Imperial College London

New Xsec Parameterisation Update

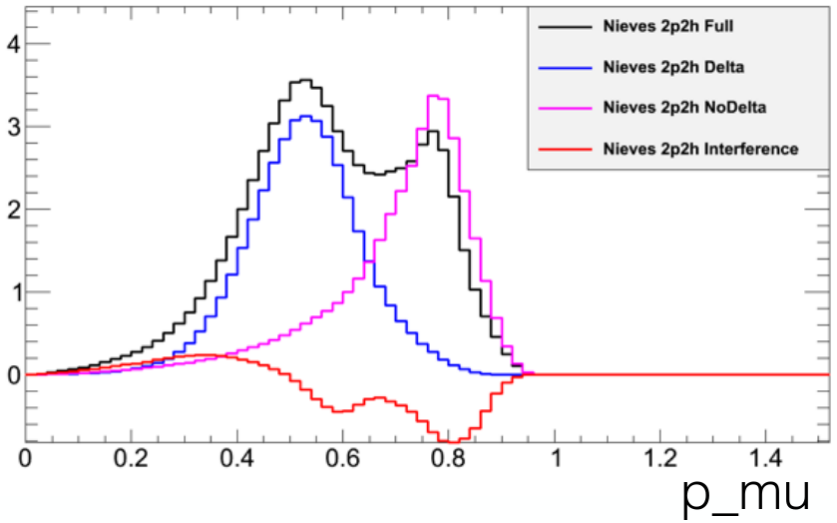
Patrick Dunne - Imperial College London

Introduction

- Caveat: Not a NIWG expert
  - Several figures taken from Kendall, Matt and Patrick S
- Will summarise proposed changes for the summer analyses
  - 2p2h shape, BeRPA, non-dipole axial form factors, Eb
  - Don't expect any change in tunings but will check matrix when done
- Will give progress of implementation and validation

2p2h shape

- 2p2h split into two components: PDD and non-PDD (+interference)



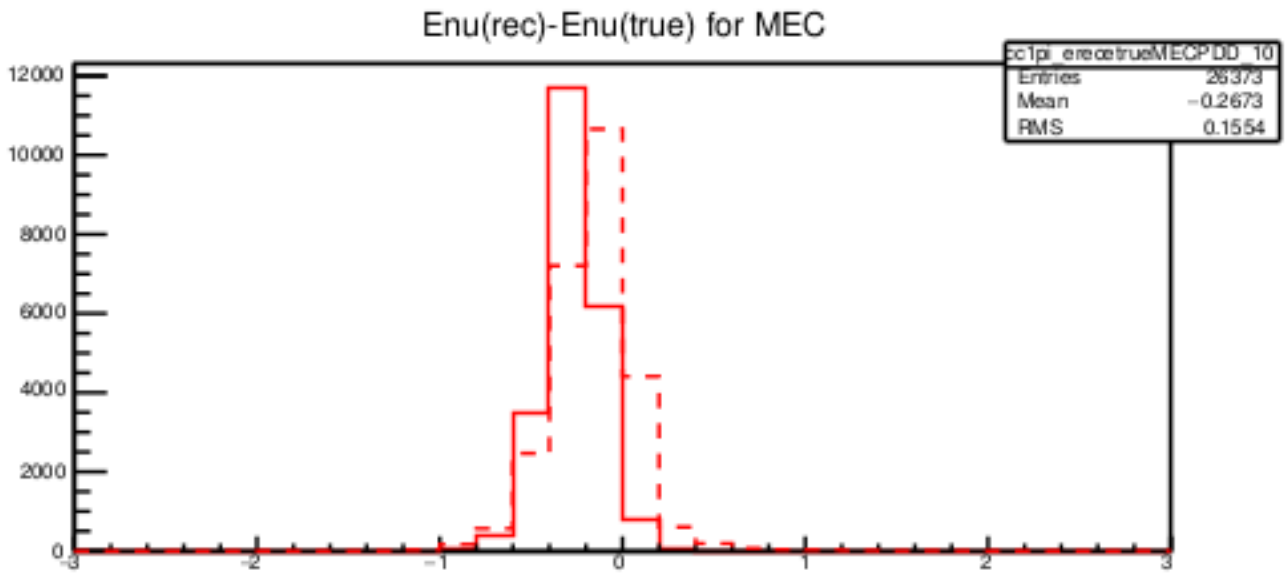
2p2h shape

$$W_{2p2h} = W_{norm}\left(\frac{W_D}{T_D}f_D + \frac{W_{nD}}{T_{nD}}f_{nD} + \frac{W_I}{T_I}f_I\right)$$

