MaCh3 Oscillation Analysis Update

Oscillation Analysis Meeting -12/09/2013

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On behalf of the MaCh3 Group

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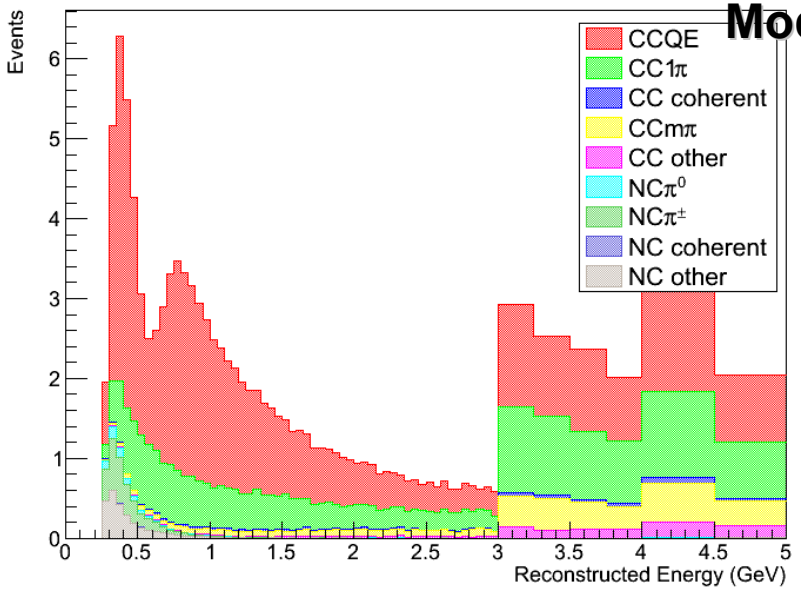
Status

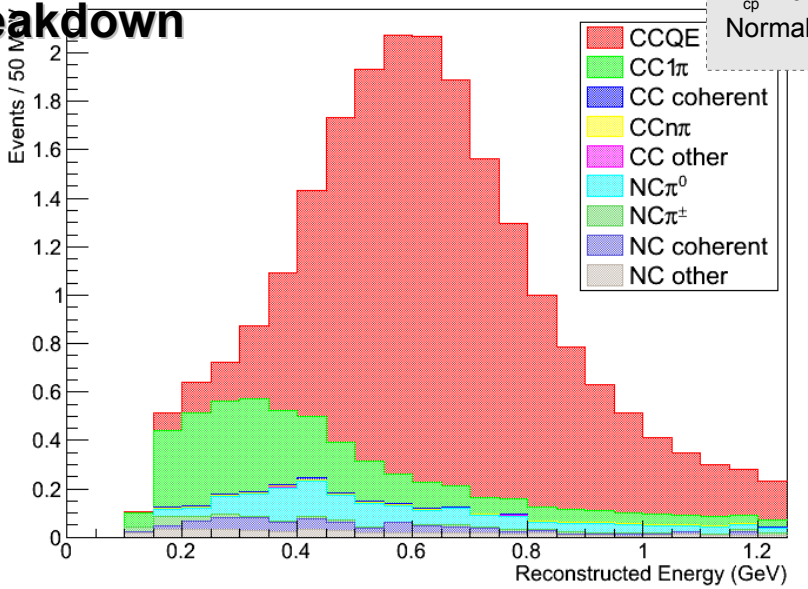
- Updated event rate comparisons
  - BANFF + NIWG tunings
- Toy fits running
  - Some preliminary toy studies
- Density fitter
  - How to determine best fit point in 4 dimensions
- Plans
  - Fake data fits
  - Data fit proposal

