# The Status of Fermilab's Test Beam Facility

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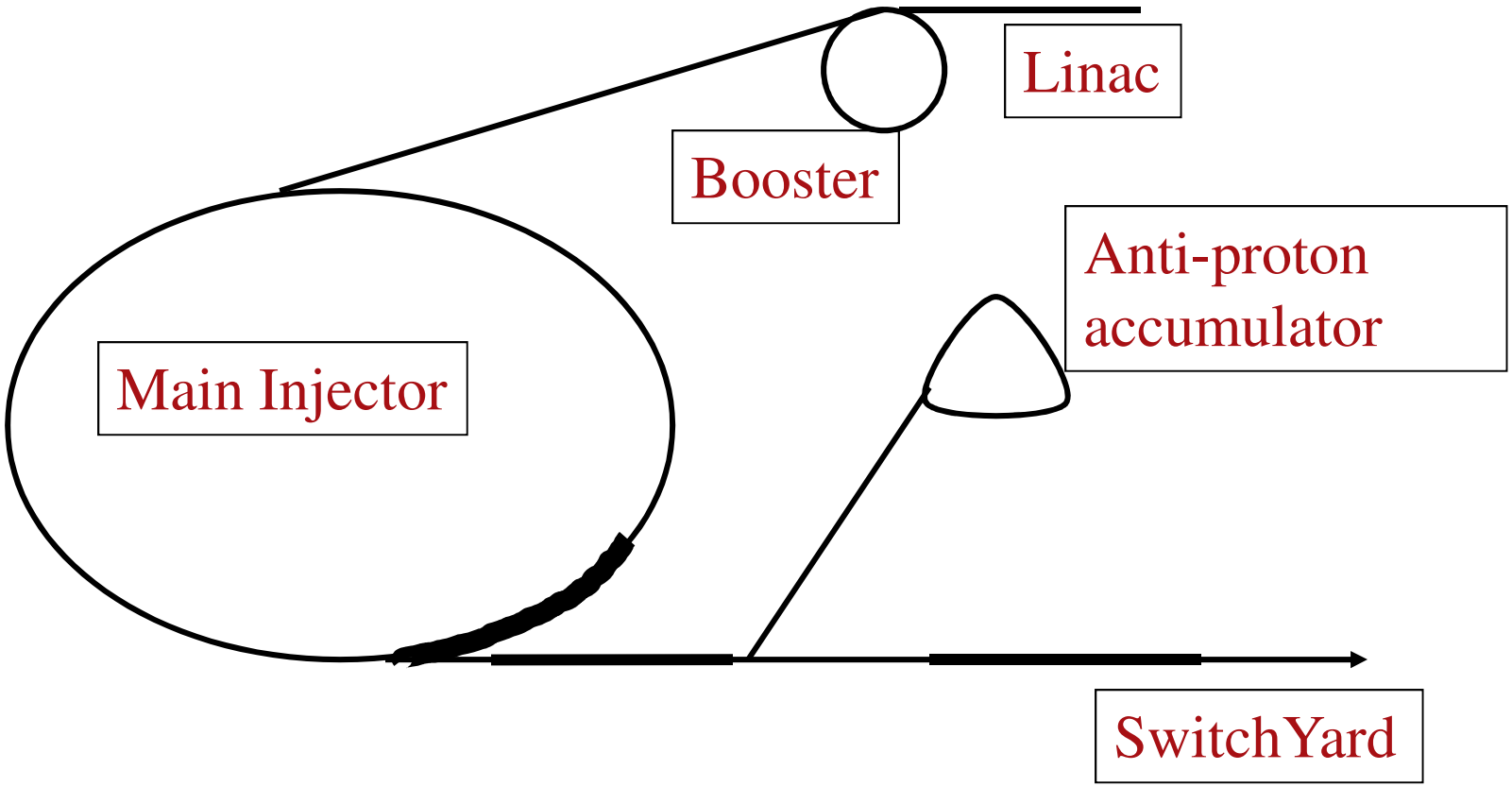
*Fermilab*

4 November, 2009
LCTW09

# EXTRACTION OF BEAM

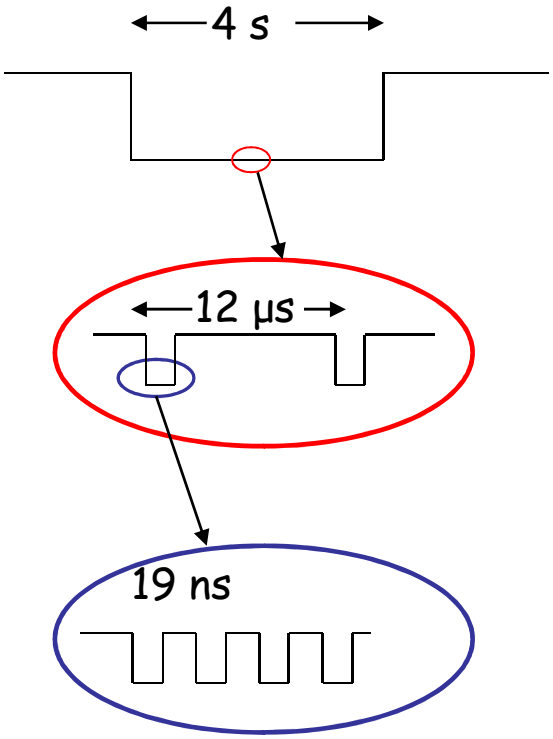
# Main Injector Extraction




**Extraction of beam from Main Injector:**

- Load 1 batch from Booster to the Main Injector
- The batch length ranges from 0.2 to 1.6 μsec in length – Full batch equals 2E11 protons
- A fraction of the beam is resonantly extracted in a slow spill for each Main Injector rotation

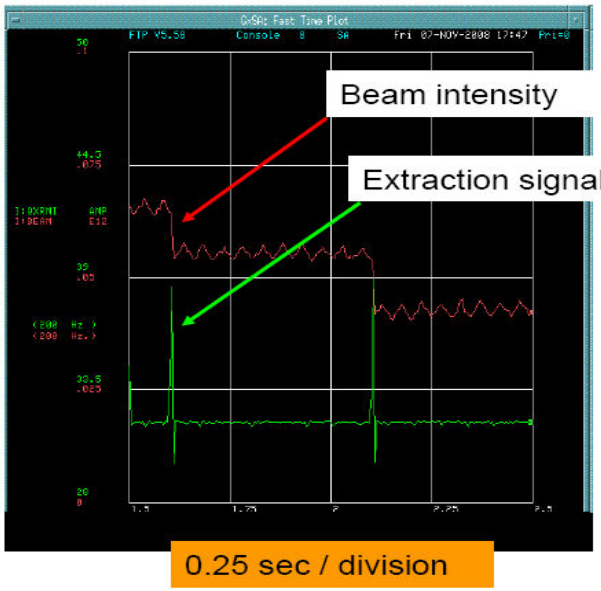
# Spill options available at MTest

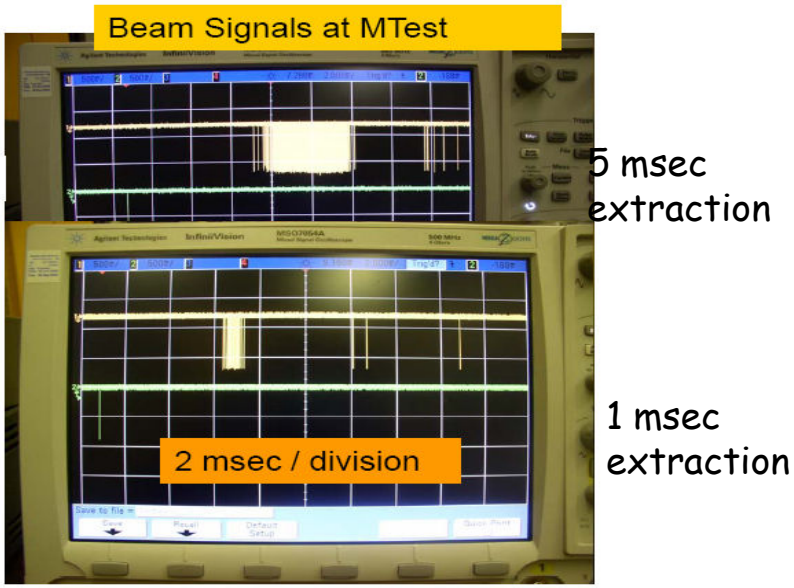



- Daily hours: 04:00 to 18:00
- Spills per min: One 4 second spill/minute, or
  Two 1 second spills/minute
- # Pulse trains: ~80,000 'batch rotations'/second
  ( 1 microsecond train, followed by
  11 microsecond void )
- # Pulses: from 5-60 'bunches' per 'batch'
  (each bunch is 19 nsec long)

