Fermilab Test Beam Facility

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TIPP 2014 - Amsterdam

Location

Fermi National Accelerator Laboratory

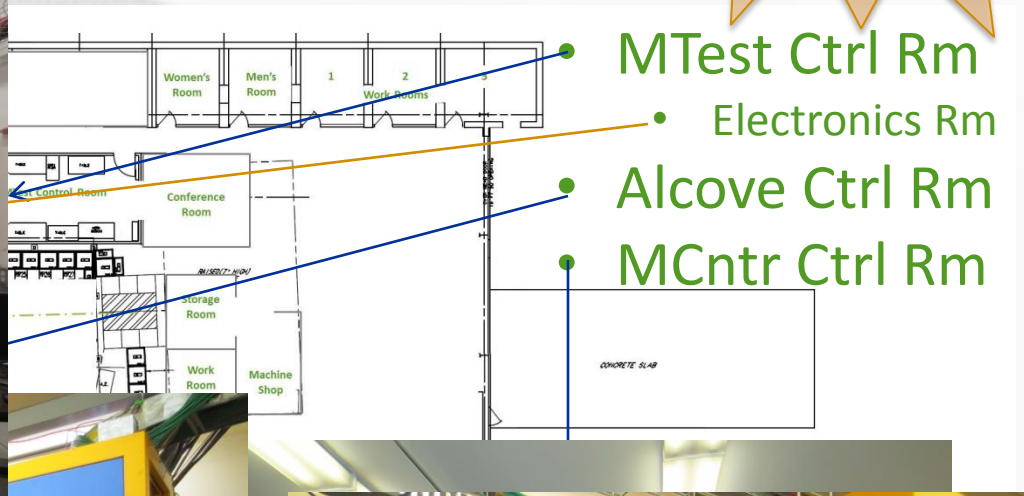
Meson Detector Building – West

Layout and Rooms

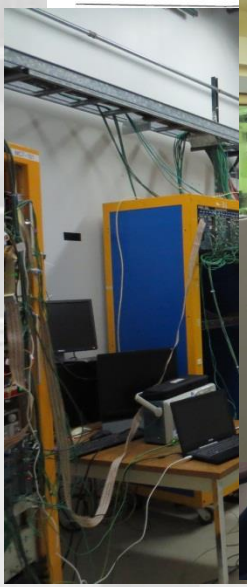
- Beam Areas
- Work Areas
- Control Rooms

3 Control Rooms

All, Newly Renovated!



- MTest Ctrl Rm
  - Electronics Rm
- Alcove Ctrl Rm
- MCntr Ctrl Rm

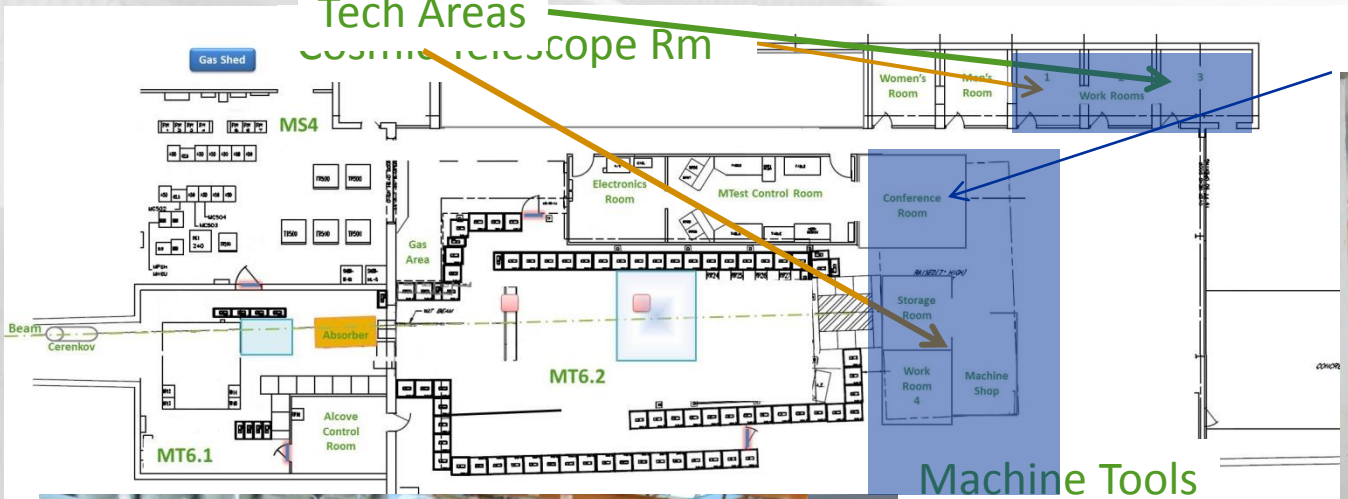


New!

Work Areas

Currently being Renovated!

