Q&A from Day 1

E1039 Collaboration

12/2

Q1.1: The schedule looks very tight, with many potential delays looming in the near future. But it was a little unclear how much work has to be done. Can you better quantify the remaining work, in terms of number of welds, remaining plumbing, etc.

Much of this is contained in my backup slides (slide # included). These items are in the schedule. The slides also contain estimates of engineering oversite of the work.

For the infrastructure installation we have the following remaining work:

- LCW manifold construction, LCW connection pressure test (~2 techs, 2 weeks): RJT slide 24
- LN2 line installation (approximately 2/3 work remaining, 160hr tech, 60hr brazer): RJT slide 23
- gHe cooldown line (80hr tech, 24hr welder): RJT slide 25
- gHe transfer lines ~ 1/2 work remaining (114hr tech, 40hr welder) RJT slide 31
- ODH installation (136hr engineering, 488hr tech) RJT slide 26
- Target cave roof installation (120hr tech)

Non-installation work to be completed

- KTeV magnet repair (64hr tech, 16hr brazing) RJT slide 28
- Spectrometer Alignment (40hr tech, 10hr geodesist) RJT slide 29 (currently not scheduled)

Q1.2: Secondly, is there any way to generate more float by deferring items until after the accelerator shutdown? What is the backup plan in case the target cannot be fully commissioned before the shutdown?

To achieve the minimal goals we have before the summer shutdown, two possible de-scope can be done in case the delay is more than the 6-week schedule contingency we have planned for:

- The connection and commissioning of the QT liquefier system can be deferred to after summer shutdown – 4 weeks schedule advance
- The modification of the fridge can be deferred as well - can only run with a dummy target – 1 week schedule advance

- Requires QT transfer-line which is already at FNAL
- Requires penetration piping to be in place
- Still requires the target cave to be closed up
- Still requires a (reduced) cryogenic safety review

Q2: What are the plans for optimizing Deuteron polarization (cold dose)?

The Deuteron polarization (cold dose) will likely have to be from the main beam. We have a setup at NIST to do this but getting in there these days is pretty hard, so on the short term we will start with warm dose and see what sort of enhancement we get with a proton cold irradiation. My guess is that the downstream end will optimize better (due to dose from secondaries) and the insert will have to be flipped to more even distribute the needed centers.

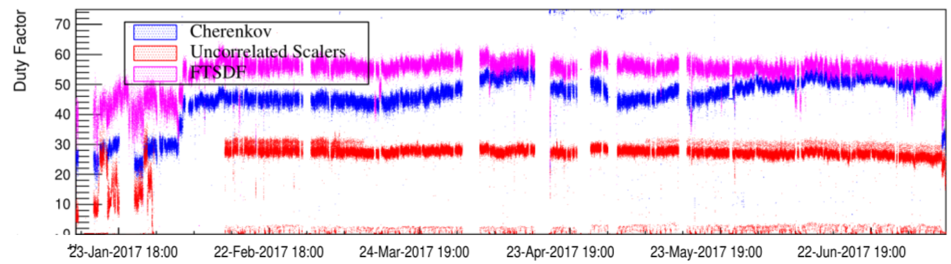
Q3: How much tolerance is there in the Figure of Merit if performance is not as expected, due to lower intensities to avoid magnet quenches, or less effective polarization, or lower bunch duty factor, etc?

