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FTBF Experience

Evan Niner
edniner@fnal.gov

Workshop on Test Beam Opportunity's at SLAC's LESA



U.S. DEPARTMENT
of **ENERGY**

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Introduction

- Fermilab Test Beam Facility (FTBF) – Supports a wide program of research and detector R&D
 - 2 Beamlines (MTest and MCenter) – can provide particles from 120 GeV protons to secondaries of 1-2 GeV in MTest, tertiaries down to ~200 MeV in MCenter
 - MTest spends ~10% of operations delivering beam with an electron component
- Beam is available ~8 months a year (roughly November through June)
 - No beam since July of 2024 due to power transformer issues, limited beam available before 2030 as the accelerator complex upgrades for PIP-II and LBNF



Where is FTBF?



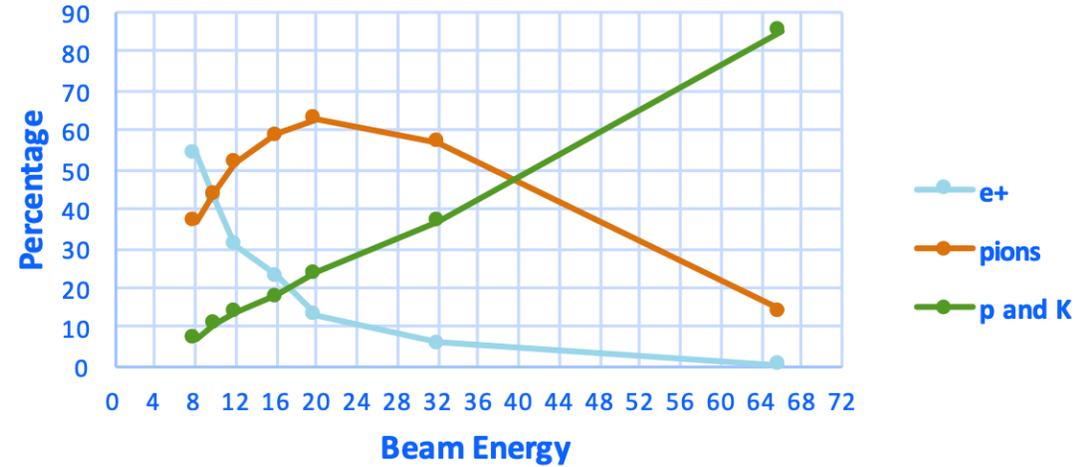
FTBF –
Meson
Detector
Building

ITA –
Irradiation
Test Area

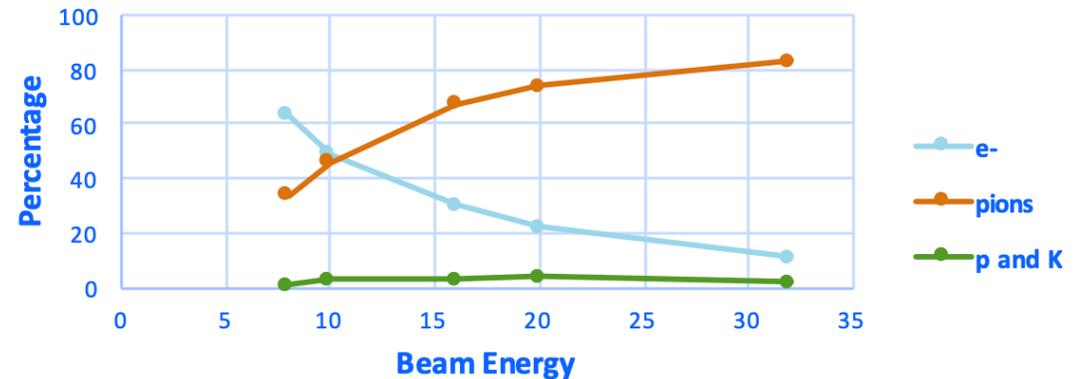
Beam Details

- 4.2 second slow extraction beam spill every super cycle from Main Injector
- ~1000 to 900,000 particles per spill
- MTest
 - 120 GeV protons
 - 1-66 GeV mixed secondary beam
 - ~2cm spot size
 - typically 1-4 week experiments
 - ~10% of a normal year spent in "low energy" mode <32 GeV with some electron component
- MCenter
 - Secondary beam, 8-90 GeV pions
 - Two tertiary beam stations down to 200 MeV
 - Longer term experiments

