CAFAna for DUNE

DUNE UK meeting – Nov 2017

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What is CAFAna?

CAfaNA

CLUB D'AFFAIRES FRANCO-ALLEMAND NANTES-ATLANTIQUE

DEUTSCH-FRANZÖSISCHER WIRTSCHAFTSCLUB NANTES-ATLANTIQUE

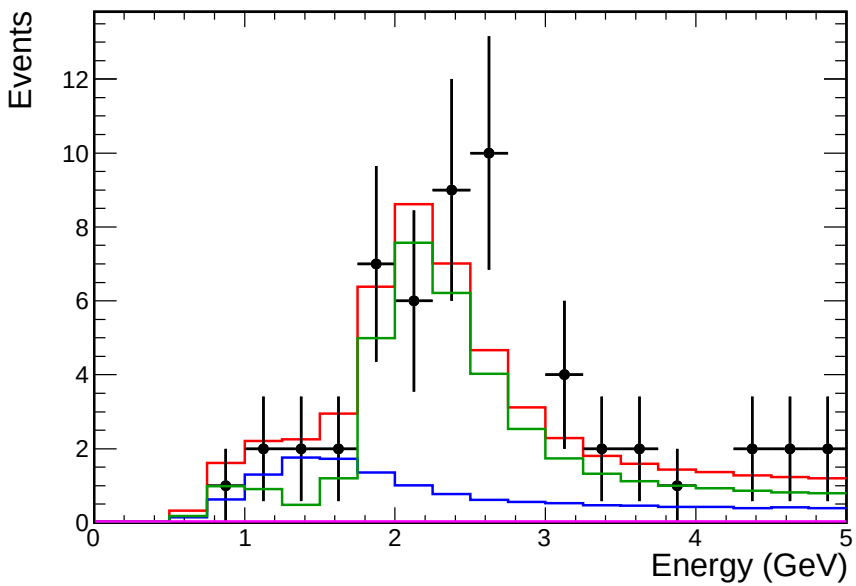
What is CAFAna?

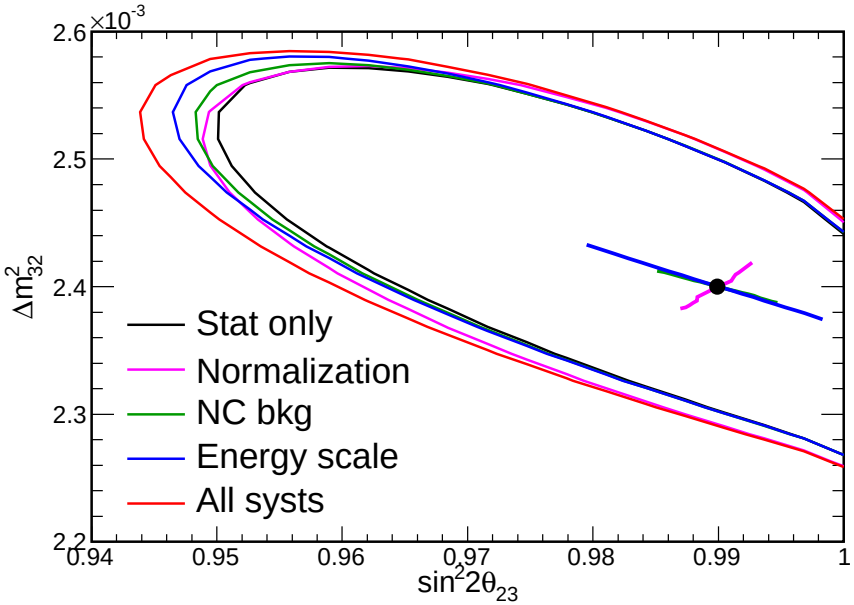
- NOvA's standard analysis framework – ν_μ, ν_e, xsecs...
- **C**ommon **A**nalysis **F**iles are NOvA's standard ntuples

- Ported to DUNE at LBL hackdays in February
- Input files are the `MVASelect` ntuples

- Not just fitting, standard framewwork for making data/MC plots etc
- Structured as a bag of tools to plug together, not monolithic
- Write a `.C` root macro to drive analysis
- Large pool of NOvA collaborators with experience
- Speed is important for productivity, aim for $\mathcal{O}$(minutes) interactively

