Fermilab Test Beam Facility

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PAC January Meeting

January 17, 2019

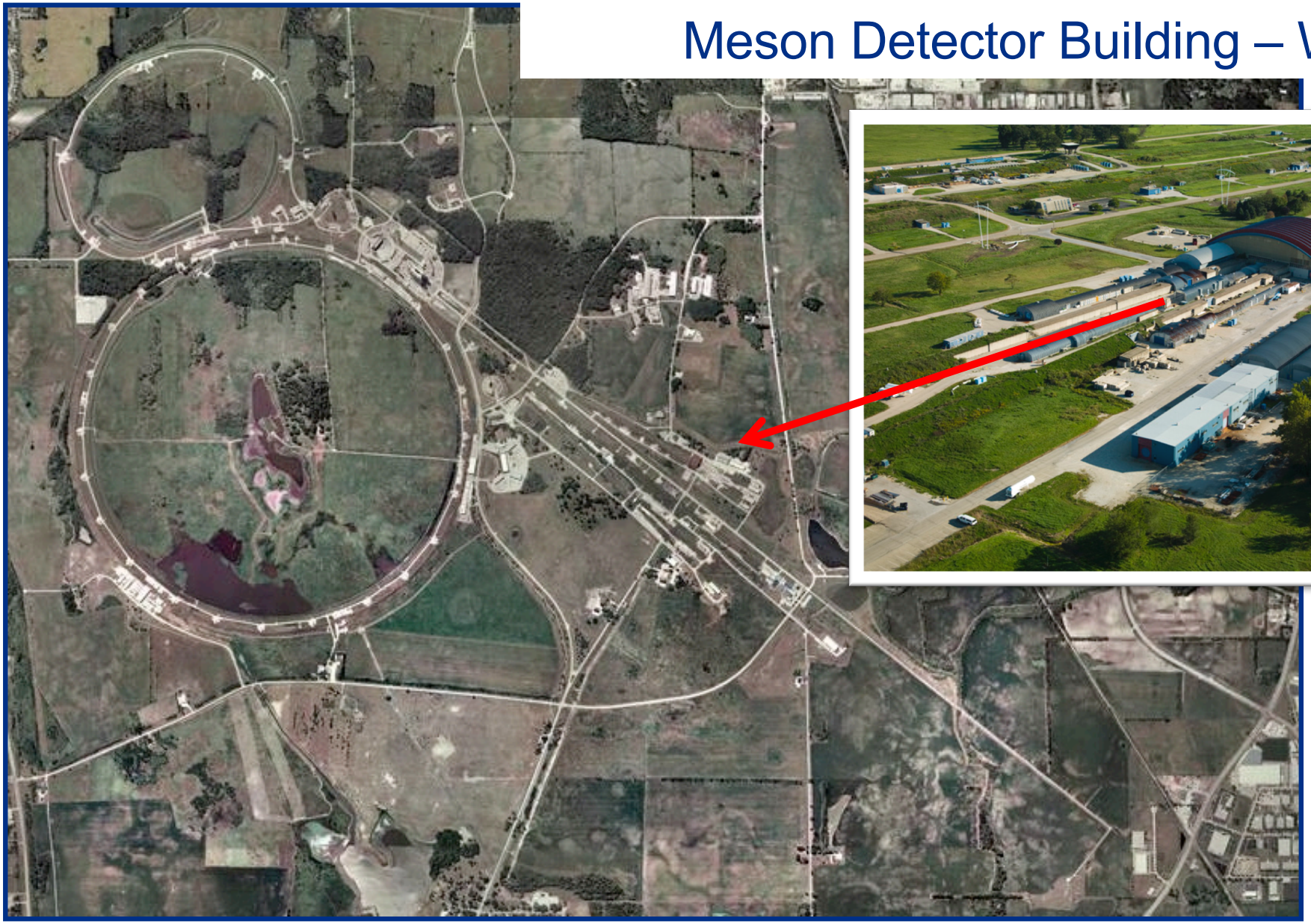
Charge

- Report on the FTBF: We ask the committee to review the status of the facility, to comment on the recent FTBF review's outcome and on the progress of the ITA
- Outline:
  - Will discuss how the facility currently operates
  - What our most recent review recommended
  - Irradiation Test Area overview
- More information:
  - FTBF website: http://fnal.gov
  - Fiscal Year Reports: https://ftbf.fnal.gov/documentation-overview/
  - FTBF Committee website: https://web.fnal.gov/experiment/FTBF/committee/SitePages/Home.aspx

Fermilab Test Beam Facility

- Facility dedicated to the research and development of detectors.
- 2 Beamlines – MTest and MCenter
  - Beam energies from 200 MeV charged particles (tertiary beamline) to 120 GeV protons (primary beamline)
- Operated during same time as the rest of the accelerator complex. Beam available 24/7.

Location



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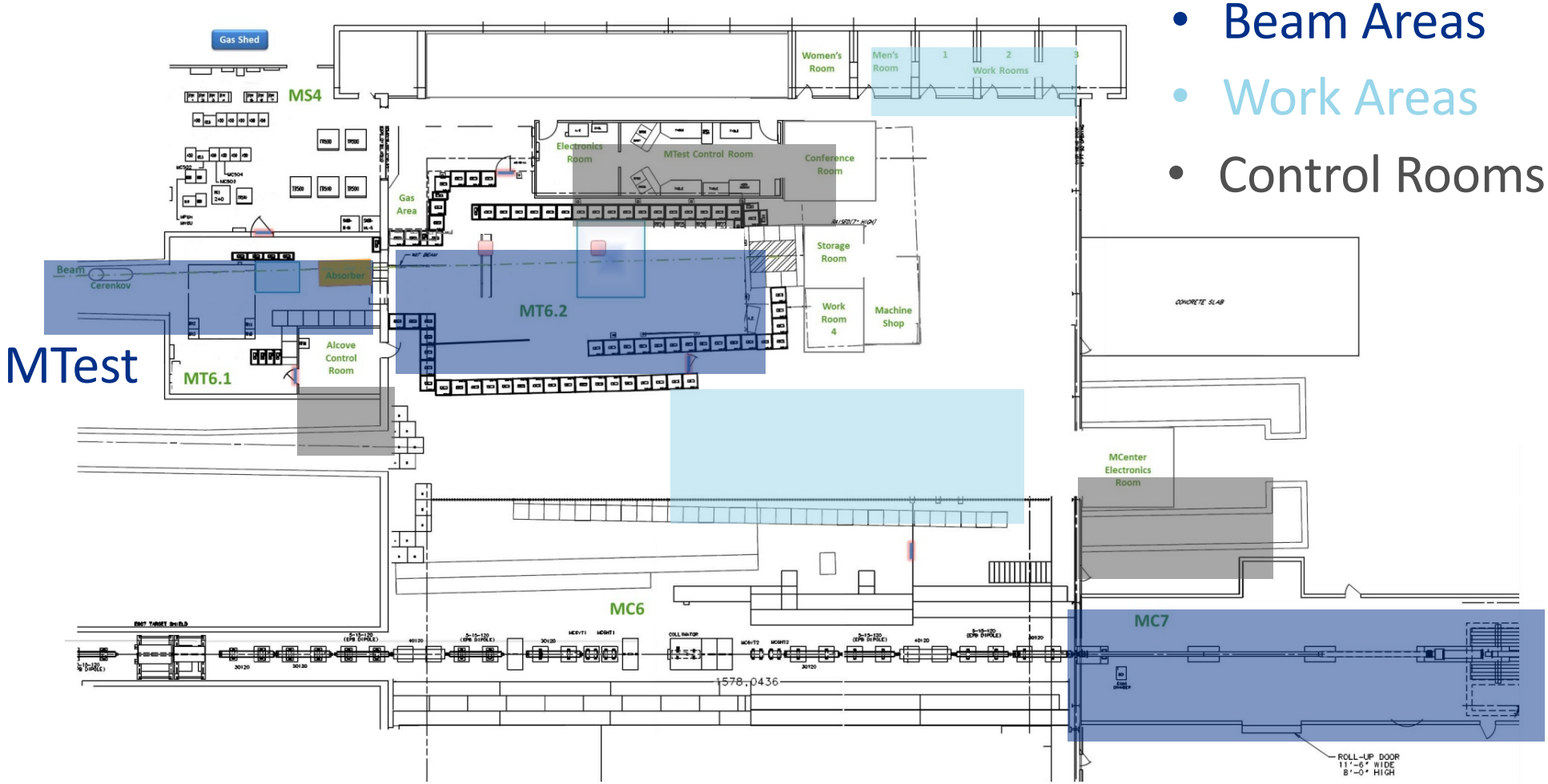
Facility Layout



- Beam Areas
- Work Areas
- Control Rooms

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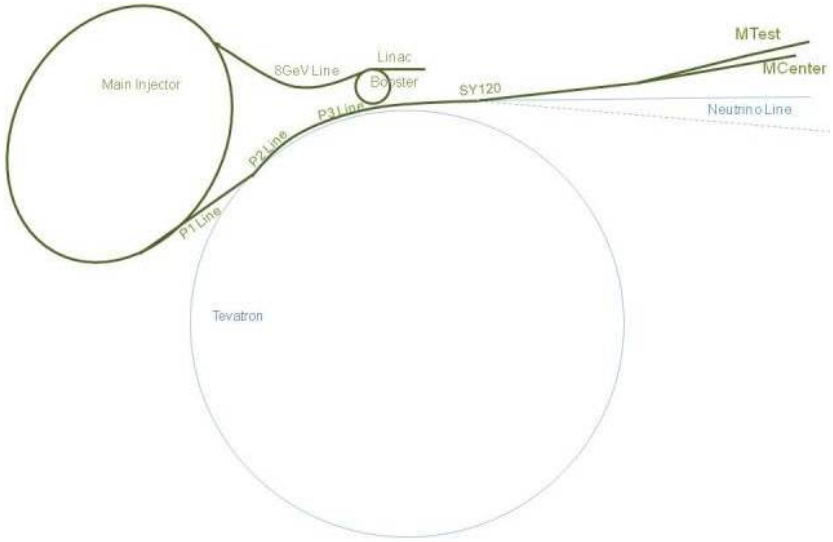
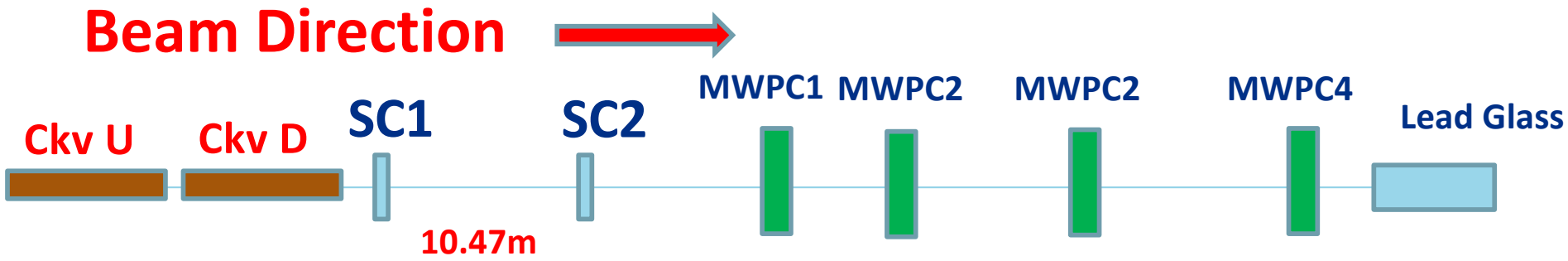
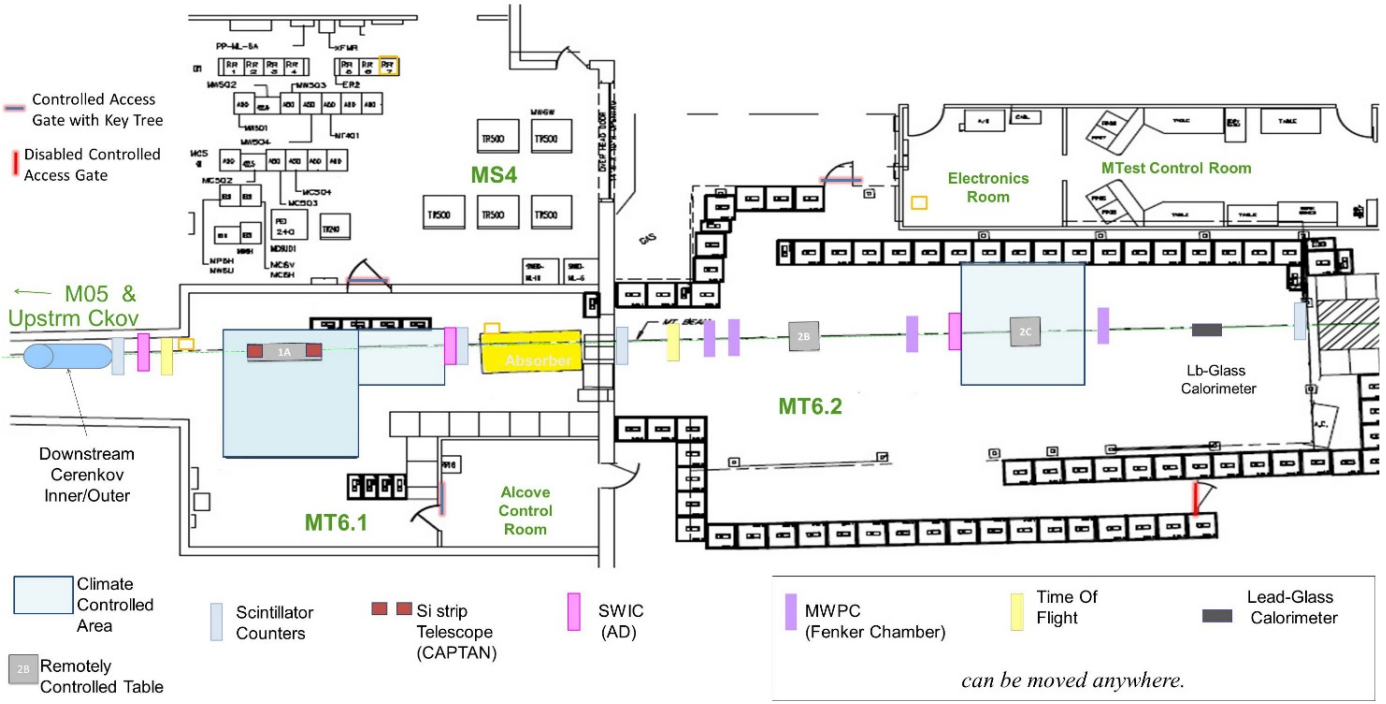
Beam Details

- Full details can be found: http://ftbf.fnal.gov/beam-overview/
  - 4 sec spill every 60 seconds
  - Tunable rate (10k counts to 1 million counts on a trigger), beam available 24/7
- MTest Beam line
  - 120 GeV protons
    - Primary beam
  - 1 – 80 GeV secondary beam (+/-)
  - Spot size about 2cm
- MCenter Beam line
  - 2 Tertiary beamlines (200 MeV – 1 GeV)
  - Currently have cryogenic support for LArIAT (Liquid Argon In A Test Beam)



Beam Instrumentation Layout – MTest





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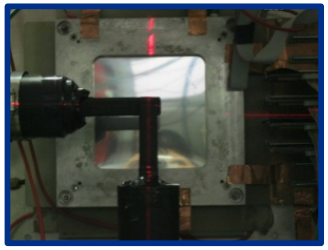
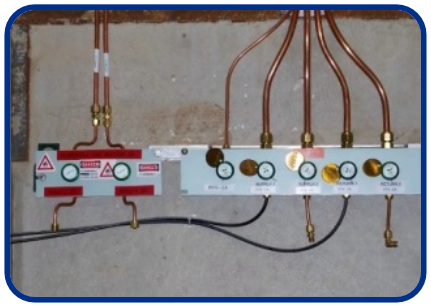
Infrastructure at MTest

- Remote controlled Motion Tables
- Laser Alignment
- Helium Tubes
- Web-based Cameras
- Crane Coverage (30 tons)
- Climate controlled Huts
- Gas Patch panels
- Signal, Network, & High Voltage cable patch panel
- In addition, experimenters have access to other facilities, such as the cleanrooms at SiDet and electrical engineers on the 14th floor.





