Fermilab U.S. DEPARTMENT OF ENERGY Office of Science

GENIE User Forum

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Genie

UNIVERSAL NEUTRINO GENERATOR & GLOBAL FIT

GENIE updates

- Work toward the next release (v3.2) continues, with a number of improvements underway
  - **SuSAv2 QE+MEC model** (see S. Dolan's presentation today)
  - PYTHIA interface refactorization
  - Radiative corrections
  - Etc.
- **Important fix to an issue affecting CCQE splines**
  - Tunes using a local Fermi gas model (G18_10**x**) are affected

GENIE v3 CCQE differential cross section

- For all official GENIE model sets (except the historical default tune), kinematics are sampled in QELEventGenerator using a 6D differential cross section

$$d\sigma = \mathcal{N} \frac{G_F^2 \cos^2\theta_C}{8\,\pi^2\, E_{\mathbf{k}}\, E_{\mathbf{p}}\, E_{\mathbf{k}'}\, E_{\mathbf{p}'}} L_{\mu\nu}\, \tilde{A}^{\mu\nu}\, P(\mathbf{p}, E) \frac{\sqrt{1 + (1 - \cos^2\theta_0)(\gamma^2 - 1)}}{\left|\mathbf{v}_{\mathbf{k}'} - \mathbf{v}_{\mathbf{p}'}\right|} \left|\mathbf{k}_0'\right|^2 \Theta(|\mathbf{p}'| - k_F)\, d\cos\theta_0\, d\phi_0\, dE\, d^3\mathbf{p}$$

- **How do we integrate this to get splines?**

$$E_{\mathbf{p}} \equiv \sqrt{\mathbf{p}^2 + m_N^2}$$

  - The trick is to remember that the spectral function is a probability density:

$$\int P(\mathbf{p}, E)\, dE\, d^3\mathbf{p} = 1$$

  - This makes an MC integration technique convenient for handling the 4D nucleon piece of the phase space

  - Approach used in the NewQELXSec integrator developed for v3.0.4

Monte Carlo integration (a reminder)

Consider an arbitrary 1D function $f(x)$

Note that
$$\int_a^b f(x)\,dx = (b-a)\int_a^b \frac{1}{b-a} f(x)\,dx$$
$$= (b-a)\int_a^b P_{\text{uniform}}(x\,|\,x \in [a,b]) f(x)\,dx$$
$$= (b-a)\cdot\langle f(x)\rangle$$

where $\langle f(x)\rangle \approx \frac{1}{N}\sum_{k=1}^{N} f(x_k)$ and the x_k are sampled from

the uniform distribution above.

Application to CCQE total cross section integration in GENIE

By analogy with what we just saw, we can write

$$\frac{d\sigma}{d\cos\theta_0\, d\phi_0} = \int P(\mathbf{p}, E)\, F(\mathbf{p}, E)\, dE\, d^3\mathbf{p} = \left\langle F(\mathbf{p}, E) \right\rangle \approx \frac{1}{N} \sum_{k=1}^{N} F(\mathbf{p}_k, E_k)$$

where

$$F(\mathbf{p}, E) \equiv \mathcal{N} \frac{G_F^2 \cos^2\theta_C}{8\,\pi^2\, E_{\mathbf{k}}\, E_{\mathbf{p}}\, E_{\mathbf{k}'}\, E_{\mathbf{p}'}}\, L_{\mu\nu}\, \tilde{A}^{\mu\nu}\, \frac{\sqrt{1 + (1 - \cos^2\theta_0)(\gamma^2 - 1)}}{\left|\mathbf{v}_{\mathbf{k}'} - \mathbf{v}_{\mathbf{p}'}\right|}\, \left|\mathbf{k}'_0\right|^2 \Theta(|\mathbf{p}'| - k_F)$$

and the nucleon variables are drawn for each trial from the spectral function.

