Hardware Readiness and MUSE 2023 Running

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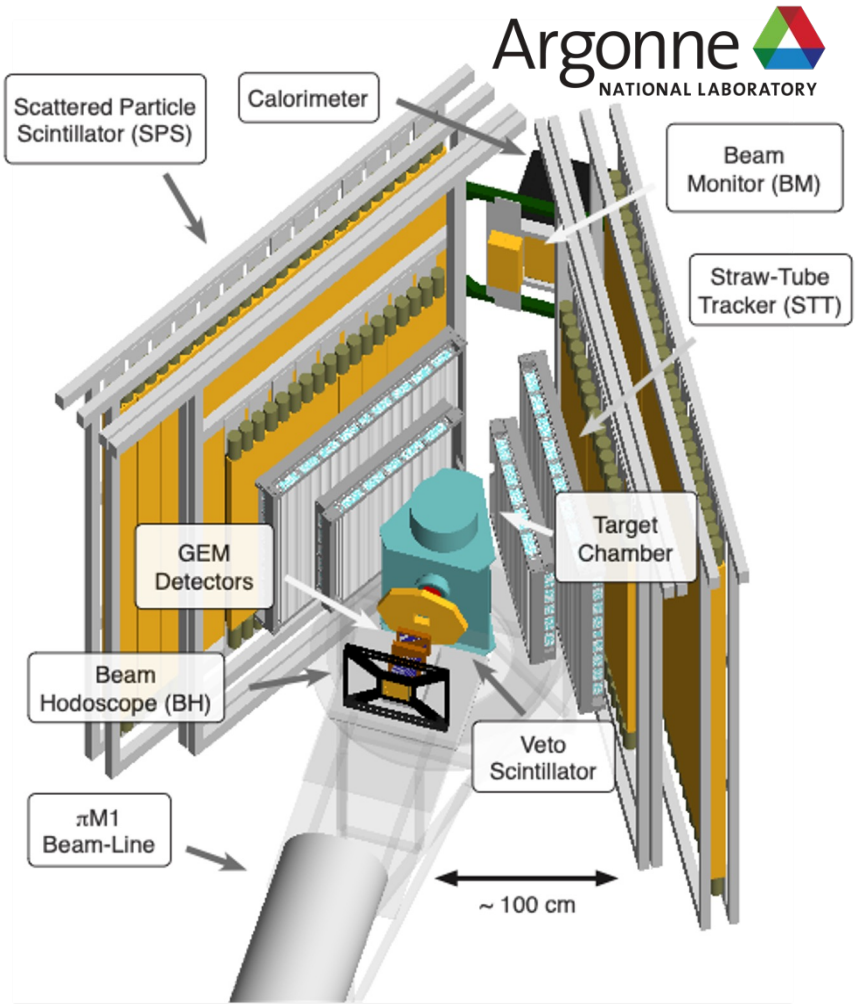
PSI, Villigen, Switzerland
23 January 2023

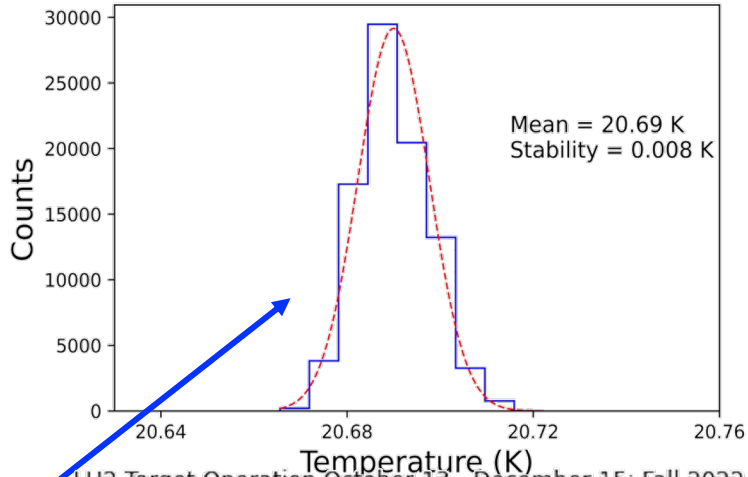


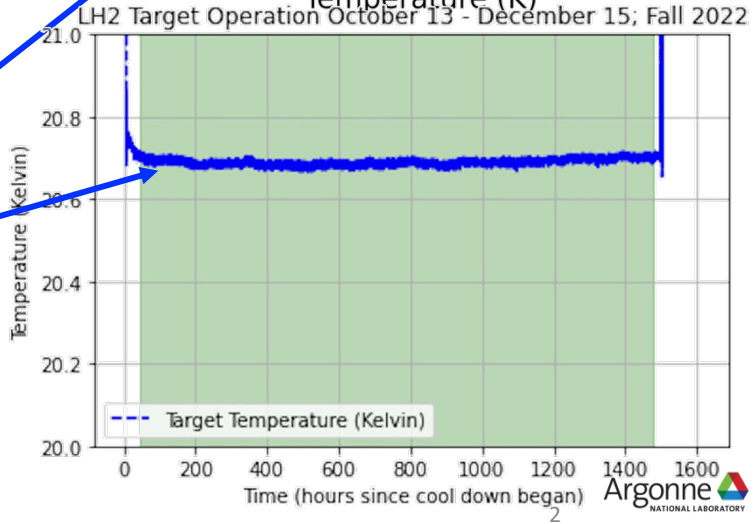
Target Operation with LH_2 (13 Oct – 15 Dec 2022)

