CCQE Neutral Hyperon Analysis

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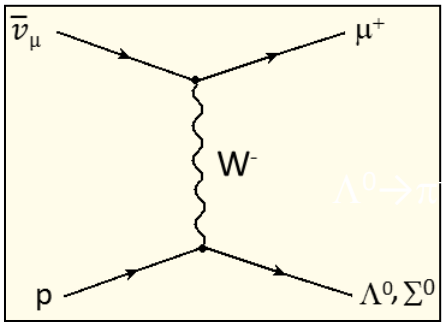
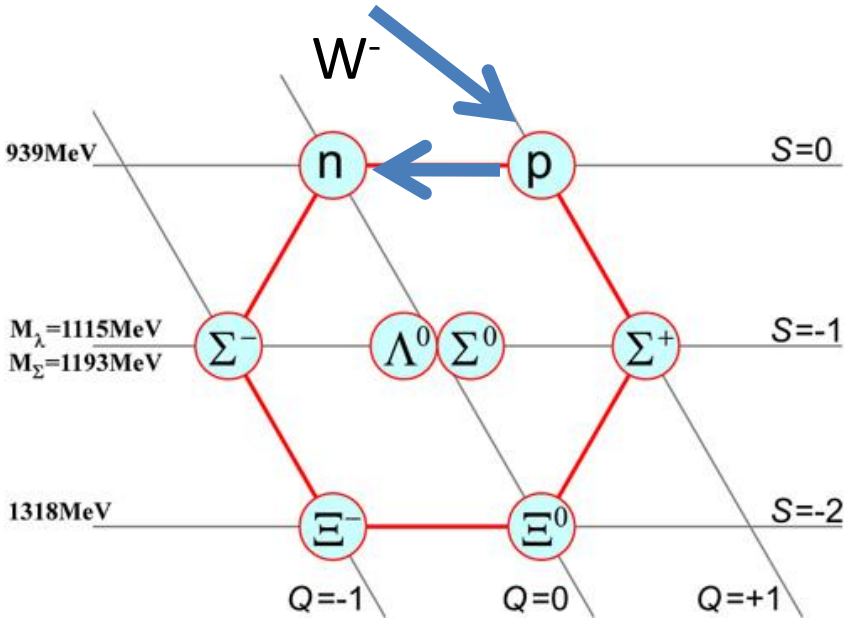
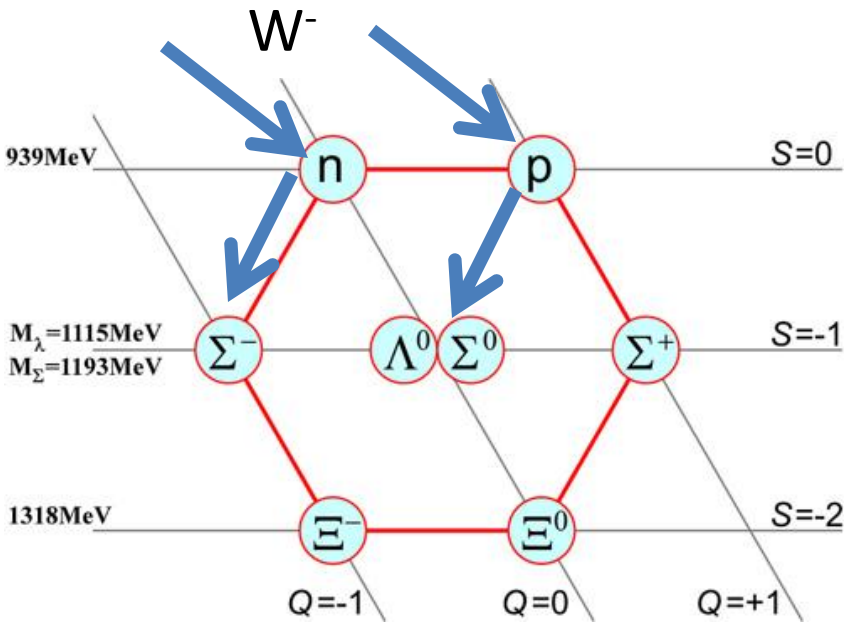
Motivation

