A Silicon Recoil Detector for the HERMES Experiment

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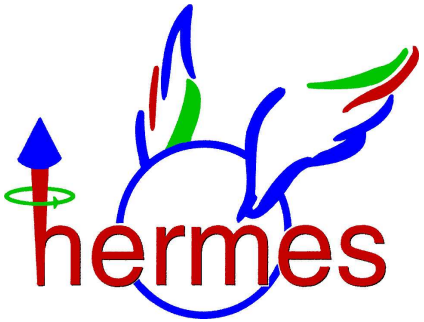
University Gent



On behalf of the HERMES collaboration

Outline

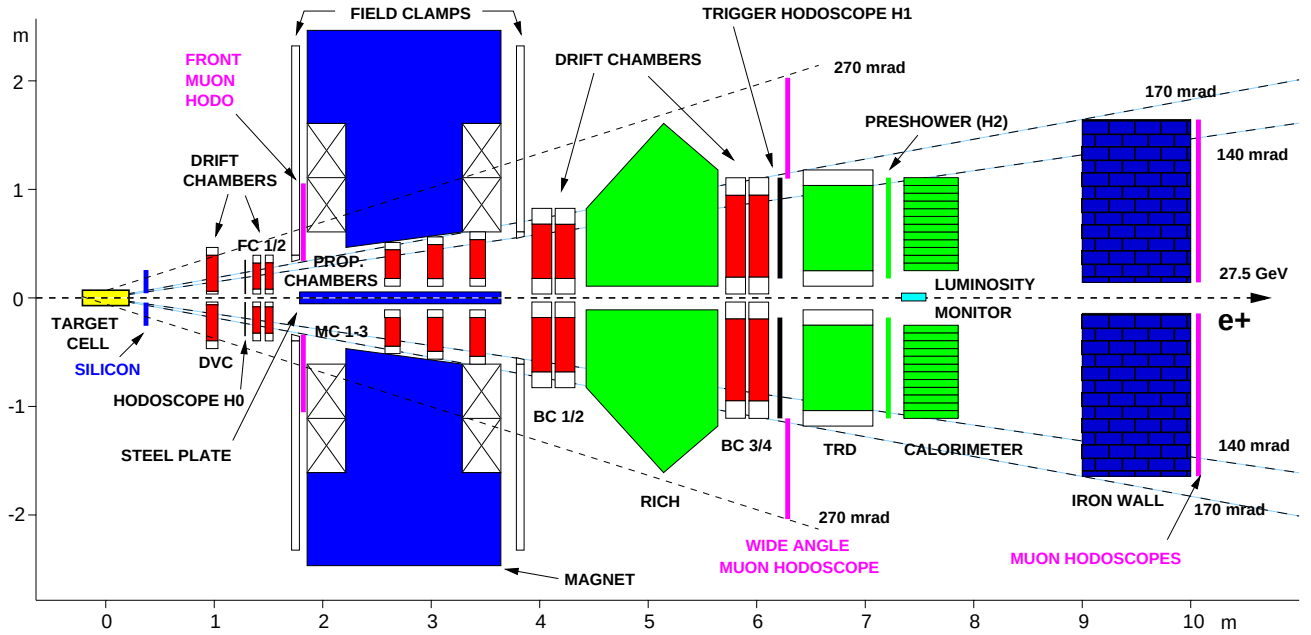
1. The HERMES Experiment
2. Recoil Detector
3. Silicon Recoil Detector
   - Sensors, Frame, Hybrid, Foils, Tests
4. Summary

The HERMES Experiment

- HERA
- MEasurement of Spin

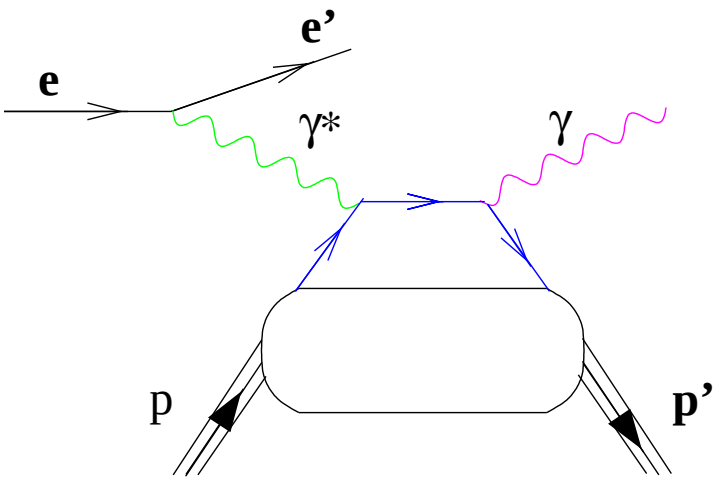
- Experiment at DESY Hamburg
- 27,5 GeV longitudinally polarised $e^{\pm}$ from HERA accelerator
- $< Q^2 >$ = 2.5 GeV^2

