Compilation of World Wide Beam Test Facilities

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- Advance apologies for my misunderstandings and all the mistakes I made summarizing the facilities

ILC Challenges

- Many detector technologies not established
  - Vertex detector technologies: SOI, MAPS, 3D, CPCCD, FPCCD, DEPFET, …
  - EM Calorimetry: Silicon-Tungsten based fine pixels
  - HAD Calorimetry: analogue/digital with RPC, GEM, MicroMegas, Scintillator readout
  - Forward Calorimetry: BeamCal and LumCal
  - TPC: Gas amplification systems, GEM, Micromegas and readout
  - Muon Detection: MPPC readout
- Simulation
  - Development of PFA algorithms and modeling of shower simulations in Monte Carlos and validation of Particle Flow algorithms
- ILC Parameters
  - Magnetic fields up to 5 Tesla
  - Power consumption requirements
  - EMI, Material Budget, Integrated Tracking

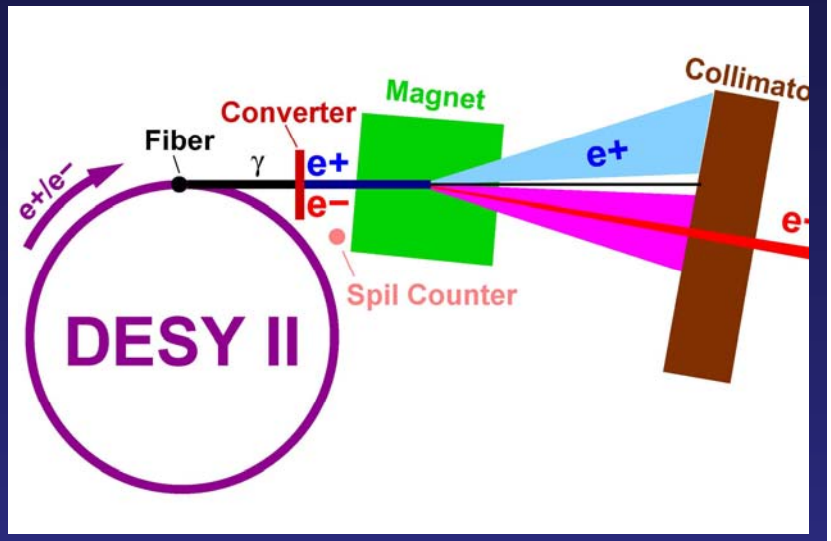
- Many of these issues can only be addressed through beam tests
- This is a compilation of beam test facilities with a look towards requests from the user community for further enhancements

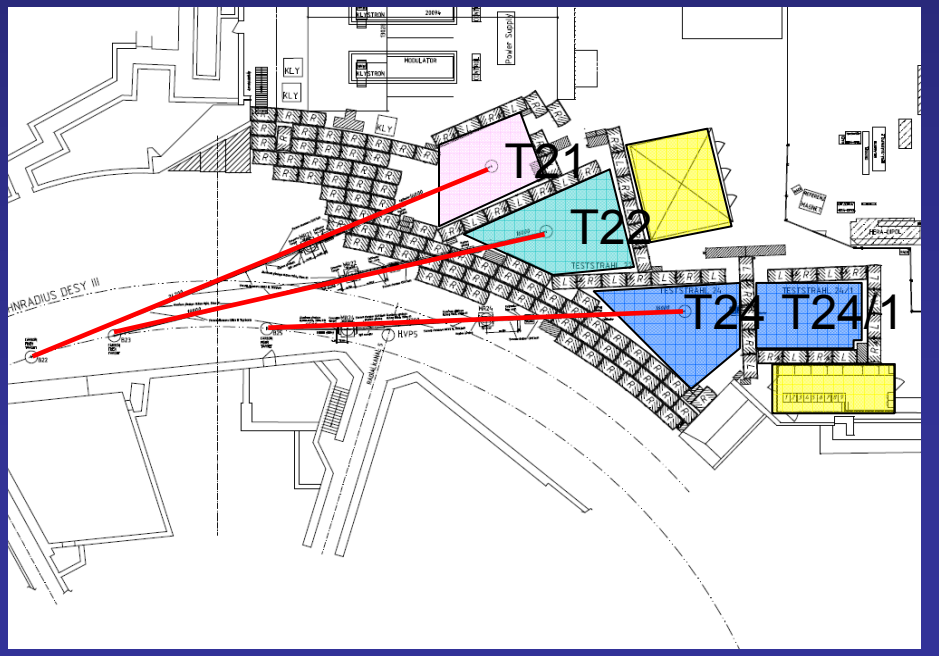
DESY Beam Test Facility

- DESY provides three test beam lines
  - No beam optics
    - Only momentum selection via magnet
  - 1-6 GeV/c electrons
  - Repetition rate 12.5 Hz
  - Bunch length 30 ps
  - Two conversion targets (Cu, Al)

Rates	Target	
Energy	3mm Cu	1mm Cu
1 GeV	~330 Hz	~ 220Hz
2 GeV	~500 Hz	~330 Hz
3 GeV	~1000 Hz	~660 Hz
5 GeV	~500 Hz	~330 Hz
6 GeV	~250 Hz	~160 Hz

- Availability: continuous?
- User brings own DAQ
- External beam diagnostics: none



