



The Fermilab Test Beam Program

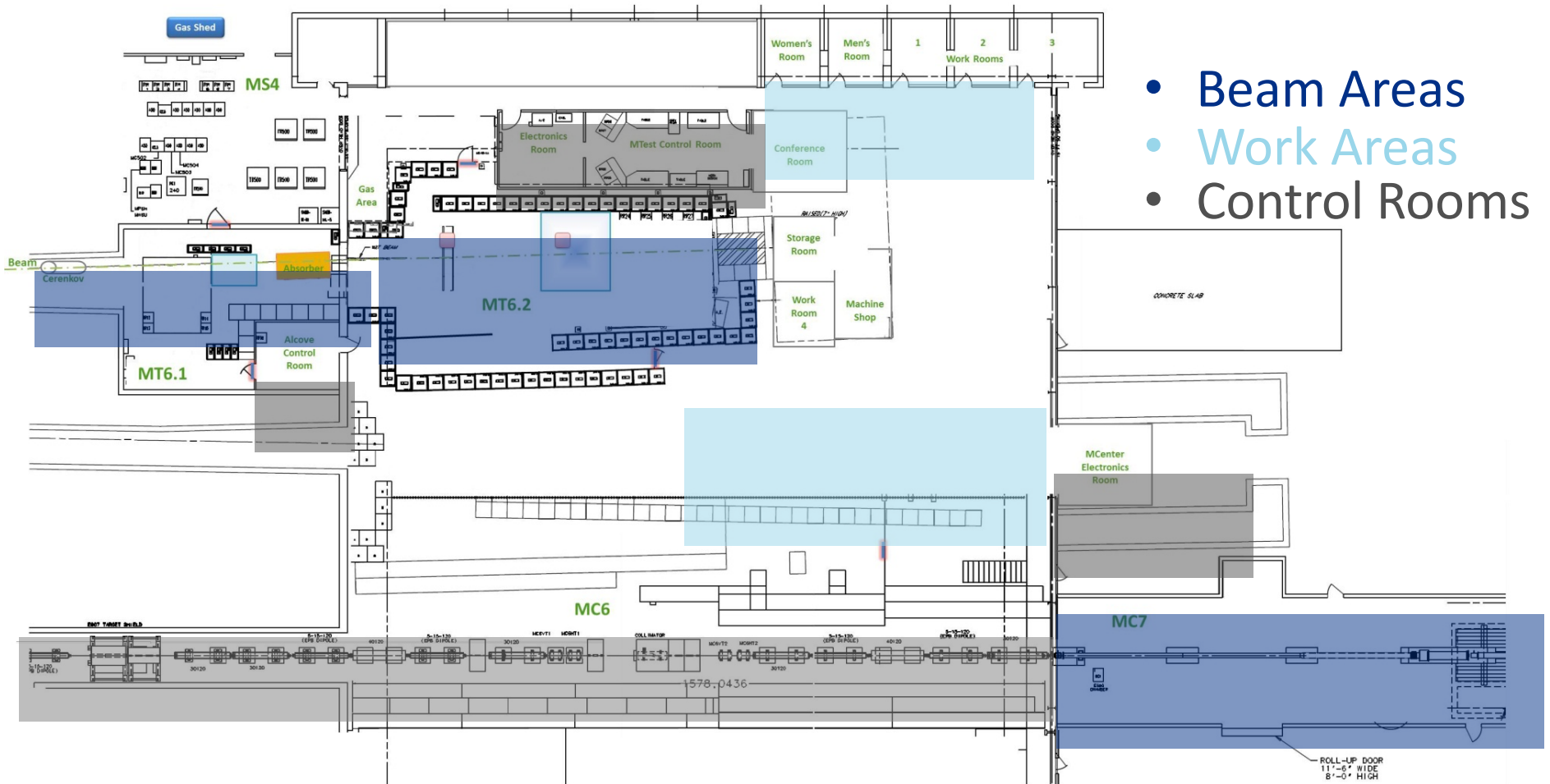
Mandy Rominsky
Pre-PAC Meeting
10 November 2017

