Resonances at *Genie*

NuSTEC Workshop on
Neutrino-Nucleus π Production in the Resonance Region
2-5 October 2019
University of Pittsburgh

Thank you: Steve Dytman, Julia Tena Vidal, Igor Kakorin and Marco Roda

Adi Ashkenazi

Resonances in GENIE

GENIE has incorporated **Rein-Sehgal (RS)**

- 18 resonances
- Axial and Vector Form Factors are dipole form.
- Resonances $W < 1.7$ GeV , DIS $W > 1.7$ GeV
- Non resonant background - Bodek Yang of $I = 1/2$ added incoherently
- Corrected Δ to $N\gamma$ and non isotropic decay

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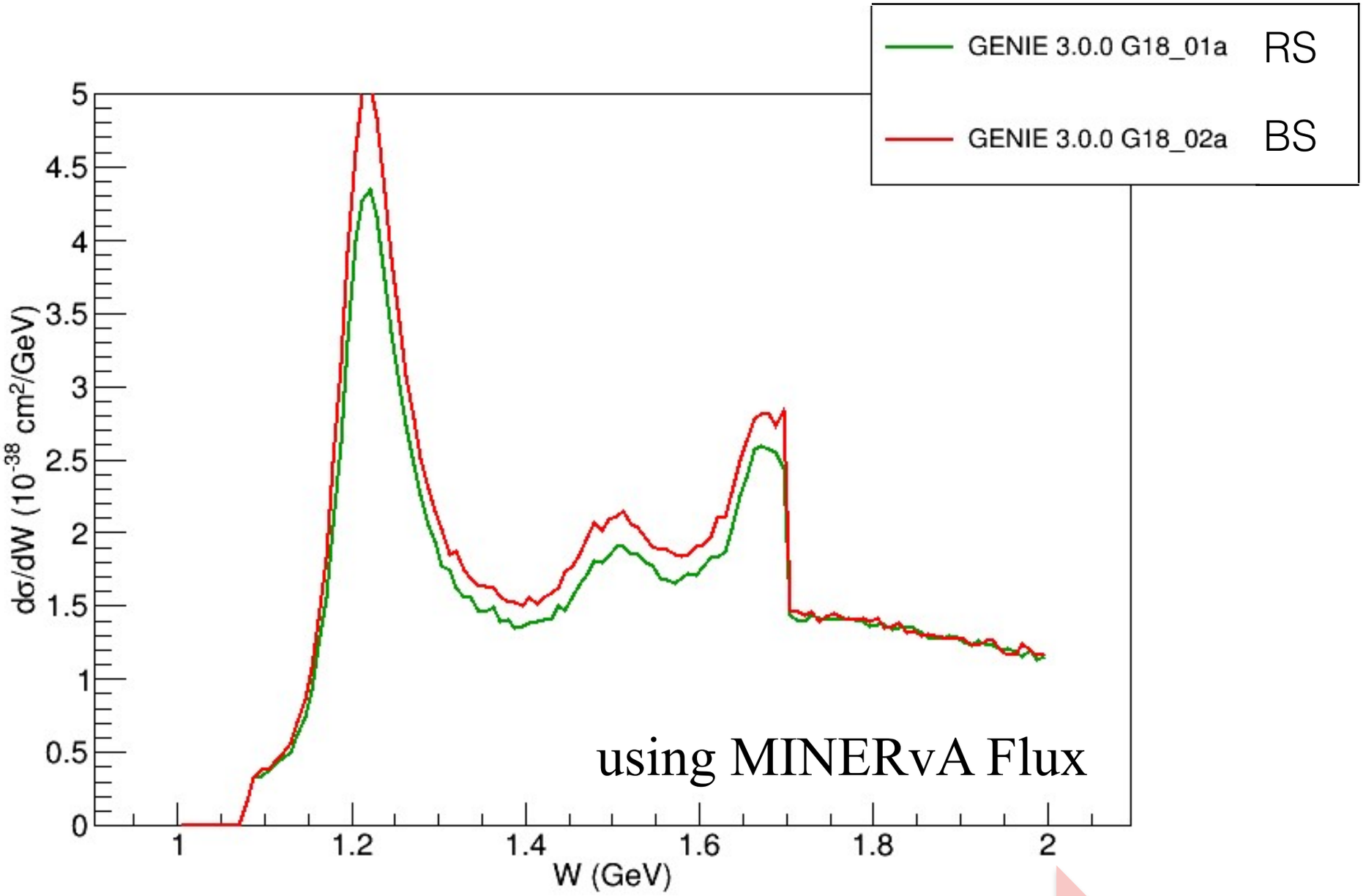
and moved to **Berger-Sehgal (BS)** see K.S. Kuzmin talk from yesterday

All of the above +

- Non zero m_μ
- Final state muon can have both helicities
- Improved Form Factors
  - Normalisation factors inherited from NEUGEN not updated
  - Tuning obtained with 2016 PDG parameters
  - Does not take into account interference terms

Resonances in GENIE RS vs BS

Overall increase in due to new Form Factors



RES+ SIS | DIS no RES

SIS - Shallow Inelastic Scattering in GENIE

The non resonant background proportional to Bodek-Yang DIS

Implemented in the same manner for BS and RS

$$\frac{d^2\sigma^{DIS}}{dQ^2dW} = \frac{d^2\tilde{\sigma}^{DIS}}{dQ^2dW} \cdot \Theta(W - W_{cut}) + \underbrace{\frac{d^2\tilde{\sigma}^{DIS}}{dQ^2dW} \cdot \Theta(W_{cut} - W) \cdot \sum_m f_m}_{\text{Non-Resonant Background: Scaled DIS}}$$

f_m multiplicity functions $= r_m \times P_m^{had}$

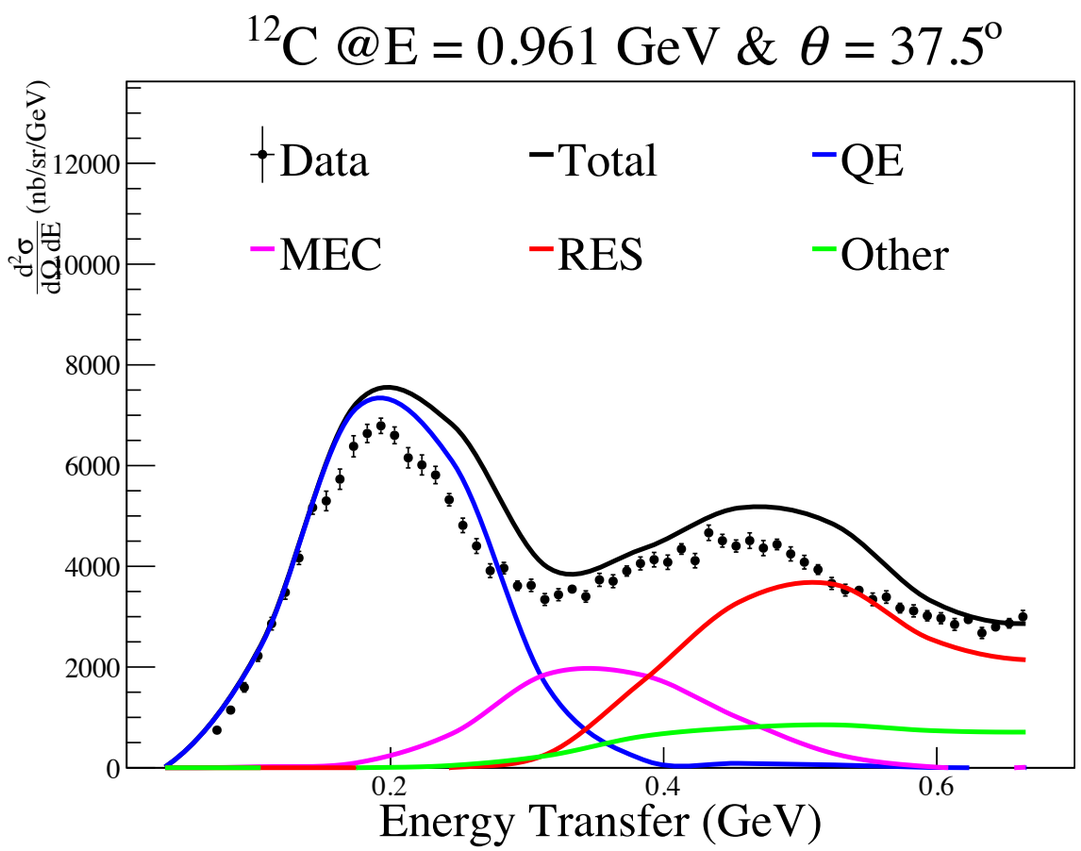
r_m is a tuneable ad hoc parameter depending on:

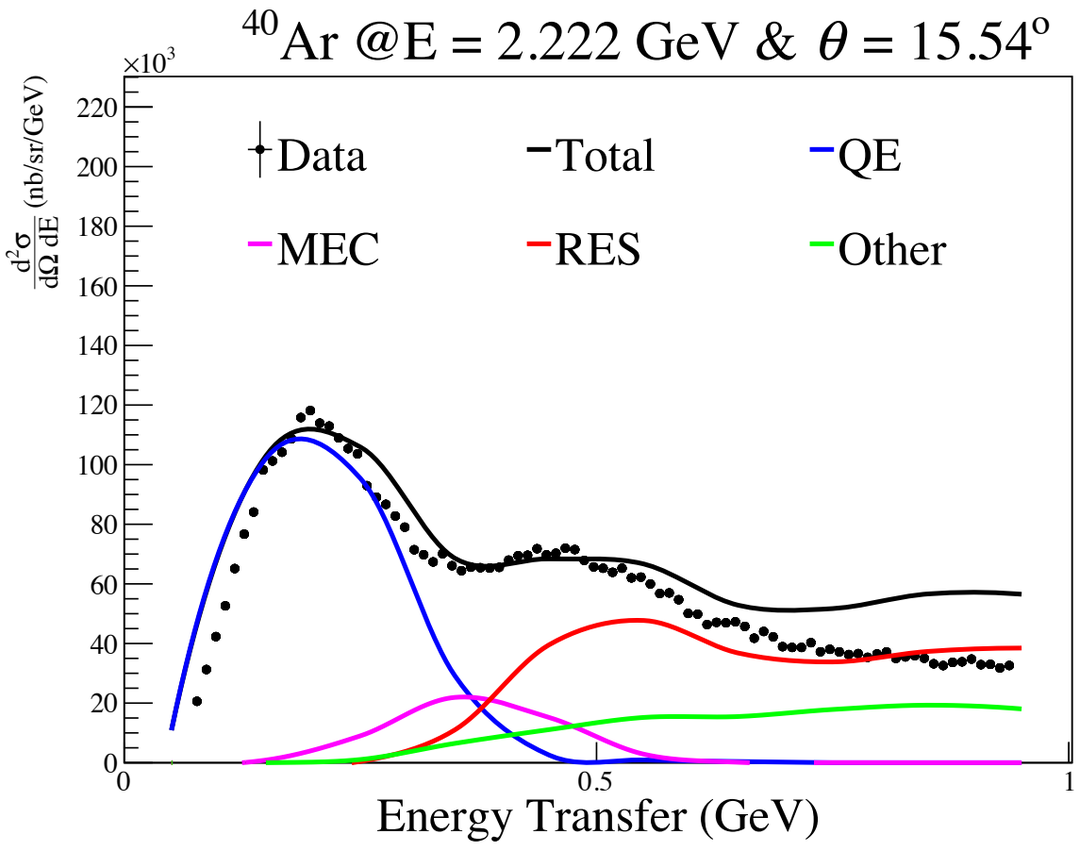
- neutrino flavour
- multiplicity of final state
- initial state nucleon

P_m^{had} is the probability of the final state m obtained from hadronization model