Positive Beams Composition, Open Collimators 2016



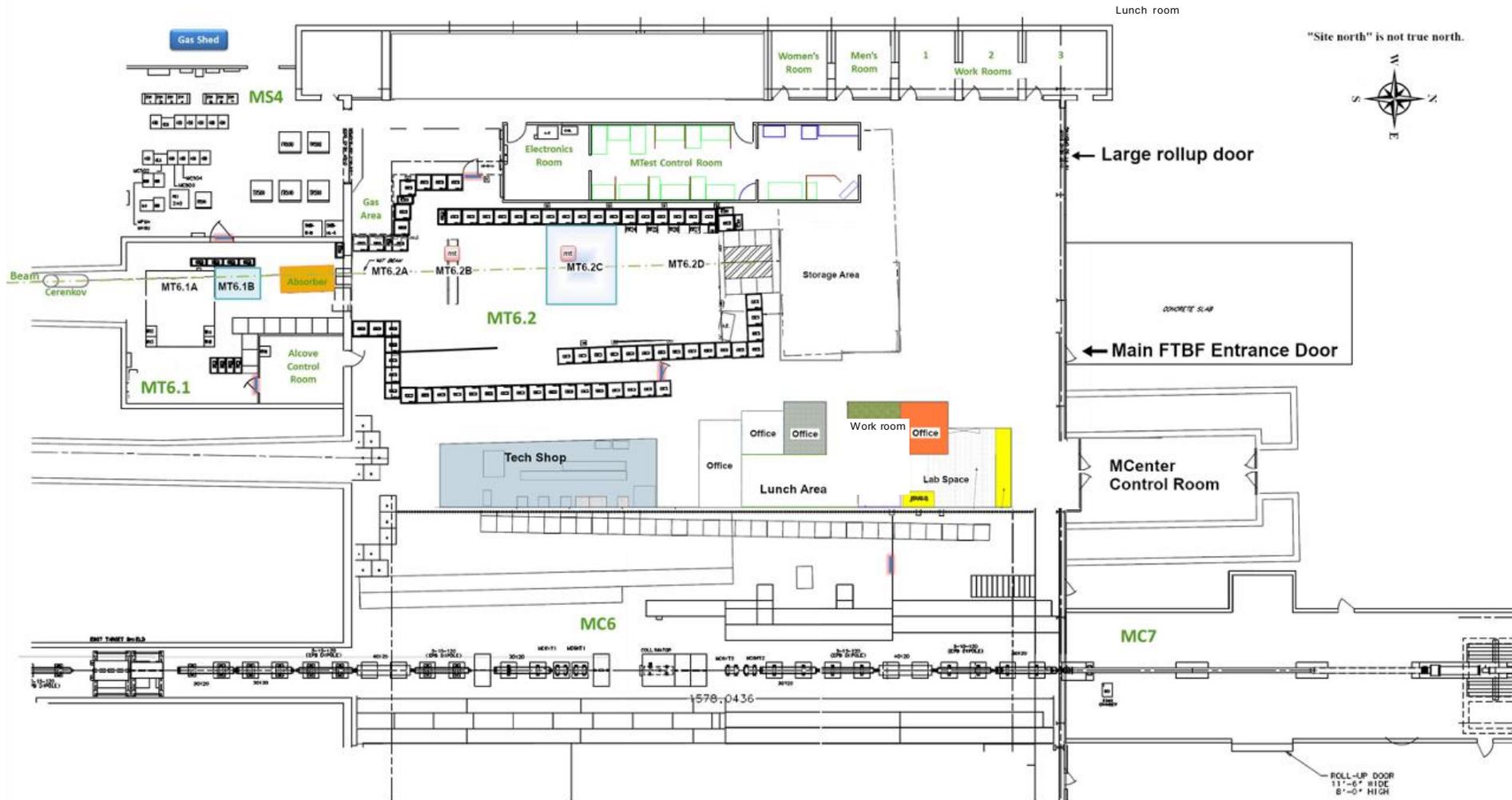
Negative Beams Composition, Open Collimators 2016