Fermilab Test Beam Facility

- A wide range of users since 2005
 - Well over 1000 users and 30 countries represented
- 2 Beamlines
 - MTest: Primary and secondary beams, 6 user stations
 - MCenter: Secondary and Tertiary beams, currently used by LArIAT, NOvA to follow

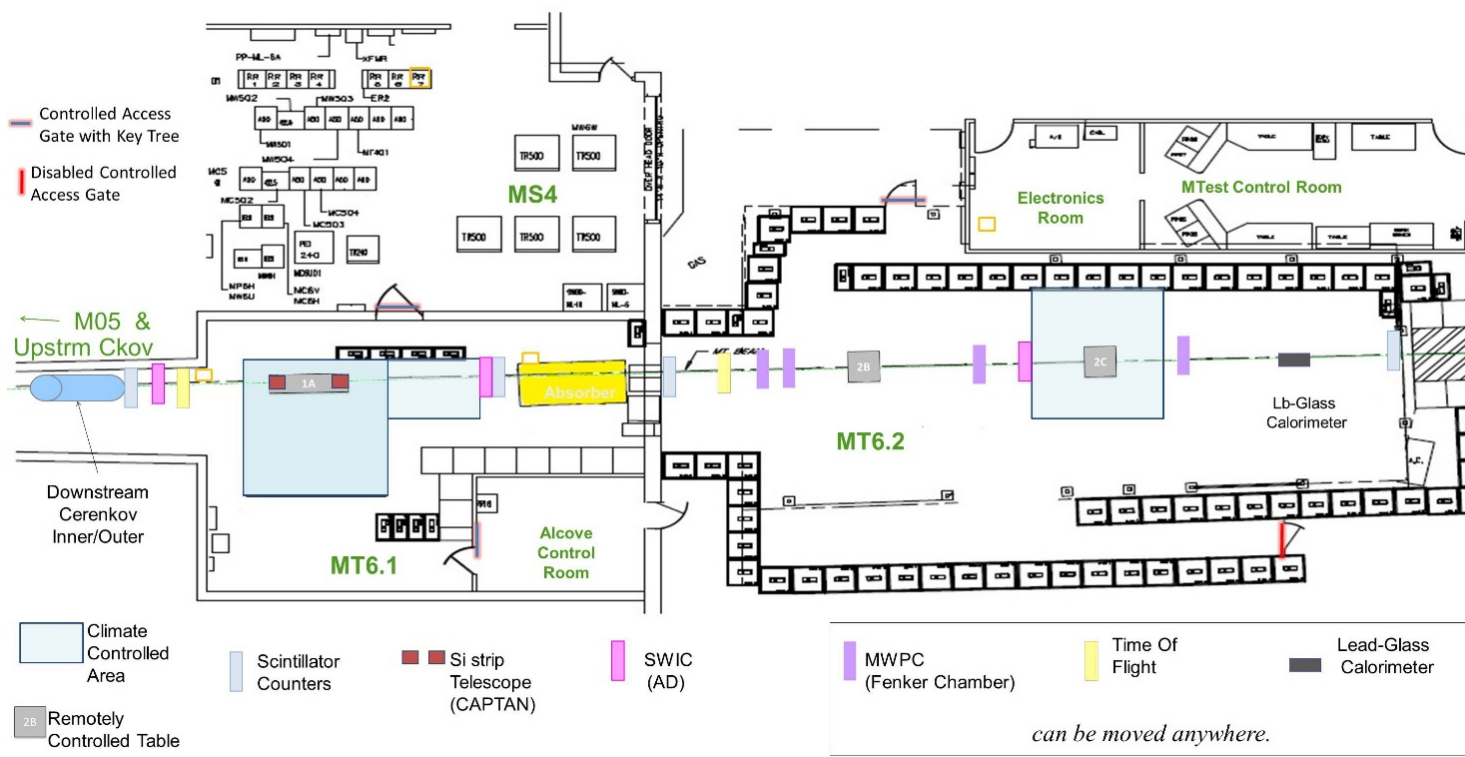
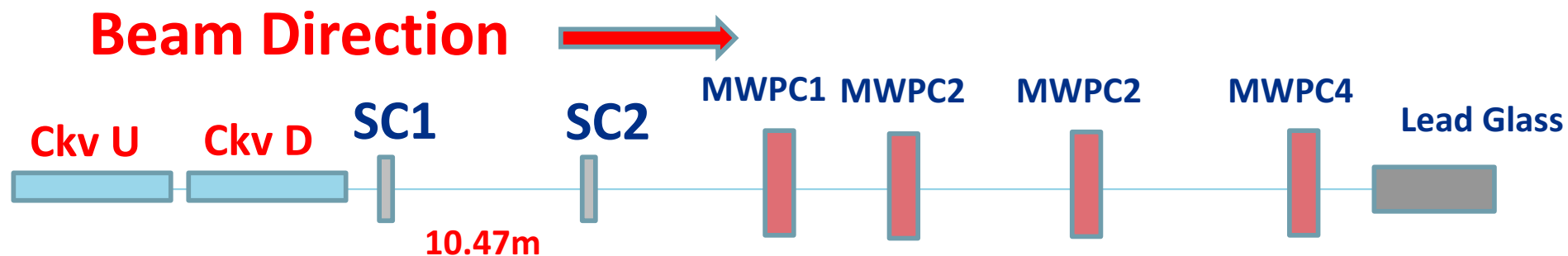


