Test beam

Felix Sefkow

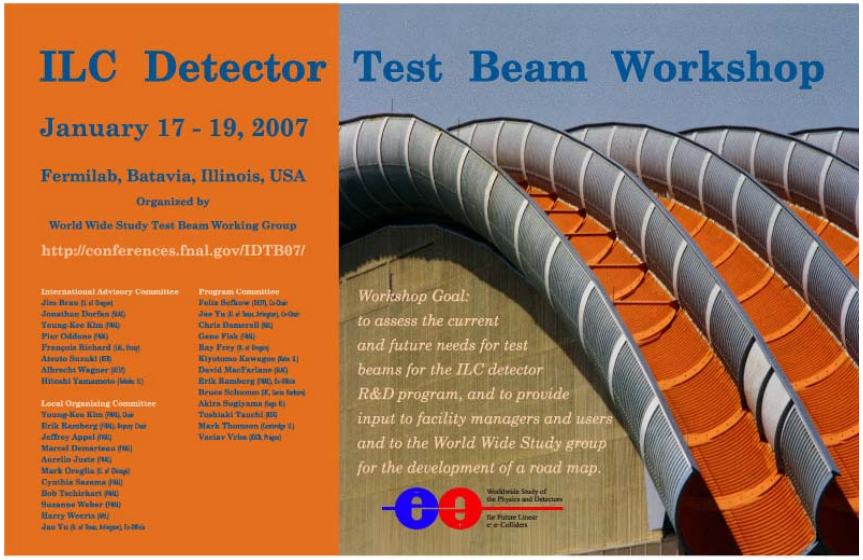
LCWS07, Hamburg, June, 2007

This talk

- The test beam workshop at FNAL and the roadmap document
- News from facilities
- Topical issues in test beam requirements for detector R&D

ILC test beam workshop at FNAL

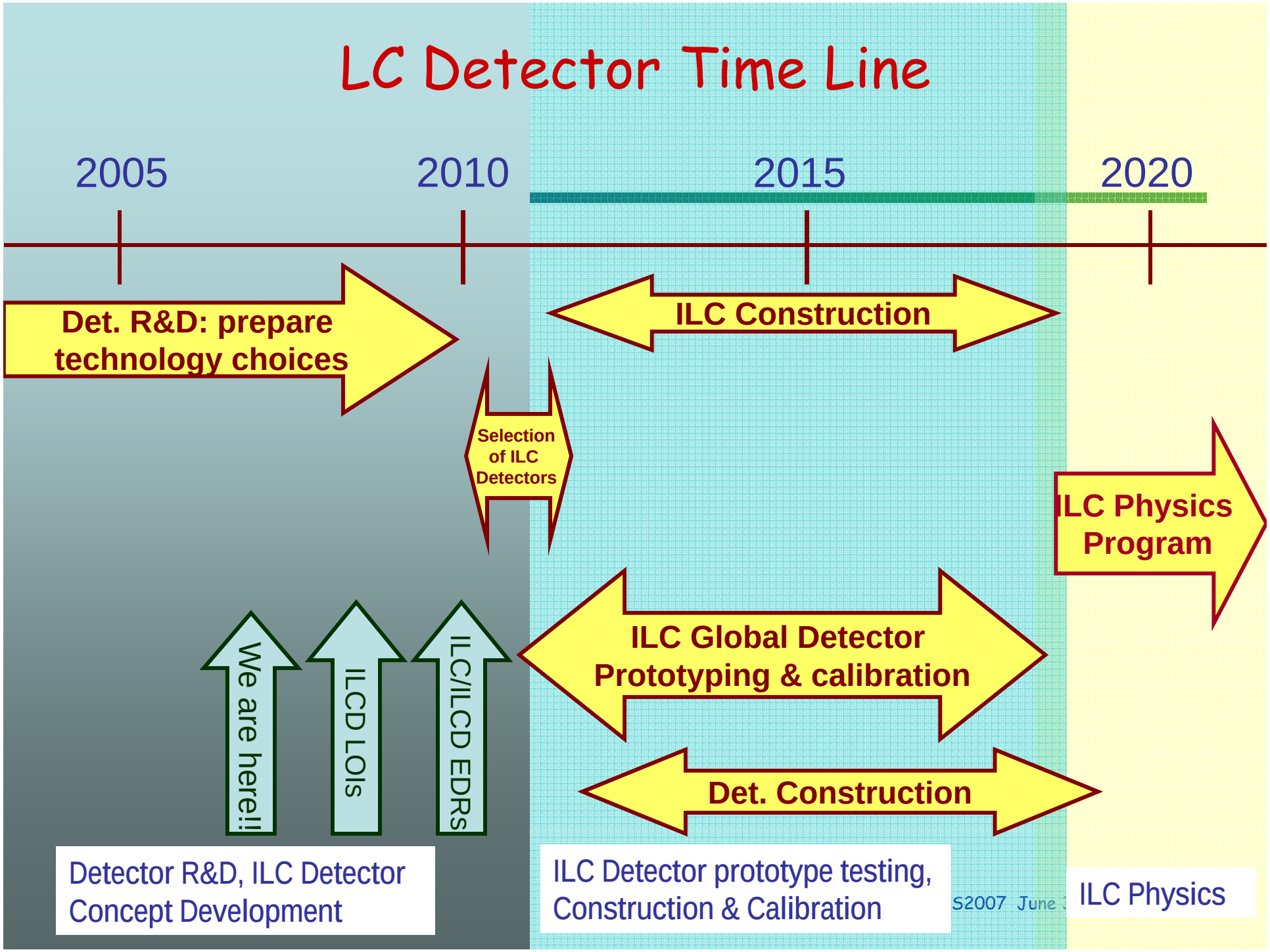
- Good overview on facilities and plans from detector groups
  - Roadmap document in summer
- Warm welcome from FNAL management
- Significant participation of FNAL physicists
- Good representation from all regions
  - 120 participants
  - Still some visa problems…



