

Topic 3: Systematics accounting for SBN Analyses

Closeout Highlights

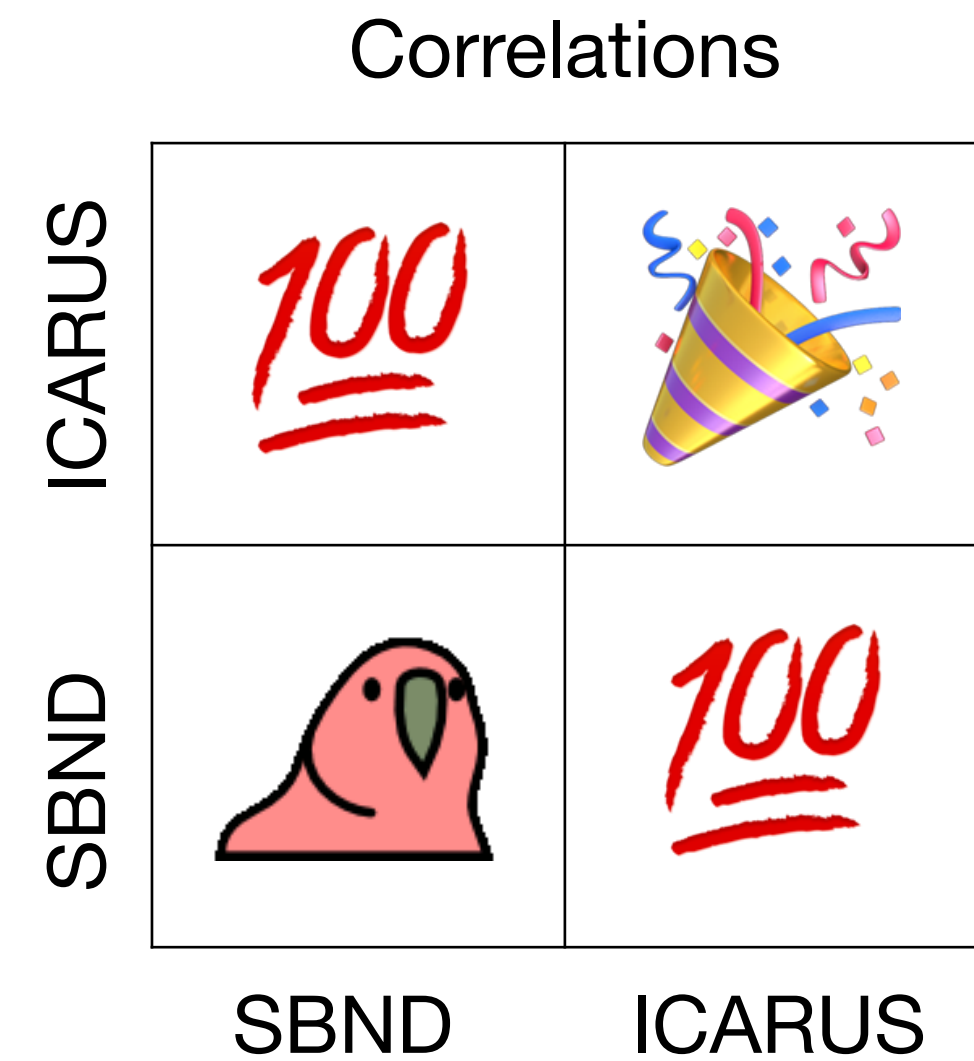
Ibrahim Safa and Andy Mastbaum



Topic 3: Systematics accounting for SBN Analyses

Closeout Highlights

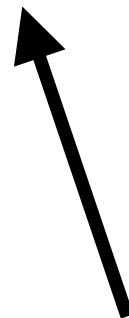
Ibrahim Safa and Andy Mastbaum



Part of the broader effort to reach physics quality data and perform the first joint SBN analysis in 2024.

For that purpose, the upcoming SBN Analysis workshop was set up to:

- 1) 2D drift simulation and deconvolution integrated in both SBND and ICARUS.
- 2) SBND and ICARUS simulation/reconstruction convergence.
- 3) **Develop methods to assess full systematics envelope for SBND and ICARUS for a first analysis, with a focus on detector and G4 systematics.**
- 4) 2024 SBN results strategy (selection type / POT / timeline)


this talk

- Overall goals:
 - Evaluating detector and geant4 uncertainties will be crucial not just for a first joint analysis, but ultimately for every SBND/ICARUS analysis.
 - (1) Study correlations in detector variation samples, (2) implement methods for efficient detector systematics propagation, (3) ensure consistent and state-of-the-art implementation of systematics tools for SBND and ICARUS
- A **HUGE** thanks again to the production team for the many samples used
 - Many lessons learned for future production requests → future discussion

detector systematics

We are constrained by compute hours, cannot produce high-stat simulation sets for every possible variation. More than one solution to this problem.

Goal: Study re-reconstruction method for calorimetry-related detector systematics using variation samples