- Charge Current Quasi-Elastic (CCQE) Hyperon Production is the Simplest $\overline{\nu}_\mu$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 $\overline{\nu}_\mu$ Mode



CCQE Λ^0/Σ^0 /Σ^- Production

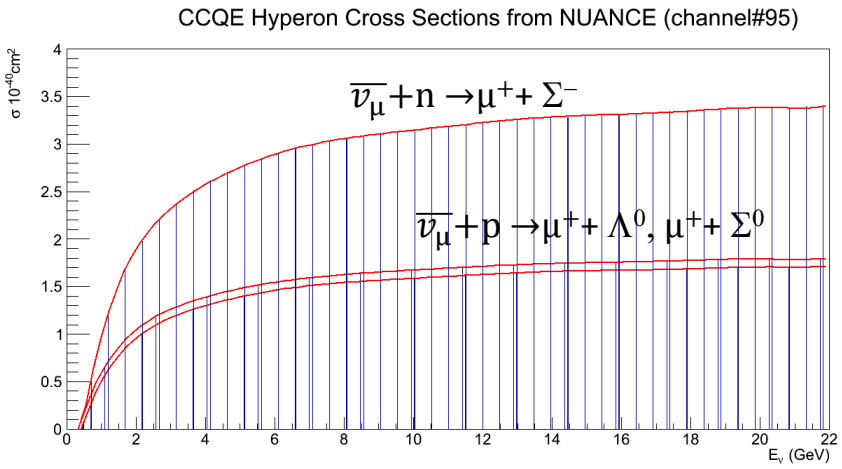




- $\overline{\nu_\mu} + n \rightarrow \mu^+ + \Sigma^-$
- $\overline{\nu_\mu} + p \rightarrow \mu^+ + \Lambda^0$
- $\overline{\nu_\mu} + p \rightarrow \mu^+ + \Sigma^0$

Above Processes NOT in GENIE, using NUANCE

Nuance and Llewellyn Smith cross section for CCQE Hyperon Production



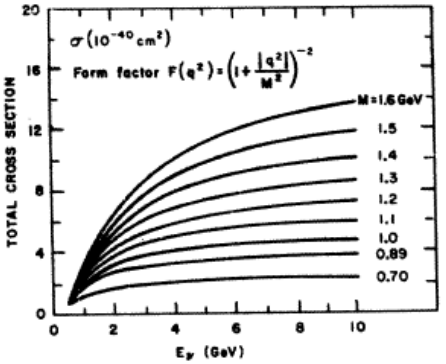


Fig. 23. Total cross section for $\bar{\nu}p \to \Lambda\mu^+$ as a function of the antineutrino energy in the Cabibbo theory. The same q^2 dependence was taken for all form factors [W9].