Resonances in GENIE - Electron Inclusive

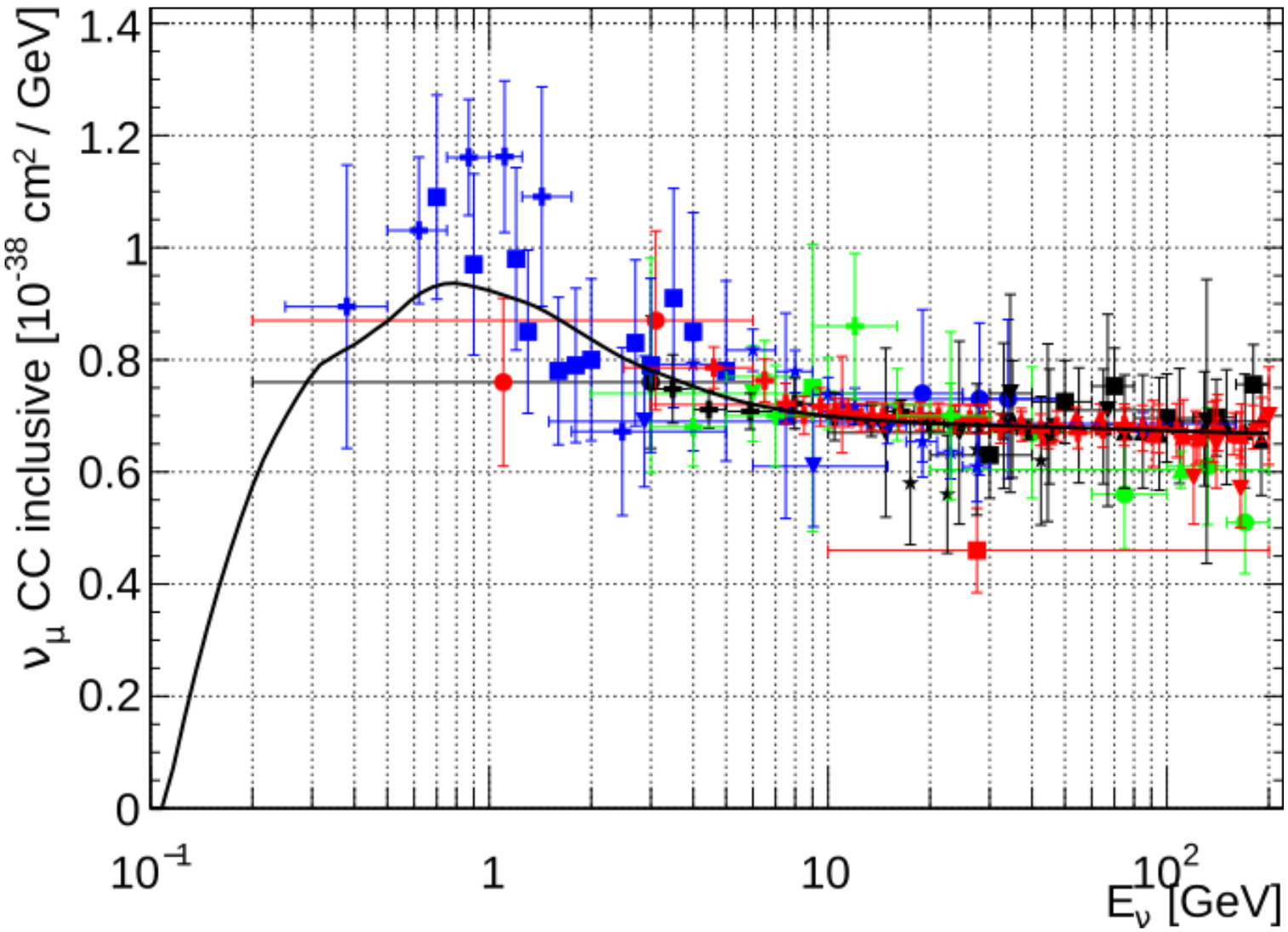
G18_02a BS





Resonances in GENIE - Neutrino Inclusive

G00_00a

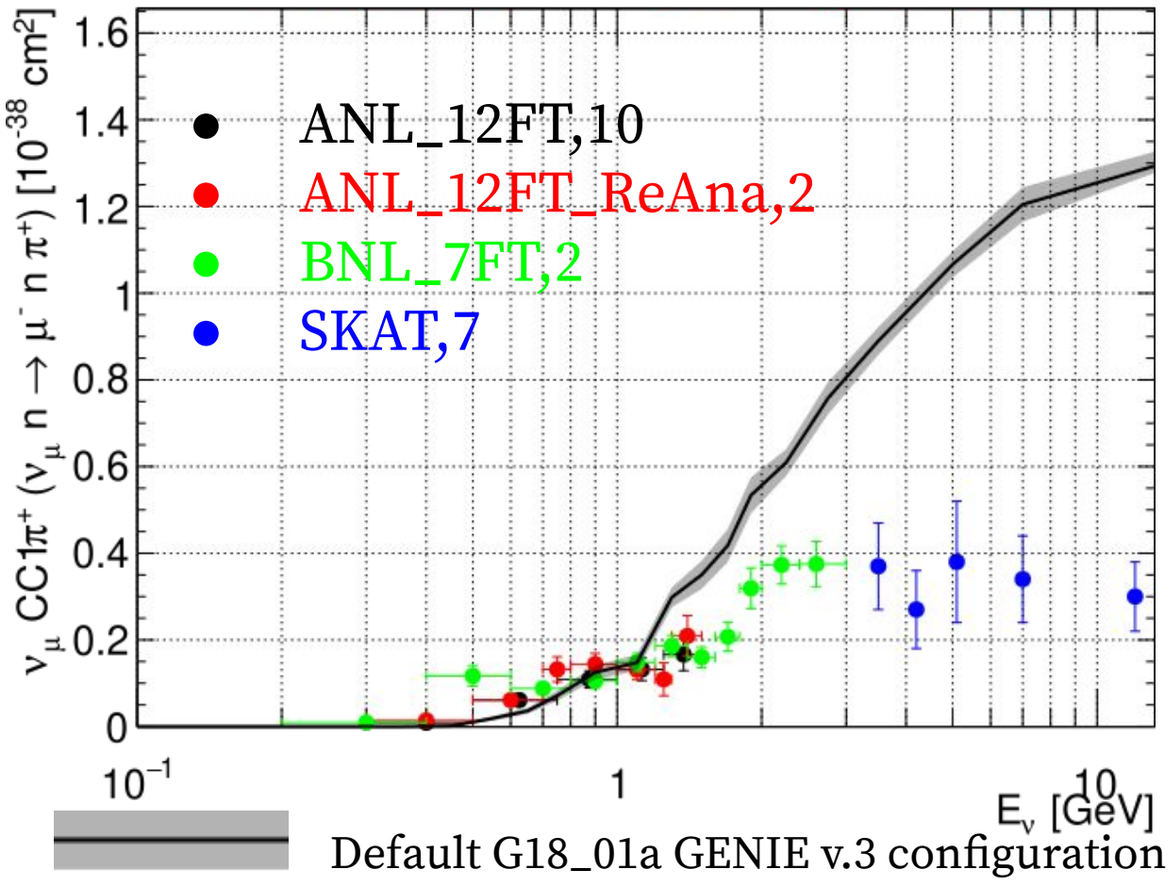


* Default tune was driven by MINOS data

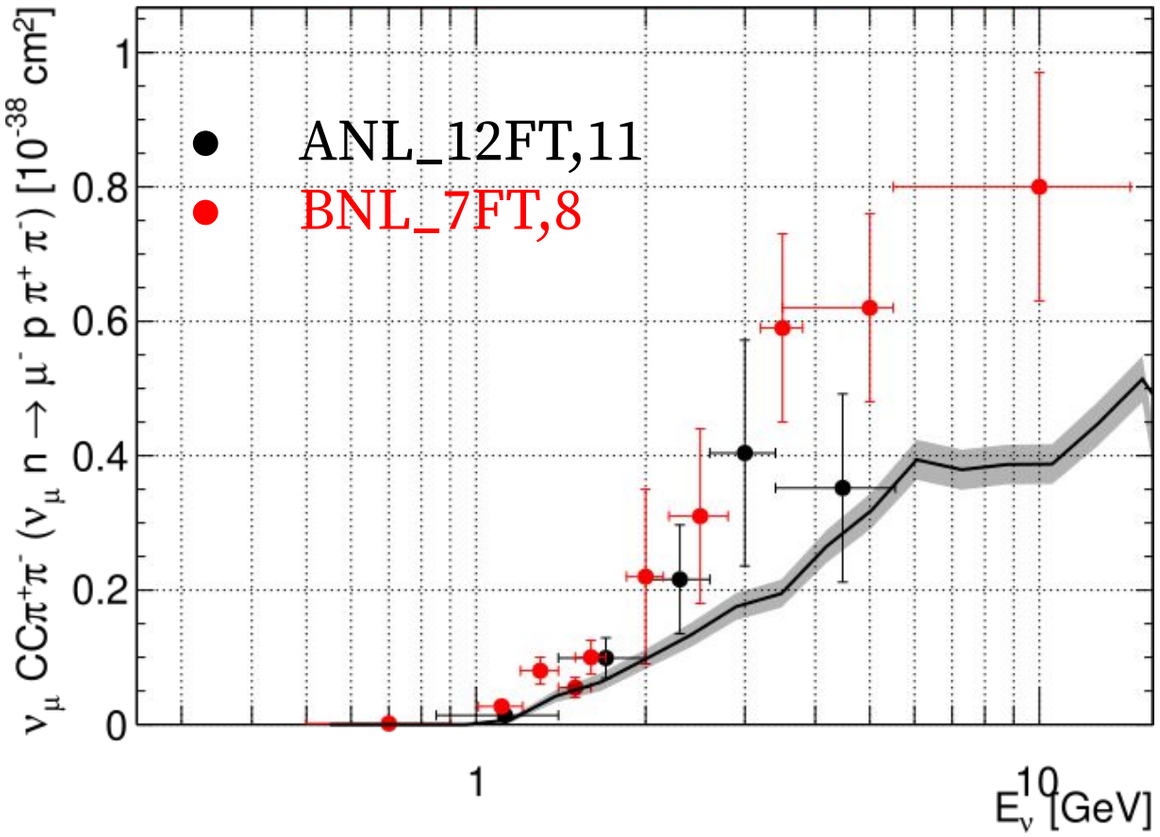
Resonances in GENIE - Neutrino Exclusive

G00_01a

Over predicting one pion production under predicting two pions



CC1π^+



CC$\pi^+\pi^-$

GENIE tune - SIS Region

Julia Tena Vidal

To address tensions between inclusive and exclusive data preform tune:

Using Inclusive, 1π and 2π CS from deuterium targets at:

ANL_12FT*

BNL_7FT*

FNAL

BEBC

Tuning 8 parameters in the SIS region:

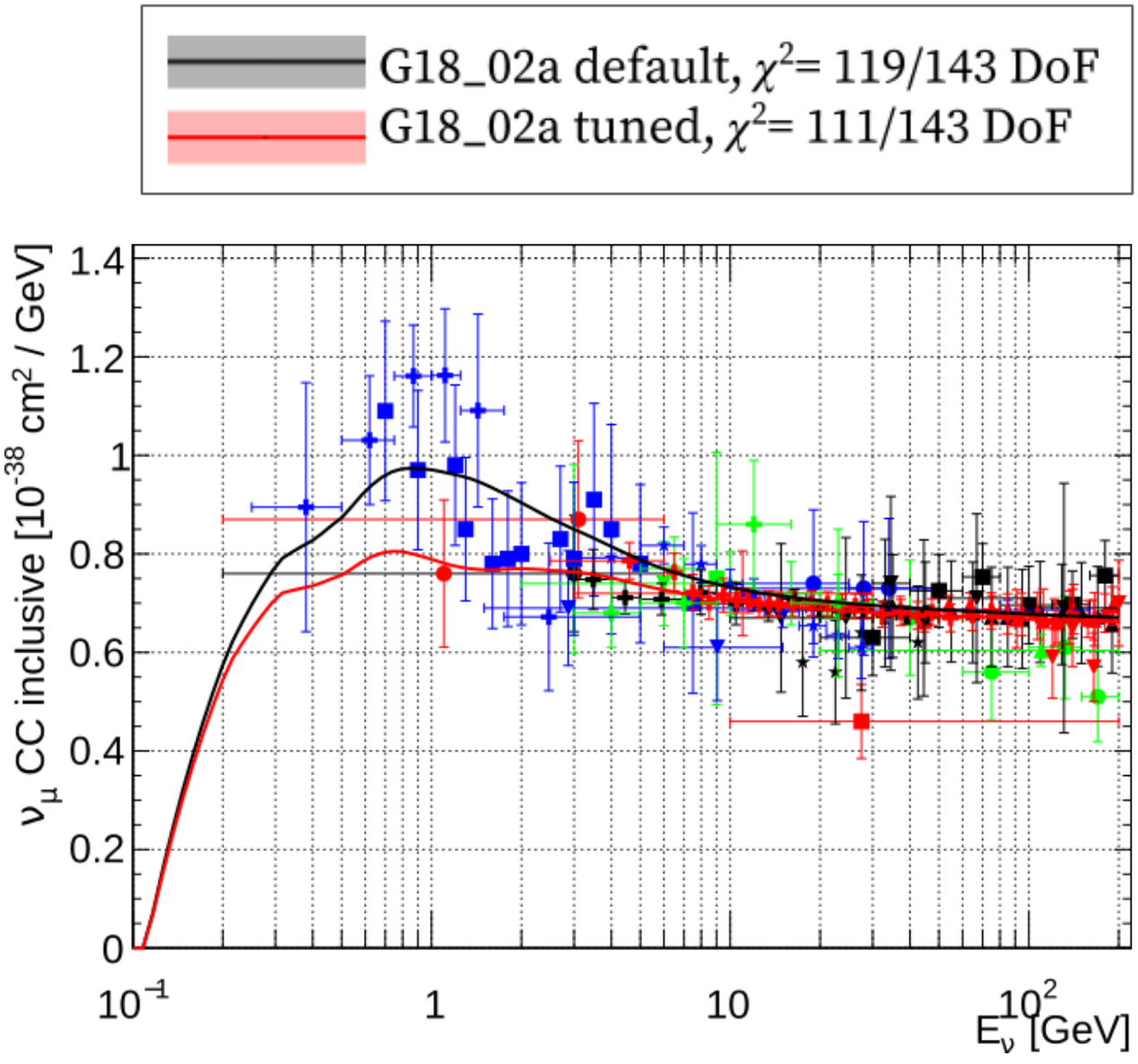
M_A^{res} RES-XSecScale

W_{cut} R_m

DIS-XSecScale

GENIE tune - SIS Region

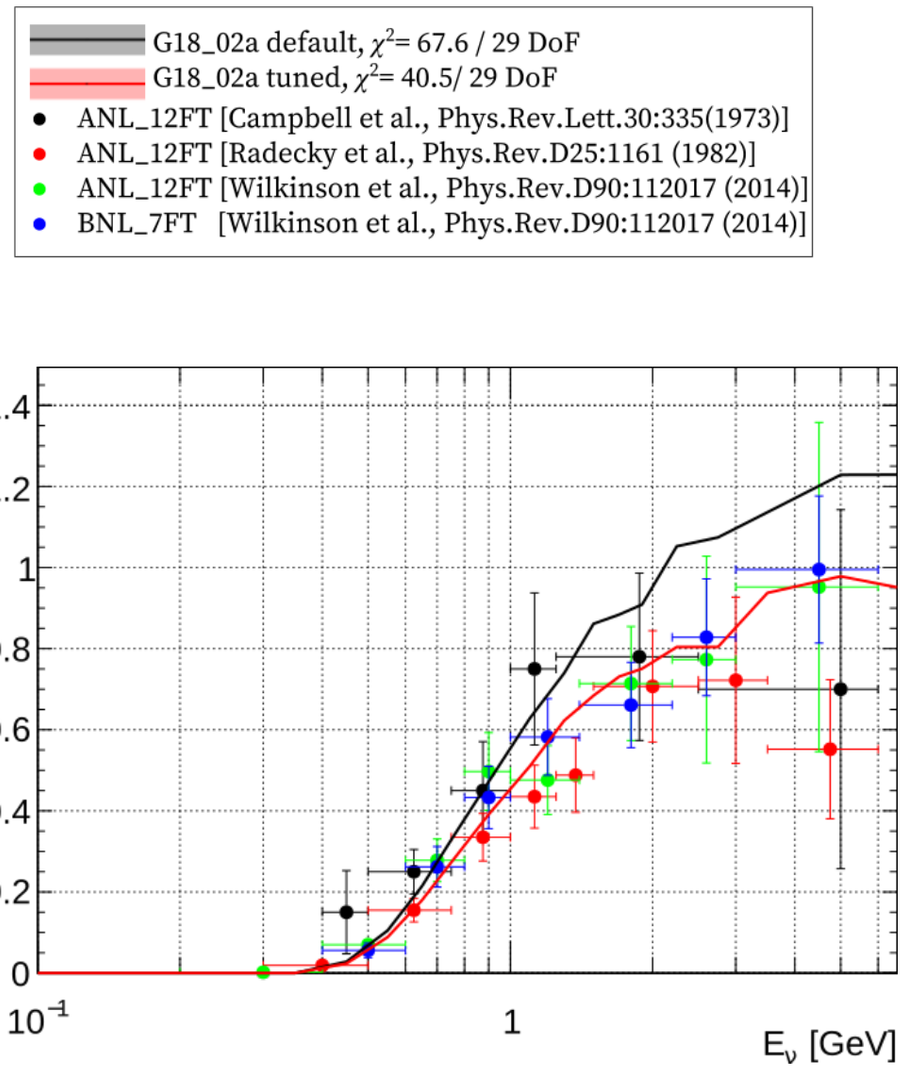
Julia Tena Vidal



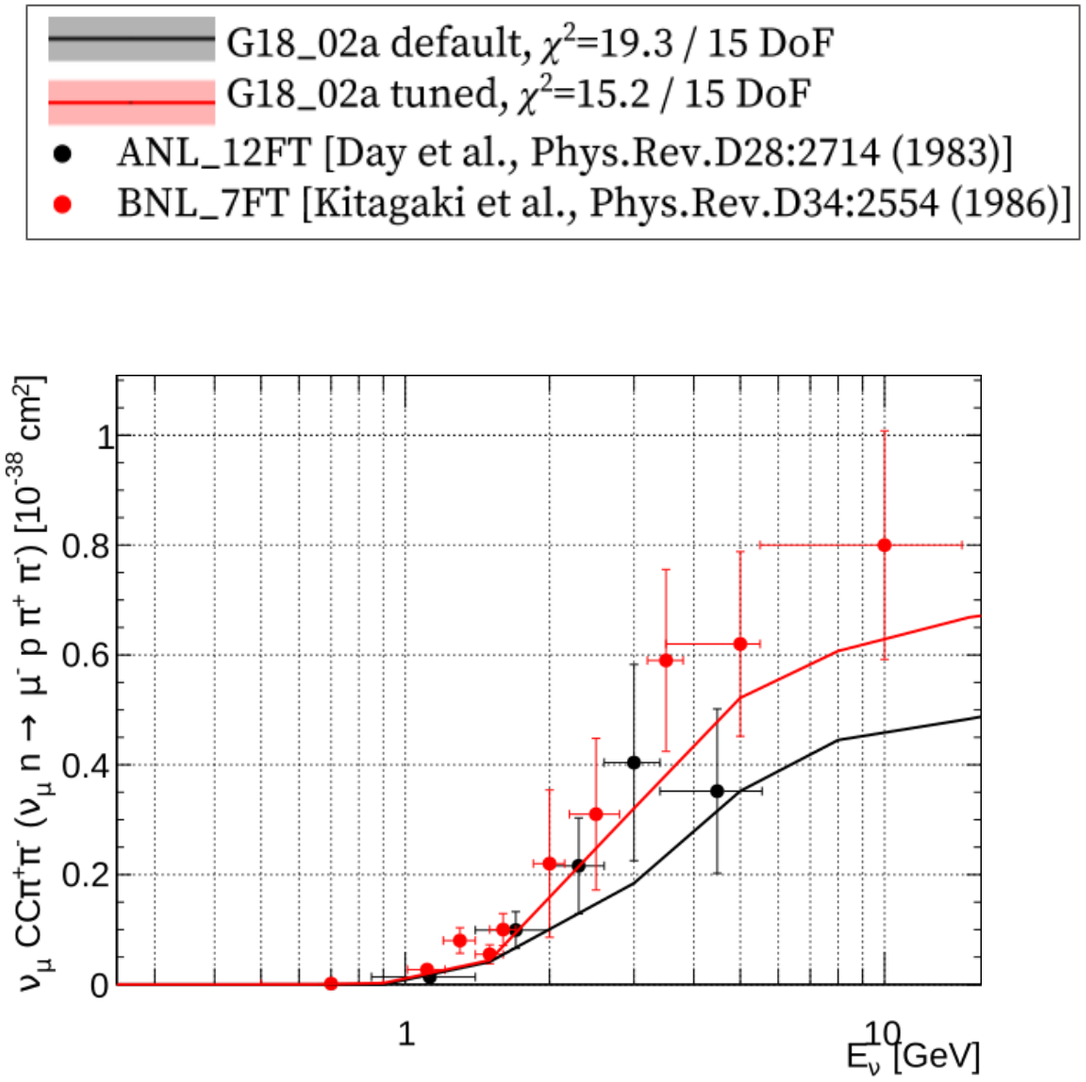
G18_02a default (black) and tuned (red) vs ν_μ CC inclusive. Just BEBC, BNL_7FT and FNAL data was used for the tune. For these datasets, $\chi^2_{default} = 18.8/26$ DoF, $\chi^2_{tuned} = 15.5/26$ DoF.

GENIE tune - SIS Region

Julia Tena Vidal



G18_02a default (black) and tuned (red) vs ν_μ CC $1\pi^+$ production data on proton. Just the ReAnalized data has been used. For these detasets, $\chi^2_{default} = 30.3/15$ DoF and $\chi^2_{default} = 16.85/15$ DoF.