Shweta Yadav

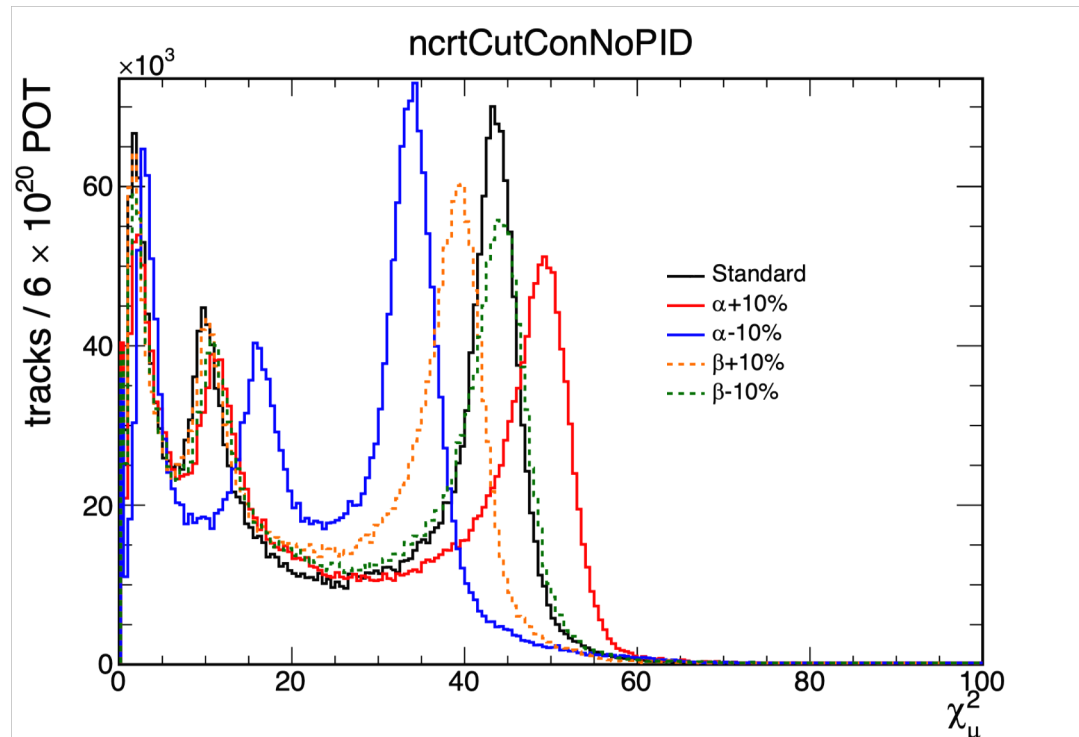
Raquel Castillo Fernández

Leo Aliaga

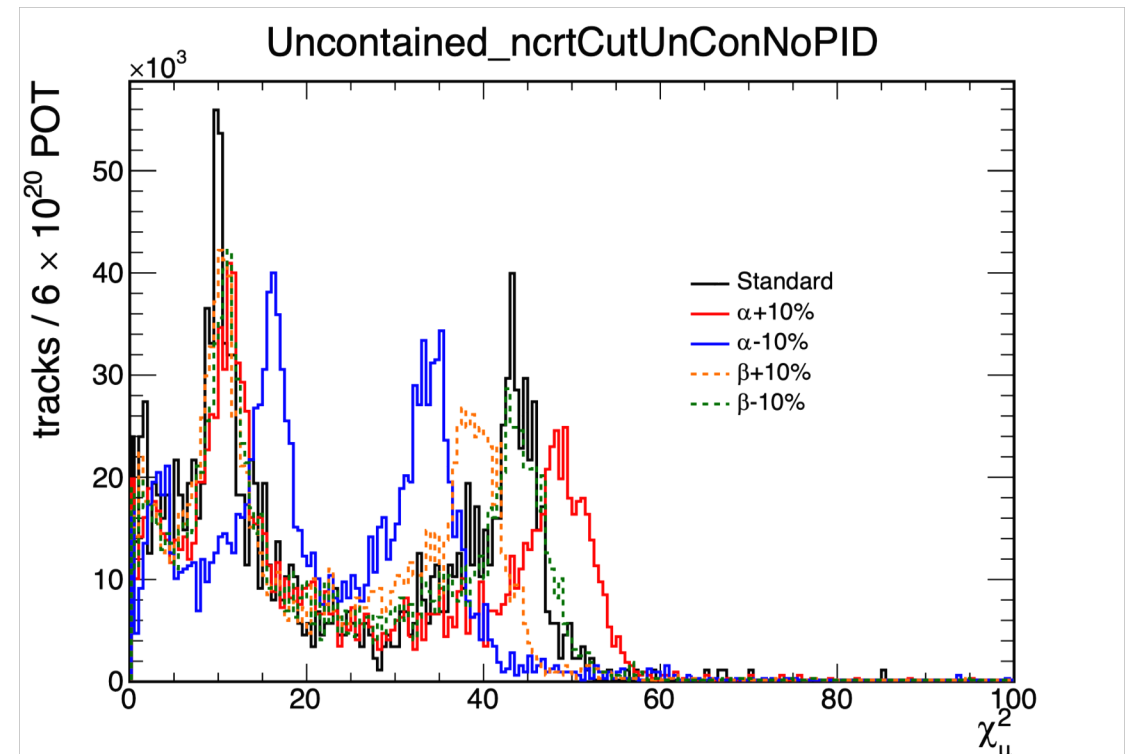
I have been preparing the closure test for the proof of principle for the calorimetry related systematics that was presented by **Leo Aliaga**.

The plots show some of the distributions we will use to validate the approach, that we can assess the uncertainty re-reconstructing in the **reco2 dE/dx** of the **detsim dE/dx**.

These plots are using previous production (not wire cell simulation), only to show the metric developed.



Longest and Contained track
per event



Longest and UnContained
track per event

Goal: Implement the wire waveform modification (WireMod) detector systematics developed within MicroBooNE for SBN

Status:

- WireMod tool compiles and runs in icaruscode
- Technical work complete for icaruscode + sbndcode
 - Refactored to use a Geometry, DetectorClocks, DetectorPropertiesData services, to generalize to multiple detectors
- Testing it with dummy reweighting splines
- Next goal: before and after example of a modified waveform.

Harry Hausner

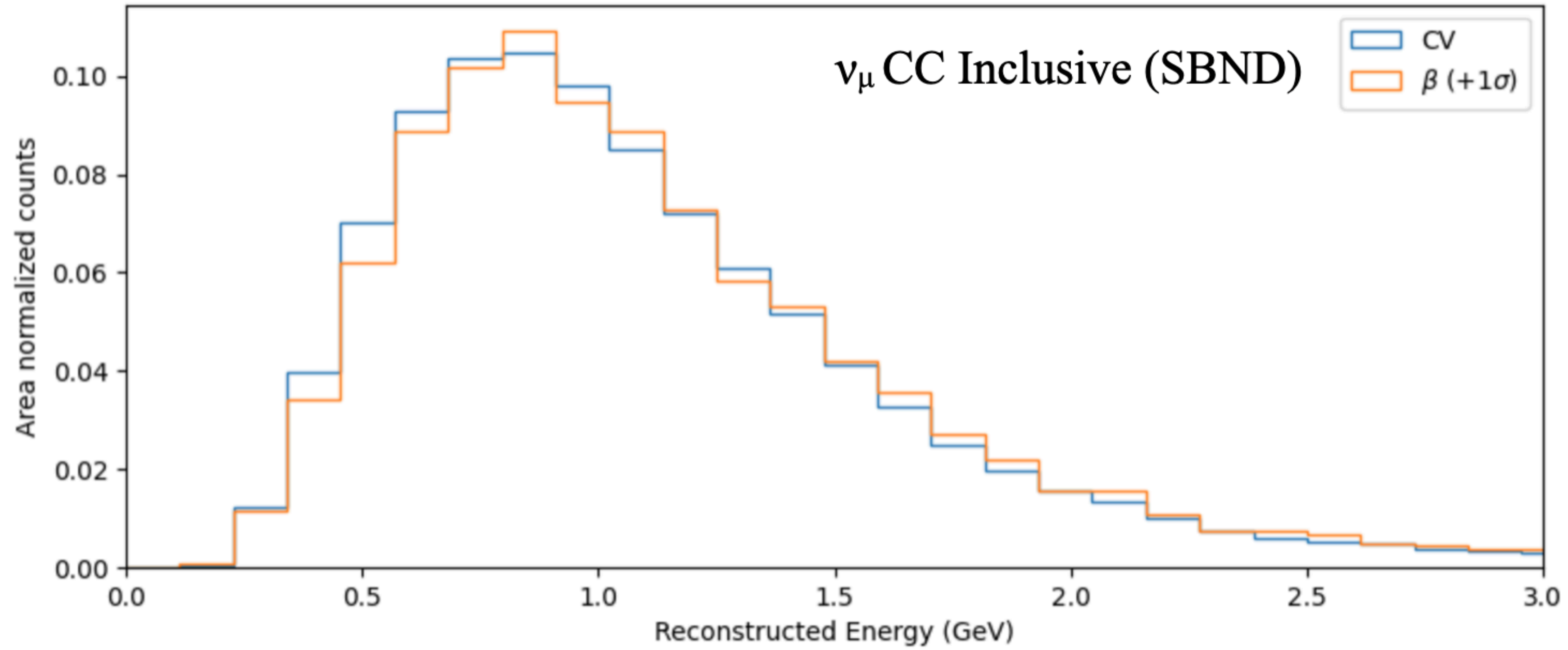
To what degree can we constrain detector systematics with detector correlations?

