# NPS Setup & Performance

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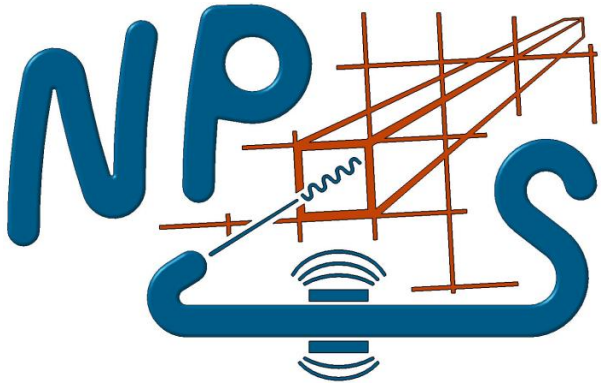
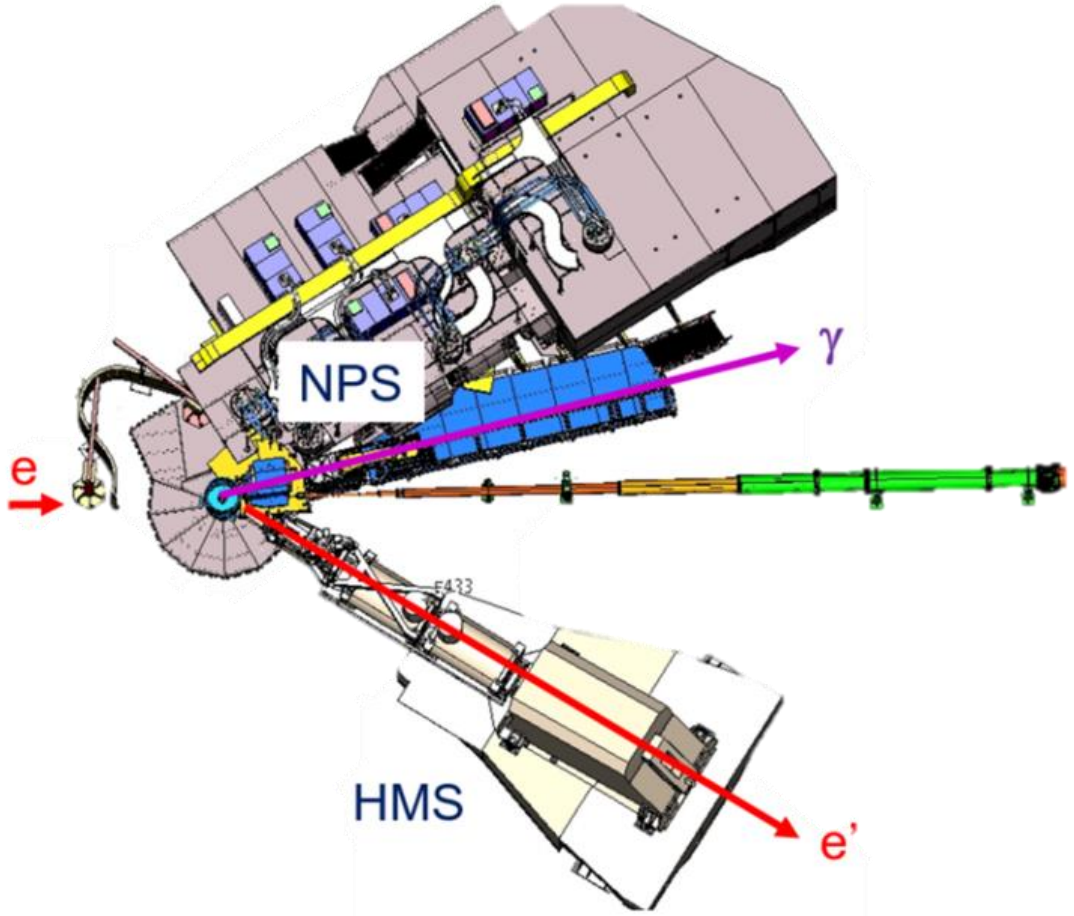


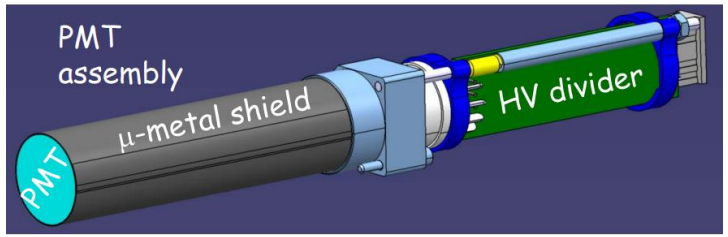
# Neutral Particle Spectrometer

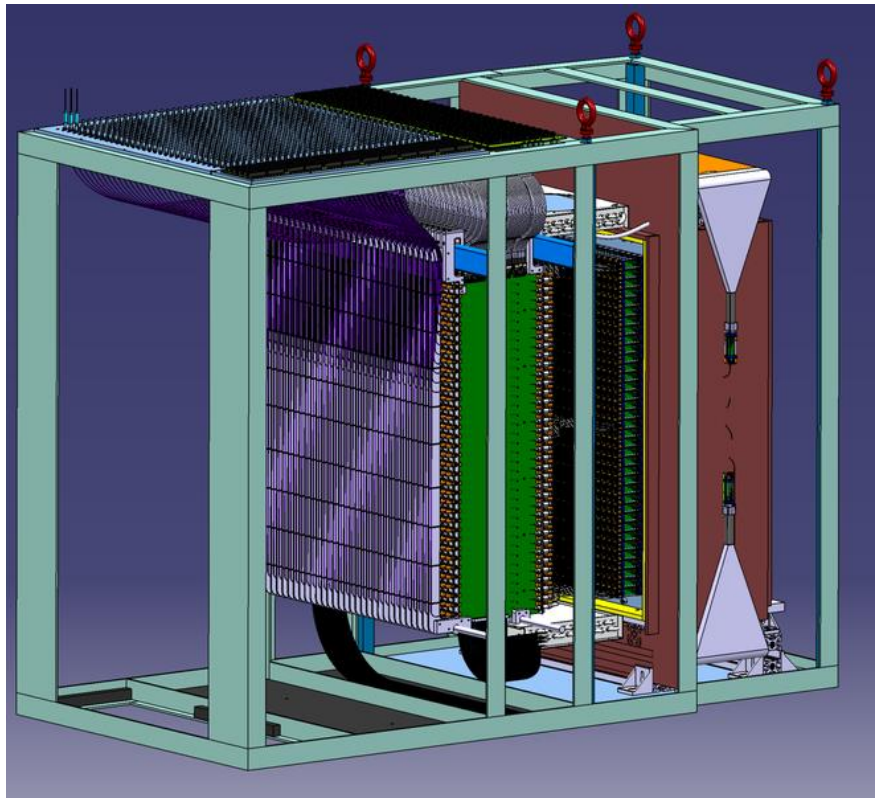
- Scattered electrons are detected in the HMS and high energy photons in the calorimeter of the Neutral Particle Spectrometer (NPS)
- The calorimeter is installed on a new platform attached to the SHMS carriage to allow remote rotation
- A sweep magnet is installed to reduce charged background
- Enables neutral particle detection with good energy and spatial resolution for precise cross-section measurements



