Test Beams in the US

Capabilities and Limitations

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SLAC

SLAC National Accelerator Laboratory

Workshop on Detector R&D

FNAL

October 2010

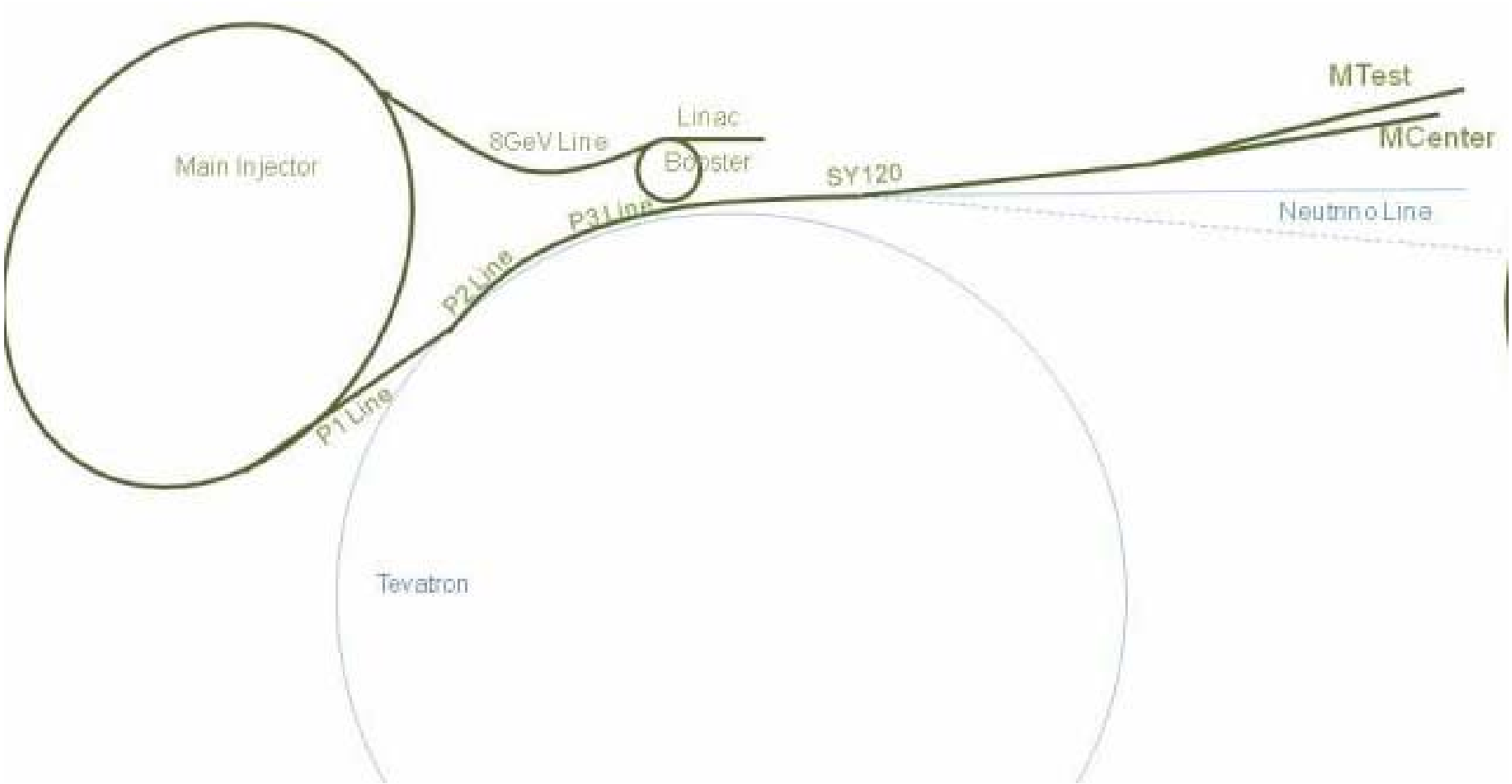
Test Beam Facilities in the US

- Only FNAL has an active Test Beam Program (FTBF)
- Only SLAC is setting one up (ESTB)
- There are several places where with some investments test beams could be (re-)established (ANL, BNL,LBNL, Cornell-CESR), but there are no plans to do so
- There are Accelerator Test Facilities at BNL and SLAC with low energetic electron beams which are not really suitable for detector R&D
  - BNL ATF (25 -76 MeV, 50nC)
  - SLAC NLCTA (60-120 MeV, 40nC)

- There are some limited possibilities at TRIUMF
  - p/n <500 MeV used for irradiation experiments
  - they can produce electrons, muons, pions < 300 MeV
  - not setup as a test beam facility

- CERN and DESY with active TB programs (not covered here)

Fermilab Test Beam Facility (FTBF)



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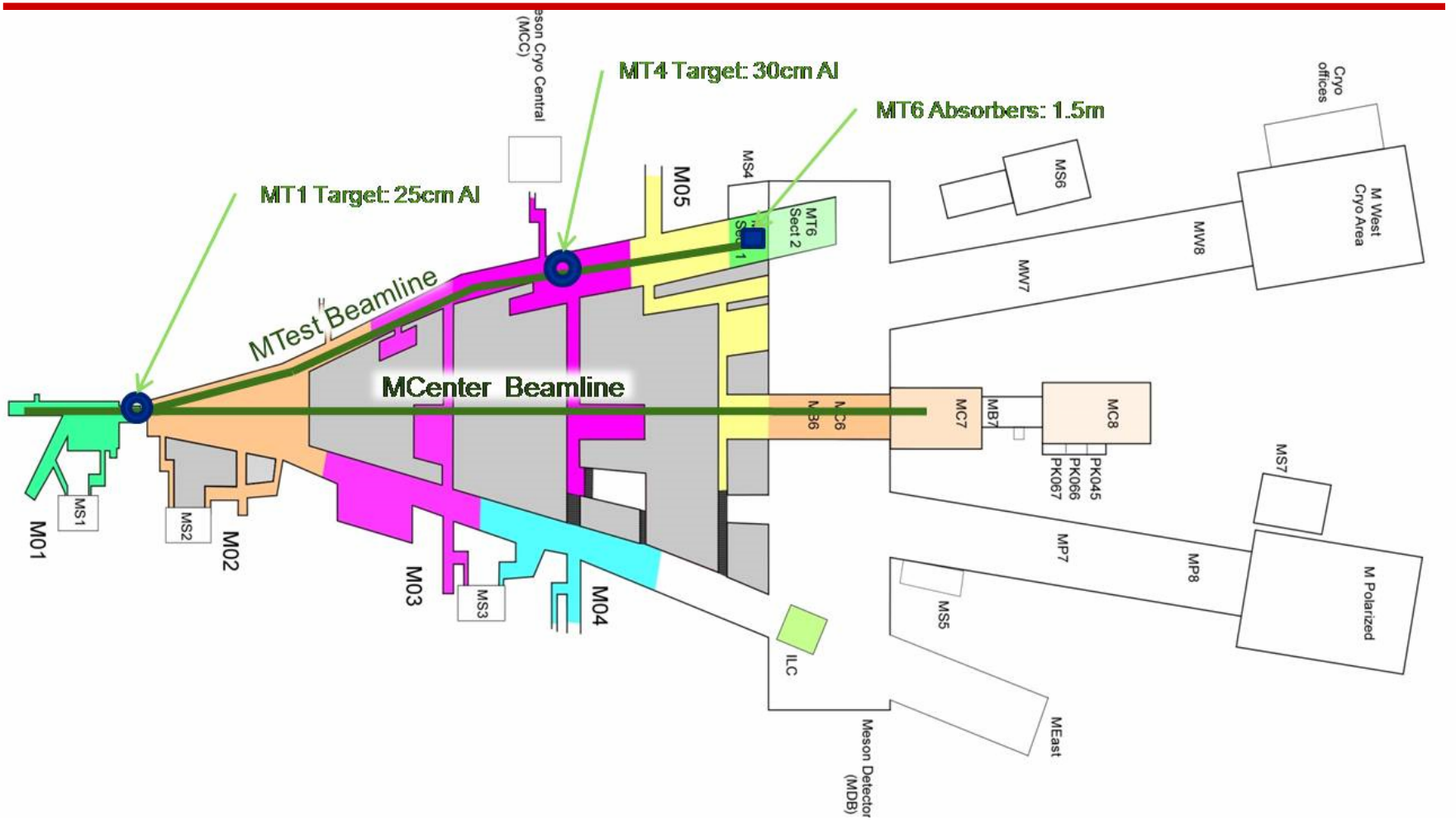
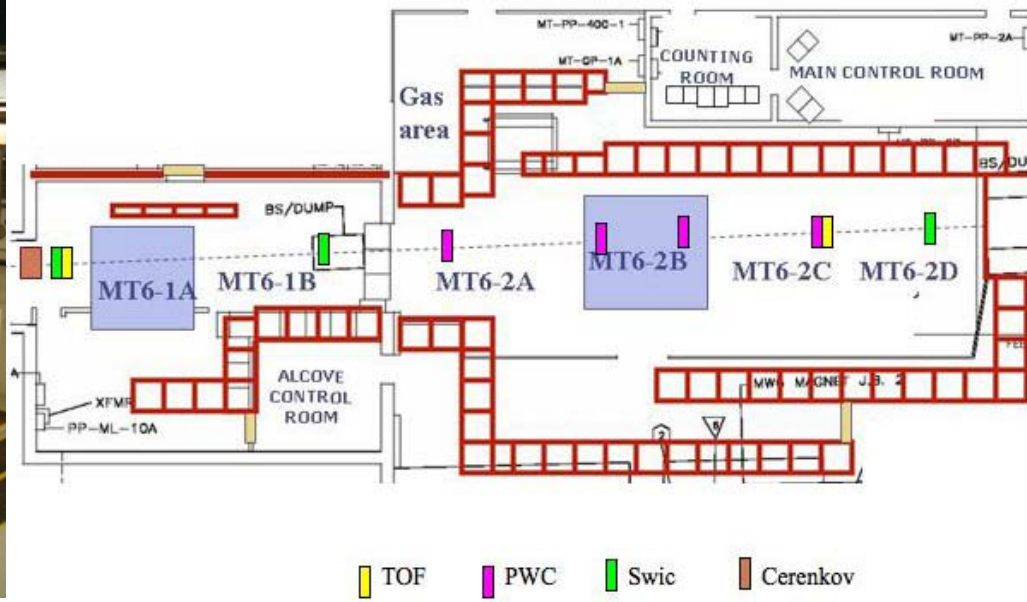
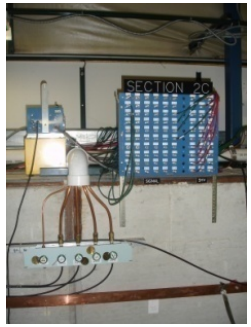


