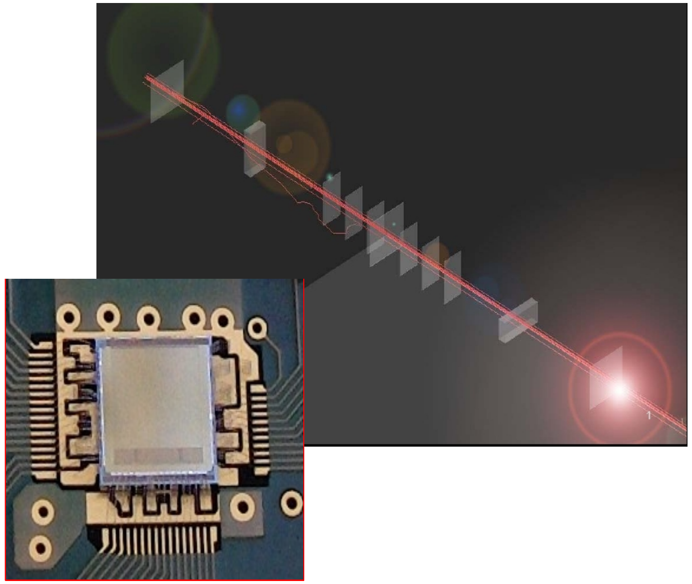
EUDET Status

High Precision Pixel Telescope

Jolanta Sztuk

(on behalf EUDET collaboration)



A Vertex Detector for the ILC
Ringberg, May 30^{th}, 2006

Outline:

- EUDET Project
- Overview of Join Research Activity 1
- Pixel Telescope:
  - ⇒ Sensor
  - ⇒ Simulation
  - ⇒ Data Acquisition System
- Summary & Outlook

EUDET Project

EUDET provides the framework for ILC detector R&D with larger prototypes

- Proposal submitted March 2005
- Officially started 1.1.2006
- Budget:
  - ⇒ 21.5M EUR total
  - ⇒ 7.0M EUR - EU contribution

EUDET Partner Institutes:

Charles University Prague
IPASCR Prague

HIP Helsinki

LPC Clermont-Ferrand
LPSC Grenoble
LPHNE Paris
Ecole Polytechnique Palaiseau
LAL Orsay
IReS Strasbourg
CEA Saclay

DESY
Bonn University
Freiburg University
Hamburg University
Mannheim University
MPI Munich
Rostock University

Tel Aviv University

INFN Ferrara
INFN Milan
INFN Pavia
INFN Rome

NIKHEF Amsterdam

AGH Cracow
INPPAS Cracow

CSIC Santander

Lund University

CERN Geneva
Geneva University

Bristol University
UCL London

+ 20 associated institutes

EUDET Structure

Detector R&D Network

⇒ Information exchange and intensified collaboration

⇒ Common simulation and analysis framework

⇒ Validation of simulation

⇒ Deep submicron radiation-tolerant electronics

Test Beam Infrastructure JRA1

⇒ Large bore magnet

⇒ **Pixel beam telescope** ⇒ This talk

Tracking Detectors JRA2

⇒ Large TPC prototype

⇒ Silicon TPC readout

⇒ Silicon tracking

Calorimeter JRA3

⇒ ECAL

⇒ HCAL

⇒ Very Forward Calorimeter

⇒ FE electronics and DAQ

Testbeam Infrastructure JRA1

Generally applicable:

⇒ Main use for pixel sensors, large volume tracking devices (TPC)

⇒ Large range of conditions: cooling, positioning, magnetic field

⇒ Easy to use: well defined/described interface

⇒ Very high precision: $<3\ \mu$m precision even at smaller energies

⇒ Suitable to different test beam environments:
- construction & initial tests at DESY (E_e up to 6 GeV)
- exploitation at CERN, FNAL etc. possible

