
LArIAT User Experience and Suggestions for Evolving the Facilities

Johnny Ho for the LArIAT Collaboration

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The LArIAT experiment

What is LArIAT?

2



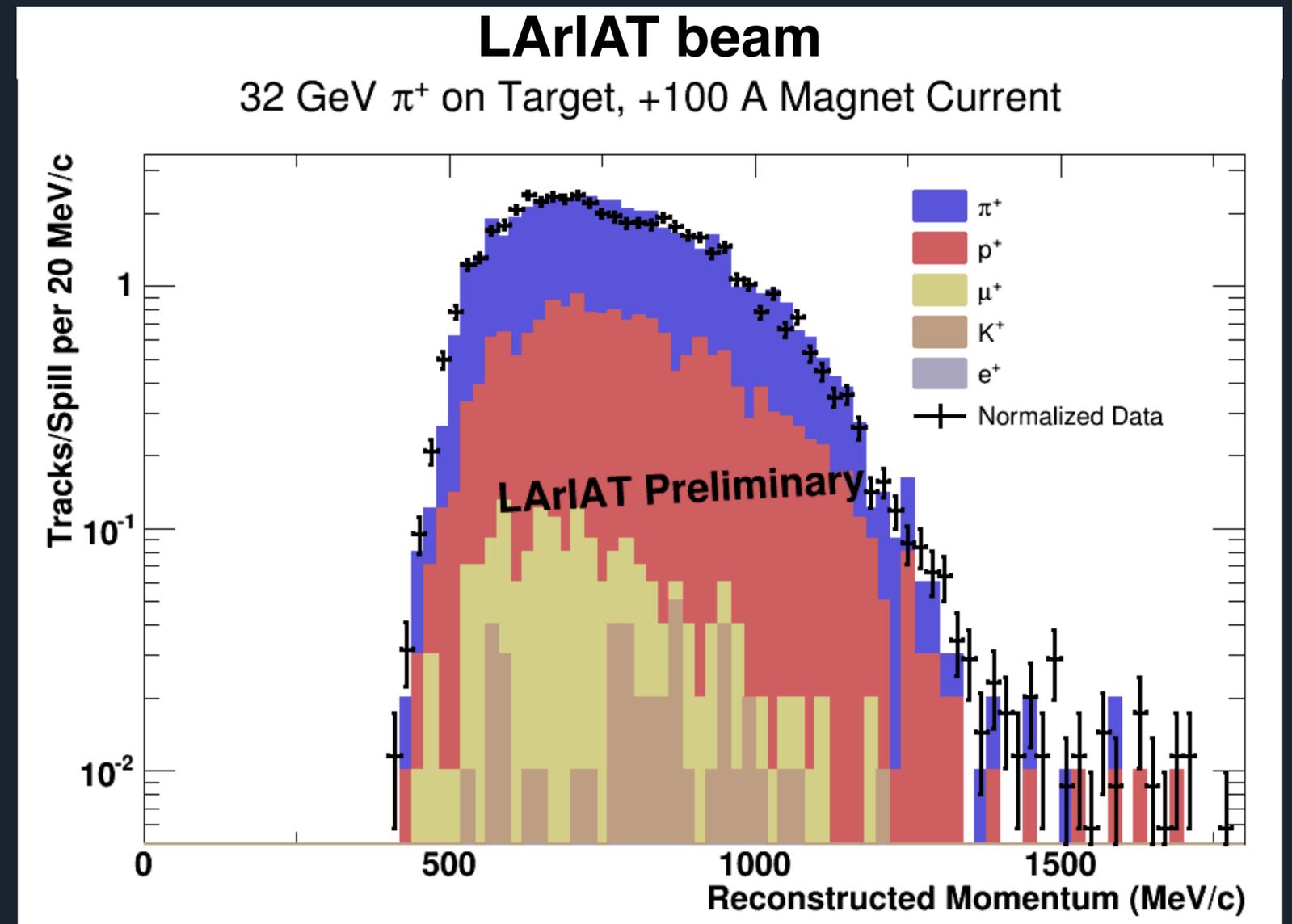
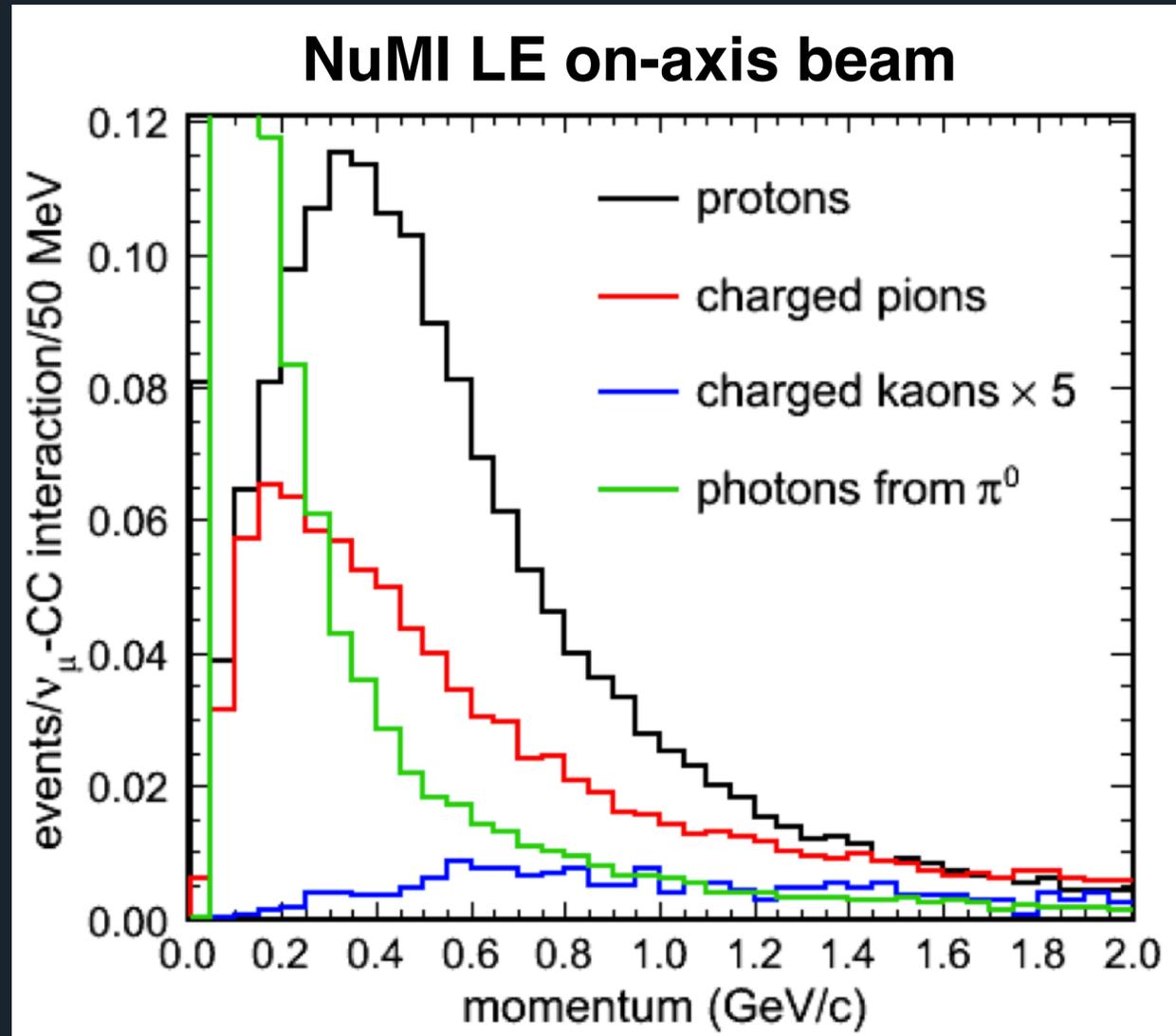
LArIAT (Liquid Argon In A Test-beam) aims to study and characterize the response of a liquid argon time projection chamber (LArTPC) to particles typically seen as final-state products in ~ 1 -GeV neutrino interactions in liquid argon.

The experiment utilizes the refurbished ArgoNeuT cryostat and its 170-litre-active-volume TPC that sit in a tunable tertiary beam in the MCenter enclosure at FTBF.

The LArIAT experiment

What is LArIAT?