Find slides at https://conferences.fnal.gov/idtb07/

Summaries

- Workshop programme:
  - Facilities
  - Detector R&D needs
  - Future and conceptual issues:
    - Common software, hadron shower simulations, lessons from LHC, relation between test beam and detector optimization
- At the workshop:
  - Facilities worldwide – by M. Demarteau
  - Roadmap overview – by J. Yu
  - Detector R&D and test beam review – colloquium by D. Karlen
- At LCWS: update of summaries (K.Kawagoe)
- This talk: not a summary of summaries


LC Detector Time Line
2005
2010
2015
2020
Det. R&D: prepare technology choices
ILC Construction
Selection of ILC Detectors
ILC Physics Program
ILC Global Detector Prototyping & calibration
We are here!!
ILCD LOIs
ILC/ILCD EDRs
Det. Construction
Detector R&D, ILC Detector Concept Development
ILC Detector prototype testing, Construction & Calibration
S2007 June
ILC Physics

Test beam parameters

Laboratory	Beam energy	# Beamlines	Δp/p	Rep. Rate (Hz)	Beam instruments
CERN PS	1 - 15 GeV	4			Cherenkov, TOF, MWPC
CERN SPS	10 - 400 GeV	4			Cherenkov, TOF, MWPC
DESY	e^- / 6 GeV	3	1% ?	12.5	Pixels (T24 is being dedicated to EUDET)
Fermilab	1 - 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			Cherenkov, 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	

From roadmap document

Test beam availability

Laboratory	Energy Range (GeV)	Particles	Availability and plans
CERN PS	1 - 15	e, h, μ	LHC absolute priority after 11/07
CERN SPS	10 - 400	e, h, μ	LHC absolute priority after 11/07
DESY	1 - 6	e	> 3 months per year
FNAL MTBF	1 - 120	e, π, h, μ	Continuous at 5% duty factor, except for summer shutdown
Frascati	0.25 – 0.75	e	6 months per year
IHEP Beijing	1.1 - 1.5 (primary) 0.4 - 1.2 (secondary)	e e, π, p	Continuous in March 2008 and later
IHEP Protvino	1 - 45	e, h, p, μ	Two one-month periods per year
J-PARC	Up to 3GeV	????	Available in 2009 earliest
KEK Fuji	0.5 - 3.4 GeV	e	Available fall 2007, for 8 months/year as long as KEKB operates
LBNL	1.5; < 0.06; < 0.03	e; p; n	Continuous
SLAC	28.5 (primary) 1.0 - 20 (secondary)	e e, π, p	Shutdown in 2008 – 2009, with uncertain plans beyond

From roadmap document

Facilities overview

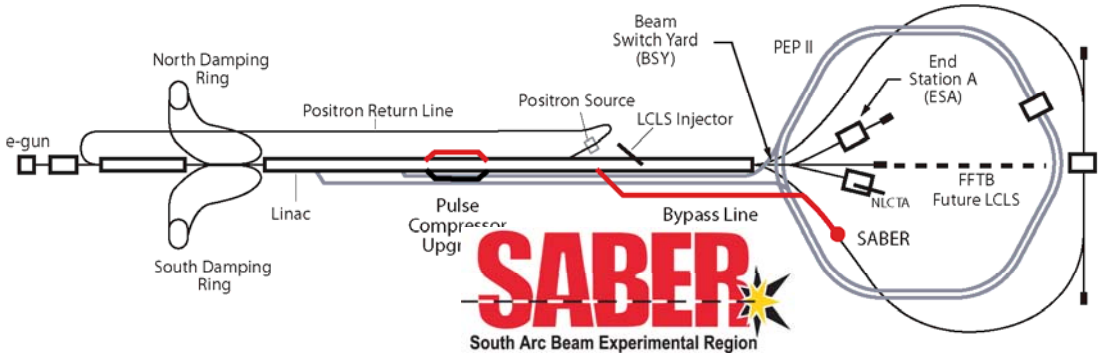
- Six low energy (<10GeV), electron facilities available at various time periods
- One med energy (<28GeV) electron facility available up to 2008 (SLAC ESA), but uncertain beyond 2008
- Two med to low E (<45GeV) hadron facilities available
  - ITEP-Protvino is available 2 months/year
  - CERN PS will be somewhat affected by the LHC start-up, but essentially continue to run
- Two high E hadron facilities available
  - CERN SPS: same as PS
  - Impressive upgrades in Fermilab MTBF for ILC detector R&D needs

SLAC

- Backbone of MDI R&D so far, active programme
- Good news: continue 2008
- Bad news: uncertain beyond (LCLS)
  - Study group set up
  - Need bypass to serve SABER independently
  - Make your voice heard!

