US Test Beams

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Introductory Remarks

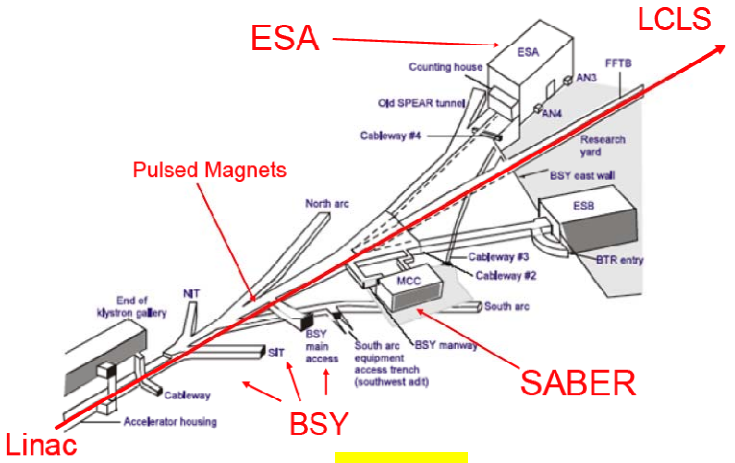
- Test Beams provide facilities for detector R & D
- Long History – always very useful
- Few Remain in the US
  - Fermilab Meson Test Beam
  - SLAC proposal (slides from Mike Woods)
    PPA (Particle Physics and Astrophysics)

SLAC End Station A Test Beam Proposal

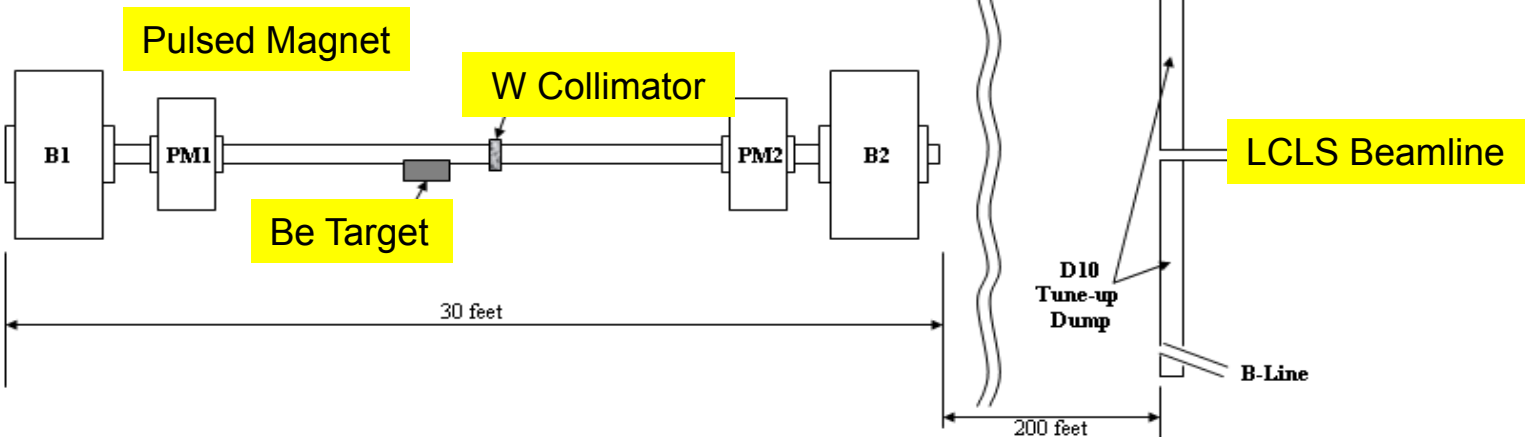
Electron and Pion beams up to 14 GeV

Test Beam Options

1. LCLS beam halo on W Collimator (***parasitic***)
   ~1 e^-/bunch, 2-6 GeV
2. Kick 14 GeV LCLS beam to A line (~1 Hz)
   1 – 1.0 x 10^{10} e^-/bunch, p ≤ 14 GeV
3. Kick 14 GeV LCLS beam to Be Target (~1Hz)
   ~1/bunch, 2-12 GeV e^+ or 2-10 GeV π^+



Beam Switch Yard (BSY) Region



SLAC End Station A Test Beam Proposal

- **Interest in both primary and secondary beams**
- **Primary beam: LCLS 14 GeV low emittance beam**
- **Secondary beam: electrons and pions**
- **Experiments can use a broad range of intensities: single particle/bunch, full intensity electrons, + variety of intermediate intensities**

Primary beam uses

- Beam instrumentation and accelerator physics studies, e.g. ILC
- Beam dump tests: Activation, residual dose rates and materials damage studies; can use thin or thick targets, with a range of bunch lengths
- Particle astrophysics detectors and techniques
- ✓ unique resource for the community, especially Linear Collider

Secondary beam uses

- Detector R&D for HEP, including particle astrophysics,
  e.g. silicon and pixel detectors,
  GEM and RPCs,
  precision time-of-flight and photon detection systems,
  calorimetry
- ✓ very clean electrons up to 14 GeV; known pulse arrival time--perfect for ILC electronics

Phased Approach to Future ESA Test Beams

Phase 1: 2010-2013 Low Rep Rate or Parasitic, Cost ~1M$

- Modernize the ESA PPS System,
- Develop kicker magnets and negotiate for shared beam use with LCLS

