Physicist's Summary

Asher Kaboth

21 Sept 2016

Thank you!

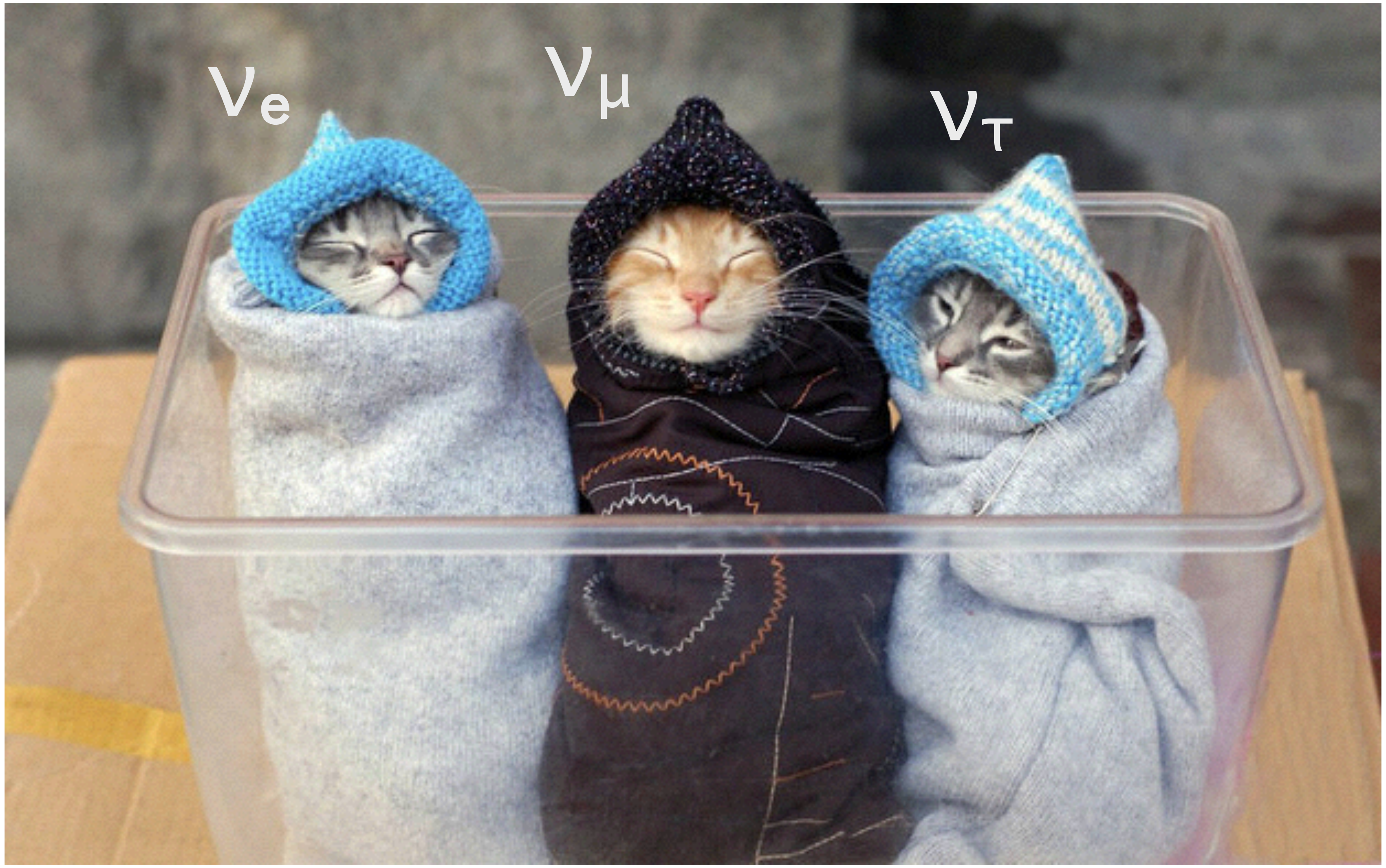
- Thank you to the organizers!
- Thank you to the panel members for the interesting discussion!
- Thank you to the attendees for all your contributions!

Reminder

PhyStat-ν Kashiwa has an in-progress summary document of the discussions there: www.hep.ph.ic.ac.uk/~yoshiu/PhyStat-nu-IPMU-2016-Summary-Draft

Let's think about a summary document for this meeting!

