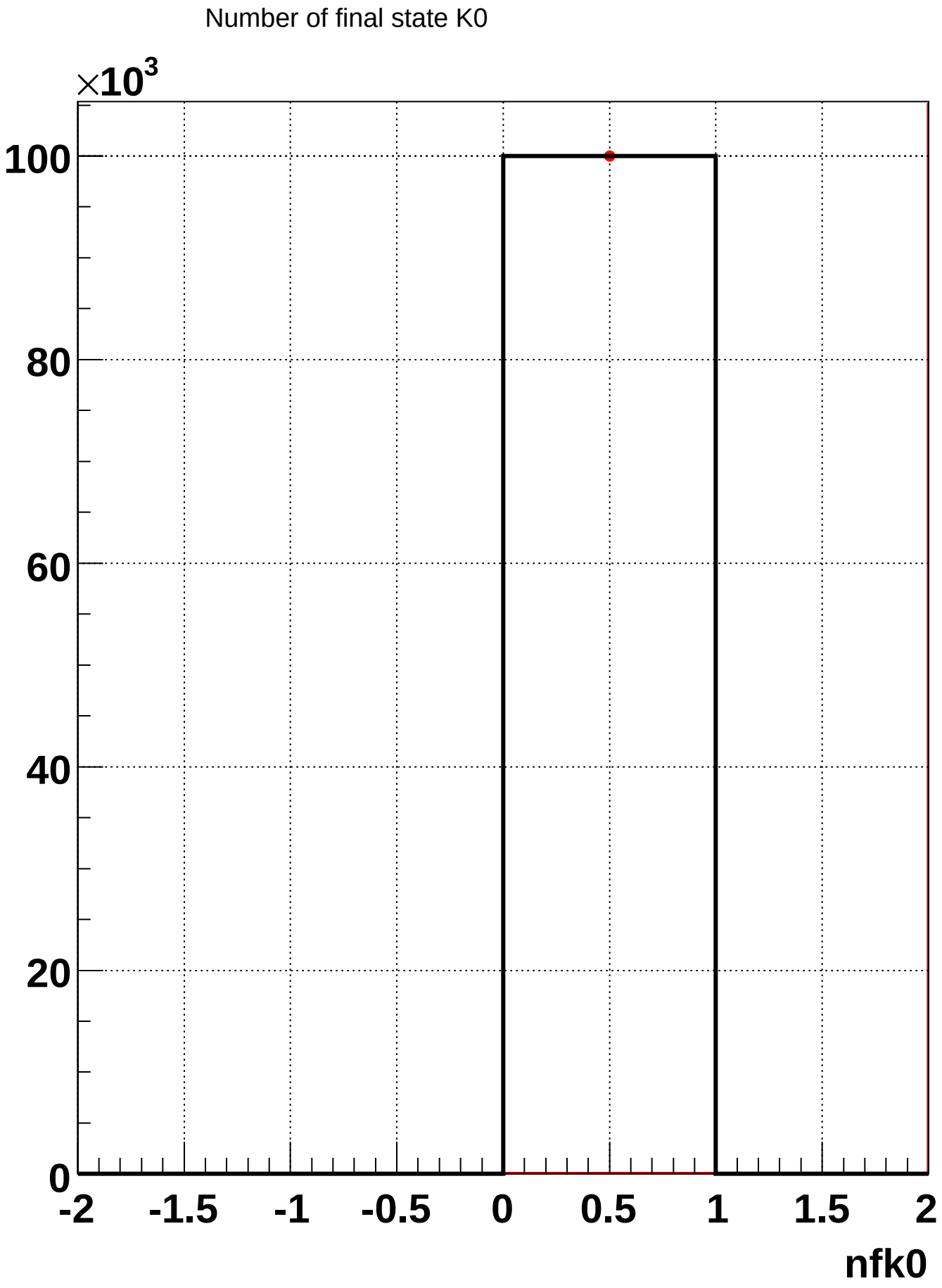

Number of final state pi-
×10^3
100
80
60
40
20
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
nfpim

Number of final state pi0

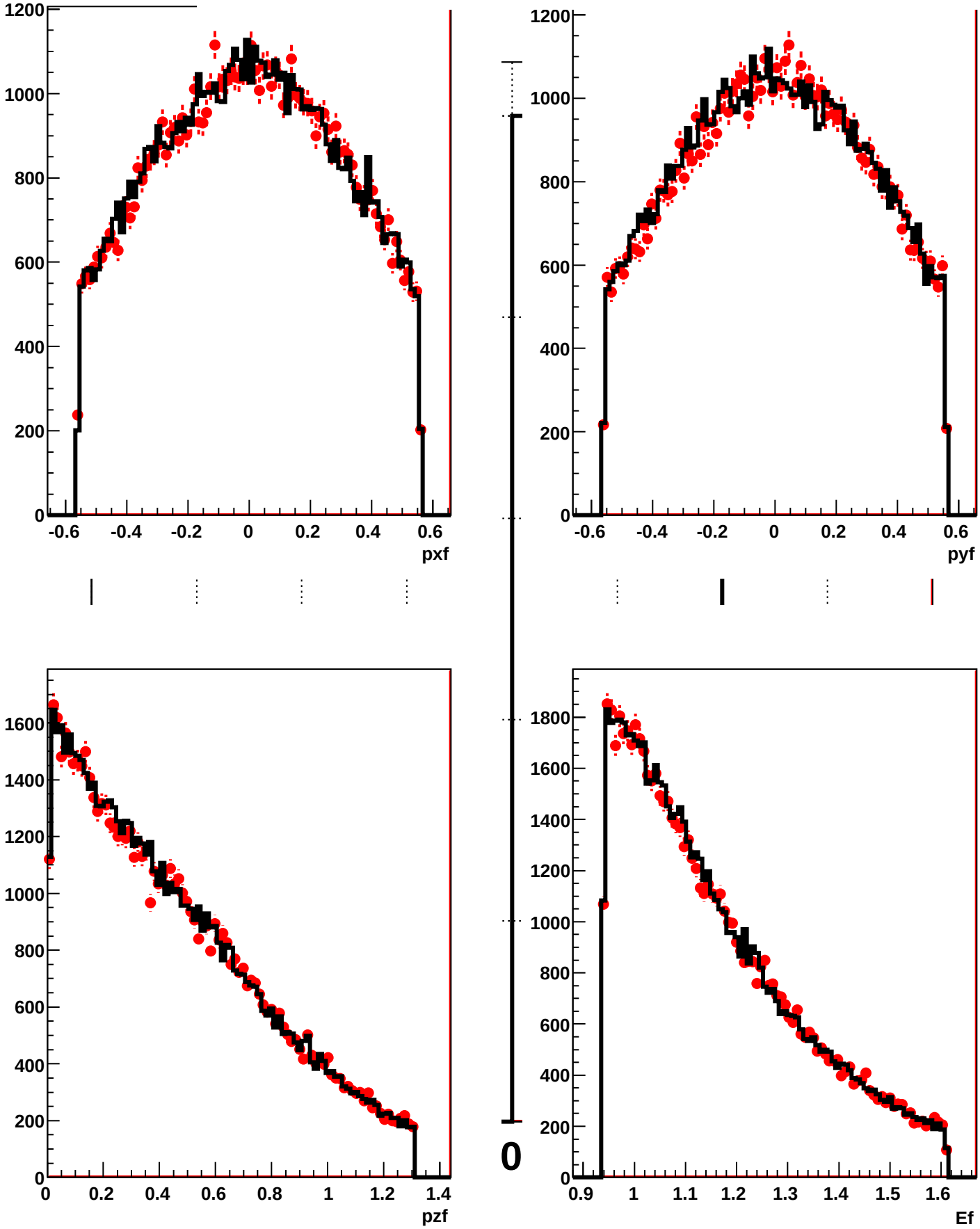



Number of final state K+
×10^3
100
80
60
40
20
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
nfkp

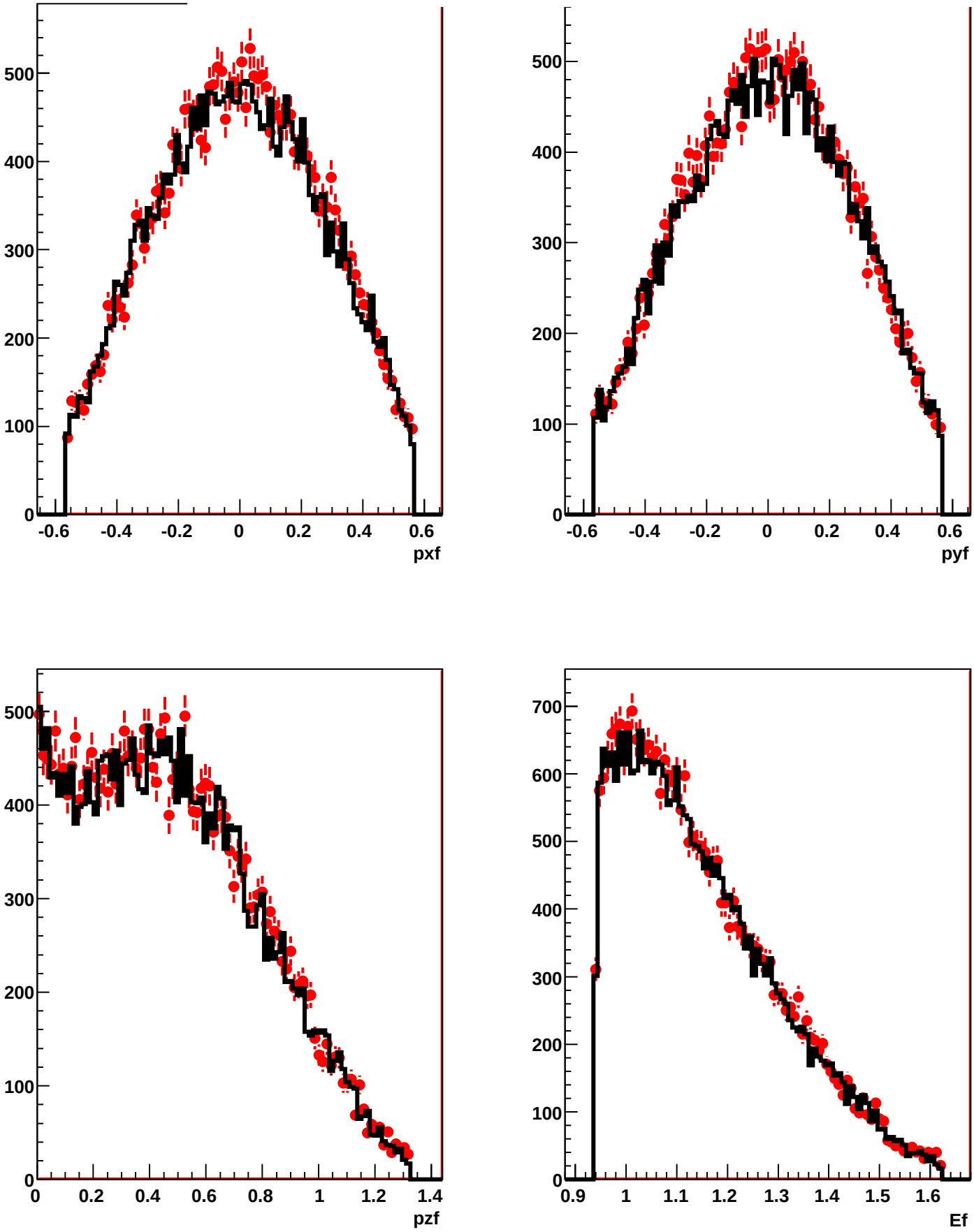

Number of final state K-
×10^3
100
80
60
40
20
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
nfkm


Number of final state K0
×10^3
100
80
60
40
20
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
nfk0

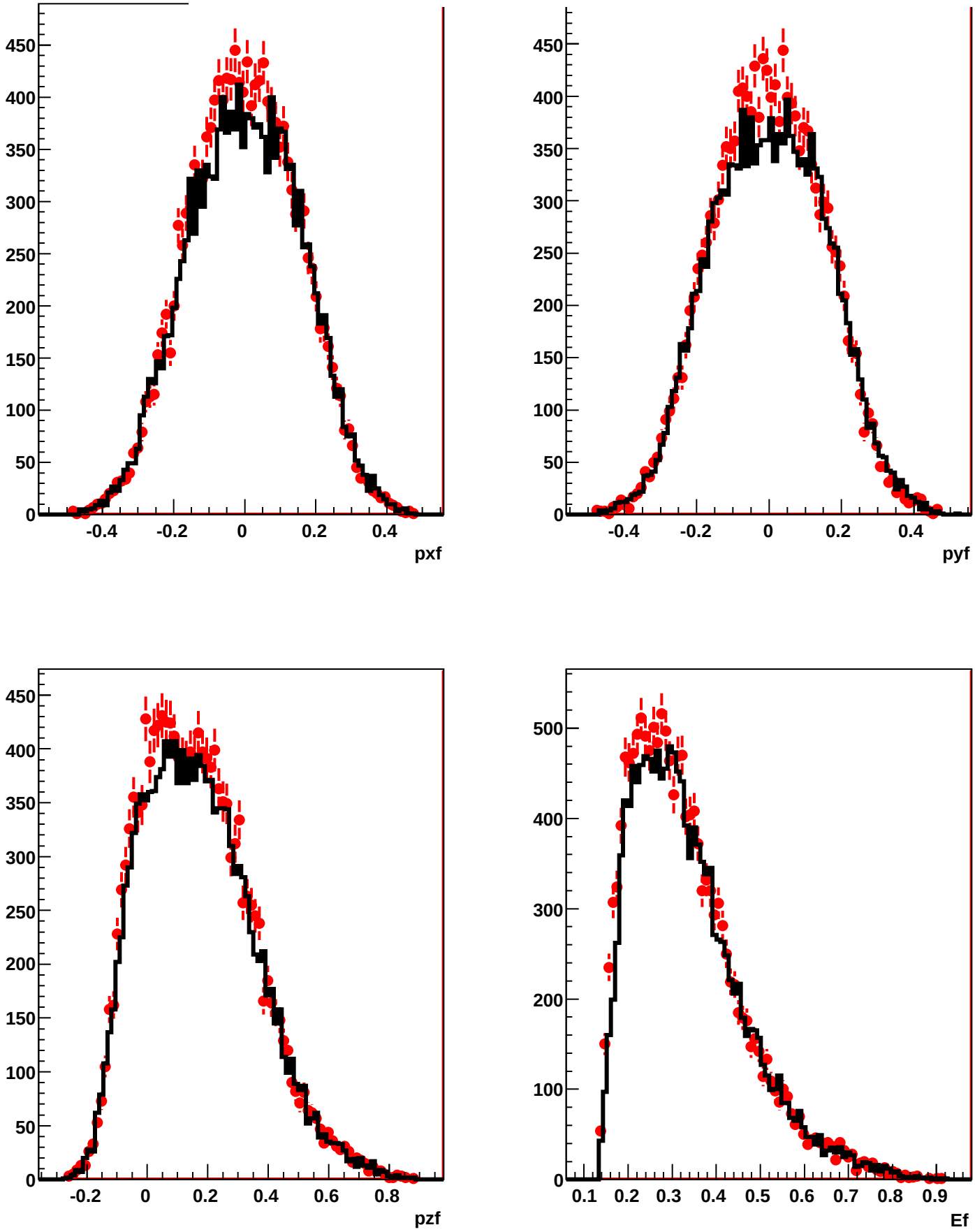
Final state protons 4-momentum



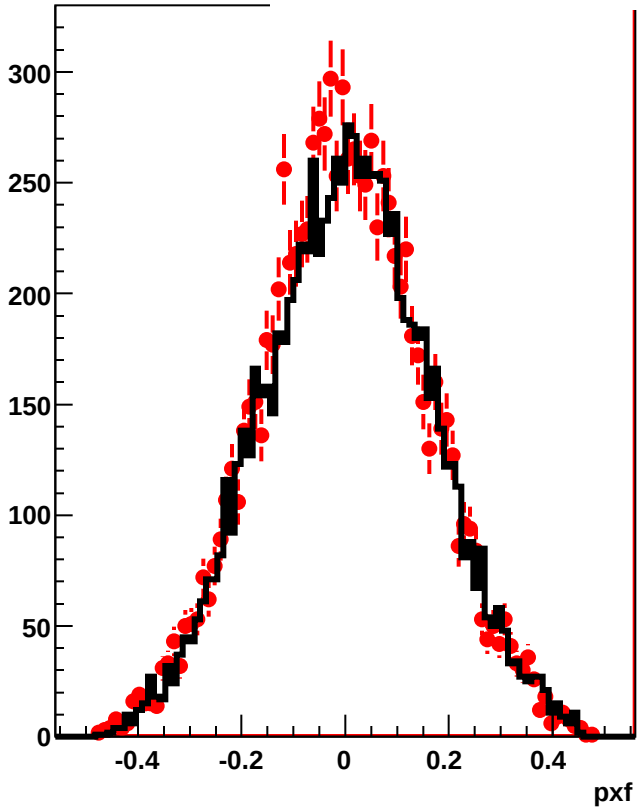
Final state neutrons 4-momentum

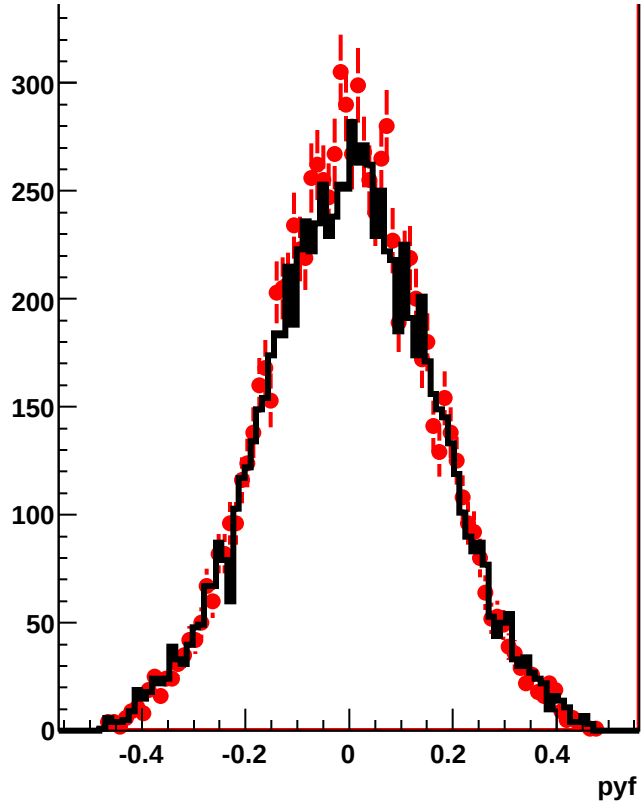


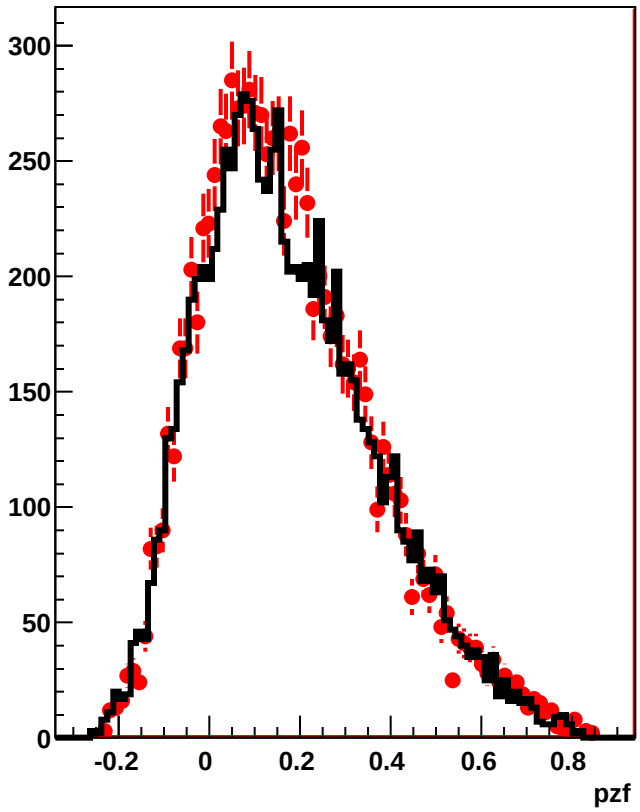
Final state pi0's 4-momentum

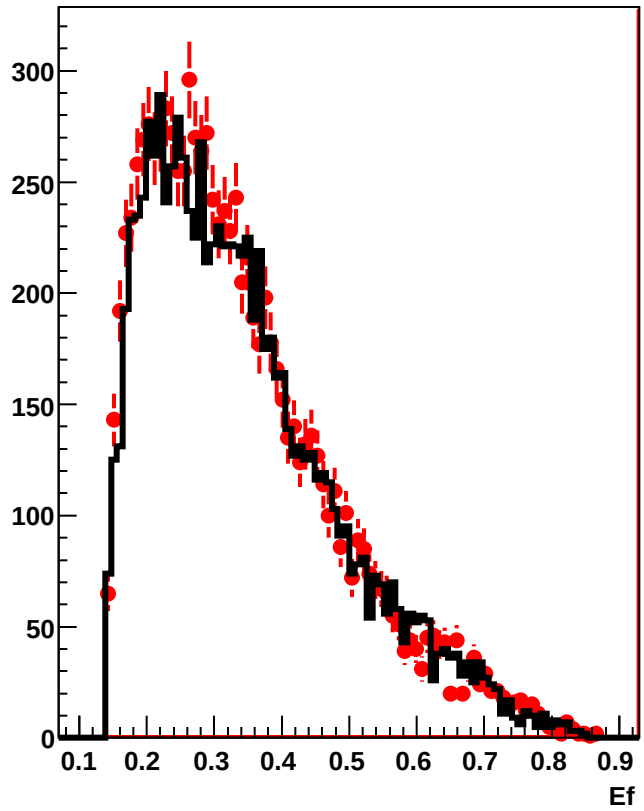


Final state pi+’s 4-momentum

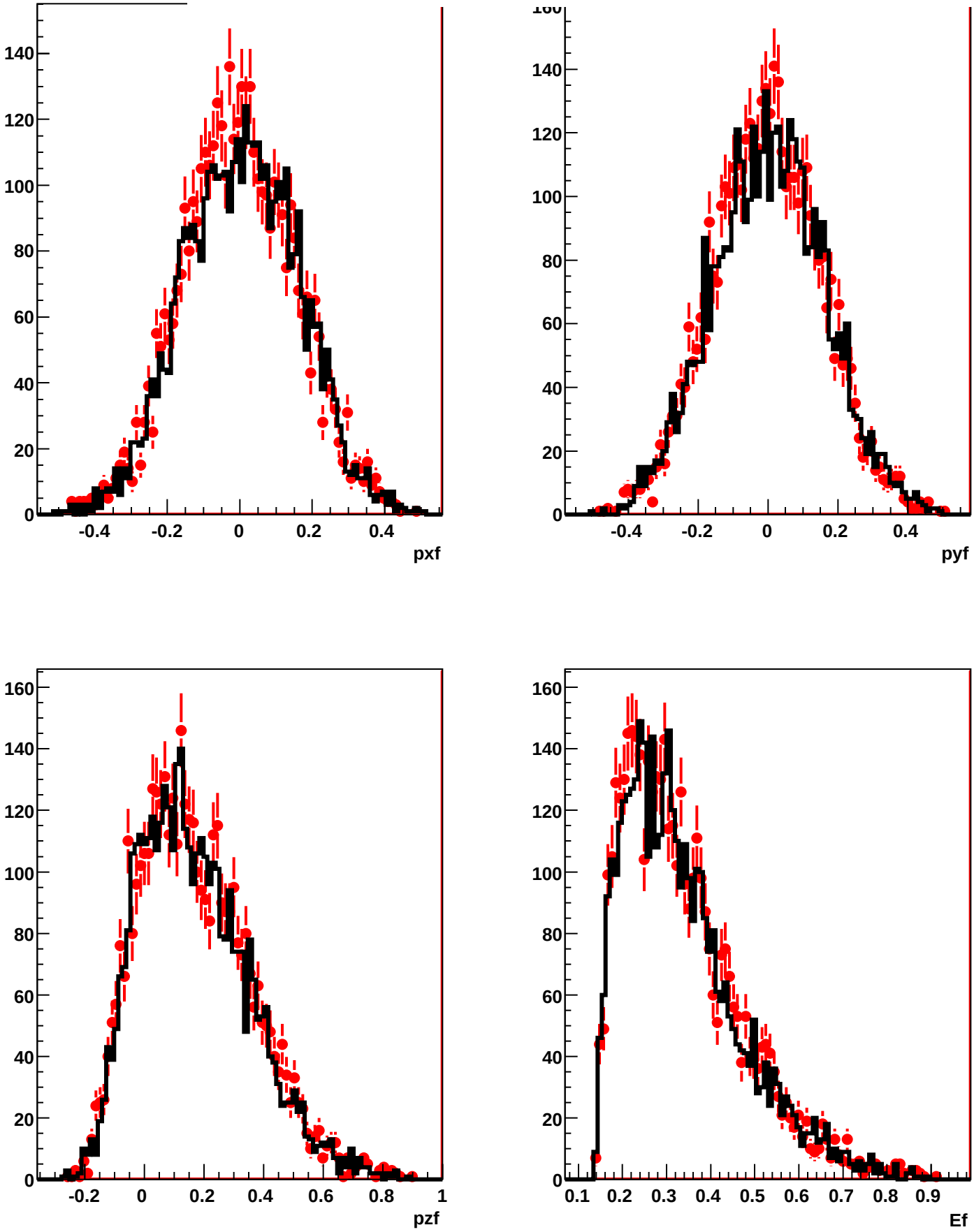








Final state pi-'s 4-momentum



GENIE-2.0.0 vs NEUGEN/Daikon+ Event Sample Comparisons

Event Sample:

100k events, numu+n, 5GeV, all processes

Notes:

Daikon+ is a NEUGEN Daikon revision version

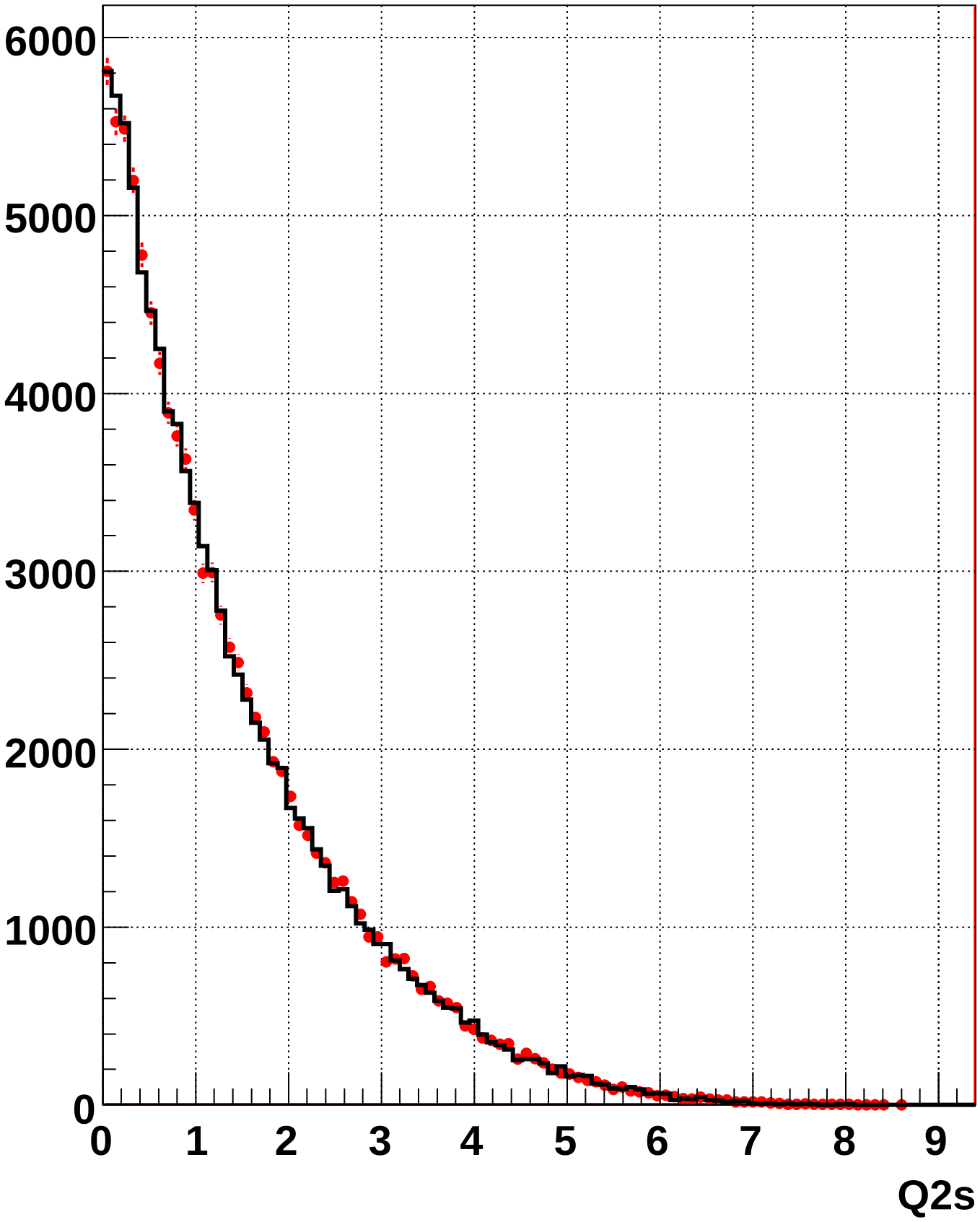
GENIE predictions shown with lines / NEUGEN's with markers

Event Numbers:

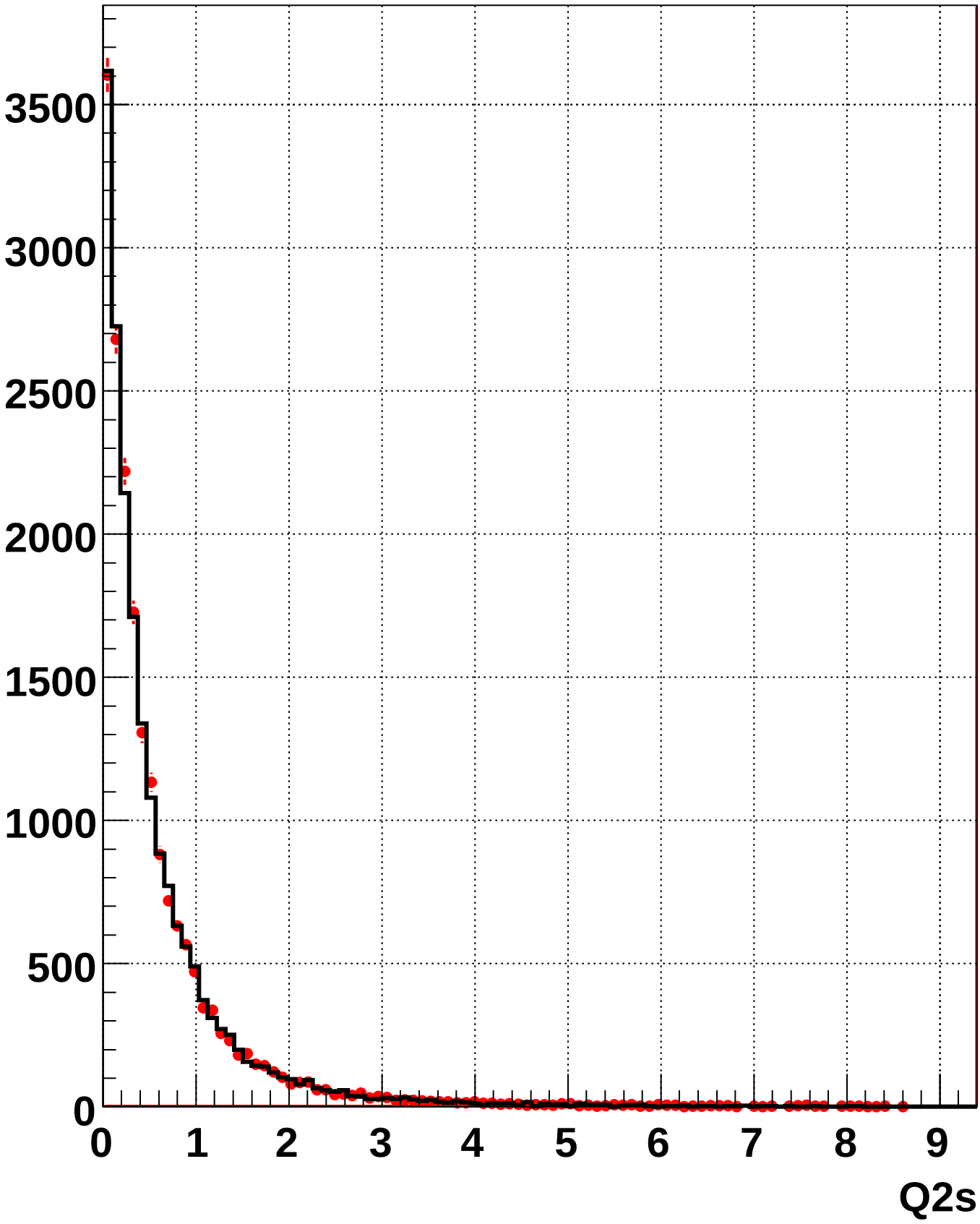
ALL :	100000 [NeuGEN],	100000 [GENIE]
QEL :	19038 [NeuGEN],	19086 [GENIE]
QEL-CC :	15324 [NeuGEN],	15442 [GENIE]
QEL-NC :	3714 [NeuGEN],	3644 [GENIE]
RES :	18770 [NeuGEN],	18549 [GENIE]
RES-CC :	13734 [NeuGEN],	13577 [GENIE]
RES-NC :	5036 [NeuGEN],	4972 [GENIE]
DIS :	62192 [NeuGEN],	62365 [GENIE]
DIS-CC :	49214 [NeuGEN],	49345 [GENIE]
(charm):	110 [NeuGEN],	89 [GENIE]
DIS-NC :	12978 [NeuGEN],	13020 [GENIE]
COH :	0 [NeuGEN],	0 [GENIE]
COH-CC :	0 [NeuGEN],	0 [GENIE]
COH-NC :	0 [NeuGEN],	0 [GENIE]
IMD :	0 [NeuGEN],	0 [GENIE]

Selected Kinematical Quantities

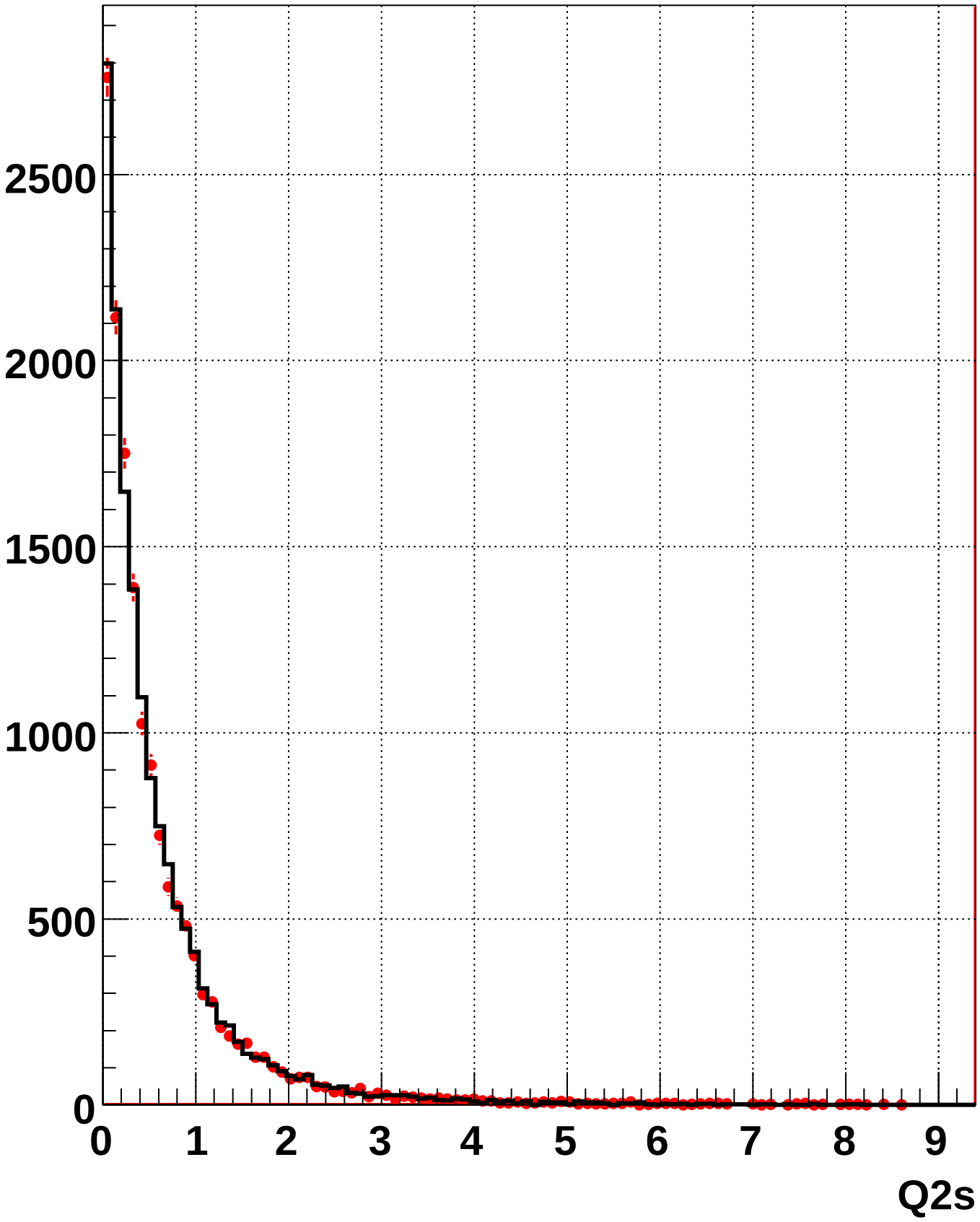
selected Q2 for all events



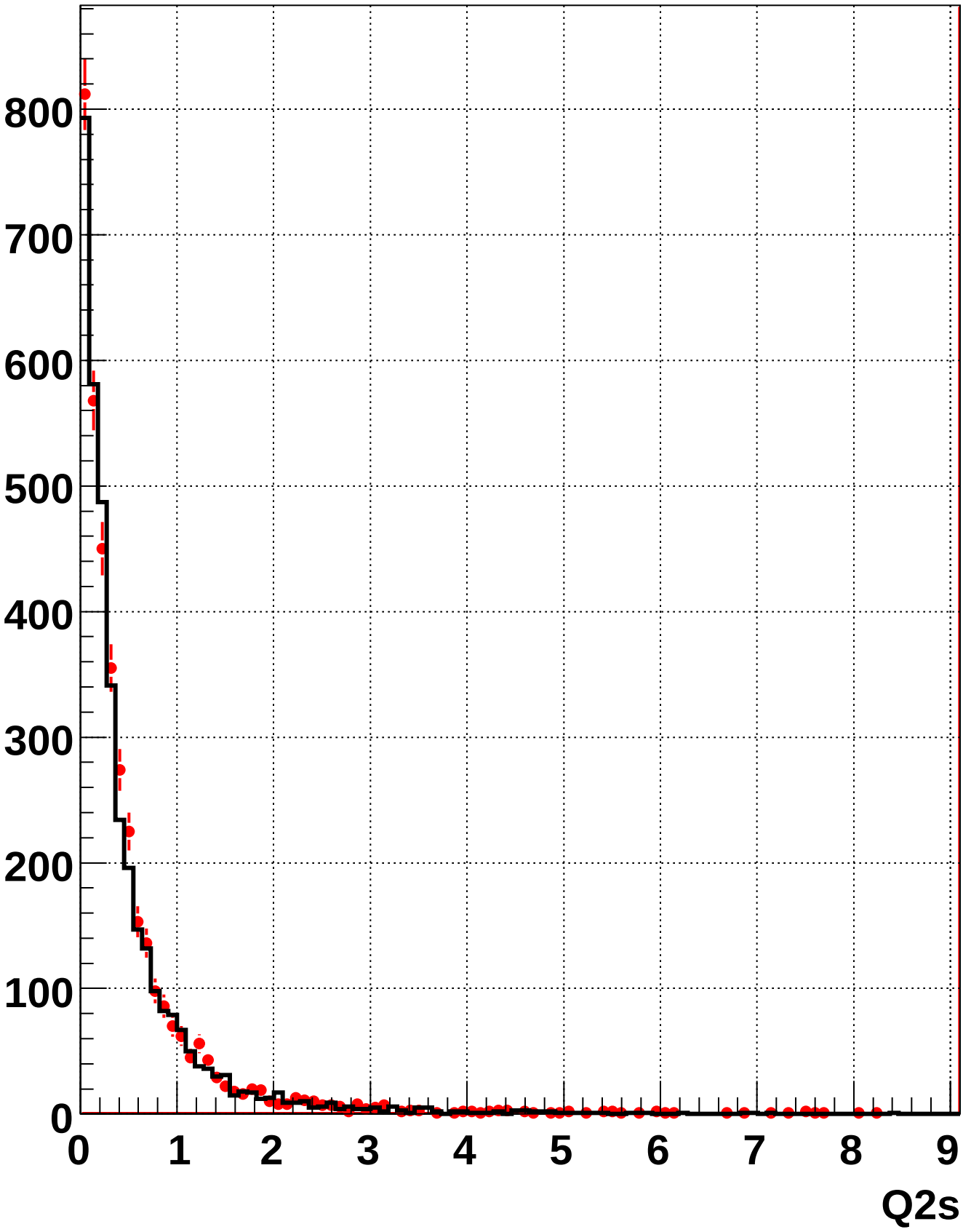
selected Q2 for QEL events



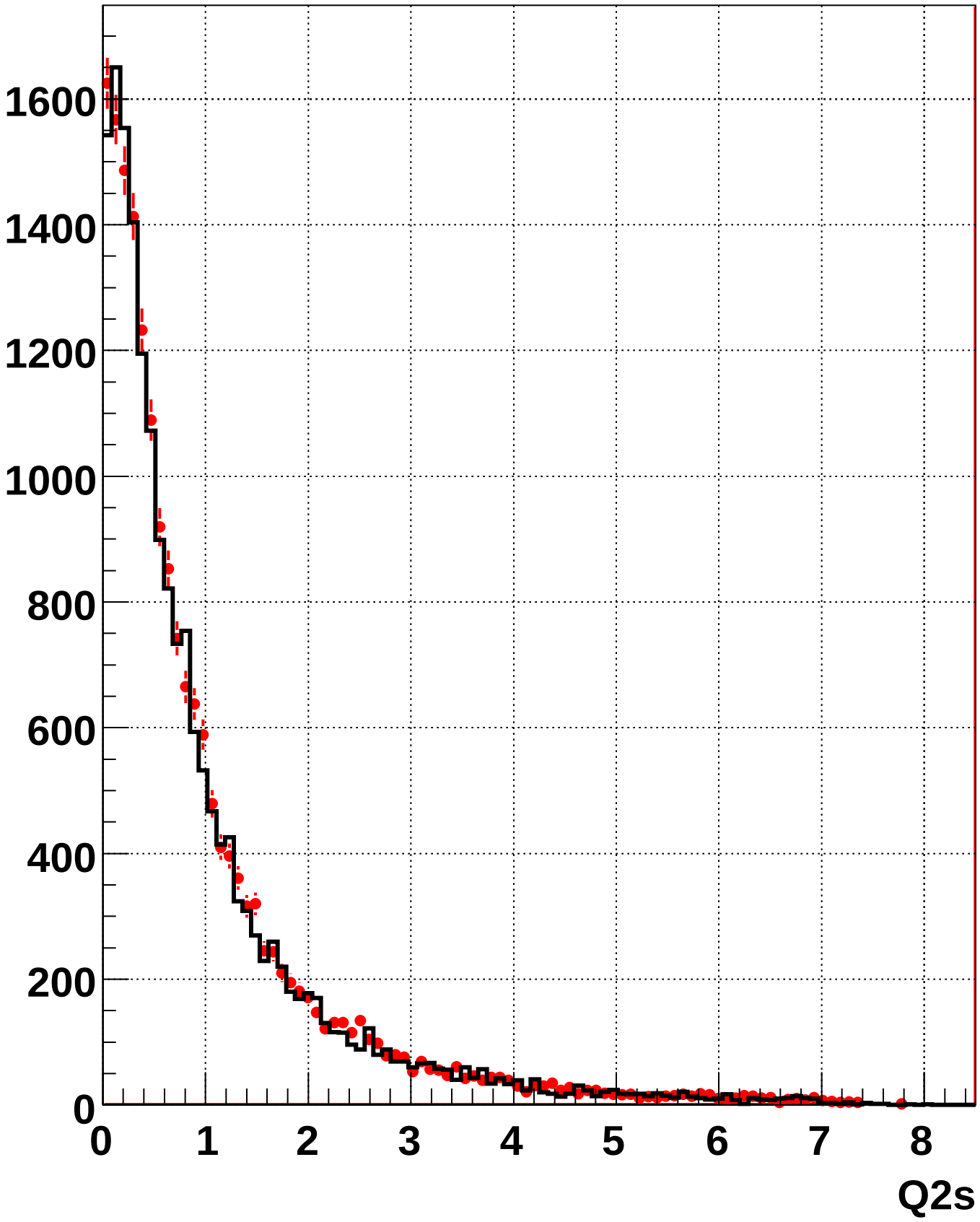
selected Q2 for QEL CC events



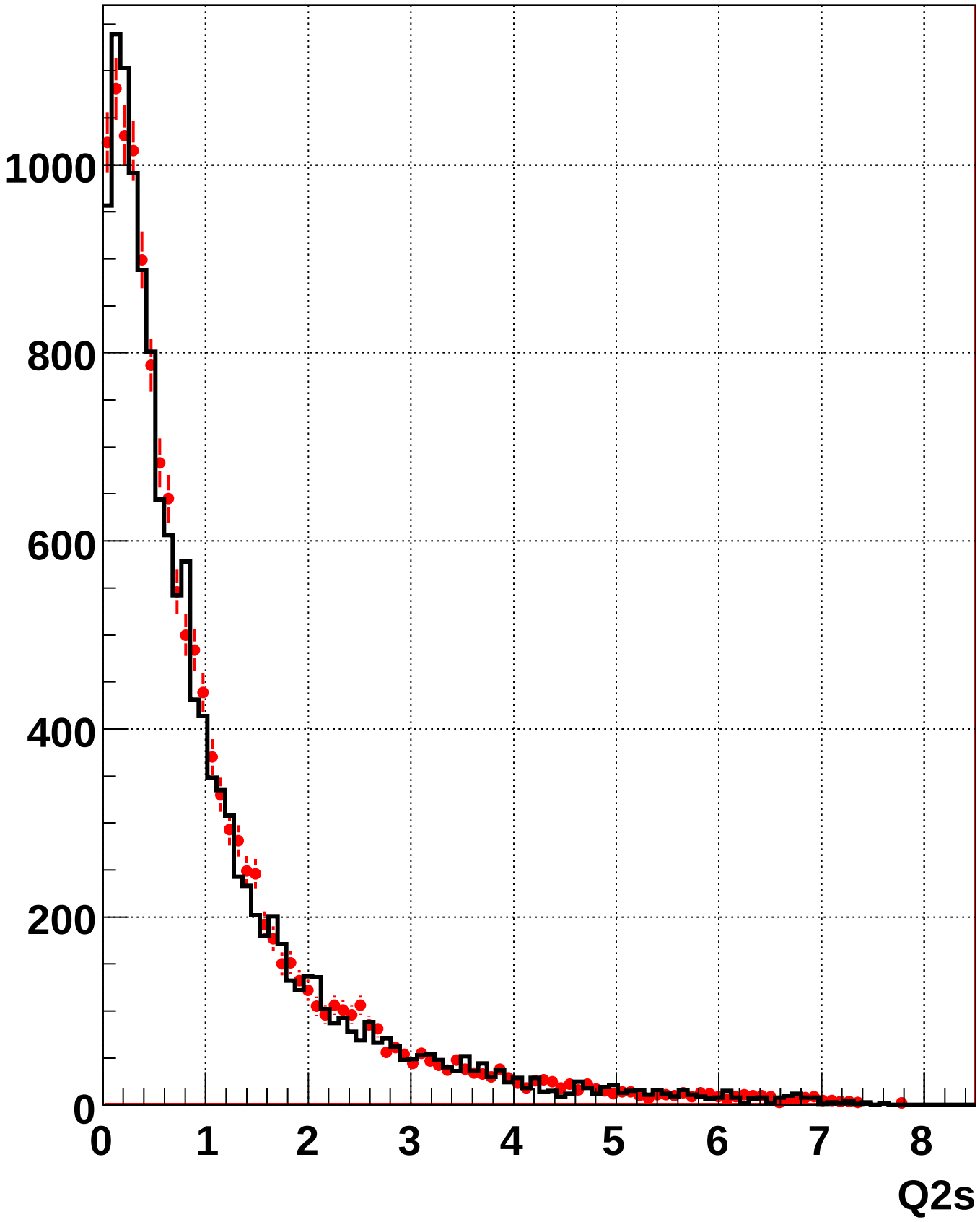
selected Q2 for QEL NC events



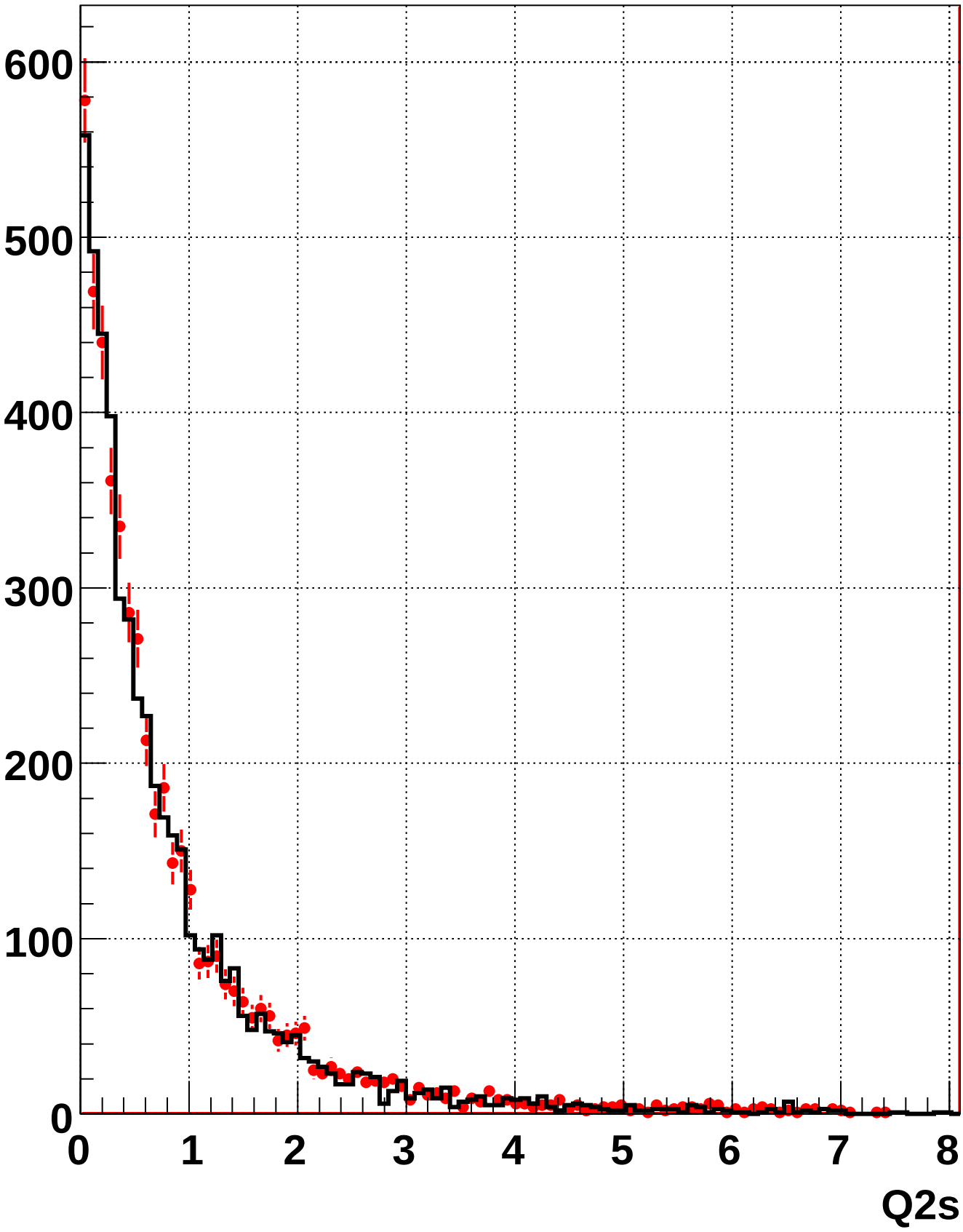
selected Q2 for RES events



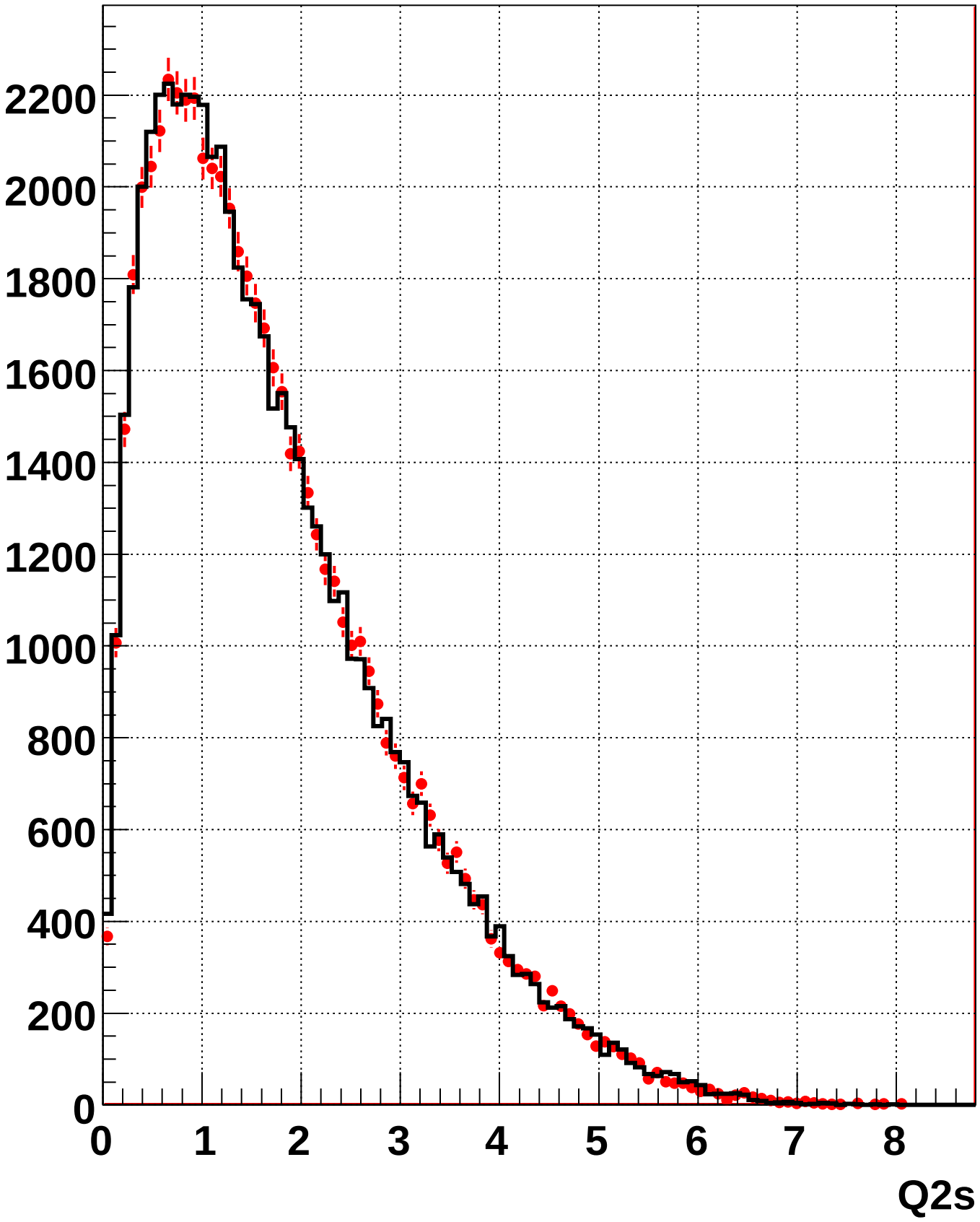
selected Q2 for RES CC events



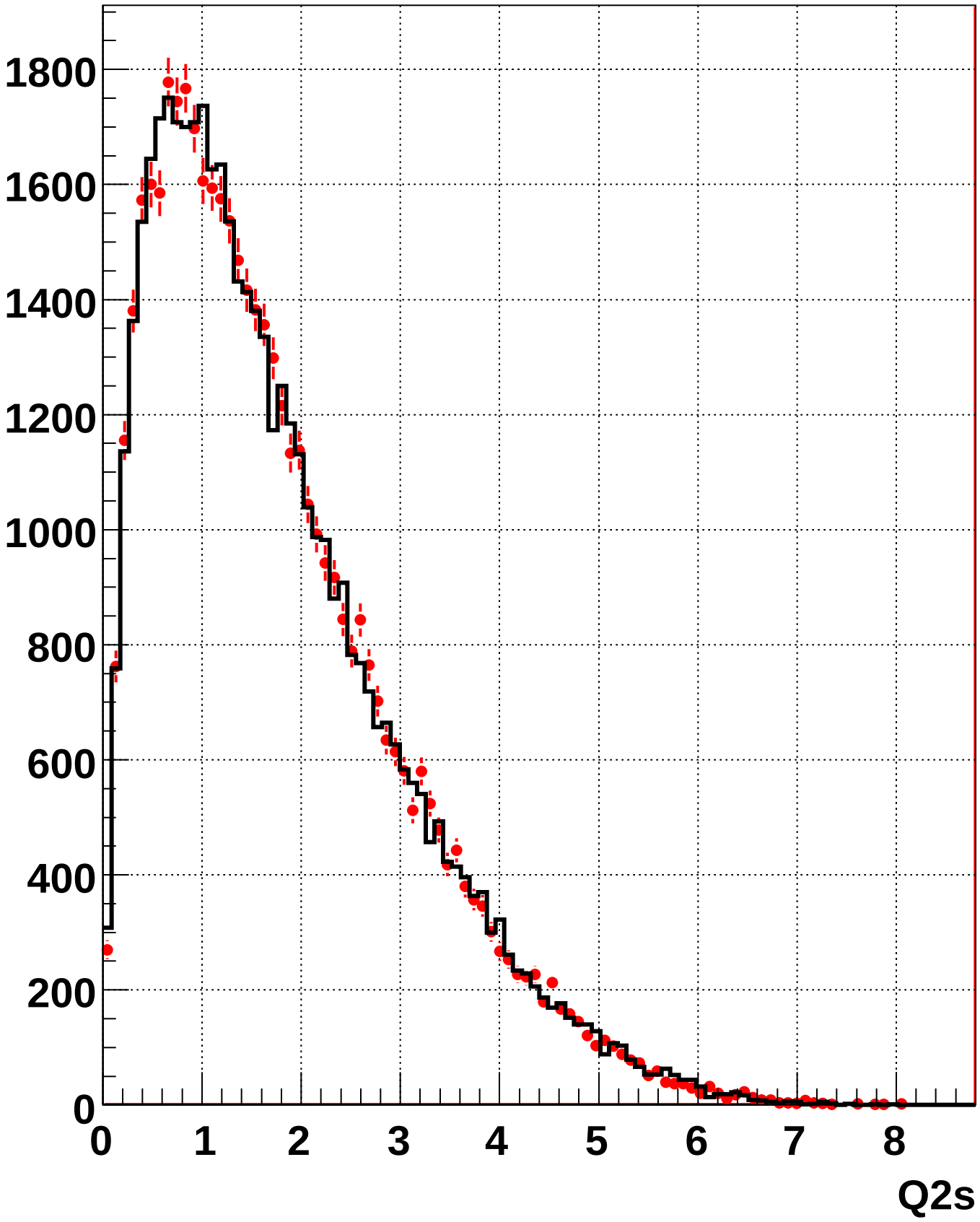
selected Q2 for RES NC events



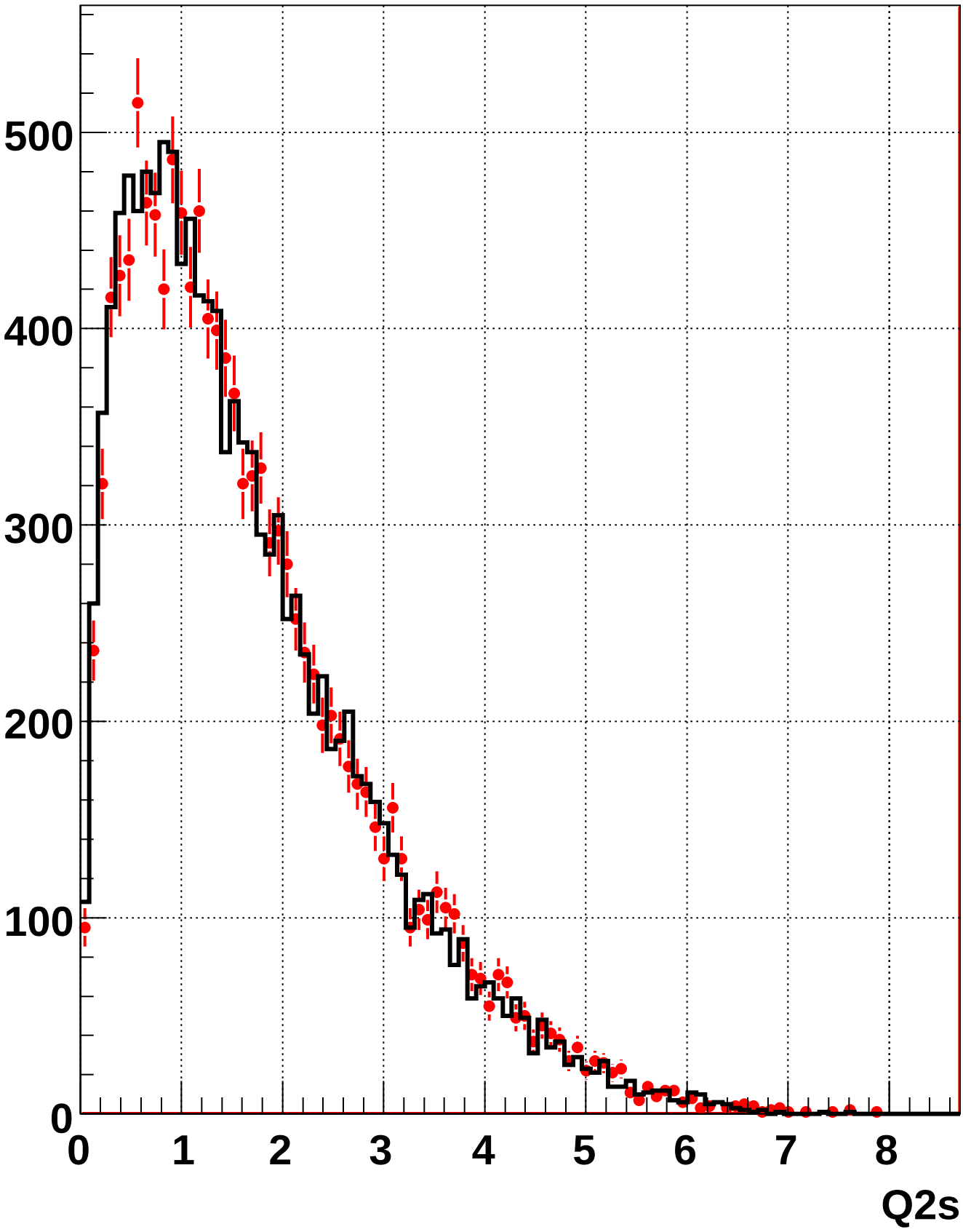
selected Q2 for DIS events



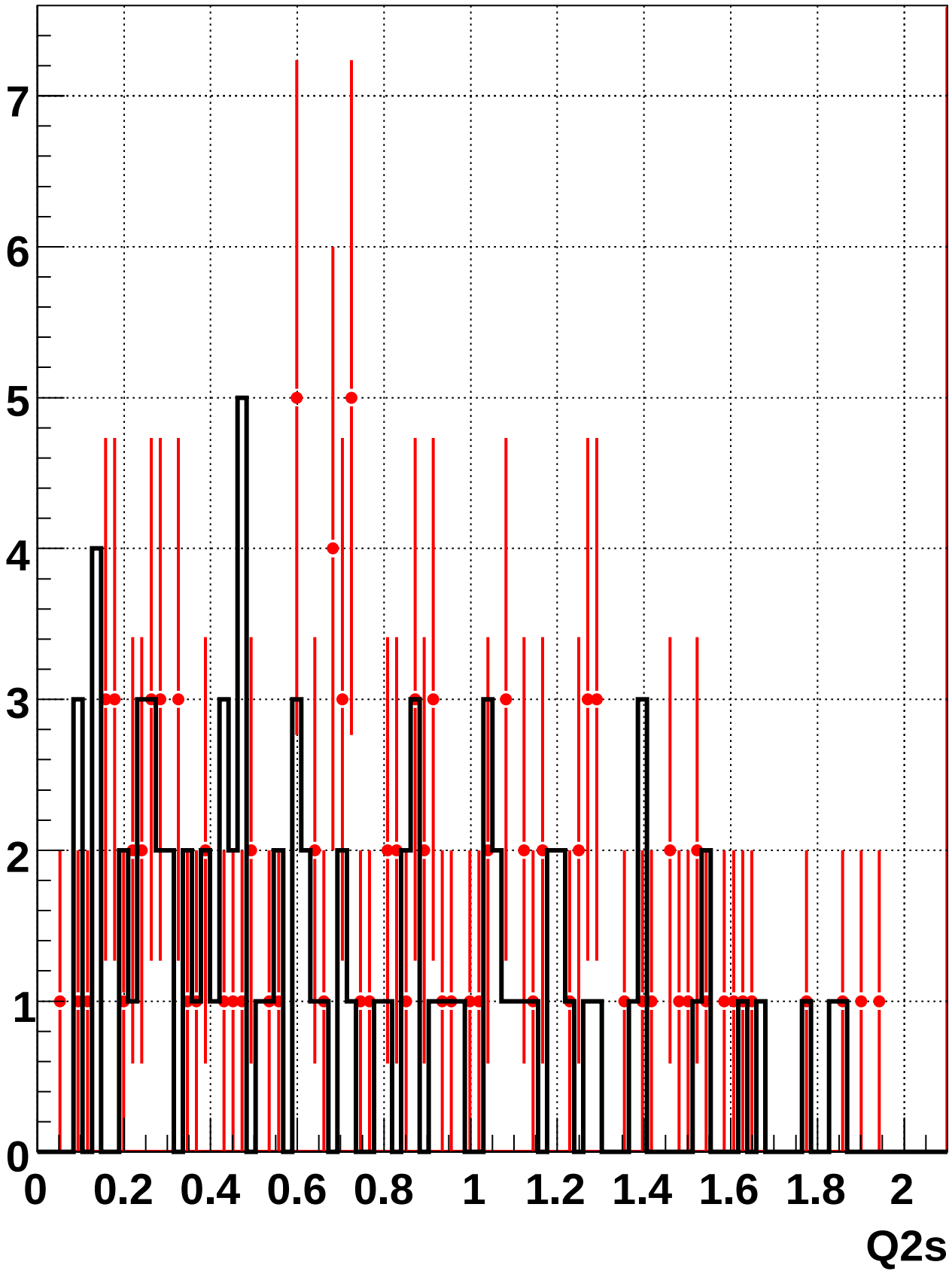
selected Q2 for DIS CC events



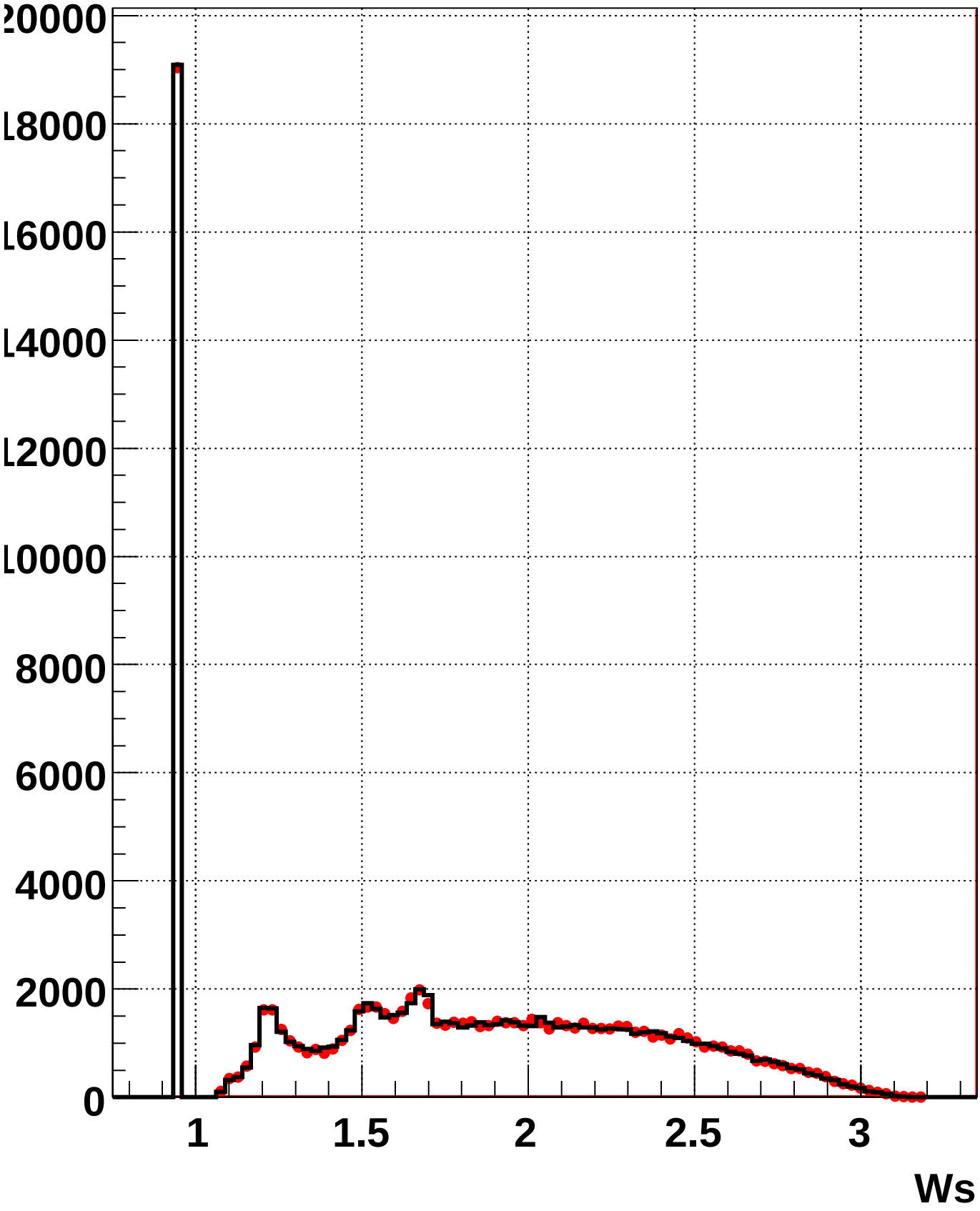
selected Q2 for DIS NC events



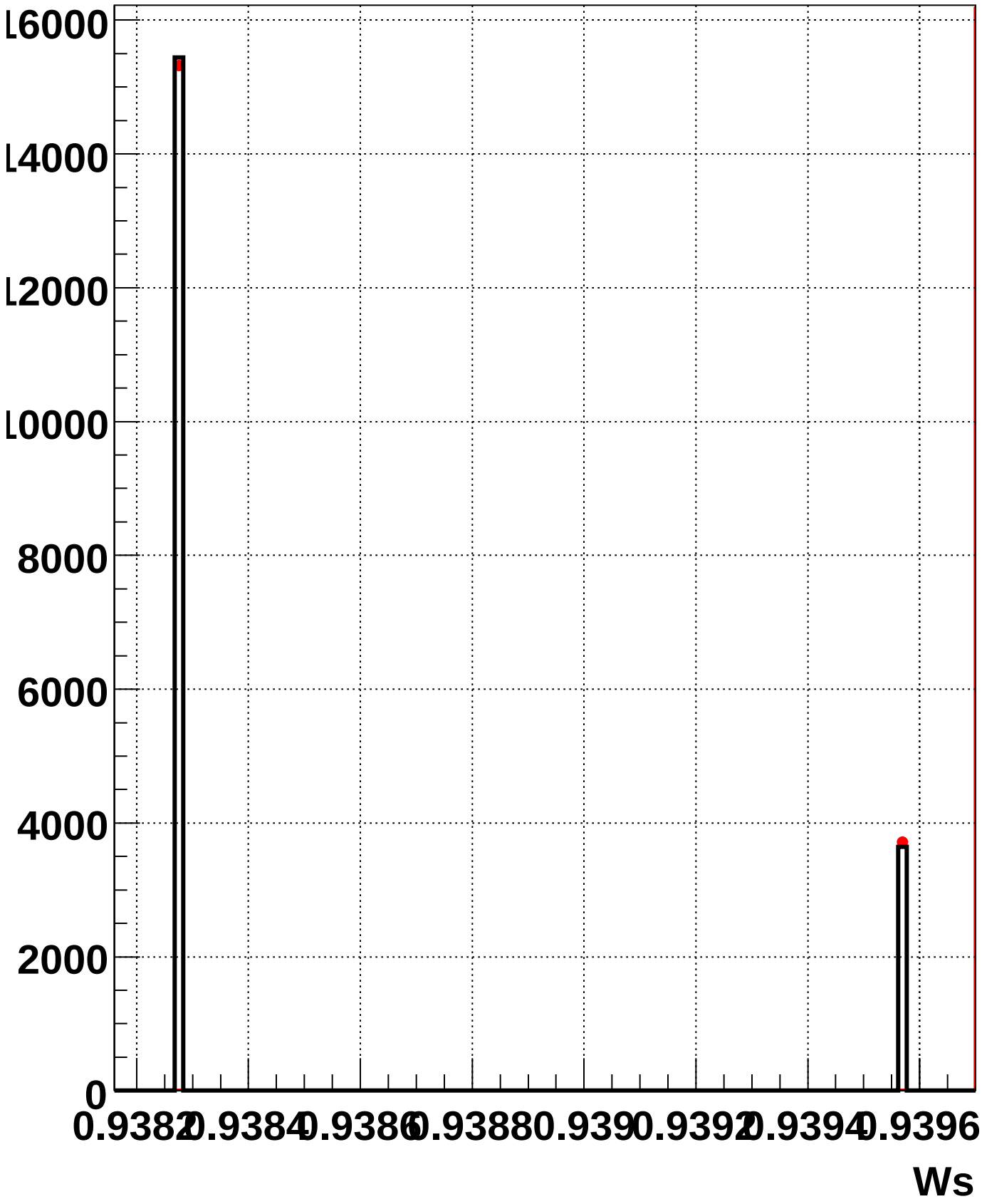
selected Q2 for Charm/DIS events



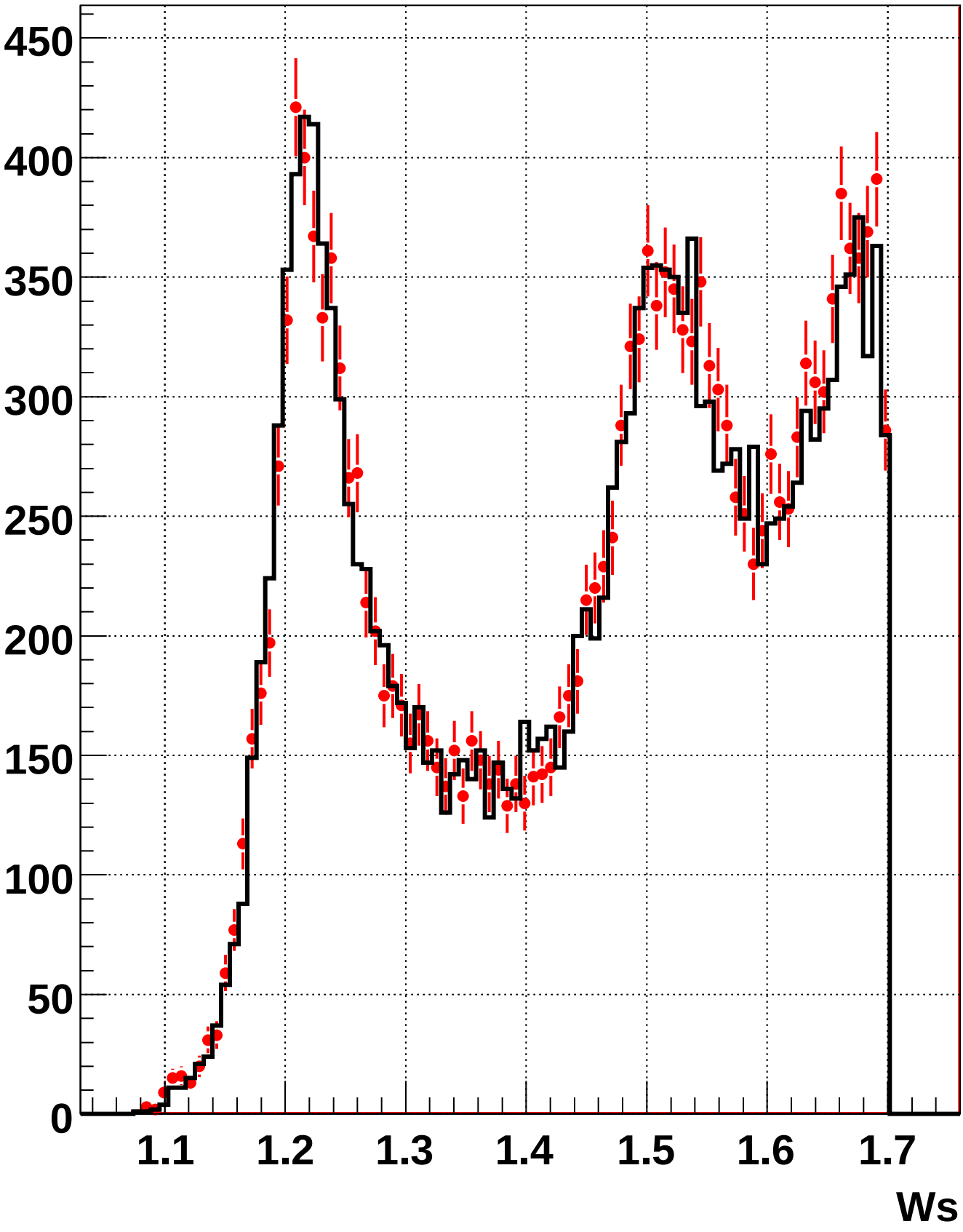
selected W for all events



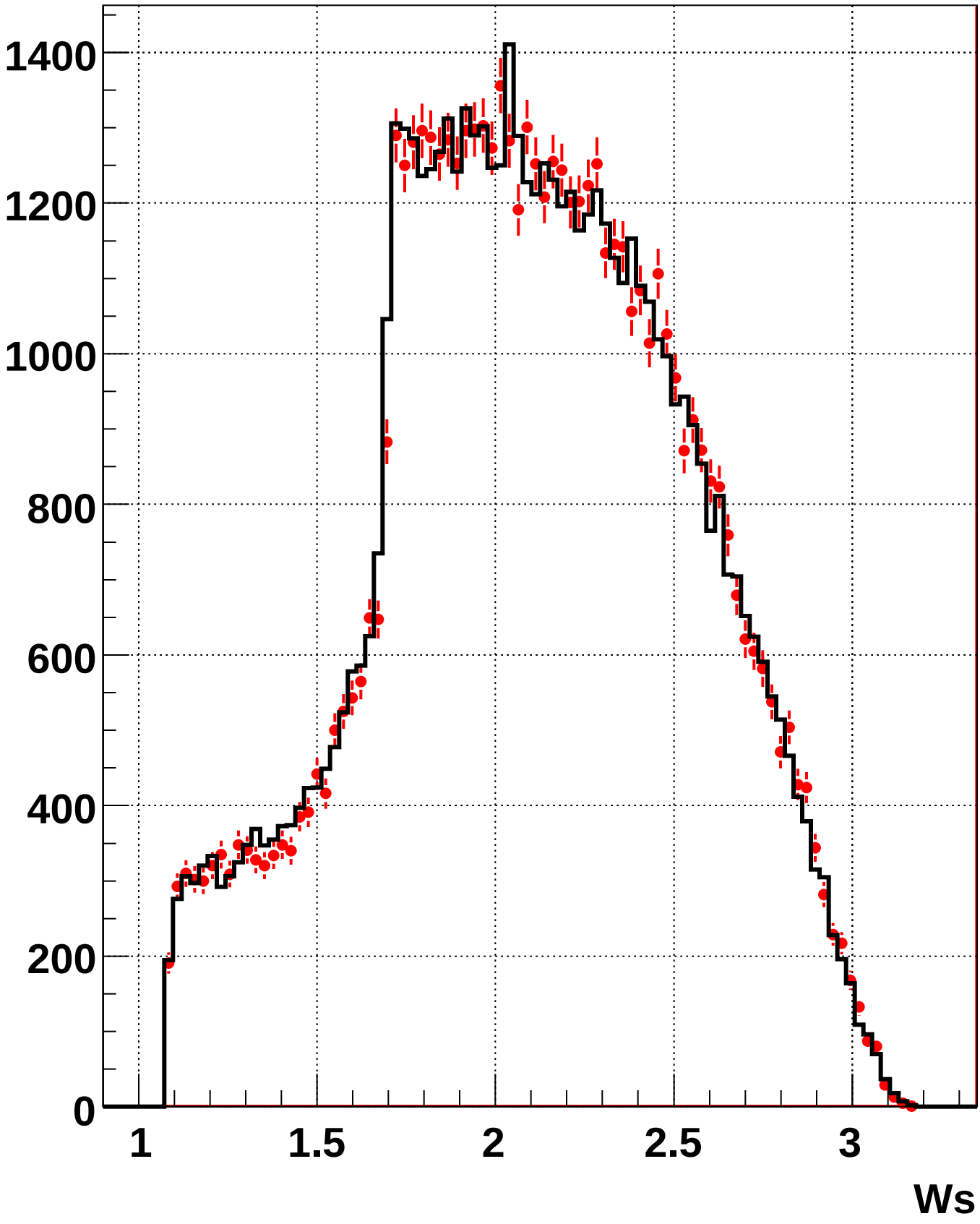
selected W for QEL events



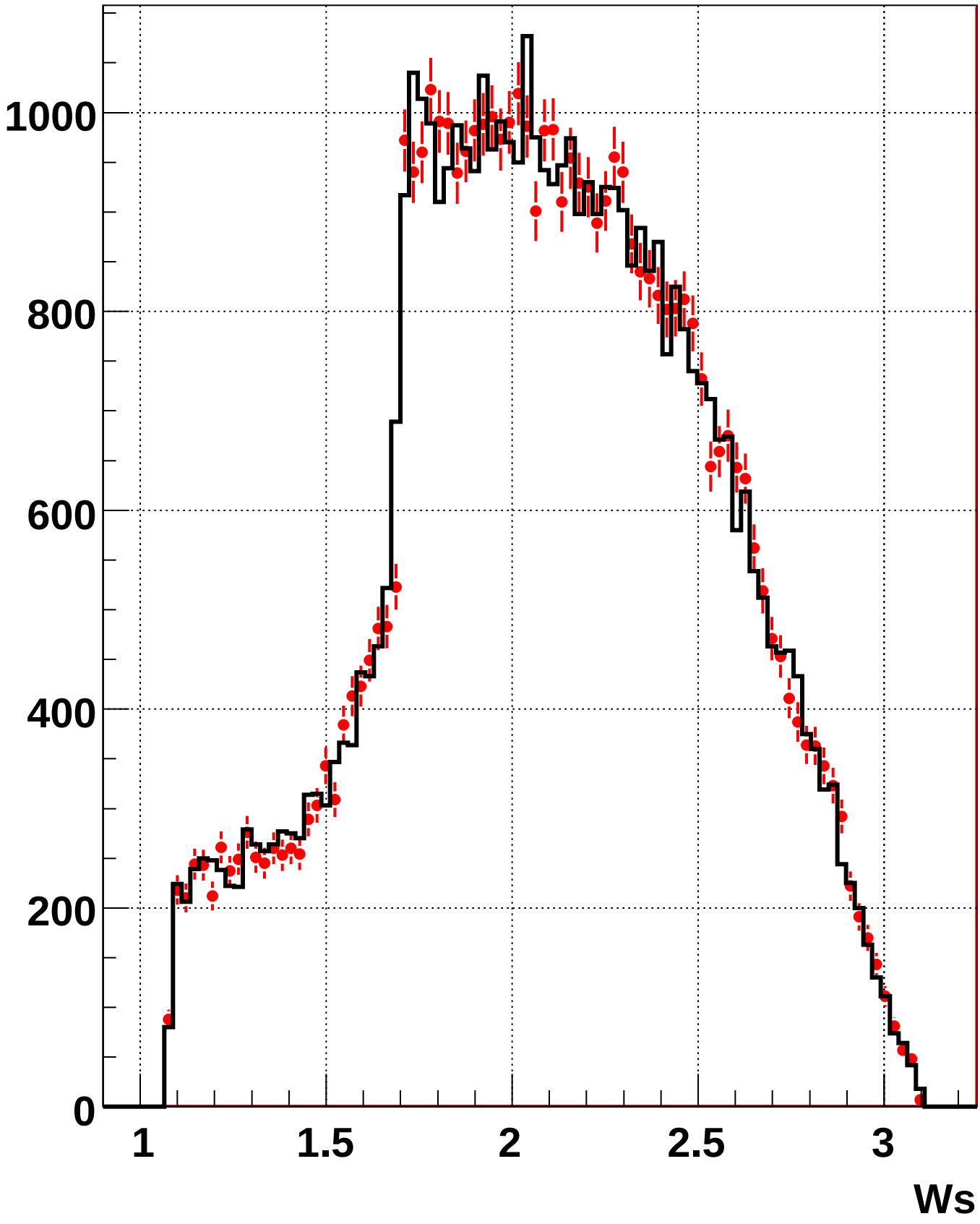
selected W for RES events



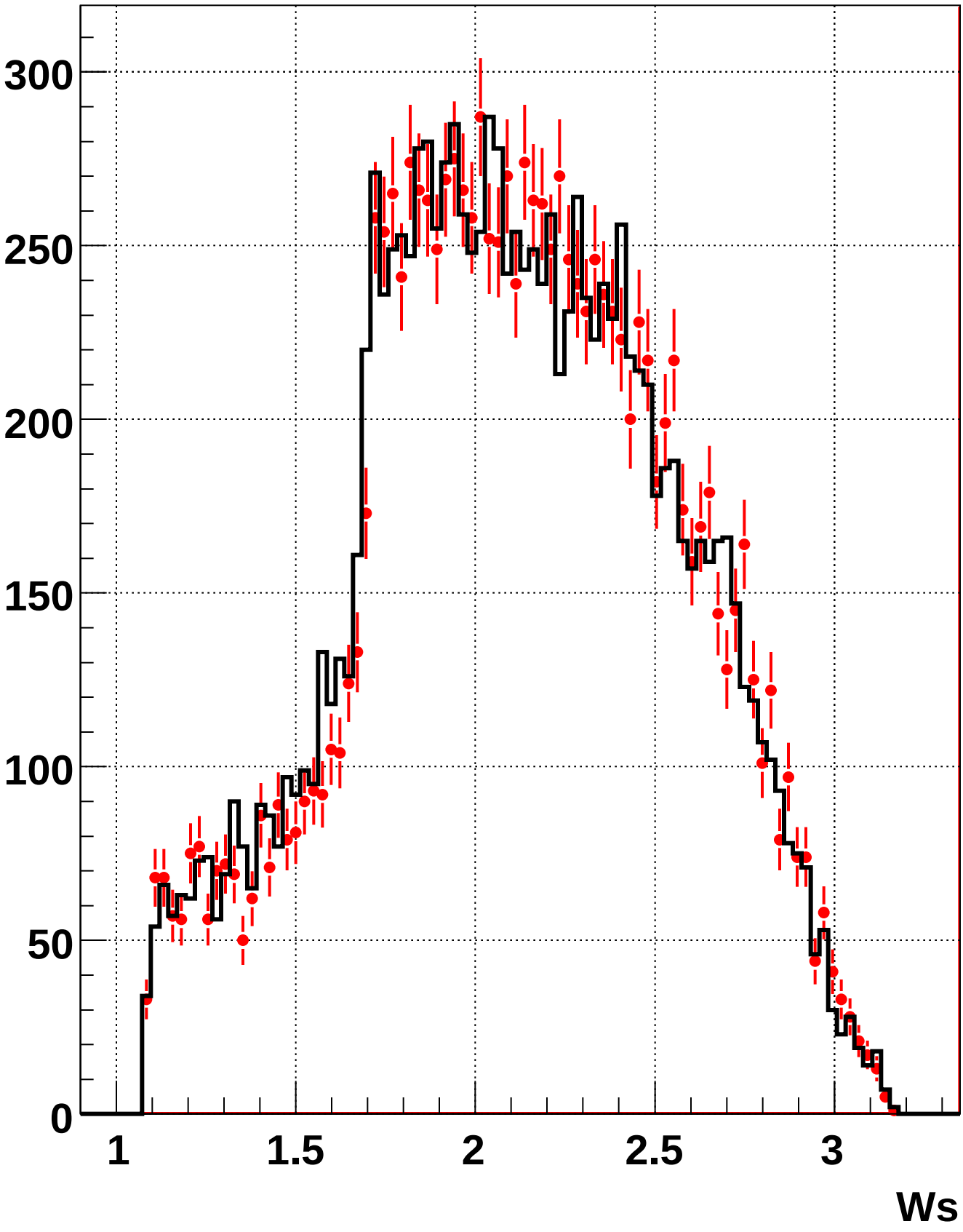
selected W for DIS events



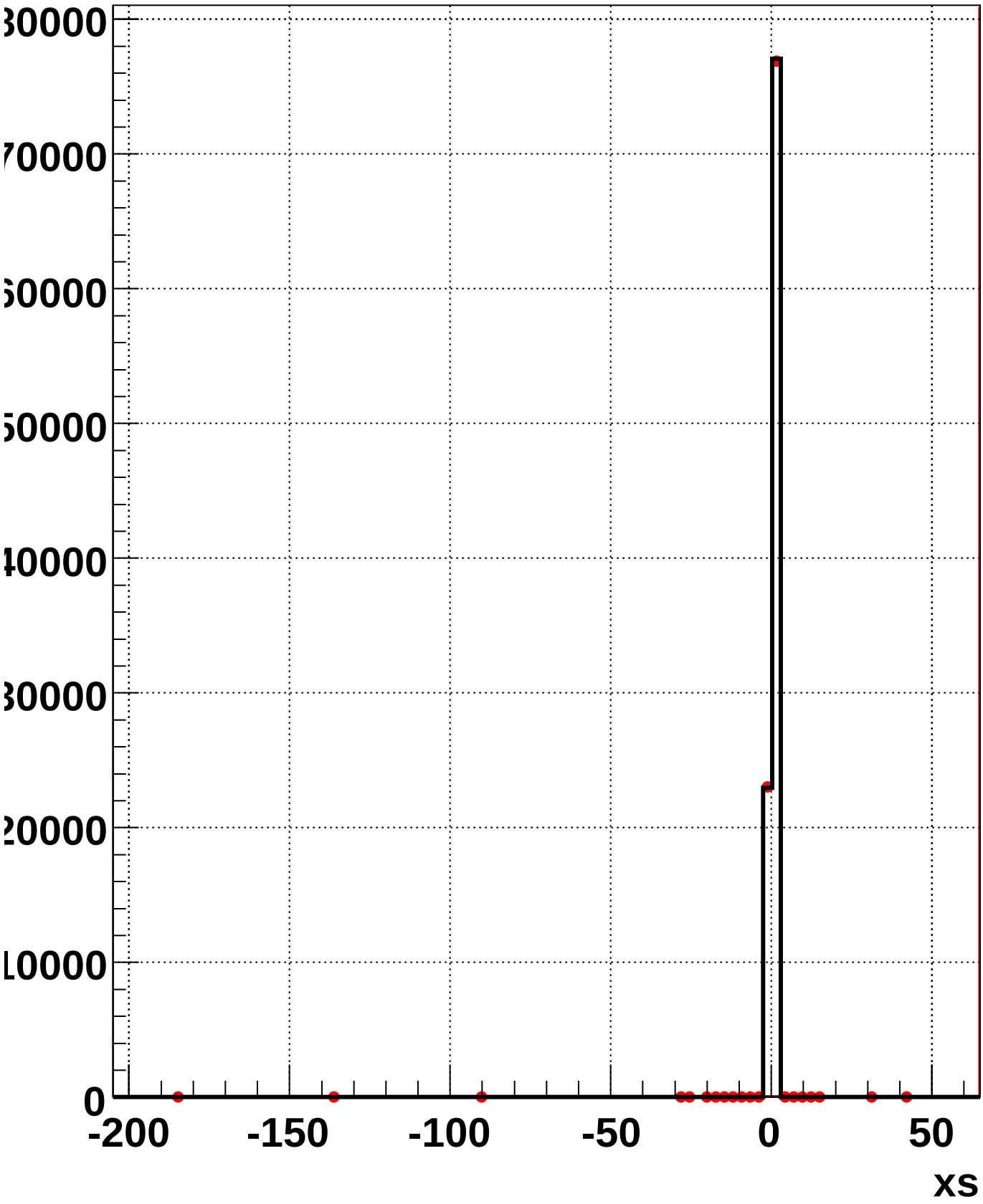
selected W for DIS CC events



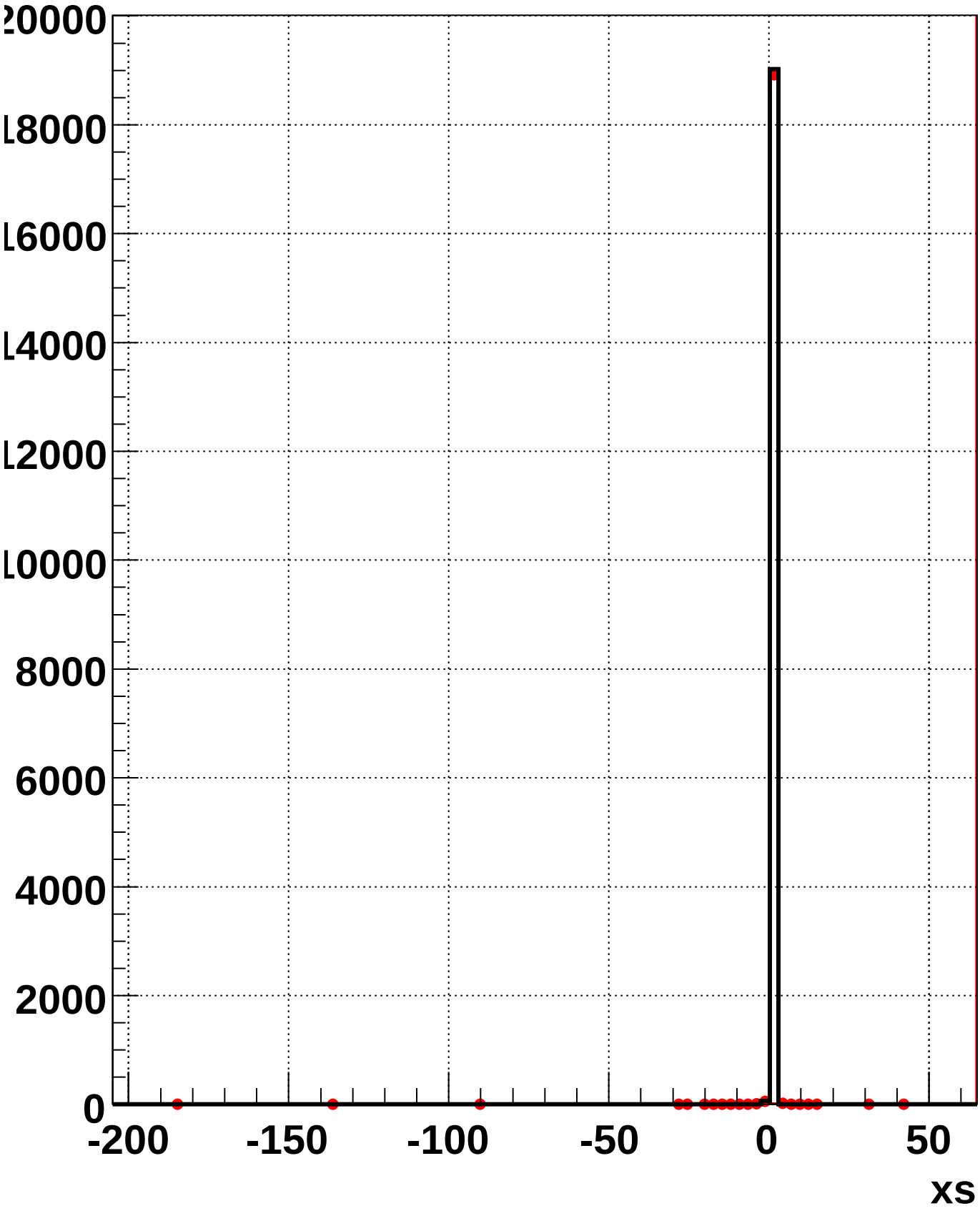
selected W for DIS NC events



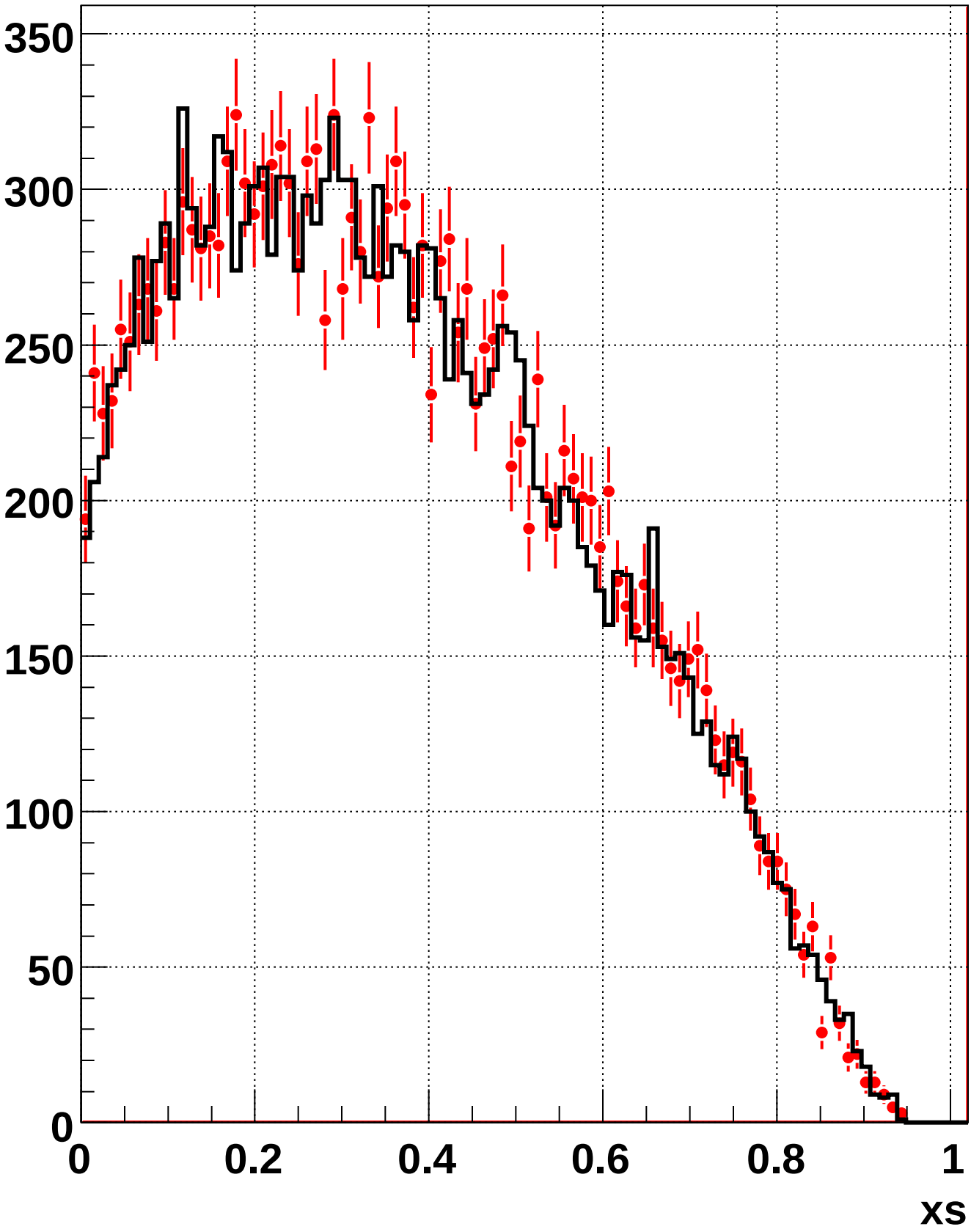
selected x for all events



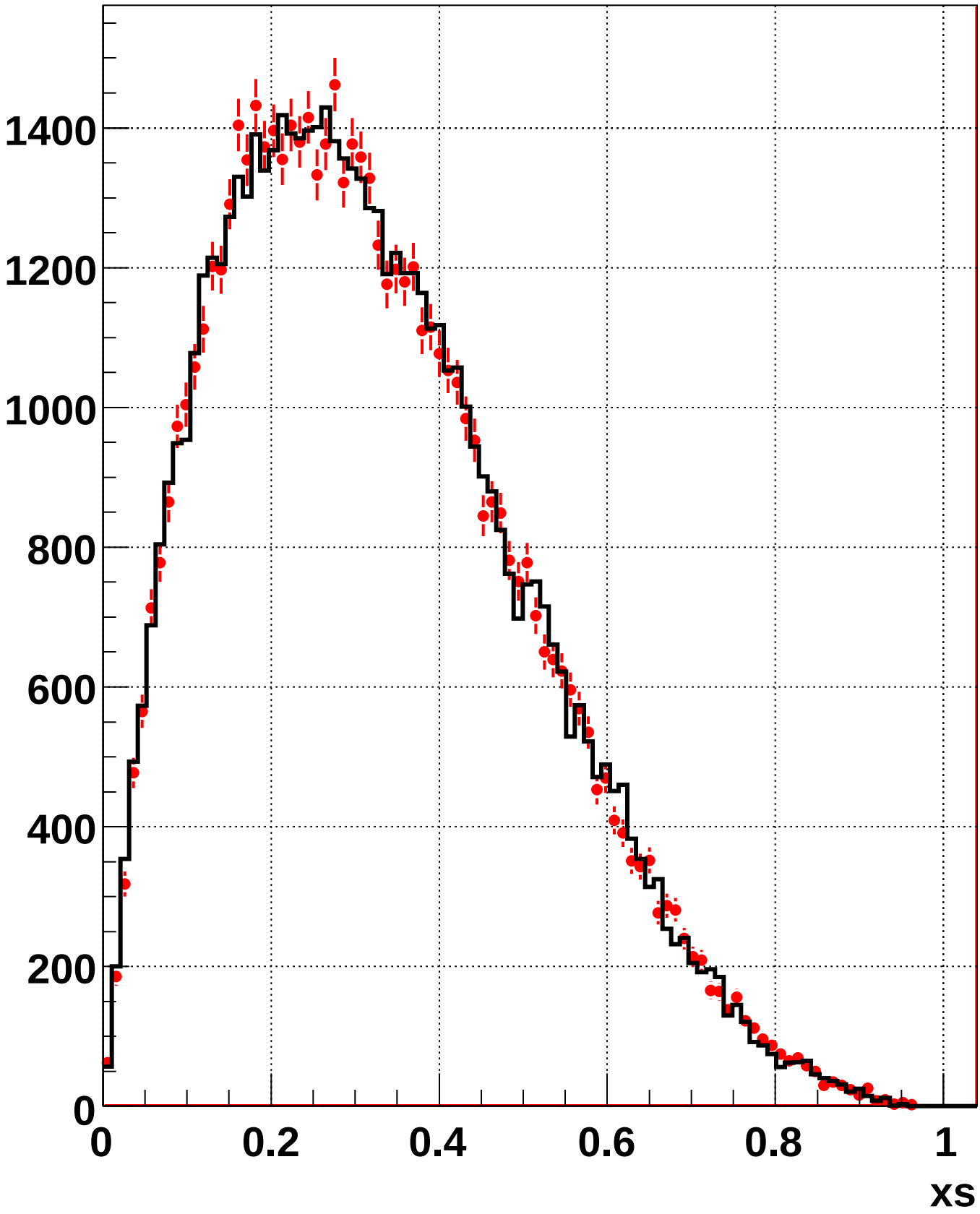
selected x for QEL events



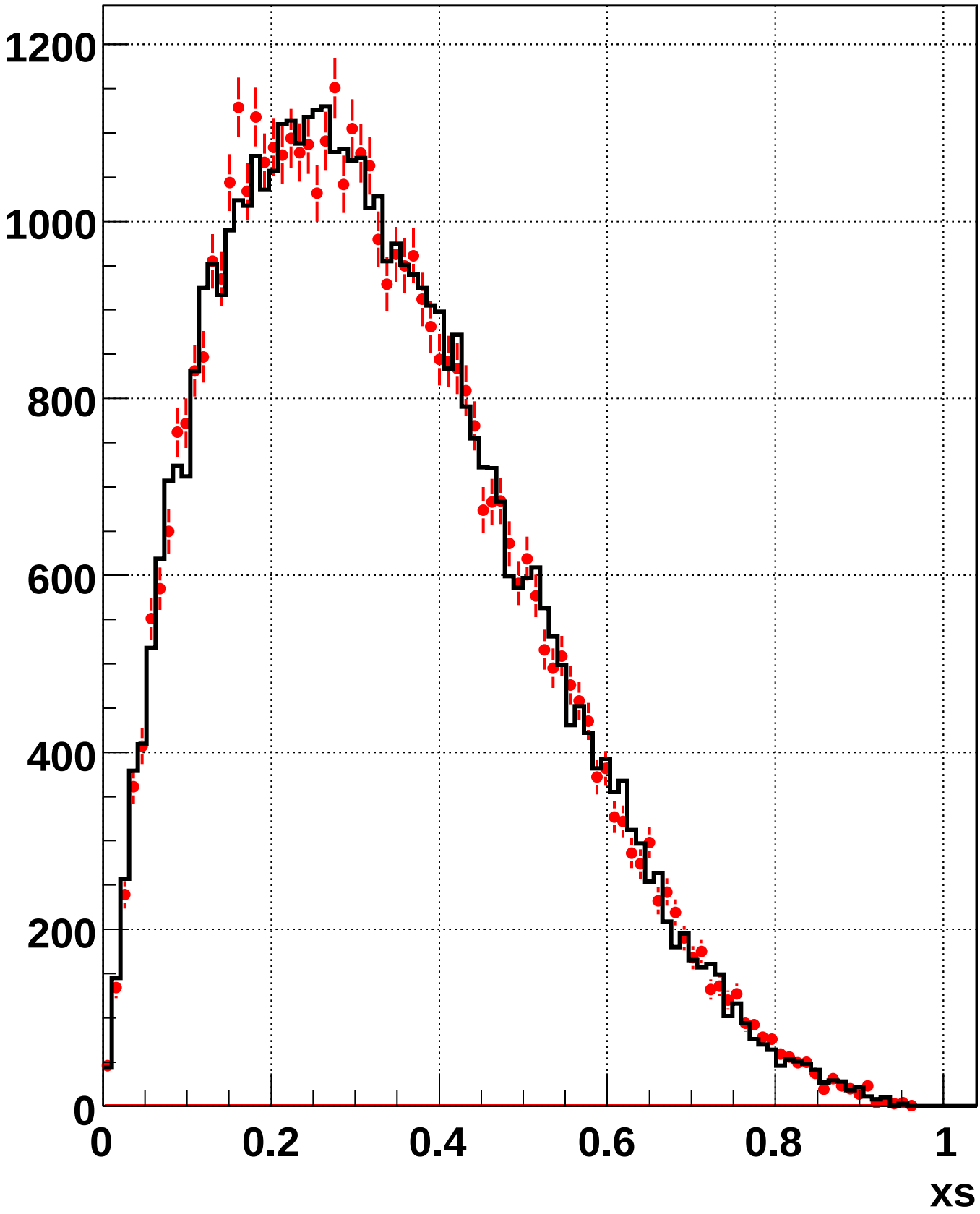
selected x for RES events



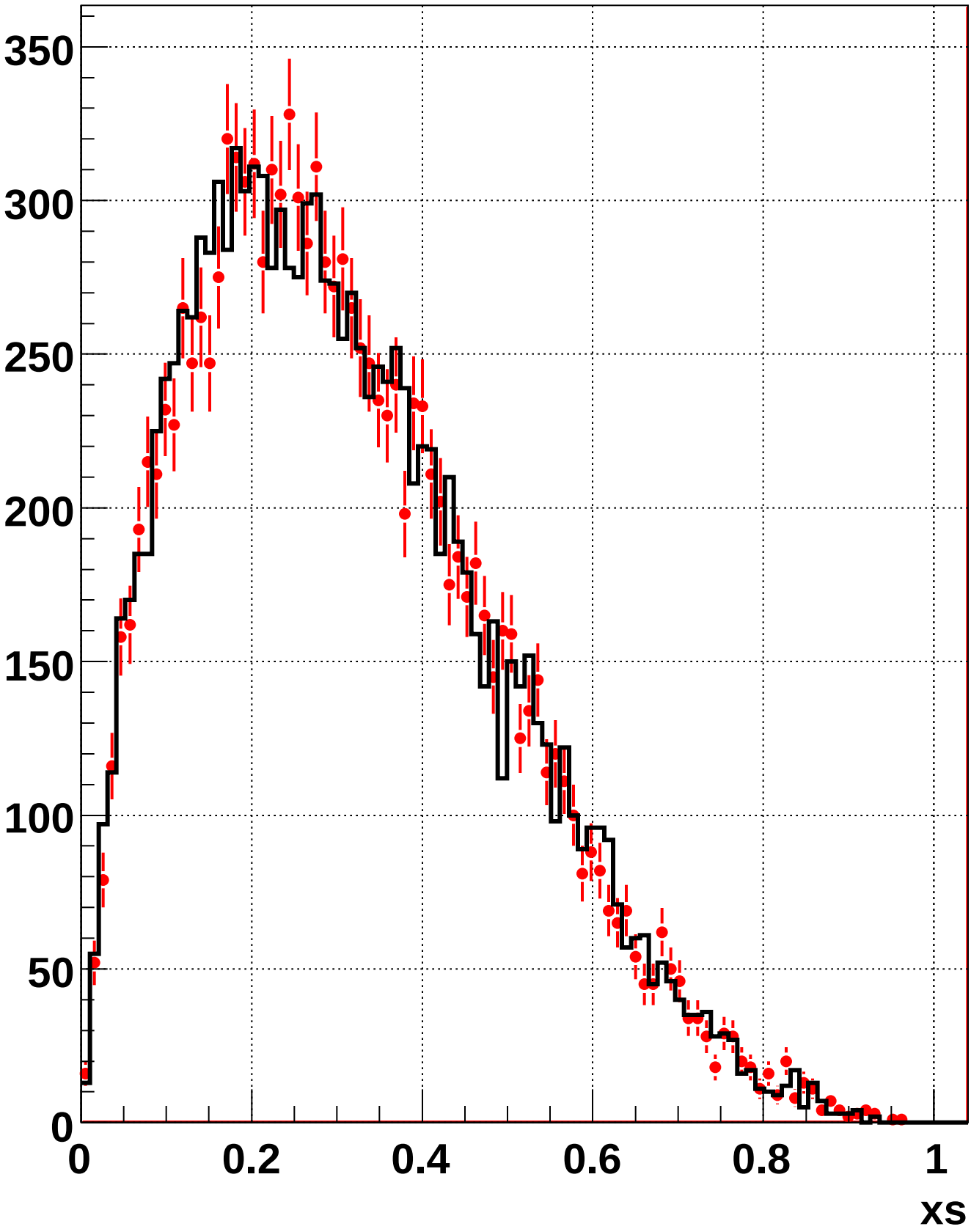
selected x for DIS events



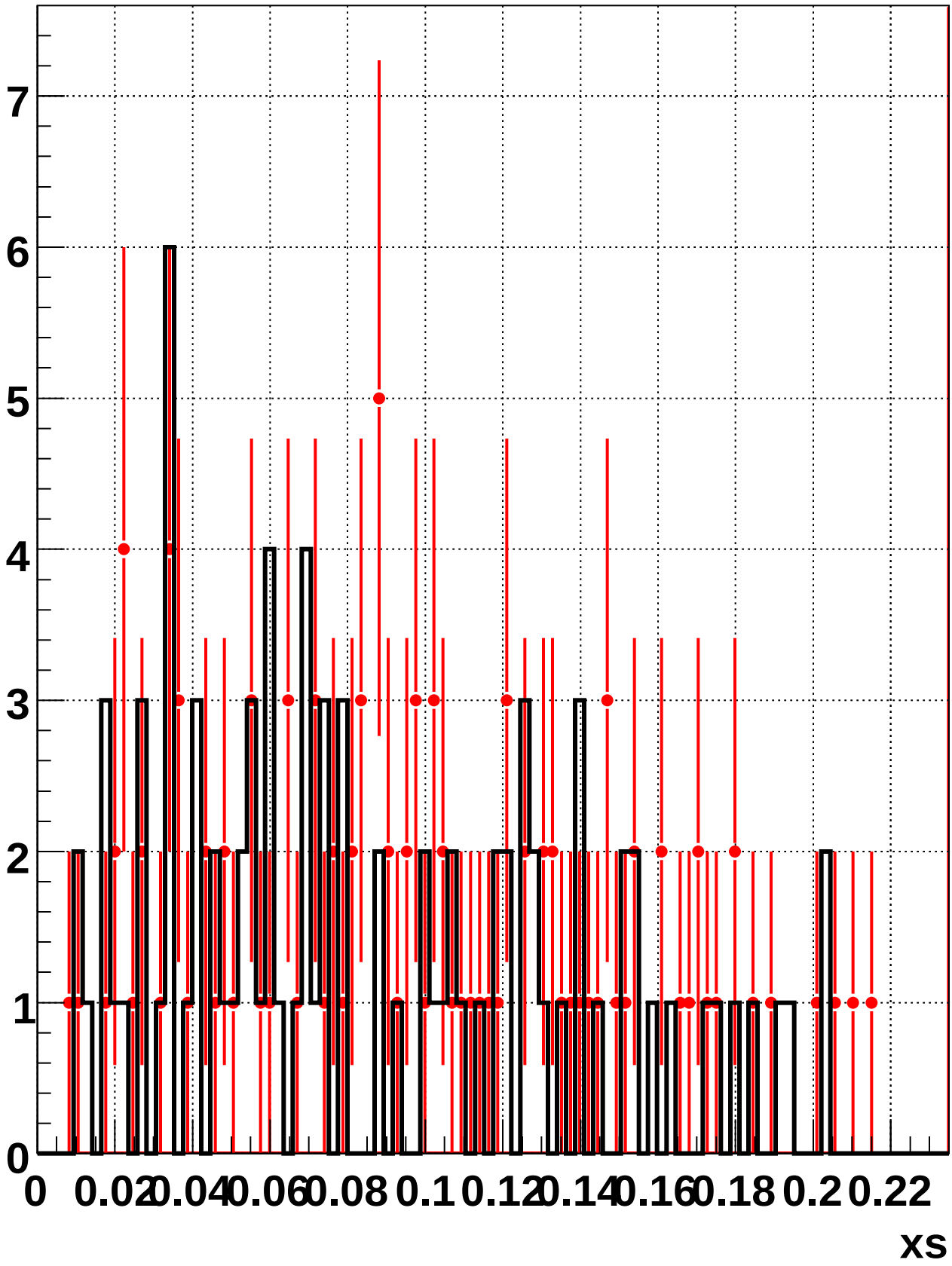
selected x for DIS CC events



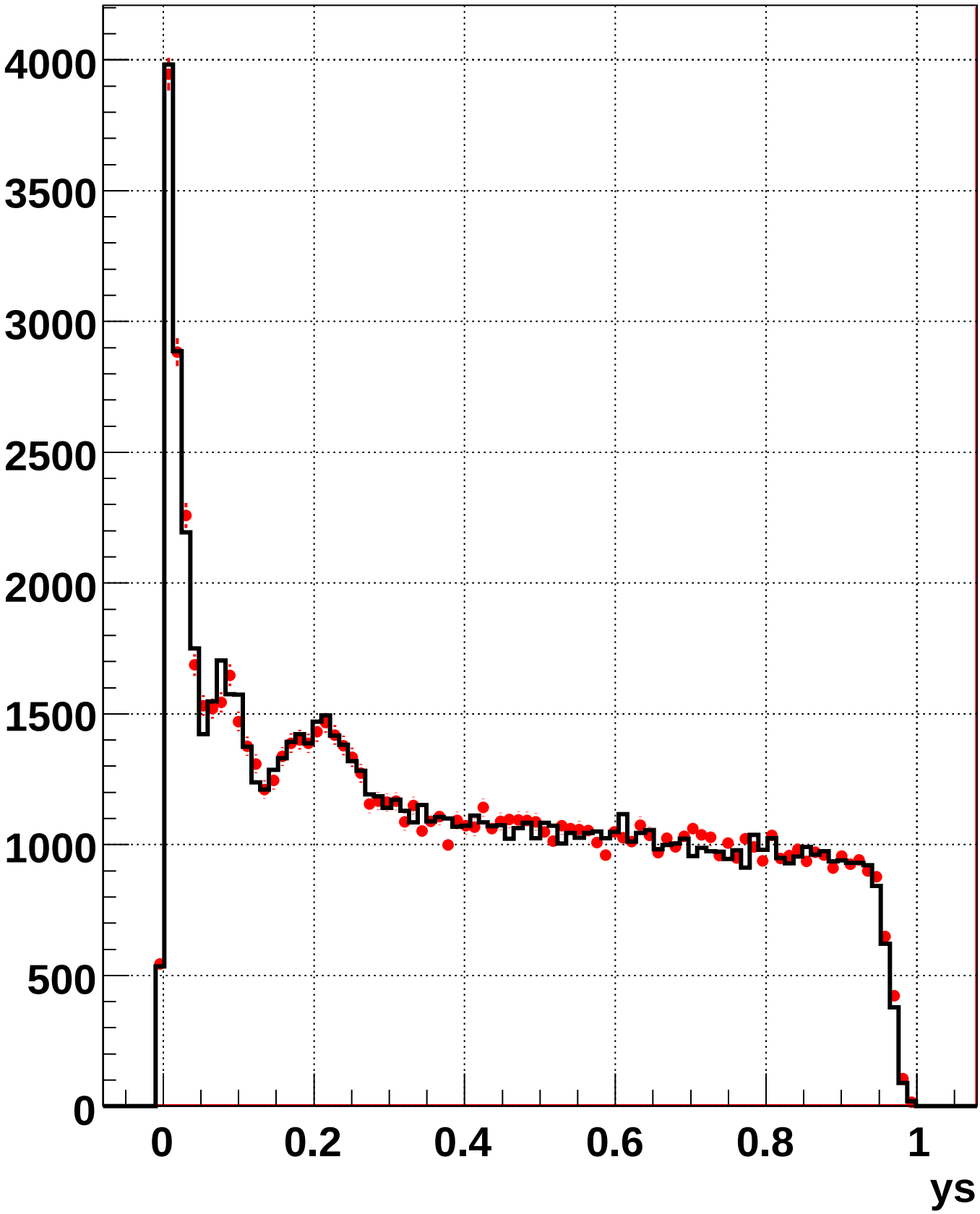
selected x for DIS NC events



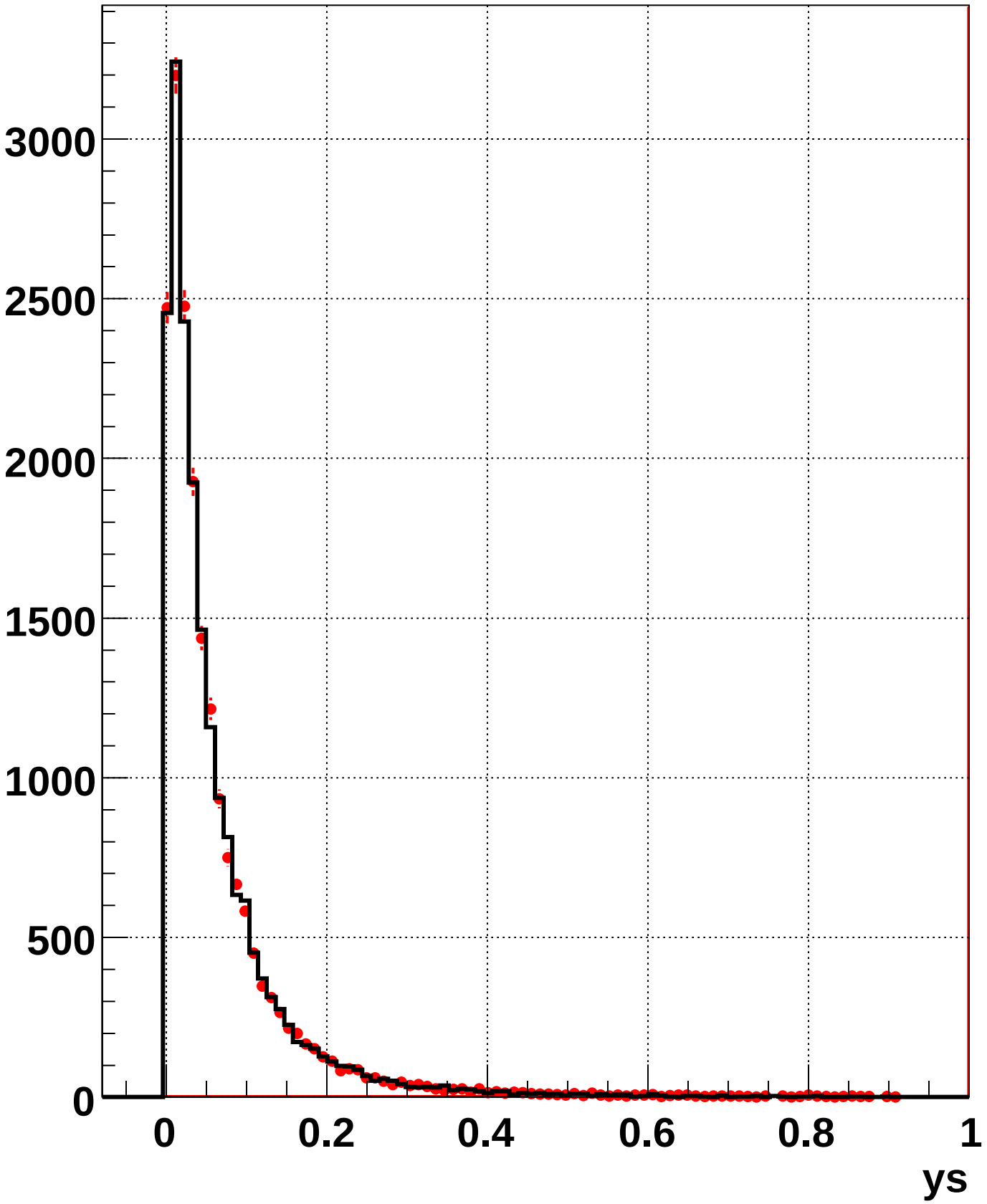
selected x for Charm/DIS events



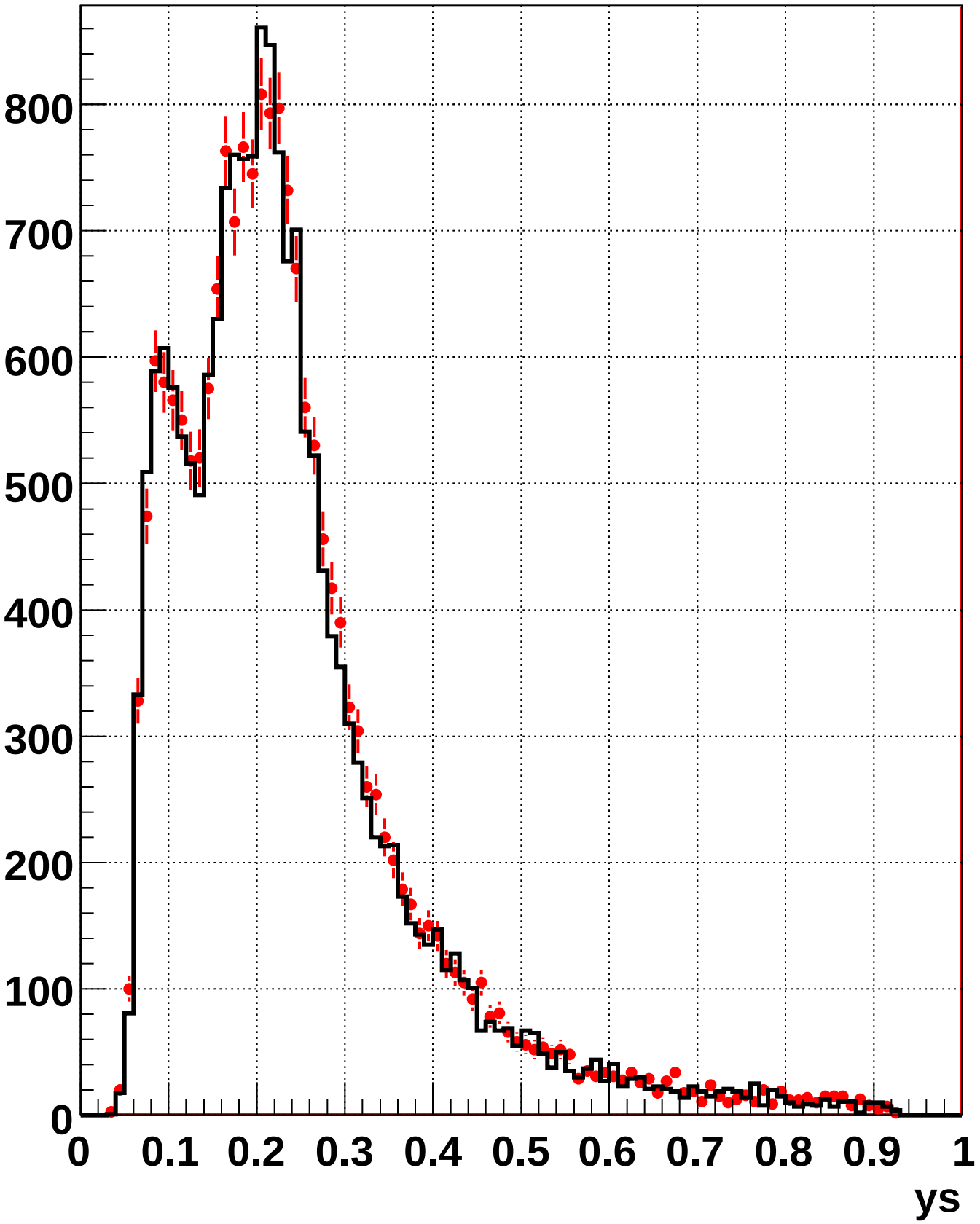
selected y for all events



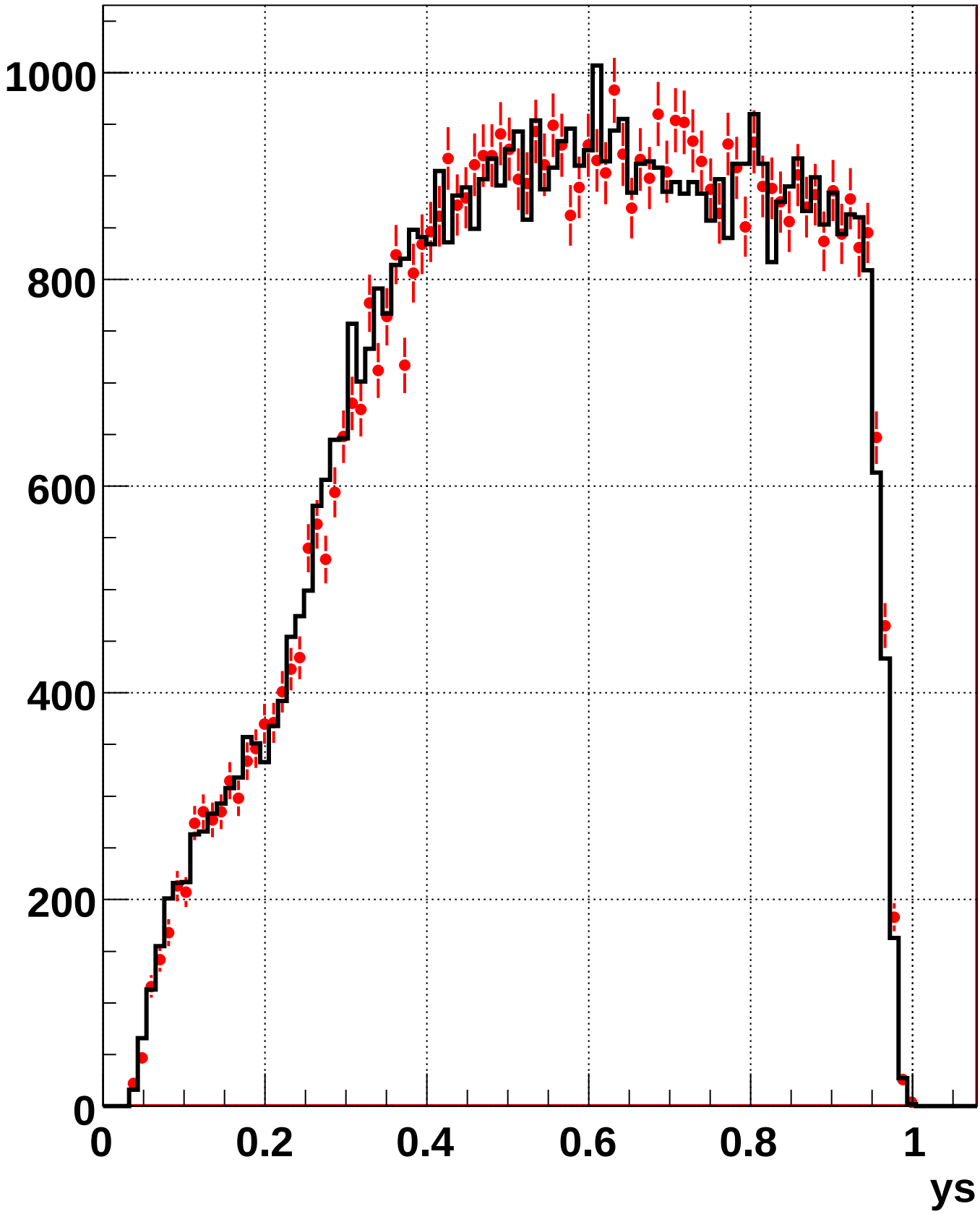
selected y for QEL events



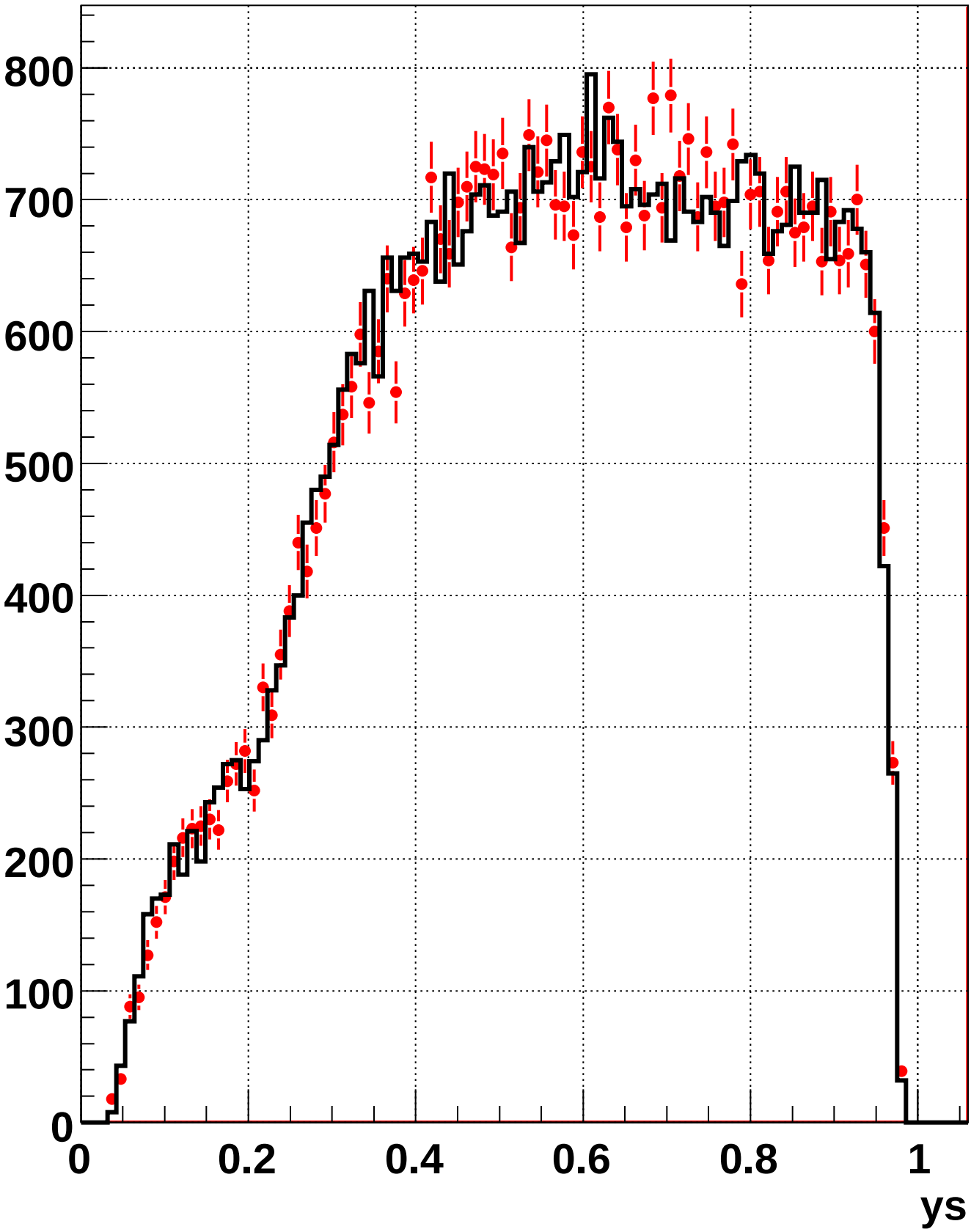
selected y for RES events



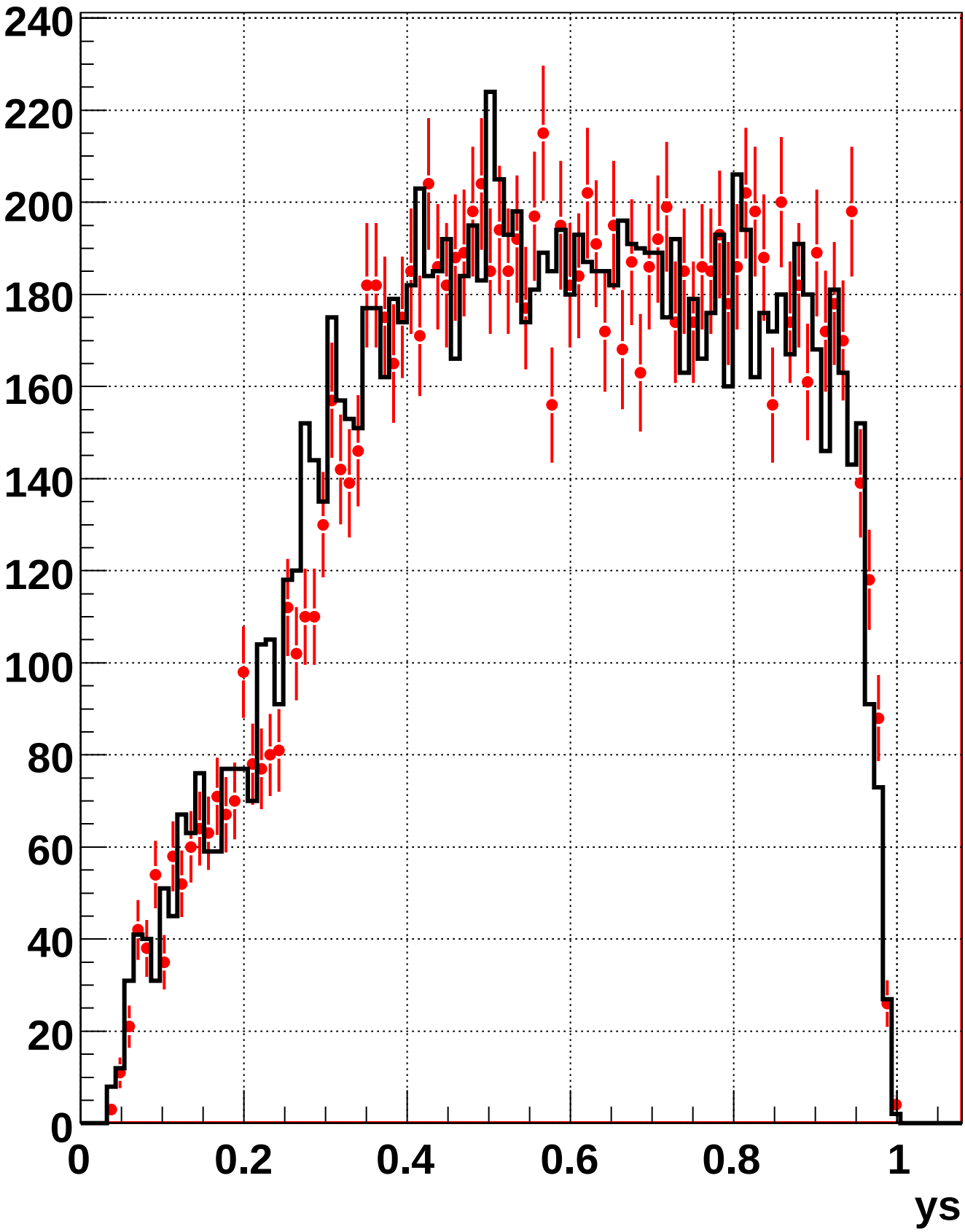
selected y for DIS events



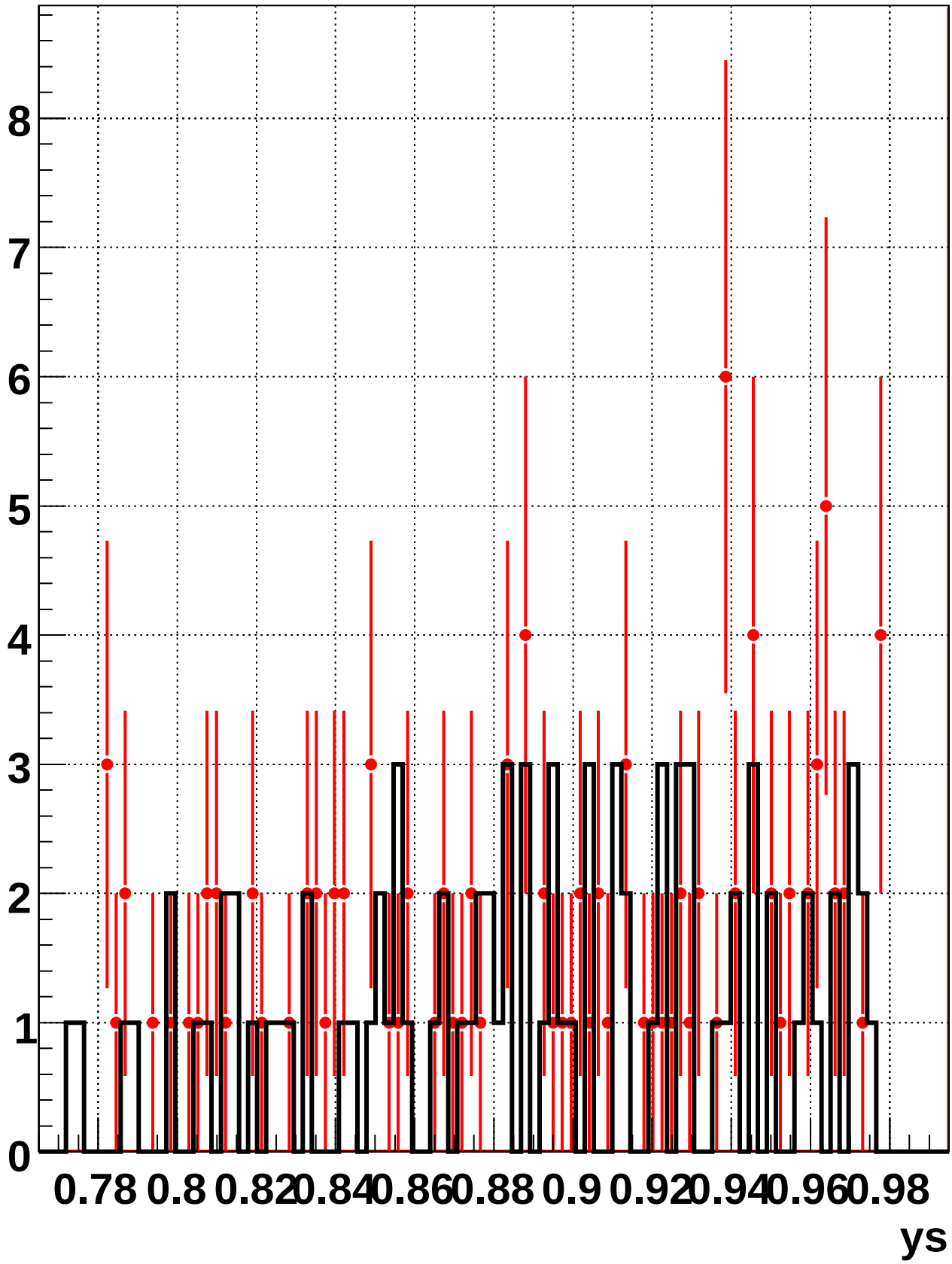
selected y for DIS CC events



selected y for DIS NC events



selected y for Charm/DIS events

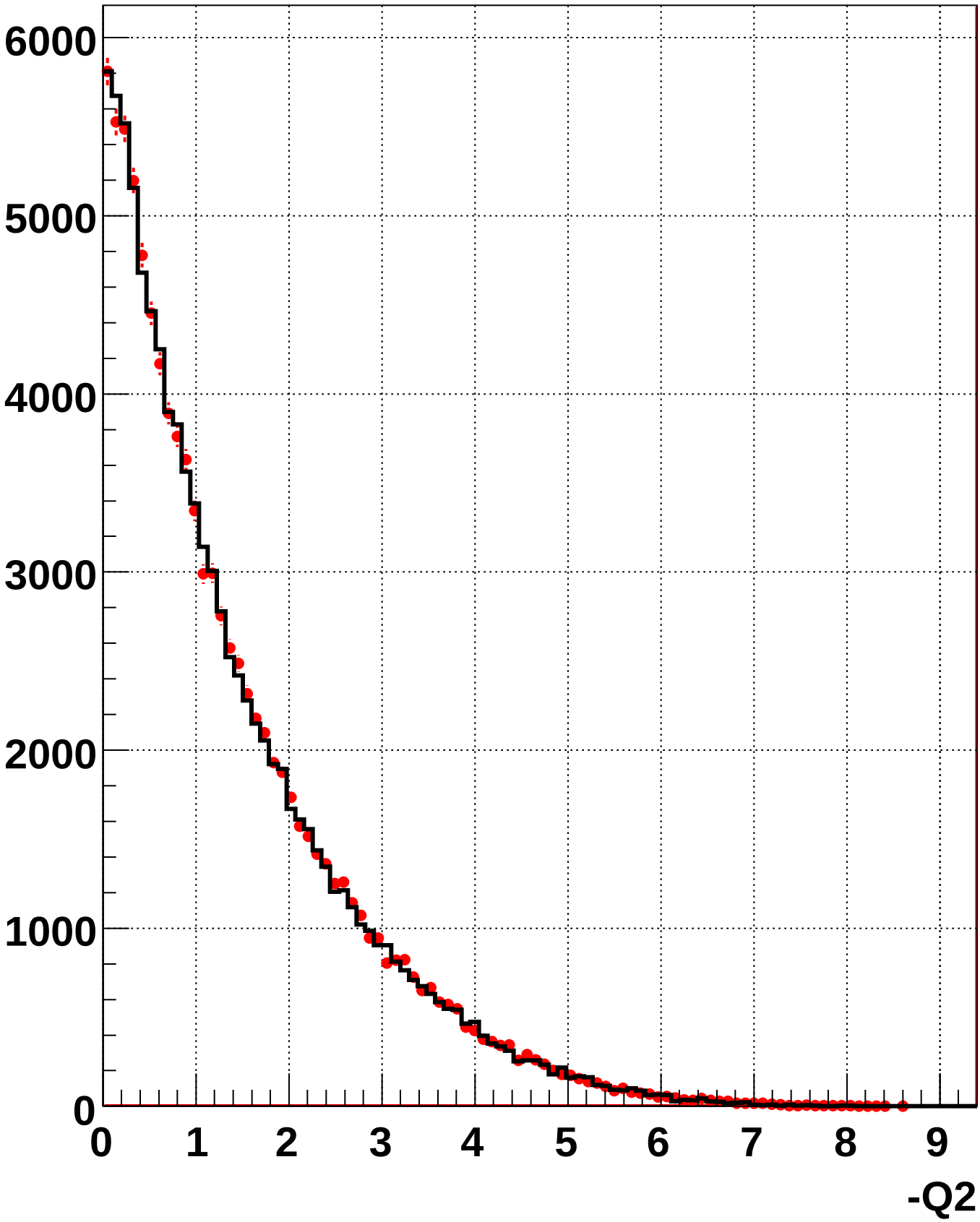


Kinematical Quantities

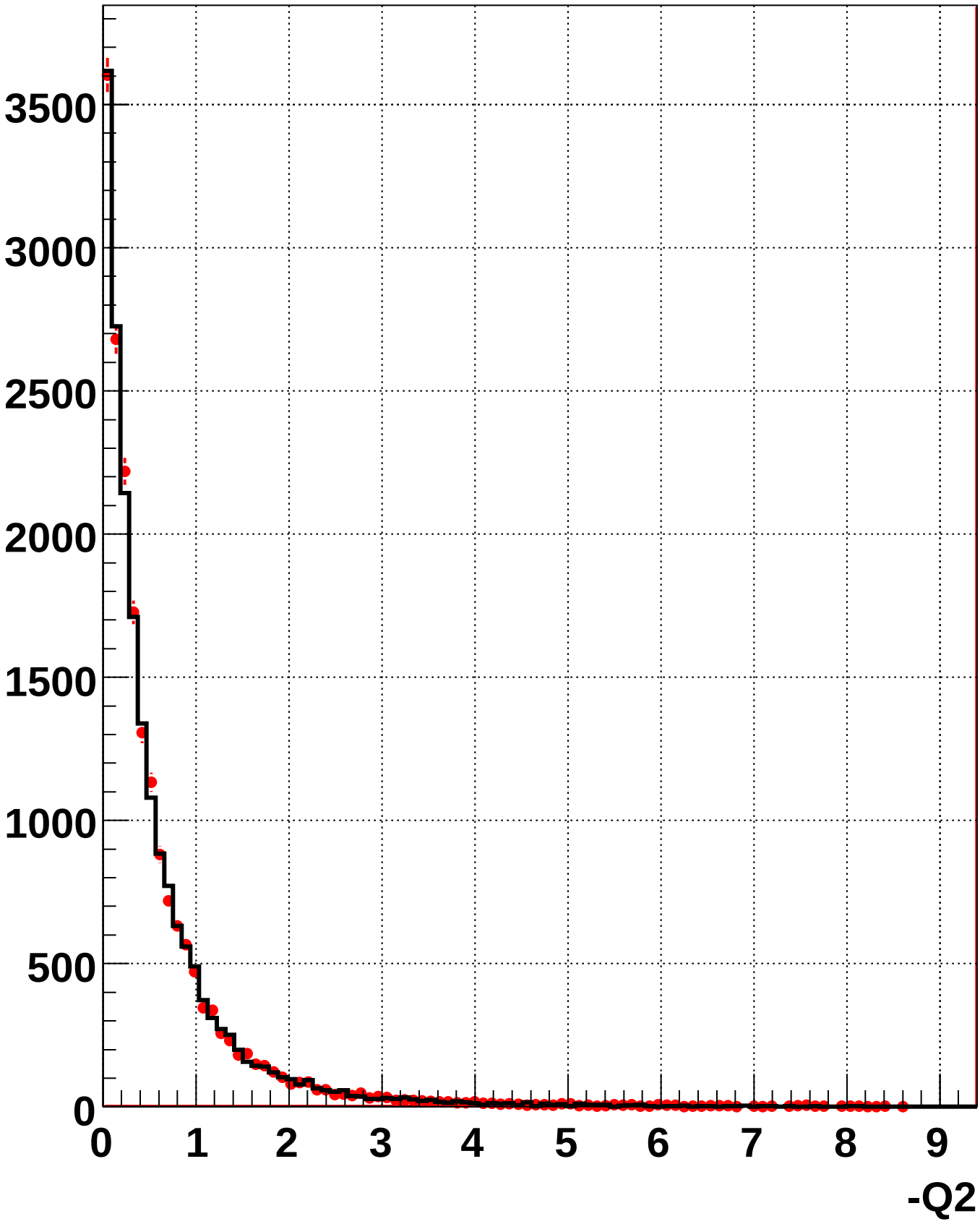
Similar to the previous set of plots but

showing ’computed’ rathen than ’selected’ variables

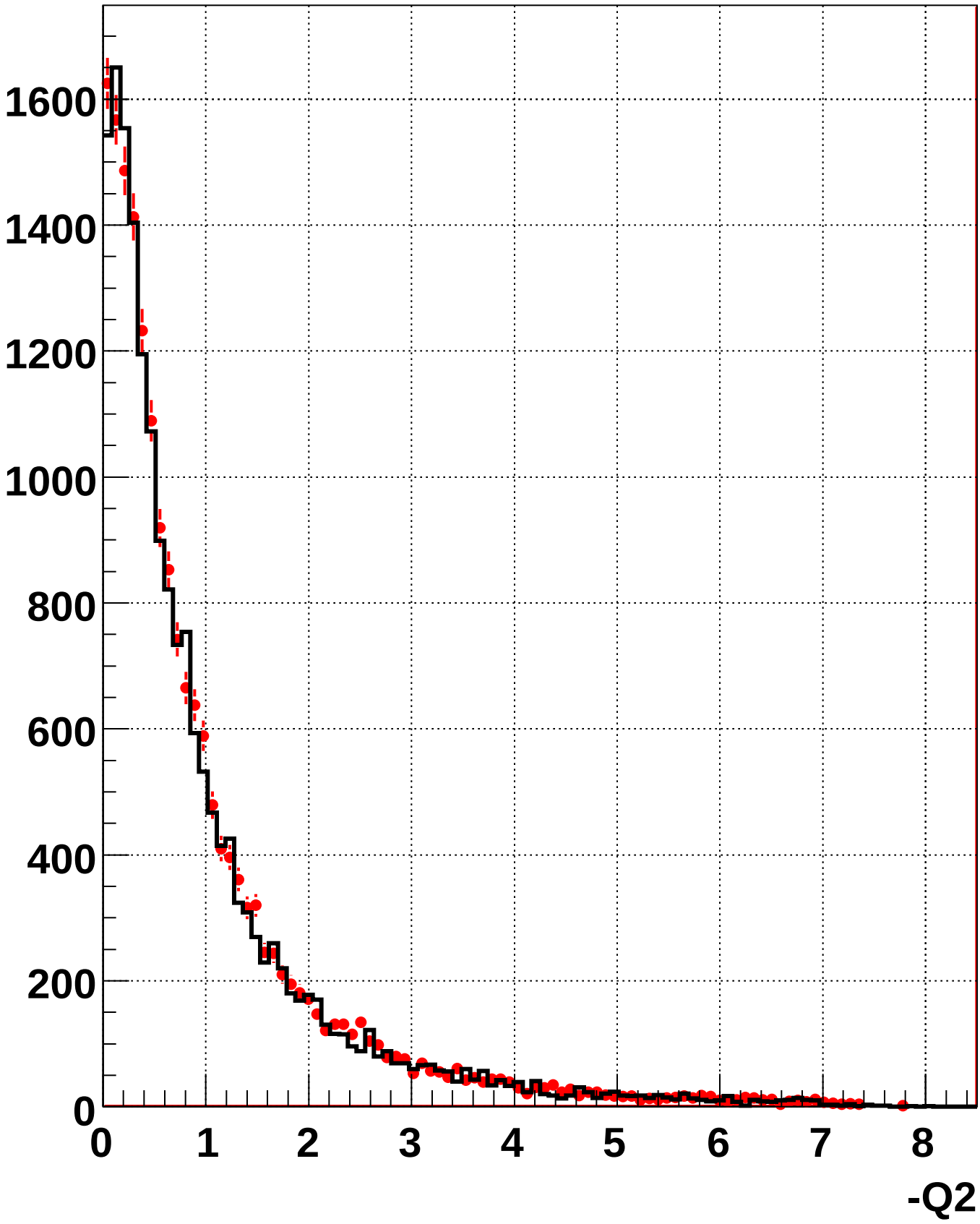
computed Q2 for all events



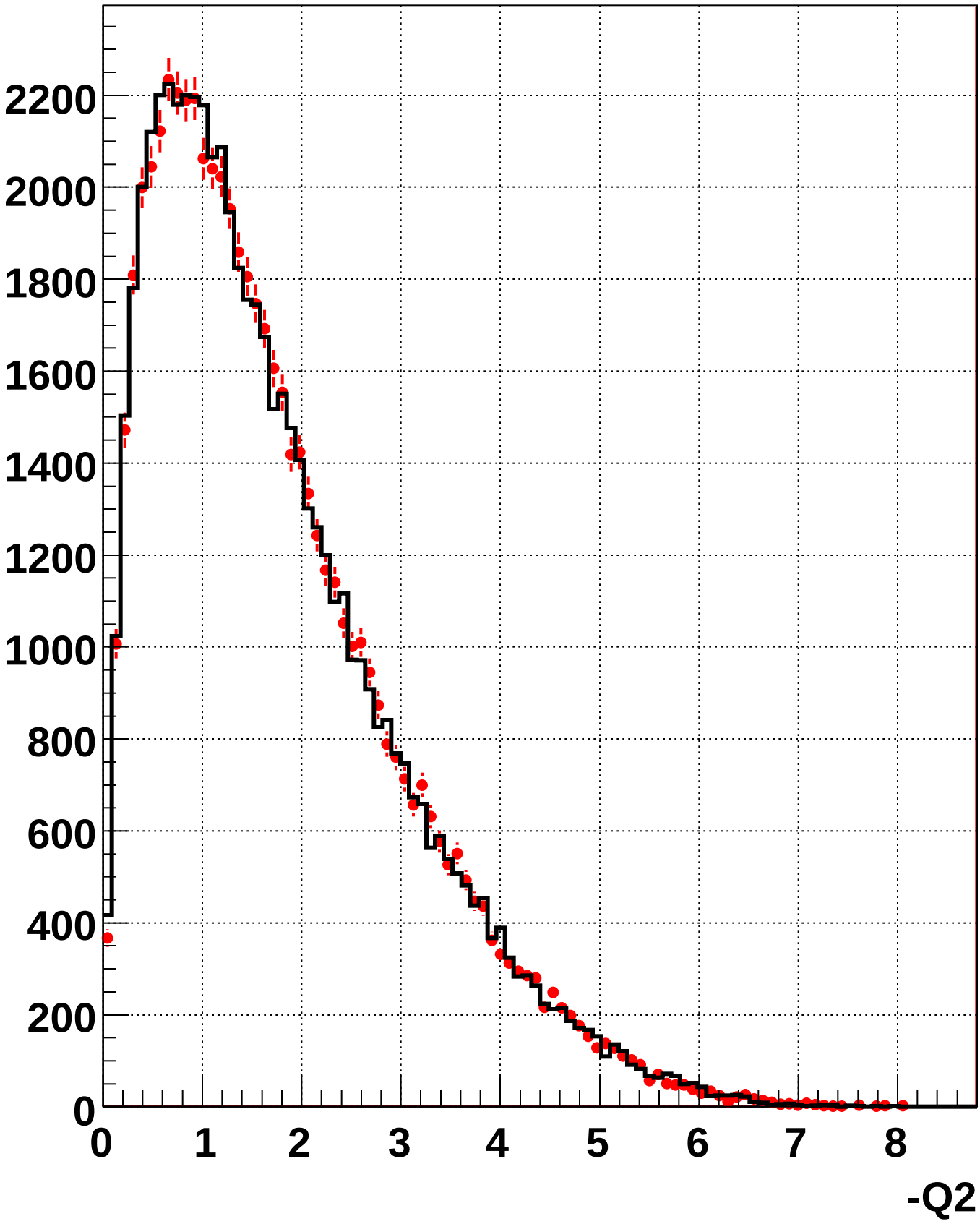
computed Q2 for QEL events

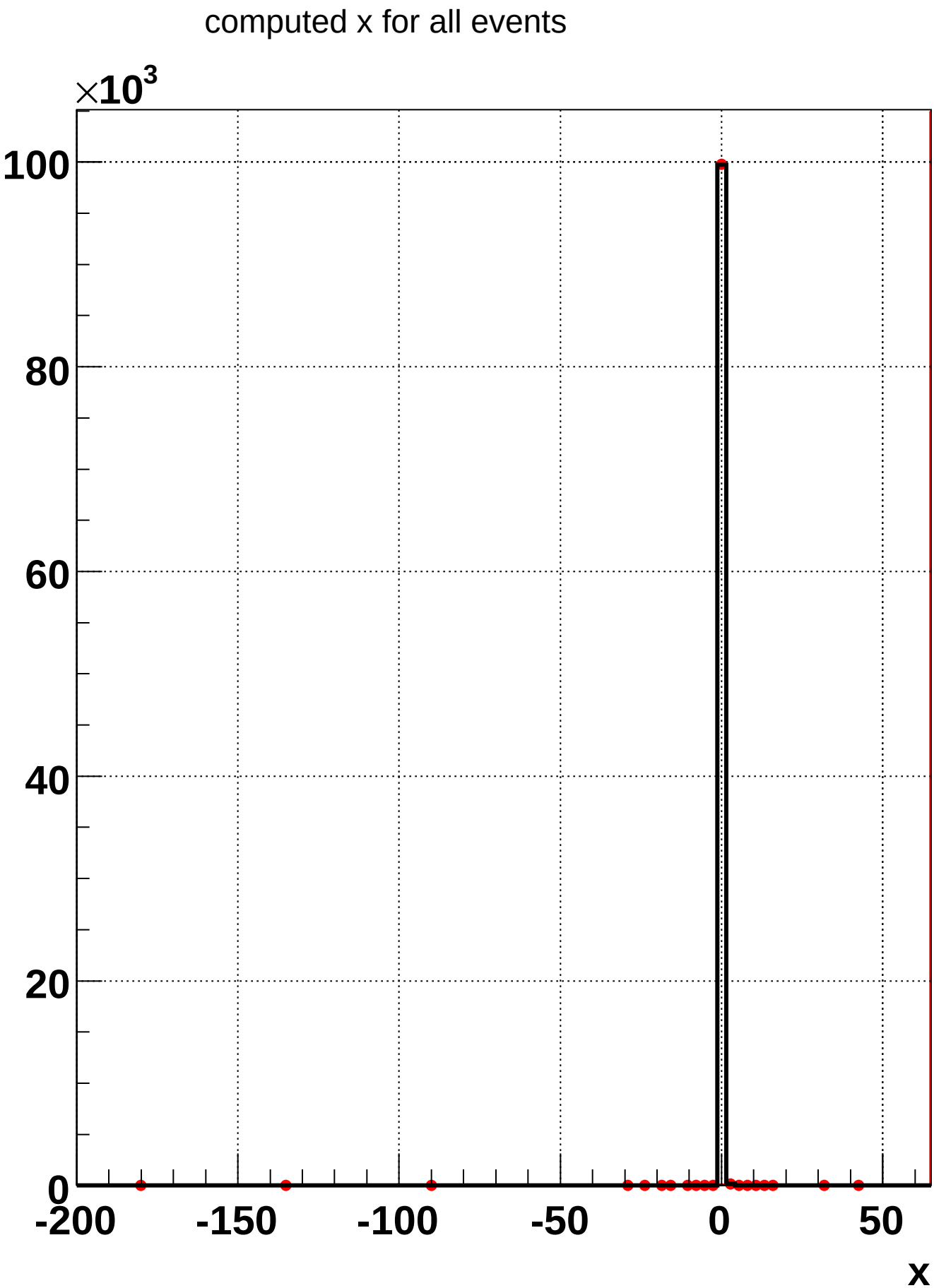


computed Q2 for RES events

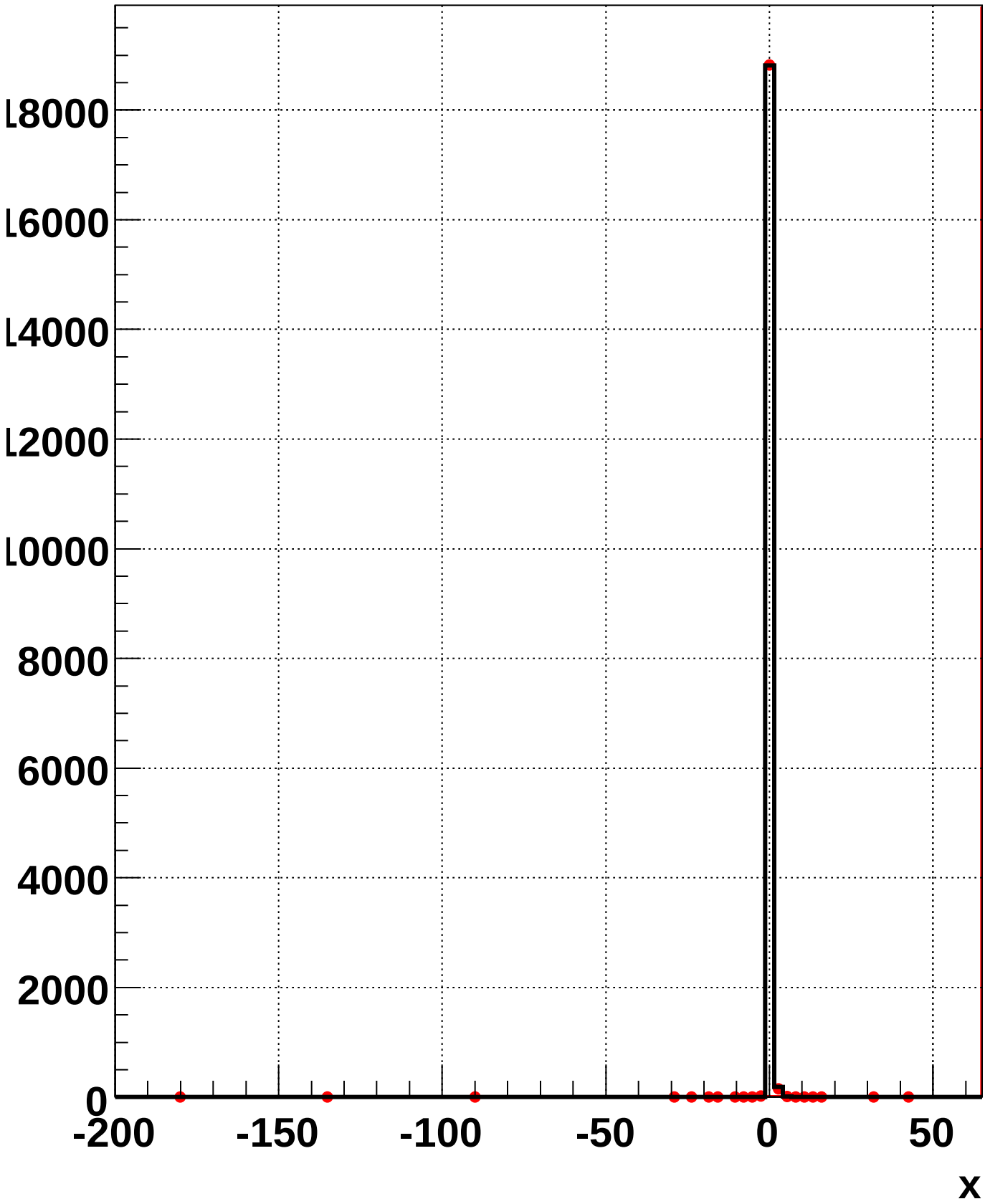


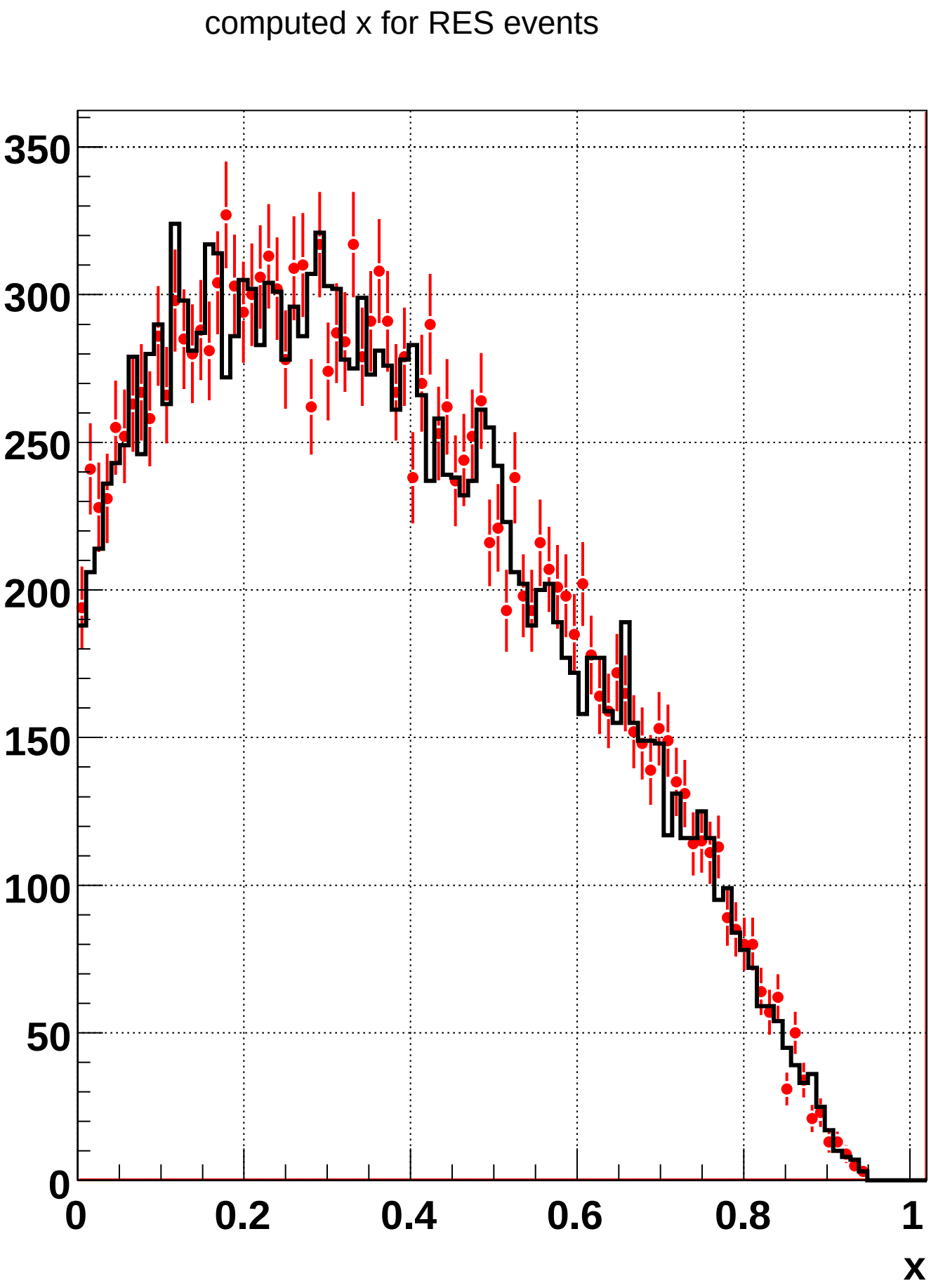
computed Q2 for DIS events



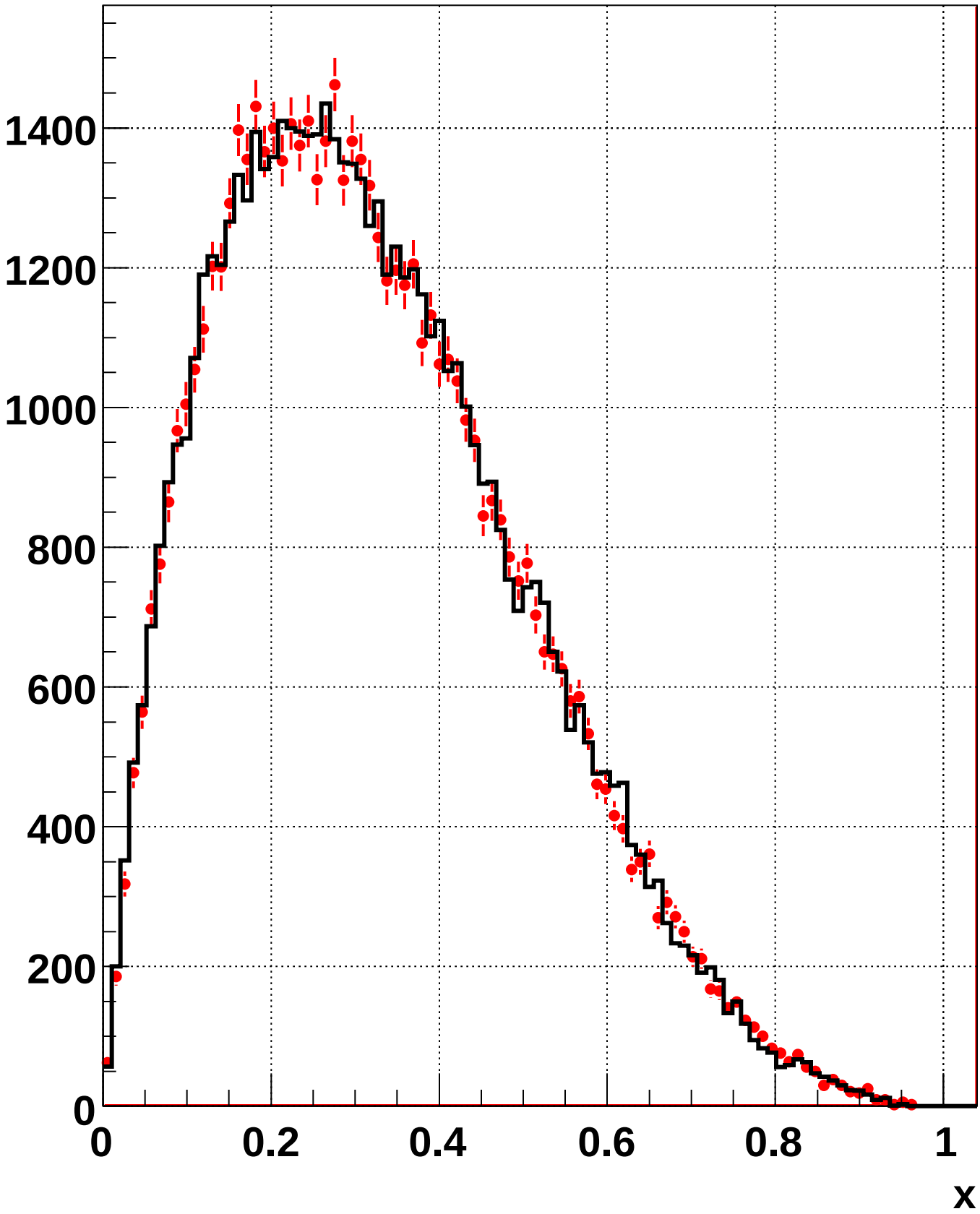

computed x for all events
×10^3
100
80
60
40
20
0
-200
-150
-100
-50
0
50
x

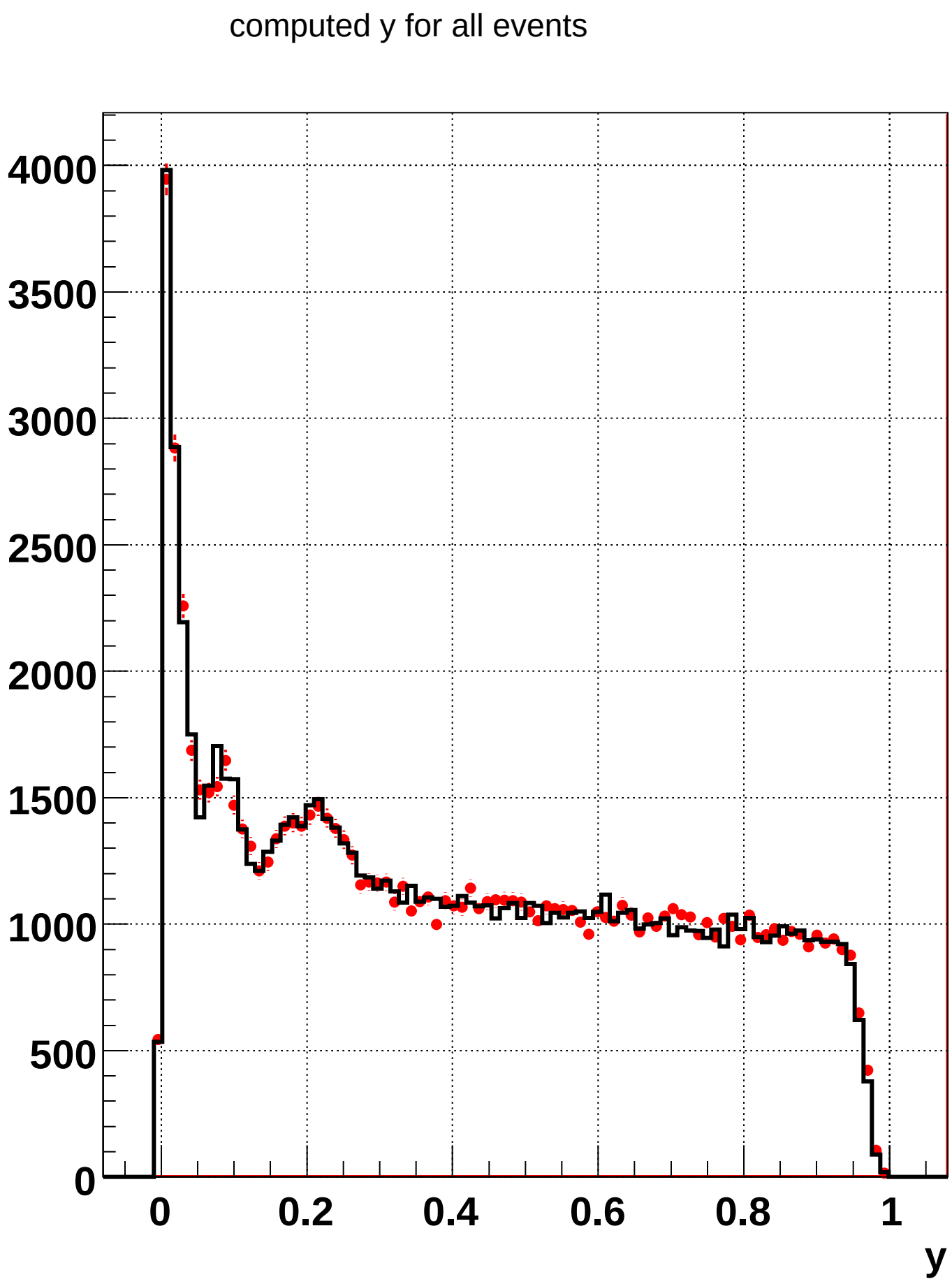
computed x for QEL events



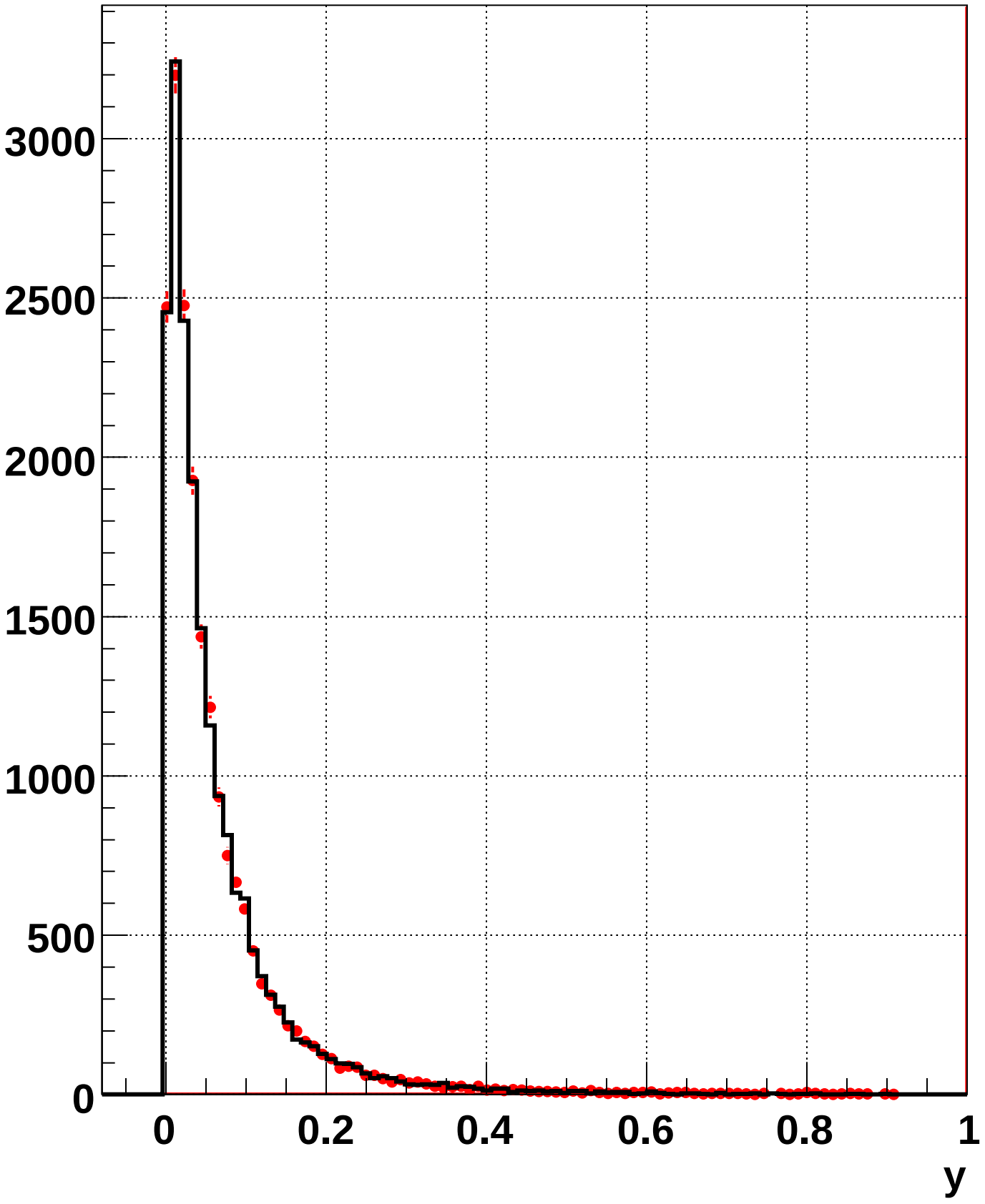

computed x for RES events
350
300
250
200
150
100
50
0
0
0.2
0.4
0.6
0.8
1
x

computed x for DIS events

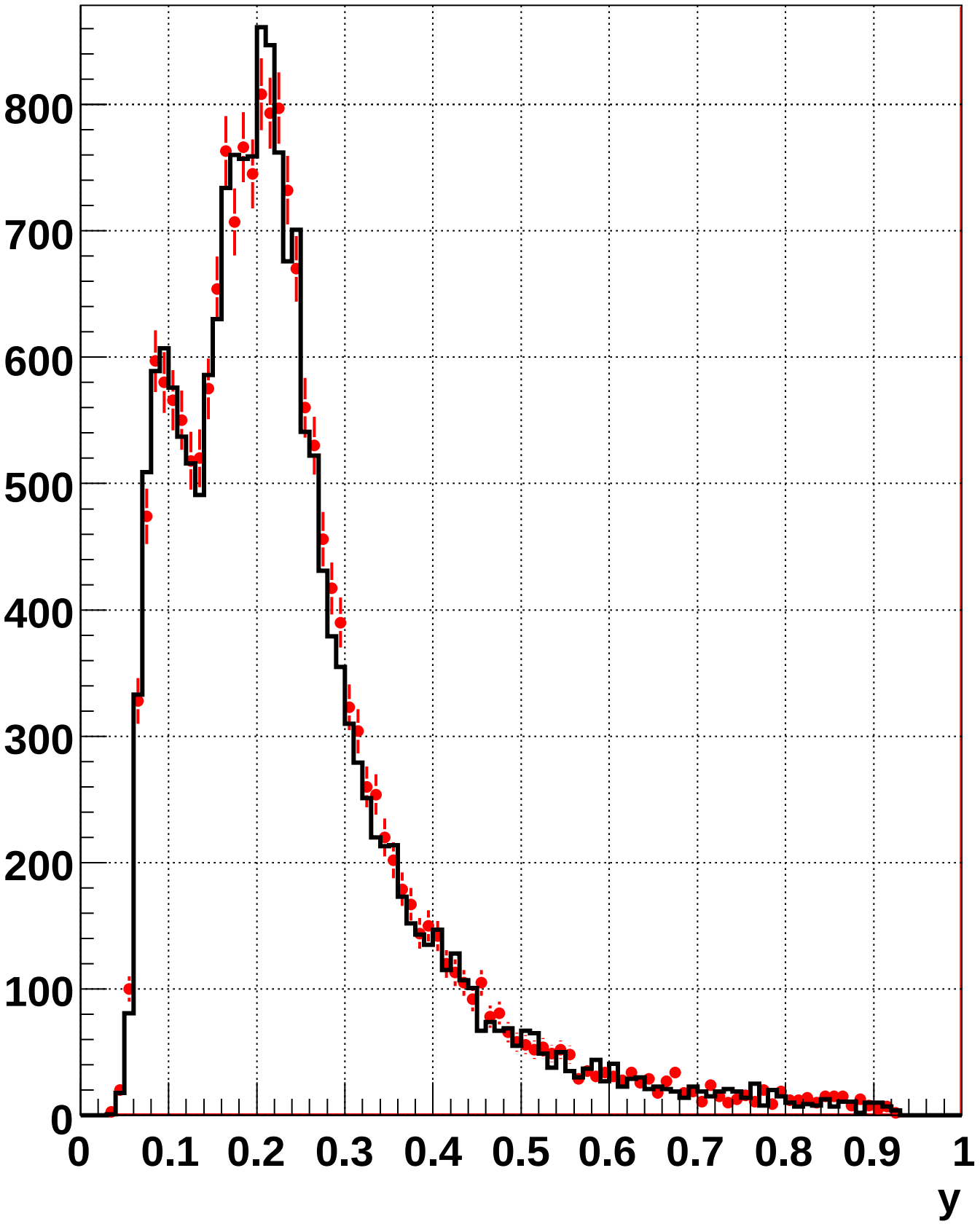



computed y for all events
4000
3500
3000
2500
2000
1500
1000
500
0
0
0.2
0.4
0.6
0.8
1
y

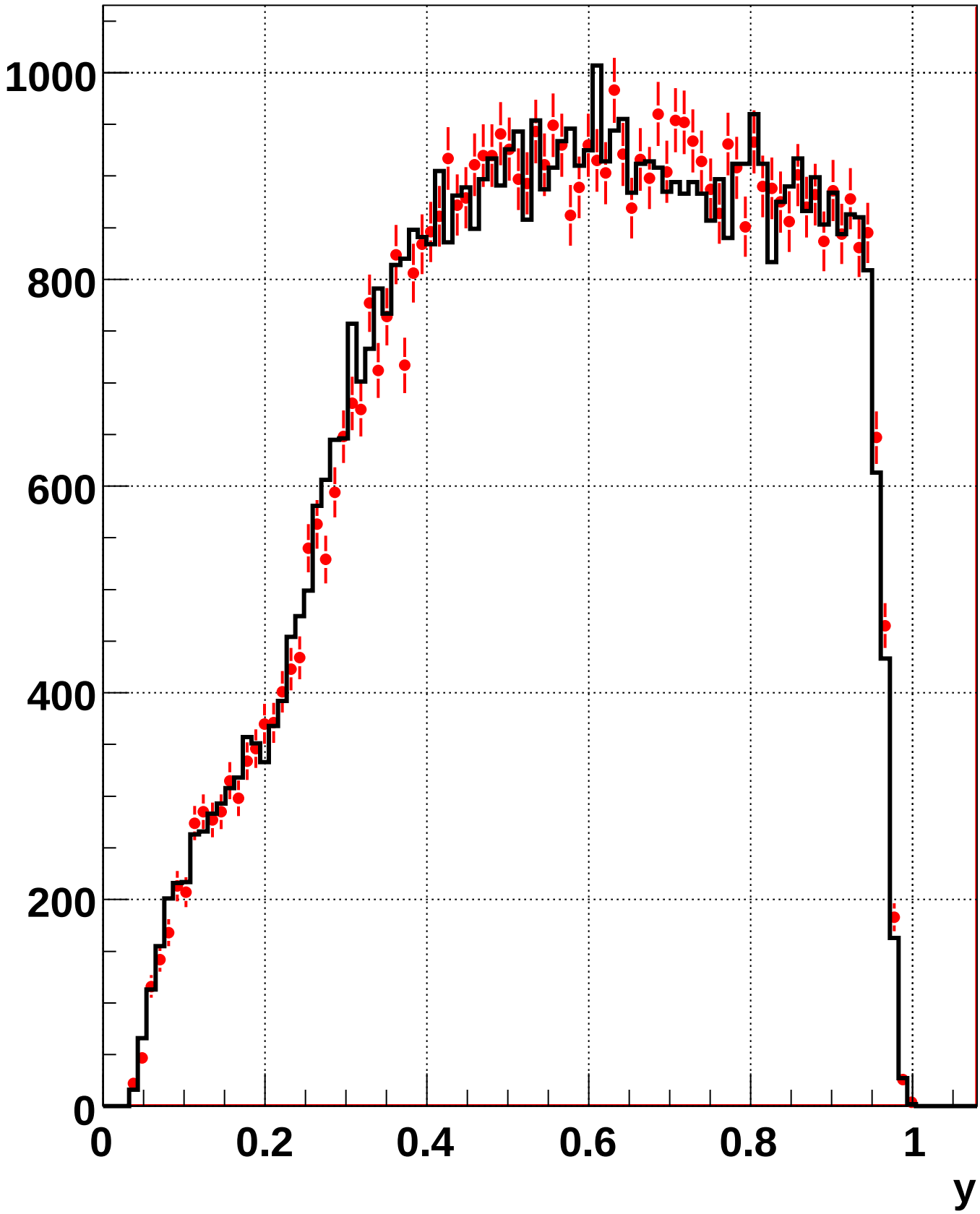
computed y for QEL events



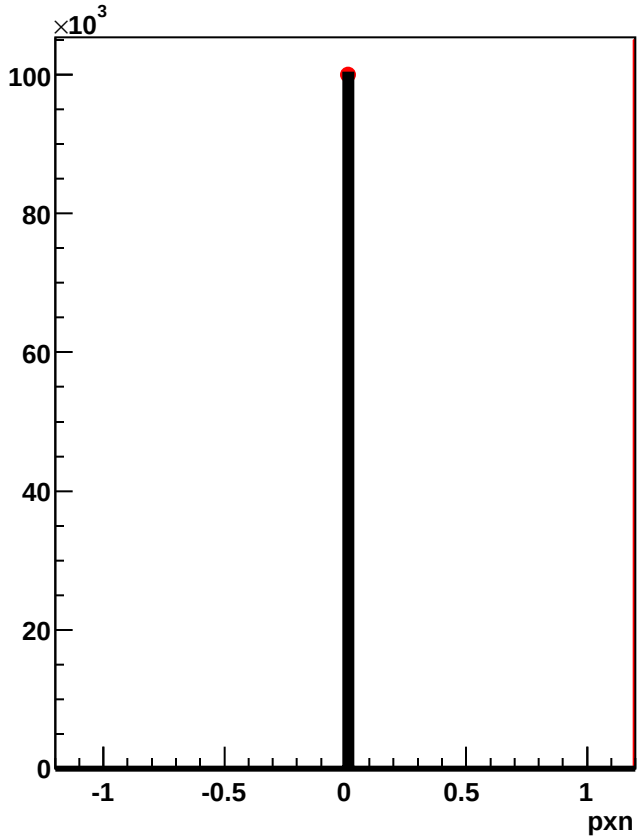
computed y for RES events

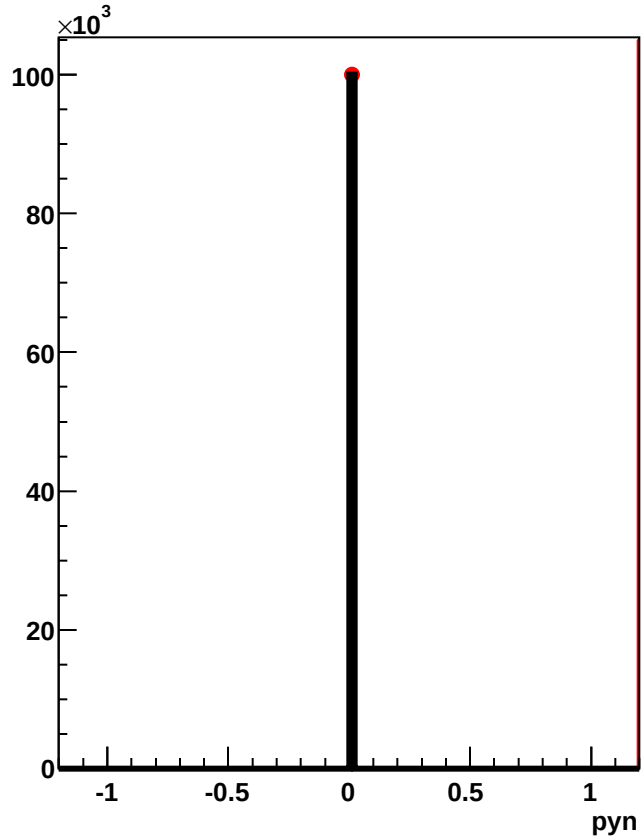


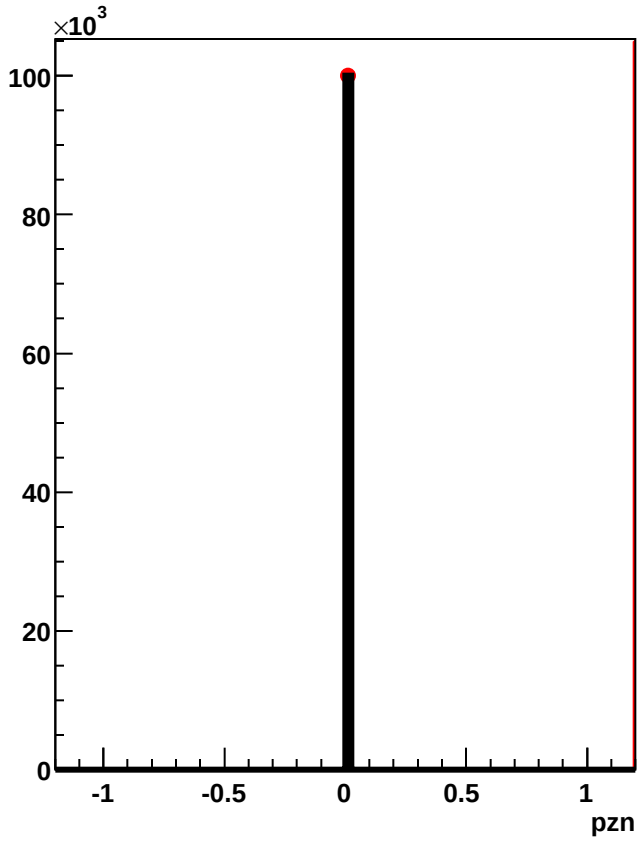
computed y for DIS events

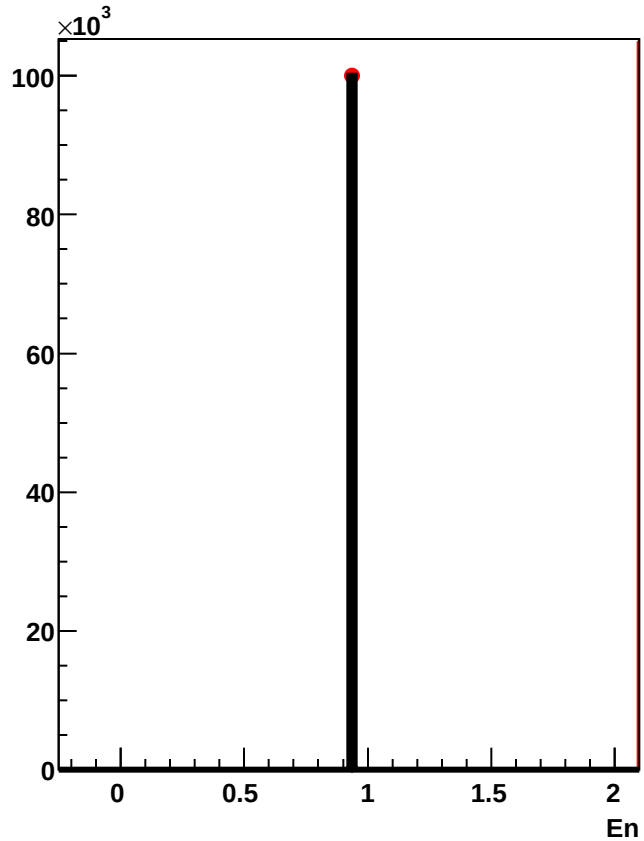


Initial state nucleon 4-Momentum


×10^3
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pxn

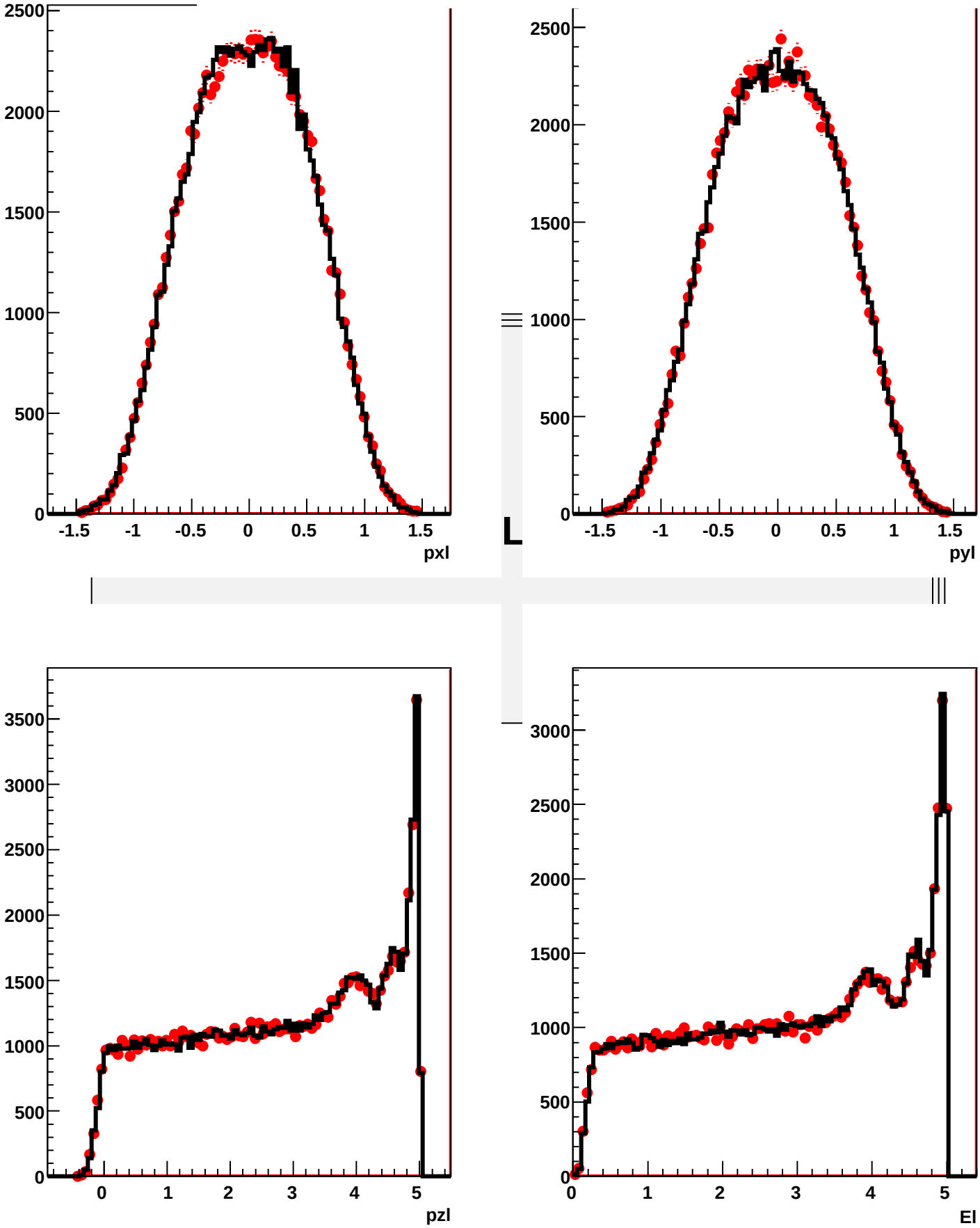

×10^3
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pyn


×10^3
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pzn

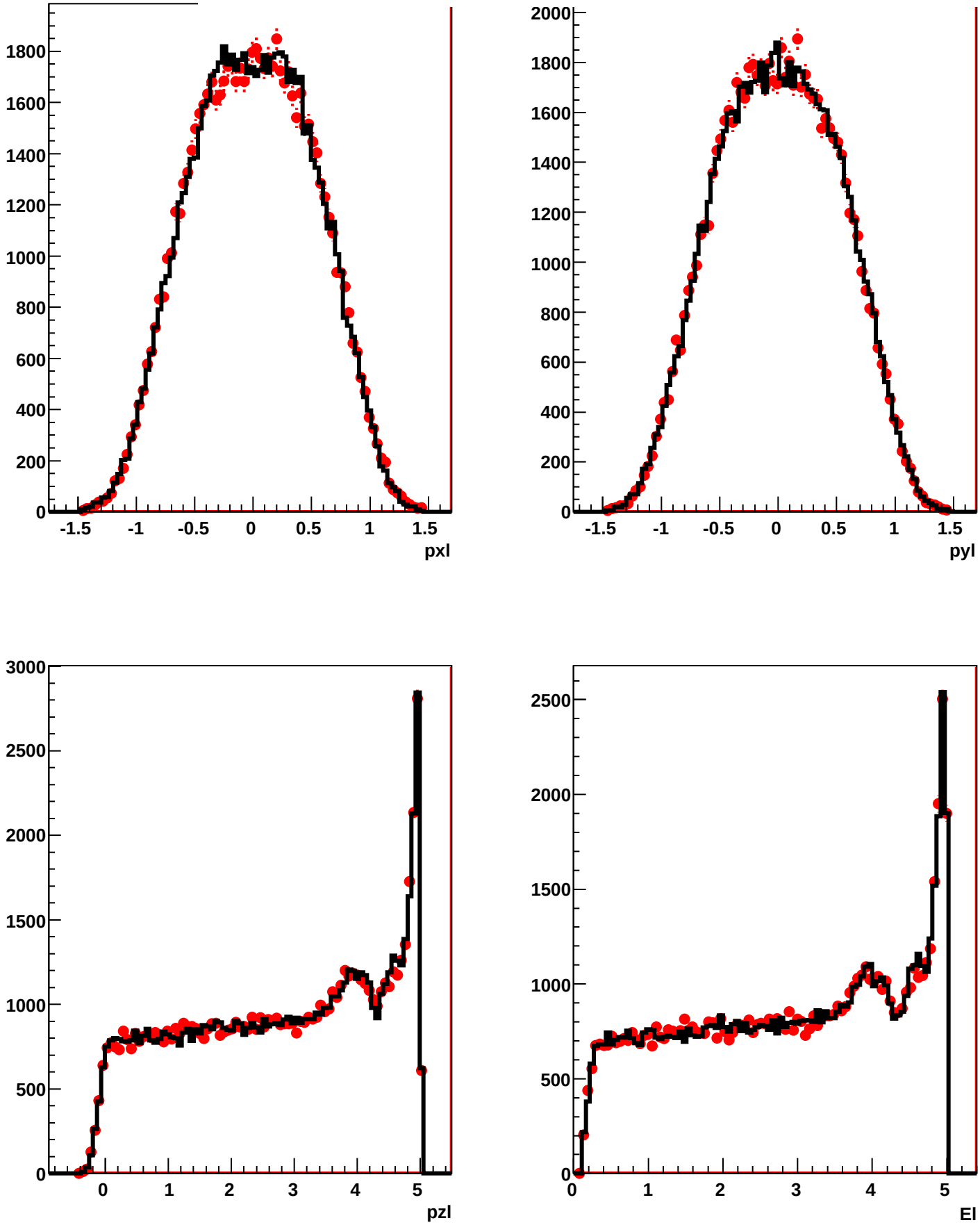

×10^3
100
80
60
40
20
0
0
0.5
1
1.5
2
En

Final State Primary Lepton 4-Momentum

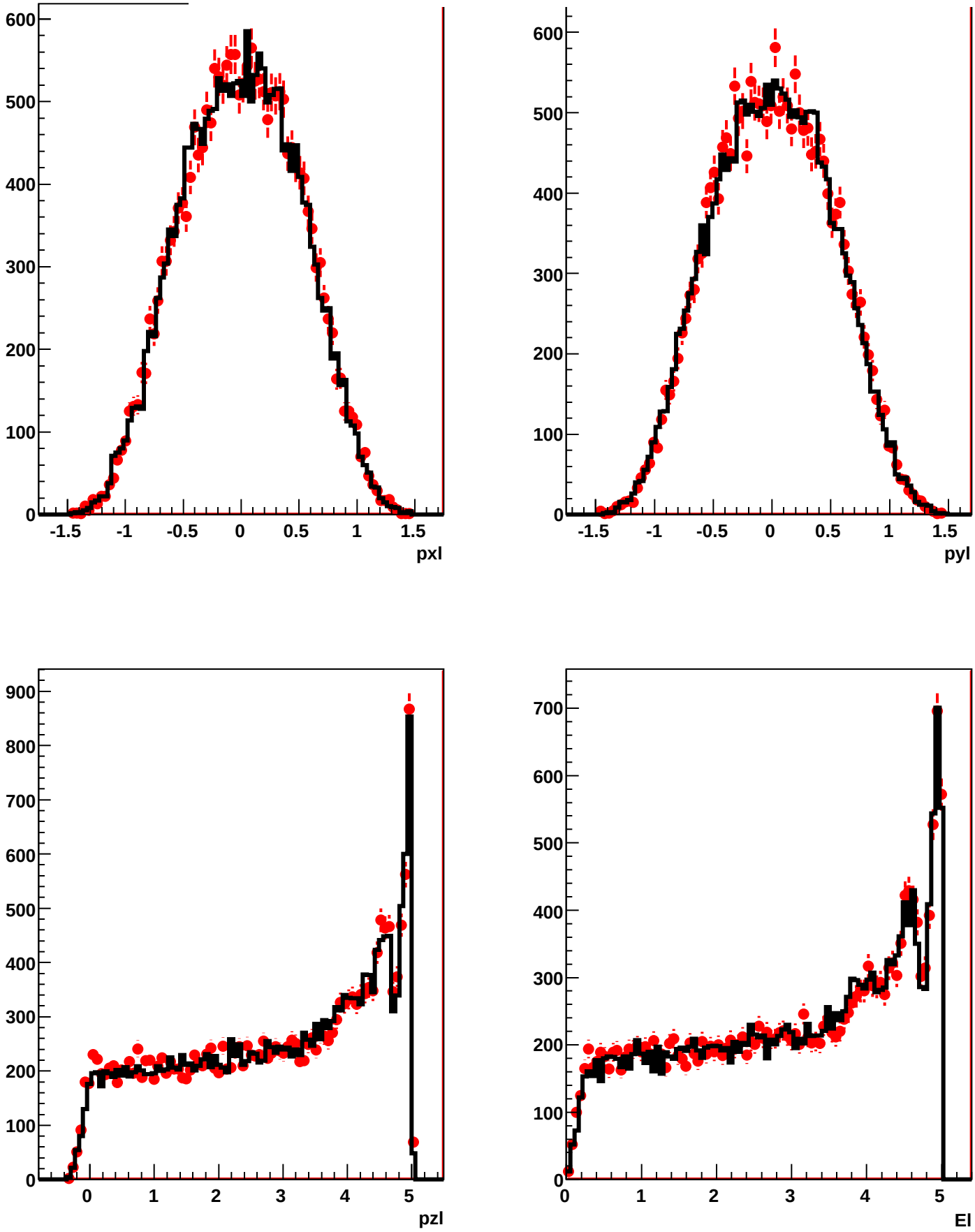
Final state primary lepton 4-p: All events



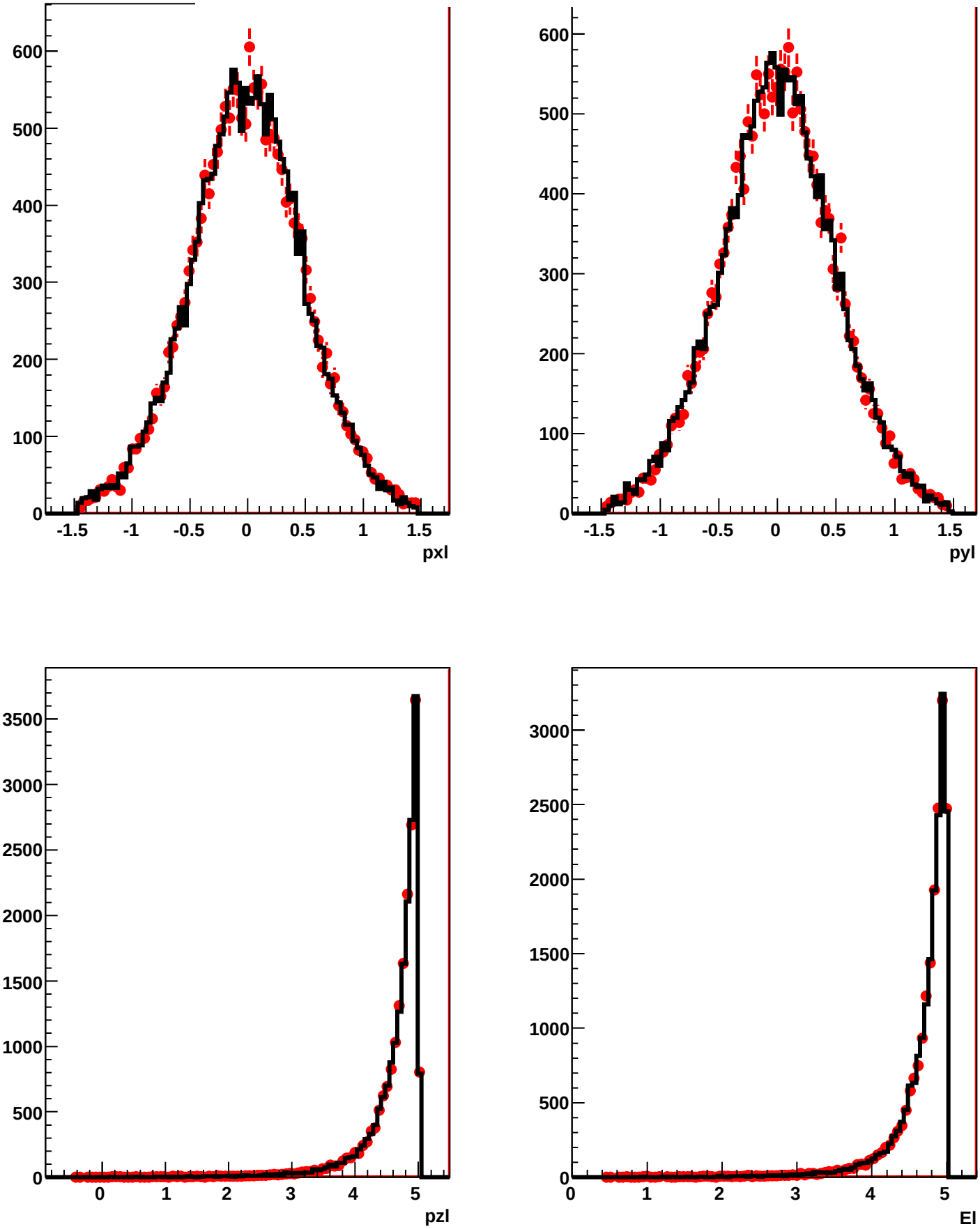
Final state primary lepton 4-p: All CC events



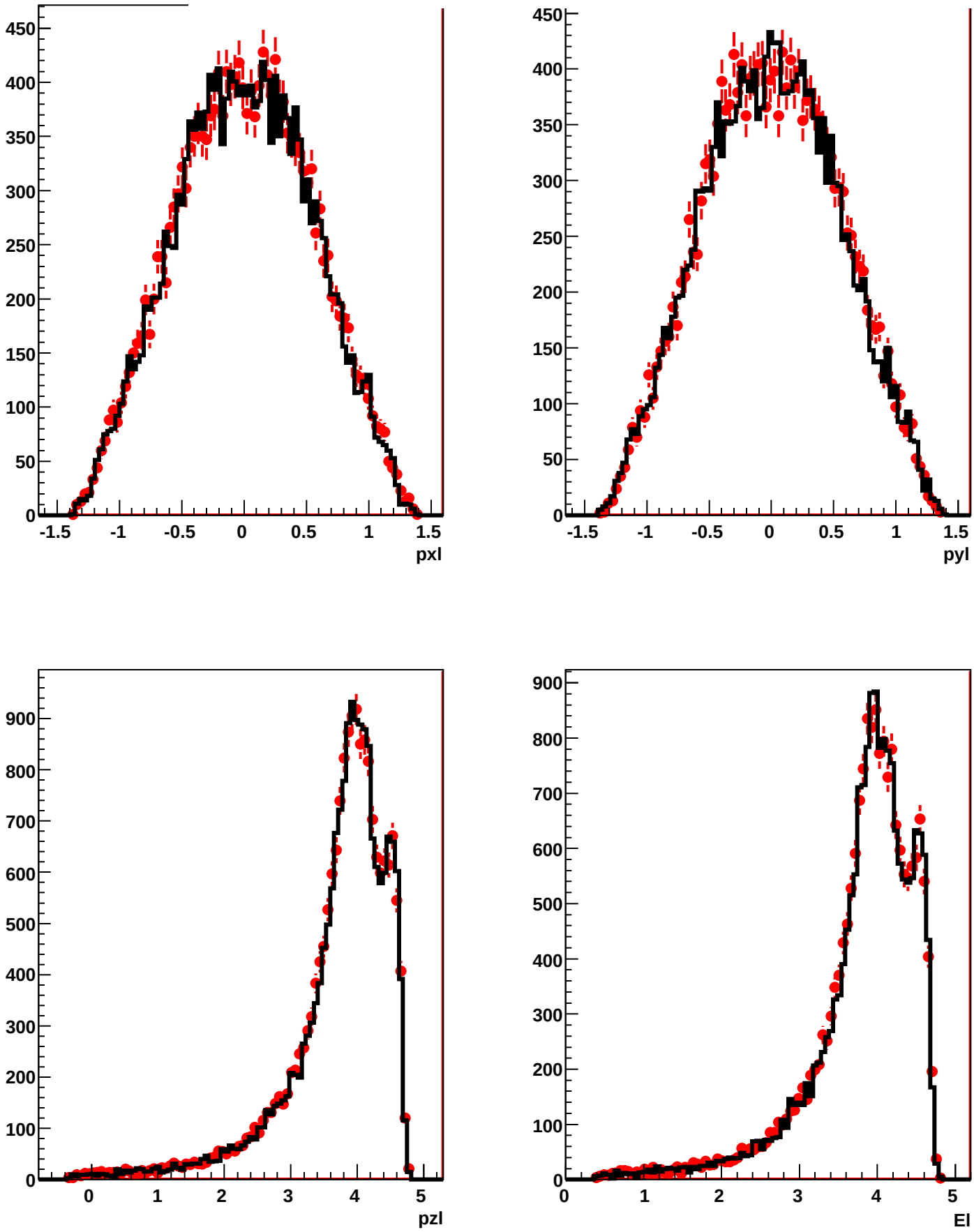
Final state primary lepton 4-p: All NC events



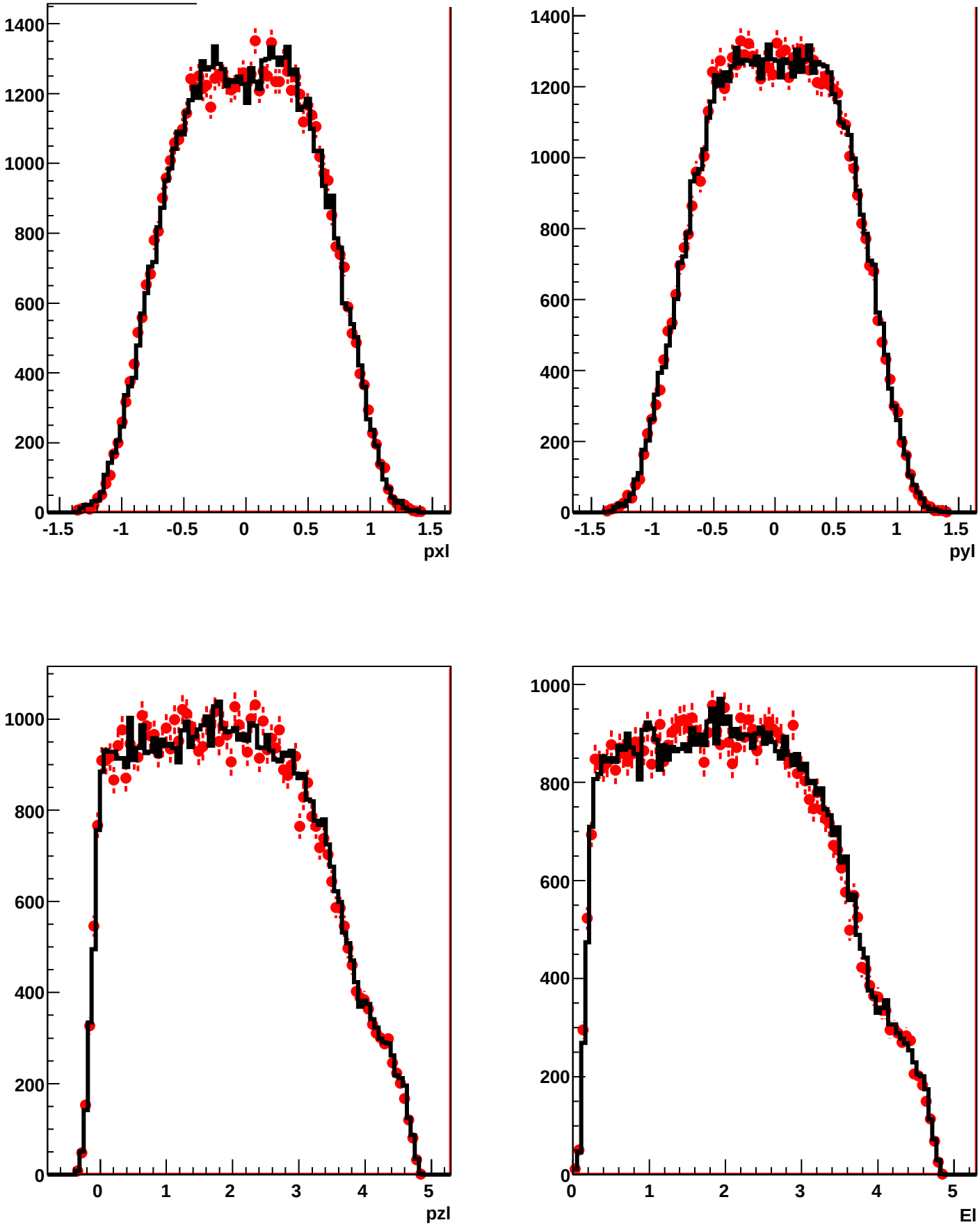
Final state primary lepton 4-p: QEL events



Final state primary lepton 4-p: RES events



Final state primary lepton 4-p: All DIS events



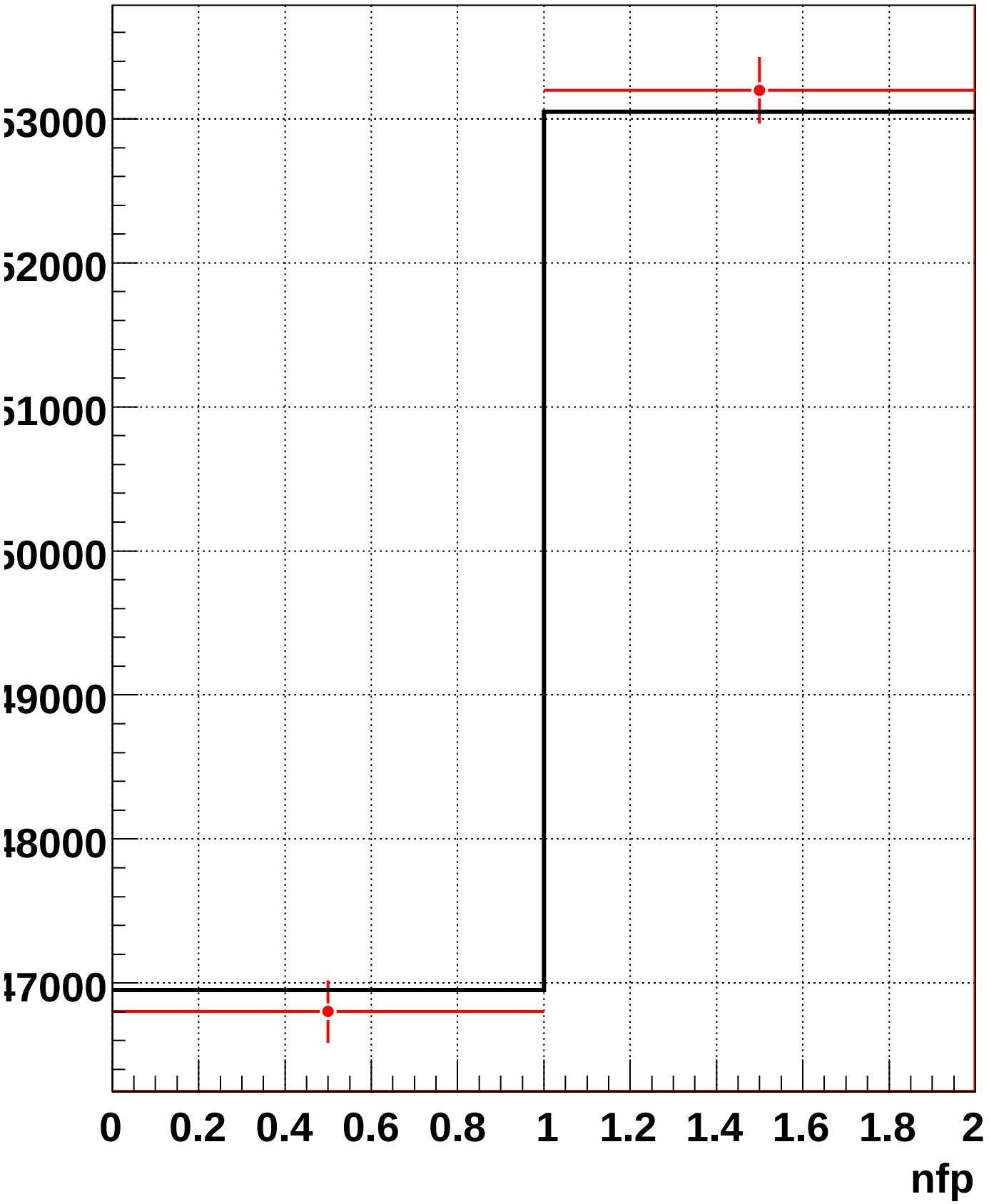
Final State Hadronic System

Multiplicities and 4-Momenta

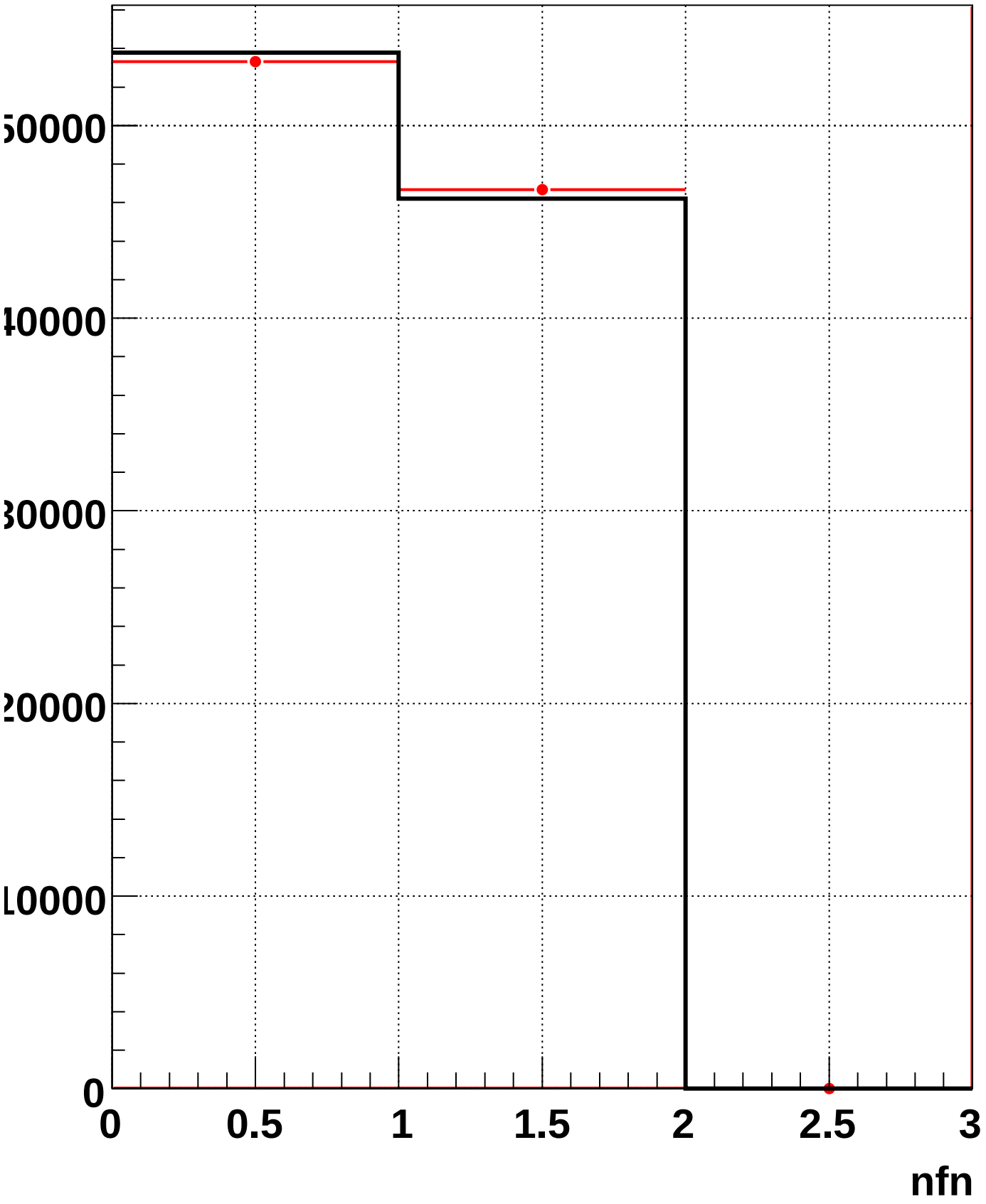
Note:

For nuclear targets these plots include the effect of intranuclear hadron transport / rescattering

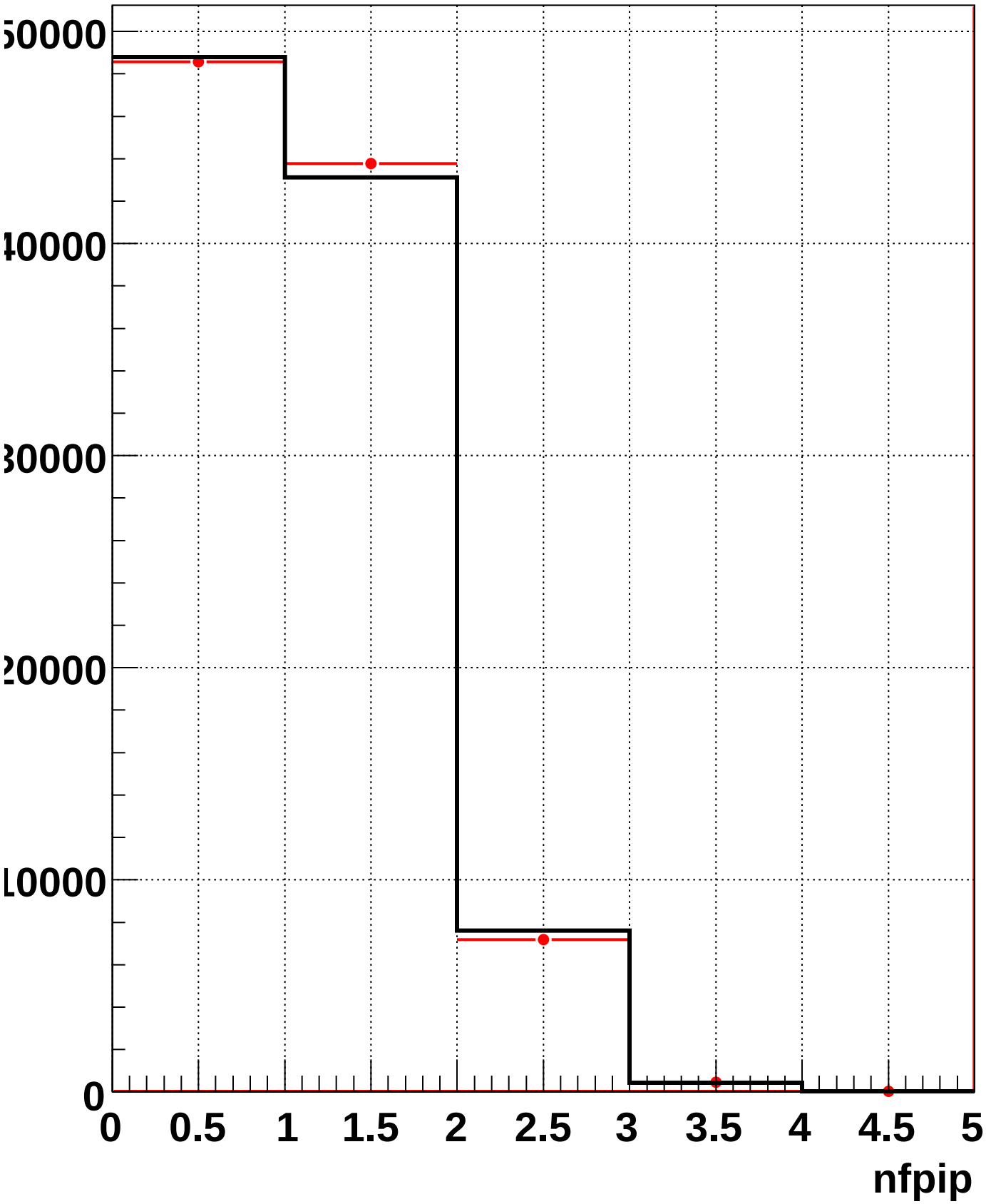
Number of final state protons



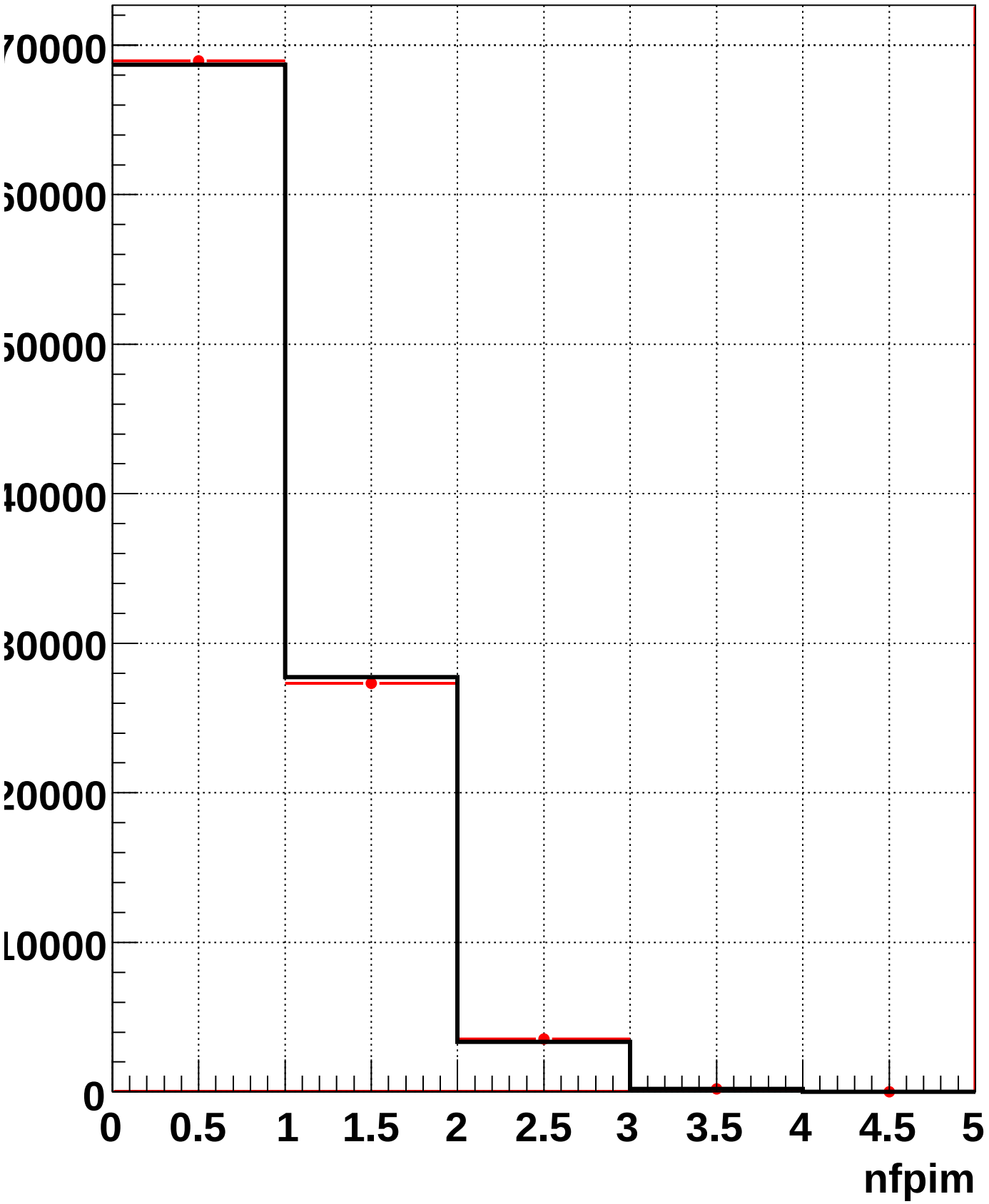
Number of final state neutrons



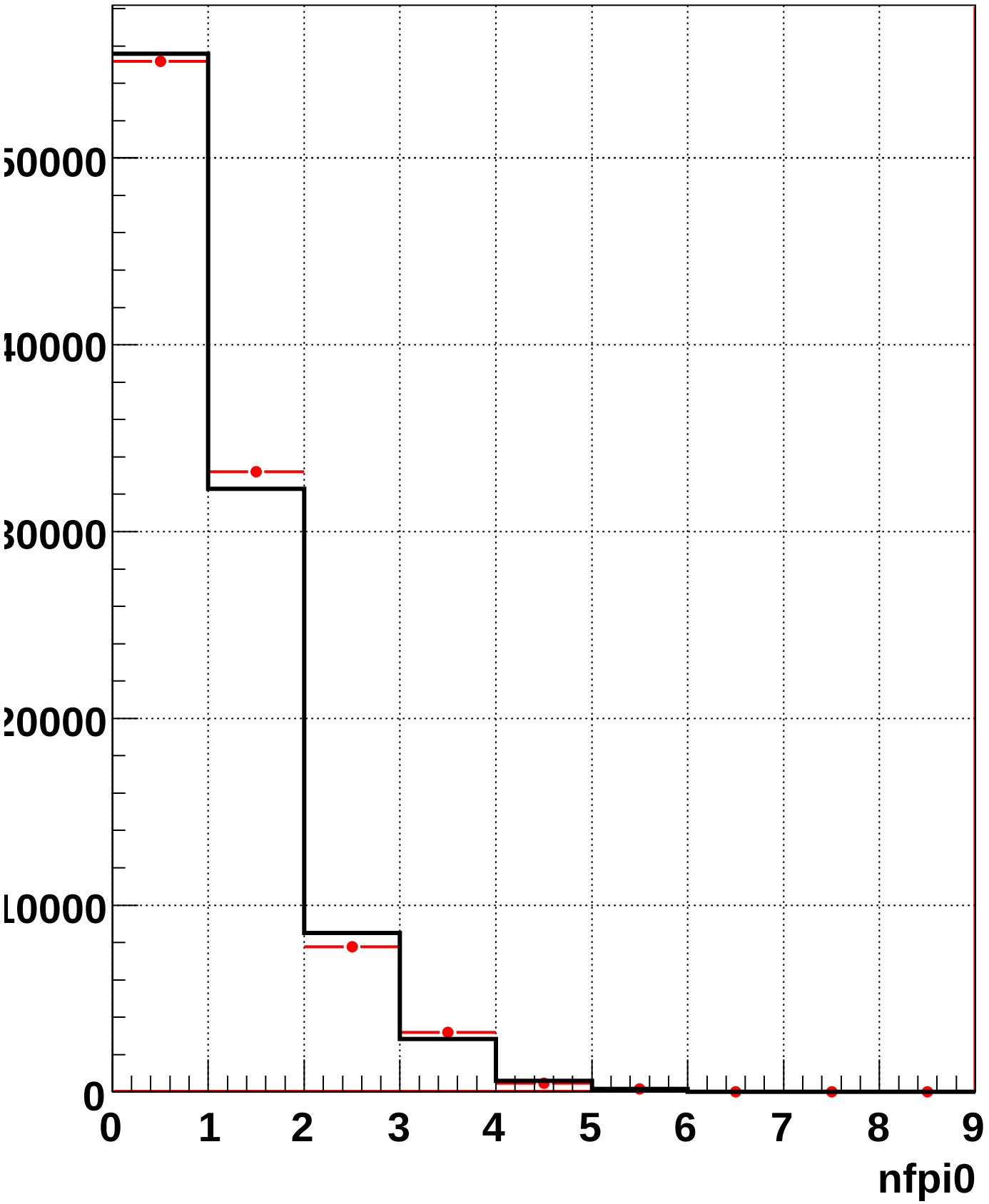
Number of final state pi+

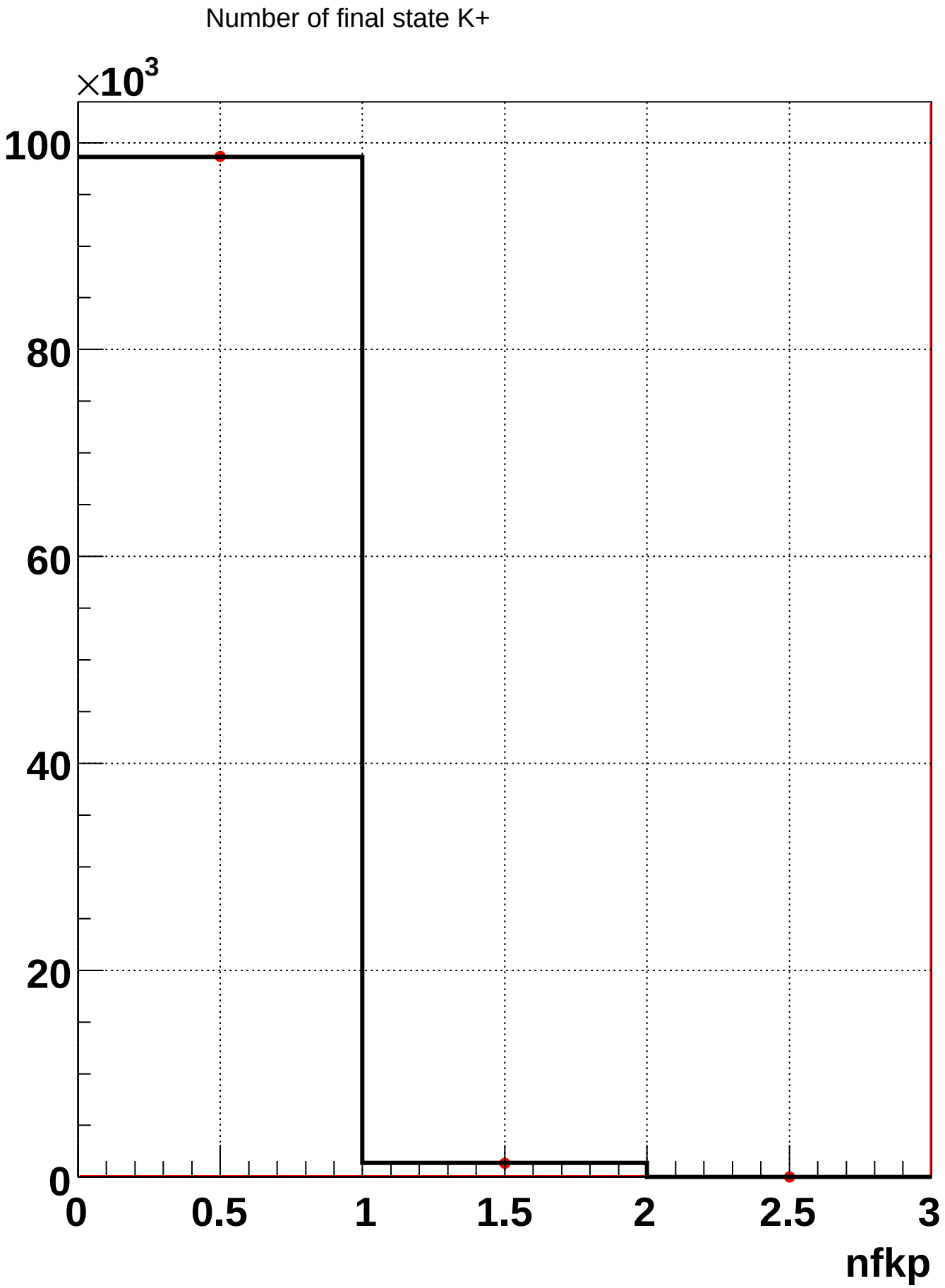


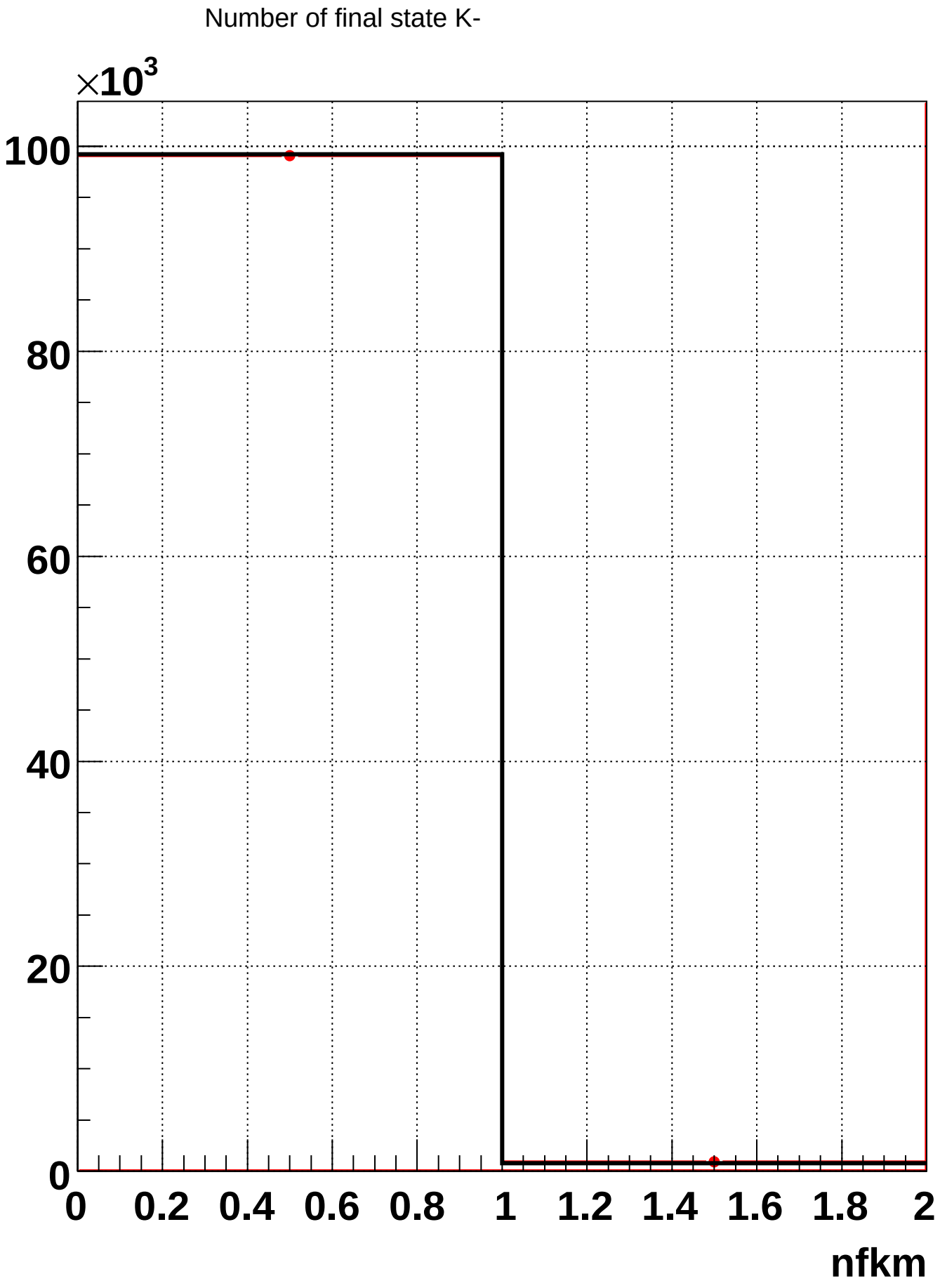
Number of final state pi-

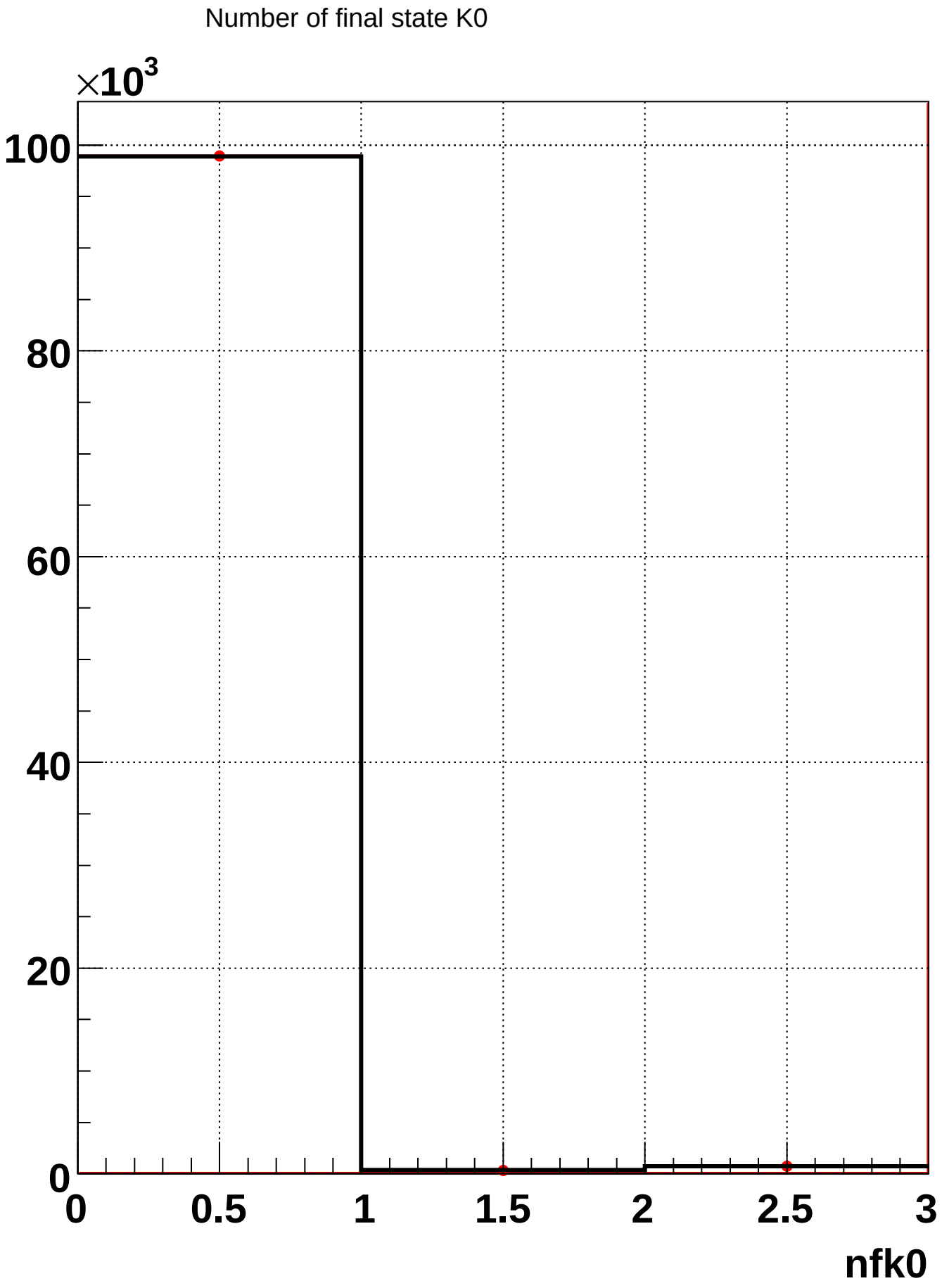


Number of final state pi0

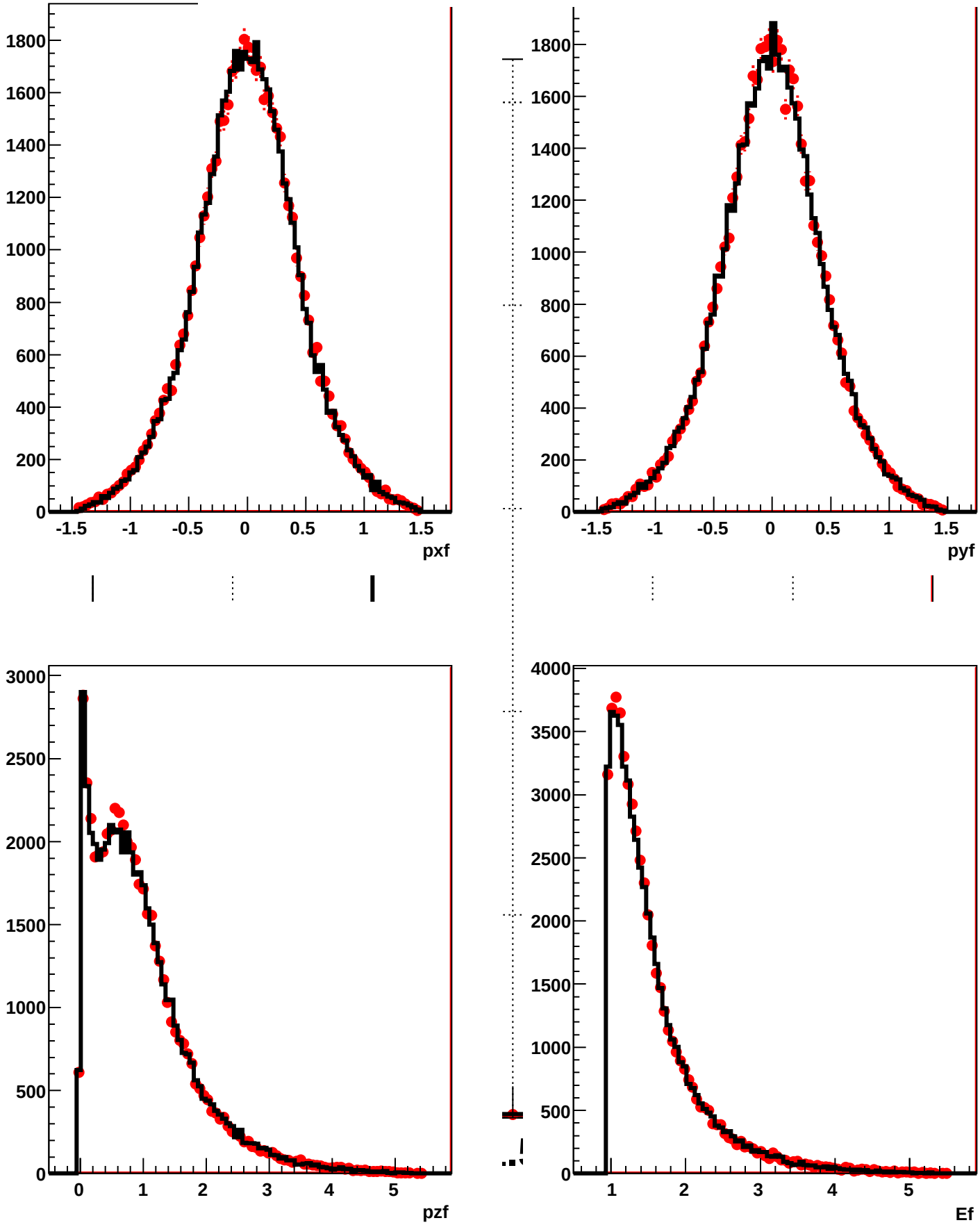



Number of final state K+
×10^3
100
80
60
40
20
0
0
0.5
1
1.5
2
2.5
3
nfkp

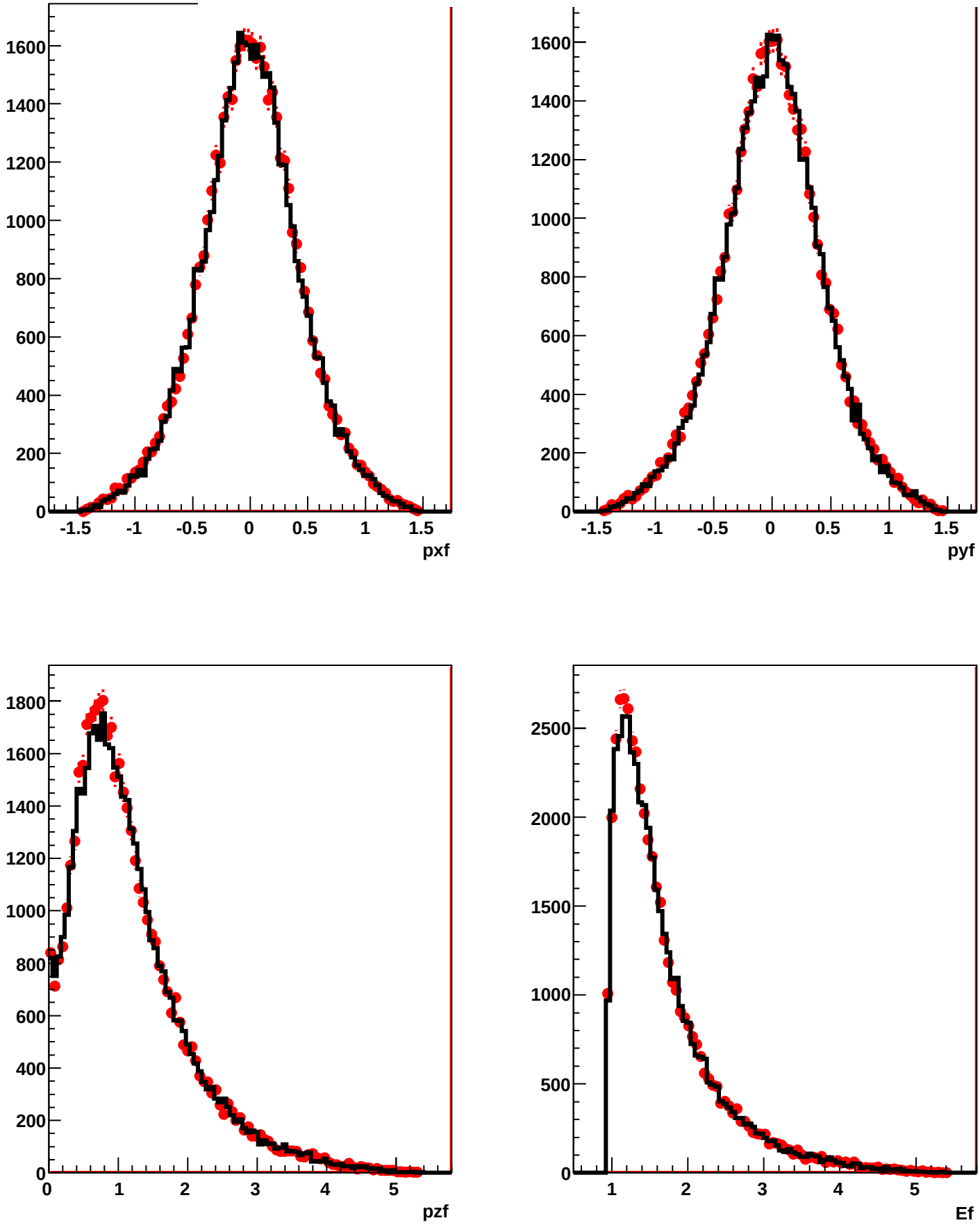

Number of final state K-
×10^3
100
80
60
40
20
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
nfkm


Number of final state K0
×10^3
100
80
60
40
20
0
0
0.5
1
1.5
2
2.5
3
nfk0

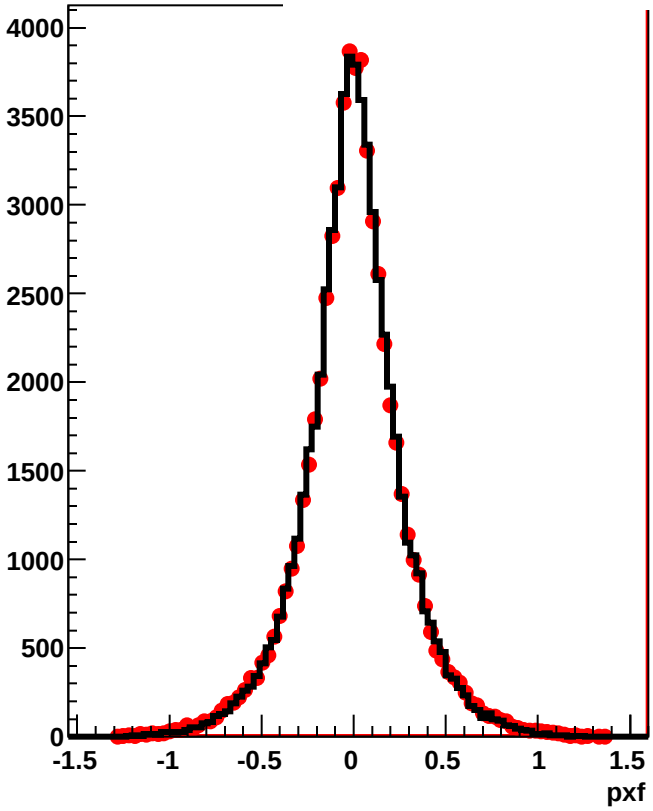
Final state protons 4-momentum

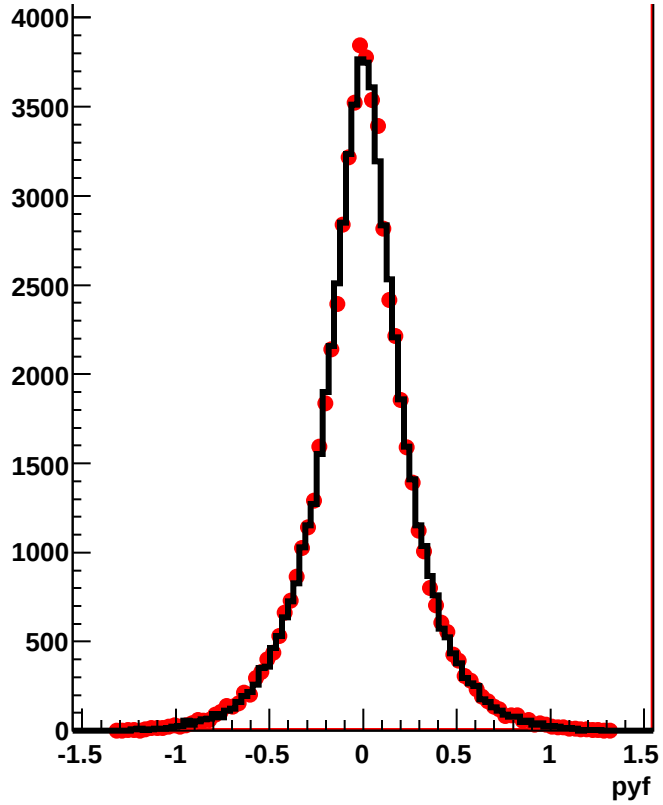


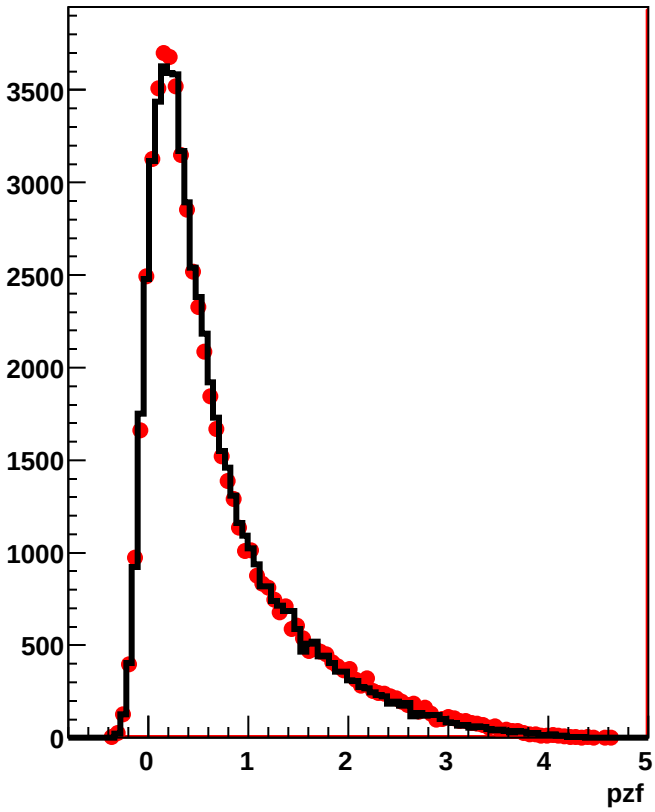
Final state neutrons 4-momentum

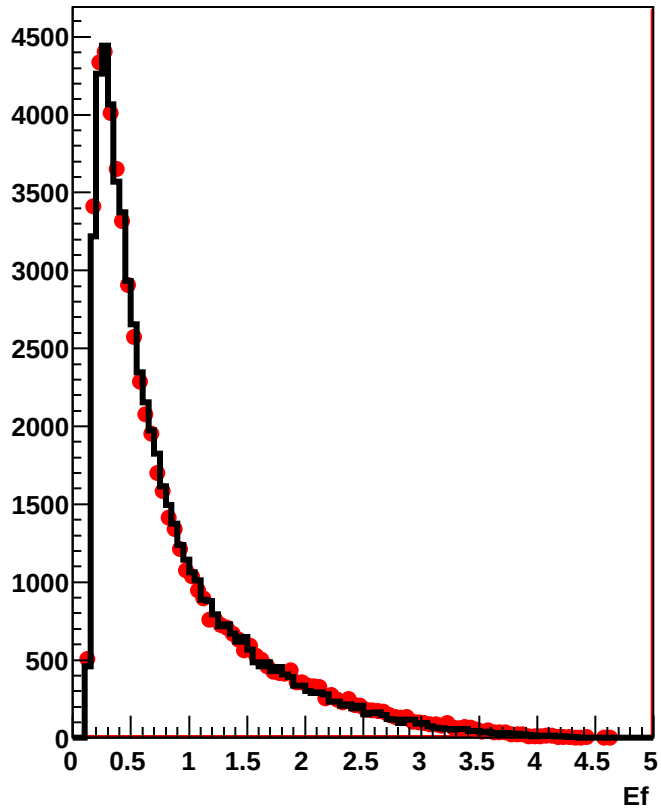


Final state pi0's 4-momentum

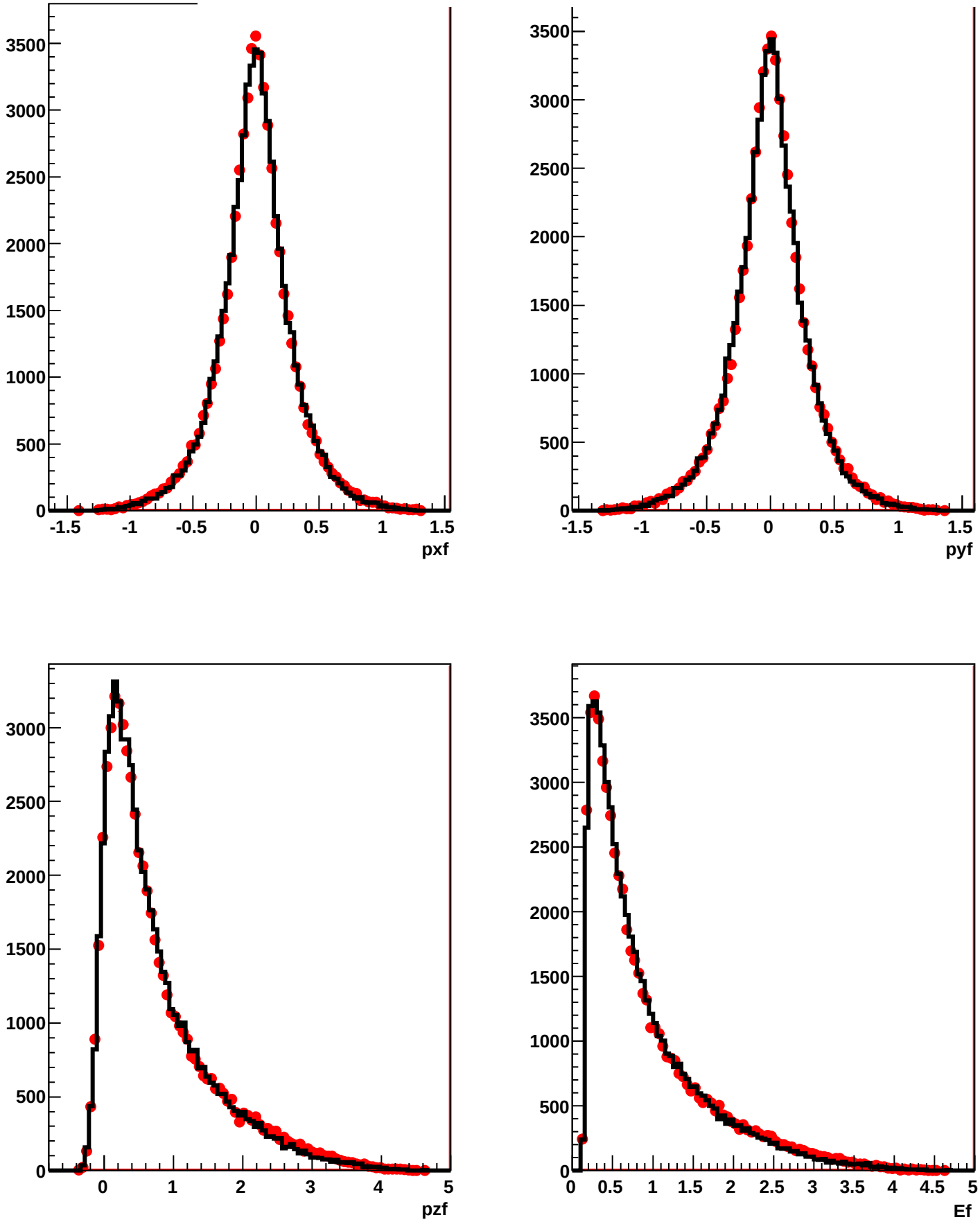




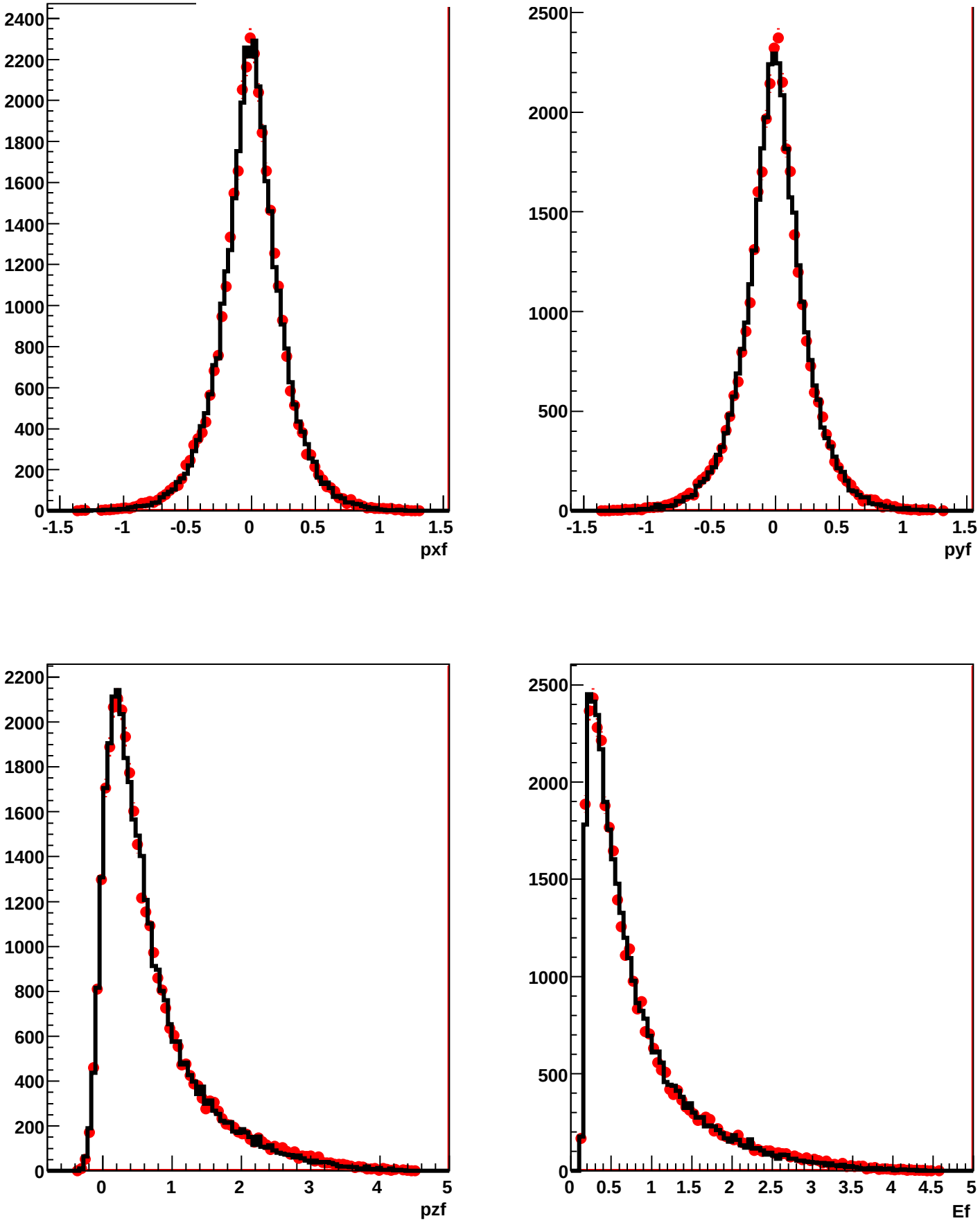




Final state pi+’s 4-momentum



Final state pi-'s 4-momentum



GENIE-2.0.0 vs NEUGEN/Daikon+ Event Sample Comparisons

Event Sample:

100k events, numu+n, 50GeV, all processes

Notes:

Daikon+ is a NEUGEN Daikon revision version

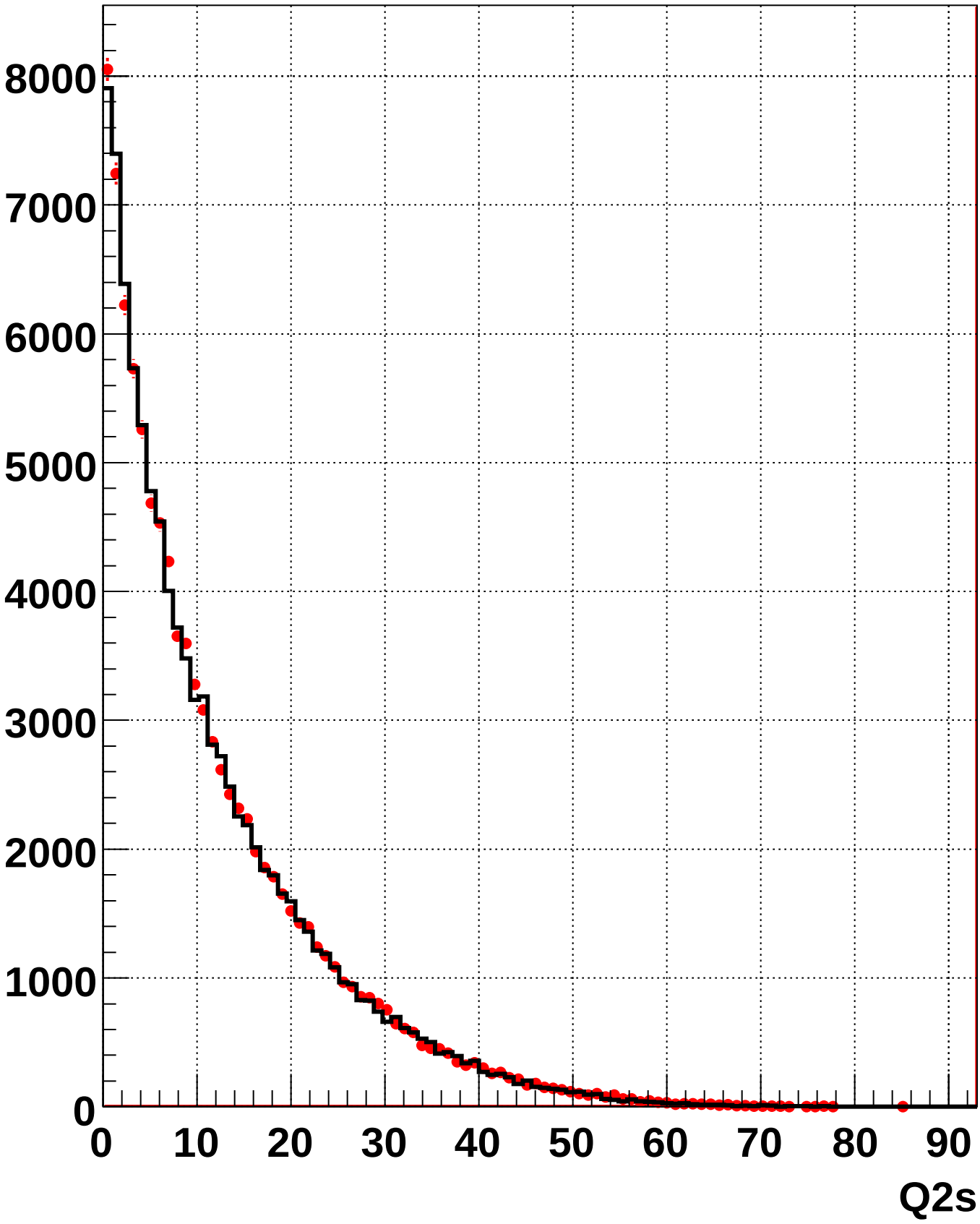
GENIE predictions shown with lines / NEUGEN's with markers

Event Numbers:

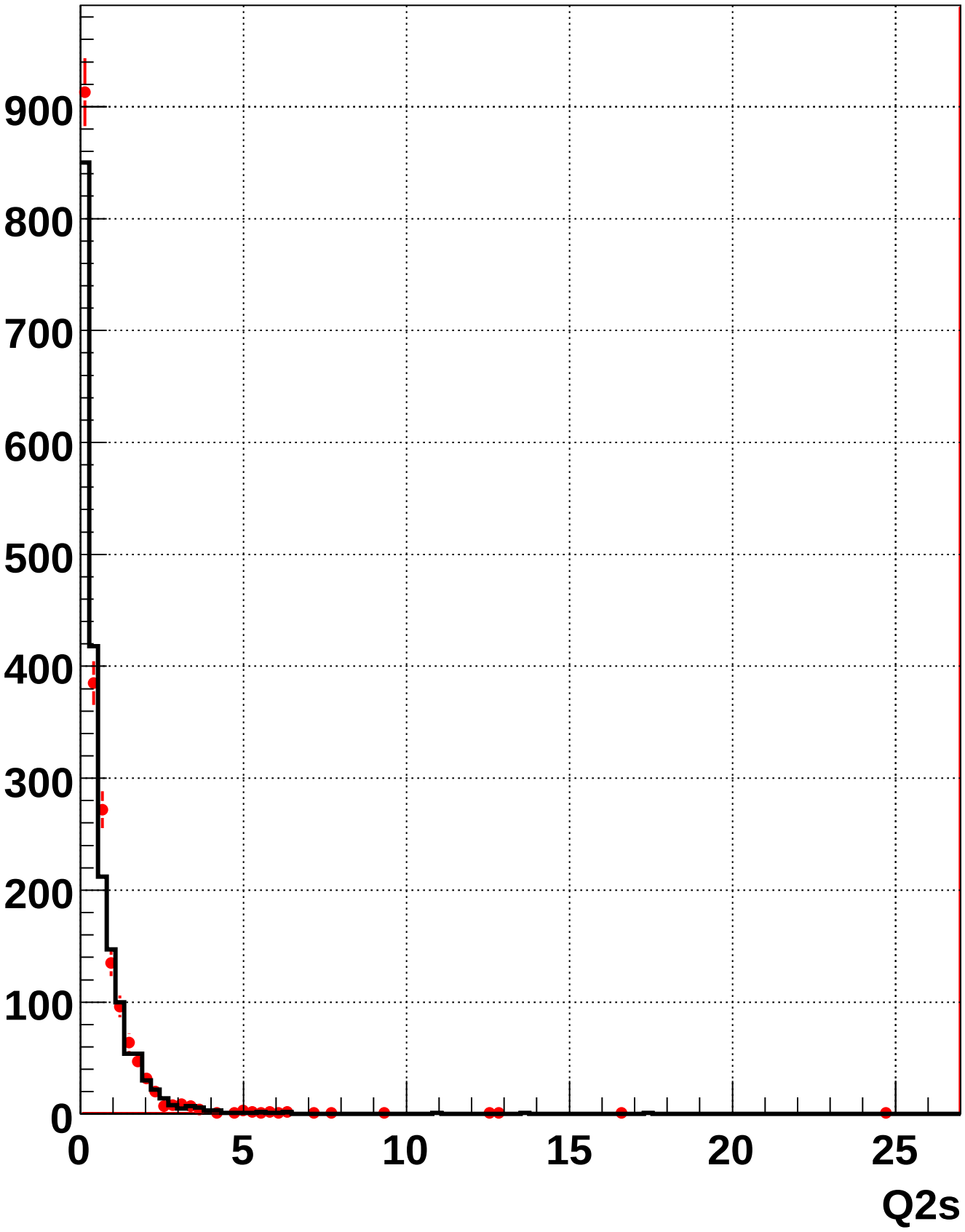
ALL :	100000 [NeuGEN],	100000 [GENIE]
QEL :	2019 [NeuGEN],	1946 [GENIE]
QEL-CC :	1609 [NeuGEN],	1564 [GENIE]
QEL-NC :	410 [NeuGEN],	382 [GENIE]
RES :	2179 [NeuGEN],	2117 [GENIE]
RES-CC :	1572 [NeuGEN],	1527 [GENIE]
RES-NC :	607 [NeuGEN],	590 [GENIE]
DIS :	95802 [NeuGEN],	95937 [GENIE]
DIS-CC :	76381 [NeuGEN],	76627 [GENIE]
(charm):	4064 [NeuGEN],	4183 [GENIE]
DIS-NC :	19421 [NeuGEN],	19310 [GENIE]
COH :	0 [NeuGEN],	0 [GENIE]
COH-CC :	0 [NeuGEN],	0 [GENIE]
COH-NC :	0 [NeuGEN],	0 [GENIE]
IMD :	0 [NeuGEN],	0 [GENIE]

Selected Kinematical Quantities

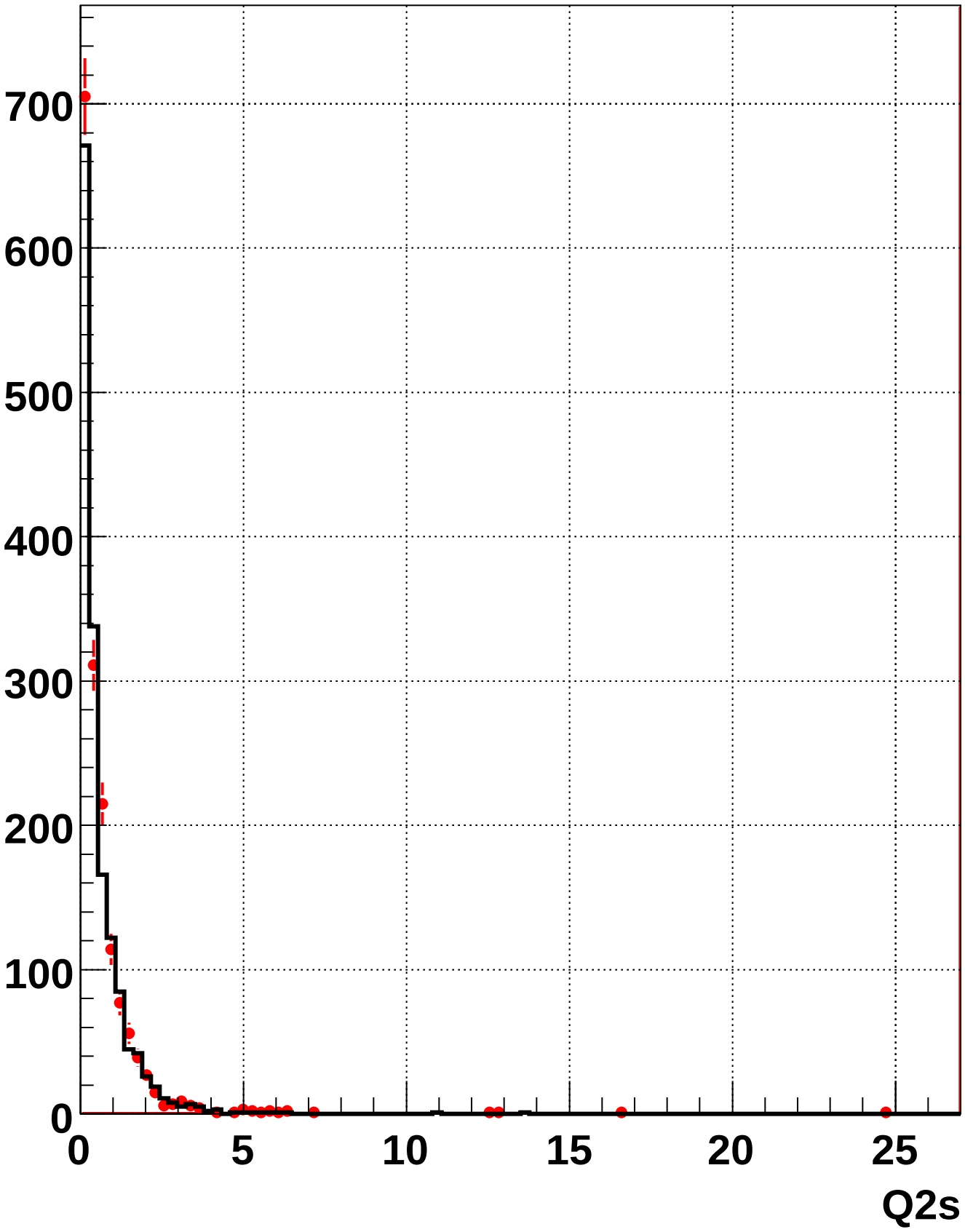
selected Q2 for all events



selected Q2 for QEL events

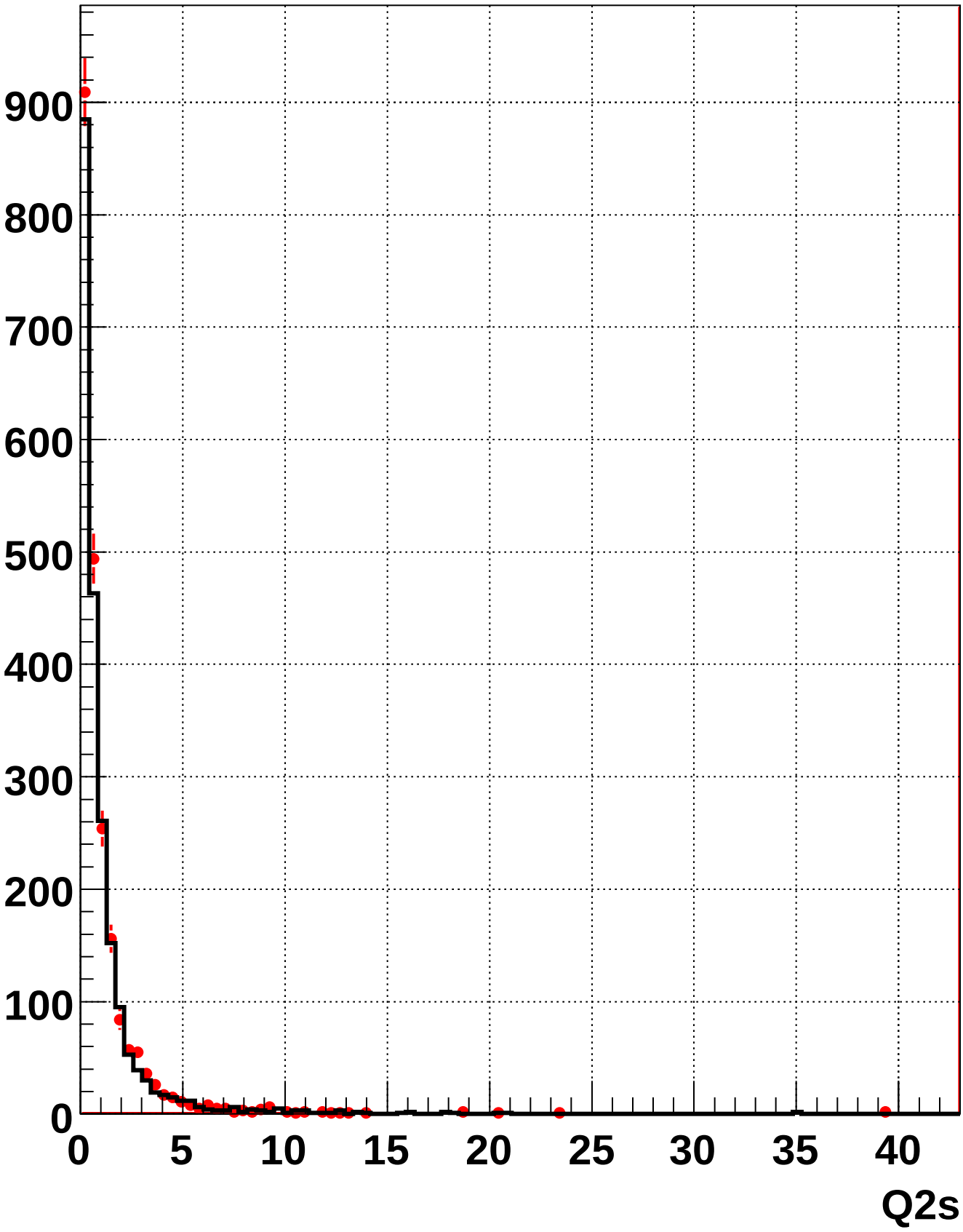


selected Q2 for QEL CC events

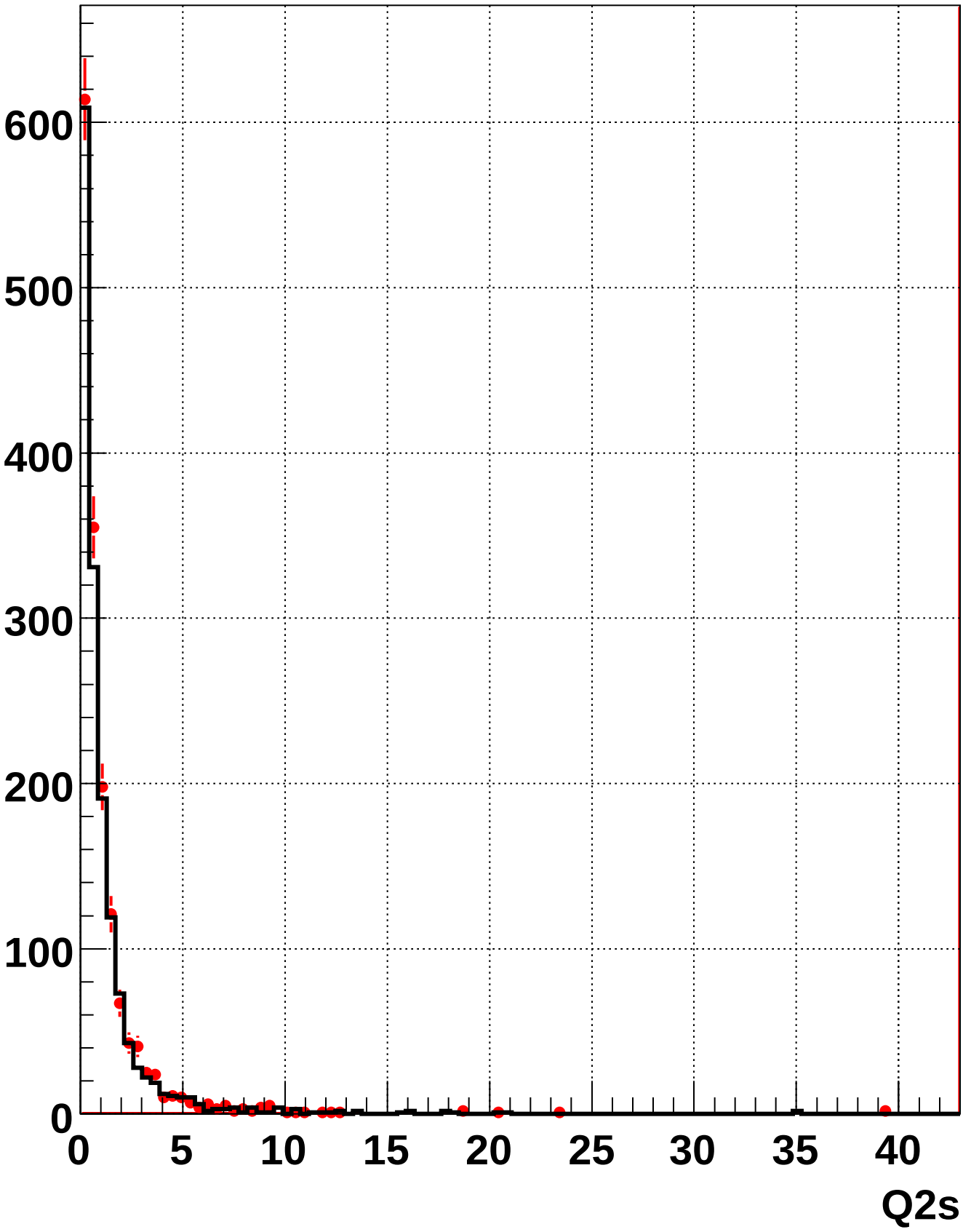


selected Q2 for QEL NC events

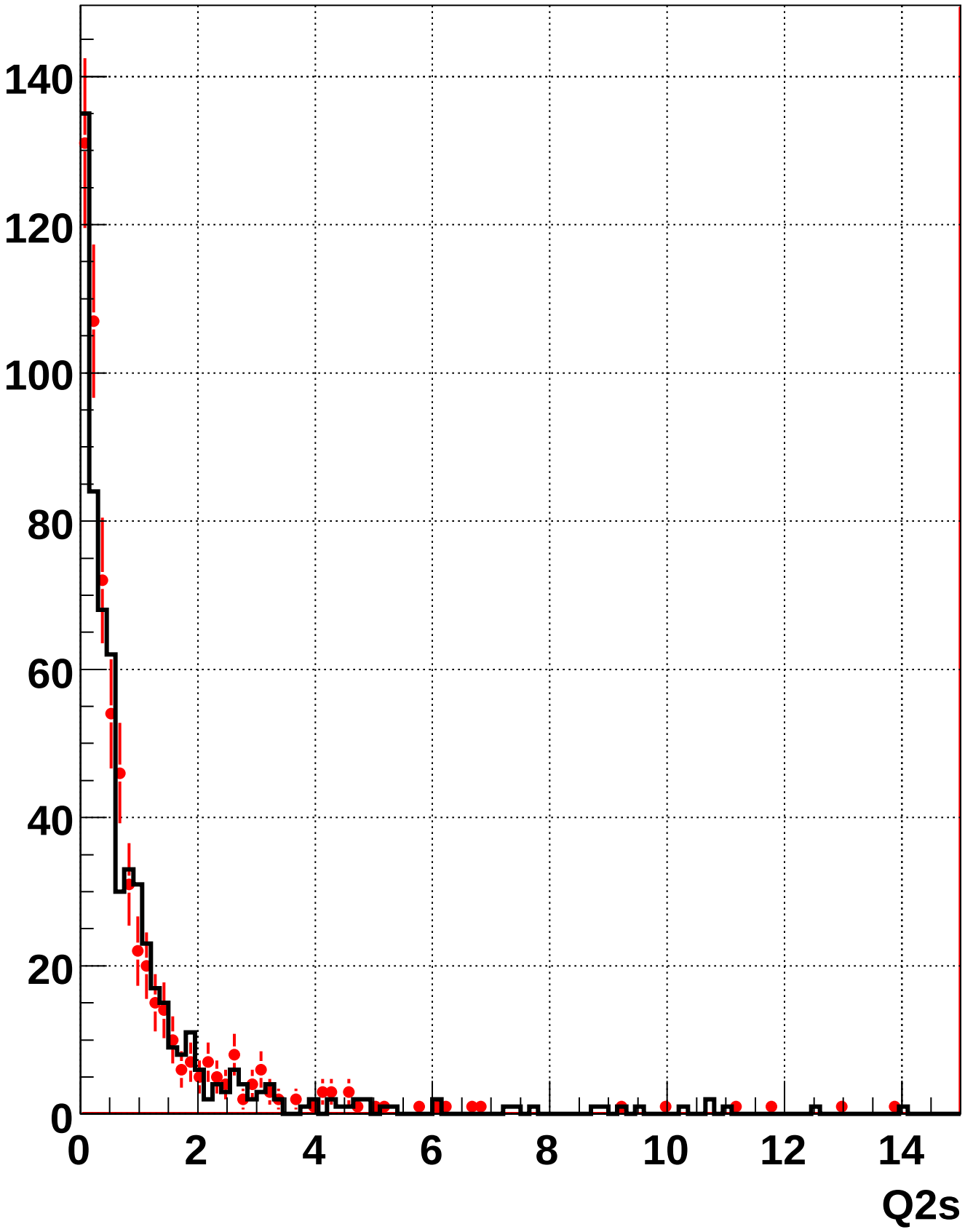
selected Q2 for RES events



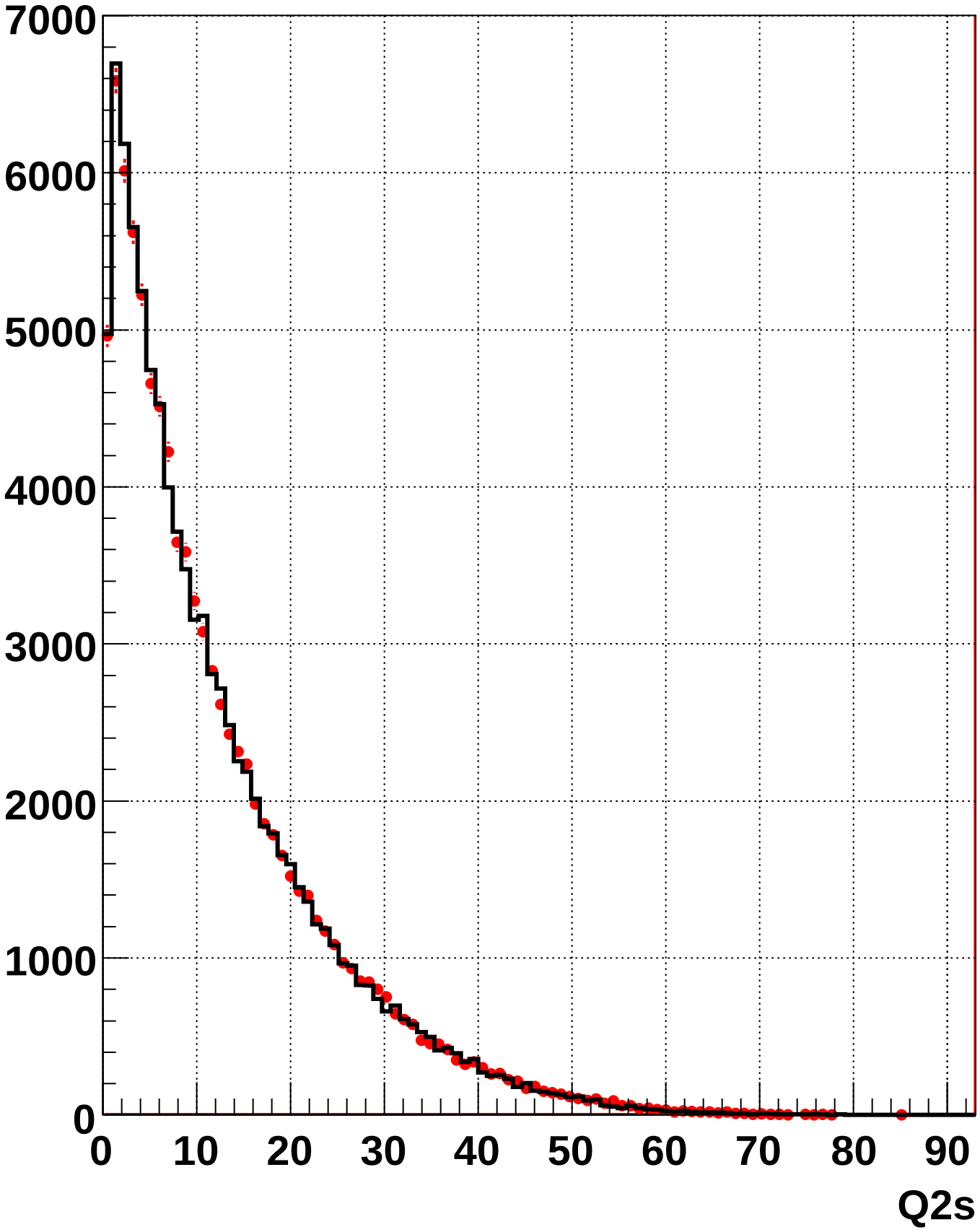
selected Q2 for RES CC events



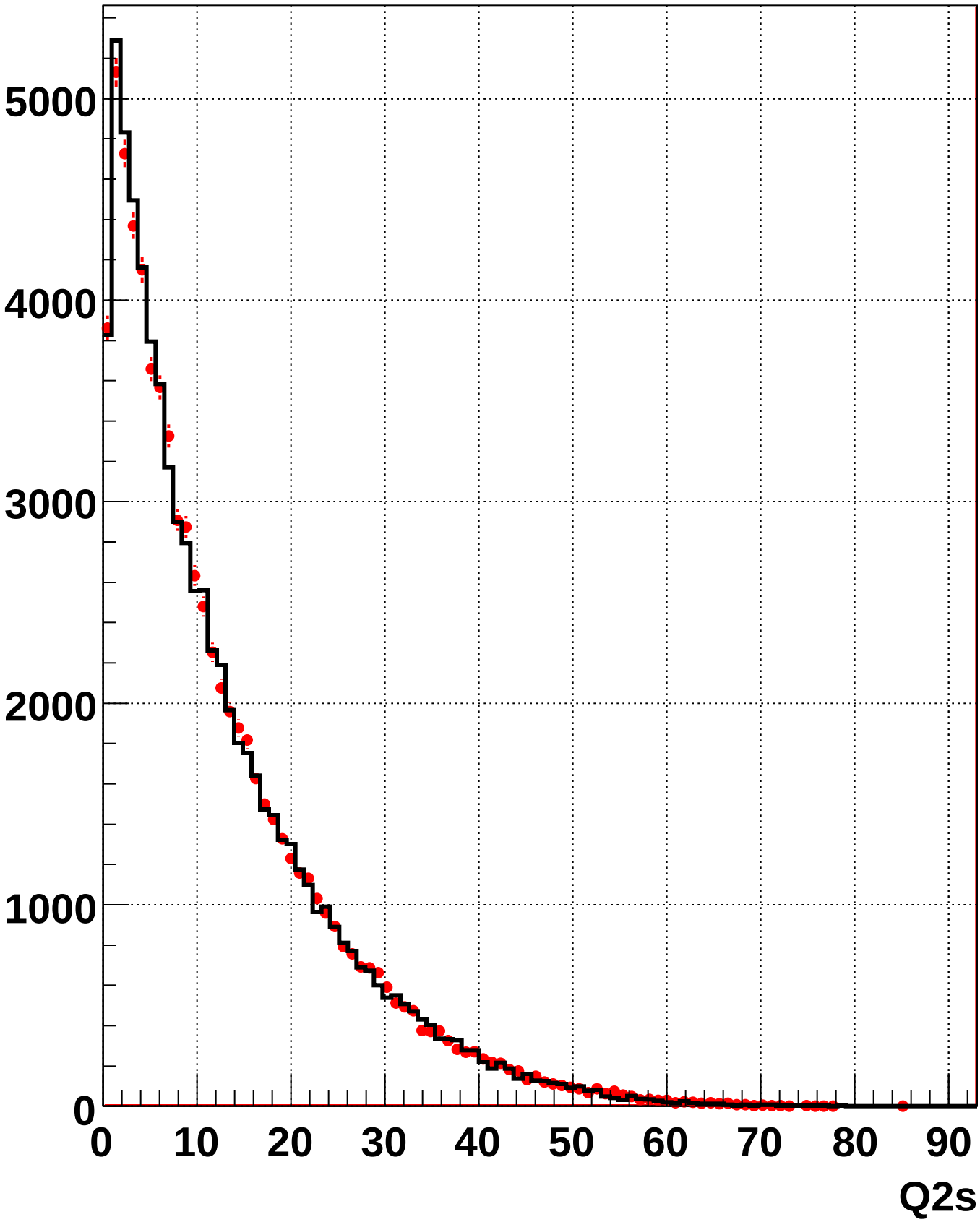
selected Q2 for RES NC events



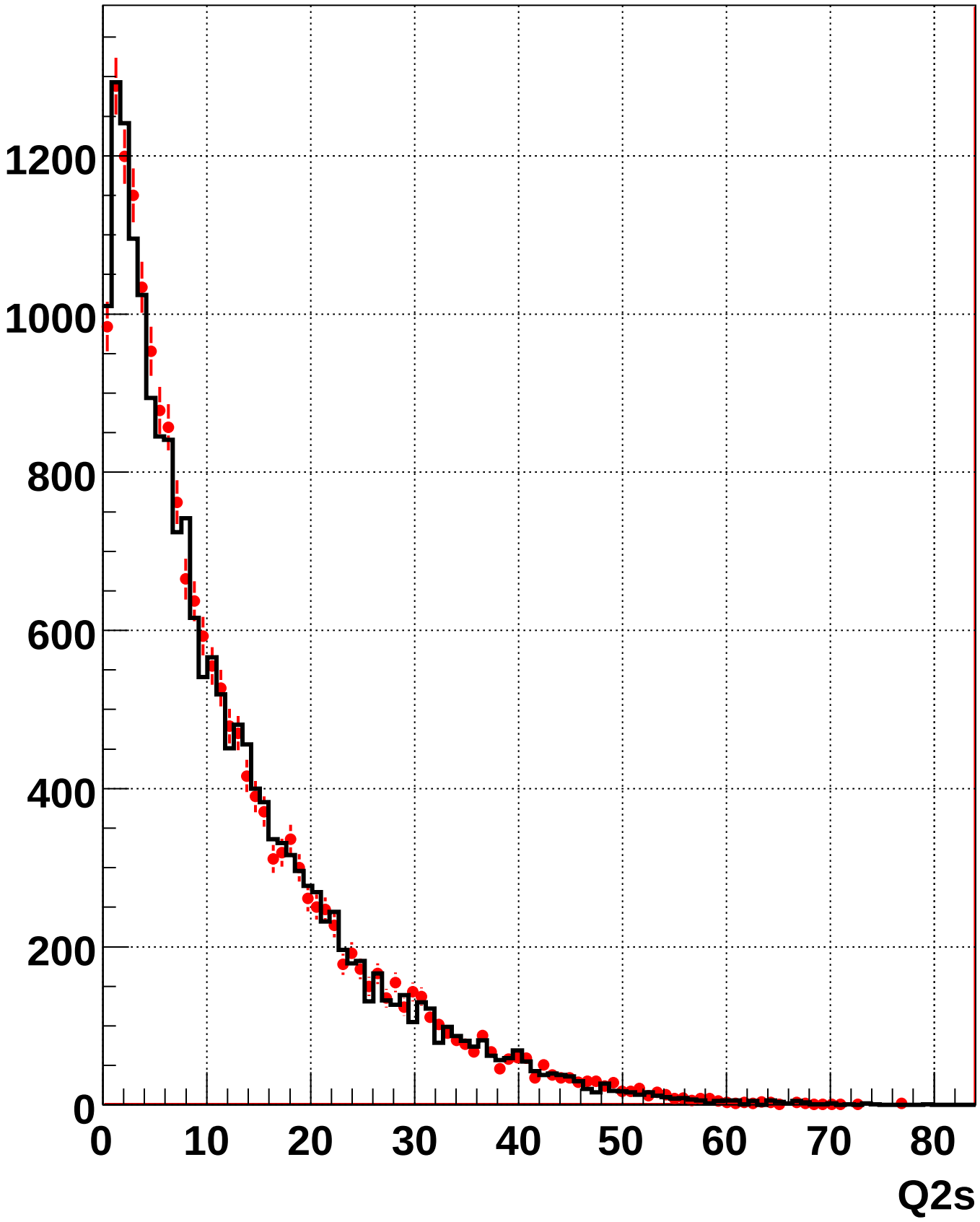
selected Q2 for DIS events



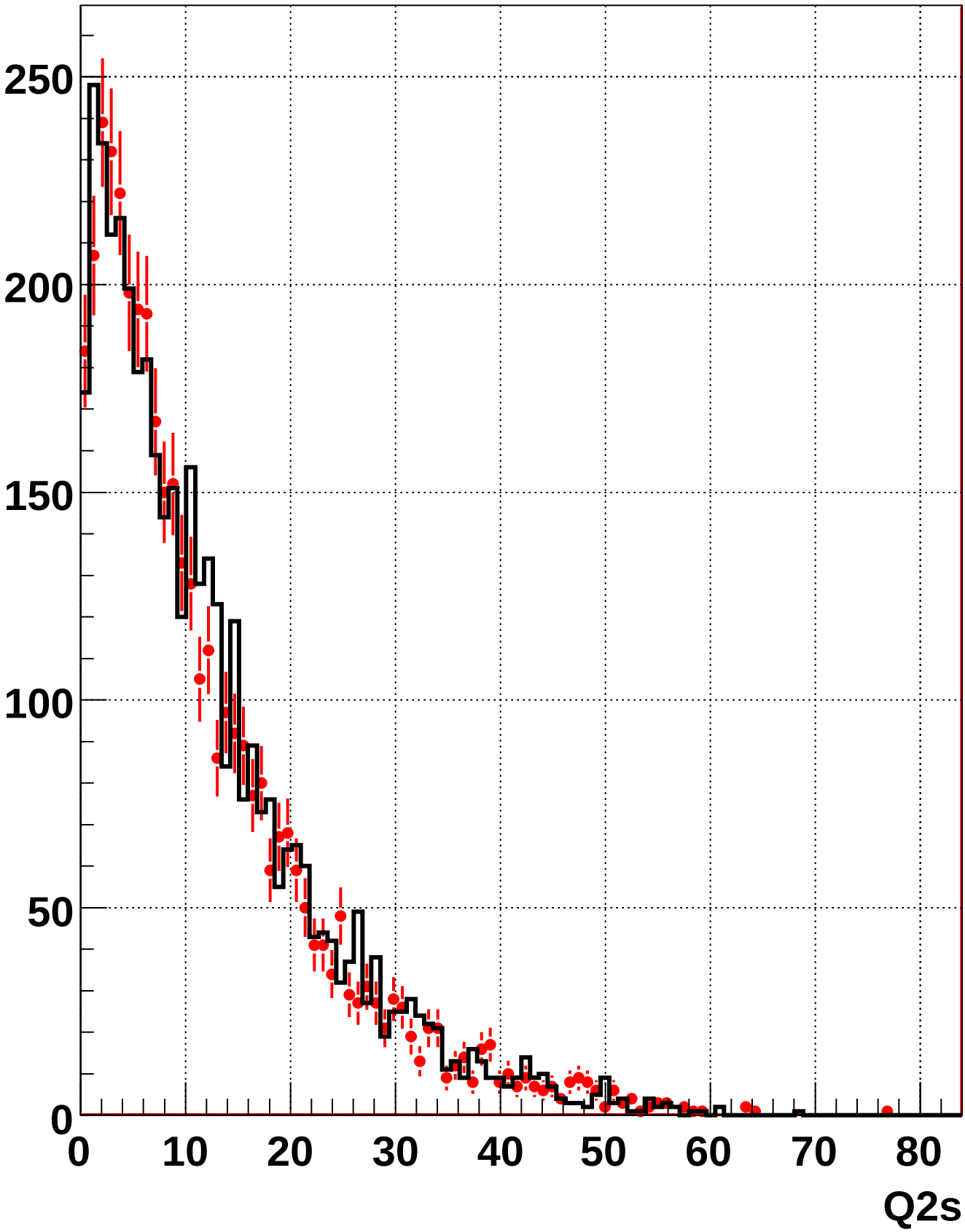
selected Q2 for DIS CC events



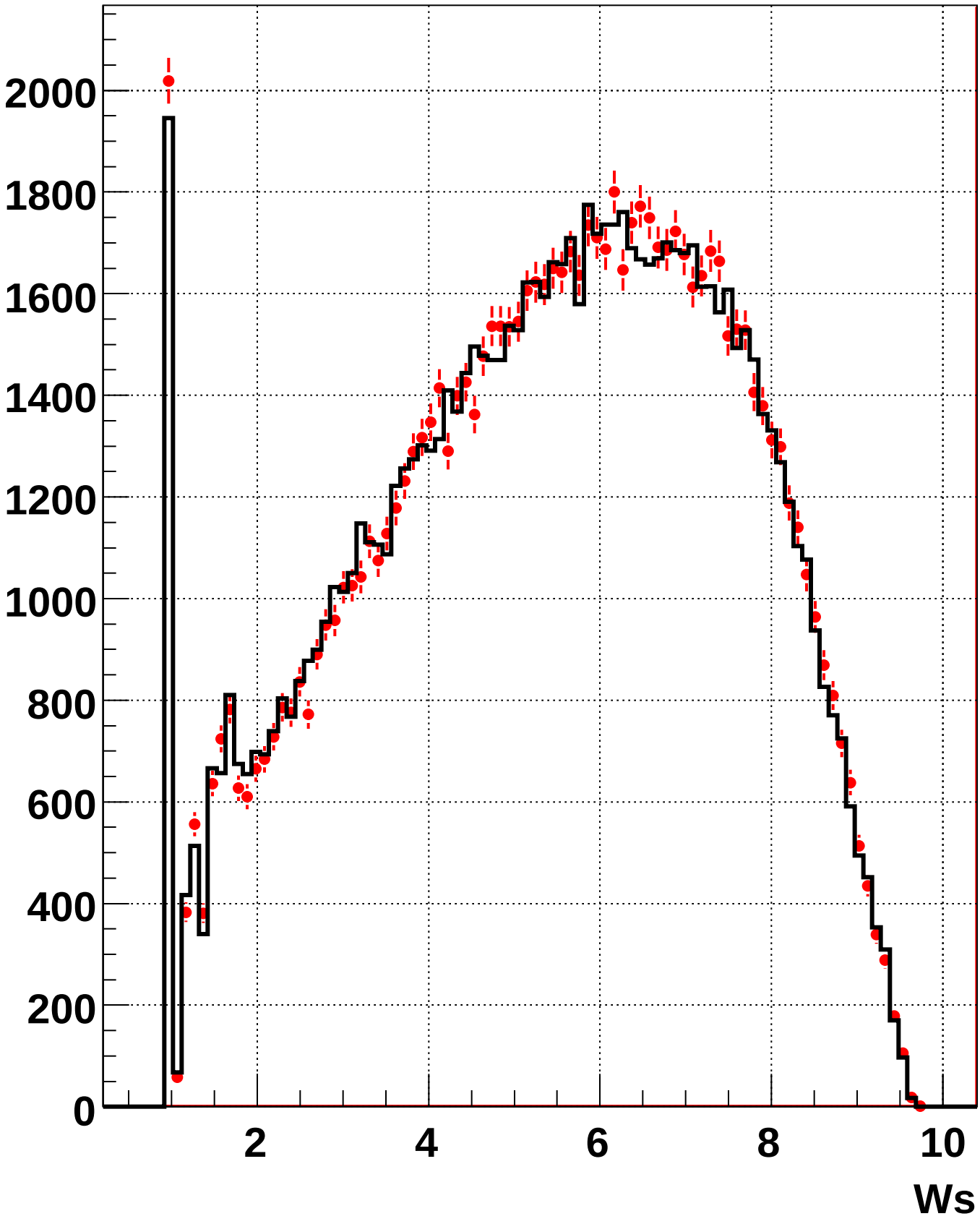
selected Q2 for DIS NC events



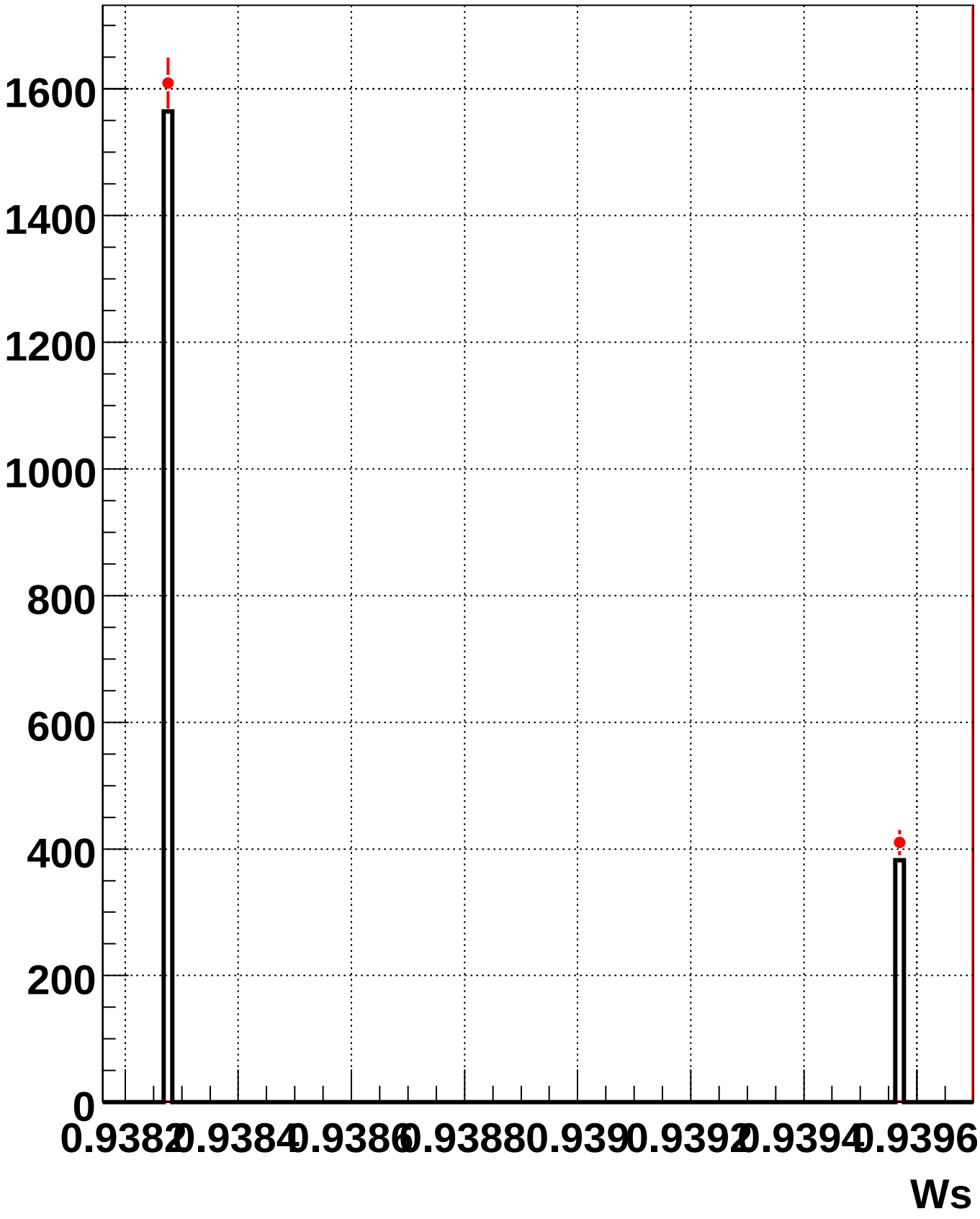
selected Q2 for Charm/DIS events



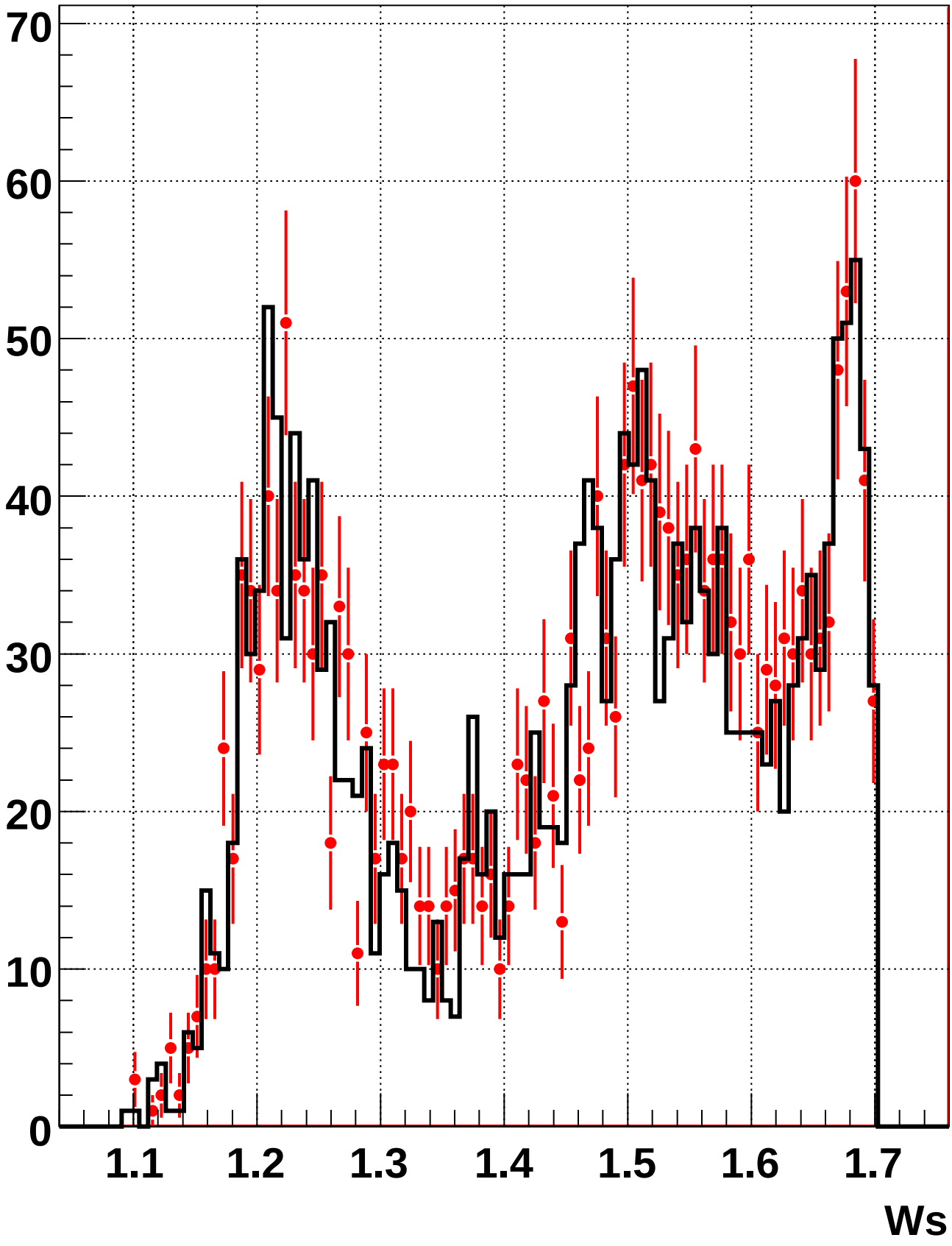
selected W for all events



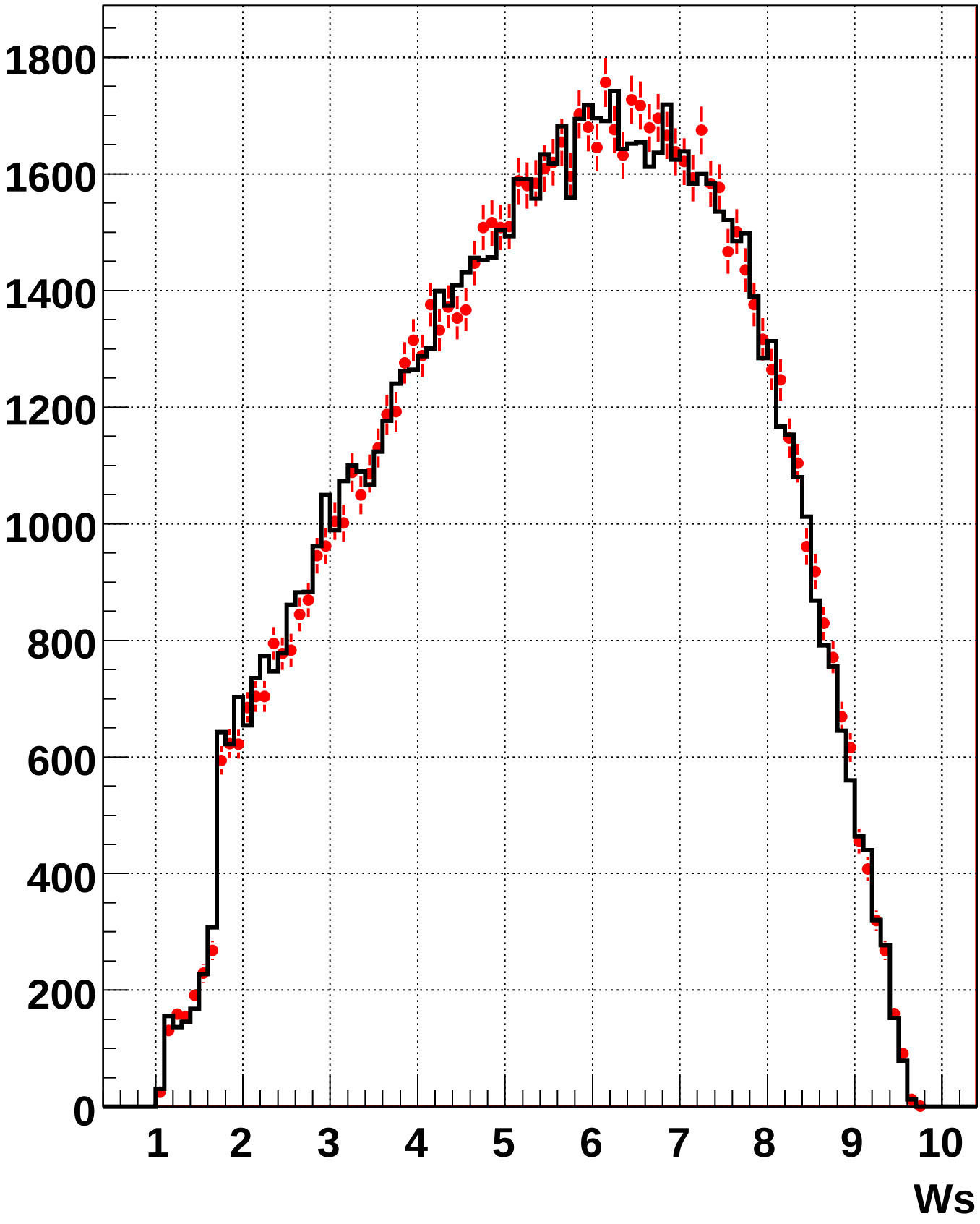
selected W for QEL events



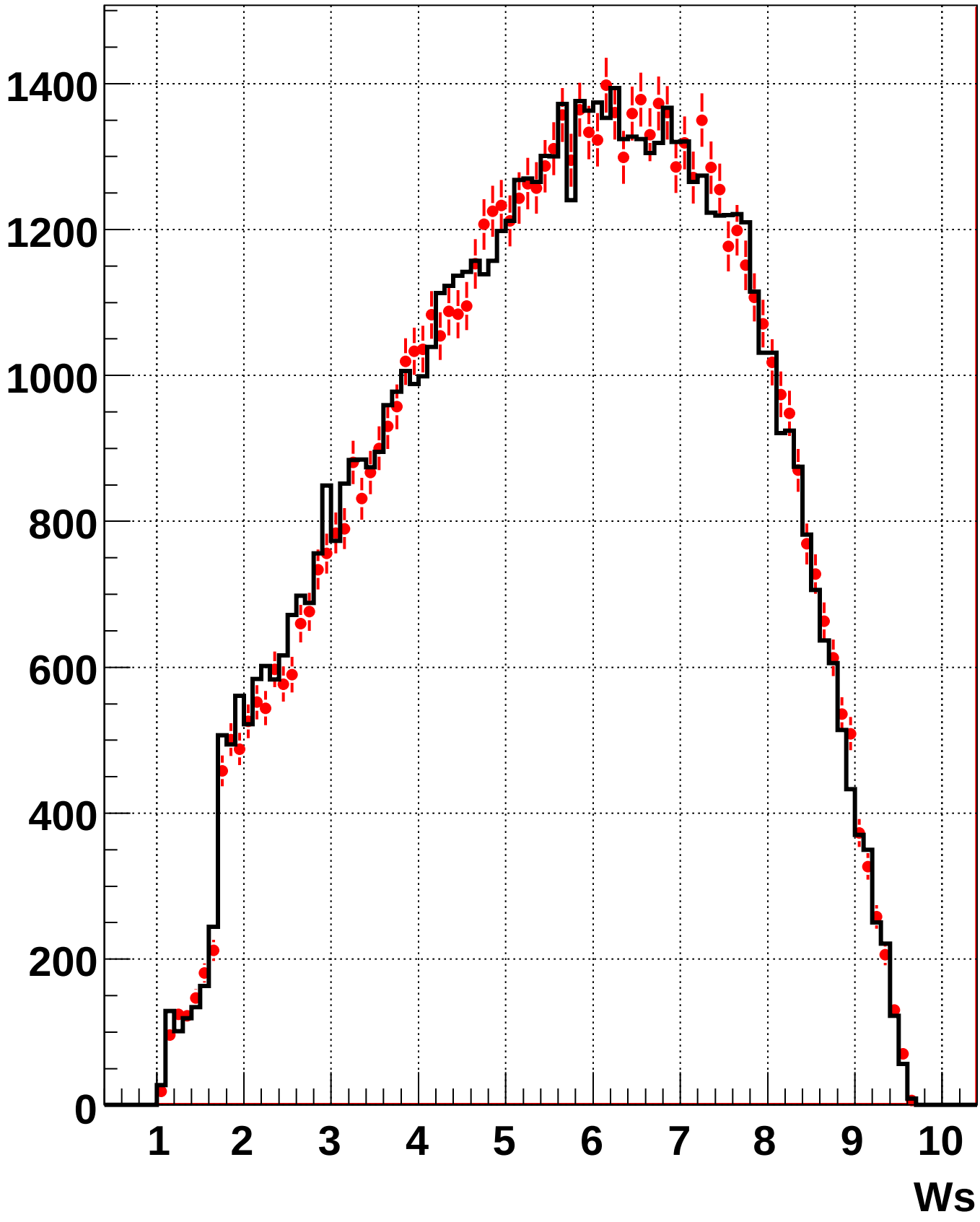
selected W for RES events



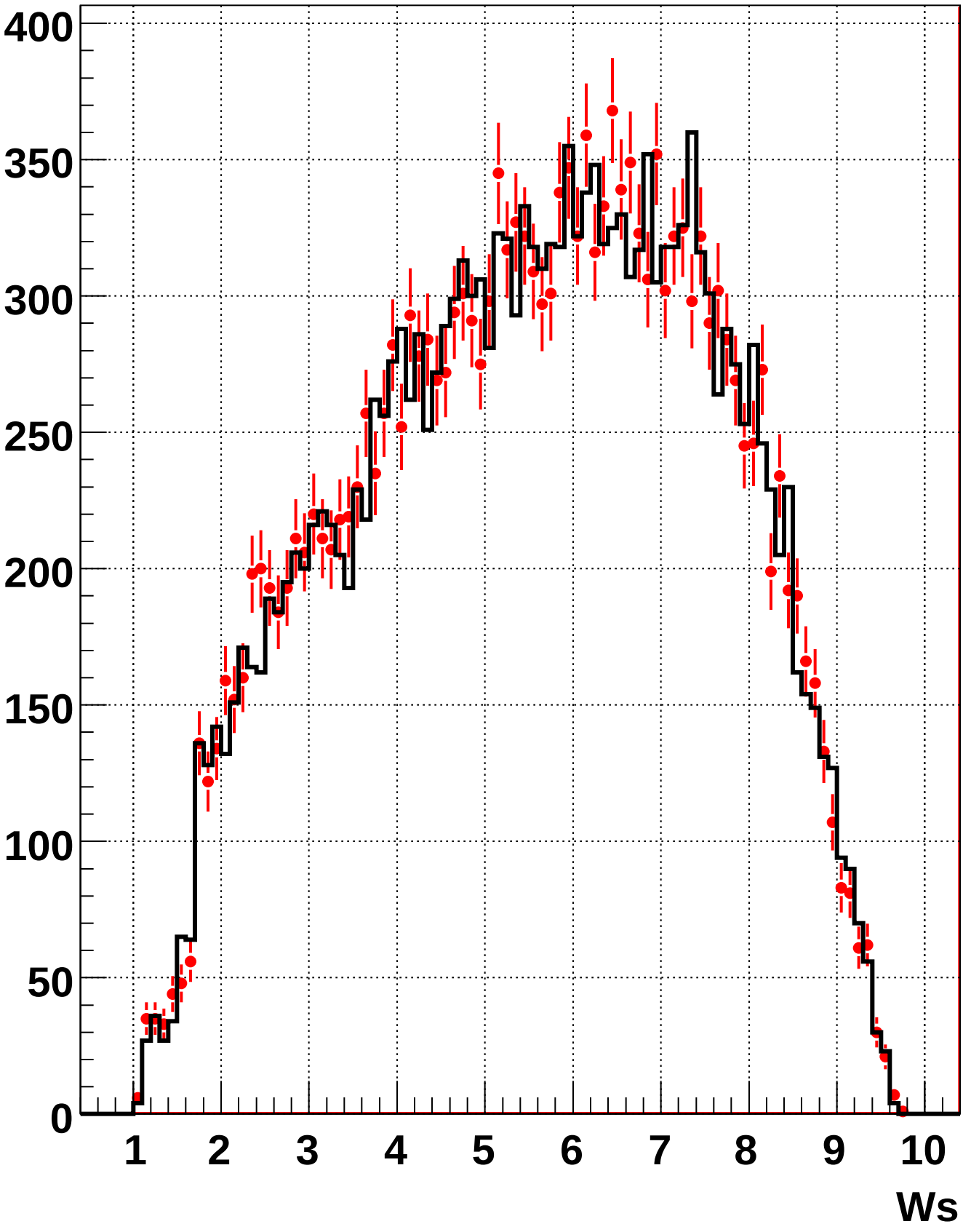
selected W for DIS events



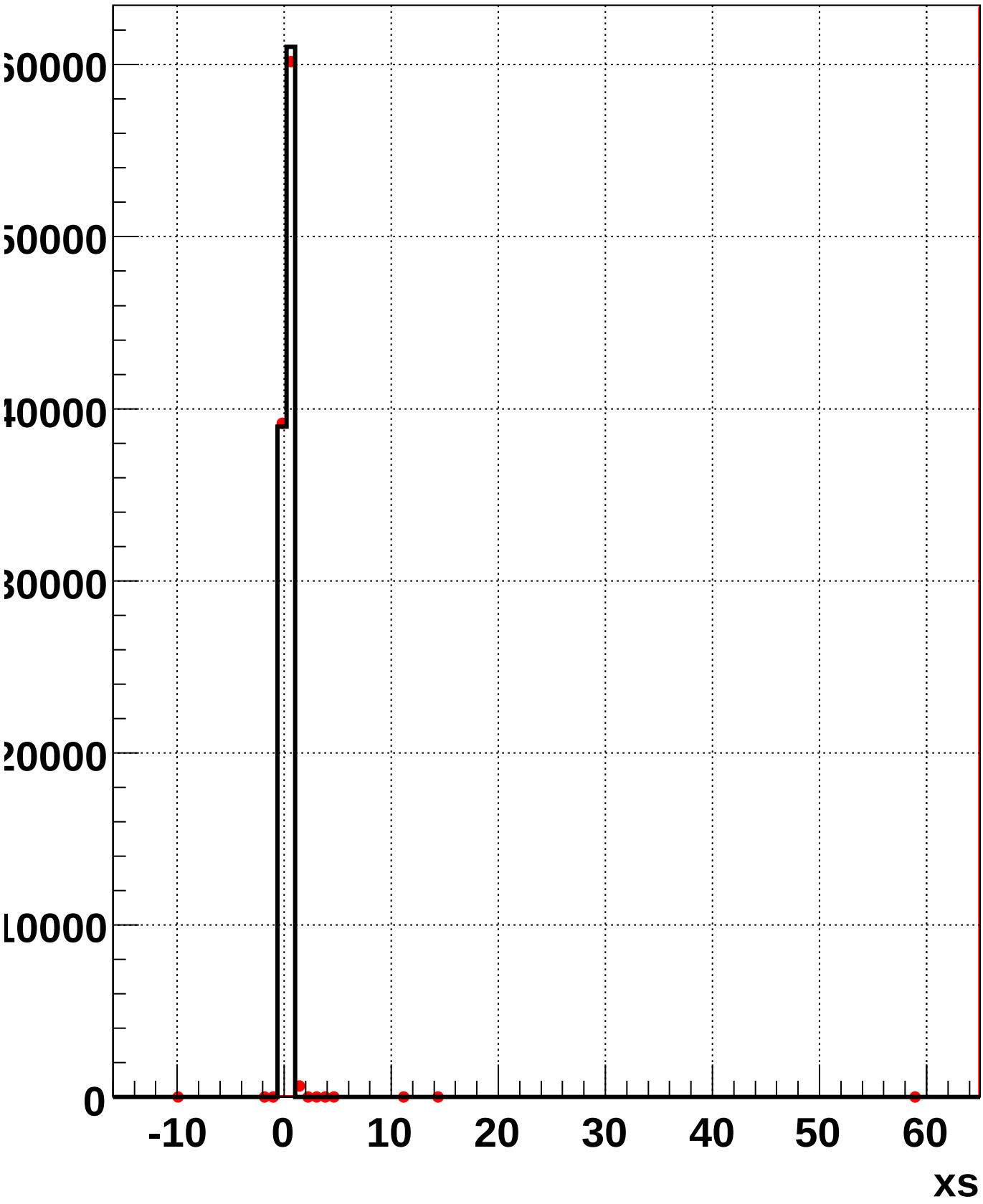
selected W for DIS CC events



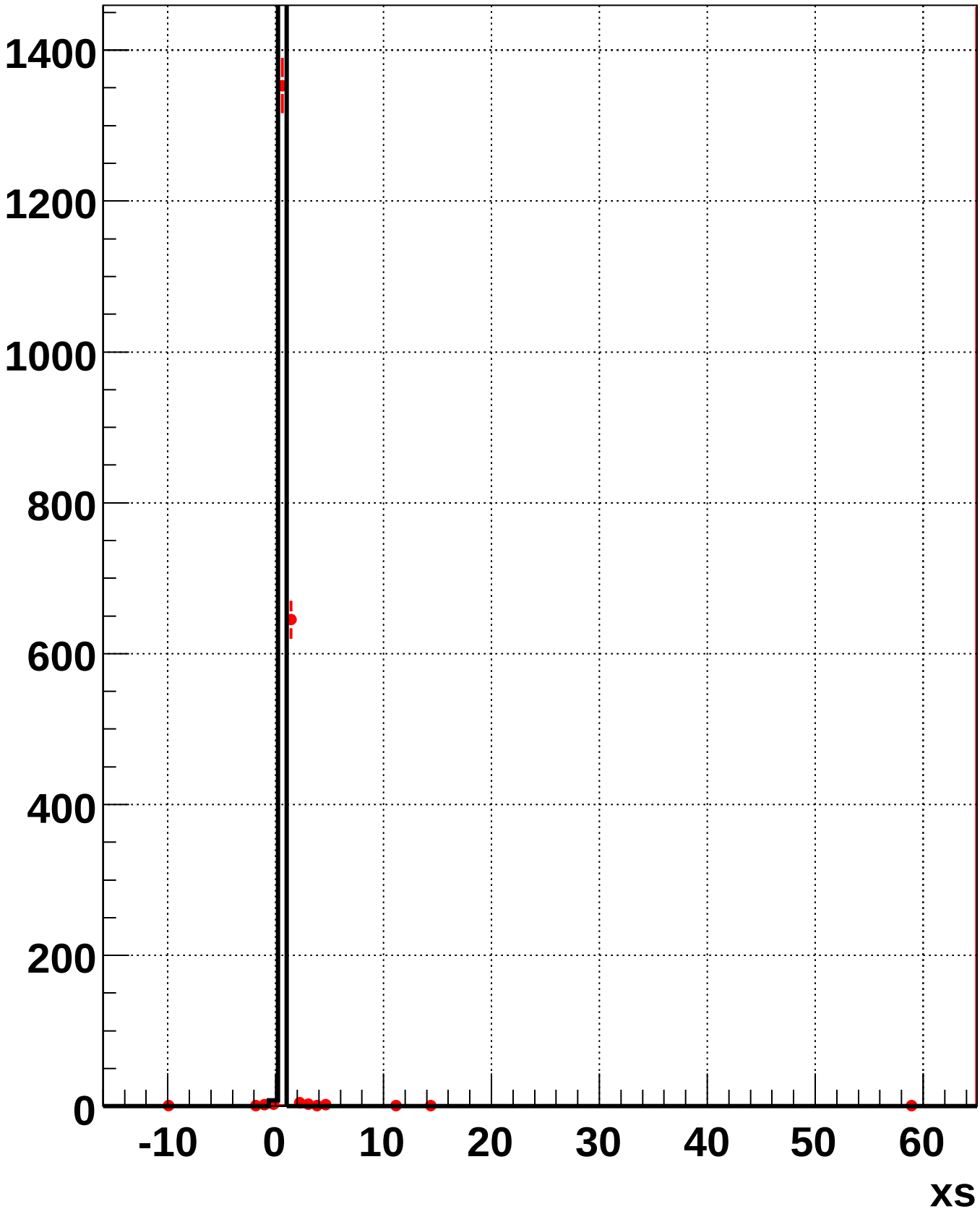
selected W for DIS NC events



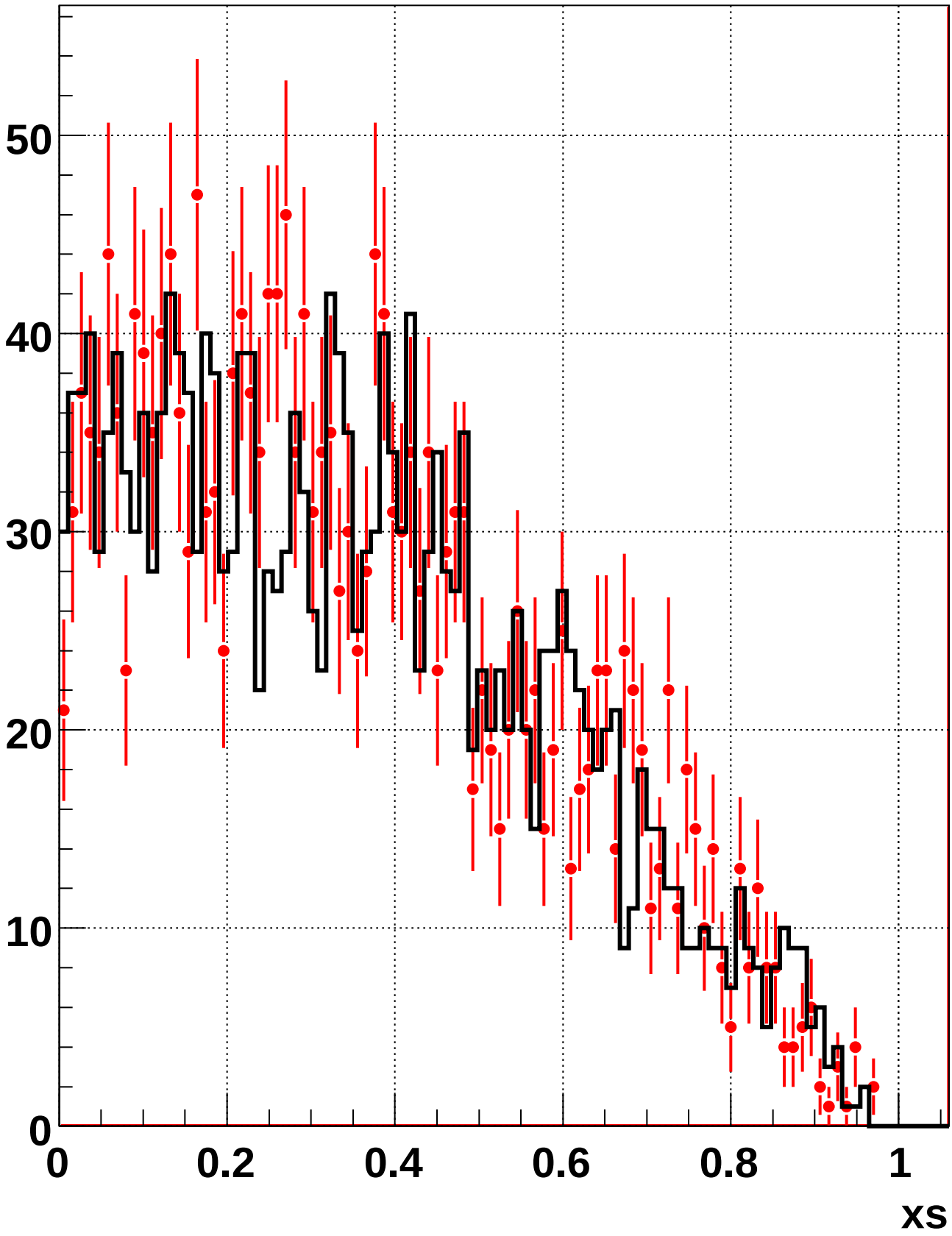
selected x for all events



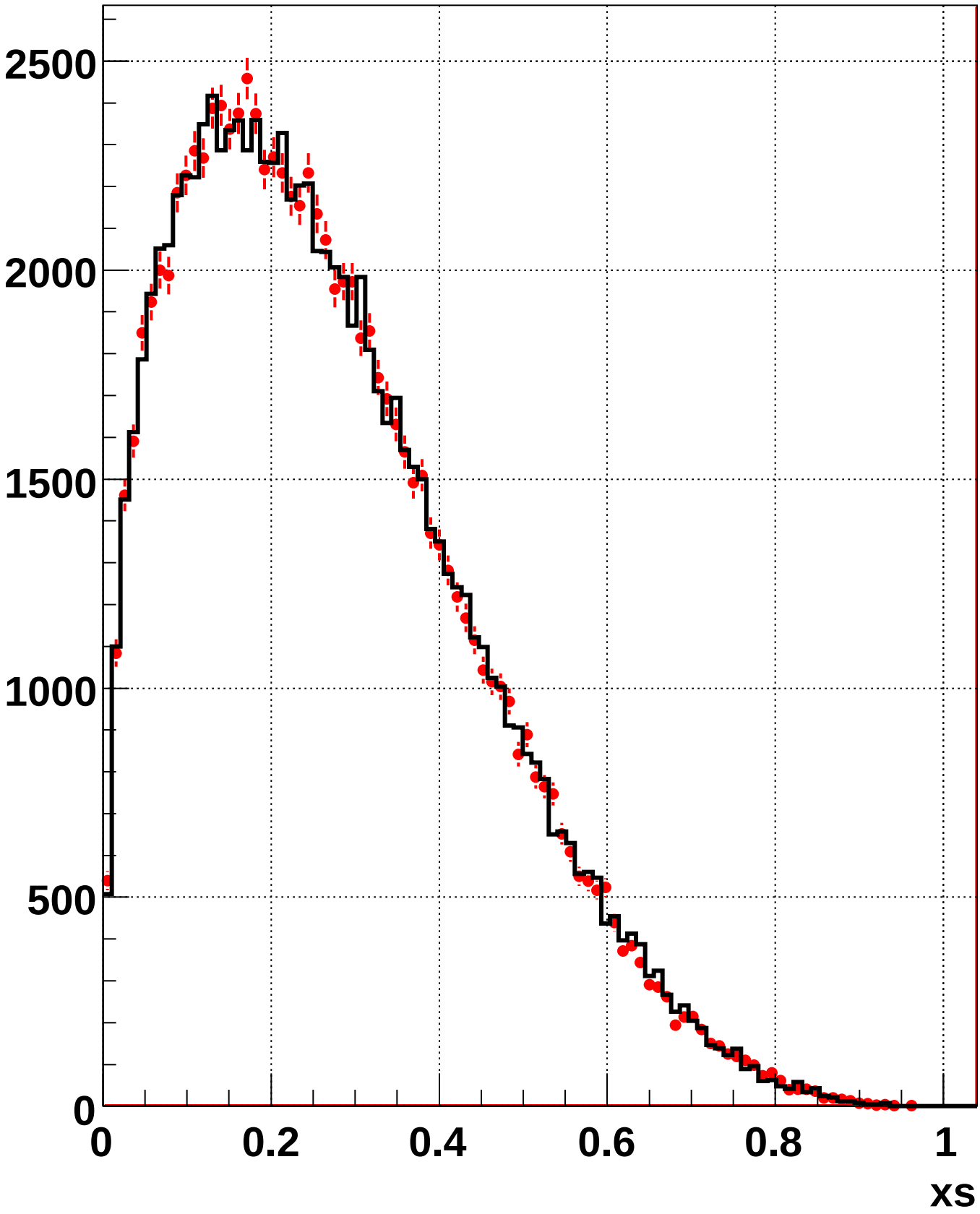
selected x for QEL events



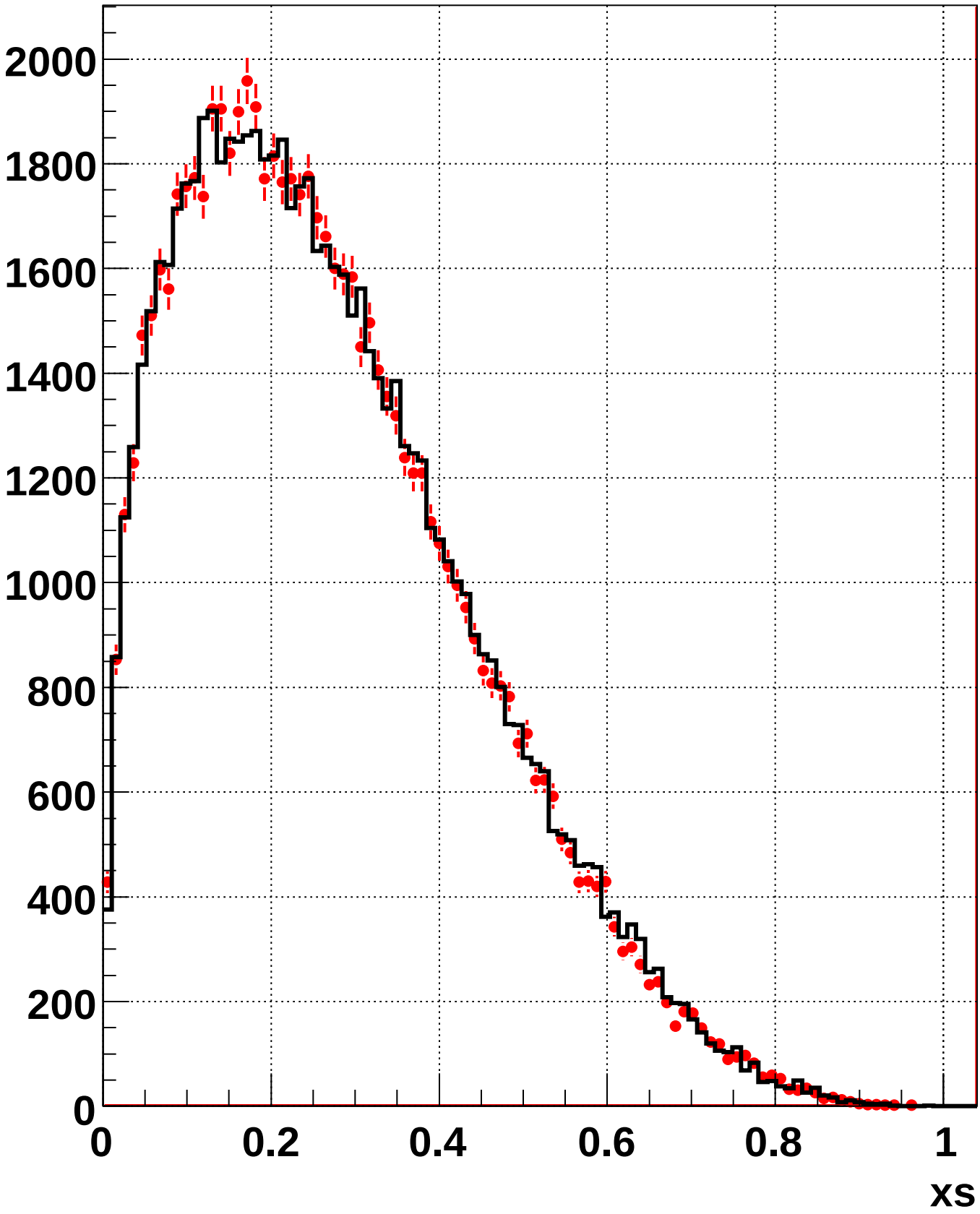
selected x for RES events



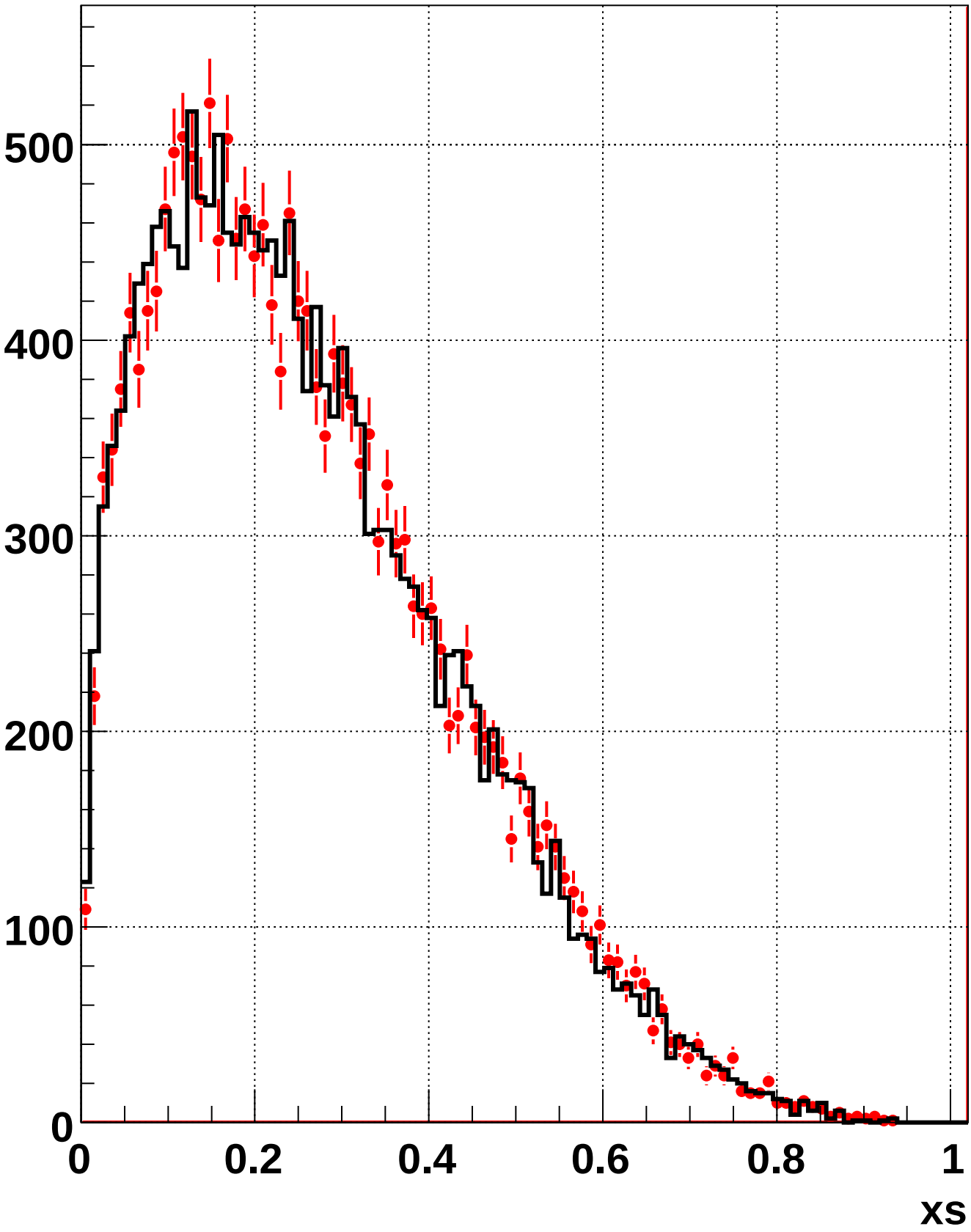
selected x for DIS events



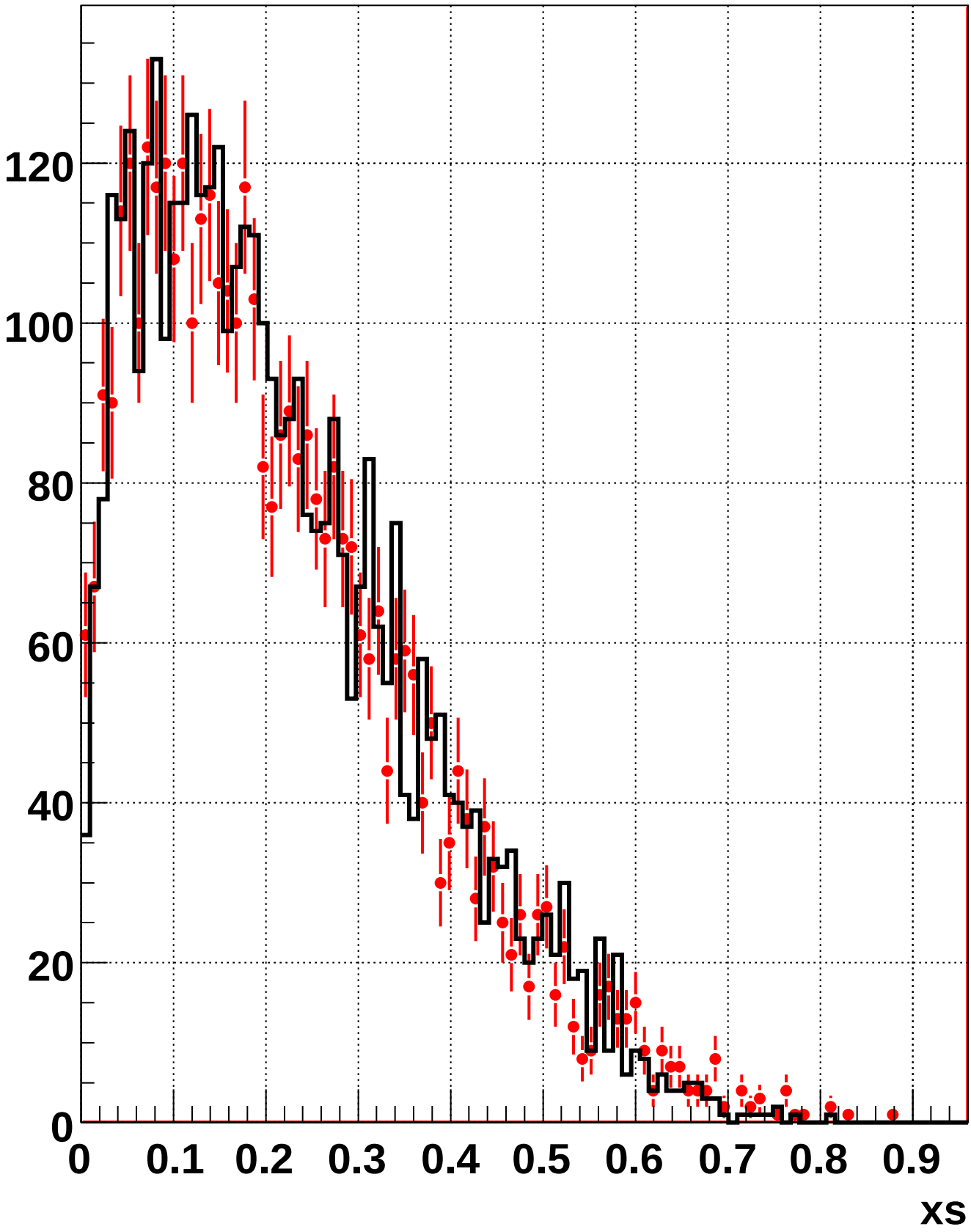
selected x for DIS CC events



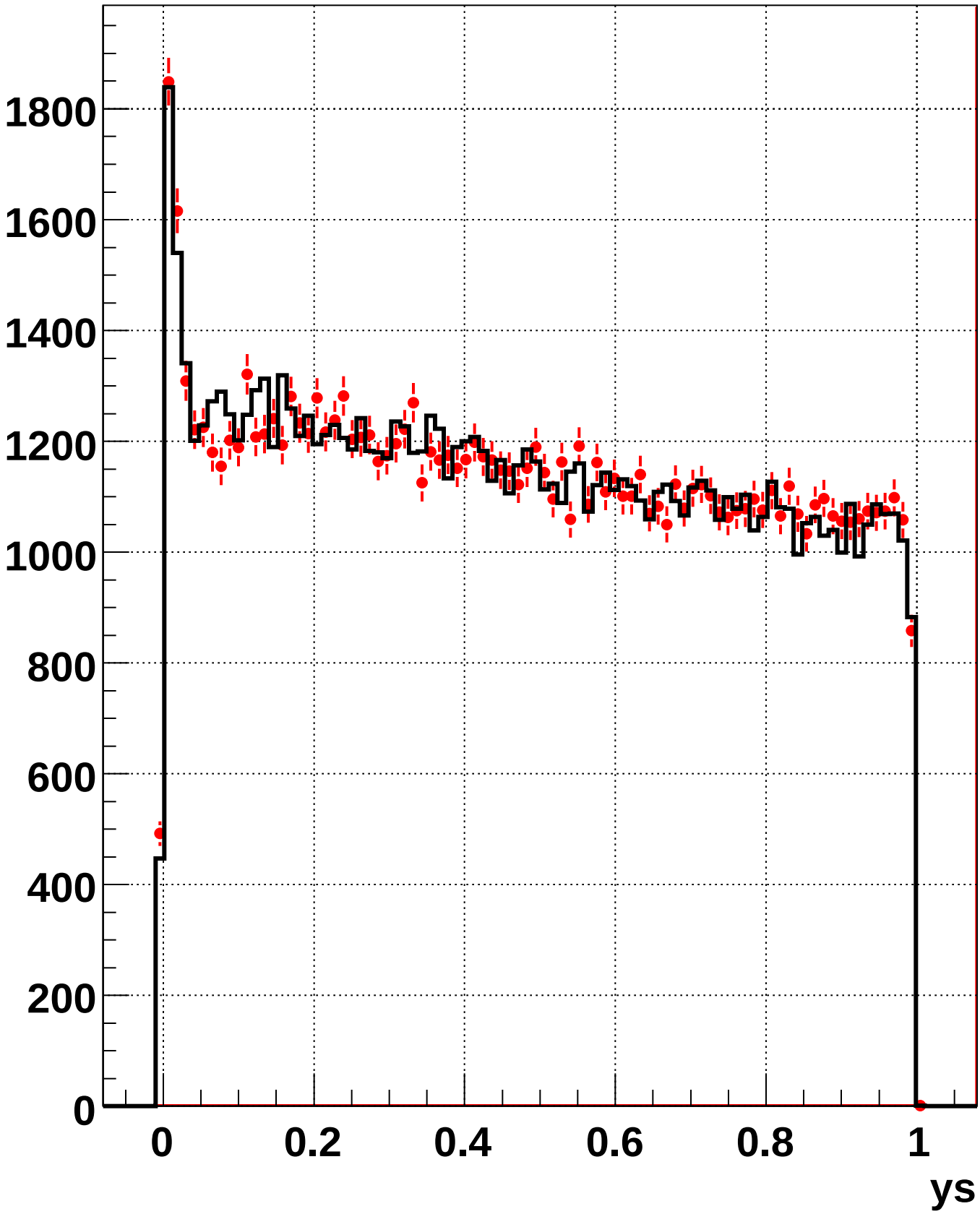
selected x for DIS NC events

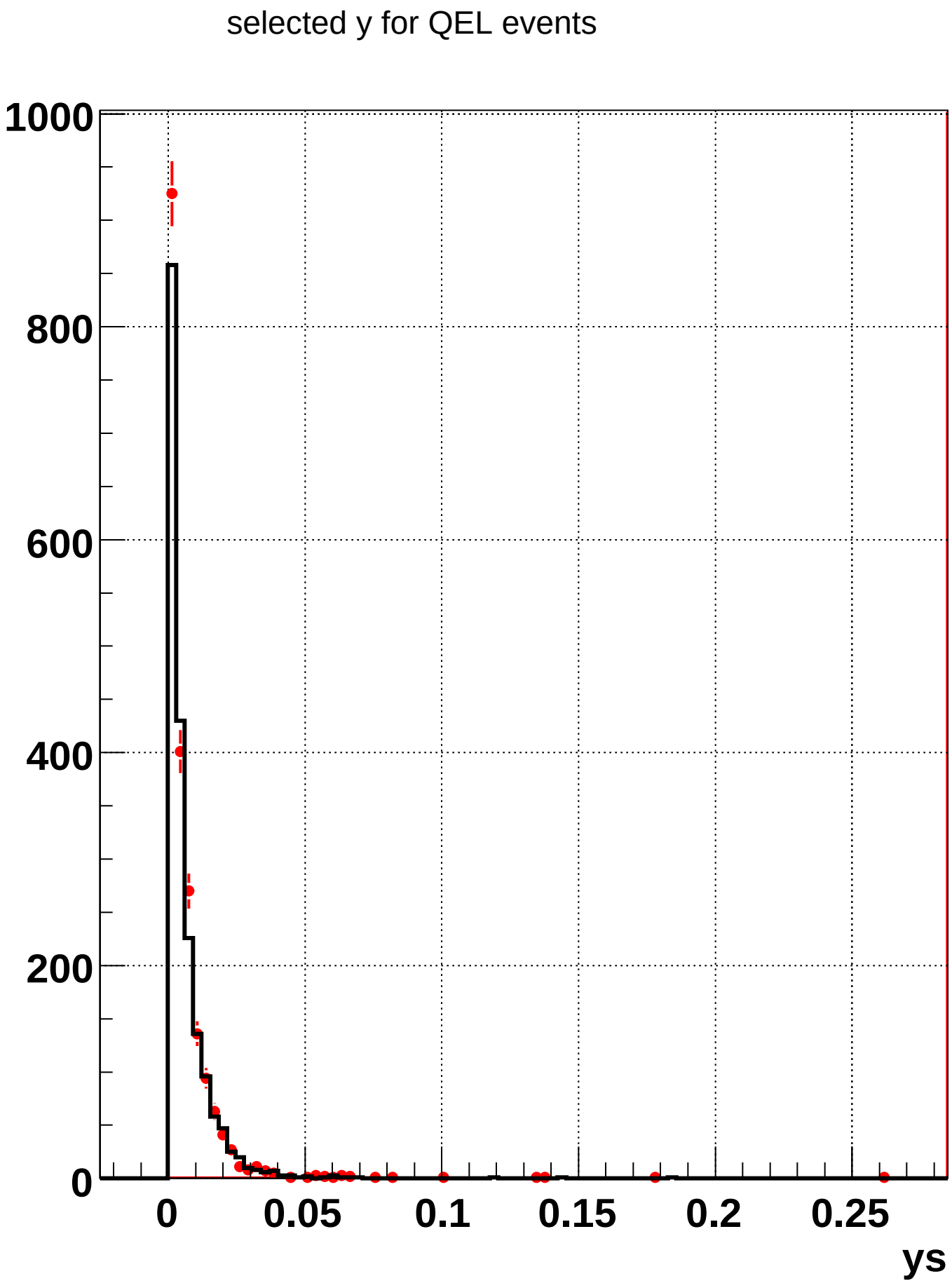


selected x for Charm/DIS events

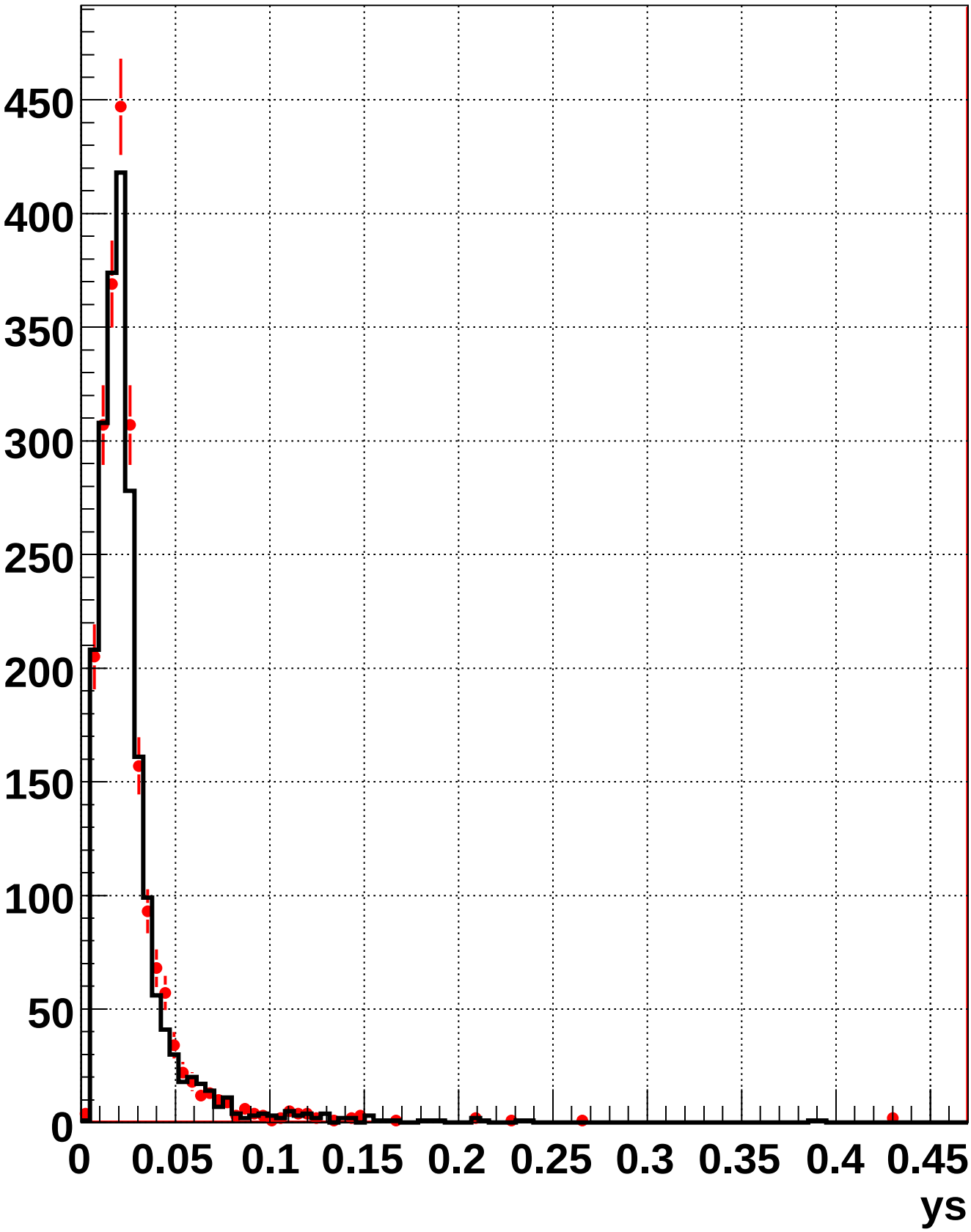


selected y for all events

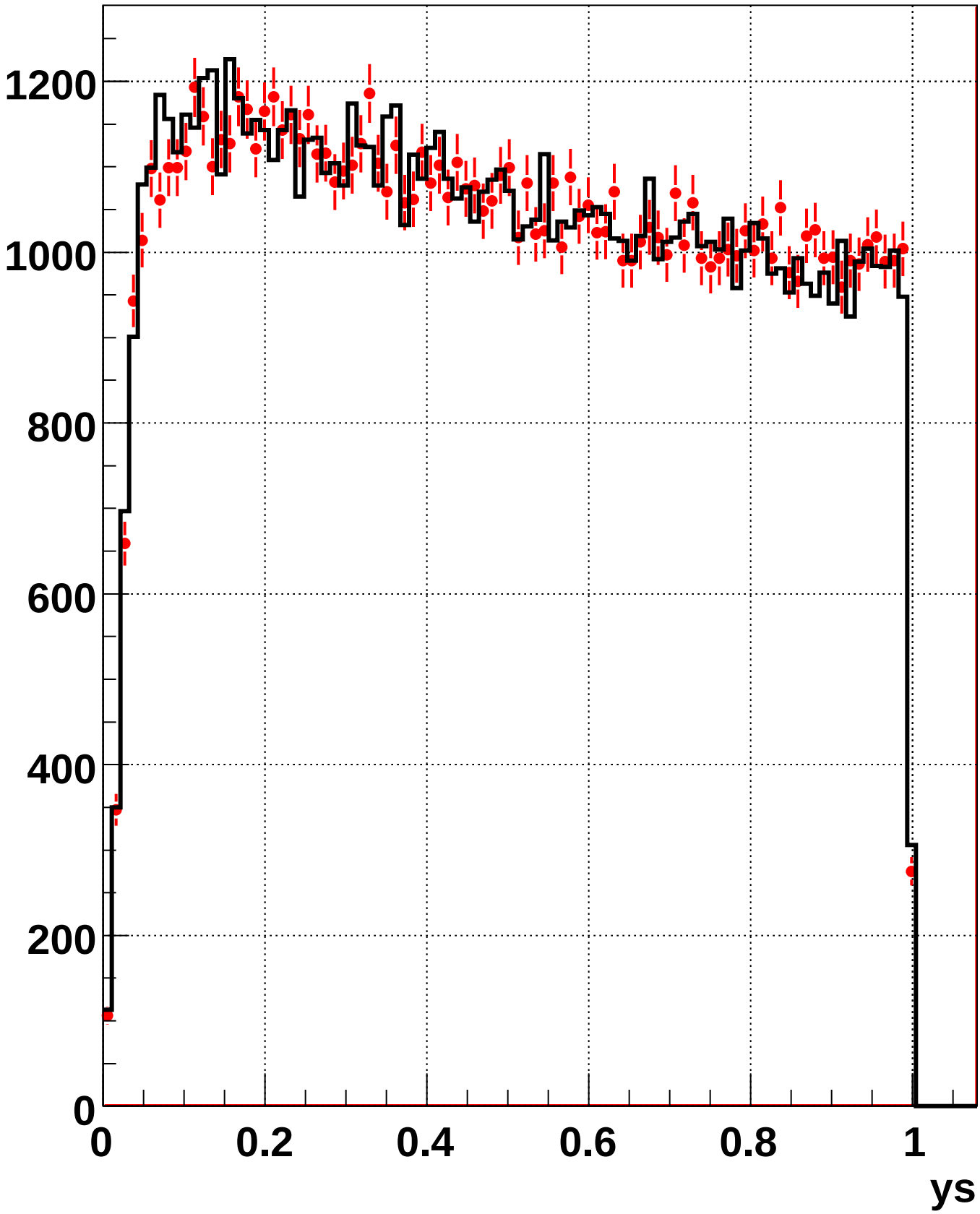



selected y for QEL events
1000
800
600
400
200
0
0
0.05
0.1
0.15
0.2
0.25
ys

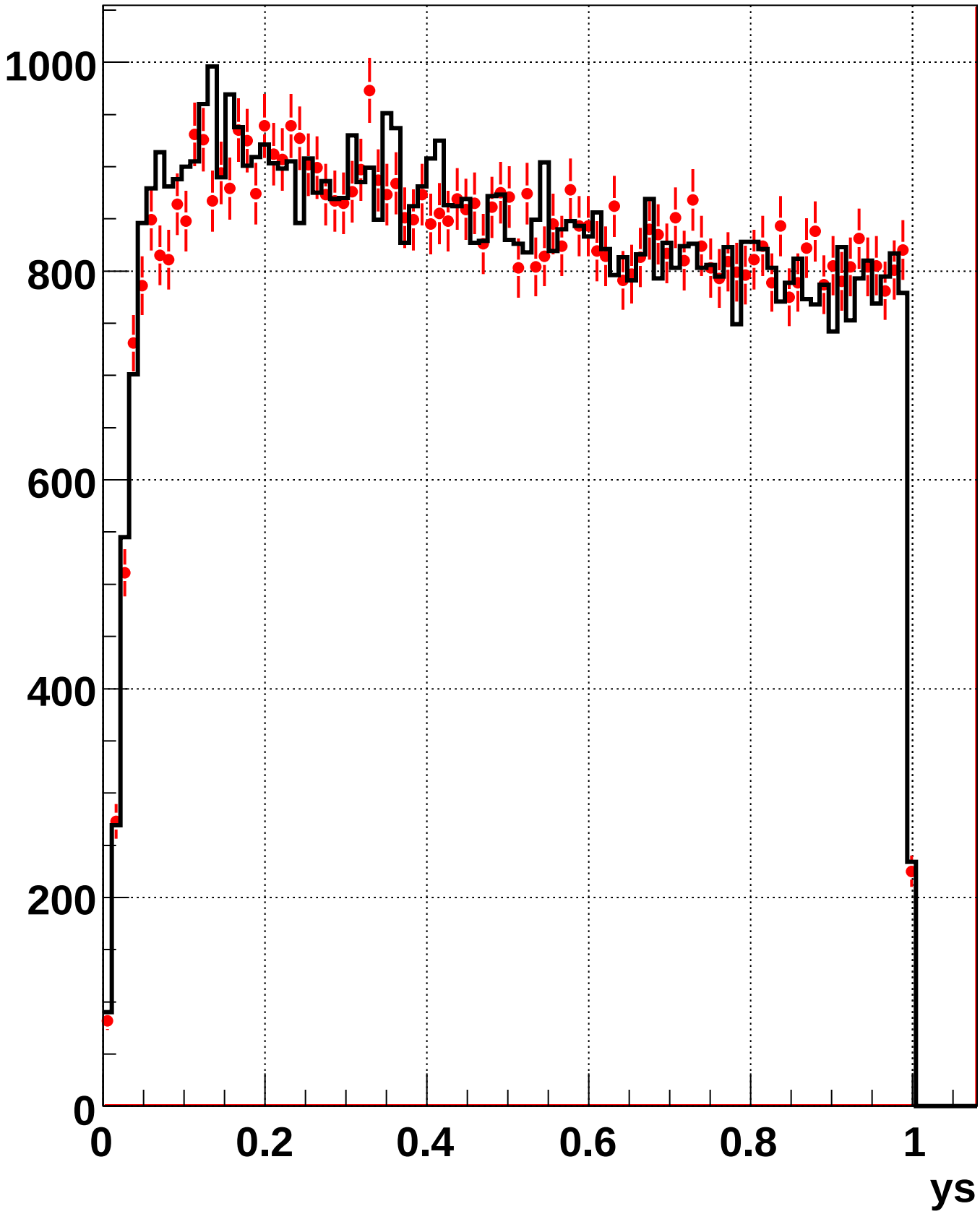
selected y for RES events



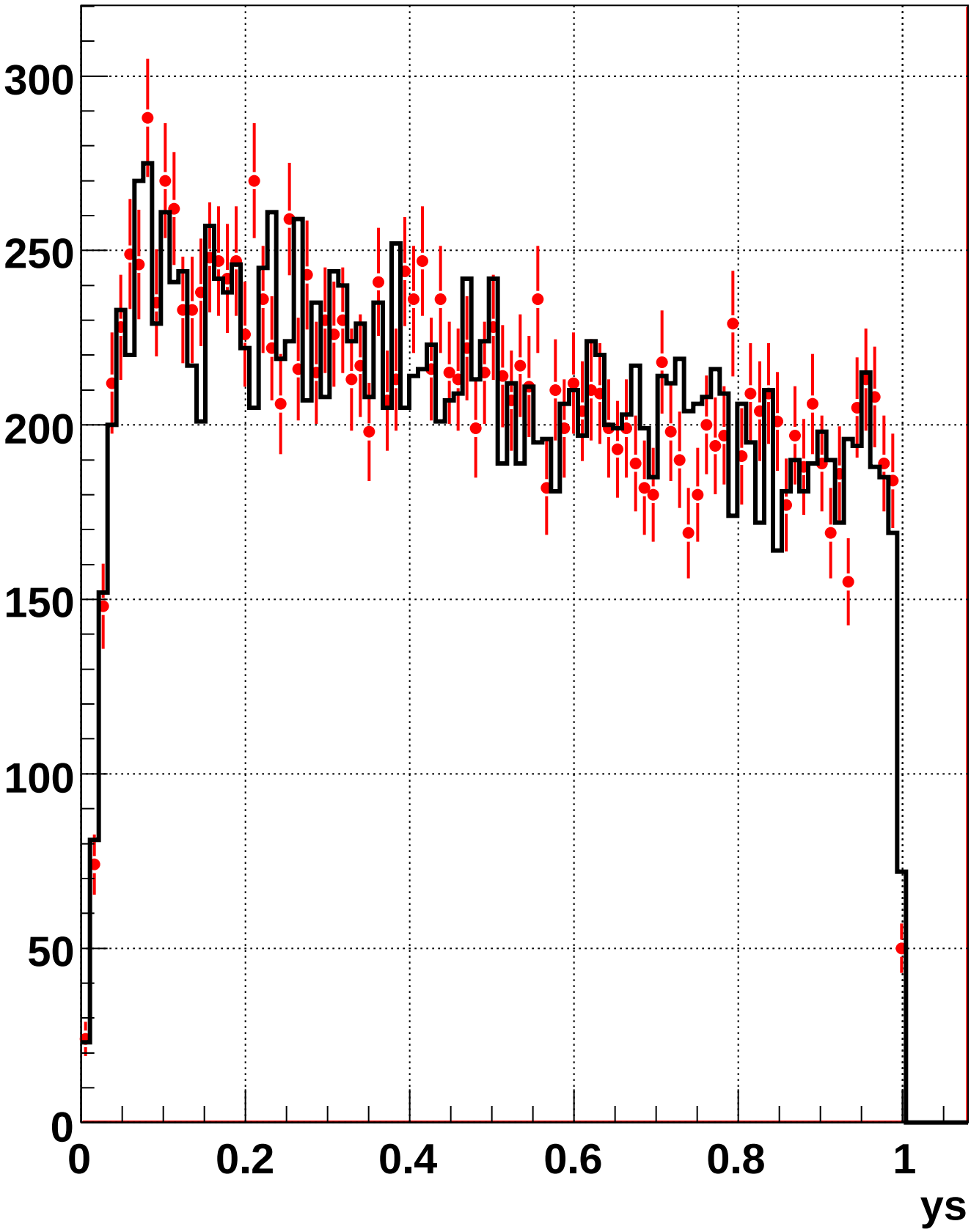
selected y for DIS events



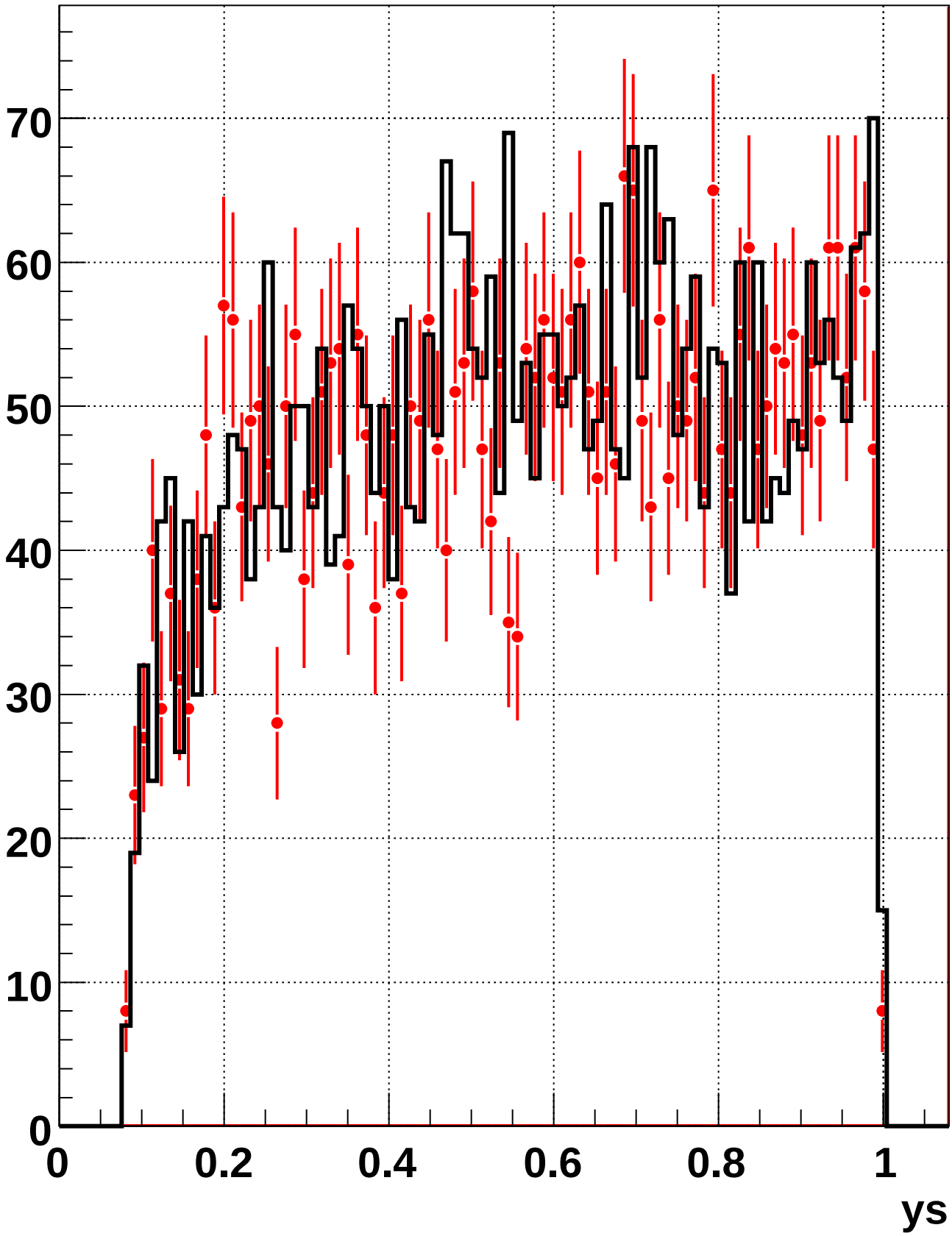
selected y for DIS CC events



selected y for DIS NC events



selected y for Charm/DIS events

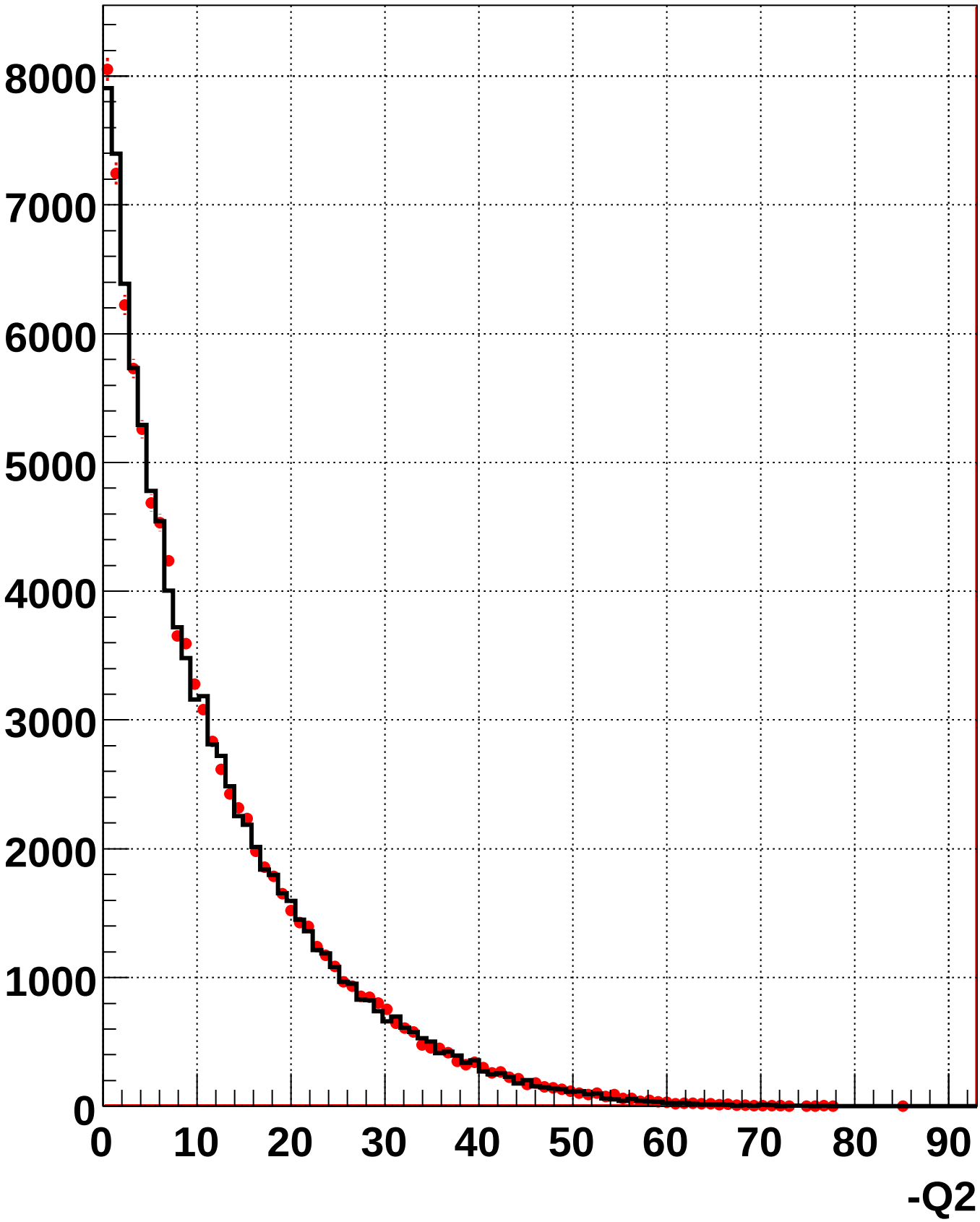


Kinematical Quantities

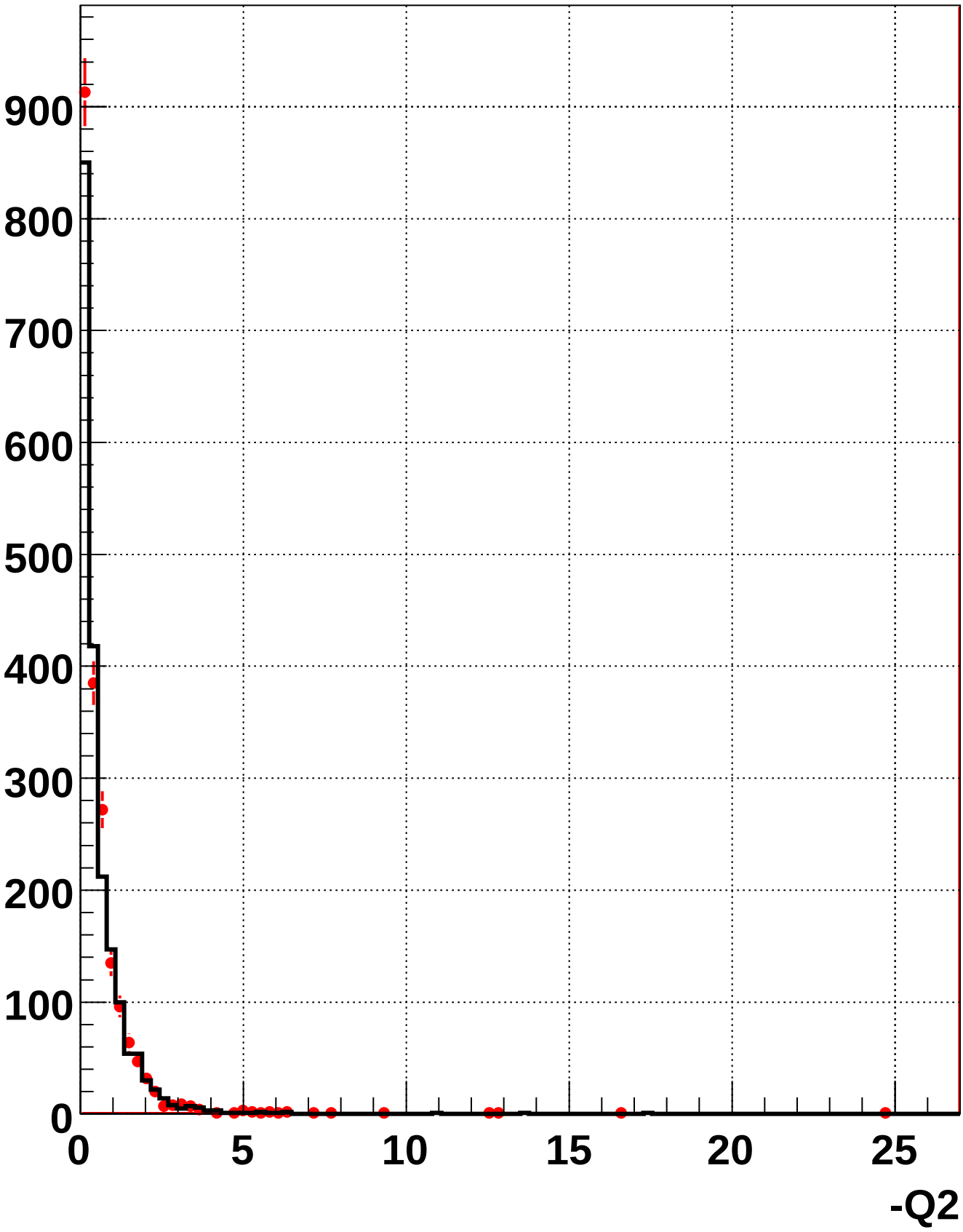
Similar to the previous set of plots but

showing ’computed’ rathen than ’selected’ variables

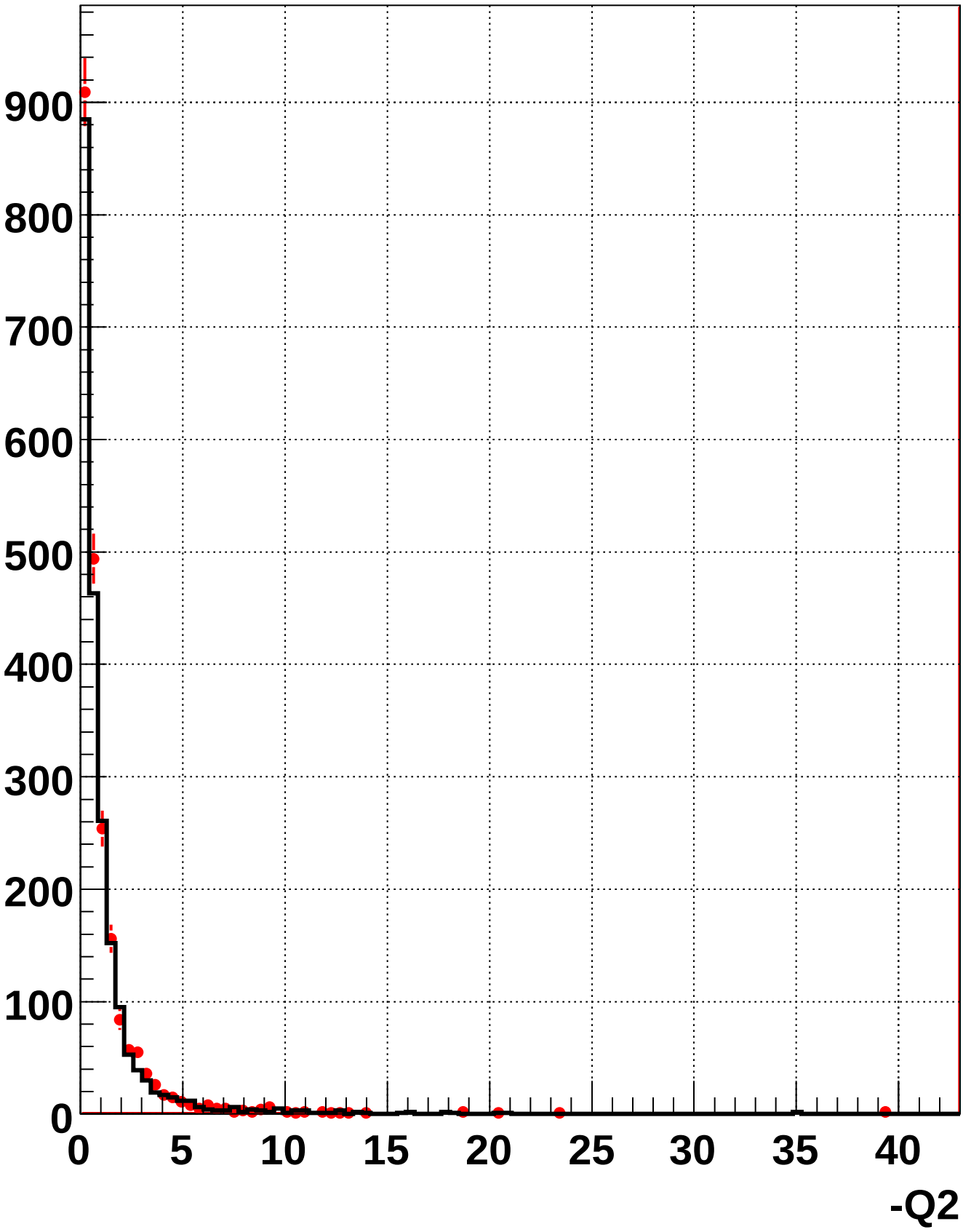
computed Q2 for all events



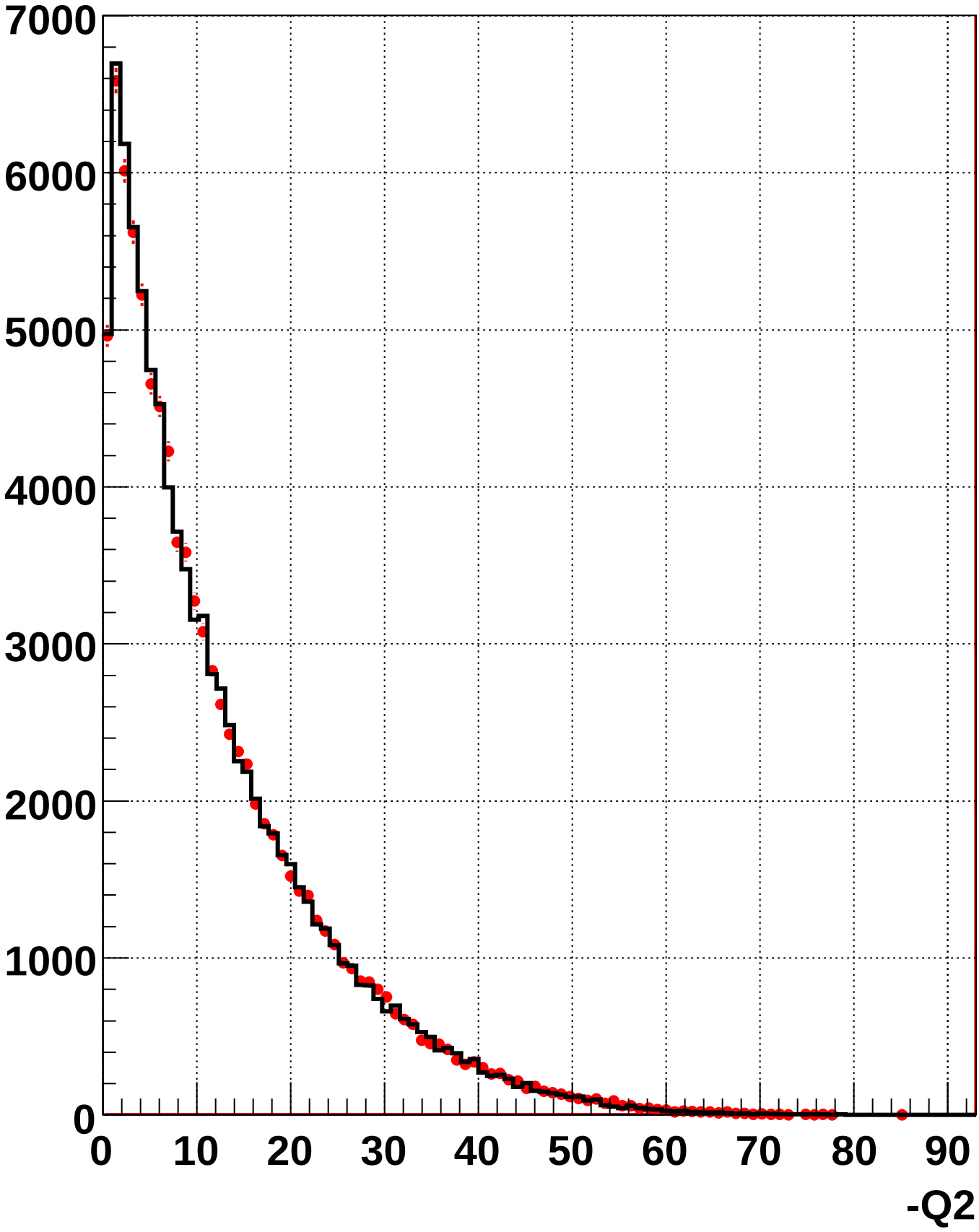
computed Q2 for QEL events



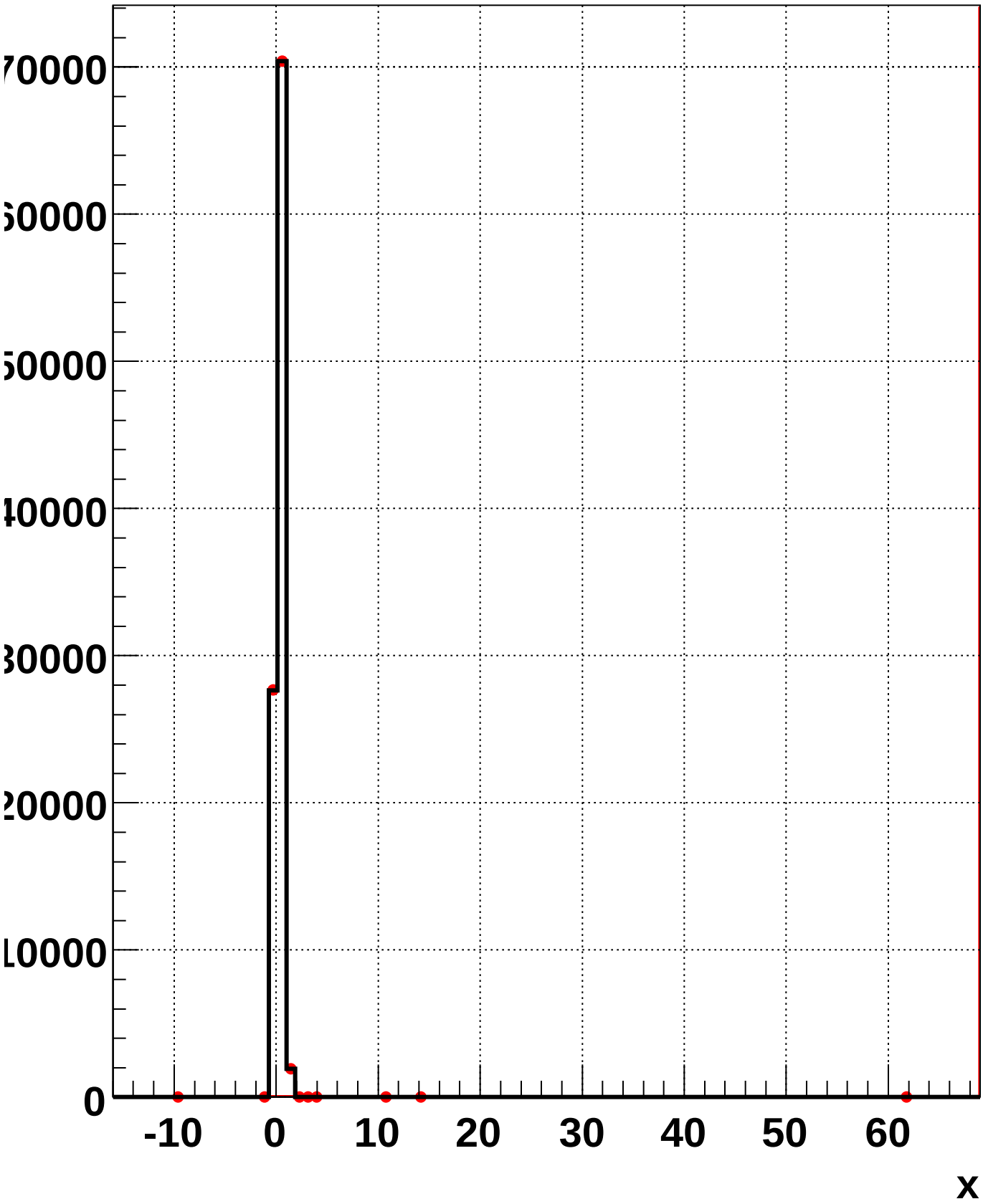
computed Q2 for RES events



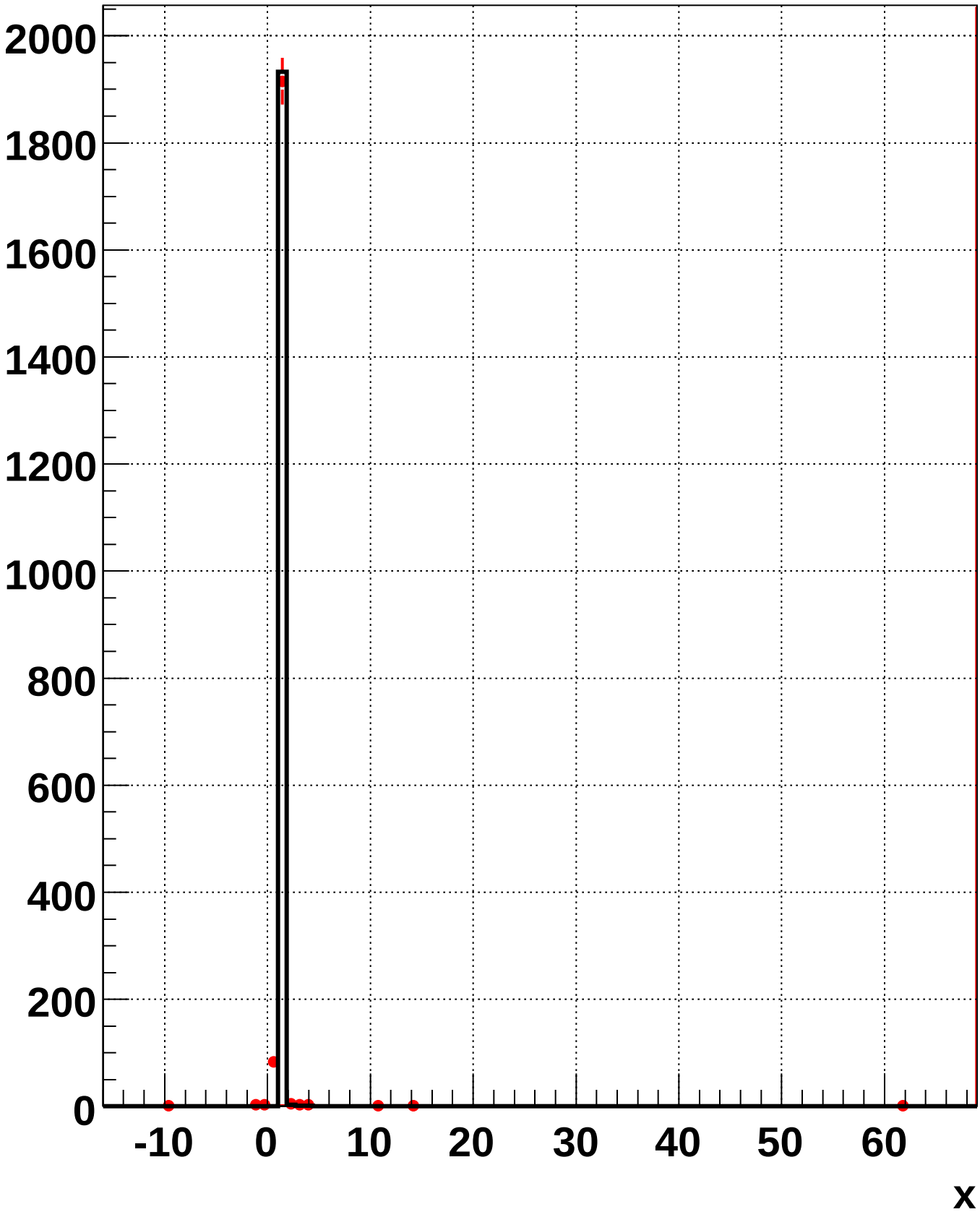
computed Q2 for DIS events



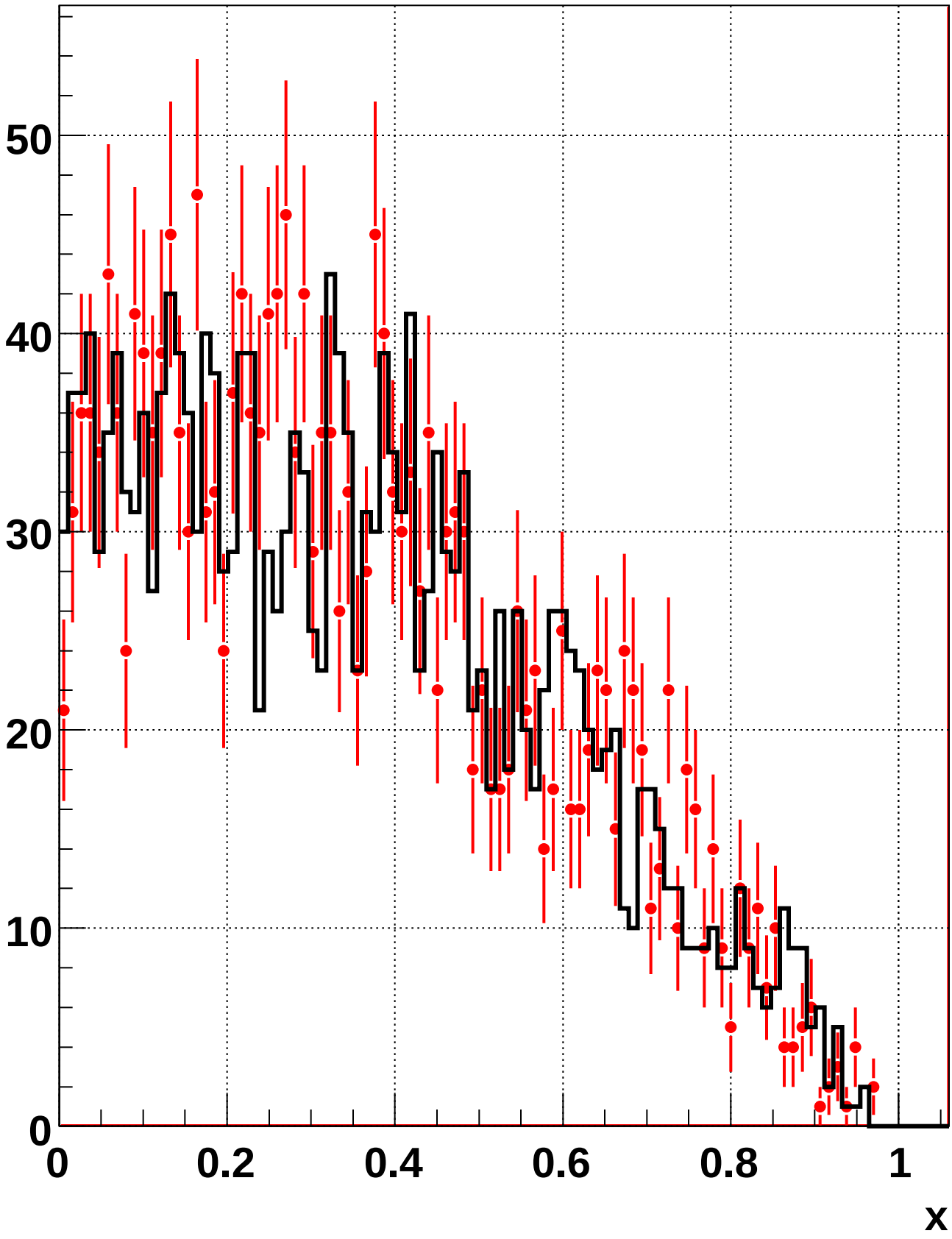
computed x for all events



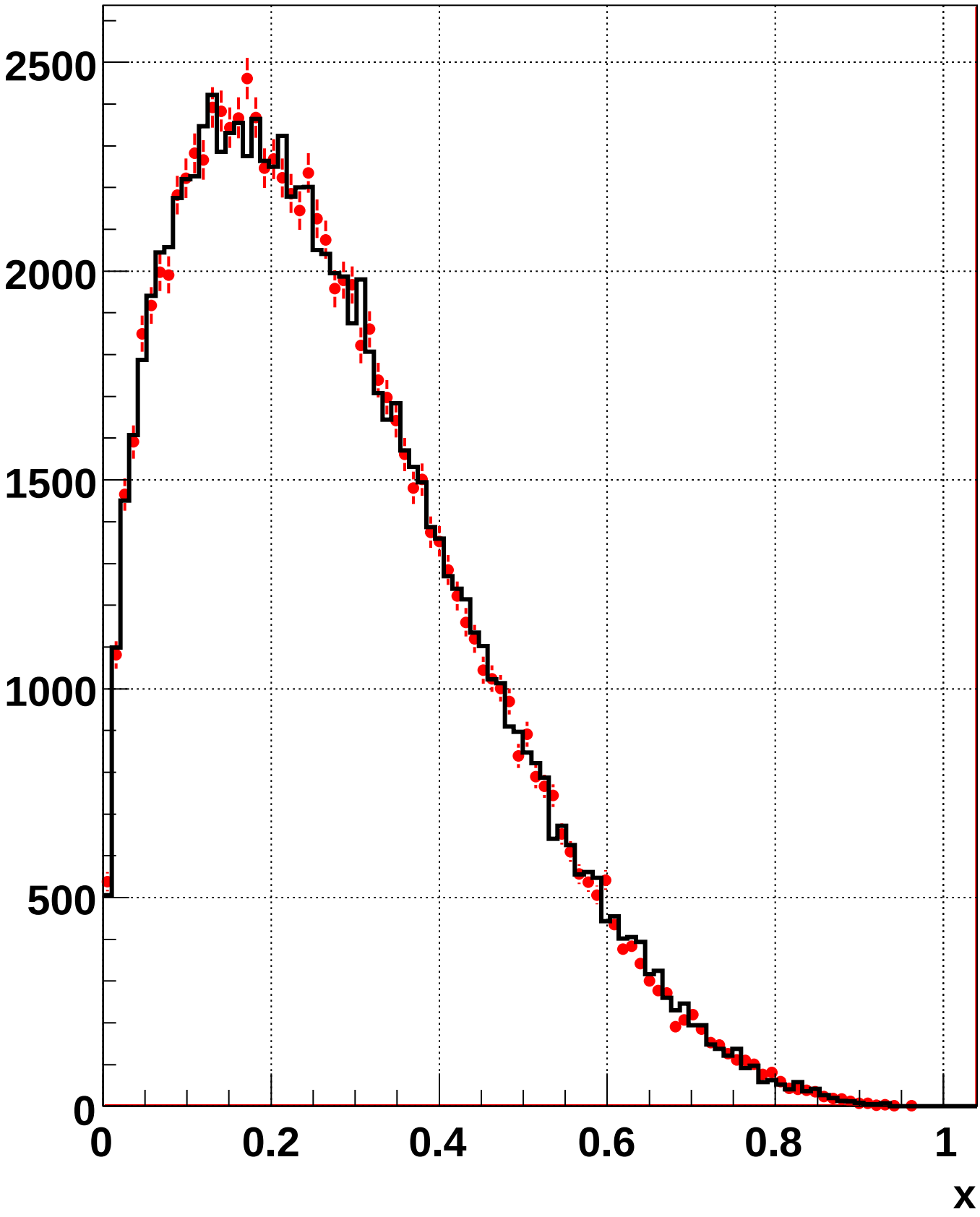
computed x for QEL events



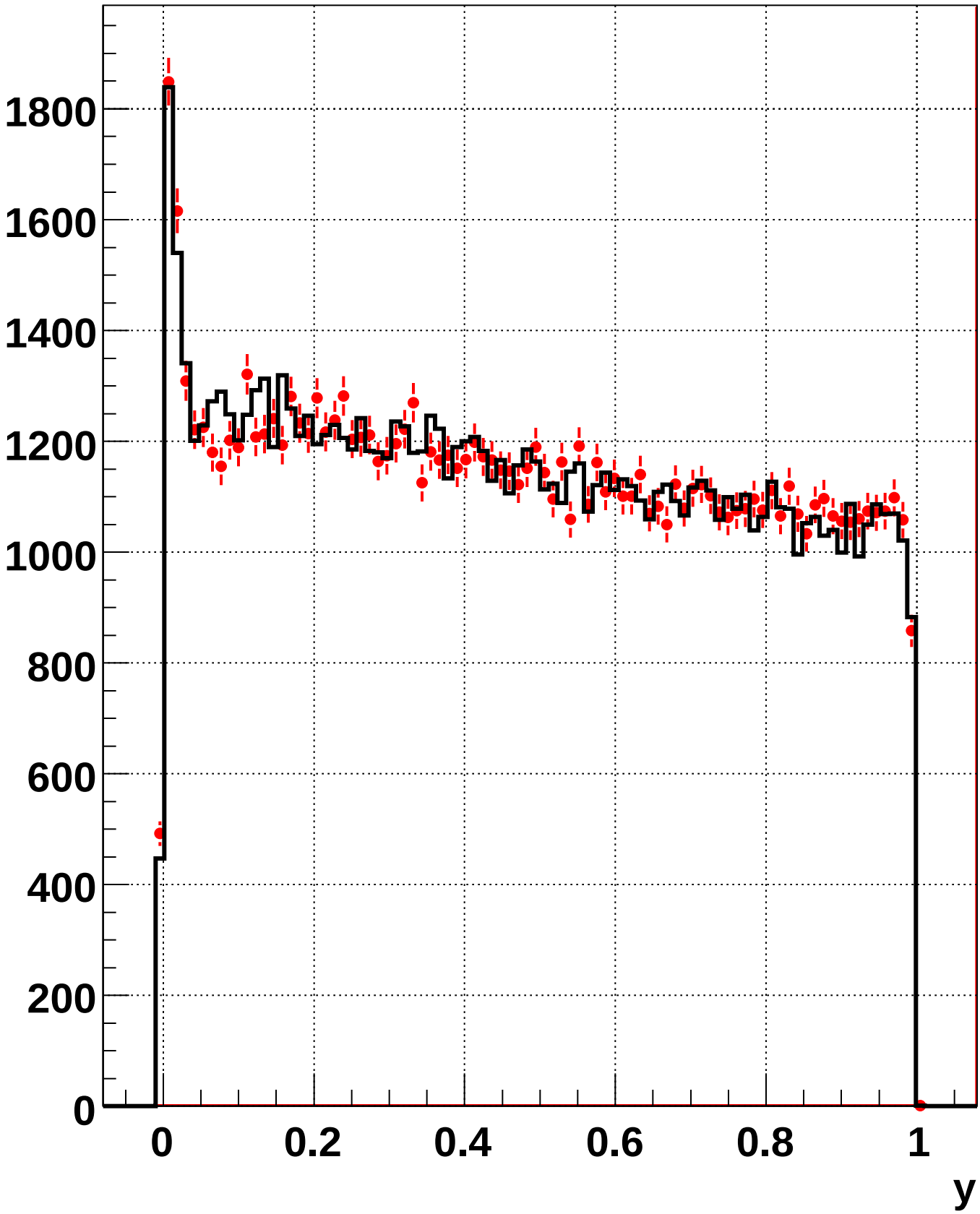
computed x for RES events

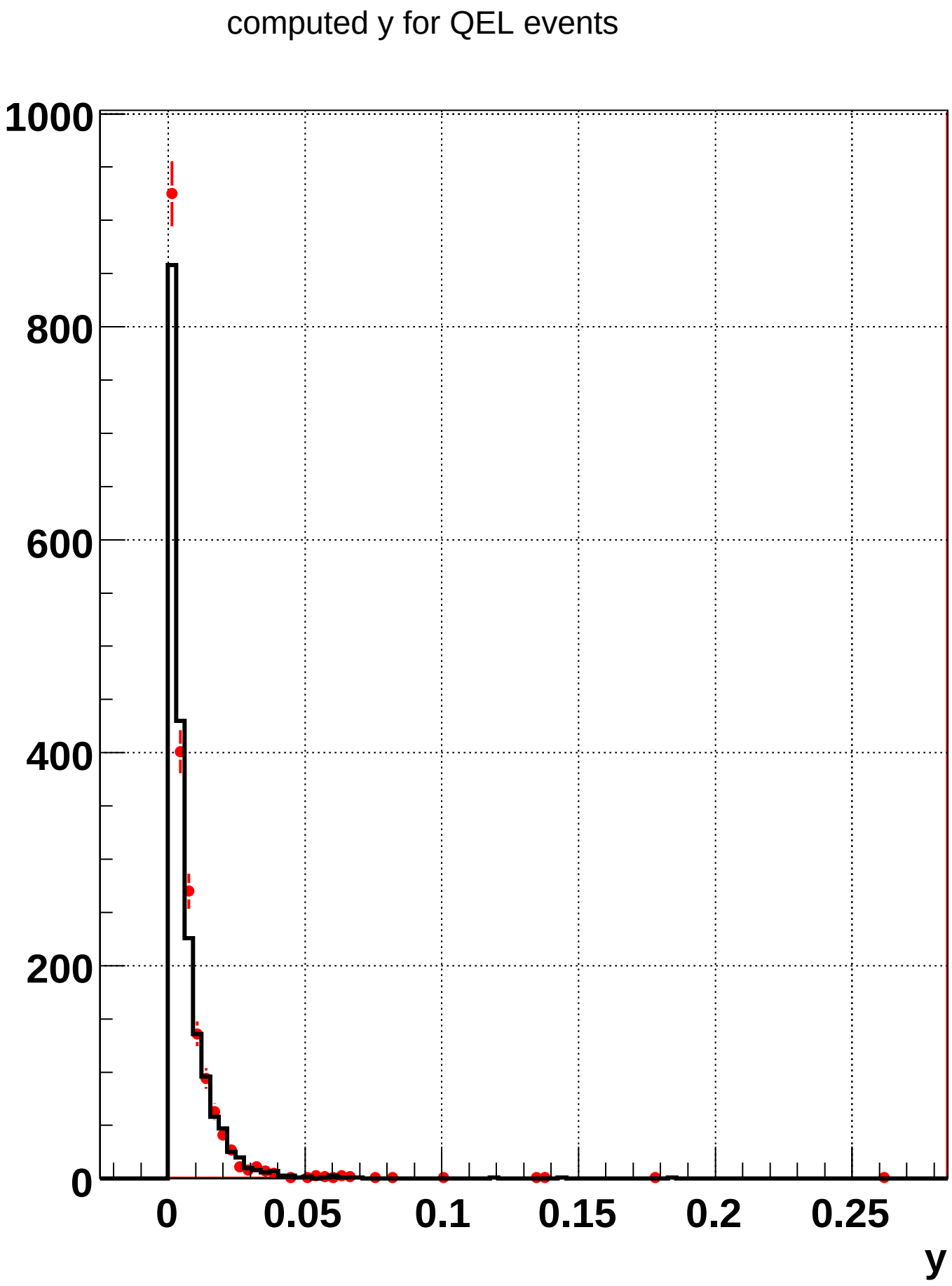


computed x for DIS events

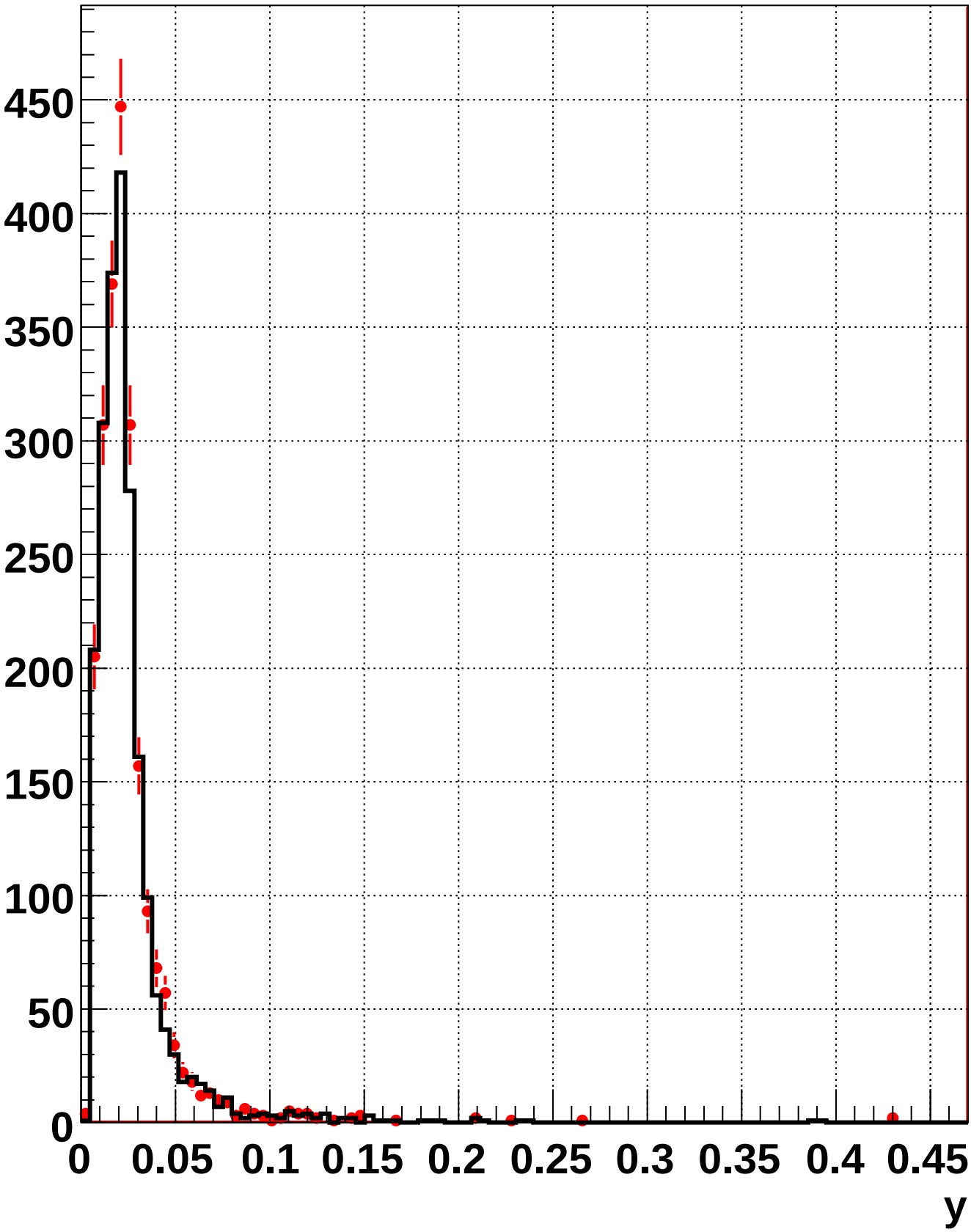


computed y for all events

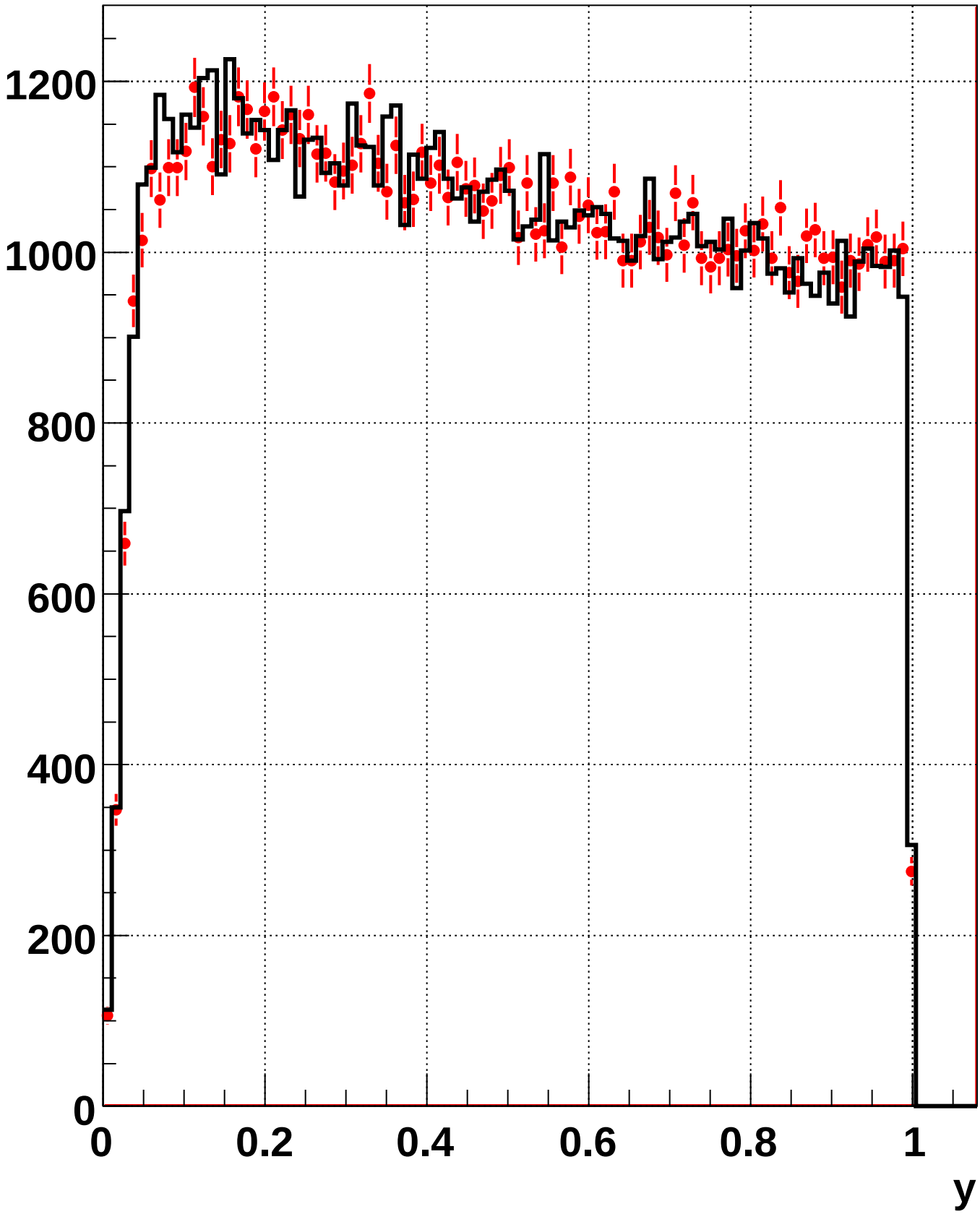



computed y for QEL events
1000
800
600
400
200
0
0
0.05
0.1
0.15
0.2
0.25
y

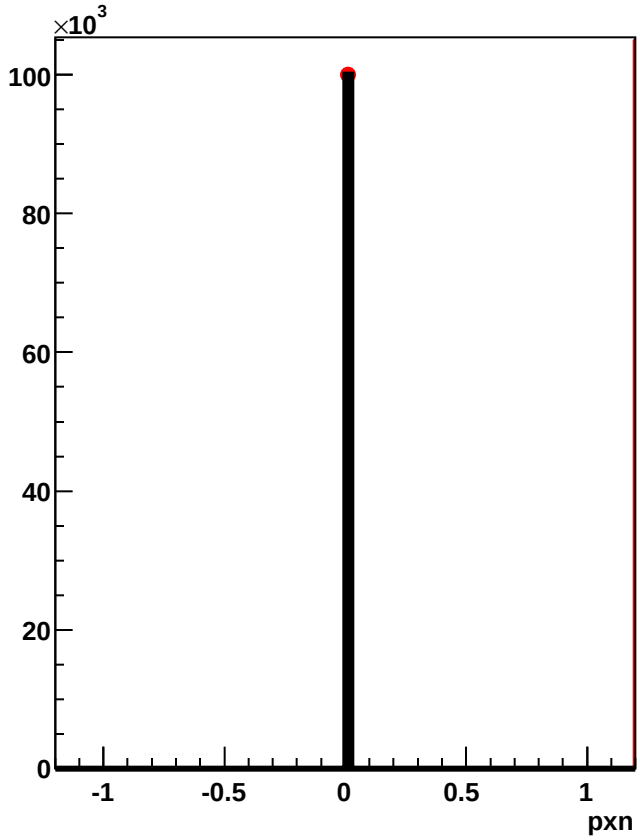
computed y for RES events

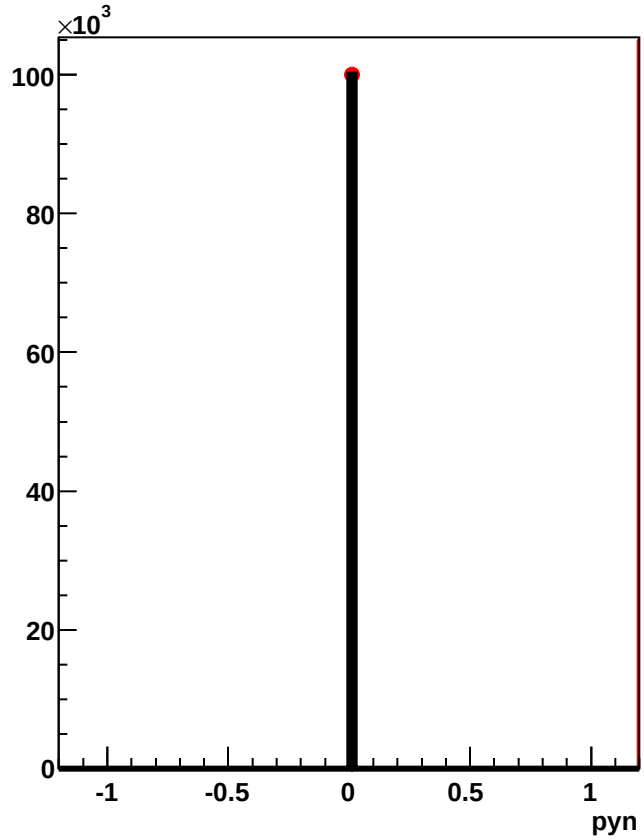


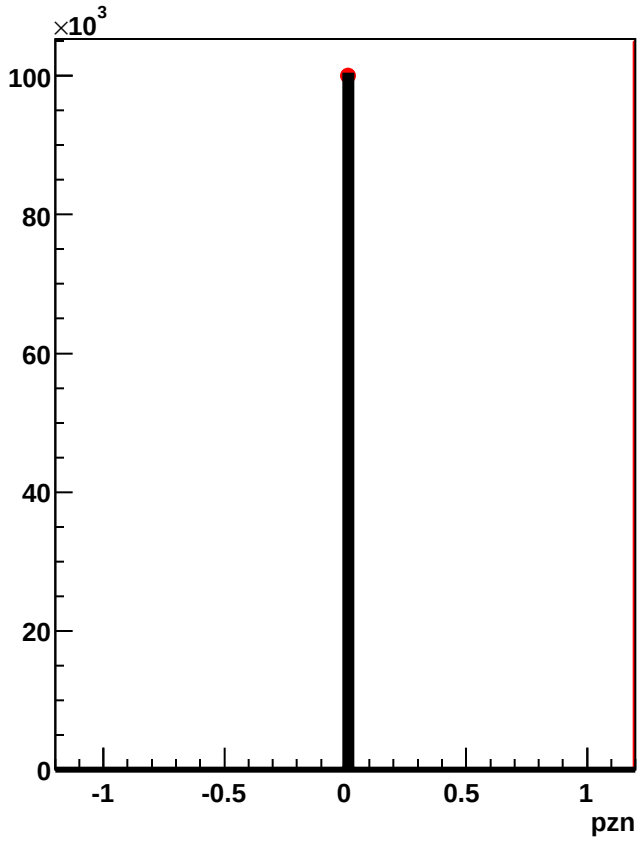
computed y for DIS events

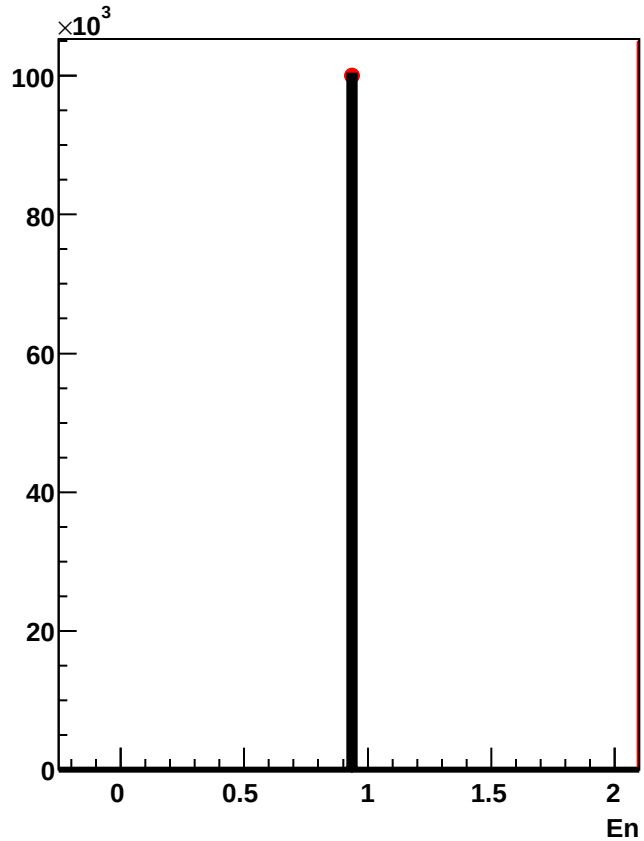


Initial state nucleon 4-Momentum


×10^3
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pxn

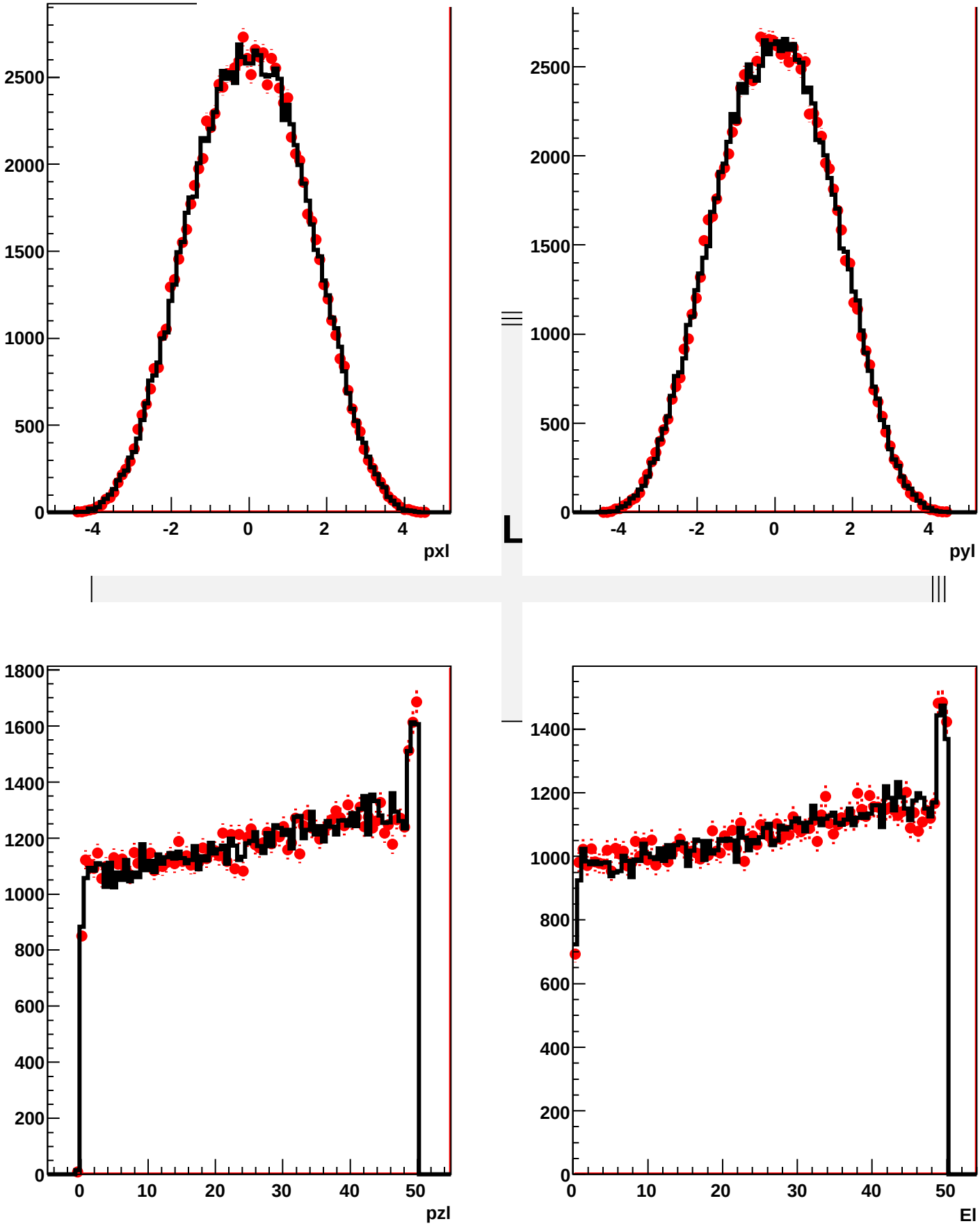

×10^3
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pyn


×10^3
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pzn

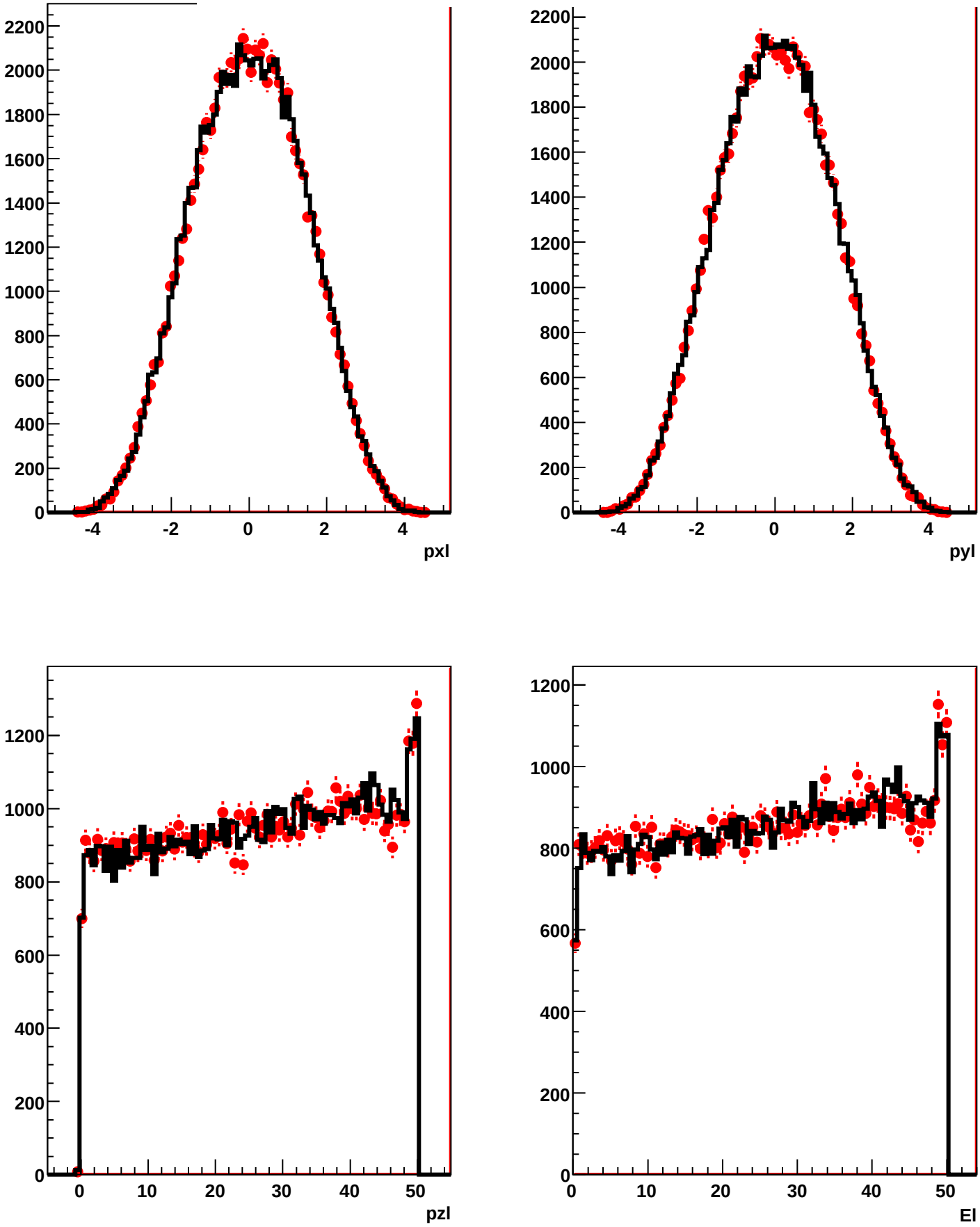

×10^3
100
80
60
40
20
0
0
0.5
1
1.5
2
En

Final State Primary Lepton 4-Momentum

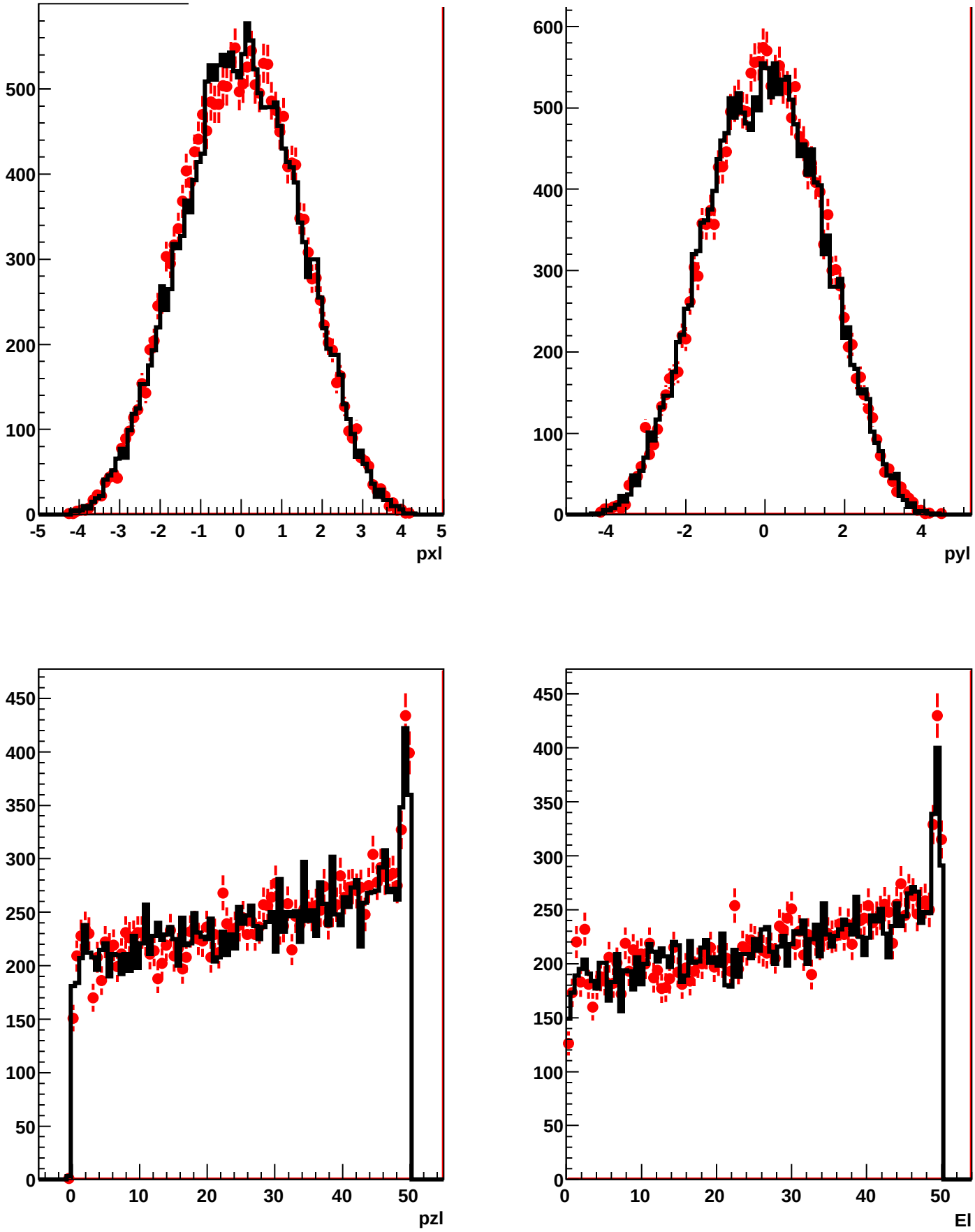
Final state primary lepton 4-p: All events



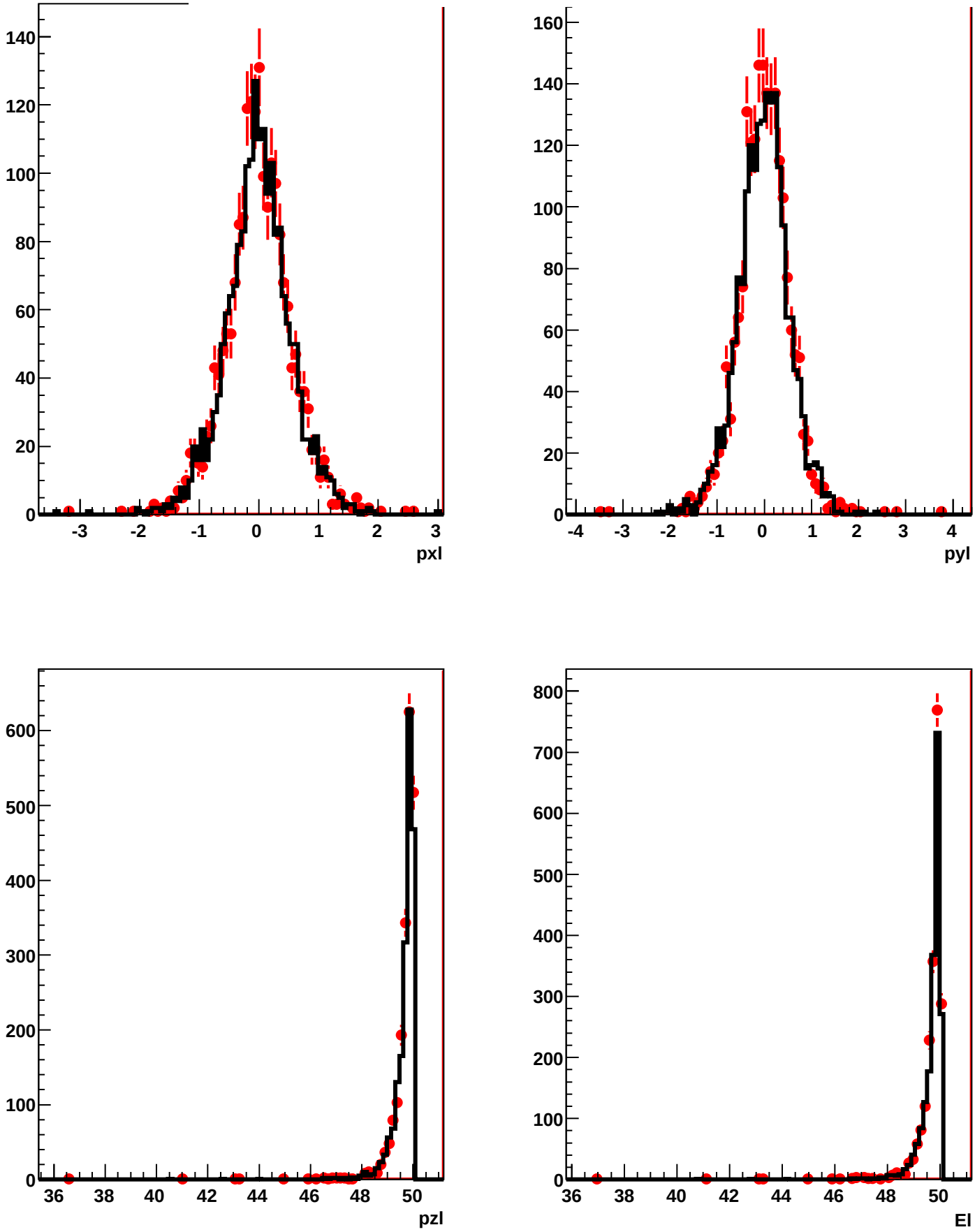
Final state primary lepton 4-p: All CC events



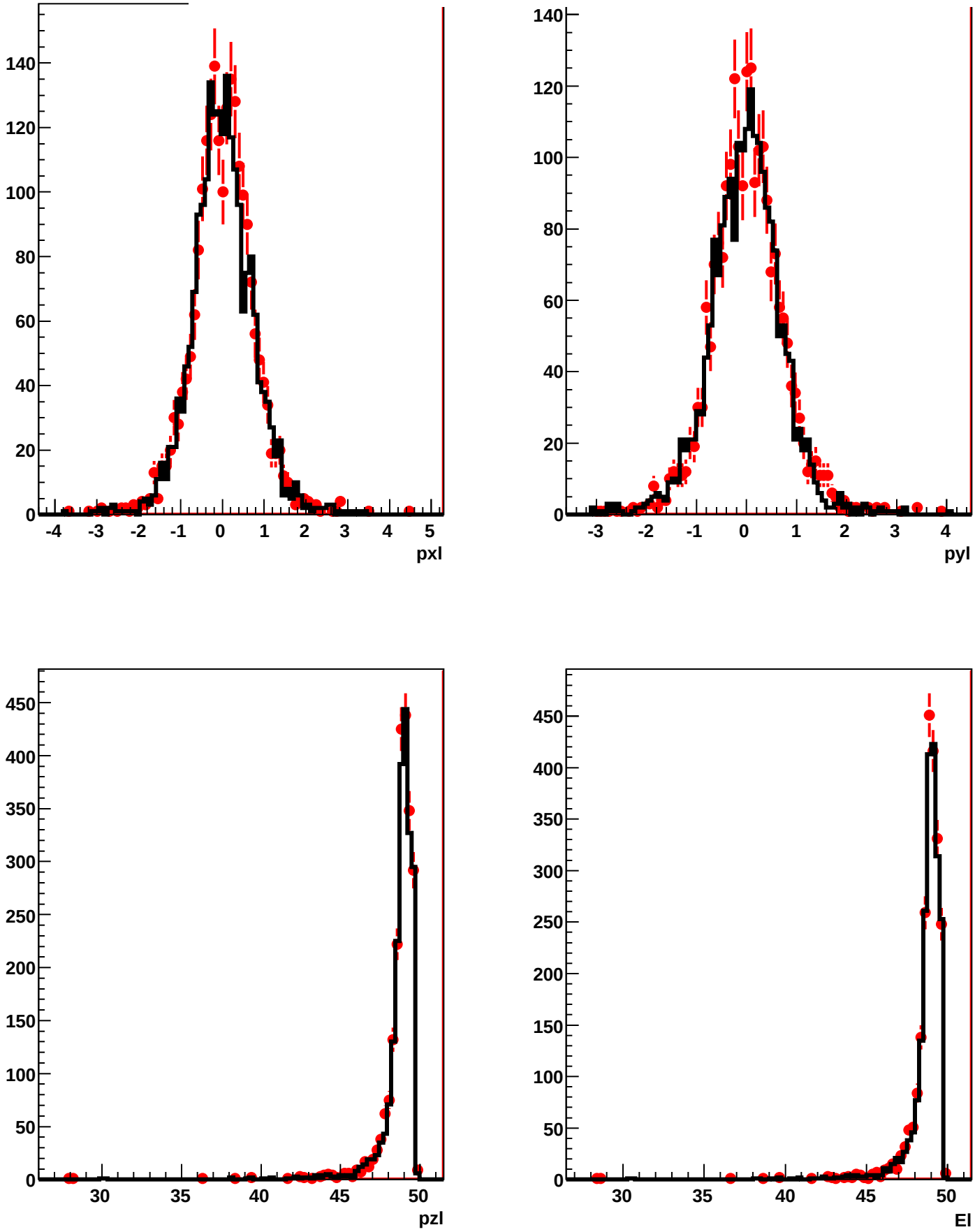
Final state primary lepton 4-p: All NC events



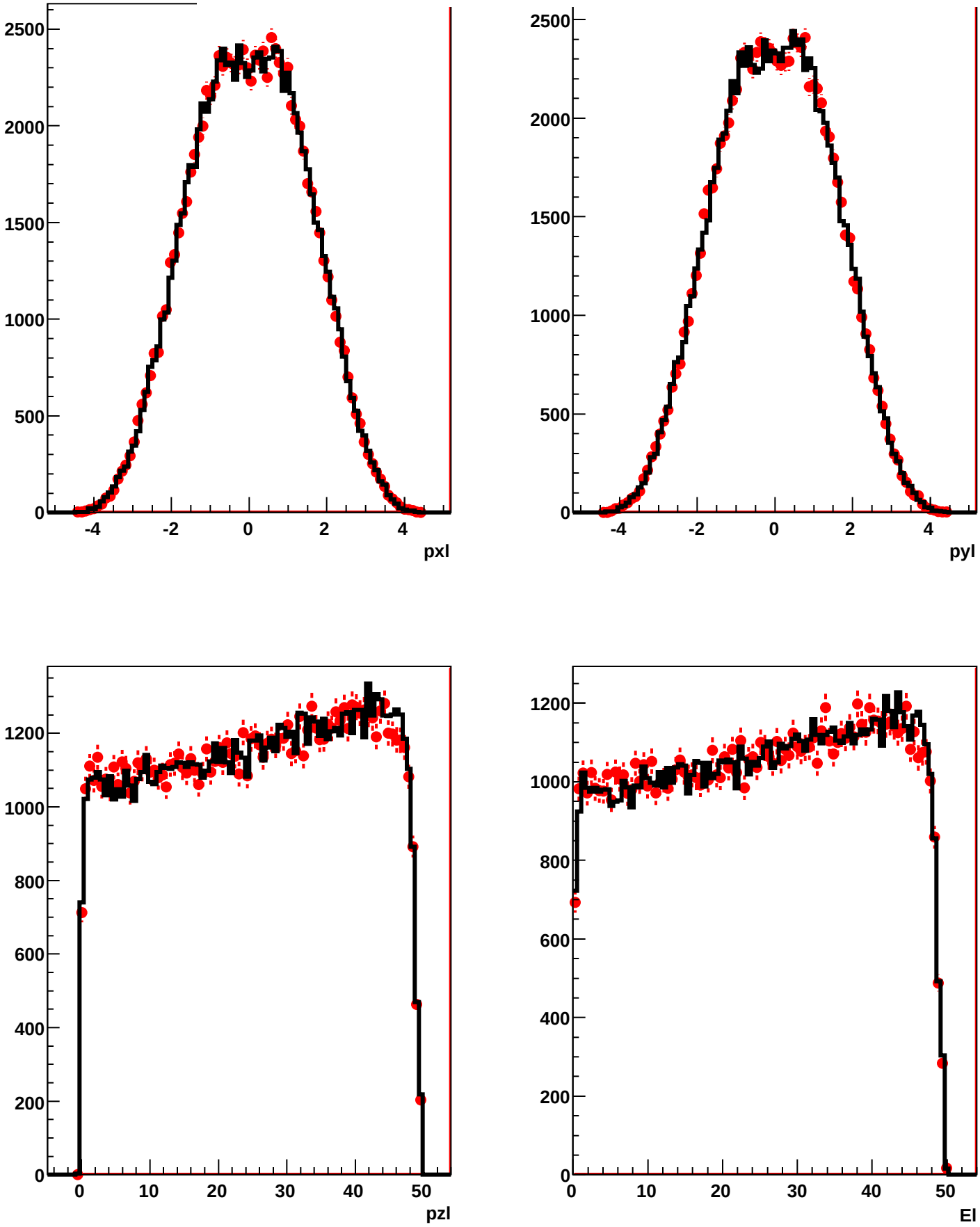
Final state primary lepton 4-p: QEL events



Final state primary lepton 4-p: RES events



Final state primary lepton 4-p: All DIS events



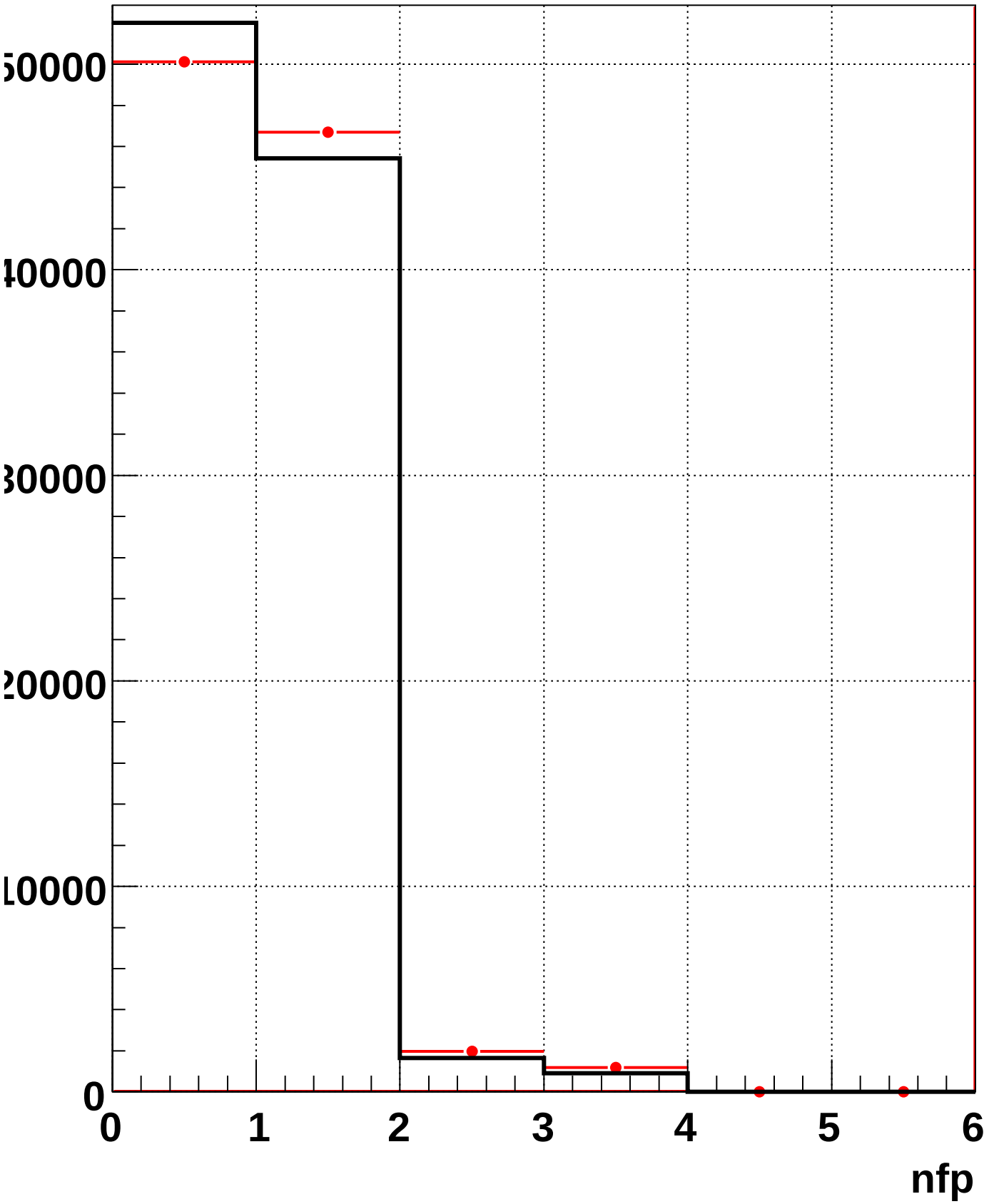
Final State Hadronic System

Multiplicities and 4-Momenta

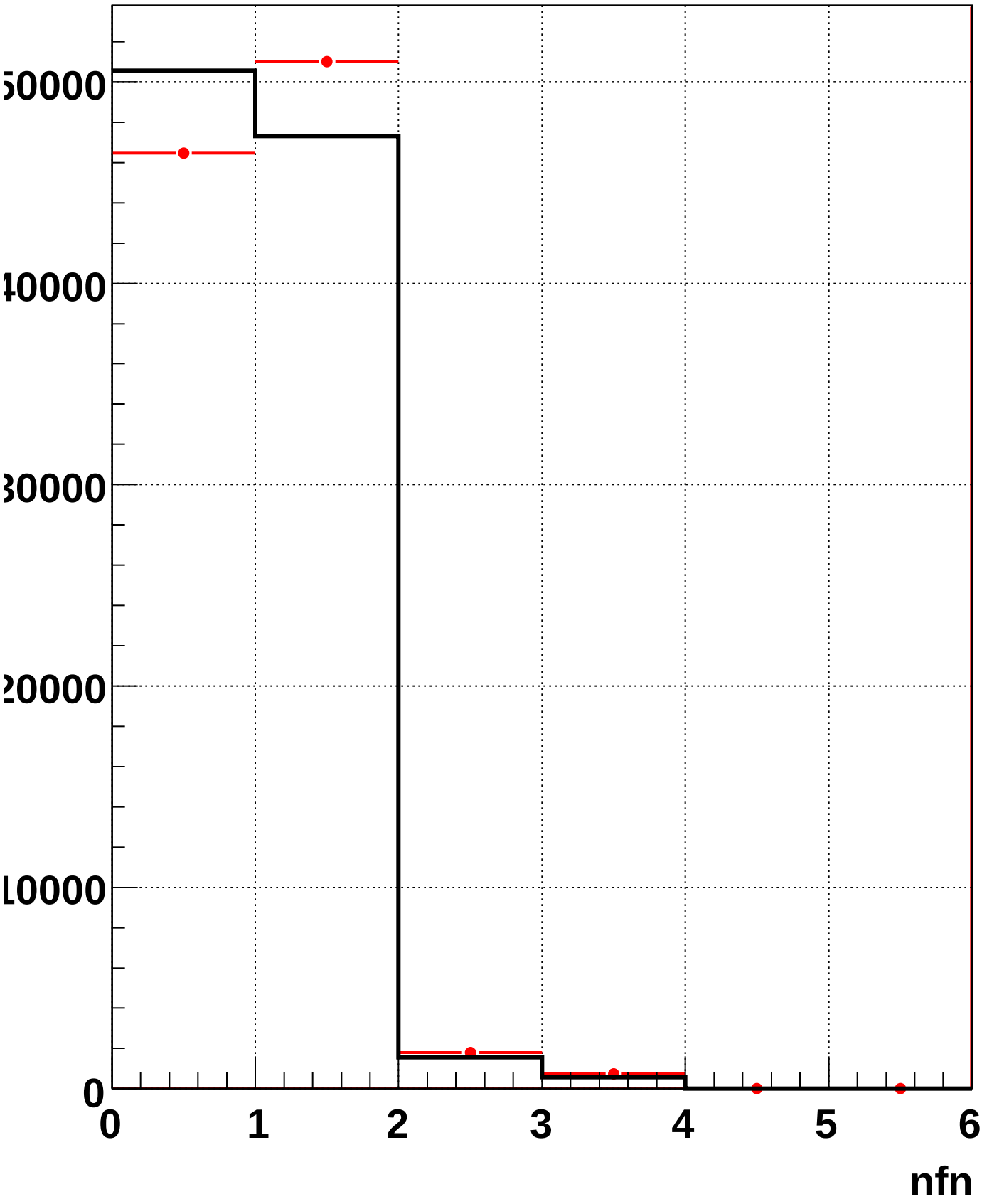
Note:

For nuclear targets these plots include the effect of intranuclear hadron transport / rescattering

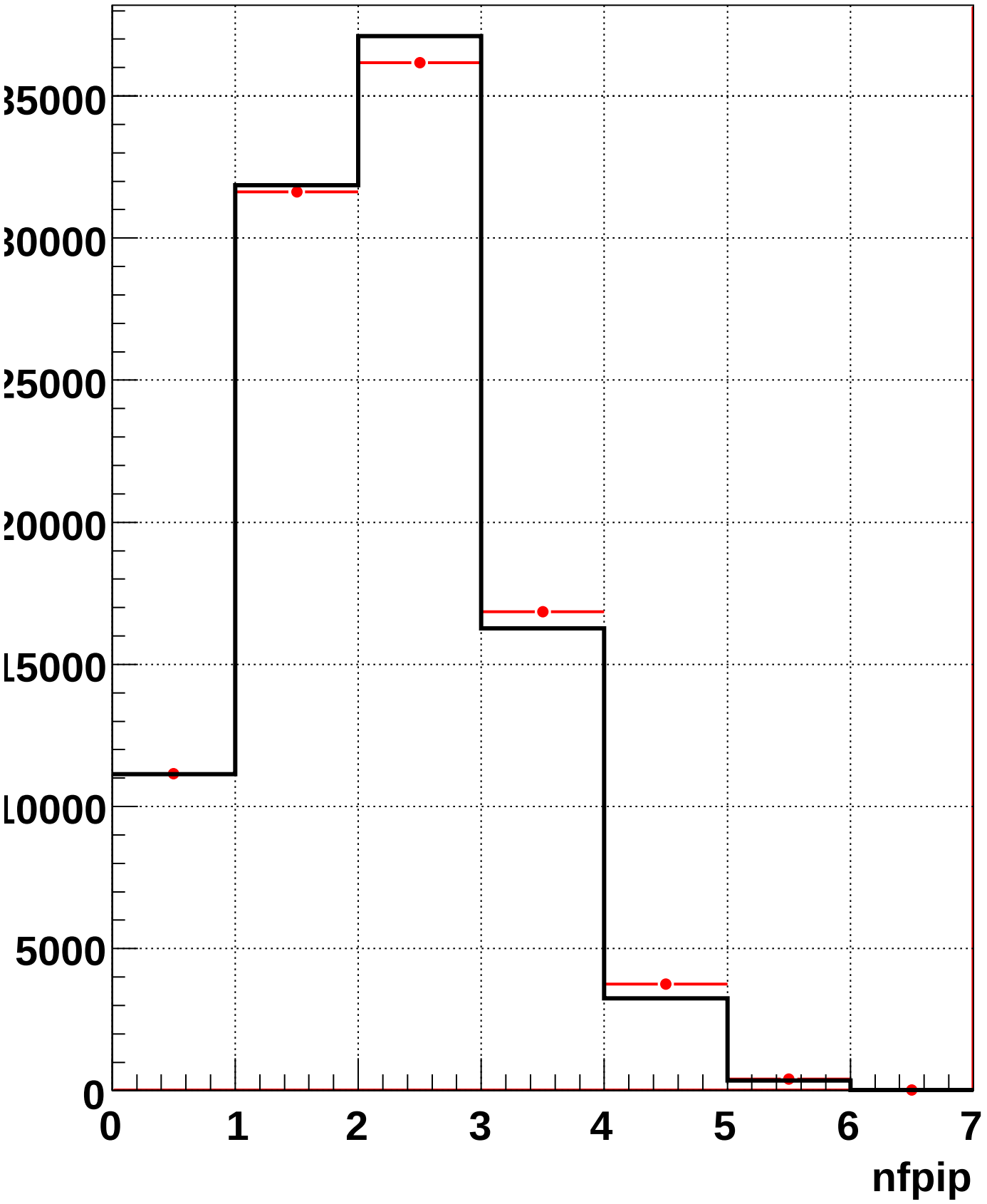
Number of final state protons



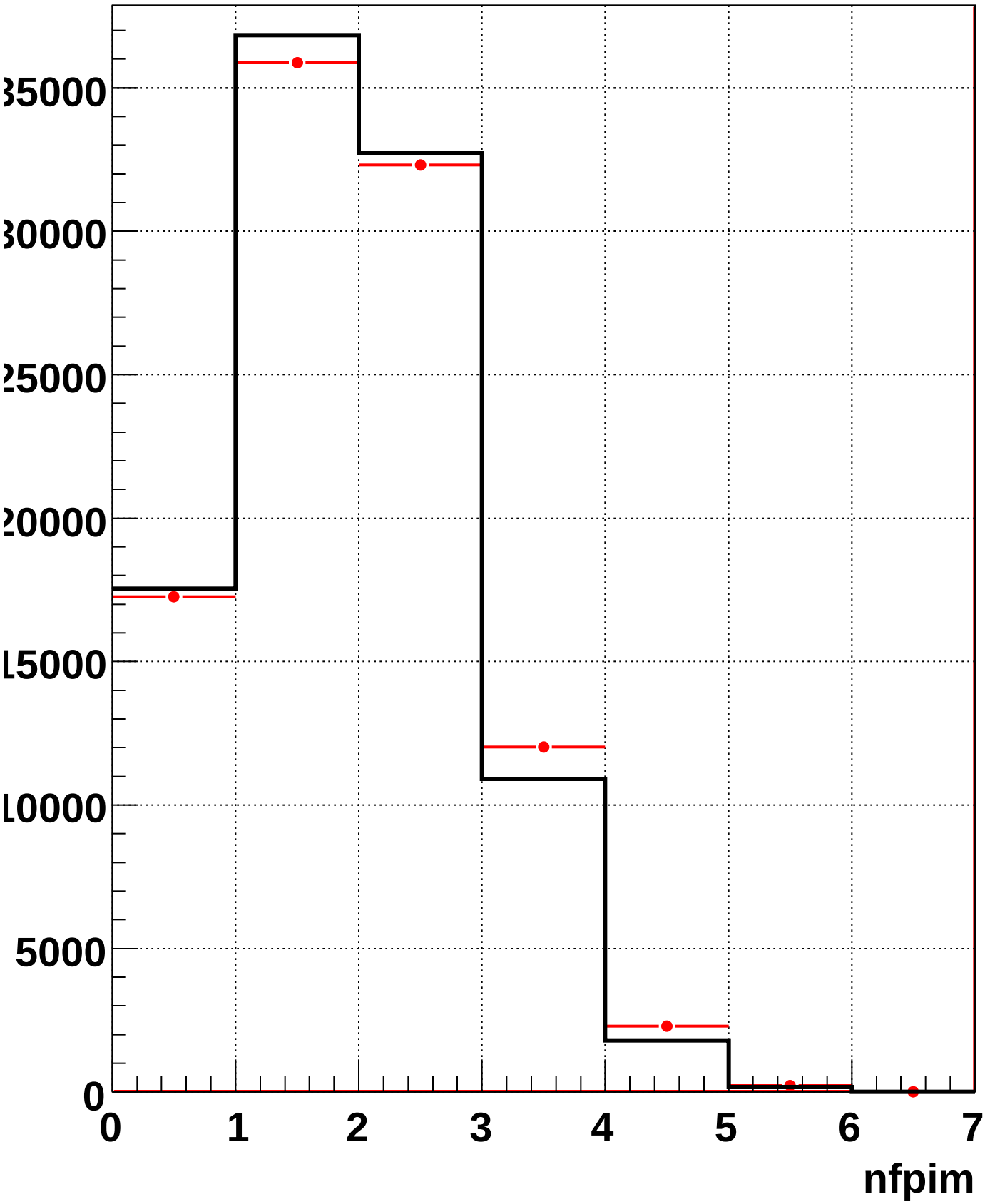
Number of final state neutrons



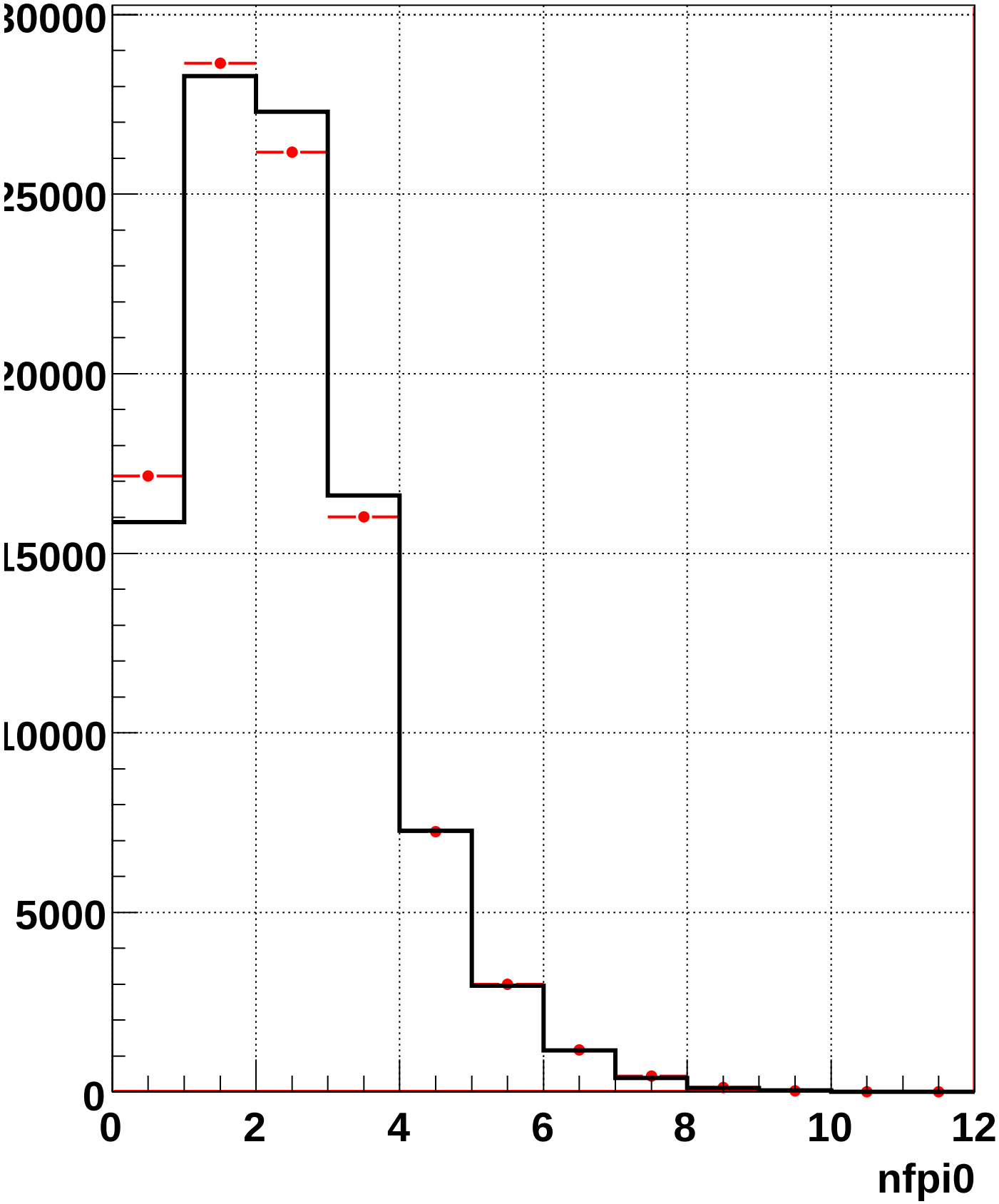
Number of final state pi+



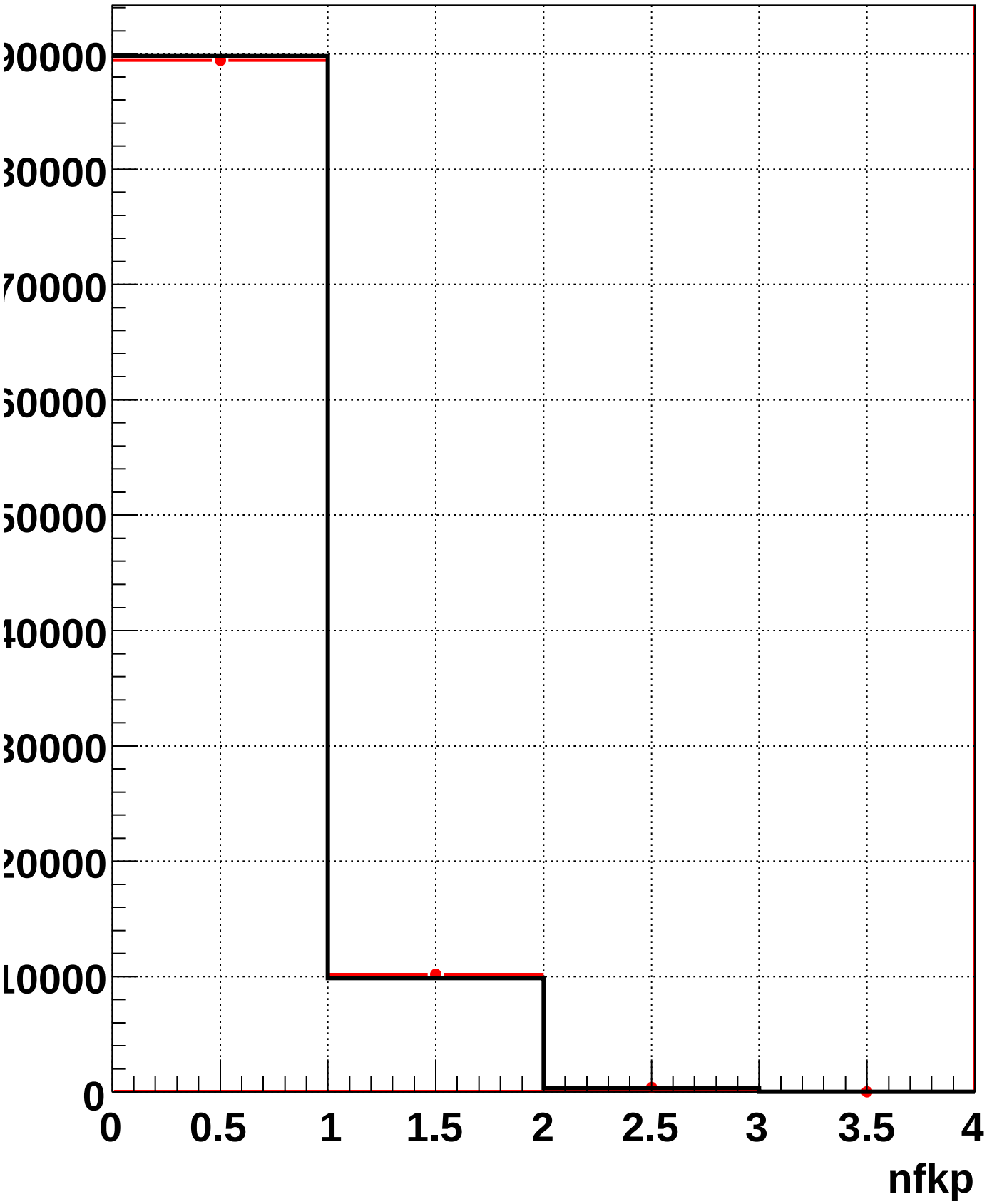
Number of final state pi-



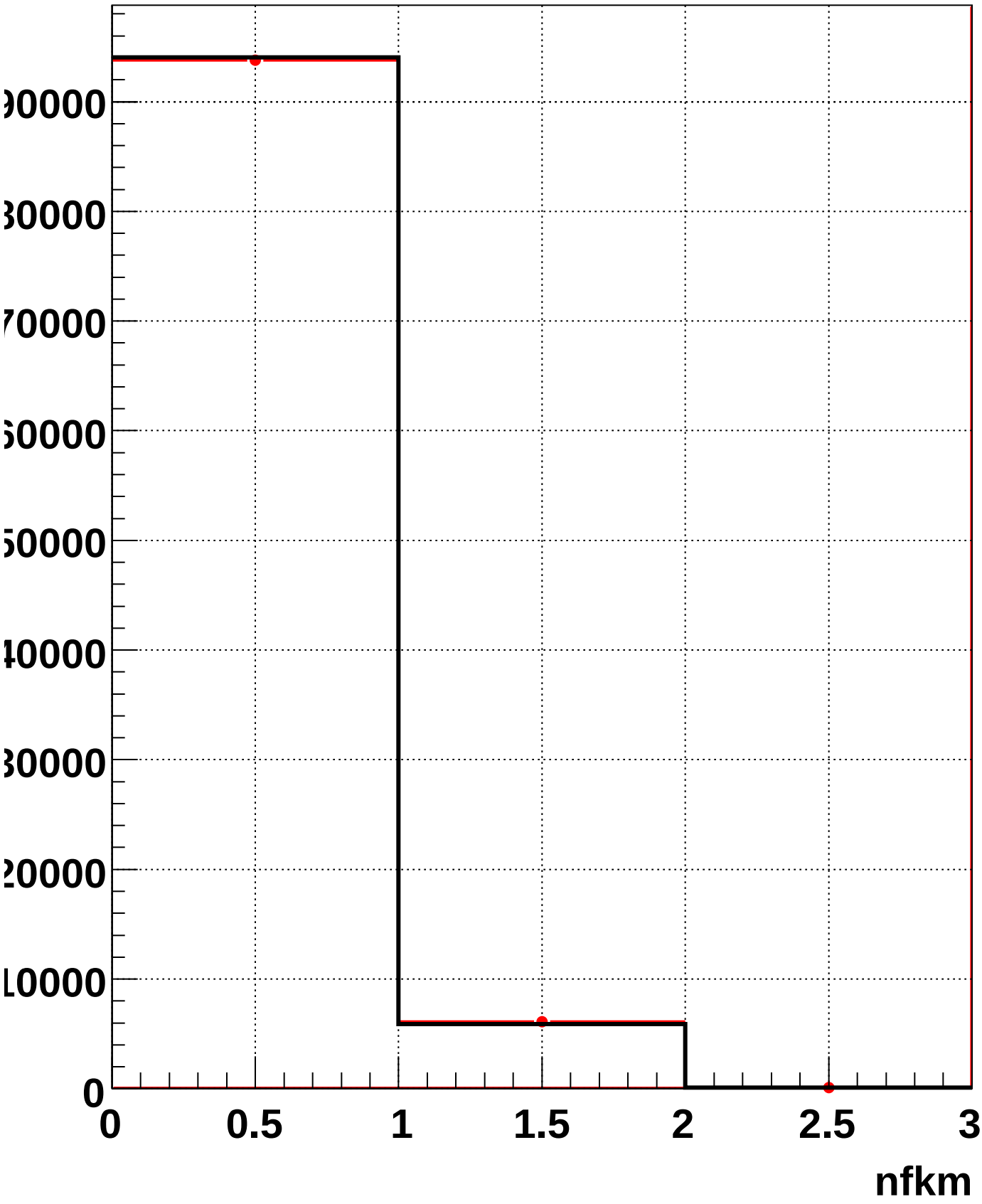
Number of final state pi0



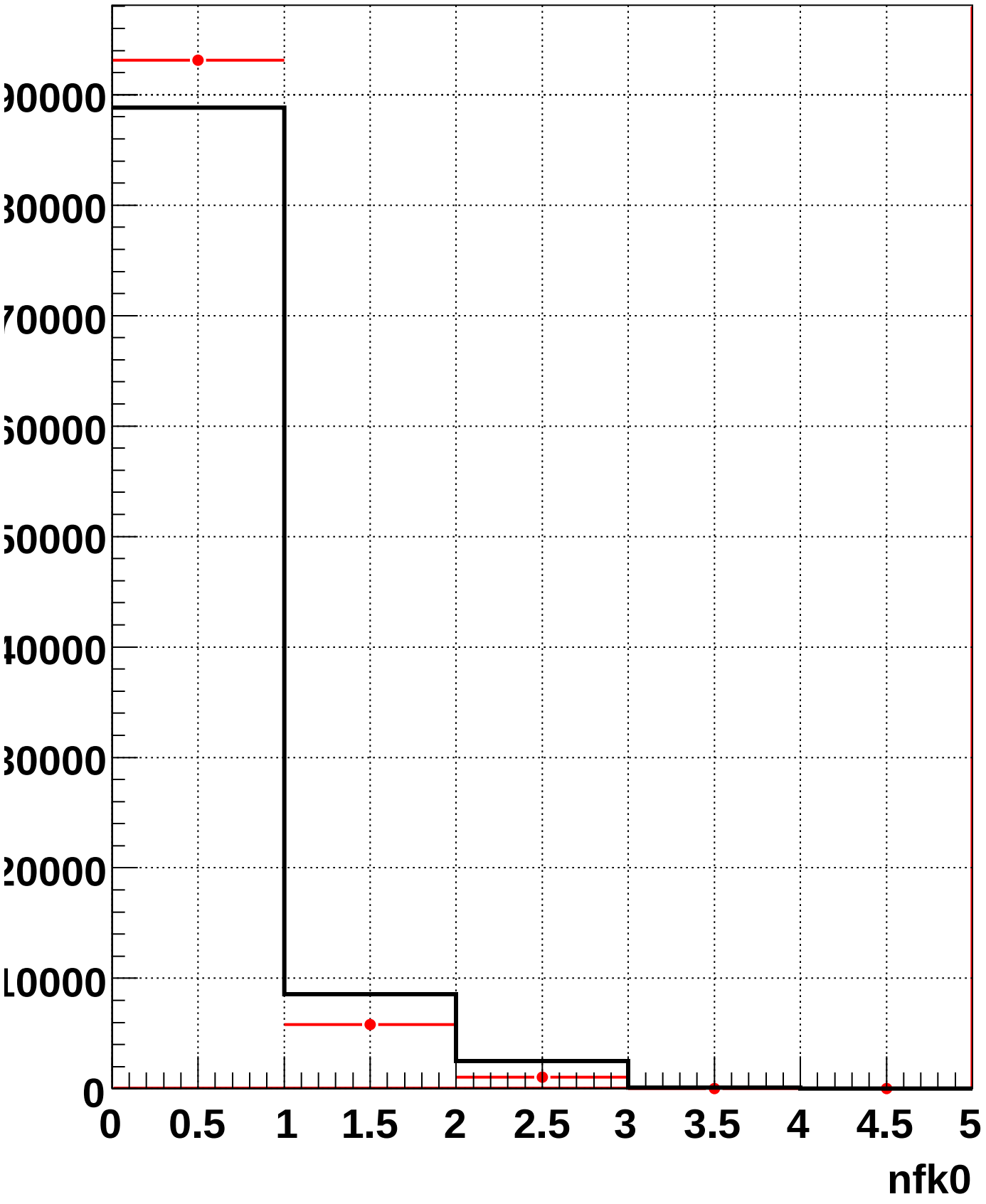
Number of final state K+



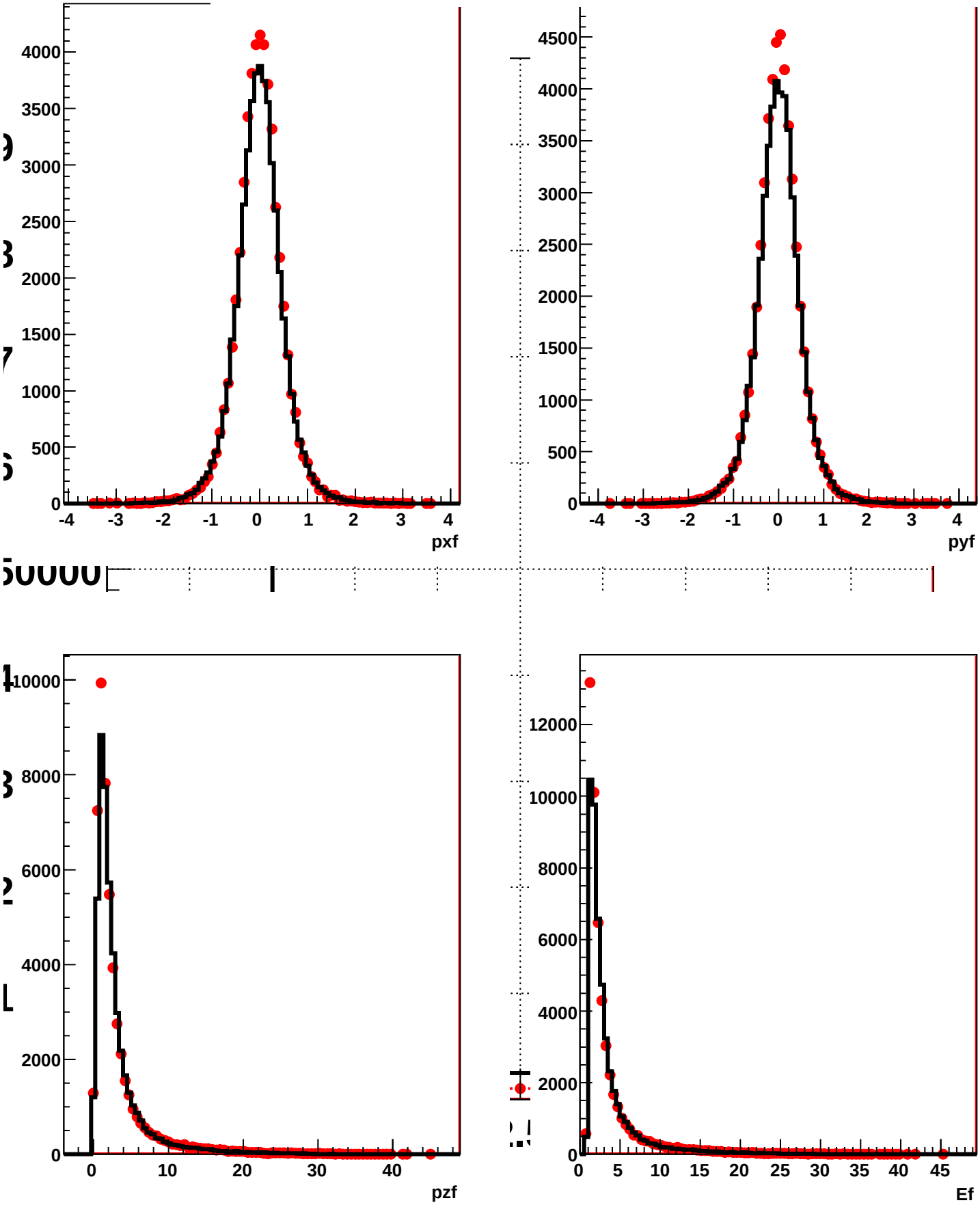
Number of final state K-



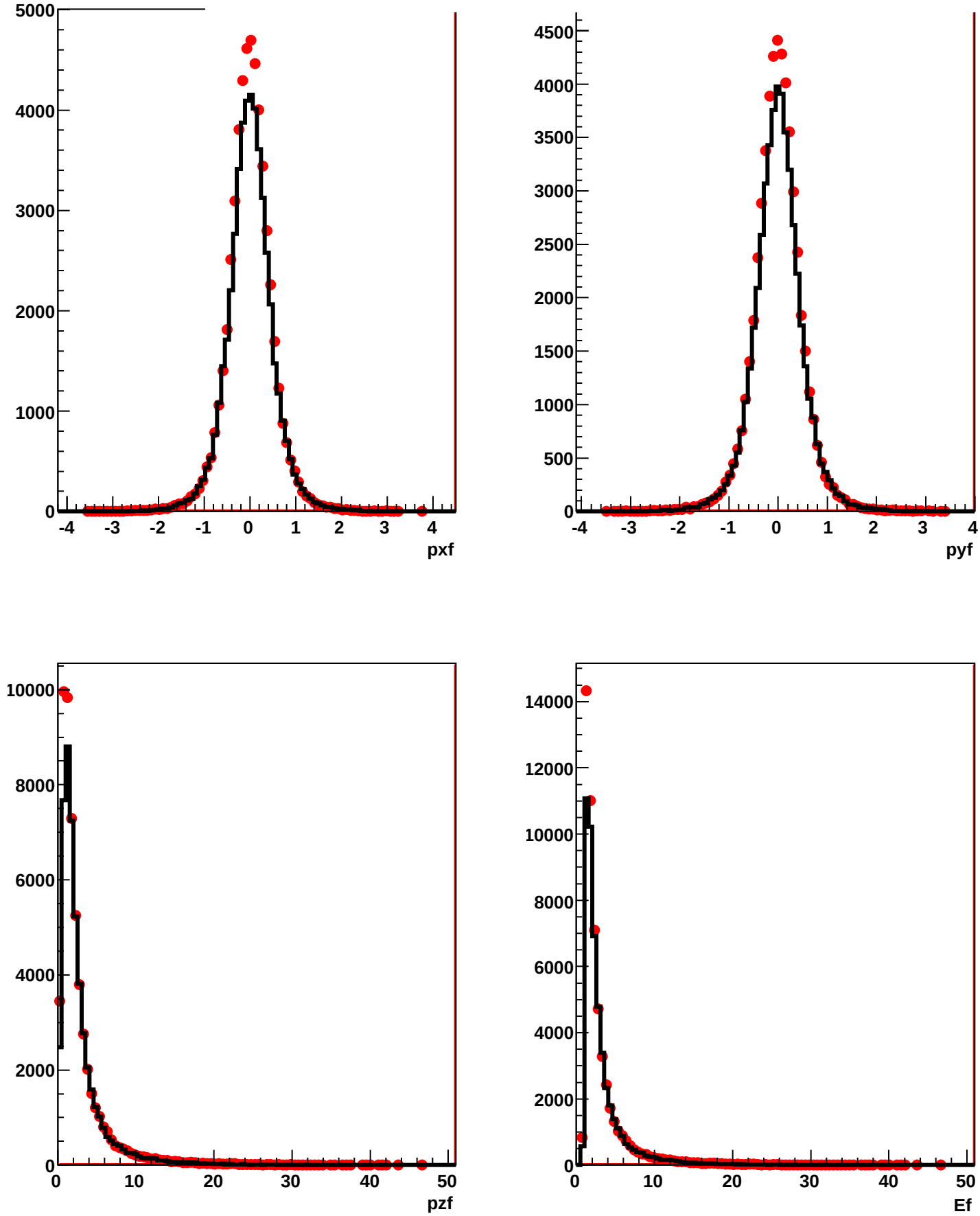
Number of final state K0



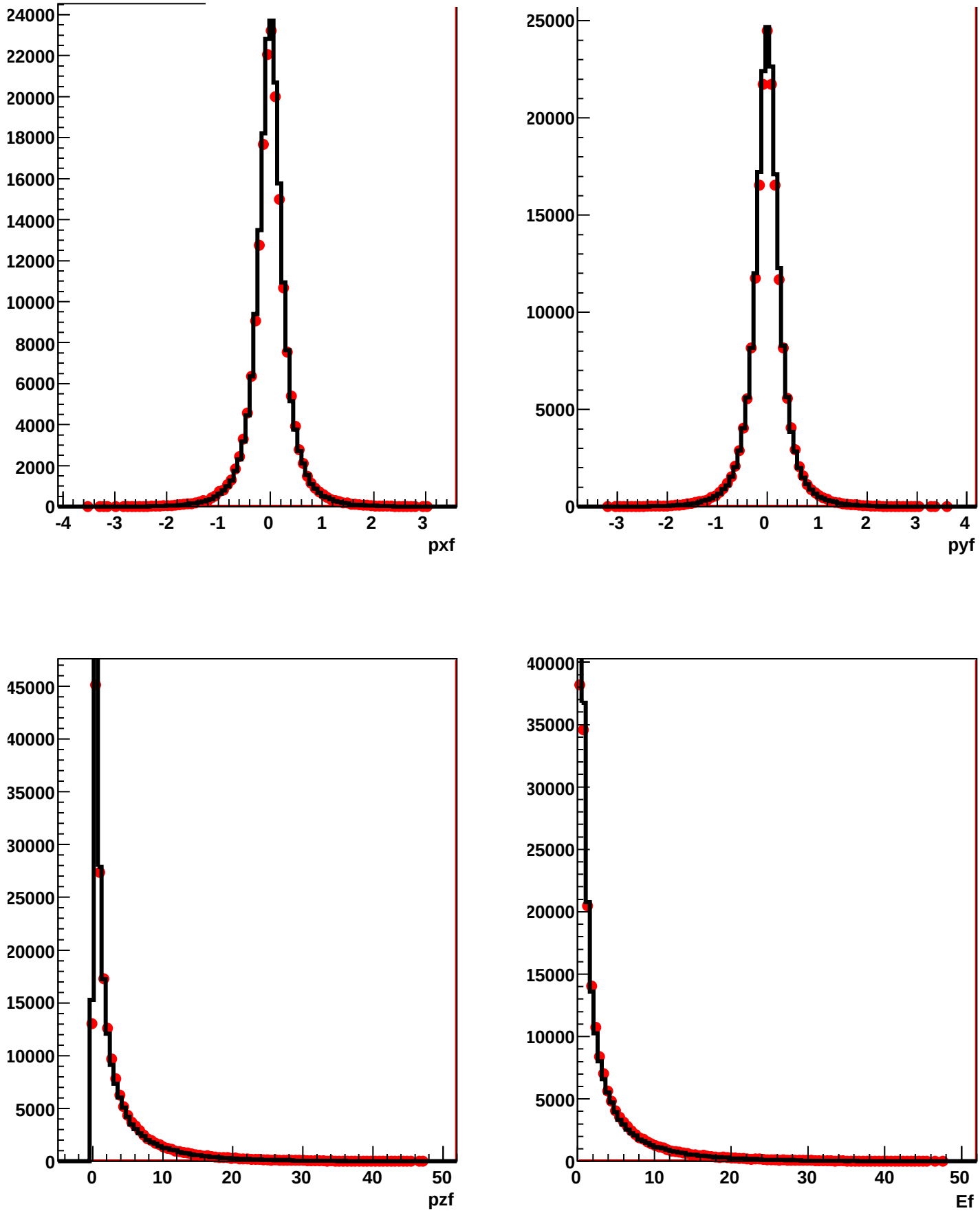
Final state protons 4-momentum



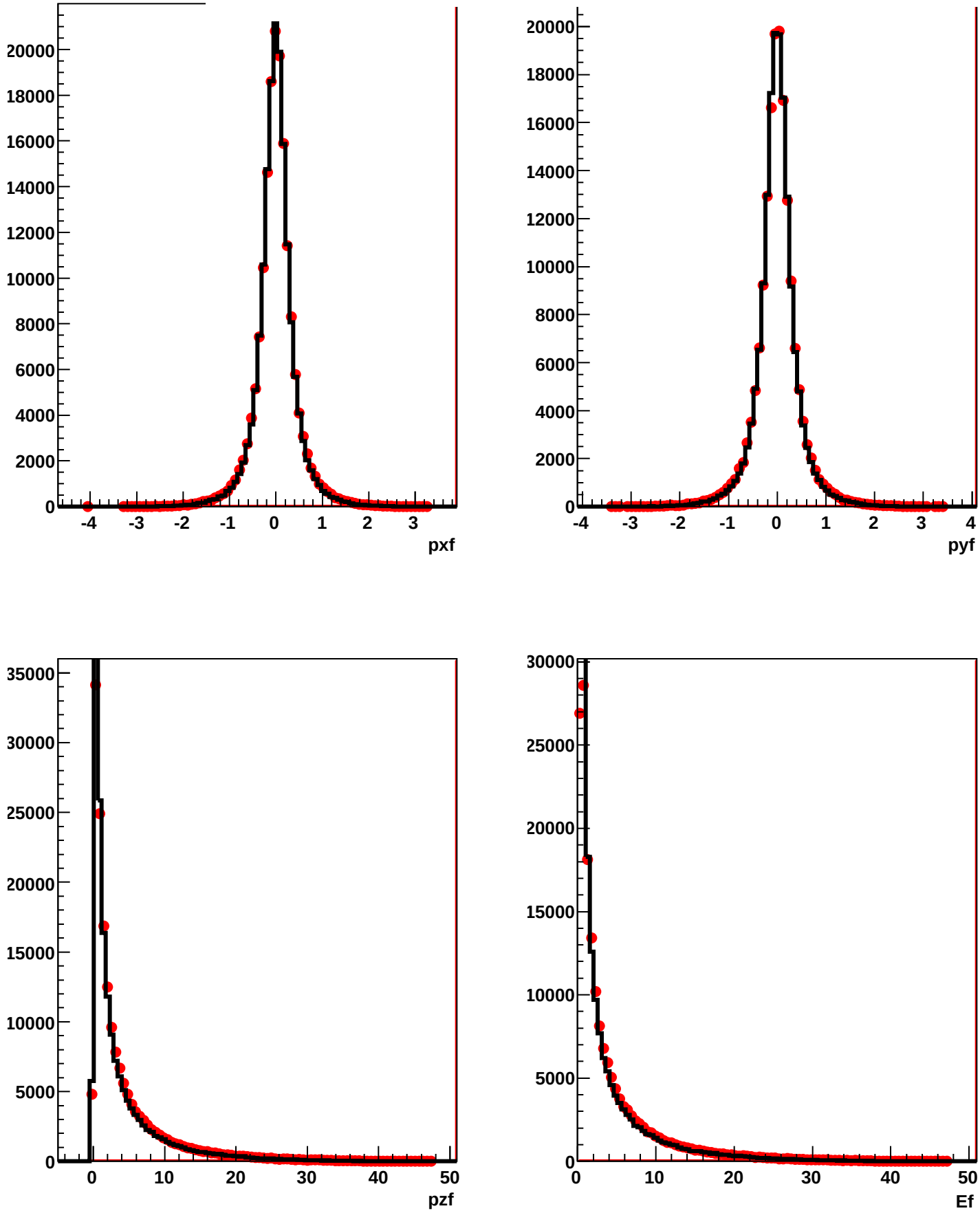
Final state neutrons 4-momentum



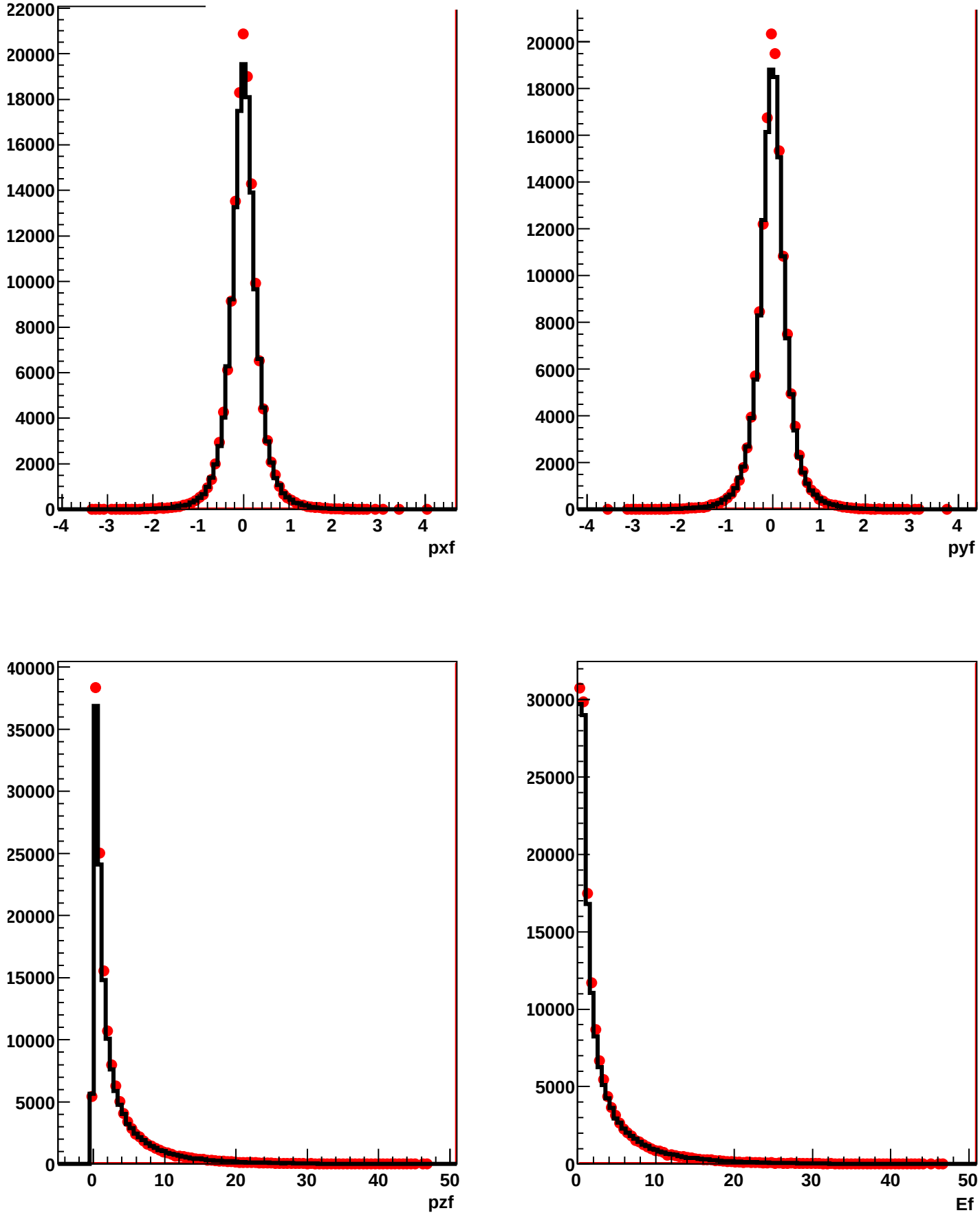
Final state pi0's 4-momentum



Final state pi+’s 4-momentum



Final state pi-'s 4-momentum



GENIE-2.0.0 vs NEUGEN/Daikon+ Event Sample Comparisons

Event Sample:

100k events, numubar+p, 1GeV, all processes

Notes:

Daikon+ is a NEUGEN Daikon revision version

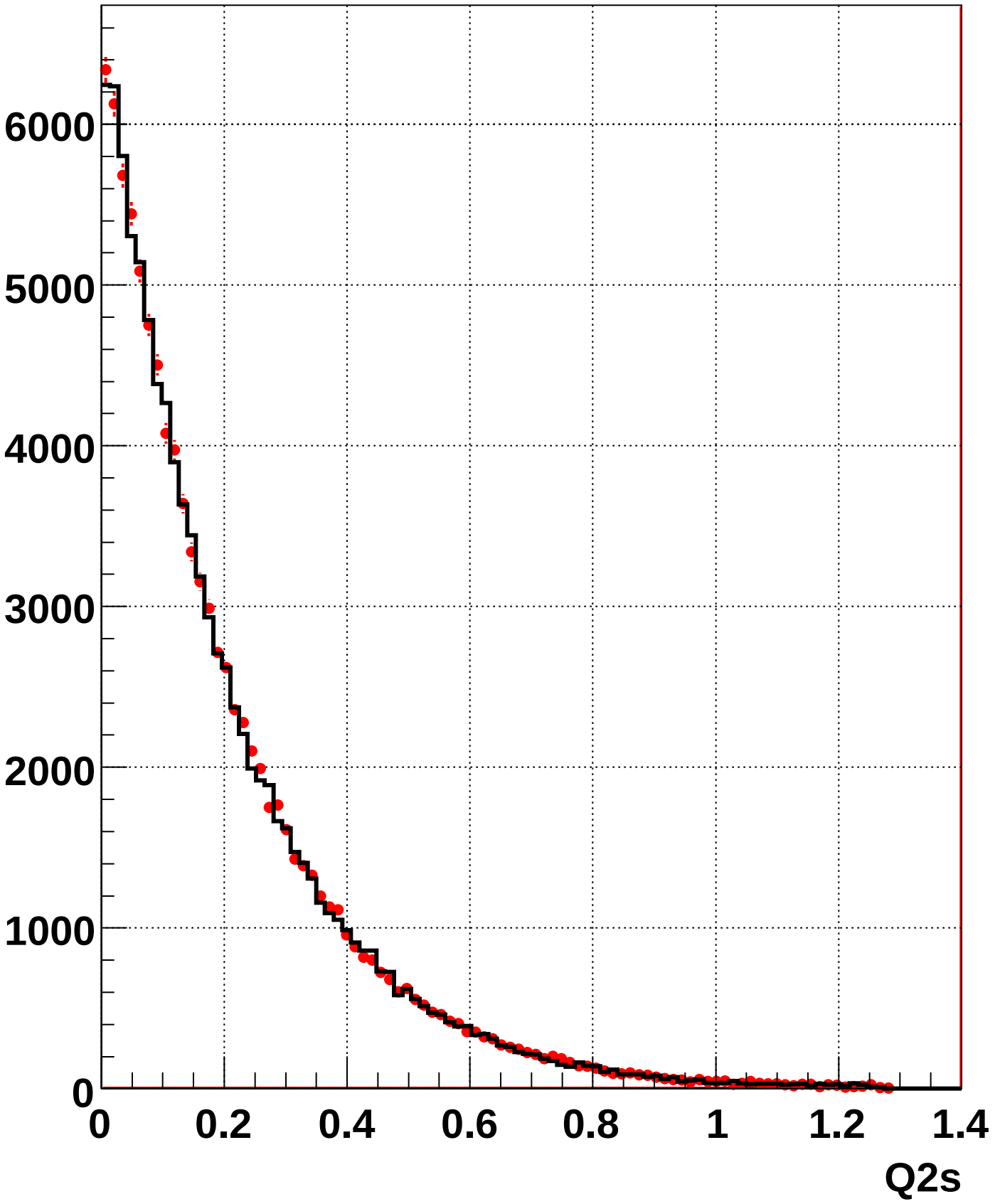
GENIE predictions shown with lines / NEUGEN's with markers

Event Numbers:

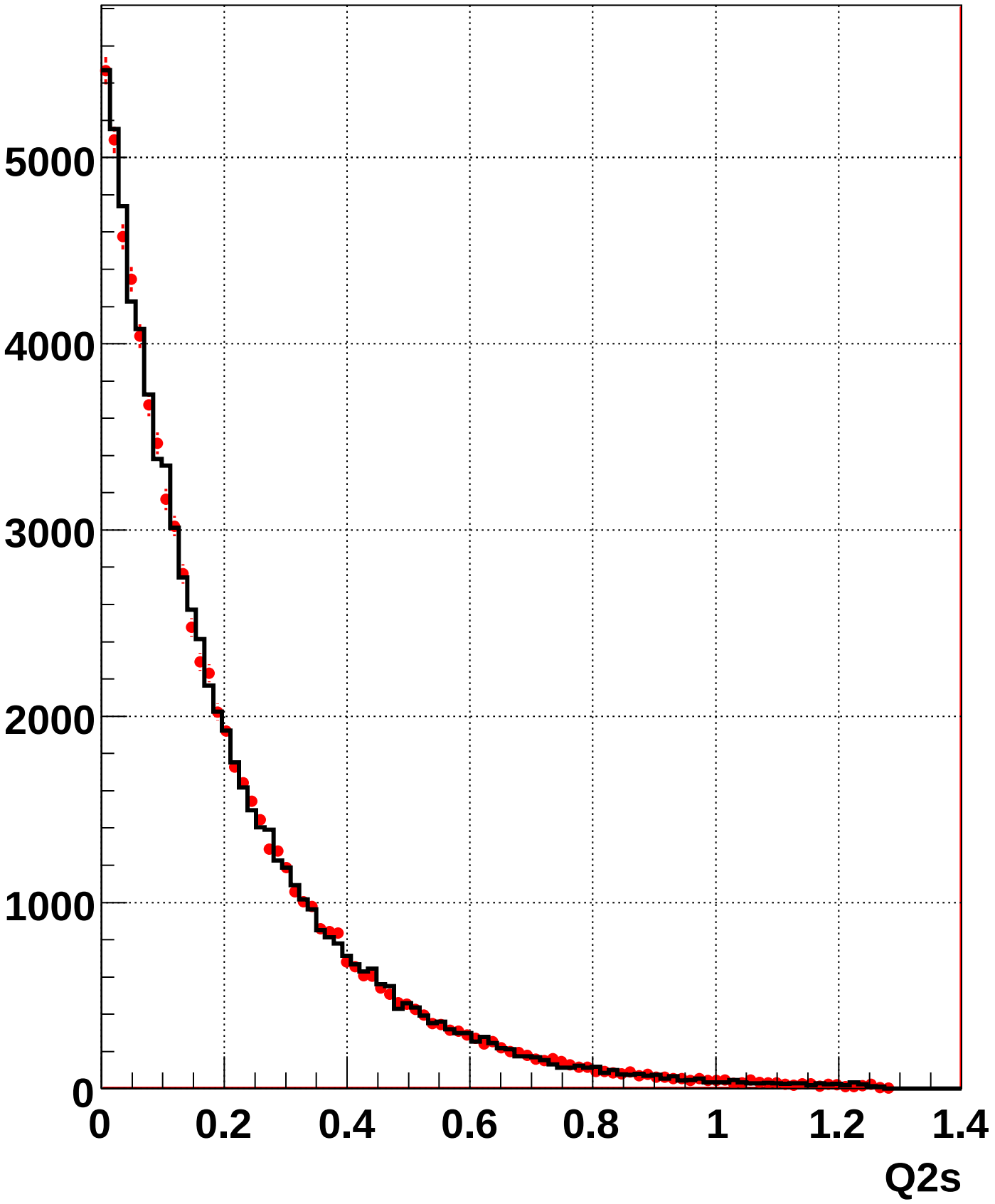
ALL :	100000 [NeuGEN],	100000 [GENIE]
QEL :	77196 [NeuGEN],	77695 [GENIE]
QEL-CC :	62811 [NeuGEN],	62832 [GENIE]
QEL-NC :	14385 [NeuGEN],	14863 [GENIE]
RES :	16728 [NeuGEN],	16248 [GENIE]
RES-CC :	8684 [NeuGEN],	8303 [GENIE]
RES-NC :	8044 [NeuGEN],	7945 [GENIE]
DIS :	6076 [NeuGEN],	6057 [GENIE]
DIS-CC :	4455 [NeuGEN],	4466 [GENIE]
(charm):	0 [NeuGEN],	0 [GENIE]
DIS-NC :	1621 [NeuGEN],	1591 [GENIE]
COH :	0 [NeuGEN],	0 [GENIE]
COH-CC :	0 [NeuGEN],	0 [GENIE]
COH-NC :	0 [NeuGEN],	0 [GENIE]
IMD :	0 [NeuGEN],	0 [GENIE]

Selected Kinematical Quantities

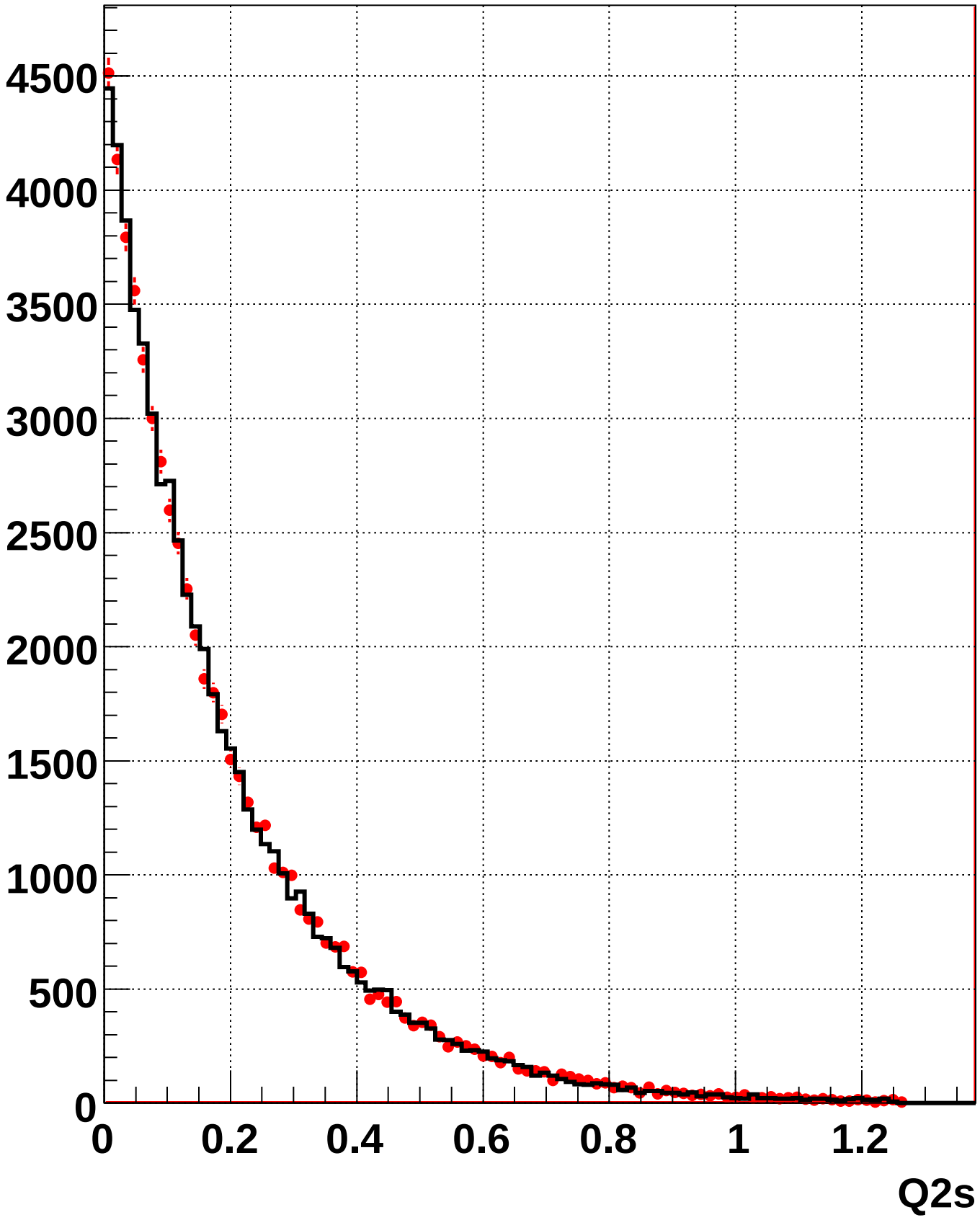
selected Q2 for all events



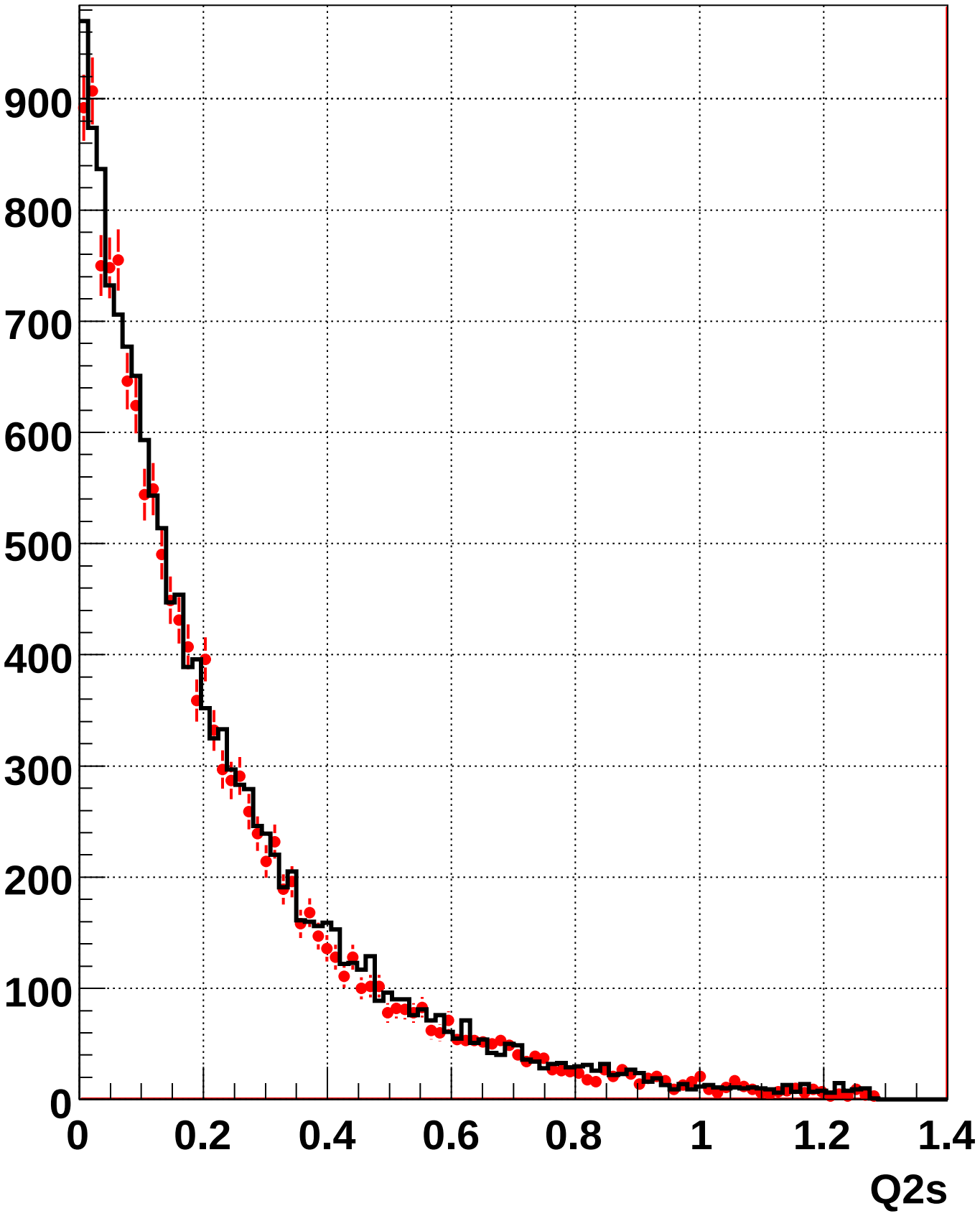
selected Q2 for QEL events



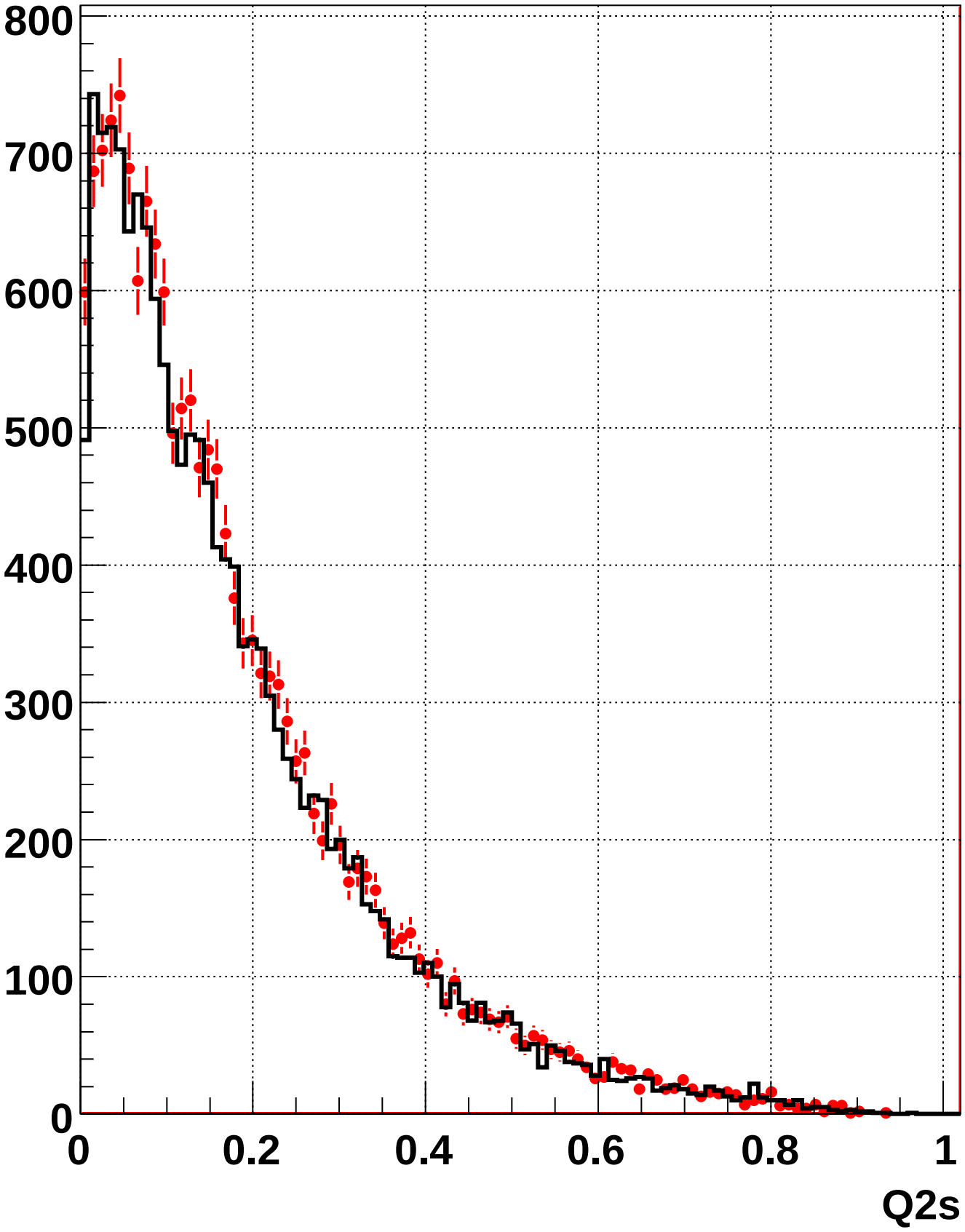
selected Q2 for QEL CC events



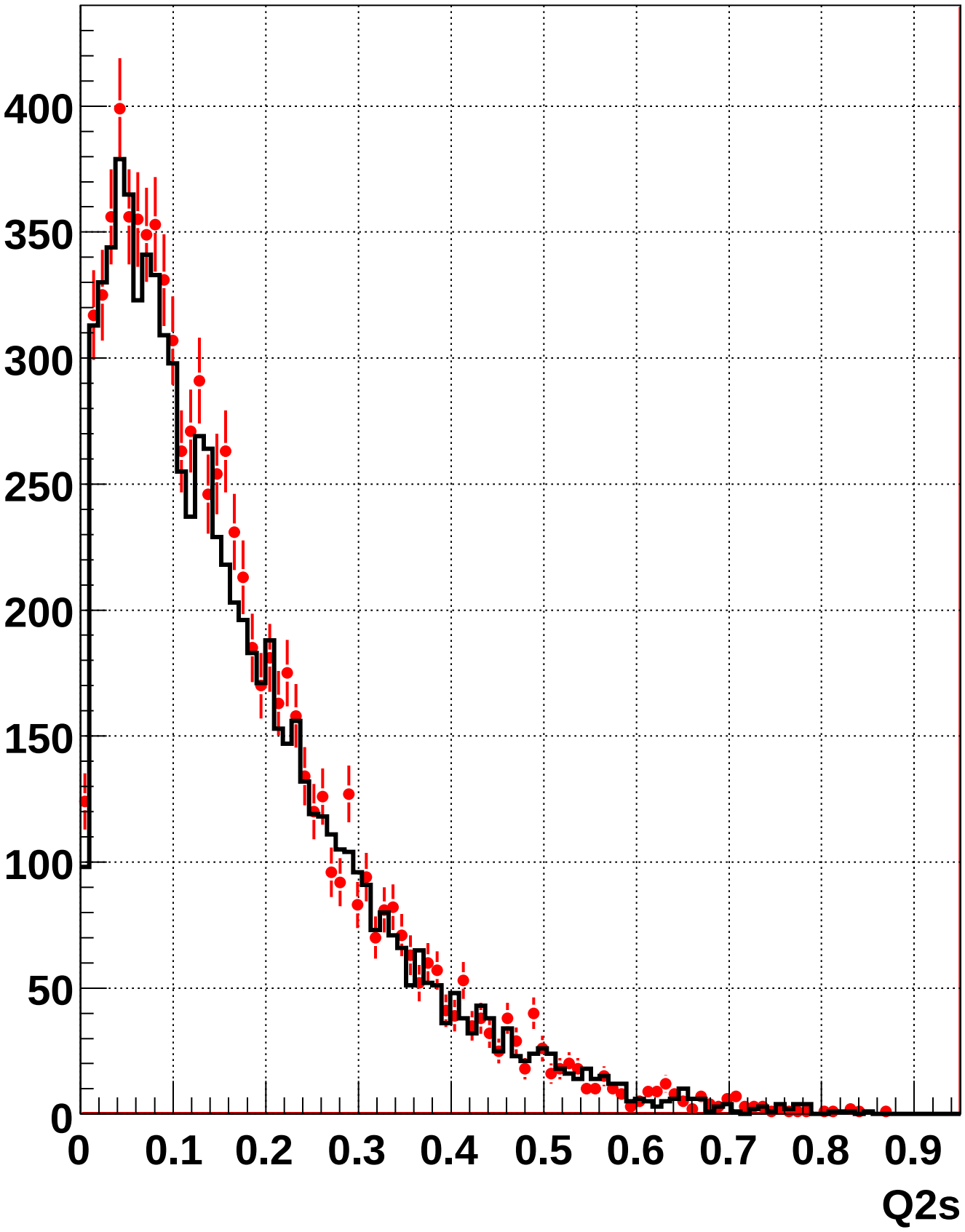
selected Q2 for QEL NC events



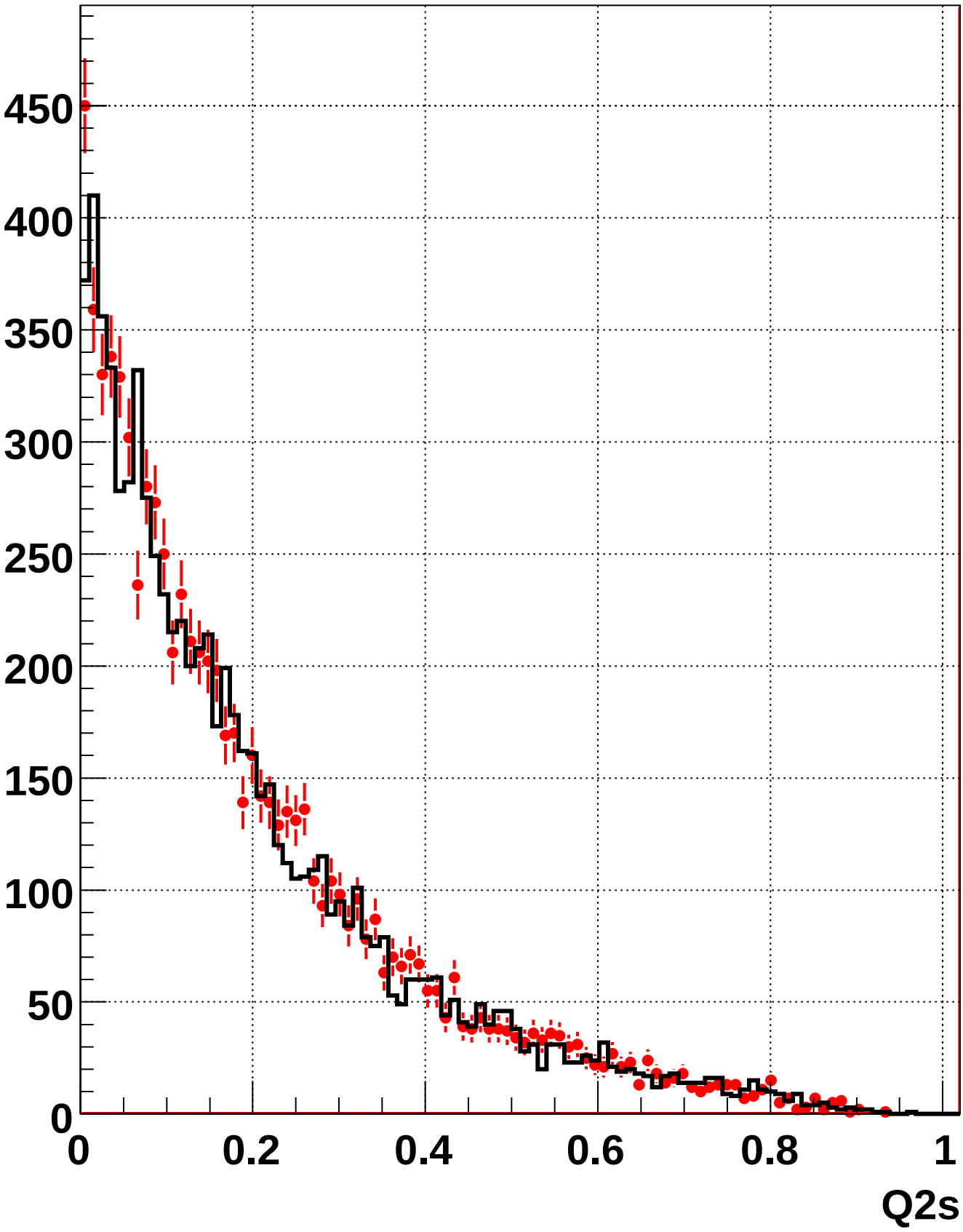
selected Q2 for RES events



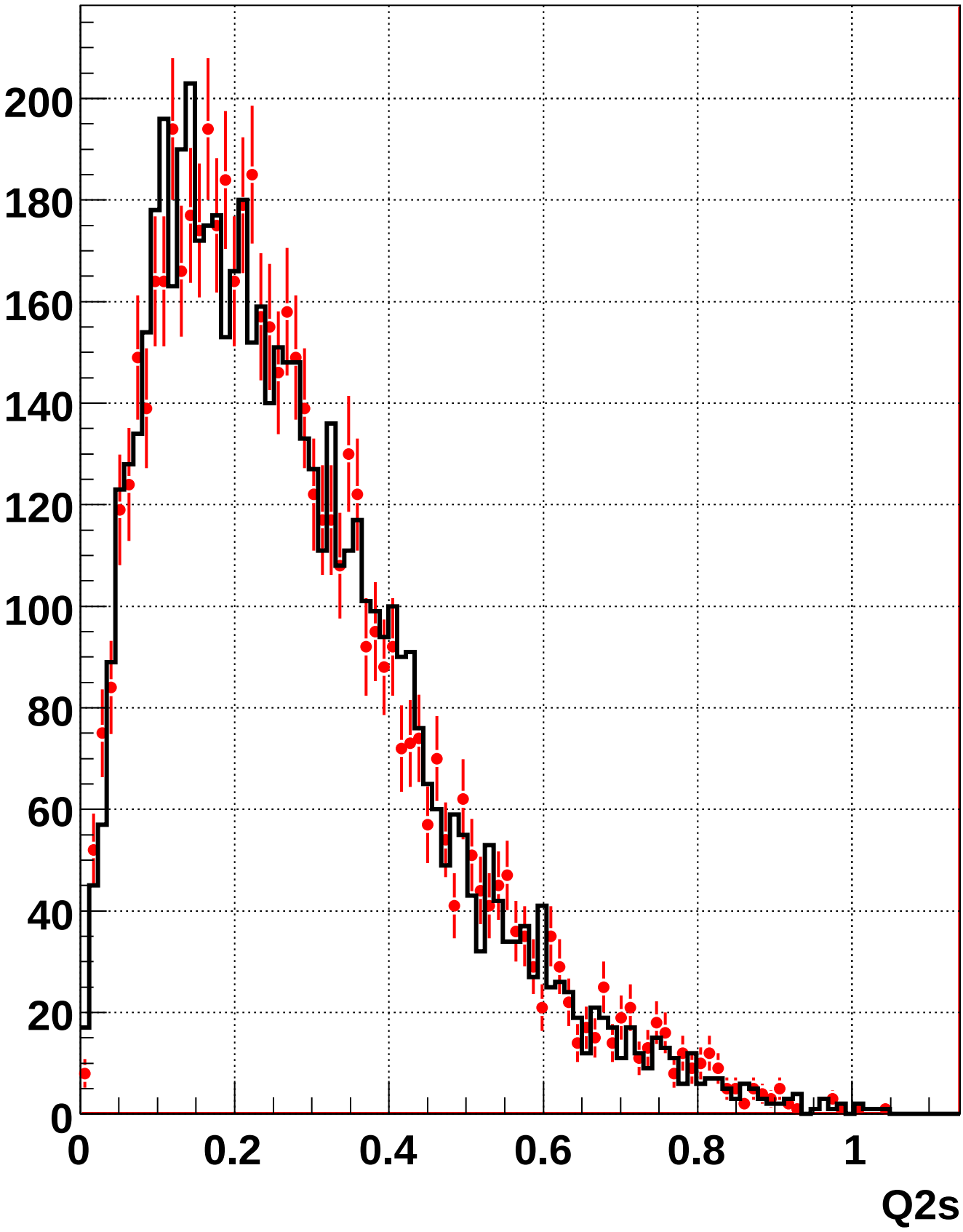
selected Q2 for RES CC events



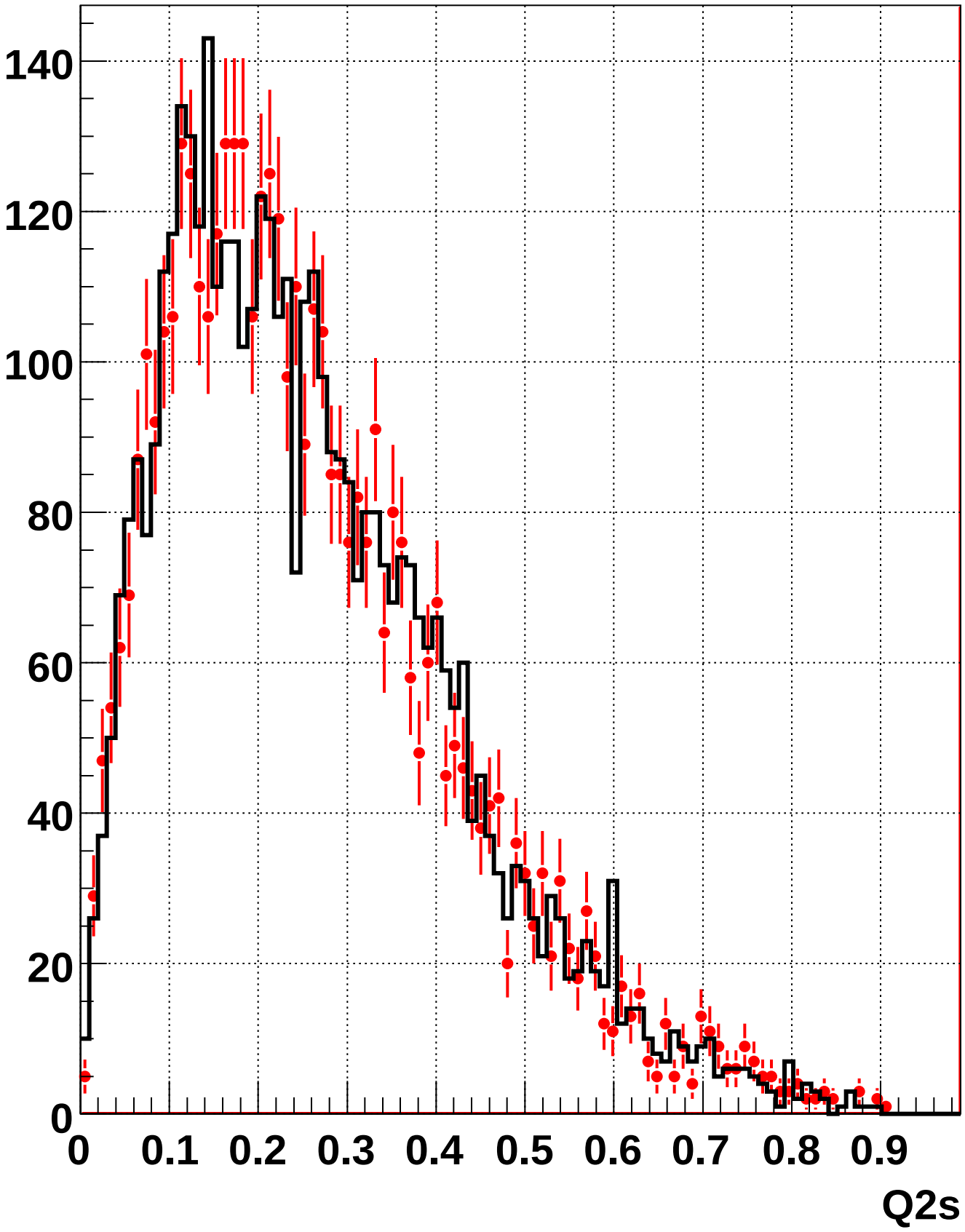
selected Q2 for RES NC events



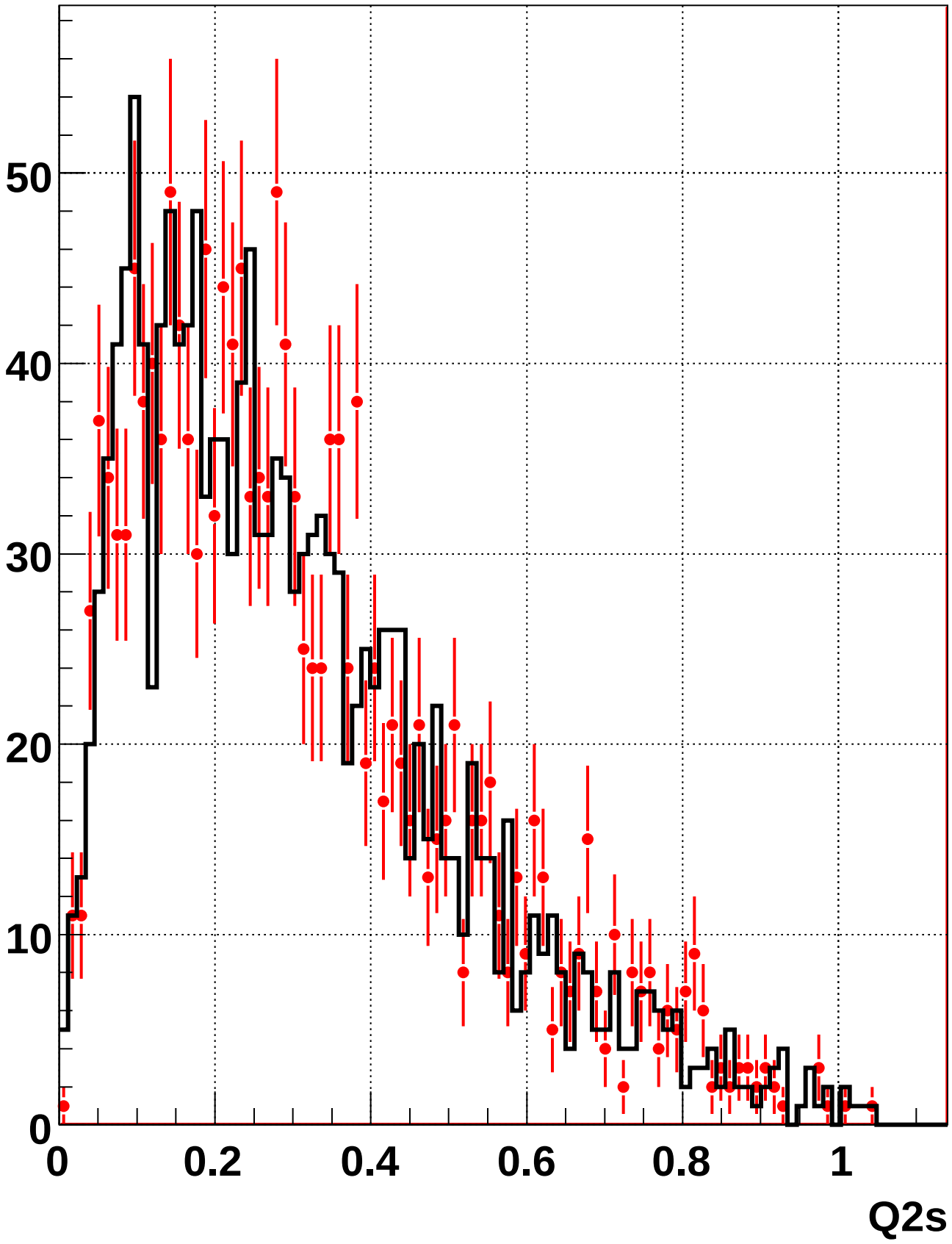
selected Q2 for DIS events



selected Q2 for DIS CC events

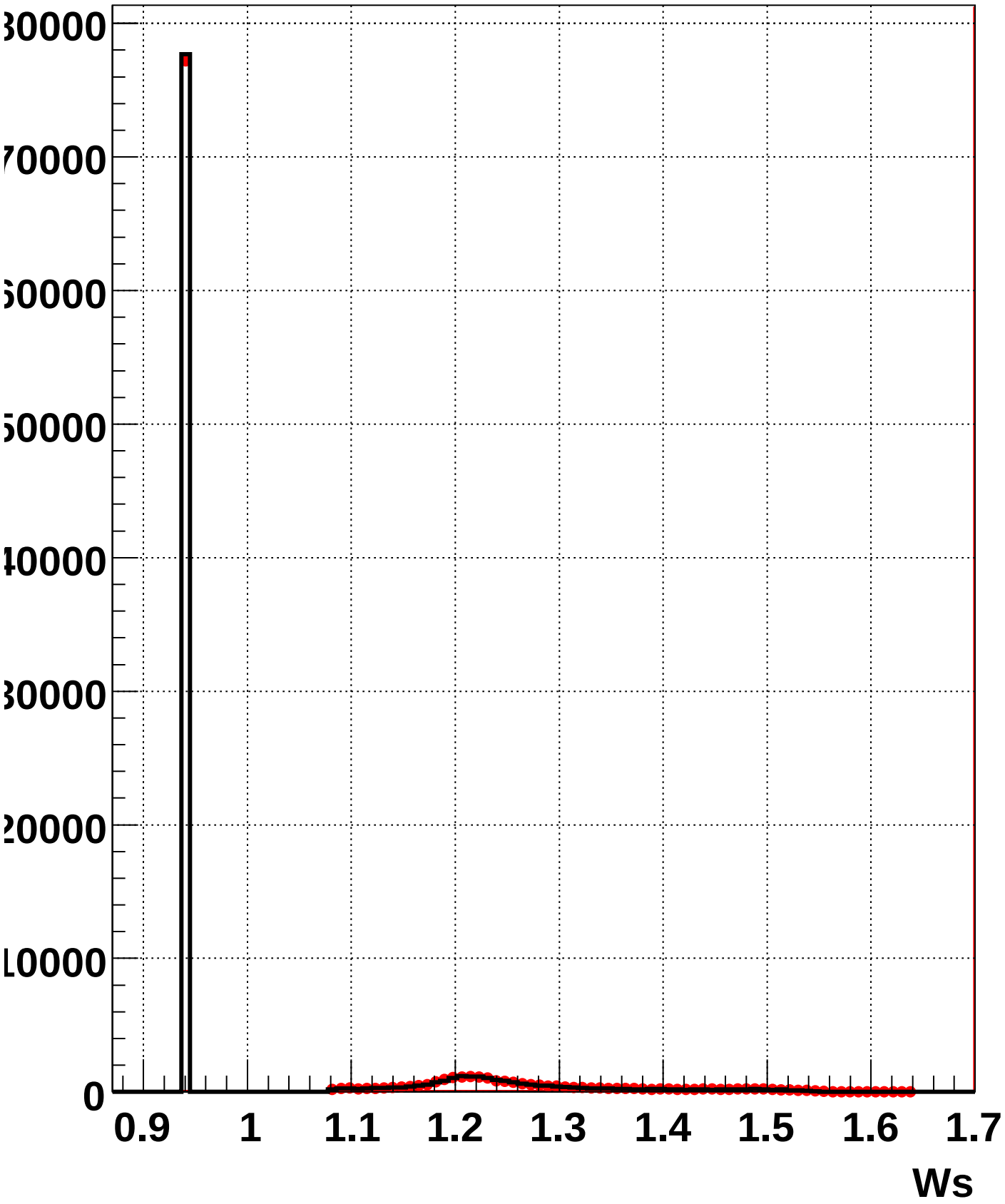


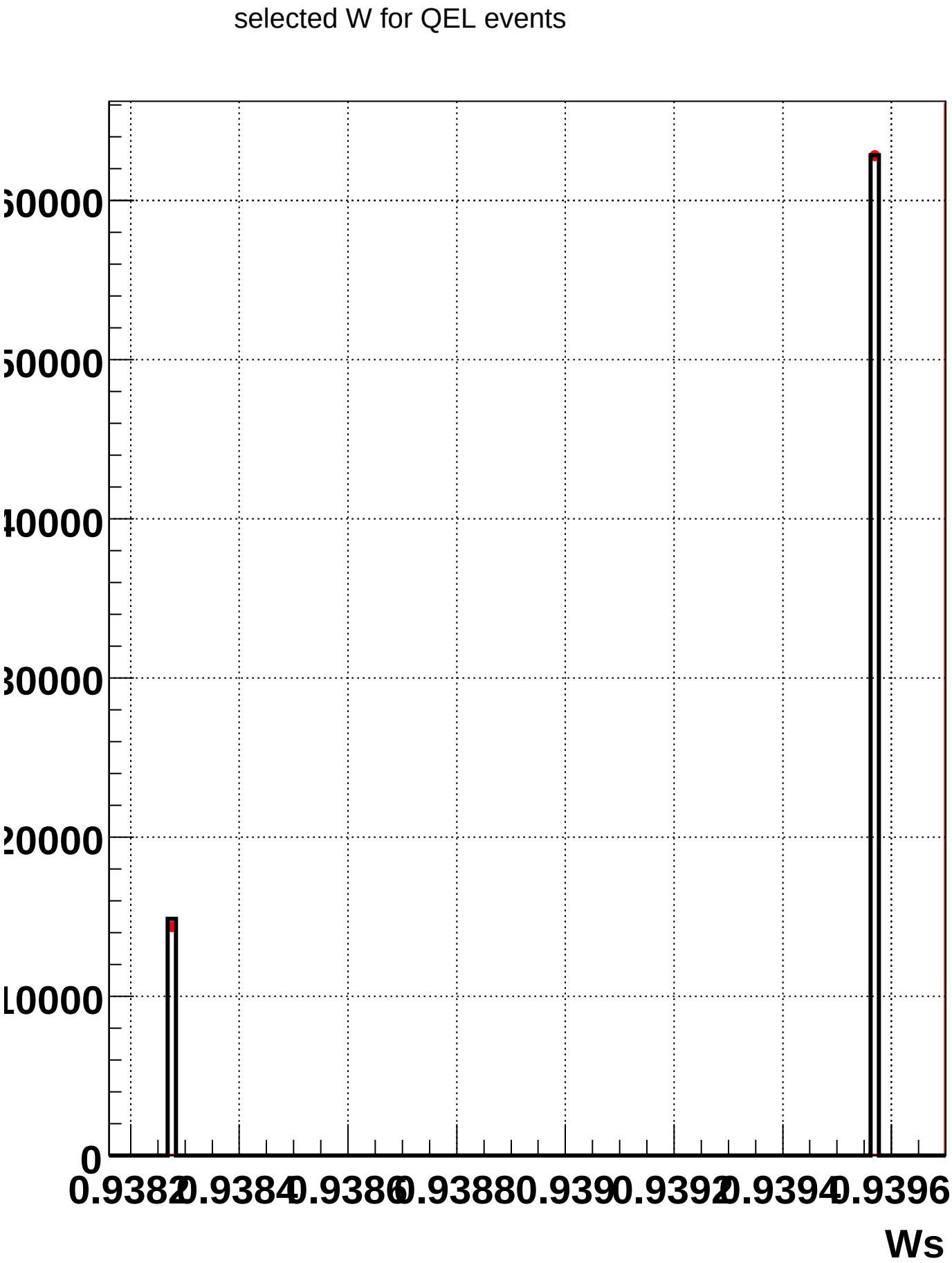
selected Q2 for DIS NC events



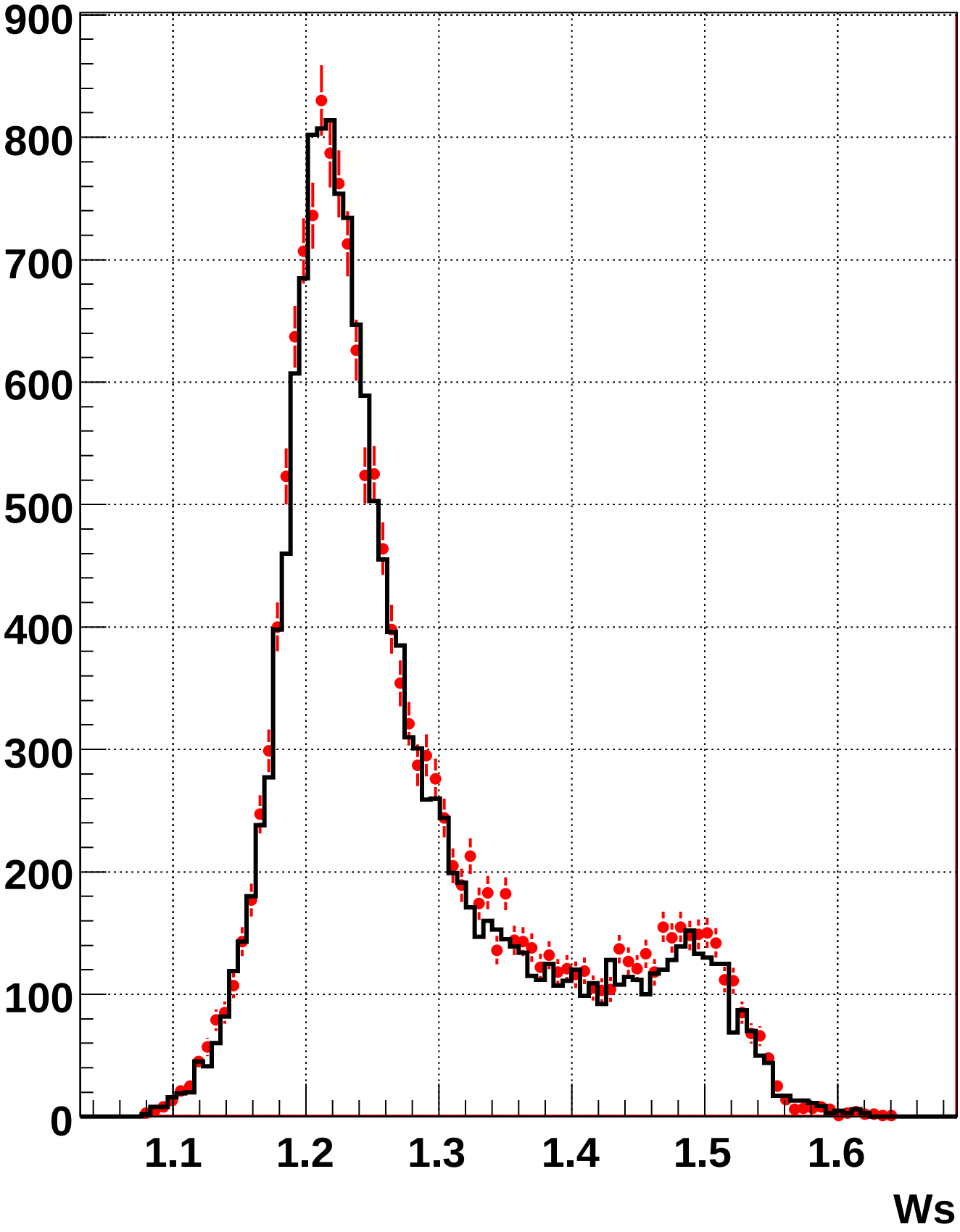
selected Q2 for Charm/DIS events

selected W for all events

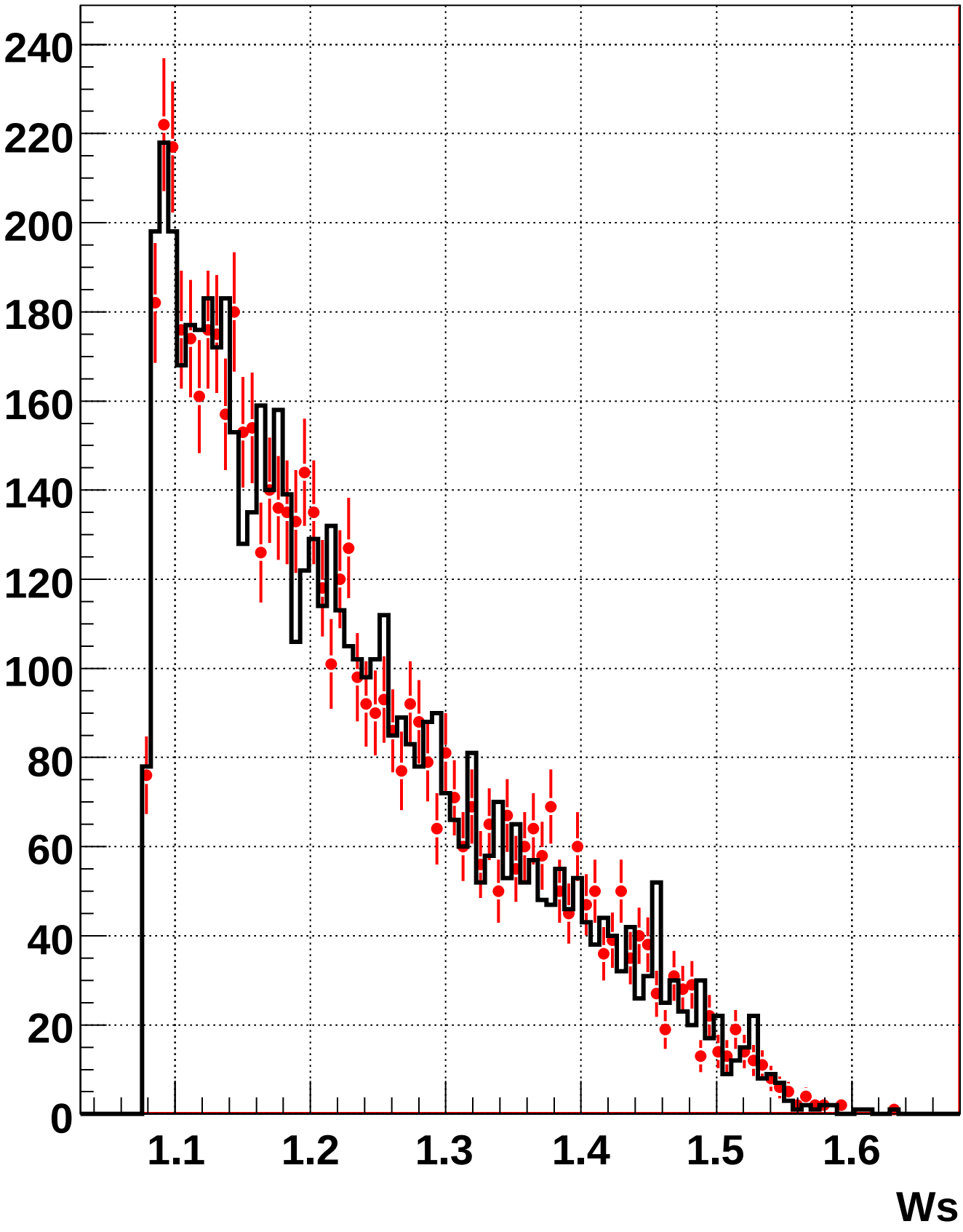



selected W for QEL events
60000
50000
40000
30000
20000
10000
0
0.9382
0.9384
0.9386
0.9388
0.939
0.9392
0.9394
0.9396
Ws

