Fermilab

Managed by Fermi Research Alliance, LLC for the U.S. Department of Energy Office of Science

Fermilab Irradiation Test Area: ITA

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Recent Recommendations from DOE Reviewers

- 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.

Other users beyond CMS/ATLAS

- We distributed a survey to potential users
  - Not comprehensive but indicative of extent of the need for this type of beam facility
  - https://www.dropbox.com/s/z4lfshhl7b2lrqw/Responses_All_180522.pdf?dl=0

- The need is strong enough to support a variety of radiation testing areas, world-wide:
  - CMS, ATLAS, Mu2e-II, DUNE, LHC-B, sPHENIX, TOTEM, RD50, RD53, CubeSats

- Need within aeronautics industries:
  - Boeing used 2000 hours of beam time at Indiana cyclotron until that facility closed

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

Beam extraction in Fermilab LINAC

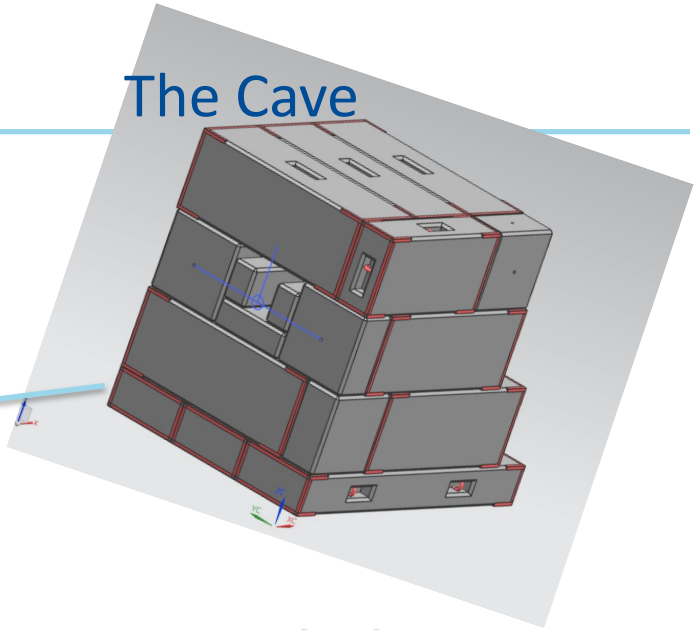
- "Pulses" from the LINAC can be extracted during the 6 second flattop of the SY120 spill and thus have minimal effect on Neutrino pulses
- By running the Irradiation Test Area simultaneously with FTBF, we have no impact on the rest of the program:
  - Conservative estimate is 40 pulses available.