- Mix delta, non-delta and interference parts
- W is targeted fraction
- T is integrated fraction in nominal
- f is fraction in a particular bin
- Components add to 1 e.g. $W_D + W_{nD} + W_I = 1$
- Tweak method chosen to ensure W_D and W_{nD} fractions vary (see backup)

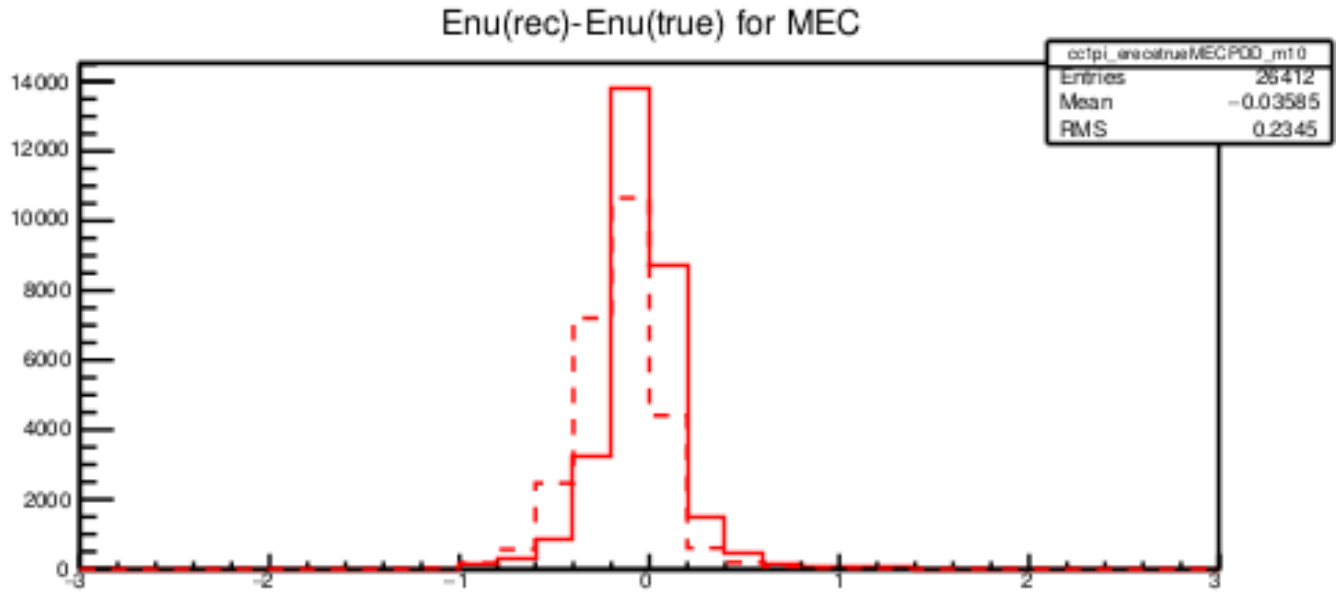
2p2h shape

- Plus and minus 1 variations move in the direction expected



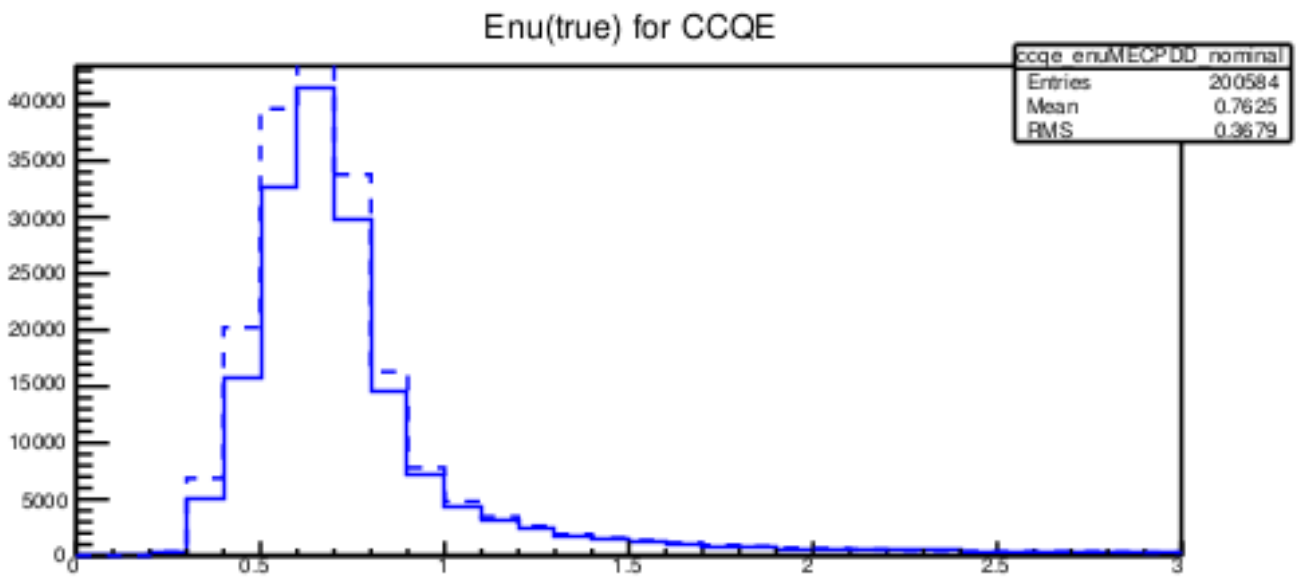
2p2h shape

- Plus and minus 1 variations move in the direction expected