Facility Layout



- Beam Areas
- Work Areas
- Control Rooms

Beam Instrumentation Layout – MTest



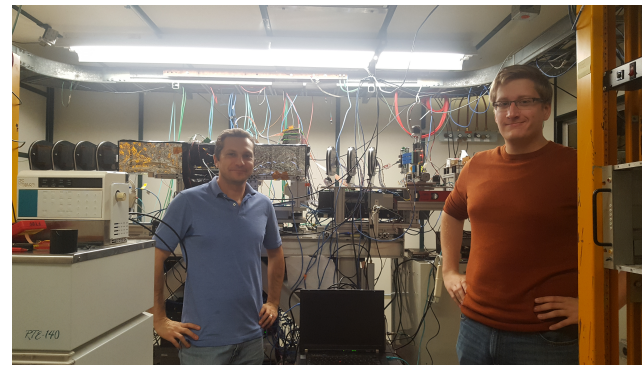
Beam Details and Infrastructure

- MTest Beam line
 - 120 GeV protons (primary)
 - 1 – 60 GeV secondary beam
 - Spot size between 1cm and 2cm
 - Energy can be changed in just a few minutes
- MCenter Beam line
 - Tertiary beamline down to 200 MeV
 - Mainly used for longer term (~months) experiments
- Infrastructure available
 - Remote controlled motion tables, Gas hookups (including flammable) cameras, signal/HV/ethernet patch panels
 - Cables, supplies, test benches for prep work
 - Much more, just ask!



FTBF Operations

- Operate the Test Beam when accelerator complex is running
 - Typically 9 months out of the year.
- Call for beam requests spring before next FY starts
 - Sent out call May 2017 for FY18 beam requests
 - Available weeks driven by shutdown schedule
- Users submit requests for certain weeks, tell me if they need 12 hours or 24 hours
 - Their needs are captured in a Technical Scope of Work
 - If 2 users want the same week, work with them to resolve issues (both go, one moves, etc)



