Imperial College London

MaCh3 Summer 17 OA

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for the MaCh3 group

Oscillations at T2K

- Standard PMNS oscillations apply to mass eigenstates as:

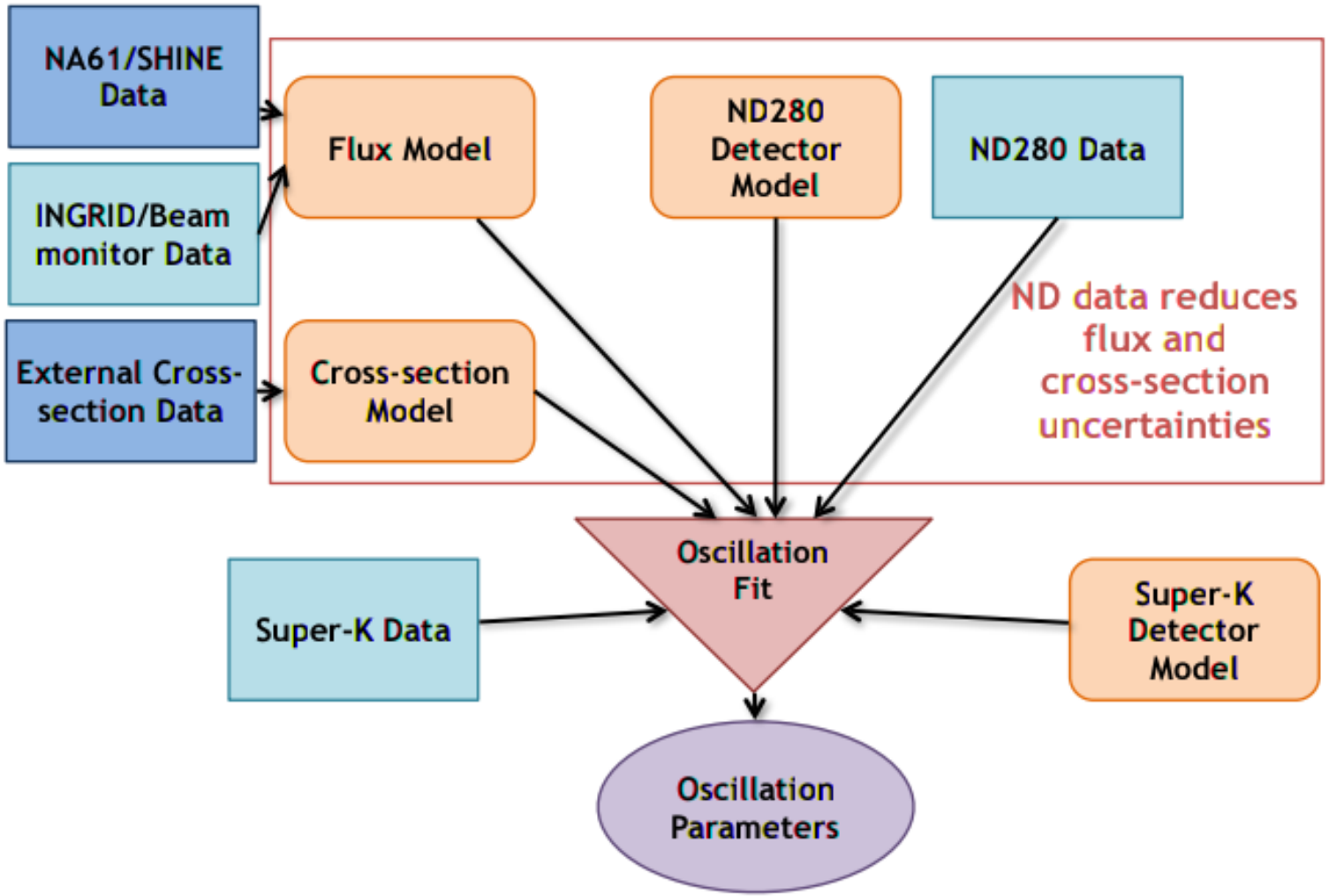
$$\begin{pmatrix} \nu_e \\ \nu_\mu \\ \nu_\tau \end{pmatrix} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & c_{23} & s_{23} \\ 0 & -s_{23} & c_{23} \end{pmatrix} \begin{pmatrix} c_{13} & 0 & s_{13}e^{i\delta} \\ 0 & 1 & 0 \\ -s_{13}e^{-i\delta} & 0 & c_{13} \end{pmatrix} \begin{pmatrix} c_{12} & s_{12} & 0 \\ -s_{12} & c_{12} & 0 \\ 0 & 0 & 1 \end{pmatrix} \begin{pmatrix} \nu_1 \\ \nu_2 \\ \nu_3 \end{pmatrix}$$

