

# SBN Joint Working Groups Update

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*SBN Oversight Board Meeting, June 10<sup>th</sup>, 2022*

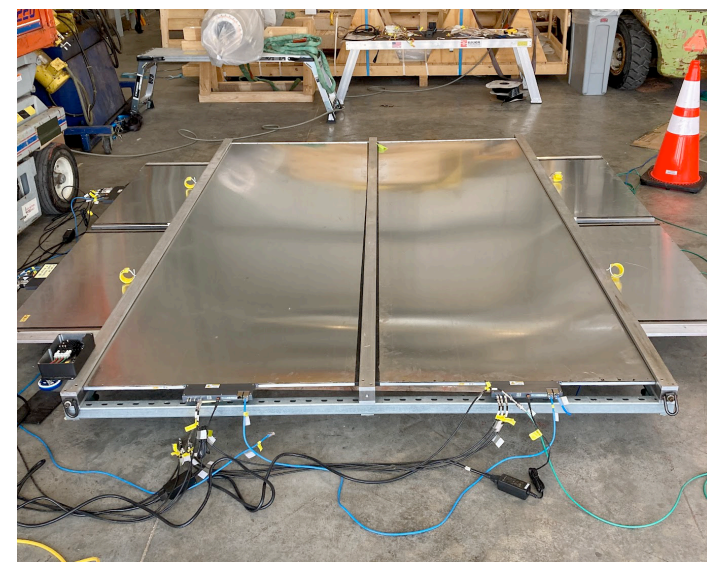
# SBN Working Groups

- **SBN DAQ and Data Pre-Processing** [conveners: Bill Badgett, Angela Fava, Wes Ketchum, Yun-Tse Tsai]
  - Goal: Develop common tools for trigger, data acquisition and data pre-processing, and coordinate activities in those areas.
- **SBN Slow Controls** [convener: Geoff Savage]
  - Goal: Develop control systems based on hardware and software interfaces as much as possible identical for the two detectors.
- **SBN Cosmic Ray Tagger** [conveners: Umut Kose, Igor Kreslo, Minerba Betacourt]
  - Goal: Review the CRT production status and the installation plans for the two detectors, develop common CRT DAQ and monitoring.
- **SBN Analysis Infrastructure** [conveners: Wes Ketchum, Joseph Zennamo → Chris Backhouse (change in leadership in May 2022)]
  - Goal: Coordinate and address data and software infrastructure and computing resource needs across the SBN
- **SBN Analysis Trigger** [conveners: Angela Fava, Michelle Stancari]:
  - Goal: Share and discuss strategies for cross-checking trigger efficiencies independently measured by the two detectors
- **SBN Analysis** [conveners: Daniele Gibin, Georgia Karagiorgi]
  - Goal: Take care of all the aspects of the multi-detector physics analysis for **SBN sterile neutrino oscillation searches**

# SBN DAQ WG: DAQ and Data Pre-processing progress

- ICARUS DAQ commissioned (along with detector) and ready for physics:
  - Updates/improvements on PMT readout handling;
  - Improved interface to trigger, including more complete beam gate reporting;
    - Including additional data streams for beam and trigger type;
  - Updates in online monitor and monitoring metrics;
  - Plans for summer shutdown being finalized:
    - Focus on support for other work, and improvements in error-reporting/monitoring, documentation, etc.
- SBND DAQ development, integration/early commissioning efforts ongoing
  - Commissioning has begun using a muon telescope @SBN-ND;
  - Timing and trigger distribution undergoing installation and testing
  - Data synchronization across digitizers and across subsystems ongoing
  - Developing Data Quality Monitoring (DQM) for PMTs and Arapuca light detectors

