A Pixel Telescope for Detector R&D for an ILC

- Introduction: EUDET
- First general ideas (with some interludes)
- Pixel Telescope group
- Actual plans
- Summary

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DESY

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This Talk

- Introduction: EUDET

- First general ideas
  (with some interludes)
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  group
- Actual plans
- Summary

Tobias Haas: Pixel Telescope

What is EUDET?

- 4 year Project to build/improve the *infrastructure* for linear collider detector R&D in Europe

- Supported by European Union
  - I^3 (Integrated Infrastructure Initiative) in the 6th framework
  - Total budget 17Mio € with a 7 Mio € EU contribution
  - 22 partners, 15 associates, lead by DESY
  - Approved this summer, contract negotiations are currently ongoing
  - Start 2006

Tobias Haas: Pixel Telescope

What is EUDET?

- Networking and general measures to improve access to a wide range of research groups:
  - Organize *meetings* and *conferences* and provide *computing resources,*
  - Make the *DESY test beam infrastructure* available to a wide community of physicists involved with detector developments.
  - Make Detector R&D infrastructure available for new groups joining the ILC detector development, for other particle and nuclear physics groups as well as for groups from other fields of science.

Tobias Haas: Pixel Telescope

What is EUDET?

- 3 areas of joint research:
  - *Vertex/Pixel Detectors:* Develop and build a novel general purpose pixel detector test stand and telescope and improve the test beam infrastructure.

    this talk →

  - *Tracking Detectors*: Wants to integrate the efforts of European institutions working on tracking detectors for the ILC. This includes the improvement of existing infrastructures for tracking detectors, the developments of common prototypes, and the development of novel techniques for SI based tracking detectors.
  - Calorimeters: Aims at improving the existing calorimeter prototype stack, novel stack instrumentation, and novel readout systems.

Interlude: DESY Testbeam
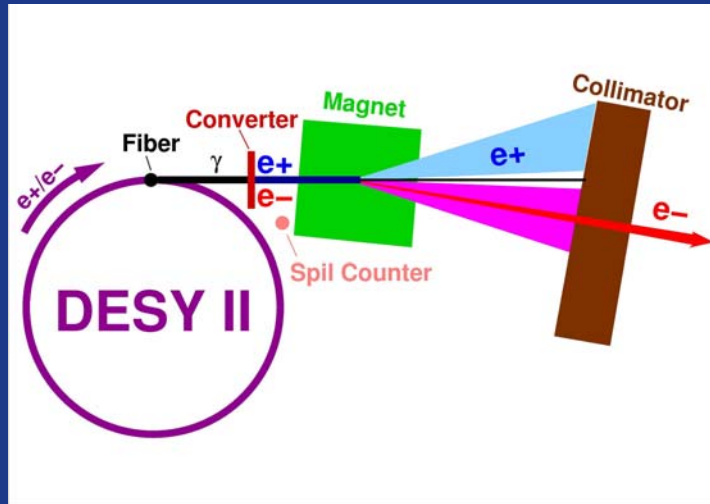
Testbeam 24

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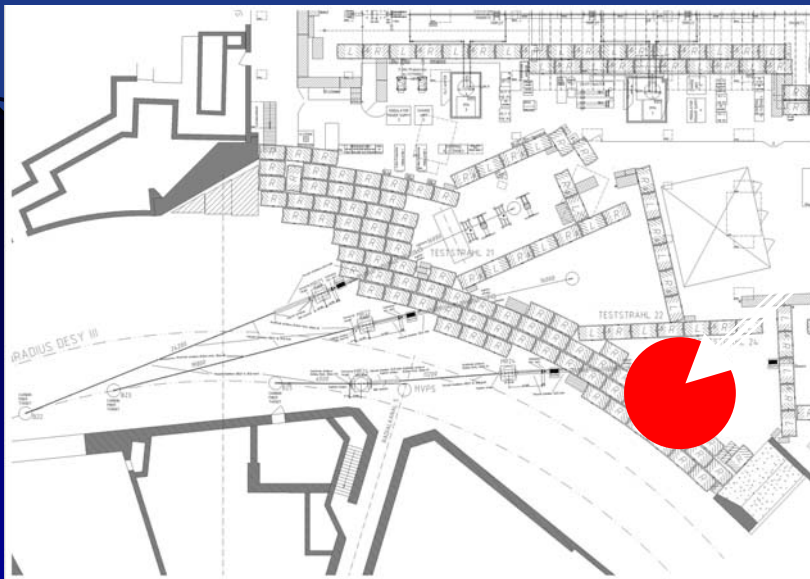
Rates	Target	
Energy	3mm Cu	1mm Cu
1 GeV	~330 Hz	~ 220Hz
2 GeV	~500 Hz	~330 Hz
3 GeV	~1000 Hz	~660 Hz
5 GeV	~500 Hz	~330 Hz
6 GeV	~250 Hz	~160 Hz