# NPS Calorimeter

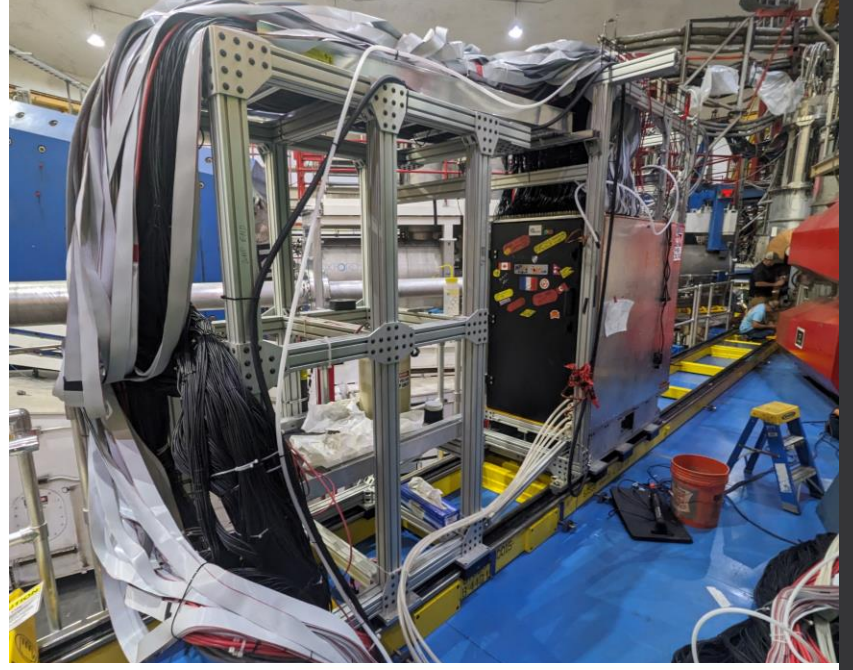
- 1080 $PbWO_4$ blocks
  - High energy resolution
  - High light yield
  - RadHard
- Temperature controlled frame
- Hamamatsu 4125 PMTs
- HV divider and amplifier to reduced HV requirements
- LED system for curing and gain monitoring
- HV, LV, and LED signals distributed to an entire column through distribution board

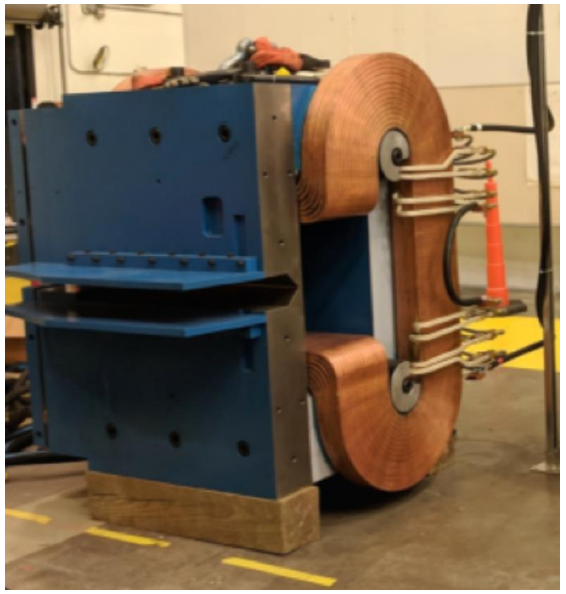


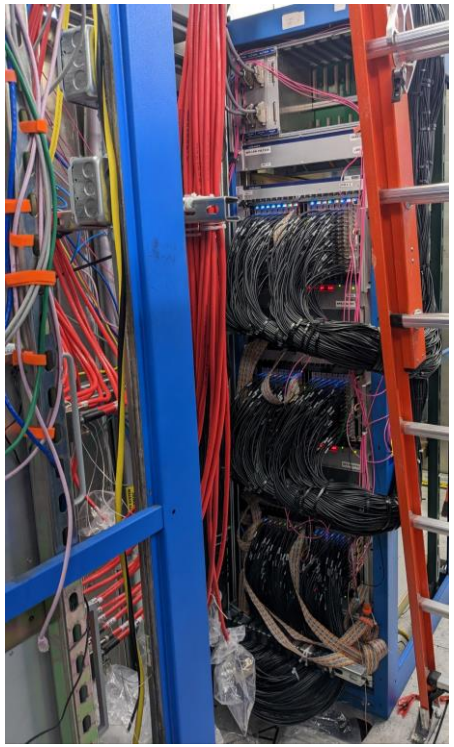



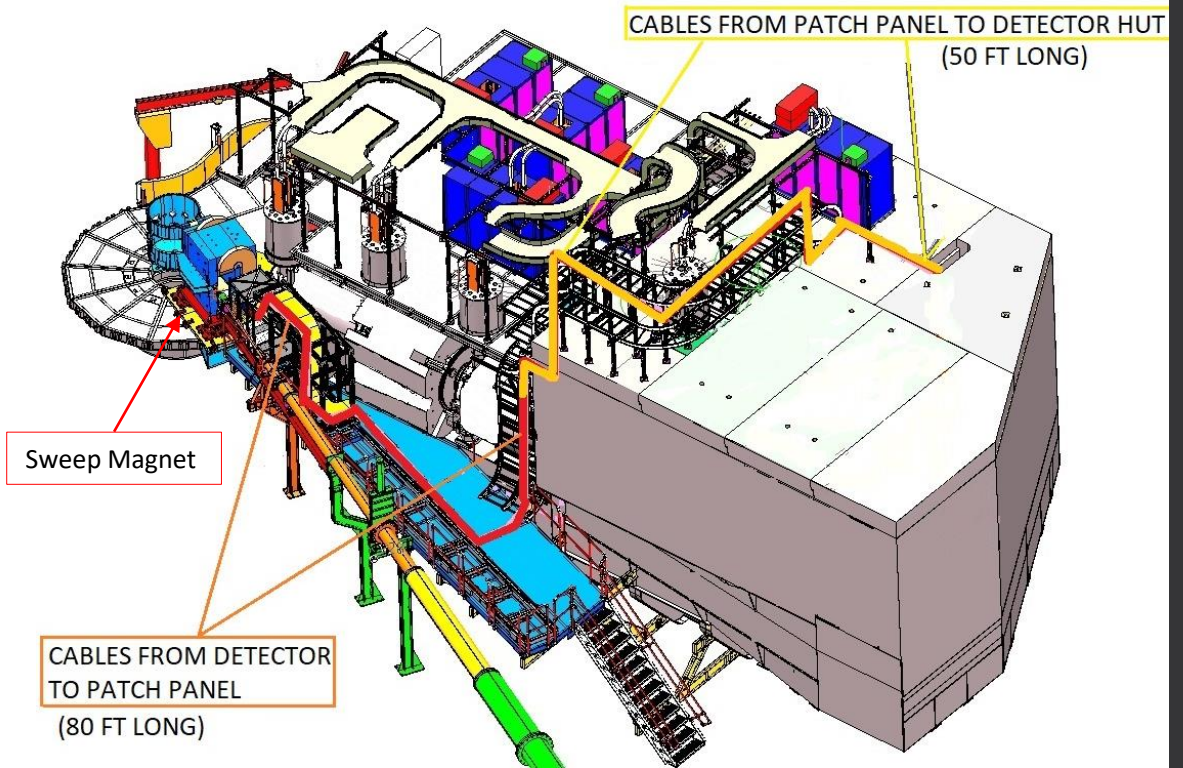
# NPS Installation

- Installation and cabling began in April and finished Jun 26th
- Calorimeter installed on sliding rail
- 5 VME crates, 2 HV , and 1 LV power supplies added to SHMS hut
- Cables ran through the hut roof down to the NPS platform
- Sweeper magnet installed in place of Horizonal Bender