- T2K sees disappearance of ν_μ, appearance of ν_e and equivalents for antineutrino
- Gives sensitivity to $\sin^2(\theta_{23})$, $\sin^2(\theta_{13})$, Δm^2_{23} and δ

MaCh3 introduction

- MaCh3 is a Bayesian Markov Chain Monte Carlo (MCMC) oscillation fitter
- Performs MCMC integration to give the posterior probability
- Choose to fit ND280 and SK simultaneously

What goes into an oscillation fit?



K. Duffy

Updates for Summer OA

- SK data: Use full Run 1-8 SK data for all 5 samples
  - All analyses fitting in E_{rec} for ν_μ and 2D for ν_e
- ND280 data: No new data, but new RHC binning
- New SK reconstruction using fitQun
- New xsec model

fitQun

- SK reconstruction with significantly lower mis-ID probability
- Available for all samples used in OA fit

Maximize:

$$L(\mathbf{x}) = \prod_{j}^{unhit} P_j(unhit|\mathbf{x}) \prod_{i}^{hit} \{1 - P_i(unhit|\mathbf{x})\} f_q(q_i|\mathbf{x}) f_t(t_i|\mathbf{x})$$

Track parameters:

particle ID
vertex
direction
momentum

Probability of i^{th} PMT registering a hit

Probability of observing charge q at time t in i^{th} PMT

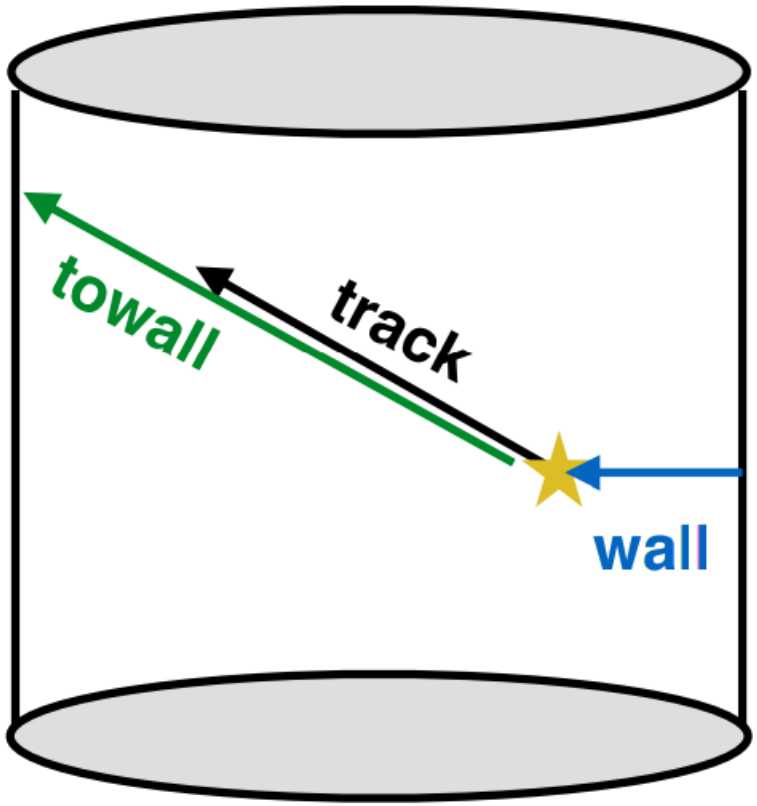
A. Missert

fitQun: Fiducial volume

- Much lower mis-ID probability allows fiducial volume (FV) to be expanded
- Optimise 2 variables cut values based on:

$$\sum_{i}^{bins} \frac{\left(\frac{dN_i}{d\theta}\right)}{N_i + \left(\sigma^2_{syst}\right)_i}$$

- Results in 20% larger FV with more events around oscillation max. energy



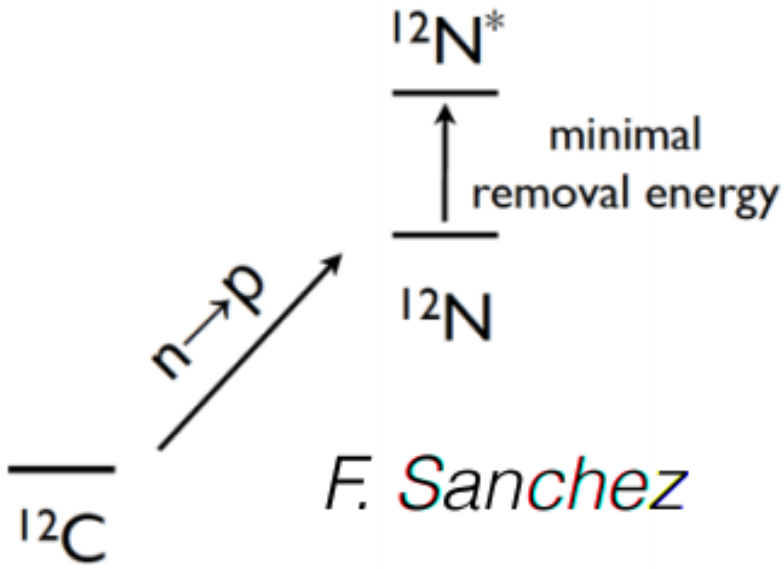
A. Missert

New xsec model (2017b)

- Large changes made to this year's cross-section model:
- Removal of E_B dial
- 2p2h uncertainty treatment
- Change to RPA treatment

