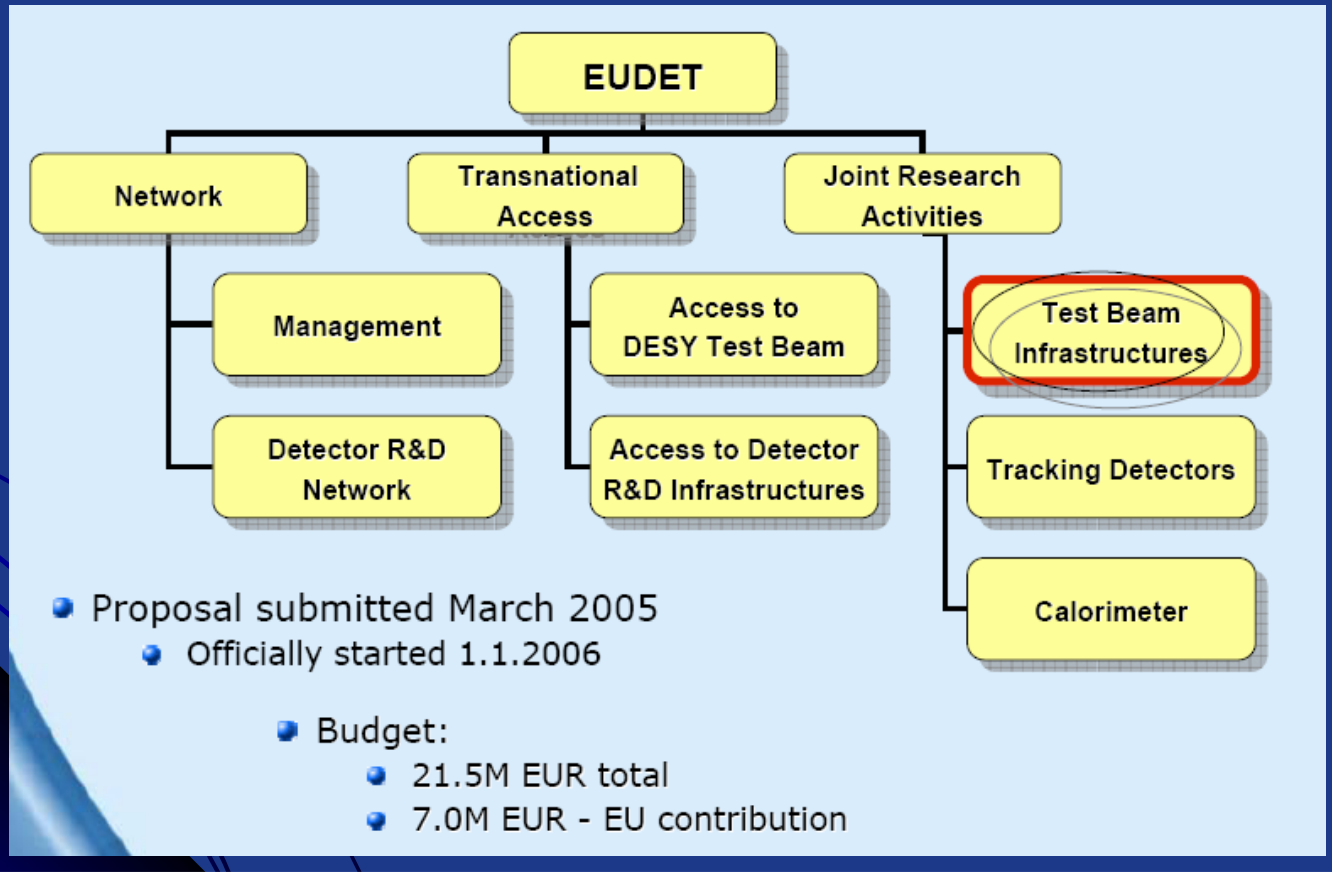
A Pixel Telescope for Detector R&D for an ILC

- Introduction: EUDET
- Pixel Telescope
  - Sensors
  - Readout
  - Simulations
  - Mechanics
- Summary