$$\Delta A_N = \frac{1}{f}\frac{1}{P}\frac{1}{\sqrt{N}}$$

Dilution factor

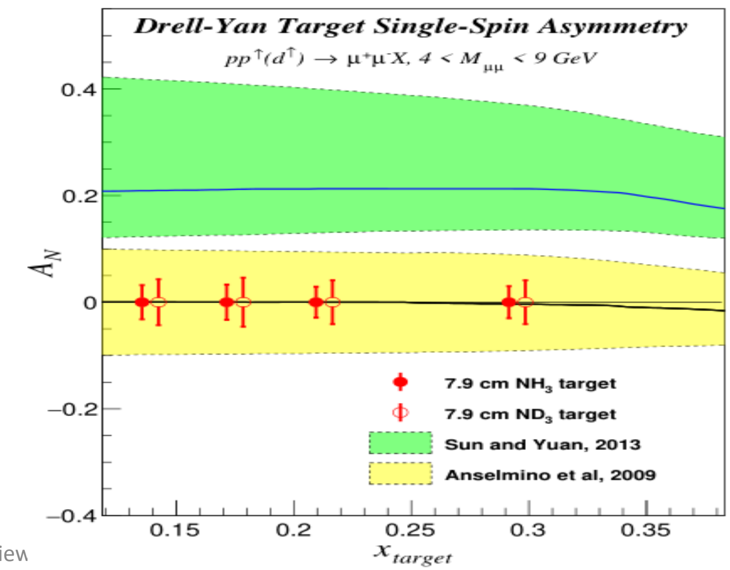
Average pol.

Luminosity, or "useful POT"



- Lower duty factor will impact us significantly, but given AD has been consistently delivering high quality beam during the last run of the E906, we consider the risk to be very low

- Assuming 80% average pol., and 1.5E18 "useful" POT, we expect to have 4-5% statistical uncertainty for each of the 8 points
- If average pol. is only 60%, the expected uncertainty will be 25% larger
- If the quench threshold is a factor of 4 worse, the expected uncertainty will be a factor of 2 larger
- If both turned out to be true, we will reduce the number of bins in x_{target} from 4 to 1, and achieve a single measurement around x ~ 0.2 with the uncertainty between 5 to 6%



Q4: Summarize the activity spreadsheet, categorize the remaining QC - what needs pressure testing, what follows from ASME standards, what still needs final development, etc.

For the infrastructure part, the following systems need QC

- Pressure test LCW line and connections (hydrostatic test)
- Gaseous He tank material certification (2 tanks)
- Gaseous He tank pressure test (MAWP 125 psig)
- Leak test/thermal shock brazed joints for LN2 transfer lines (part of assembly)
- Leak check gHe lines to/from tanks (part of assembly)
- LN2 dewar pressure test
- “Bump” tests for all 3 phase compressor motors (QT liquefaction plant, Roots stack) (Is the 3phase power wired correctly; do the pump motors turn the correct direction?)
- Test ODH system for target cave (part of installation)

For the target, the answer is more complicated:

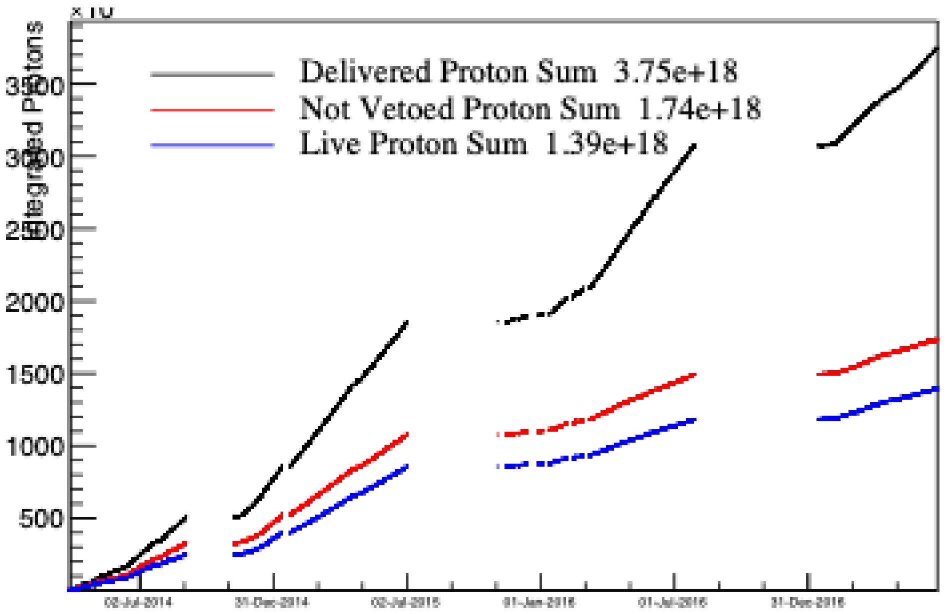
- Our cryogenic engineer is still learning about our system and learning how best to advise us
- Possible vessels/piping that have been discussed as possible need pressure tests some of which would be challenging or impossible to preform standard pressure test and how to proceed has not been clearly determined
  - Possible pressure tests: Fridge separator, nose/shell, bellows, U-tube, He-gas manifold, separator line(in cave), manometer line, magnet relief (in cave), nitrogen relief (in cave)
  - Built ASME: Quench line, magnet pump line and connection to KNF, separator one in penetration, backfill line

