Fermilab

GENIE Status

Gabriel N. Perdue

Simulations for Neutrinos

April 27, 2015

GENIE Release Roadmap: 2.9/2.10

- Latest production release is 2.8.6, released 14 November, 2014.
- New release candidate 2.9.0 (beta) will graduate into production release 2.10.0
- Model introduction release.
  - Effective Spectral Functions from A. Bodek, E. Christy, B. Coopersmith (EPJC (2014) 74:3091). (B. Coopersmith and A. Bodek)
  - Very-High Energy extension (5 TeV, working toward PeV) (K. Hoshina)
  - Inclusive Eta production. (J. Liu)
  - New Berger-Sehgal resonant pion production model, tuned with MiniBooNE data by J. Nowak. Berger, Sehgal Phys. Rev. D76, 113004 (2007) & Kuzmin, Lyubushkin, Naumov Mod. Phys. Lett. A19 (2004) 2815 (J. Nowak and S. Dytman)
  - Improved hA FSI model. (S. Dytman and N. Geary)
  - Single Kaon production model by Alam, Simo, Athar, and Vacas (PRD 82, 033001 (2010)). (C. Marshall and M. Nirkko)

GENIE Release Roadmap: 2.9/2.10

- Updates to the flux driver (R. Hatcher):
  - Implemented a GFluxDriverFactory, where flux drivers can self-register and be returned by name.
  - Introduced two common flux interfaces GFluxExposureI and GFluxFileConfigI, allowing GNuMIFlux, GSimpleNtpFlux and the external GDk2NuFlux to be used interchangeably. Other flux drivers can start to incorporate these.
  - Renamed gevgen_numi executable to gevgen_fnal to emphasize its use in FNAL experiments at other beam lines (e.g. Dune); executable will dynamically pick up GDk2NuFlux flux driver if available (i.e. no longer a build dependence). Flux entries from the input driver will be copied to a branch along side the GHepRecord; flux metadata from all ntuple files will be copied to the output file.
- Event records:
  - Reinstated method in GHepRecord to return the stored KinePhaseSpace_t, allowing records to be fully recreated from elements stored in non-genie formats (R. Hatcher)
  - Note: We updated the XclsTag object with a new field for strange production for one of the new models in 2.9.0. This could impact the ability of some users to read older GENIE files.

GENIE Release Roadmap: 2.9/2.10

- Other changes in 2.9 / 2.10
  - Numerous updates to the validation packages for new models and some improvements to the old ones.
  - Changed the numerical integration routines to use GSL (GNU Scientific Library).
    - Necessary for several new, higher-dimensional models:
      - Single kaon in 2.9/2.10
      - Alvarez-Ruso et al, Coherent Pion in 2.12
    - Results in many small changes in the total cross section splines.
      - One or two wiggles are puzzling, but most are "arbitrary" and well within uncertainties (examples to follow).

GENIE Release Roadmap: 2.12

- GENIE 2.12.0 - likely this Summer/Fall
  - QEL Lambda production (J. Poage and H. Gallagher)
  - Berger-Sehgal coherent pion production (PRD 79, 053003 (2009)) (G. Perdue, H. Gallagher, D. Cherdack)
  - Local Fermi Gas & Nieves et al CCQE with RPA (J. Johnston and S. Dytman)
  - Valencia Model Meson Exchange-Currents (J. Schwer and R. Gran)
  - Alvarez-Ruso et al microscopic coherent pion production (PRC 75, 055501 (2007) and PRC 76, 068501 (2007)) (S. Dennis and S. Boyd)
  - Oset FSI model (T. Golan)
  - Kaon FSI (F. de Maria Blaszczyk, S. Dytman)
  - Z expansion of QEL form factor (Hill et al, PRD 84, 073006) (A. Meyer)
  - Benhar Spectral Functions (C. Mariani, M. Jen, and A. Furmanski)
    - Ambitious to get it all… (and I may have forgotten something)
- GENIE 3.0 - likely early 2016
  - New default physics tune incorporating all of these models and recent neutrino-nucleus cross section data, plus many tuning and data comparison tools.

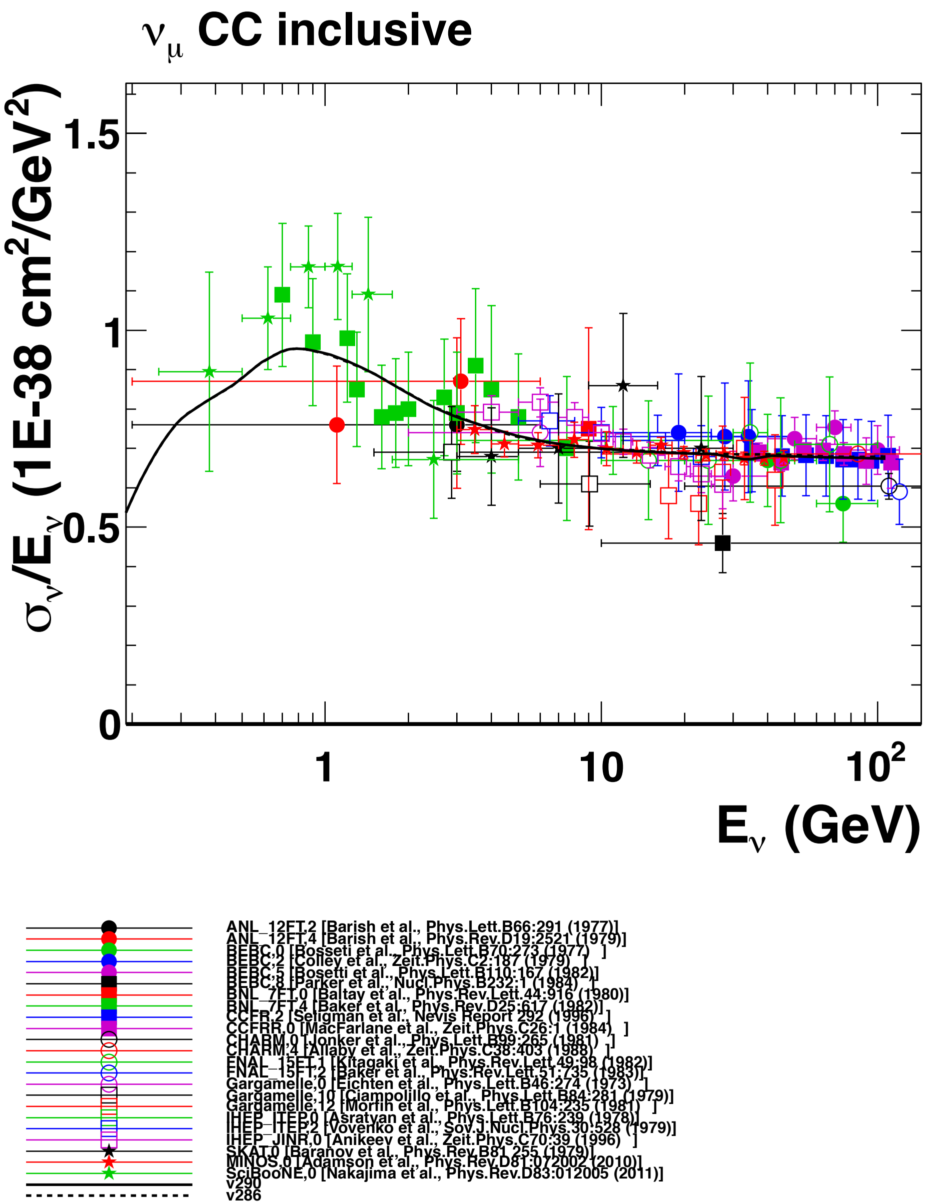
Tuning GENIE 3.0

- Our long-term goal is just getting underway.
  - Simultaneous fits to multiple neutrino data sets (e.g., pion production in MiniBooNE, MINERvA, and T2K).
  - These sorts of fits always have lots of trouble! Understanding correlated uncertainties between measurements, Peele's Pertinent Puzzle (normalization uncertainties common to an entire data set can cause bias in a least-squares minimization), etc.
  - Significant software and production infrastructure required (we would like to run large pieces of the required simulation on the Open Science Grid).
    - Substantial recent progress here, especially in the fitting framework, but we're also finally beginning to make some inroads into automated validation on the Grid.