<https://ftbf.fnal.gov/beam-overview/>

FTBF Layout

Onsite technical and scientific staff coordinate experiments from planning through execution safely and efficiently.



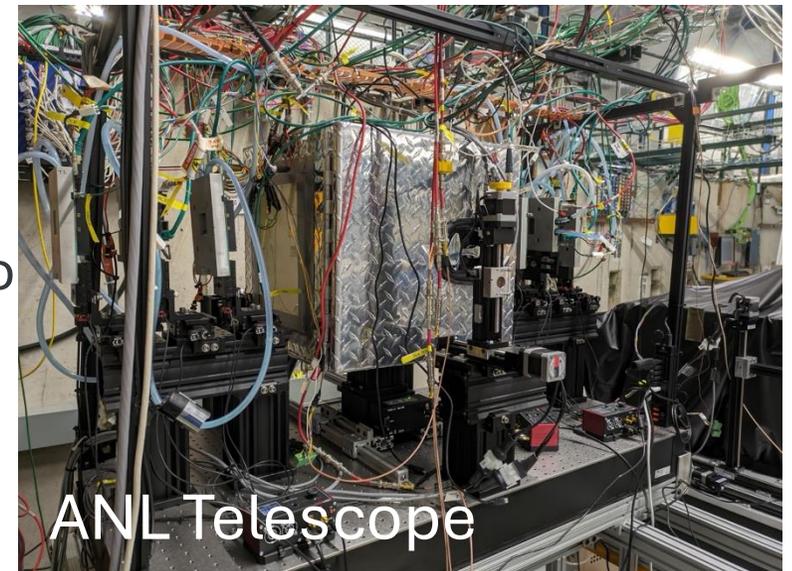
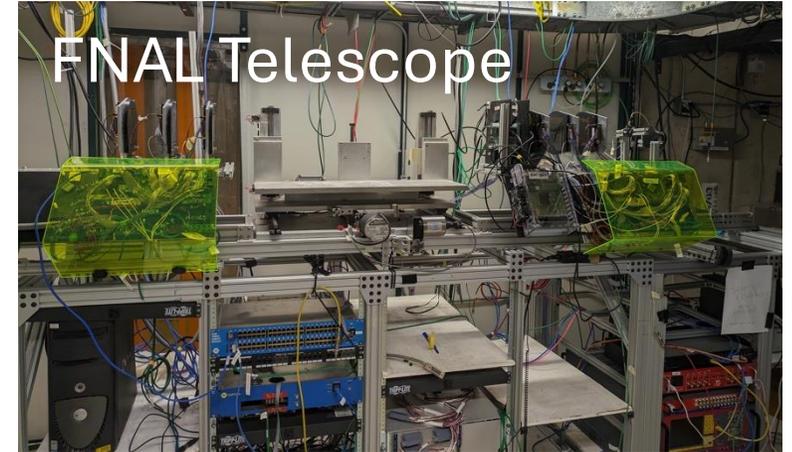
FTBF Layout - MTest

- Maintain plug-and-play infrastructure to minimize installation overhead and maximize beam efficiency
- FTBF provides beamline instrumentation and DAQ, tools, cabling and patch panels, motion tables, common equipment pools, gas delivery systems, control room and computing, access to other lab resources
- One experiment changeover day per week, six days beam delivery