# ILC-like millisecond pulsed extraction

## First Pings to MTest



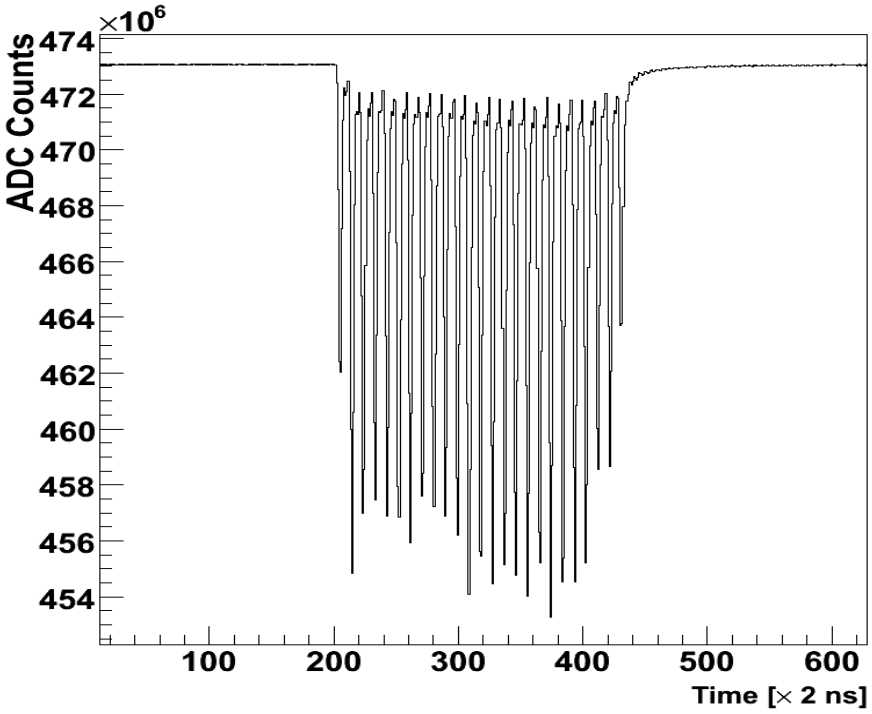




The Accelerator Division has installed pulsed quadrupole extraction hardware that can deliver beam within 1 to 5 millisecond short spills, or 'pings'. Several of these pings can be delivered within the assigned 1 second spill time.

The head of the Main Injector department says "We can coalesce 2 or more groups of protons (3-7 bunches each ) with 400 nsec spacing."

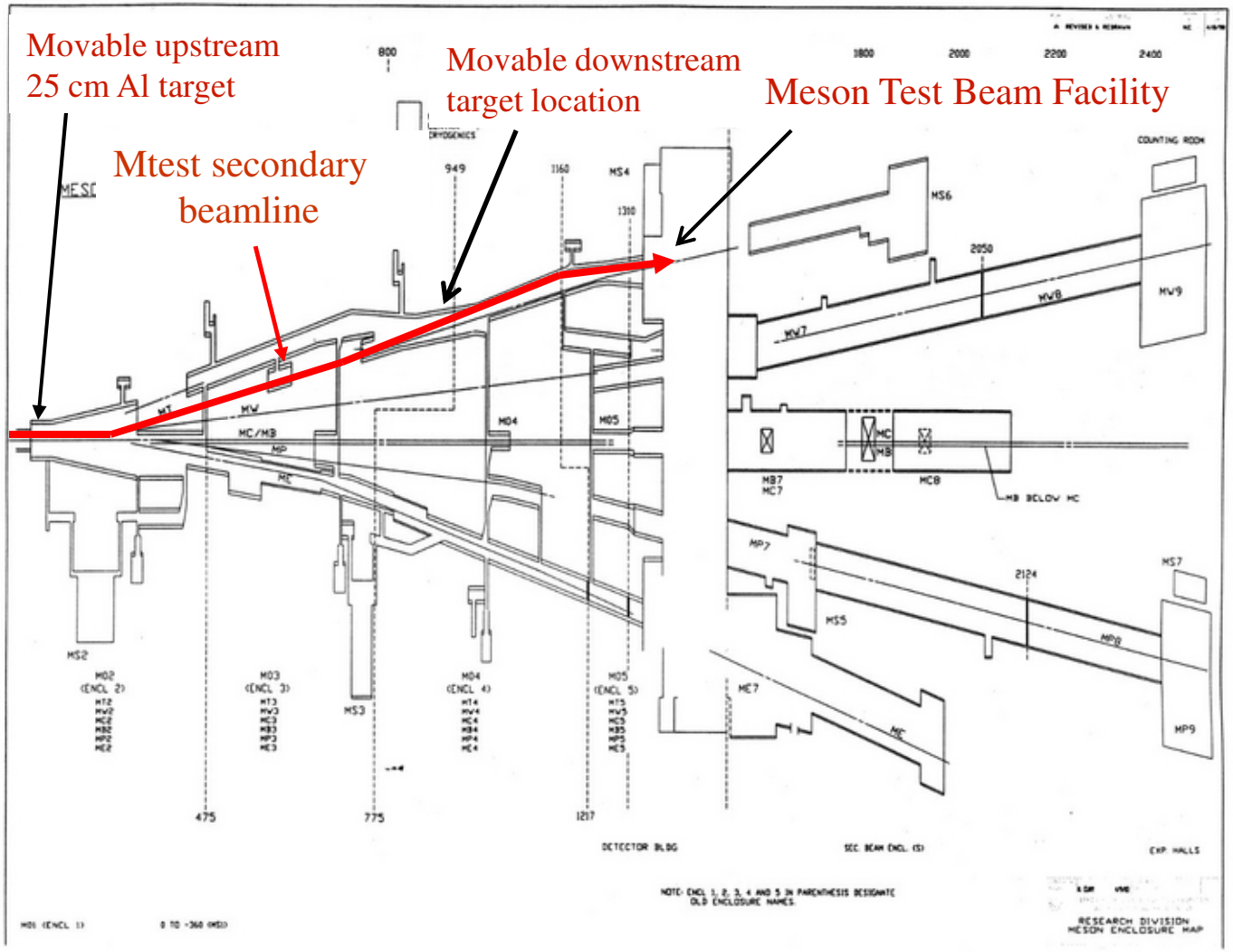
# Uniformity of Beam Delivery

- The Airfly collaboration (T988) has built a DAQ that can resolve the bunch spacing of beam arrival (19 nsec) within the entire macroscopic 4 second spill
- The population distribution is relatively uniform in each batch, as shown here