2p2h shape

- Problems seen with zero tweak not returning nominal distribution
  - Believed to be due to dial not being initialised



BeRPA

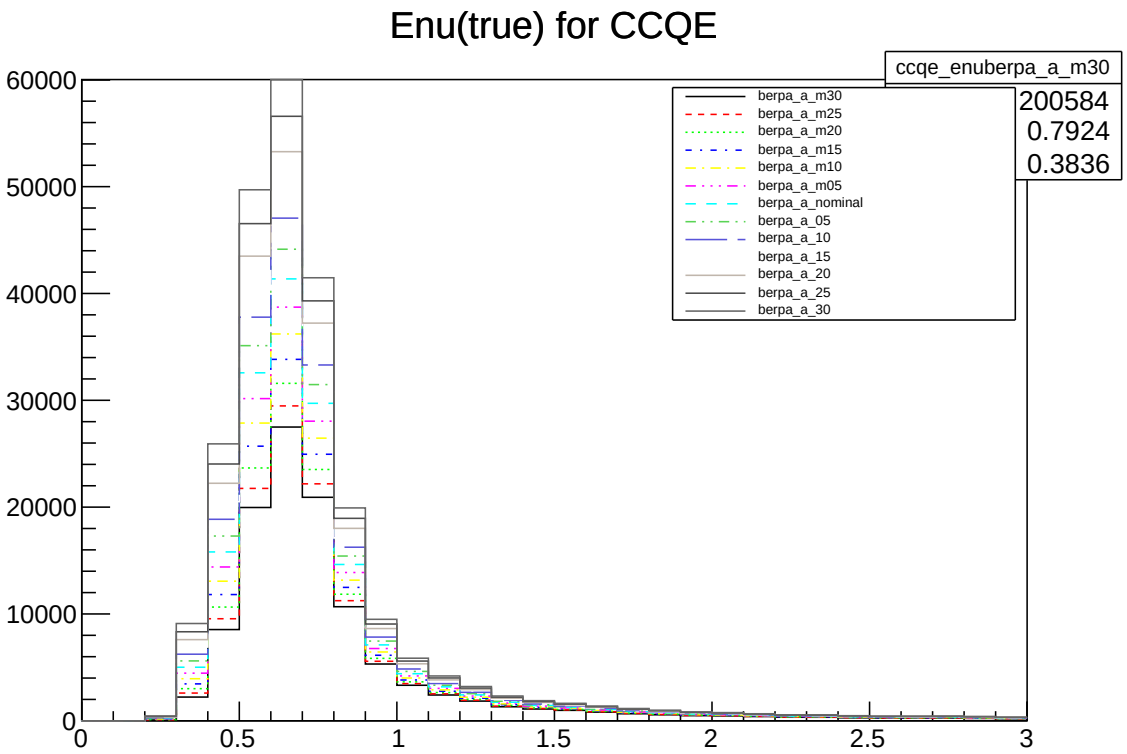
- Introduced to allow continuous variation of RPA
- Define a functional form and fit to RPA and errors to get nominal and uncertainty:

$$f(x) = \begin{cases} A(1-x)^3 + 3B(1-x)^2 x + 3\alpha(1-x)x^2 + Cx^3, q^2 < U \\ 1 + (C-1)\, e^{-D\left(q^2 - U\right)}, q^2 \geq U \end{cases}$$