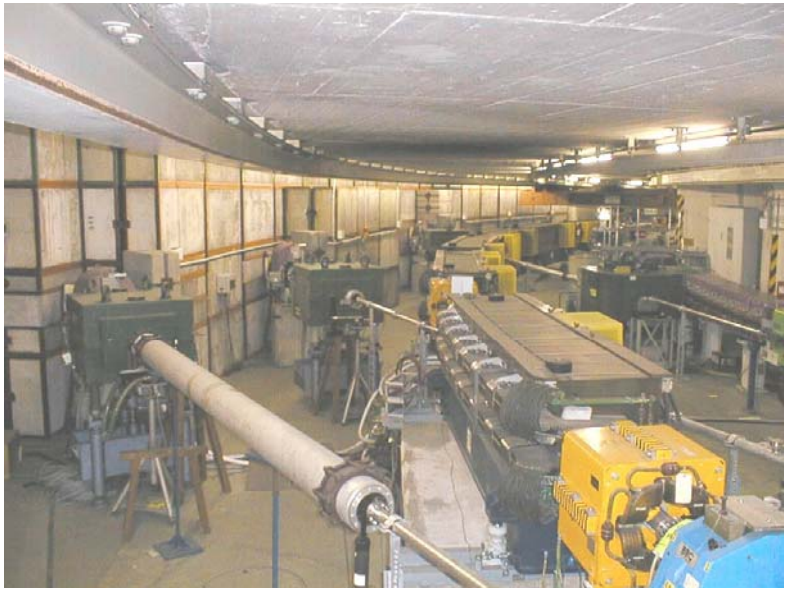
Parameter	SLAC ESA	ILC-500
Repetition Rate	10 Hz	5 Hz
Energy	28.5 GeV	250 GeV
Bunch Charge	2.0×10^{10}	2.0×10^{10}
Bunch Length	300-500 μm	300 μm
Energy Spread	0.2%	0.1%
Bunches per train	1 (2*)	2820
Microbunch spacing	- (20-400ns*)	337 ns

C.Hast, M.Woods



DESY

- Several month shutdown in 2008
- Then will mainly serve PETRA III (top-up mode)
- New orbit bumps needed to preserve test beam intensity
  - in preparation
- EUDET magnet installed for tracking R&D

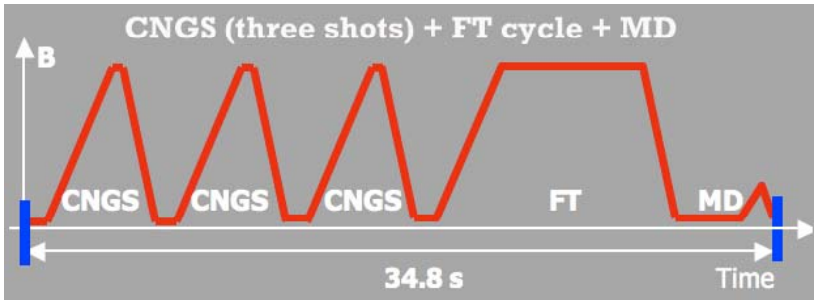


CERN

- Fixed target experiments are integral part of the CERN physics programme
- The SLHC detector upgrade effort is taking shape
- ➔ SPS (and PS) must and will serve the test beam areas also in the LHC era
- Provisions made and tested to serve all needs in single accelerator "super-cycles"
  - LHC set-up, CNGS (neutrinos), fixed target and test beam
  - Reduced duty factor (29 -> 14/24 %), but continuous
- LHC single user only during filling
  - "Crystal ball" expectation: test beams served >80% of the time
  - LHC commissioning has absolute priority

