Fermilab Hadron Test Beam and Irradiation Facilities

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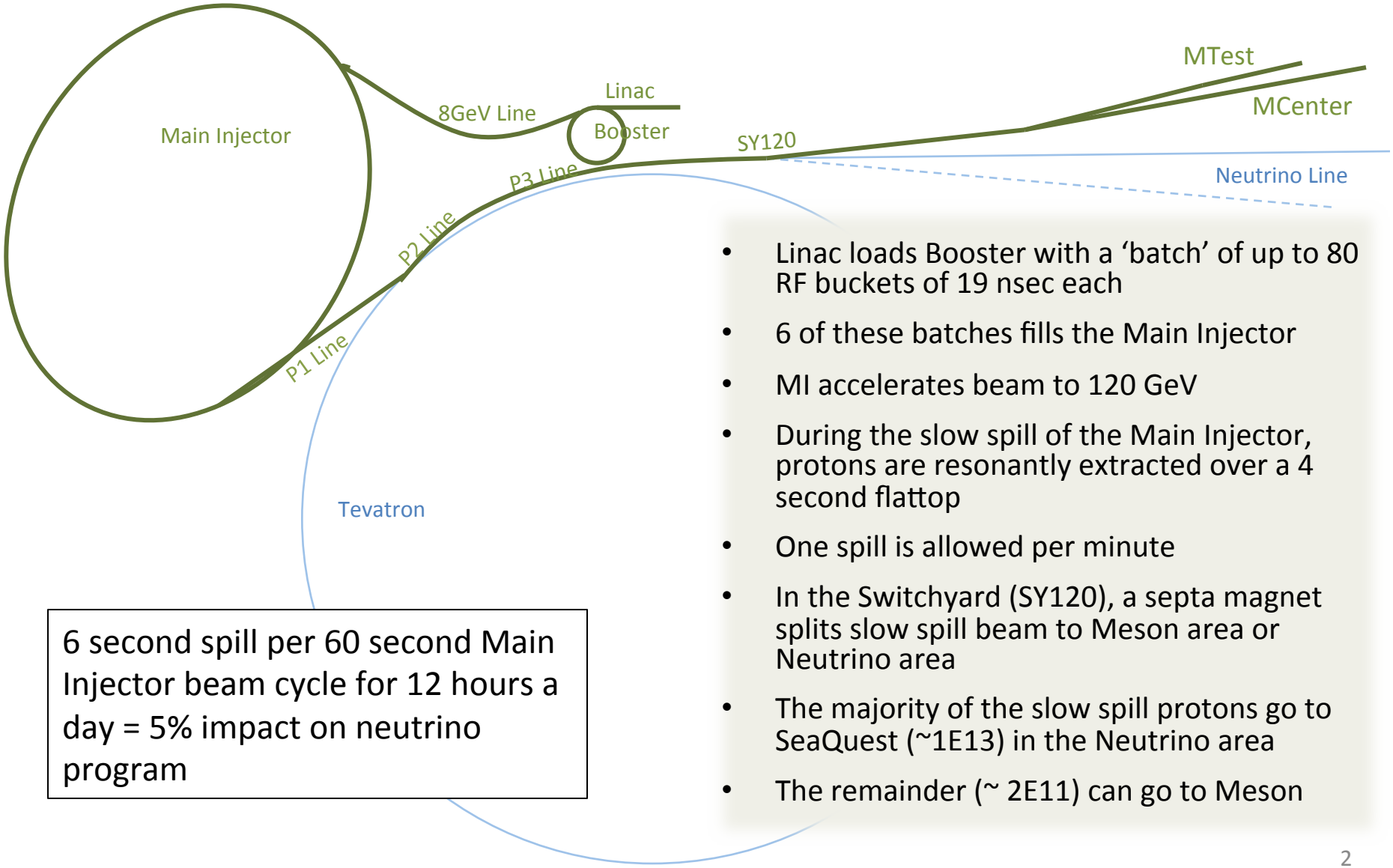
10 January, 2013

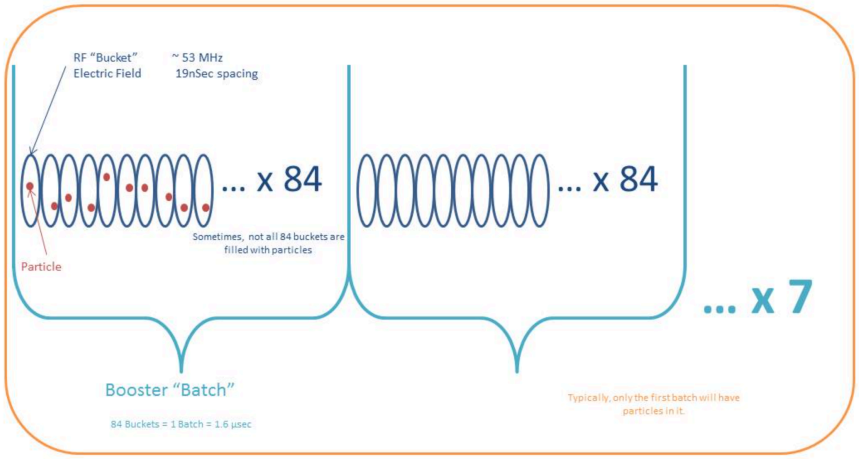
Test Beam Delivery



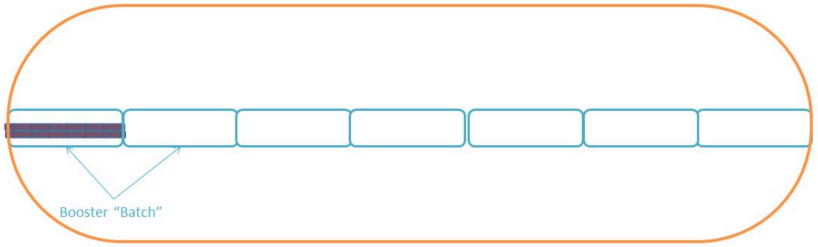
- Linac loads Booster with a 'batch' of up to 80 RF buckets of 19 nsec each
- 6 of these batches fills the Main Injector
- MI accelerates beam to 120 GeV
- During the slow spill of the Main Injector, protons are resonantly extracted over a 4 second flattop
- One spill is allowed per minute
- In the Switchyard (SY120), a septa magnet splits slow spill beam to Meson area or Neutrino area
- The majority of the slow spill protons go to SeaQuest (~1E13) in the Neutrino area
- The remainder (~ 2E11) can go to Meson

6 second spill per 60 second Main Injector beam cycle for 12 hours a day = 5% impact on neutrino program

Beam Structure



7 Batches = 1 MI Cycle = 11.2 µSec



Typically, only the first batch will have particles in it.