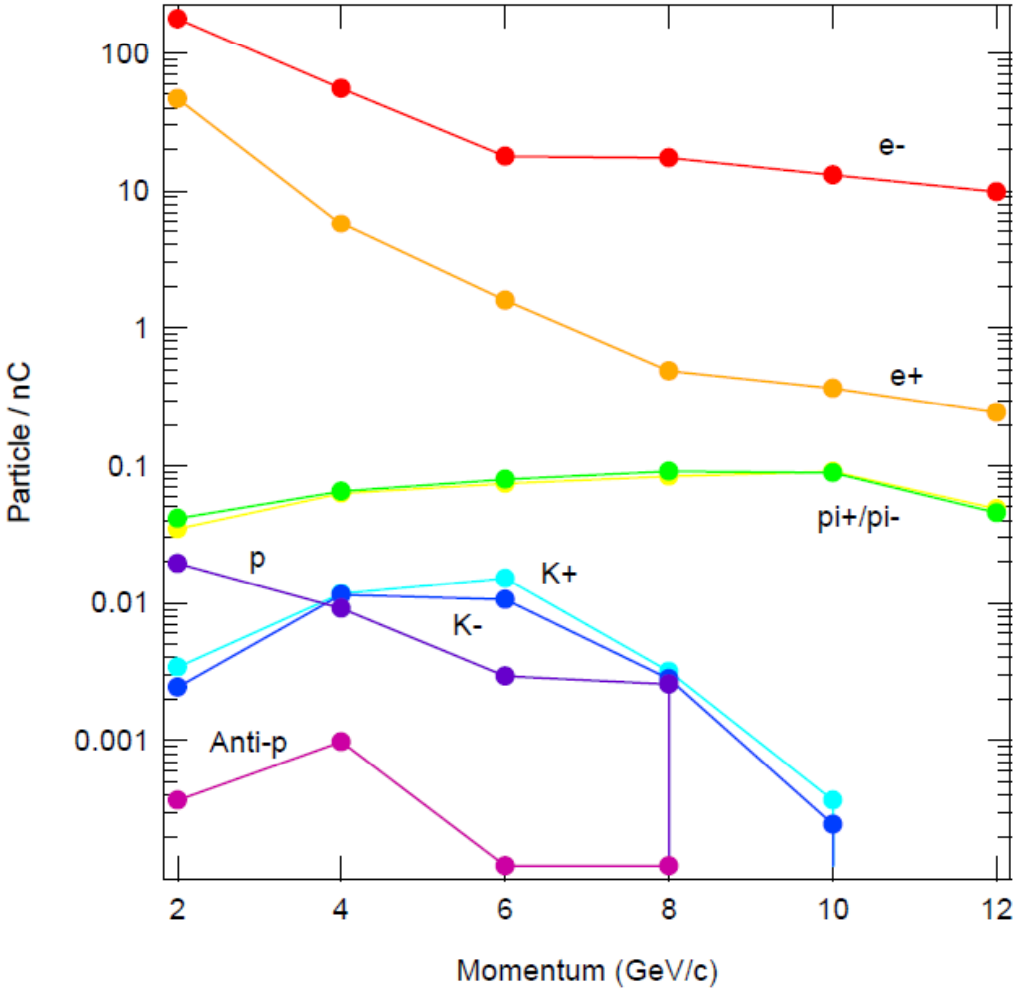
→ Small investment for PPS and magnets + leverage availability of new LCLS beam, gives U.S. a second and very cost effective test beam for hep and other fields

- Also, explore using LCLS beam halo hitting collimators as a parasitic source; beam test soon to measure amount of halo; high rate possible
  - ➢ ***Plan to submit proposal in December***

Phase 2: 2014 onwards? Full Beam Available

- Task force looking at option to modify A-line optics to preserve low emittance beam and install 2nd undulator,LCLS-U2. Kickers in Beam Switch Yard would give high rep rate primary beam to undulator for photon science. Achromat following undulator would allow spent beam to be available for HEP test beam
- Would plan to add target and secondary beamline in ESA, to give capability for secondary test beams as well as low emittance, primary test beam

Secondary Hadron Yields



0.87 r.l. Be target*
0.75-degree production angle
13.6 GeV primary electron beam
Expect ~1nC primary beam incident on Be target, using new pulsed magnets

*investigating possibility for longer targets; also for W filter to improve π^+/e^+ ratio

Results from FLUKA simulation
by T. Maruyama

Fermilab

Meson

Test Beam Facility

A broad overview of the available / possible facilities

- http://www-ppd.fnal.gov/MTBF-w/
- Contact: Erik Ramberg Ramberg@fnal.gov
- Doug Jensen DJensen@fnal.gov

Meson Test Beam Facility
The Beam

Start with 120 GeV protons from the MI
- pin hole collimator to get primary protons
  - may use the dump to produce muons
- one of two secondary targets (and absorbers)
  - upstream target 8 GeV/c – 66 GeV/c
  - downstream target 1 GeV/c – 32 GeV/c

Developing low energy tertiary beam ~0.2 – 2 GeV/c (see below)

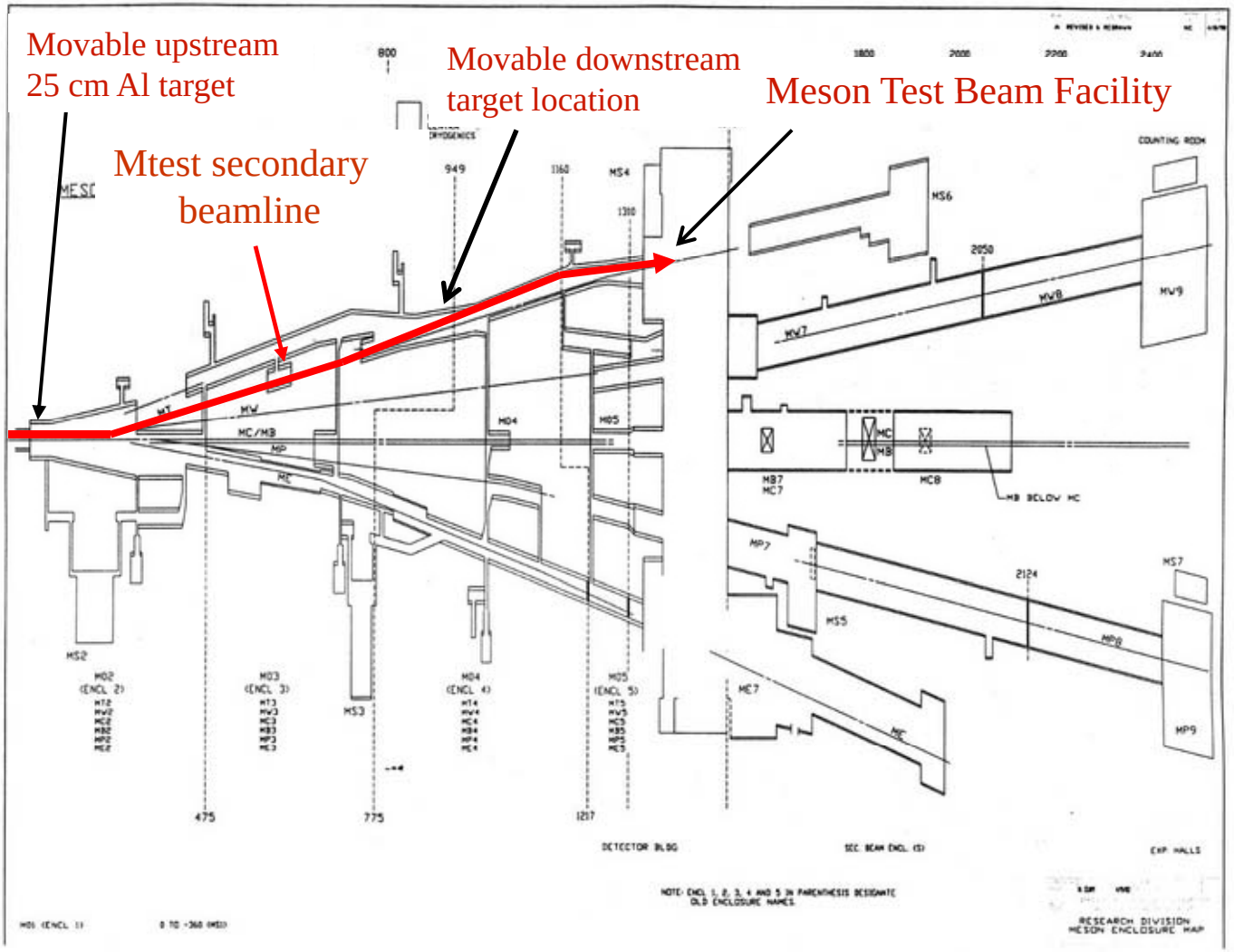
Fast pings (ILC time structure) under development (see below)