- Using samples with consistently varied recombination (α/β) and diffusion parameters in both SBND and ICARUS
- Goal: Apply common selections in SBND and ICARUS and study correlations

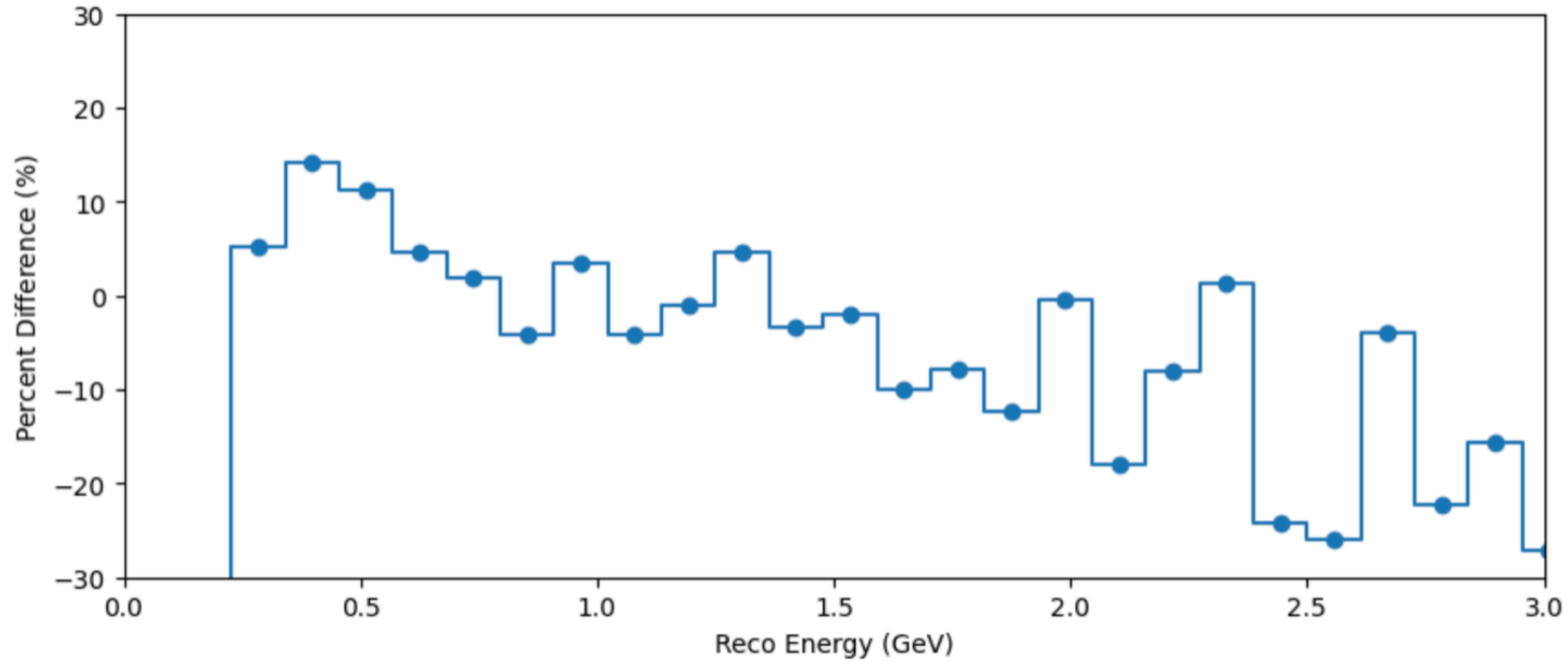
Status:

- Correlation studies:
 - Updated selections for latest CAF variables
 - Applied event selections (numu CC inclusive) in SBND and ICARUS detector samples
 - Building covariance matrix for the events common to the CV and variation samples

Nupur Oza
Daisy Kalra
Ibrahim Safa



Nupur Oza
Daisy Kalra
Ibrahim Safa



reco efficiency and resolution studies

- Goal: understand better how detector variations affect efficiency of various reconstructions.
- Goal: Use the generated samples to investigate hit efficiency, track efficiency, shower efficiency, trigger efficiency etc.

Status:

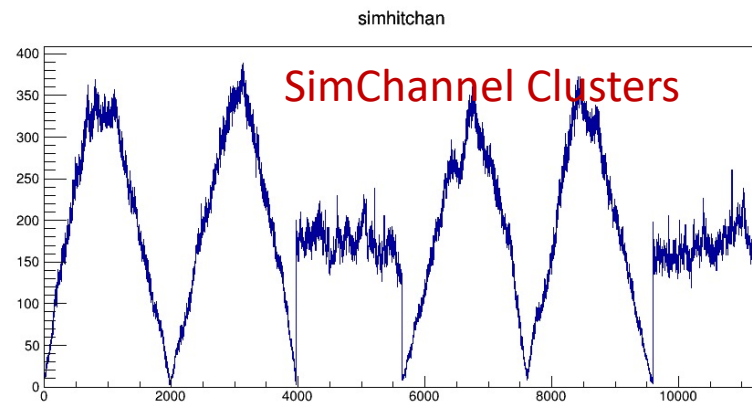
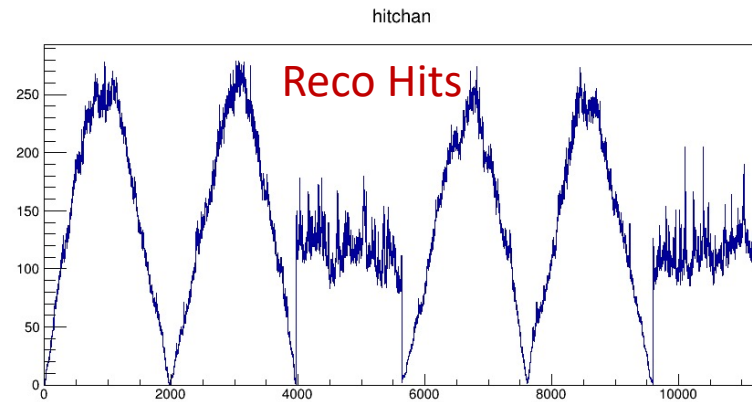
- Efficiencies and resolutions:
 - Progress on analysis tools development
 - Applying to variation CAFs now in hand

Mun Jung
Katie Ream
Natalie Floreancig
Logan Rice
Tom Junk

Hit Efficiency – Tom Junk

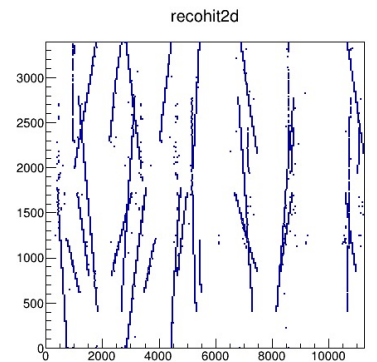
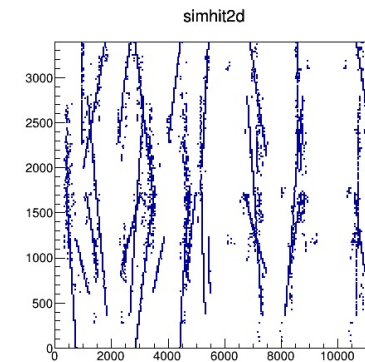
- Used one of the RECO2 central samples with GENIE+Cosmics
- Wrote a Gallery script to analyze hit distributions – just getting started
- Efficiency is computed by comparing reconstructed hits and sim::SimChannels (currently using "simdrift" simchannels)

Hit Distributions by channel ID



SimChannel clusters found by looking for 20-tick gaps in electron arrival times

First event in one of the files.