Ingredients

- Beam
- High precision pixel telescope
- Magnetic field
  ⇒ Mostly for TPC but also for pixels and calorimeter
- General purpose infrastructure:
  ⇒ DAQ system
  ⇒ Cooling, positioning...
  ⇒ Simulation
  ⇒ User support

Testbeam Infrastructure JRA1

Institutes taking part in the JRA1:

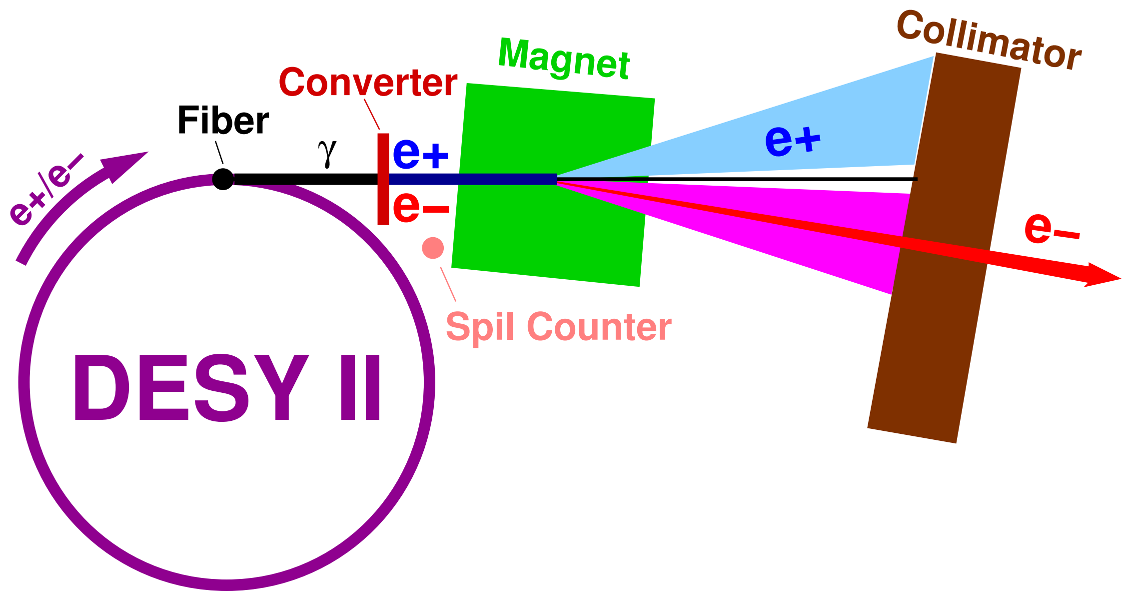
- DESY, CEA-DAPNIA, CNRS-IRES, CERN, MPI München, Bonn, Mannheim, Geneve, Bristol, INFN (Ferrara, Milano, Pavia, Roma)

Tasks:

- Infrastructure - DESY
- Magnet - DESY
- Pixel Telescope - CNRS/IRES
- DAQ - Geneve, Mannheim, Bonn, Strasbourg, INFN
- Validation - Bonn, Bristol, MPI

DESY Test Beam

- bremsstrahlung/conversion beam with E_e up to 6 GeV
- Beam momentum is chosen by magnet current
- Rates depending on energy, metal, collimator setting and operation



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

In practice, the maximum event rate around 1 kHz
(3 GeV, 3mm Cu convert, Collimator ca. 5mm x 5mm)