Limited to 5% impact on MI program
- one 5 sec spill / min 14 hours/day
- or several 1 sec spills / min

Fast pings under development (ILC time structure)

Rick Coleman, Check Brown – Make it all work nicely

Beam Delivery



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

To Participate
Become a Test Beam User
All are welcome – no charge-back

- MOU (Memorandum of Understanding)
  - Beam – what beam for how long
  - Other needs – detectors, gas, mechanical, electonics, other electrical, …
  - Plan Safety Reviews
- Come, Install, Review and Take Data

Test Beam Experiments over last 5 Years

Many details on the web site

- T979: Ultra-fast timing
- T978: CALICE Experiment
- T977: MINERVA Experiment
- T976: CsI Timing Experiment
- T971: LHCb Silicon Detector Upgrade
- T970: DHCAL Detector Research
- T967: Muon g-2 Calorimeter Test
- T966: Monolithic pixel detector for ILC
- T965: PSiP Photosensors
- T964: ILC GEM Chamber Characteristics
- T963: STAR Muon Telescope Detector
- T959: Microparticle Shielding Assessment
- T958: FP420 Fast Timing Test
- T957: NIU Tail Catcher/Muon Test
- T956: ILC Muon Detector Tests

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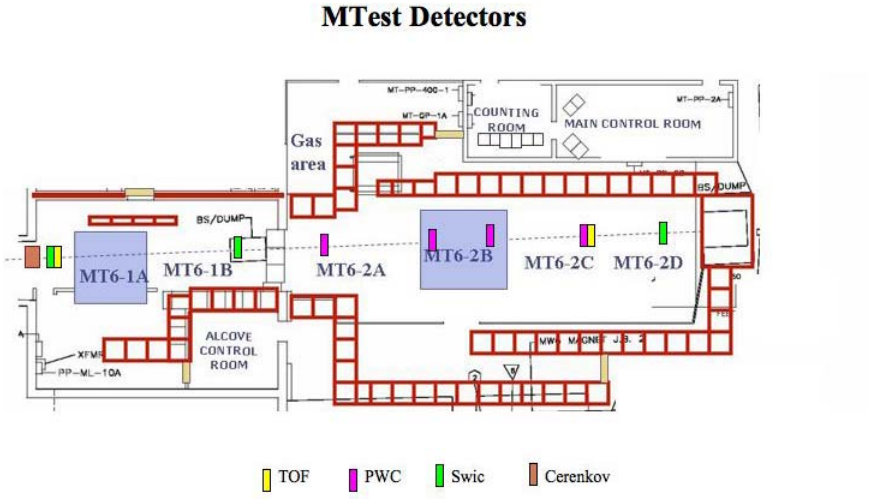
T956: ILC Muon Detector Tests

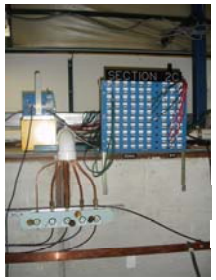
Facilities

- Two experimental areas, counting room
- Cerenkov Counters
- Beam monitoring, logging – including scalers from the beam line, experiment
- Counters, ADC, TDC -> CAMAC DAQ
- Wire Chambers -> CAMAC DAQ
- Computers
- Work with Experimenters to provide needed upgrades / modifications.

User Facility



Spacious control room



Signal and HV cables

Gas delivery to 6 locations

4 station MWPC spectrometer

Two motion tables

The Small and the Large

- The Small (carry in a few small items)
  - Pixels
  - Solid State pmt + quartz crystal

- The Large (remove roof sections, 20 T crane)
  - CALICE
  - Minerva Test Beam

Beam Rates and 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%

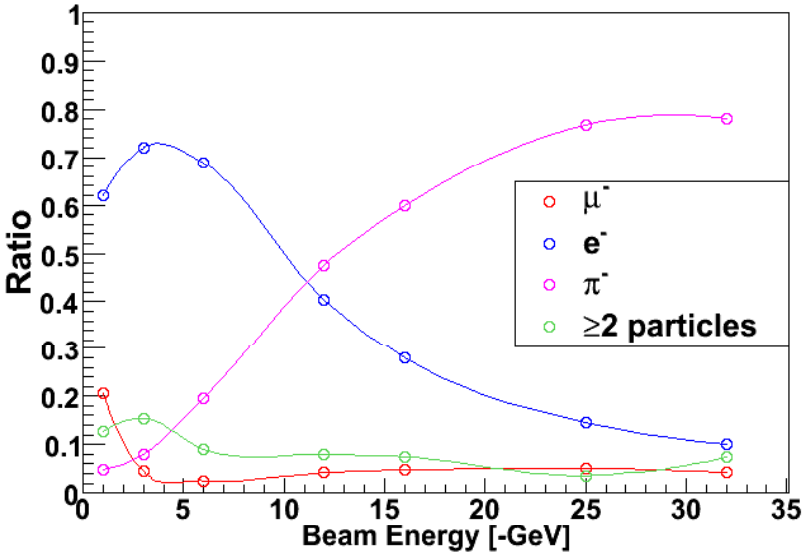
*Rates here are normalized to 1E11 at MW1SEM