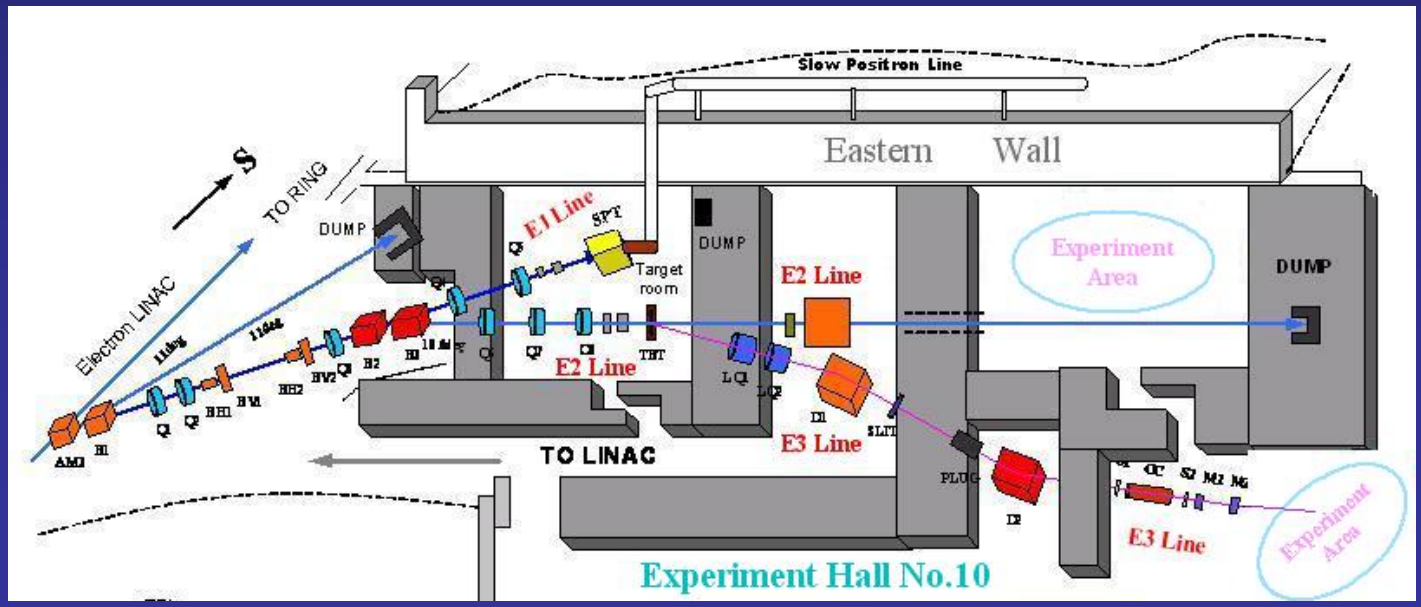


DESY Beam Test Facility Plans

- Area T24 will be dedicated to EUDET facility
- Improvements to facility:
  - First half of 2008: long shutdown
    - New Vacuum System
    - New Control System
  - No further improvements foreseen
- Availability of test beam area
  - Available on continuous basis to users
  - Currently no conflicts between users foreseen
  - Impact of PETRA3 on test beam under evaluation

IHEP-Beijing Beam Test Facility

- IHEP-Beijing provides three test beam lines
  - Two primary beam lines E1 and E2
    - 1.1-1.5 GeV electrons/positrons
    - Repetition rate 25 Hz
    - Bunch length 1.2 ns
  - Secondary beam line E3
    - 0.4-1.2 GeV/c, $e^{\pm}$, $\pi^{\pm}$, p
    - Repetition rate 1.5 Hz (single particle)
  - External beam diagnostics
    - TOF system
    - Threshold Č-counter
    - MWPC with 50% dE/dx resolution



IHEP-Beijing Beam Test Facility Plans

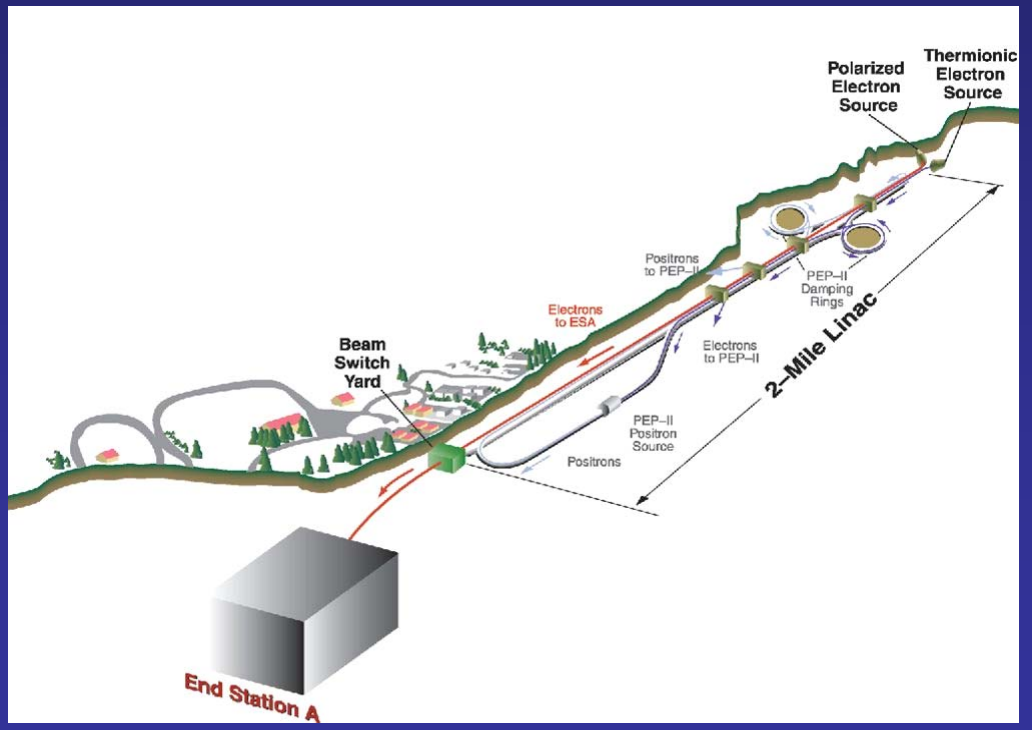
- Alteration of the E2 Line to extend vacuum pipe to reduce particle multiplicity
- A New E3 Line in Hall 10
  - Enhancement of pion's intensity by shortening the decay length from 23m to 15m long
  - New optics for the new beam lines
    - Two dipole and two quadrupole magnets
  - New hodoscopes H1-H3, three triggers S1-S3 and a new Cherenkov counter
    - Improved particle track reconstruction
    - Improved momentum resolution
    - Better particle id.
- Availability of test beam area
  - In 2007 dedicated to calibration of Yangbajing Airshower Core detectors and an experiment of the Electron Scattering.
  - A six month shut down period follows for upgrade
  - Available on continuous basis to users starting March '08