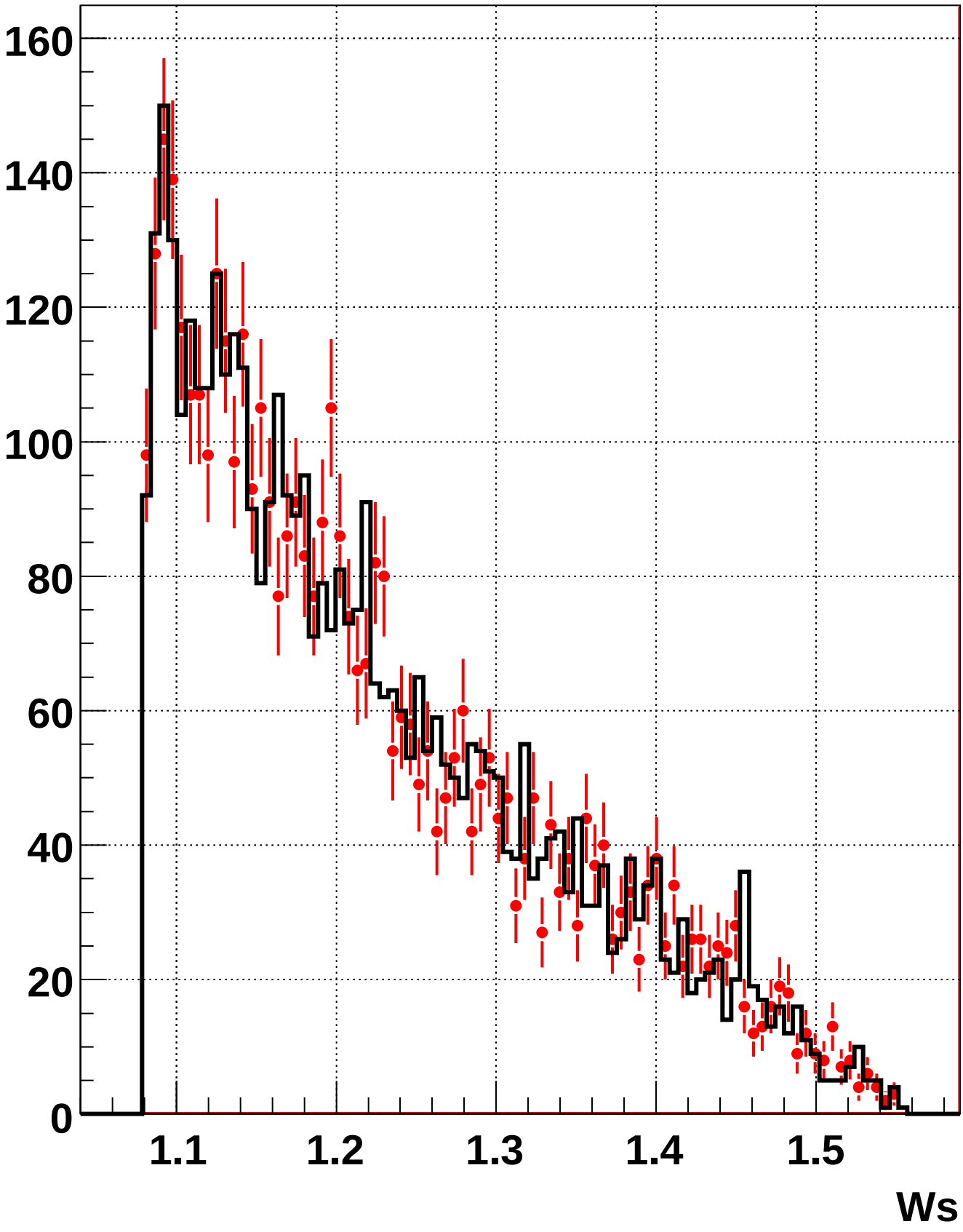
selected W for RES events



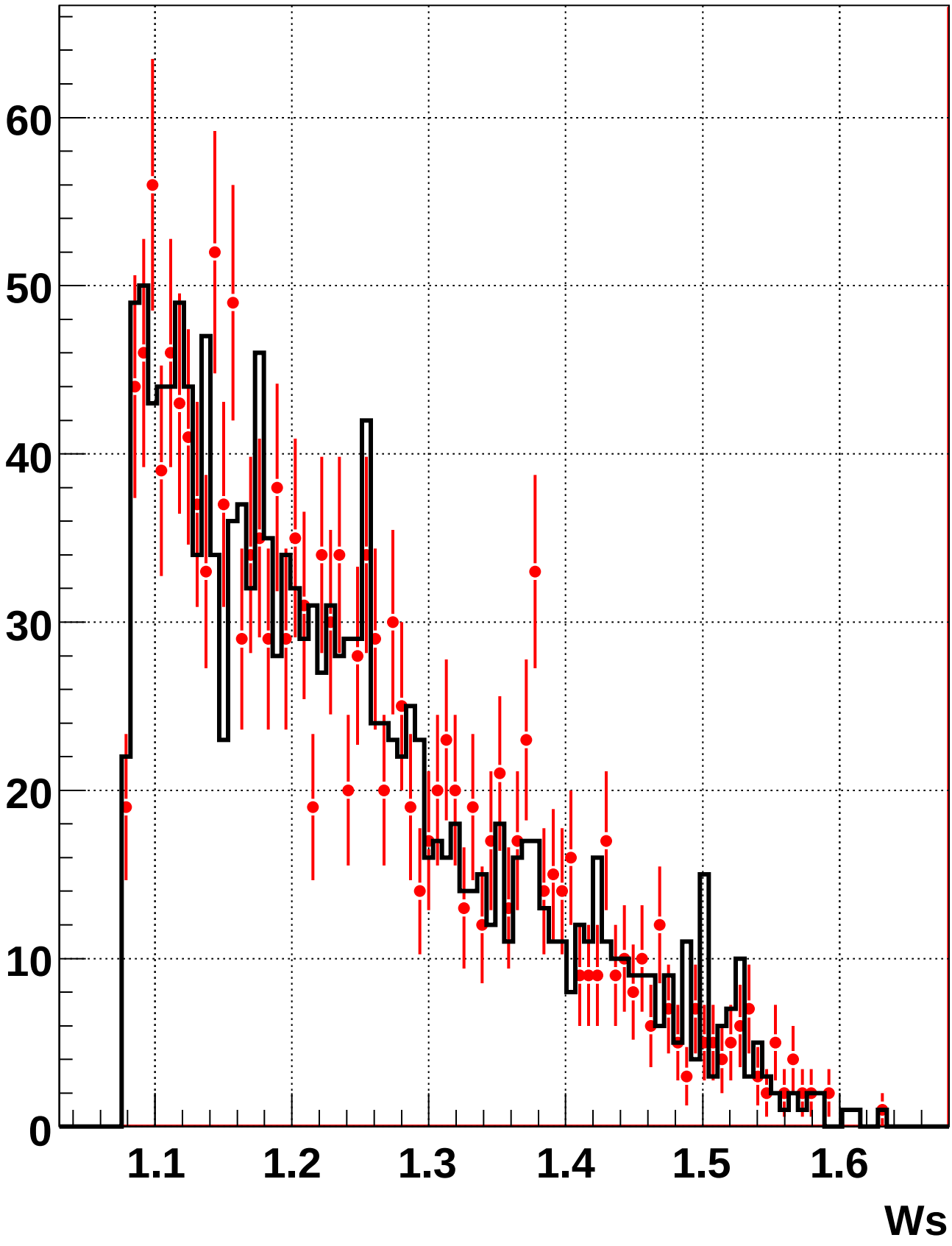
selected W for DIS events



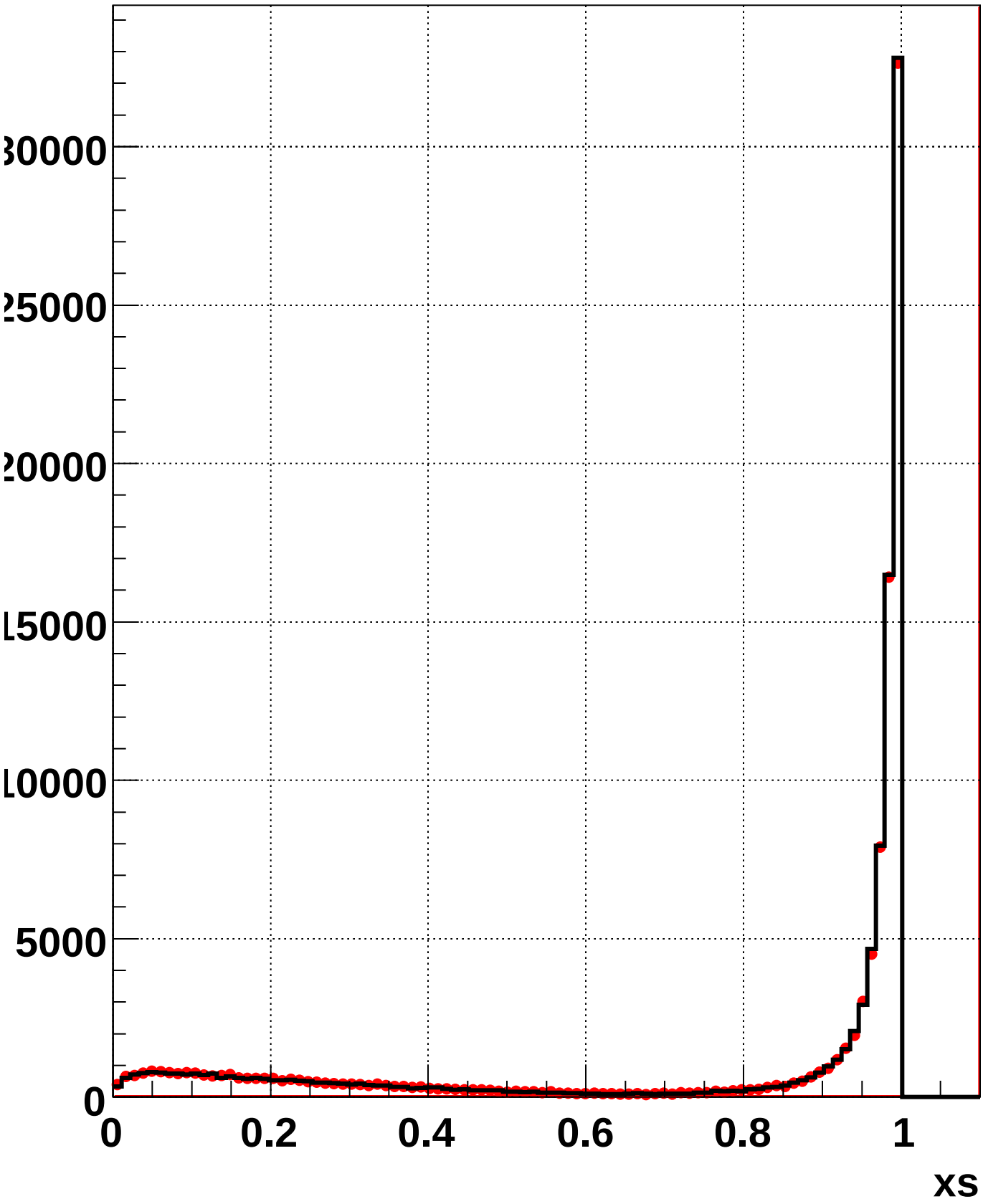
selected W for DIS CC events



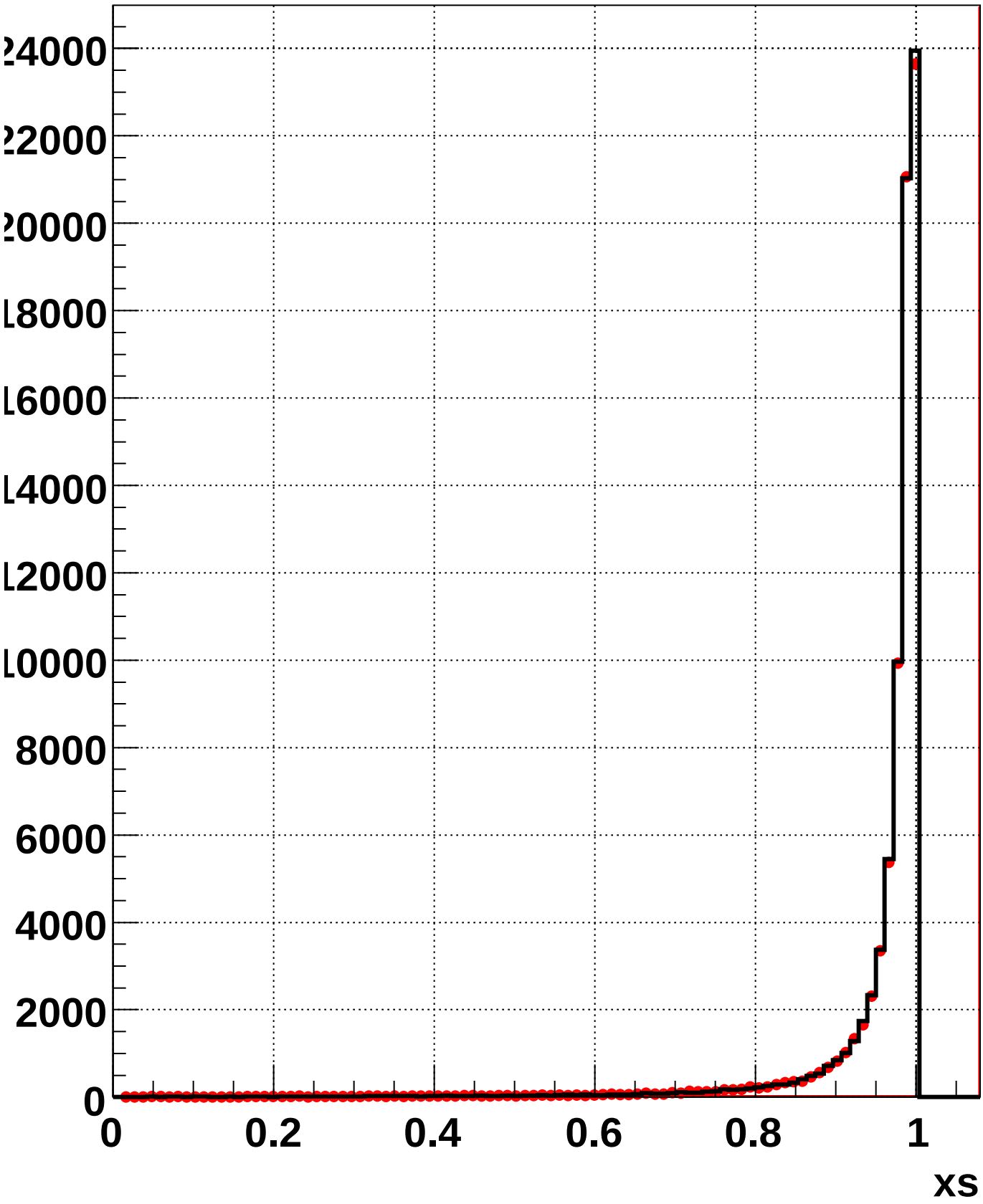
selected W for DIS NC events



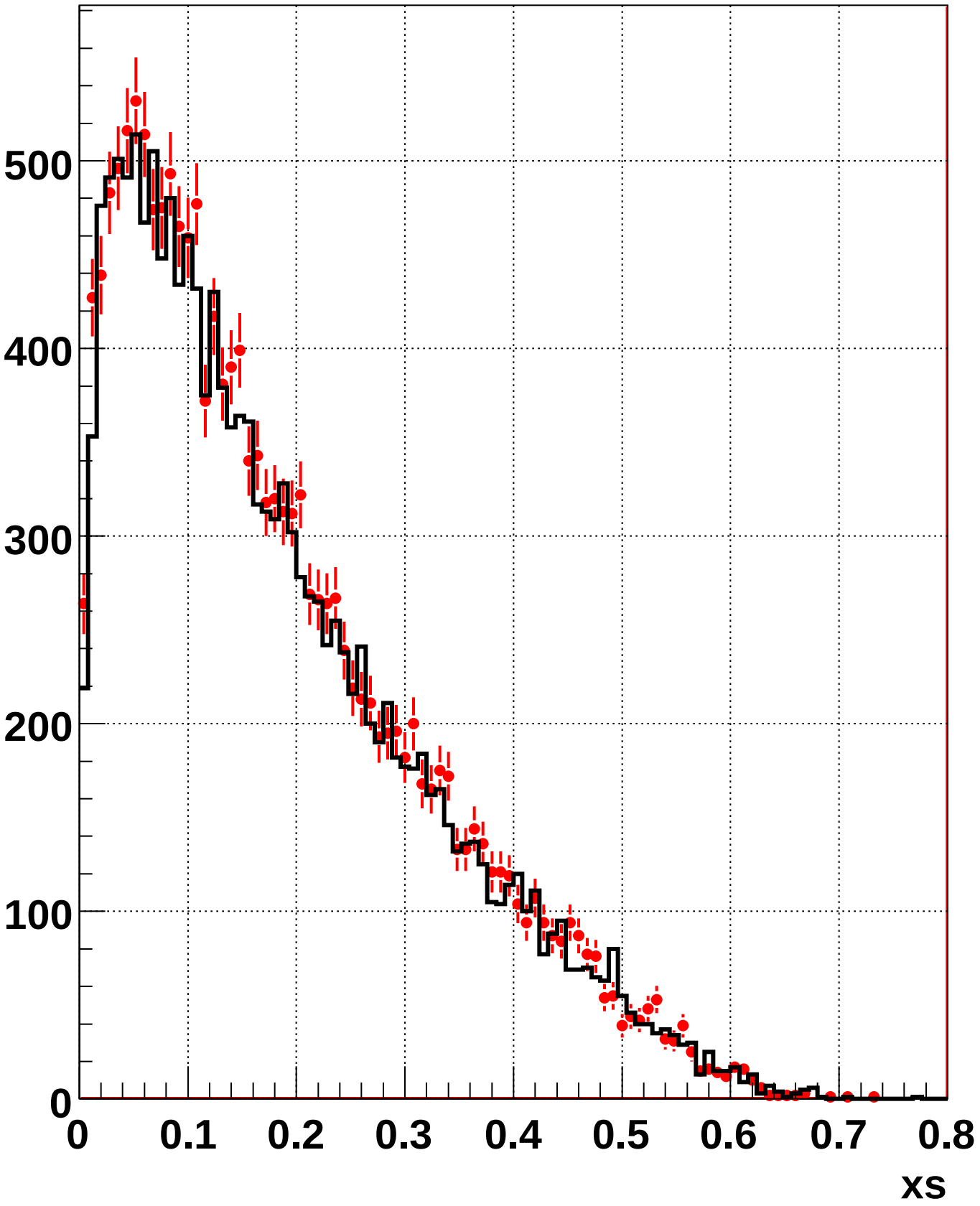
selected x for all events



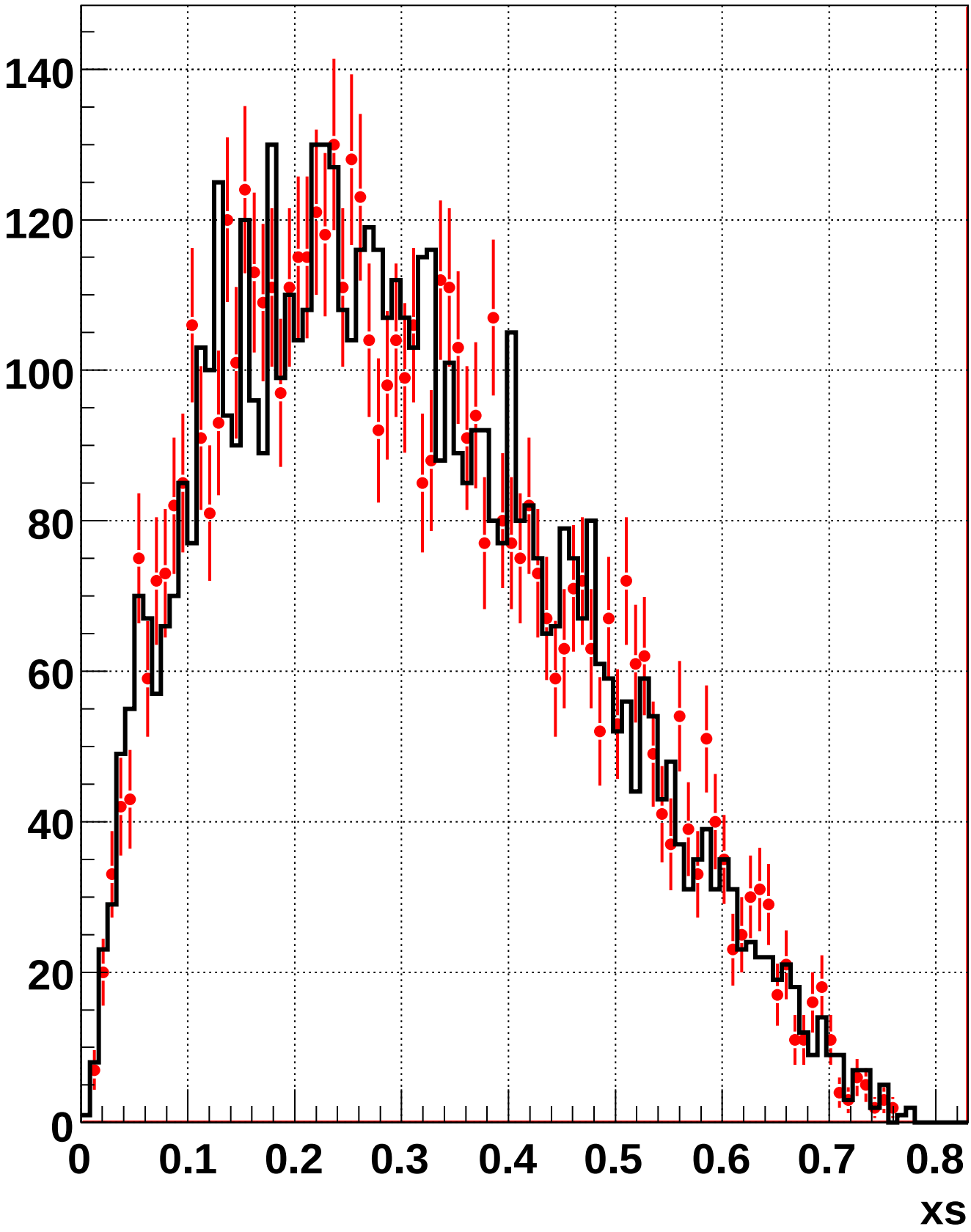
selected x for QEL events



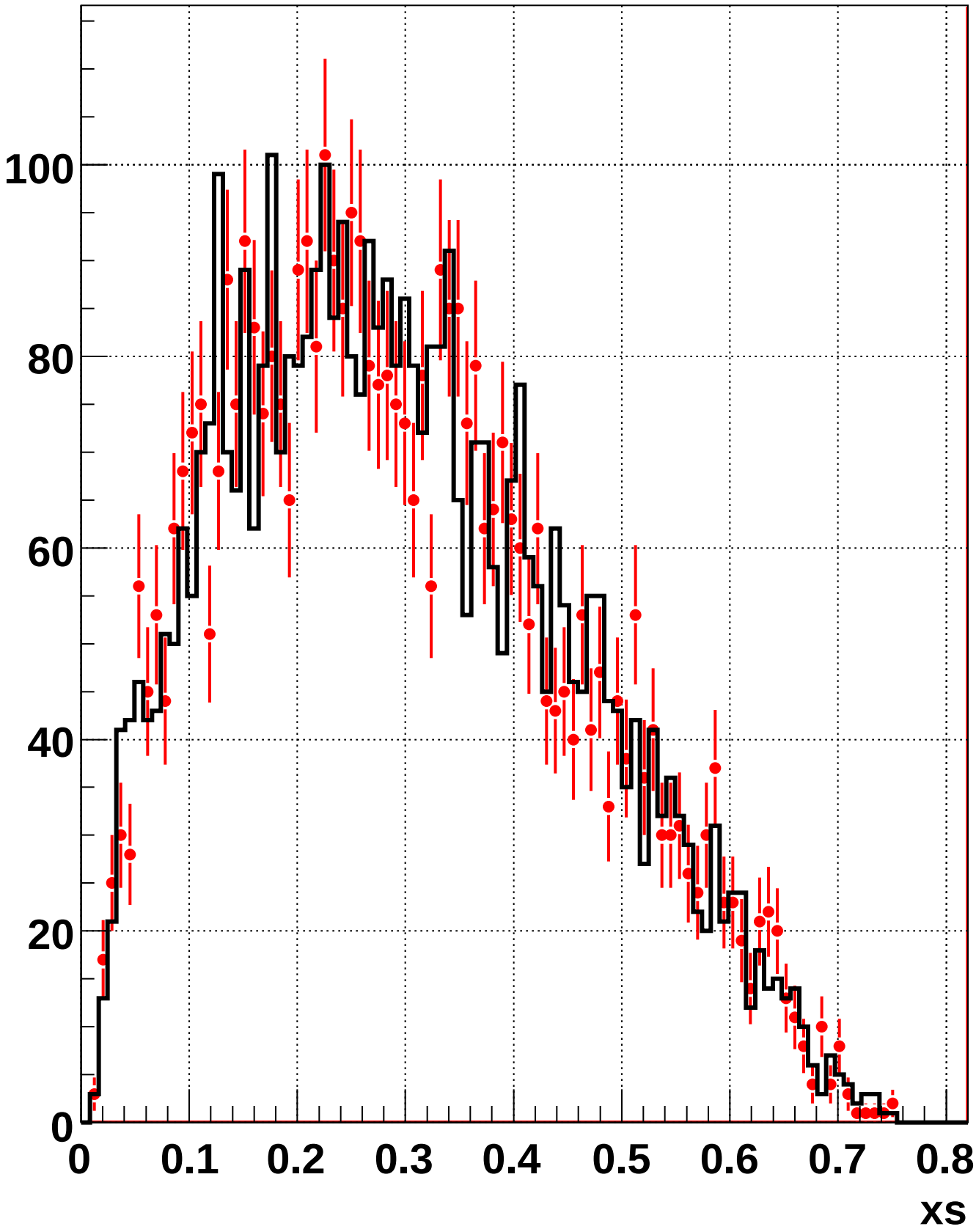
selected x for RES events



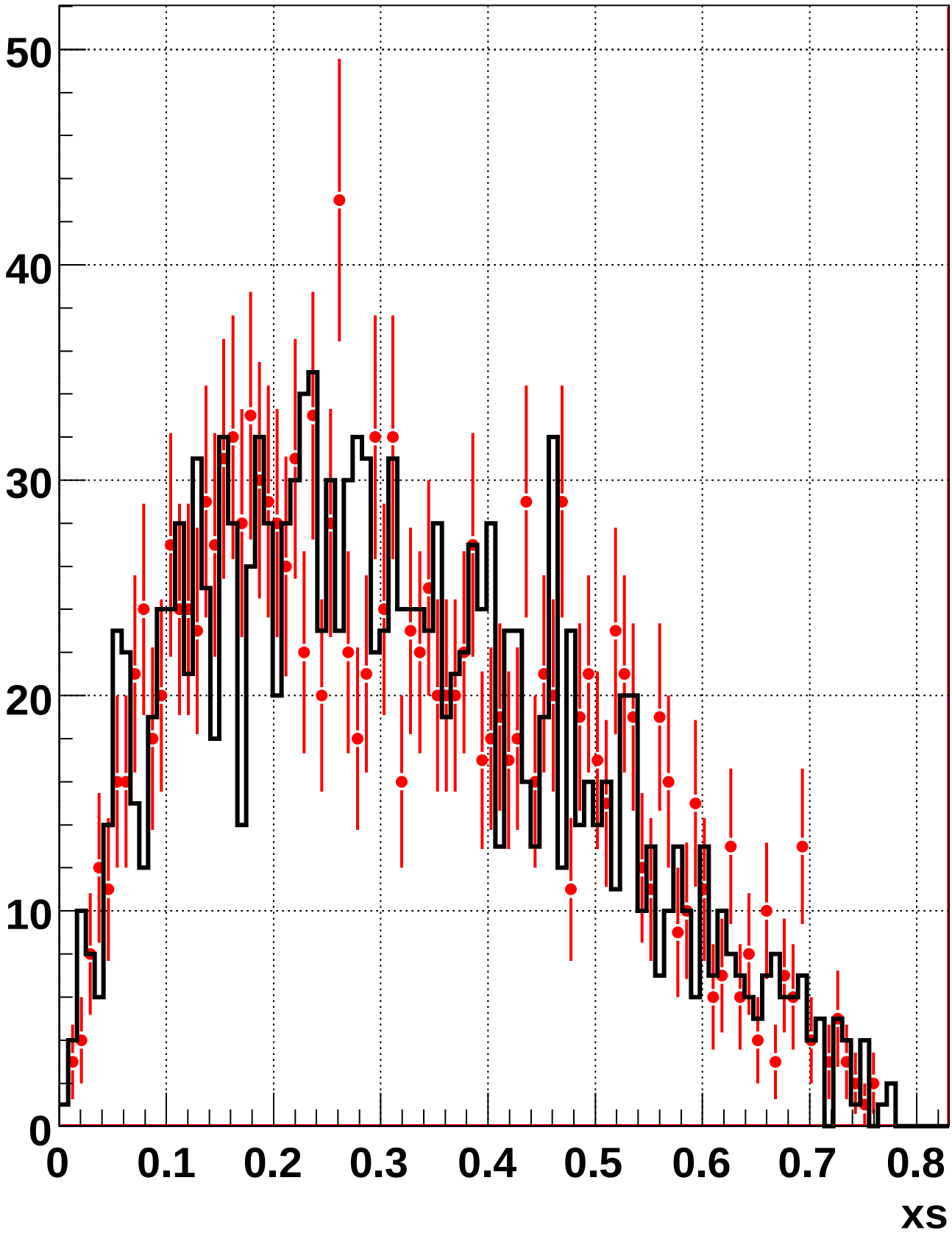
selected x for DIS events



selected x for DIS CC events

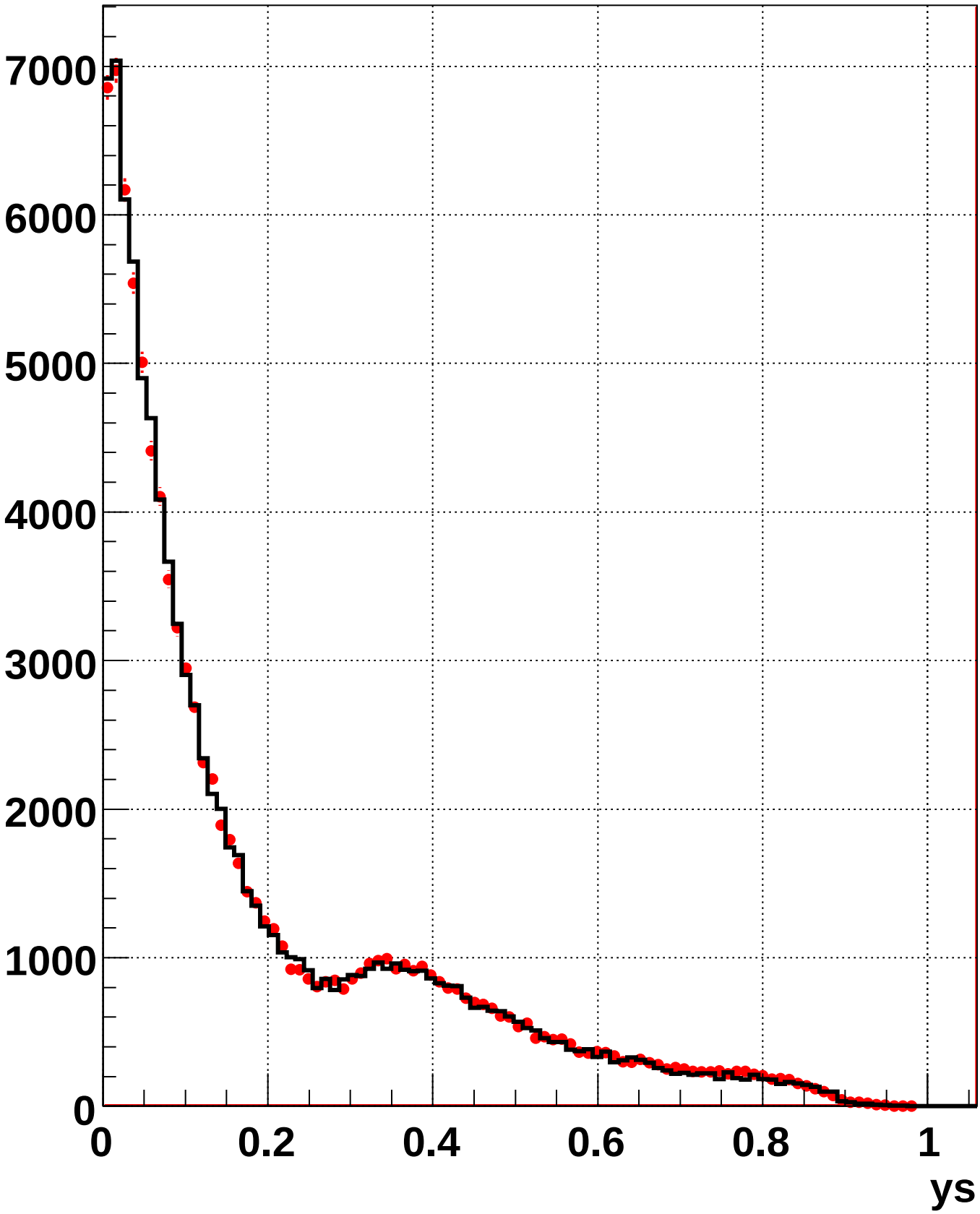


selected x for DIS NC events

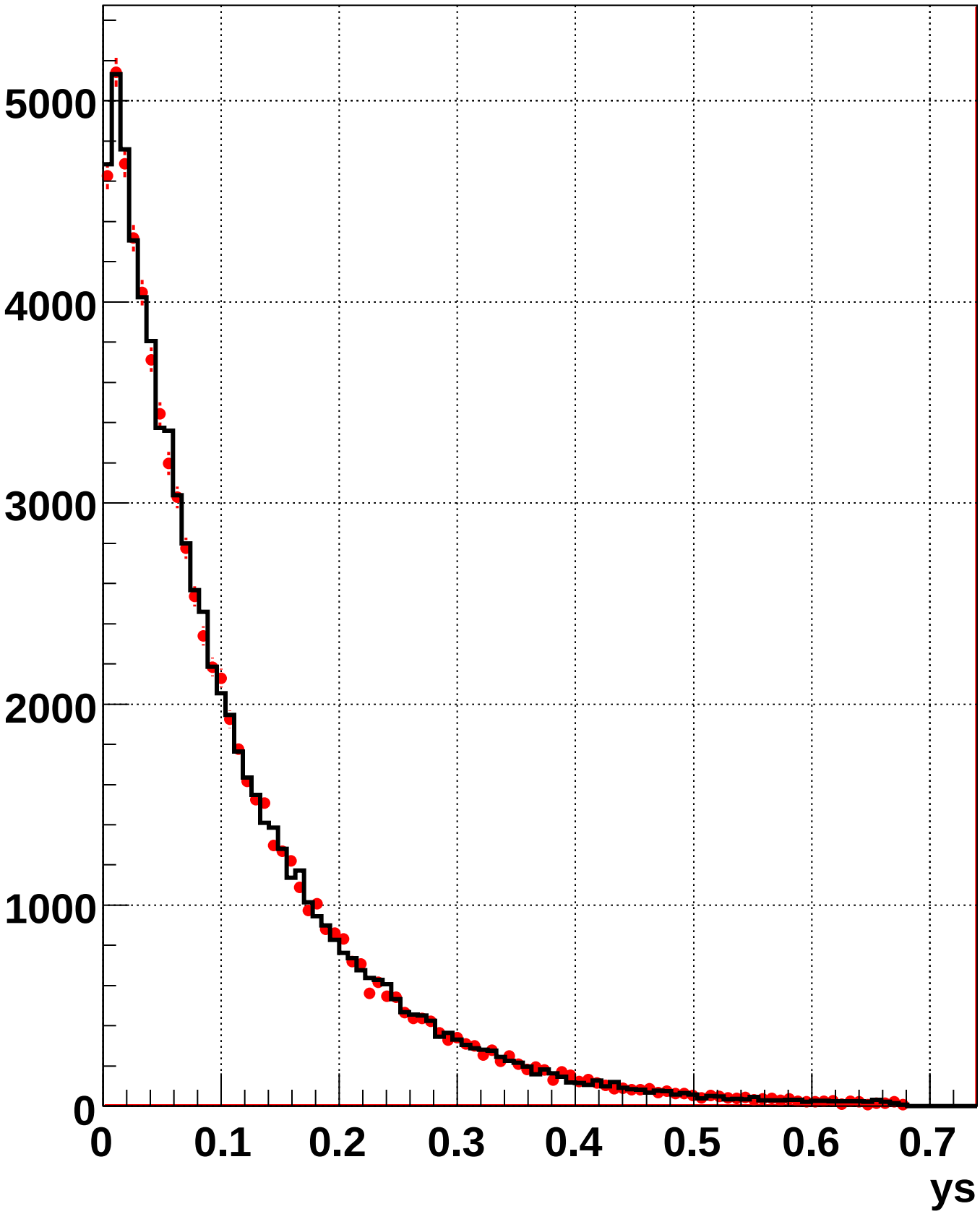


selected x for Charm/DIS events

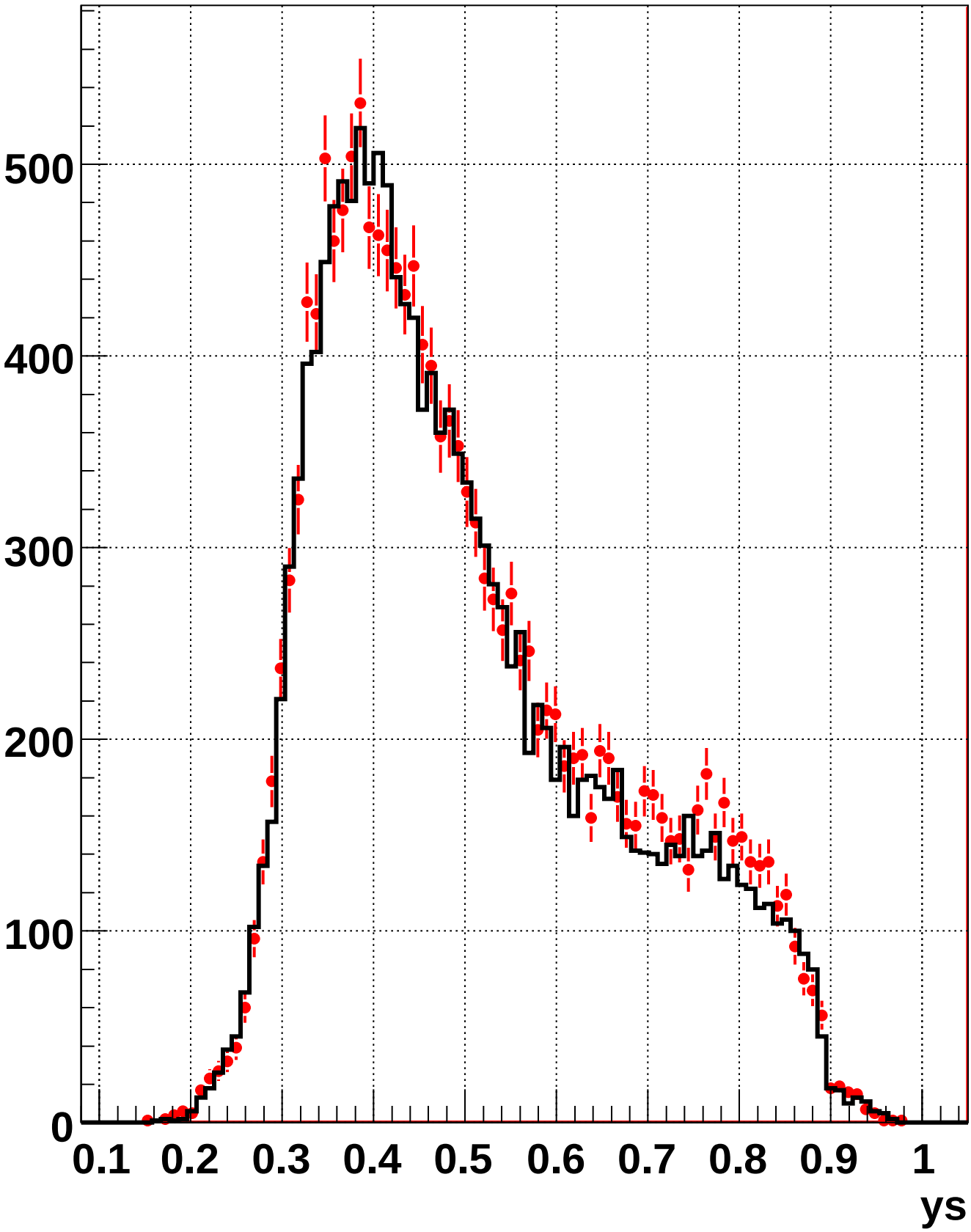
selected y for all events



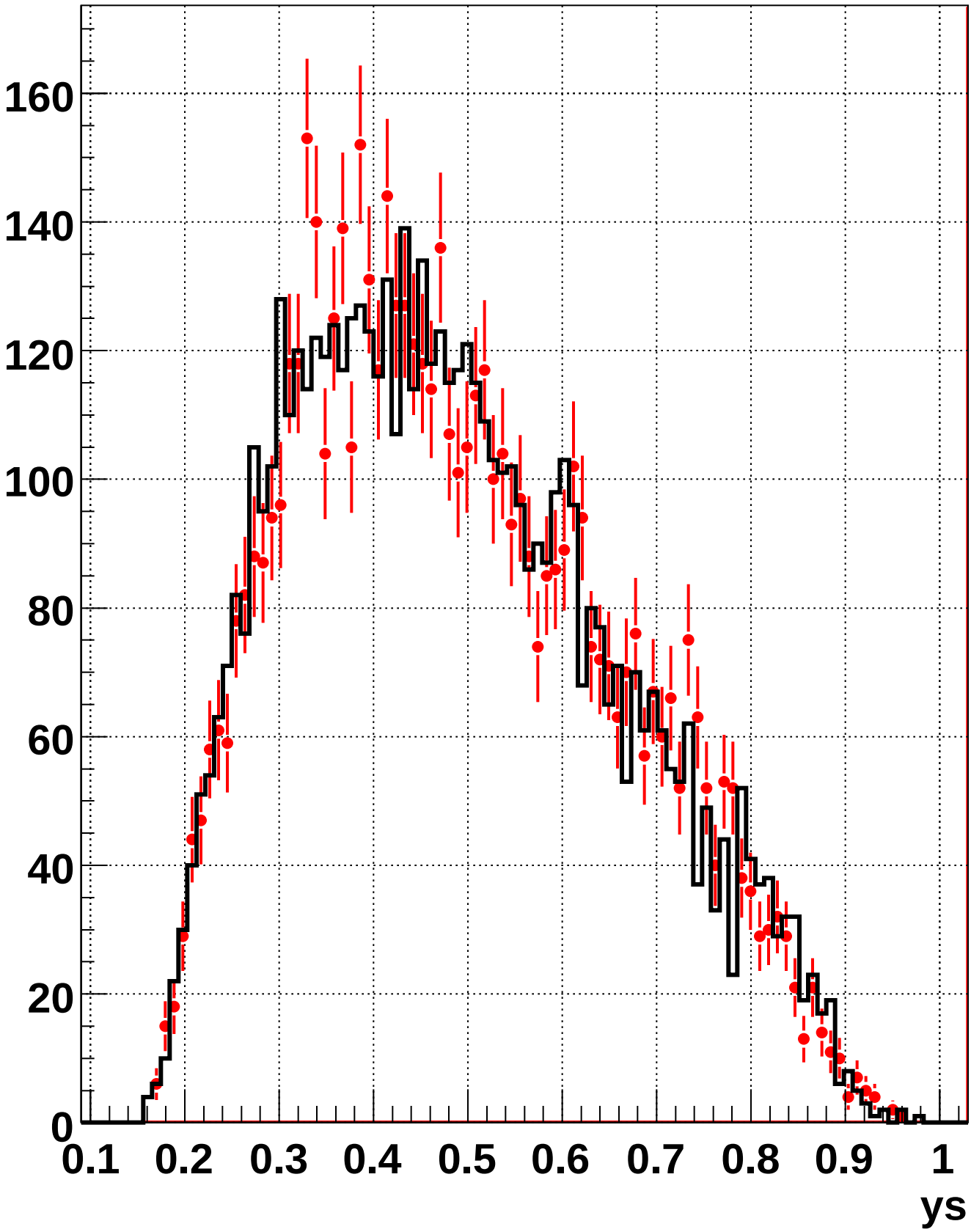
selected y for QEL events



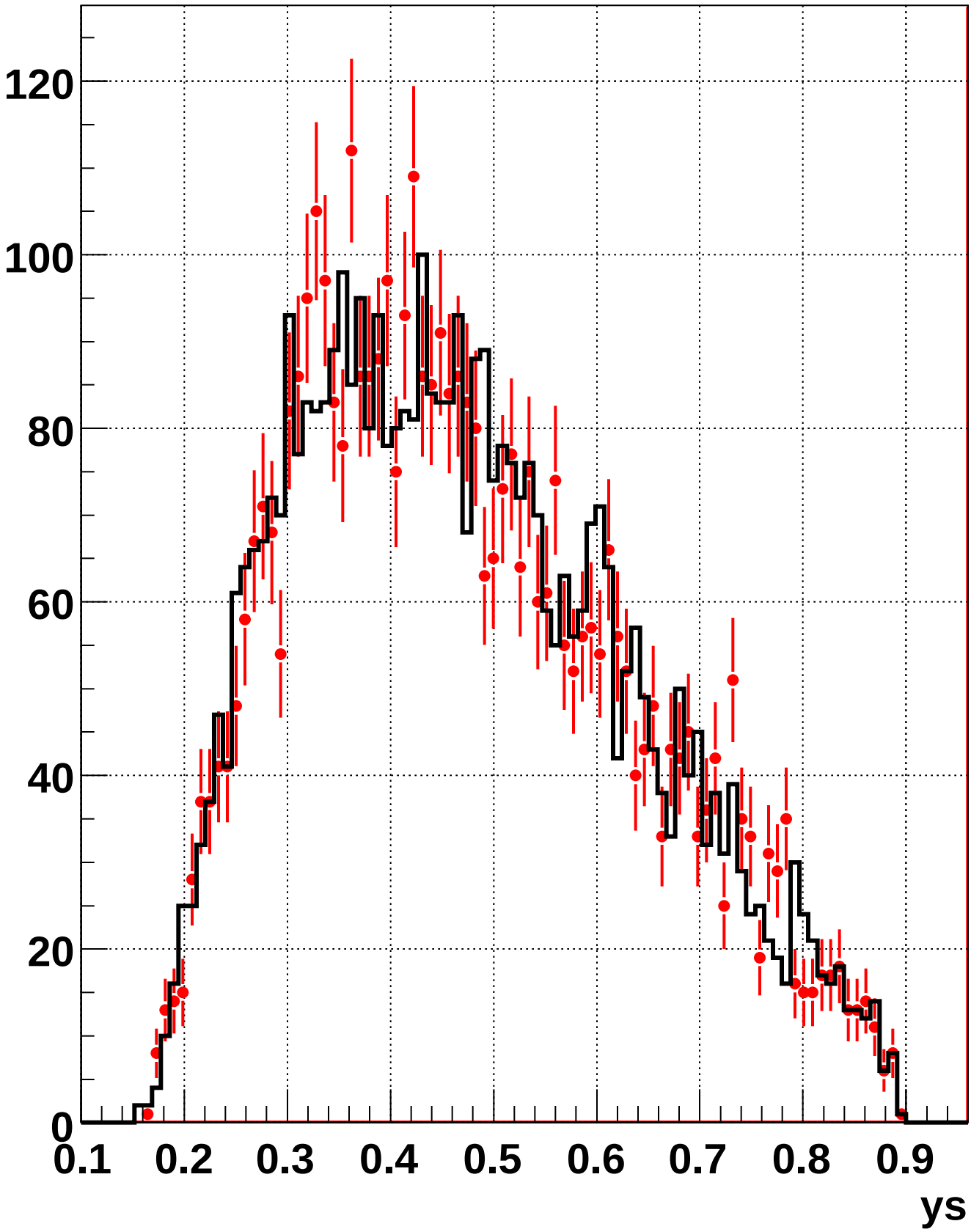
selected y for RES events



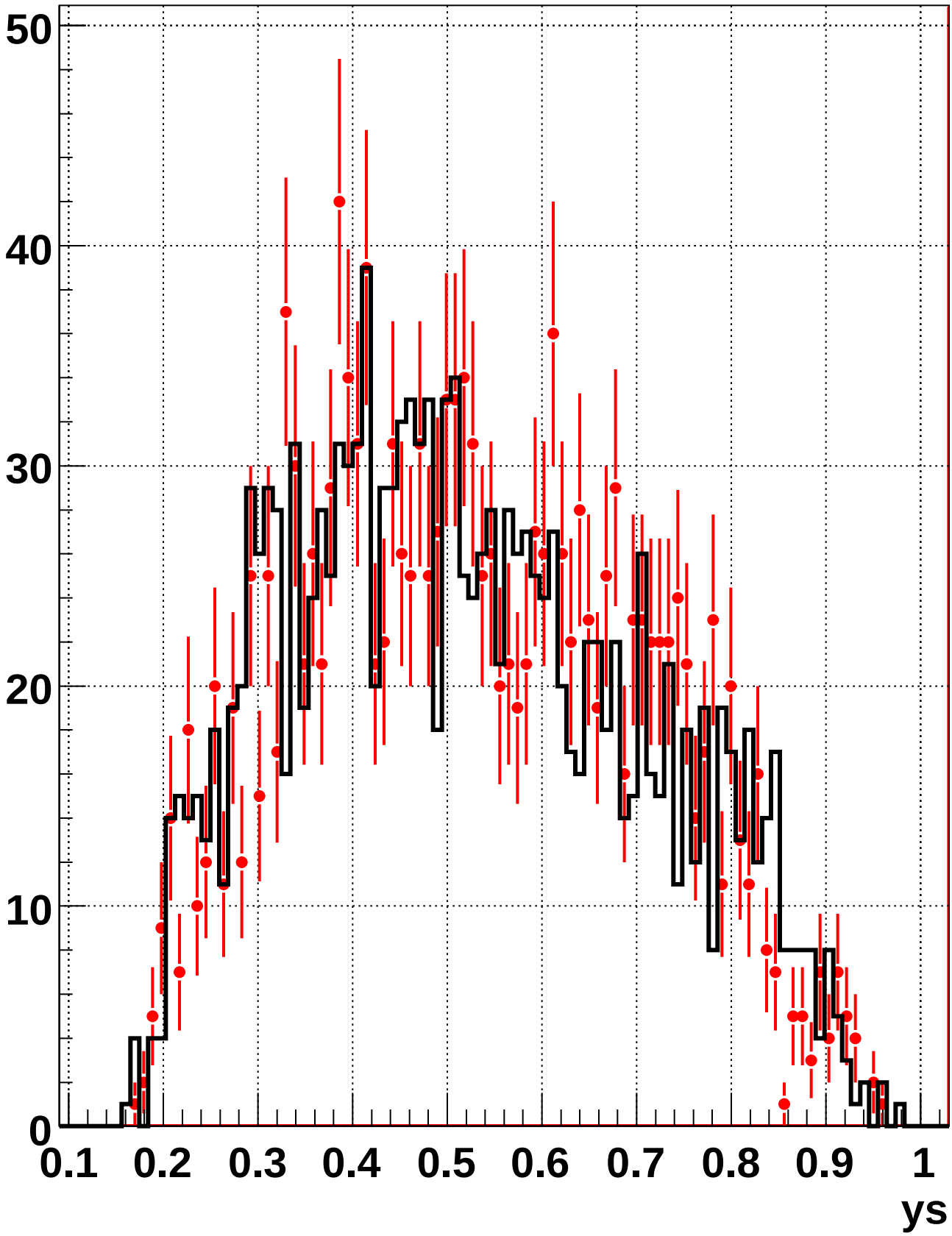
selected y for DIS events



selected y for DIS CC events



selected y for DIS NC events



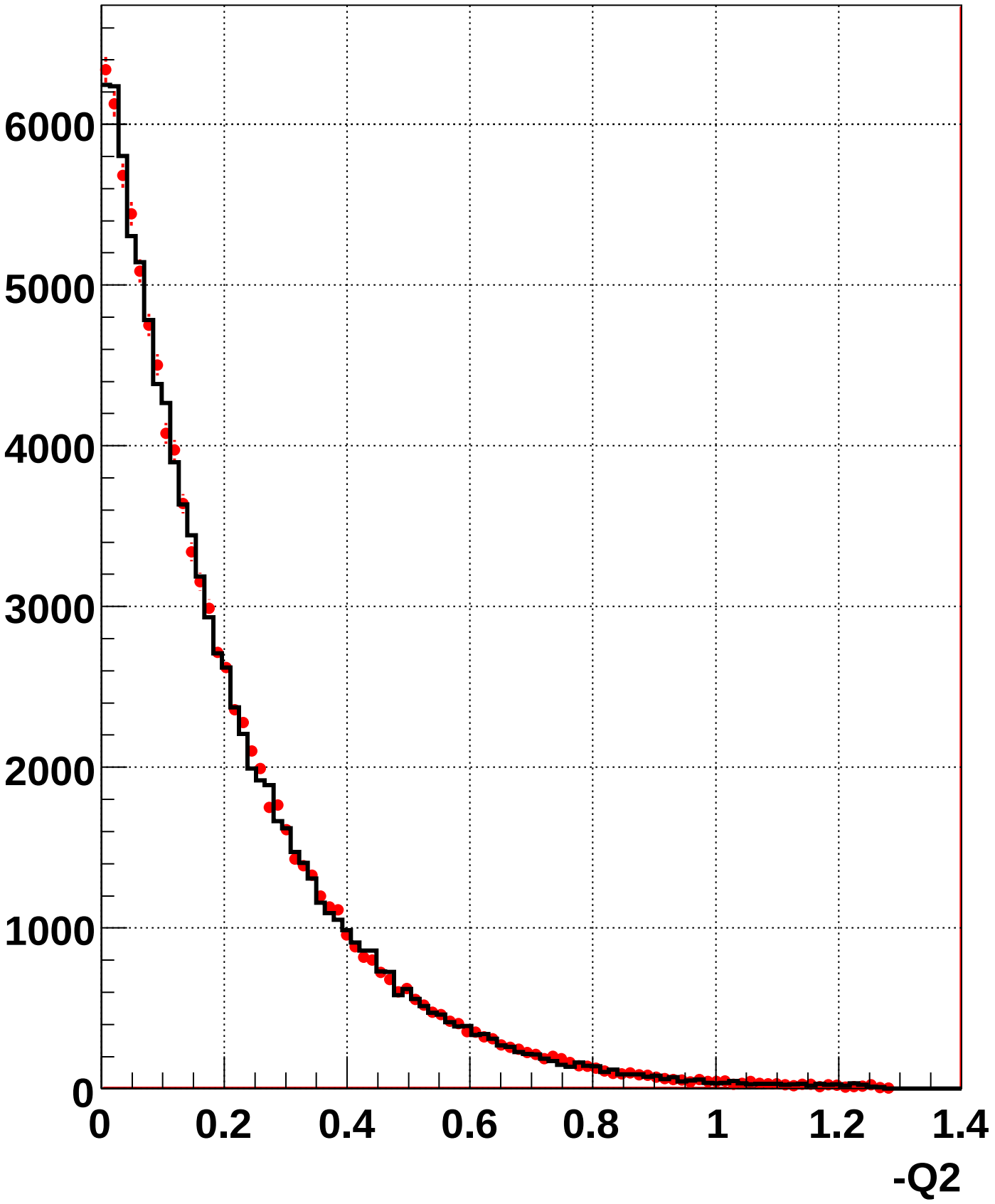
selected y for Charm/DIS events

Kinematical Quantities

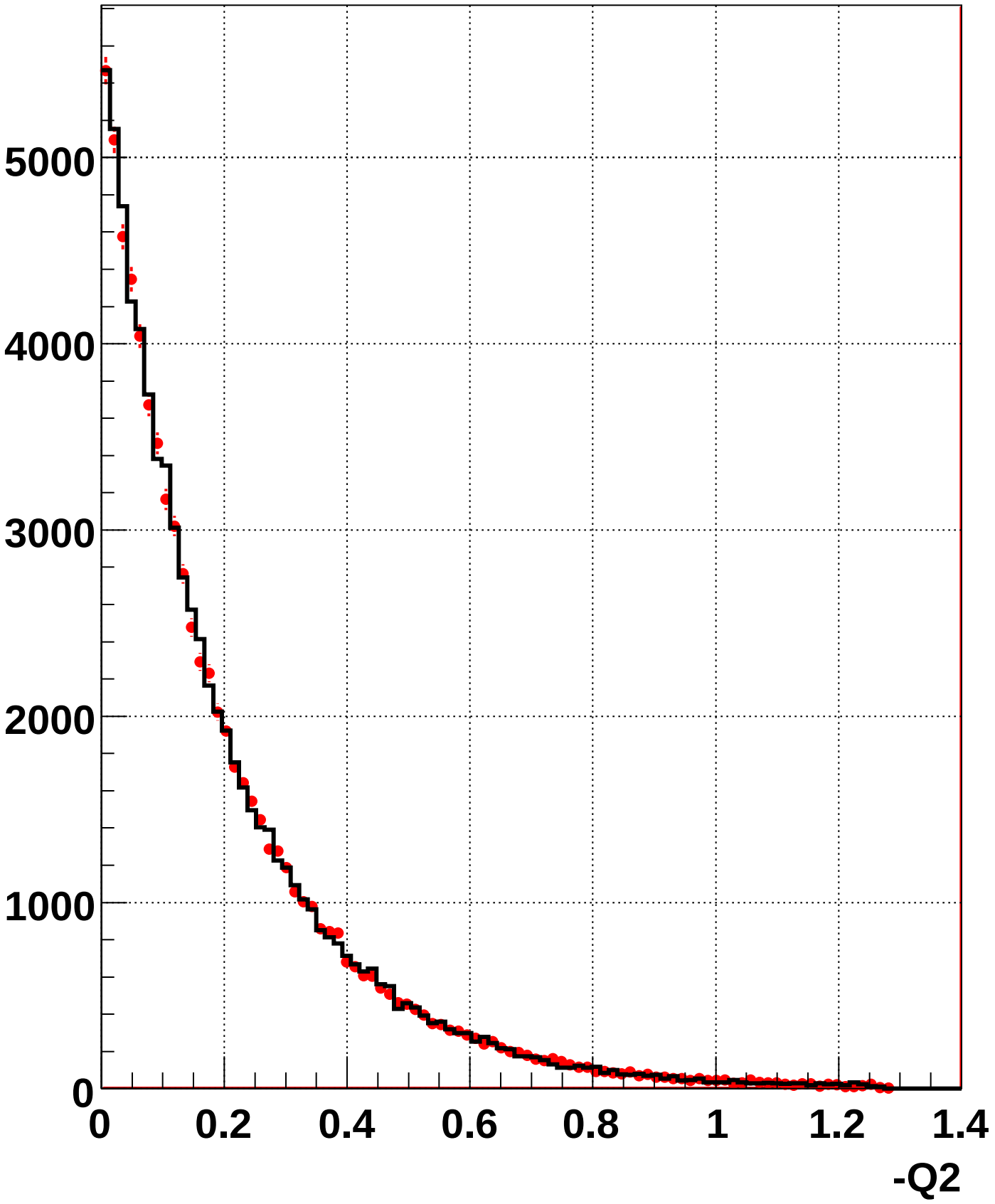
Similar to the previous set of plots but

showing ’computed’ rathen than ’selected’ variables

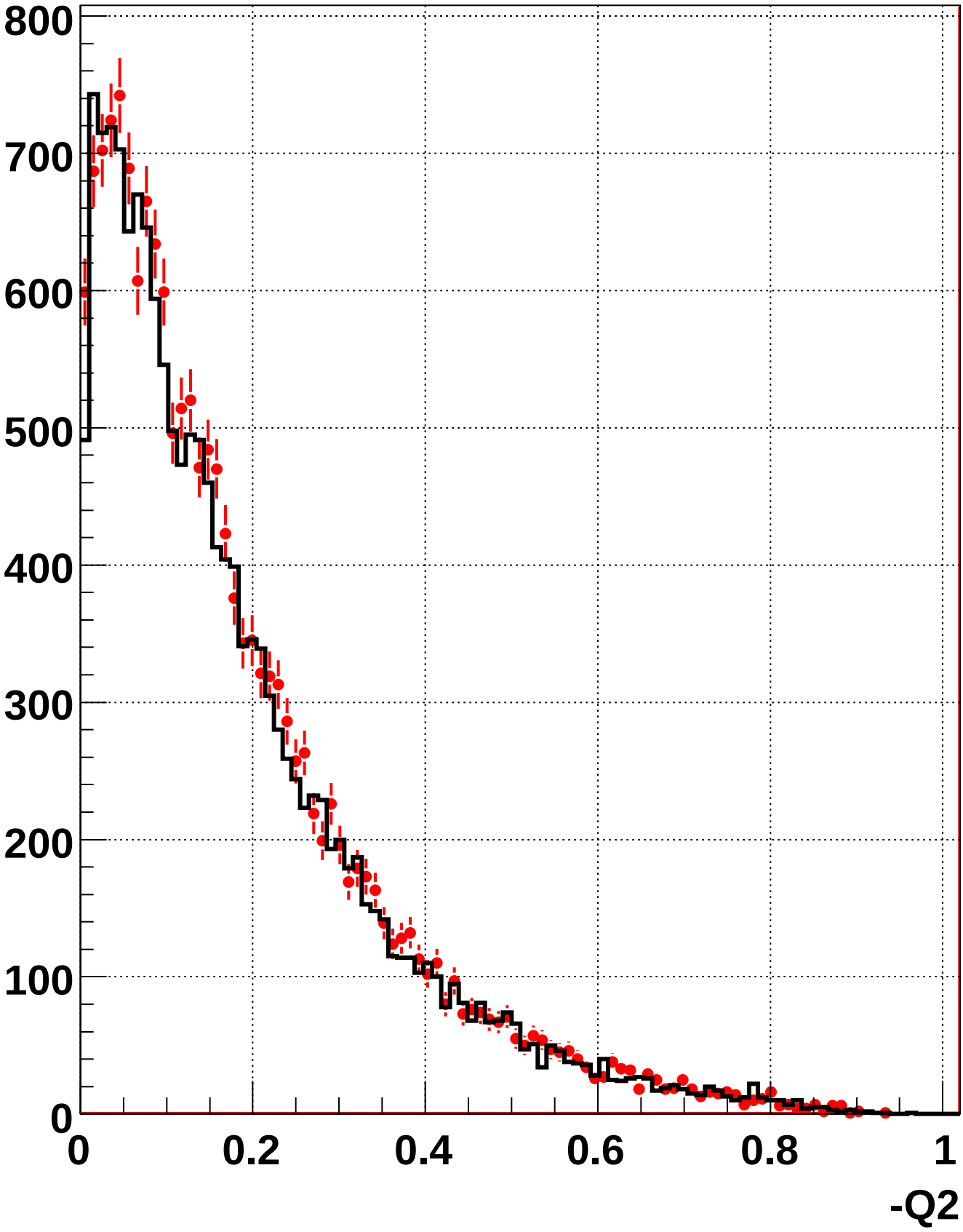
computed Q2 for all events



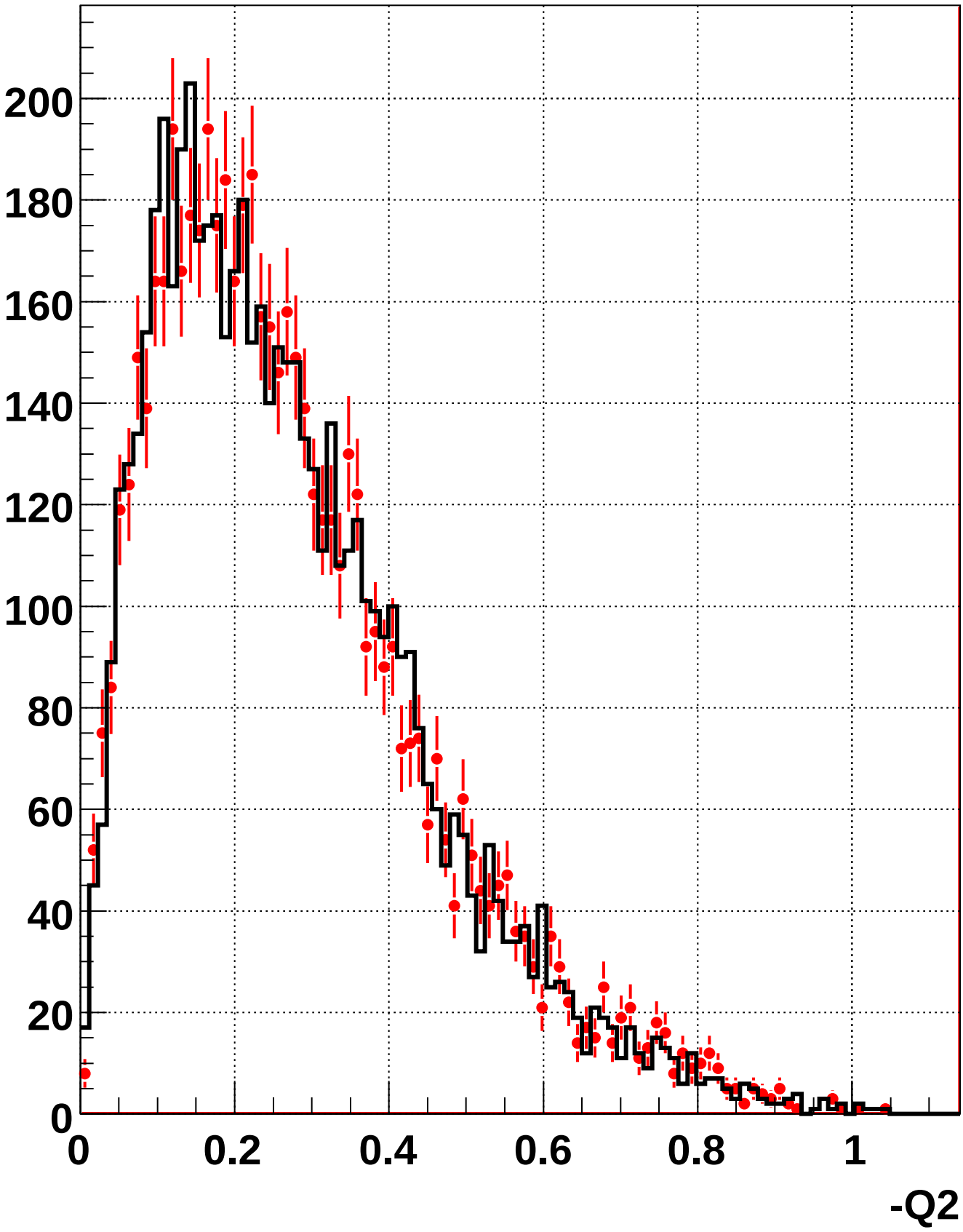
computed Q2 for QEL events



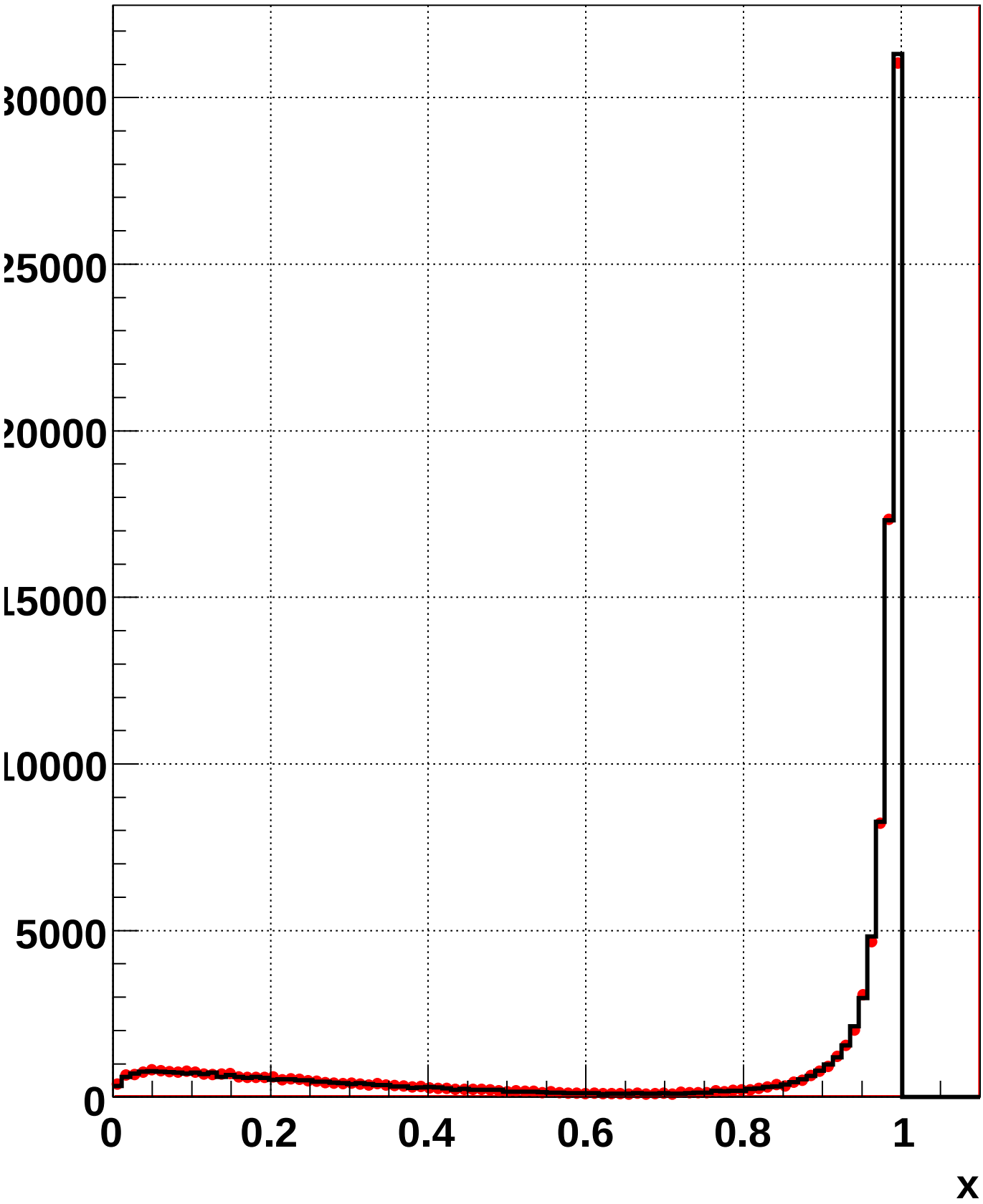
computed Q2 for RES events



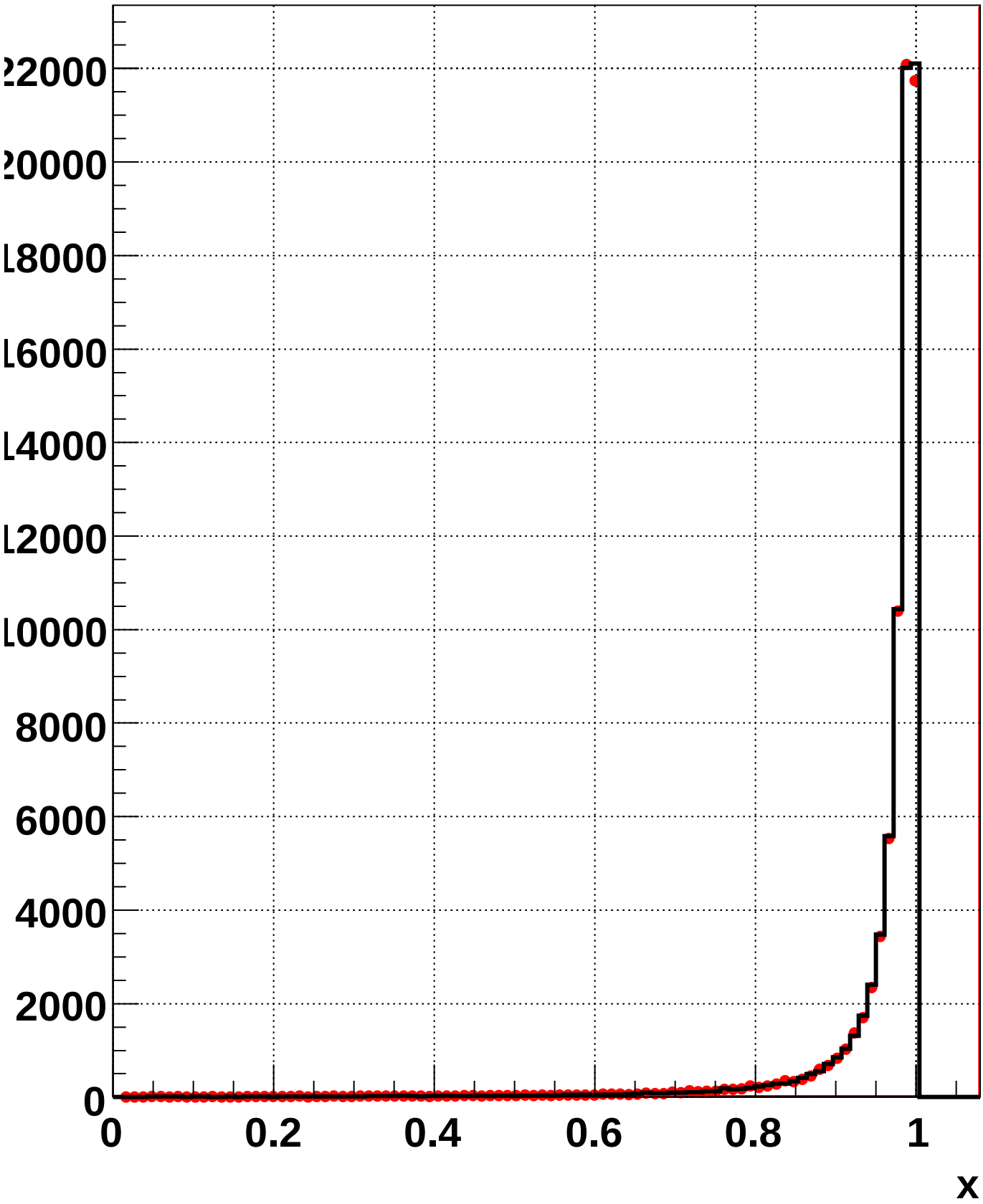
computed Q2 for DIS events



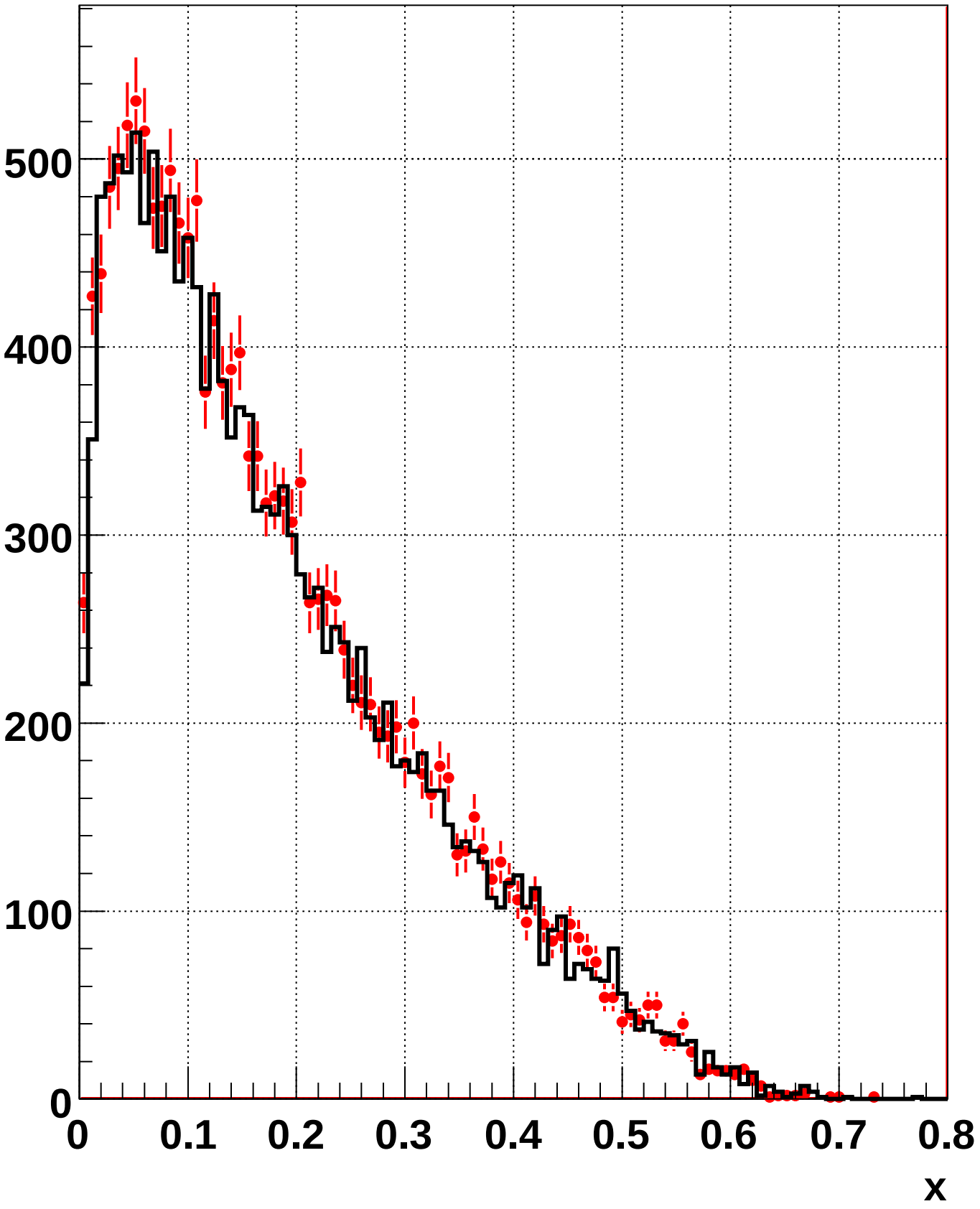
computed x for all events



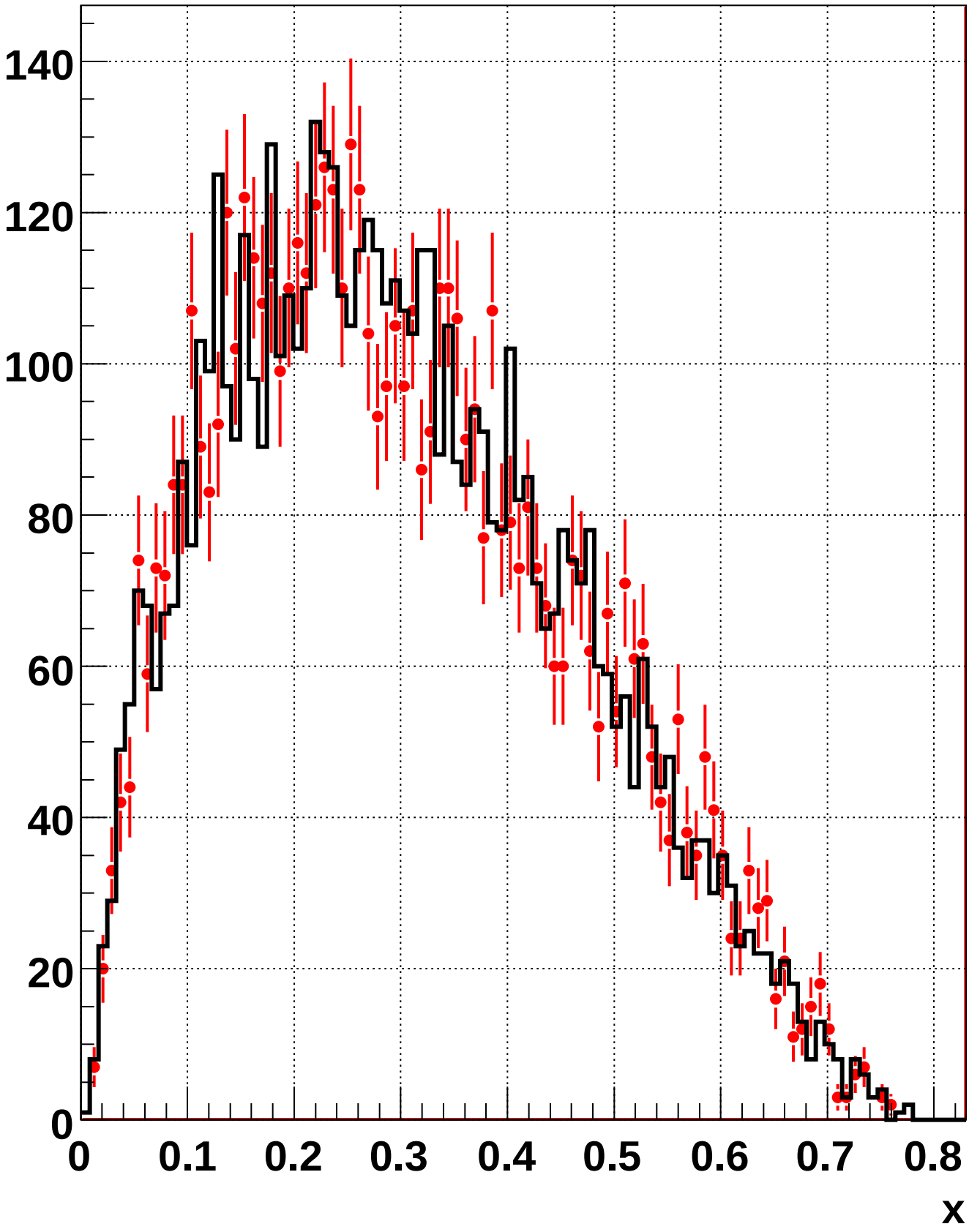
computed x for QEL events

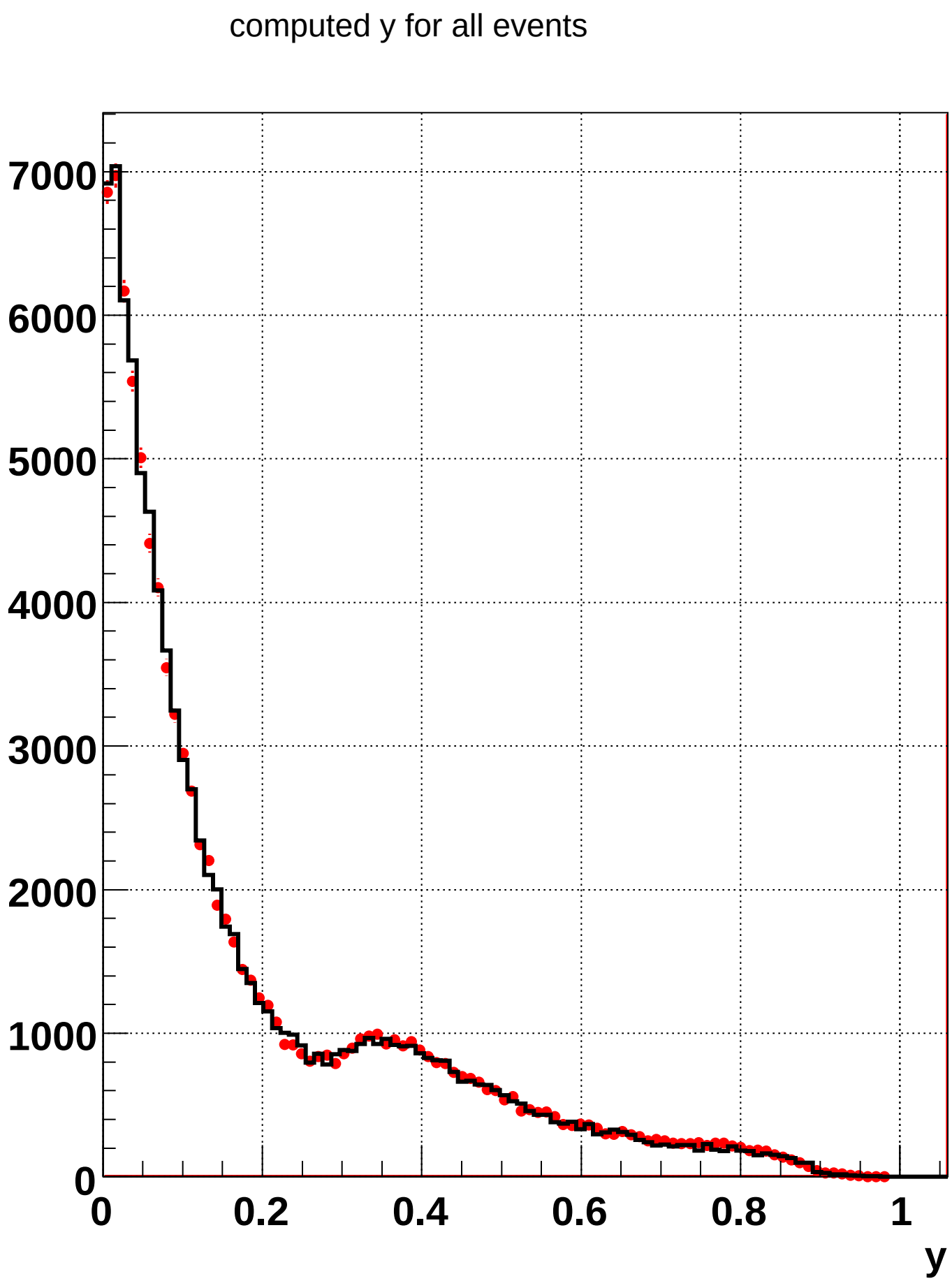


computed x for RES events

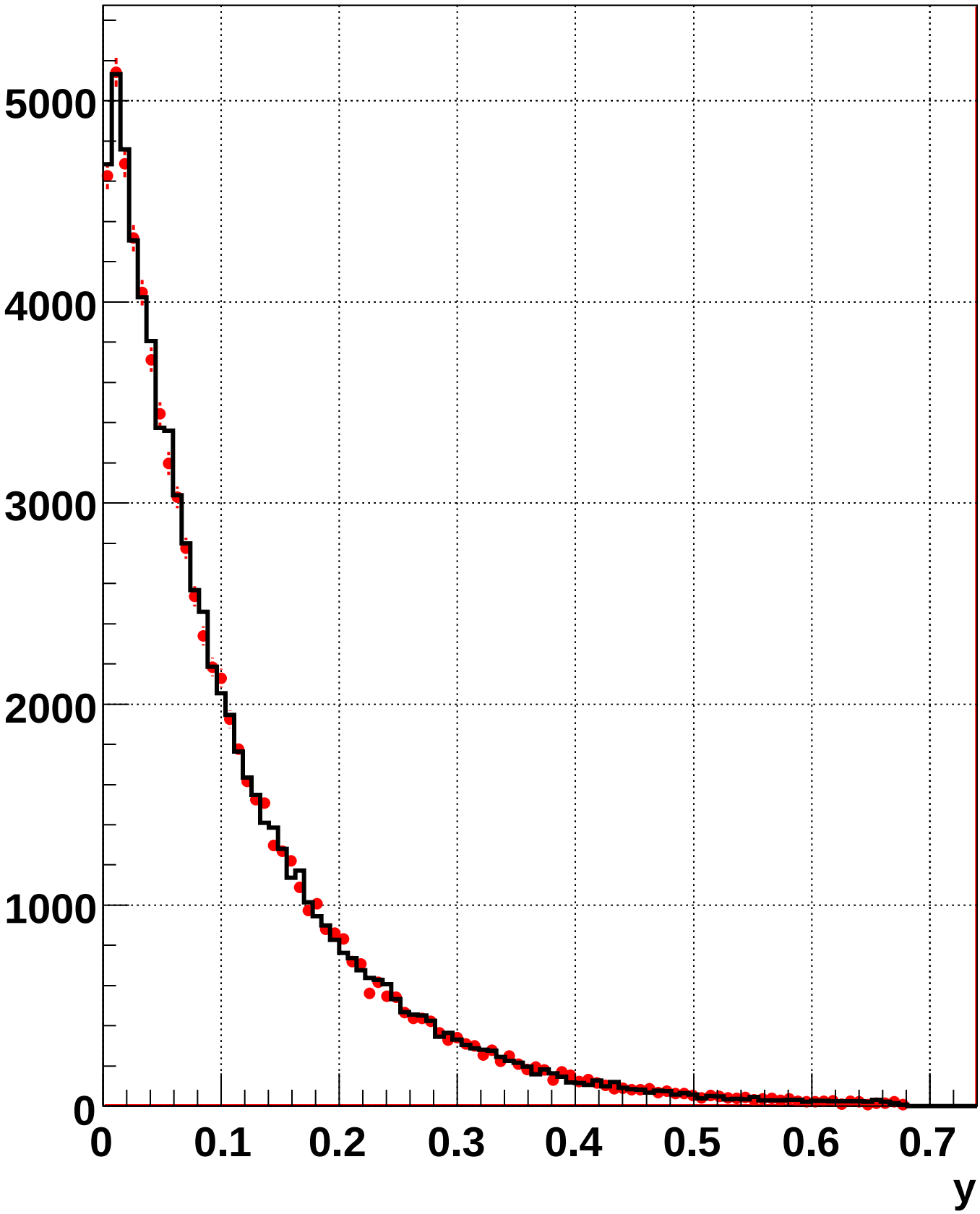


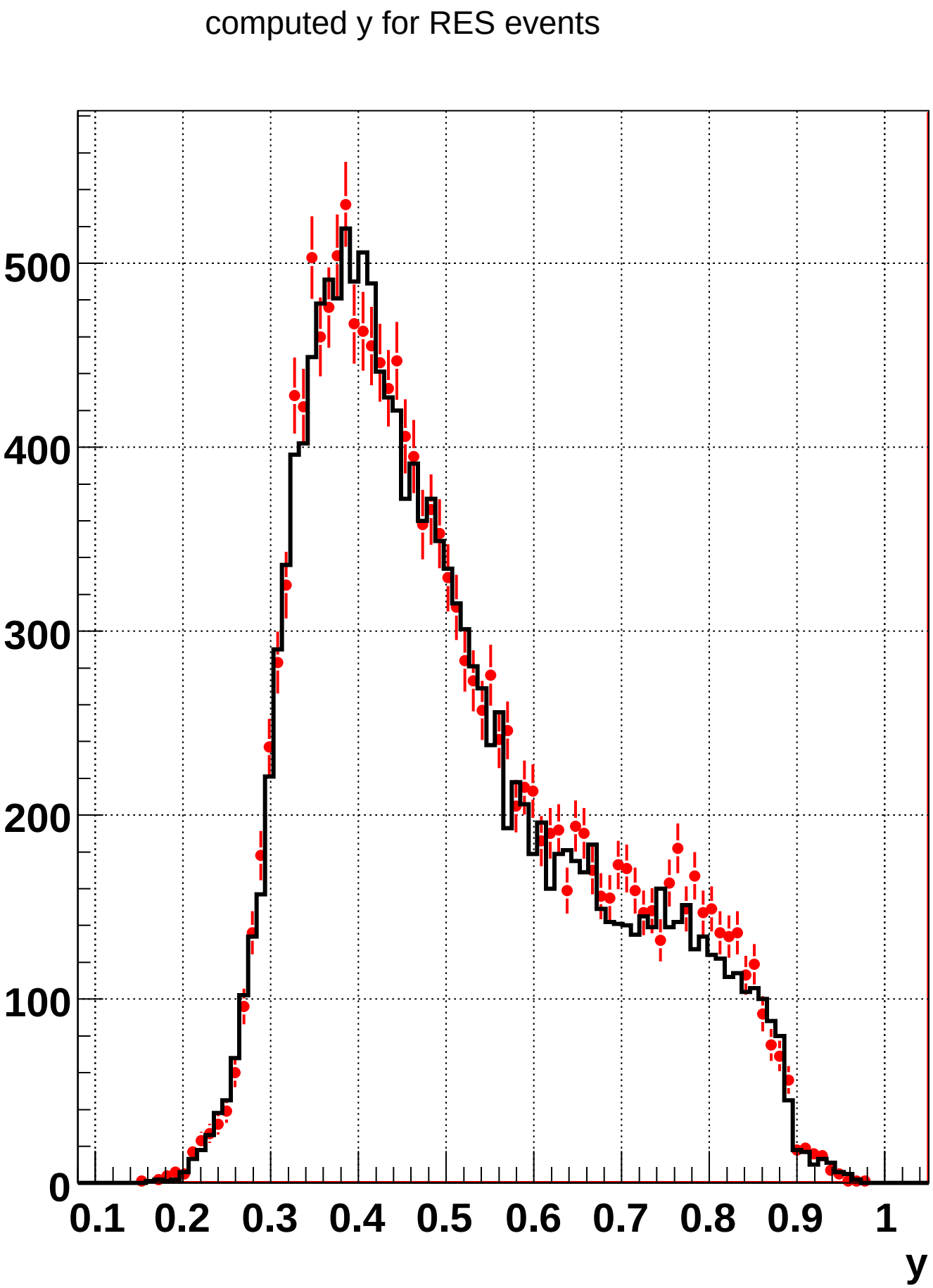
computed x for DIS events



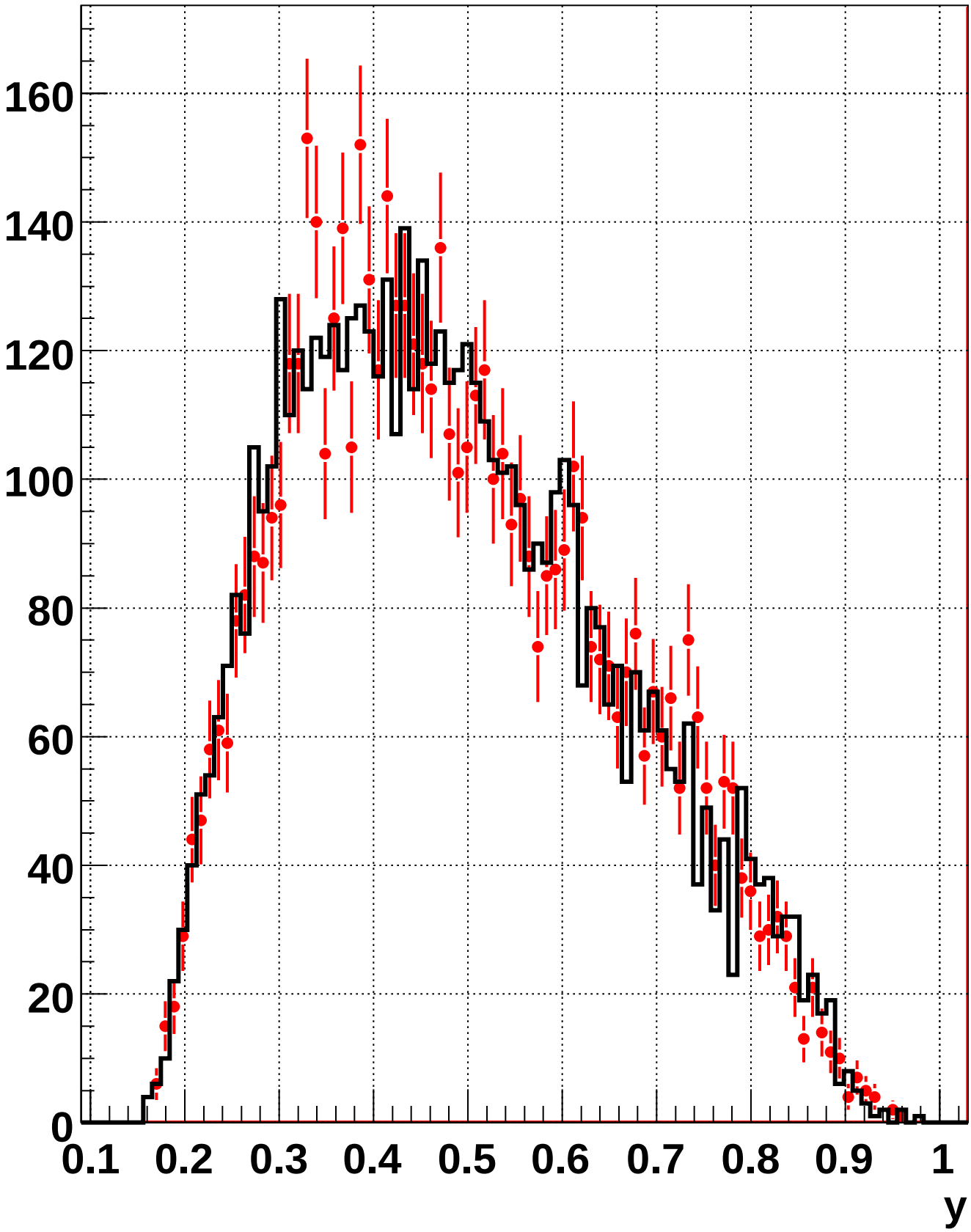

computed y for all events
7000
6000
5000
4000
3000
2000
1000
0
0
0.2
0.4
0.6
0.8
1
y

computed y for QEL events

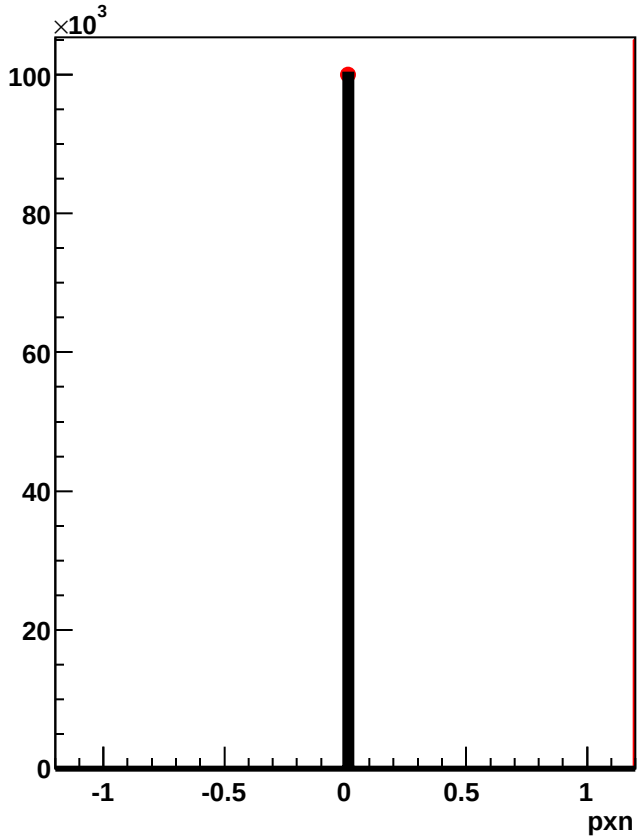


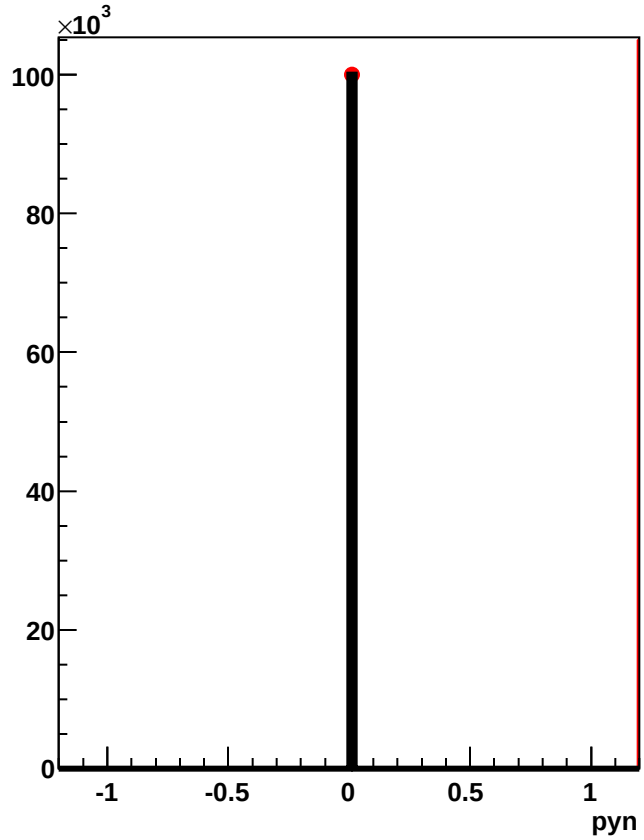

computed y for RES events
500
400
300
200
100
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
y

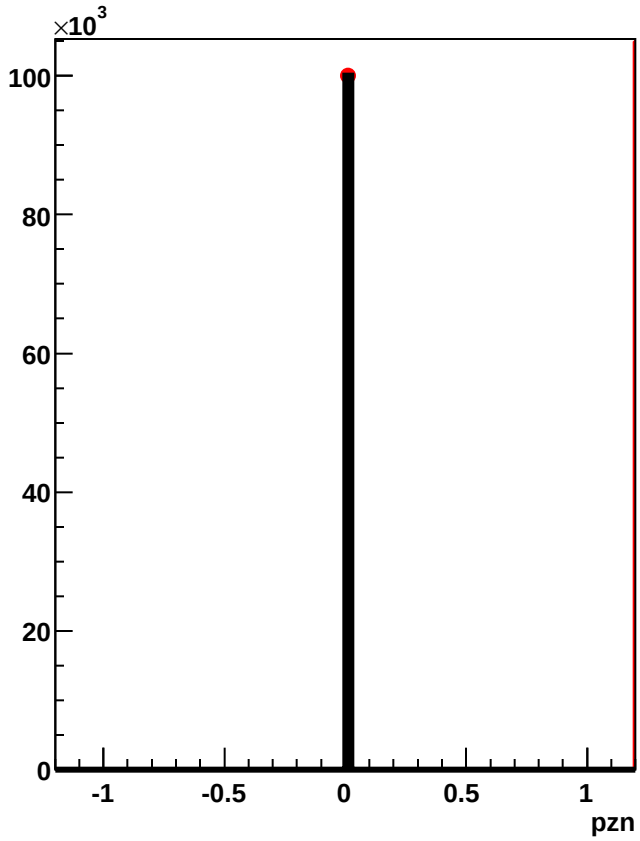
computed y for DIS events

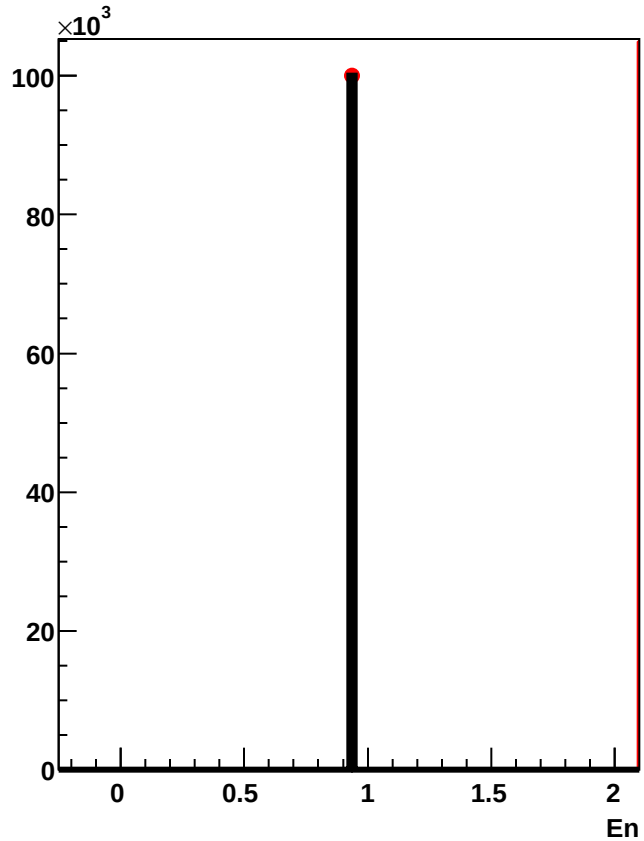


Initial state nucleon 4-Momentum


×10^3
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pxn

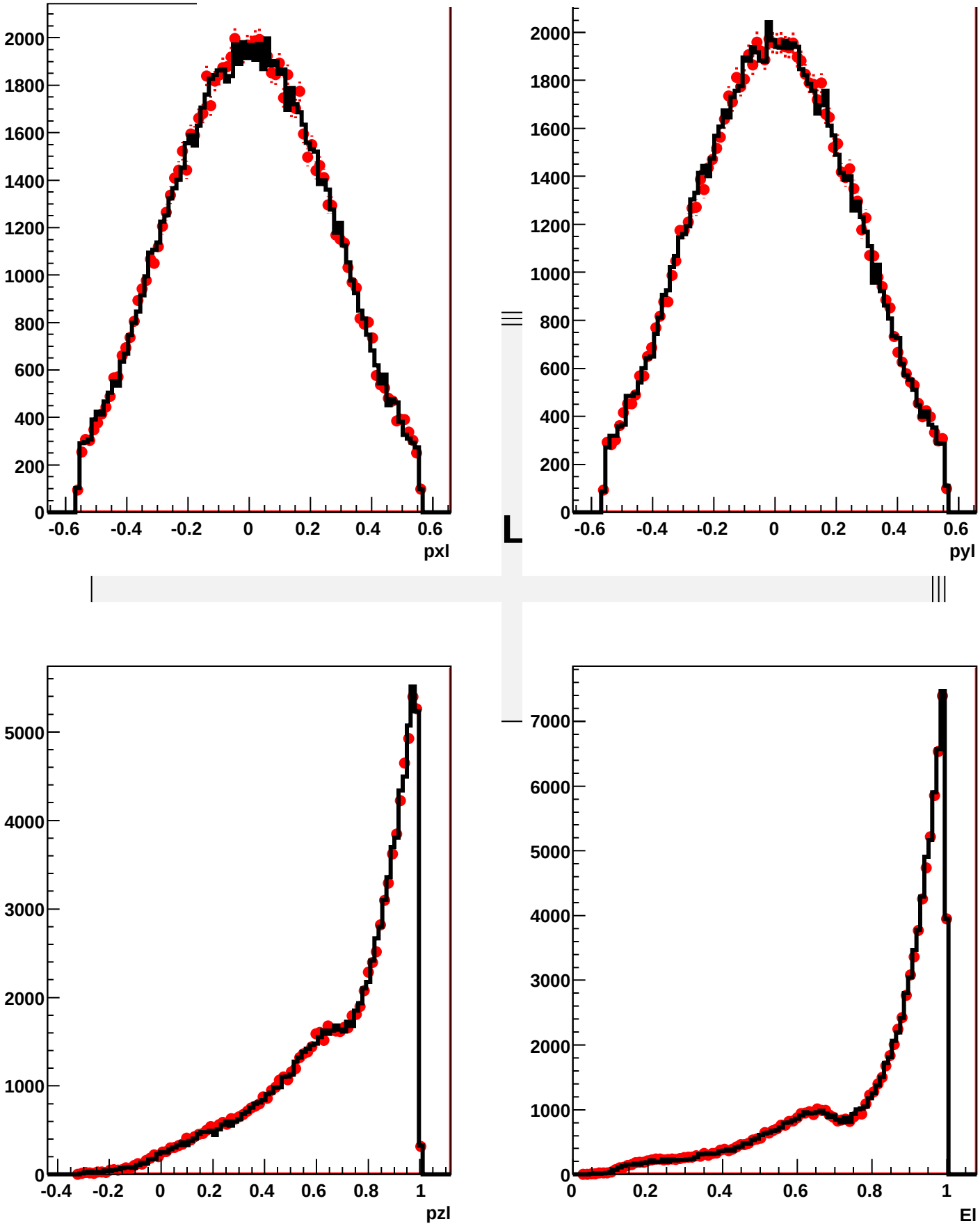

×10^3
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pyn


×10^3
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pzn

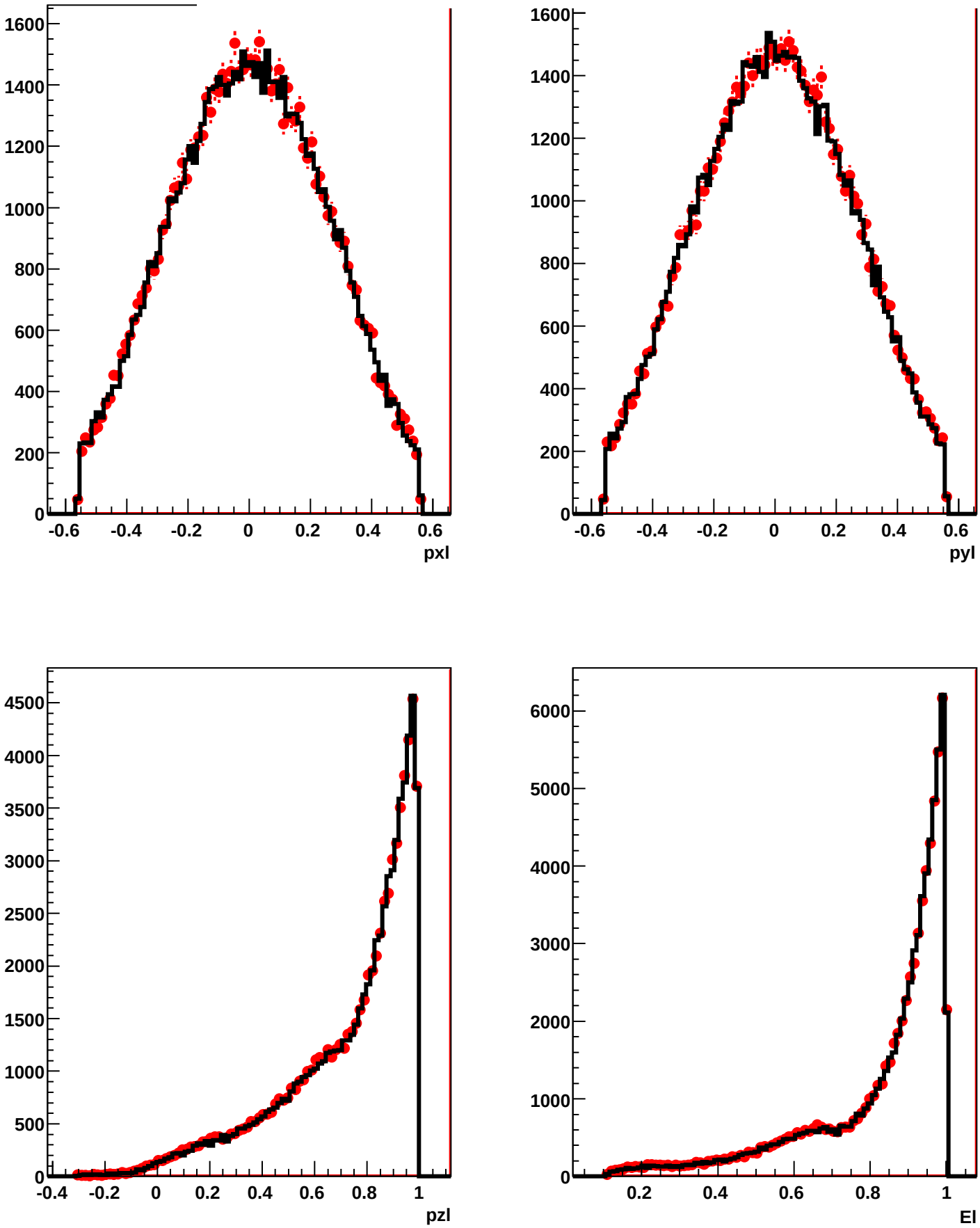

×10^3
100
80
60
40
20
0
0
0.5
1
1.5
2
En

Final State Primary Lepton 4-Momentum

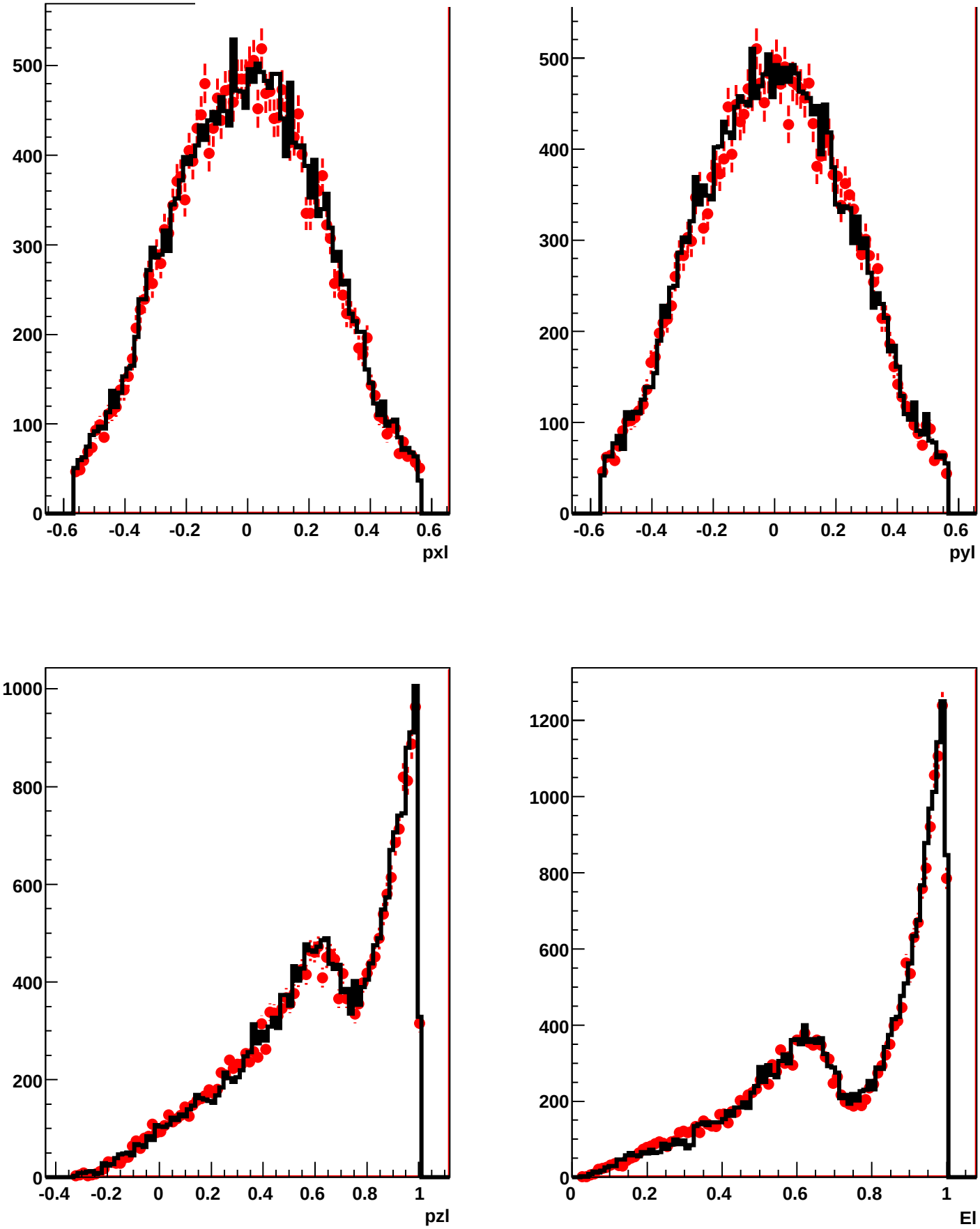
Final state primary lepton 4-p: All events



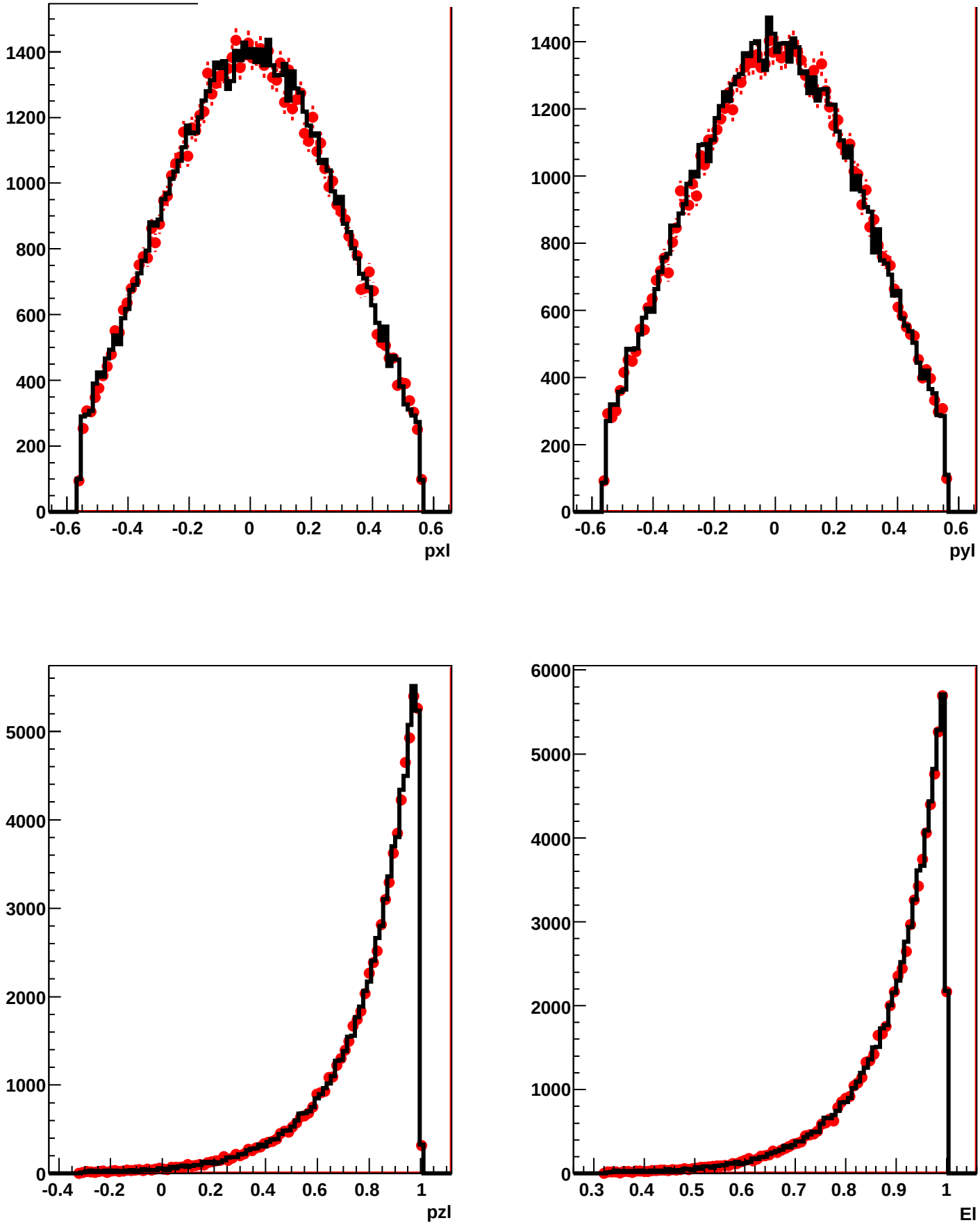
Final state primary lepton 4-p: All CC events



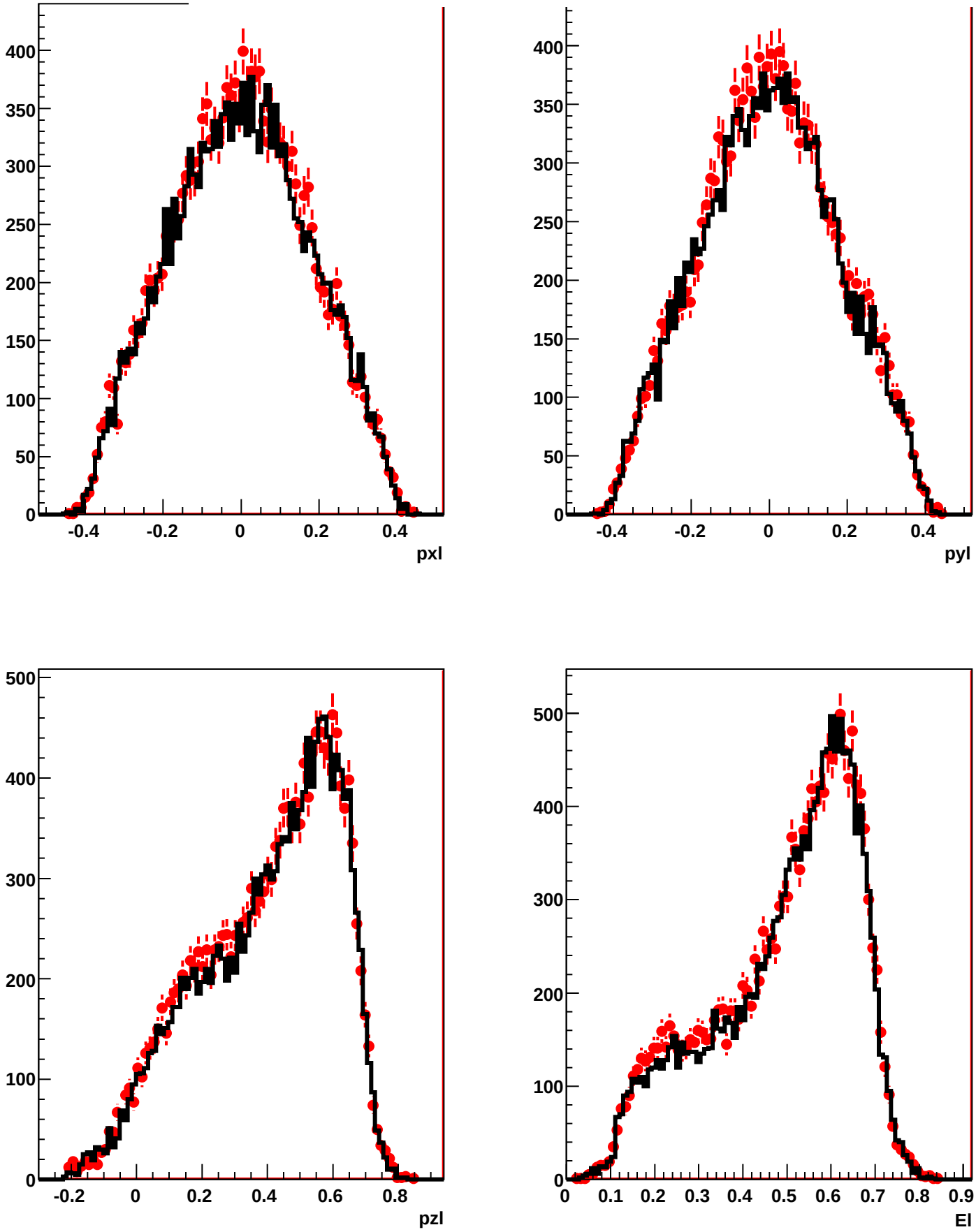
Final state primary lepton 4-p: All NC events



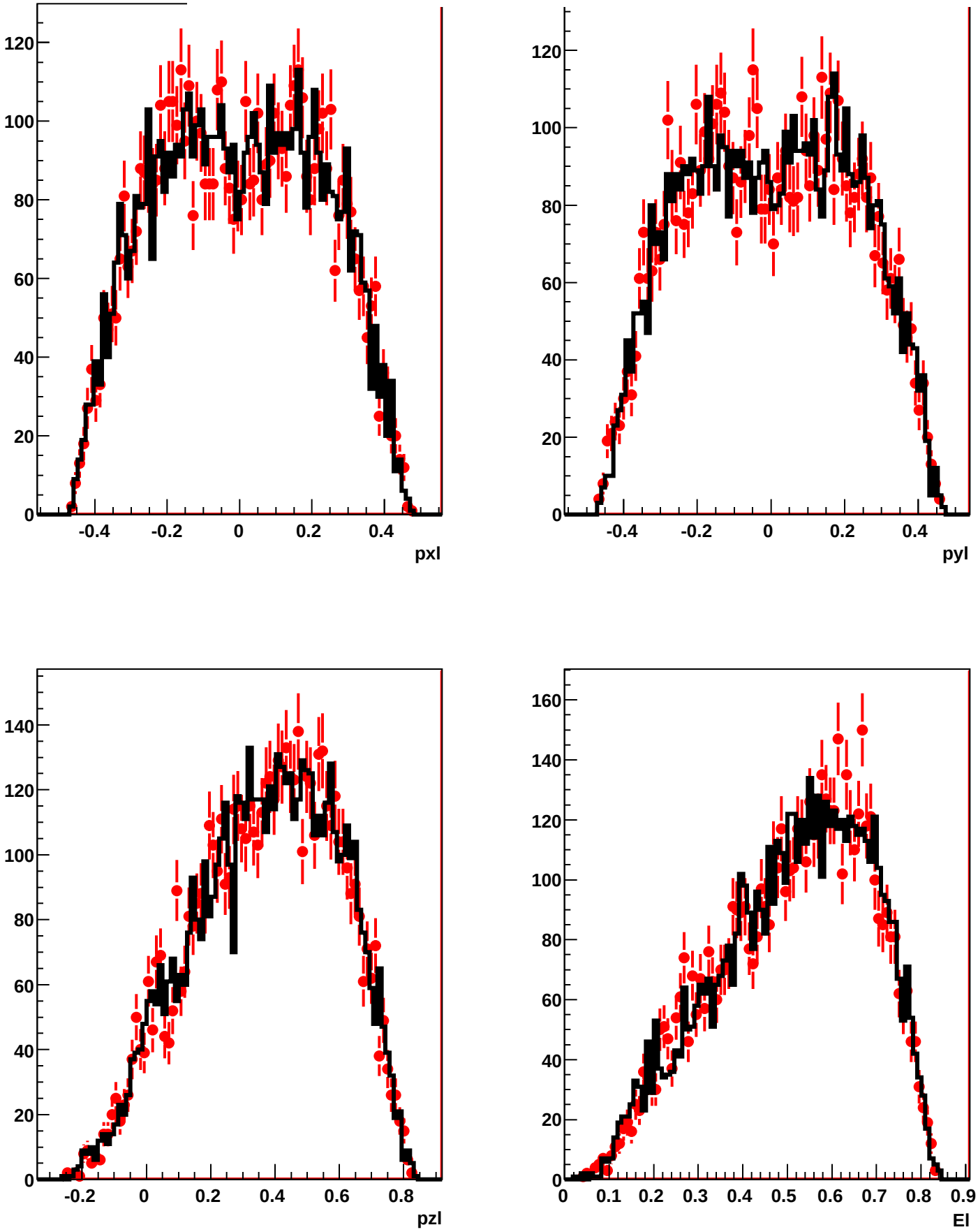
Final state primary lepton 4-p: QEL events



Final state primary lepton 4-p: RES events



Final state primary lepton 4-p: All DIS events



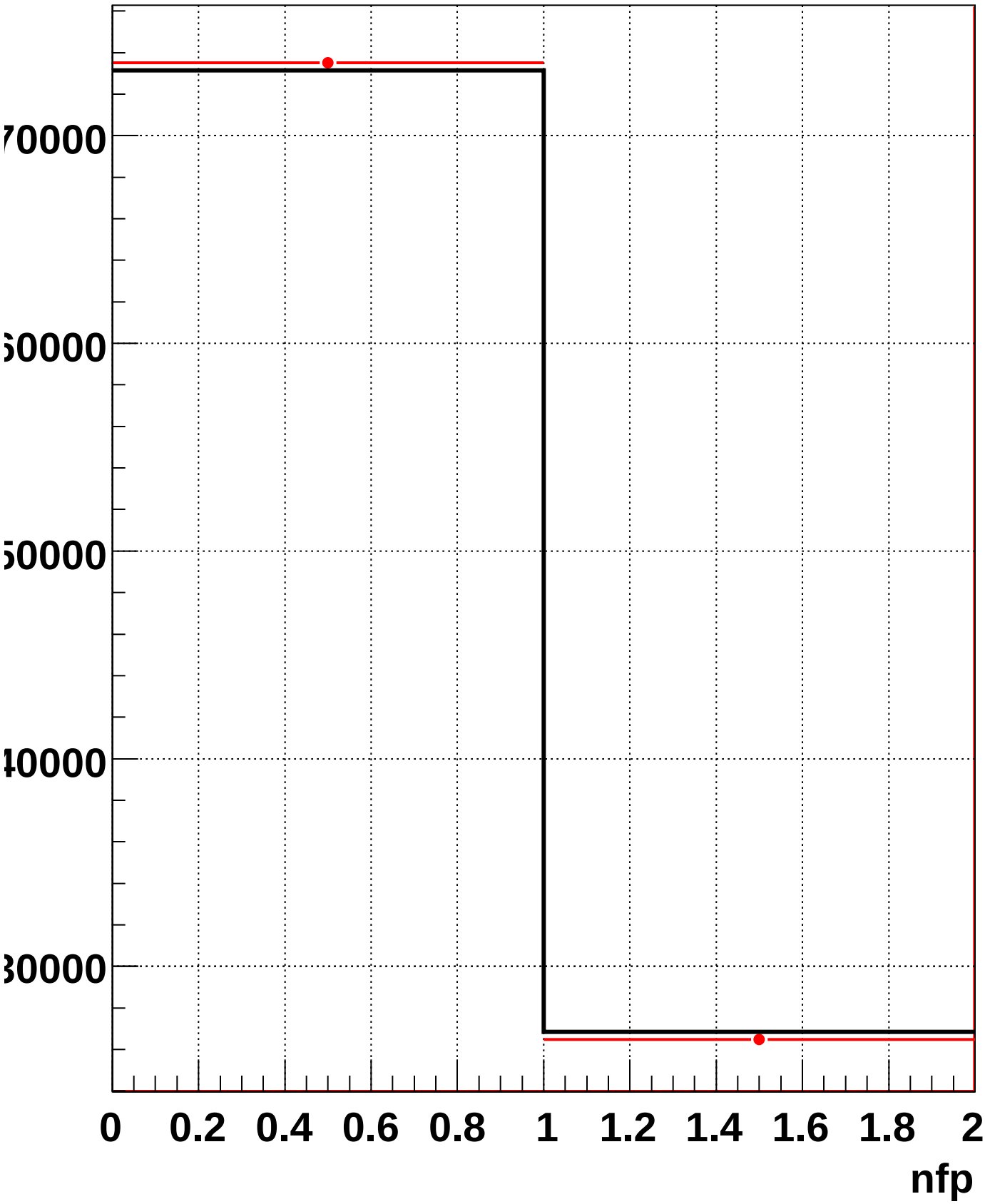
Final State Hadronic System

Multiplicities and 4-Momenta

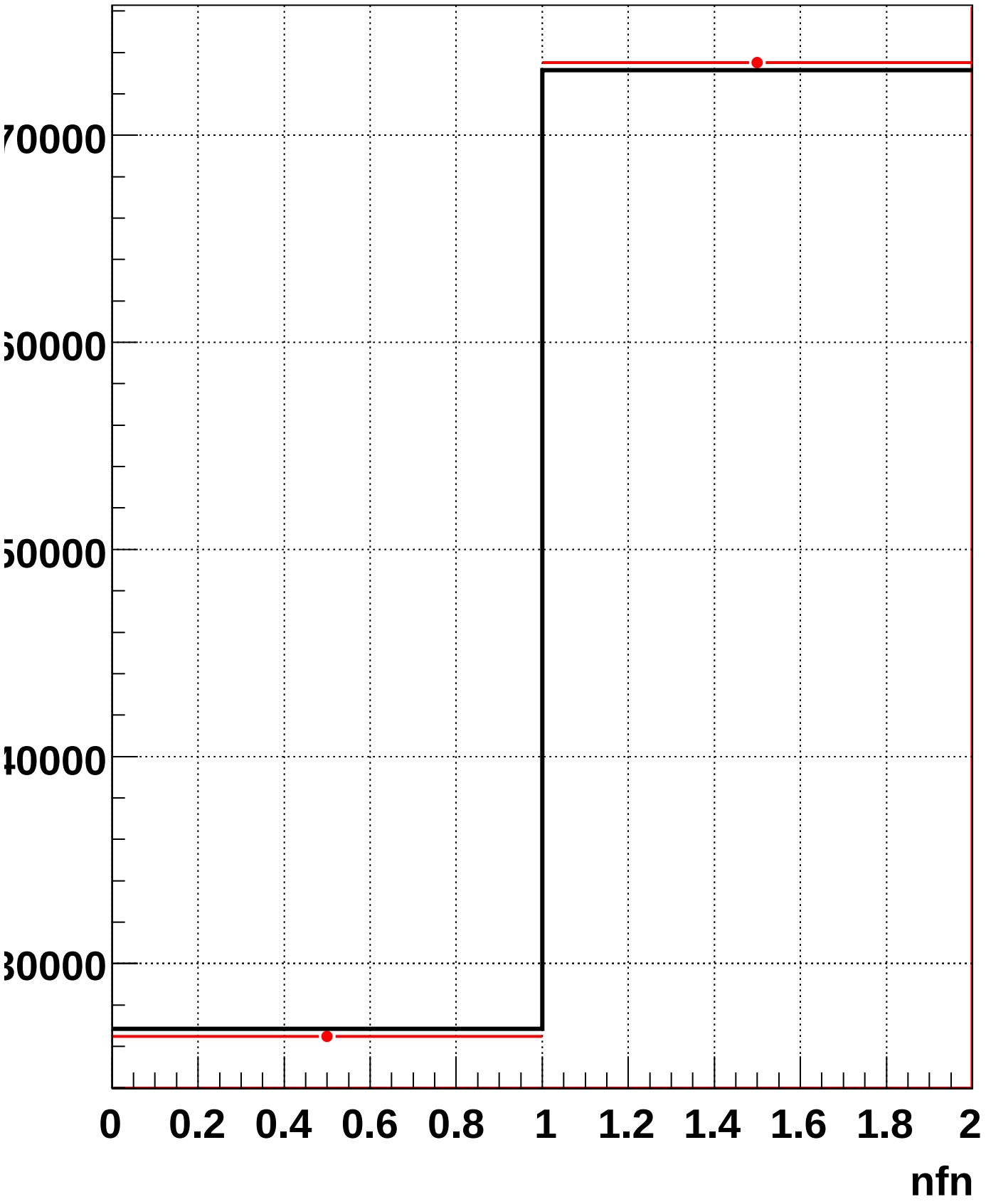
Note:

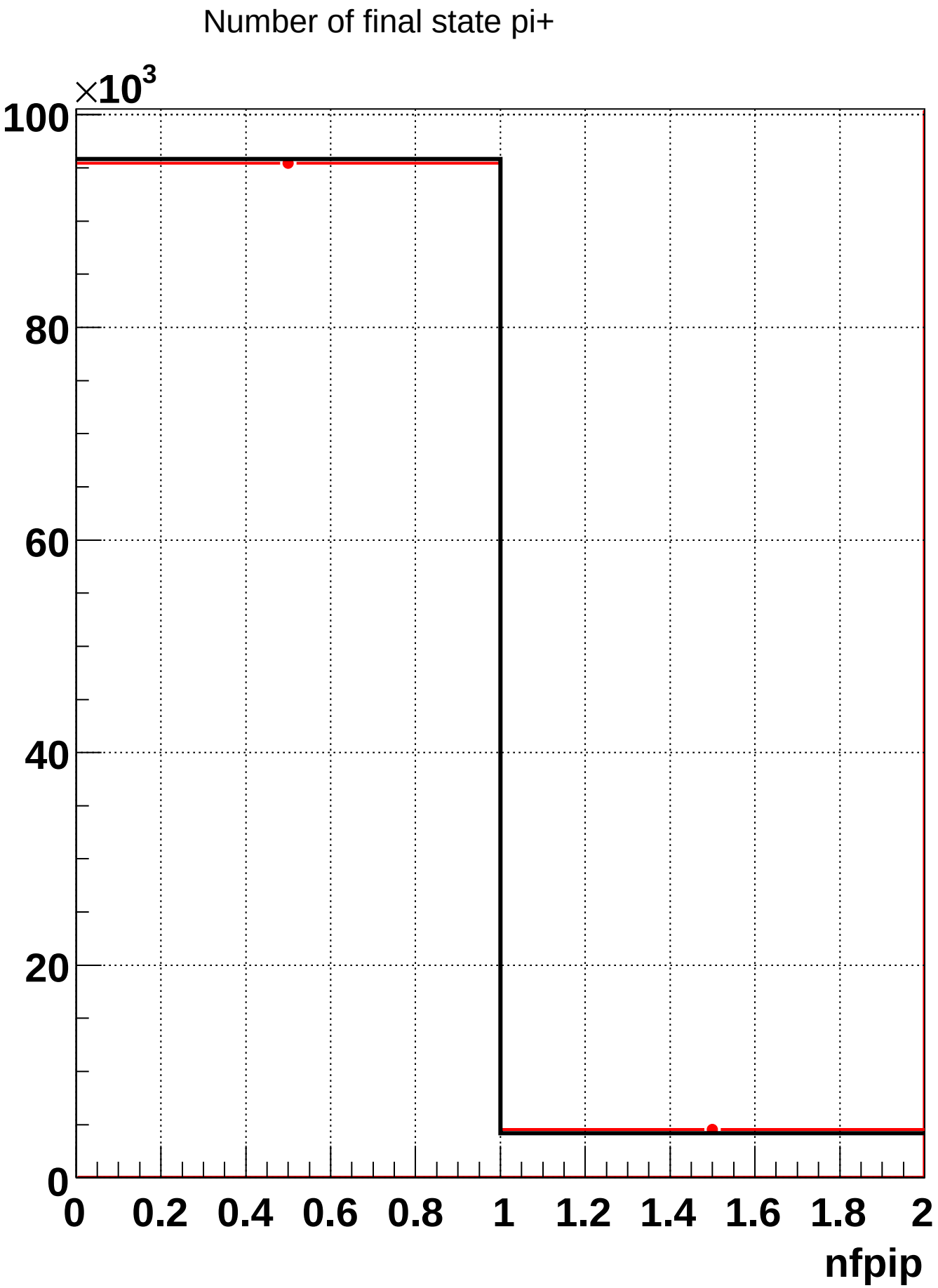
For nuclear targets these plots include the effect of intranuclear hadron transport / rescattering

Number of final state protons

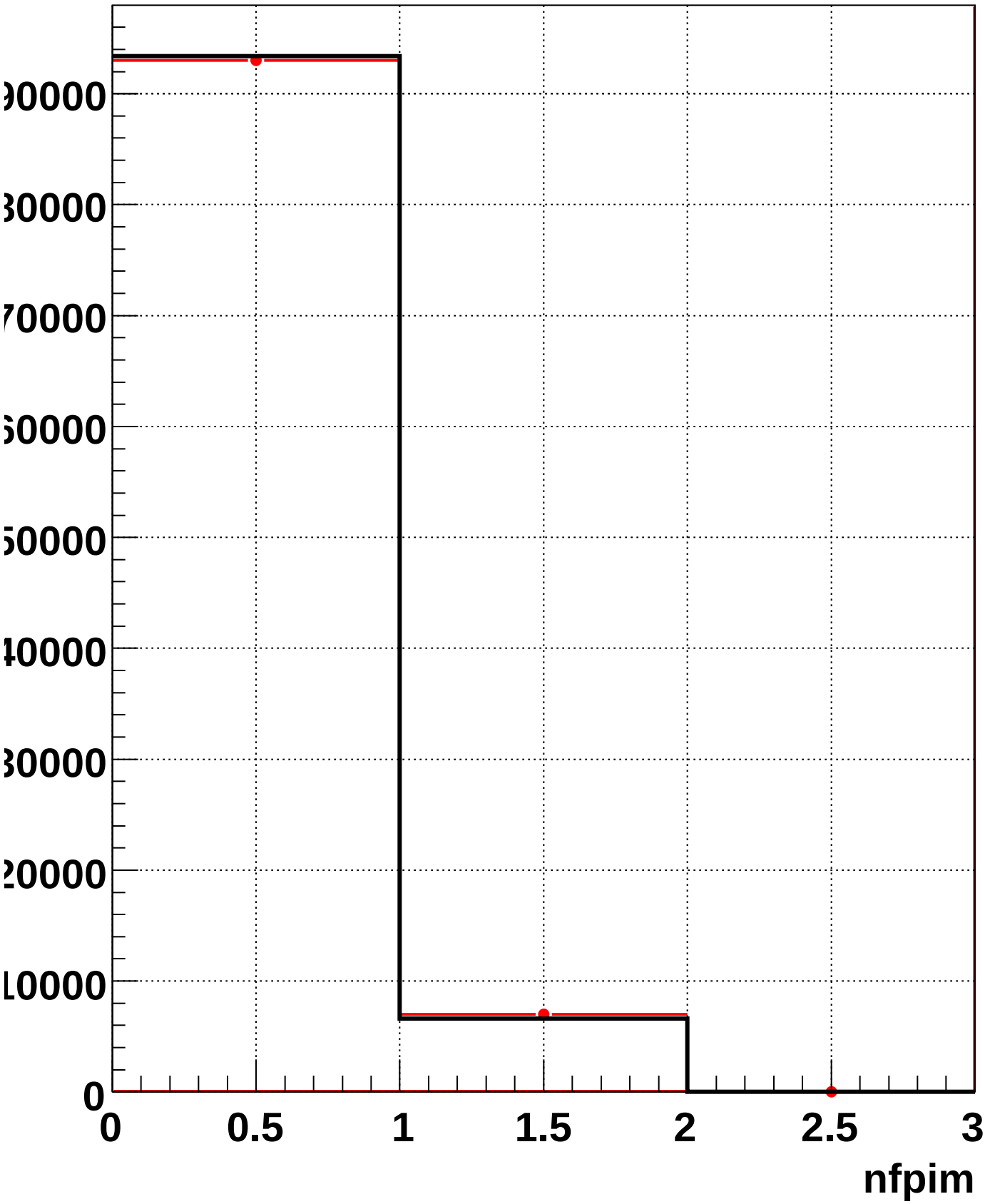


Number of final state neutrons

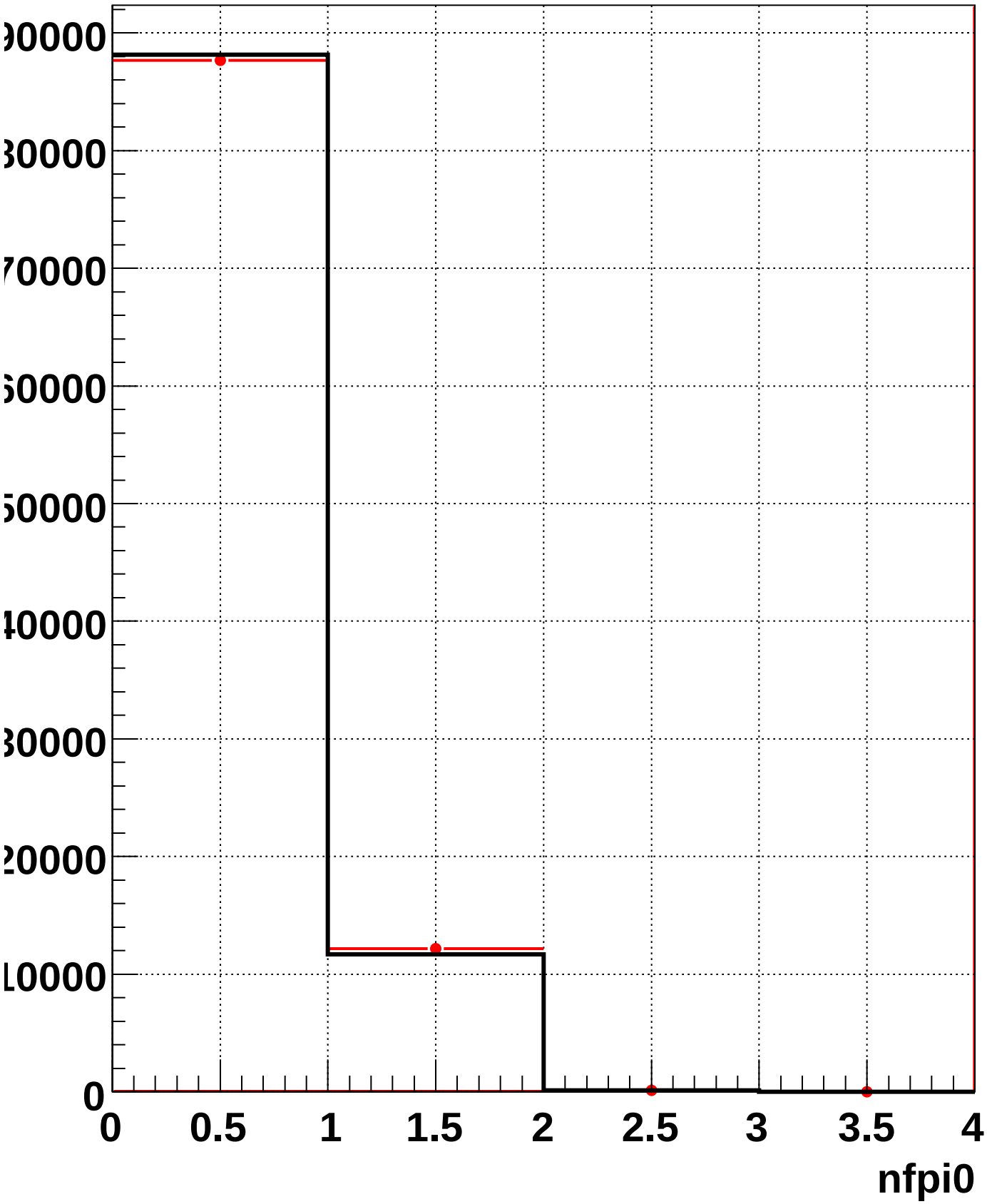


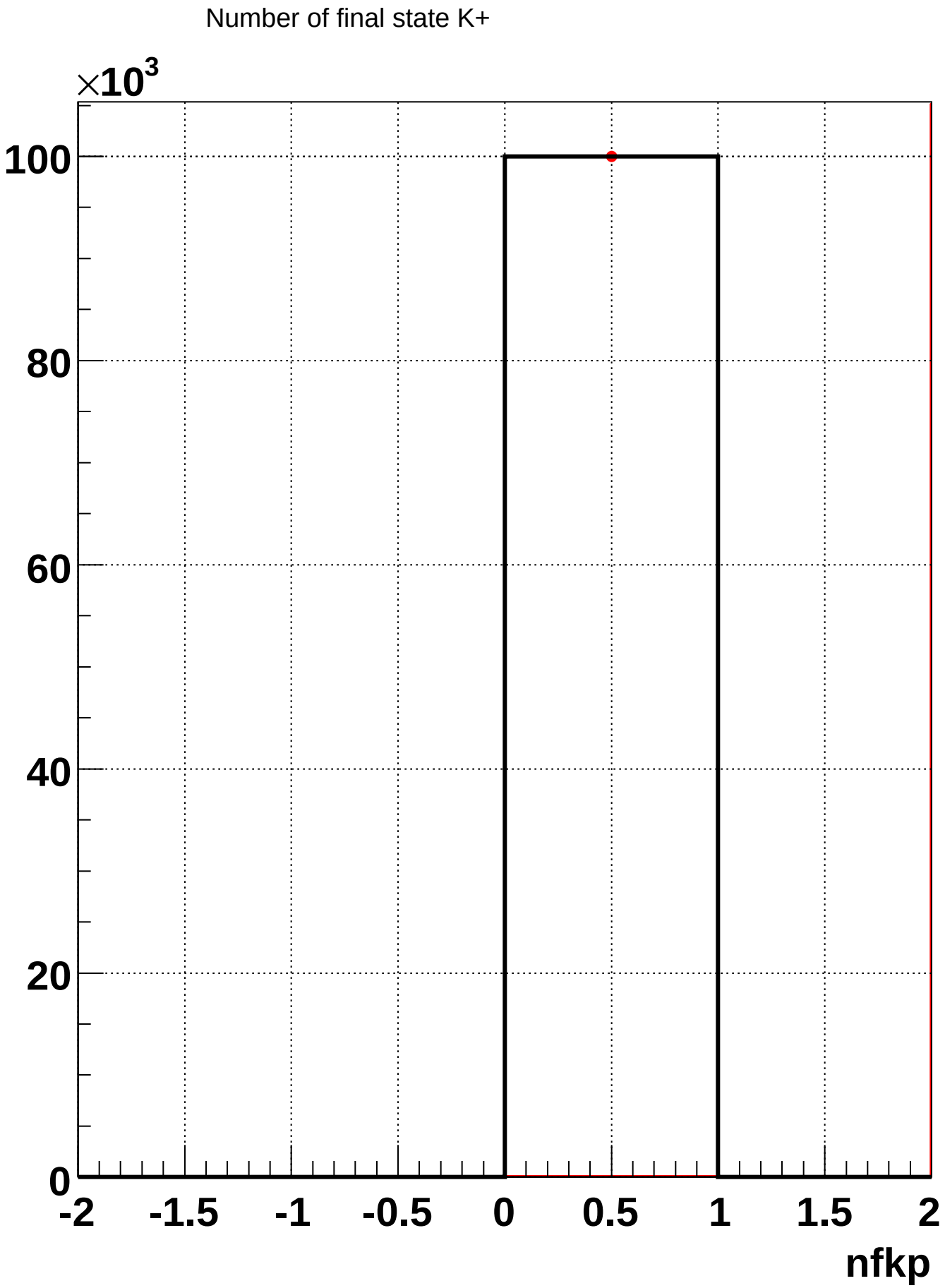

Number of final state pi+
×10^3
100
80
60
40
20
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
nfpip

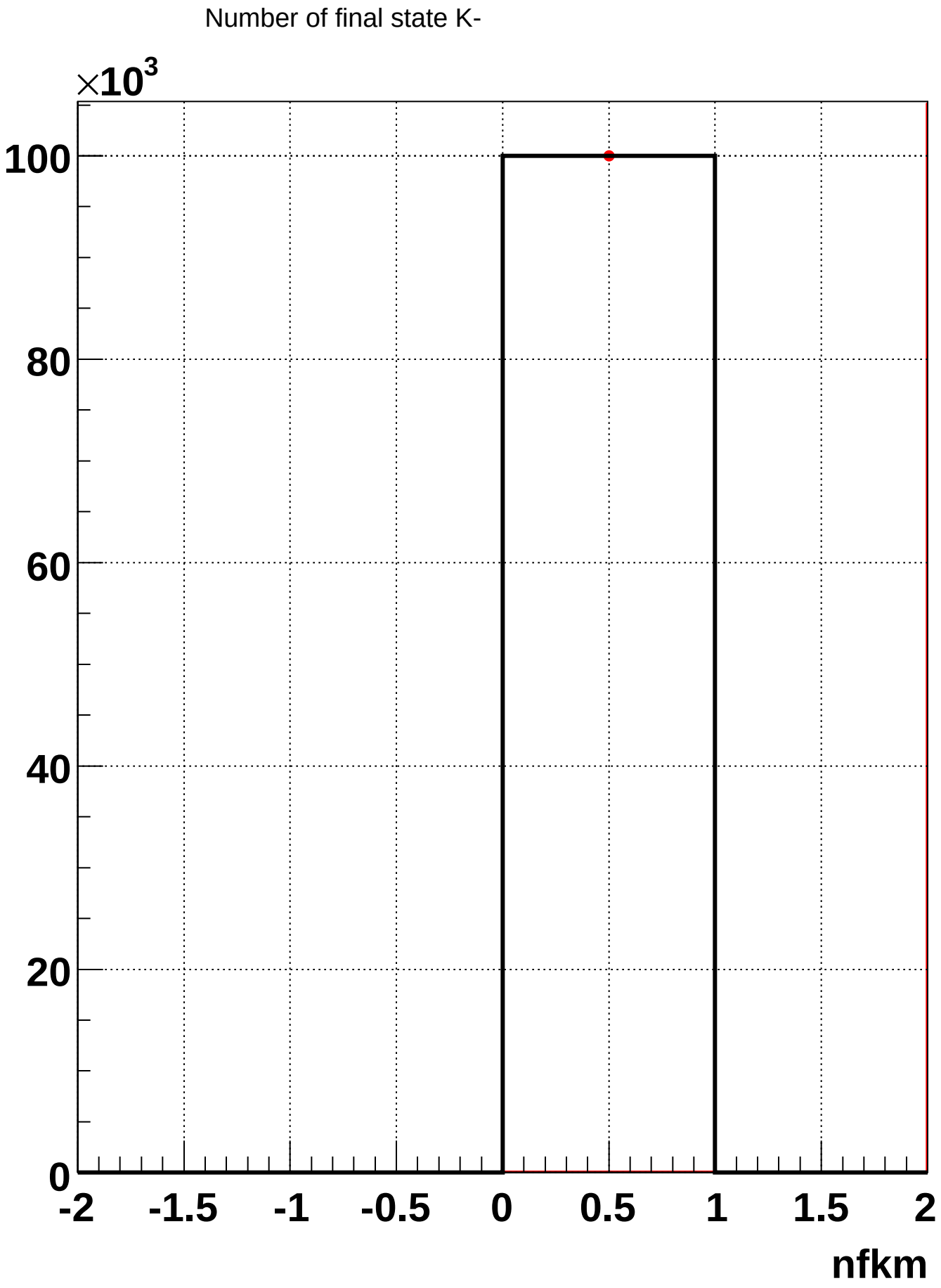
Number of final state pi-

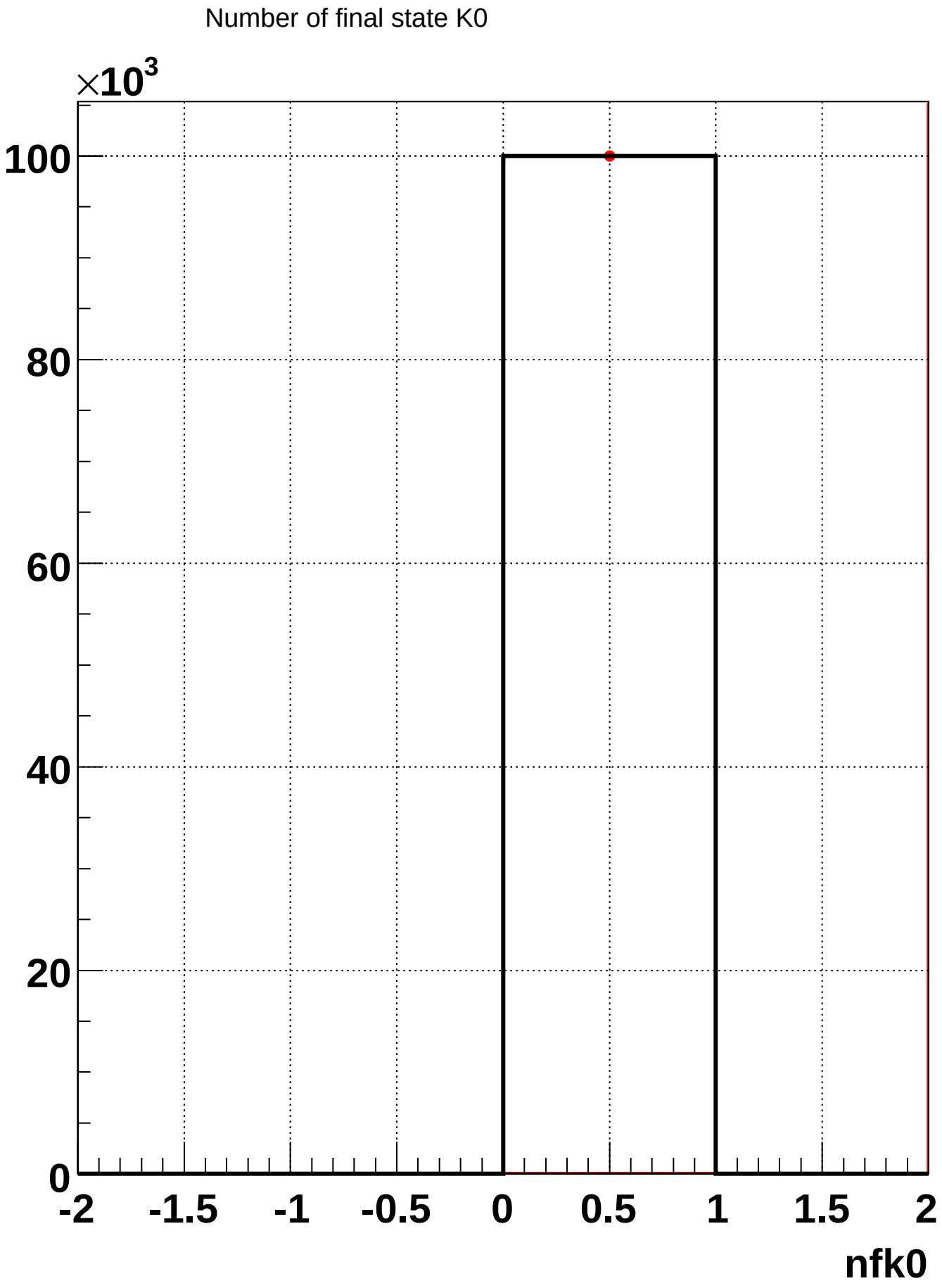


Number of final state pi0

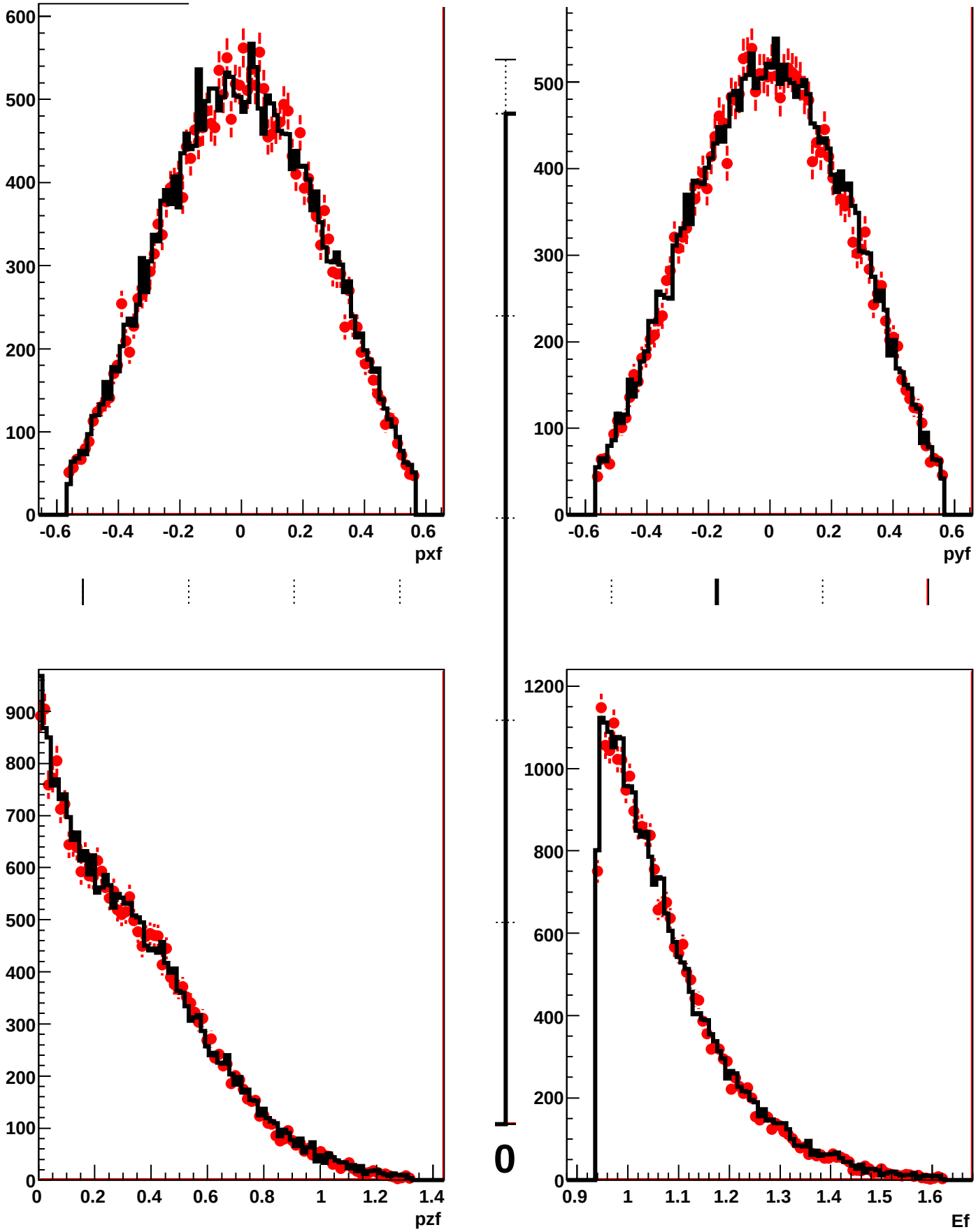



Number of final state K+
×10^3
100
80
60
40
20
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
nfkp

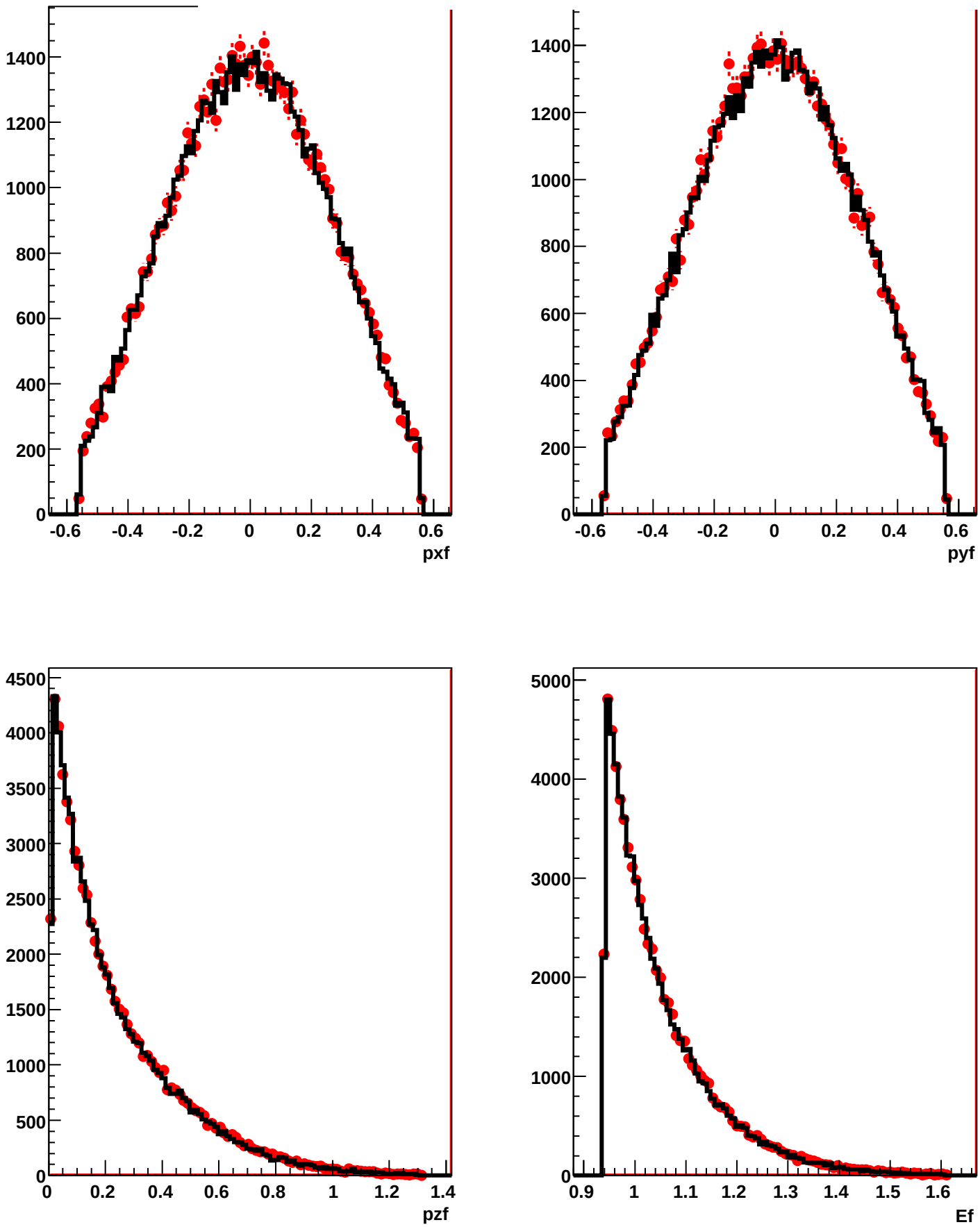

Number of final state K-
×10^3
100
80
60
40
20
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
nfkm


Number of final state K0
×10^3
100
80
60
40
20
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
nfk0

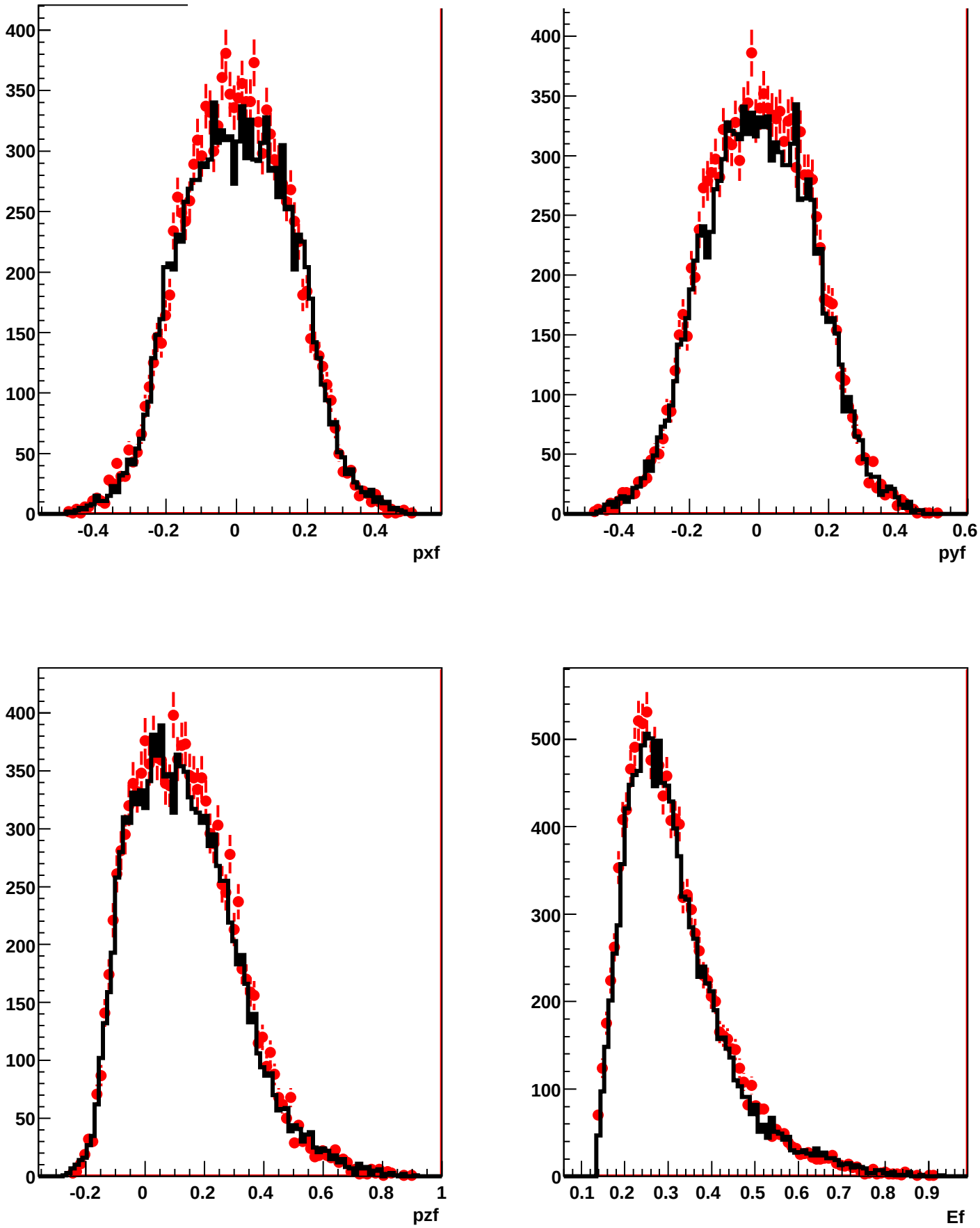
Final state protons 4-momentum



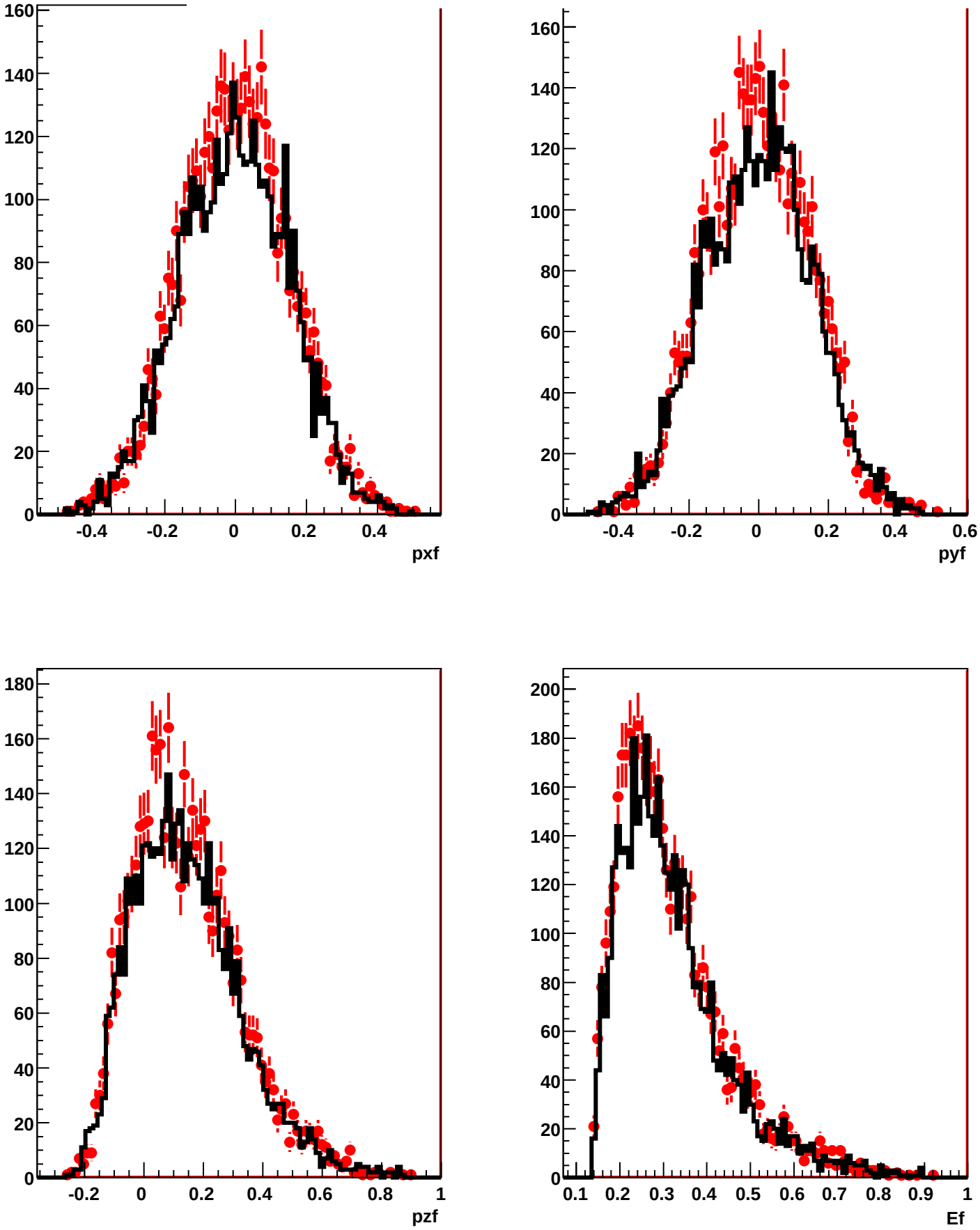
Final state neutrons 4-momentum



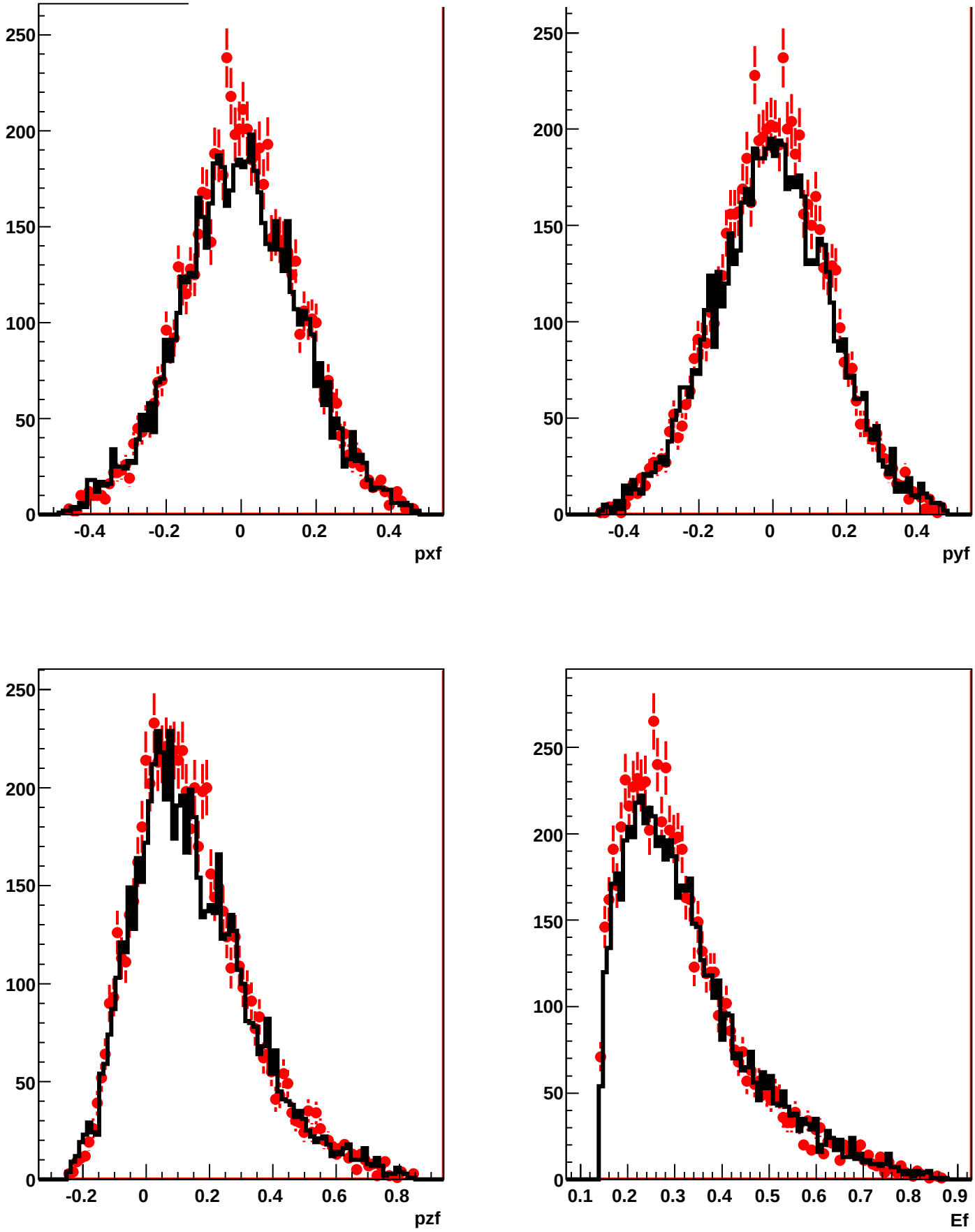
Final state pi0's 4-momentum



Final state pi+’s 4-momentum



Final state pi-'s 4-momentum



GENIE-2.0.0 vs NEUGEN/Daikon+ Event Sample Comparisons

Event Sample:

100k events, numubar+p, 5GeV, all processes

Notes:

Daikon+ is a NEUGEN Daikon revision version

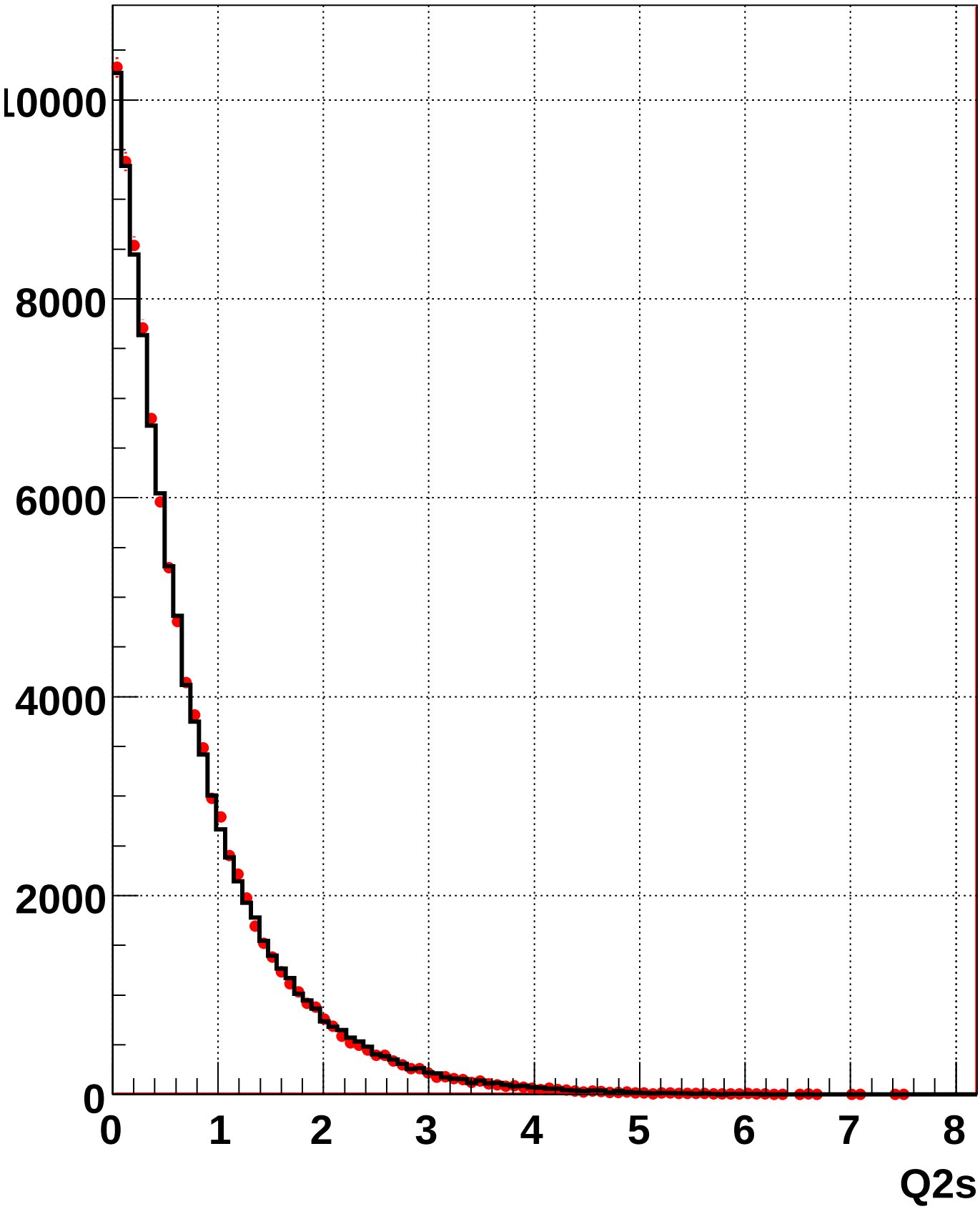
GENIE predictions shown with lines / NEUGEN's with markers

Event Numbers:

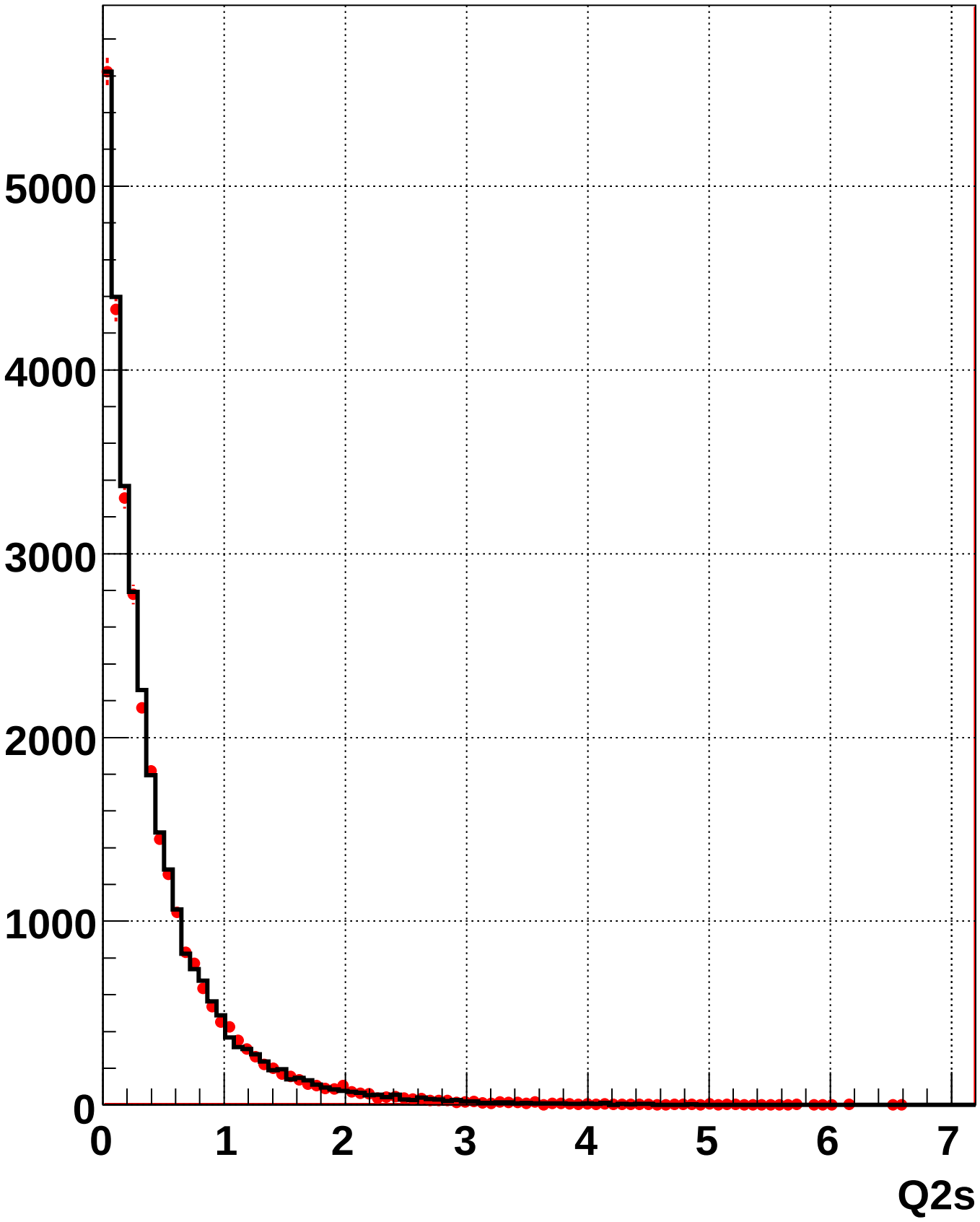
ALL :	100000 [NeuGEN],	100000 [GENIE]
QEL :	30462 [NeuGEN],	30827 [GENIE]
QEL-CC :	25727 [NeuGEN],	26035 [GENIE]
QEL-NC :	4735 [NeuGEN],	4792 [GENIE]
RES :	27007 [NeuGEN],	26280 [GENIE]
RES-CC :	19171 [NeuGEN],	18417 [GENIE]
RES-NC :	7836 [NeuGEN],	7863 [GENIE]
DIS :	42531 [NeuGEN],	42893 [GENIE]
DIS-CC :	31900 [NeuGEN],	32431 [GENIE]
(charm):	38 [NeuGEN],	22 [GENIE]
DIS-NC :	10631 [NeuGEN],	10462 [GENIE]
COH :	0 [NeuGEN],	0 [GENIE]
COH-CC :	0 [NeuGEN],	0 [GENIE]
COH-NC :	0 [NeuGEN],	0 [GENIE]
IMD :	0 [NeuGEN],	0 [GENIE]