Beam delivery for CALICE

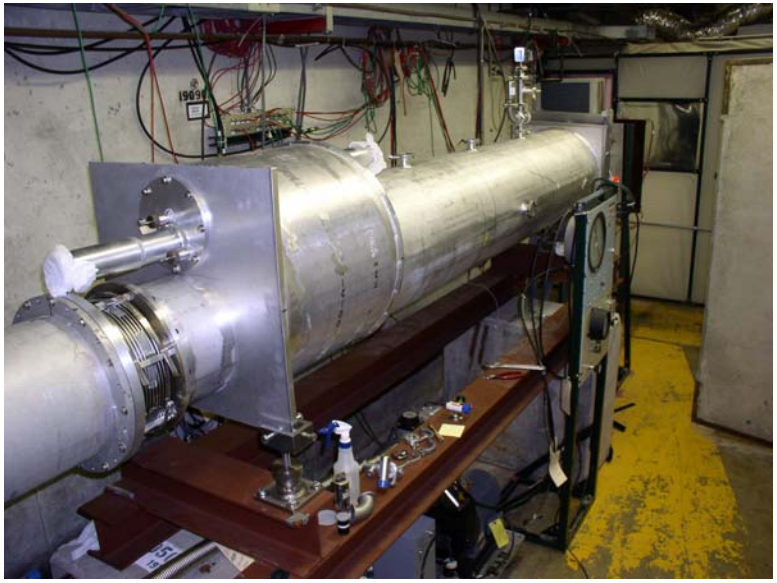
- CALICE experiment has challenged the capabilities of MTest,as well as provided the most sophisticated detector system to be installed there for beam measurements.
- The Fermilab Accelerator Division has created beam tunes for:

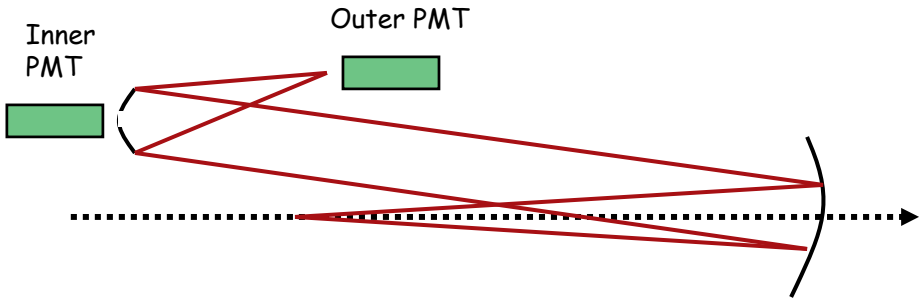
  Negative 1,2,3,4,6,8,10,12,15,20,30 GeV, as well as

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



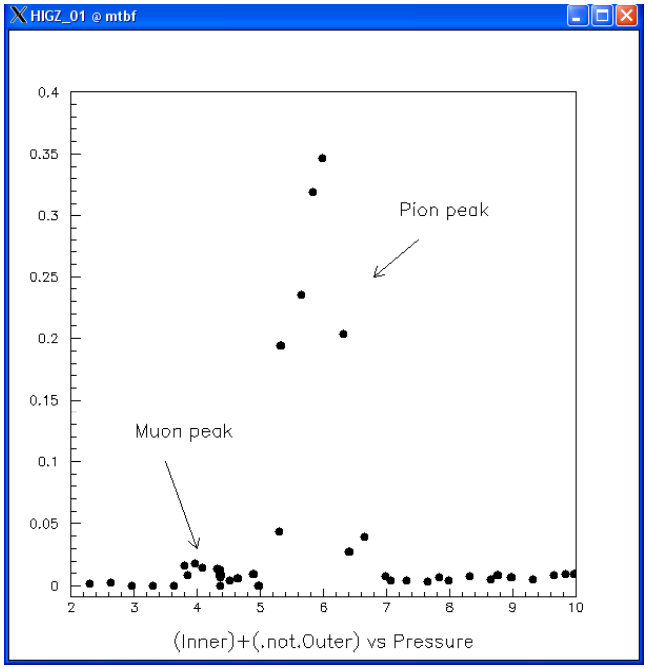
Differential Cerenkov Counter





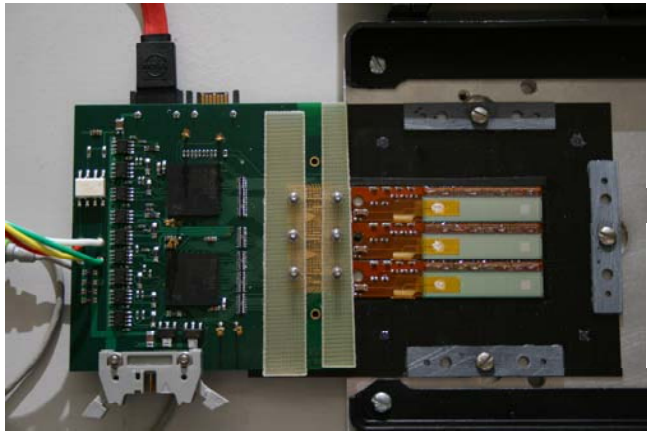
Copied design used successfully in Main Injector Particle Production experiment (MIPP)

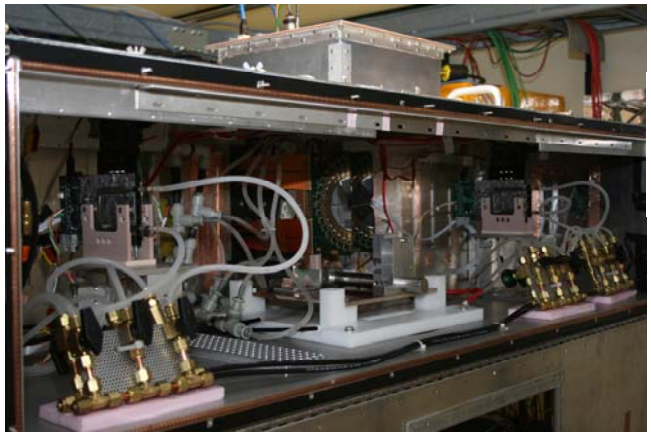
“Inner PMT” - accepts light near threshold
“Outer PMT” - accepts light from plateau region
“Inner x OutBar” - highly specific as to particle species



New Pixel Tracking System

- Collaboration of:
  - FNAL
  - LANL (sensors)
  - Nevis (DAQ)
  - Syracuse (software)
- Sensors are from PHENIX project
- Readout is with FPIX 2.1 chip
- Coverage is 6x6 cm^2
- 2 stations of X,Y orientation of sensors
- Resolution of ~10-15 microns
- Initial test this spring outlined data synch problems that are being worked on. More tests in December.