Tracking Telescopes

- 2 silicon telescopes are in the MTest beam line
 - One built and operated by FNAL
 - One built and operated by ANL
- Allow precision tracking of particles to $\sim 5\mu\text{m}$
- Motion tables allow scanning location of devices under test
- Used largely for CMS and ATLAS tracker tests, but available to all users
- Crucial infrastructure for a test beam facility

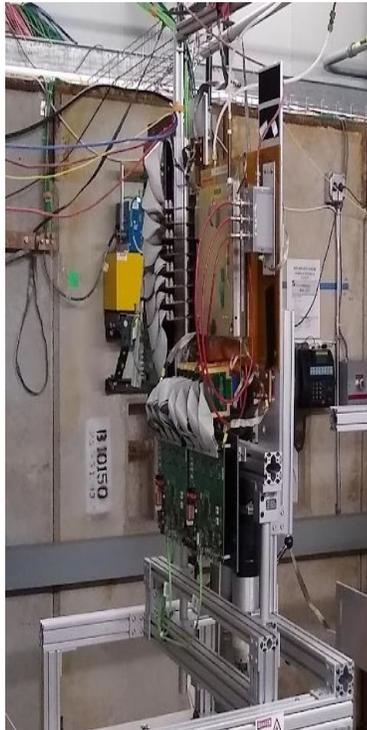




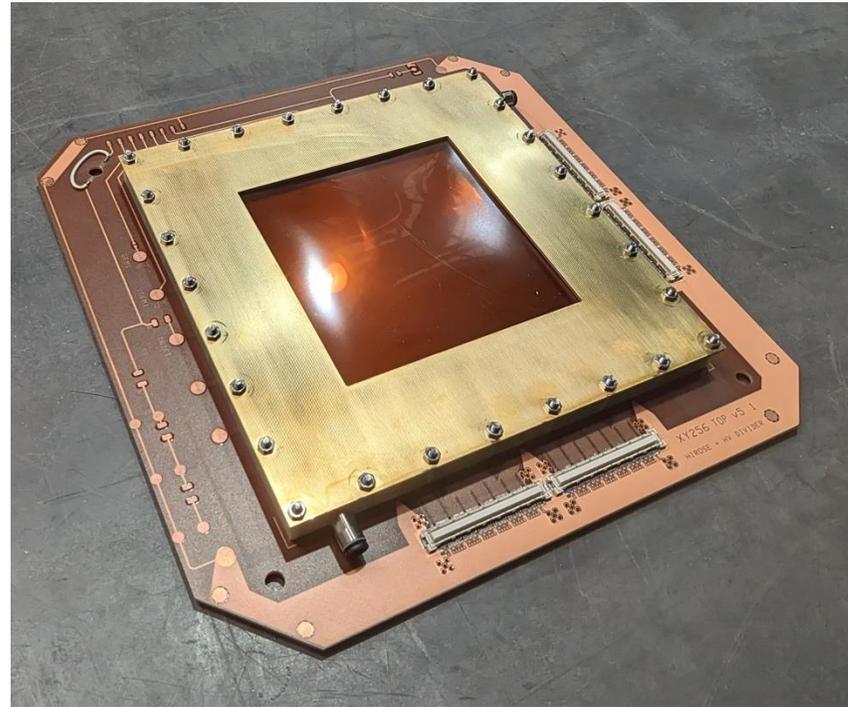
Instrumentation upgrades – Particle tracking

- Replacing Fenker chambers for particle tracking in MT6.2 with CERN GEM chambers
- GEM chambers have arrived at FNAL in March
- Scalable Readout System DAQ solution, developed by RD52 collaboration, has arrived and system is in process of being deployed