Fermilab Test Beam Facility (FTBF)



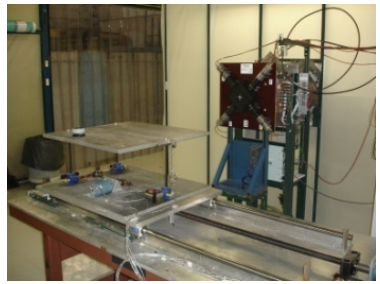
Spacious control room



Signal and HV cables

Gas delivery to 6 locations

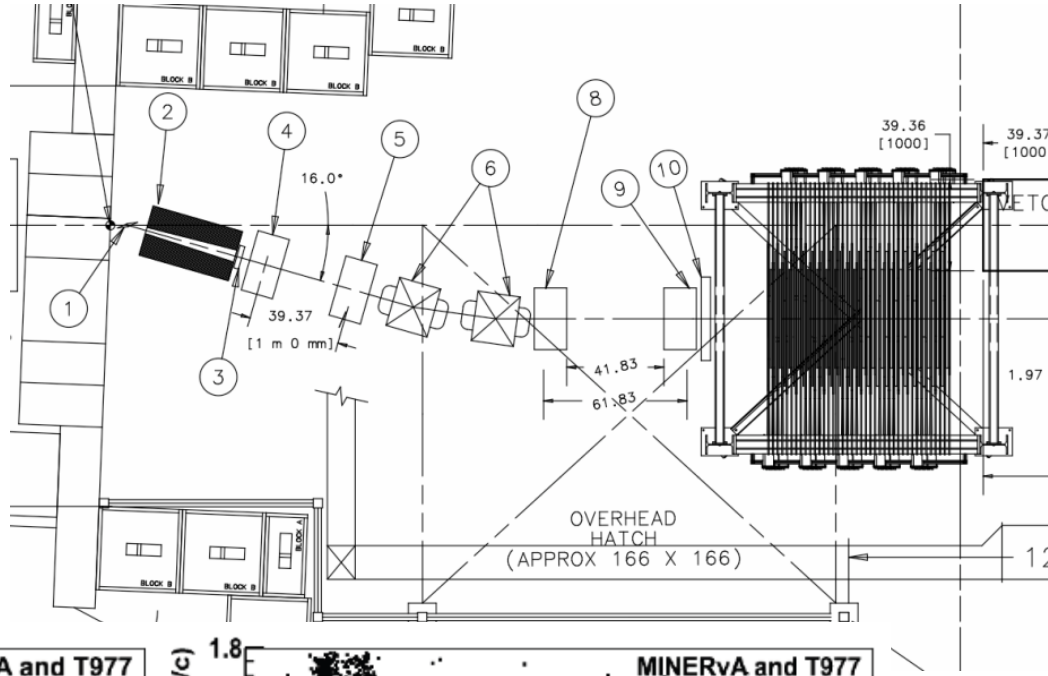
4 station MWPC spectrometer

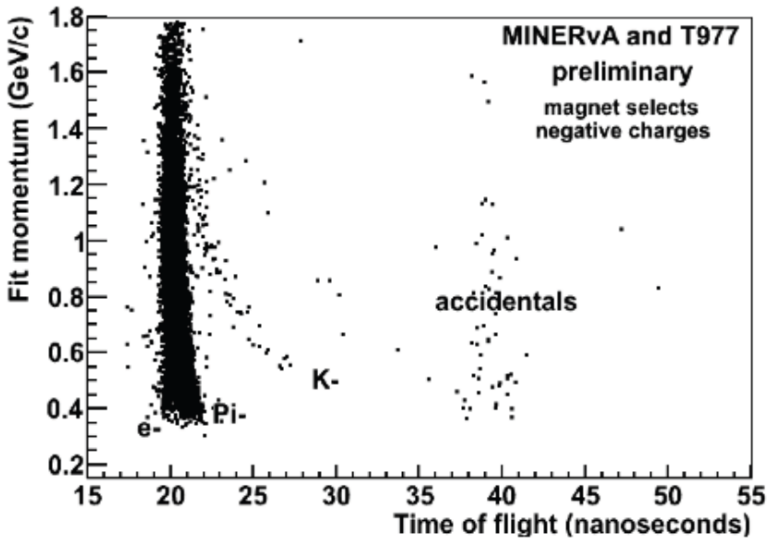


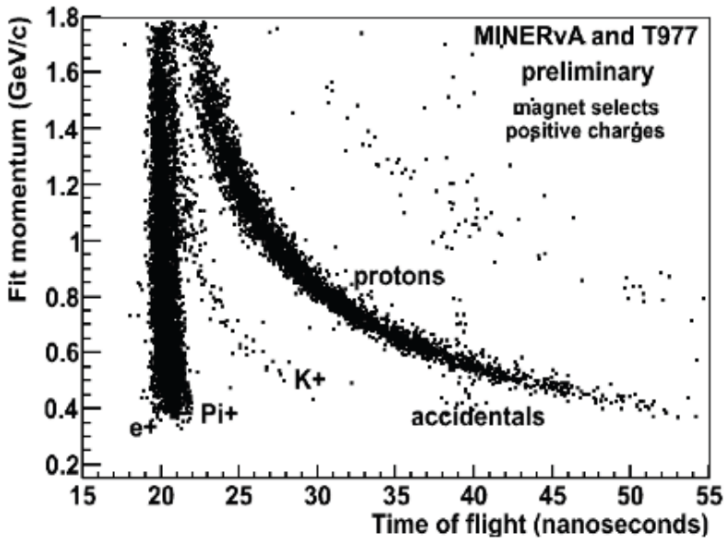
Three motion tables

FTBF new Tertiary 400 MeV/c Beam Line

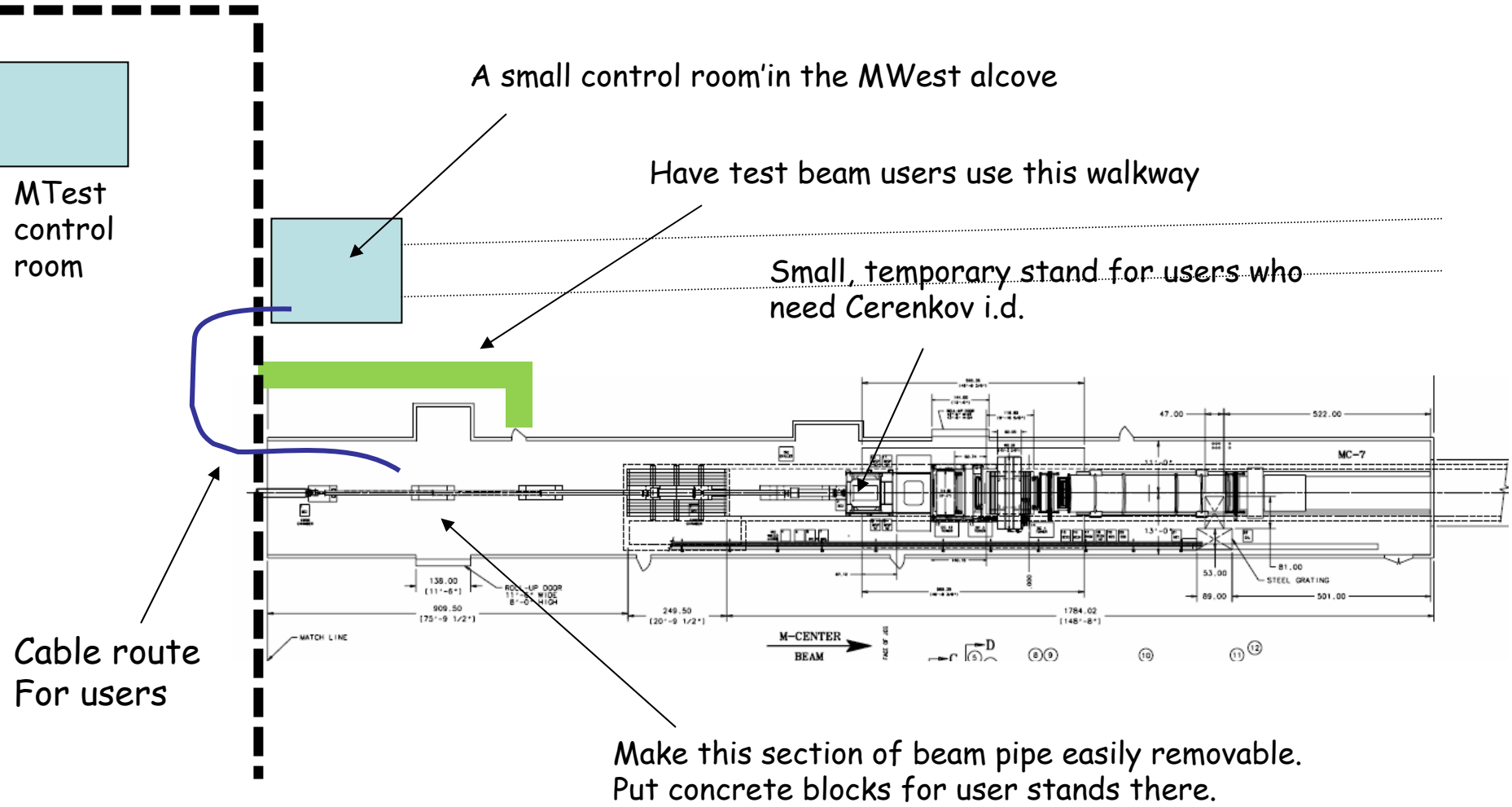
- The MINERVA experiment requested space to create a new tertiary beamline that could deliver particles down to 400 MeV/c momentum.
- Tracking and TOF allows for momentum measurement and particle i.d.
- This new location is now open for users.