PDF Validation

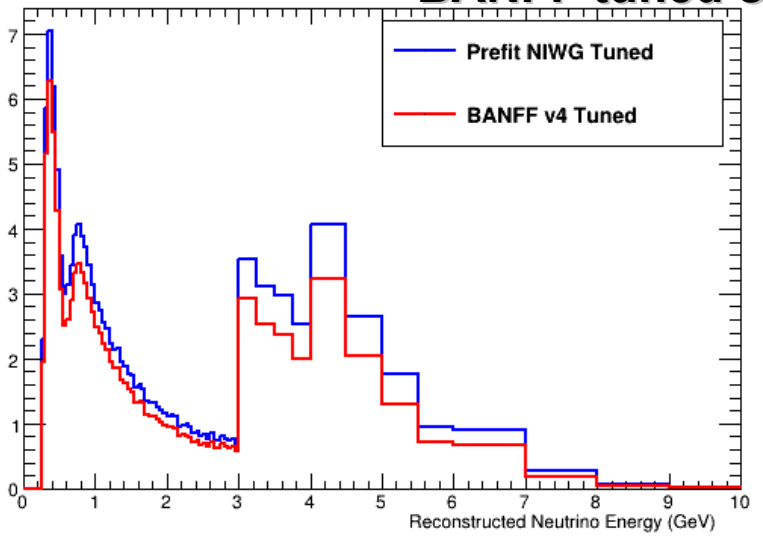
$\sin^2\theta_{23} = 0.5$
$\sin^2\theta_{13} = 0.0251$
$\sin^2\theta_{12} = 0.311$
$\Delta m^2_{12} = 7.5 \times 10^{-5}$ eV
$\Delta m^2_{32} = 2.4 \times 10^{-3}$ eV
$\Delta_{cp} = 0$
Normal hierarchy

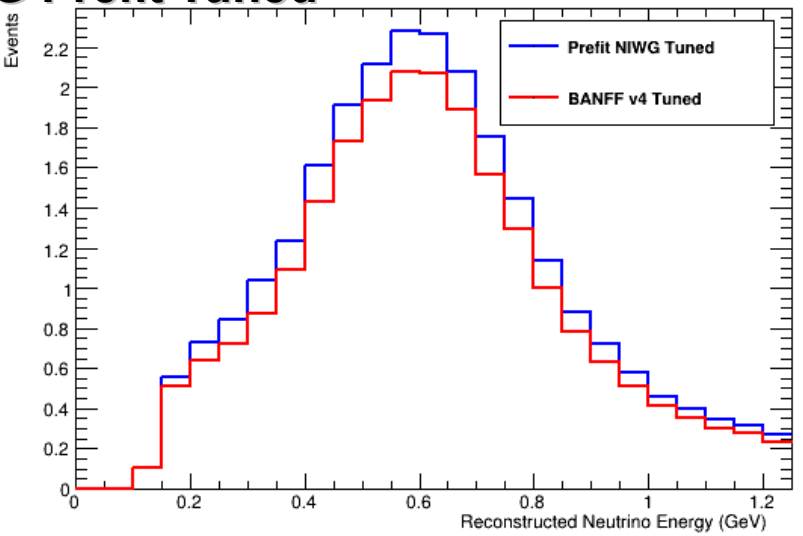
Mode Breakdown





BANFF tuned & NIWG Prefit Tuned





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Super-K ν_μ BANFF v4 Tuned

SKMC 13a @ 6.3933E20 POT

Oscillations

	ν_μ	ν_e	$\bar{\nu}_\mu$	$\bar{\nu}_e$	ν_e signal
CCQE	67.2	0.0328	4.35	0.00188	0.186
CC1π	27.4	0.0208	1.97	0.00117	0.0681
CC coherent	0.878	0.00105	0.241	0.000126	0.00509
CCnπ	6.27	0.00376	0.377	0.000235	0.00101
CC other	2.04	0.00251	0.093	0.000159	0.000533
NCπ^0	0.635	0.0199	0.0318	0.00203	0
NC$\pi^{+/-}$	2.84	0.0723	0.139	0.00787	0
NC coherent	0.016	0.000382	0.000729	7.48e-05	0
NC other	2.4	0.0929	0.132	0.00905	0
Sample Totals	110	0.247	7.33	0.0226	0.26
Total Rate			118		

N_{SK} (nominal MC)	N_{SK} (NA61-tuned MC)	N_{SK} (BANFF tuned MC)
113.170201	127.802057	117.776282