C.Rembser

example



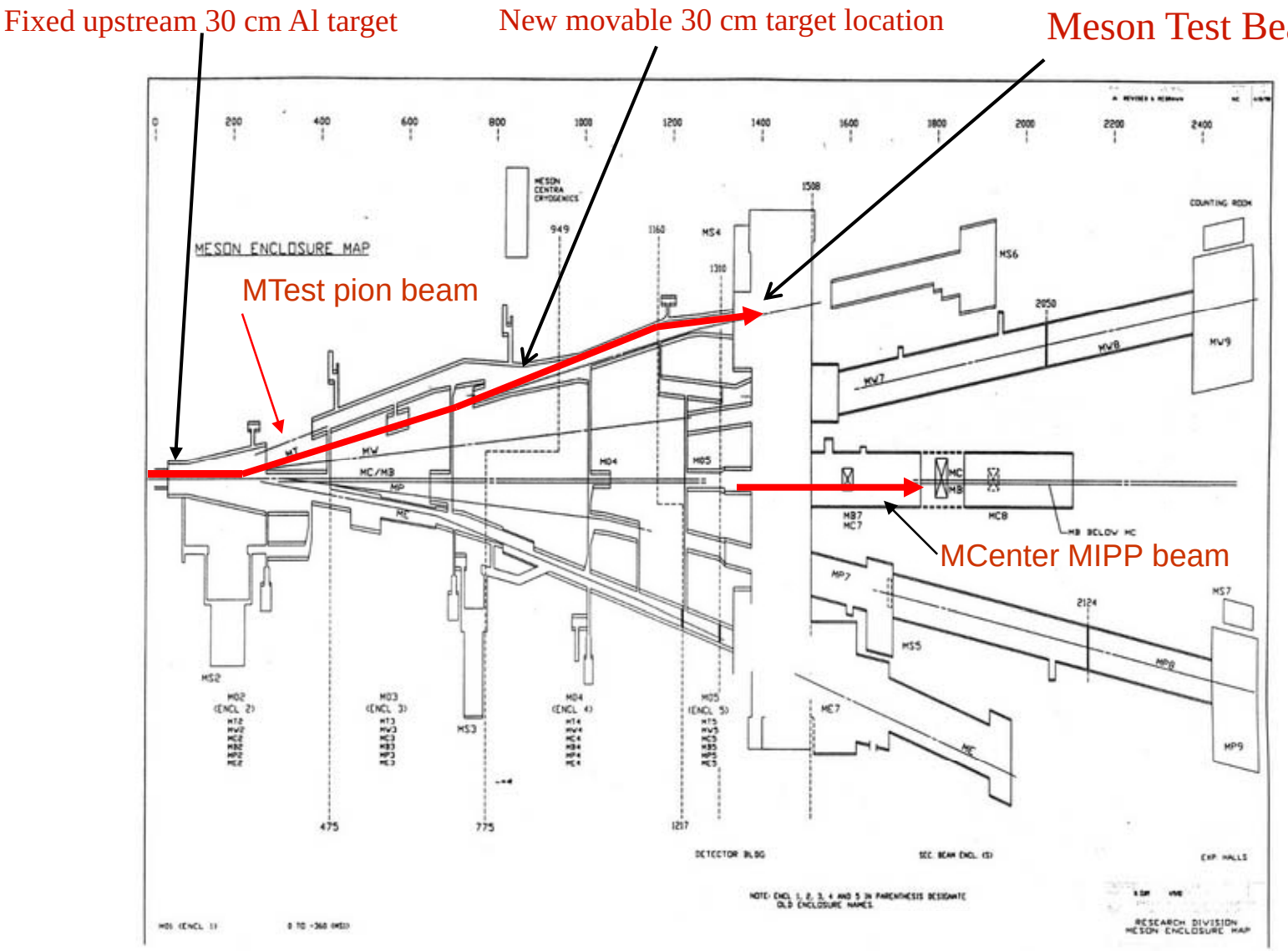
FNAL

- Upgraded beam line
  - Improved rates at low energies
- Upgraded instrumentation
- Flexibility in spill structure
- Further extension of possibilities under discussion
  - Tagged neutrals
  - ILC-like spill structure
  - Magnet
- Message from the management (M.Demarteau)
  - We are open to suggestions, but: Be aware that for infrastructure investments there are **lead times** !

MTest Beam Layout and Modes

Eric Ramberg

Meson Test Beam 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 new downstream target

Upstream target will be installed on a motion platform to improve rates x10

Some measured rates in the MTBF beamline

Tune (GeV)	Rate in MT6/spill*	e^- fraction	Resolution
120	800,000	0	-
66**	90,000	0	-
33	40,000	0.7 %	1.0 %
16	14,000	10 %	1.2 %
8	5,000	30 %	-
4	500	60 %	2.4 %
16***	72,000	20 %	5 %
8	44,000	30 %	5 %
4	27,000	80 %	5 %
2	7,000	>90 %	5 %
1	7,000	>90 %	10 %