SLAC Beam Test Facility

- SLAC provides one beam line to End Station A (ESA)
  - 28.5 GeV primary electron beam, 3.5 x 10^{10} e^-/pulse at 10 Hz
  - Secondary beam accepted into A-line at 0.5 deg production angle
    - 1.0 - 20 GeV
    - Momentum analyzed to <1%
    - PID through time-of-flight and threshold Cherenkov counters
      - At 13 GeV: 50% π^+, 50% e^+, 0.4% protons, <1% K^+

- Many machine and MDI related tests being carried out at ESA
  - Collimator design, wakefields
  - Energy spectrometer, BPM's
  - Bunch length diagnostics, …

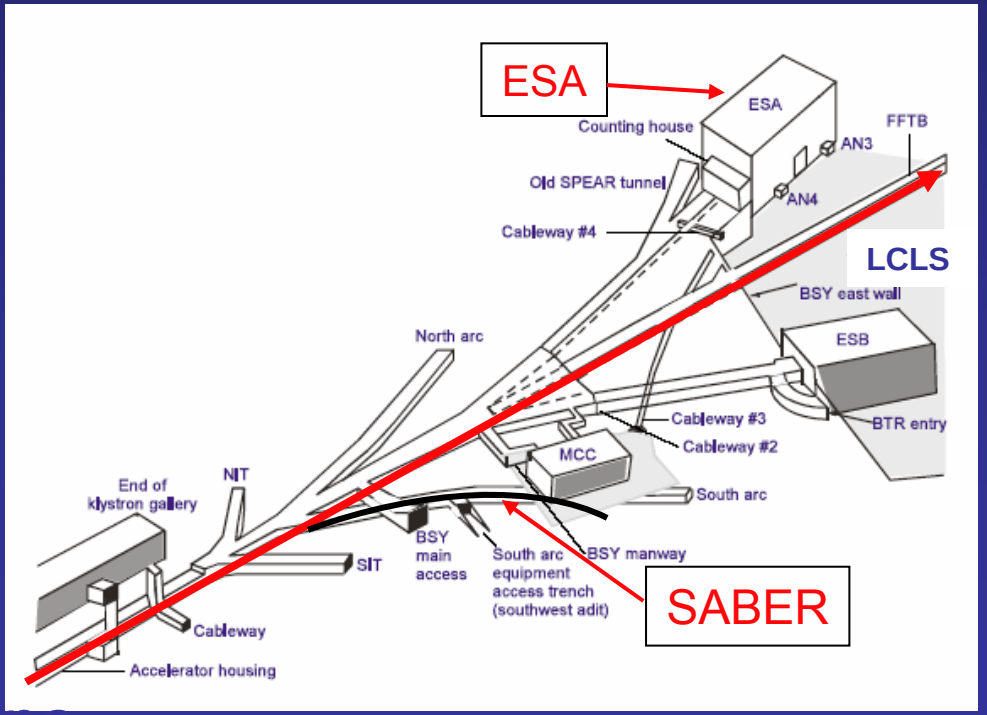
- 2007-2008
  - Running parasitic to PEP II



SLAC Beam Test Facility Plans

- PEP II will end operation at the end of 2008; LCLS will start operating in 2009
- Current plans for ESA undetermined
- As follow-up to FFTF (Final Focus Test Facility) SLAC is pursuing SABER (South Arc Beam Experiment Region)
  - A proposed facility for experiments requiring compressed, focused, high-energy beams of electrons or positrons
  - To be built in the Instrument Section in the SLC South Arc tunnel

- SABER program
  - Plasma Wakefield Acceleration
  - Dielectric Wakefield Acceleration
  - Short Pulse Photon Science
  - …
  - Using
    - High Beam Energy
    - Short Bunch Length
    - High Peak Current
    - Power Density