3

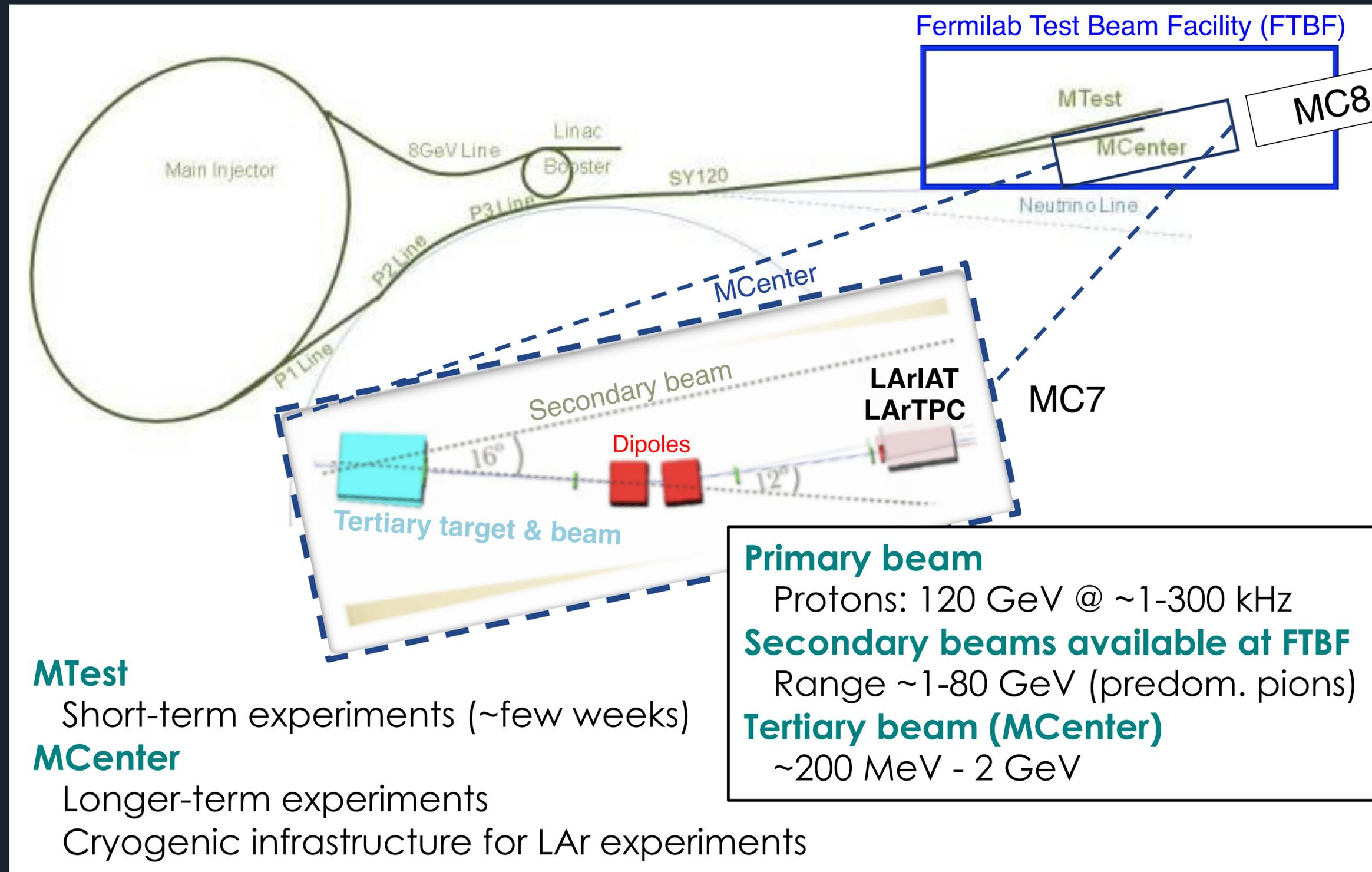


Particles emerging from neutrino interactions in the energy range relevant for MicroBooNE, SBND, and DUNE.

Particles emerging from LArIAT's dedicated charged particle beam at the Fermilab Test Beam Facility.

The LArIAT experiment at FTBF

Where is LArIAT?



The LArIAT beamline

And all of its detector systems

5

2 time-of-flight (TOF) detectors, upstream and downstream, **provided by FTBF**

4 multi-wire chambers (MWCs) for momentum and tracking along beam line, **provided by FTBF**

2 aerogel Cherenkov detectors for pion/muon tagging and ID

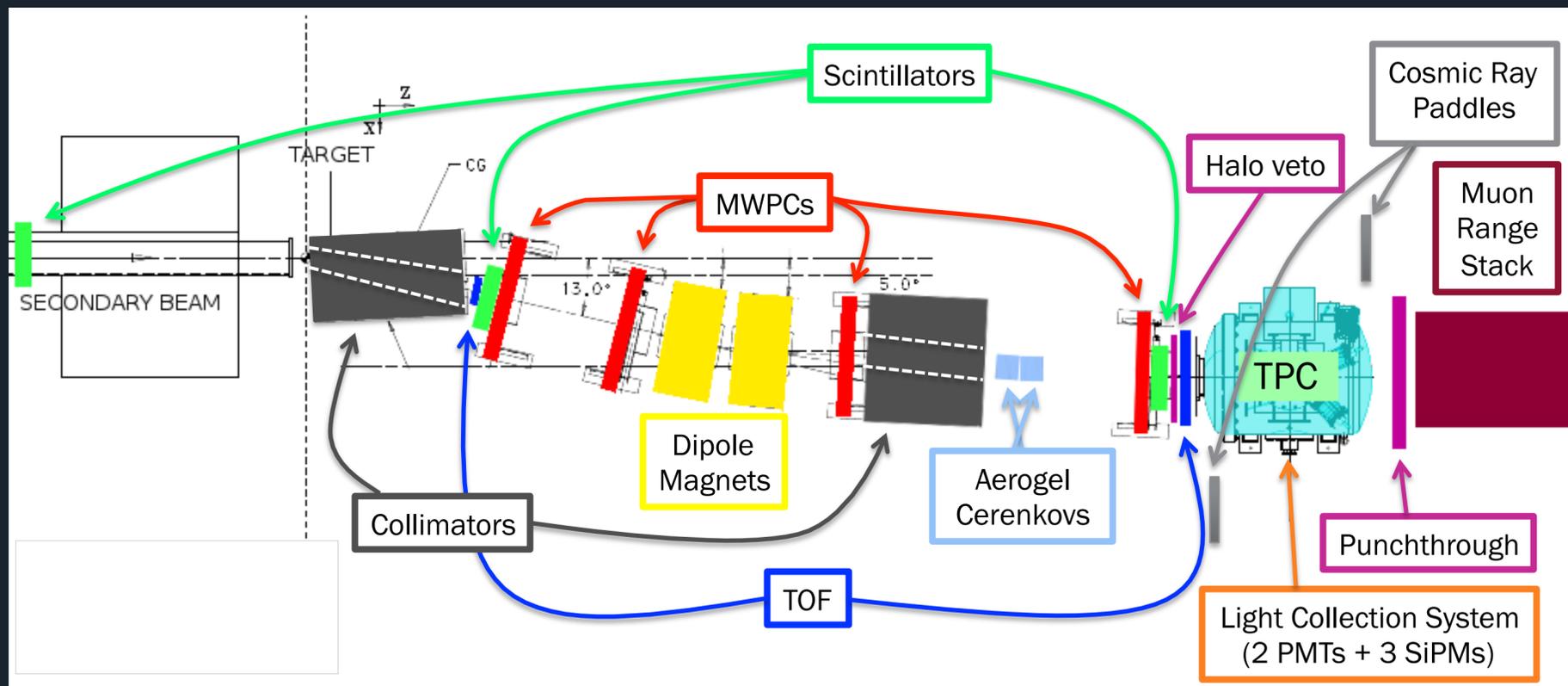
2 beamline scintillators, halo veto and punch-through, **provided by FTBF**