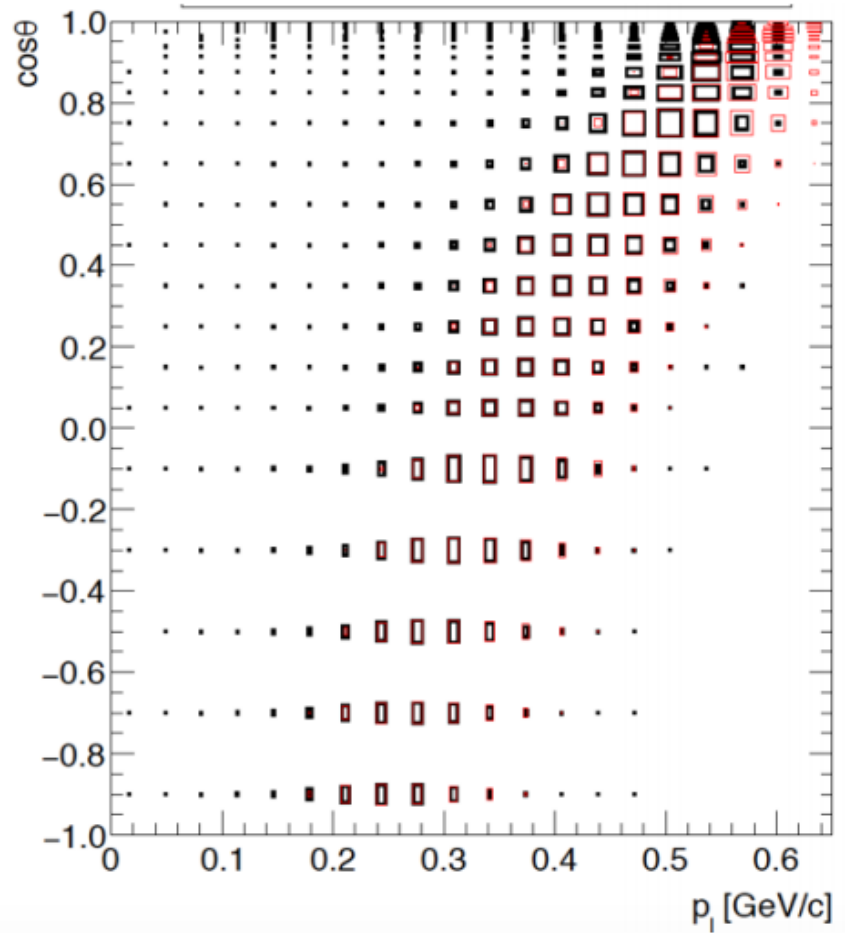
E_B

- Part of model of inital nucleon momentum
- Describes energy needed to remove nucleon from atom
- E_B dial in 2015 parametrisation didn't migrate events as desired
- Also it's effect was very small, so we dropped it



E_B

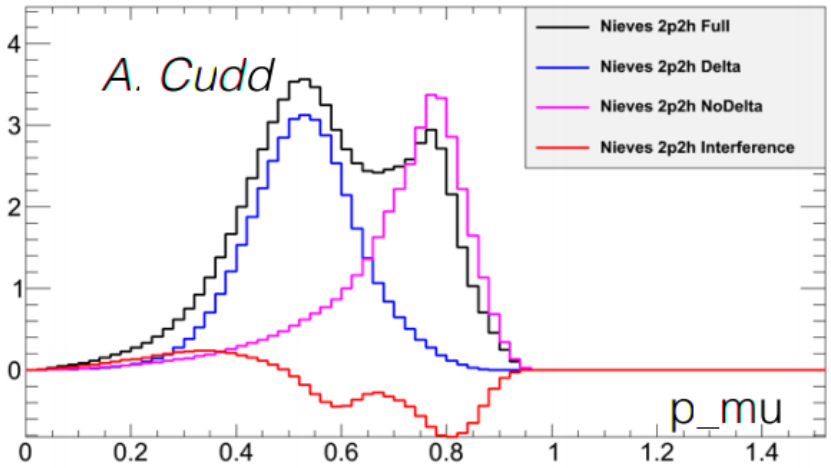
- Planned new dial based on comparison of nominal SF model with RFG model with varied E_B
- SF has larger phase space than RFG so should work
- Problem: larger $\neq$ covering
  - RFG (red) populates some areas SF (black) doesn't
  - Large bias in forward region
- Dropped new dial as well



M. Dunkman

2p2h

- 2p2h is multi-nucleon hard scatter
- Effect largest at flux peak
- Old model only varied normalisation
- Add shape modelling