Pictures of Cute Animals are Obligatory



A ToDo List

Possible Future Neutrino Prizes:

- Nature of the Neutrino (Majorana (2) v Dirac (4)) David Moore
- Observing CPV in Neutrino Sector ($\sin\delta \neq 0$) Pilar Coloma, Christopher Backhouse, Shao-Feng Ge
- Demonstrating the Existence of the Sterile Neutrinos Aixin Tan, Zarko Pavlovic
- Observation of New Physics in Neutrino Sector? Neutrino Decay, Non-Standard Interactions, ...
- A convincing Model of Neutrino Masses and Mixing with confirmed predictions. Everyone, basically!

Starting Point

Almost here!

One thing I learned:

- collaboration might converge on high-level statistical procedure. Put in likelihood / probability model and turn the crank.
- Practical improvements to analysis mainly lie in techniques used for modeling the data ! (eg. systematics, ND->FD extrapolation, etc.)
- Useful to factorize discussion & software in terms of **modeling** and high-level statistical **procedure**

This is still a good idea!

Oscillation Analyses

Statistical Approaches for IceCube, DeepCore, and PINGU Neutrino Oscillation Analyses

Joshua Highnight
for the IceCube-PINGU Collaboration

MICHIGAN STATE UNIVERSITY

September 21st, 2016

Long-Baseline Neutrino Experiment Analysis Techniques

PhysStat-ν

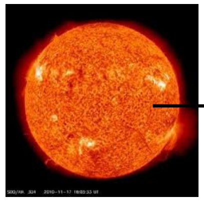
Christopher Backhouse

California Institute of Technology

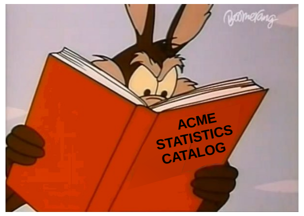
February 5, 2015

C. Backhouse (Caltech) LBL analysis February 5, 2015 1 / 30

Statistical Issues for the Solar Neutrino Researcher



ν



Scott Oser
University of British Columbia
PhyStat-ν 2016
September 20, 2016

Sensitivity to CP violation in neutrino oscillation experiments

Pilar Coloma
Fermilab

Based on:
Blennow, PC, Fernandez-Martinez, arXiv: 1407.3274 [hep-ph]
JHEP 1503 (2015) 005

Phystat-nu Workshop
Fermilab
Sep 19th, 2016

Daya Bay θ_{13} DOUBLE CHOOZ RENO ν θ_{13}

Statistical Methods used in Reactor Neutrino Experiments

Xin Qian
BNL

BROOKHAVEN NATIONAL LABORATORY JUNO

Short-baseline analysis techniques

Zarko Pavlovic

PhyStat-nu Fermilab 2016

Good Points

- It looks like most experiments consider their approximations!
- There's a wide variety of methods, frequently on the same experiment

Things to Work On

- My biggest request: show the diagnostics!
  - There's lots of algorithms:MCMC, F-C, MultiNest, etc
  - Diagnostics for each are different, but all important
- What do we communicate to the future?

Consensus?

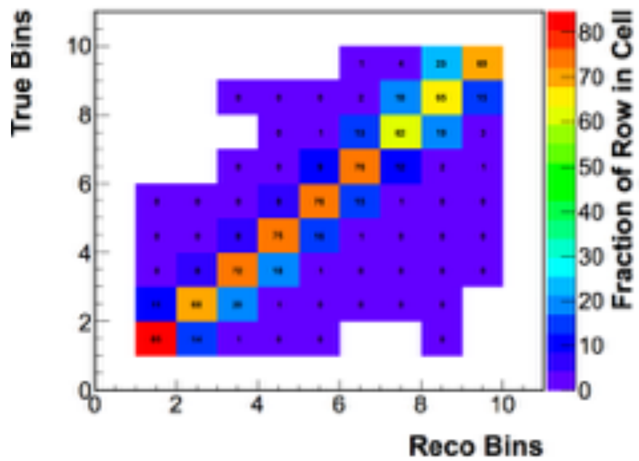
- We’re pretty much on the right track!
- Treatment of systematics is important here, especially in model tests