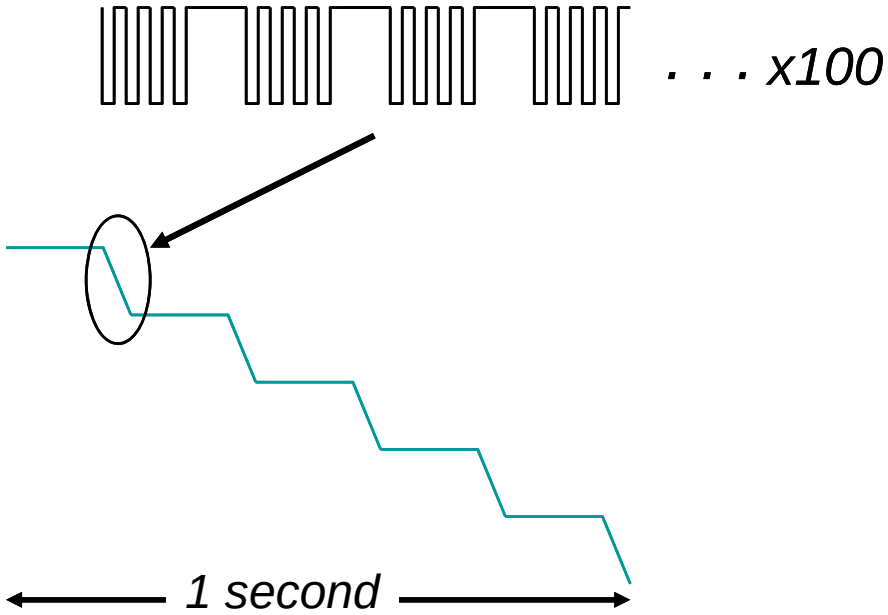




Can Fermilab Test Beam simulate ILC structure?

Possible path to ILC beam structure:

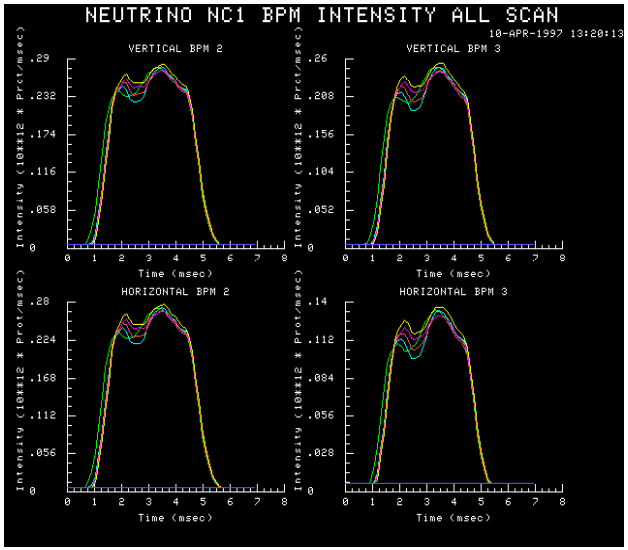
- Turn on already existing 2.5 MHz coalescing cavities. This results in an ILC like particle bunch spacing, with gap after 4 buckets.
- Implement a shorter partial extraction cycle (‘ping’) using current quadrupole resonance magnet.
- Fit 5 of these pings in a 1 second spill



Many thanks to Accelerator Division for their efforts

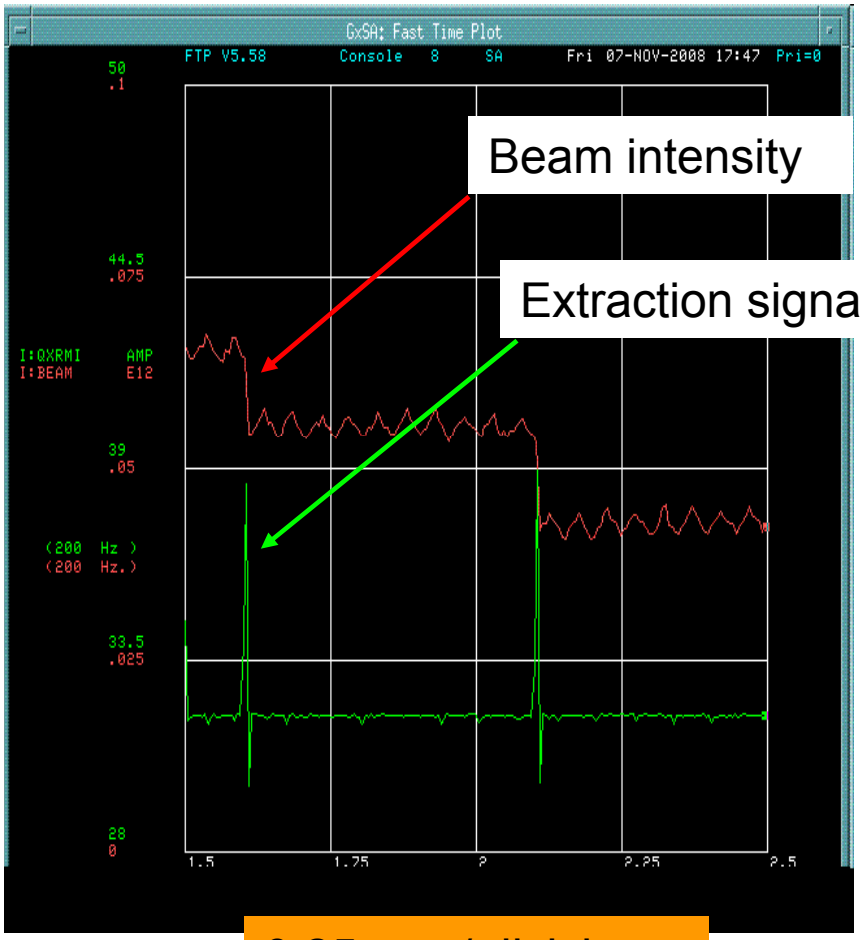
Peter Prieto in front of pulsing circuit for QXR

