ILC Detector Test Beam Worskhop (IDTB07)

Fermilab, January 17-19, 2007

Sessions

- Test Beam Facilities (2)
- Fermilab Facility Tour
- Beam Instrumentation and MDI
- Vertex and Tracking
- Calorimetry and Muons (2)
- Software/DAQ/Simulations
- Future Planning (2)

→ will offer some overview/summary of the workshop.
from a personal/SLAC MDI perspective

Detector Test Beam Facilities

Talks

- Fermilab
- SLAC
- KEK
- LBNL
- Beijing
- Protvino
- DESY
- CERN
- EUDET Beam Test Infrastructure
- + compilation, by M. Demarteau

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

Worldwide Test Beam Facilities, IDTB07, Jan. 17, 2007 -- M. Demarteau *Slide 3*

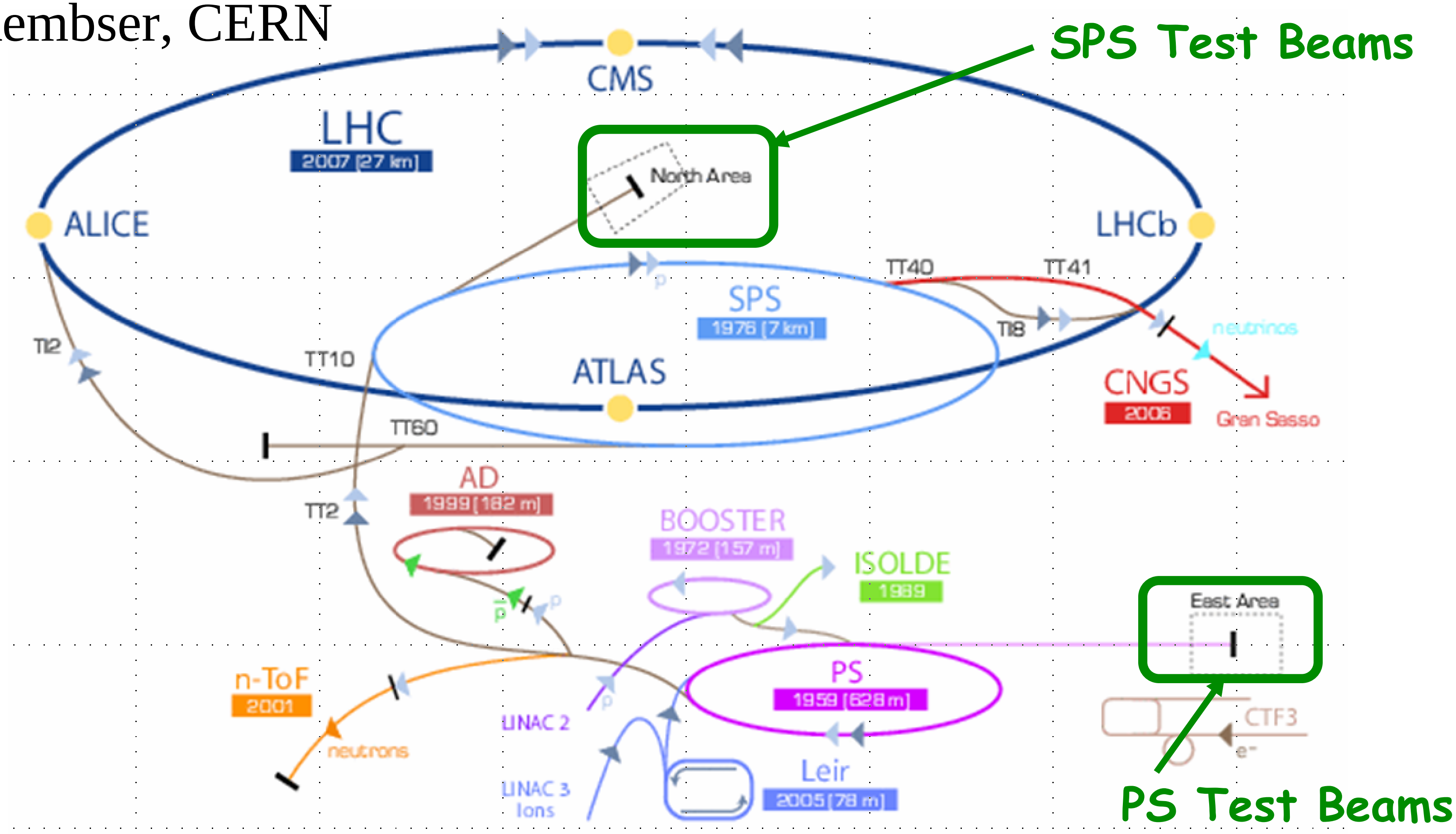
Detector Test Beam Facilities Summary*

Laboratory	Primary Beam	# Beamlines	Particles	Δp/p	Rep Rate
CERN PS	24 GeV p	4	e,π,K,p,μ		kHz
CERN SPS	400 GeV p	4	e,π,K,p,μ		kHz
DESY	7 GeV e	3	e	1%?	300 Hz
Frascati	750 MeV e	1	e		
Protvino	70 GeV p	4	e,π,K,p,μ	2%	kHz
Beijing	1.5 GeV e	3	e, π, p	1%	1.5 Hz
KEK Fuji	8-GeV e	1	e	0.4%	100Hz
KEK ATF(2)	1.5 GeV e	1	Primary e		1.5Hz w/ train
J-PARC	50 GeV p	1			
SLAC	28.5 GeV e	1	e, (π); also Primary e	(0.1-2)%	10 Hz
LBNL	1.5 GeV e	1	e		1 Hz
Fermilab	120 GeV p	1	e,π,K,p,μ	2%	kHz

*adapted from M. Demarteau's talk

CERN PS/SPS Test Beams

C. Rembser, CERN



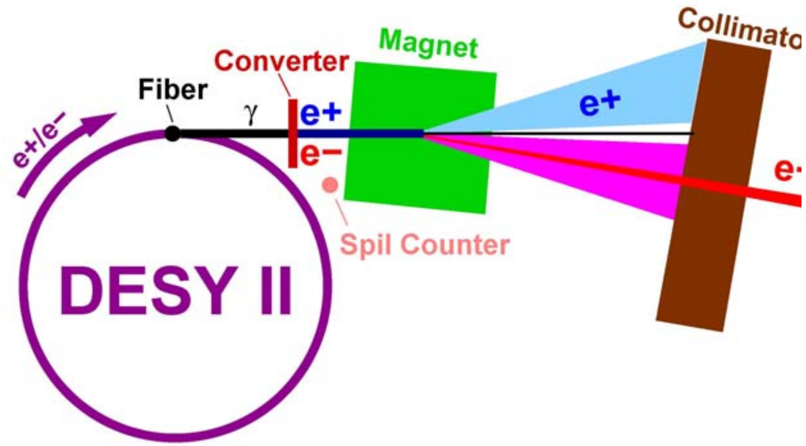
2007: Beam time requests from 47 groups, O(1500) users

PS test beams: 28 weeks requested
- ~43% LHC & LHC upgrade
- ~12% external users

SPS test beams: 23.5 weeks requested
- ~52% LHC & LHC upgrade
- ~35% external users