Half of the  $\mu$  telescope



# SBN Analysis Infrastructure group – present

- Change of leadership. Chris Backhouse replaces Joseph Zennamo (thanks!), Wes Ketchum continues
- “2022A” MC production underway: \*For production campaign definitions, see [link](#)
  - All SBND production files complete (roughly 1.5 M events);
  - ICARUS production ongoing (keep-up processing of current data now underway).
- Presented at Fermilab Computing Resources Scrutiny group (see [link](#)):
  - Our resources are manageable (with a lot of hard work), but extremely limited by rate of reads/writes to tape:
    - Unsustainable for target production goals unless our disk allocation increases to hold samples at intermediate steps.
  - We are also relying on “keep-up” processing of detector data to perform signal processing and reduce data volume:
    - Will be *very* hard/impractical to reprocess all raw data as part of standard processing campaigns;
    - Need to invest in understanding detector / low-level processing as fast as possible.
- Ongoing improvements in many areas particularly in common analysis format (CAF) files to support analysis work and continuous integration and validation framework.

# SBN Analysis Infrastructure group – future

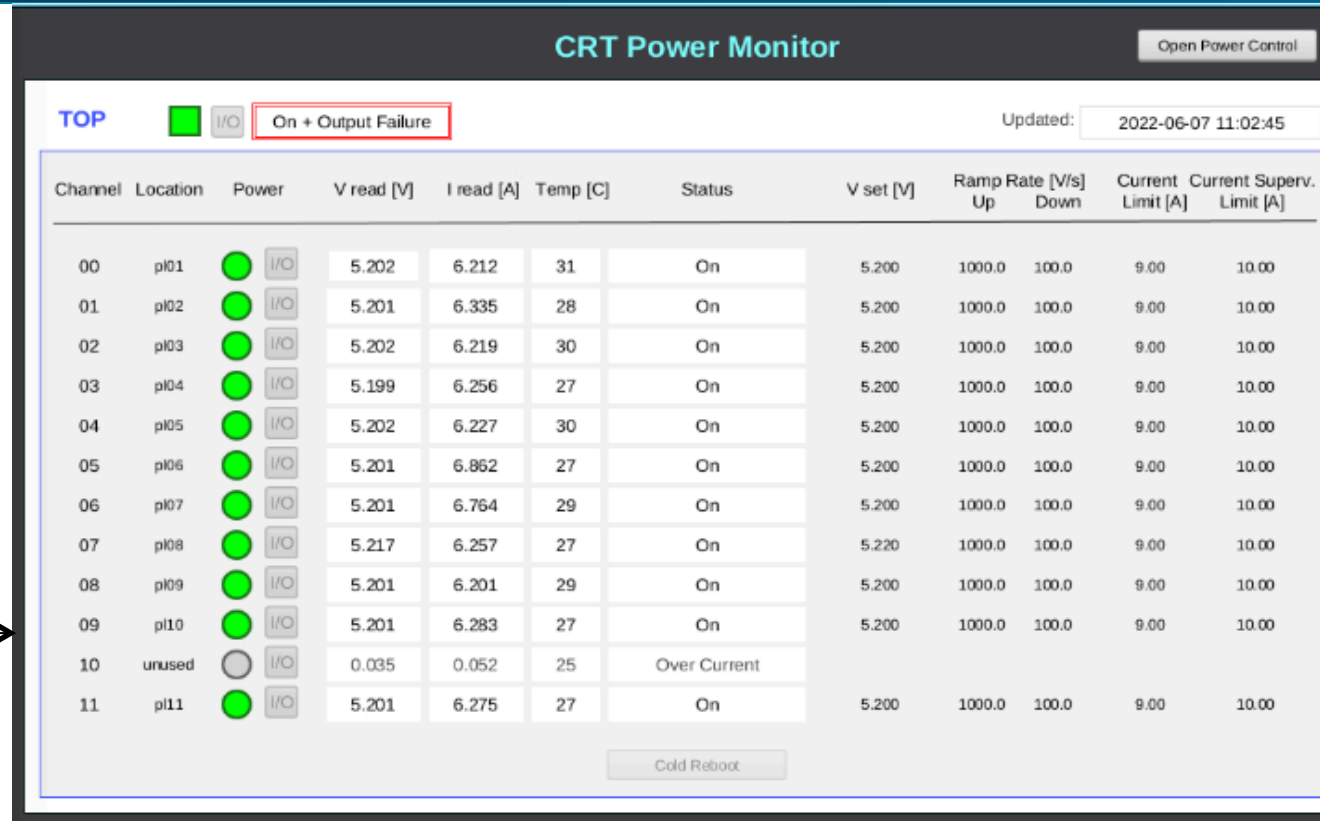
- Begin planning for 2022B MC production \*For production campaign definitions, see [link](#)
  - When do we need it?
  - What needs to be in it?
  - How much do we need?
- Working to converge with DUNE on systematic treatment infrastructure:
  - Will allow easy technology transfer for newly-developed systematic effects;
  - New implementation has resource-usage benefits.
- Work with ICARUS Analysis Taskforce to facilitate oscillation analysis of first ICARUS data;
- Implement developments into continuous integration/validation system;
- Follow-up/push forward into standard production recent developments with groups using High Performance Computing (HPC) for SBN workflows:
  - ML-based workflows, standard data processing, final fits / Feldman-Cousins corrections calculation at HPC.