5 LAr light-collection detectors, 2 PMTs and 3 SiPMs

1 LArTPC, 480 wires

2 cosmic ray stands

1 muon range stack, **provided by FTBF**



Collimators and dipole magnets **provided by FTBF**

Installation of LArIAT

Getting beamline detectors into the MC7 enclosure

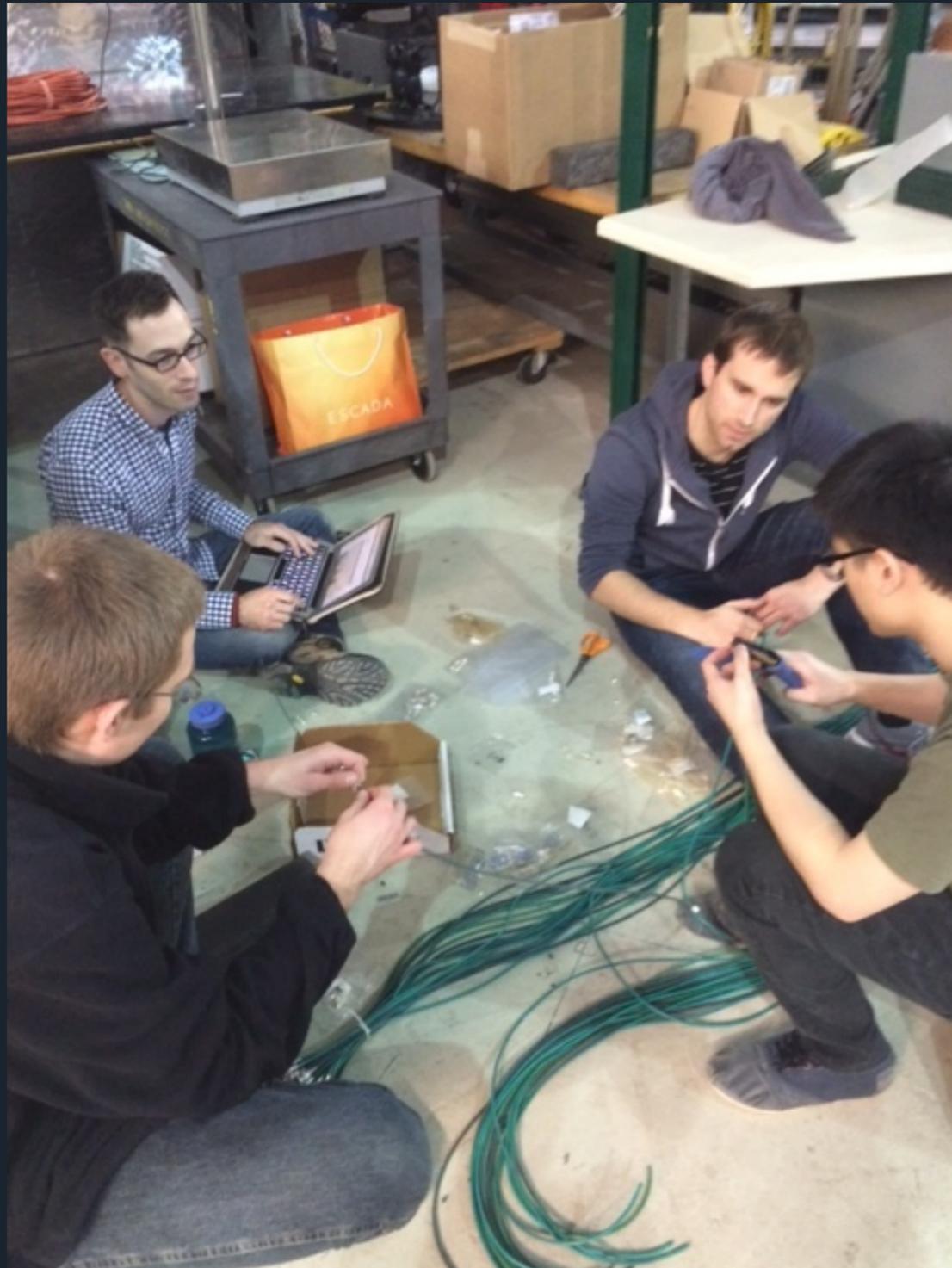


When we were installing our beamline detectors, the FTBF staff were extremely helpful.

Installation of LArIAT

The hunt for longer and longer cables, and electronic equipment

7



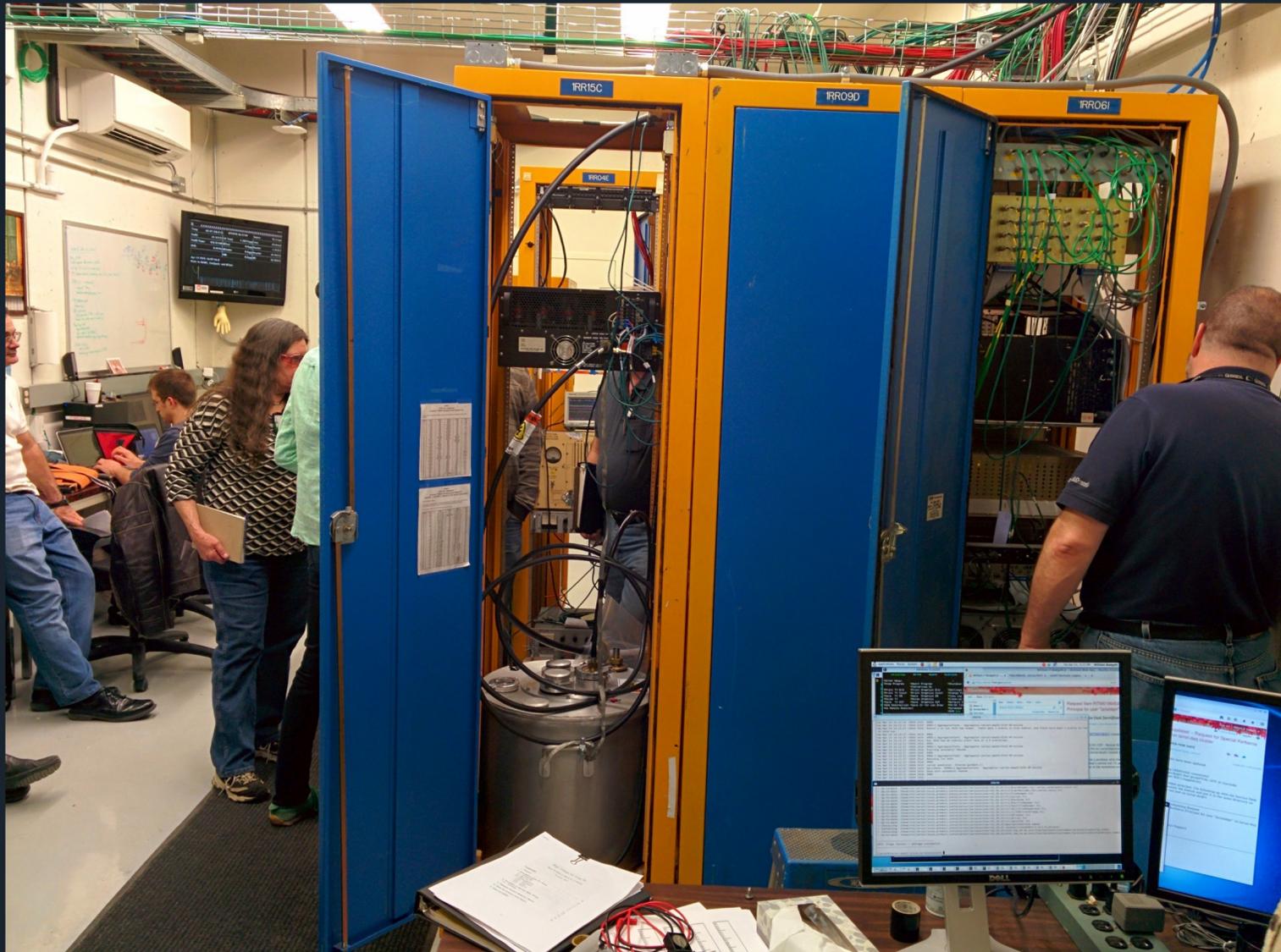
The length of the cables that we needed for our detectors typically exceeded the lengths of the cables that were readily available by FTBF, so we had to search a nearby enclosure (MC8) for longer cables (with permission, of course). Fortunately, we were able to find a ton of longer cables that we cut and crimped into the desired length.

Whenever we needed electronic equipment that we didn't have on hand (usually NIM modules), we would utilize Fermilab's Physics Research Equipment Pool (PREP) for loaning equipment. We simply went to the PREP website (prep.fnal.gov), searched through their online catalog for whatever we needed, filled out their online equipment request form, and picked up the equipment from the Feynman Computing Center (FCC).

Before we can start running with beam...

Operational Readiness Clearance

8



After the installation and before we can run with beam, an Operational Readiness Clearance (ORC) inspection must be done.