- α fixed by continuity
- SK Implement as event by event weight in mtuples for nominal
- Variations around that nominal done with splines
- Have implemented a dial for U, A, B, C, D and Unom, Anom, Bnom, Cnom, Dnom
- ND280 use event by event for nominal and variations

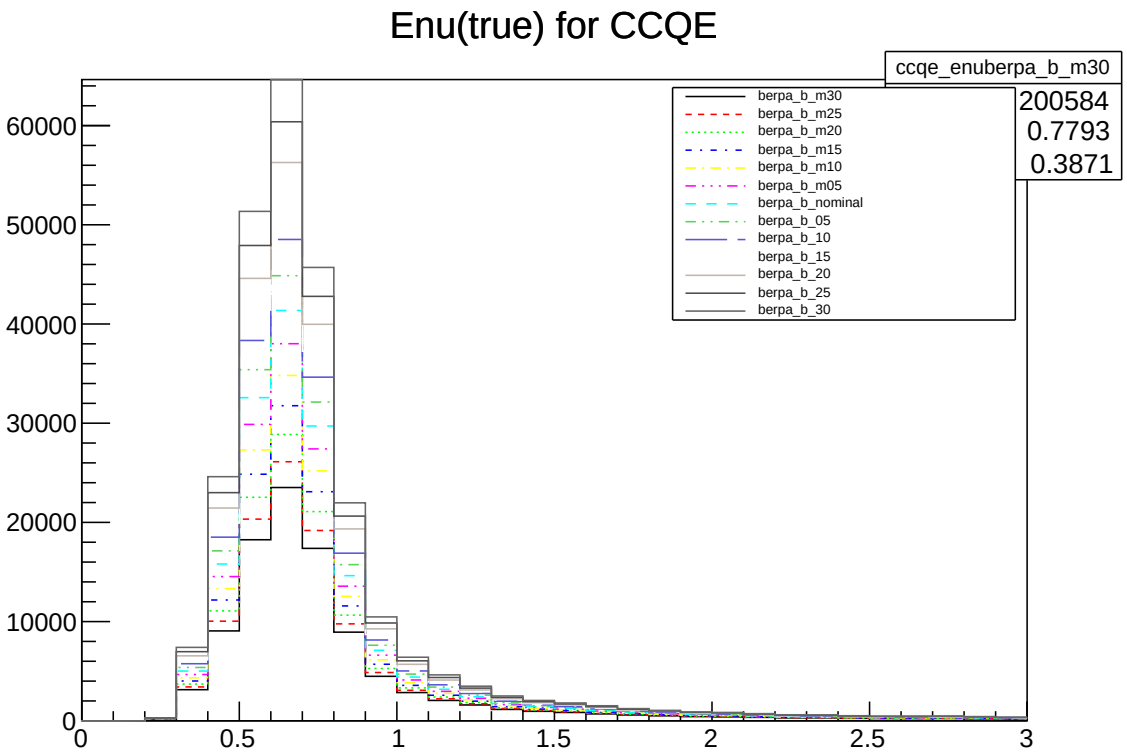
BeRPA

- Varies as expected as each dial is varied
  - Affected by 2p2h zero tweak not returning nominal issue