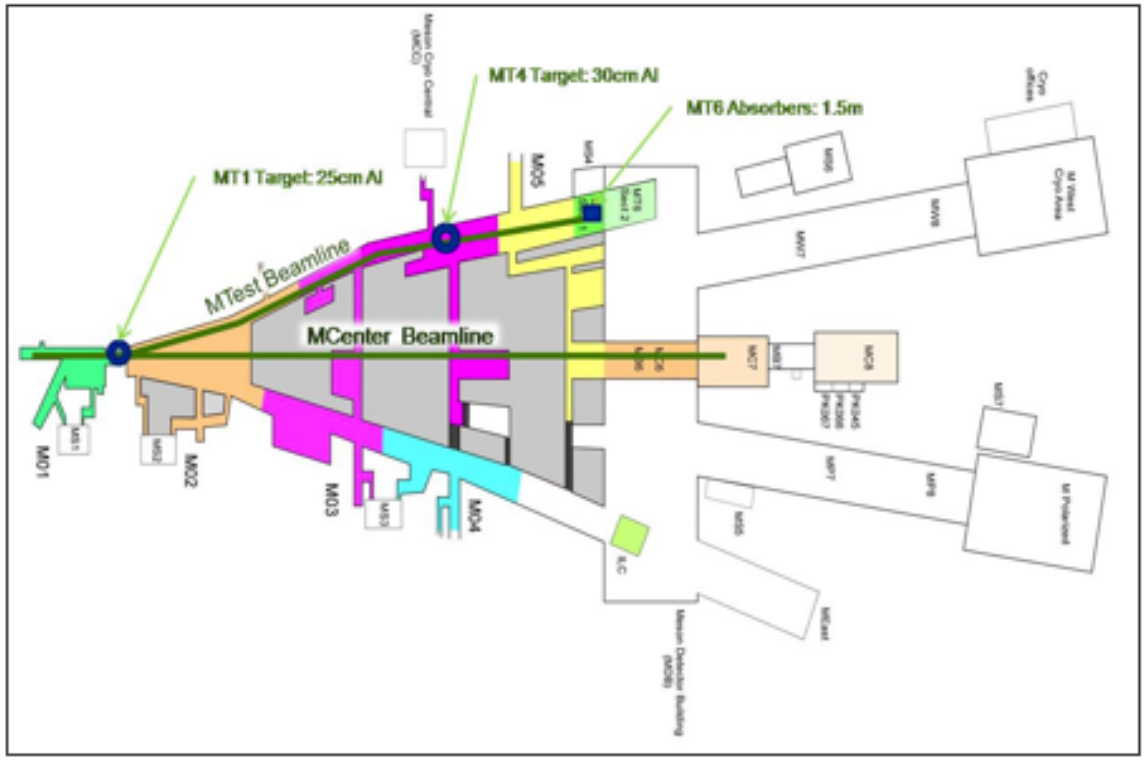
7 Batches = 1 MI Cycle = 11.2 microSec

Beam is resonantly extracted over 375,000 MI Cycles, to create a 4.2 second Spill.

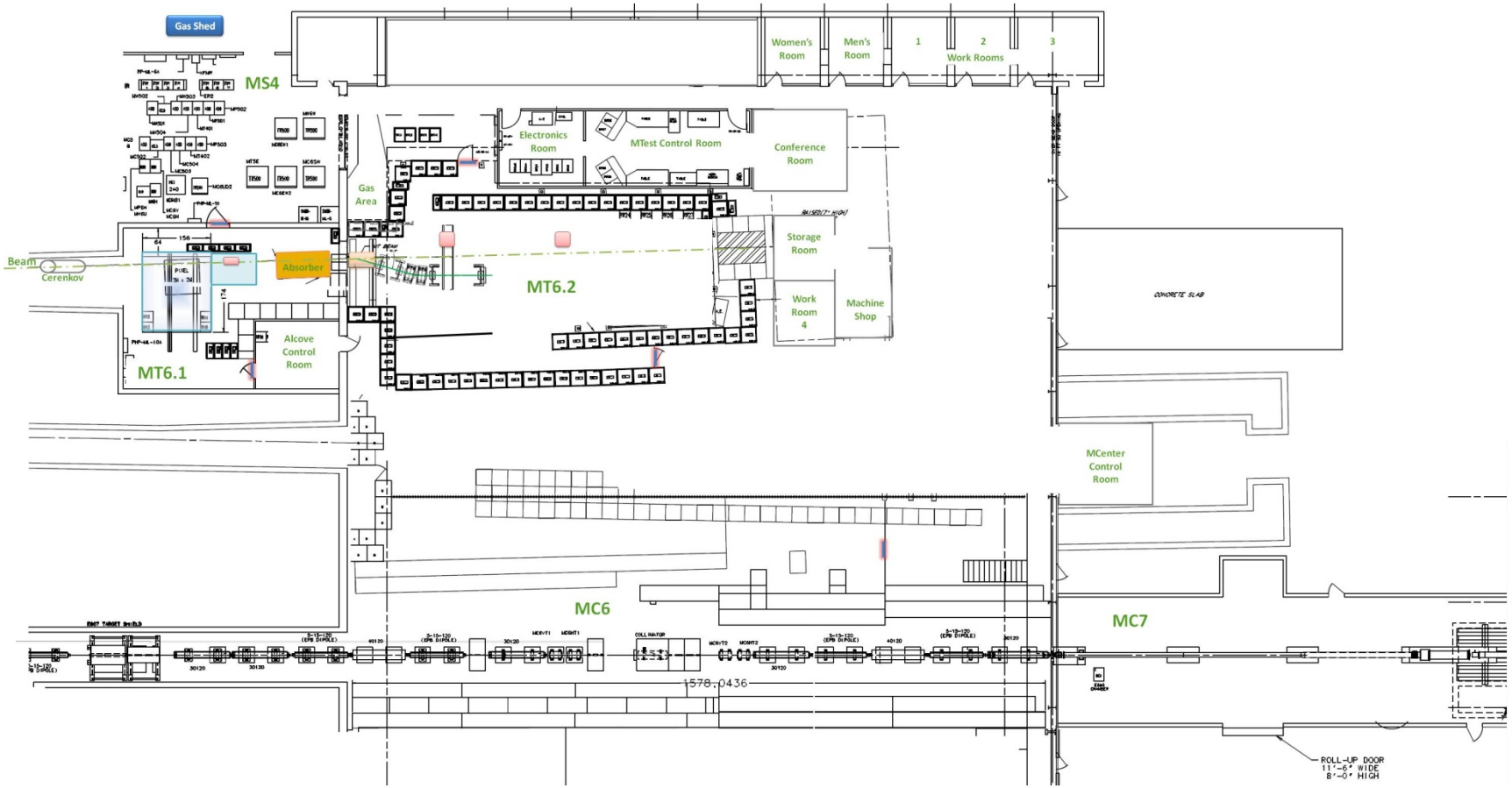
If beam were smoothly extracted, 100 kHz or less would imply 1 particle per MI rotation (1 particle every 11.2 microsec) would occur.
Beam extraction is not smooth, resulting in up to 35% double occupancy per MI rotation

Meson Area Beams

- In the Meson area, beam can be delivered simultaneously to the MTest and MCenter beamlines.
- Spill structure is the same for both areas.
- In MTest, there are 2 targets – one is far upstream and can give higher momentum tunes (>32 GeV)
- After the downstream target, the magnets have special low current power supplies that give accurate tunes down to 1-2 GeV
- In MCenter, there is a single target located near the beginning of the Meson Detector Building
- Mcenter can tune accurately down to about 5 GeV.