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No Oscillations

	ν_μ	ν_e	$\bar{\nu}_\mu$	$\bar{\nu}_e$	ν_e signal
CCQE	334	0.0354	8.98	0.00197	0
CC1π	57.2	0.0219	2.82	0.00121	0
CC coherent	2.04	0.00112	0.451	0.000131	0
CCnπ	7.14	0.00384	0.431	0.000238	0
CC other	2.17	0.00253	0.0994	0.00016	0
NCπ^0	0.635	0.0199	0.0318	0.00203	0
NC$\pi^{+/-}$	2.84	0.0723	0.139	0.00787	0
NC coherent	0.016	0.000382	0.000729	7.48e-05	0
NC other	2.4	0.0929	0.132	0.00905	0
Sample Totals	408	0.25	13.1	0.0227	0
Total Rate			422		

N_{SK} (nominal MC)	N_{SK} (NA61-tuned MC)	N_{SK} (BANFF tuned MC)
406.885590	451.896983	421.761456

Note: MaCh3 calculates oscillation weights for each MC event, as opposed to each bin center.

Super-K ν_e Fitqun π^0 BANFF v3 Tuned

SKMC 13a @ 6.3933E20 POT

Oscillations

	ν_μ	ν_e	$\bar{\nu}_\mu$	$\bar{\nu}_e$	ν_e signal
CCQE	0.0461	2.14	0.000803	0.0911	13.9
CC1π	0.0185	0.714	0.000278	0.0383	2.45
CC coherent	1.4e-05	0.00885	4.54e-06	0.00632	0.0421
CCnπ	0.000781	0.0483	0.000121	0.00315	0.0296
CC other	0.000161	0.00788	0	0.000342	0.00221
NCπ^0	0.382	0.0102	0.0265	0.00109	0
NC$\pi^{+/-}$	0.107	0.00298	0.0073	0.00031	0
NC coherent	0.121	0.00327	0.0151	0.000581	0
NC other	0.218	0.00693	0.0126	0.000632	0
Sample Totals	0.893	2.94	0.0627	0.142	16.5
Total Rate			20.5		

No Oscillations

	ν_μ	ν_e	$\bar{\nu}_\mu$	$\bar{\nu}_e$	ν_e signal
CCQE	0.0456	2.32	0.000807	0.0976	0.354
CC1π	0.0187	0.76	0.000279	0.0401	0.0347
CC coherent	1.12e-05	0.00953	4.75e-06	0.00675	0.000737
CCnπ	0.000786	0.0499	0.000121	0.00325	0.000267
CC other	0.000166	0.00808	0	0.000349	1.8e-05
NCπ^0	0.382	0.0102	0.0265	0.00109	0
NC$\pi^{+/-}$	0.107	0.00298	0.0073	0.00031	0
NC coherent	0.121	0.00327	0.0151	0.000581	0
NC other	0.218	0.00693	0.0126	0.000632	0
Sample Totals	0.893	3.17	0.0627	0.151	0.39
Total Rate			4.67		

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$\sin^2 2\theta_{13} = 0.1$

	Nominal	Pre ND280 fit	Post ND280 fit
ν_e CC signal	17.4	17.9	16.0
ν_μ background	1.1	1.2	0.9
$\overline{\nu}_\mu$ background	0.1	0.1	0.1
ν_e background	3.0	3.3	2.9
$\overline{\nu}_e$ background	0.2	0.2	0.1
Total	21.6	22.6	20.4

$\sin^2 2\theta_{13} = 0.0$

	Nominal	Pre ND280 fit	Post ND280 fit
ν_e CC signal	0.4	0.4	0.4
ν_μ background	1.1	1.2	0.9
$\overline{\nu}_\mu$ background	0.1	0.1	0.1
ν_e background	3.3	3.5	3.2
$\overline{\nu}_e$ background	0.2	0.2	0.2
Total	4.9	5.3	4.6