Selected Kinematical Quantities

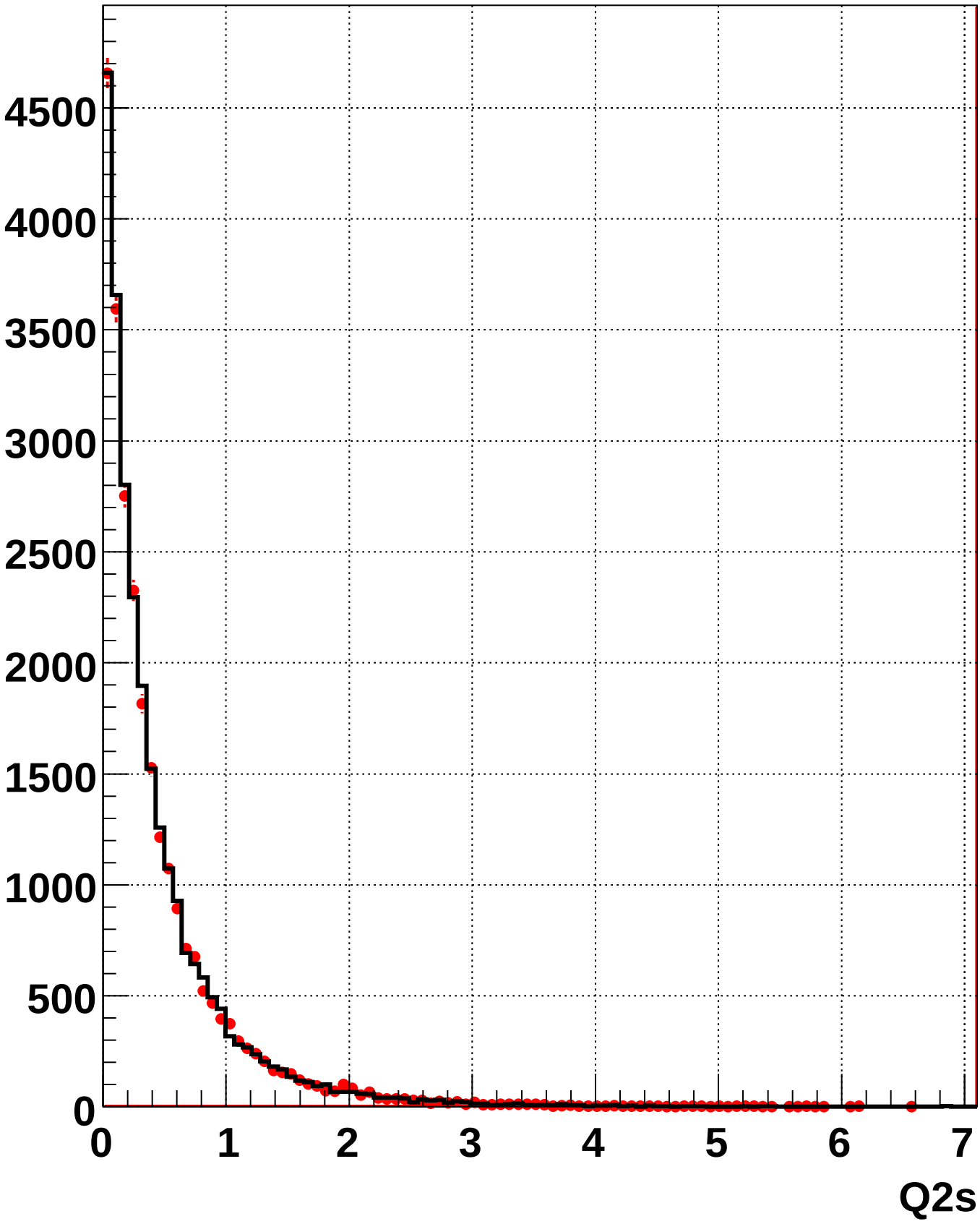
selected Q2 for all events



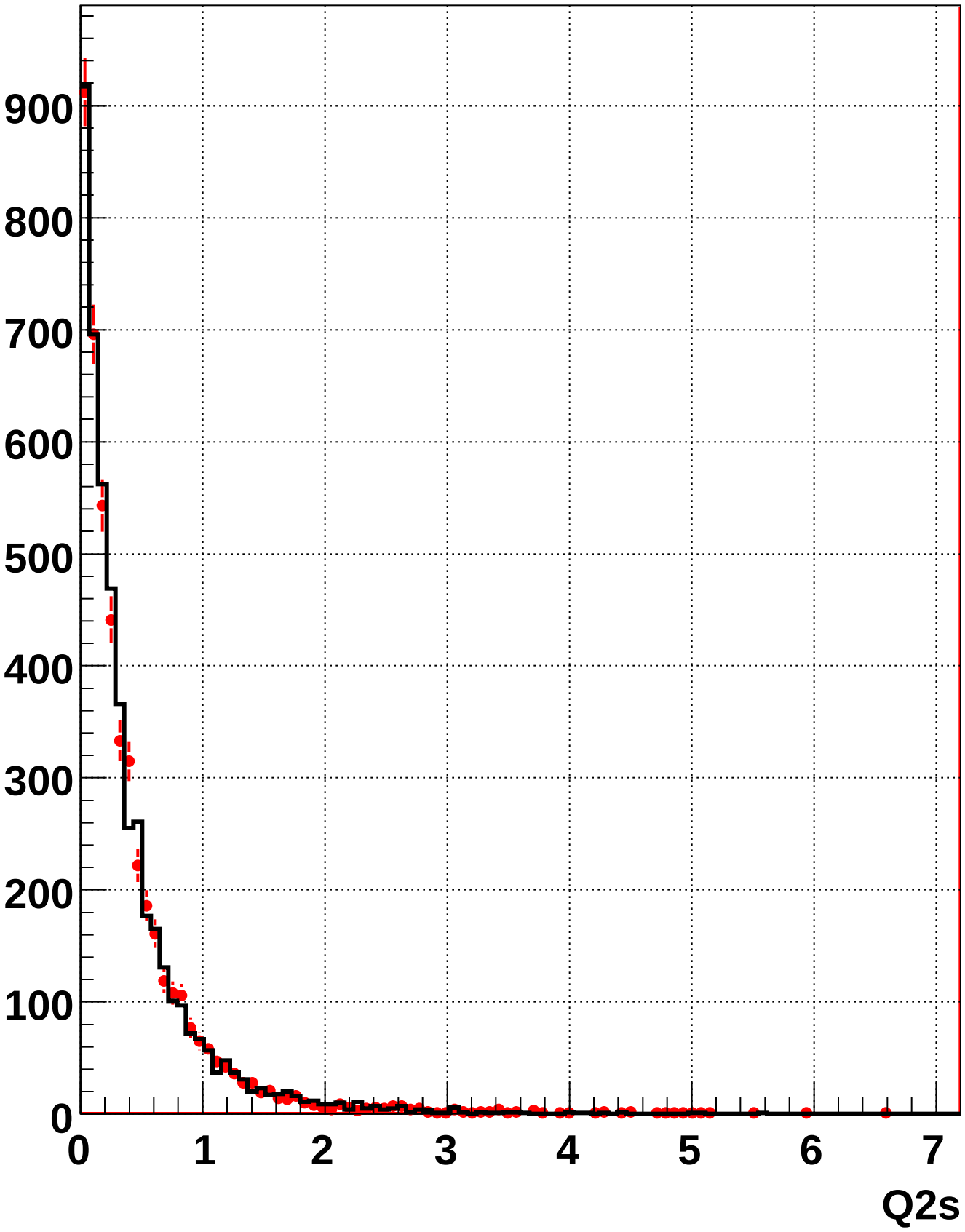
selected Q2 for QEL events



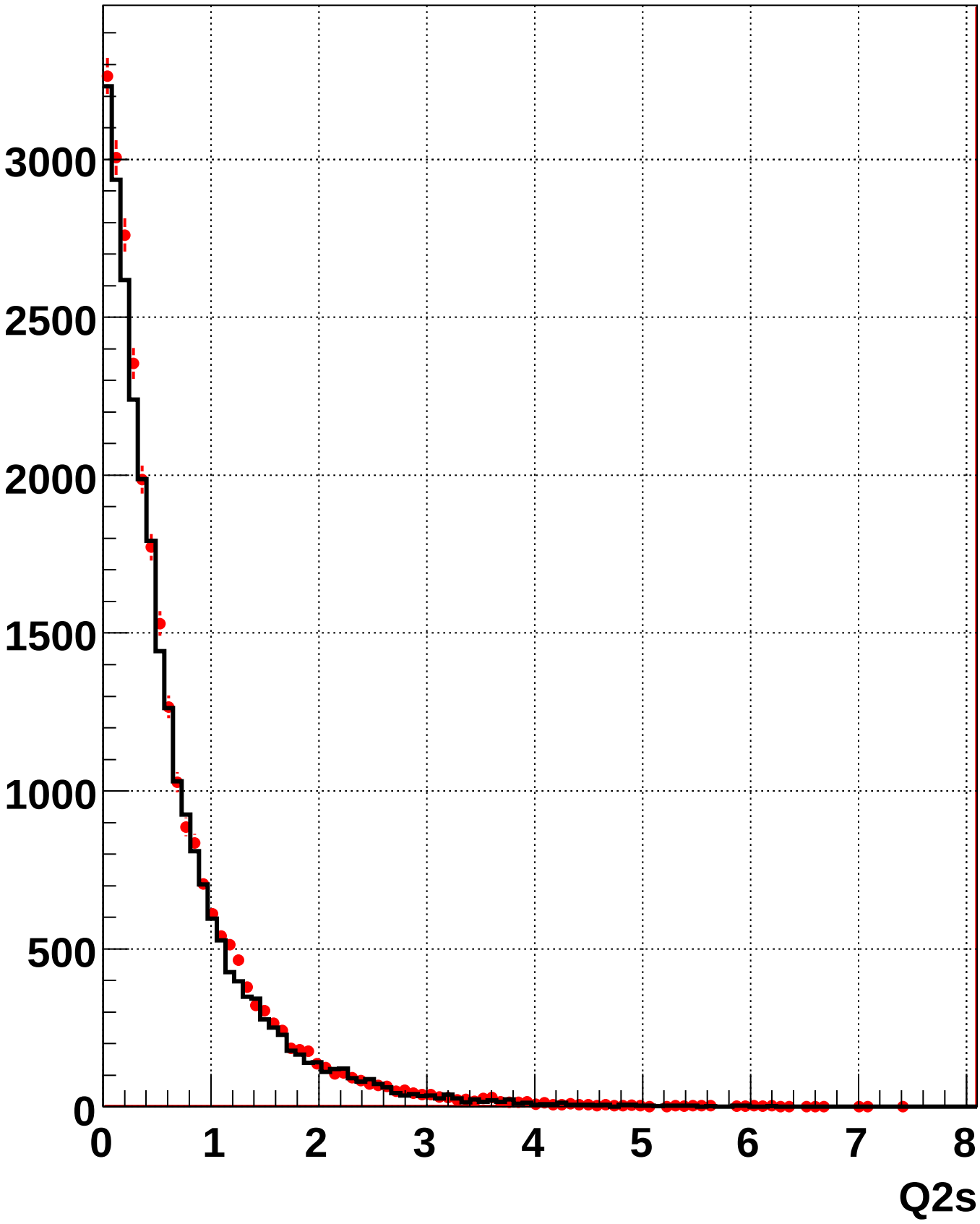
selected Q2 for QEL CC events



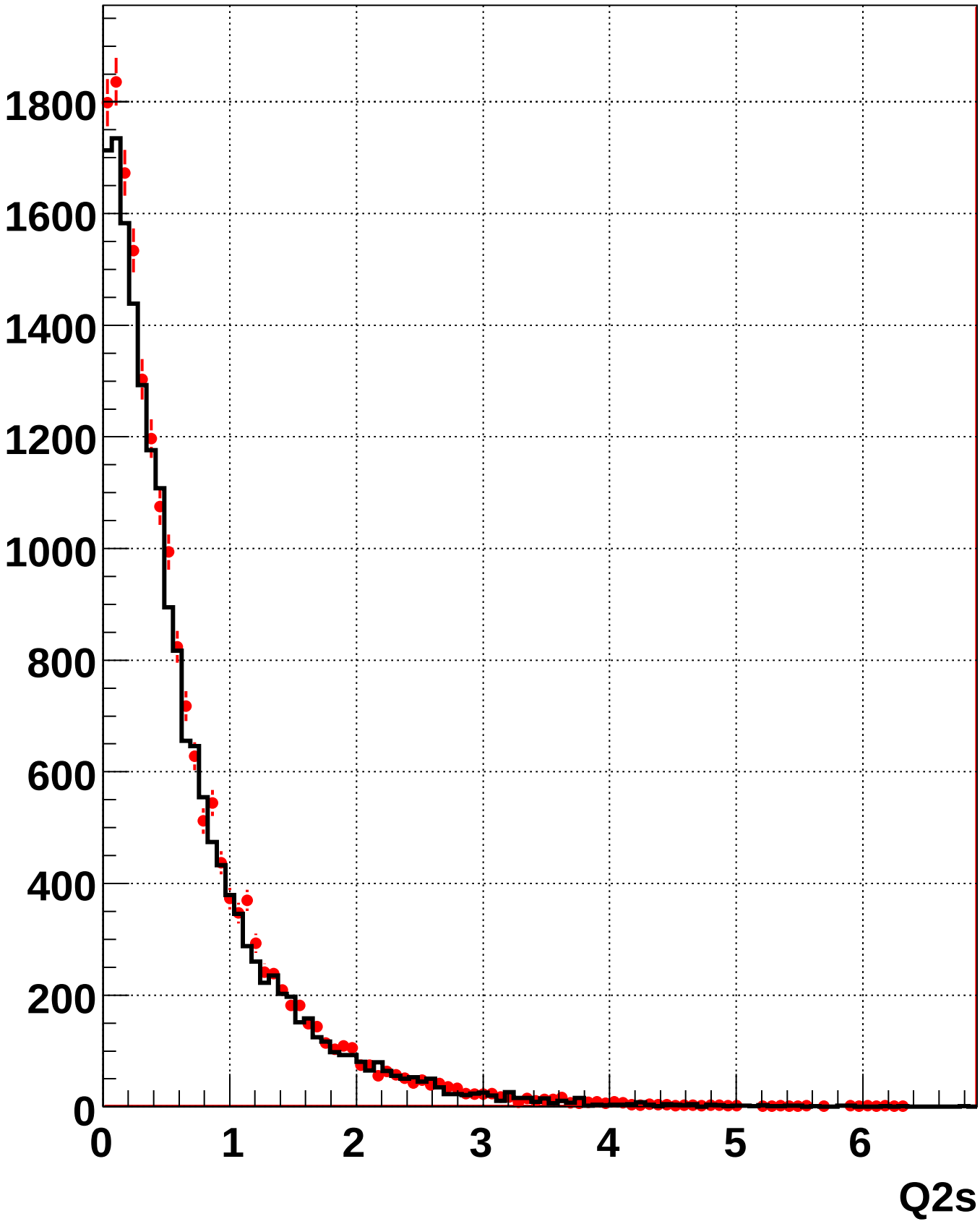
selected Q2 for QEL NC events



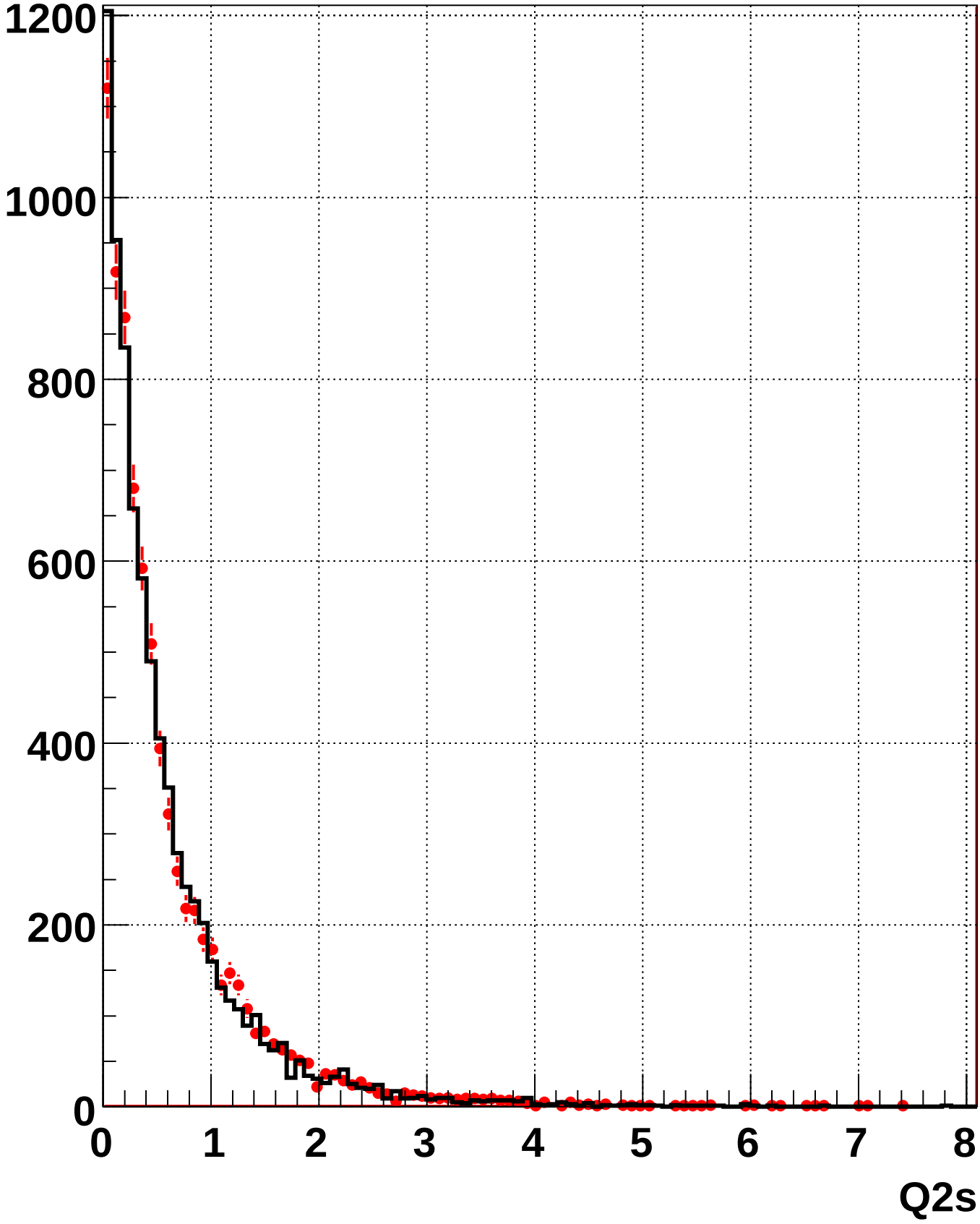
selected Q2 for RES events



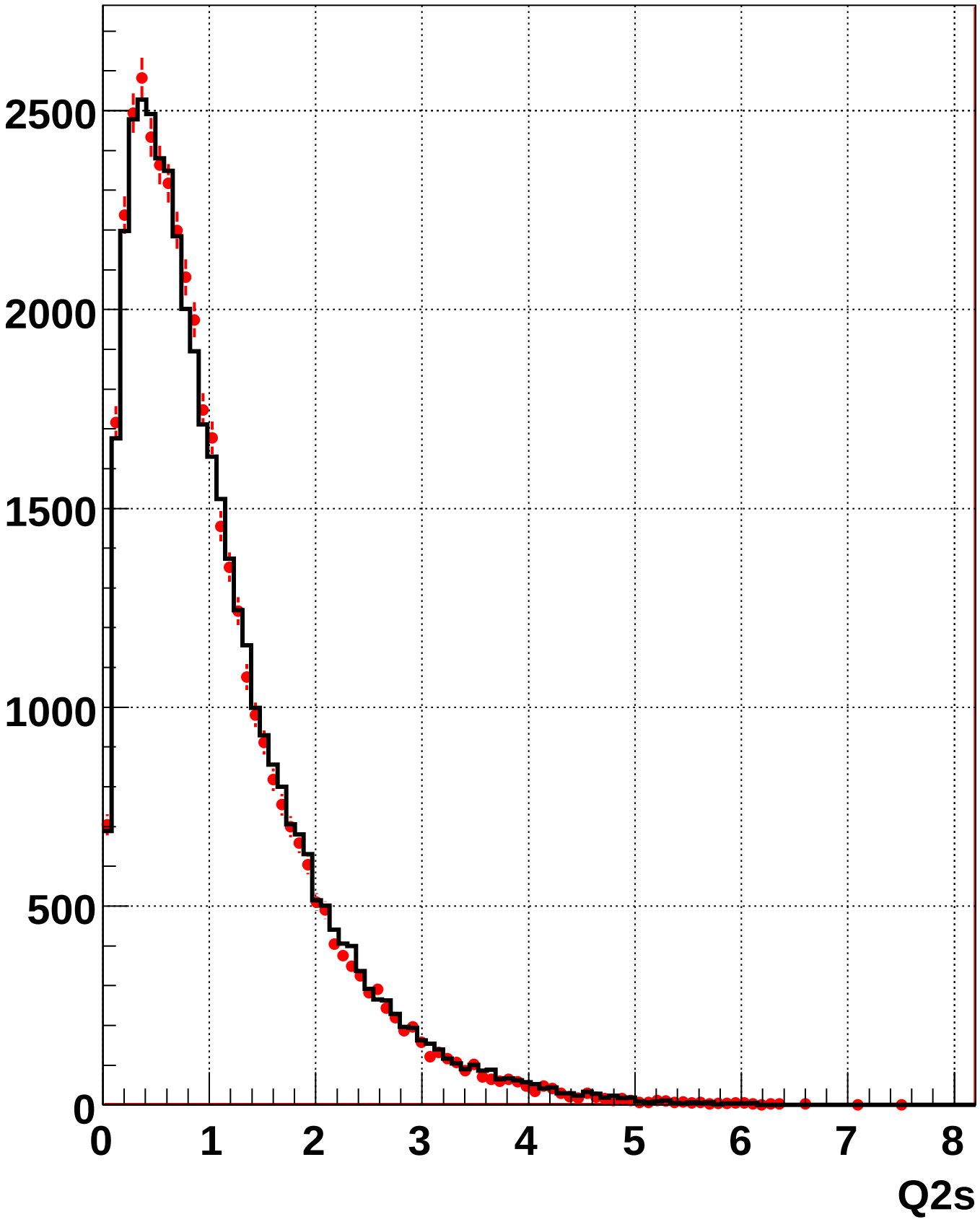
selected Q2 for RES CC events



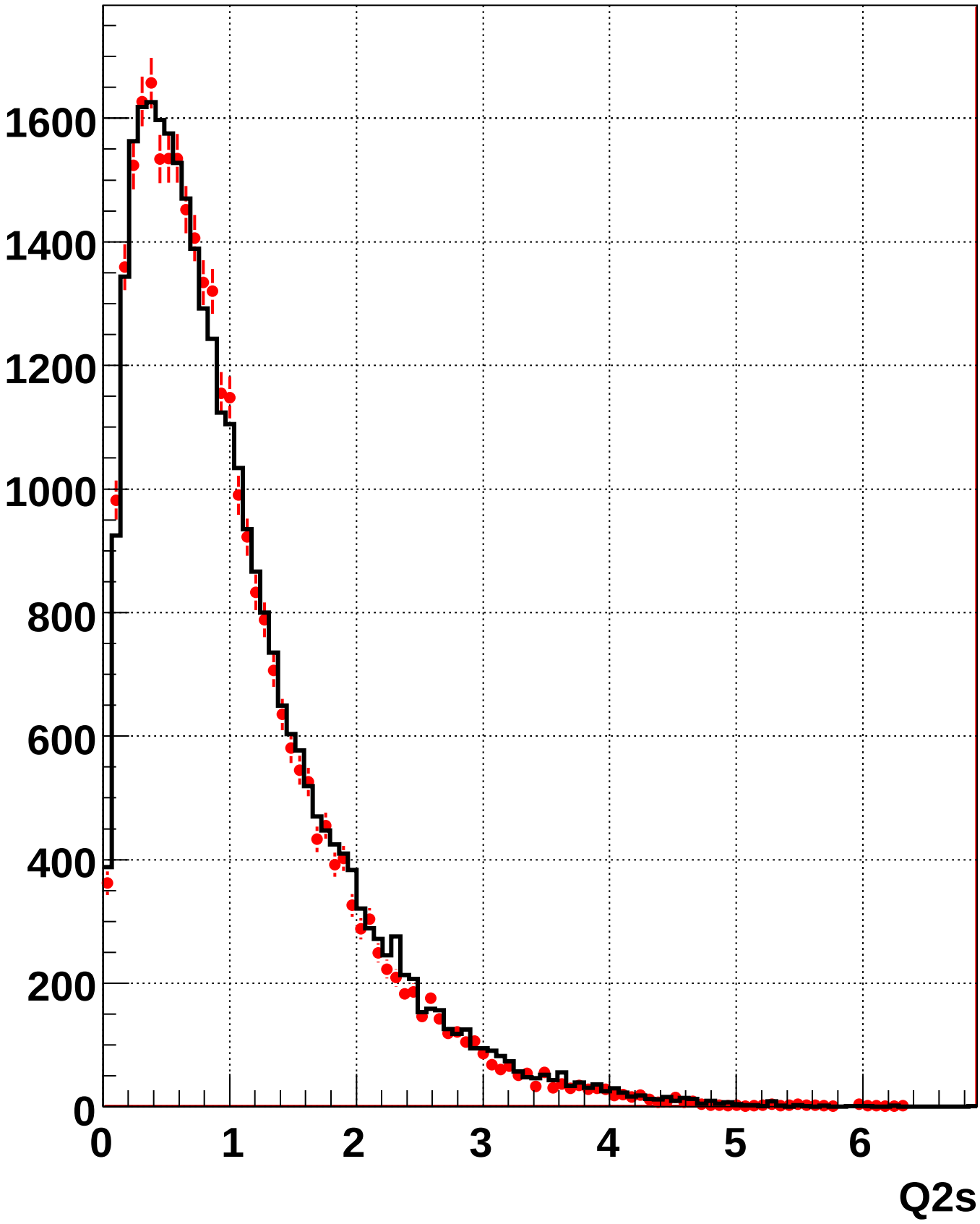
selected Q2 for RES NC events



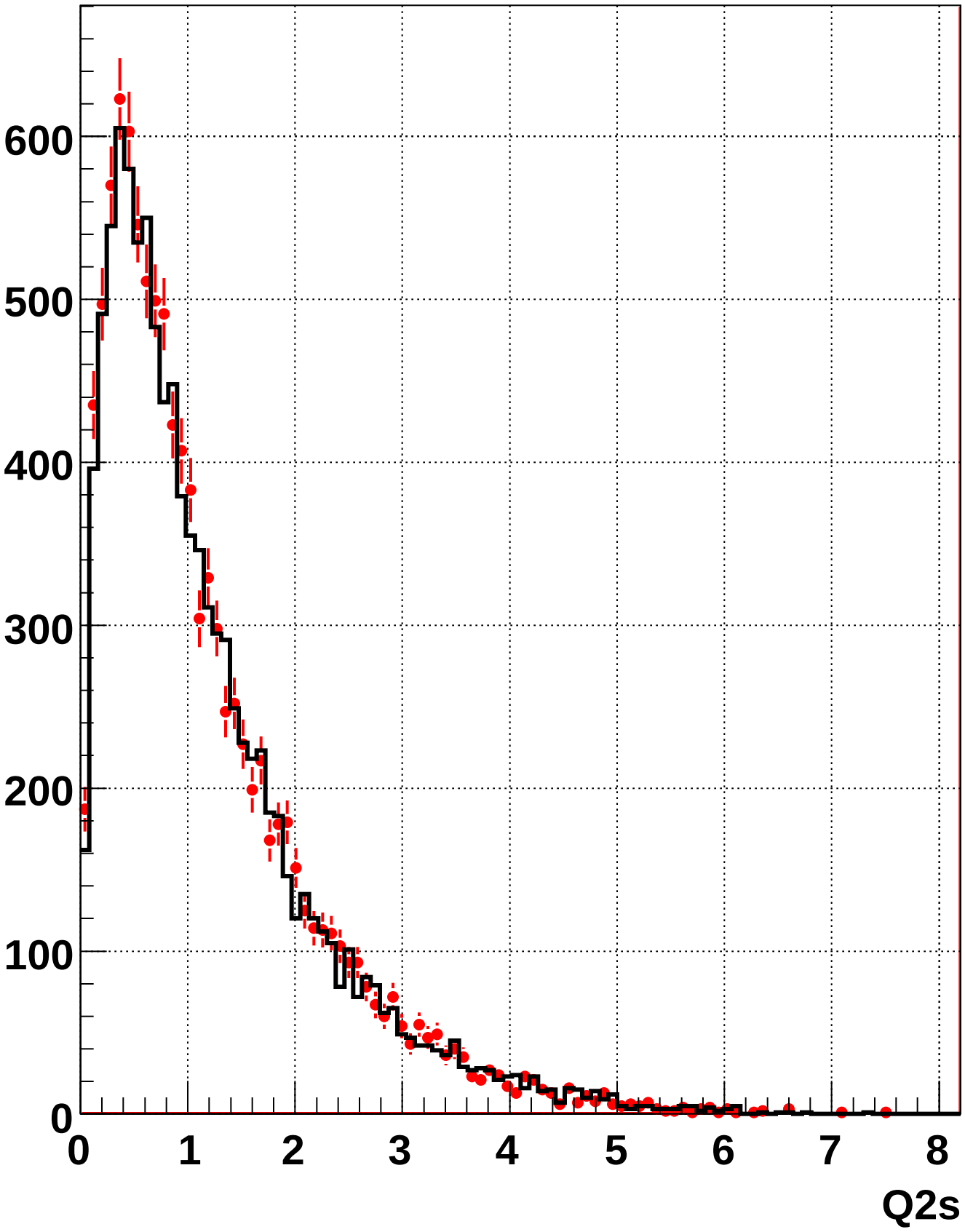
selected Q2 for DIS events



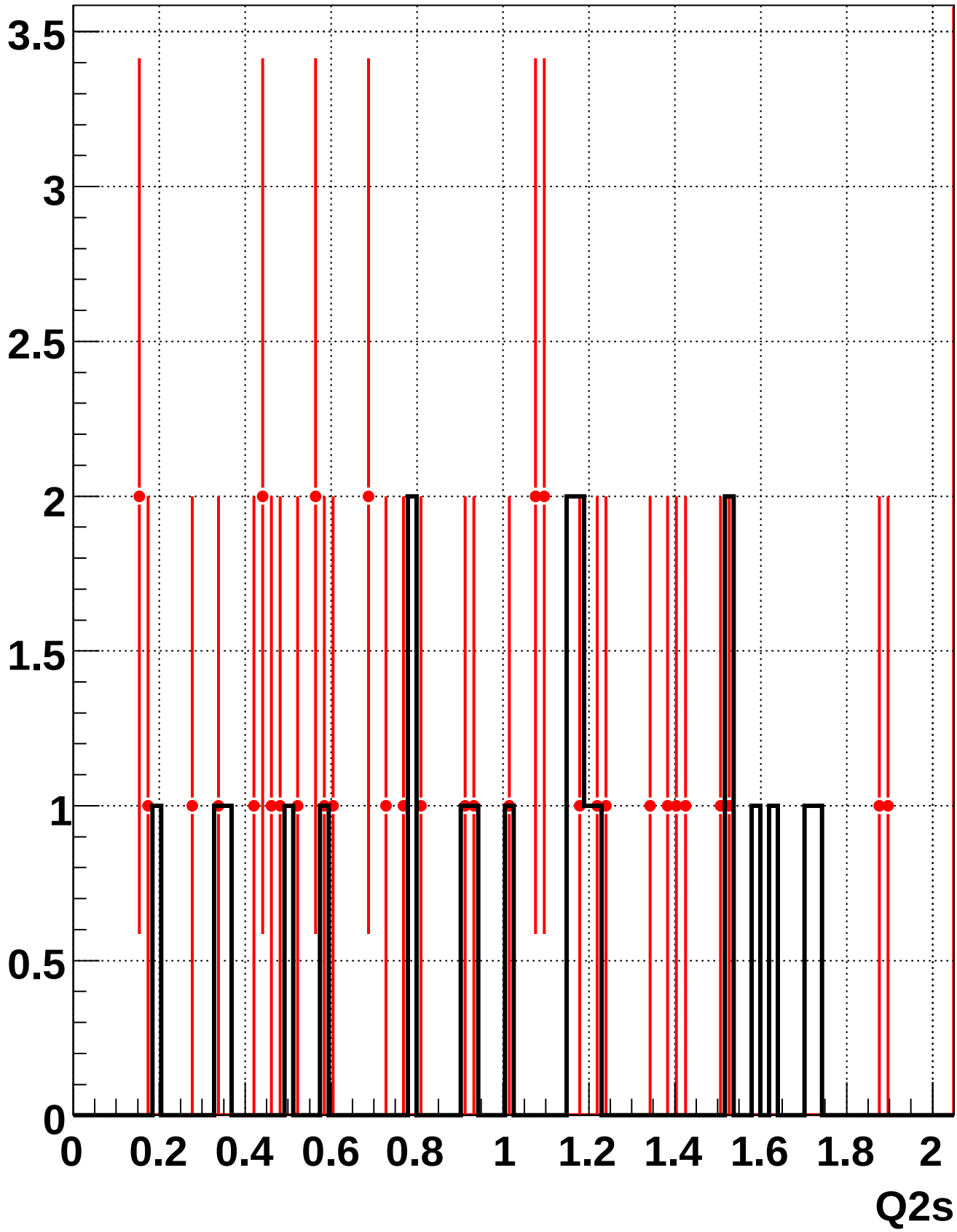
selected Q2 for DIS CC events



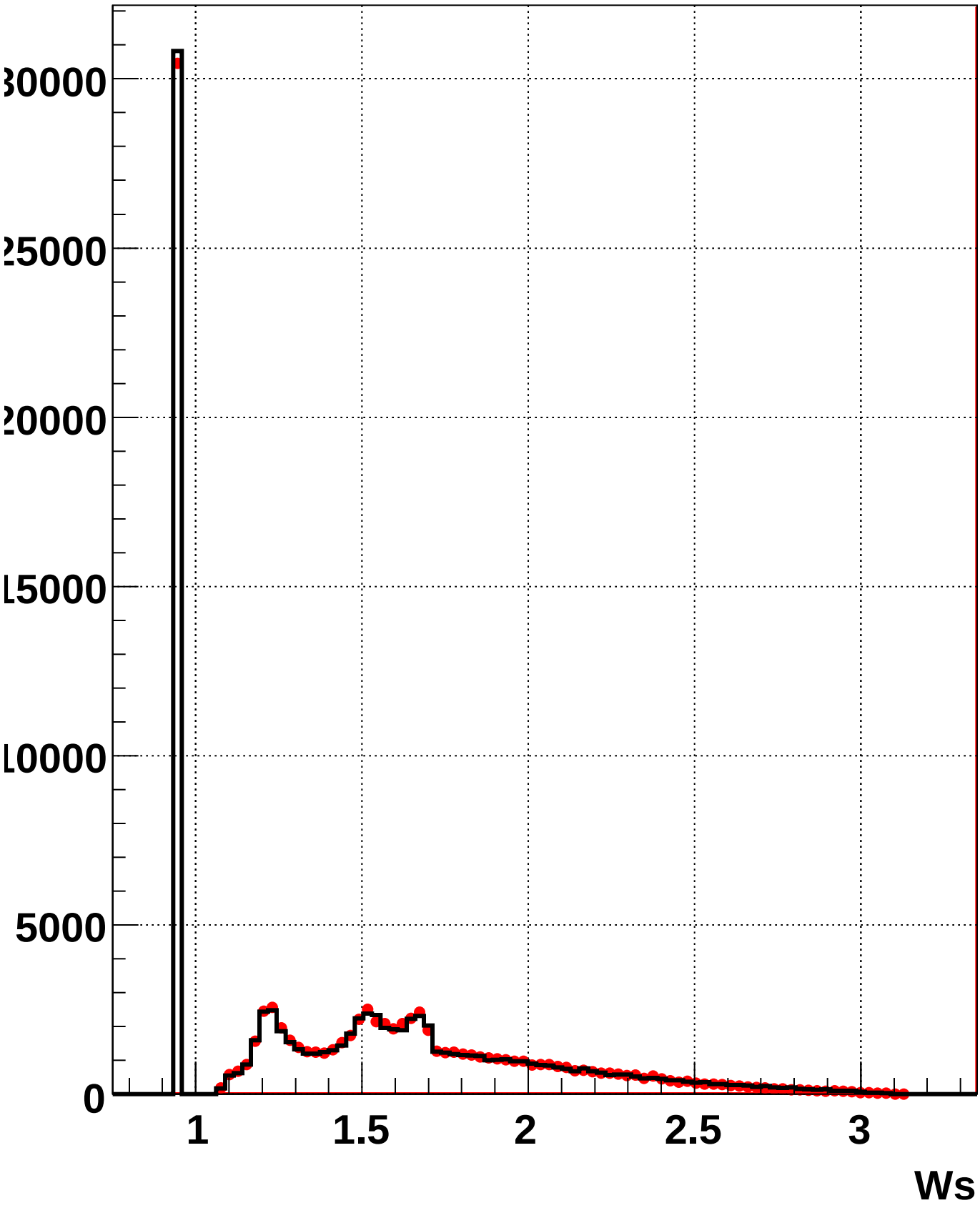
selected Q2 for DIS NC events



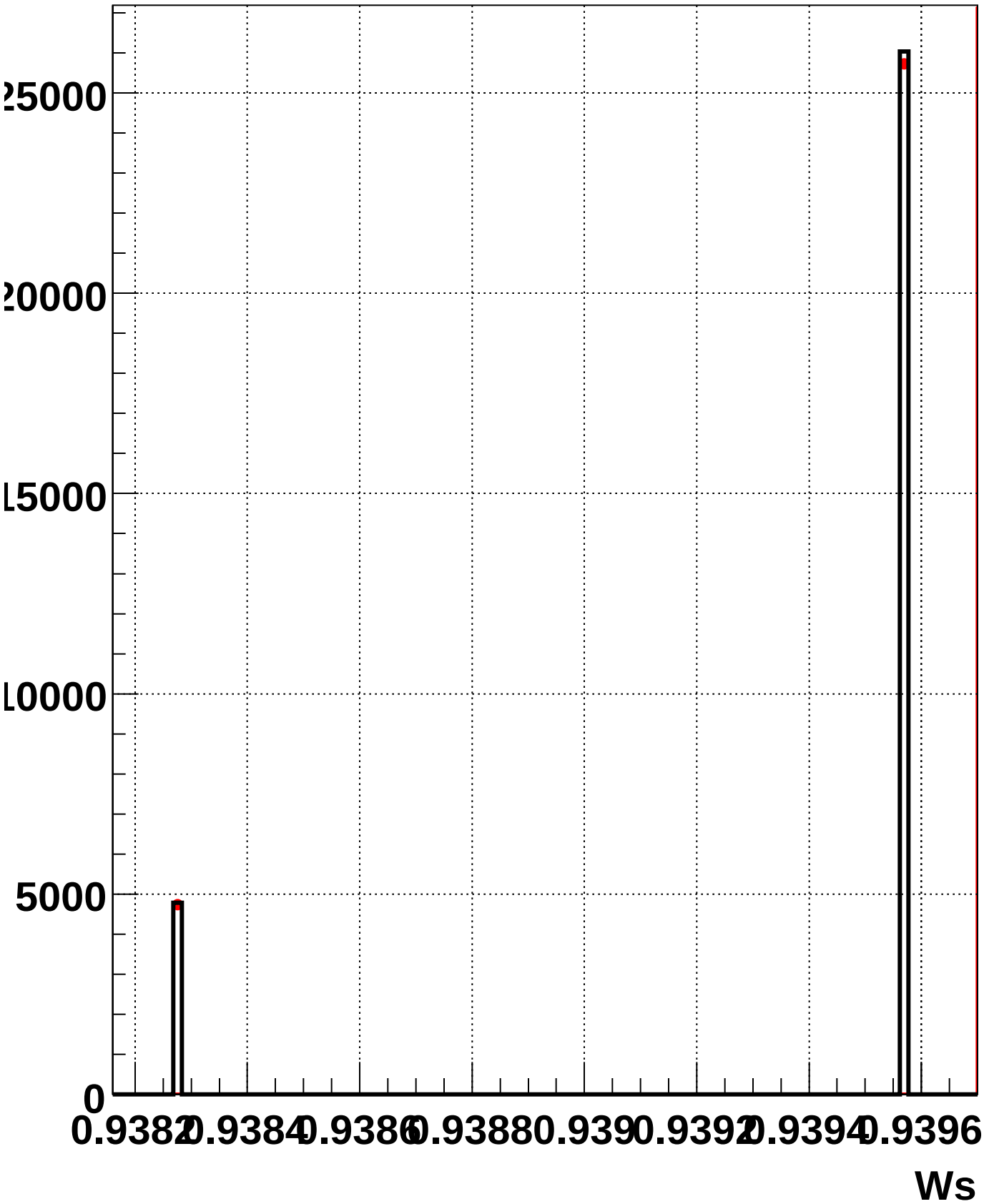
selected Q2 for Charm/DIS events



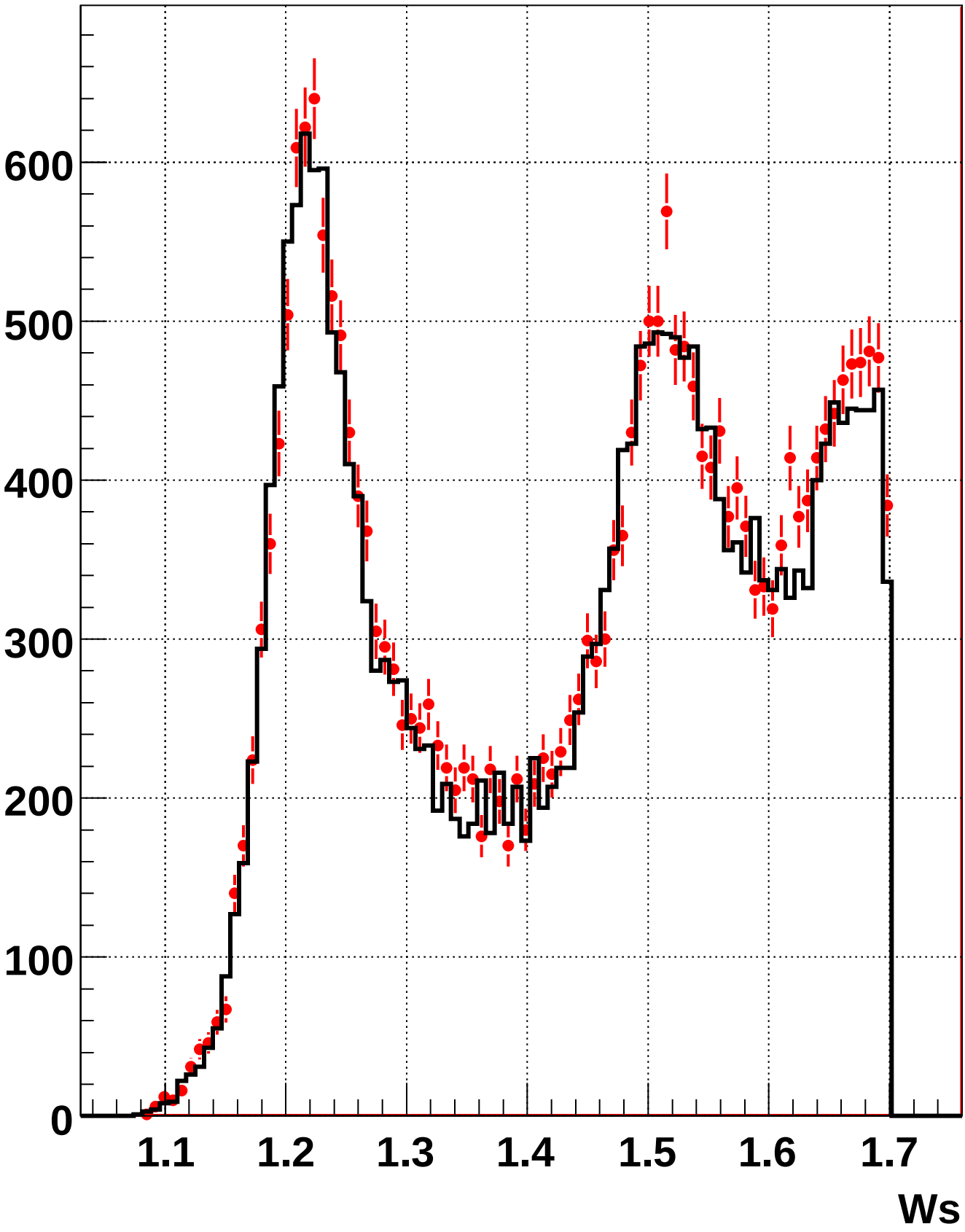
selected W for all events



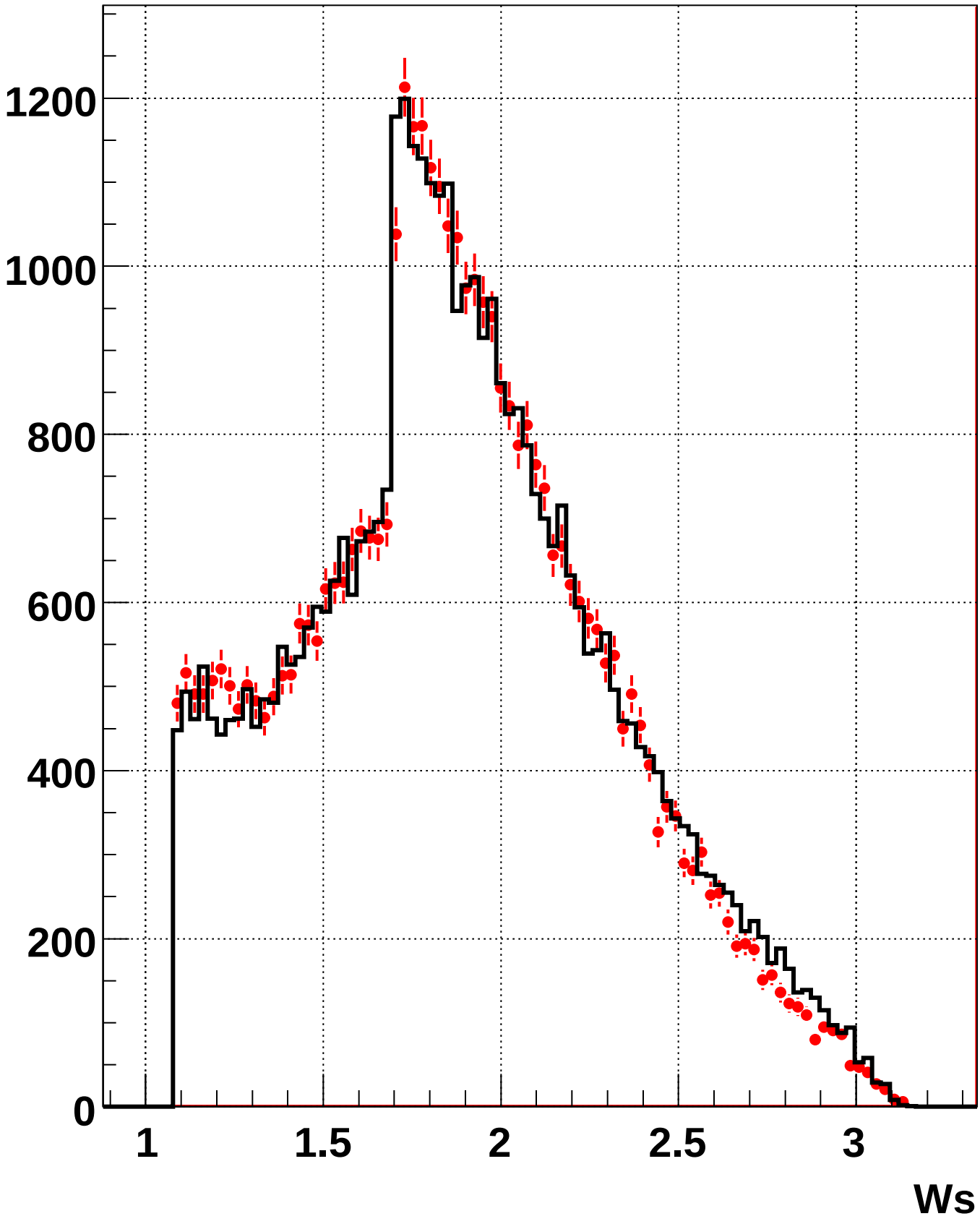
selected W for QEL events



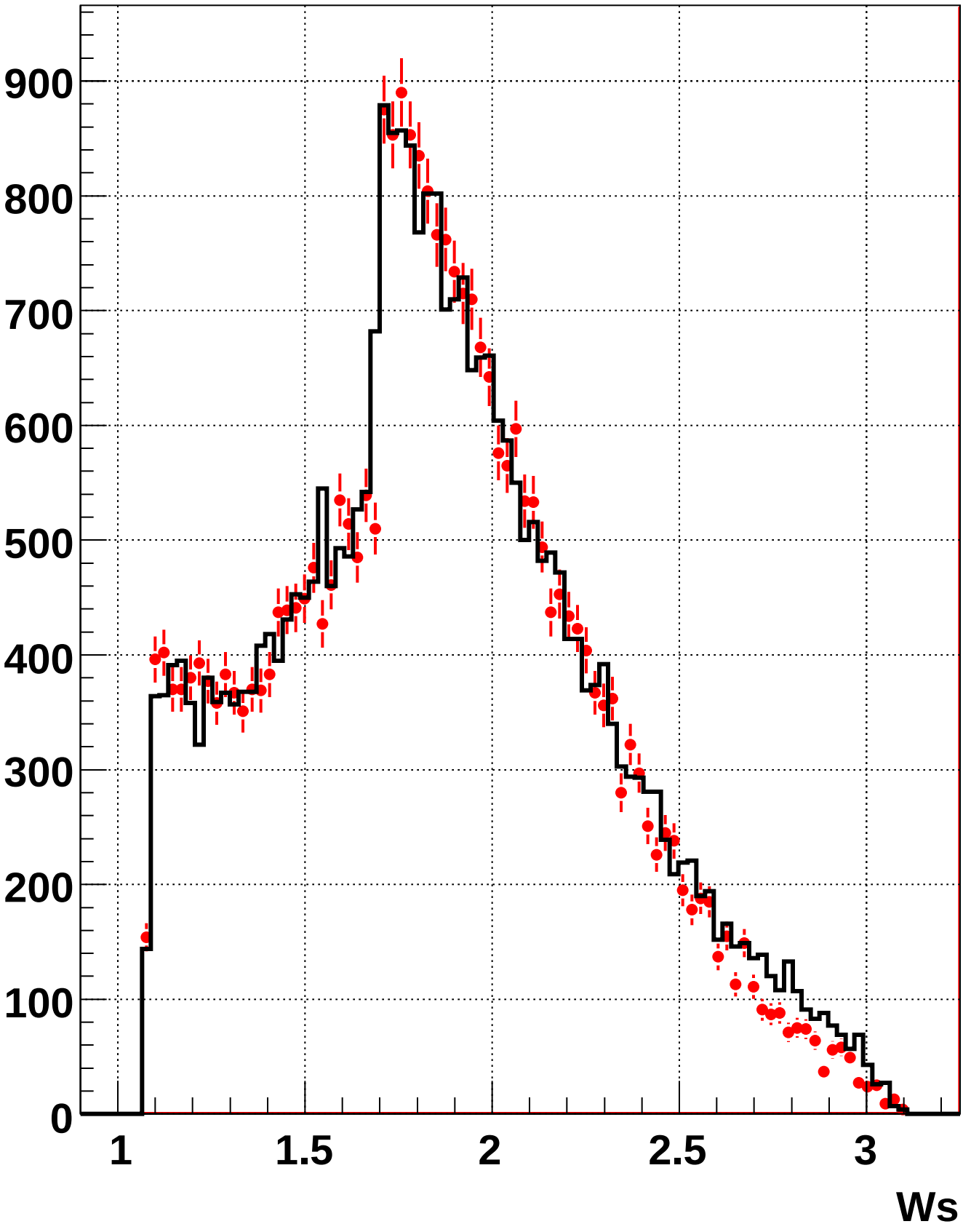
selected W for RES events



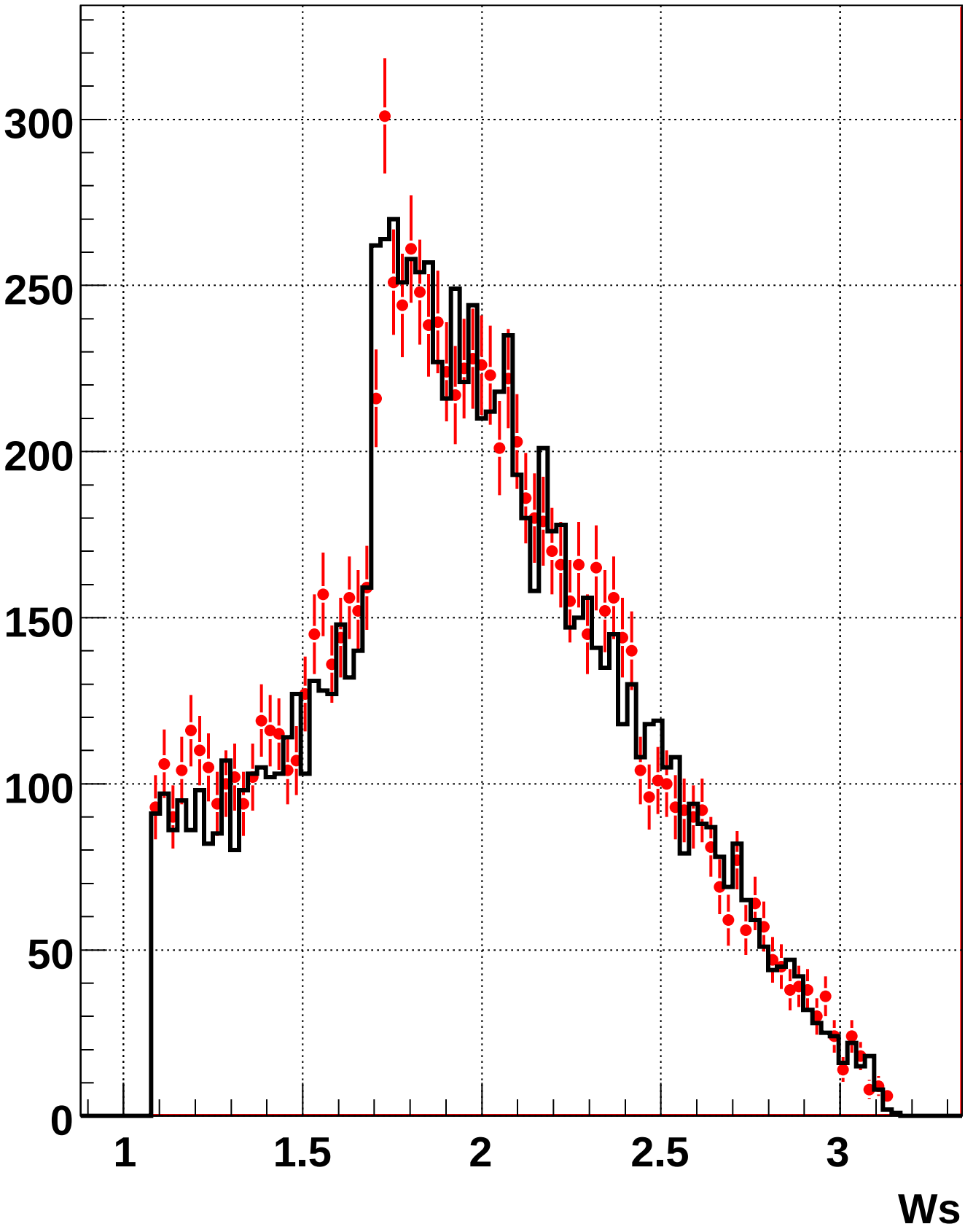
selected W for DIS events



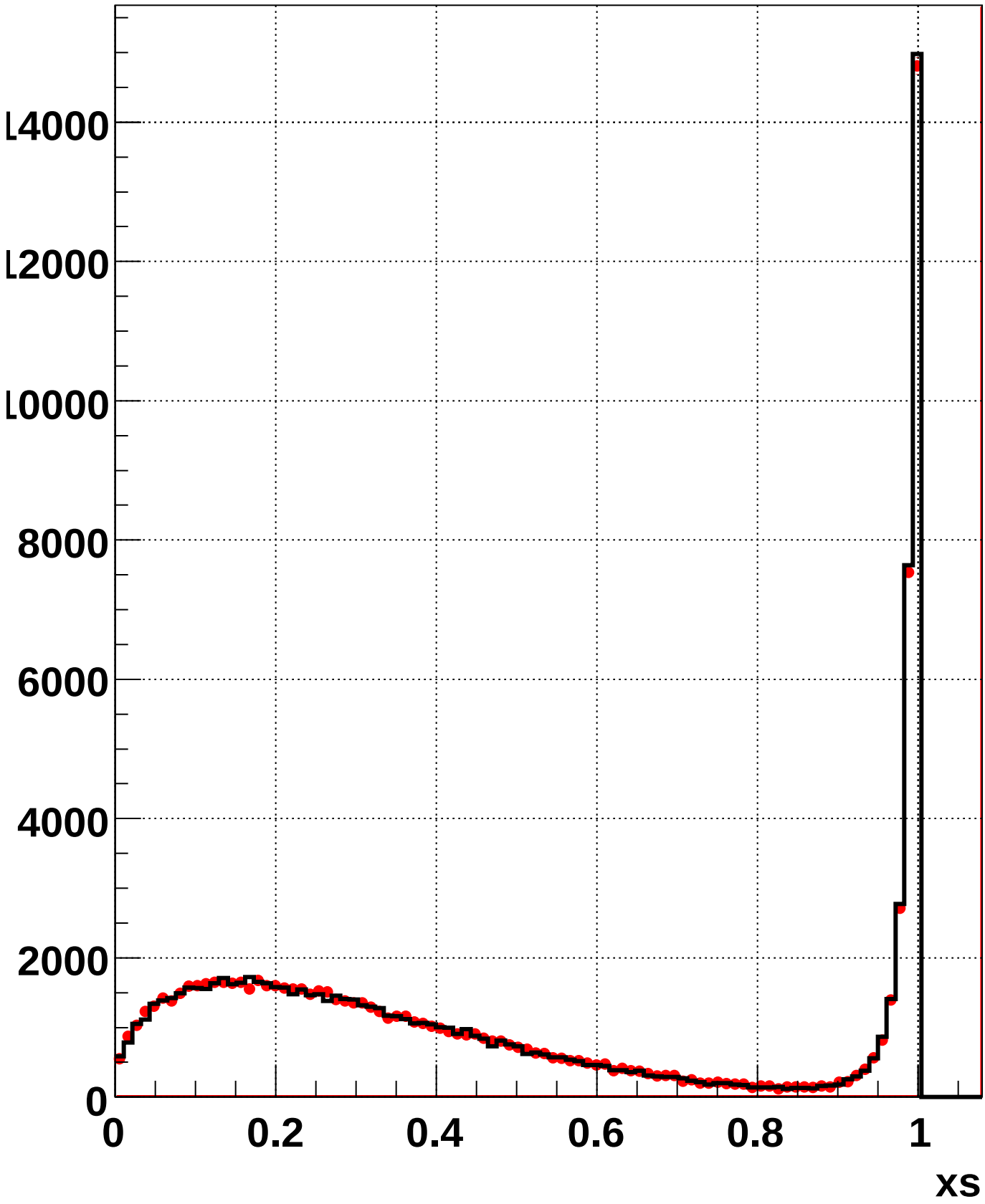
selected W for DIS CC events



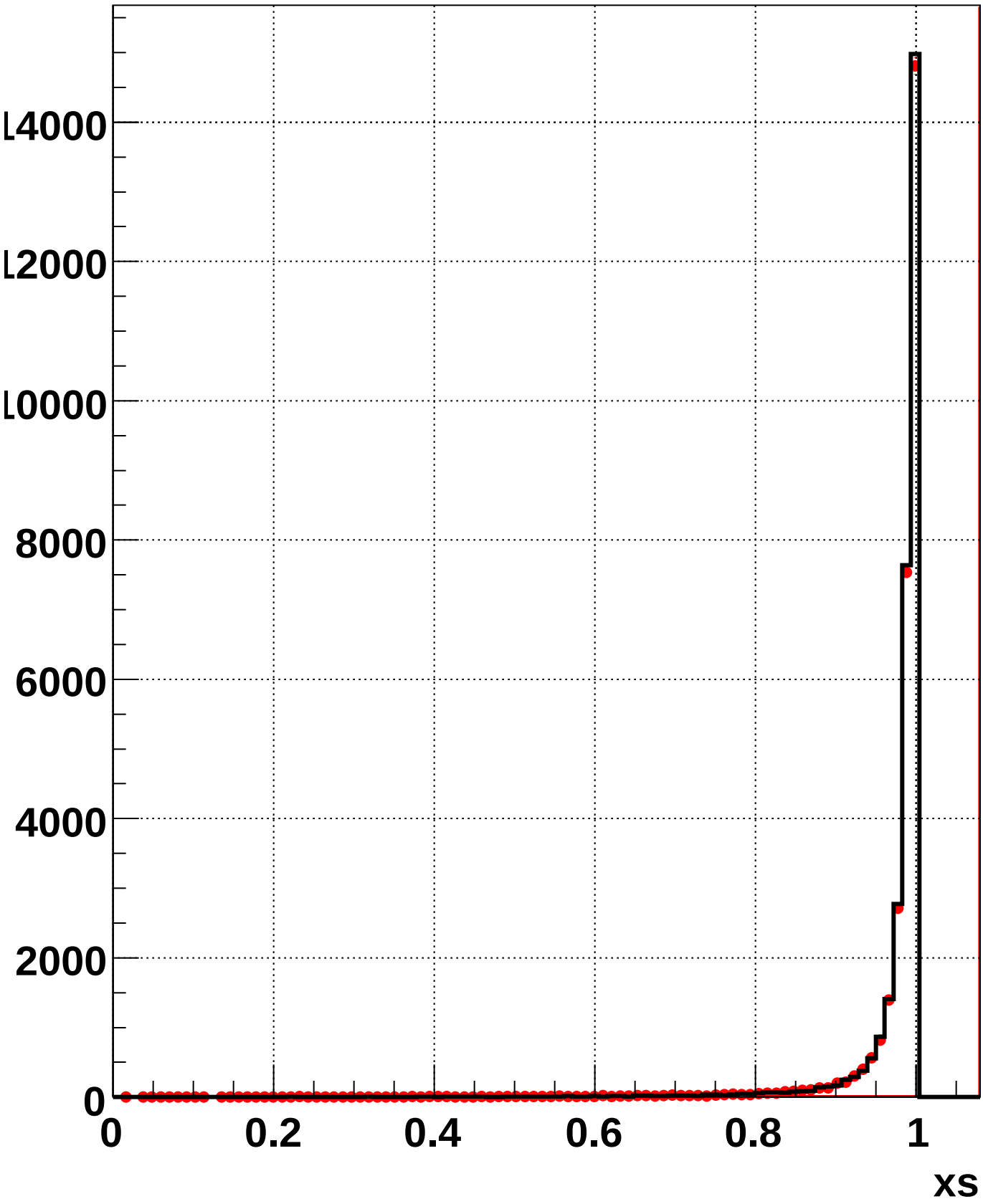
selected W for DIS NC events



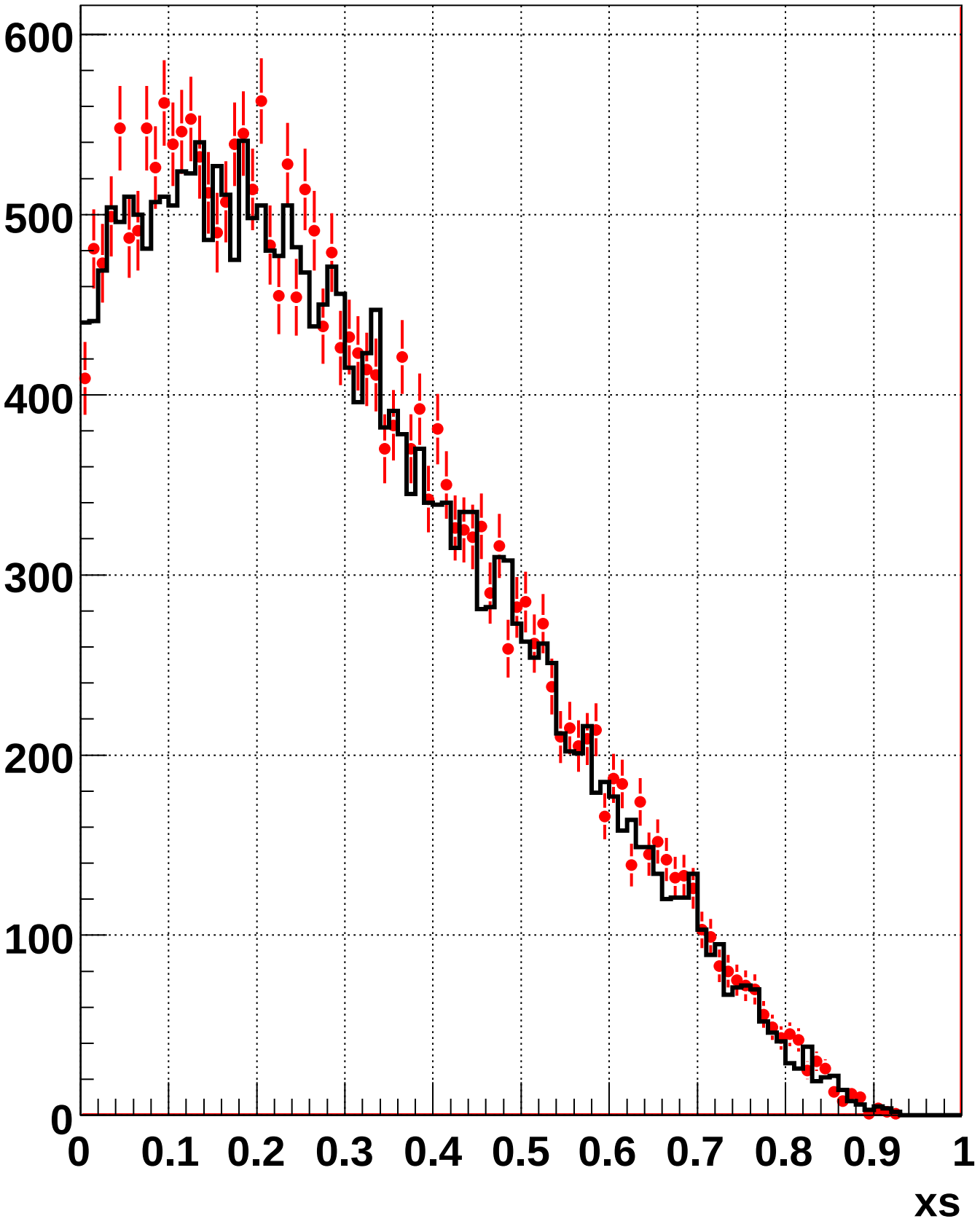
selected x for all events



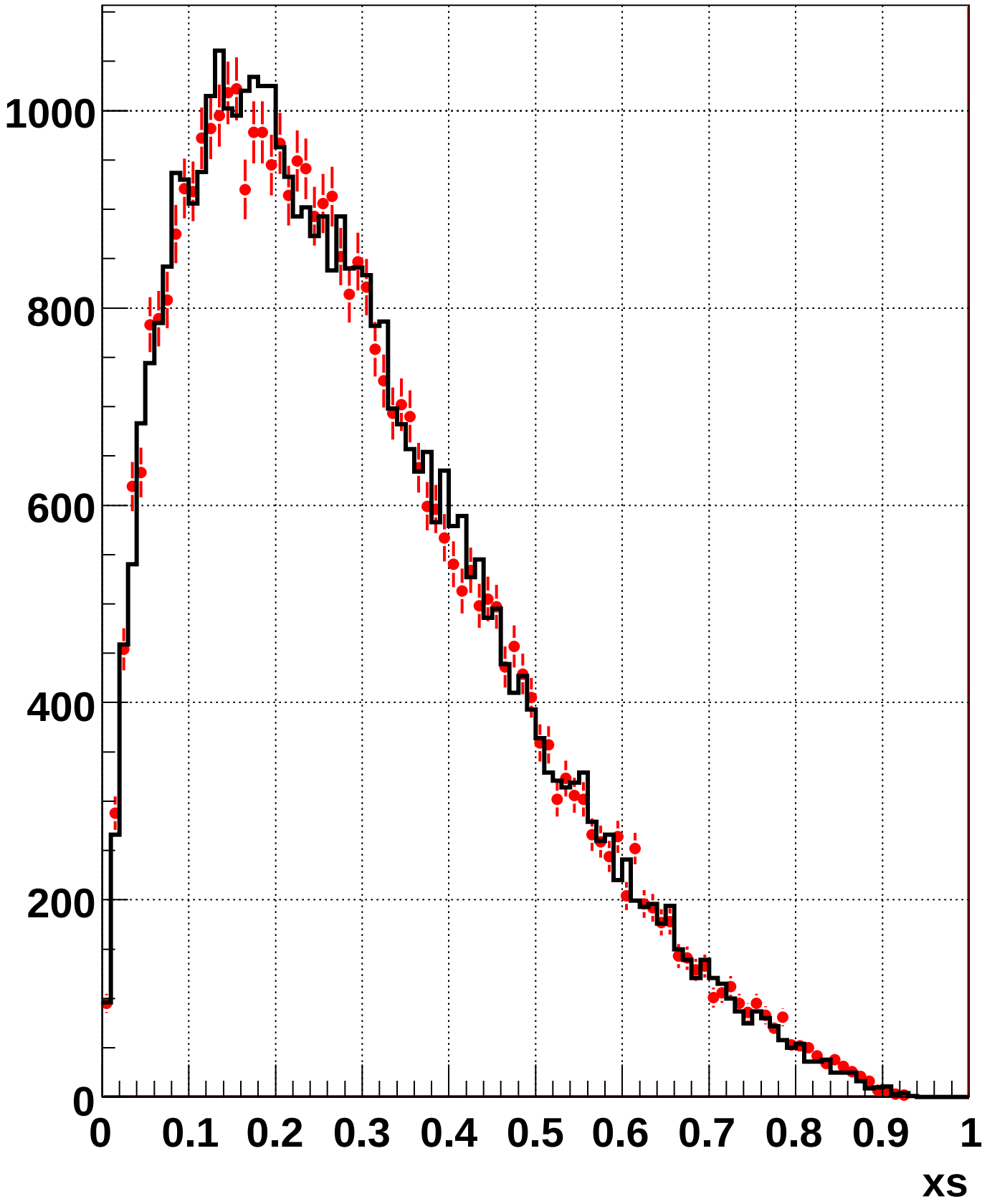
selected x for QEL events



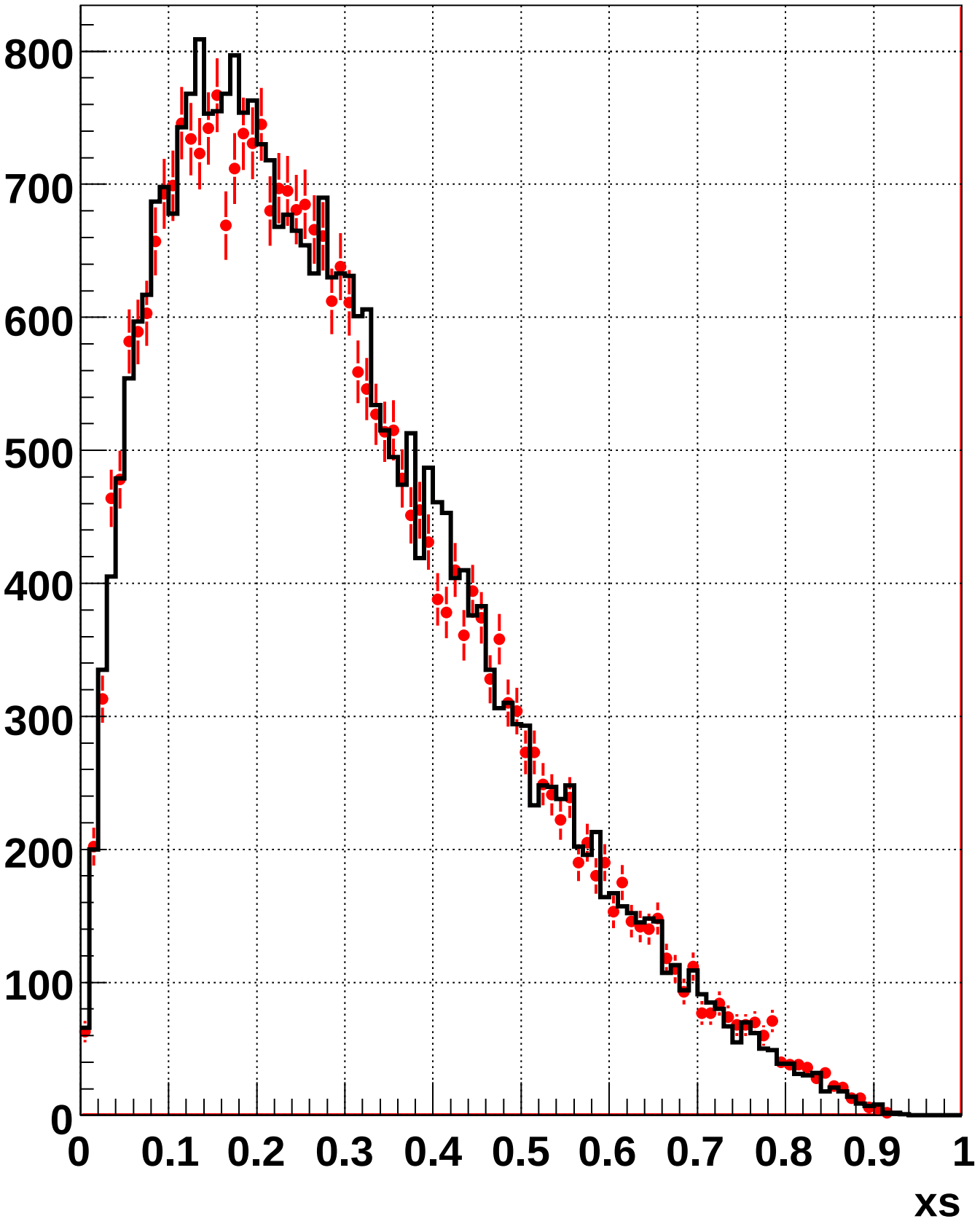
selected x for RES events



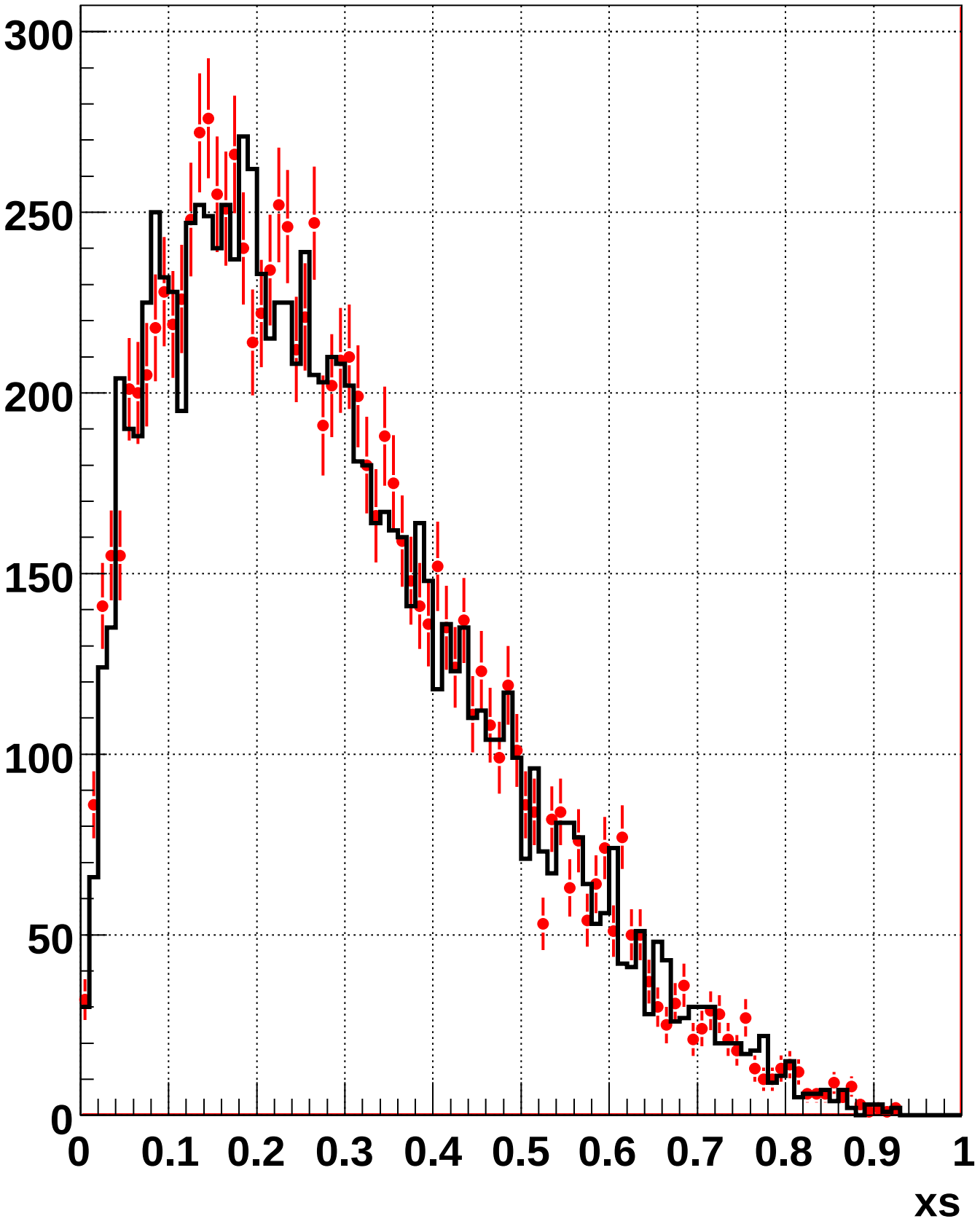
selected x for DIS events



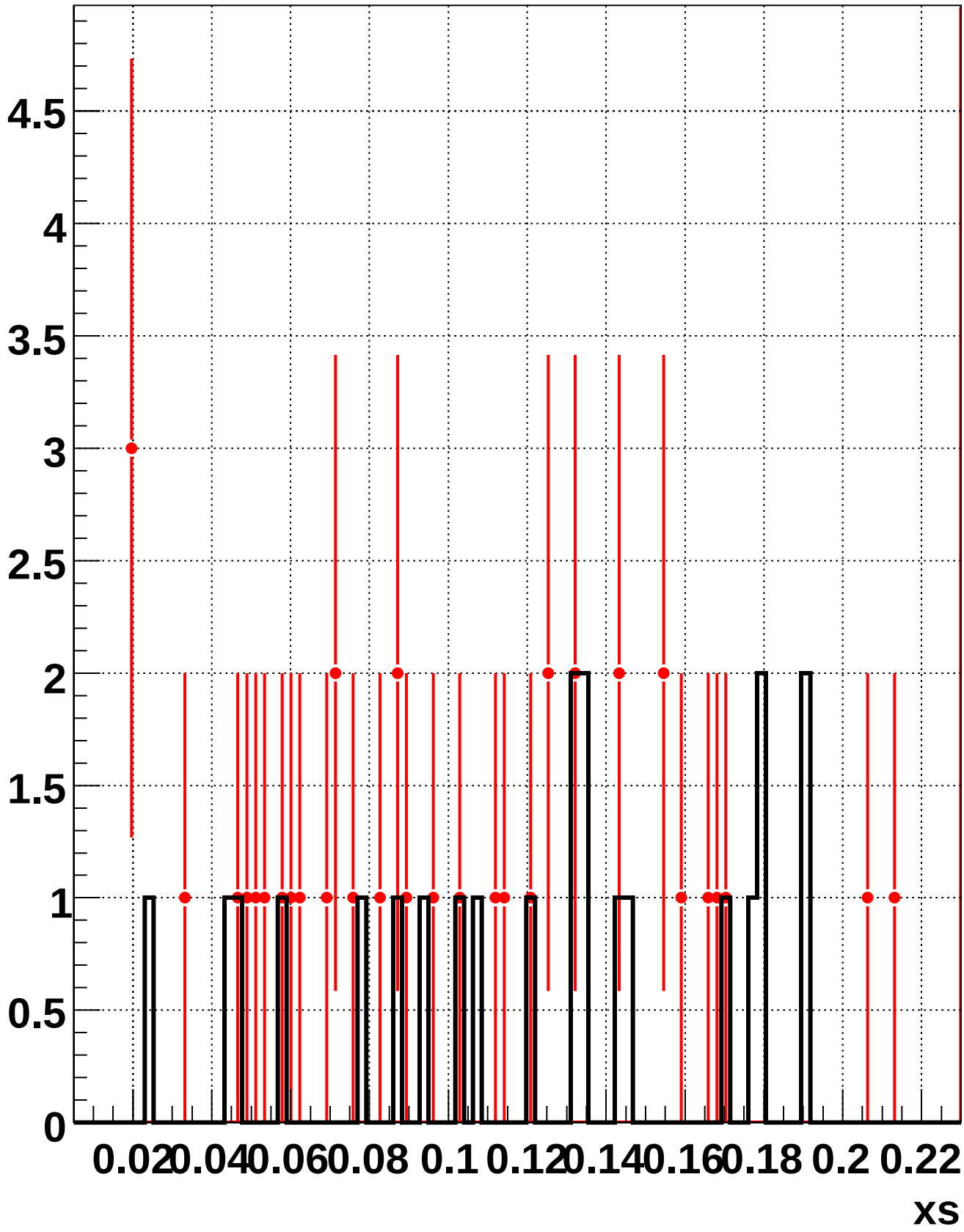
selected x for DIS CC events



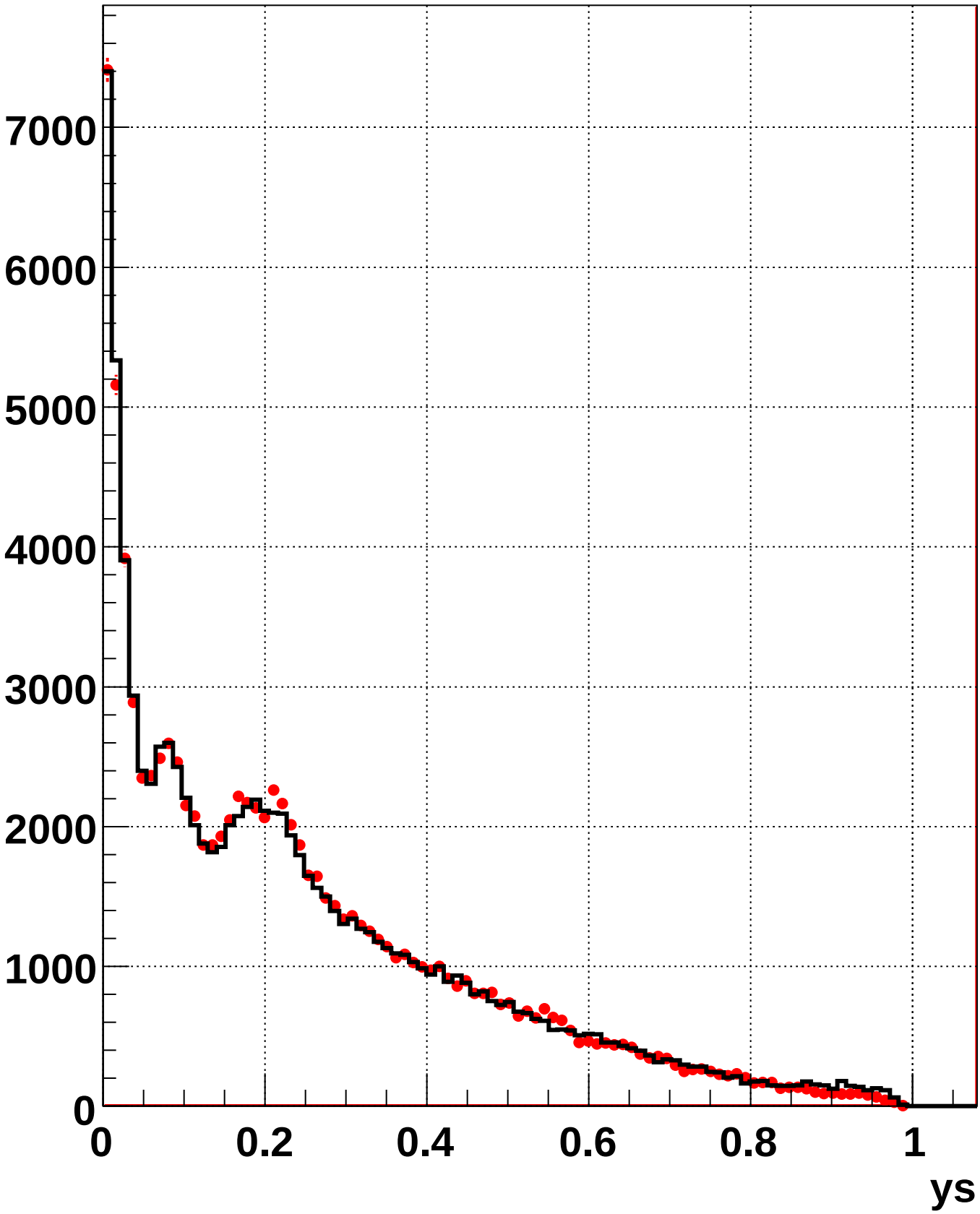
selected x for DIS NC events



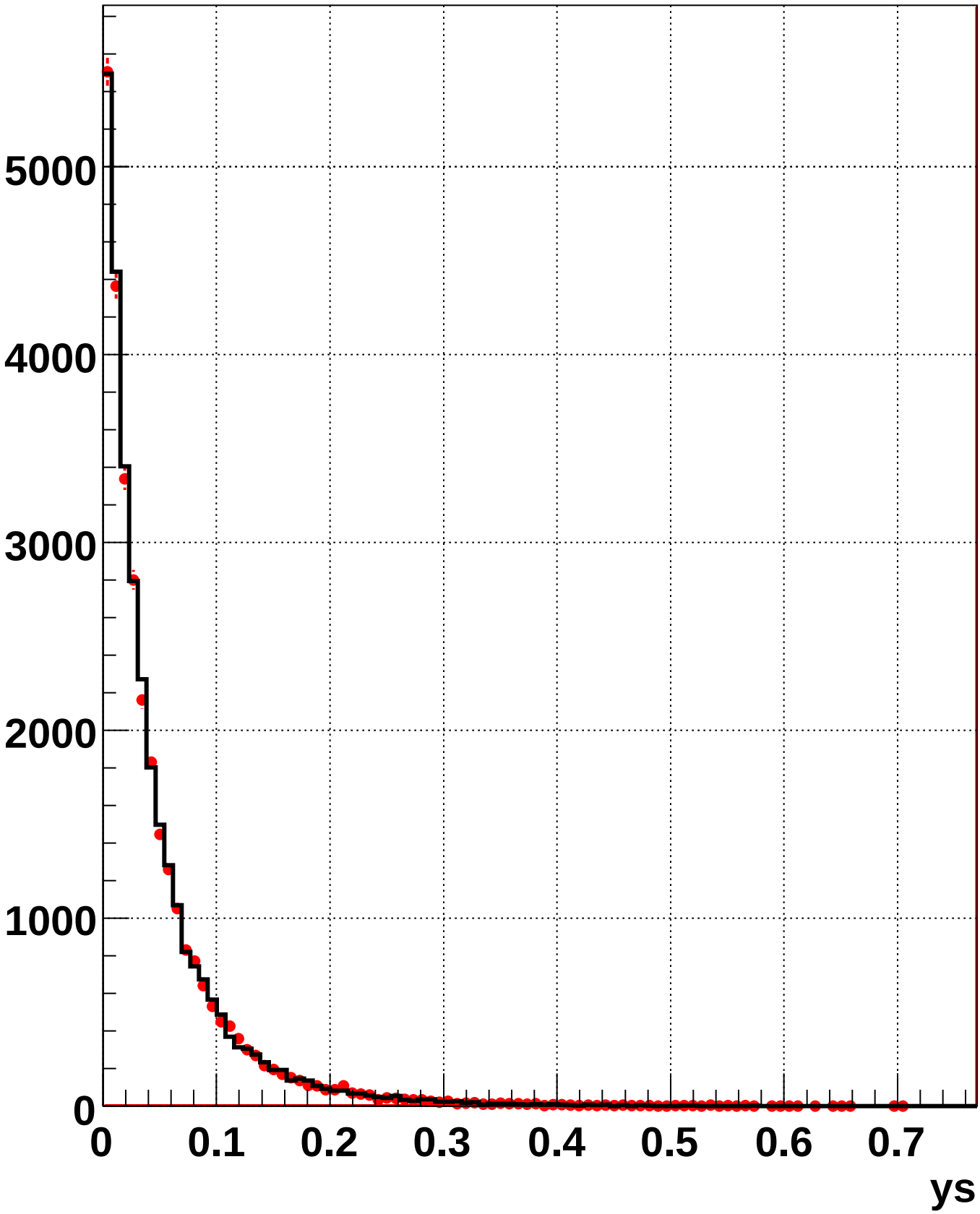
selected x for Charm/DIS events



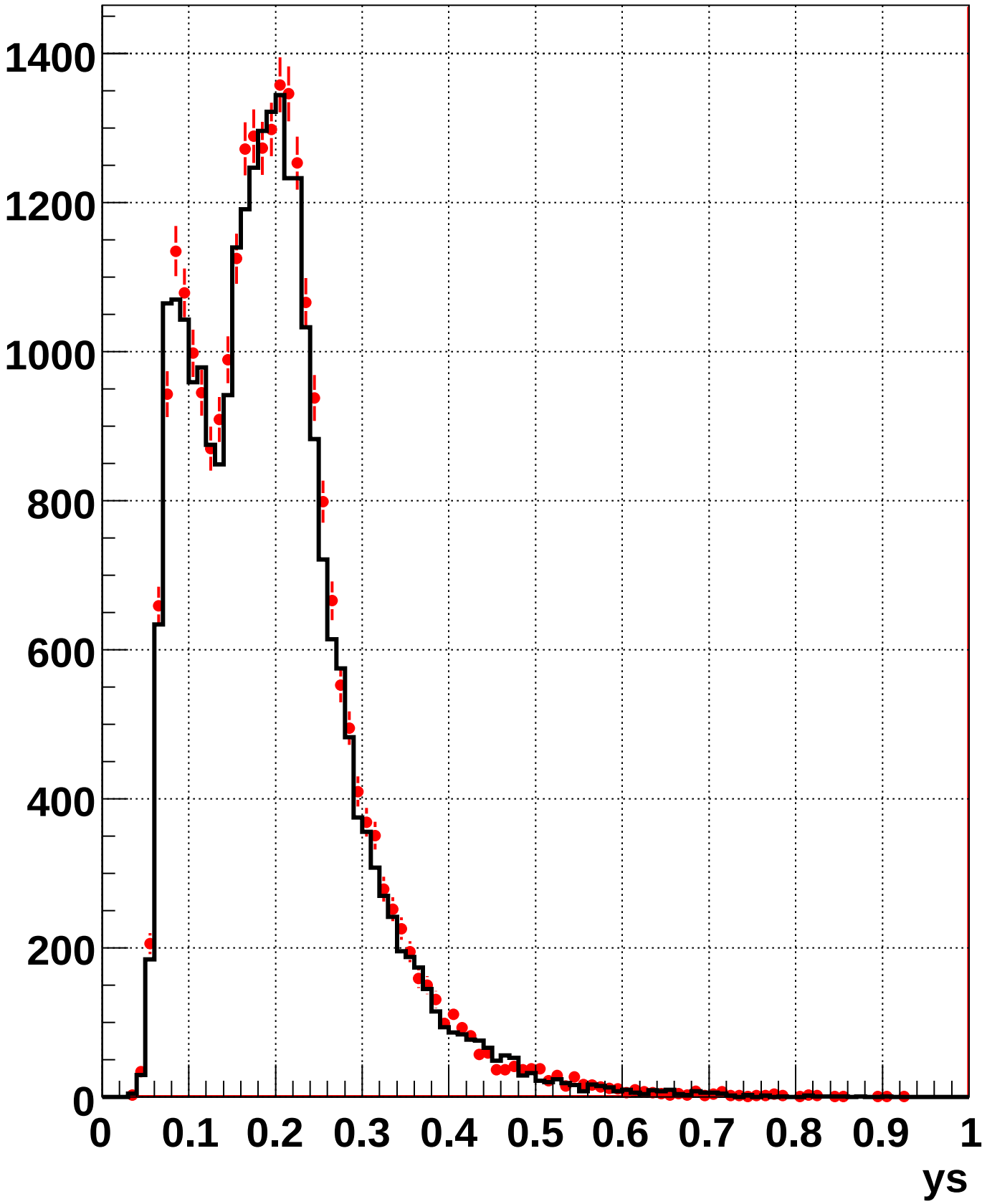
selected y for all events



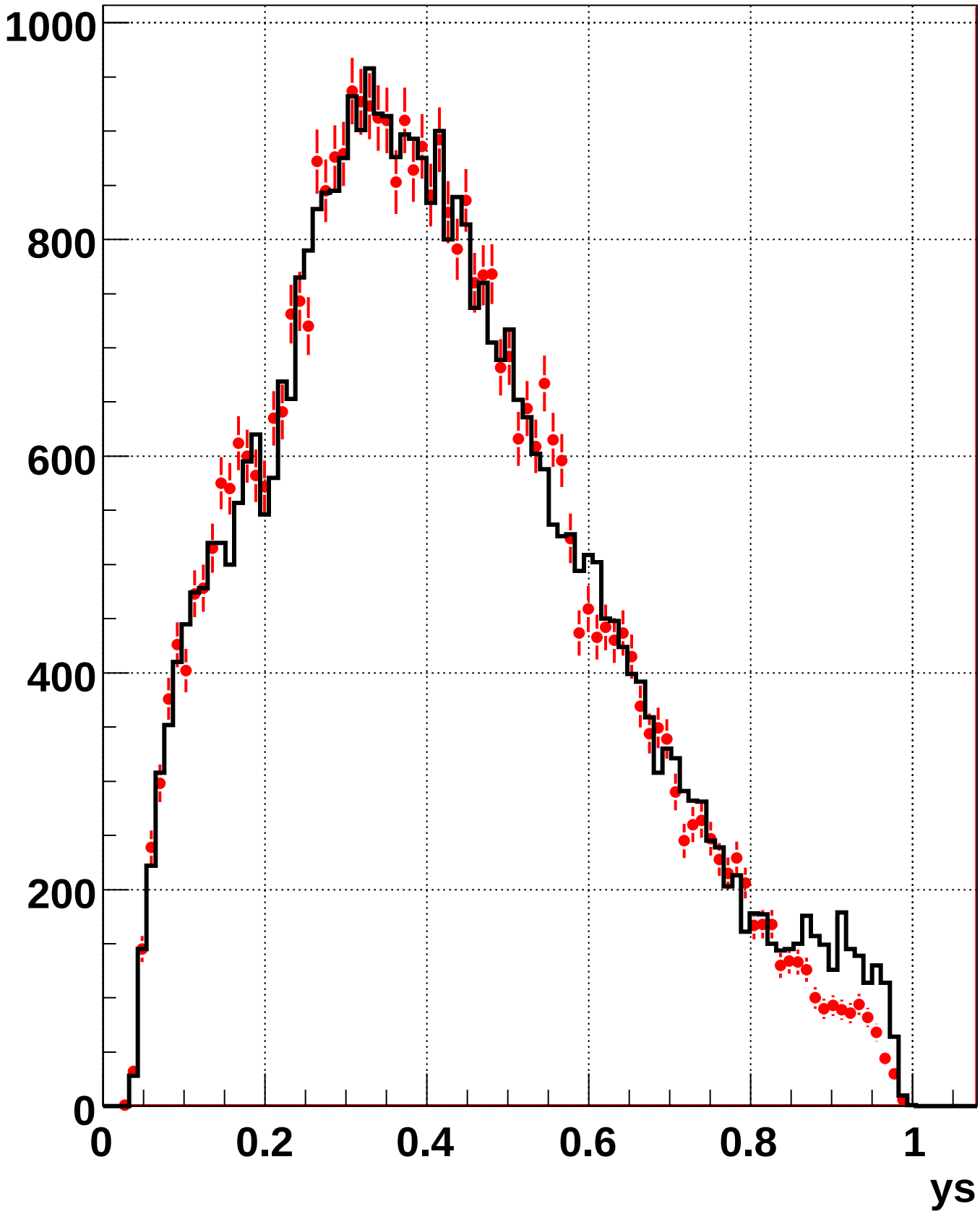
selected y for QEL events



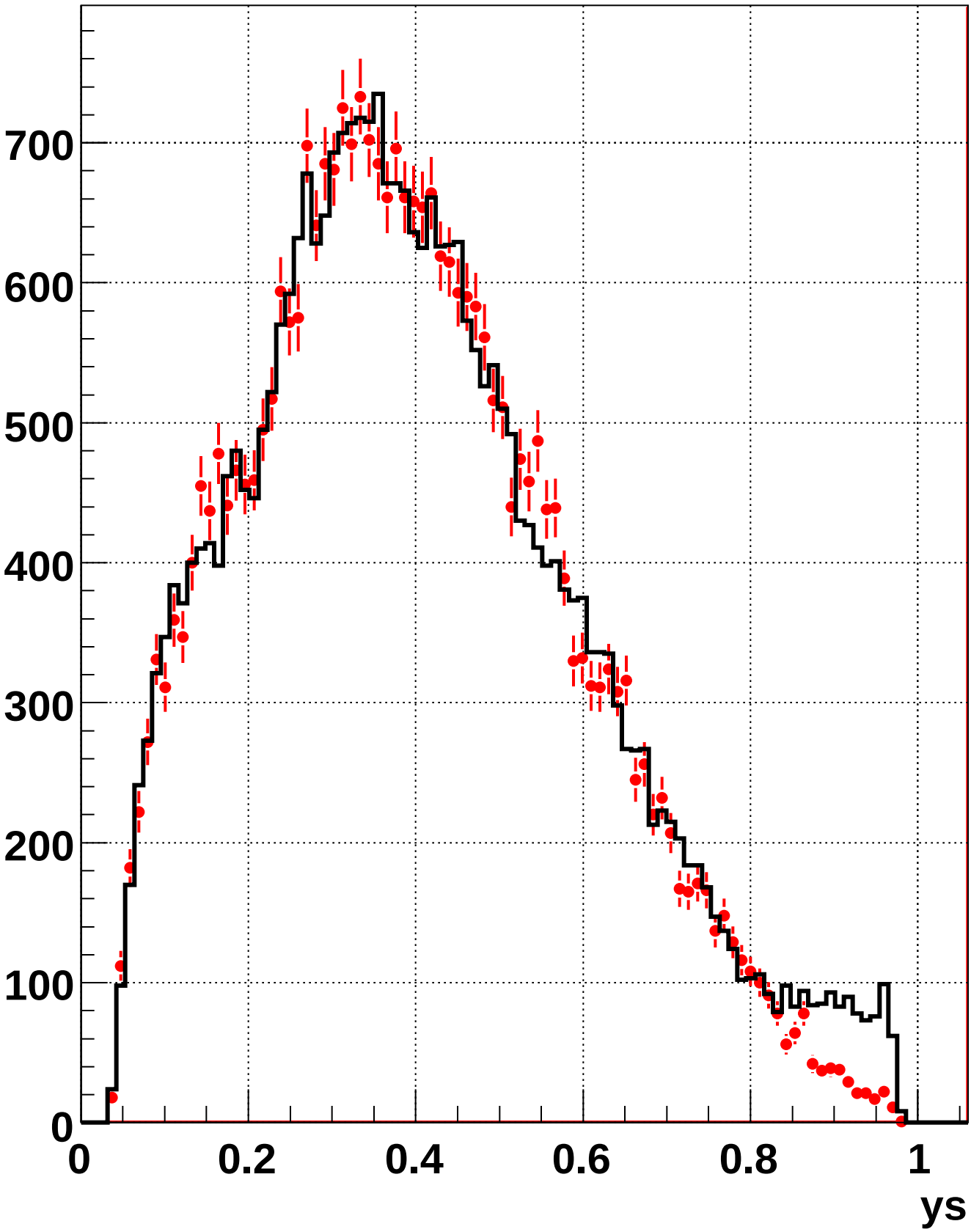
selected y for RES events



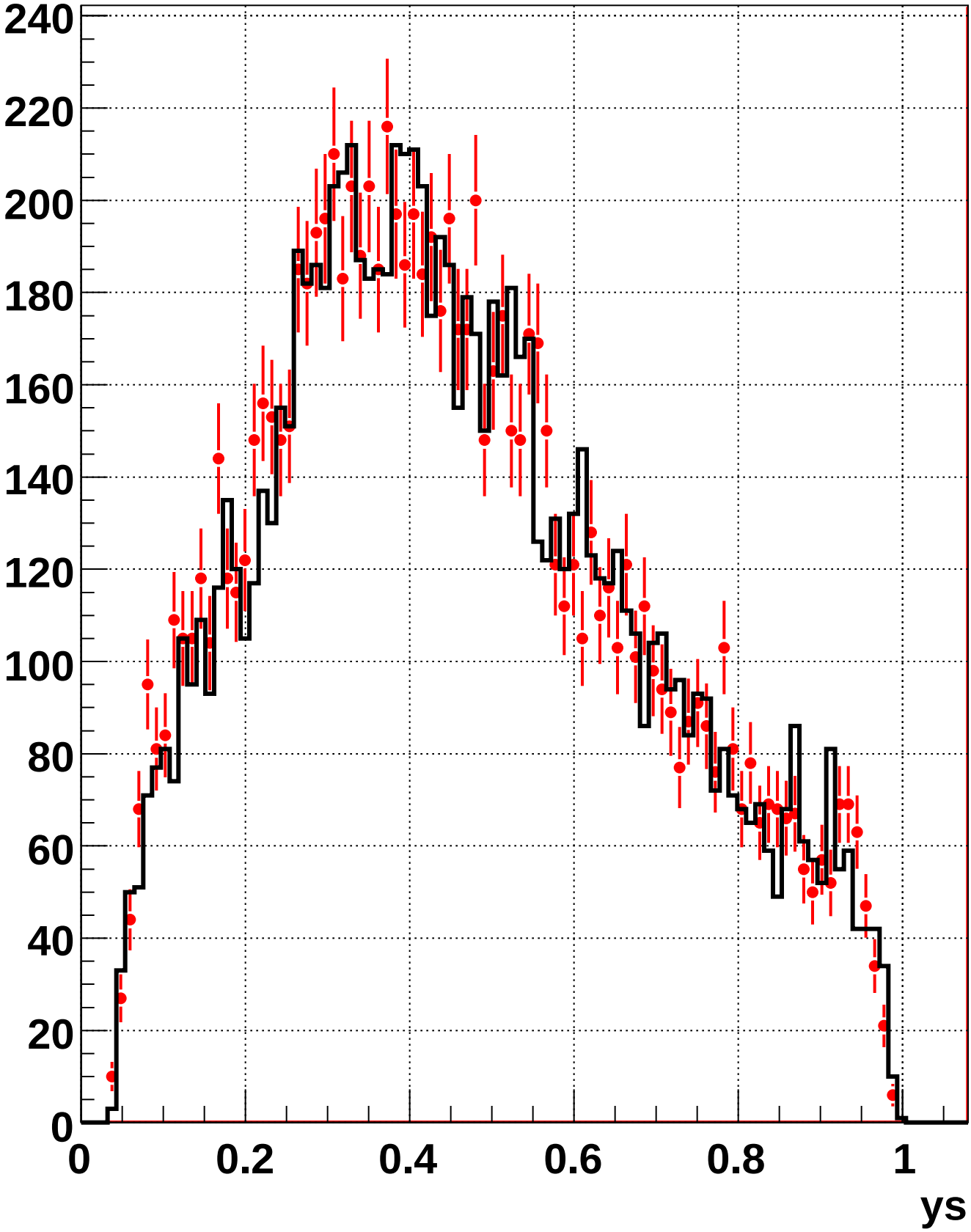
selected y for DIS events



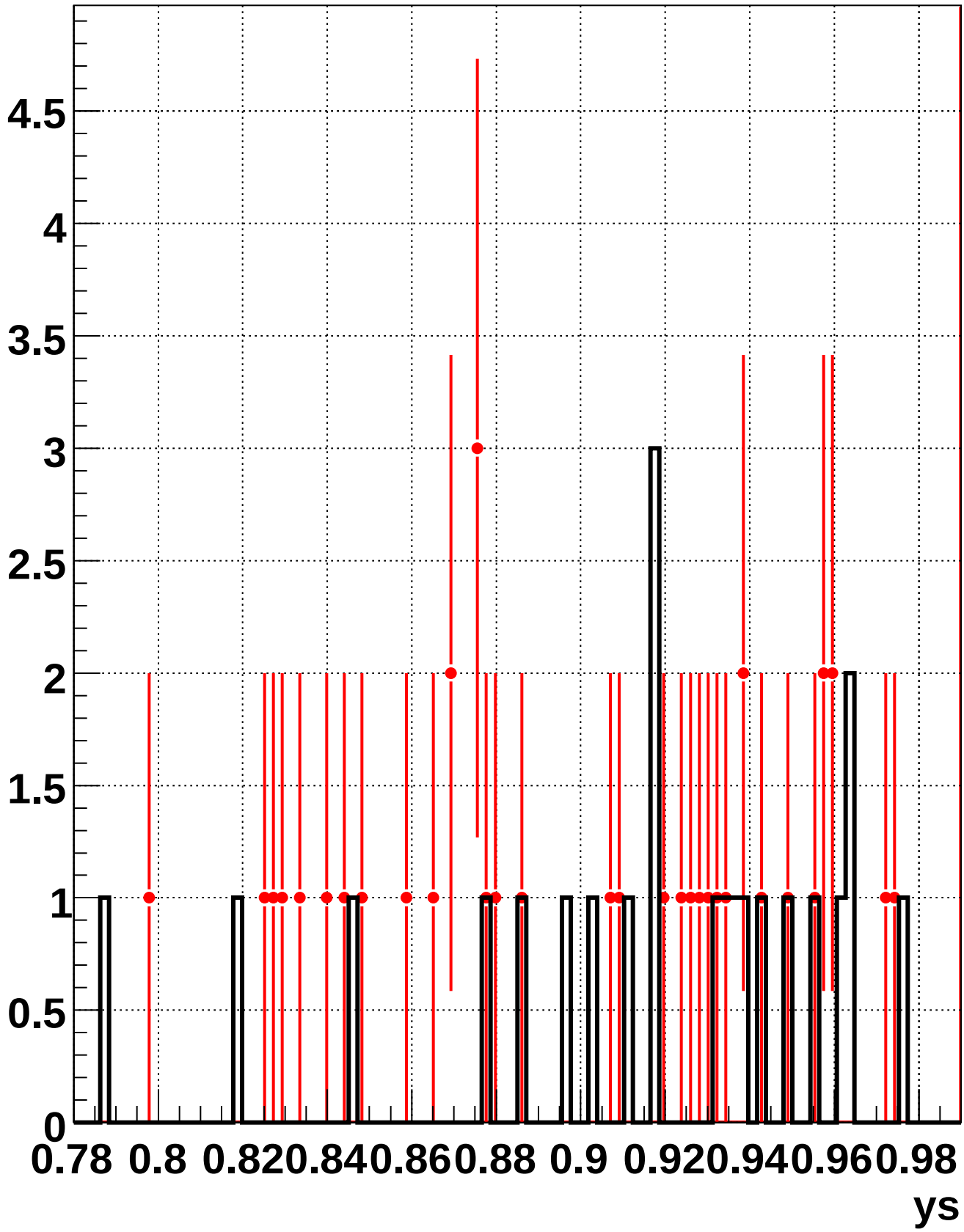
selected y for DIS CC events



selected y for DIS NC events



selected y for Charm/DIS events

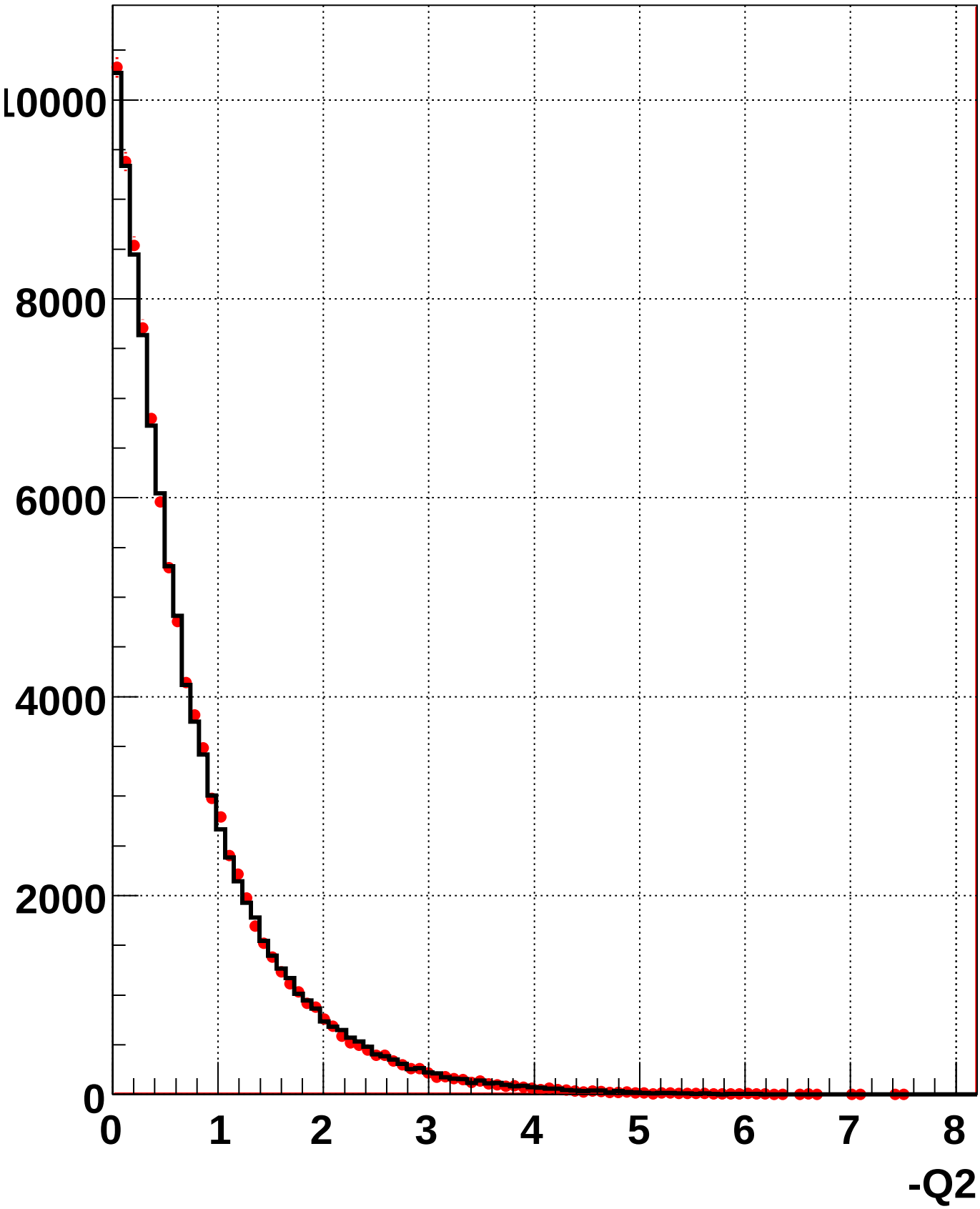


Kinematical Quantities

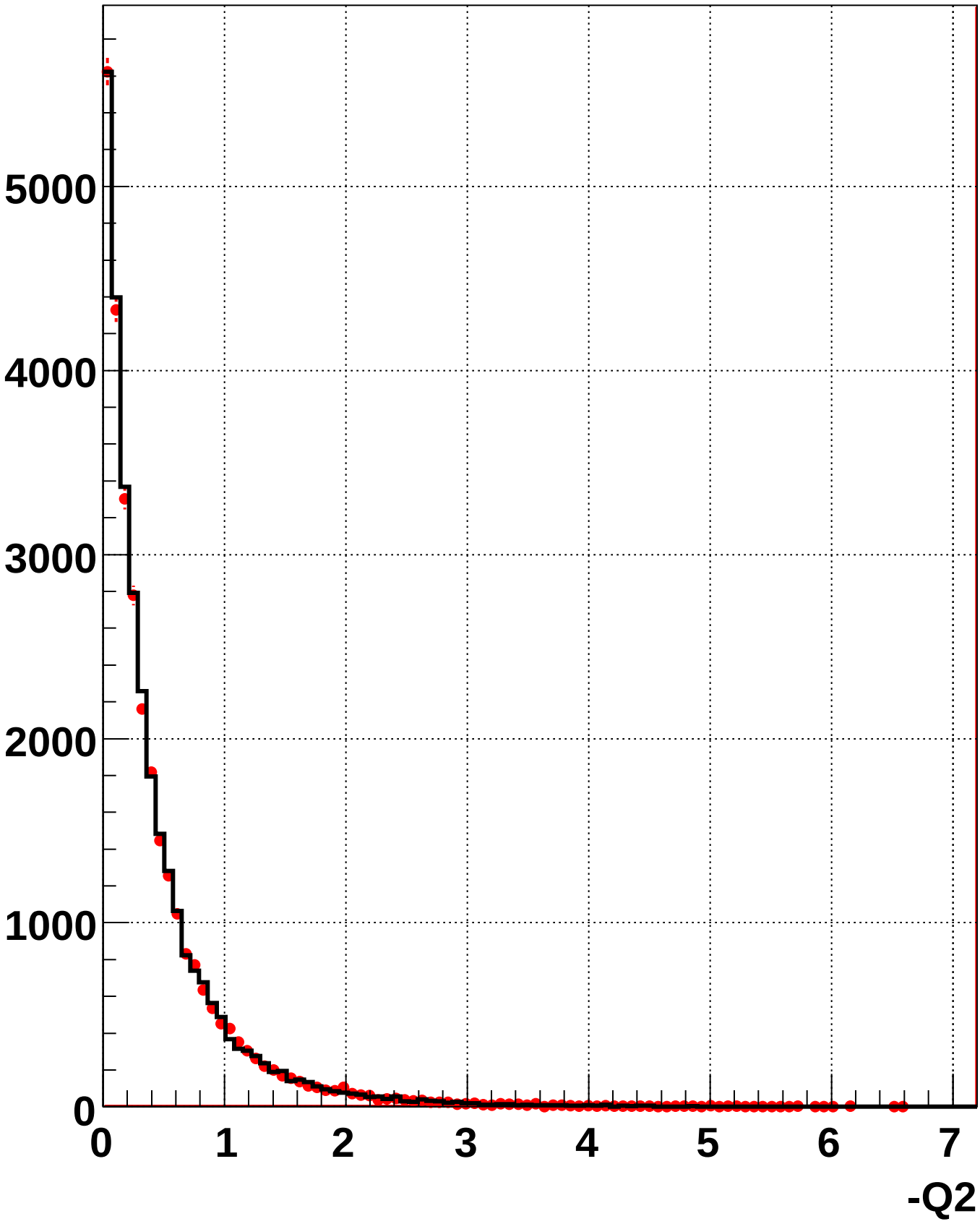
Similar to the previous set of plots but

showing ’computed’ rathen than ’selected’ variables

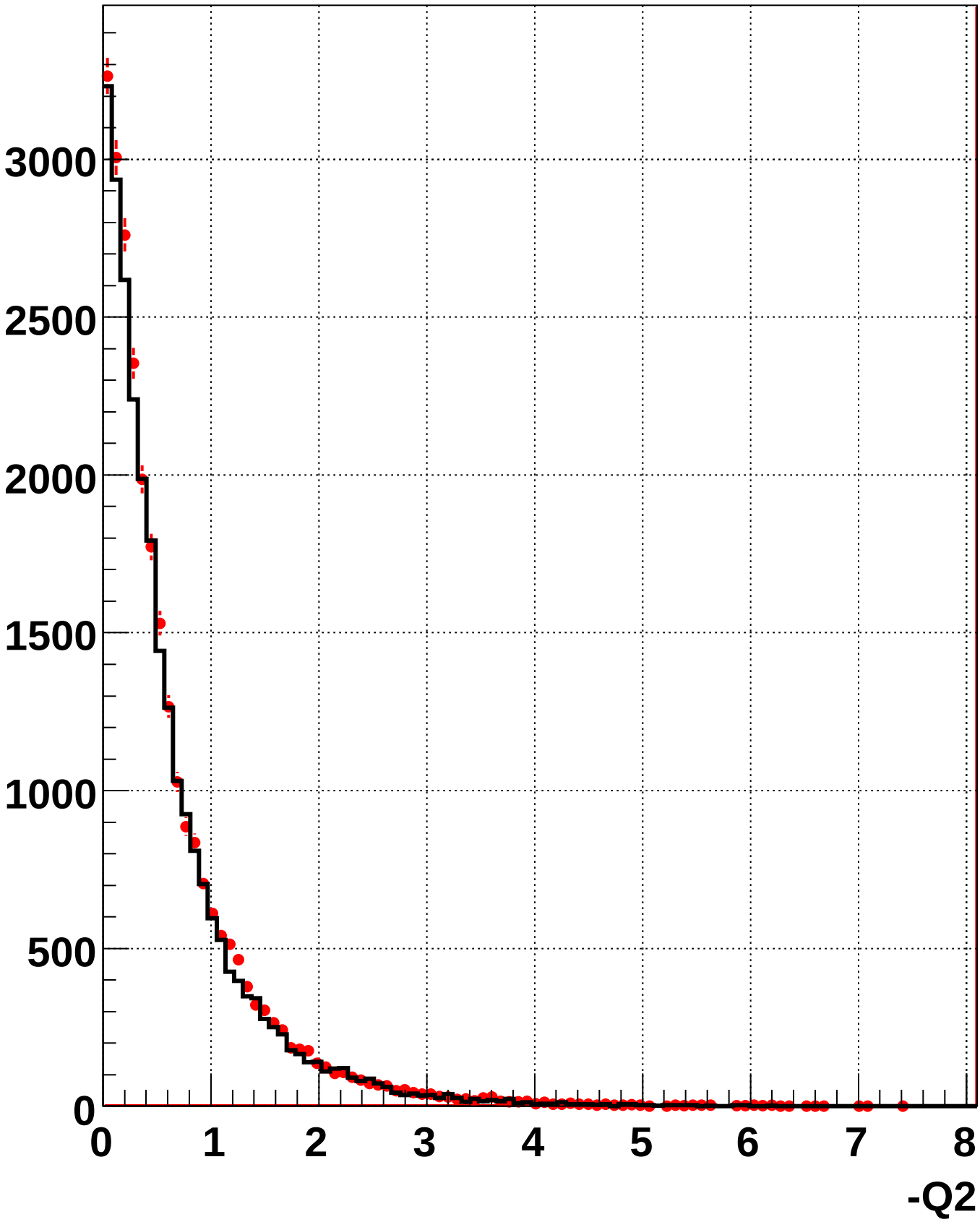
computed Q2 for all events



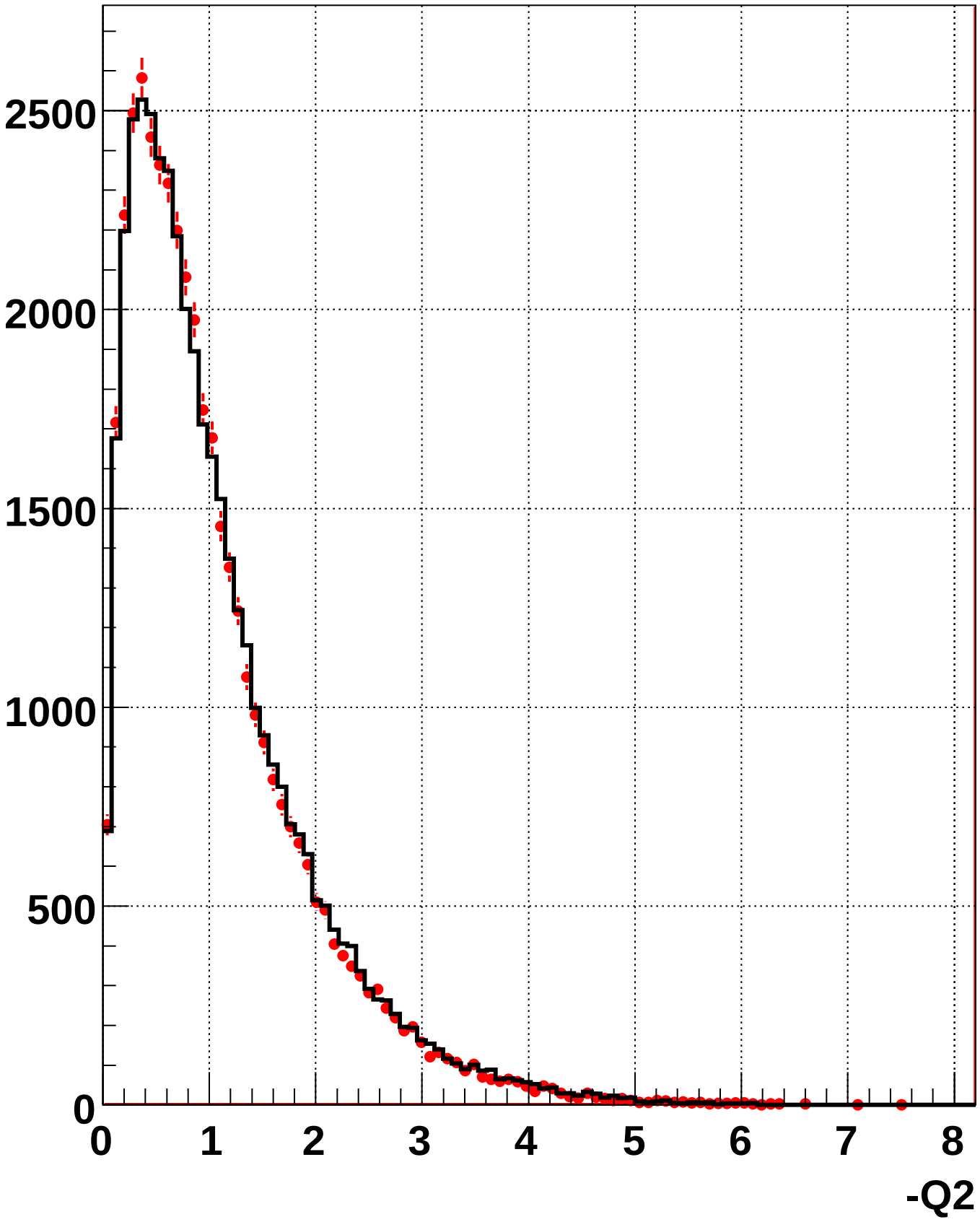
computed Q2 for QEL events



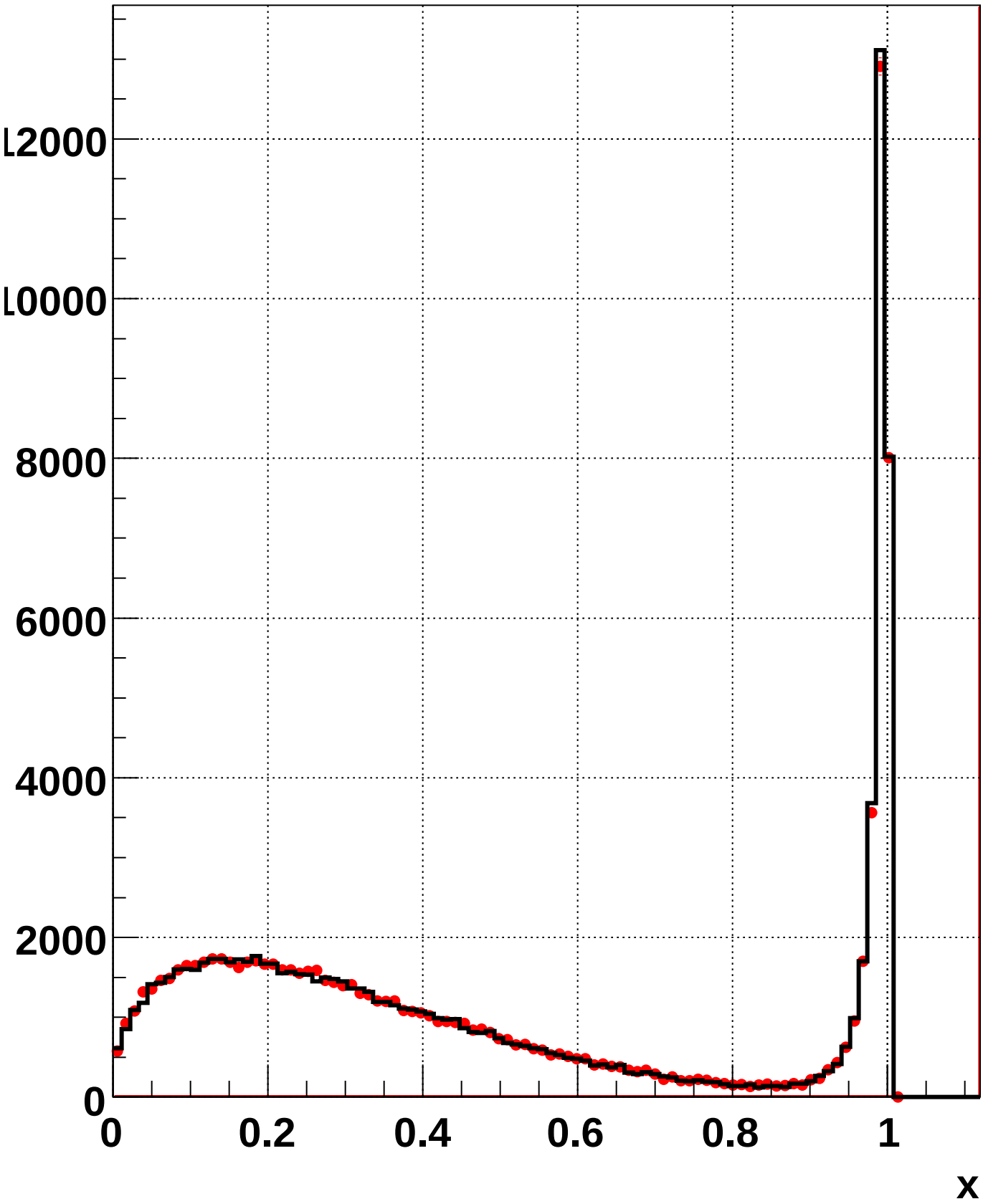
computed Q2 for RES events



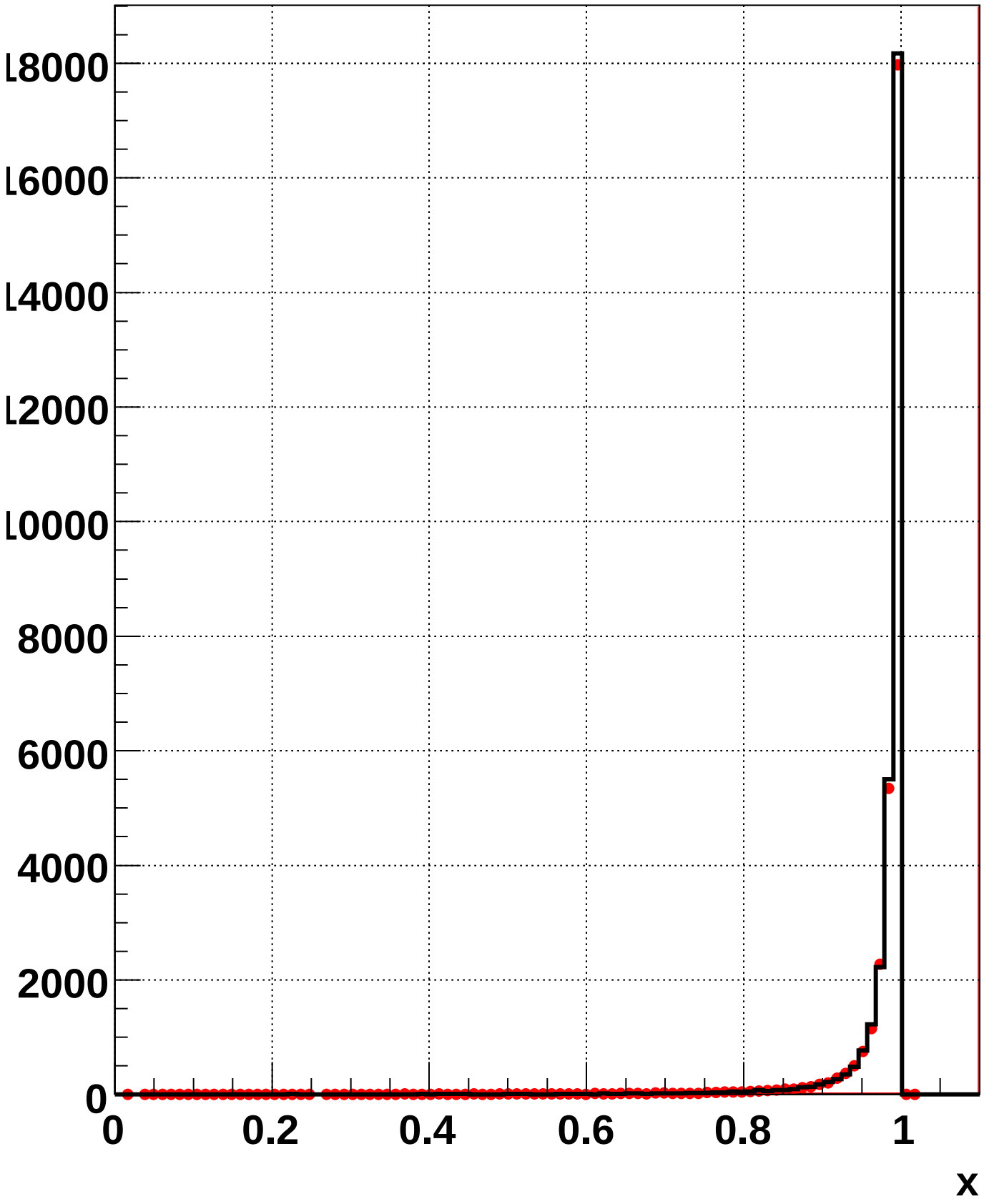
computed Q2 for DIS events

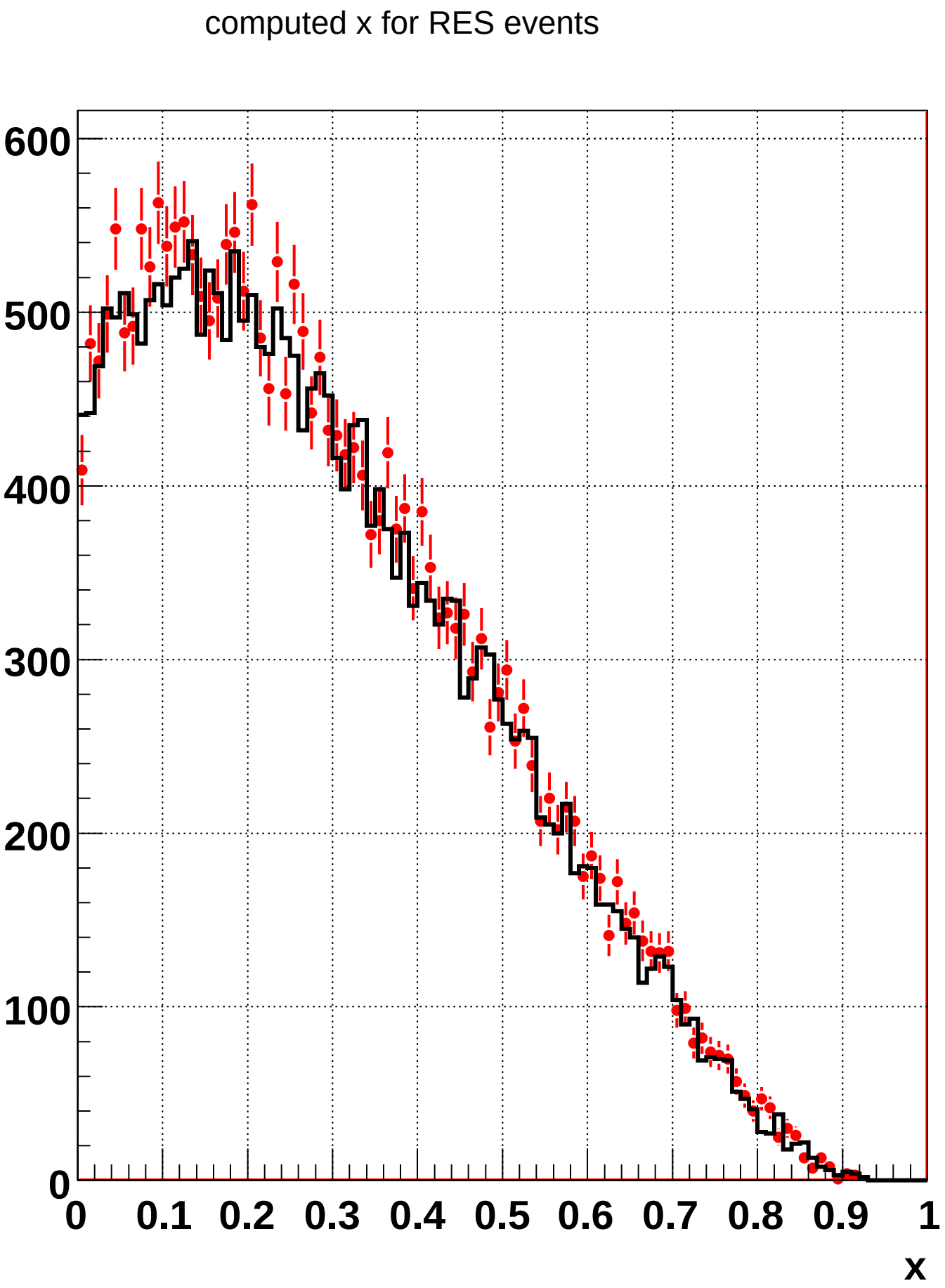


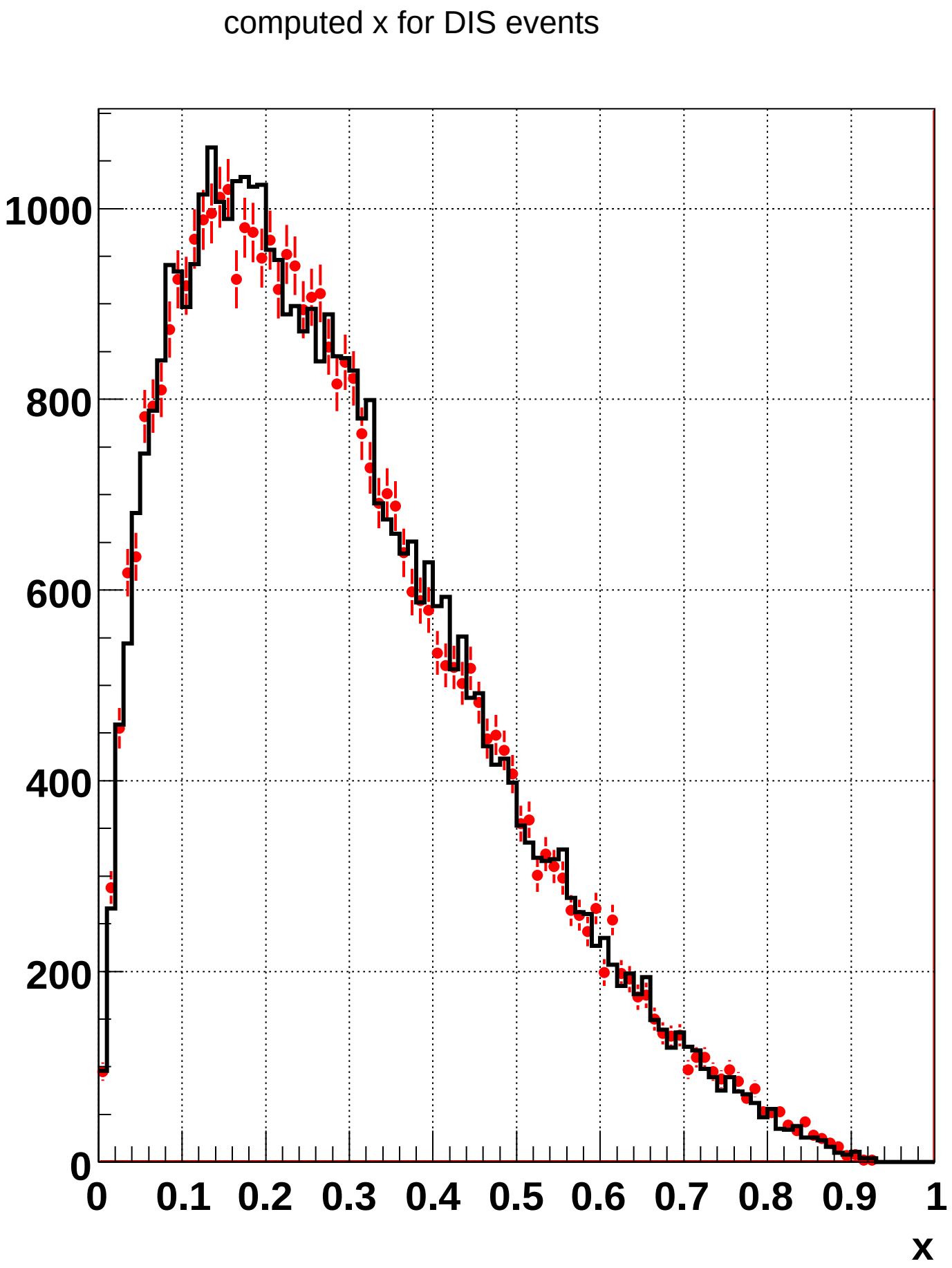
computed x for all events



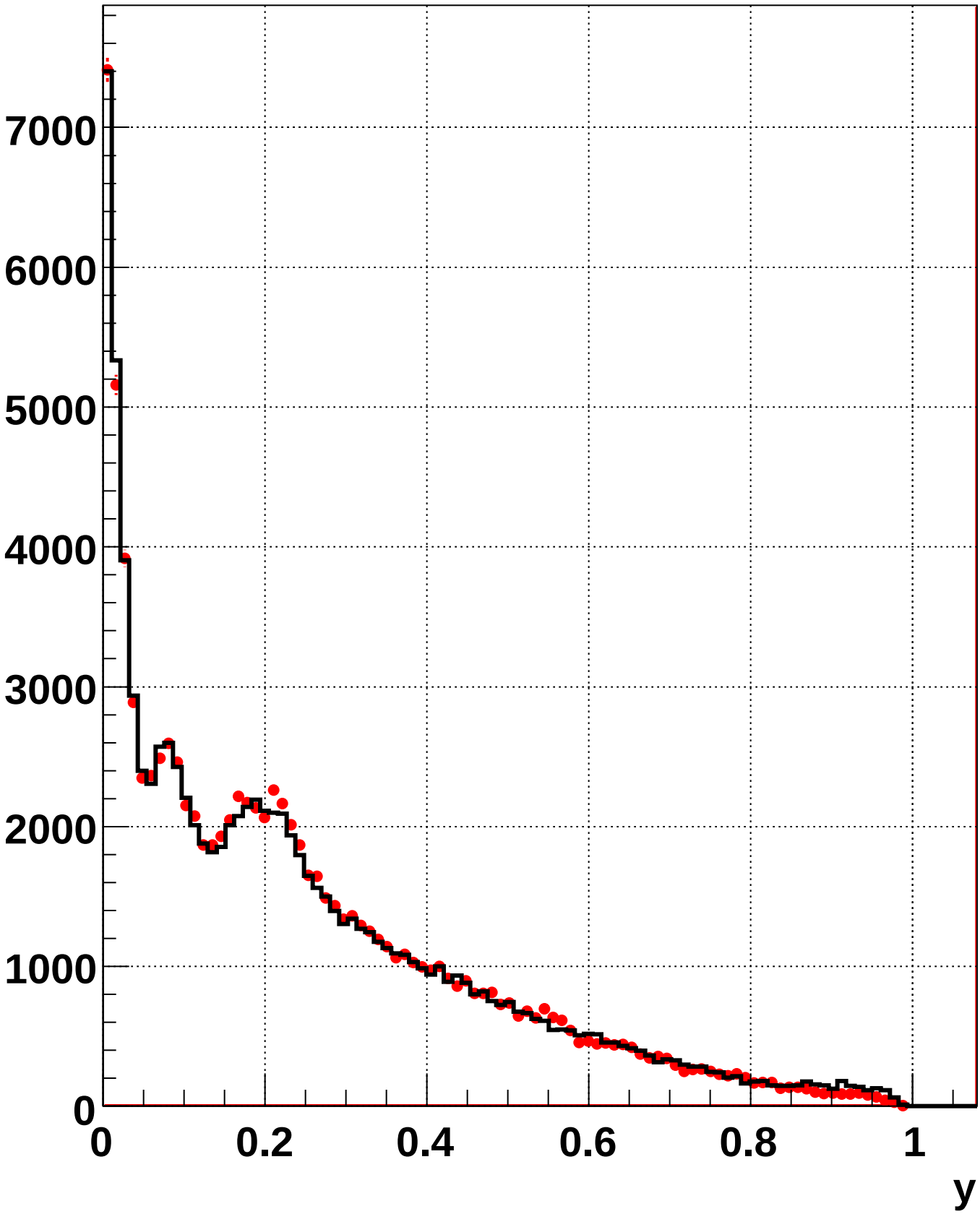
computed x for QEL events



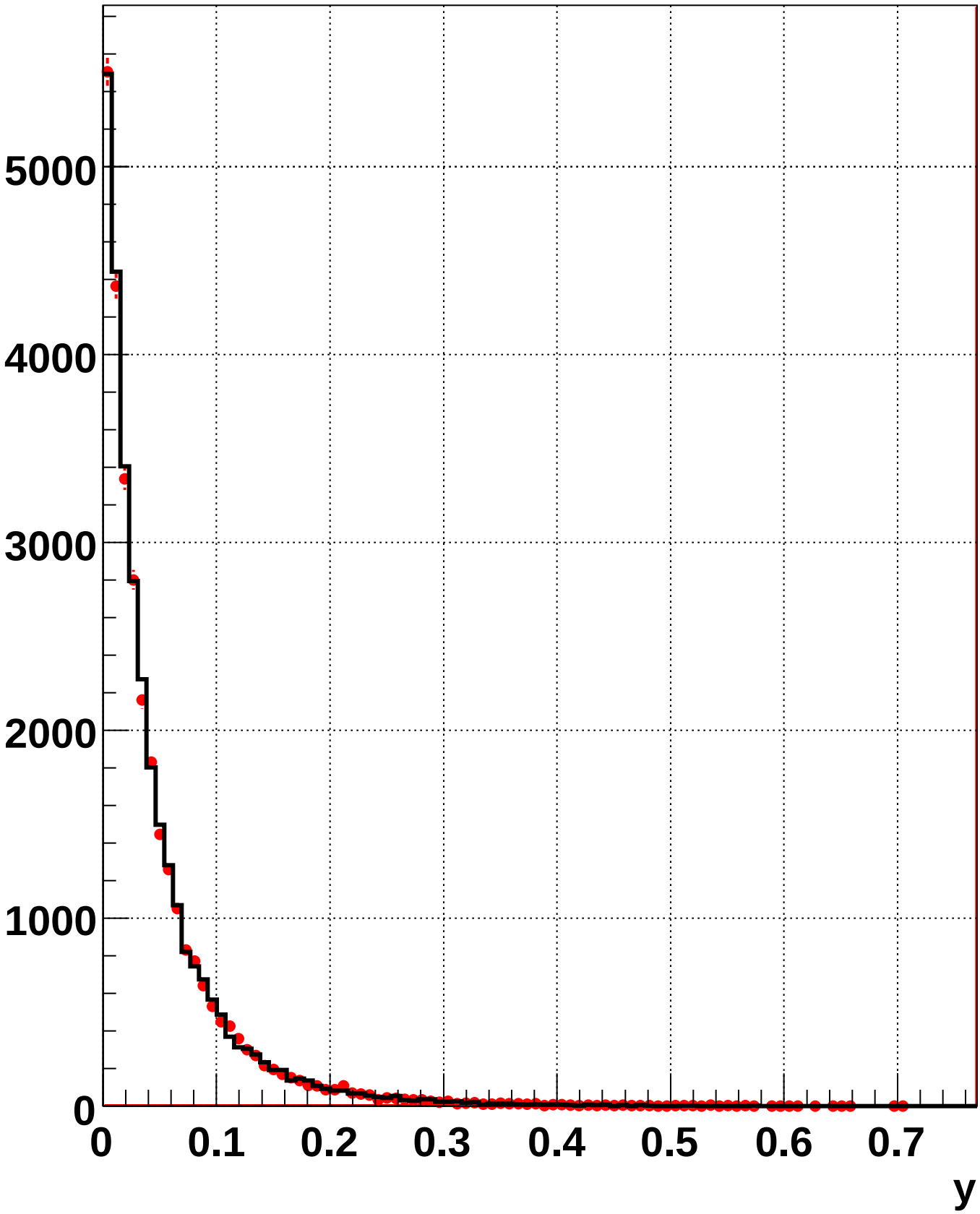

computed x for RES events
600
500
400
300
200
100
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
x

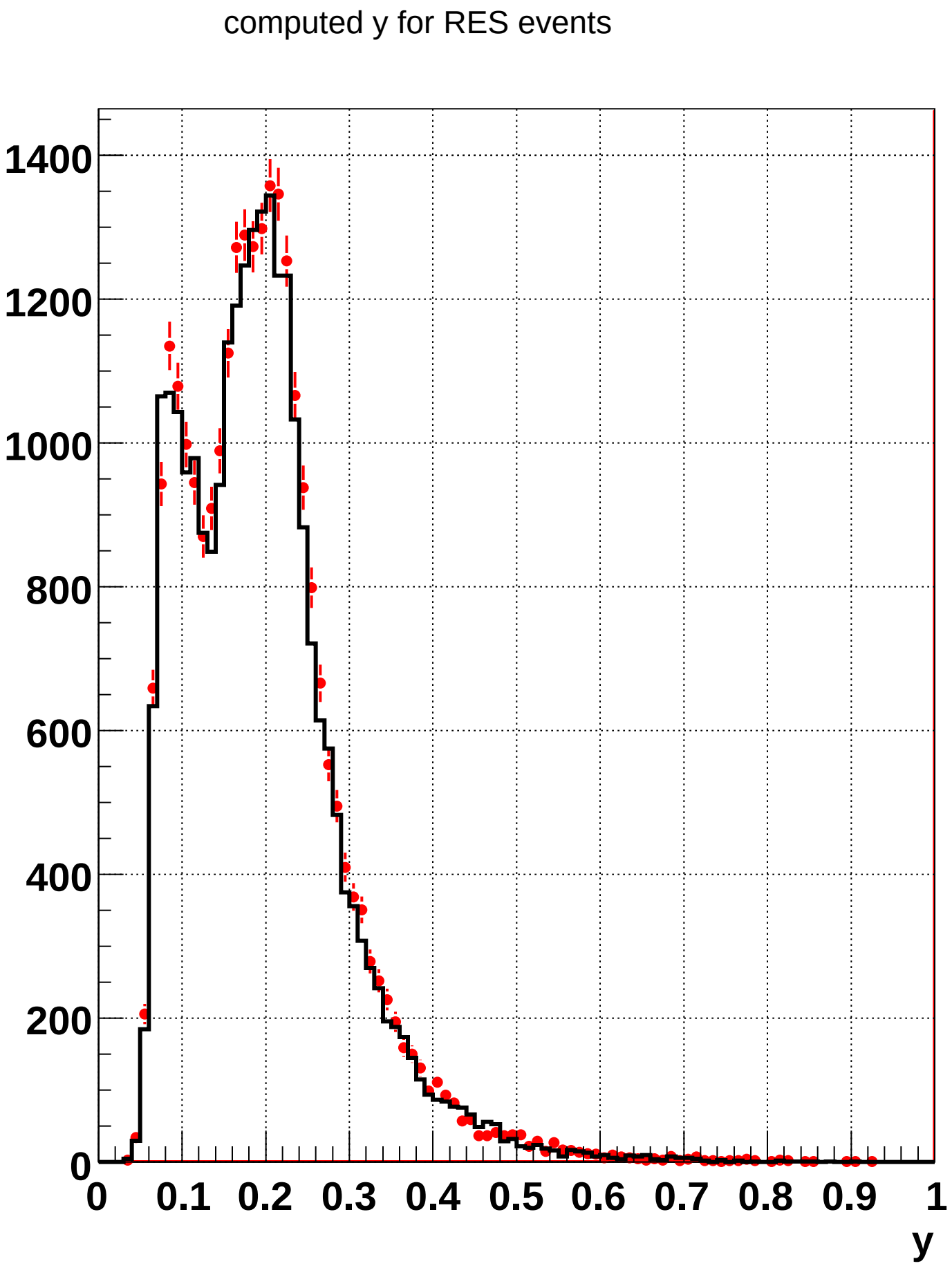

computed x for DIS events
1000
800
600
400
200
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
x

computed y for all events

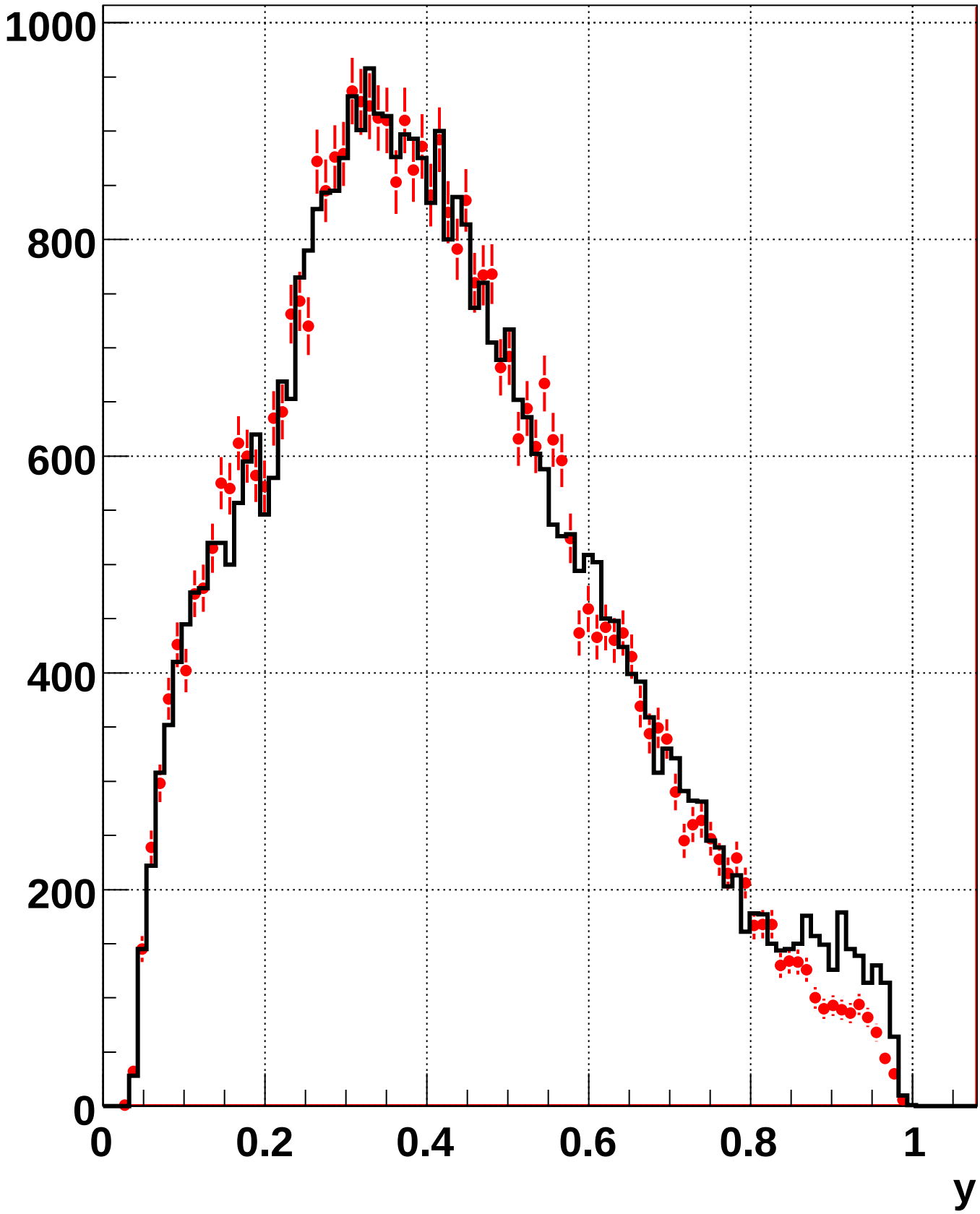


computed y for QEL events

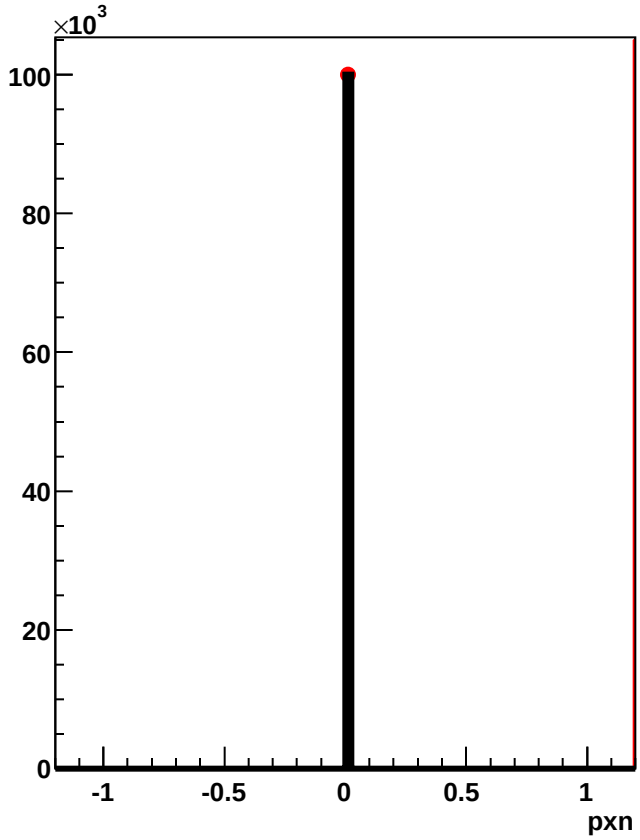


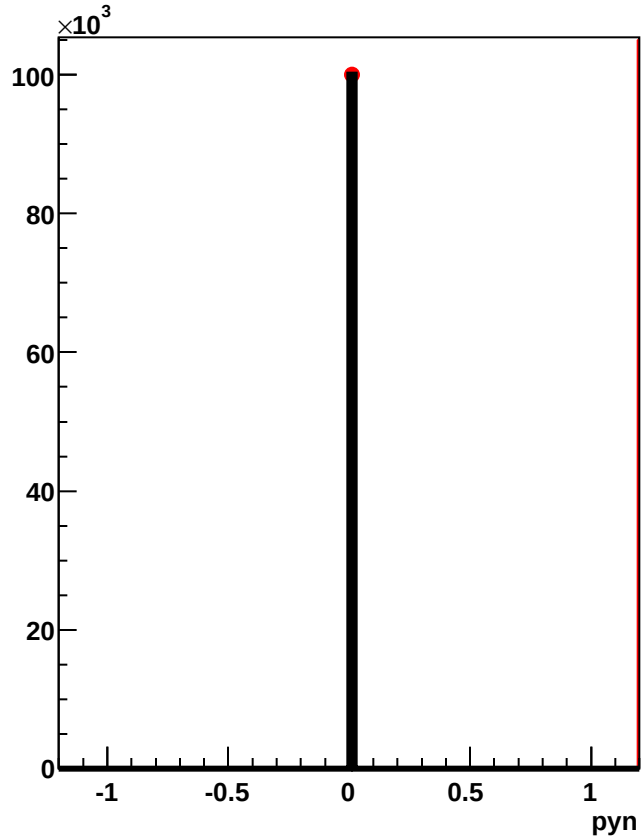

computed y for RES events
1400
1200
1000
800
600
400
200
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
y

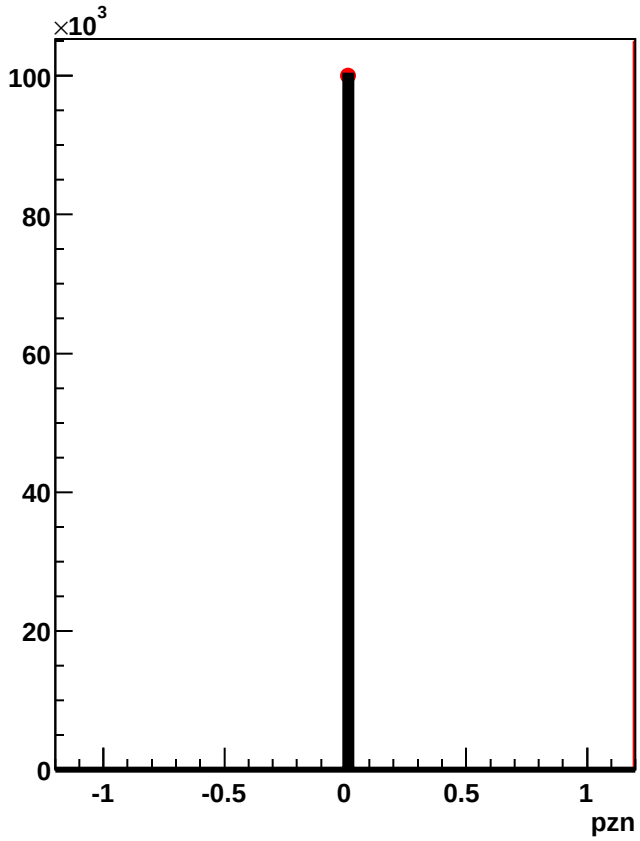
computed y for DIS events

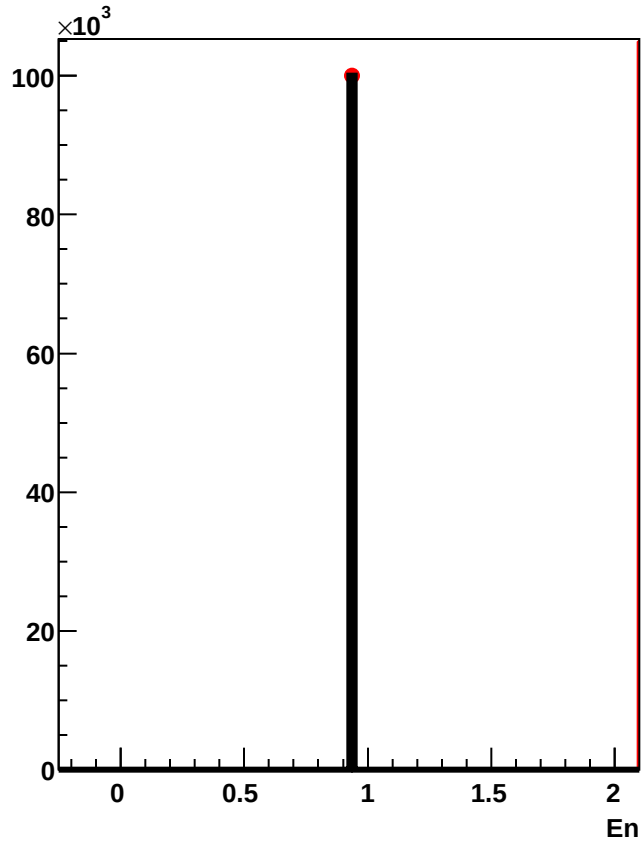


Initial state nucleon 4-Momentum


×10^3
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pxn

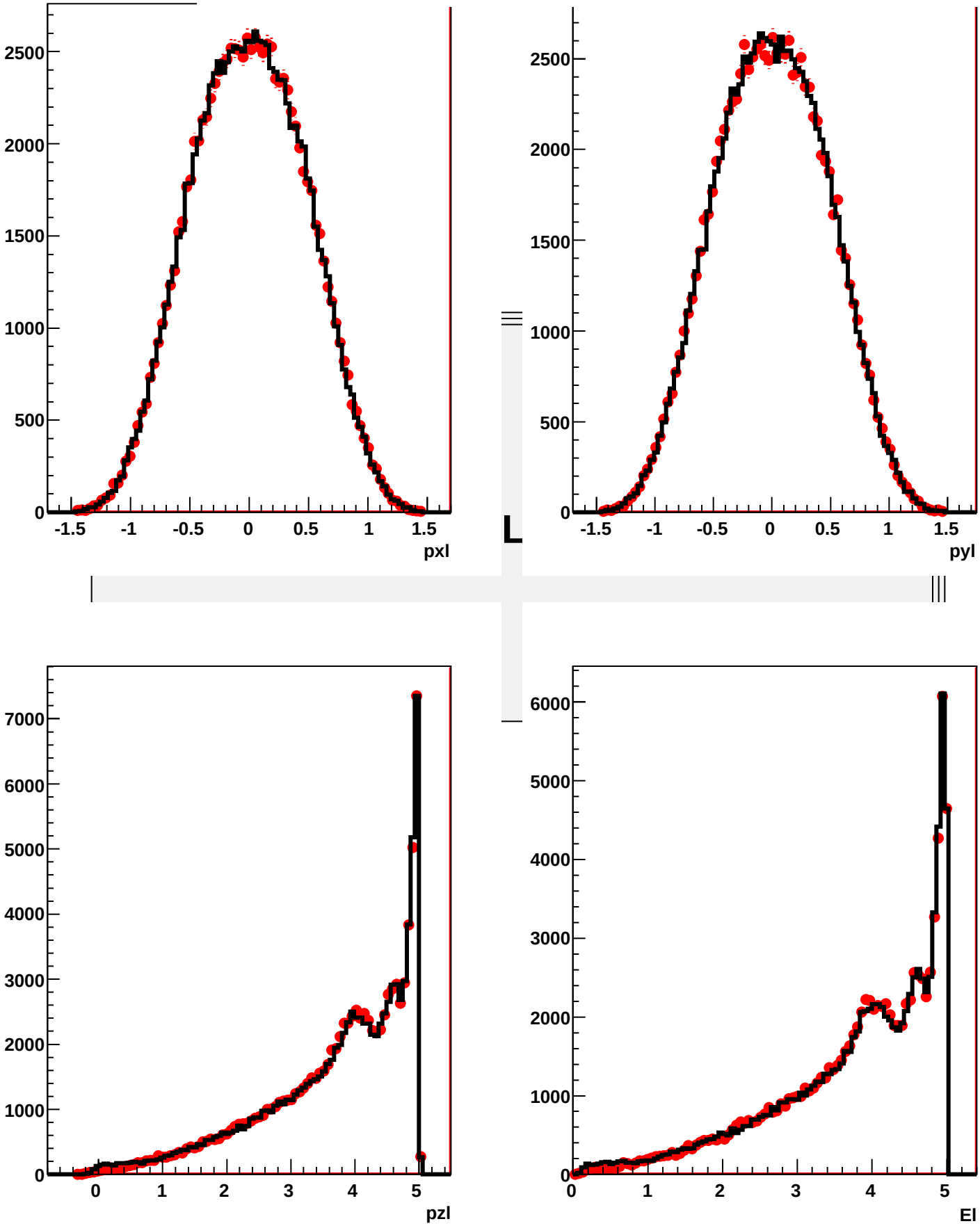

×10^3
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pyn


×10^3
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pzn

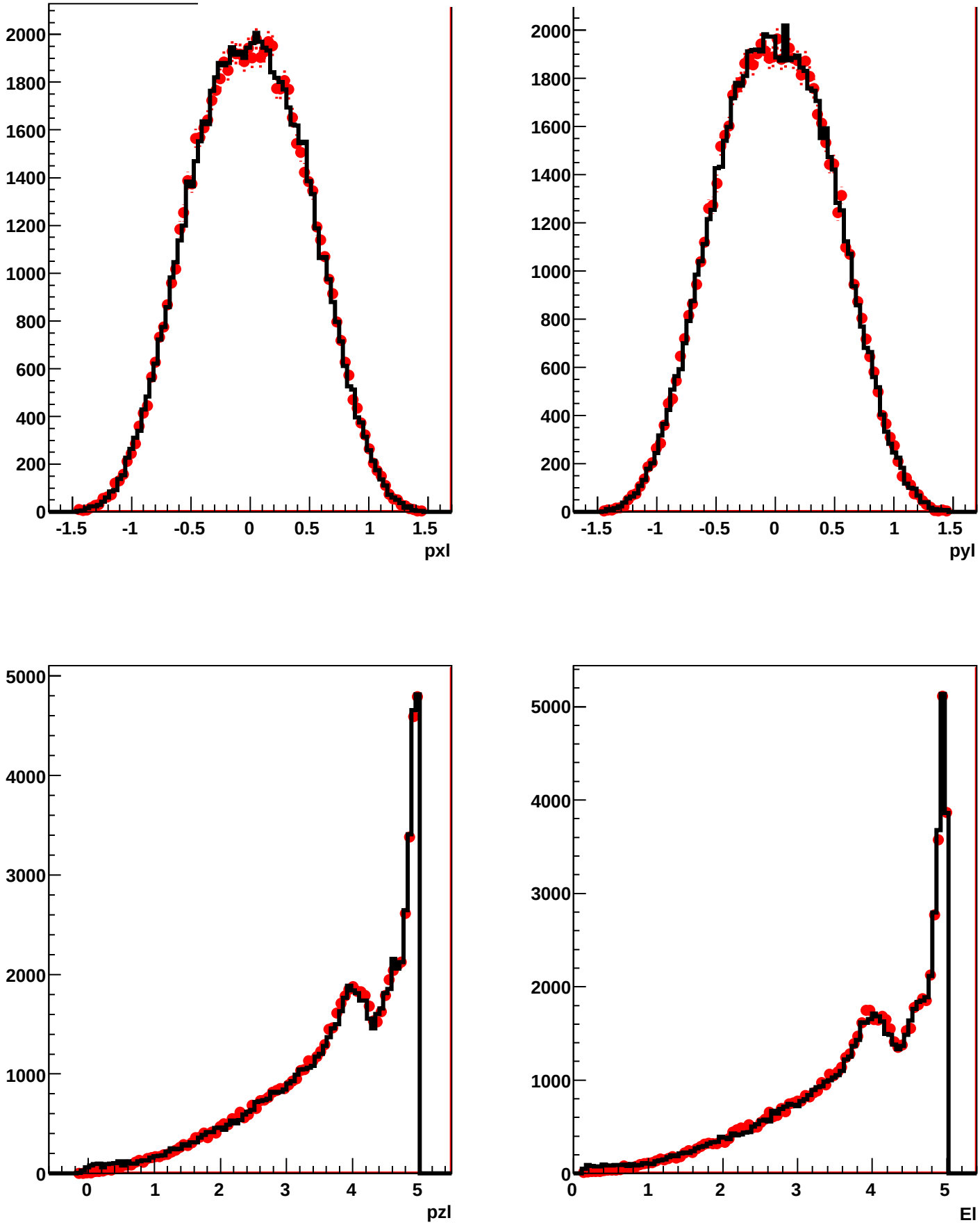

×10^3
100
80
60
40
20
0
0
0.5
1
1.5
2
En

Final State Primary Lepton 4-Momentum

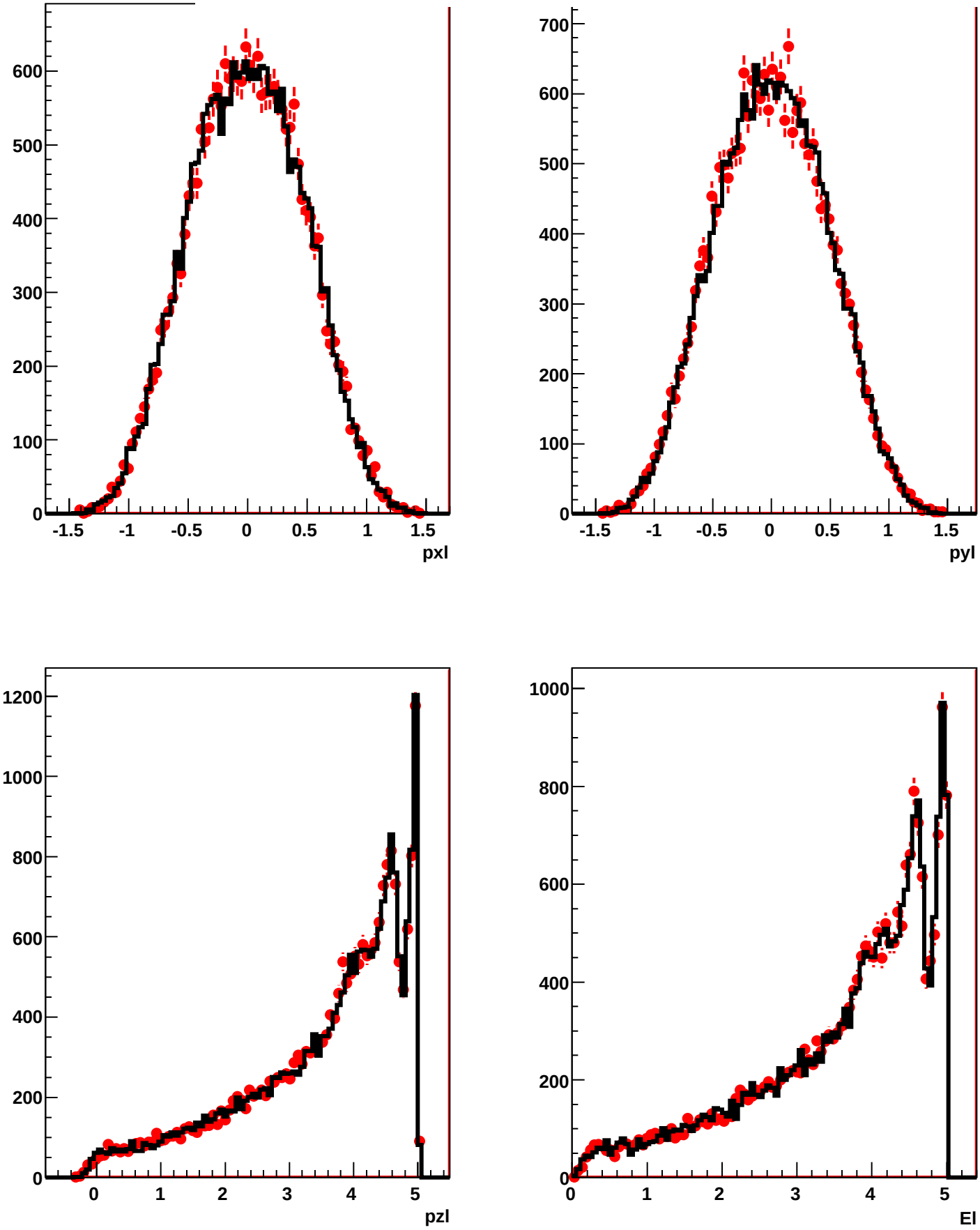
Final state primary lepton 4-p: All events



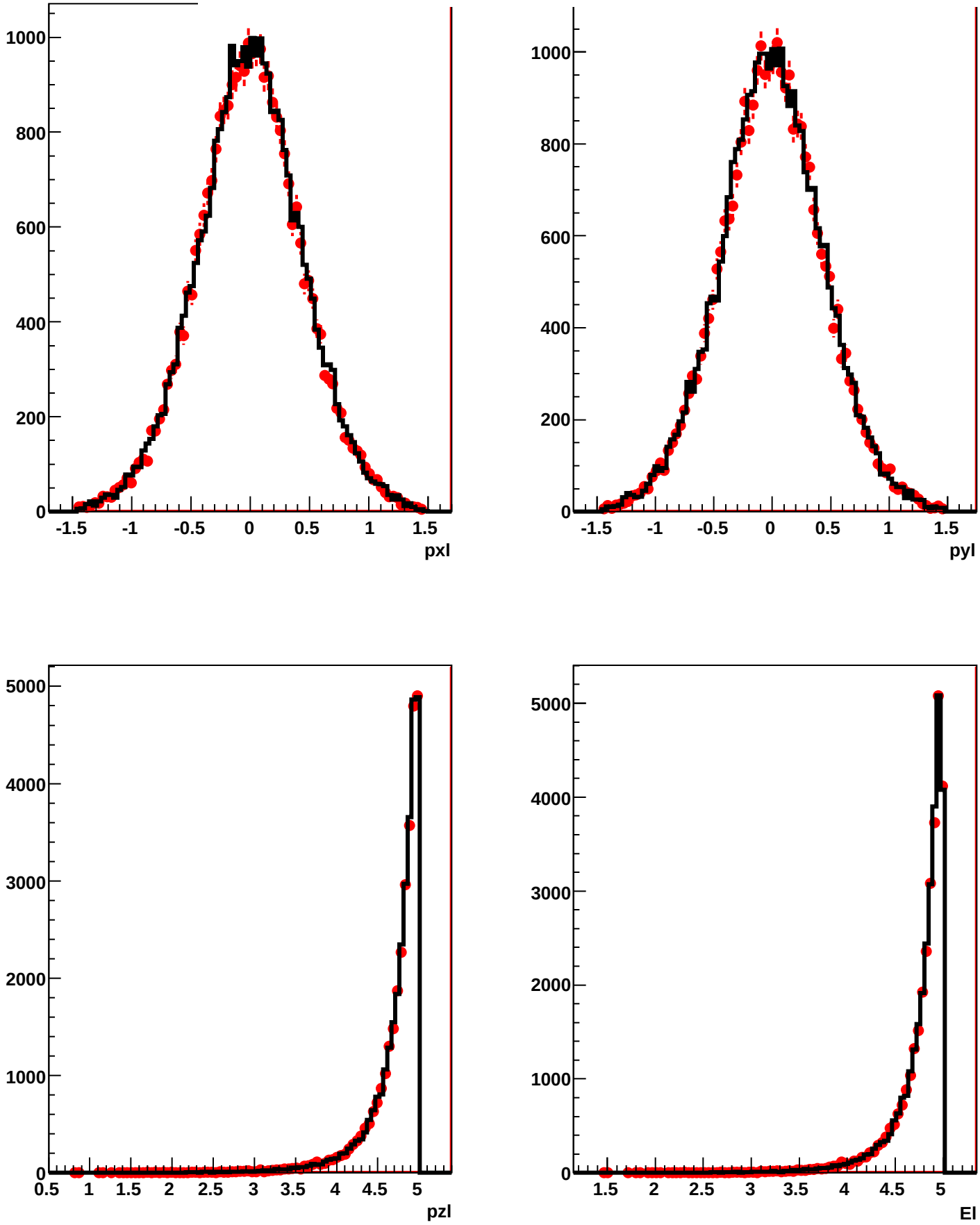
Final state primary lepton 4-p: All CC events



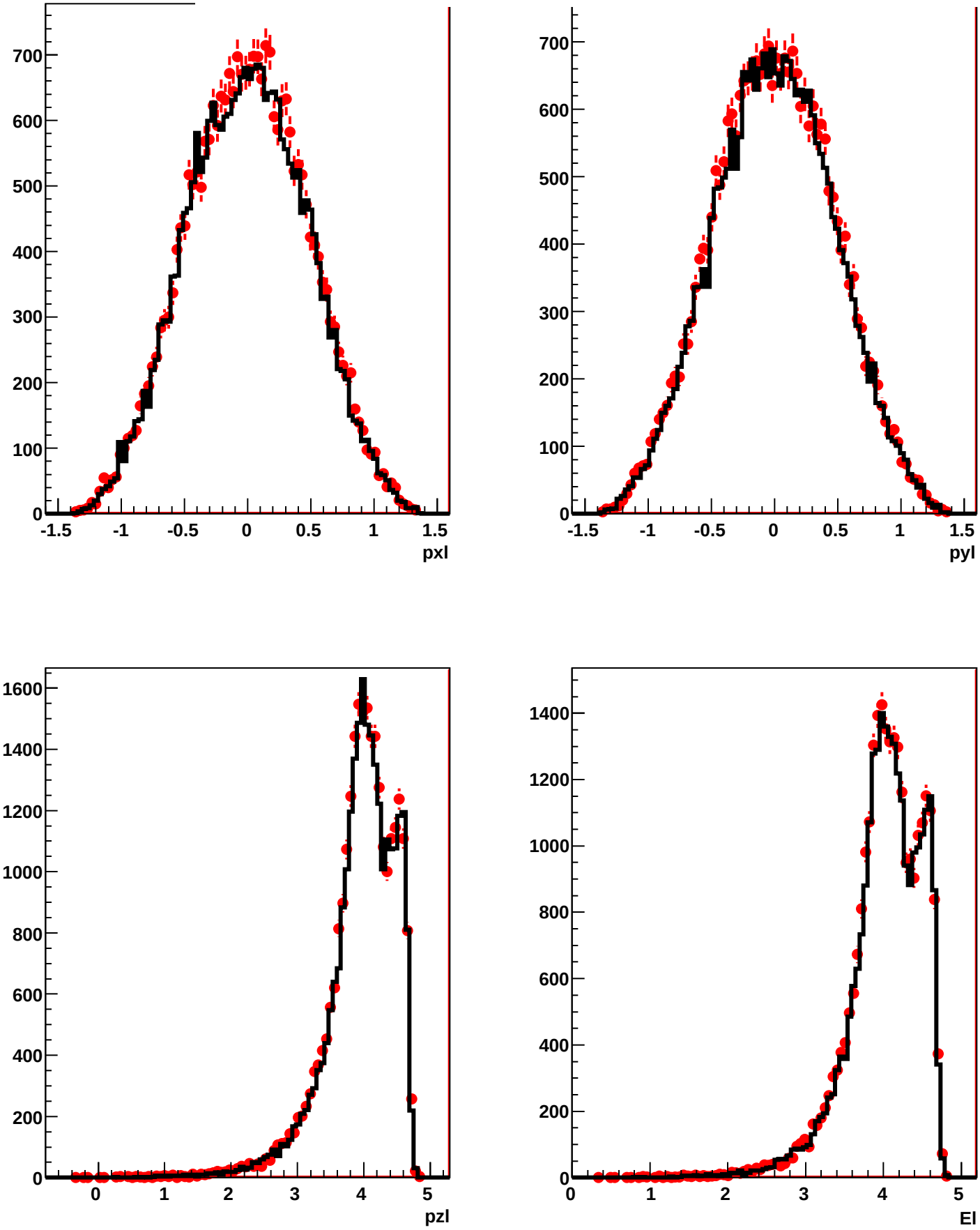
Final state primary lepton 4-p: All NC events



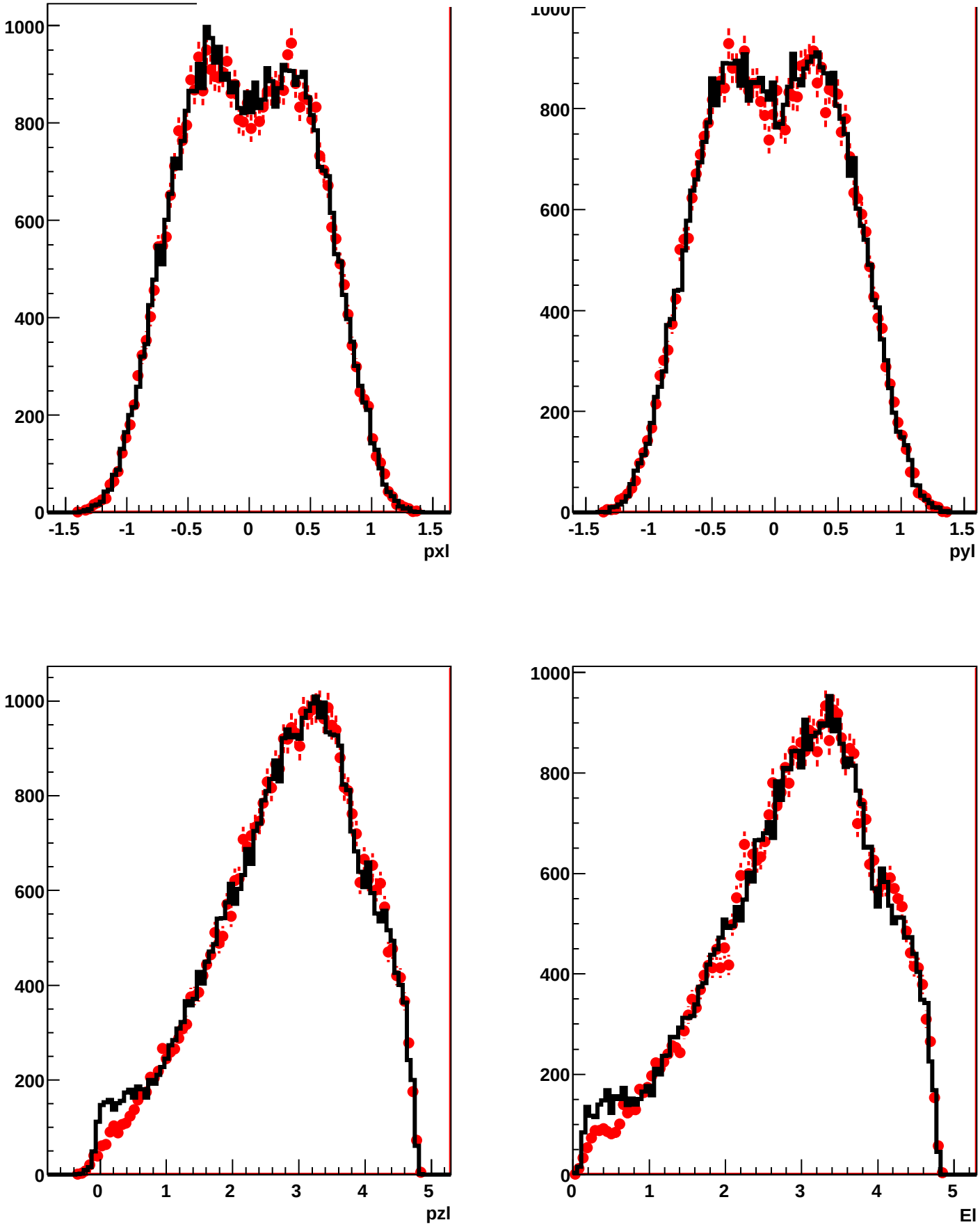
Final state primary lepton 4-p: QEL events



Final state primary lepton 4-p: RES events



Final state primary lepton 4-p: All DIS events

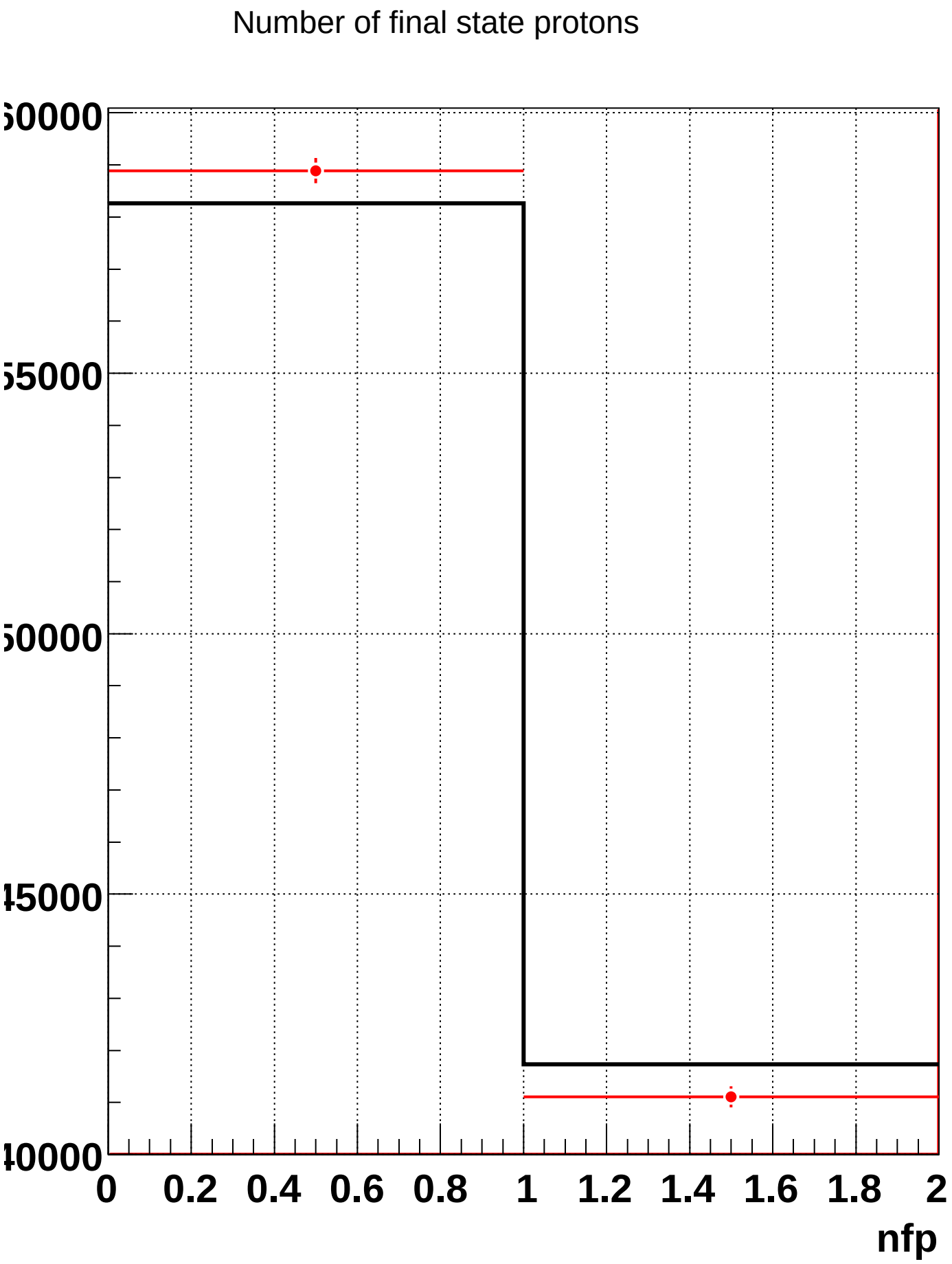


Final State Hadronic System

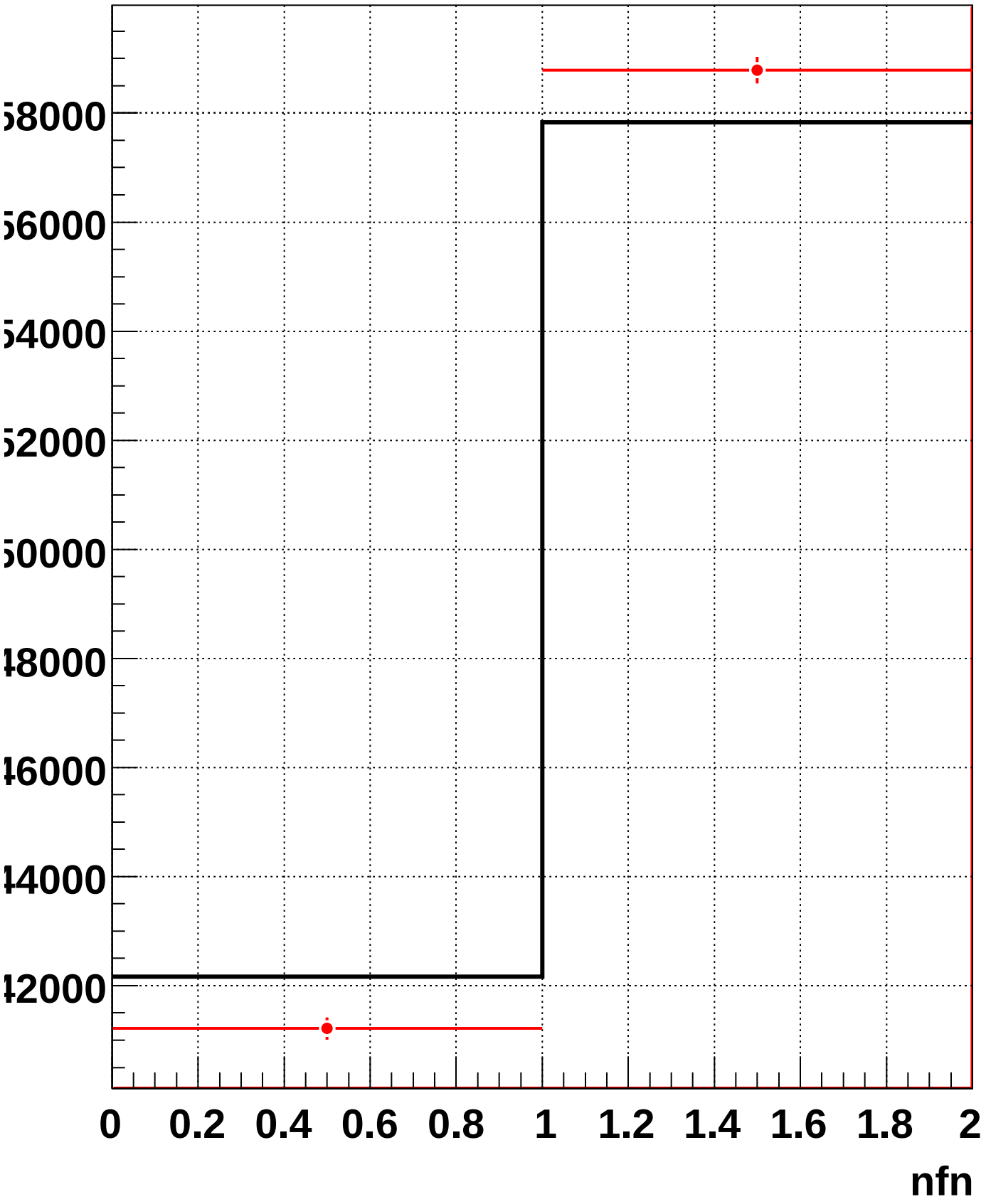
Multiplicities and 4-Momenta

Note:

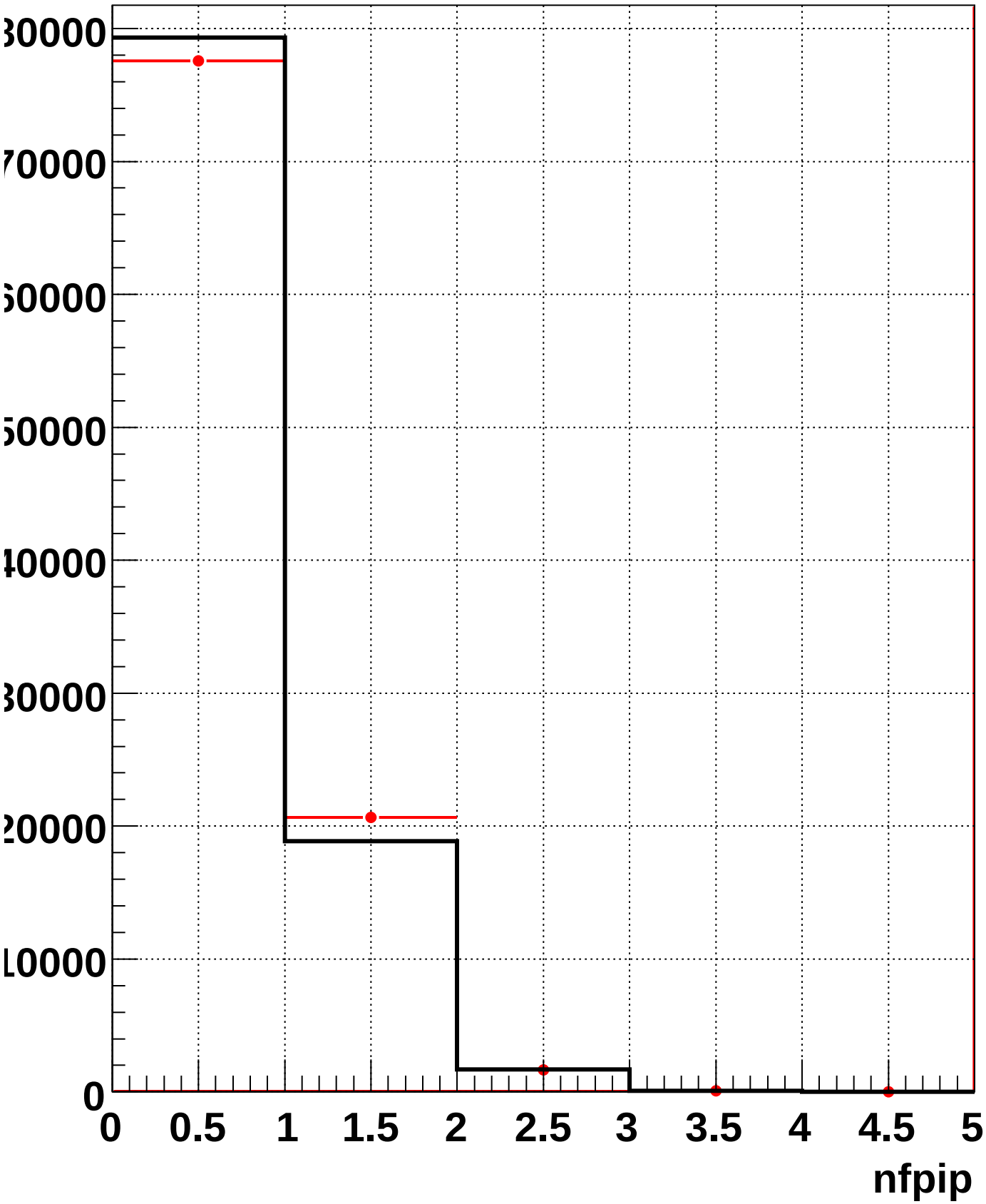
For nuclear targets these plots include the effect of intranuclear hadron transport / rescattering


Number of final state protons
60000
55000
50000
45000
40000
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
nfp

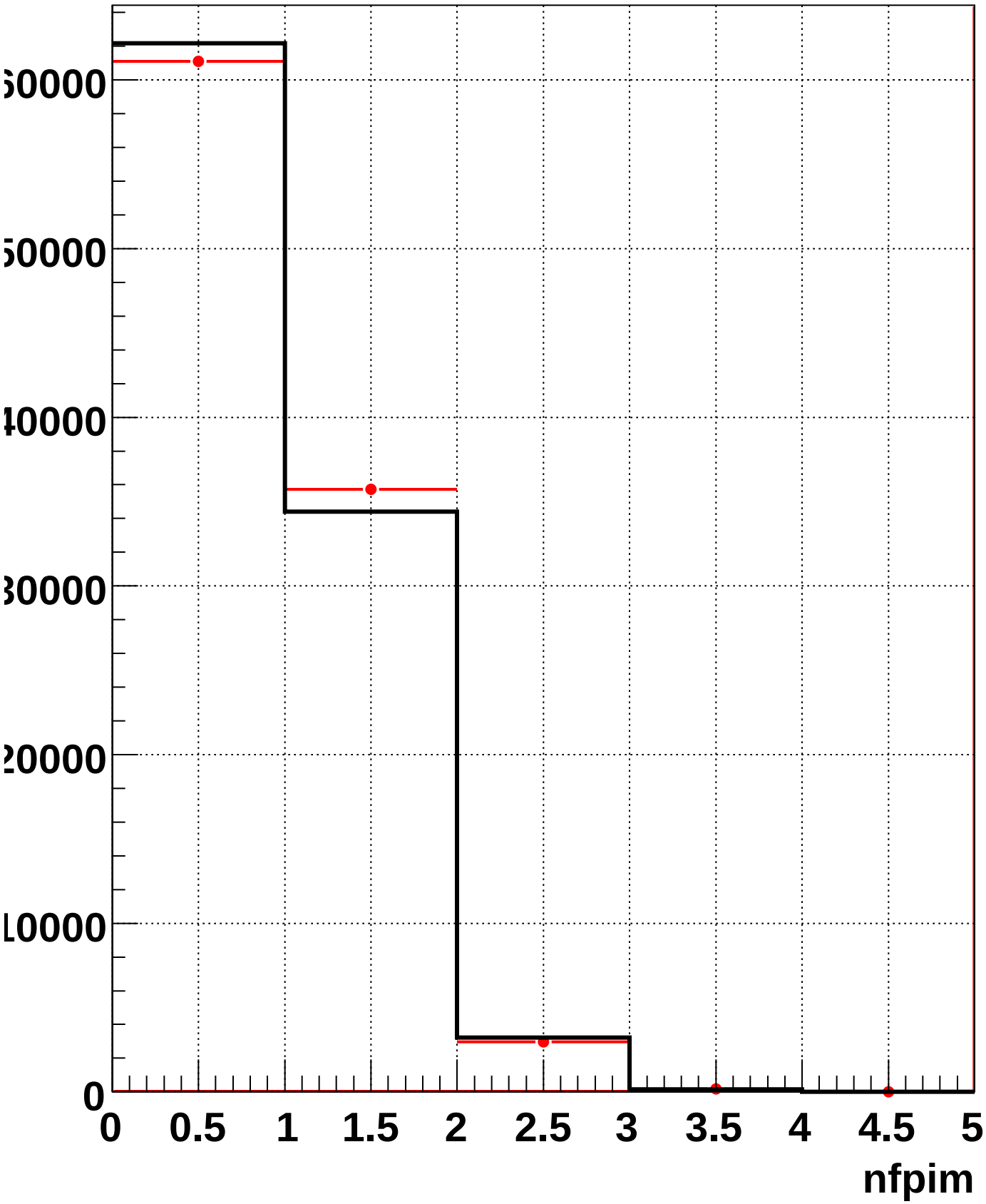
Number of final state neutrons



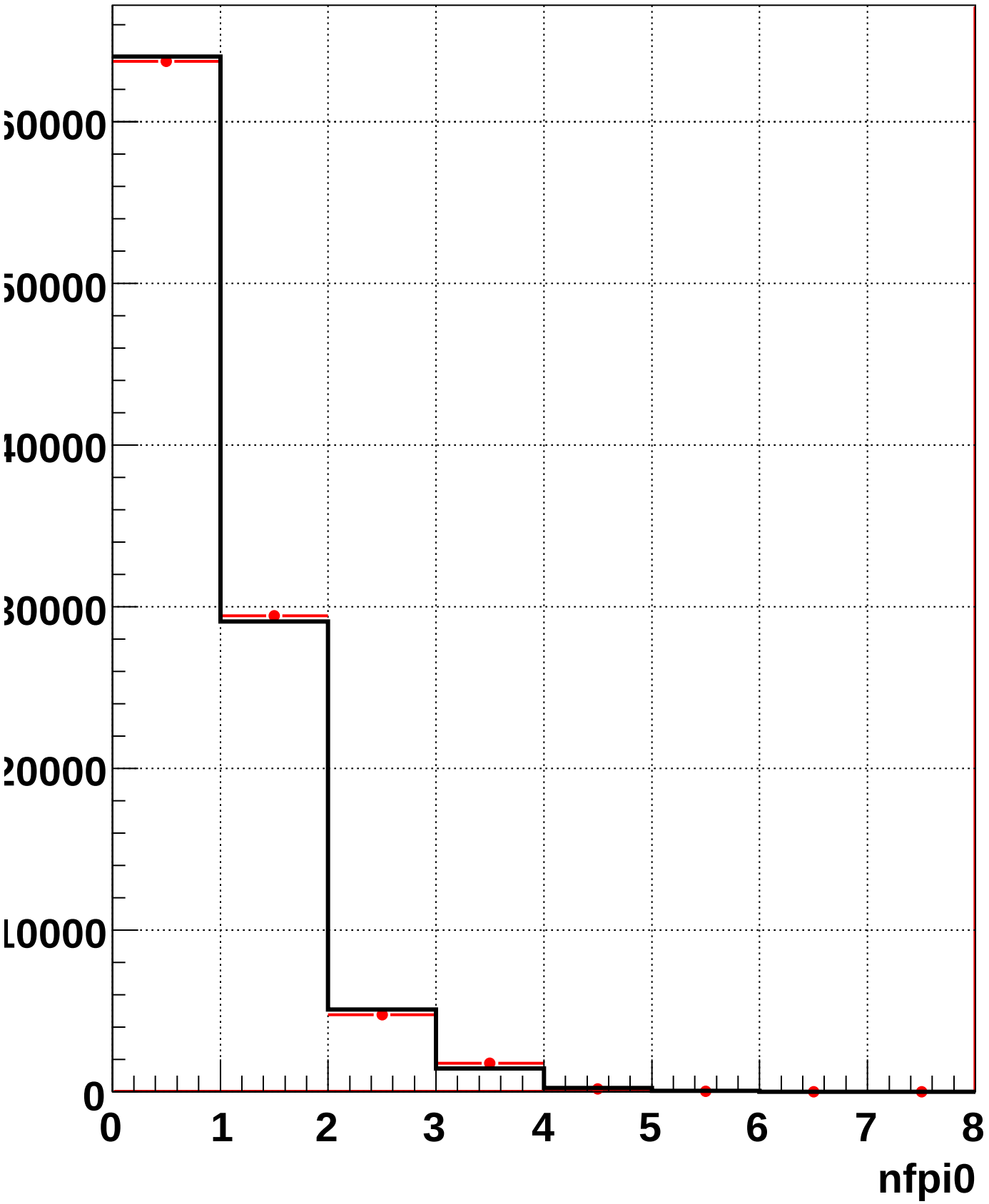
Number of final state pi+

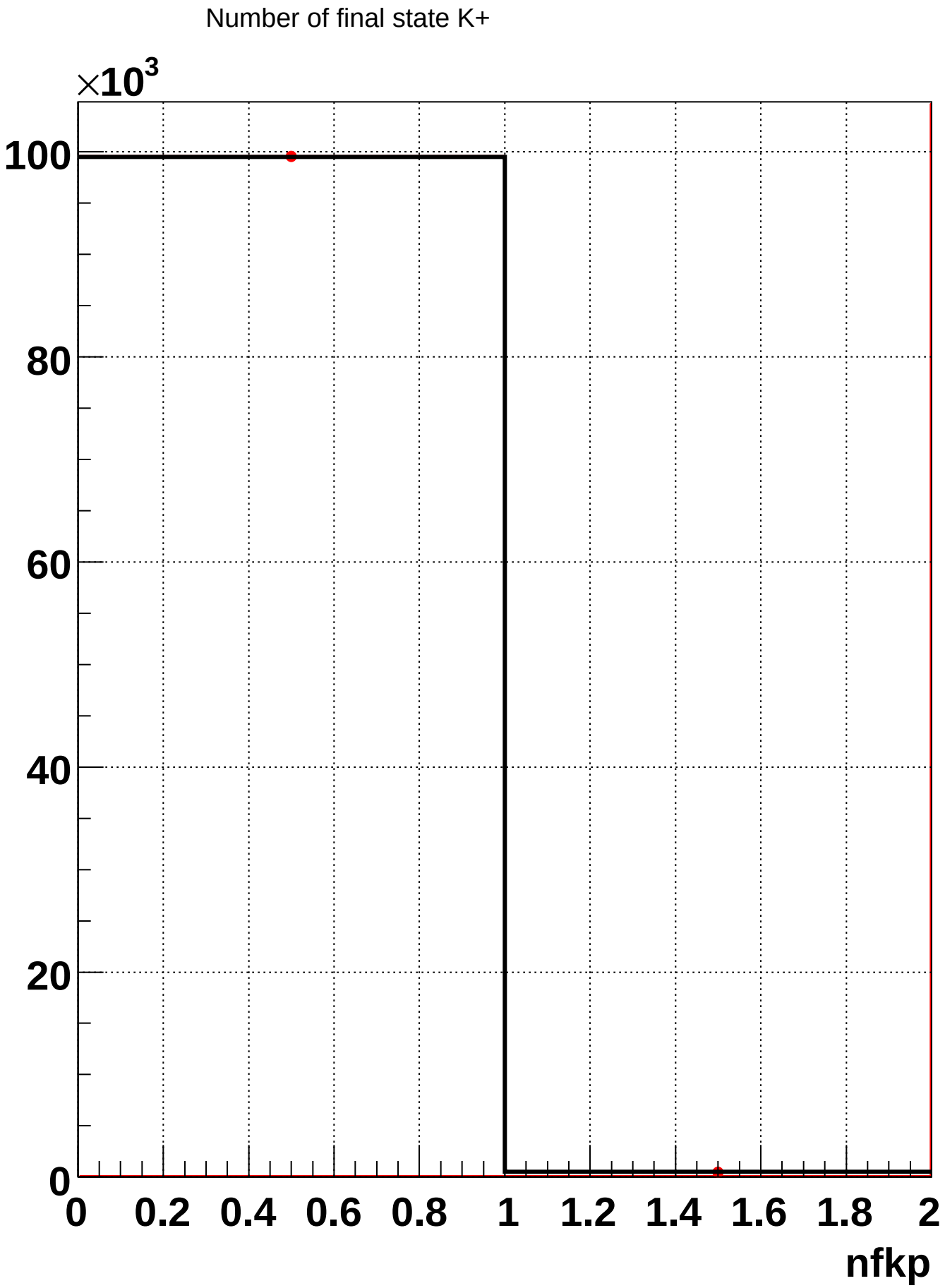


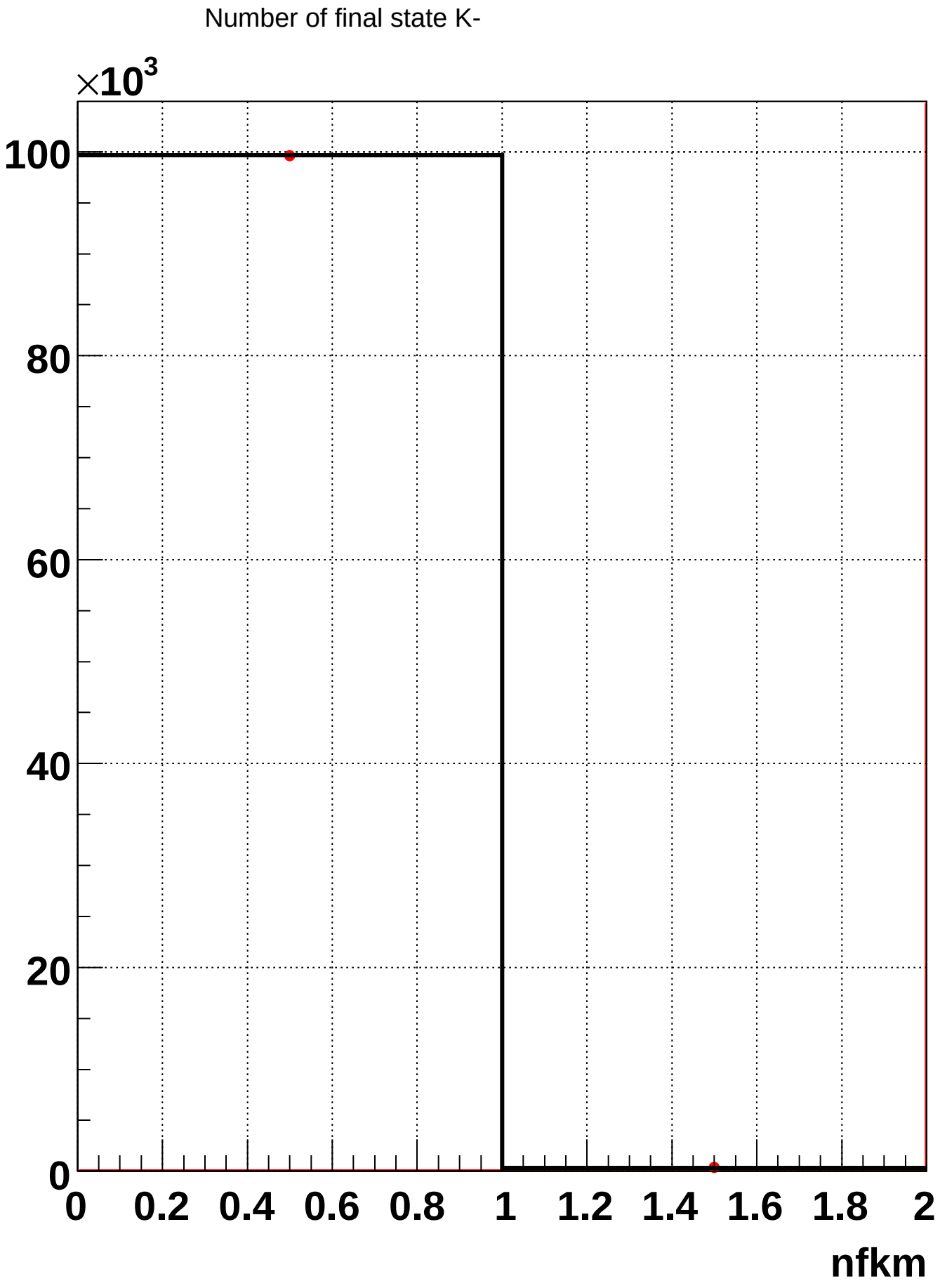
Number of final state pi-

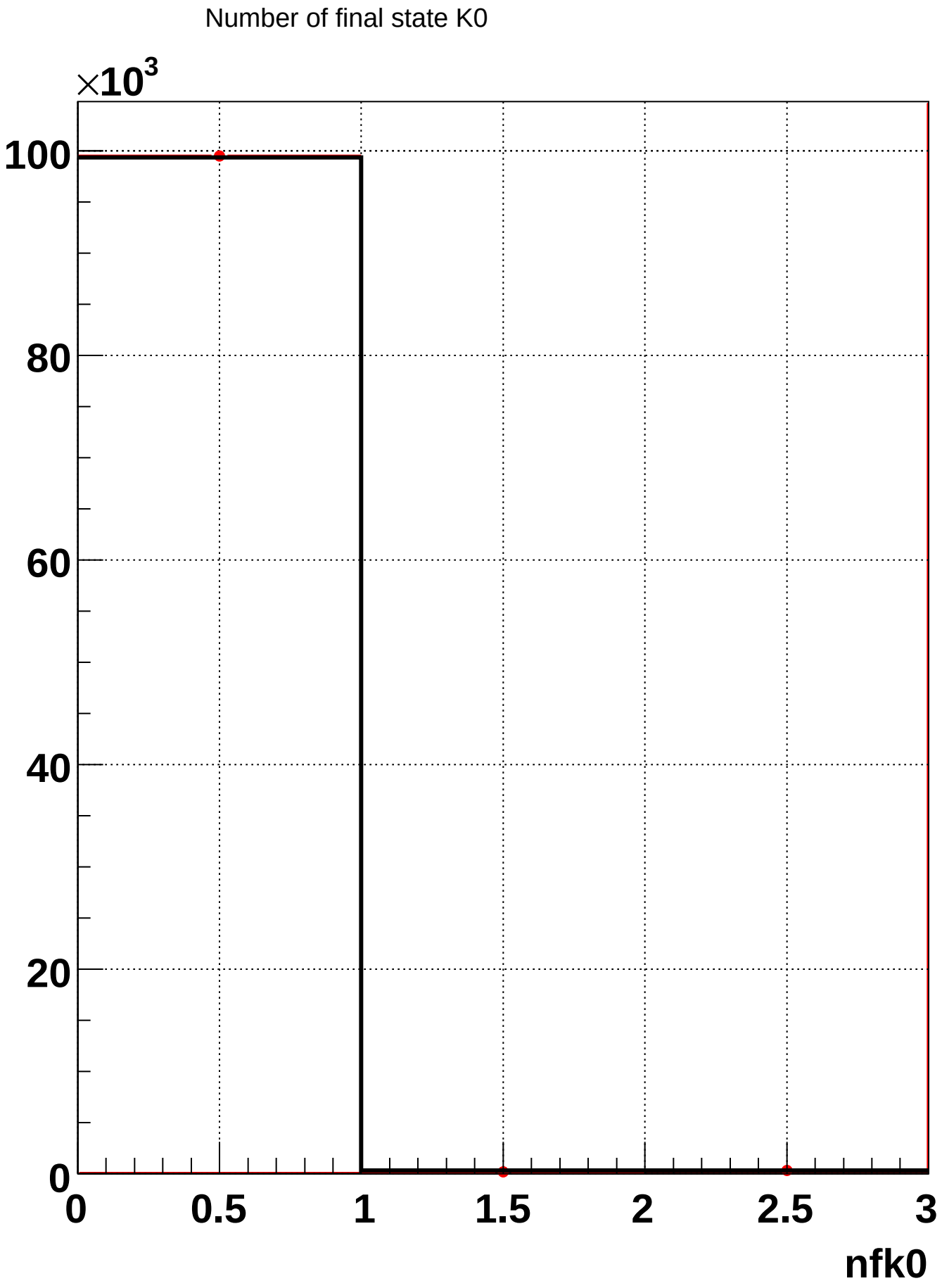


Number of final state pi0

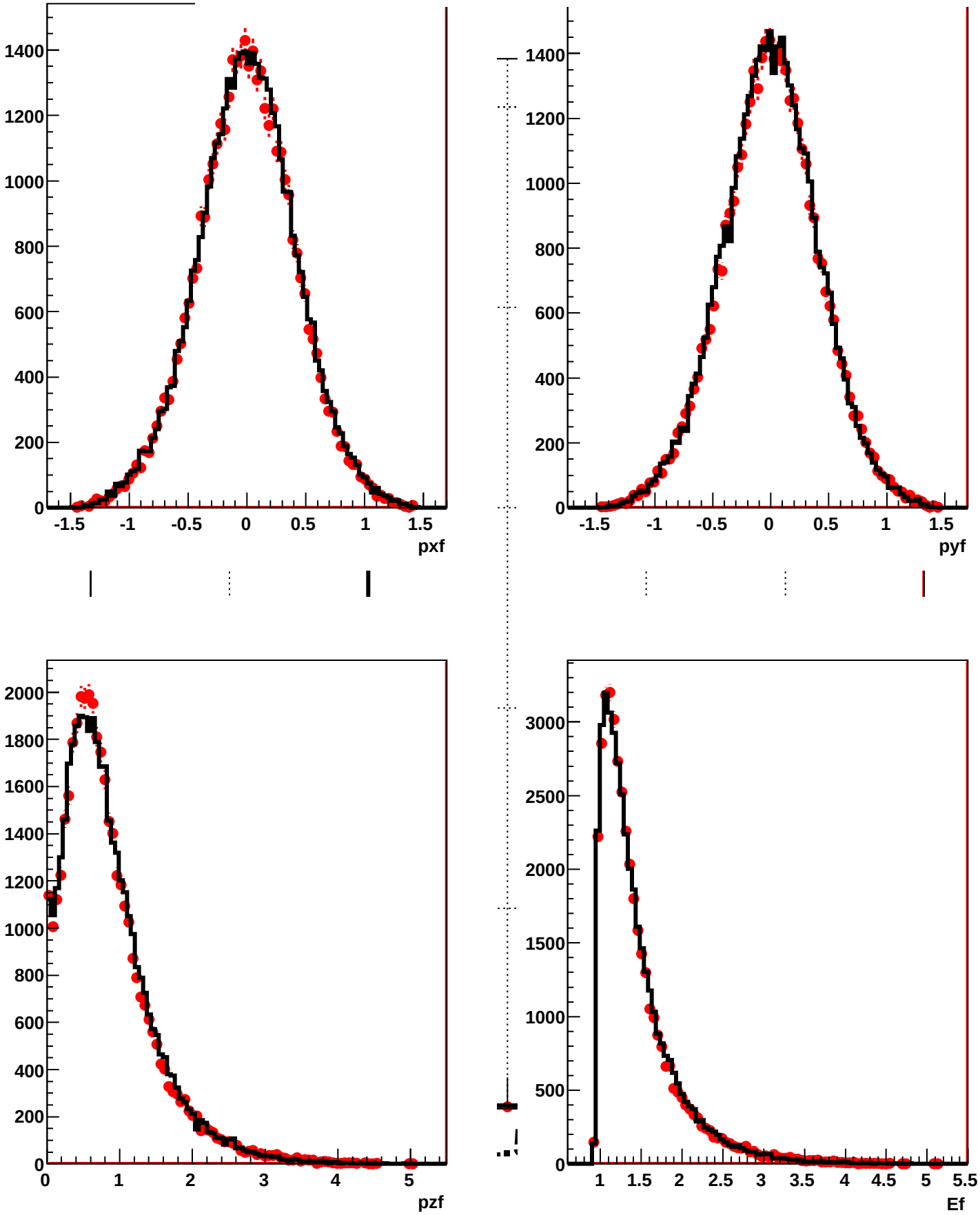



Number of final state K+
×10^3
100
80
60
40
20
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
nfkp

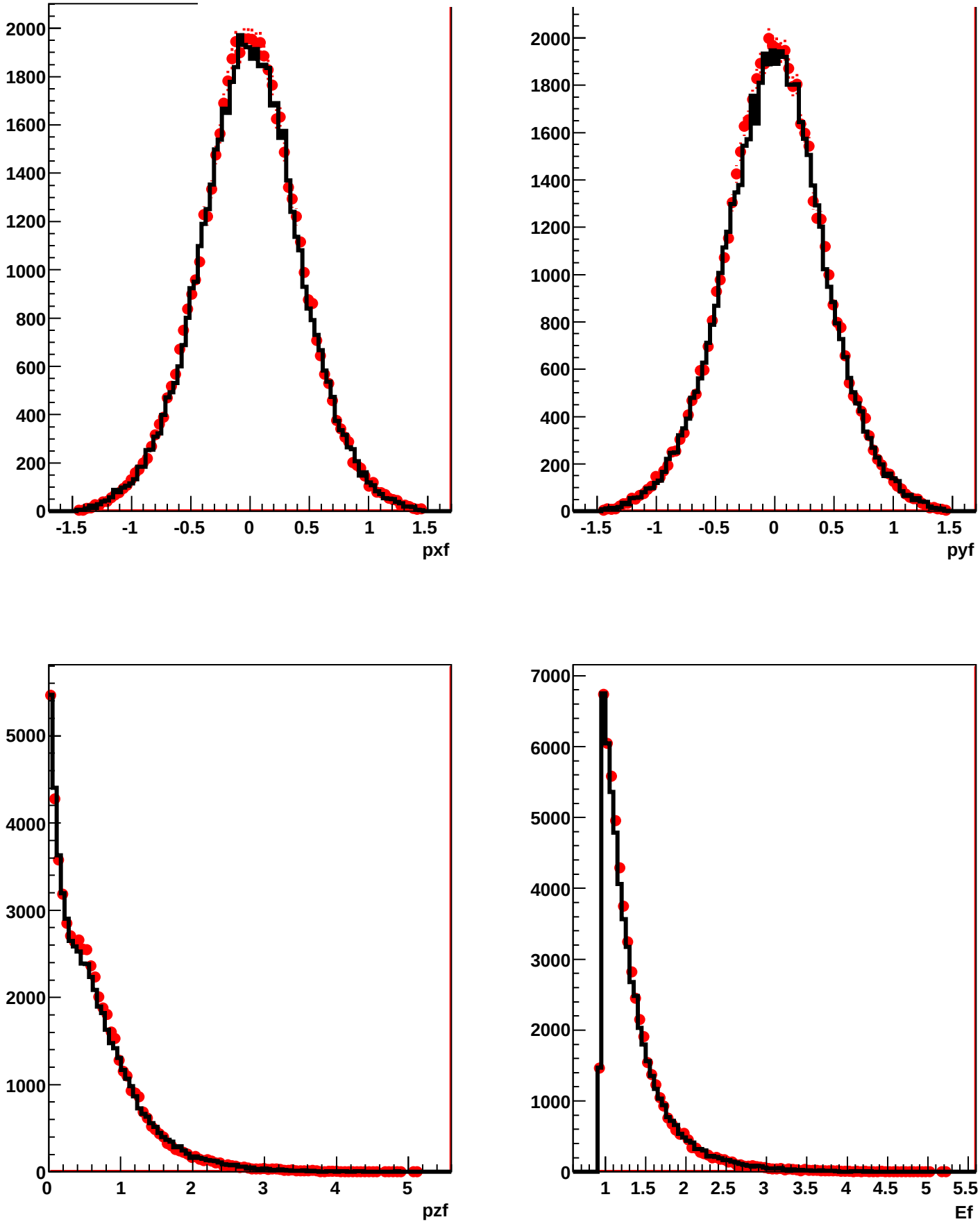

Number of final state K-
×10^3
100
80
60
40
20
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
nfkm


Number of final state K0
×10^3
100
80
60
40
20
0
0
0.5
1
1.5
2
2.5
3
nfk0

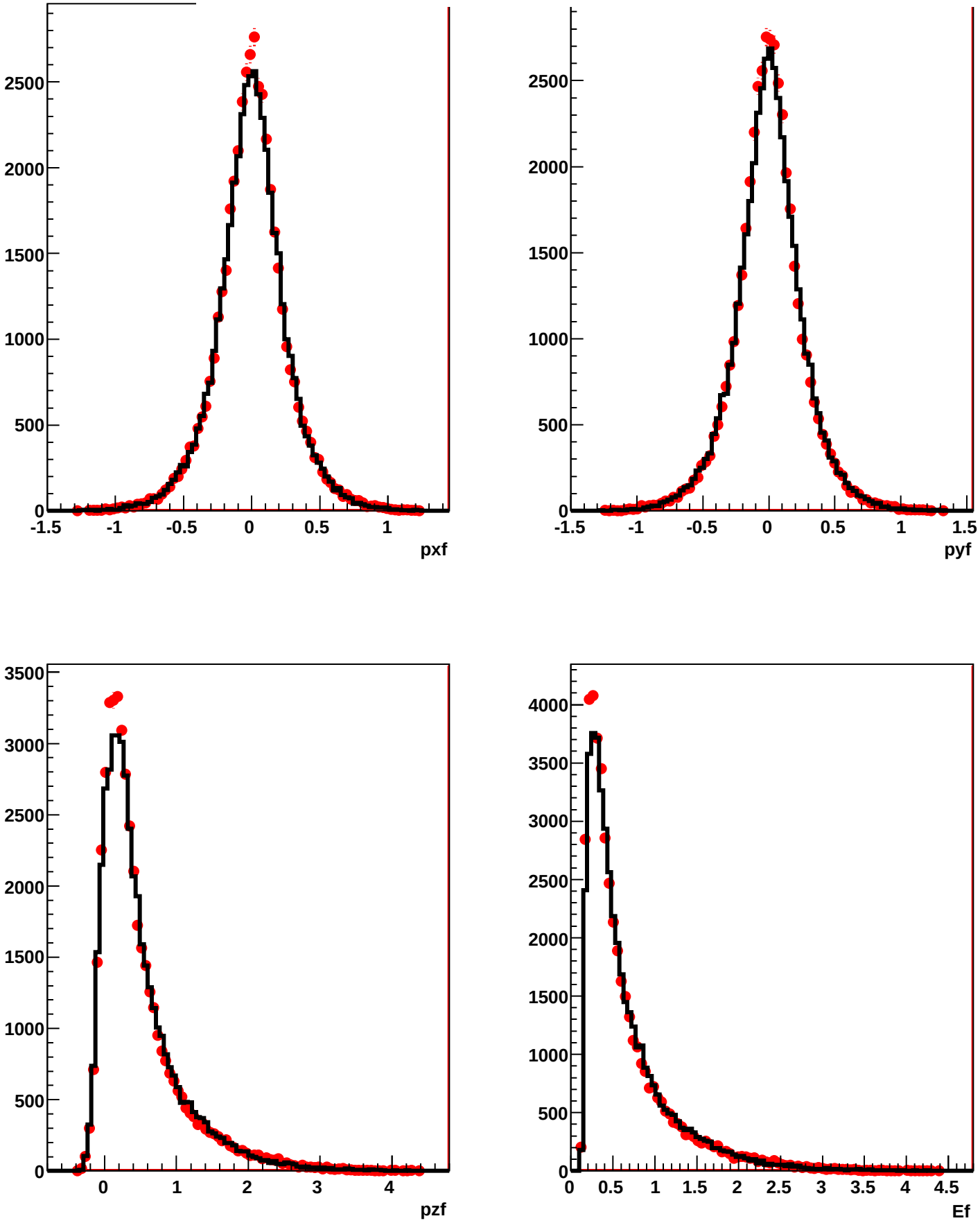
Final state protons 4-momentum



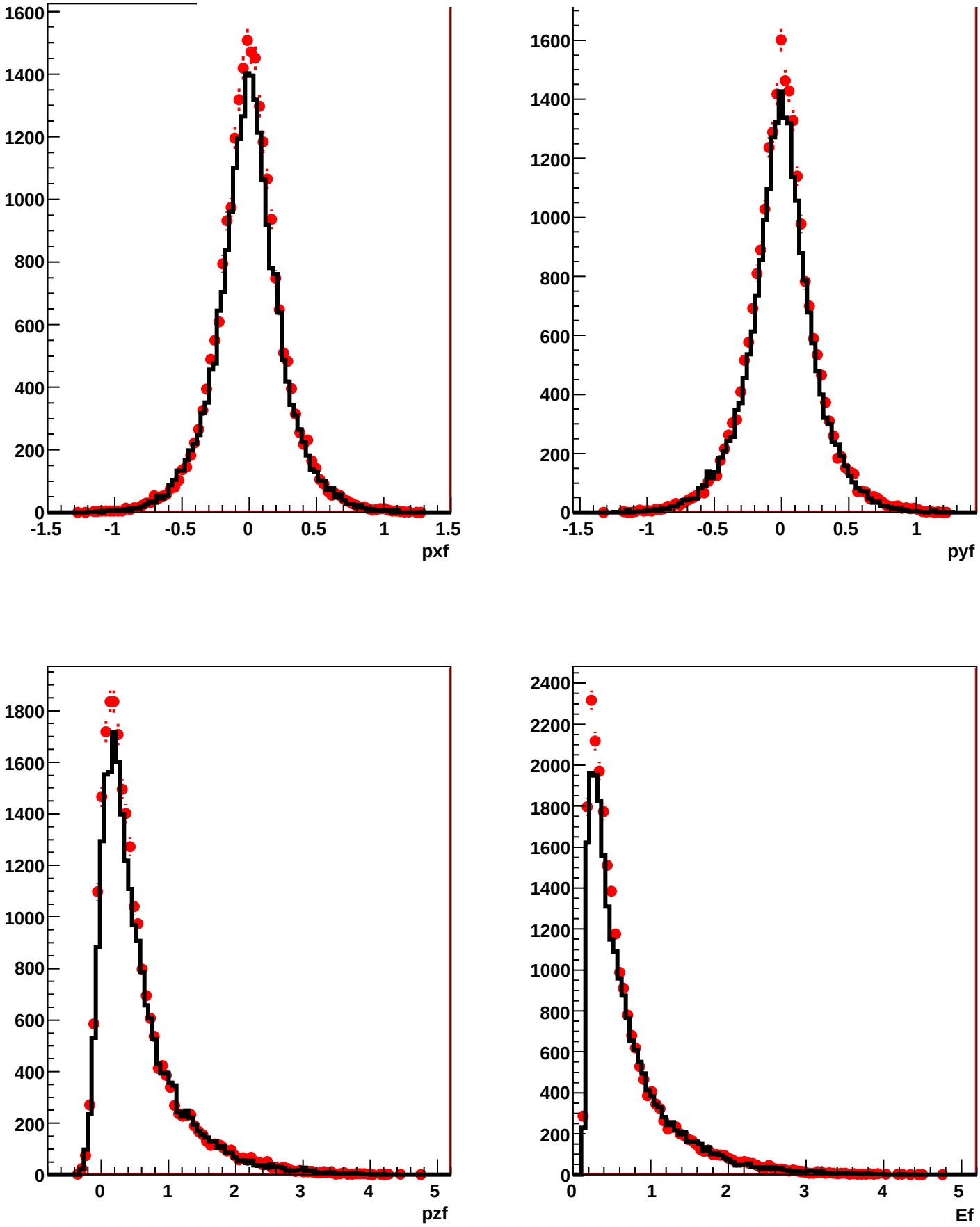
Final state neutrons 4-momentum



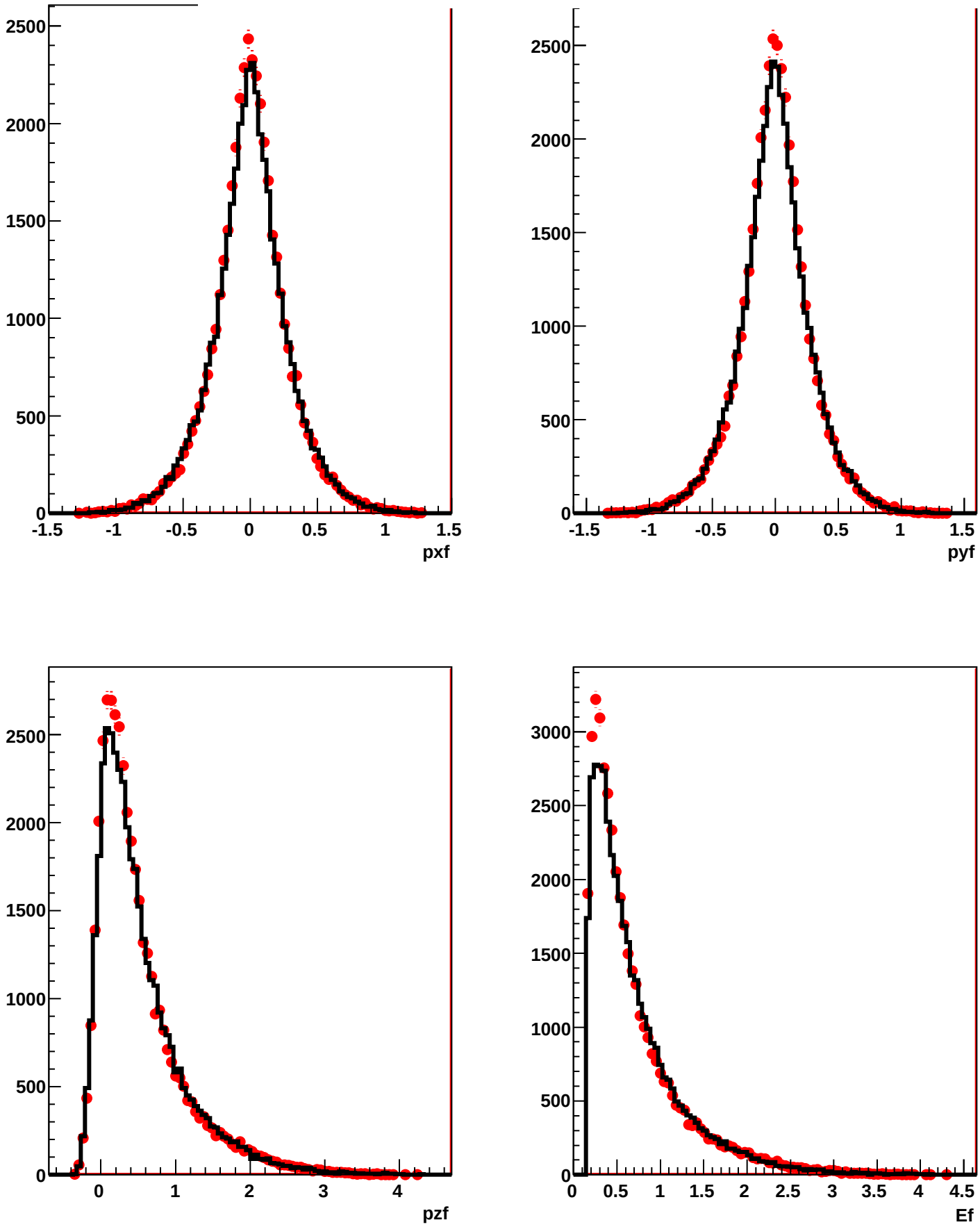
Final state pi0's 4-momentum



Final state pi+’s 4-momentum



Final state pi-'s 4-momentum



GENIE-2.0.0 vs NEUGEN/Daikon+ Event Sample Comparisons

Event Sample:

100k events, numubar+p, 50GeV, all processes

Notes:

Daikon+ is a NEUGEN Daikon revision version

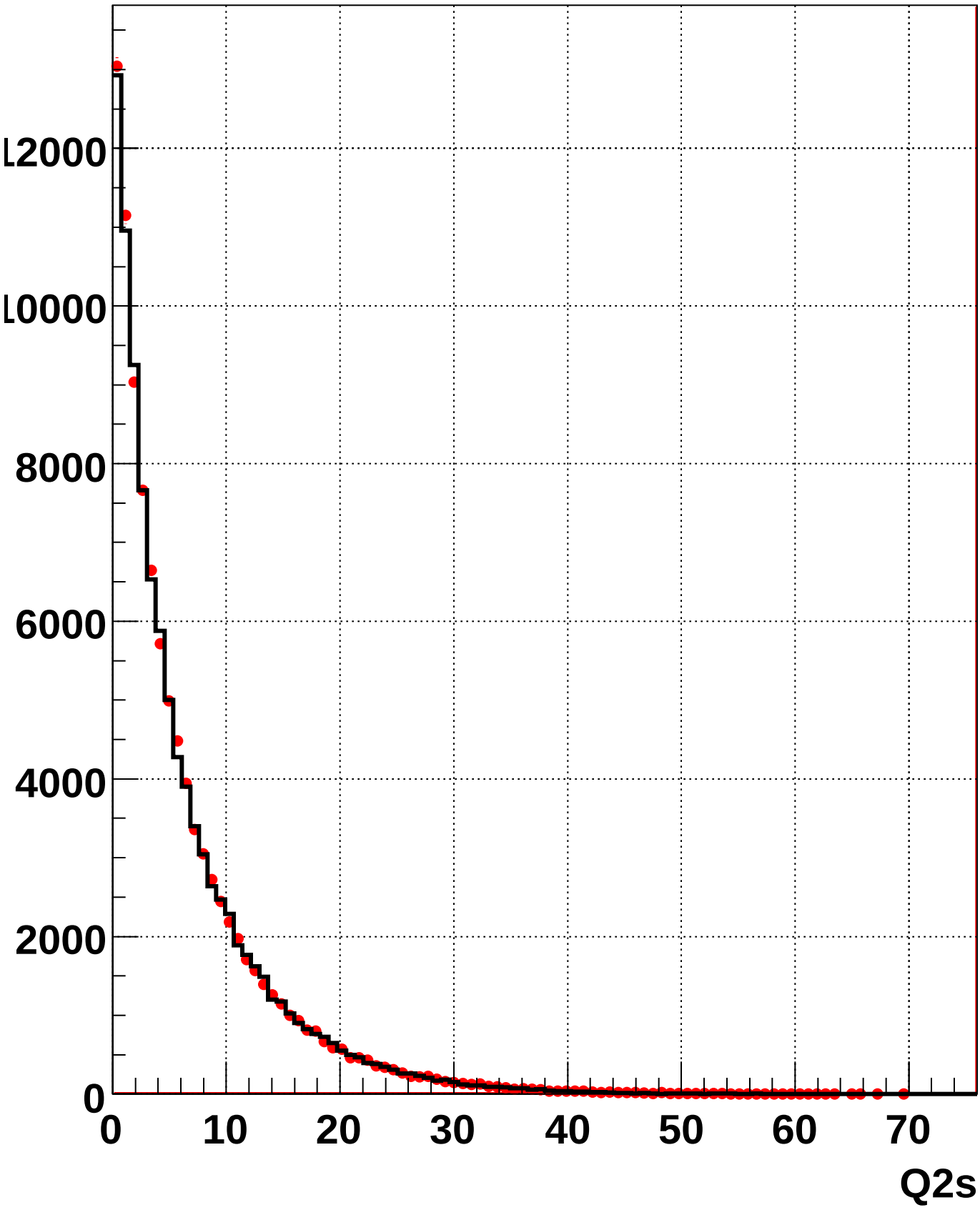
GENIE predictions shown with lines / NEUGEN's with markers

Event Numbers:

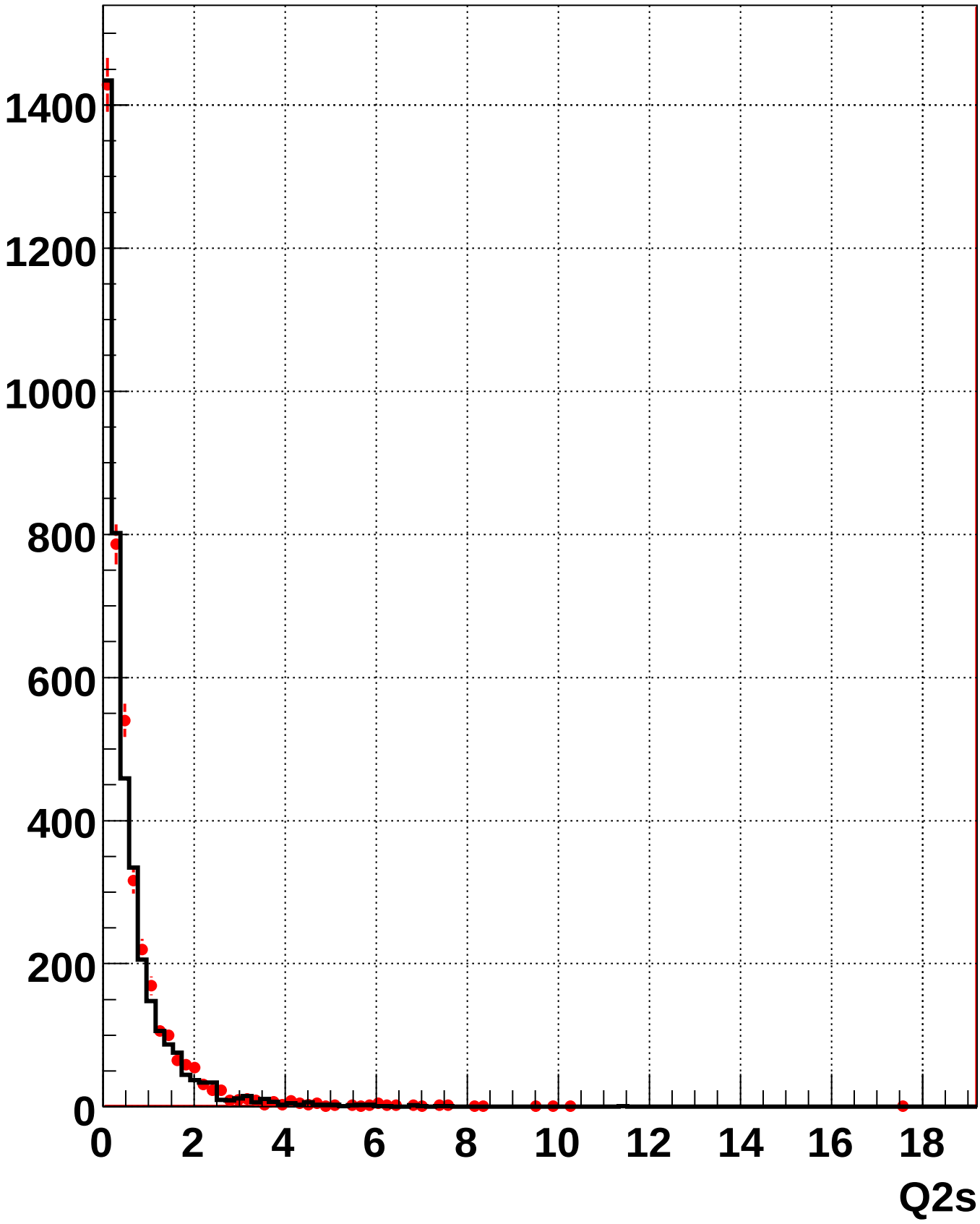
ALL :	100000 [NeuGEN],	100000 [GENIE]
QEL :	4024 [NeuGEN],	3915 [GENIE]
QEL-CC :	3421 [NeuGEN],	3330 [GENIE]
QEL-NC :	603 [NeuGEN],	585 [GENIE]
RES :	4363 [NeuGEN],	4379 [GENIE]
RES-CC :	3182 [NeuGEN],	3248 [GENIE]
RES-NC :	1181 [NeuGEN],	1131 [GENIE]
DIS :	91613 [NeuGEN],	91706 [GENIE]
DIS-CC :	70852 [NeuGEN],	70944 [GENIE]
(charm):	3101 [NeuGEN],	3034 [GENIE]
DIS-NC :	20761 [NeuGEN],	20762 [GENIE]
COH :	0 [NeuGEN],	0 [GENIE]
COH-CC :	0 [NeuGEN],	0 [GENIE]
COH-NC :	0 [NeuGEN],	0 [GENIE]
IMD :	0 [NeuGEN],	0 [GENIE]

Selected Kinematical Quantities

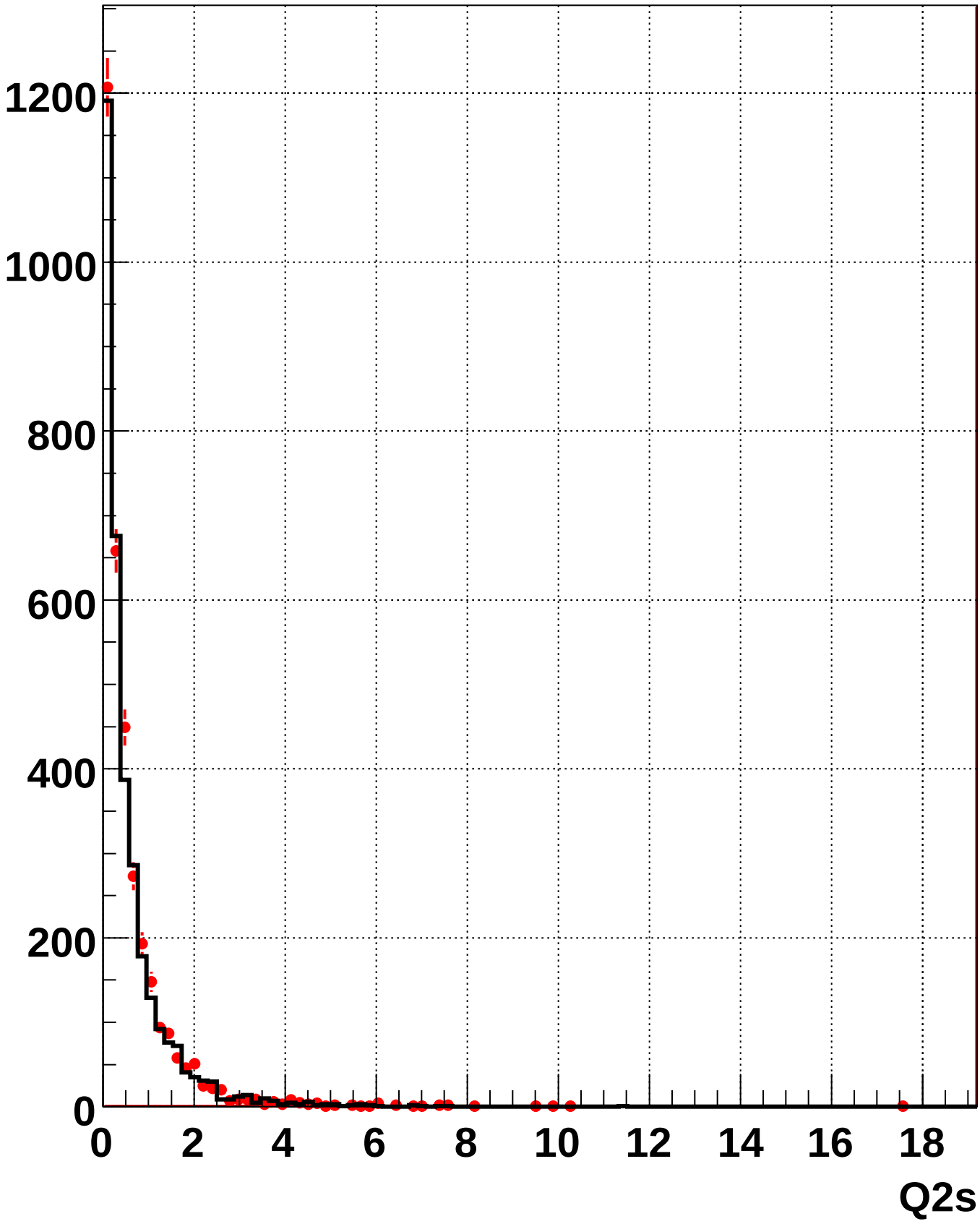
selected Q2 for all events



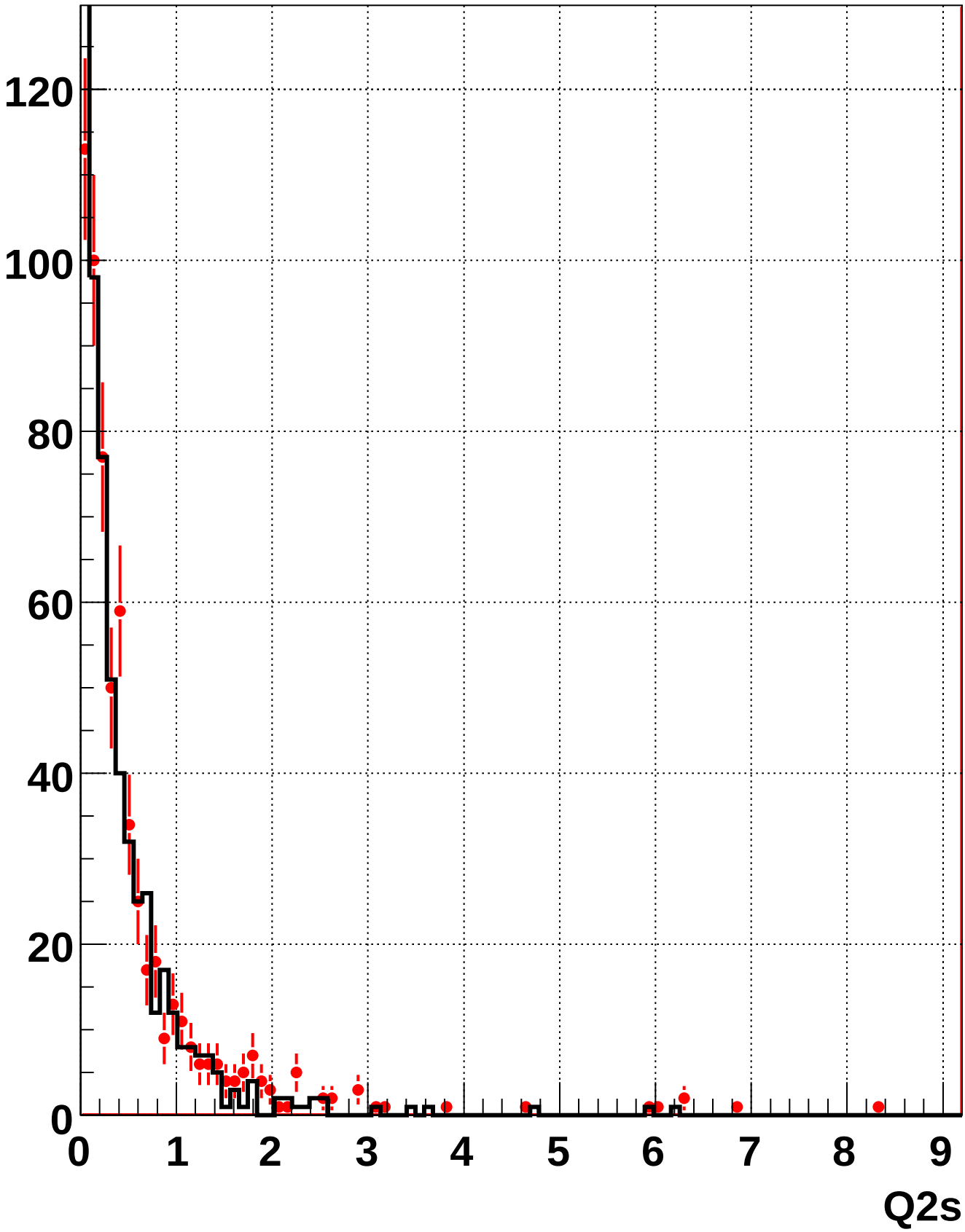
selected Q2 for QEL events



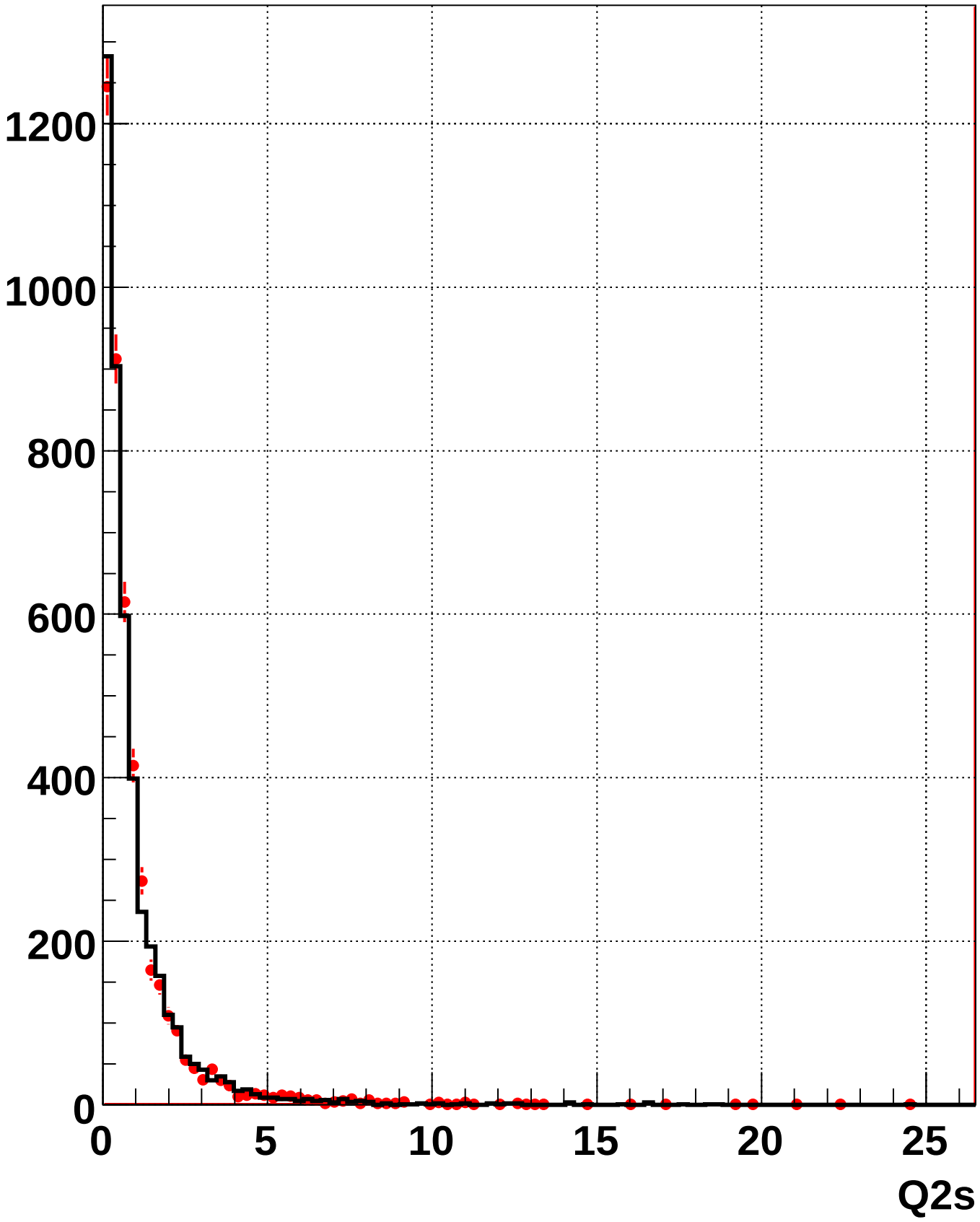
selected Q2 for QEL CC events



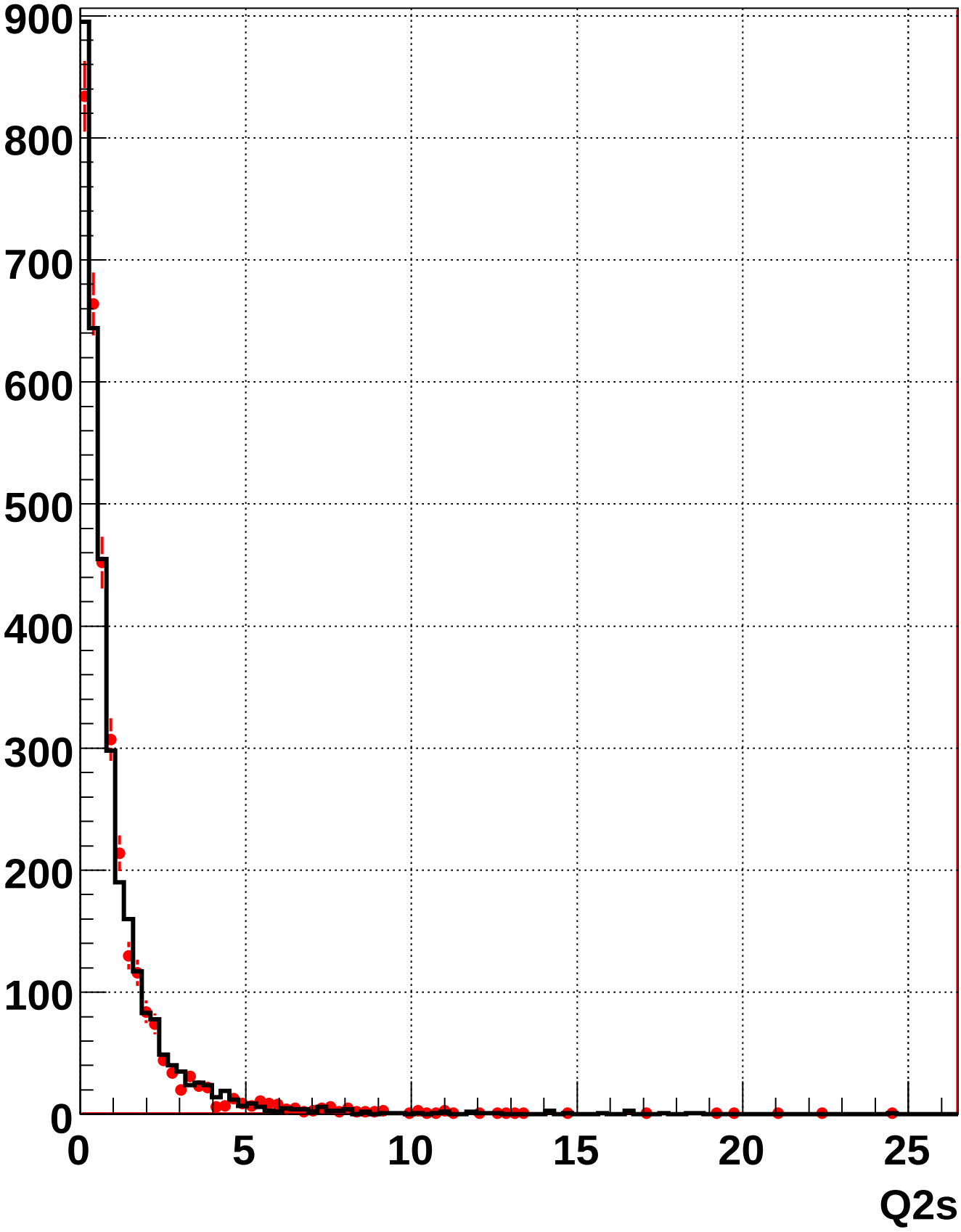
selected Q2 for QEL NC events



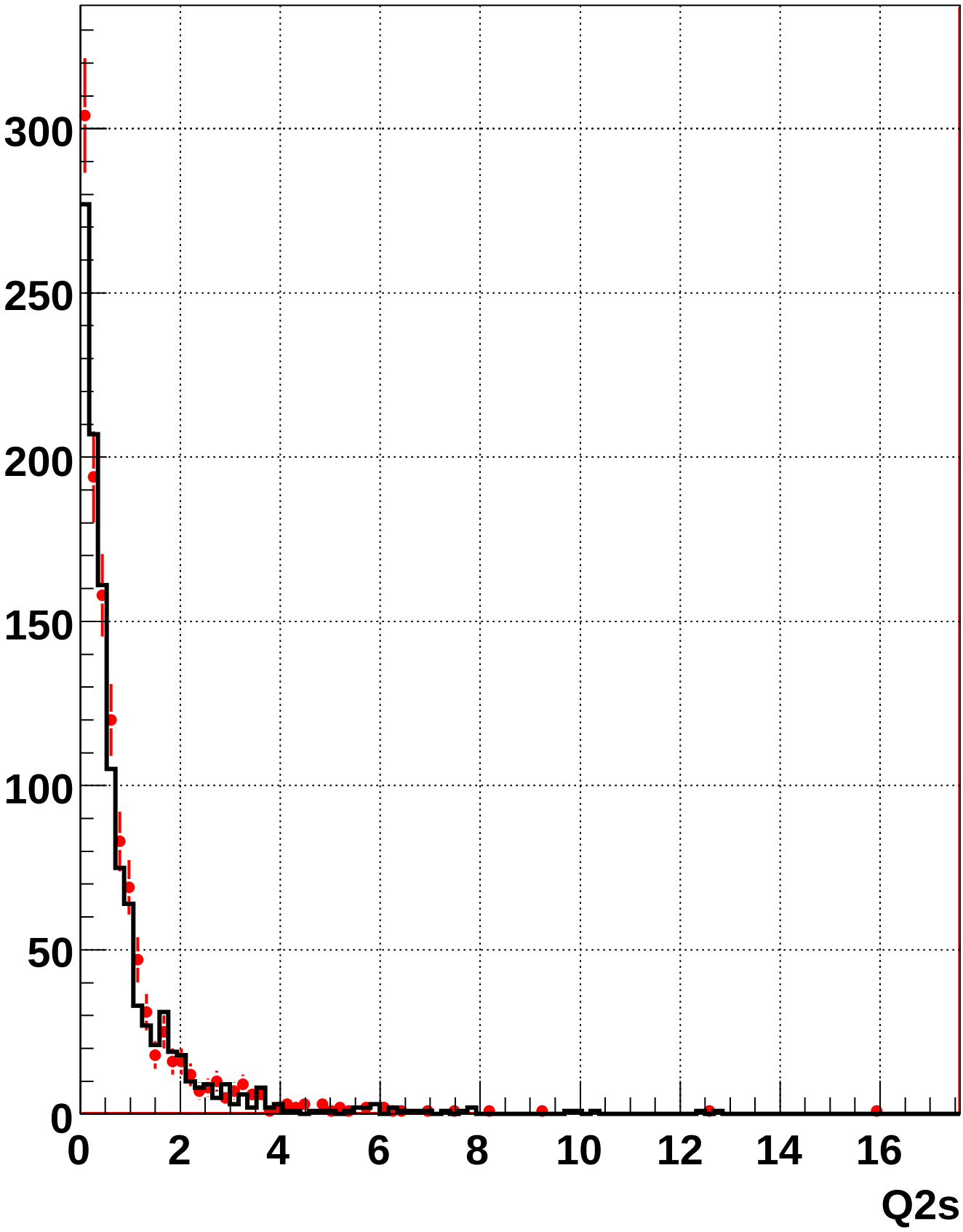
selected Q2 for RES events



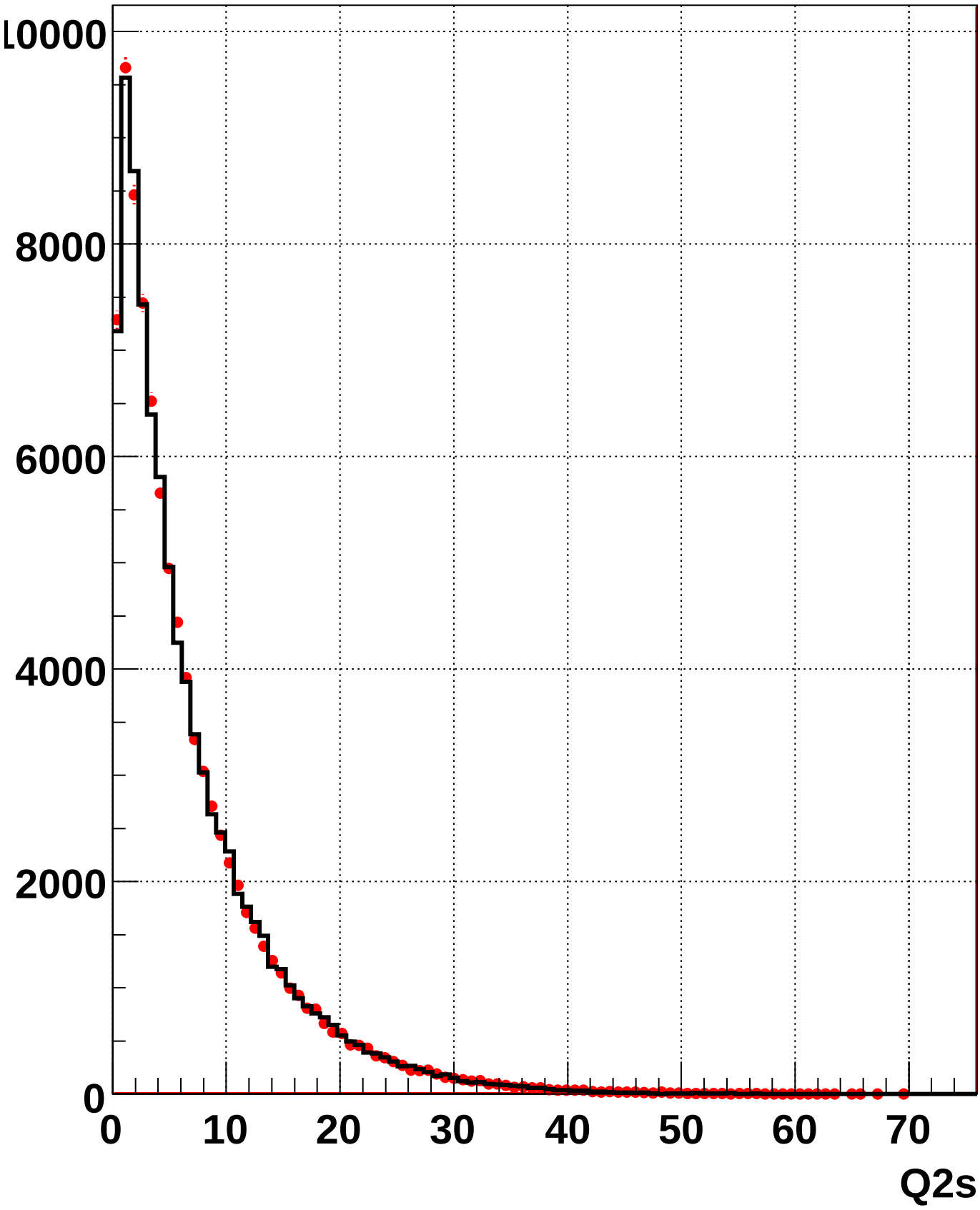
selected Q2 for RES CC events



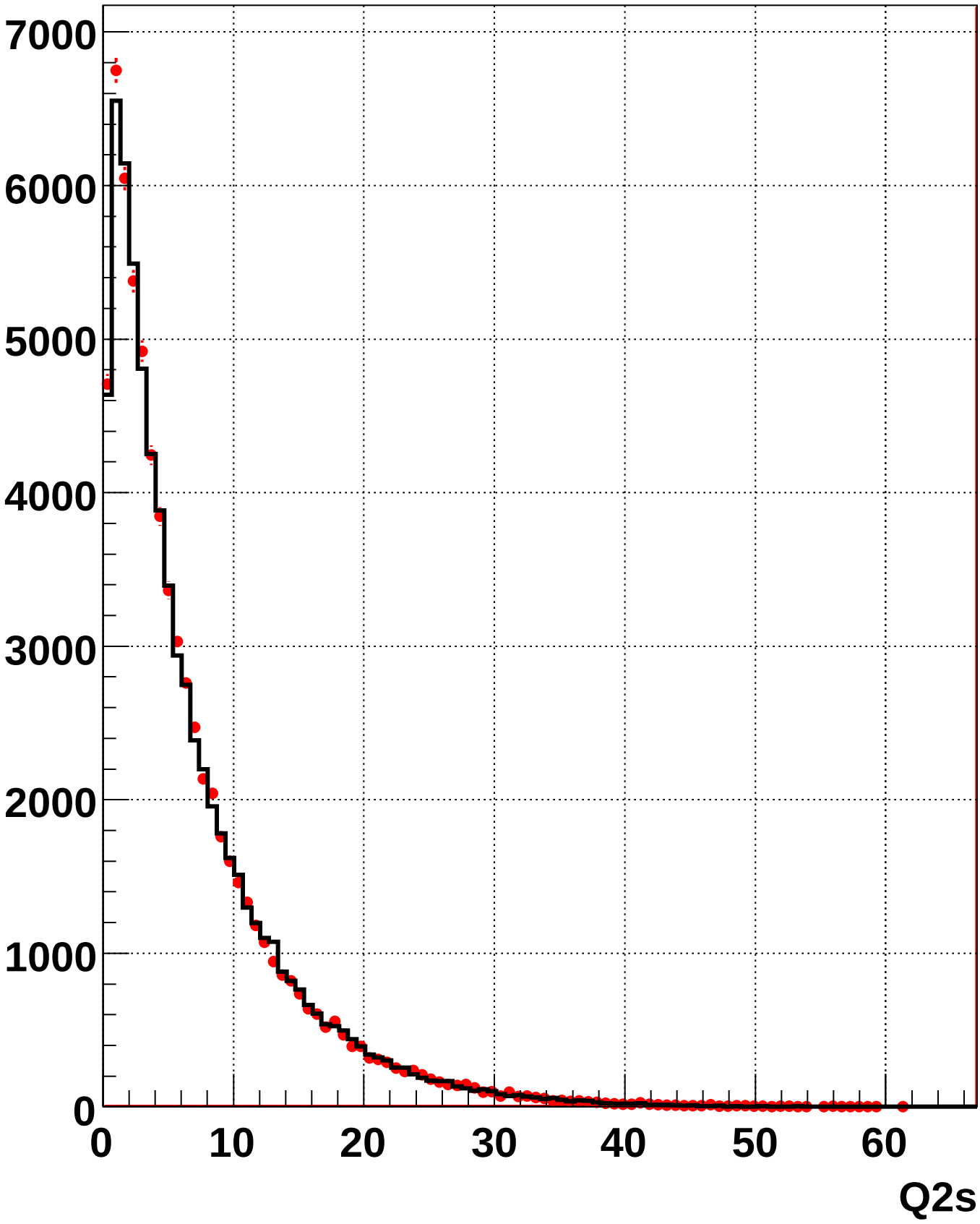
selected Q2 for RES NC events



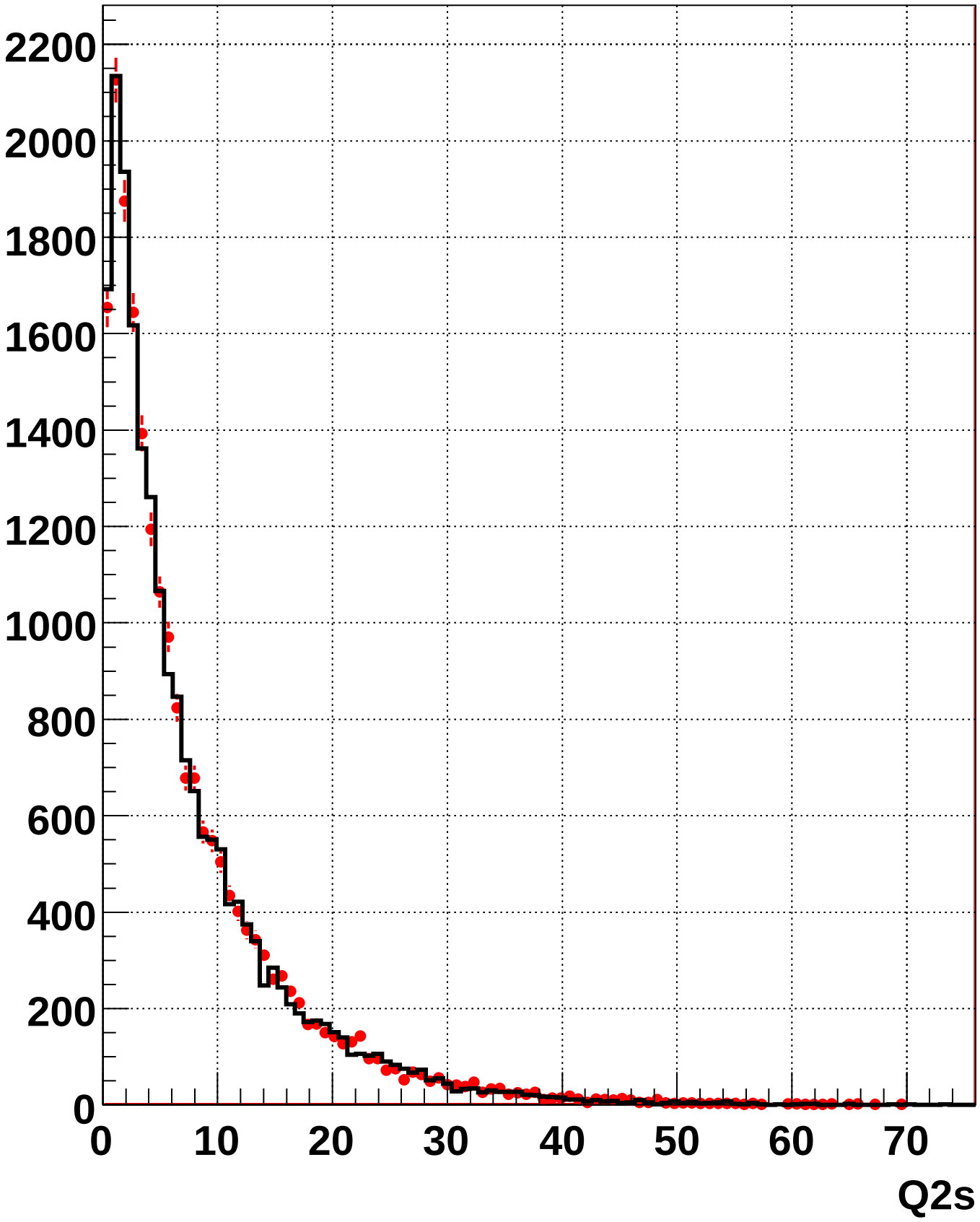
selected Q2 for DIS events



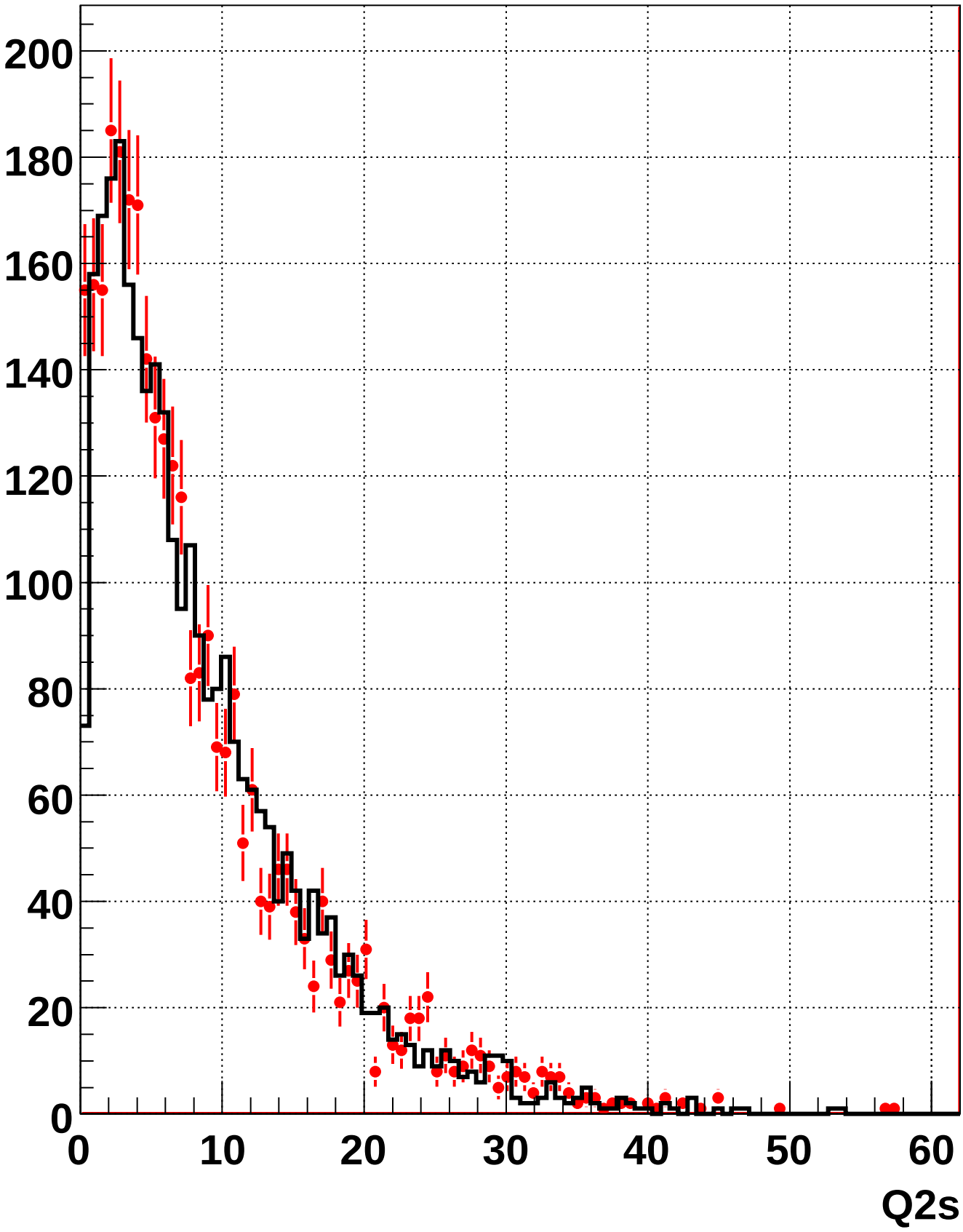
selected Q2 for DIS CC events



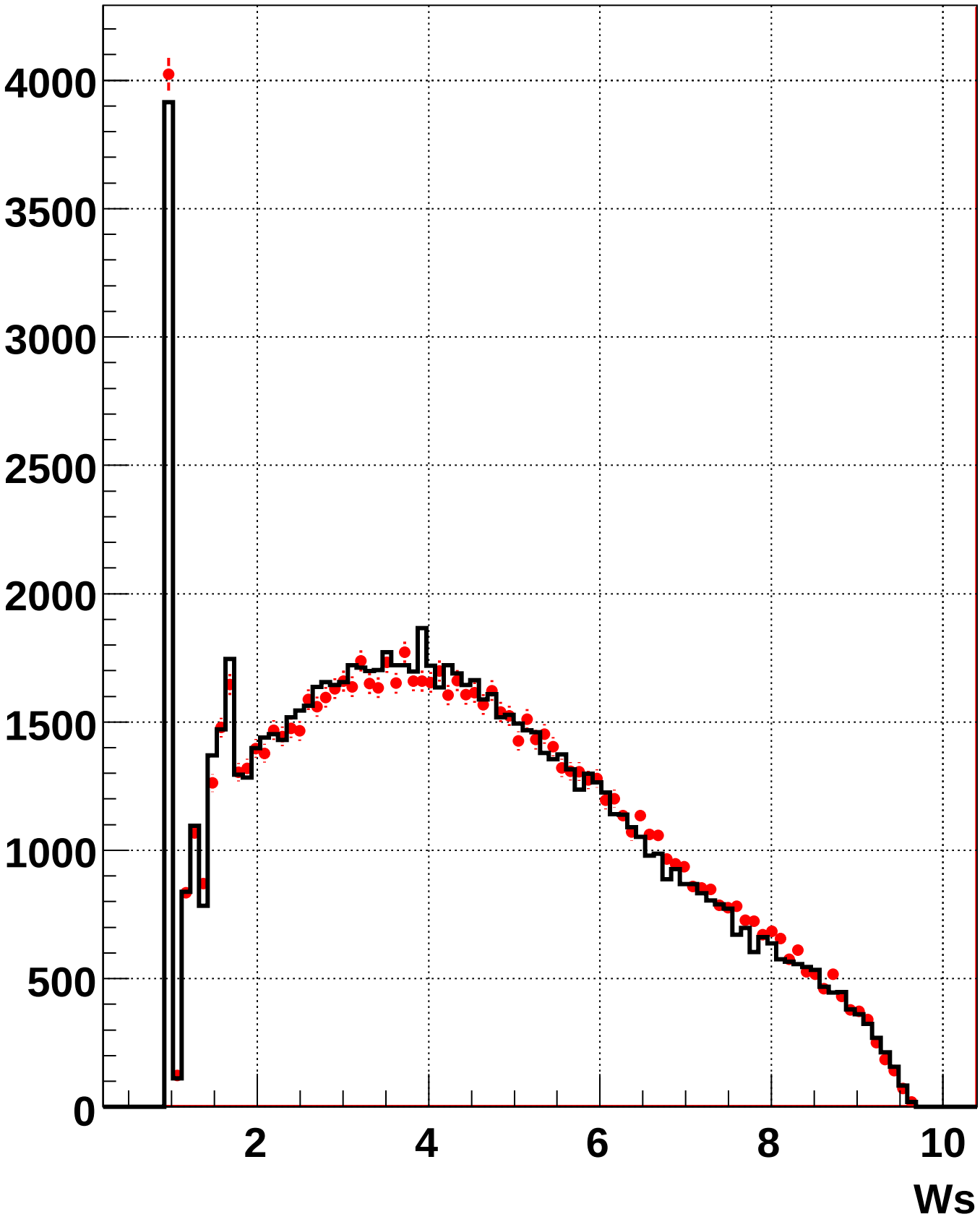
selected Q2 for DIS NC events

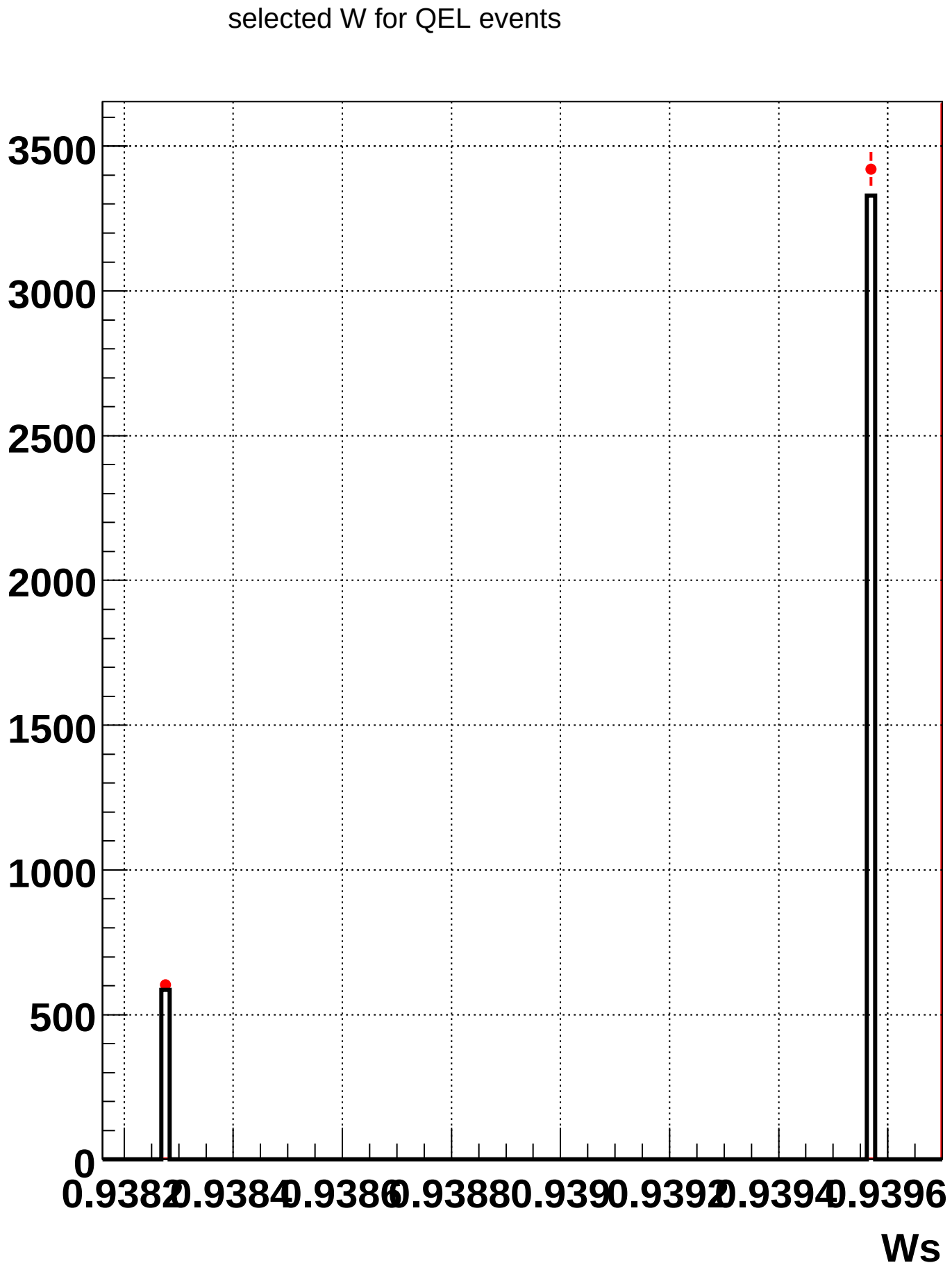


selected Q2 for Charm/DIS events

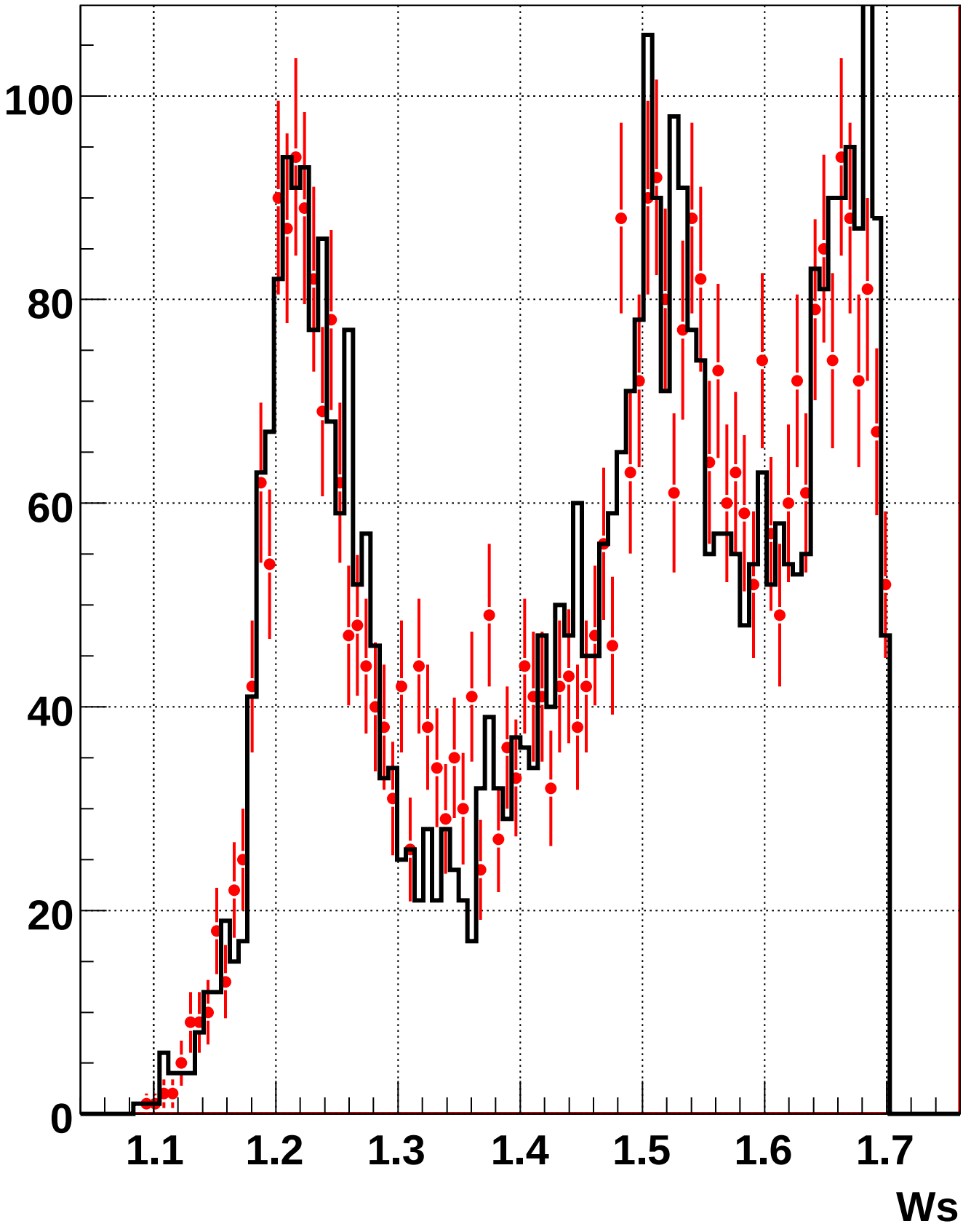


selected W for all events

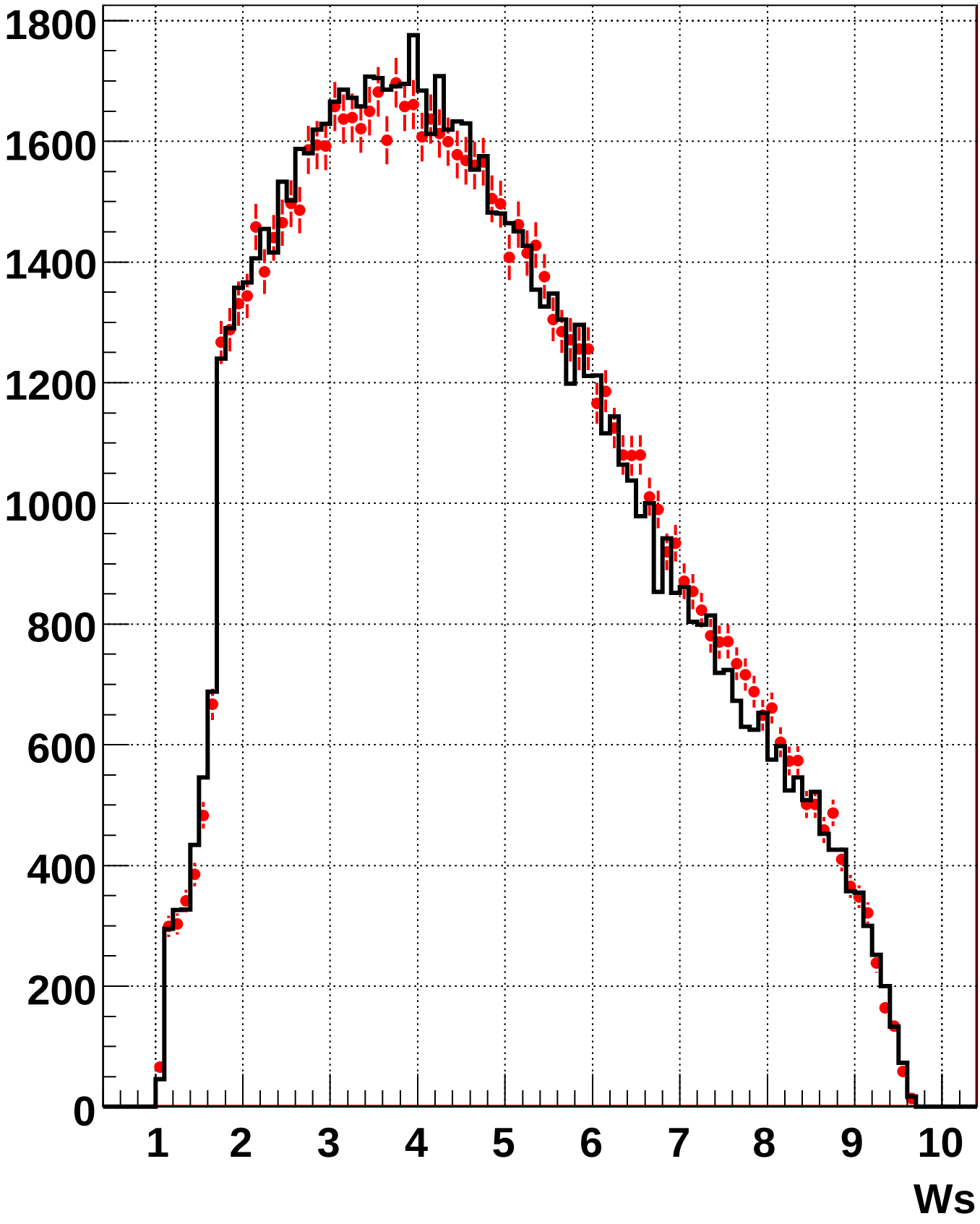



selected W for QEL events
3500
3000
2500
2000
1500
1000
500
0
0.9382
0.9384
0.9386
0.9388
0.939
0.9392
0.9394
0.9396
Ws

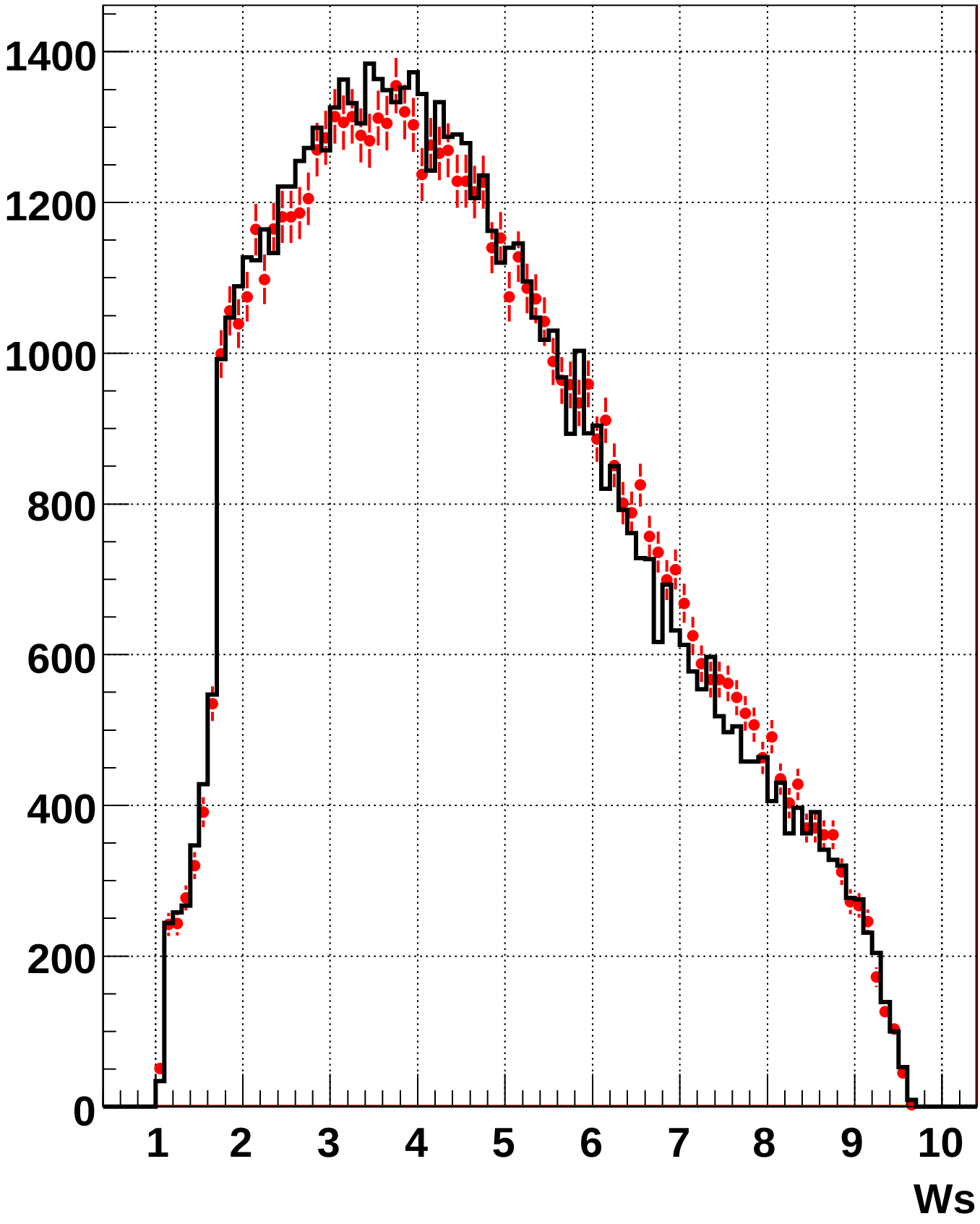
selected W for RES events



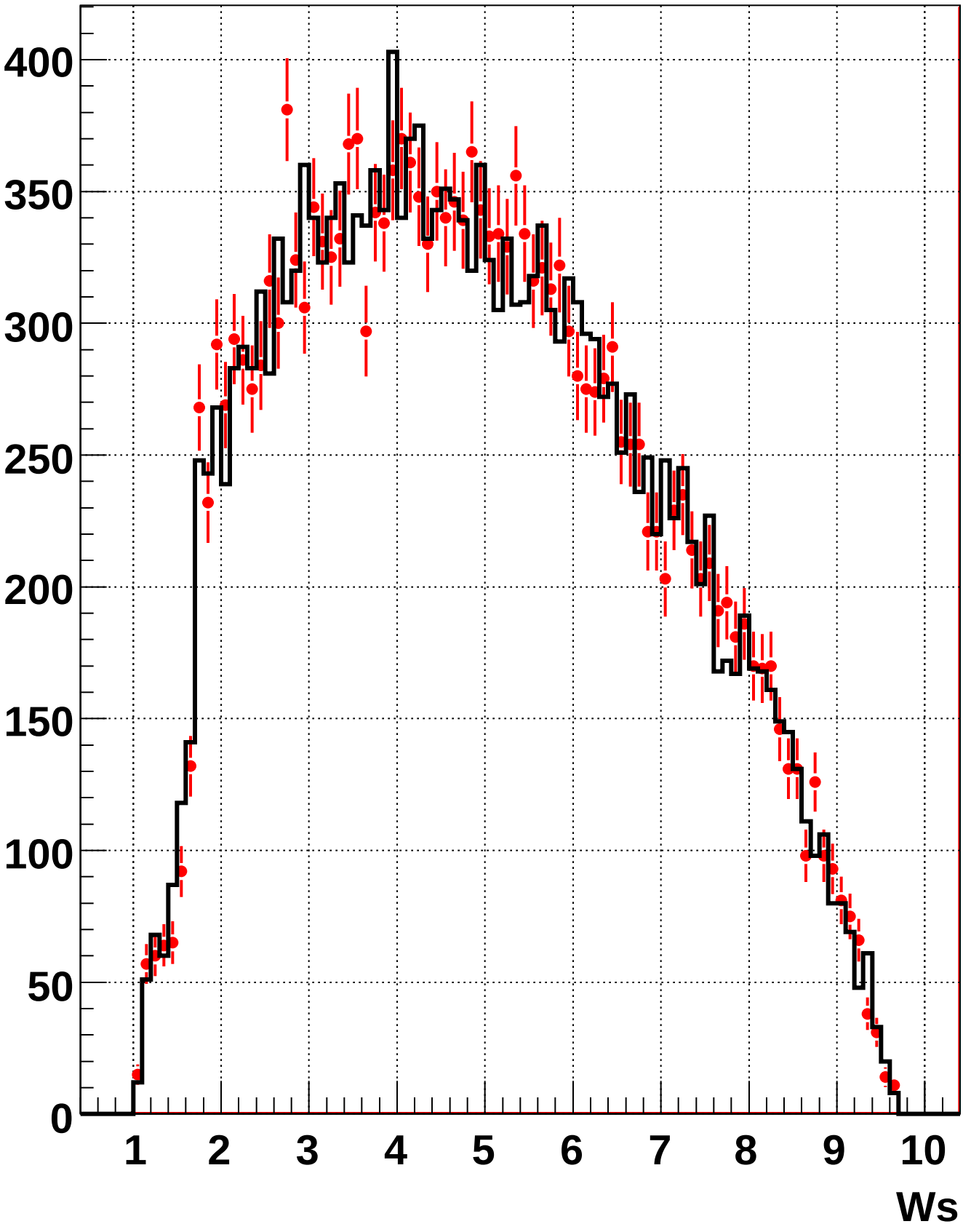
selected W for DIS events



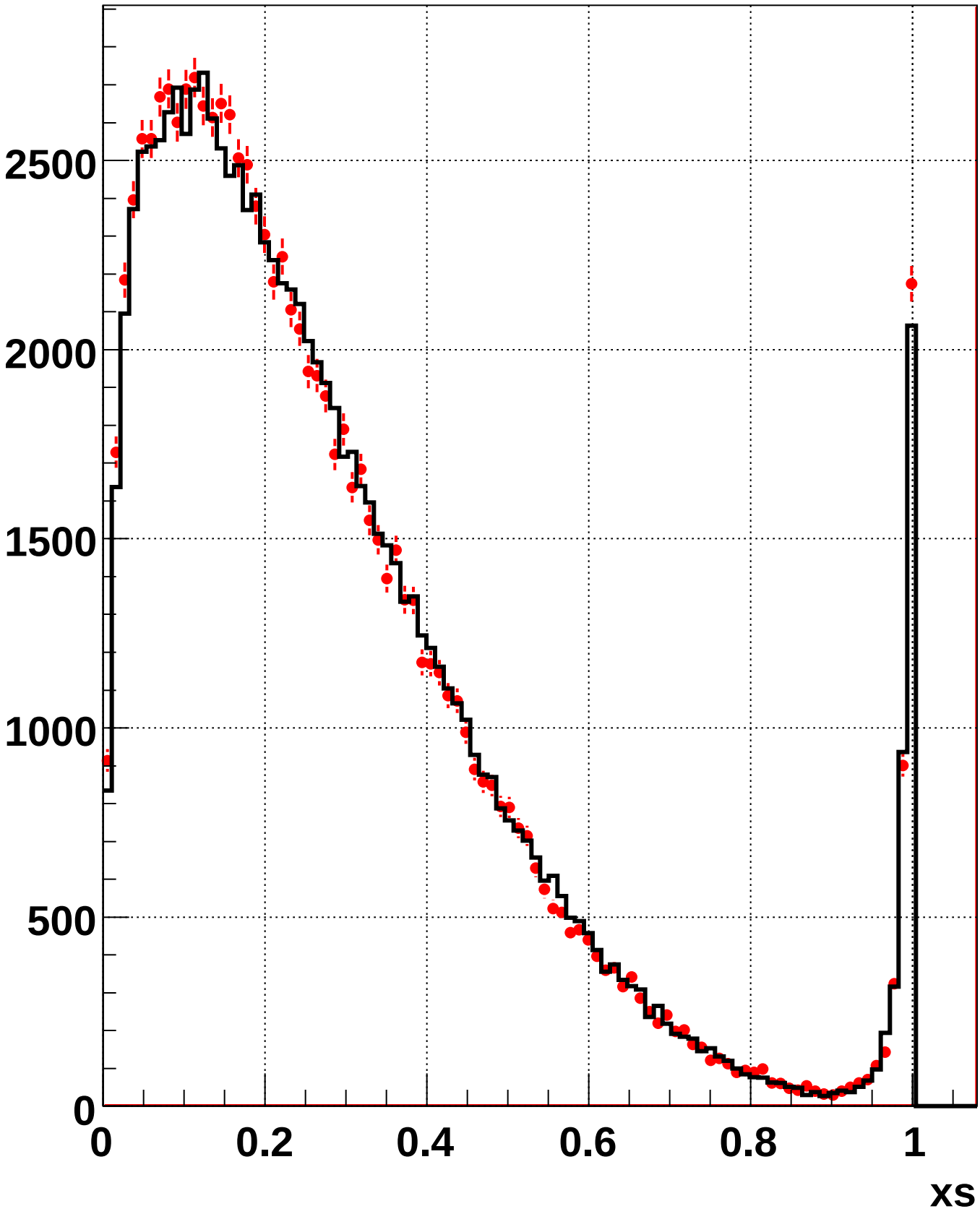
selected W for DIS CC events



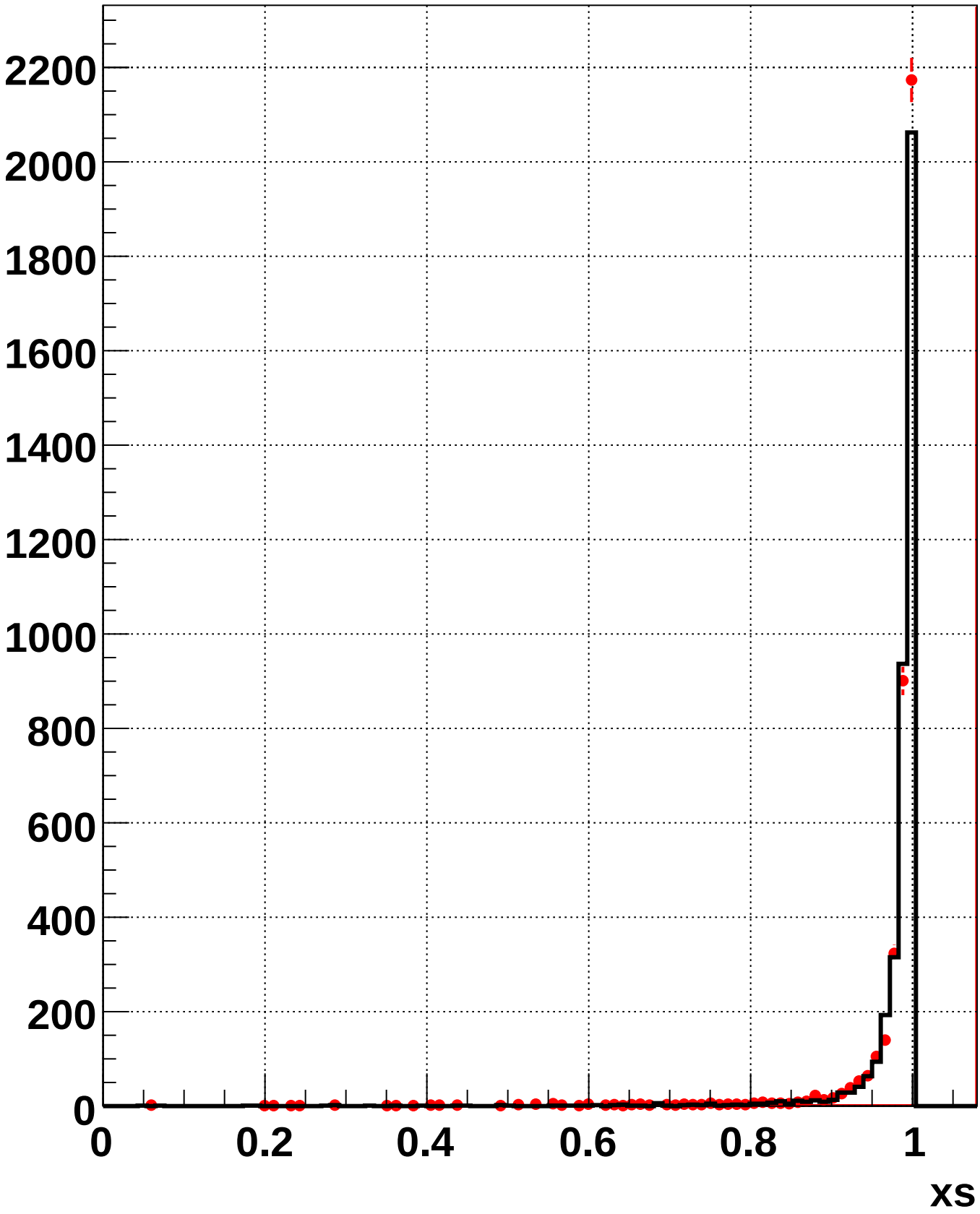
selected W for DIS NC events



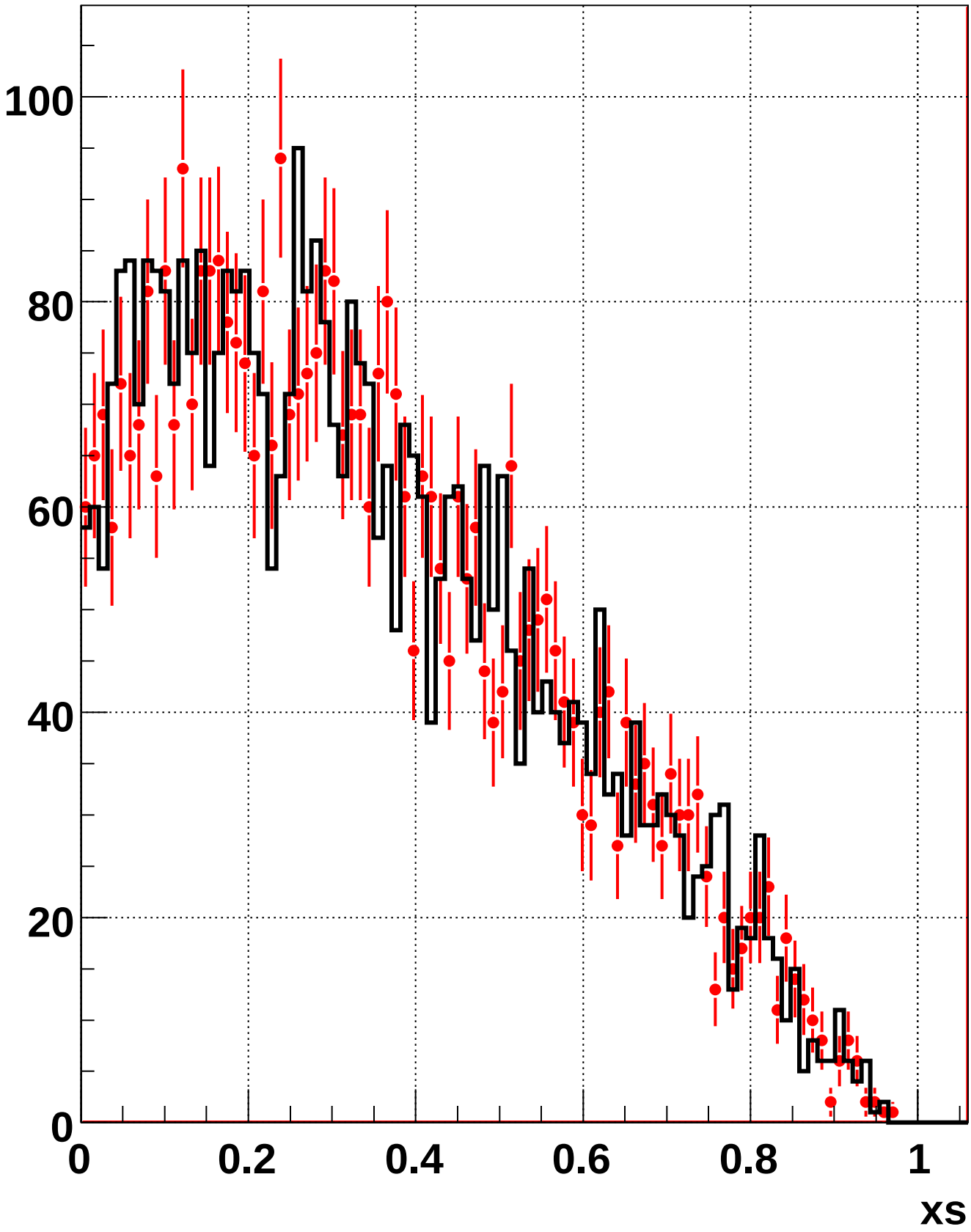
selected x for all events



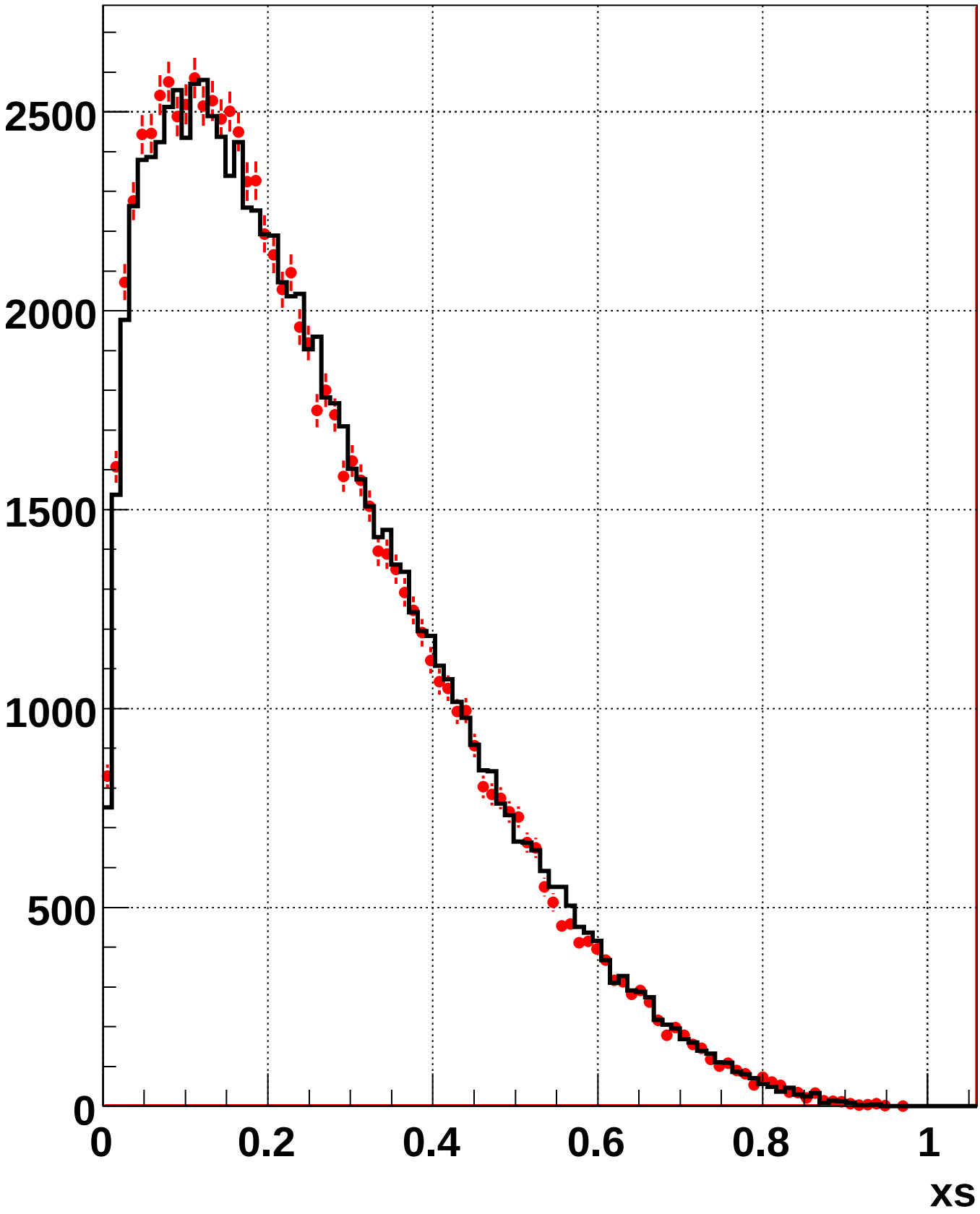
selected x for QEL events



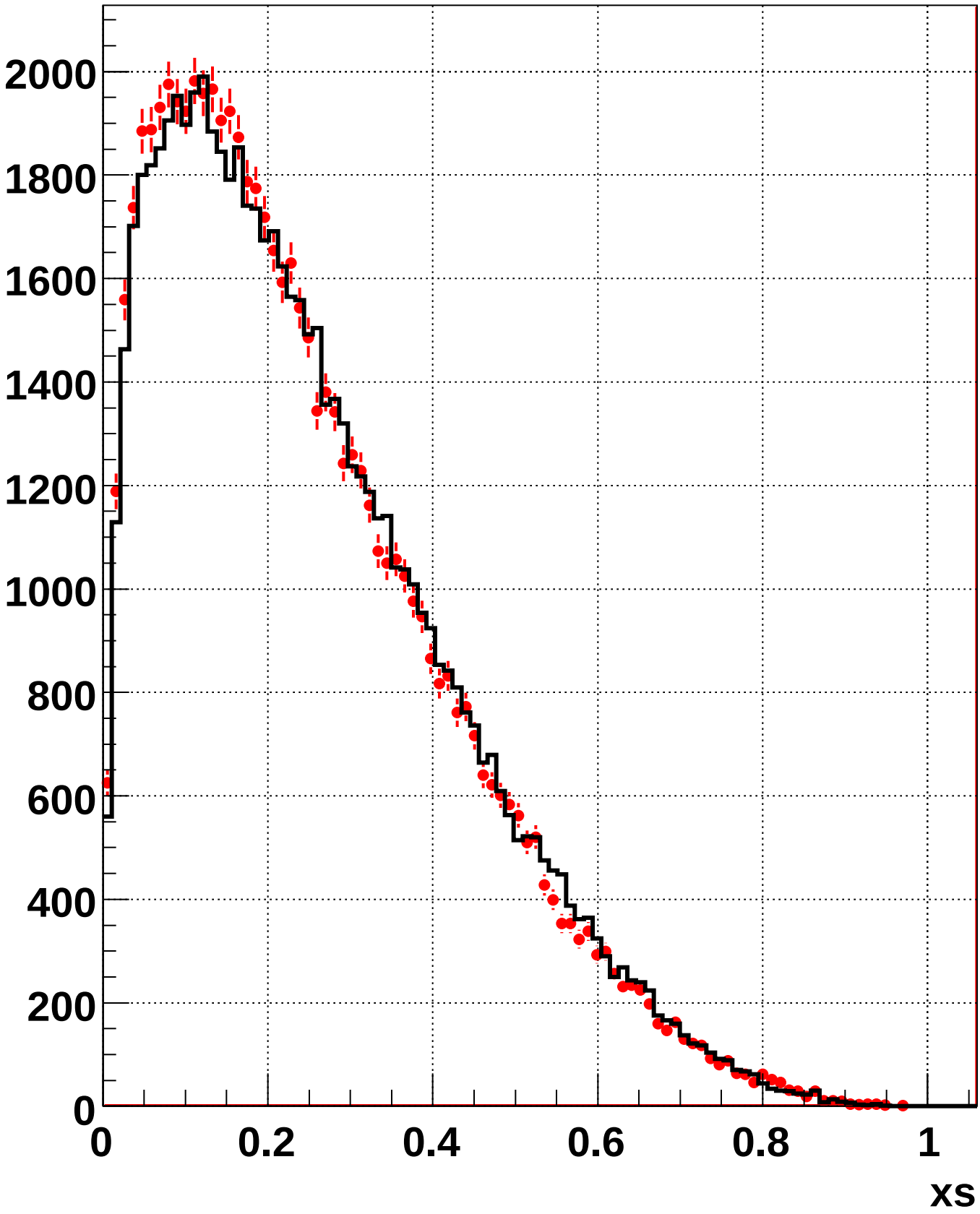
selected x for RES events



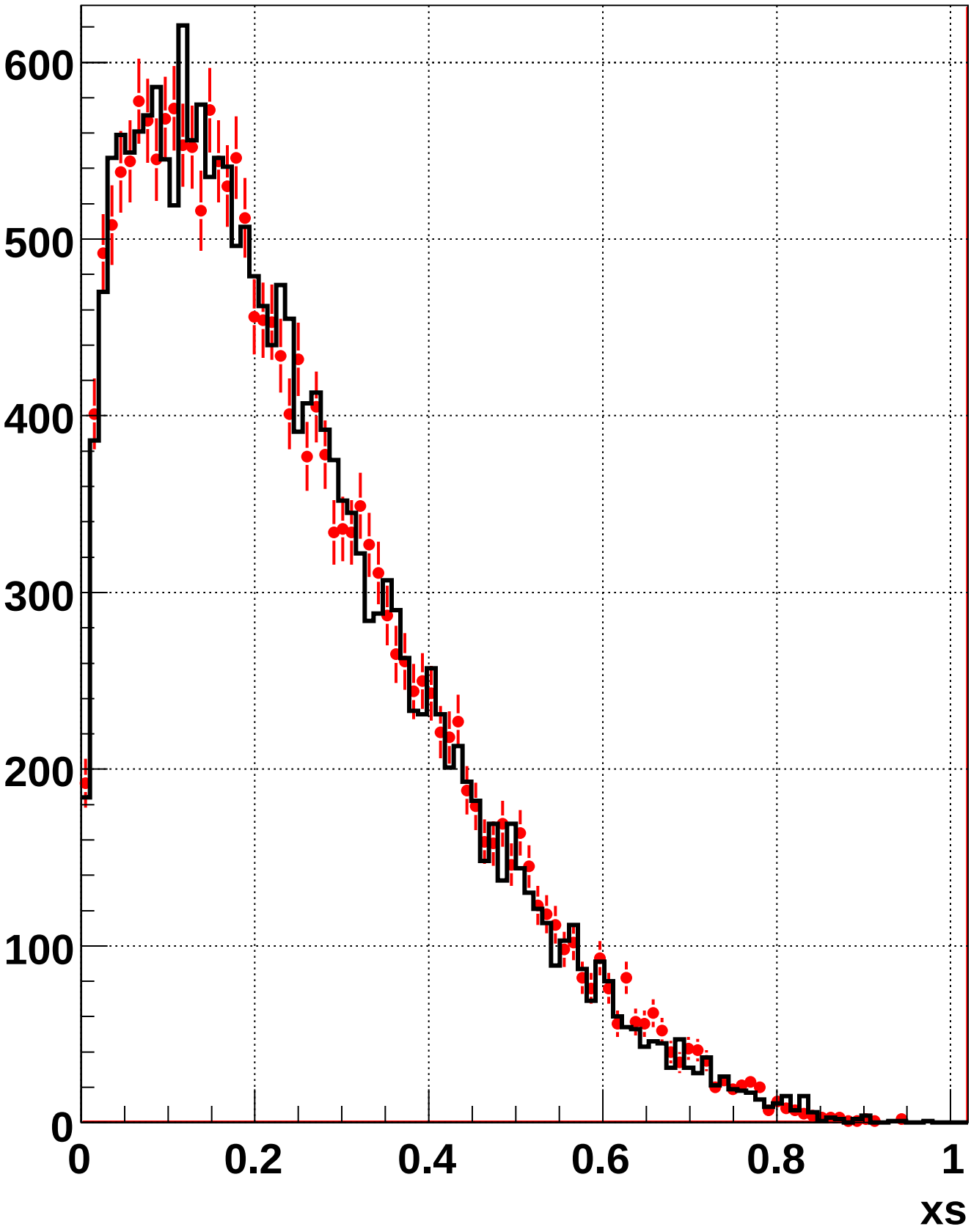
selected x for DIS events



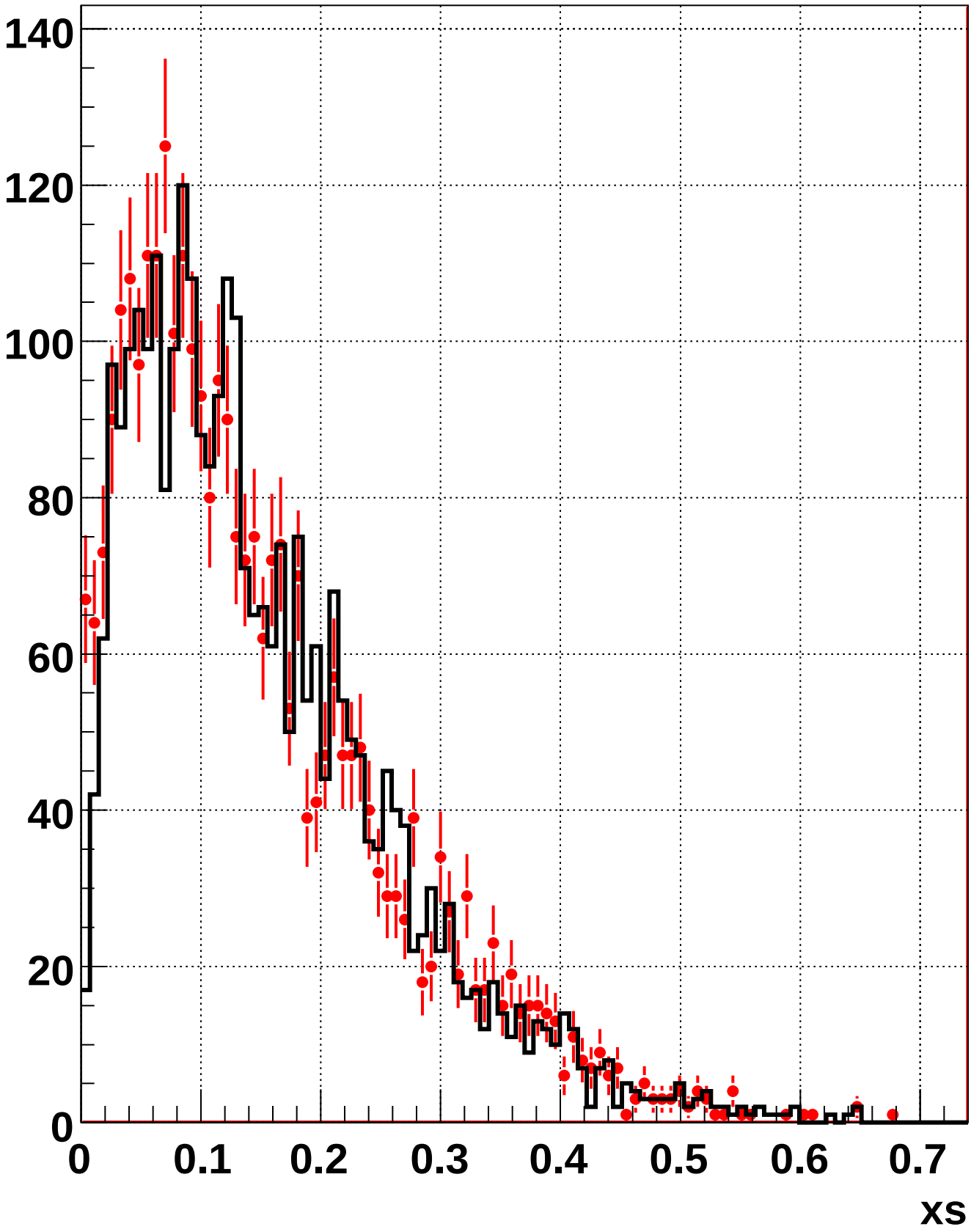
selected x for DIS CC events



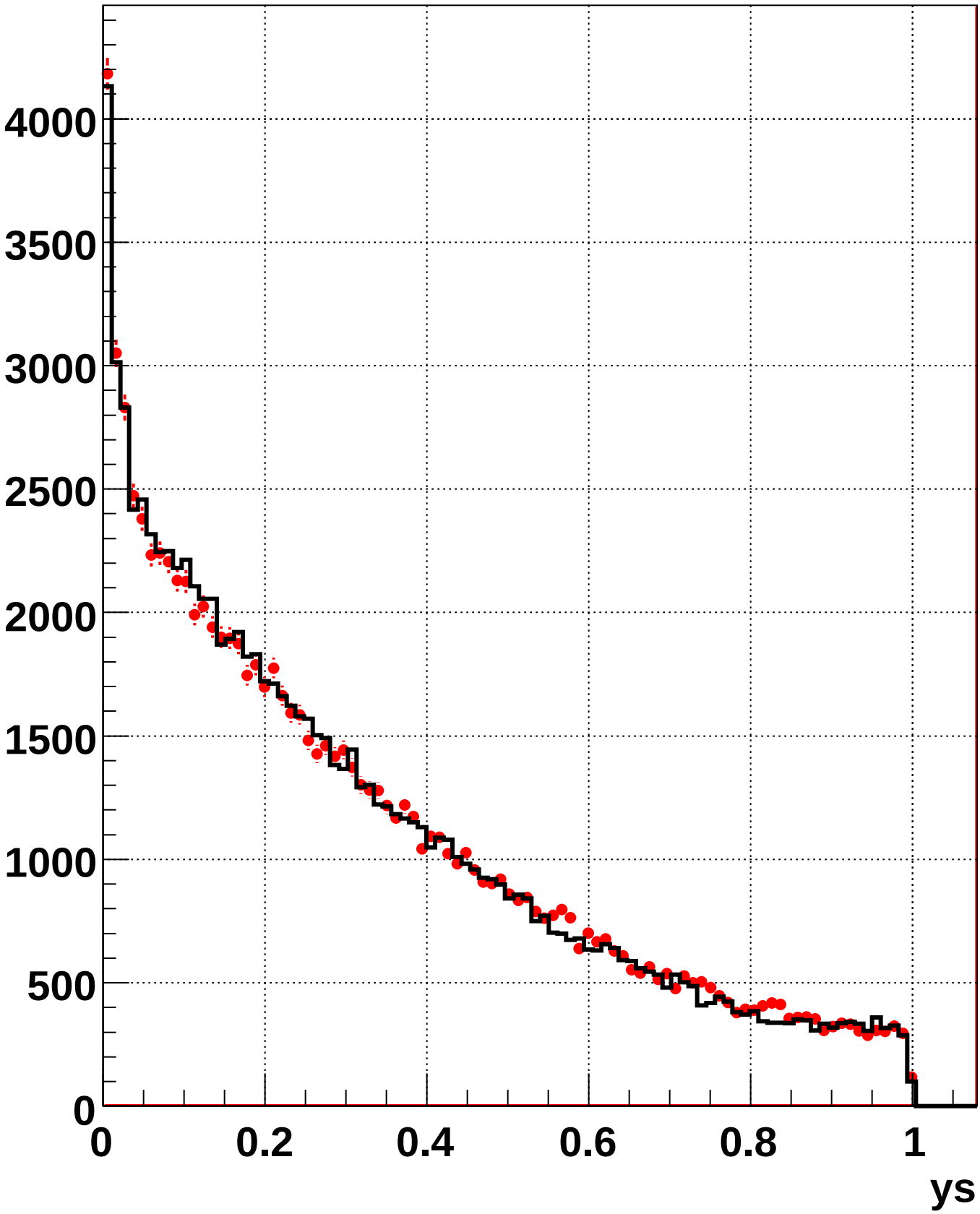
selected x for DIS NC events



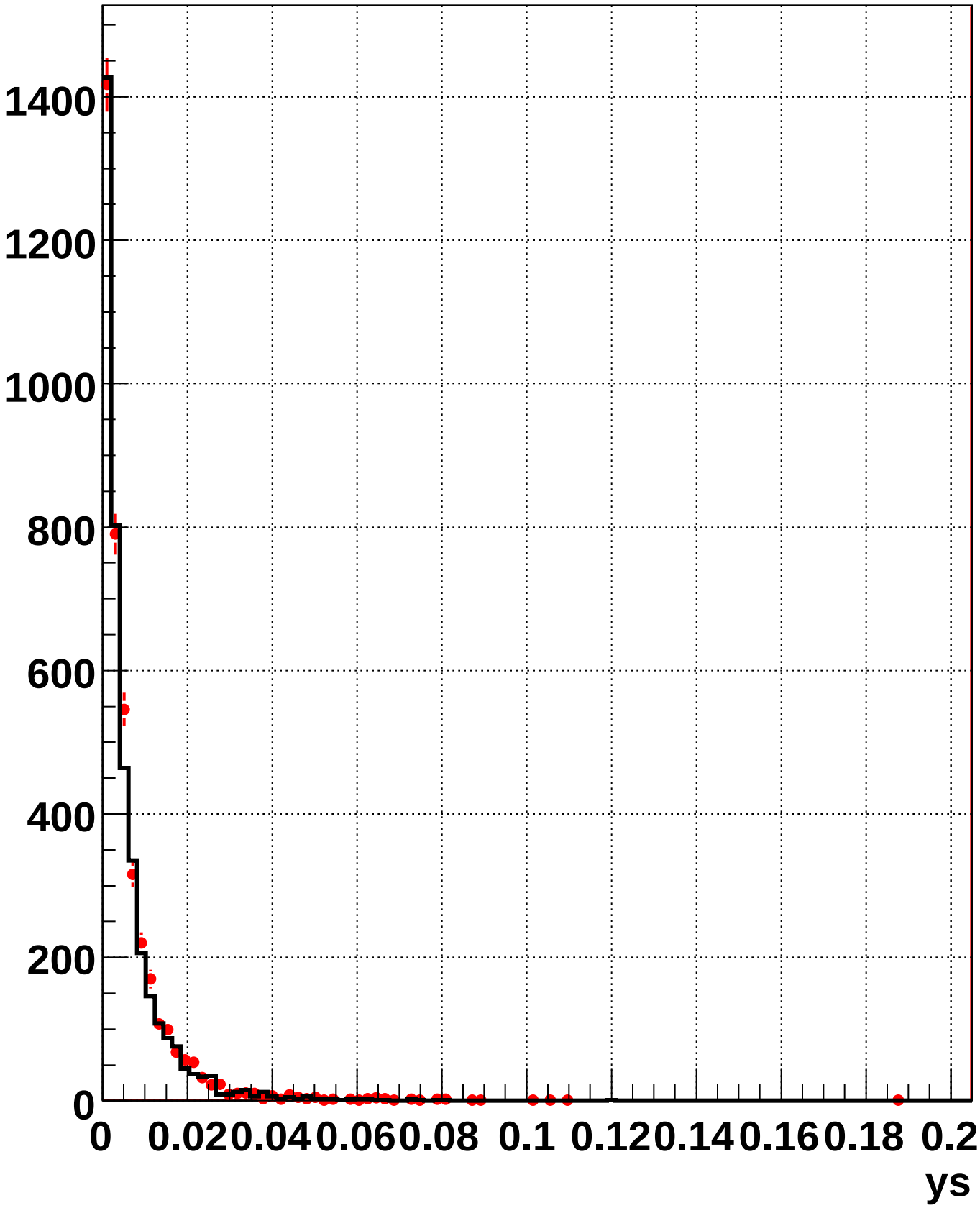
selected x for Charm/DIS events



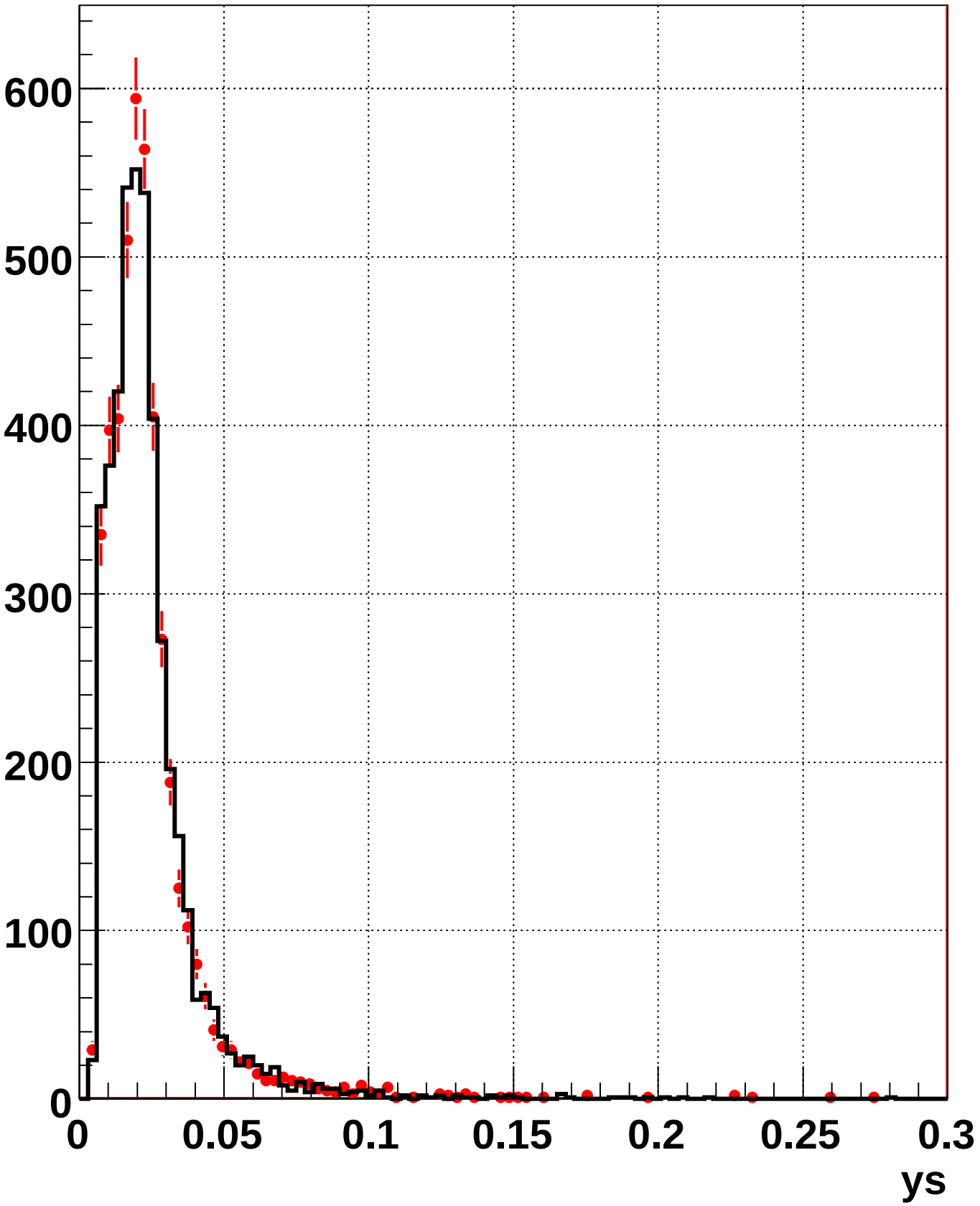
selected y for all events



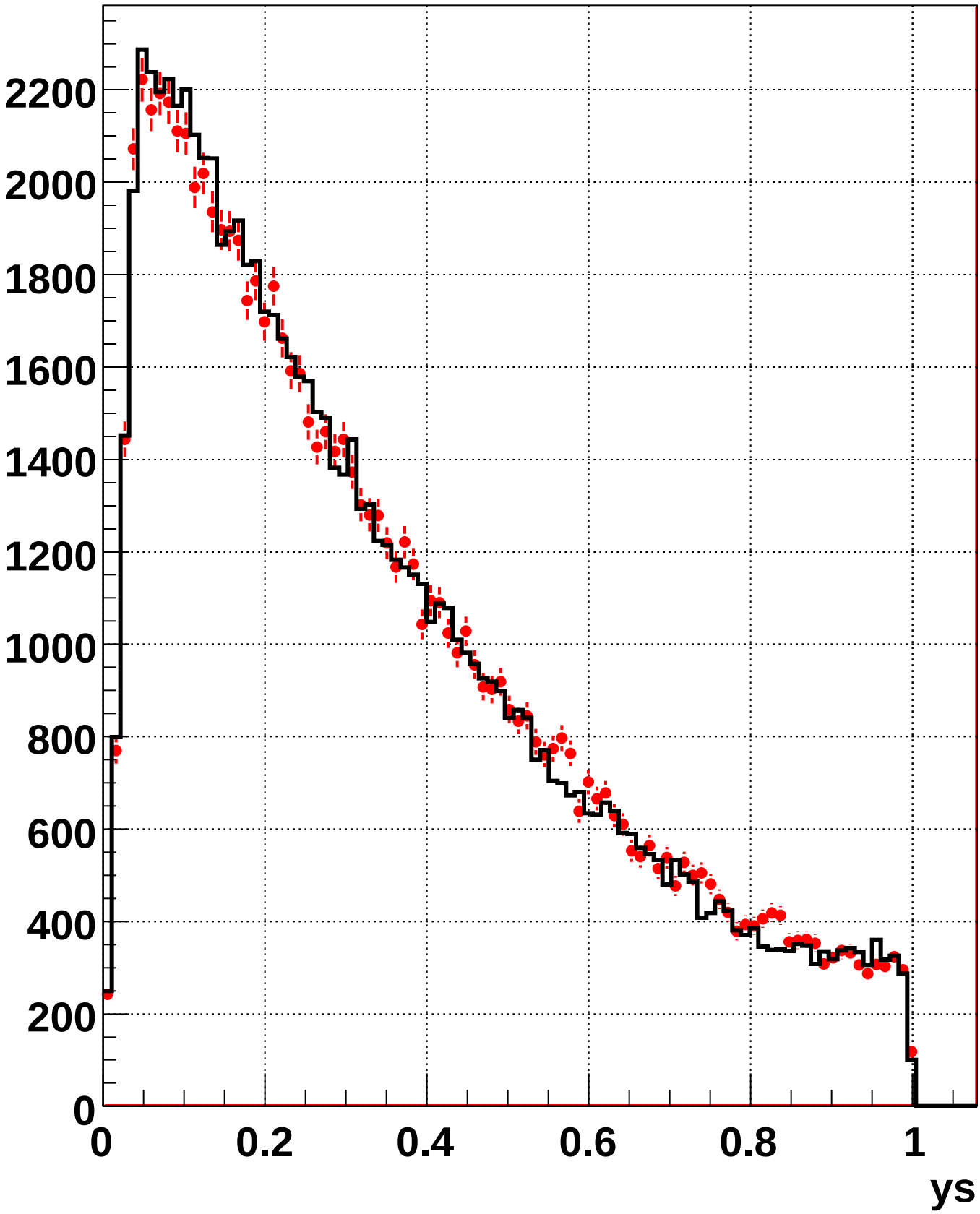
selected y for QEL events



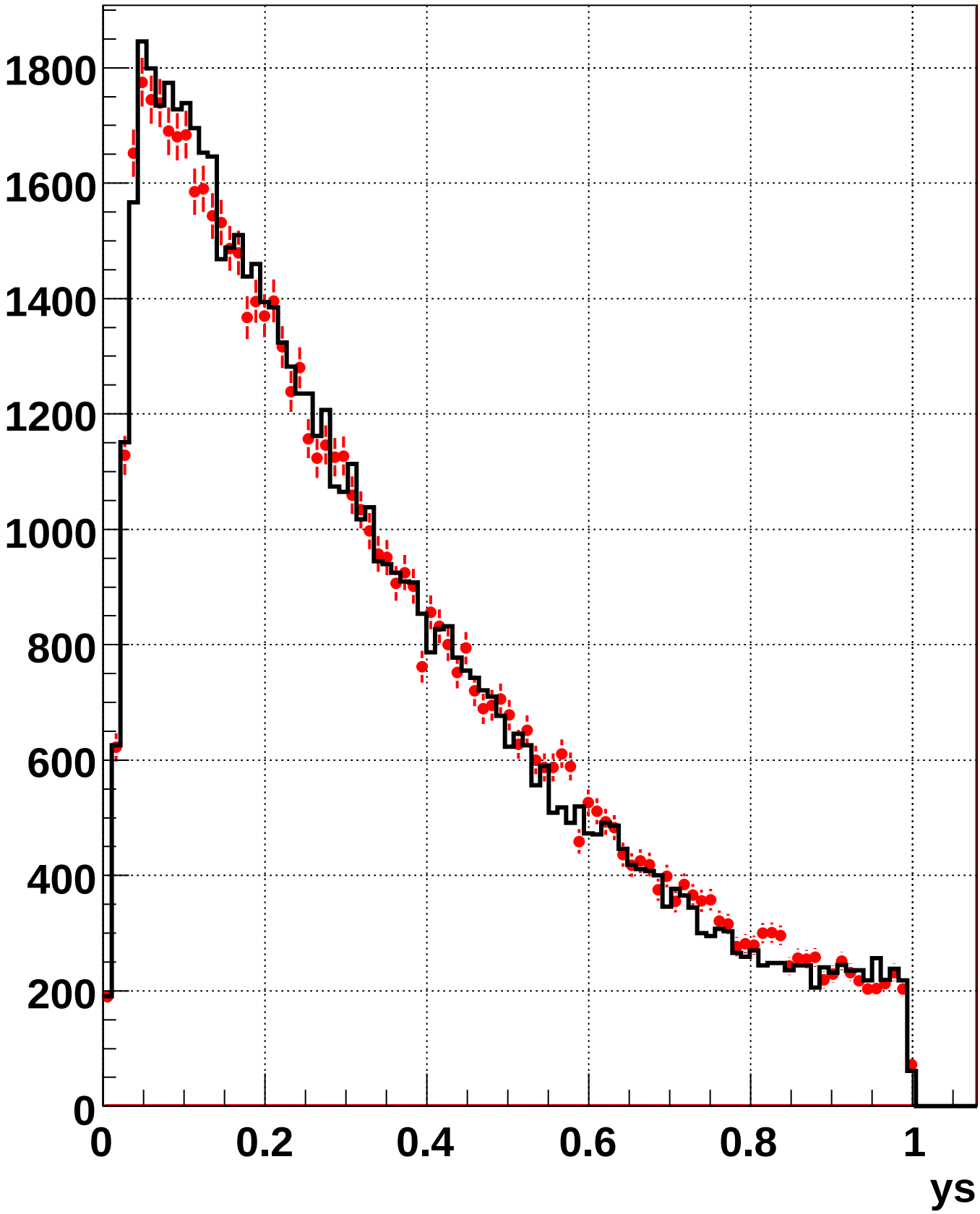
selected y for RES events



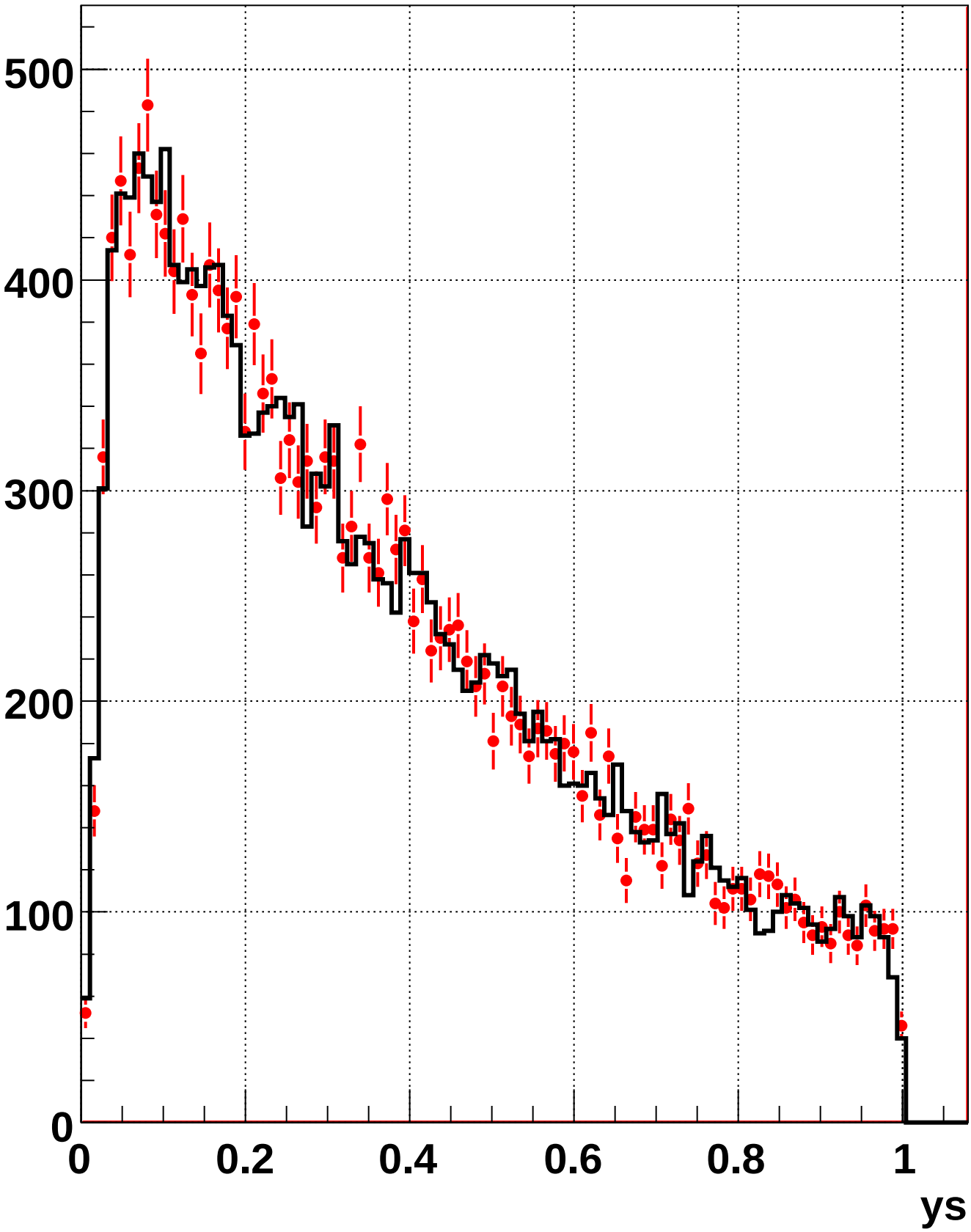
selected y for DIS events



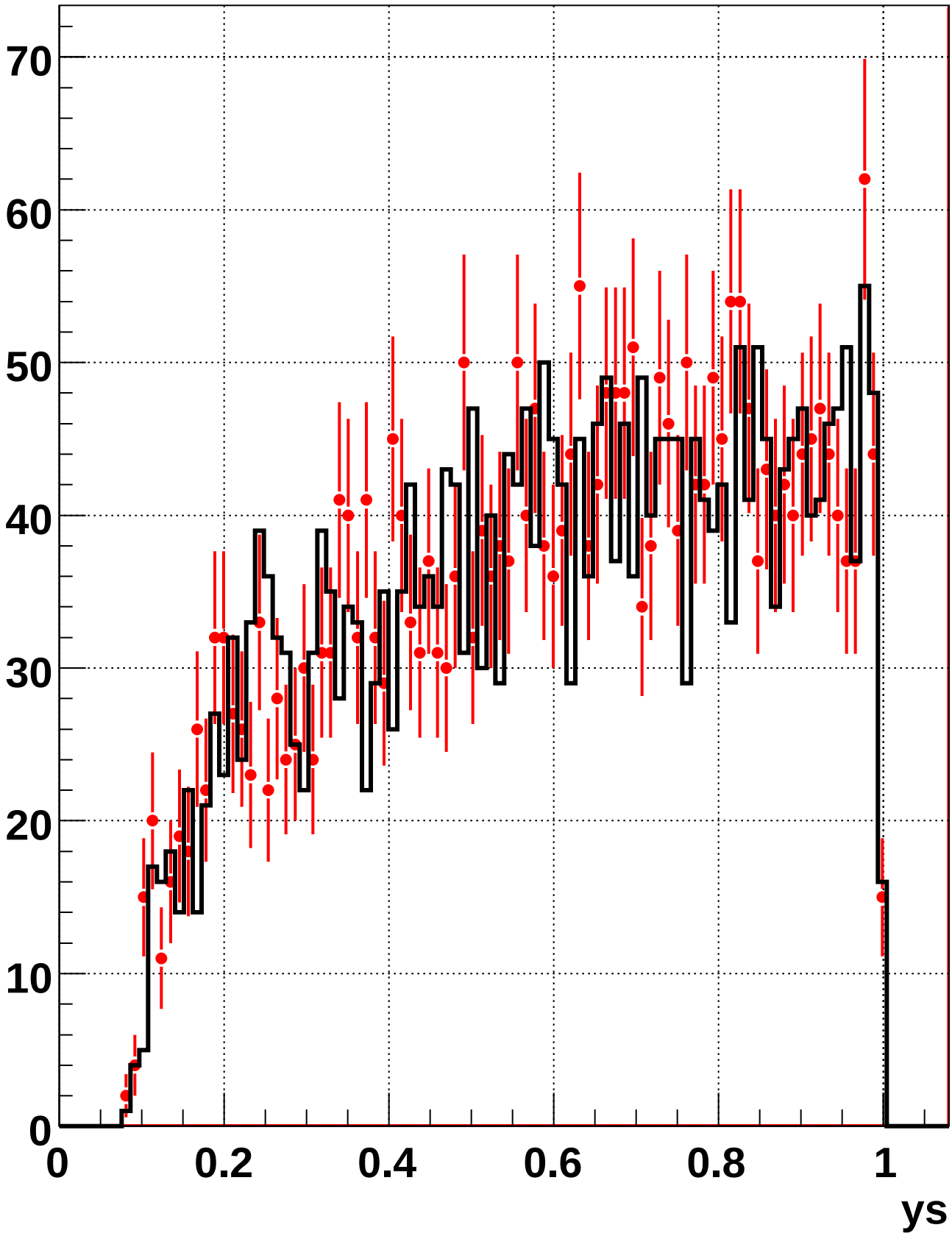
selected y for DIS CC events



selected y for DIS NC events



selected y for Charm/DIS events

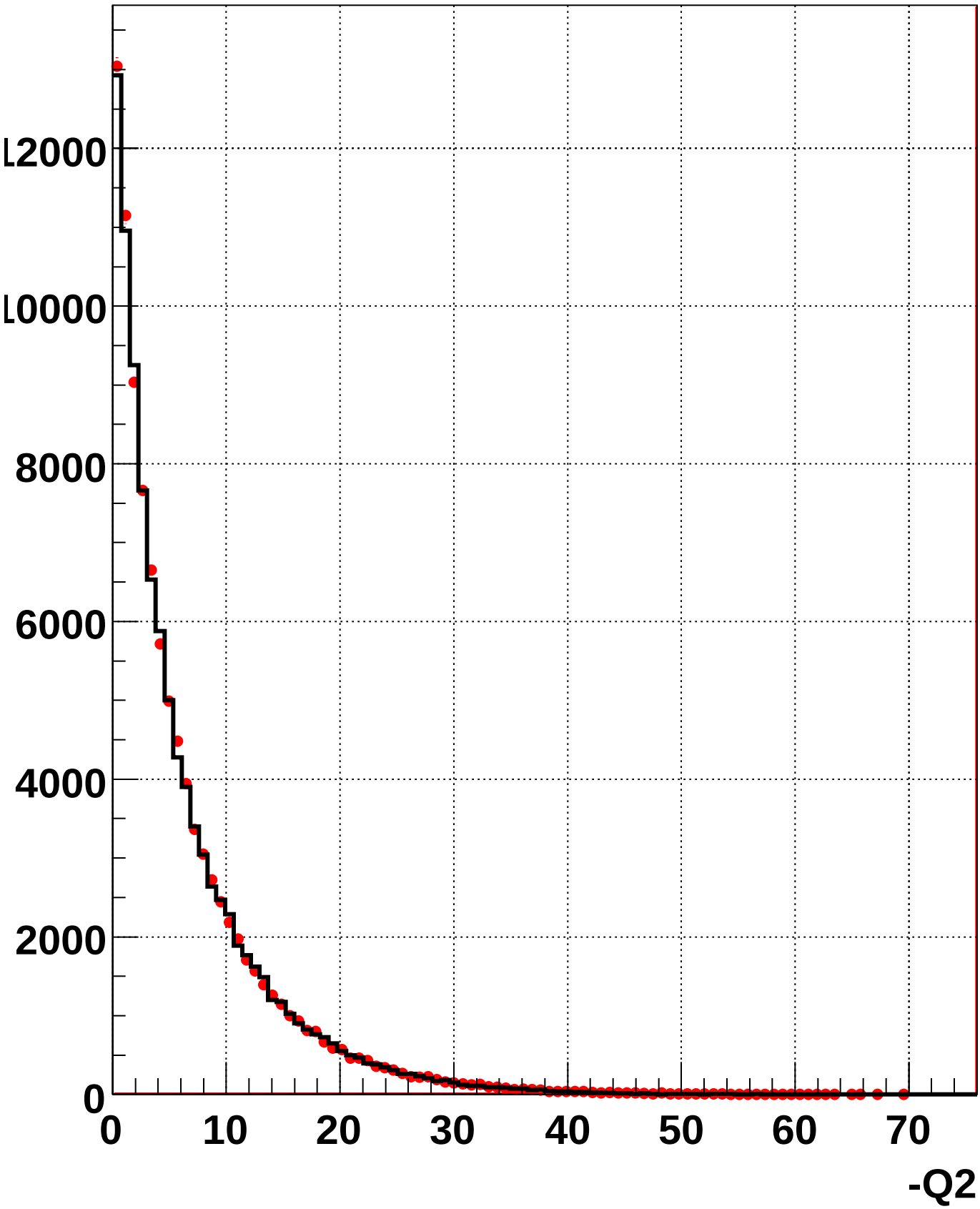


Kinematical Quantities

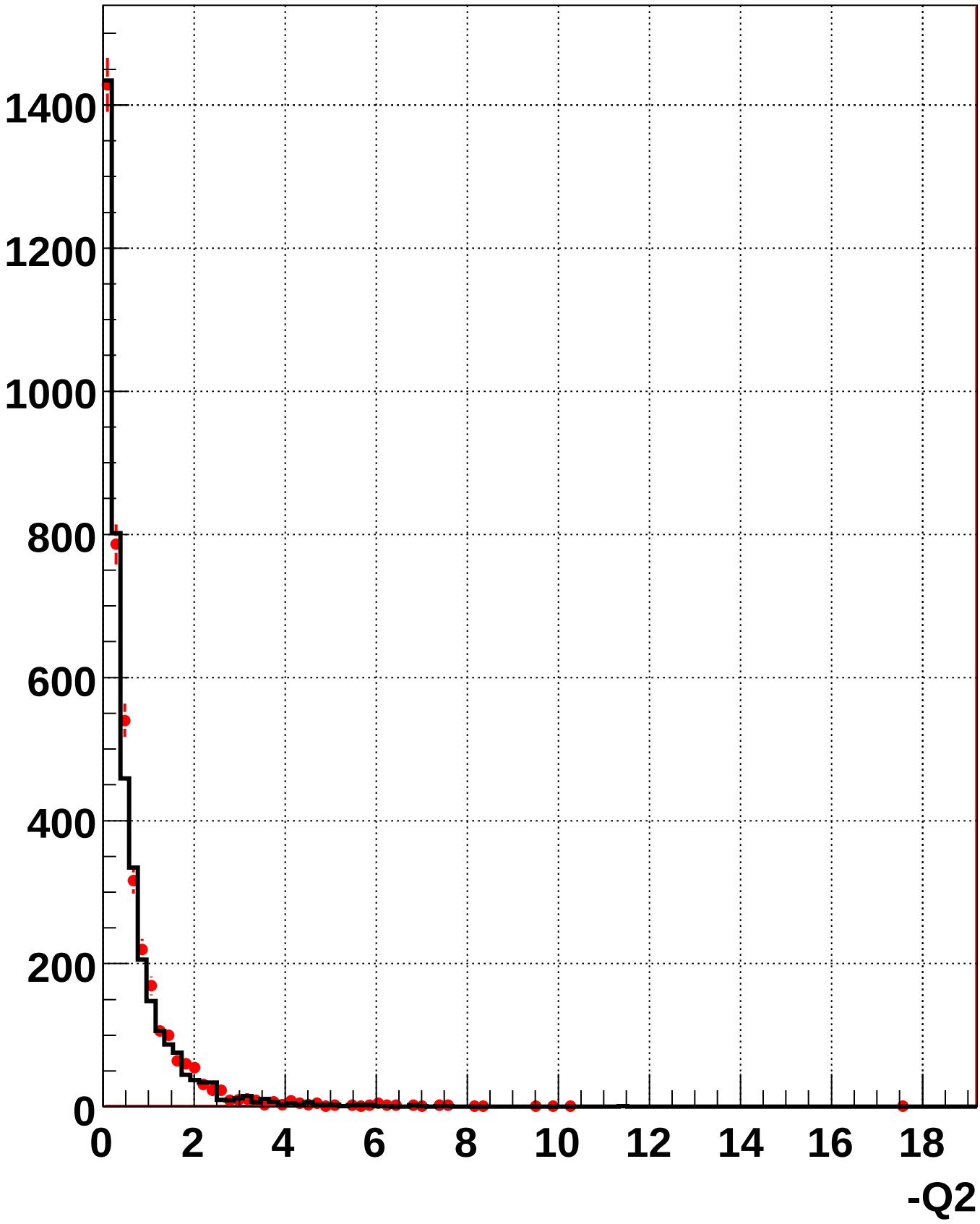
Similar to the previous set of plots but