# DELIVERY OF BEAM

# Beam Delivery to MTest User Facility




**Proton Mode: 120 GeV protons transmitted through upstream target**

**Pion Mode: 8-66 GeV beam tuned for secondaries from upstream target**

**Low Energy Pion Mode: 1-32 GeV beam tuned for secondaries from downstream target**

# Beam Rates and Electron Content

## Measured rates* without lead scatterer

| 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% |

## Measured rates* with 1/4” lead scatterer

| Beam Energy (GeV) | Rate at Entrance to Facility (per spill) | Rate at Exit of Facility (per spill) | %Pions, Muons** | % Electrons** |
|---|---|---|---|---|
| 16 | 86,000 | 59,000 | 100% | 0% |
| 8 | 31,000 | 18,000 | 98% | 2% |
| 4 | 5,400 | 1,300 | 74% | 15% |
| 2 | 4,100 | 250 | <30% | >70% |
| 1 | 4,900 | 120 | <30% | >70% |

*Rates here are normalized to 1E11 at MW1SEM

# Beam Delivery for CALICE

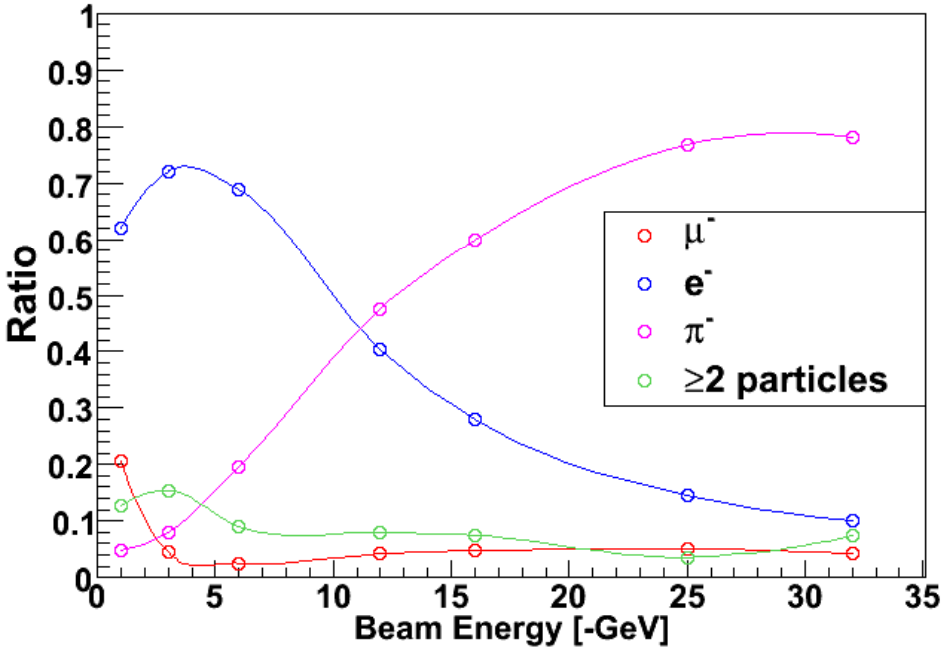
- The CALICE experiment (T978) has been the most comprehensive detector system to be installed at MTest and has summarized their results for beam composition.
- The Fermilab Accelerator Division has created beam tunes for CALICE as follows:

  **Negative**

  1,2,3,4,6,8,10,12,15,20,30 GeV

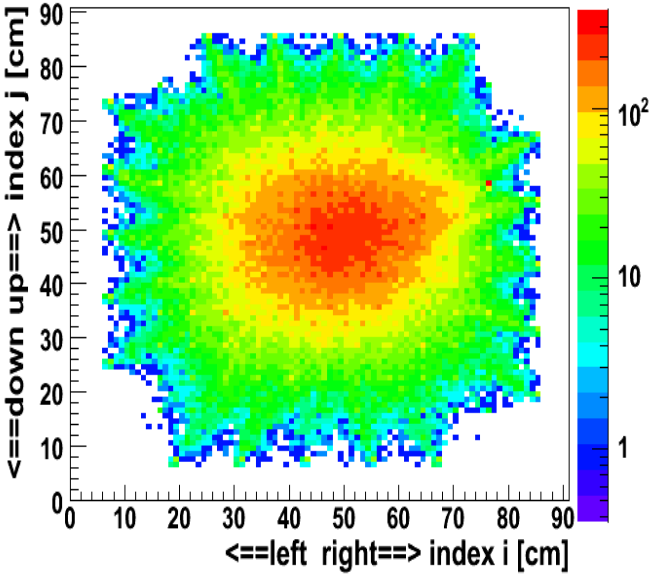
  **Positive**

  32 GeV (high rate muon mode), 120 GeV (proton mode)



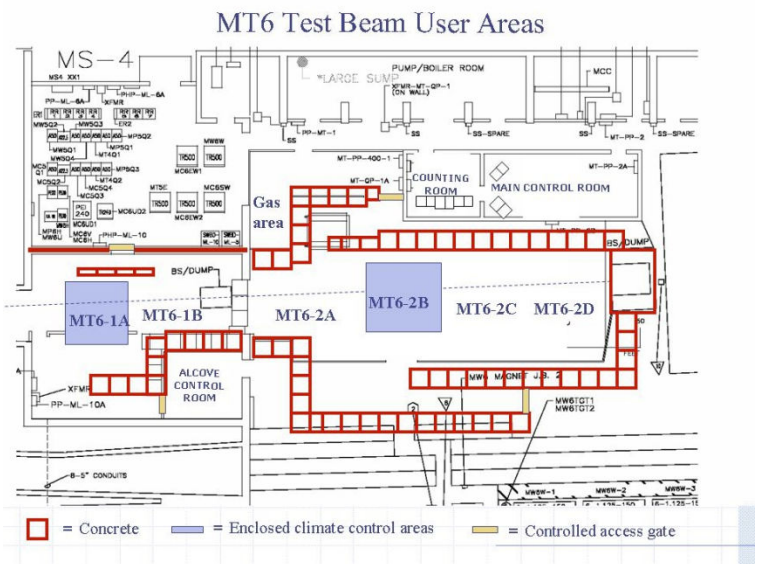
# Muon beam at MTest

- Can maximize muon flux by running high intensity at 32 GeV, and inserting 2.5 meter beamstop just before the user area.
- Broad-band muon flux can be delivered at several kHz over a square meter, as shown by CALICE