Facility Overview



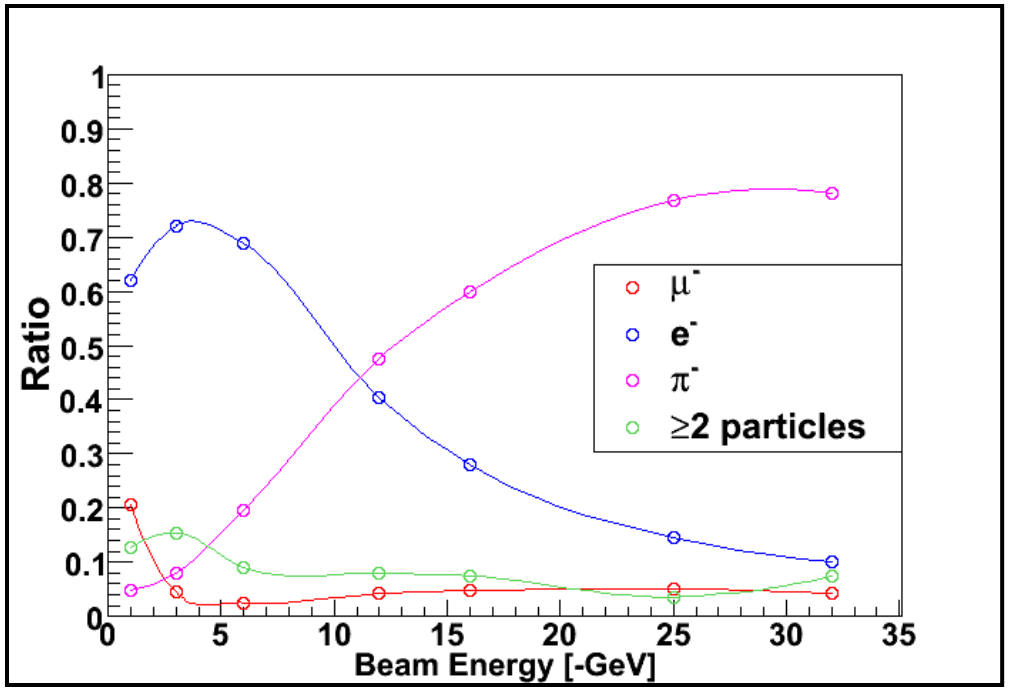
Facility Overview

Particle Composition of MTest Beam

Tuning modes:

- 120 Gev Protons
- 32-66 GeV Pions
- 1–32 GeV Mixed Beam
- Broadband Muons from Steel absorber/target

Flux can go from about 50-5000 Hz below 8 GeV and up to 100,000 Hz for high energy tunes



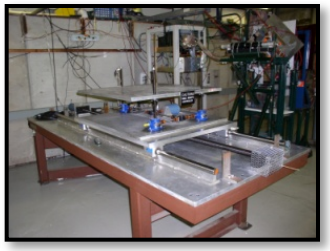
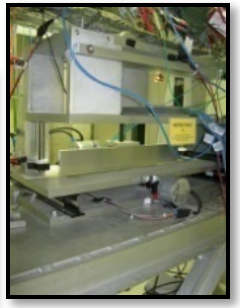
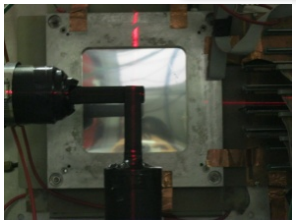
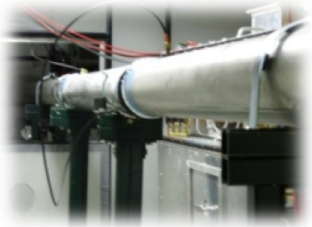
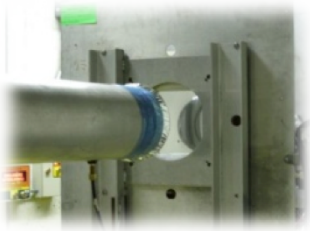
Results from CALICE experiment

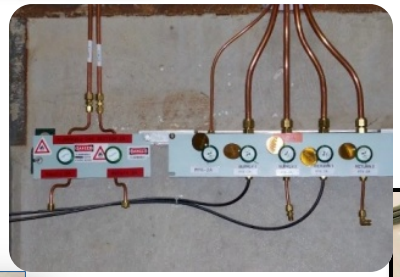
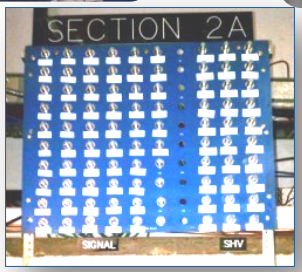
Facility Details - Accommodations

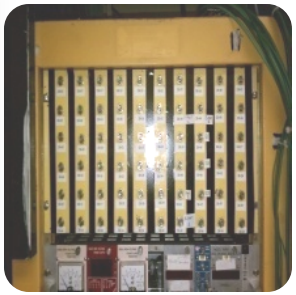
- Multiple Control Rooms
- Conference Room
- Climate-controlled areas for experiments
- Machine Shop
- Several Work Rooms
- Storage Rooms and Cabinets

Facility Details - Infrastructure

- Remotely controlled Motion Tables
- Laser Alignment
- Web-based Cameras
- Helium Tubes
- Gas Delivery
- Signal and High Voltage cable patch panels