Tech Areas

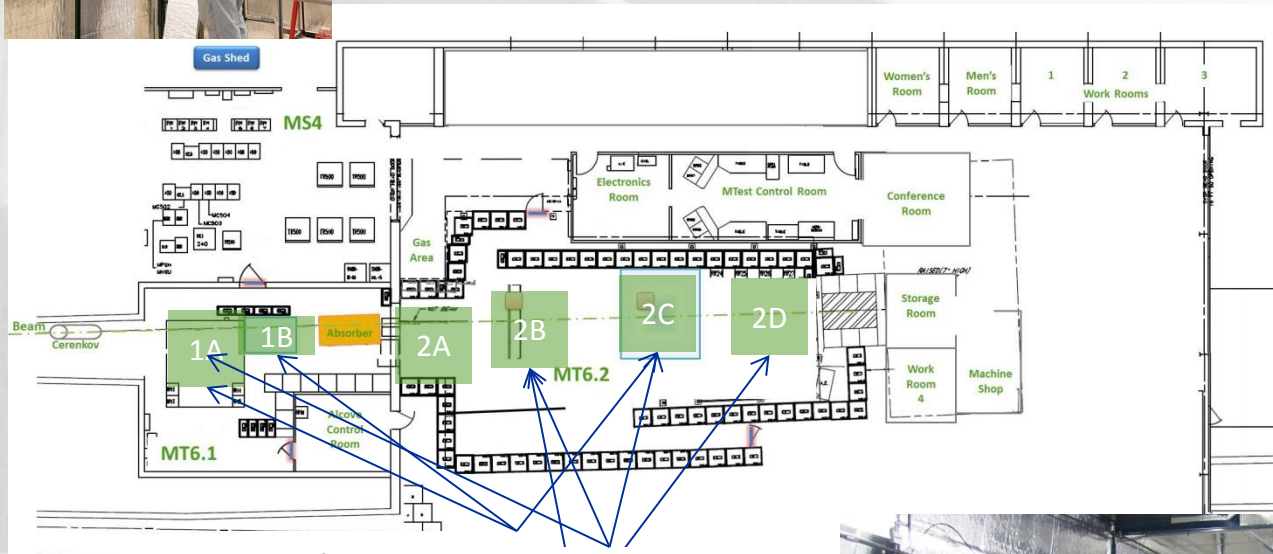


Machine Tools

Beam Areas

Section 2 Newly Insulated!

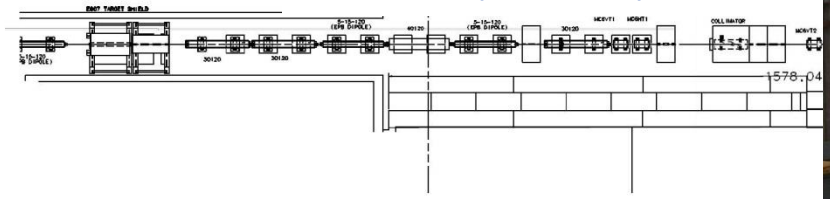
6 MT6 Experiment Areas



2 MC7 Experiment Areas under development

3 CI

3 areas with ACNET Controlled Motion Table (30 Tons)



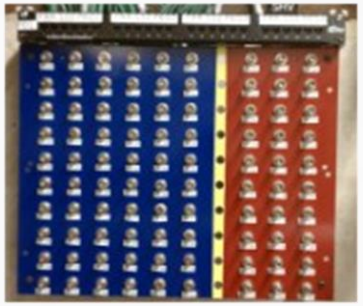
New!

MCenter Beamline

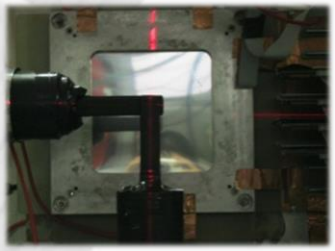
- Beamline Now Operational!
  - Similar beam to MTest
  - Long dwell time experiments
  - Overflow/make-up experiments
- Supports Liquid Argon (Under development)

- Tertiary beamline Option
  - Protons & Pions
  - 200 MeV – 1 GeV range
- Large Dipole Magnets
  - ~ 1 Tesla
  - 1 meter bore

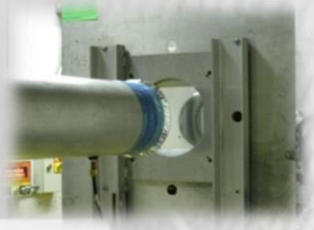
Facility Equipment



- Patch Panels (Newly Upgraded!)
  - in enclosures and control rooms
  - Signal (lemo & BNC), SHV, Network (CAT5), Power, and other assorted cables are available to users in various lengths and quantities.
  - Including network controlled power strips



- Lasers for Alignment (Newly Upgraded!)
- Helium Tubes

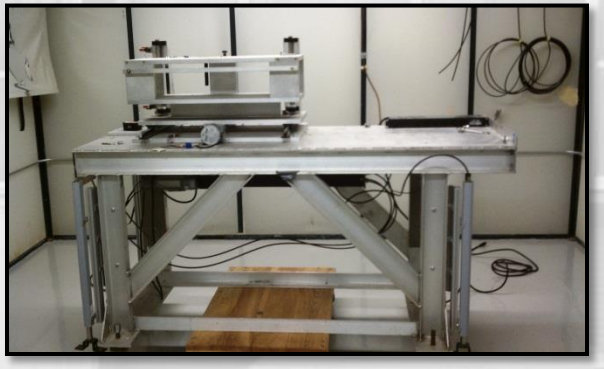


- Phone System (Newly Upgraded!)
- Web-based Cameras (Now in MT6.1A & 1B!) (All of MT6.2)

Motion Tables

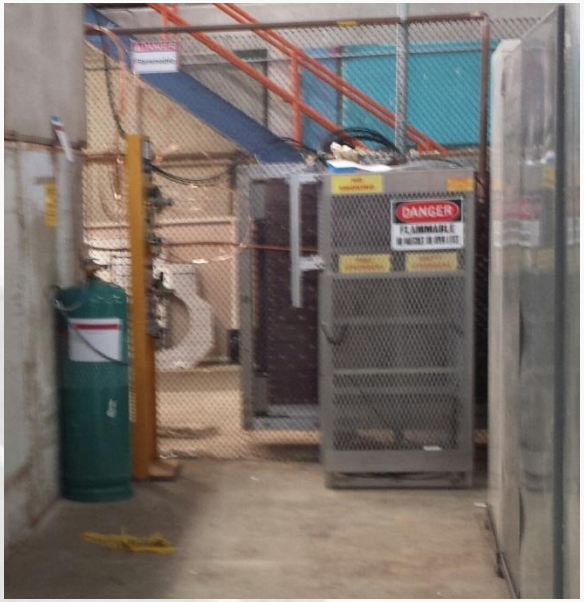
New, Better Control System!