FTBF proposed new MCenter Beam Line



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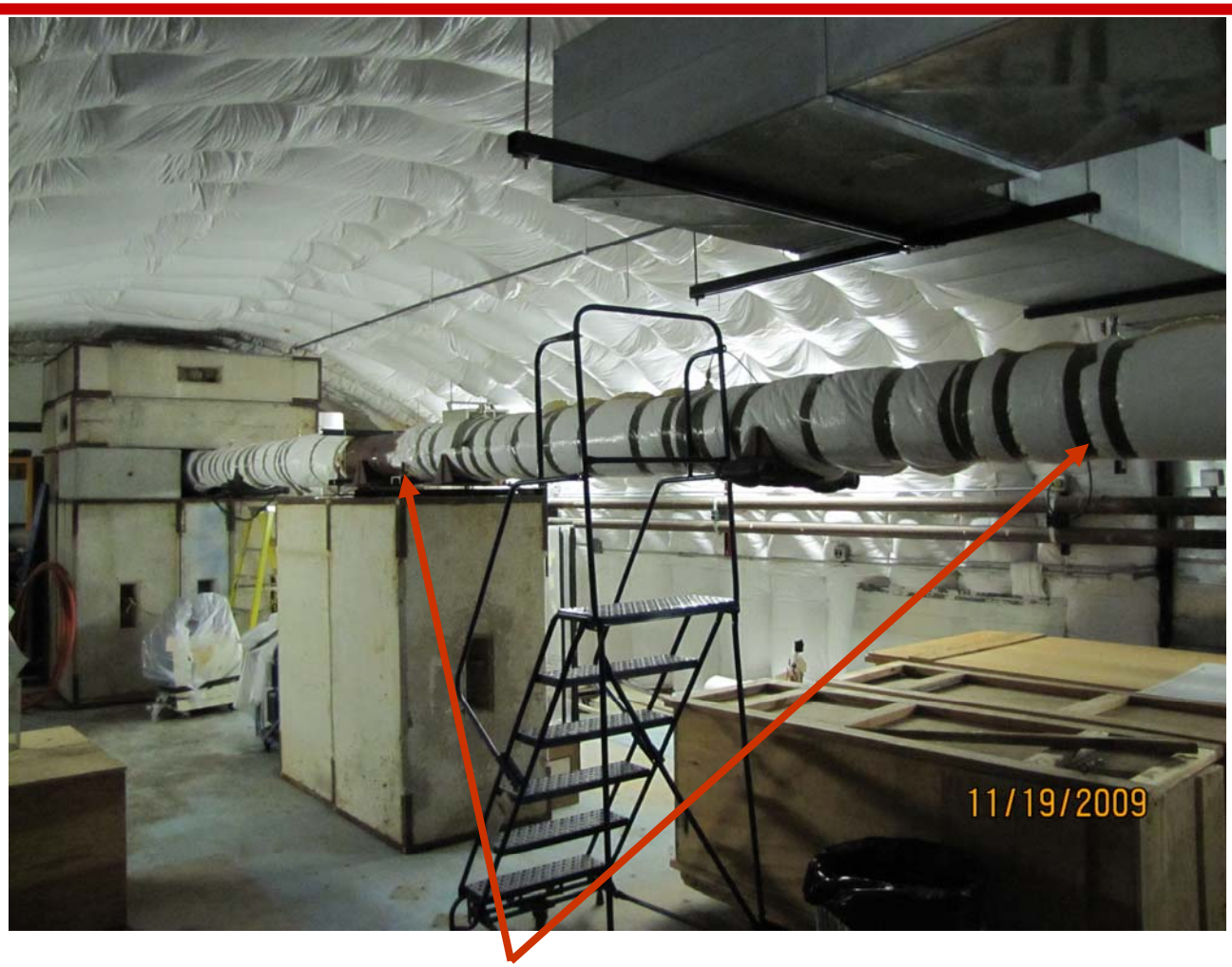
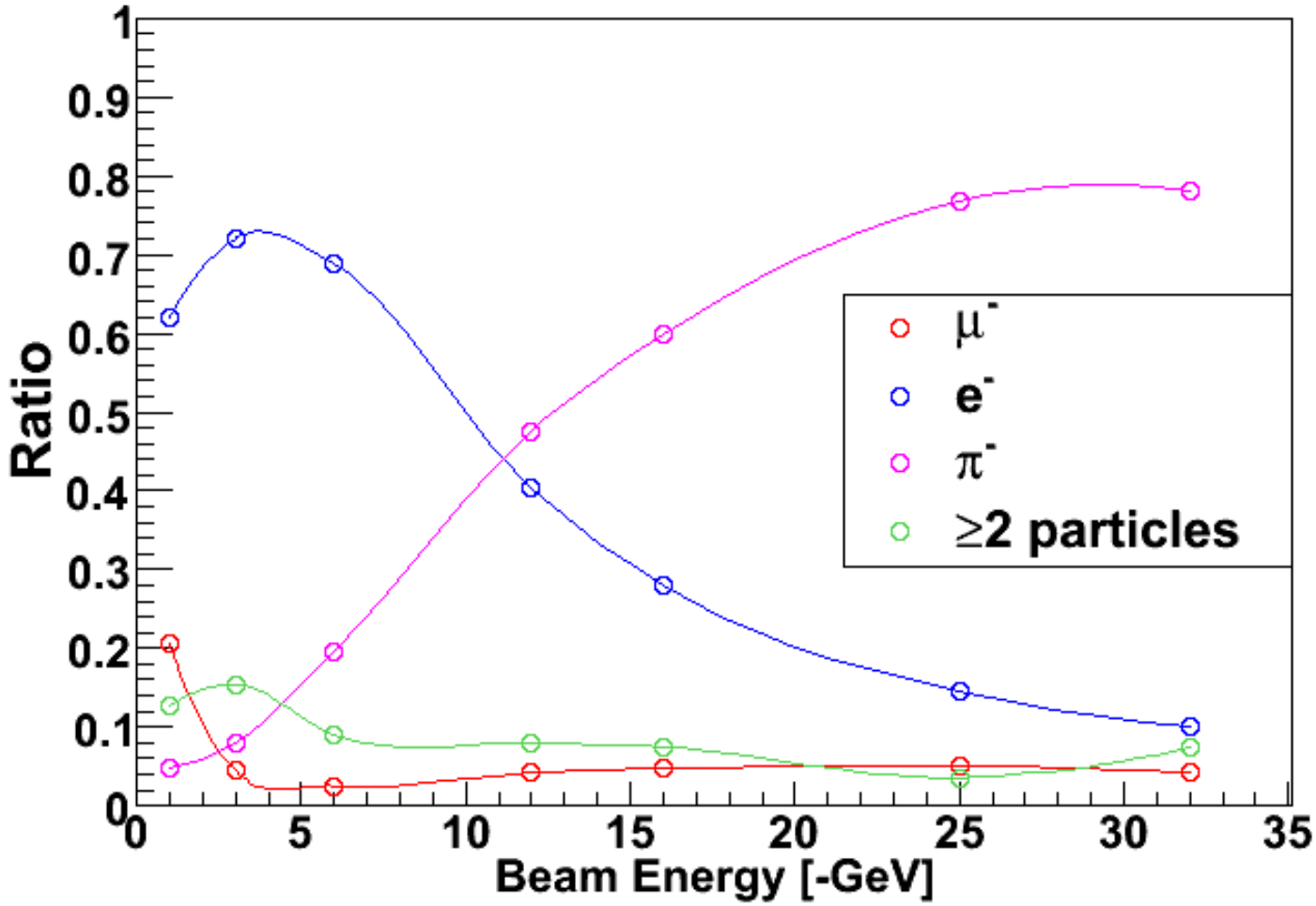


This section of beam pipe can be removed for experiments

FTBF Beam Composition (MTest)

Measured by CALICE in 2008



Beam Rates and Electron Content (MTest)

- One spill per minute, up to 12 hours per day
- Measured rates (normalized to 1E11 at MW1SEM)

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%

With ¼" Pb absorber

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%

FTBF Operation Schedule

- **FTBF is pretty booked until March 2011**
- **Scheduling for rest of 2011 has started**
- **If Tevatron run is not extended, no beams in 2012**