QXR quadrupole in Main Injector



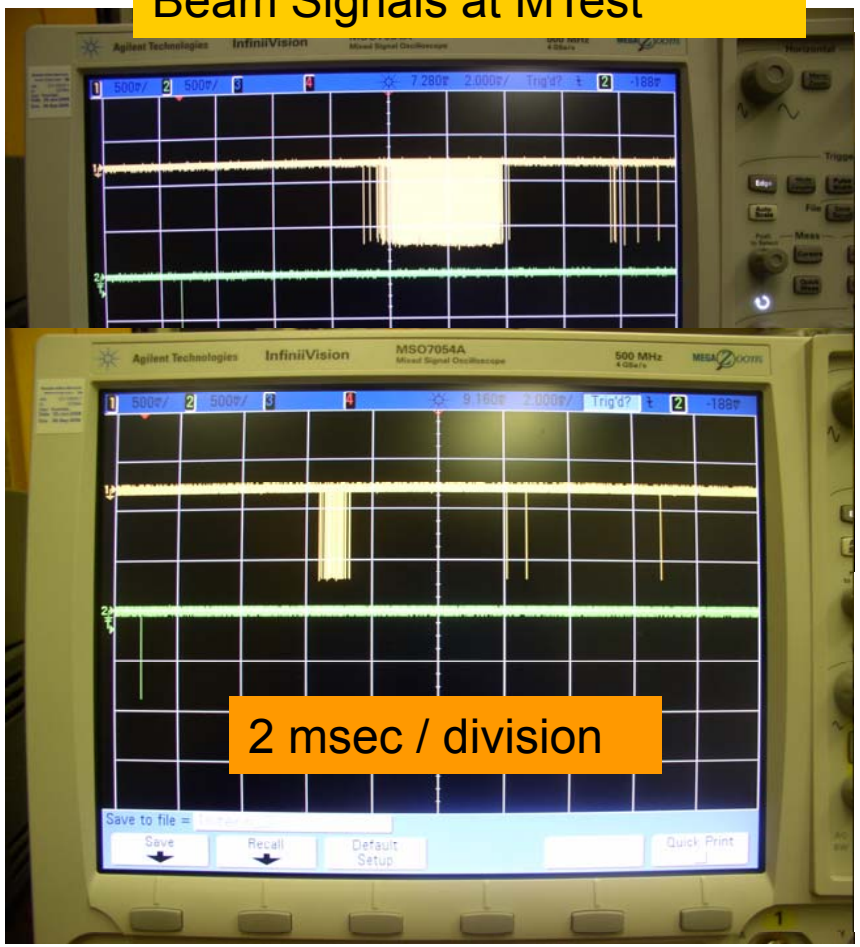
Fast pulse performance in Tevatron - 1997