- ACNET Controlled to minimize accesses
- 1mm precision in X/Y
- Rotation option now available!
- Smaller stages with centimeters of travel available for small loads

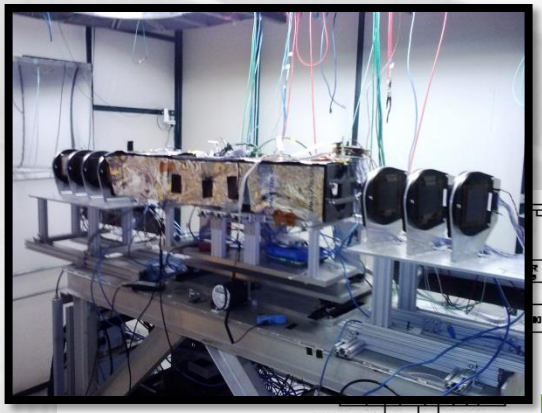


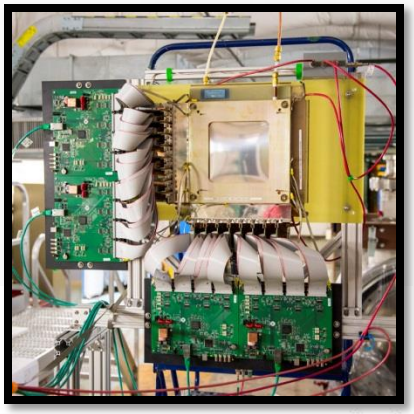
Gas

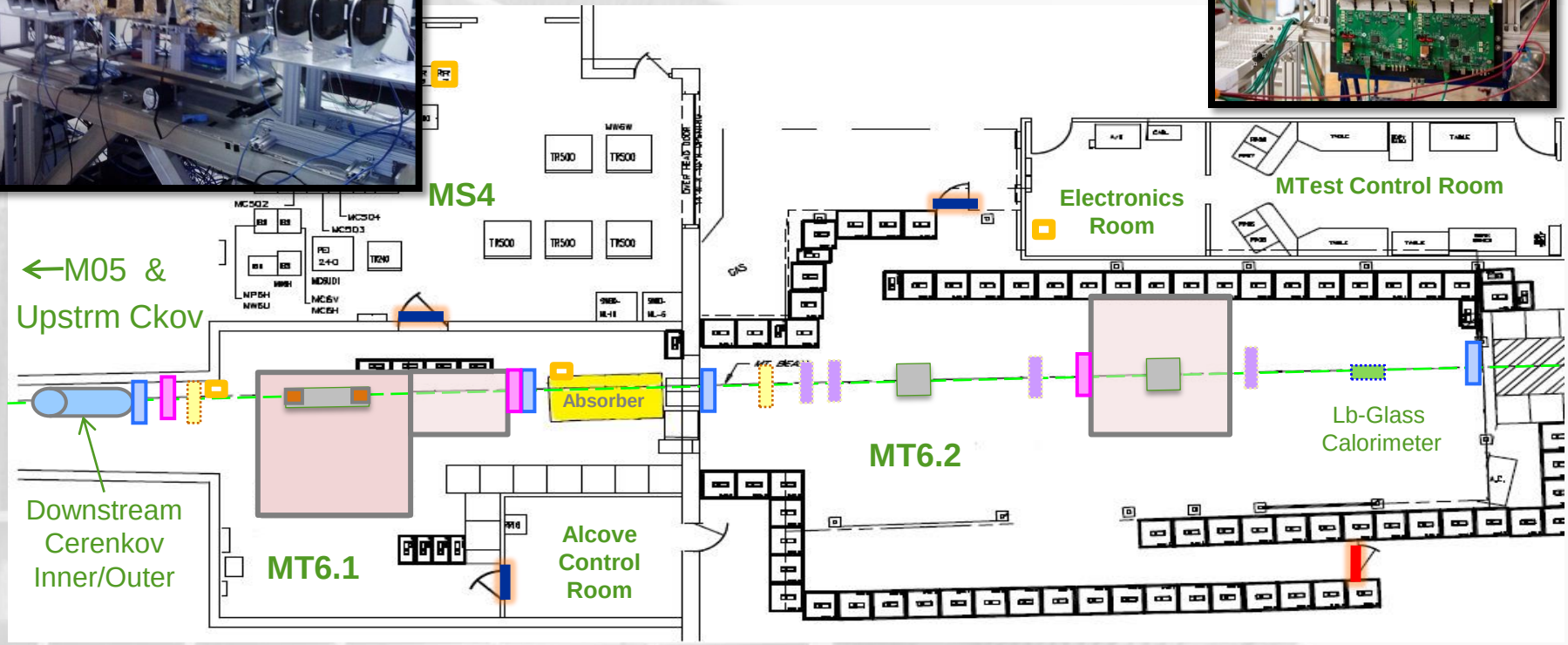
- Gas Distribution system throughout facility
- MT6.2 and MC7 have flammable capability
- Some gasses provided



Instrumentation







Climate Controlled Area

Scintillator Counters

SWIC

MWPC (Fenker Chamber)

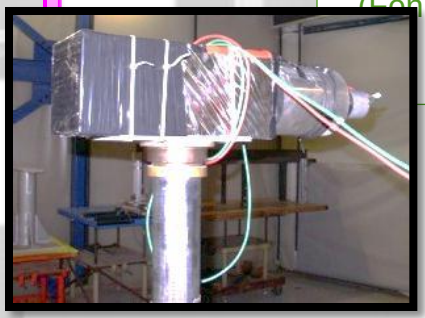
Time Of Flight

Lead-Glass Calorimeter

can be moved anywhere.