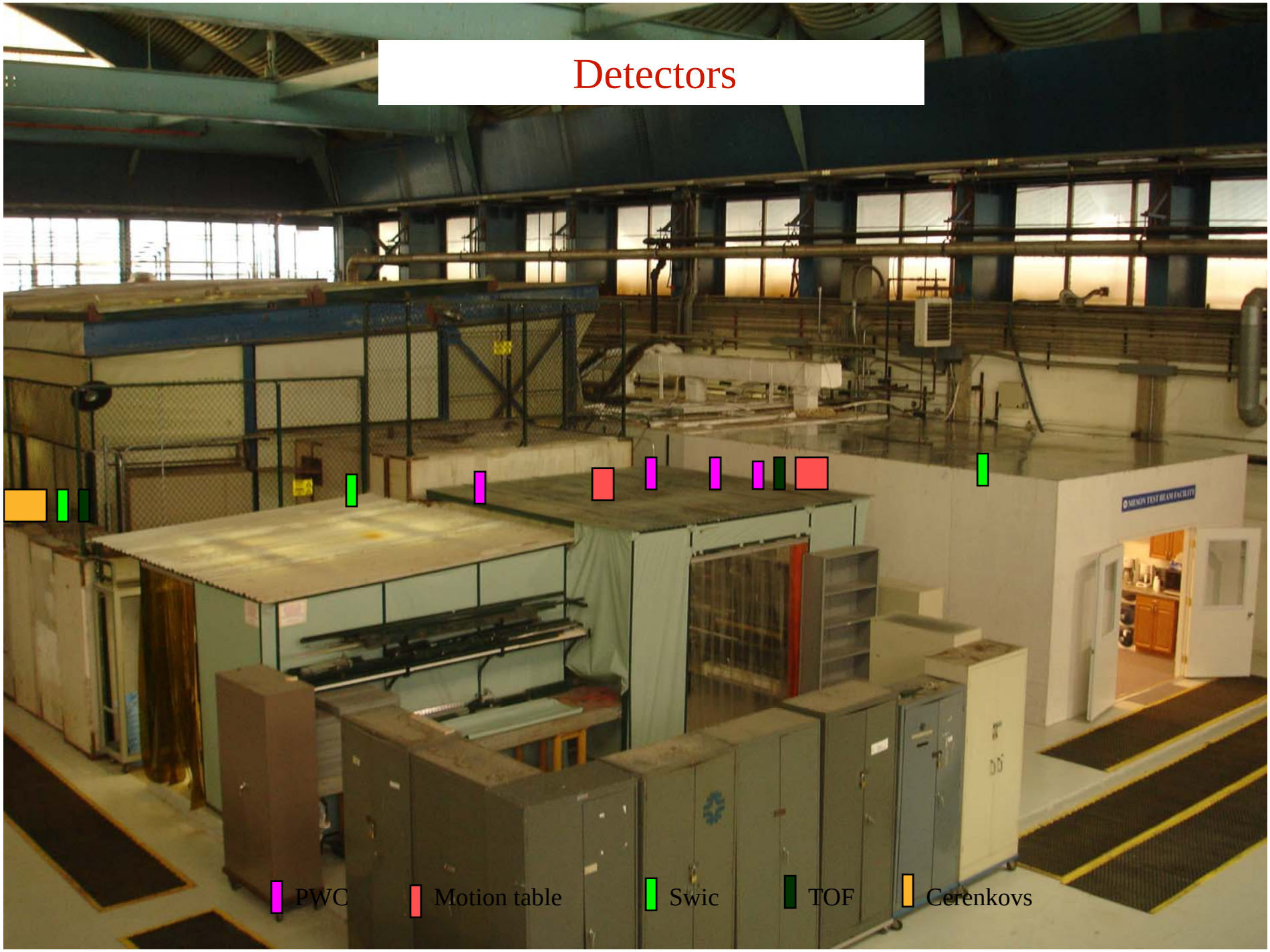
Pion prediction 1%

*(Rates are normalized to 2.4E12 protons in Main Injector)

**(Rates in green are for pion mode)

***(Rates in red are for low energy pion mode. These rates can improve x10 with upstream target removal.)

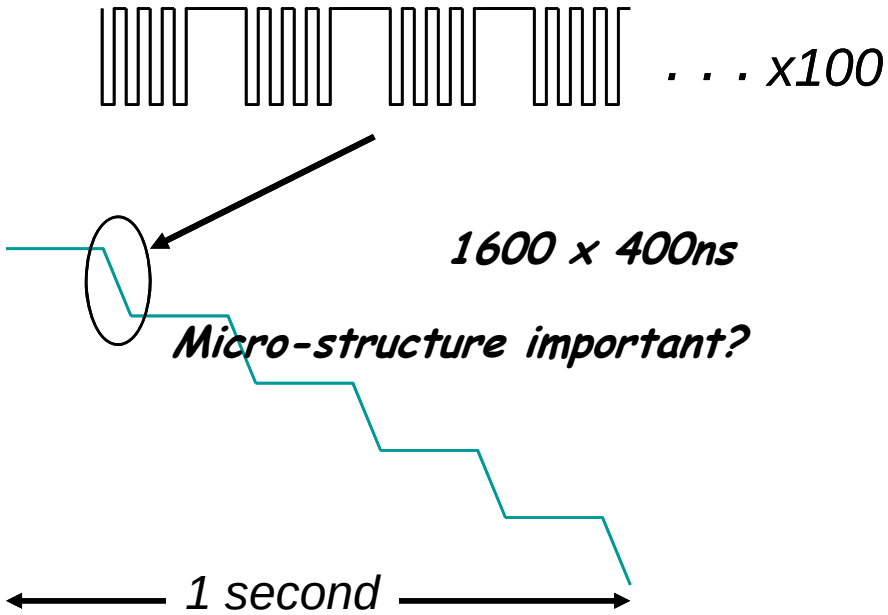
Detectors



Can Fermilab Test Beam simulate ILC structure?