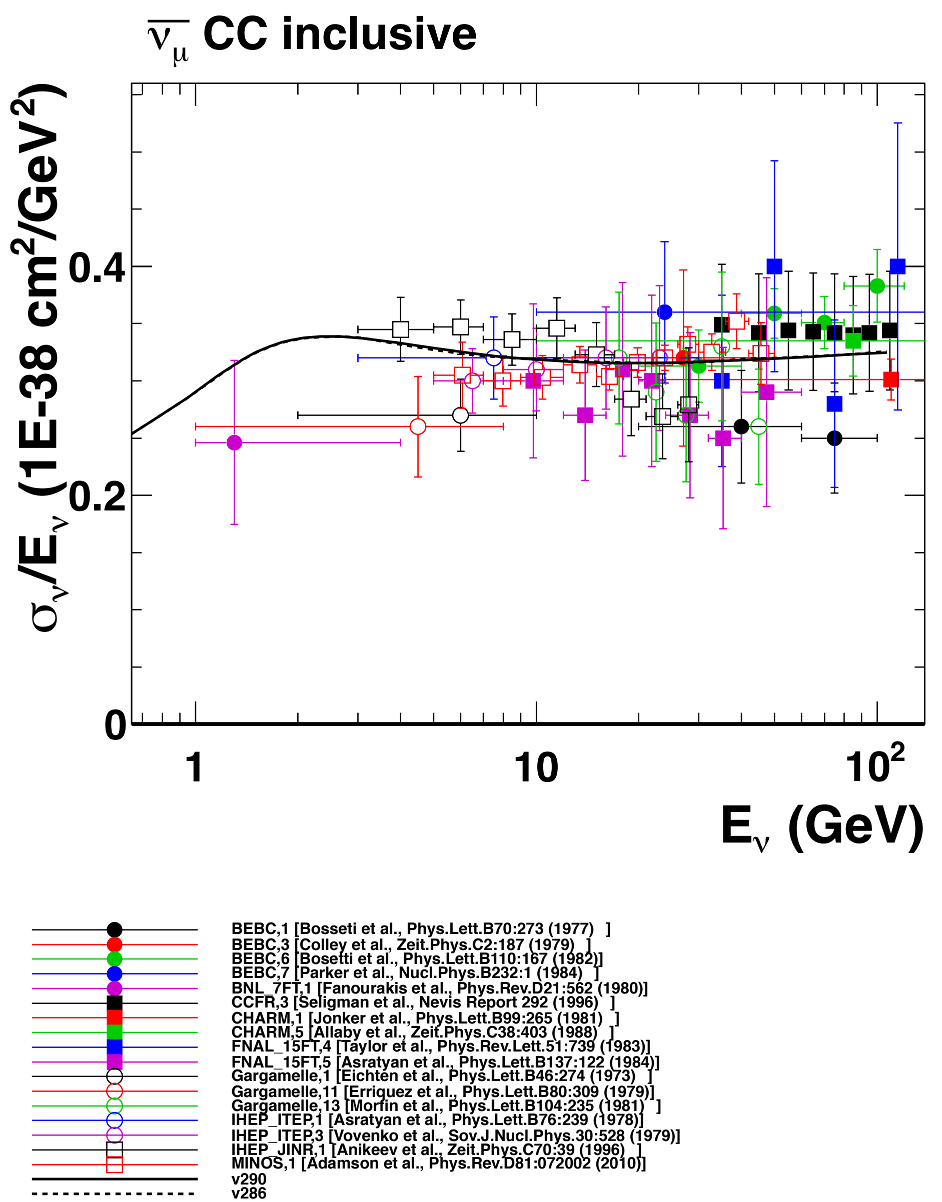
Other Updates

- New project incubators page on HepForge:
  - https://genie.hepforge.org/load.php?include=incubator
  - Some links on the page are not publicly accessible.
  - Main point of the page is to provide a place the community can clearly see what we're working on.
- Plan to release (at least) a citable arXiv e-print for future production releases.
  - We won't be seeking peer-review for these e-prints.
  - The author list will be comprised of all contributors to the release.
  - Find a bug and you can be a co-author on the 2.10.0 eprint!

2.9.0 vs. 2.8.6



ν_μ CC inclusive
σ_ν/E_ν (1E-38 cm²/GeV²)
E_ν (GeV)
0
0.5
1
1.5
1
10
10²
ANL_12FT,2 [Barish et al., Phys.Lett.B66:291 (1977)]
ANL_12FT,4 [Barish et al., Phys.Rev.D19:2521 (1979)]
BEBC,0 [Bosseti et al., Phys.Lett.B70:273 (1977)]
BEBC,2 [Colley et al., Zeit.Phys.C2:187 (1979)]
BEBC,5 [Bosetti et al., Phys.Lett.B110:167 (1982)]
BEBC,8 [Parker et al., Nucl.Phys.B232:1 (1984)]
BNL_7FT,0 [Baltay et al., Phys.Rev.Lett.44:916 (1980)]
BNL_7FT,4 [Baker et al., Phys.Rev.D25:617 (1982)]
CCFR,2 [Seligman et al., Nevis Report 292 (1996)]
CCFRR,0 [MacFarlane et al., Zeit.Phys.C26:1 (1984)]
CHARM,0 [Jonker et al., Phys.Lett.B99:265 (1981)]
CHARM,4 [Allaby et al., Zeit.Phys.C38:403 (1988)]
FNAL_15FT,1 [Kitagaki et al., Phys.Rev.Lett.49:98 (1982)]
FNAL_15FT,2 [Baker et al., Phys.Rev.Lett.51:735 (1983)]
Gargamelle,0 [Eichten et al., Phys.Lett.B46:274 (1973)]
Gargamelle,10 [Ciampolillo et al., Phys.Lett.B84:281 (1979)]
Gargamelle,12 [Morfin et al., Phys.Lett.B104:235 (1981)]
IHEP_ITEP,0 [Asratyan et al., Phys.Lett.B76:239 (1978)]
IHEP_ITEP,2 [Vovenko et al., Sov.J.Nucl.Phys.30:528 (1979)]
IHEP_JINR,0 [Anikeev et al., Zeit.Phys.C70:39 (1996)]
SKAT,0 [Baranov et al., Phys.Rev.B81 255 (1979)]
MINOS,0 [Adamson et al., Phys.Rev.D81:072002 (2010)]
SciBooNE,0 [Nakajima et al., Phys.Rev.D83:012005 (2011)]
v290
v286