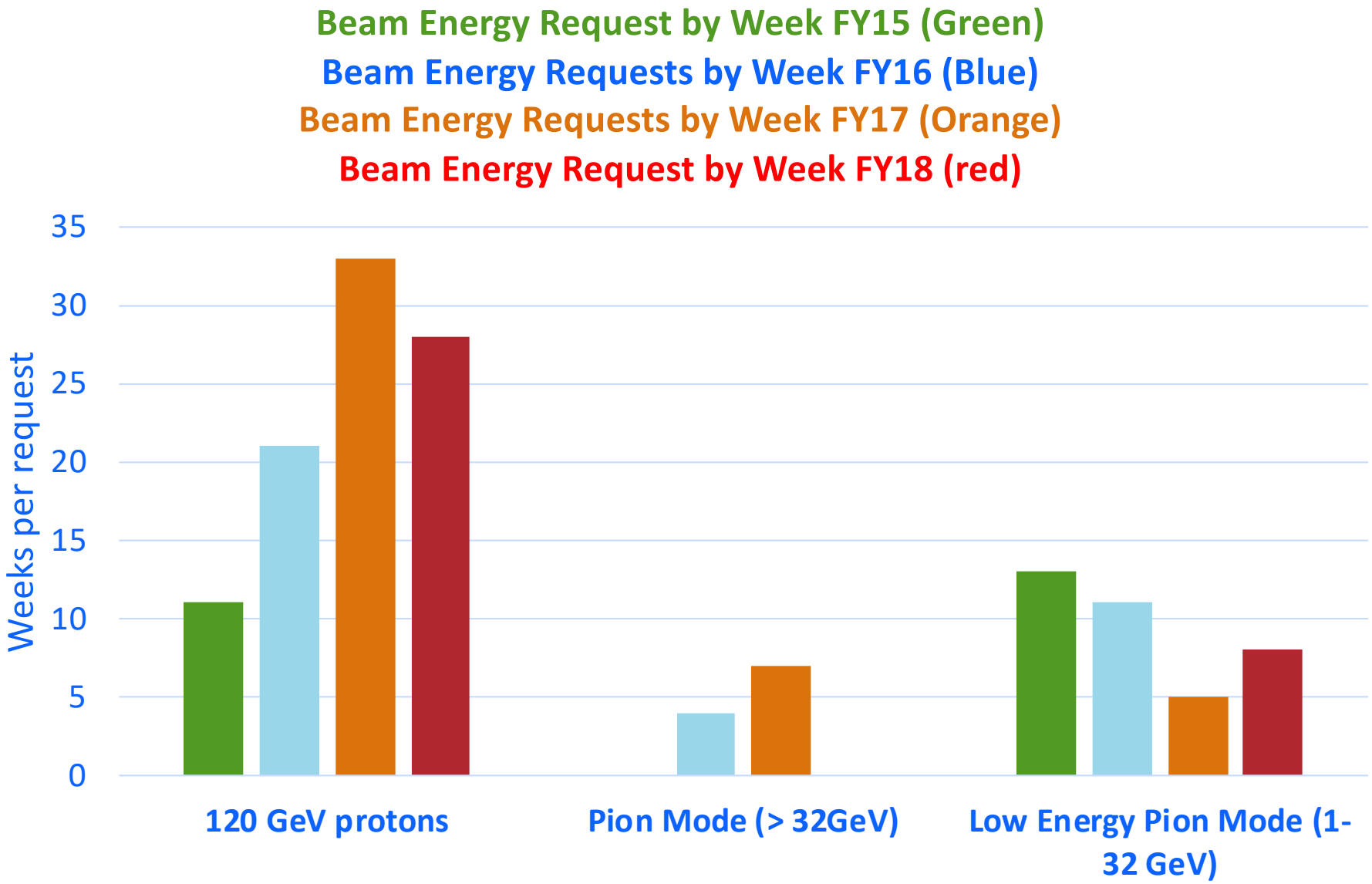
FTBF Users

- **How to get beam time:**
  - Send out a notice around May for following fiscal year
  - Experimenters contact me or fill out our web form
  - Currently use a first come first serve model for time.
- **All users complete a Technical Scope of Work (TSW).**
  - Reviewed by FTBF staff, approved by all divisions and the directorate
  - TSW is an agreement on what resources are needed and provided. It includes a discussion of what the physics is.
- **Once approved and before their beam starts:**
  - Gather all the information on people attending, then make a training plan for everyone

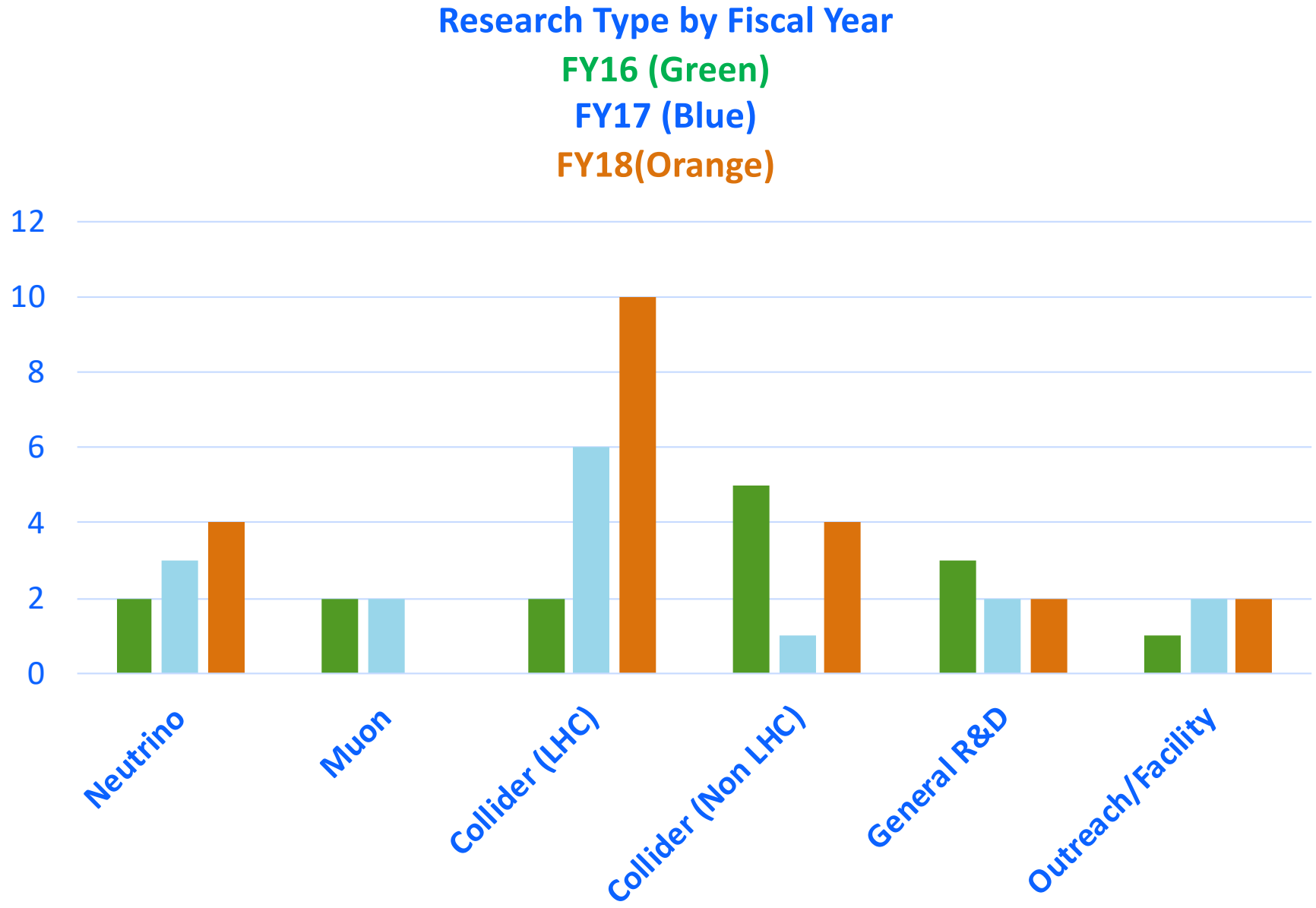
FTBF Users – Beam Time

- **Installation day**
  - Put MTest into open access, our technicians work with users to safely install the devices.
  - Each group does has an Operational Readiness Clearance review.
  - Hazards are outlined in a form, we convene a committee of SMEs based on those hazards (electrical, mechanical, etc).
  - Reviewers comment, recommend corrective action, then approve the setup.
  - Final approval from participating divisions.
- **Main Control Room will then take beam requests and will help to steer beam as needed.**

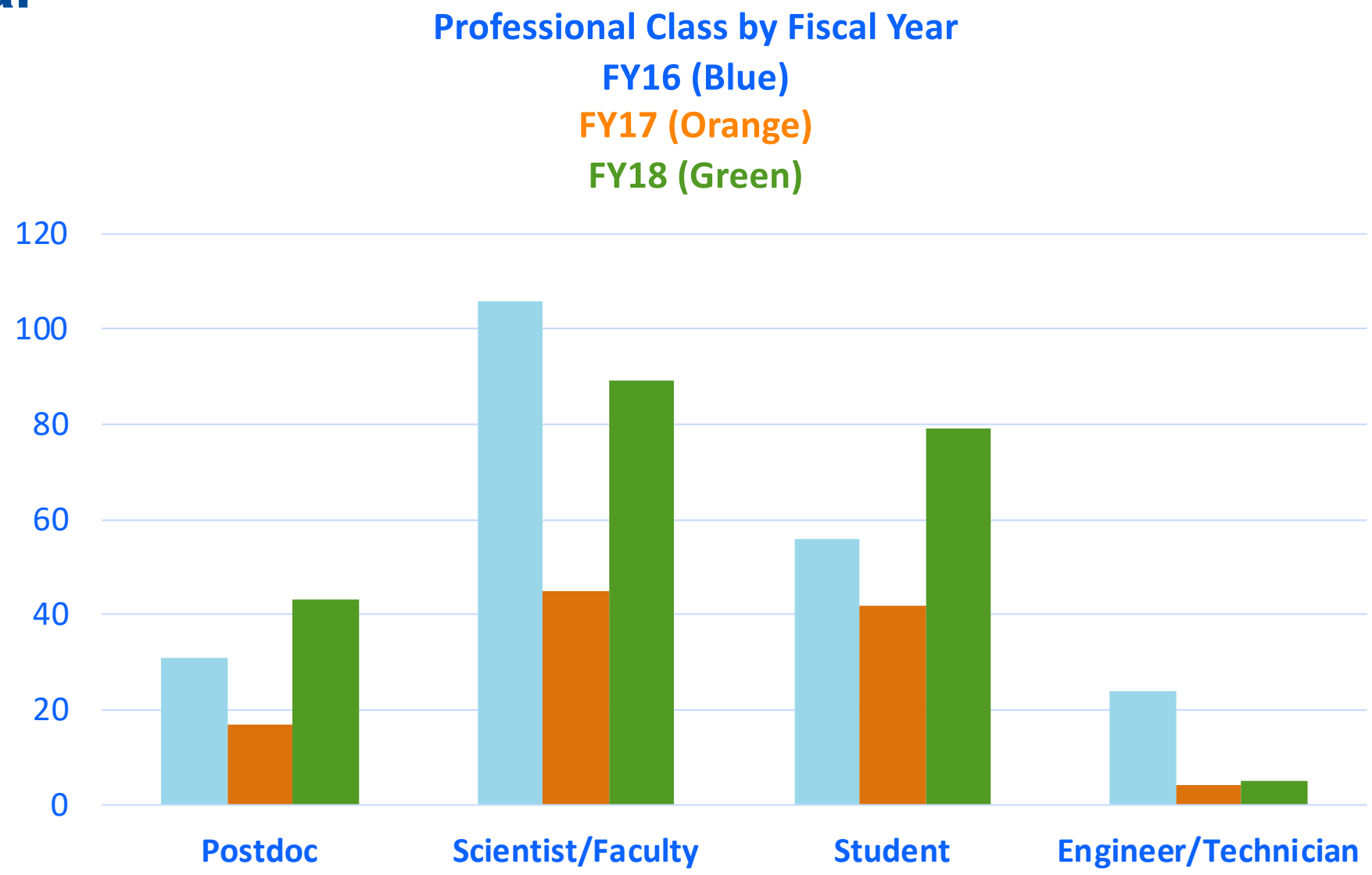
FTBF Beam Requests by Week



Users by research group



Users by Professional Class: 100 – 200 Users per year



FTBF Committee Review

- From the recent review:
  - The FNAL computing division should consider putting resources into the FTBF to get a working DAQ system.
  - Work with CD to get otsDAQ integrated into an overall system that is transparent to the users.
- Context: Facility instruments do not have a unified DAQ system
  - A combination of DAQs, python scripts and ACNET commands
  - One of the goals is to provide this to users and also have a DAQ for beam studies

FTBF DAQ Work - Plan

- Triggering and how to integrate a users' DAQ and our own
  - Currently, working with otsdaq, which has components from CMS and ART
  - Possibly will integrate other DAQs into the facility
  - At this time, all instruments have a frontend written, working on integration
  - Currently have support from CD on this matter and enough manpower at FTBF to learn and start to take this over.
  - Tutorials have been written, continue to work on documentation.

Slow Controls

- From the Committee report:
  - Consider developing a unified slow control system. Consider ACNET, iFix or SYNOPTIC before rolling your own.