- Target operated with LH_2 for 9 weeks
- **Target uptime 100%**
  - 1450 hours (62 days w/o cool down and warmup)
  - no interruptions/warmups during these 9 weeks
  - temp. regulated by Lakeshore PID on condenser

- Target Temperature (bottom end cap):
  - stable at 0.008 K level over entire beam time
- Data recorded every ~60 seconds
- Across full operating time:
  - Temperature = 20.69 ± 0.008 K

Stable operation

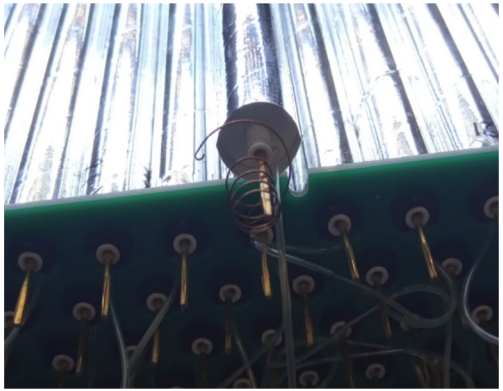
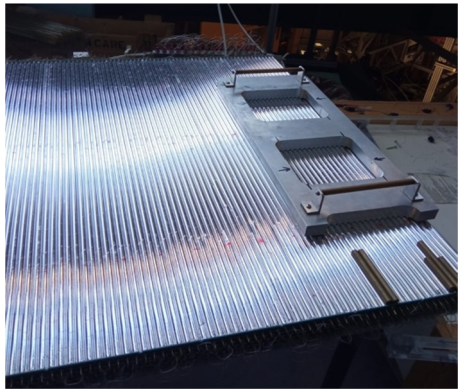


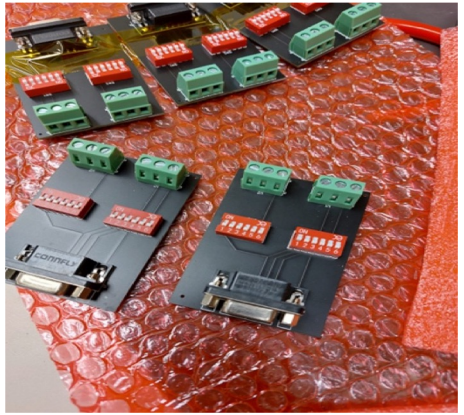


Straw Tube Tracker (STT)

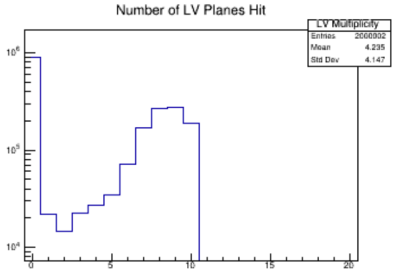
- Rebuild RH90 2022:
  - Replaced some broken straws;
  - Retest wires.

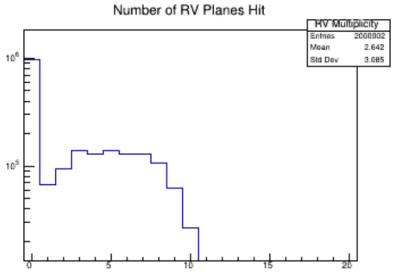
- STT pressure interlock:
  - **Hardware** and **Software** interlocks for each chamber turn off STT high voltage during under-pressure conditions;
  - Pressure monitored and gas is supplied independently for each chamber;
- Control software runs on Raspberry Pi
  - previous failure was due to an antivirus incident MS windows

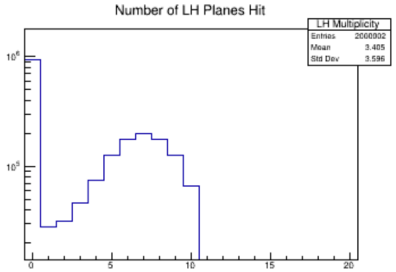



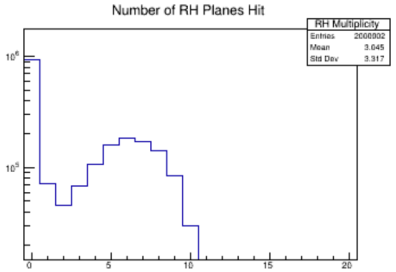


STRAW MULTIPLICITY

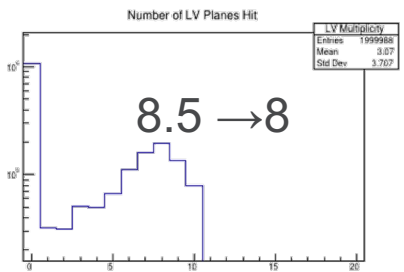


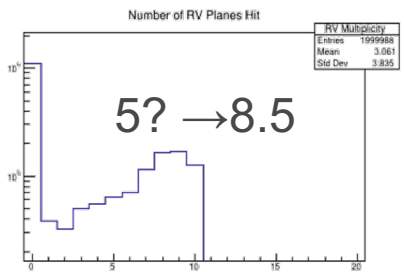


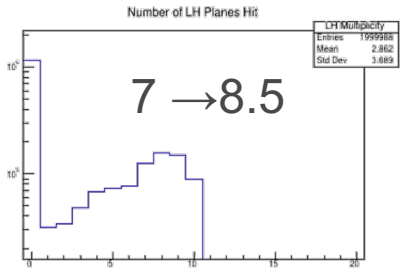


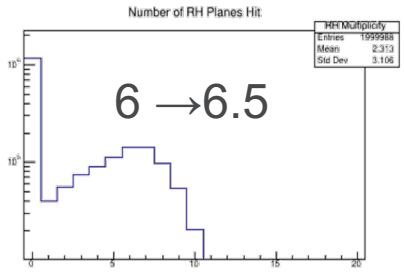


run 9422
fall 2021
(shown in last year's BVR)









