CCQE Neutral Hyperon Analysis

Saima Farooq
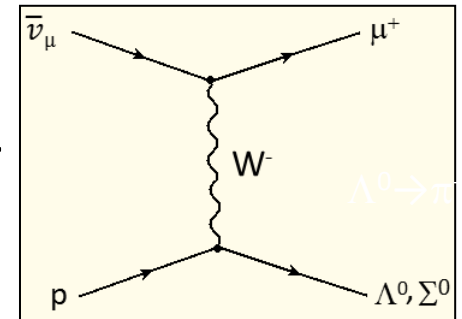Tim Bolton
Kansas State University
ArgoNeuT Meeting Dec 11, 2012

Motivation

- Charge Current Quasi-Elastic (CCQE) Hyperon Production is the Simplest $\bar{\nu}_\mu N$ Process after CCQE Neutron Production

- Existing Experimental Data on Hyperon Production via CCQE scattering with anti-neutrinos is Sparse

- CCQE Hyperon Production will have Different Nuclear Response than CCQE Neutron Production due to the absence of Pauli effects for the Hyperons

- LArTPC can SEE a Hyperon. Other Coarser Grained Detectors Probably Cannot

- Much of the ArgoNeuT Data is in $\bar{\nu}_\mu$ Mode

CCQE $\Lambda^0/\Sigma^0/\Sigma^-$ Production

W$^-$

W$^-$
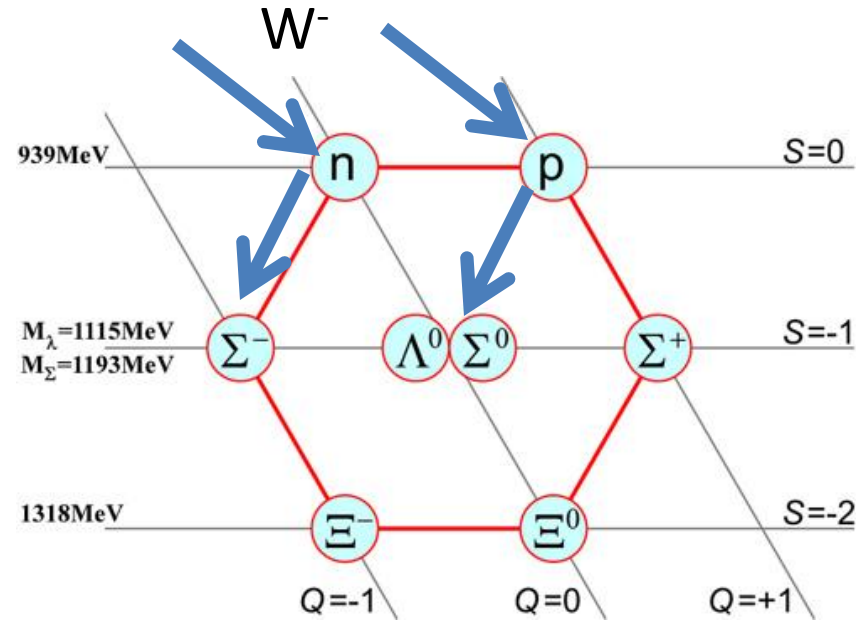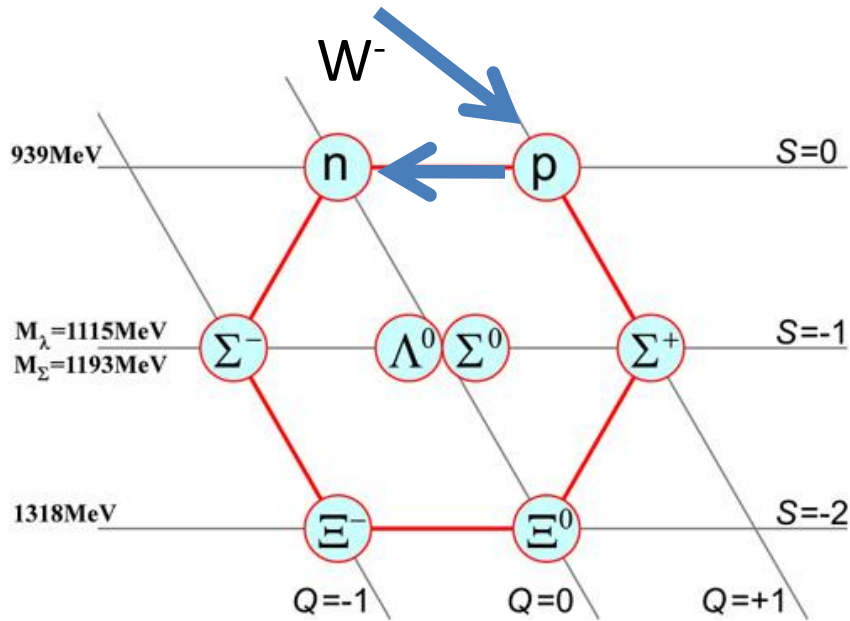
- $\overline{\nu_\mu}+n \rightarrow \mu^+ + \Sigma^-$
- $\overline{\nu_\mu}+p \rightarrow \mu^+ + \Lambda^0$
- $\overline{\nu_\mu}+p \rightarrow \mu^+ + \Sigma^0$