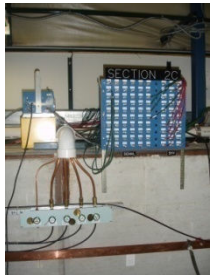


# THE USER FACILITY

# User Facility



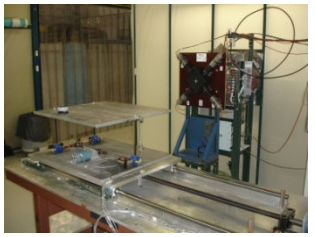

Spacious control room



Signal and HV cables

Gas delivery to 6 locations

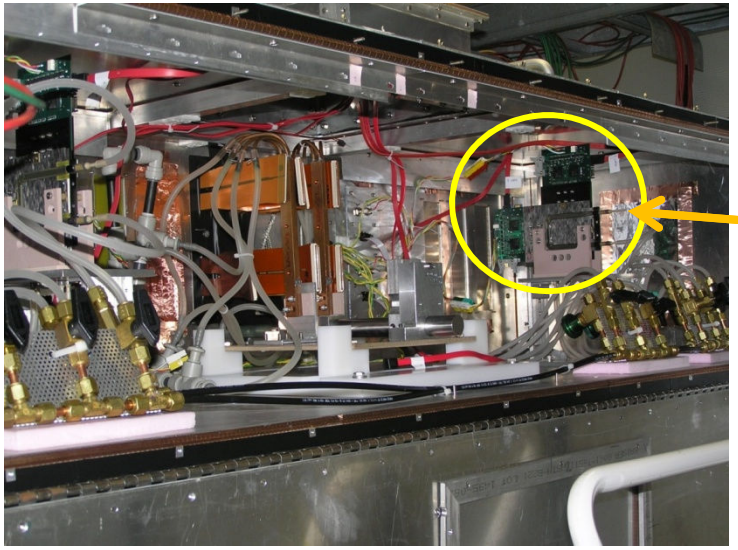
4 station MWPC spectrometer

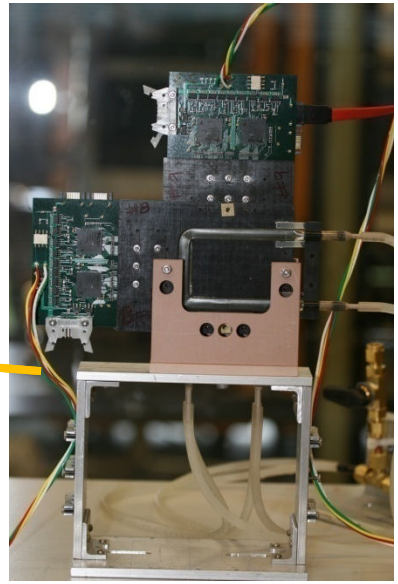


Two motion tables

# 2 New Pixel Tracker telescopes in MTest

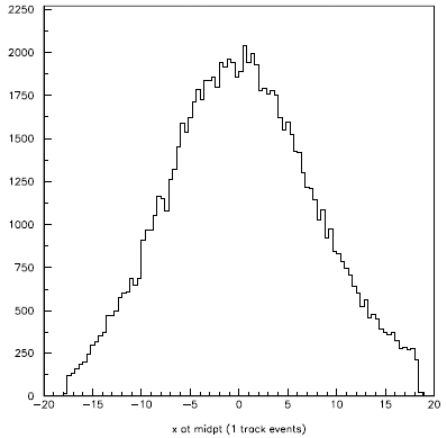
PHENIX SENSOR TELESCOPE:

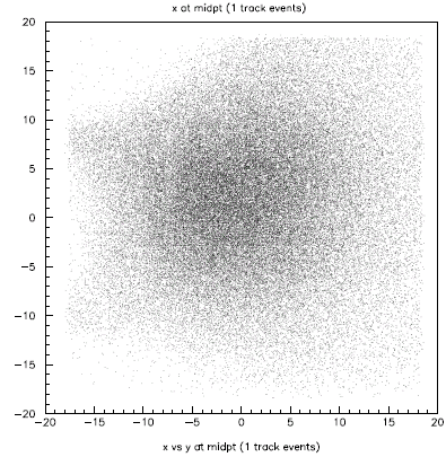




- Sensors are spares from PHENIX, read out with FPIX chip
- pixel size is 50 x 400 $\mu^2$
- Resolution is <10 $\mu$
- Total active area per X-Y station is 6x6 $cm^2$
- Two stations currently

# Beam spot (last quads off)

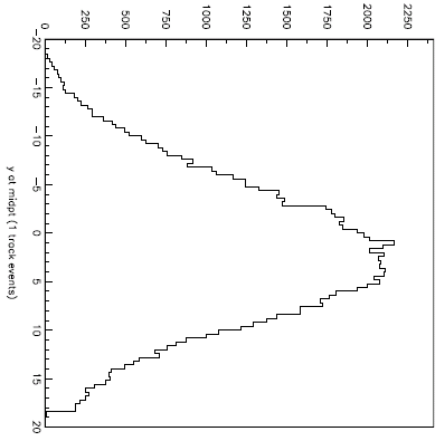


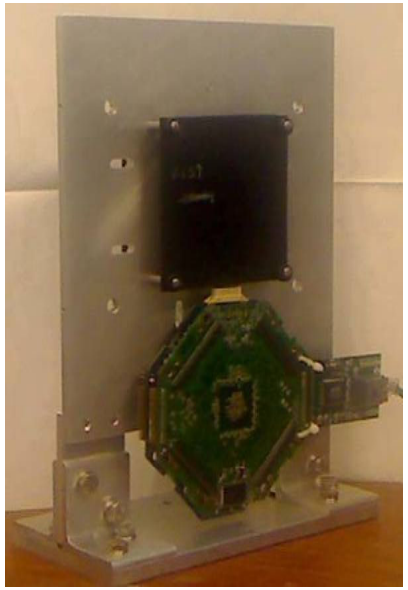

mm

mm

120 GeV proton beam:
1-track events; 3-4 spills
at low intensity
(5 Booster buckets)
93k tracks
3/20/09



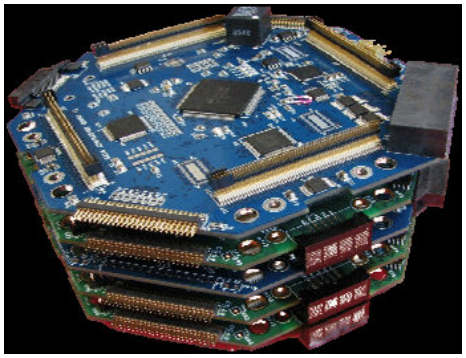
# New CMS Sensor Pixel Telescope

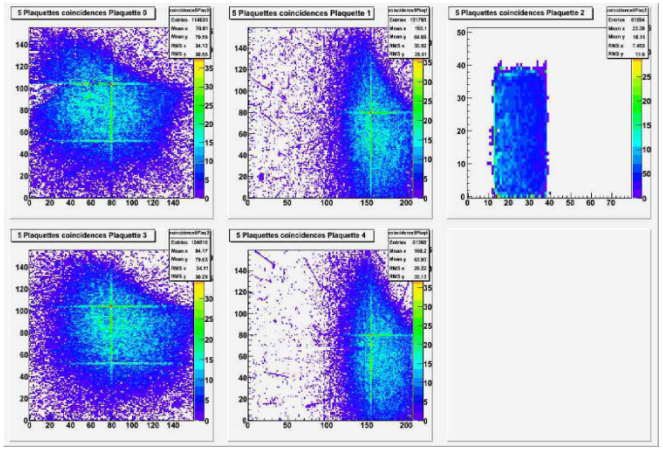


Sensors are B-grade, but functional at low intensity.

Overlap area is 2 cm x 2 cm

4 stations of 100x150 $\mu m^2$ pixels gives <6 $\mu$m resolution

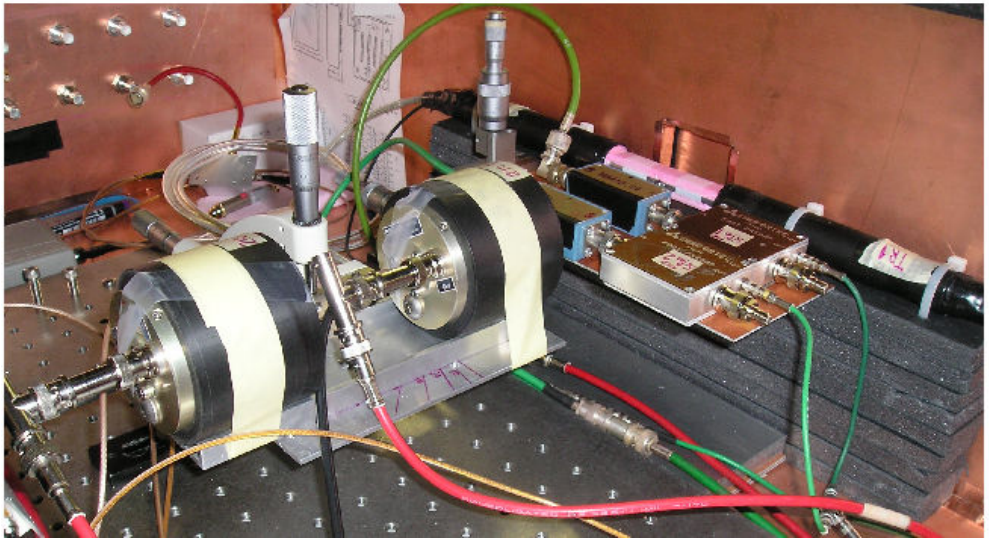




Clever vertically integrated DAQ, called “CAPTAN”, has node processing boards and data conversion boards. Horizontal connectivity for output. Multi-threaded application software running on Windows.