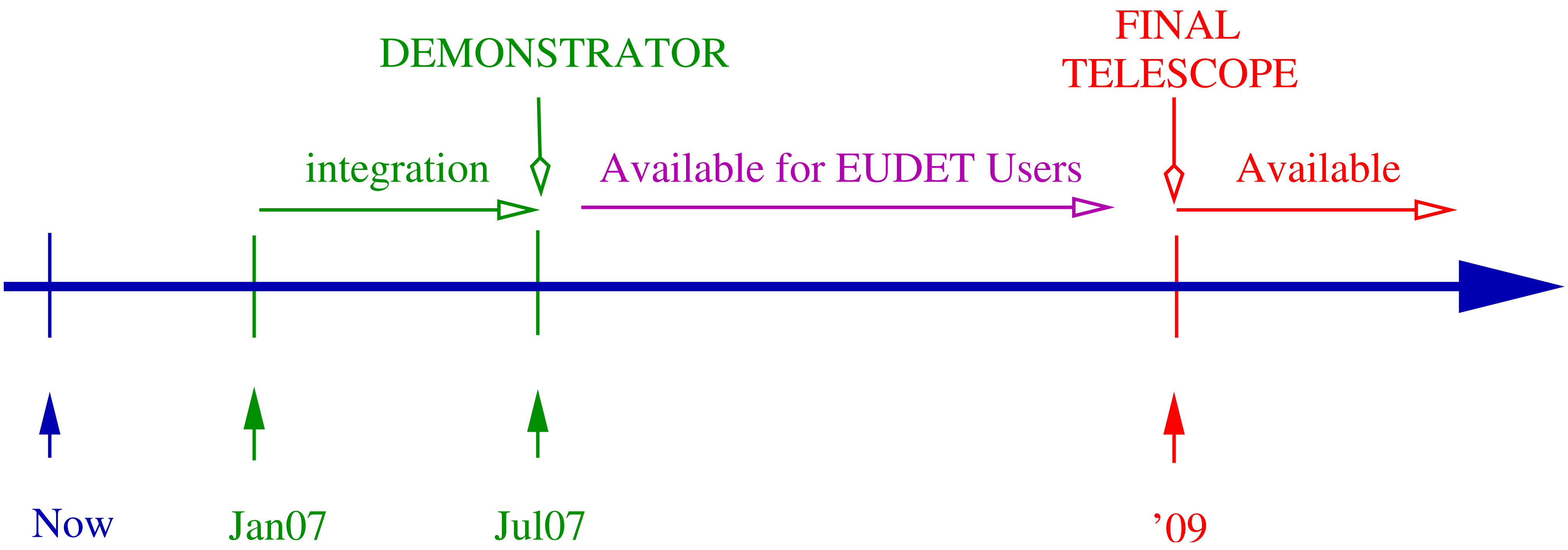
EUDET Pixel Telescope

Beam Telescope: a precision tool for testing a new generation of detectors being developed for ILC

$\Downarrow$

- Compact: to be mounted inside existing magnets, transportable
- User friendly: easy to run and to interface with various users
- Sensitive area: few cm^2 (at least 2 cm in one direction)
- High precision tracking: down to 3 μm (or better)
- Thin sensor for reference planes: Can be thinned down $\leq$ 100 μm
- Fast readout: event rates $\sim$ kHz
- Start with existing CMOS sensors

Telescope Time-line



Telescope implementation plan

Phase1: “Demonstrator”

⇒ Use the Mimo⋆3M prototype developed for STAR microvertex upgrade

⇒ AMS 0.35 OPTO process, now with 12 or 17 μm epitaxial layer

⇒ 4 sub-arrays (64 $\times$ 256 pixel), 30 $\times$ 30 μm^2 pitch,
active area: 7.7 $\times$ 7.7 mm^2, 10 MHz, $t_{r.o.} \sim 1.6$ ms

⇒ engineering run in summer 06, available February 07

For special studies:

⇒ high density sensor with resolution: $\sim 1 \mu m$

Telescope implementation plan 2

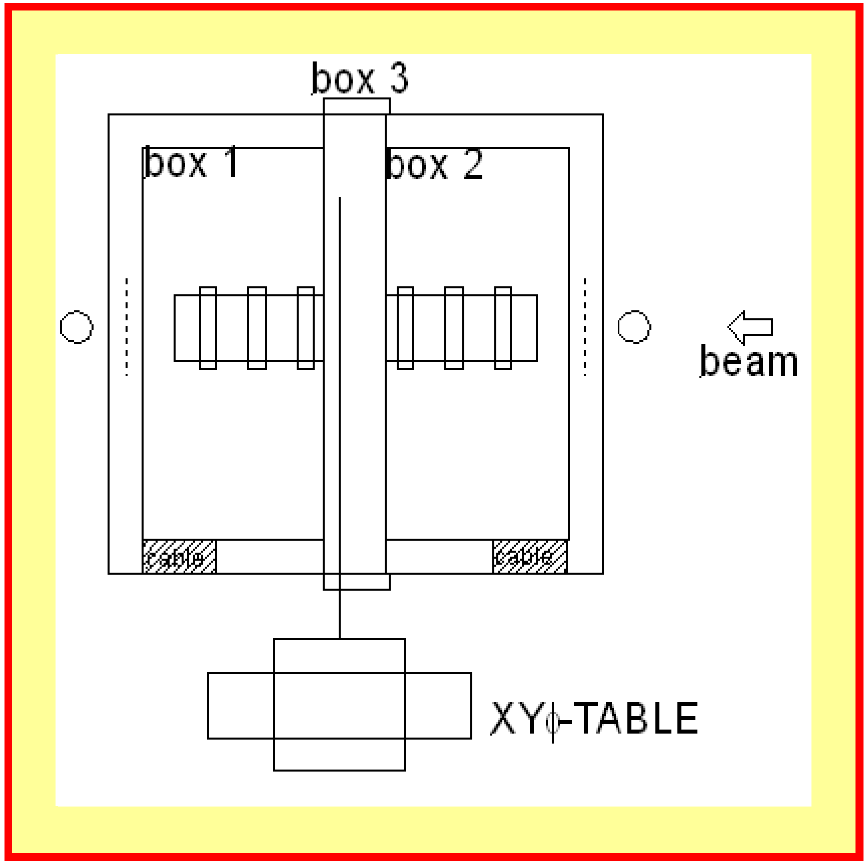
Phase2: Final telescope device

- $\Rightarrow$ On pixel CDS and discriminator at the end of column
- $\Rightarrow$ Good results with Mimosa8, translation into AMS 0.35 OPTO
- $\Rightarrow$ Pixel Rad. Tolerant at room temperature
  (tolerance: $\geq 10^{12} n_{eq}/cm^2$, $\geq$ 1MRad)
- $\Rightarrow$ 800 $\times$ 800 pixels device, 25 $\times$ 25 μm^2 pitch,
  active area: 20 $\times$ 20 mm^2
- $\Rightarrow$ The final device: available early 2008

High precision sensor $\Rightarrow$ same as for demonstrator

The beam telescope ready for the end of 2008

Telescope Mechanics



Box 1:

⇒ Fixed position, optical bench for three reference planes, temperature controlled

⇒ Wall to DUT can be removed

Box 2:

⇒ Movable in z-direction, optical bench for three reference planes, temperature controlled

⇒ Wall to DUT can be removed

Box 3:

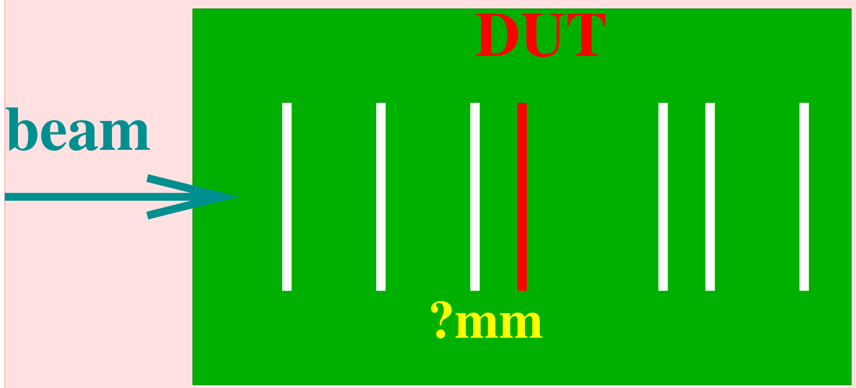
⇒ Gap between Box 2 and Box 3, closed by thermal cover