run 15600
fall 2022

STRAW MULTIPLICITY

run 9422
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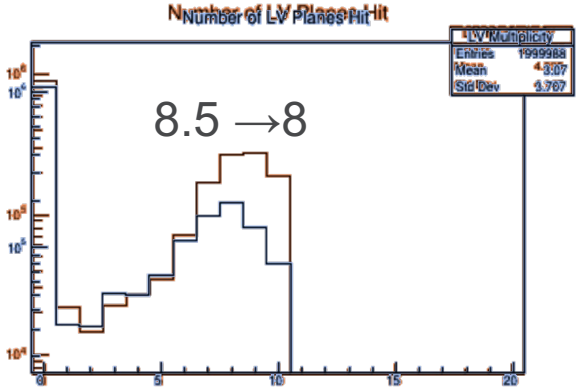
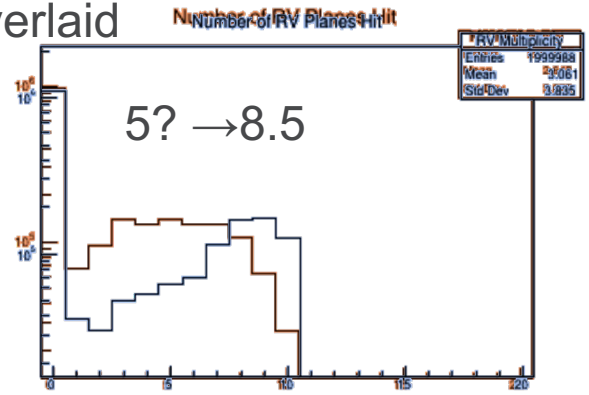
(shown in last year's BVR)



overlaid



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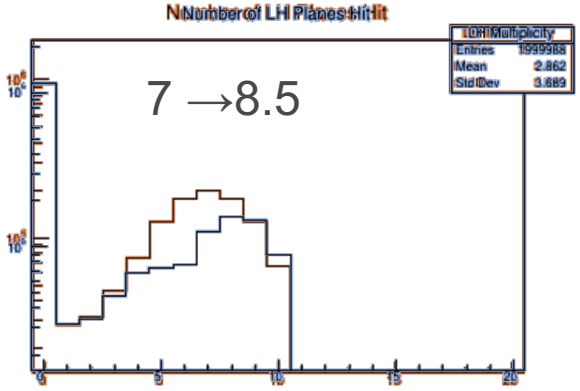
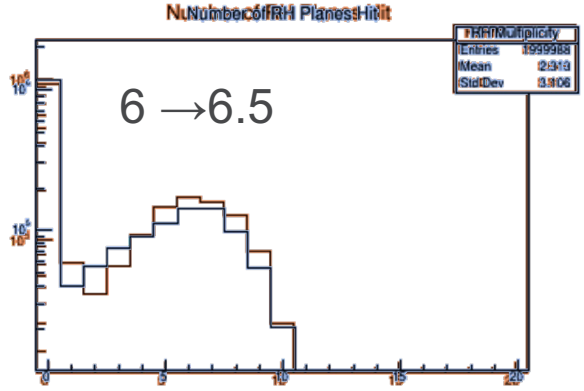
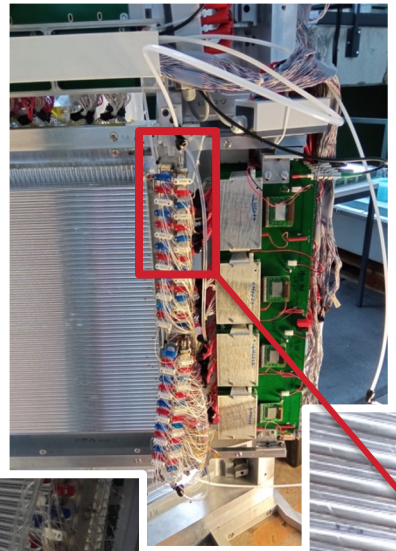


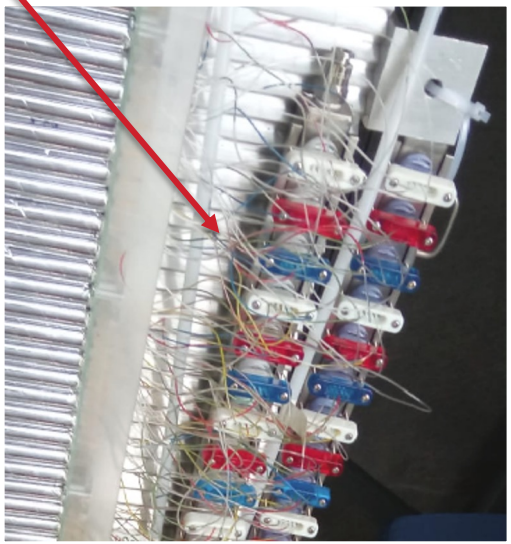


Straw Tube Tracker (STT)