SLAC Beam Test Facility Plans

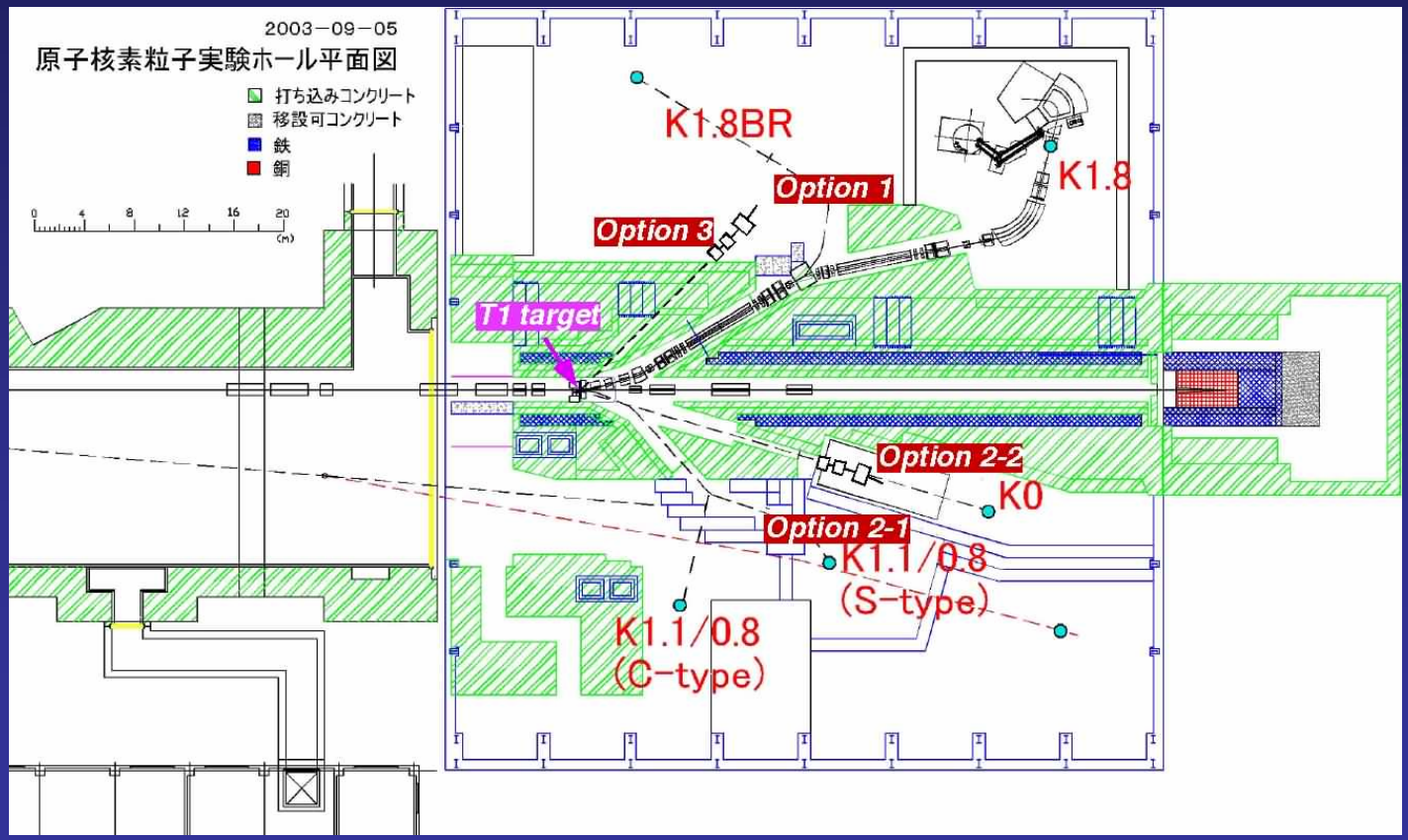
- SABER available for test beams in south arc
  - Space limited for larger scale efforts in SABER
  - 28.5 GeV primary electron beam, no hadrons for secondary beams
- Possibilities for beam at ESA
  - High energy beam 28.5 GeV available when LCLS not running; will compete with SABER for pulses; needs extension of SABER bypass line into ESA
  - Use LCLS beam with pulsed magnets to have 10Hz e^- beam to ESA Energy reach reduced to 5 - 14 GeV
  - Parasitic running from halo of LCLS; allows running all the time at 120 Hz
- Awaiting decision by the laboratory based on feedback from user community

KEK Beam Test Facility Plans

- Currently no beam tests possible at KEK
- Working on implementing “Fuji Test Beam Line”
  - Bremsstrahlung photons from beam v.s. residual-gas scattering
    - 1.6x105 photons/sec
  - Photons are converted in Tungsten converter, 3mm thick, ~$1X_0$
  - Converted particles are extracted to experimental area outside of KEKB tunnel
- Expected performance
  - > 100 electrons/sec (continuously)
  - momentum range: 0.5 - 3.4 GeV/c
  - Momentum resolution ~ 0.4%
  - Spot size +/- 1cm
- Anticipated startup date September ’07

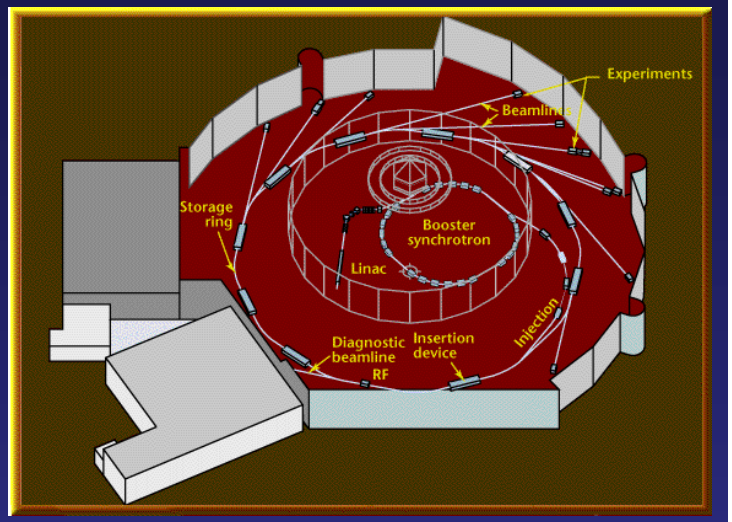
J-PARC Beam Test Facility Plans

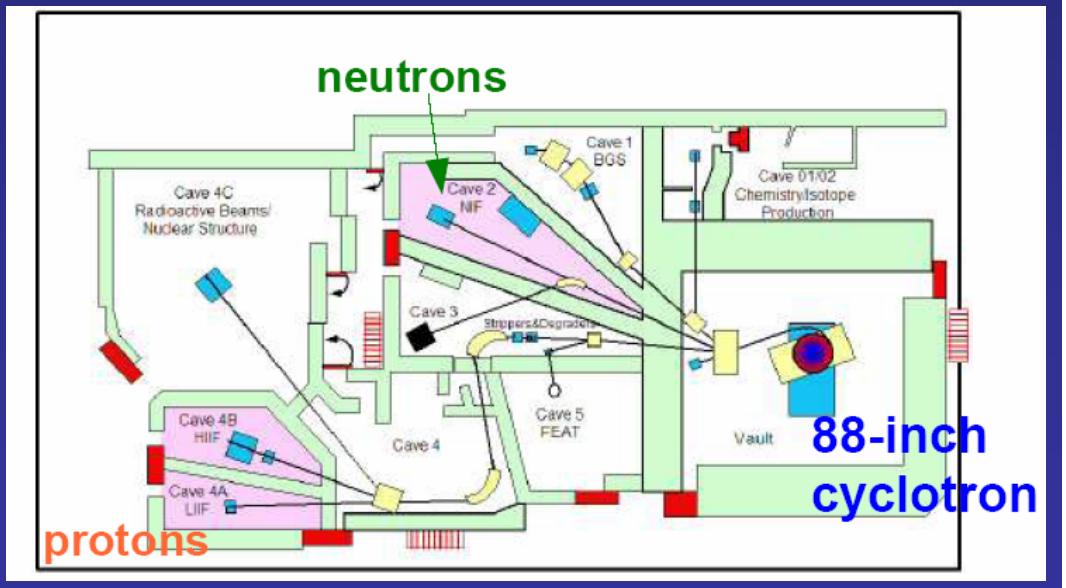
- "Option 3" aimed at providing a beam test facility at the 50 GeV PS at J-PARC
- Currently no concrete plans
- Earliest possible availability is fall 2009