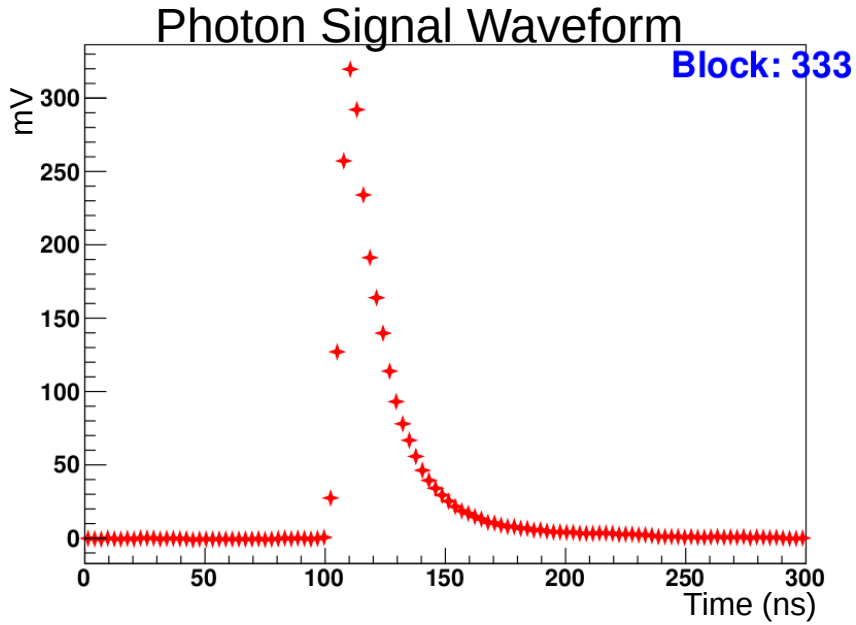


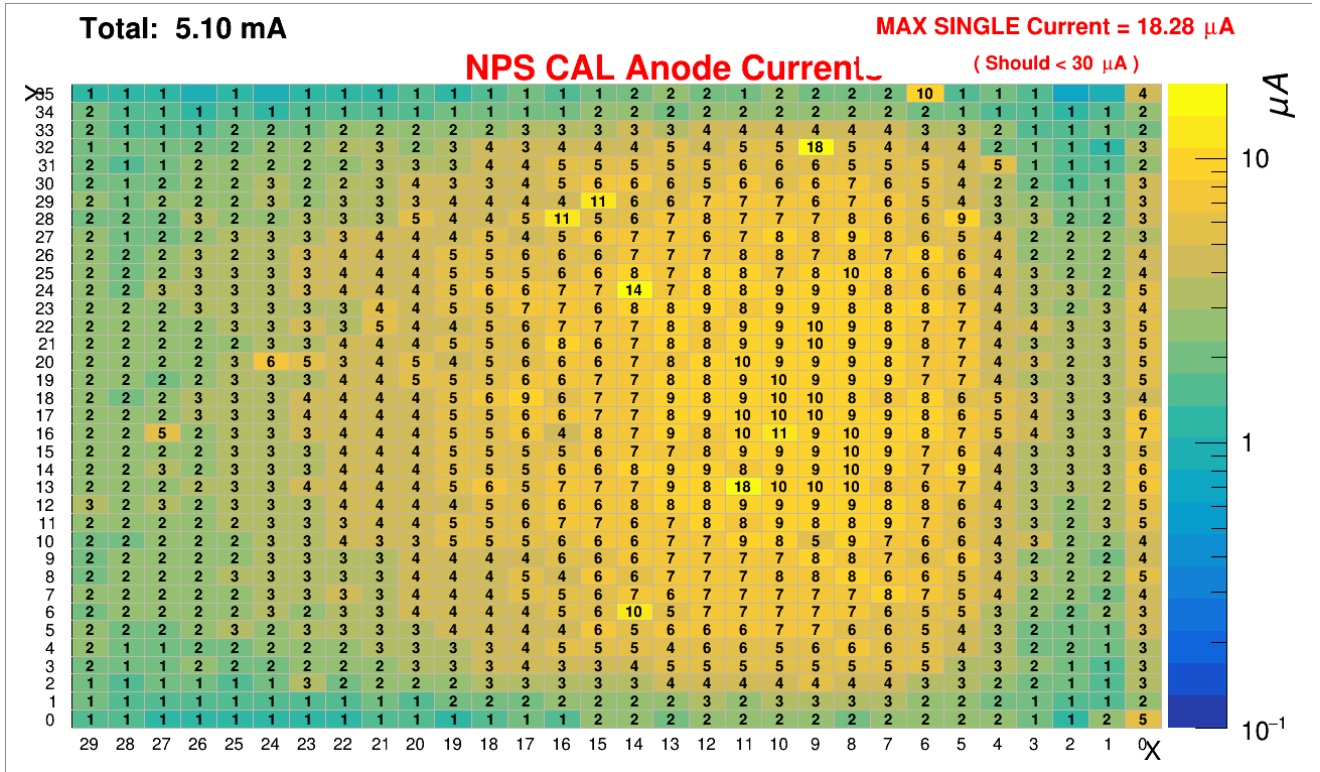


# NPS Performance:
## It Works!

- Stable temperature control
- Sweep magnet effective at reducing background
- Manageable amount of crystal darkening
- Acceptable timing resolution
- Energy resolution in progress

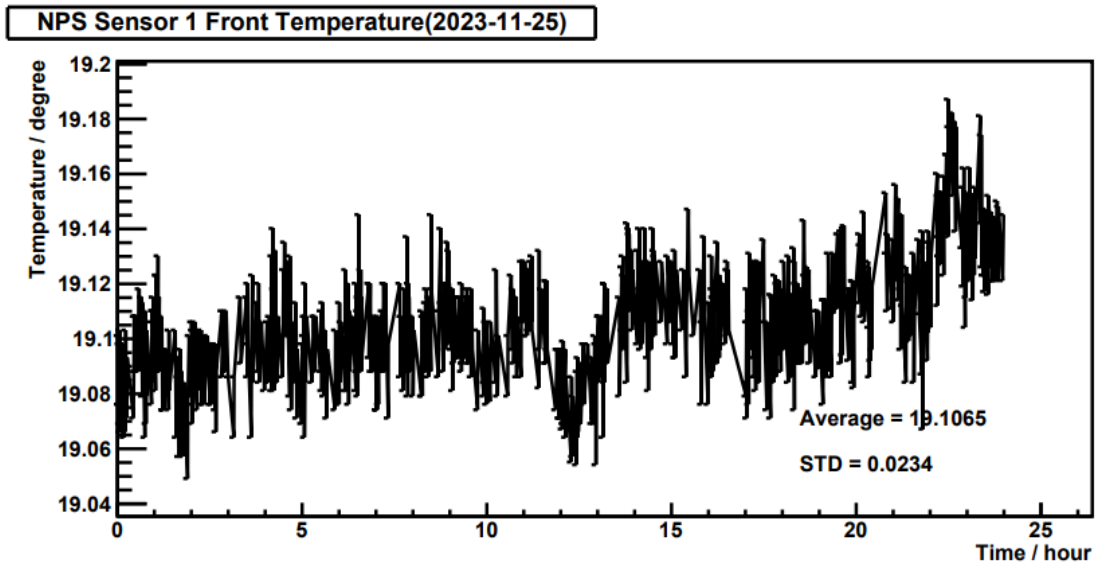
- All while achieving a high luminosity($7.5 \times 10^{37}$ cm$^2$/s)