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General Idea

- Build a general purpose infrastructure:
  - Generally applicable:
    - use for pixel sensors, large volume tracking devices (TPC), other areas (imaging, biology, medical)
    - large range of conditions (cooling, positioning, magnetic field)
  - easy to use
    - Well defined/described interfaces interfaces
  - very high precision
    - < 2µm precision even at smaller energies
  - suitable to different test beam environments
    - rates, energies, …
- Do some device R&D along the way.

First Idea

- Pixel telescope with sensors that
  - provide high precision (~ 2 – 4 μm)
  - with reasonably large area (~ 1 – 2 cm)
  - can be thinned down (~ 100 μm)
  - can be read out fast quickly

☞ *Start with MIMOSA V (CMOS MAPS) chip*
  - … but not fast enough

☞ *then go to next generation chip which is fast:*
  - … on chip discriminator and ADC

Interlude: CMOS MAPS
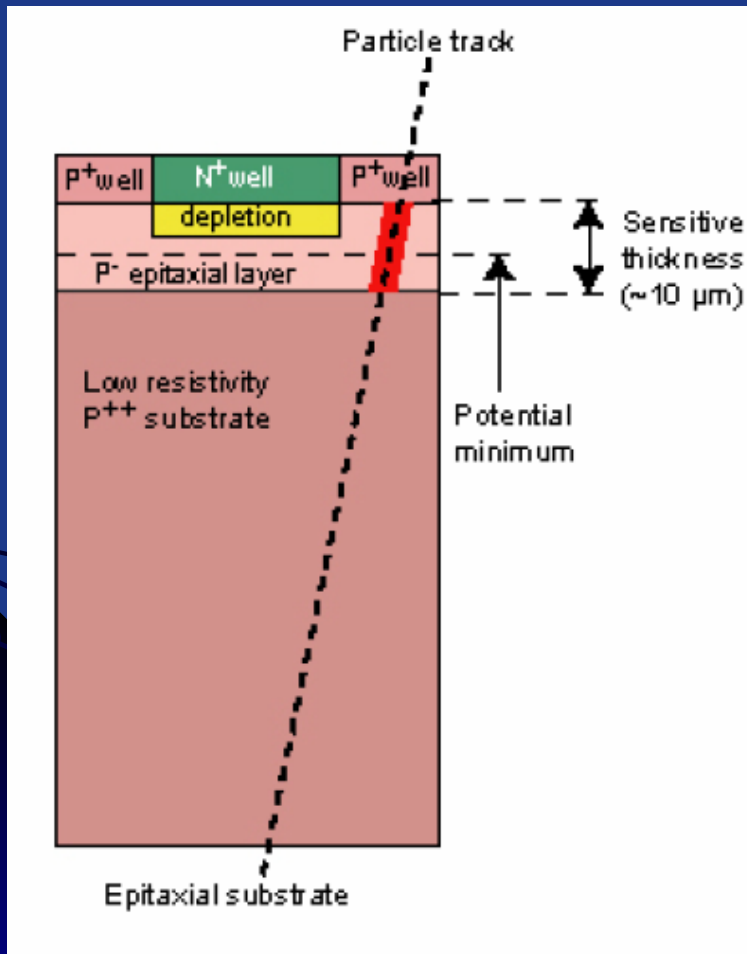
- Active area underneath the electronics (epi-layer 10μm thick)
- Charge generated by ionization is collected by n-well/p-epi diode
- Charge collection occurs through thermal diffusion