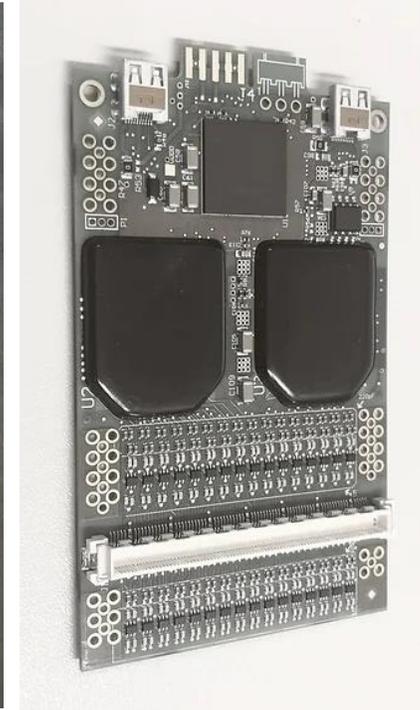
Fenker Chamber



GEM Chamber



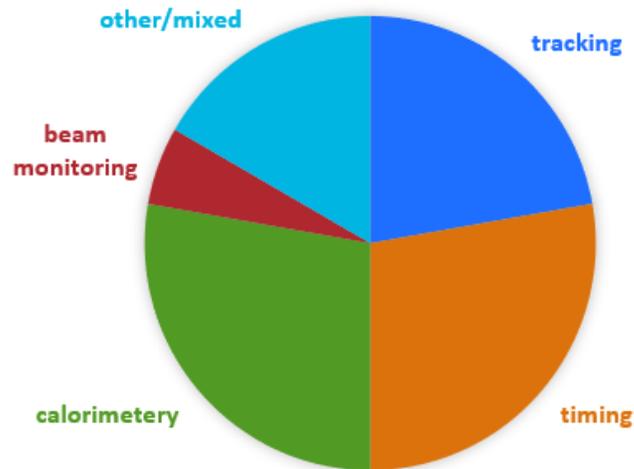
SRS VMM3a card



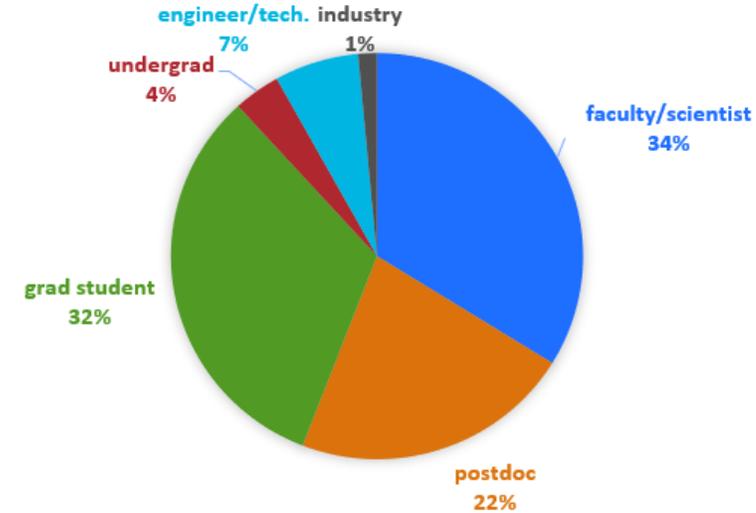
Who Uses FTBF?

- 223 users in FY23
- Users from 53 Universities/Labs (18 international)
- 20 Experimental efforts, 4 new efforts