- This goes with the DAQ system
  - Would monitor HV, temperatures, gas levels, etc
  - Have started circulating a requirements document to solicit help and recommendation from within PPD.

FTBF Paper

- From the Committee report:
  - Dedicate resources to publishing the FTBF paper.

- Would like to have a definitive paper that describes what the test beam does and what is available to users. This would serve as something for people to cite in their papers on data taken at the test beam.
- Paper is started and I've identified co-authors. Should finish it this year.

Plans and what we still need

- **The next few years will be challenging with CERN being off.**
  - Already in communication with ATLAS and CMS groups.
  - Will call on the FTBF Committee if necessary to help decide on proposals
- **Upcoming long shutdowns at FNAL and CERN are problematic for test beams around the world.**
- FTBF needs infrastructure updates
  - For some users, ***FTBF is their only experience with Fermilab***.
- FTBF needs instrument updates
  - Power supplies
  - Faster triggers
- Community input
  - Need for a magnetic field
  - Muon or electron beams.
  - Irradiation Facility

Irradiation Test Facility

- With the shutdown of CERN for 2 years and R&D for the HL-LHC in high demand, we've been discussing having an irradiation facility here at Fermilab.
- It is vital to have QA/QC tests for both ATLAS and CMS to make sure detectors will survive this environment.
- Solicited input from HEP community and beyond
  - Huge amount of support
- Developed a plan for a facility that can be built in a short time frame and be ready for the immediate need of the community.
  - Will be built at the end of the Linac, in the MTA area.
- Proximity to FTBF is a huge draw
- Would provide cooling and power for SEU tests.

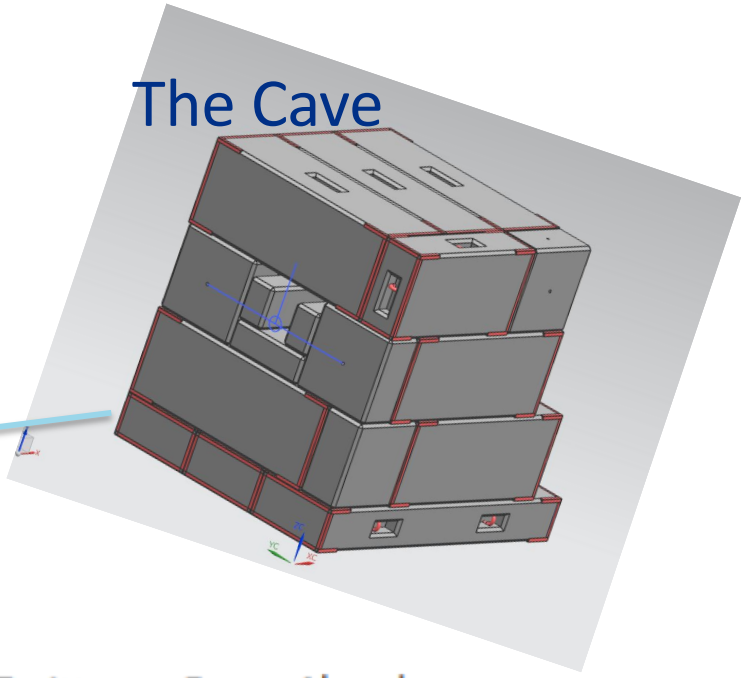
Existing Facilities

	Particle Type	Beam Energy	Beam Size	Time to $2x10^{16}/cm^2$	SEE Tests	Availability
CERN	protons	24 GeV	0.5-1.5 cm	111h	yes	LS2 shutdown
Birmingham	protons	40 MeV	1 cm	1h	yes	
Louvain	heavy ions	100s MeV		not feasible	yes	Being built
Ljubljana	neutrons	-	-	1.4h	no	
KIT (operated by ZAG company)	protons	23.5 MeV	0.5 cm	1.5h	(yes) too expensive	4h/week 6 week turnaround
Rhode Island	neutrons	-	-		no	limited
ANL (LEAF)	electrons neutrons	55 MeV 0.5 MeV		7h		Might be planned
BNL (BLIP)	protons+ neutrons	65-200 MeV		20h	no	Might be planned
TRIUMF	protons	5-500 MeV	0.5-1 cm	not feasible	yes	
FSU	protons	17 MeV				limited
LANL	protons	800 MeV		72h	no	2x/year
FNAL ITA	protons	400 MeV	1-7 cm	0.7h	yes	40x/year

ITA Continued

- Very strong community support
  - Letters from sPHENIX, ATLAS, CMS (see back up)
  - ITA was called out as necessary in recent DOE reviews.
    - HL LHC CMS CD-1 Director's Review -- Outer Tracker Recommendation, Page 8 of Final report: 1. The review committee recommends that Fermilab work with the DOE to establish a proton irradiation facility at Fermilab. This is particularly important during LS2 when the CERN PS facility will be down. This is critical not only for the CMS Outer Barrel but also for all the HL-LHC projects.
    - HL LHC CMS CD-1 Review, Outer Tracker Comments, Page 8 of Final Report (now also IPT Tracking item R06) The Committee encouraged FNAL to establish a proton irradiation facility. This will be of great use for the upgrade program and beyond. In case this facility will not be realized or not be available in time, an alternative needs to be developed. An analysis that supports the preferred alternative needs to be performed.
    - HL LHC ATLAS CD-1 Review, Pixel Recommendation #3 (available on request) 3, Work with DOE to pursue a dedicated proton irradiation facility in the U.S., e.g. by supporting the proposed irradiation facility at FNAL.
- We have survey results from the community as well that shows high support and a large need.
  - Day one customers: ATLAS, CMS, others.

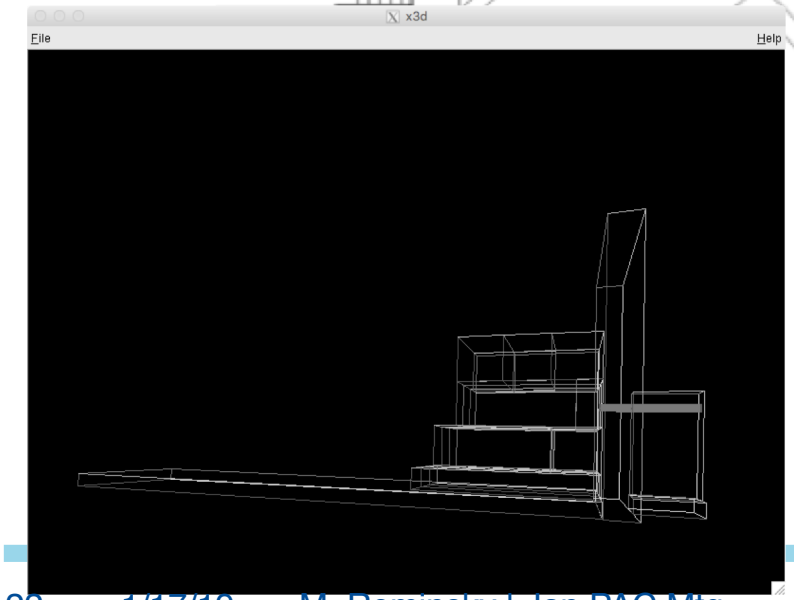
Layout of MTA



Final Beam Absorber

Emittance Beam Absorber

Shield Wall
Between Linac
and MTA Hall



Fermilab

Beam extraction in Fermilab LINAC

- "Pulses" from the LINAC can be extracted during the 6 second flattop of the SY120 spill and ***thus have minimal effect on Neutrino pulses***
- By running the Irradiation Test Area simultaneously with FTBF, we have no impact on the rest of the program:
  - NuMI requires the Main Injector, as does FTBF.
  - G-2 and FTBF share a common section of beamline, and cannot run simultaneously.
  - BNB is rate limited.

- A "standard" we have been using consists of
  - Single pulse of 5E12 protons per LINAC batch, 400 MeV
  - Nominally 15 Hz
  - 12 hours availability one day per week
  - A typical run would have beam impacting on 4.7 cm of Si (10%Λ)
  - Cooldown period of 1 day
  - One user per week.
  - 40 weeks/year

Table 1: Beam parameters to be expected at the DUT (Device Under Test)

Beam Specifications	Min	Max
Beam Size (±3σ) at DUT	1 cm	5-7 cm
Beam Divergence (±3σ) at DUT	0.1 mr	1 mr
Number of Proton/pulse	0.3×10^{12}	7.5×10^{12}
Pulse Duration	2 μs	50 μs

ITA – What needs to be done

- Clean up of the area
- Shielding assessment – in progress
- Development of administrative procedures.
- Our work plan shows this could be done in 3 months.

Conclusions

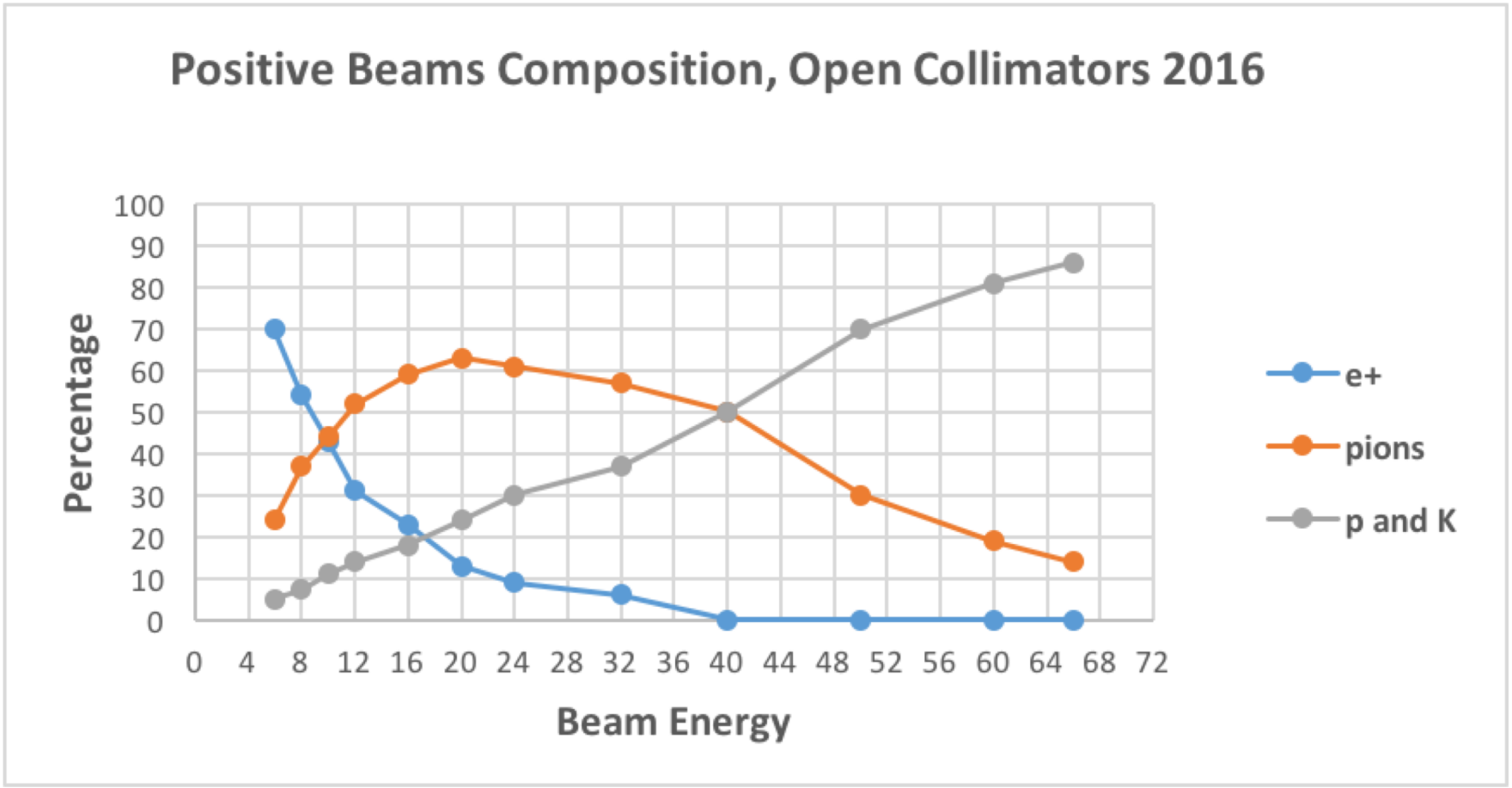
- FTBF supports a broad scientific community
  - Around 200 users every year
  - All experiments at the lab and from the broader HEP community use our facility
  - We provide access to small institutions as well
  - Outreach and student engagement is an important part of what we do.
- We are trying to address shortcomings at the test beam
  - Unified DAQ system
  - Power supplies, development of new test areas
- We strive to listen to the community and provide help on a timely basis
  - The ITA is a clear need that we can meet within the community.