ν̄_μ CC inclusive
σ_ν/E_ν (1E-38 cm²/GeV²)
E_ν (GeV)
0
0.2
0.4
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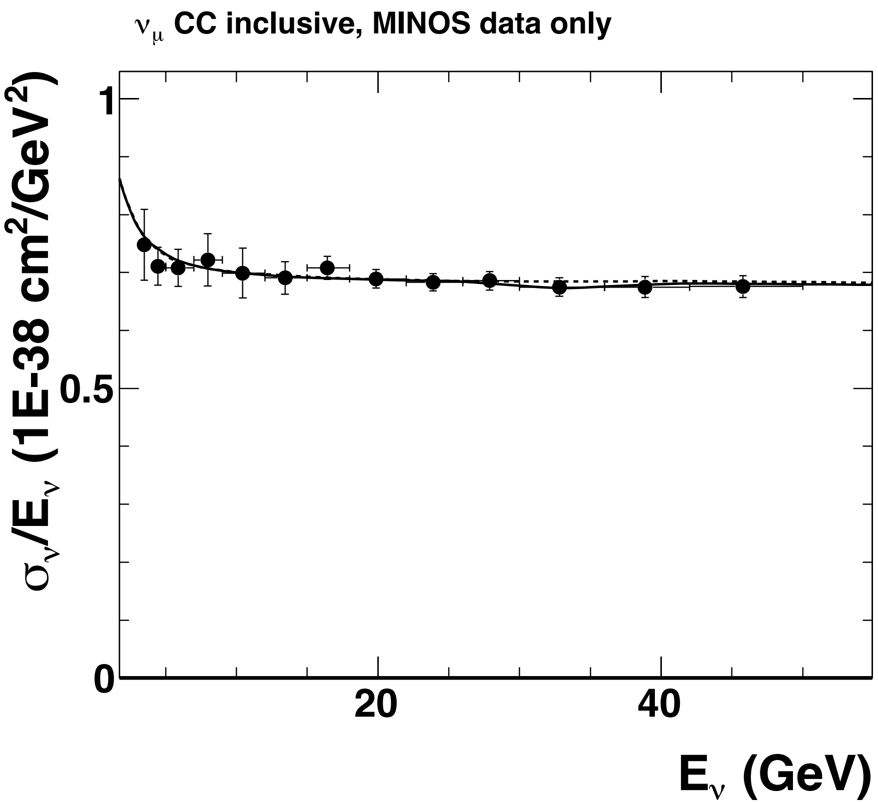
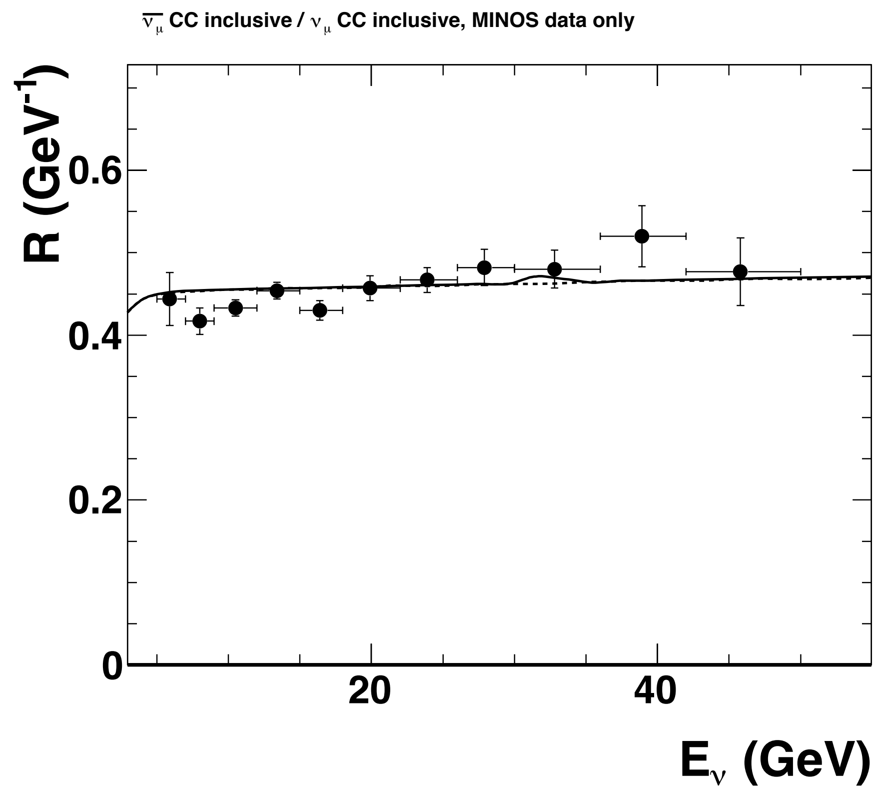
10²
BEBC,1 [Bosseti et al., Phys.Lett.B70:273 (1977)]
BEBC,3 [Colley et al., Zeit.Phys.C2:187 (1979)]
BEBC,6 [Bosetti et al., Phys.Lett.B110:167 (1982)]
BEBC,7 [Parker et al., Nucl.Phys.B232:1 (1984)]
BNL_7FT,1 [Fanourakis et al., Phys.Rev.D21:562 (1980)]
CCFR,3 [Seligman et al., Nevis Report 292 (1996)]
CHARM,1 [Jonker et al., Phys.Lett.B99:265 (1981)]
CHARM,5 [Allaby et al., Zeit.Phys.C38:403 (1988)]
FNAL_15FT,4 [Taylor et al., Phys.Rev.Lett.51:739 (1983)]
FNAL_15FT,5 [Asratyan et al., Phys.Lett.B137:122 (1984)]
Gargamelle,1 [Eichten et al., Phys.Lett.B46:274 (1973)]
Gargamelle,11 [Erriquez et al., Phys.Lett.B80:309 (1979)]
Gargamelle,13 [Morfin et al., Phys.Lett.B104:235 (1981)]
IHEP_ITEP,1 [Asratyan et al., Phys.Lett.B76:239 (1978)]
IHEP_ITEP,3 [Vovenko et al., Sov.J.Nucl.Phys.30:528 (1979)]
IHEP_JINR,1 [Anikeev et al., Zeit.Phys.C70:39 (1996)]
MINOS,1 [Adamson et al., Phys.Rev.D81:072002 (2010)]
v290
v286

2.9.0 vs. 2.8.6





MINOS,0 [Adamson et al., Phys.Rev.D81:072002 (2010)]