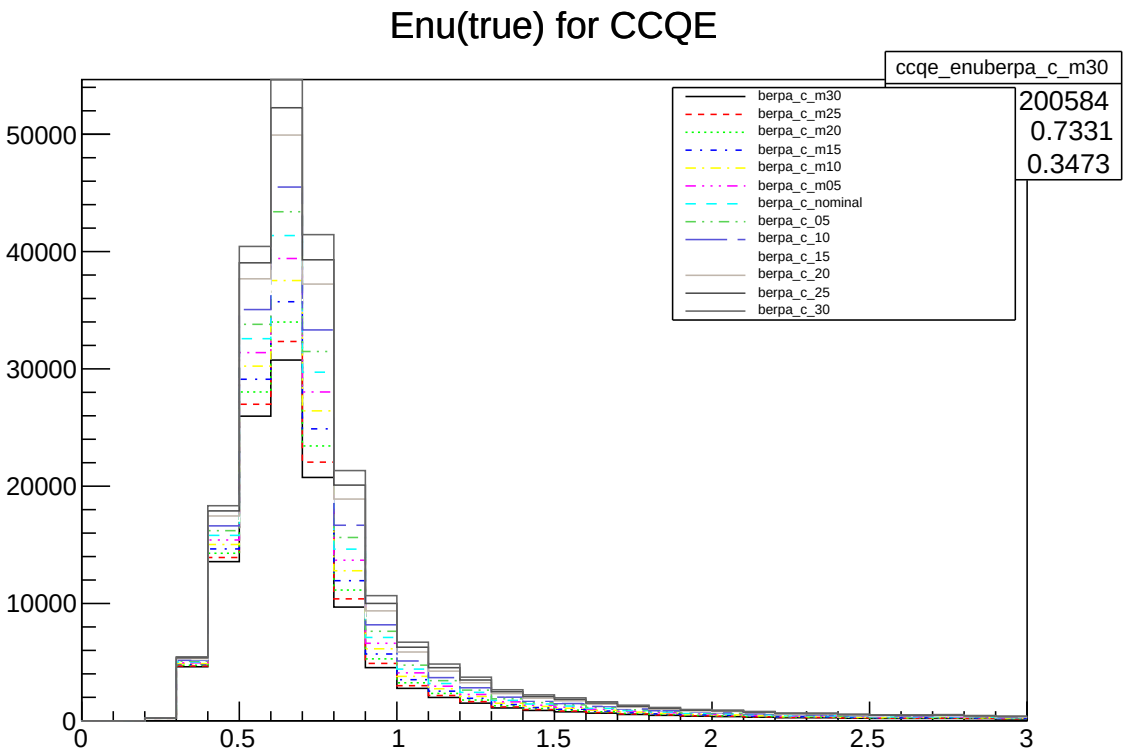
BeRPA

- Varies as expected as each dial is varied
  - Affected by 2p2h zero tweak not returning nominal issue



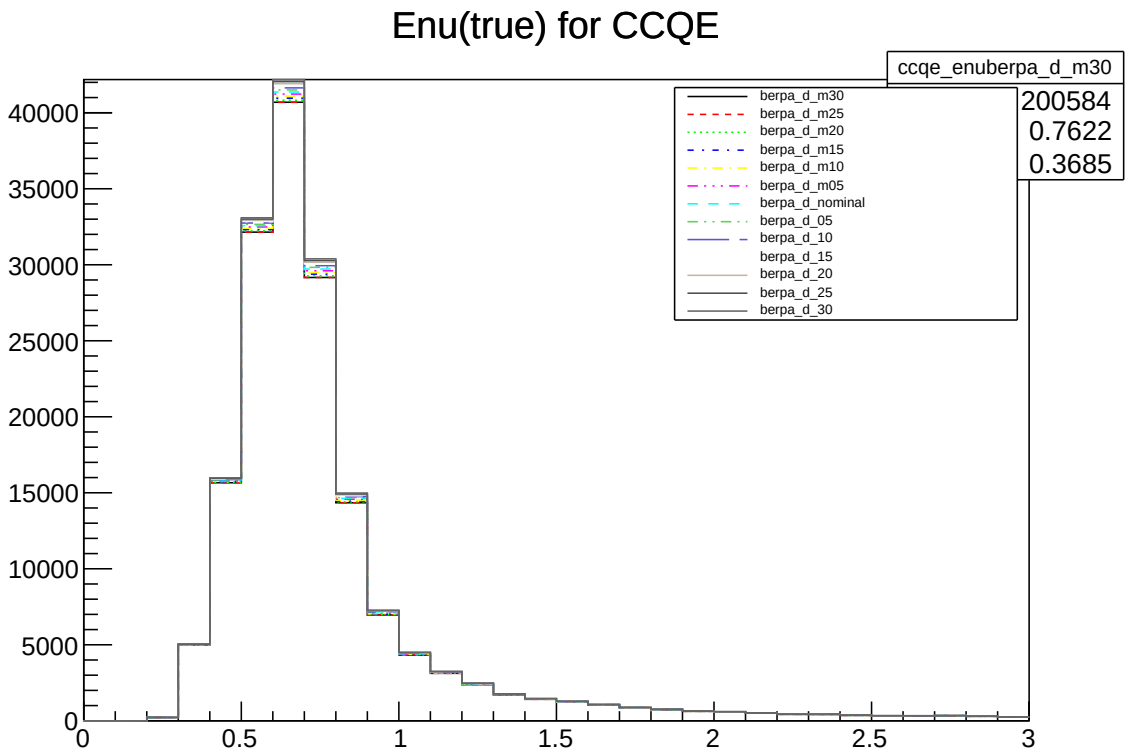
BeRPA

- Varies as expected as each dial is varied
  - Affected by 2p2h zero tweak not returning nominal issue