Si strip Telescope (CAPTAN)

Remotely Controlled Table



See Poster #143
Ewa Skup

Beam Delivery

- Booster captures protons into 84 bunches (1 batch) and accelerates them to 8GeV
- Bunches are 19nsec long: 1 RF Bucket (53 MHz)
- Booster batch = 1.6 microsecond in length
- Up to 6 batches go into Main Injector
- Main Injector = 11.2 microsecond
- Beam is ramped from 8 to 120 Gev and held at the flattop value
- Fraction of the beam resonantly extracted each rotation over 4.2 sec to Switchyard
- In Switchyard electrostatic Septa split beam twice. First split beam to NM line (Sea Quest) and M line, the second splits the beam between MTest and MCenter.

- Beam Available 24 hrs /day
- 6 sec event (4.2 sec spill) every 60 seconds
- Control room manned during beam hours

- If beam were smoothly extracted, 100 kHz or less would imply 1 particle per MI rotation would occur.
- Beam extraction is not smooth resulting in up to 35% double occupancy per MI rotation (11μSec)

Particles & Energies

- 120 Gev Proton Mode
  - Maximum intensity: 5E5 p/spill
- High Energy Pion Mode
  - + 60
  - + 50
  - + 40
- Muon Mode:
  - Every LE or HE Pion Mode with additional absorbers in MT6-1.

p

π

μ

New 'Energy Script' will be able to select particles at any discrete energy.

- Low Energy Pion Mode
  - +/- 32
  - +/- 30
  - +/- 25
  - +/- 20
  - +/- 16
  - +/- 15
  - +/- 12
  - +/- 10
  - +/- 8
  - +/- 6
  - +/- 5
  - +/- 4
  - +/- 3.5
  - +/- 3
  - +/- 2.5
  - +/- 2
  - +/- 1.5
  - +/- 1

Some kaons

k

Mostly Electrons/ Positrons

e

New!

High Rate Tracking Area

- Located in MTest beamline upstream of pinhole collimator (MT3 Alcove)
- 2.5 GHz/cm^2 Rates for protons
- Patch panels for signal, HV, and network link the enclosure alcove area with the MS3 service Building
- Acnet controlled table
- Pions also available

See Poster #144

FTBF Summary

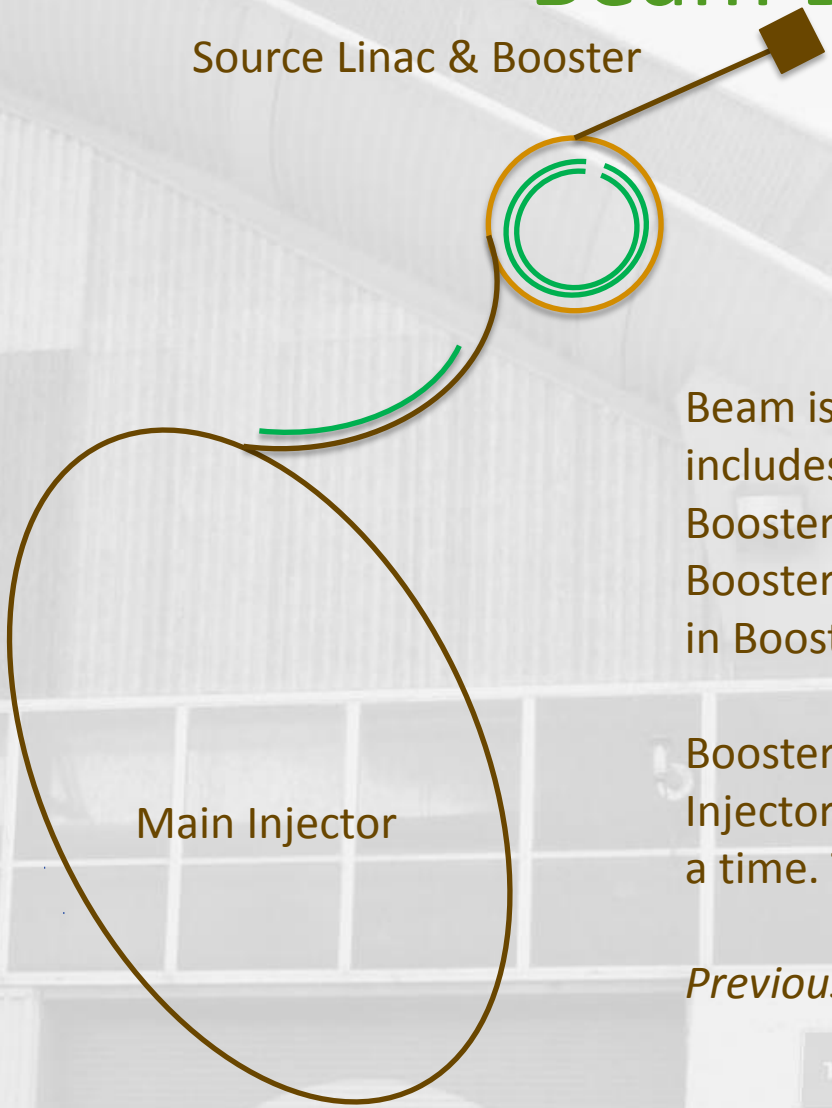
- Fermilab Test Beam Facility is an HEP Beam facility for world-wide Detector R&D
- Extensive facility infrastructure & instrumentation
- Flexible beam delivery
  - Protons, pions, muons, electrons, kaons
  - 200 MeV – 120 GeV
  - 1 – 300 kHz intensities
- Beam time available!
  - http://www-ppd.fnal.gov/FTBF
  - Become a User

ADDITIONAL SLIDES

Tertiary Beam Details

- **Rates:** ~200 particles / 4 sec spill (~50 Hz)
- 60% pions, 40% protons,
- very few electrons, kaons, and deuterons
- **Momentum Resolution:** dp = 3%
  - multiple scattering limited for this momentum range
- design momentum is 200MeV minimum