LBNL Beam Test Facility

- Advanced Light source (ALS)
  - Beam test line extracted from injection booster
  - e^- at 1.5 GeV at 1 Hz
  - Pixel telescope being provided
- Laser Optics and Accelerator Systems Integrated Studies (LOASIS)
  - 1 GeV e^-, with possibility for tuning beam energy from ~50 MeV to 1 GeV
  - Plans for upgrade to 10 GeV
- 88-inch cyclotron
  - Dedicated beam-lines for proton (heavy ion) and neutron irradiations
  - E_p up to 55 MeV, E_n < 30 MeV
  - Tunable flux
    - typical ~$1\times10^8/cm^2/s$



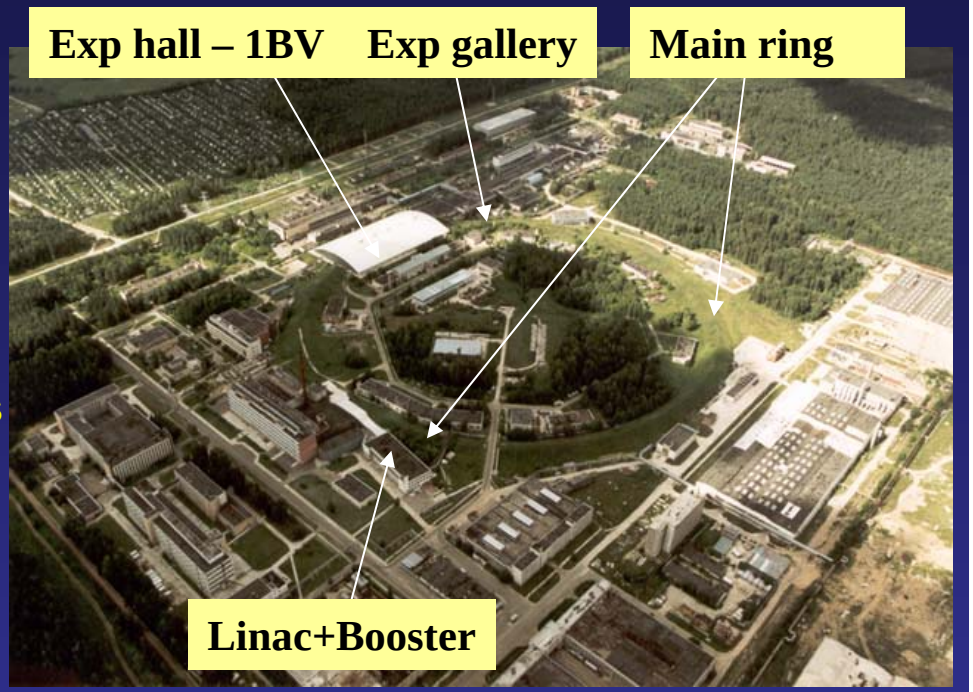


LBNL Beam Test Facility Plans

- Neutron line at 88-inch cyclotron recently developed and commissioned
- Feedback from user community appreciated

IHEP-Protvino Beam Test Facility

- At least four beam lines available
- Beam parameters:
  - cycle time: 10 s
  - spill time: 1.8 s
  - intensity: ~ 10^{13} p/cycle
  - number of bunches: 30
  - bunch length: 40 ns, spacing 160 ns
- High intensity and low intensity beams available



Beamlines	N2B	N4V	Soft Hadron	N22
Momentum Range	e: 1 - 45 GeV μ: 33 - 55 GeV h: 33 - 55 GeV	e: 3 - 15 GeV μ: 20 - 40 GeV h: 20 - 40 GeV	h: < 4 GeV	e: 7 - 40 GeV h: 1 - 70 GeV
Spill Duration	1.8 s	1.8 s	1.8 s	1.8 s
Duty Cycle	1 spill / 10 s	1 spill / 10 s	1 spill / 10 s	1 spill / 10 s
Intensity	~ 10^7 part./spill	~ 10^7 part./spill	~ 10^7 part./spill	~ 10^7 part./spill

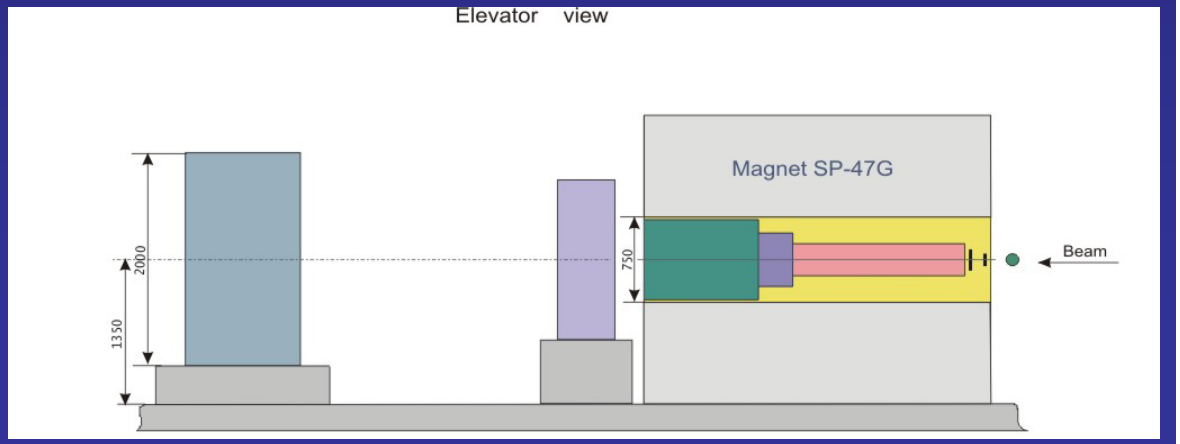
IHEP-Protvino N2B Beam Line

- N2B to be dedicated to ILC slice tests

Electron Beam				
Energy, GeV	Intensity in spill on 10^{12} pot	Content		
		e (%)	μ (%)	h (%)
1	$4 \cdot 10^2$	82	10	5
2	$1 \cdot 10^3$	77	15	8
5	$2 \cdot 10^3$	50	32	18
10	$5 \cdot 10^3$	34	35	30
27	$4 \cdot 10^4$	77	9	13
45	$2 \cdot 10^4$	91	4	5