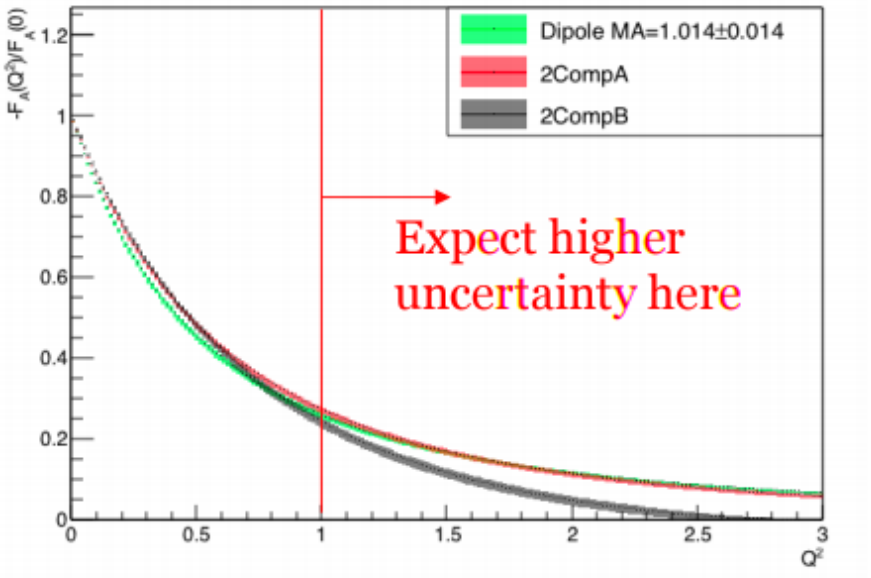
BeRPA

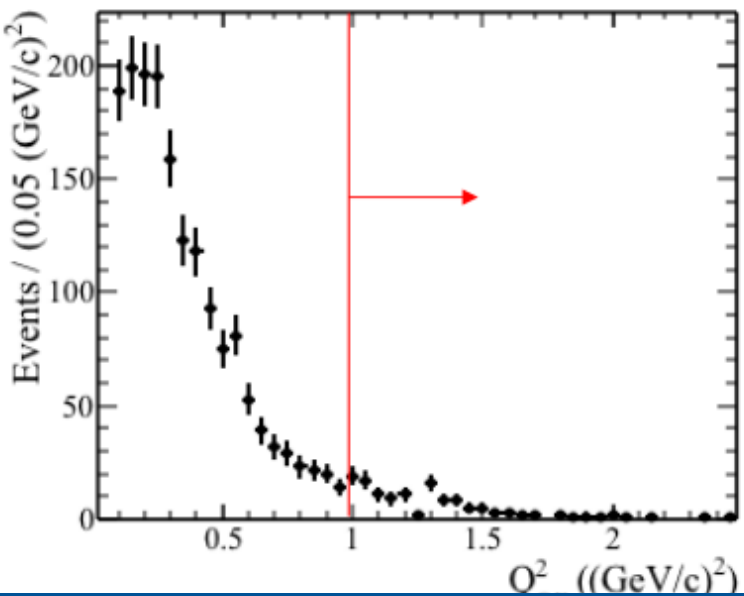
- Varies as expected as each dial is varied
  - Affected by 2p2h zero tweak not returning nominal issue