- New gas manifolds developed @ HUJI
  - 6 mm quick connects + 15 plastic manifolds = 75 straws;
  - Modular chamber design allows speedy repair at the cost of losing individual straws;

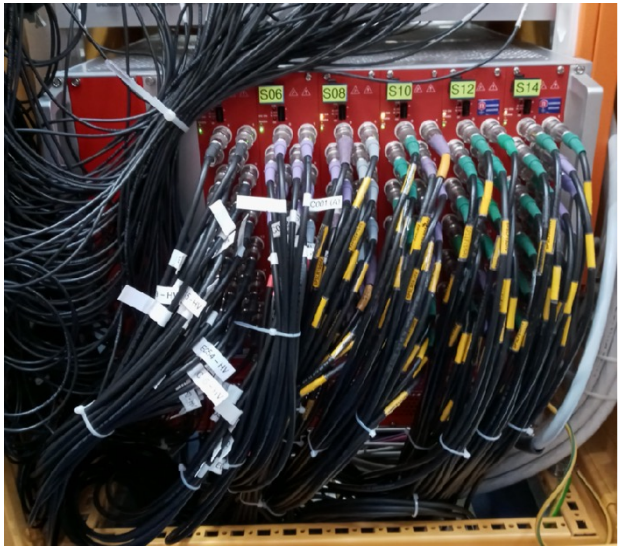
  - Prior to 2022 beam time 10 manifolds were installed, supporting 713 straws—¼ of the total.





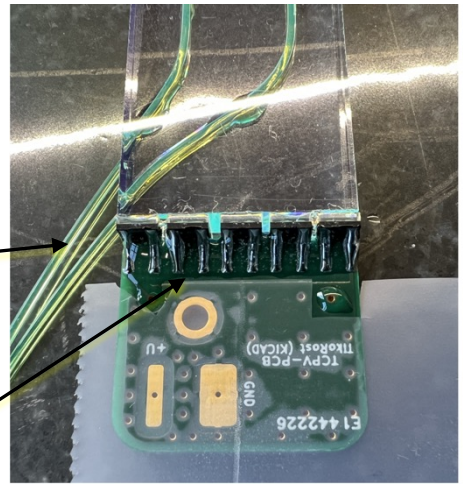
HARDWARE: NEW CAEN HV SYSTEM

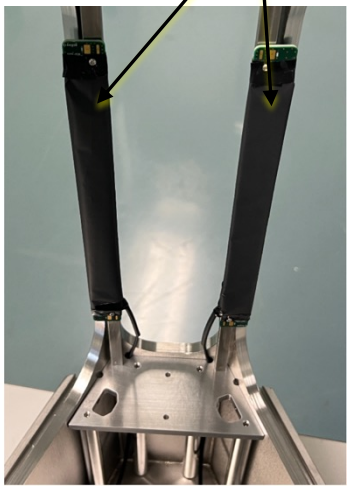
- Two new CAEN HV systems were purchased (GW, UM, PSI, USC), received, installed, and working.
- Currently in use to power all conventional PMTs.
- Detector calibrations were performed prior to 2022 beamtime.



TARGET POST VETO

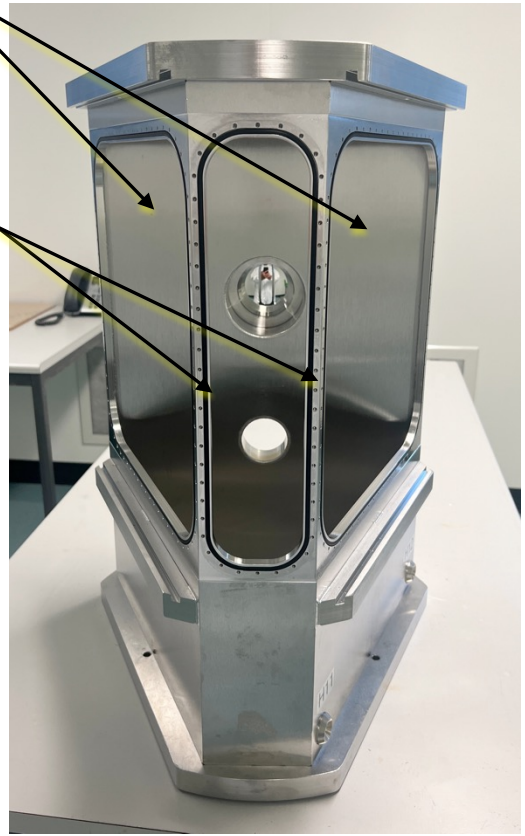
- GEM-STT vertex reconstruction shows many triggers from scattering from target chamber support posts
- Balance veto coverage with proximity to thin vacuum chamber windows during installation
- 10% reduction of trigger rate