First Pings to MTest



0.25 sec / division

Beam Signals at MTest



2 msec / division

Minerva Test Beam
Low Energy Tertiary Beam

- As the secondary beam has few π's below 1.5 to 2 GeV/c :
- Tertiary Beam

  ~ 1 interaction length Cu target

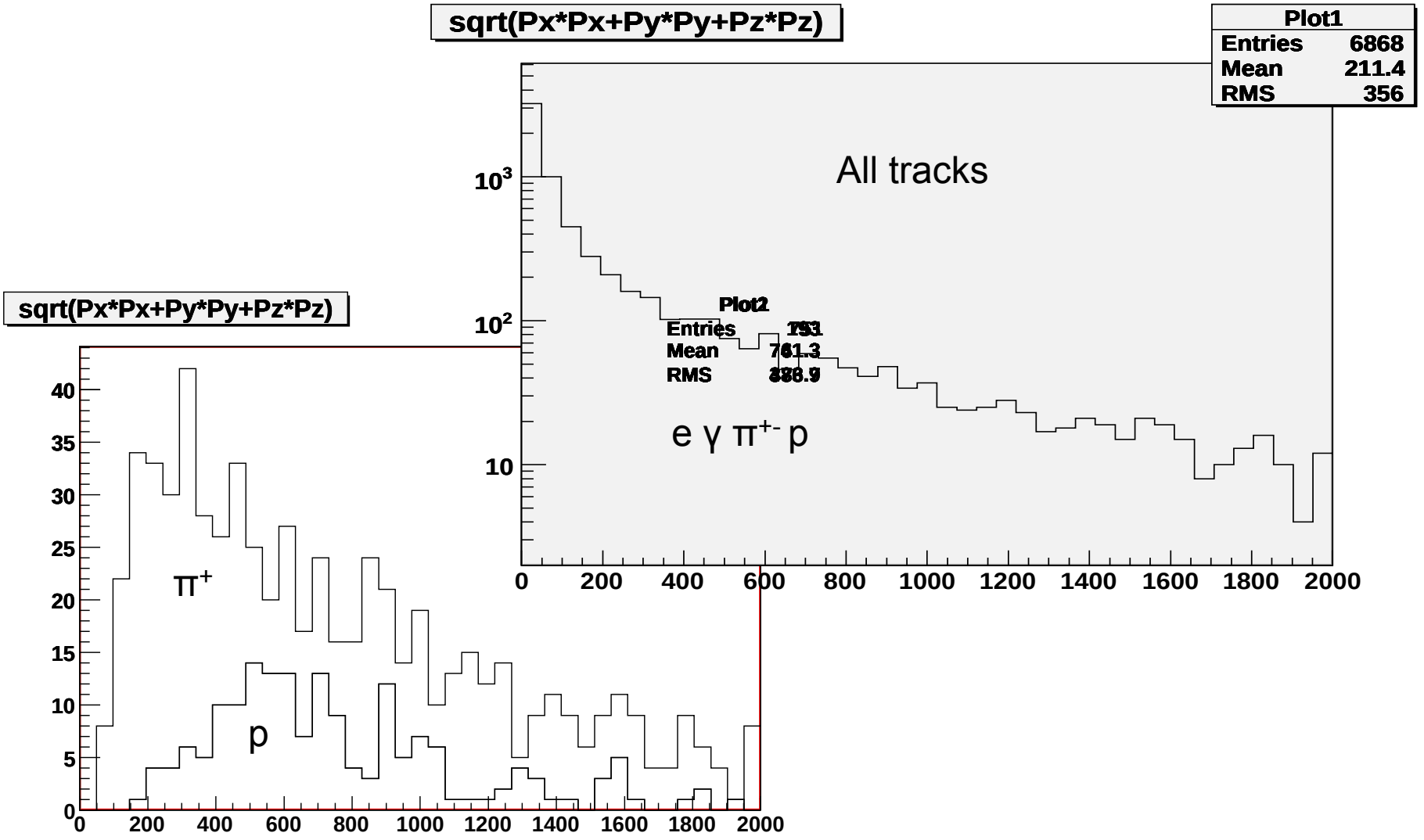
  16 GeV/c π^+ beam (for example),

  collimator at 16 deg wrt the incoming π^+ beam

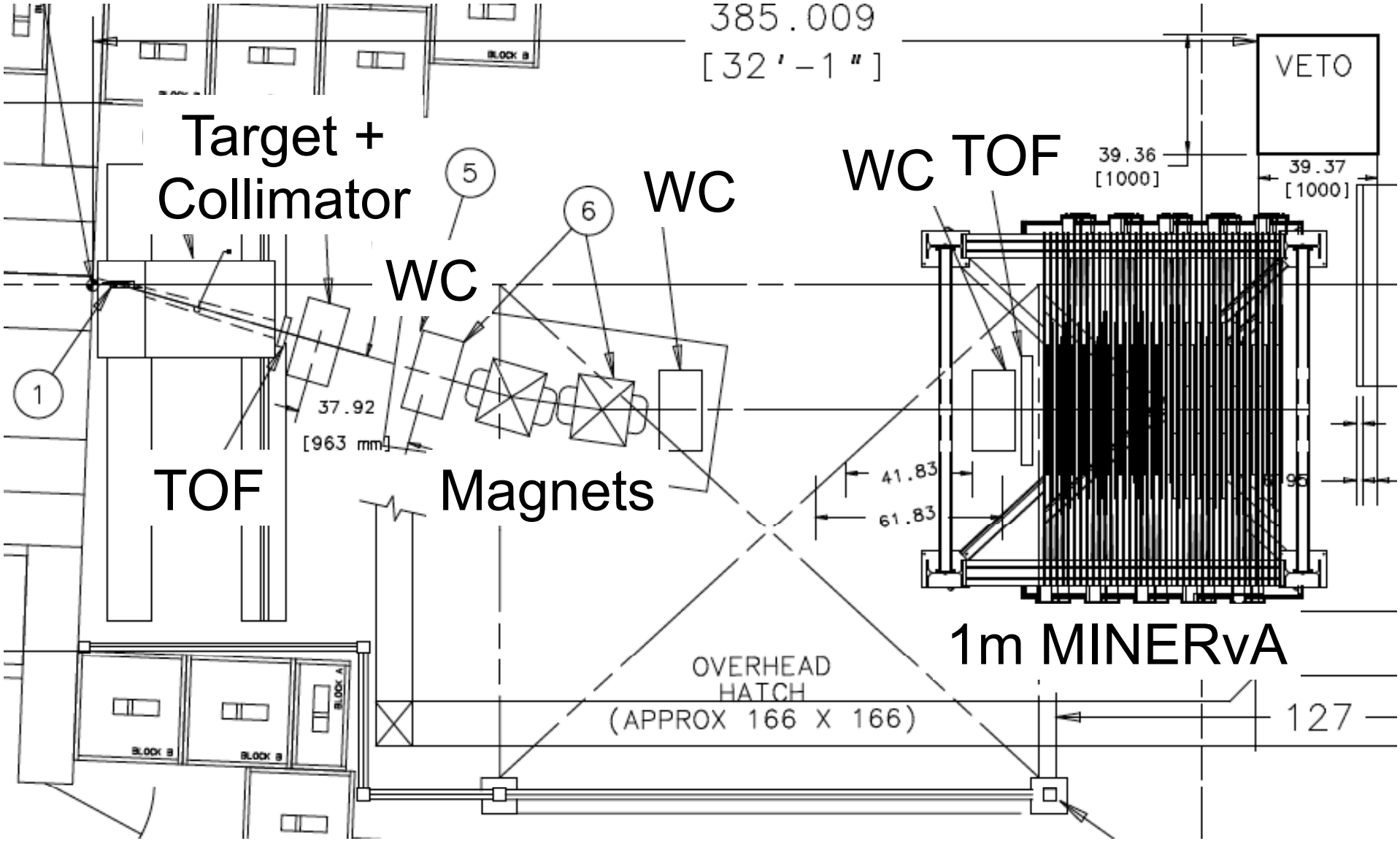
  Study options using G4Beamline

  (Tom Roberts – muons inc.)