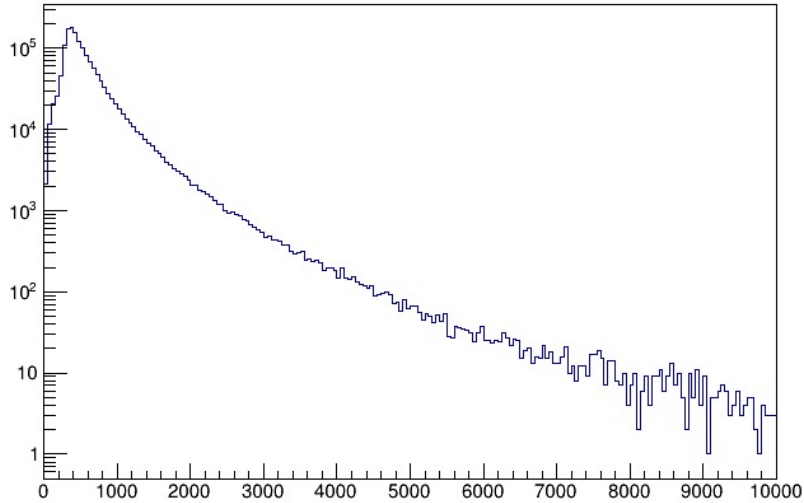
SIM

Reco

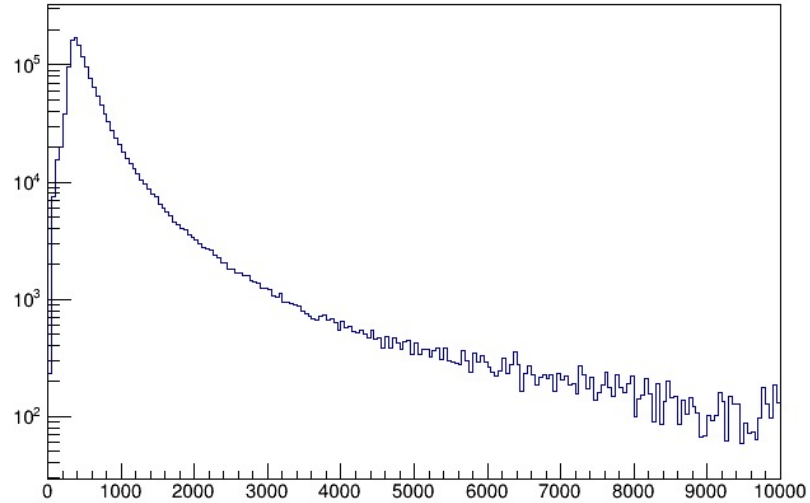
Many small true blips we don't expect to reconstruct

Hit Charge Distributions and Efficiency vs Charge

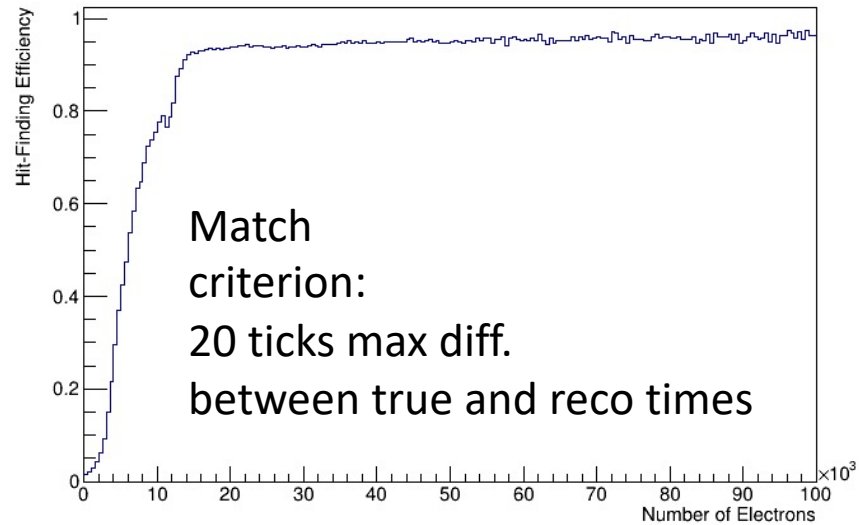
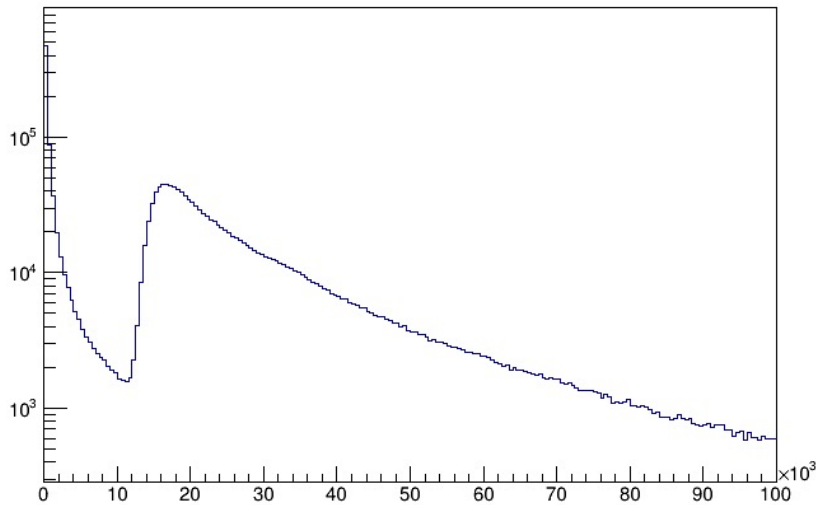
recohitintegral



recohitsumadc



simhitnelectrons



Hit Efficiency Things to Think About

Hit efficiency as functions of

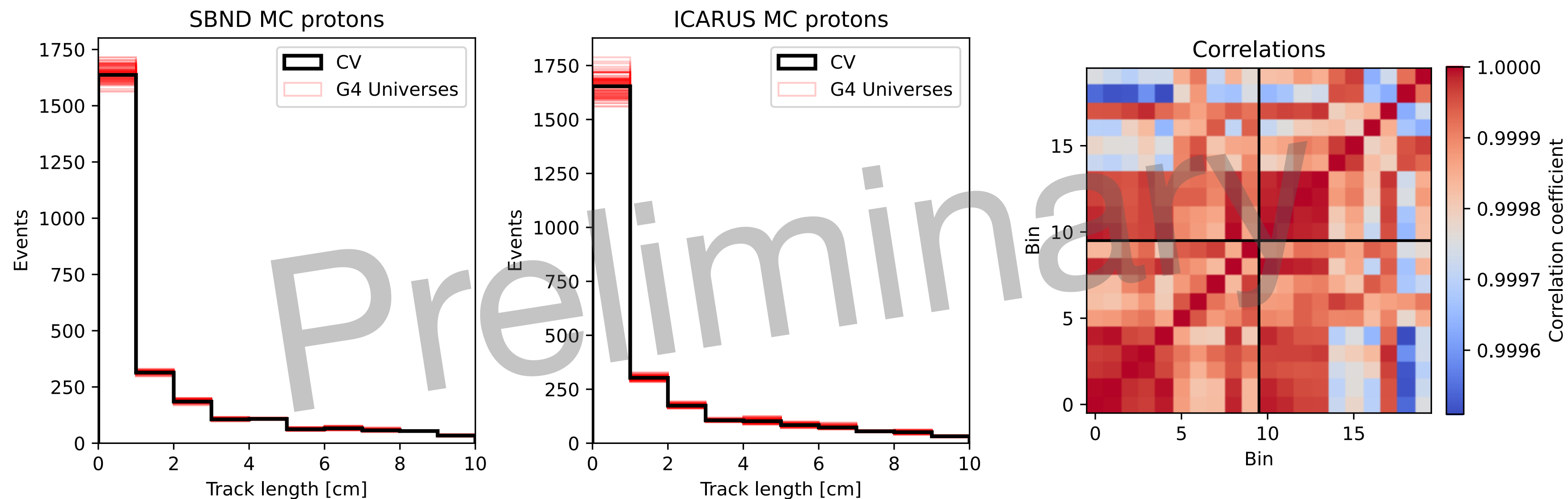
- plane
- true width of charge distribution
- isolation from other hits
- track angle

Look at charge resolution. Collect split hits.

Found an old analysis module from Tracy Usher and Andrew Scarff

Goal: Implement the Geant4Reweight developed for DUNE and adopted by MicroBooNE: github.com/calcuttj/GeantReweight

Status: Ported from uboonecode to sbncode (SBNEventWeight), added to weight generation in CAF stage fcls for sbncode and icaruscode. Branches for sbncode, sbndcode, icaruscode, sbndata.