Tobias Haas
DESY
7 November 2006

EUDET Project

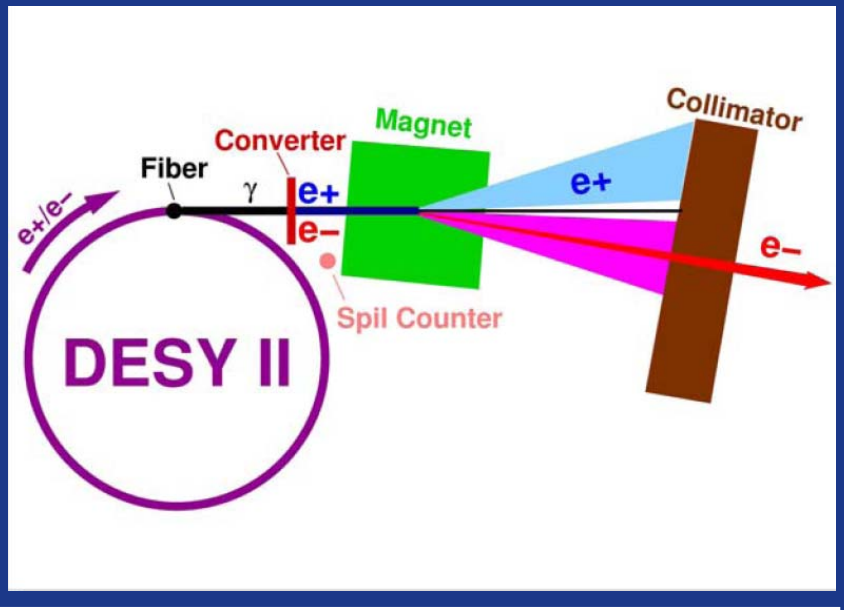
- Build *INFRASTRUCTURES* for LC R&D



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

Testbeam Infrastructure (JRA1)

- Provide a large bore high field magnet
- Provide beam telescope with:
  - Very high precision (< 3µm precision even at lower energies)
  - High readout speed (frame rate > 1 kHz)
  - Easy to use (well defined/described interfaces)
  - Wide range of conditions for devices under test (cooling, positioning, magnetic field
- Major uses
  - Pixel sensors
  - Large volume tracking devices
- Initial setup @ DESY
  - < 6GeV/c electrons
- Transportable
  - Hadron beams at FNAL or SLAC



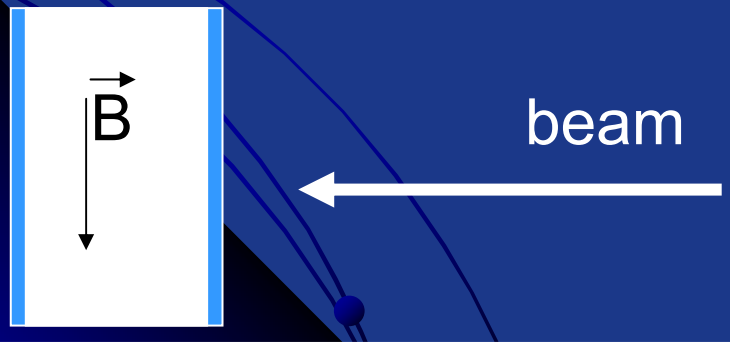
EUDET JRA1 Institutes

- EUDET comprises 21 partners and 9 associates from 3 continents
- JRA1:
  - Bristol (UK)
  - CNRS-IRES Strasbourg, CEA (France)
  - DESY, MPI Munich, Bonn, Mannheim (Germany)
  - Genève, CERN (Switzerland)
  - INFN (Italy)
  - Warsaw (Poland)