G4beamline predicted spectra @ 16 deg

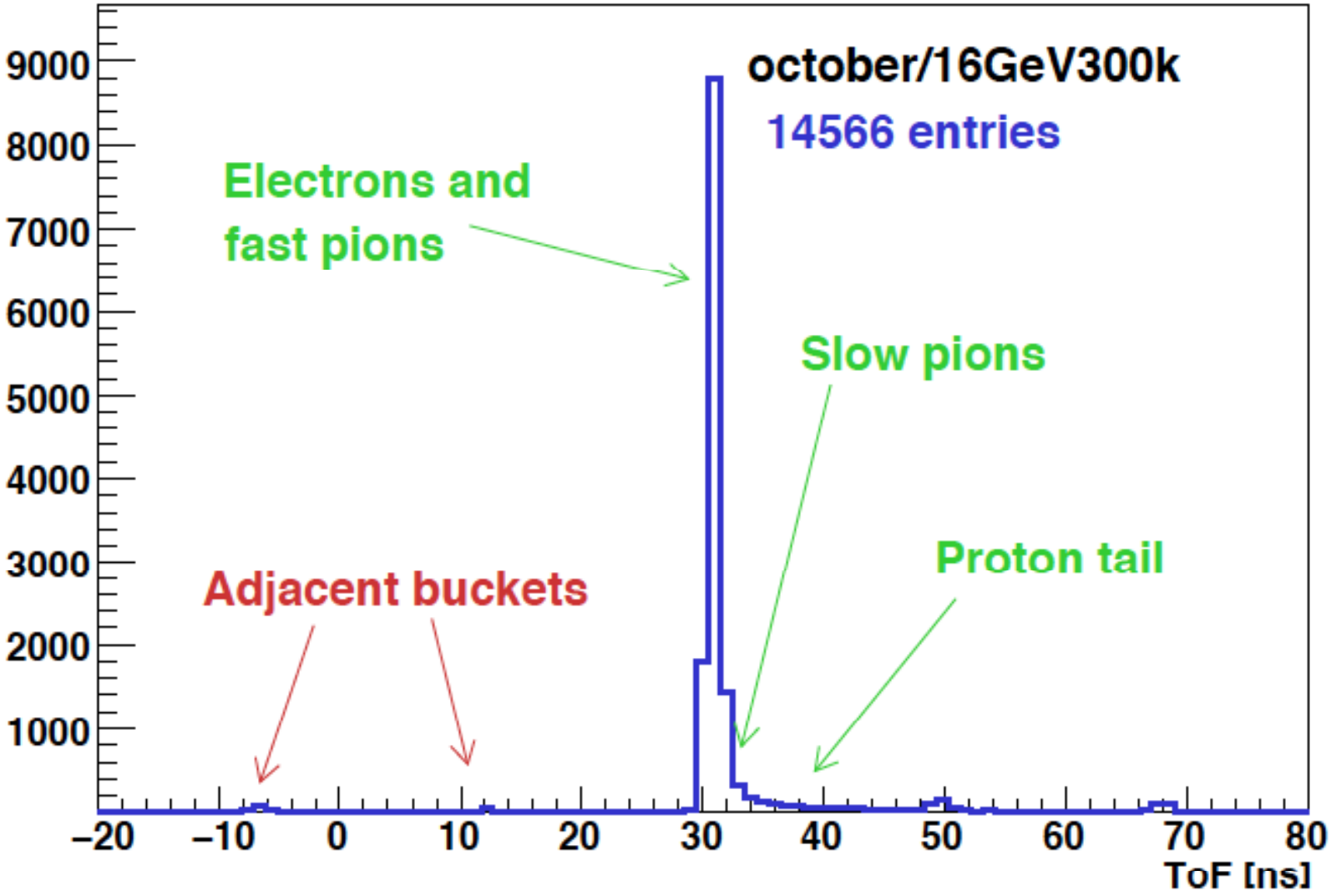


Build a tertiary beamline here at MTest



Commissioning Target and Collimator

Measured TOF spectrum



Approximate cable delays are corrected, TOF resolution is ~160ps

Final Remarks

- Possible Test Beams coming at SLAC
- Fermilab Test Beam
  - Running many experiments

    LARGE and **small**
  - Many Options
  - Evolving as needs arrise

Extra

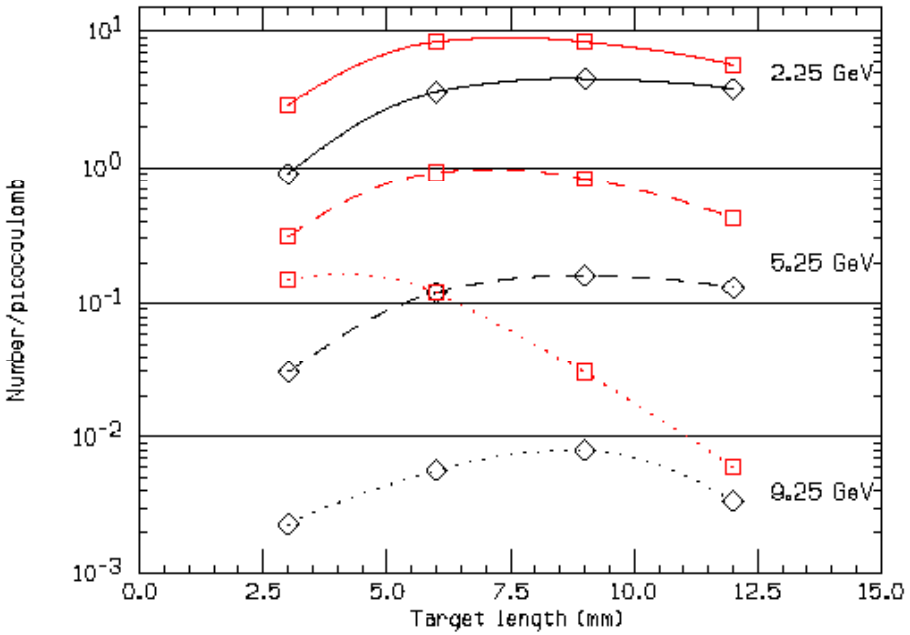
- SLAC – secondary electron, positron yields in ESA
- Additional pictures of MTest experimental areas

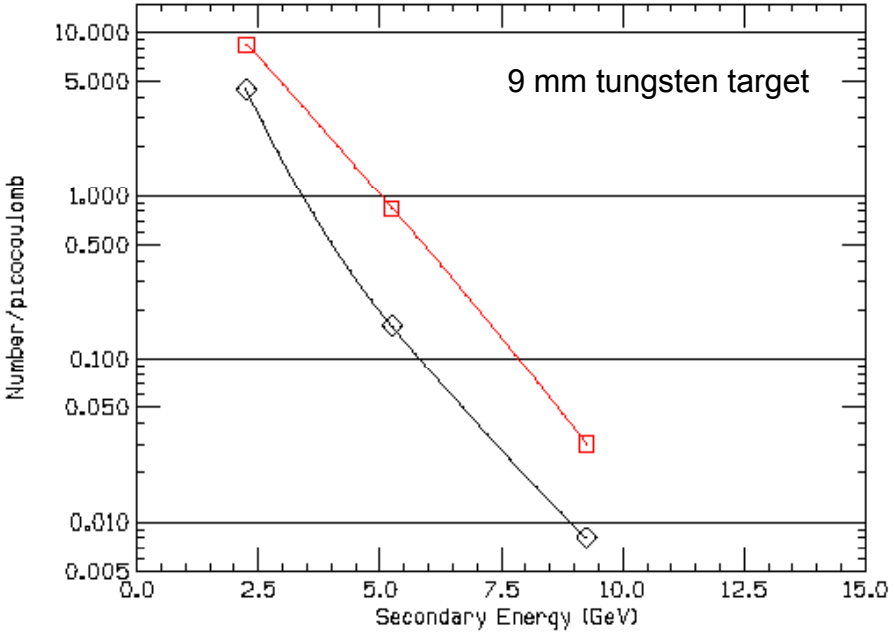
Secondary Electron and Positron Yields in ESA

EGS4 results for yields per pC halo incident on W target in Beam Switch Yard

- 14.1 GeV primary beam energy
- 0.5-deg production angle
- Acceptance: 0.14 μsr , $\Delta E/E = 0.02$

LCLS bunch charge is 1 nC ($6 \cdot 10^9$ electrons)





electrons

positrons

Results from EGS4 simulation by L. Keller,
FLUKA simulation by T. Maruyama gives similar results

Experimental Areas A, B_{us}, B_{ds}

CALICE Apparatus