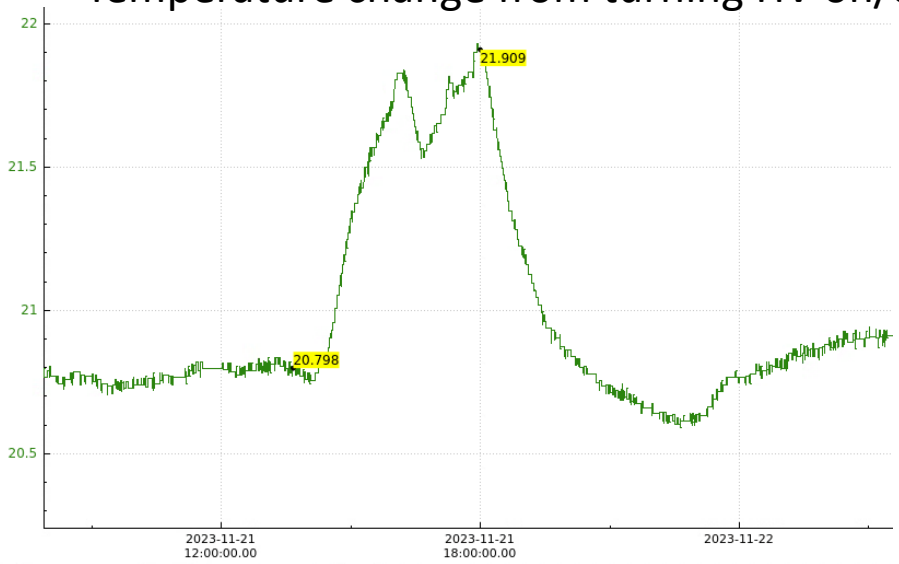



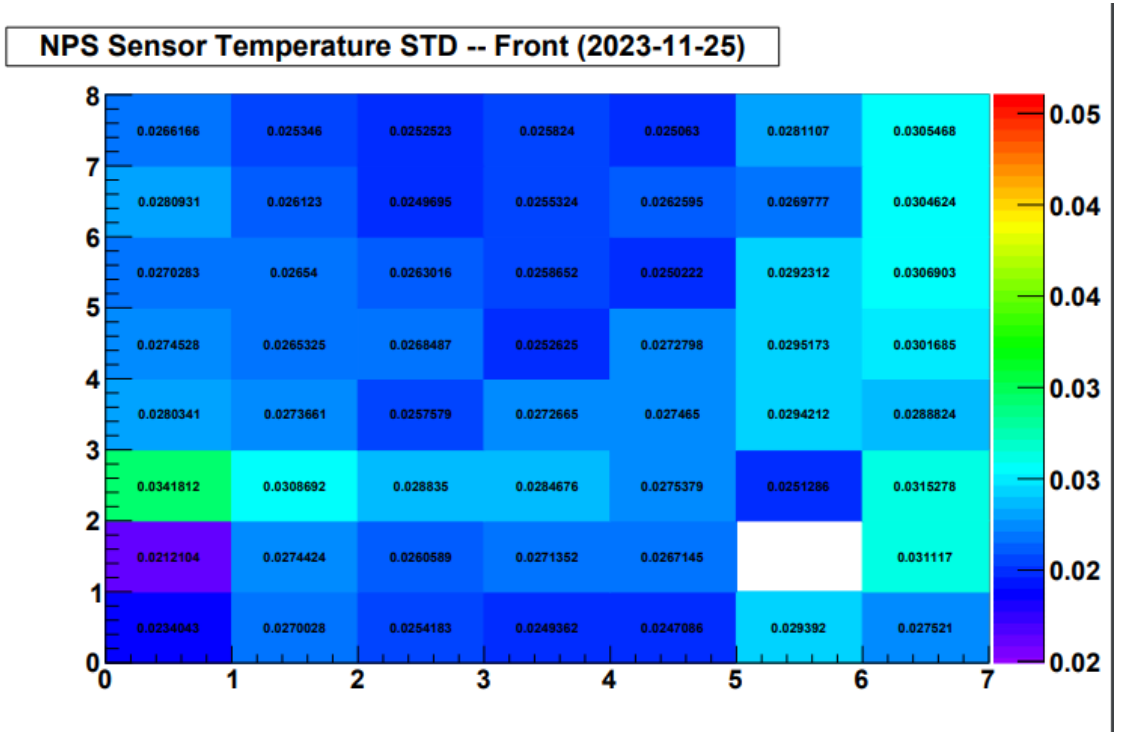
# Temperature Control

- Light yield from PbWO4 are temperature dependent (-2% / °C at 20°C)
- For 0.5% energy stability need 0.1°C stability
- The high-voltage dividers on the PMTs dissipate several hundred Watts
- Water chillers cool copper frame
- Takes up to 9hr to re-stabilize temperatures after changing HV




Temperature change from turning HV on/off

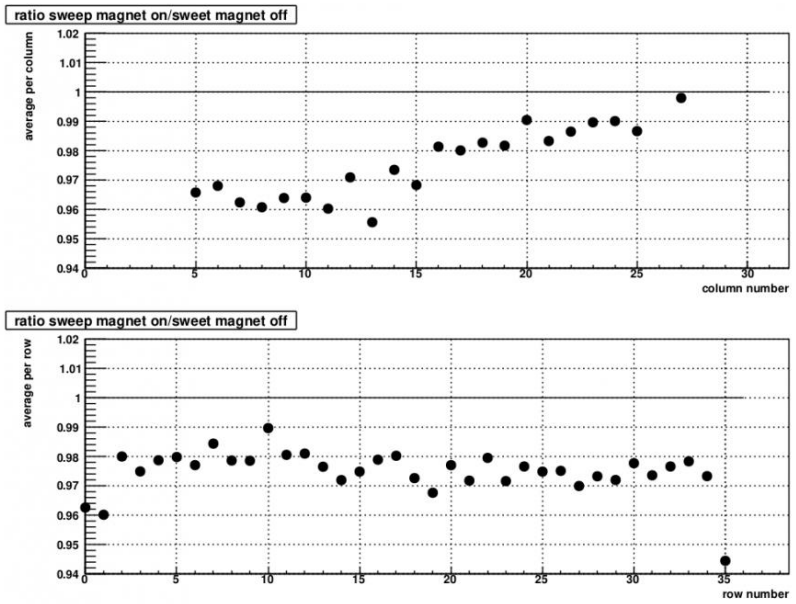


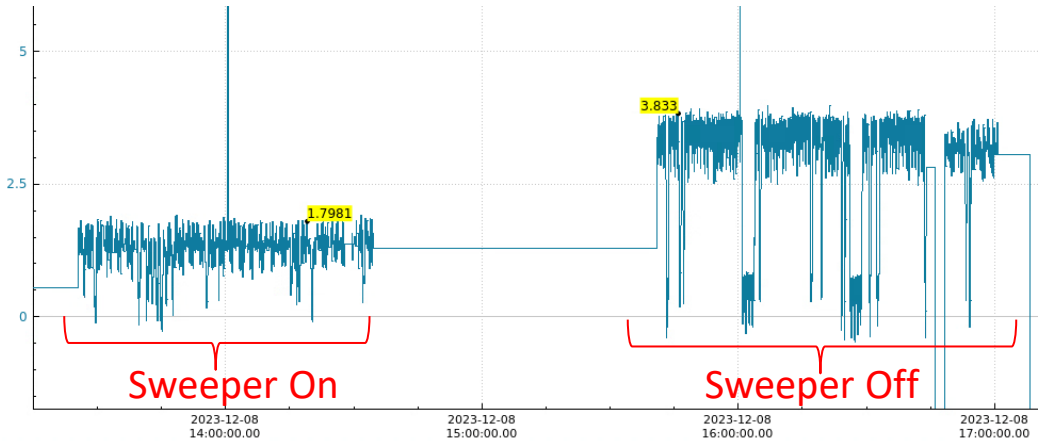
# NPS Sweeper Magnet

- 0.3 Tm conventional copper coil
- Reduces electromagnetic background for high-rate environment
- With 15uA beam on LD2 the maximum anode current reduced from 9.88uA →3.71 uA with the sweeper on/off
- 0-6% change in PMT gain as a function of the column #