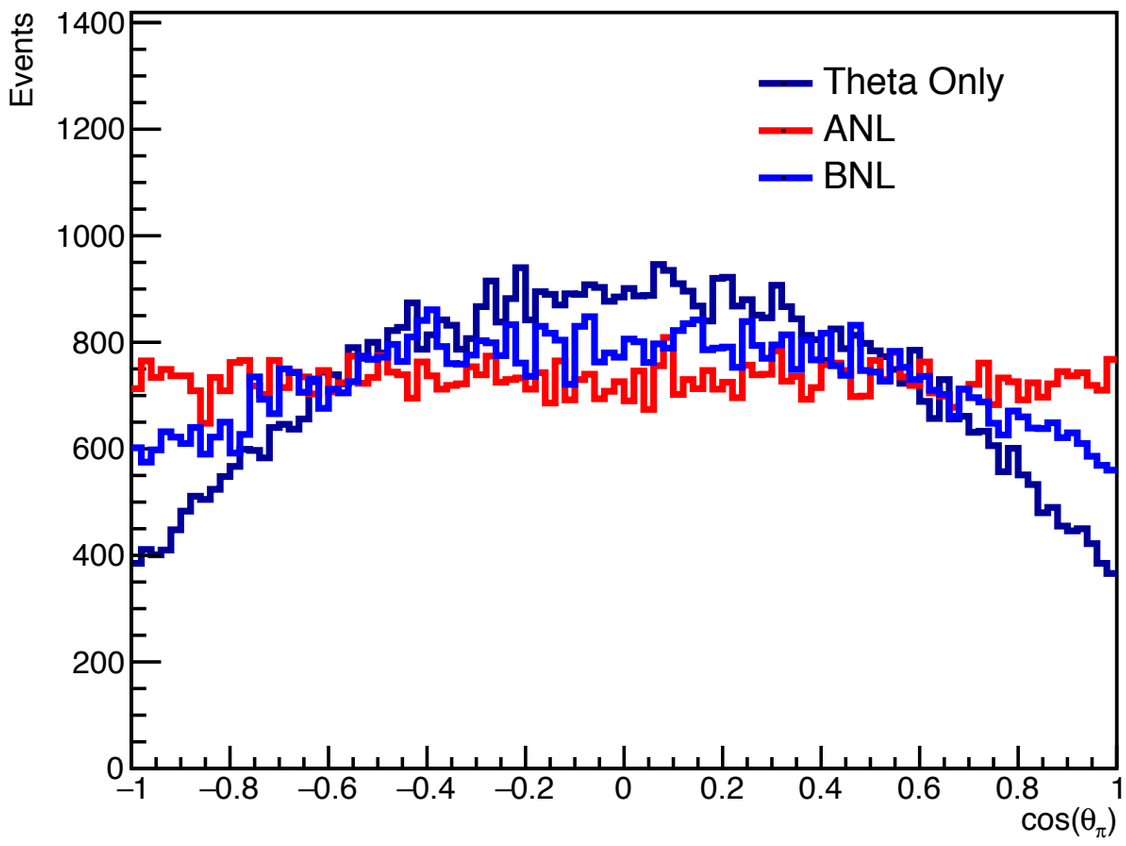


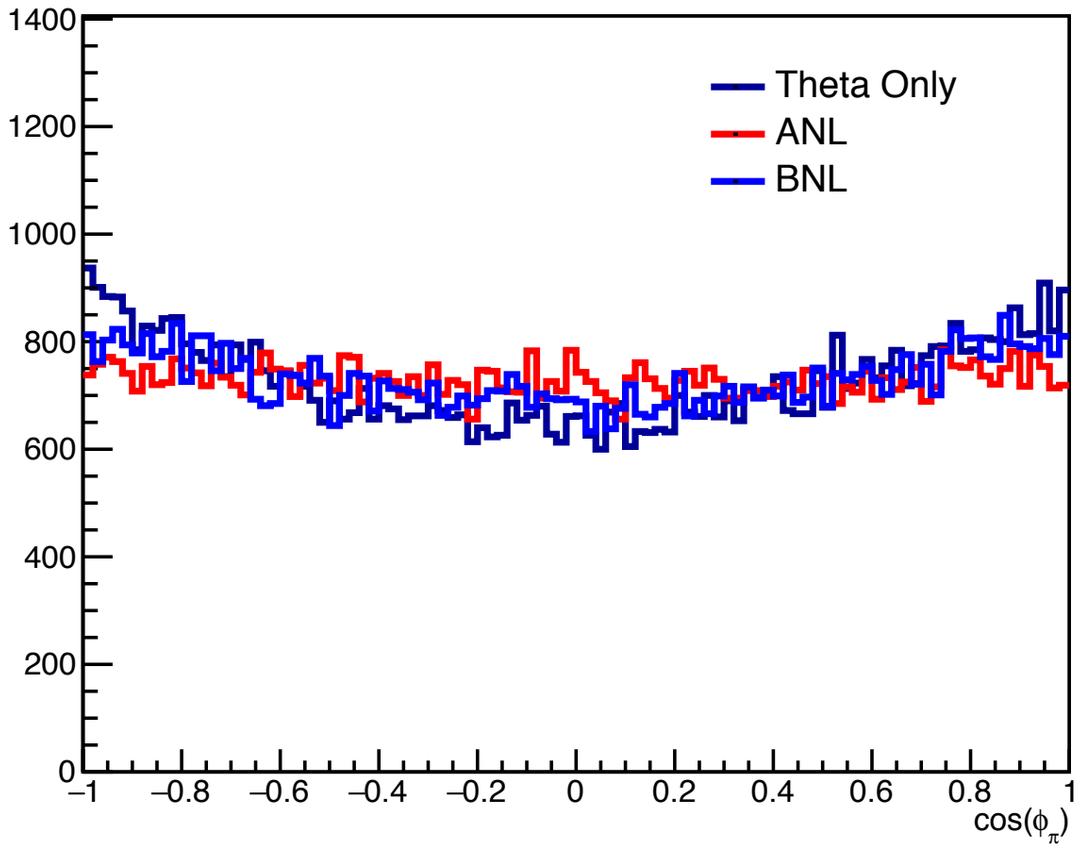
G18_02a default (black) and tuned (red) vs ν_μ CC two pion production data sets. Both datasets are included in the tune.