# SBN Slow Control WG

- CRT power supply monitoring (Niccolo Moggi):

- Wiener 512;
- Top CRT completed - developed, tested, deployed;
- Working on side CRT now.

CRT TOP power supply  
Graphical User Interface →



- Alarm system

- Infrastructure for reporting alarms is operational
- Two systems tested - drift hv and ground short monitoring
- In progress
  - Automate system startup
  - Expand systems monitored
  - Recording all alarms for review in database

# SBN Analysis Trigger WG

- Mini-workshop on configuration of PMT readout completed on Dec 16. Mostly informal discussion driven by input provided beforehand by SBND and ICARUS experts cooperatively.
- Outcome of the discussion incorporated in ongoing upgrade of the ICARUS trigger system. i.e. optimization of PMT acquisition window to always record at least 4  $\mu$ s before the beginning of the beam gate.
- Next mini-workshop will address strategies for evaluating trigger efficiency, starting with  $t_0$  tagged cosmic tracks (work in progress in ICARUS). Dates to be defined.
- SBND Trigger WG has been actively reviewing the trigger hardware functionality (including light, CRT, and accelerator low-level triggers) and is working to develop a "trigger menu", which will carry SBND through commissioning and early operations.

- Ivan Lepetic is stepping down from CRT convener;
- sbndcode now has time of flight module;
- Completed study for optimal location for top plane;
- Some changes to CRT simulation as well (waveforms, deadtime...) implemented.
- working on studying what MINOS modules look like in SBND (different from Bern) and currently off in simulation:
  - In next couple weeks SBND CRT group plan to turn them on in real life and look at data and needs for tuning simulation.



# SBN CRT WG: TOP CRT (ICARUS)

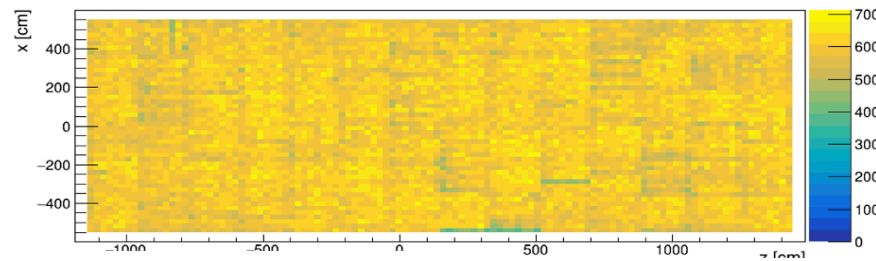
- Continue with the commissioning of the top CRT

- Analyzing the data after overburden installation (3 meters)
- Validation of the CRT hit reconstruction