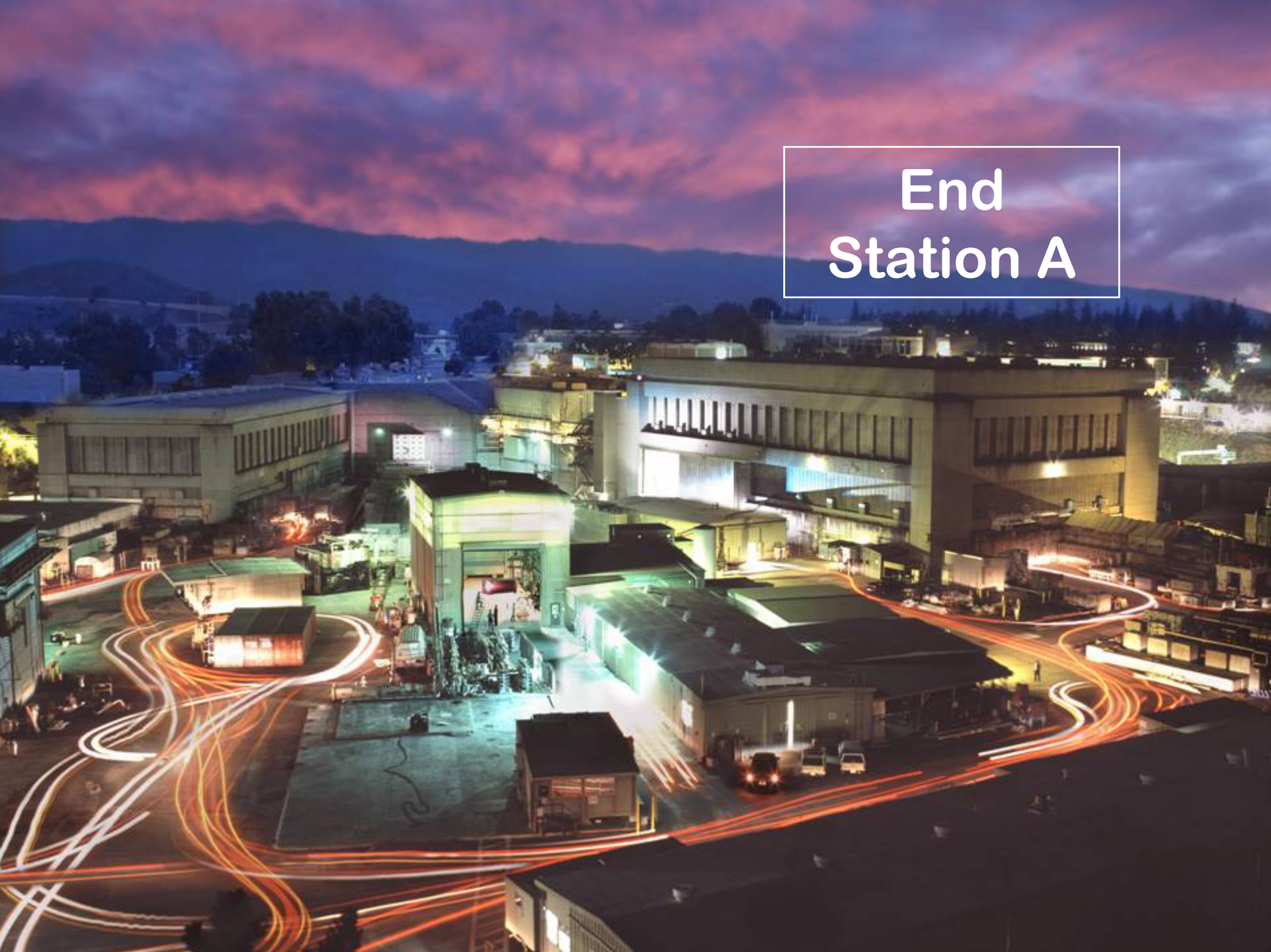
Typically Revised Annually - This Version from June, 2010

Calendar Year		2010	2011	2012	2013
Tevatron Collider		CDF & DZero	CDF & DZero	OPEN	OPEN
Neutrino Program	B	MiniBooNE	MiniBooNE #		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/SeaQuest	E-906/SeaQuest		E-906/SeaQuest

Fermilab Test Beam Facility Summary

- The Test Beam 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.
- A new tertiary beam is available, which delivers tagged particles down to 400 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
- Can support irradiation tests for thin detectors
- Contact: Aria Soha (aria@fnal.gov) http://www-ppd.fnal.gov/FTBF

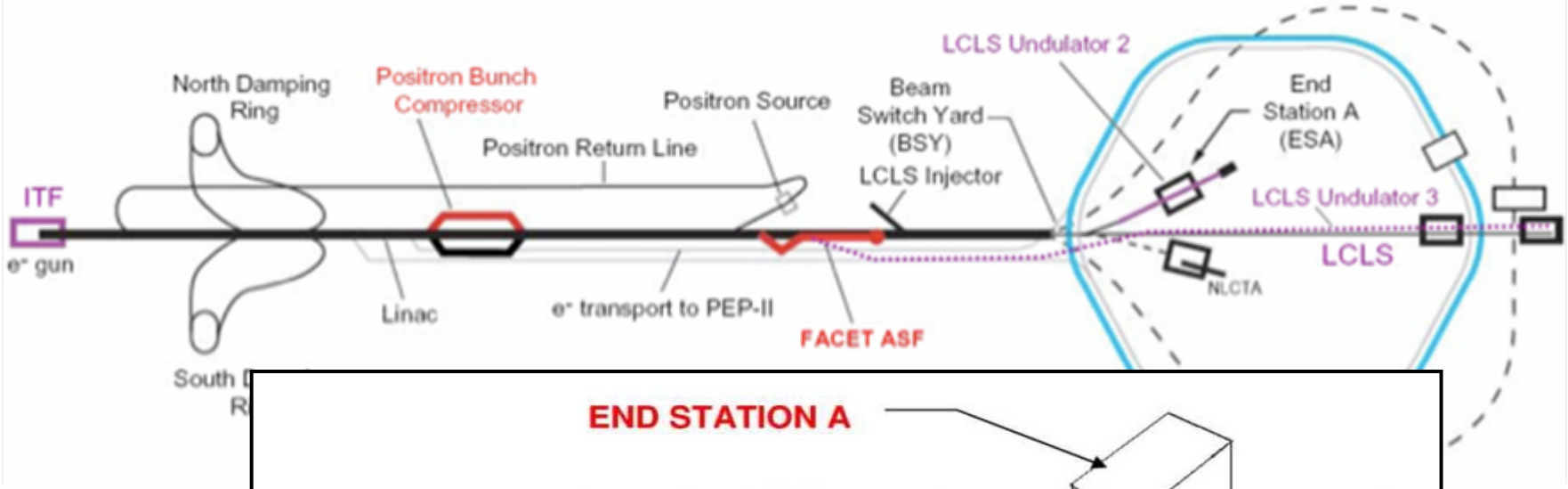
Users are happy with and eager to continue to use this facility

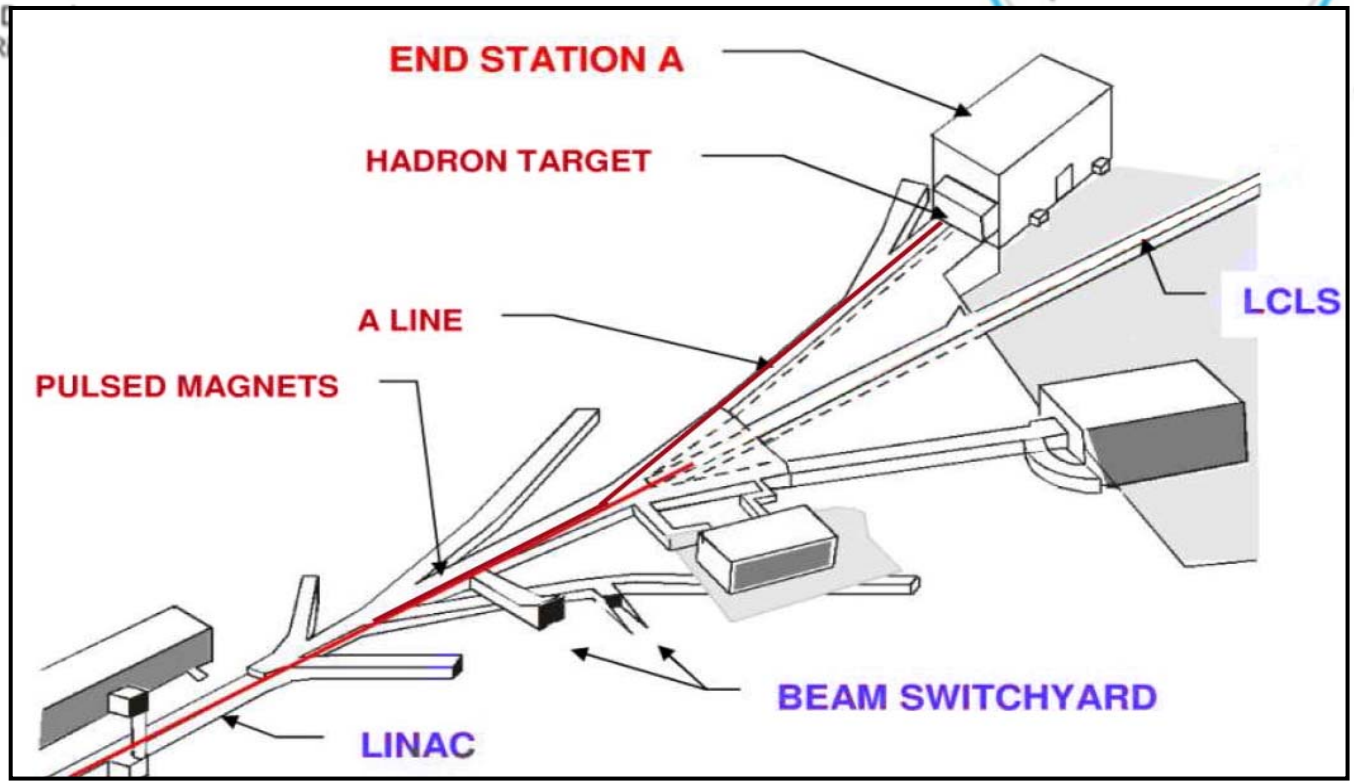

End
Station A

SLAC End Station A Test Beam (ESTB)