Q5: Please clarify and explain your proton budget - number of protons delivered and number used by the experiment, clearly defining “usable protons”?

Three kinds of Protons

SeaQuest developed three different ways of talking about protons in the beam.

- Delivered Protons ("POT") – number of protons delivered to the beam dump irrespective of any other consideration
- Nonvetoed Protons – protons in buckets that did not trigger the Cherenkov veto
- Live Protons – protons that arrived on the target when the DAQ was live



Protons on Target

	Nominal Cooling	Enhanced Cooling
Spill Intensity	$3x10^{12}$ protons/spill	$10x10^{12}$ protons/spill
Spills per day	1440	1440
Number of days	400	400
→ Delivered Protons (POT)	$1.7x10^{18}$	$5.8x10^{18}$
Target uptime	0.73	0.73
Beam Quality Factor	0.5	0.5
DAQ Live Time	0.95	0.95
→ Live Protons	$0.60x10^{18}$	$2.0x10^{18}$

SpinQuest proposal and sensitivity plots assumed $1.5x10^{18}$ live protons over the two-year running period.

→ Some enhanced cooling (involving pumping of helium) will be necessary to achieve our physics goals.

Q6: Do you have a person (not necessarily full-time) playing the role of a project engineer, coordinating the preparation of material and the plan for going through the review process. If not, is there a candidate and budget for this role?

- We have 2 "lead" engineers:
  - Mechanical: Don Mitchell (PPD mechanical enginner)
  - Cryo: Greg Tatkowski (AMSTD cryo engineer) with assistance From Del Allspach (PPD cryo engineer)
- Operational Readiness Clearance (ORC) coordination is performed by R. Tesarek
- Currently the effort for coordination cryo-system eviews, consultation, etc. is rolled up in the "activities list". Details of that budget are found in R. Tesarek's slides: 17, 27 under "target safety prep"