Non-dipole axial form factors

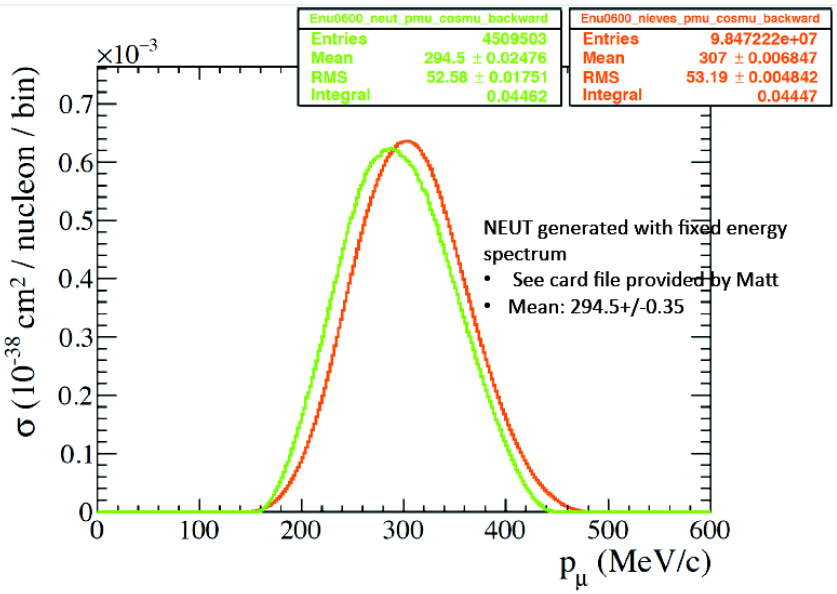
- Axial form factors previously assumed to be dipole
- This gives quite small uncertainties in high Q^2 despite not much data
- Patrick S has implemented new form factors see here
- Current plan is to understand with fake data study, but Will be in T2KReWeight for ease of studies





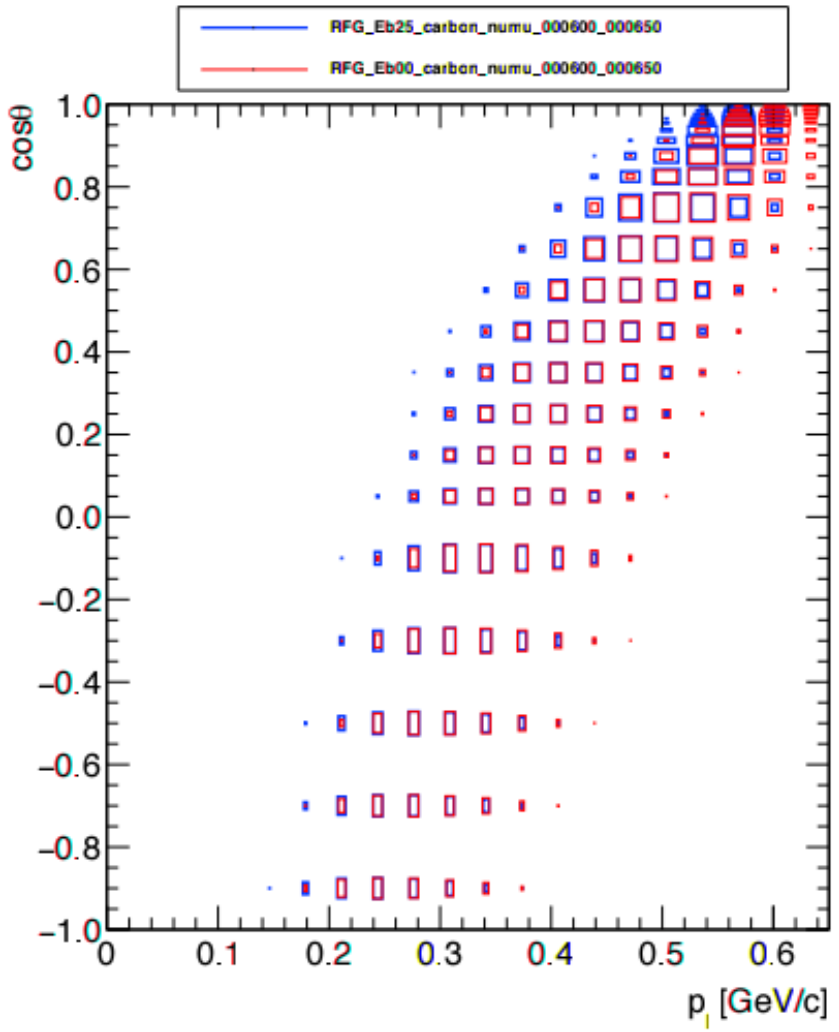
E_b

- RFG currently used has a certain value of Eb
- Previously did Neut vs Nieves fake data study
- Bias seen in fixed energy studies
- Studies done into using variable Eb dial