v290

v286

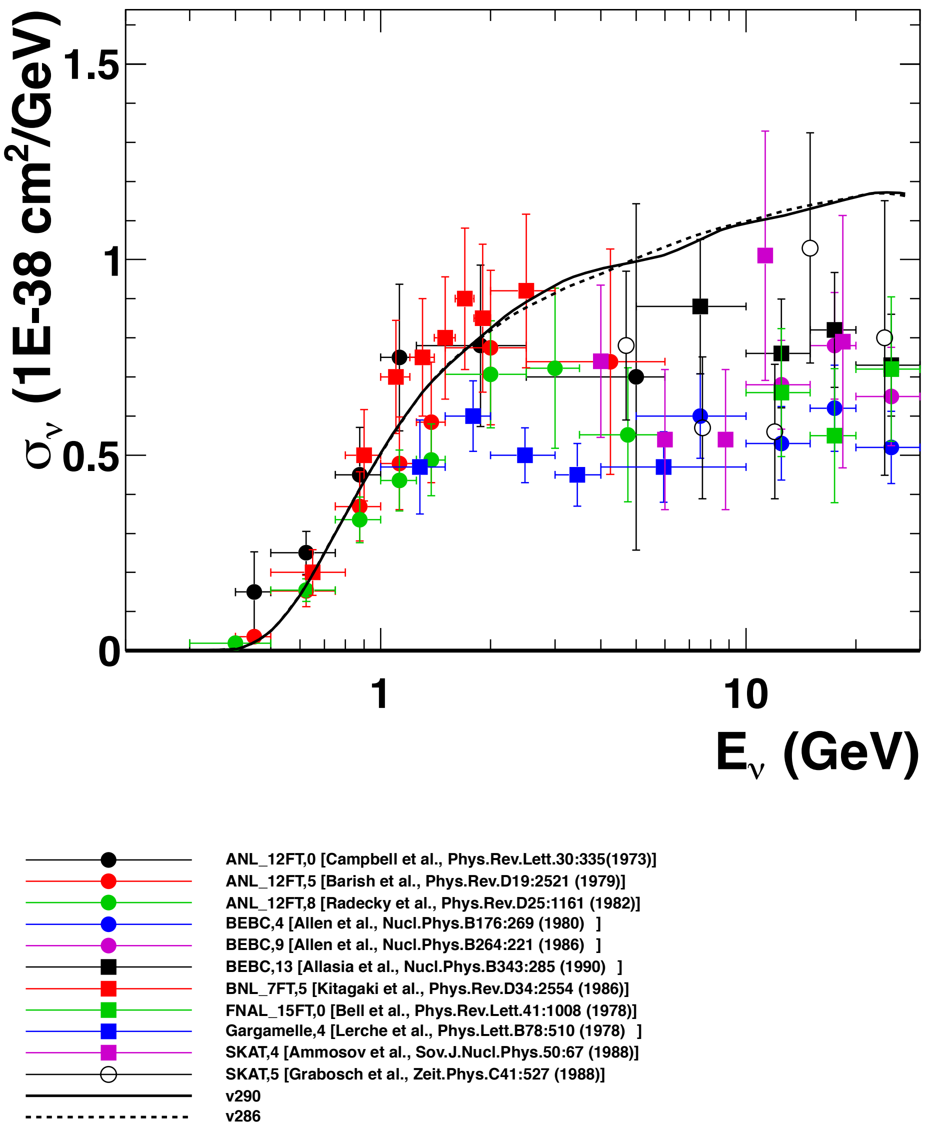
MINOS,2 [Adamson et al., Phys.Rev.D81:072002 (2010)]

v290

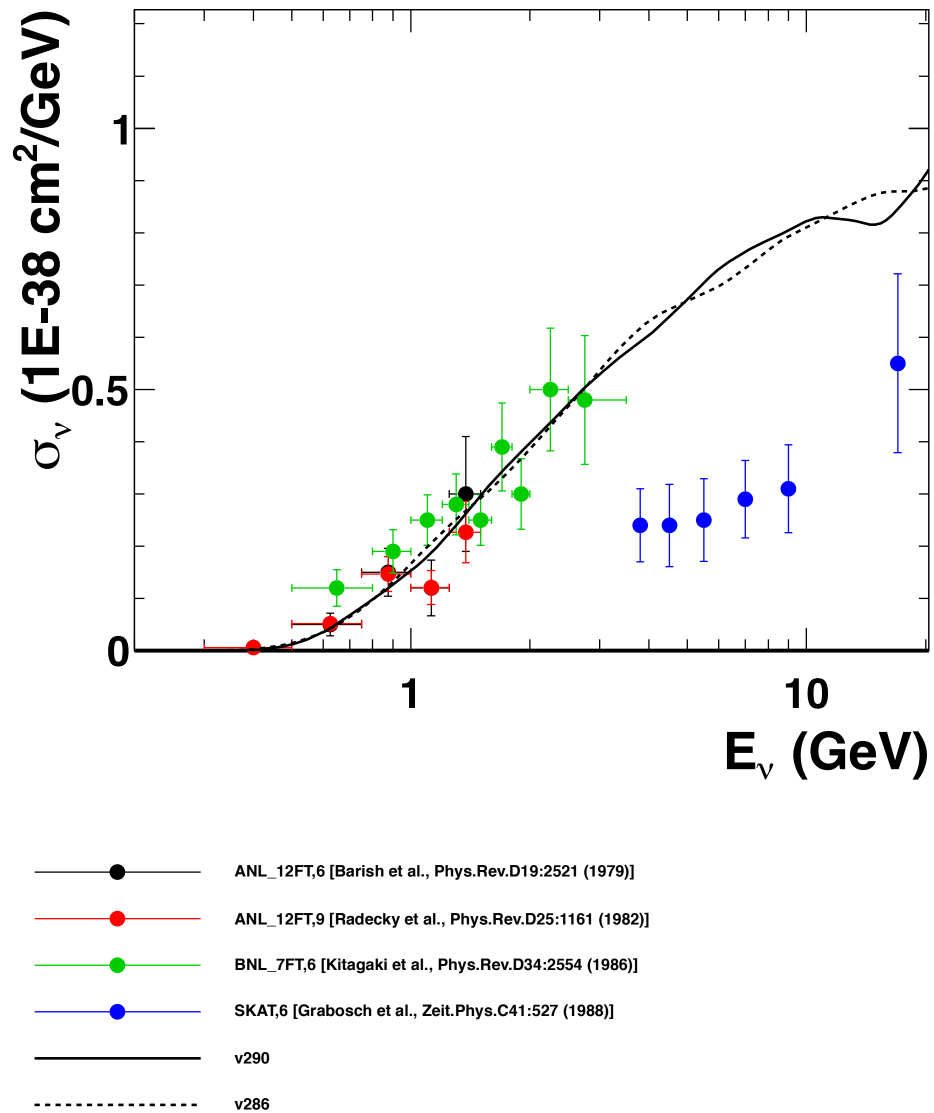
v286

2.9.0 vs. 2.8.6

ν_μ CC1π^+ ($\nu_\mu\, p \rightarrow \mu^-\, p\, \pi^+$)

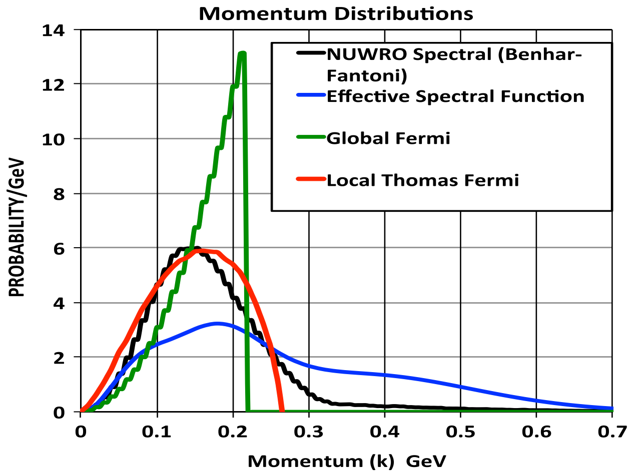


ν_μ CC1π^0 ($\nu_\mu\, n \rightarrow \mu^-\, p\, \pi^0$)