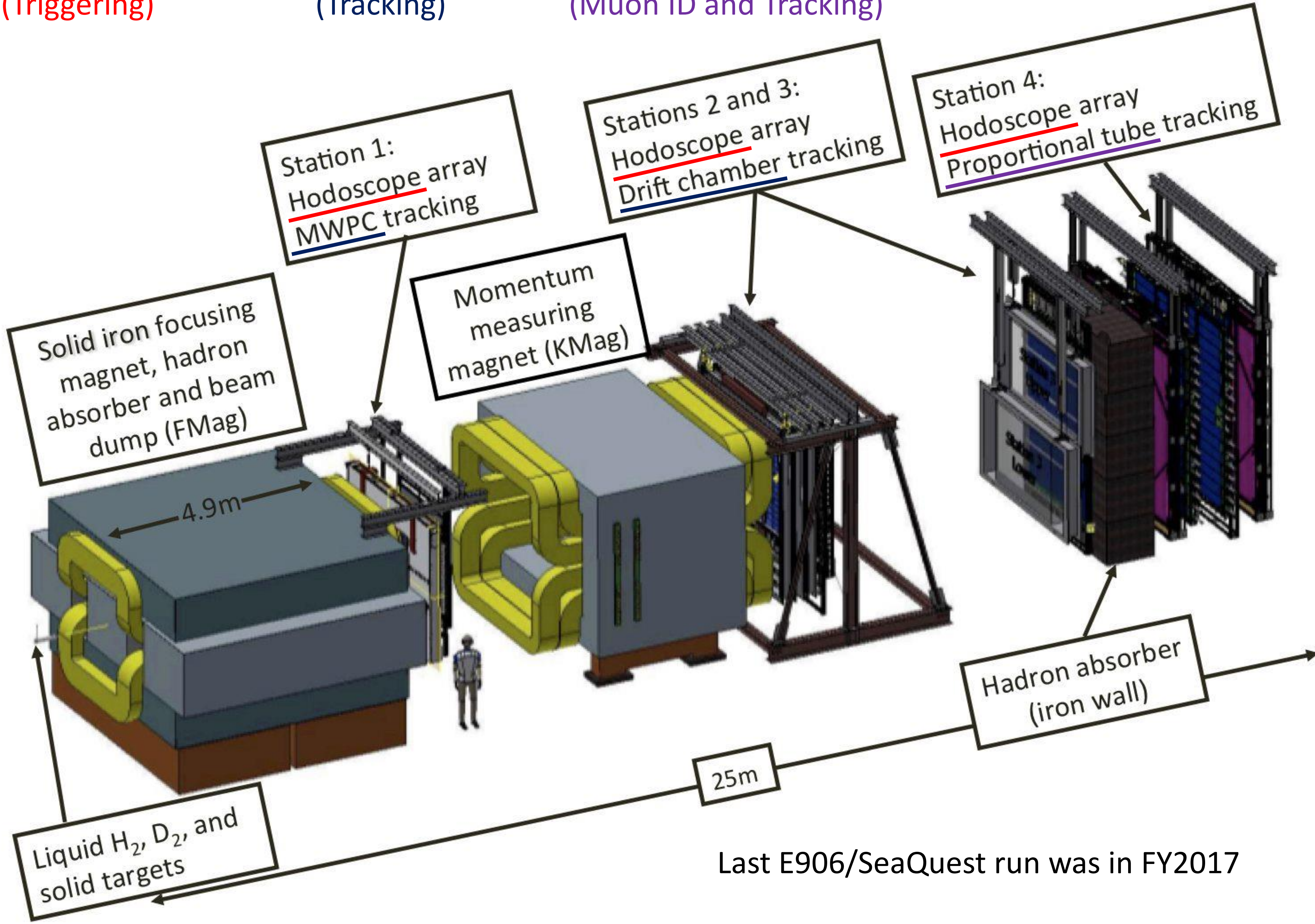
- To reduce risk/delays, the target/cryo-system needs more attention from the lab in order to get through the cryo-safety review
- This might best be achieved by a dedicated cryo-engineer (like G. Takowski) learning the system and leading the effort through the review as a full-time "project" engineer until the review is complete (additional $48k needed for "target safety prep")

Q7: When was the last time SeaQuest took data, and what is the status of the rest of the detector elements (not the new portions) that are necessary for the physics you want to accomplish?