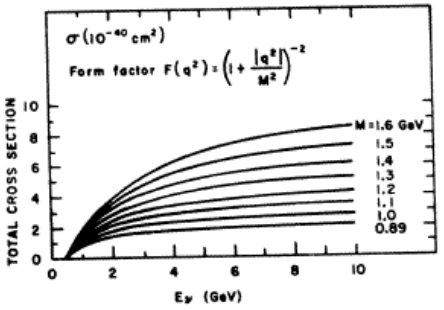
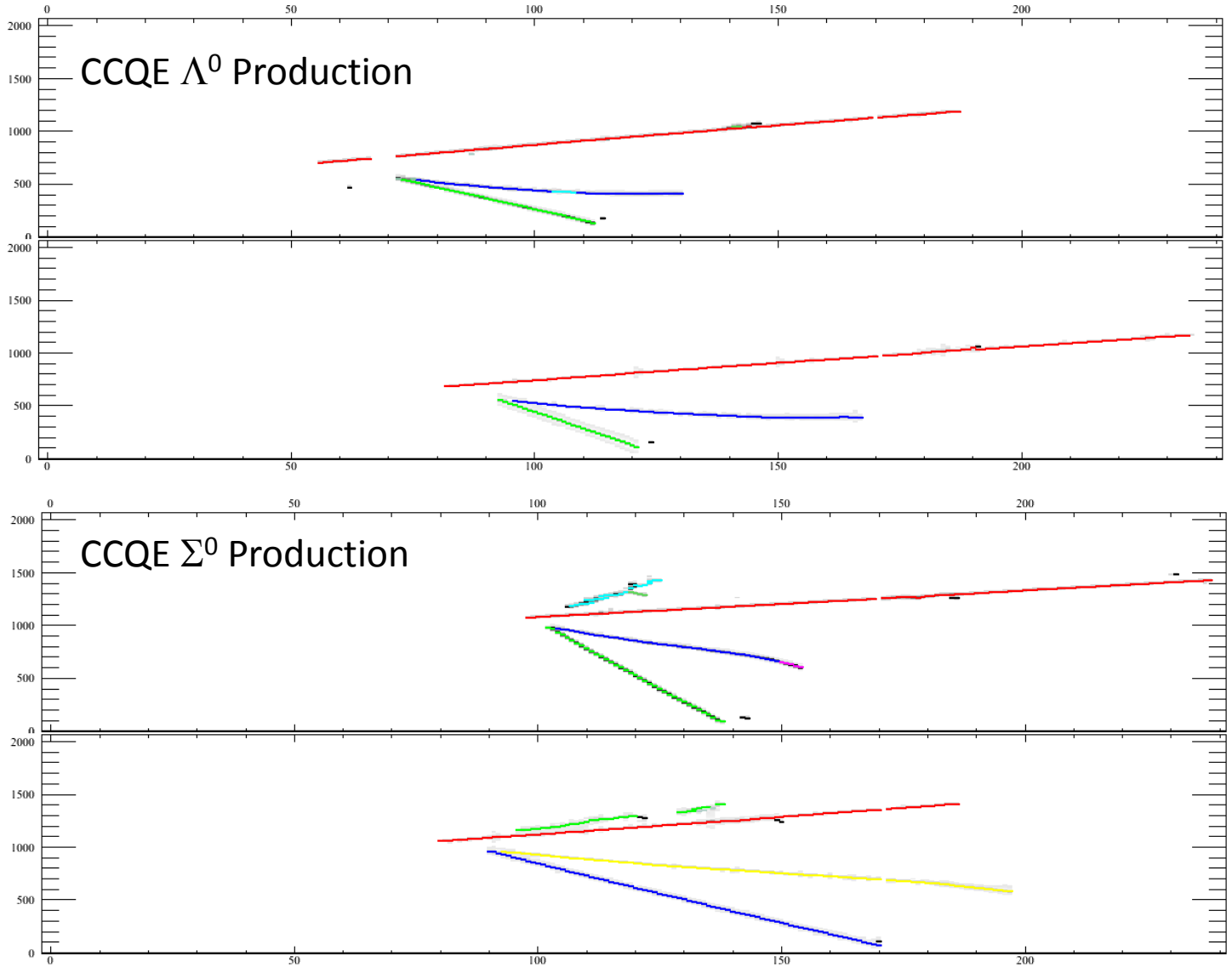


Fig. 24. Total cross section for $\bar{\nu}n \to \Sigma^-\mu^+$ (otherwise as for fig. 23) [W9].