From our safety training and consultation with the FTBF staff, we know how to work safely, preparing our apparatus for the ORC committee to inspect. Once the committee got involved (walkthroughs and discussions), we sometimes had to work to clarify where the equipment stood with respect to two important states:

"Approved for Unattended Operation," vs.
"Approved to Operate in Beam."

These most often overlap, but not always. At times we struggled to get clarification on these and the requirements to reach them.

Before we can start running with beam...

Operational Readiness Clearance

9

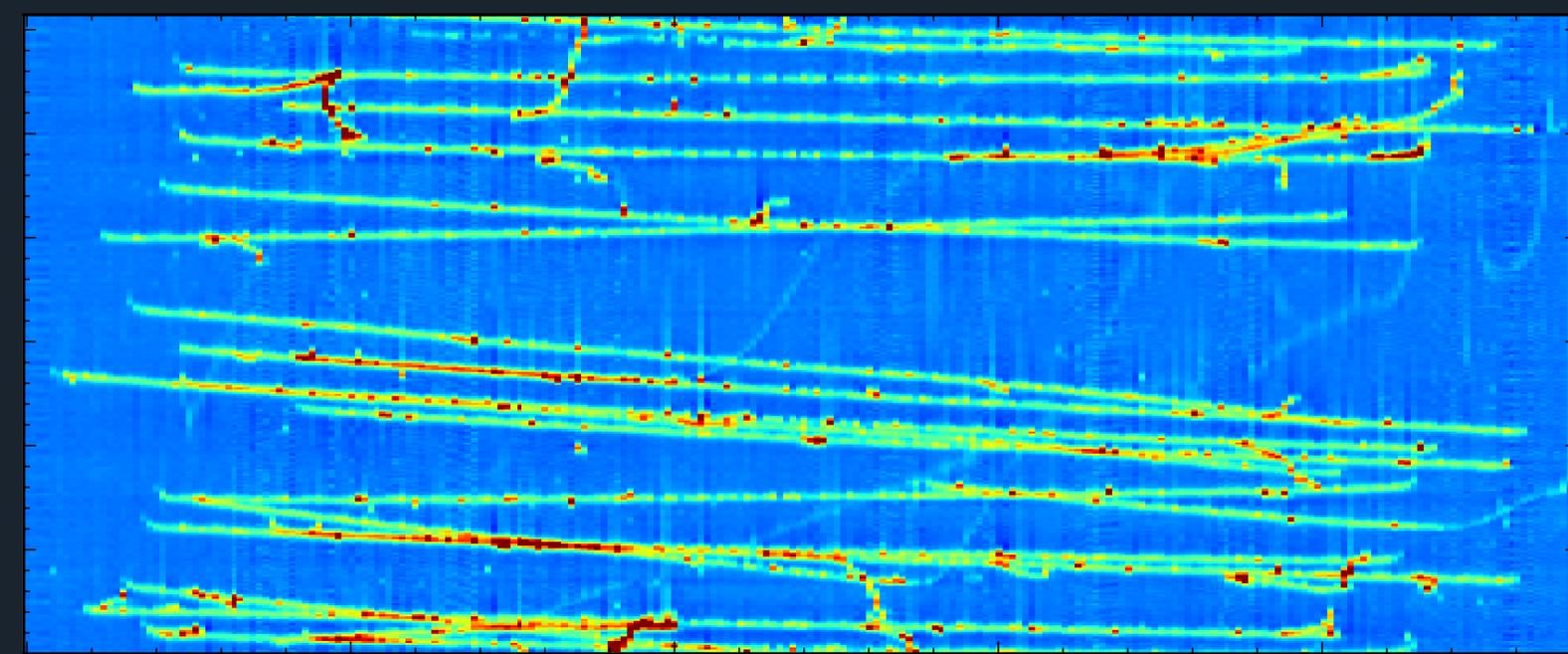


FTBF guidance was most important at the second step, the sign-off which follows the approval of the safety committees, since there are quite a lot of signatures to get and not everyone can be found in their offices all the time. If this could be done by email or a simple form online, it would be great for the experiments.

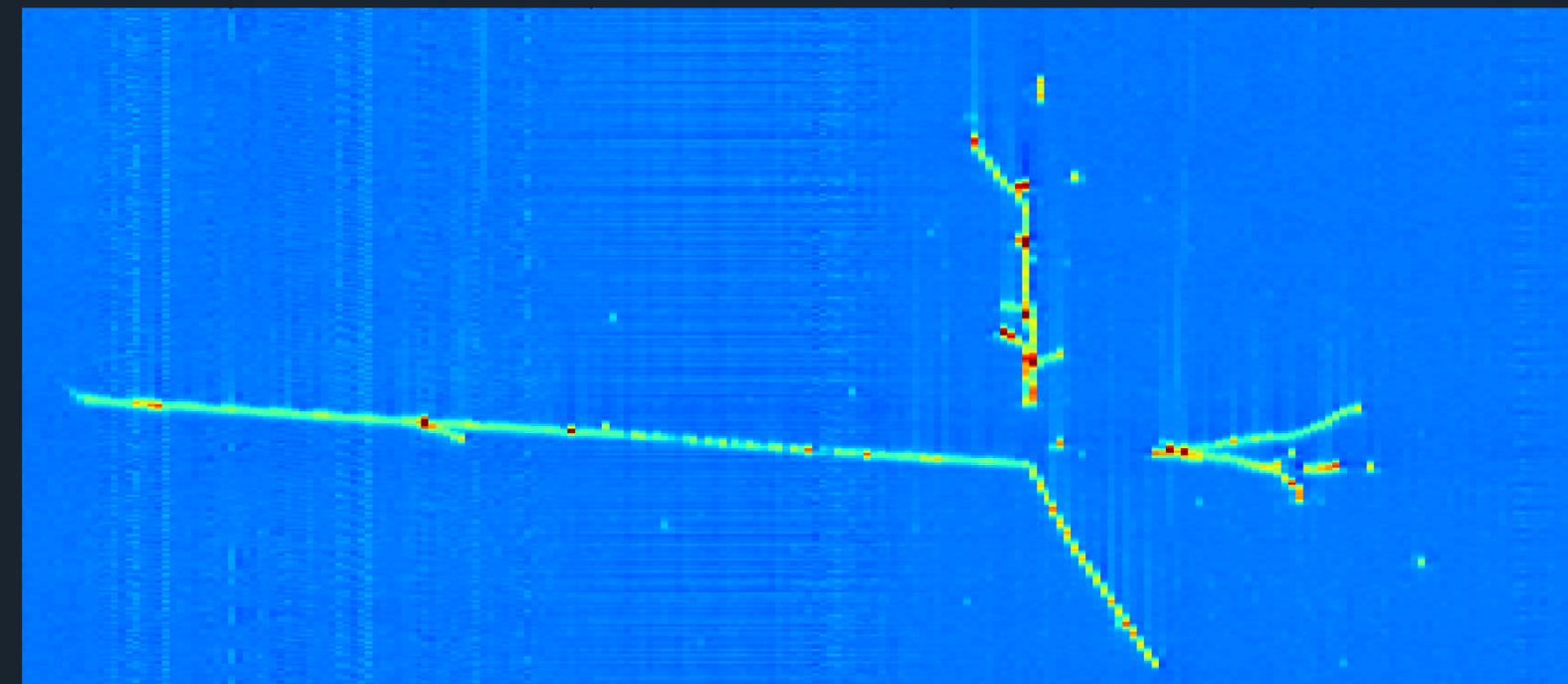
Running LArIAT with beam

Reducing beam halo and pile-up with MCR

10



LArIAT LArTPC readout with pile-up :(



LArIAT LArTPC readout without pile-up :)

LArTPCs are slow detectors — a single drift/readout window in the LArIAT TPC is $\sim 350 \mu\text{s}$! This was a problem for us as we saw a lot of beam pile-up in our data.

We've had to provide feedback to MCR using our beam line detectors for them to help reduce the beam halo and pile-up. We have halo counters around the MC7 enclosure that we connect to scalars that send the counts to MCR.

Before our next run begins, Fermilab's Accelerator Division (AD) are implementing and testing some shielding in the secondary beam to help reduce the beam halo and pile-up!