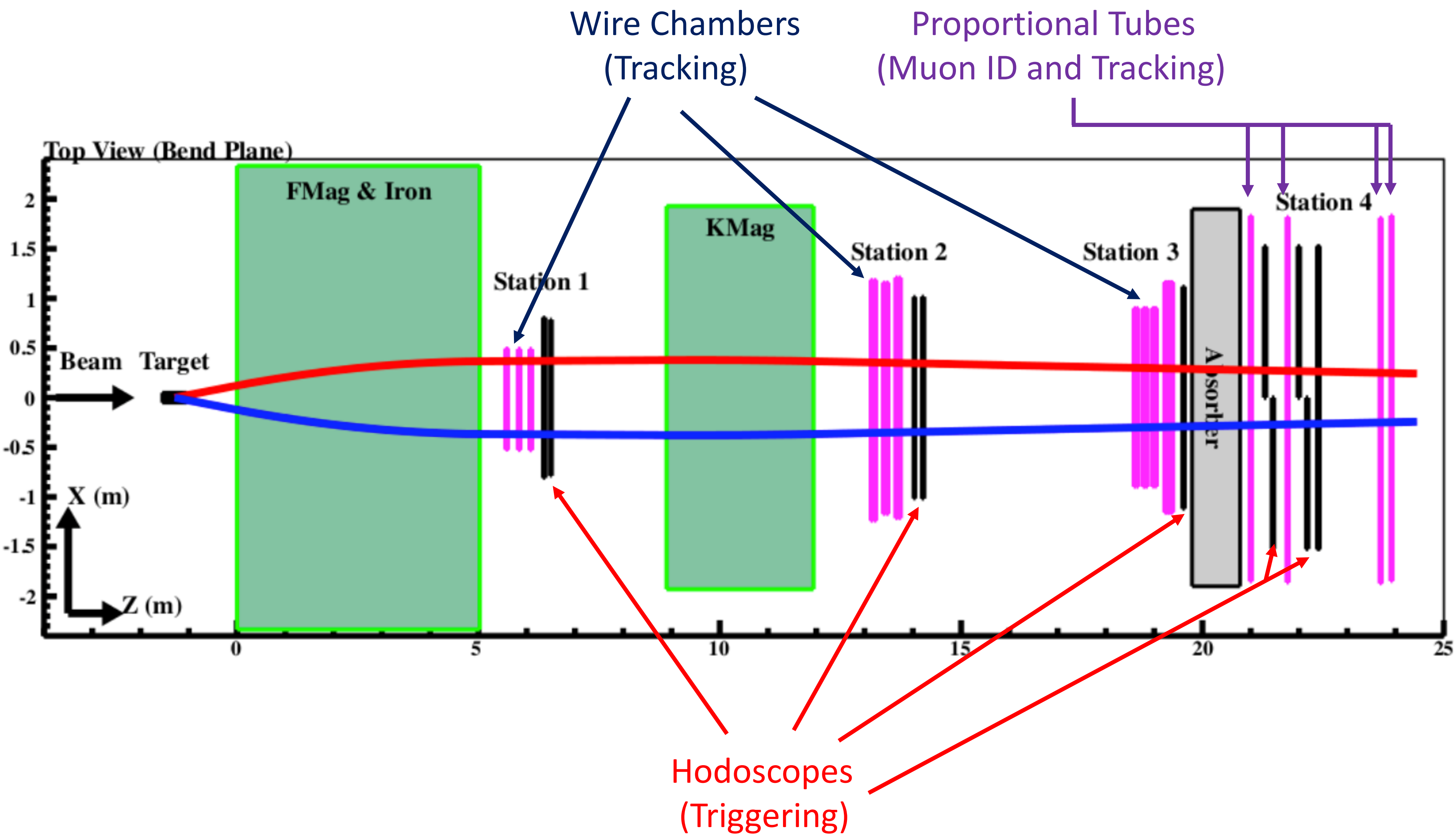
Hodoscopes
(Triggering)

Wire Chambers
(Tracking)

Proportional Tubes
(Muon ID and Tracking)



Last E906/SeaQuest run was in FY2017



Wire Chambers
(Tracking)
Proportional Tubes
(Muon ID and Tracking)
Top View (Bend Plane)
FMag & Iron
KMag
Station 1
Station 2
Station 3
Station 4
Absorber
Beam
Target
X (m)
Z (m)
2
1.5
1
0.5
0
-0.5
-1
-1.5
-2
0
5
10
15
20
25
Hodoscopes
(Triggering)

Hodoscopes

- Forhad Hossain and Stephen Pate (NMSU), Liliet Calero Diaz (UVa), and Rick Tesarek (FNAL)
- Four stations of hodoscopes
  - H1X and H1Y
  - H2X and H2Y
  - H3X
  - H4X, H4Y1, and H4Y2
- 100% of these channels are operational
- HV tuning is at an advanced stage
- Using cosmic rays to test efficiencies