Interlude: MIMOSA V
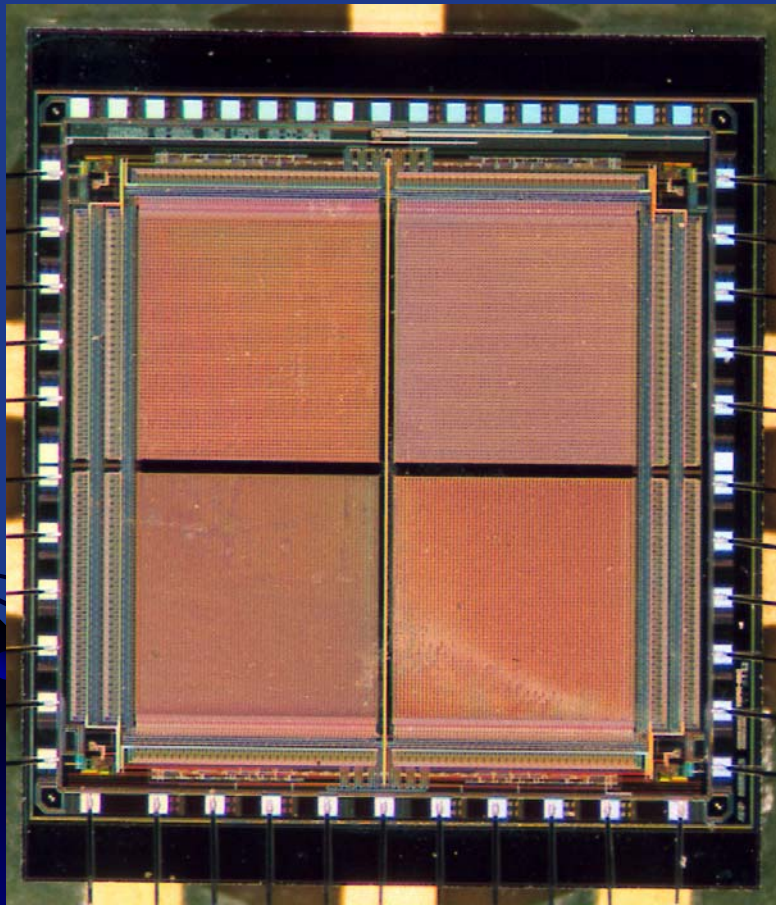
20 mm

20 mm

- Developed by LEPSI/CNRS-IRES, Strasbourg

- Point resolution: 1.5μm – 2.5 μm

- Efficiency ~ 99%

- Pixels size: 20 x 20μm

- Thinned to 20μm

- S/N ~ 20 (at ca. -15° C)

MIMOSA V @ DESY

- Electrons up to 6 GeV

- reference telescope with 2μm nominal resolution (multiple scattering is much larger)