BeRPA

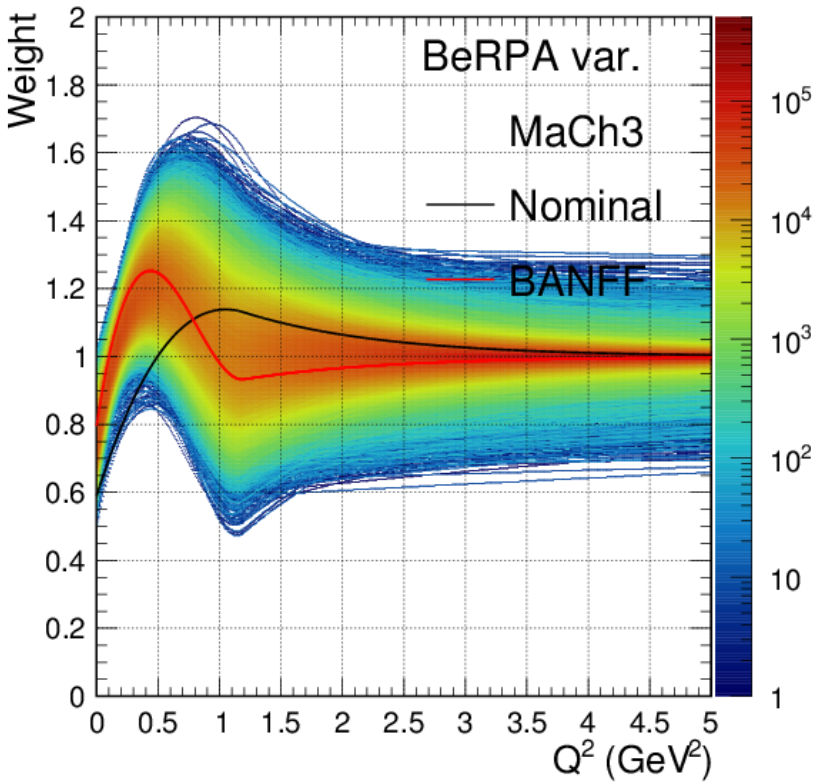
- RPA describes screening of nucleon by rest of nucleus
- Old model weighted to Nieves model nominal
  - No uncertainty
- Introduce BeRPA parametrisation

$$f(x) = \begin{cases} A\left(1-\frac{x}{U}\right)^3 + 3B\left(1-\frac{x}{U}\right)^2\frac{x}{U} + 3p_1\left(1-\frac{x}{U}\right)\left(\frac{x}{U}\right)^2 + D\left(\frac{x}{U}\right)^3, x < U \\ 1 + p_2\exp\left(-E\left(x-U\right)\right), x > U \end{cases}$$

- Values and errors for A, B, D, E and U obtained by fitting to Nieves model
  - p_1 and p_2 fixed by continuity

BeRPA

- A, B, D, E and U varied in ND280 Data fit
- Appear to go away from nominal
- High flux parameters seen last year return to normal
- NB MaCh3 implement BeRPA event-by-event, other fitters don't