Target vacuum chamber

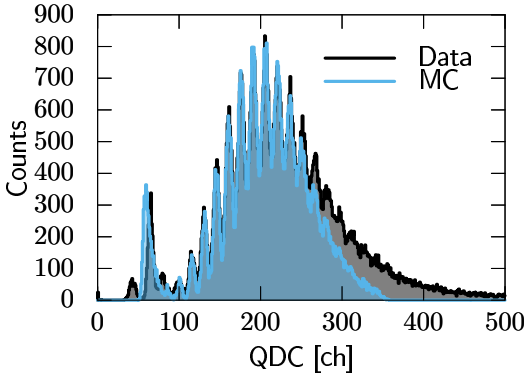
Beam out of page

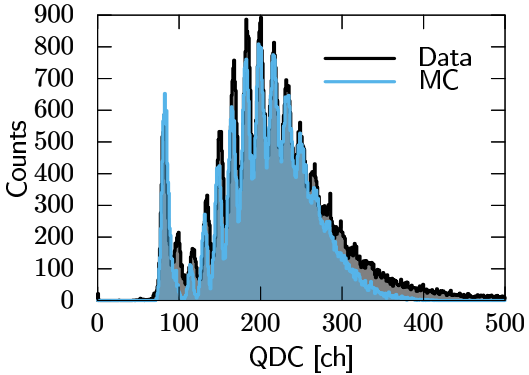


Target Post Veto

- Fiber readout—light limited
  - Average of 9 photoelectrons
  - MC of pe statistics tuned to data with Gaussian distributions (energy loss not modeled).
  - Higher energy loss events will fill in high QDC tail.

- Comparison of SiPM and Fiber readout ongoing.





HARDWARE: ANALYSIS/STORAGE UPGRADE 2022

- The MUSE analysis and storage setup consists of several computers, mostly located in building WHGA.

- Four-nodes computing cluster is up and running:

  New — mpc3070 (on platform) => 4 Tb SSD for DAQ cache + 10 Gb Ethernet.

  mpc2781
  mpc2698
  Inst. late 2021 — mpc2965

  } (WHGA) 12 cores/ 24 threads each, 64/128 GB ram

- MUSE Data Storage:

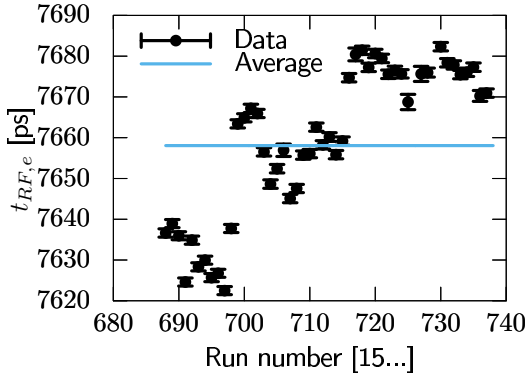
  musefs00 (WHGA) => 64 TB
  mpc2199 (WHGA) => 30 TB
  Inst. late 2021 — mpc2965 (WHGA) => 100 TB
  New — museds01 (WHGA) => 665 TB*.

  } Analysis/storage/backup (2x copy of raw files) (Rutgers, Argonne)

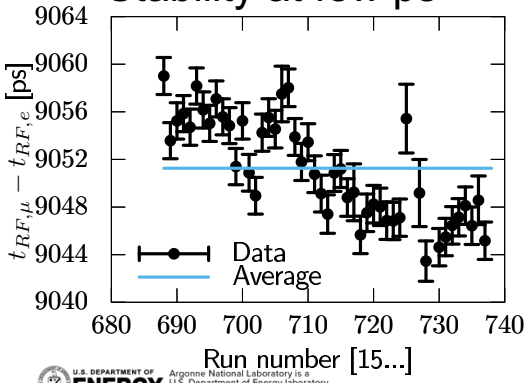
*Half of disk slots are used, can be extended.

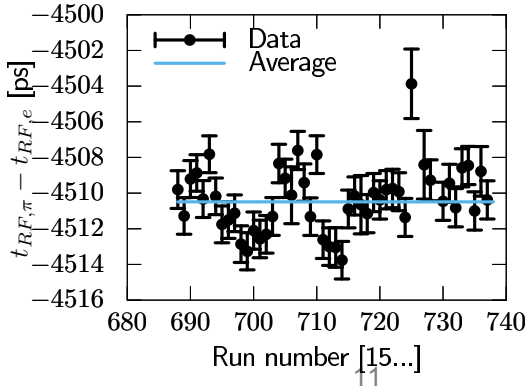
Stability Over Time

- RF vs electron timing
  - Stability at 50 ps



- μ and π compared with e time
  - Stability at few ps





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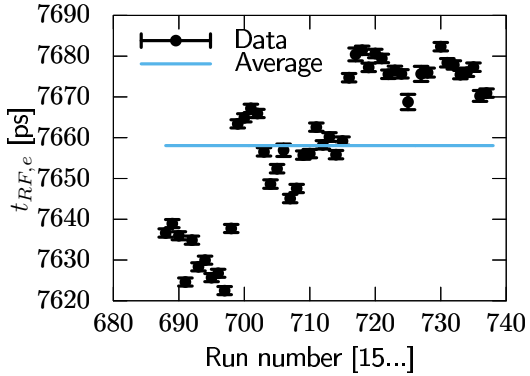