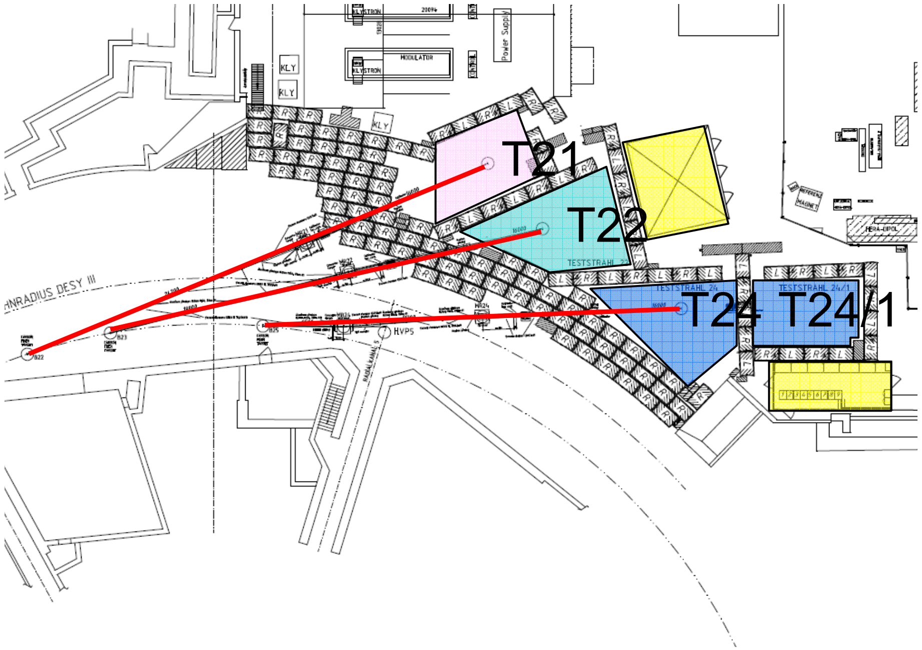
DESY Test Beams

I. Gregor, DESY



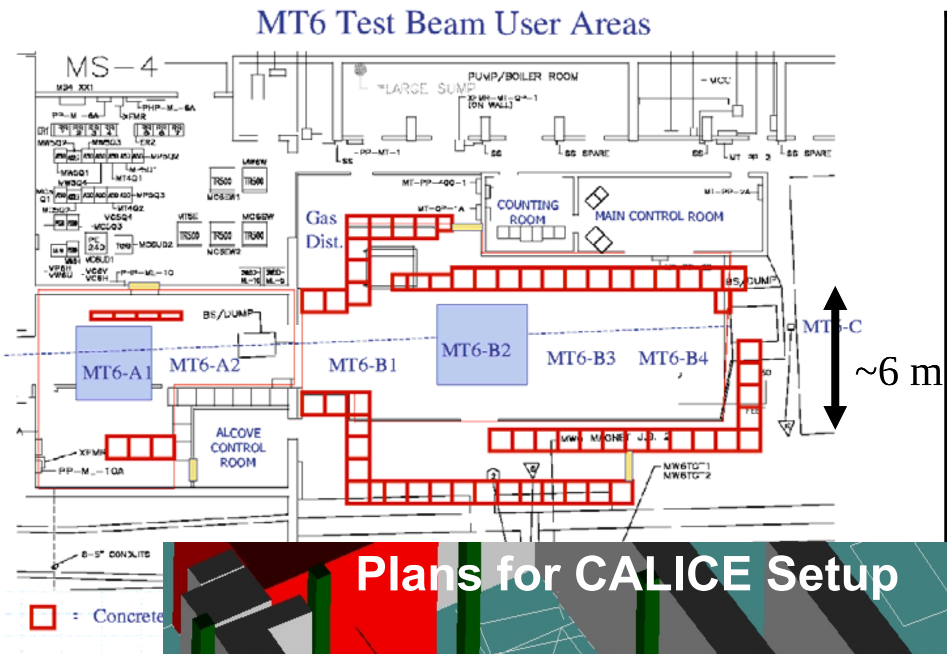
Secondary e- Rates

	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

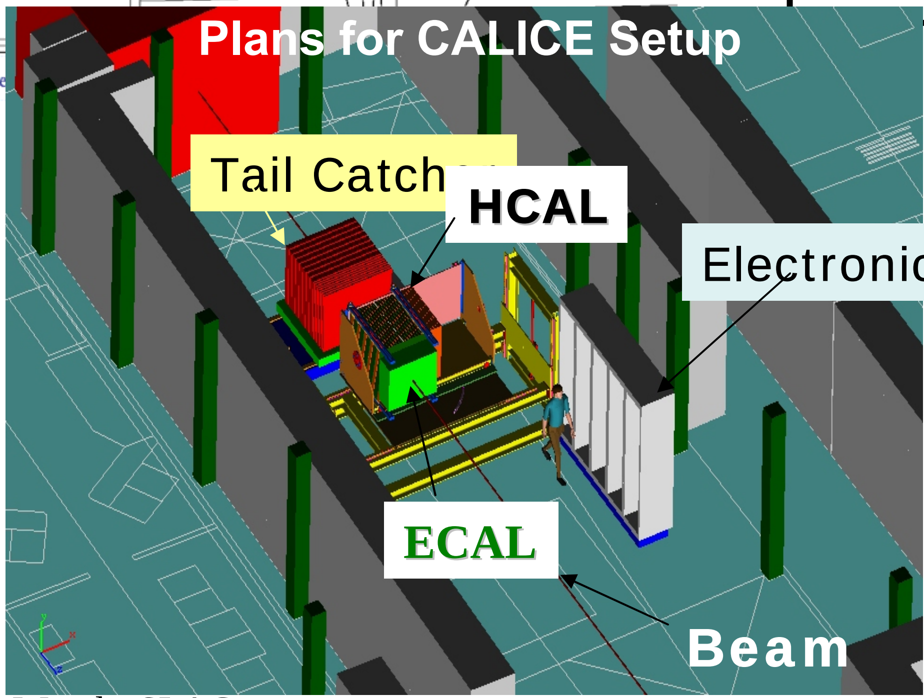


Fermilab M-Test Beamline

Erik Ramberg, FNAL



Energy (GeV)	Present Hadron Rate MT6SC2 per 1E12 Protons
1	---
2	---
4	~700
8	~5K
16	~20K

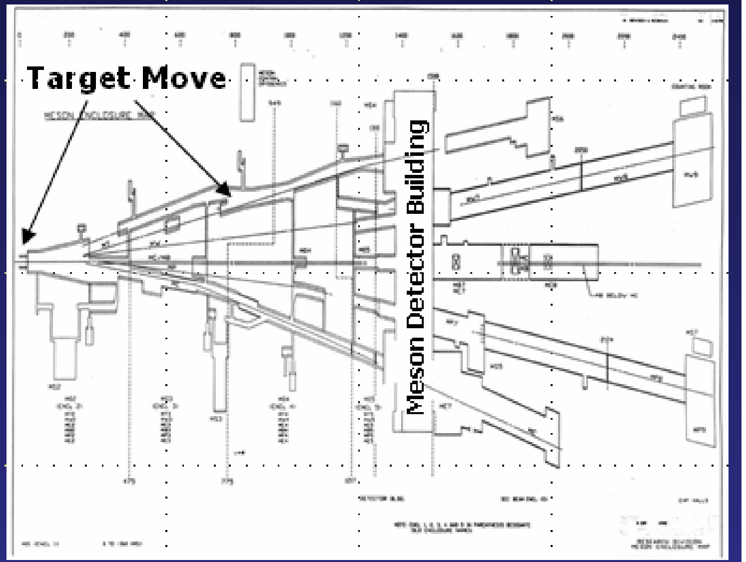


Spill structure

- one (1-4)s spill every 2 minutes
- likely possibility for 1ms "pings" at 5Hz during spill
- 3MHz bunch structure uncertain?

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 $pp \rightarrow p,n,\pi^+$

SLAC Test Beams

C. Hast, SLAC

End Station A facility

- for both primary and secondary electron beams
- primary beam has similar bunch charge, bunch length, energy spread as ILC parameters; 28.5 GeV
- 10Hz beams parasitic with PEP-II operation
- future beyond FY08 uncertain

- ESA is large (60m x 35m x 20m)
- 50/10 t crane
- Electrical power, cooling water
- DAQ system for beam and magnet data

SLAC Test Beams

C. Hast, SLAC

SABER Proposal: test beams available starting in FY10

- Beam has a downward pitch of 3.7 deg
- Beam position rather close to wall and floor:
  - 42 inches above the tunnel floc
  - 39 inches from south tunnel wa
- Experimental section is ~100 feet long
- Infrastructure has to be developed

Mainly a facility for accelerator physics (ex. Plasma-Wakefield studies)
→ Primary electron or positron beams with low emittance and compressed bunches

Test beams can either use the primary beam

with reduced charge if necessary

or it can be collimated down to a few electrons or positrons per pulse

Secondary Electron or Positron Beams are possible

a few or 1 or less than 1 particles per pulse (few GeV to 10 -- 15GeV)

Secondary hadrons are very unlikely

Beam Instrumentation and MDI

Talks

- **Experiments at SLAC ESA**
  (M. Woods, SLAC)
- **Experiments at KEK ATF and ATF2**
  (M. Ross, Fermilab)
- **Energy Spectrometer R&D**
  (M. Hildreth, U. of Notre Dame)
- **FONT R&D**
  (C. Clarke, Oxford U.)
- **Collimator R&D**
  (A. Sopczak, Lancaster U.)
- **Very Forward Calorimeter R&D**
  (W. Lohmann, DESY)

SLAC-ESA Program and the ILC

M. Woods, SLAC

Machine-Detector Interface at the ILC

- ❖ Impact of ILC Parameters on Detector design and Physics reach
- ❖ Impact of Detector designs on ILC design and parameters
  - (L,E,P) measurements: Luminosity, Energy, Polarization
  - Forward Region Detectors
  - Collimation and Backgrounds
  - IR Magnets, Crossing Angle
  - EMI (electro-magnetic interference) in IR

MDI-related Experiments at SLAC's End Station A

- Collimator Wakefield Studies (T-480) ⇨ Talk by A. Sopczak
- Energy spectrometer prototypes (T-474/491 and T-475)
- IR background studies for IP BPMs (T-488) ⇨ Talk by M. Hildreth
- EMI studies ⇨ Talk by C. Clarke

Beam Instrumentation Experiments in ESA

- Rf BPM prototypes for ILC Linac (part of T-474)
- Bunch length diagnostics for ILC and LCLS (includes T-487)

Future for continuing the SLAC ILC Test Beam Program?

FY08 → continue program in ESA, requesting 4 weeks of Beam Tests
→ beam scheduling more difficult: priority for LCLS, also for SABER
→ reduced funding available (?) from SLAC and ILC, but major installations are complete

FY09 and beyond (LCLS era, parasitic operation with PEP-II ends at end of FY08)
→ ESA PPS upgrade needed for continued ESA operation
→ ILC beam instrumentation tests in SABER are possible
→ Study group looking at SLAC test beam capabilities with primary and secondary beams for Detector and MDI-related R&D – need input from Fermilab ILC test beam workshop

SABER
- assume SABER exists with bypass line and operational for beam tests by 2010
- parameters for primary beam can be similar to ILC for bunch charge, energy spread, bunch length. 28.5 GeV energy.
- limited space and infrastructure
- should be able to carry out small scale tests, ex. tests for BPMs, bunch length detectors
- unlikely to continue T-474/T-475 here; T-480 may be possible, but difficult
- need to investigate capability for low-intensity secondary beams for ILC detector R&D

ESA
• several possibilities exist for primary and secondary beams to ESA in LCLS era; most require PPS upgrade and some require pulsed magnets in Beam Switchyard
• primary beam modes: i) high energy beam when LCLS not running, iii) extend SABER bypass line to ESA (expensive), iii) interleaved 10Hz running using LCLS beam with pulsed magnets,
• secondary beam modes: i) high energy beam when LCLS not running, ii) parasitic operation with LCLS using beam halo and production collimator in BSY, iii) extend SABER bypass line to ESA (expensive), iv) pulsed magnets in BSY using 10Hz LCLS beam and BSY production collimator,

ATF2 Project

M. Ross, Fermilab

- Beam Delivery Optics, Tuning, Control and Instrumentation Demonstration
    - 2008 - 2010
  - 35 nm vertical beam size
  - 2 nm stabilization
- Fully international project with funding and in-kind contribution from all three regions.
- Project meetings 2x yearly
    - http://ilcagenda.linearcollider.org/categoryDisplay.py?categId=47
- (Strong SLAC participation)
- Project Leadership: Andrei Seryi (SLAC) & Toshiaki Tauchi(KEK)

ATF & ATF2 Projects

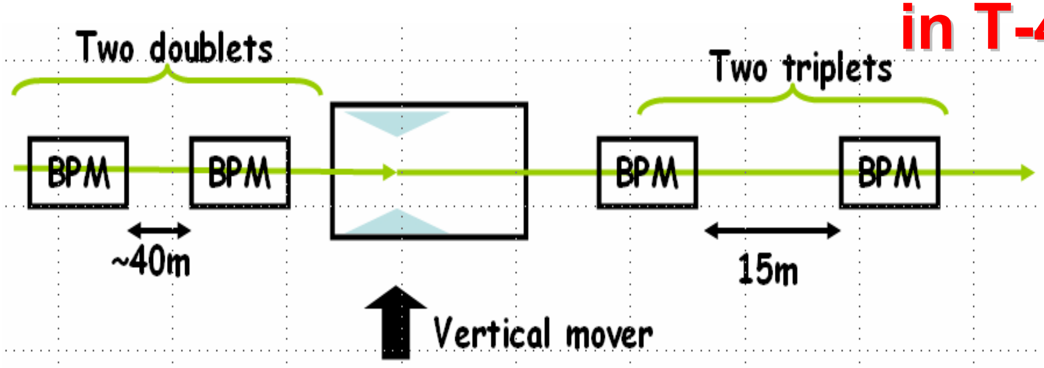
M. Ross, Fermilab

Beam Instrumentation / MDI 2001→ present

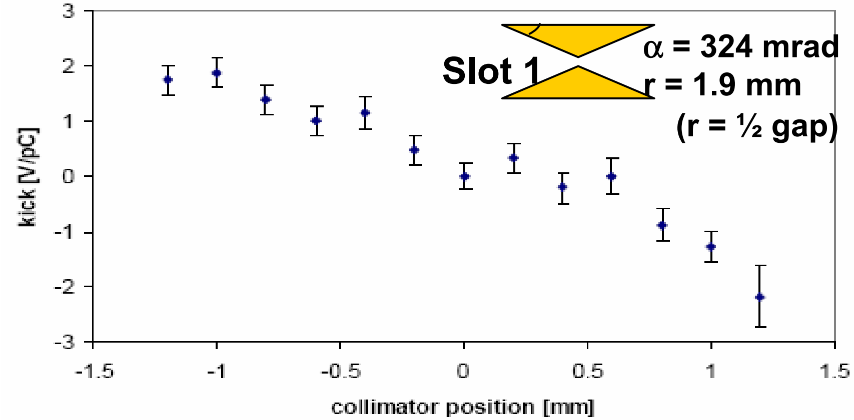
- Energy Spectrometer (MDI) (S. Boogert)
  - UK Univ, Cockroft, US Univ, SLAC, KEK, Japanese Univ
  - demonstrate 1e-4 abs E online monitor
- Laserwire (Instrumentation) (G. Blair)
  - UK Univ, Adams KEK, SLAC
  - demonstrate 1um resolution
- Fast feedback (Controls) (P. Burrows)
  - UK Univ, KEK
  - intra-train ‘IP’ feedback
- Optical Diffraction Radiation
- Compton-based generation of polarized e+
- Ultra-high resolution optical transition radiation
- Cavity Beam Position Monitor
- High resolution wire scanners
- Fast avalanche photo-diode detectors