PCMAG

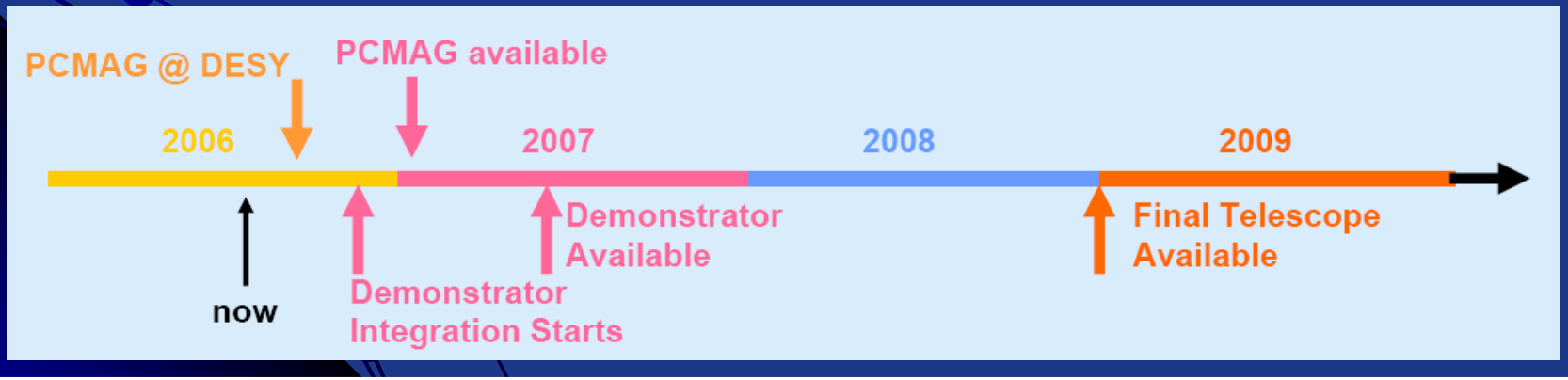
KEK, DESY

- Large bore
  - D ~ 86 cm
  - L ~ 100 cm
  - B ≤ 1.2 T
- Superconducting
  - B ≤ 1.2 T
- Thin
  - 0.2 X_0
- Field map

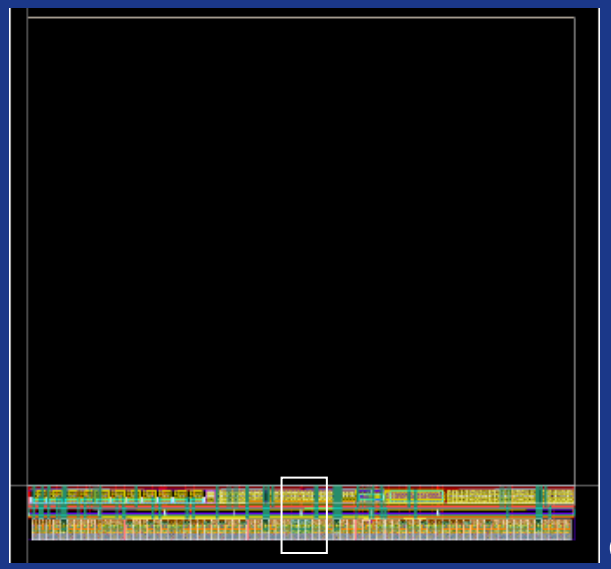


Beam Telescope

- Phase 1 “Demonstrator”
  - First test facility available quickly
  - Established pixel technology with analog readout
- Phase 2 “Final Telescope”
  - Fully digital readout with integrated CDS and sparsification
  - Ready end 2008



Reference Plane Sensors



CNRS-IRES, Strasbourg

- Demonstrator: Mimo*3M
  - Developed for Star micro vertex detector upgrade
  - AMS 0.35 OPTO process
  - 4 sub-arrays with 64x256 pixels:
    - 30 x 30 μm^2 pitch, active are 7.7 x 7.7 mm^2
    - Frame readout: 1.6 ms
    - First wafers delivered, currently being tested

- Final Telescope: Mimosa16++
  - Fast column-parallel architecture
  - Integrated CDS and discriminator
  - Active area 2 – 4 cm^2