Backup

- Beamline information
- Information on user groups
- ITA letters of support

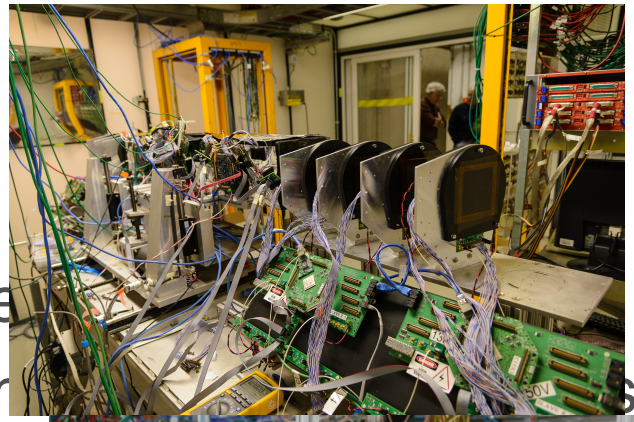
Beam Composition for Secondary beam in MTest

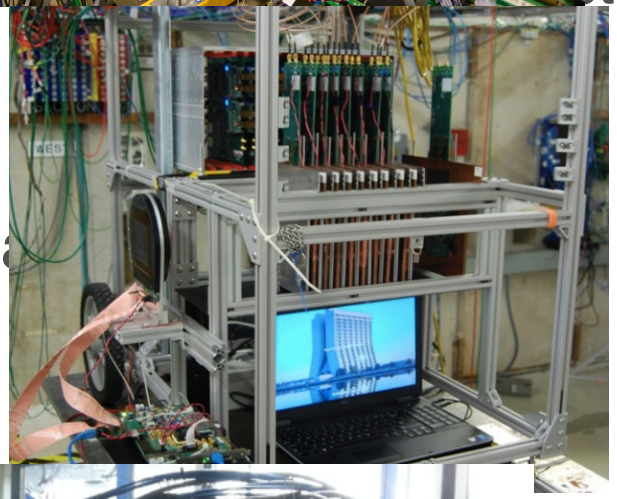
- Table with energies, beam spread, percentages: http://ftbf.fnal.gov/particle-composition-in-mtest/

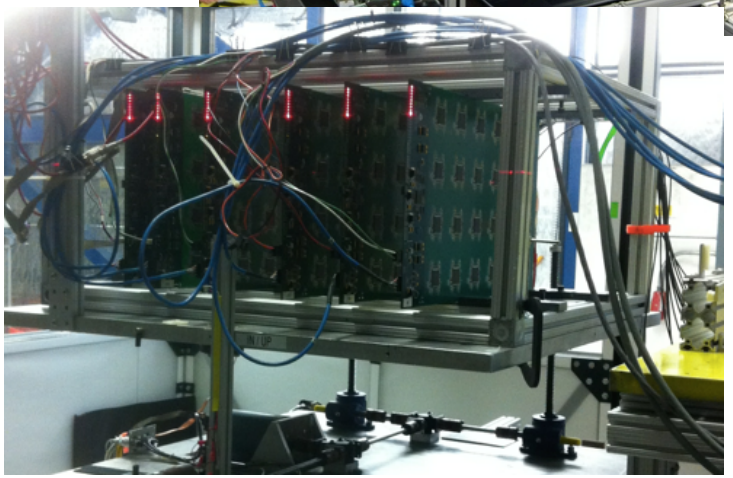


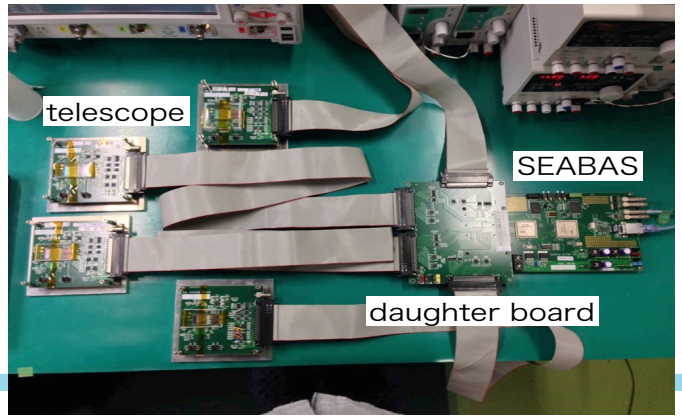
LHC studies

- CMS (T992, T1041)
  - T992: Testing rad hard sensors for the
  - T1041: Multiple groups testing calorim stive plate chambers
- ATLAS (T1068)
  - Testing telescopes for future radiated s
  - Have runs scheduled in FY17



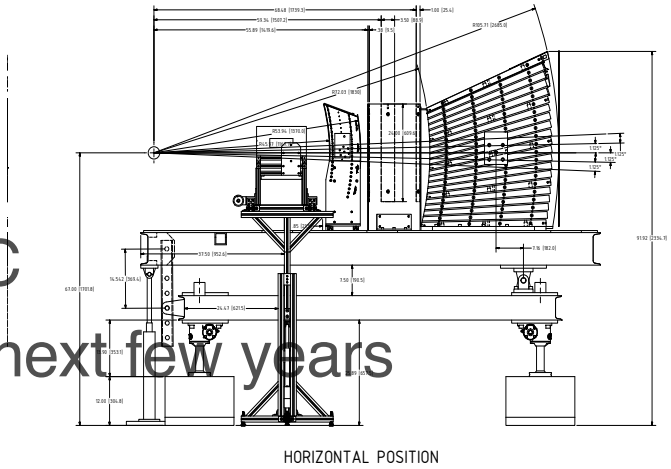


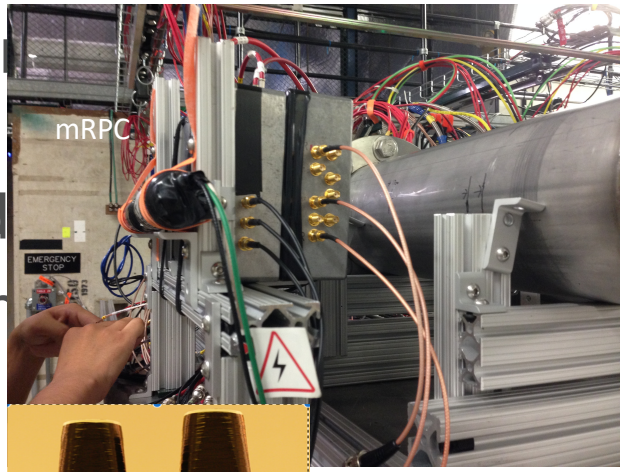


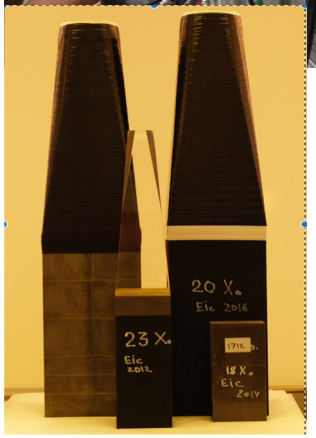


Collider studies – non LHC

- sPHENIX (T1044)
  - Large group testing calorimeter for RHIC
  - Will continue to use test beam over the next few years
- EIC Studies (T1037, T1048, T1018)
  - T1048 studying 3 ToF detectors to deter
    suited
  - T1037 studying combination of TPC and
  - T1018 exploring W powder SciFi calorim



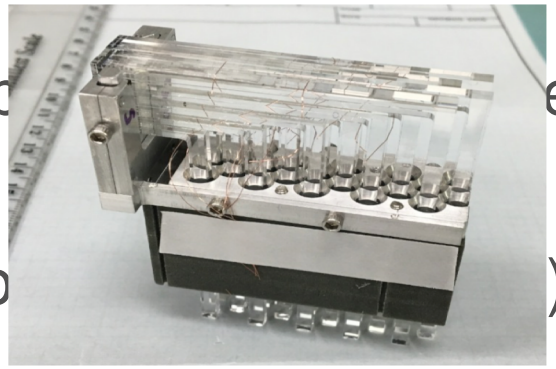


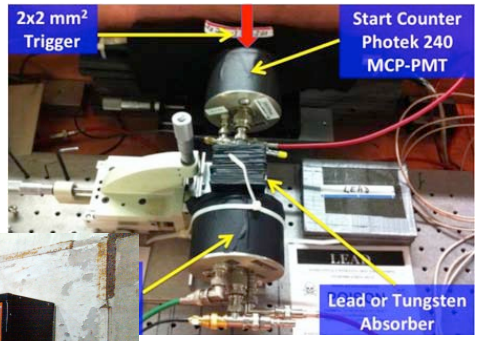


Fermilab

General R&D

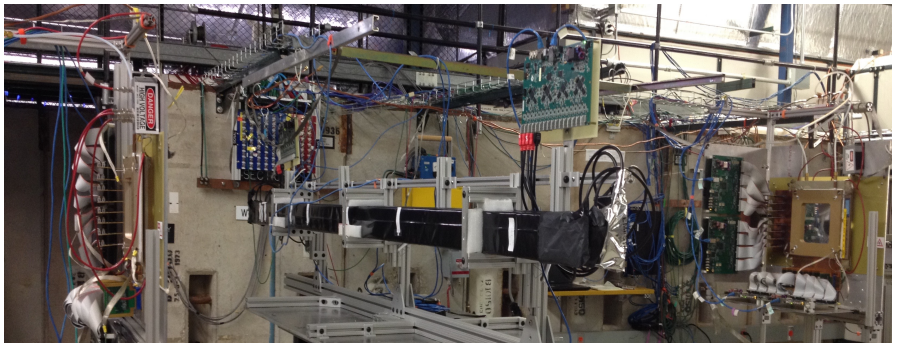
- Future lepton collider experiments (
  - Dual readout for calorimeters
- Timing detectors (T979)
  - Initial use at CMS, but would be app es
- Timing detectors (T1065)
  - World's best timing resolution (8.3 p)
- Muon strip detectors
  - For future colliders
  - Stayed outside the enclosure



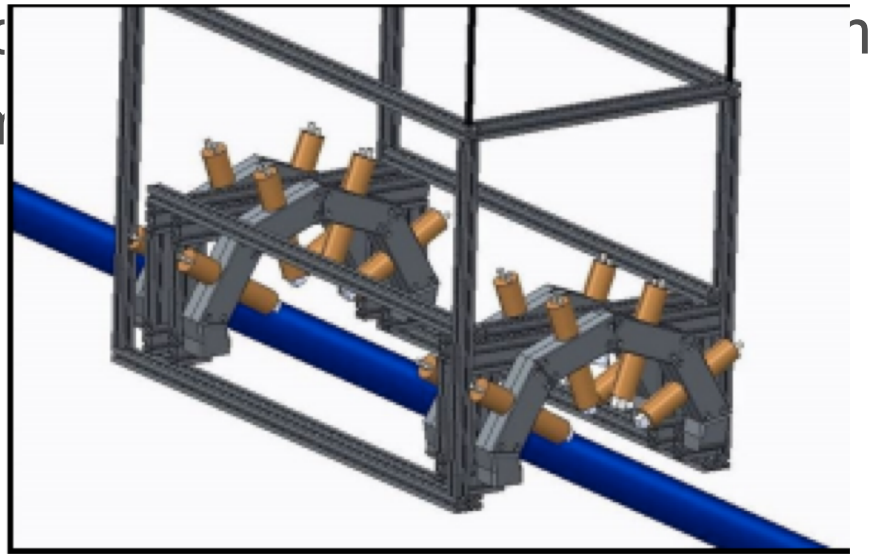


Fermilab

Muon Physics

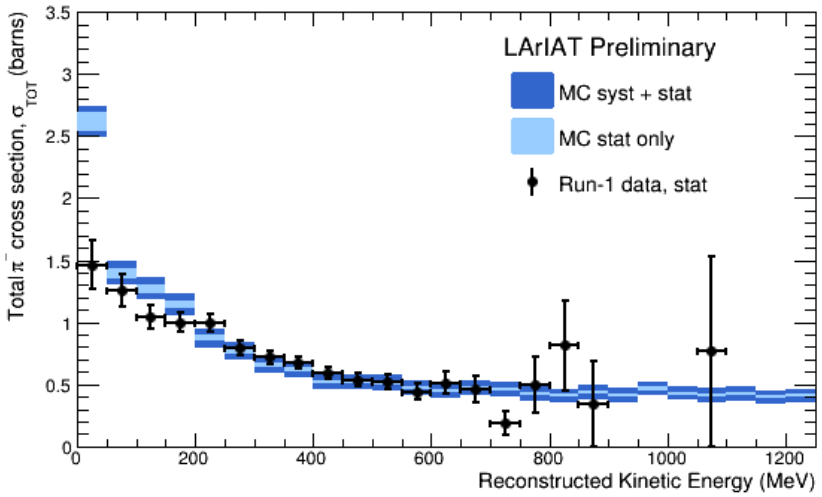


- Cosmic Ray Veto Tests (T1043)
  - Testing PE yields for a variety of
  - Results shown at conferences
  - Will continue to test this year
- Beam Monitor Studies (T1073)
  - Beam monitor for Mu2e, basis for LDRD work
  - Measuring quartz Cherenkov rad
  - Continuing work at the test beam

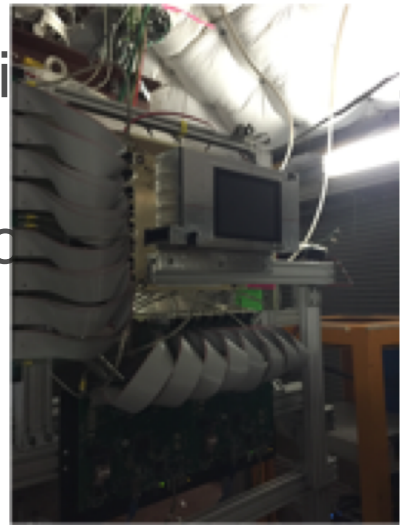


Neutrino Physics

- LArIAT (T1034)
  - Continued their physics programs
  - Will run until summer shutdown
  - Publication in progress

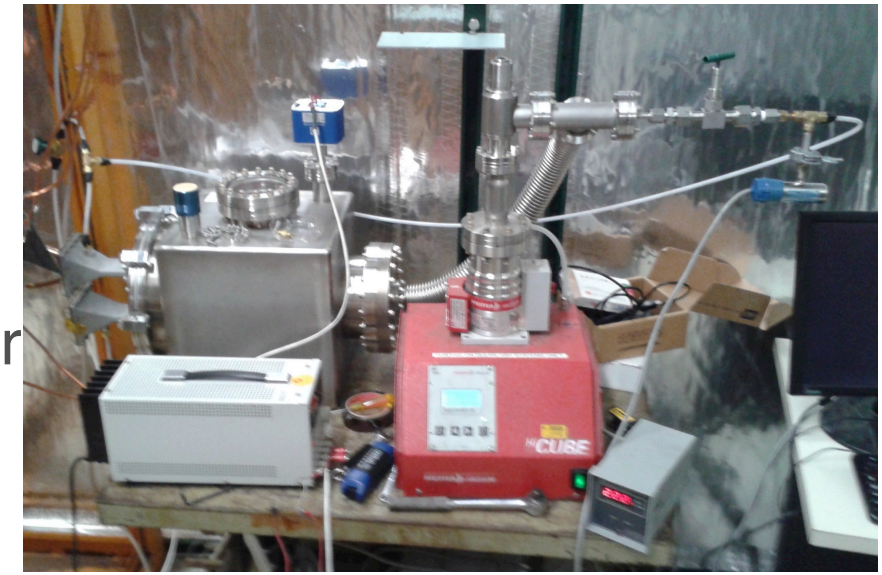


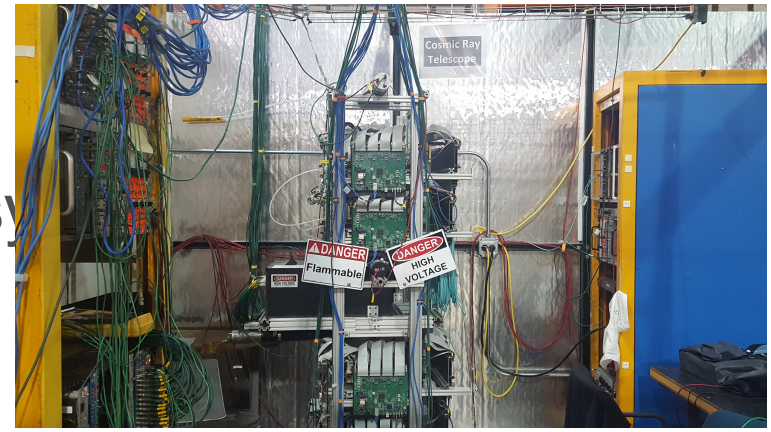
- pLAPPDs for ProtoDUNE (T1075)
  - Short test at the end of summer to measure effi and position resolution
  - Will continue to test in MCenter, MTest and also telescope



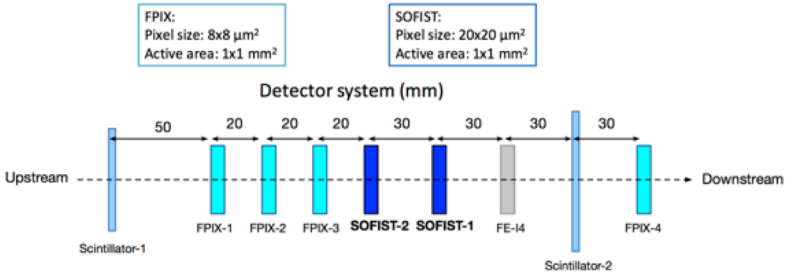
Non Beam users

- Rate of Rise test for g-2 (T1042)
  - Testing the rate of rise in straws
  - Didn't need the beam, needed our
- Cosmic ray telescope working
  - Users testing pLAPPDs
  - Testing a calorimeter prototype
- Mu2e continuing to develop DAQ sy
  Mu2e runs.