Andy Mastbaum
Steven Gardiner

Low-stats demo of correlated geant4reweight throws in SBND and ICARUS CAFs [Andy]

cross section uncertainties

Goal: Update cross section uncertainty model to our best understanding

- Updated, documented list of GENIE systematics
- Single-universe (model switch) knobs
 - VecFFCCQEshape, DecayAngMEC Theta_Delta2Npi ThetaDelta2NRad
 - Updated SystToolsEventWeight to treat as a correction
- New GENIE knobs
 - RPA_CCQE, CoulombCCQE, ThetaDelta2NRad, NormCCCOH and NormNCCOH
- Status: Updated systematics implemented in nusystematics and validated, represented in multiple open PRs

Jaesung Kim
Afro Papadopoulou
Steven Gardiner

GENIE dial updates

- Thanks to S. Gardiner, we now have updated list of GENIE systematics: [icaruscode PR#612](#)
- Detailed comments on each dials!

```
# This dial provides the ability to scale the CCQE cross section
# normalization by a constant factor while using the z-expansion
# for the axial-vector form factor. However, since varying the
# coefficients for the individual terms (as is done above) also
# impacts the normalization, this one is left out for now.
#
#ZNormCCQE_central_value: 0
#ZNormCCQE_variation_descriptor: "[-1,+1,-2,+2,-3,+3]"
```

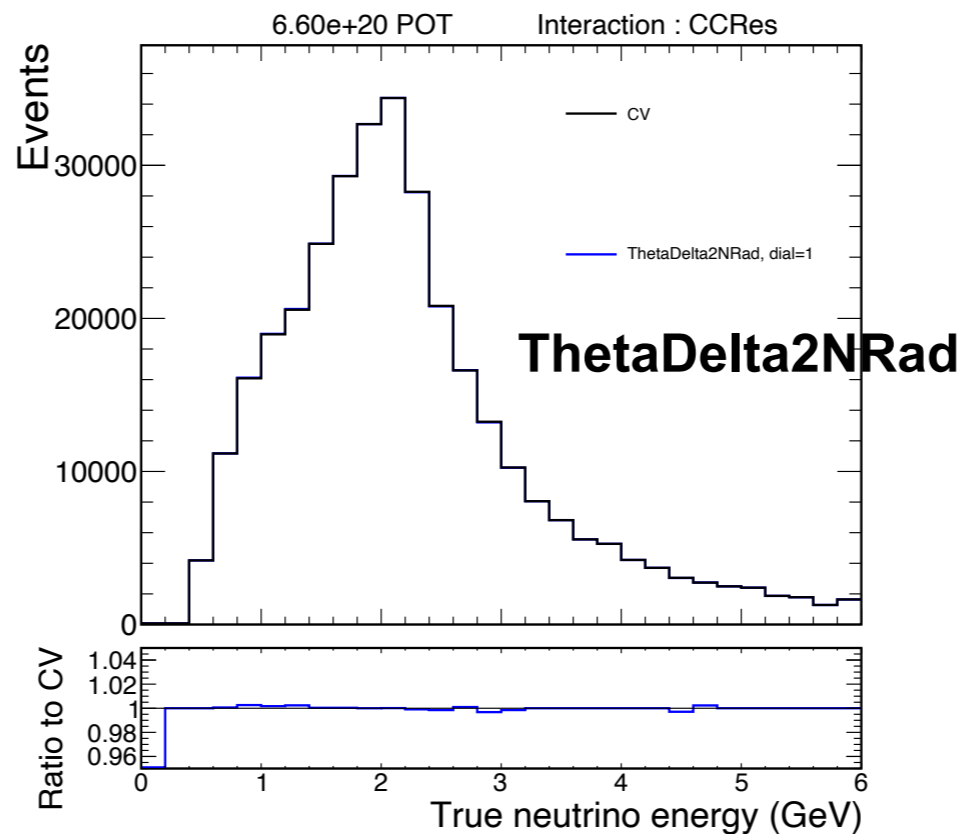
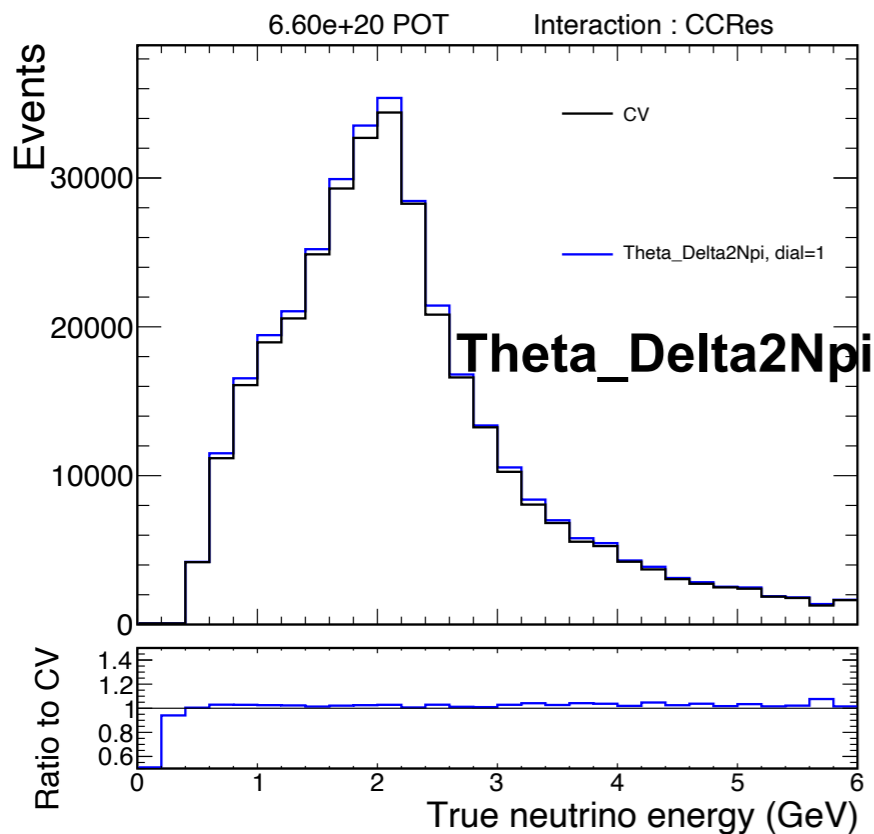
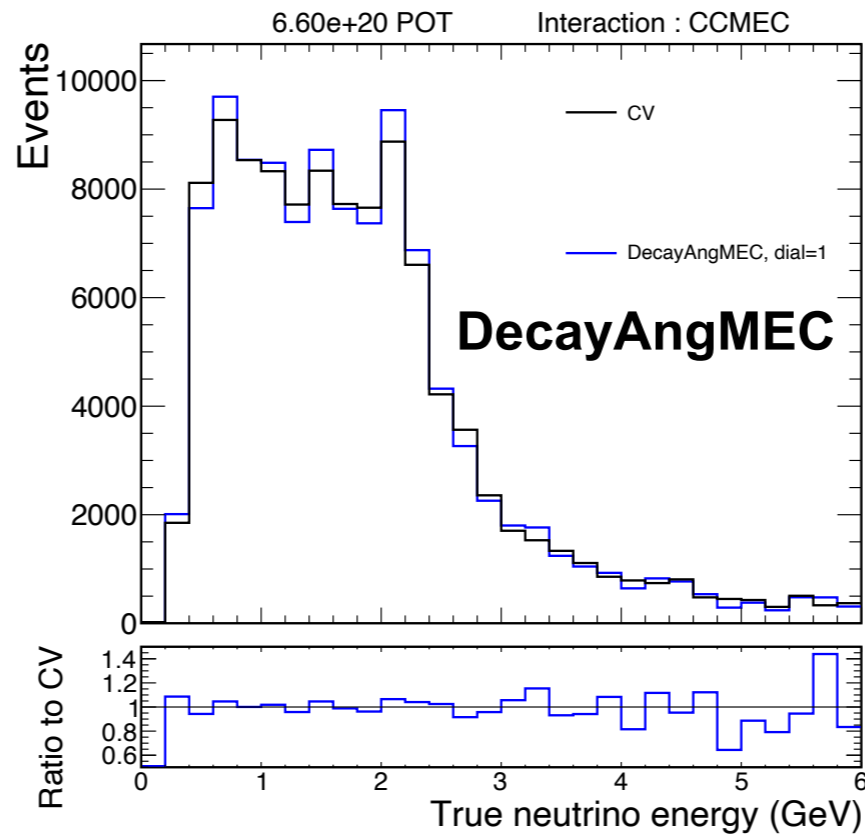
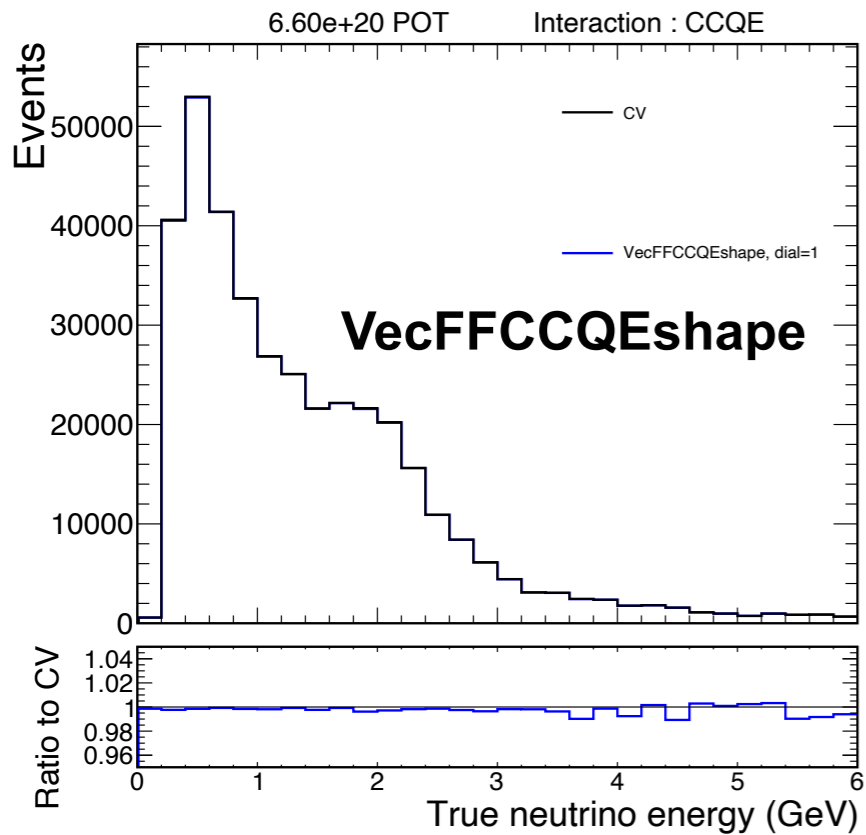
- Code updates were necessary to handle new features (next slides)