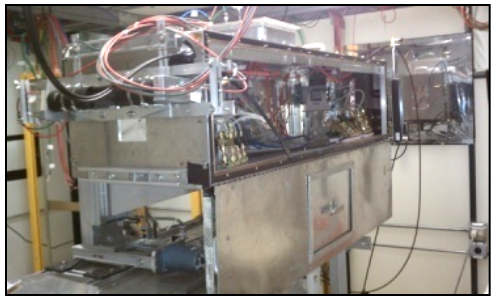







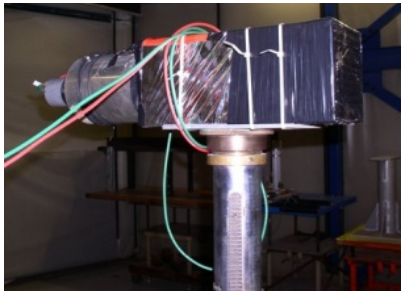






Facility Instrumentation

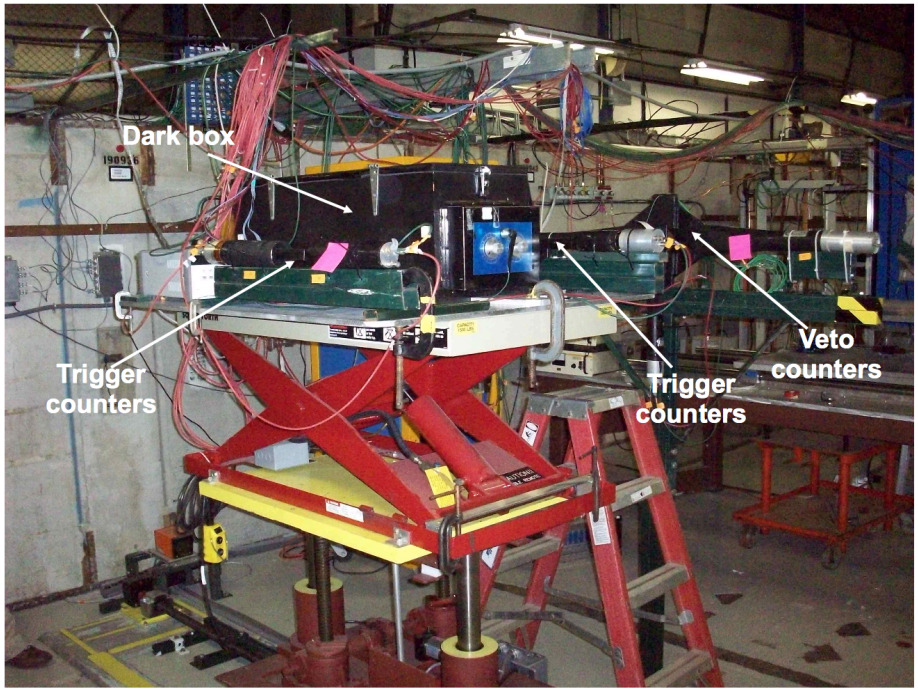
- 2 Cerenkov Detectors (one is differential)
- Pixel Telescope with about 10 micron resolution
- Silicon strip telescope with similar resolution
- Two sets of 4 MWPC Tracking System with about 500 micron resolution
- Two Time of Flight Systems with 160 psec or 24 psec resolution
- Lead Glass Calorimeters
- Scintillators



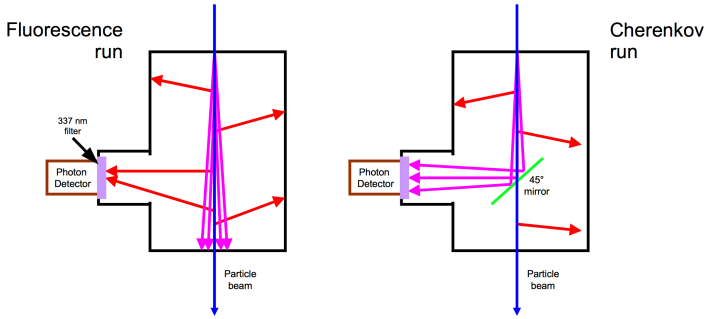


T988 at Fermilab Meson Test Beam

The AIRFLY experiment measured absolute scale of nitrogen fluorescence to the 5% level.

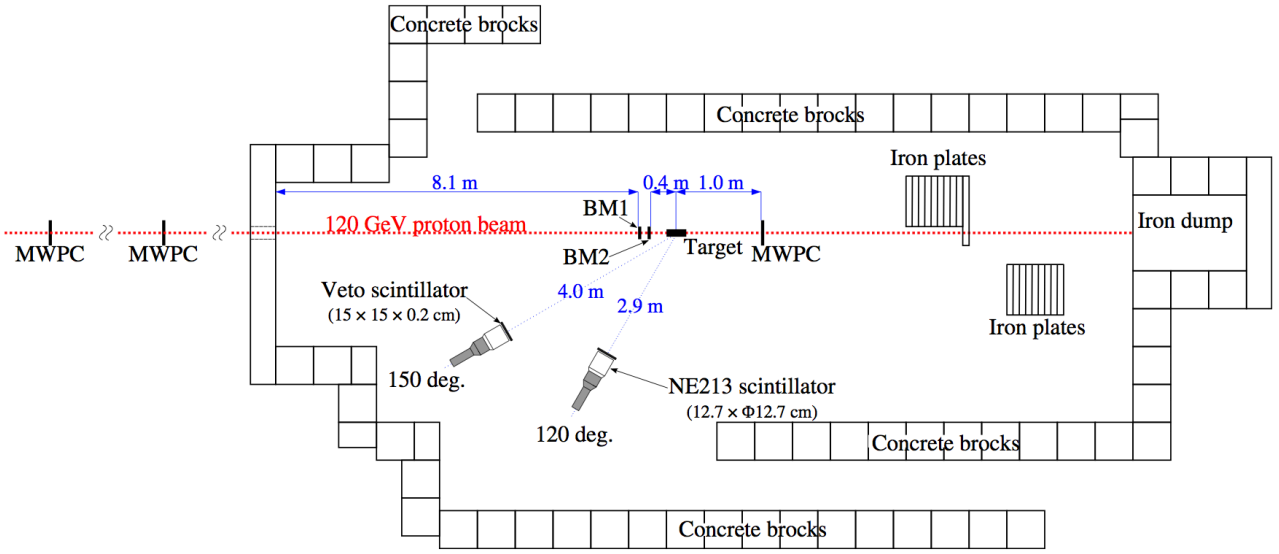


Airfly absolute calibration

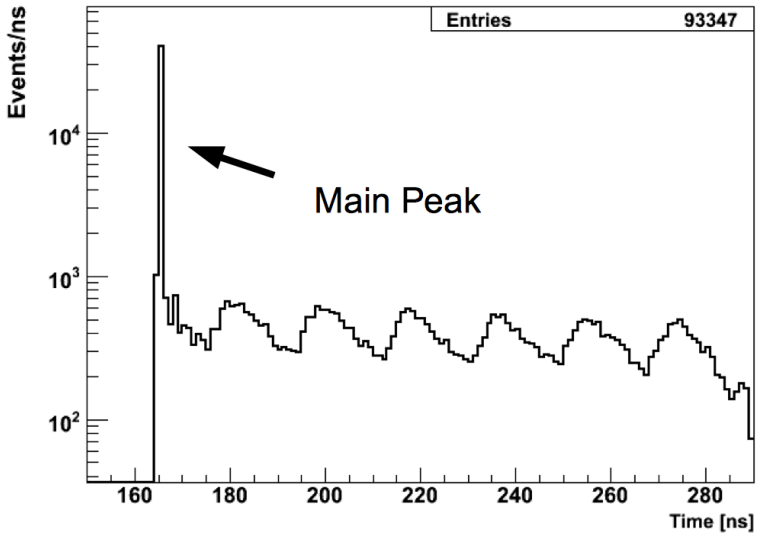


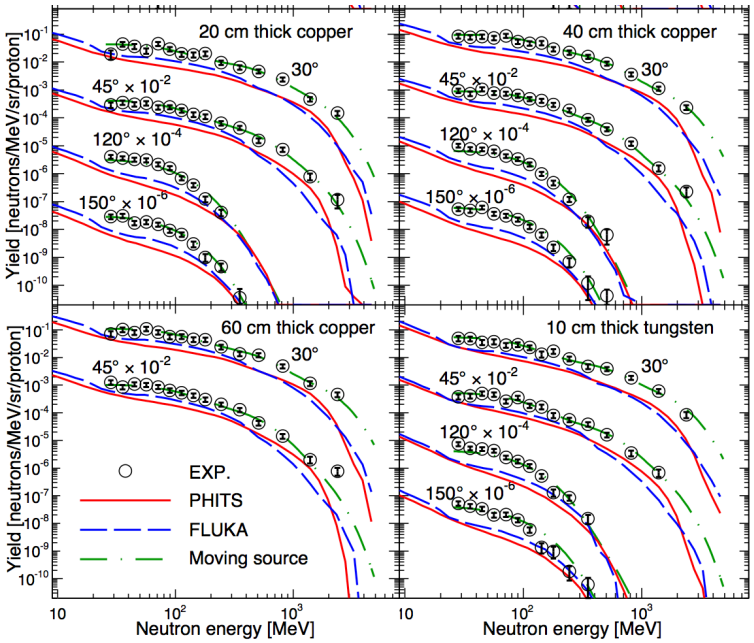
Normalize to well-know process

The JASMIN experiment studied neutron production from 120 GeV protons (and other beams on-site) with time-of-flight.