FTBF Operations for FY18

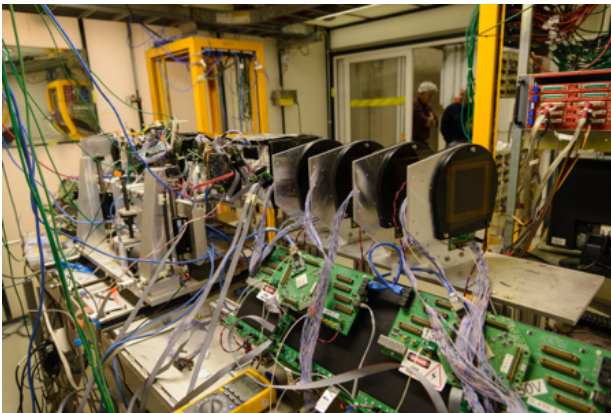
- Plan for about 35 weeks of running time
 - Could be reduced depending on shutdown start
 - As always, could have beamline problems that cause us to lose weeks.
- Split the day into 2 parts, each 12 hours long.
 - Users can either request 12 hour days or 24 hour days
 - Users who only request 12 hours allow us to run a second set of users during other 12 hours
- Currently, every week has *at least one* 12 hour user, many weeks have 24 hour users
 - Can still have secondary users running parasitically behind primary user (depends on detector type and test)

Beam Usage for SY120

- When running, SY takes 10% of the timeline
 - Means that ~6 seconds out of every ~60 seconds is sent to SY.
 - When SY doesn't request beam, it is sent to NuMI
 - Includes SeaQuest (NML), MCenter (LArIAT), MTest
- FY18
 - No SeaQuest
 - Limited MCenter running (PixLAr running about 6 weeks plus NOvA commissioning)
 - MTest scheduled normal program (similar to FY17)
- Impact of MTest Running
 - Based on historical information, impact to NuMI is much less than 10%
 - Last three FY, on average, taken beam half the hours as NuMI

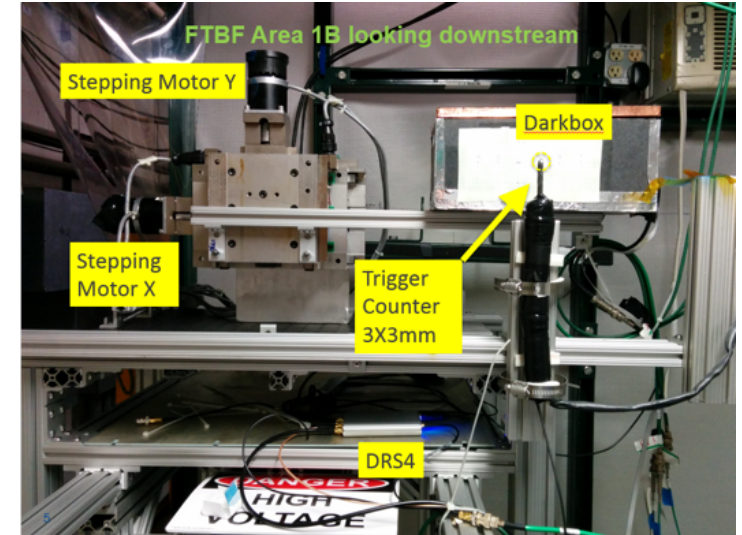
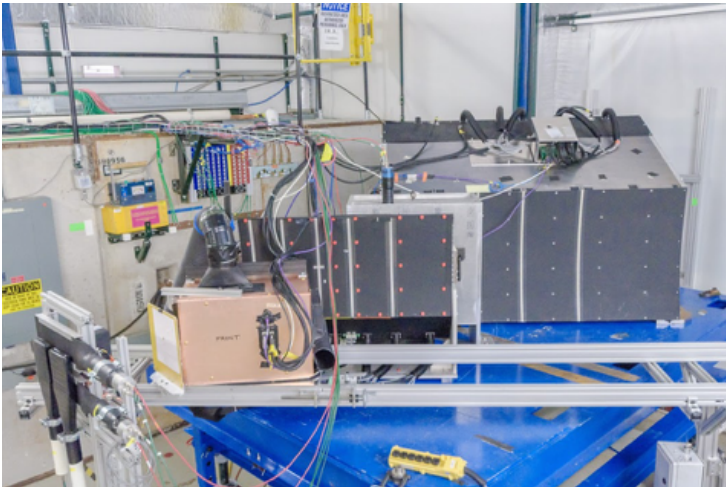
FTBF Typical Use Case