Single universe knobs

- Knobs with single universe, dial=1 (reweighting to different model)
 - VecFFCCQEshape
 - DecayAngMEC
 - Theta_Delta2Npi
 - ThetaDelta2NRad
- sbncode PR#364 includes a commit to treat these dials properly in **SystToolsEventWeight**
 - When **GenerateSystProviderConfig** builds **SystParamHeaders**, parameters with single element of **variation_descriptor** are considered as a "correction" rather than a reweight
 - **paramVariations** remains empty, but the dial value is put into **centralParamValue**, and **isCorrection** is set to true

```
# Assesses a shape-only variation of the CCQE cross section by  
# switching the parameterization of the vector form factors  
# from BBBA07 (default for the AR23_20i_00_000 model set) to  
# a dipole (VecFFCCQEshape = 1).  
#  
VecFFCCQEshape_central_value: 0  
VecFFCCQEshape_variation_descriptor: "[1.0]"
```

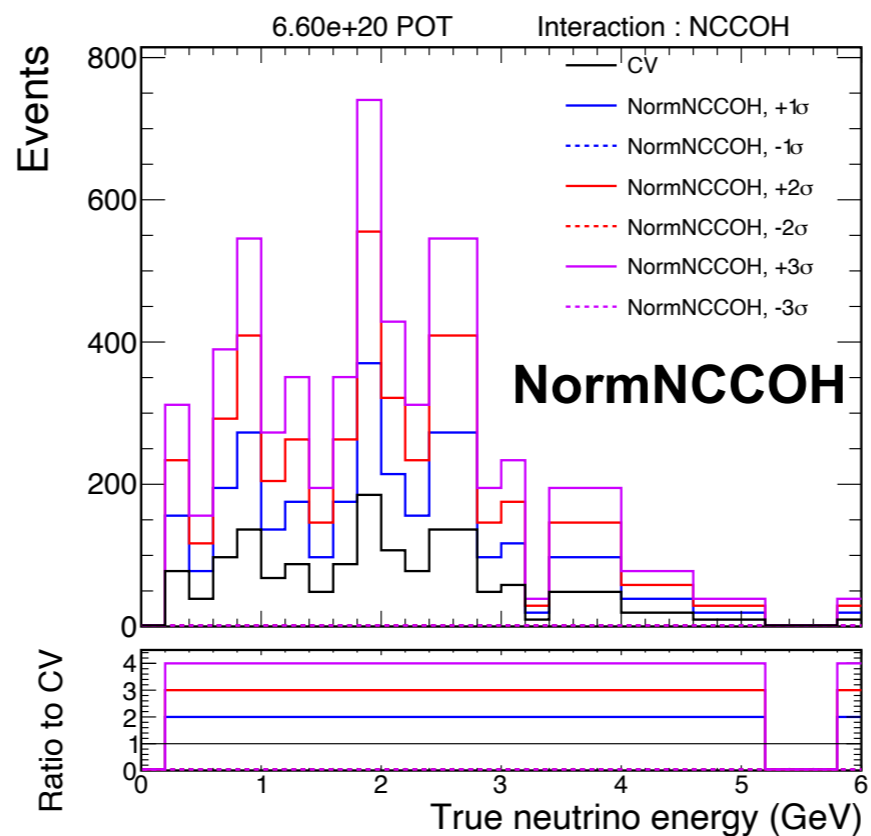
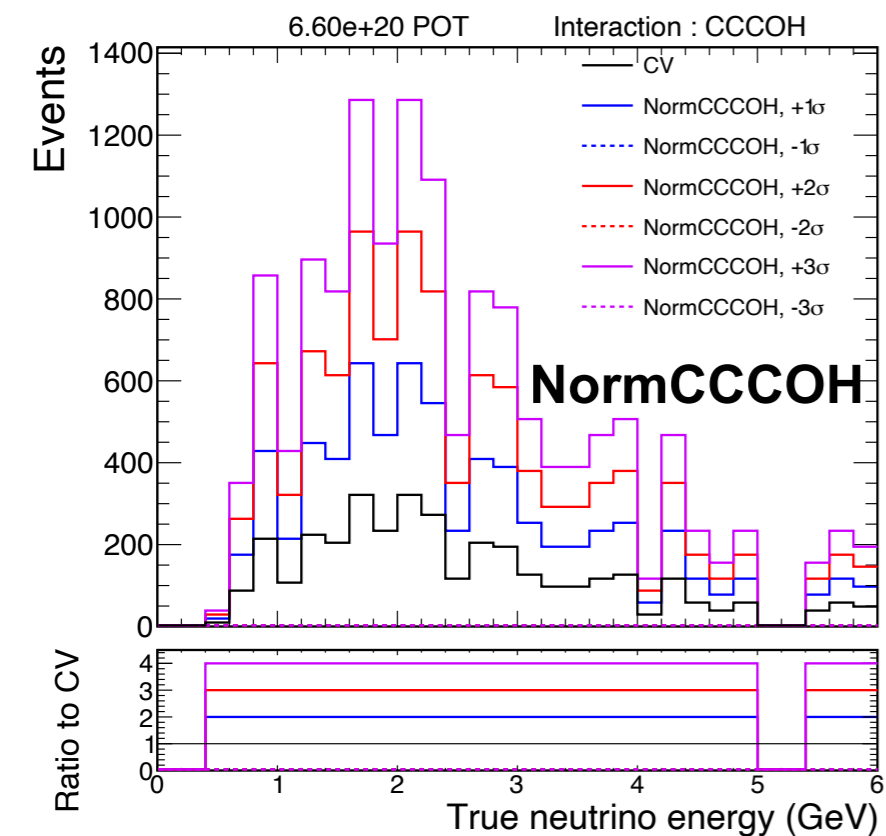
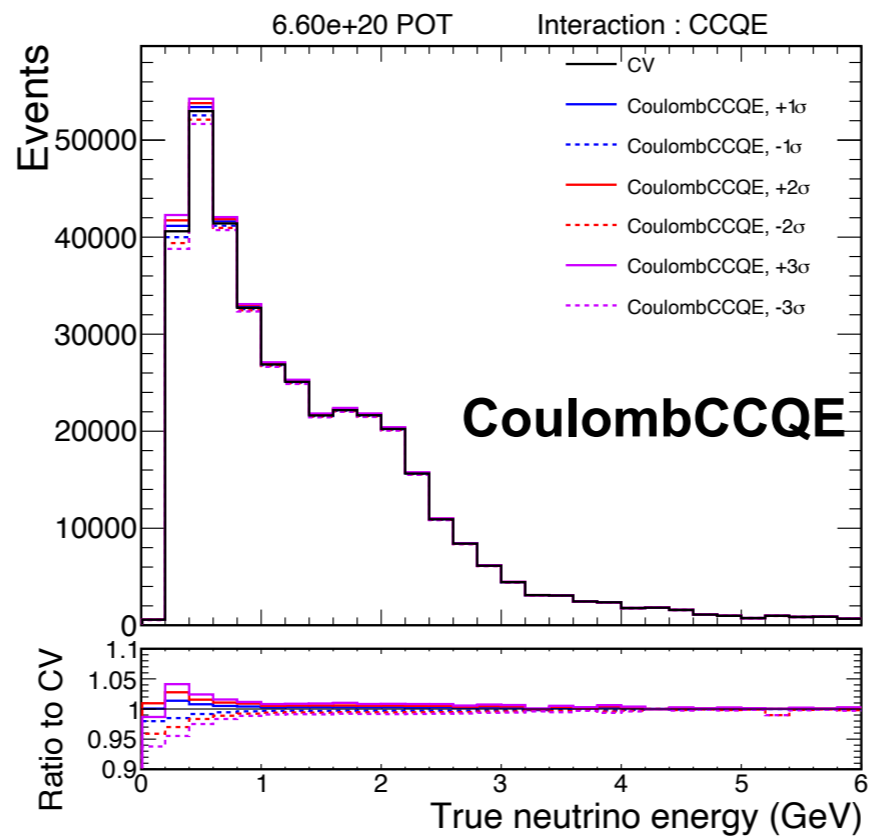
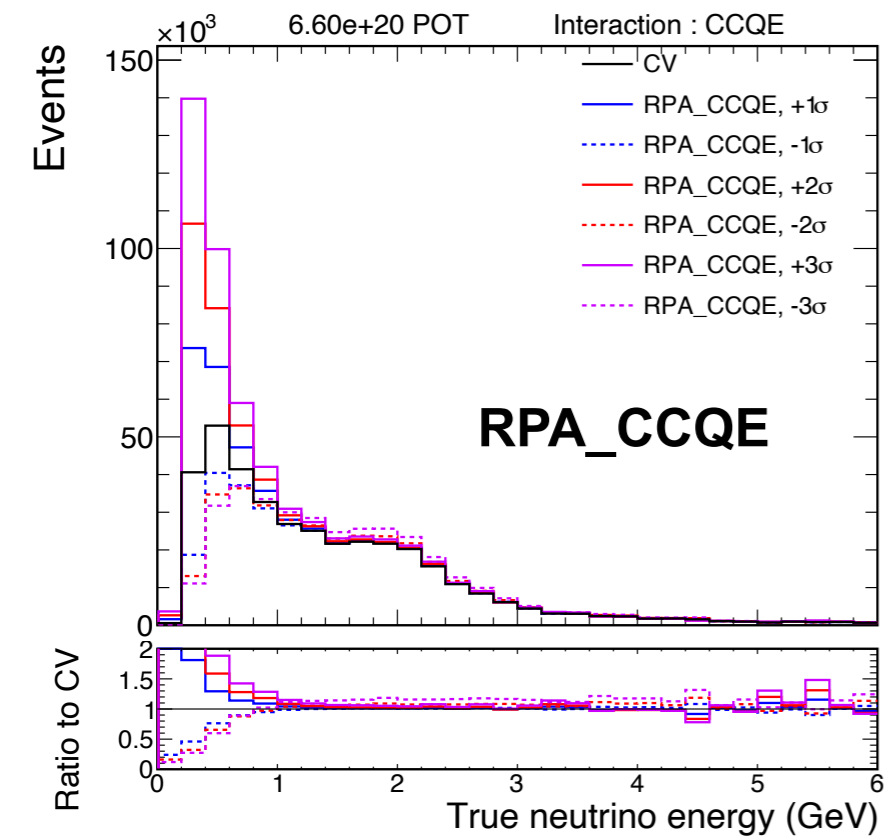
Single universe knobs



New GSyst not activated in nusyst

- RPA_CCQE, CoulombCCQE, ThetaDelta2NRad, NormCCCOH and NormNCCOH were not enabled in nusystematics
 - Enabled in nusystematics PR#4