Slow Extraction to MTest - General Beam Delivery

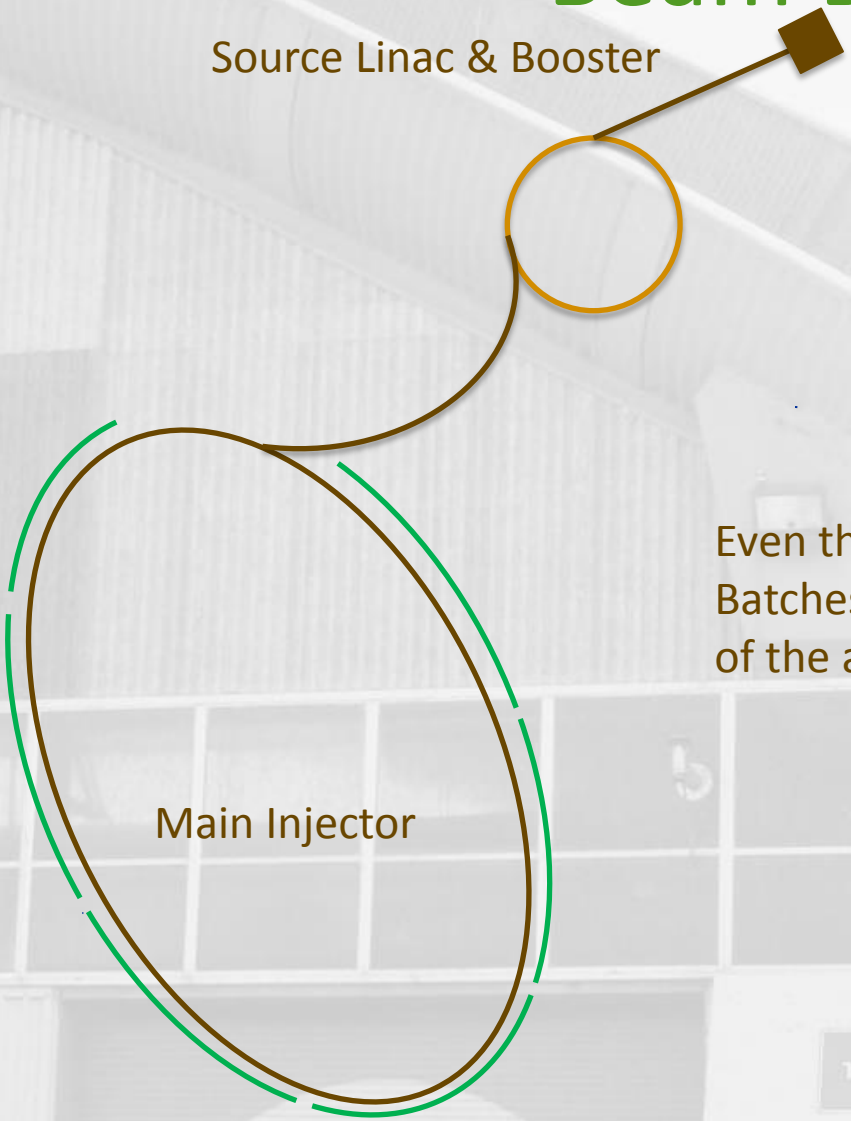


Beam is produced from AD's Proton source which includes three machines. The Source, Linac and the Booster Ring. Depending on the request intensity Booster over laps beam from Linac. Each revolution in Booster is called a Turn.

Booster then delivers 8 GeV proton beam to Main Injector in bunches at a maximum of ~84 bunches at a time. This term is called a Batch.