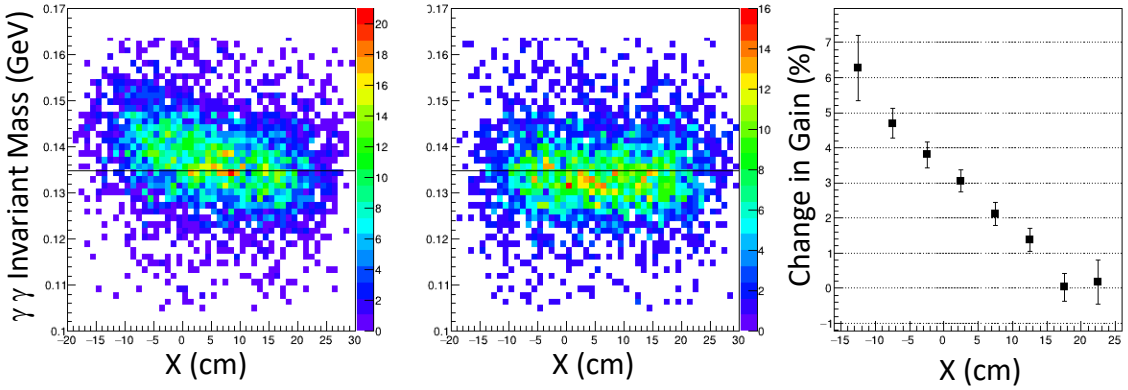
Change in PMT gain from LED data

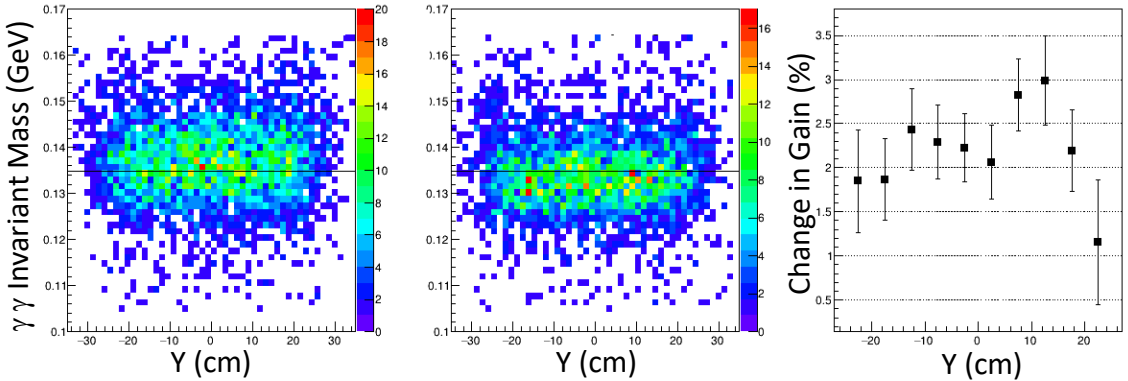



Anode Current with Sweeper on/off




Change in γ γ Invariant Mass

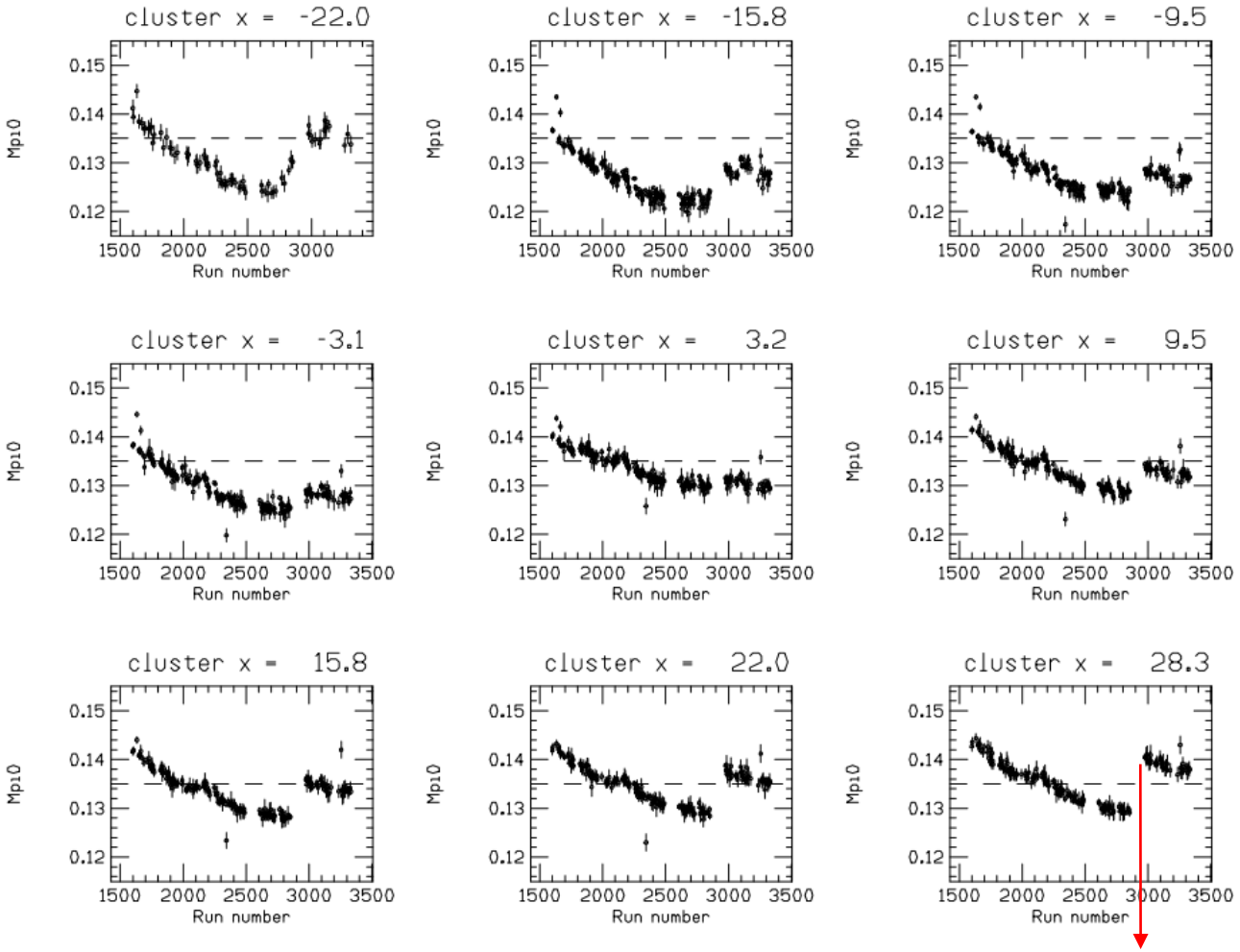


# Crystal Darkening

- Radiation causes darkening and discoloring of crystals which reduces the light transmission
- 
- So far, no visual discoloring of the crystals, but there has been a shift in the $\pi^0$ mass over time
- Columns on the edges of the calorimeter saw a larger shift in $\pi^0$ mass
- This effect is manageable and will be accounted for in calibration