Time distribution of signal





Booking is solid for FTBF

hedule

he **official** schedule for FTBF activities. Typical run periods establish beam on Wednesdays, and run through Tuesday. Sche
s are held most Mondays at 2pm. To schedule beam time please see our Guidelines for Requesting Beam and contact the T
oordinator.

Popular Demand: Experiments are now limited to a total of 8 weeks of 12 hr shifts per Fiscal Year. (For example, Four 2 we
per Fiscal Year.) This is regardless of whether they are Primary or Secondary users.

est FY14 | MTest FY15 | MCenter FY14 | Previous Years | Calendar | Legend

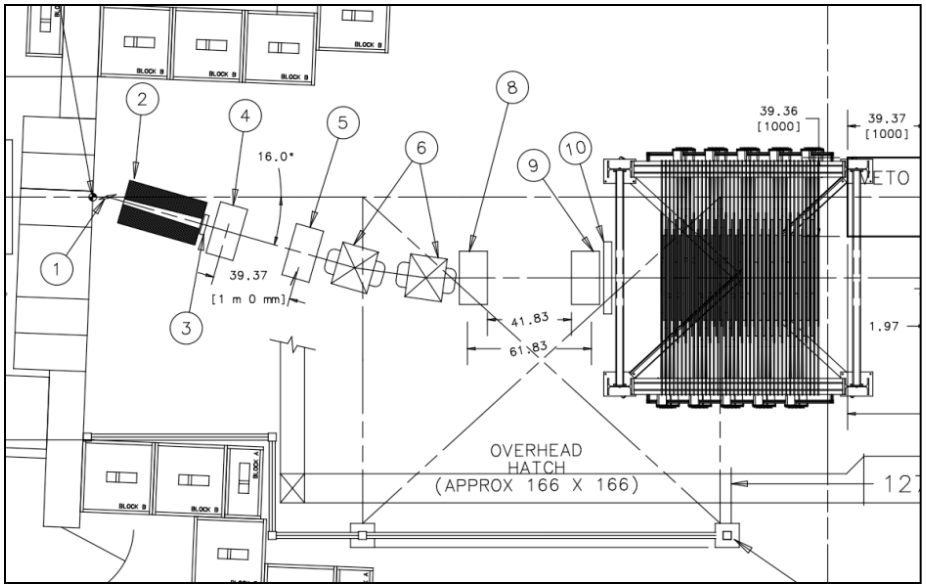
2013

Dates	Experiment	User	Hours	Area	Contact
- Oct 8	T1037 FLYSUB-Consortium	Primary	12 Day	MT6.2	Dehmelt
	T1031 Atlas Tile Calorimeter Electronics Test	Passive	24	M03	Oreglia
- Oct 15	T1037 FLYSUB-Consortium	Primary	12 Day	MT6.2	Dehmelt
	T1031 Atlas Tile Calorimeter Electronics Test	Passive	24	M03	Oreglia
	T1036 CMS High Rate Pixel Detector	Primary	12 Night	M03	Spiegel
6 - Oct 22	T1037 FLYSUB-Consortium	Primary	12 Day	MT6.2	Dehmelt
	T1031 Atlas Tile Calorimeter Electronics Test	Passive	24	M03	Oreglia
	T1036 CMS High Rate Pixel Detector	Primary	12 Night	M03	Spiegel
3 - Oct 29	T1015 ADRIANO (for High Energy)	Primary	1700-0700	2-B	Gatto
	Beamline studies	Make-up	0700-1700	MTest	Ops Co
0 - Nov 5	T1015 ADRIANO (for High Energy)	Primary	12 Day	2-B	Gatto
5 - Nov 12	T992 Radiation-hard Sensors for the SLHC	Make-up	12 Day	1-A	Rivera
	T1015 ADRIANO (for High Energy)	Make-up	12 Day	2-B	Gatto
13 - Nov 19	T992 Radiation-hard Sensors for the SLHC	Make-up	12 Day	1-A	Rivera
	T1015 ADRIANO (for High Energy)	Make-up	12 Day	2-B	Gatto
	Beamline studies	Make-up	0800-1400	MTest	Ops Co
20 - Nov 26	T1041 CMS Forward Calorimetry	Primary	24	2-D	Bilki
27 - Dec 3	T1015 DRC Crystals	Primary	24	2-C	Pauletta
	T979 Fast Timing w/Cherenkov Counters	Secondary	0700-1500	2-A	Albrow

- Experiments typically ask for time in 1-3 week chunks.
- Often come back for further runs.
- Installation on nights and Wednesday day.
- Quite often there are multiple users setting up simultaneously.
- Safety approval for each experiment takes place on Thursday and often up and running that afternooon.
- Make-up time is scheduled at night.

Accommodating Low Energy Users

- The lowest energy we can realistically deliver with the secondary beam is ~1 GeV.
- In 2008, T-977 MINERvA experiment requested pions with momentum as low as 200 MeV/c
- To accommodate this request, Fermilab created a secondary target and tertiary beam spectrometer