Hunting for noise in our detectors



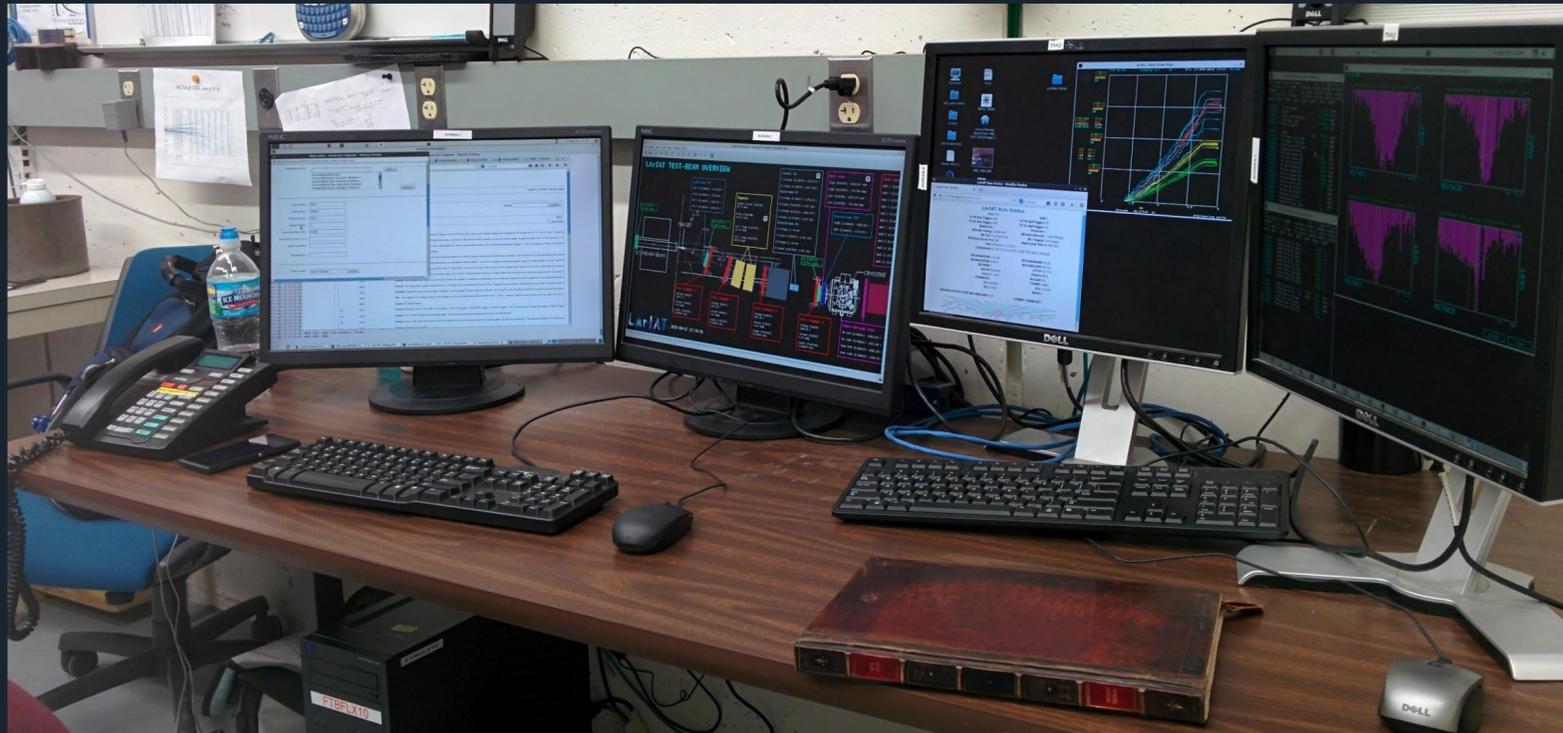
At one point, we found out that a fluorescent lamp in the MC7 enclosure was inducing noise into our detectors.

There is no light switch for fluorescent lights in the MC7 enclosure, so we had JJ Schmidt, the Deputy Facility Manager of FTBF, turn off the lights using the circuit breaker.

Computing resources

Requesting computing resources from Fermilab's Scientific Computing Division

12



Requesting computing resources from Fermilab's Scientific Computing Division (SCD) is fairly simple. All we had to do was submit service desk tickets with our requests and SCD would be working on fulfilling the request within a few hours to a day.

Suggestions for evolving the facilities

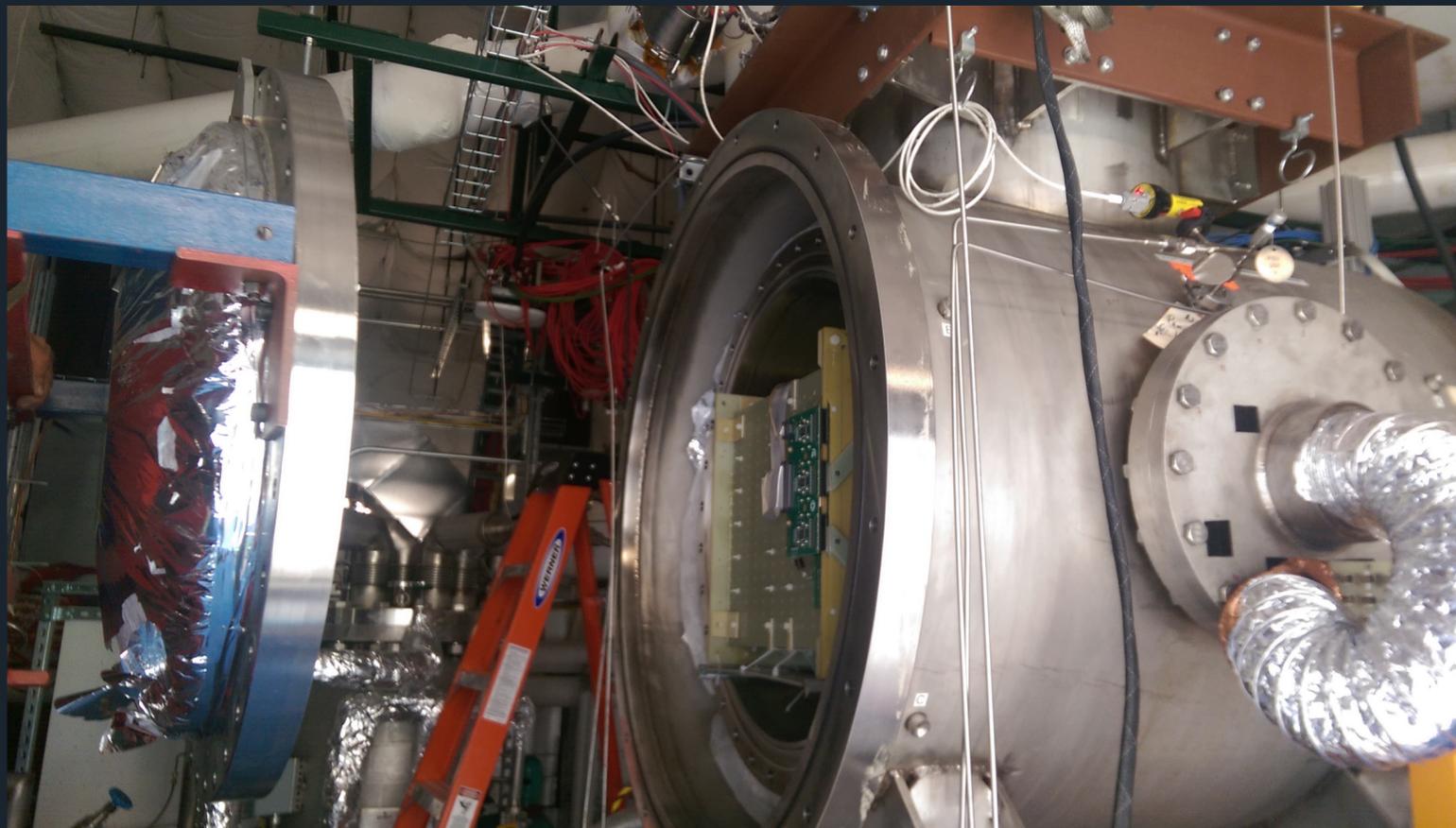


Light switch in the MC7 enclosure

Longer signal and HV cables readily available

The multi-wire proportional chambers do not read out waveforms from the wires, but read out hits instead (the *proportional* part of the MWPCs cannot be used). The spacing between the wires in the MWPCs is 1 mm, so if an experiment requires better resolution than this, reading out the waveforms is essential.

We also see a lot of noise in the MWPC data. We figured out a way to suppress the noise offline and have informed FTBF about the methods we use to do this.



