

Off-axis Flux Uncertainties

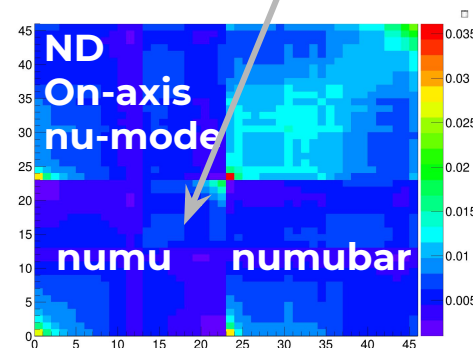
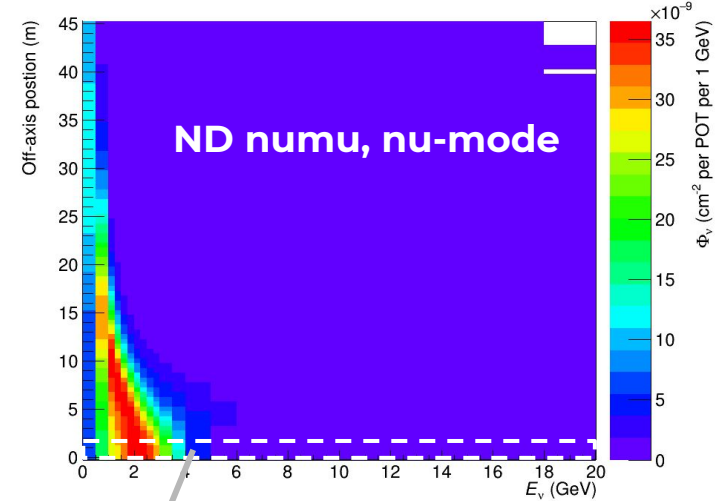
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Long Baseline Physics
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Tools

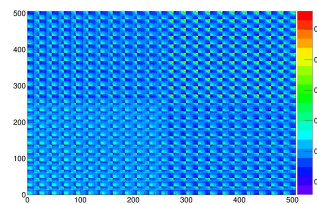
- Not ideal, but currently all code lives in a public github repo: “DunePrismTools”
- Have dk2nu_lite format -- flat, primitive-only ttree that throws away all branches not needed to calculate the flux through an arbitrary flux window.
 - 1E5 POT: 80mb dk2nu -> 8mb dk2nu_lite
 - Would be better if this lived in dk2nu
- I have hand-copied/tweaked code for calculate flux through a window from g4lbne macros:
 - Have checked and it looks identical to the dk2nu equivalent (from the MINOS fortran simulation originally)
 - But would be better to use the dk2nu tools
- Hand written a new job submission script that runs dk2nu -> dk2nu_lite before pulling the files back from the node:
 - Reduces disk usage by factor 10 for the same sim, but full recalculation/re-binning possible.
 - If running PPFX, ties in PPFX weights to dk2nu_lite tree
 - 100 universes ~double file size, but now that we save space, might try upping it.

Off-axis Flux Predictions

- For any analysis including off-axis positions, need new correlated flux uncertainties.
- Can introduce very many columns to flux matrix:
 - E.g. 20 energy bins, 50 cm flux windows, 0-33 m, 4 species, 2 beam modes, + FD: ~10kx10k flux matrix.
- 'Standard' procedure is to distribute flux matrix and let analysers choose how to use:
 - Prior-constrained energy bin weights
 - Effect flux parameters from matrix decomposition.