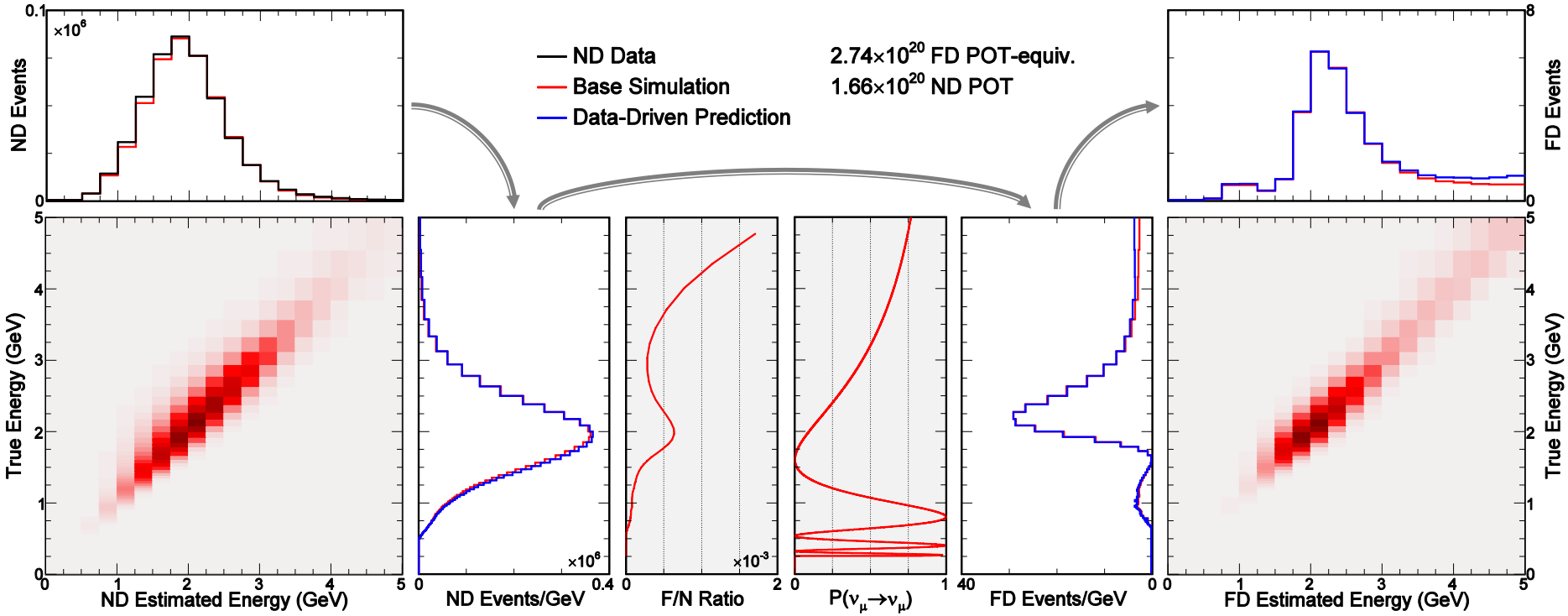
Fits





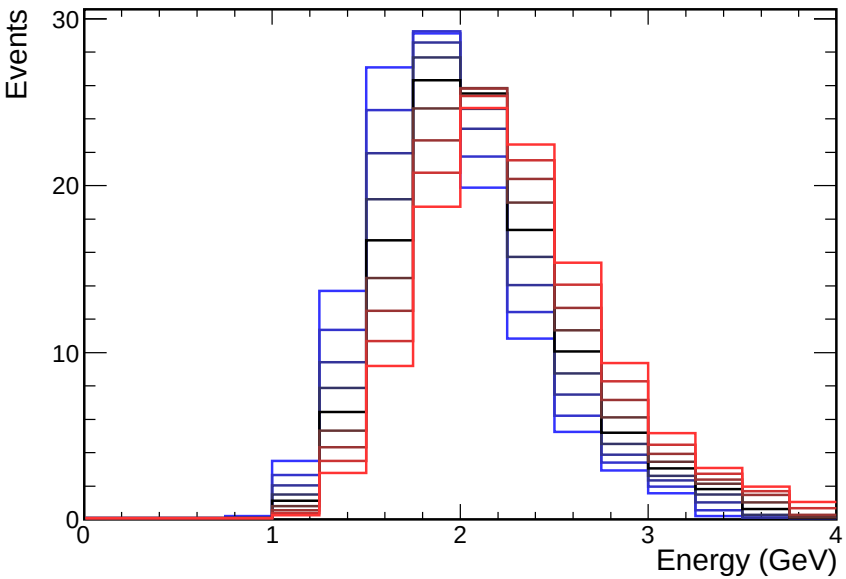
- Oscillatable spectra stored as 2D histograms (speed)
- Maximum likelihood fit, systematics included by profiling

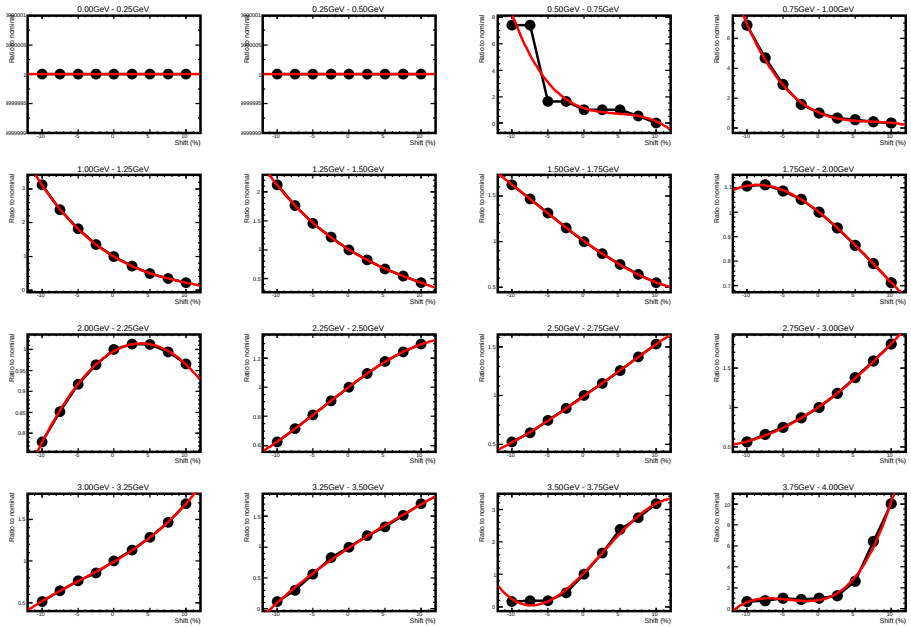
Extrapolation



- NOvA heritage means hooks included for direct ND→FD extrap
- No implementation for DUNE yet (I am interested though)
- All work so far has been joint fit between ND and FD