The LArIAT experimental setup is an ideal facility for LArTPC R&D:

Low momentum beams of all charged particle types of both positive and negative charge

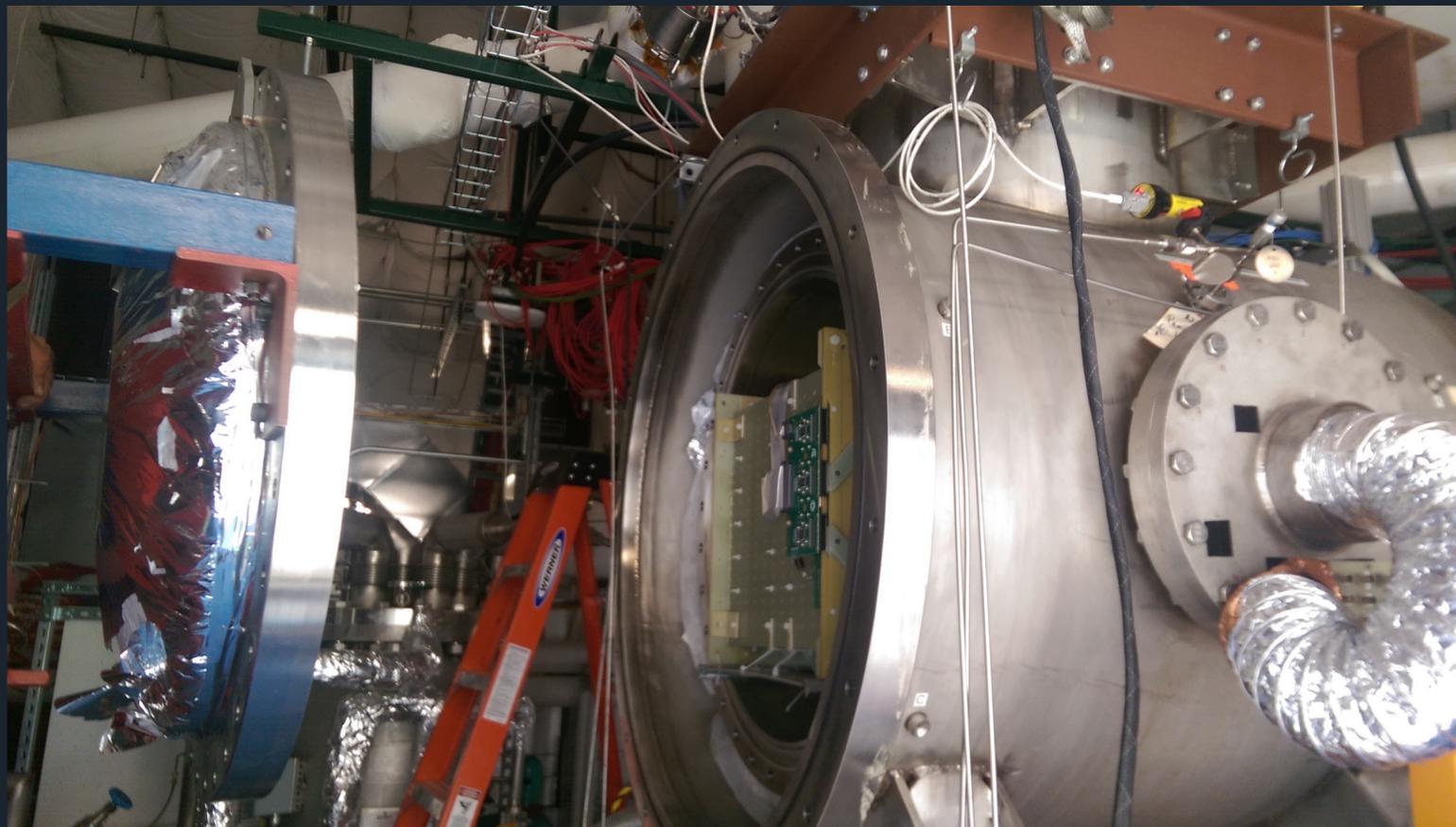
Cryogenic infrastructure (LAr storage, filling line, purification system, with possible recirculation system upgrade)

500-litre cryostat with easy access from front and side port

Flexible DAQ system for TPC wire and PMT/SiPM readout

LArIAT beyond the next run

15



The system when intended as a test/R&D "facility" is

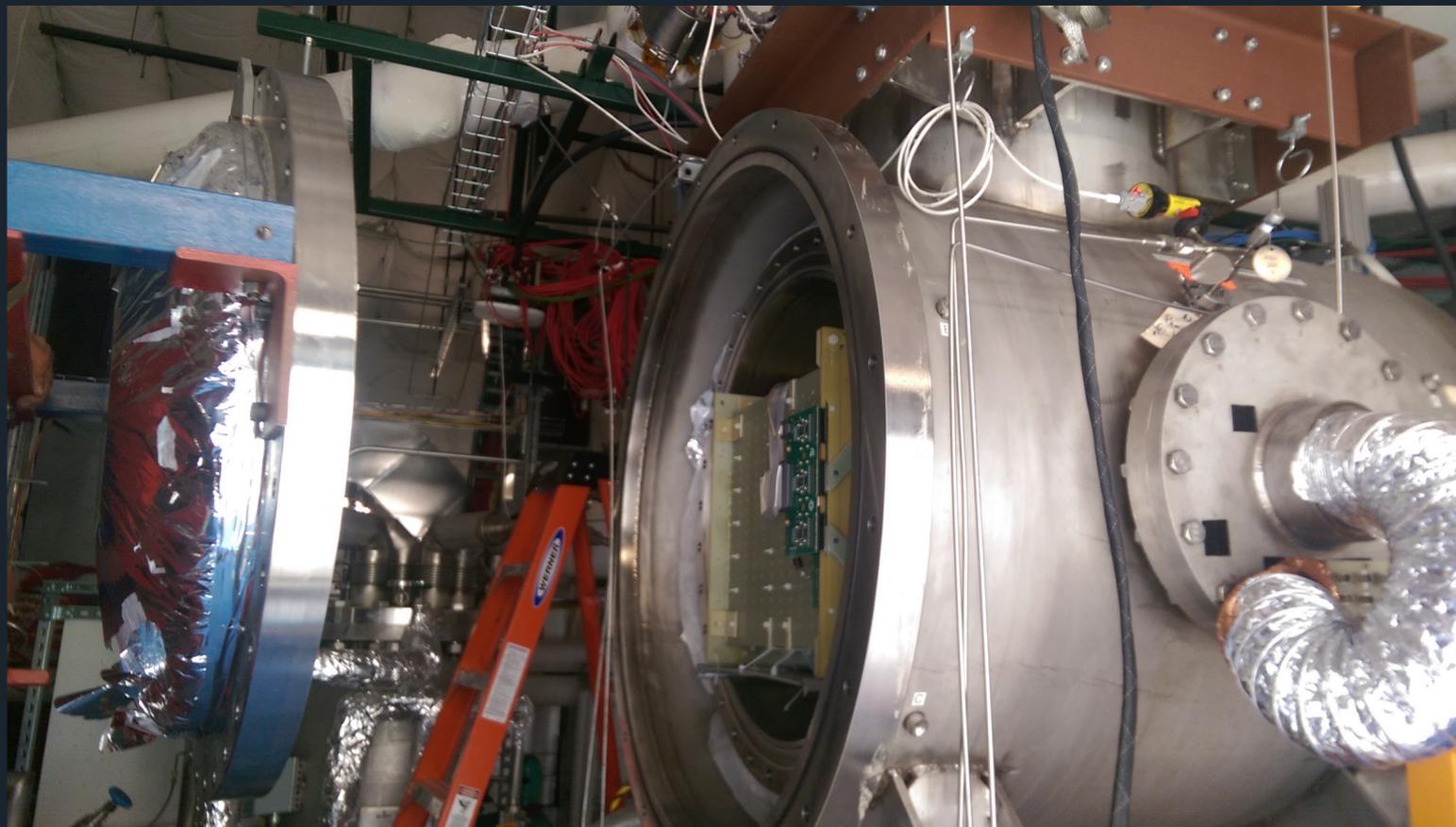
Extremely flexible

Allows quick turnaround (2-3 weeks to switch into a new test)

Economical (500-litre of LAr to fill the cryostat)

Reproducible experimental conditions (useful for comparative tests)

From now until 2018, LArIAT@FNAL will be the only active "facility" for LAr detector tests and R&D.