New GSystems

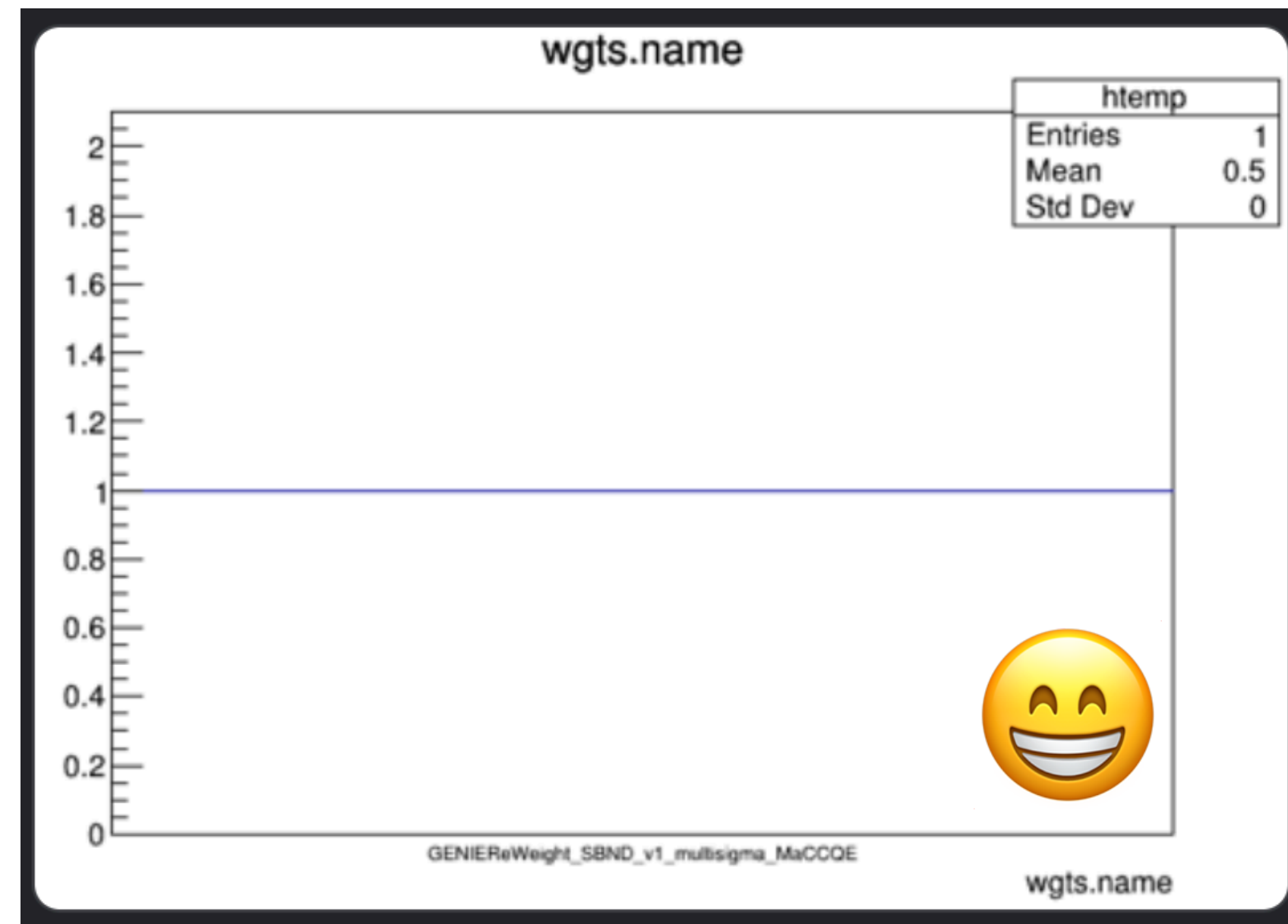


Next steps

- Wait for nusystematics PR#4 to be merged
 - new release on nusystematics
- Update the version of nusystematics
 - I can add this into sbncode PR#364
- Thrown universes are written in the NuSyst configuration fcl
 - e.g., icaruscode/blob/develop/fcl/caf/SystTools/syst_params_icarus_v1.fcl#L1203-L1208
 - ND and FD should use the same dials
 - icaruscode PR#612 then should be moved to sbncode

cross section uncertainties

Goal: re-run CAFmaker on SBND simulation using "nusystematics" tool and study relevant cross section systematics for available selections.



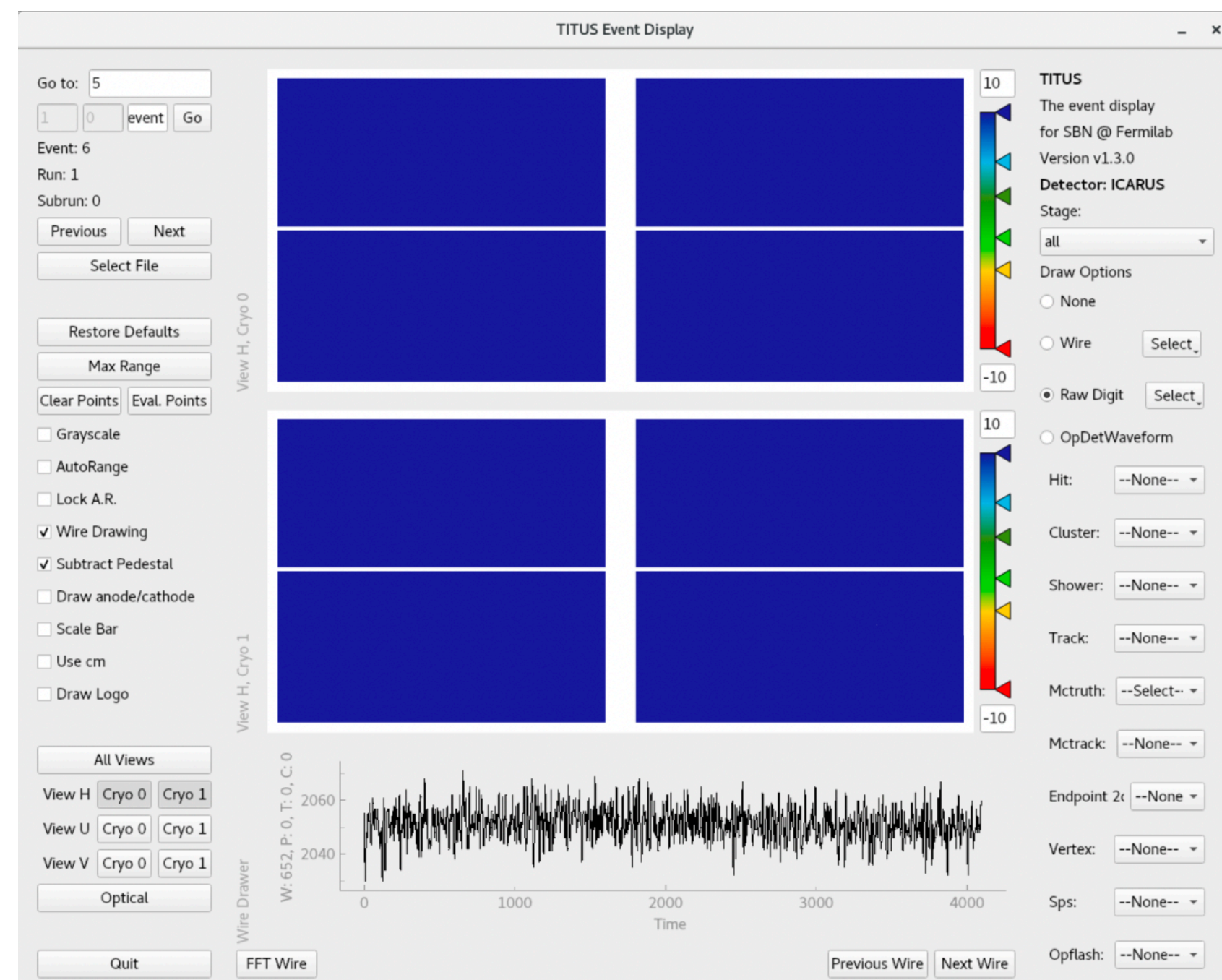
nusystematics weights in SBND CAFs! [Afro]

Status: nusystematics running in sbndcode, and an updated set of common GENIE systematic fcls for SBND and ICARUS.

Jaesung Kim
Afro Papadopoulou
Steven Gardiner

two detector correlations

Goal: Study differences in detector response between SBND and ICARUS by simulating identical energy depositions in both detectors



An apparently empty ICARUS event :([Andy]

Status:

- Able to load sbndcode LArG4 events into icaruscode and run the rest of the geant4 stage + detsim, etc.
- But events are empty. Possibly (hopefully?) due to offsets in timing, coordinate system, needs further investigation.

Andy Mastbaum

next steps

- A very productive week for SBN and systematics!
- Thank you again to all who contributed to these efforts
- Several PRs to finalize and/or review
- Several more studies can proceed with newly available detector variation samples
- Propose to have detailed updates on each of these topics at upcoming SBN analysis and/or AI meetings

- Let's keep the discussion going in #sbn_systematics!