Possible path to ILC beam structure:

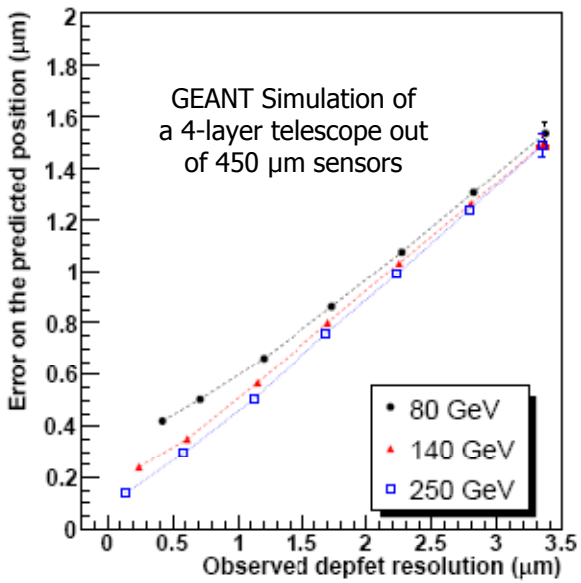
- Fill Main Injector with 4 Booster batches, with 19 nsec RF structure.
- Turn on already existing 2.5 MHz coalescing cavities. This results in a 400 nsec particle bunch spacing, with gap after 4 buckets.
- Implement a shorter - 1msec? - partial extraction cycle ('ping') using current quadrupole resonance magnet.
- Fit 5 of these pings in a 1 second spill



It is important for the ILC detector community to formulate the specific spill structure parameters they require for their tests. Stricter requirements make the job more difficult. If given a specific, realistic goal,then the Fermilab Accelerator Division has agreed to look into this possibility

Vertex detector R&D needs

- We would need both, a high energy hadron beam (~100 GeV) for position resolution testing and a low energy beam for the low momentum tracking.
- The beam spot should be adjustable from ~mm2 to ~cm2
- For all candidate technology we would like to have "ILC-like" spills (1ms beam at 200ms intervals) to see the effects on the read out when particles arrive and to allow a read out during a "quite" phase.



Ladislav Andricek

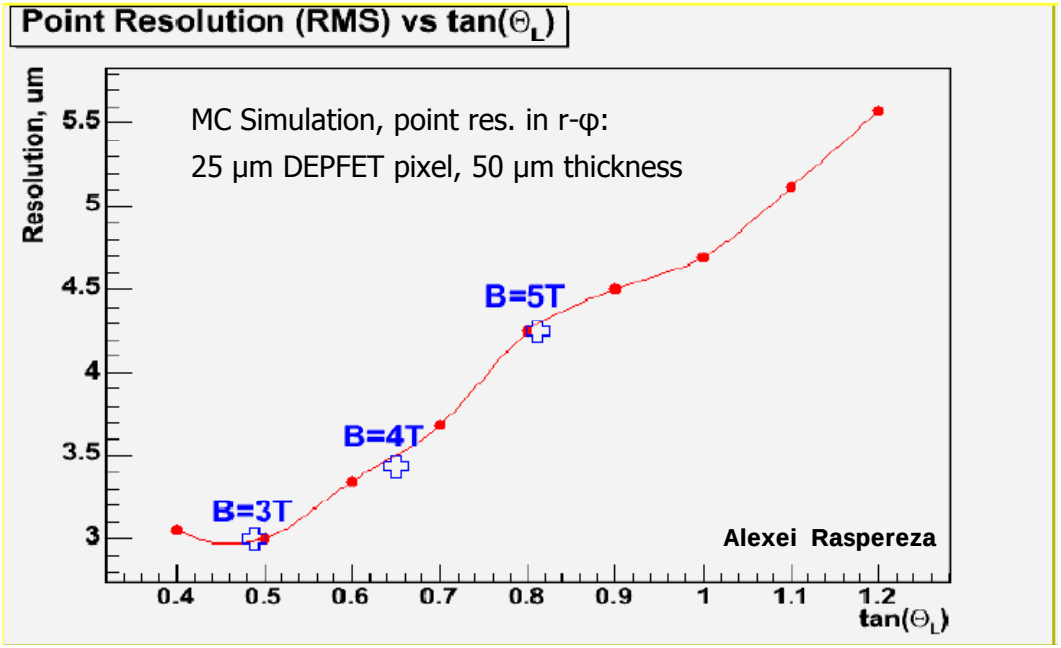
What do we want to test? → **Magnet**

At the level of single ladders:

-: Single point resolution in various magnetic fields (Lorentz angle effects)
-: Robustness against power pulsing in magnetic field (mechanical forces)

With multiple layers:

-: combined tracking in magnetic field
-: mechanical stability in the field



What does it mean for the magnet?