Systematic interpolation

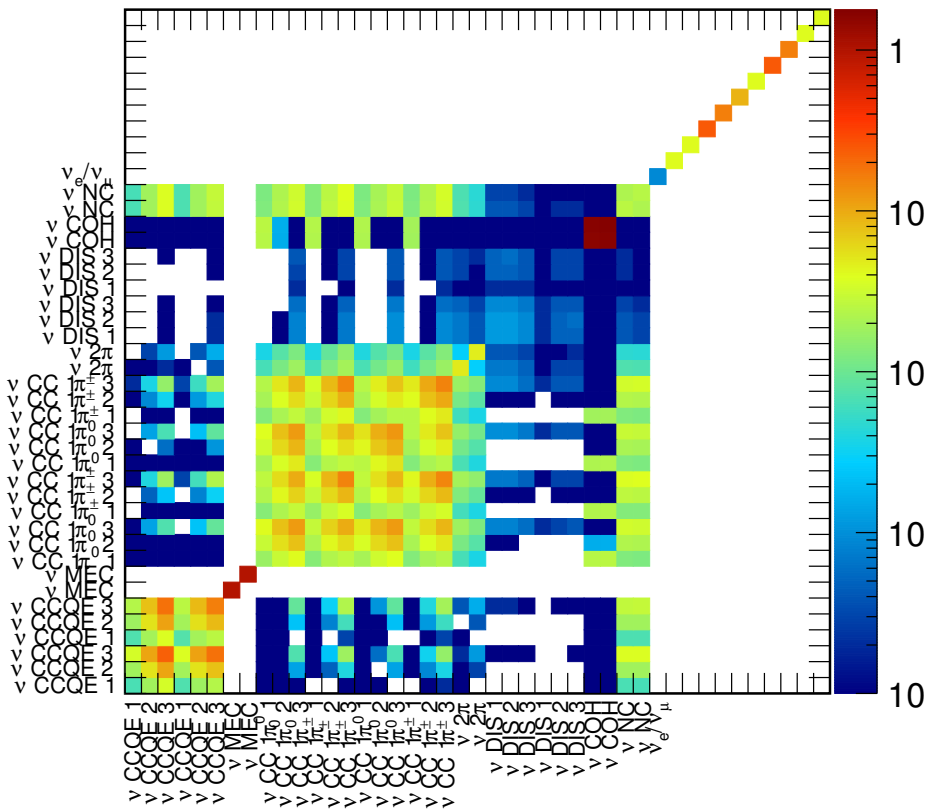




- Systematic pull terms can deal with non-gaussianicity not encoded by covariance matrices
- Shift prediction by interpolating between discrete templates
- Apply reweights or changes to event record, or interpolate between specially-generated samples

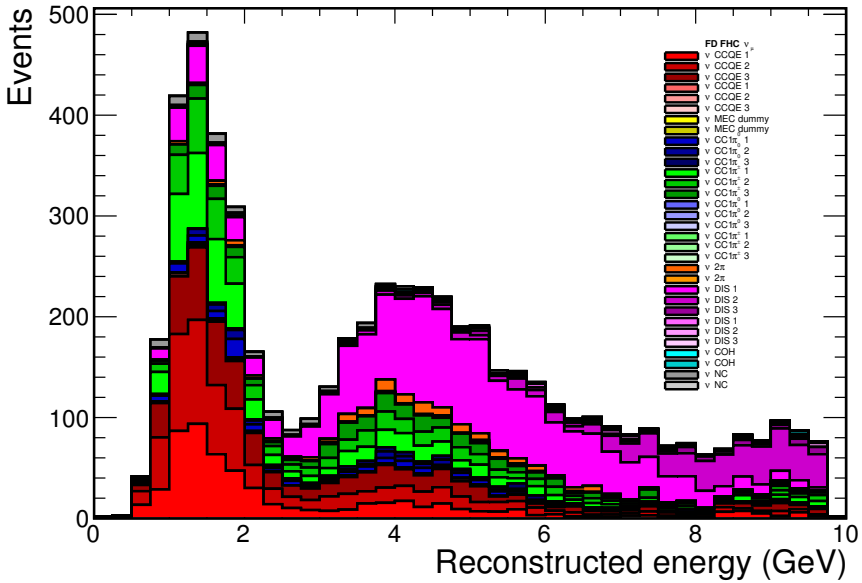
XSec systematics

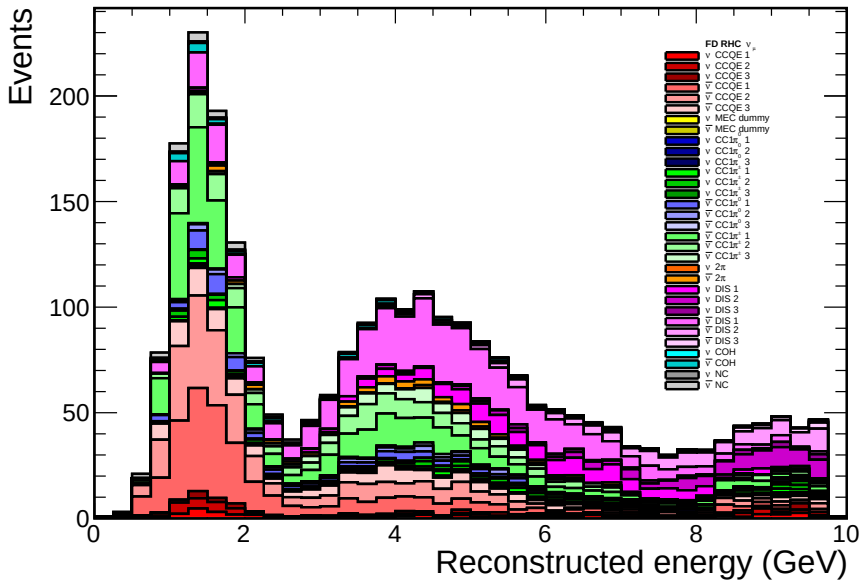
- Implementation of simple CDR-style scales
- Implementation of 32 VALOR xsec categories (right)