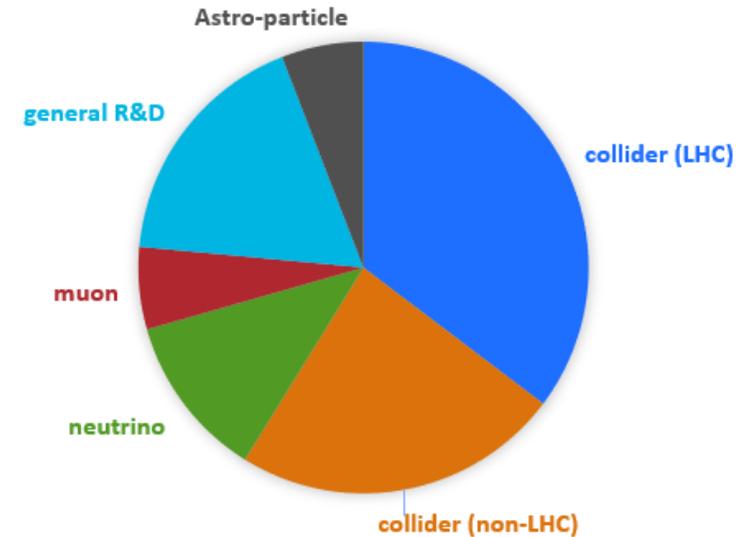
Experiment by detector



Users by professional category

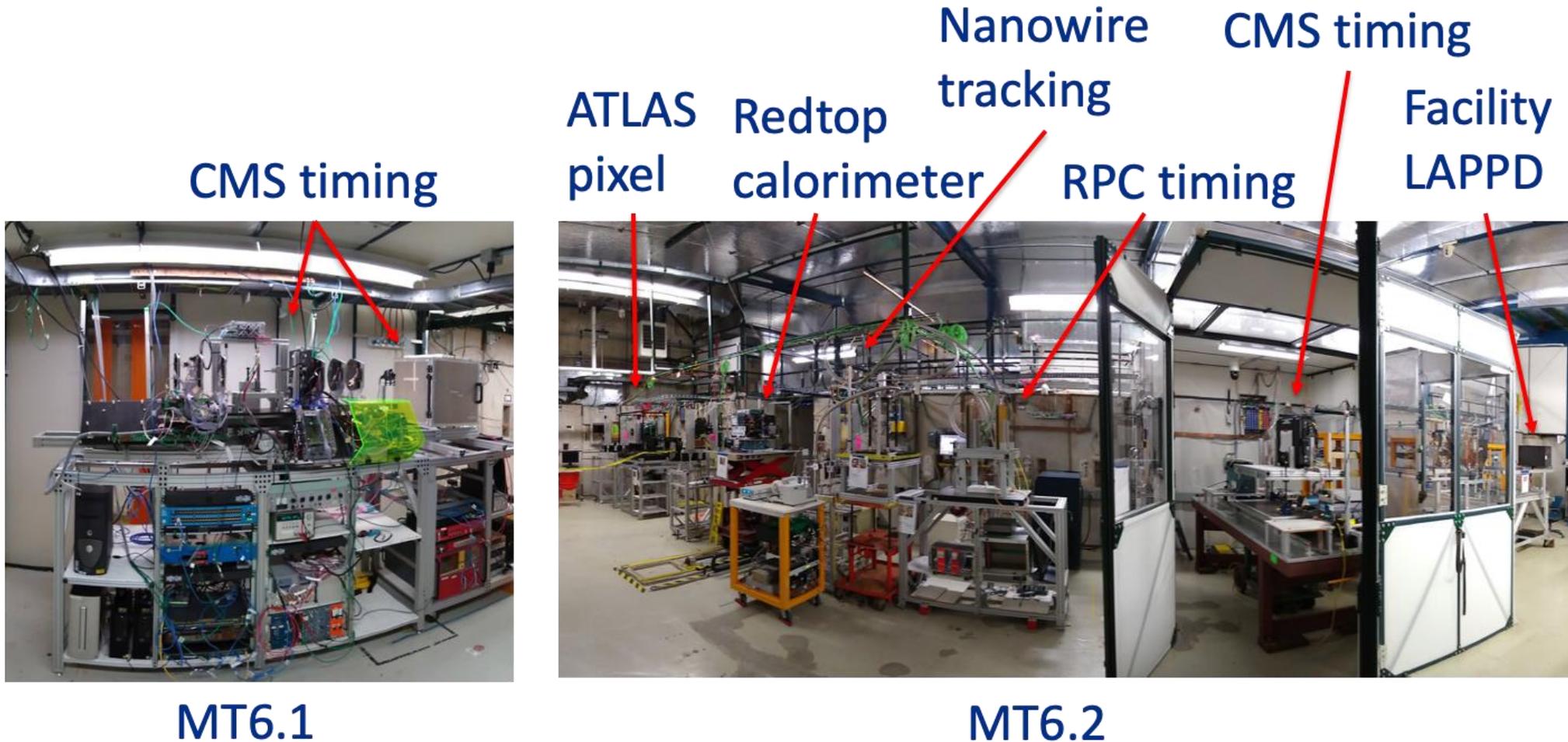


Experiment by research focus



Experiments at MTest

- FY23, MTest users have included experiments from the CMS, ATLAS, EIC, neutrino, quantum, and general R&D communities





Electron Requests at MTest

- ~10% of a beam year may be spent in low energy pion beam modes (<32 GeV) with some fraction of electron composition
 - Mostly testing a variety of calorimeter prototypes (CMS, ATLAS, EIC, blue sky R&D), NASA satellite payloads, dark matter prototypes (DarkQuest, DAMSA), and hadron production measurements for neutrino experiments (EMPHATIC)
- Facility features in use or desired by these users
 - X-Y motion tables capable of holding up to a couple tons of detector with sufficient range to scan across detector surface
 - Gas distribution system. Users were bringing their own carts to mix custom ratios of gases but increased time and cost in the Fermilab engineering review process to approve these setups led the facility to build its own gas mixing system for users in 2024.
 - Tracking stations, both precision telescopes and larger chambers
 - Eliminating material in the beam and air gaps to reduce scattering
 - Clock distribution and improved DAQ interfaces
 - Users would like a more precise calibration of the beam energy and spread being delivered. Accelerator operators set magnet settings based on old measurements, not direct readout of beam energy being delivered unless users report it back.

FTBF Beam Status

- The FNAL Main Injector (MI) is currently unable to operate due to issues with site power transformers
 - Fermilab complex powered by 8 main transformers split between 2 substations
 - On August 3, 2024 one of the transformers caught fire and was destroyed due to faulty high voltage bushing