- cooled to -15°C

Noise

Signal
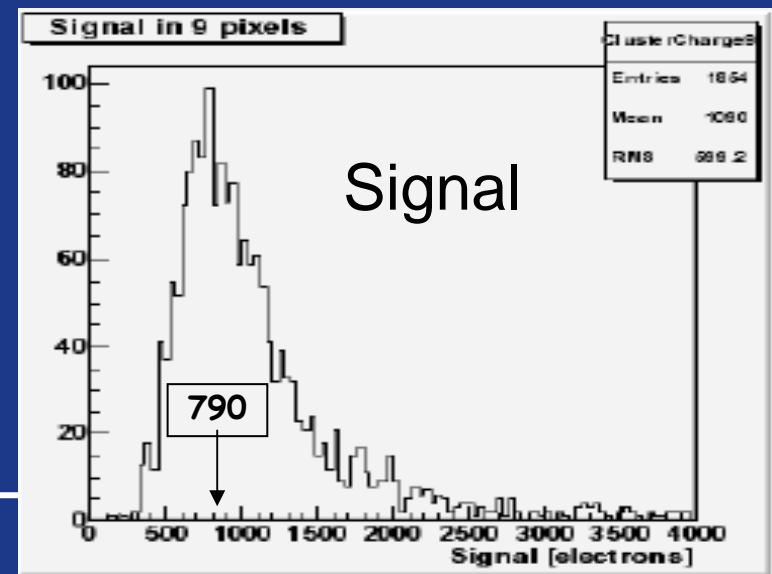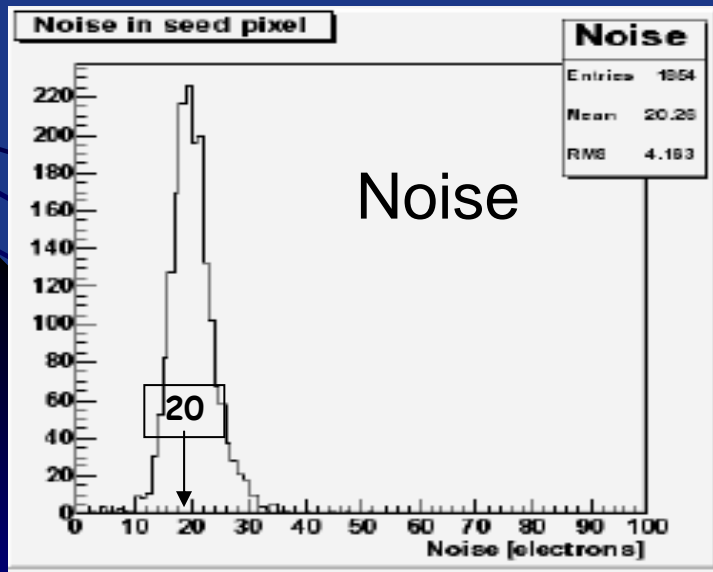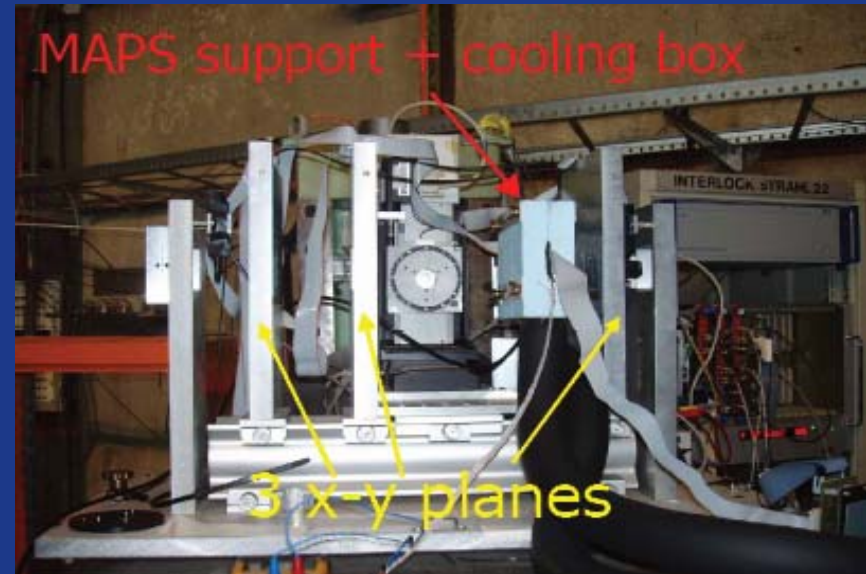
What about other pixel technologies?

source top gate drain clear bulk

p+ n+ p+ n+ n+

p

n

internal gate

DEPFET

n⁻

p+
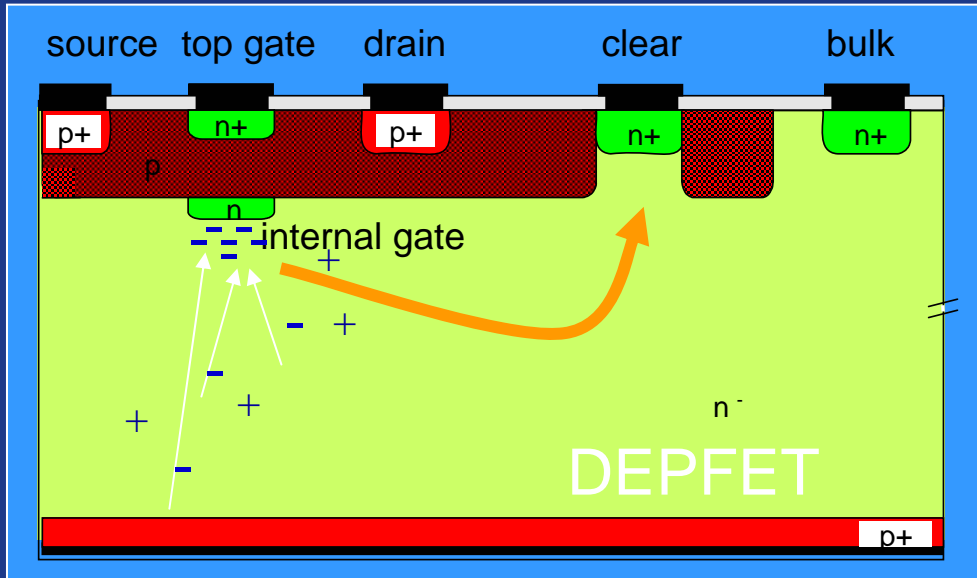
- DEPFET:
  - no large scale devices (yet)