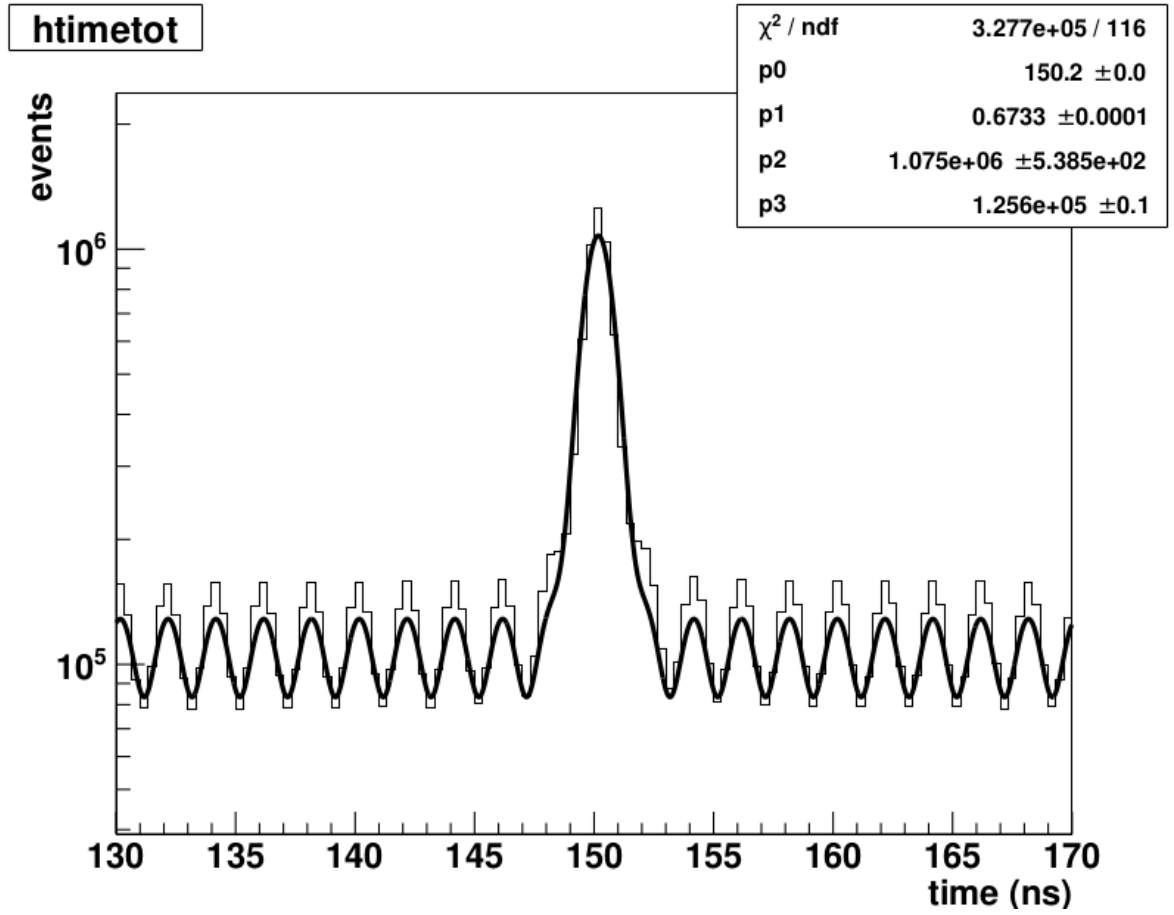
$\pi^0$ Mass as a Function of Run# for Different Values of x




Re-calibrated with new HVs

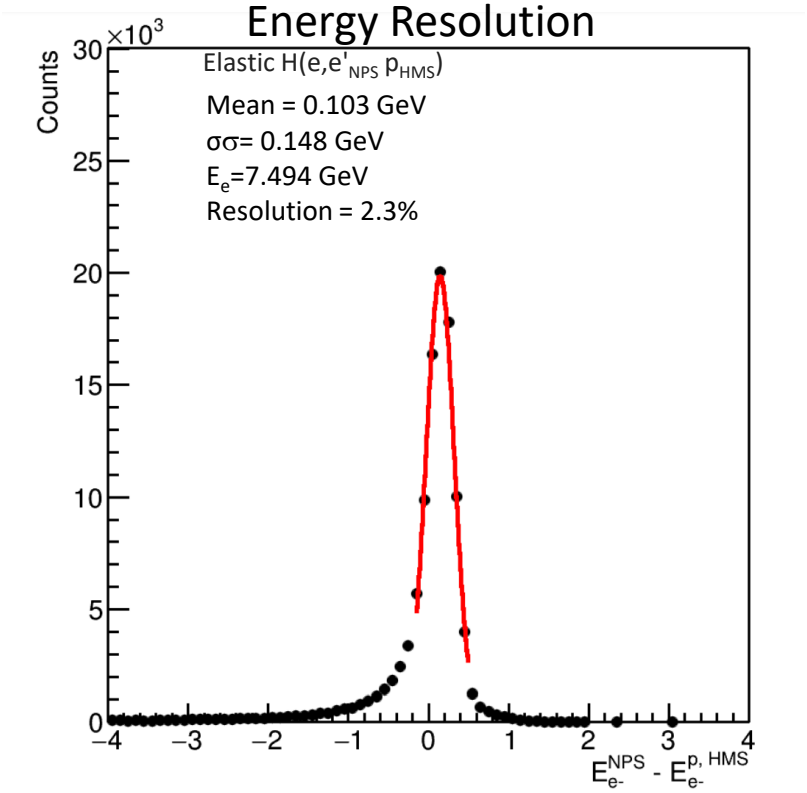
# Timing Resolution

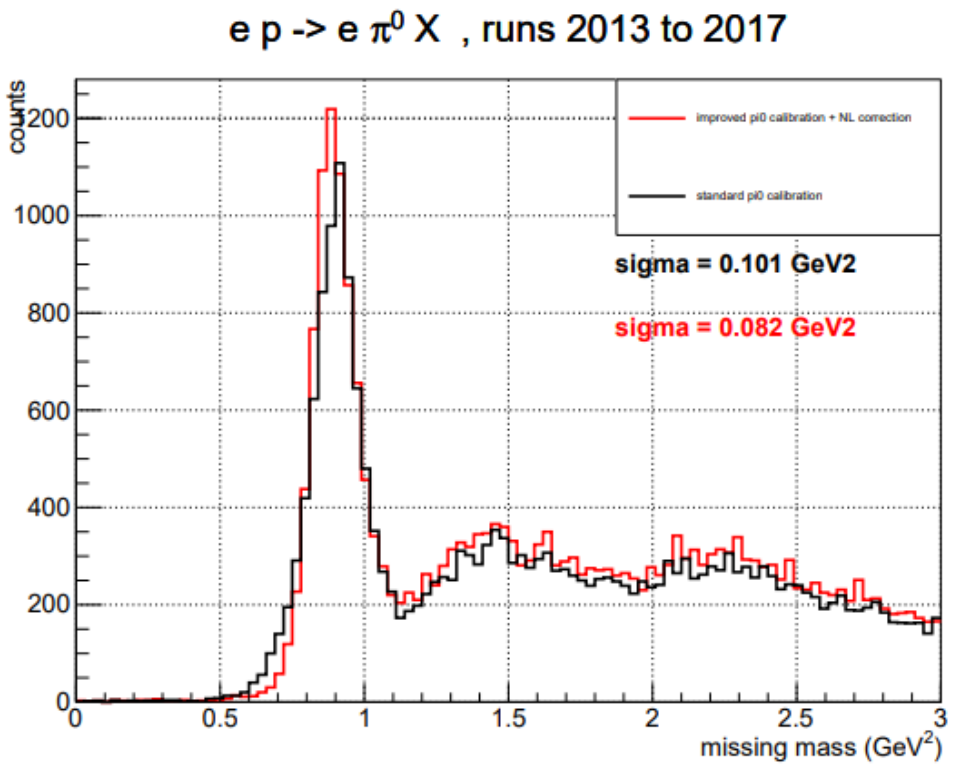
- Time spectrum for all channels show a timing resolution of 0.67ns
- True to accidentals ratio of 10:1