Hadron Beam (33-55 GeV)	
Particle Type	Content
π^-	96.4 %
μ^-	1.0 %
k^-	2.3 %
p^-	0.3 %

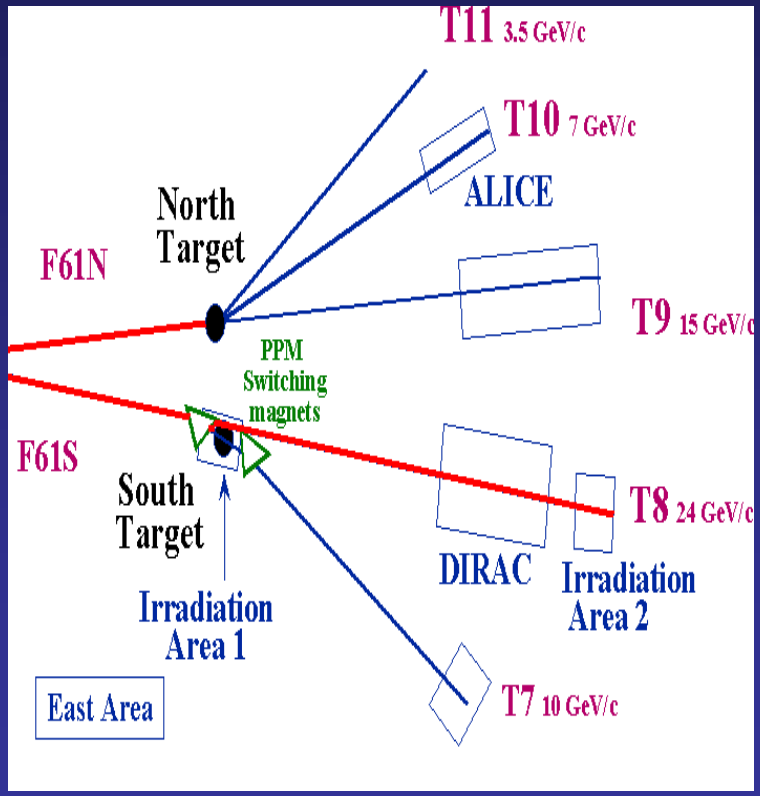
- Plan for full TESLA sector test from Si to muon tail catcher in magnetic field
  - 300 cm long
  - ∫ B dl = 4 Tm



CERN Beam Test Facilities

- Two areas at two machines, with four beam lines each: North area at the SPS and East area at the PS
- PS Area:

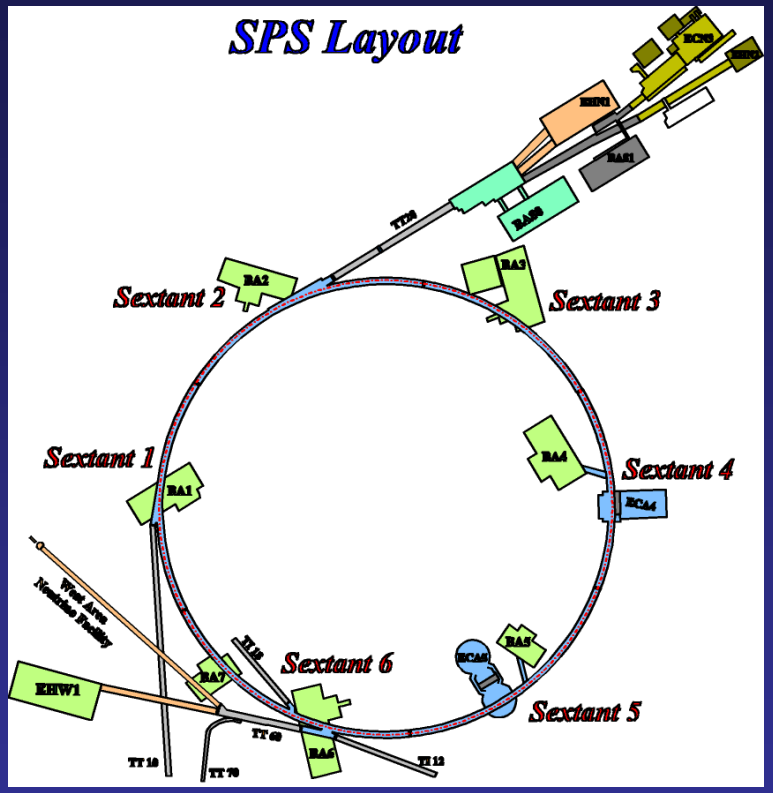
PS Beamlines	
Momentum Range	1 - 3.6 GeV (T11) 1 - 7 GeV (T10) 1 - 10 GeV (T7) 1 - 15 GeV (T9)
Spill Duration	400 ms
Duty Cycle	2 spills / 16.8 s
Particle Type	electrons hadrons muons
Intensity	1 - 2 10^6 part. /spill



CERN Beam Test Facilities

- SPS Area:

SPS Beamlines	
Momentum Range	10 - 400 GeV (H2) 10 - 400 GeV (H4) 10 - 400 GeV (H8) 10 - 205 GeV (H6)
Spill Duration	4.8 – 9.8 s
Duty Cycle	1 spill / 14 – 40 s
Particle Type	electrons hadrons muons
Intensity	~ 10^8 part./spill