# Fast Timing Detectors at MTest

- Use Photek 210 (10 mm area) and 240 (40 mm) devices
- Several different configurations tested in last run
- In-line configuration gives astonishing 6 psec resolution with the 240 device
- Configuration with quartz bars at Cerenkov angle minimizes material at first measurement position

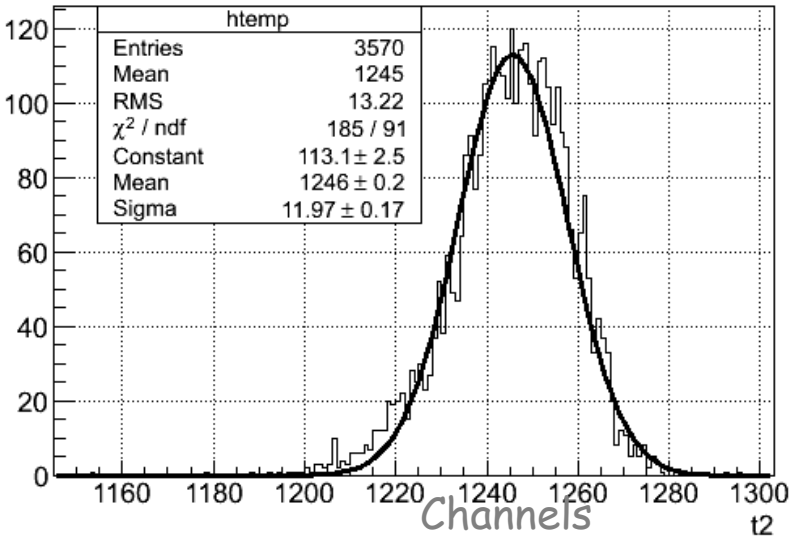


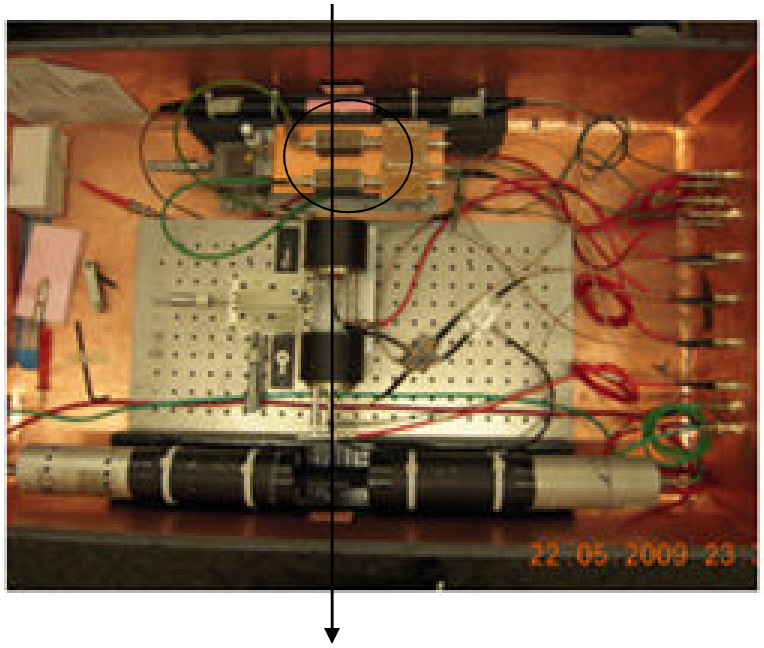
# Tests of SiPMs = silicon photomultipliers

Eight Hamamatsu SiPMs, 3mm x 3mm
In beam with quartz Cherenkov radiators
several thicknesses (4 – 12mm),
mirrored and not mirrored.