- User comes in and needs 120 GeV primary proton beam to test irradiated sensors
 - Common: CMS, ATLAS, LHCb all do this
- Need multiple runs throughout the year
 - Test chip, irradiate, then test again
 - Large volume because of high failure rate
- Typically need *time*, NOT number of protons



FTBF Typical Use Case

- Developing technologies
 - sPHENIX finalizing design choice and readout chips for their calorimeters
 - CMS HGCal testing SiPMs and scintillator properties.



FY18 Users

- Scheduled requests for:
 - CMS Outer Tracker, CMS Pixel, CMS HGCal, CMS Timing: using the FTBF Telescope
 - ATLAS Pixels: Building a telescope for multi-year use, also using FTBF telescope
 - sPHENIX: final Calorimeter test
 - Flysub: PID and Tracking for an EIC machine
 - Hadron Emulsion detectors (Calibrating Cross sections)
 - PixLAr (LArIAT follow on with pixel planes)
- Requests (Not Scheduled)
 - LHCb and ATLAS users
 - EIC testing users (BNL and Jlab)
 - ?

Impact of reduced running in FY18

- December 2018 is a critical deadline for CMS
 - No slots at CERN test beam, FTBF is only possibility for tests
- sPHENIX has a CD-1 review that depends on Test Beam results
- ATLAS cannot test chips at CERN this year (no slots)
 - Investing in program by building an ATLAS telescope
- No flexibility for R&D groups, other groups
 - LHC dominating program (because of time critical tests)
 - Loss of diversity at the test beam in research focus
 - Expect to get requests from future collider groups and ILC groups

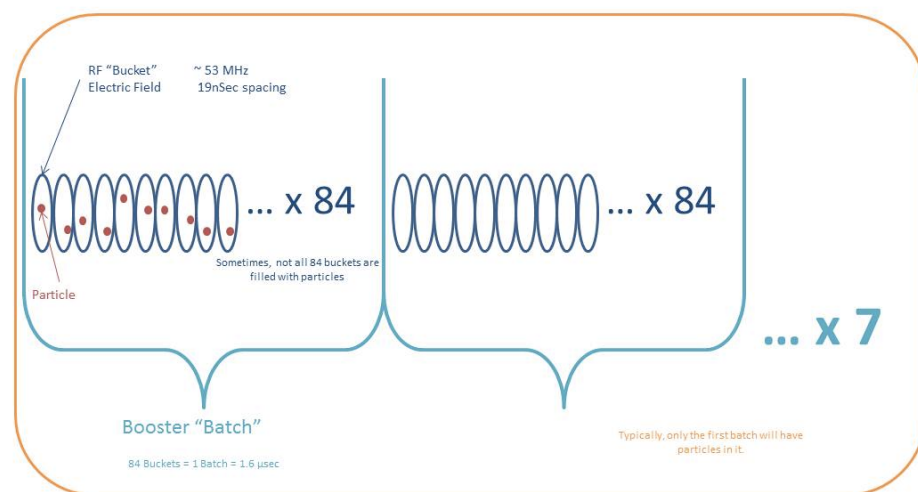
Conclusions

- **The Fermilab Test Beam program is a vital component of each program at Fermilab**
 - Every major thrust and experiment has a planned test beam component
 - Well aligned with P5
- **The Fermilab Test Beam program is effective with the resources and beam we have**
 - Incredible user community that will work with each other to get all the tests done
 - Looking for efficiencies between AD and FTBF to maximize program and minimize impact on NuMI
- **The Fermilab Test Beam program provides critical information to experiments on design choices and provides flexible access to the beam**