Delta

Libo Jiang

Delta decay in GENIE is nonisotropic for theta only

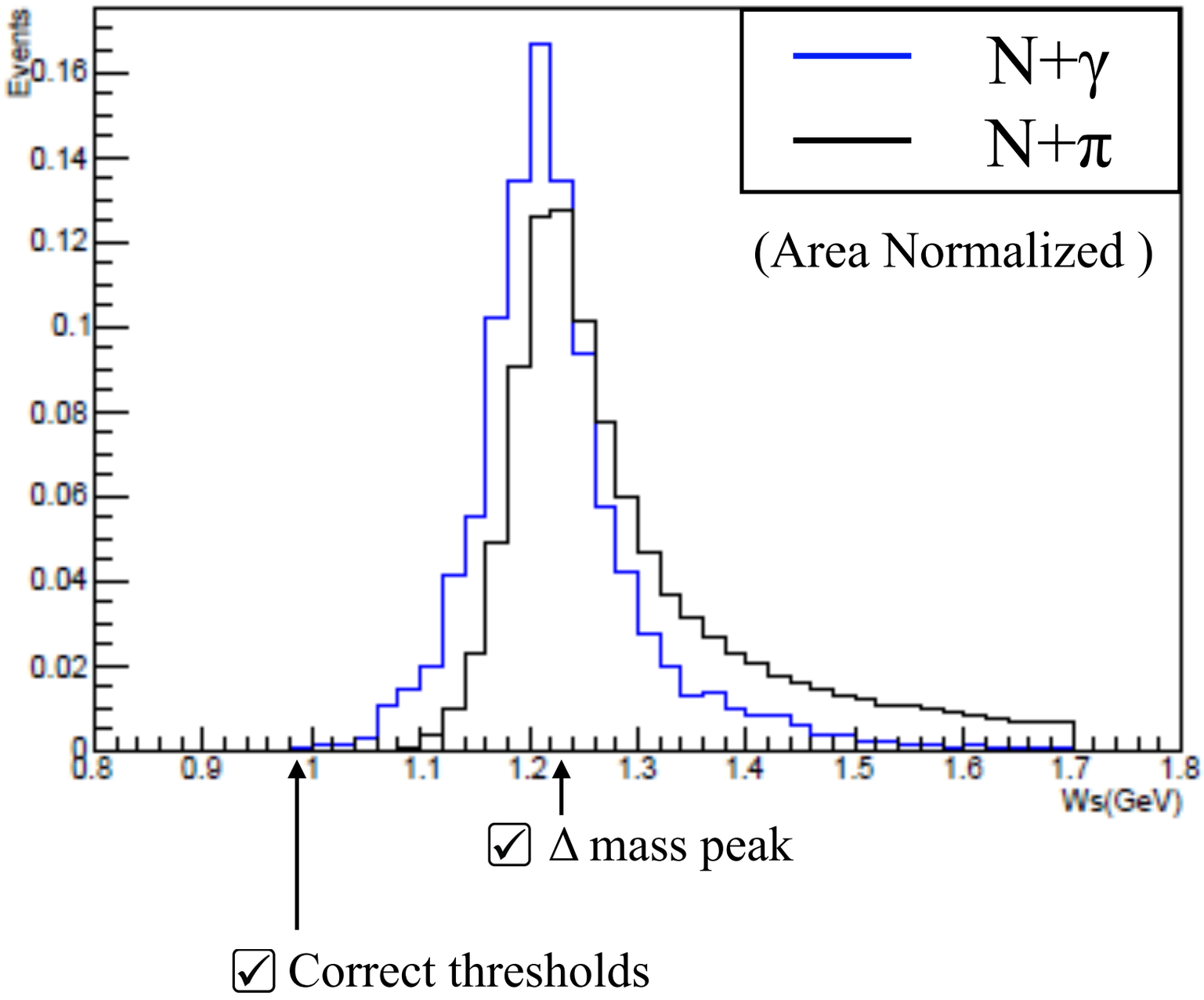




The GENIE model is compared to
fits to ANL and BNL data done by NuWro

Delta

GENIE model has Δ to Nγ corrected

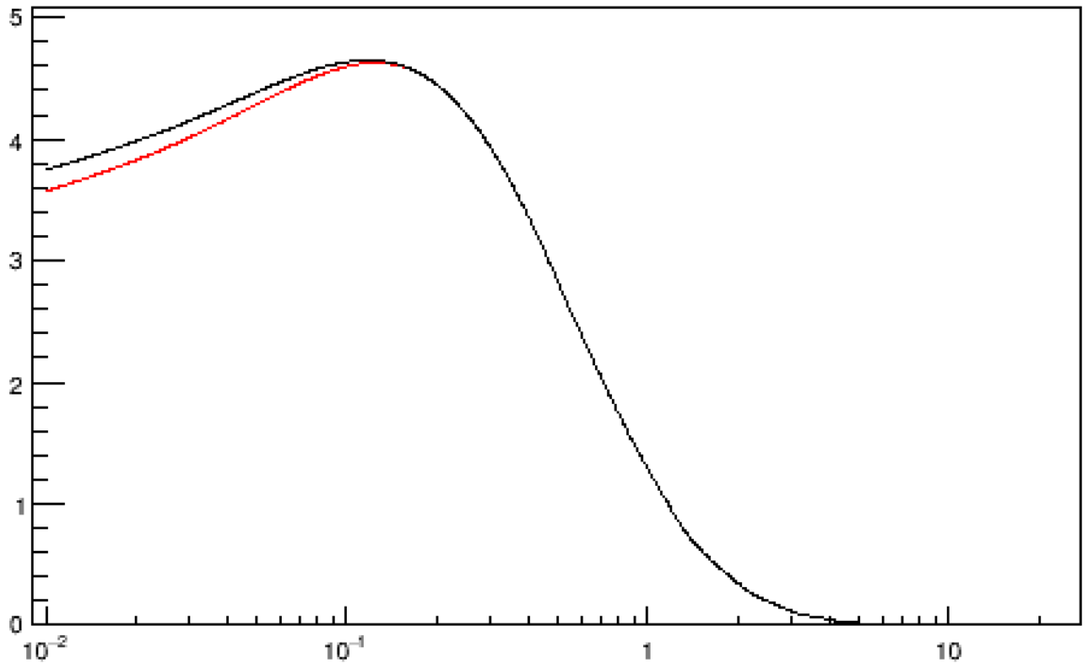


Pauli Blocking

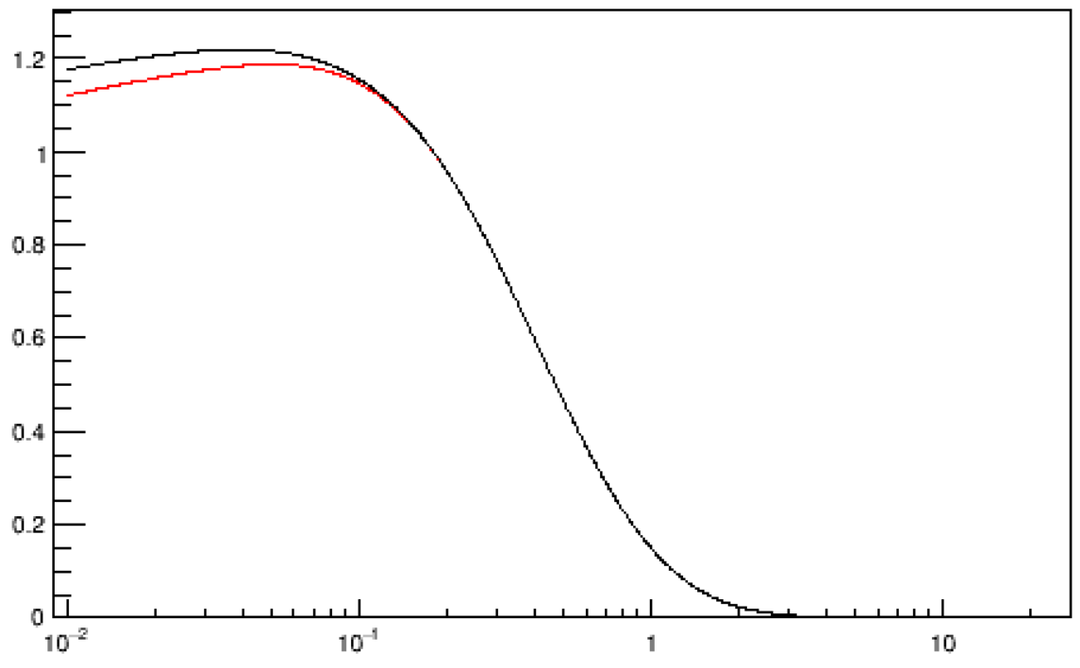