## Reconstructed X, Y and Z positions

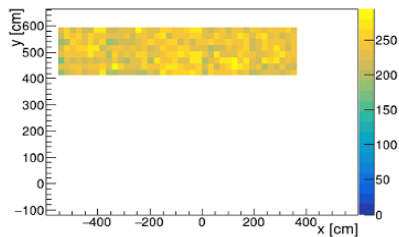
### X versus Z positions

TOP HORIZONTAL



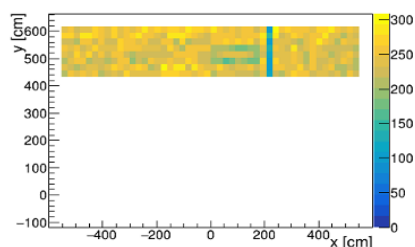
### Y versus X positions

TOP VERTICAL SOUTH

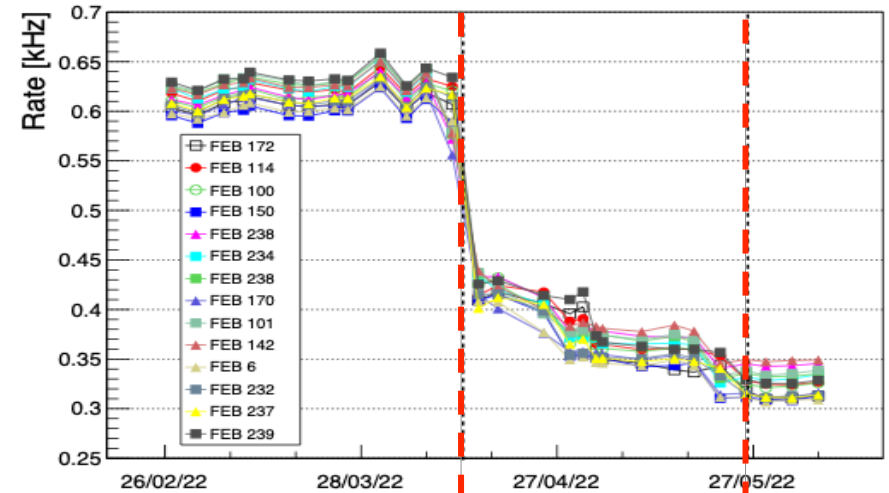


### Y versus X positions

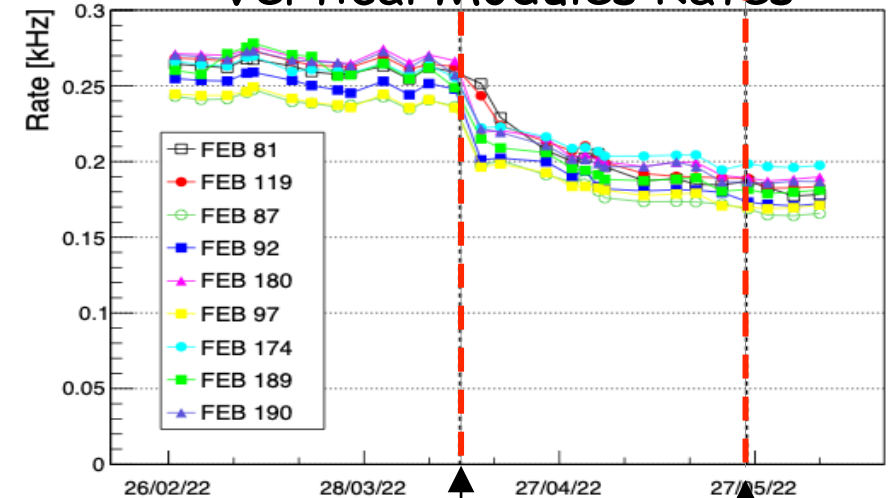
TOP VERTICAL NORTH



## Horizontal Modules Rates



## Vertical Modules Rates



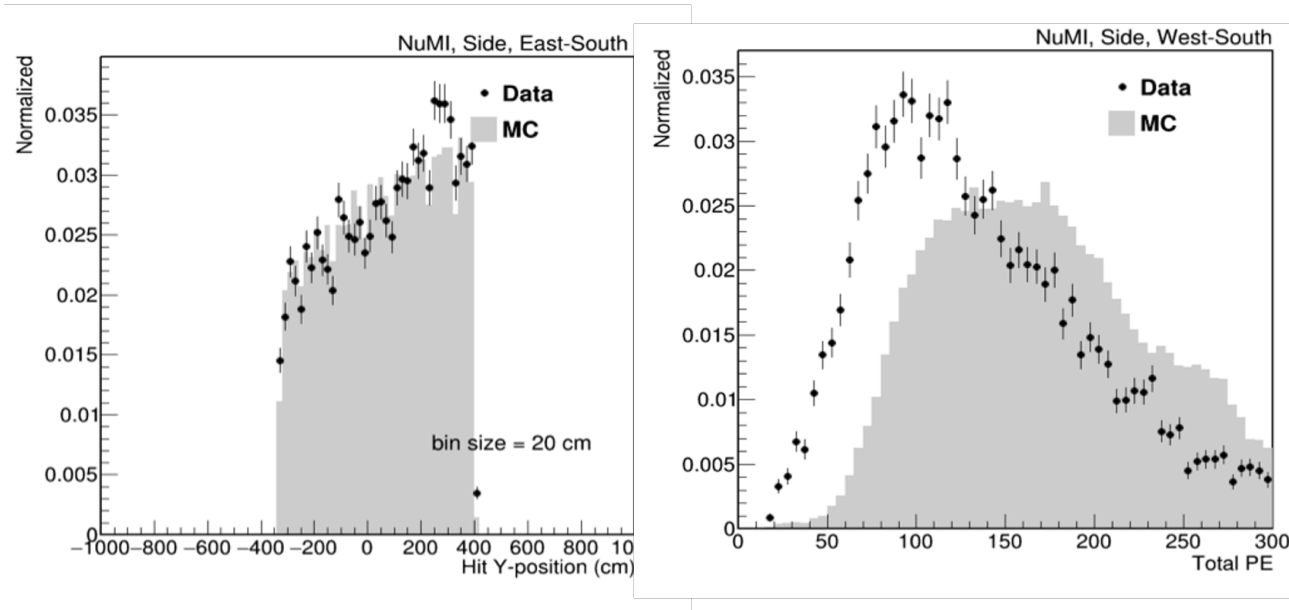