We have a list of proposals for tests and R&D efforts, all of great interest for the development of the LAr technology for the future neutrino experiments in the short- and long-baseline beams.

Test impact of different wire pitch of the TPC (i.e. 3 mm vs. 5 mm) in real reproducible experimental conditions

New solutions for LAr scintillation light detection

New cold electronics (including fast ADC stage)

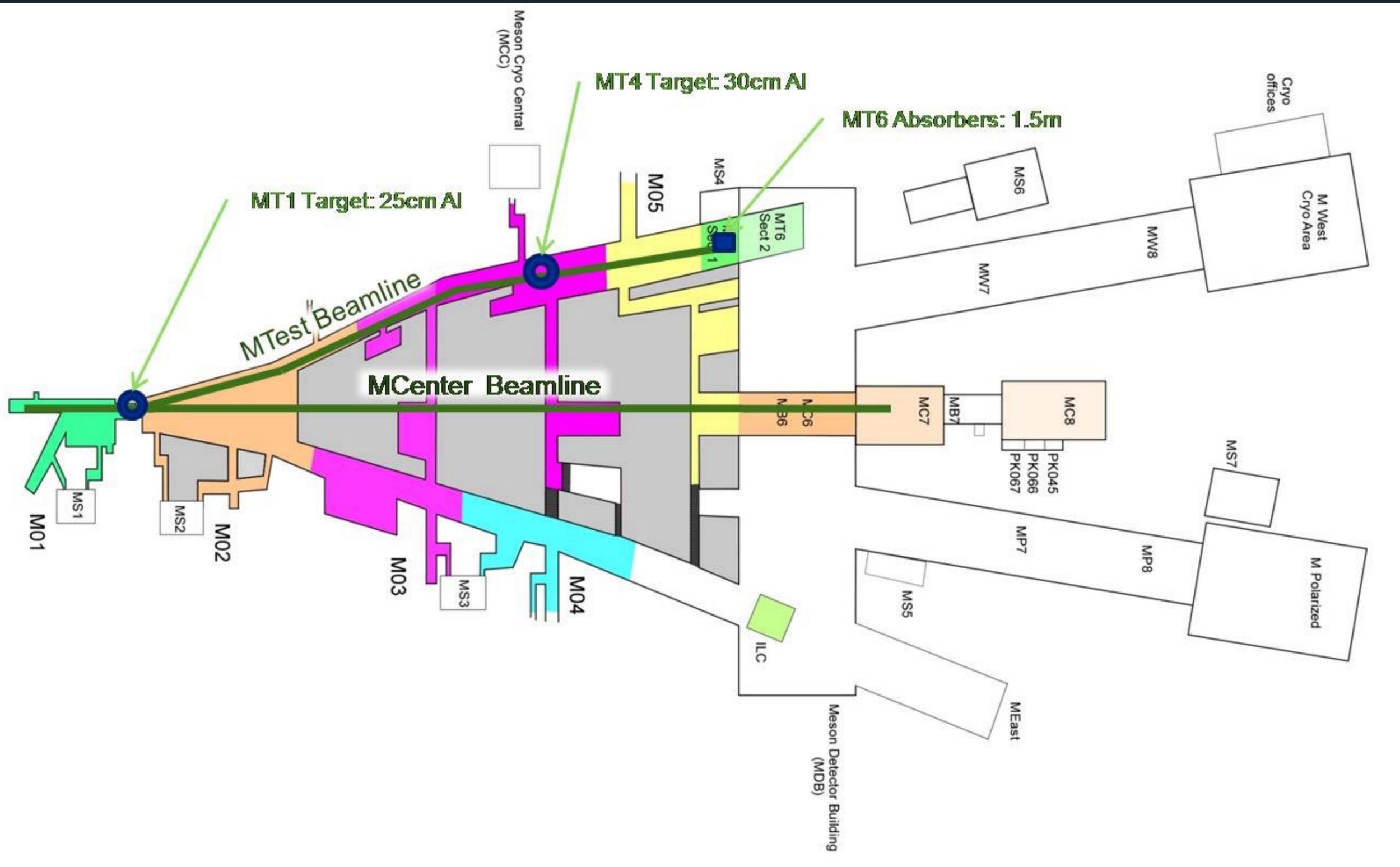
Development of Gas Ar TPC

Test magnetized LArTPC (?)

Thank you!

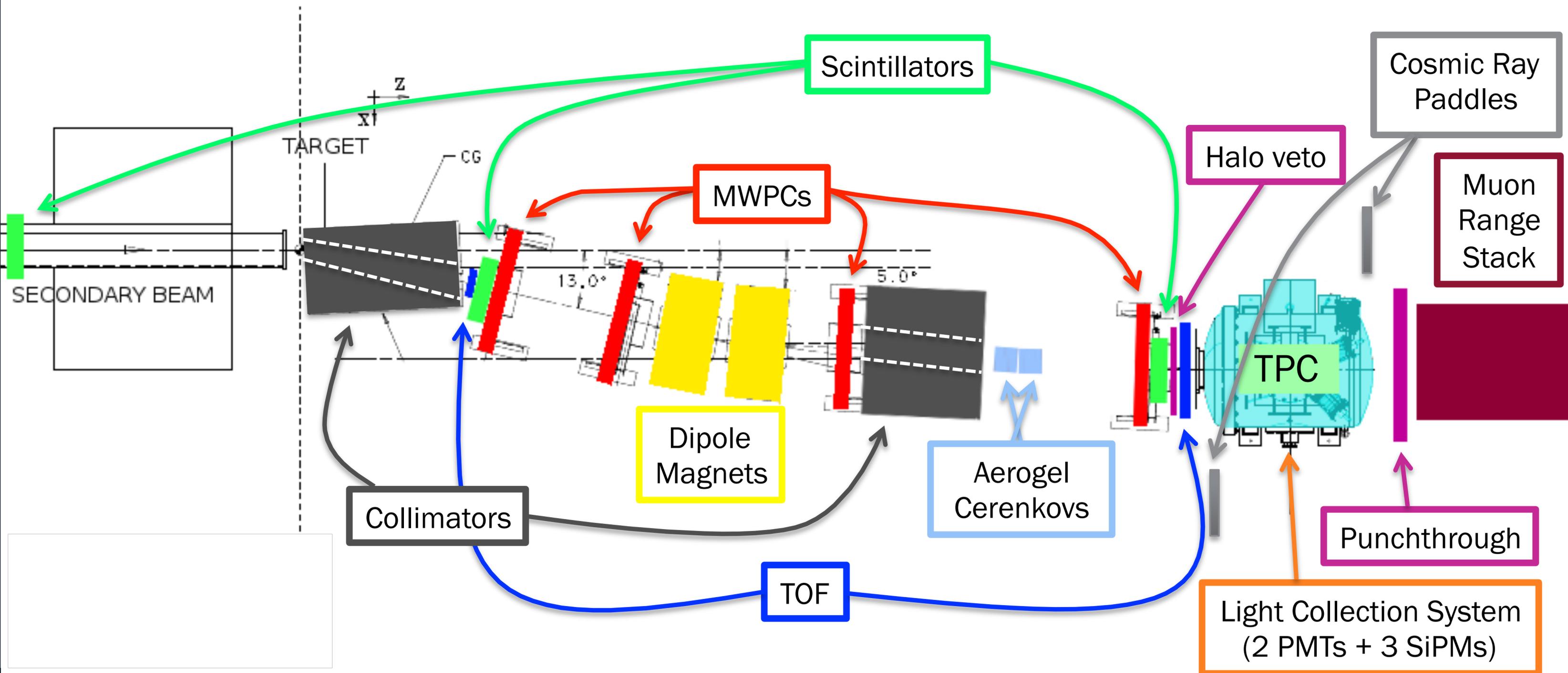
BACKUP

Fermilab Test Beam Facility



The LArIAT beamline

And all of its detector systems



Before we can start our work

Training!