Igor Kakorin

Pauli blocking effect on cross section $< 5\ \%$ at low Q_2

ν_μ C (p) resonance 0



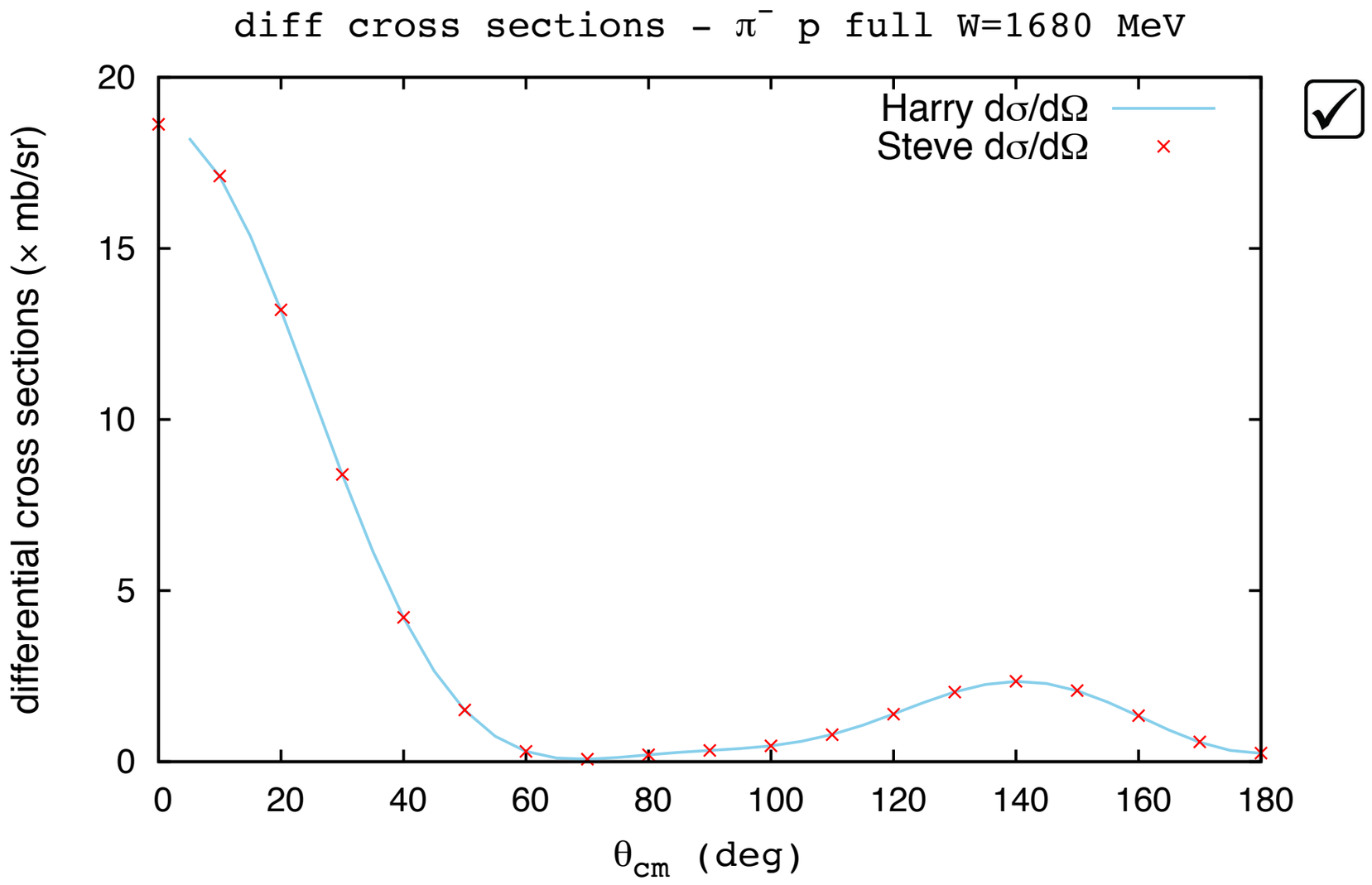
$\overline{\nu}_\mu$ C (p) resonance 0



DCC implementation

Steve Dytman

First validation tests - reproducing DCC prediction towards its implementation in GENIE