start of  
overburden  
installation

end of overburden  
installation over the  
displayed modules

# SBN CRT WG: Side CRT (ICARUS)

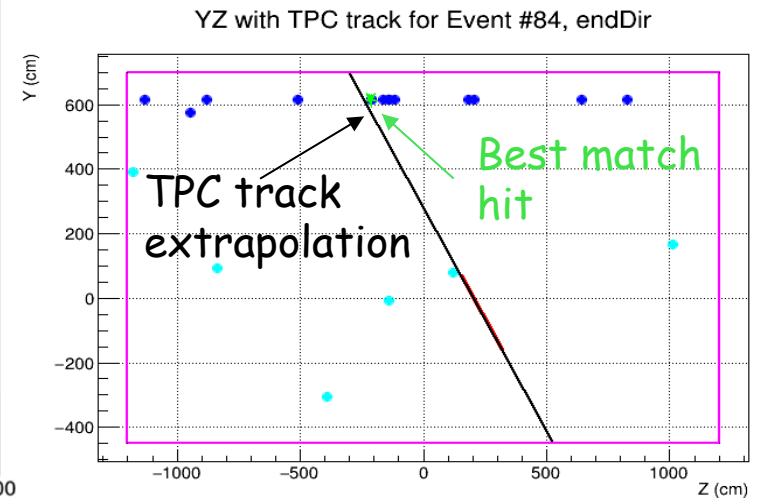
- Starting to benchmark the MC simulation and working with CRT-TPC and CRT-PMT matching reconstruction tools.
- CRT-TPC matching code ported from SBND, in validation stage using ICARUS data.