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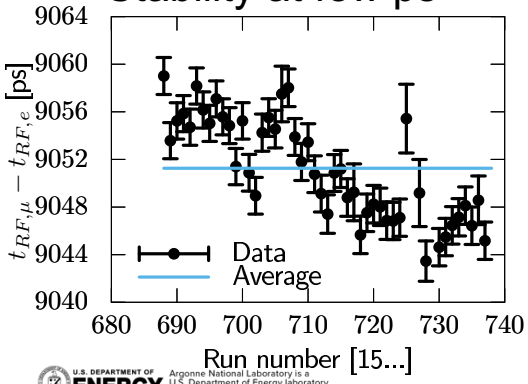
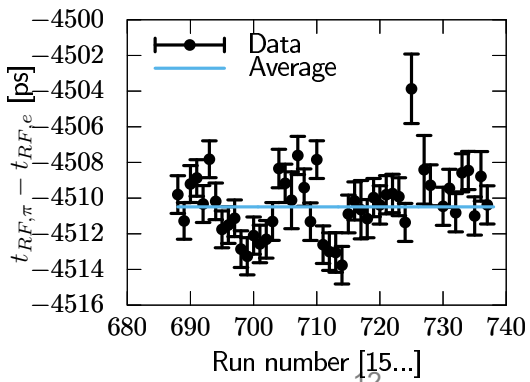
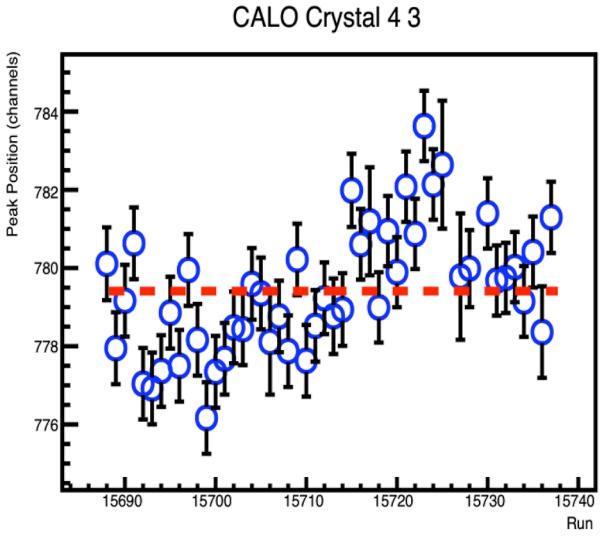
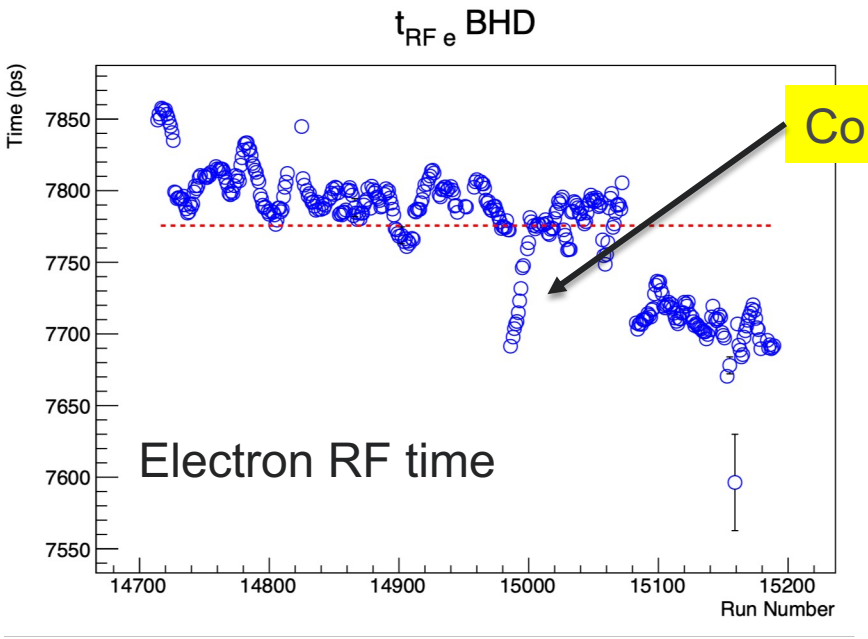




- Gain Stability
  - stability of pedestal at few channels.