⇒ $XY\Phi$-table: external with "long" mechanical structure to locate the DUT between the reference planes

⇒ This "arm" is the interface for the different DUTs

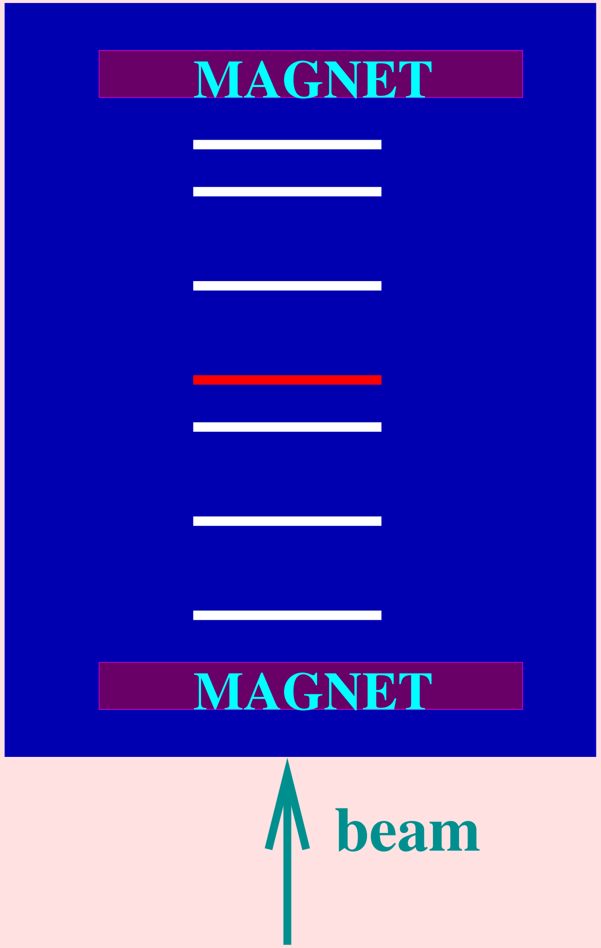
⇒ Boxes can be placed into magnetic field

Telescope Configuration



Compact for pixels

Inside magnet:



Beam telescope geometry studies

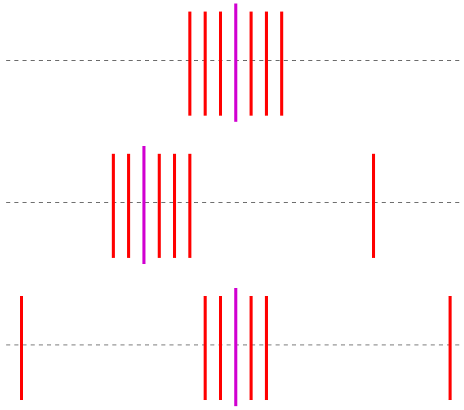
In the idealized case, simple analytical method can be used to describe the performance of the telescope and estimate errors. A.F.Żarnecki, Warsaw University

Configurations studied:

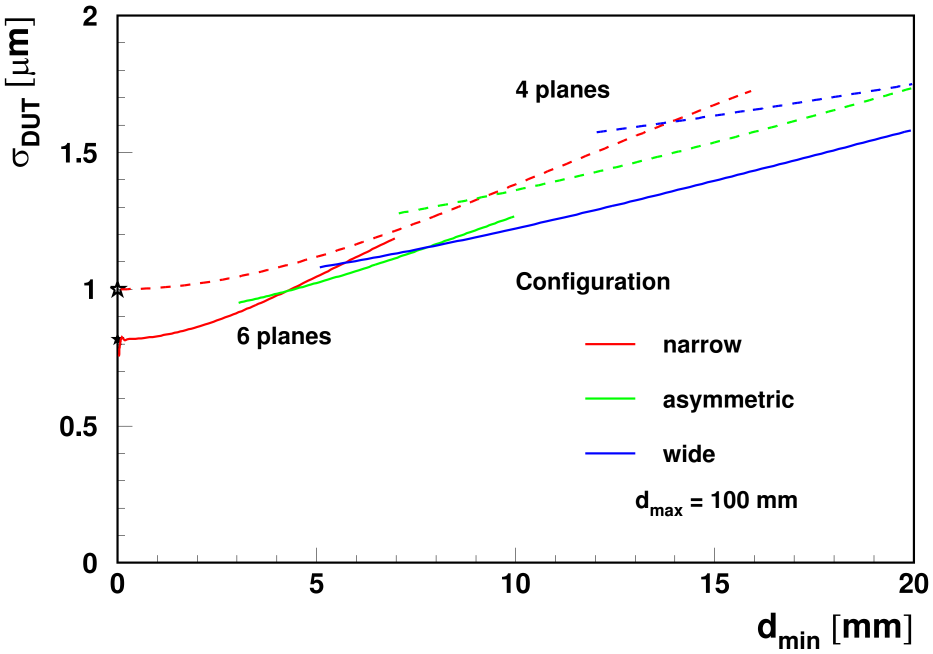
Narrow

Asymmetric

Wide



d_{min} - minimum distance between planes



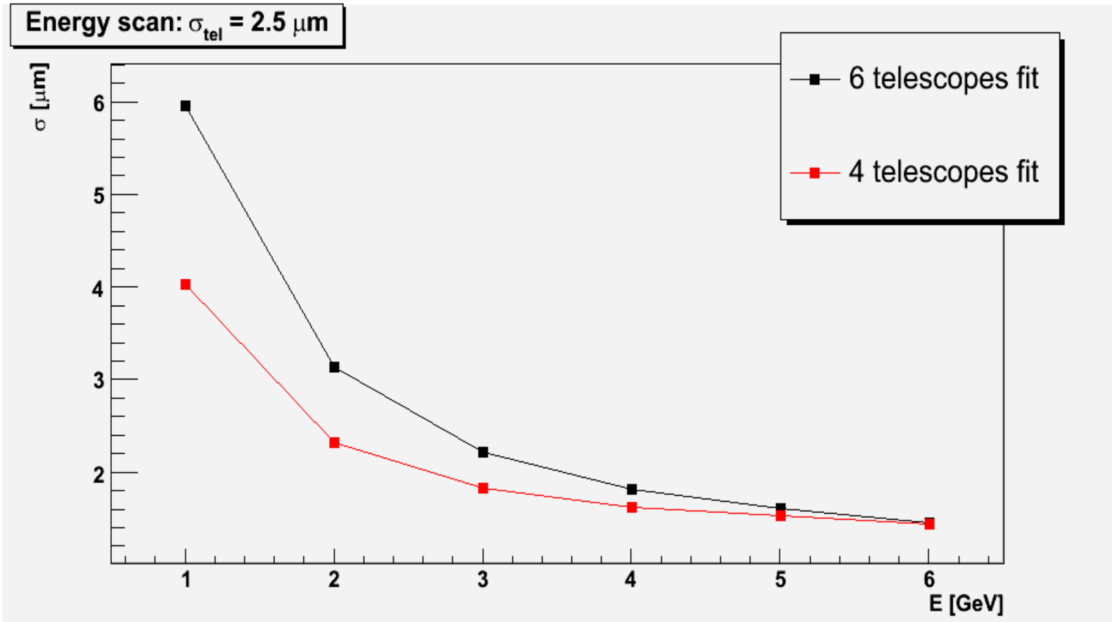
The optimum telescope setup depends on the assumed parameters.

It is essential to place sensor planes as close to DUT as possible.

Analytical results can be used to guide future simulation studies.