- Test beam activities have been interrupted by ending PEP II operation and start of LCLS
- ESTB will be a unique HEP resource
  - World's only high-energy primary electron beam for large scale Linear Collider MDI and beam instrumentation studies
  - Exceptionally clean and well-defined secondary electron/positron beams for detector development
  - Huge experimental area, good existing conventional facilities, and historically broad user base
  - secondary hadron beams available as an upgrade

Use LCLS Beam



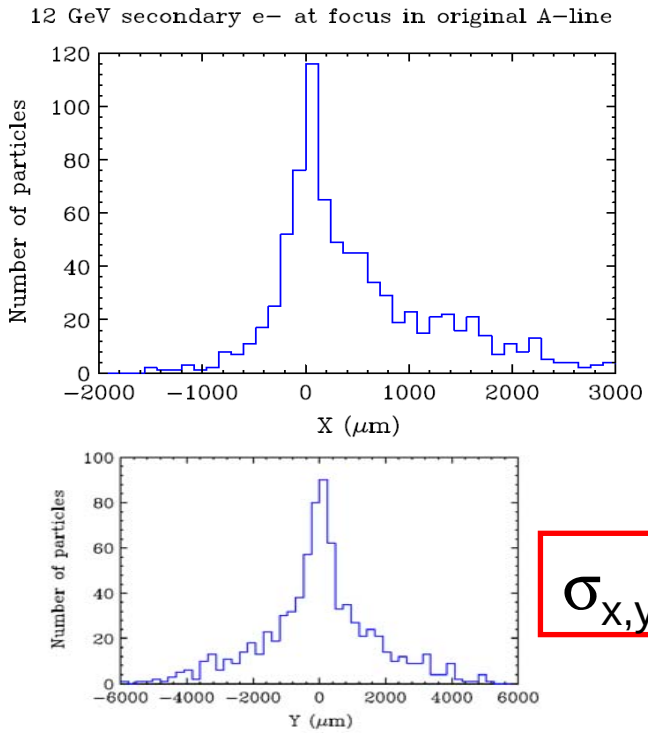


ESTB Beam Parameters

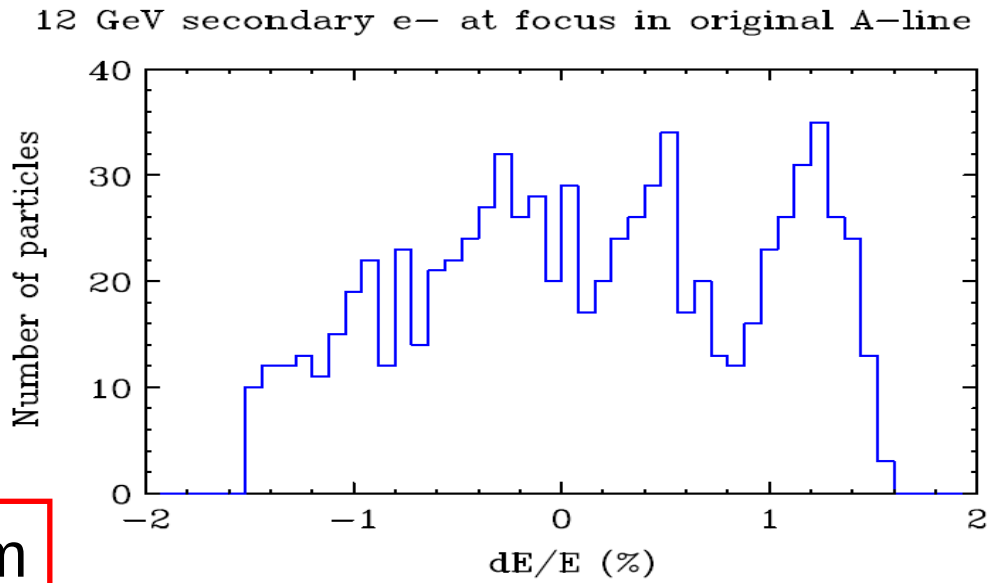
- LCLS beam
  - Energy 3.5 – 13.6 GeV
  - Currents 20 to 250 pC
  - Repetition rate 120Hz
- ESTB beam
  - Kick LCLS beam into A-line @ 5 Hz
  - Primary beam 3.5-13.6 GeV
    - determined by LCLS
    - $<1.5 \times 10^9$ e^-/pulse
  - Clean secondary electrons or positrons
    - p<13.6 GeV, 0.1/pulse to 1×10^9 e^-/pulse

Secondary Electrons and Positrons

Inserting a thin foil in the transport line to ESA, and using the beamline as a spectrometer, creates a clean secondary electron/positron beam over the full range of energies (<13.6GeV) and a wide range of intensities down to <1/pulse