LCFI CPCCD1

- CCD:
  - (conventional) CCDs stil slow
  - CPCCD could be used

Should be part of this effort from the very beginning:
- Collaborate closely during design phase
- α-users of the infrastructure
- Fallback solution if MAPS fails

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Pixel Telescope Group

- MAPS Sensors:
  - CNRS-IRES (Strasbourg), CEA DAPNIA (Saclay)
- System Integration and test-beam
  - DESY
- DAQ:
  - Genève, INFN (Milano, Roma III, Ferrara, Pavia)
- Validation:
  - Bonn, MPI-Munich, Mannheim, LCFI (Bristol, RAL, Oxford, ICL), Nijmegen

☞ *Brings together almost groups doing ILC pixel research in Europe!*

Project Details

- This is a good size project
  - 3.8 Mio € total budget
  - 1.5 Mio € EU contribution
  - 501 person months
- We have four years starting in January
- At the end a number of things have to be achieved:

Obvious goals

- There should be a very high precision beam telescope for characterizing pixel sensors

- There should be a very general purpose test beam infrastructure usable by other ILC R&D groups and even groups outside the field

- Various pixel technologies should be step closer to LC vertex detector

Planned layout

Compact:
for pixels

DUT

5mm
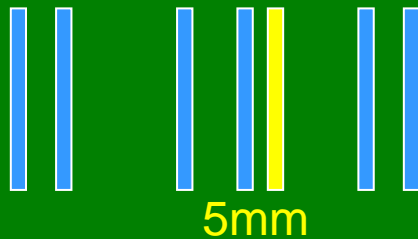
5 Telescope planes usable in different configurations:

Two-arm:
TPC etc…

DUT
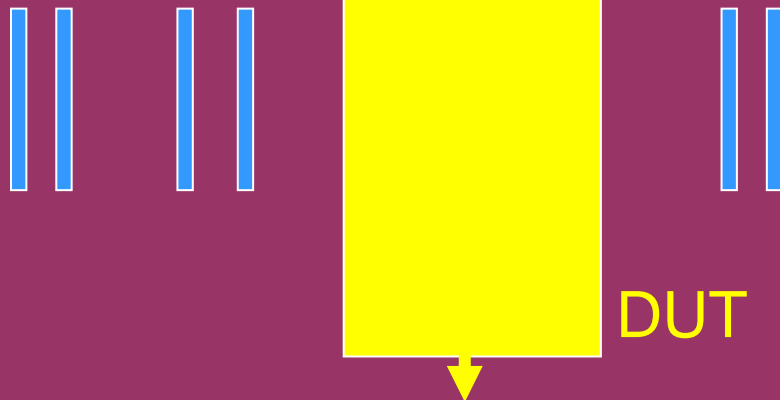
In a magnet:

Magnet

Magnet
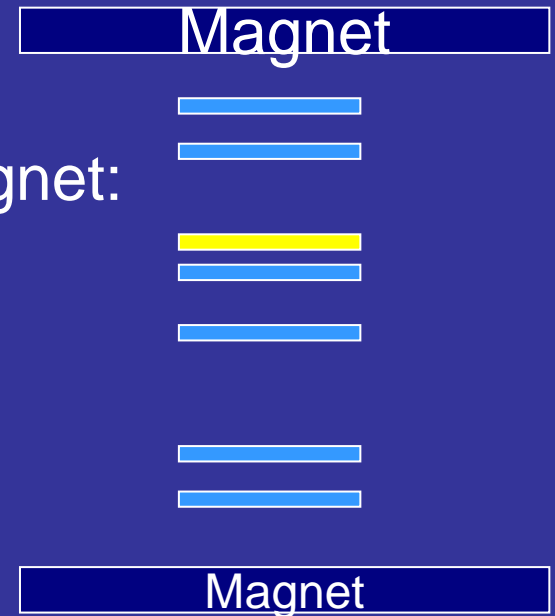
Telescope Chip

- 1st Iteration:
  - Demonstrator using an existing well understood chip:
    - MIMOSA V
    - MIMO* III (MIMOSA V derivative:30x30μm AMS-035 OPTO)
  - Ready within 18 months
    - Use to characterize final telescope chip
- Final telescope:
  - Use followup of MIMO* III with discriminator and ADC integrated
  - Ready after 36 months

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Interlude: MIMO* II/III

- MIMOSA derivative in AMS 035 OPTO

- Simplest 2T   30x30 µm pitch

- 10 parallel subarrays R/O @ 10 MHz

- MIMO* II (2 arrays with 128x64 pixels) currently in the DESY test-beam

- MIMO* III is a large version of MIMO* II
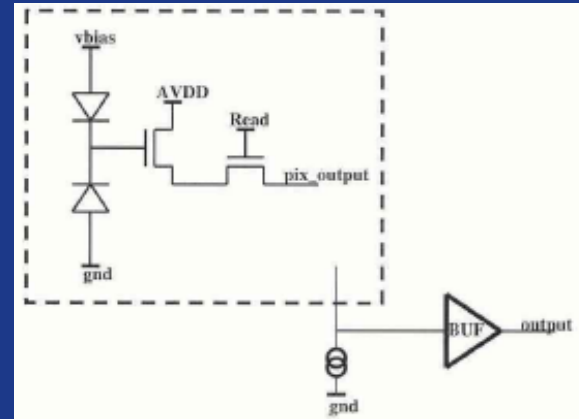
General Infrastructure

- Cooling: What is actually wanted?

- Magnetic field:
  - 1.5 T superconducting solenoid with 85cm bore can be obtained on loan from KEK (originally from BESS experiment)

Fig. 3. Cross section of the superconducting solenoid.

- What else is needed?

DAQ
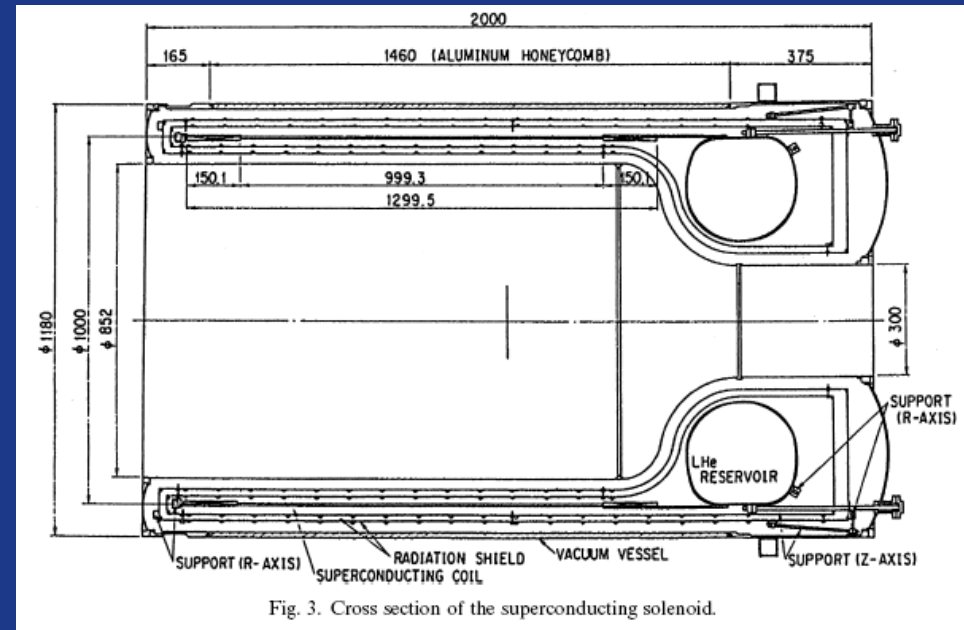
- First interation: Digitize on front-end:
  - 1 Mimosa V = 1M pixels
    - Raw mode: 12 bit/pixel, 12Mbit/event
  - Example: USB-2, 480 Mbit/s, allows < 40Hz on single Mimosa V
- Data reduction board: 1/plane, output few hundred bytes/event
- DUT integration:
  - 4 lemo cable approach:
    - Trigger/busy/hold/Evt Nr
  - Independent of telescope
  - Integrated on the data level