Pixel Telescope Precision

(Simulation by Daniel Scheirich, Charles University, Prague)



6 telescopes fit

Fract.	1 GeV	2 GeV	3 GeV	4 GeV	5 GeV	6 GeV
100 %	5.96 +- 0.03	3.13 +- 0.02	2.22 +- 0.01	1.813 +- 0.009	1.609 +- 0.008	1.457 +- 0.008

4 telescopes fit

Fract.	1 GeV	2 GeV	3 GeV	4 GeV	5 GeV	6 GeV
100 %	4.03 +- 0.02	2.32 +- 0.01	1.827 +- 0.009	1.622 +- 0.008	1.533 +- 0.008	1.445 +- 0.008

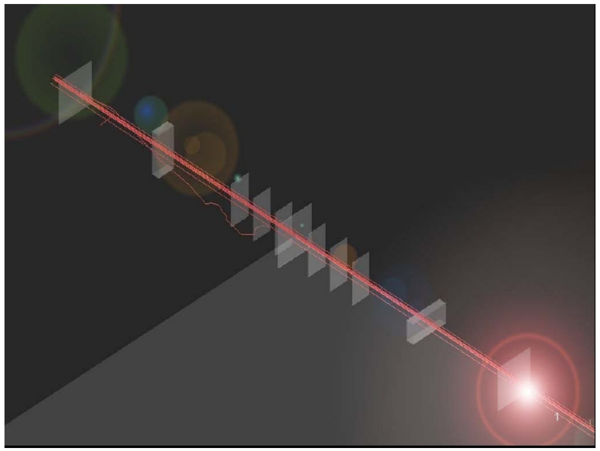
Telescope resolution $\sim 1.5\mu m$ at 6 GeV

Parameters:

$\Rightarrow$ Distance between telescope planes: 1 cm

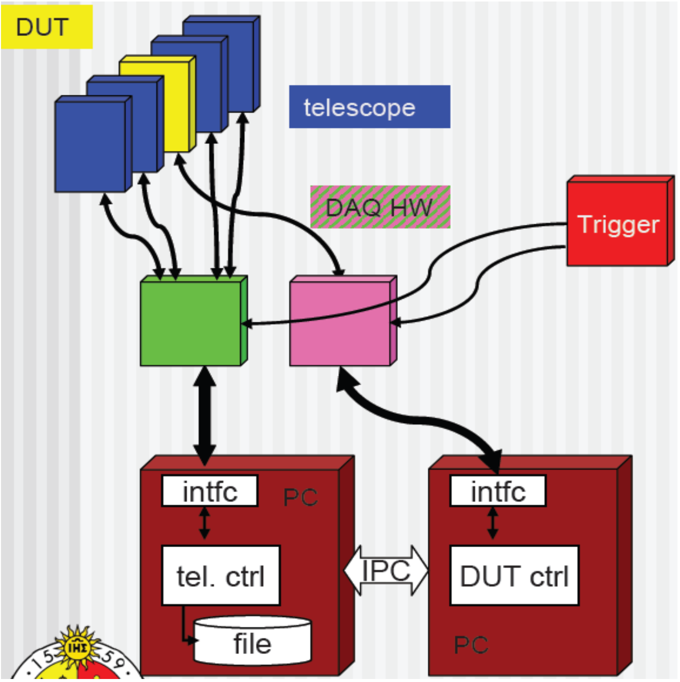
$\Rightarrow$ One plane at 5 mm from DUT