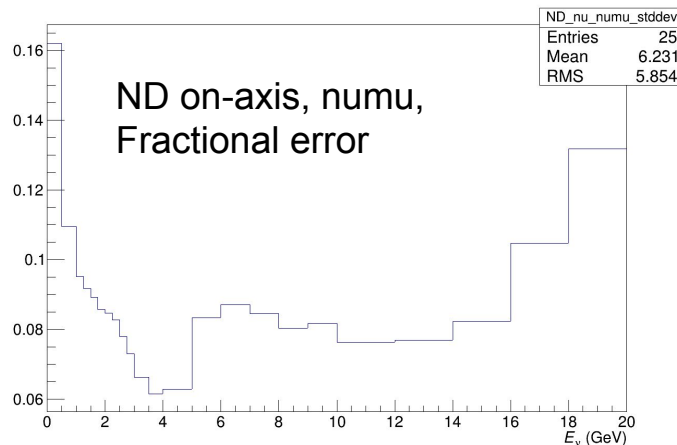
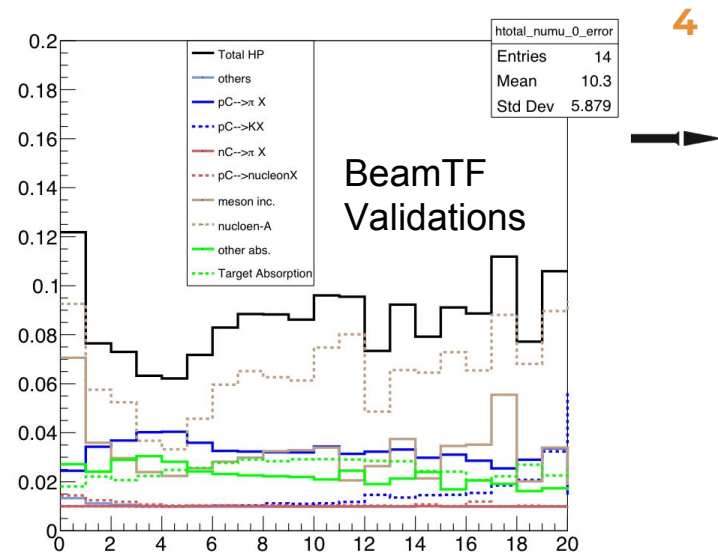


ND, nu-mode,
Numu, numubar,
0-33 m



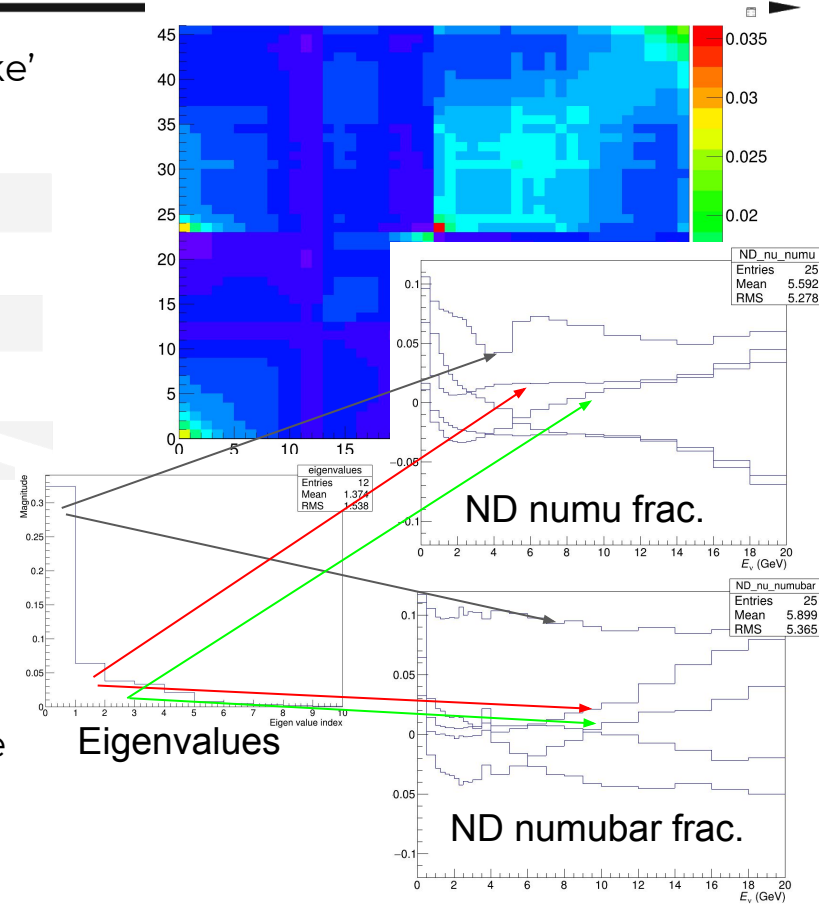
Since last time: PPFX

- Previously shown off-axis flux errors from three most important focussing sources.
- PPFX, used for hadron-production uncertainties had not been updated to work with the Nov2017Engineered geometry.
- Got the soon-to-be-committed code from A. Bashyal, so now have PPFX universe weights for hadron-parents.
 - Preliminary low-stats comparisons look like I'm using them sensibly.