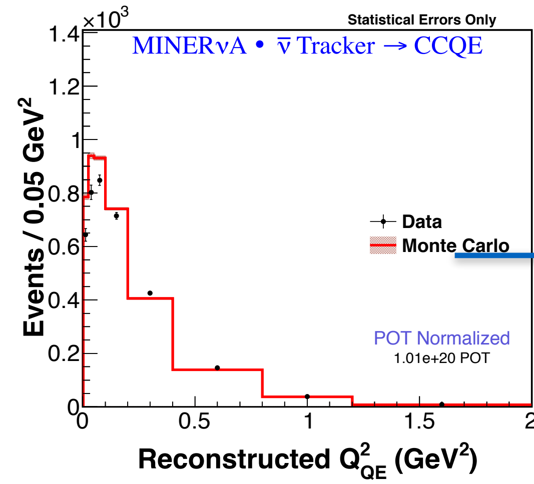
Unfolding

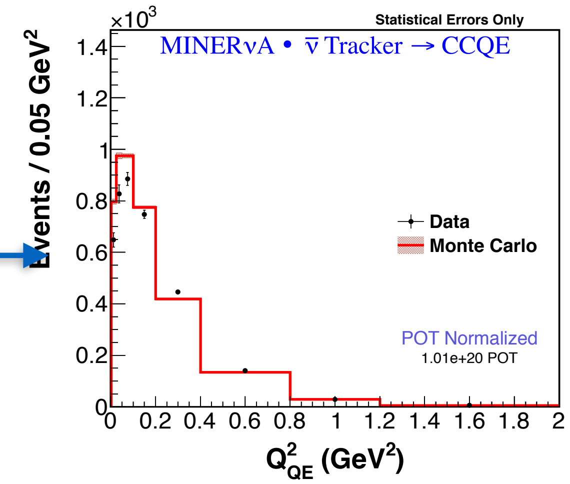
- Lots of discussion here!
- What to do in different situations?