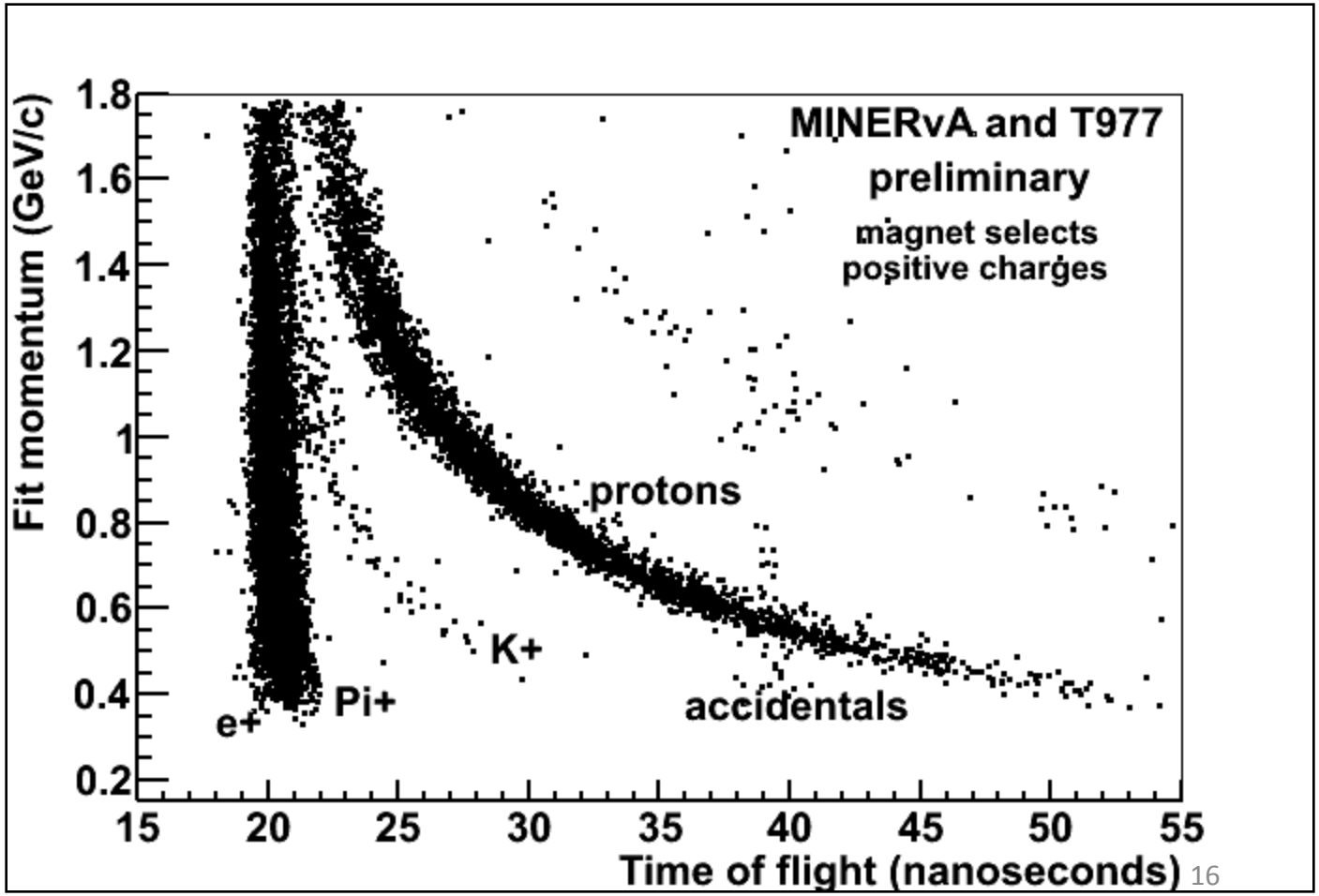
Tertiary Beamline

Target/ Collimator | TOF 1 | WC 1 | WC 2 | Spectrometer Magnets | WC 3 | WC 4 | TOF 2

Tertiary Beam Details

Plot of fit momentum vs. TOF shows separation of species

- 60% pions,
- 40% protons,
- very few electrons, kaons, and deuterons.
- Yields will be different at MCenter



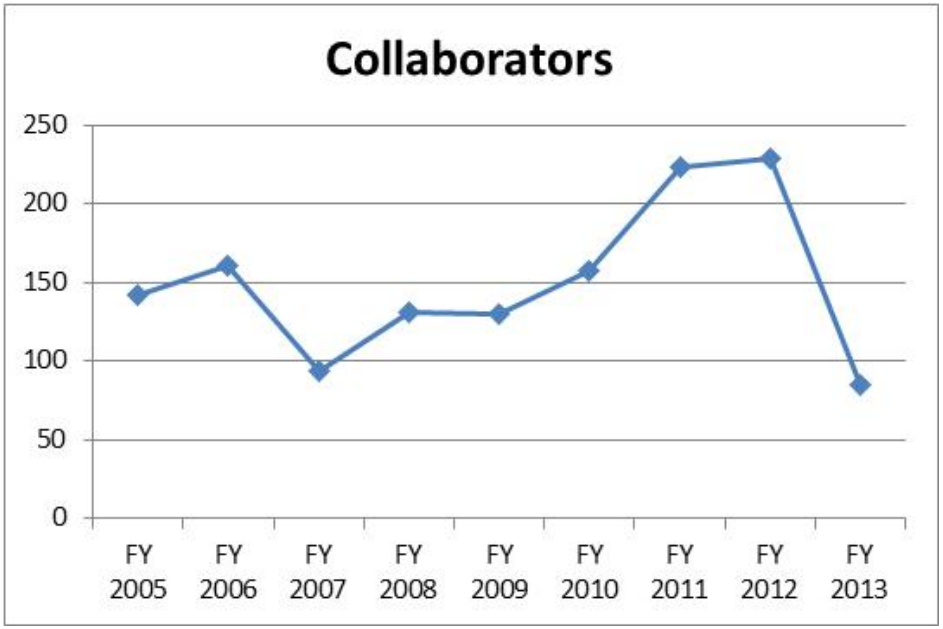
The Need for a New Test Beamline

- The Fermilab Test Beam Facility is extremely popular and will remain so for the foreseeable future.

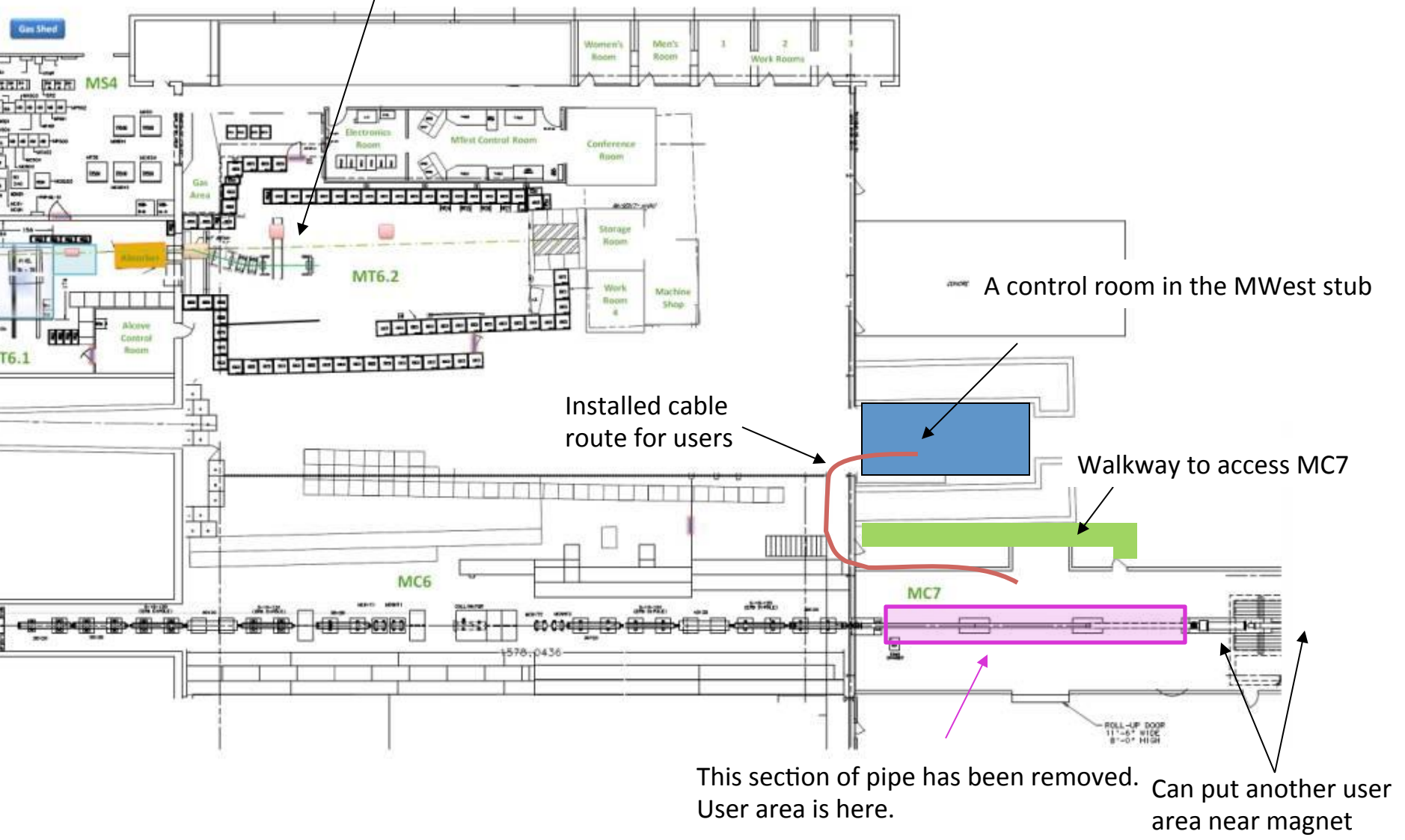
-Having multiple users running simultaneously is a common occurrence.