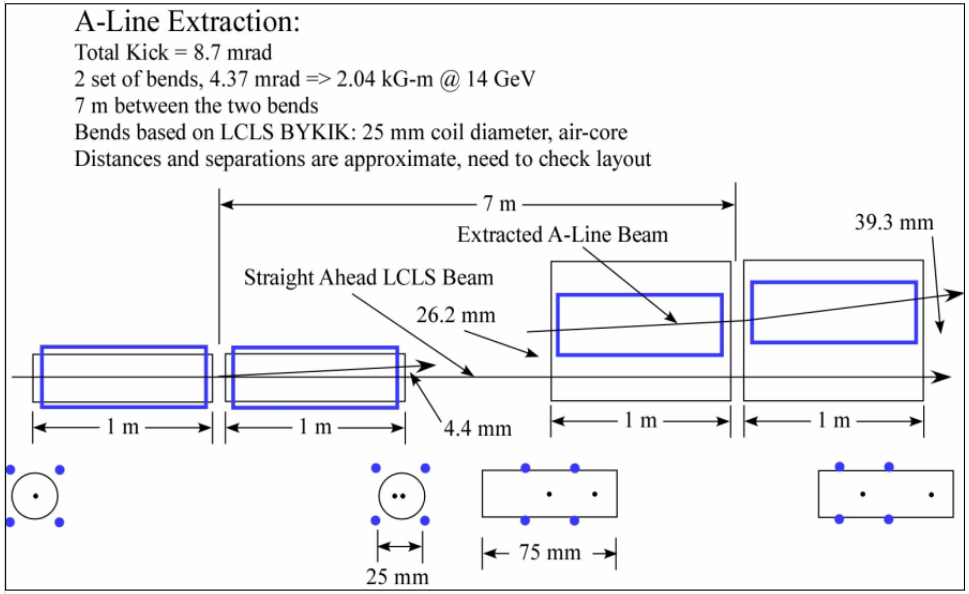
$\sigma_{x,y}$~ 1 mm

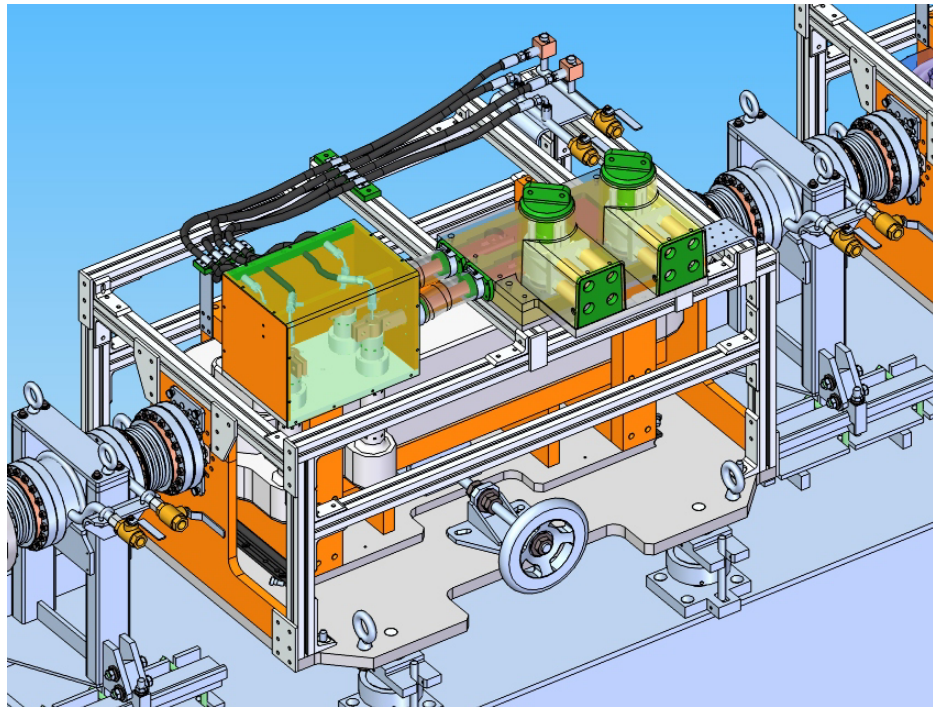


$\Delta p/p \sim \pm 1\%$

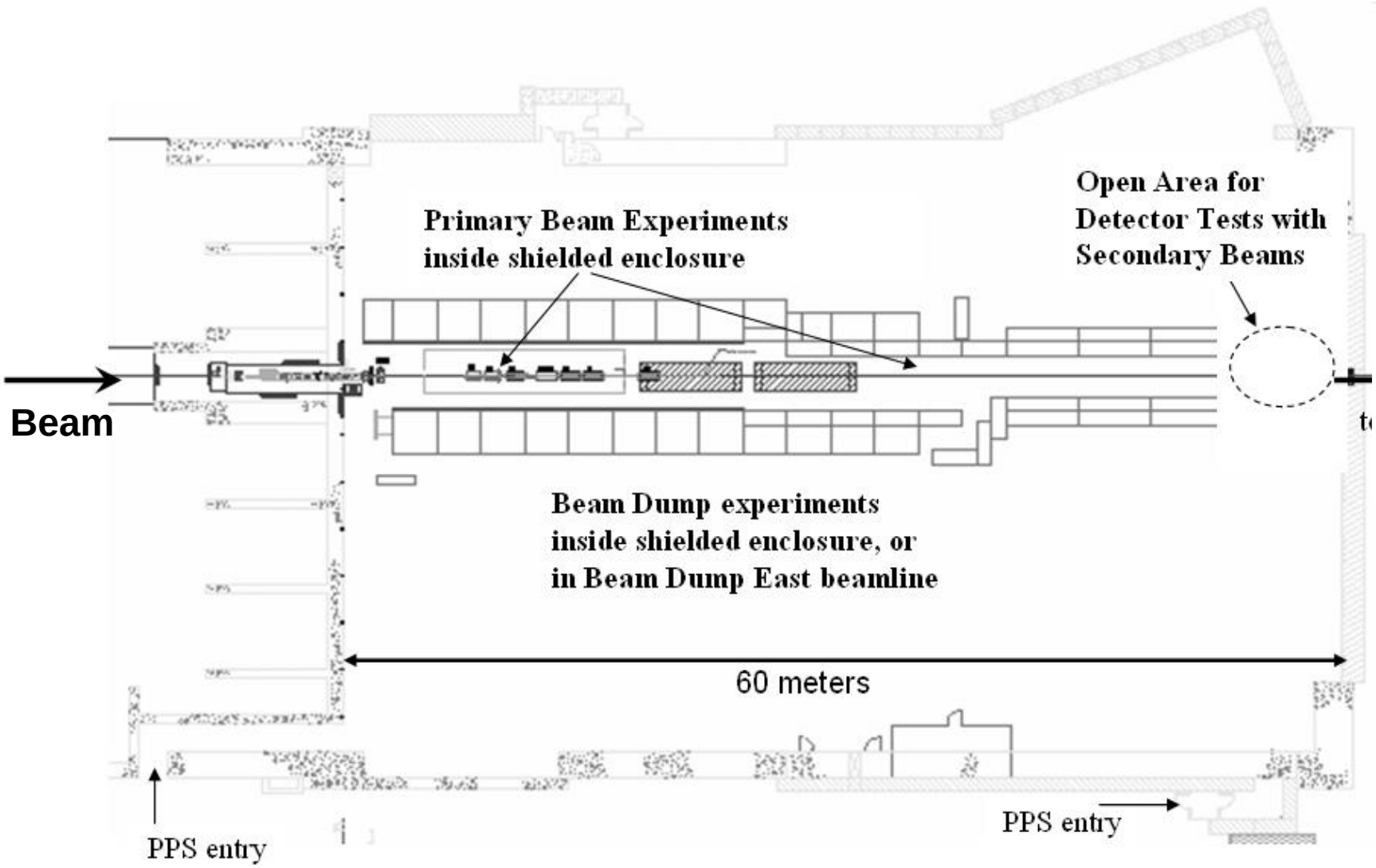
Kicker Magnets

- 4 new kicker magnets including power supplies and modulators and vacuum chambers are designed and components are being ordered
- Build new PPS system and install new beam dump





ESA Experimental Area



ESA Infrastructure

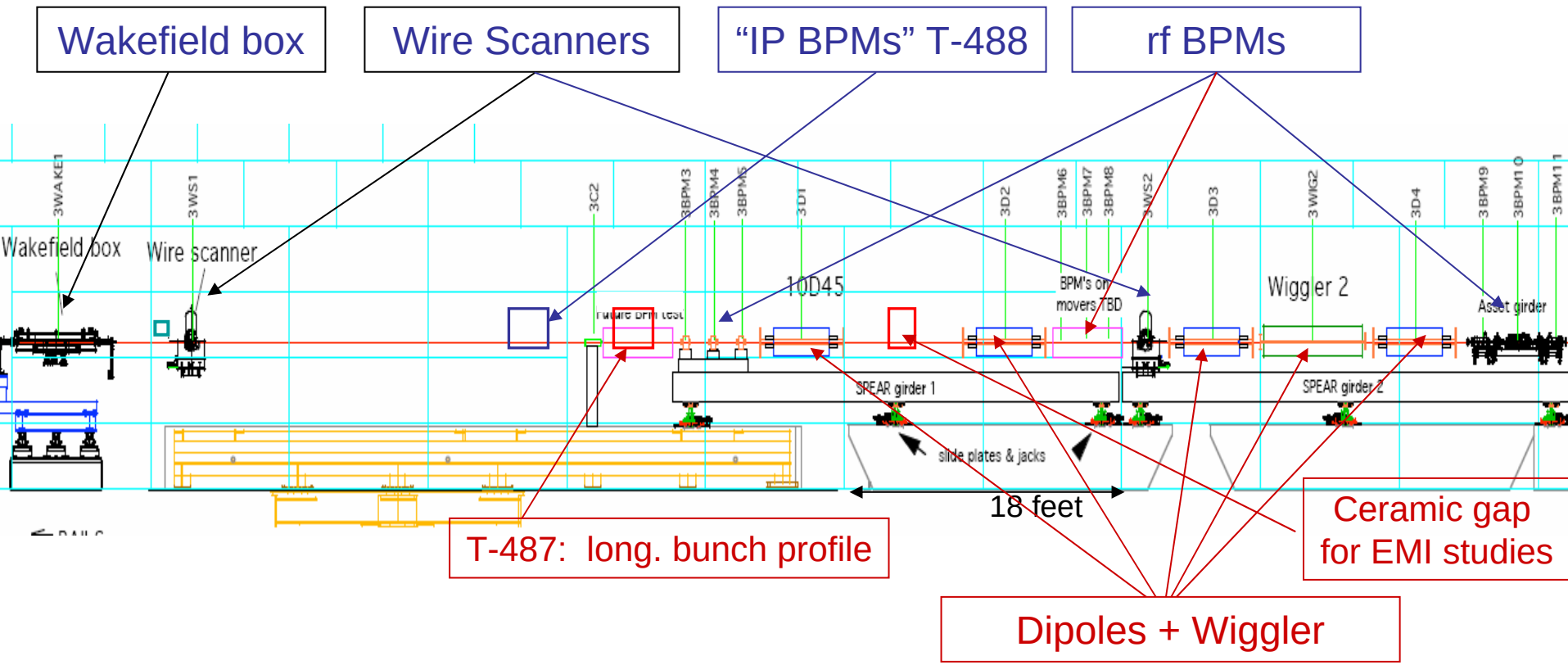
Available Instrumentation

- Trigger counters
- Halo veto counters
- High resolution beam hodoscope
- Particle ID (Cerenkov, TOF, shower counter)
- Small, high field solenoid
- sturdy support table with remote movers

Cranes

- 15 and 50-ton cranes available

ESA Primary Beam for MDI Test



BPM energy spectrometer (T-474/491)
Synch Stripe energy spectrometer (T-475)
Collimator design, wakefields (T-480)
Bunch length diagnostics (T-487)
Smith-Purcell Radiation

IP BPMs—background studies (T-488)
LCLS beam to ESA (T490)
Linac BPM prototypes
EMI (electro-magnetic interference)
Irradiation Experiments

Activation Experiment (SLAC and CERN RP)

- Comparison of Data with Monte Carlo

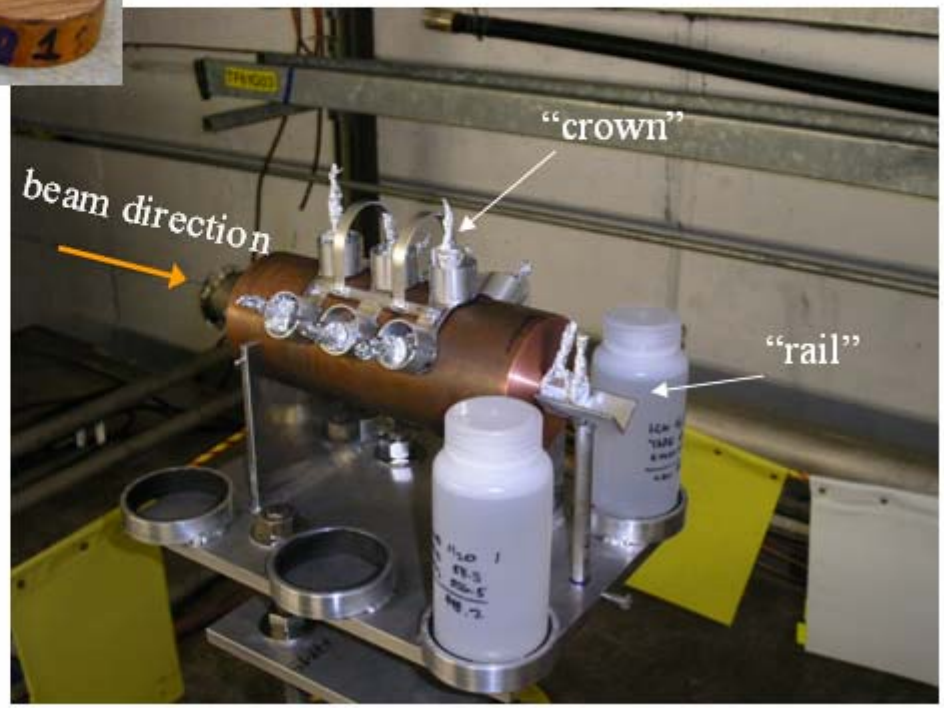
Solid samples: larger for dose rates
smaller for gamma spectroscopy