Backups

Information on Beam Structure

- 19 nanoseconds = 1 RF bucket (53 MHz)
- 1.6 microseconds = size of booster (84 RF buckets), called a “batch”
- 11.2 microseconds = size of Main Injector (7 Batches)
- 4.2 seconds = length of spill (2 second overhead to deliver)
- 60 seconds = approximate rep rate of spill



7 Batches = 1 MI Cycle = 11.2 microSec

Following slides repeated from July PrePAC mtg

- Discussion from reduced or no running at FTBF

Overall Impacts of Reduced Running

- Looked at the scenario where beam is only available for a few months
- Looked reduced running from 10% to 5% of the timeline
- Asked currently scheduled users what the impact to their physics programs would be with reduced running
 - Also, in case they couldn't run their programs
 - Note that the CERN beam areas are off in 2019 and 2020
 - Several new groups this year from CERN were very happy and are planning extensive programs back here
 - Very happy with our high rate tracking area
 - We are working with a new group using US-Japan Funds that is supposed to start up this year.

Impacts on ATLAS Pixels – Kazunori Hanagaki

- Tests for the ATLAS pixel and ASIC upgrades
 - These can be done at CERN, but limited time as many groups from ATLAS are competing for the same beam time
- Testing SOI chips developed by KEK
 - These cannot be tested at CERN
 - The last 2 years Kazu's group received special funding to come to the test beam and work on the SOI chips. The delay this year from the septa caused significant problems for them.
 - They have funding to come again, as they were successful in the tests ultimately. Delaying their run or canceling it is incredibly detrimental to their research program.

ATLAS Pixel Detector (RD53A) – Jessica Metcalfe

- Commonly developed chip used by CMS and ATLAS
 - Critical testing period coming up this fall
- Can use either DESY or SLAC if FTBF or CERN are not available
- Planning on building a telescope at the test beam facility sometime in FY18
- Will also use this for general R&D
- Brings in new ATLAS groups to the test beam

Impacts on sPHENIX – John Haggerty/ Eric Mannel

- sPHENIX (upcoming flagship experiment for RHIC) tests for about 4 weeks each year
- They have received CD0 from the DOE Nuclear Physics funding agency and are working on testing the final design necessary for CD1 and CD2. They are funded in the FY18 PBR.
- The FY16 and FY17 test beam runs have been submitted for publication and is on arXiv (<https://arxiv.org/abs/1704.01461>)
- The final run in FY18 will be used to confirm final design and provide data to characterize the detector in a variety of beam energies

Impacts on CMS HGCal – Jim Freeman and Roger Rusack

- This is a test of the High Granularity calorimeter. Considering the possibility of bringing in 5 interaction lengths and setting up a full calorimeter test
- These tests will advance the project, but maybe not delay it.
- The beamline they use at CERN is being used by DUNE, which cuts down HGCal's beamtime in FY18
- There are no CERN test beams in 2019 and 2020.

Impact on CMS Pixels and Outer Tracker – Lorenzo Uplegger

- Testing the CMS pixel detector and Outer Tracker designs
- A spread in time is crucial for them
 - Test sensors, irradiate, then test again
 - This process takes many months
- If currently designed chip fails, it delays detector construction
 - Also means if they don't test, detector construction also is delayed
- The Outer Tracker is also divided between Fermilab and CERN.
 - Failed chips will also delay the Outer Tracker

Impact on NOvA Test Beam: Alex Sousa

- Impacts the commissioning of the new tertiary beamline for NOvA
- These tests are used to reduce the systematics for the NOvA
 - Maximum impact if the test beam can be completed before Spring 2019
- Reduced running or delays will make the test beam less valuable for the mass hierarchy measurement, but still useful for later analyses
 - However, world wide competition might be caught up by then.

Impact on Gaseous TPC: Jennifer Raaf

- Work for an Early Career Award
- Doesn't need much statistics, so a delay or reduction is not a problem
- Could possibly switch the order of the tests – run in a neutrino beam first, then the test beam.