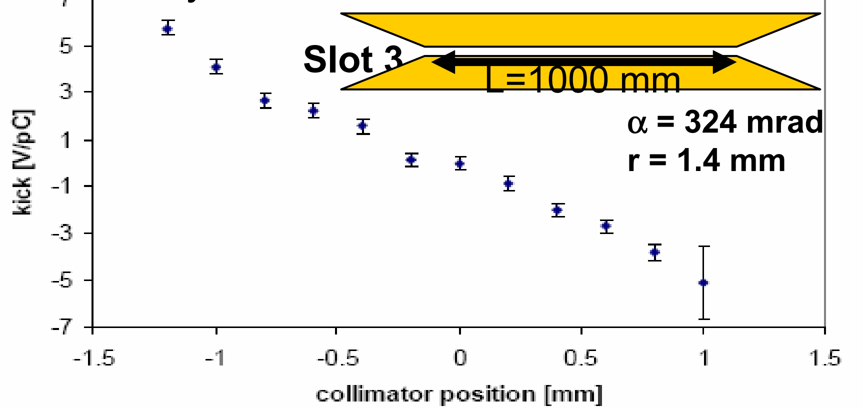
Collimator Wakefield Measurements in T-480 at SLAC in FY06

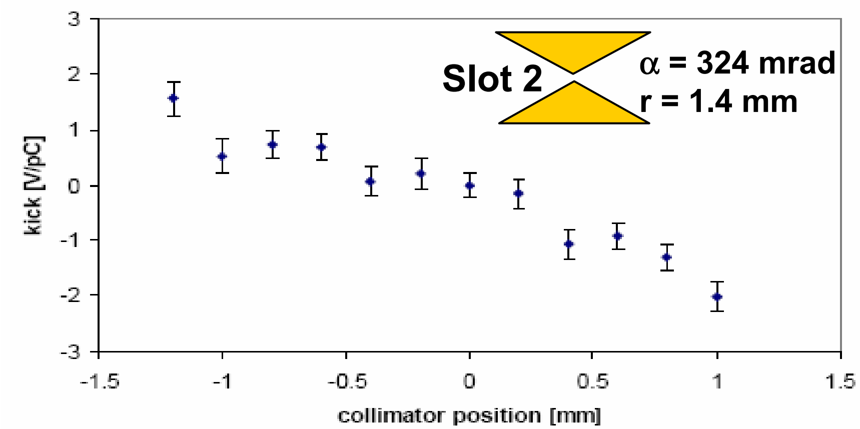
A. Sopczak, Lancaster U.

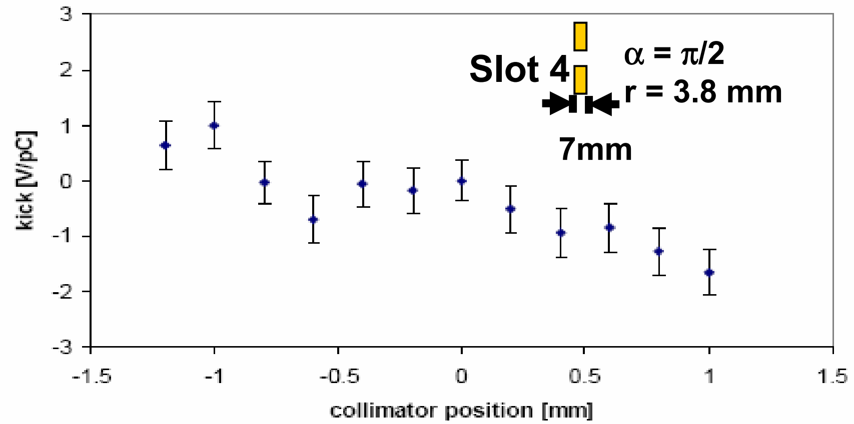


Analysis results from L. Fernando-Hernandez









Some Future Collimator Activities

A. Sopczak, Lancaster

LHC Phase II collimators. New test stand at CERN possible in 2008. Studies for larger luminosity. Collaboration with SLAC **(US LHC Accelerator Research Program (LARP))**

EU Framework 7 projects discussions:

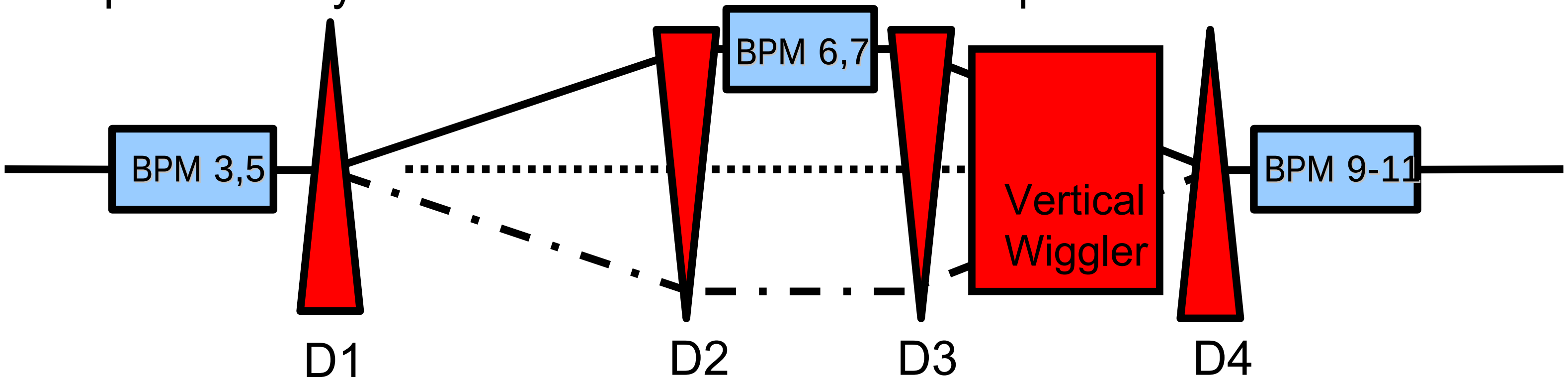
- Phase II collimator development and material damage studies. High density protons. (proposal May 2007)
- GADGET, **G**eneration **A**nd **D**iagnostics **G**ear for tiny **E**mi**T**tance. Ongoing discussions including ILC collimator wakefield studies. Design aspects: BPM resolution and locations. (proposal March 2008)

Prototype Energy Spectrometers at SLAC-ESA

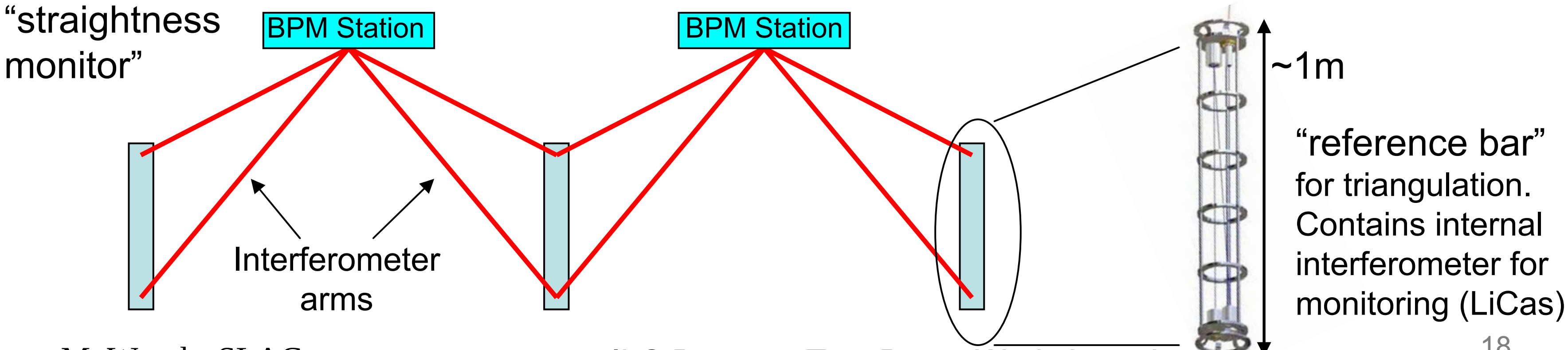
M. Hildreth, Notre Dame U.

FY07/08 Plans

- Install wiggler and 4 chicane magnets
- Move BPM4 to BPM6 location
- New BPM7, design optimized for spectrometry
- Operate chicane in both polarities
- Install Metrology grid (staged approach)
- Install Detector for Wiggler SR stripe



<u>Metrology Grid</u> ⇒ Crucial for Mechanical Stability Tests



Prototype Energy Spectrometers at SLAC-ESA

M. Hildreth, Notre Dame U.

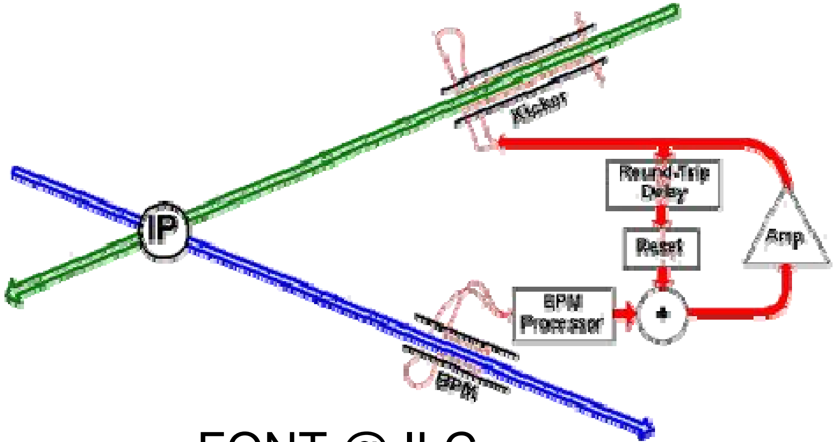
- Basic Goal: Performance tests of realistic spectrometers
  - Investigate calibration procedures, systematics at 100ppm level due to
    - BPM electronics stability
    - mechanical stability
    - magnetic fields
    - sensitivity to beam parameters
  - compare results from BPM, synch stripe measurements and upstream beam diagnostics

- Rate of progress funding-limited
  (may be facility-limited, too)
  - do not have any designs with proven resolution
    - complicated, multi-element systems working at tiny resolutions
    - components slow to fabricate/build/install/understand
  - will probably not be able to install and understand complete prototypes by end of FY08 (or CY08, for that matter)
  - will need capability to run longer

FONT at ATF and ATF2: nanometer beam stabilization for the ILC

C. Clarke, Oxford U.

- Continue with digital processors to close the feedback loop in March/April 2007.
- Develop better resolution processors (currently 5μm, require 1μm) with striplines, if possible. If not, cavities.
- Correct for x,x',y,y' using 4 BPMs and kickers (2008).
- Demonstrate feedback works with long ILC train of 20-60 bunches (2009).
- Implement feedback algorithms.
- Integrate feed-forward from the ring to the extraction line.
- In the future, the FONT system will be used for stabilisation in y at the ATF2 Interaction Point.