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]

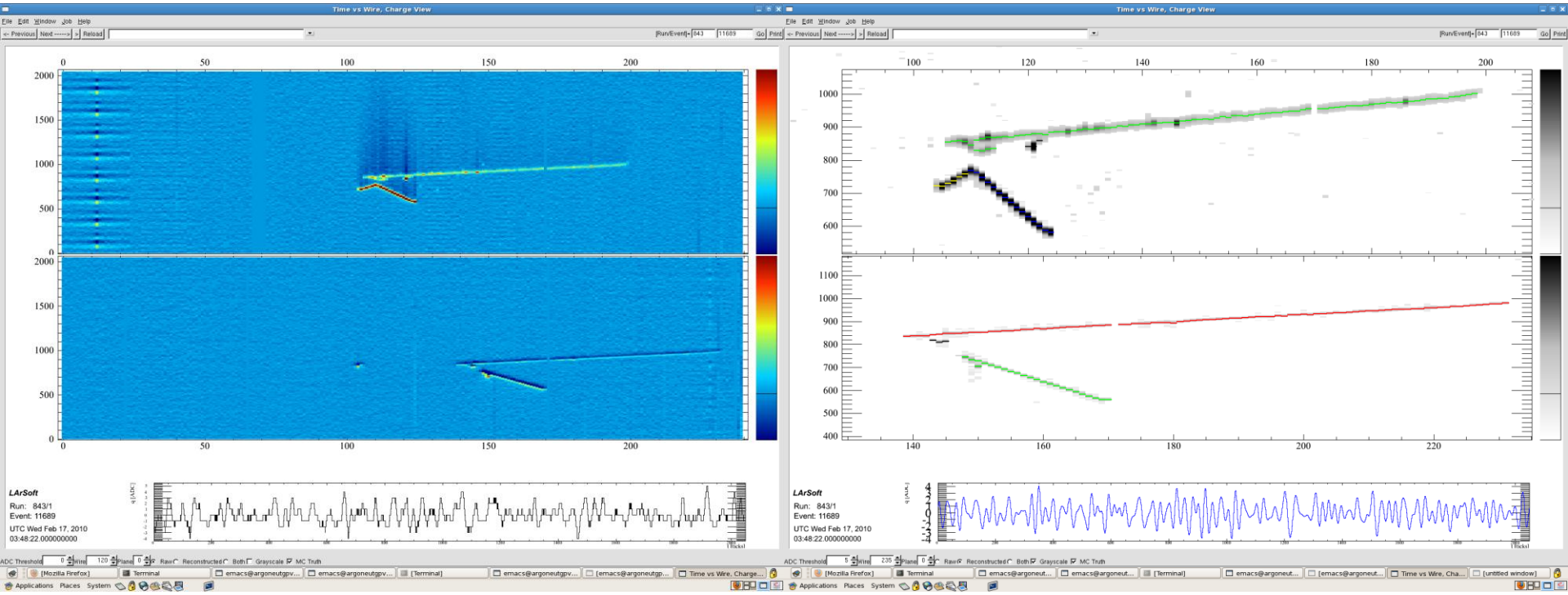
[1]D. Casper (UC, Irvine). Aug 2002. 10 pp. Published in Nucl.Phys.Proc.Suppl. 112 (2002) 161-170