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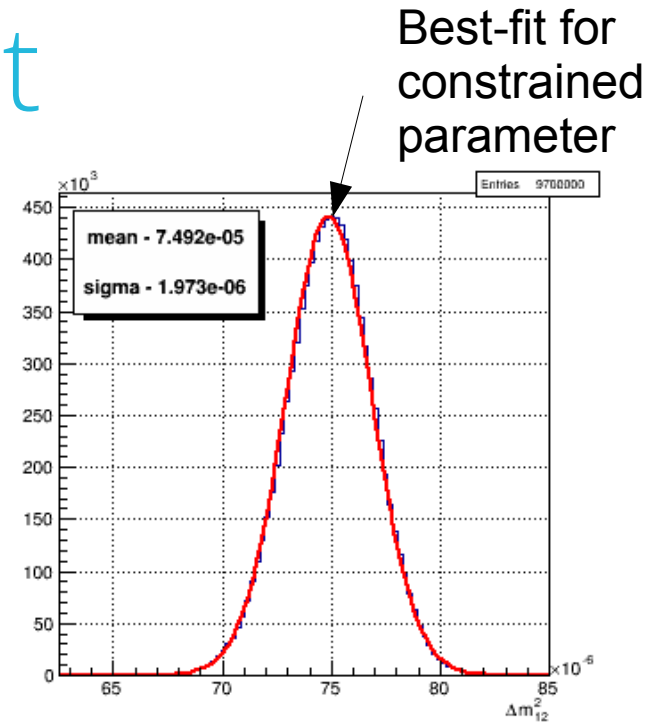
Best Fit Point

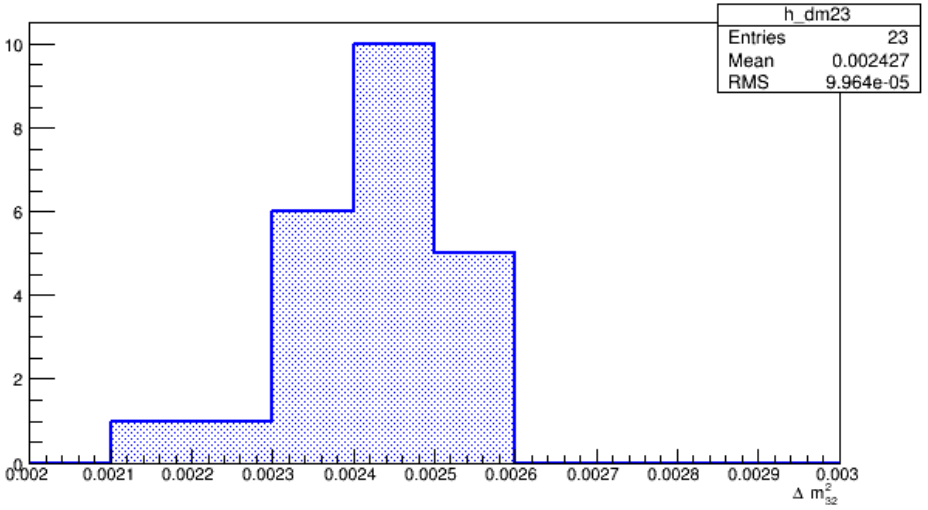
- Constrained systematics are determined from the mean of gaussian fit to the posterior
- For oscillation parameters of interest, the point of highest density in 4-dimensional space must be found

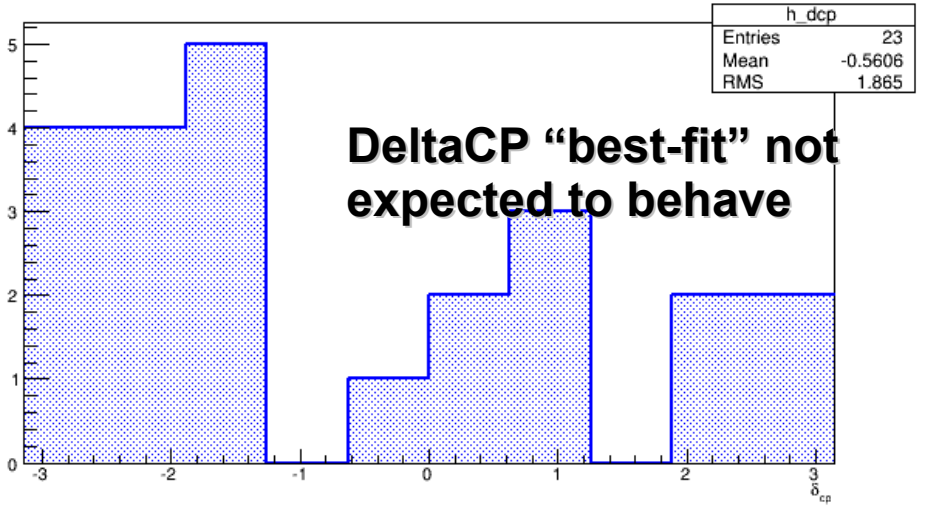


- We use a *kernel density estimation method (KDE)* to find the most dense point of the posterior distribution
  - Turn discrete steps into a continuous distribution
  - Use minuit to find the highest density