Above Processes <u>NOT</u> in GENIE, using NUANCE

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Nuance and Llewellyn Smith cross section for CCQE Hyperon Production

CCQE Hyperon Cross Sections from NUANCE (channel#95)

$\overline{\nu_\mu} + n \rightarrow \mu^+ + \Sigma^-$

$\overline{\nu_\mu} + p \rightarrow \mu^+ + \Lambda^0, \; \mu^+ + \Sigma^0$

$\sigma \; 10^{-40} cm^2$

E_ν (GeV)

$\sigma (10^{-40} cm^2)$

Form factor $F(q^2) = \left(1 + \frac{|q^2|}{M^2}\right)^{-2}$

M=1.6 GeV
1.5
1.4
1.3
1.2
1.1
1.0
0.89
0.70

TOTAL CROSS SECTION

E_ν (GeV)

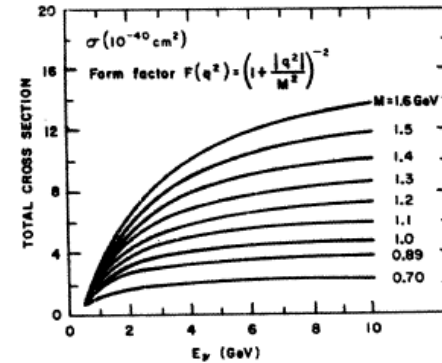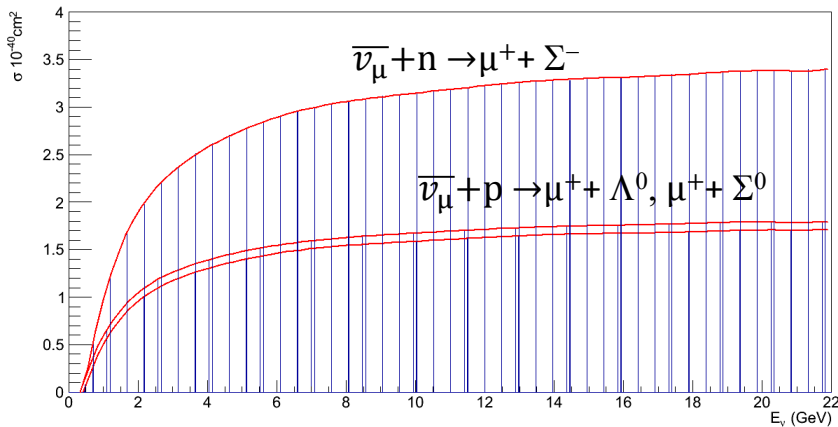Fig. 23. Total cross section for $\overline{\nu}p \rightarrow \Lambda\mu^+$ as a function of the antineutrino energy in the Cabibbo theory. The same q^2 dependence was taken for all form factors [W9].
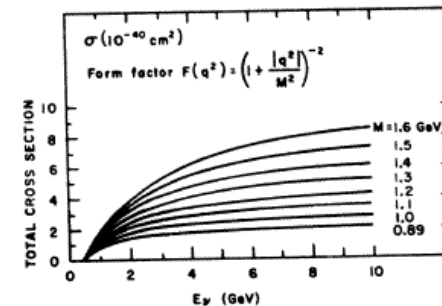
$\sigma (10^{-40} cm^2)$

Form factor $F(q^2) = \left(1 + \frac{|q^2|}{M^2}\right)^{-2}$

M=1.6 GeV
1.5
1.4
1.3
1.2
1.1
1.0
0.89

TOTAL CROSS SECTION

E_ν (GeV)

Fig. 24. Total cross section for $\overline{\nu}n \rightarrow \Sigma^-\mu^+$ (otherwise as for fig. 23) [W9].