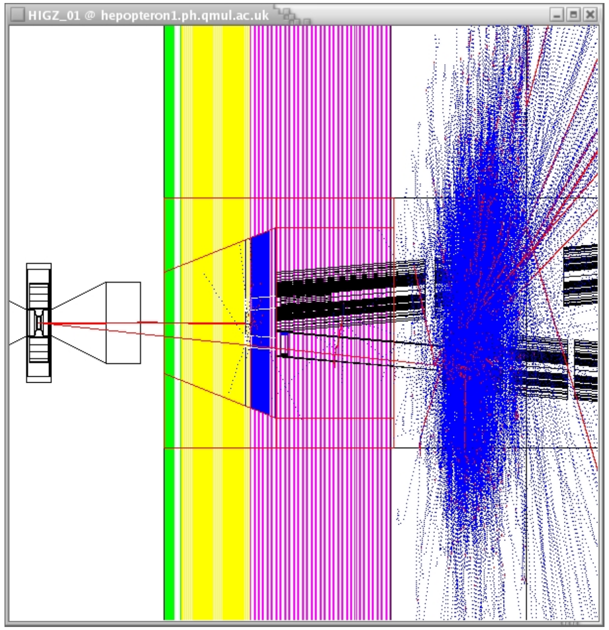


FONT @ ILC

FONT at ESA: Simulating ILC Background Environment

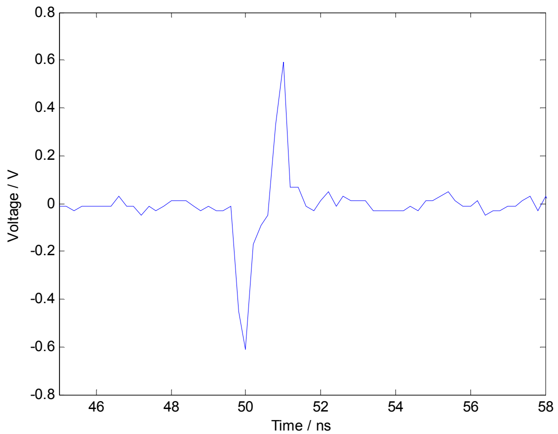
C. Clarke, Oxford U.

- Despite energy disparity, GEANT simulations suggest the charges hitting the strips are similar to those at ILC.
- Signals with the beam on the Low Z mask were different from BPM stripline signal- suggestive of secondary emission.

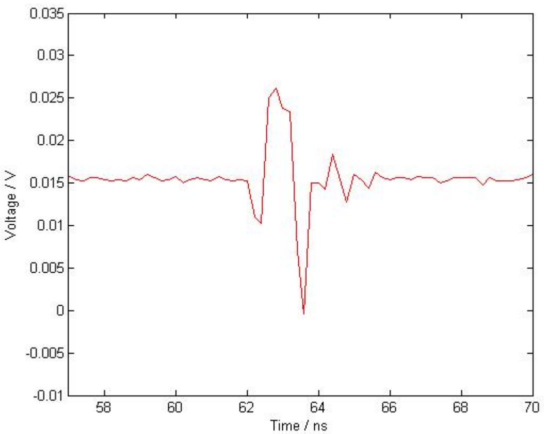


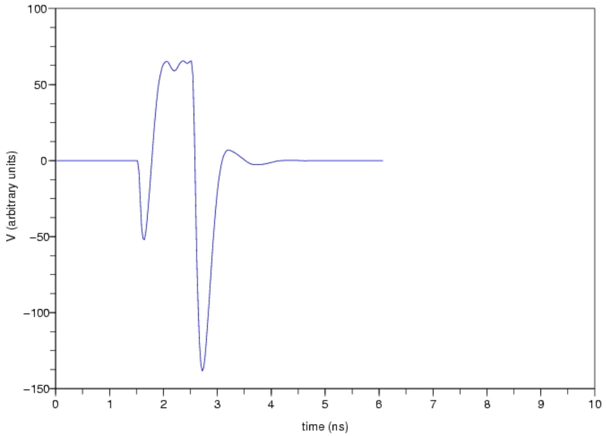
Simulation (T. Hartin)

Typical stripline signal



Real Data from ESA





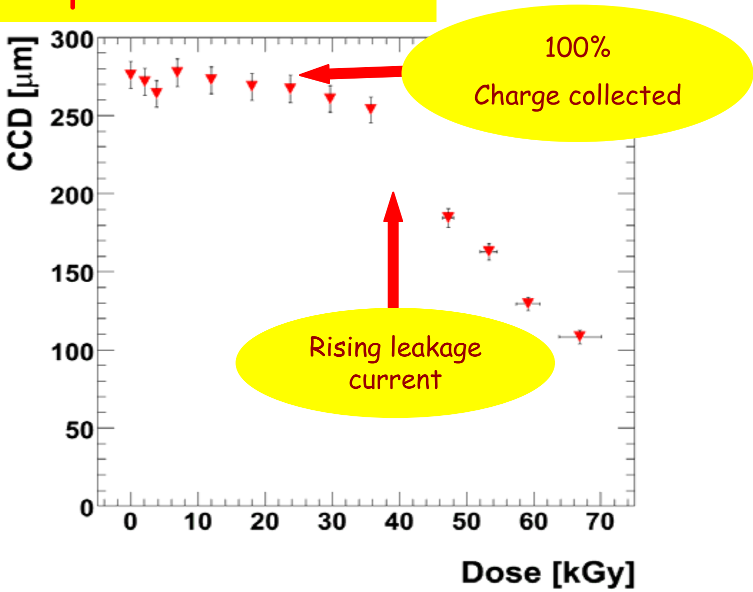
- Simulating these results in GEANT has had some success but is problematic as secondary emission is a few eV and the cutoff in GEANT is 100eV.
- The signals caused by secondary emission were not large enough to cause problems for the operation of the stripline BPM.

Very Forward Region Detectors: BeamCal, LumiCal, GamCal

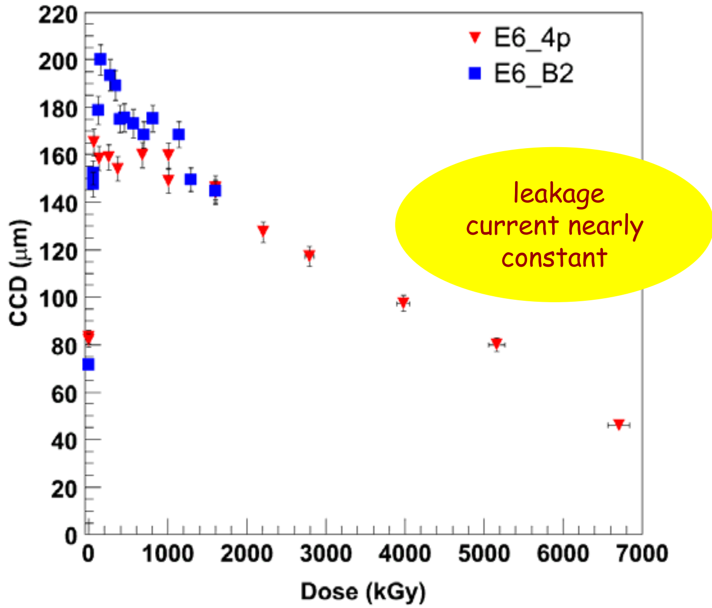
W. Lohmann, DESY

BeamCal: Radiation Damage Tests

Si pad sensor



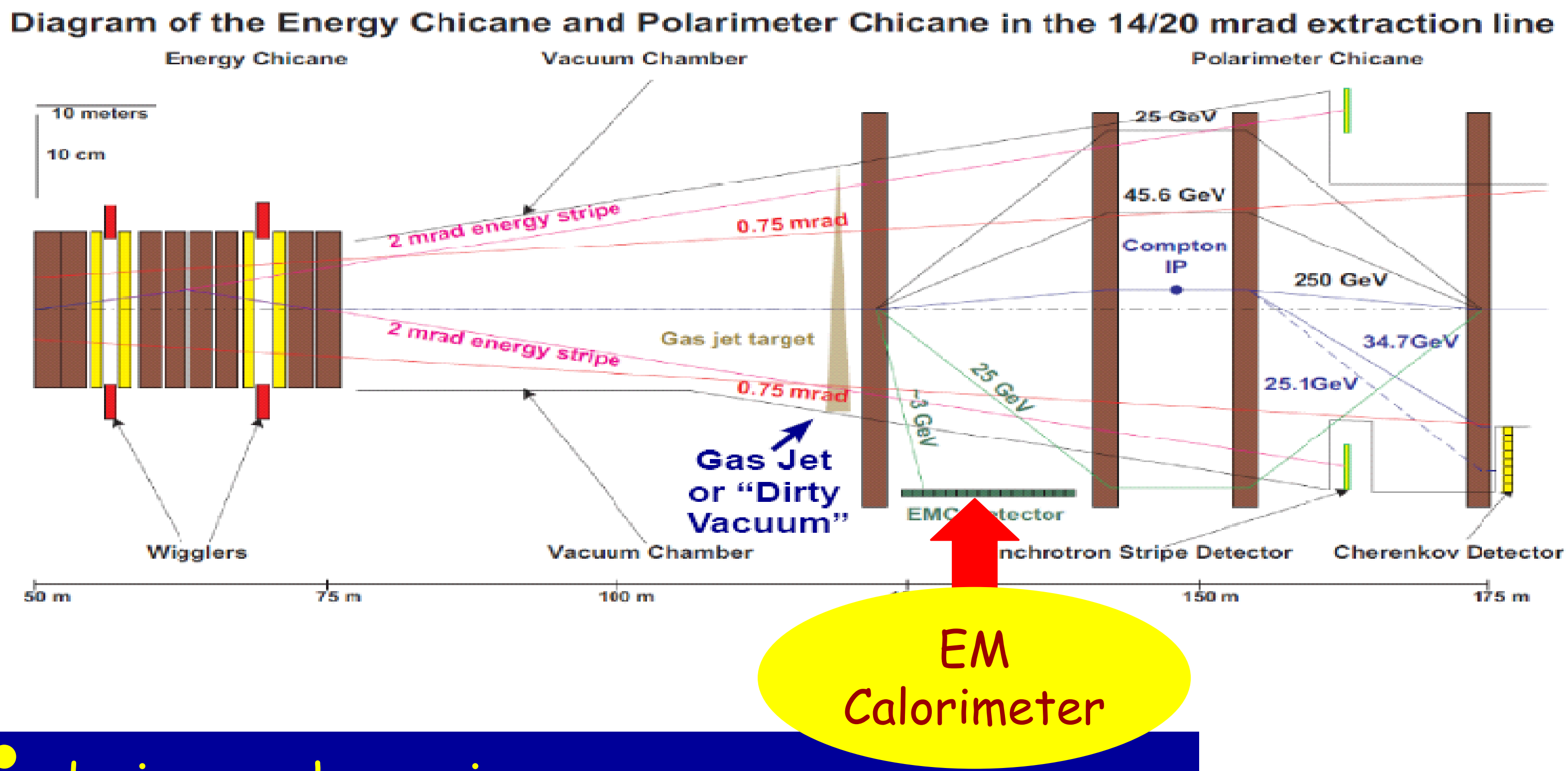
Diamond sensor



Very Forward Region Detectors: BeamCal, LumiCal, GamCal

W. Lohmann, DESY

GamCal



- design work ongoing
- prototype for beamtests planned ~2009

Vertexing, Tracking

Talks

- **Current Vertex Detector Beam Test Activities**
  (M. Battaglia, LBL)
- **Vertex Detector Future Beam Test Requirements**
  (I. Gregor, DESY)
- **Si-based Main Tracking R&D**
  (A. Savoy-Navarro, LPNHE Universite de Paris 6
  /IN2P3-CNRS
- **Gaseous Tracking R&D**
  (M. Dixit, Carleton U.)