We can get the total cross section by integrating over the lepton angles:

$$\sigma = \int \left(\frac{d\sigma}{d\cos\theta_0\, d\phi_0} \right) d\cos\theta_0\, d\phi_0 \approx \frac{1}{N} \sum_{k=1}^{N} \left(\int F(\mathbf{p}_k, E_k)\, d\cos\theta_0\, d\phi_0 \right)$$

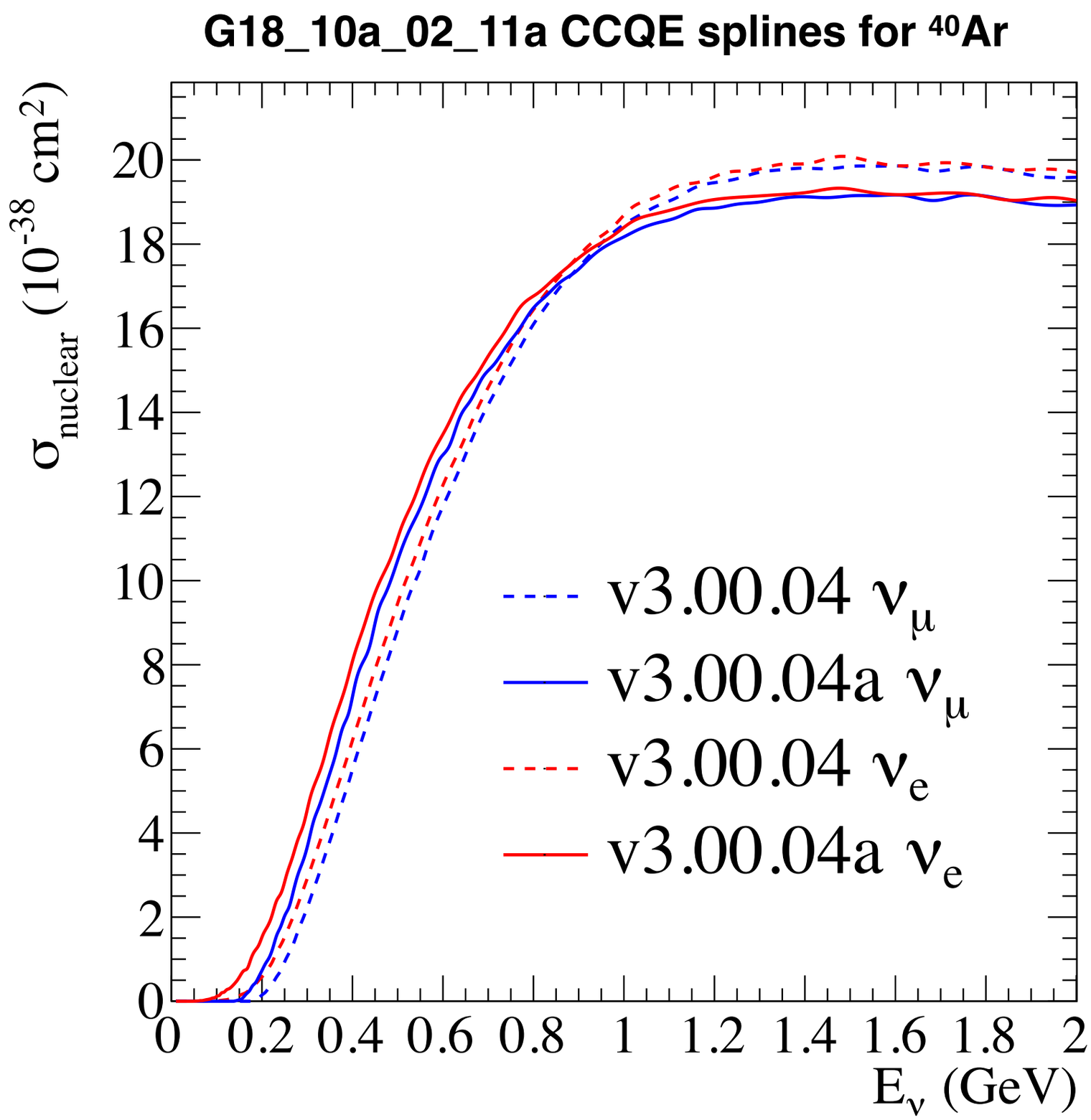
GENIE v3.0.4 integration problem

$$\sigma = \int \left(\frac{d\sigma}{d\cos\theta_0\, d\phi_0} \right) d\cos\theta_0\, d\phi_0 \approx \frac{1}{N} \sum_{k=1}^{N} \left(\int F(\mathbf{p}_k, E_k)\, d\cos\theta_0\, d\phi_0 \right)$$