- 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

Layout of MTA enclosure



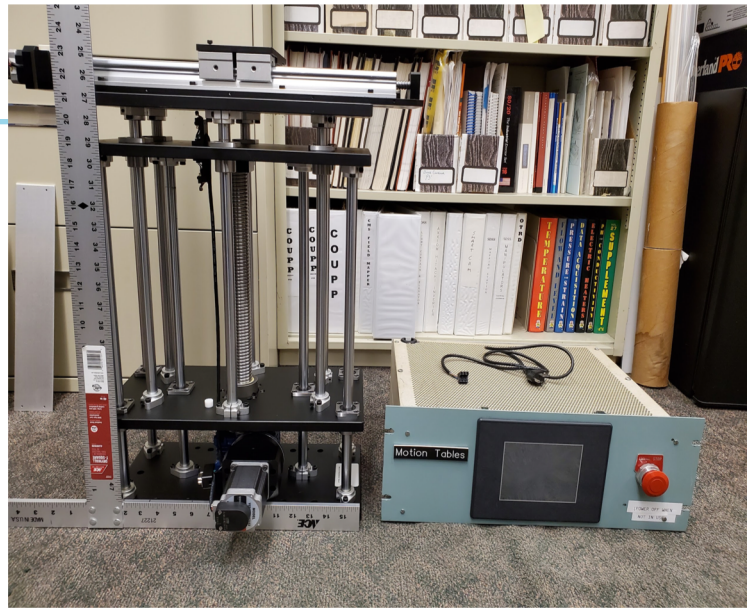
Final Beam Absorber

Emittance Beam Absorber

Shield Wall
Between Linac
and MTA Hall

User Infrastructure

- Motion stage in front of cave for initial running (low radiation length material only)
- Install trolley system next summer shutdown (maybe earlier, but cannot guarantee)
- Cold box & chiller, power, cable run (user cables can be pulled if needed), freezer
- Upstairs user room for remote readout of DUTs (maybe only after summer shutdown?)
- Beam instrumentation, dose measurements, etc.



Residual activation of outside (of cave) surfaces

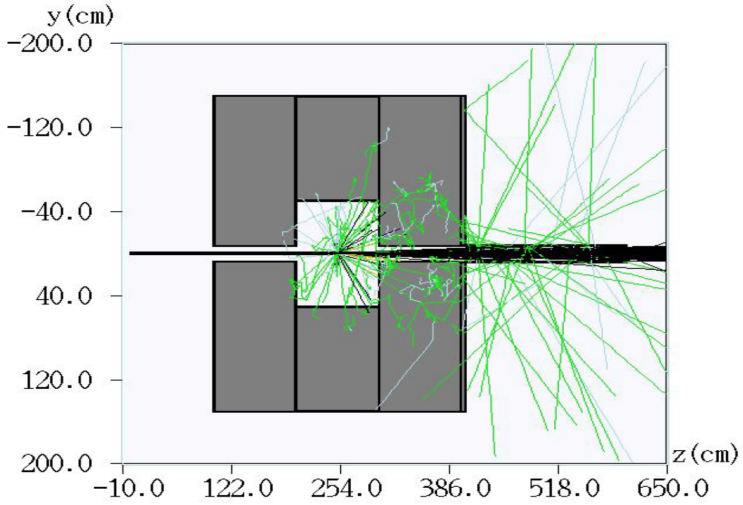
From preliminary shielding assessment

Outside Surfaces after 1 day	10% X_0 (0.9 cm Si)	10% λ (4.7 cm Si)	Worst Case (45 cm Fe)
Upstream wall	0.06	0.12	1.16
Side walls	0.96	0.97	5.00

mRem/hour

(for comparison: Radiation Area at Fermilab: 5-100 mRem/hr)

Table 2. Results from MARS calculation. [4] Predicted residual activation in mrem/hour of the outer surfaces of the shielding cave blocks following twelve hours of irradiation by 400 MeV protons at 5×10^{12} protons/second and one day of cool-down time. [5]



Timeline

- Got money from DOE for construction in September → Thank you!
- Started site prep and construction immediately
- Ongoing:
  - Beamline reconstruction (repositioning of magnets)
  - e^- stripping station
  - Repair of several MWPCs
  - Shielding assessment
  - Safety and interlock plans and documentation
  - Construction of shielding cave and user infrastructure
- Goal is to finish all this in January and commission in February
- First users in March → very optimistic
  - Preference for silicon-only users first
  - Attempting to coordinate with beam time at testbeam
- Additional user infrastructure over summer shutdown
- Scheduled to run until PIP-II comes online (LINAC will be turned off) ~2025?

Operations

- Users will be scheduled and coordinated through FTBF (testbeam) group
  - 1 user per week: install, 12 hour run, cool-off, retrieve
- In communication with users from CMS and ATLAS on needs and timeline, both groups in FTBF this week
  - Tentative scheduling timeline to be developed in January
  - Please visit: https://ftbf.fnal.gov/ to contact the coordinators and schedule beam time

Summary

- It is highly recommended that the U.S. embark on providing a HL-LHC intensity proton irradiation facility on-shore for quick turnaround and high reliability.
- After getting input and comments from the HEP (and other) communities, we believe that a radiation facility could be built cheaply and quickly in the MTA enclosure at the end of the Femrilab LINAC beam line.
- Proximity to the Fermilab Test Beam Facility is highly synergistic for quick turnaround on testing new devices.