Front/End
Signal cond
Sequencer
Digitizer

Digital I/F, USB-2

Data Reduction
Ped/CN or CDS
Cluster finder

USB output

Trigger

Busy

Event #

Standard DAQ Bus, VME?

PC
Event bld.

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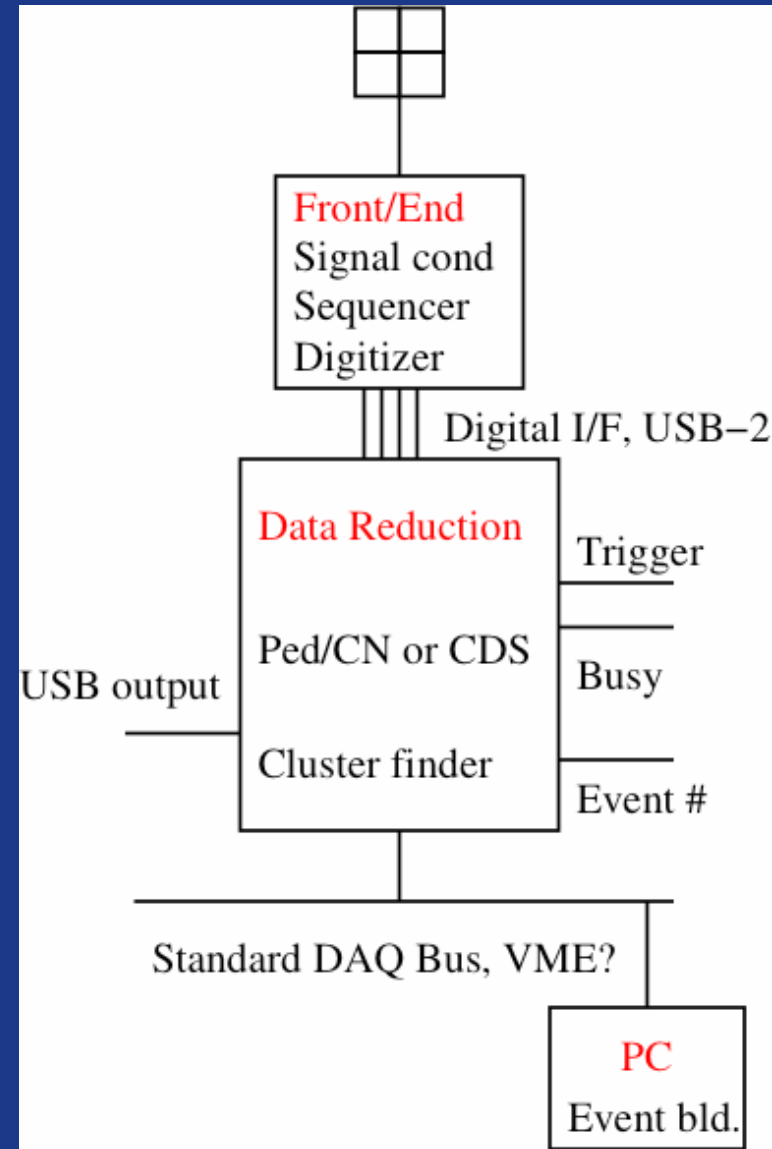
Summary

- We are building a pixel telescope within the context of EUDET, a project to provide general test beam infrastructure for ILC detector R&D

- The project is just getting off the ground

- The project brings together most groups working on ILC pixel R&D

- A demonstrator will be available mid 2007

- The final telescope is planned for end 2008

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Inviting your comments!