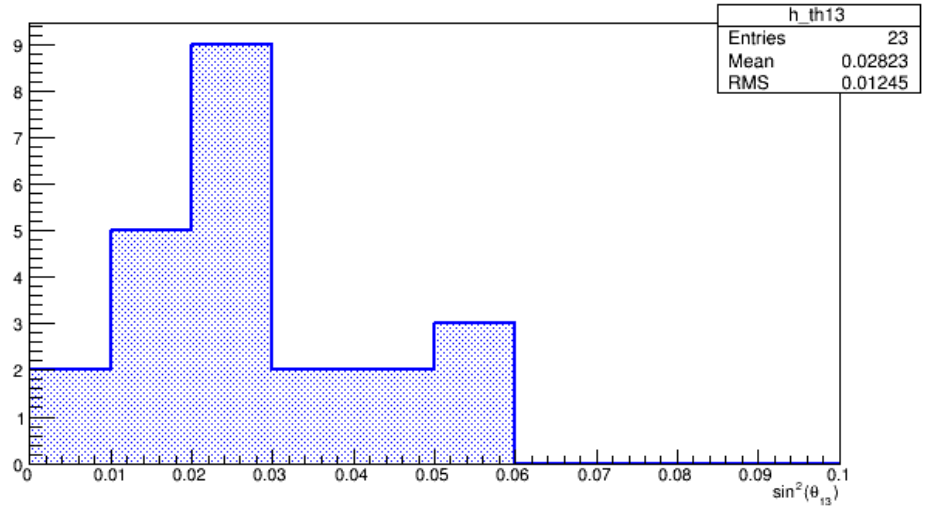
Cranmer KS, Kernel Estimation in High-Energy Physics. Computer Physics Communications 136:198-207,2001 - e-Print Archive: hep ex/0011057

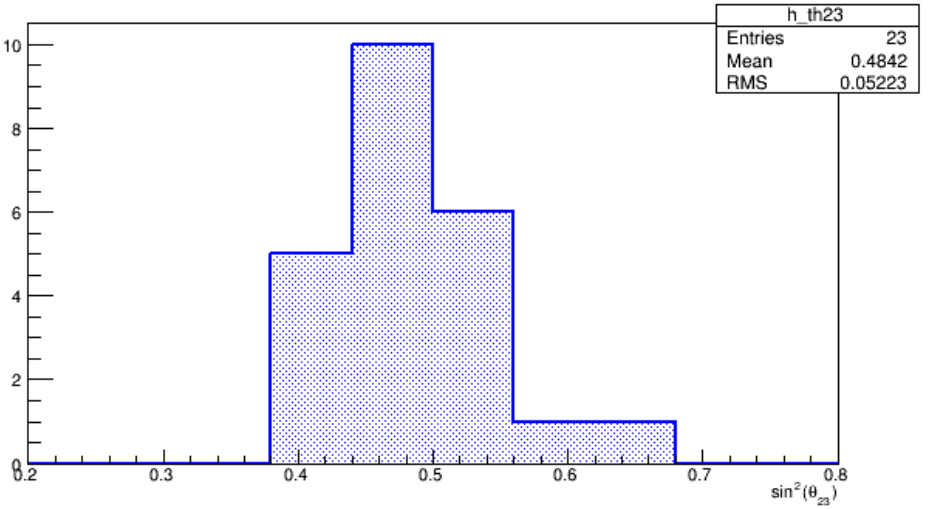
KDE – Toy Fit Results (In progress)