showing ’computed’ rathen than ’selected’ variables

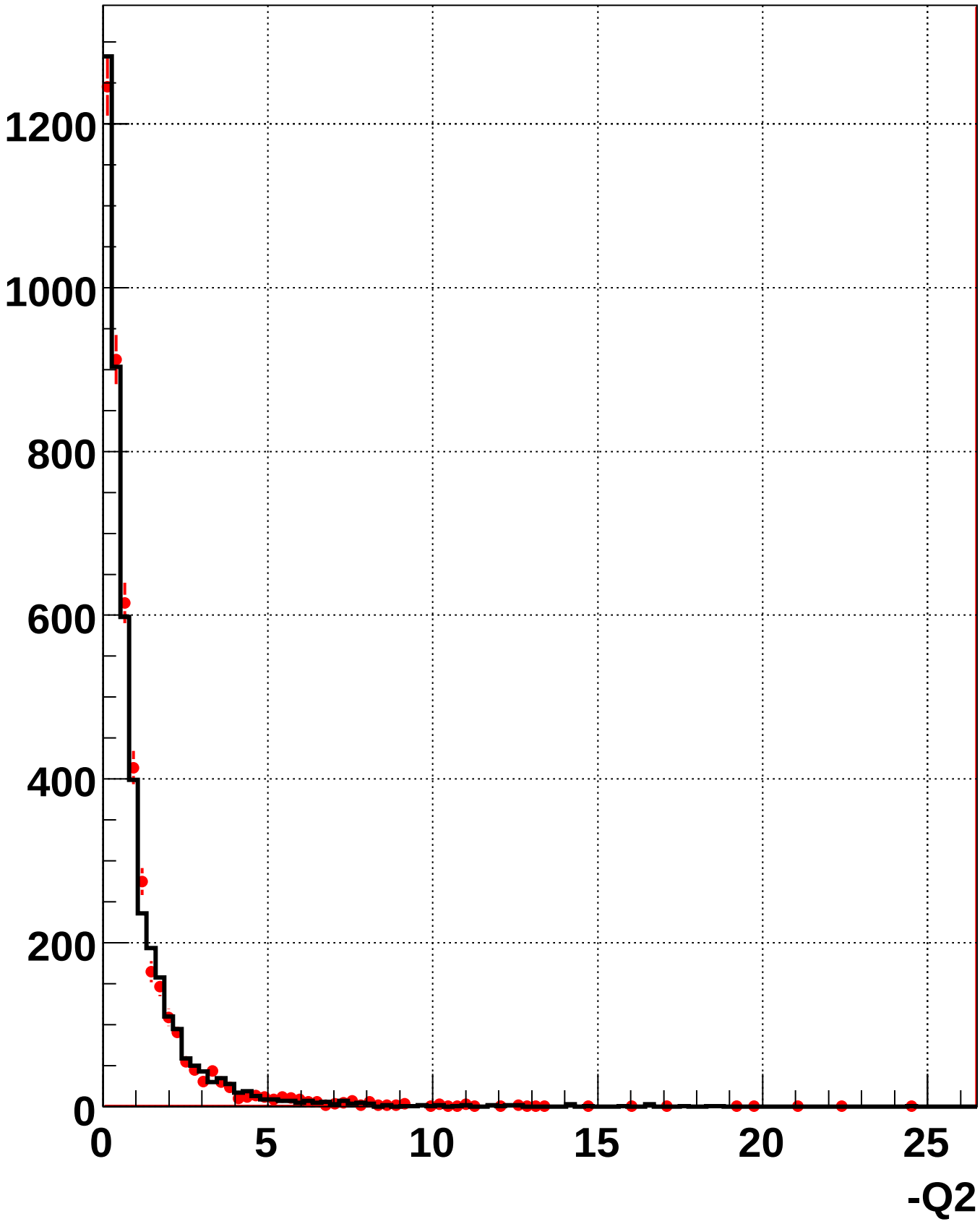
computed Q2 for all events



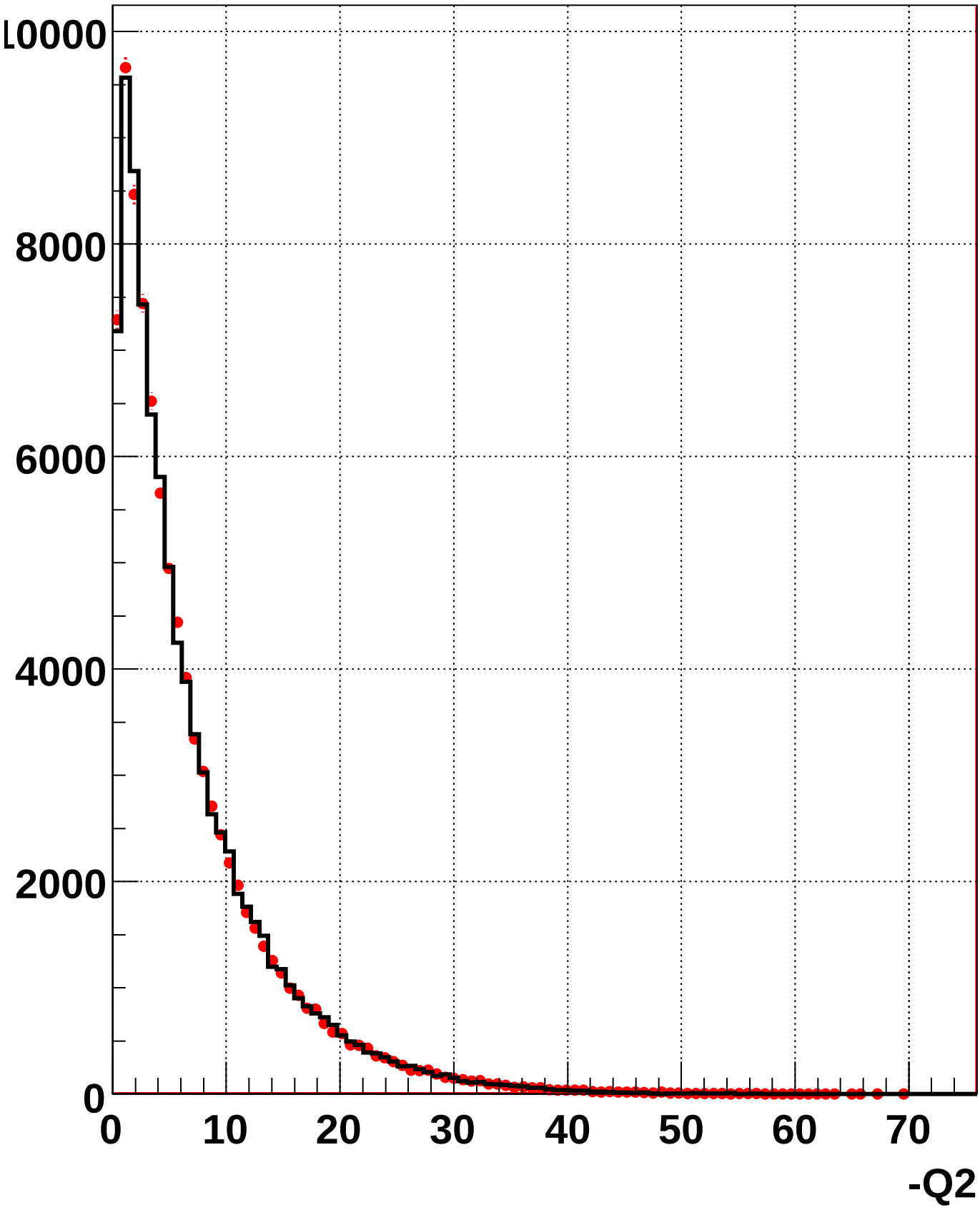
computed Q2 for QEL events



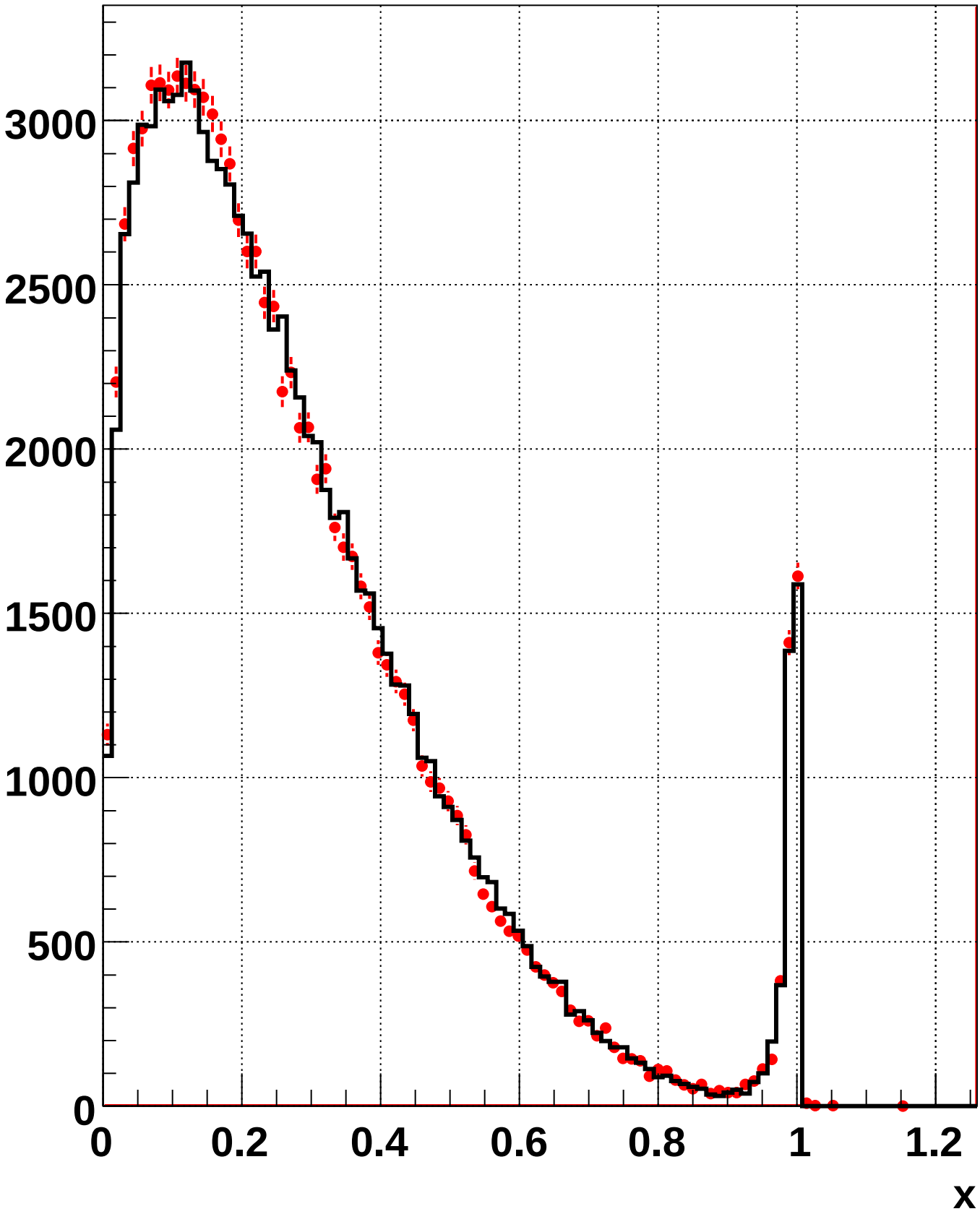
computed Q2 for RES events



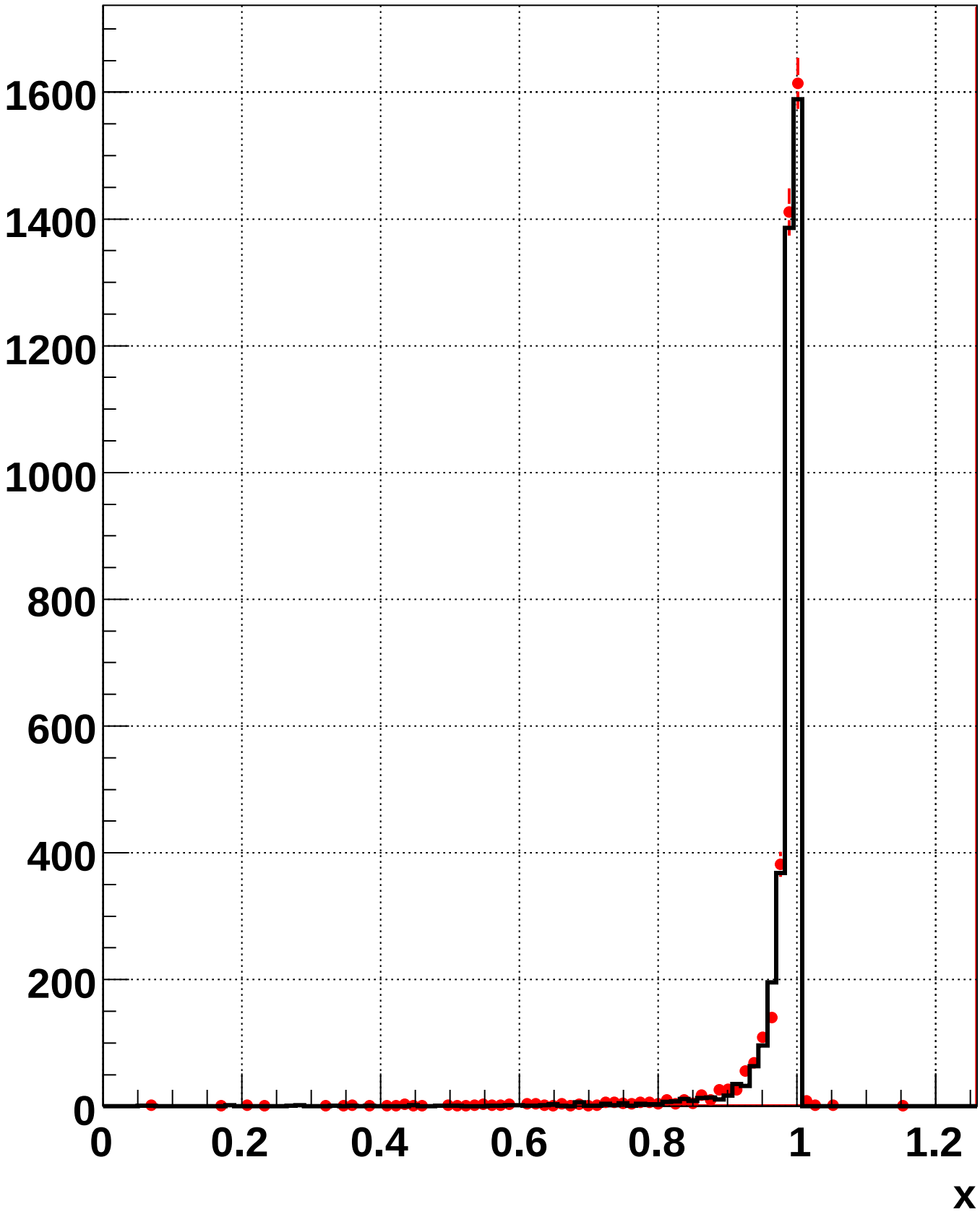
computed Q2 for DIS events



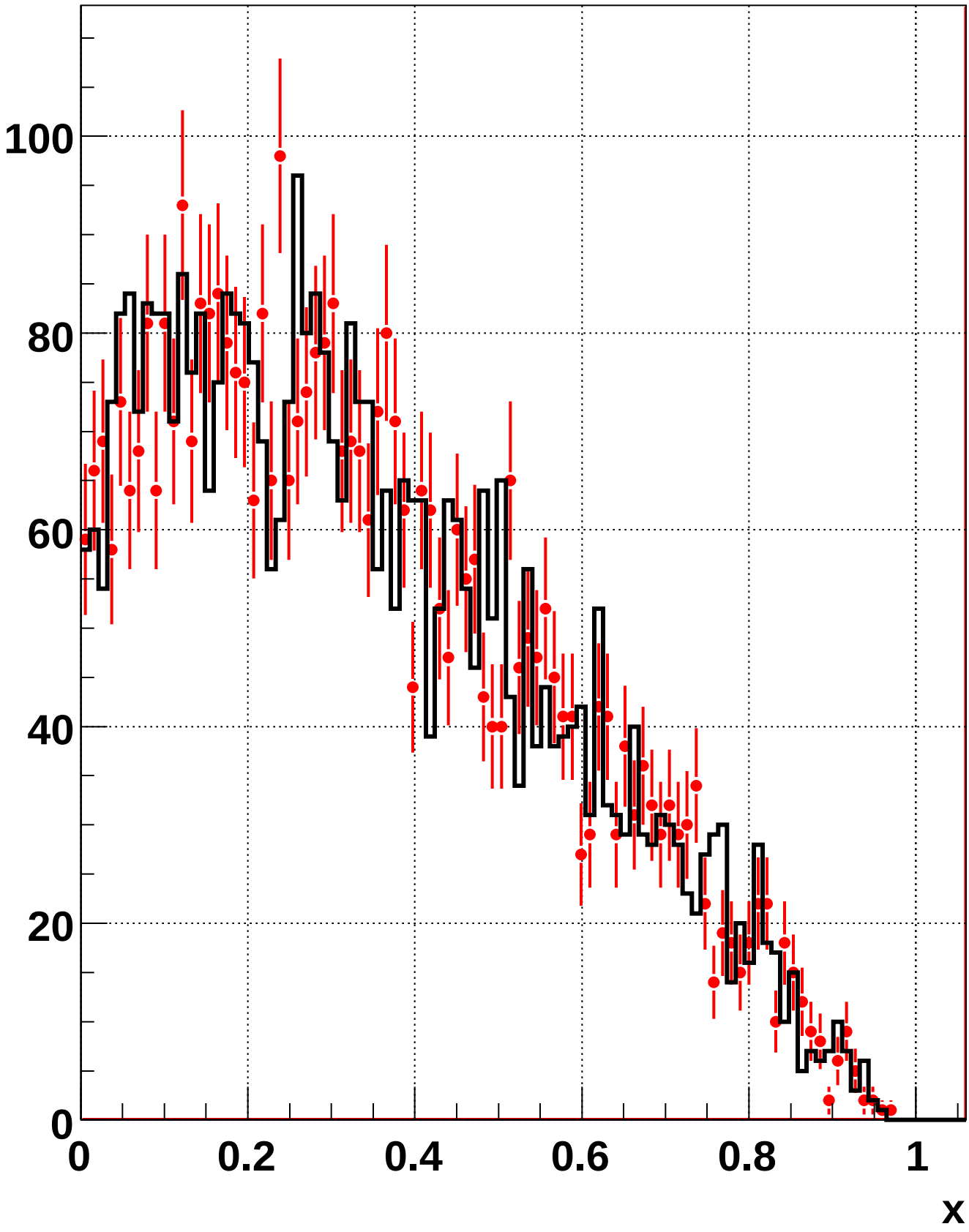
computed x for all events



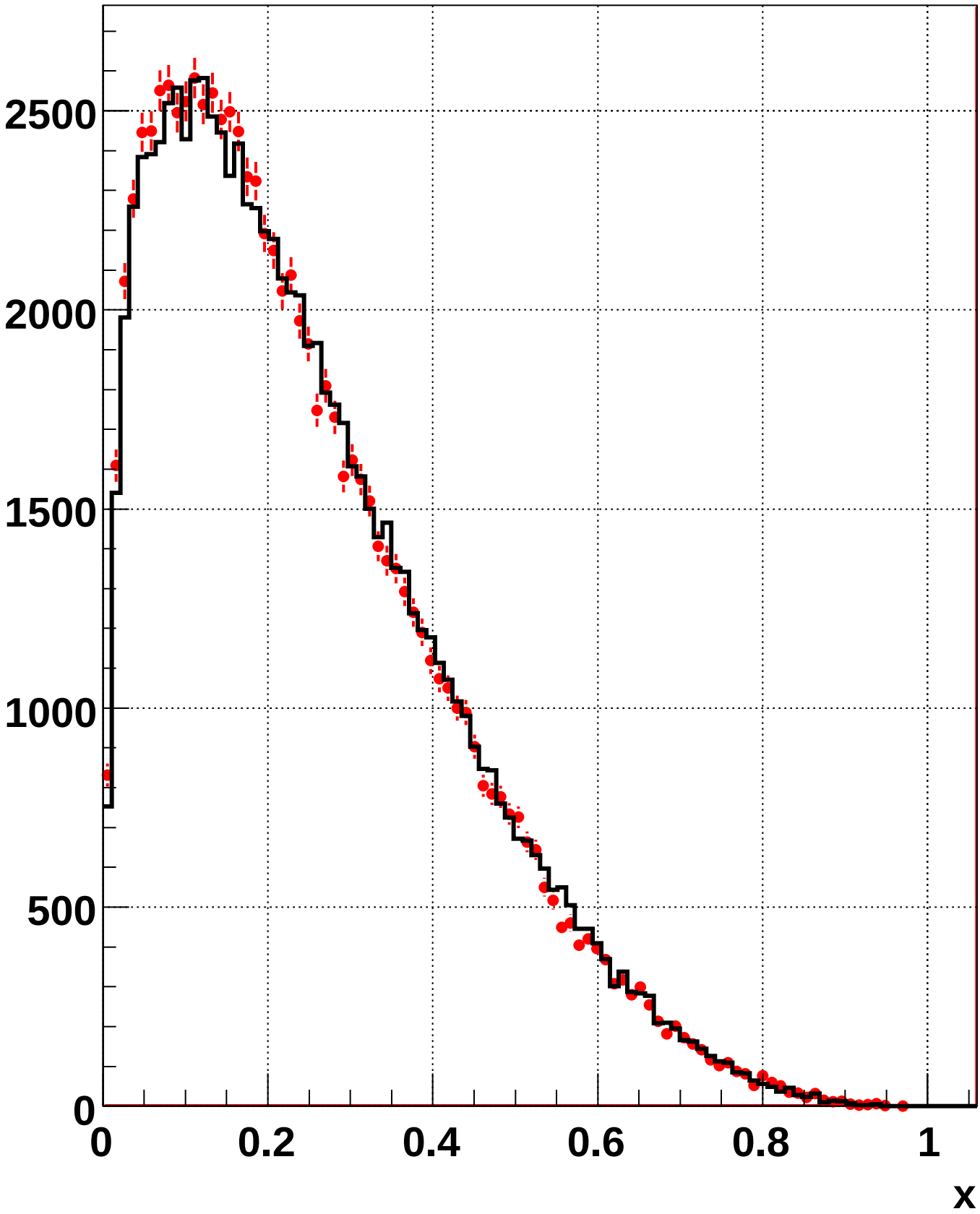
computed x for QEL events



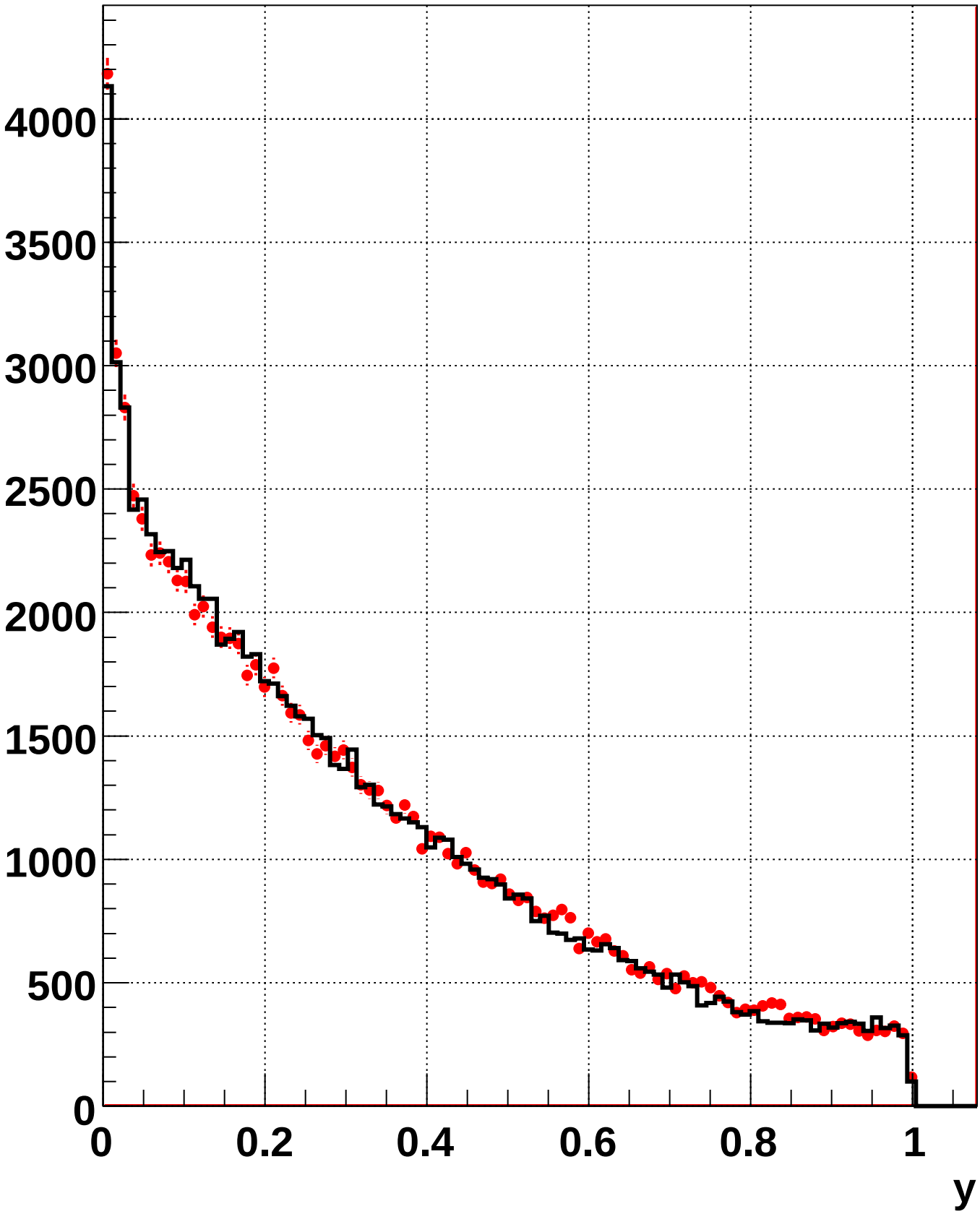
computed x for RES events



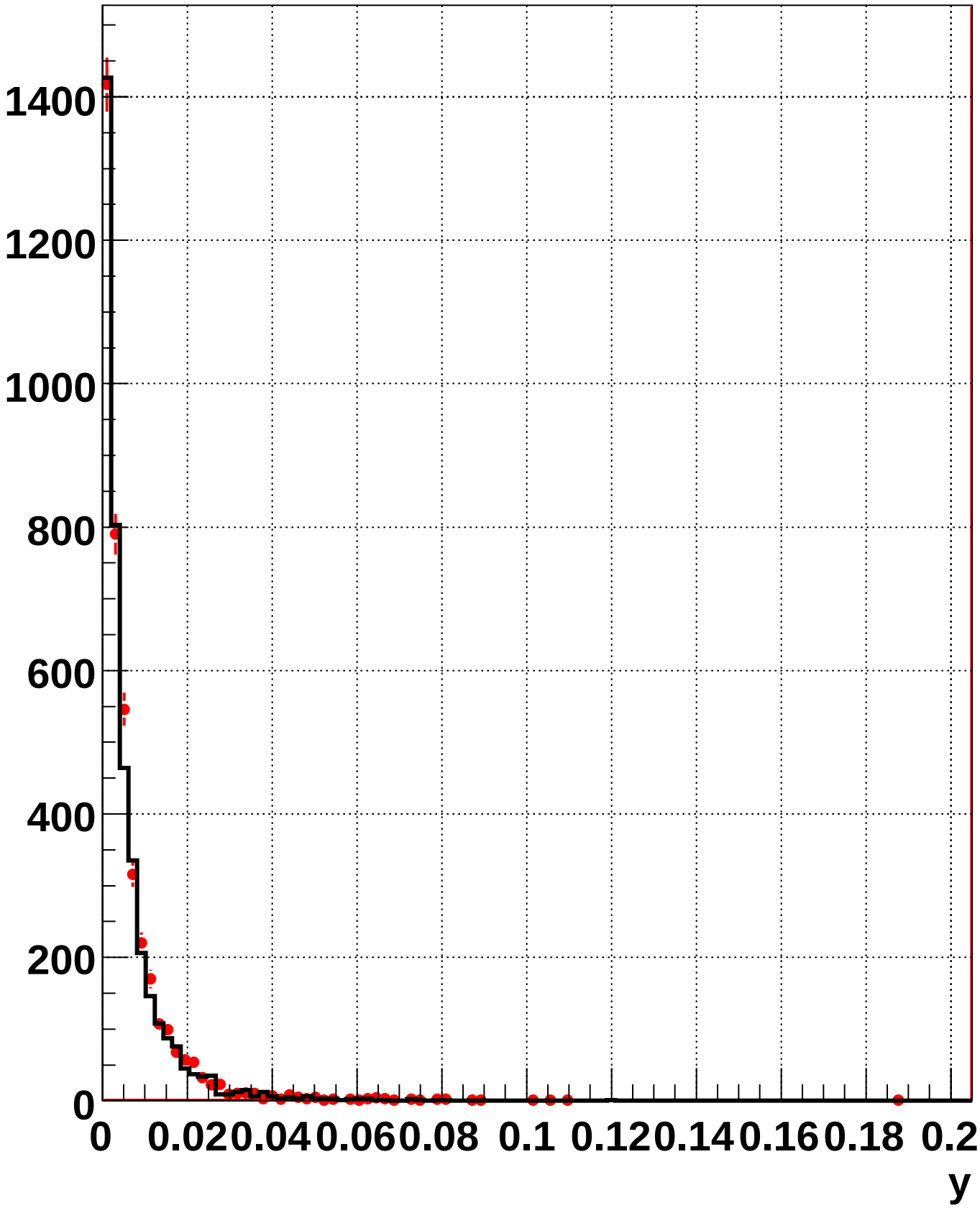
computed x for DIS events



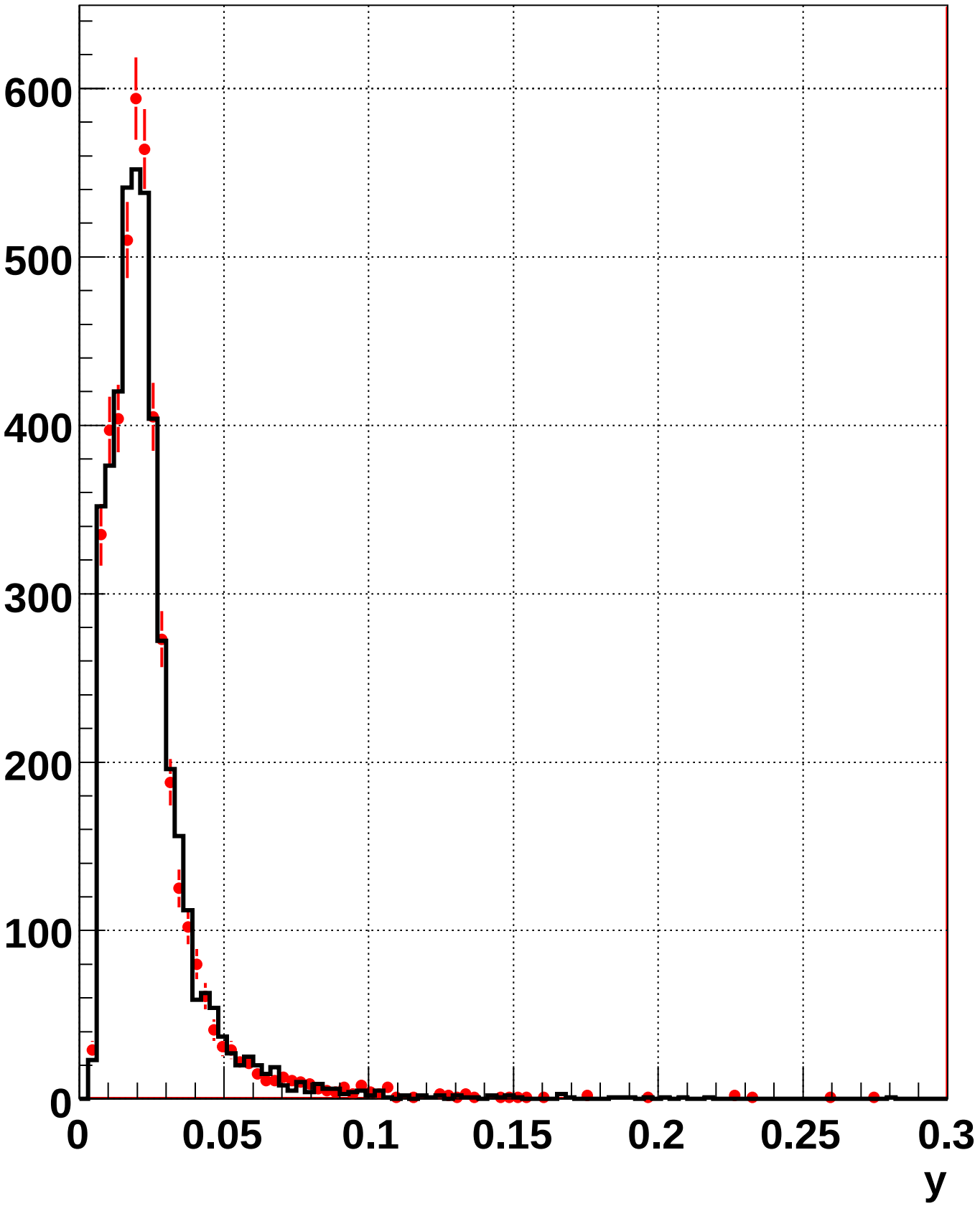
computed y for all events



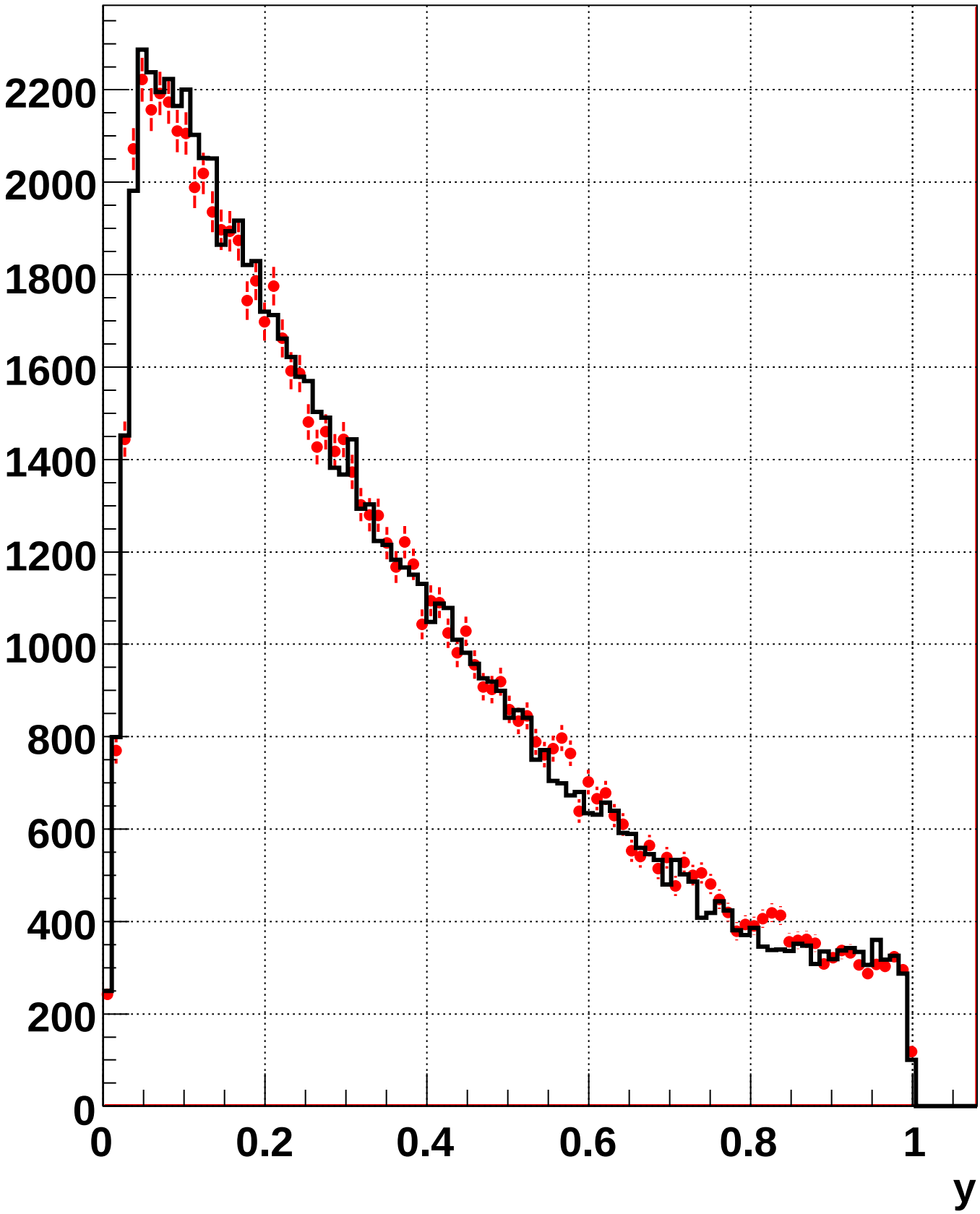
computed y for QEL events



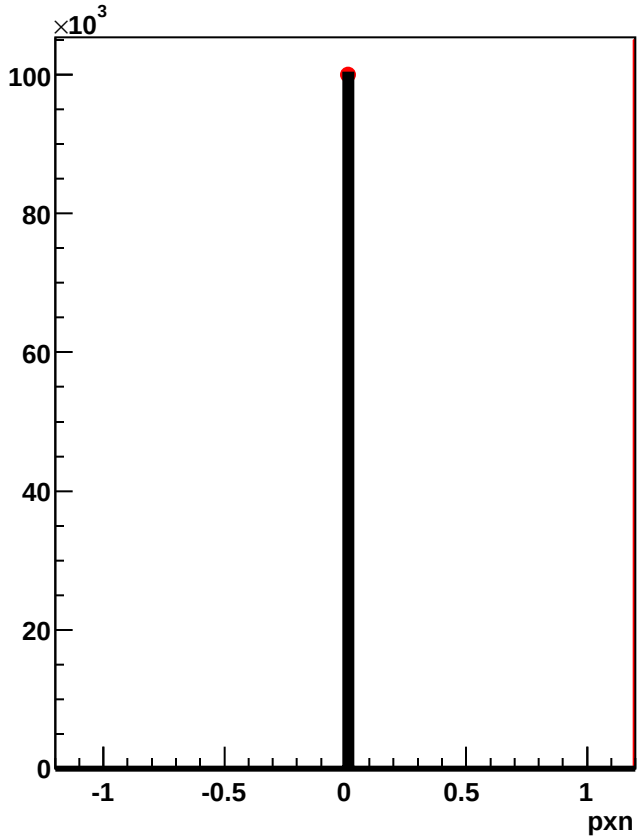
computed y for RES events

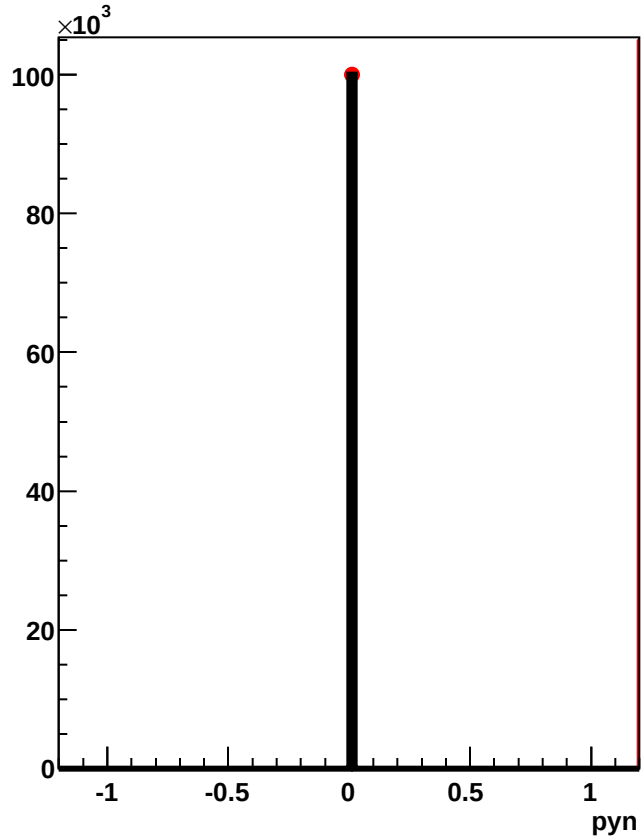


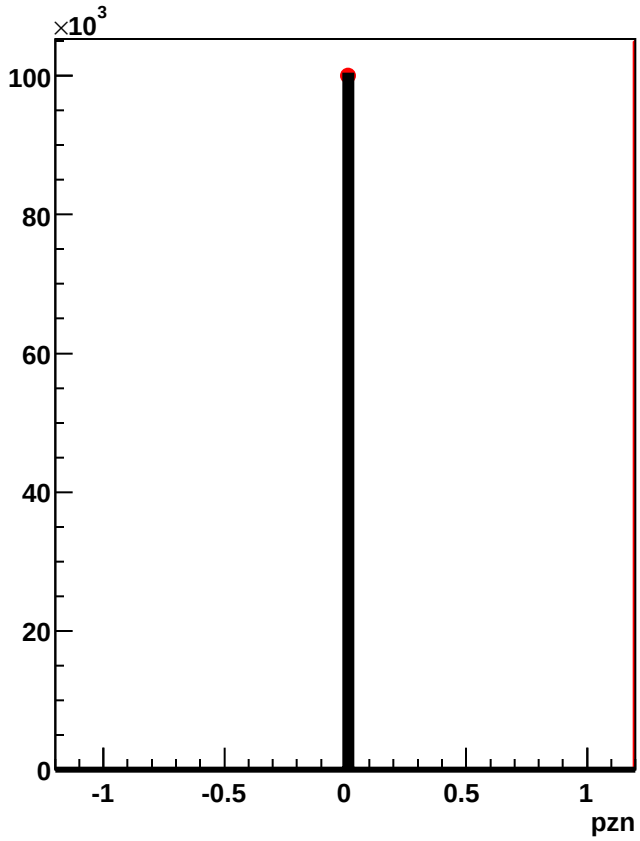
computed y for DIS events

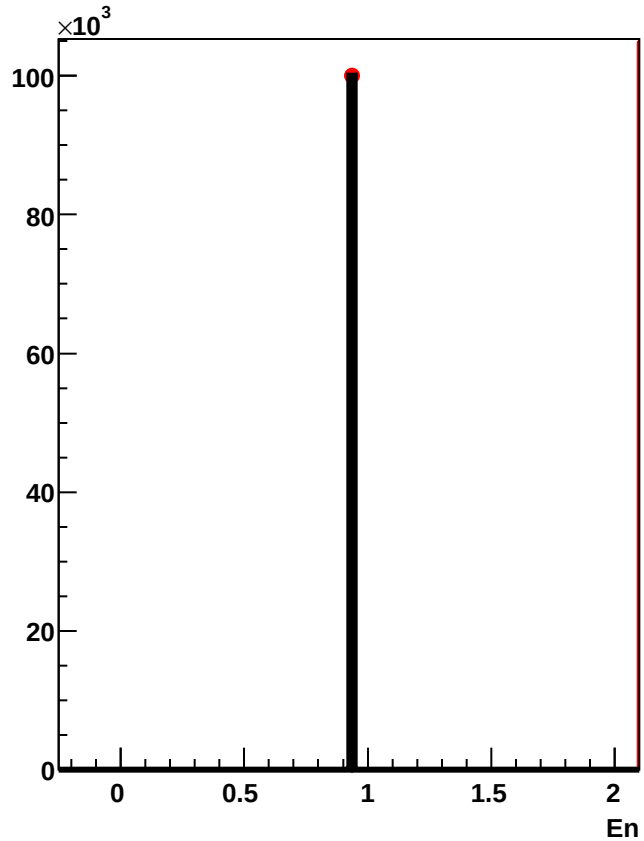


Initial state nucleon 4-Momentum


×10^3
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pxn

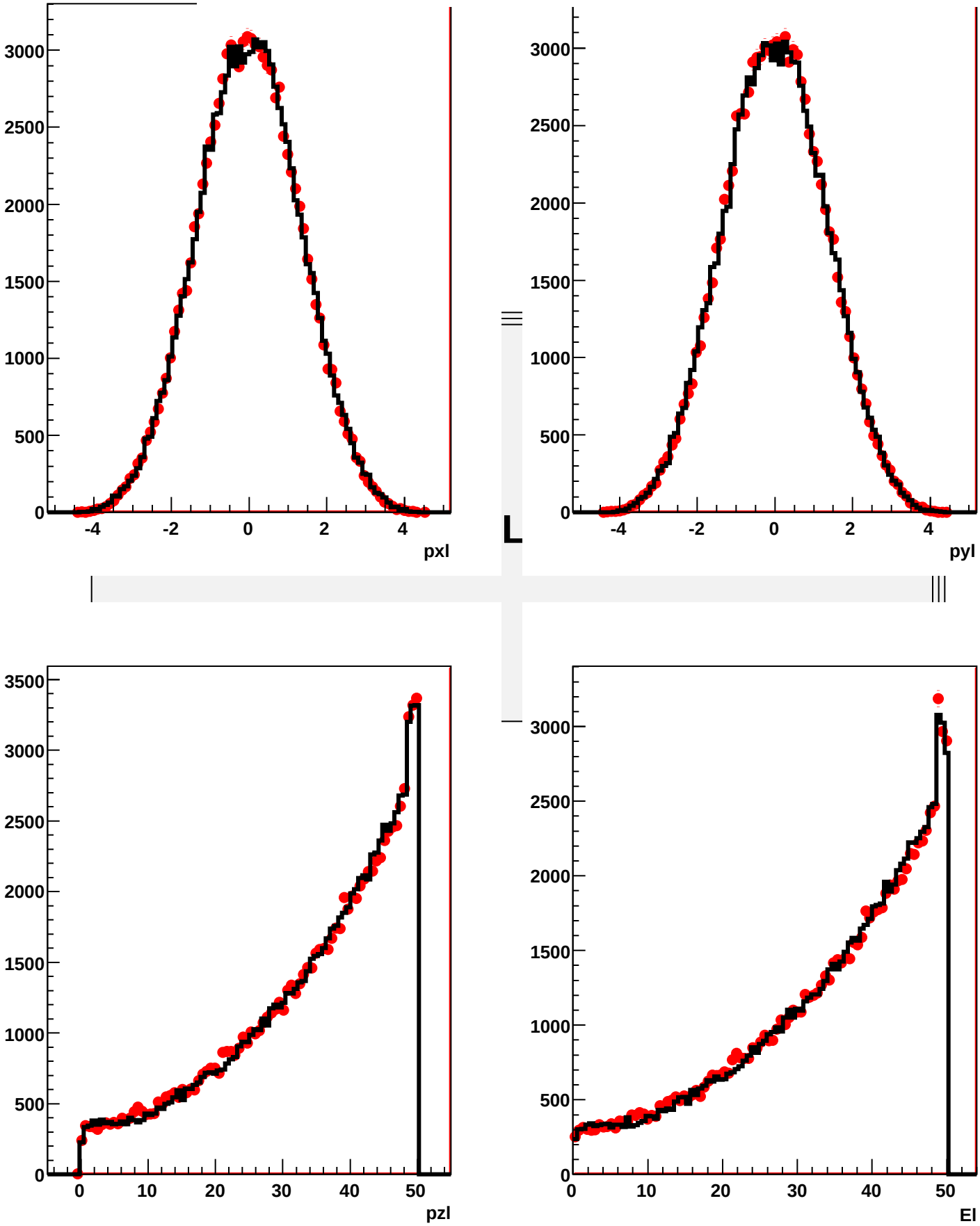

×10^3
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pyn


×10^3
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pzn

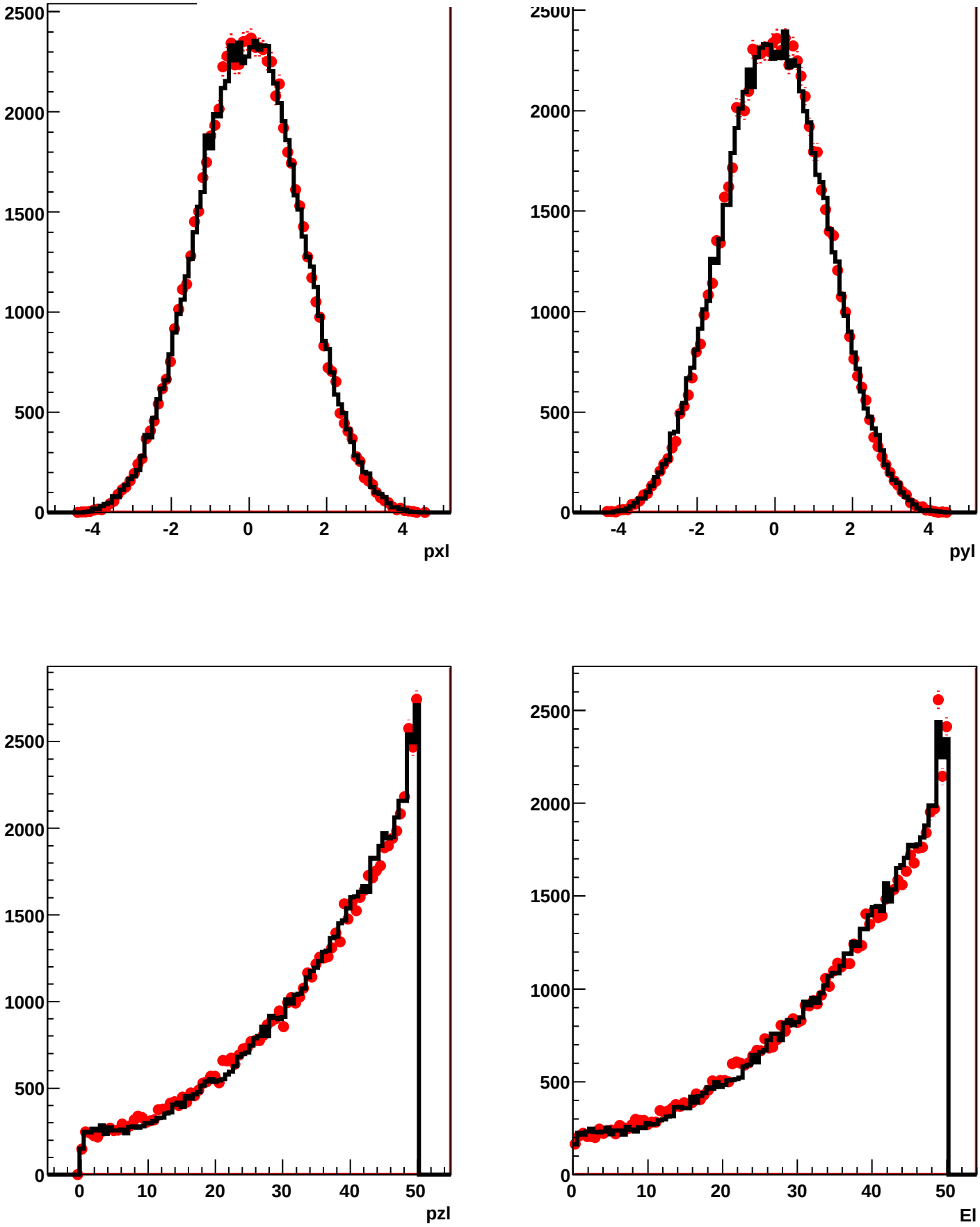

×10^3
100
80
60
40
20
0
0
0.5
1
1.5
2
En

Final State Primary Lepton 4-Momentum

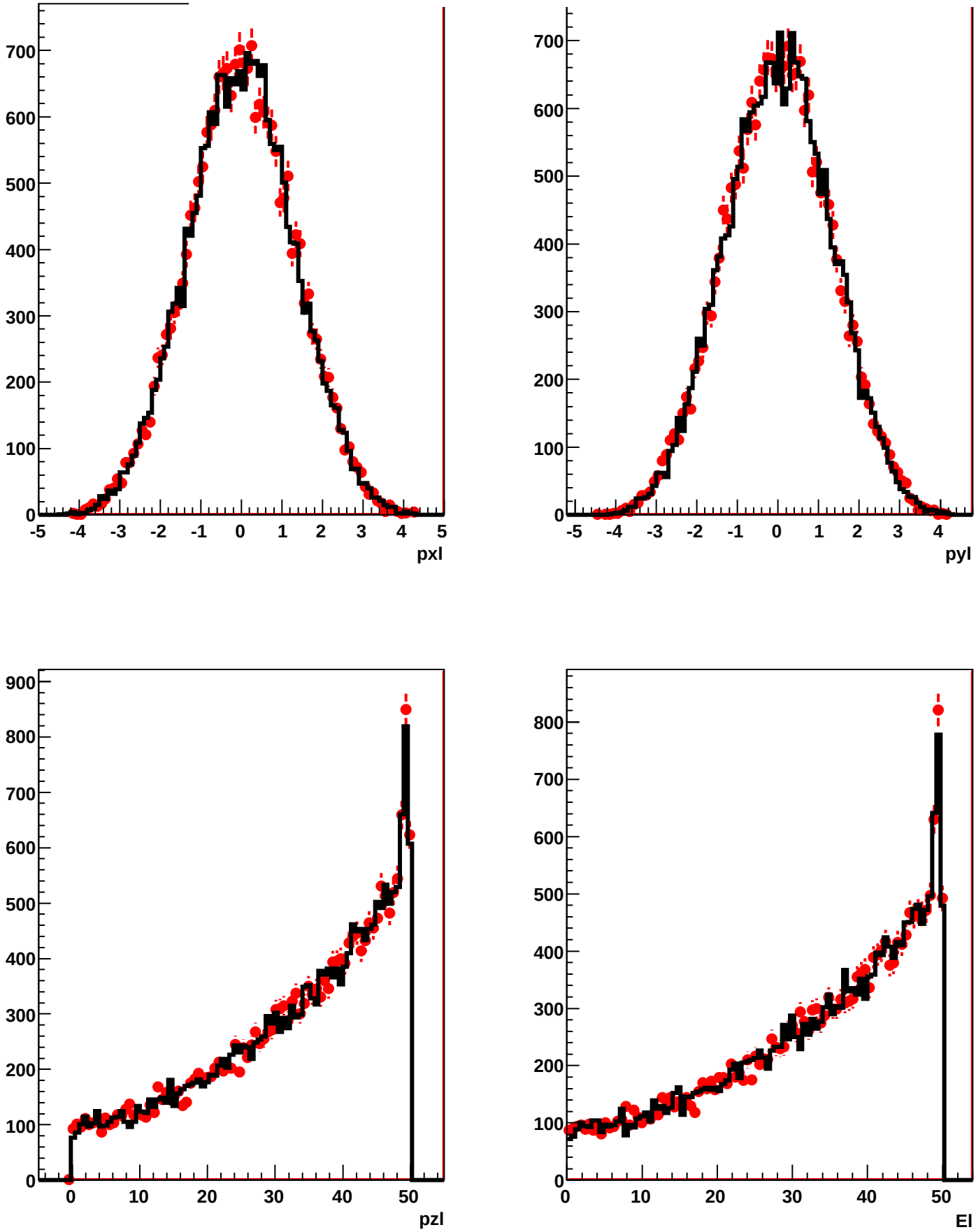
Final state primary lepton 4-p: All events



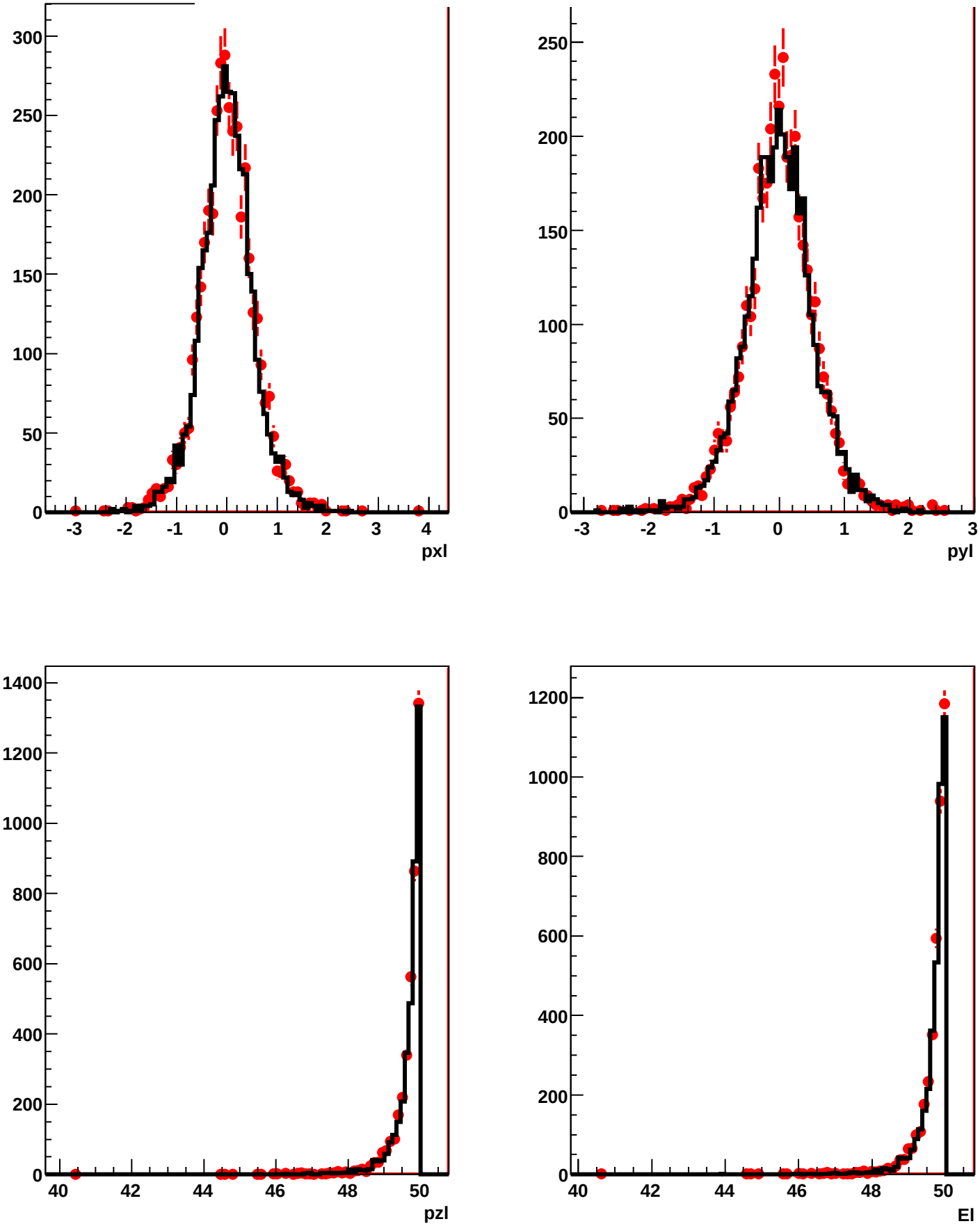
Final state primary lepton 4-p: All CC events



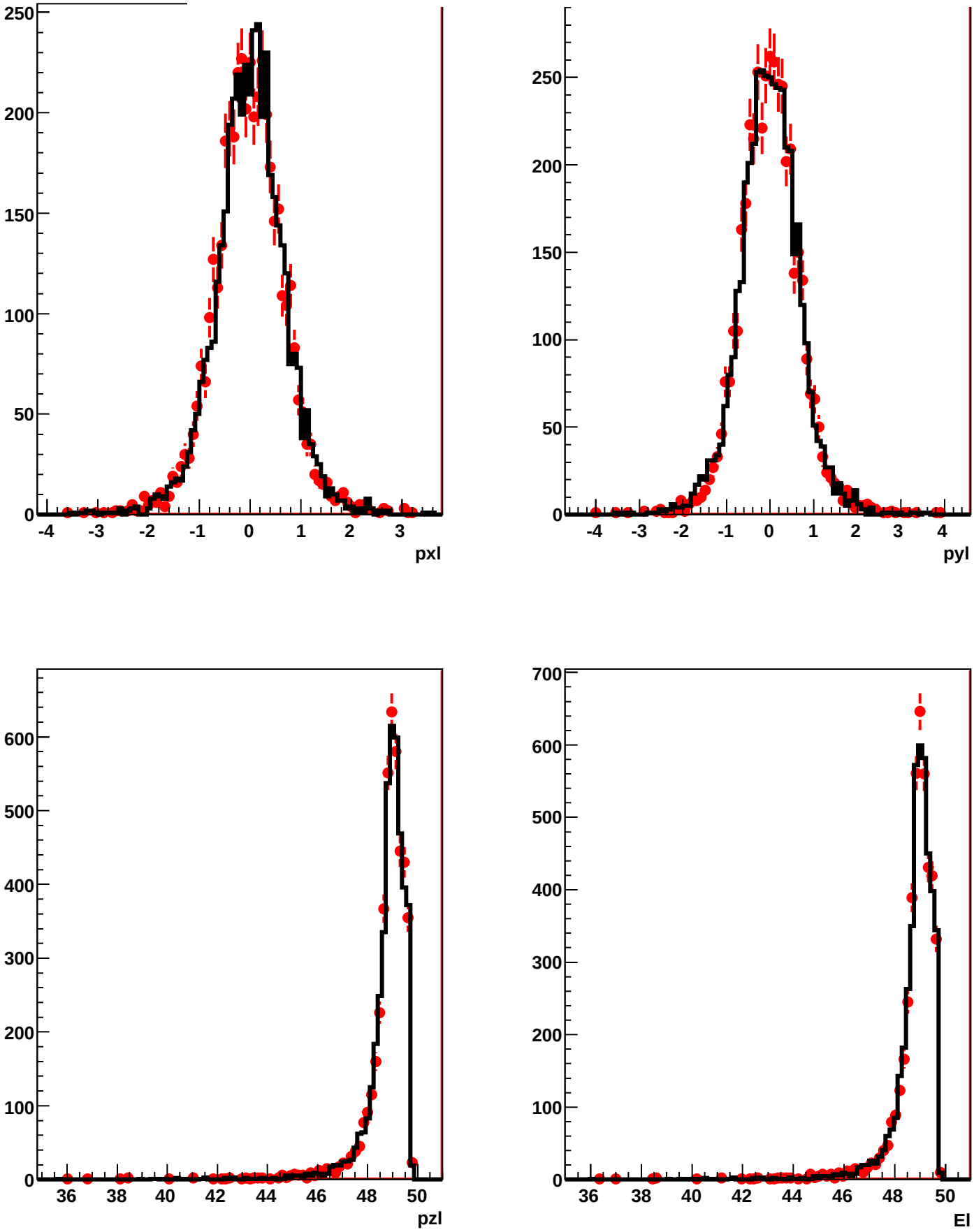
Final state primary lepton 4-p: All NC events



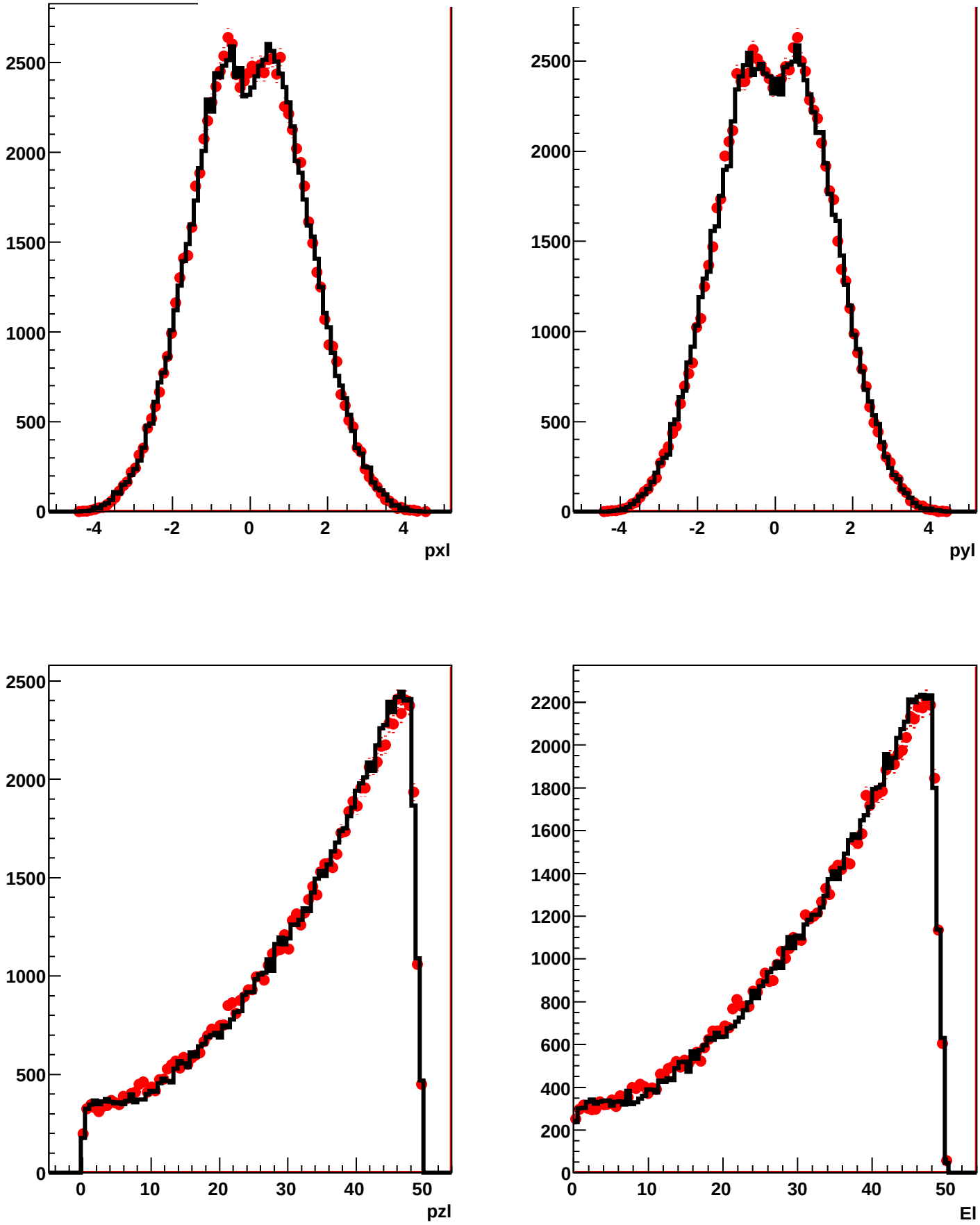
Final state primary lepton 4-p: QEL events



Final state primary lepton 4-p: RES events



Final state primary lepton 4-p: All DIS events



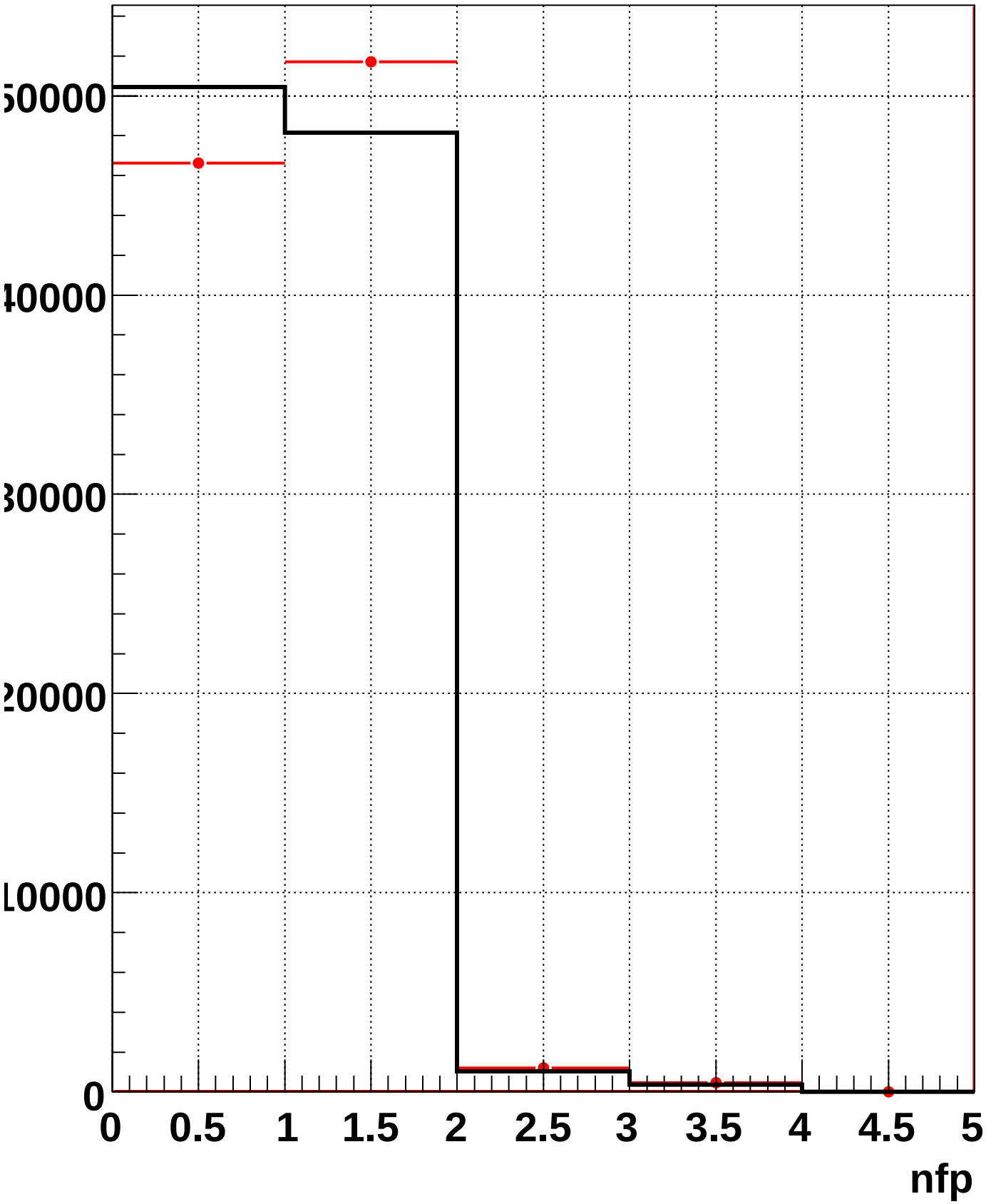
Final State Hadronic System

Multiplicities and 4-Momenta

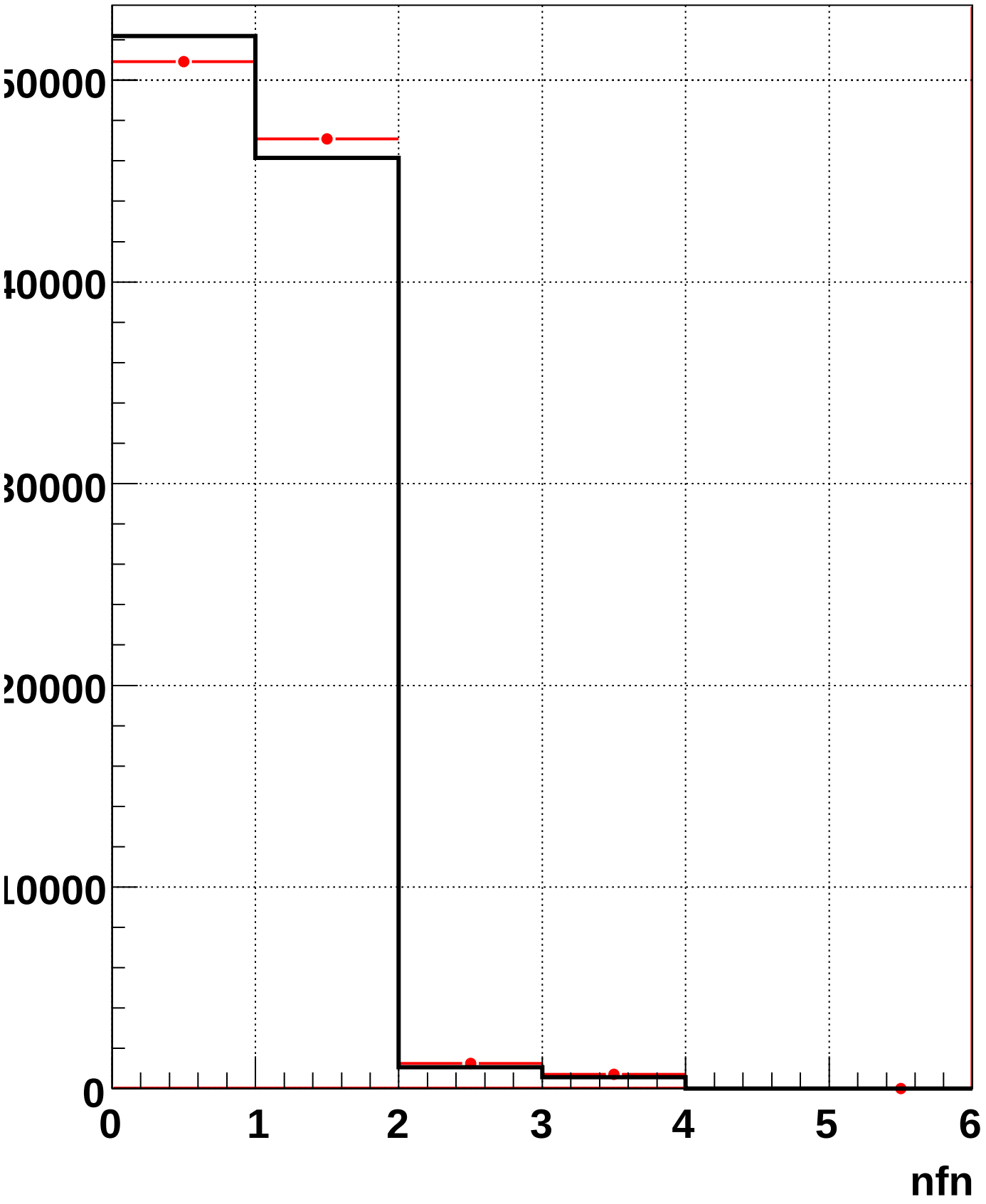
Note:

For nuclear targets these plots include the effect of intranuclear hadron transport / rescattering

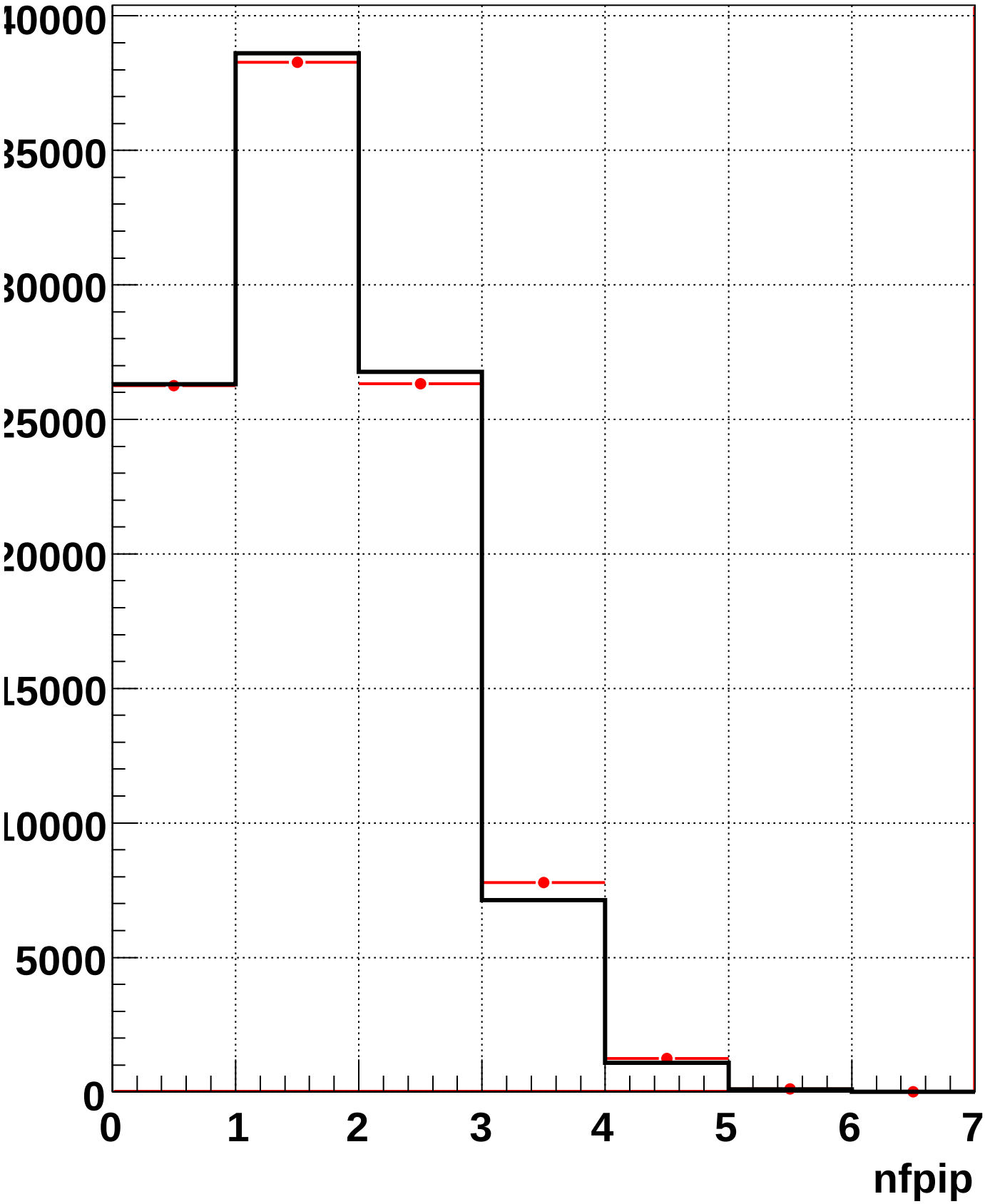
Number of final state protons



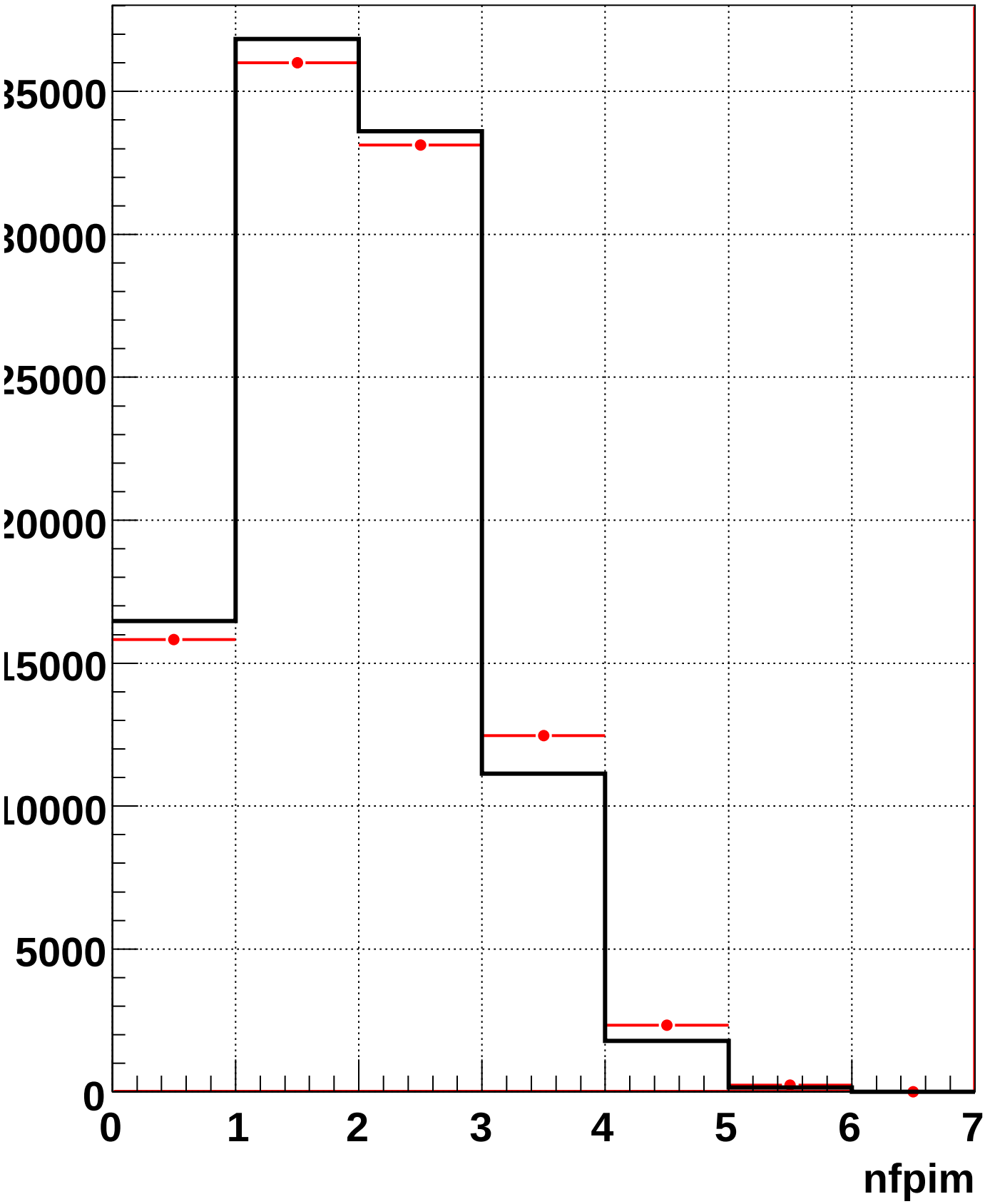
Number of final state neutrons



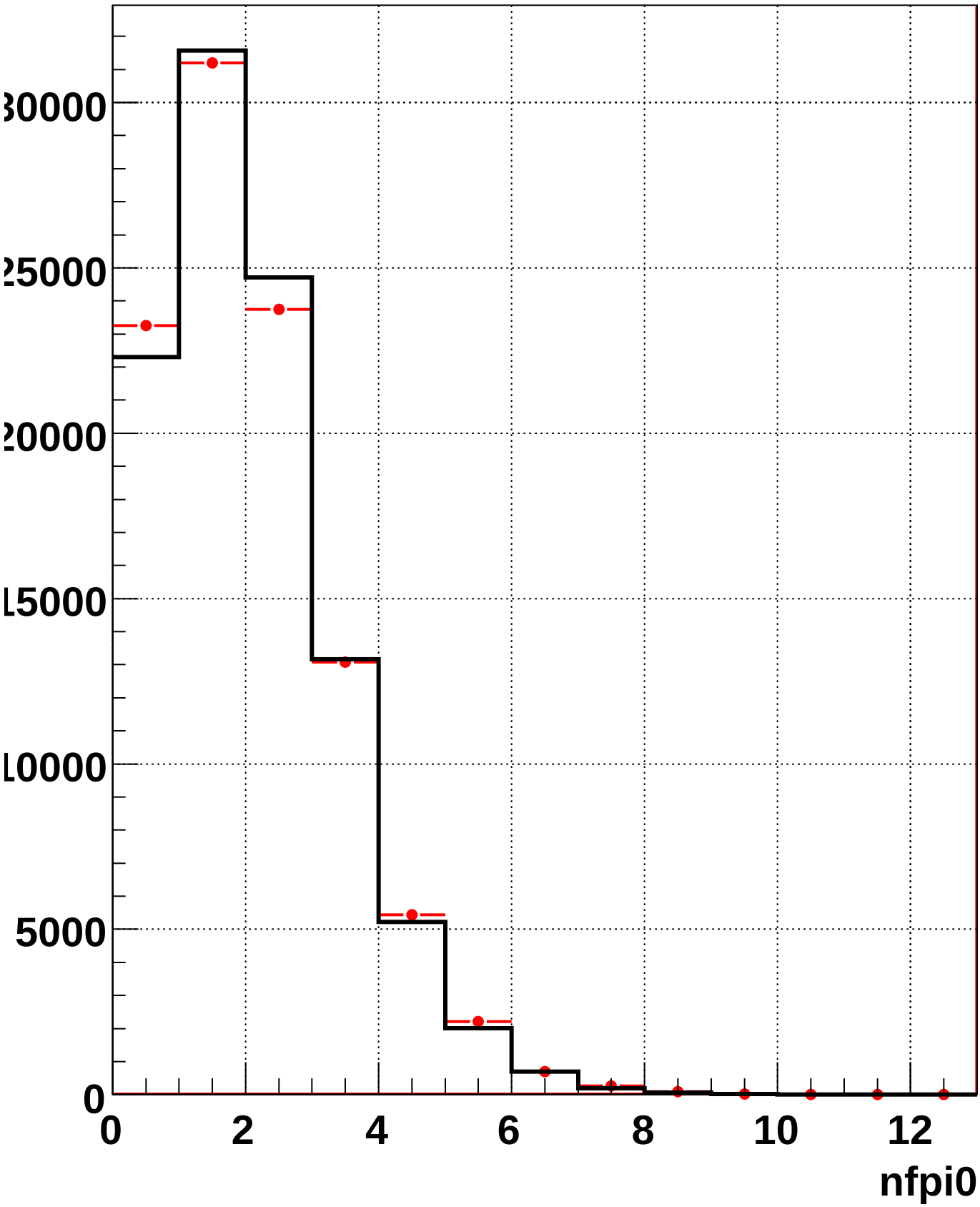
Number of final state pi+



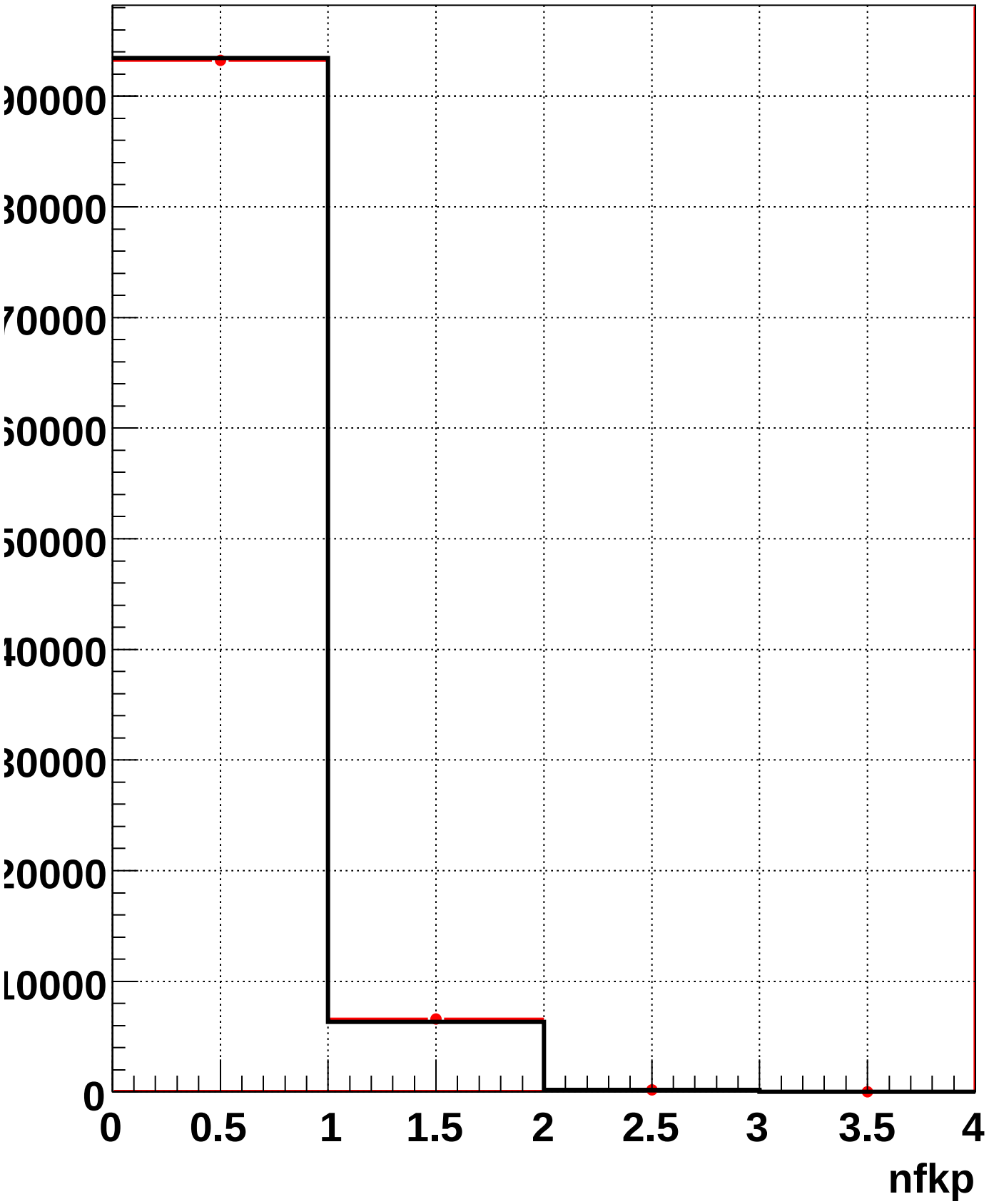
Number of final state pi-

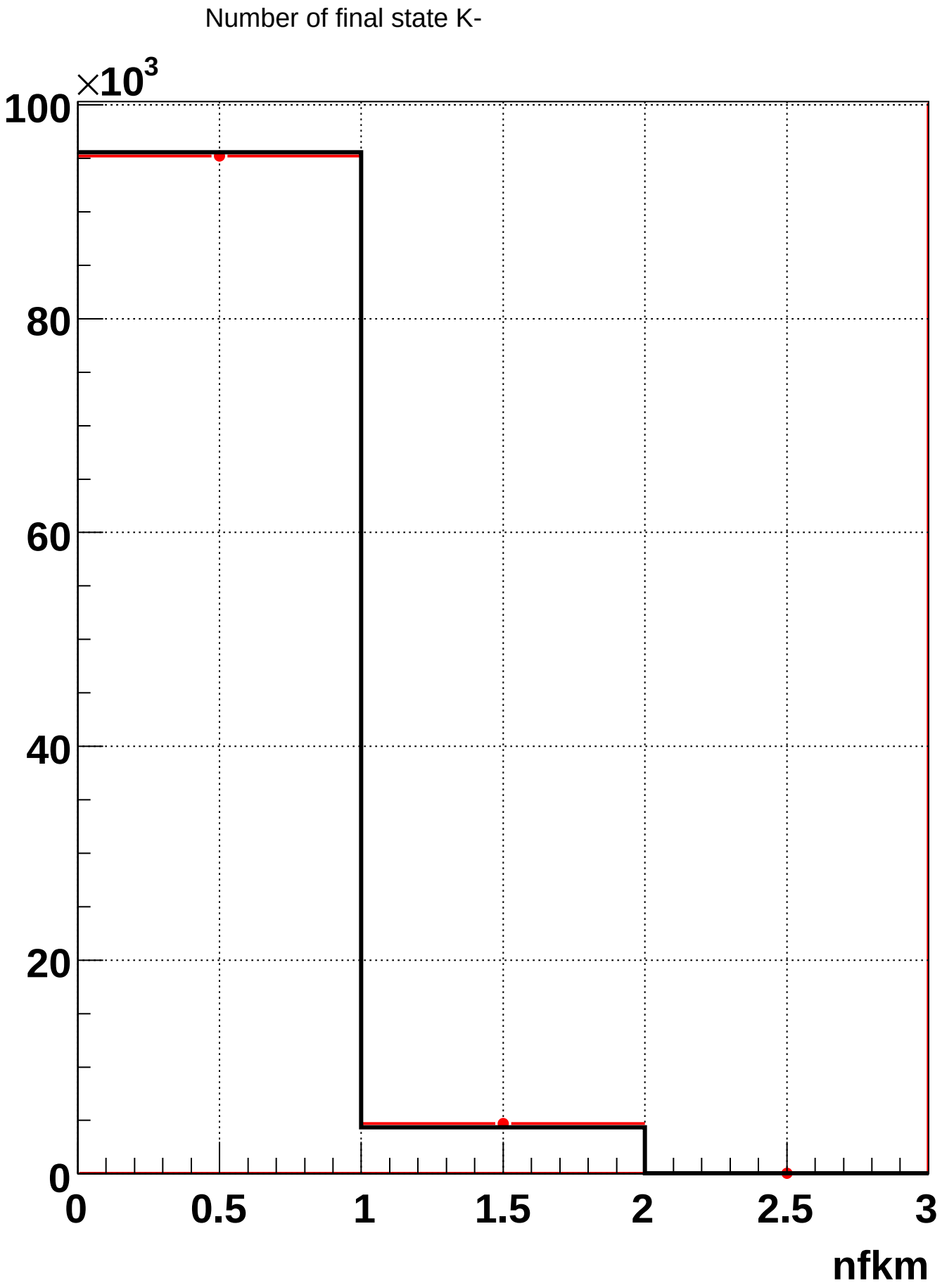


Number of final state pi0

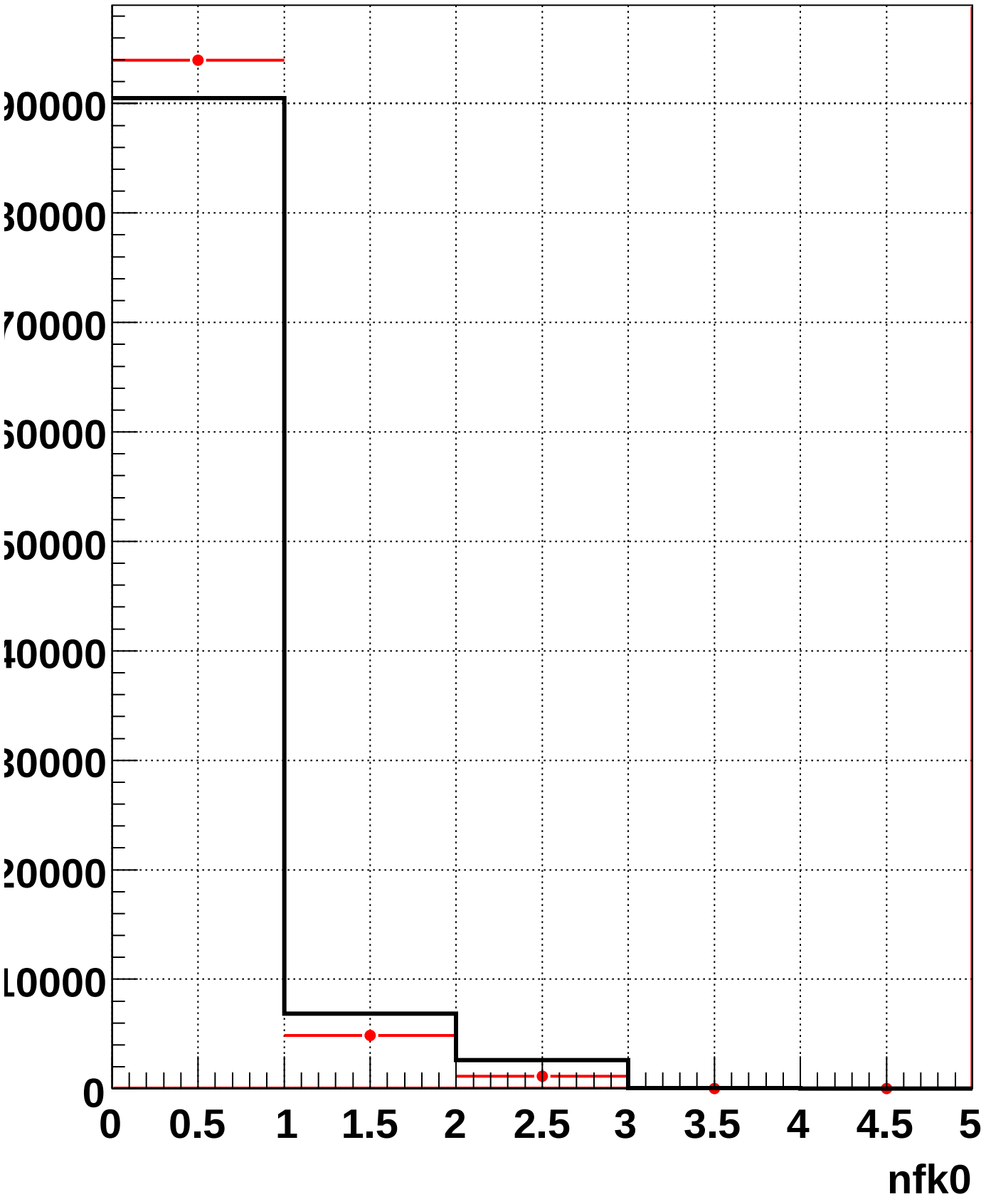


Number of final state K+

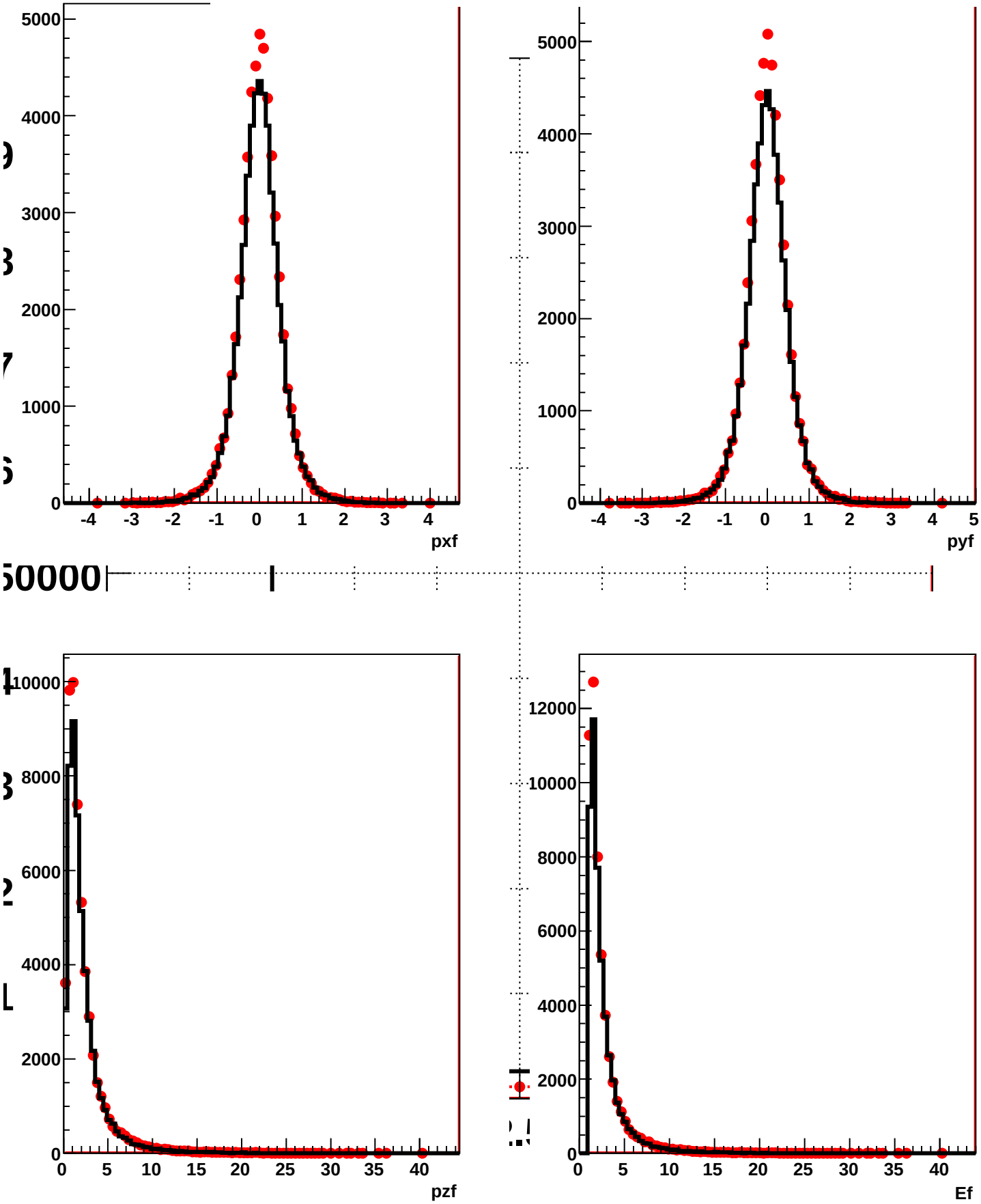



Number of final state K-
×10^3
100
80
60
40
20
0
0
0.5
1
1.5
2
2.5
3
nfkm

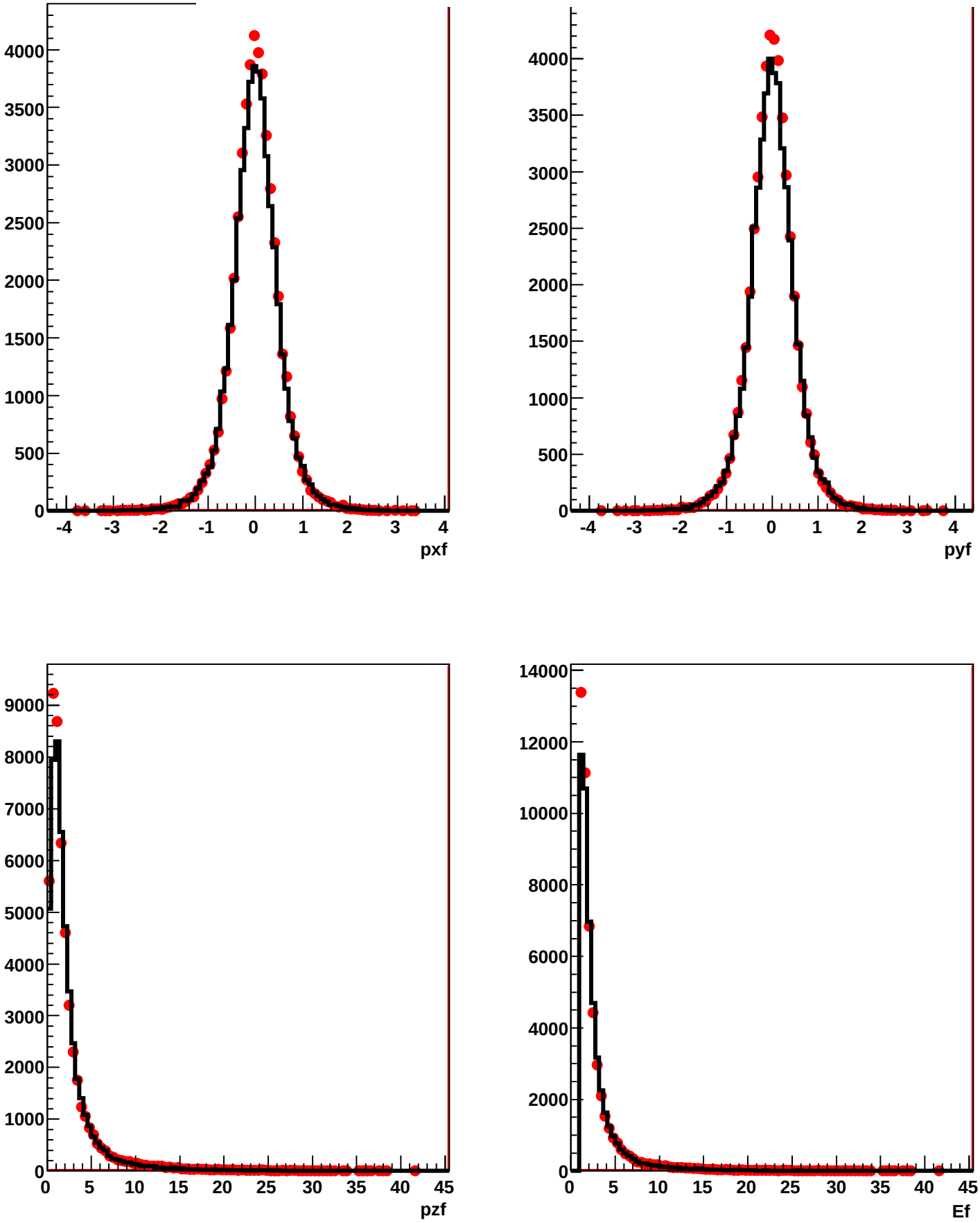
Number of final state K0



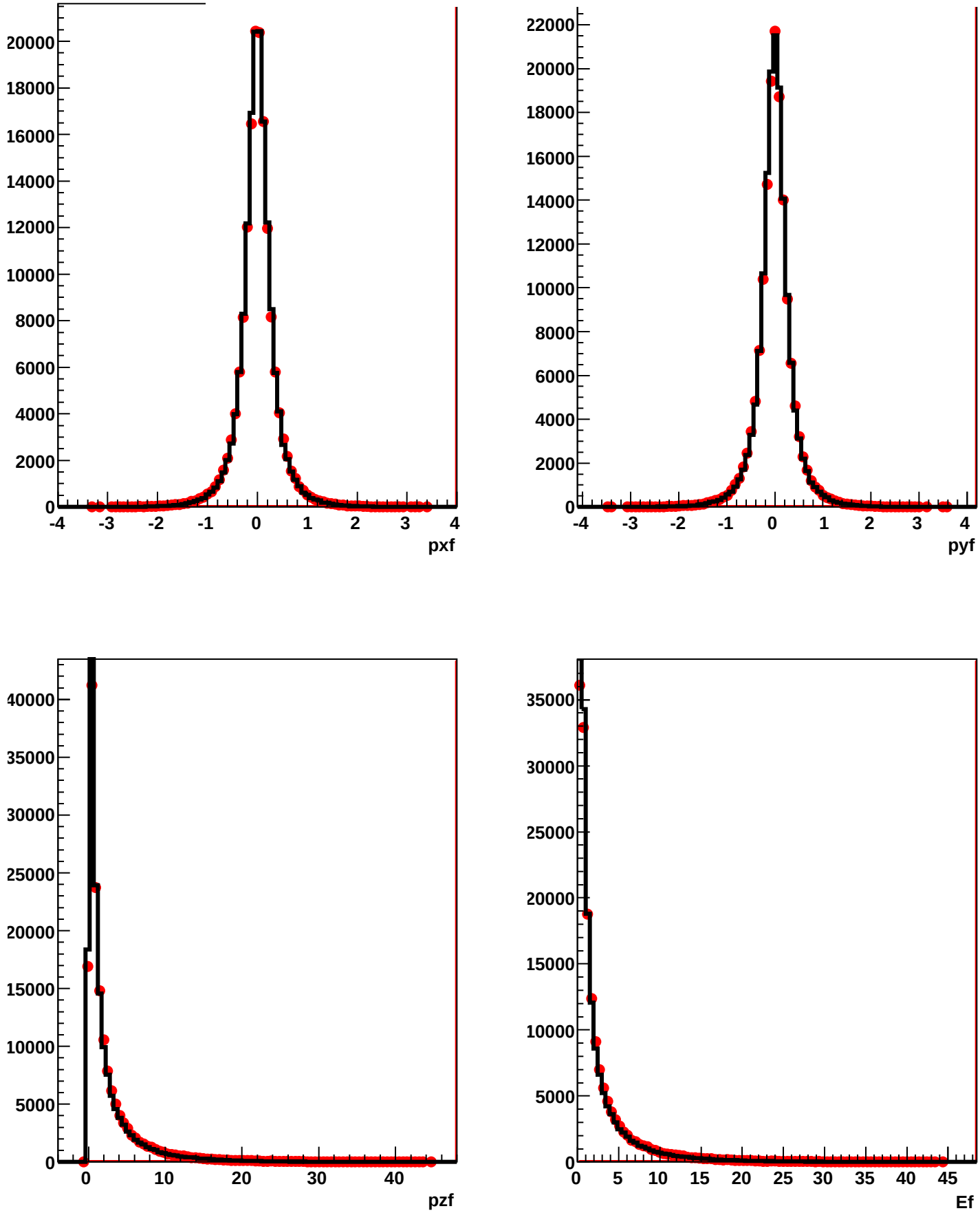
Final state protons 4-momentum



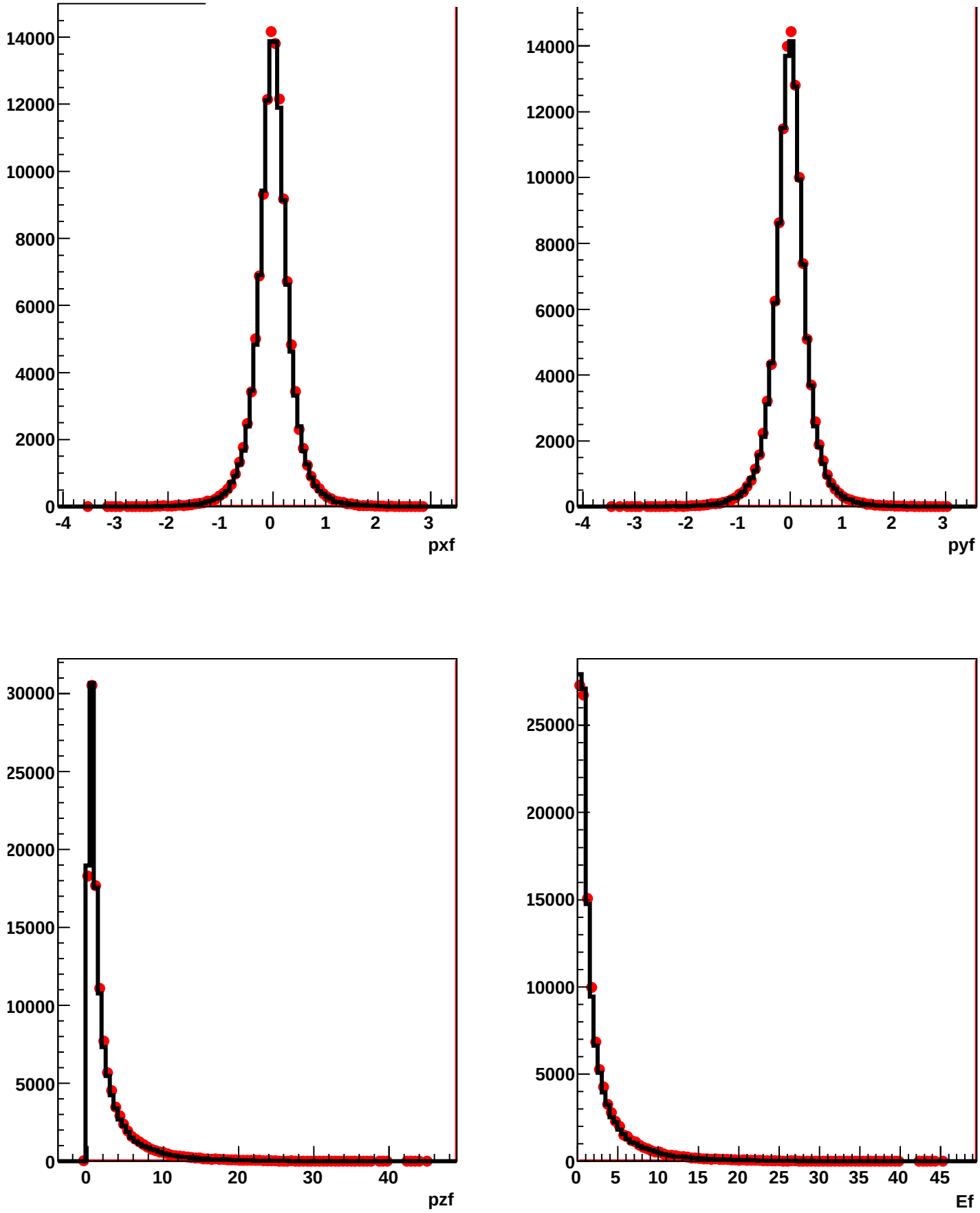
Final state neutrons 4-momentum



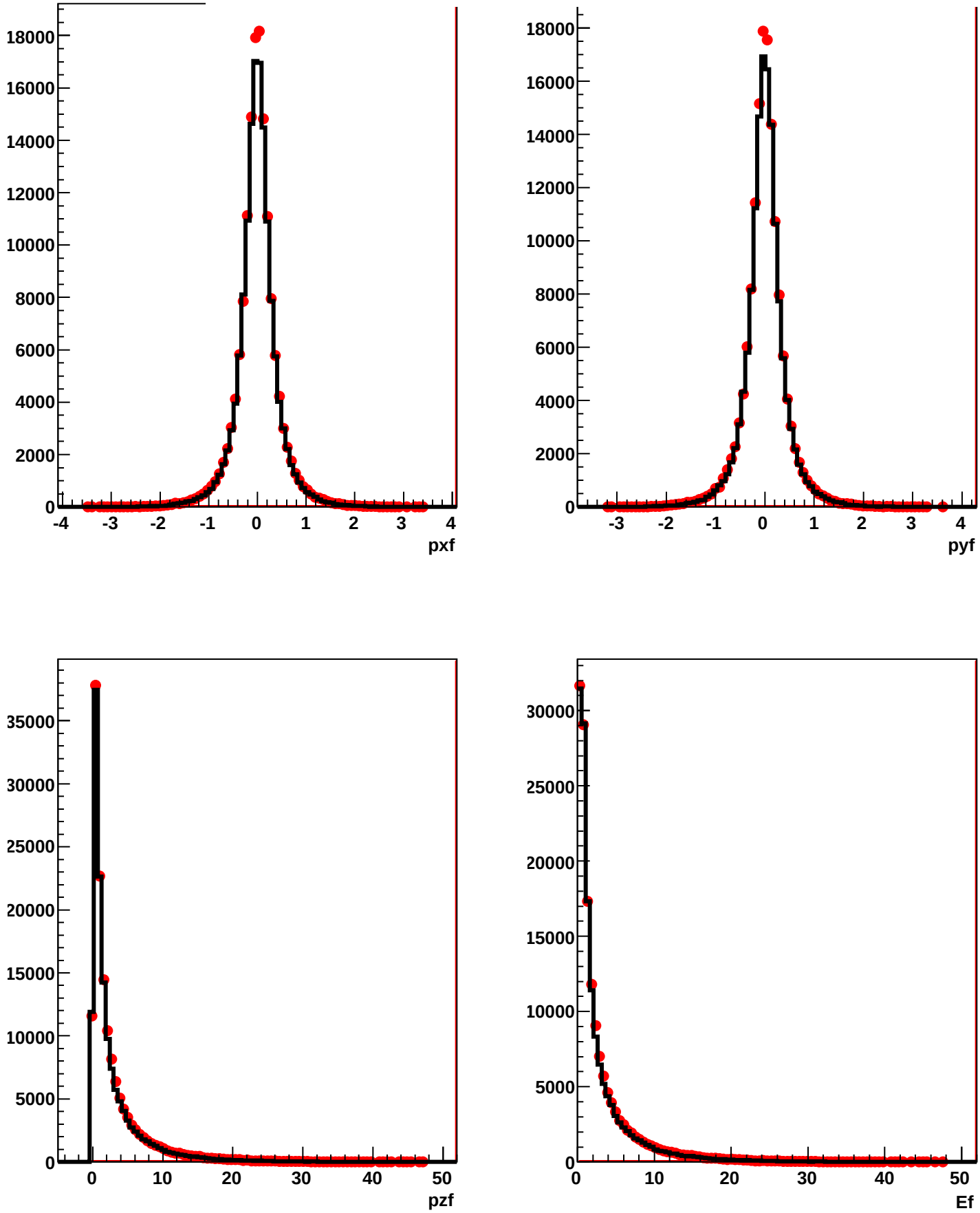
Final state pi0's 4-momentum



Final state pi+’s 4-momentum



Final state pi-'s 4-momentum



GENIE-2.0.0 vs NEUGEN/Daikon+ Event Sample Comparisons

Event Sample:

100k events, numu+Fe56, 1GeV, all processes

Notes:

Daikon+ is a NEUGEN Daikon revision version

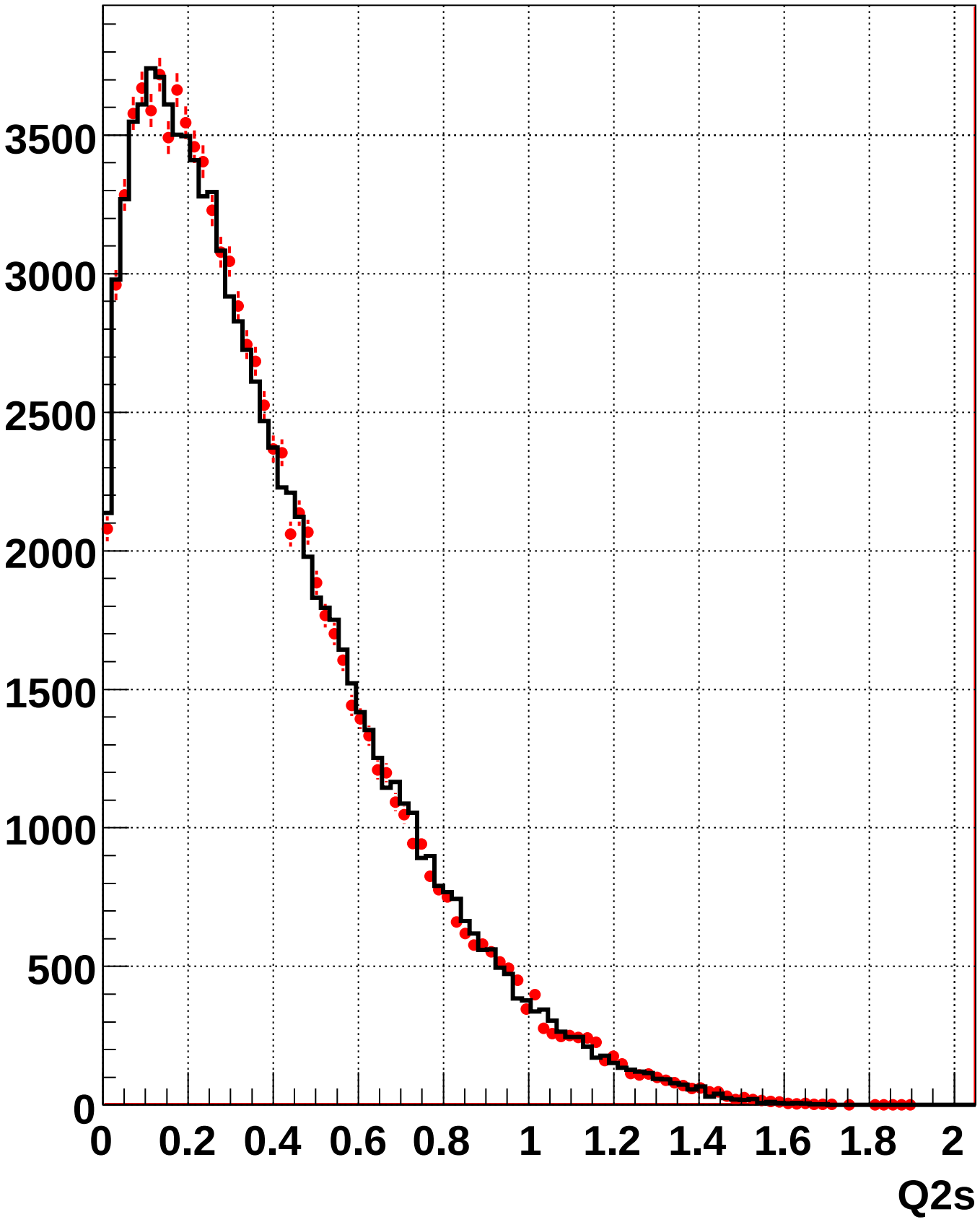
GENIE predictions shown with lines / NEUGEN's with markers

Event Numbers:

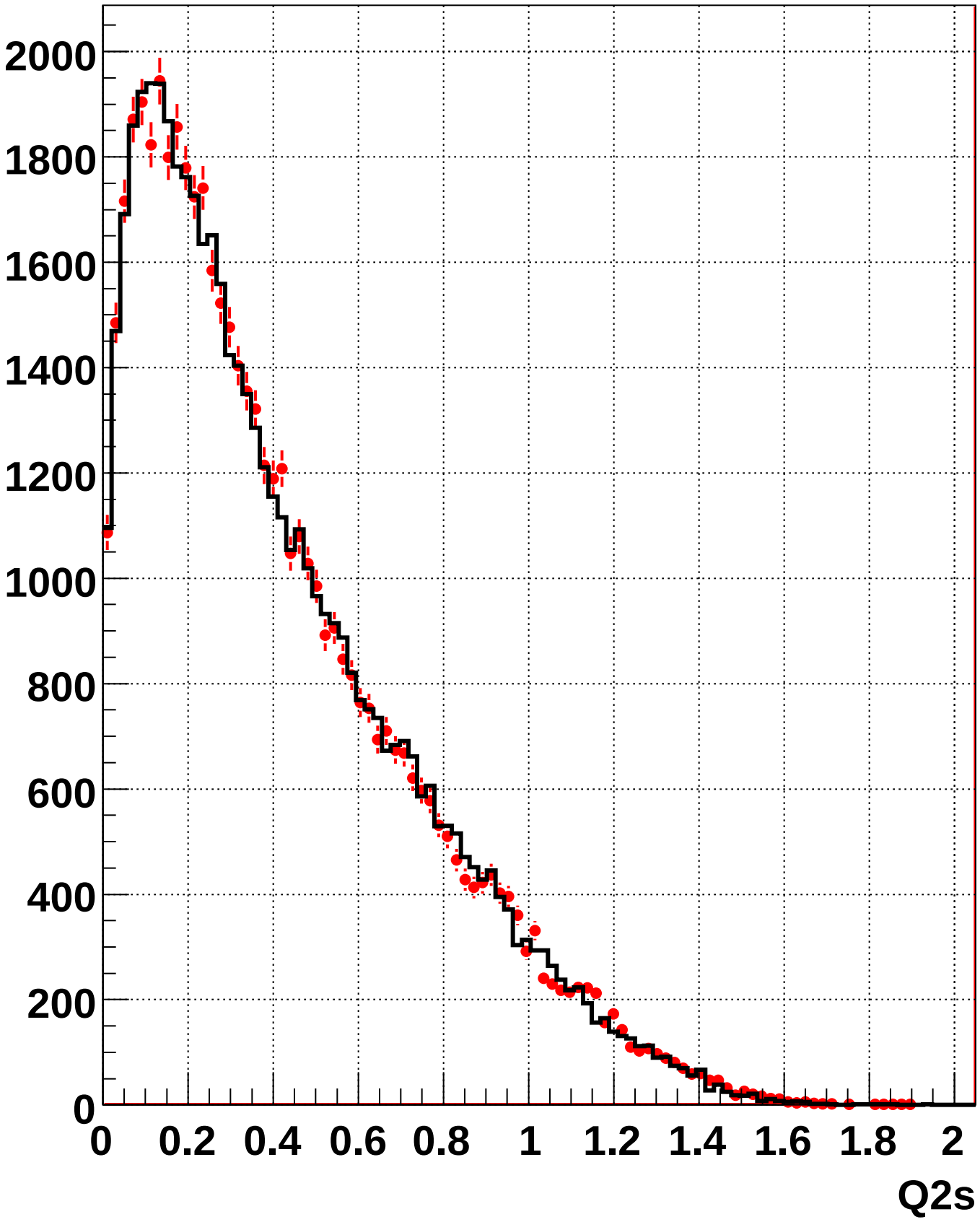
ALL :	100000 [NeuGEN],	100000 [GENIE]
QEL :	54718 [NeuGEN],	54768 [GENIE]
QEL-CC :	39930 [NeuGEN],	39749 [GENIE]
QEL-NC :	14788 [NeuGEN],	15019 [GENIE]
RES :	36825 [NeuGEN],	36767 [GENIE]
RES-CC :	26787 [NeuGEN],	26861 [GENIE]
RES-NC :	10038 [NeuGEN],	9906 [GENIE]
DIS :	7999 [NeuGEN],	8042 [GENIE]
DIS-CC :	6036 [NeuGEN],	6103 [GENIE]
(charm):	0 [NeuGEN],	0 [GENIE]
DIS-NC :	1963 [NeuGEN],	1939 [GENIE]
COH :	458 [NeuGEN],	423 [GENIE]
COH-CC :	273 [NeuGEN],	249 [GENIE]
COH-NC :	185 [NeuGEN],	174 [GENIE]
IMD :	0 [NeuGEN],	0 [GENIE]

Selected Kinematical Quantities

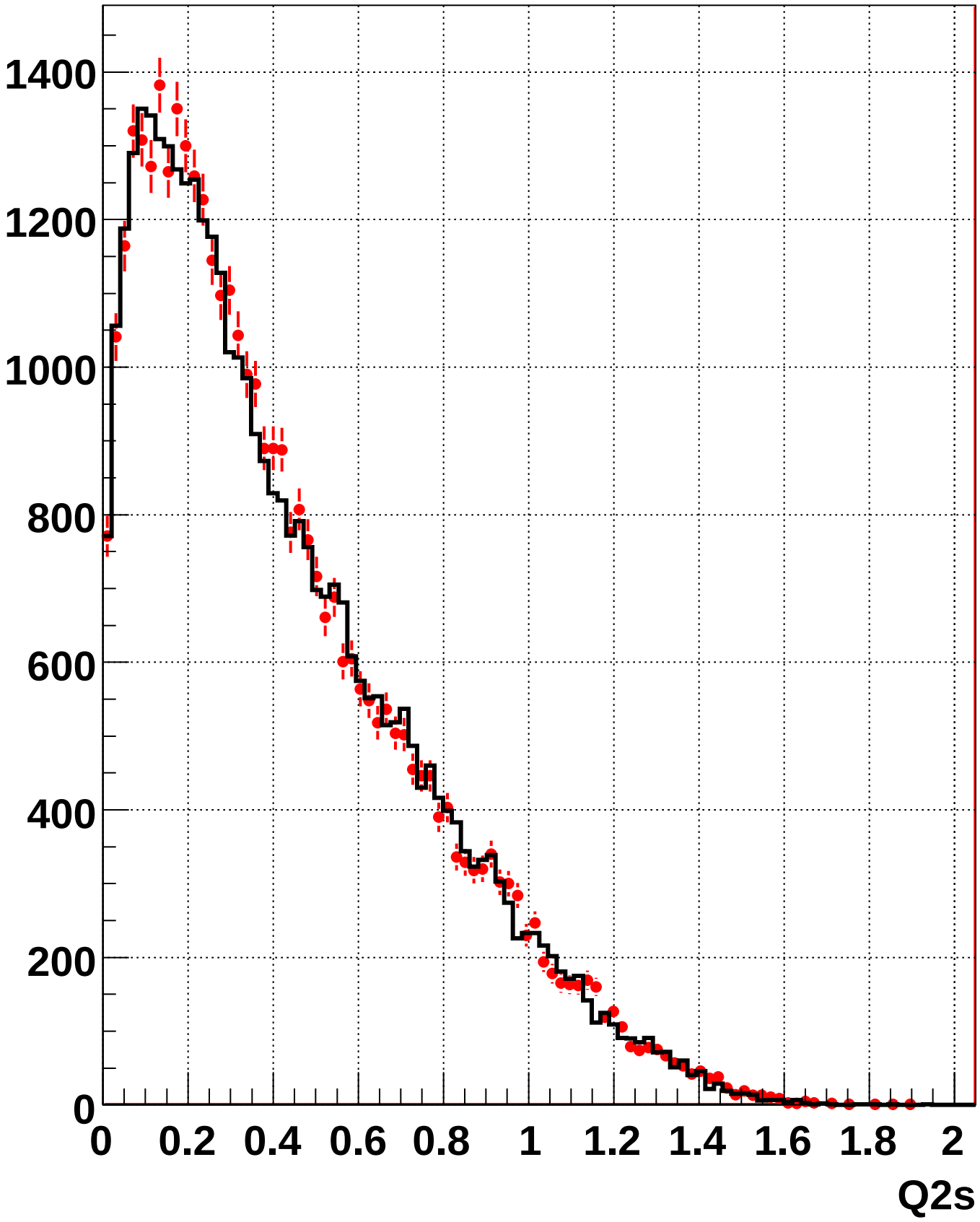
selected Q2 for all events



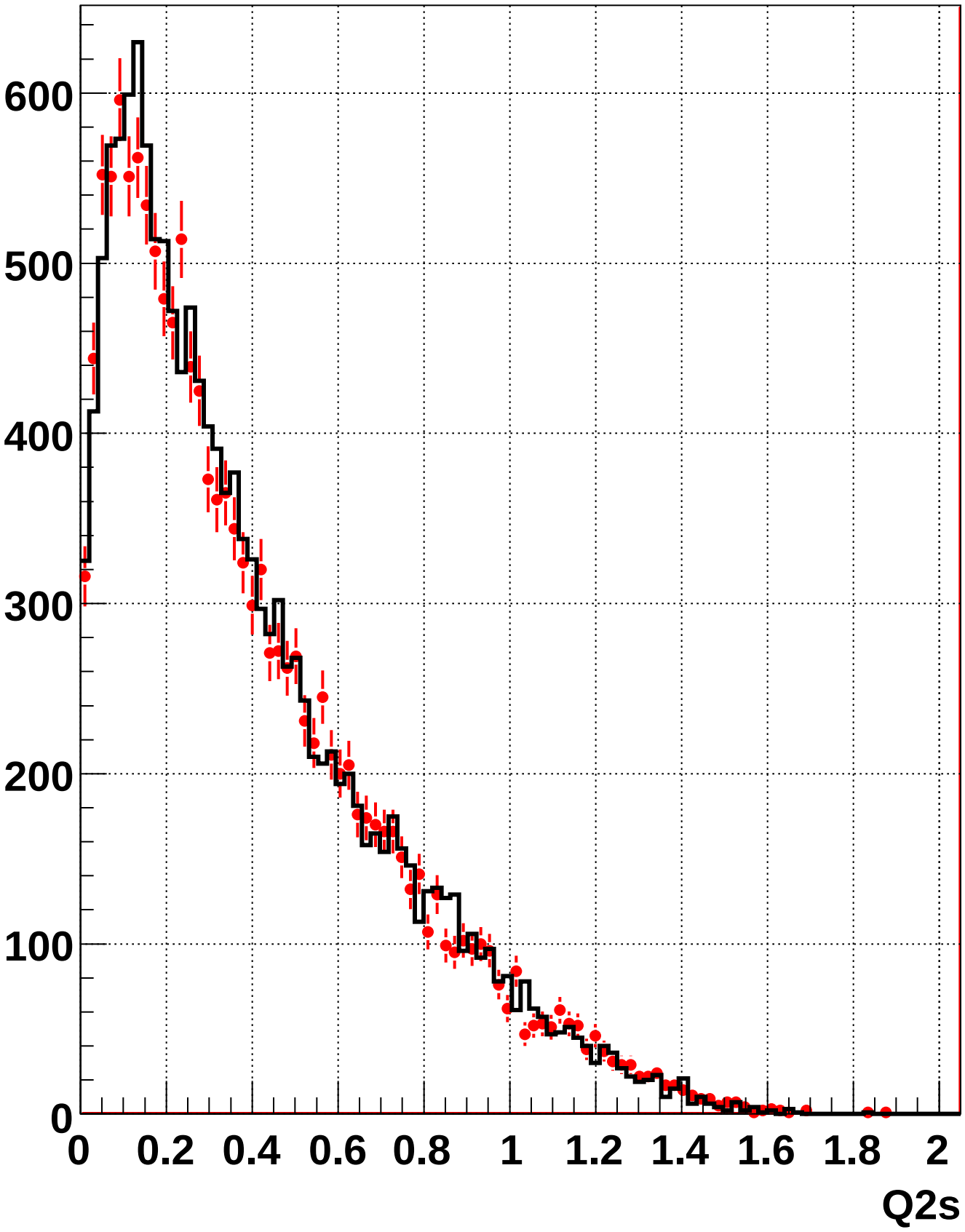
selected Q2 for QEL events



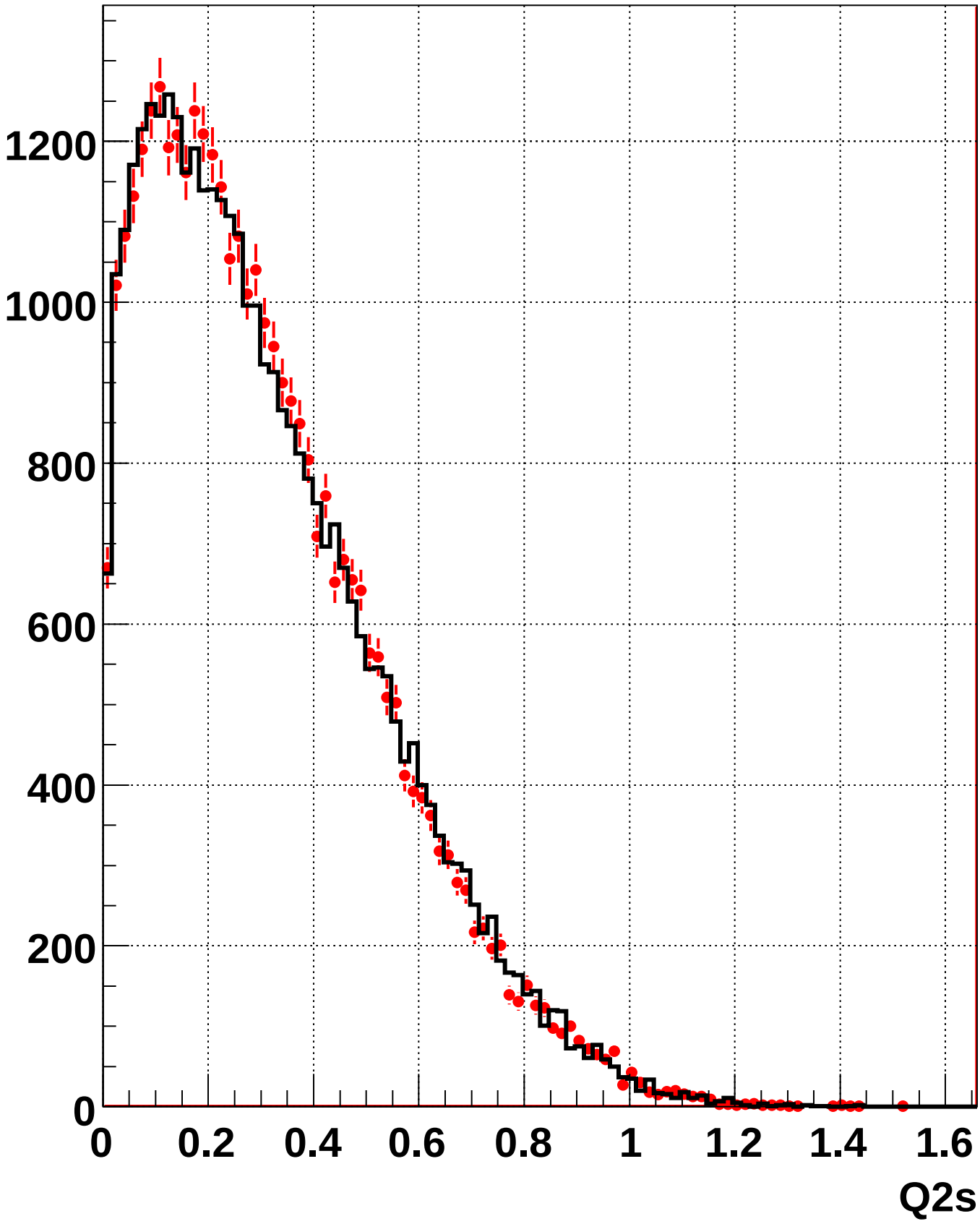
selected Q2 for QEL CC events



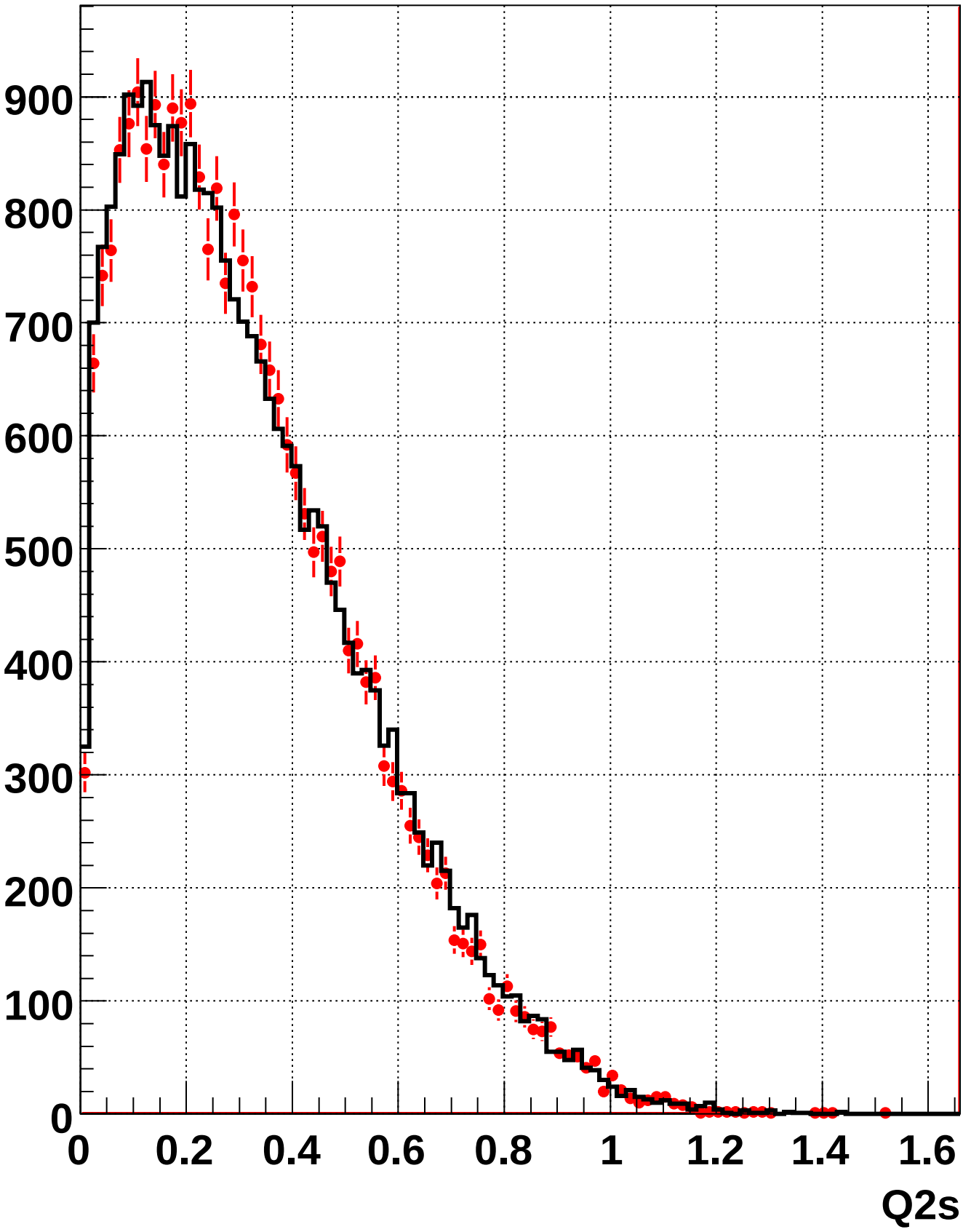
selected Q2 for QEL NC events



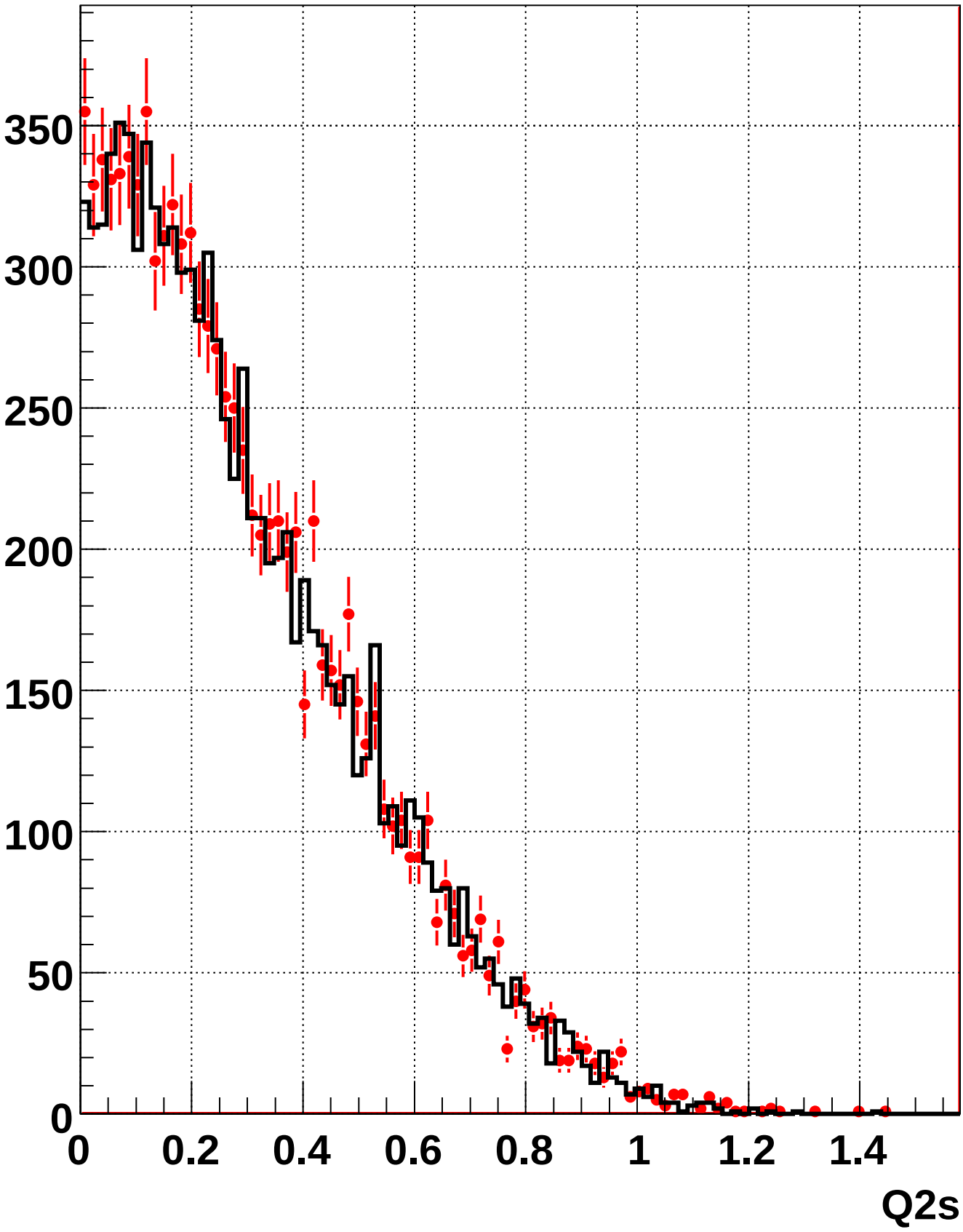
selected Q2 for RES events



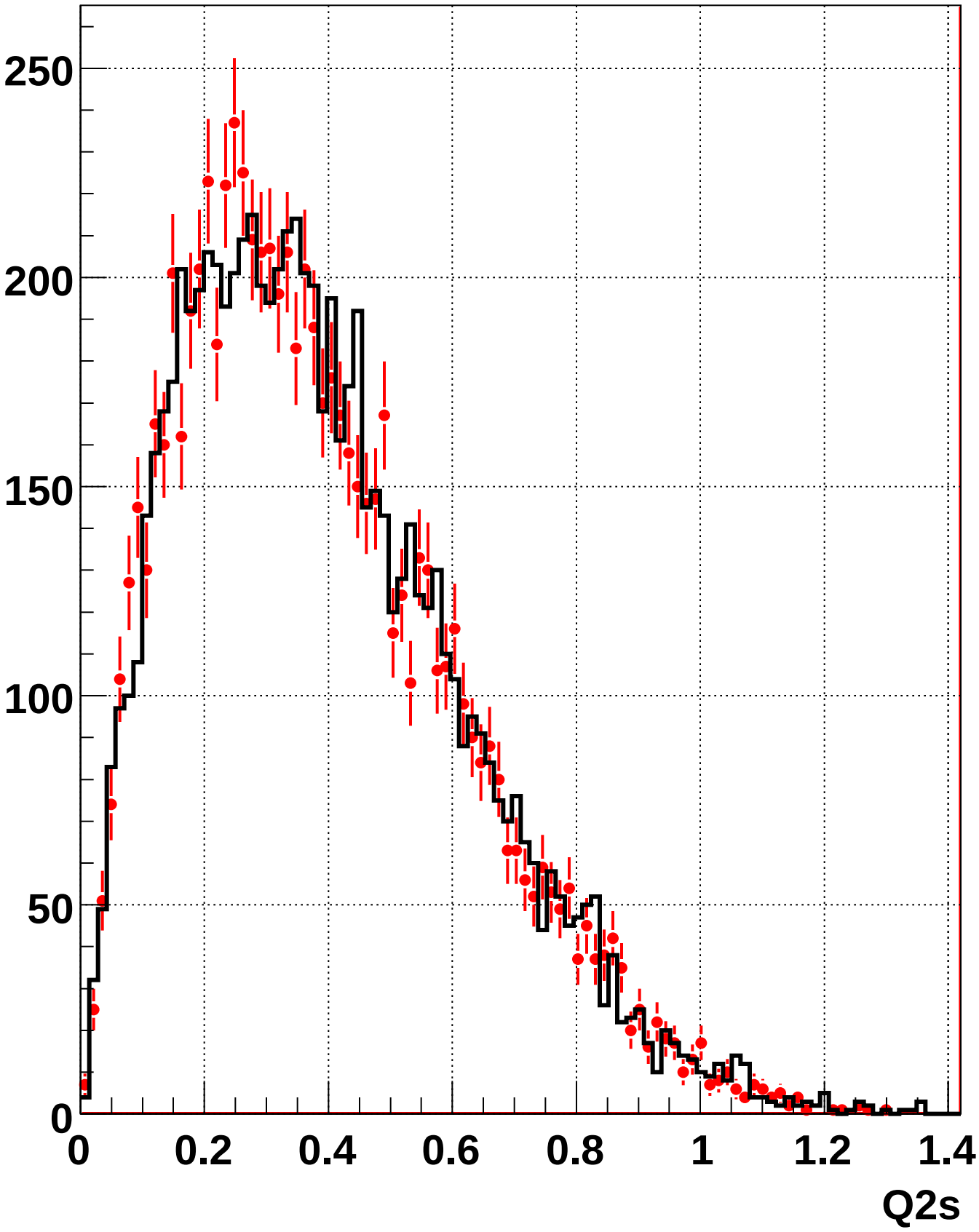
selected Q2 for RES CC events



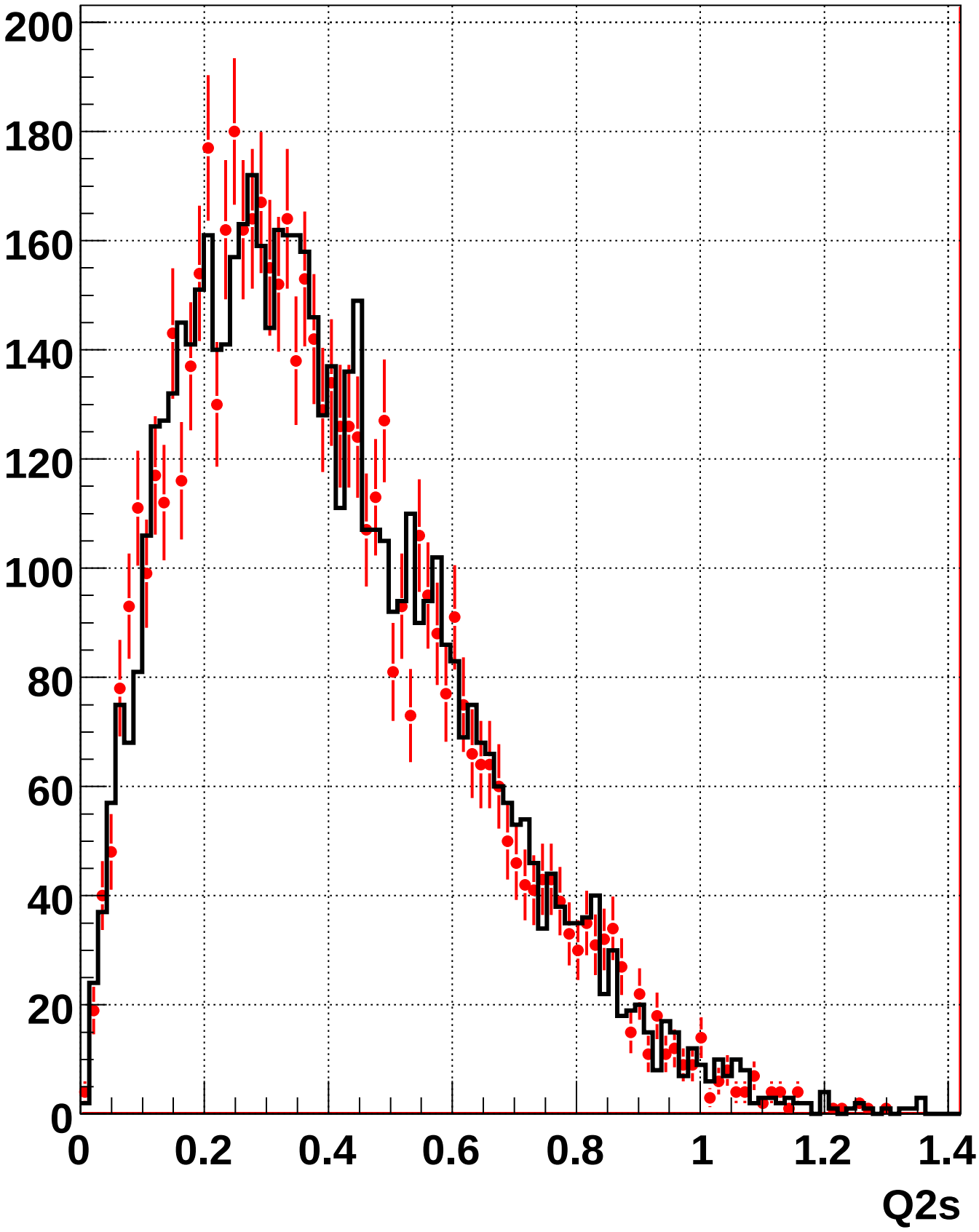
selected Q2 for RES NC events



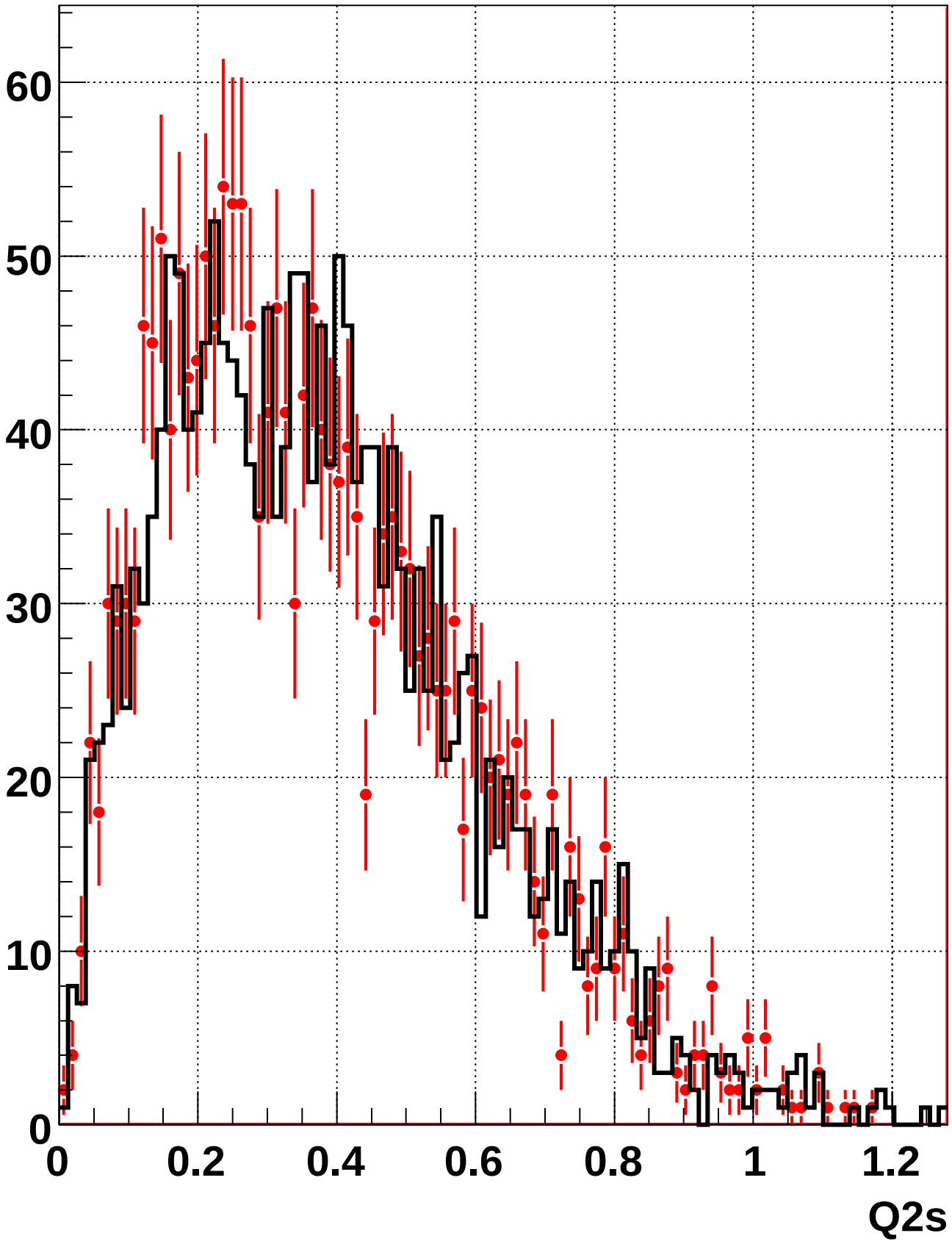
selected Q2 for DIS events



selected Q2 for DIS CC events

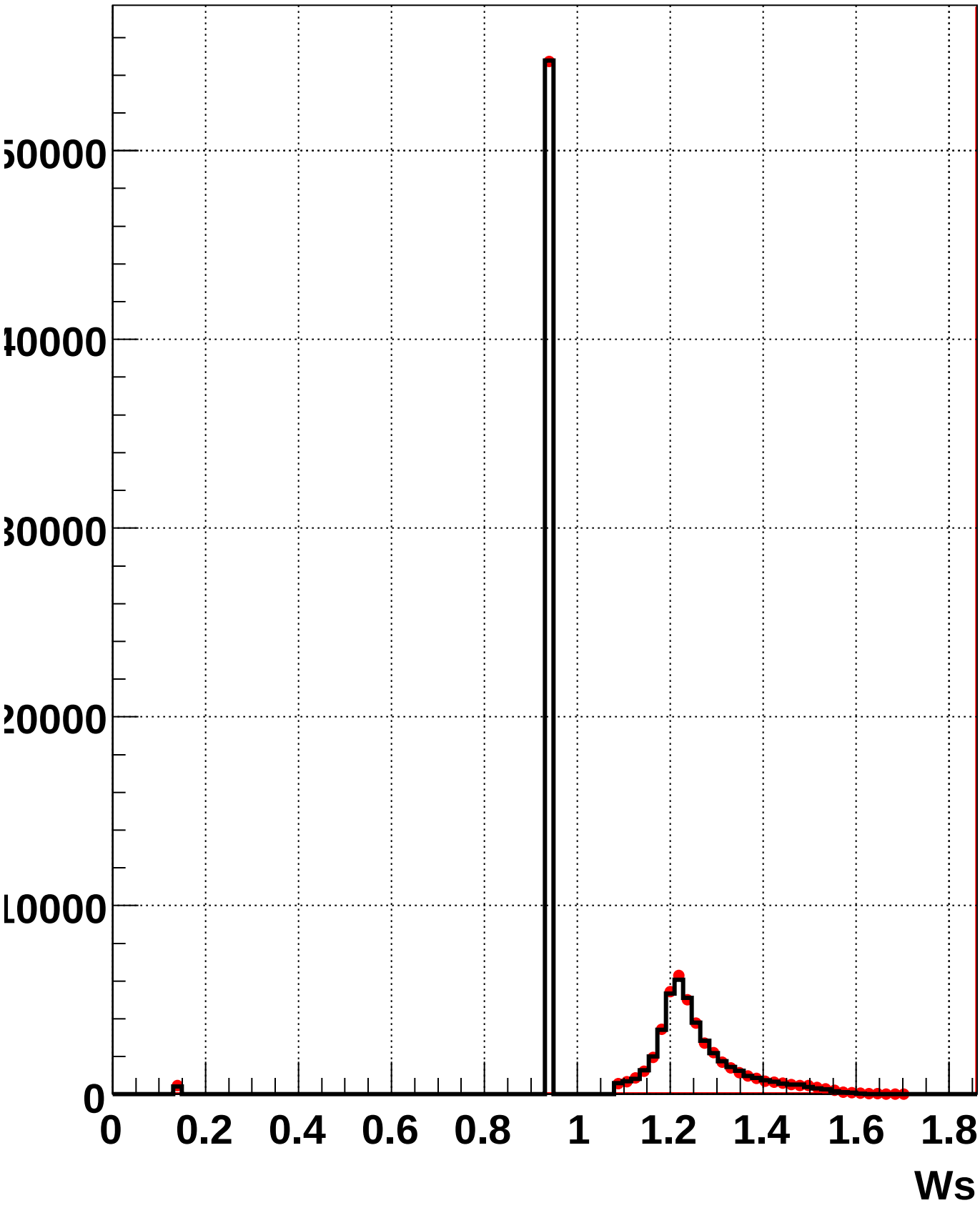


selected Q2 for DIS NC events

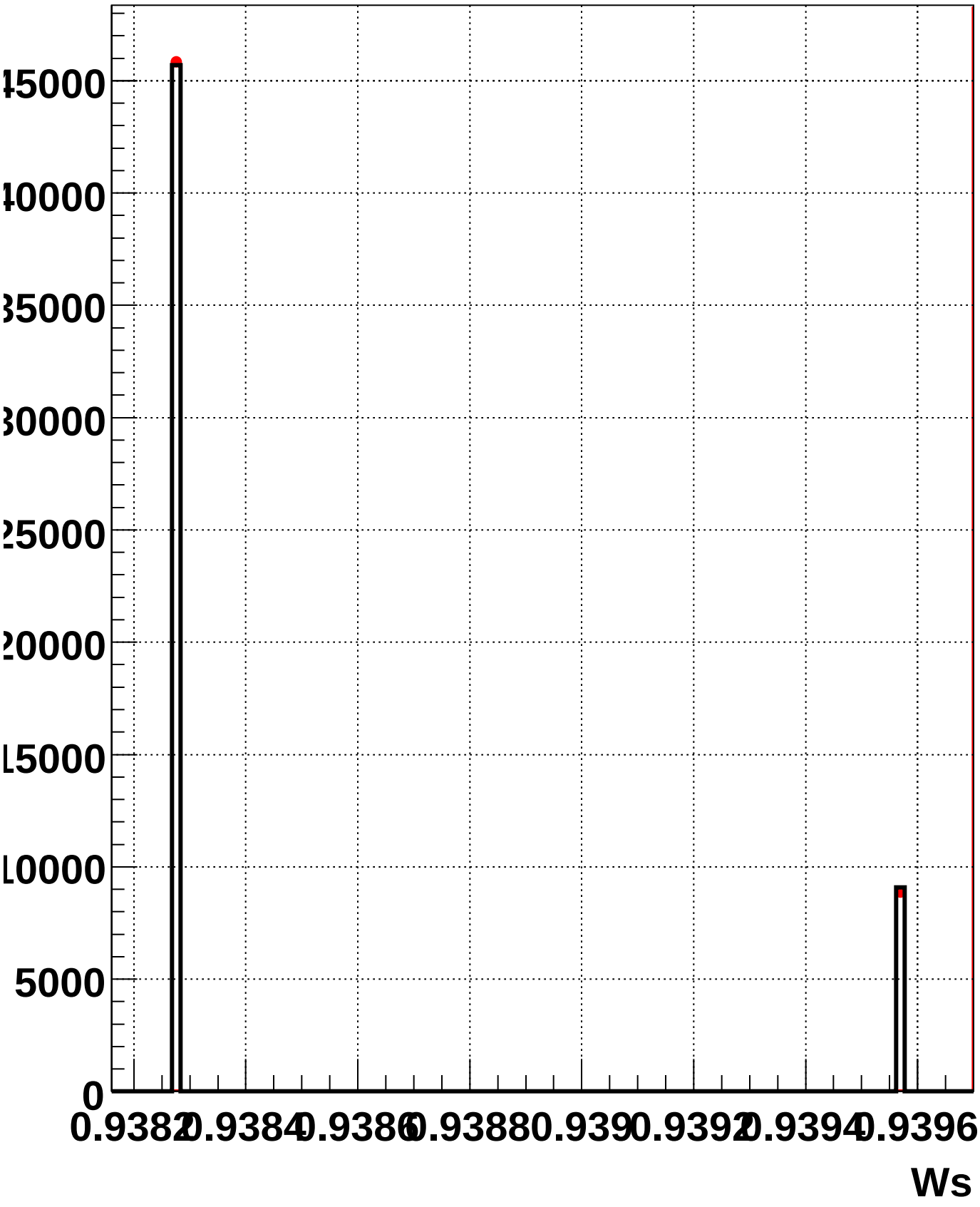


selected Q2 for Charm/DIS events

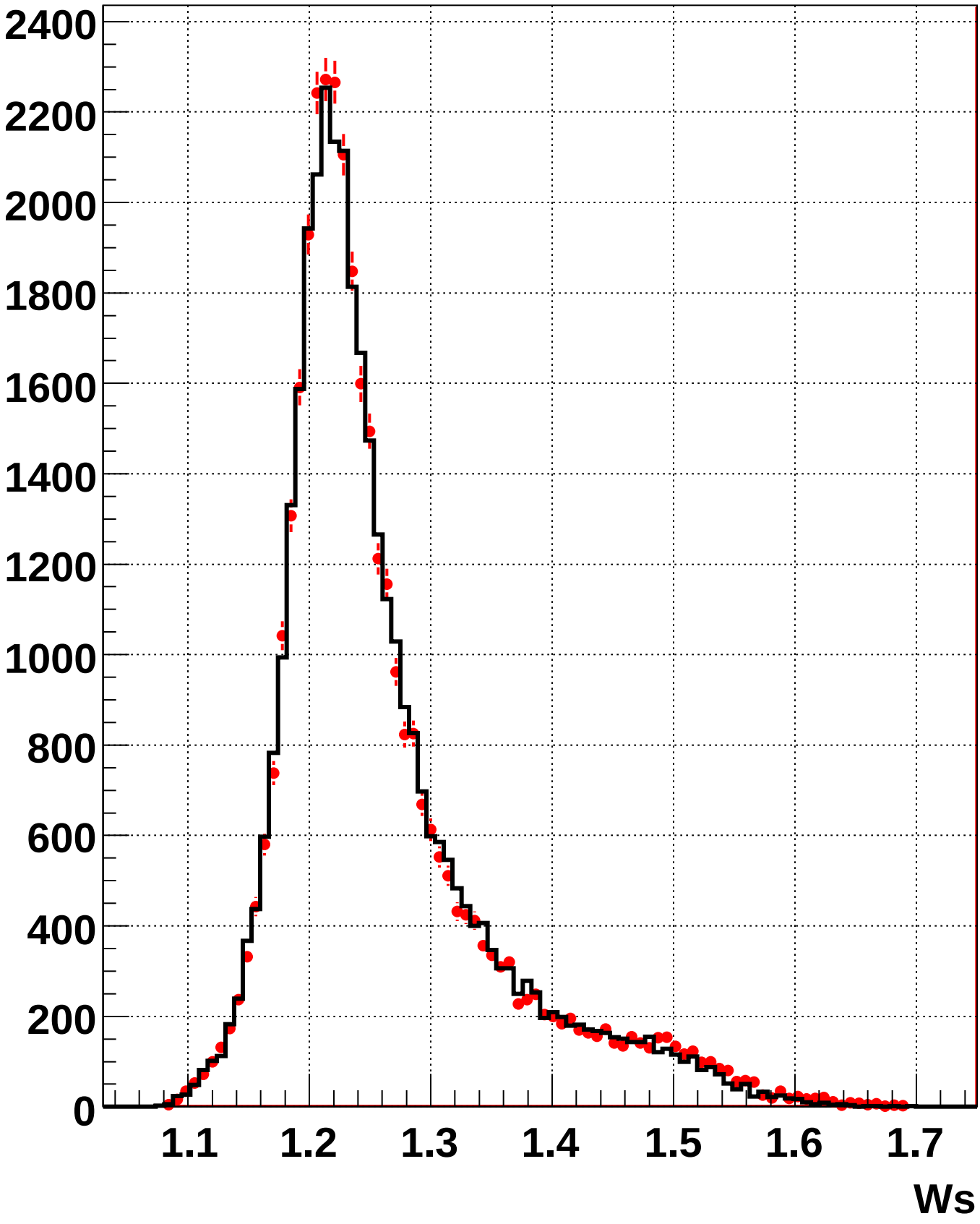
selected W for all events



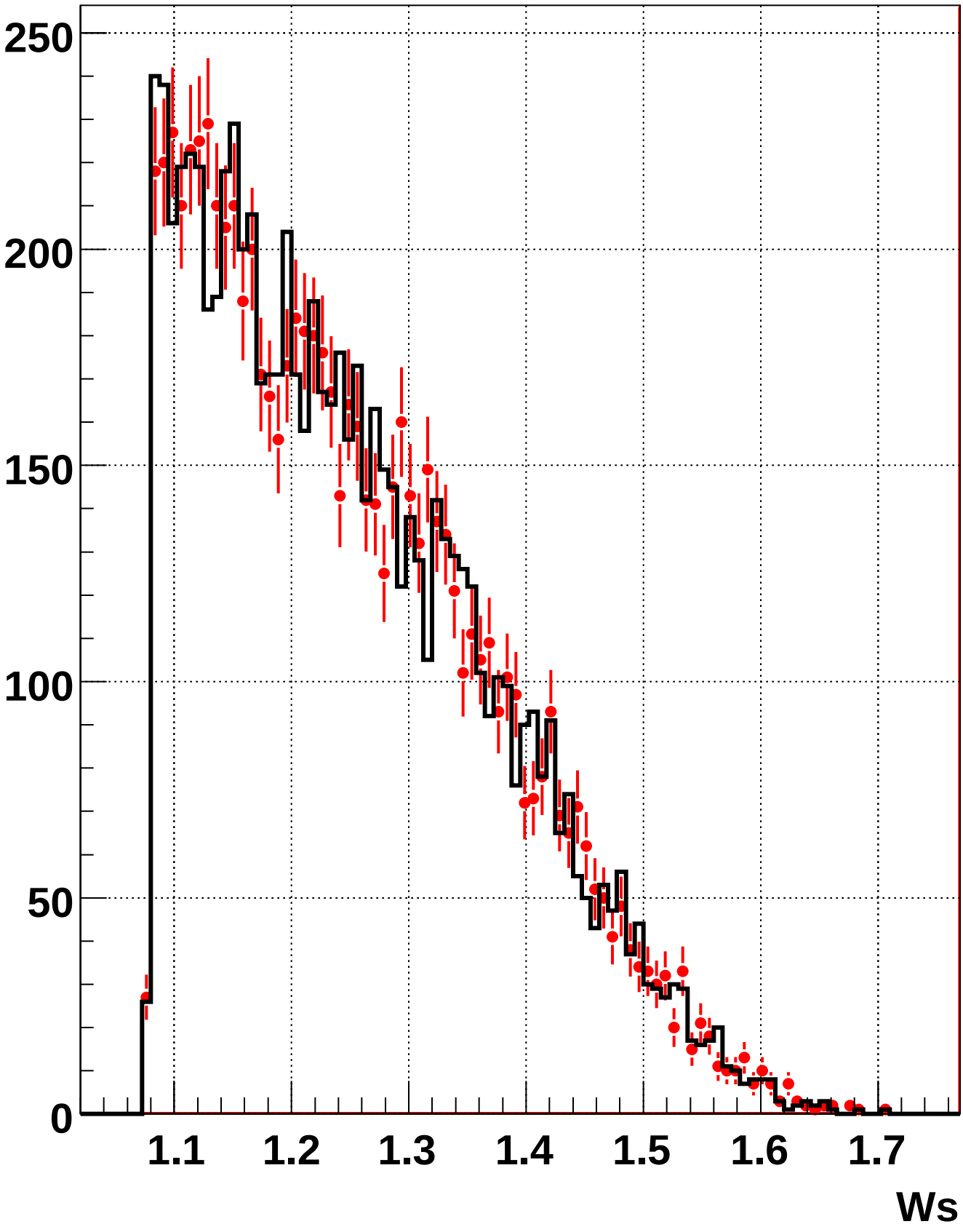
selected W for QEL events



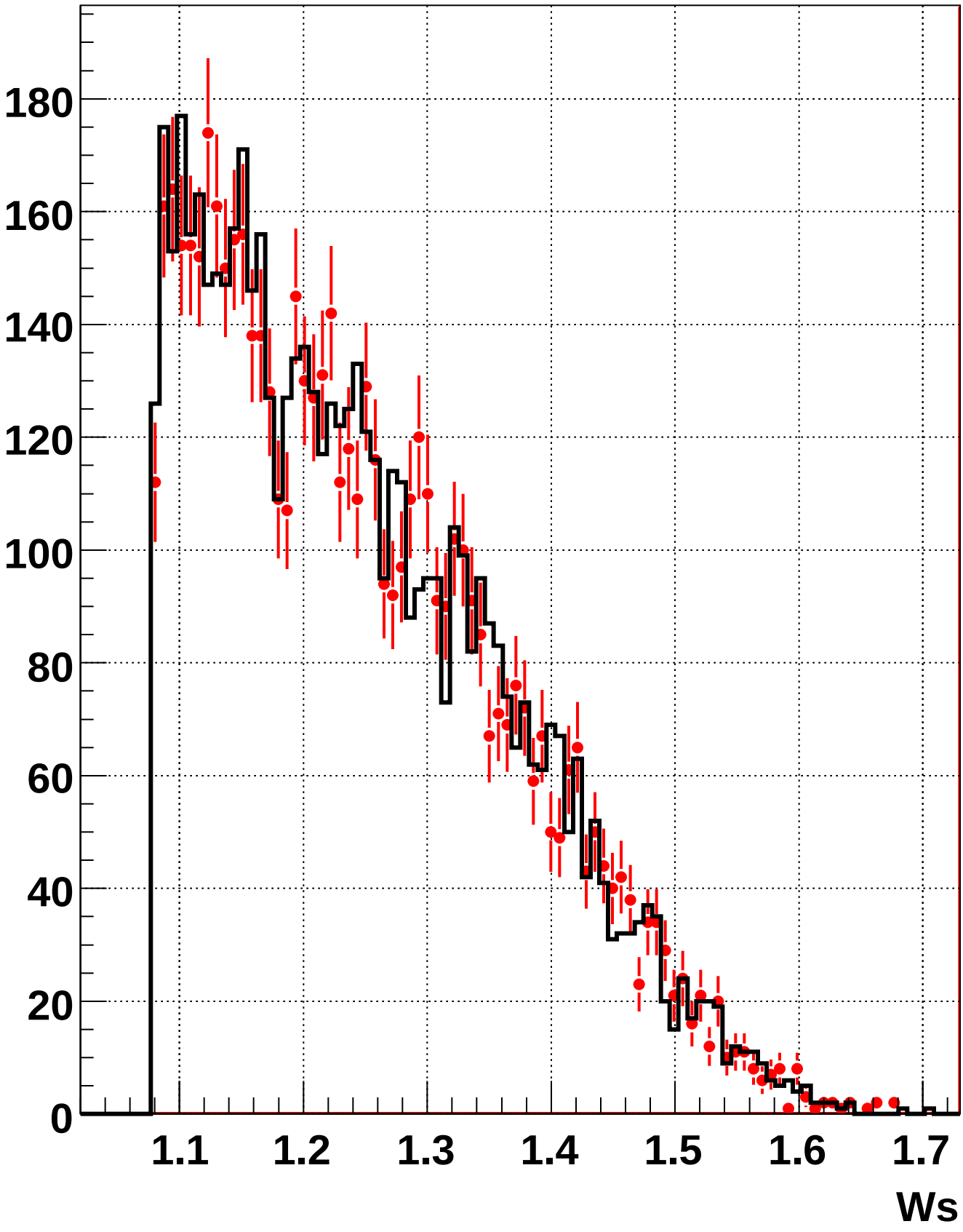
selected W for RES events



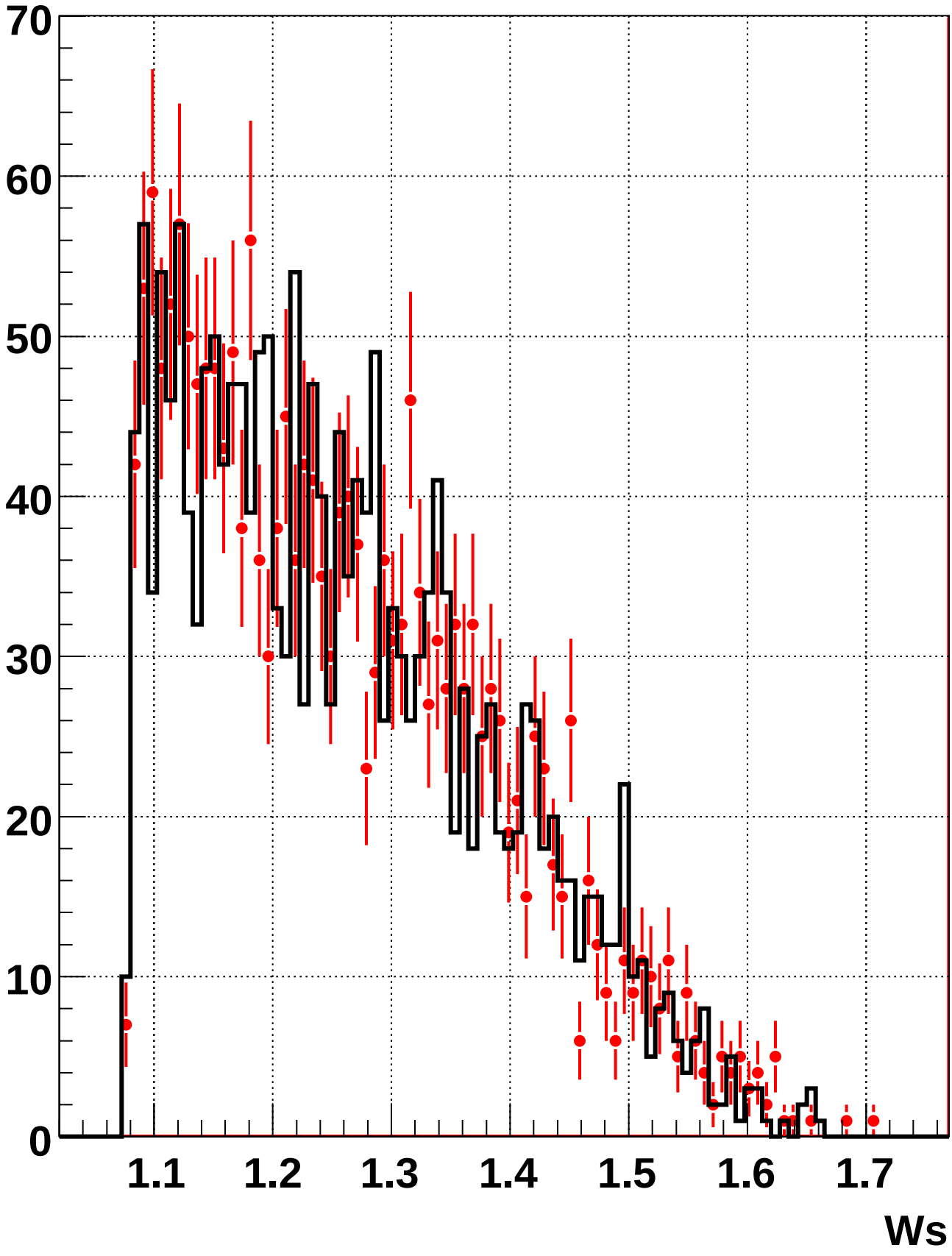
selected W for DIS events



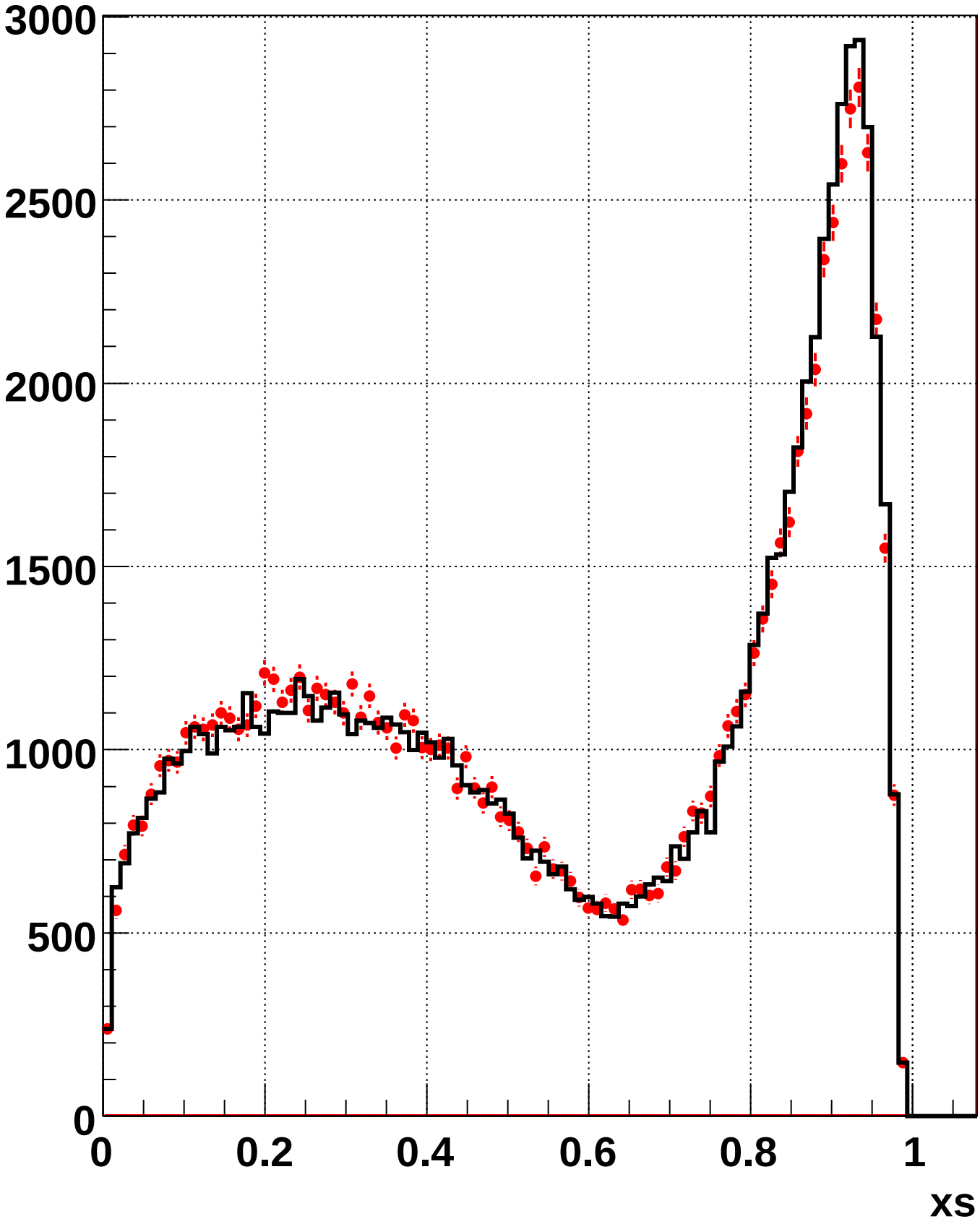
selected W for DIS CC events



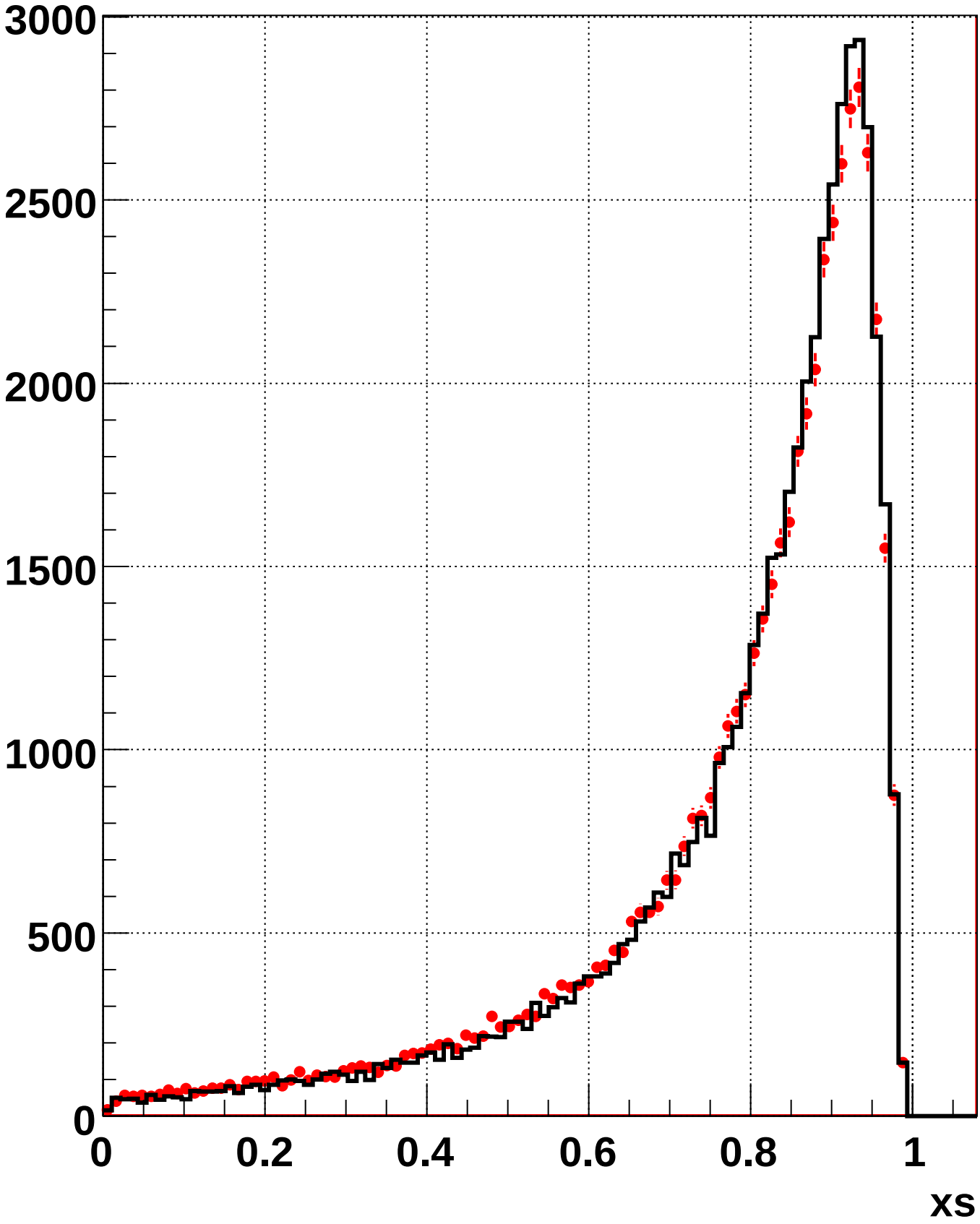
selected W for DIS NC events



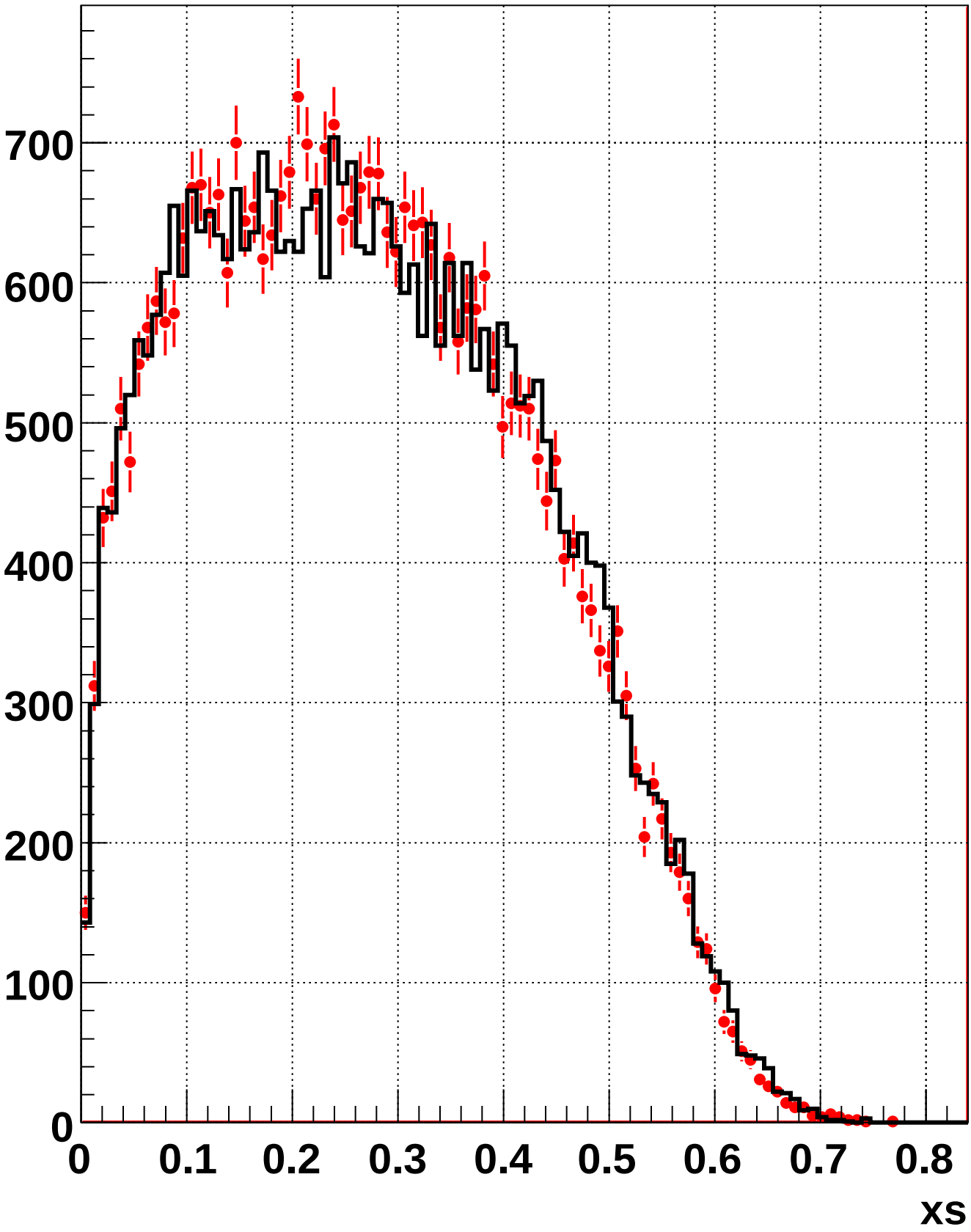
selected x for all events



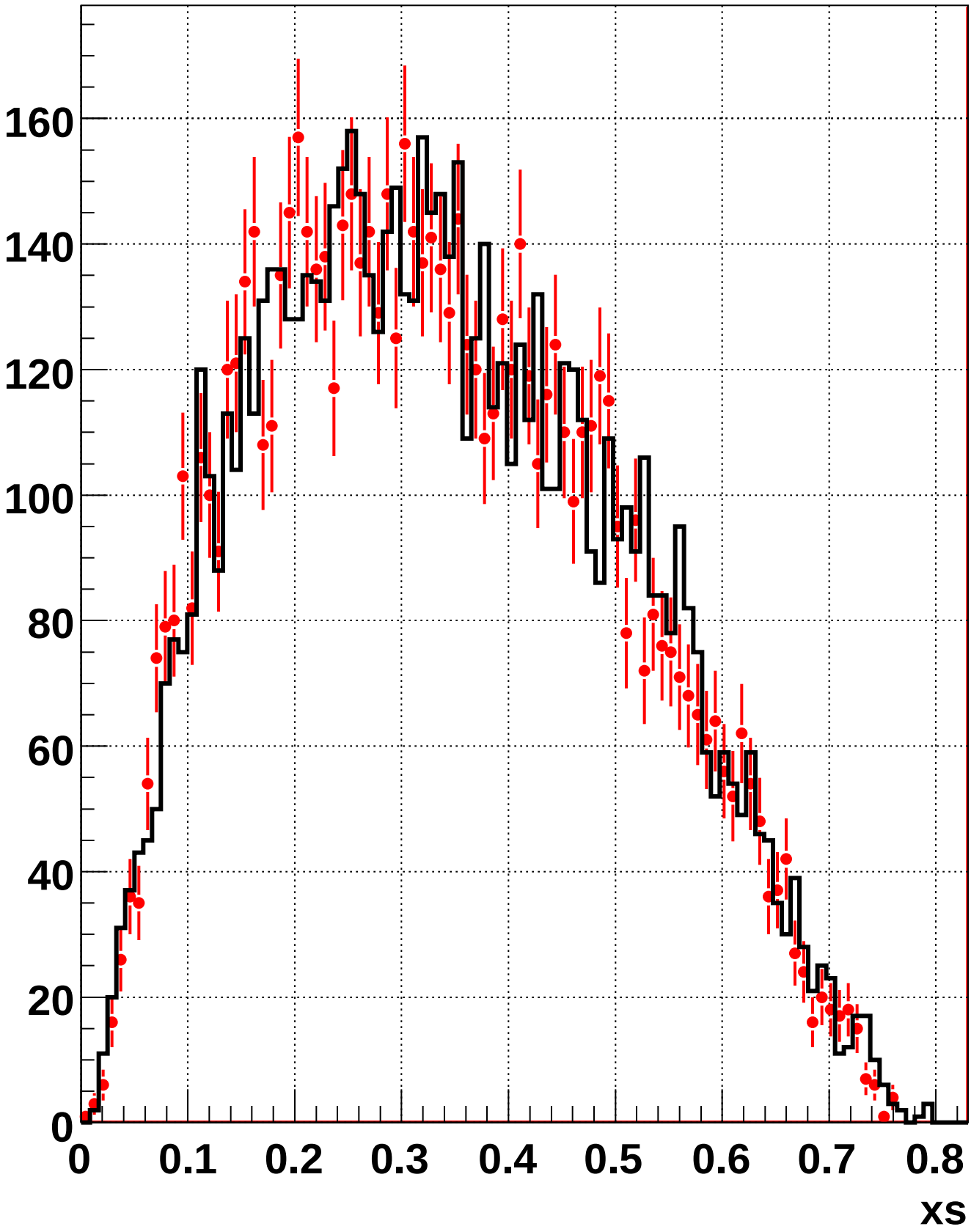
selected x for QEL events



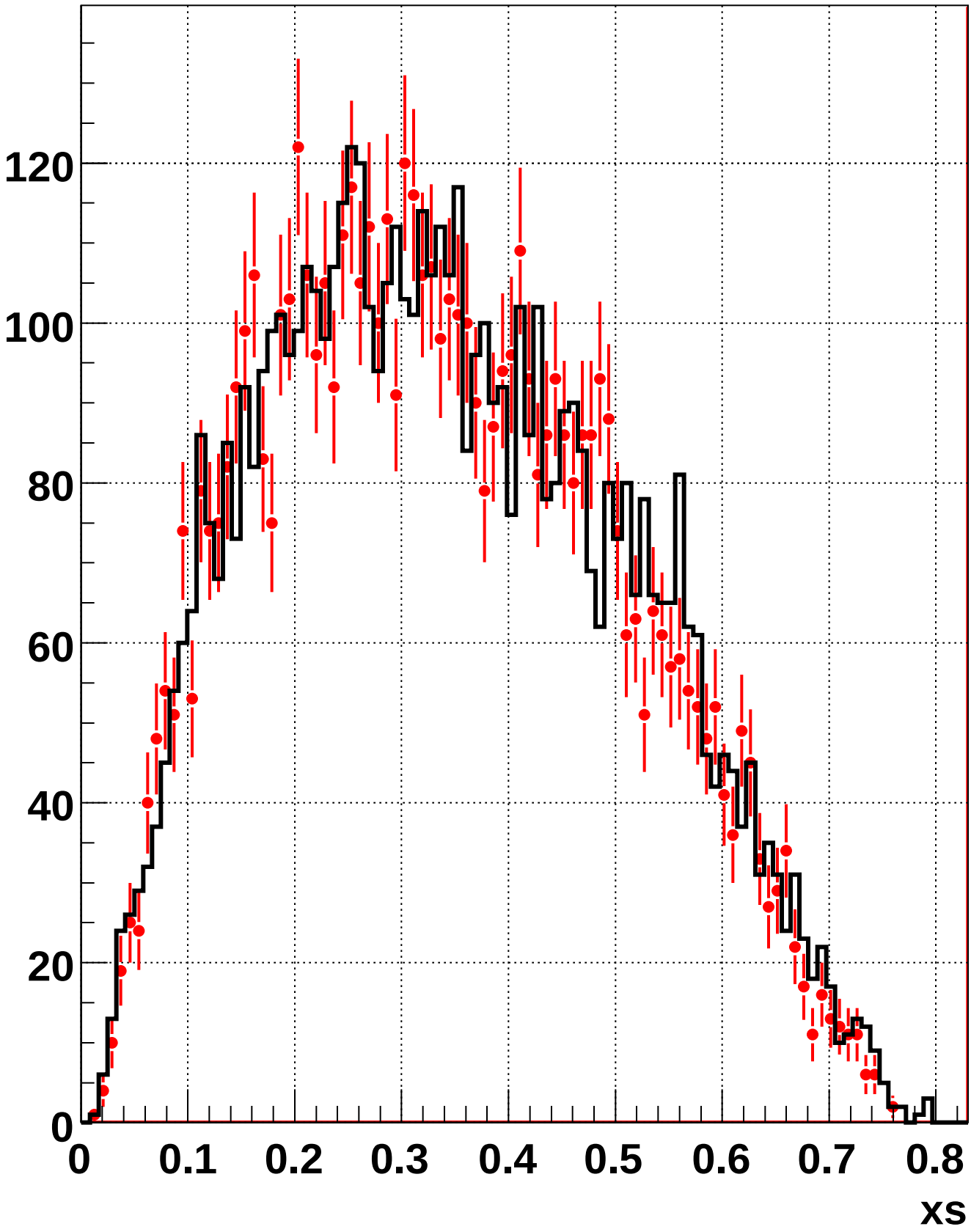
selected x for RES events



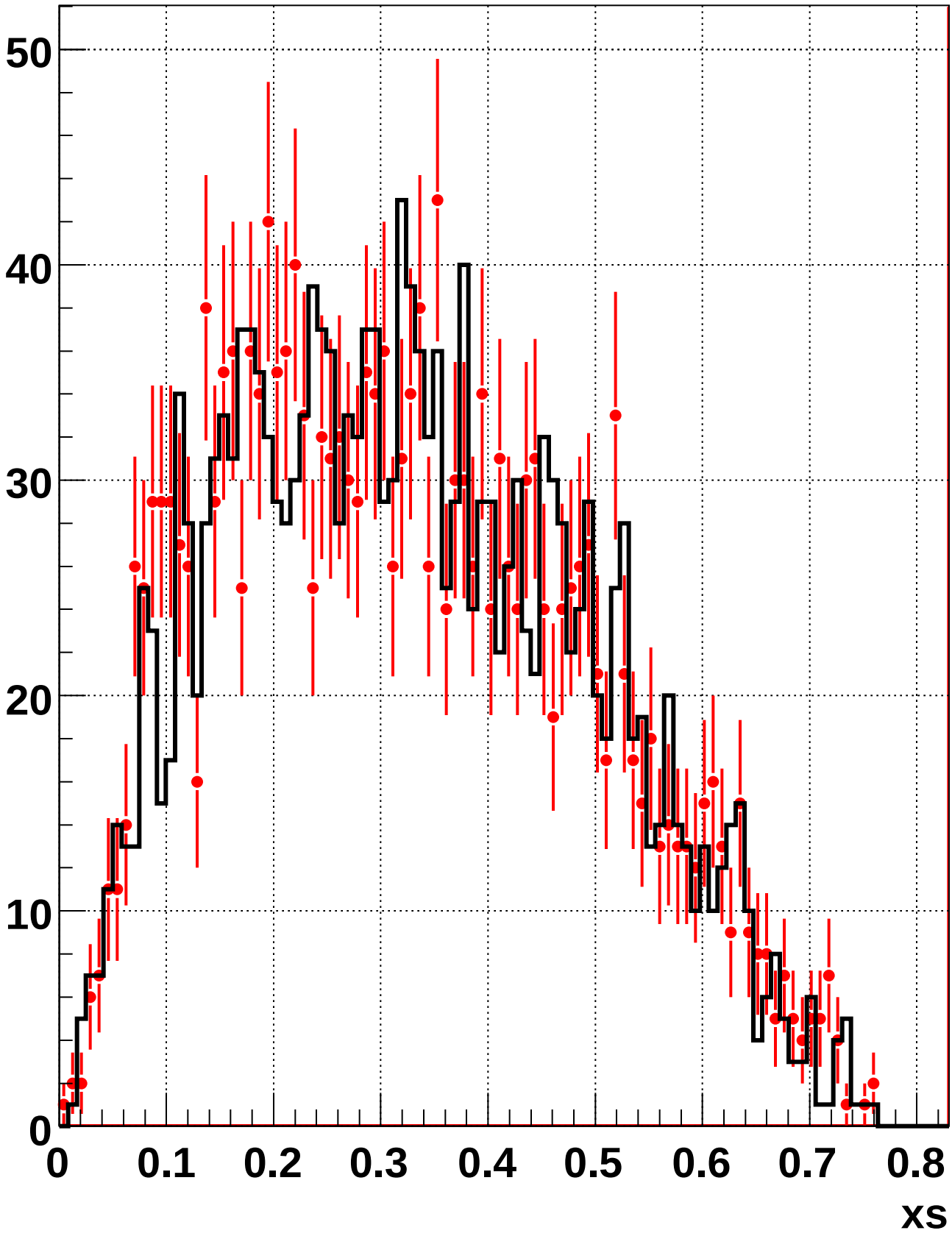
selected x for DIS events



selected x for DIS CC events

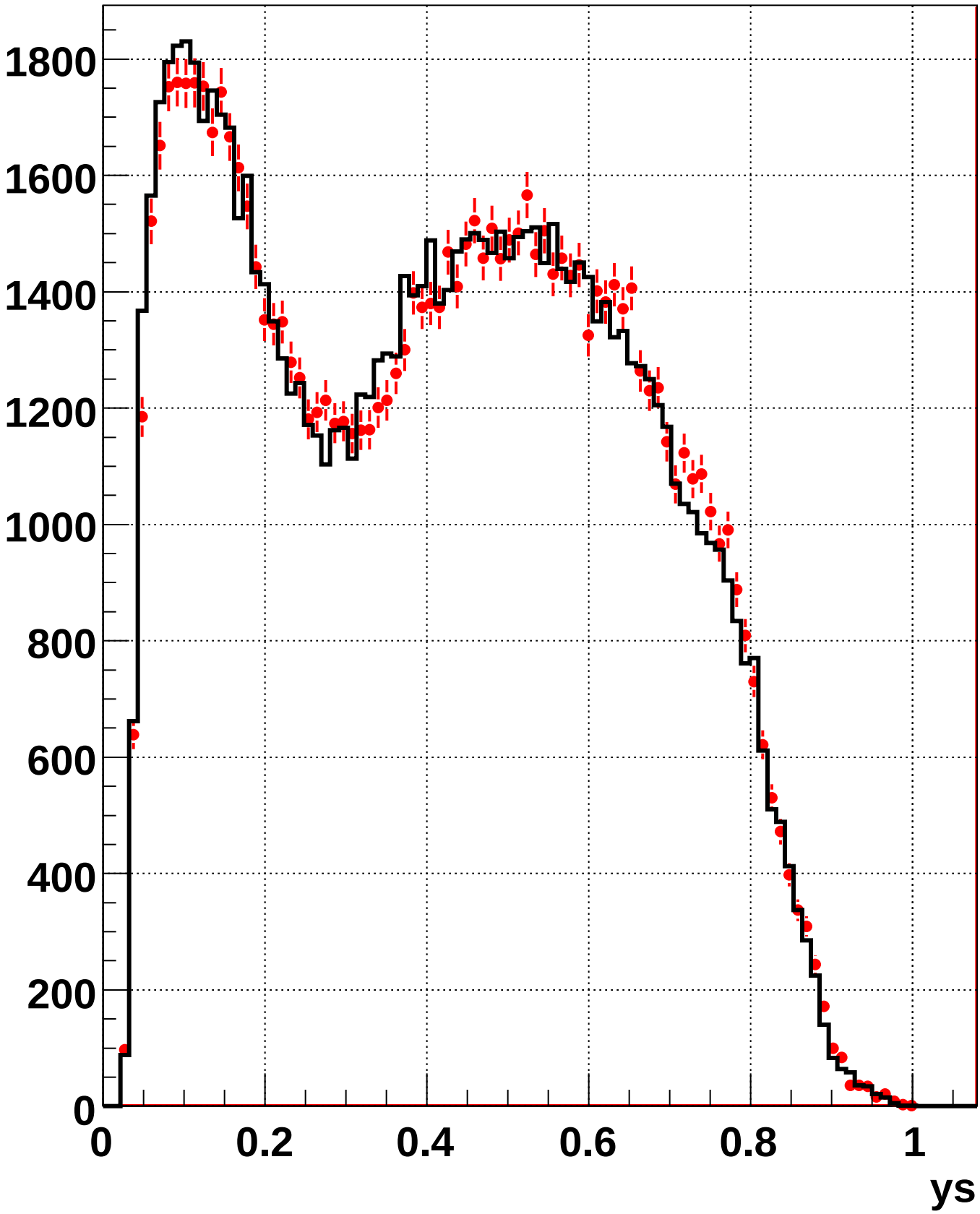


selected x for DIS NC events

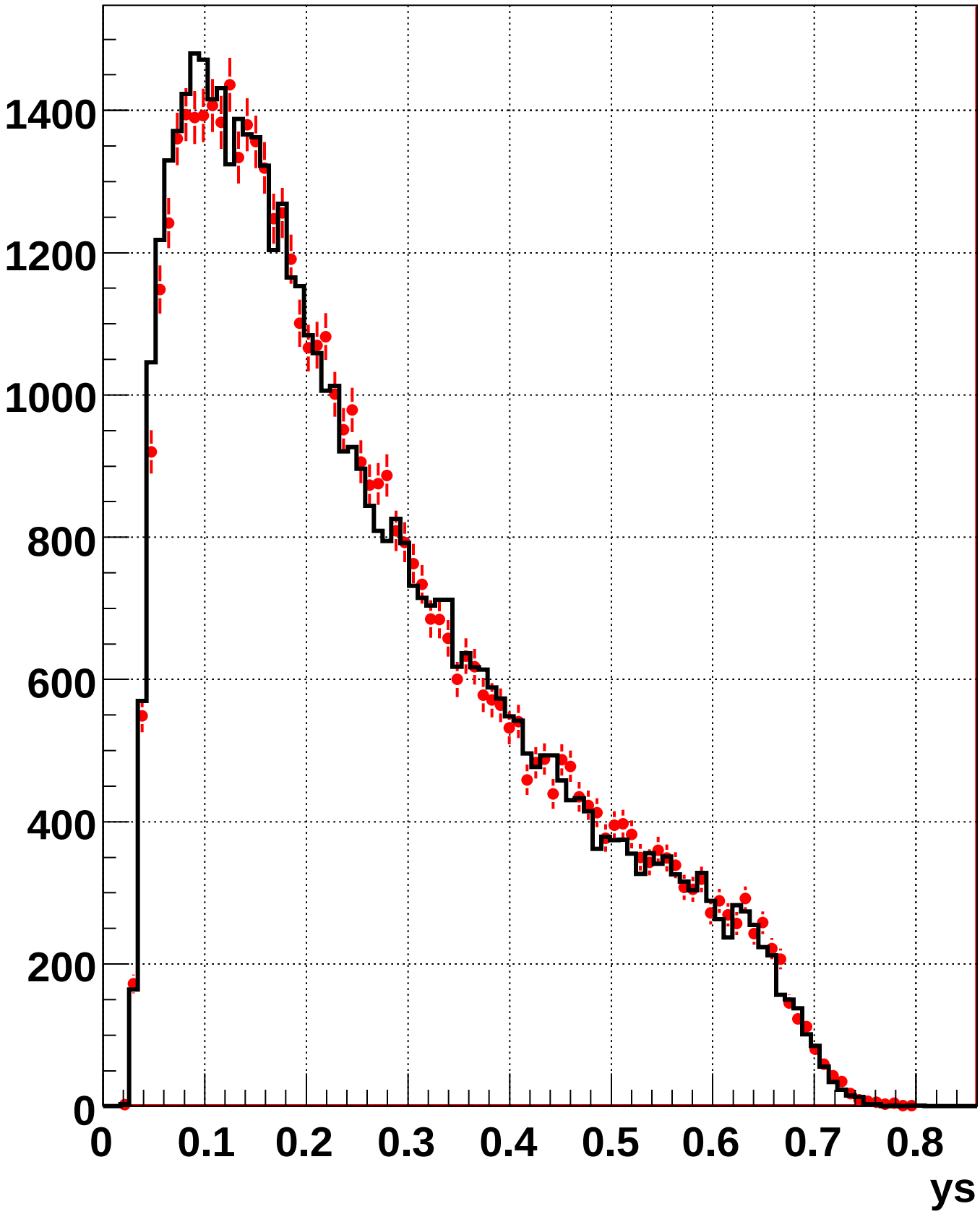


selected x for Charm/DIS events

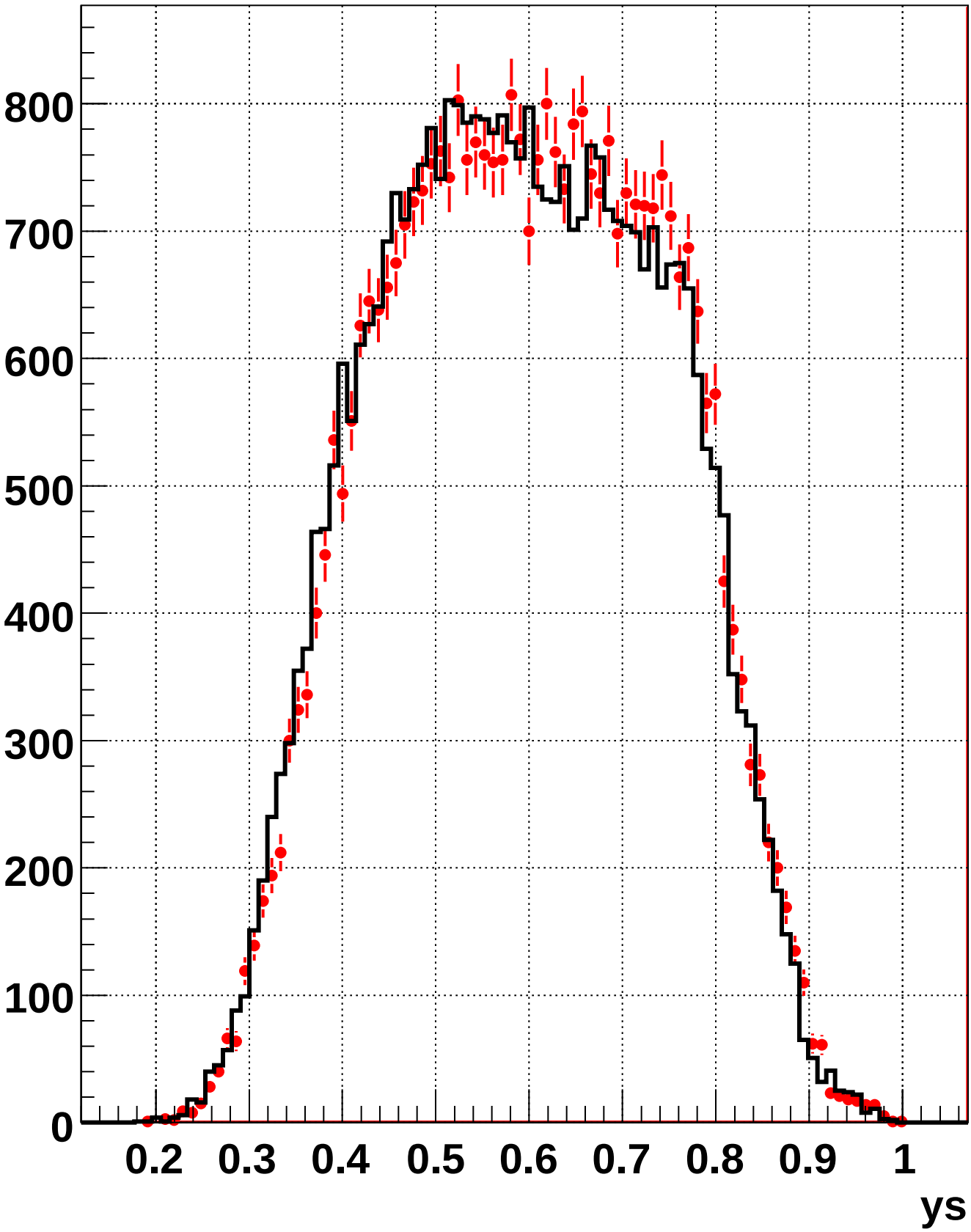
selected y for all events



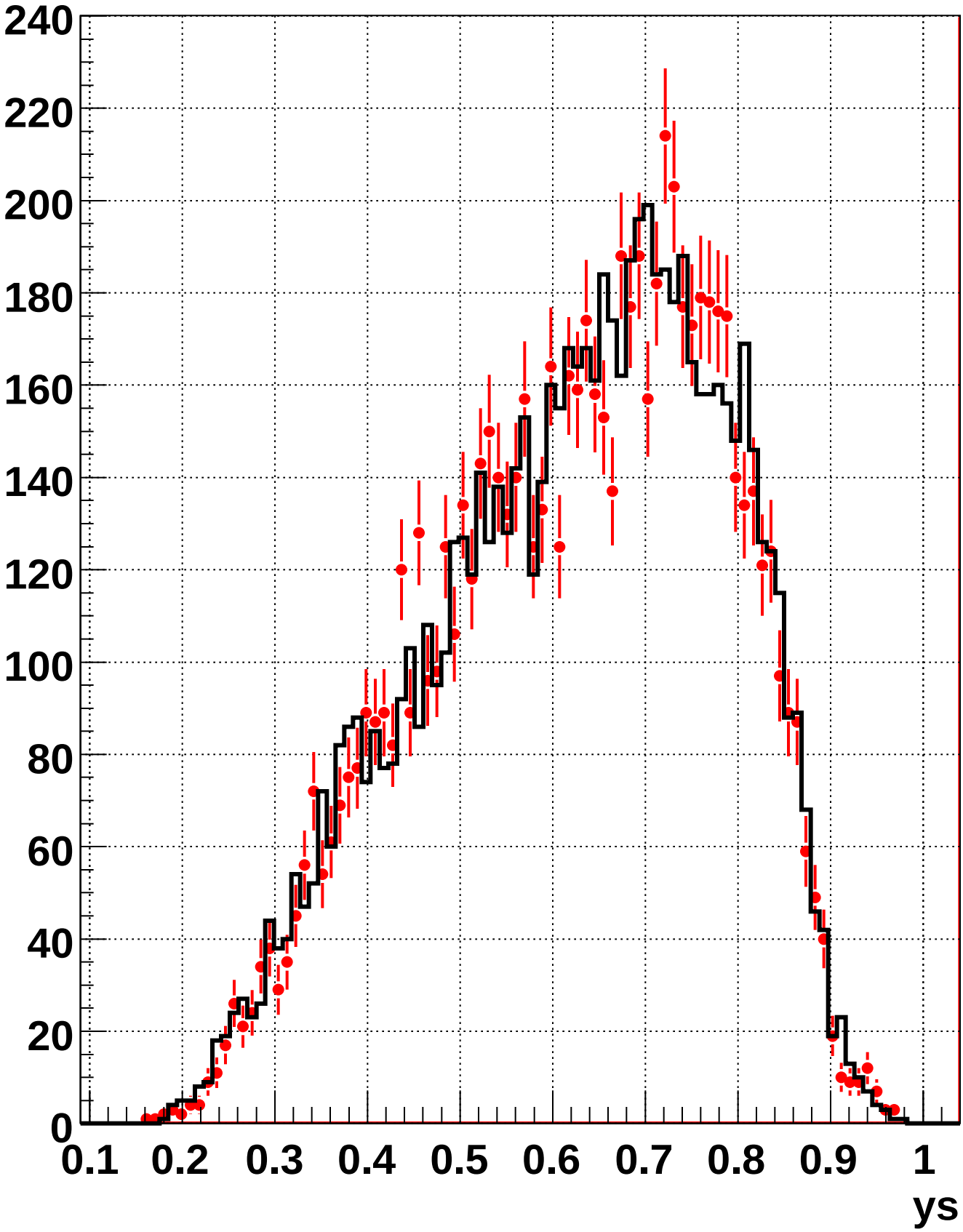
selected y for QEL events



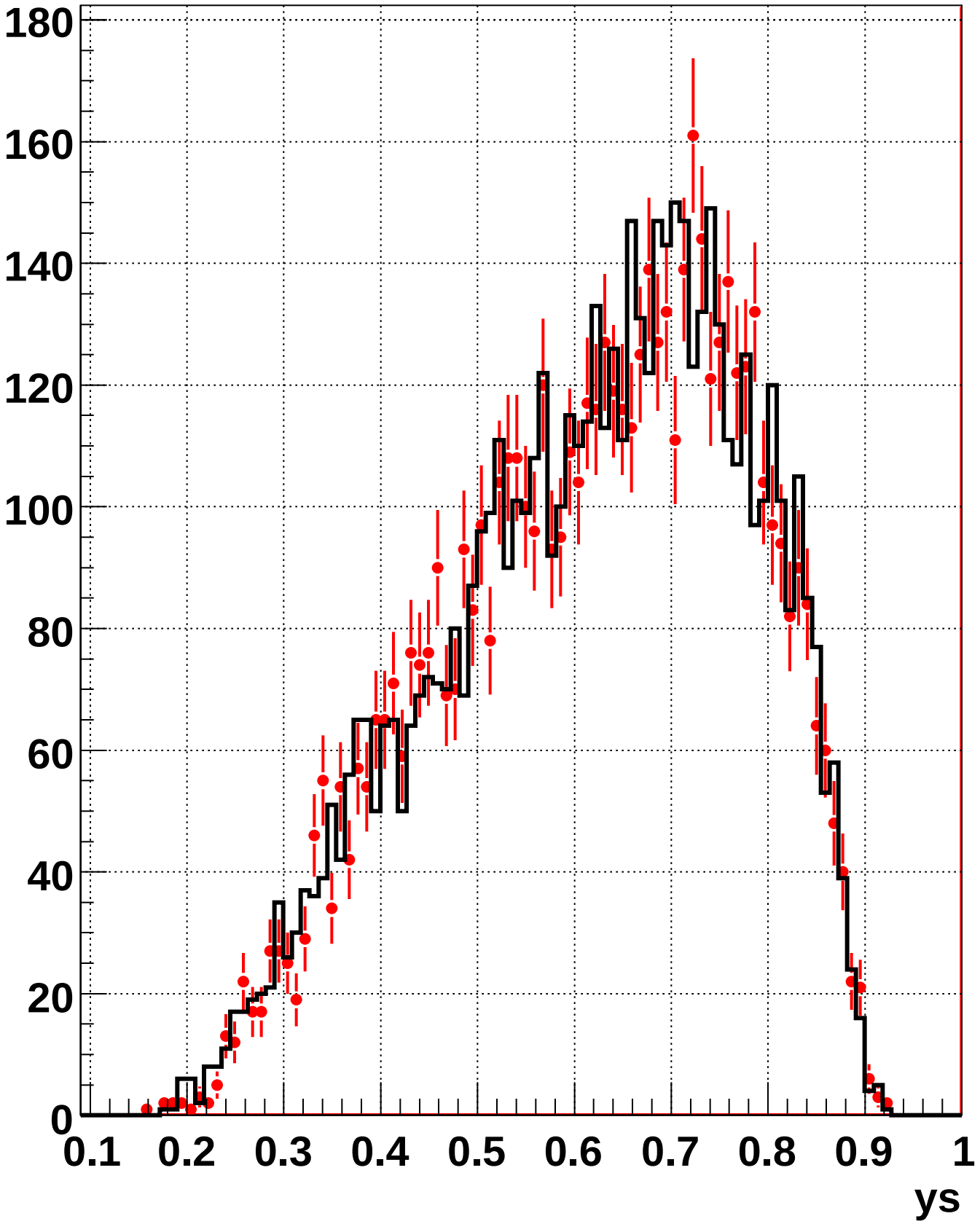
selected y for RES events



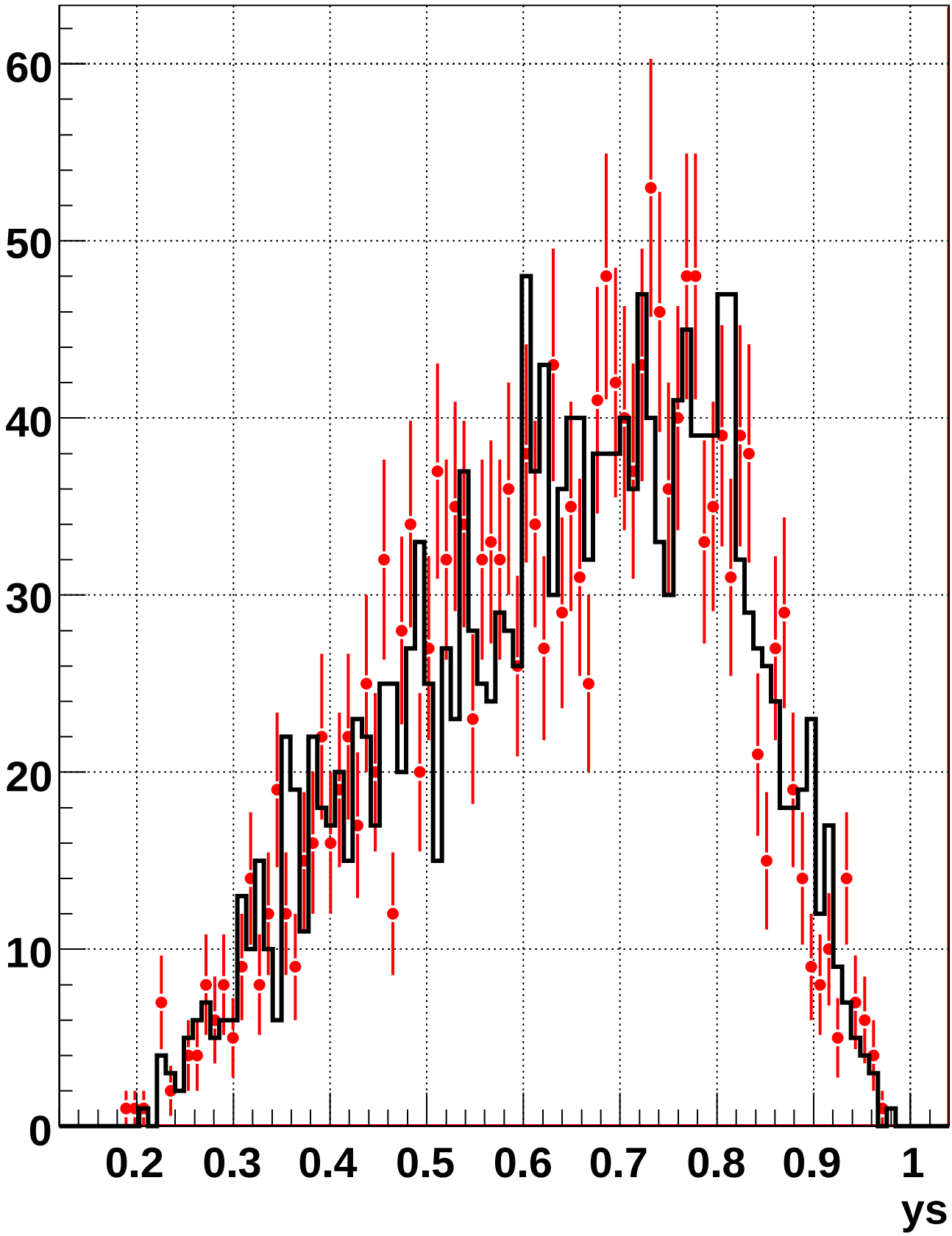
selected y for DIS events



selected y for DIS CC events



selected y for DIS NC events



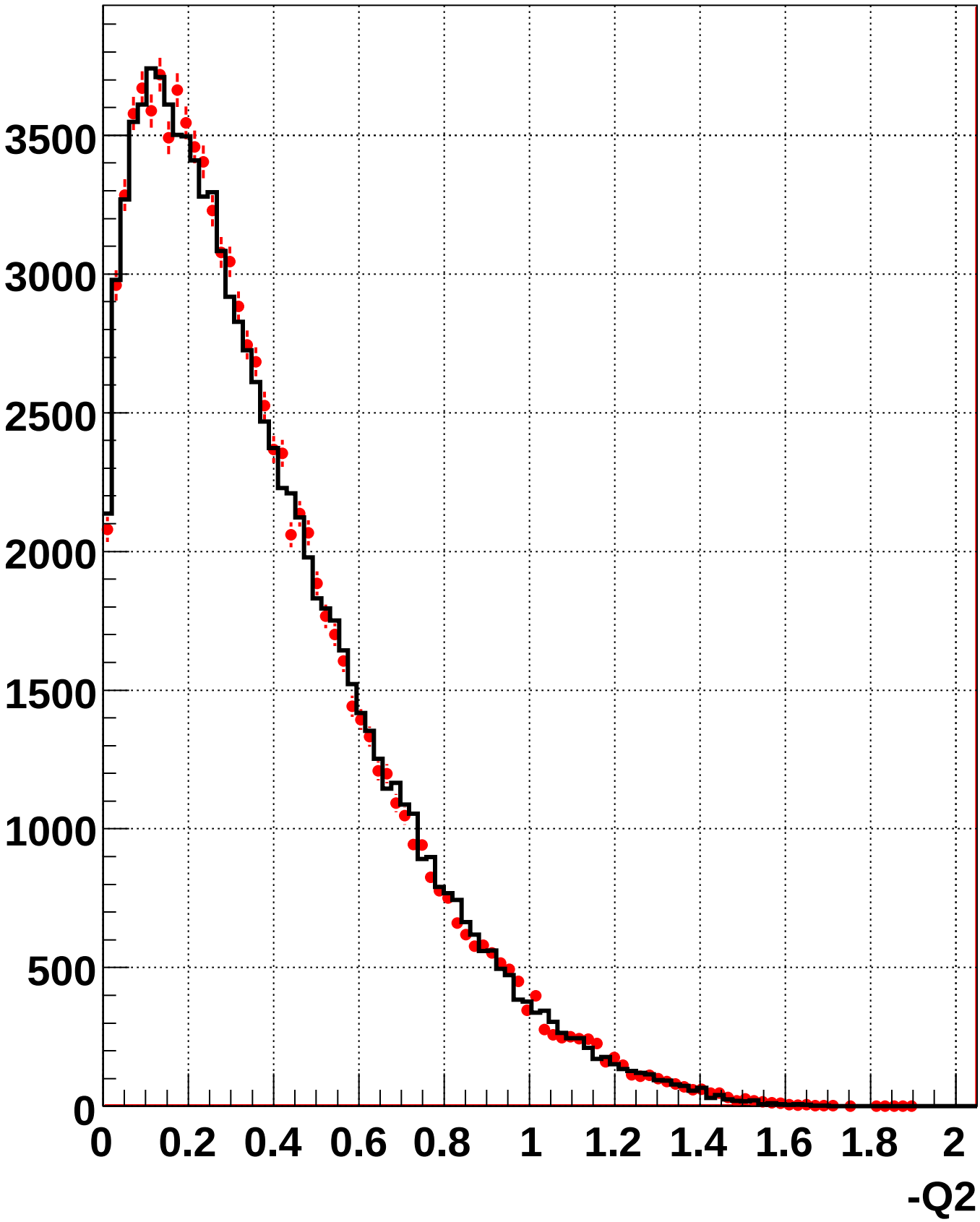
selected y for Charm/DIS events

Kinematical Quantities

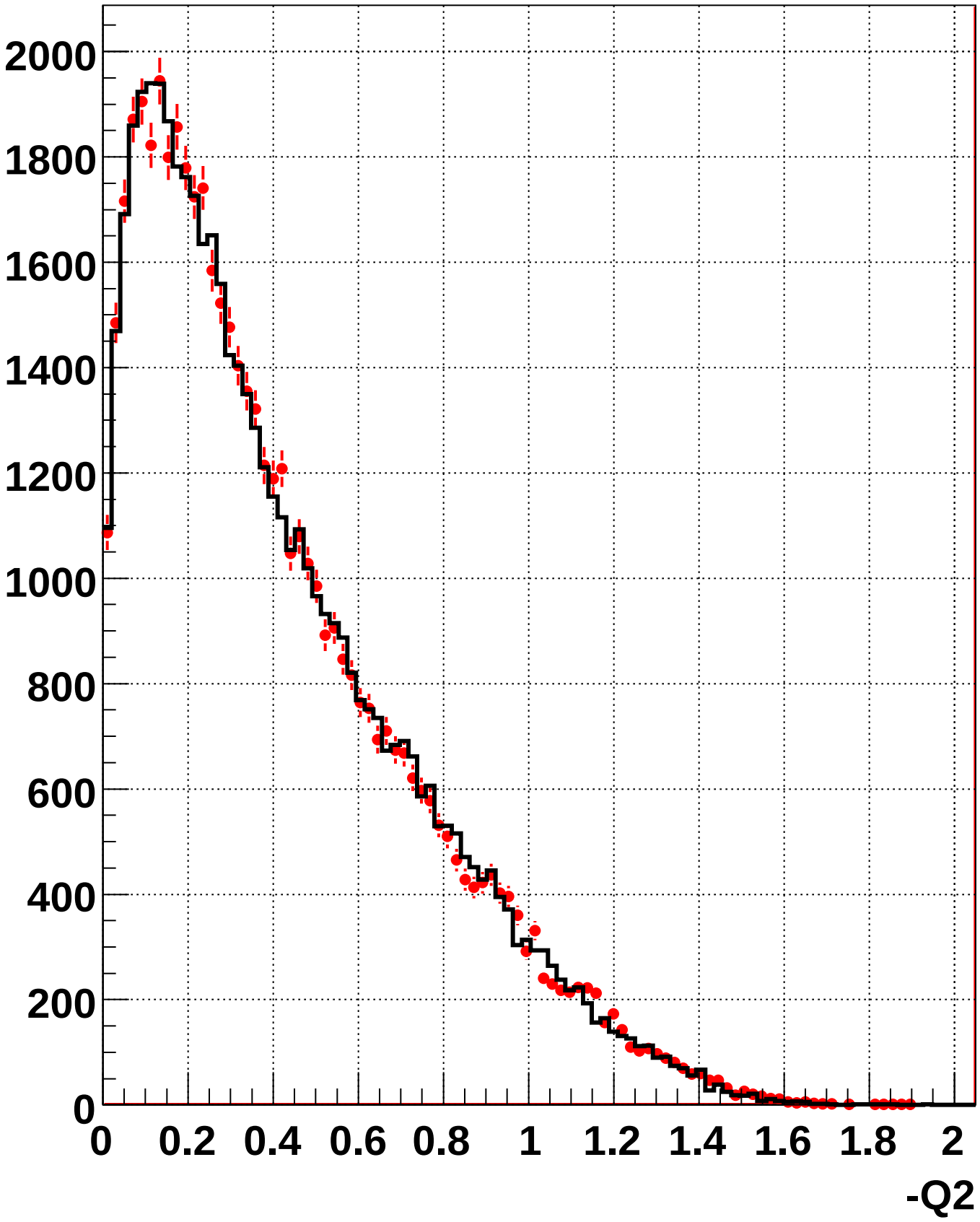
Similar to the previous set of plots but

showing ’computed’ rathen than ’selected’ variables

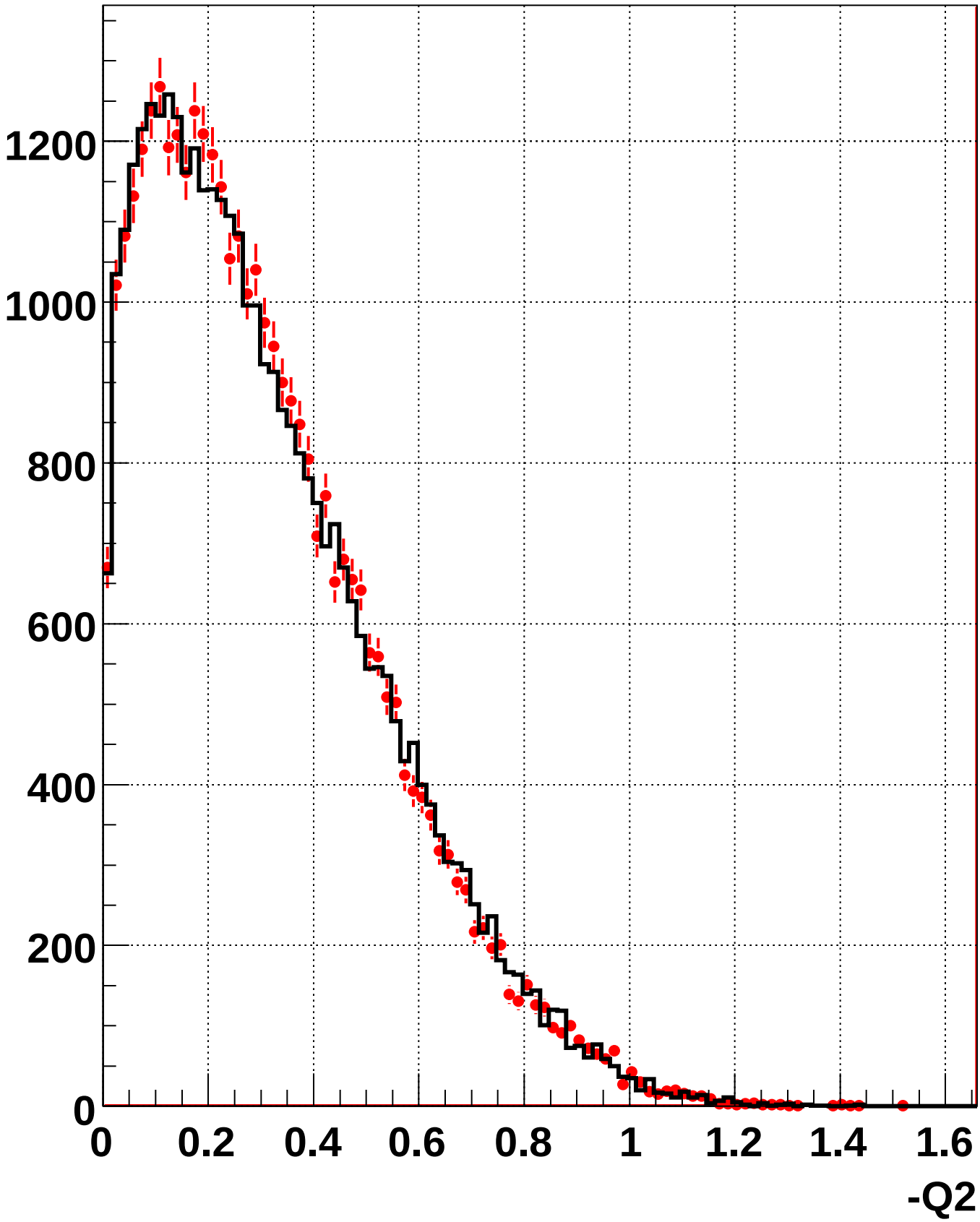
computed Q2 for all events



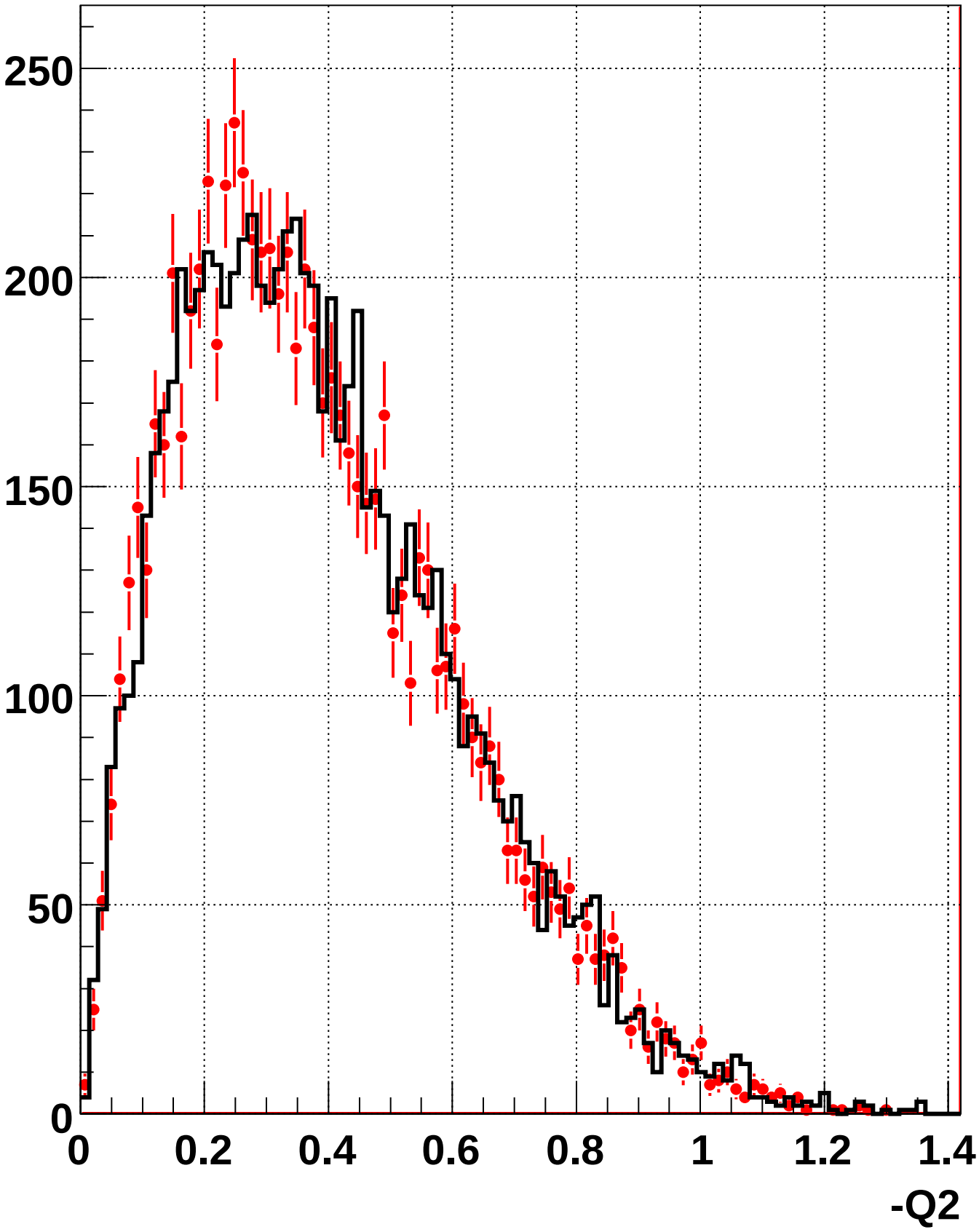
computed Q2 for QEL events



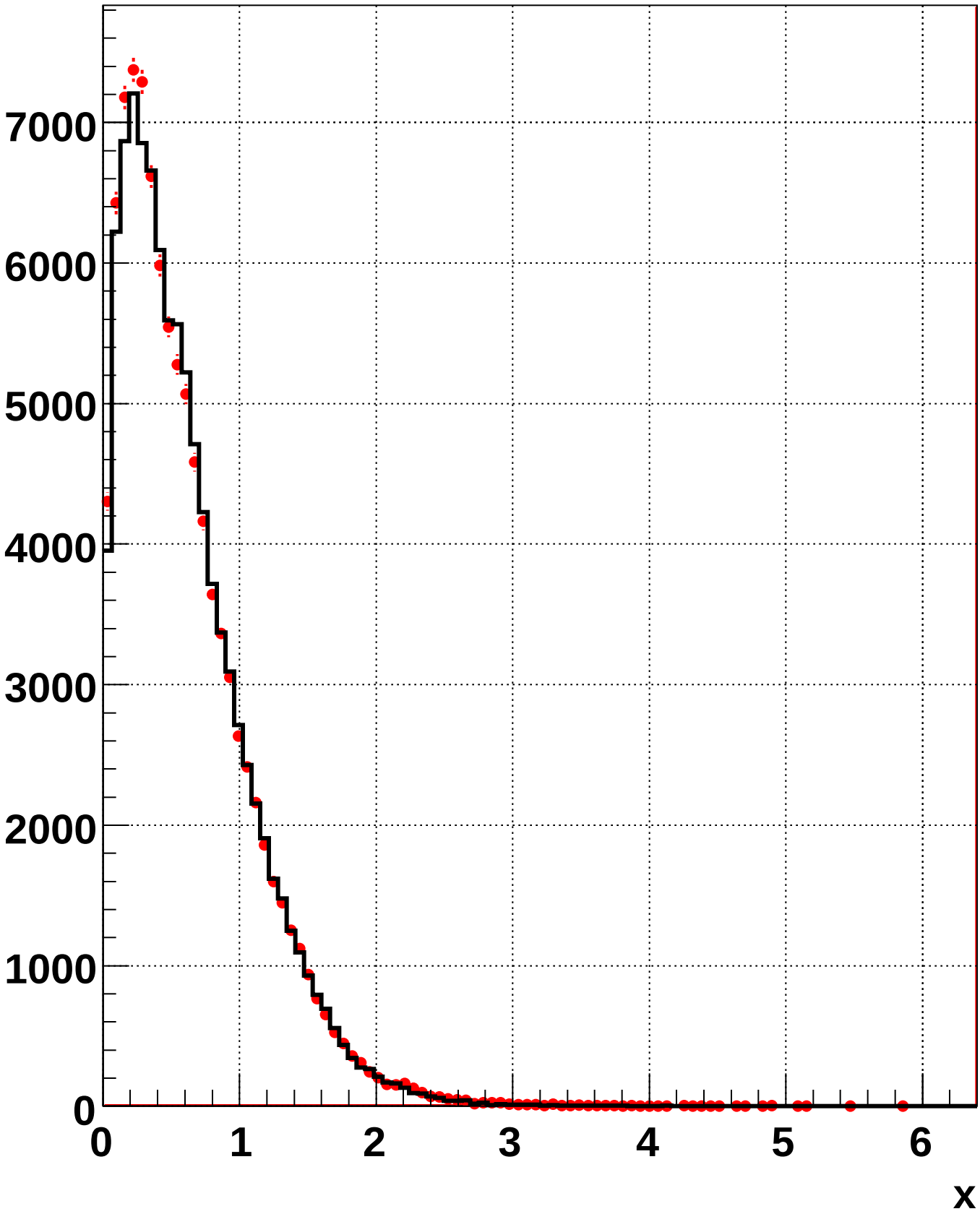
computed Q2 for RES events

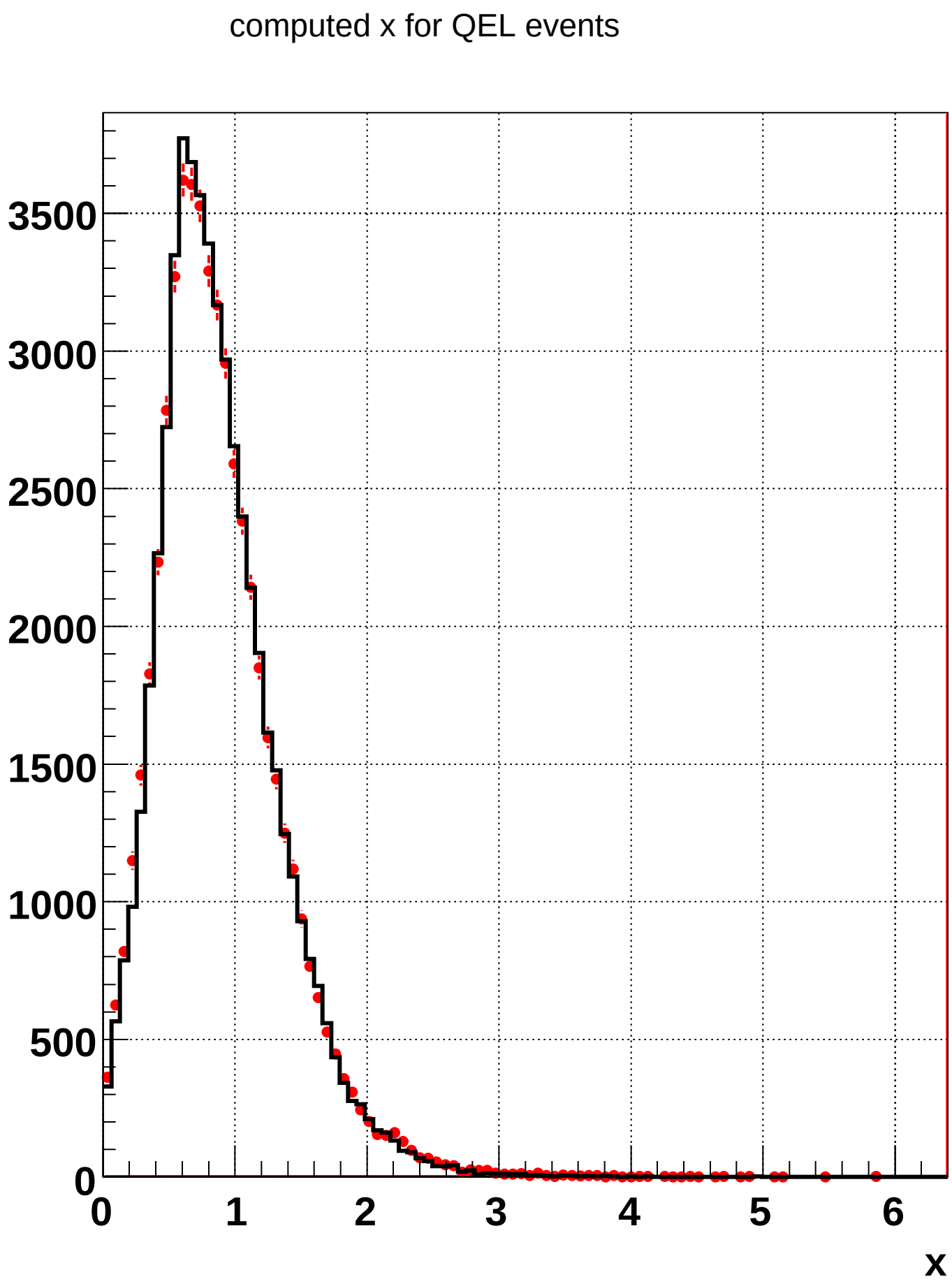


computed Q2 for DIS events

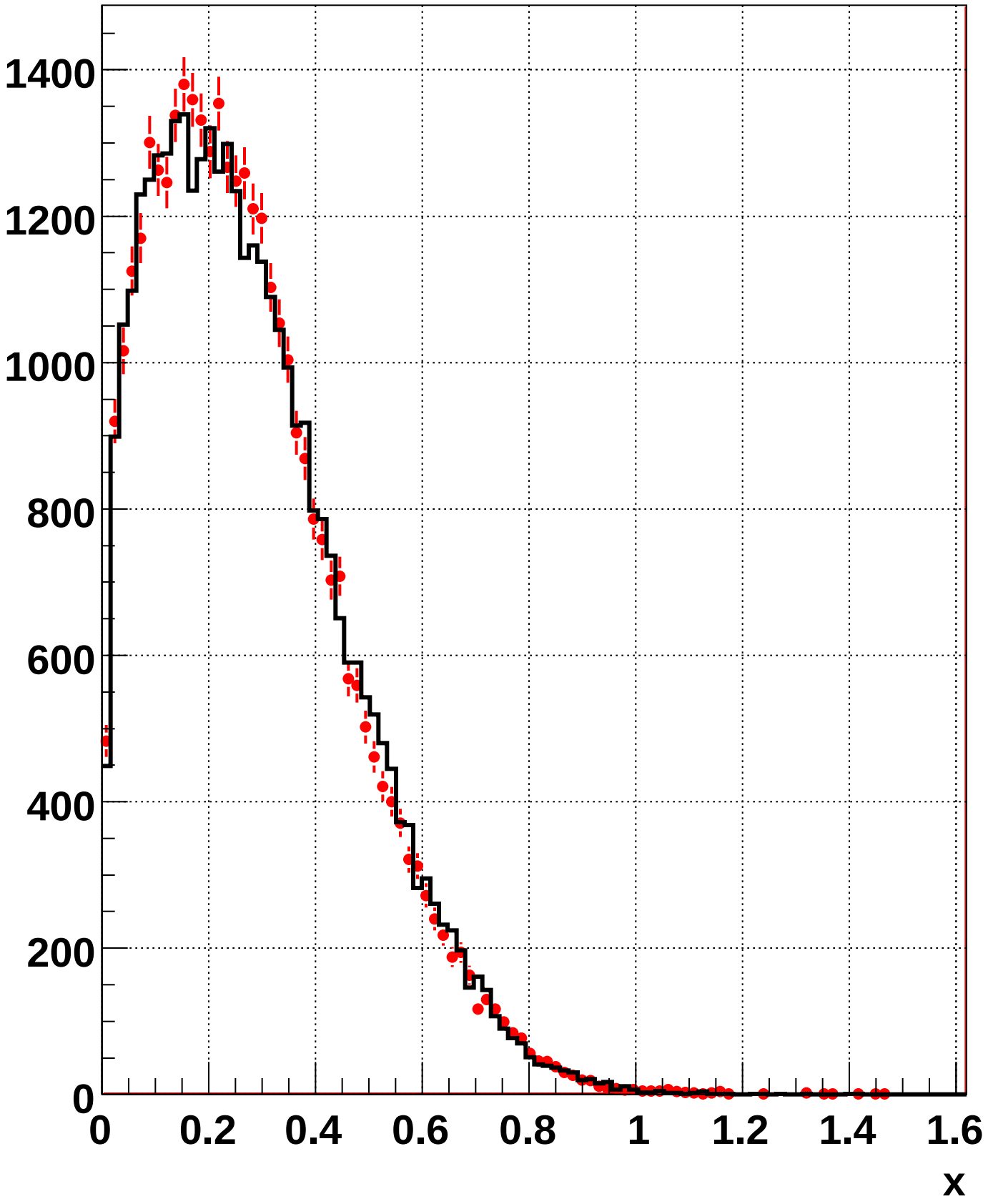


computed x for all events

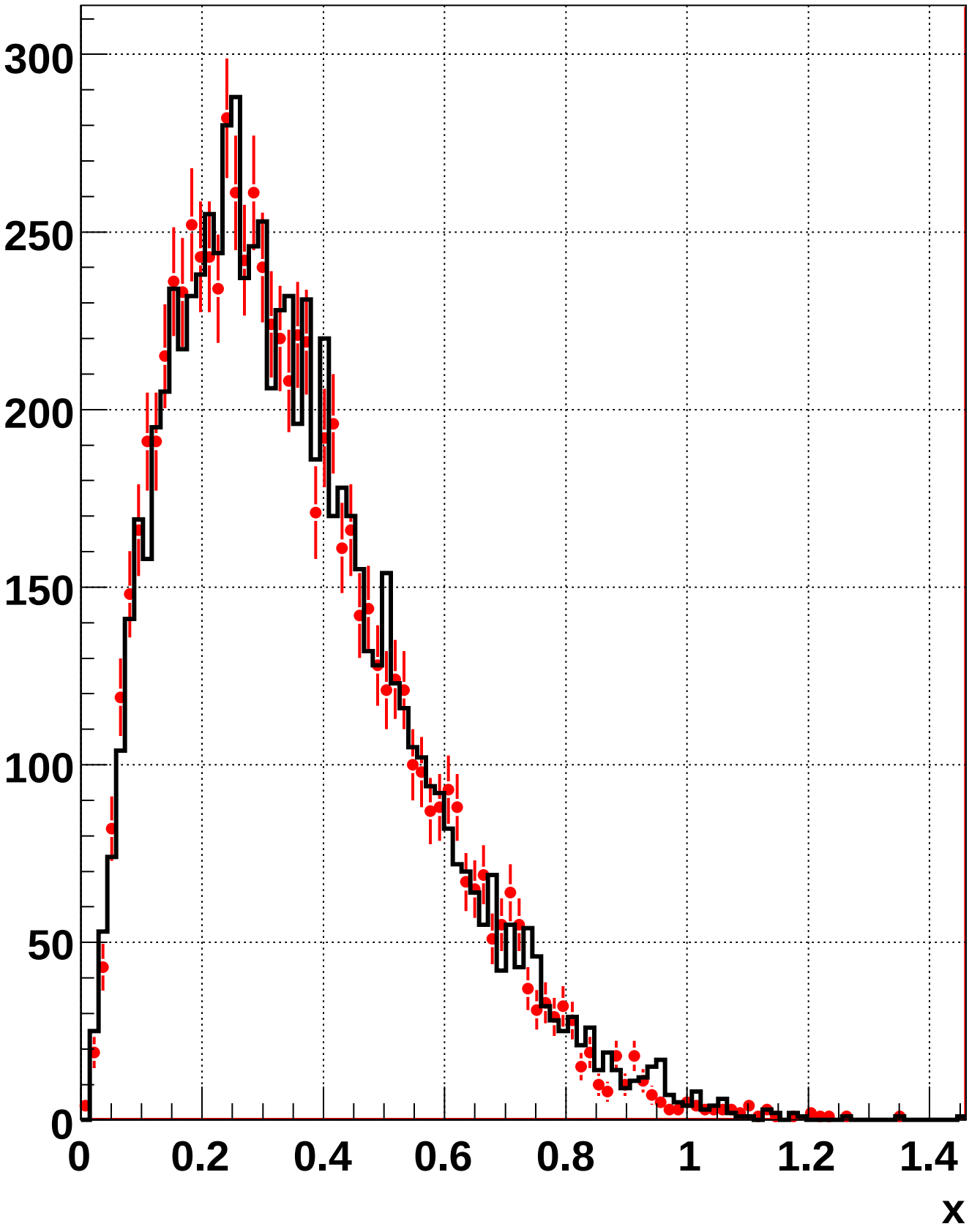



computed x for QEL events
3500
3000
2500
2000
1500
1000
500
0
0
1
2
3
4
5
6
x

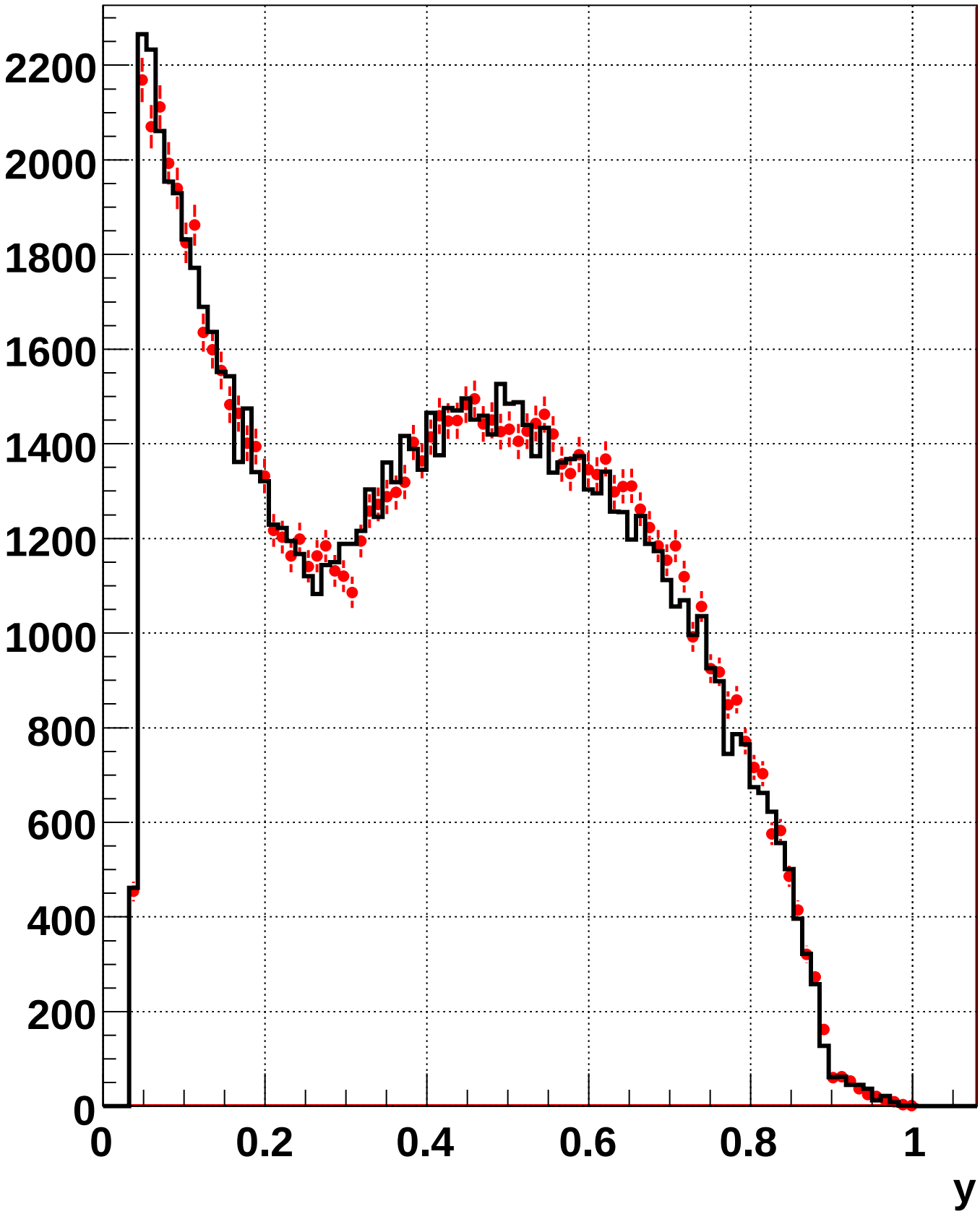
computed x for RES events

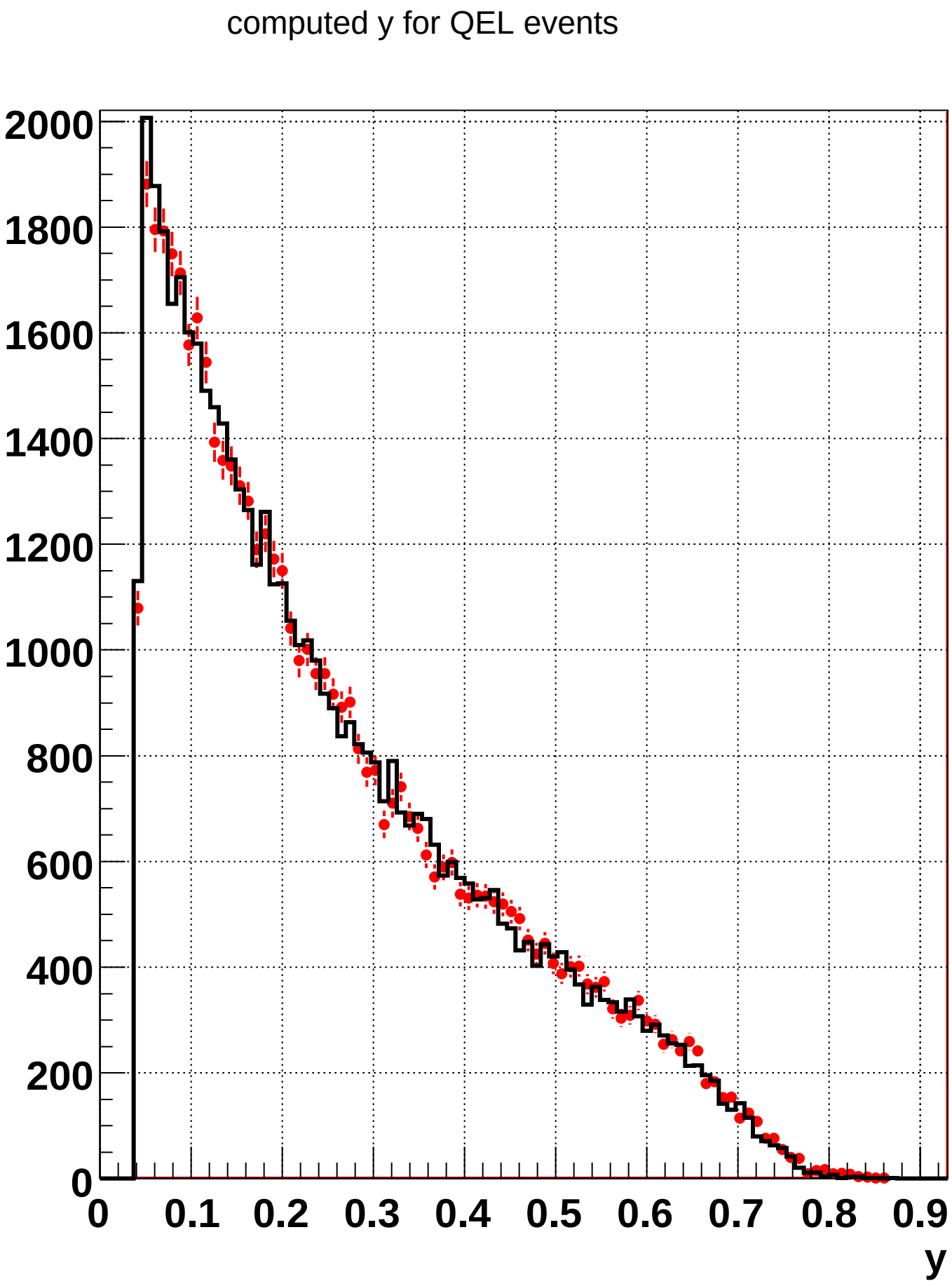


computed x for DIS events

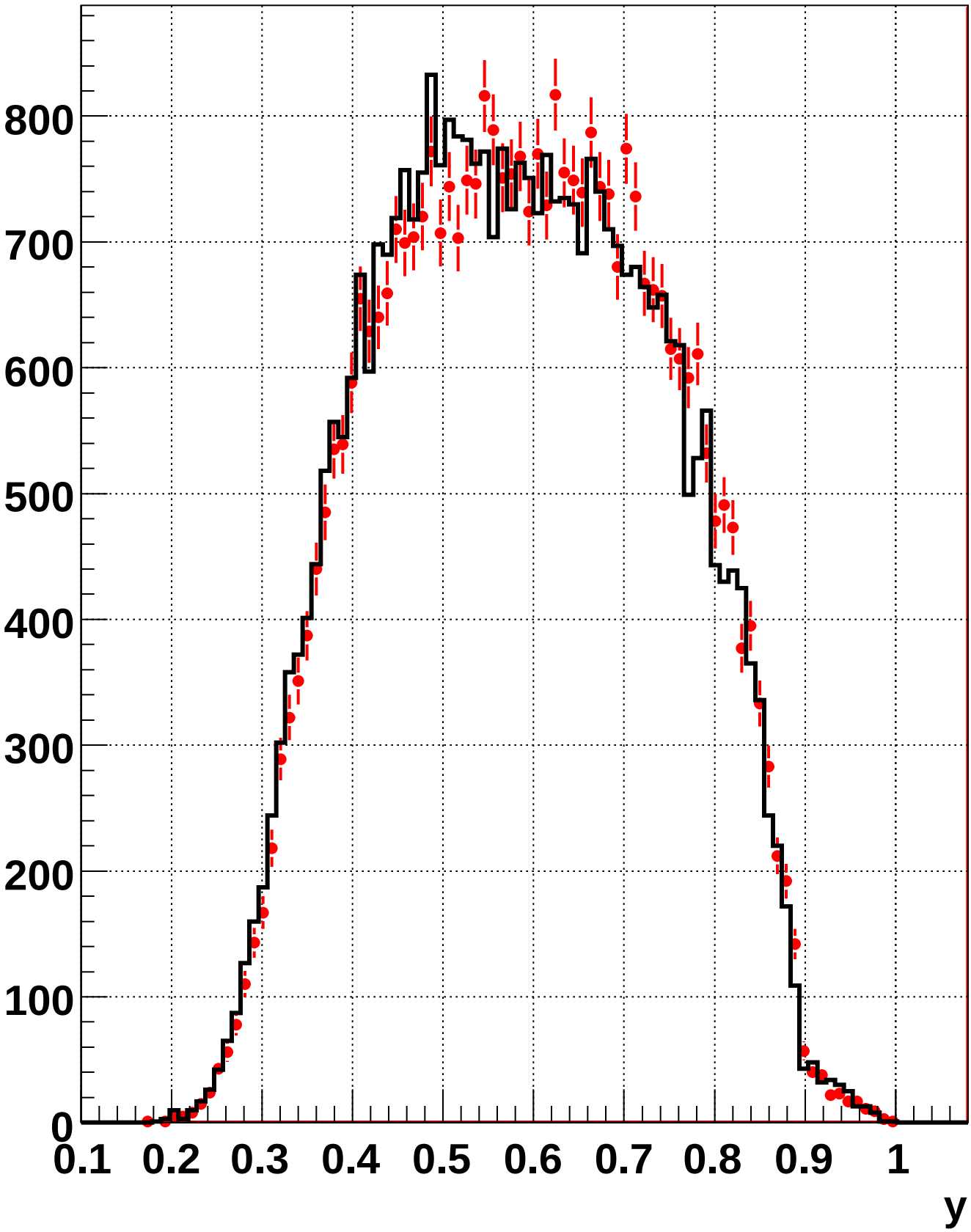


computed y for all events

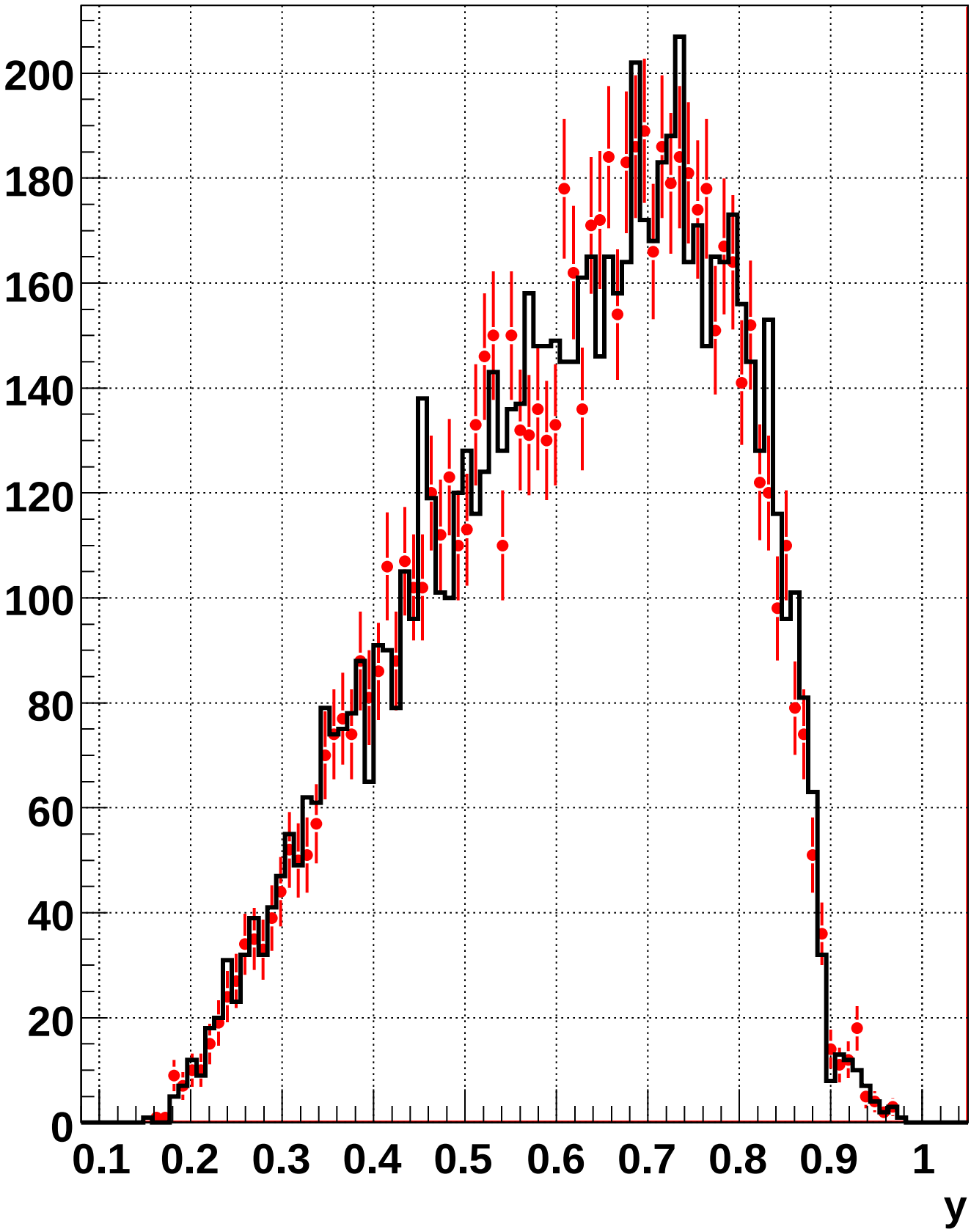



computed y for QEL events
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
y