- Total number of experimenters rivals large HEP experiment

- The need for a second beamline was endorsed and funded by DOE.



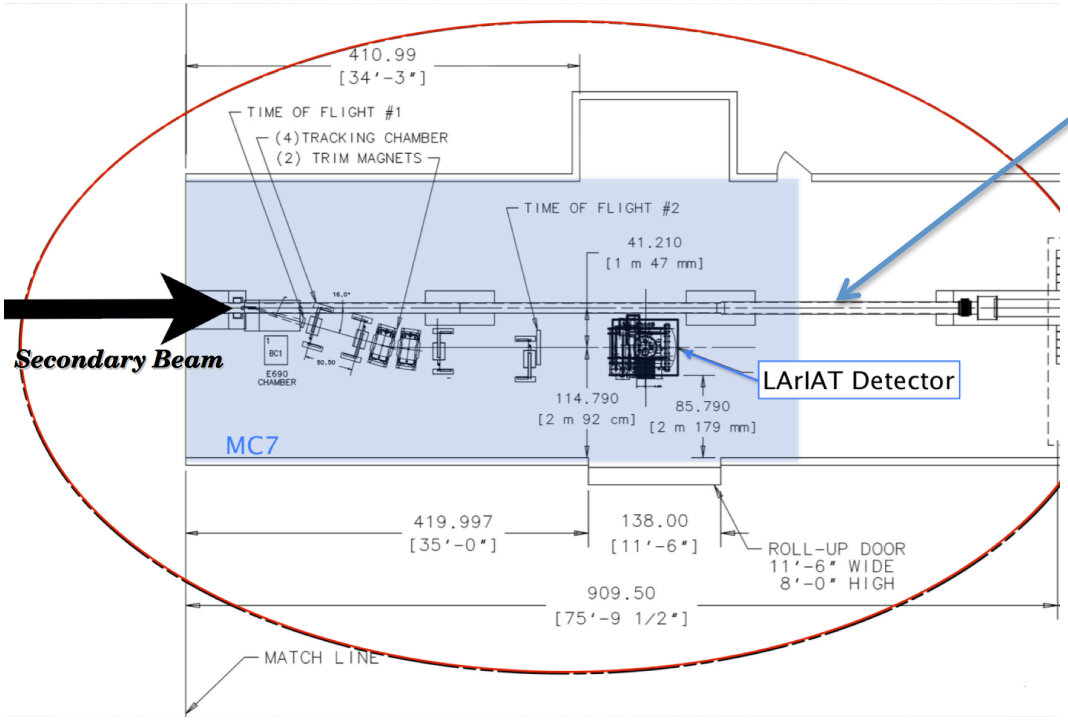
New MCenter Beam as part of the Fermilab Test Beam Facility



Ribbon Cutting Ceremony at MCenter

T-1034 LAriaT proposal

- 'LAriaT = 'Liquid Argon in a Testbeam'
- Two stage proposal:
  - Stage 1: Put ArgoNeut (300 kg) into tertiary beam in Mcenter
  - Stage 2: Put as large a new detector as possible (2x2x5 m^3) in downstream half of MC7
- Imagine being able to study low momentum tagged kaon and proton tracks or photon showers in liquid Argon.
- We are creating a cryogenic system large enough for Stage 2, using some parts already purchased.



Still support secondary beam users

MCenter User Area

Path of secondary beam

Path of tertiary beam

Primary target is 300 meters upstream

Copper secondary target and 13° collimator:

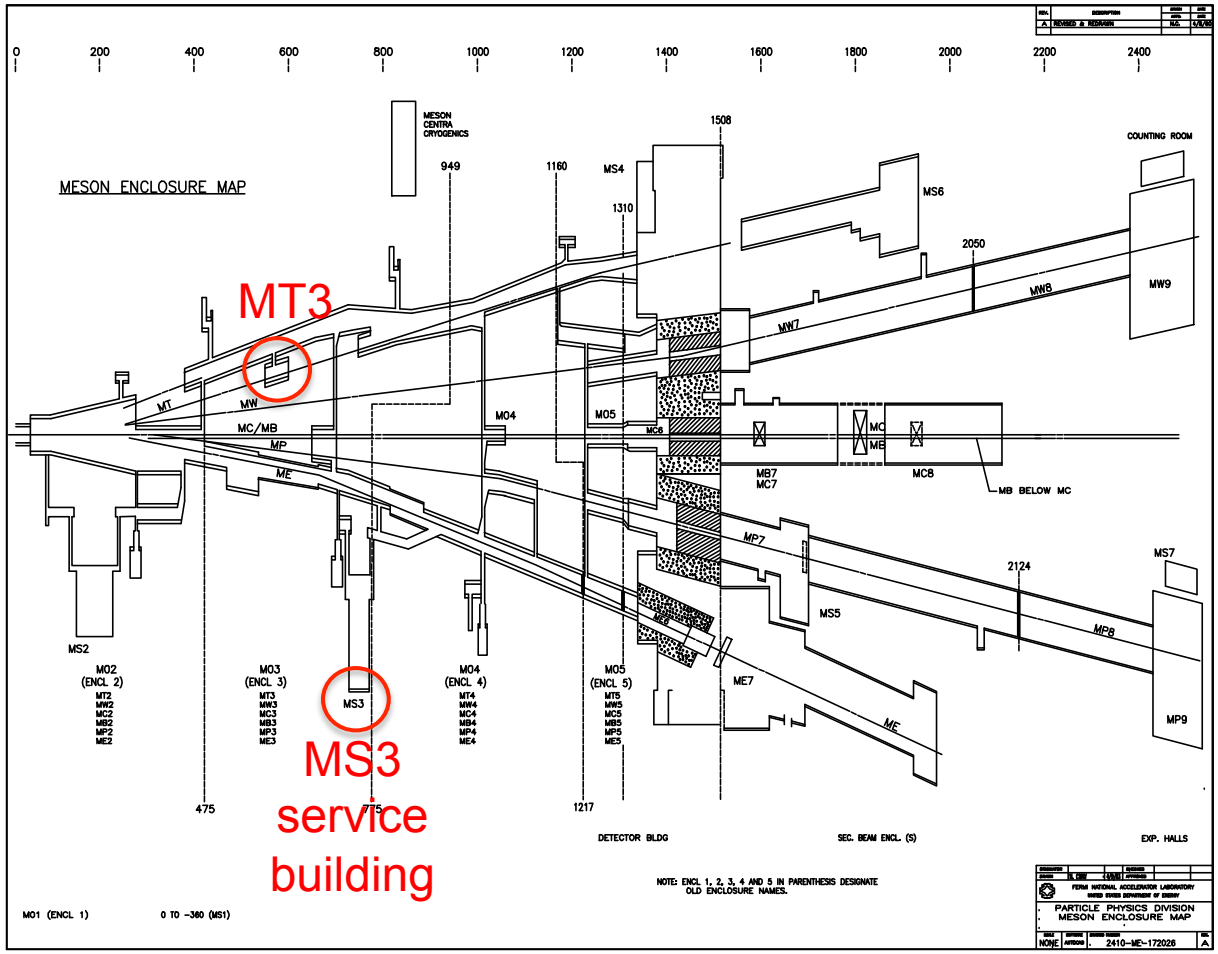
Secondary target and collimator can be rolled aside in minutes