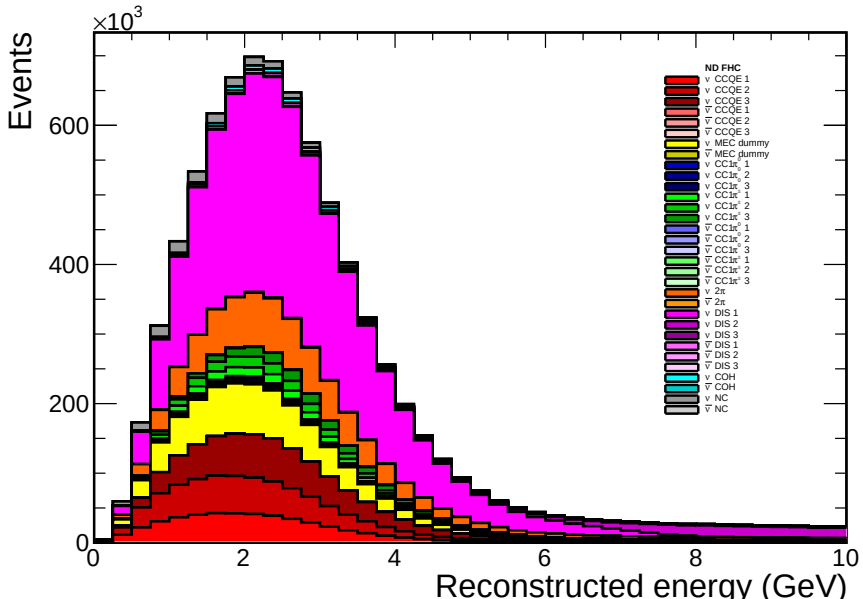


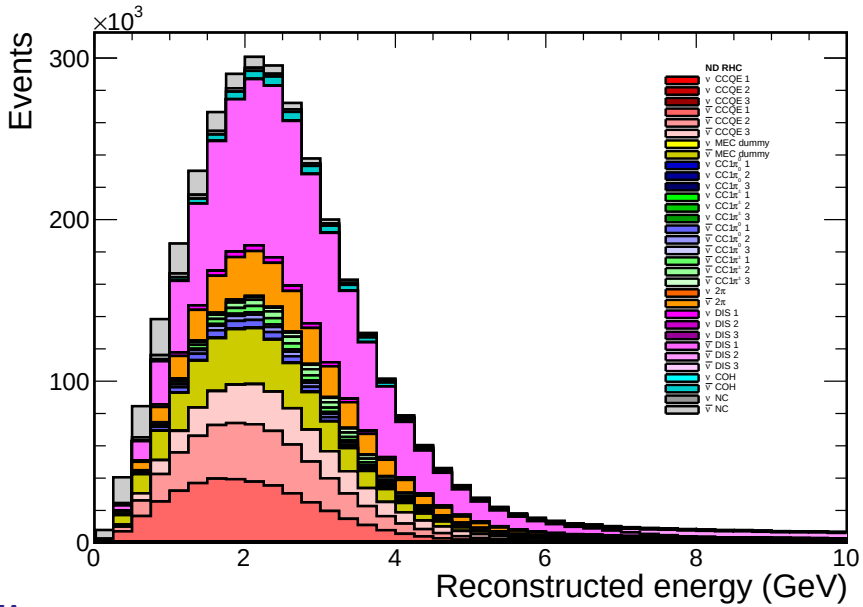
Component	Magnitude	Comment
ν CCQE 1	8.2%	$Q^2 < 0.2$
ν CCQE 2	23%	$0.2 < Q^2 < 0.55$
ν CCQE 3	48%	$Q^2 > 0.55$
$\bar{\nu}$ CCQE 1	8.7%	$Q^2 < 0.2$
$\bar{\nu}$ CCQE 2	24%	$0.2 < Q^2 < 0.55$
$\bar{\nu}$ CCQE 3	40%	$Q^2 > 0.55$
ν MEC dummy	100%	-
$\bar{\nu}$ MEC dummy	100%	-
ν CC1π^0 1	13%	$Q^2 < 0.35$
ν CC1π^0 2	23%	$0.35 < Q^2 < 0.90$
ν CC1π^0 3	35%	$Q^2 > 0.90$
ν CC1$\pi^\pm$ 1	13%	$Q^2 < 0.30$
ν CC1$\pi^\pm$ 2	24%	$0.30 < Q^2 < 0.80$
ν CC1$\pi^\pm$ 3	40%	$Q^2 > 0.80$
$\bar{\nu}$ CC1π^0 1	16%	$Q^2 < 0.35$
$\bar{\nu}$ CC1π^0 2	27%	$0.35 < Q^2 < 0.90$
$\bar{\nu}$ CC1π^0 3	35%	$Q^2 > 0.90$
$\bar{\nu}$ CC1$\pi^\pm$ 1	16%	$Q^2 < 0.30$
$\bar{\nu}$ CC1$\pi^\pm$ 2	30%	$0.30 < Q^2 < 0.80$
$\bar{\nu}$ CC1$\pi^\pm$ 3 3	40%	$Q^2 > 0.80$
ν 2π	22%	-
$\bar{\nu}$ 2π	22%	-
ν DIS 1	3.5%	$E_\nu < 7.5$
ν DIS 2	3.5%	$7.5 < E_\nu < 15$
ν DIS 3	2.7%	$E_\nu > 15$
$\bar{\nu}$ DIS 1	1%	$E_\nu < 7.5$
$\bar{\nu}$ DIS 2	1.7%	$7.5 < E_\nu < 15$
$\bar{\nu}$ DIS 3	1.7%	$E_\nu > 15$
ν COH	128%	-
$\bar{\nu}$ COH	134%	-
ν NC	16%	-
$\bar{\nu}$ NC	16%	-
ν_e/ν_μ dummy	3%	Not implemented yet