Hodoscope Efficiency Measurement: One Example

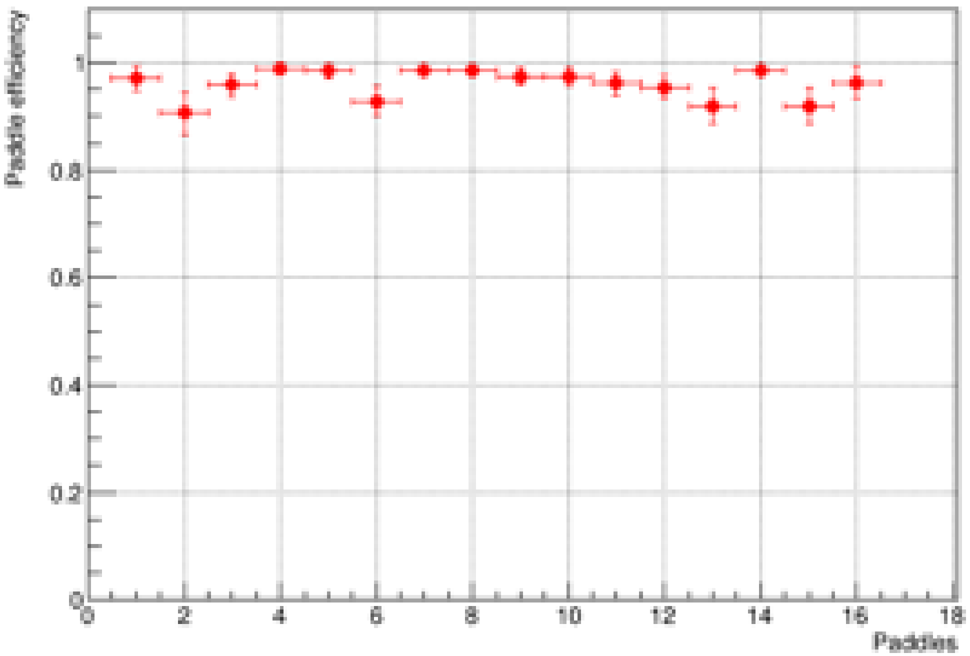
In this measurement, a cosmic ray must satisfy a trigger requiring hits in the station-2 and station-4 hodoscopes, and then a straight-line track is formed using space points from the station-2 and station-3 wire chambers and the station-4 proportional tubes. That track is interpolated to the station-3 hodoscope plane, and we can predict which paddle it should have hit.

Then we ask if that paddle did indeed have a hit; the fraction of times we see a hit there is the efficiency.

As is seen in the figure, all paddles in the H3XT plane have efficiencies in excess of 90%, and the average efficiency of the whole plane is calculated to be 97.5%.

Similar procedures have been carried out for other planes.