Best conditions $\sigma(t) \sim 33 - 37$ ps

10-15 photoelectrons

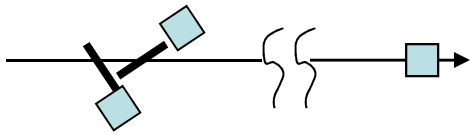


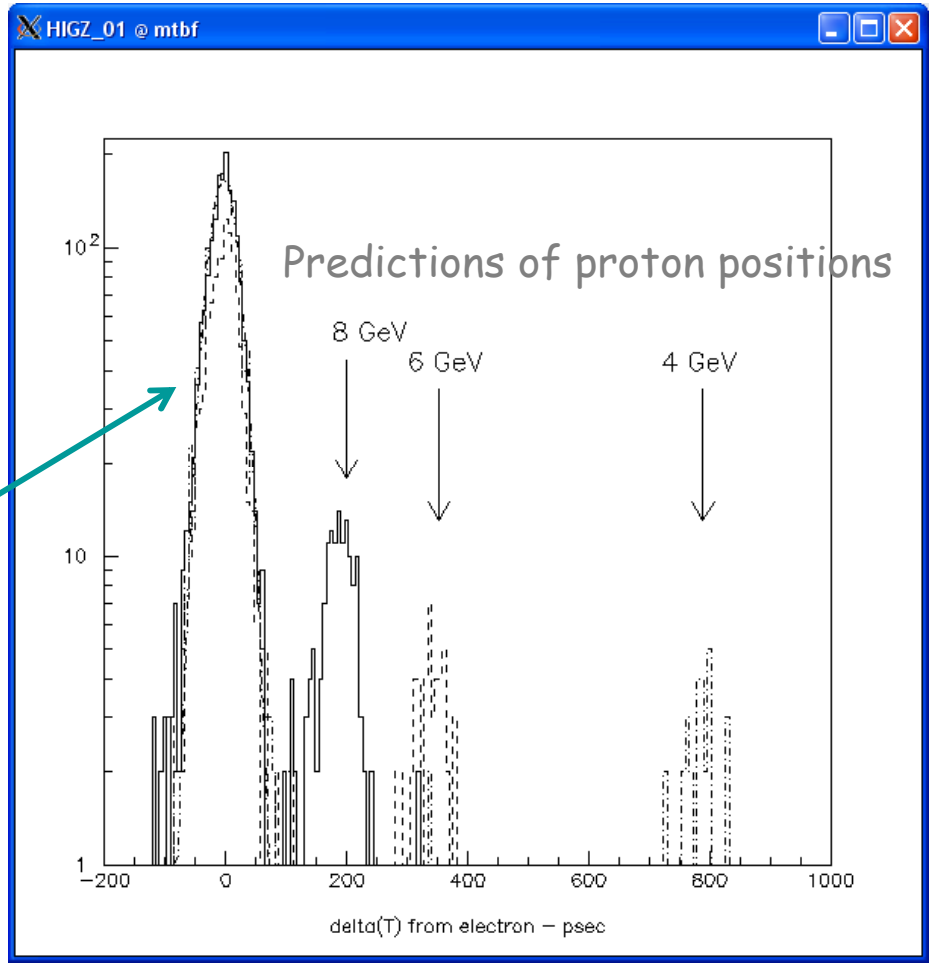
Pulse height slewing correction applied

# Extreme Time-of-Flight System

Start = Double-Q-bar
Stop = Photek 240
Start-stop dist. = 8.7 m



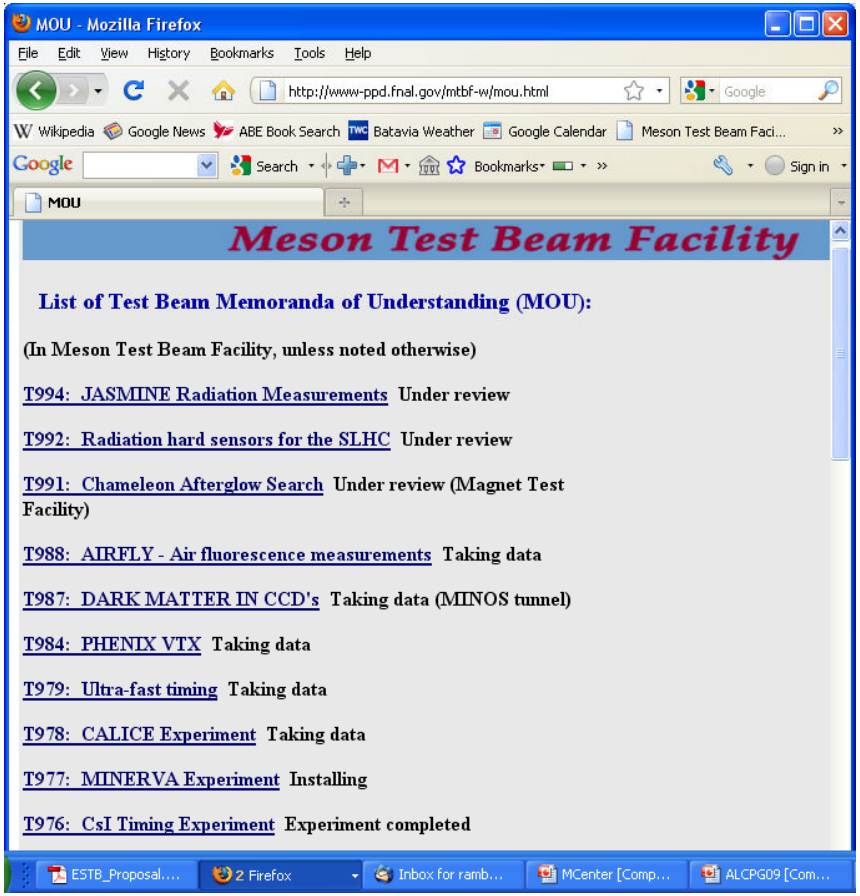
24 psec resolution positron peak, using average of A & B times




We can measure momentum of a high-energy proton (~10 GeV) using this system

# USER SCHEDULE

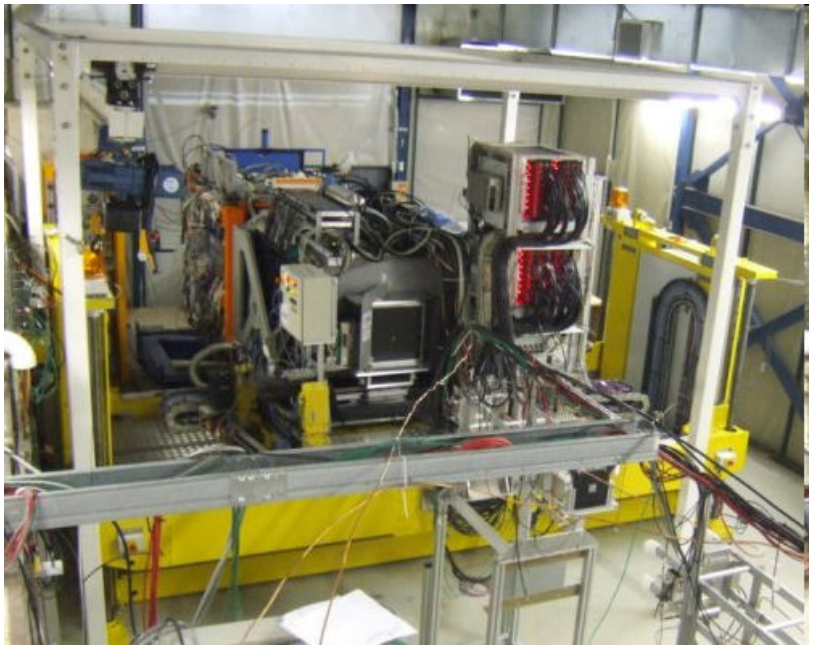
# A World-Class Program

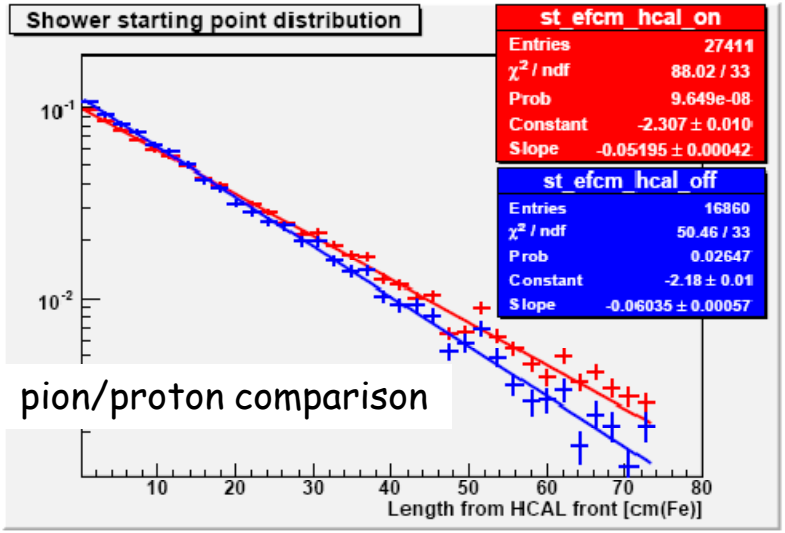


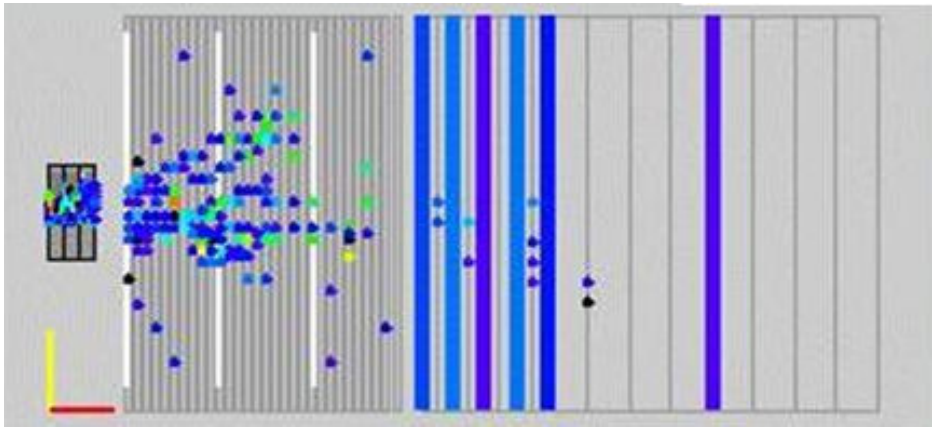

Affiliations of Test Beam Users, According to their MOU

| Year | Experiments | Institutions | People | Countries |
|---|---|---|---|---|
| 2009 | 7 | 49 | 147 | 14 |
| 2008 | 5 | 42 | 112 | 13 |
| 2007 | 10 | 28 | 102 | 8 |
| 2006 | 5 | 18 | 65 | 6 |