R/O: EUDET Data Reduction Board

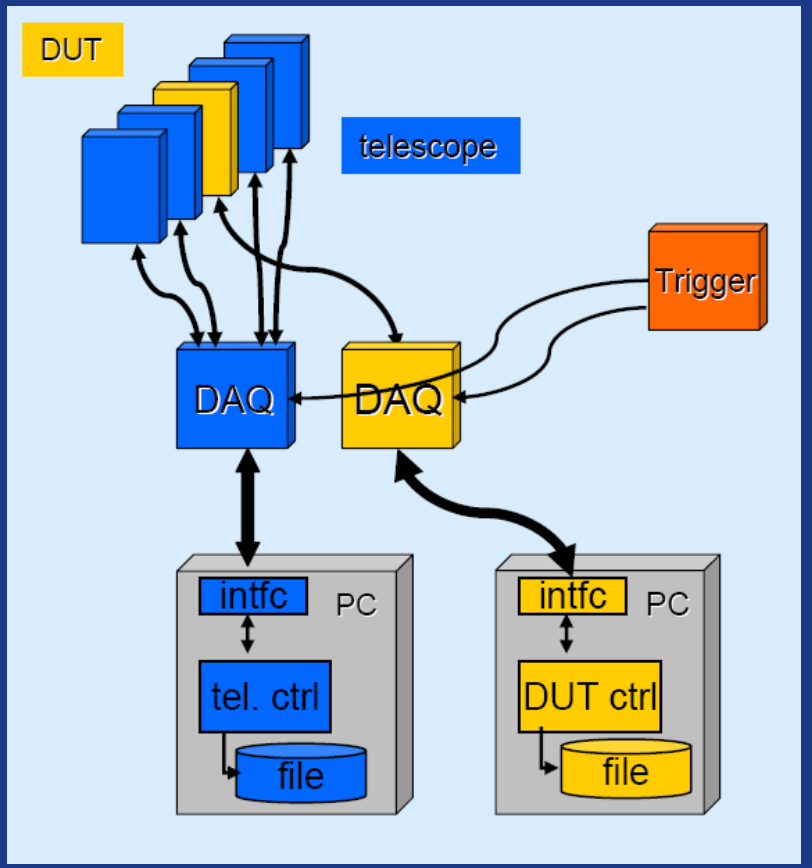
- Mother board:
  - Online calculation of pixel pedestal noise
  - Based on ALTERA Cyclone II FPGA
- 1 Analog mezzanine card:
  - 4 independent signal processing digitizing stages
- 1 Digital mezzanine card:
  - Detector control and status
  - USB 2 link
- Adoptable to a large range of different sensors
- Zero-suppressed and Full frame readout available
- Boards are available and are currently under test

INFN

DUT and DAQ Integration

- Trigger Logic Unit:
  - Readout of DUT and telescope independent
  - Integrate via trigger, busy, reset
  - DUT readout provided by users