## Data versus MC simulations



**Tuning is needed in the simulation**

## CRT-TPC Matching



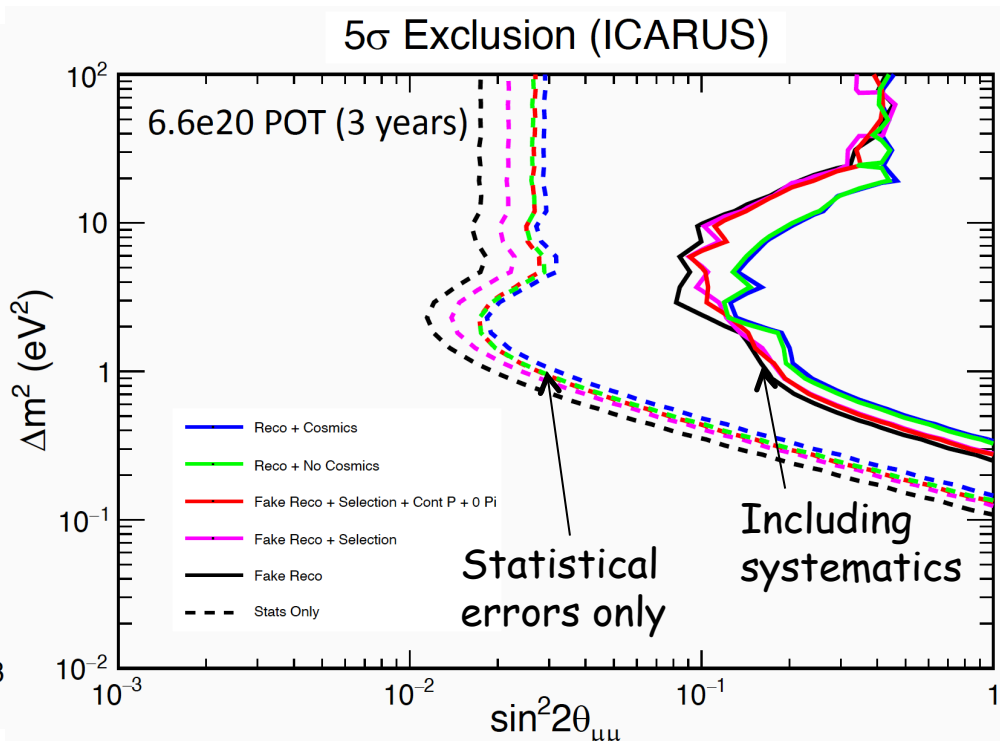
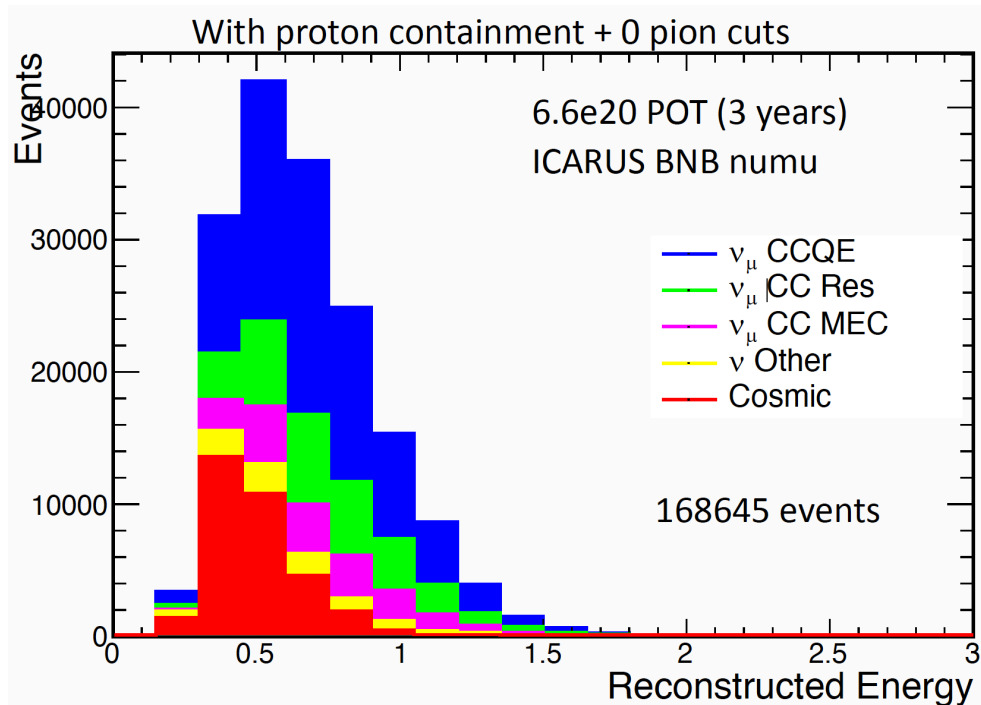
**Dark blue points: top CRT hits**  
**Light blue points: side CRT hits**