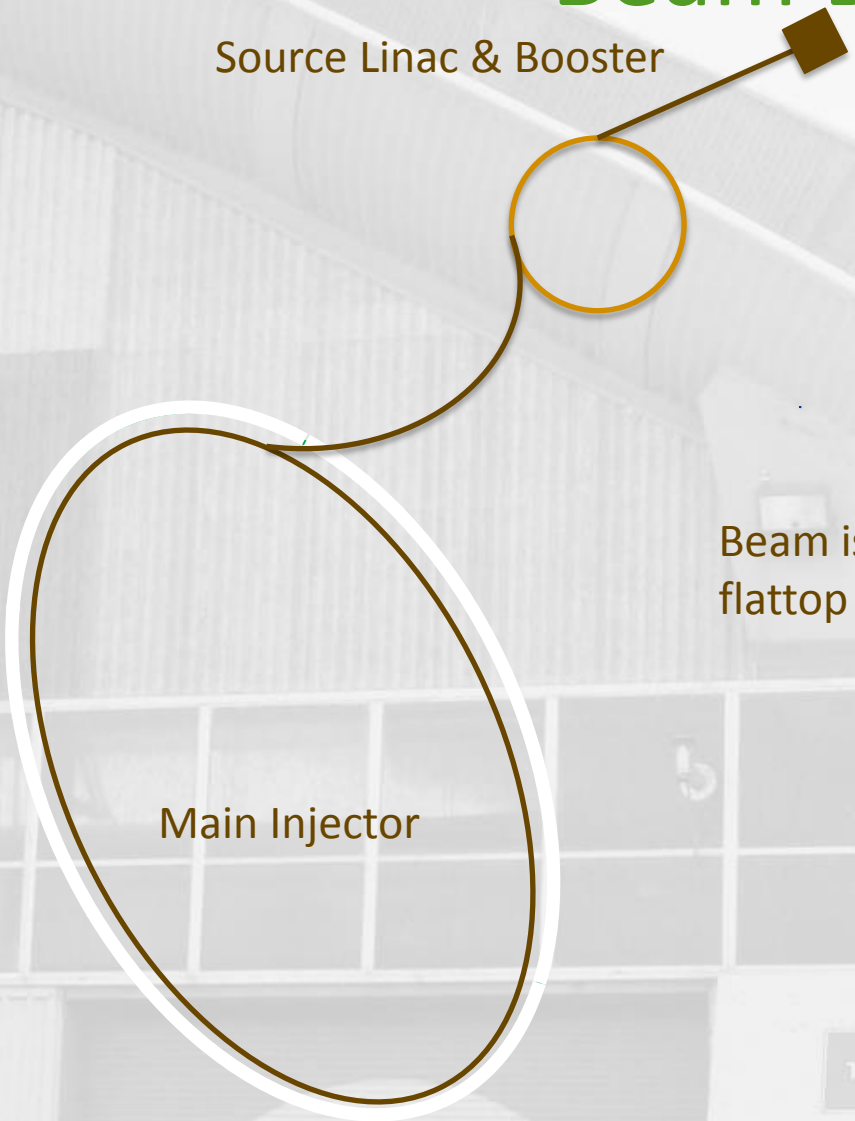
*Previous runs were partial batching**

Slow Extraction to MTest - General Beam Delivery



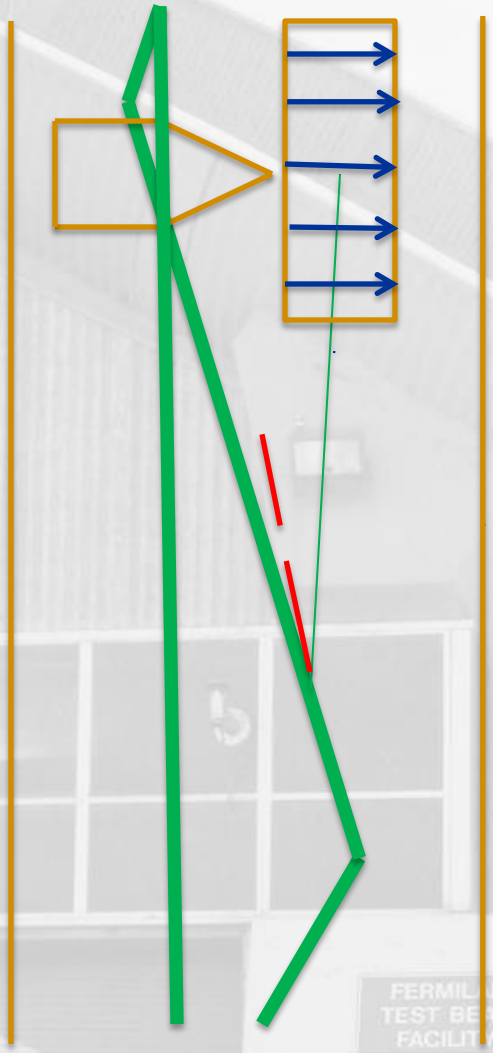
Even though physically Main Injector can hold 7 Batches, the maximum number is 6. This is because of the abort gap needed for operations.

Slow Extraction to MTest - General Beam Delivery



Beam is ramped from 8 to 120 Gev and held at the flattop value and resonantly extracted 4 seconds.