Motivation

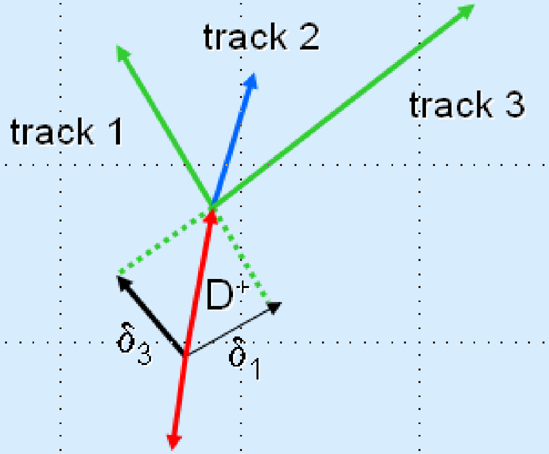
- Two out of ~10 pixel technologies need to be chosen some years before the ILC starts
- ILC vertex detector community informally agreed that any candidate ladder will need to be proven in one test beam (2010-2012)
- Many questions to answer:
  - What is needed for interim evaluation ?
  - What is needed for final sub-detector evaluation ?
  - What kind of test beam(s) are needed?
- This talk: some ideas to start discussion and detailed planning

Outline

- ❑ Vertex Detector for ILC
- ❑ Possible tests for different stages
- ❑ Bunch Structure

The Vertex Detector at the ILC

Measure impact parameter, charge for every charged tracks in jets, and vertex mass.



Need:

- Good angular coverage with many layers close to vertex:
  - $|\cos\theta| < 0.96$.
  - First measurement at r ~ 15 mm.
  - Five layers out to r ~ 60 mm.
- Efficient detector for very good impact parameter resolution
- Material ~ 0.1% X_0 per layer.
- Capable to cope with the ILC beamstrahlungs background
- Modest average power consumption < 100W
- Hit resolution better than 5 μm.

Summary

- Preparation for this talk showed that the different technologies also have different requirements at the test beam facilities
- Define a single test beam facility that can be used for all technologies
- This talk -> starting point for discussions to get an idea what is needed

- What is for sure needed:
  - **High energy beam for resolution studies (~100 GeV)**
  - **Low energy for ladder performance (~5 GeV)**

- For final decision tests: test beam with ILC bunch structure might be useful ->significant investment necessary
- High precision telescope with adequate readout speed
- Magnetic field: 4-5T split pair solenoid would an essential tool

  - ILC Detector R&D panel was asked by WWS-OC (World-Wide Study Organisation Committee) to form a task force for ILC vertexing
  - Task force will be charged to study the requirements in detail, also all infrastructure

Vertex Detector Beam Test Activity Summary Table

Beam	E (GeV)	Technology	Detector	Activity	Status
SPS X7, H2	120 GeV π	CMOS	MimosaX	Resolution,S/N, Efficiency	In Progress
SPS X7, X5	120 GeV π	CMOS	Mimosa5	Rad Hard, Backthinning	Completed
SPS H2	120 GeV π	DEPFET	CGE,HE	Telescope Setup, Res.	Completed
KEK PS	4 GeV e-	CMOS	CAP	Telescope Setup, Res.	Completed
DESY II	3-6 GeV e-	CMOS	Mimosa5	Resolution, Rad Hard.	Completed
DESY II	6 GeV e-	CMOS	MimosaX	Resolution,SN,	In Progress
DESY II	6 GeV e-	DEPFET	CGE,HE	S/N, Resolution	Completed
DESY II	6 GeV e-	DEPFET	CGE,HE	Inclined Tracks	Completed
LBNL ALS	1.5 GeV e-	CMOS	LDRD-1	S/N,Inclined Trks,Rad Hard	Completed
LBNL ALS	1.5 GeV e-	CMOS	Mimosa5	Backthinning, Inclined Trks	Completed
LBNL ALS	1.5 GeV e-	CMOS	Mimosa5	Telescope Setup, Tracking	Completed
LBNL ALS	1.9 GeV e-	CMOS	MimoStar	S/N, r/o Tests	In Progress
LBNL ALS	1.9 GeV e-	CMOS	LDRD-2	S/N, Tests, Resolution	In Progress
LBNL LOASIS	0.1-1 GeV e-	CMOS	LDRD-1	Pair Response	In Progress

Study of single point resolution limited by low momentum beams in all these facilities except CERN.

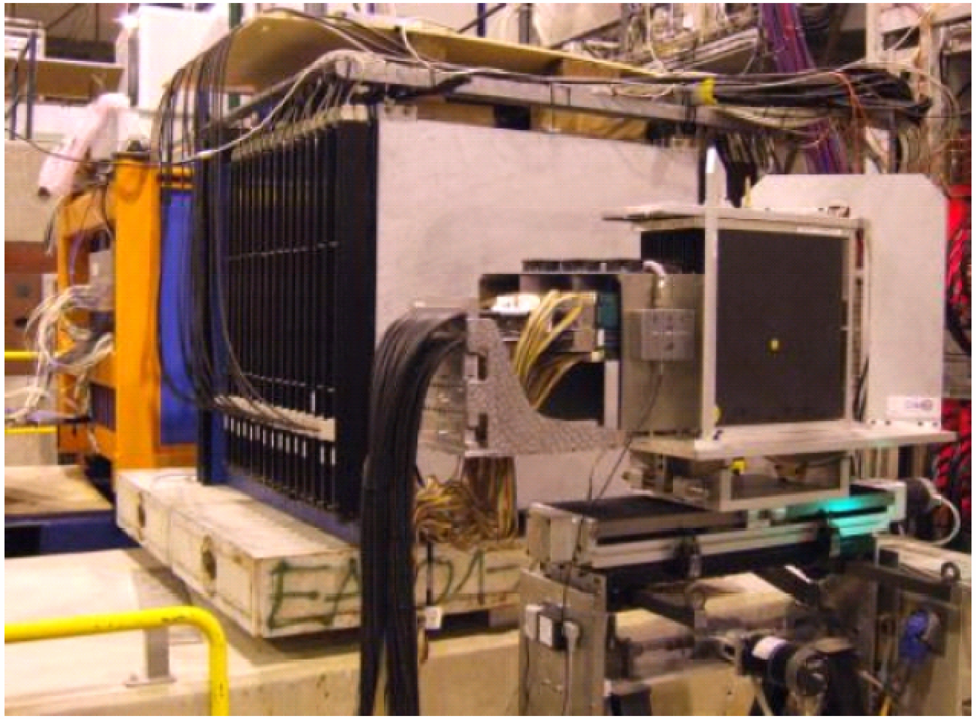
M. Battaglia, LBL

Calorimetry & Muons

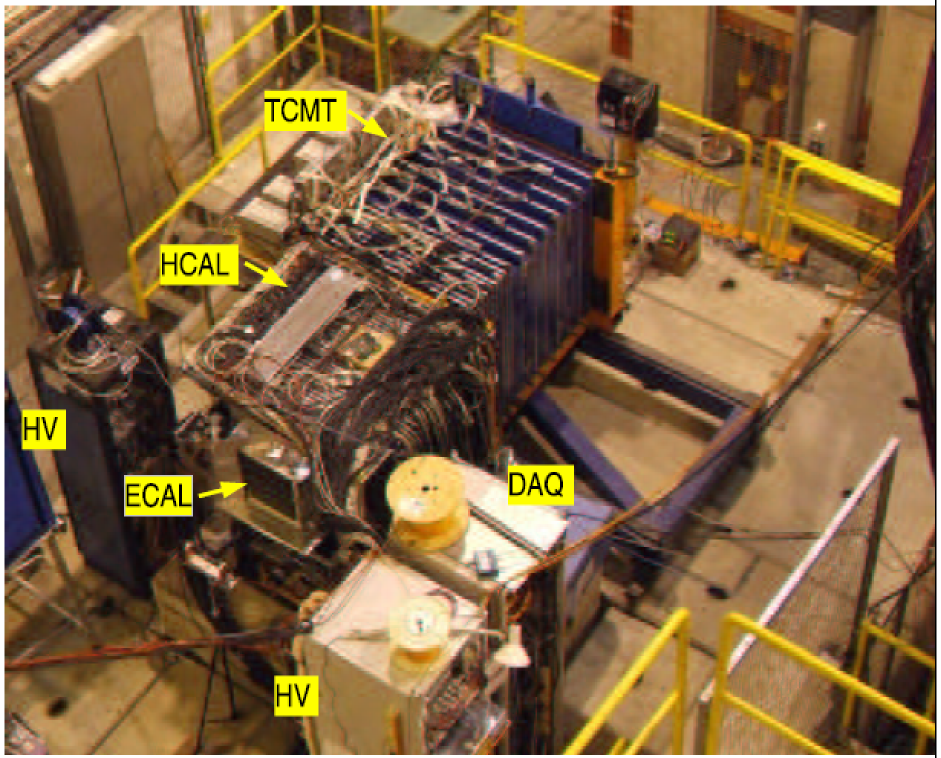
Talks

- **CALICE Test Beam Program**
  (G. Mavromanolakis, Cambridge U./FNAL)
- **Scintillator Strip Calorimeter R&D**
  (K. Kawagoe, Kobe U.)
- **CALICE Digital HCAL Options**
  (Lei Xia, Argonne)
- **ECAL with Integrated Readout**
  (R. Frey, U. of Oregon)
- **Dual Readout Calorimeter R&D**
  (J. Hauptmann, Iowa State U.)
- **ILC Muon Identification, RPC and Scintillator Detector Plane Studies** (C. Milstene, FNAL)
- **Early TCMT MTBF & CERN SiPM Results for Calorimetry & Muon Detection**
  (K. Francis, Northern Illinois U. / NICADD)