DeltaCP "best-fit" not expected to behave





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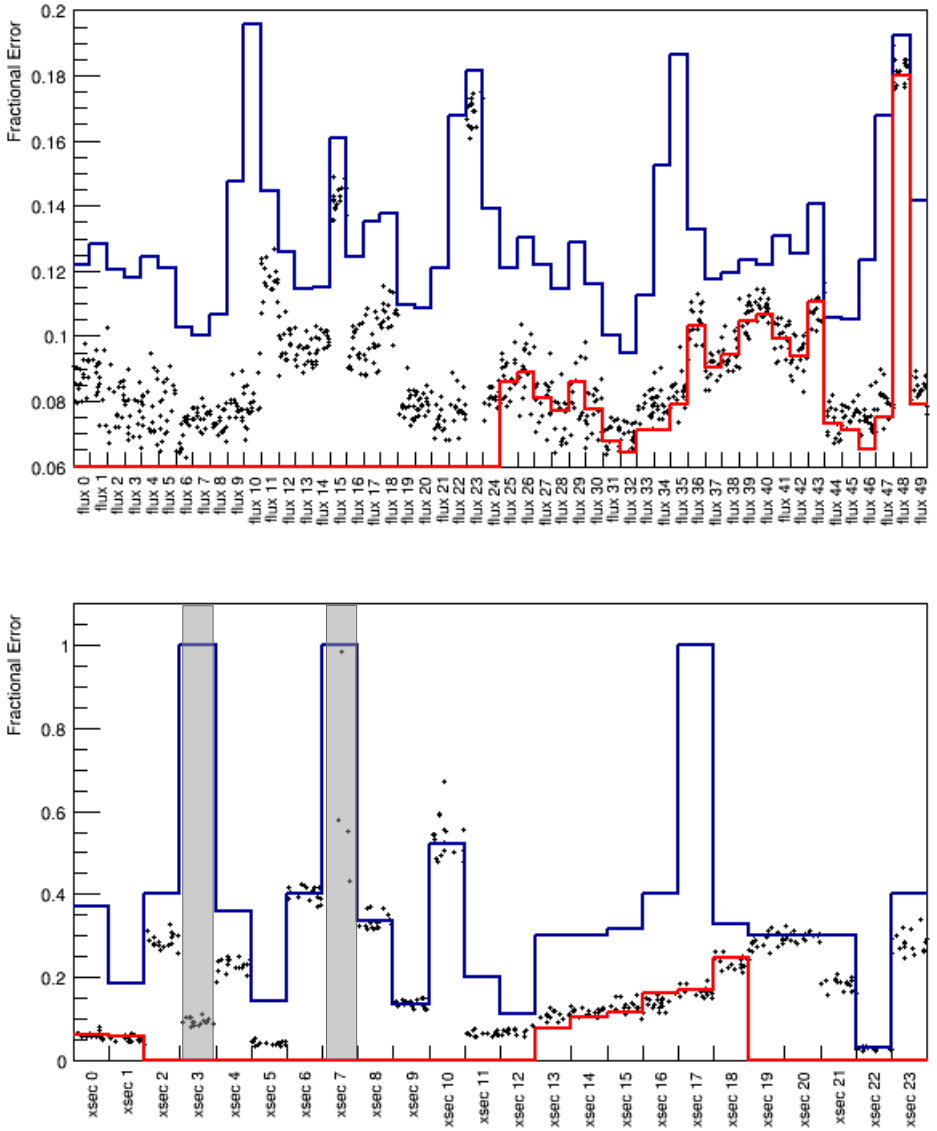
Plots generated with ~10% of full posterior (preliminary testing), results still look promising.

Toy Fit Studies

- Toy experiments are running on the emerald GPU cluster
  - Bugs found (and fixed), but had to restart toys
  - Currently have 20-30 complete toys, aiming for 50-100
- Not enough statistics yet, but so-far nothing alarming
- Expect toy studies to be complete in 1-2 weeks

Error Reduction



- For each toy experiment, calculate error on each parameter posterior
- Compare to prior error and BANFF postfit error (v4)
- Error reduction from simultaneous fit matches error reduction from BANFF fit
- Spectral function parameters are unconstrained in the fit (xsec par 3 & 7)

Scatter plot – MaCh3 Toy Posterior Error
Blue – Prior Error
Red – BANFF v4 (joint matrix)

Conclusion

- PDFs are producing valid event rates
- Toy fits are halfway finished
- We have determined a best fit method for oscillation parameters
- Preparing to perform fake data fits
- Hope to start performing run1-4 data fits in the next couple of weeks
  - **4 fits:** both hierarchies & with/without reactor constraint
- What would OA group like to see before beginning to fit data?