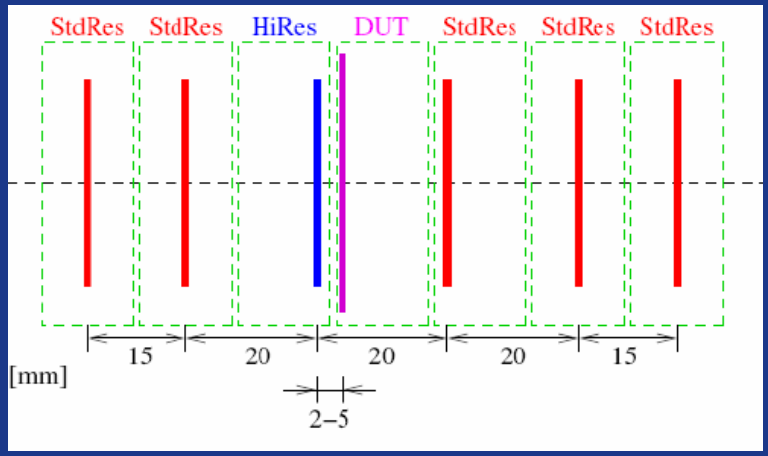
Genève

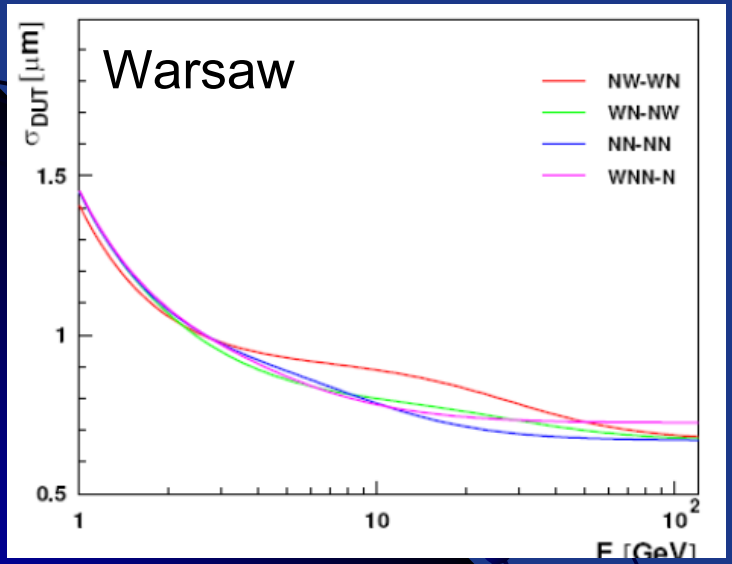


Bristol

Telescope Precision: Simulations

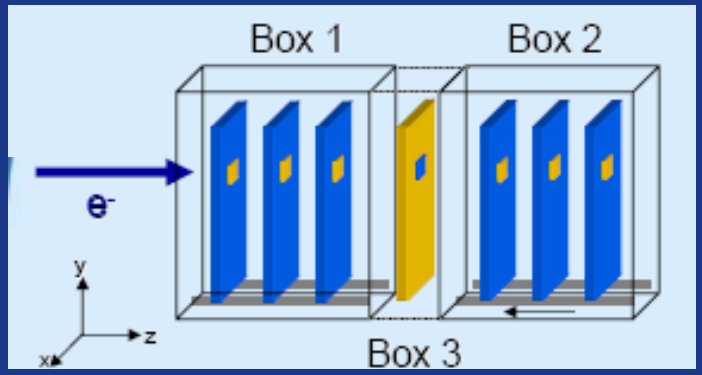
- Analytic method for track fitting has been developed and verified with GEANT4
- Various two-arm configurations have been investigated





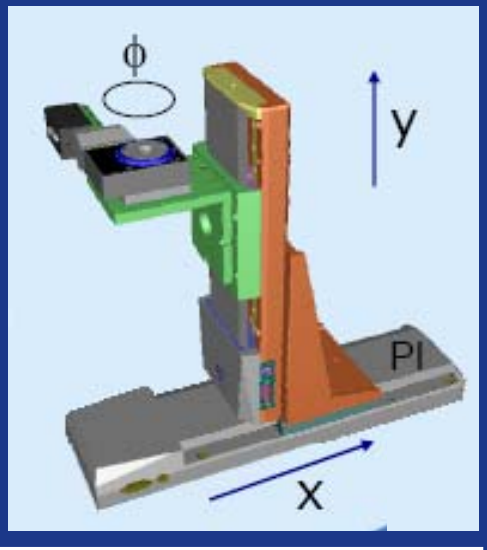
- Results:
  - One HiRes plane (σ < 1.5 μm) is needed close (d < 5mm) to DUT
  - Optimum telescope configuration depends strongly on beam and DUT parameters
  - At DESY (6 GeV): 6 planes, 1 HiRes plane and two long arms