Irradiation Facilities at Fermilab

- 120 GeV direct proton beam (5E11 protons/spill)
  - Located in the Meson beam section MT3, upstream of collimator
  - Can only support thin tracking chambers
- Radiation fields from high energy proton primary interactions
  - Located in MT4, next to primary target
- Low Energy protons
  - New MTA area has primary LINAC beam at 400 MeV
  - Has not supported irradiation yet (probably within next few months
- Medium energy Neutrons
  - ~5-30 MeV neutrons at the Neutron Therapy Facility
- Medium flux gamma irradiation
  - At ES&H instrument calibration department

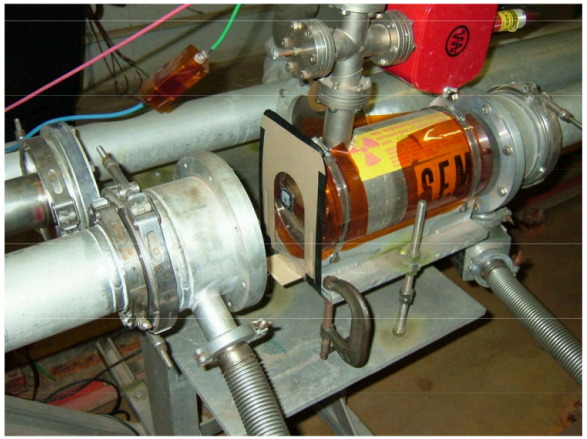
New High Rate Tracking Area

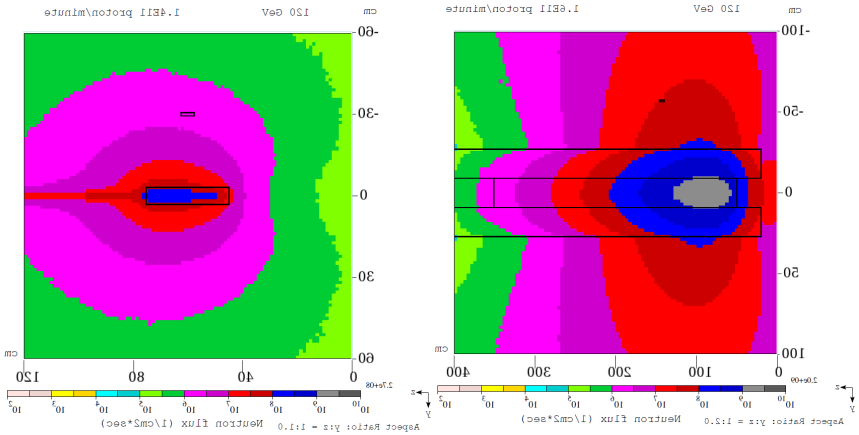
- To support R&D on very high rate trackers we have removed a section of beam pipe just upstream of the proton collimator in MT3, and have put a movable table station in this area. Signals are sent to MS3 service building, not Meson Detector Building. Can support rates up to 5E11 Hz.



MTest irradiation areas

- Have several areas in MT beamline where irradiation studies can take place:
  - Near primary target in MT4 you can have a mixed field of radiation that simulates conditions in the LHC halls, for instance.
    - (Calculated dose for a Si sample irradiated @ 30 cm away from the aluminum target and pinhole collimator is ≈ **1.2E4** and ≈ **4.5E3 Gy/yr**, respectively (very similar to LHC cavern)



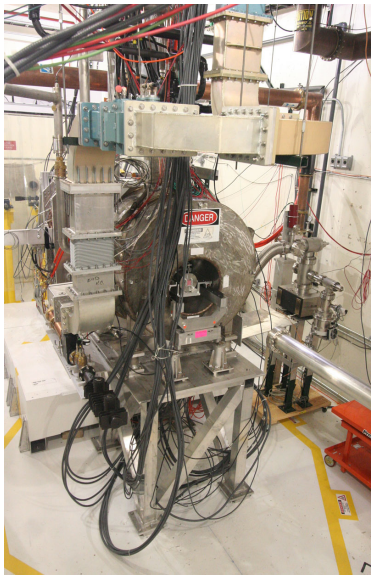


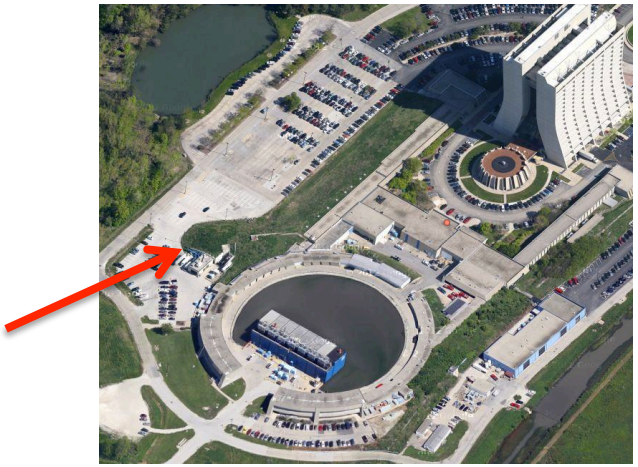
Al Target

Beam Dump

MTA - Muon Test Accelerator

- Purpose is to provide an experimental area for the Muon Accelerator Project to test cavities inside high magnetic field, with intense beam.
- 400 MeV protons from Linac
- 1 Hz repetition rate with >1E12 beam available
- First detector test MOU is up for approval now.





Summary

- Fermilab has a very active test beam program, based on the Test Beam Facility in the Meson area.
  - It consists of two beamlines (MTest and MCenter), along with a movable tertiary spectrometer for very low energy beam delivery.
  - The support infrastructure is extensive and is constantly being improved.
  - The schedule is typically full months in advance, but Fall/Winter 2014-15 has many open slots.
- Several irradiation facilities exist that can deliver moderately high intensity radiation.

Tips for a Test Beam Manager

- It has been my experience that “If you build it, they will come!”.
- Incremental improvements to the beamline and user area are important
  - Keep looking for ways to improve the facility.
- Sharing beam with other programs can actually be beneficial
- It’s important to have a service mentality:
  - Always encourage customers.
  - Don’t say that something is too hard to accomplish