XSec systematics

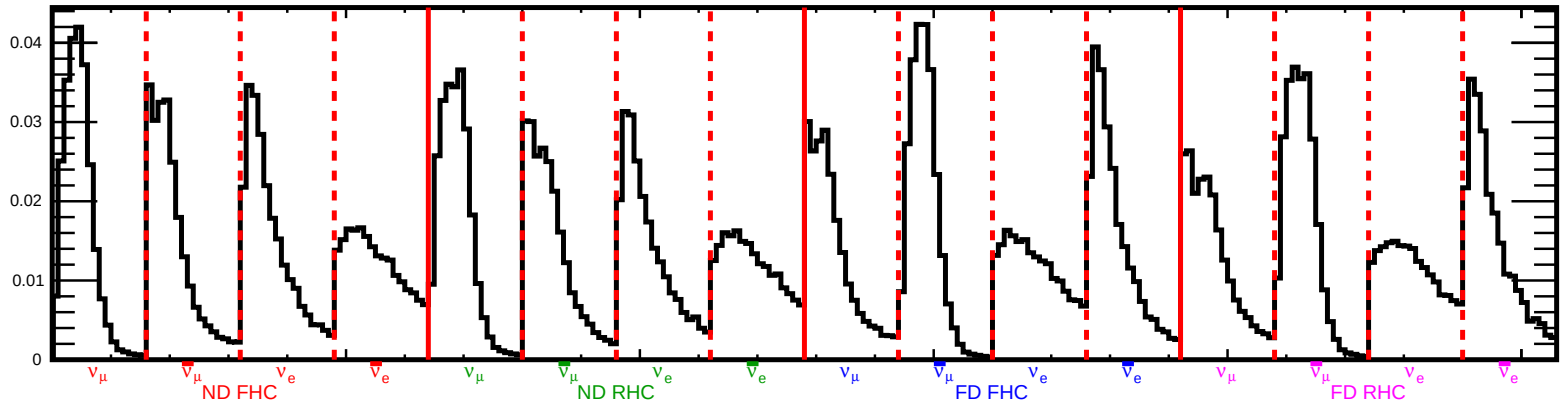






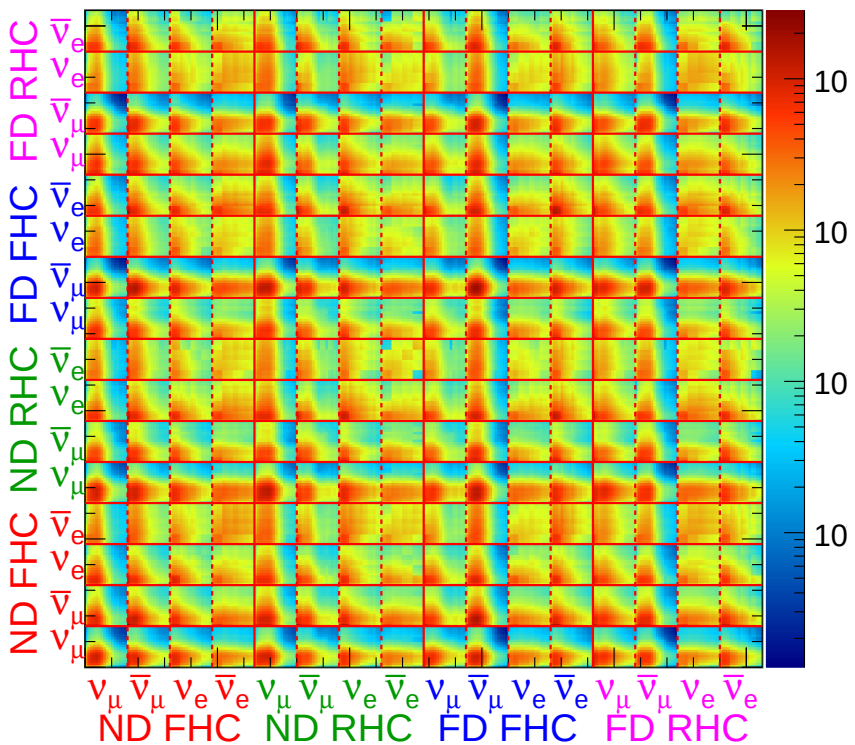


Flux systematics

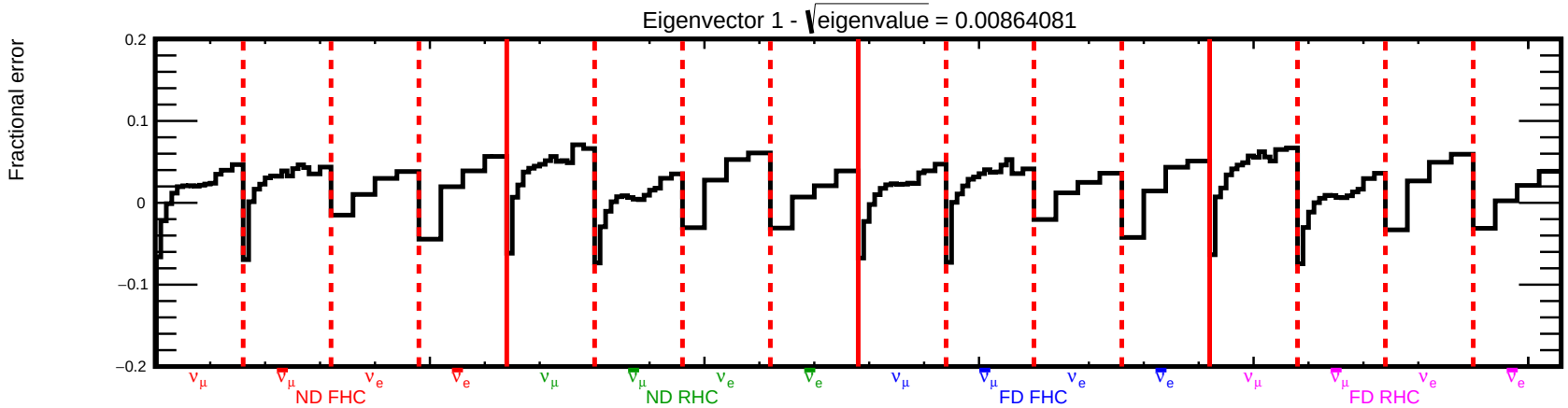


- Flux systs from beam group's covariance matrix
- Use PCA to find smaller basis that covers most of the effect