Solid:

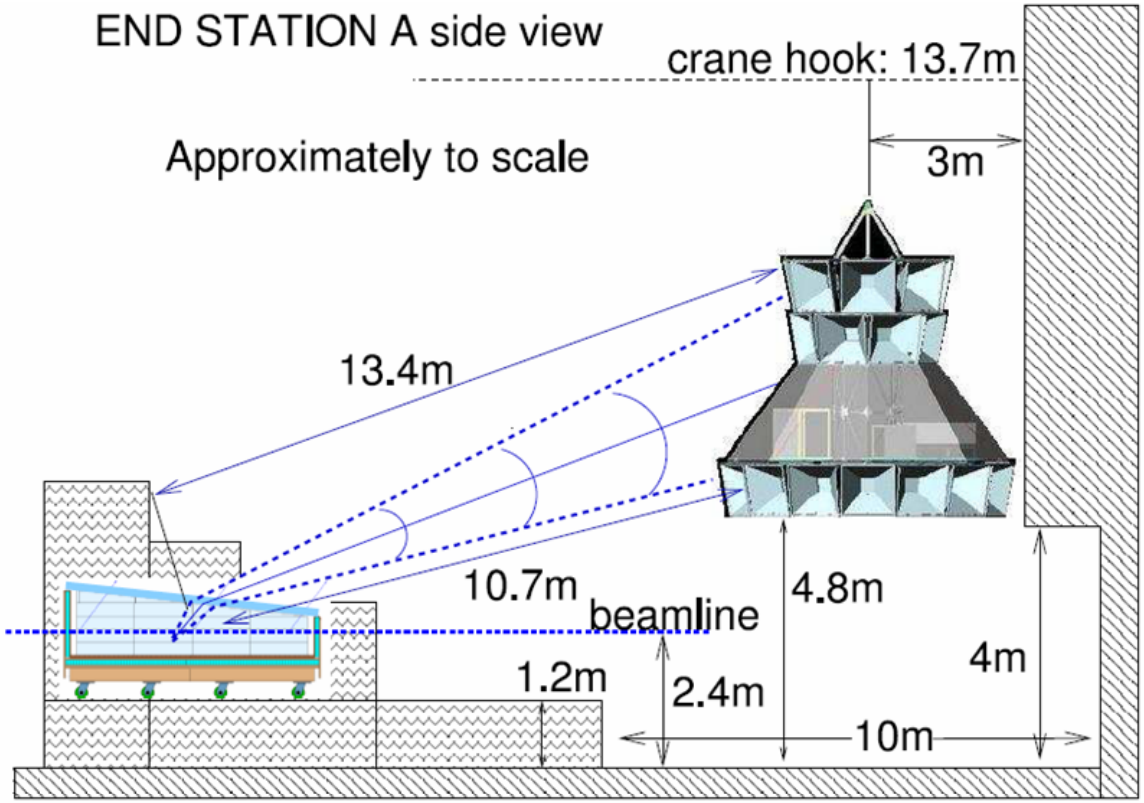
- Copper
- Iron
- Titanium
- Aluminum
- Stainless steel
- Titanium alloy

Samples in bottles:

- Ground water
- Distilled water
- Soil (from SLAC site)



ANITA Payload and Ice Target in ESA



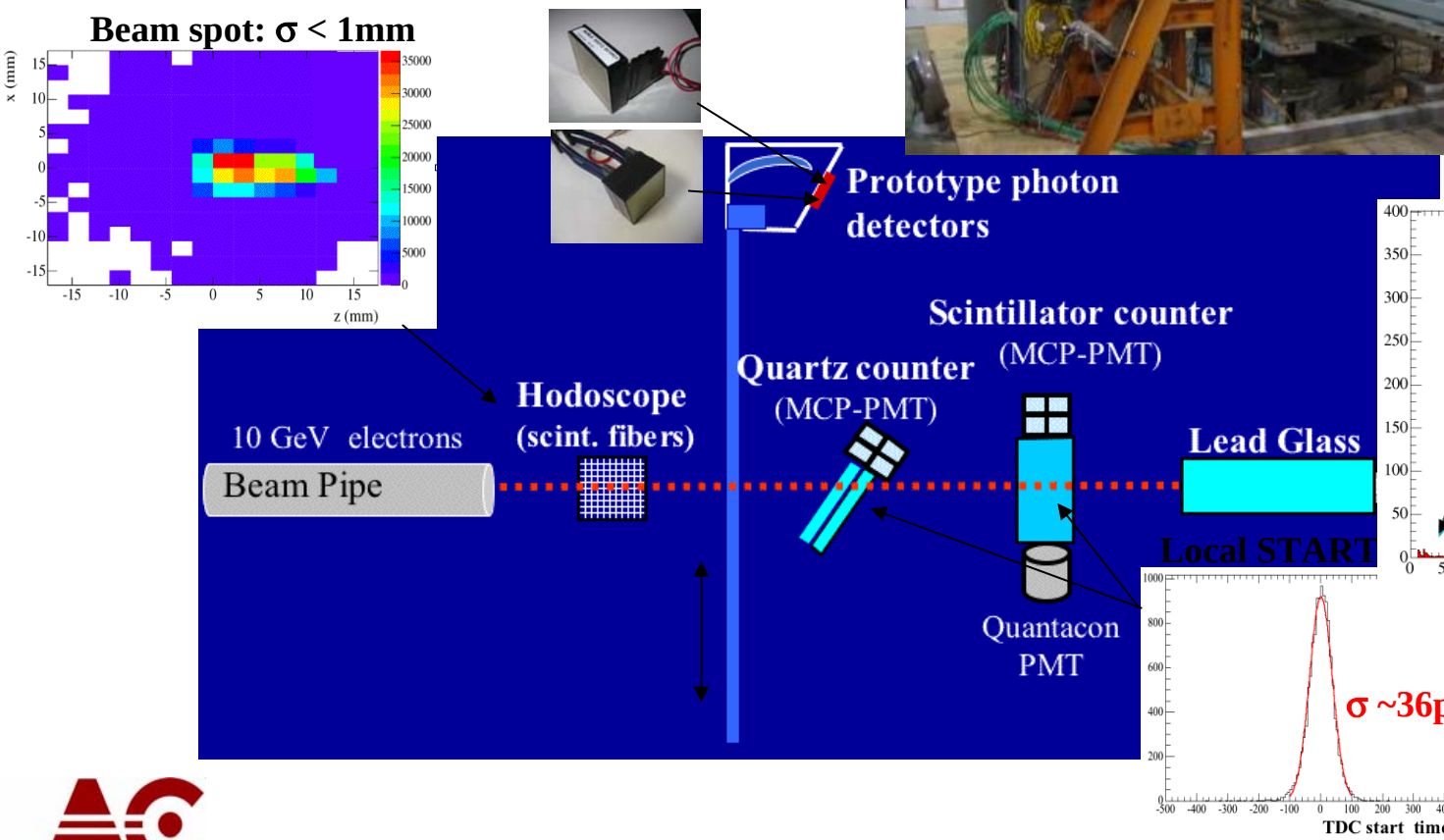
- Calibrated entire ANITA balloon flight antenna array
- First observation of the Askaryan effect in ice
- Results published in Phys.Rev.Lett.99:171101,2007 etc.

Illustrates capability of ESA Test Beam Facility

SLAC NATIONAL ACCELERATOR LABORATORY

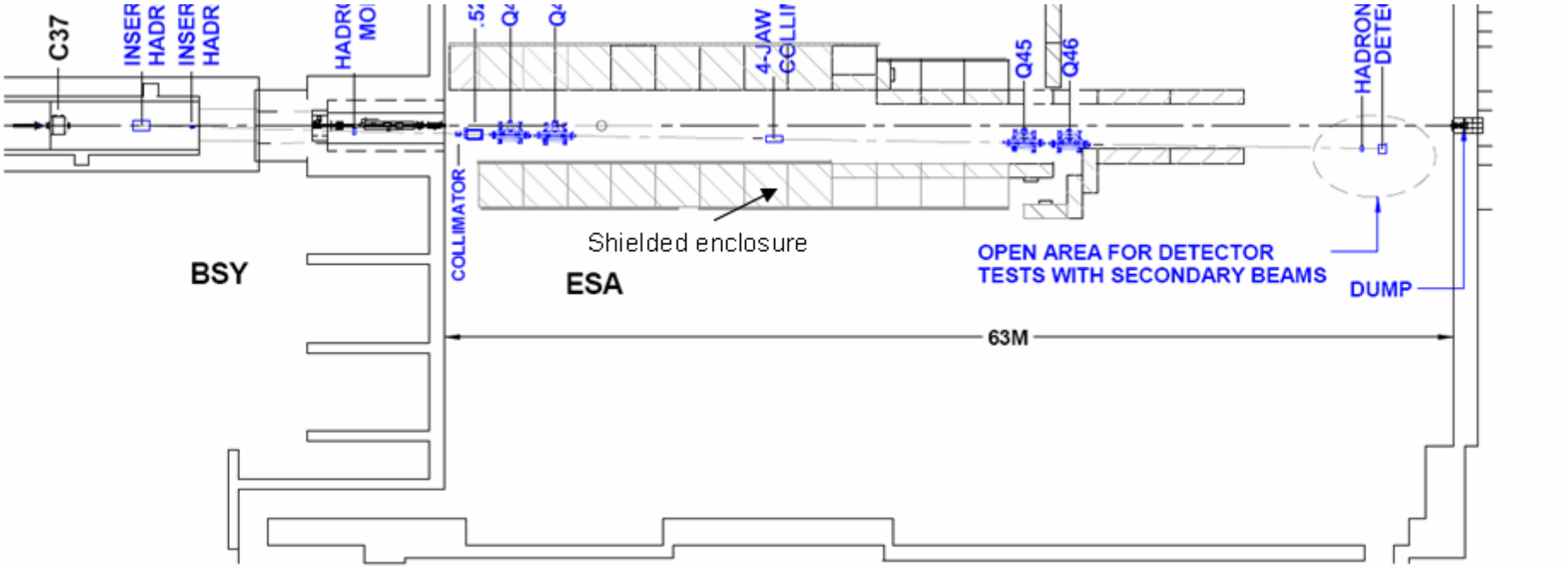
Jerry Va'vra's focusing DIRC Tests

- SLAC 10 GeV/c 2nd electrons
- Beam enters bar at 90º angle
- Prototype is movable to 7 beam positions along bar.
- Time start from the LINAC RF signal, but correctable with a local START counter