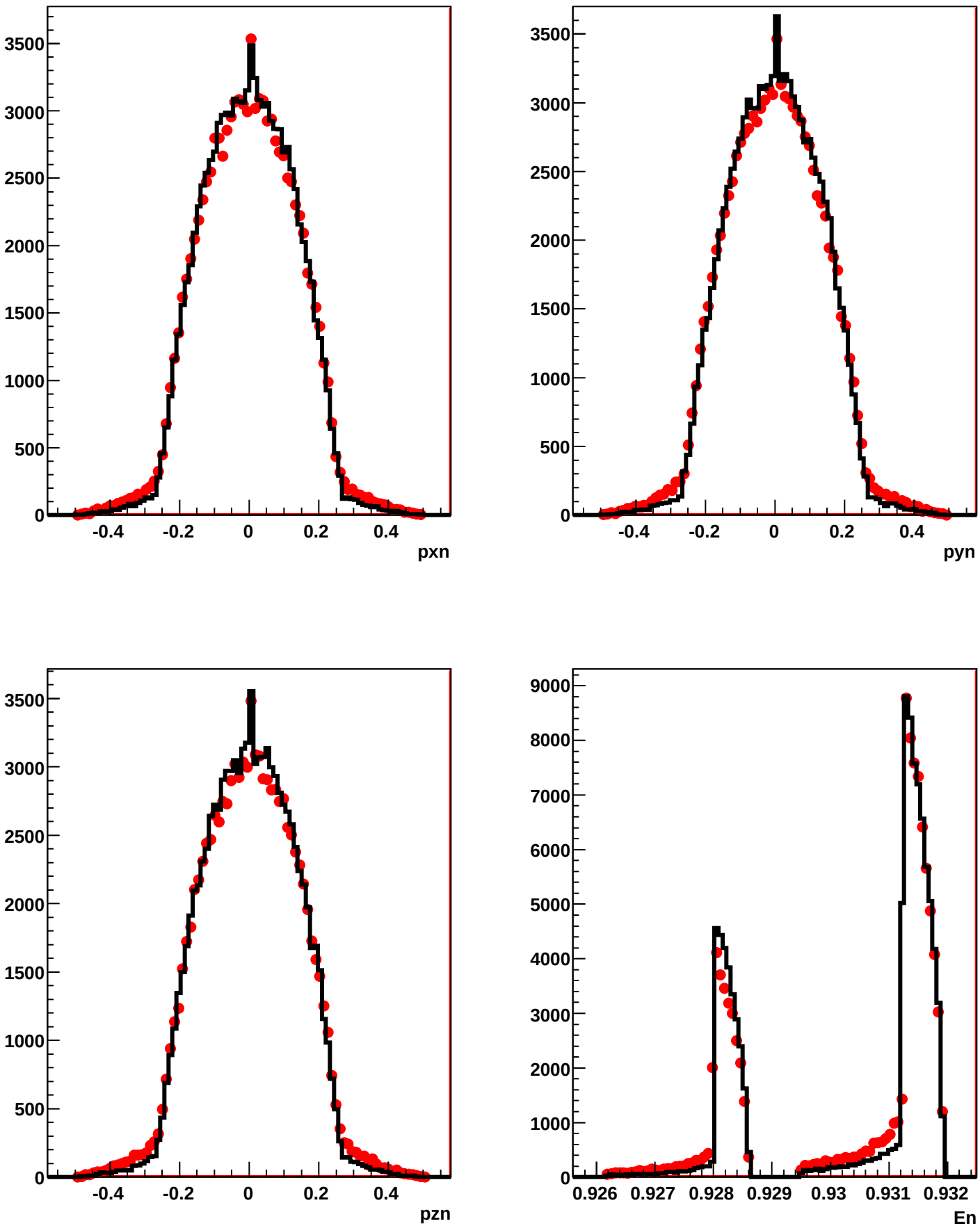
computed y for RES events



computed y for DIS events

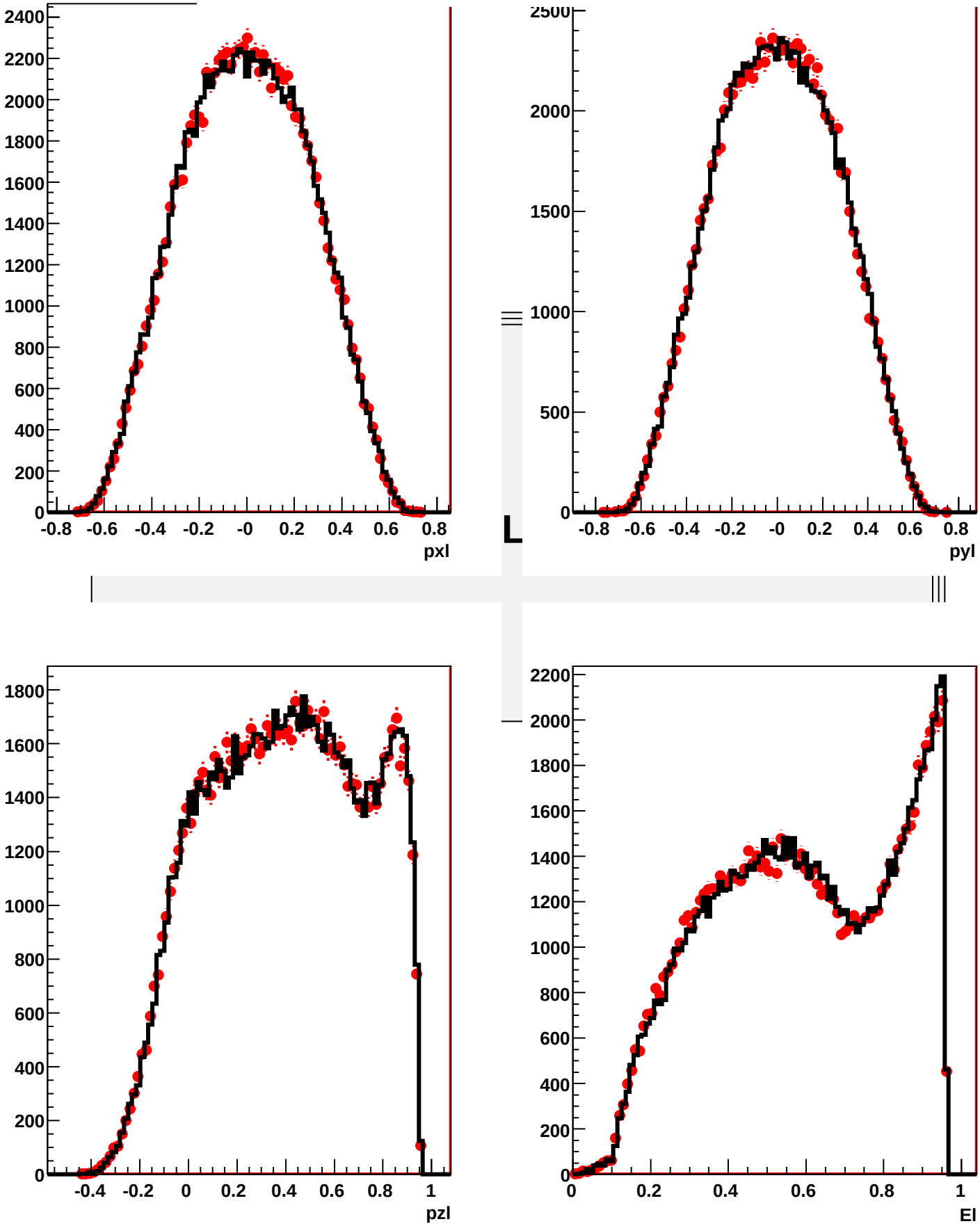


Initial state nucleon 4-Momentum

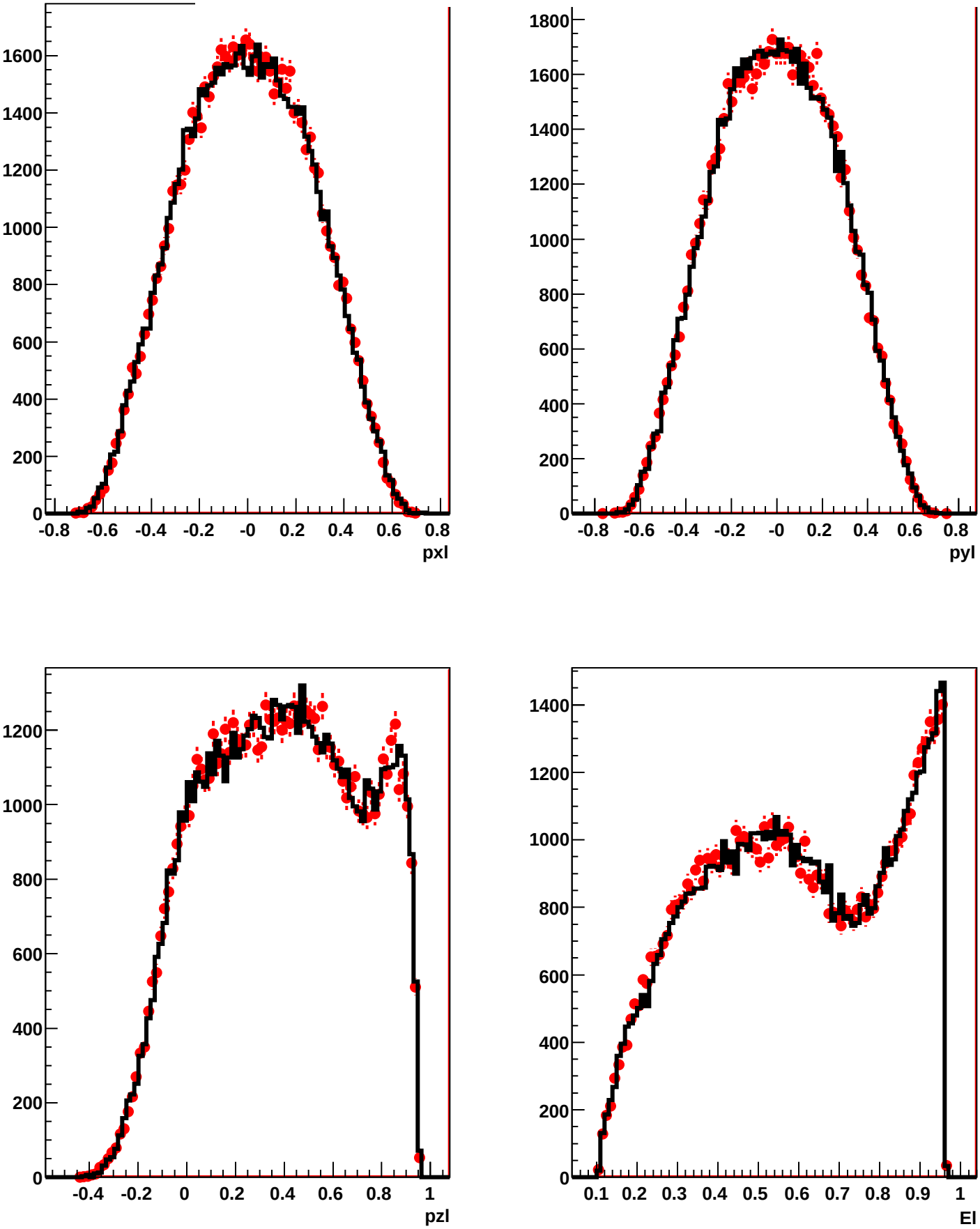

3500
3000
2500
2000
1500
1000
500
0
-0.4
-0.2
0
0.2
0.4
pxn
pyn
pzn
9000
8000
7000
6000
5000
4000
0.926
0.927
0.928
0.929
0.93
0.931
0.932
En

Final State Primary Lepton 4-Momentum

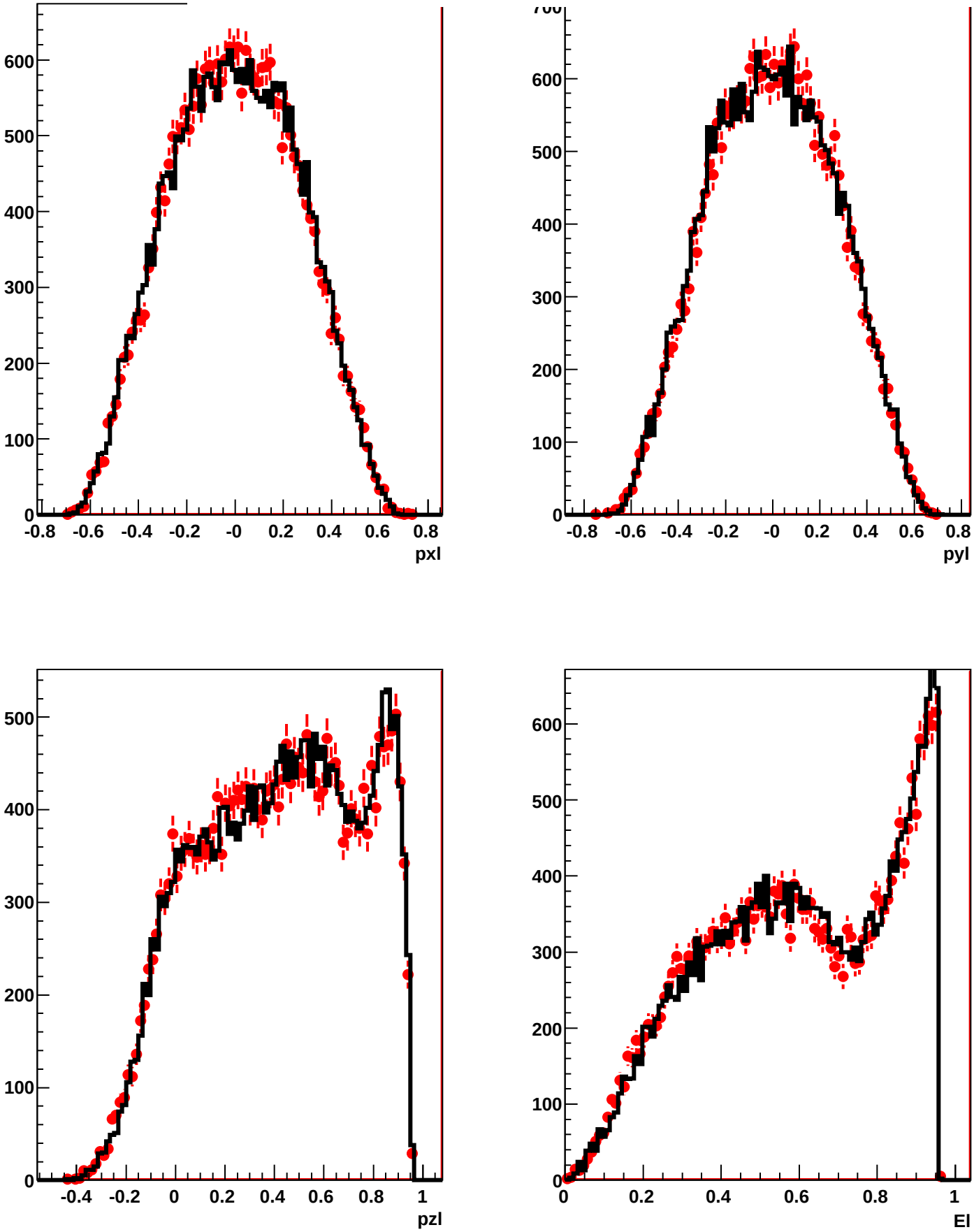
Final state primary lepton 4-p: All events



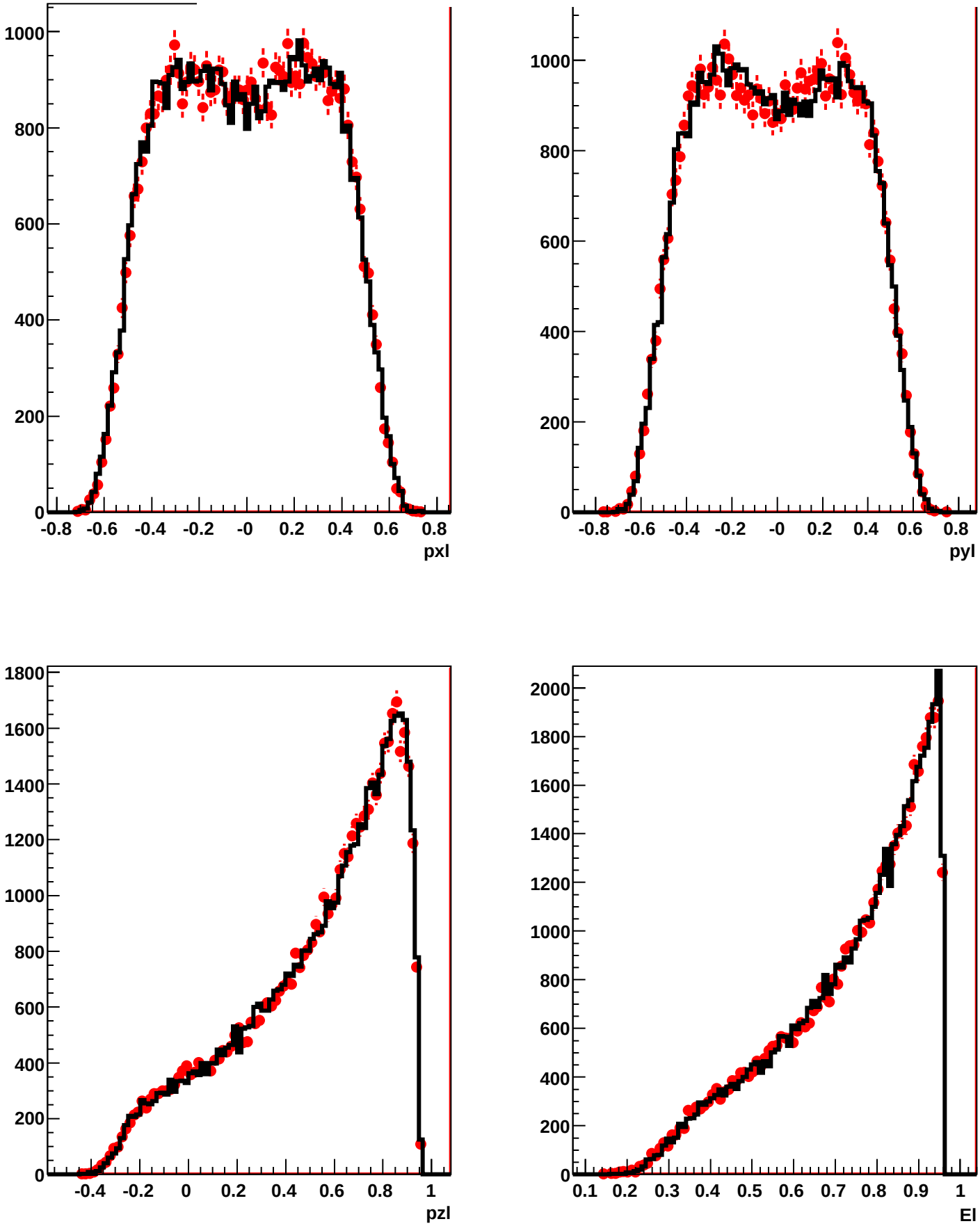
Final state primary lepton 4-p: All CC events



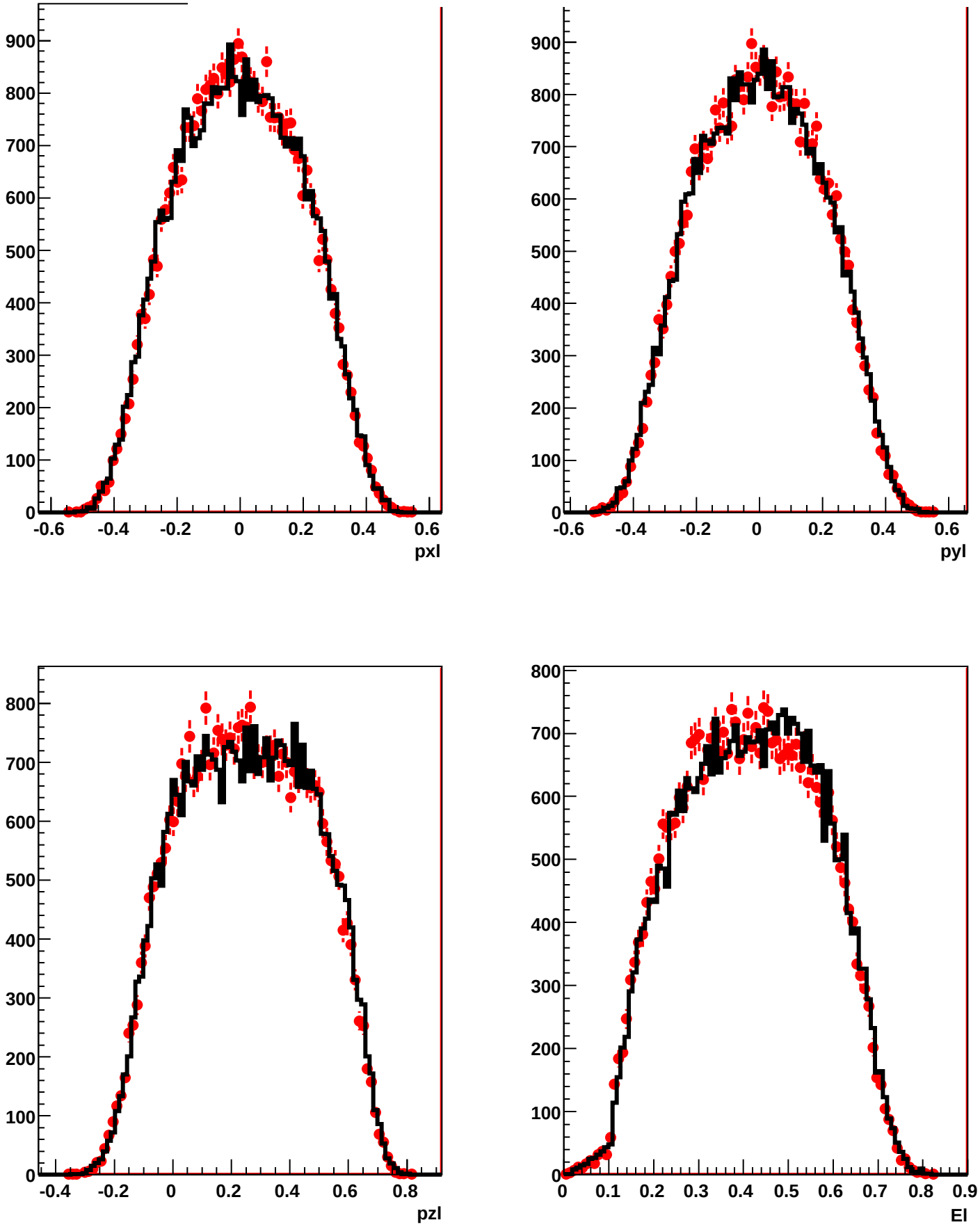
Final state primary lepton 4-p: All NC events



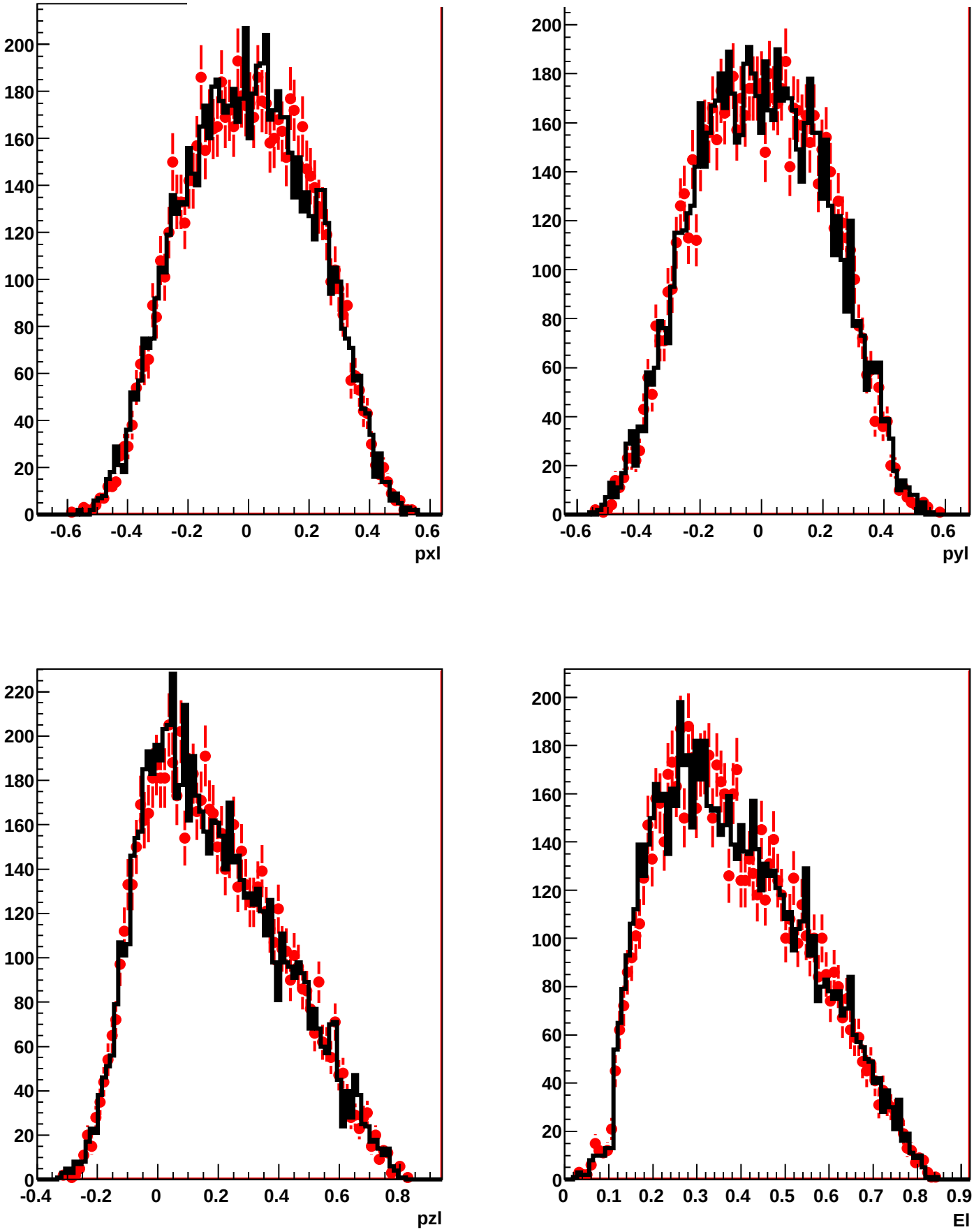
Final state primary lepton 4-p: QEL events



Final state primary lepton 4-p: RES events



Final state primary lepton 4-p: All DIS events



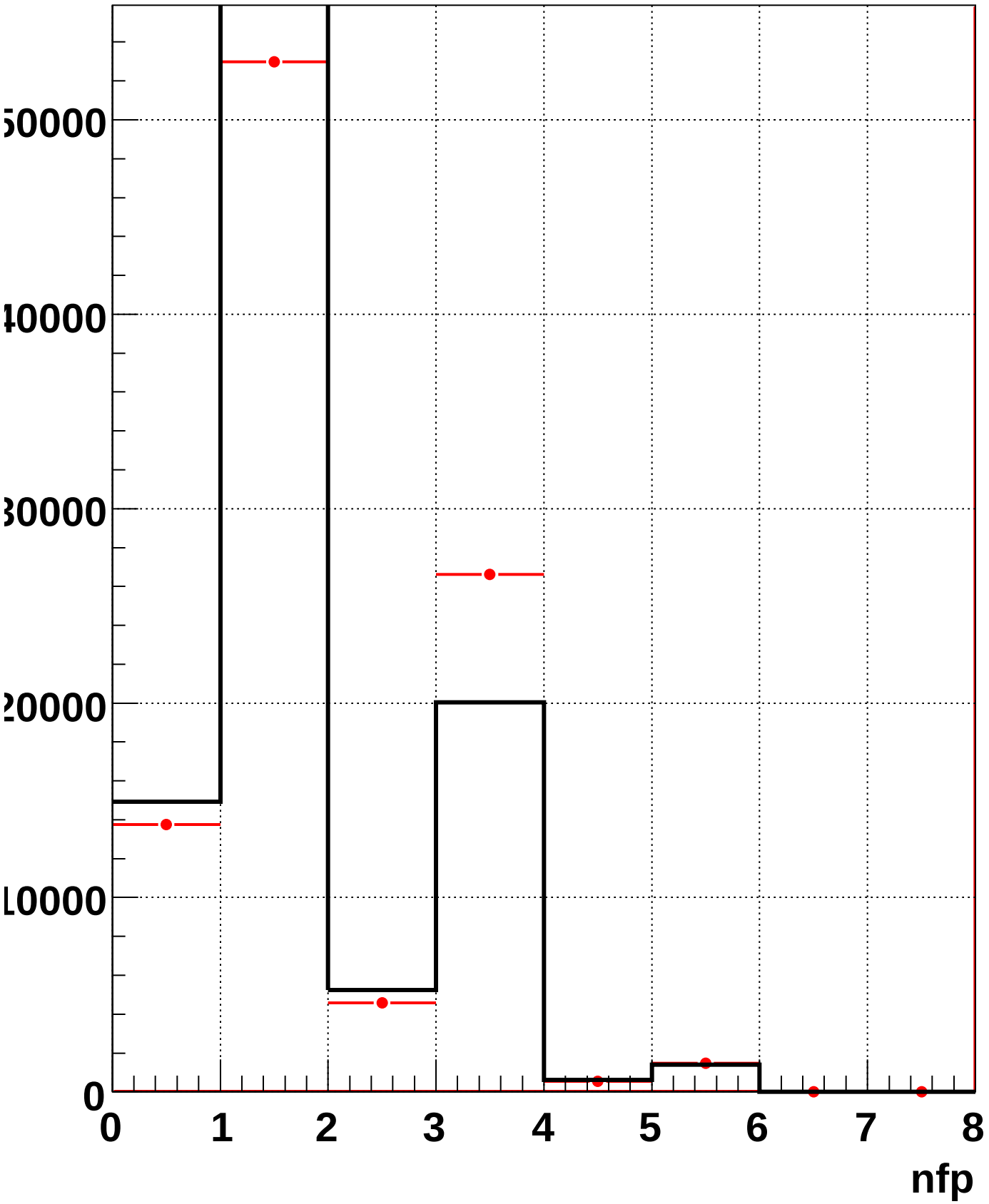
Final State Hadronic System

Multiplicities and 4-Momenta

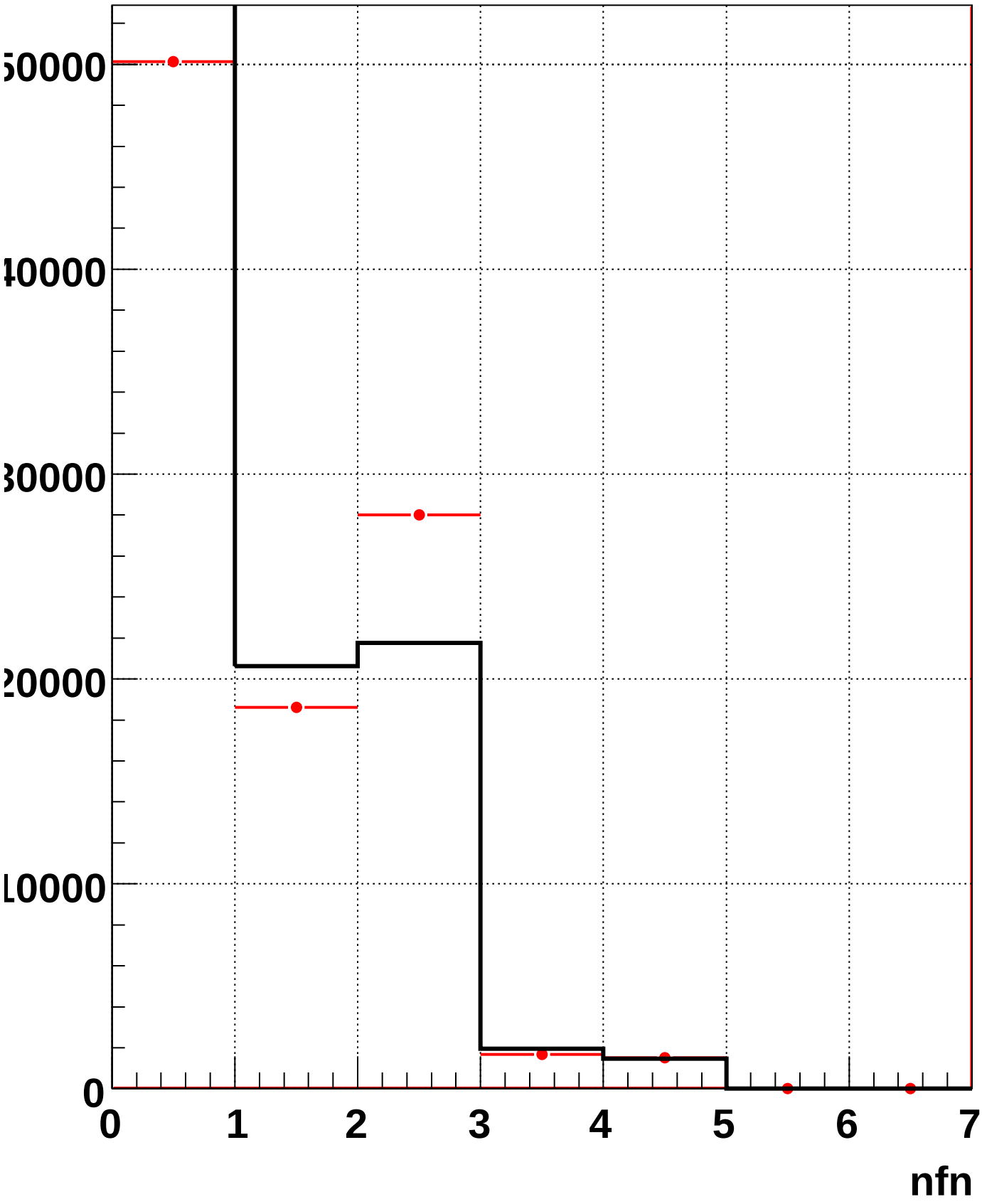
Note:

For nuclear targets these plots include the effect of intranuclear hadron transport / rescattering

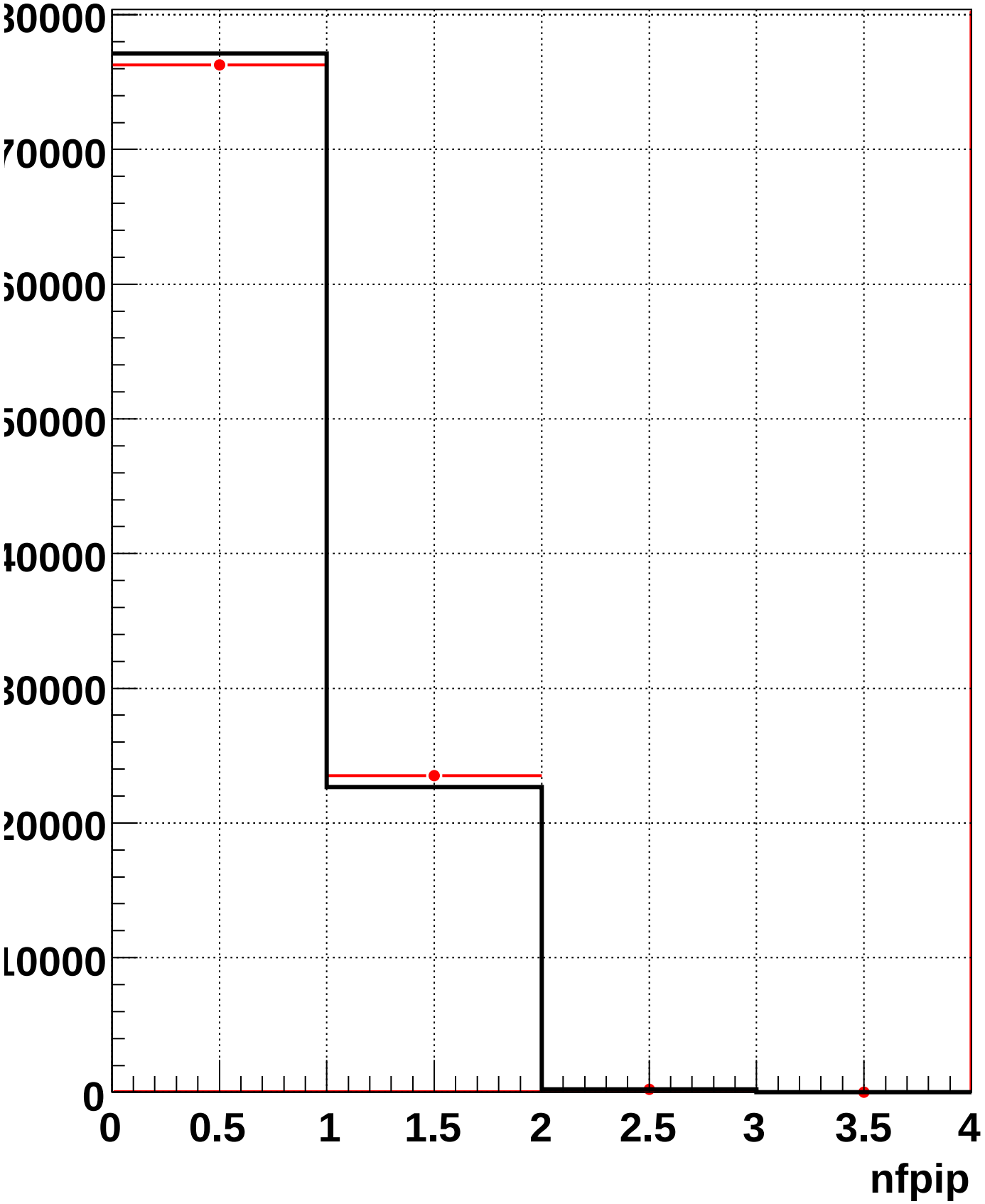
Number of final state protons

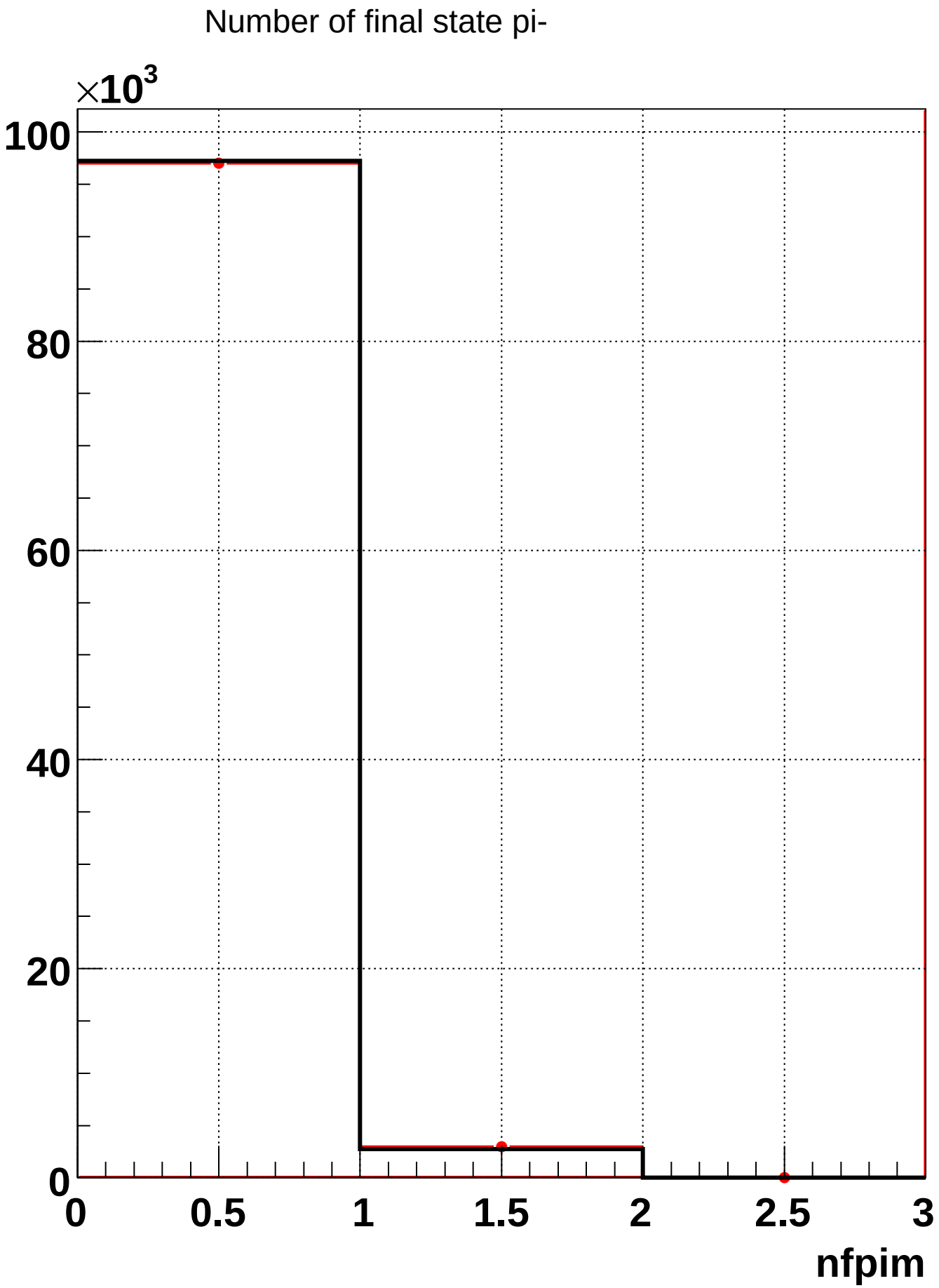


Number of final state neutrons

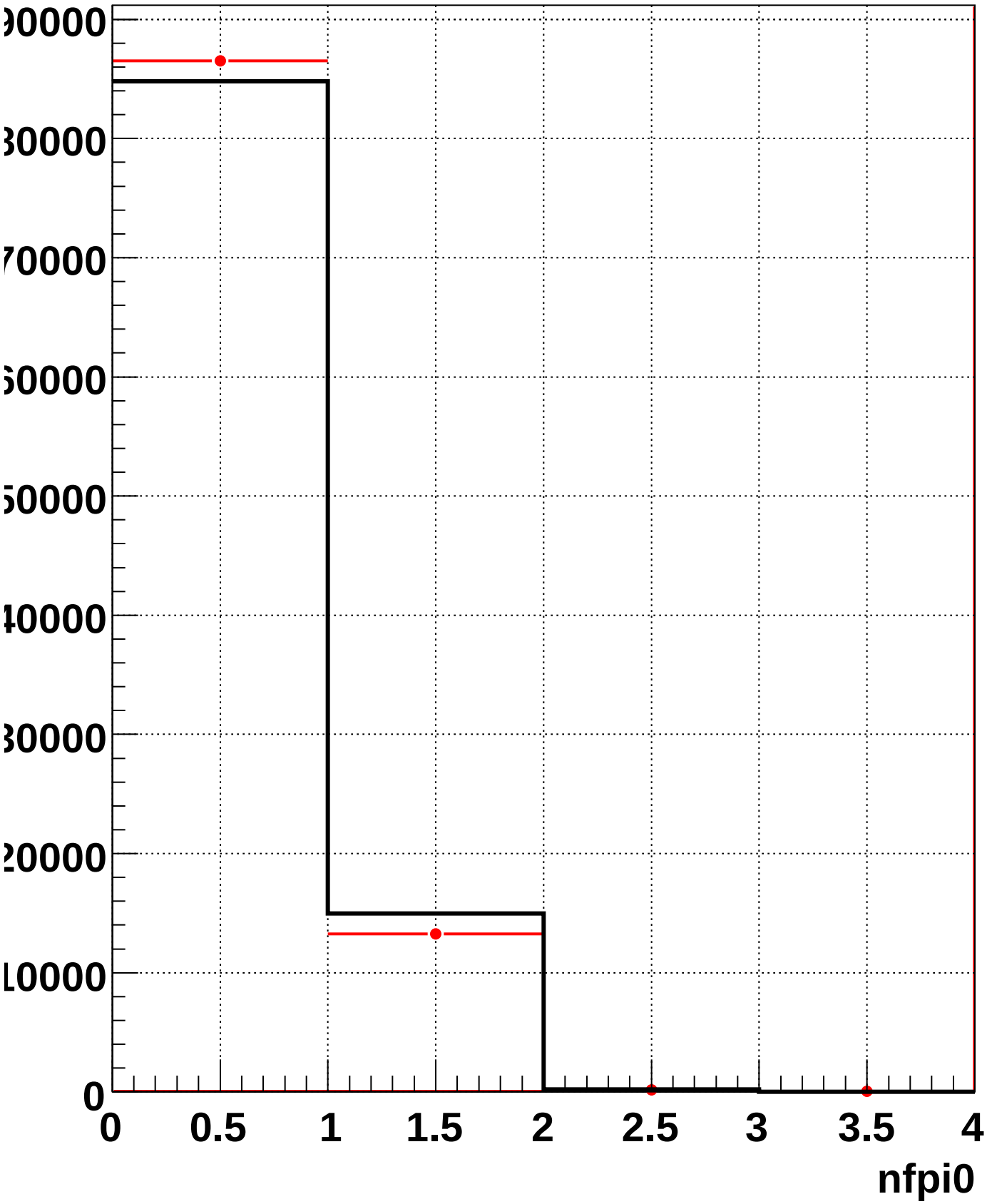


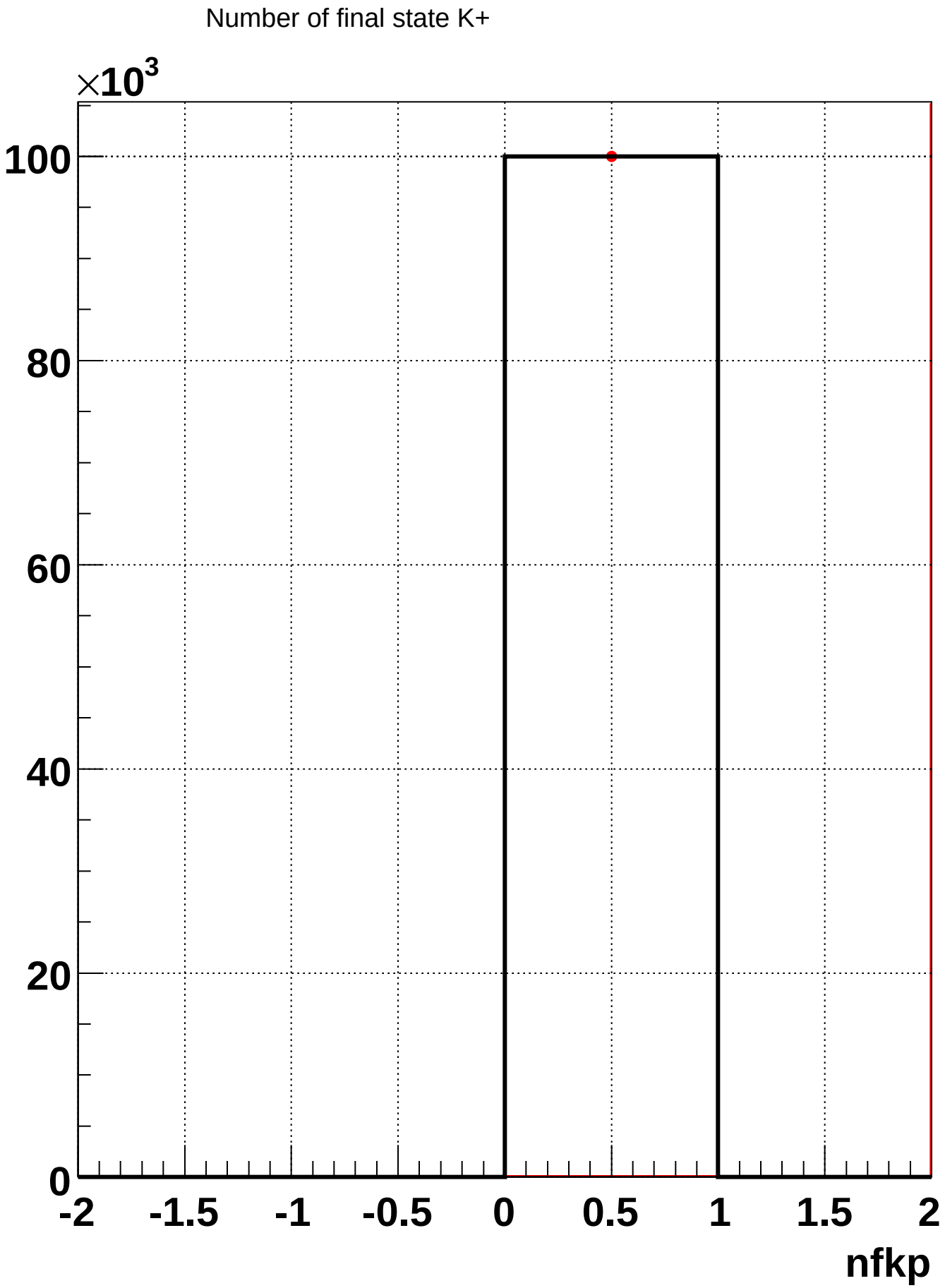
Number of final state pi+

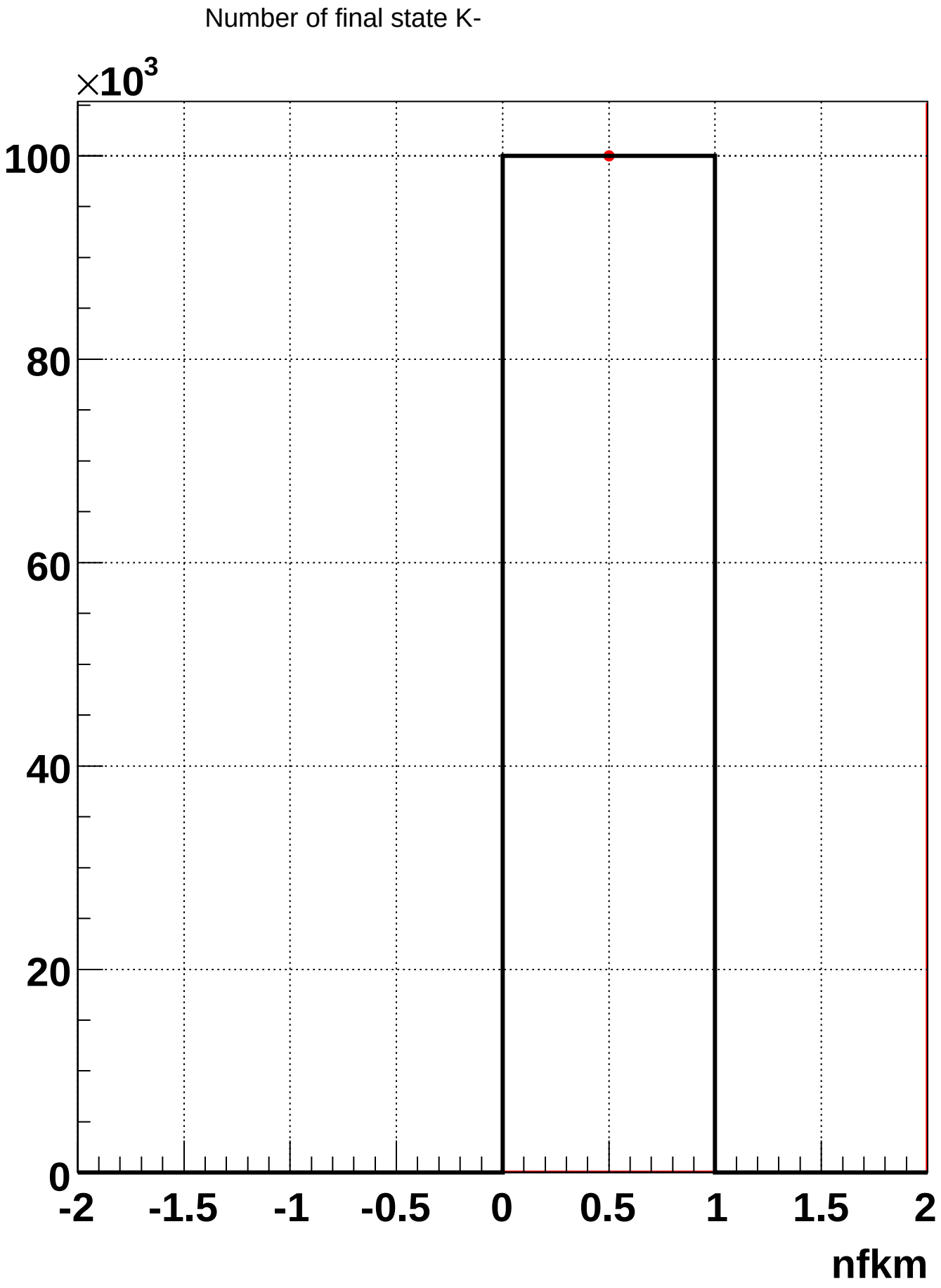


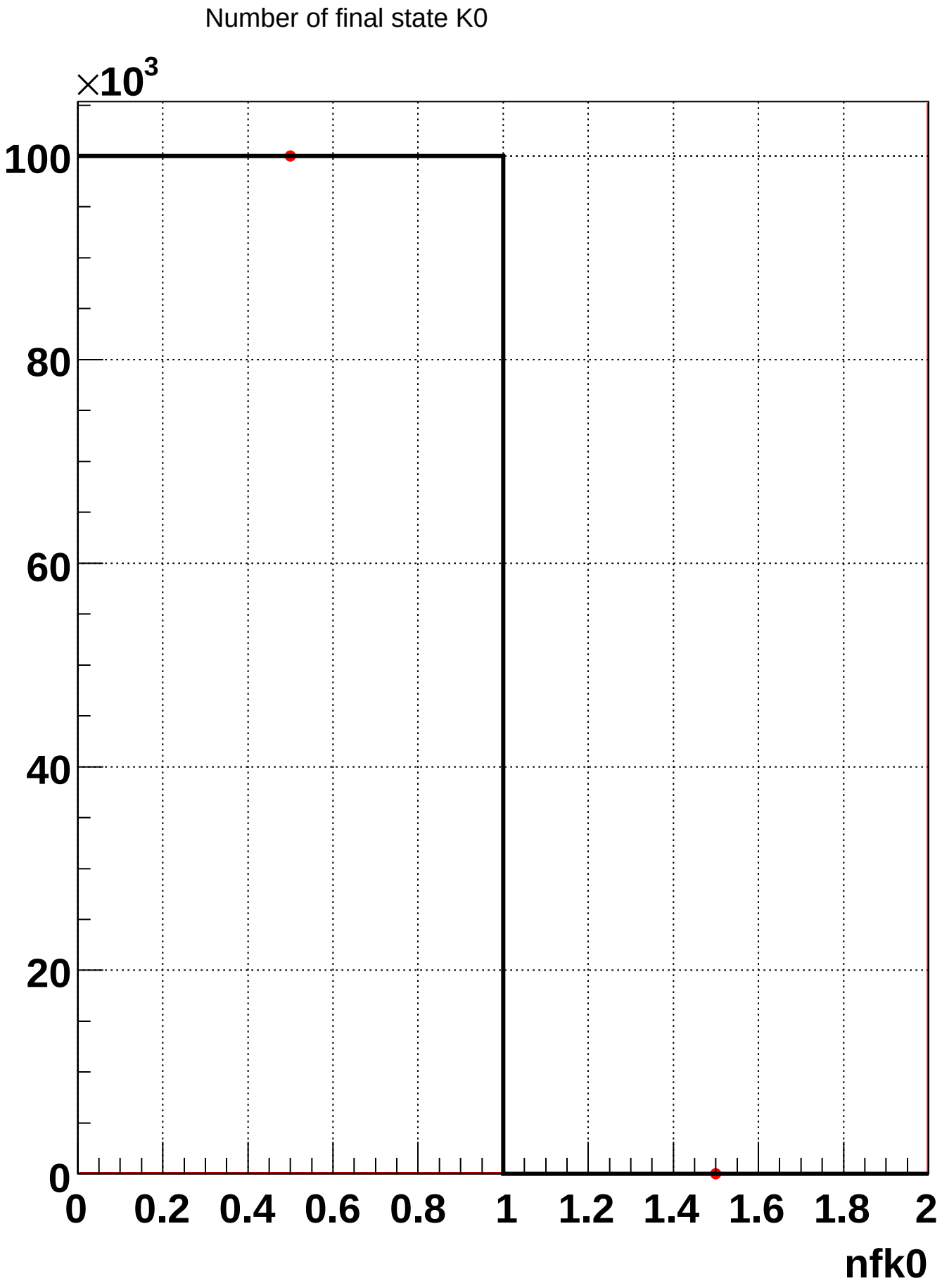

Number of final state pi-
×10^3
100
80
60
40
20
0
0
0.5
1
1.5
2
2.5
3
nfpim

Number of final state pi0

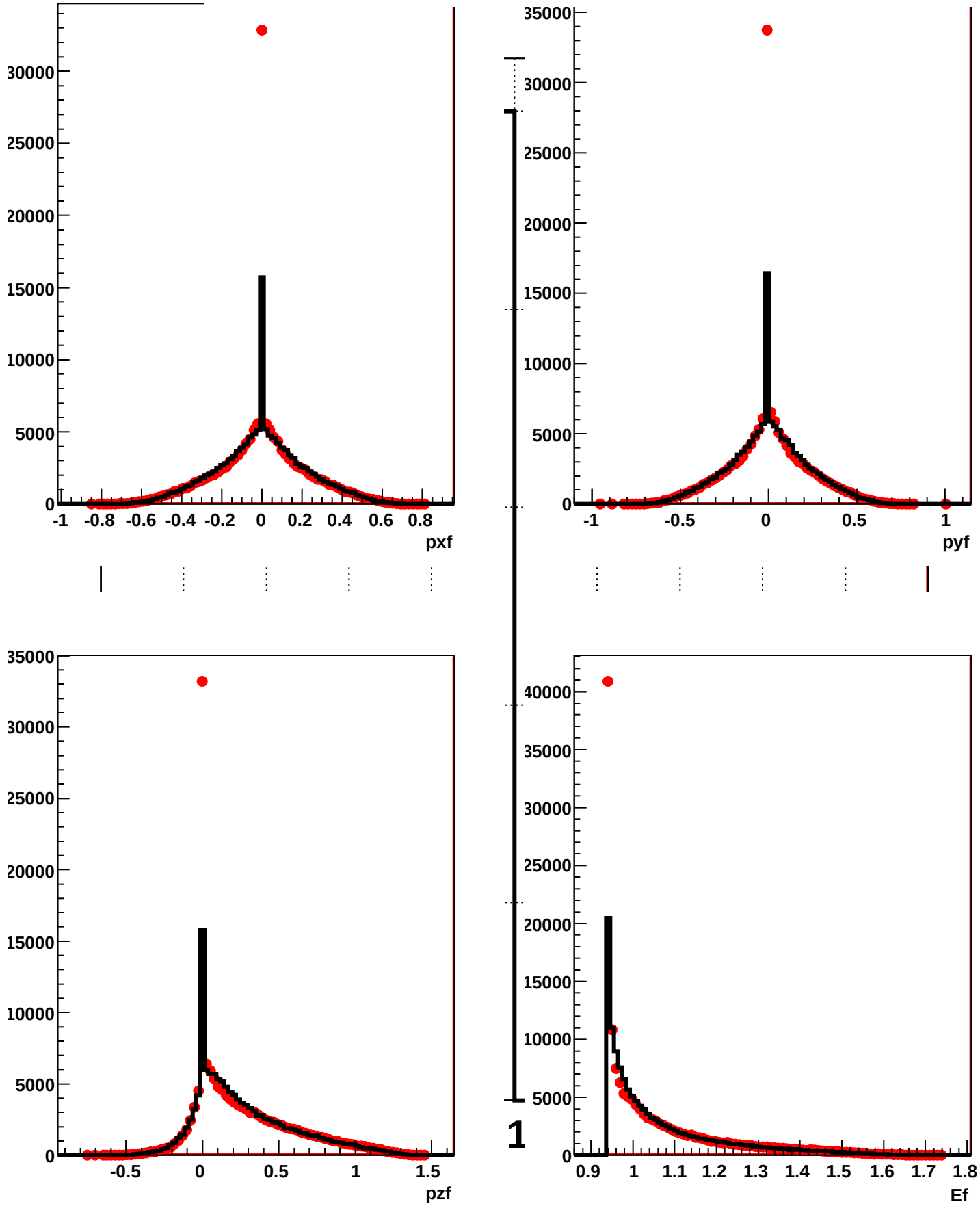



Number of final state K+
×10^3
100
80
60
40
20
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
nfkp

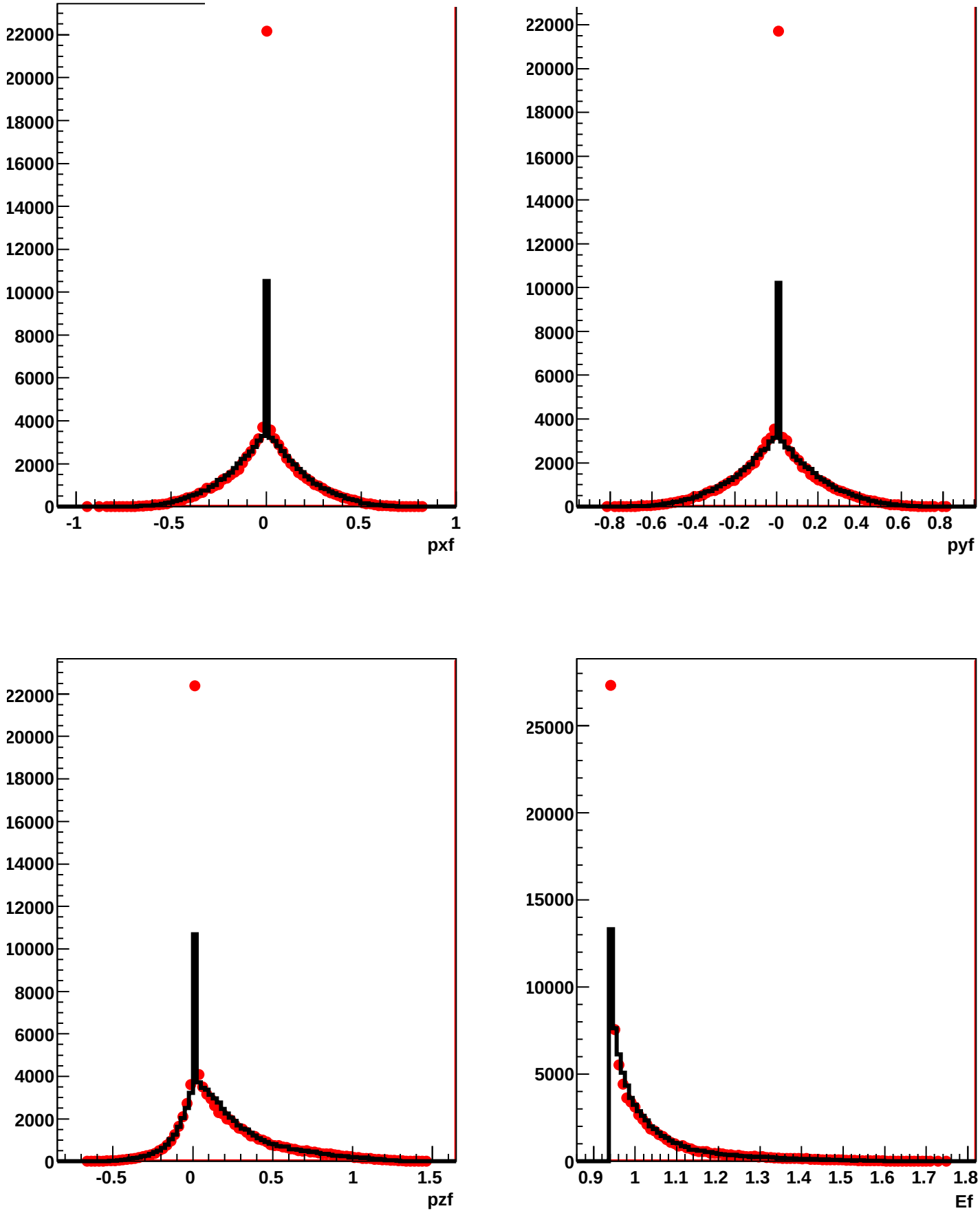

Number of final state K-
×10^3
100
80
60
40
20
0
-2
-1.5
-1
-0.5
0
0.5
1
1.5
2
nfkm


Number of final state K0
×10^3
100
80
60
40
20
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
nfk0

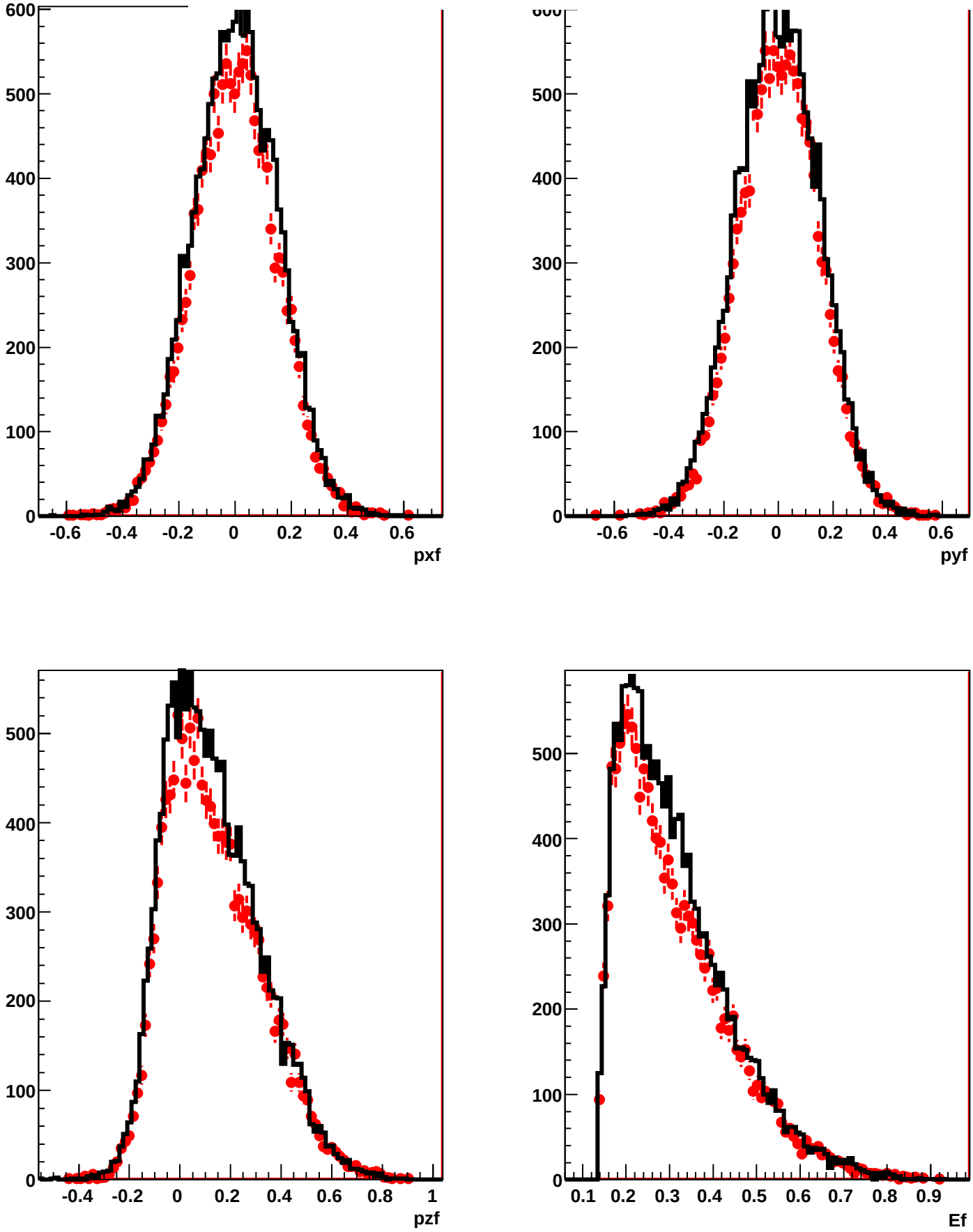
Final state protons 4-momentum



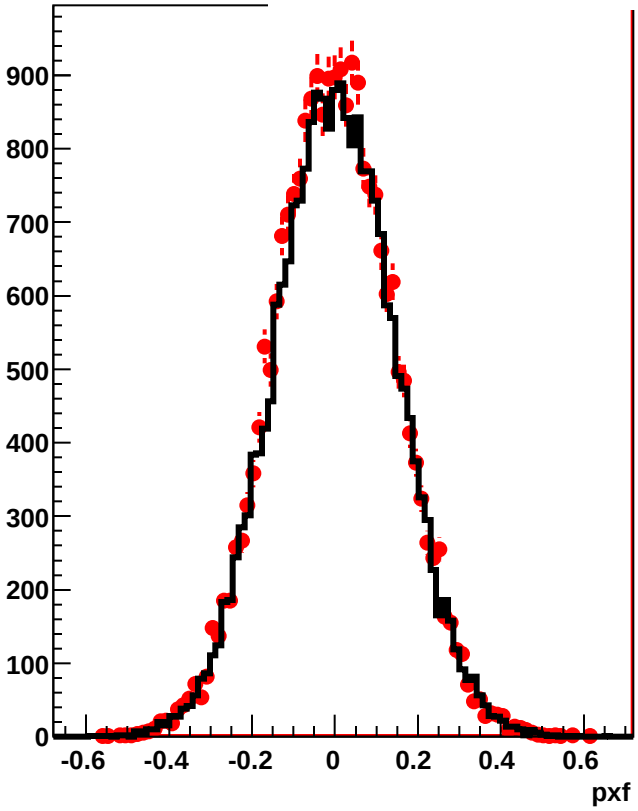
Final state neutrons 4-momentum

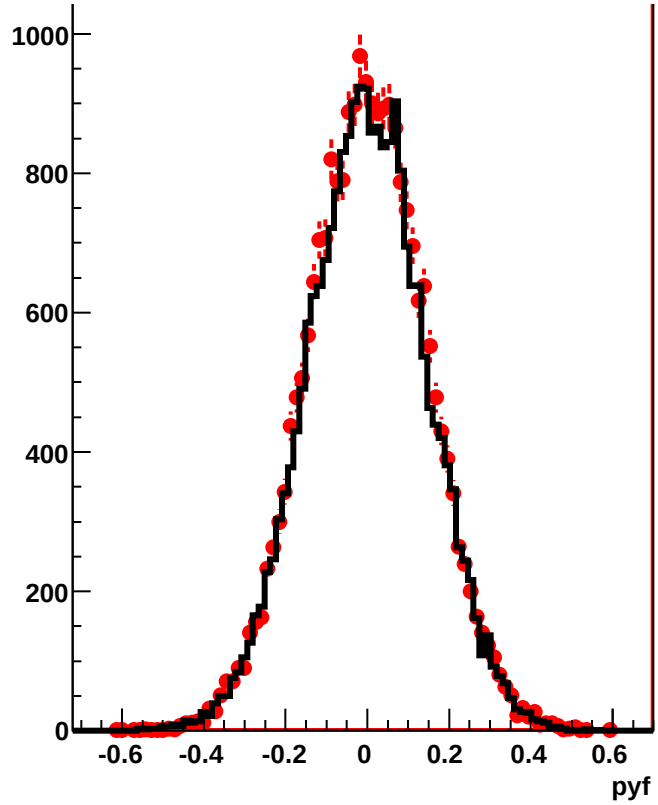


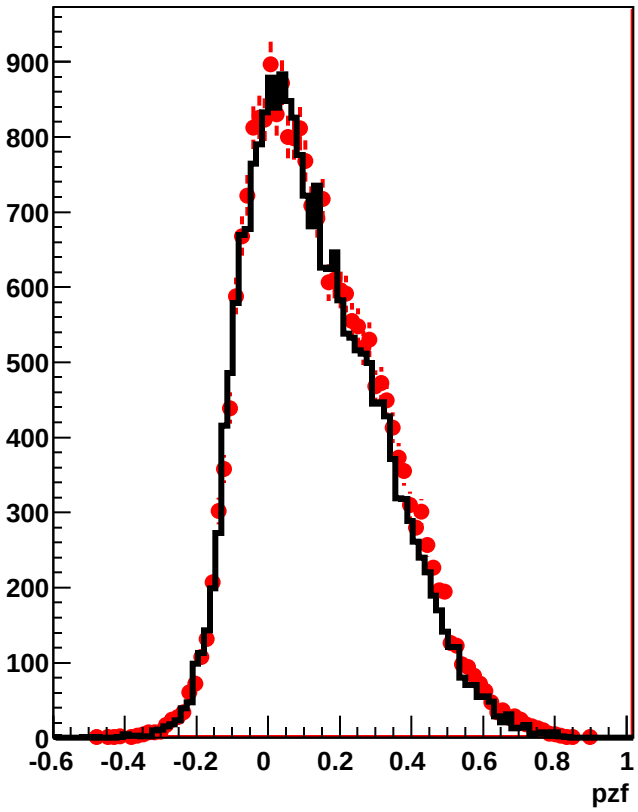
Final state pi0's 4-momentum

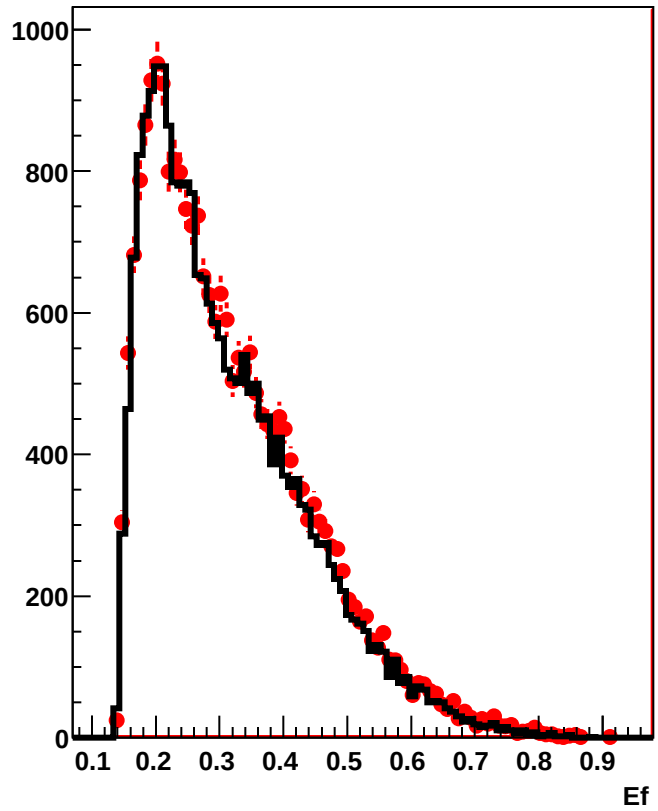


Final state pi+’s 4-momentum

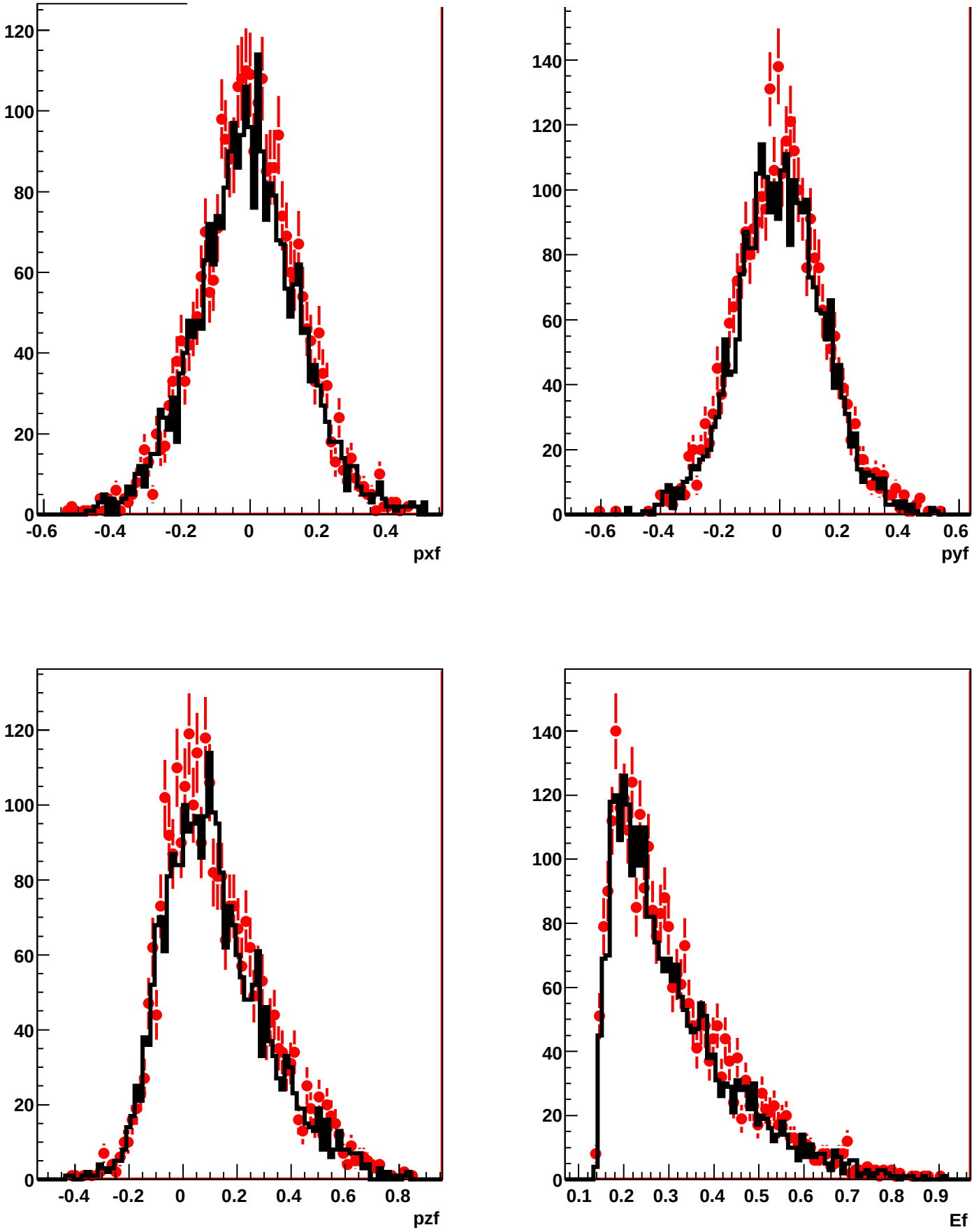








Final state pi-'s 4-momentum



GENIE-2.0.0 vs NEUGEN/Daikon+ Event Sample Comparisons

Event Sample:

100k events, numu+Fe56, 5GeV, all processes

Notes:

Daikon+ is a NEUGEN Daikon revision version

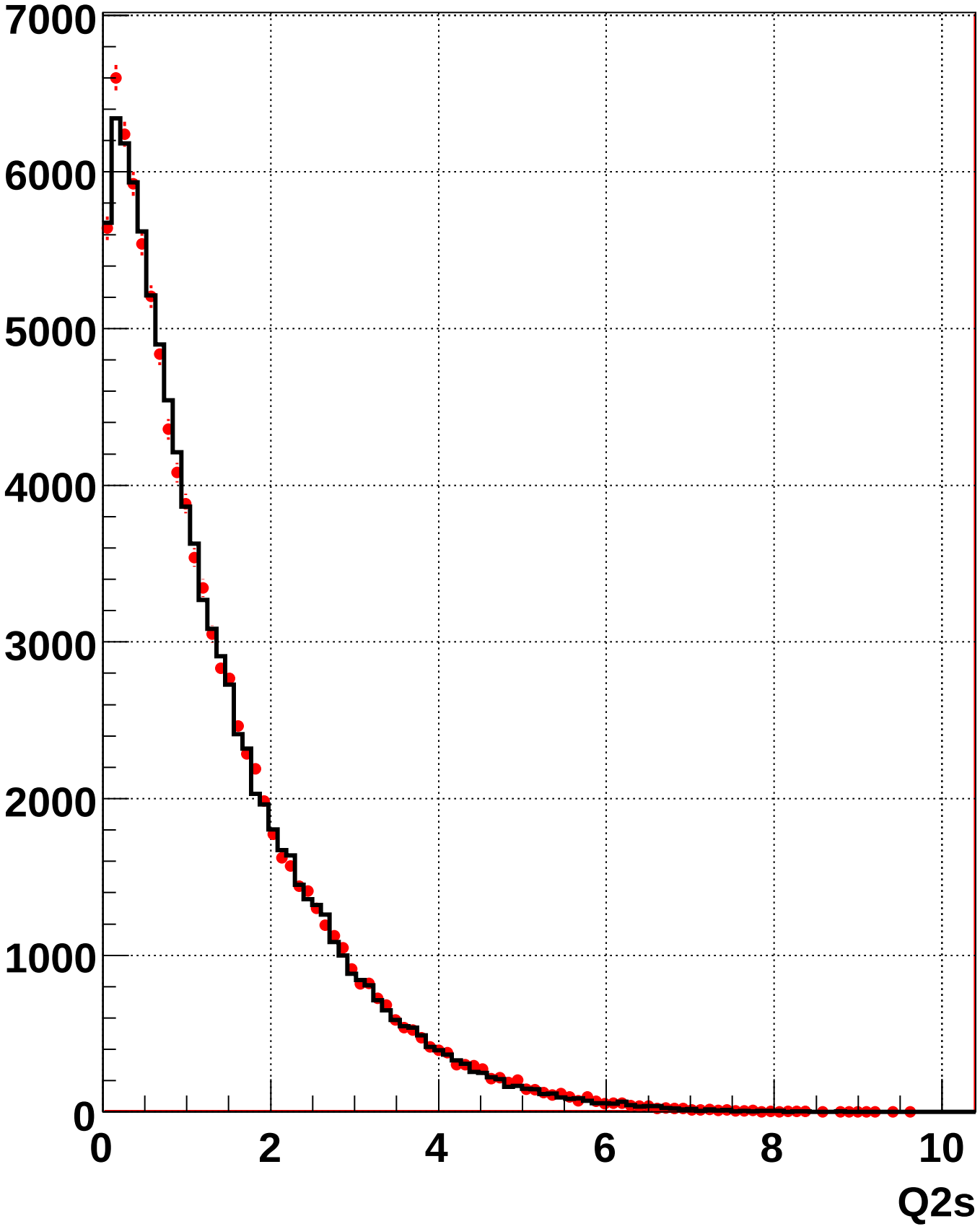
GENIE predictions shown with lines / NEUGEN's with markers

Event Numbers:

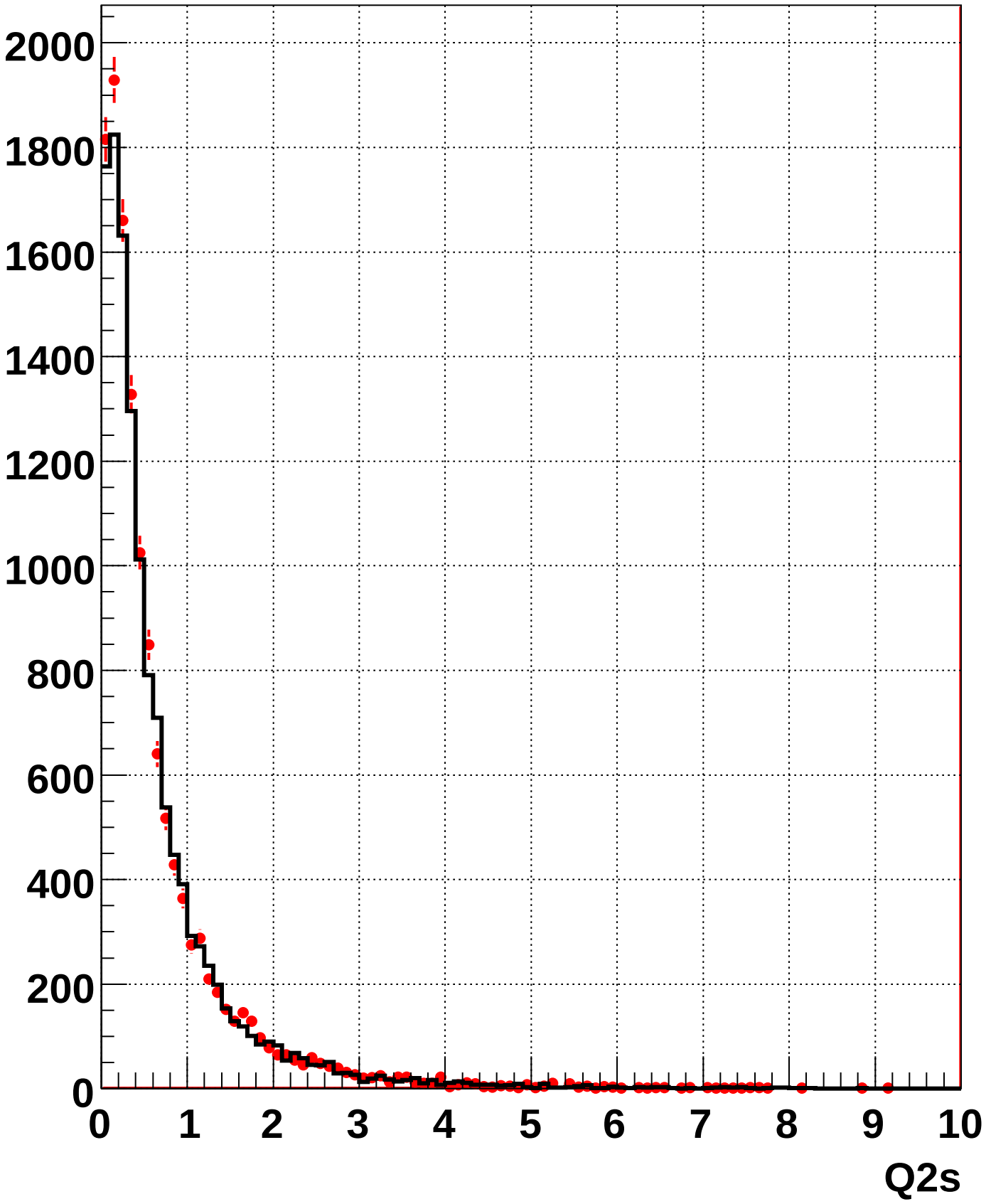
ALL :	100000 [NeuGEN],	100000 [GENIE]
QEL :	13024 [NeuGEN],	12888 [GENIE]
QEL-CC :	9343 [NeuGEN],	9313 [GENIE]
QEL-NC :	3681 [NeuGEN],	3575 [GENIE]
RES :	23392 [NeuGEN],	23232 [GENIE]
RES-CC :	17086 [NeuGEN],	17030 [GENIE]
RES-NC :	6306 [NeuGEN],	6202 [GENIE]
DIS :	62991 [NeuGEN],	63314 [GENIE]
DIS-CC :	47631 [NeuGEN],	47798 [GENIE]
(charm):	99 [NeuGEN],	63 [GENIE]
DIS-NC :	15360 [NeuGEN],	15516 [GENIE]
COH :	593 [NeuGEN],	566 [GENIE]
COH-CC :	378 [NeuGEN],	406 [GENIE]
COH-NC :	215 [NeuGEN],	160 [GENIE]
IMD :	0 [NeuGEN],	0 [GENIE]

Selected Kinematical Quantities

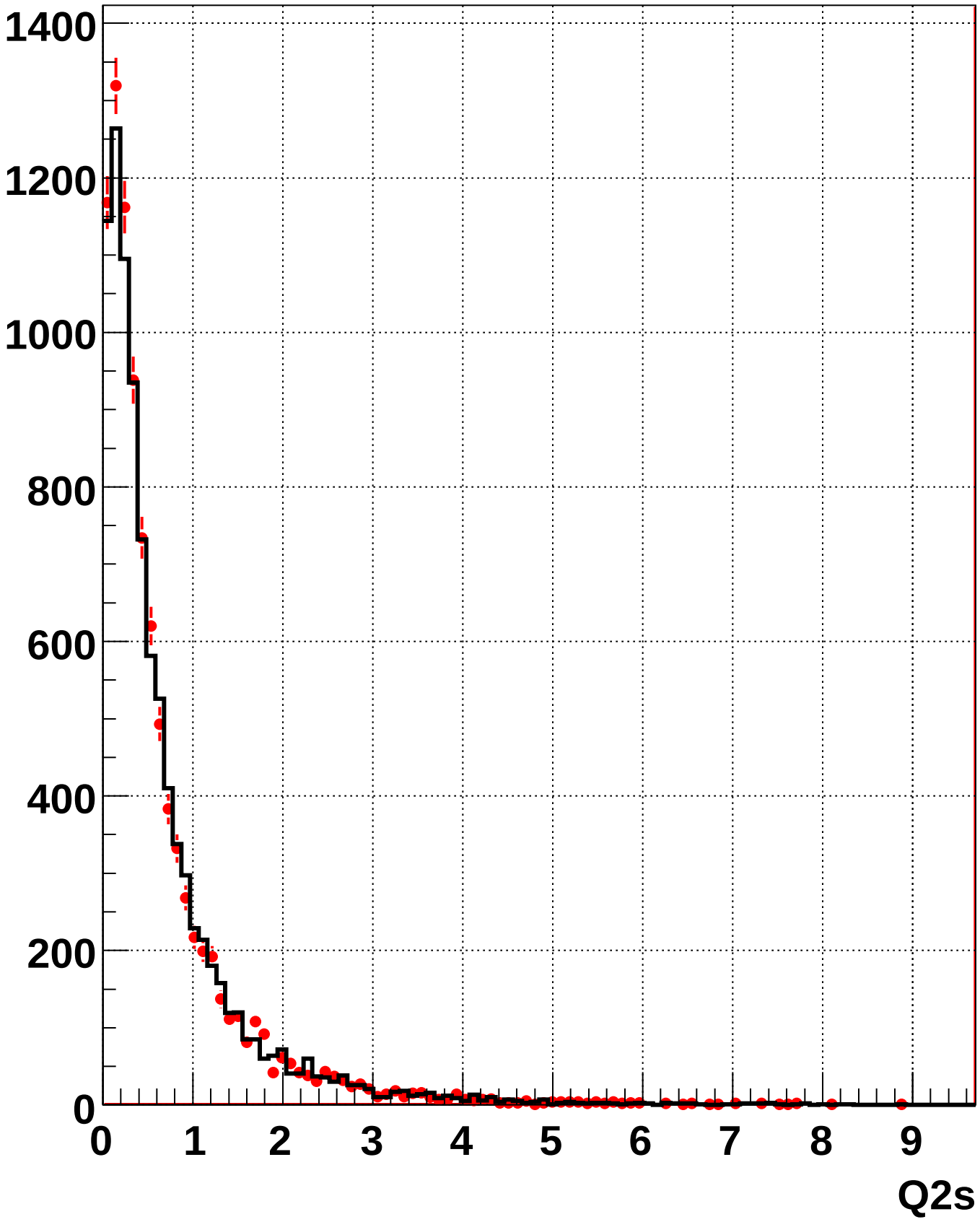
selected Q2 for all events



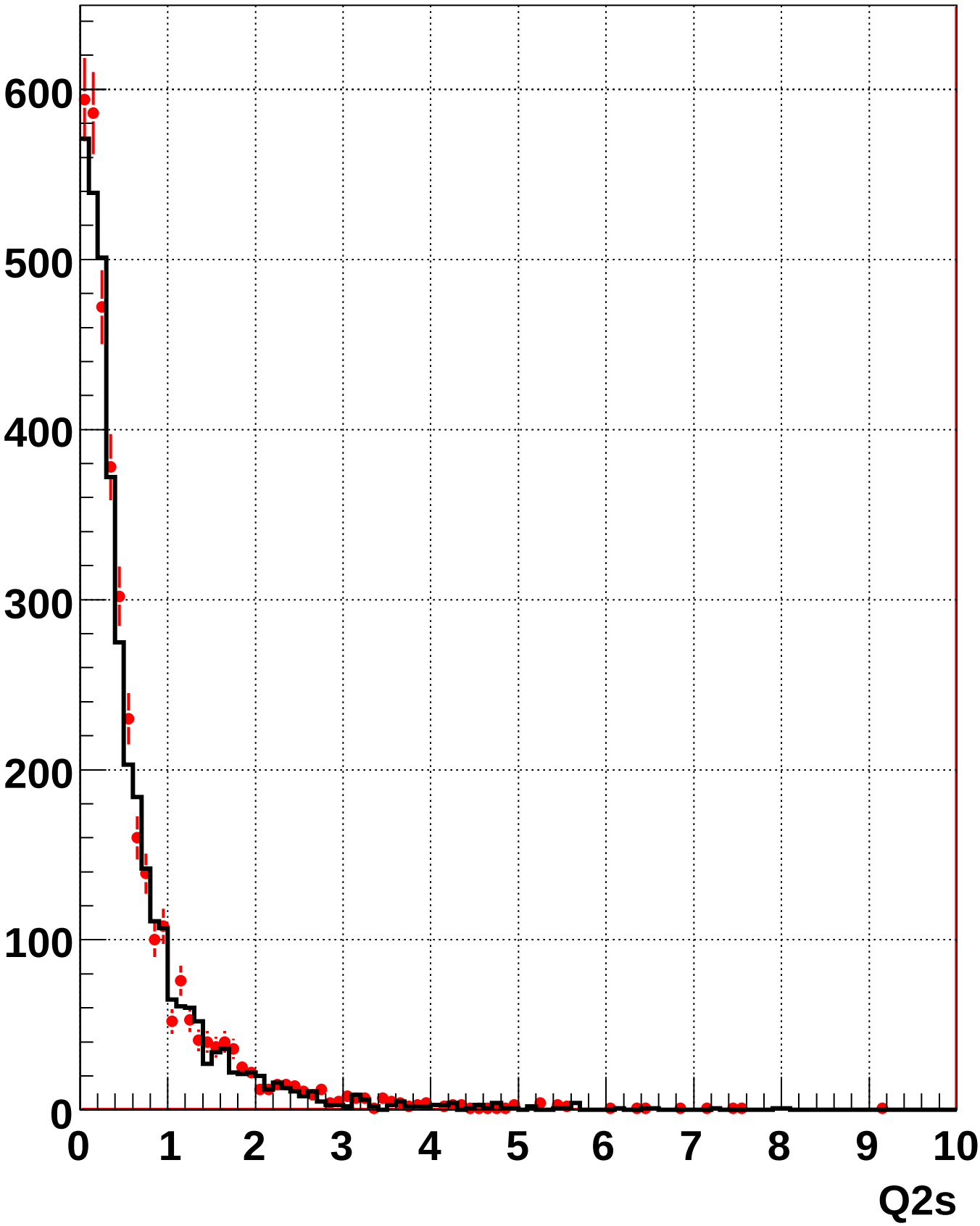
selected Q2 for QEL events



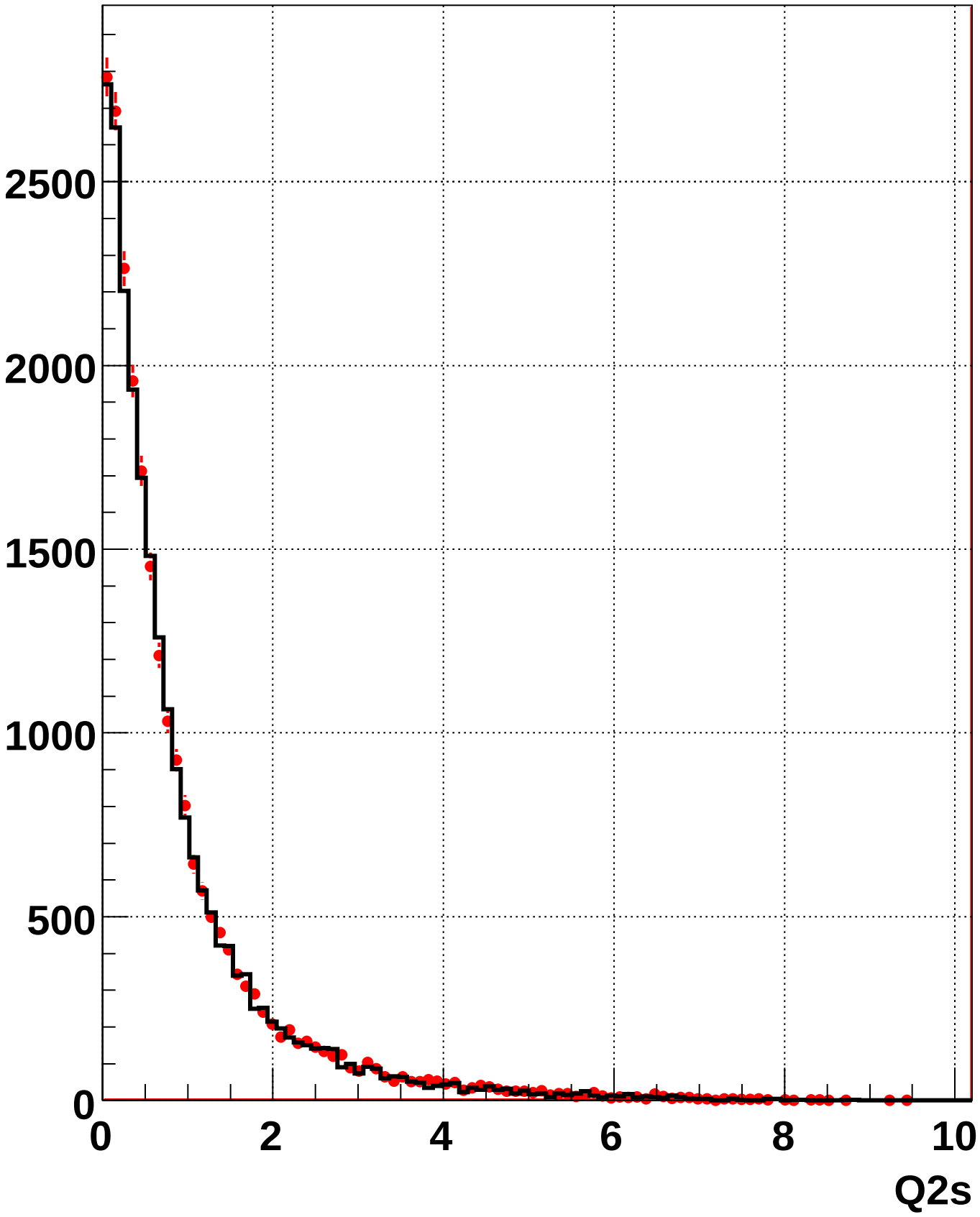
selected Q2 for QEL CC events



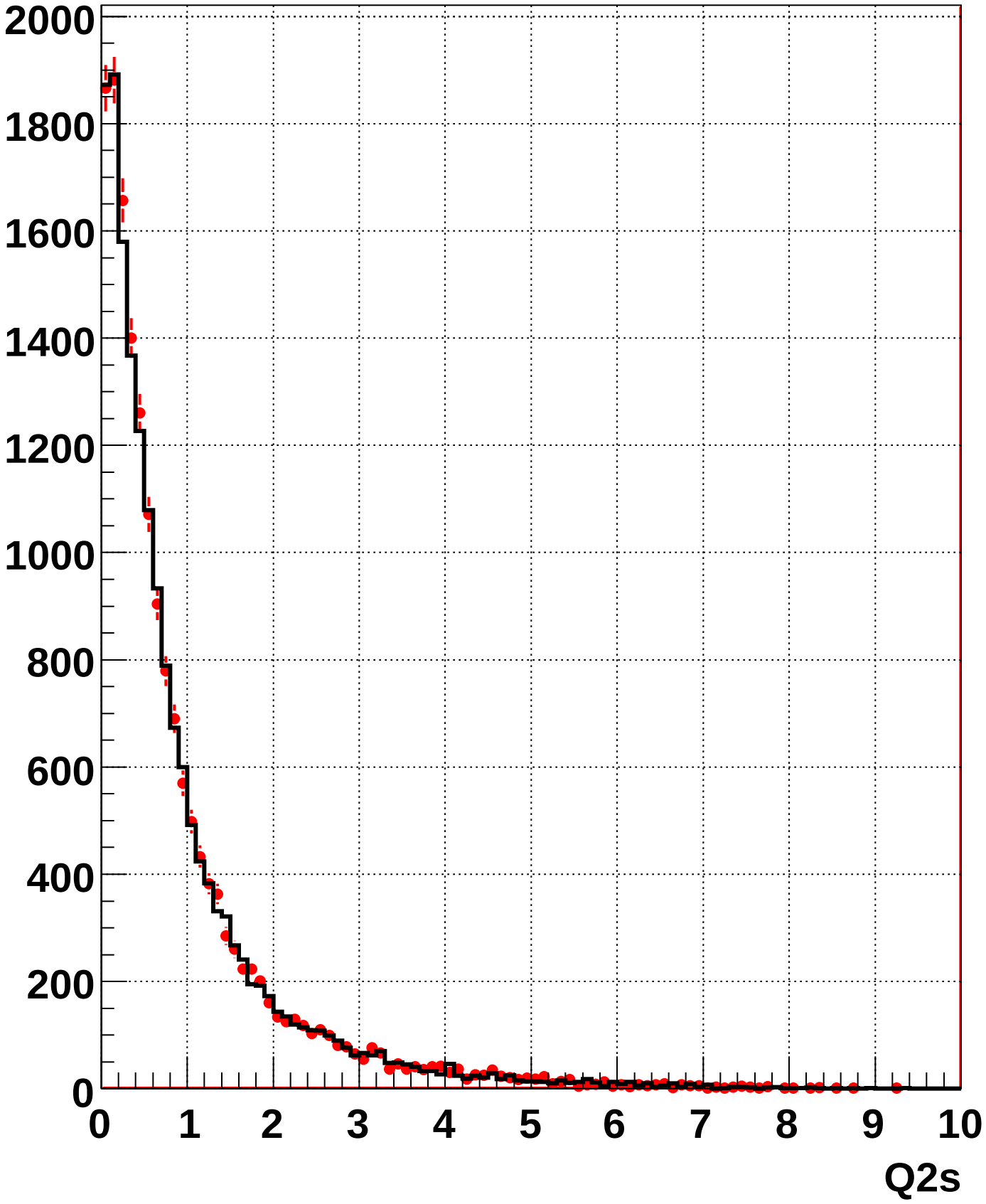
selected Q2 for QEL NC events



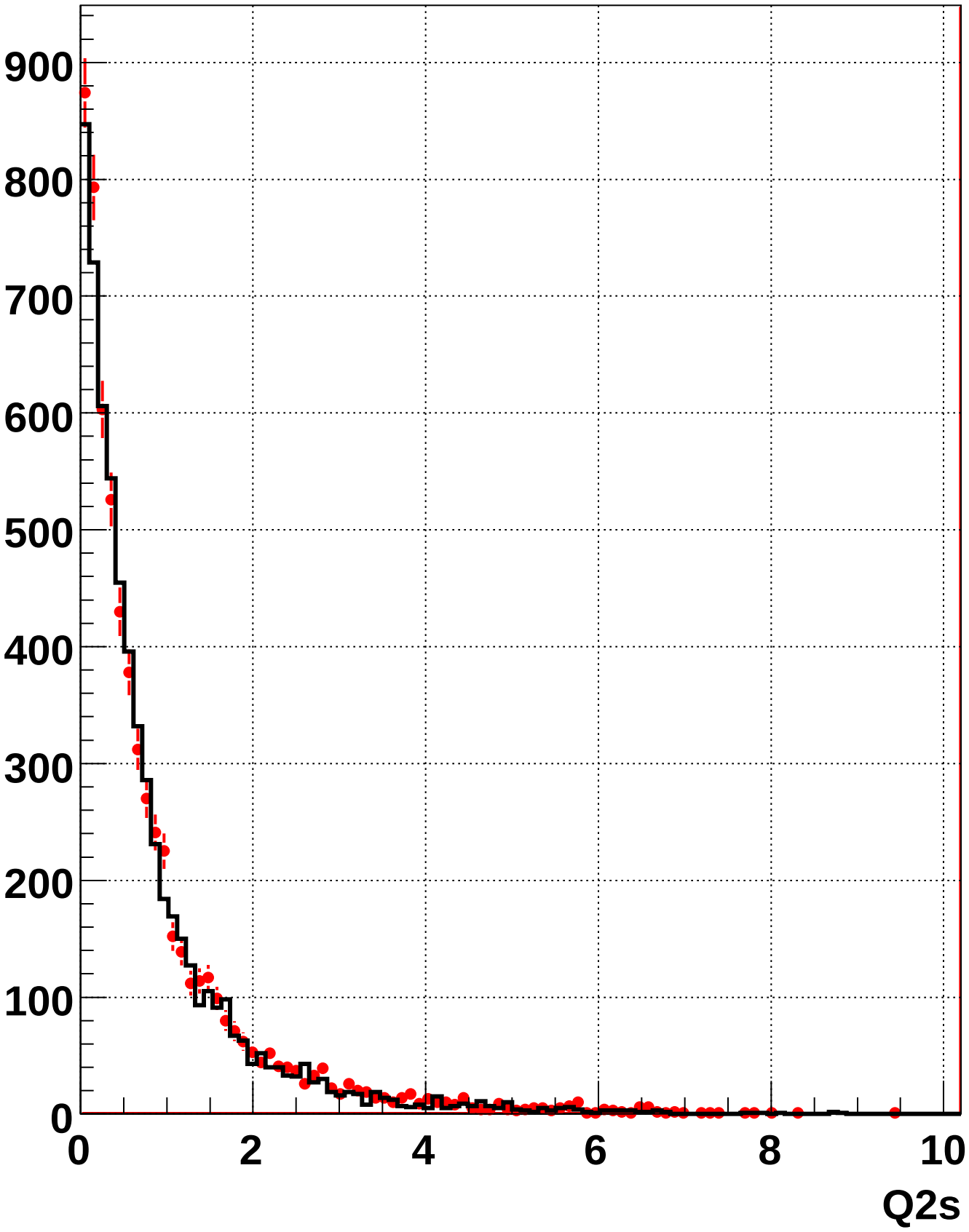
selected Q2 for RES events



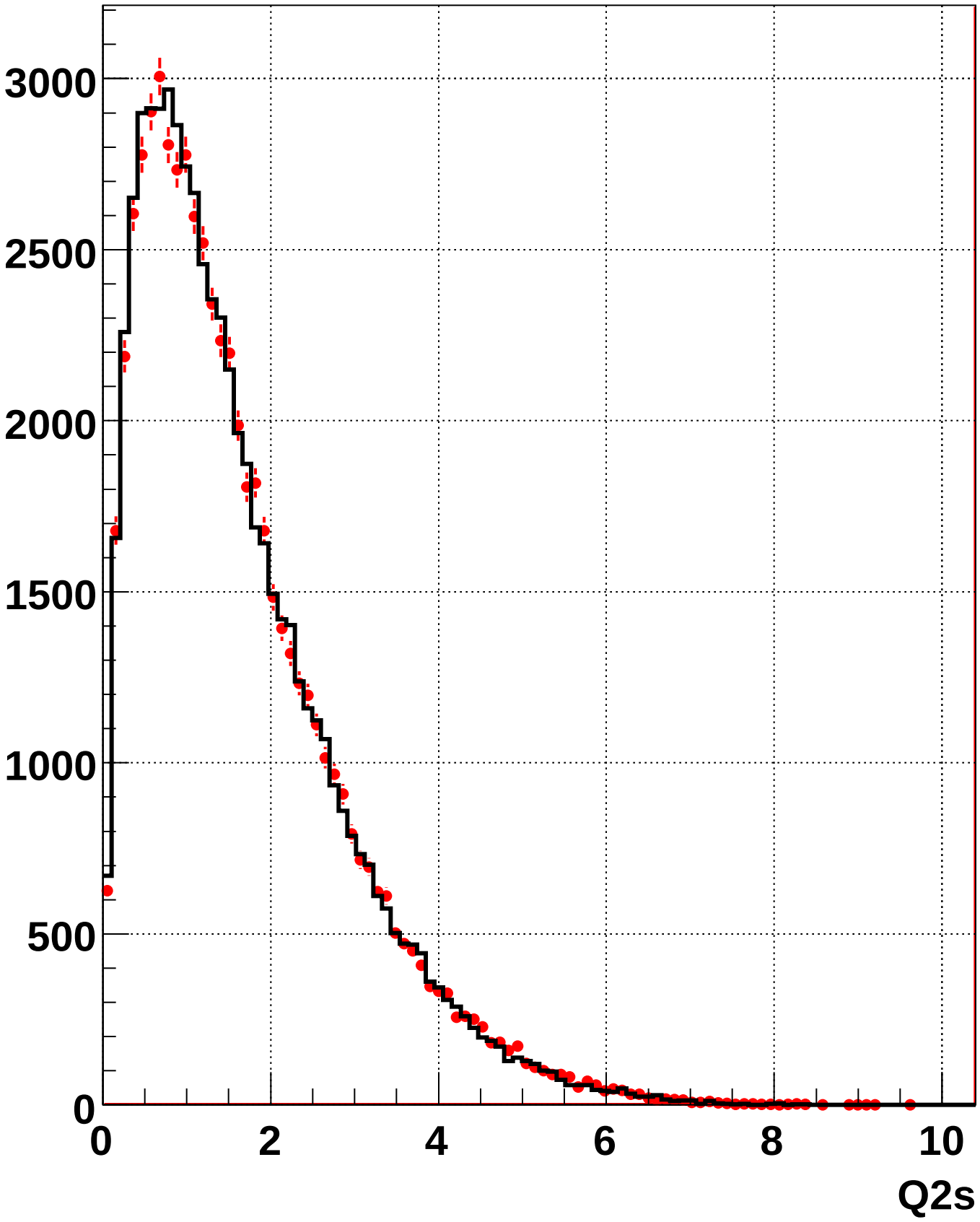
selected Q2 for RES CC events



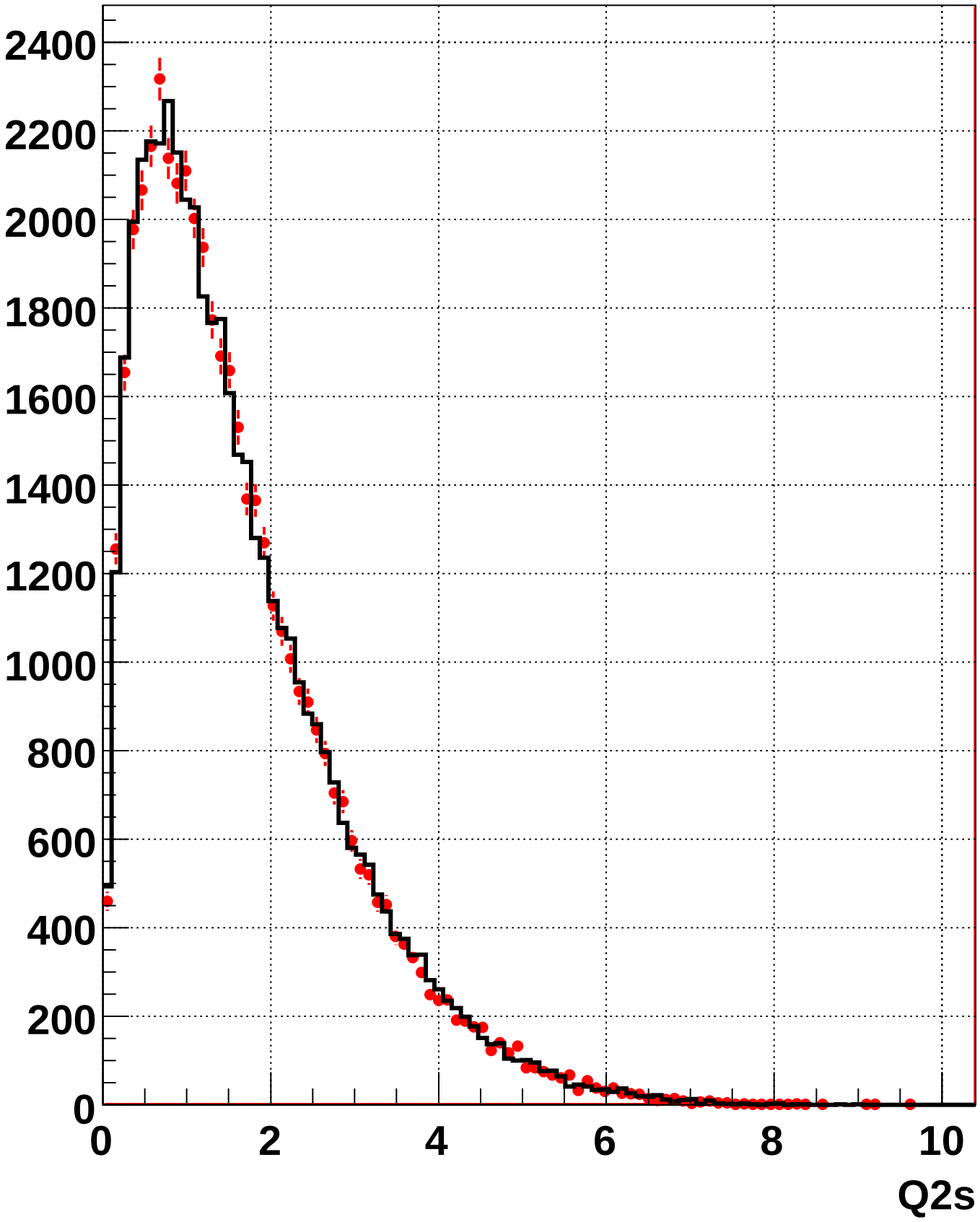
selected Q2 for RES NC events



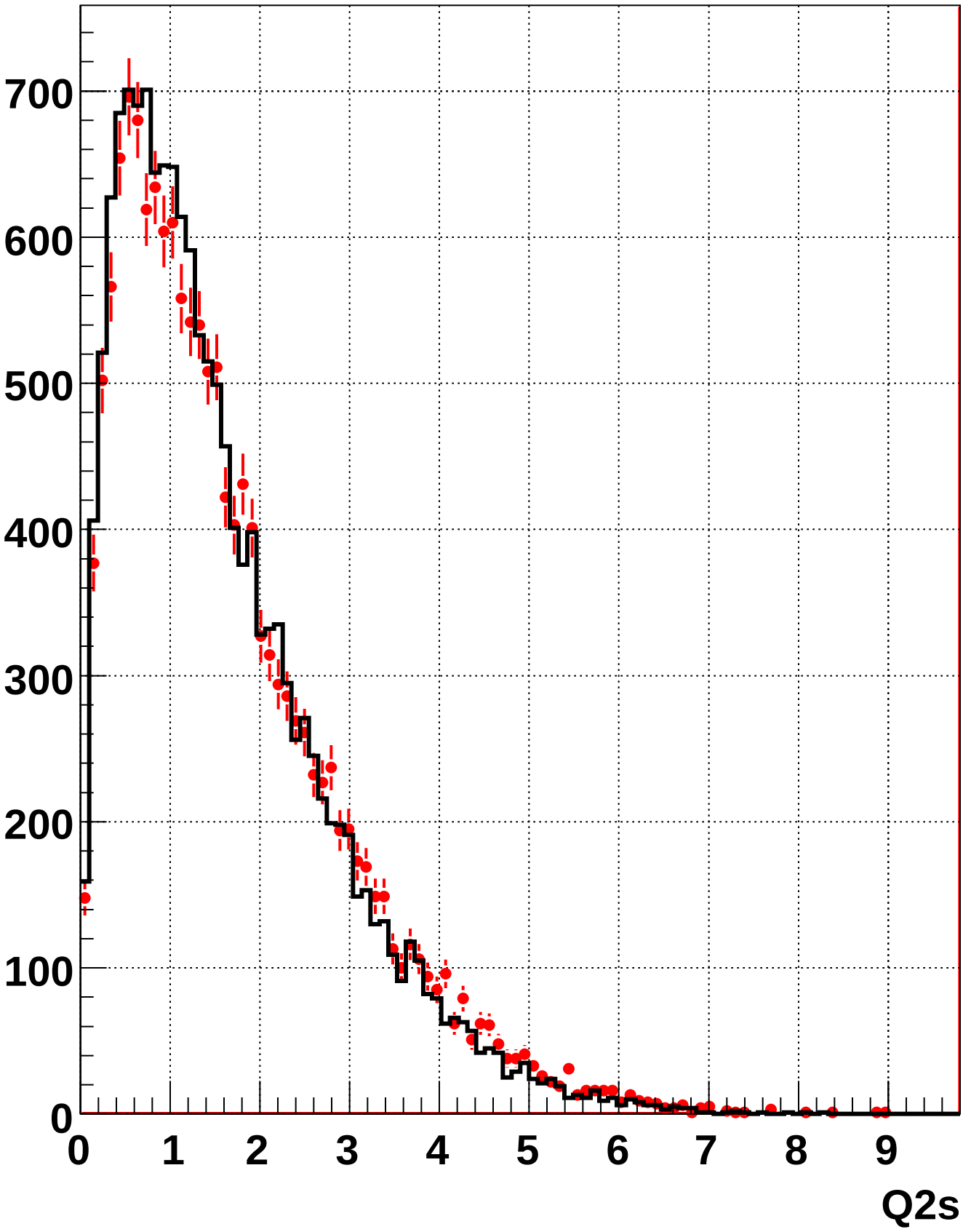
selected Q2 for DIS events



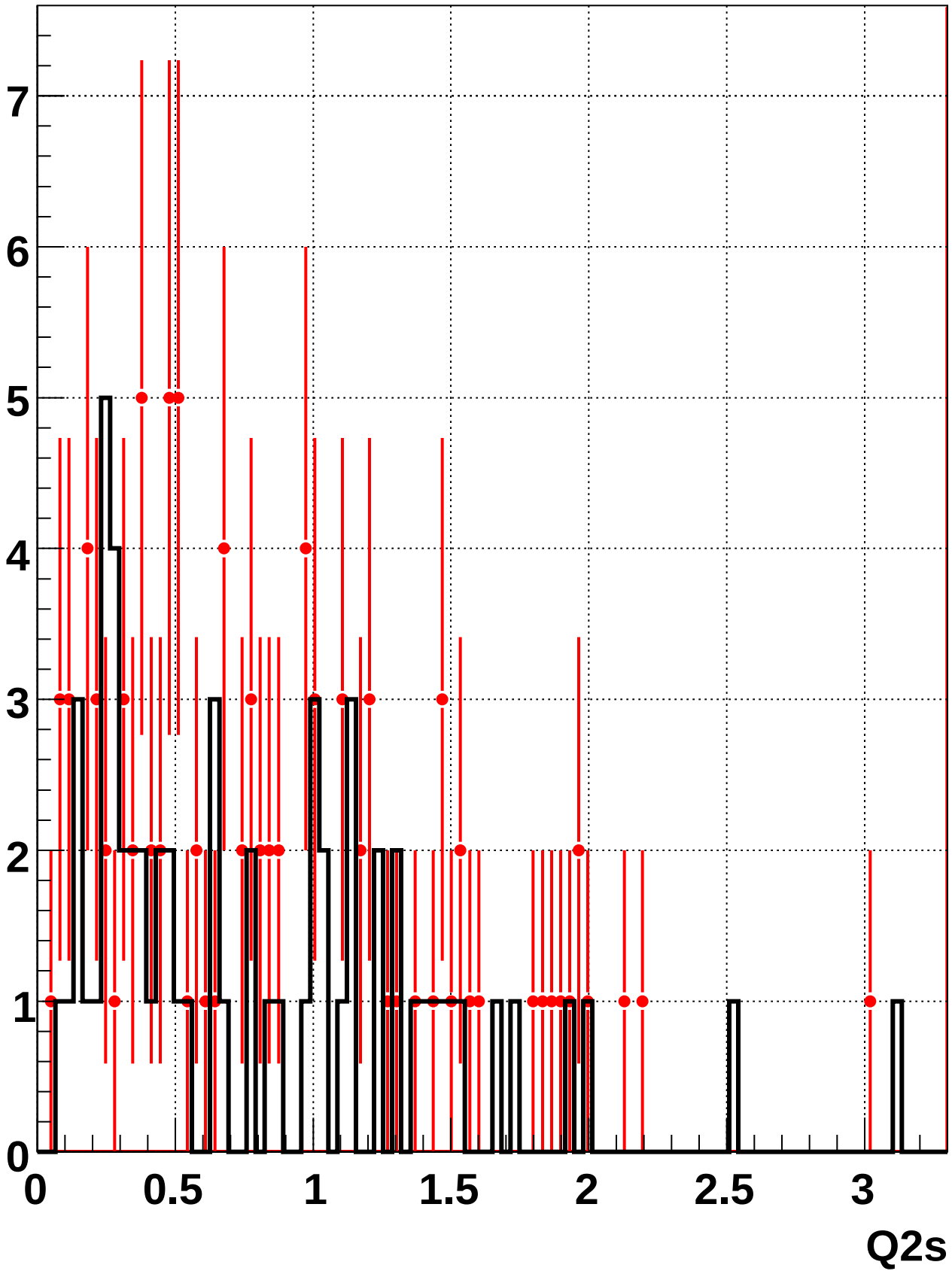
selected Q2 for DIS CC events



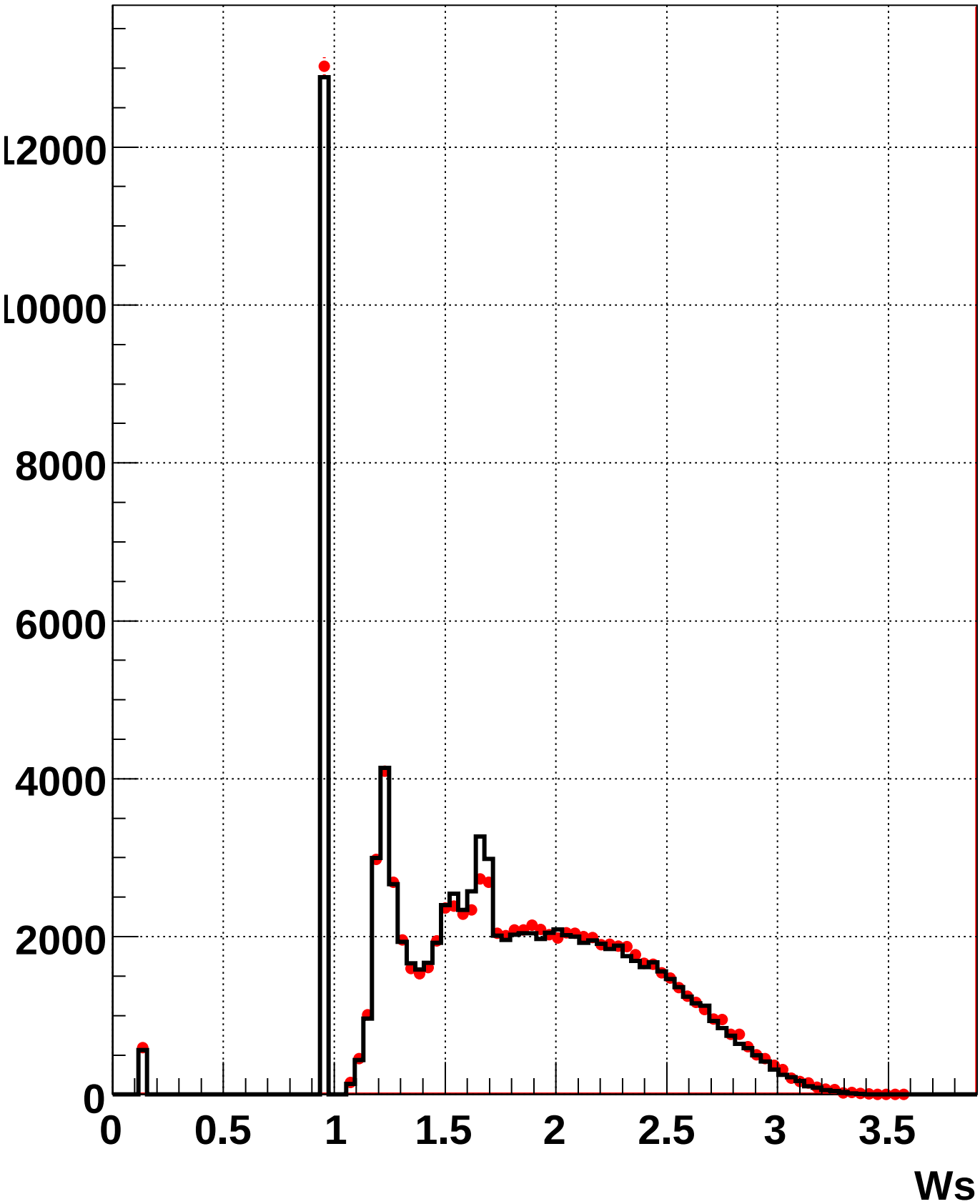
selected Q2 for DIS NC events

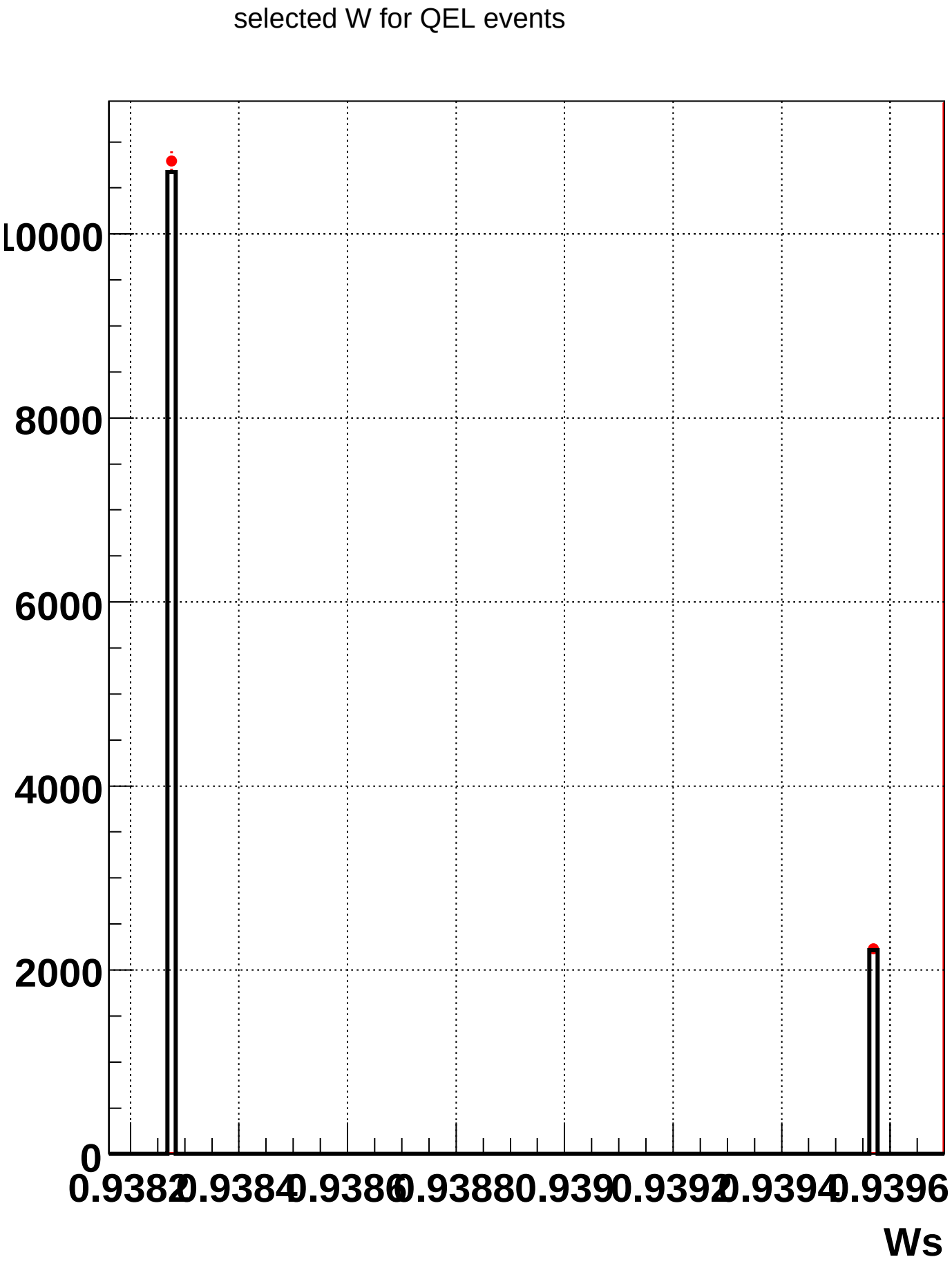


selected Q2 for Charm/DIS events

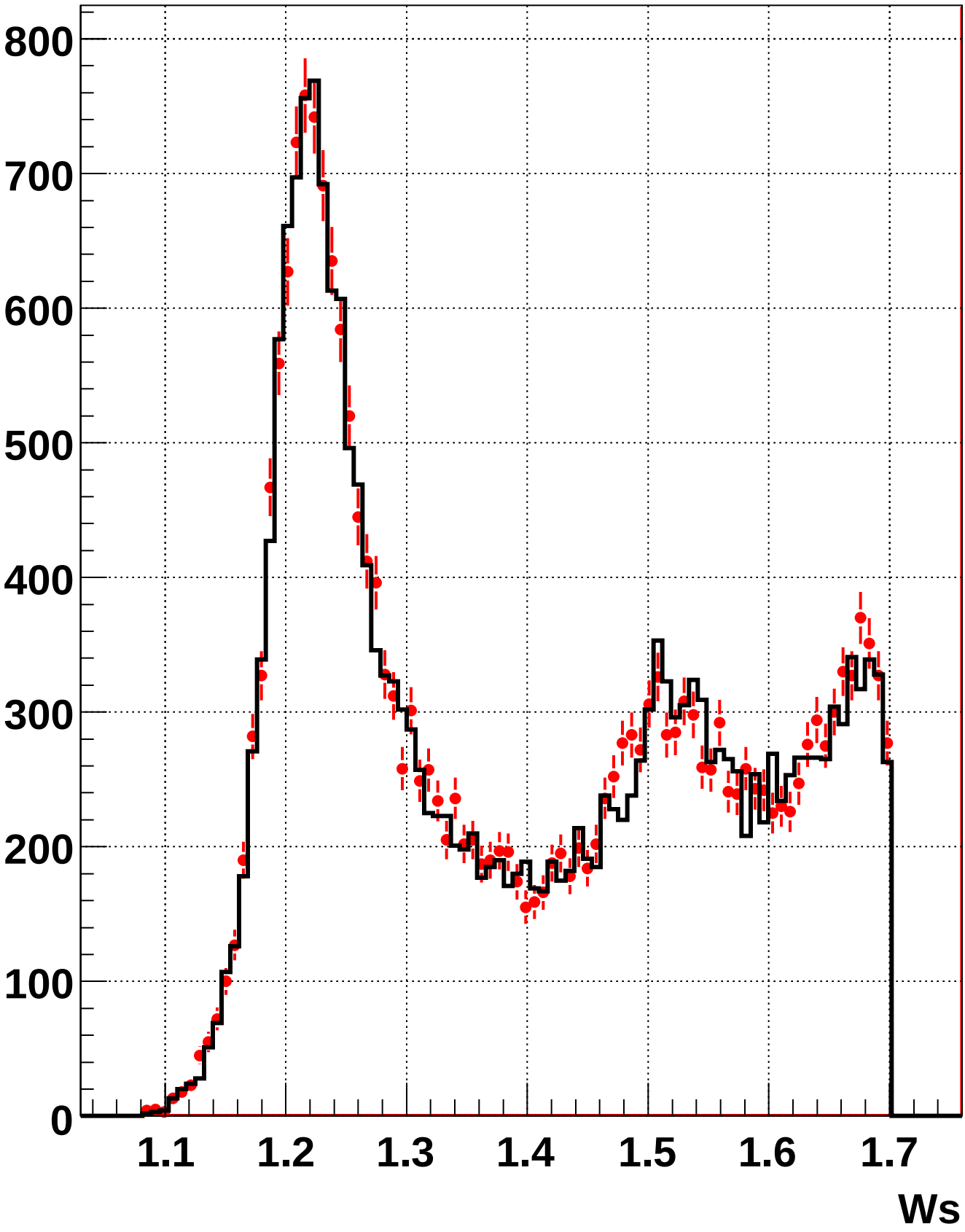


selected W for all events

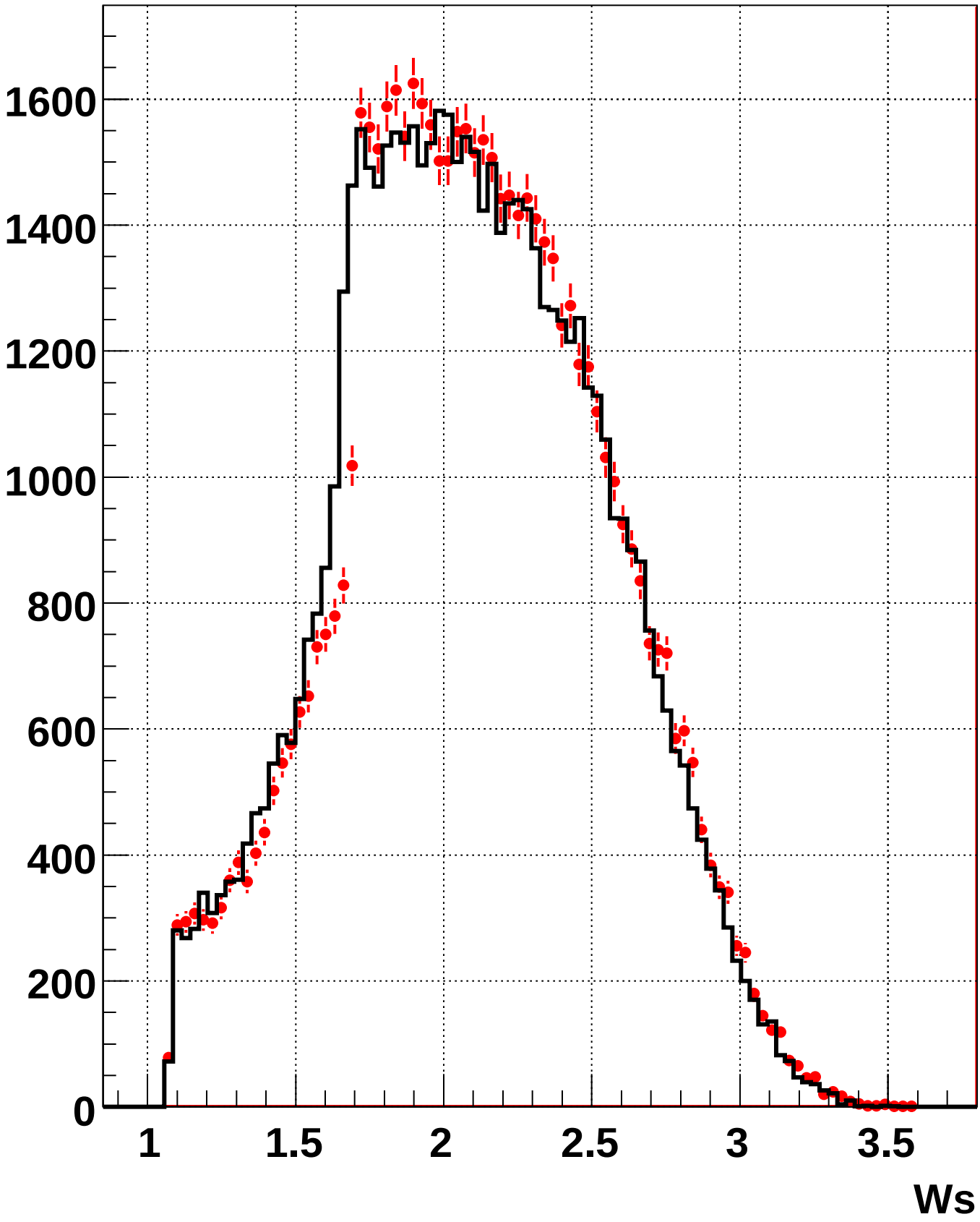



selected W for QEL events
10000
8000
6000
4000
2000
0
0.9382
0.9384
0.9386
0.9388
0.939
0.9392
0.9394
0.9396
Ws

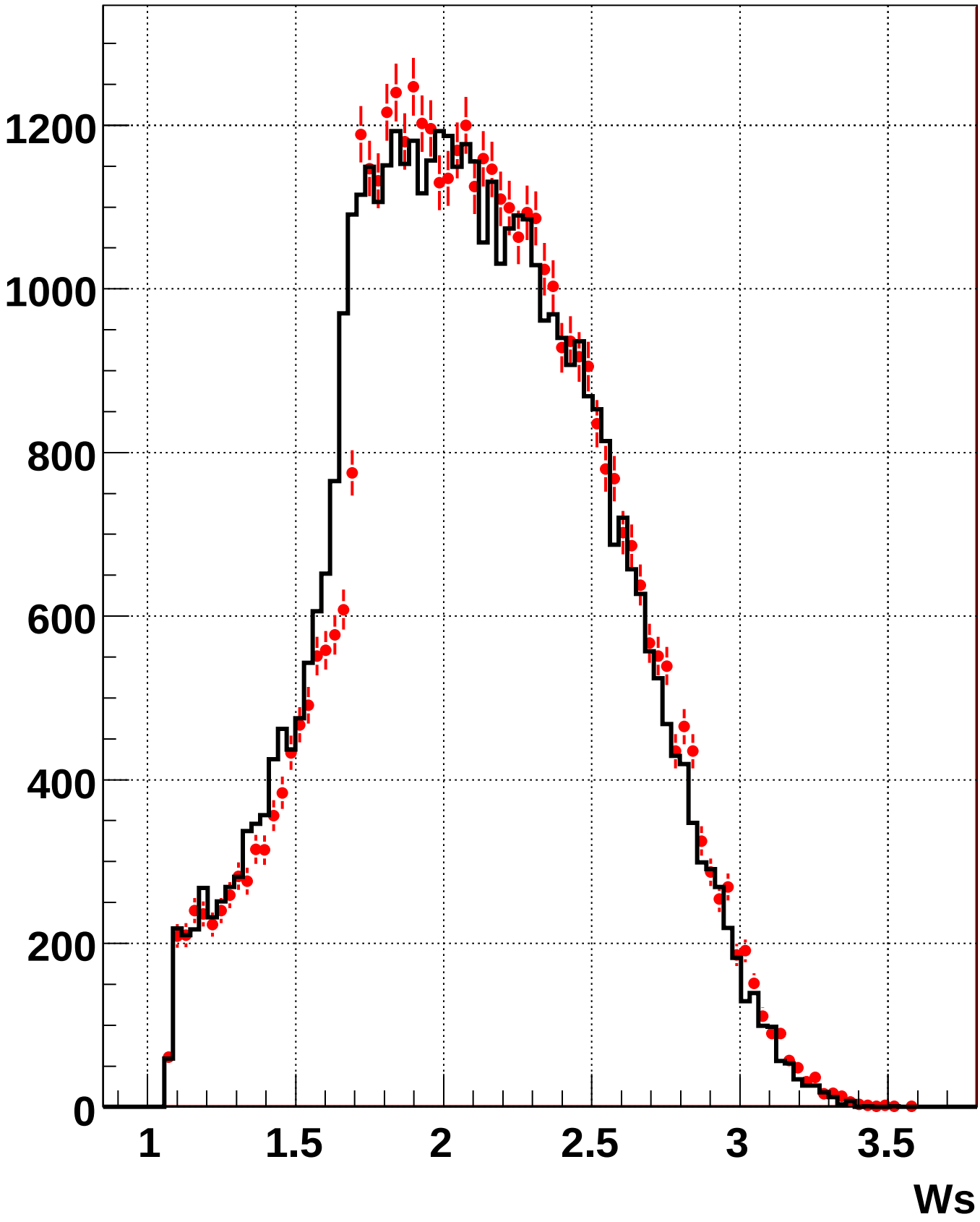
selected W for RES events



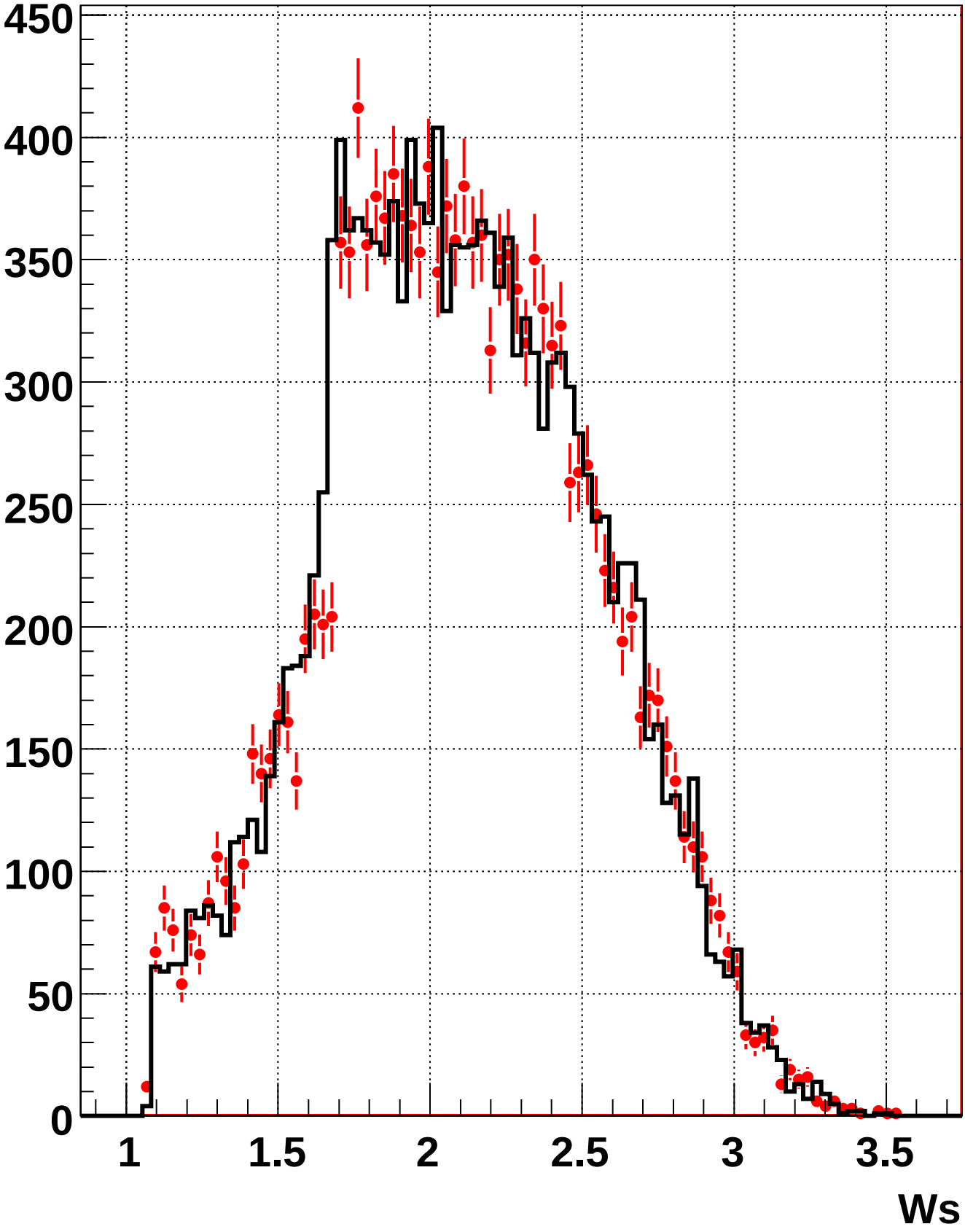
selected W for DIS events



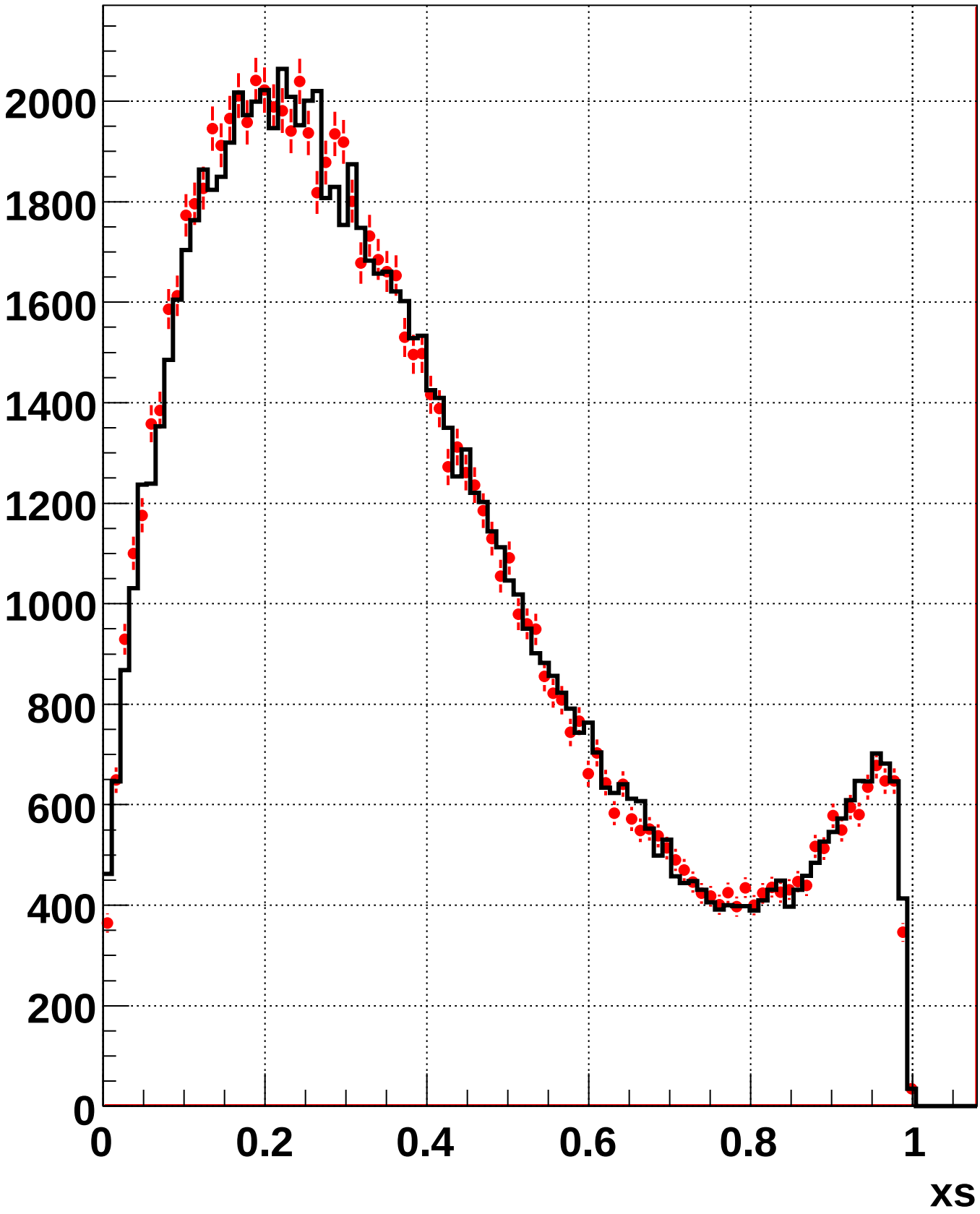
selected W for DIS CC events



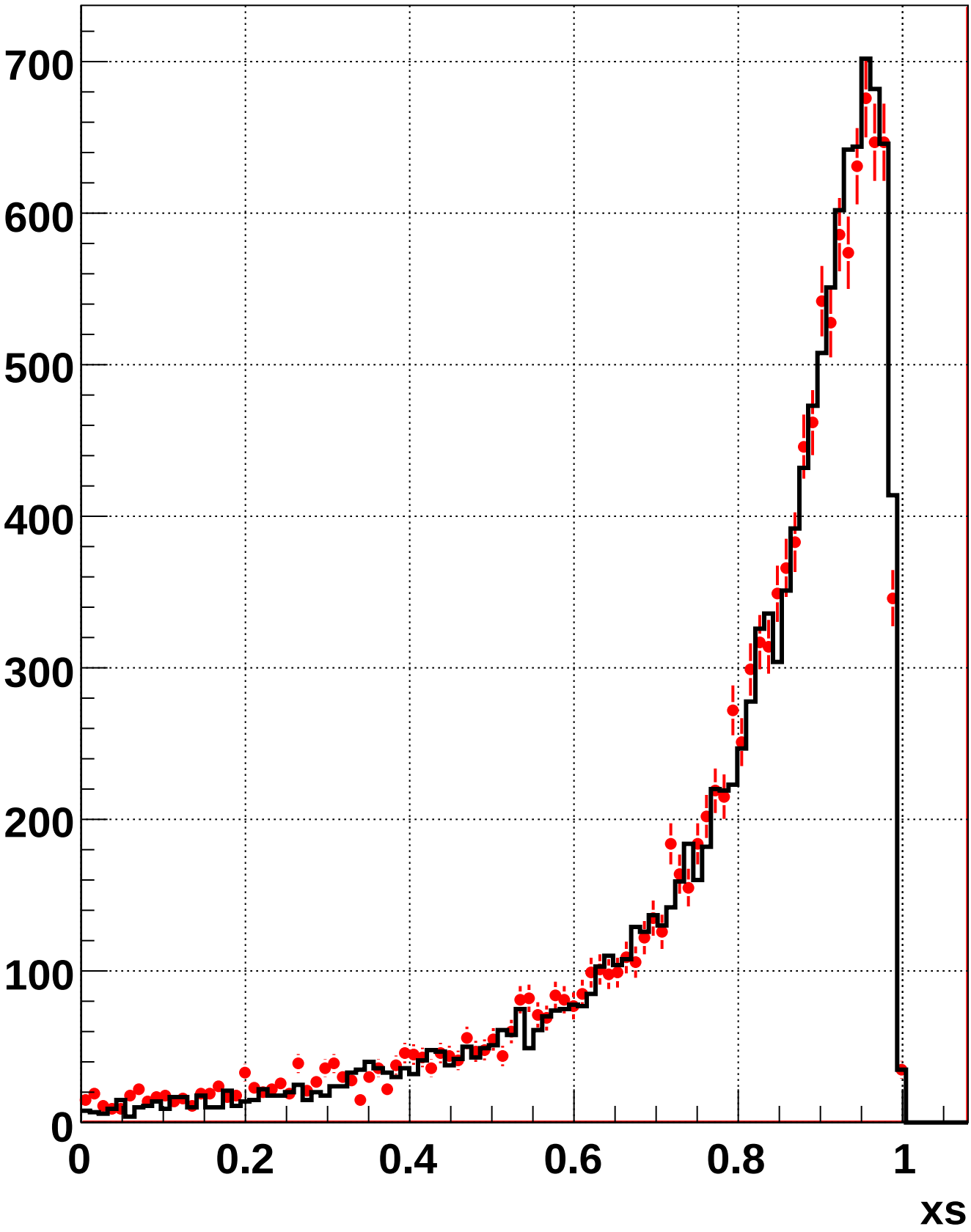
selected W for DIS NC events



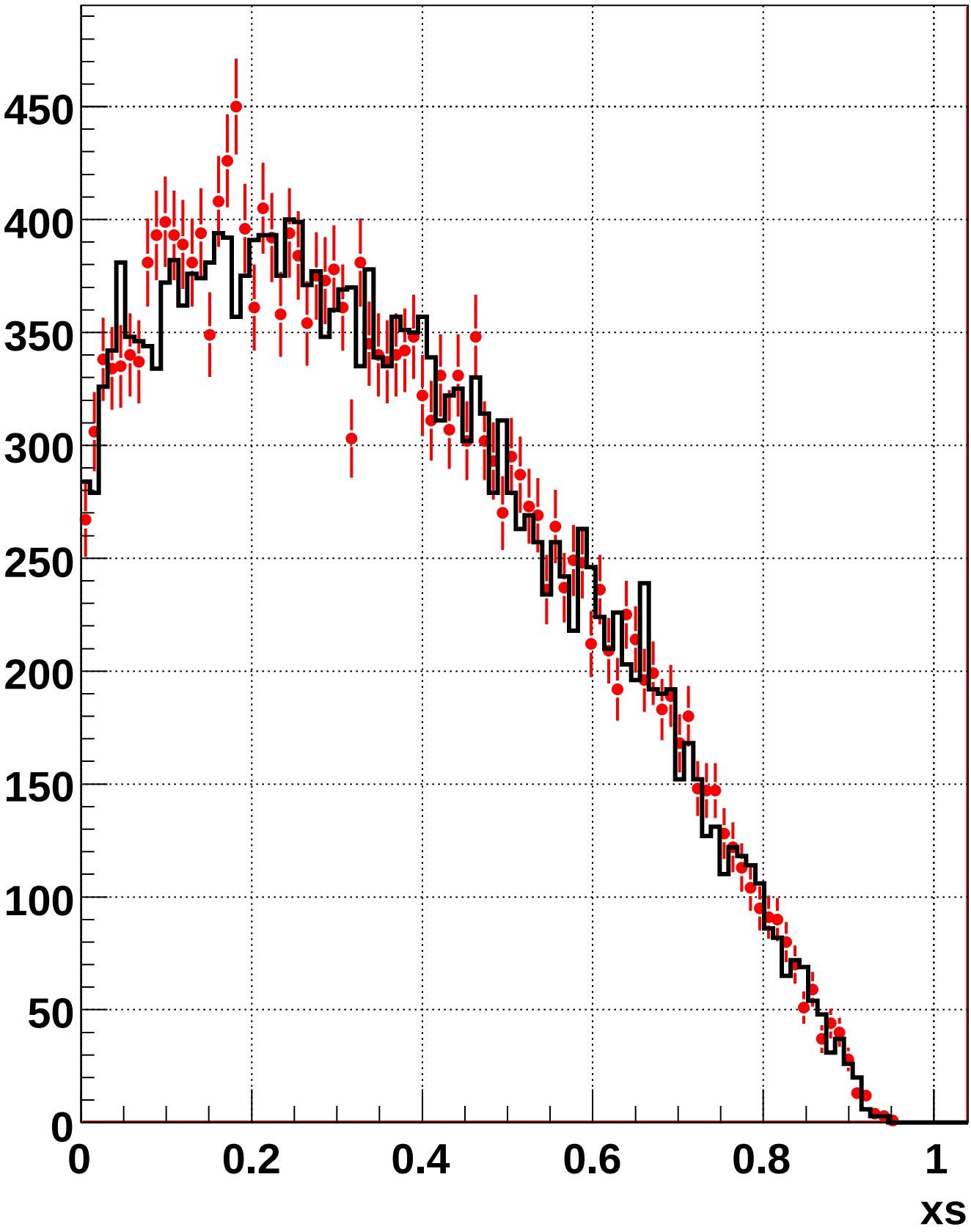
selected x for all events



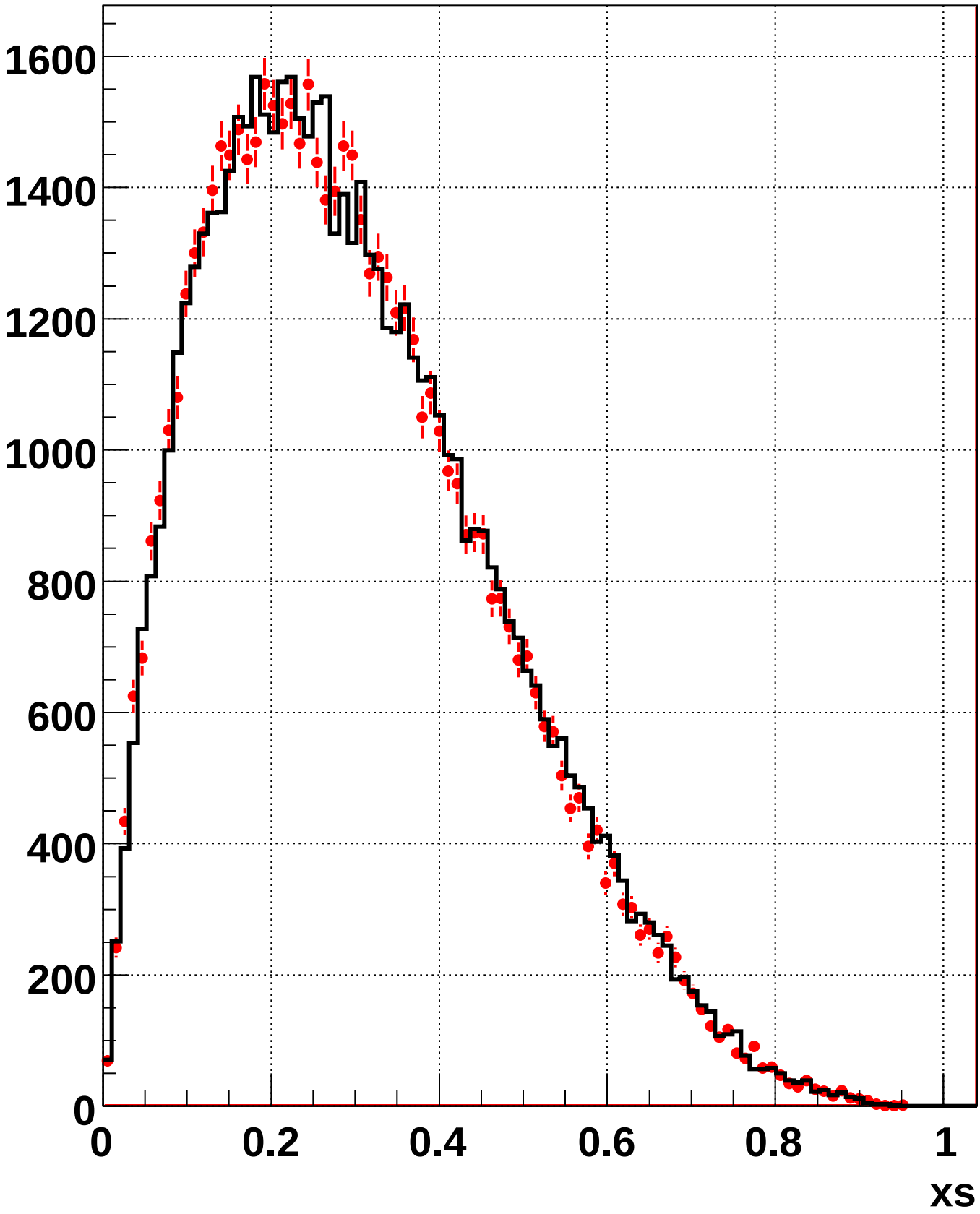
selected x for QEL events



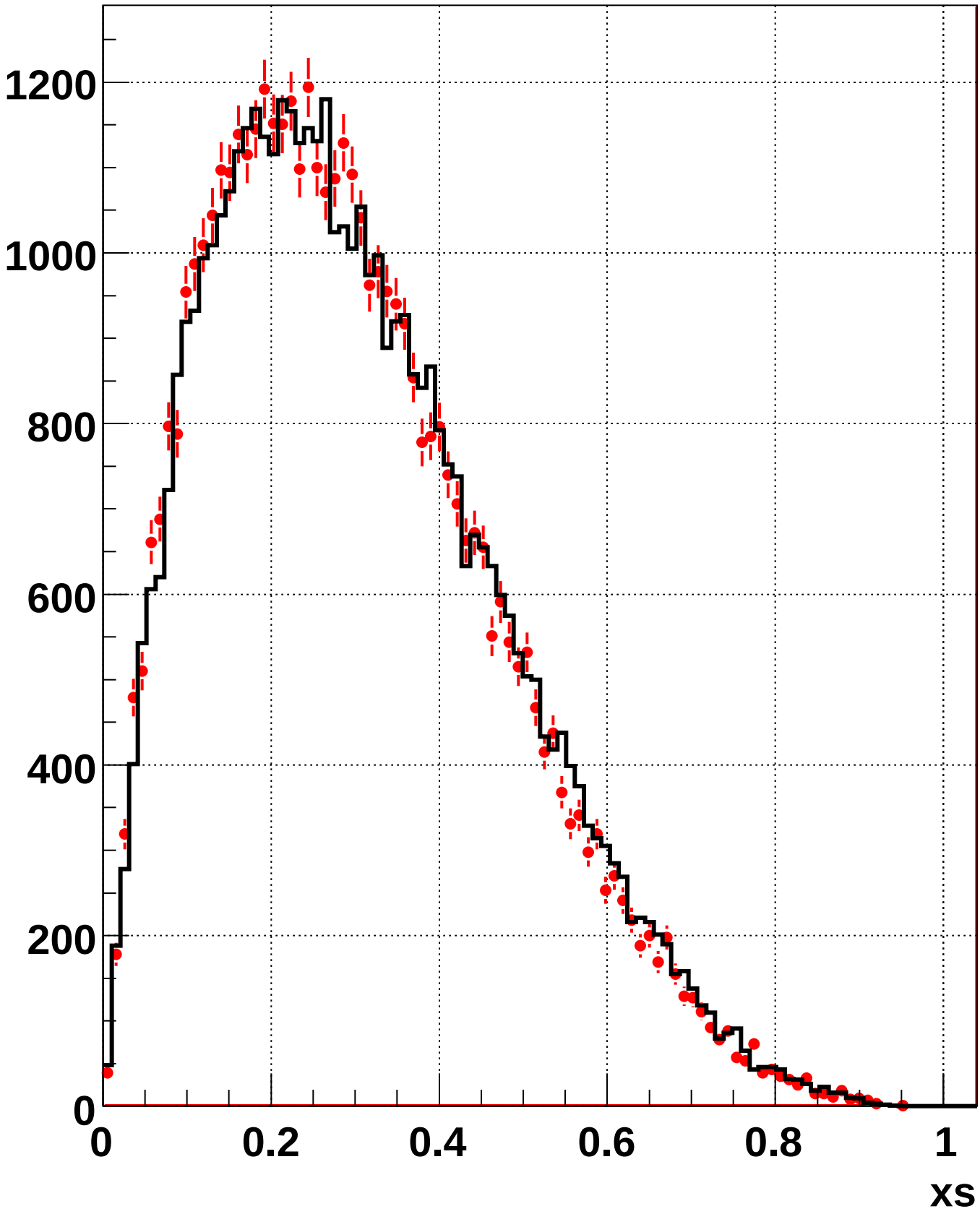
selected x for RES events



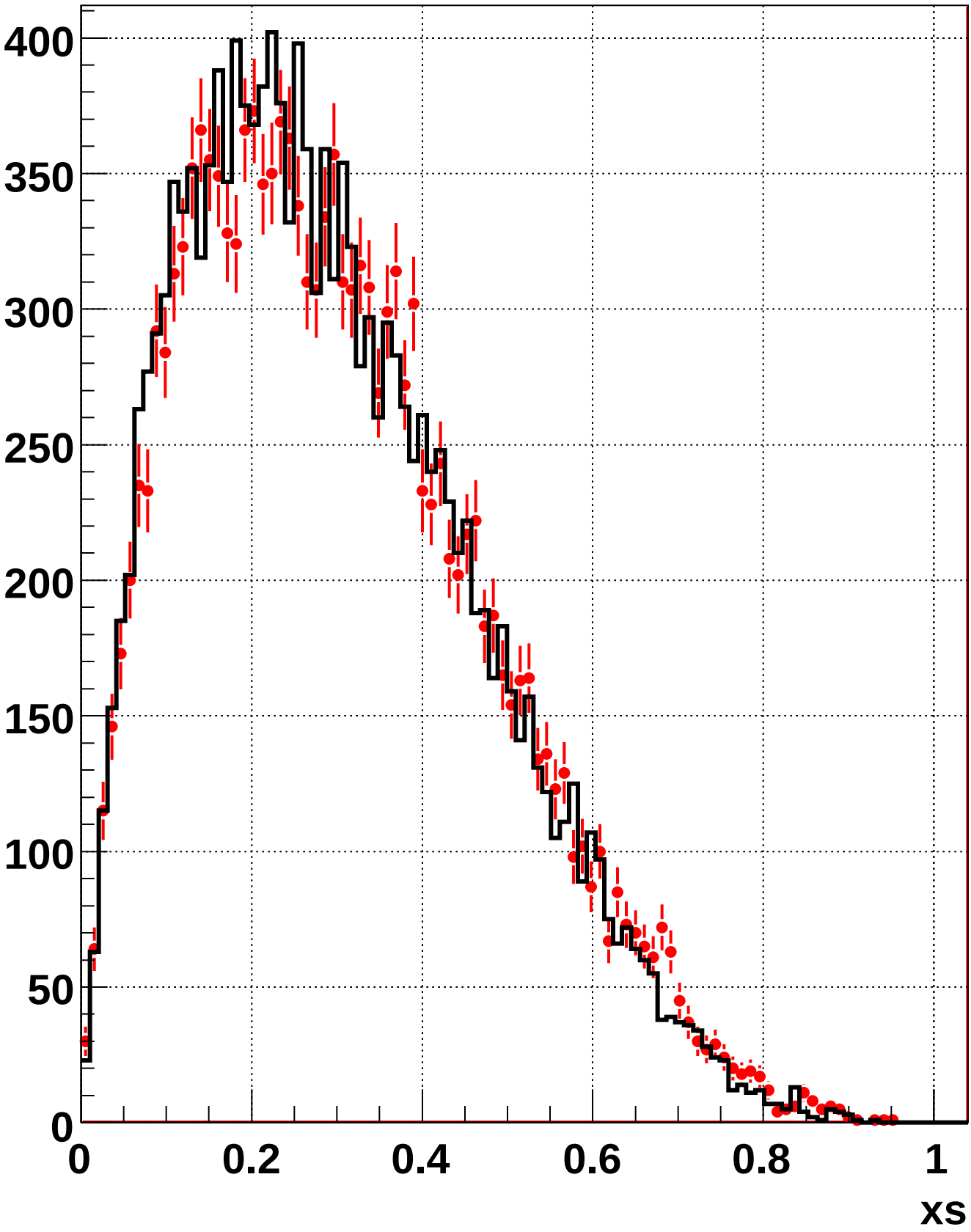
selected x for DIS events



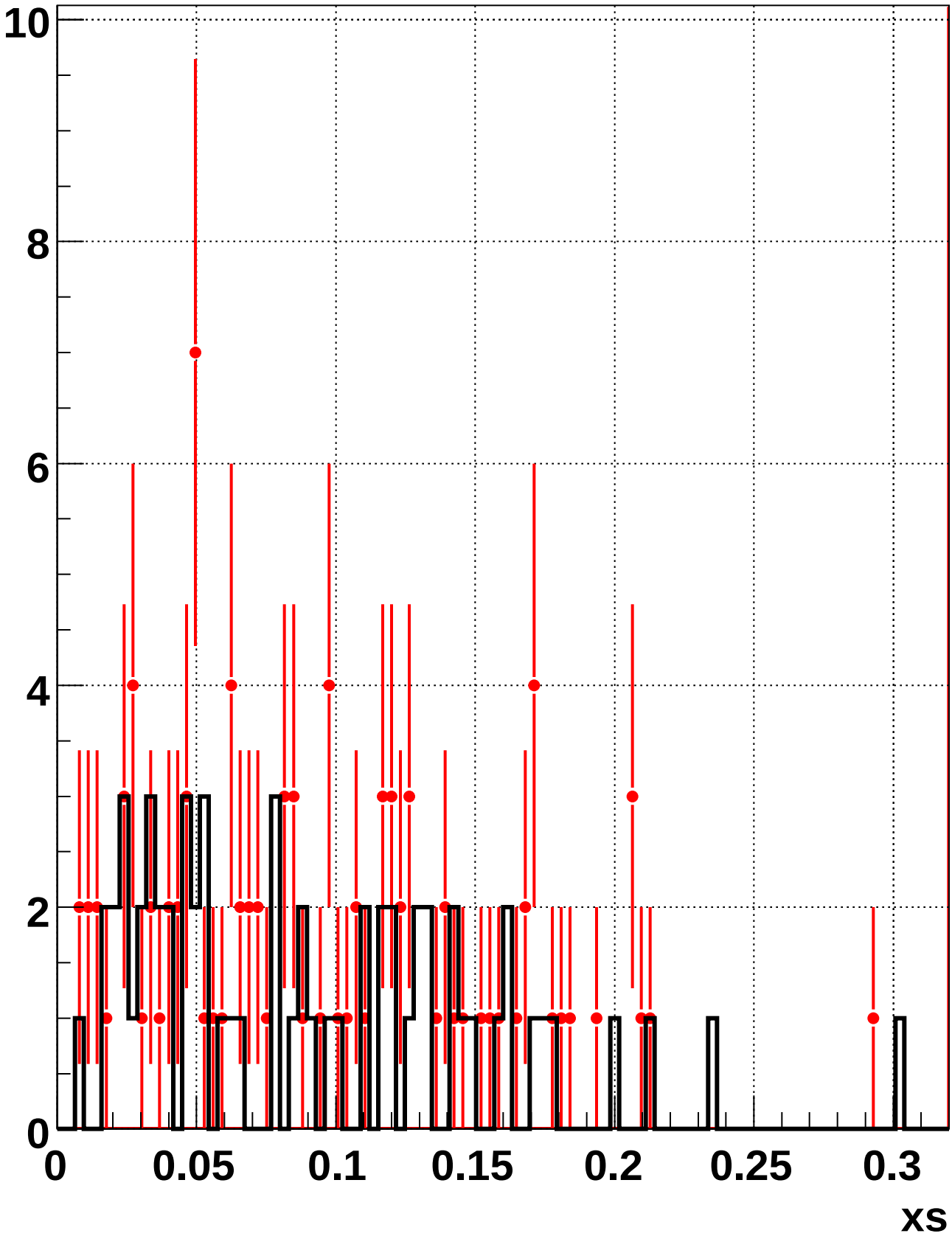
selected x for DIS CC events



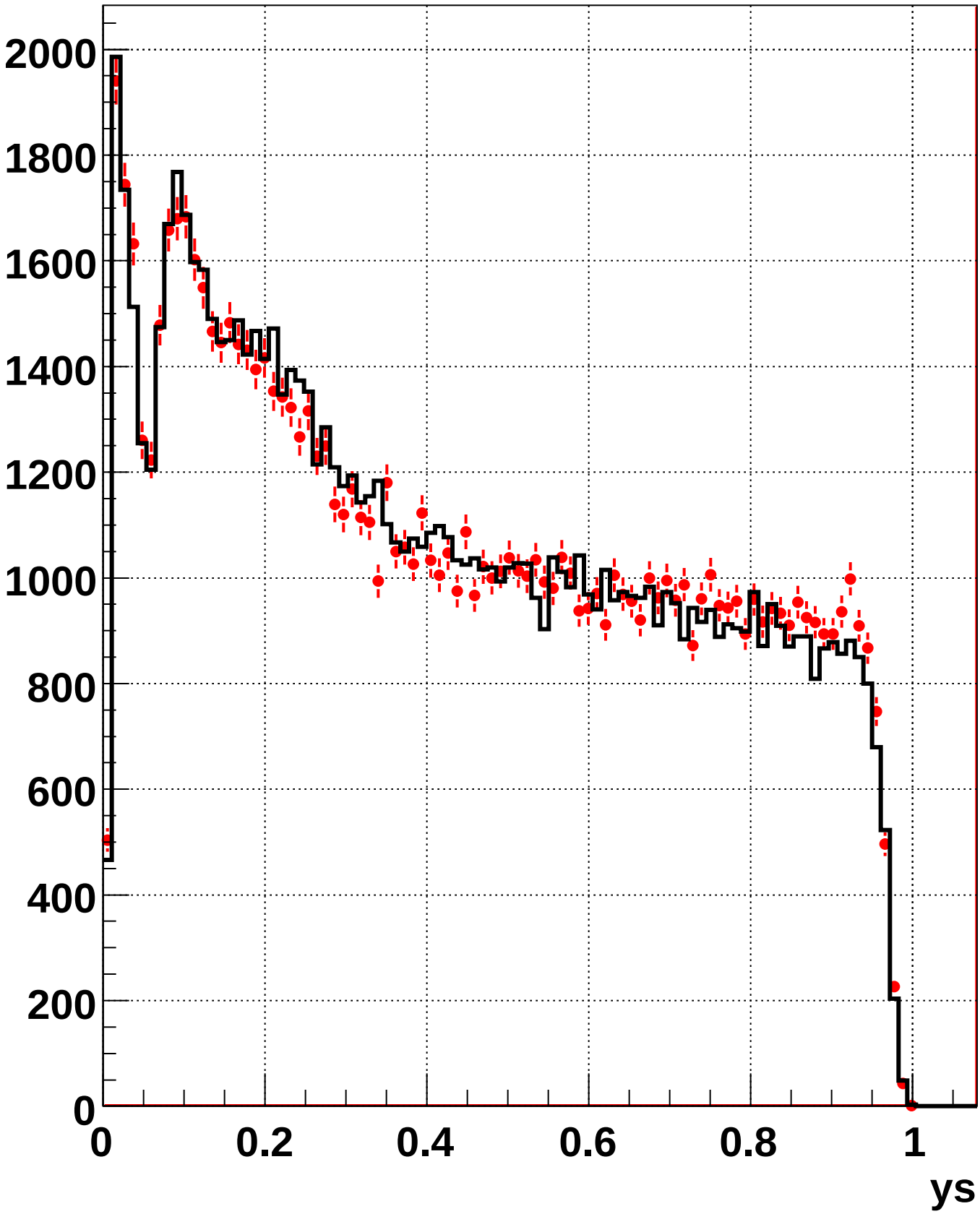
selected x for DIS NC events



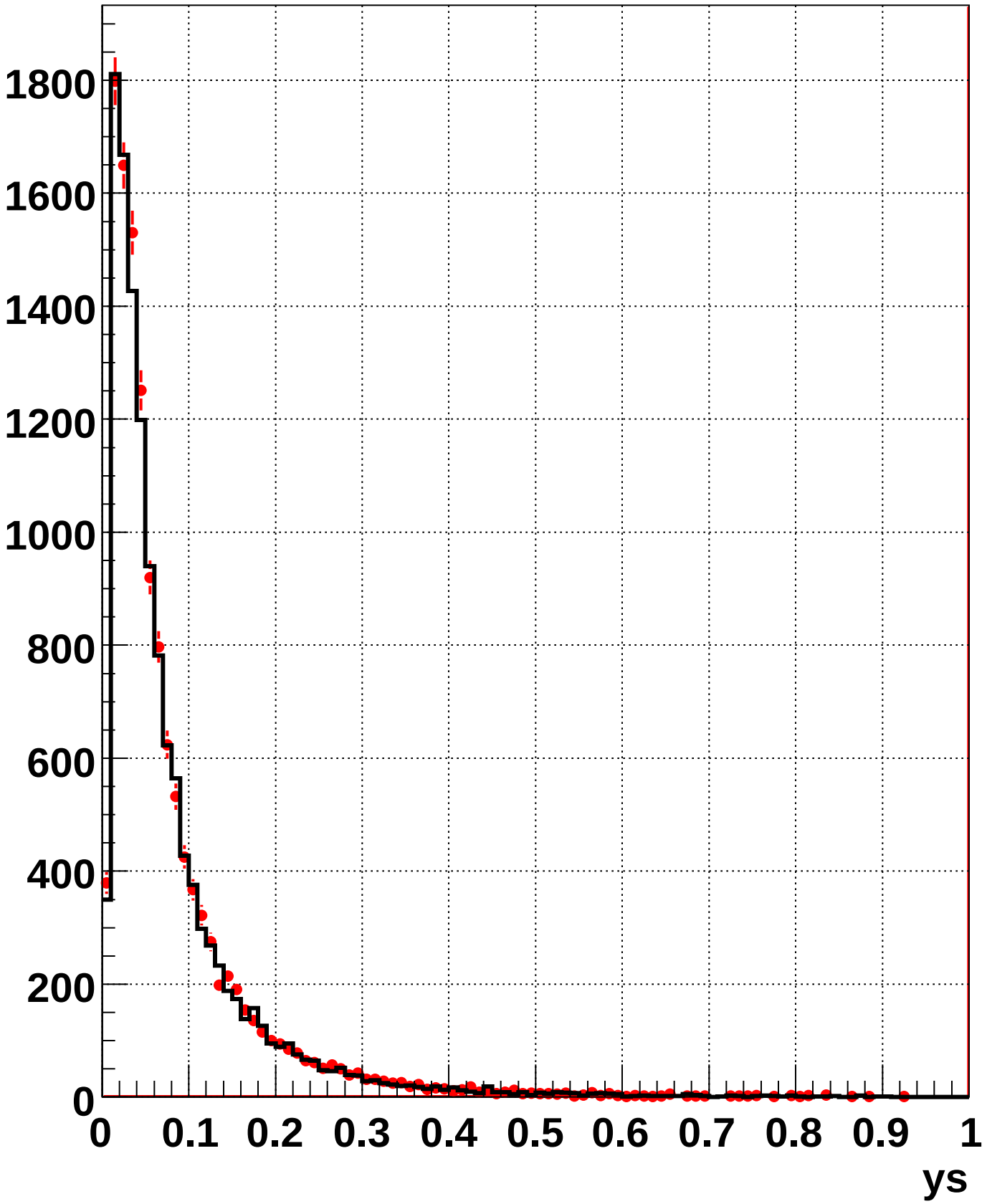
selected x for Charm/DIS events



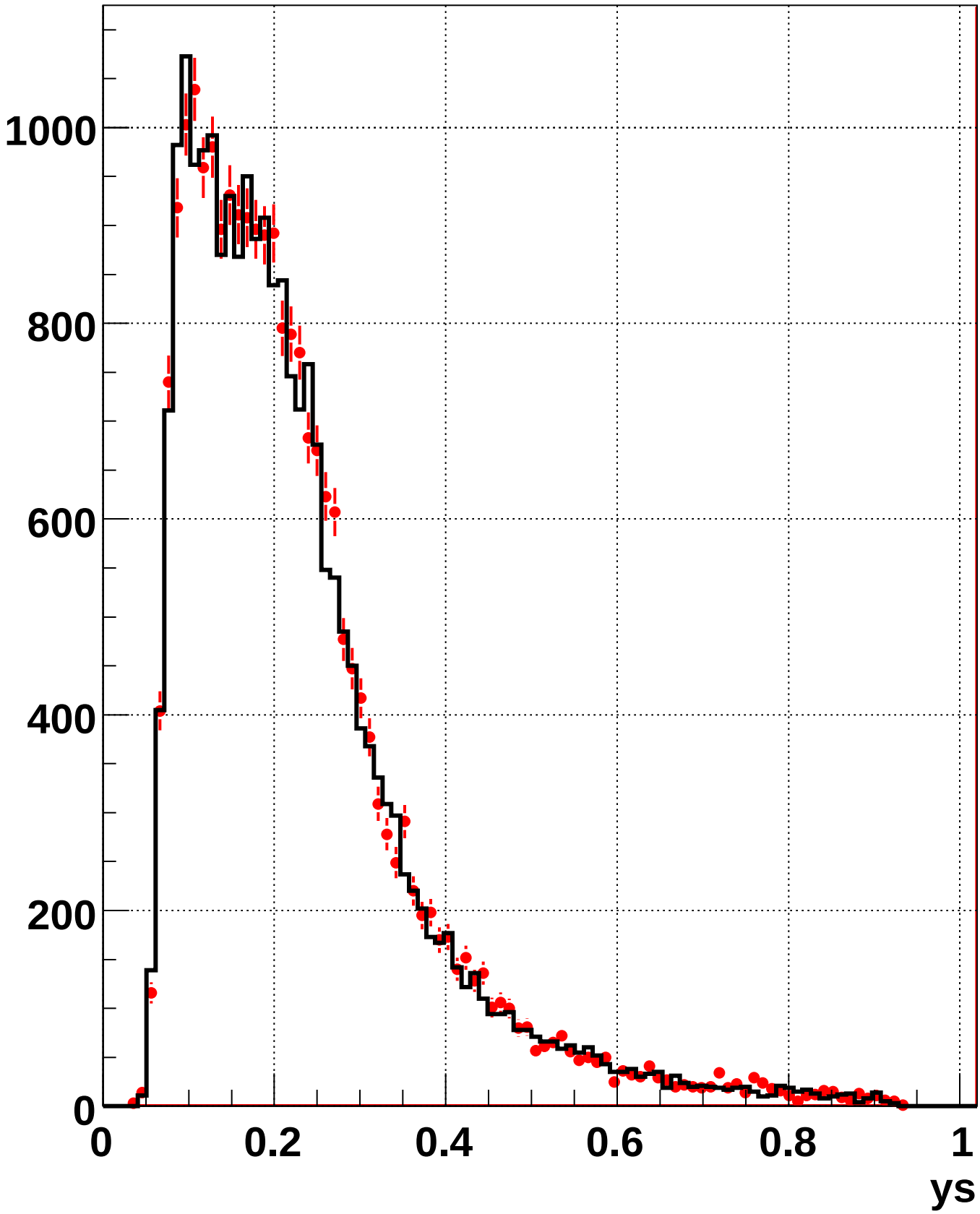
selected y for all events



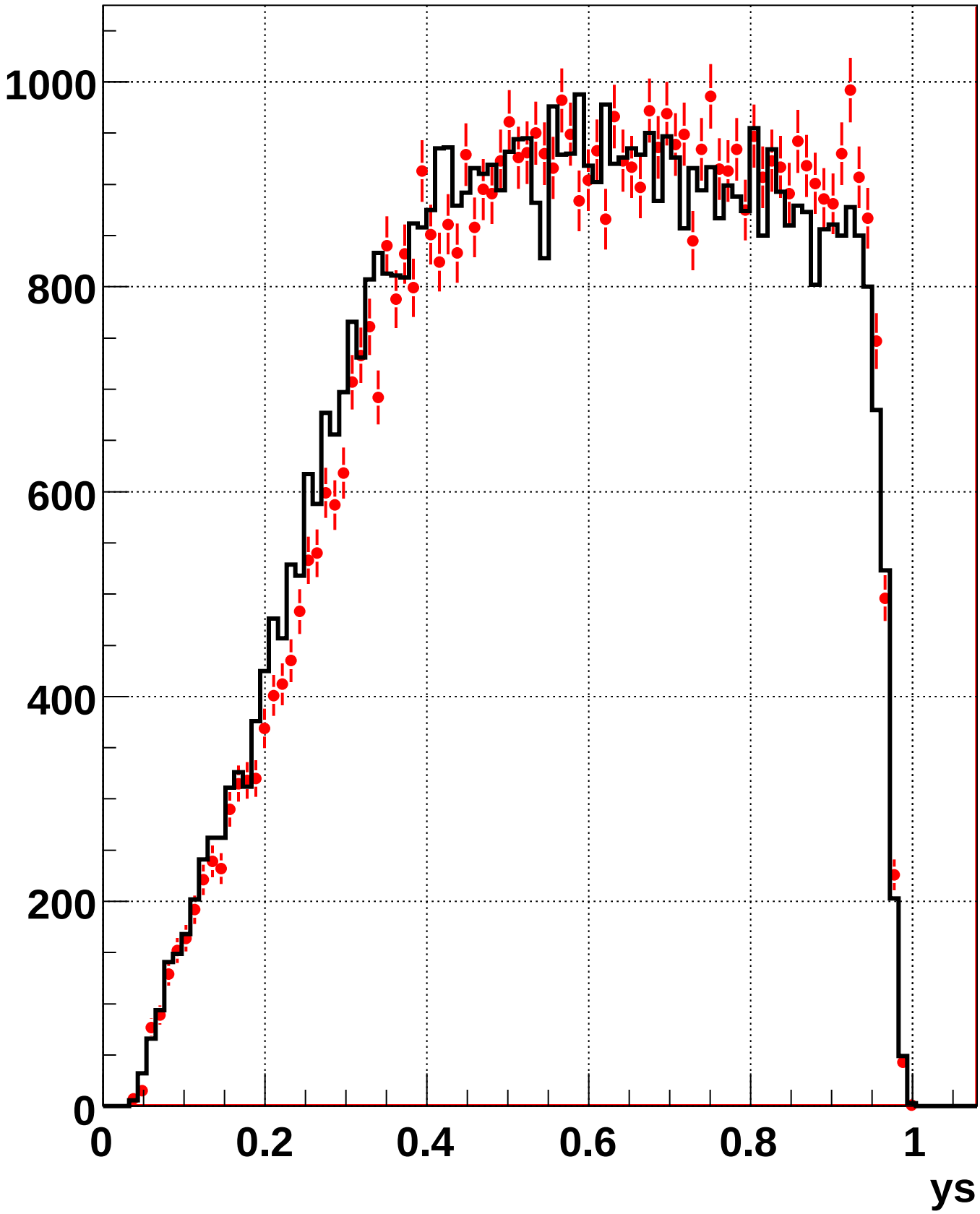
selected y for QEL events



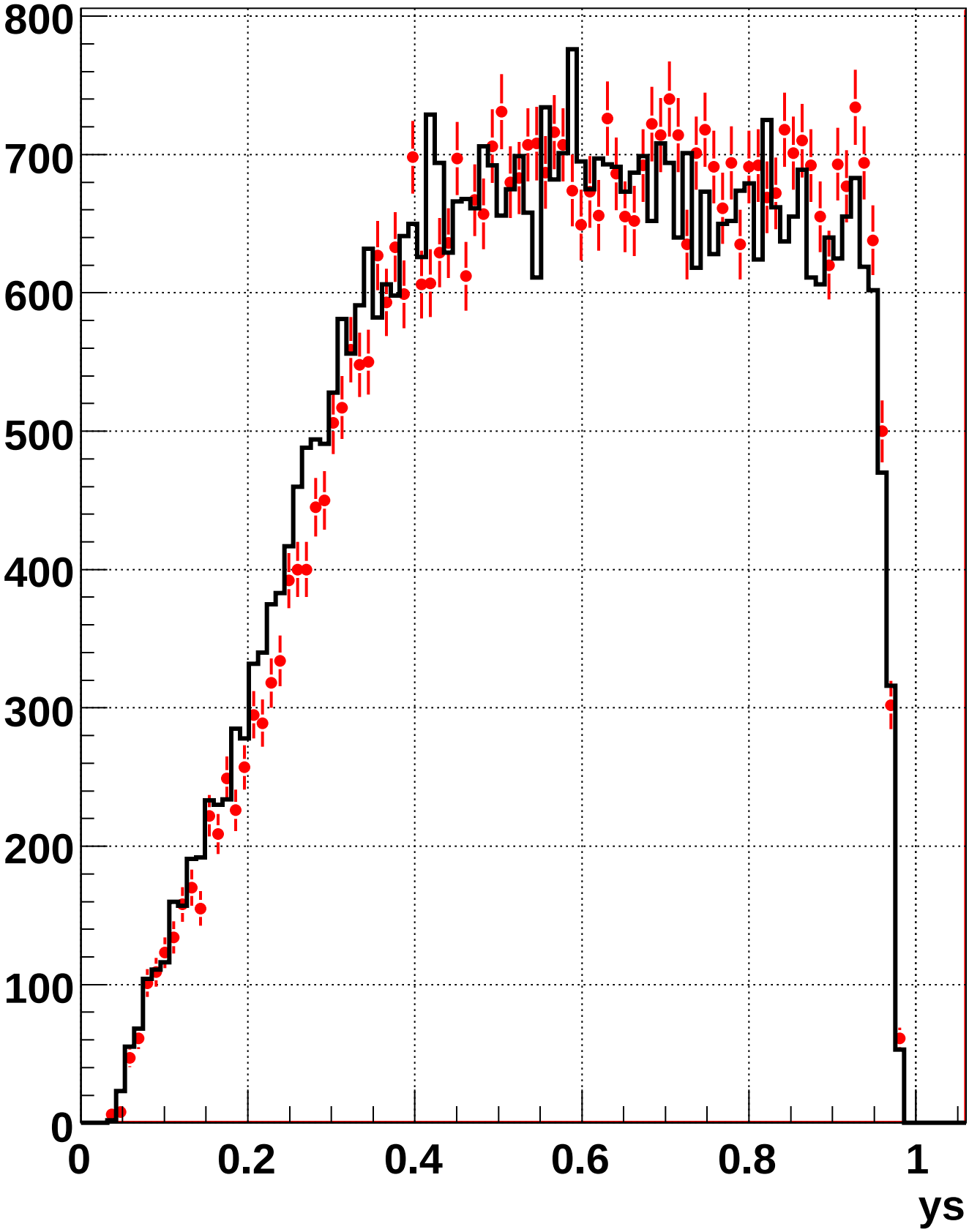
selected y for RES events



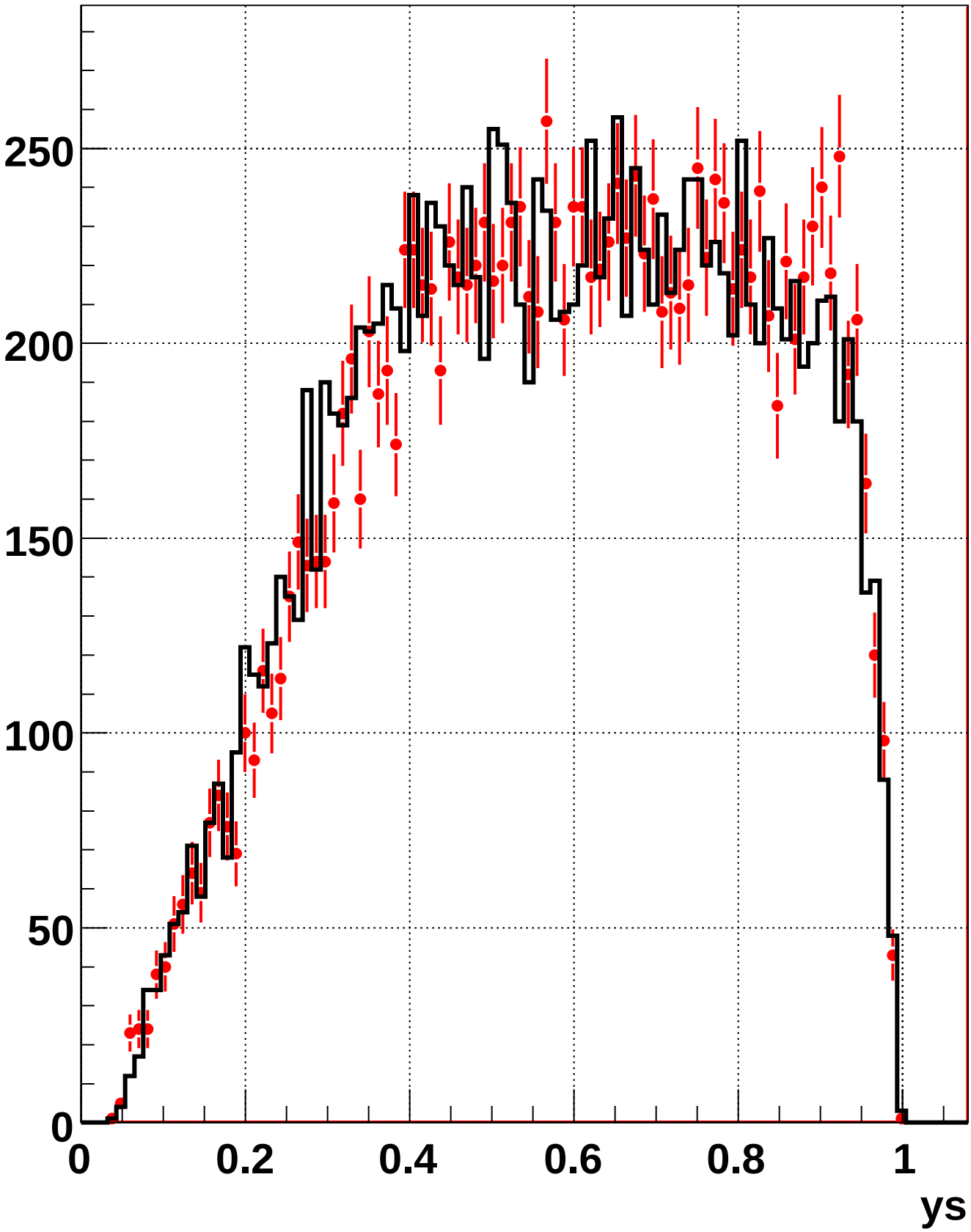
selected y for DIS events



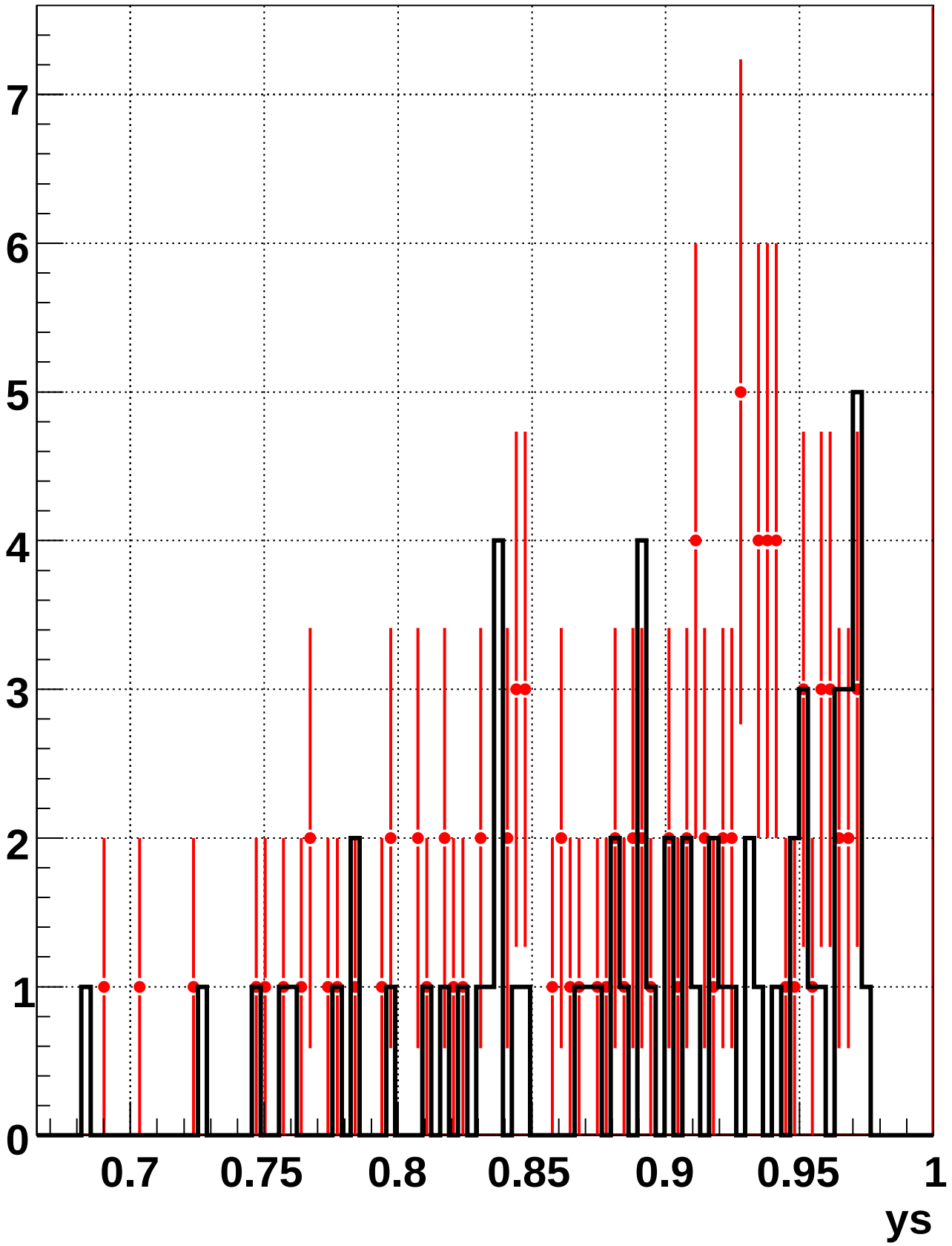
selected y for DIS CC events



selected y for DIS NC events



selected y for Charm/DIS events

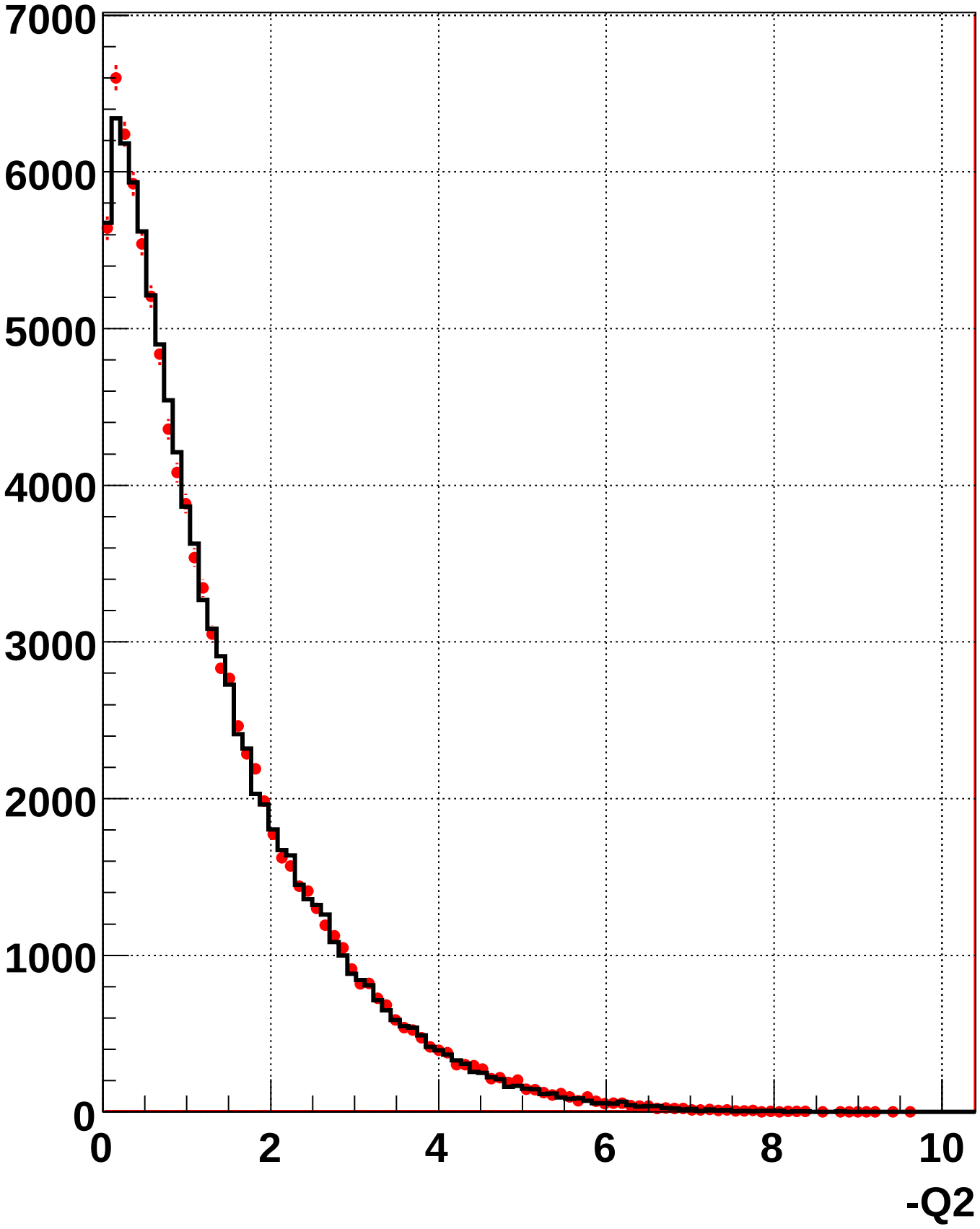


Kinematical Quantities

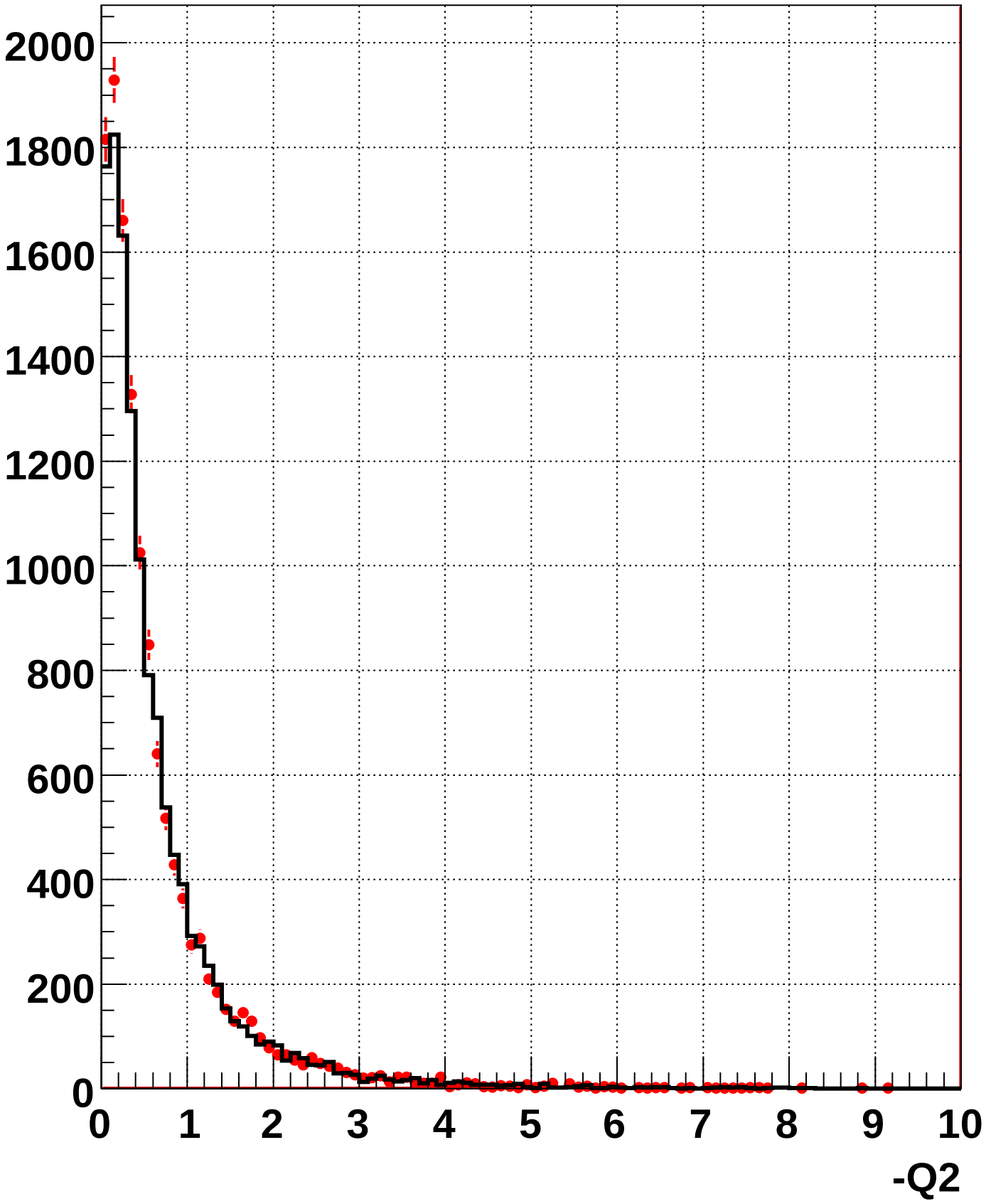
Similar to the previous set of plots but

showing ’computed’ rathen than ’selected’ variables

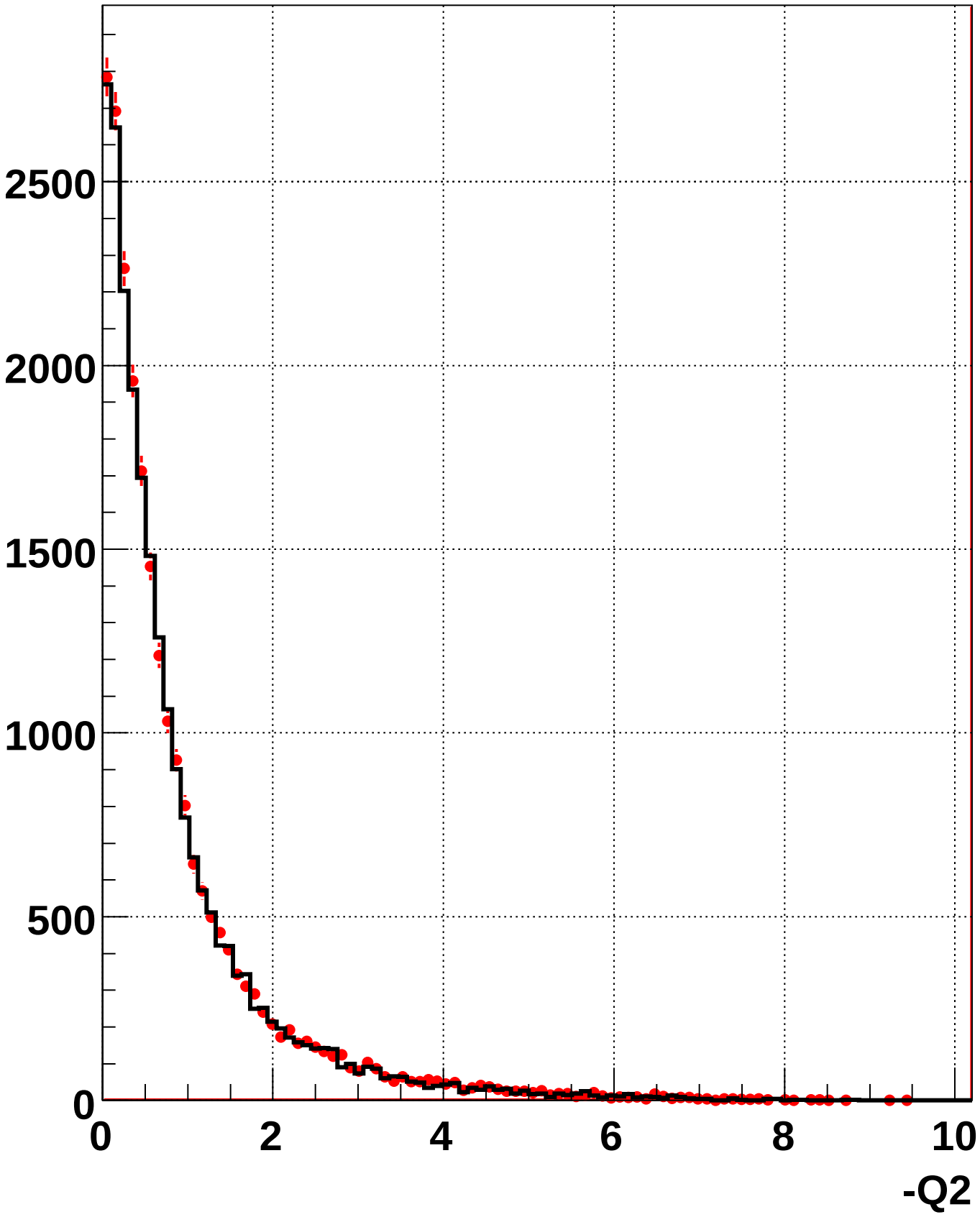
computed Q2 for all events



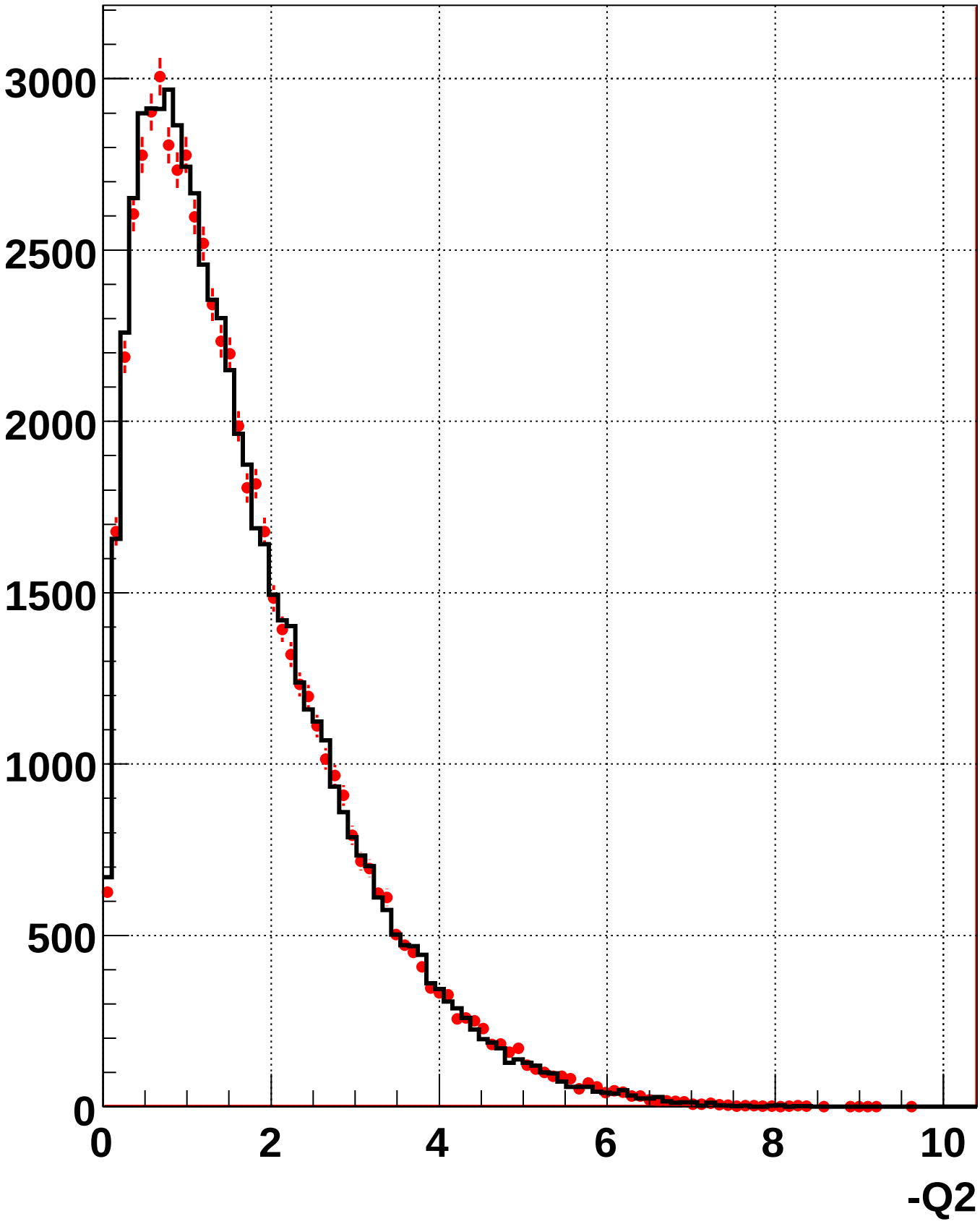
computed Q2 for QEL events



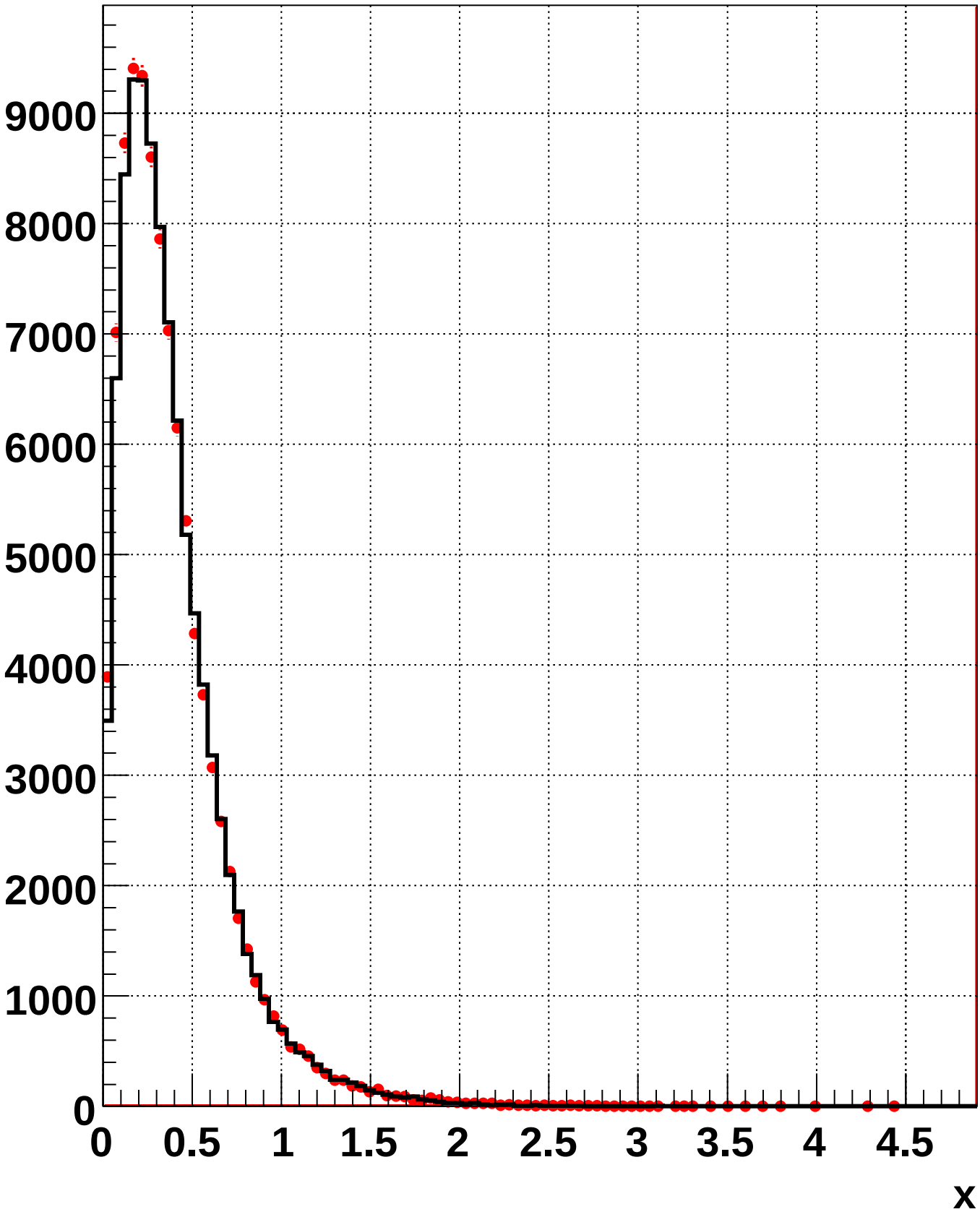
computed Q2 for RES events



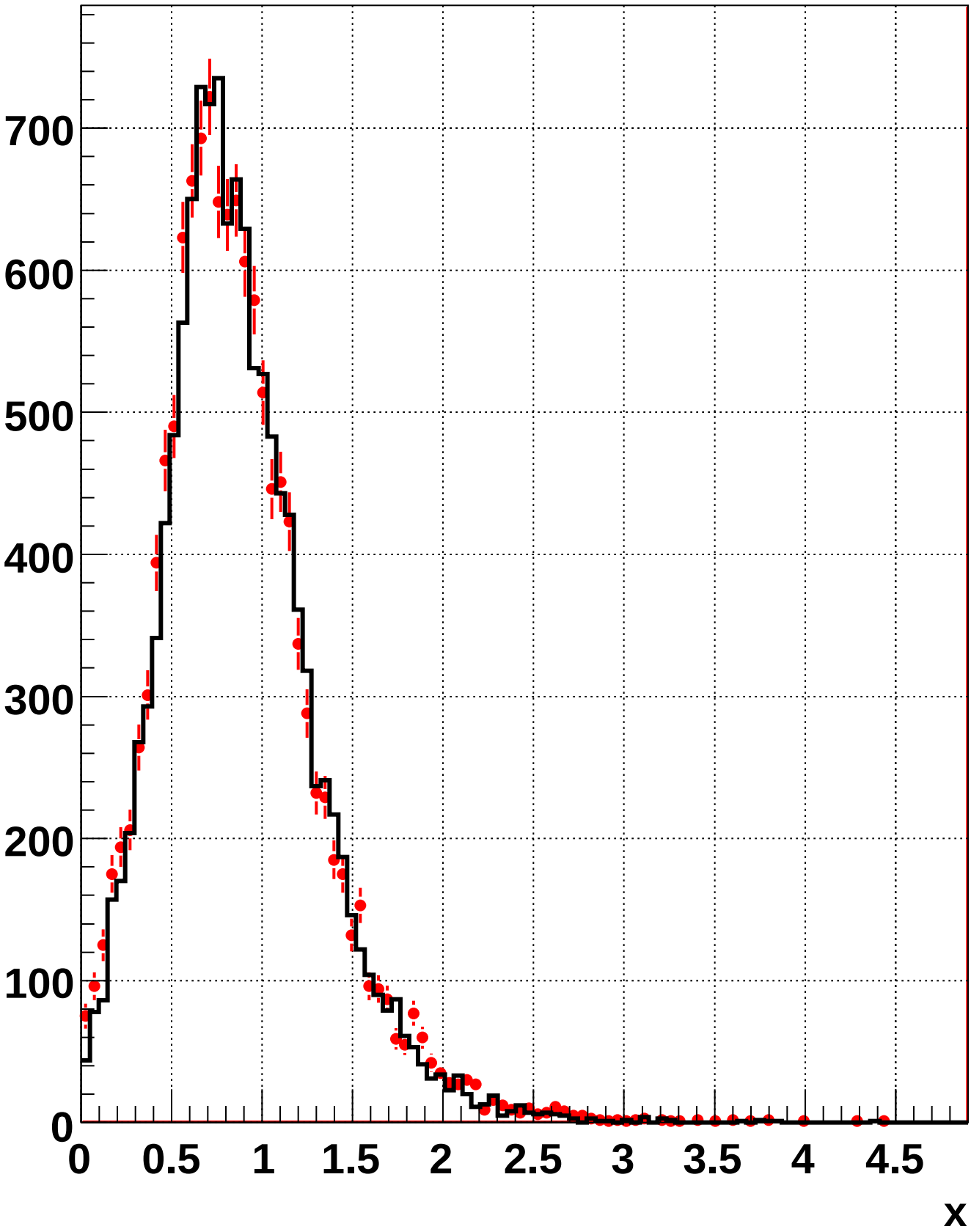
computed Q2 for DIS events



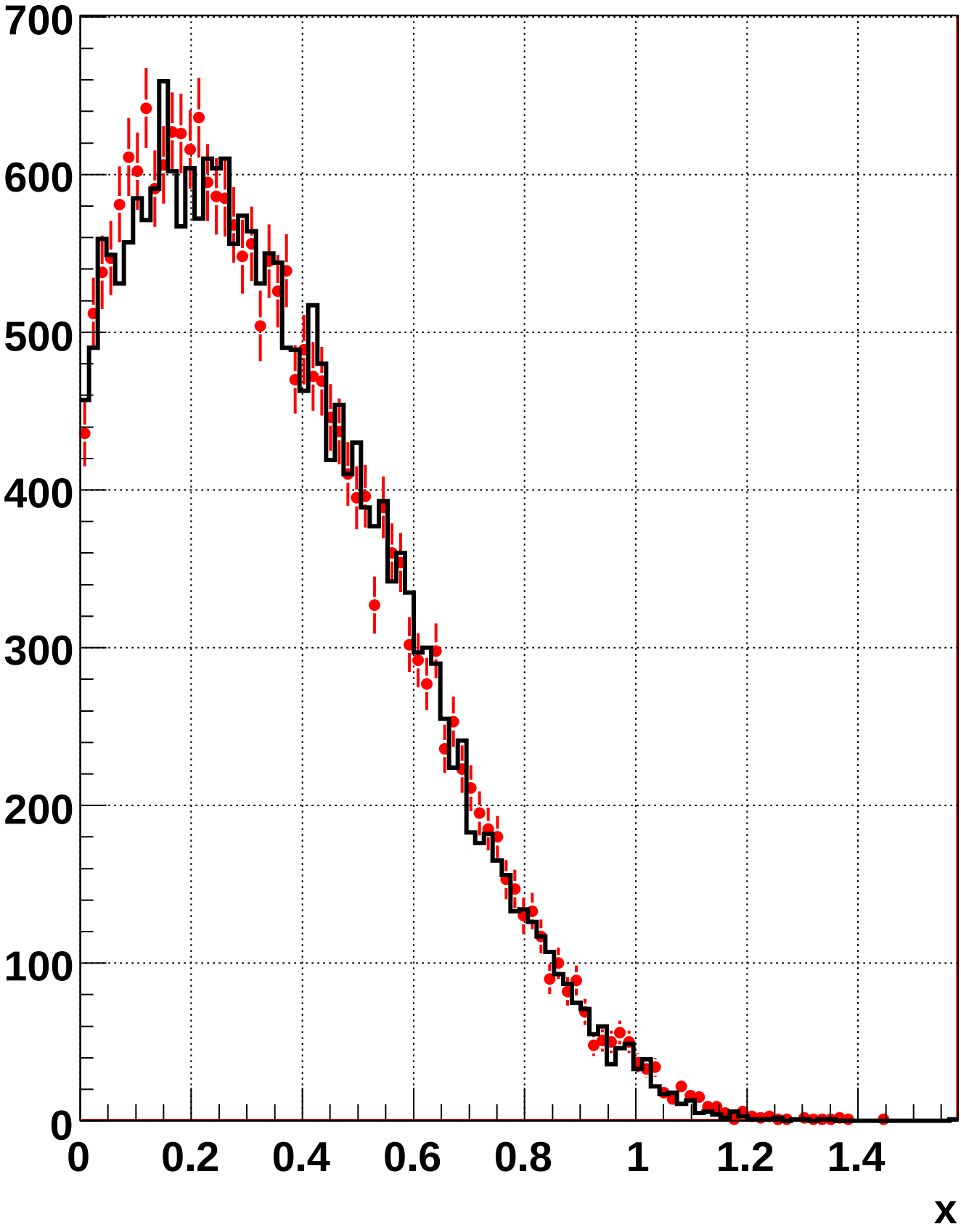
computed x for all events



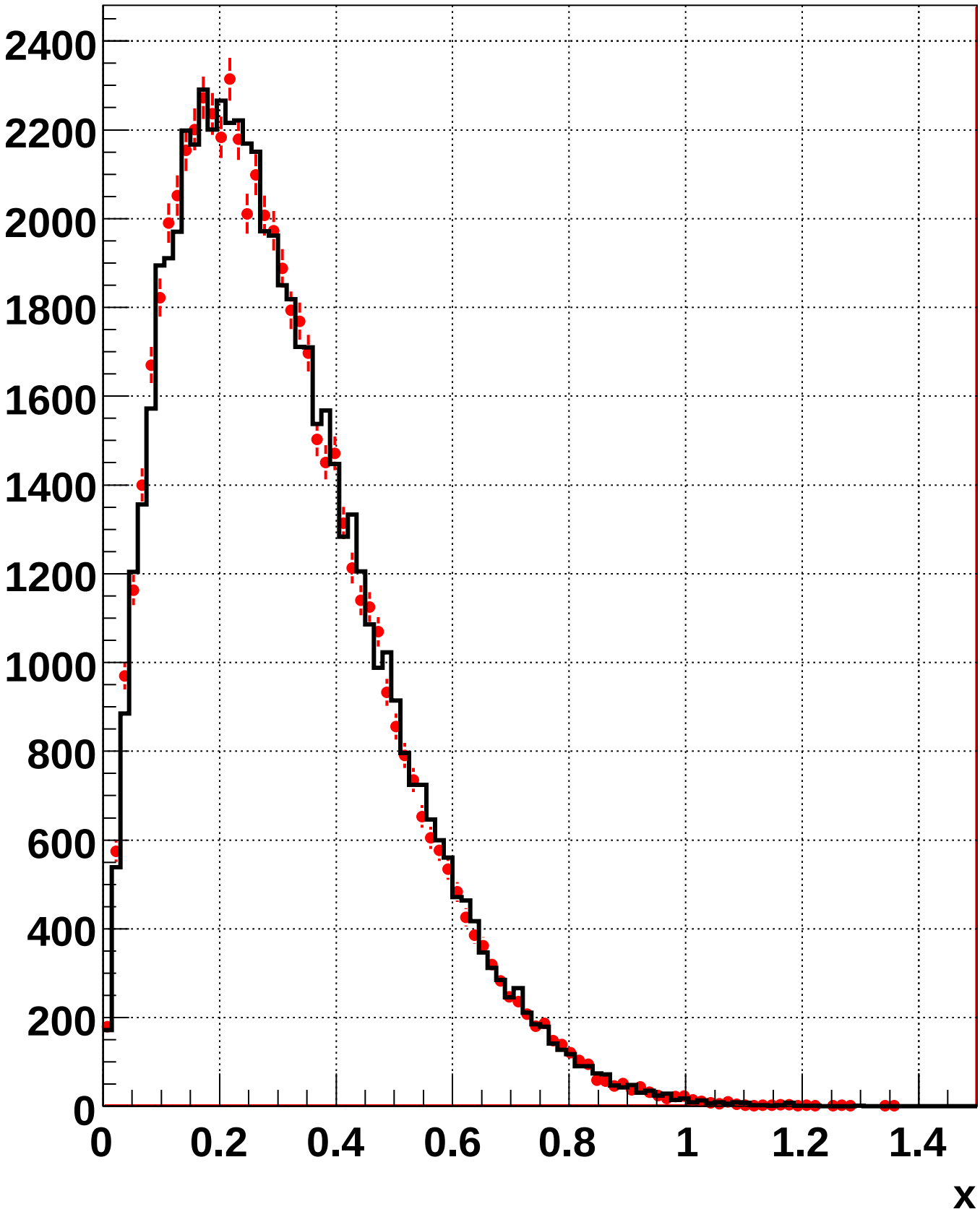
computed x for QEL events



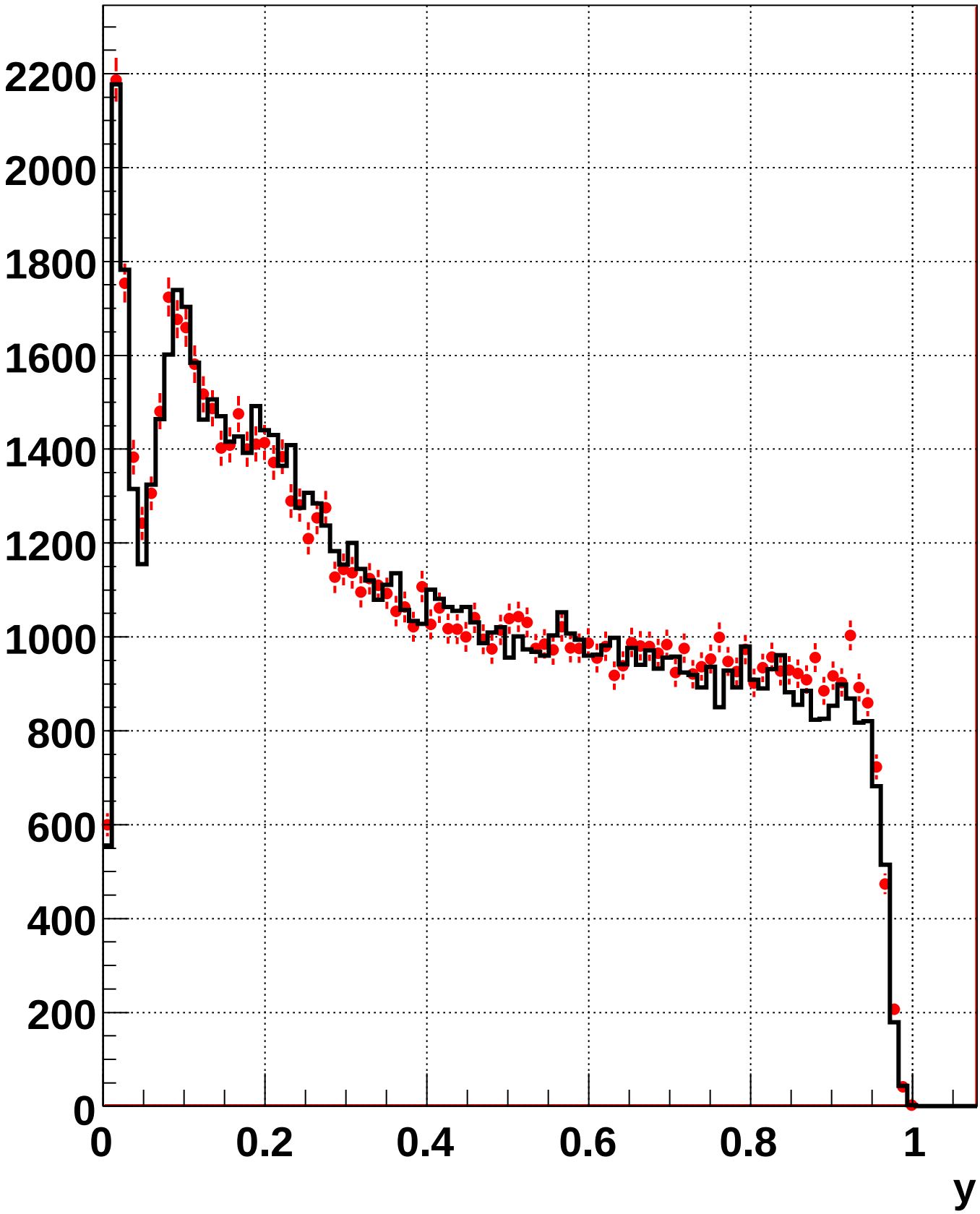
computed x for RES events



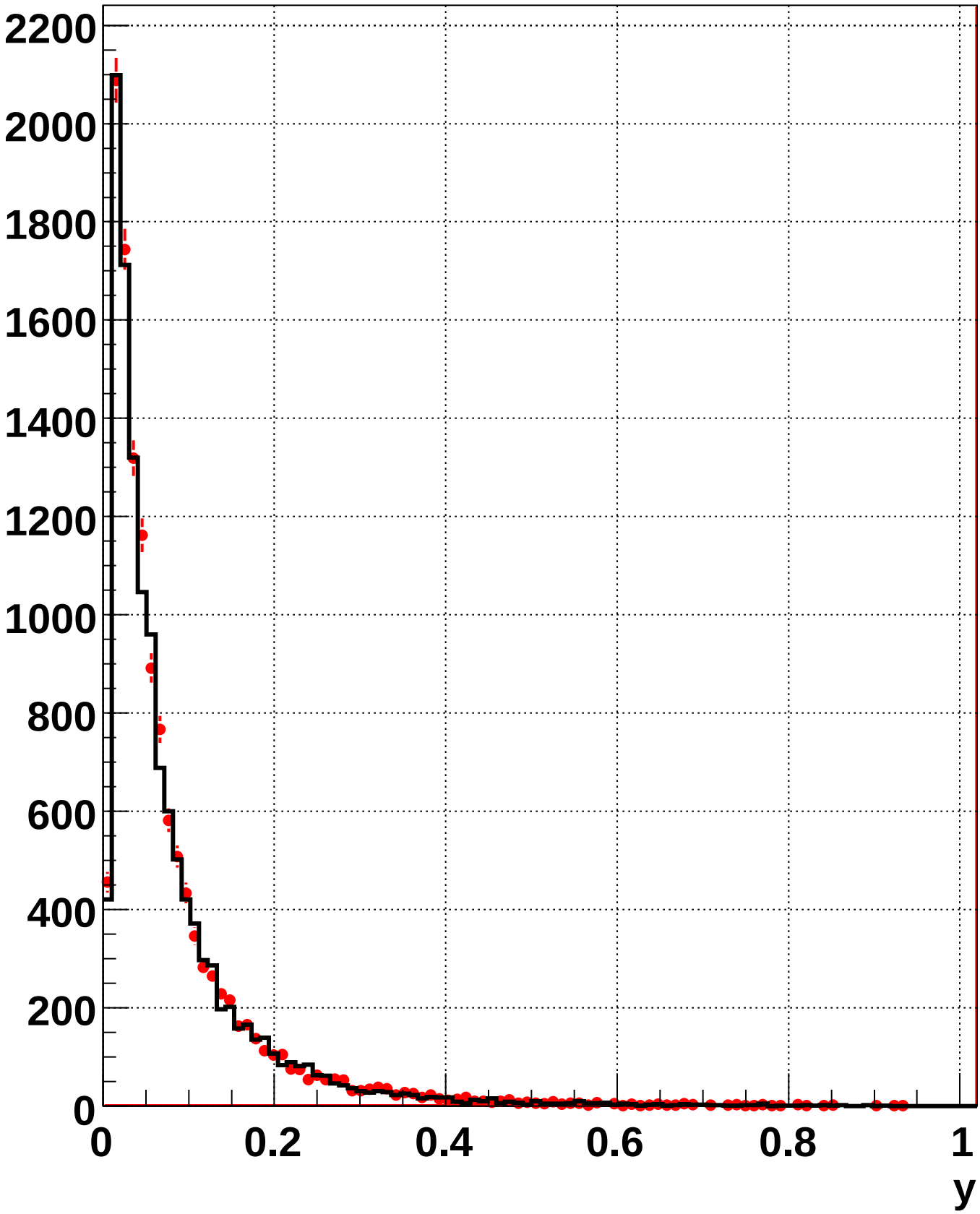
computed x for DIS events

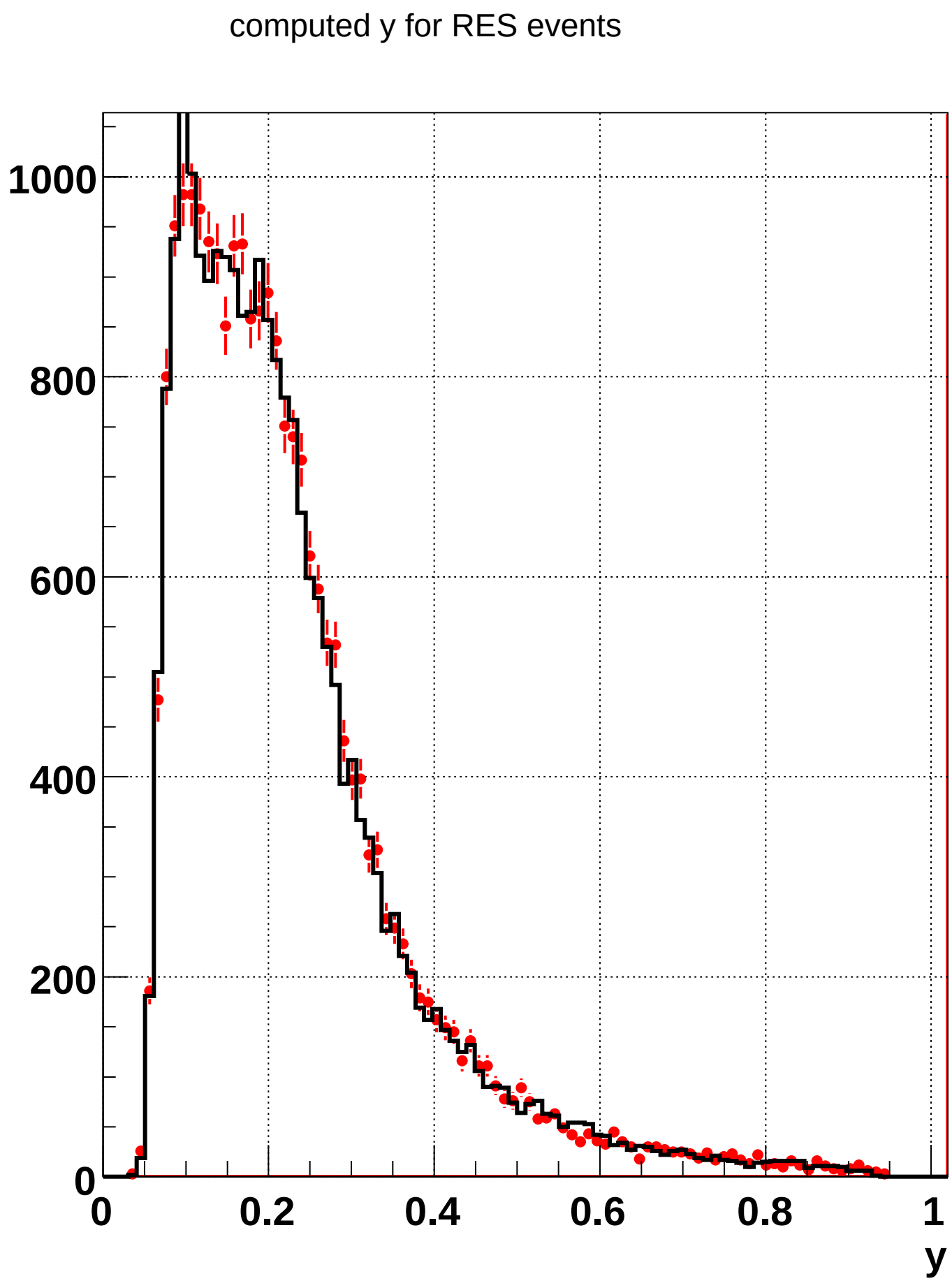


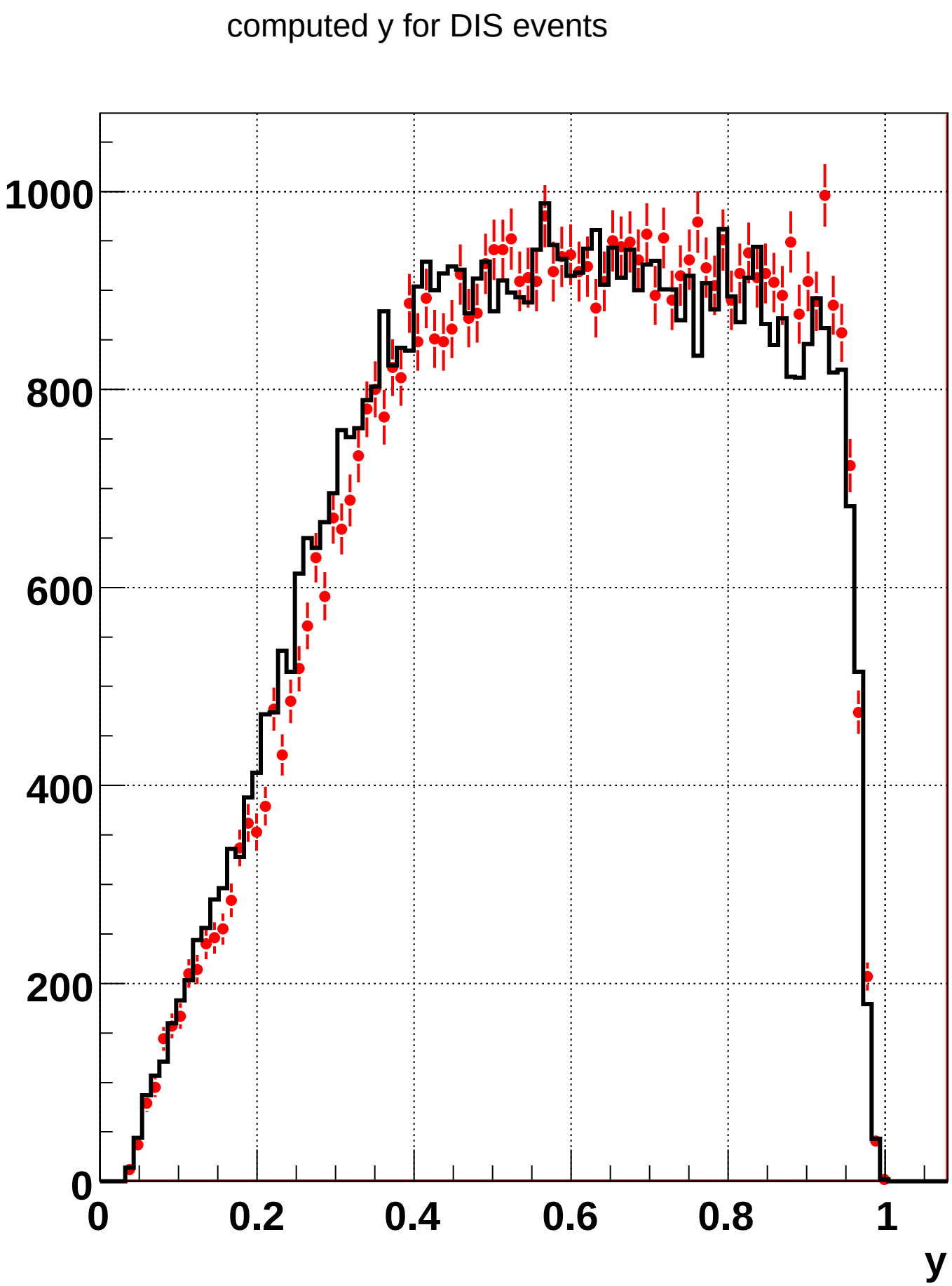
computed y for all events



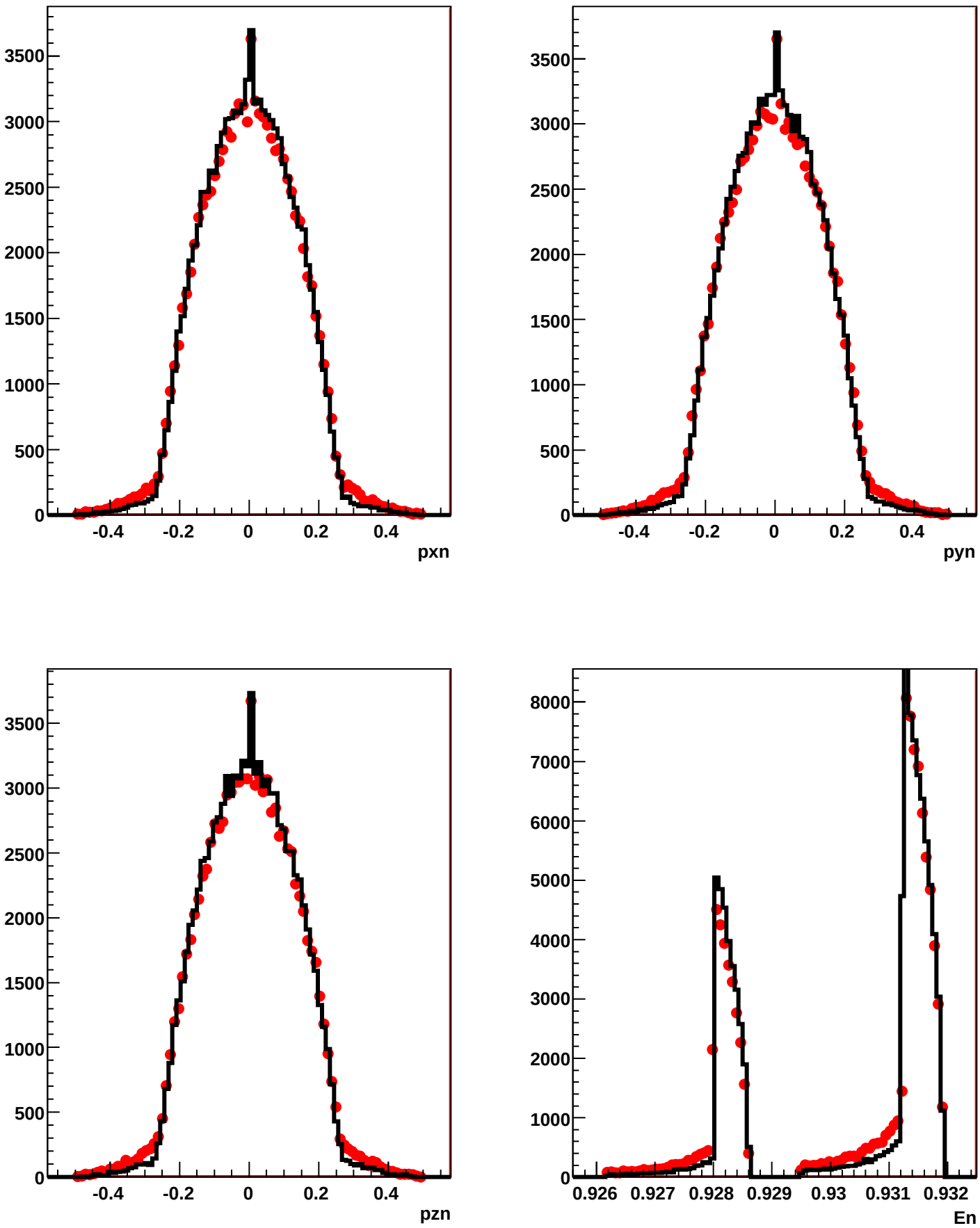
computed y for QEL events




computed y for RES events
1000
800
600
400
200
0
0
0.2
0.4
0.6
0.8
1
y

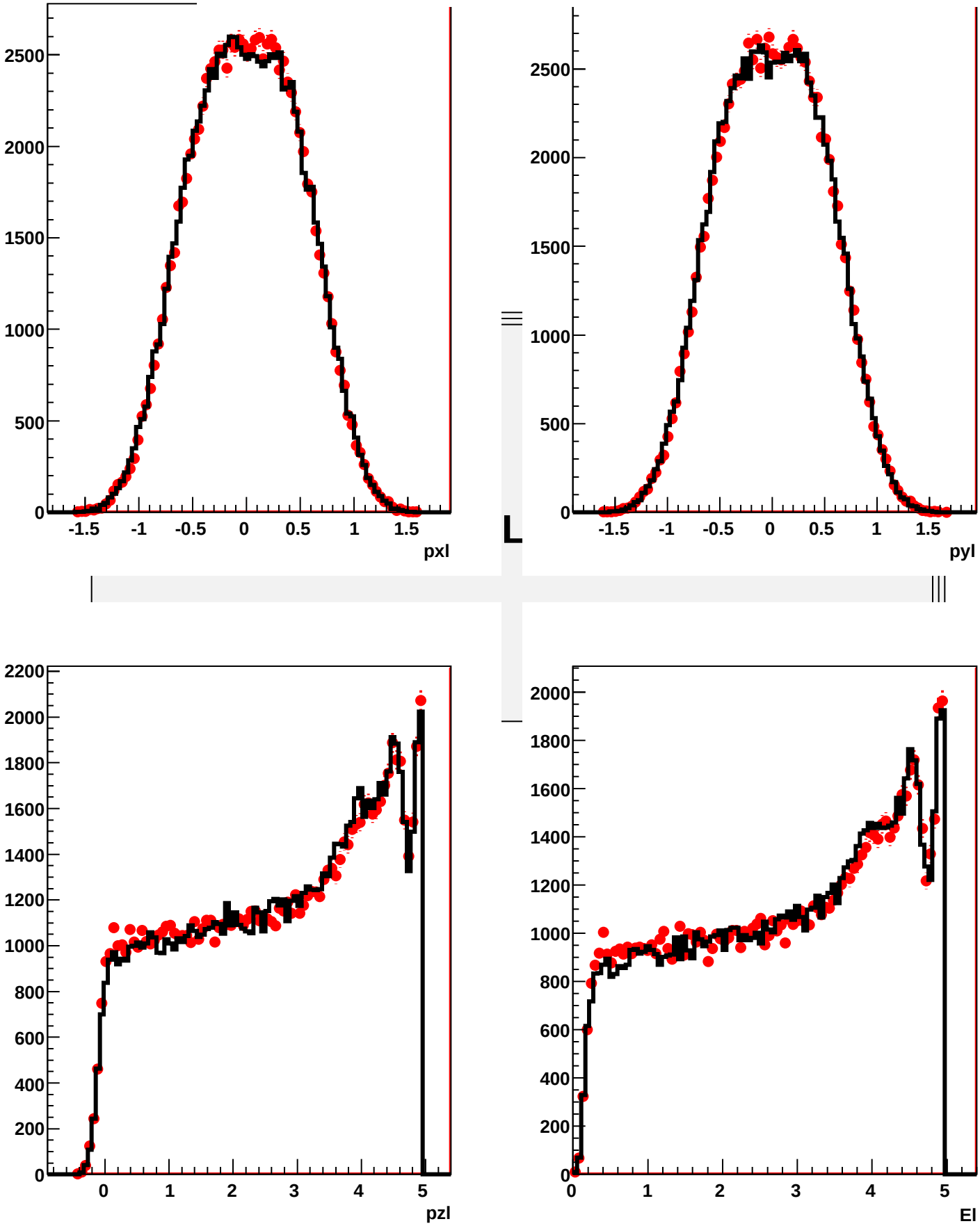

computed y for DIS events
1000
800
600
400
200
0
0
0.2
0.4
0.6
0.8
1
y

Initial state nucleon 4-Momentum

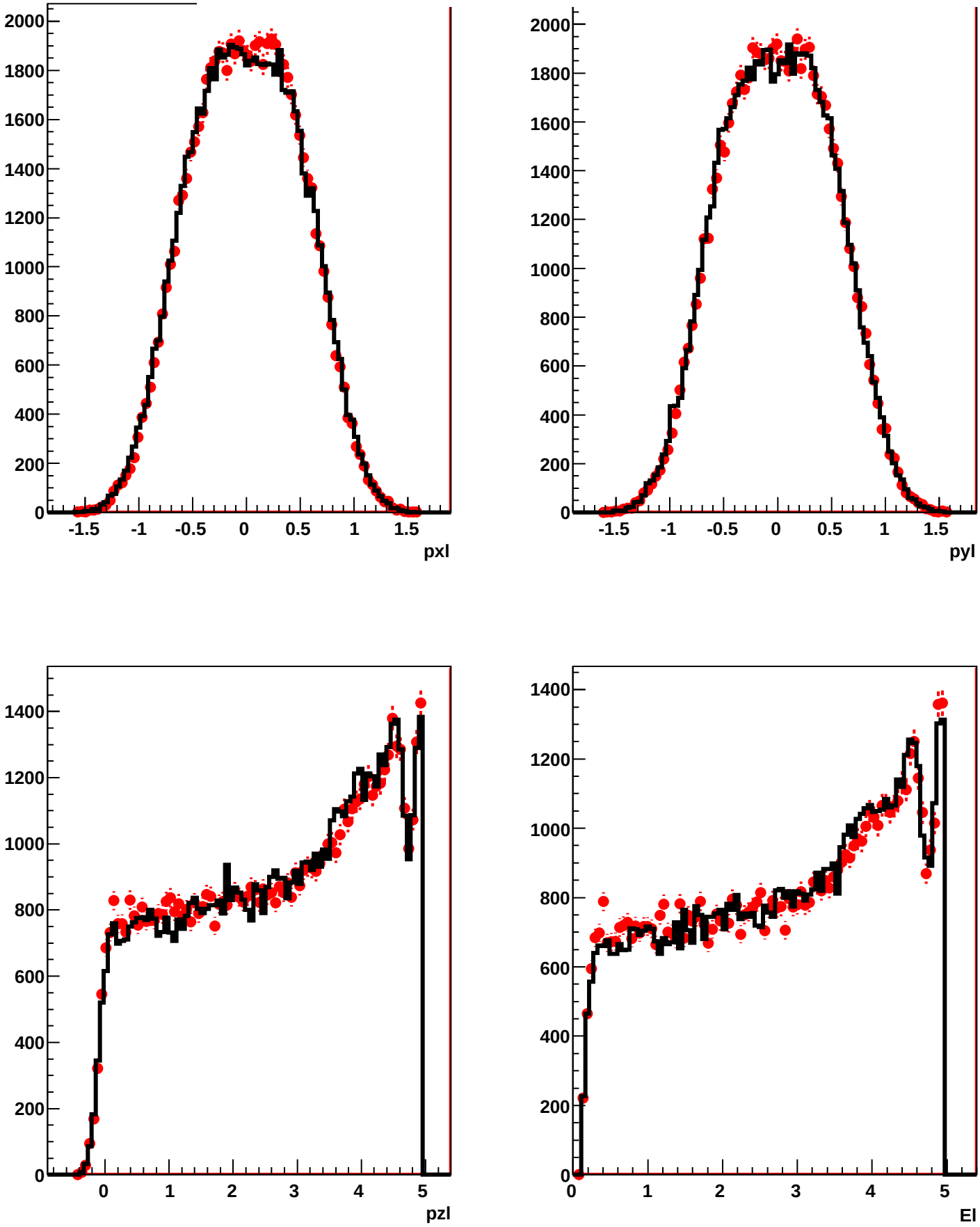

3500
3000
2500
2000
1500
1000
500
0
-0.4
-0.2
0
0.2
0.4
pxn
pyn
pzn
8000
7000
6000
5000
4000
3000
2000
1000
0.926
0.927
0.928
0.929
0.93
0.931
0.932
En