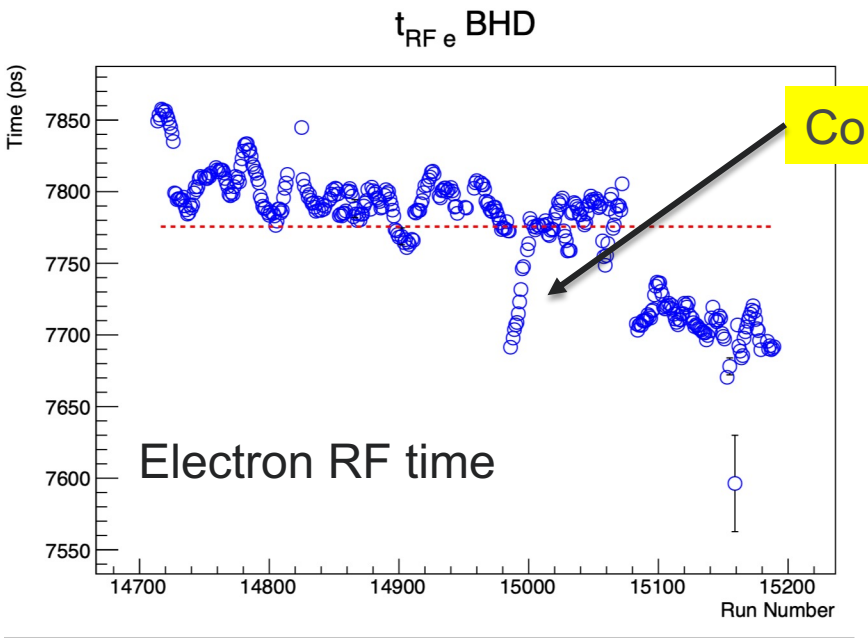


Stability over Time



Coliminator Scan

Stability over Time



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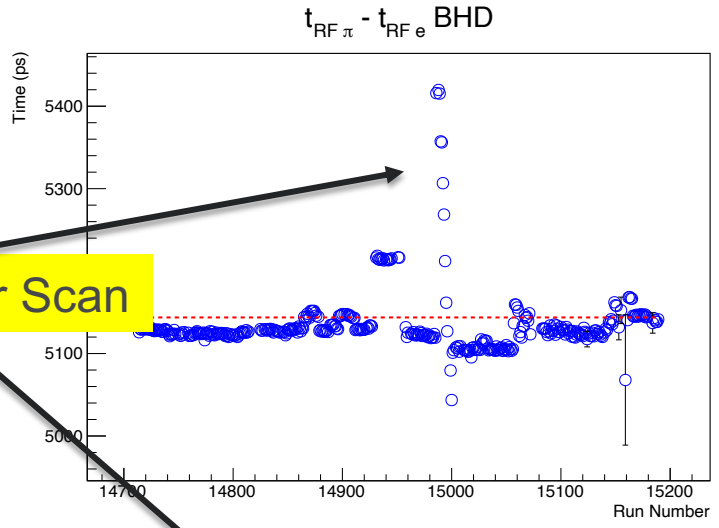
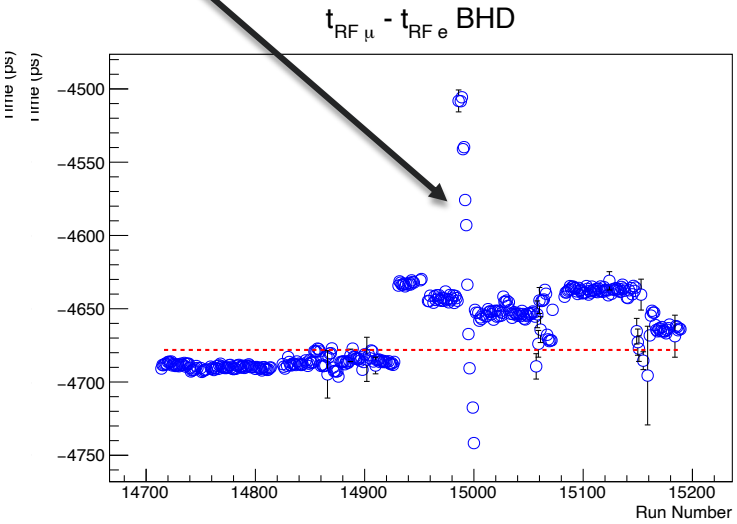




Recent Major Financial Investments

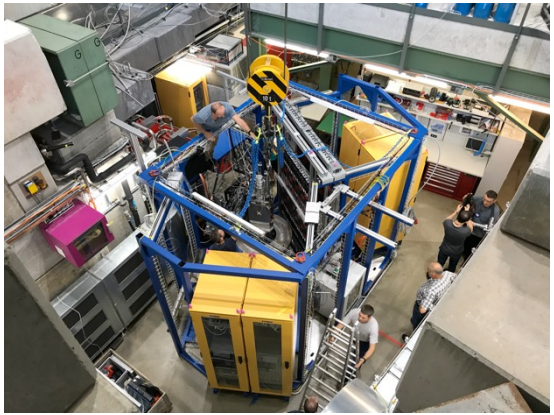
Item	Groups	
CAEN HV	GW, UM, PSI, USC	$75,000
PB Storage	Rutgers, ANL	$45,000
Mesytec CFD & QDC	GW, Rutgers	$40,000
Total		$160,000

Misc. Hardware and Maintenance for 2023

System	Issue
Beamline	Improved collimator (FS11, FS13) readback (request to PSI)
BHC	Replace high current SiPMs or exchange BHC plane
BHD	Install delay cables (will allow walk corrections)
GEMs	Complete DAQ upgrade
PV	Evaluate if WLS sufficient/positioning sufficient, adjust
BMC	Investigate/replace low gain paddles (possible crazing).
STT	Replace remaining old gas manifolds, re-enable cards
SPS	Fix broken SPSF lower PMT
	Additional source tests
DAQ	QDC pedestal shifts, investigate Mesytec firmware from end October, v10.xxxxx
	STT TRB TDC loss, while data was seen in scalers. Under investigation, immediate solution was to switch TRB FPGA
	Data backup to tape
DAQ-trigger	Timing test
computer cluster	UPS selected, will be ordered

Beam Request

- Request 6 ***Contiguous*** Months
  - Recent experience shows that each move into the area costs > 3 weeks of beam for calibrations, recommissioning, etc.
    - Earlier, shorter estimate was not based on experience



  - Crane time & electronics connections are quick (few days).
  - Data check out within 1-2 days

  - Each move has risk of damage. (*Crane operators are very careful*, but just having more people around increases risk.)
  - Move in prior to beam eliminates most (not all) of this time.
  - *Each move requires a survey (hard to schedule)*
    - best before run (not included in 3 weeks).