# SBN Oscillation

- Kicked off detailed comparisons between different fitter frameworks (CAFAnaFit, SBNFit, VALOR) . Considerable advances in
  - Understanding what impacts the sensitivity calculation
  - Assessing the effects of various fitter approximations
  - Assessing the effects of systematic uncertainties
  - Improving analysis inputs and methodologies
- The next step is to integrate actual reconstruction into the analysis and complete the detector systematics study.
- Some study of a NC disappearance search, and how it rests on low-energy proton/neutron reconstruction improvements, beneficial also for CC reconstruction.

# SBN event reconstruction: MC study (ICARUS)

- An exercise to apply fitting methods to fully reconstructed MC events and study variations w.r.t. the fake reconstruction applied so far;
- First end to end application to ICARUS alone  $\nu_\mu$  disappearance;
- Only events with contained protons and no reconstructed pion;
- $E_\nu = E_\mu + \sum_{\text{Trk}} EK_{\text{trk}}$  for tracks identified as protons.

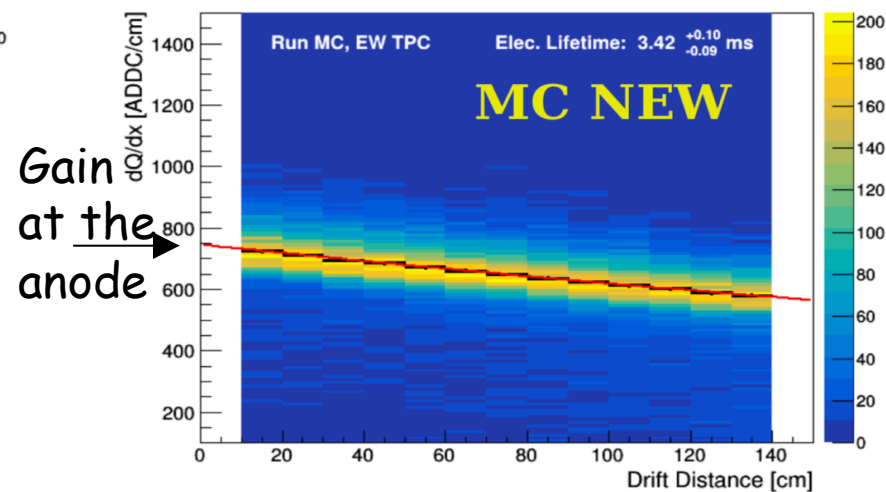
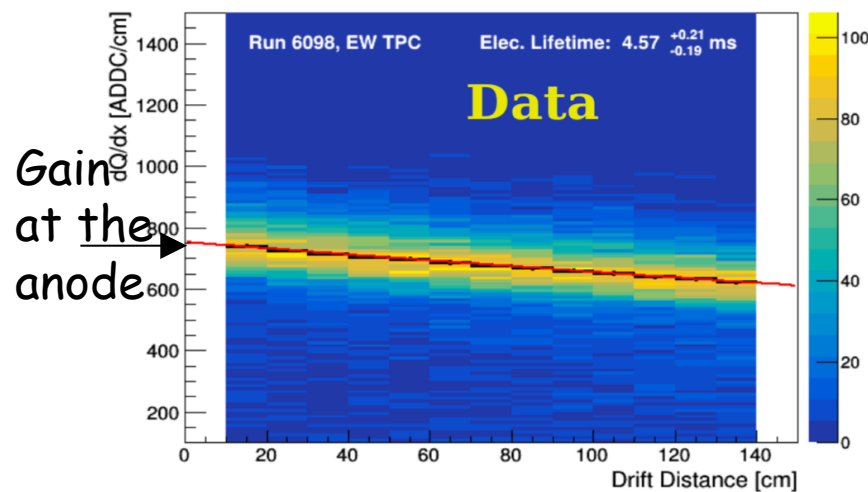