-: Adjustable magnetic field from (3 to 5 T)
-: Large enough to accommodate a multi-layer assembly, small enough to be rotatable

Ladislav Andricek

A possible solution…

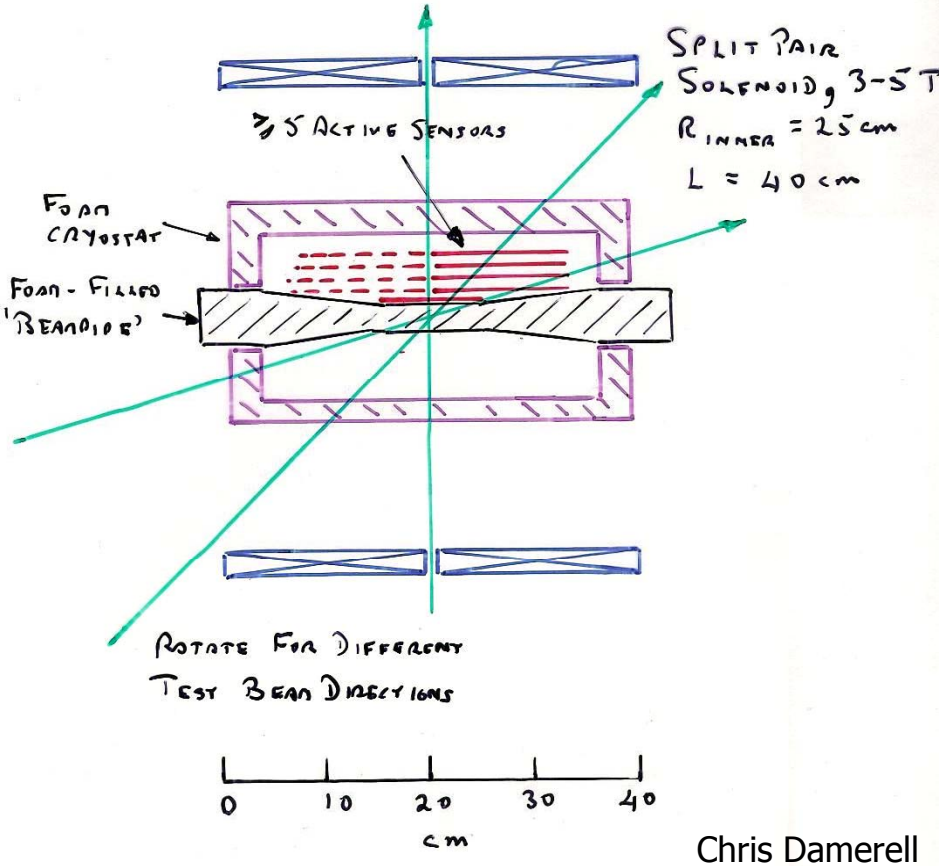
proposed by Chris:

<u>Split pair super-conducting solenoid</u>,

-: large enough to accommodate the whole CCD Kryostat
(and for all the other technologies of course)

-: B-Field 3-5T, R_{inner}=25cm, L=40cm

-: rotatable for different incident angles of the beam

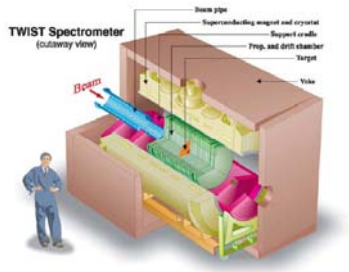


Chris Damerell

Ladislav Andricek

Tracking R&D

- Up to now:
  - Small high field magnet & cosmics
    - E.g study of charge trasnport and ExB effects in GEMs
  - and large low field magnet with beam
    - E.g study field cage distortions and large endplates
    - Compensate larger diffusion with higher statistics
- To move closer to ILC reality: possible large SC magnets
  - Triumf (Twist) Magnet (Madhu Dixit)
    - 2 T, 1m φ, 2.2m length
  - Available beginning 2008
  - KeK (Amy) Magnet (Takeshi Matsuda)
    - 3 T, 2.4m φ, 1.6m length
    - Available now (in principle)



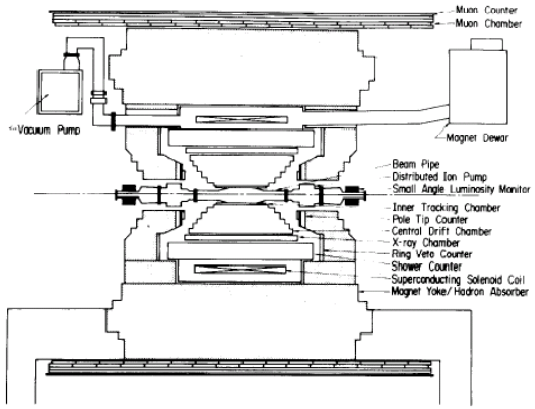


Fig. 1. A cross-sectional view of the AMY detector.

Ron Rettles

Magnet

- Vertex and main tracker
  - Have some needs in common
  - will eventually need to be tested together

  - Are asked to get together and prioritize their requirements
    - From the absolute essentials to the nice-to-haves
  - Specify: size, filed strength, support structure, ability to rotate

  - Now

  - Use the roadmap document!