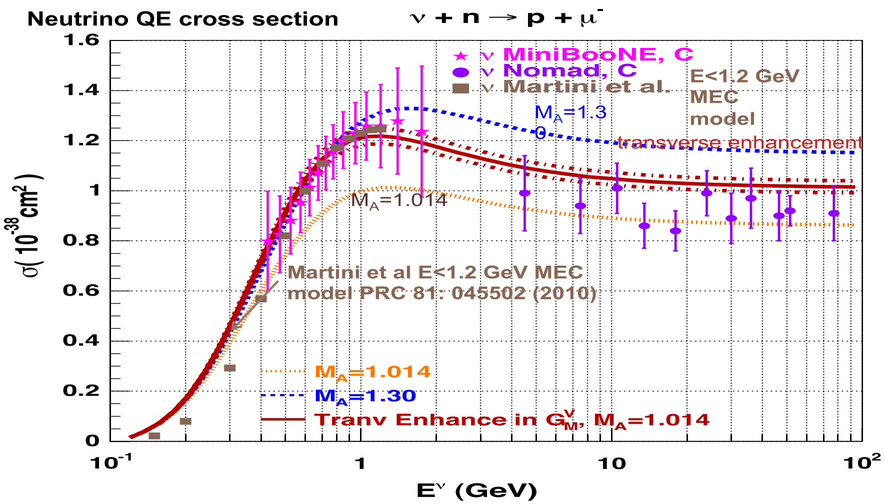


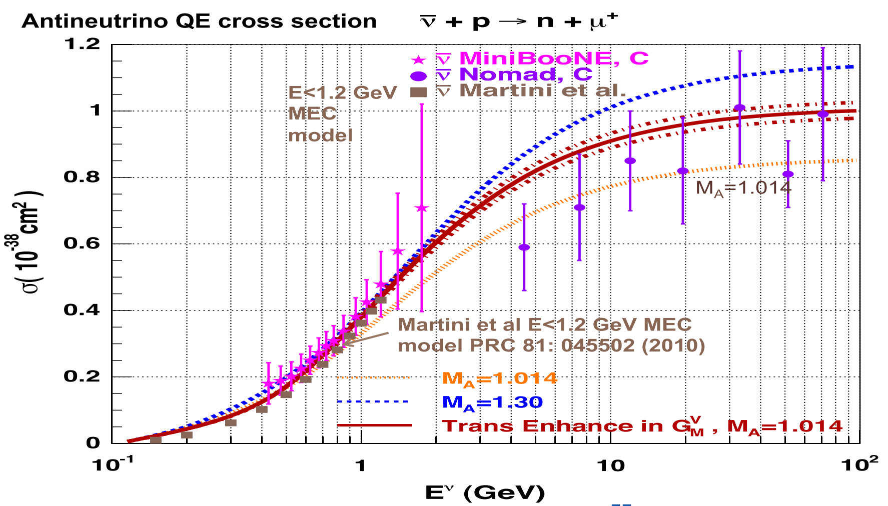
2.9/2.10: Effective Spectral Functions

- The Effective Spectral Function model combines a superscaling formalism together with hadronic energy sharing prescription to form a complete QE model.
  - An eight parameter spectral function is fit to the superscaling function extracted from electron scattering data (plus two parameters for binding energy and 2p2h fraction).
- Implemented by B. Coopersmith (also implemented Transverse Enhancement Model)



Bodek, Christy, Coopersmith EPJ C (2014) 74:3091





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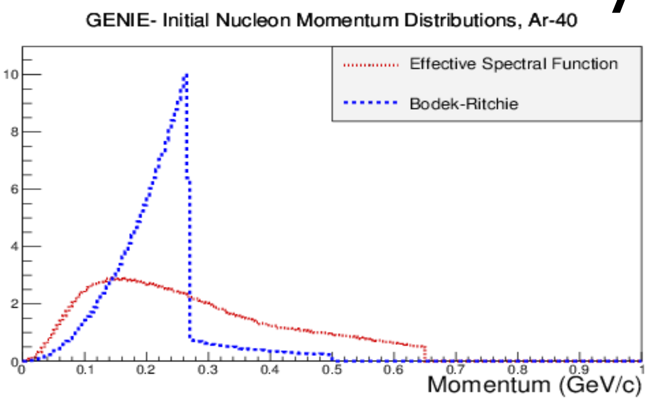
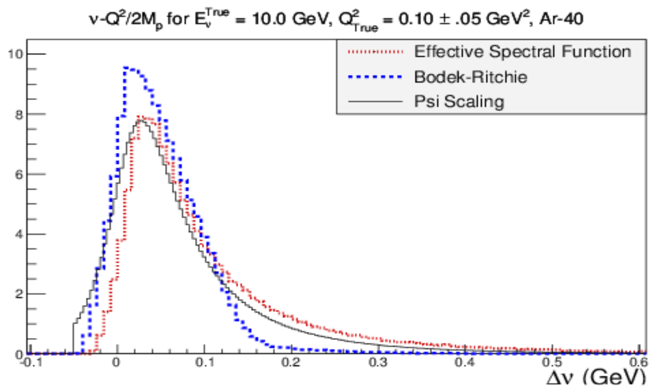
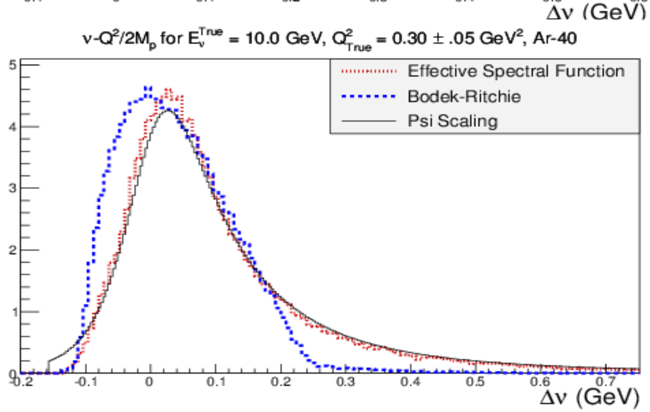
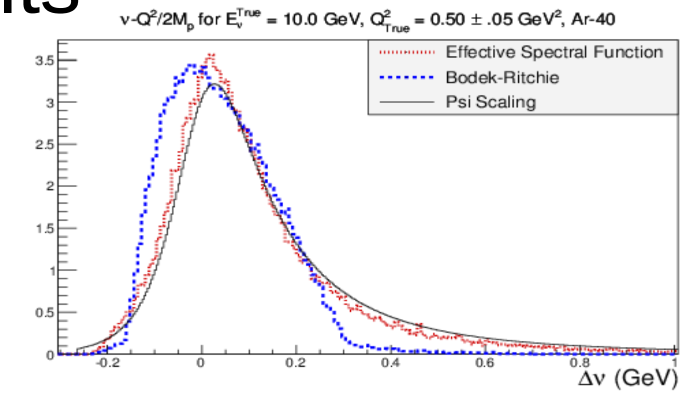
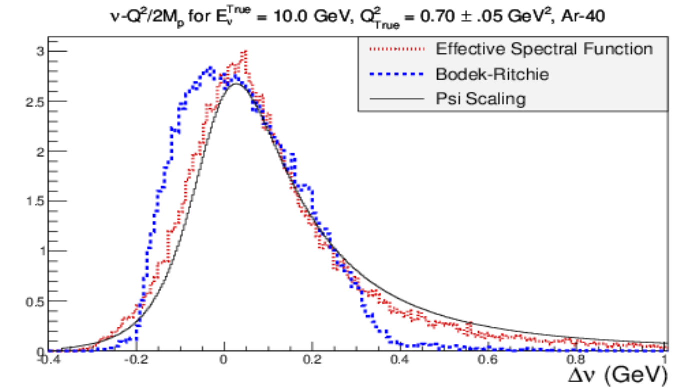
Ar-40 Results