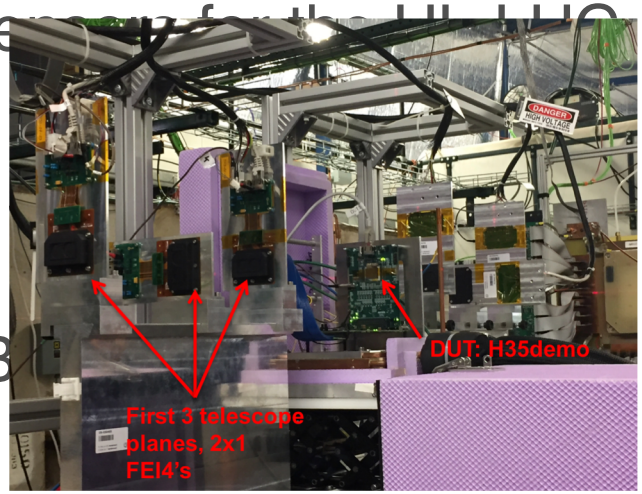


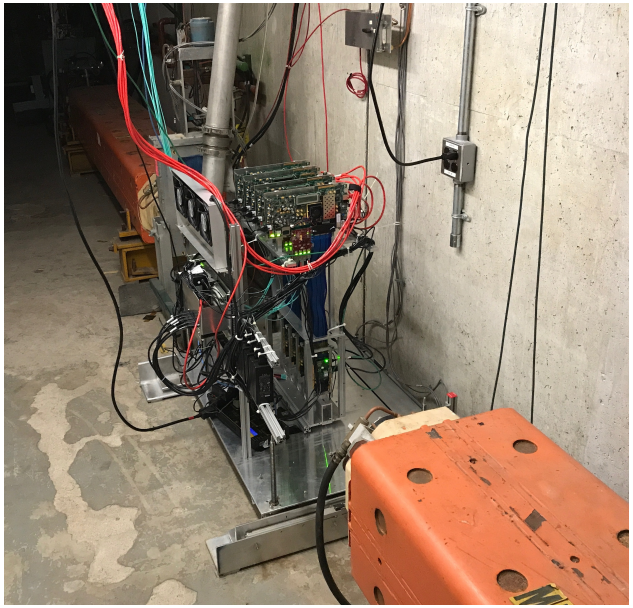


LHC Groups



- ATLAS (T1068 and T1224)
  - Both groups testing radiation effects on se[illegible] for the HL-LHC upgrade
  - Results from the test beams are used for appropriate technology
  - T1224 intends to build a telescope at FTB the next few years.



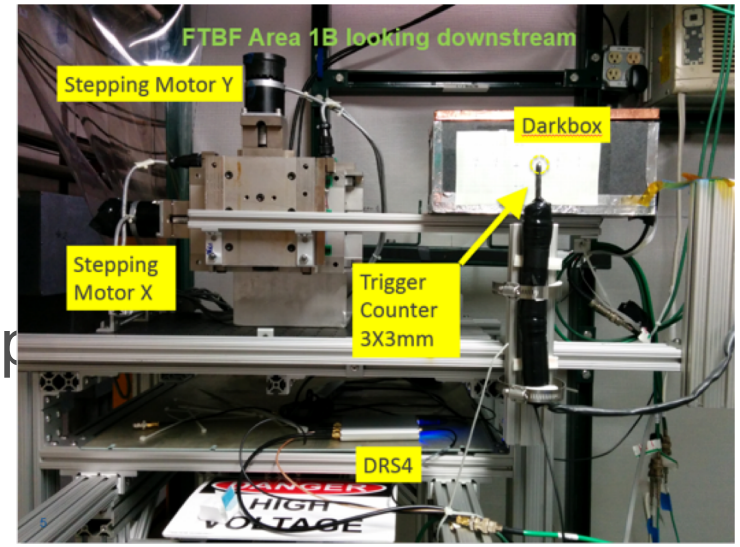


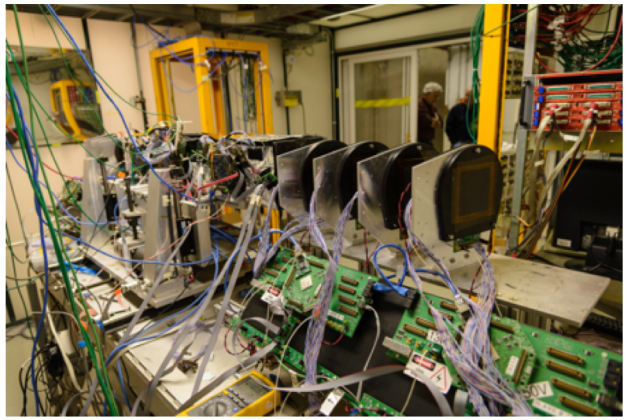
- LHCb
  - Testing irradiated sensors

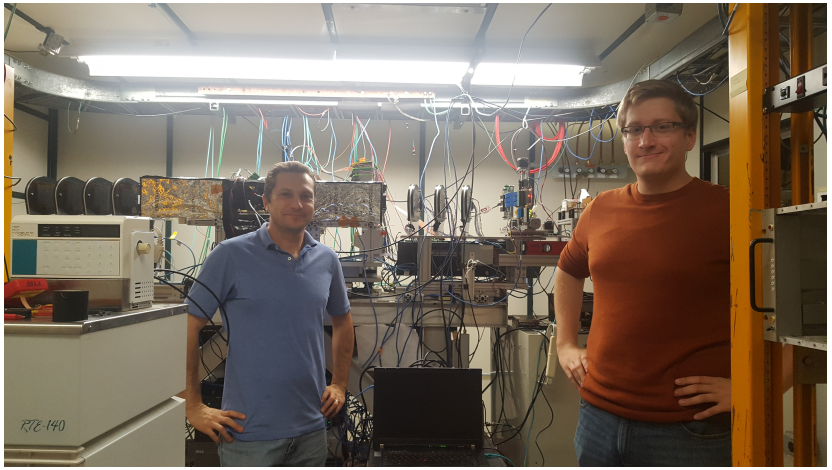
Fermilab

LHC

- CMS
  - Testing irradiated sensors
  - Testing Outer Tracker readout chip
  - Testing properties for SiPMs and scintillator for HGCal

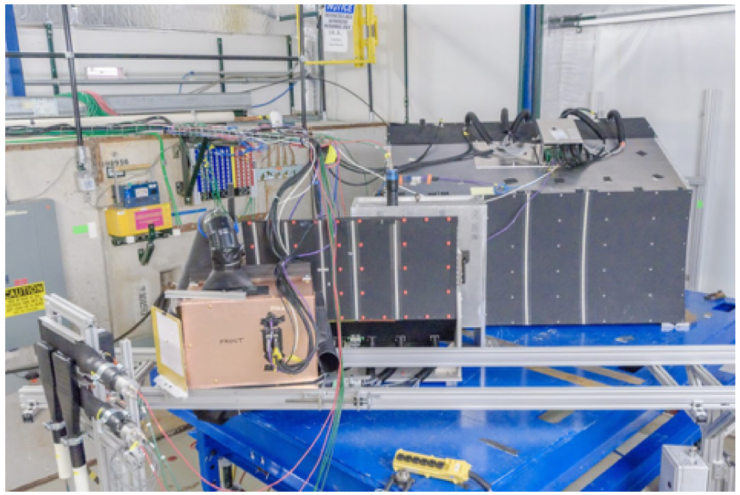




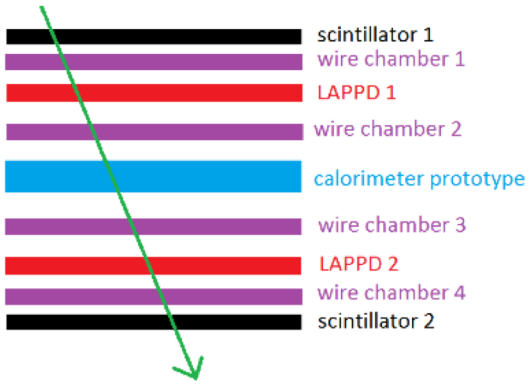


Non LHC Collider

- sPHENIX
  - Continuing tests of EMCal and Hadronic calorimeter including new readout electronics
  - Using this information for their upcoming CD review
  - Will be returning this year for last test
  - Continues to send other users our way as well.

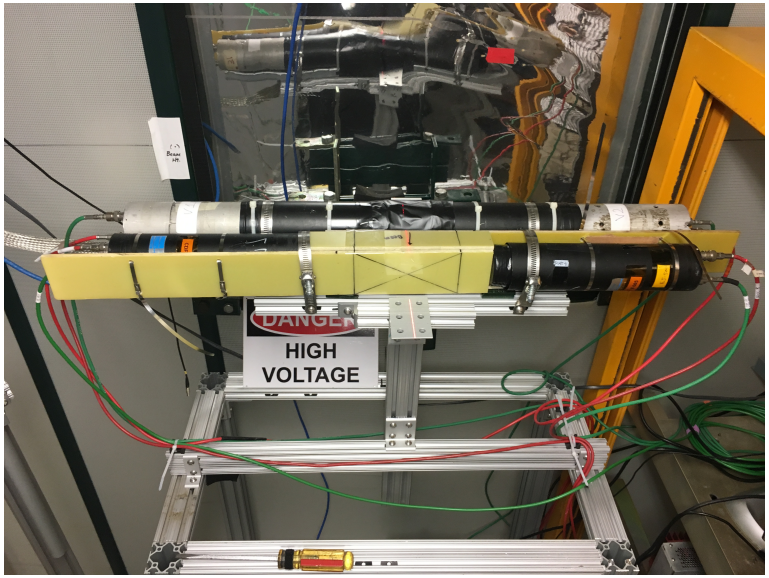


Neutrino experiments

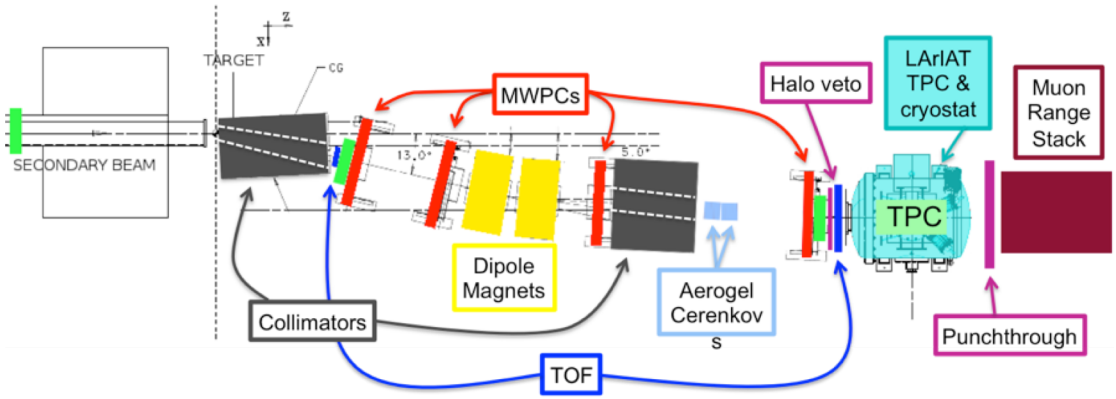


- LAFTBFToF for ProtoDUNE
  - Testing in and out of beam
  - Possible ToF detector for ProtoDUNE

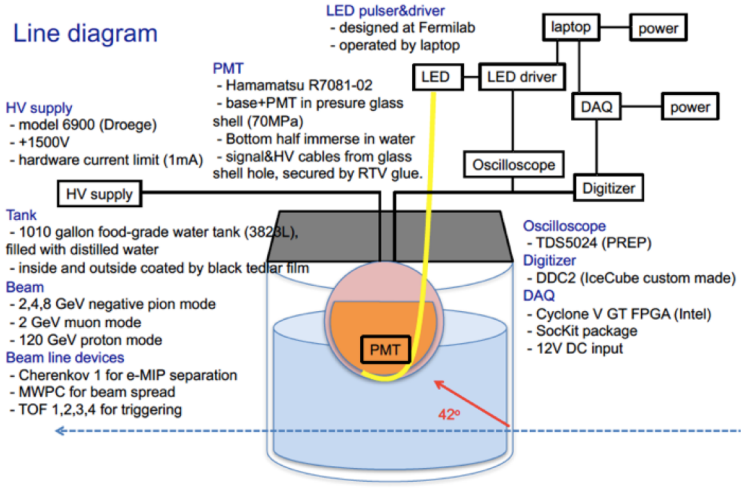
- LBNF Spectrometer
  - Testing DAQ duty cycle
  - Prelimiary R&D for a LBNF horn testing facility
  - Understanding available beam for future studies



Neutrino Experiments

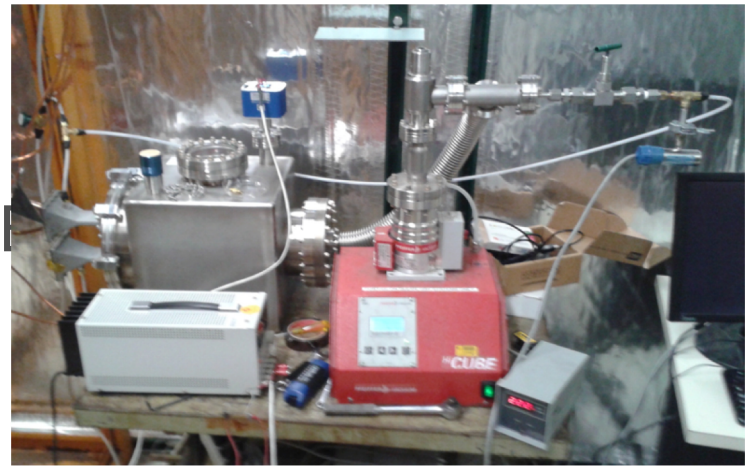


- LArIAT
  - Continued their program
  - Did R&D for other experiments during their run (SBND, DUNE)
  - Running for a few weeks this fall with a pixel detector
- IceCUBE
  - Studying electronics for their 10 inch DOM
  - Interesting challenge to locate 1000 gallons of DI water
  - Successful test for this group