- For the local Fermi gas model, the initial nucleon 3-momentum $\mathbf{p}$ is a function of its radial position, as is the Fermi momentum k_F and the Coulomb potential used for corrections in the Nieves CCQE model
- While sampling initial nucleons to do the MC integration, v3.0.4 fails to set the radius correctly, and a default value of $r = 0$ is used instead.
- This leads to a value of k_F that is constant and too high, shifting up the threshold and suppressing the total cross section at low energies due to excessive Pauli blocking

Fixed "v3.0.4a" splines

- Radius bug is now fixed on the Generator master branch on GitHub
- The collaboration has produced **new official splines** ("v3.0.4a") intended for use with the v3.0.4 release
  - Problem occurred in spline integrator only, so consistency with event generation is preserved
  - Old splines removed from GENIE website, officially deprecated



Where to find the fixed splines

Genie Ever

Home

Mission statement
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Project incubator

Physics & user manual
Document database

Slack workspace

User mailing list
Developer mailing list

GitHub organization page

Get started
GENIE course

News

Open genie-mc.org in your browser

Click on the “associated data releases” link

Where to find the fixed splines

Clicking on the v3_00_04a folder will take you to download links for the new sets of splines

v3_00_04	22 elements
v3_00_04_rc	1 elements
v3_00_04a	15 elements
v3_0_0beta4	1 elements

Name	Last modification	Size
genie_xsec-3.00.04a-noarch-G0000b00000-k250-e1000.tar.bz2	2 weeks ago	298 MB
genie_xsec-3.00.04a-noarch-G1801a00000-k250-e1000.tar.bz2	2 weeks ago	302 MB
genie_xsec-3.00.04a-noarch-G1801a0211a-k250-e1000.tar.bz2	2 weeks ago	302 MB
genie_xsec-3.00.04a-noarch-G1801b00000-k250-e1000.tar.bz2	2 weeks ago	302 MB
genie_xsec-3.00.04a-noarch-G1801b0211a-k250-e1000.tar.bz2	2 weeks ago	302 MB
genie_xsec-3.00.04a-noarch-G1802a00000-k250-e1000.tar.bz2	2 weeks ago	302 MB
genie_xsec-3.00.04a-noarch-G1802a0211a-k250-e1000.tar.bz2	2 weeks ago	302 MB
genie_xsec-3.00.04a-noarch-G1802b00000-k250-e1000.tar.bz2	2 weeks ago	302 MB
genie_xsec-3.00.04a-noarch-G1802b0211a-k250-e1000.tar.bz2	2 weeks ago	302 MB
genie_xsec-3.00.04a-noarch-G1810a00000-k250-e1000.tar.bz2	2 weeks ago	298 MB
genie_xsec-3.00.04a-noarch-G1810a0211a-k250-e1000.tar.bz2	2 weeks ago	297 MB

Where to find the fixed splines

The old v3_00_04 folder now contains warnings that the old splines have been deprecated

v3_00_04	22 elements
v3_00_04_rc	1 elements
v3_00_04a	15 elements
v3_0_0beta4	1 elements

One old set of v3.0.4 splines has been **temporarily** retained at the request of MicroBooNE

Name	Last modification	Size
genie_xsec-3.00.04-noarch-G1810a0211a-k250-e1000.tar.bz2	6 days ago	297 MB
IMPORTANT_NOTE	1 week ago	273 B
SERIOUSLY_THIS_ISNT_THE_FILE_YOU_WANT	6 days ago	273 B
USE_v3_00_04a_VERSION_FILES	1 week ago	273 B

Do not use these.