  `indico.fnal.gov/event/12345/contribution/85`
- More effort required to stand up a full fit with everything included



Flux systematics



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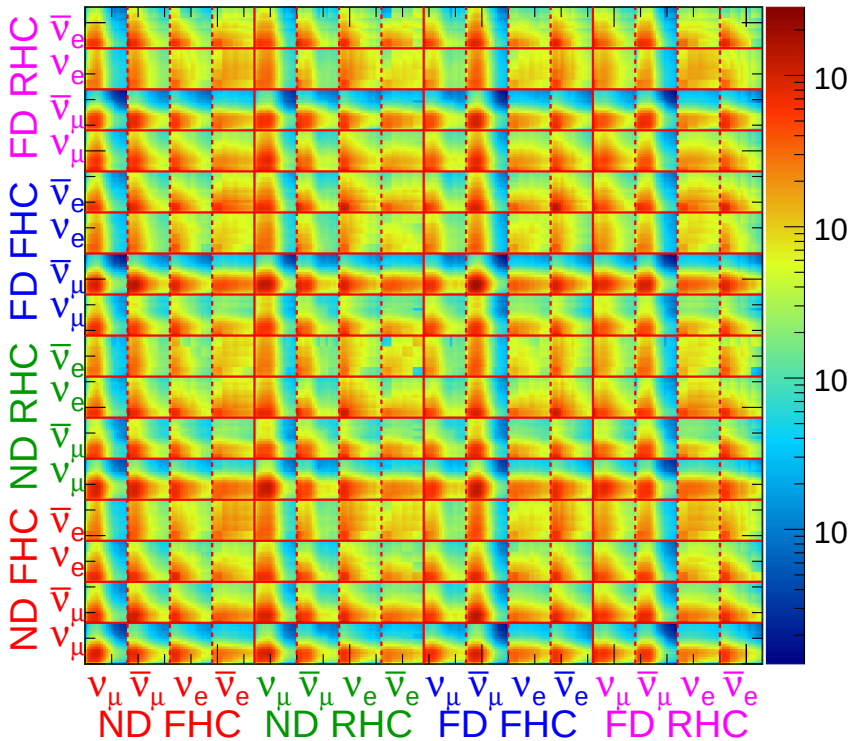
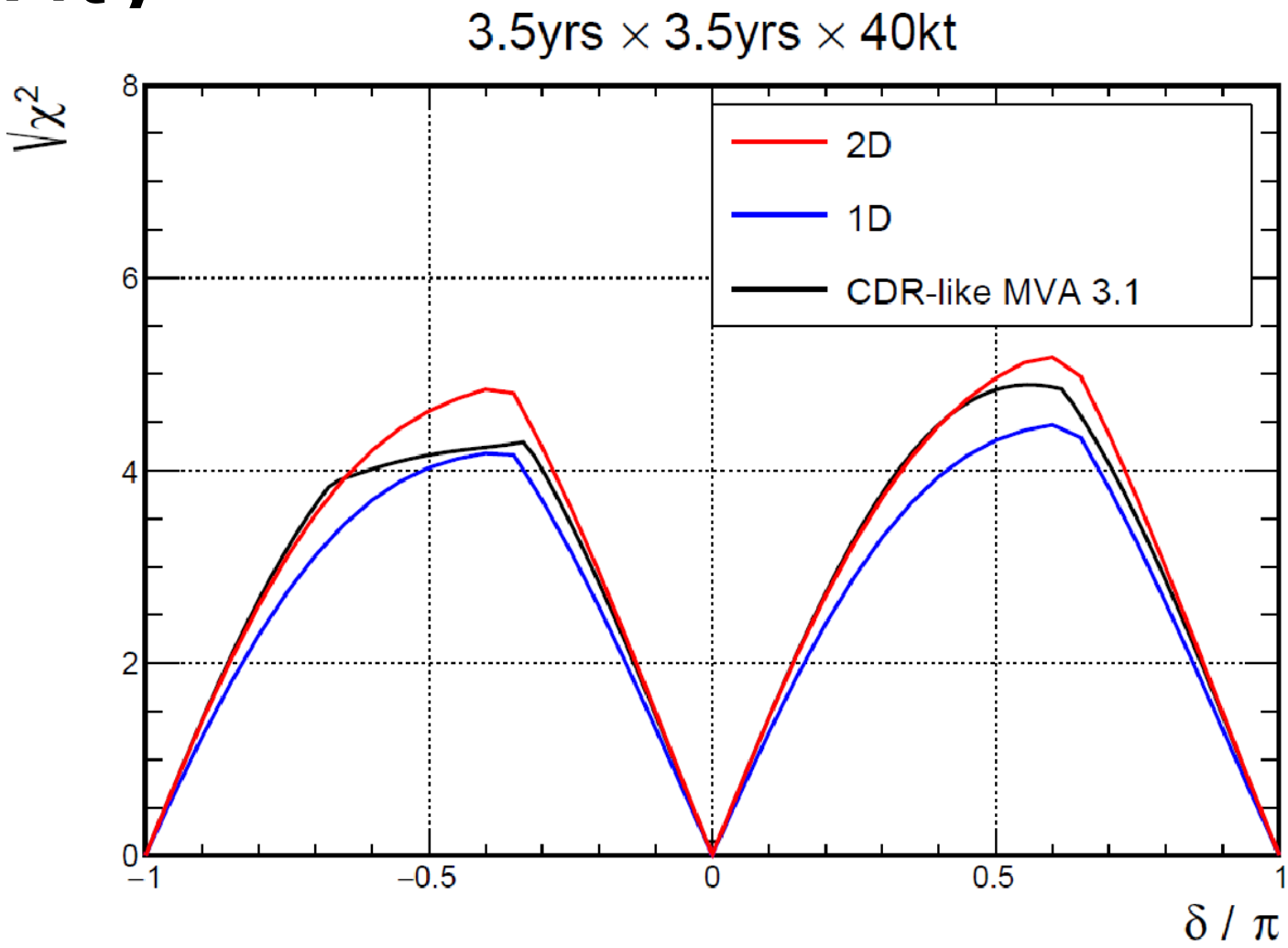