CCQE Hyperon Simulation in LArSoft



Run: 843, Event: 11689

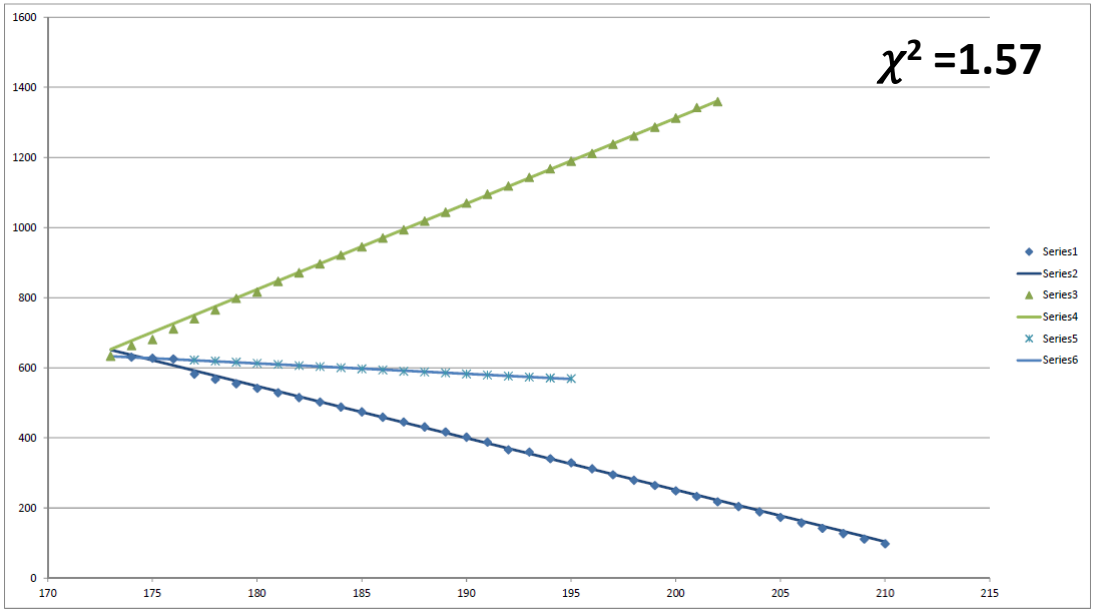
- Muon Exiting and Matched with MINOS
- Muon Charge Reconstructed by MINOS is +1 so it is $\overline{\nu_\mu}$ event

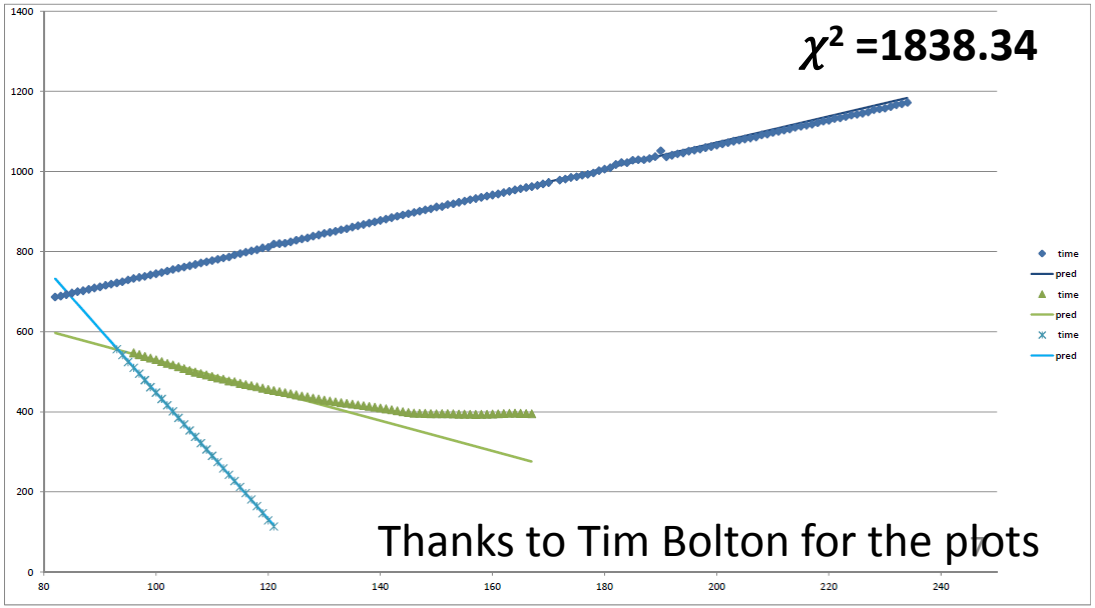


*Sent by Flavio and Corey

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





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