21



Training for open access and taking shifts, which can be taken online:

New Employee/User ESH&Q Orientation

FTBF Hazard Awareness Training

Training for controlled access, which require in-classroom instruction the first time around:

Radiological Worker

Fermilab Controlled Access

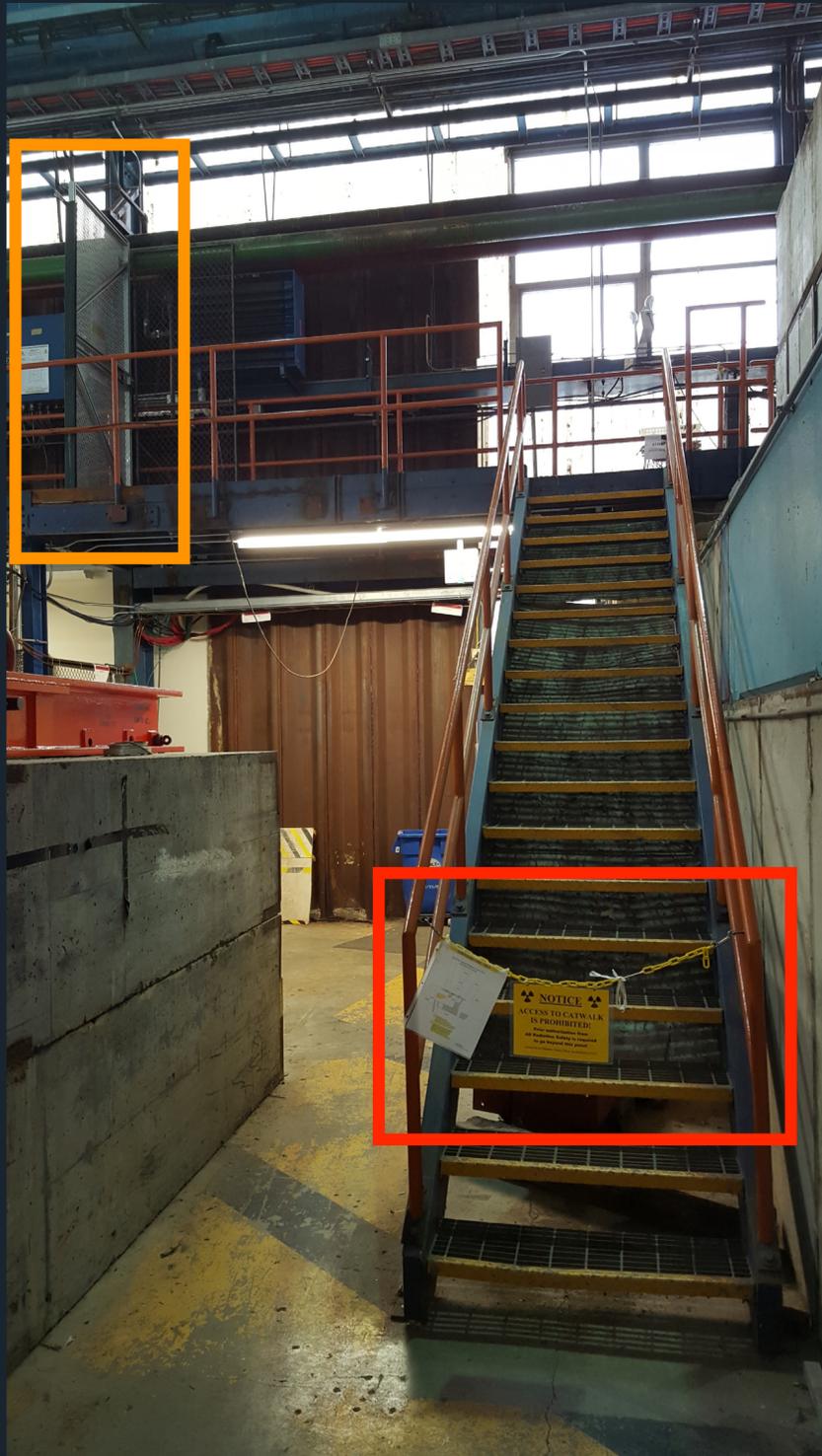
We found that it would be a good idea to complete the online training *before* arriving on site so that more time can be spent on tasks that require you to be on site.

Some confusion during installation

Stairway of uncertainty

22

↑
Stairs over here too.



There was a bit of confusion at one point when we needed to access a catwalk to get to a patch panel.

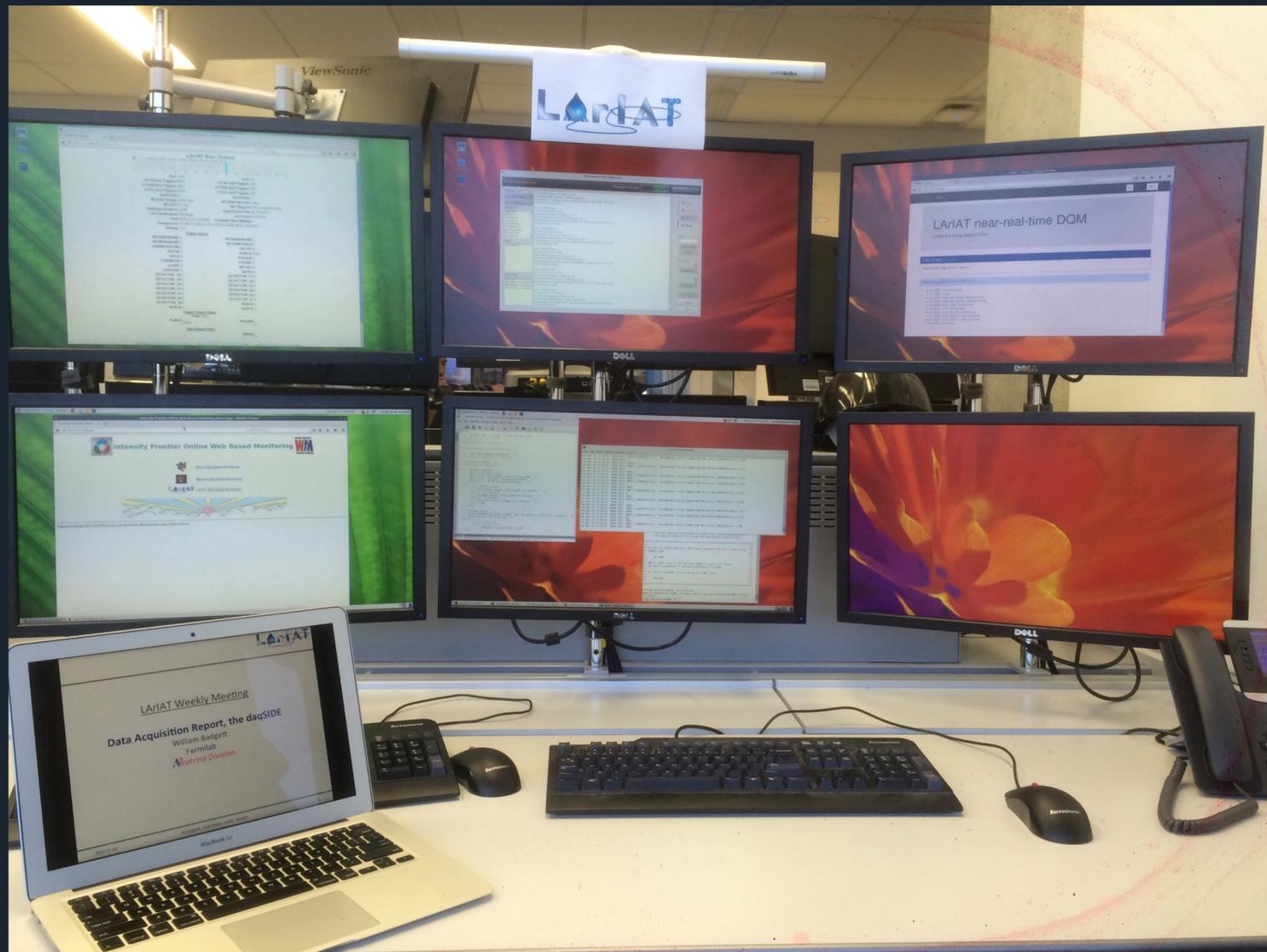
In the **orange** box is a gate on the catwalk that can only be opened with a key by calling MCR. In the **red** box is a chain blocking access to a set of stairs leading up to the catwalk. Before you can take the stairs up to the catwalk, you *must* open the gate by calling MCR first.

What can be done better here? Perhaps a gate can be installed at the bottom of the stairs.

Running LArIAT with beam

Sharing beam at MCenter with MTest

23



Call MCR for starting/stopping beam, tuning beam, controlled access, open access, etc. The operators at MCR are super friendly folks.

Communicate with both MCR and the experiment running at MTest. The beam intensity requested by one experiment will affect the beam intensity delivered to the other experiment.