File formats

- `MVASelect` files are fairly crude, first thing to hand
- `AnaTree` files are $\sim$ the standard, a little unwieldy
- Consensus that we need a standard file format
  - Lightweight for oscillation fits
  - Ideally customizable, include only the variables you need
  - Ideally matching ND and ProtoDUNE too
  - A lot of ideas at Physics Week
  - Time, Interest, Expertise: pick two
- Fragmentation of file formats makes it extremely difficult to combine analyses, and forces collaborators to keep relearning basic skills

Activity



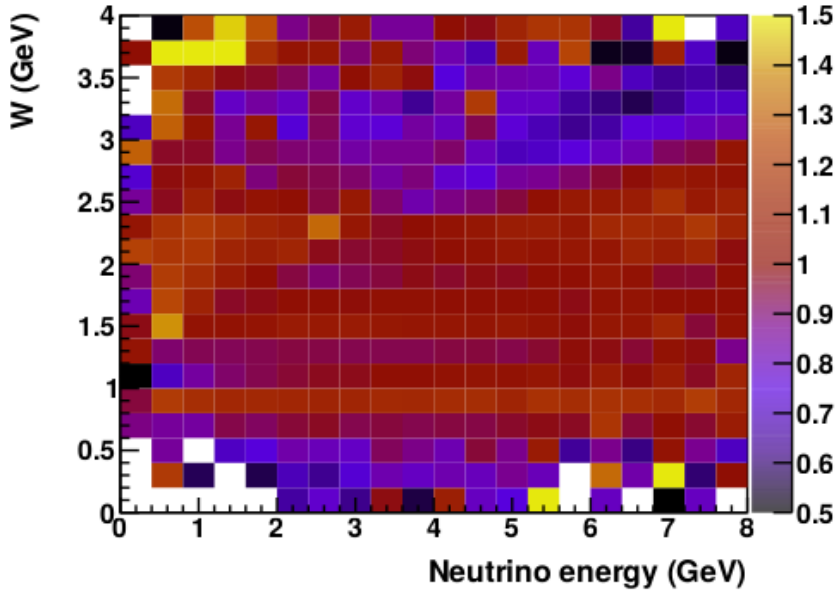
- Kirk Bays has been studying LBL sensitivity
- *e.g.* gains from 2D energy/PID binning