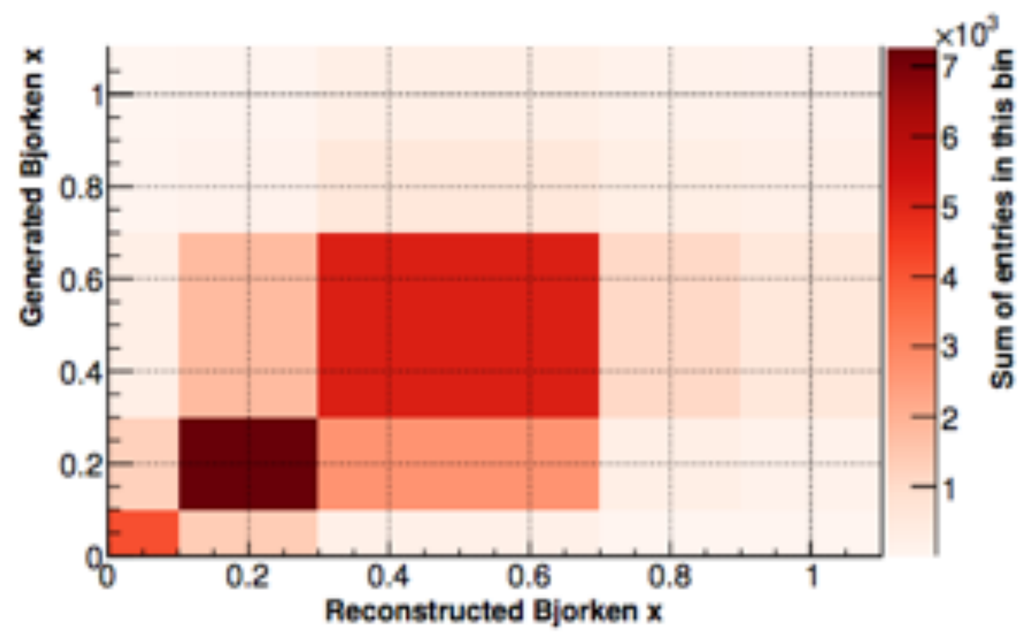
https://arxiv.org/pdf/1607.07038v1.pdf

Cross Section Unfolding

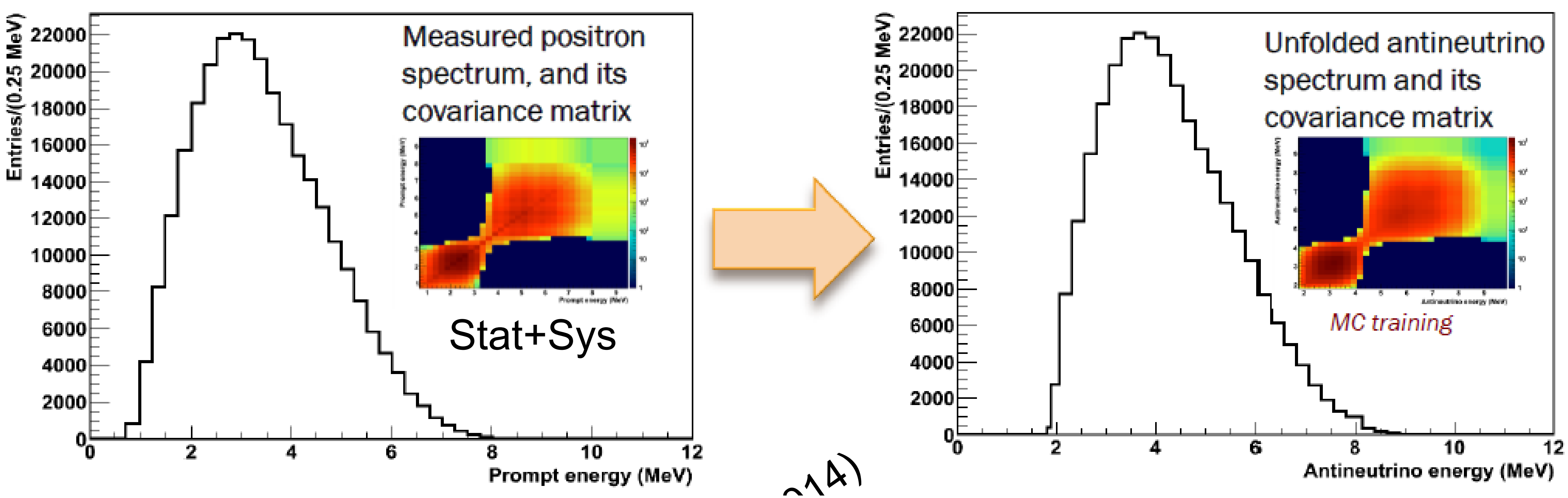








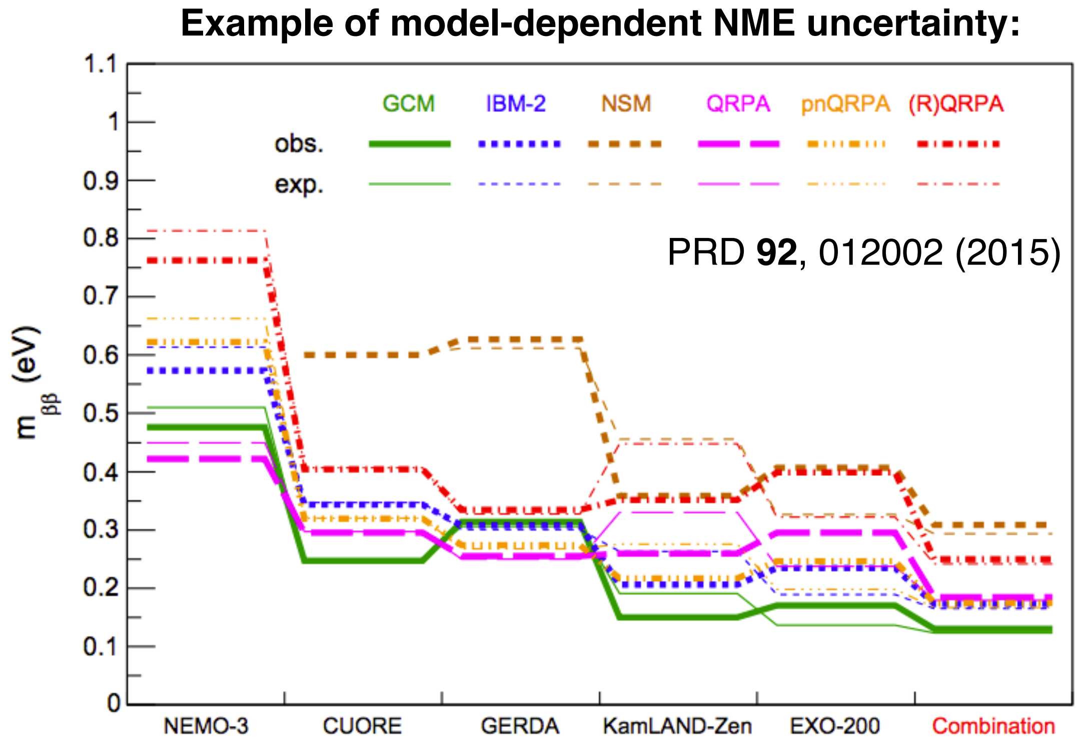
Daya Bay Unfolding



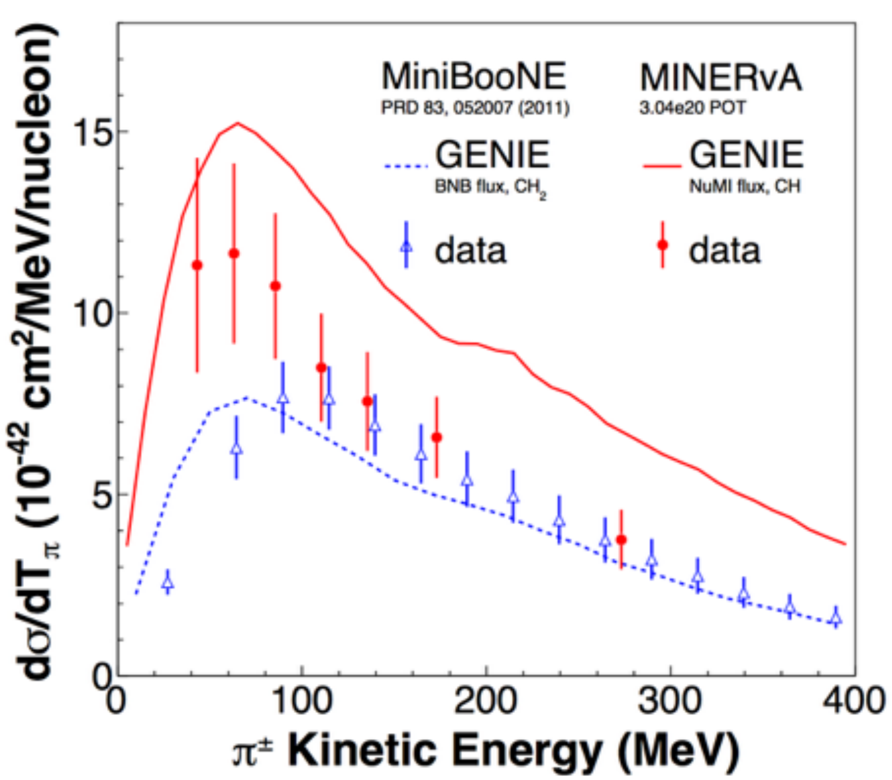
Consensus?

- My sense is that there’s a preference for not unfolding—and if doing so, show more diagnostics
- There should be more investment by experimentalists in providing information to outside the experiment to go from physics to detector quantities

Comparing Models



This shows up in a number of places! Several different techniques, but problems with inputs, too.



	3+1 GLO	3+1 PrGLO	3+1 noMB	3+1 noLSND	3+2 GLO	3+2 PrGLO
χ^2_{min}	306.0	276.3	251.2	291.3	299.6	271.1
NDF	268	262	230	264	264	258
GoF	5%	26%	16%	12%	7%	28%
$(\chi^2_{\mathrm{min}})_{\mathrm{APP}}$	98.9	77.0	50.9	91.8	86.0	69.6
$(\chi^2_{\mathrm{min}})_{\mathrm{DIS}}$	194.4	194.4	194.4	194.4	192.9	192.9
$\Delta\chi^2_{\mathrm{PG}}$	13.0	5.3	6.2	5.3	20.7	8.6
$\mathrm{NDF}_{\mathrm{PG}}$	2	2	2	2	4	4
$\mathrm{GoF}_{\mathrm{PG}}$	0.1%	7%	5%	7%	0.04%	7%
$\Delta\chi^2_{\mathrm{NO}}$	49.2	47.7	48.1	11.4	55.7	52.9
$\mathrm{NDF}_{\mathrm{NO}}$	3	3	3	3	7	7
$n\sigma_{\mathrm{NO}}$	6.4σ	6.3σ	6.4σ	2.6σ	6.1σ	5.9σ