The HERMES Experiment

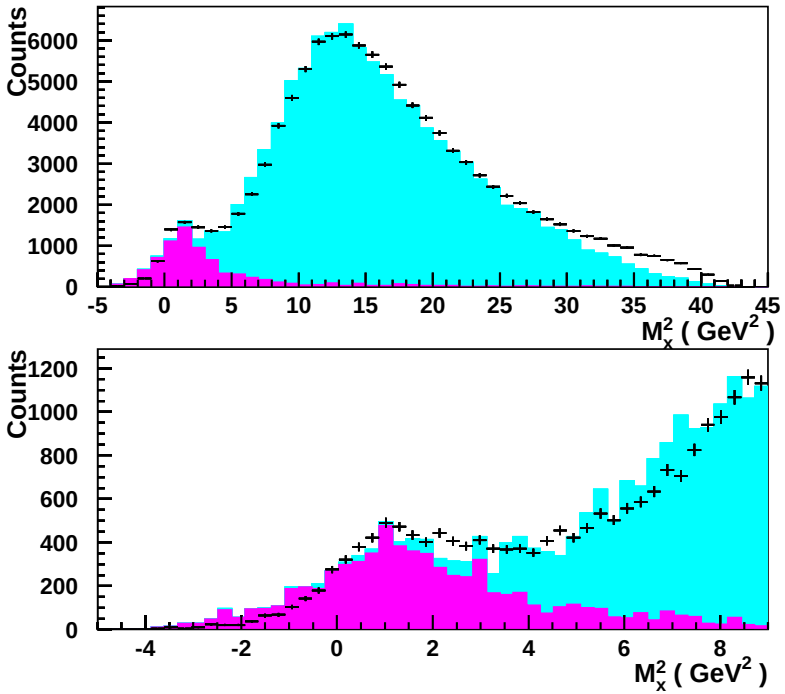


- Internal polarized gas target (H,D ,He,Ne,Kr)
- Tracking: Silicon, Drift Chambers
- PID: RICH, TRD, E/p Calorimeter