CALICE Testbeam at CERN 2006



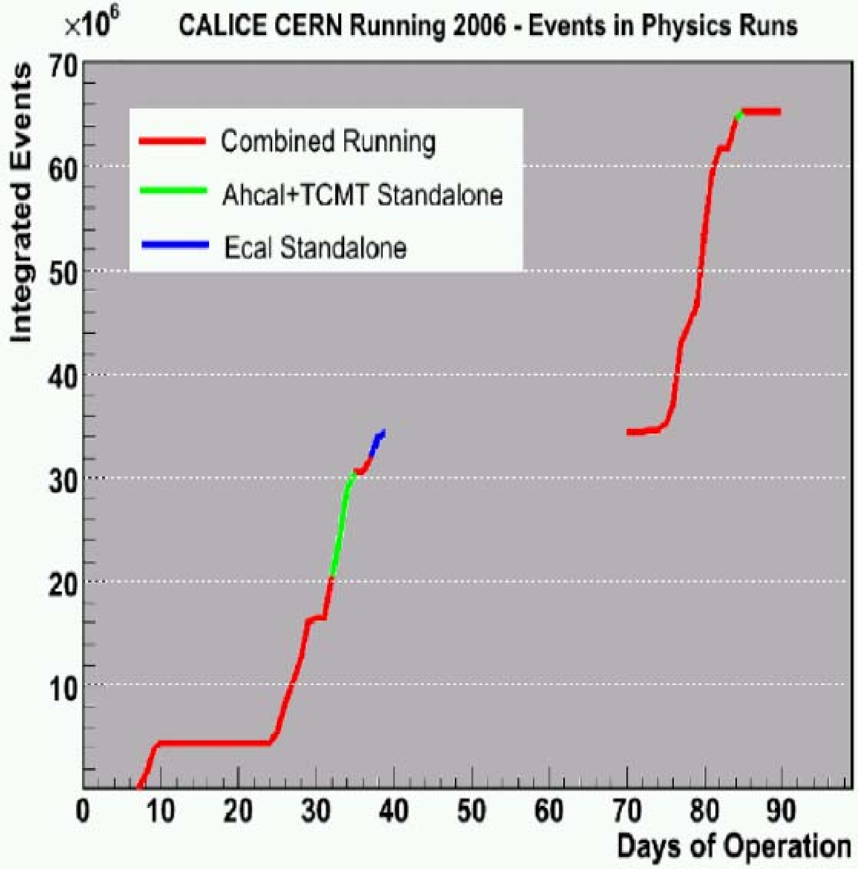
(perspective view)



(top view)

Testbeam Program at CERN 2006

- total data taking time: ~ 25 days
- people on shift: 56
- beam duty cycle: ~ 60%
- detector up time > 90%
- DAQ showed excellent performance, stable operation and continuous running without failures
  120 Hz max average rate ,
  about 500 Hz peak rate in spill



(see talk by R.Poeschl)

G.Mavromanolakis, ILC Detector Testbeam Workshop 2007, FERMILAB

→ plan to move to MTBF at Fermilab in Fall 2007

ECal with Integrated Electronics

Ray Frey, U of Oregon

Ongoing R&D Efforts:

- CALICE silicon-tungsten ECal – 2 parallel efforts:

  Technology Prototype → "Eudet Module" (integrated electronics)

  Prototype → currently in test beam (electronics external)

- MAPS ECal

  Led by a sub-group of CALICE

  More recent – needs some proof of principle work before test beams

- "U.S." silicon-tungsten ECal

  Has developed only an integrated approach from the start

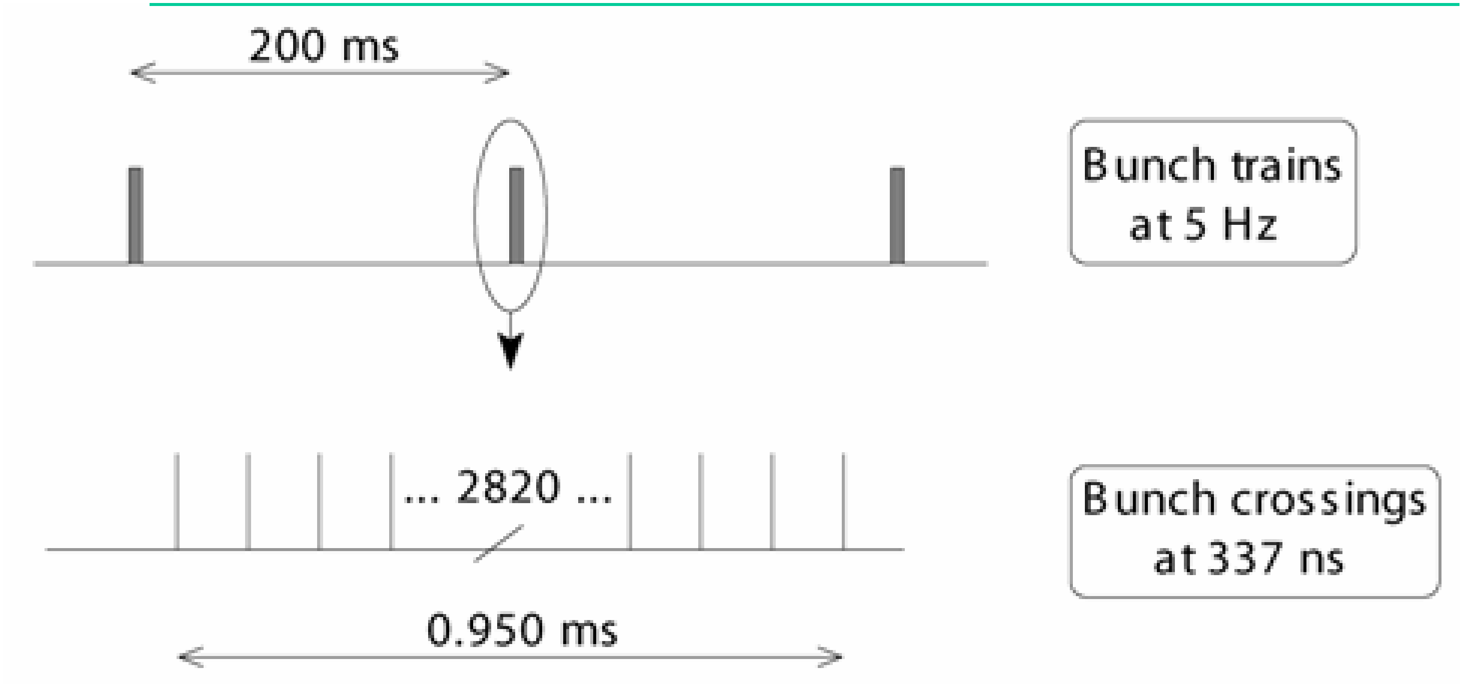
SiD Approach: The physics case implies a highly segmented "imaging calorimeter" with modest EM energy resolution → Si-W

Baseline configuration:

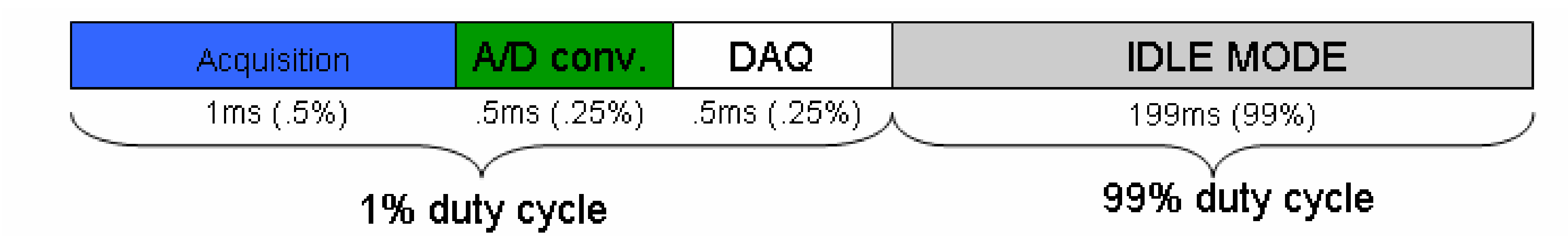
- transverse segmentation: 12 mm^2 pixels
- longitudinal: (20 x 5/7 X_0) + (10 x 10/7 X_0) ⇒ 17%/sqrt(E)
- 1 mm readout gaps ⇒ 13 mm effective Moliere radius

R. Frey

Power Pulsing

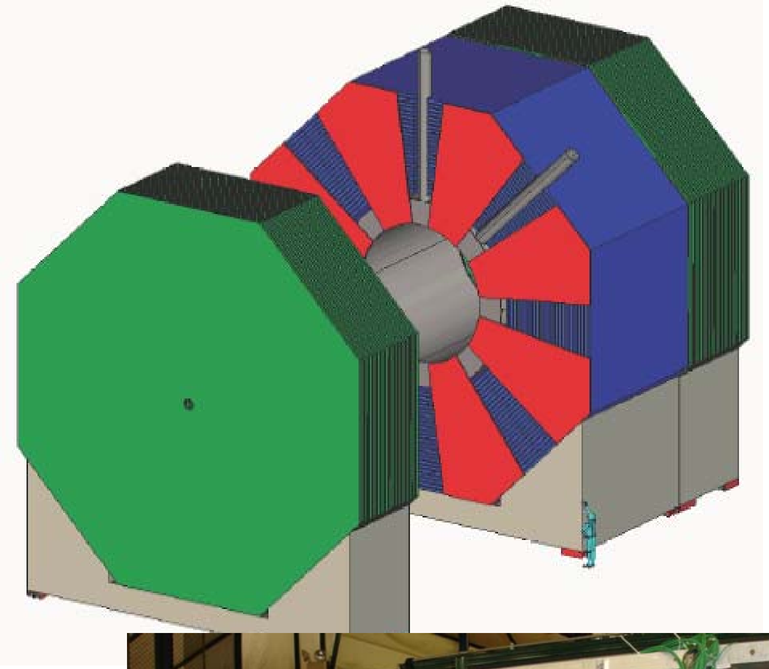


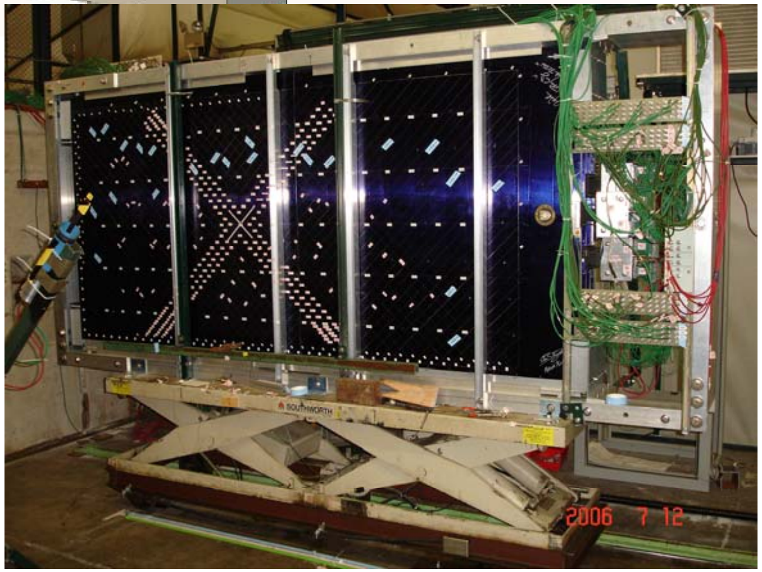
de La Taille



Proposed SiD Muon System/Tail Catcher

C. Milstene





Central Muon System

- after 6 nuclear interaction lengths of calorimeters, 5T solenoid coil and cryostat
- Installed in the Iron of the 5T solenoid flux return ~ 2.30m of Fe, ~18 int. lengths total.
- Central barrel 5.7 m long, R = 3.5 m.
- Barrel and EndCaps Muon System unit: 10 cm thick Fe; 4 cm gaps
- Total detector area ~6000 m^2 for 14 layers.

Candidate detector technologies:
RPCs and/or Strip-scintillator

Prototypes installed in Fermilab Beam Test Facility

- 256 scintillator strips
- 384 PMT channels

Future Plans

- Procure SiPMs/Multi-Channel Photon Counters;
- Bench Test at SiDet. Continue collaboration with IRST Trento (C. Piemonte) and INFN - Udine (G. Pauletta).
- R&D and beam tests of ILC muon scintillation counters with Si PMs at MTest
  - A supplementary LCRD proposal (IU, WSU, UND, UCD and NIU) has been submitted for this work.
- Test of Geiger-mode Avalanche Photo-diodes developed by A-Peak and Colorado State Univ (SBIR) with scintillator strips at MTest in a few months. (D. Warner - CSU)
- Because SiPM/MPPCs look very promising we expect to build additional prototypes with NIU style scintillator and SiPM readout. Will be tested at MTest.