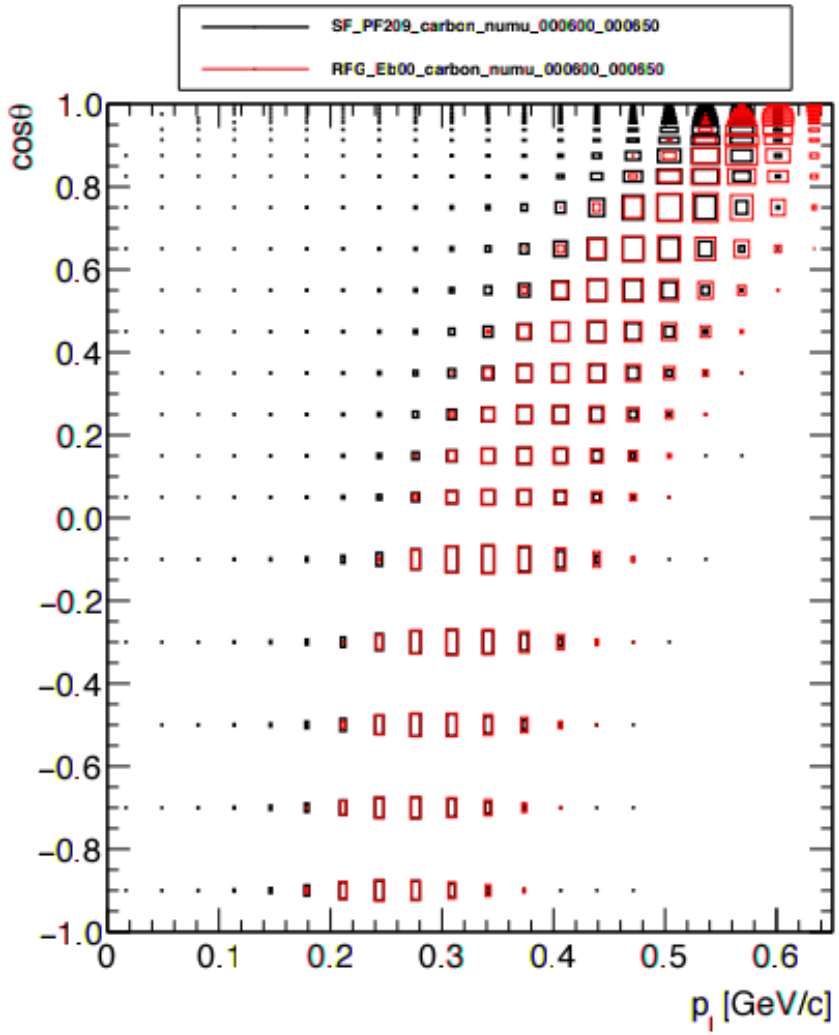
E_b dial studies

- Saw issues due to different phase space of RFG models with different Eb
  - Red where there is no blue
- Recoverable because RFG is reweighted from SF which has larger phase space



E_b dial studies

- Also problem with RFG phase space where no SF phase space
- Red where there is no black
- Fix with lower limit on Eb of 14 MeV



E_b dial studies

- After fix for both of the above bias still seen
- Remaining bias believed to be incompatibility between Eb event by event reweighting and template SF→RFG reweighting
  - Idea to fix but will take too long
- Should still do Neut vs Nieves fake data
- Possibly also fake data vs other Eb values to make sure bias isn't too large

Conclusions

- Final proposal to NIWG this afternoon
- Main change from old model will be addition of 2p2h shape dial and BeRPA dial and nominal weight
- 2p2h nominal issue is being debugged
- BeRPA nominal weight replaces RPA weight
- Will have fake data studies for Eb, and axial form factors
- Other elements same as old parameterisation

Backup

- Tweak dial k, range:[-1,+1]
  - k=-1, c=0 (all into non-Delta-like)
  - k=+1, c=1 (all into Delta like)

The tweak value undergoes the standard conversion to a "current value", $c(k) \in [0, 1]$,

$$c(k) = 0.5 \times (1 + k \times \hat{\sigma}) \tag{5}$$

We can then determine the values of W_X as a function of c to be the following:

$$W_D(c) = \begin{cases} (2T_D) \times c & \text{if } c \leq 0.5; \\ 2(1 - T_D) \times c + (2T_D - 1) & \text{else.} \end{cases} \tag{6}$$

$$W_I(c) = \begin{cases} (2T_I) \times c & \text{if } c \leq 0.5; \\ (2T_I) \times (1 - c) & \text{else.} \end{cases} \tag{7}$$

$$W_{nD}(c) = 1 - W_D - W_{nD}. \tag{8}$$