Backup
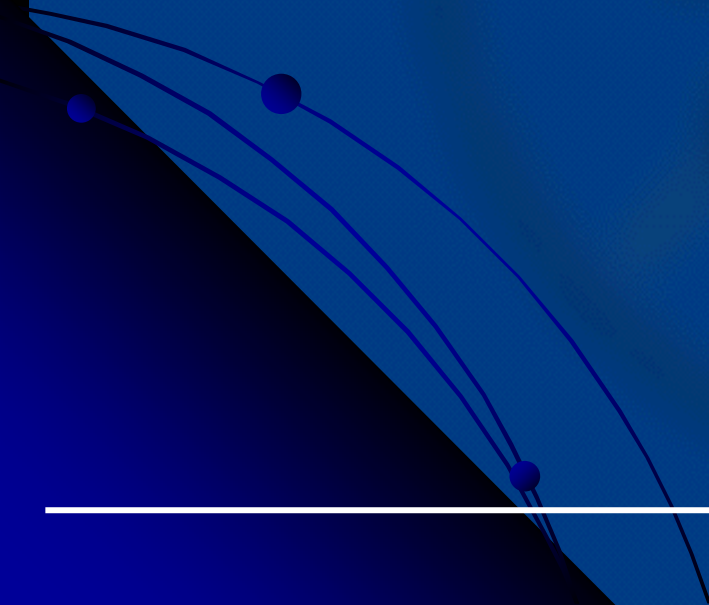
Institutes

Activity Number	JRA1			Start month		1		End month	48
Activity Title	Testbeam Infrastructure								
Participant number	1	4	5	6	13	15	19		
Participant short name	DESY	CEA	CERN	CNRS/IN2P3	MPS-MPI	UBONN	UMA		
Total person month	84 (18)	42	8 (0)	60	36 (18)	36 (18)	24 (12)		
Participant number	20	21	23						
Participant short name	UNI-GE	UNIV BRIS	INFN						TOTAL
Total person month	72 (36)	48 (24)	91 (34)						501 (160)

Budget

Grand Total JRA1	Total (incl. estim. internal costs of AC part.)	3877,000
	EC requested contribution	1503,300

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ID	Task Name	Year 1				Year 2				Year 3				Year 4				
		Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1	Qtr 2	Qtr 3	Qtr 4	Qtr 1
58	**JRA1: Test beam infrastructure TBINF**																		
59	**Magnet**																		
60	Delivery and installation																		
61	Magnet ready for operations																		
62	Magnet operation																		
63	Field measurement device																		
64	Field measurement																		
65	Field map																		
66	Magnet report																		
67	Magnet report available																		
68	**Pixel Telescope Integration**																		
69	Upgrade of beam line																		
70	Design of cooling and support																		
71	Construction of telescope infrastructure																		
72	Integration of Analogue Telescope																		
73	Analogue Telescope integrated in beam																		
74	Analogue Telescope operation																		
75	Integration of Final Telescope																		
76	Final Pixel Telescope integrated in beam																		
77	Pixel Telescope available at beam																		
70	Pixel Telescope Integration Report																		
79	Pixel Telescope Integration Report available																		
80	**Pixel Telescope**																		
81	SDC prototype 1 design																		
82	SDC prototype 1 manufacturing																		
83	SDC prototype 1 test																		
84	SDC prototype 1 available																		
85	SDC prototype 2 design																		
86	SDC prototype 2 manufacturing																		
87	SDC prototype 2 test																		
88	SDC prototype 2 available																		
89	IDC prototype design																		
90	IDC prototype manufacturing																		
91	IDC prototype test																		
92	IDC prototype available																		
93	TC design																		
94	TC manufacturing																		
95	TC test																		
96	TC ready																		
97	TC available																		
98	Pixel Telescope Report																		
99	Pixel Telescope Report Ready																		
100	**Data acquisition**																		
101	System development																		
102	Readout for prototype available																		
103	Development of final readout																		
104	Final readout ready																		
105	Tracking software development																		
106	Tracking software available																		
107	Readout system operation																		
108	Data Acquistion Report																		
109	Data Acquistion Report available																		
110	**Validation of Infrastructure**																		
111	Integration with prototype telescope																		
112	Tests with prototype telescope																		
113	Test Report Analogue Telescope																		
114	Test Report Analogue Telescope available																		
115	Integration with final telescope																		
116	Tests with final telescope																		
117	Test Report Final Telescope																		
118	Test Report Final Telescope available																		