C. Wret

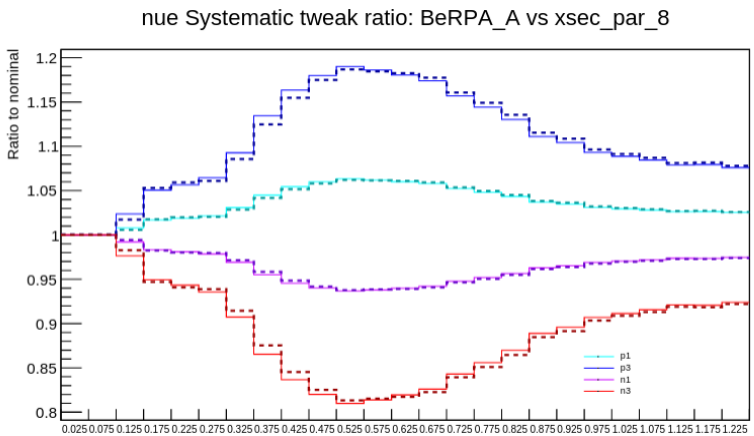
Validation progress: event rate

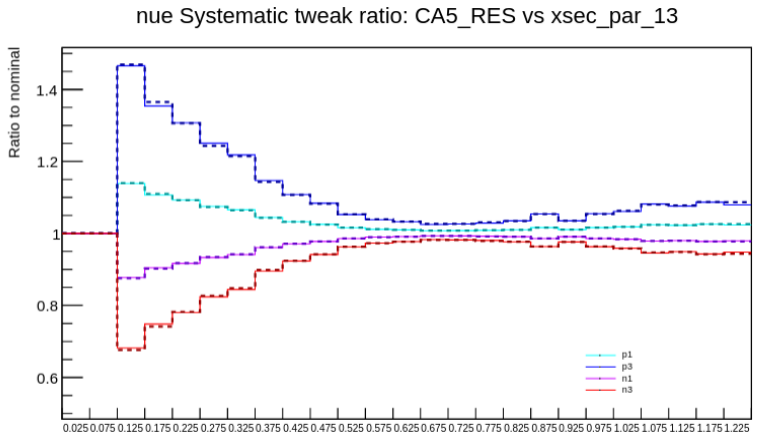
- All of the above changes implemented in MaCh3
- Validate that code is ok by checking against other analyses
  - expect some differences due to BeRPA treatment
  - Still validating CC1pi

	MaCh3	p-theta
FHC 1Rmu	145.817	148.031
FHC 1Re	41.050	41.6955
RHC 1Rmu	8.468	8.494
RHC 1Re	67.039	68.0174
FHC CC1pi	3.9659	3.63896

Validation progress

- Validate systematic model implementation too
- MaCh3 (dashed) vs p-theta (solid)
  - Expect small differences due to different spline binning





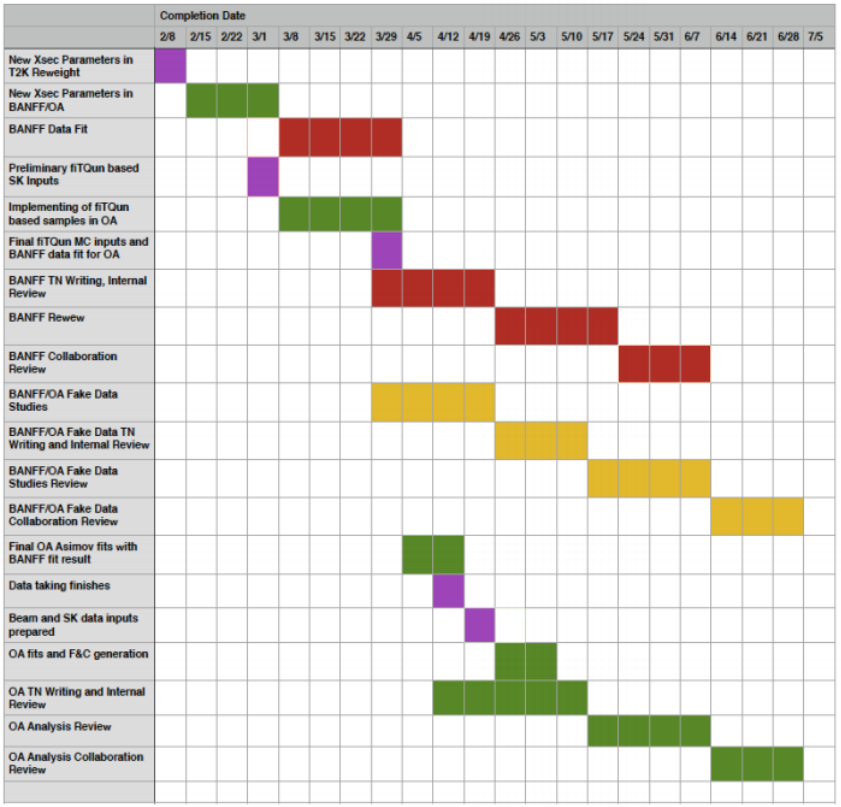
Asimov fits

- Hot off the presses!
- woRC Asimov A ($\delta = -1.601$, $\sin^2(\theta_{23}) = 0.523$)

Asimov fits: Comparison with p-theta

Timeline

- Targeting EPS-HEP: July 5-12
- Currently on time (just)



Conclusions

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Backup