Dual Readout Calorimetry, 4th Concept

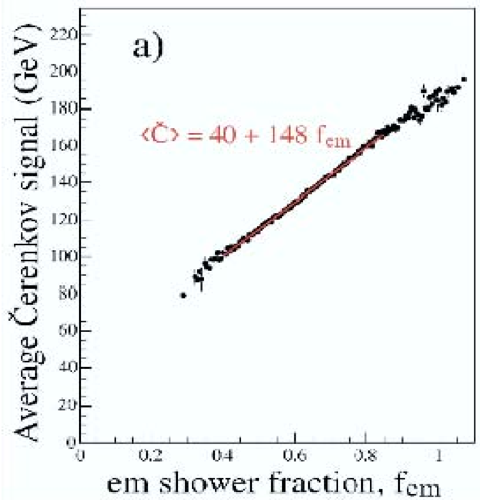
J. Hauptmann

Measure every shower twice –
in scintillation light and in Cerenkov light;
Use scintillating and quartz fibers

$$(e/h)_C = \eta_C \approx 5$$
$$(e/h)_S = \eta_S \approx 1.4$$

$$C = [f_{em} + (1 - f_{em})/\eta_C]E$$
$$S = [f_{em} + (1 - f_{em})/\eta_S]E$$

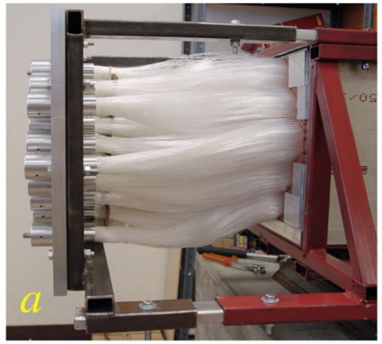
$$\rightarrow C/E = 1/\eta_C + f_{em}(1 - 1/\eta_C)$$



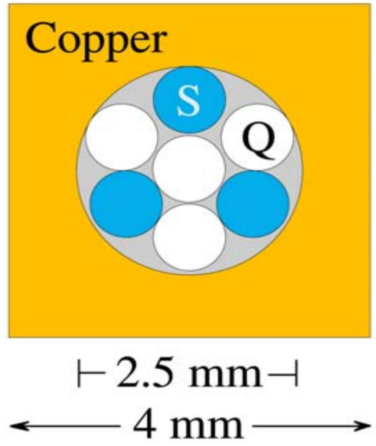
Data NIM A537 (2005) 537.

DREAM Test Module

Back end of 2-meter deep module



Physical channel structure



Software/DAQ/Simulations

Talks

- **Global Detector Network**
  (S. Karstensen, DESY)
- **Test Beam Data Handling**
  (R. Poeschl, LAL, IN2P3)
- **Hadron Shower Simulation**
  (D. Wright, SLAC)

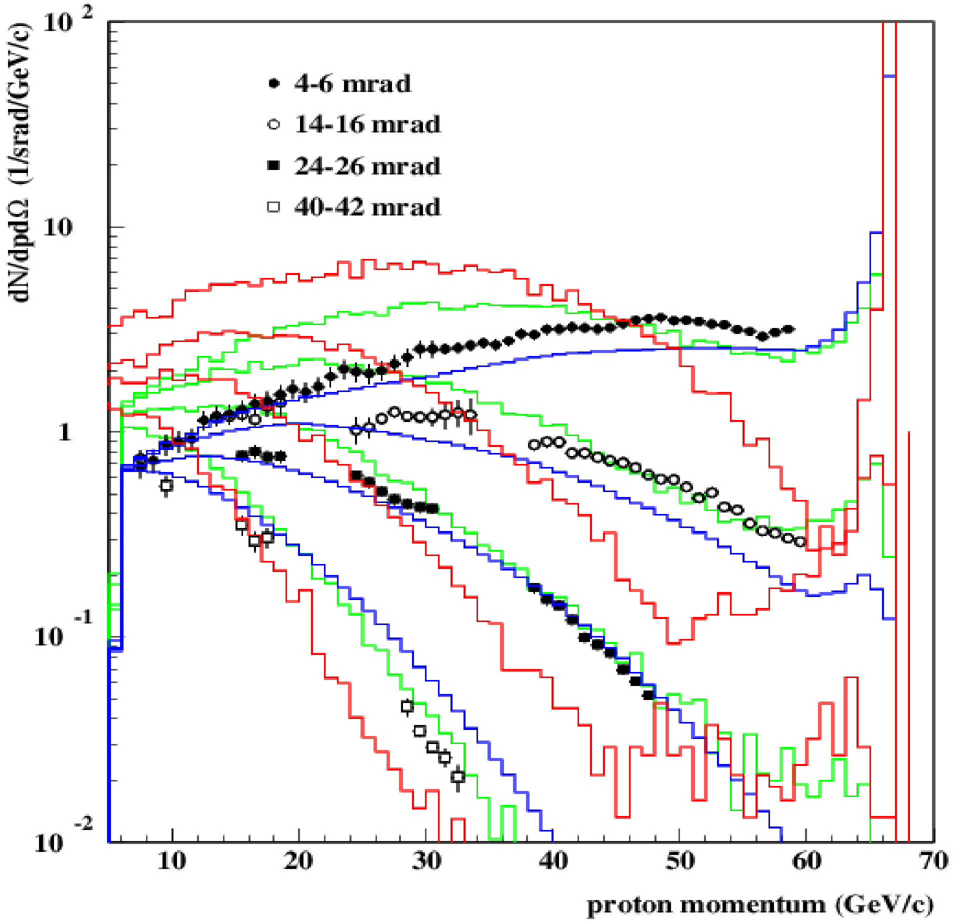
General information for various all-particle transport codes

General	MCNPX	GEANT4	FLUKA	MARS	PHITS
Version	2.5.0	8.1 p1	2005	15	2.09
Lab. Affiliation	LANL	CERN ESA IN2P3 PPARC INFN LIP KEK SLAC TRIUMF	CERN INFN	FNAL	JAEA RIST GSI Chalmers Univ.
Language	Fortran 90/C	C++	Fortran 77	Fortran 95/C	Fortran 77
Cost	Free	Free	Free	Free	Free
Release Format	Source & binary	Source & binary	Source & binary	Binary	Source & binary
Availability Conditions	RSICC Beta test team	Open web None		User's Agreement	
User Manual	470 pages	280 pages	387 pages	150 pages	176 pages
Users	~2000	~2000	~1000	~300	220
Web Site	mcnpx.lanl.gov	cern.ch/geant4	www.fluka.org	www-ap.fnal.gov/MARS	Under const.
Workshops	~7/year	~4/year	~1/year	~2/year	~1/year
Input Format	Free	C++ main Fixed geometry	Fixed or free	Free	Free
Input Cards	~120	N/A	~85	0 to 100	~100
Parallel Execution	Yes	Yes	Yes	Yes	Yes

D. Wright, SLAC

p + Al at 67 GeV/c -> p X

red: Geant4, blue: MARS, green: PHITS



Models disagree with each other and with data.

Two kinds of test beam data needed:

1. **Thin target.** Cross section measurements on thin, simple targets (HARP, MIPP?)
2. **Full setup.** Data from complete, or test beam detectors used as integration tests of all physics, but never for tuning.
   ATLAS and CMS longitudinal shower shape data available; transverse shower shape data would be very useful

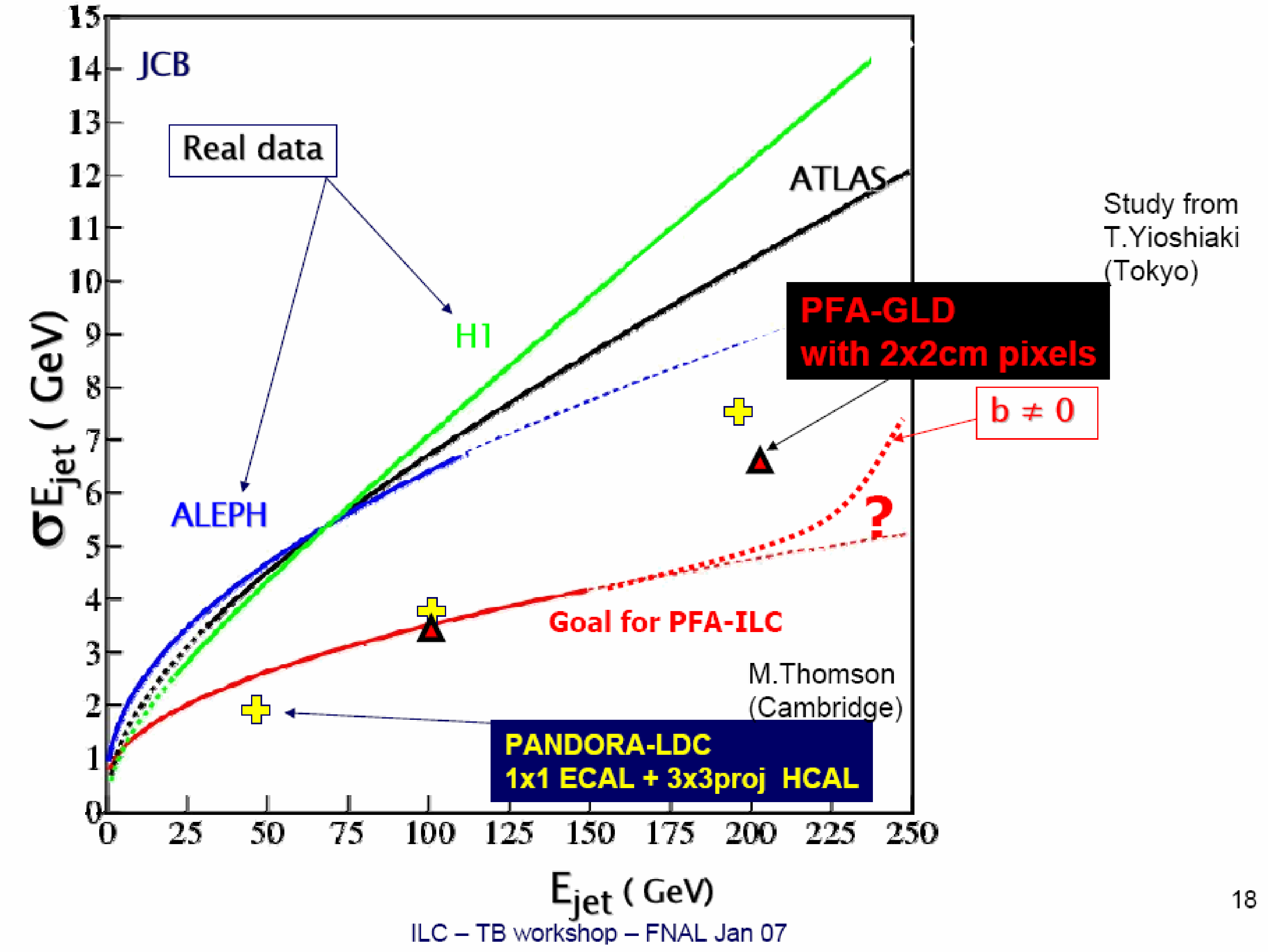
D. Wright, SLAC

Future Planning Sessions

Talks

- **Particle Flow Algorithm and Test Beam Validation, J.-C. Brient**
- **LHC Test Beam Experience,** P. Schacht
- **Thoughts on Test Beams for the ILC Detector(s),** A. Para
- **ILC Detector R&D Test Beam Roadmap,** J. Yu