In NUANCE, "Smith-Moniz model has been extended to include charged-current, Cabibbo-suppressed hyperon production, following the treatment of Pais to account for the inelasticity of such reactions and the $\Delta I = \frac{1}{2}$ rule"[1]
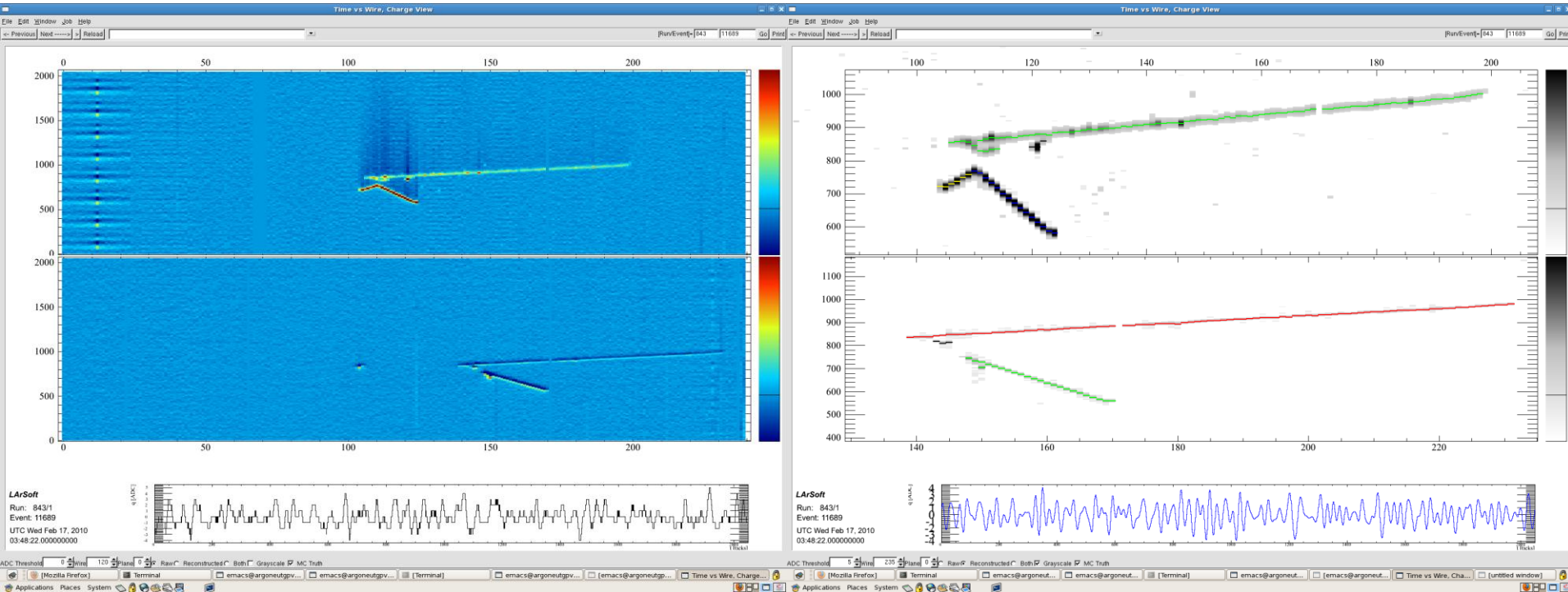
[1]D. Casper (UC, Irvine). Aug 2002. 10 pp. Published in Nucl.Phys.Proc.Suppl. 112 (2002) 161-170