Slow Extraction to MTest - General Beam Delivery



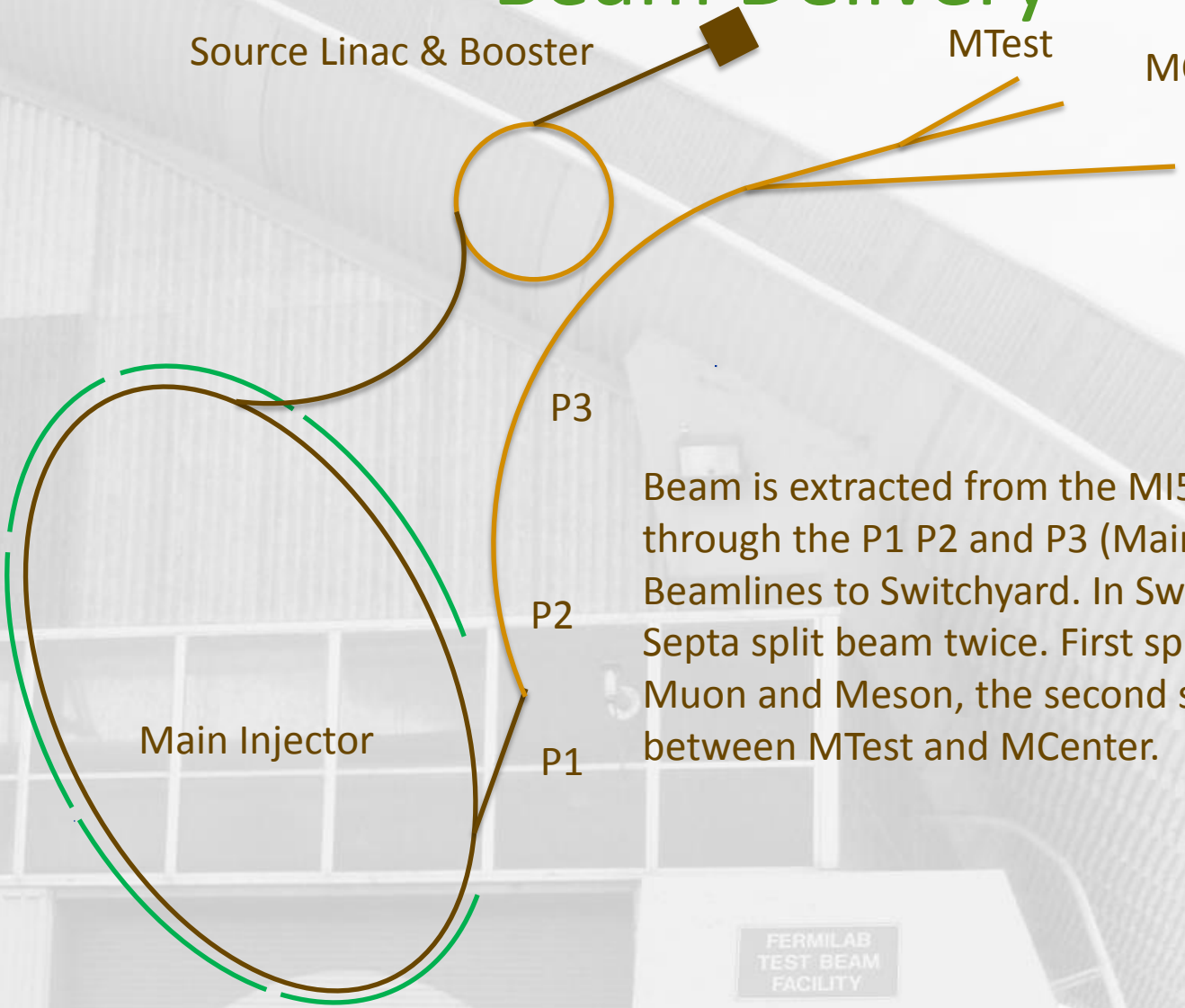
Field Free Region

Field Region

2 Electrostatic Septa

Not to scale*

Slow Extraction to MTest - General Beam Delivery



Beam is extracted from the MI52 area transported through the P1 P2 and P3 (Main Ring remnant) Beamlines to Switchyard. In Switchyard electrostatic Septa split beam twice. First split beam to Neutrino Muon and Meson, the second splits the Meson beam between MTest and MCenter.

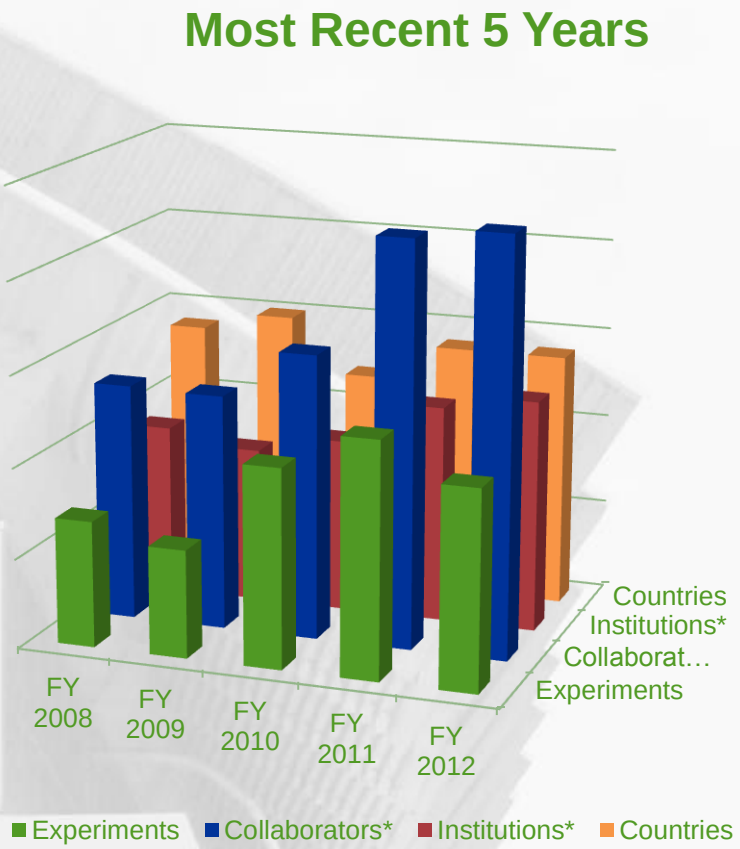
Slow Extraction to MTest – Running Modes

Key Requirements

- 120 Gev Proton Mode
  - ✓ M01 target in place for attenuation
  - ✓ MT3 Pinhole Collimator for attenuation
  - ✓ Quadrupole magnets off for larger spot size
- Low Energy Pion Mode
  - ✓ MT4 target in place for production
  - ✓ MT3 Pinhole Collimator out for transmission
  - ✓ Quadrupole magnets specific settings
- High Energy Pion Mode
  - ✓ M01 target in place for production
  - ✓ MT3 Pinhole Collimator out for transmission
  - ✓ Quadrupole magnets specific settings