- Beamline configurations
  - Beamlines share targets (H2/H4, H6/H8)
    - Beam use coupled
  - Up to three user areas per beamline
  - H4 can be set up for very clean electron beam up to 300 GeV
  - H2 and H8 have low energy (2 - 10 GeV) tertiary beams

CERN Irradiation Facilities

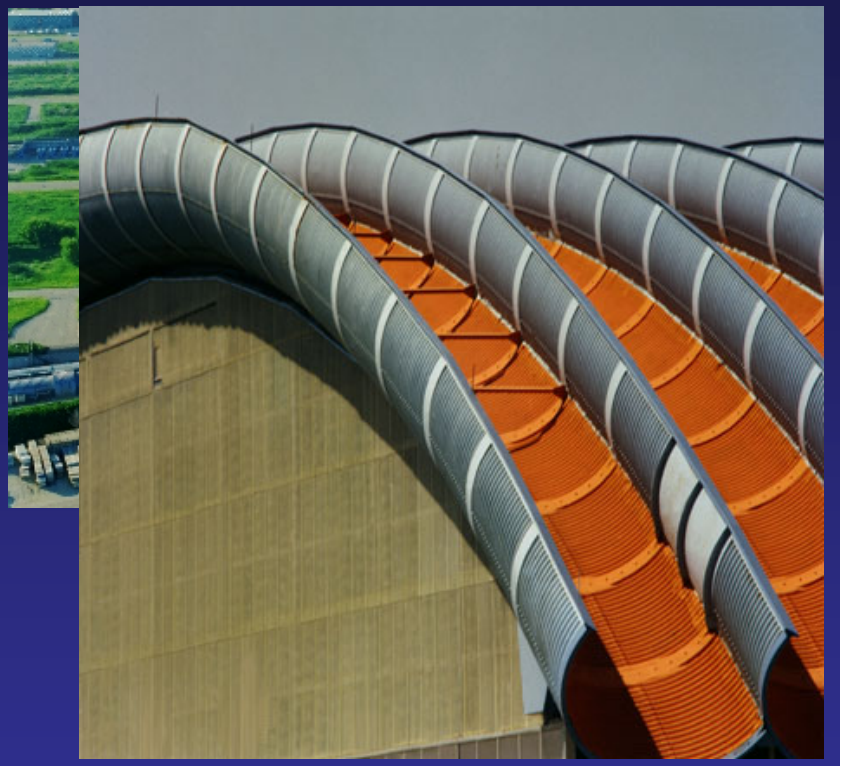
- Gamma Irradiation Facility (GIF), former SPS West Area
  - Cs137 source, 662 keV photons, <720 GBq
  - 2007 may be the last year of GIF operation; new facility under discussion
- Proton/Neutron irradiation facilities, PS East Hall
  - 24 GeV/c primary protons from PS
    - $2*2cm^2$ beam spot
    - $2.5*10^{11}$ protons/spill
- Neutrons from beam dump, spectrum similar to LHC environment

CERN Beam Test Facility Plans

- 2007:
  - PS test beams: May 2 - Nov 12 (28 weeks)
  - requested beam time (T7,T9-T11)
    - ~43% LHC & LHC upgrade
    - ~12% external users
  - SPS test beams: May 25 - Nov 12 (23.5 weeks)
  - requested beam time (H2-H8):
    - ~52% LHC & LHC upgrade
    - ~35% external users
- PS/SPS will start operating as LHC injectors on Nov. 12
- 2008:
  - Heavily dependent on LHC status and LHC beam requests
  - LHC has absolute highest priority for SPS beam
  - Second highest priority is CNGS

Fermilab Beam Test Facilities

- The old Fermilab Meson Test Beam Facility (MTBF)
  - Could not deliver a pion beam lower than 4 GeV
  - Electrons had a low flux because of significant material in the beam
- Motivated by the ILC community, the laboratory designed a new beamline that was completed a few weeks ago



- Also motivated by the ILC community, revised the spill structure and restated the program impact
  - SY120 beam can impact the program at the 5% level following a flexible algorithm
  - Spill structures:
    - One 4 second spill every minute, for 12 hours a day
    - Two 1 second spills every minute, for 12 hours a day
    - One 4 second spill every two minutes, 24 hours a day (this is implemented if MIPP is running in MCenter)

Fermilab Beam Test Facility

- Moving the target to MT3 (L=1273-1388' goes to L= 451-566') reduces the decay length for pions
- Reduce the material in beamline
  - From 17.8 % X_0 to ~ 3.4% X_0

Energy (GeV)	Hadron Enhancement	Electron Enhancement
4	25	~90
8	6.4	14
16	2.5	6.3

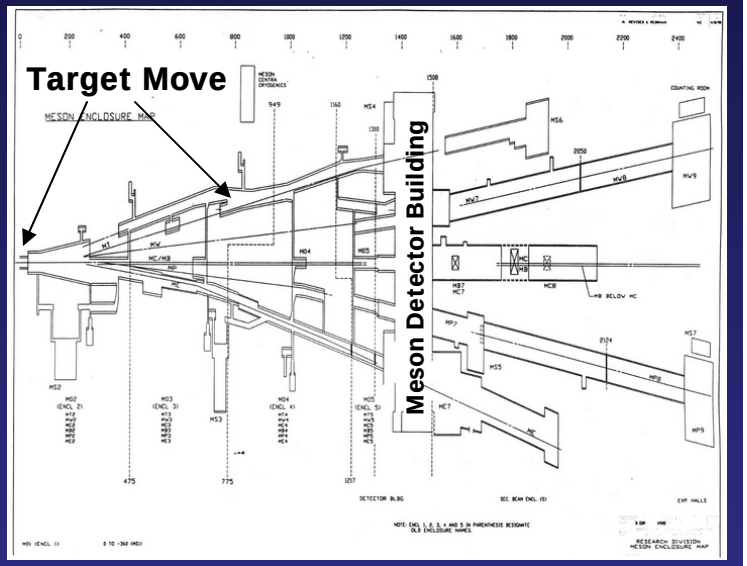
Energy (GeV)	Gain due to Pion Decay factor
1	90
2	9.2
4	3.0
8	1.8
16	1.3
33	1.2
66	1.1