# CALICE runs continue to be analyzed

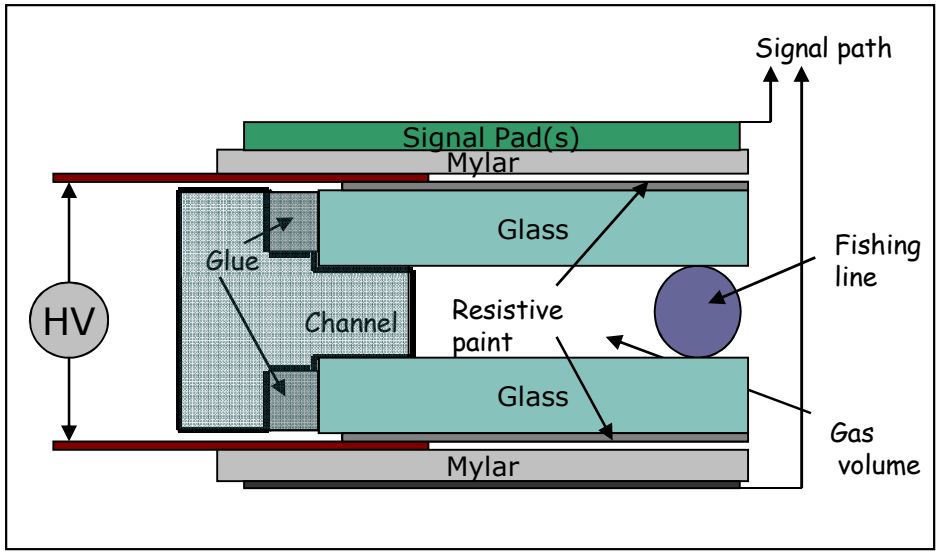


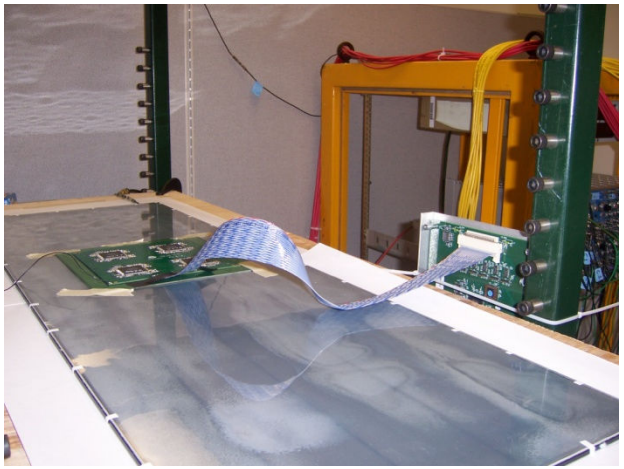


# Next step for CALICE

- Exchange the active layers of the AHCAL with the DHCAL ones
- Go for the final test beam campaign



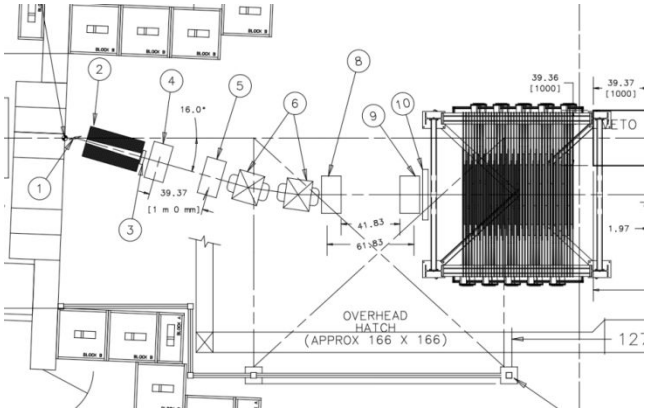
cassettes with resistive plate chambers and GEM are being built and tested

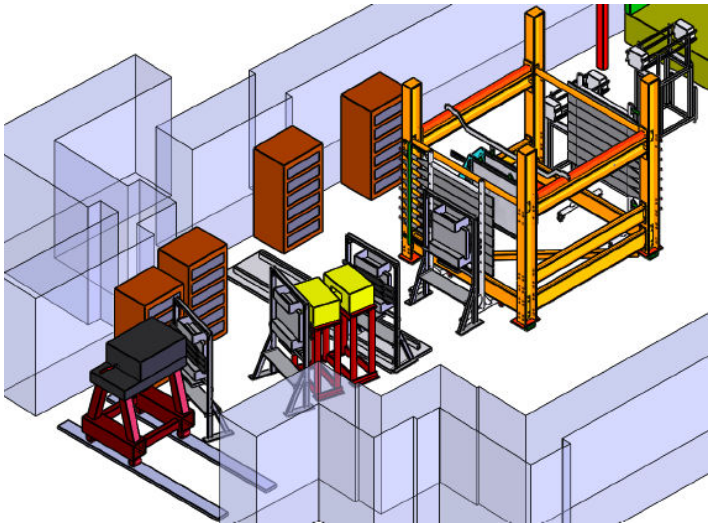
➔ Compare technologies for ECAL / HCAL with data from the same test beam

Current customs schedule indicates all CALICE material to be shipped back to DESY by March, 2011

# Tertiary 300 MeV/c Beamline for MINERVA

- The MINERVA experiment requested space to create a new tertiary beamline that could deliver pions down to 300 MeV/c momentum.
- The Particle Physics Division and Accelerator Division have agreed to help and are proceeding on installation.
- Full tracking and TOF will allow for momentum measurement and particle i.d.
- Target station rolls away for other users.
- The full spectrometer will be tested in November, 2009 and full detector test in April, 2010



# Draft 2010-13 Fermilab Accelerator Experiments' Run Schedule

## Typically Revised Annually - This Version from October, 2009

| Calendar Year | | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|
| Tevatron Collider | | CDF & DZero | CDF & DZero | OPEN | OPEN |
| Neutrino Program | B | MiniBooNE | MiniBooNE | | OPEN |
| | | OPEN | OPEN | | MicroBooNE |
| | MI | MINOS | MINOS | | OPEN |
| | | MINERvA | MINERvA | | MINERvA |
| | | ArgoNeuT | | | |
| | | | NOvA | | NOvA |
| SY 120 | MT | Test Beam | Test Beam | | Test Beam |
| | MC | OPEN | OPEN | | OPEN |
| | NM4 | E-906/Drell-Yan | E-906/Drell-Yan | | E-906/Drell-Yan |

This draft schedule is meant to show the general outline of the Fermilab accelerator experiments schedule, including unscheduled periods.

Major components of the schedule include shutdowns:

In Calendar 2010, a 4-6 week shutdown for maintenance is shown.

In Calendar 2011, no shutdown for maintenance is shown.