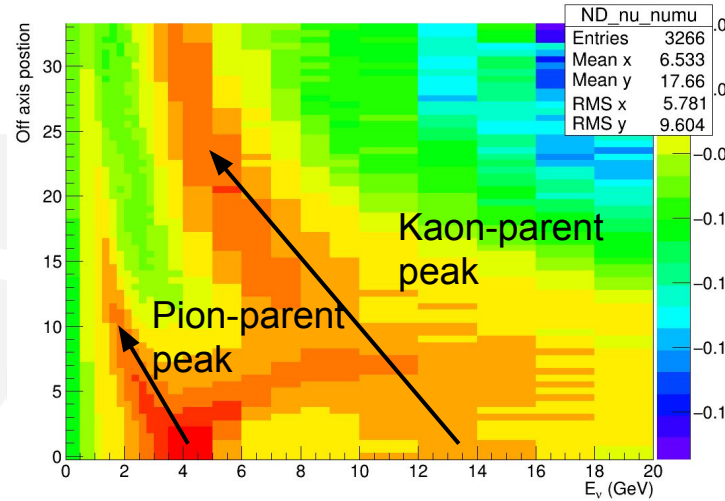


My Idea for Error Distribution v2

- Not $N_k \times N_k$ DOF in beam simulation: Making up 'fake' DOF by putting all bins in as parameters.
- Dealing with $N_k \times N_k$ matrix in fitters is not feasible:
 - Standard decomposition techniques take $O(\text{hours})$ to decompose.
- 'Power iteration' techniques find most important X eigenvalues and associated eigenvectors.
 - Can set minimum total variance retained limit to choose X , $\text{Sum}(\text{Eval}) = \text{Trace}(\text{covmat})$.
 - Distribute just the pre-decomposed $\text{sqrt}(\text{eval}) * \text{evec}$ -- become X uncorrelated effective flux parameters.
 - These are 'easy' to intuitively look at, unlike the full flux matrix.



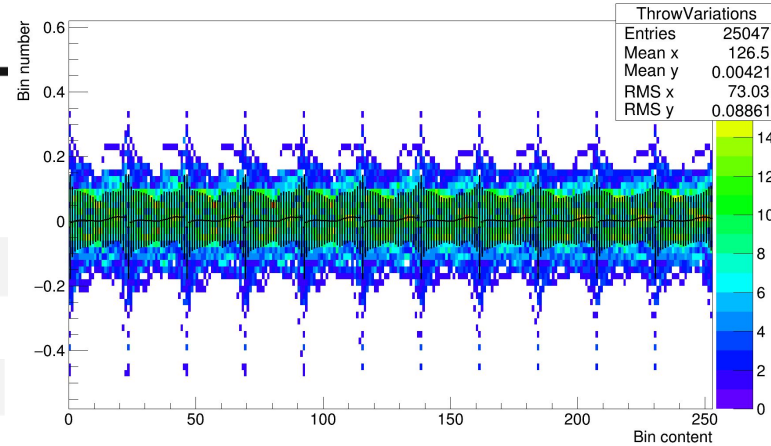
Example: PPFX-only



- Part of the Eigenvector of largest Eigenvalue for ND numu, nu-mode.
- Will get a part for each detector/beam-mode/species.
- Each tied to the same eigenvalue, when moving Eff Param 1, must apply all of the relevant weights.

Gaussianity

- Covariance matrix inherently gaussian.
- Multi-universe weights need to make ~gaussian responses in flux bin content.
- How to handle discrete errors: e.g. HC?
 - No need to put in covmat and take out again (but doing so ensures uncorrelatedness of all flux parameters)
 - Can generate $\pm 1, 3, 5$ 'sigma' predictions, using standard math will take gaussian approximation of the response.
 - Can handle discrete errors separately in fitters with interpolated $\pm 1, 3, 5$ 'sigma' predictions,



//TODO

- Throw other focussing/alignment uncertainties that were ignored first time.
- Integrate with CAFAna:
 - They read in pre-decomposed effective uncertainties anyway... so this shouldn't take very long (FLW).

Plan for More TDR

- Kendall has copied my write up for the DUNE-PRISM technote
 - Has some words but no plots for flux uncertainties off-axis
 - I don't think that there is space/room/a pretty way to show the full 2D uncertainties for each source in the same way that you have for the 1D uncertainties.
 - Maybe include 2D plots for total hadron-production and total focussing uncertainties and a few words about them.
 - Likely earliest that I can do it is week after next.
- Is it worth having any discussion of the rest of this talk in that section?
 - There's nothing on the dissemination/application-in-analysis techniques of the on-axis flux, so I guess this could go in the error propagation sub-section of the analysis section.

Thanks for listening