Final State Primary Lepton 4-Momentum

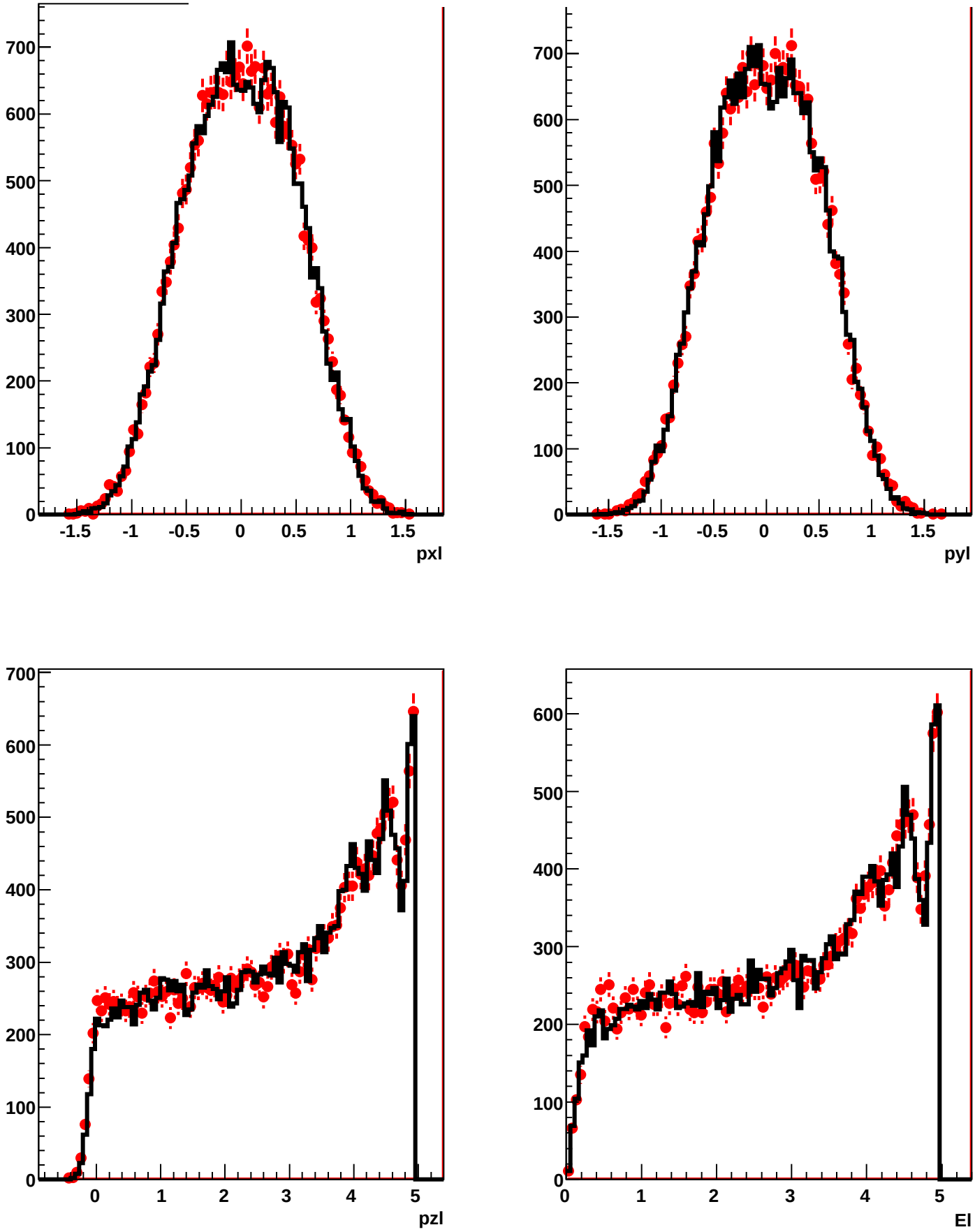
Final state primary lepton 4-p: All events



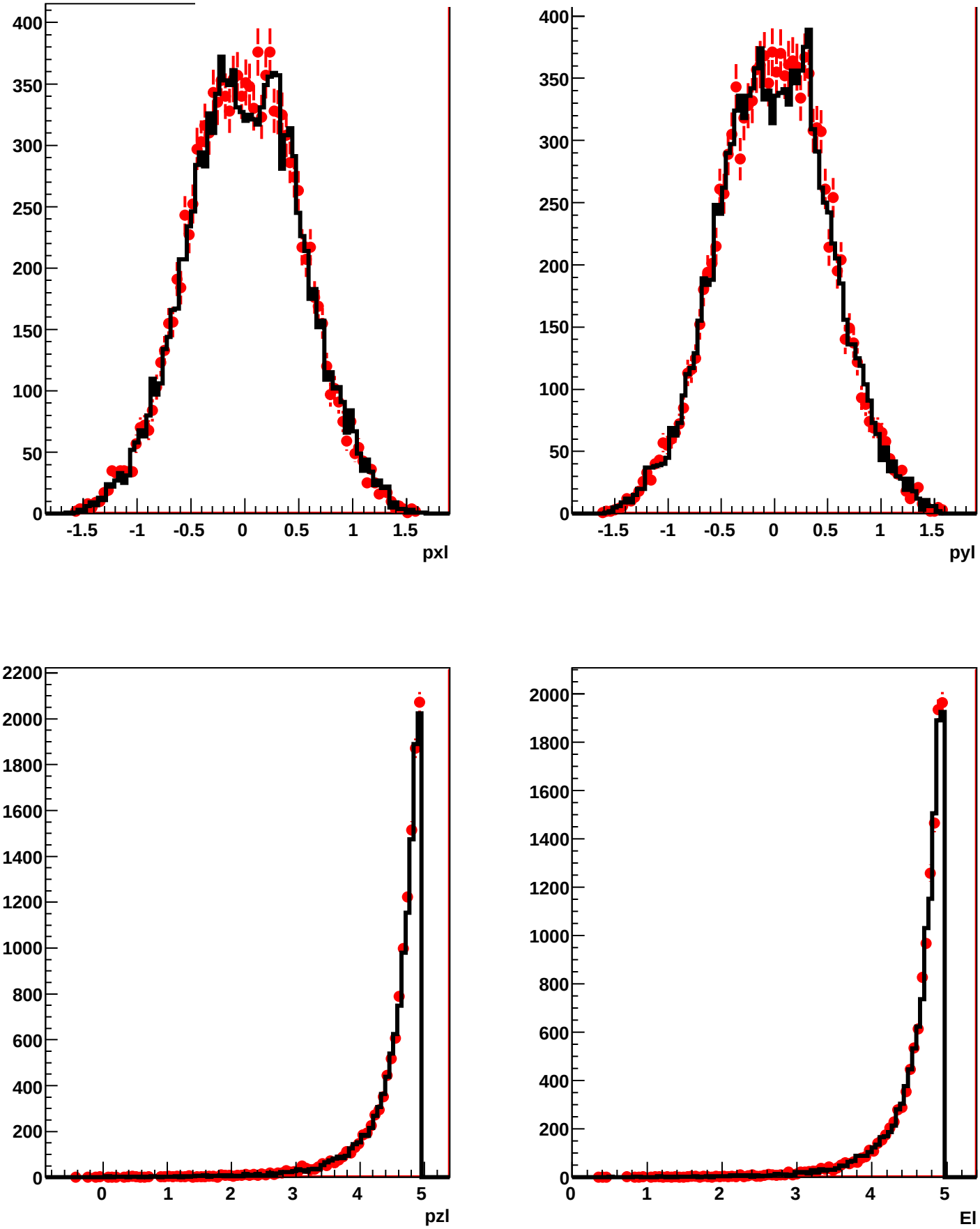
Final state primary lepton 4-p: All CC events



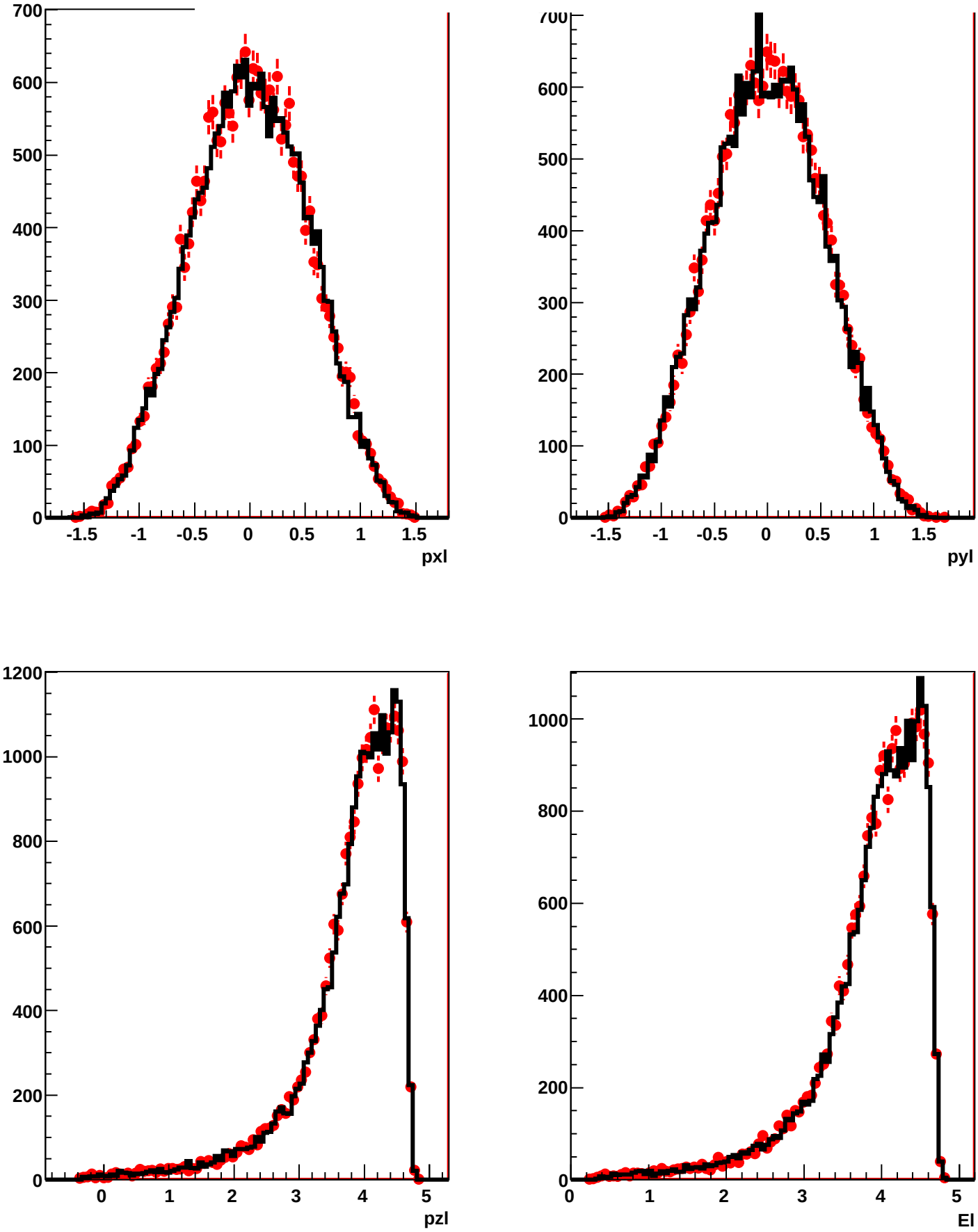
Final state primary lepton 4-p: All NC events



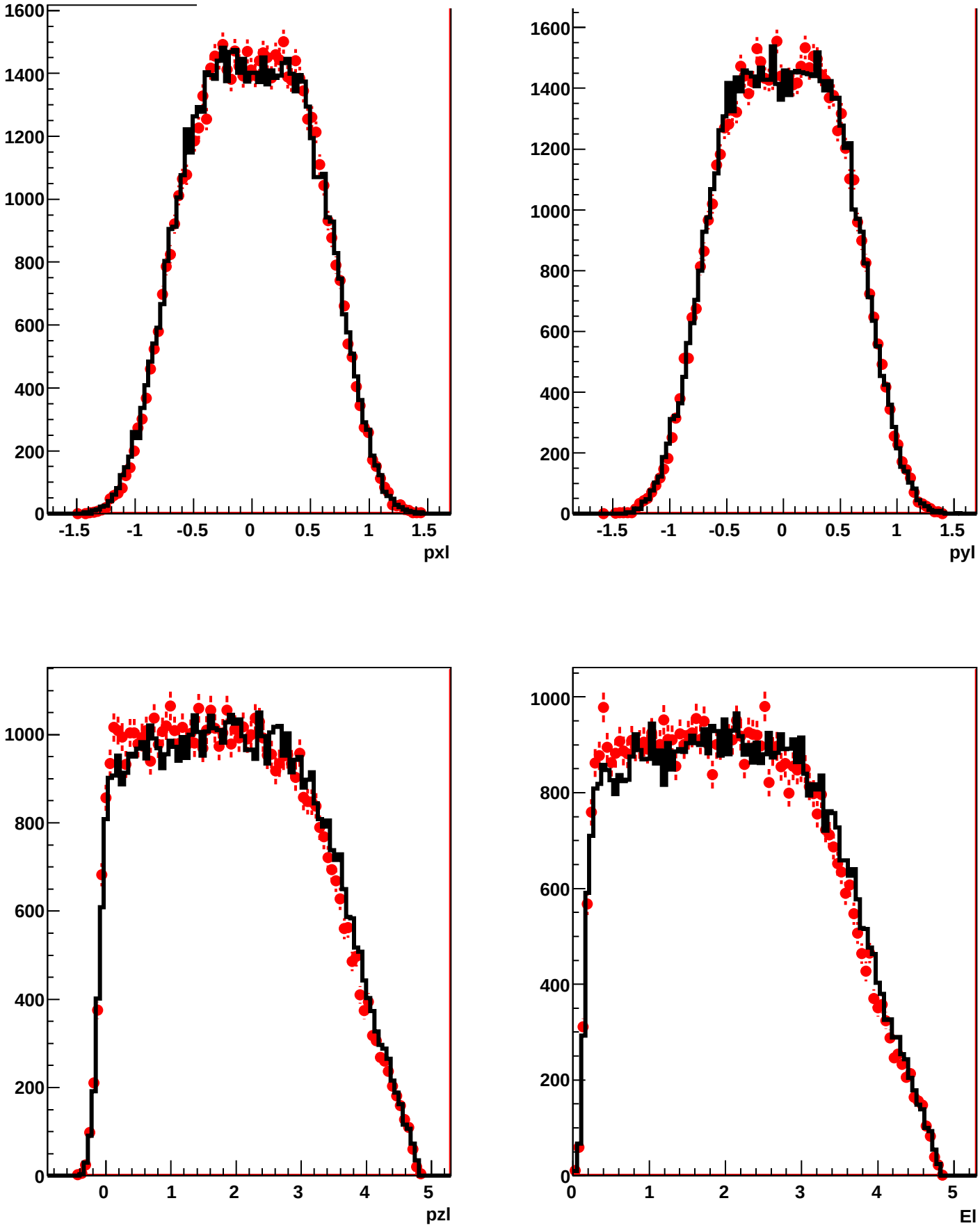
Final state primary lepton 4-p: QEL events



Final state primary lepton 4-p: RES events



Final state primary lepton 4-p: All DIS events



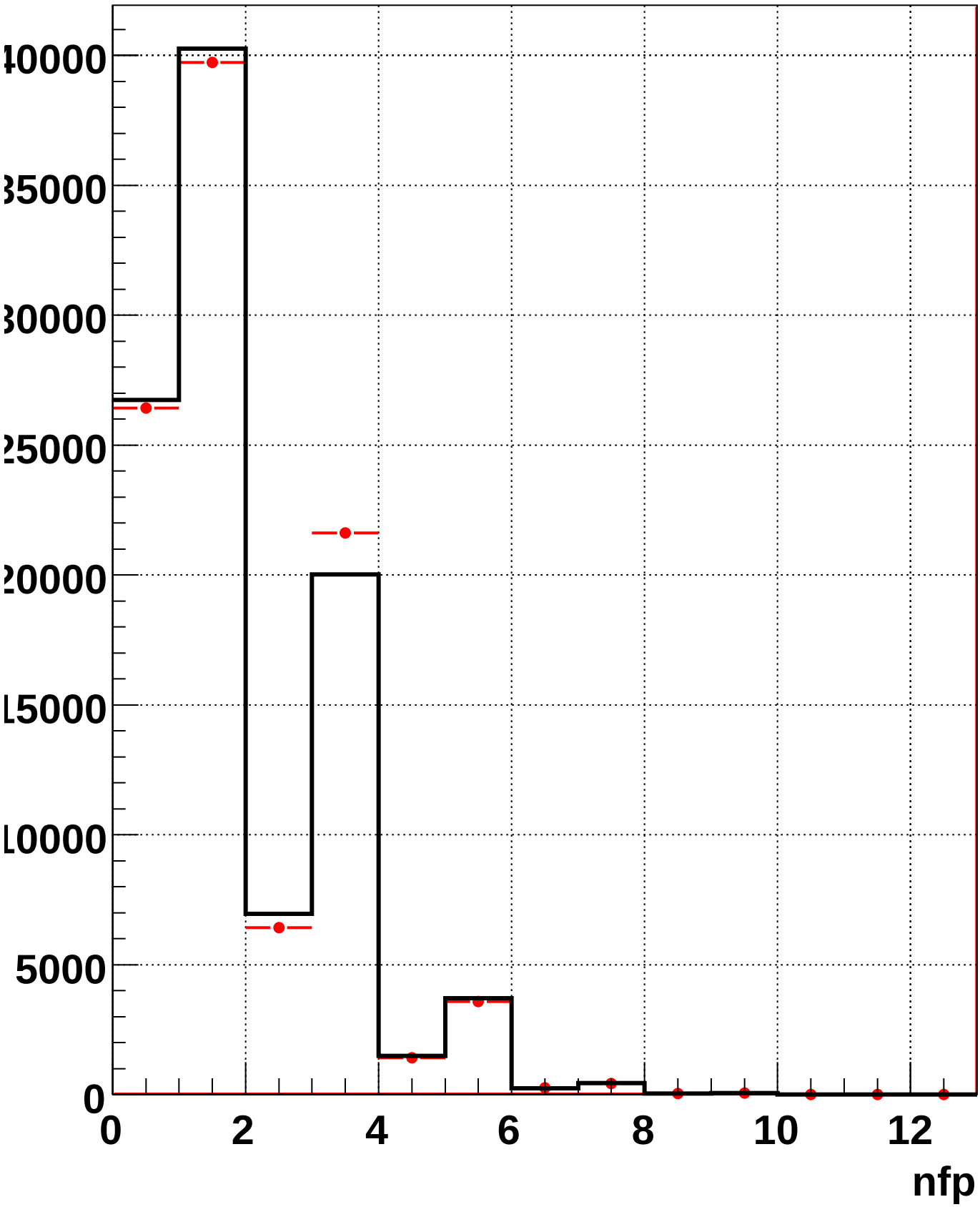
Final State Hadronic System

Multiplicities and 4-Momenta

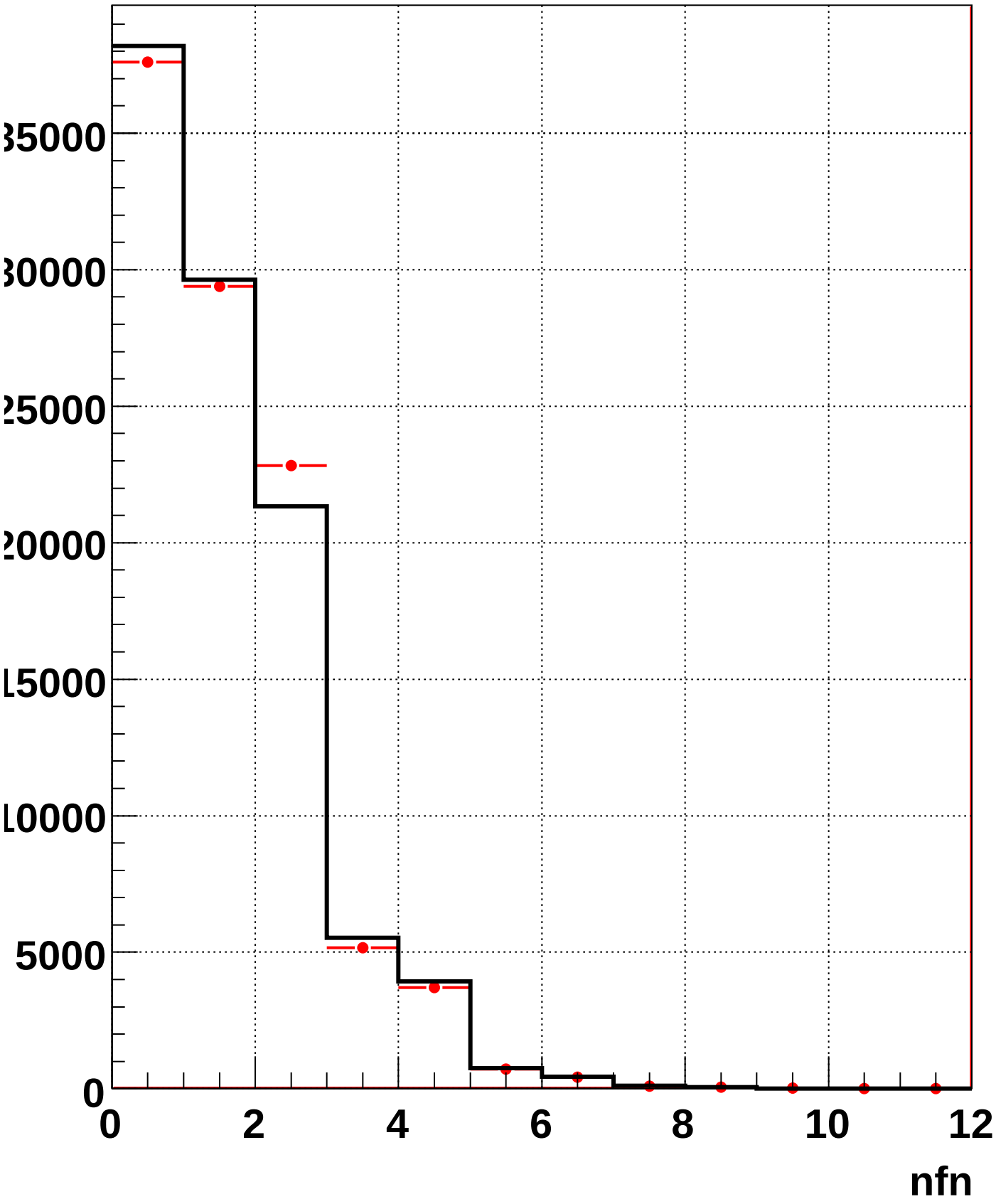
Note:

For nuclear targets these plots include the effect of intranuclear hadron transport / rescattering

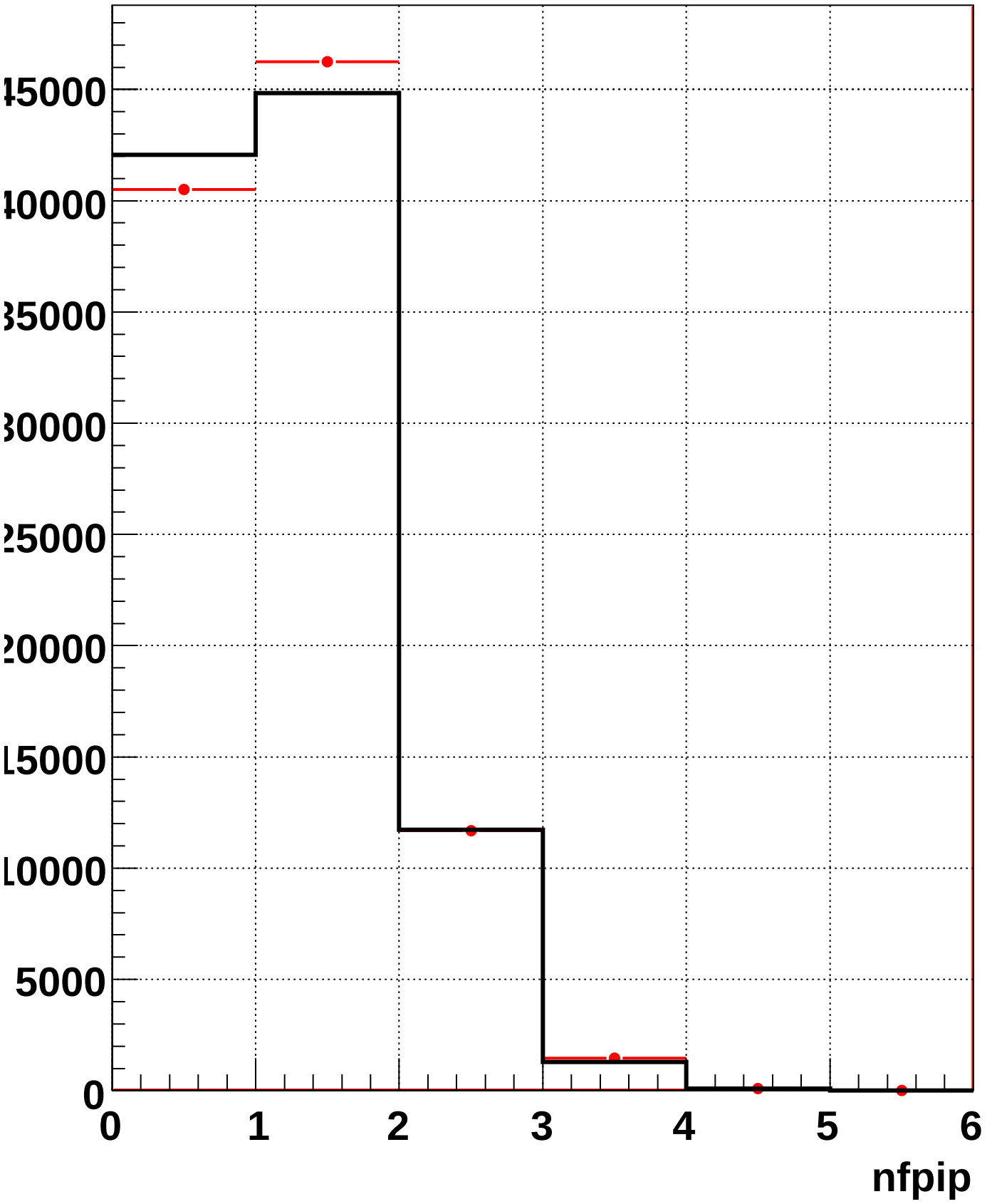
Number of final state protons



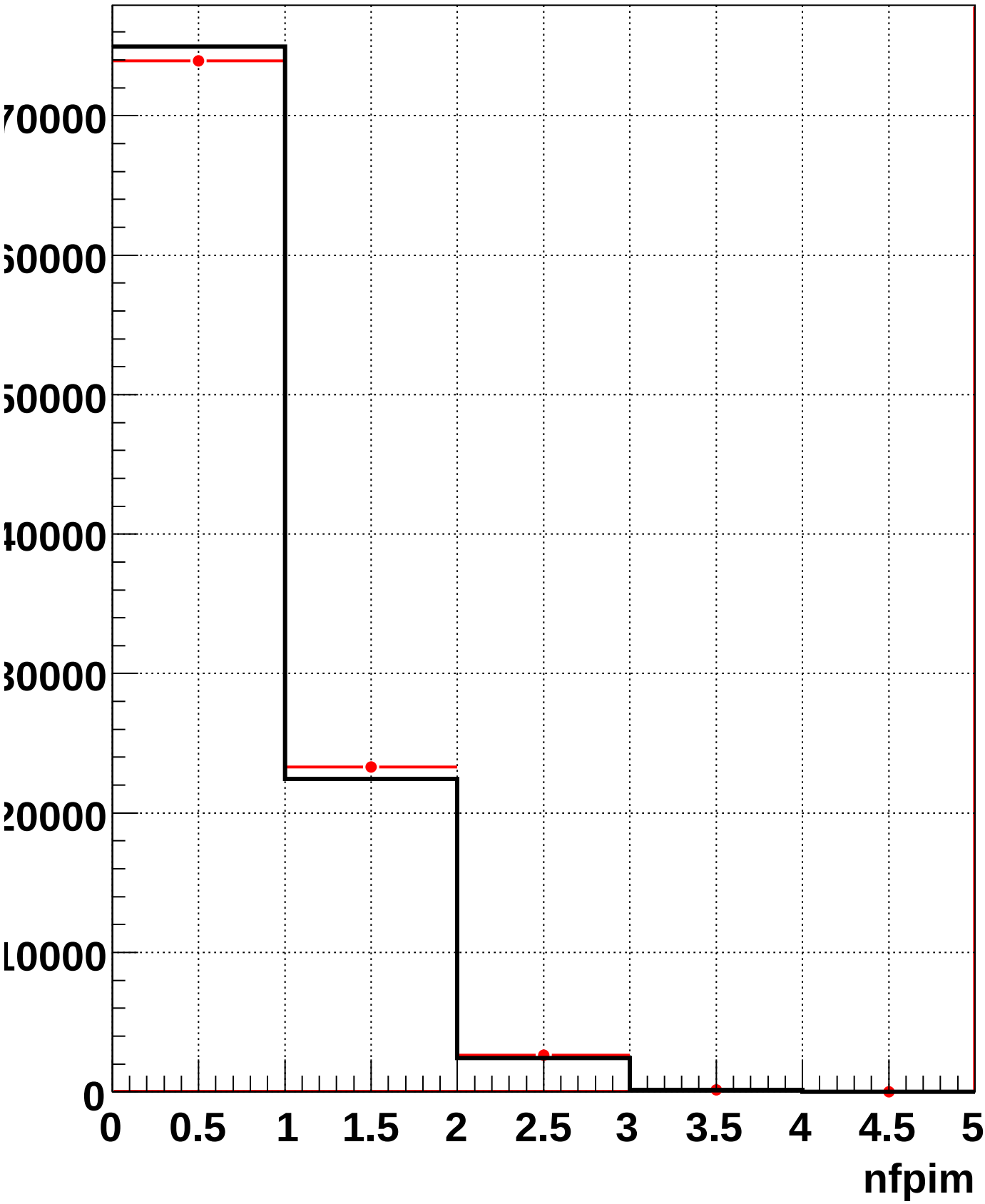
Number of final state neutrons



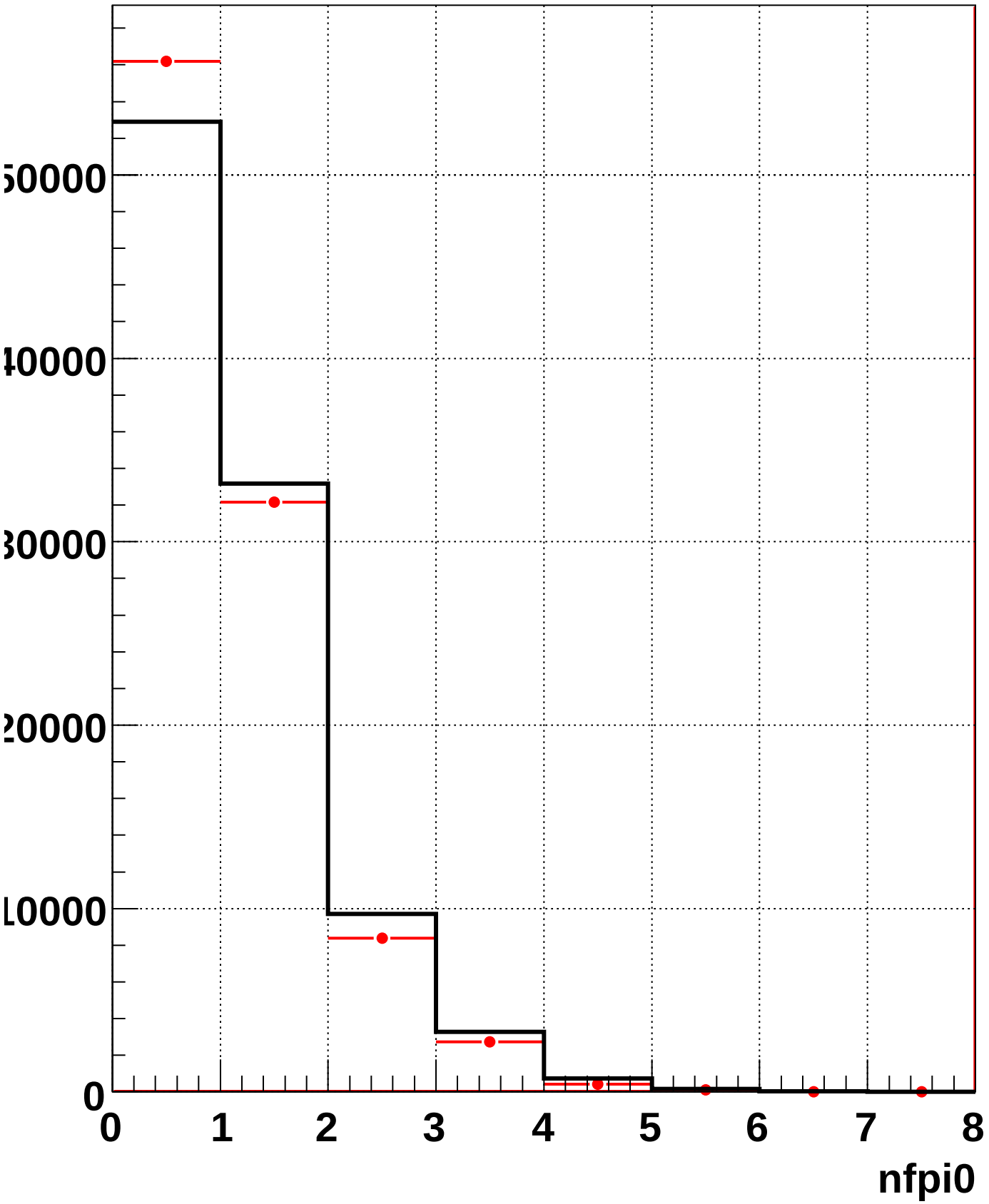
Number of final state pi+

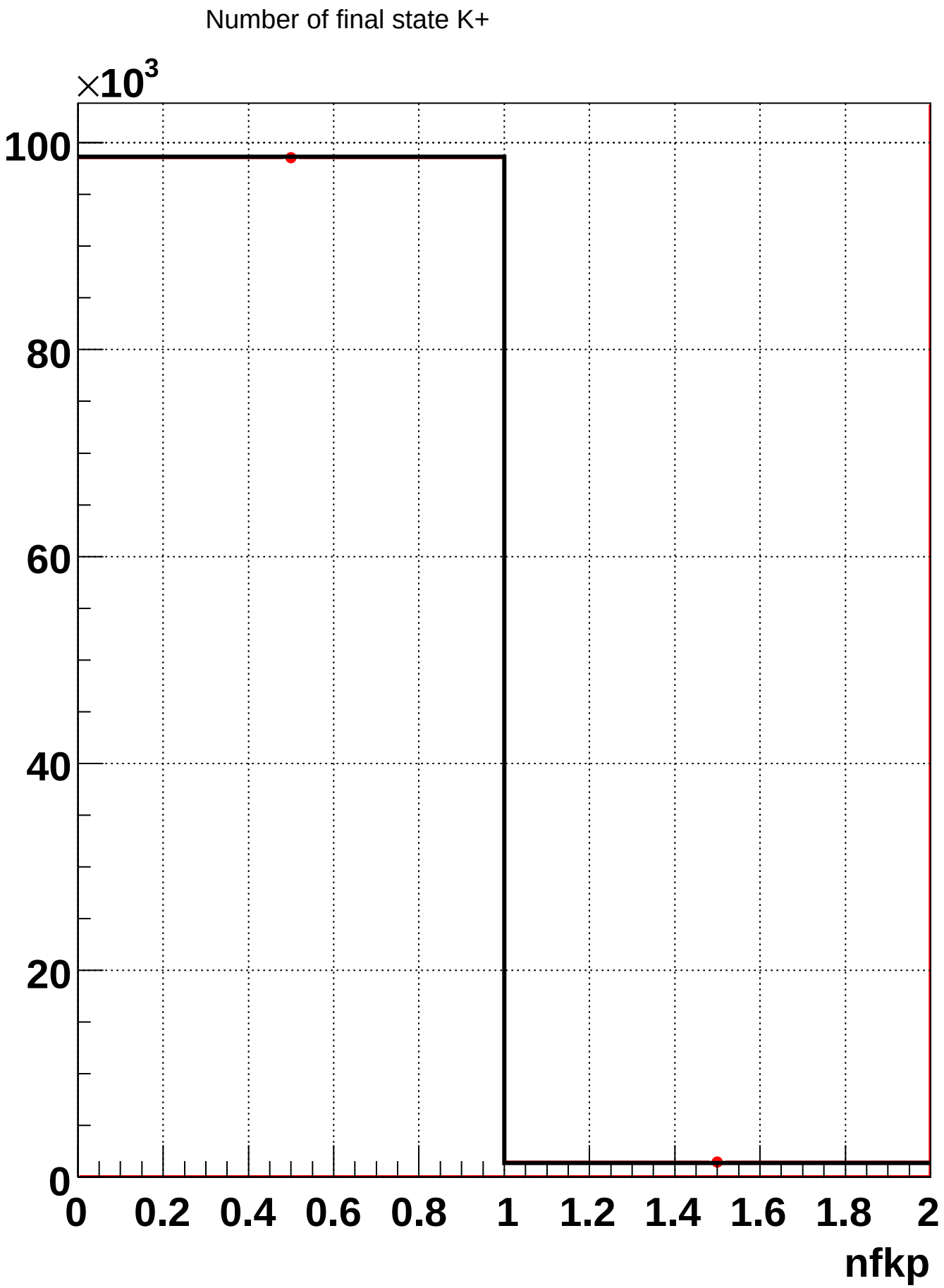


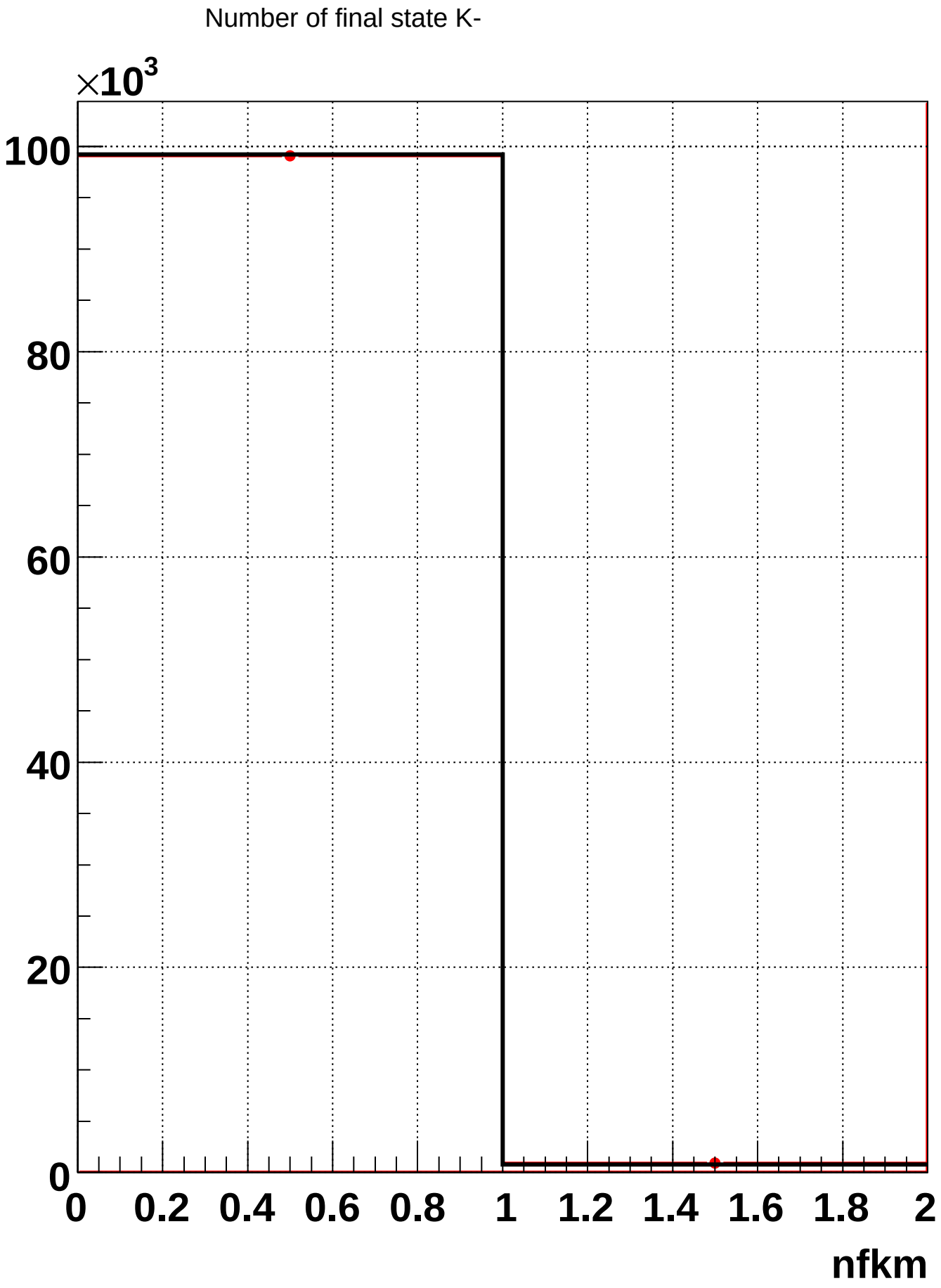
Number of final state pi-

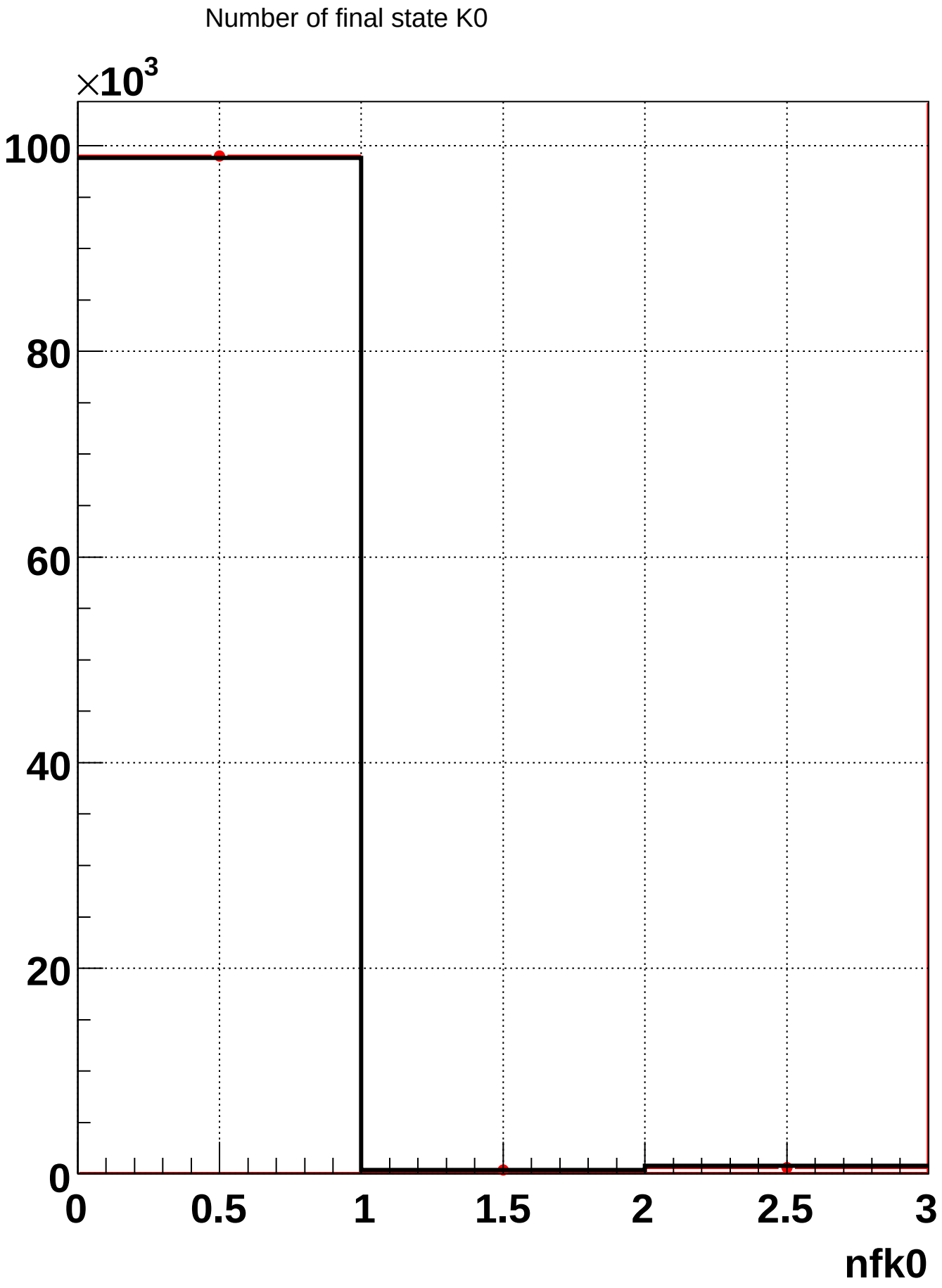


Number of final state pi0

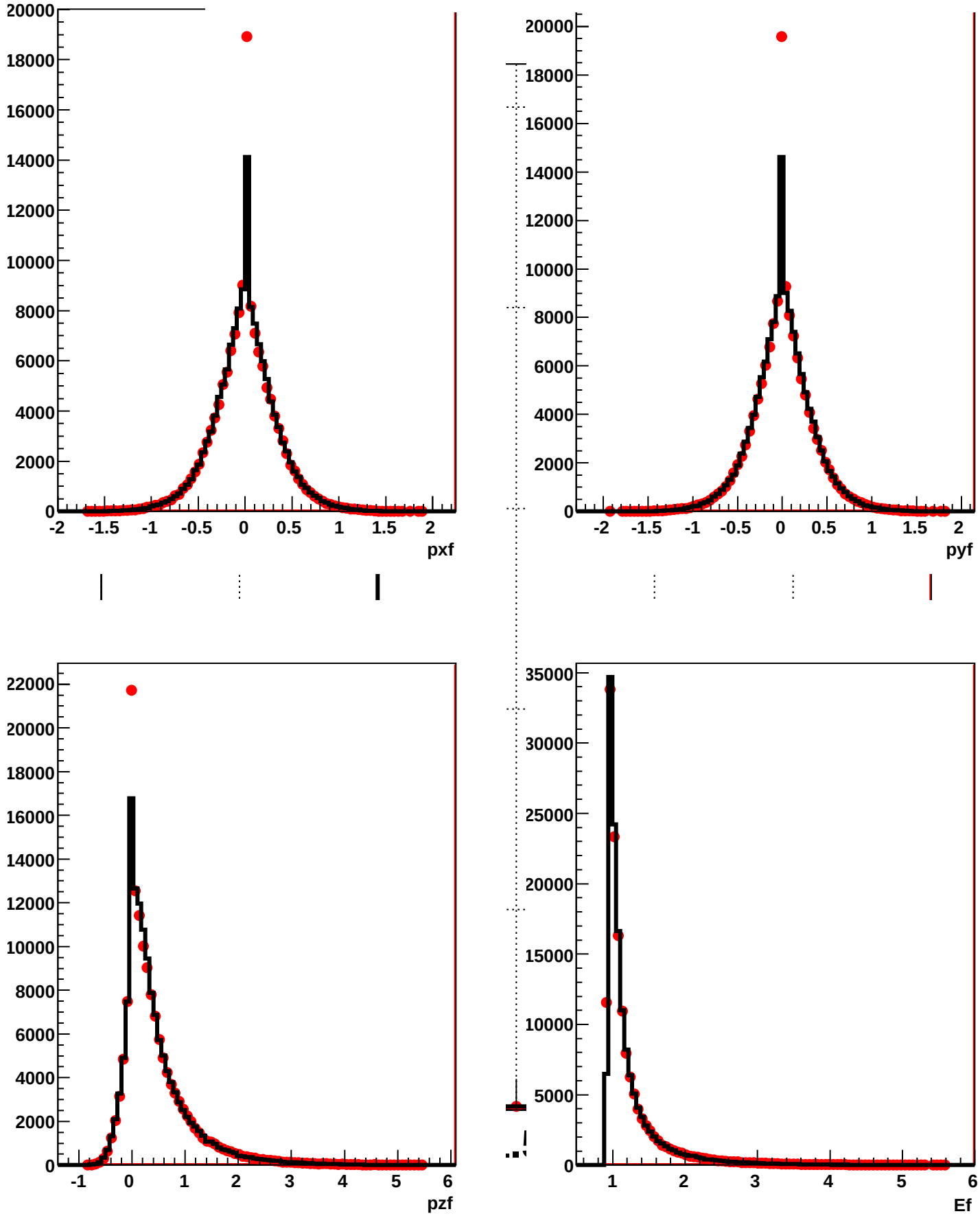



Number of final state K+
×10^3
100
80
60
40
20
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
nfkp

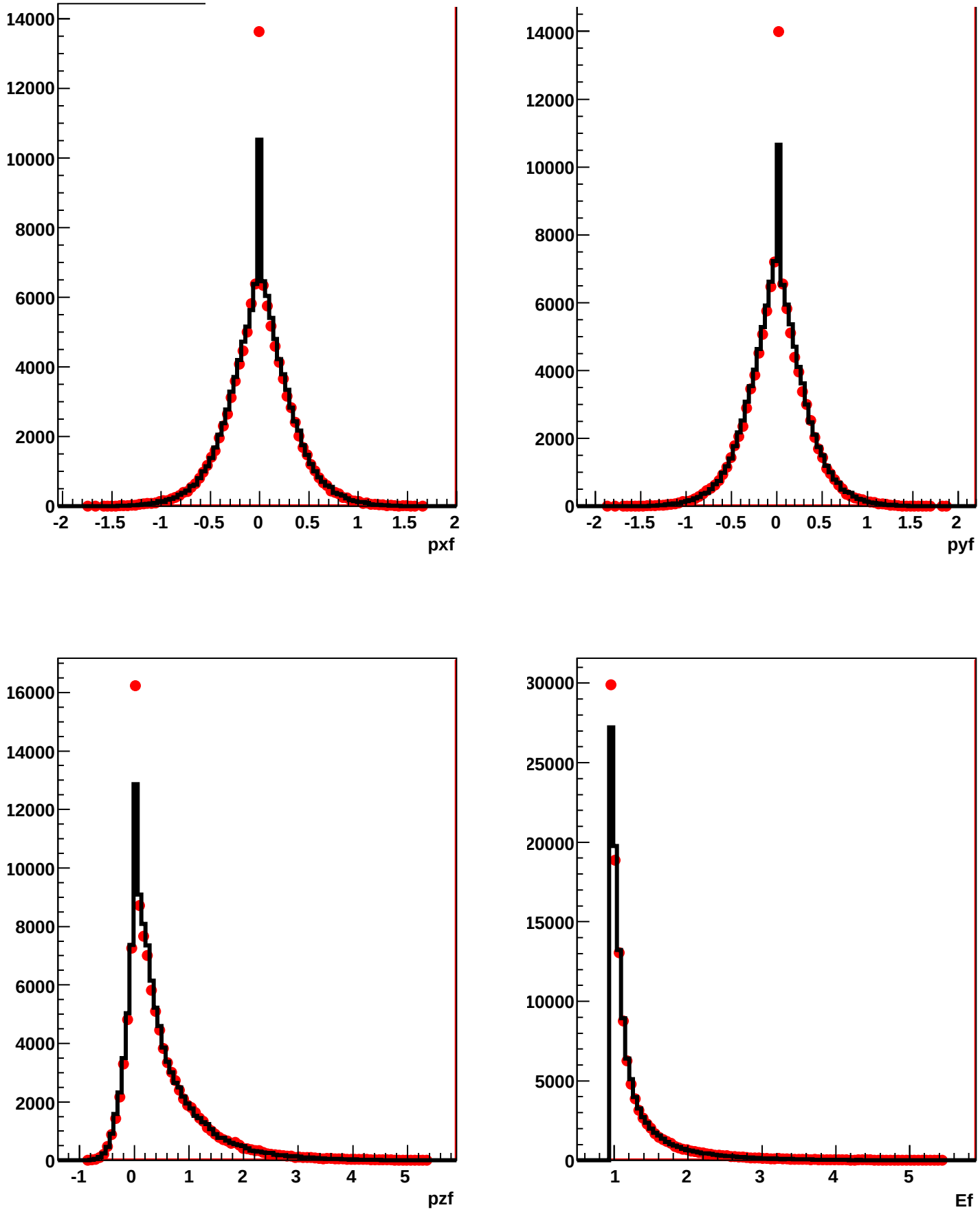

Number of final state K-
×10^3
100
80
60
40
20
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
nfkm


Number of final state K0
×10^3
100
80
60
40
20
0
0
0.5
1
1.5
2
2.5
3
nfk0

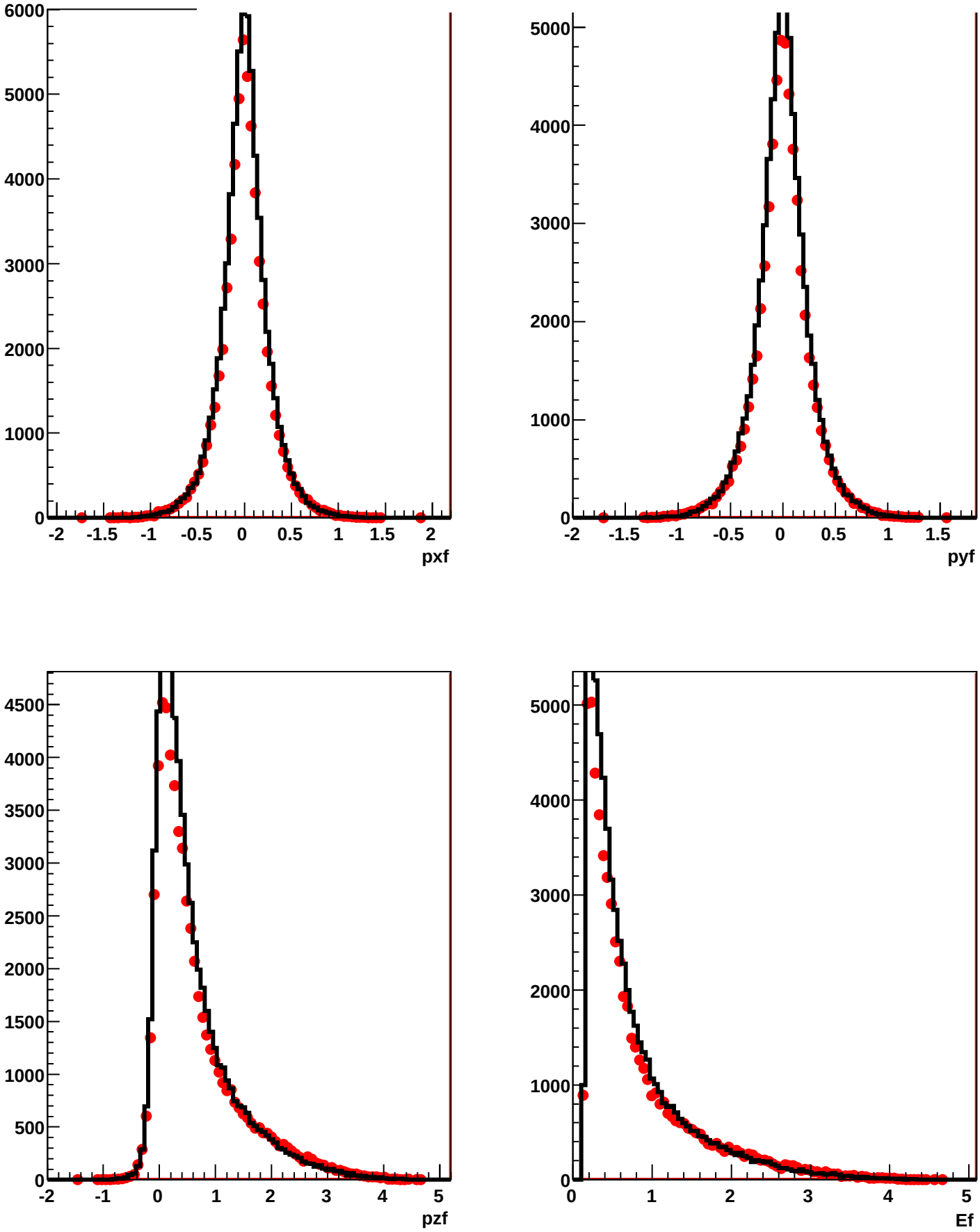
Final state protons 4-momentum



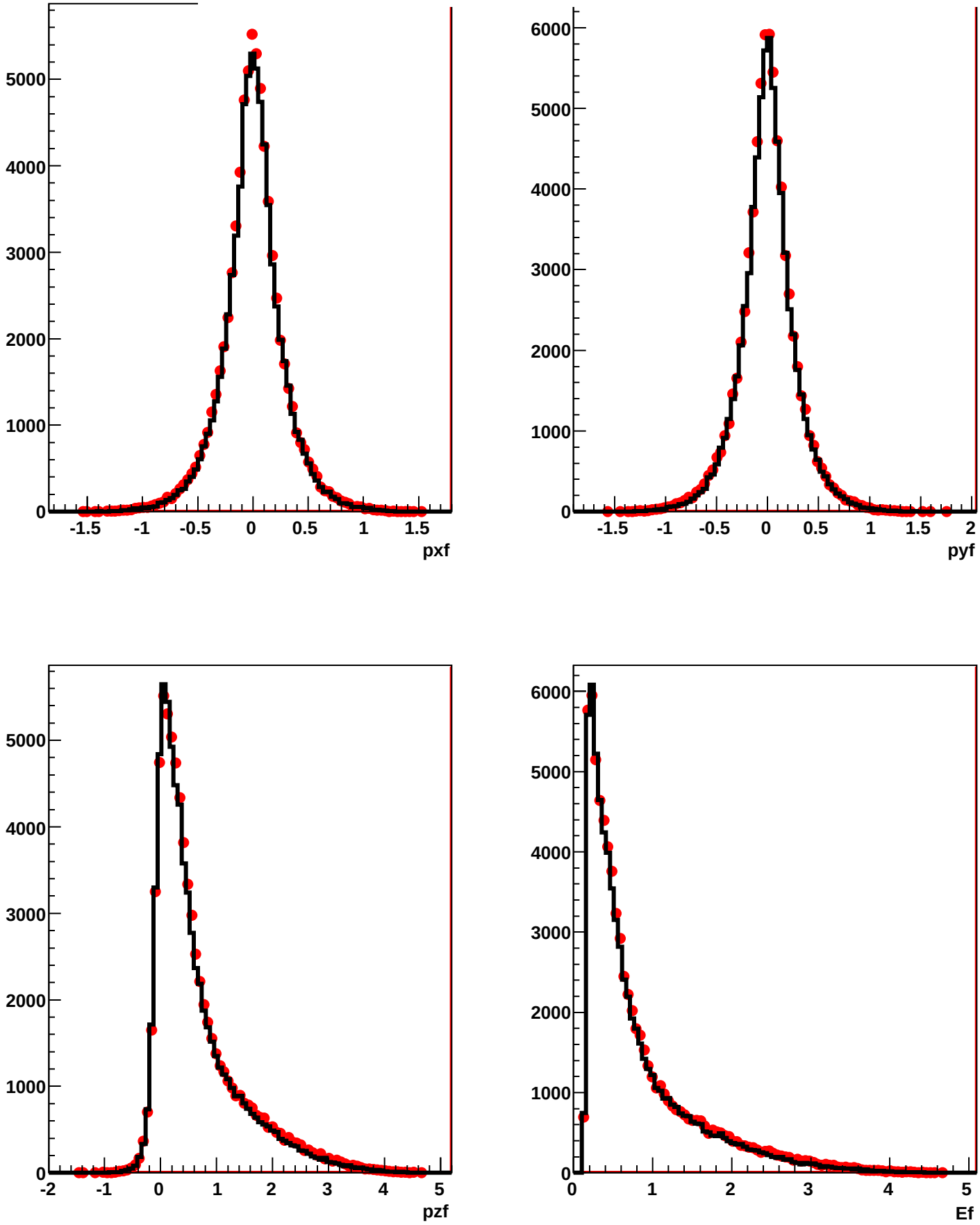
Final state neutrons 4-momentum



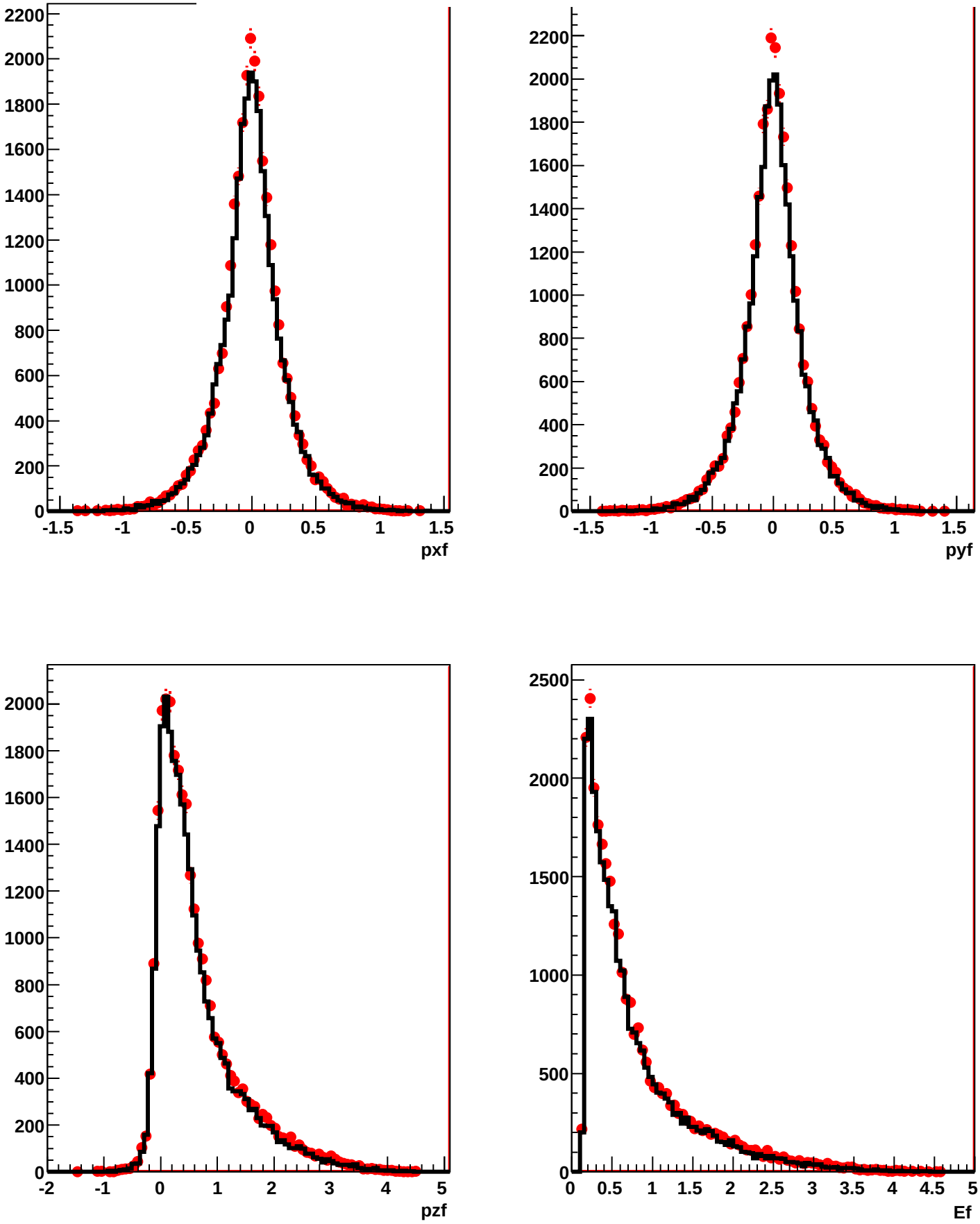
Final state pi0's 4-momentum



Final state pi+’s 4-momentum



Final state pi-'s 4-momentum



GENIE-2.0.0 vs NEUGEN/Daikon+ Event Sample Comparisons

Event Sample:

100k events, numu+Fe56, 50GeV, all processes

Notes:

Daikon+ is a NEUGEN Daikon revision version

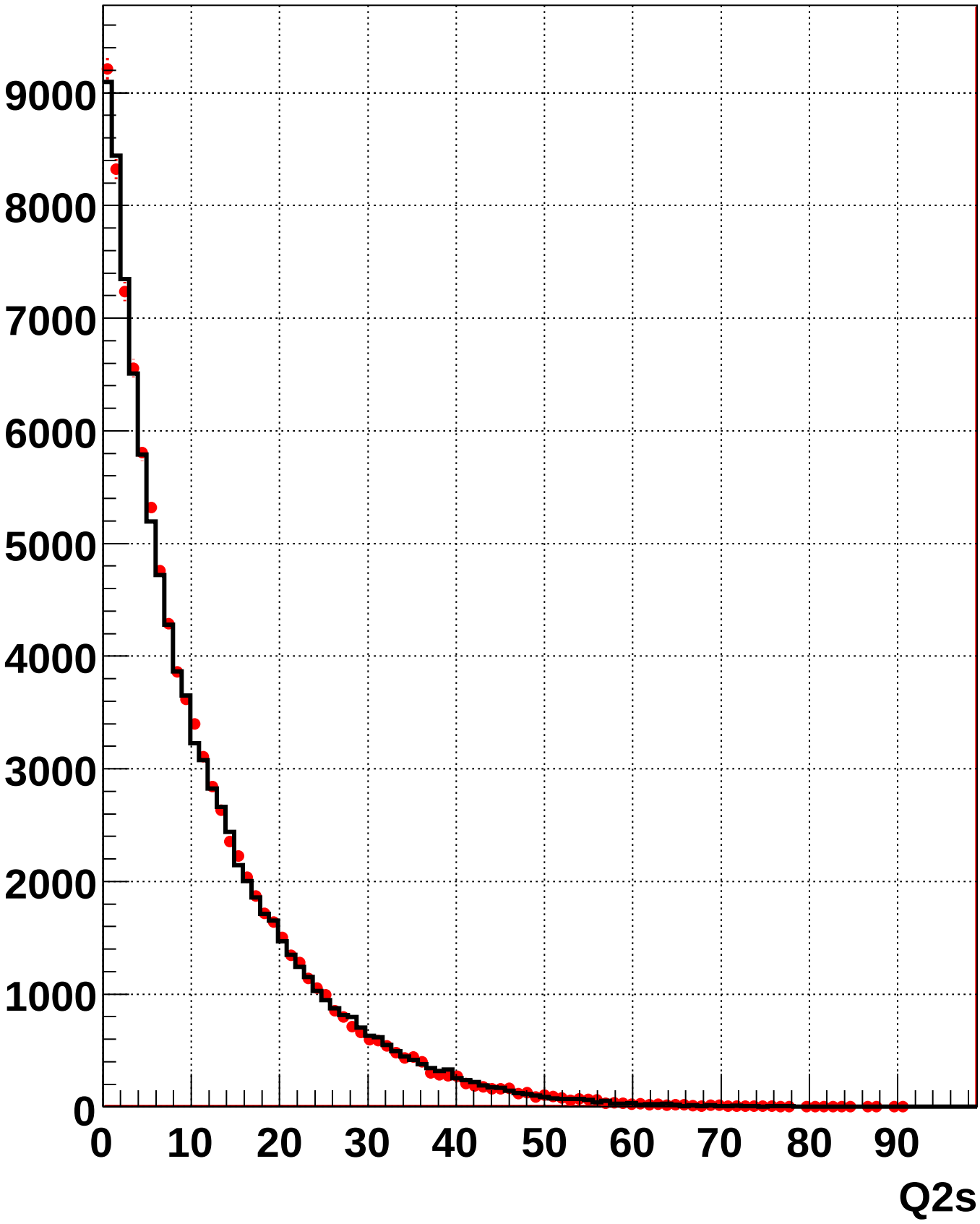
GENIE predictions shown with lines / NEUGEN's with markers

Event Numbers:

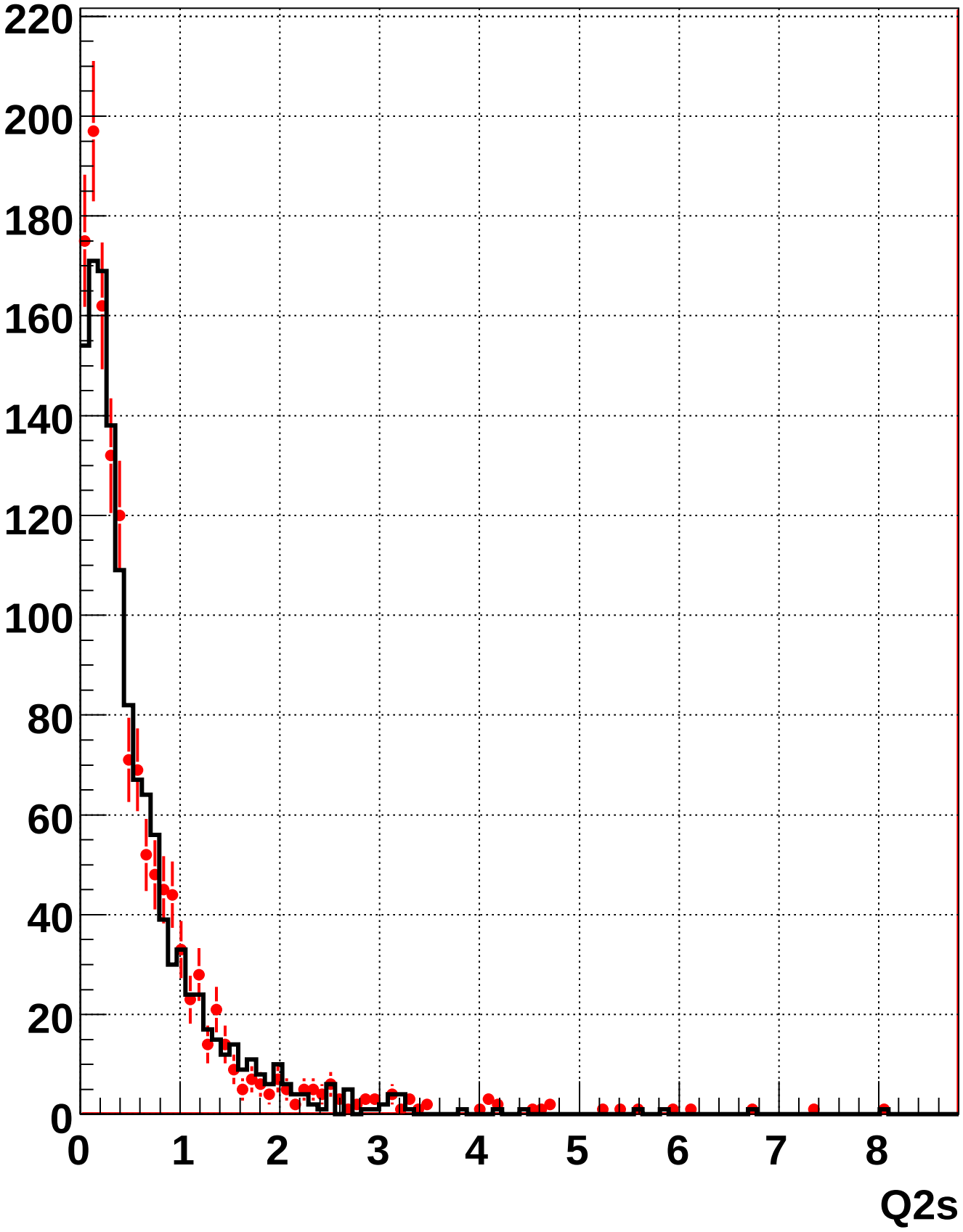
ALL :	100000 [NeuGEN],	100000 [GENIE]
QEL :	1354 [NeuGEN],	1314 [GENIE]
QEL-CC :	974 [NeuGEN],	950 [GENIE]
QEL-NC :	380 [NeuGEN],	364 [GENIE]
RES :	2582 [NeuGEN],	2550 [GENIE]
RES-CC :	1887 [NeuGEN],	1874 [GENIE]
RES-NC :	695 [NeuGEN],	676 [GENIE]
DIS :	95810 [NeuGEN],	95828 [GENIE]
DIS-CC :	73268 [NeuGEN],	73056 [GENIE]
(charm):	4072 [NeuGEN],	4116 [GENIE]
DIS-NC :	22542 [NeuGEN],	22772 [GENIE]
COH :	213 [NeuGEN],	243 [GENIE]
COH-CC :	146 [NeuGEN],	156 [GENIE]
COH-NC :	67 [NeuGEN],	87 [GENIE]
IMD :	41 [NeuGEN],	65 [GENIE]

Selected Kinematical Quantities

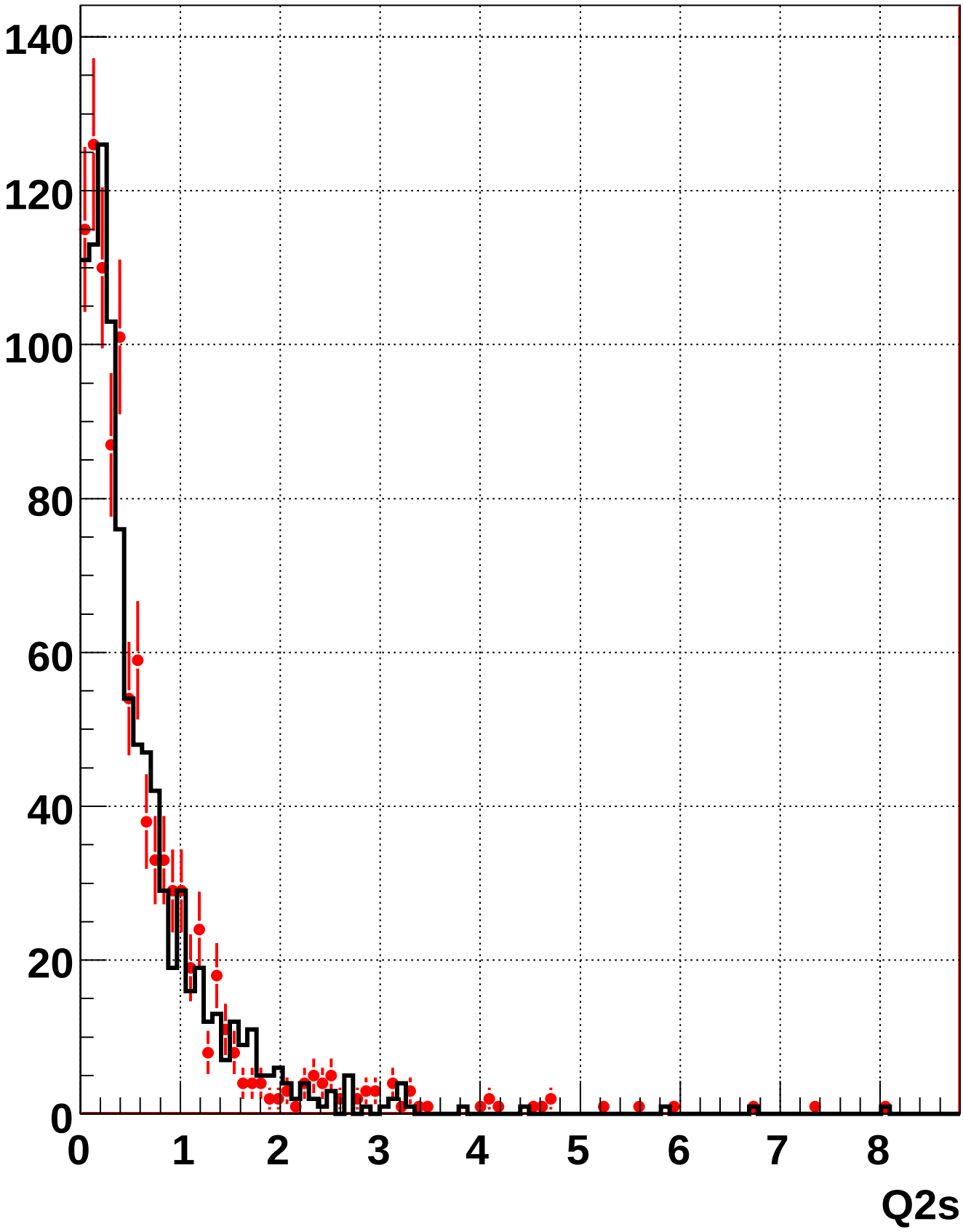
selected Q2 for all events



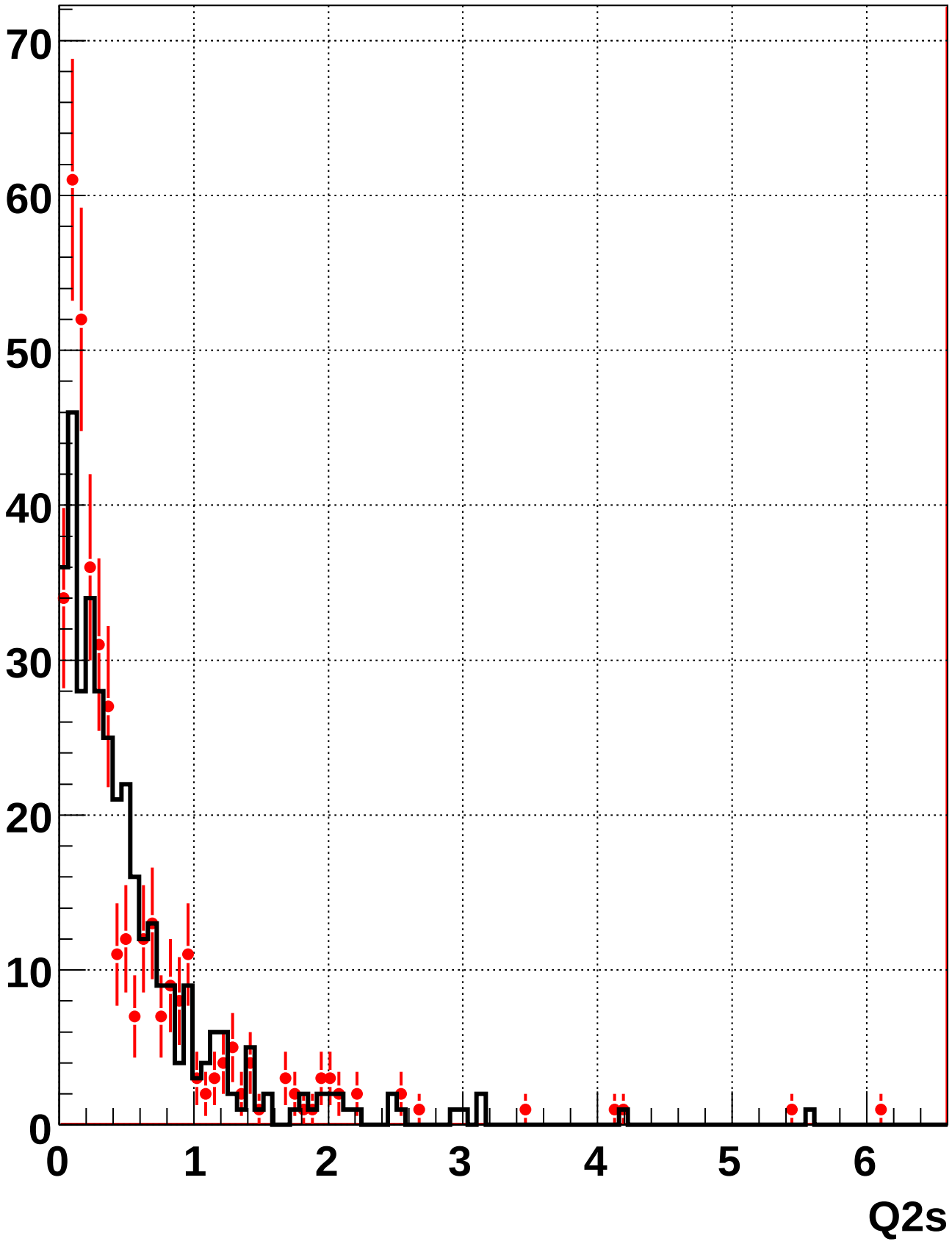
selected Q2 for QEL events



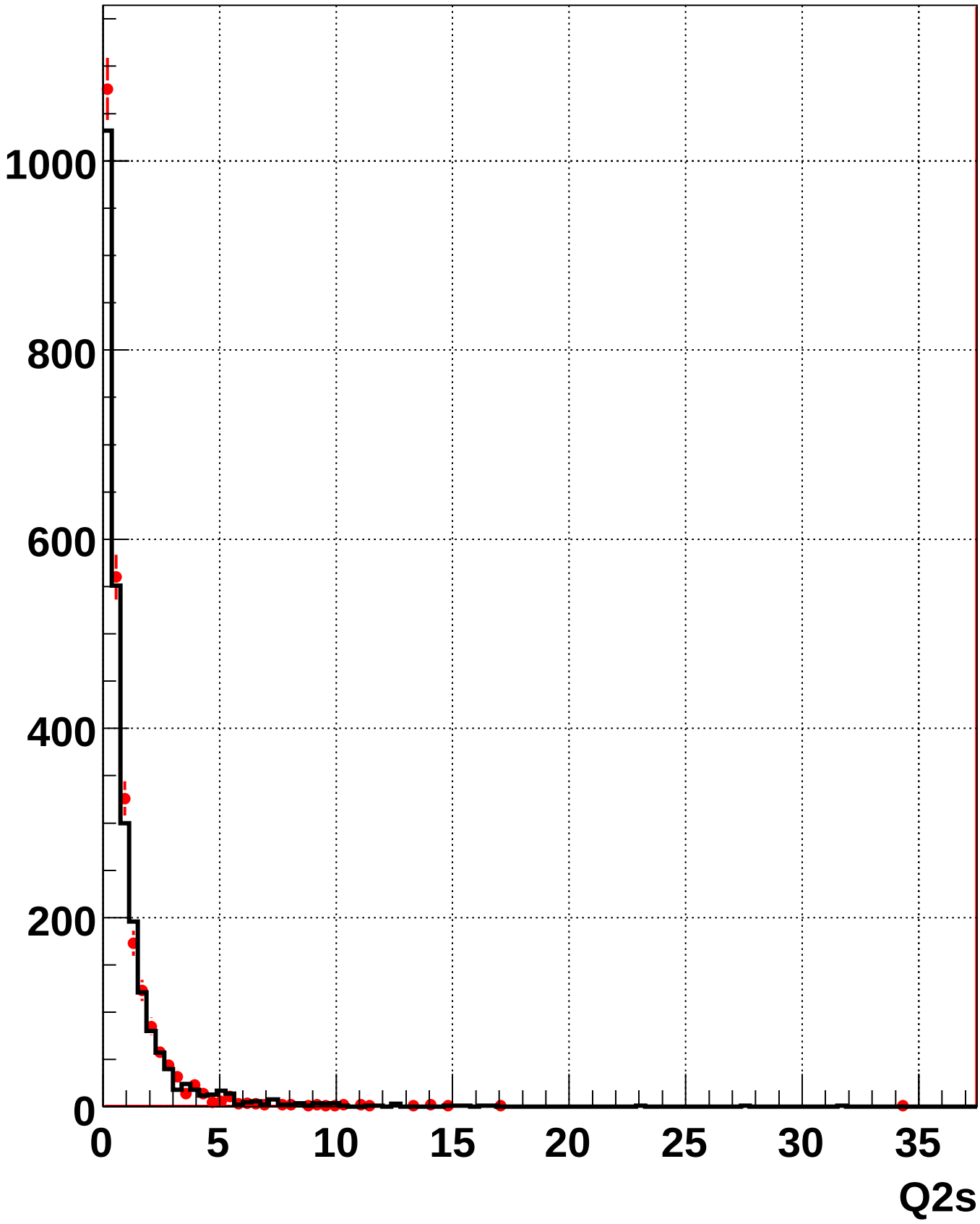
selected Q2 for QEL CC events



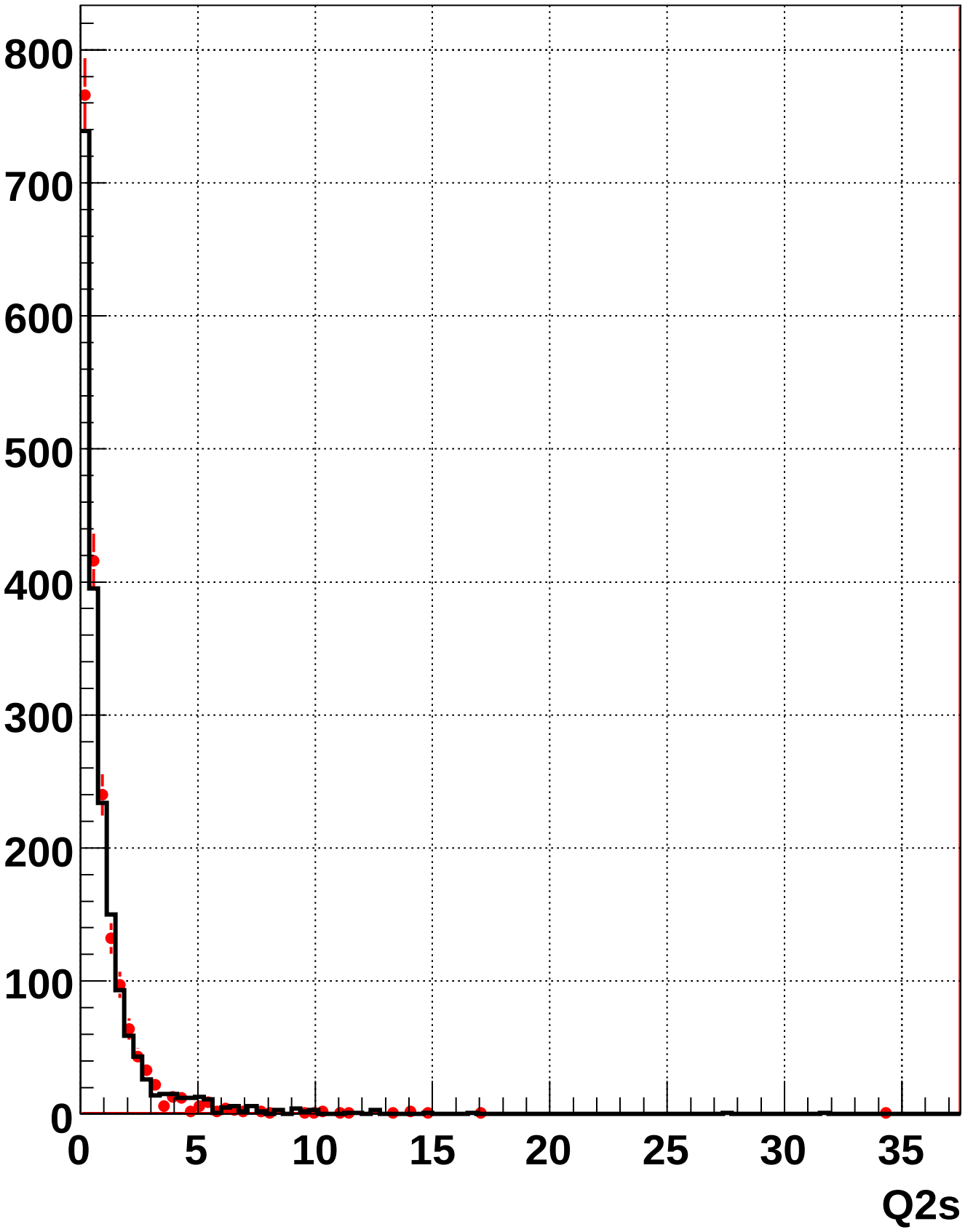
selected Q2 for QEL NC events



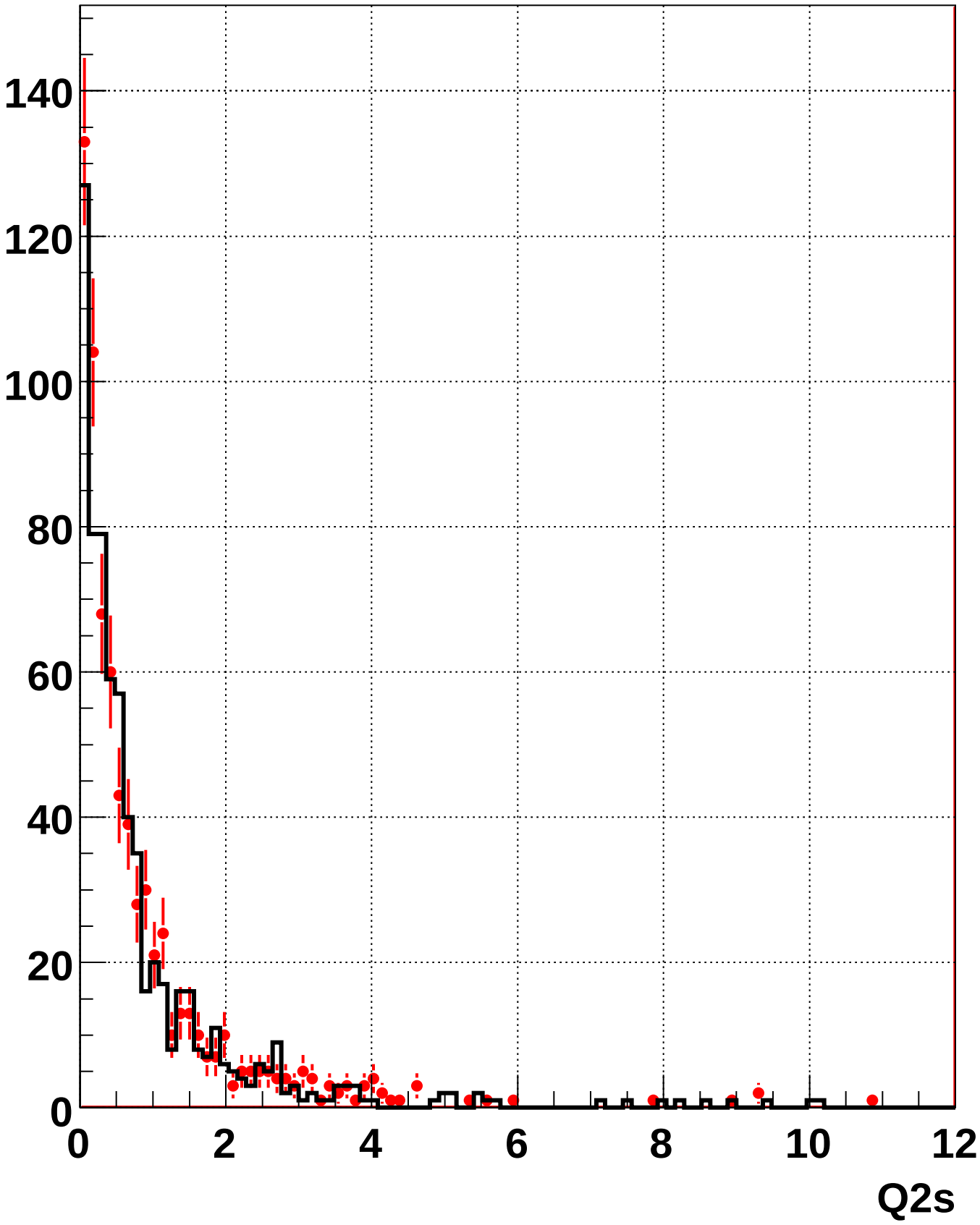
selected Q2 for RES events



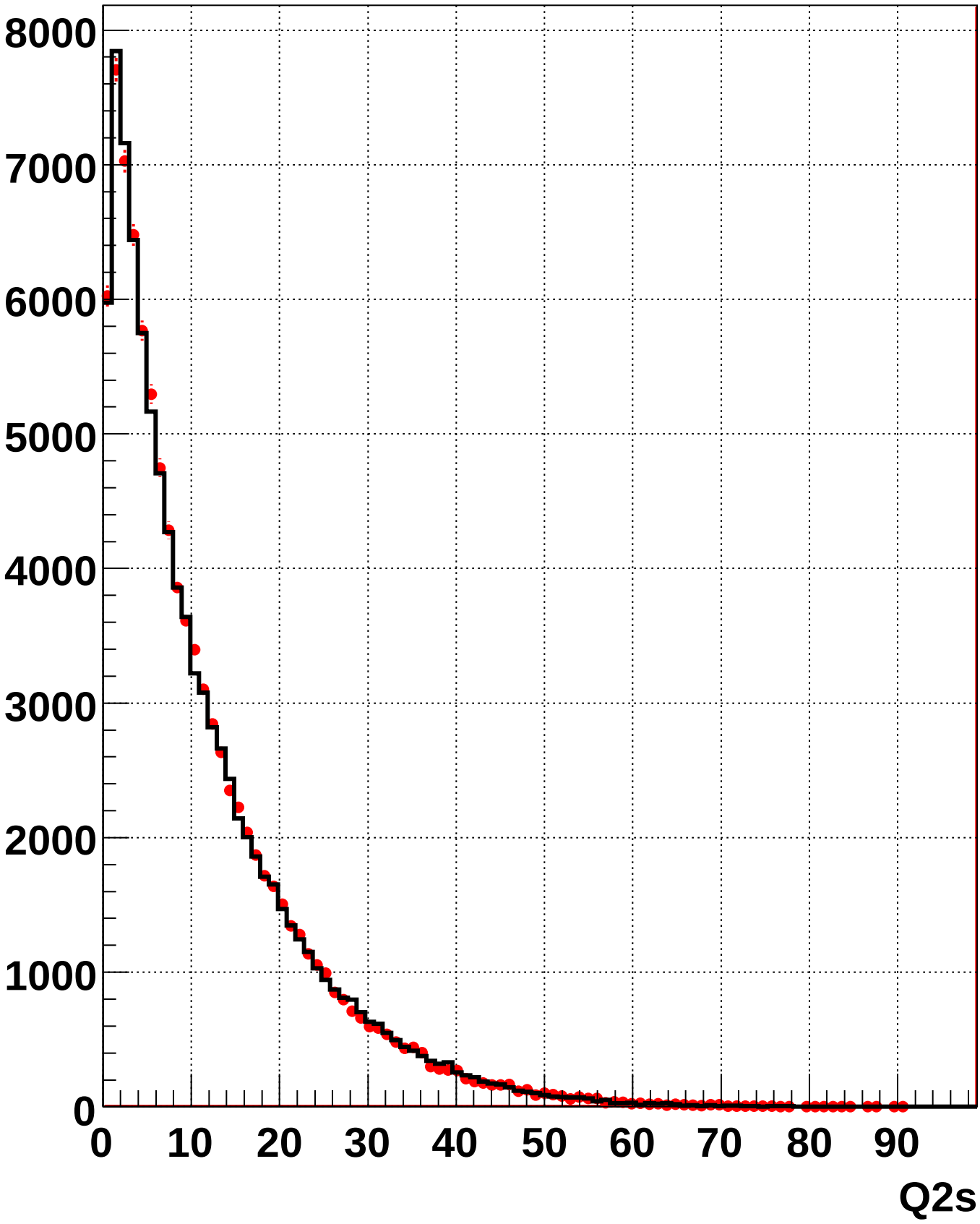
selected Q2 for RES CC events



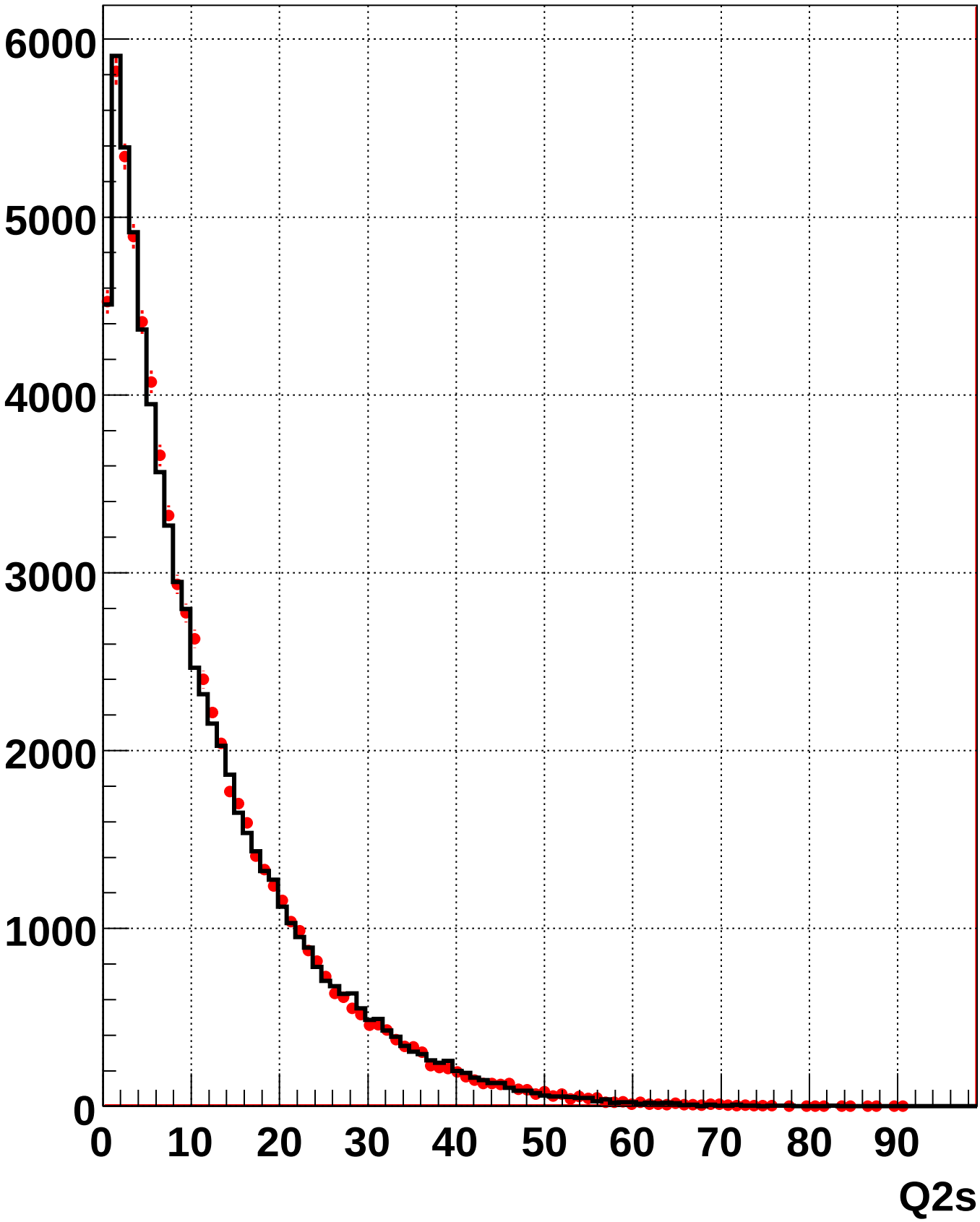
selected Q2 for RES NC events



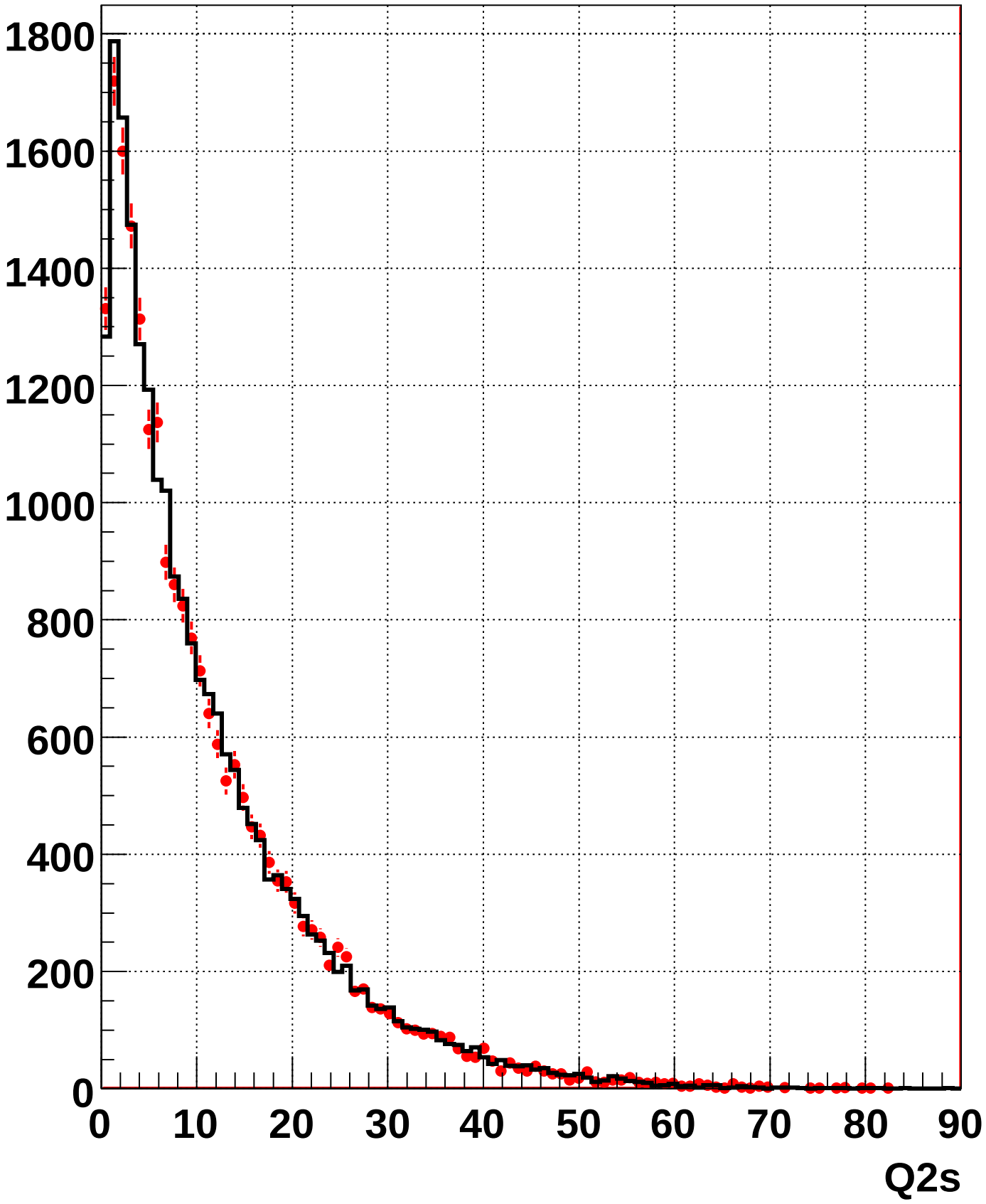
selected Q2 for DIS events



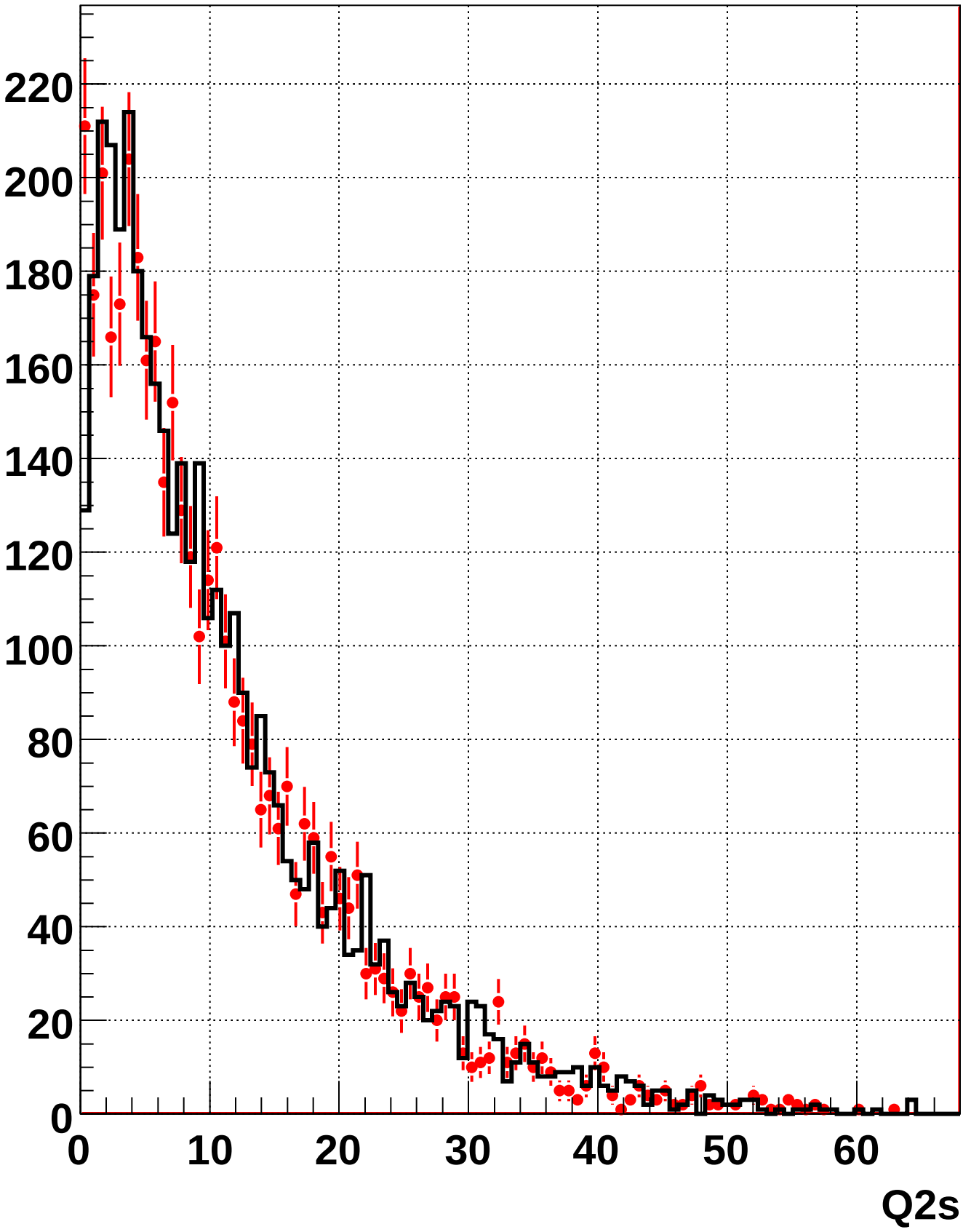
selected Q2 for DIS CC events



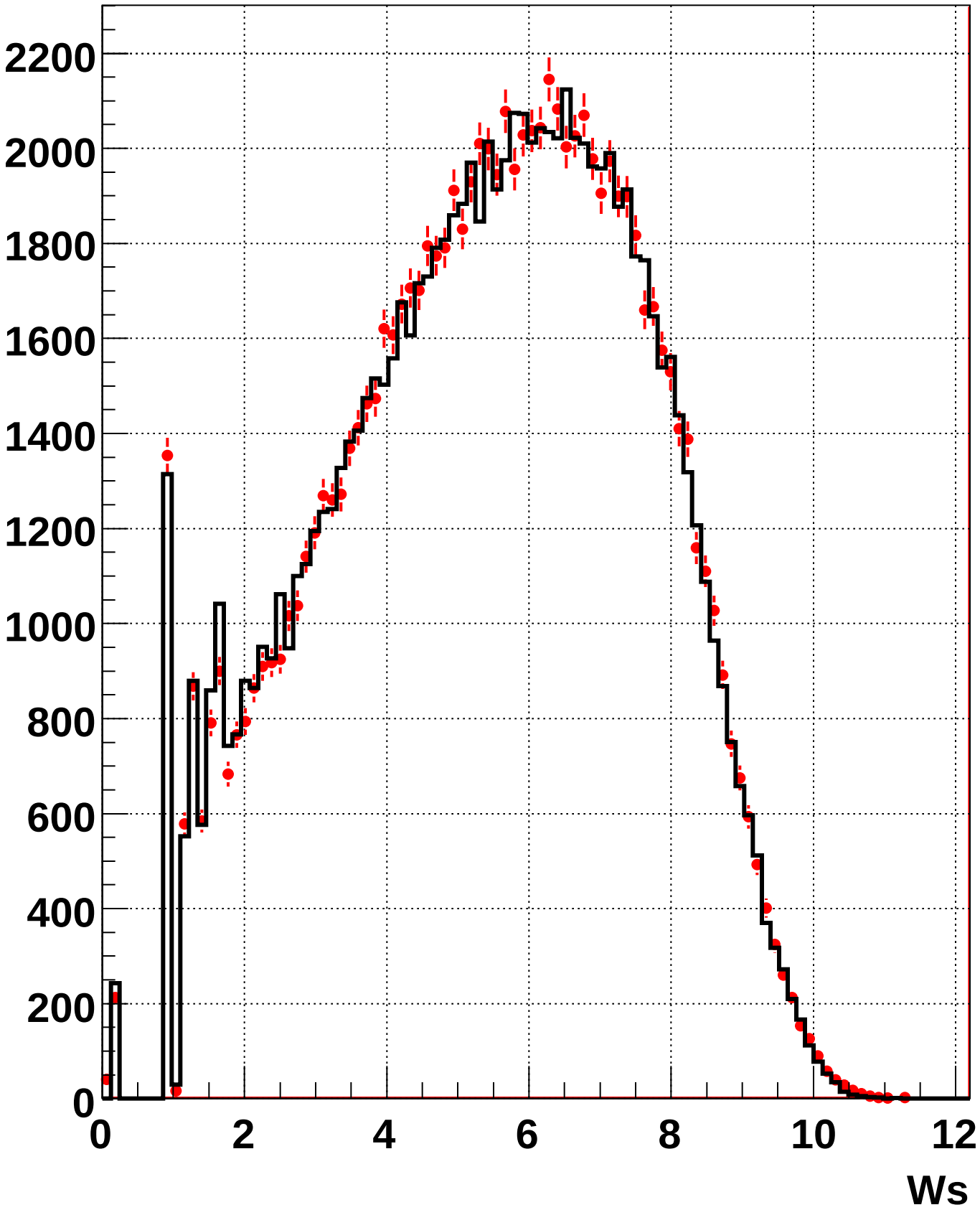
selected Q2 for DIS NC events

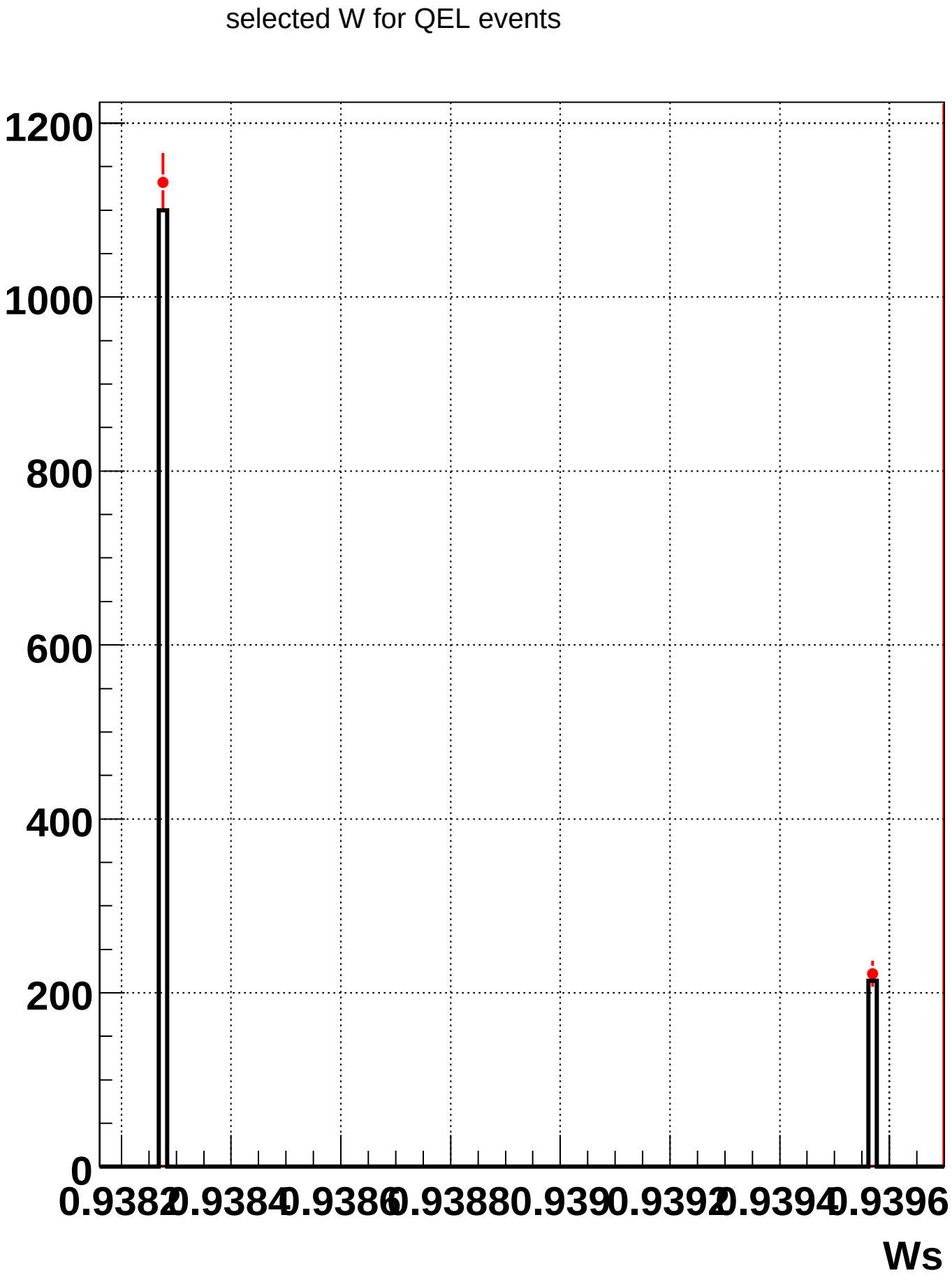


selected Q2 for Charm/DIS events

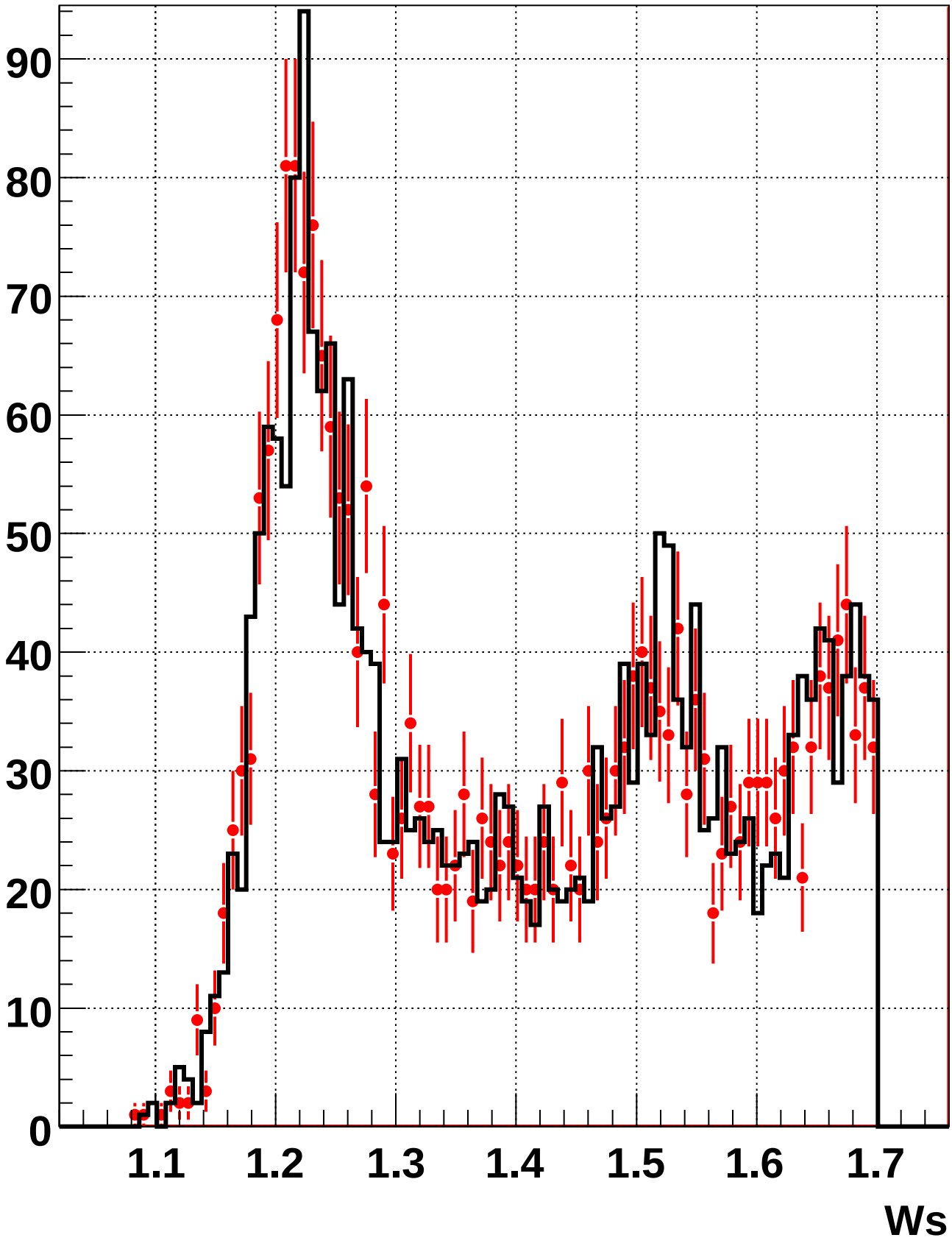


selected W for all events

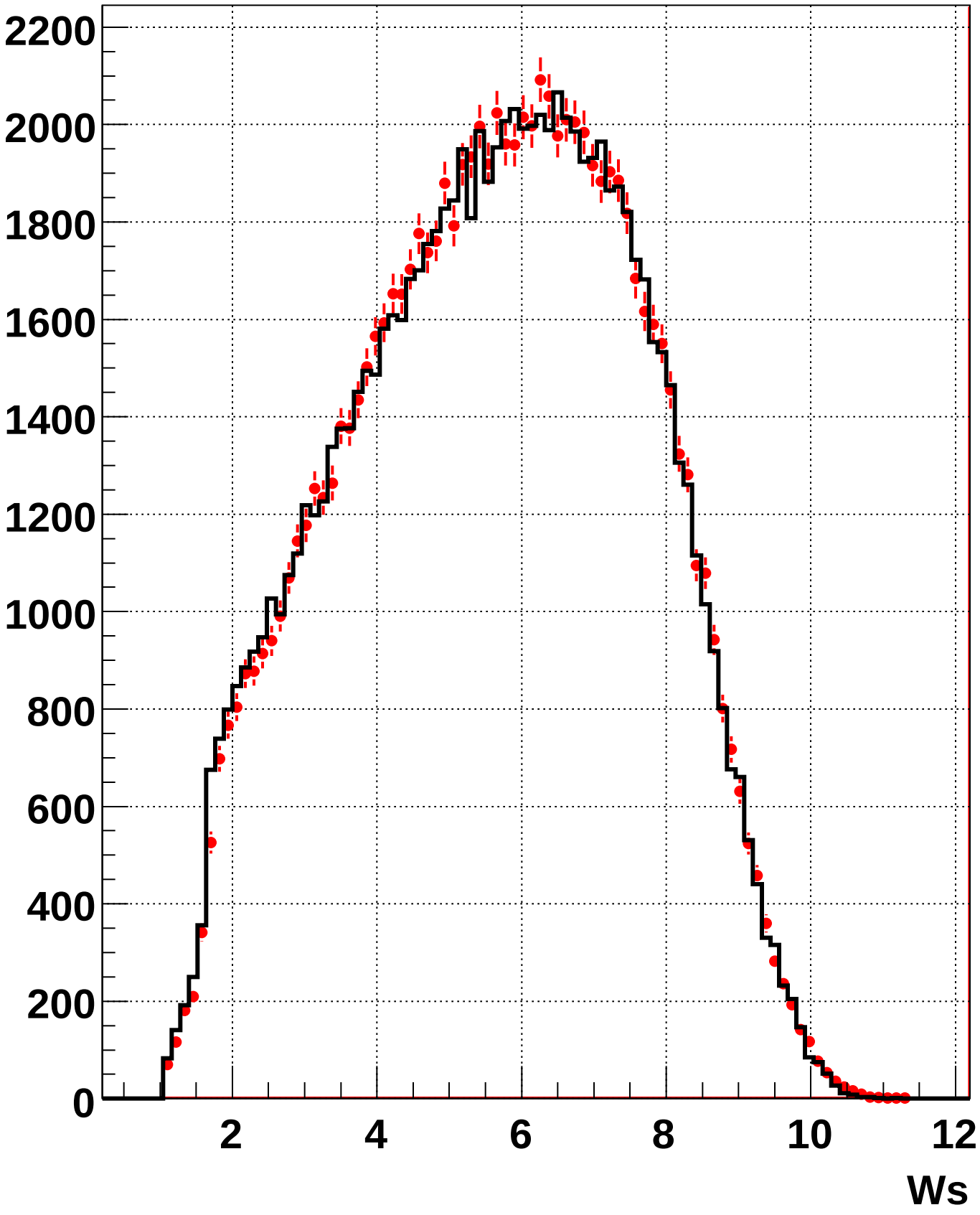



selected W for QEL events
1200
1000
800
600
400
200
0
0.9382
0.9384
0.9386
0.9388
0.939
0.9392
0.9394
0.9396
Ws

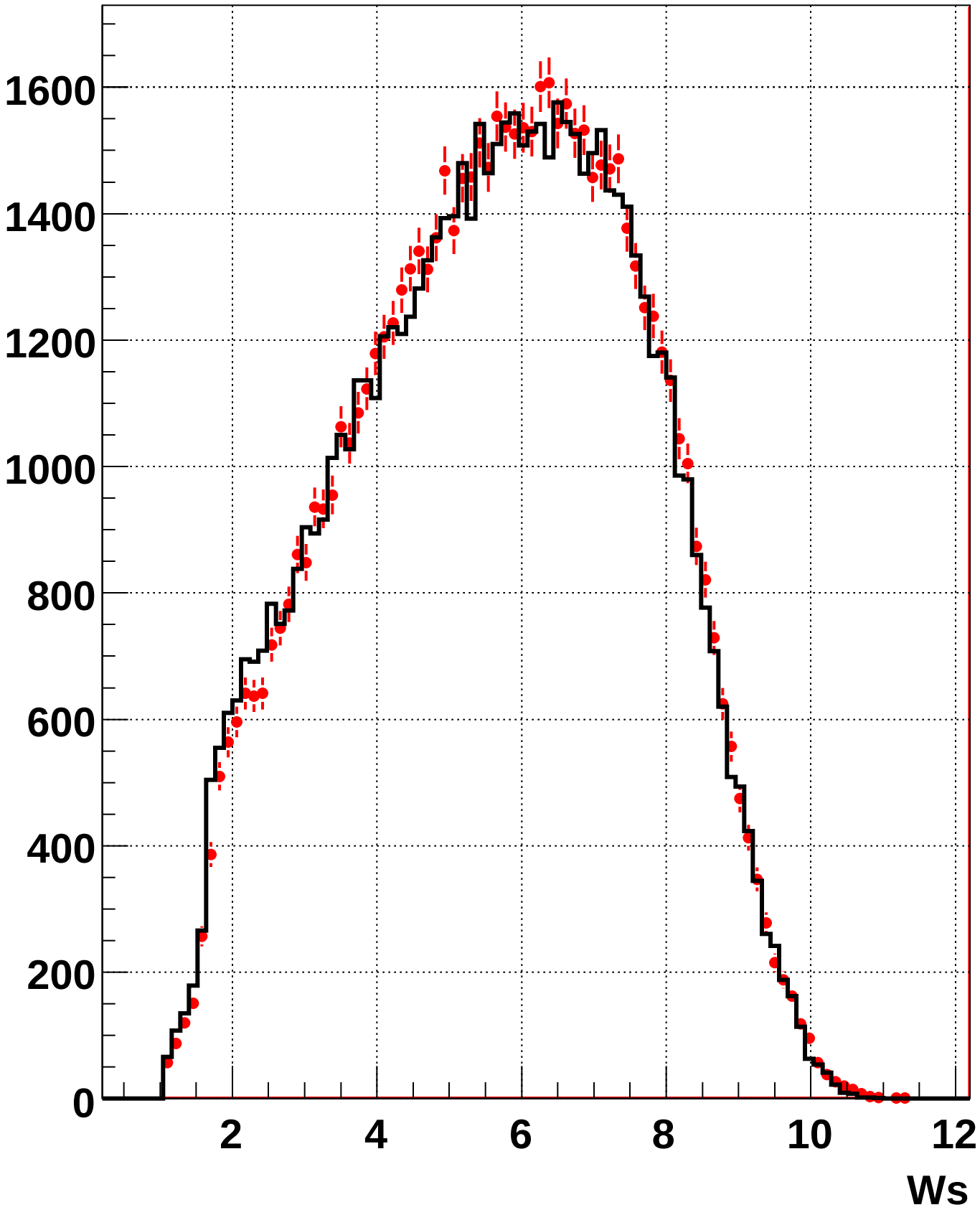
selected W for RES events



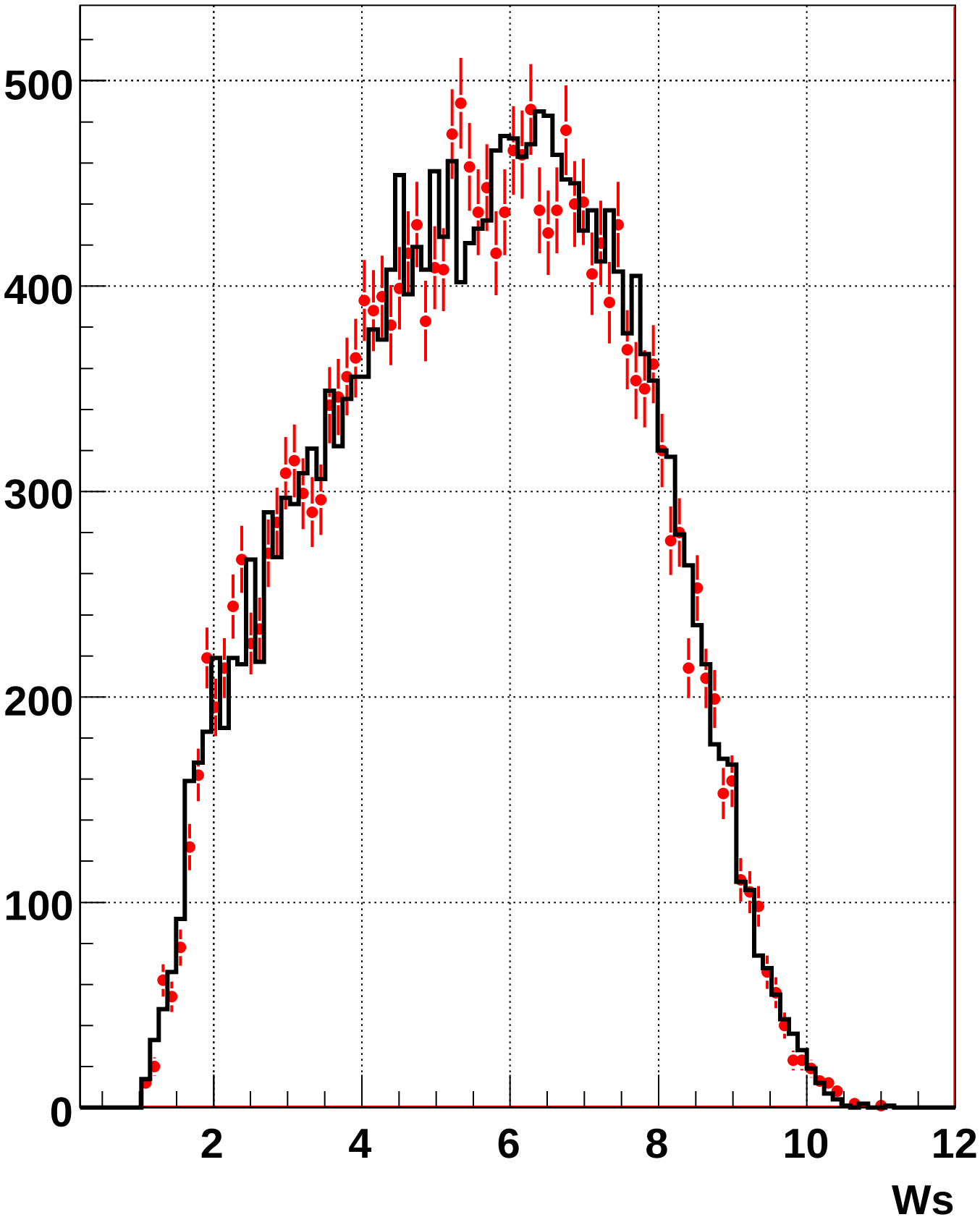
selected W for DIS events



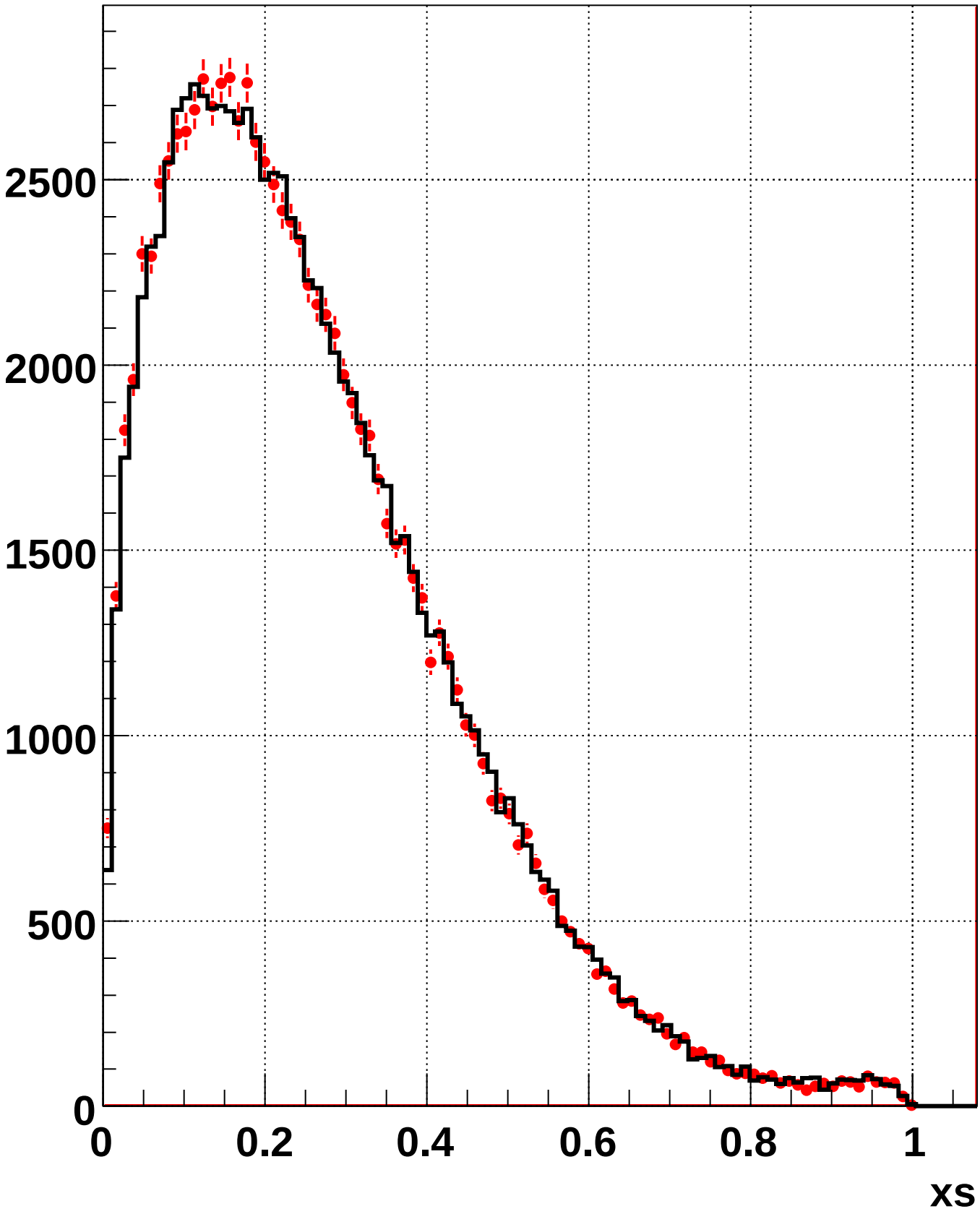
selected W for DIS CC events



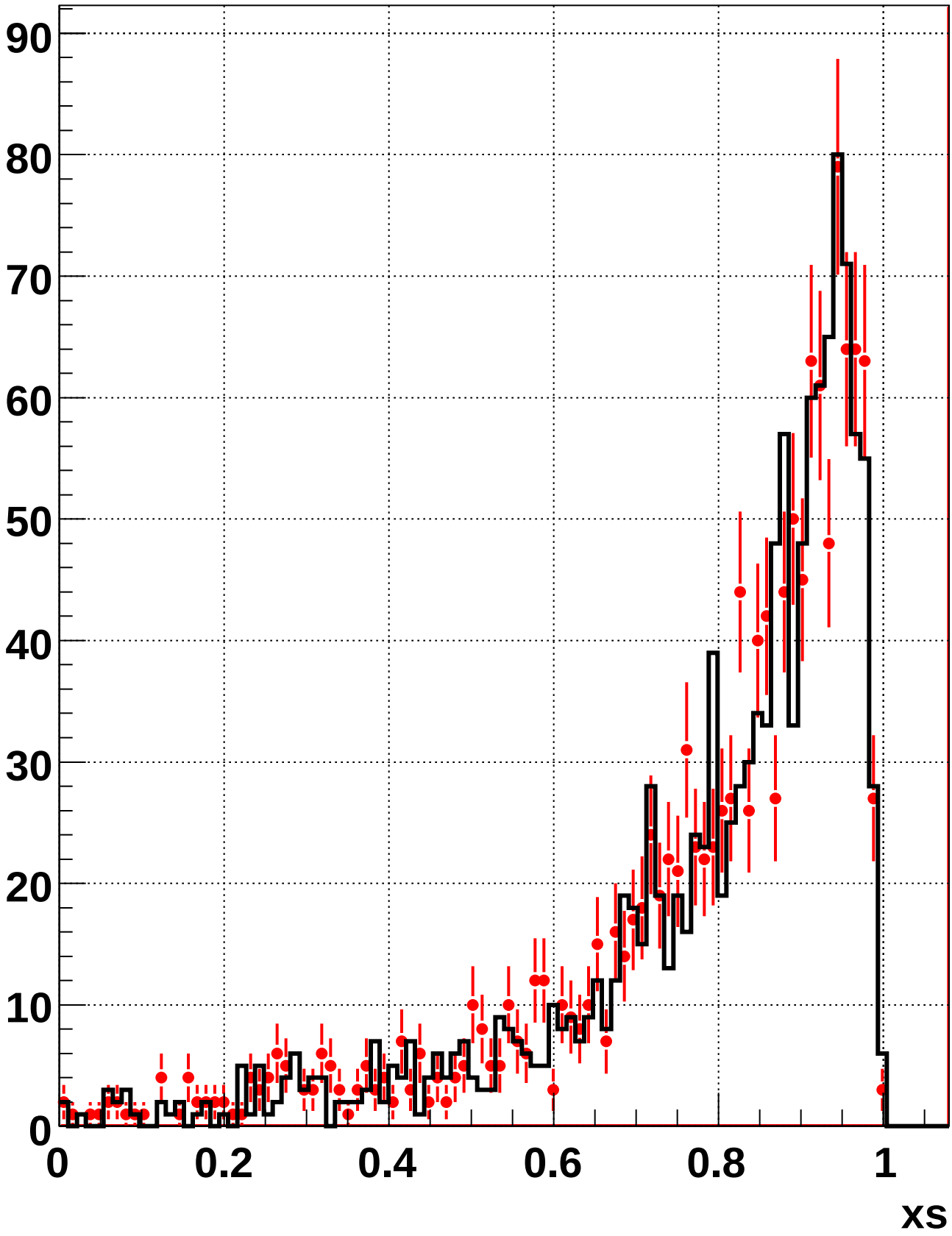
selected W for DIS NC events



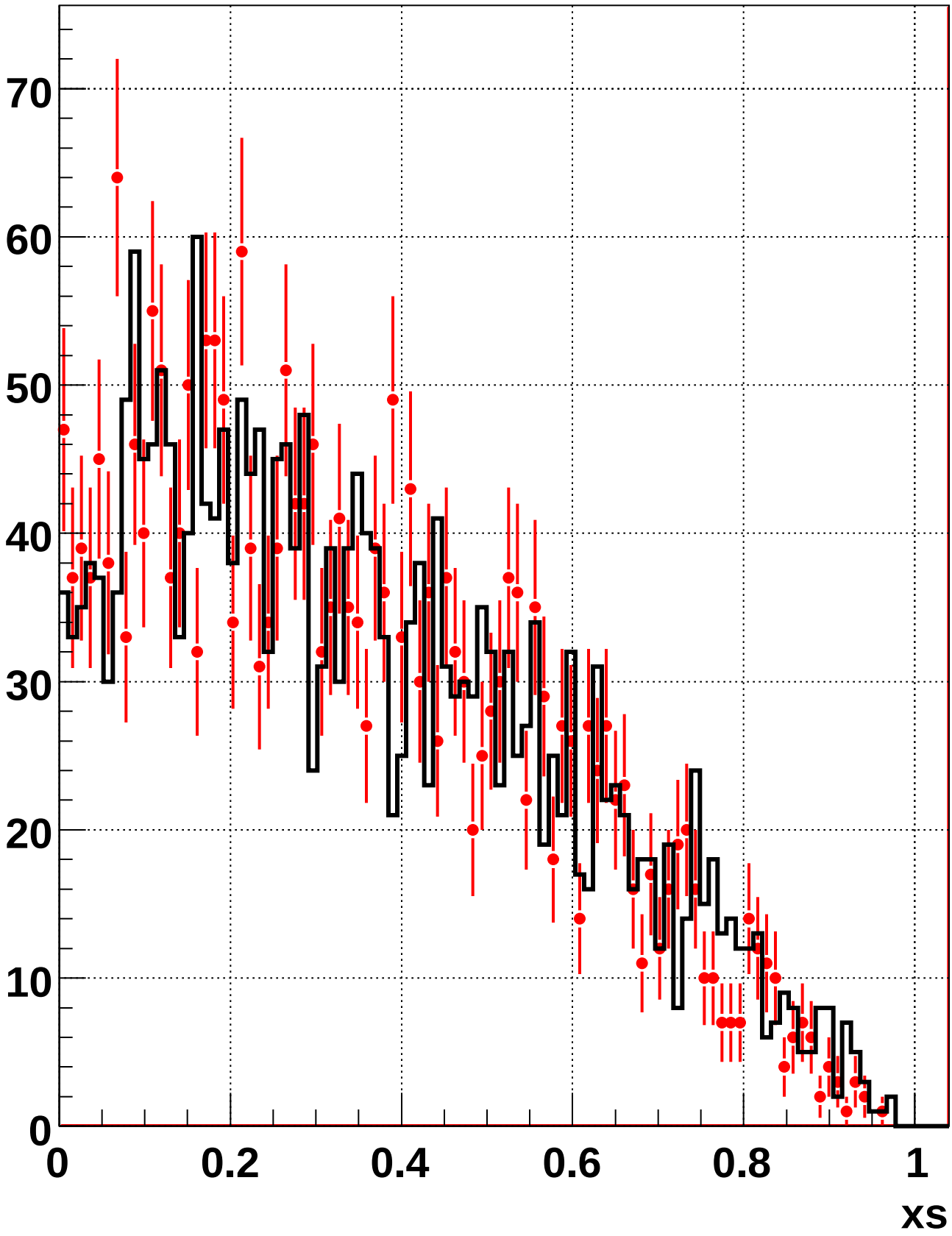
selected x for all events



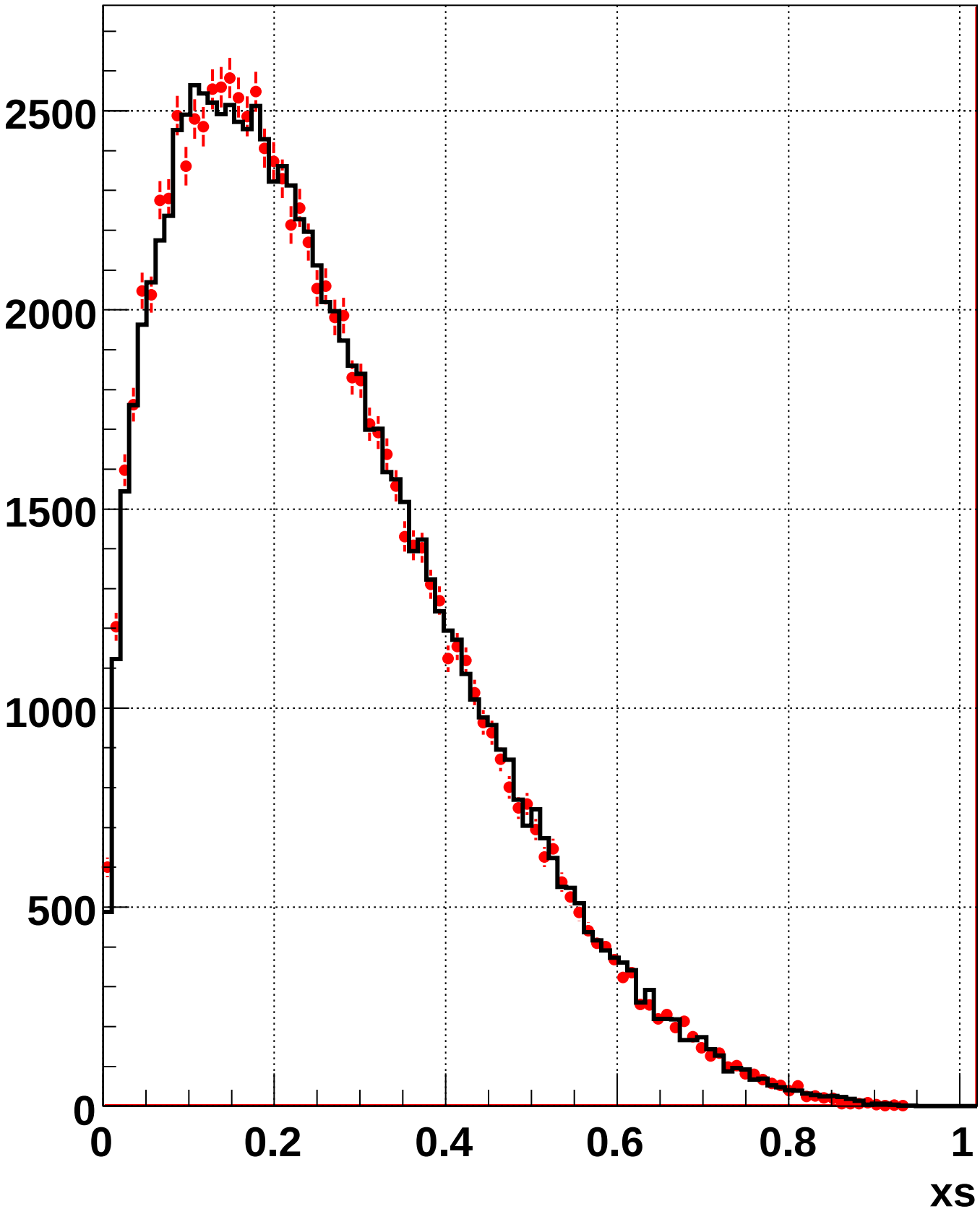
selected x for QEL events



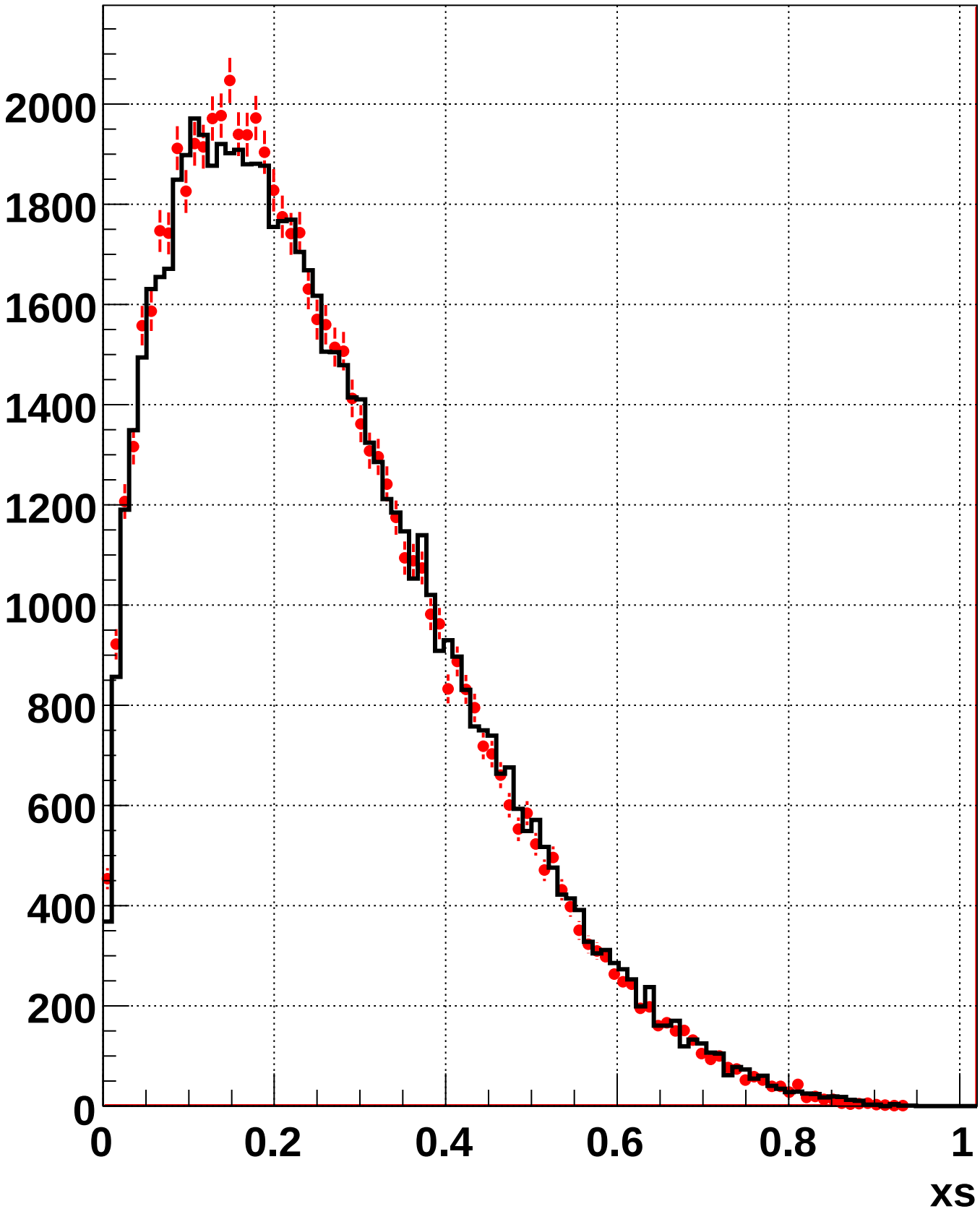
selected x for RES events



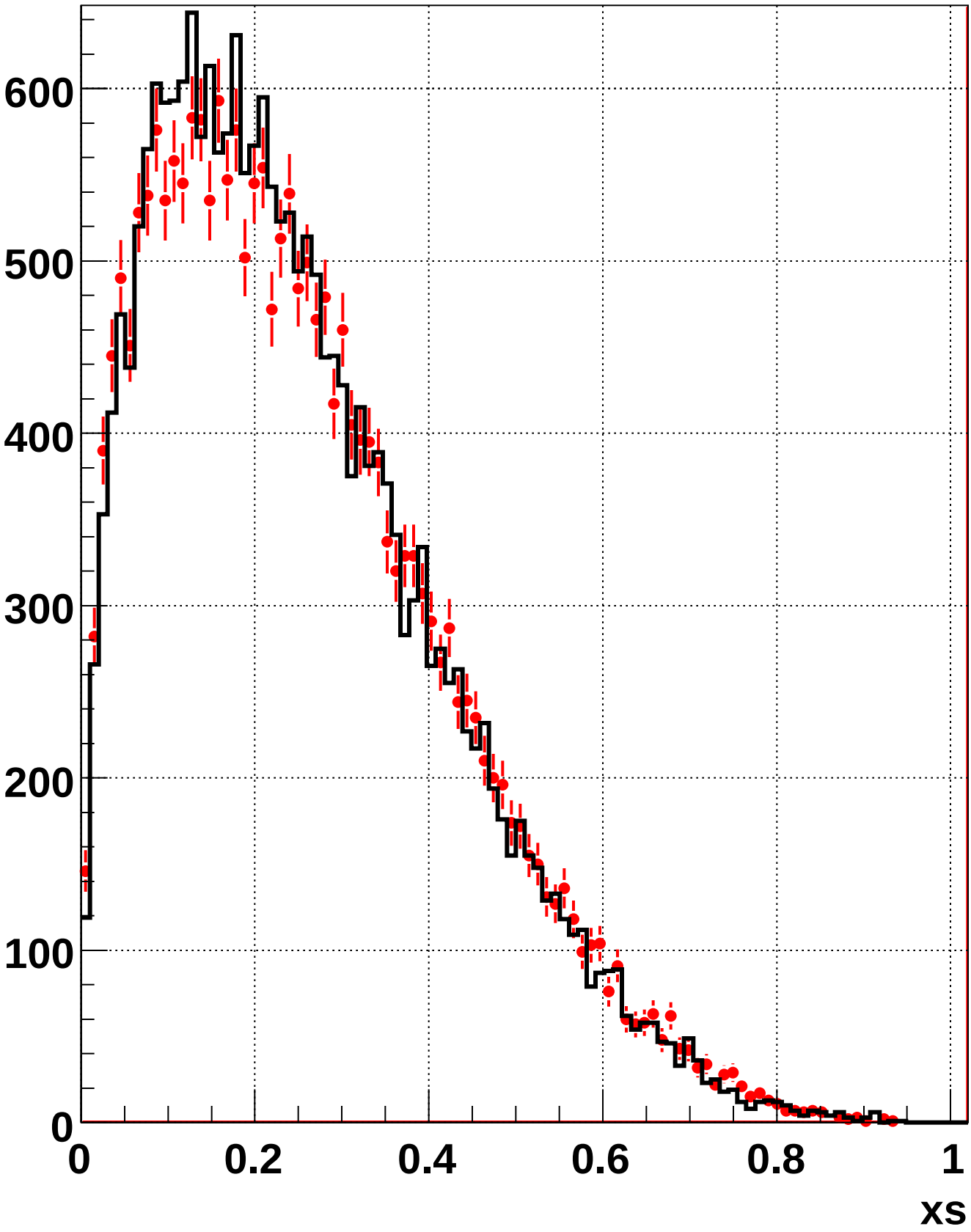
selected x for DIS events



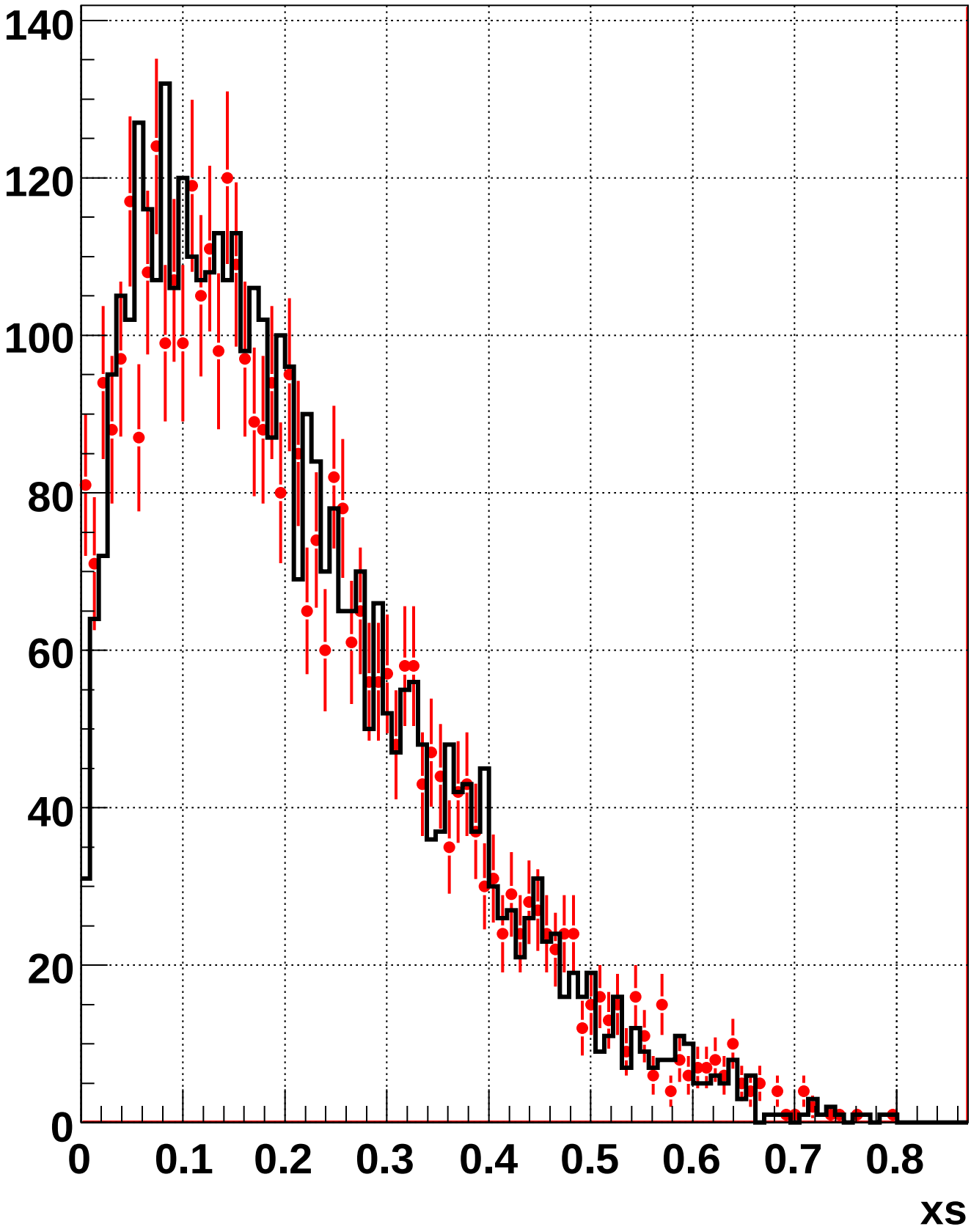
selected x for DIS CC events



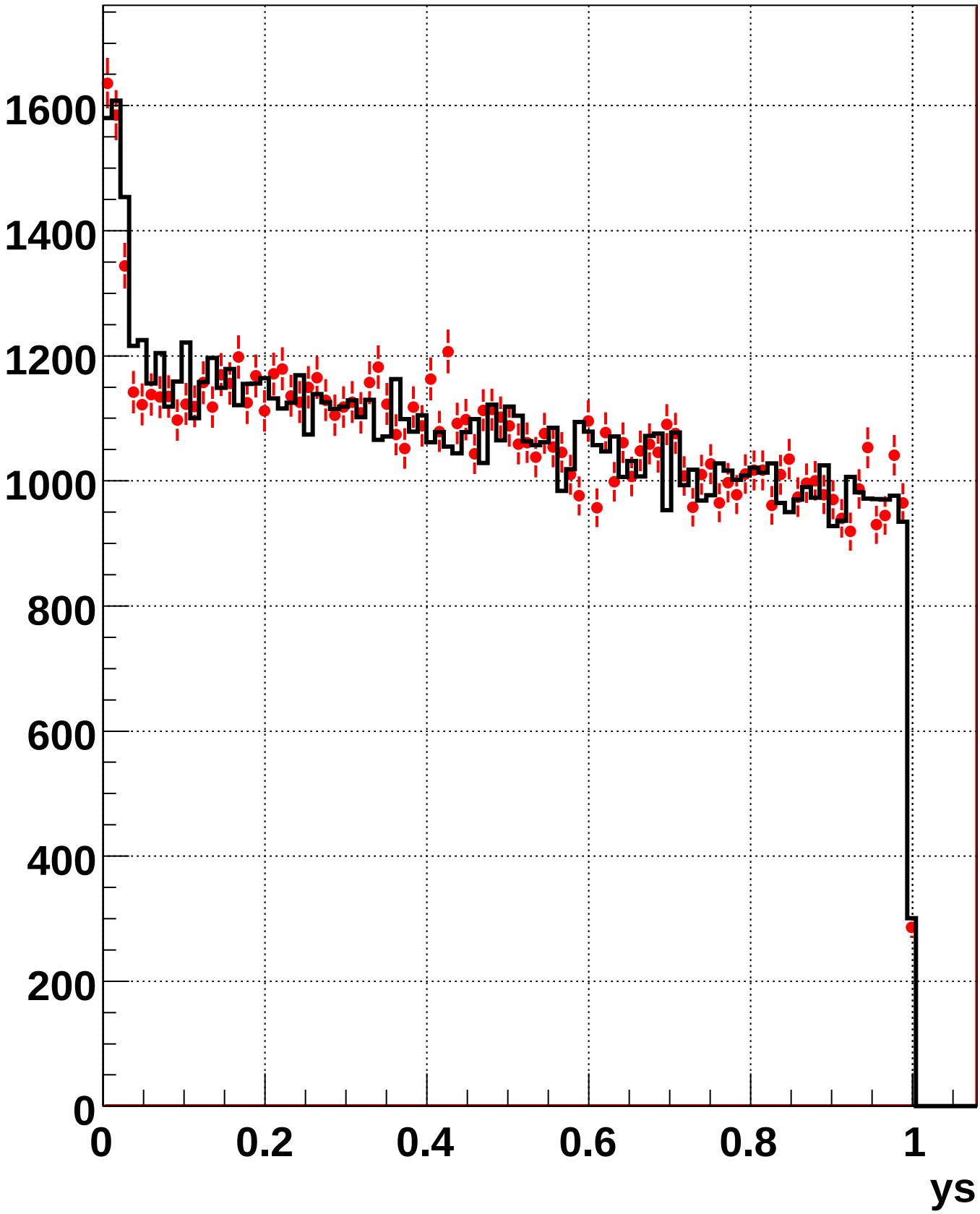
selected x for DIS NC events



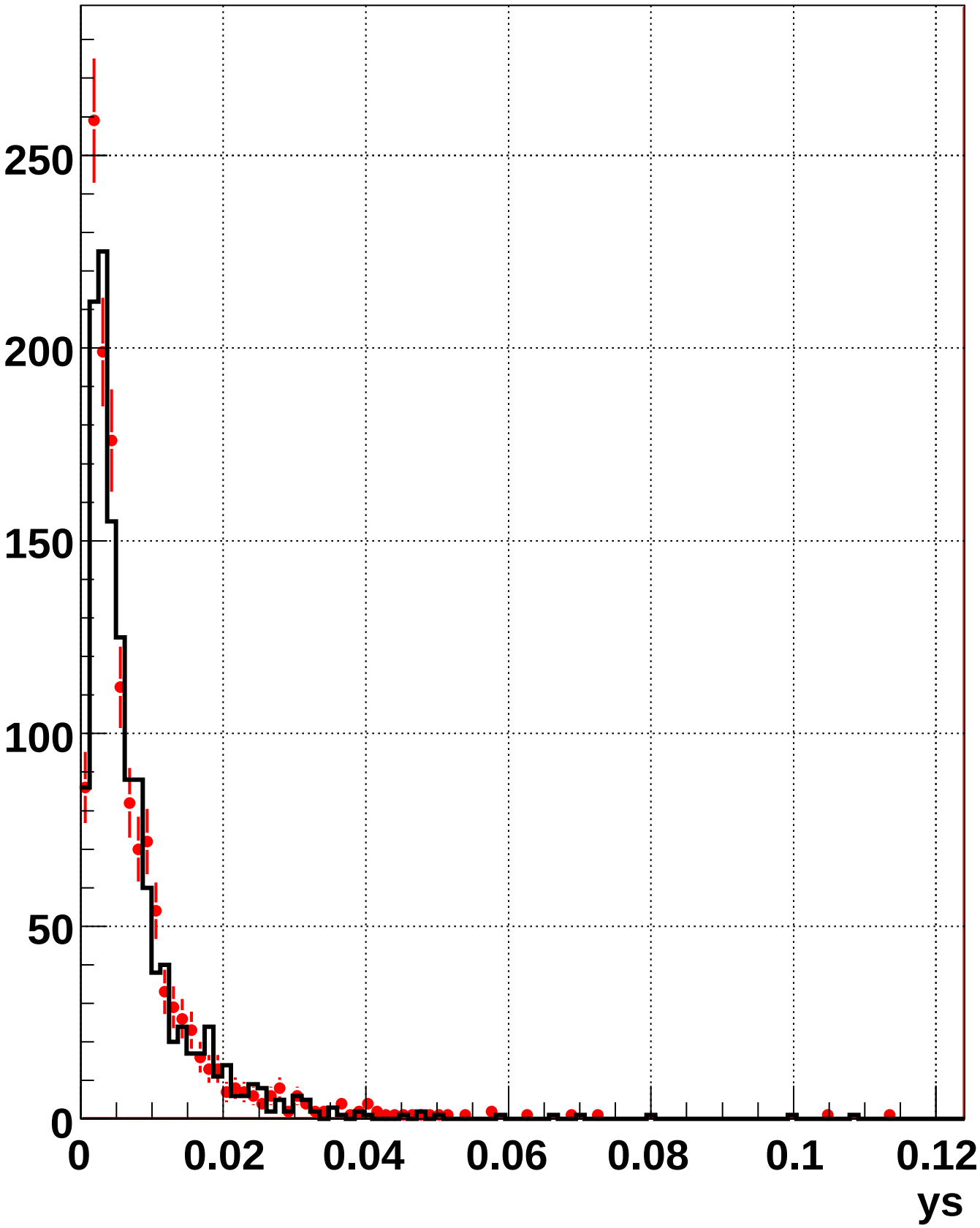
selected x for Charm/DIS events



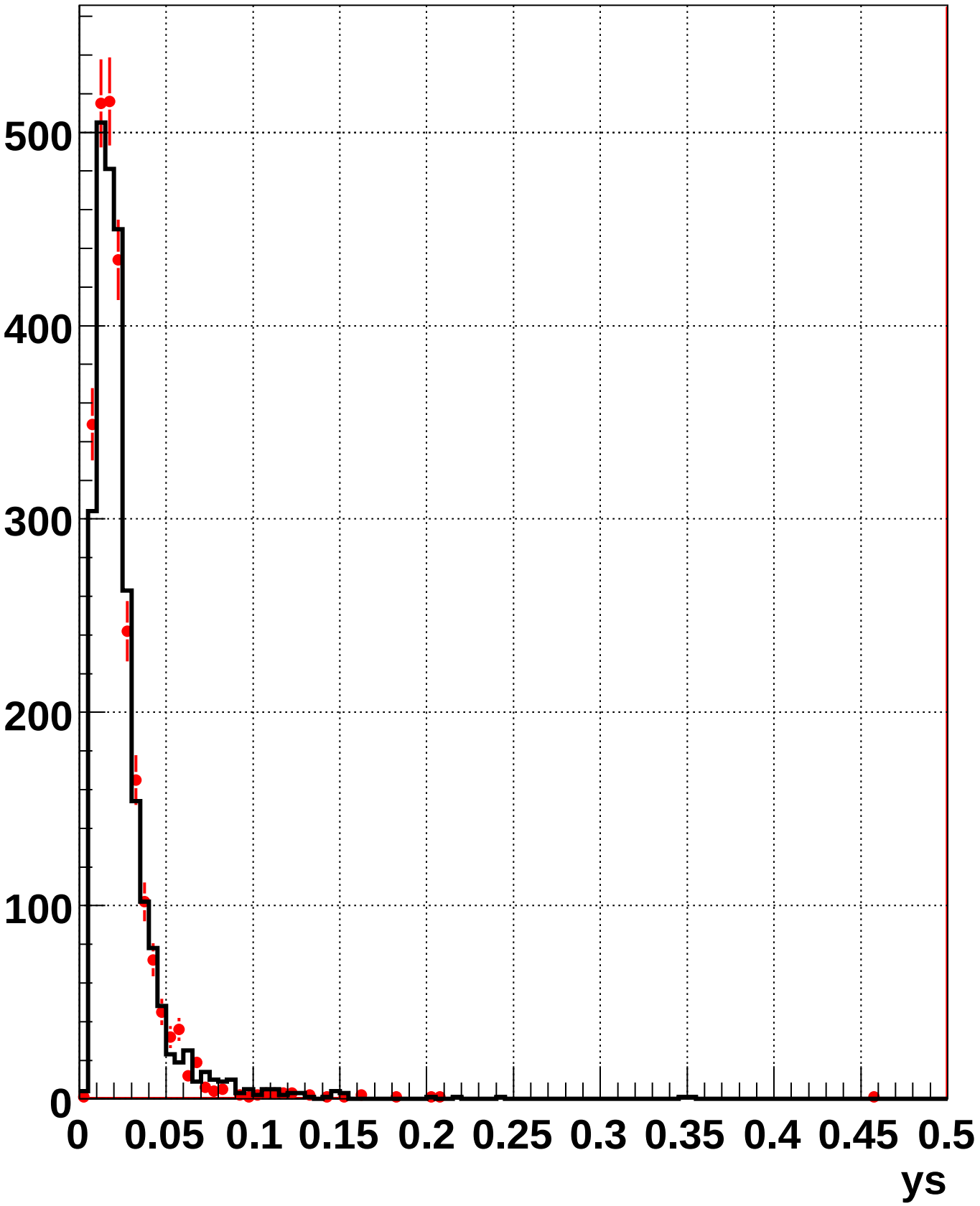
selected y for all events



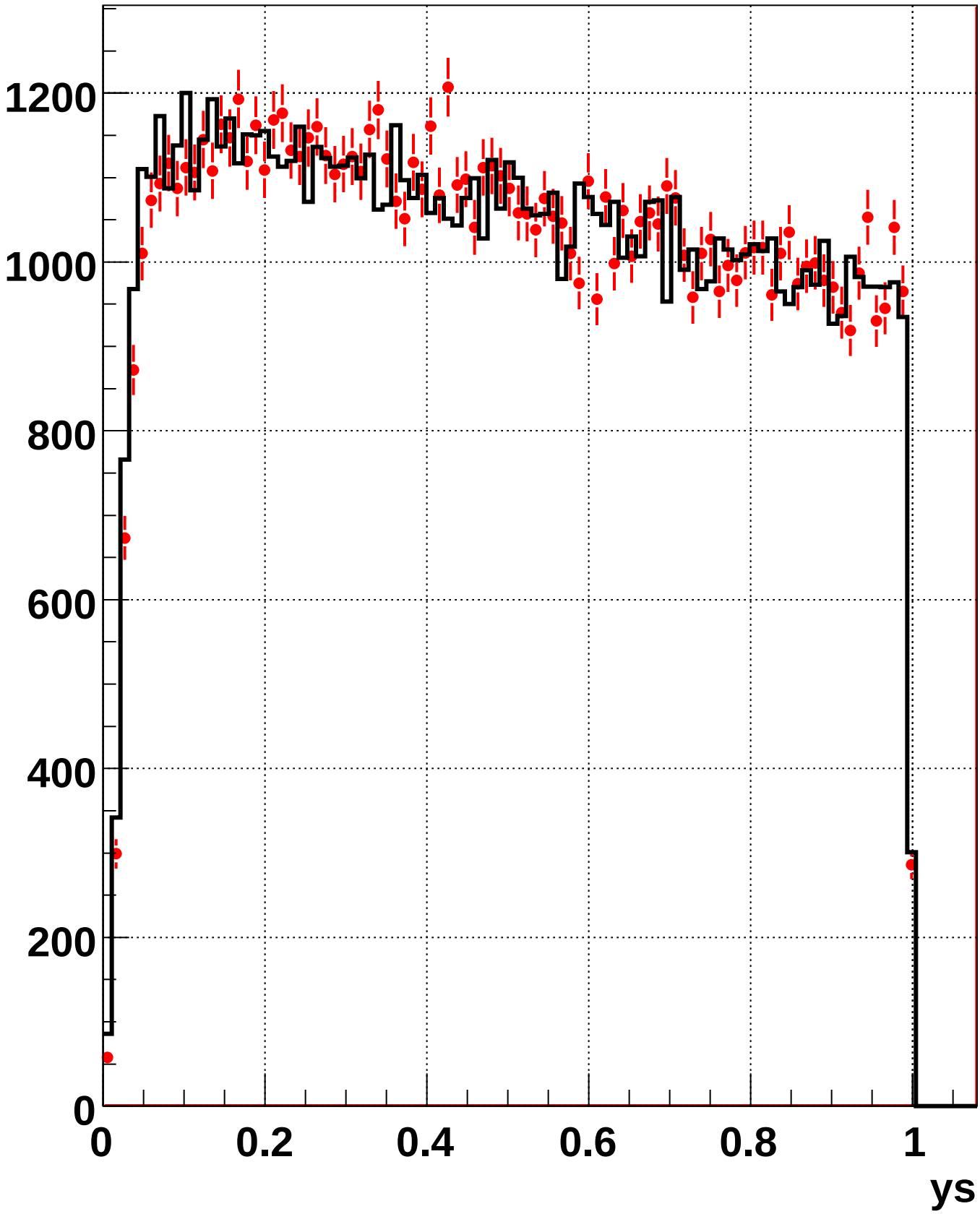
selected y for QEL events



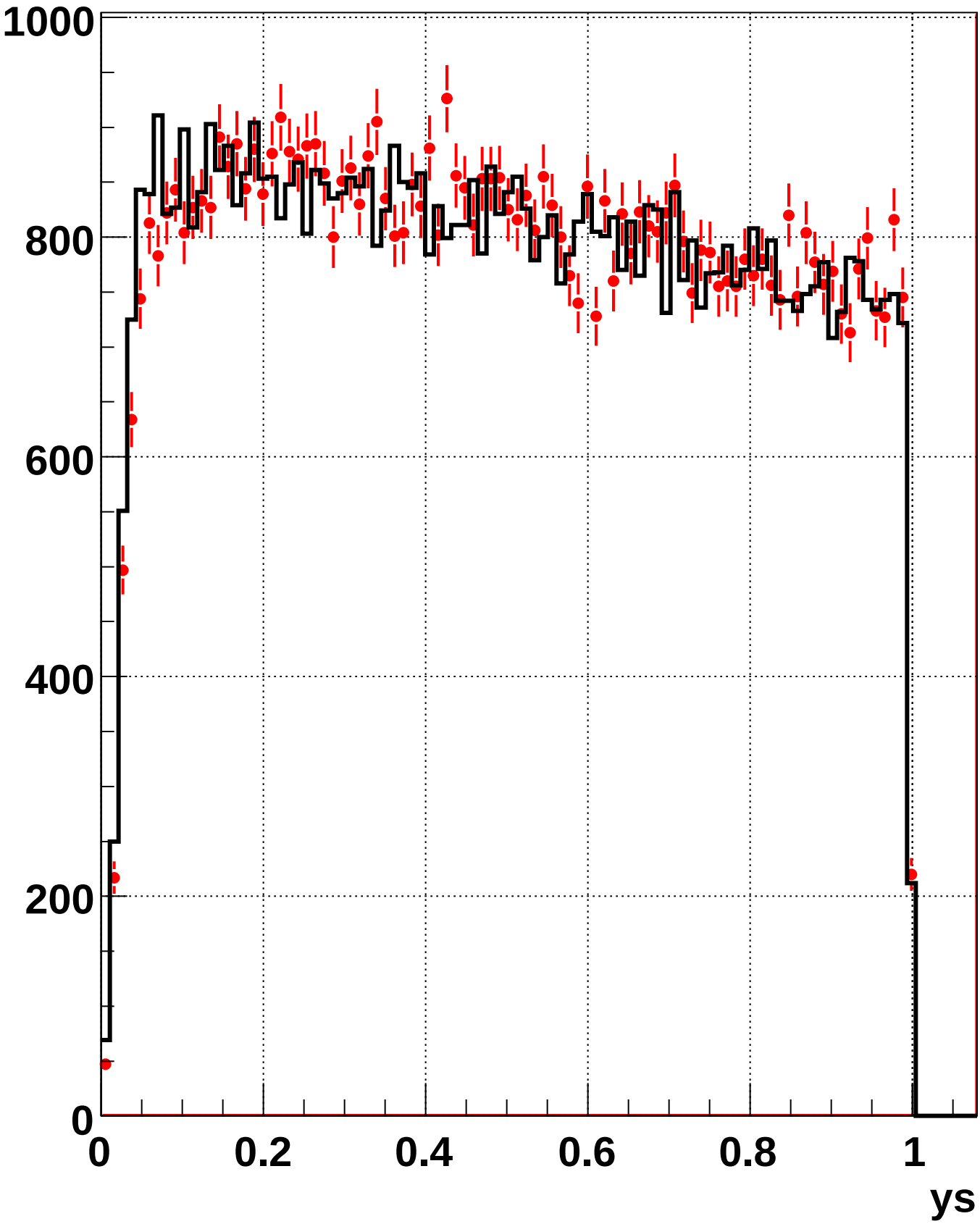
selected y for RES events



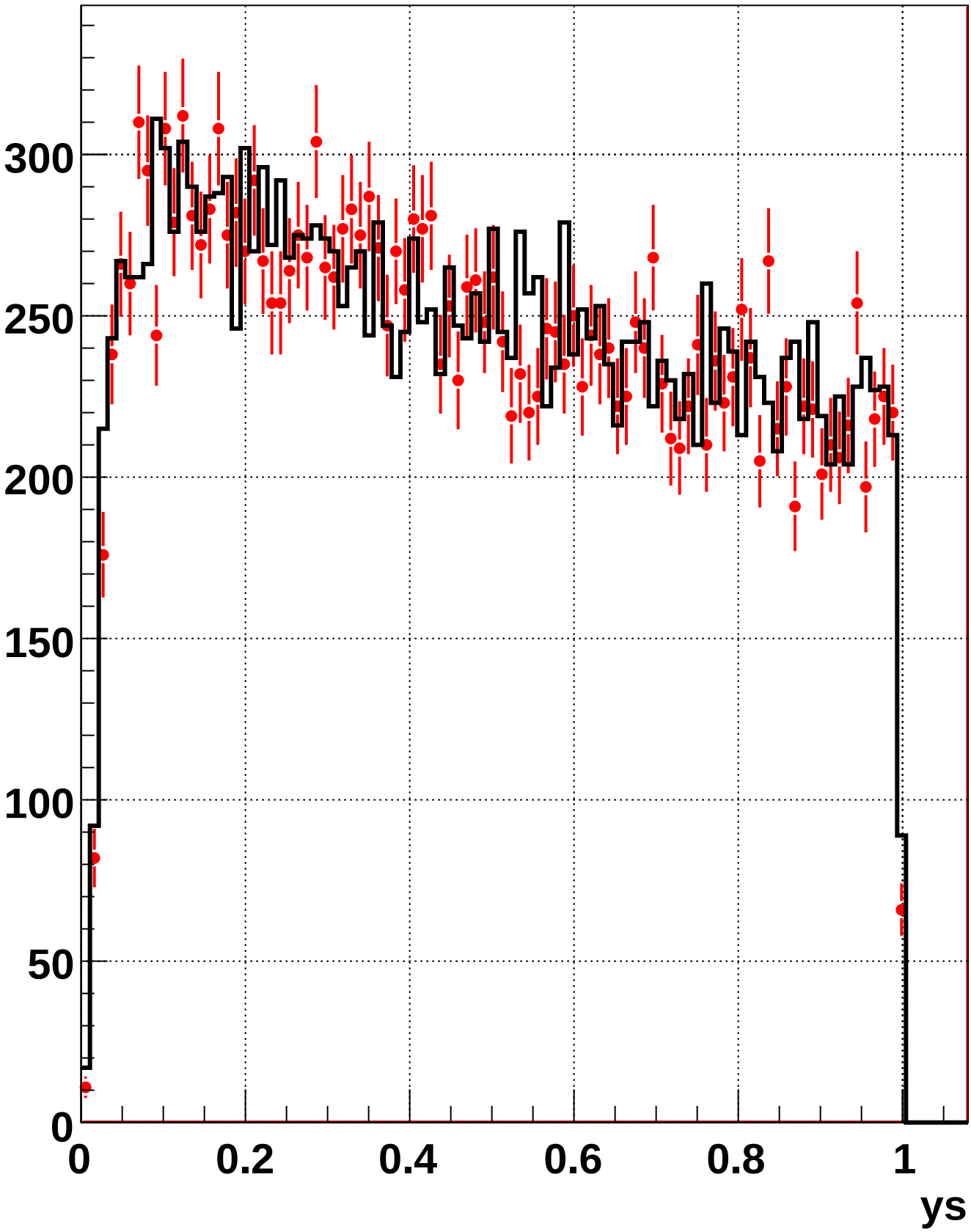
selected y for DIS events



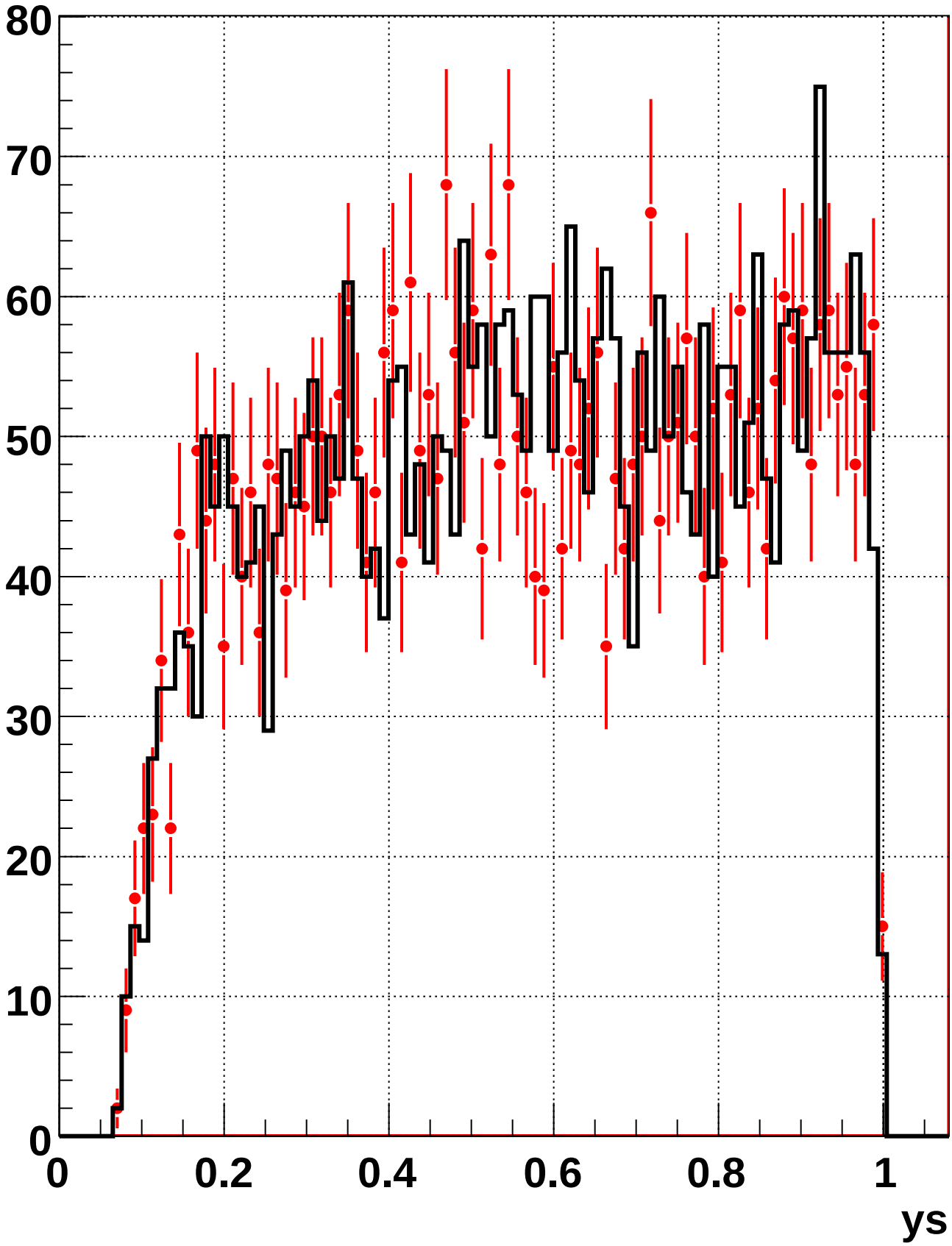
selected y for DIS CC events



selected y for DIS NC events



selected y for Charm/DIS events

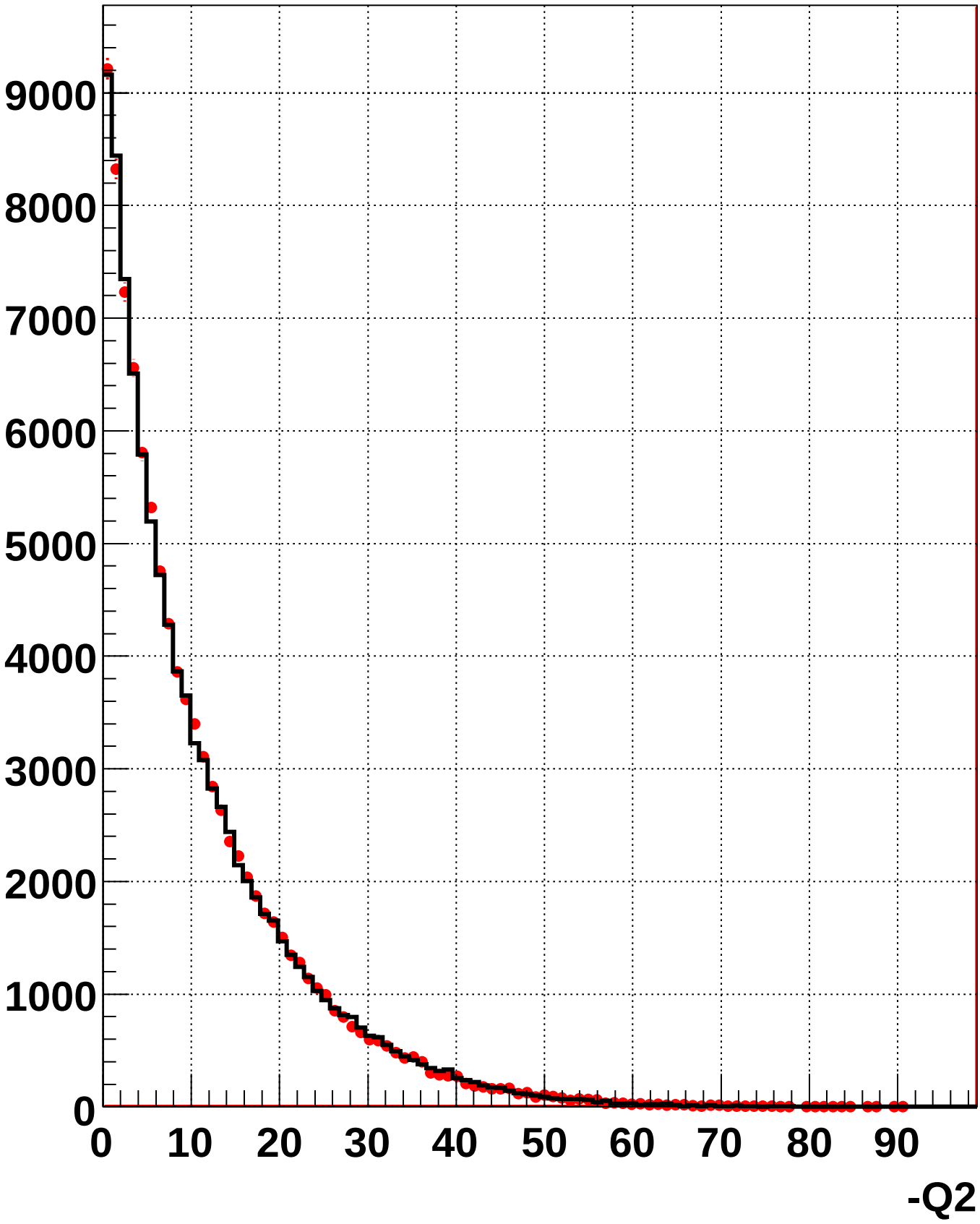


Kinematical Quantities

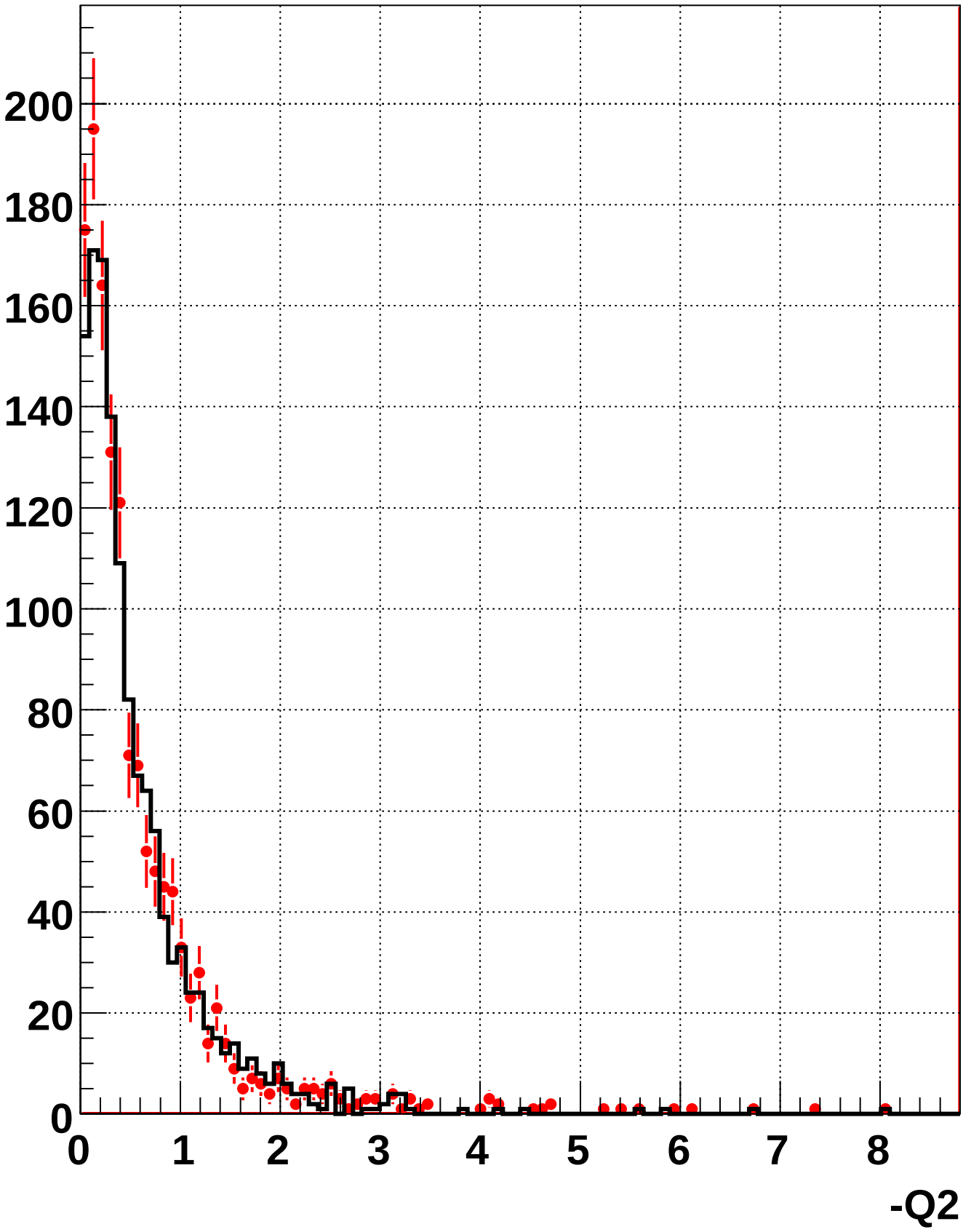
Similar to the previous set of plots but

showing ’computed’ rathen than ’selected’ variables

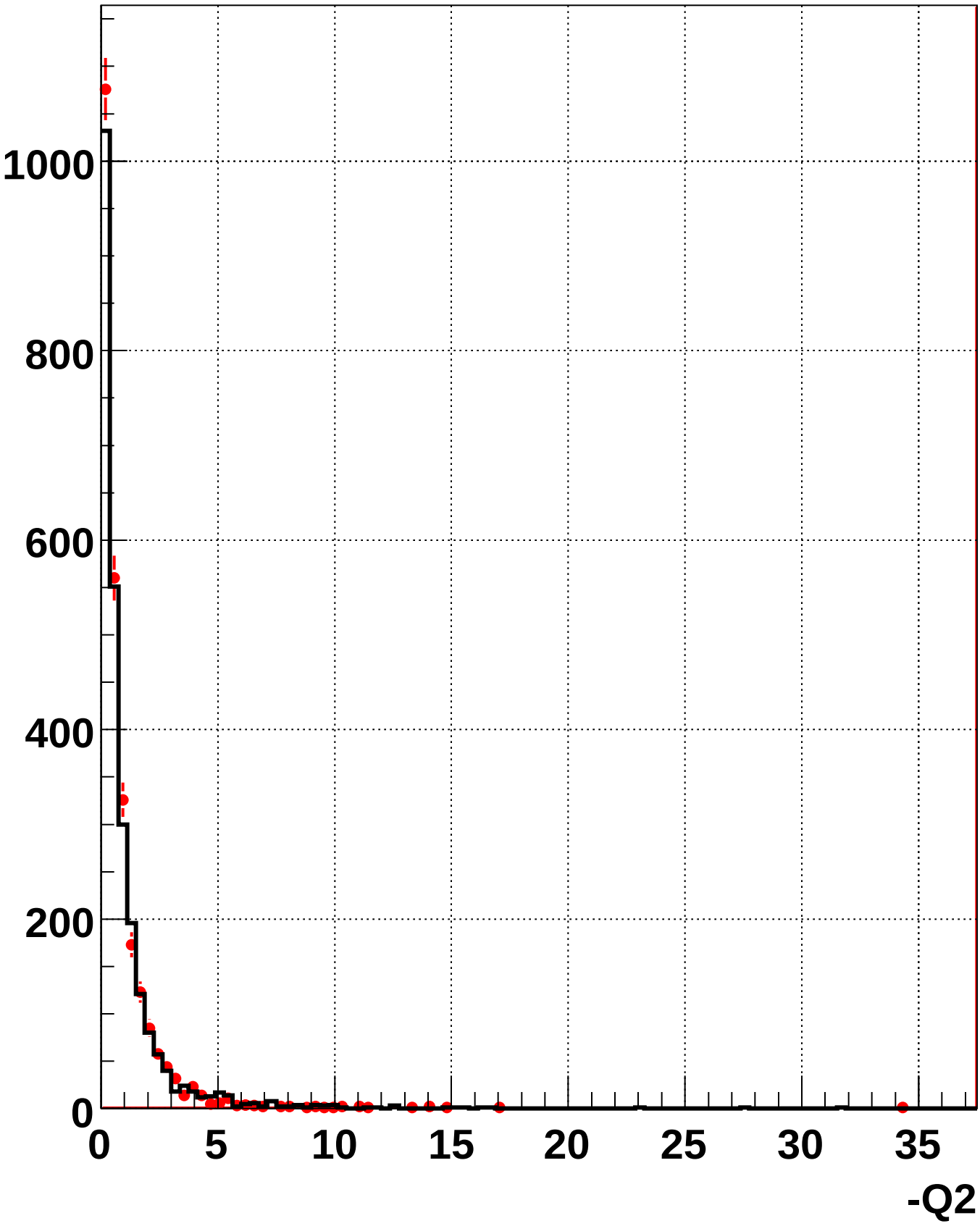
computed Q2 for all events



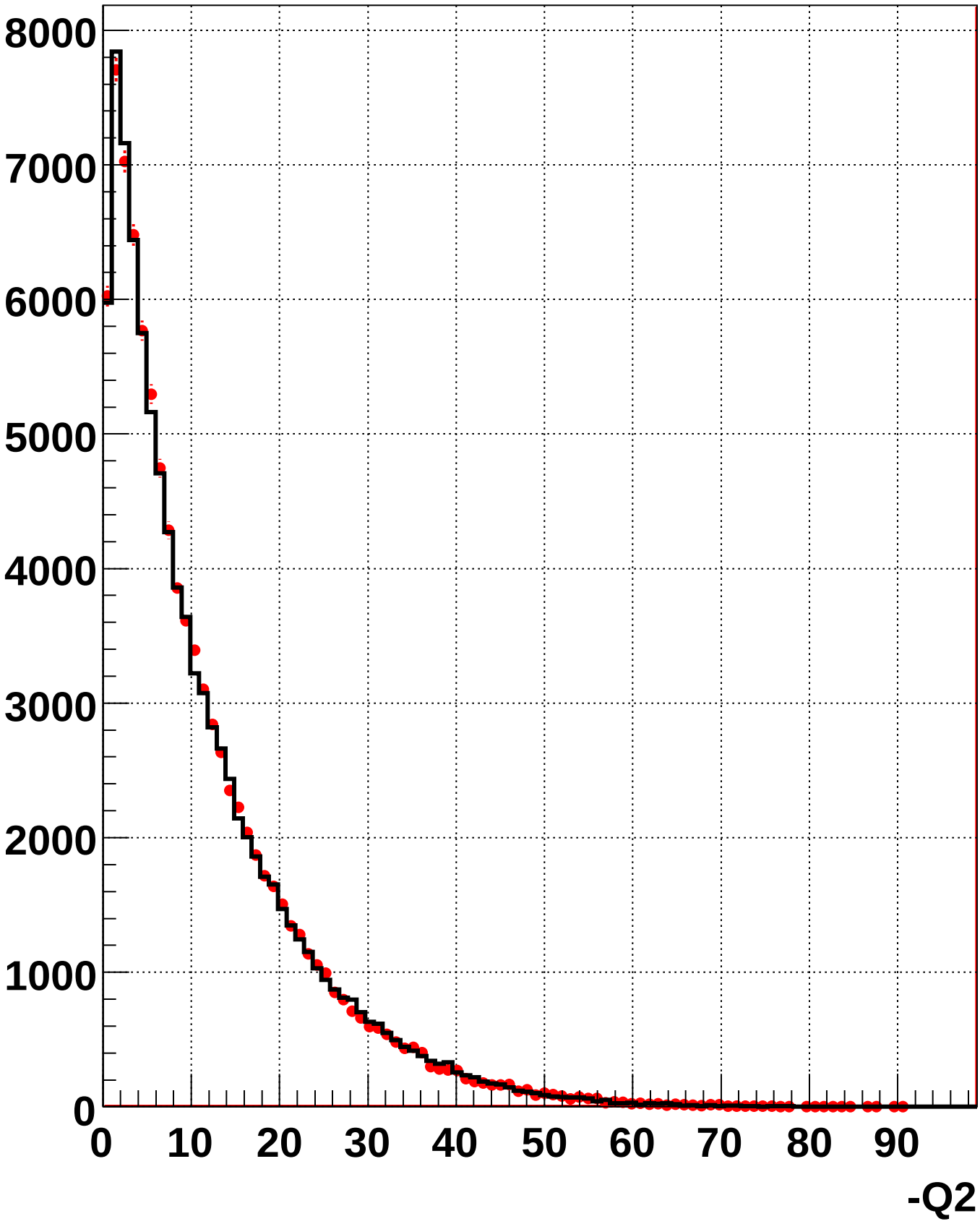
computed Q2 for QEL events



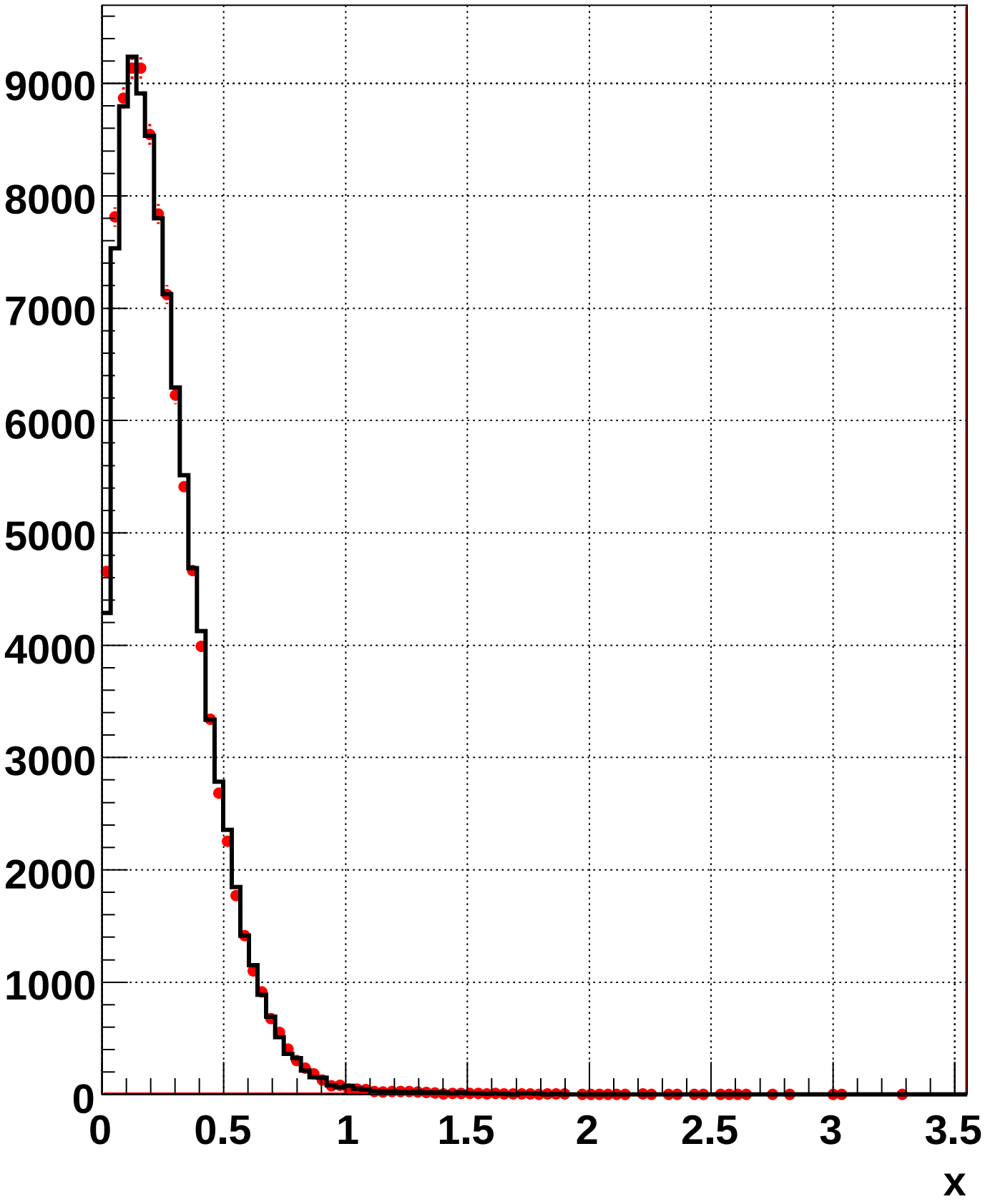
computed Q2 for RES events



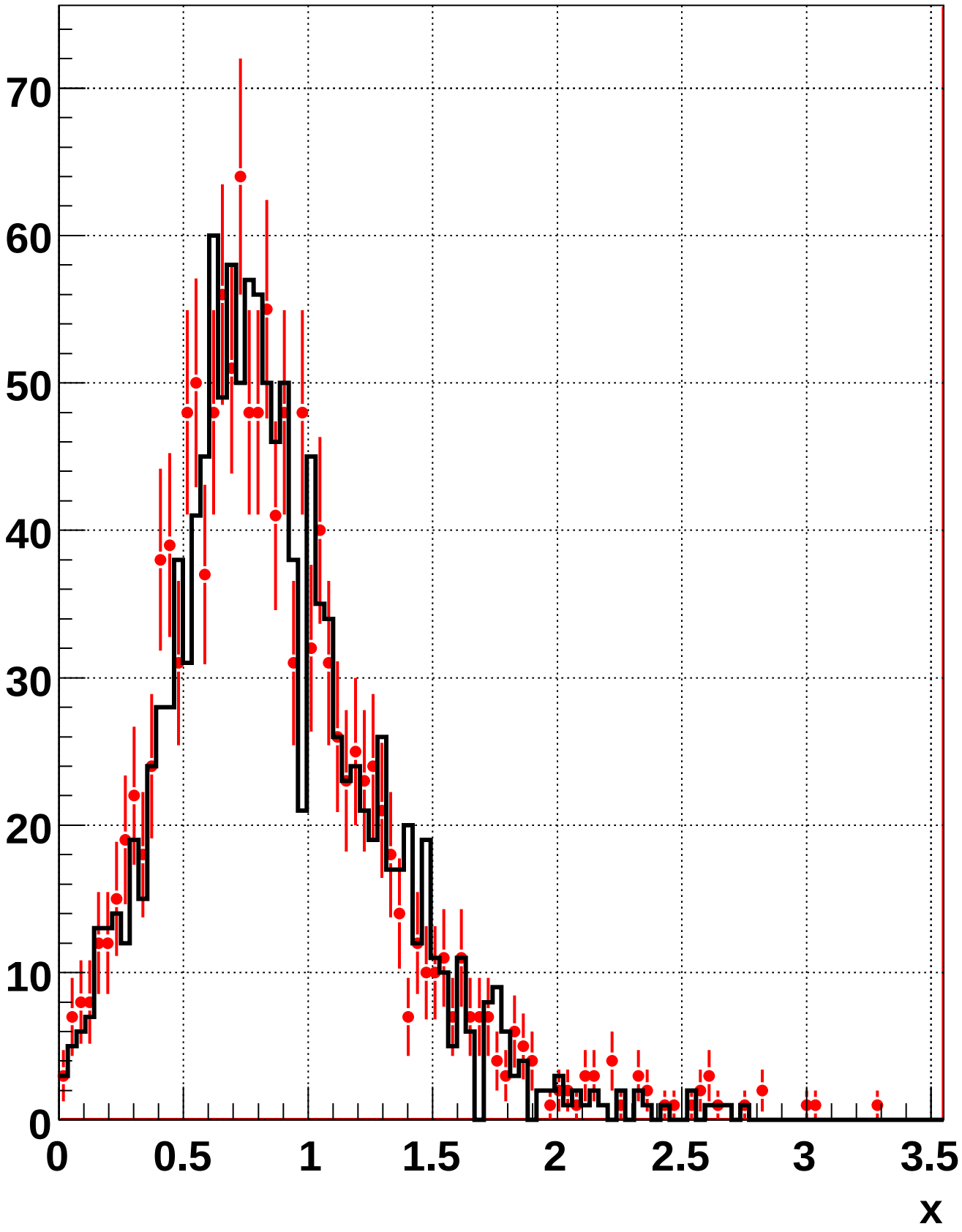
computed Q2 for DIS events



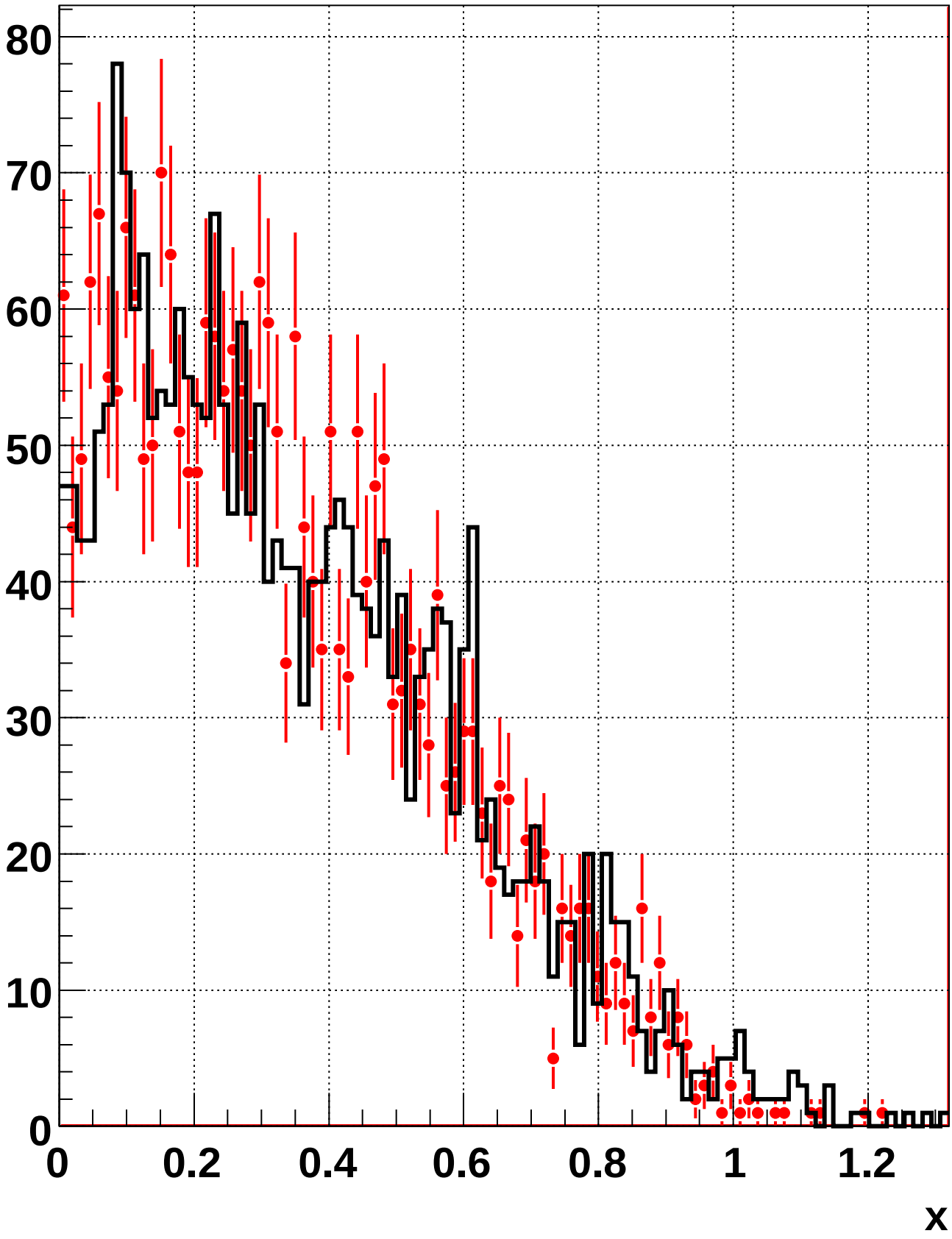
computed x for all events



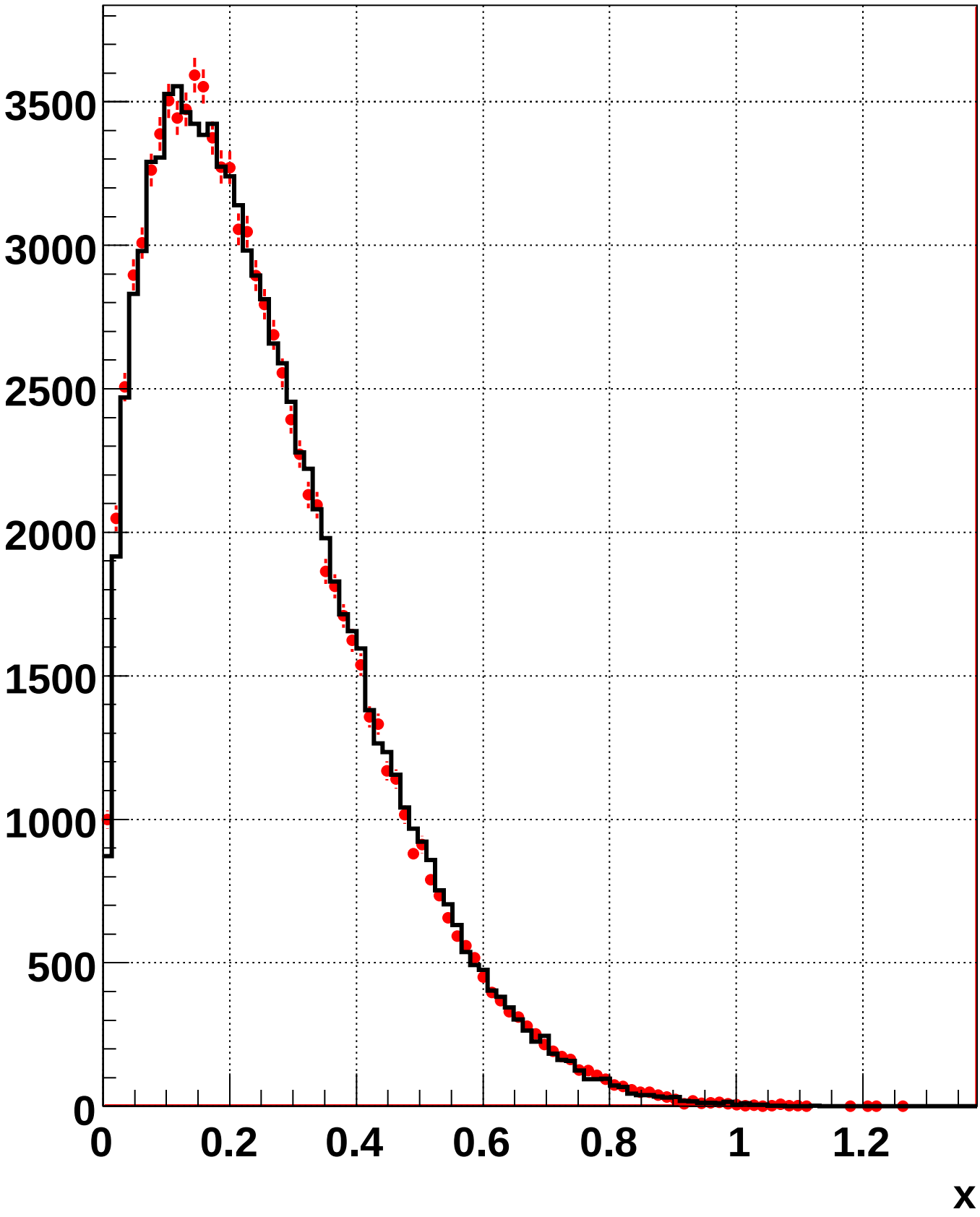
computed x for QEL events



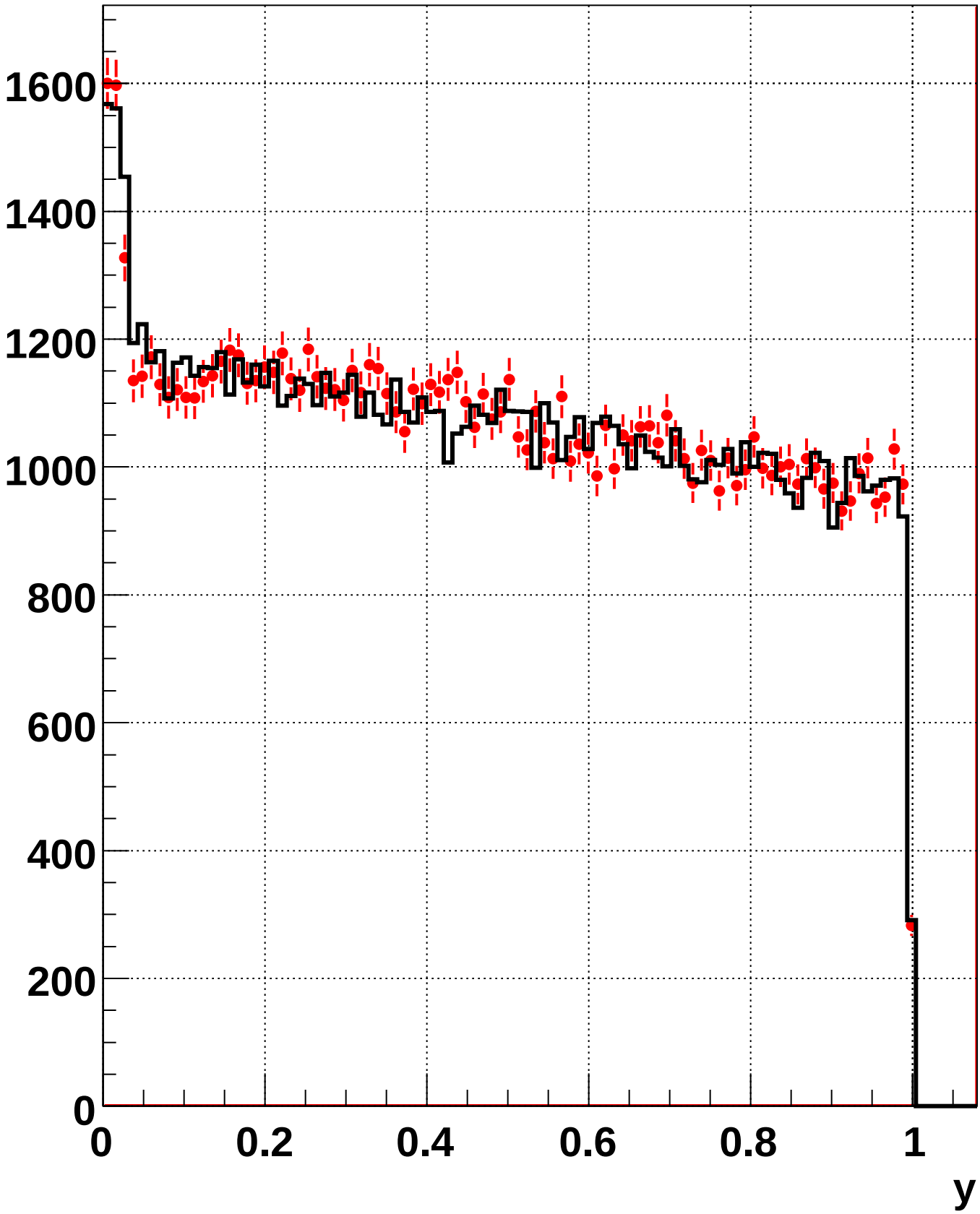
computed x for RES events



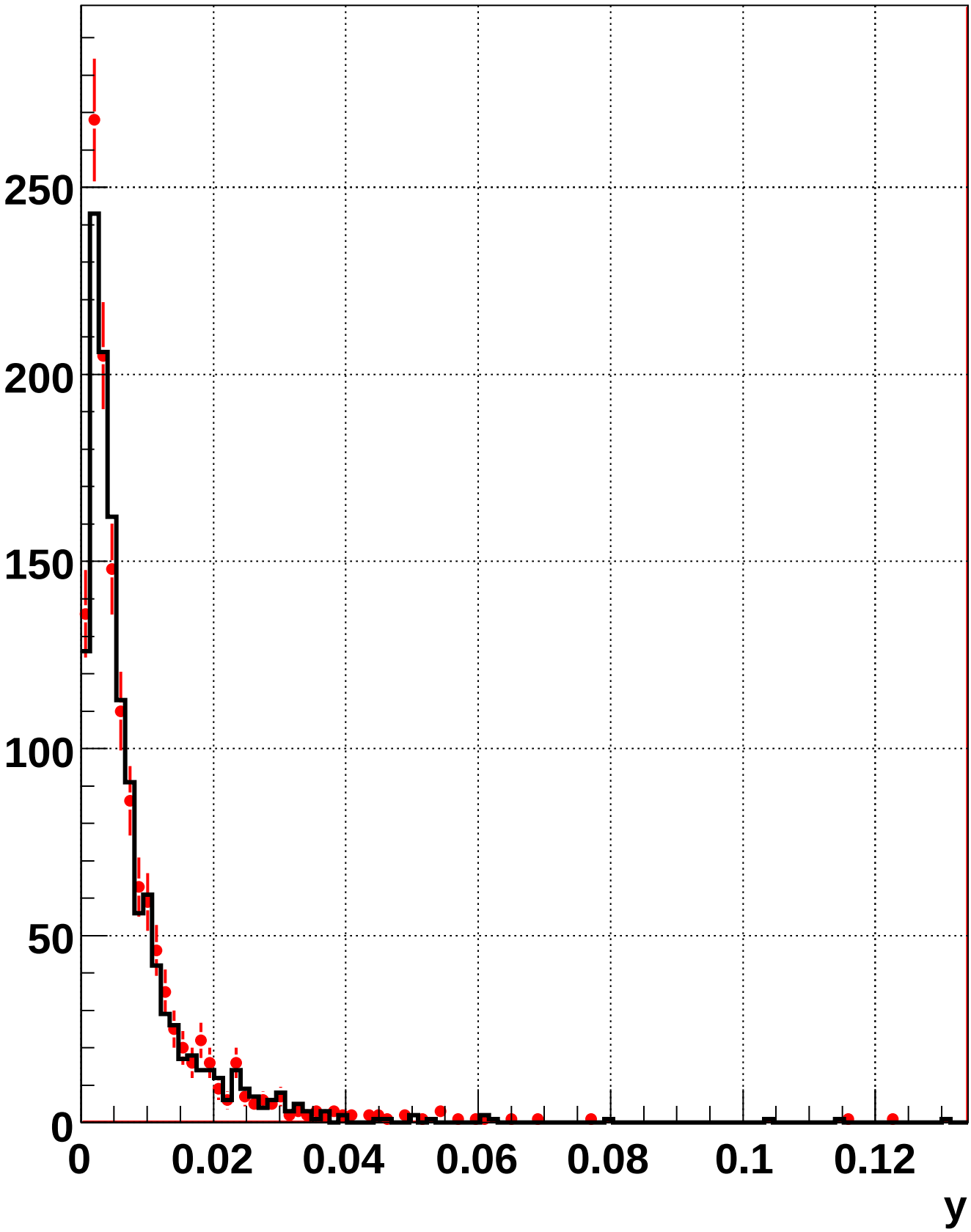
computed x for DIS events



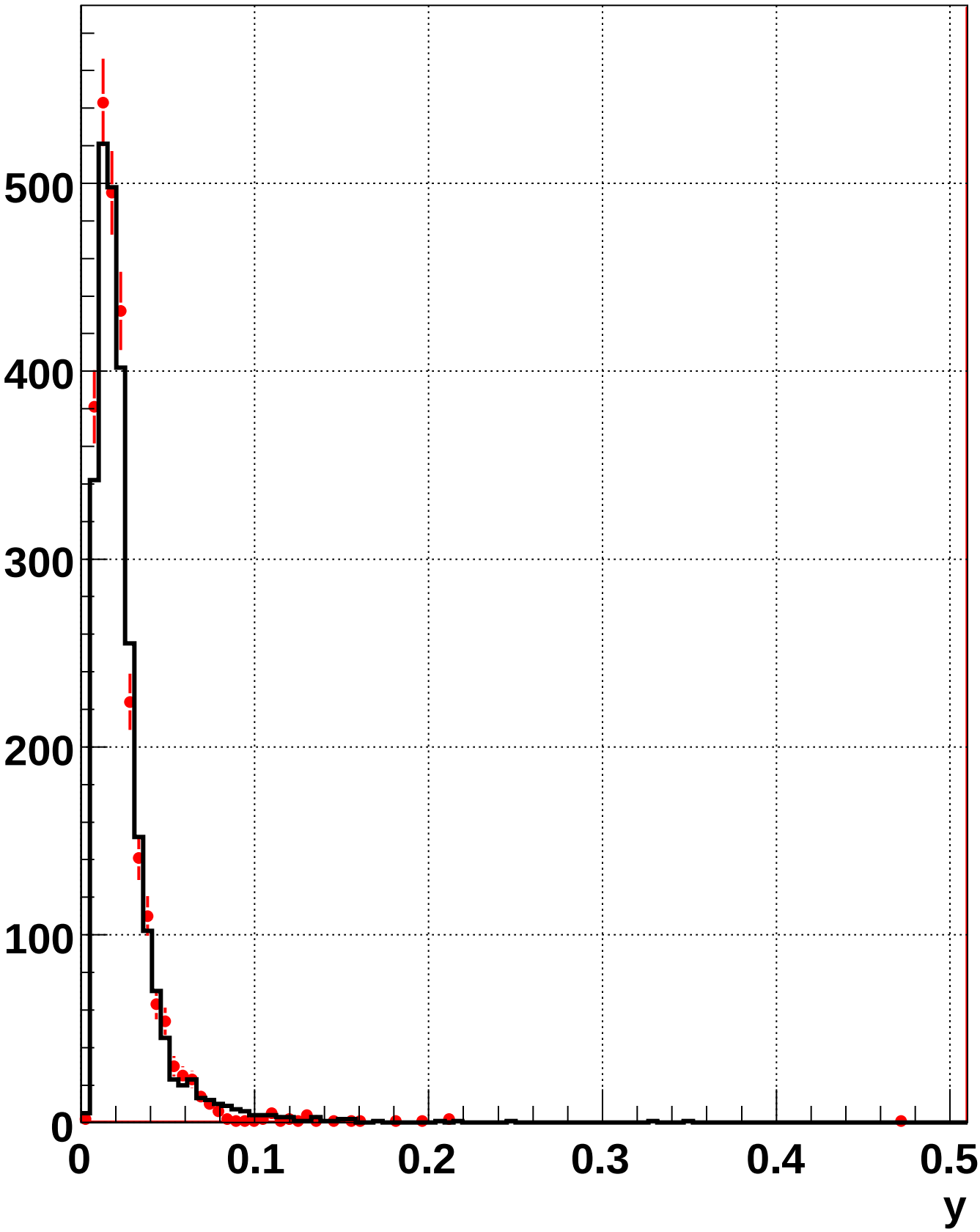
computed y for all events



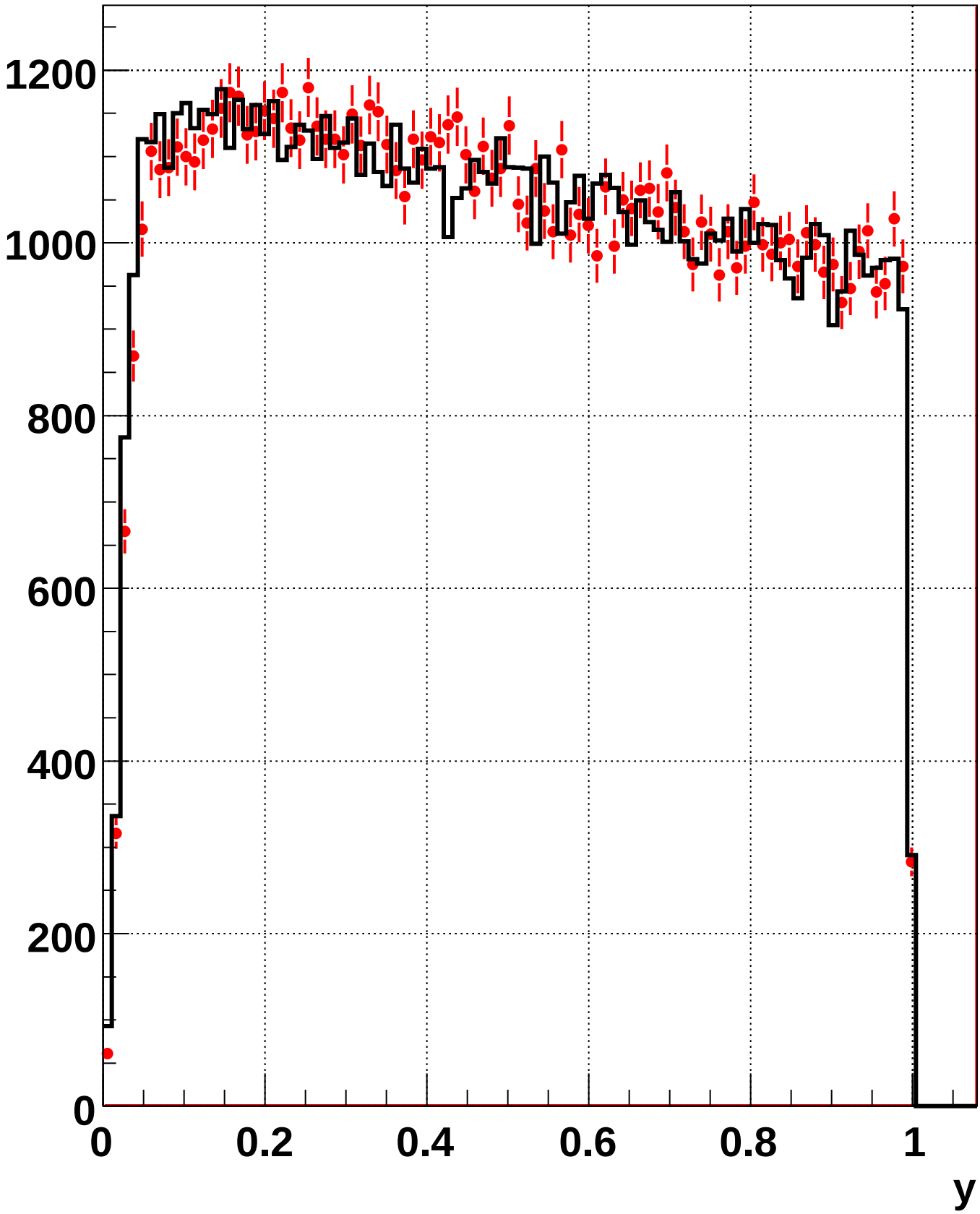
computed y for QEL events



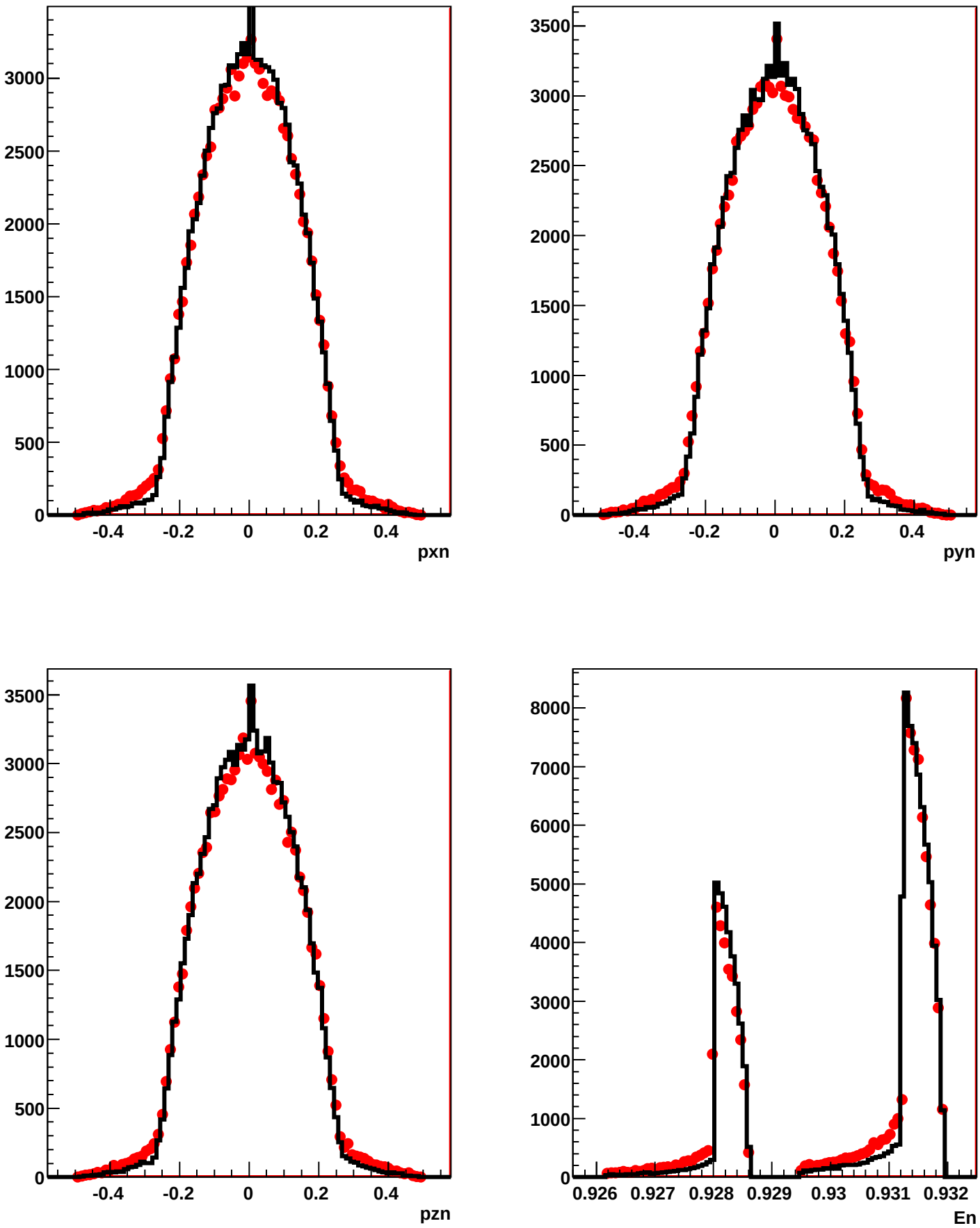
computed y for RES events



computed y for DIS events

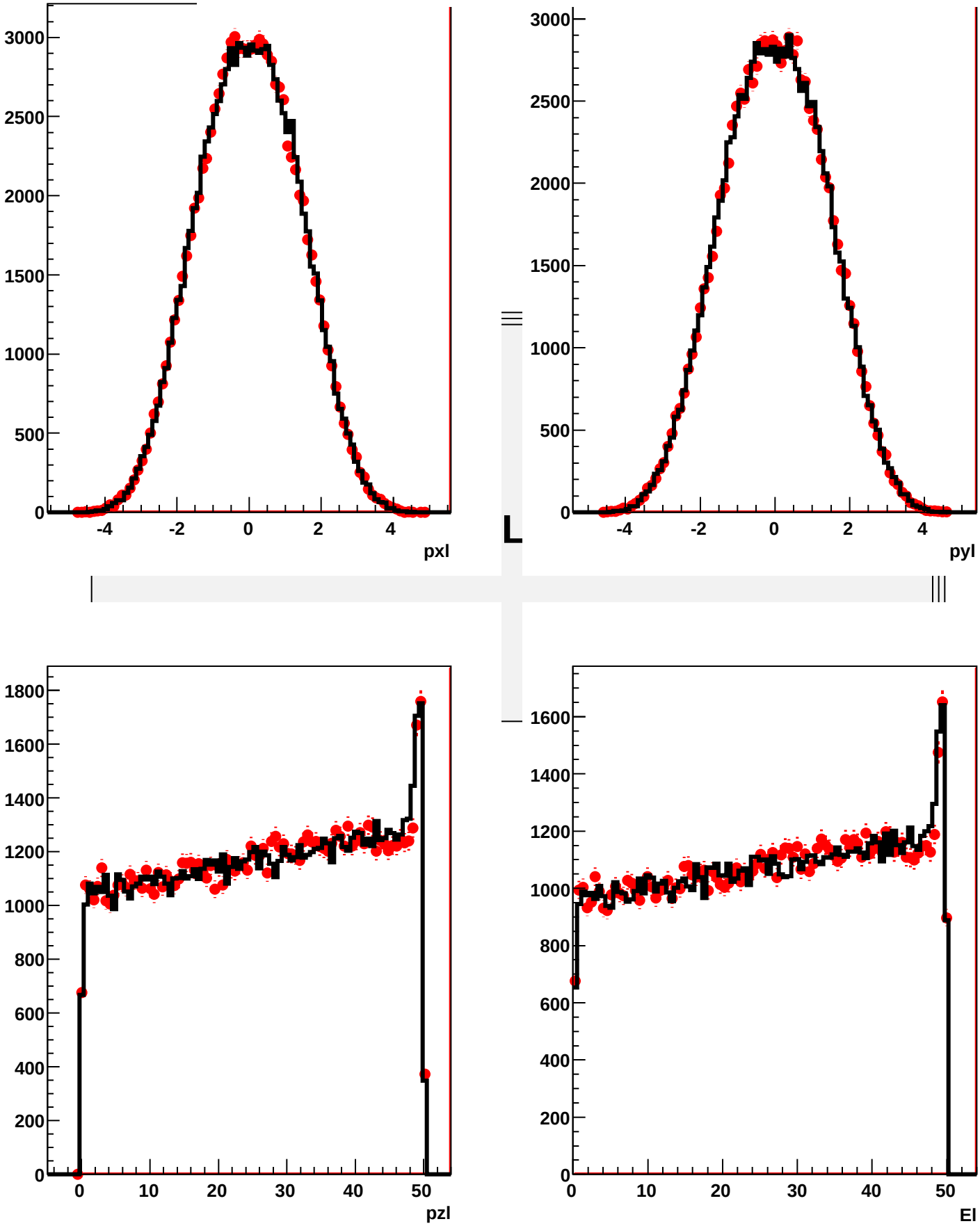


Initial state nucleon 4-Momentum

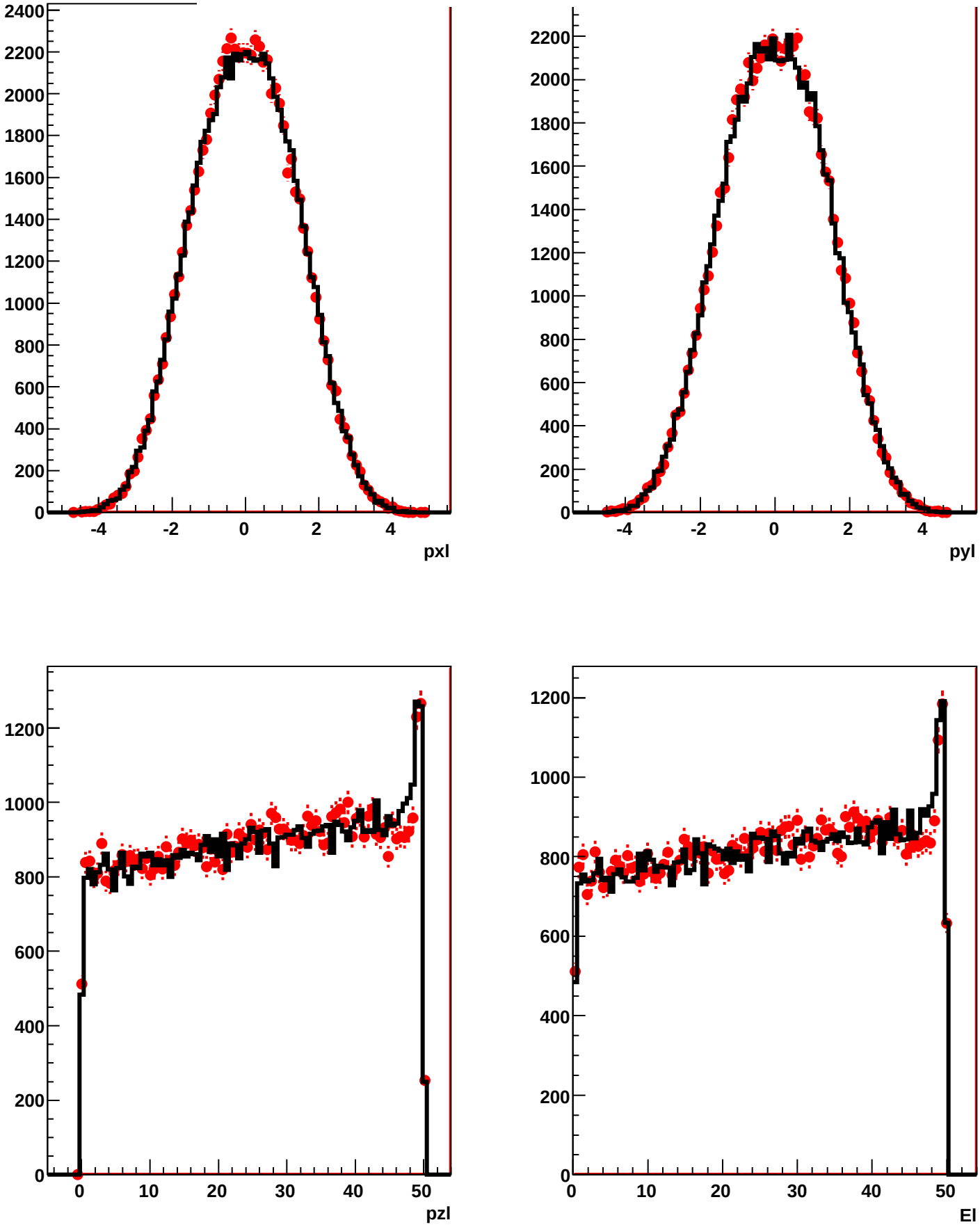

3000
2500
2000
1500
1000
500
0
-0.4
-0.2
0
0.2
0.4
pxn
3500
3000
2500
2000
1500
1000
500
0
-0.4
-0.2
0
0.2
0.4
pyn
3500
3000
2500
2000
1500
1000
500
0
-0.4
-0.2
0
0.2
0.4
pzn
8000
7000
6000
5000
4000
3000
2000
1000
0
0.926
0.927
0.928
0.929
0.93
0.931
0.932
En

Final State Primary Lepton 4-Momentum

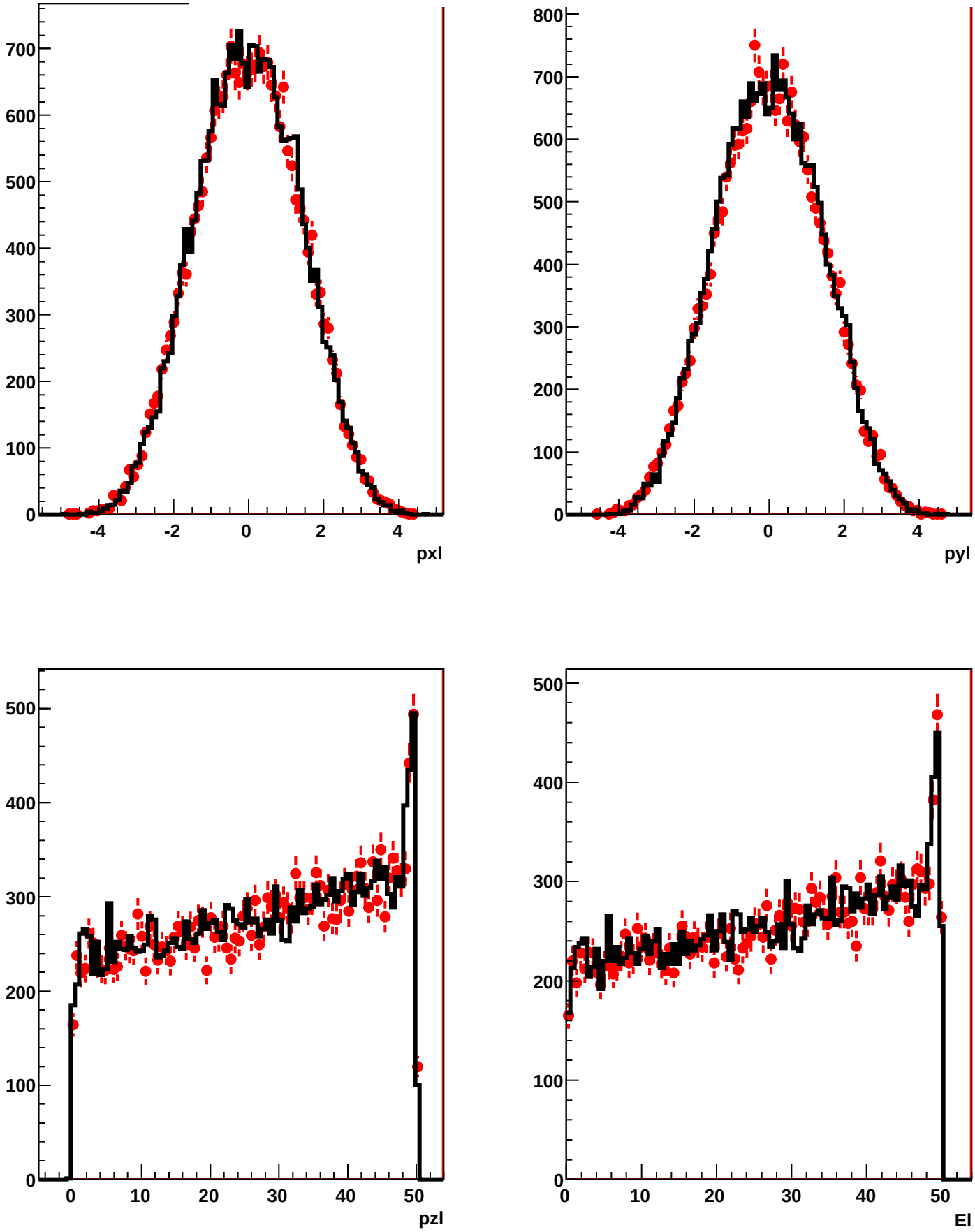
Final state primary lepton 4-p: All events



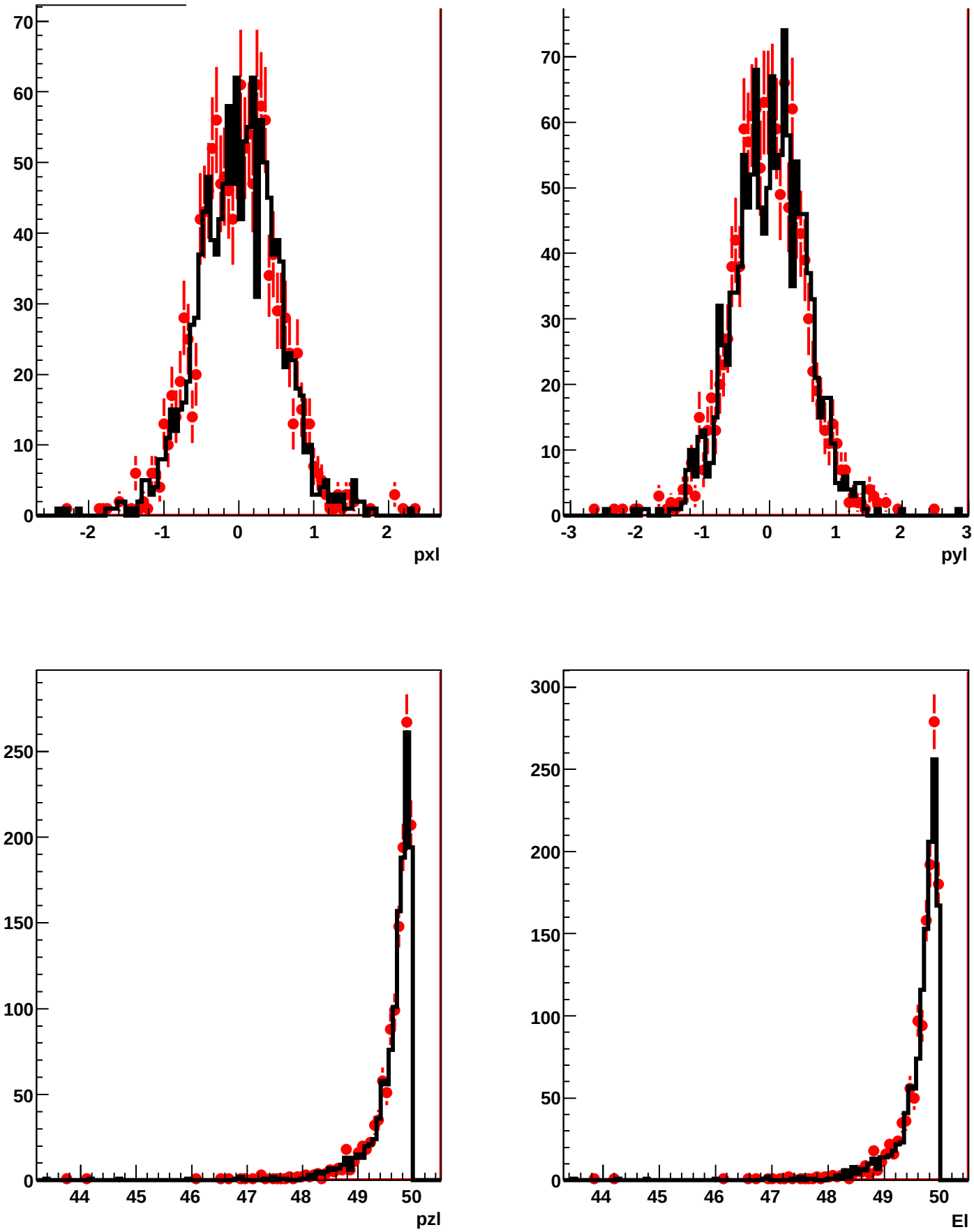
Final state primary lepton 4-p: All CC events



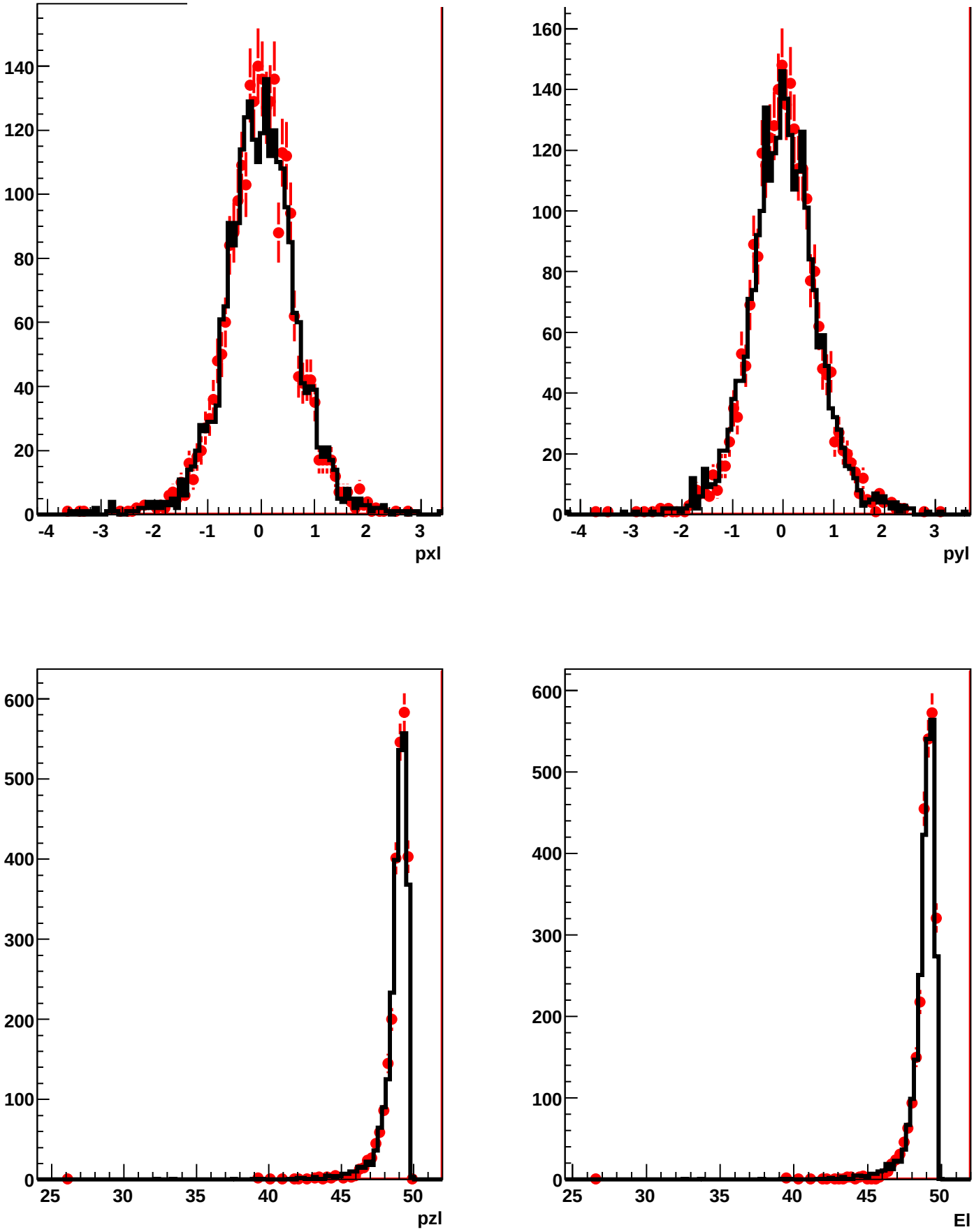
Final state primary lepton 4-p: All NC events



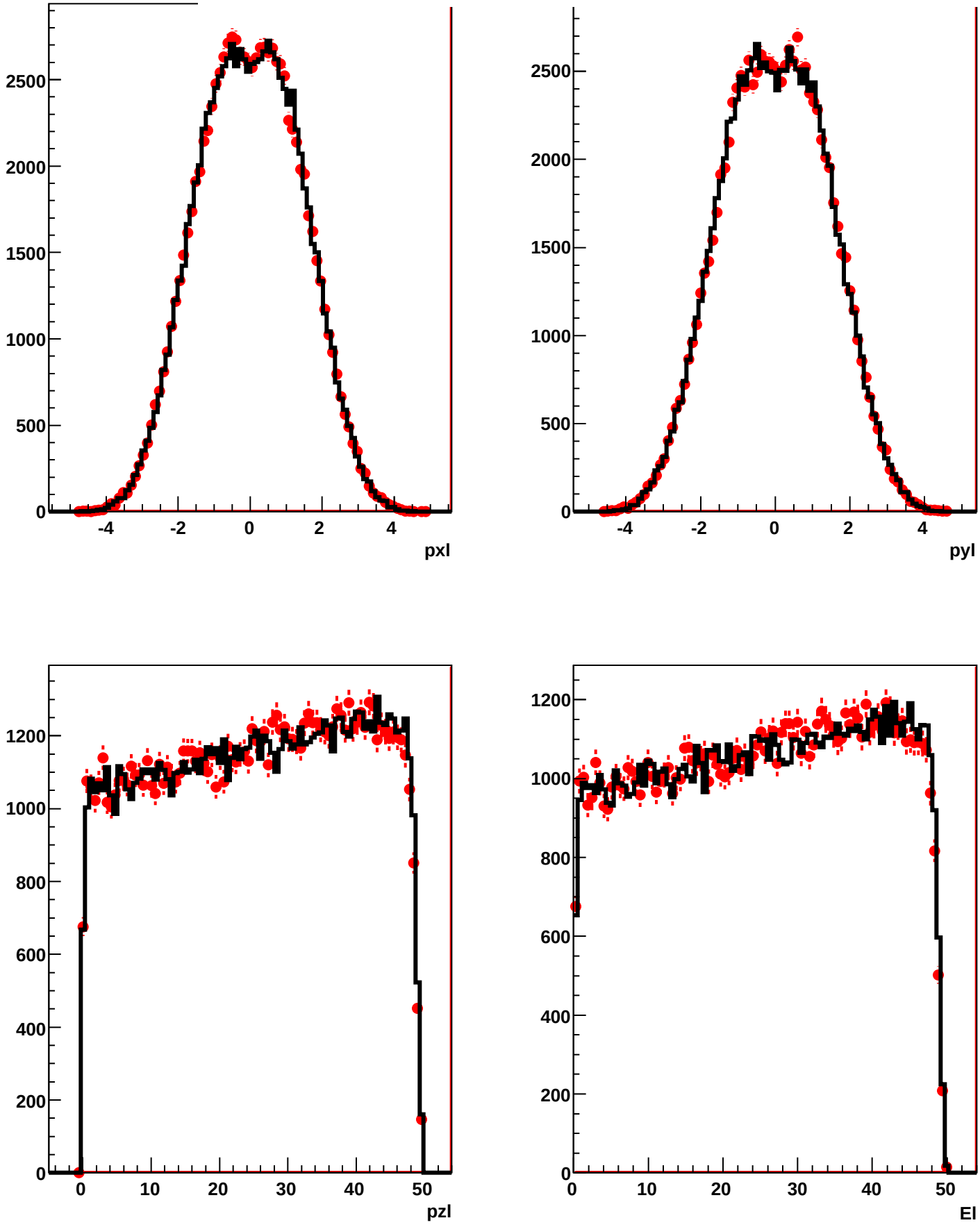
Final state primary lepton 4-p: QEL events



Final state primary lepton 4-p: RES events



Final state primary lepton 4-p: All DIS events



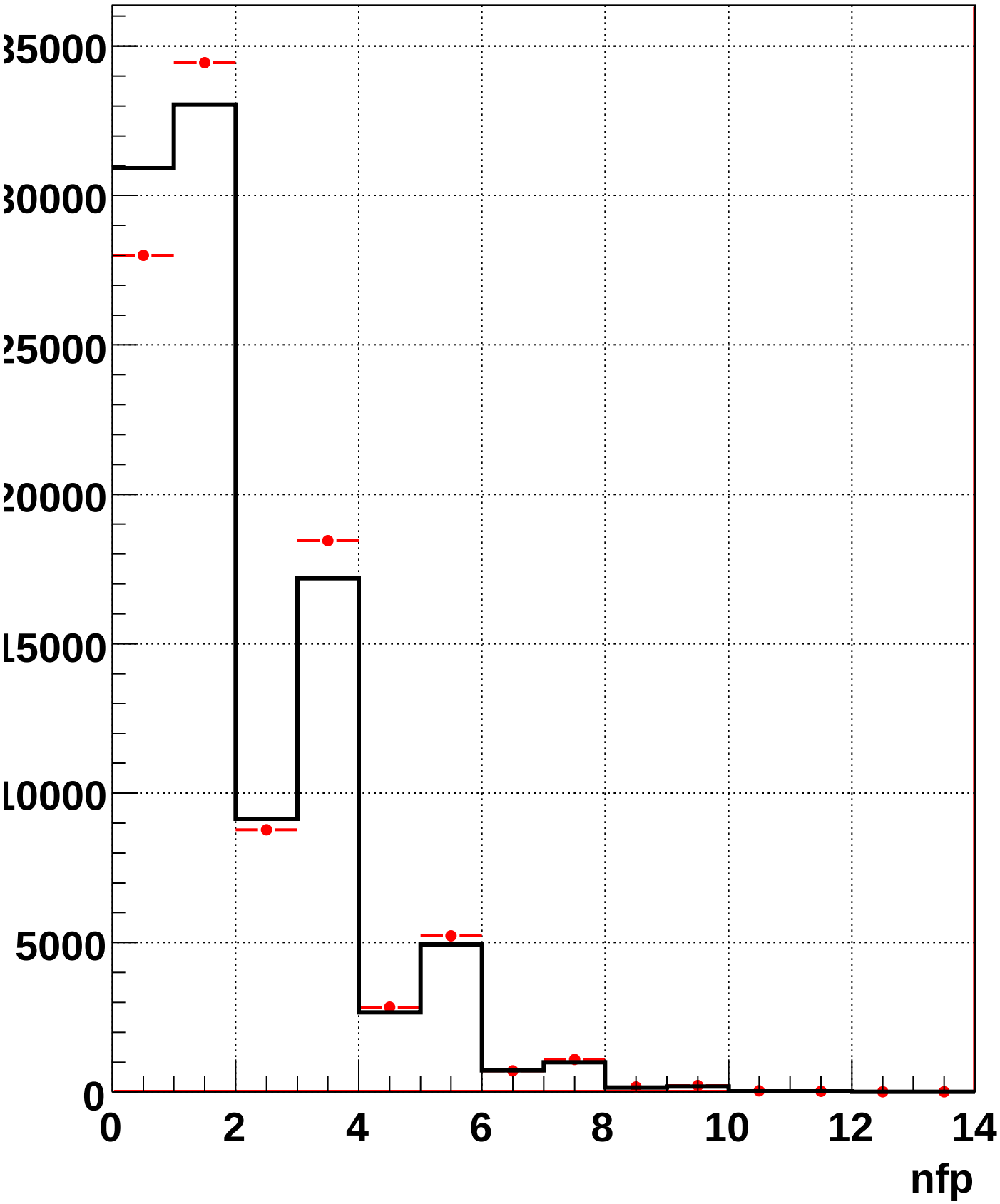
Final State Hadronic System

Multiplicities and 4-Momenta

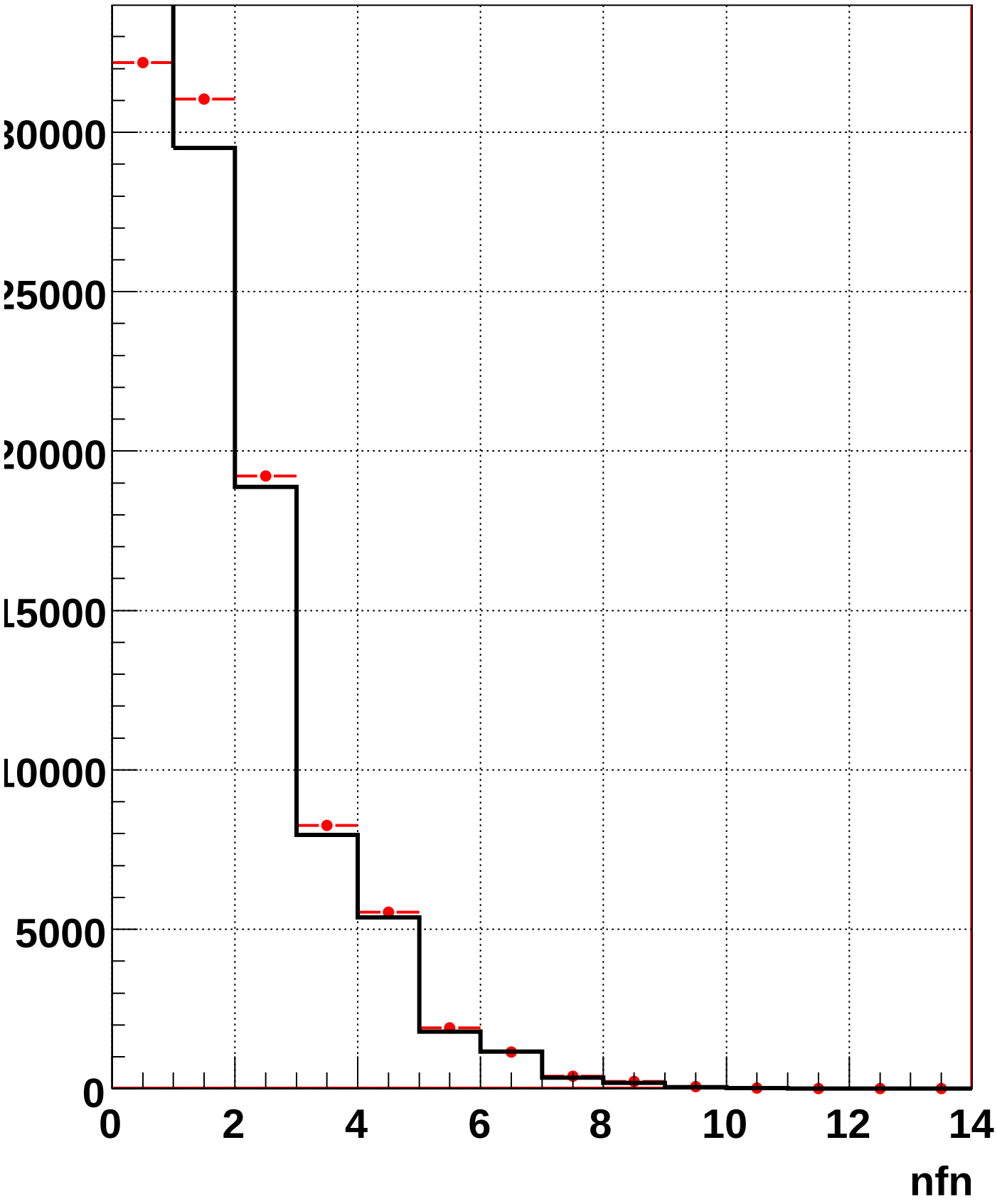
Note:

For nuclear targets these plots include the effect of intranuclear hadron transport / rescattering