Run Plan

- Equal time on each beam momenta, 115, 160 & 210 MeV
- Equal time in each polarity

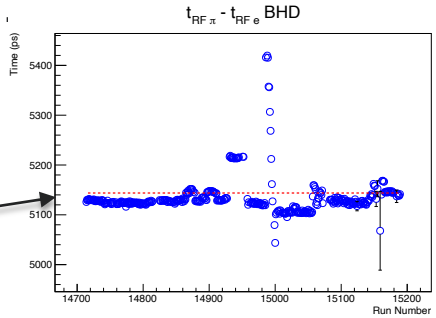
Target	
LH2	45%
Empty	35%
C	10%
No Veto	3%
SPS efficiency	3%
No Target	3%

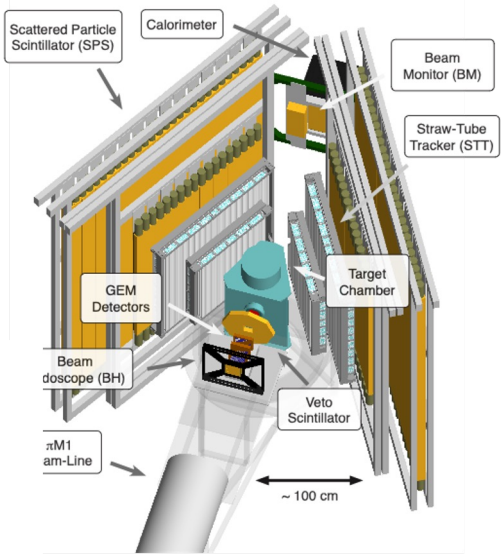
- 2022 distribution of target time; expect similar in 2023
- Tune analysis on C target
- Provide slightly more events than 2022
  - Quicker startup if done during down time

SUMMARY:

The MUSE spectrometer is ready to go!

- Straw Tube Tracker (STT)—repaired & operates reliably
- Target—Lakeshore communication has been solved.
- Target post vetos in place and operating
- Computing resources/facilities in place.
- Minor maintenance activities in 2023
- Demonstrated system Stability
- Major advances in Analysis
  - Tracking, Calorimeter, Scintillators responses understood
  - Good agreement between Monte Carlo & data
  - Clean reconstructed vertices
  - Blinded C Cross Section – more to implement





Request 6 ***Contiguous*** Months

ITEMS FROM LAST BVR MEETING

Analysis		
	Backup => Have to figure out details.	2nd copies of raw data are kept on site/different storage system
	Get data off-site	Current analysis model is using data on site
Tracking Straws		
	STT Hardware pressure interlock	Completed before 2022 run
	New metal manifold and o-rings	Completed before 2022 run
	Rebuild STT RH90 before beamtime 2022	Completed before 2022 run
	Replace broken straws.	Completed before 2022 run
Beamline		
	NO issues reported.	

ITEMS FROM LAST BVR MEETING

Tracking GEM		
	Check and improve seating of APV cards on US GEM.	Did not remove beam telescope so APV's were not accessible
	Remove one GEM when 3 GEMs are proven to be sufficient	Maintained 4 GEM configuration for fall 2022 running
	Complete MPD4 firmware update for dual word packing.	In progress
	Add GEM HV to the MUSE Slow Control.	Low priority
	Multi-sample analysis for GEM.	Currently using clustering of time-averaged strips
	Track based alignment	Software ready
	Tracking efficiencies at low and high rates	In progress
	Further improvement of clustering, signal/noise, efficiency.	In progress. Masking and interpolation of hot and dead channels. 1D clusters now being stored before pairing X and Y.

ITEMS FROM LAST BVR MEETING

Timing Detectors & Calorimeter		
	Rare loss of QDC DC-offset;	Mesytec MQDC Firmware updated/downgraded
	Rare false reporting of rising and falling edges.	Handled by analysis used with 2022 data
	Transient and very brief departures of the HV from the set values	New CAEN HV system installed and used in 2022 run
	New CAEN HV modules	Completed and used in 2022 run
Target		
	Target Lakeshore Communication tests	New Lakeshore controller installed and used in 2022 run
	Upgrade Target monitoring GUIs for shift workers	Completed and used in 2022 run

ITEMS FROM LAST BVR MEETING

Trigger & Electronics		
	Accelerator RF digitization with a new custom module;	Completed and used in 2022 run
	PID trigger adjustments;	Completed and used in 2022 run
	LUT tables adjustments based on survey.	Low importance, not complete
	Convert Veto and BM Triggers from NIM to FPGA.	Still using NIM triggers
	Trigger analysis and trigger configuration scripts;	Completed and used in 2022 run
	Purchase of spare QDCs and CFDs;	Completed and available in 2022 run (GW, Rutgers)
	Testing MEsytec VME controller;	M VME controller not appropriate for MUSE
	Edge flip in TRBs;	Handled in Analysis
	TRB3 stability;	Much improved, cause was buffer overflow in STTs for high-rate channels