H3XT Hodoscope Plane Efficiency



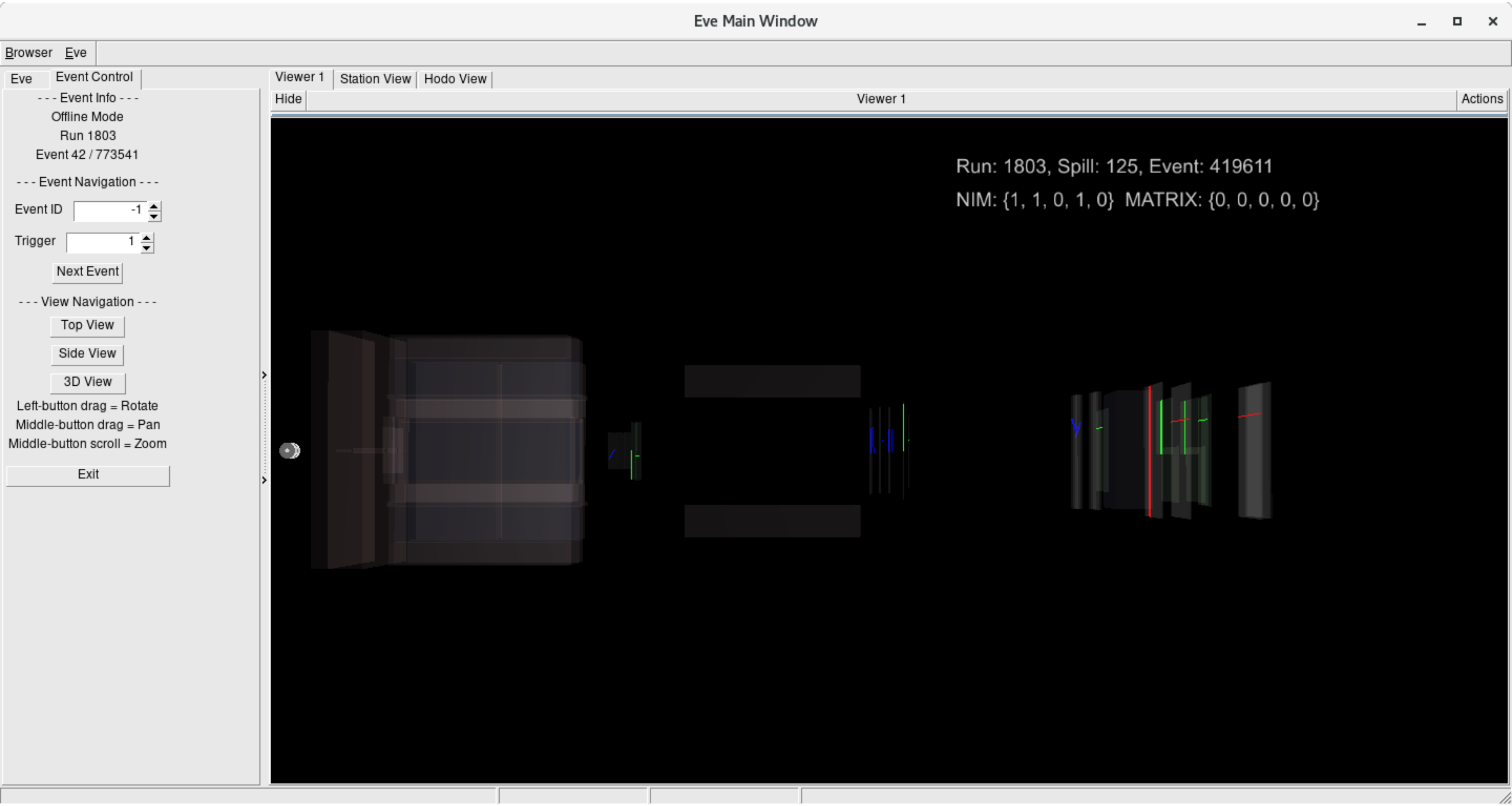
Wire Chambers

- Kei Nagai (LANL) and Nuwan Chaminda (Miss. State U.)
- Three stations of chambers
  1. "D0" X, X', U, U', V, V'
  2. "D2" X, X', U, U', V, V'
  3. "D3" X, X', U, U', V, V'
- D0XX' had problems with capacitors; fixed; undergoing HV training
- D0UU' and VV' had gas leaks; fixed.
- The D0 chambers will return to NM4 soon.
- D2 and D3 chambers have some noise issues that are under investigation but are otherwise operational and were used to test efficiencies of hodoscopes. We are beginning efficiency measurements on them.

Proportional Tubes

- Zhaohuizi Ji (LANL and Shandong Univ.), Kun Liu (LANL), Anchit Arora (UVa)
- Four planes located at Station 4
- P1X, P1Y, P2X, P2Y
- Almost all tubes hold operational voltage without tripping
- A few noisy channels are under investigation
- Basically operational and have been used in tracking to measure hodoscope efficiencies.

Event Display



Summary

- Except for one wire chamber (D0), all spectrometer detectors are installed and working at a very high level.
- All these systems have been through the ORC process.
- We have been running with cosmic rays overnight almost continuously for months, except for a hiatus caused by COVID-19.
- We will be ready to commission with beam in the Spring.

Q8: How much of the electronics subject to Operational readiness Clearance is custom? Are the commercial components all built with NRTL (e.g. U.L.) testing or are there some CE or unrated? This is to understand the scope of documentation needed for the ORC.

Following systems still need to receive ORC. Labeled red are custom designed systems, labeled blue are commercial systems, but their installation still needs to be reviewed.

- Vacuum system
- Racks: NMR, cryogenic controls, magnet rack
- VME NMR, UVA NMR
- Microwave generator
- Microwave power supply
- Level/flow monitoring system
- Actuator for target position