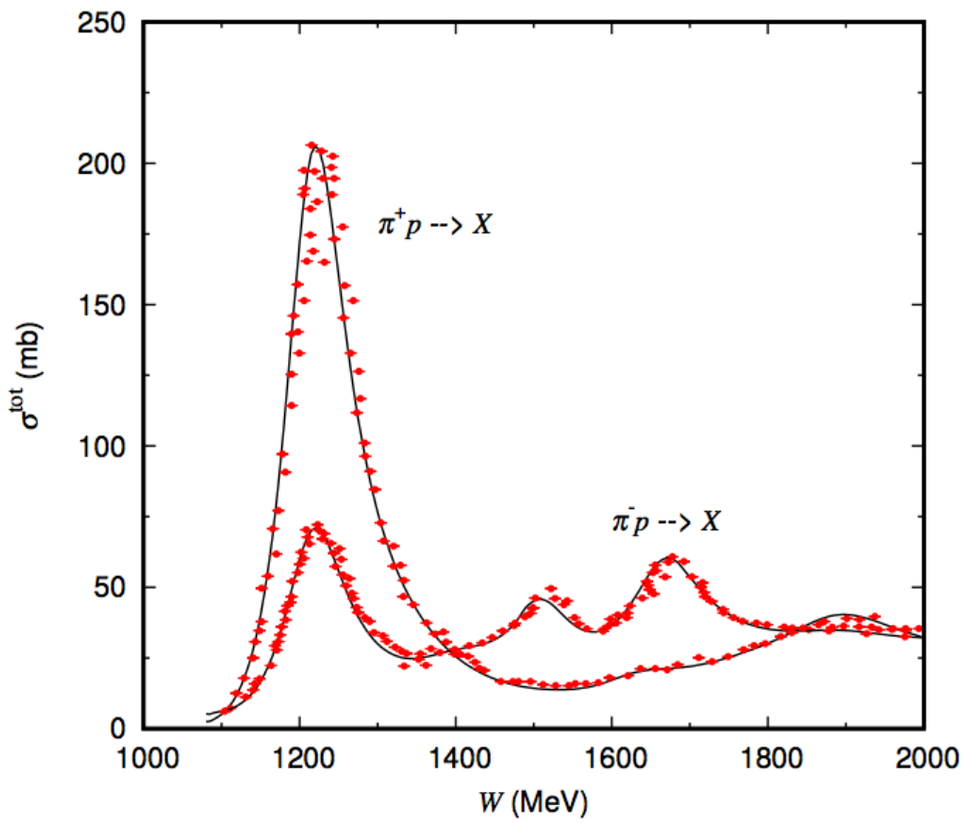


DCC

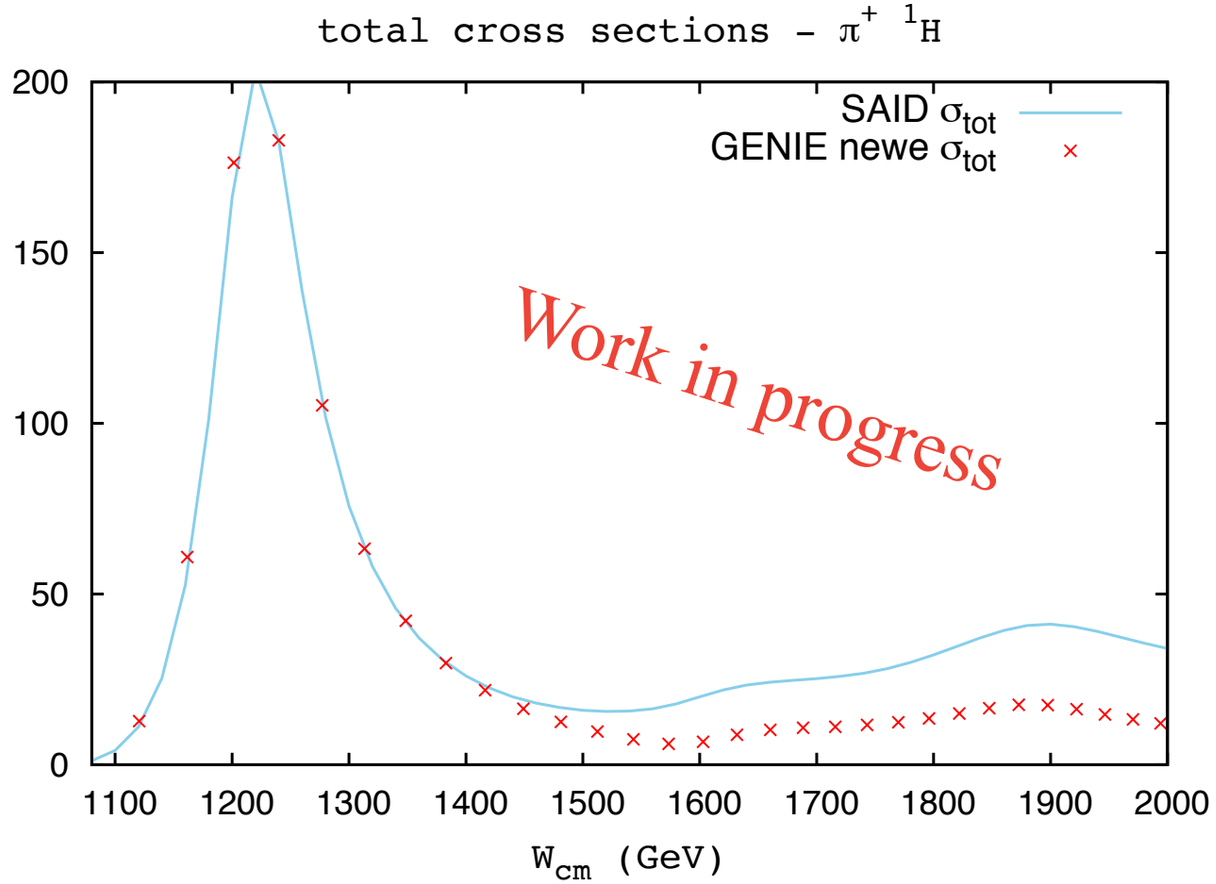
Steve Dytman

Still in progress

π^+ p total xs shows that DCC is missing 1π-exchange at high W



From Toru Sato talk yesterday



Summary

GENIE Resonance model BS and SIS region based on scaled Bodek-Yang

New tune to inclusive and exclusive (1π,2π) data is available.

GENIE validation is Δ dominated, with corrected $\Delta N\gamma$ and directionality.
GENIE has no :

- Delta FSI now
- Medium corrections to Delta formation.

Though both are standard in electron scattering theory.

Lack of neutrino data above Delta:
A call for Minerva to supply new data
A call for theorists to supply equivalent predictions for electrons.

Future Plans

GENIE is person power limited.

Wishlist includes :

- DCC FSI implementation - S. Dytman
- MK model - I. Kakorin, M. Kabirnezhad
- MAID vector form factors, possibly retune of axial form factors
- Coupling of Naomi Rocco model with DCC FSI

STAY TUNED