CCQE Hyperon Simulation in LArSoft

CCQE Λ^0 Production

CCQE Σ^0 Production
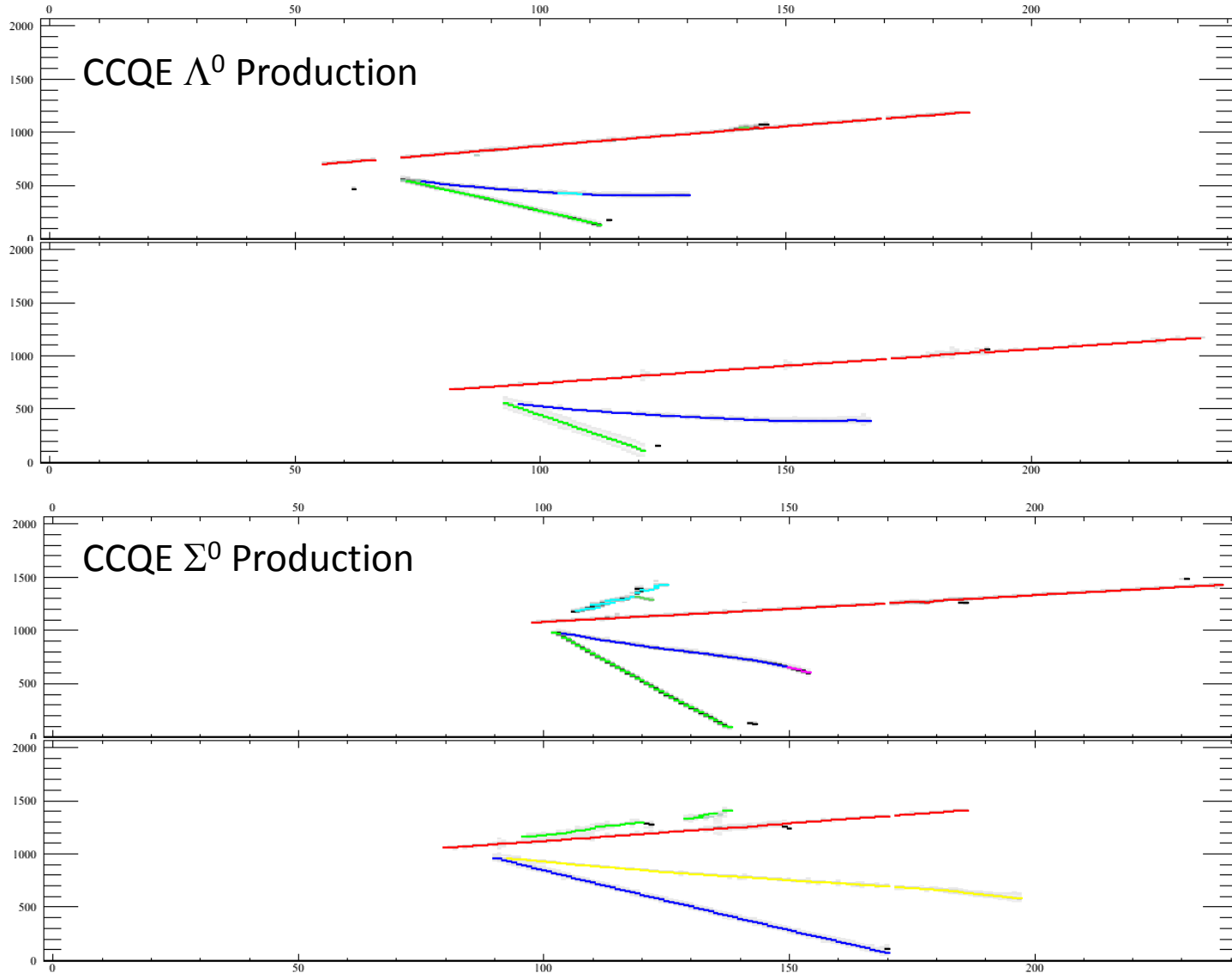
Run: 843, Event: 11689

- Muon Exiting and Matched with MINOS
- Muon Charge Reconstructed by MINOS is +1 so it is $\overline{\nu_\mu}$ event