# Energy Resolution

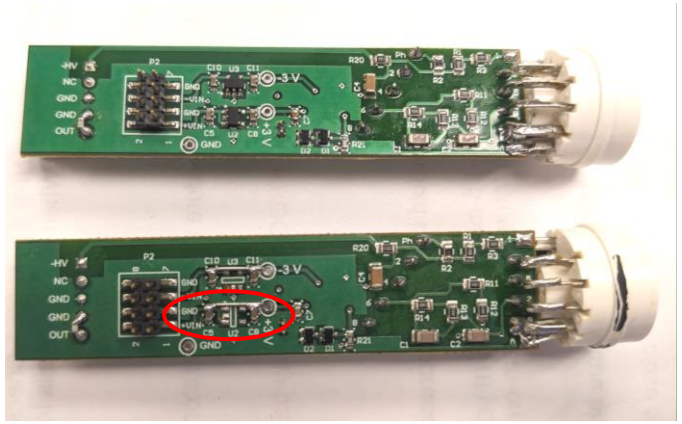
- Exclusivity of the reaction is determined by the missing mass technique
- Missing mass resolution is dominated by the energy resolution of the calorimeter
- Energy resolution from elastic calibration ~2.3% at $E_e$=7.494 GeV
- Missing mass resolution from $\pi^0$ calibration 82MeV
  - Hear Hao's talk for more details on calibrations



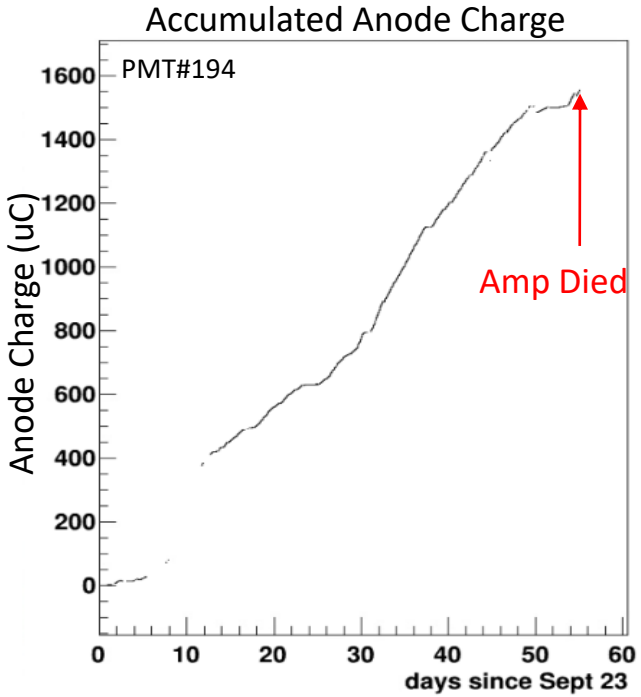



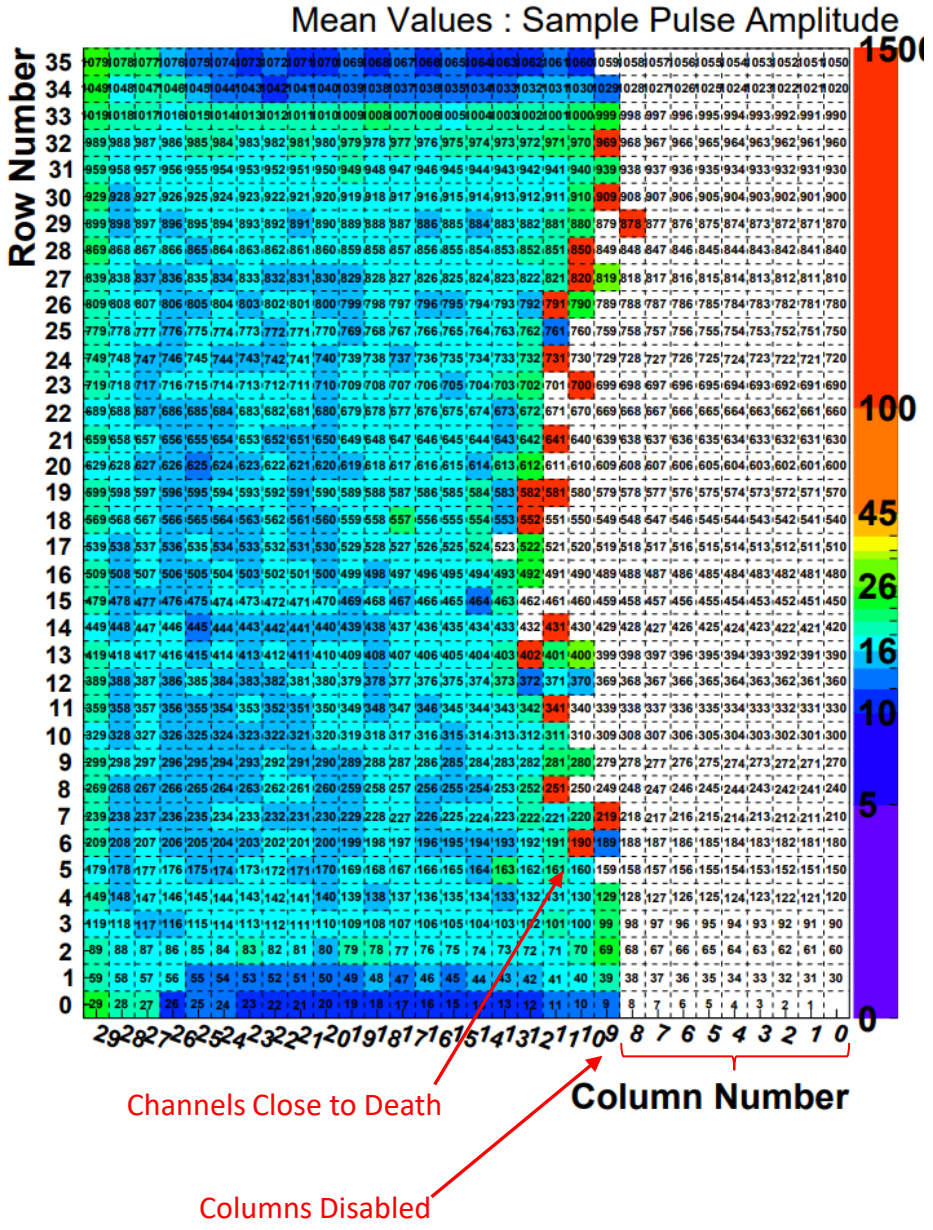
# Radiation Damage

- Radiation damage to the LV regulators on the PMT base pre-amps
- Damaged amplifiers cause instability in the LV power supply for all channels in the column
- Regions at beam height die faster
- Use accumulated anode charge as an approximation of when bases will die