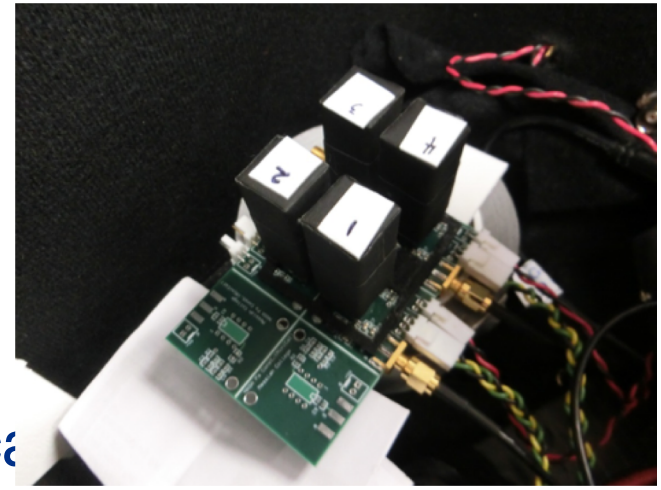
Muon Experiments

- Mu2e
  - Final test for CRV
  - Integration of all components
  - Results will be used in upcoming TDR

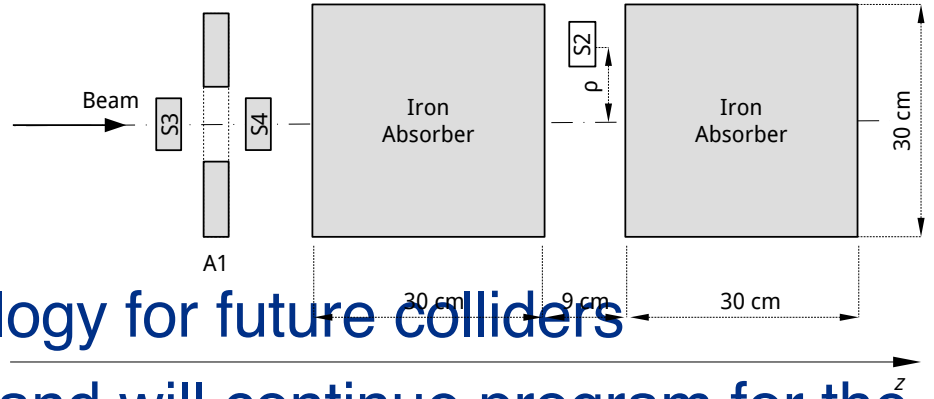


- g-2 no beam
  - Testing modules for leaks in vacuum
  - All modules installed tested first at FT

General R&D



- Mini EM Calorimeter
  - Located in the MT6.2b area
  - Testing construction and readout for mini ca in space.
  - Small college group, mostly students

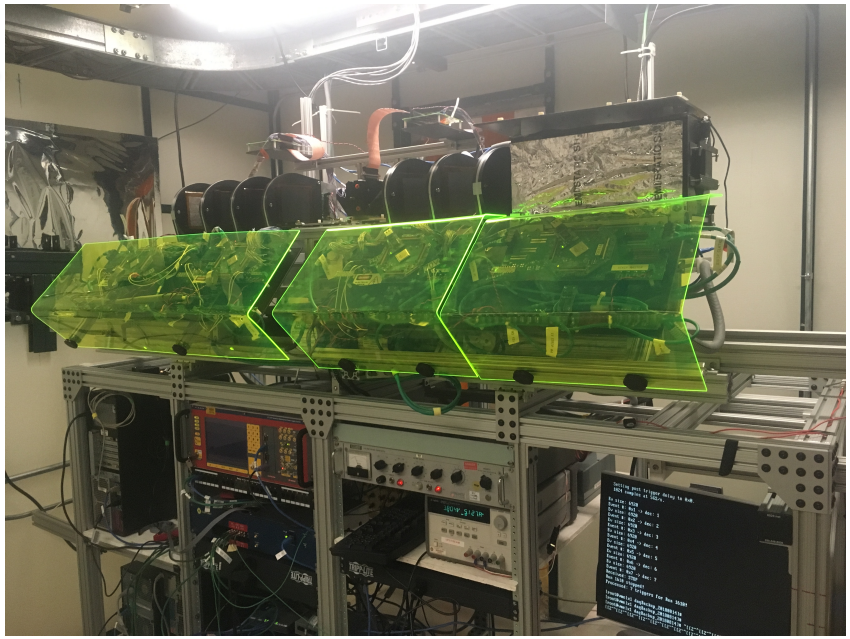


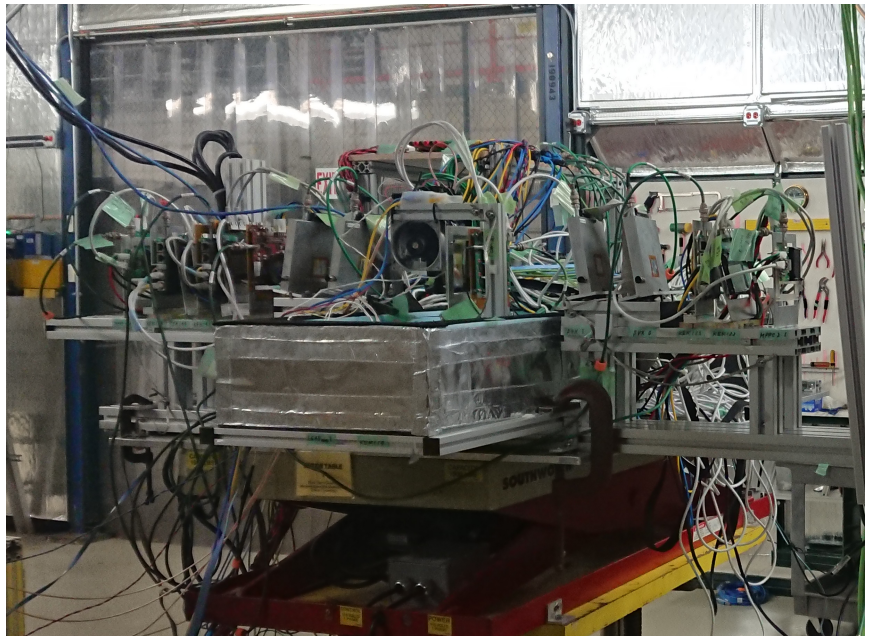
- FastHCal muon stuff
  - Located in MT6.2c
  - Testing muon counter technology for future colliders
  - Have used the facility before and will continue program for the new few years.

LHC: CMS and ATLAS

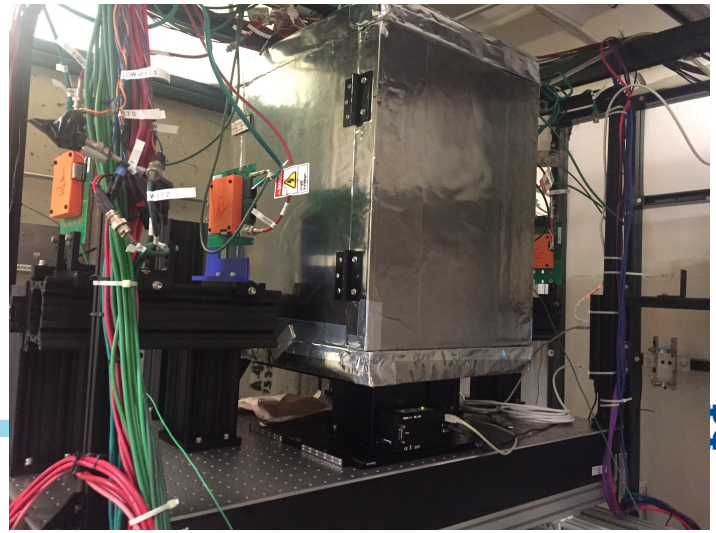
- Both experiments did a variety of sensor and ROC tests using telescopes
-

CMS →





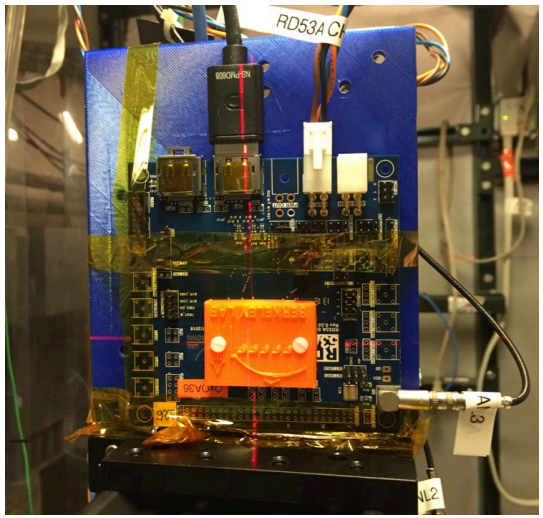
ATLAS Telescopes →



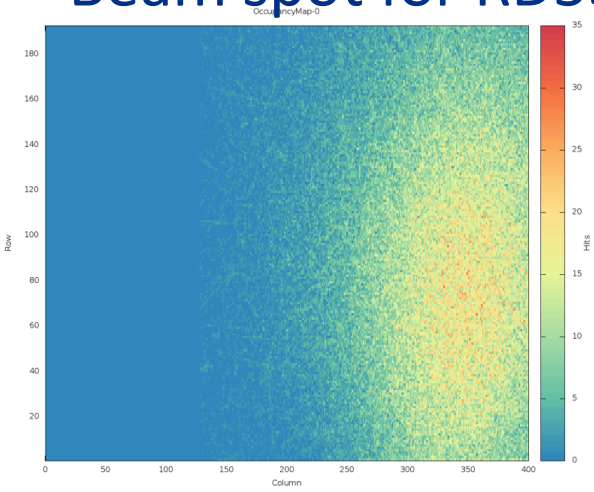
Fermilab

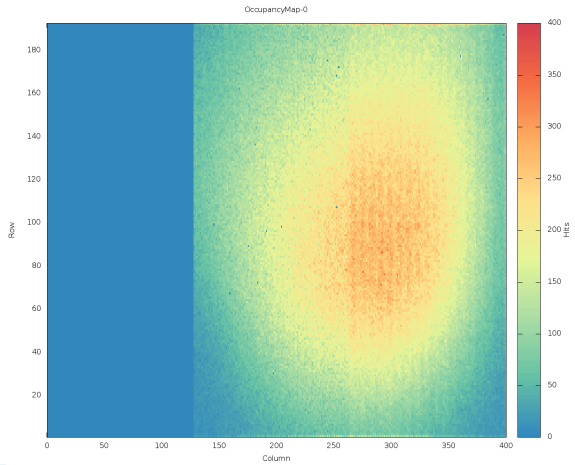
Sensor Testing

- A large variety of sensors, both irradiated and not, were tested in these telescopes
  - 3D sensors (T992)
- Readout chips
  - RD53a (both CMS and ATLAS)
- LGAD detectors also tested



Beam spot for RD53a chips: ATLAS (Left), CMS (Right)

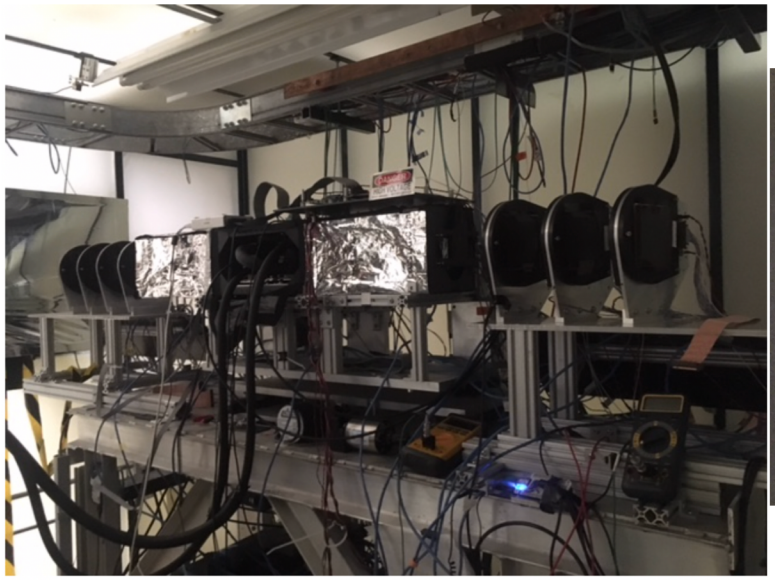


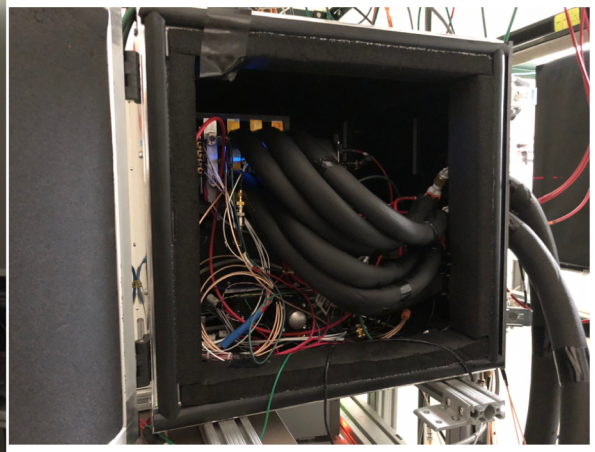


Fermilab

CMS Timing

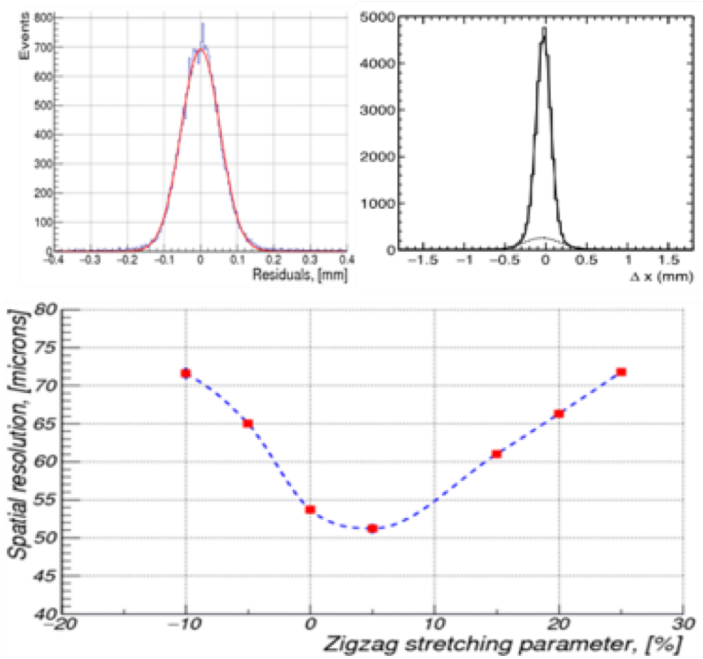
- High priority for the US CMS group
- Looking for radiation hard solutions with timing resolutions between 30-40 ps.
- Endcap and barrel detectors technologies tested
  - Endcap: LGAD
  - Barrel: SiPM-LYSO