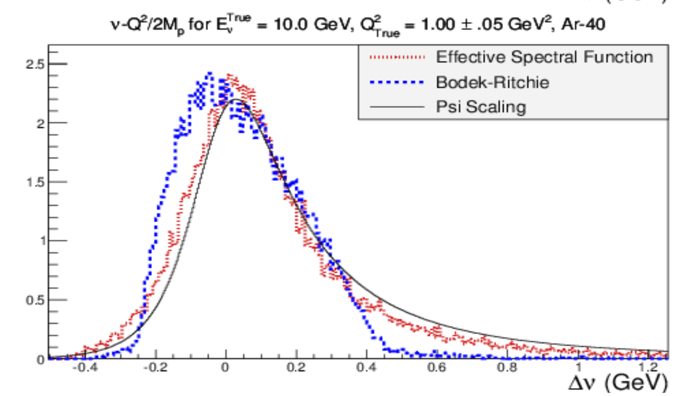










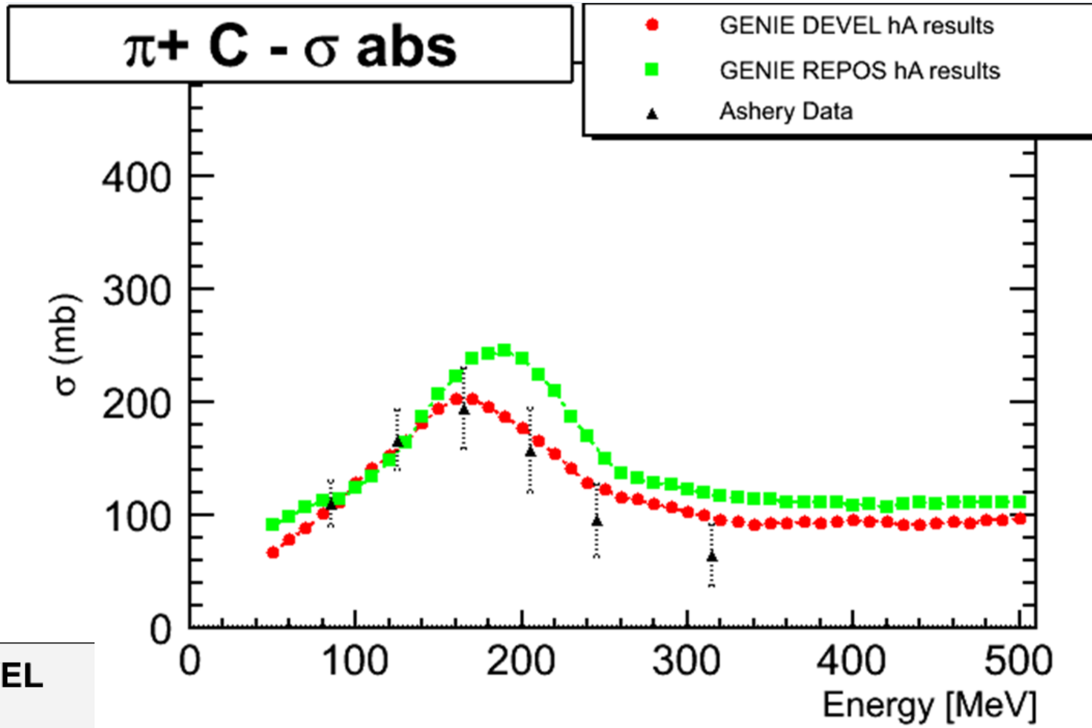


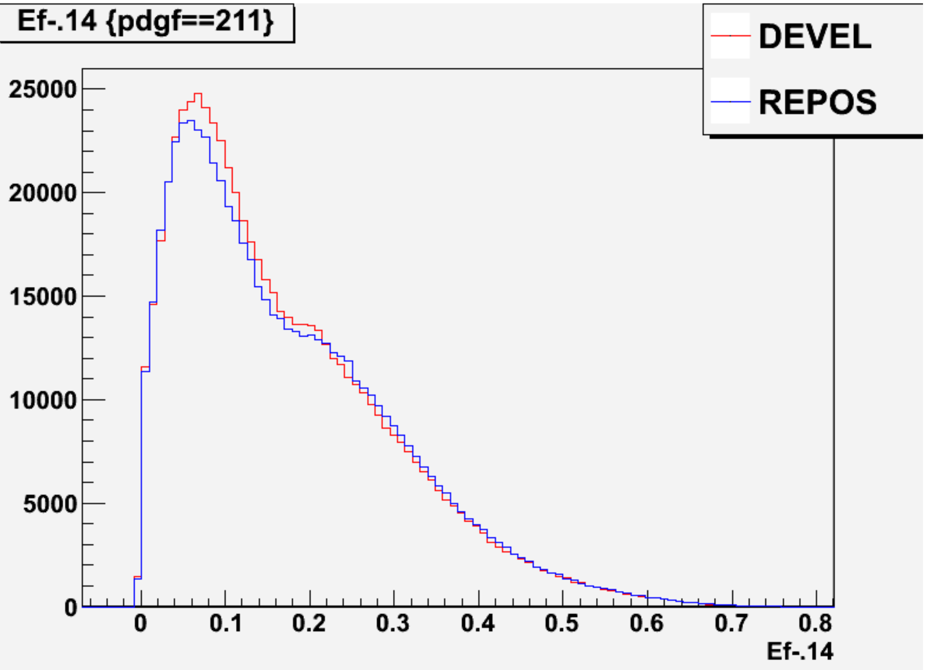
Brian Coopersmith- University of Rochester

2.9/2.10: Updated hA Model (FSI Model)

- Recall that in hA mode we parameterize a cascade with one effective interaction.
  - Easily re-weightable.
  - Good agreement with data.
- Previously we used data on iron and f(A) scaling.
  - Now including Li-7, C-12, Al-27, Fe-56, Nb-93, Bi-209
- Previously, all cross sections for different "fates" had an $A^{2/3}$ dependence - but this doesn't agree with data.
  - Now absorption scales as $A^{2/3+0.18}$, charge exchange as $A^{2/3}$, elastic as $A^{2/3 + 0.25}$, inelastic like $A^{2/3}$, pion production as $A^{2/3}$
  - Total cross section scales as $A^{2/3}$ (used to convert a fate cross section to a fraction)
- Implemented by N. Geary and S. Dytman

Better A dependent performance.