 - During investigation in the following weeks vendors provided documentation that 2 more transformers has the same faulty bushings and they were taken offline
 - During startup inspections after the usual summer shutdown 2 more transformers were discovered to have critical issues and needed to be removed from service



FTBF Beam Prospects

- To run the entire FNAL accelerator complex 4 of 8 transformers are required With only 3 of 8 transformers operational the MI can not be run
 - The fastest way to recover MI operation is to replace the recalled bushings in 2 transformers
 - New bushings for these transforms are a custom order and are not expected to arrive until ~Jun 2026
 - New transformers have a 2–3-year lead time
 - **After installation and recommissioning the transformers, MI beam can be restored, leaving the possibility of only a few months of running in 2026 at best for FTBF before the FNAL accelerator complex is taken offline for the long shutdown to upgrade the linac with the new PIP-II linac. Beam to Switchyard and FTBF will not be possible after December 2026 until late 2030 during the accelerator shutdown.**
- All of our regular FTBF users will be searching for test beams. We expect that many of our customers who come to FTBF for 120 GeV proton beam (such as the silicon sensor and timing detector communities) would be interested in SLAC beam. This population at FTBF has typically required a precision tracking telescope and cares about the clock distribution and DAQ integration.



Summary

- Due to complications from power transformers and the upcoming long accelerator shutdown for PIP-II/LBNF, between now and late 2030 FTBF only anticipates a few months of beam operations in late 2026 at best.
 - Anticipate that many of our regular users (both electron beams and protons) would be interested in another US test beam option during this time
- Having sufficient dedicated scientific and technical support staff with a flexible infrastructure helps support a wide range of experiments.