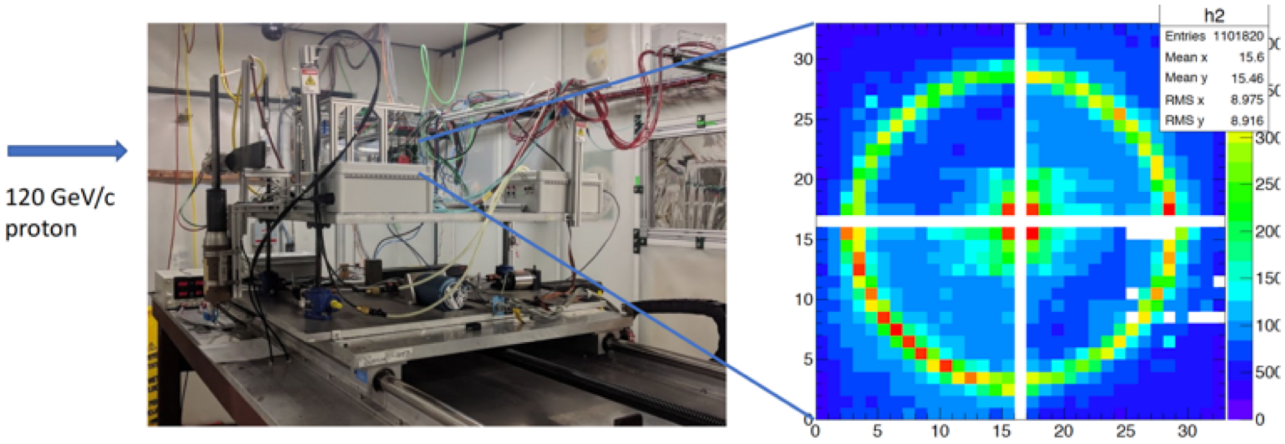
EIC R&D Groups

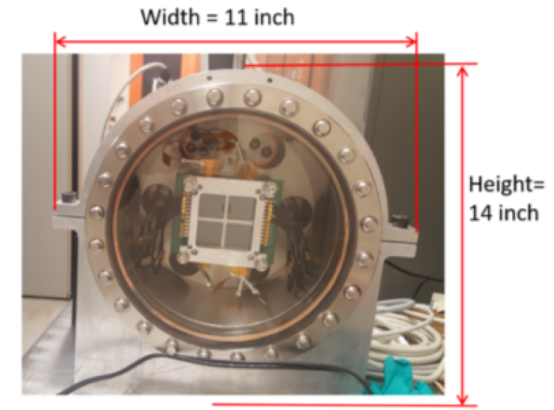
- ZigZag readout for GEMs and Micromega detectors
  - Testing different type of zigzags
  - Resolutions between 50 and 90 microns



EIC R&D groups

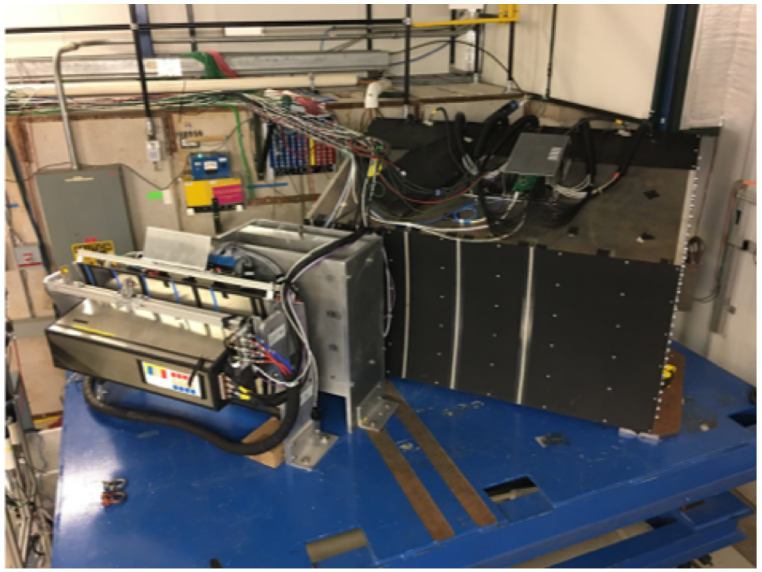
- EIC PID groups (Argonne, Hawaii, Georgia)
  - Using LAPPD Style MCP-PMTs
  - Looking at imaging detectors (RICHs, DIRCs)

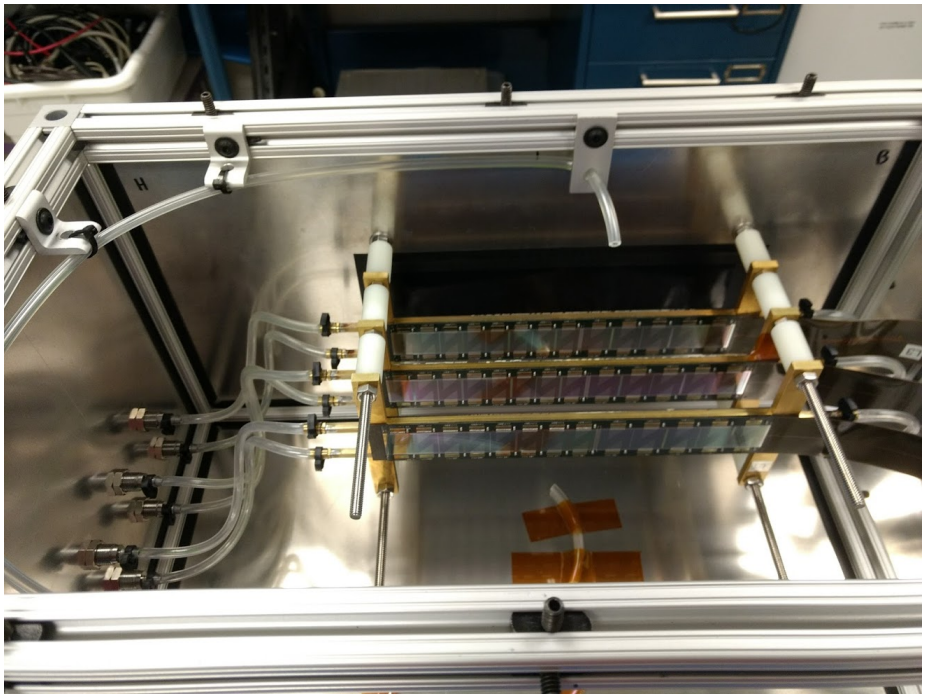




sPHENIX Groups

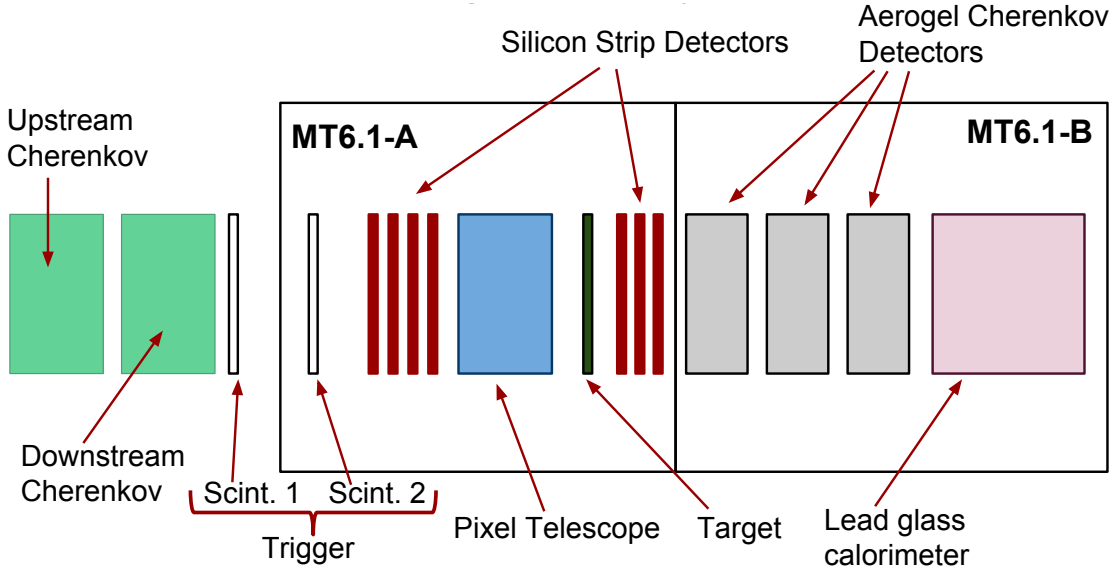
- Calorimeter, Silicon Strip, MAPS vertex Detector tests
  - Part of the goal was integrated tests of these detectors and DAQ system





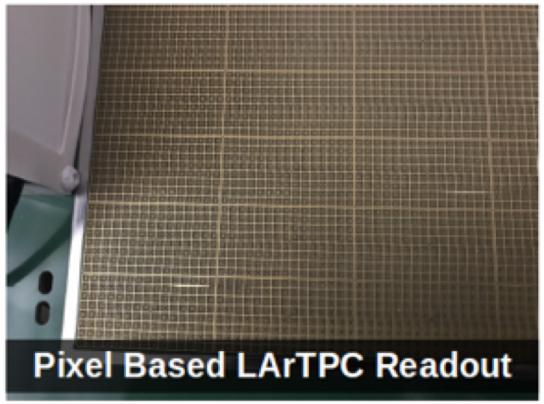
EMPHATIC

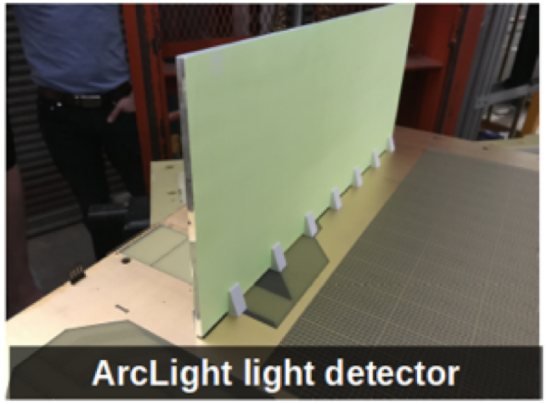
- Testing emulsion detectors to be used for hadron identification.
  - Goal is to measure pion, proton, and kaon production cross sections
  - Big neutrino experiment background, goal is to help reduce that
  - Funded via US-Japan funding stream
  - Multi-year testing

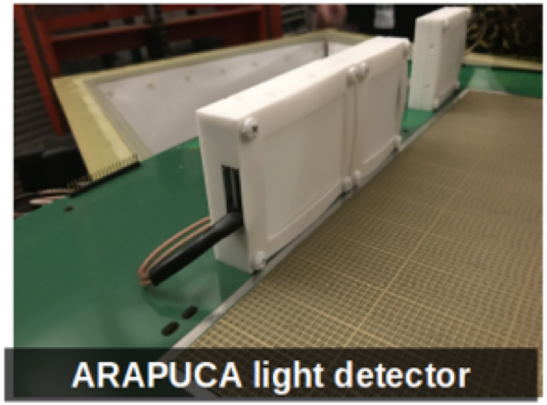


PixLAr and SBND Cold electronics

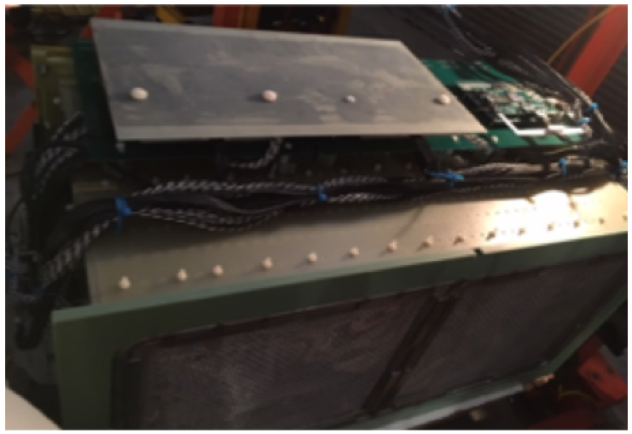
- PixLAr testing pixel planes instead of wires for LAriAT