Generative Modeling

http://indico.ipmu.jp/indico/getFile.py/access?contribId=22&sessionId=5&resId=0&materialId=slides&confId=82

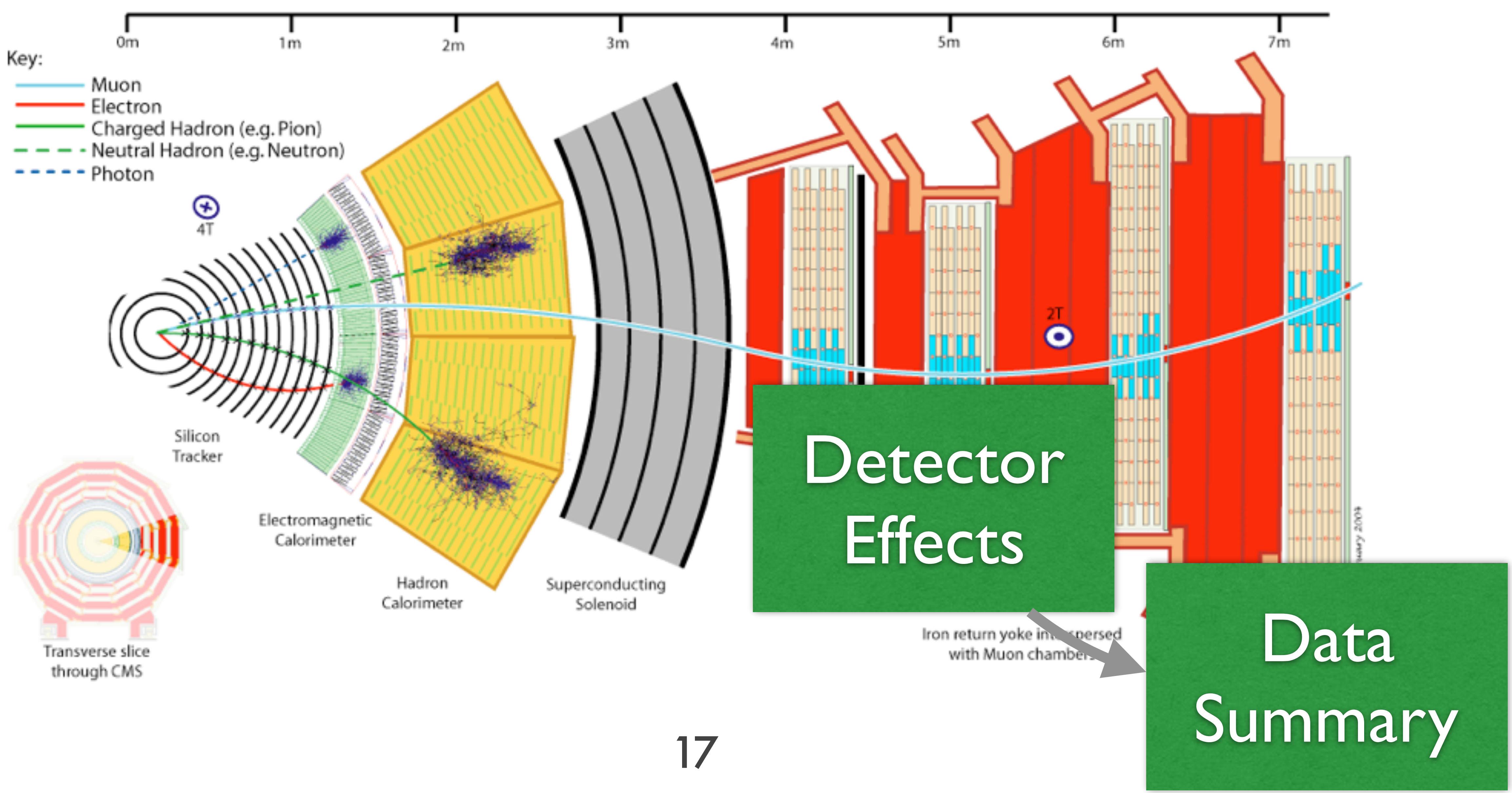
Fundamental Theory → Auxiliary Theory → Detector Effects → Data Summary