Telescope Mechanics



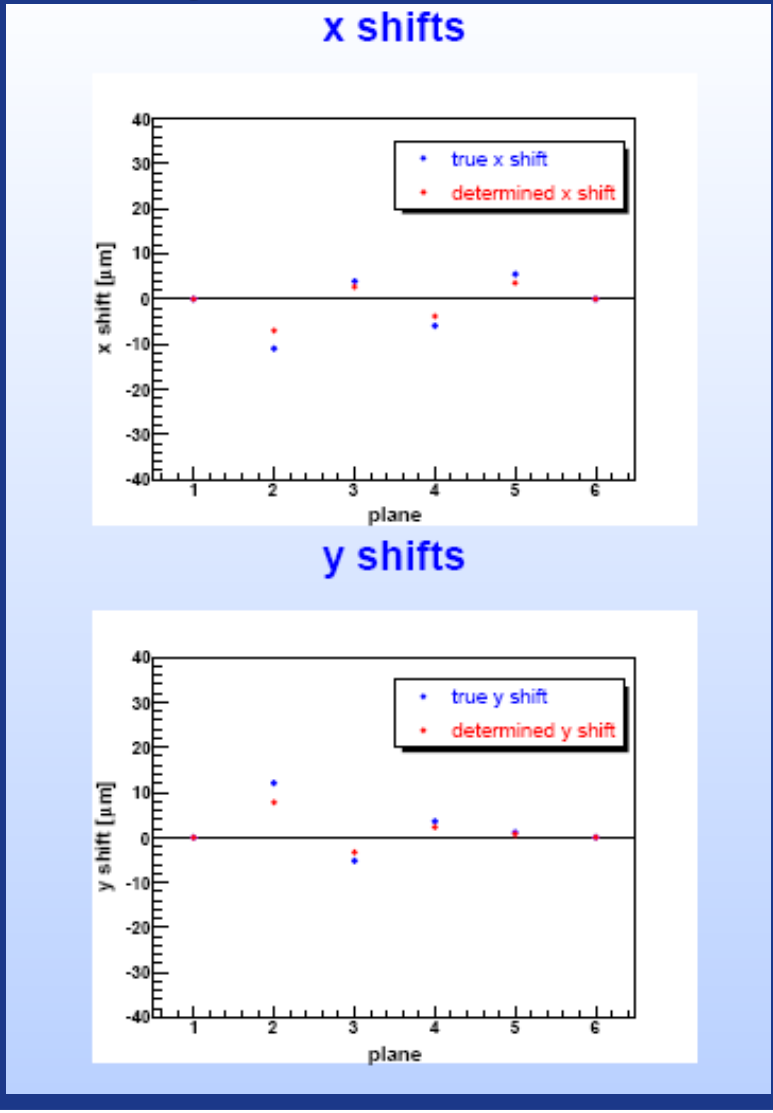
- Boxes 1 & 3: Reference planes
  - Movable along Z
  - Temperature controlled
- Box 2: DUT
  - Cooling (> -40° C)
  - Walls to Boxes 1&2 removable

- DUT Actuator:
  - External XYΦ-Table with “long arm”
  - Accuracy: < 10µm, Repeatable: < 0.5µm/axis
  - Initial mechanical alignment: < 100µm
  - Beam-based final alignment
- Magnetic Field:
  - Only boxes 1 & 2 are suitable



Telescope Alignment

- Test alignment procedure using telescope simulation
  - 50k 6 GeV/c electrons from Geant 4
  - Millipede program (V. Blobel)
  - Inject artificial shifts of reference planes
- Questions:
  - How well can the shifts be recovered?
  - What statistics are needed for an alignment
  - How much redundancy (planes) is needed?



Access to the Facility

- This will be an open general purpose facility with these ingredients:
  - DESY test beam
  - Large bore high field magnet
  - Pixel telescope
- Access is via the EUDET “Transnational Access” (TA) mechanism:
  - Written applications to EUDET
  - Review by the EUDET review committee
- TA not only comprises access to the facility but also some travel funds.
- Please contact the EUDET coordinator (J. Mnich, joachim.mnich@desy.de) or myself (T. Haas, tobias.haas@desy.de)

Summary

- A general purpose test beam infrastructure is currently being constructed within EUDET:
  - 6 GeV/c electron test beam @ DESY
  - Large bore high field magnet
  - High precision fast beam telescope.
- Demonstrator setup will be available mid 2007
- Final facility will be available end 2008
- Access to the facility is via the EUDET TA review mechanism
- Open to everybody