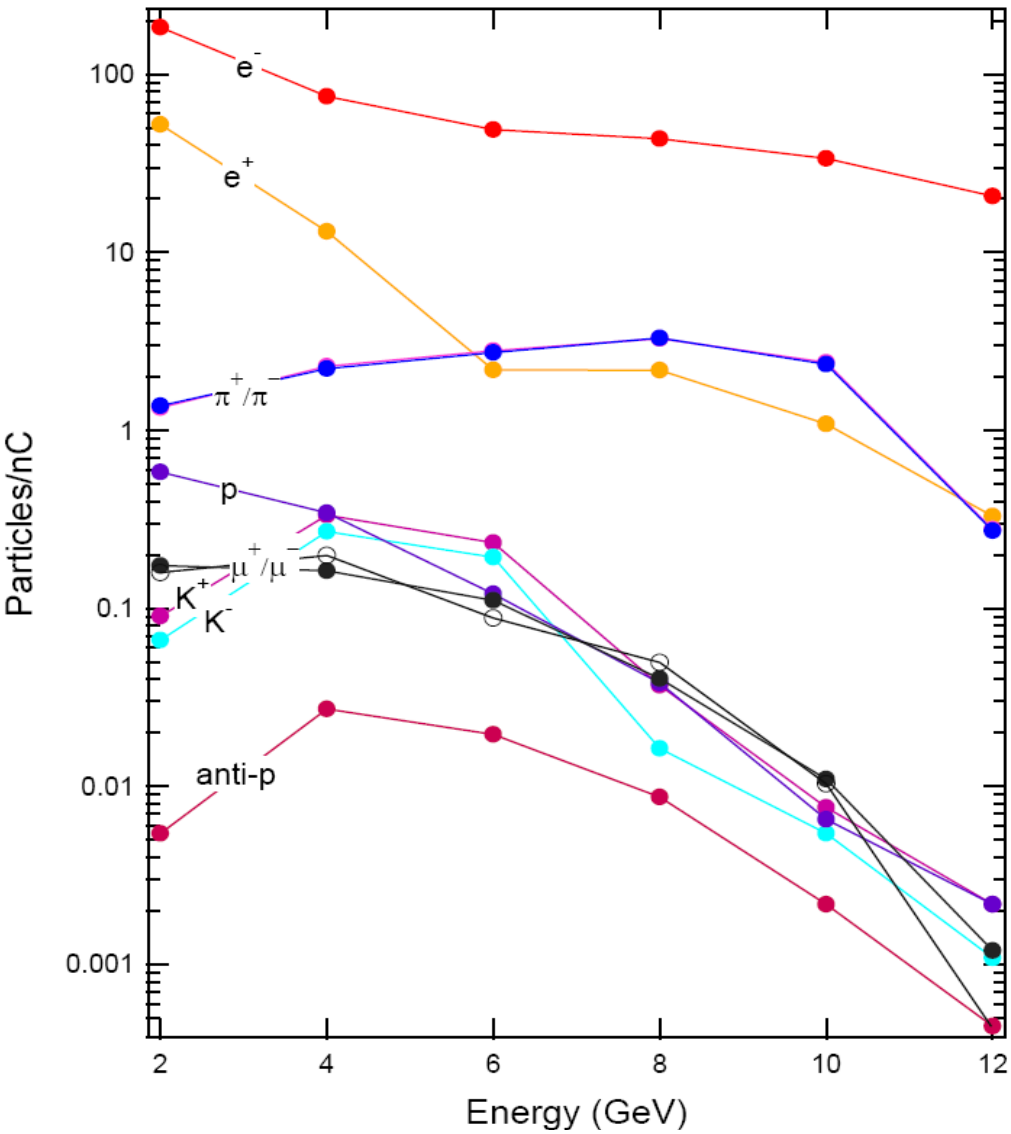


ESTB Stage II: Hadron Production

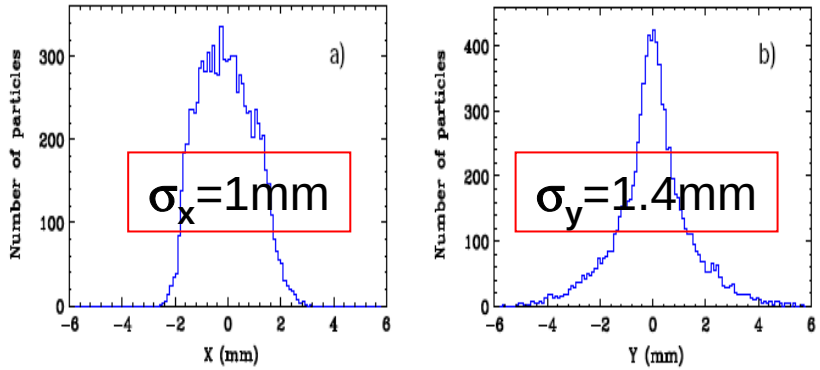
- Add Be target, beam dump, analyzing magnet, momentum slit, and quadrupole doublets to produce a secondary hadron beam
- Production angle = 1.35^{O} and Acceptance = 10 μsr

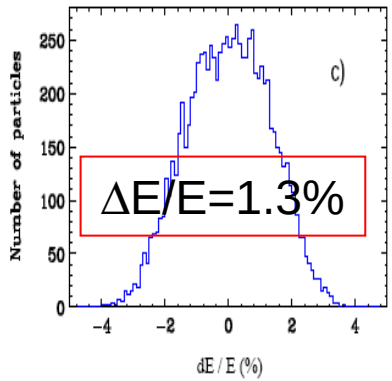


Secondary Hadron Beam Properties



Beam Properties at Detector Plane





Possible Running Scenarios

- LCLS is and will always be the main user
  - Beam Energy is defined by LCLS Users
  - Ranges between 3.5 to 13.6 GeV
  - Rate is 120Hz
  - Schedule: Thursdays 8am to Tuesdays 9am
- Divert 5 Hz to ESTB (5 days, 24h)
- When LCLS users access their detectors we can send 60 Hz into ESTB for short times (few minutes to maybe an hour or two per day)
- Tuesdays 24h machine development needs only 10 Hz

  ➔ 50 Hz to ESTB possible
- Wednesdays 8h scheduled LINAC Maintenance with recovery and MD over night

  ➔ 50 Hz for 10 hours

- Max Rate (per week)
  - 120h at 5Hz = 2.2 x 10^6
  - 30h at 50Hz = 5.5 x 10^6

ESTB Status

- New BSY kicker magnets, power supply and vacuum chambers
  - All items designed, currently in procurement of materials
  - Magnets to be build January and February 2011
  - Will be installed during the SLAC down March - May 2011
- New small beam dump for ESA
  - Exists and will be installed early 2011
- New Personnel Protection System (PPS)
  - Is the most time consuming of the needed upgrades (multiple reviews)
  - Design is pretty advanced and implementation plan is under development
  - My hope is to get it installed and certified by May 2011

- We are planning on a User Workshop in conjunction with another meeting late this year or early 2011

  (possibly Thursday March 17 at SLAC before Oregon ALCPG11 (March 19-23 2011)

First beam early summer 2011

Contact: Carsten Hast (hast@slac.stanford.edu)
https://slacportal.slac.stanford.edu/sites/ard_public/tfd/Pages/Default.aspx

ESTB Time Line for Hadrons and 120Hz Upgrade

Funding will be made (hopefully) available after we have had beam in ESA

- June 2011 primary beam to ESA
  - ➔ Additional funds may be released…
- Need about 4-6 month to design and build hadron target and auxiliary infrastructure, new magnet stands, beam pipe
- About 2 month to install equipment in ESA
- During short winter shutdown 2011/2012 install target in A-line (inside of BSY)

Hadron Beam to ESA Winter 2011/12

Just in time to provide hadron TB in the US in 2012

if Tevatron run will not be extended

- For a modest investment we could upgrade our kicker power supplies and modulators for 120Hz operation

Test Beam Summary

- Yesterday the Summary of the Linear Collider Testbeam Workshop 2009 - LCTW09 has been submitted to arXive http://arxiv.org/abs/1010.1337
  - Very complete summary of LC detector TB needs and TB facilities world wide
  - Very worth the read

- FNAL FTBF is the only operating user facility
  - Well understood
  - Very popular and is increasing its capacities
- SLAC ESTB will come online mid 2011
  - Beam energy is determined by LCLS
  - Needs to re-establish a user base
  - Stay tuned for the first user meeting end of this year or early next year
- Potentially no hadron test beams in 2012
  - Tevatron run not extended
  - ESTB Phase II not funded

Both, Aria (FTBF) and I (ESTB) invite you to use our beams