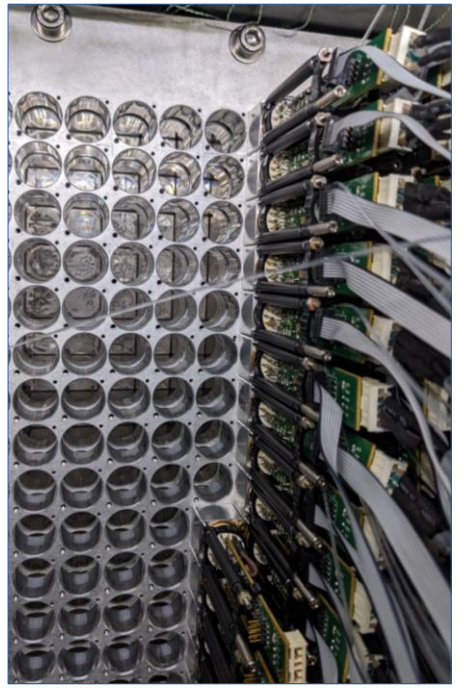
Top:Original Bottom: Bypassed Amplifier

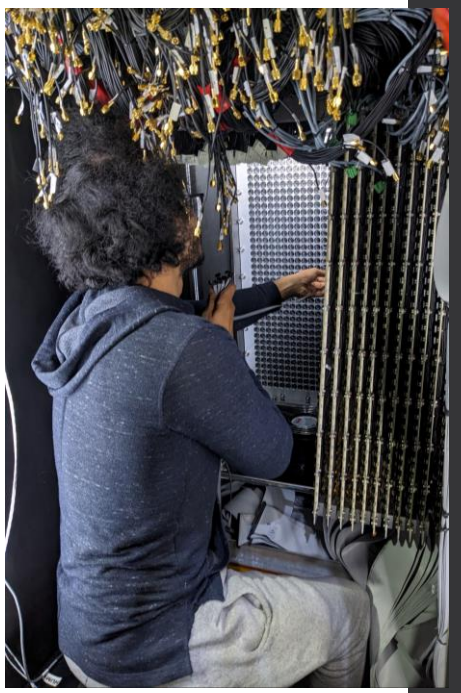


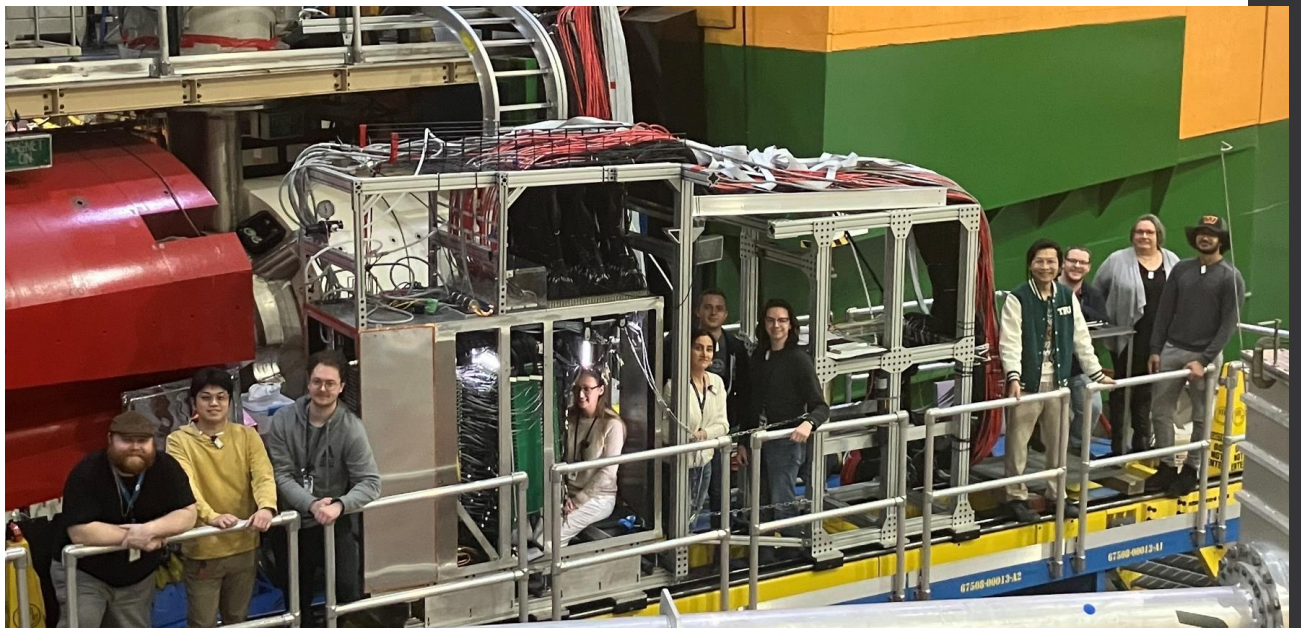



# Repair Work

- Started removing damaged bases on Nov 1
- From Dec 15 – Jan 13 full-time work began repairing all channels in columns 0-19
- We removed and disassembled 720 PMT+base assemblies
- LV regulators were bypassed by Chris Stanislav and Josh Crafts
  - Amplifiers were tested without the regulators and seem stable + rad hard
- Lead and polyethylene shielding added to side of calorimeter



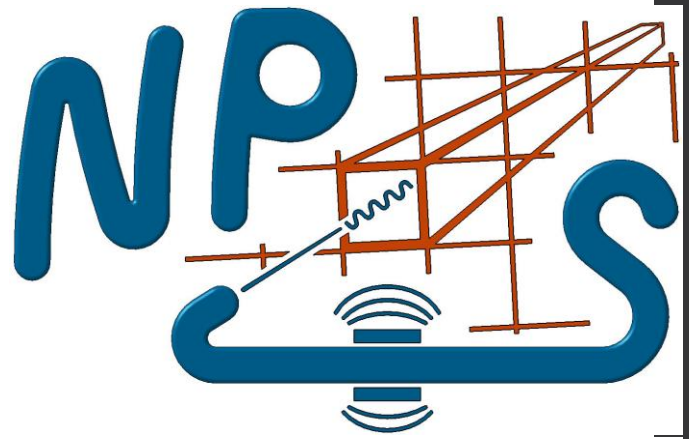


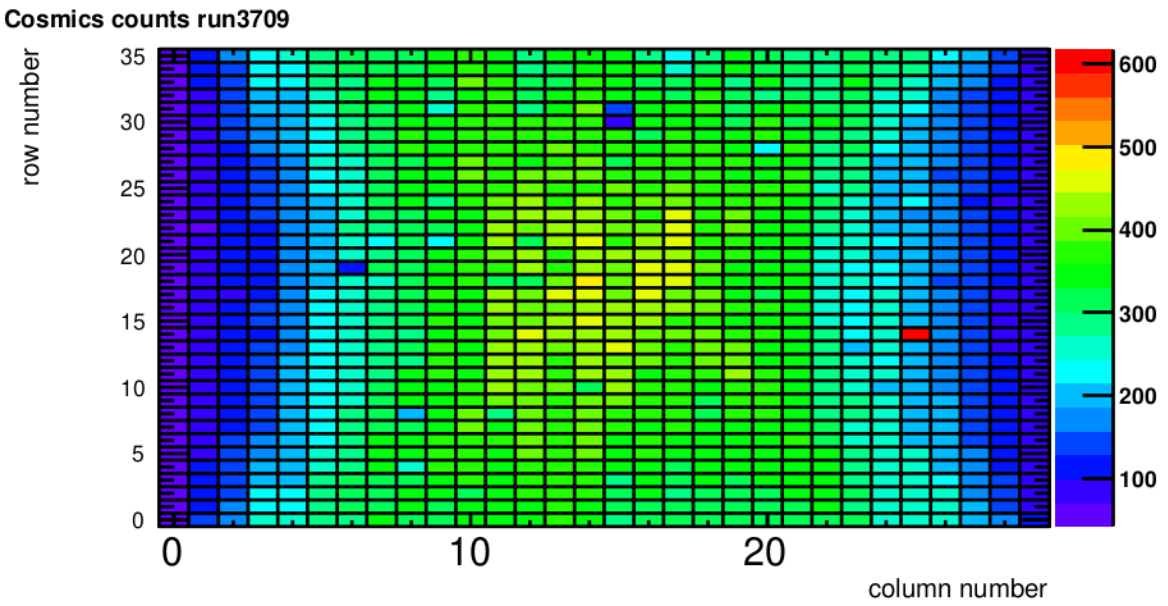


# Summary

- NPS calorimeter and sweep magnet installed
- 20 columns of PMT bases have been removed, repaired, and reinstalled!
- Sweep magnet successfully reduces EM background with small effect on the PMT gains
- Temperature control system able to maintain <0.5°C stability
- Elastic calibration data shows 2.3% at 7.494 GeV energy resolution
- Timing Resolution of ~0.67ns

- More data & analysis soon to come!




Thank you to everyone in the NPS Collaboration, the fast electronics group and Radcon for timely help with the repairs, and all other JLab staff involved!