$\Rightarrow$ Sensor resolution: 2.5 μm



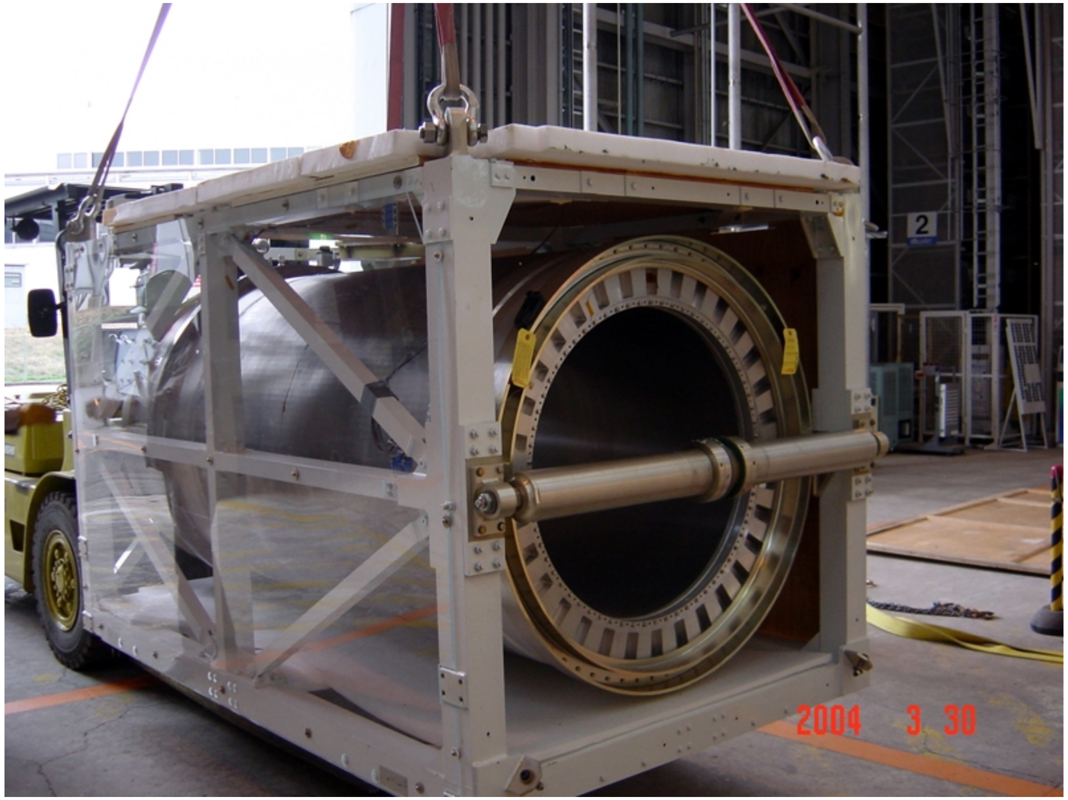
Data Acquisition system

DAQ system important issue beyond beam telescope



- JRA1 DAQ system:
  - ⇒ pre-existing knowhow: Bonn, Strasbourg, SUCIMA
  - ⇒ dedicated board under development at INFN
  - ⇒ architecture by Geneva and Mannheim
- Idea: Different "producers" handle the hardware, one "writer task" digests this into a file
- Central process control and run control
- Producers for monitoring data (position, temperature, time, TLU) so be attached to each event
- Initially, producer provides CDS and sparsification, must be able to provide raw and reduced data
- Clusterization and tracking in monitoring task
- Synchronization via common Trigger Logic Unit (TLU)

Magnetic field



- Large bore superconducting solenoid
  - $\Rightarrow$ $\oslash = 850$ mm
  - $\Rightarrow$ L = 1300 mm
  - $\Rightarrow$ $B < 1.2$ T
- Loan from KEK
- Originally developed for a balloon experiment in Antarctica
- Standalone operation
- Magnet will arive and commissioned this summer

Summary and Outlook

- EUDET - project to improve the infrastructure for linear collider detector R&D in Europe
- Effort to build a general purpose test beam infrastructure is under way
- EUDET JRA1 telescope:
  - a very high precision tool for characterizing new pixel sensors
  - improve the test beam infrastructure usable by other ILC R&D groups and even groups outside the field
  - test environment for wide variety of pixelated sensor technologies
- DAQ system development under way, also to learn for ILC
- Simulations will give us the optimal geometry in order to reach $< 2\mu m$ resolution
- A demonstrator will be available mid 2007
- The final telescope is planned for end 2008