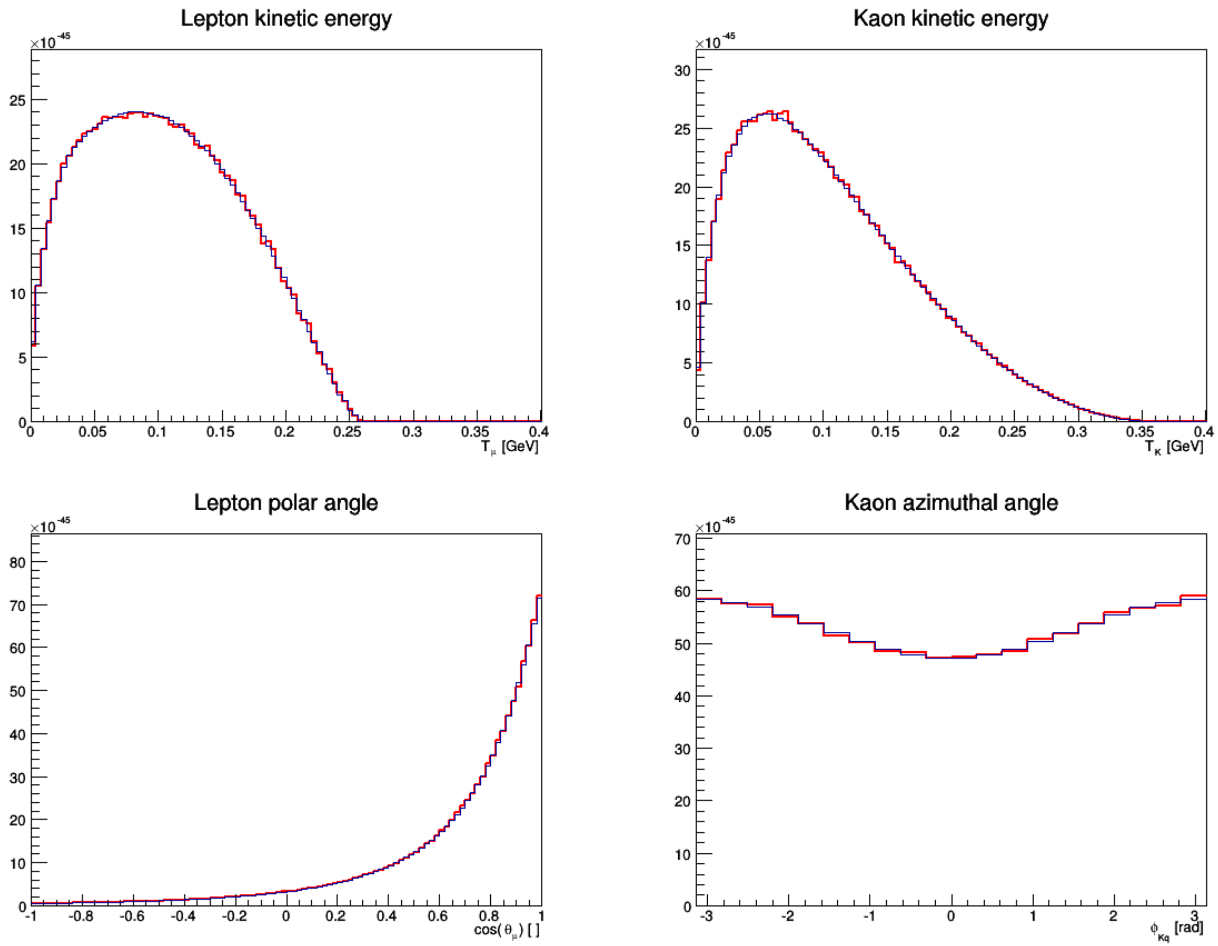




Shift to lower energy due to increased inelastics, more pions due to decreased (effectively) absorption.

2.9/2.10: Single Kaon Production

- Alam, Simo, Athar, and Vacas (PRD 82, 033001 (2010)).
- Implemented by C. Marshall and M. Nirkko



Blue histograms are from the a 4D integral based on the original paper and the red are from the GENIE implementation.

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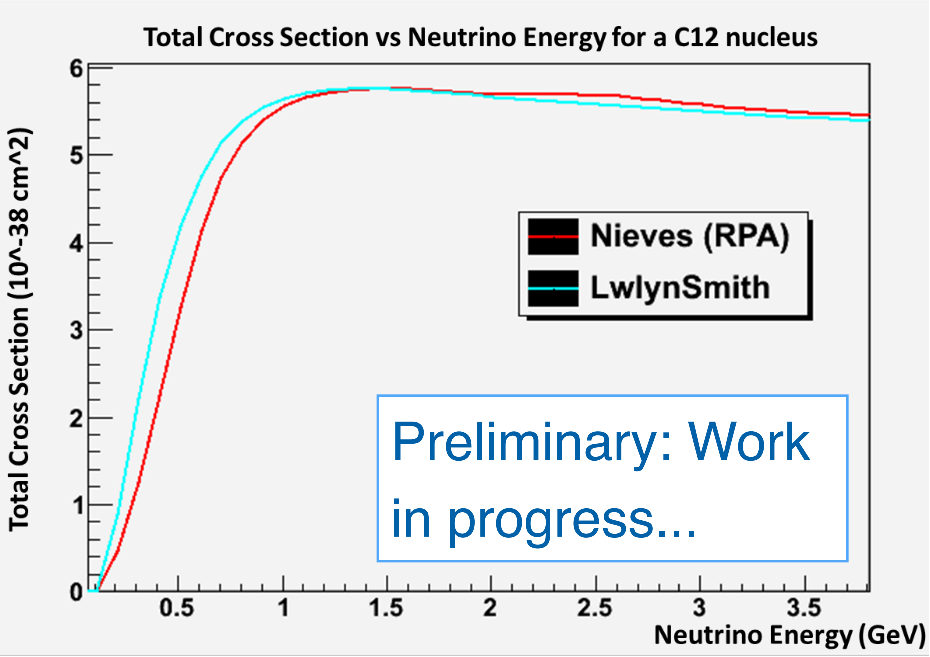
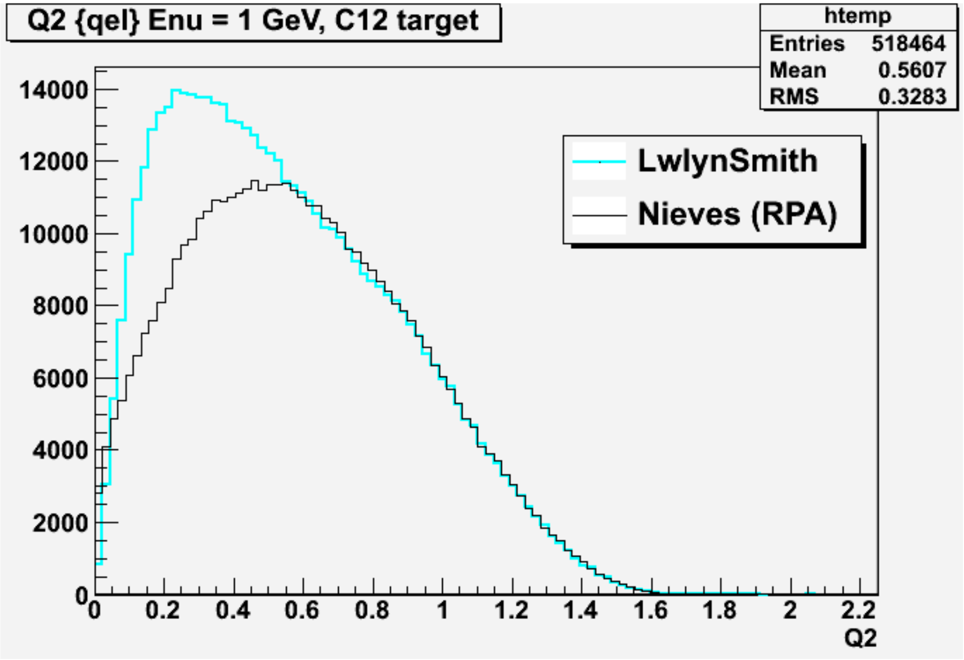
2.12: "Nieves CCQE with RPA"

- Potential replacement for current Llewelyn-Smith QEL
- Add RPA (long-range correlation)
- Use local Fermi Gas model for the nucleus (still under construction)
- Implemented by J. Johnston and S. Dytman