# SBN event reconstruction: MC study (SBND)

- SBND working on neutrino energy reconstruction improvements;
- Cosmic rejection improvements, combining TPC, Photon Detection System (PDS) and CRT info into a Multivariate Analysis:
  - Effort to improve rejection of cosmics and increase neutrino efficiency.
  - Expected to become available should be available by next production.
- Started thinking of reconstruction areas related to commissioning, e.g. Michel electron reconstruction.
- PDS reconstruction:
  - very close to having the full reco 1 chain ready (by end of June) for PMTs, including signal deconvolution + optical hit finding + optical flashes;
  - X-Arapucas benefiting from all improvements and moving forward fast and efficiently;
  - should be able to run by default with new+realistic simulation for 2 subsystems by ~July..

# TPC calibration and simulation working group

- Experience gained with ICARUS commissioning data invaluable to improve signal processing and the detector modeling in the present data and MC production:
  - tune simulations for better reproduction of real data:
    - Average MC correction of overall TPC gain factor (relative gain equalization studies are ongoing);

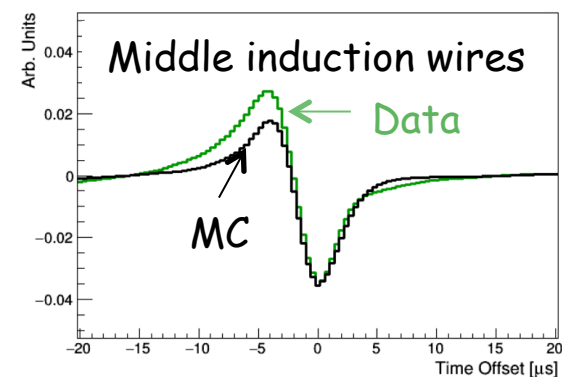
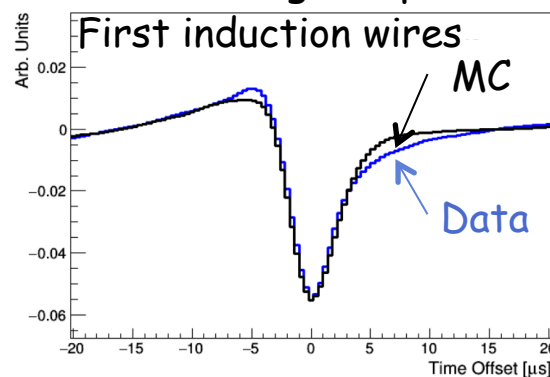
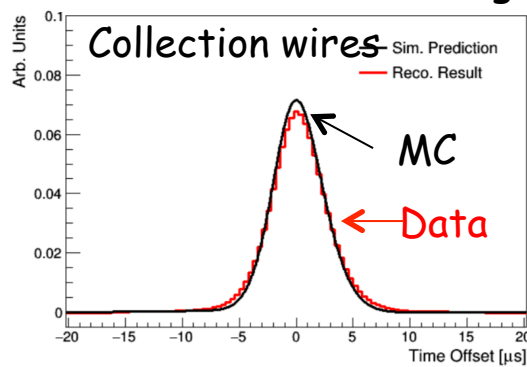


- Average correction of simulated wire noise RMS, reproducing noise spectrum and individual 64 ch. card noise to few percent after coherent component removal.
- Improvements in electron lifetime measurement algorithms;
- Major effort in TPC calorimetric calibration with stopping muons in data.

# TPC calibration and simulation working group

- Several effects have been identified with a view to precisely correct them on the longer term in ICARUS:
  - TPC signal shape studies to validate a) the electronic response and b) modeling of the signals induced by drifting electrons on the sense wires (transition to 2D simulation of the induced signals) ;

average waveforms of signals produced near the anode



- Accurate model the space charge effects and electric drift field in-homogeneities;
- Measure local cathode non planarity and correct for local cathode non planarity.
- Detector systematics will be evaluated starting from residual differences after the corrections for the different effects after the tuning of the detector modeling.