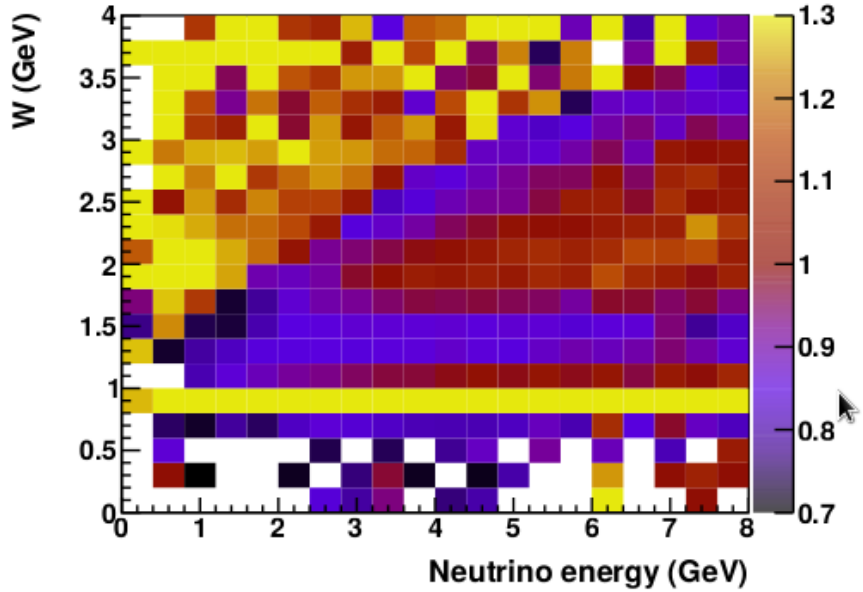
Activity

NEUT

NuWRO

ν





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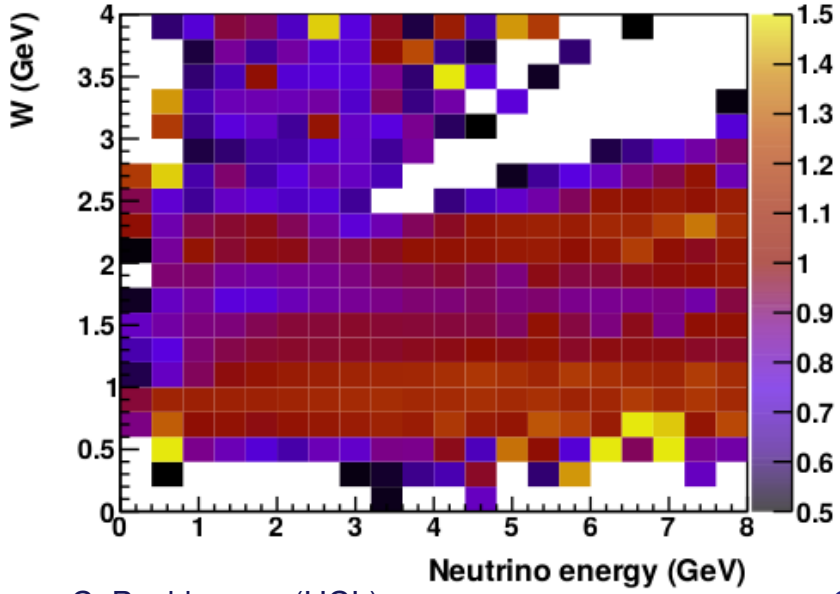
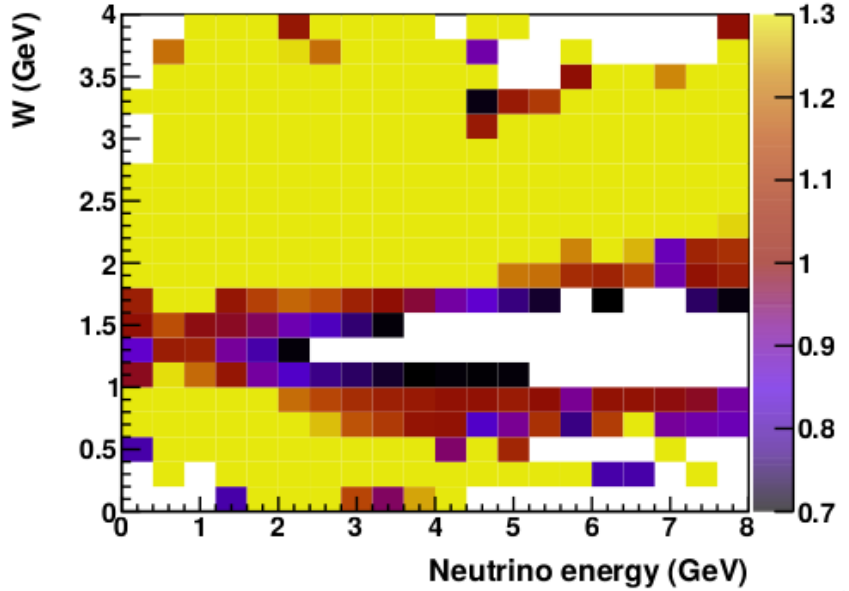
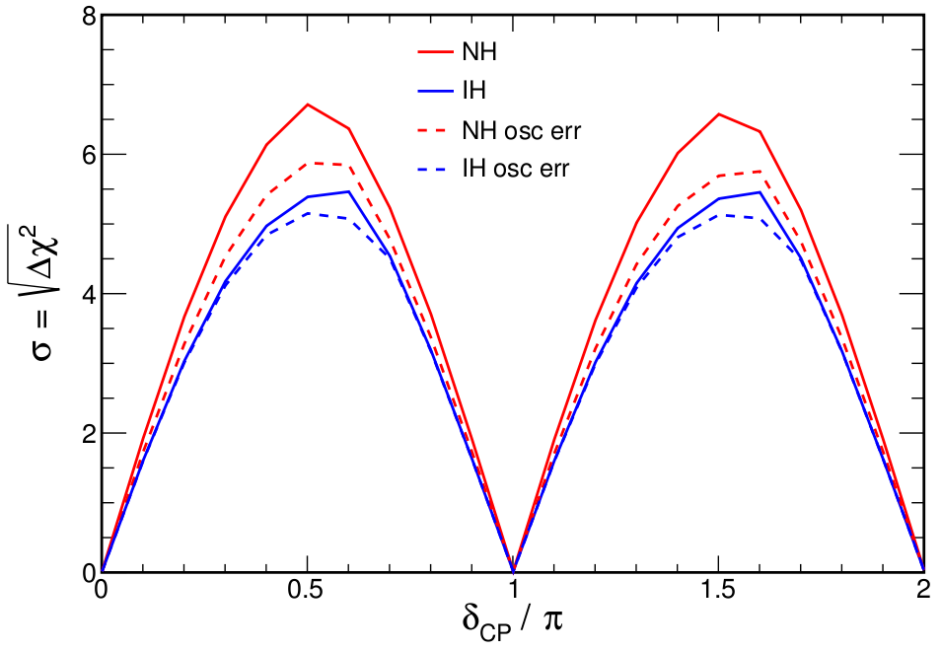




Activity

- Elizabeth Worcester is working on file format improvements
- Alex Radovic is interested in evaluating CVN performance
- DUNEPrism folks interested in quantification of that technique
- Effort to validate fitters against each other



Conclusion

- If your work involves fitting...
- Or histogramming event properties...
- Then CAFAna can help you
  - Possibly after adding info to the files

- None of the names on my previous slides are UK-based, yet...
- Many ideal starter studies haven't been done due to lack of time
- A lot of ways to contibute to the tools themselves
- Features can be added/ported, but you have to yell
- Best way to get involved is to email me – c.backhouse@ucl.ac.uk

- Probably the best more-technical talk is `https://indico.fnal.gov/event/14362/contribution/2`