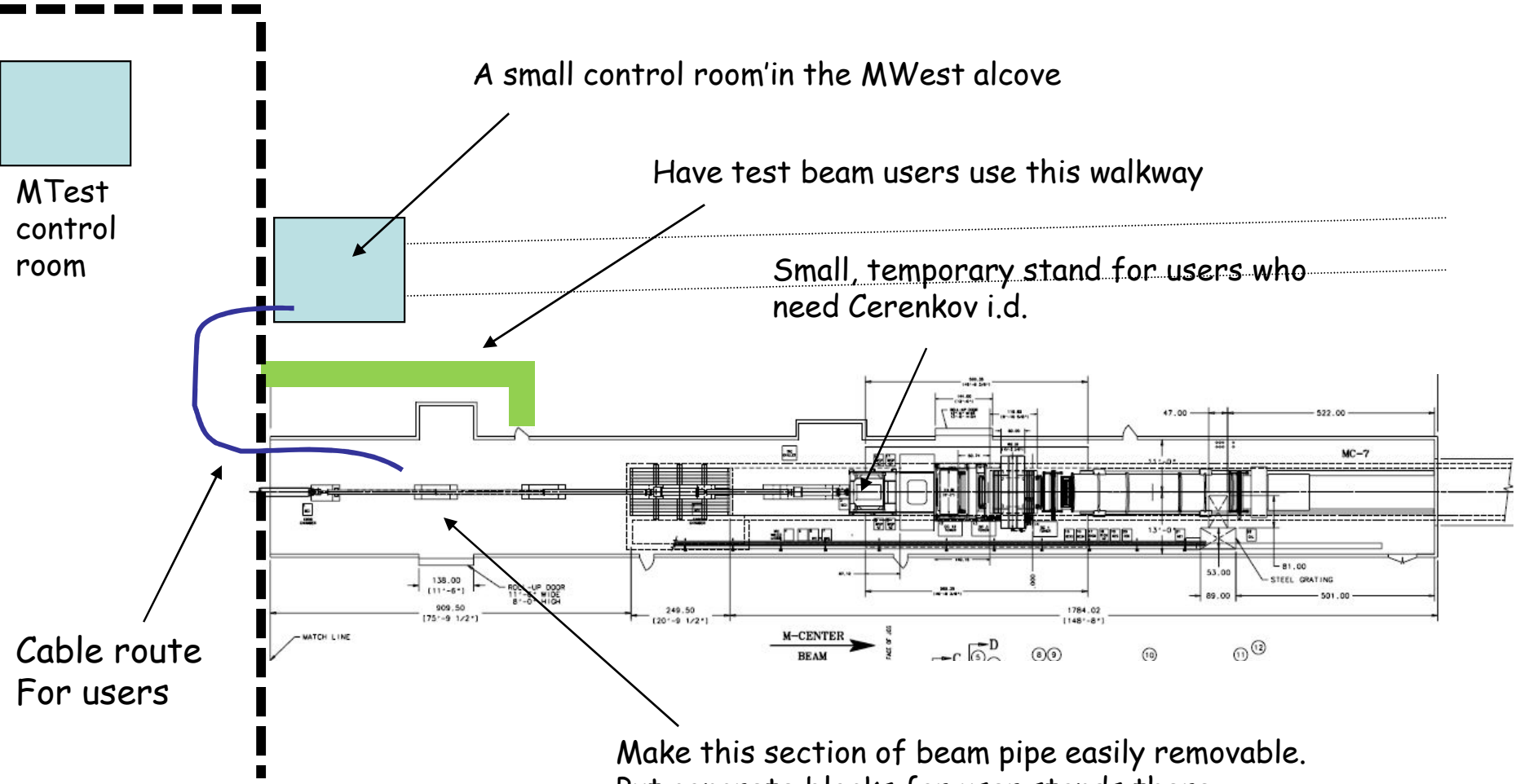
A 2012-3 11-month shutdown is shown to upgrade the proton source and change the NuMI beam to the Medium Energy (ME) config.

- RUN/DATA
- STARTUP/COMMISSIONING
- INSTALLATION
- M&D (SHUTDOWN)

19-Oct-09

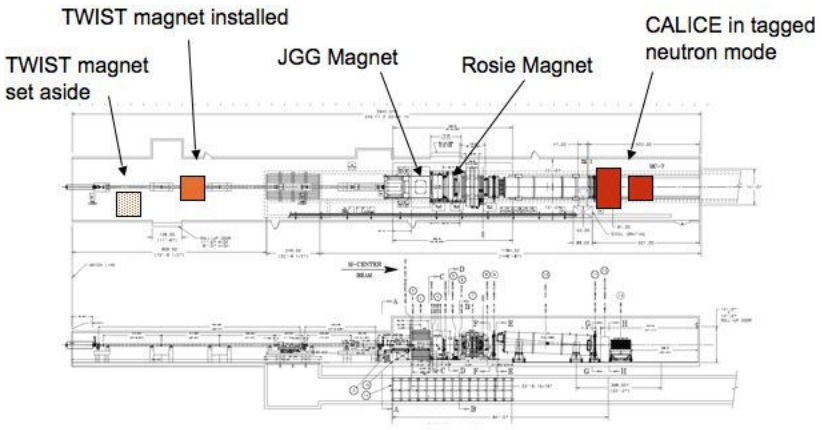
# FUTURE ADDITIONS

# Proposal for a Small Test Beam Area in MCenter

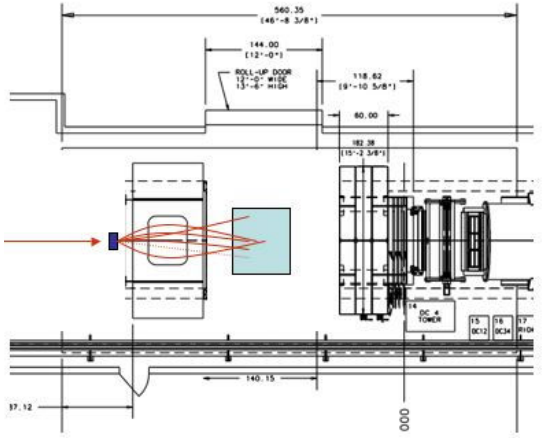


# A possible future program at MCenter

- MIPP experiment performs measurements with updated tracking and a repaired JGG magnet.
- Use the MIPP apparatus to create a tagged neutron facility.
- Import a large bore solenoid for TPC tests (the TWIST magnet from TRIUMF is a possibility)
- Use the MCenter spectrometer to simulate jet physics for advanced calorimetry.




Programs possible at MCenter



Creating a 'jet' in the Jolly Green Giant

# Recommendations from Review Panel

- The laboratory should complete the Jolly Green Giant repair.
- A shielding assessment for MCenter should be completed without delay.
- The beamline magnet power supplies should be upgraded to extend the momentum range of the MCenter beam to lower momentum.
- The proposed MCenter test beam plan should be encouraged.
  - The switch between uses of the beamline should be made simple and fast.
  - A study of potential users and needed instrumentation should be done.
- Additional resources should be assigned to minimize space and time conflicts in the MCenter area.
- Ways should be found to increase the analysis manpower on MIPP , including supporting efforts by universities to gain funding.

# An Irradiation Facility

- The JASMIN experiment (T993) plans on irradiating thin foils as part of their shielding and neutron production program.
- They will be using the M01 area, where the split between MCenter and MTest takes place.
- A small area, with SEM measurement of beam flux, can support future irradiation experiments for thin detectors
- Full intensity is 2 x $10^{11}$ protons per minute, in about 1 $cm^2$

# Summary

- The MTest facility continues to support a large variety of advanced detector tests
- The beamline is quite versatile, delivering secondary beams from 1 to 64 GeV, and a primary beam of 120 GeV protons. Electrons are dominant at low energies. Muons can be selected for with a beam stop.
- A new tertiary beam is being developed, which should deliver tagged pions down to 300 MeV/c.
- Two new pixel telescope systems have been created for the facility, with resolutions of 5-10 microns.
- A new TOF system has been tested, with a resolution of 24 psec. Individual measurements on a 4 cm MCP/PMT show 6 psec resolution
- A proposal has been approved at Fermilab to support test beam activities in the MCenter beamline, perhaps in conjunction with the MIPP experiment.
- Can support irradiation tests for thin detectors