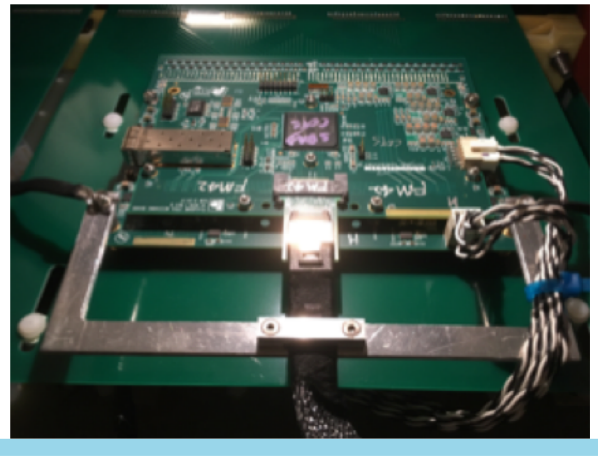

Pixel Based LArTPC Readout


ArcLight light detector

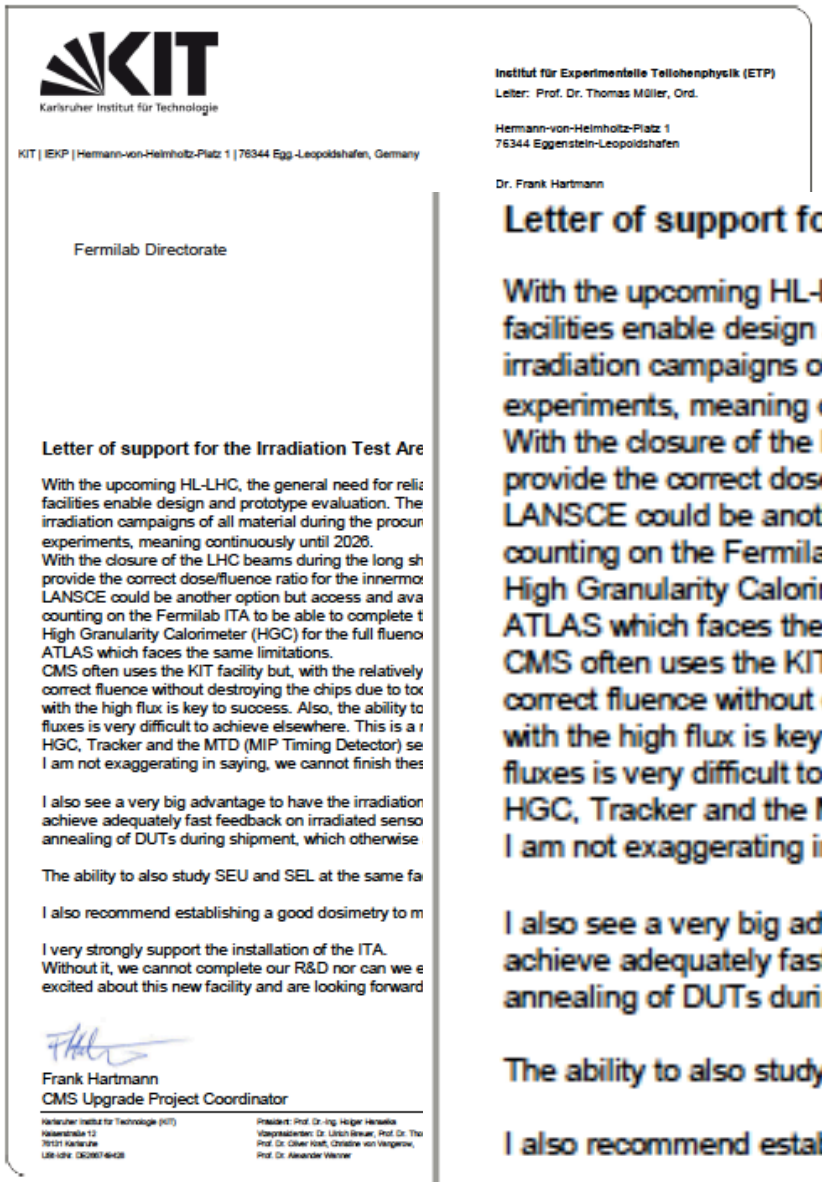

ARAPUCA light detector

- SBND
  - Testing TPC readout, DAQ, online monitoring, etc





Letter of Support from CMS Upgrade Coordinator



Karlsruher Institut für Technologie

KIT | IEKP | Hermann-von-Helmholtz-Platz 1 | 76344 Egg.-Leopoldshafen, Germany

Institut für Experimentelle Teilchenphysik (ETP)
Leiter: Prof. Dr. Thomas Müller, Ord.

Hermann-von-Helmholtz-Platz 1
76344 Eggenstein-Leopoldshafen

Dr. Frank Hartmann

Fermilab Directorate

Letter of support for the Irradiation Test Are

With the upcoming HL-LHC, the general need for reli
facilities enable design and prototype evaluation. The
irradiation campaigns of all material during the procur
experiments, meaning continuously until 2026.
With the closure of the LHC beams during the long sh
provide the correct dose/fluence ratio for the innermo
LANSCE could be another option but access and ava
counting on the Fermilab ITA to be able to complete t
High Granularity Calorimeter (HGC) for the full fluenc
ATLAS which faces the same limitations.
CMS often uses the KIT facility but, with the relatively
correct fluence without destroying the chips due to to
with the high flux is key to success. Also, the ability to
fluxes is very difficult to achieve elsewhere. This is a
HGC, Tracker and the MTD (MIP Timing Detector) se
I am not exaggerating in saying, we cannot finish thes

I also see a very big advantage to have the irradiation
achieve adequately fast feedback on irradiated senso
annealing of DUTs during shipment, which otherwise

The ability to also study SEU and SEL at the same fa

I also recommend establishing a good dosimetry to m

I very strongly support the installation of the ITA.
Without it, we cannot complete our R&D nor can we e
excited about this new facility and are looking forward

Frank Hartmann
CMS Upgrade Project Coordinator

Karlsruher Institut für Technologie (KIT)
Kaiserstraße 12
76131 Karlsruhe
USt-IdNr: DE260764436

Präsident: Prof. Dr.-Ing. Holger Hanselka
Vizepräsidenten: Dr. Ulrich Breuer, Prof. Dr. Tho
Prof. Dr. Oliver Kraft, Christine von Vangerow,
Prof. Dr. Alexander Wanner

KIT – Die Forschungsuniversität in der Helmholtz-Gemeinschaft

Letter of support for the Irradiation Test Area "ITA" at Fermi National Laboratory

With the upcoming HL-LHC, the general need for reliable irradiation facilities is increasing. These facilities enable design and prototype evaluation. They are also vital for long term Quality Assurance irradiation campaigns of all material during the procurement and assembly stages of the HL-LHC experiments, meaning continuously until 2026.
With the closure of the LHC beams during the long shutdown LS2, we lost access to any facility able to provide the correct dose/fluence ratio for the innermost radii of the tracker and forward detectors. LANSCE could be another option but access and availability are not adequate. We are therefore counting on the Fermilab ITA to be able to complete the required studies for the CMS inner tracker and High Granularity Calorimeter (HGC) for the full fluence range. Many studies are conducted together with ATLAS which faces the same limitations.
CMS often uses the KIT facility but, with the relatively low available energy, it is impossible to reach the correct fluence without destroying the chips due to too high TID. The high energy at ITA in combination with the high flux is key to success. Also, the ability to irradiate large areas (full sensors/modules) at high fluxes is very difficult to achieve elsewhere. This is a mandatory requirement for the irradiation of the HGC, Tracker and the MTD (MIP Timing Detector) sensor/modules.
I am not exaggerating in saying, we cannot finish these studies without the ITA.

I also see a very big advantage to have the irradiation on site of the major contributing CMS institute to achieve adequately fast feedback on irradiated sensors/electronics and to be able to avoid uncontrolled annealing of DUTs during shipment, which otherwise always adds large uncertainties to the results.

The ability to also study SEU and SEL at the same facility seems unique and will open new possibilities.

I also recommend establishing a good dosimetry to minimize uncertainties on the applied fluence/dose.

I very strongly support the installation of the ITA.
Without it, we cannot complete our R&D nor can we evaluate our prototypes correctly. We are very excited about this new facility and are looking forward to extensively use it.

Letter of Support from ATLAS

From: "Kotcher, Jonathan" <kotcher@bnl.gov>

Subject: Radiation testing

Date: September 28, 2018 at 3:41:47 PM CDT

To: Vivian O'Dell <odell@fnal.gov>

Dear Vivian:

The U.S. ATLAS institutions participating in the High Luminosity LHC (HL-LHC) Upgrade Project are developing many different devices that require verification of radiation tolerance to significant levels. The Application-Specific Readout Circuits (ASICs) for the ATLAS inner trackers and calorimeters are good examples of this. Currently operating facilities that can reach the required fluences have limited availability, which often leads to prohibitively long wait times (up to 1 year). Such wait times can have a significant impact on the overall construction schedules. Access to a facility that can meet the highest radiation tolerance test levels required with high availability would significantly reduce the risks associated with ensuring that our designs meet the radiation tolerance specifications. Such a facility available at Fermilab will enhance our ability to meet our international obligations.

If there are any additional details we can provide, please don't hesitate to let us know.

Sincerely,

Dr. Jonathan Kotcher
Senior Scientist
Brookhaven National Laboratory
Project Manager, U.S. ATLAS HL-LHC Upgrade Project

Professor Gustaaf Brooijmans
Professor of Physics
Columbia University
Deputy Project Manager, U.S. ATLAS HL-LHC Upgrade Project

Professor Harold Evans
Professor of Physics
Indiana University
Deputy Project Manager, U.S. ATLAS HL-LHC Upgrade Project

Professor Michael Tuts
Professor of Physics
Columbia University
NSF Principal Investigator, U.S. ATLAS HL-LHC Upgrade Project

Letter of Support from sPHENIX Group at BNL

BROOKHAVEN
NATIONAL LABORATORY

Physics Department
Building 510
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Upton, NY 11973-5000
Phone 631 344-7626
Fax 631 344-3253
mannel@bnl.gov

managed by Brookhaven Science Associates
for the U.S. Department of Energy

October 15, 2018

Dr Joe Lykken

I am writing to you to express my support for a proton irradiation facility at Fermilab. One of the many challenges facing the experimental heavy-ion and nuclear physics programs is designing detectors and electronics that can operate in the radiation environments that are present in the experimental areas. While the effects of ionizing radiation can be studied using radioactive sources such as ^{60}Co, it is also important to understand the effects from charged hadrons on the electronics. A facility at Fermilab that would allow the performance of electronics in a controlled radiation environment to be studied would be extremely beneficial to the community. The ability to monitor the operation of prototype boards, and characterize the degradation of the performance as a result of irradiation would allow for optimization of component selection and board design. In addition to electronics, studies of the effects of radiation on materials used in detector construction (e.g. glues, plastics) will also be of value. These combined studies will result in improved detector designs that will enhance the physics programs in heavy-ion and nuclear physics.

Should Fermilab pursue implementing a proton irradiation facility in the coming year, the sPHENIX calorimeter electronics group would be interested in conducting tests on electronics that has been design for the sPHENIX calorimeters to understand the long term effects on the the electronics.

Sincerely,

Eric J. Mannel, Ph.D.
PHENIX Group
Physics Department
Brookhaven National Laboratory

Test beams* in the world, status September 2017

Laboratory	Number of beam lines	Particles	Energy range	Diagnostics etc.	Availability	Information, contacts & comments
CERN / PS (CH)	2	e, h, μ (sec.)	0.5 - 10 GeV/c	Threshold Cherencov, scintillators, MWPCs, delay wire chambers, scintillators, magnet, movable platform	9 months per year, continous except winter shutdown Duty cycle depends on PS / SPS / LHC operation mode and is typical * PS ~1-3% * SPS: 20-40% No test beams in 2019 and 2020	contact beam time request and scheduling: Sps.Coordinator@cern.ch http://sps-schedule.web.cern.ch/sps-schedule/ contact beam lines: sba-physicists@cern.ch http://sba.web.cern.ch/sba/
CERN / SPS (CH)	4	p (prim.) e, h, μ (sec.) e, h (tert.) Pb ions (prim) other ion species (out of fragmented primary Pb ions)	400 GeV/c 10 - <400 GeV/c 10 - 200 GeV/c 20 - 400 GeV/c proton equivalent (z=1)	Delay wire chambers, filament scanners, XEMC calorimeters, Threshold & CEDAR, hodoscopes, magnet, movable platform		
DAFNE BTF Frascati, (IT)	1	e+/e- both primaries and secondaries	25-750 MeV/c Rep Rate 50Hz 1-40 ns 1 to 10^{10} p/pulse	Calorimeter, silicon pixel, remote trolley, gas system, HV, trigger	depending on DAFNE schedule, from 25 to 35 weeks/year	contact: btf@lnf.infn.it, paolo.valente@lnf.infn.it info at: http://www.lnf.infn.it/acceleratori/btf http://www.lnf.infn.it/acceleratori/padme
DESY (D)	3	e+, e- (sec.) e- (prim., planned for 201X)	1 - 6 GeV/c 6.3 GeV/c	Trigger systems and beam telescopes, magnet (~1T)	10 months per year, Duty cycle ~ 50%	contact: Testbeam-Coor@desy.de http:// testbeam.desy.de
ELPH (Sendai) (JP)	2	photons (tagged) e+, e- (conv.)	0.7-1.2 GeV/c 0.1-1.0 GeV/c beam rate < 500kHz (typical rate: 2kHz)		2 months/year	contact: Toshimi Suda (suda@lns.tohoku.ac.jp) info: http://hayabusa1.lns.tohoku.ac.jp/en/users/?id=a5
FERMILAB/FTBF (US)	2	p (prim.) e, h, μ (sec.) h (tert.)	120 GeV/c 1-66 GeV/c 200-500 MeV/c	Cherencov, TOF, pb-glass calorimeters, MWPC, Si Tracker, see website for more	24 hrs/day 6% duty cycle	contact: FTBF_Co@fnal.gov http://ftbf.fnal.gov/ contact: Mandy Rominsky (rominsky@fnal.gov) Erik Ramberg (ramberg@fnal.gov)
IHEP Bejing (CN)	2	e (prim.) e (sec.) p, π (sec.)	1.1 - 2.5 GeV/c 100 - 300 MeV/c 0.4 - 1.2 GeV/c	MWPC, TOF Cherencov, CAMAC system, platform	Availability: 3 mouths per year, duty cycle depends on BEPCII operation mode	contact: Hu Tao (hut@ihep.ac.cn)
IHEP Protvino (RU)	5	p (prim), p, K, π, μ, e (sec.) C-12 (prim)	70 GeV/c 1-45 GeV/c 6-300 GeV/c	Cherenkov, TOF, MWPC	two months per year duty cycle (U-70 machine): 15-30%	contact: Alexandre Zaitsev (alexandre.zaitsev@cern.ch)
KEK / JPARC (JP)						no dedicated lines for test beams contact: Masaharu Ieiri (masaharu.ieiri@kek.jp) http://j-parc.jp/researcher/Hadron/en/index.html
KEK / Tsukuba (JP)						Fuji beam line in KEKB main ring unavailable until Super KEKB will resume operation http://www.kek.jp/ja/Facility/IPNS/K11BeamLine/
PSI / piE1, piM1, etc. (CH)	2-4	π+-, μ+-, e+-, p	50-450 MeV/c, rate <10^9 sec^{-1} 20nsec structure continuous beam at very high rate		6-8 months per year	beam time allocated by programme committee (twice per year) contact: Davide Reggiani (davide.reggiani@psi.ch)
PSI / PIF (CH)	1	p	5 - 230 MeV/c max. current 2 - 5 nA, rate <10^9 sec^{-1}, typ. flux 10^8 cm^{-2} sec^{-1} for wide beam, energy, beam spot and flux selectable by user		11 months per year, mostly during weekends	contact: Wojtek Hajdas (wojtek.hajdas@psi.ch)
SLAC (US)	1	e (prim.) e (sec.)	2.5 - 15 GeV/c 1 - 14 GeV/c		9 months per year, 50% duty cycle	contact: Carsten Hast (hast@slac.stanford.edu) https://slacportal.slac.stanford.edu/sites/ard_public/tfd/
SPRING-8, Compton Facility (JP)	1	photons (tagged) e+, e- (conv.)	1.5 - 3.0 GeV/c 0.4 - 3.0 GeV/c		>60 days per year	contact: Takashi Nakano (nakano@rcnp.osaka-u.ac.jp) http://www.spring8.or.jp/en/
University of Bonn ELSA	1	e-	Energy range: 1.2 - 3.2 GeV rate: ~1 kHz - 1 GHz	Trigger, beam telescope	upon request, ~30 days/year	contact: Daniel Elsner elsner@physik.uni-bonn.de http://www-elsa.physik.uni-bonn.de/elsa-facility_en.html

*Beam lines with beams of energies higher than 100 MeV/c

CR, Sept 2017