J.-C. Brient, PFA Talk

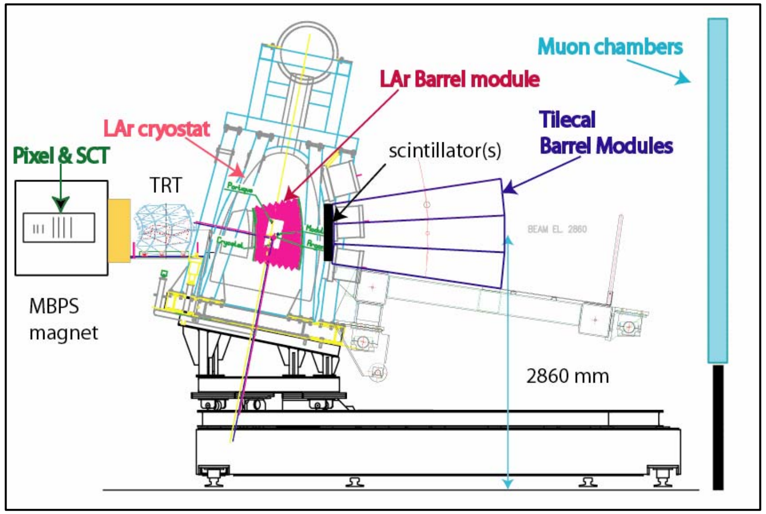


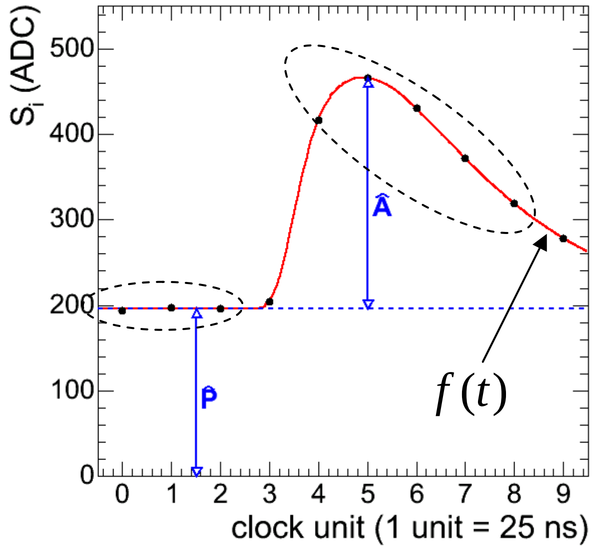
→ how sensitive is jet energy resolution to uncertainty in hadronic shower simulations? Also, can use Z and W events to calibrate.

LHC Test Beam Experience

P. Schacht

ATLAS Test Beam





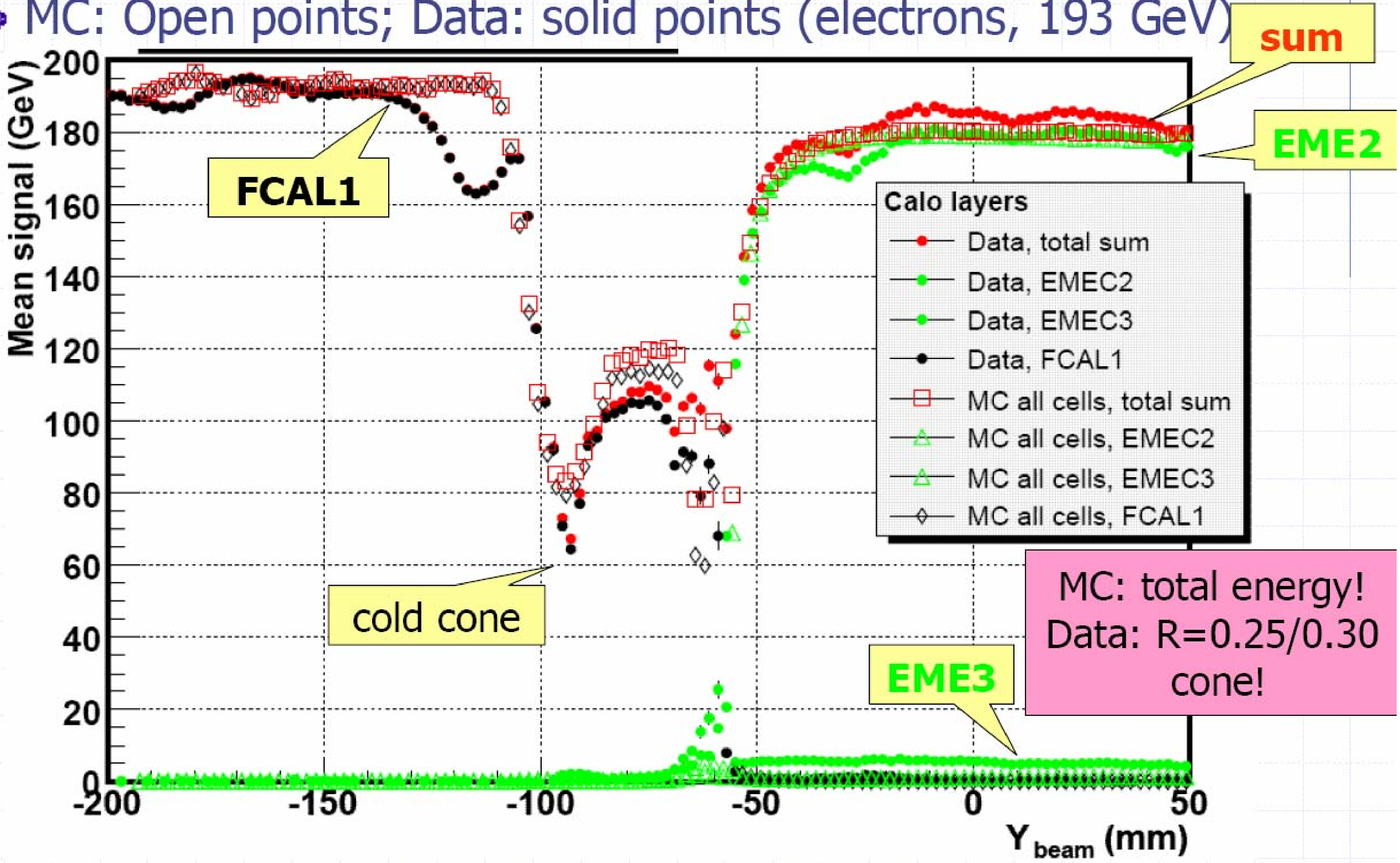
Signal Amplitude Reconstruction, e.g. CMS ECAL

Signal Amplitude Reconstruction in ATLAS

- Calibration signal injected extremely close to physics signal
- Understanding of calibration system up to the injection point is crucial!;
- Model full calibration and signal chain; Deconvolute physics shape from the calibration shape using model;
- **Crucial: have in testbeam identical electronics chain (cables, patch panels, cold electronics etc.) as in final detector!**

Test 'Transition Region', e.g. ATLAS EMEC/HEC/FCAL

- MC: Open points; Data: solid points (electrons, 193 GeV)



Thoughts on Test Beams for the ILC Detector(s)

Adam Para, Fermilab

Early History of LHC Experiments

- 1990 – LHC announced as a new CERN project (expected commissioning in 1998)
- July 1990: Detector Research and Development Committee established to initiate and manage the necessary R&D and test beam studies program.
- 50 Projects approved and funded
- Recognition of a need for 'generic' detector R&D to establish the possible solutions/technologies enabling a successful detector concept

LHC Experiments/Collaborations

- March 1992: 4 proto-collaborations (CMS, ASCOT, EAGLE, L3+1)
- June 1993: LHCC recommends that ATLAS (merger of ASCOT, EAGLE) and CMS proceed with Technical Proposals. Vast majority of the detector concepts/ technologies resulting from the generic R&D and progress in technology.
- November 1995: LHCC approves ATLAS and CMS projects
- January 1995: End of generic R&D era. Start of test beam effort focused on specific experiments, under the guidance of the LHCC.

Thoughts on Test Beams for the ILC Detector(s)

Adam Para, Fermilab

Post-Generic 'Test Beams' Studies

- 1995 – 2000: preparation of Technical Design Reports (~ 500 pages each)
  - Test beam validation/evaluation of specific pre-production prototypes

- 2000-2007: Calibration, understanding, commissioning of 'final' detectors. (ex. CMS request: 64-66 weeks of test beams/year, 5 different beam lines)
  - ~ 10 test beams at CERN, more then 50% dedicated to LHC experiments (including LHCb, ALICE, TOTEM)
  - Dedicated areas/floor space (large, not moveable infrastructure)

- 1995: recognition of a need for 40 MHz time structure. Possible, but requiring significant modifications to the accelerator complex. 80 MHz RF cavities built in collaboration with TRIUMF, test beam operational in May 2000.

Thoughts on Test Beams for the ILC Detector(s)

Adam Para, Fermilab

Challenges of ILC Detector R&D

- Precision measurements, little room for imperfections and/or inefficiencies. Trade-offs between detector performance and (costly) machine operation.
- Principal differences between ILC experiments and LHC (LEP) experiments:
  - High resolution jet energy measurement (W/Z separation a benchmark)
  - High precision ('massless') vertex detector (efficient b/c tagging)
  - Machine-detector interface (forward calorimetry, luminosity, backgrounds)

Concluding Remarks

- Intensive detector R&D and test beam studies necessary to ensure successful design and construction of ILC detector(s).
- Pressure on existing test beam infrastructure is relatively low due
- Specific needs of the test beam infrastructure for the ILC experiment(s) are not very well known at this moment; will emerge soon, especially once final collaborations are formed.
- Availability of CERN test beams is a significant unknown. If used mostly to support LHC experiments, then a major test beam infrastructure must be constructed 'somewhere'.

ILC Detector R&D Roadmap Document

J. Yu, U. Texas

Introduction

- Physics Needs
- Time scale considered in the document

Facilities

- Summarize the current capabilities and plans

Detector R&D ➔ Organized by detector types

- Current activities
- Requirements
- Plans

Summary of requests to facilities

First draft by LCWS 2007 at DESY (01-jun-07)
Final draft July 1, 2007

Deliver document to facility managers and ILC leadership on July xx, 2007

(some personal) **Summary/Conclusions**

LHC experience indicates there will be a very large and growing demand for ILC Detector Test Beams

Excellent test beam facilities are required in all 3 regions

Major HEP facilities need to provide test beams. CERN shows great leadership in this. Fermilab is making significant investments in its facilities.

Test Beams are an integral part of Detector R&D, from prototypes to integration tests of final systems.

ILC Detector challenges include:

- excellent jet separation, reconstruction and energy resolution
- very thin vertex detectors
- also, many MDI aspects:
  - rad hard sensors for BeamCal, and precise forward region detectors
  - collimation and backgrounds
  - precise energy spectrometers
  - attention to developing EMI standards

Excellent planning and review for test beam programs is essential