Calorimeter needs

- Wide energy range: 1-100 GeV
- Wide range of particle types: e, μ, π, p (K, n)
- Large statistics
  - For reasons above
  - To study tails
- Eventually: ILC-like beam structure

Observations from recent efforts

- Competition with LHC groups
- Next: competition with SLHC groups
- Competition with Silicon vertexing groups
  - From (S)LHC
  - From ILC (!)
  - They need higher energies (> 100 GeV) (!)
  - We need (high and) also lower energies (PFLOW)
- Do not forget the need of smaller facilities for commissioning an hardware testing
  - Should not interfere with "physics runs"

Future plans

- CALICE:
  - CERN 2007:
    - SiW ECAL + ScFe HCAL+TCMT complete, angle scans
  - FNAL 2008:
    - extend to lower momenta (1 GeV), p-ID
    - All scintillator run: ScW ECAL + ScFe HCAL+TCMT
    - SiW ECAL + RPC-Fe HCAL
  - FNAL 2009:
    - Exchange (some) RPCs against GEMs
    - Exchange Fe against Pb (with Scint)
    - Scint with time-resolved electronics
  - To be scheduled
    - SiD ECAL with CALICE HCALs
- DREAM
  - To be scheduled

3 months each

Tagged neutrals

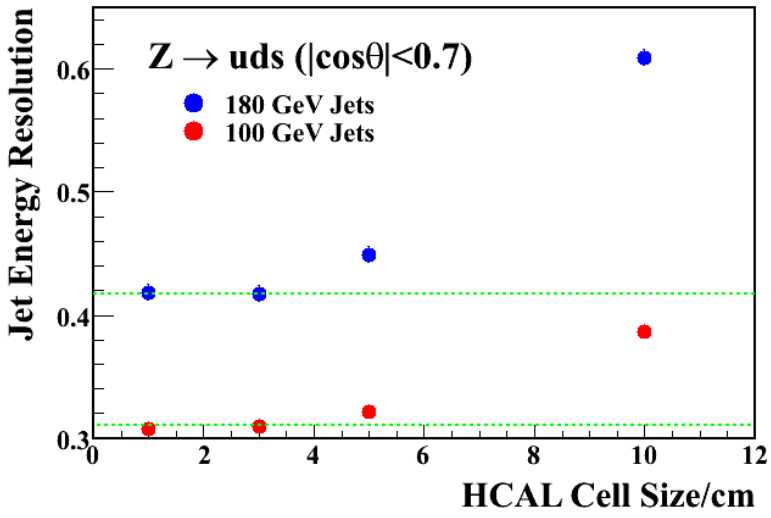
- Possibility to obtain momentum-tagged neutral particles @ MIPP
- Questions to be addressed:
  - Practical: how long do we need to run?
    - Cannot trigger on neutrals, but only tag offline
    - Purity is small (1% or less, energy dependent?
    - DAQ rate limited: instantaneous, average, buffer depth, spill structure
    - Rate limitations (RPCs, photo-sensors)
  - Conceptual:
    - High granularity data will provide detailed diagnostics on shortcomings o simulations (em part, neutron part, correlations,…)
    - Is it really possible to get the simulation of shower development right for pions and protons – and wrong for kaons and neutrons?
    - Geant4 community expressed primarily interest in "thin target" data

Goals

- Particle flow and detector optimization:
  - Validate or reject models, narrow model-induced systematic uncertainties
  - Tune the simulations?
  - We do have contact to GEANT4 representatives. But:
    - There are data from the 980s which are not properly modeled
  - Personal remark: if we commit ourselves that we need to ***tune*** the simulations in order to optimize and design the detector, we may not be ready even if Orbach's oracles come true…

Detector optimization

- Request to concept groups and PFLOW algorithm developers:
- We need model uncertainty error bars on these plots:
- We need performance figures of merit which we can evaluate in test beam data
  - Substructure, fragments, two-particle separation (overlays)



Conclusion

- Recent efforts for enhanced test beam infrastructure are highly appreciated
- But resources remain scarce
  - Some facilities disappear
  - Demands go up
- Coordination within ILC community, across sub-detectors needed
  - For beam time requests
  - For facilitiy upgrades
- Pressure on duty cycles is maintained!
- Clearer specifications of infrastructure requirements are requested - in time

Roadmap

- Read the document – and help to make it useful:
- http://www-hep.uta.edu/~yu/research/linear-collider/ilc-tb-roadmap-v3.1.pdf

Roadmap for ILC Detector R&D Test Beams

World Wide ILC Detector R&D Community

June 2, 2007

Version 3.1

Abstract

This document provides a roadmap of test beam needs for ILC detector R&D community for the next five years or so to the facility managers and the worldwide ILC leadership. The needs and requirements along with the approximate schedule are provided. This document is a result of the ILC test beam workshop and is expected to be updated regularly as the needs arise. The target date for the first draft release is the LCWS2007 in DESY, with the ultimate release targeted on July 1, 2007.