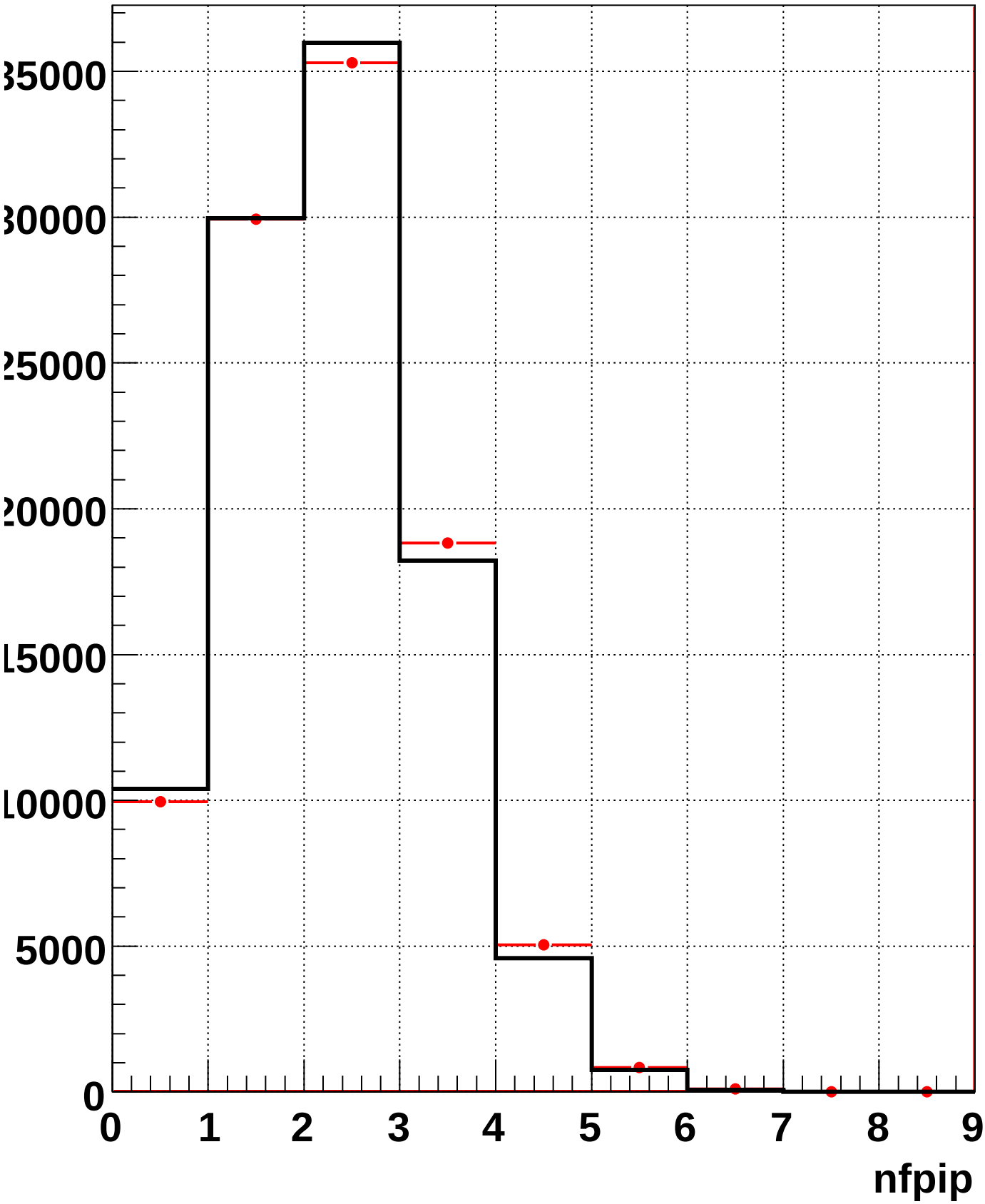
Number of final state protons



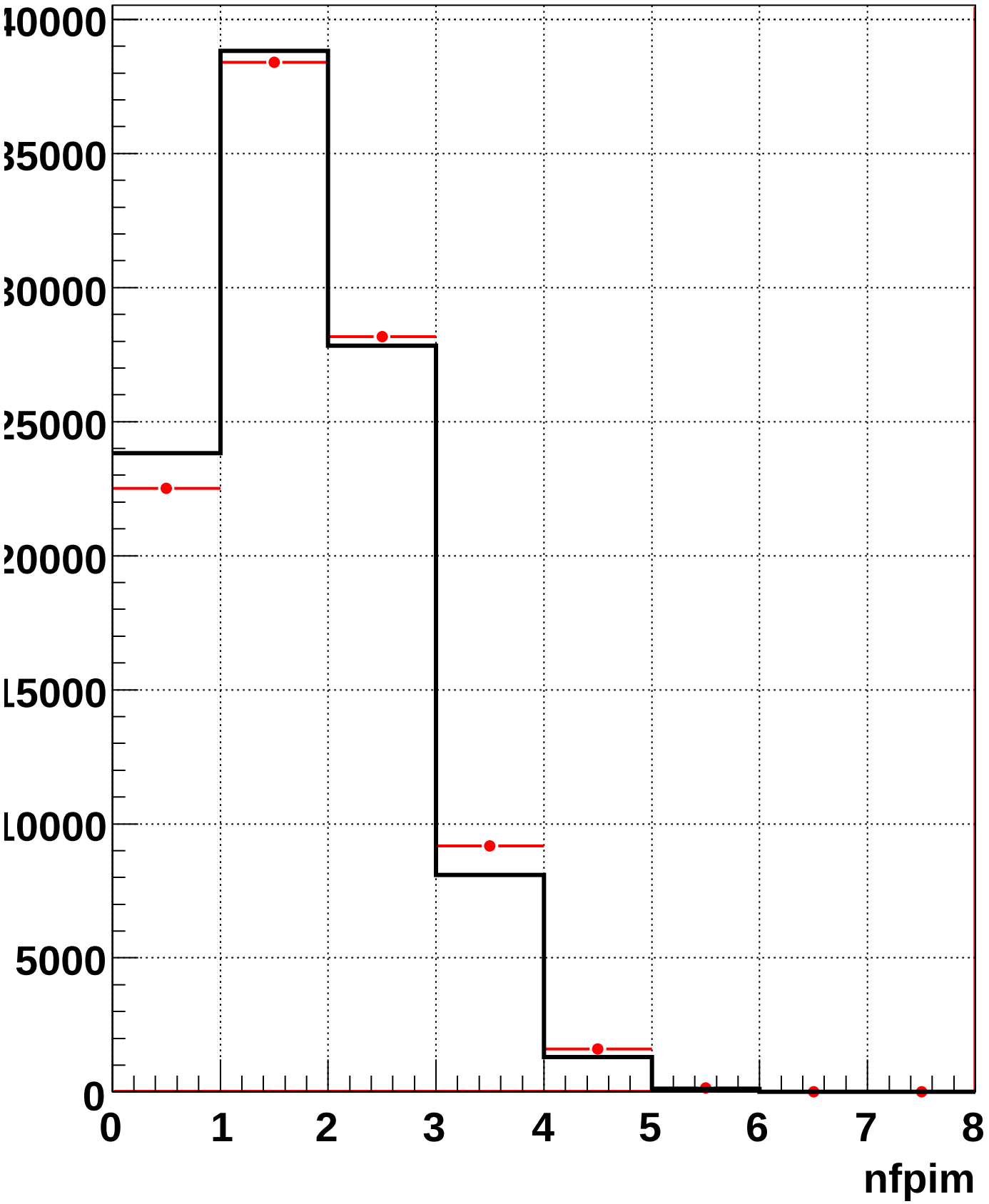
Number of final state neutrons



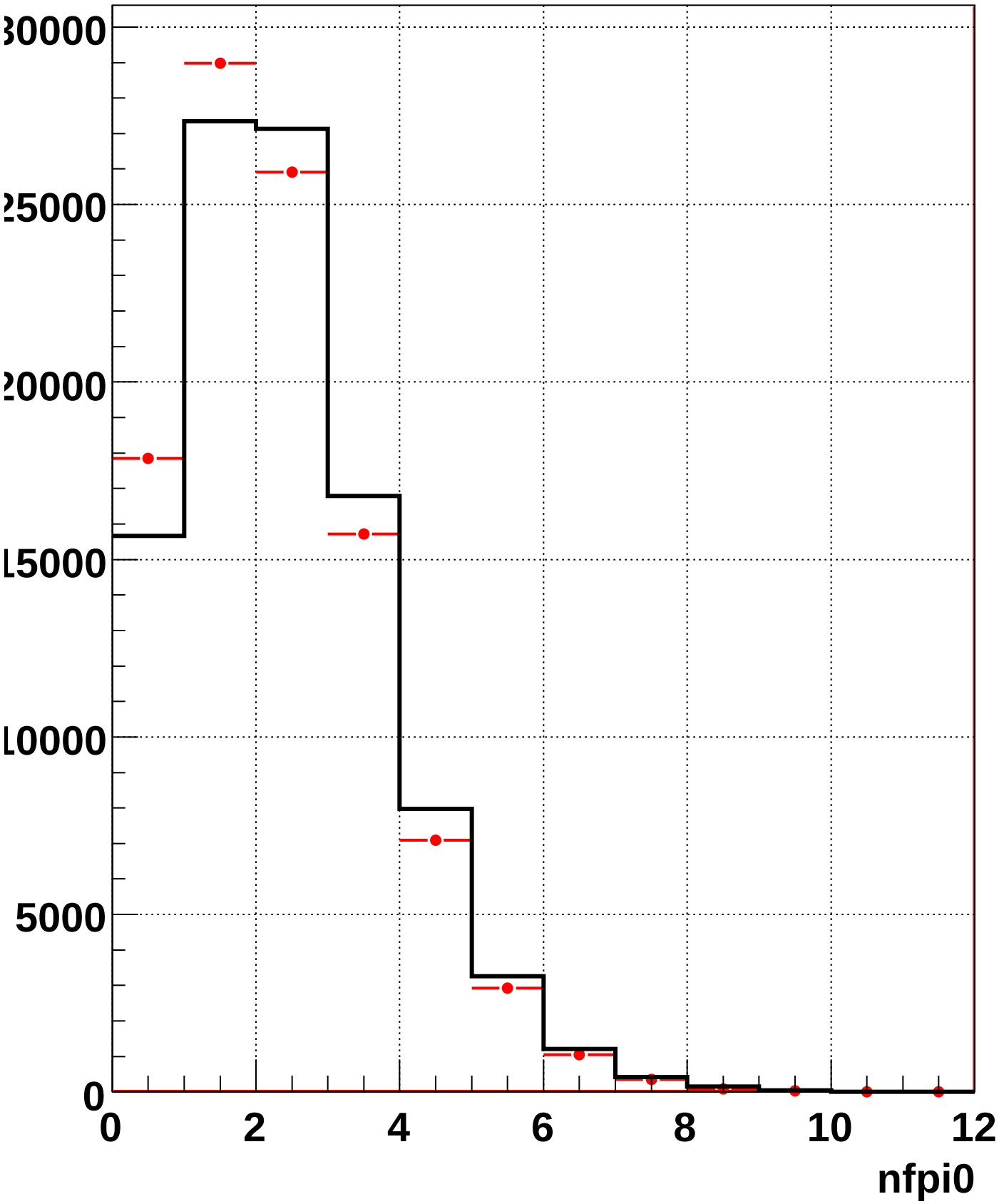
Number of final state pi+



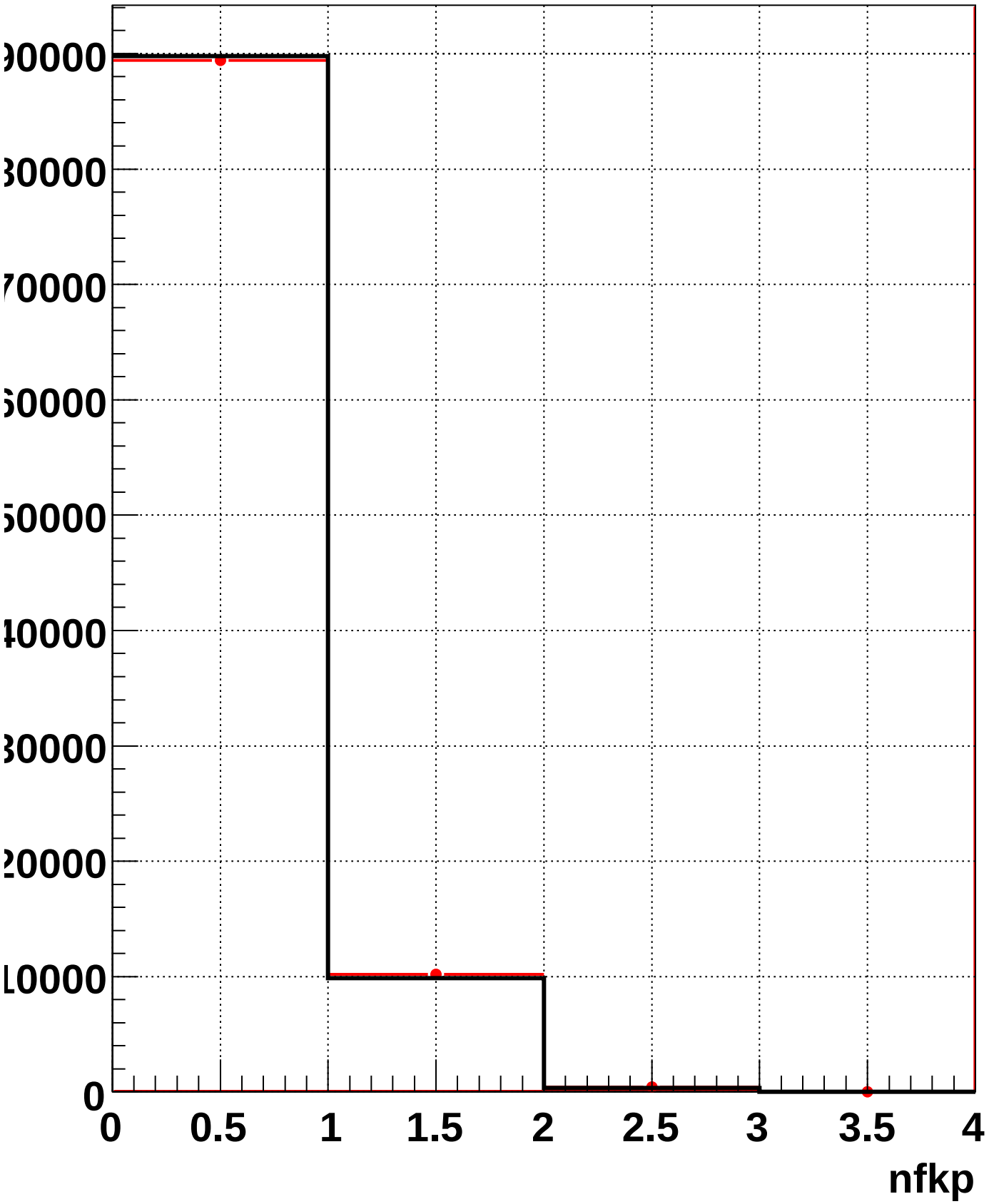
Number of final state pi-



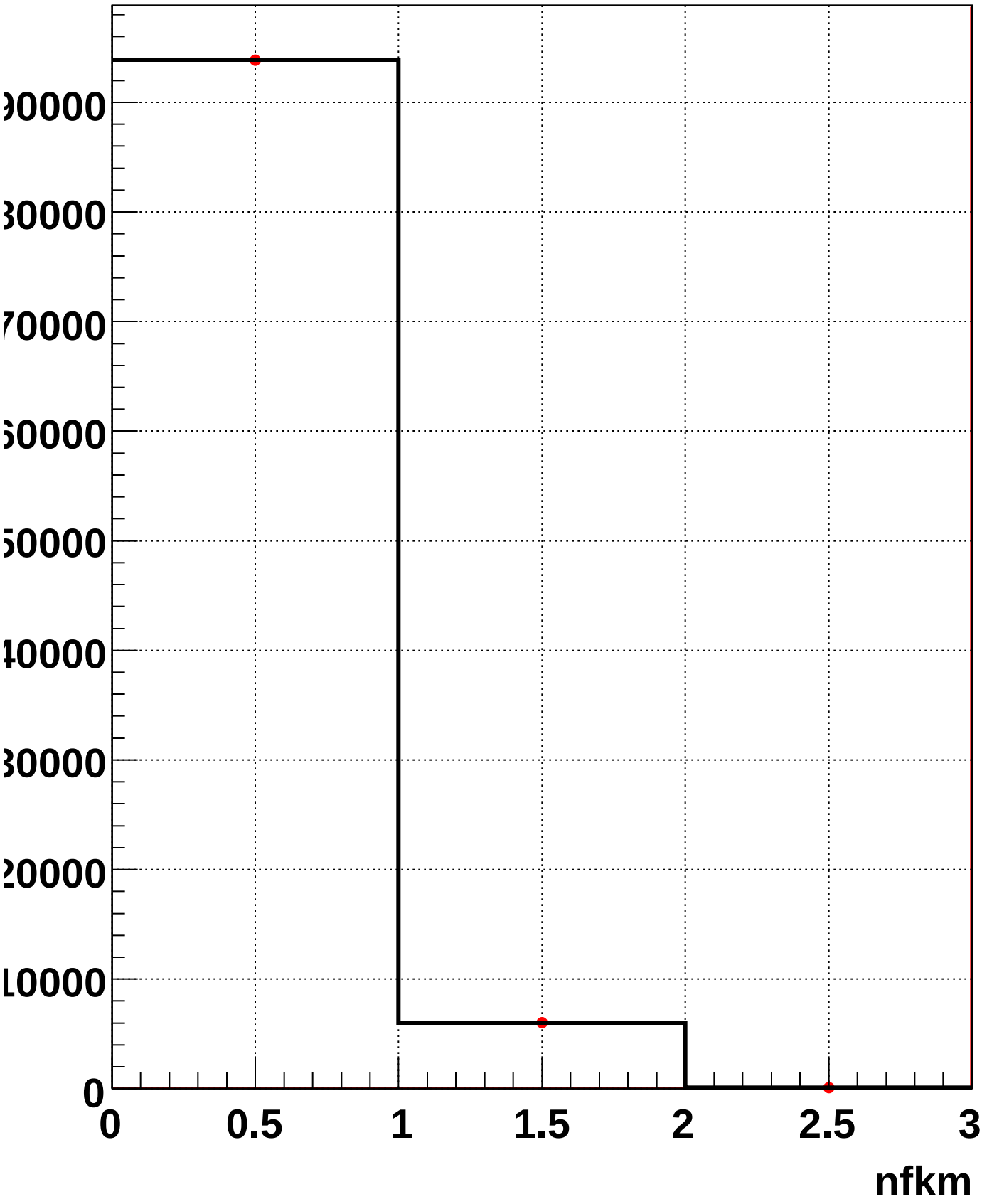
Number of final state pi0



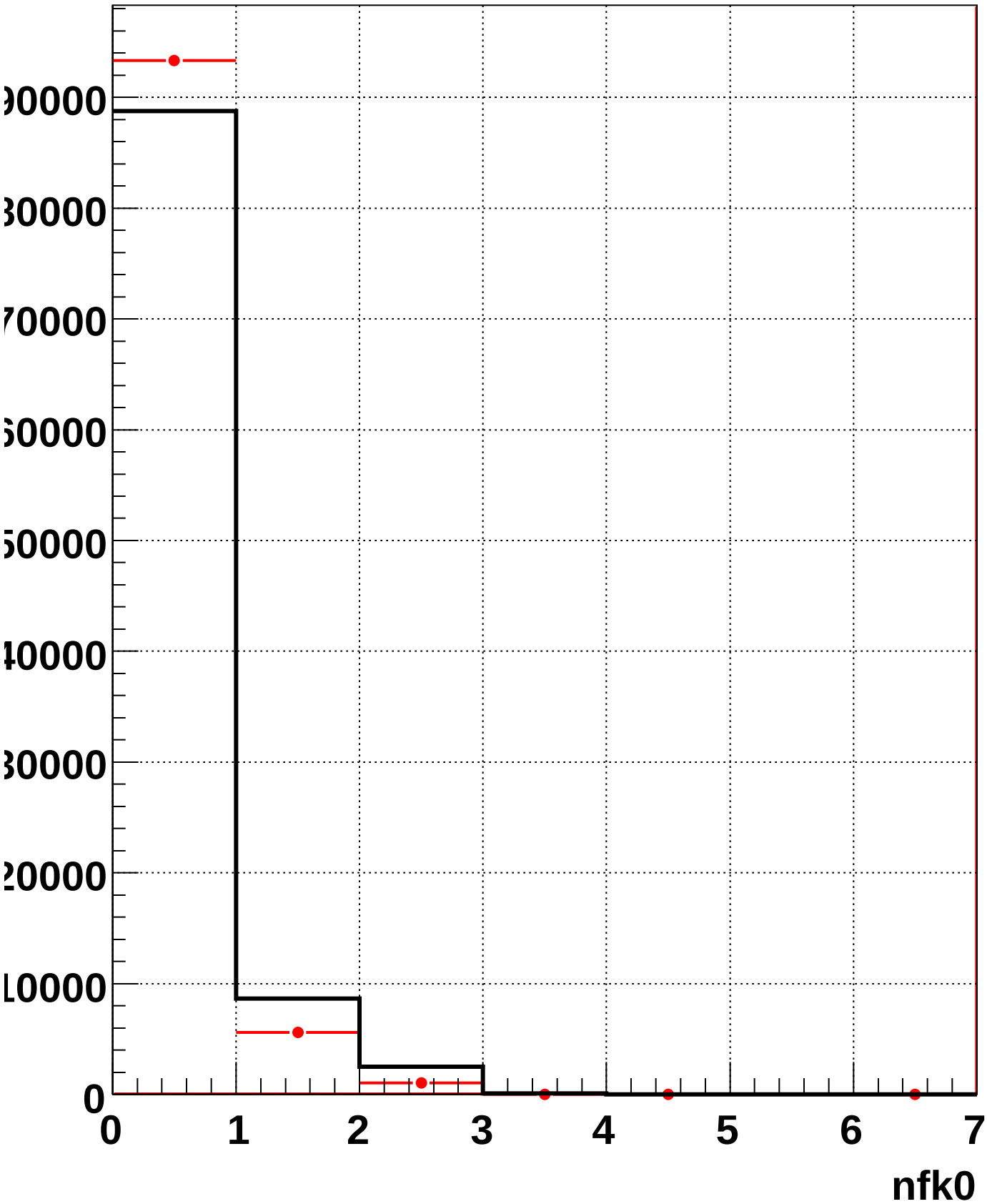
Number of final state K+



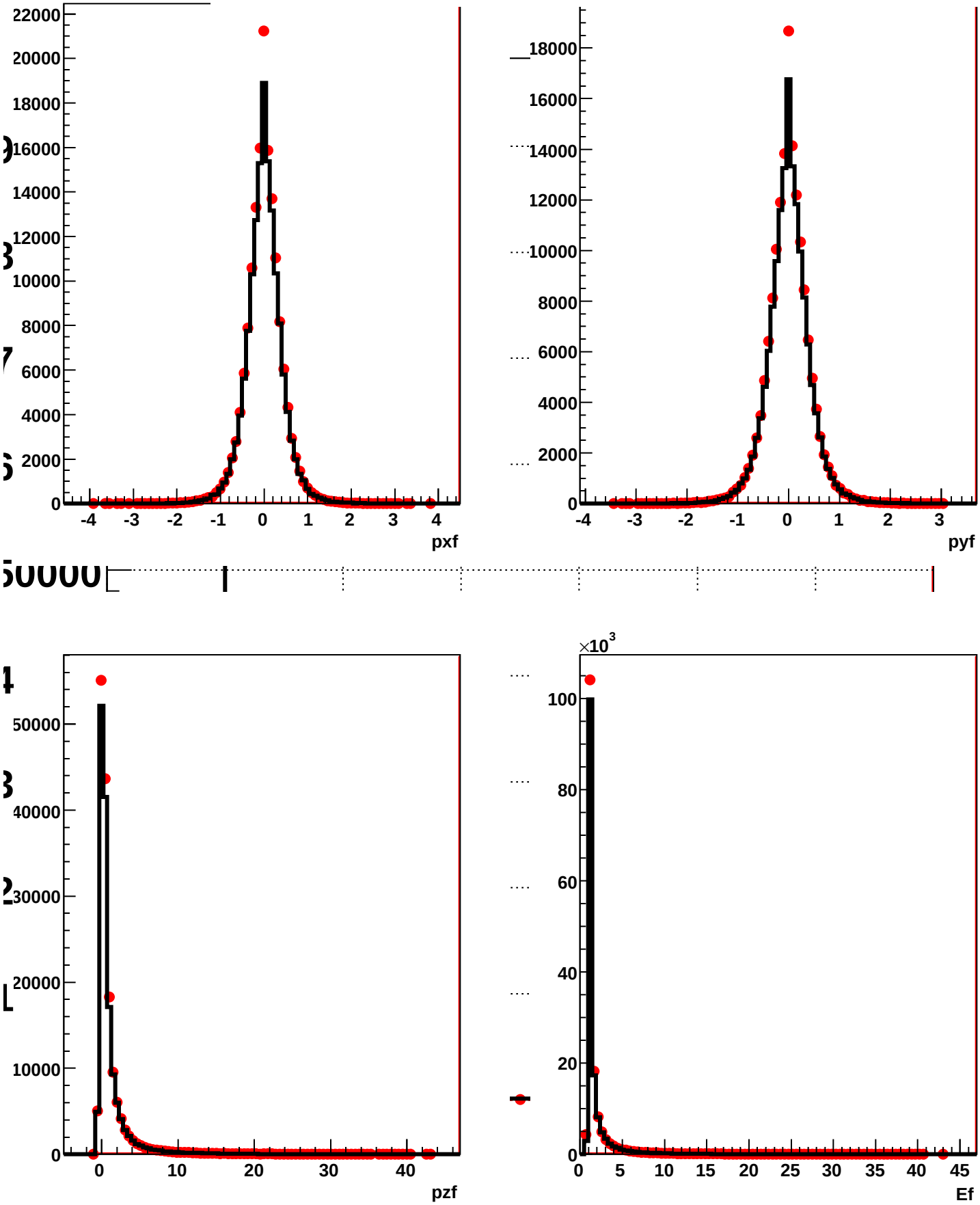
Number of final state K-



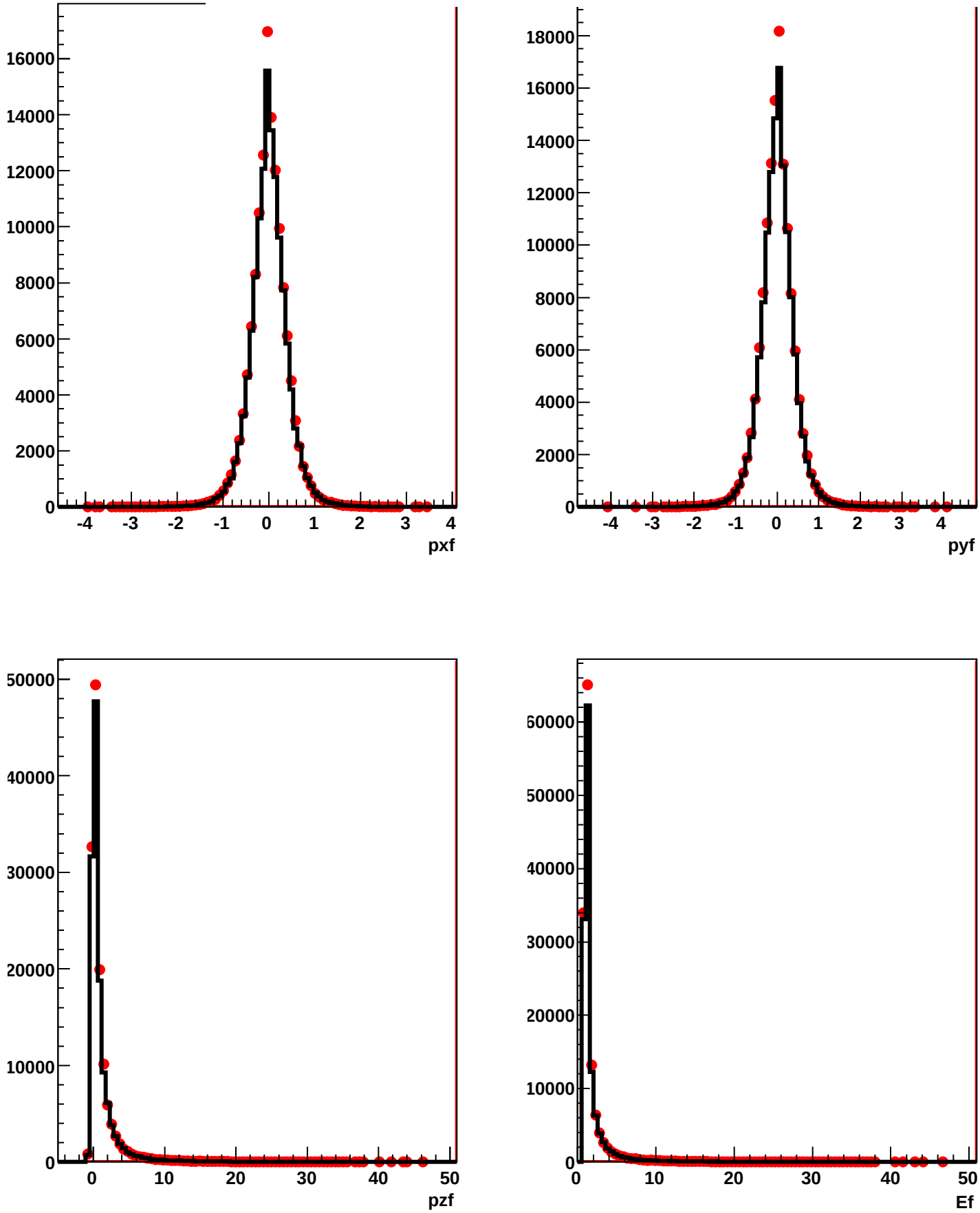
Number of final state K0



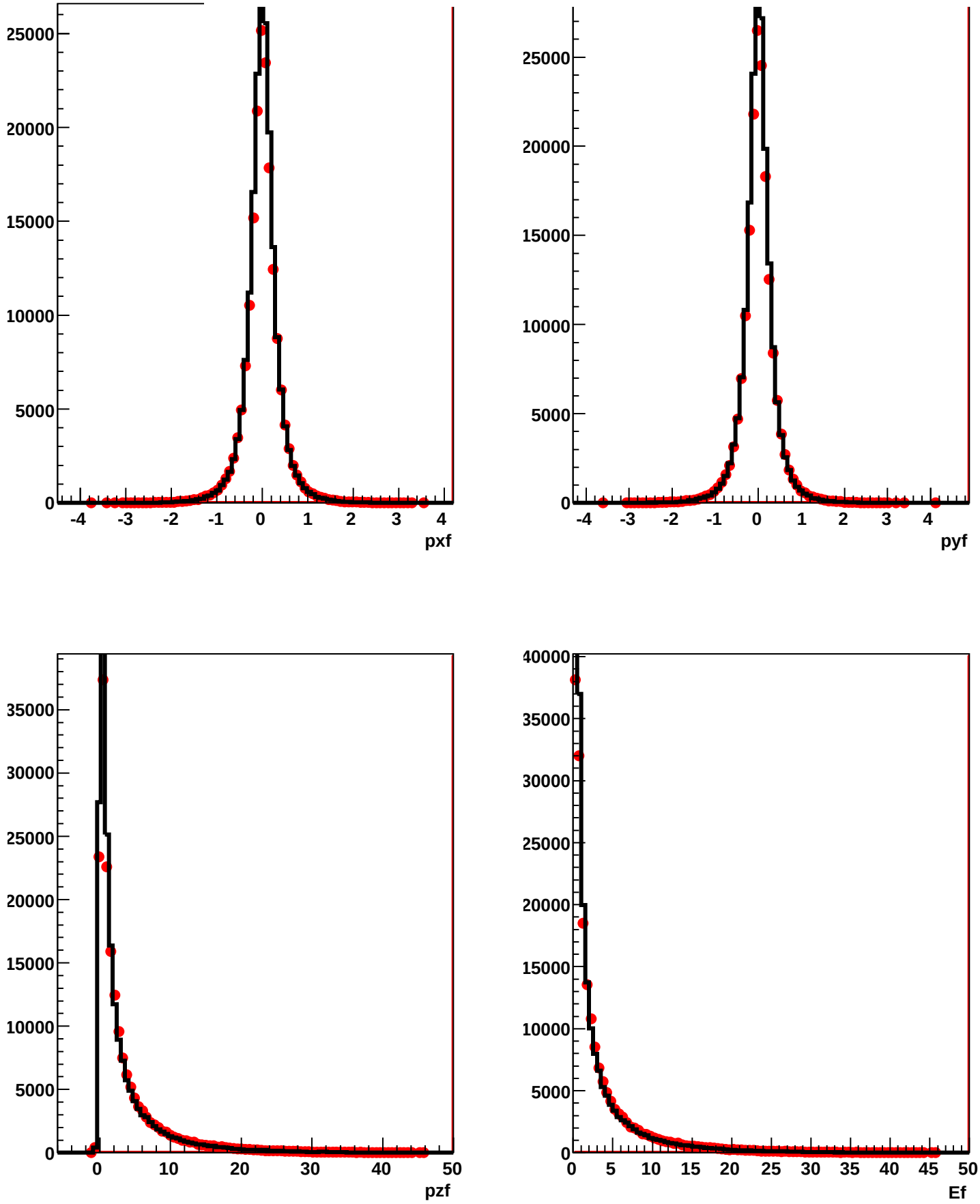
Final state protons 4-momentum



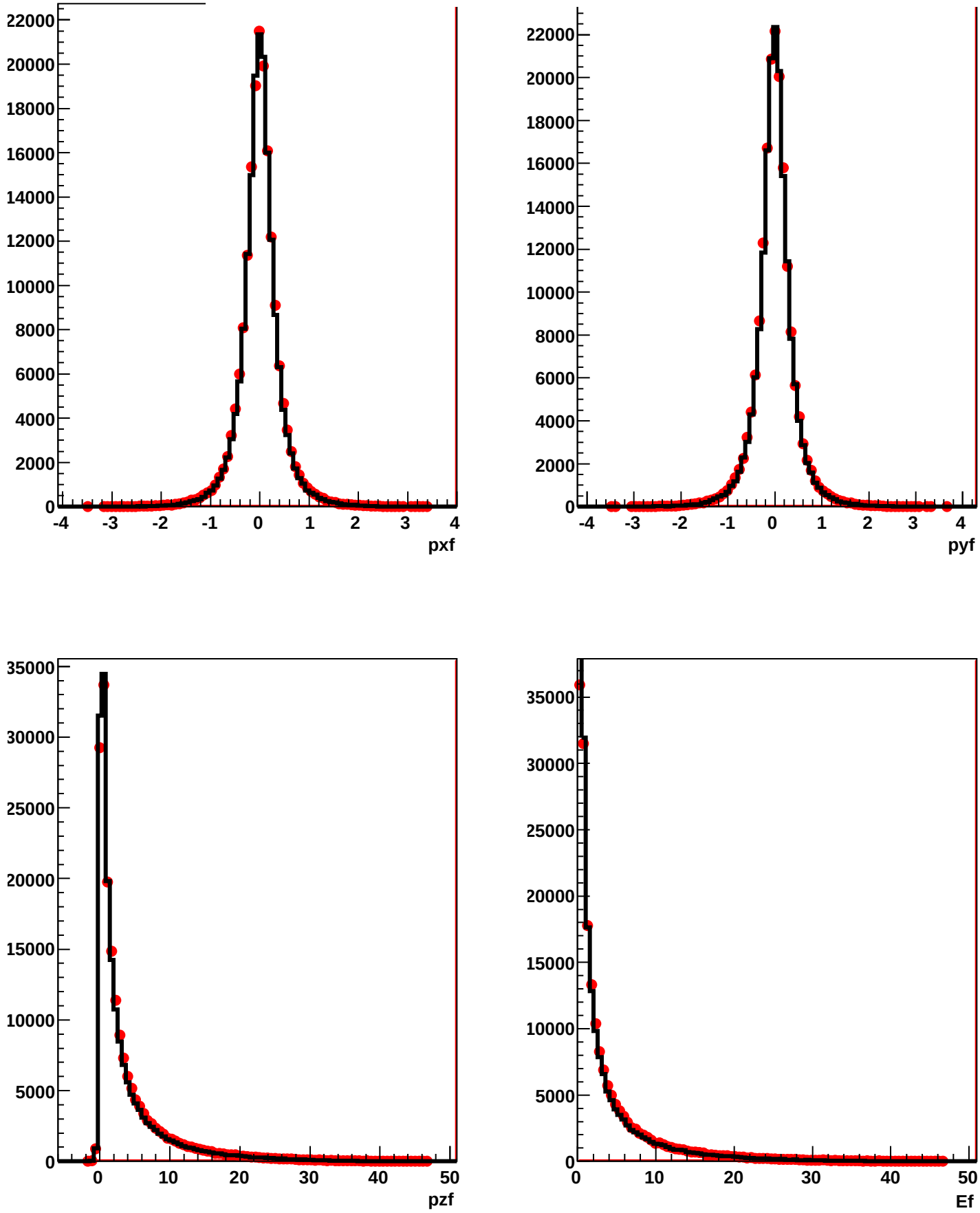
Final state neutrons 4-momentum



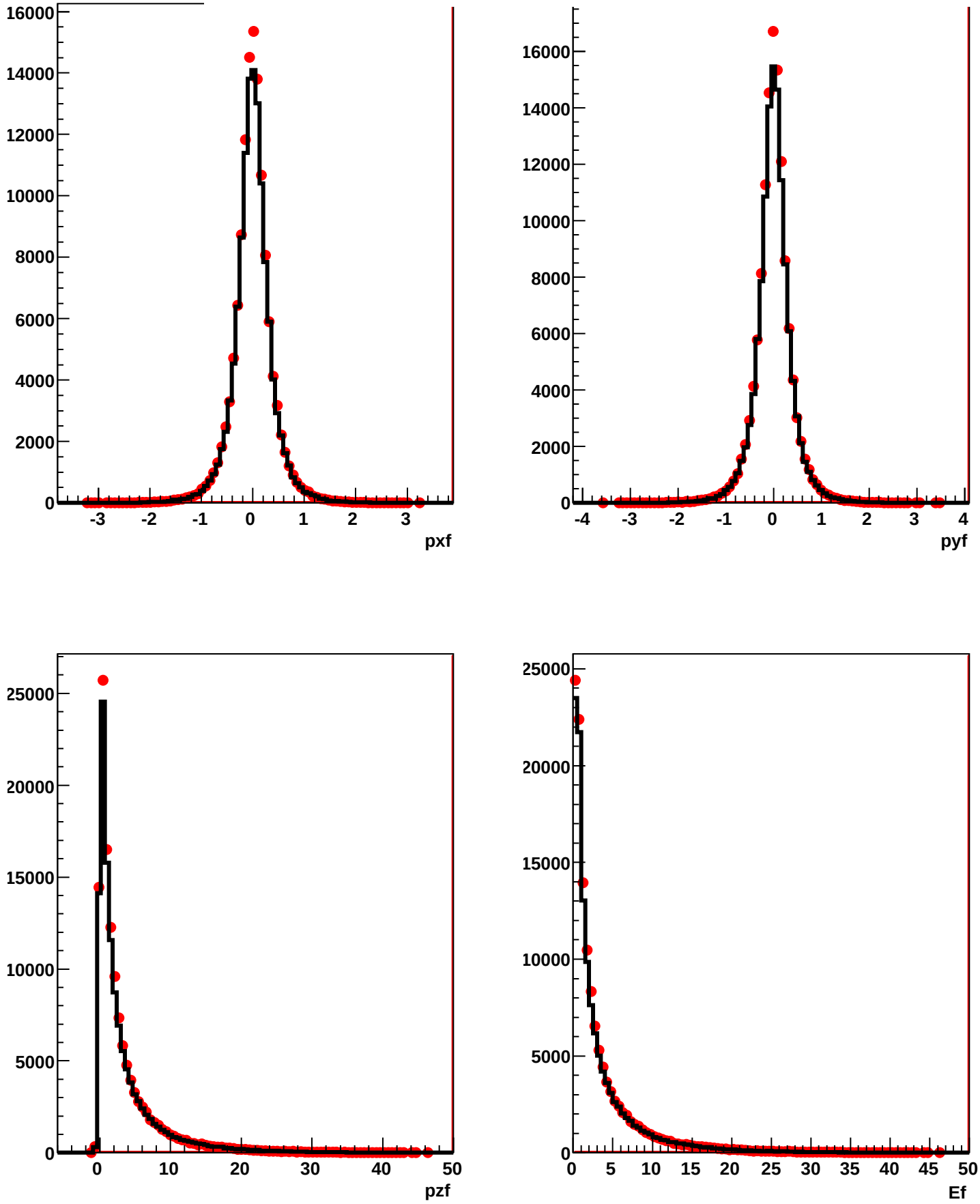
Final state pi0's 4-momentum



Final state pi+’s 4-momentum



Final state pi-'s 4-momentum



GENIE-2.0.0 vs NEUGEN/Daikon+ Event Sample Comparisons

Event Sample:

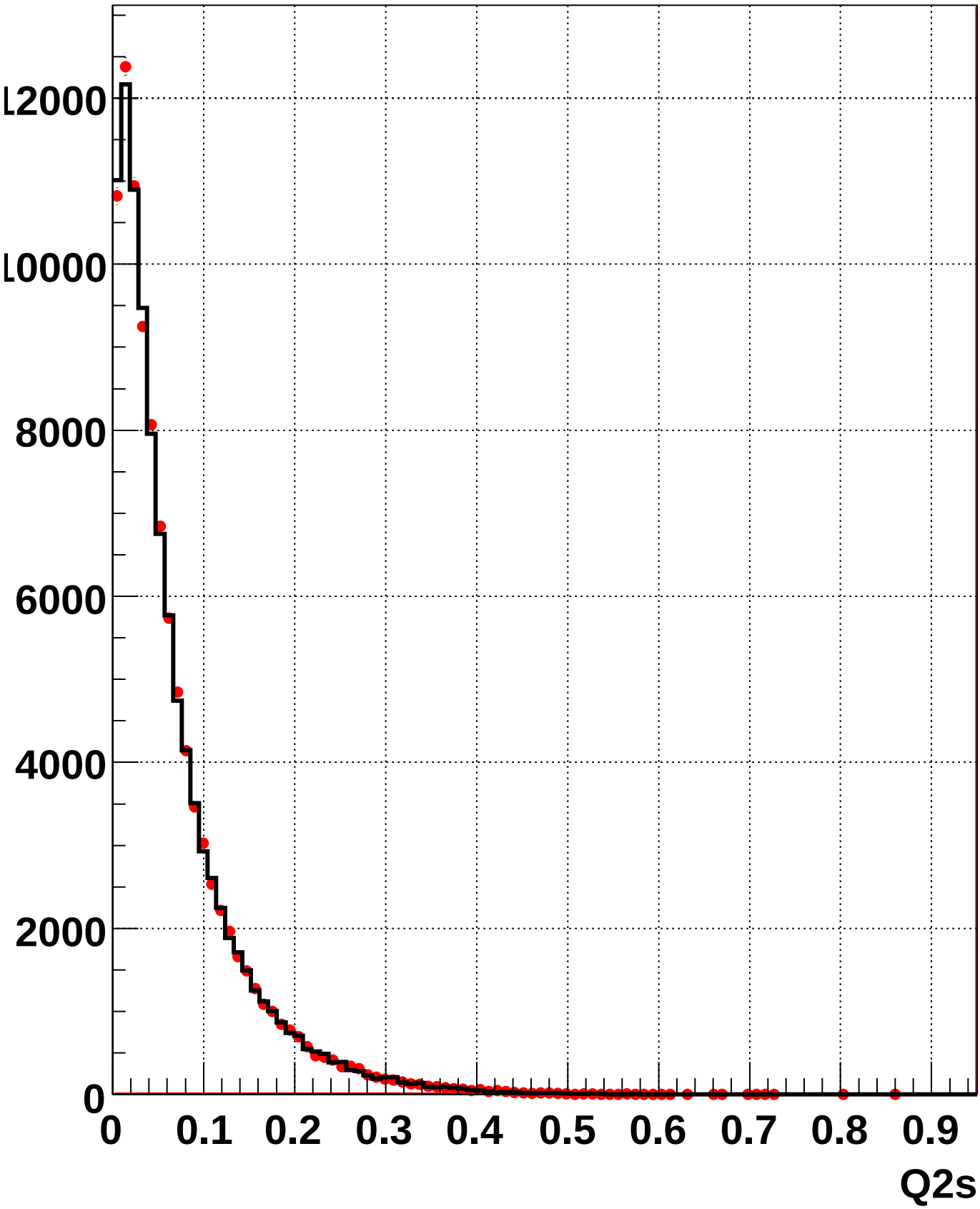
100k events, numu+Fe56, 2GeV, COH CC+NC

Notes:

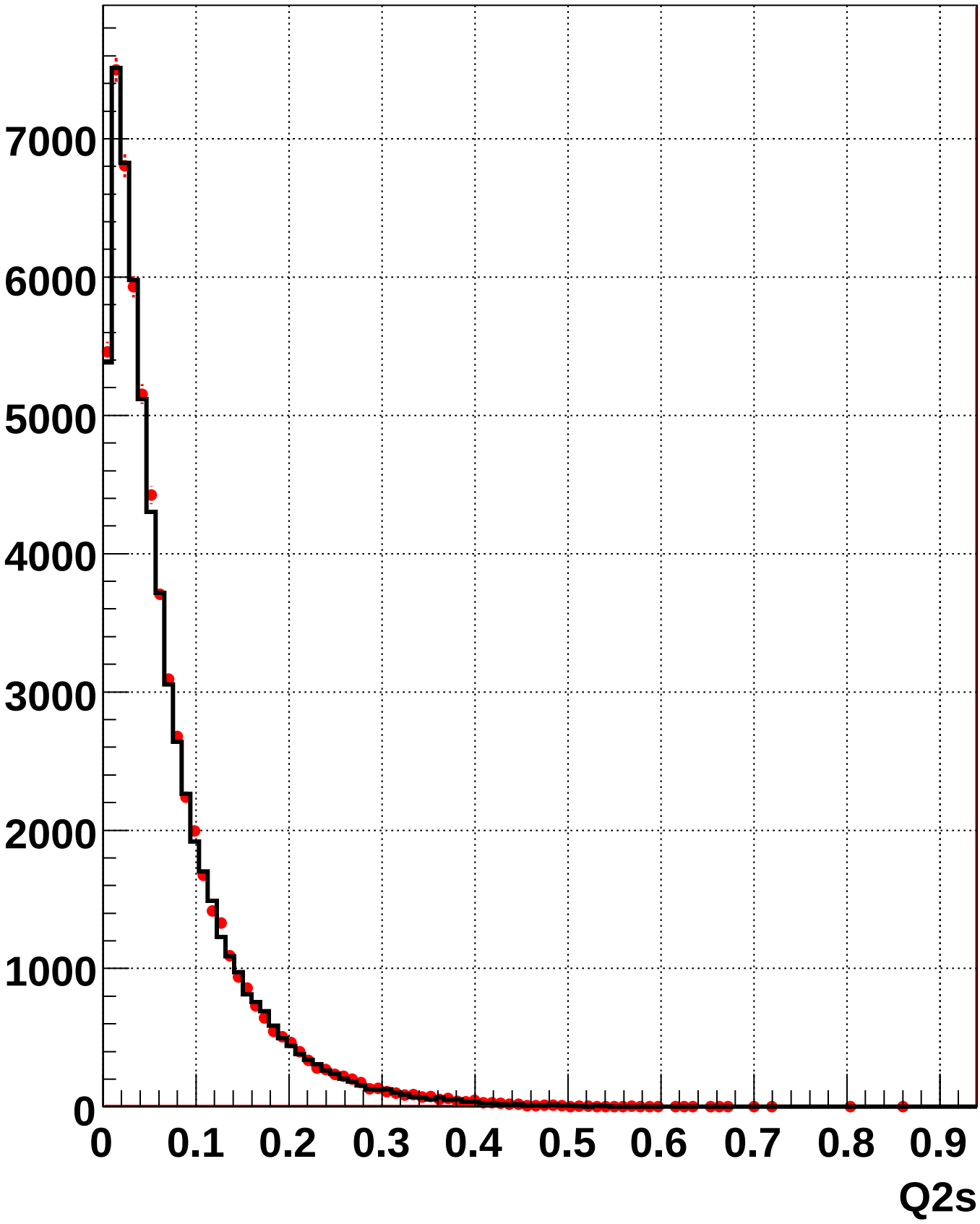
Daikon+ is a NEUGEN Daikon revision version

GENIE predictions shown with lines / NEUGEN's with markers

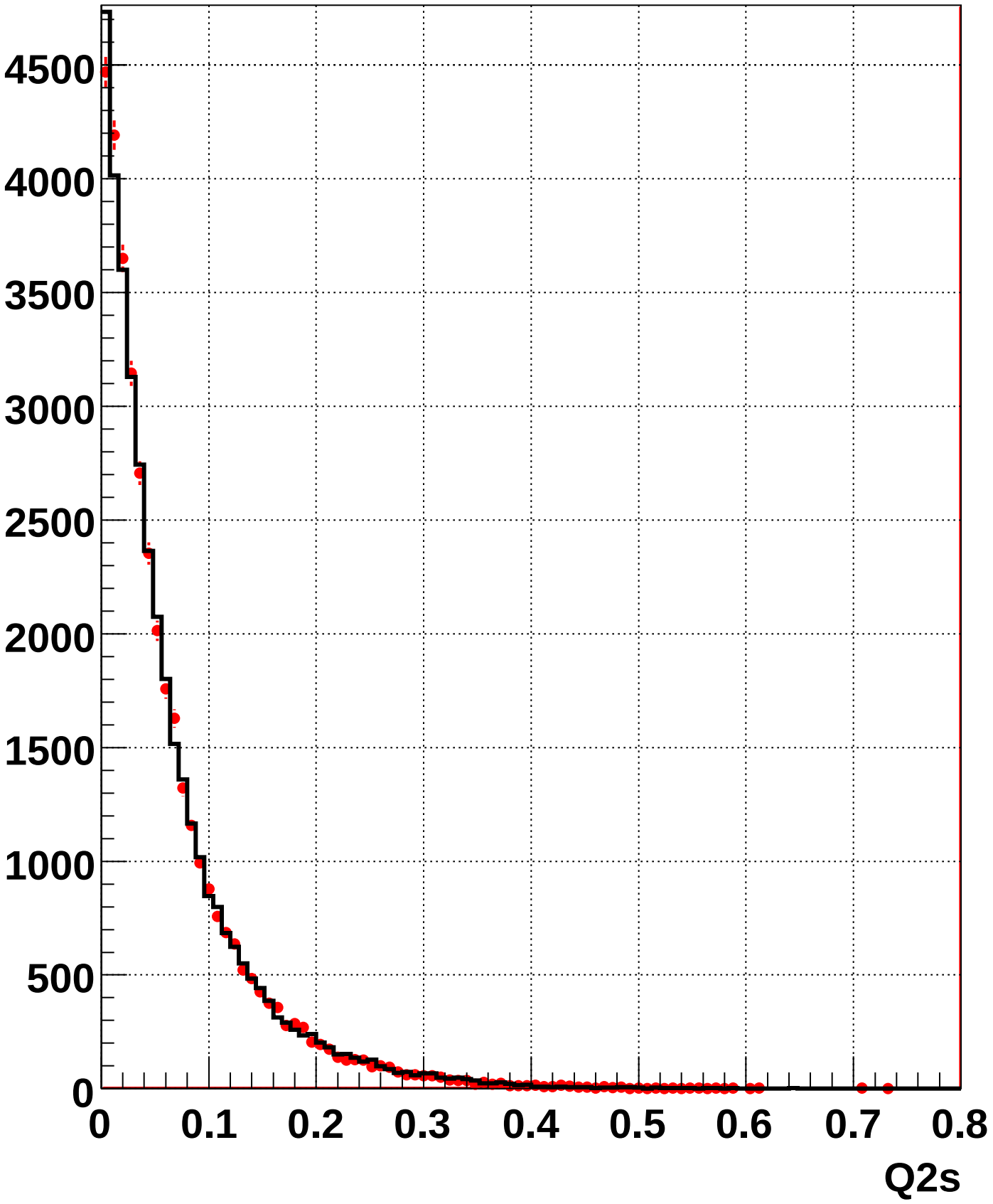
selected Q2 for COH events



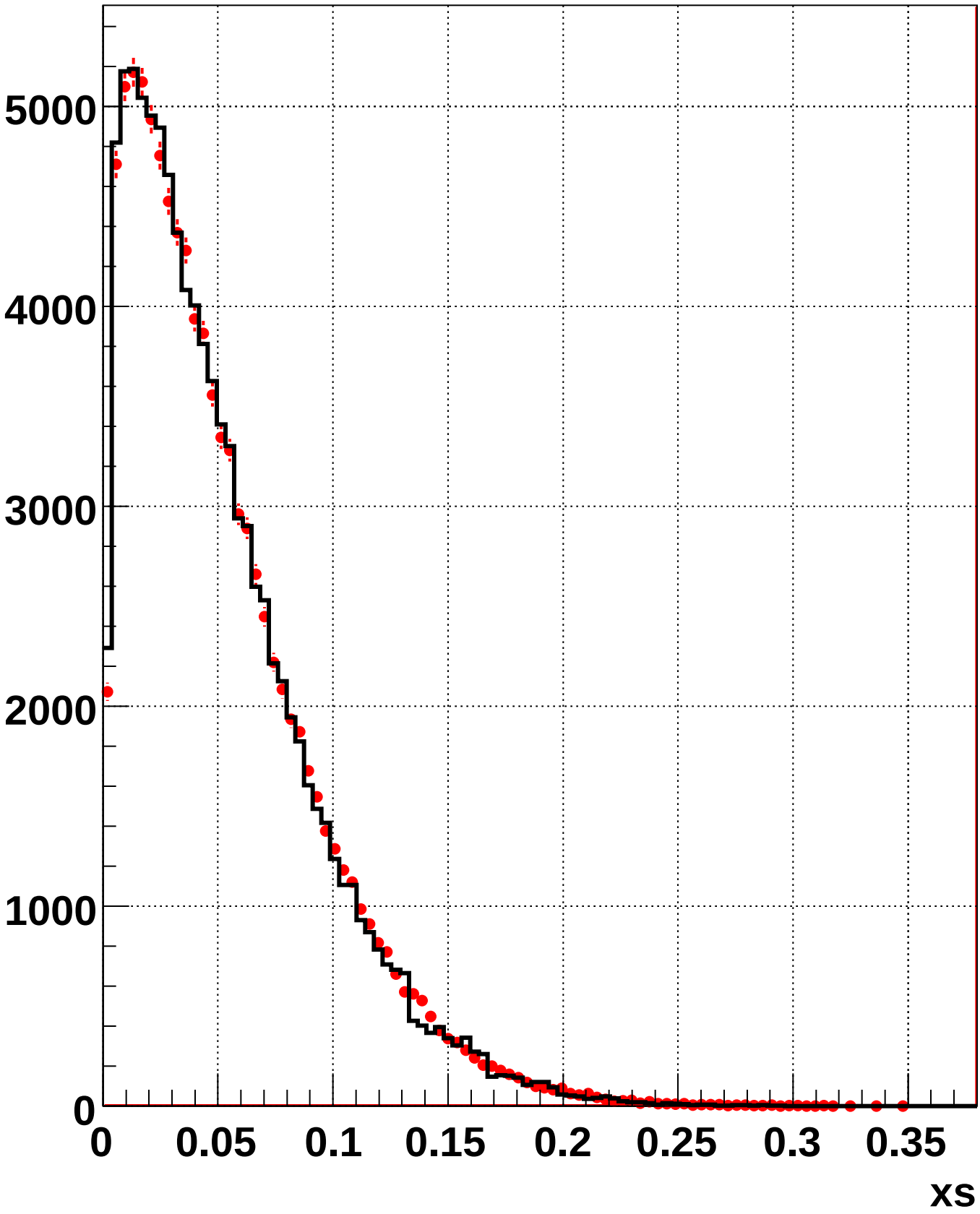
selected Q2 for COH CC events



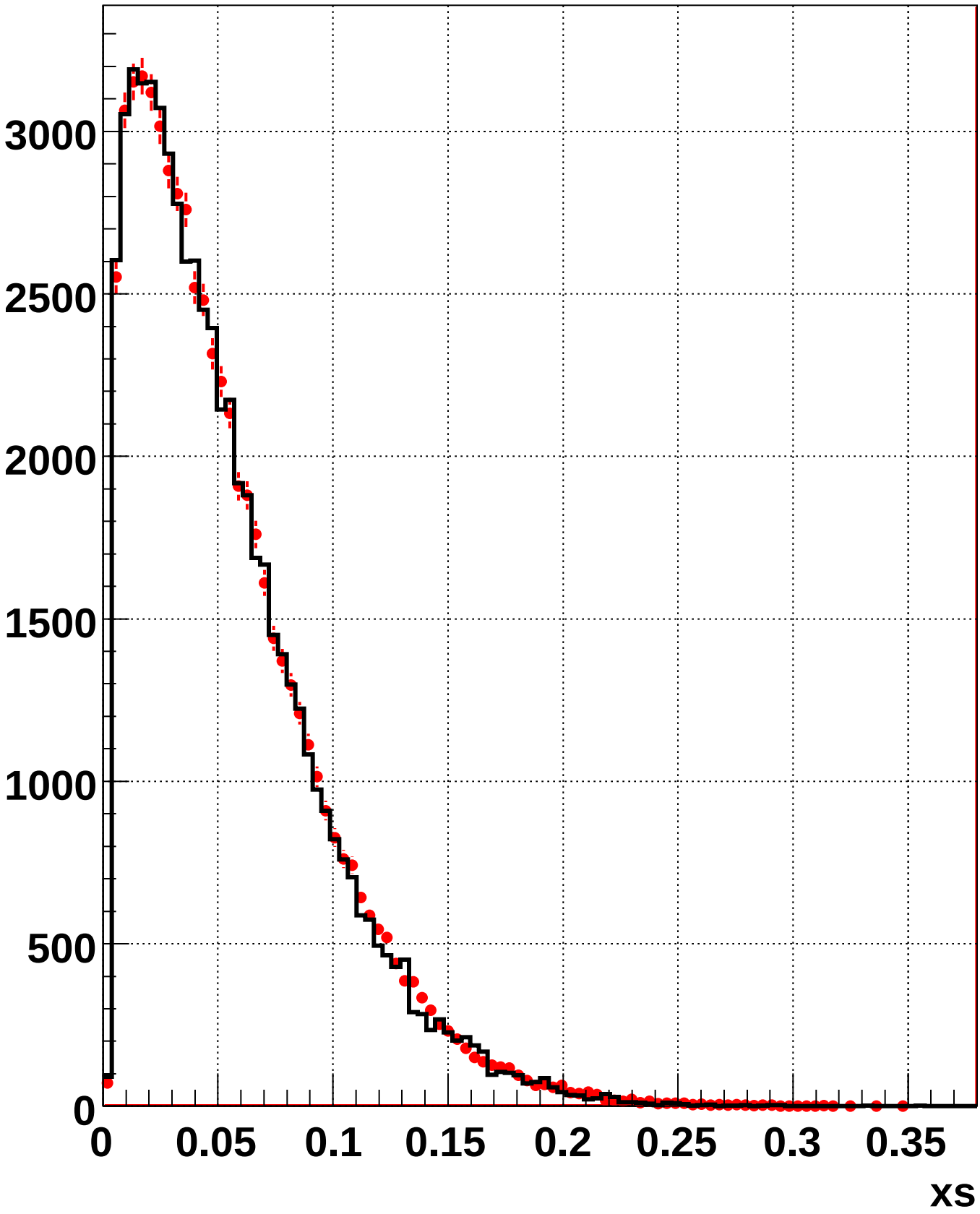
selected Q2 for COH NC events



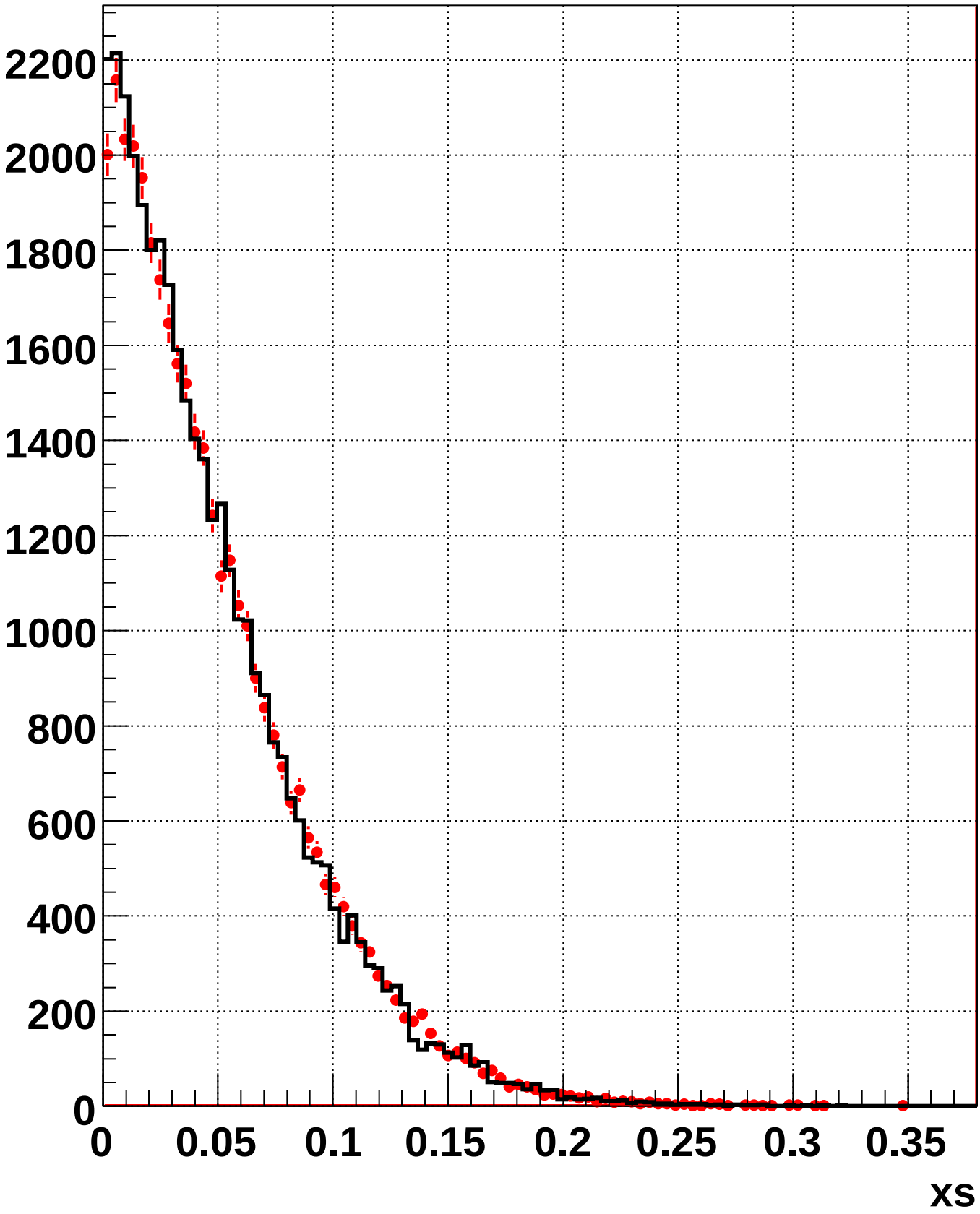
selected x for COH events



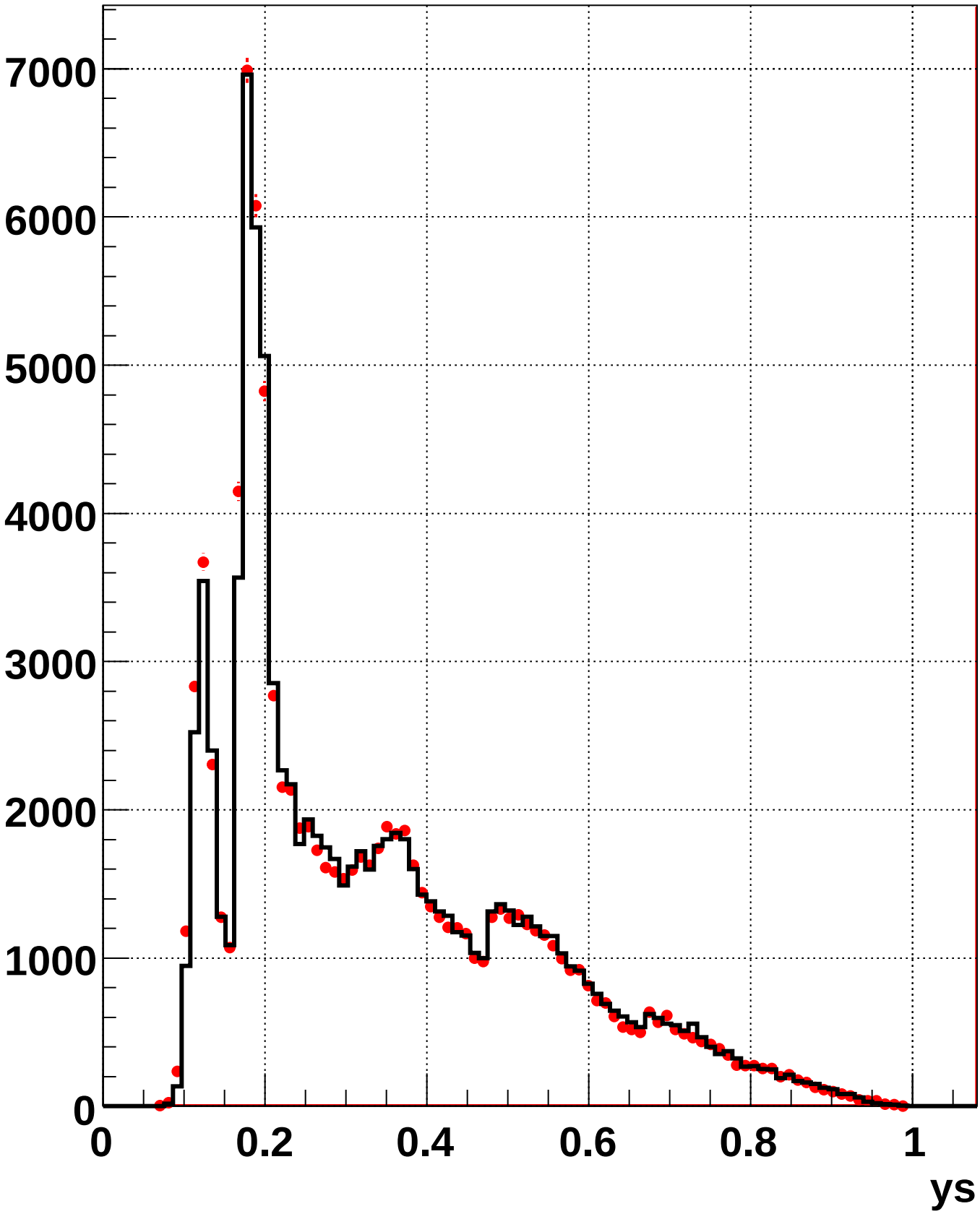
selected x for COH CC events

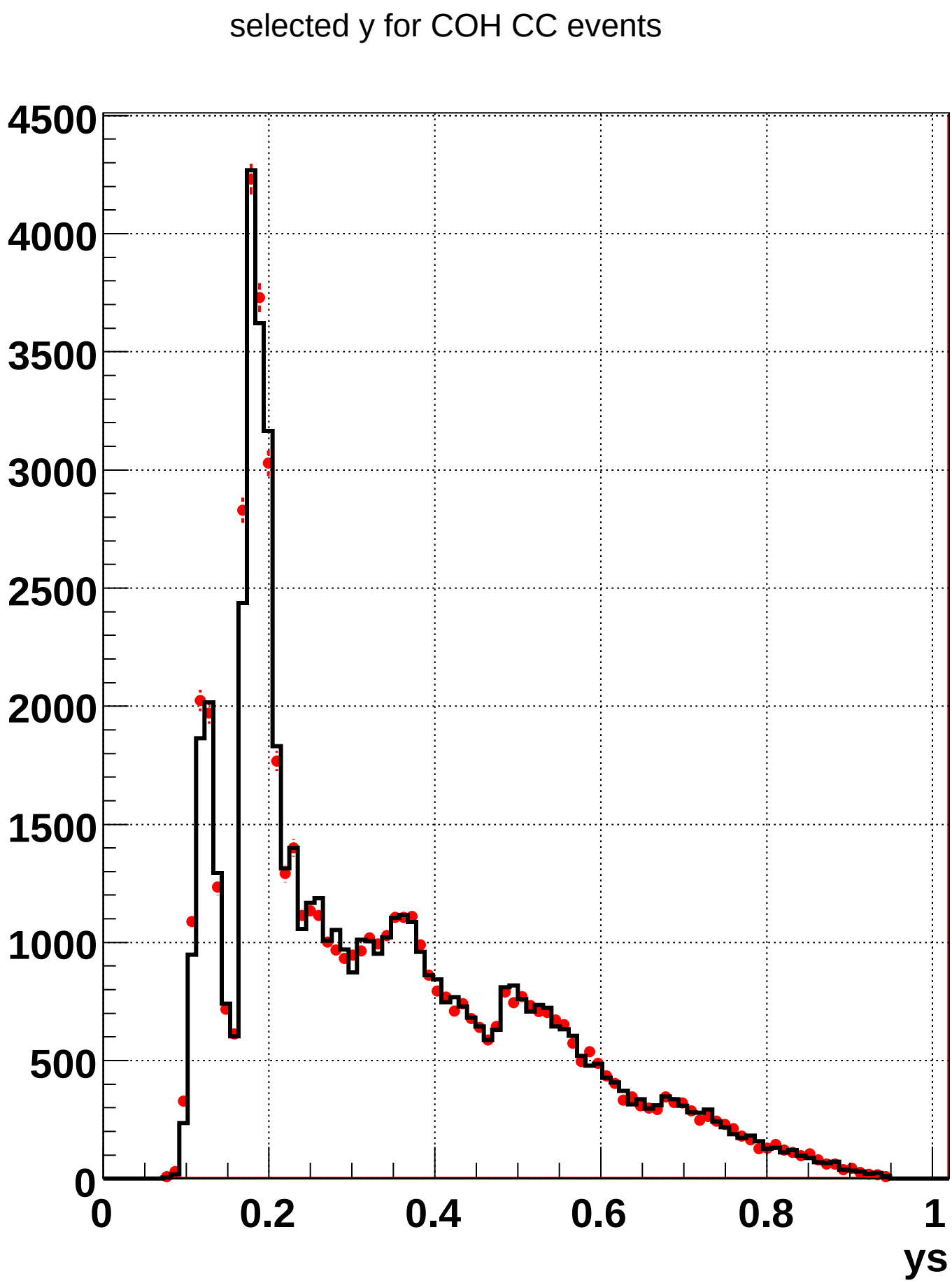


selected x for COH NC events

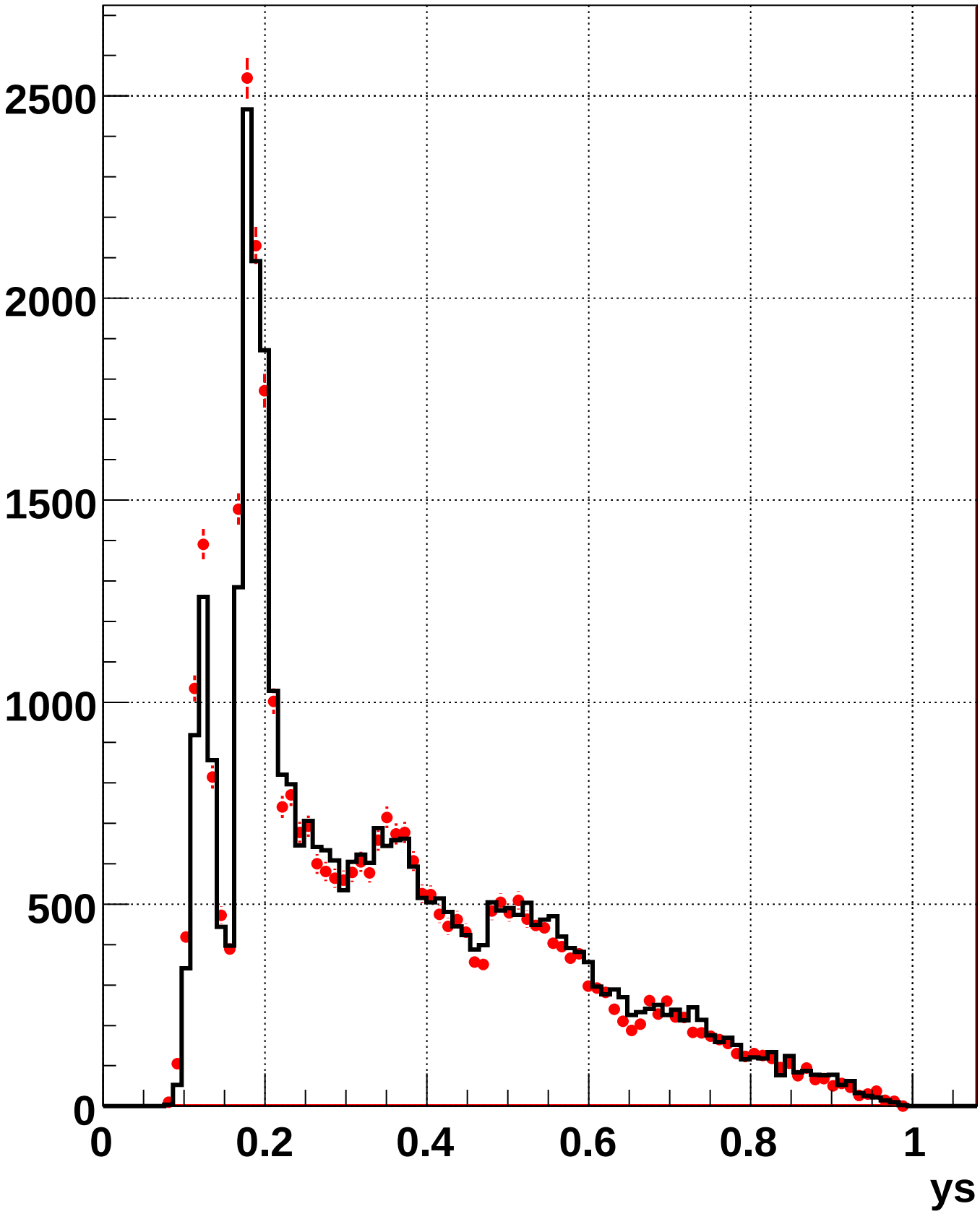


selected y for COH events

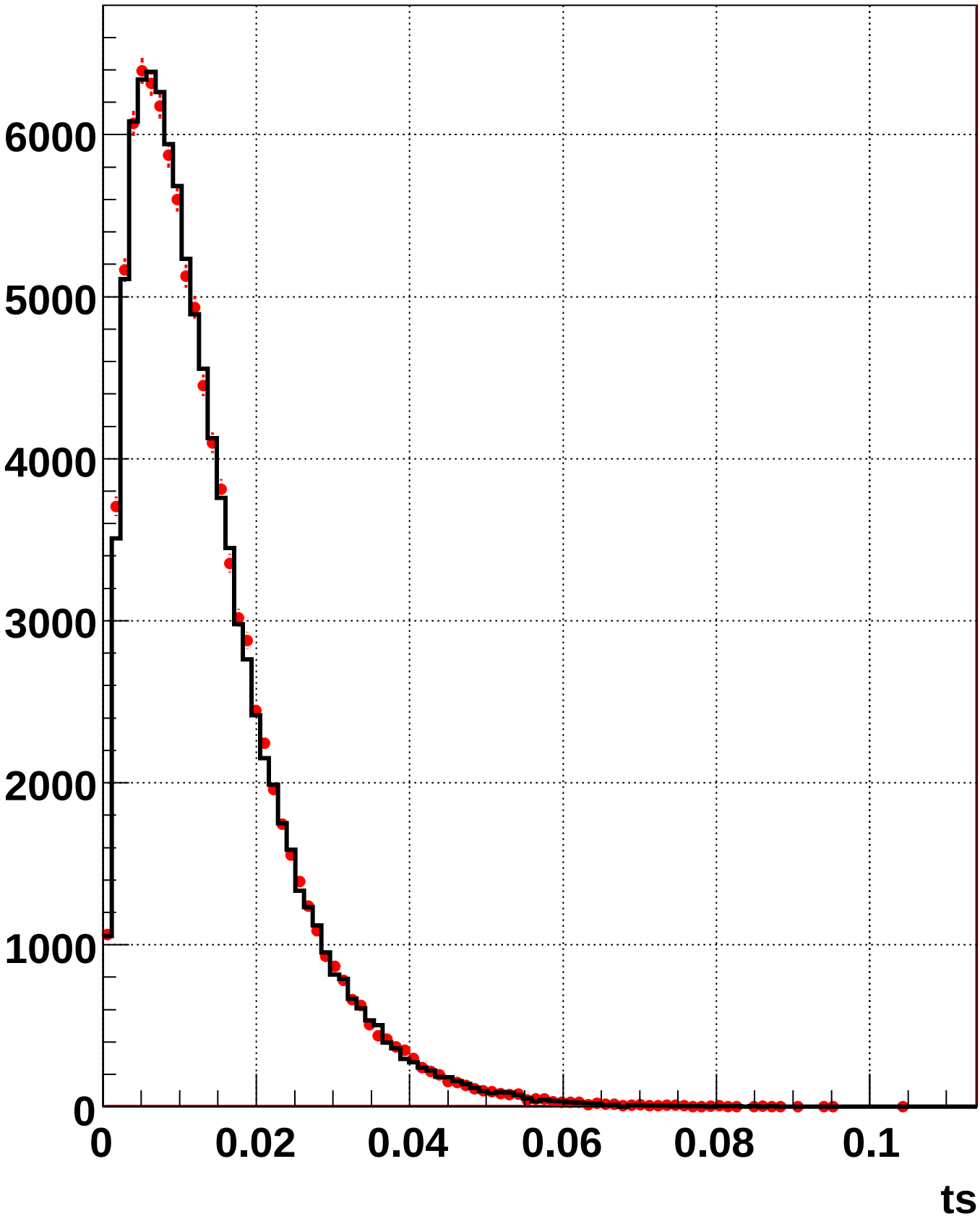



selected y for COH CC events
4500
4000
3500
3000
2500
2000
1500
1000
500
0
0
0.2
0.4
0.6
0.8
1
ys

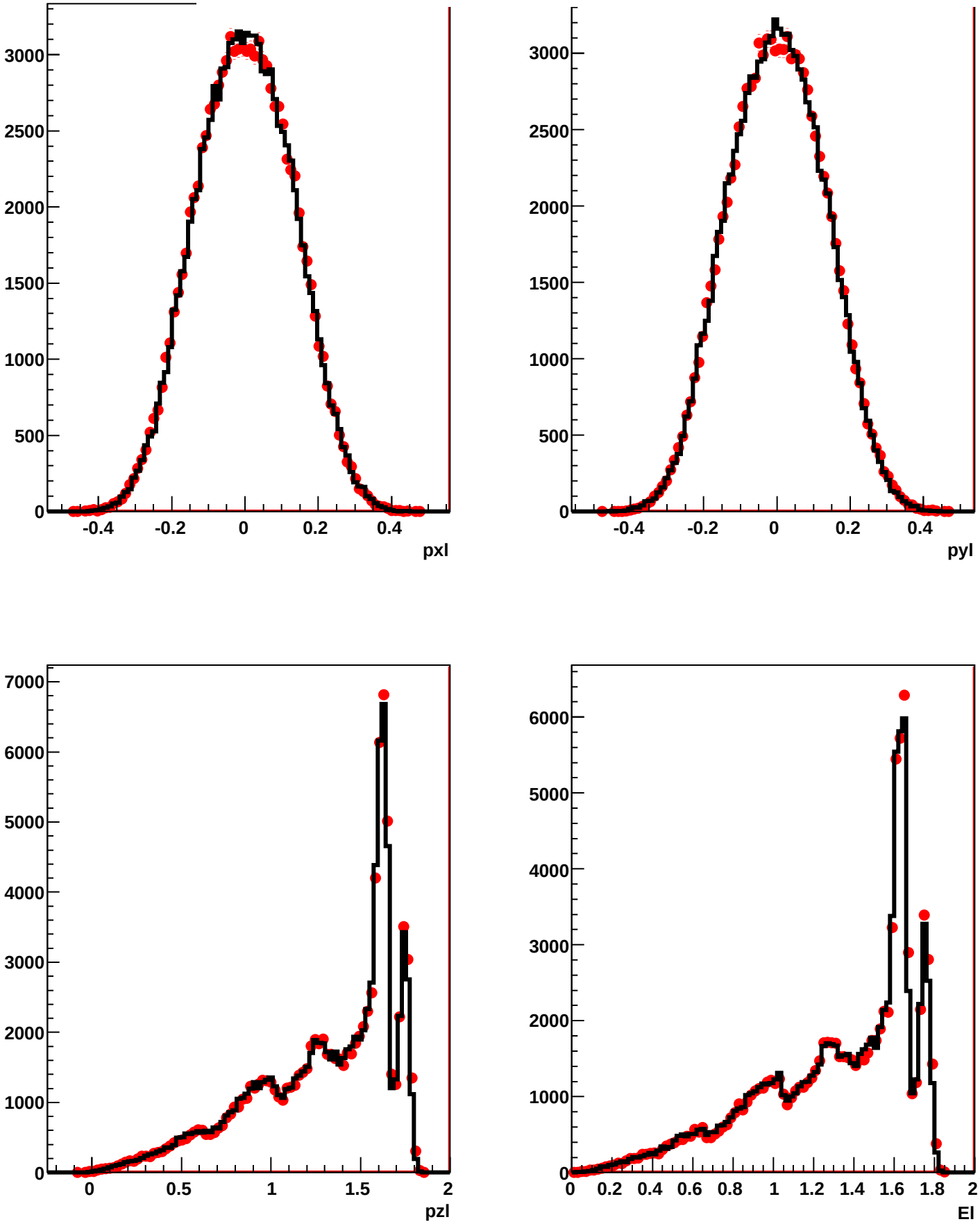
selected y for COH NC events



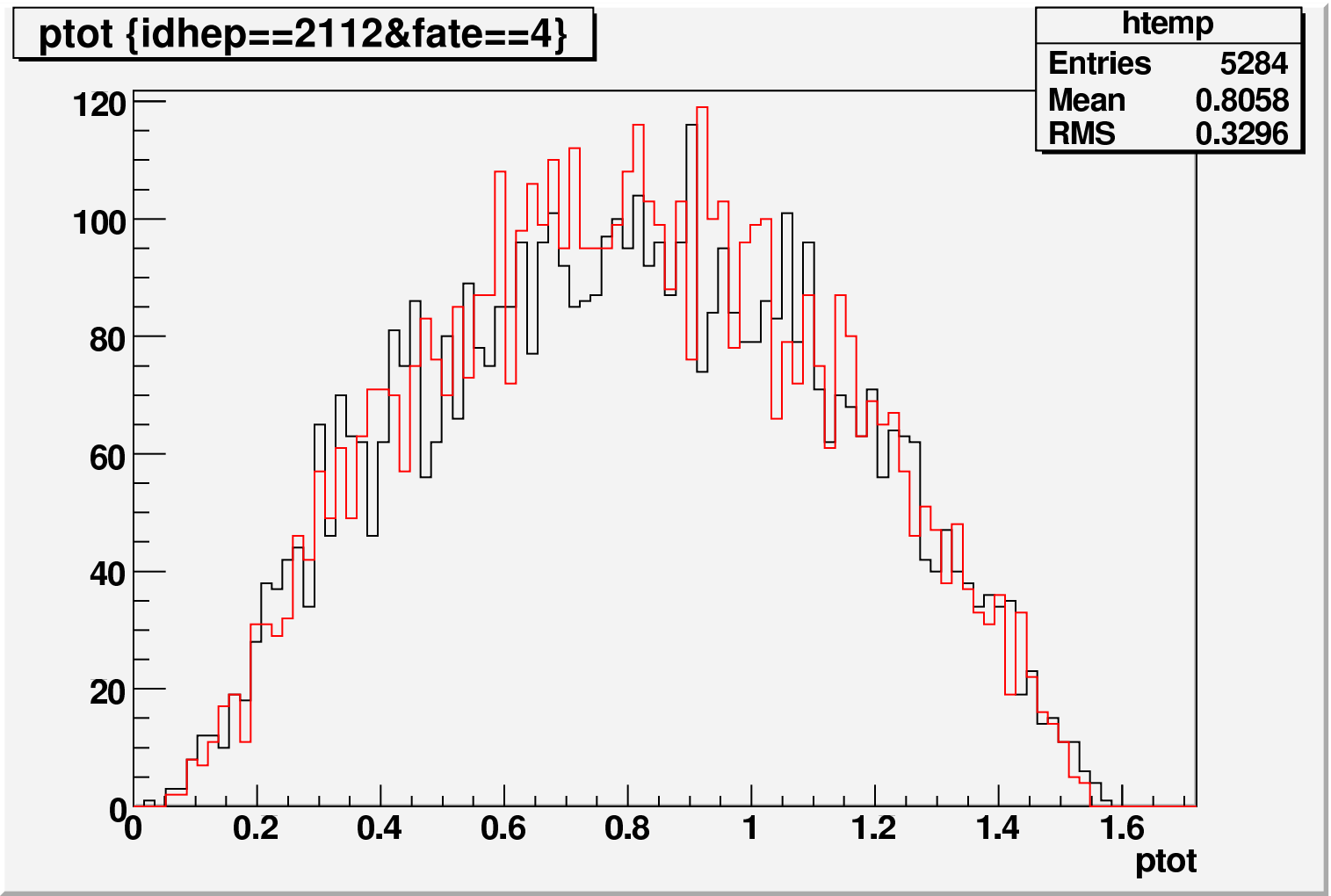
selected t for COH events

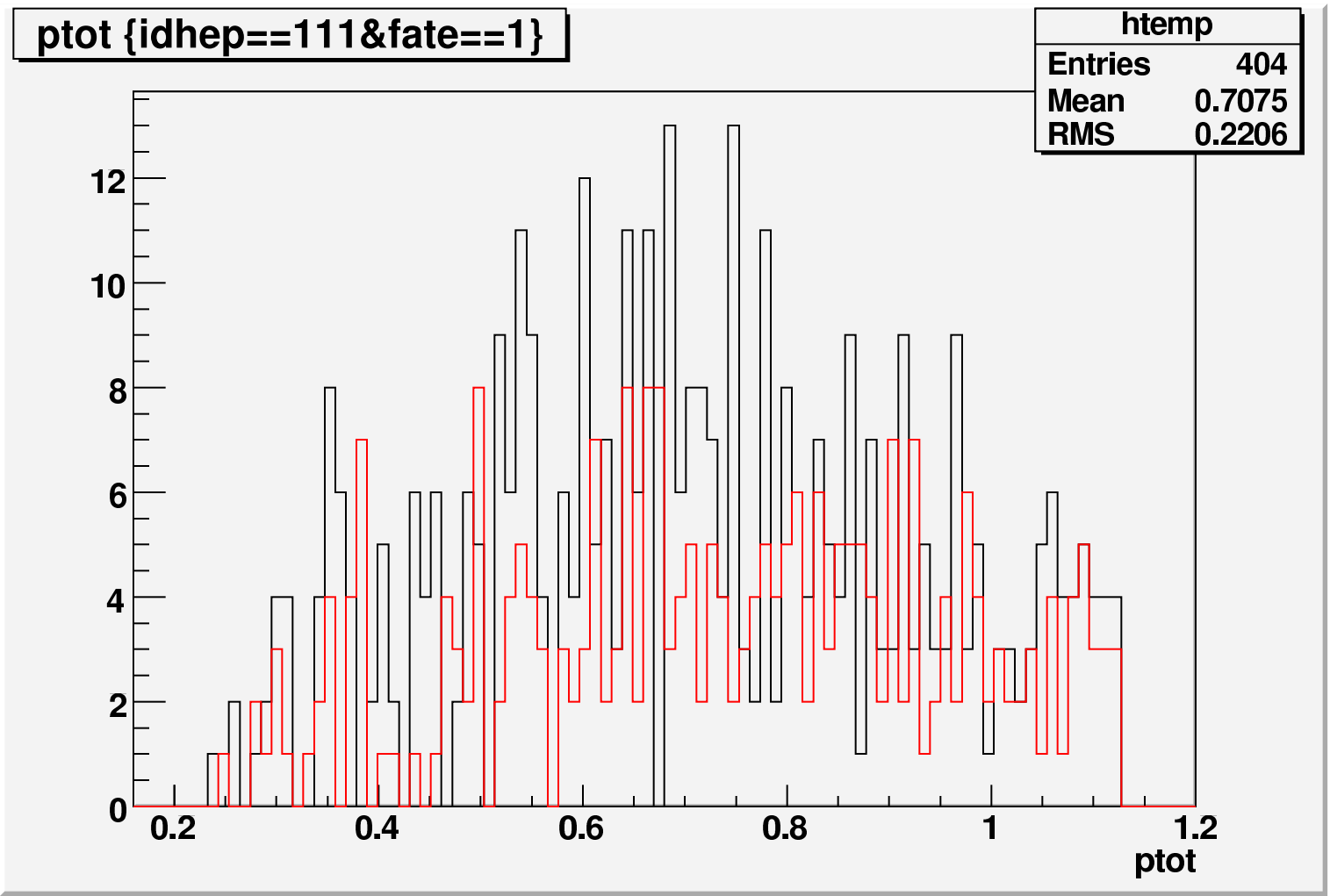


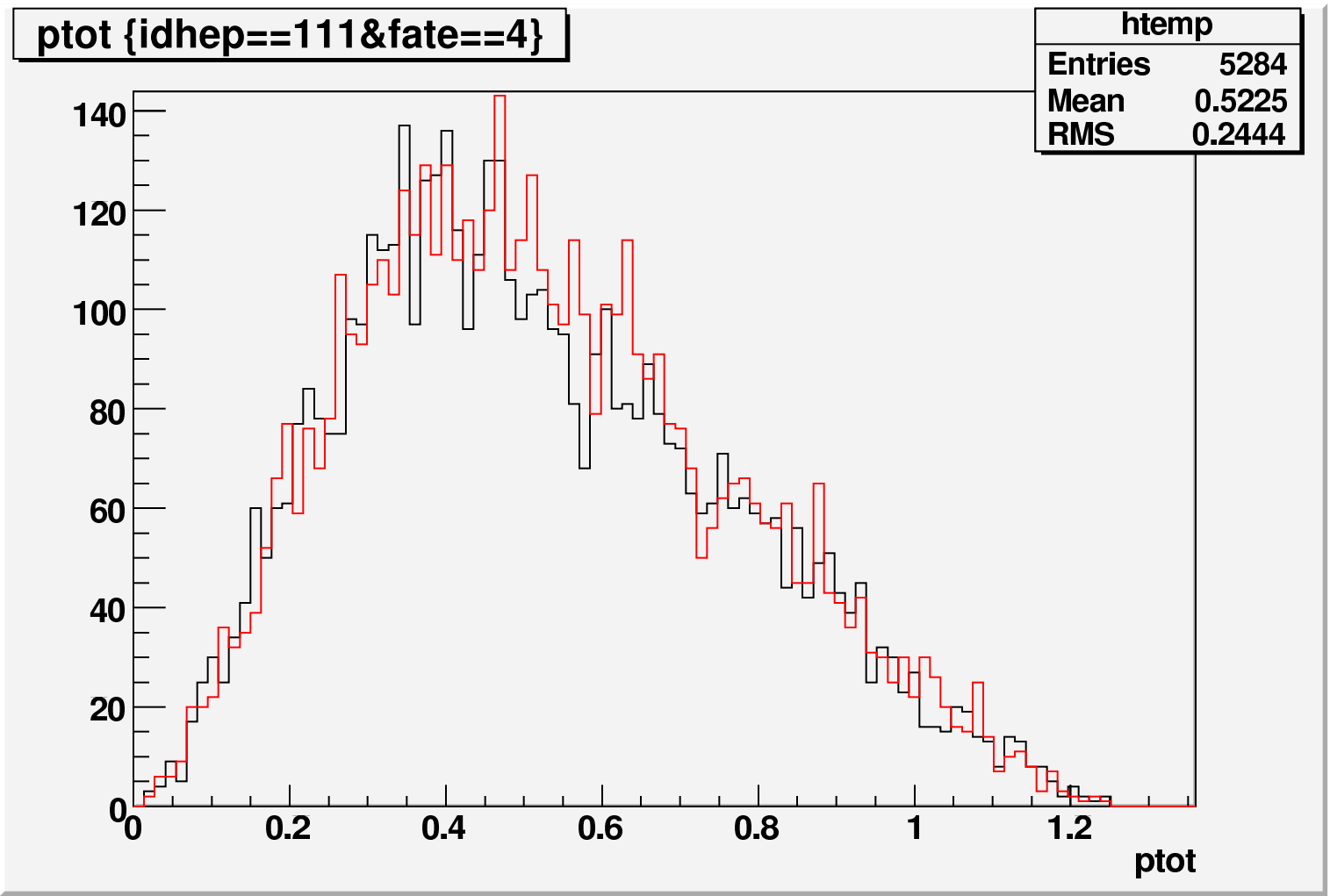
Final state primary lepton 4-p: COH events

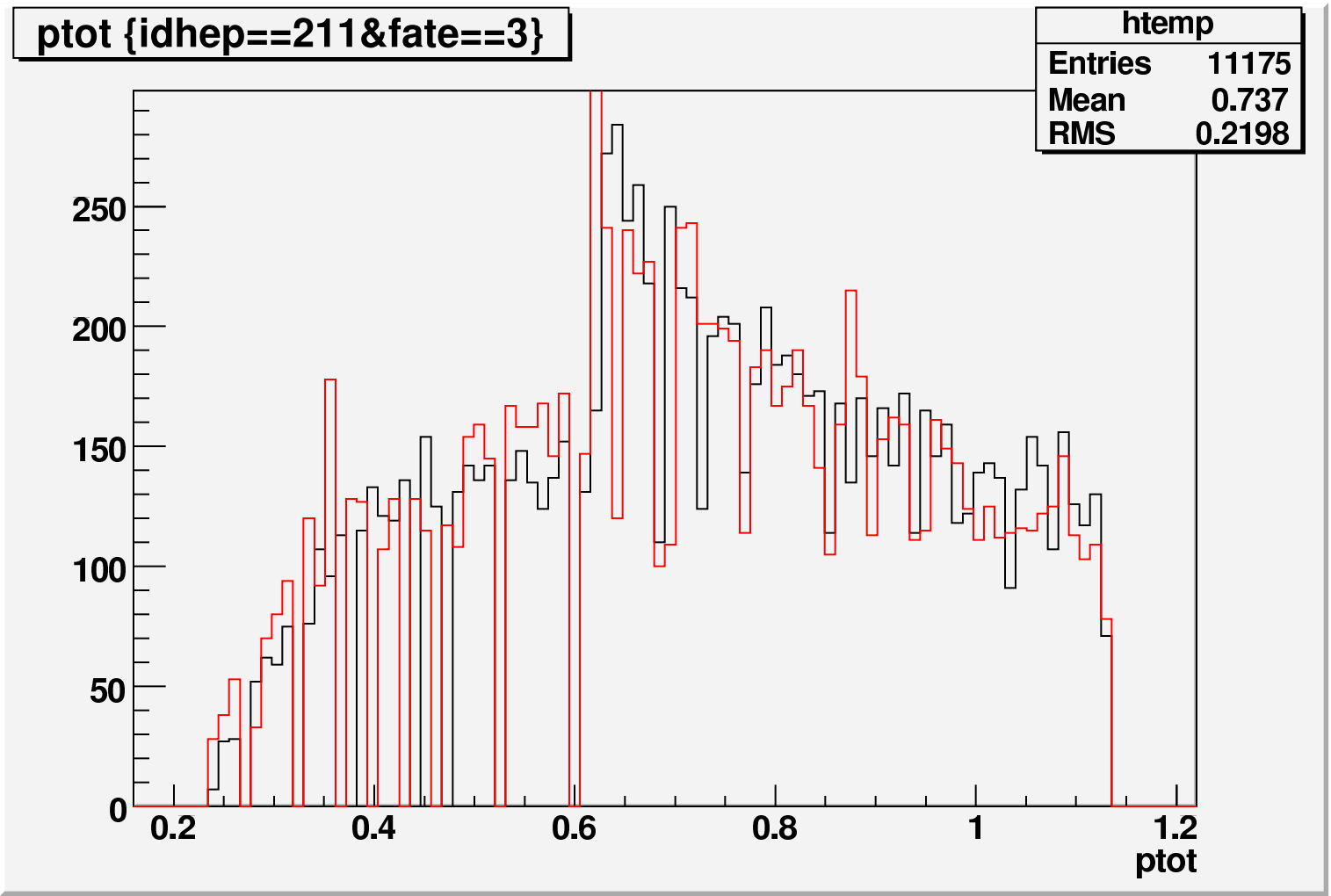


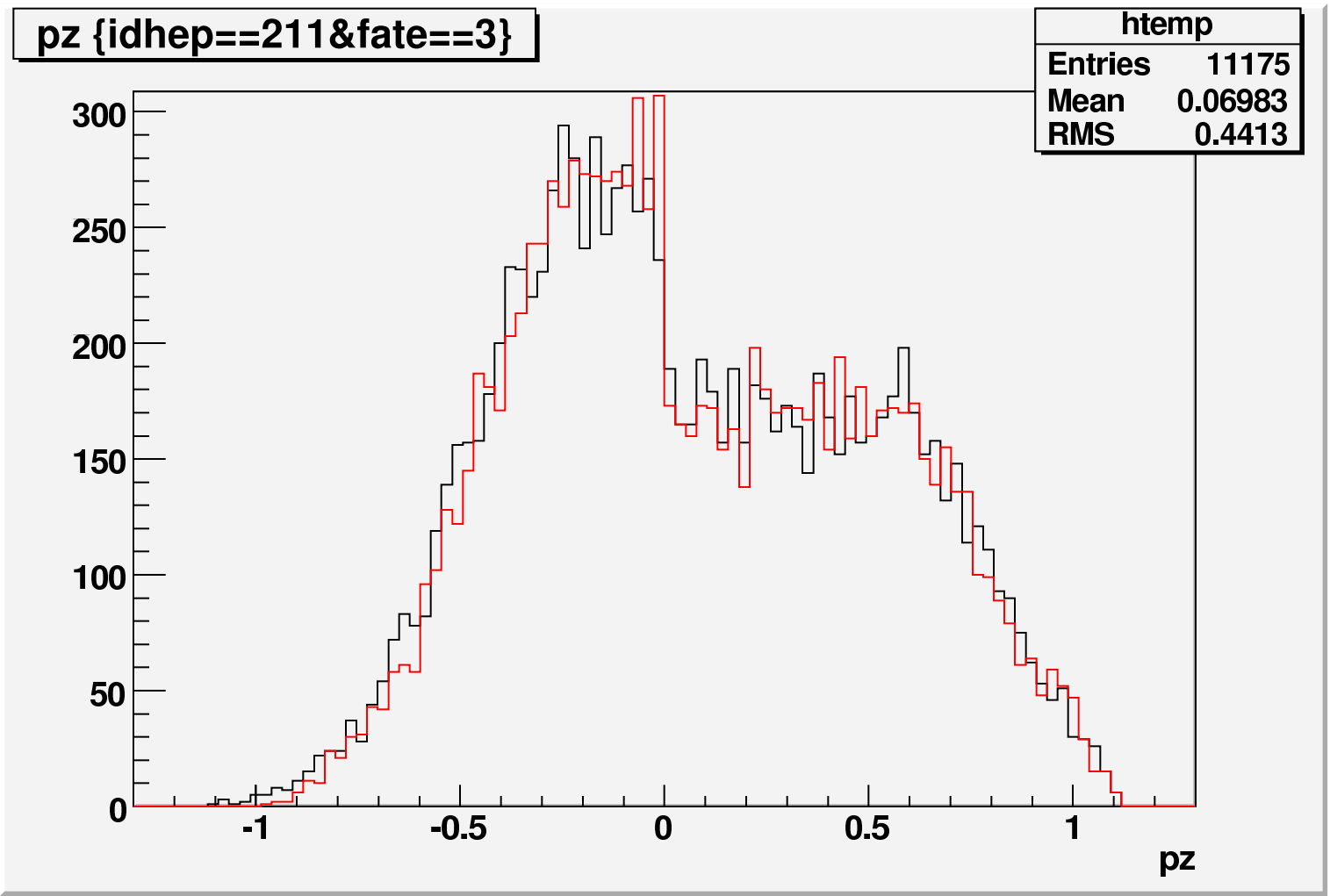
Neugen-GENIE comparison using 1 GeV pi+ Fe interactions
Neugen is black, GENIE is red histogram
June, 2007

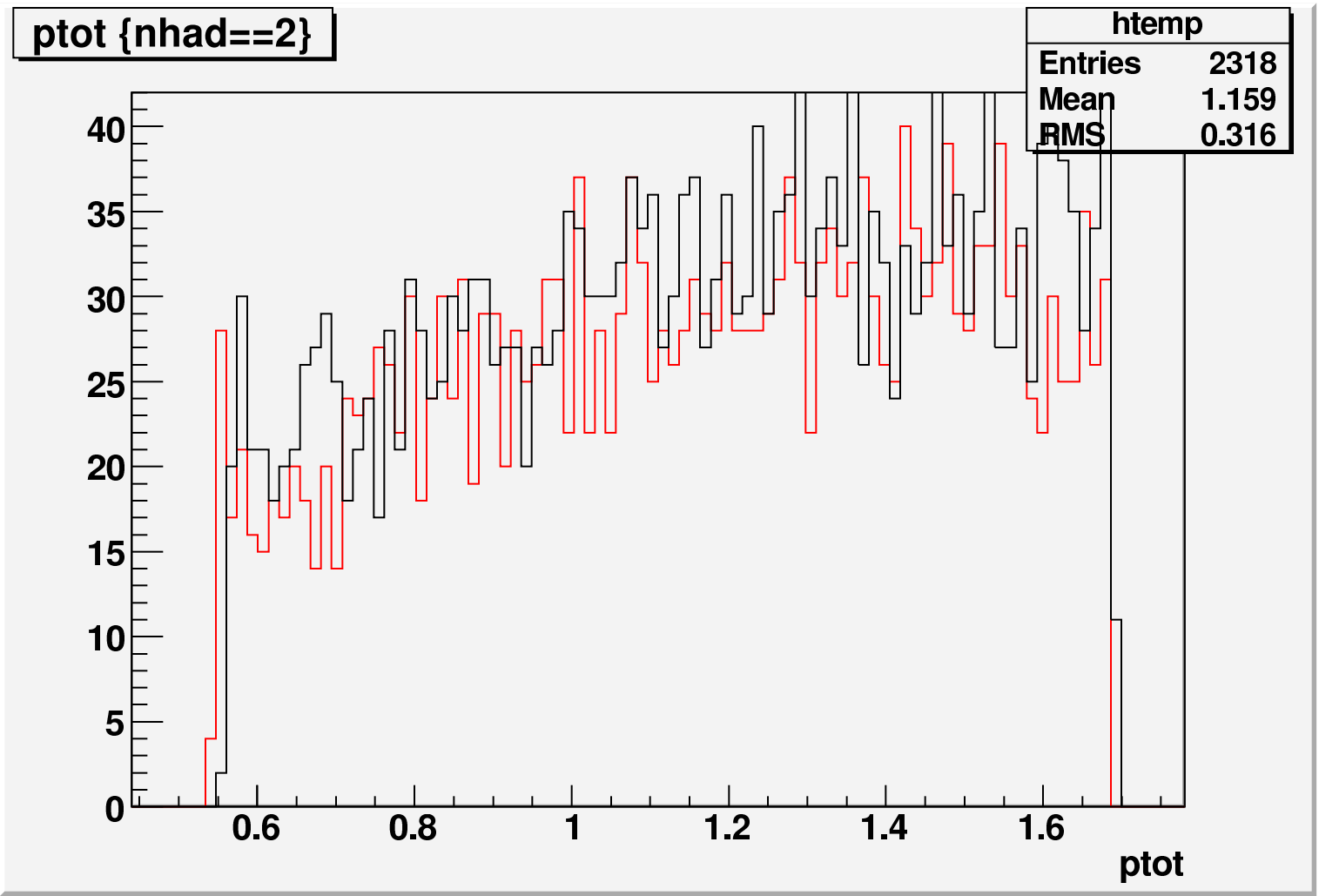


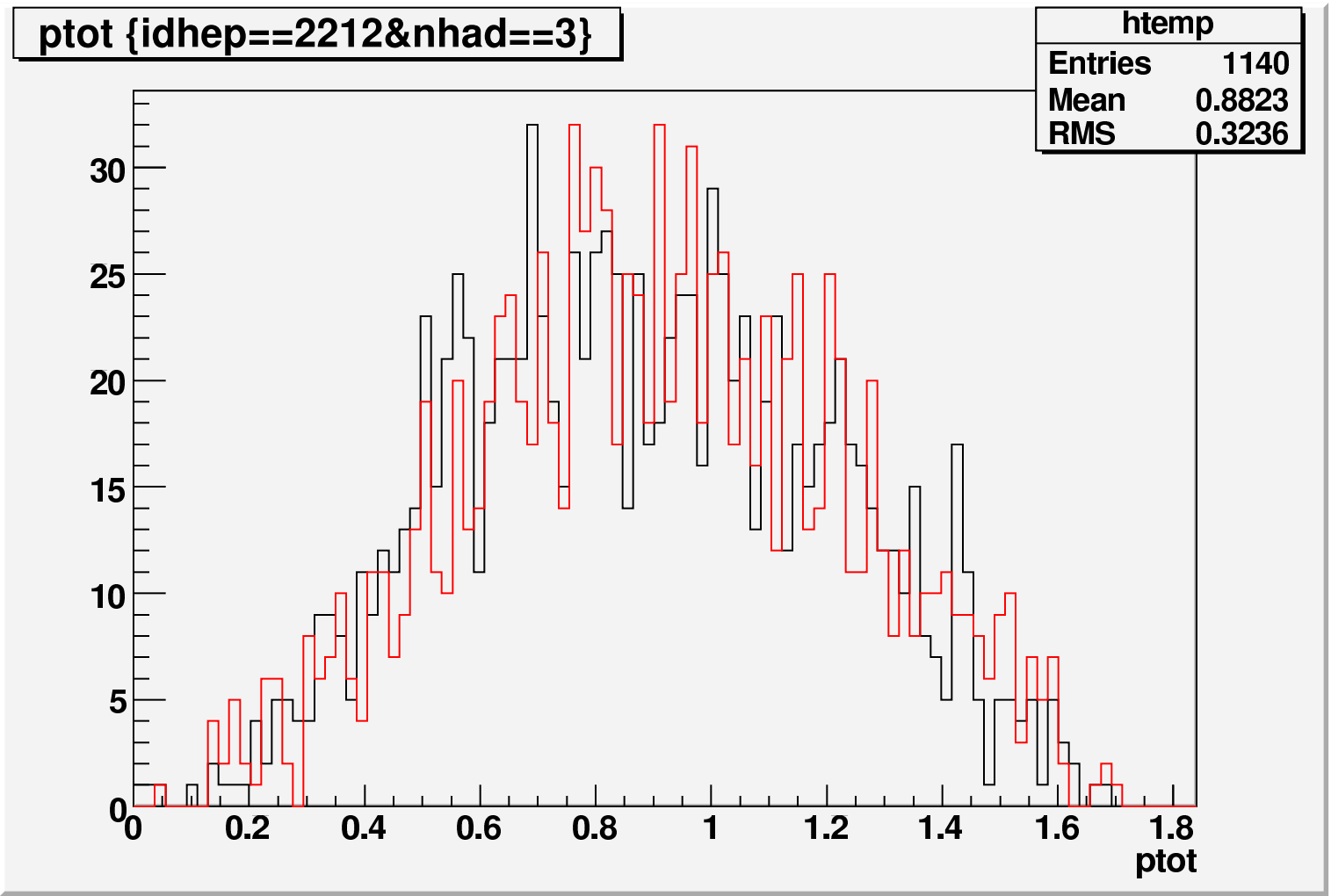

ptot {idhep==111&fate==1}
htemp
Entries 404
Mean 0.7075
RMS 0.2206
0
2
4
6
8
10
12
0.2
0.4
0.6
0.8
1
1.2
ptot

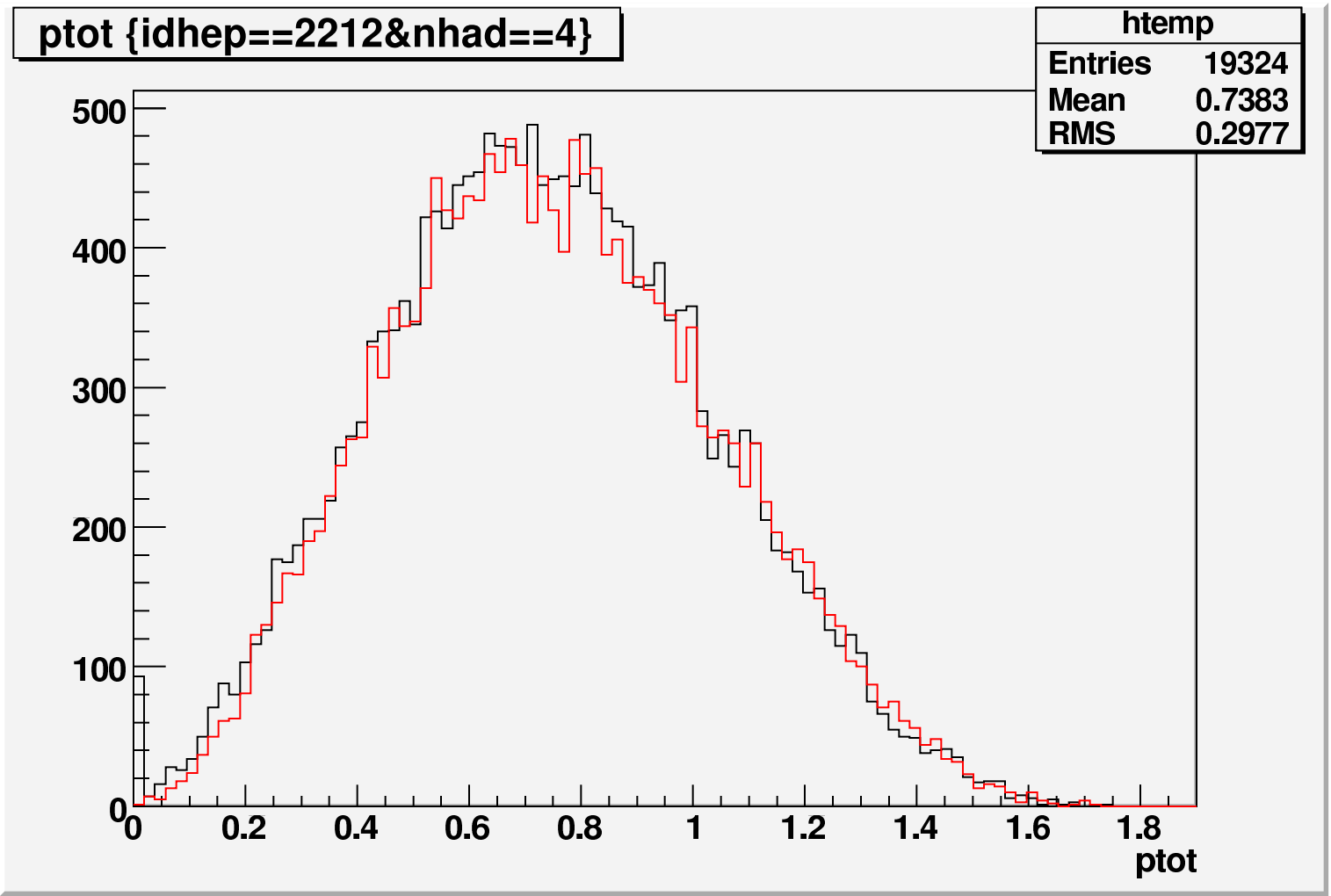

ptot {idhep==111&fate==4}
htemp
Entries 5284
Mean 0.5225
RMS 0.2444
140
120
100
80
60
40
20
0
0
0.2
0.4
0.6
0.8
1
1.2
ptot

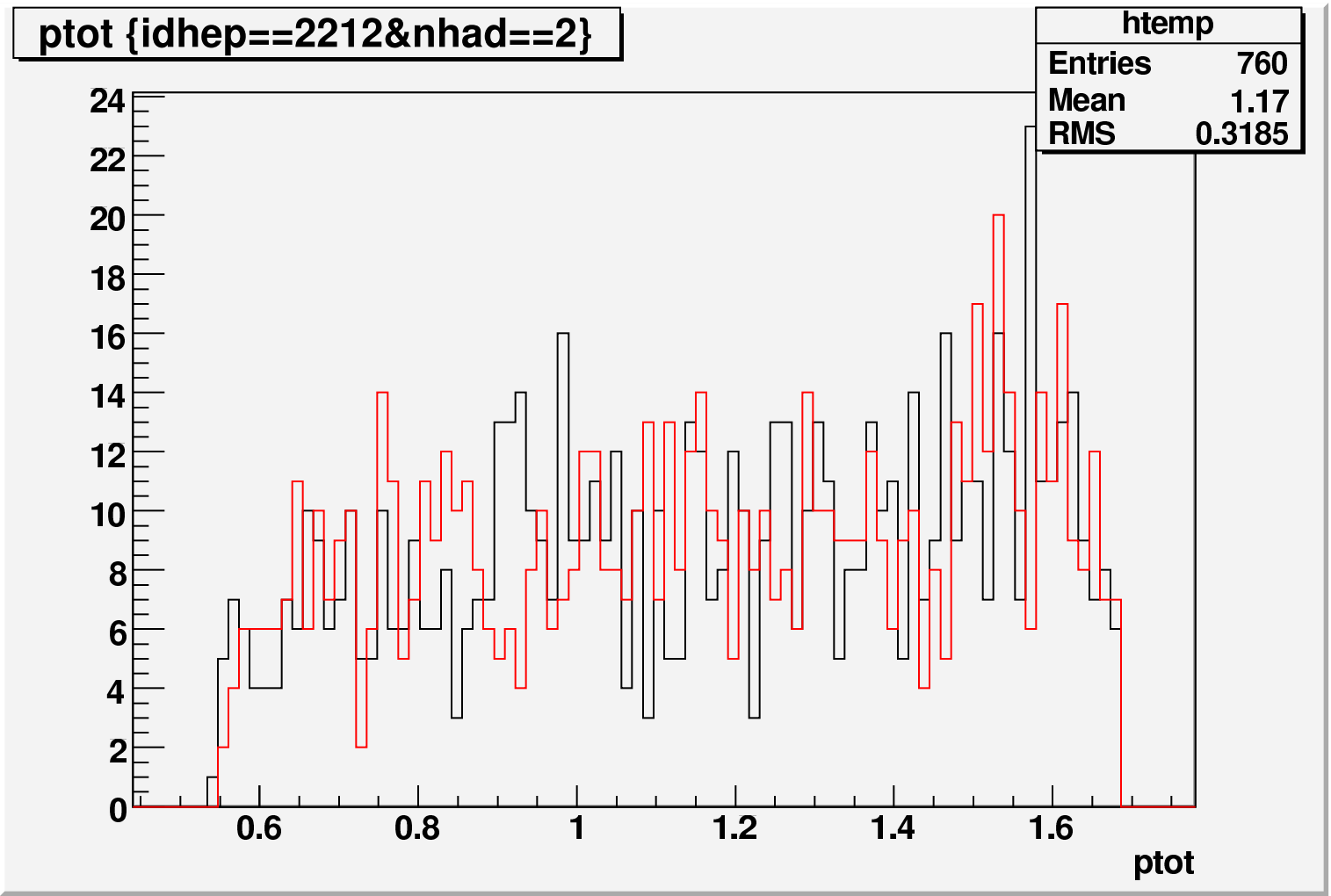

ptot {idhep==211&fate==3}
htemp
Entries 11175
Mean 0.737
RMS 0.2198
250
200
150
100
50
0
0.2
0.4
0.6
0.8
1
1.2
ptot

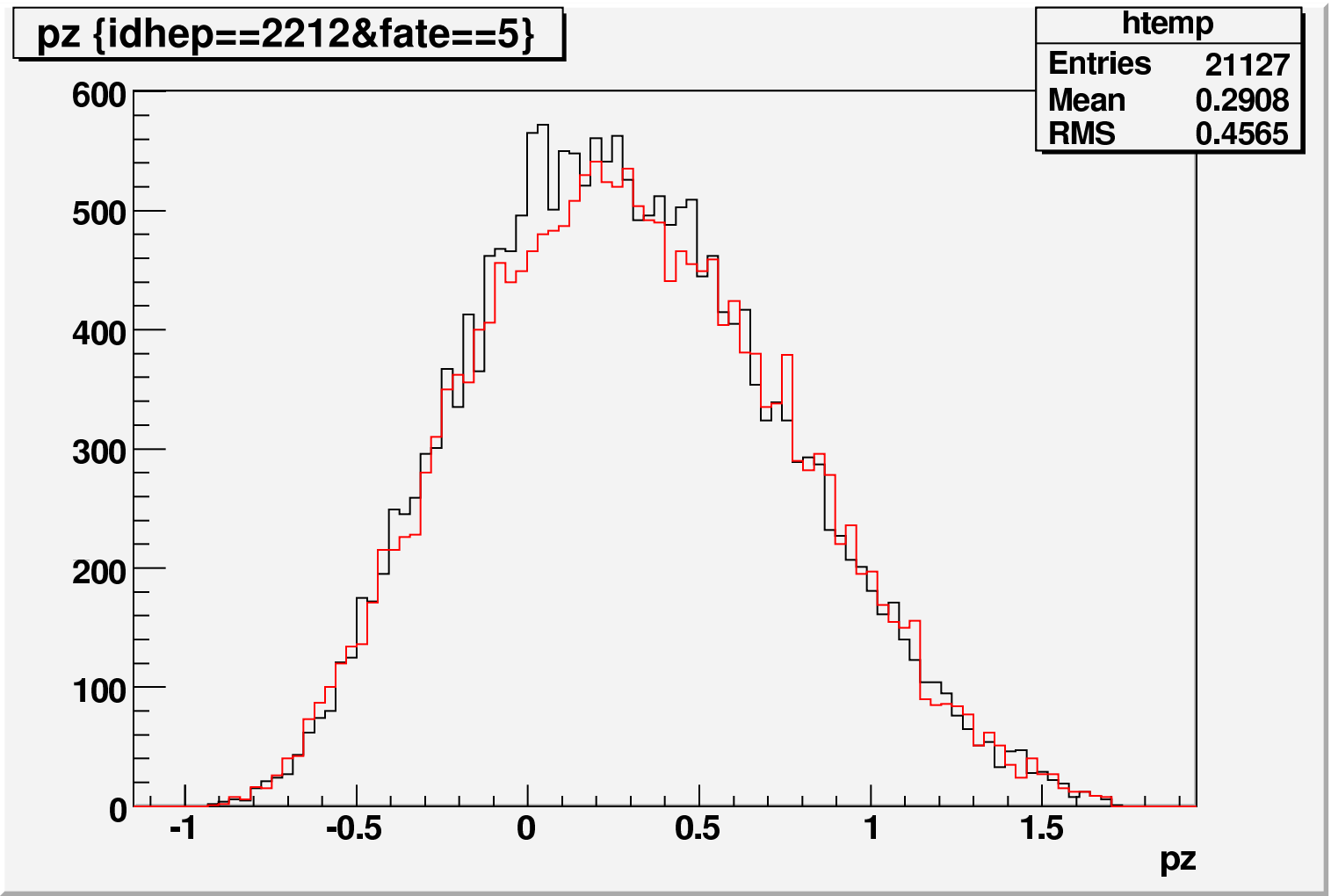

pz {idhep==211&fate==3}
htemp
Entries 11175
Mean 0.06983
RMS 0.4413
300
250
200
150
100
50
0
-1
-0.5
0
0.5
1
pz


ptot {nhad==2}
htemp
Entries 2318
Mean 1.159
RMS 0.316
40
35
30
25
20
15
10
5
0
0.6
0.8
1
1.2
1.4
1.6
ptot

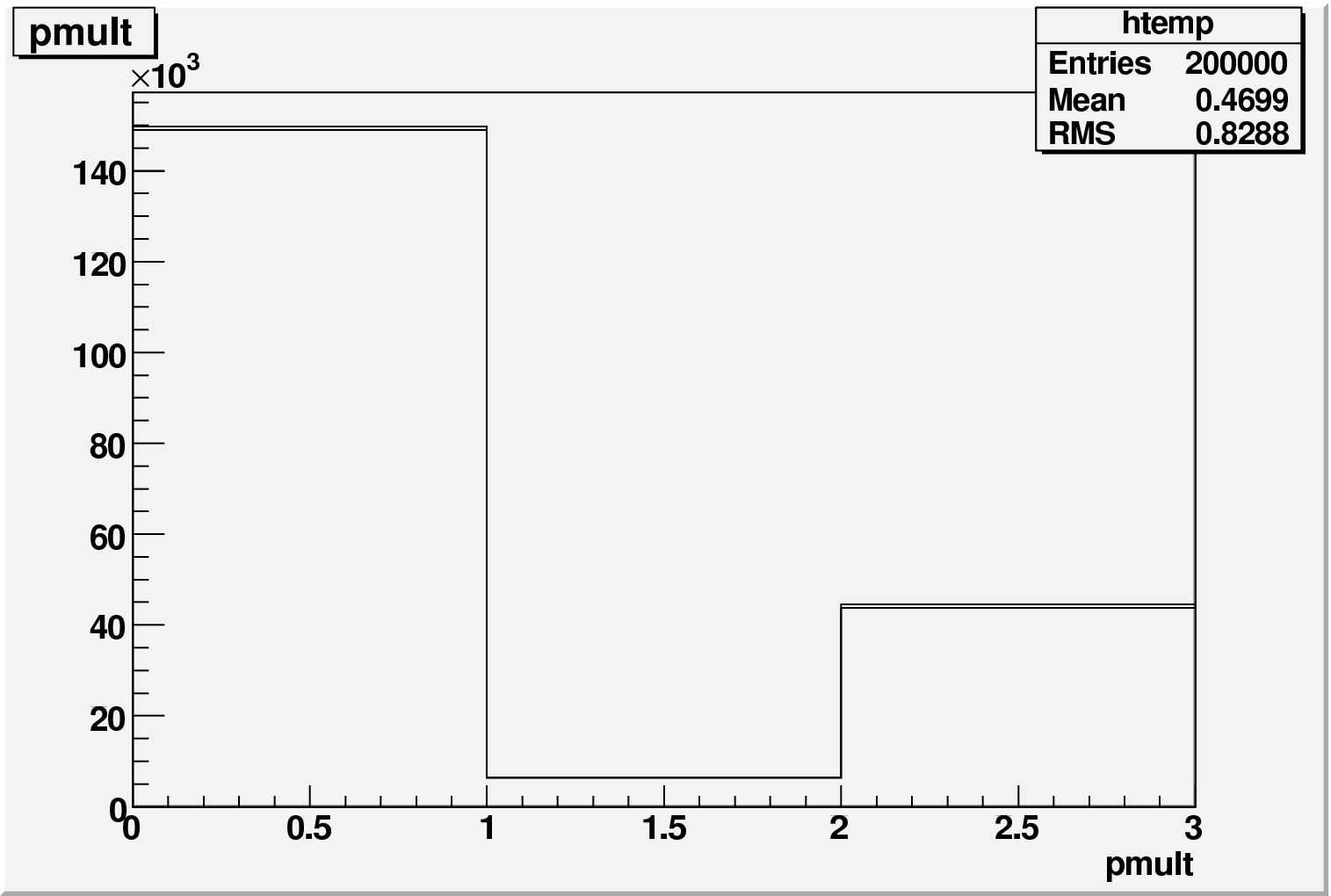

ptot {idhep==2212&nhad==3}
htemp
Entries 1140
Mean 0.8823
RMS 0.3236
0
5
10
15
20
25
30
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
ptot

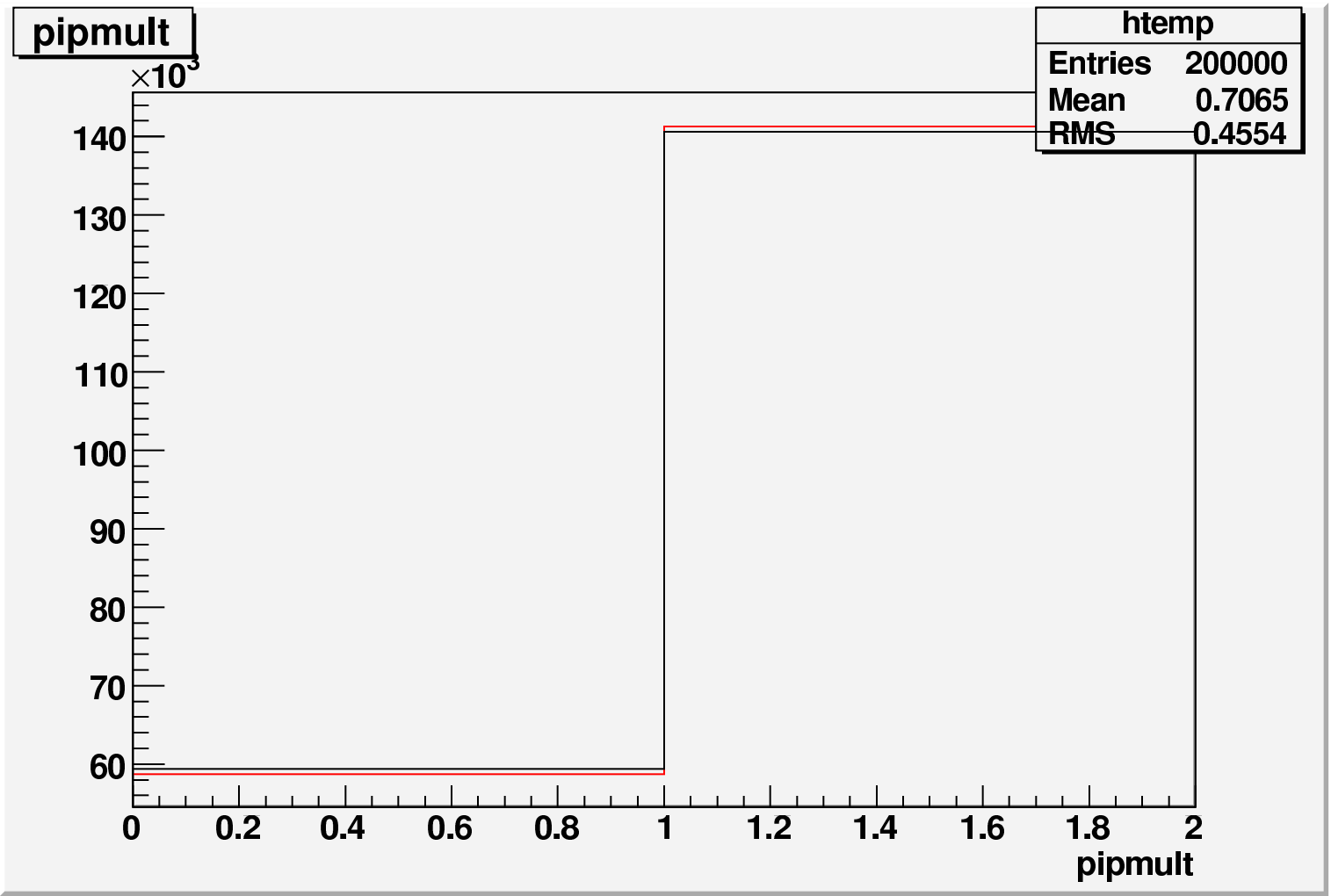

ptot {idhep==2212&nhad==4}
htemp
Entries 19324
Mean 0.7383
RMS 0.2977
500
400
300
200
100
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
ptot

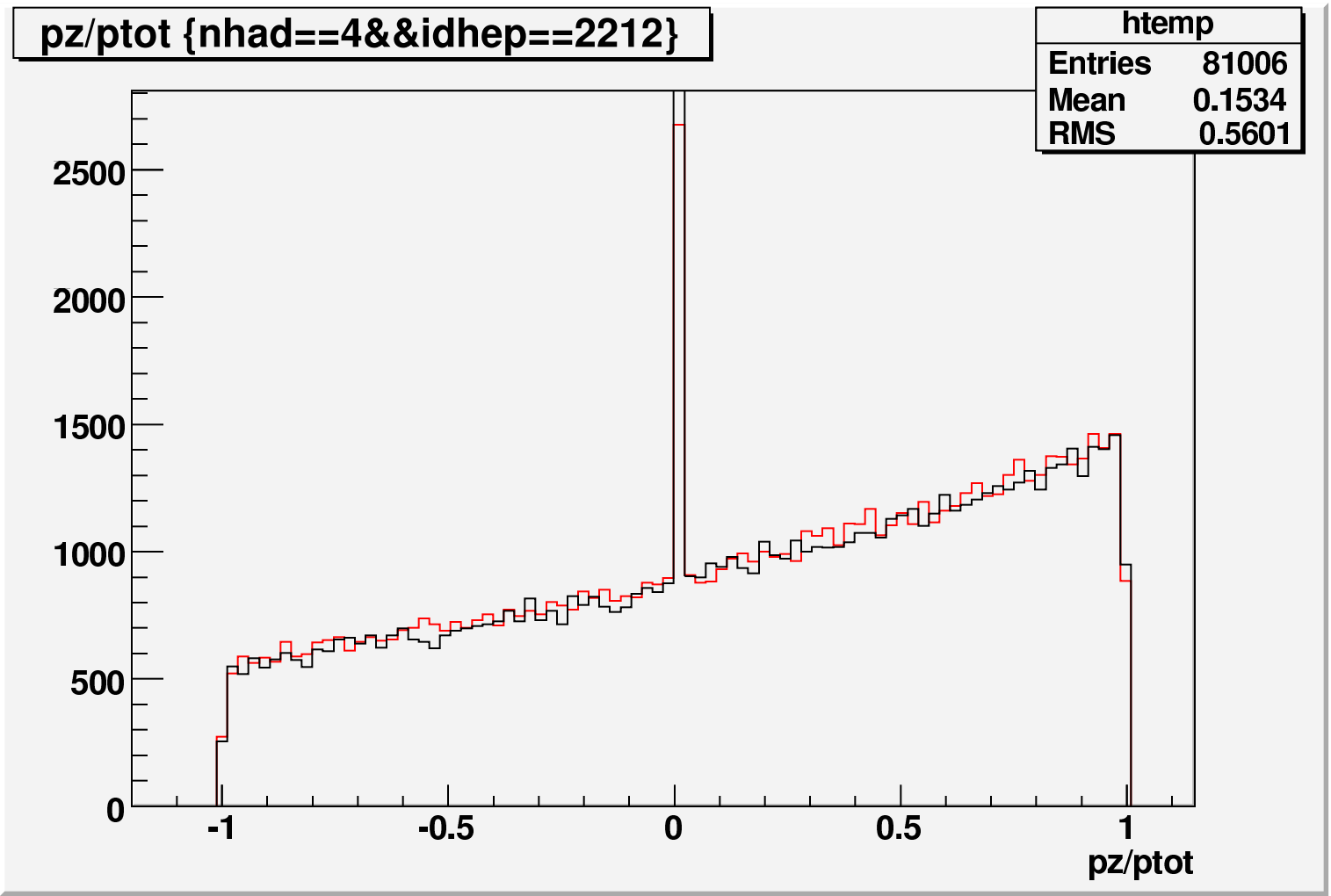

ptot {idhep==2212&nhad==2}
htemp
Entries 760
Mean 1.17
RMS 0.3185
24
22
20
18
16
14
12
10
8
6
4
2
0
0.6
0.8
1
1.2
1.4
1.6
ptot

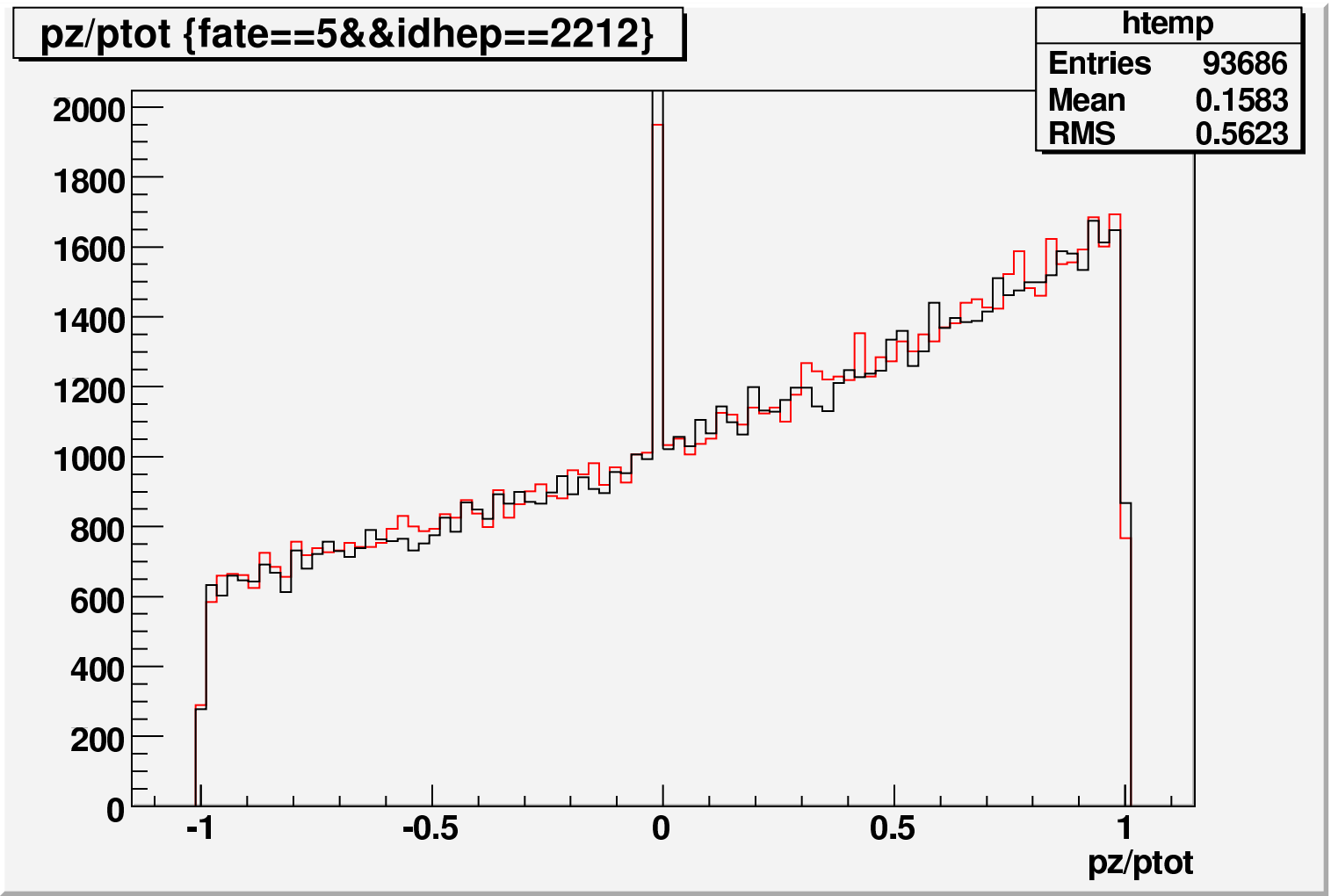

pz {idhep==2212&fate==5}
htemp
Entries 21127
Mean 0.2908
RMS 0.4565
600
500
400
300
200
100
0
-1
-0.5
0
0.5
1
1.5
pz

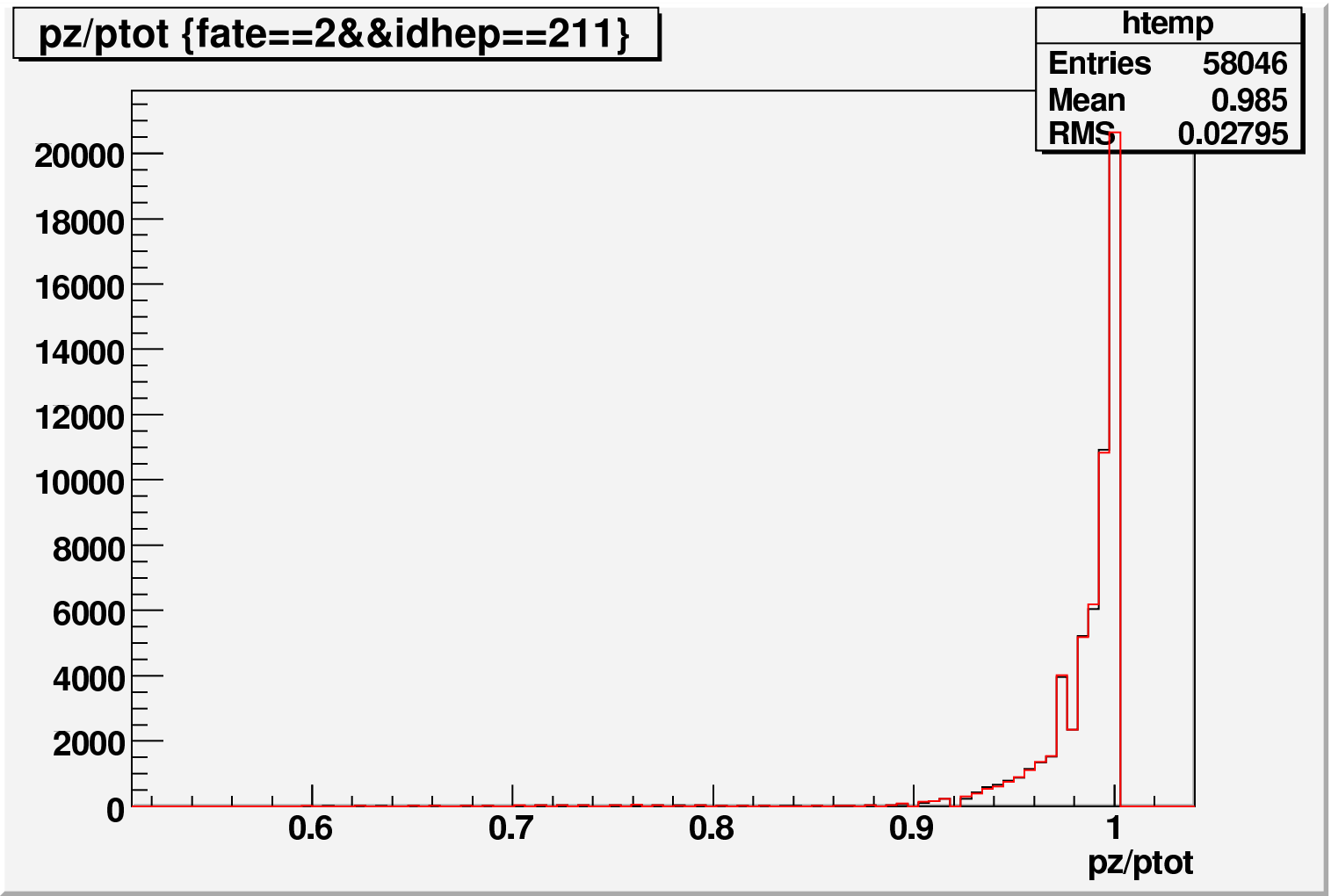
Neugen-GENIE comparison - August, 2007
200,000 events - 200 MeV pi+ Fe

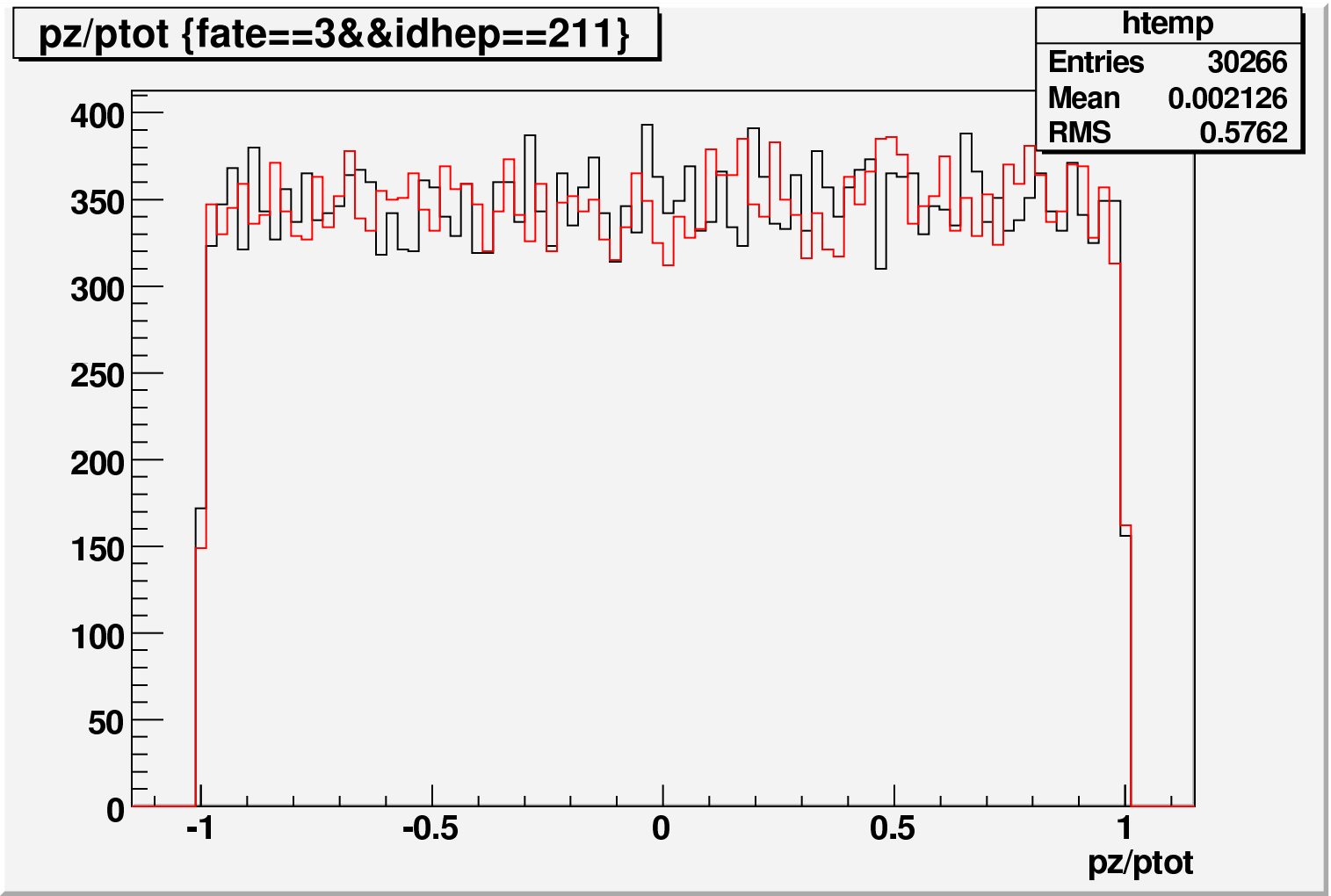


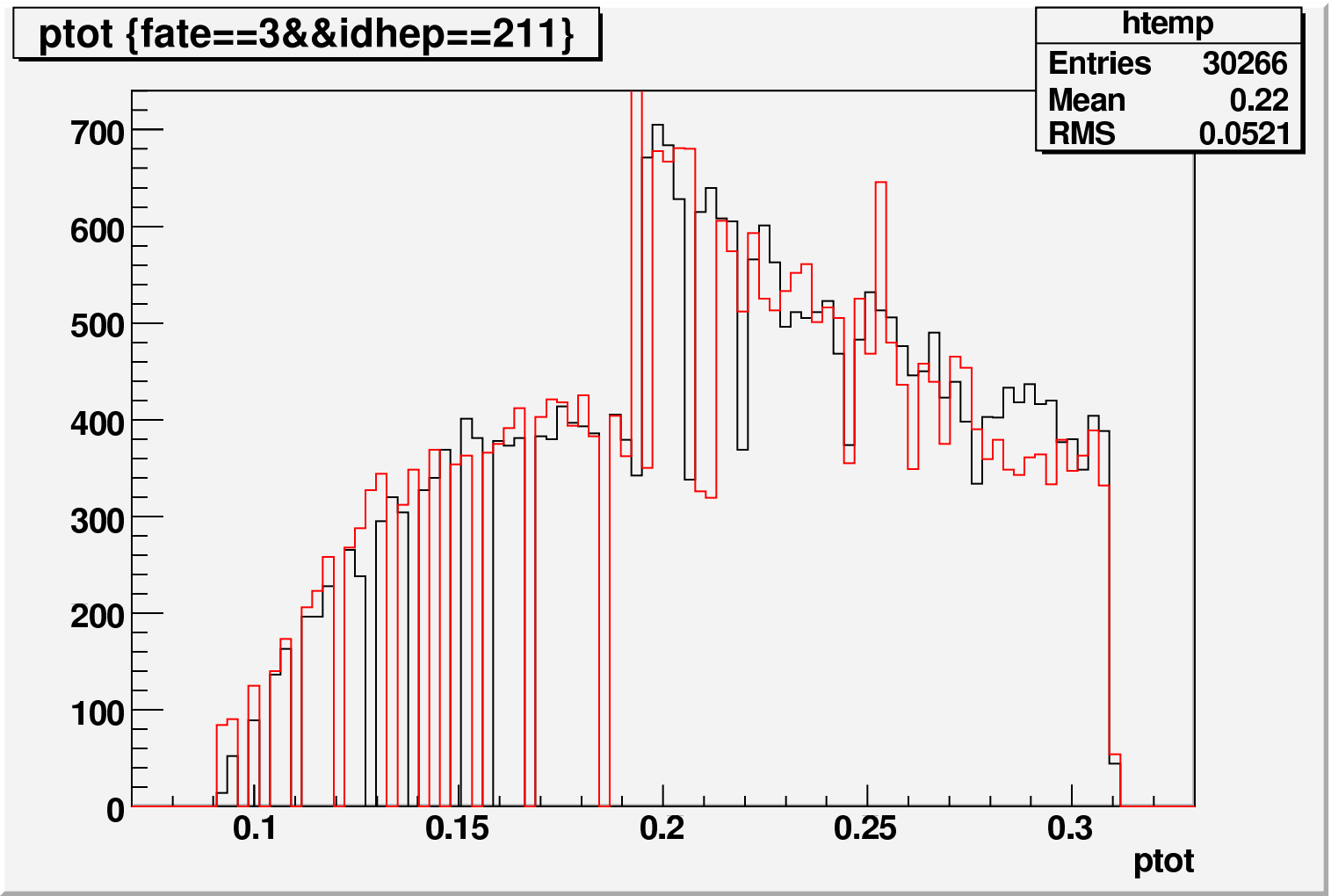

pipmult
htemp
Entries 200000
Mean 0.7065
RMS 0.4554
×10^3
140
130
120
110
100
90
80
70
60
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
pipmult

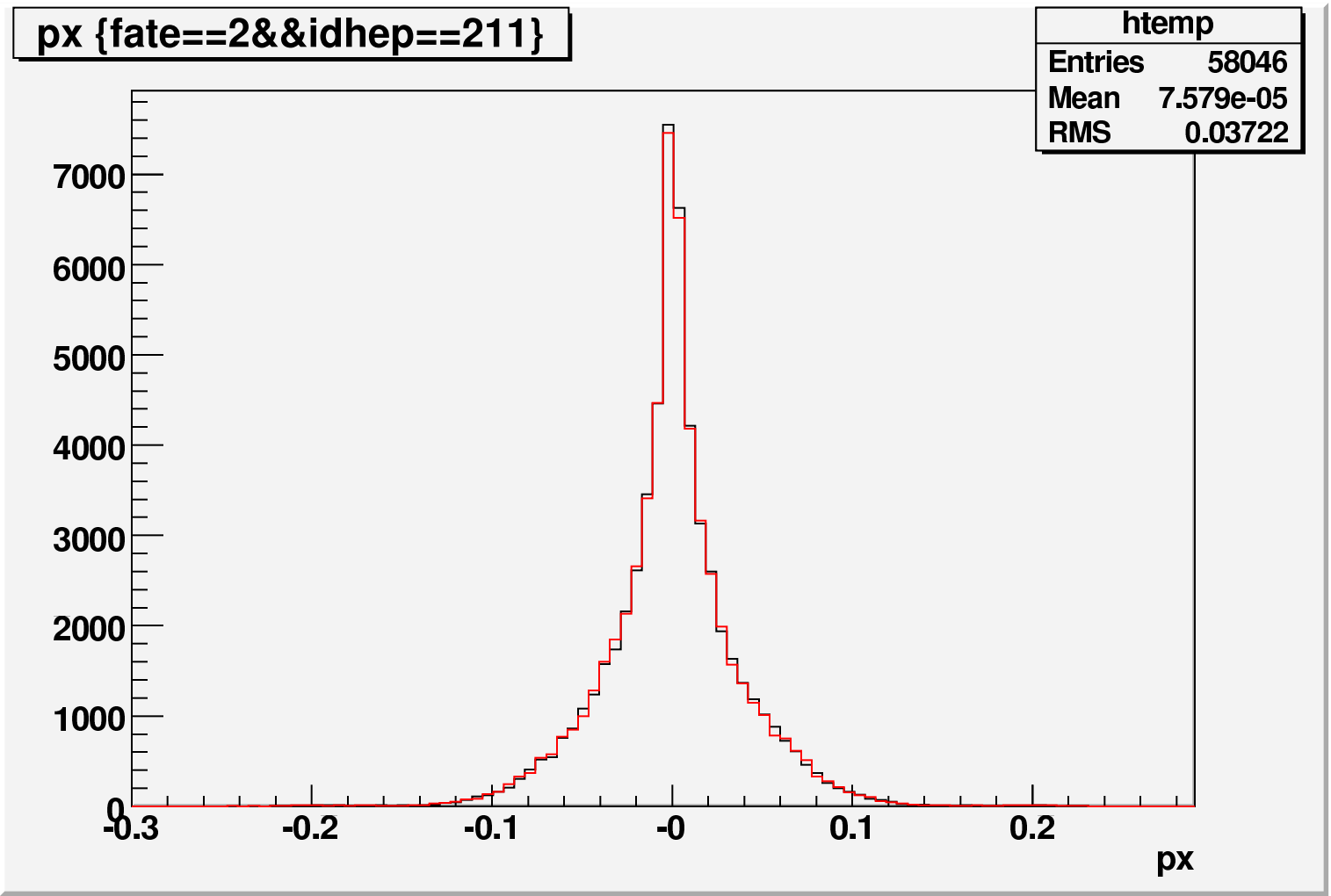

pz/ptot {nhad==4&&idhep==2212}
htemp
Entries 81006
Mean 0.1534
RMS 0.5601
2500
2000
1500
1000
500
0
-1
-0.5
0
0.5
1
pz/ptot

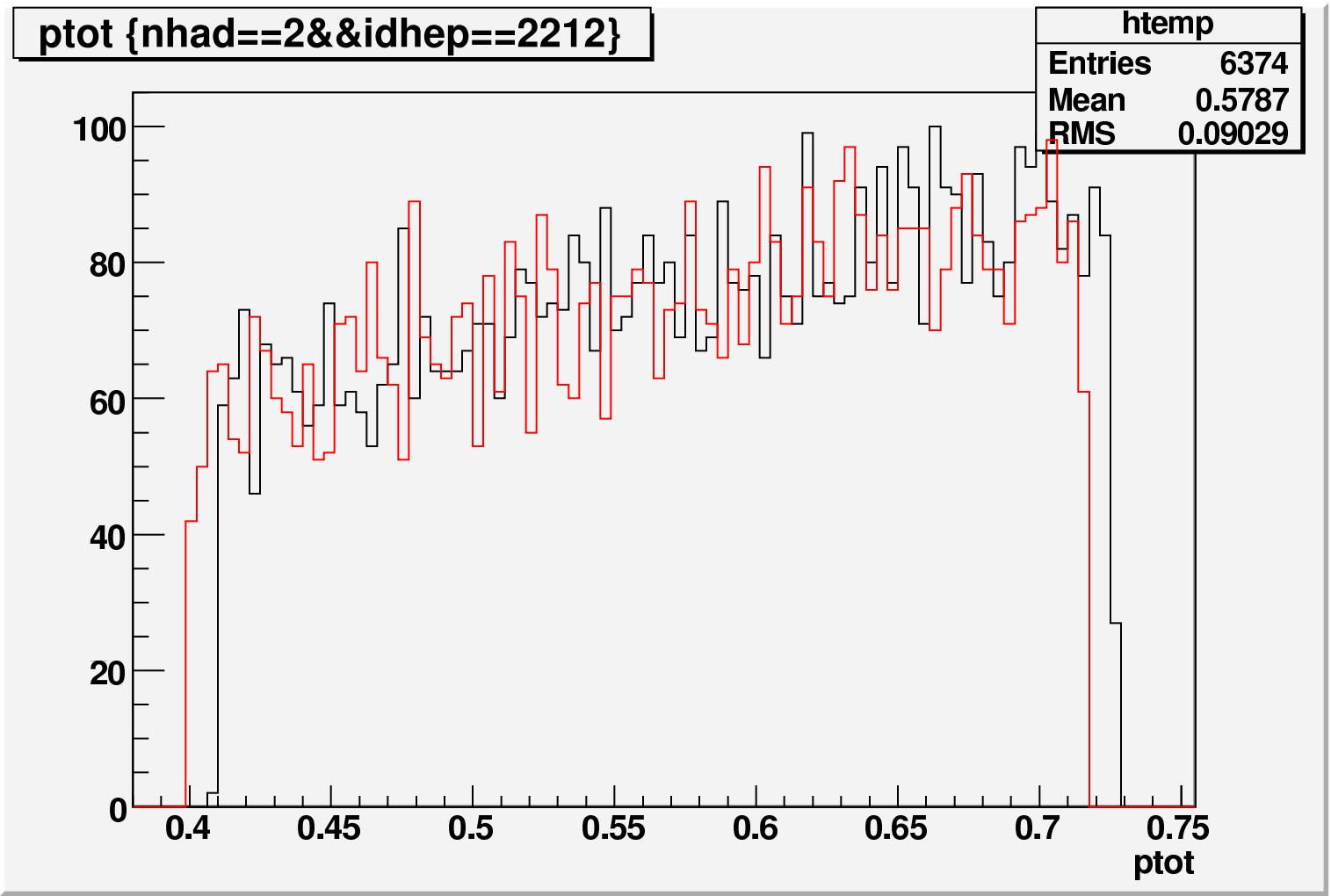

pz/ptot {fate==5&&idhep==2212}
htemp
Entries 93686
Mean 0.1583
RMS 0.5623
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-1
-0.5
0
0.5
1
pz/ptot

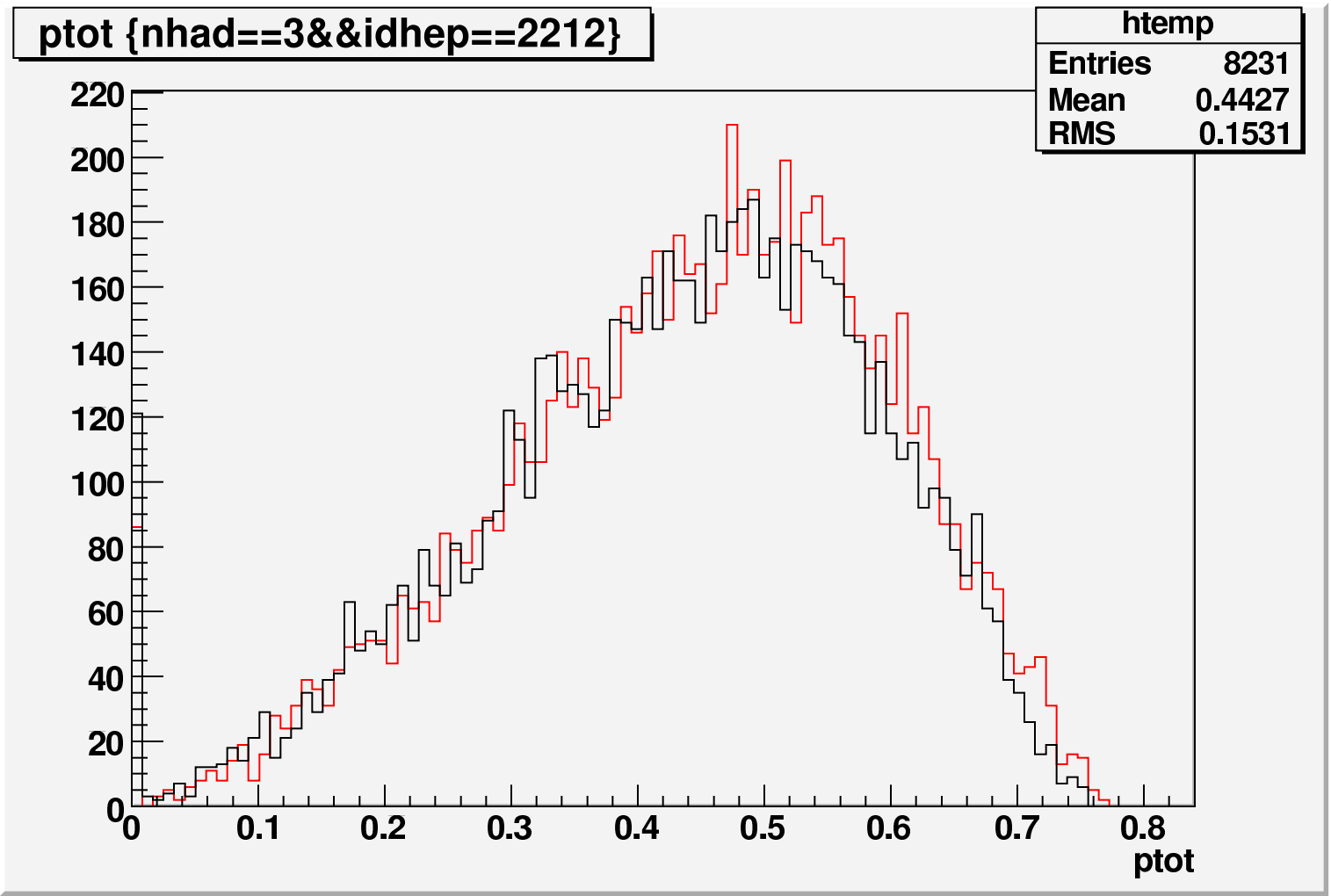

pz/ptot {fate==2&&idhep==211}
htemp
Entries 58046
Mean 0.985
RMS 0.02795
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
0.6
0.7
0.8
0.9
1
pz/ptot

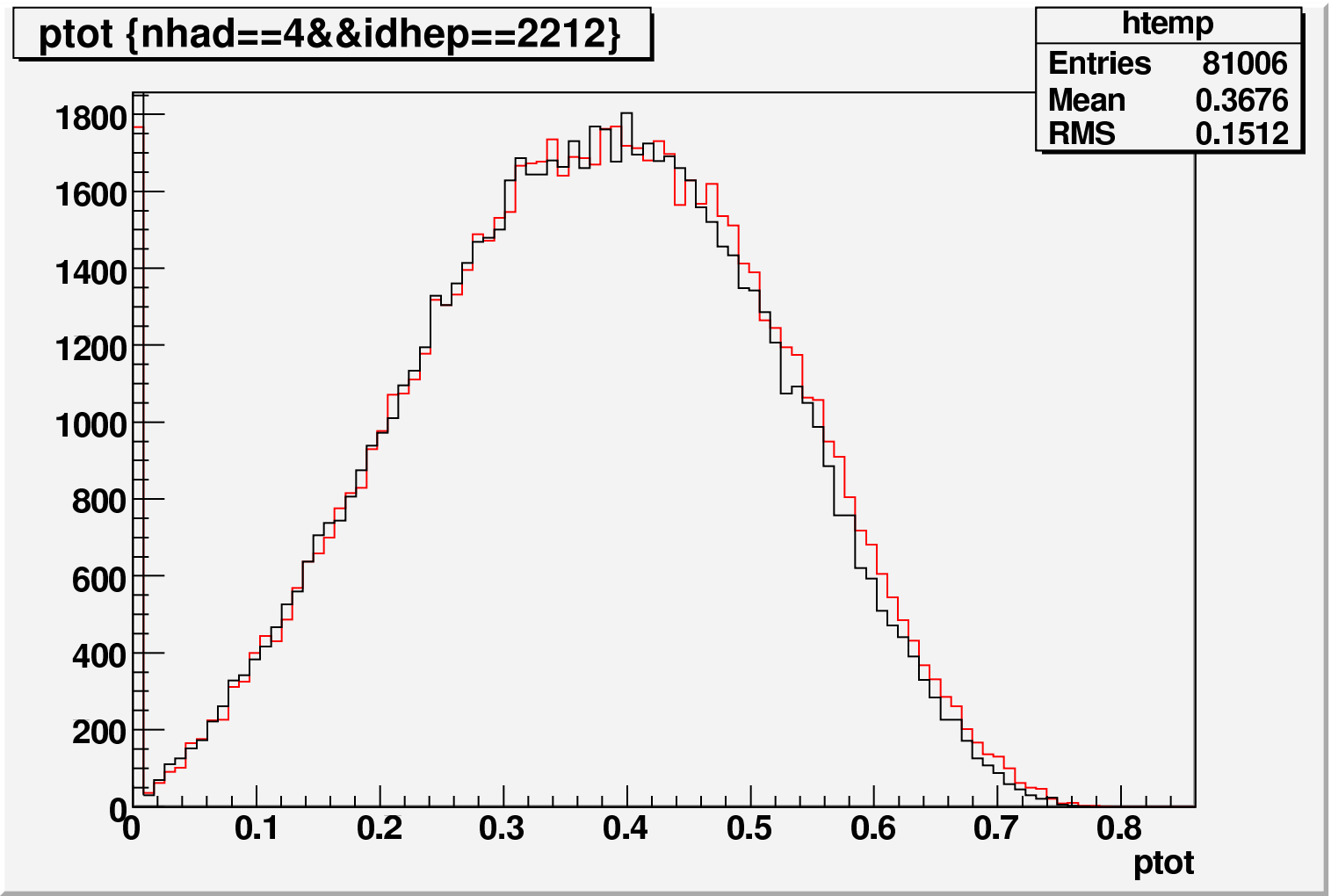

pz/ptot {fate==3&&idhep==211}
htemp
Entries 30266
Mean 0.002126
RMS 0.5762
400
350
300
250
200
150
100
50
0
-1
-0.5
0
0.5
1
pz/ptot


ptot {fate==3&&idhep==211}
htemp
Entries 30266
Mean 0.22
RMS 0.0521
700
600
500
400
300
200
100
0
0.1
0.15
0.2
0.25
0.3
ptot

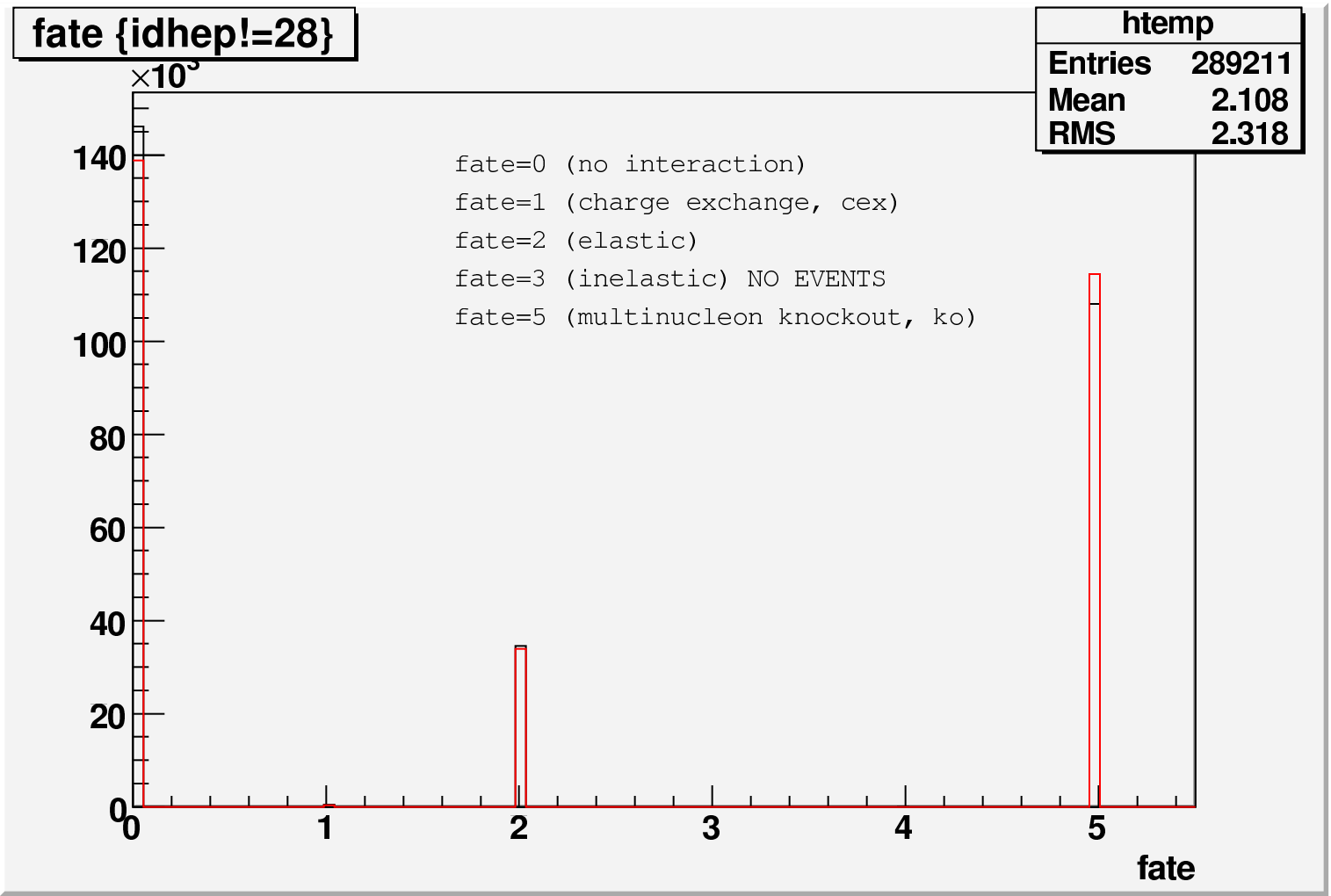

px {fate==2&&idhep==211}
htemp
Entries 58046
Mean 7.579e-05
RMS 0.03722
7000
6000
5000
4000
3000
2000
1000
0
-0.3
-0.2
-0.1
-0
0.1
0.2
px

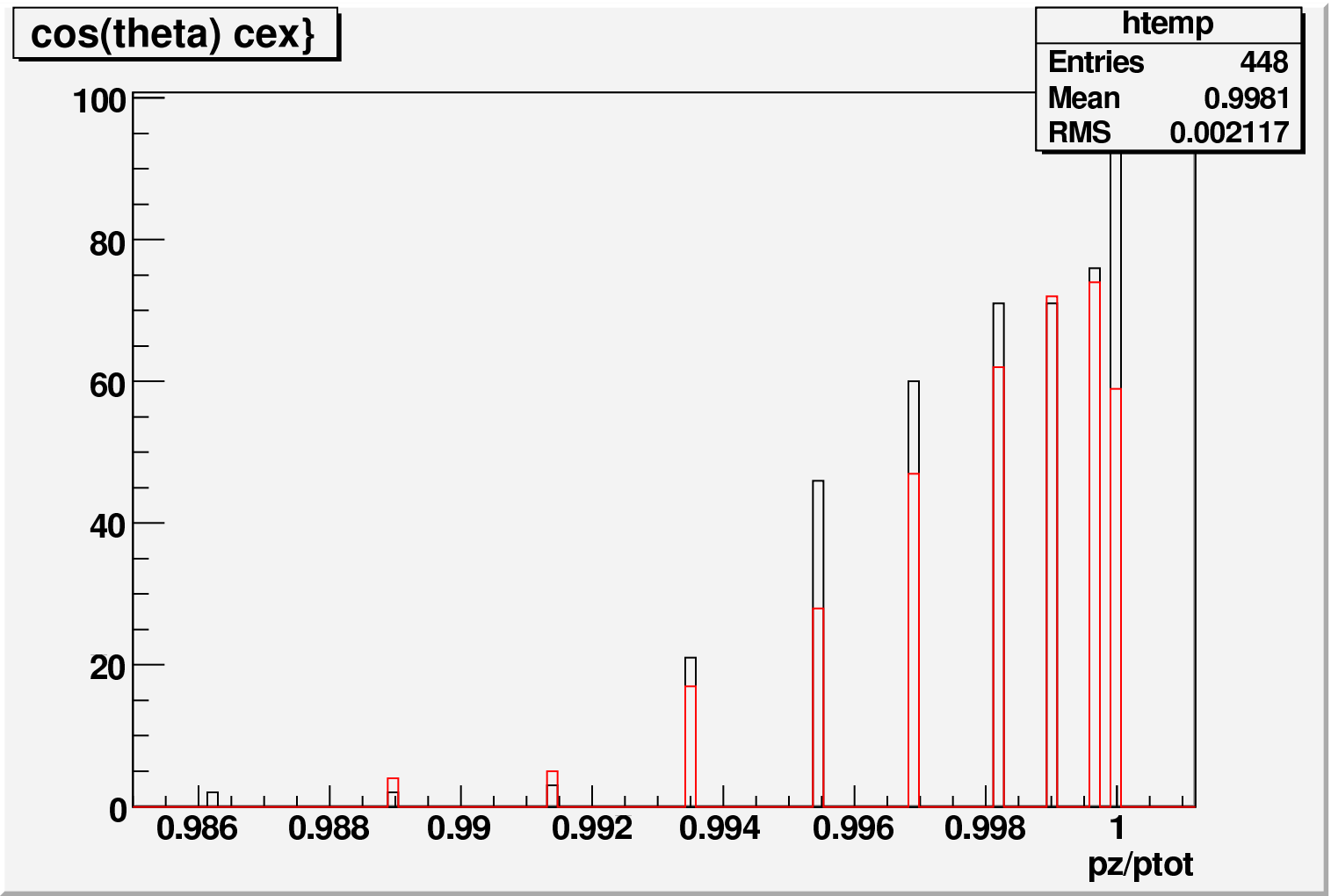

ptot {nhad==2&&idhep==2212}
htemp
Entries 6374
Mean 0.5787
RMS 0.09029
100
80
60
40
20
0
0.4
0.45
0.5
0.55
0.6
0.65
0.7
0.75
ptot

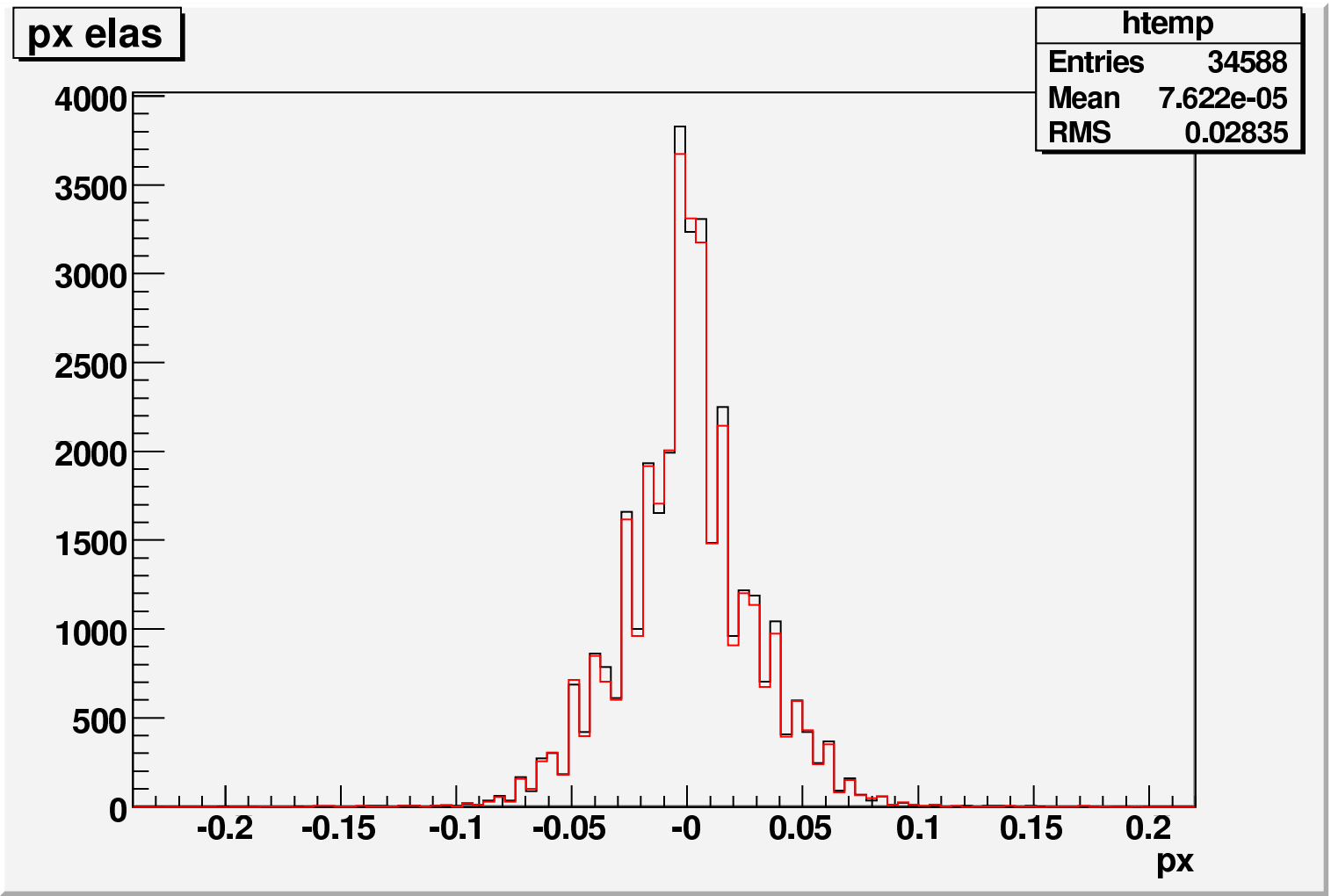

ptot {nhad==3&&idhep==2212}
htemp
Entries 8231
Mean 0.4427
RMS 0.1531
220
200
180
160
140
120
100
80
60
40
20
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
ptot

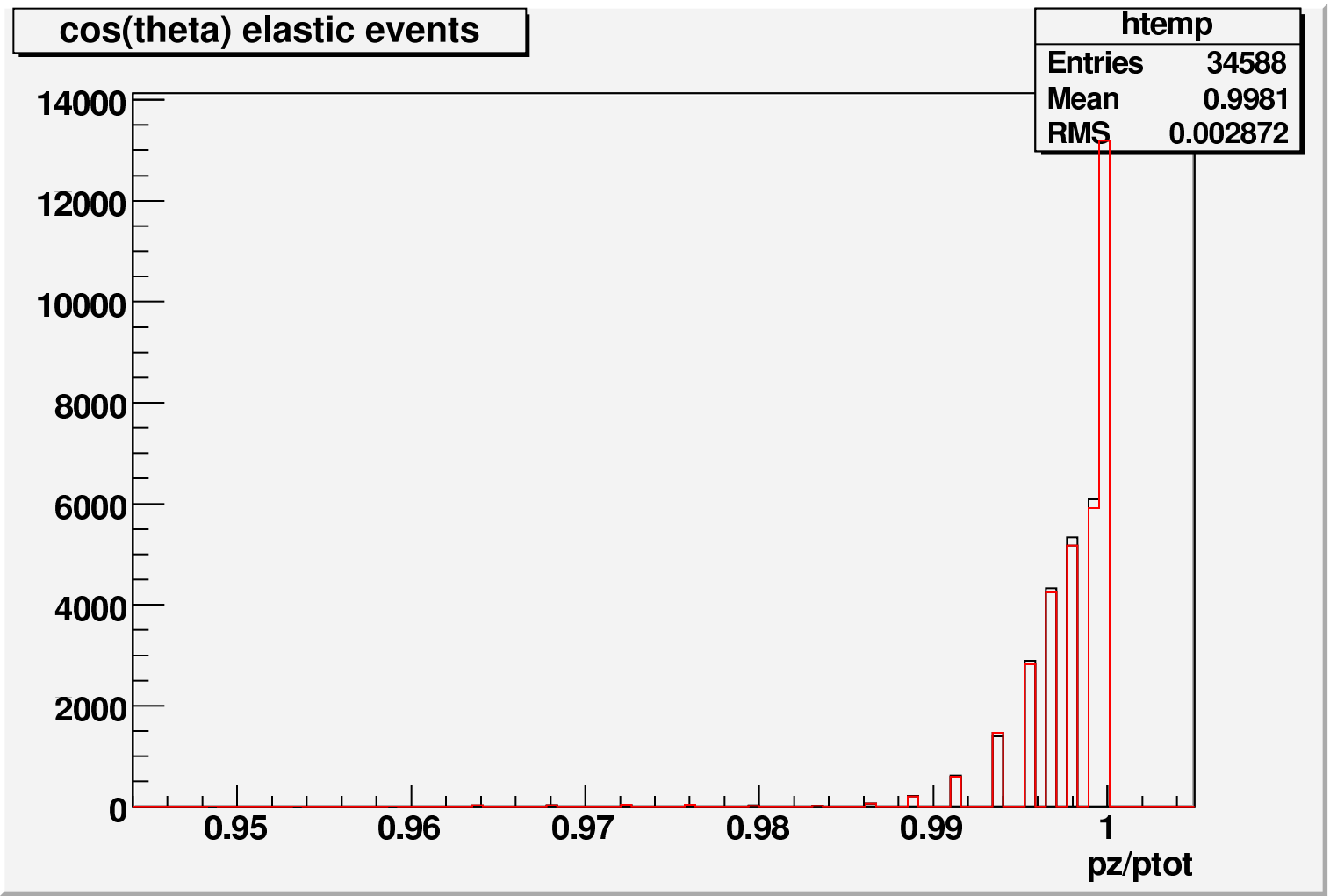

ptot {nhad==4&&idhep==2212}
htemp
Entries 81006
Mean 0.3676
RMS 0.1512
1800
1600
1400
1200
1000
800
600
400
200
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
ptot

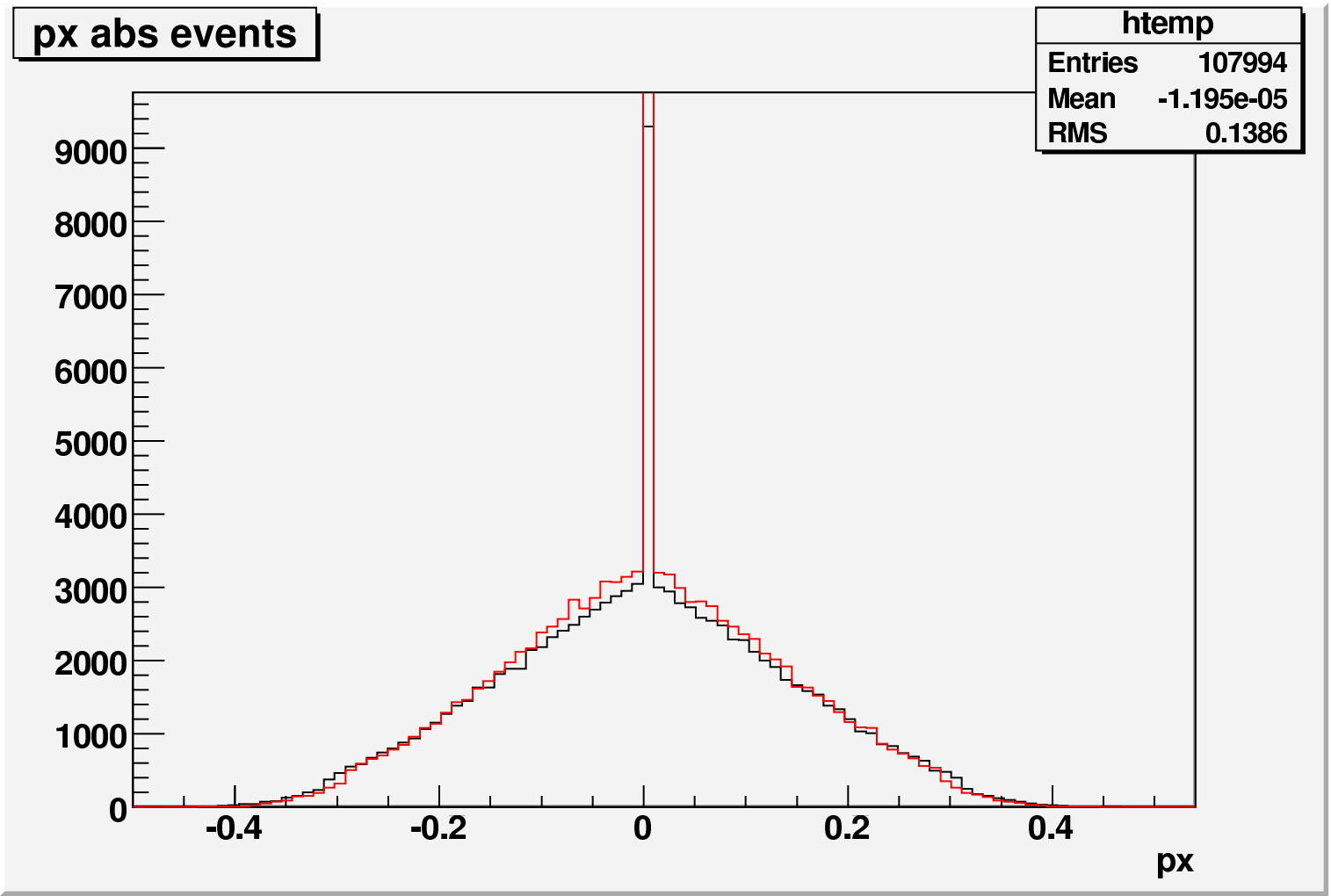
Neugen-Genie comparison specific to Intranuke
200,000 events - 200 MeV proton+iron
August, 2007

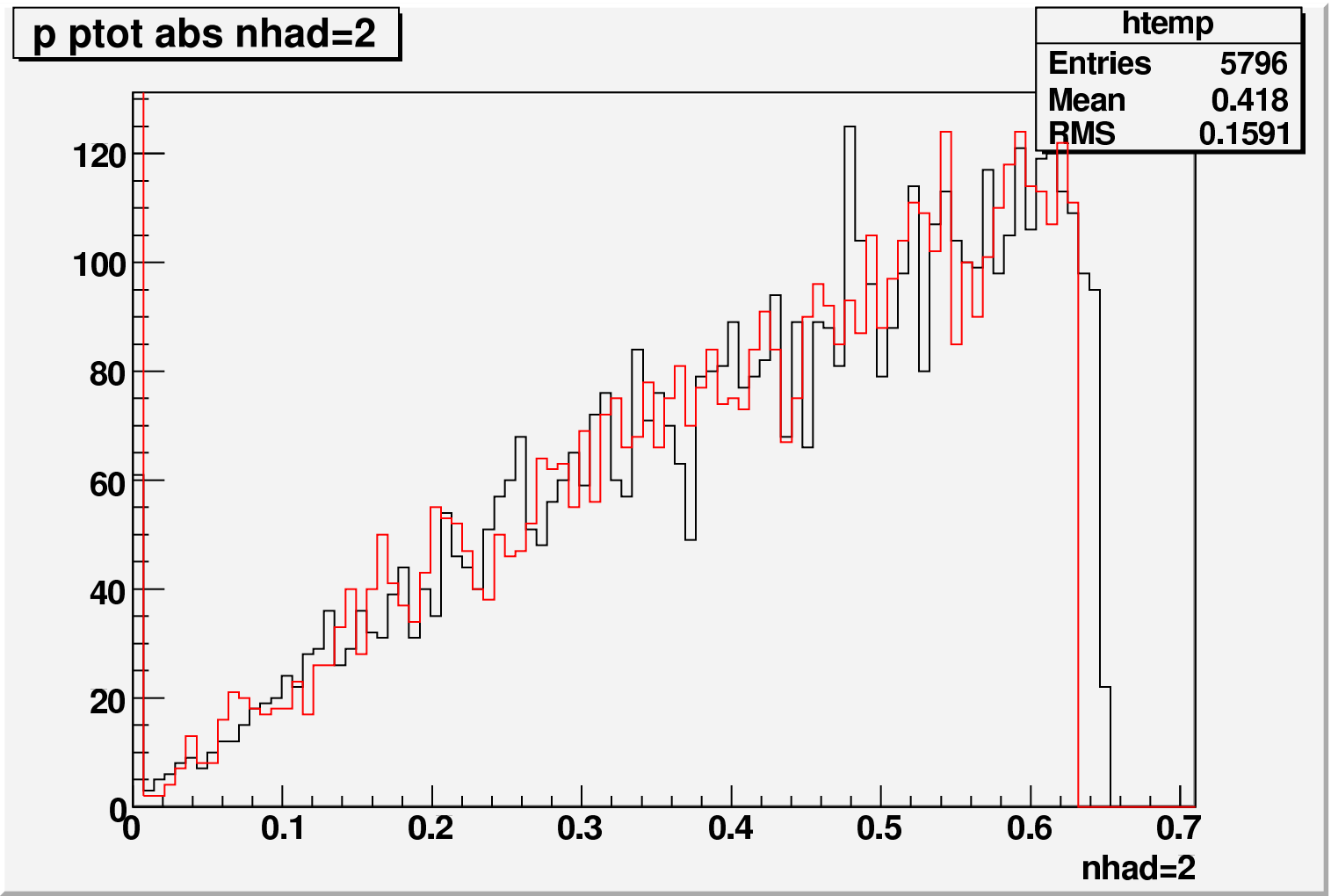


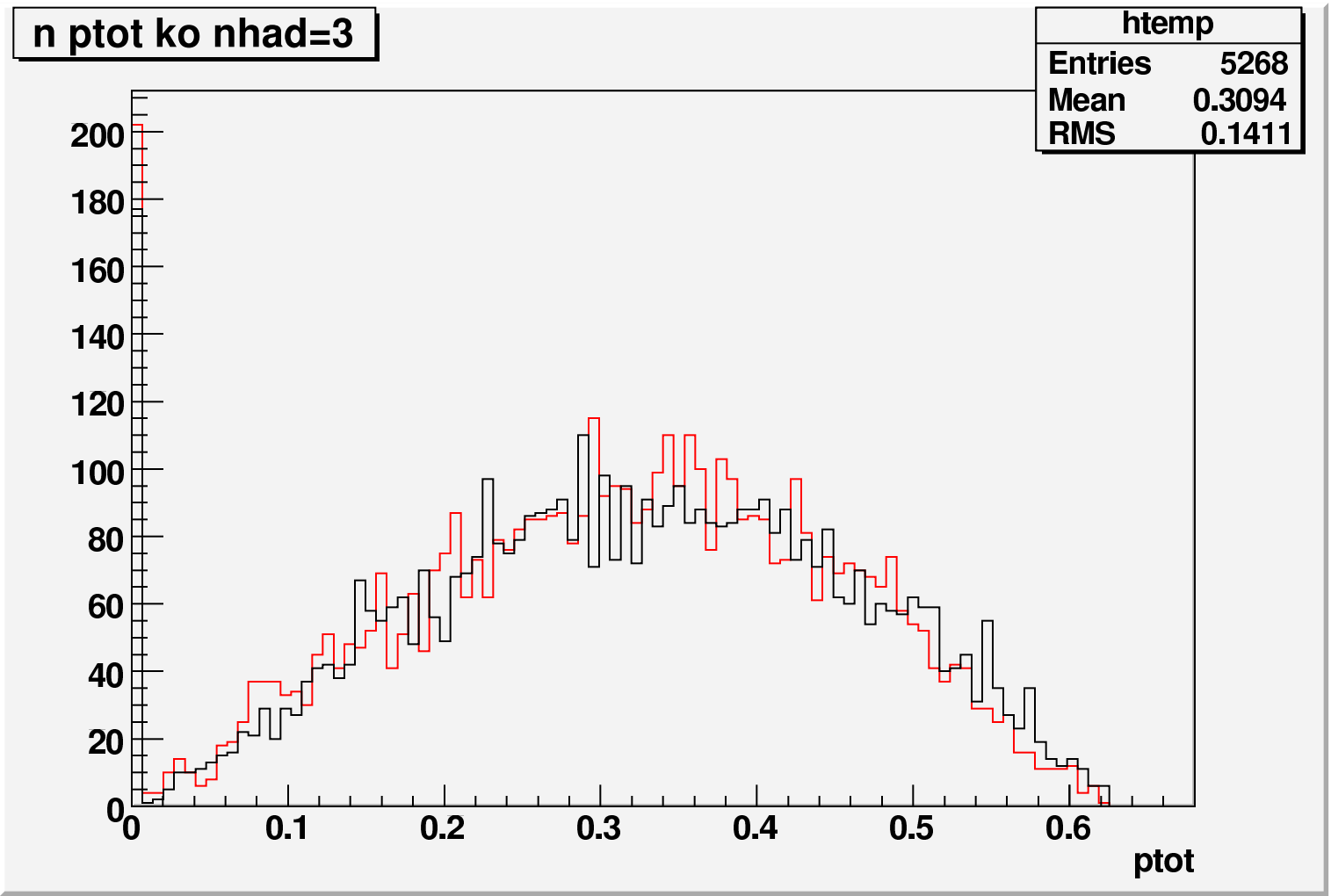

cos(theta) cex}
htemp
Entries 448
Mean 0.9981
RMS 0.002117
100
80
60
40
20
0
0.986
0.988
0.99
0.992
0.994
0.996
0.998
1
pz/ptot

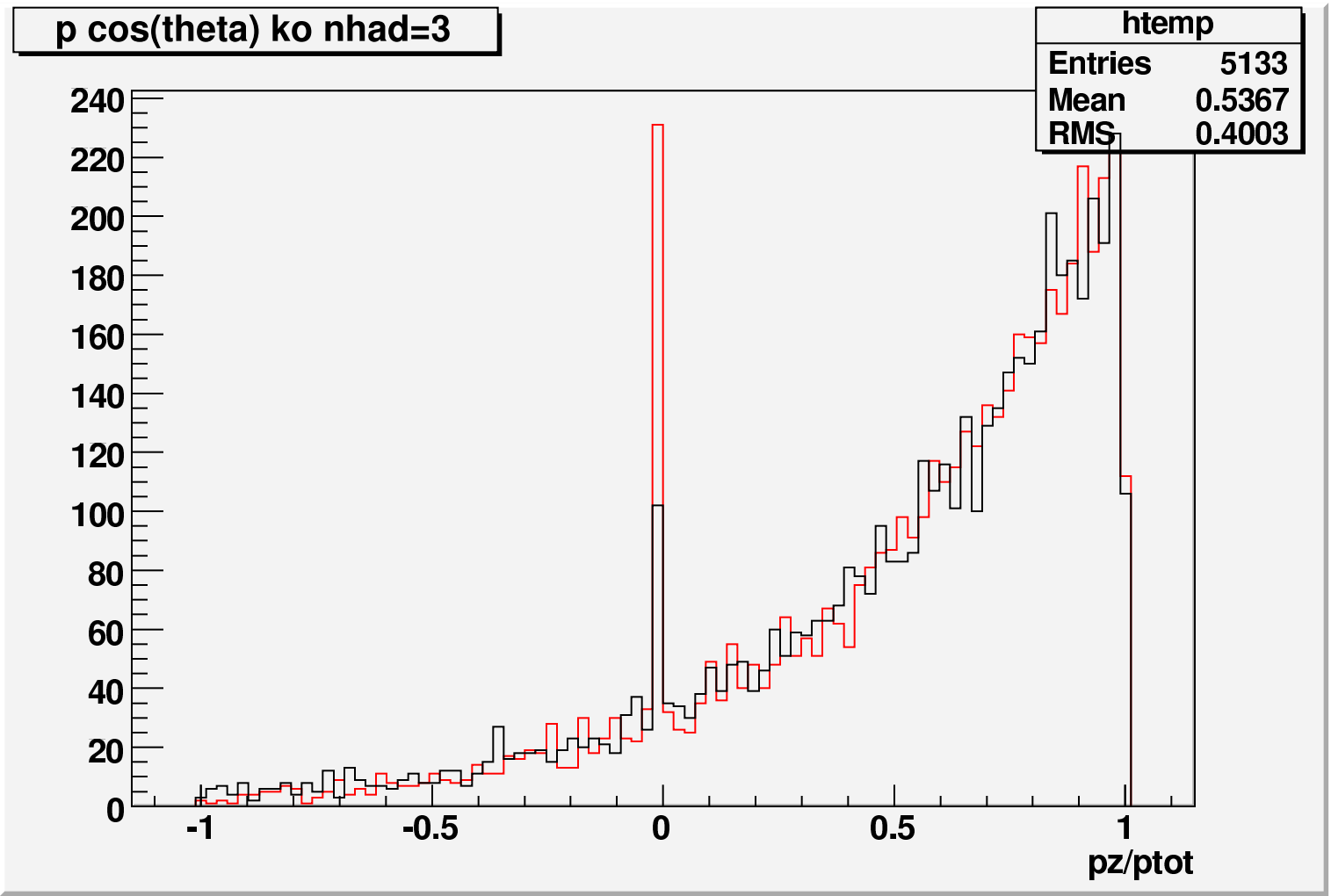

px elas
htemp
Entries 34588
Mean 7.622e-05
RMS 0.02835
4000
3500
3000
2500
2000
1500
1000
500
0
-0.2
-0.15
-0.1
-0.05
-0
0.05
0.1
0.15
0.2
px

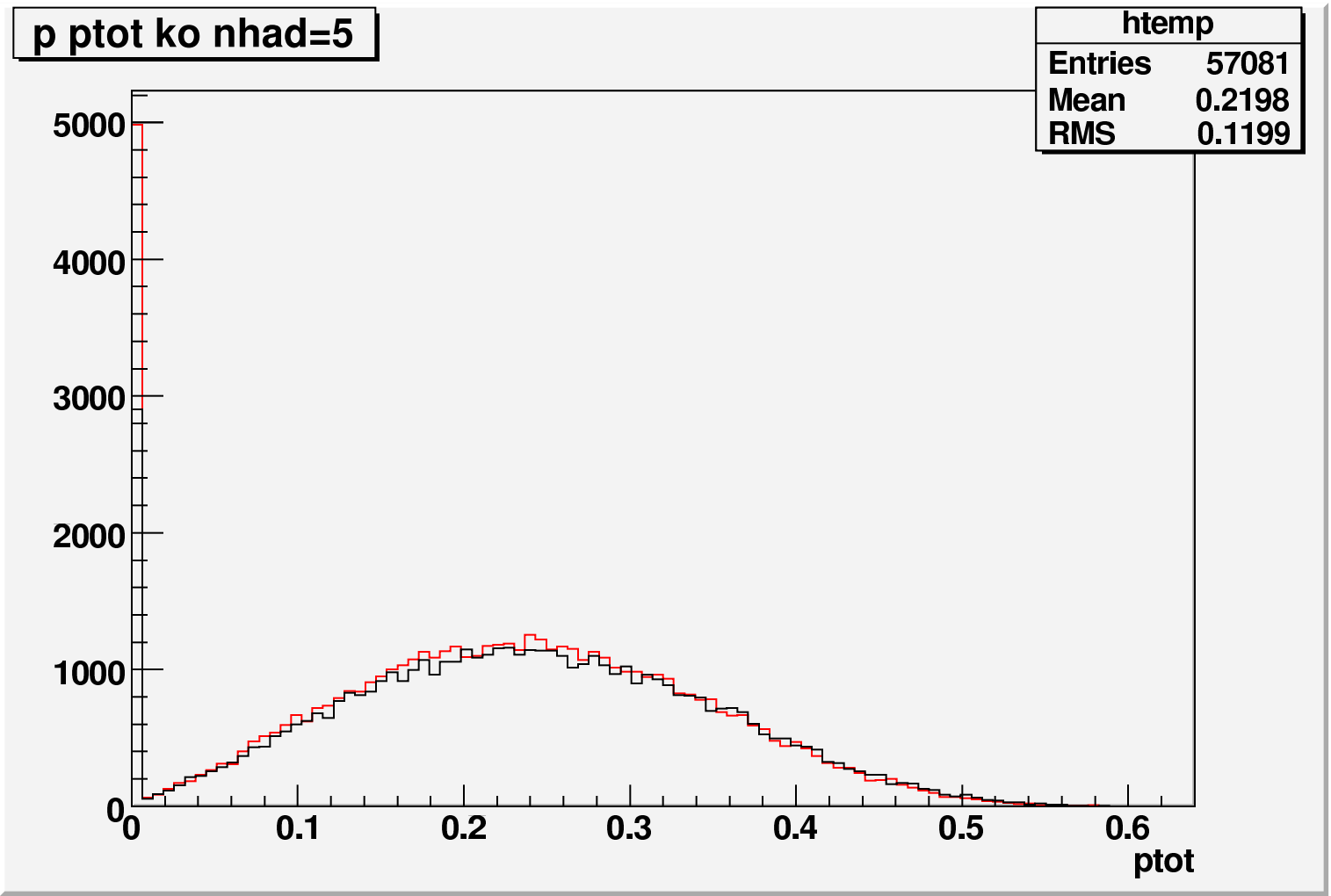

cos(theta) elastic events
htemp
Entries 34588
Mean 0.9981
RMS 0.002872
14000
12000
10000
8000
6000
4000
2000
0
0.95
0.96
0.97
0.98
0.99
1
pz/ptot

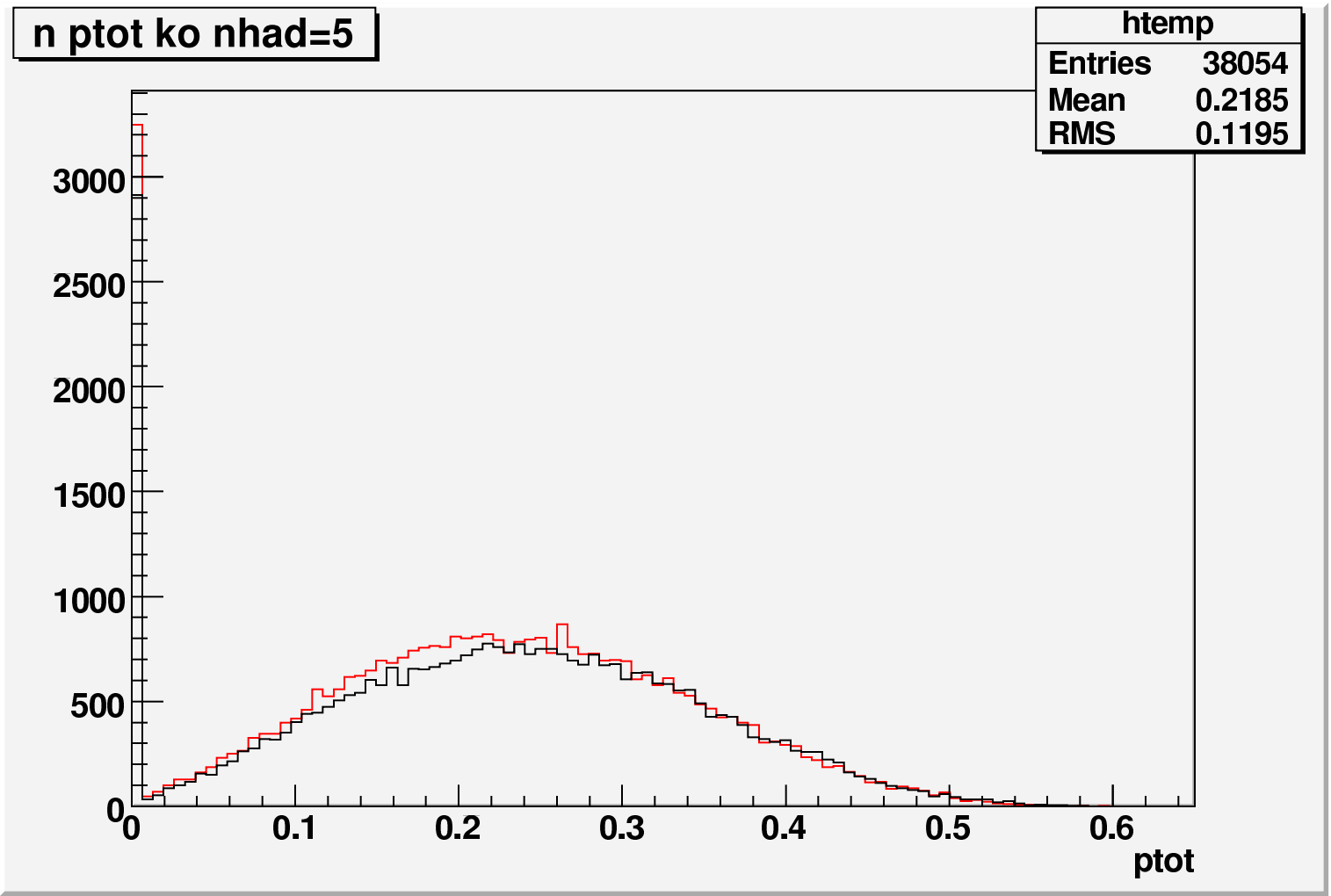

px abs events
htemp
Entries 107994
Mean -1.195e-05
RMS 0.1386
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-0.4
-0.2
0
0.2
0.4
px


p ptot abs nhad=2
htemp
Entries 5796
Mean 0.418
RMS 0.1591
120
100
80
60
40
20
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
nhad=2

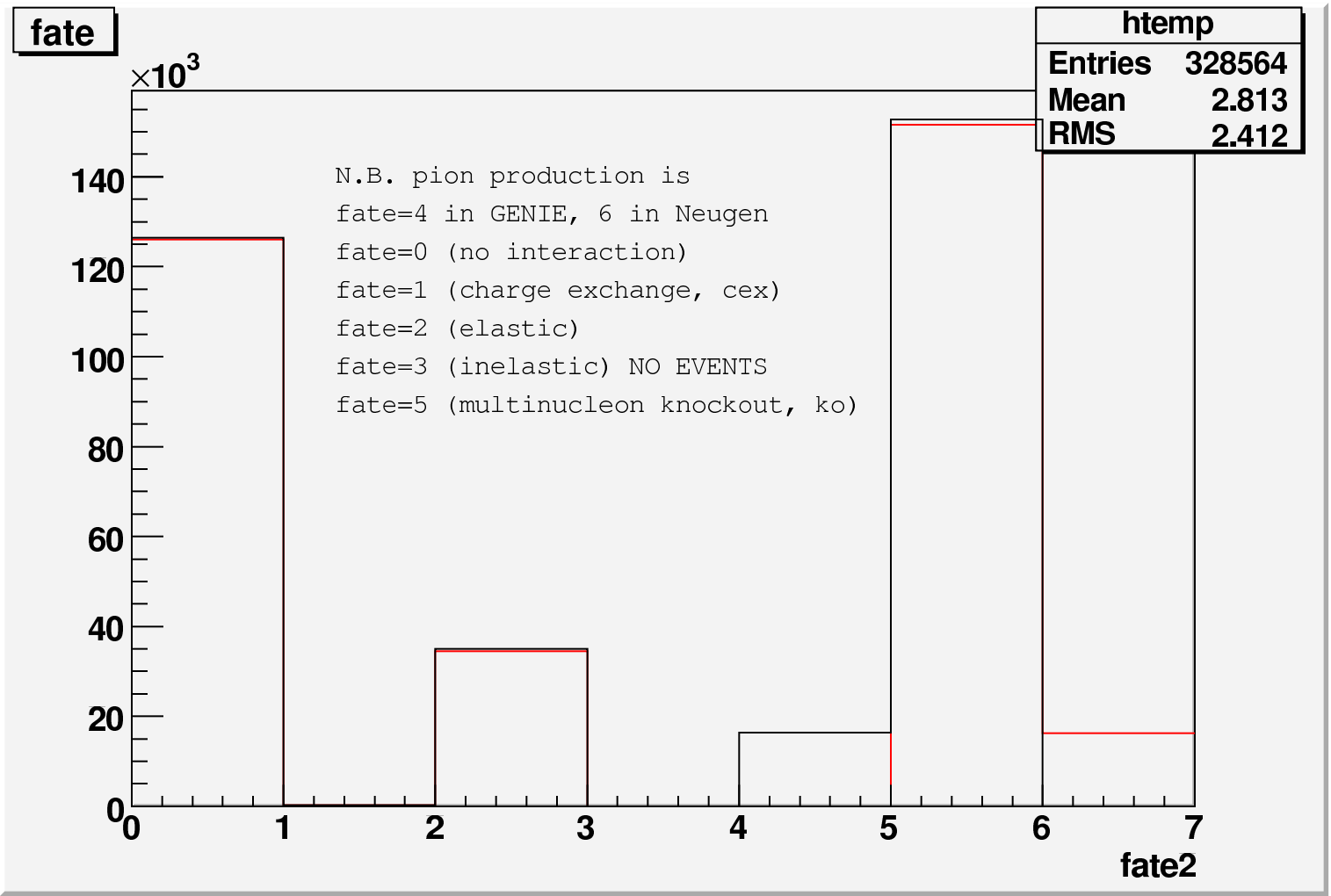

n ptot ko nhad=3
htemp
Entries 5268
Mean 0.3094
RMS 0.1411
200
180
160
140
120
100
80
60
40
20
0
0
0.1
0.2
0.3
0.4
0.5
0.6
ptot

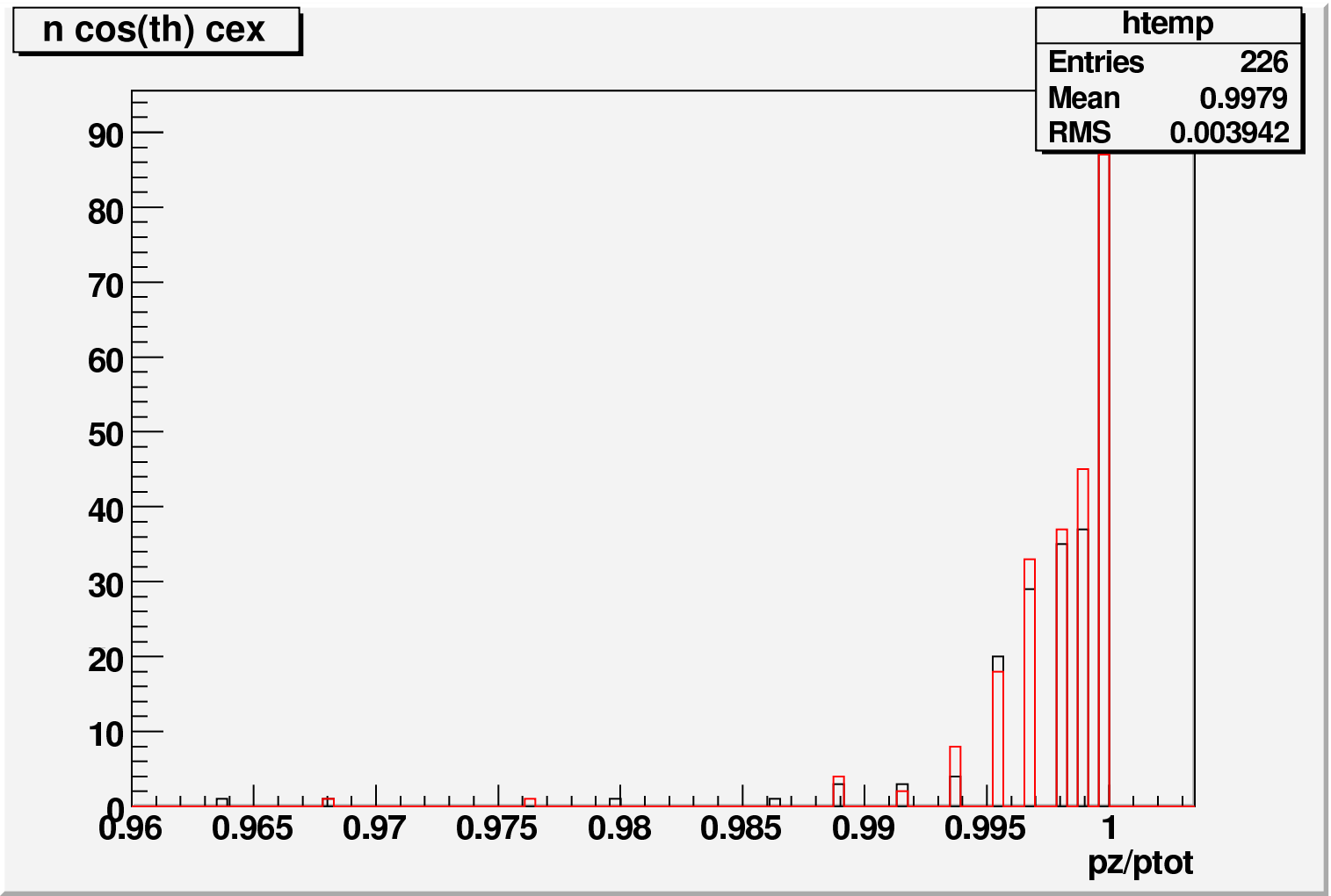

p cos(theta) ko nhad=3
htemp
Entries 5133
Mean 0.5367
RMS 0.4003
240
220
200
180
160
140
120
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pz/ptot

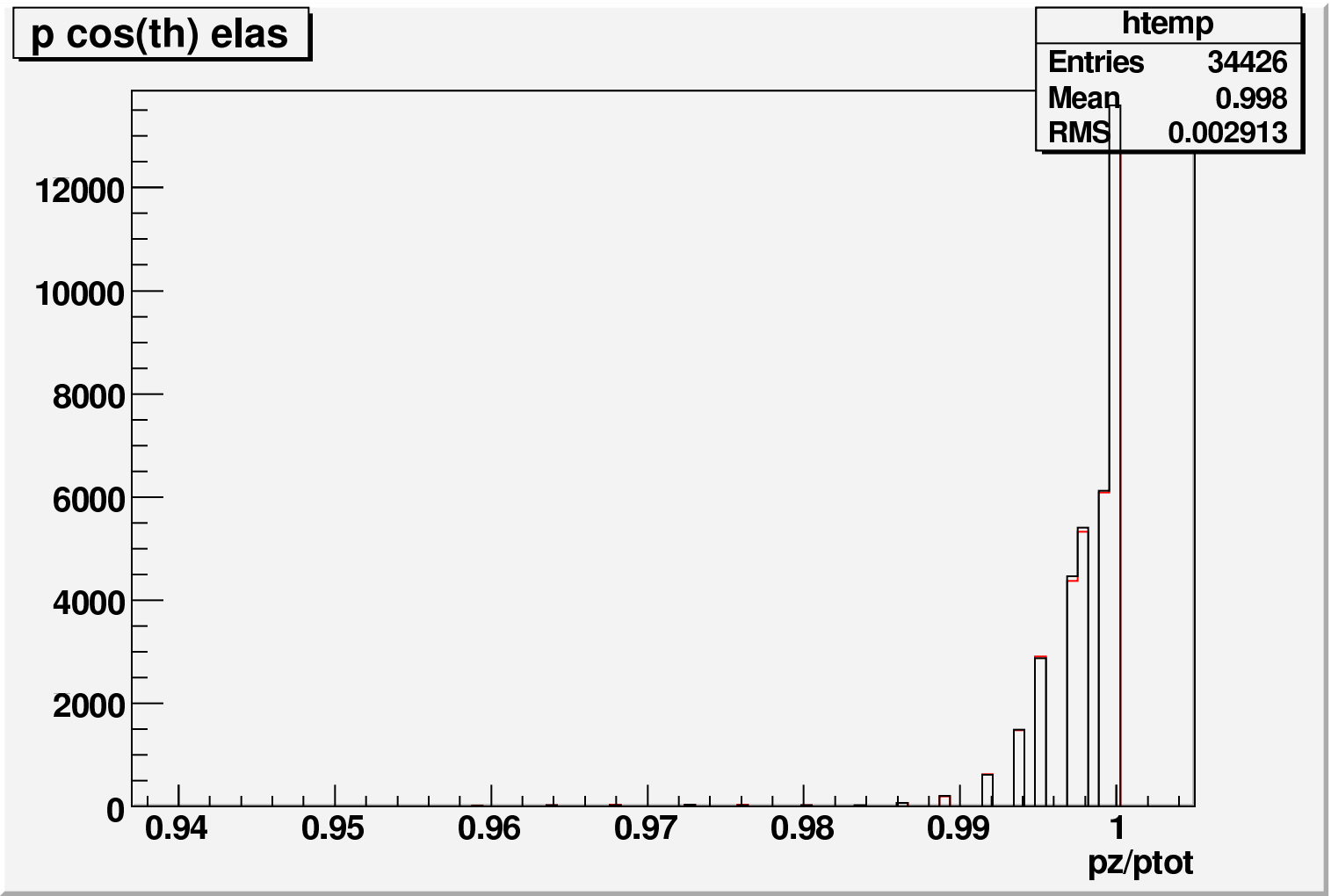

p ptot ko nhad=5
htemp
Entries 57081
Mean 0.2198
RMS 0.1199
5000
4000
3000
2000
1000
0
0
0.1
0.2
0.3
0.4
0.5
0.6
ptot

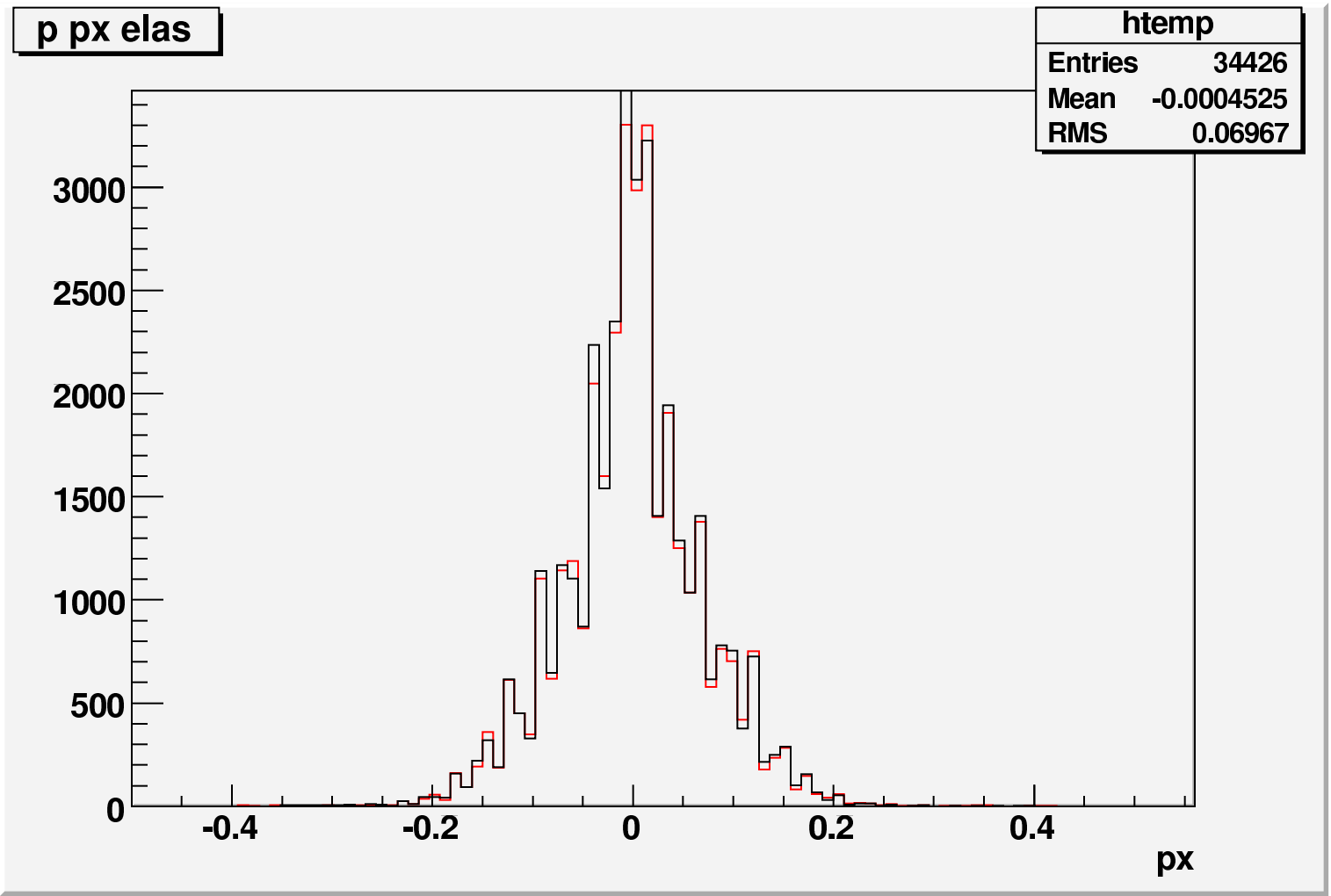

n ptot ko nhad=5
htemp
Entries 38054
Mean 0.2185
RMS 0.1195
3000
2500
2000
1500
1000
500
0
0
0.1
0.2
0.3
0.4
0.5
0.6
ptot

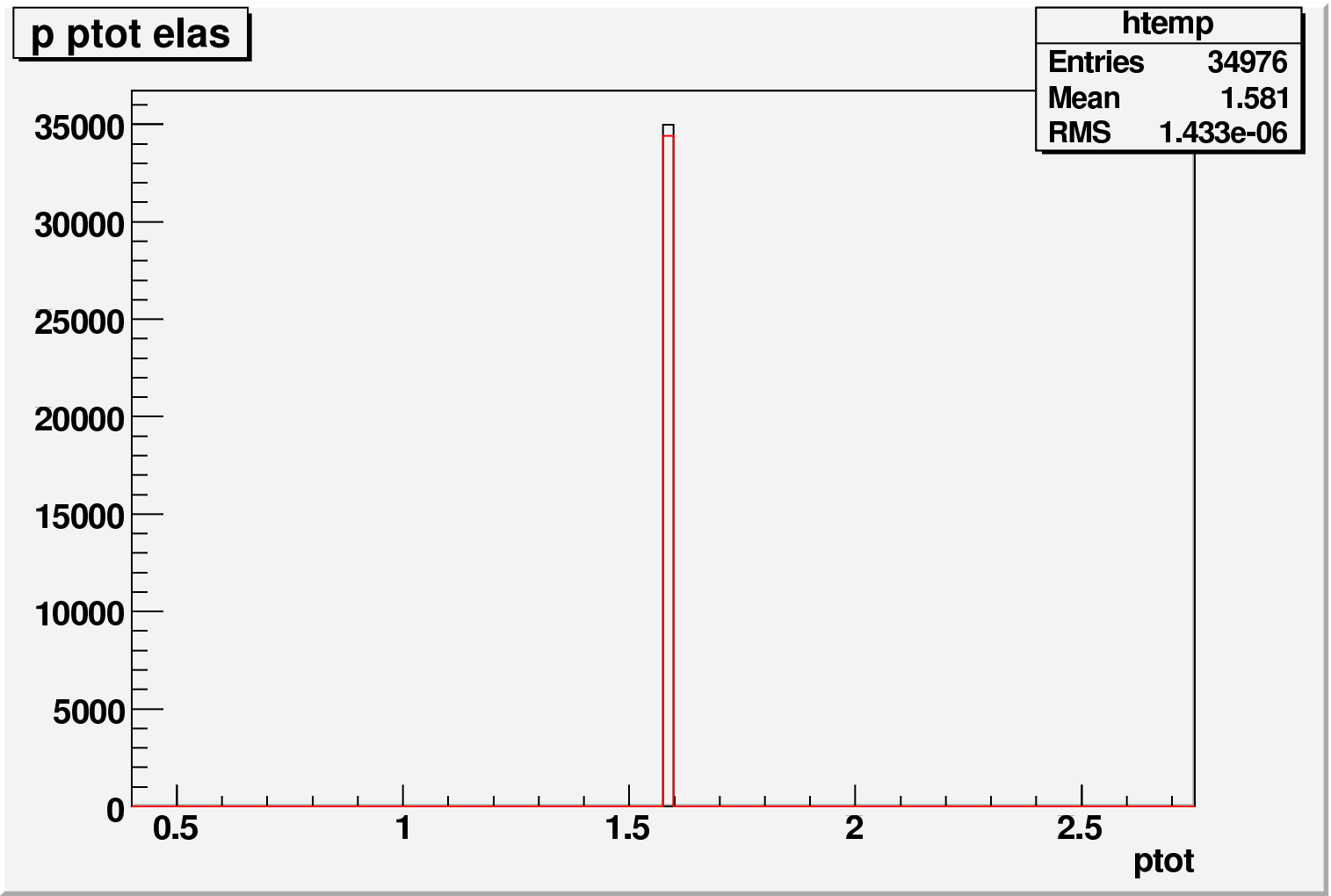
Neugen-Genie comparison specific to Intranuke
200,000 events - 900 MeV proton+iron
August, 2007

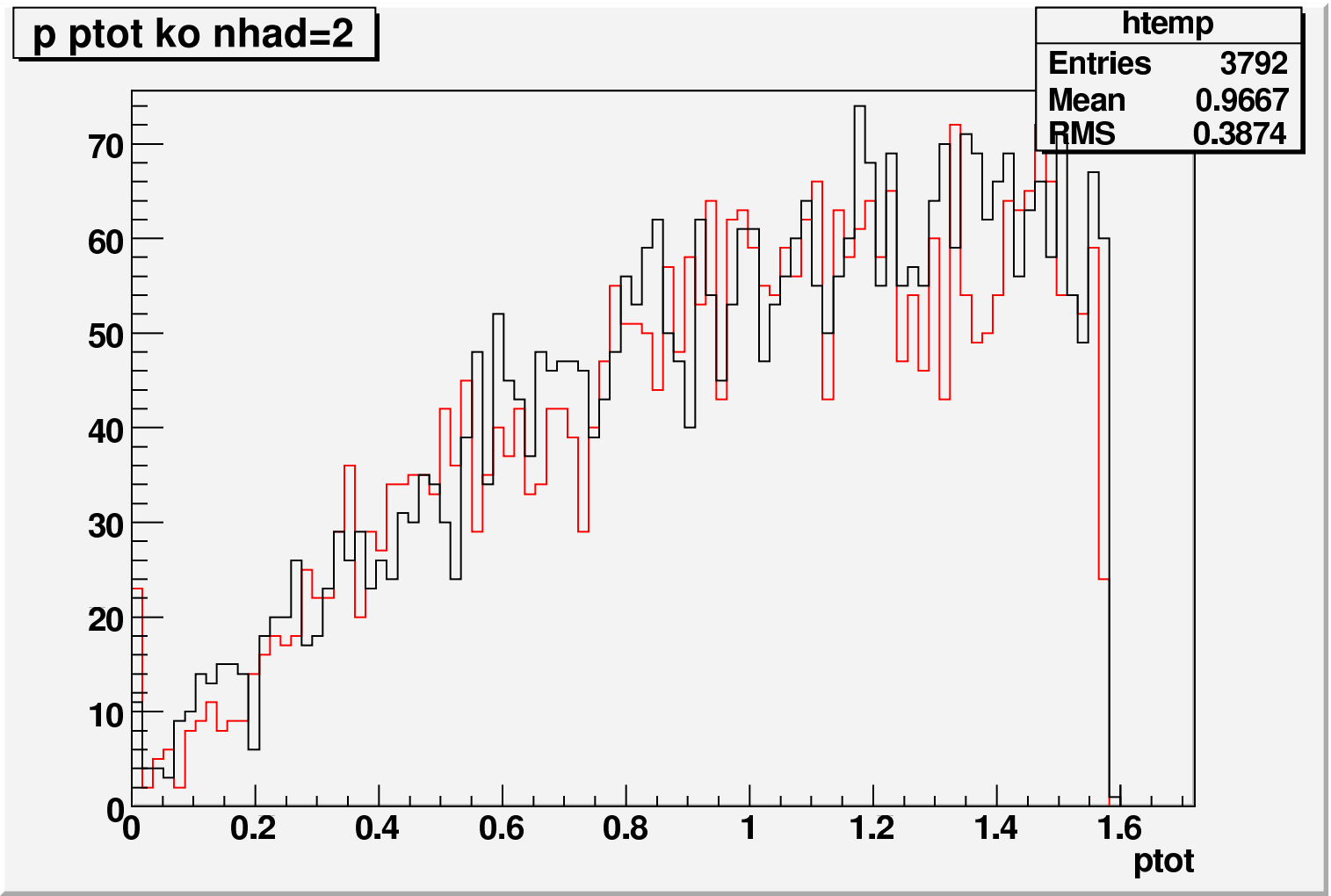


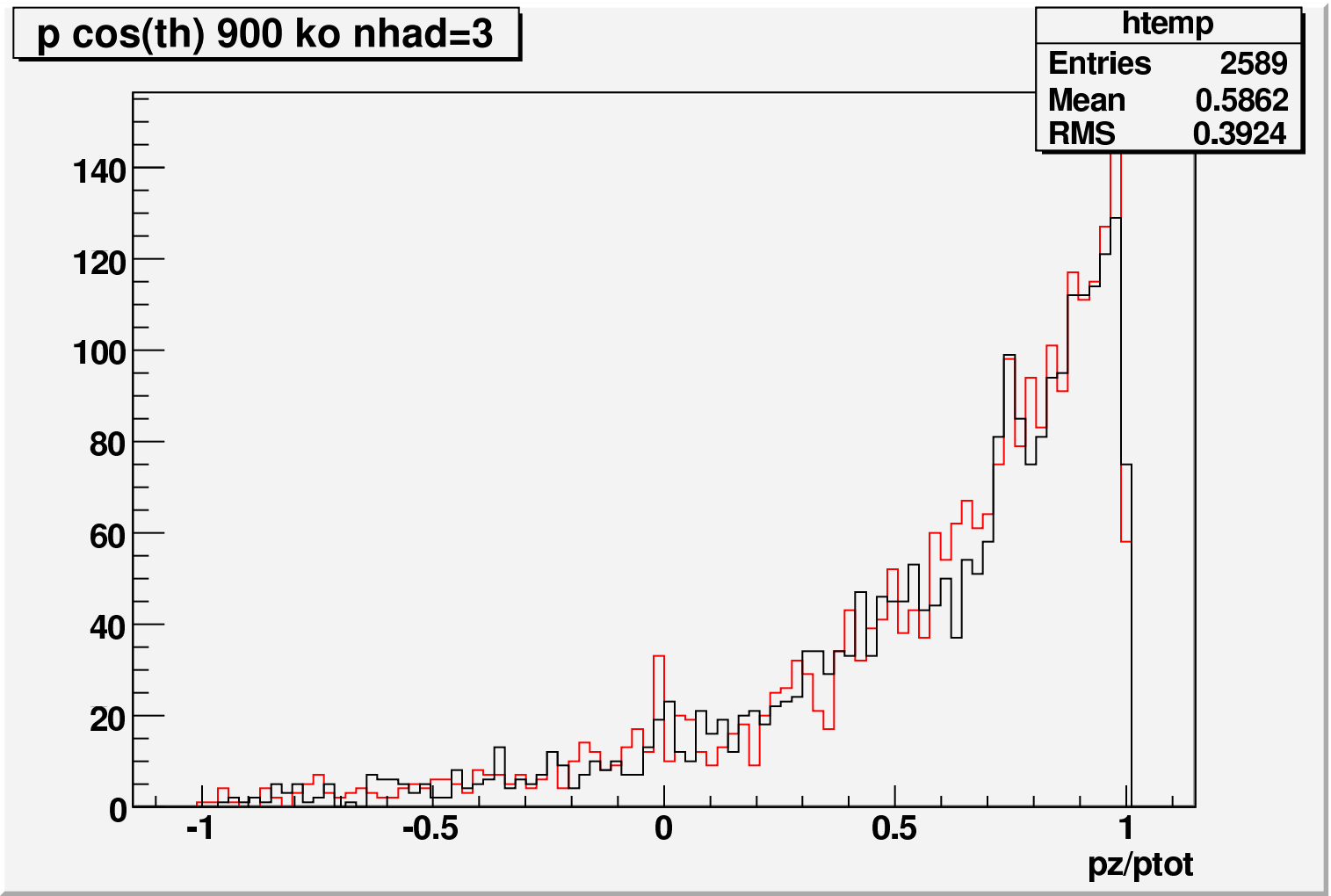

n cos(th) cex
htemp
Entries 226
Mean 0.9979
RMS 0.003942
90
80
70
60
50
40
30
20
10
0
0.96
0.965
0.97
0.975
0.98
0.985
0.99
0.995
1
pz/ptot

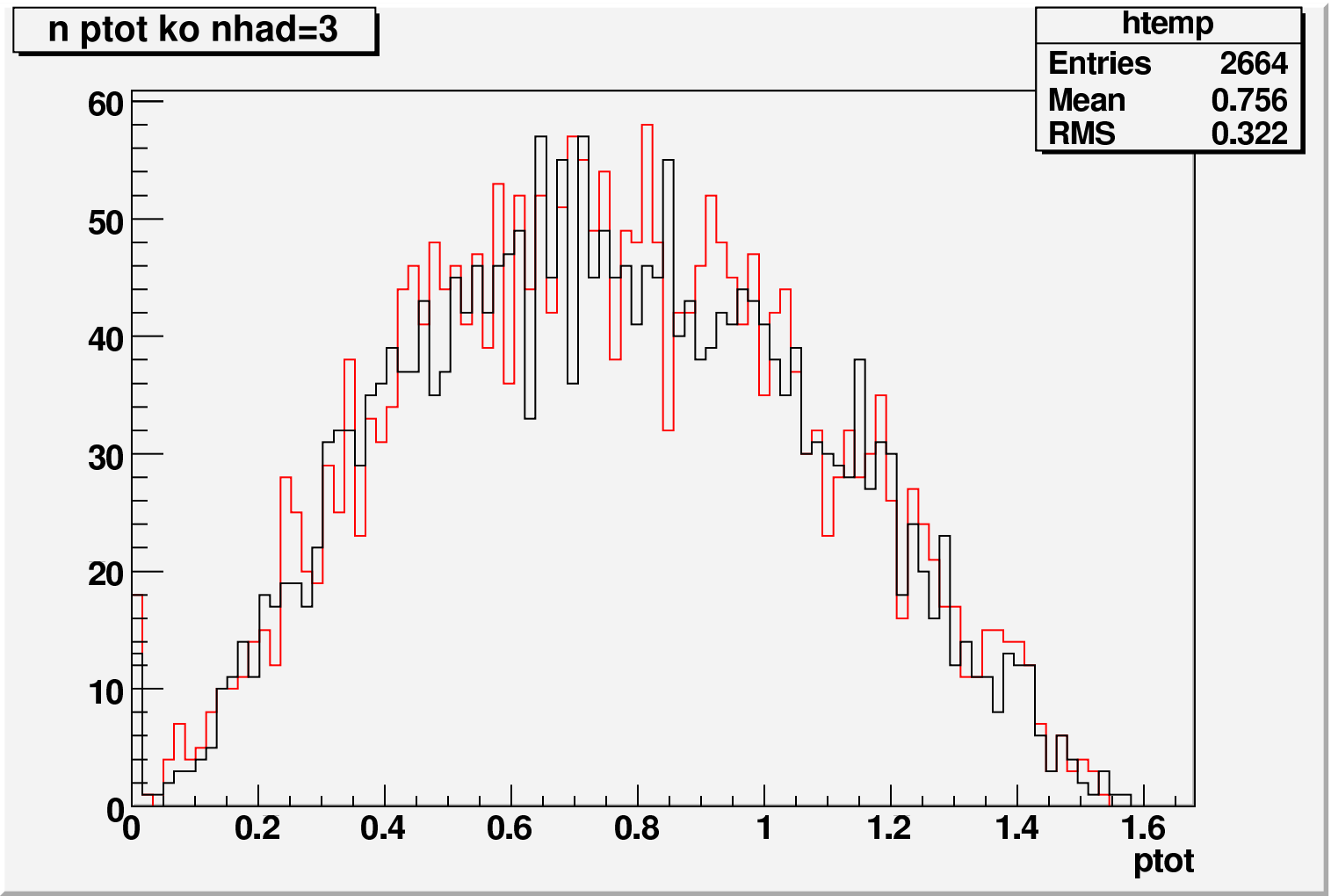

p cos(th) elas
htemp
Entries 34426
Mean 0.998
RMS 0.002913
12000
10000
8000
6000
4000
2000
0
0.94
0.95
0.96
0.97
0.98
0.99
1
pz/ptot

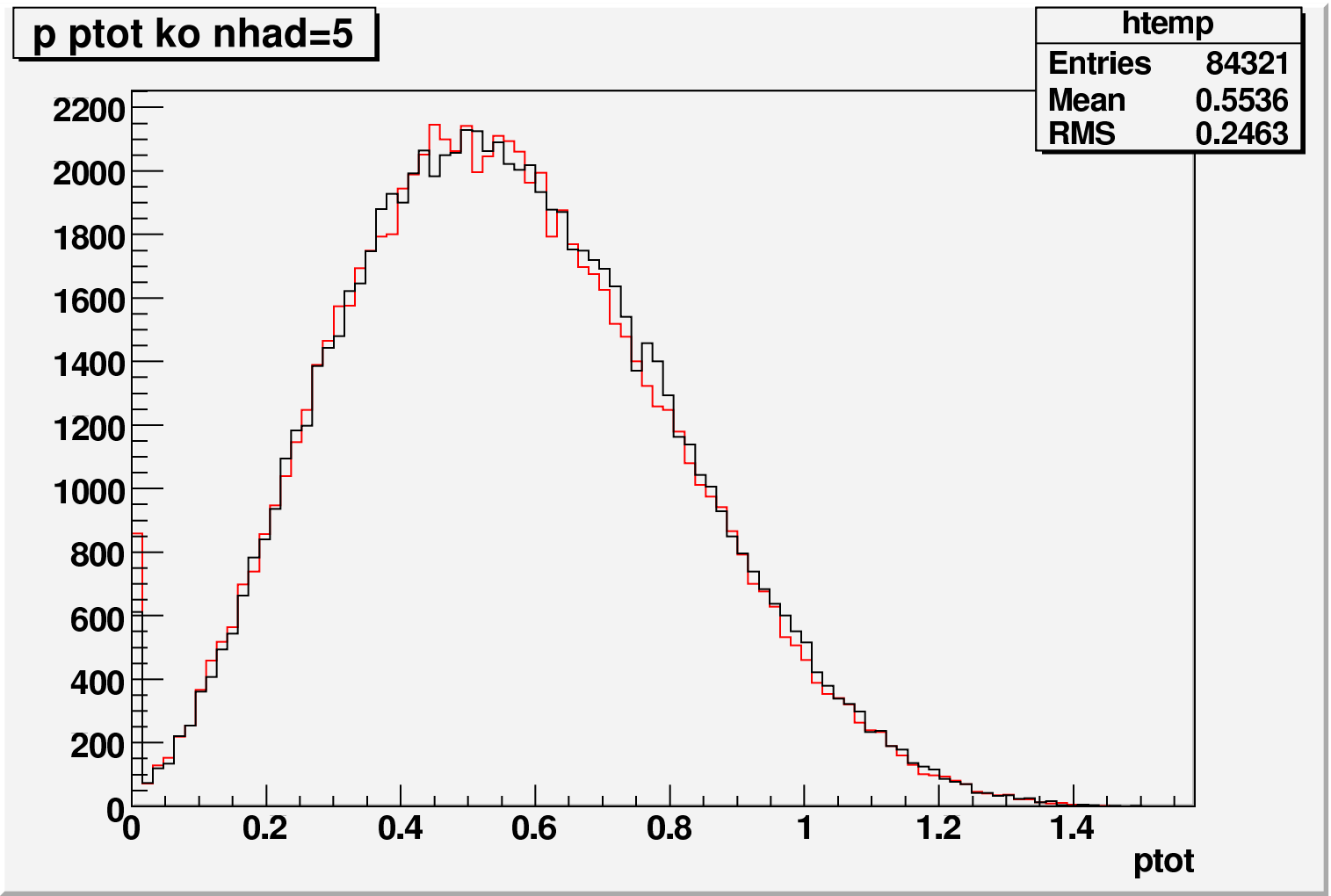

p px elas
htemp
Entries 34426
Mean -0.0004525
RMS 0.06967
3000
2500
2000
1500
1000
500
0
-0.4
-0.2
0
0.2
0.4
px

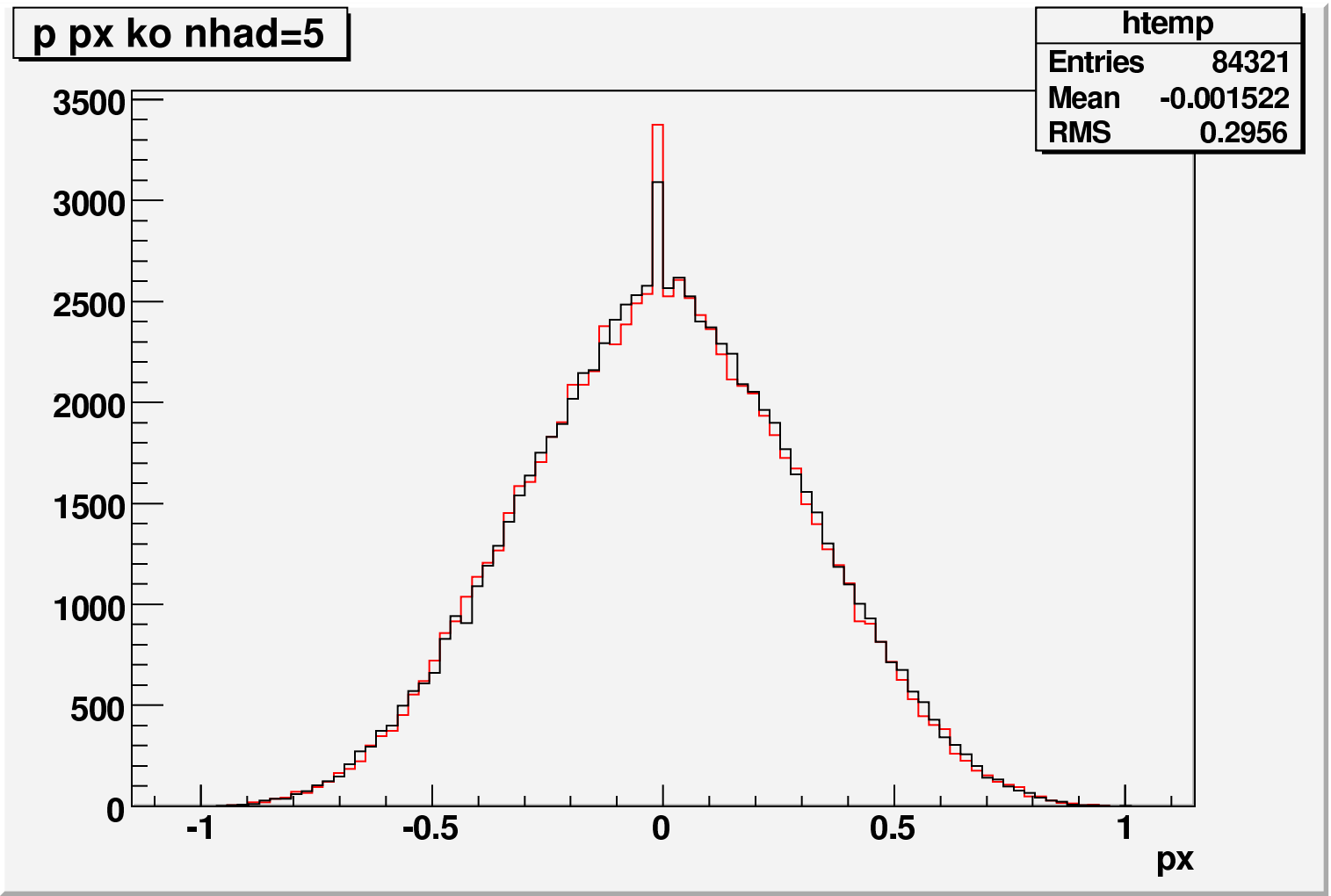

p ptot elas
htemp
Entries 34976
Mean 1.581
RMS 1.433e-06
35000
30000
25000
20000
15000
10000
5000
0
0.5
1
1.5
2
2.5
ptot

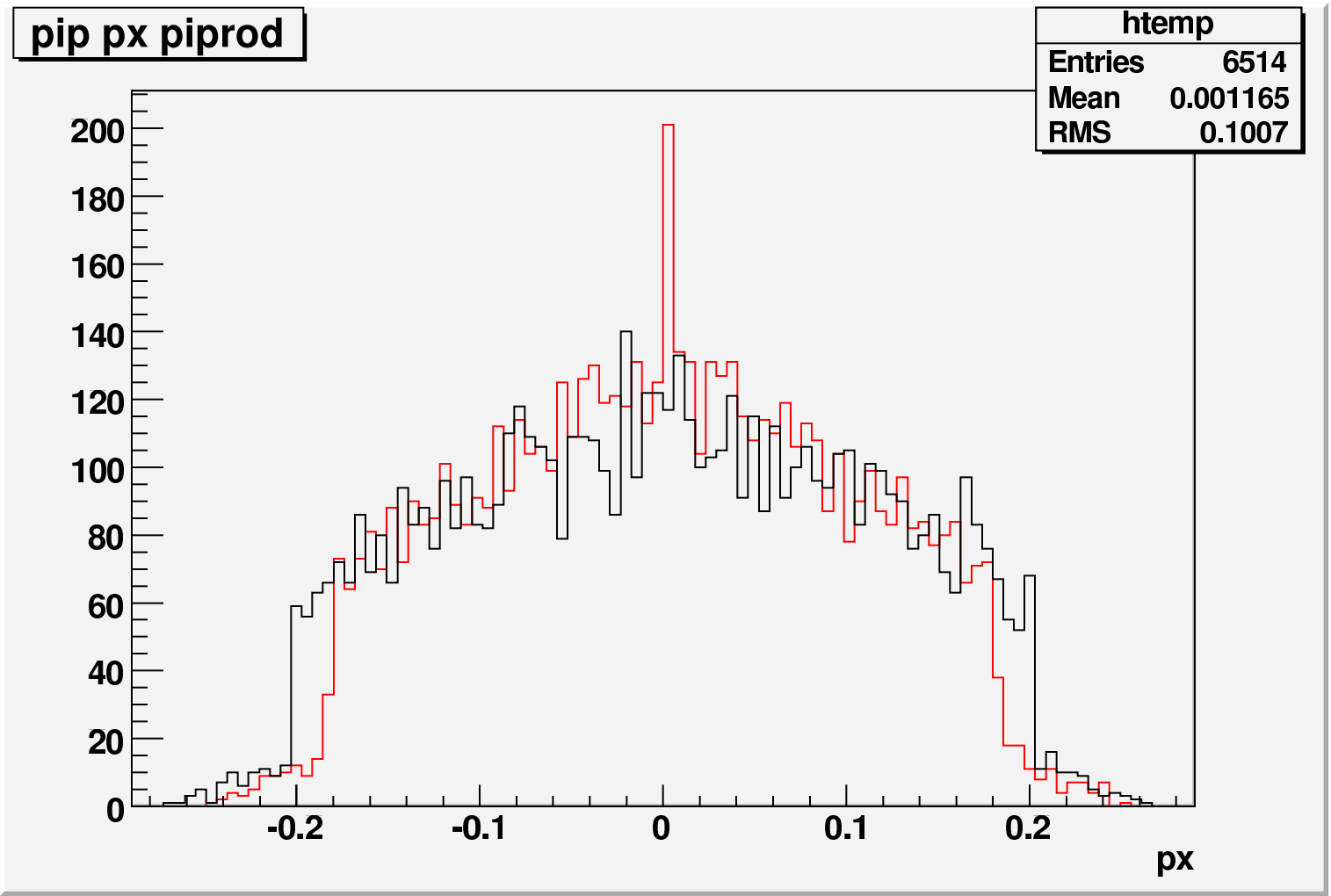

p ptot ko nhad=2
htemp
Entries 3792
Mean 0.9667
RMS 0.3874
70
60
50
40
30
20
10
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
ptot

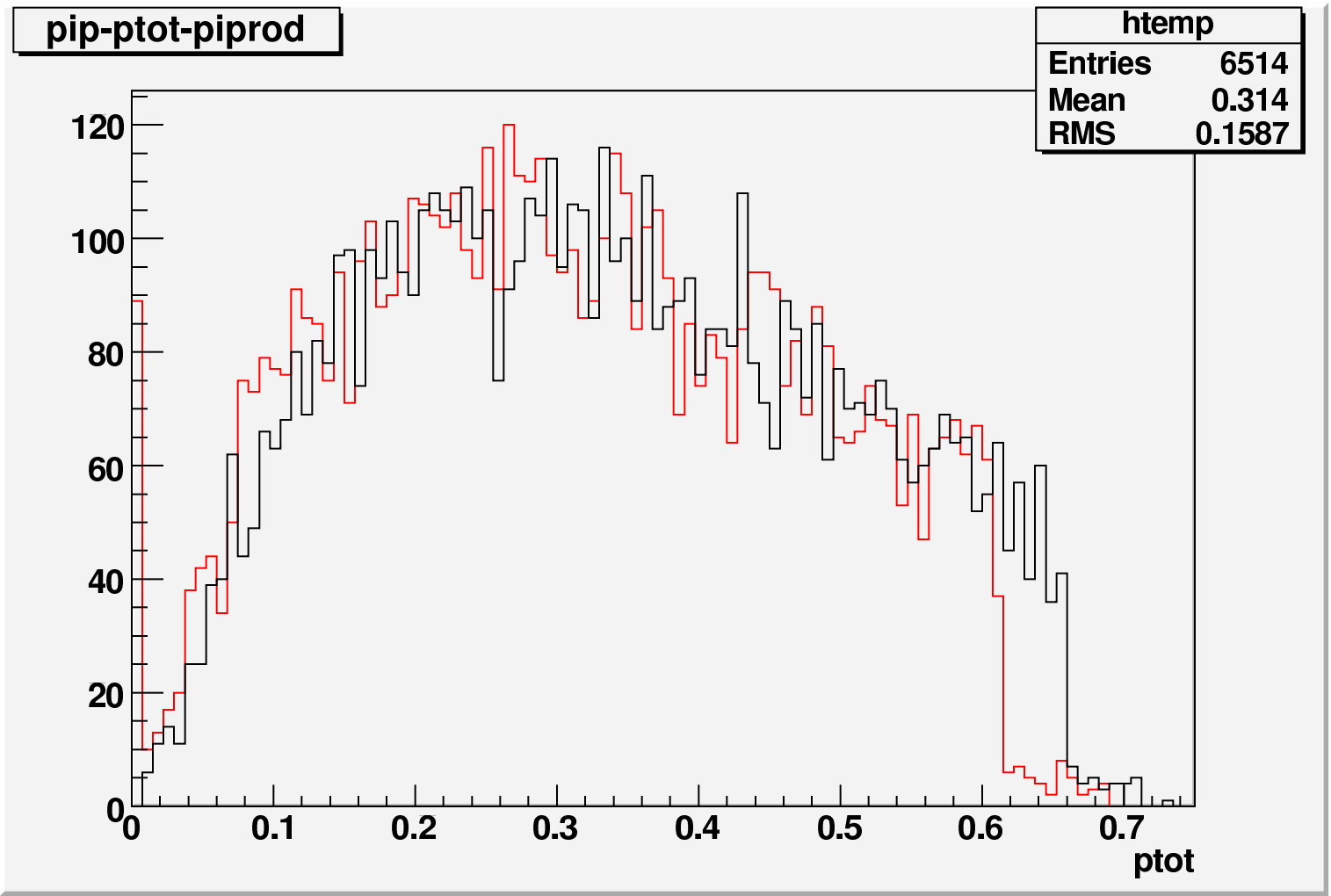

p cos(th) 900 ko nhad=3
htemp
Entries 2589
Mean 0.5862
RMS 0.3924
140
120
100
80
60
40
20
0
-1
-0.5
0
0.5
1
pz/ptot

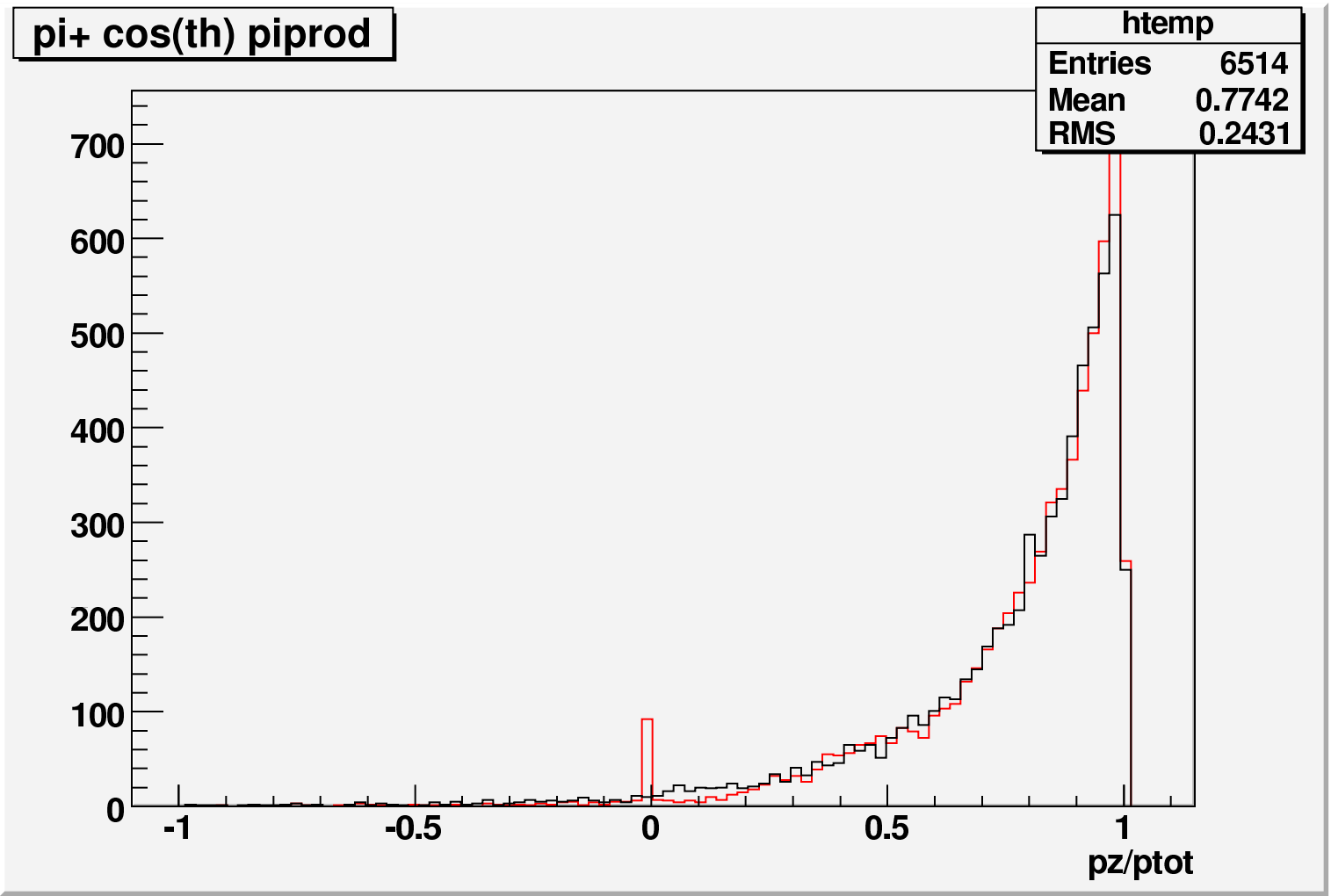

n ptot ko nhad=3
htemp
Entries 2664
Mean 0.756
RMS 0.322
60
50
40
30
20
10
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
ptot

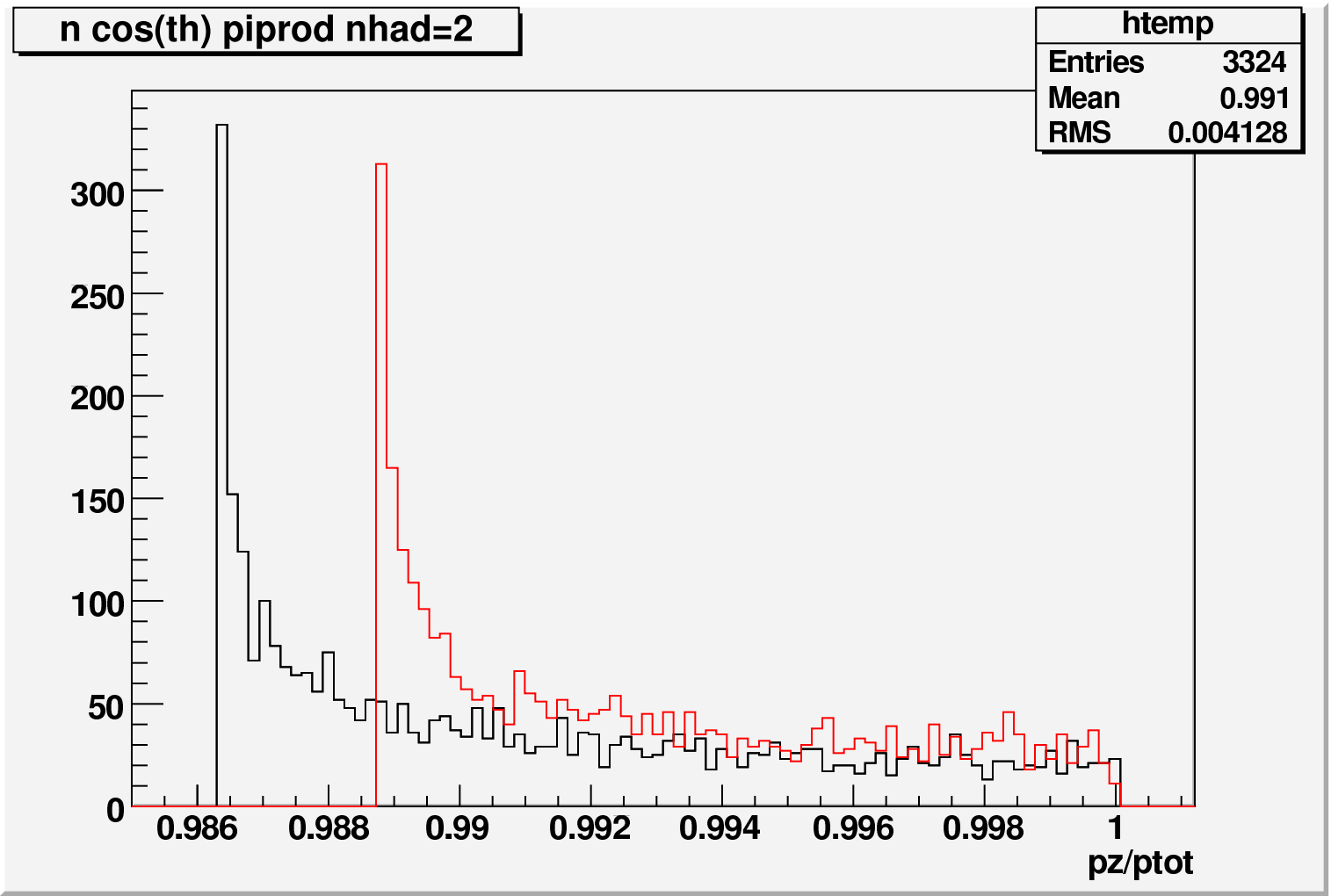

p ptot ko nhad=5
htemp
Entries 84321
Mean 0.5536
RMS 0.2463
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
ptot

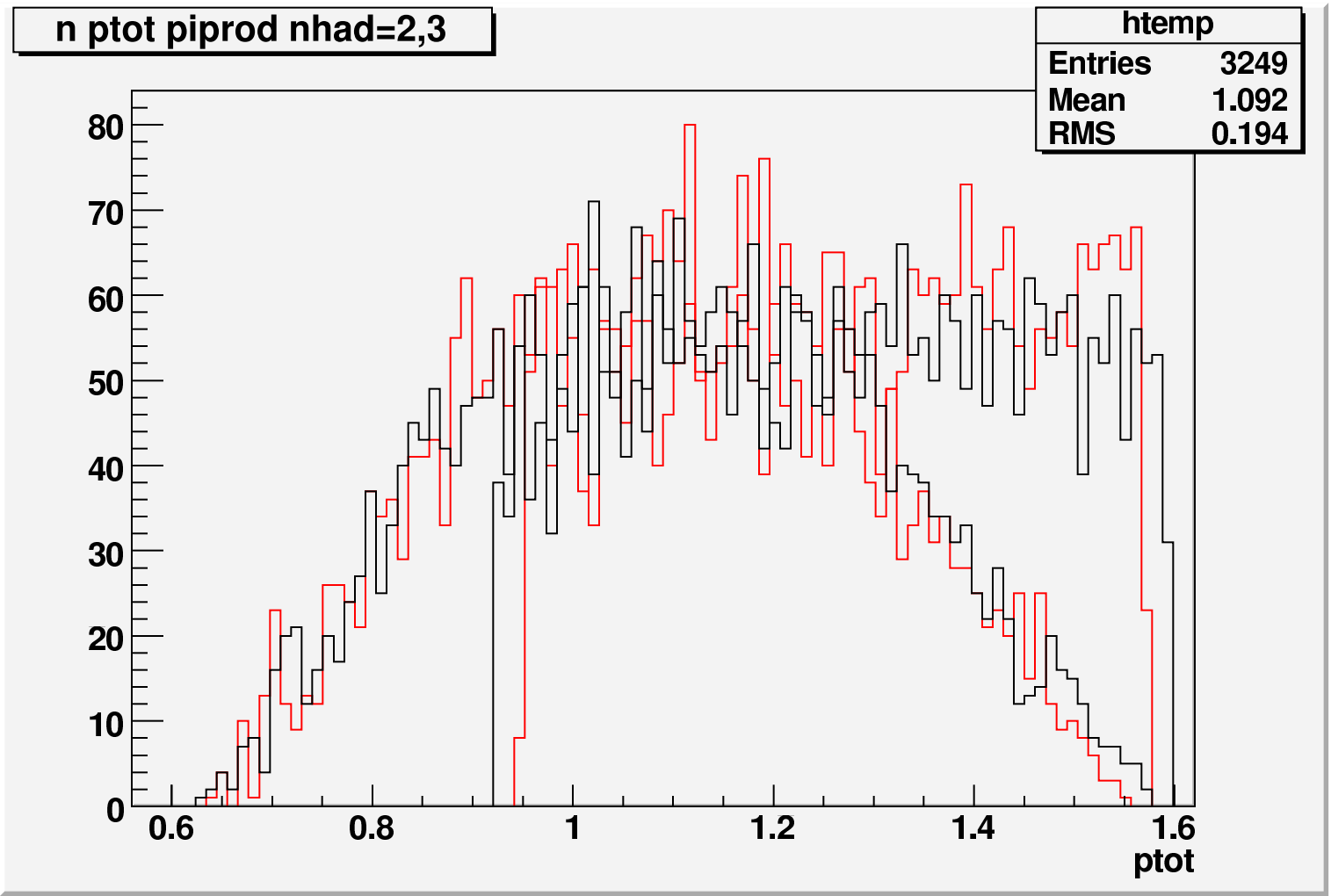

p px ko nhad=5
htemp
Entries 84321
Mean -0.001522
RMS 0.2956
3500
3000
2500
2000
1500
1000
500
0
-1
-0.5
0
0.5
1
px

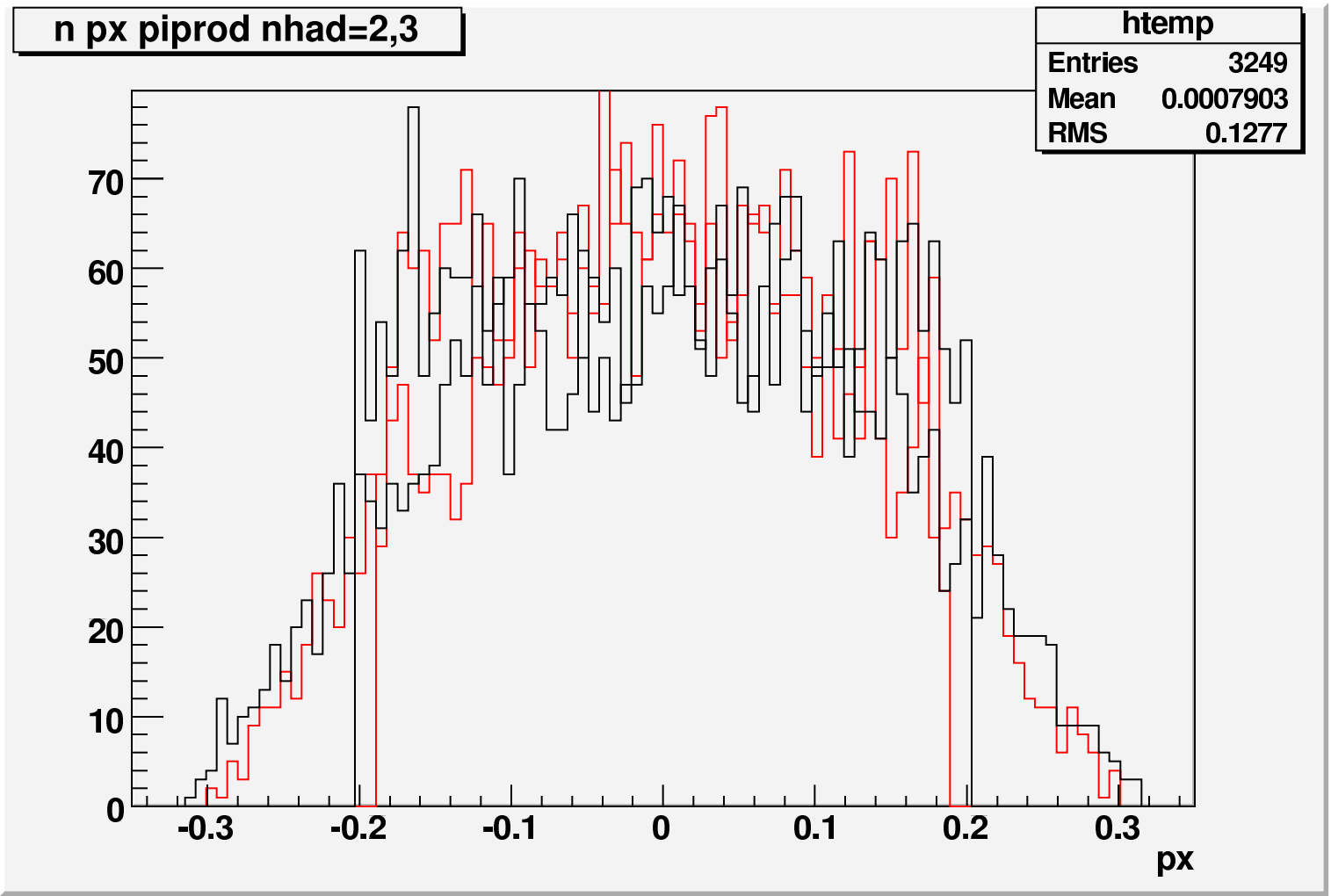

pip px piprod
htemp
Entries 6514
Mean 0.001165
RMS 0.1007
200
180
160
140
120
100
80
60
40
20
0
-0.2
-0.1
0
0.1
0.2
px

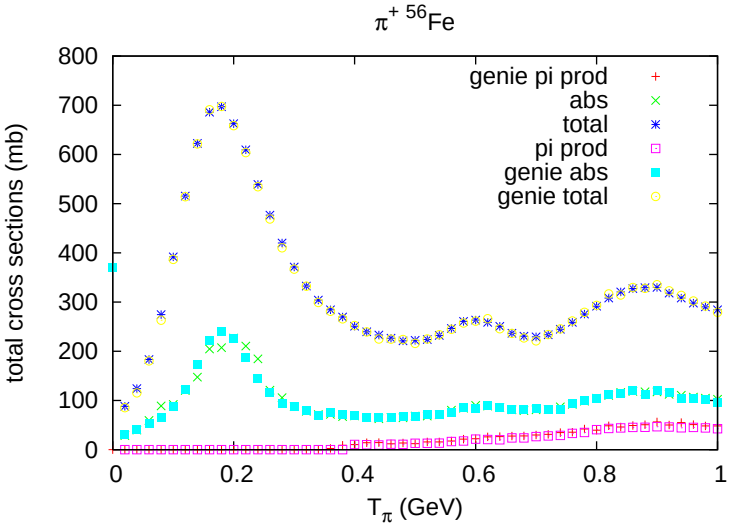

pip-ptot-piprod
htemp
Entries 6514
Mean 0.314
RMS 0.1587
120
100
80
60
40
20
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
ptot

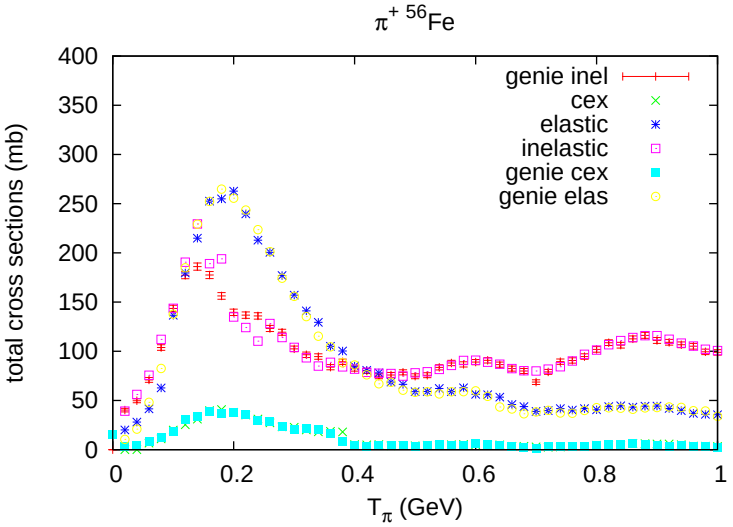

pi+ cos(th) piprod
htemp
Entries 6514
Mean 0.7742
RMS 0.2431
700
600
500
400
300
200
100
0
-1
-0.5
0
0.5
1
pz/ptot

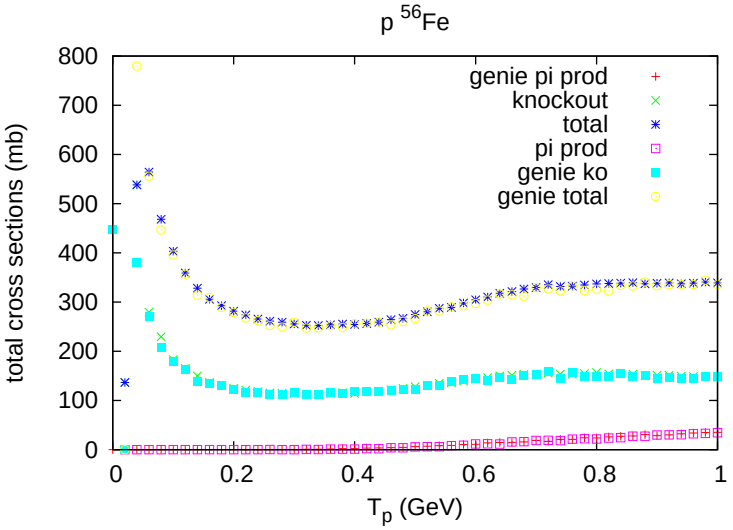

n cos(th) piprod nhad=2
htemp
Entries 3324
Mean 0.991
RMS 0.004128
300
250
200
150
100
50
0
0.986
0.988
0.99
0.992
0.994
0.996
0.998
1
pz/ptot

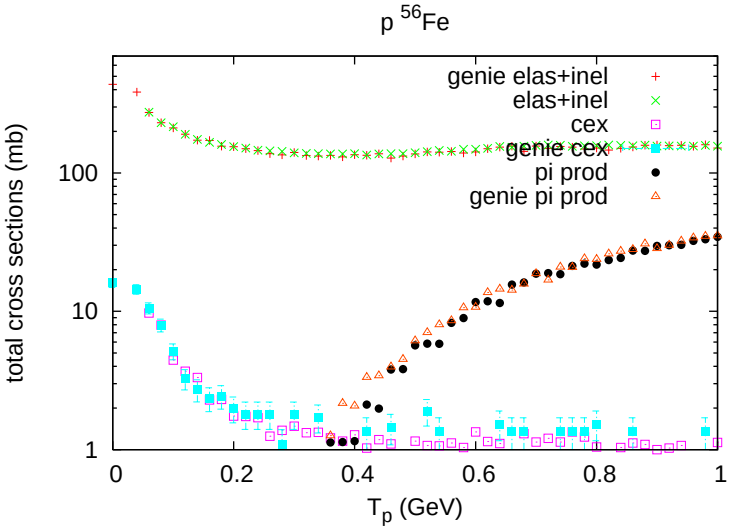

n ptot piprod nhad=2,3
htemp
Entries 3249
Mean 1.092
RMS 0.194
80
70
60
50
40
30
20
10
0
0.6
0.8
1
1.2
1.4
1.6
ptot


n px piprod nhad=2,3
htemp
Entries 3249
Mean 0.0007903
RMS 0.1277
70
60
50
40
30
20
10
0
-0.3
-0.2
-0.1
0
0.1
0.2
0.3
px


$\pi^{+}\,{}^{56}Fe$
genie pi prod
abs
total
pi prod
genie abs
genie total
total cross sections (mb)
T_π (GeV)
0
100
200
300
400
500
600
700
800
0
0.2
0.4
0.6
0.8
1


$\pi^{+}\,{}^{56}Fe$
genie inel
cex
elastic
inelastic
genie cex
genie elas
total cross sections (mb)
T_π (GeV)
0
50
100
150
200
250
300
350
400
0
0.2
0.4
0.6
0.8
1


p ^{56}Fe
genie pi prod
knockout
total
pi prod
genie ko
genie total
total cross sections (mb)
T_p (GeV)
0
100
200
300
400
500
600
700
800
0
0.2
0.4
0.6
0.8
1


p ^{56}Fe
genie elas+inel
elas+inel
cex
genie cex
pi prod
genie pi prod
total cross sections (mb)
100
10
1
0
0.2
0.4
0.6
0.8
1
T_p (GeV)