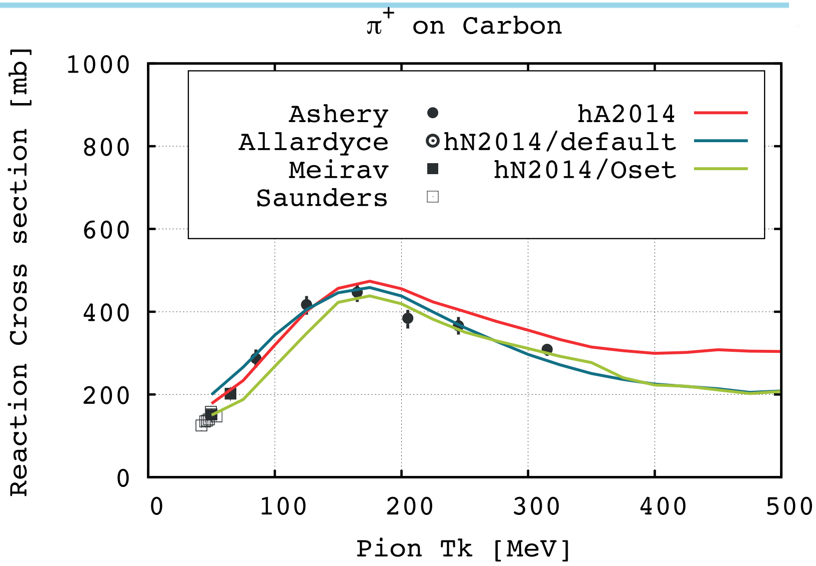


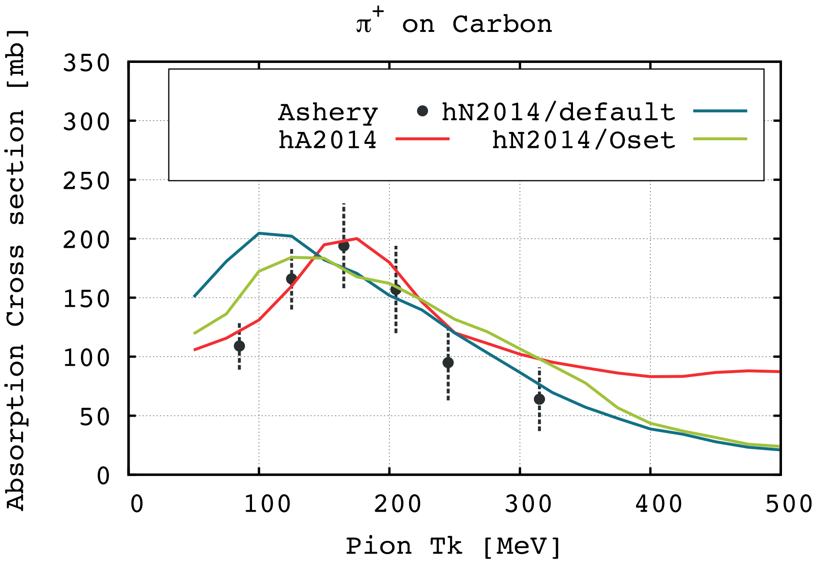


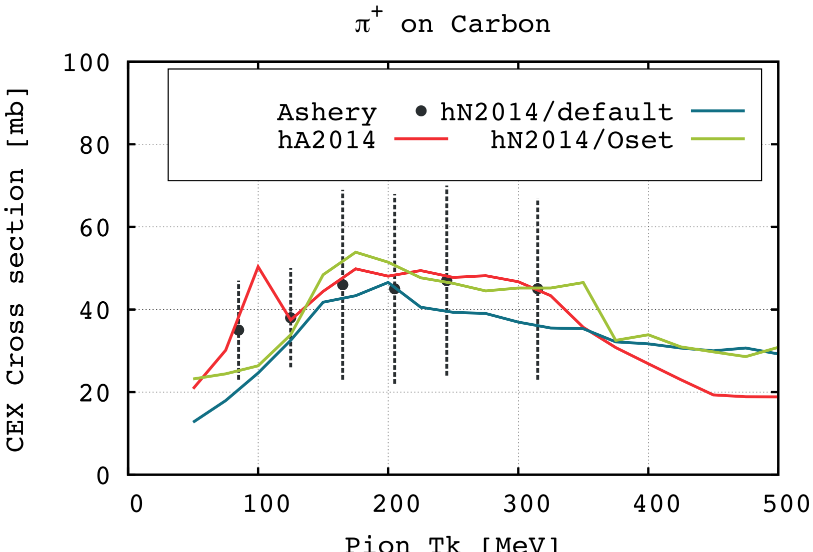
2.12: Oset FSI

Preliminary: Work in progress...

- E. Oset et al, Nucl. Phys. A484 (1998) 557-592
- E. Oset et al, Nucl. Phys. A468 (1987) 631
- Nuclear effects are introduced as modifications of the Δ width.
  - Plus many "hidden tricks" being worked through...
- GENIE hN pion model will be similar to NEUT snd NuWro.
- Implemented by T. Golan.







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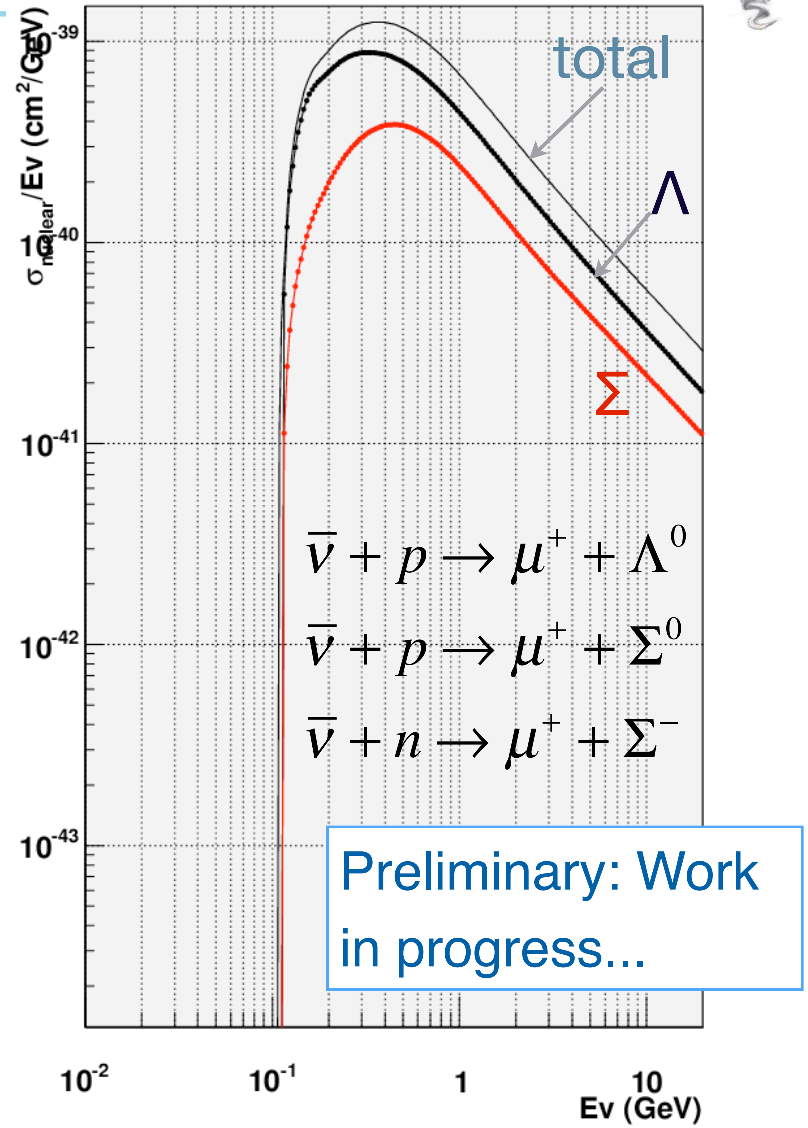
2.12: Quasielastic Hyperon Production

- Cabibo and Chilton, v136, N6B (1965)
- Pais, Ann. Phys. 63, 361 (1971)
- If we assume SU(3), we may write the p → Λ transition in terms of the form factors for the n → p transition.
- Implemented by J. Poage, E. Morrissey, H. Gallagher

$$\sigma_{\Delta S=1} \approx \tan^2 \theta_C \sigma_{QEL} = 0.05\sigma_{QEL}$$

$$\sigma_{\Lambda}/\sigma_{QEL}\,(10\text{ GeV}) = 0.038$$



Conclusions

- 2.9/2.10 is available.
- 2.12 is under construction with a loose "Summer" timetable.
- Work on 3.0 is also underway (building tuning and fitting infrastructure).
- We always welcome interested parties to collaborate / contribute!