Treat all of these probabilistically

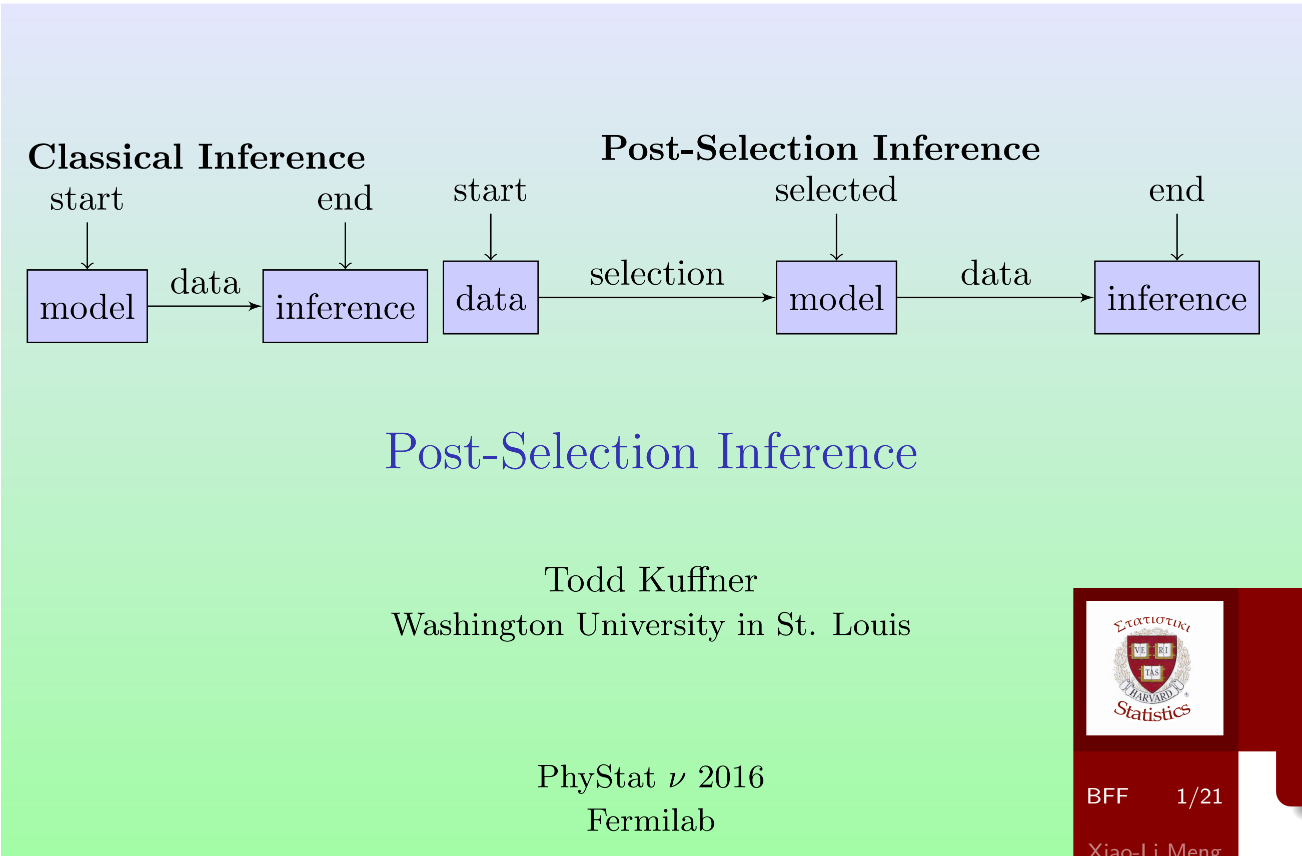
Conceptually: Prob(detector response | particles)

Implementation: Monte Carlo integration over micro-physics

Consequence: cannot evaluate likelihood for a given event



New Ideas from Statisticians



Final Thoughts

- It's so great to see the neutrino community discussing and integrating these issues!
- Clearly combinations, unfolding, and systematic uncertainties are on your minds—good!
- Let's keep this momentum going:
  - Future PhyStat-ν!
  - Think about: does your experiment need a statistics committee? What would that look like? What are *you* taking back to your experiment and analysis?