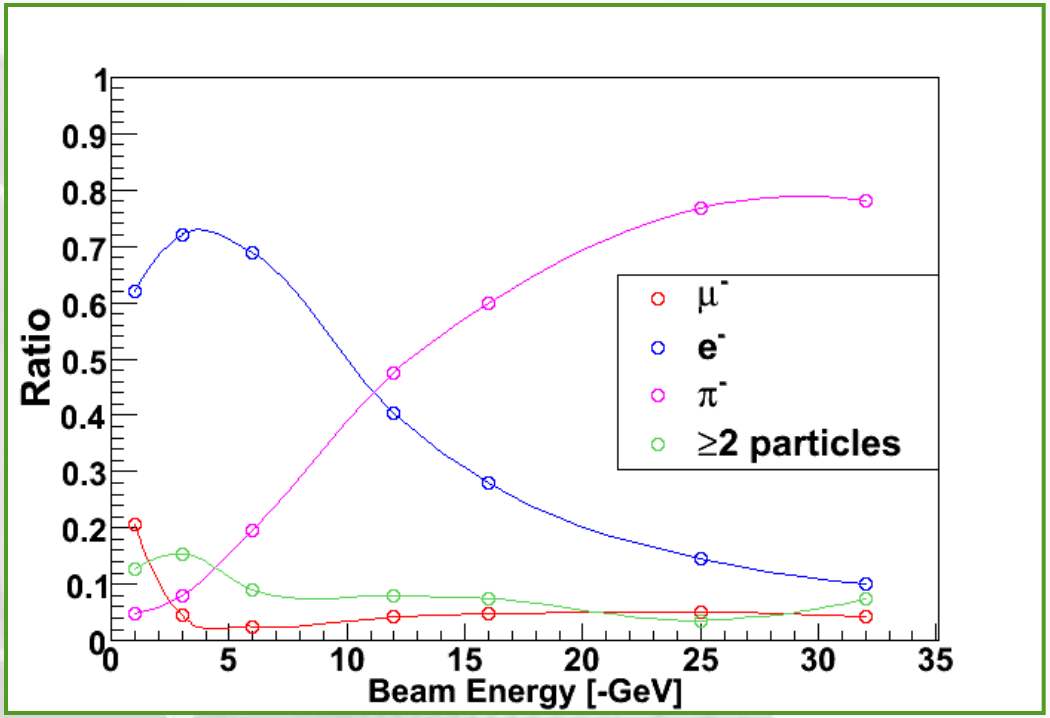
The Fermilab Test Beam Facility

- World Class Facility
- The only U.S. HEP Test Beam
- Detector R&D focus
- In 2012:
  - 11 experiments
  - 229 collaborators
  - 64 institutions
  - 14 countries



Particle Composition of Beam

- 120 Gev Protons
- 2 - 66 GeV Pions
- 0.5 – 32 GeV Electrons
- Broadband Muons



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- Beam extraction is not smooth resulting in up to 35% double occupancy per MI rotation

Beam Energy (GeV)	Rate at Entrance to Facility (per spill)	Rate at Exit of Facility (per spill)	% Pions, Muons	% Electrons
16	132,000	95,000	87%	13%
8	89,000	65,000	55%	45%
4	56,000	31,000	31%	67%
2	68,000	28,000	<30%	>70%
1	69,000	21,000	<30%	>70%

Tertiary Beam Details

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- 60% pions, 40% protons,
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- **Momentum Resolution:** dp = 3%
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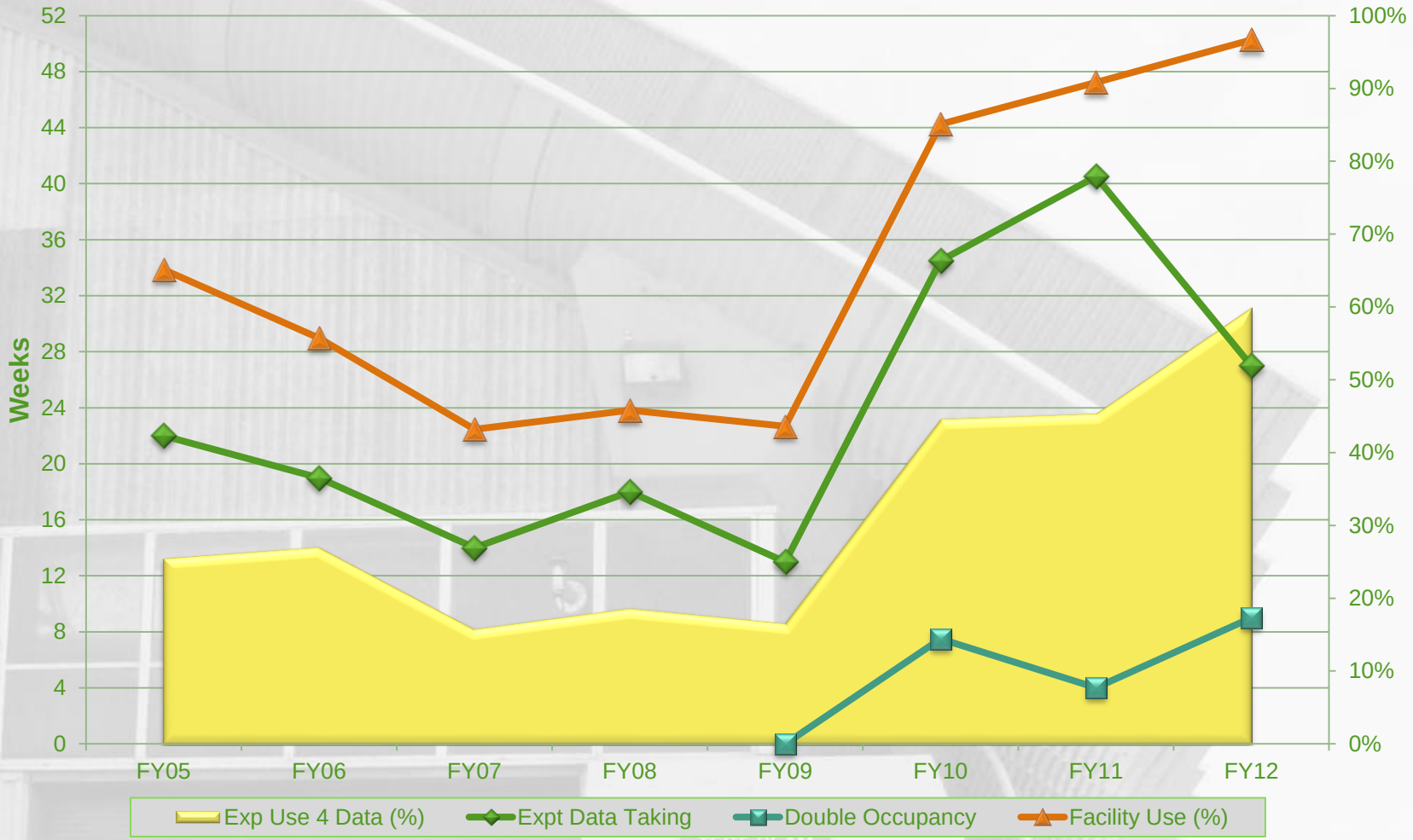
Weekly Usage



- FY2012 only consisted of 7 months of beam
- Facility use includes Beam studies, and educational support such as EDIT 2012.

Meson Area Beamlines