*Sent by Flavio and Corey

Vertex χ^2

- Fitting 3 longest clusters to a vertex

- <u>Hypothesis: all 3 clusters originate from the same vertex</u>

- Big values of vertex χ^2 reject the hypothesis

- Neutral hyperon events will tend to have big vertex χ^2

$\chi^2 = 1.57$

$\chi^2 = 1838.34$

Thanks to Tim for the plots
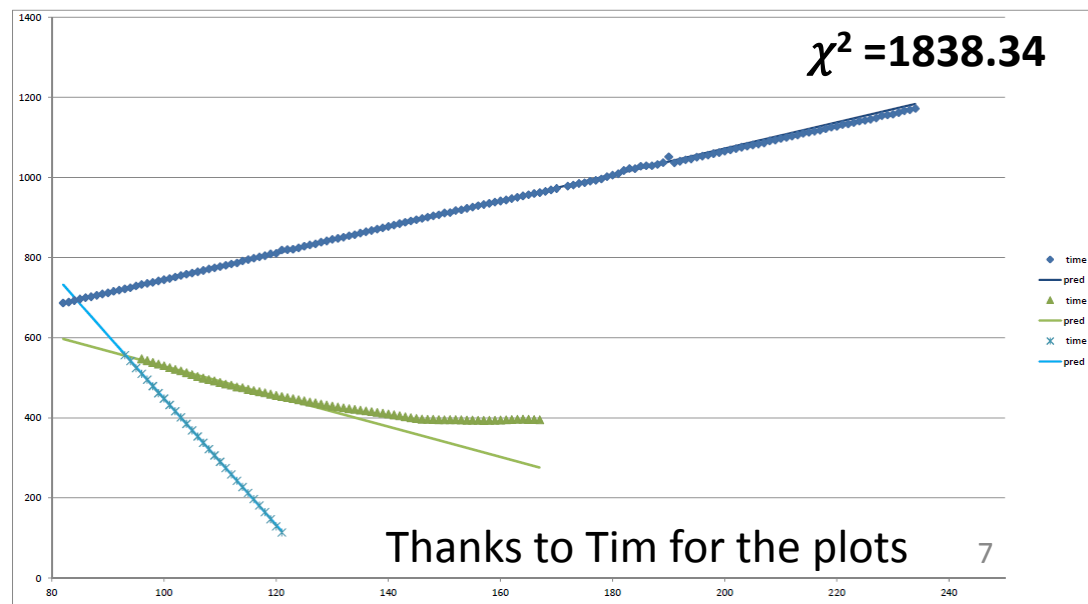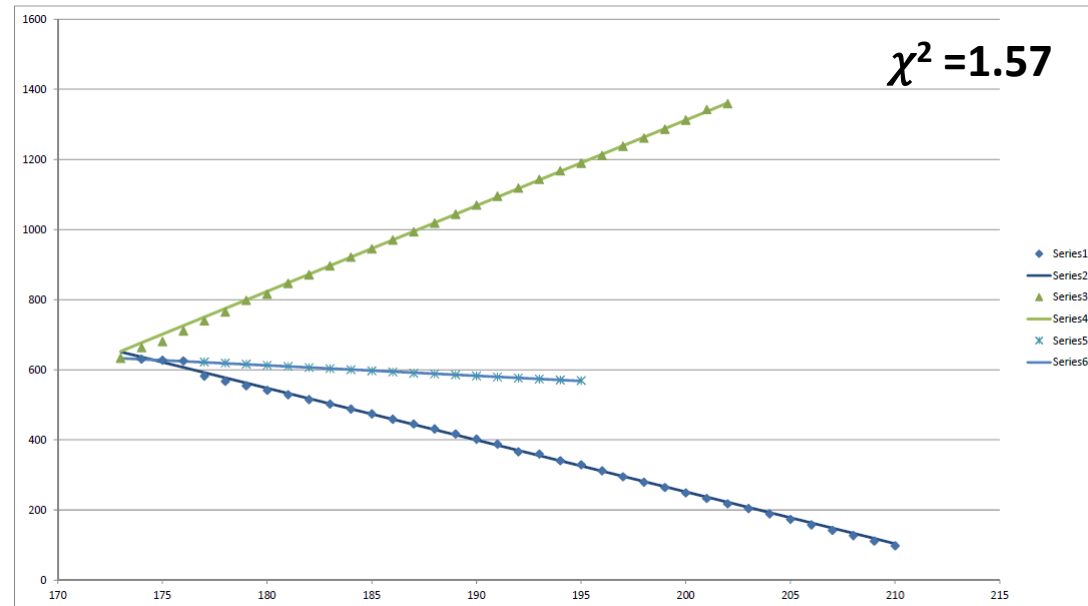
Summary

- ArgoNeuT can see a neutral hyperon decay

- Different models predict very different cross sections for this process

- Having these processes in GENIE will be great in order to compare between the generators and look which models best fits the data

- Vertex finding giving reasonable results and is working at some level

- Can pick up hyperon events based on their vertex χ^2