- New Design has larger momentum (from from ¾% to 2%) and angular acceptance available
- Commissioning of new beam line has started; low energy beam commissioning imminent

Energy (GeV)	Present Hadron Rate MT6SC2 per 1E12 Protons	Estimated Rate in New Design (dp/p 2%)
1	---	~1500
2	---	~50K
4	~700	~200K
8	~5K	~1.5M
16	~20K	~4M

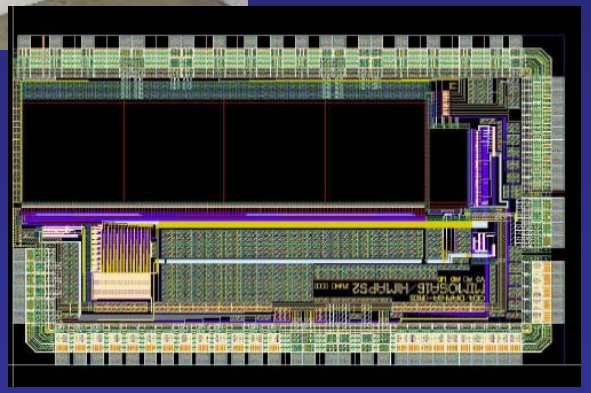
Possible Enhancement of Fermilab Beam Test

- Further enhancements of the ILC R&D activities could be explored, with a concurrent scientific program, which could benefit the ILC community
- MCenter beam line, which houses the MIPP experiment, is currently not scheduled
- MCenter beamline
  - Beamline with excellent characteristics
    - Six beam species ($p^{\pm}$,$K^{\pm}$,$p^{\pm}$) from 1 -- 85 GeV/c
  - Excellent particle id capabilities
- Experimental setup
  - Could allow for better understanding of hadron-nucleus interactions, which could benefit our understanding of hadronic shower development, which is currently poorly understood
    - Nuclei of interest that can be measured with an upgraded MIPP
      - H_2, D_2, Li, Be, B, C, N_2, O_2, Mg, Al, Si, P, S, Ar, K, Ca, Fe, Ni, Cu, Zn, Nb, Ag, Sn, W, Pt, Au, Hg, Pb, Bi, U, Na, Ti,V, Cr, Mn, Mo, I, Cd, Cs, Ba
  - Moreover, experimental setup with the full spectrometer would allow for a tagged neutron beam from fully constrained reaction pp ➔ p,n,π^+



EUDET Beam Test Infrastructure

- EUDET not a beam test facility per sé; it provides infrastructure for beam test facilities anywhere in the world
- Construction and initial tests at DESY with possibility to move it elsewhere
- Activity organized in 5 tasks
  - Large bore magnet (on loan from KEK)
    - SC high field magnet: 1.2 T
    - Large bore 80 cm diameter
    - Thin cryostat (0.2 X_0)
  - Environmental support
  - Pixel beam telescope
    - Flexible geometry (for diff. beams)
    - 1 μm precision on device under test
    - Based on MAPS technology
  - DAQ
  - Evaluation (integration of pixel detector test devices)
- Many experiments being carried out
  - TPC: field cage, end plate interface, readout, Timepix chip
  - Si tracking
  - Calorimetry and readout



Testbeam Availability

Laboratory	Energy Range	Particles	Availability
CERN PS	1 - 15 GeV	e, h, μ	LHC absolute priority
CERN SPS	10 - 400 GeV	e, h, μ	LHC absolute priority
DESY	1 - 6.5 GeV	e^-	> 3 months per year
Fermilab	1-120	e, π, K, p; μ	continuous (5%), except summer shutdown
Frascati	25-750 MeV	e	6 months per year
IHEP Beijing	1.1-1.5 GeV (primary) 0.4-1.2 GeV (secondary)	$e^\pm$ $e^\pm$, $\pi^\pm$, p	Continuous after March 2008
IHEP Protvino	1-45 GeV	e, π, K, p; μ	one month, twice per year
J-PARC			Available in 2009
KEK Fuji	0.5 - 3.4 GeV	e	Available fall 2007, 240 days/year
LBNL	1.5 GeV < 55 MeV < 30 MeV	e p n	Continuous
SLAC	28.5 GeV (primary) 1.0 - 20 GeV (secondary)	e $e^\pm$, $p^\pm$, p	Parasitic to Pep II, non-concurrent with LCLS

Testbeam Parameters

Laboratory	Primary Beam	# Beamlines	Δp/p	Rep. Rate (Hz)	Diagnostics
CERN PS	1 - 15 GeV	4			Cherenkov, TOF, MWPC
CERN SPS	10 - 400 GeV	4			Cherenkov, TOF, MWPC
DESY	e^- / 7 GeV	3	1% ?	12.5	Pixels
Fermilab	p / 120 GeV	1	1% > 10 GeV		Cherenkov, TOF, MWPC, Si Strips, Pixels
Frascati	25-750 MeV	1			
IHEP Beijing	e^- / 1.5 GeV	3	<1% 1%	25 1.5	Cherenkov, TOF, MWPC
IHEP Protvino	1-45 GeV	4			Ckov, Diff. Ckov, TOF, MWPC
J-PARC					
KEK Fuji	8 GeV	1	0.4%	100.0	
LBNL	e^- / 1.5 GeV	1		1.0	Pixel telescope
SLAC	28.5 GeV	1	0.2%	10.0	

Summary

- Detector R&D for the ILC is critical to extract the physics from the machine
- The laboratories have demonstrated to be very supportive of the requests of the user community
- The user community should formulate clearly its needs and provide feedback to the available facilities
  - Some facilities may need a strong user support to keep the facility operational
  - Plans of the facilities can only be formulated through input from the user community
- Overall, a few, but excellent facilities are available to the community with strong support for ILC detector R&D