The HERMES Experiment



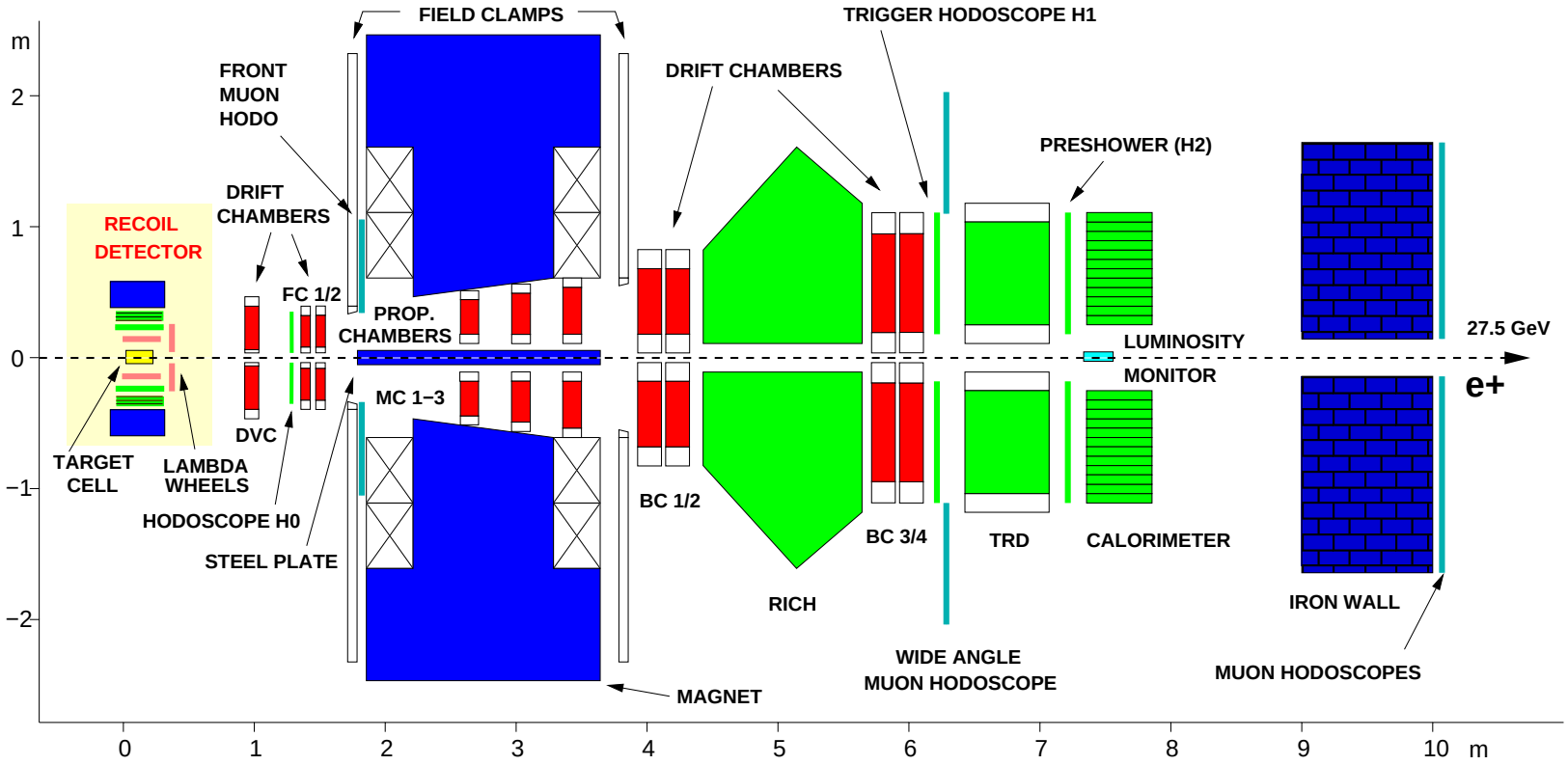
Exclusive Processes:
initial and final state fully known !



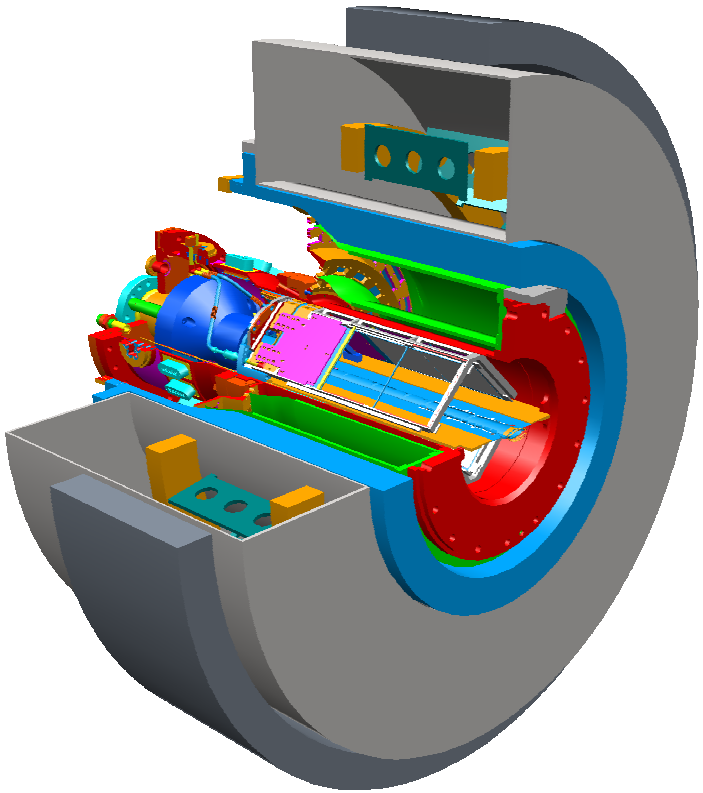
Deeply Virtual
Compton Scattering

A Recoil Detector for HERMES

To improve the measurement of exclusive processes a **Recoil Detector** is presently being built.



A Recoil Detector for HERMES



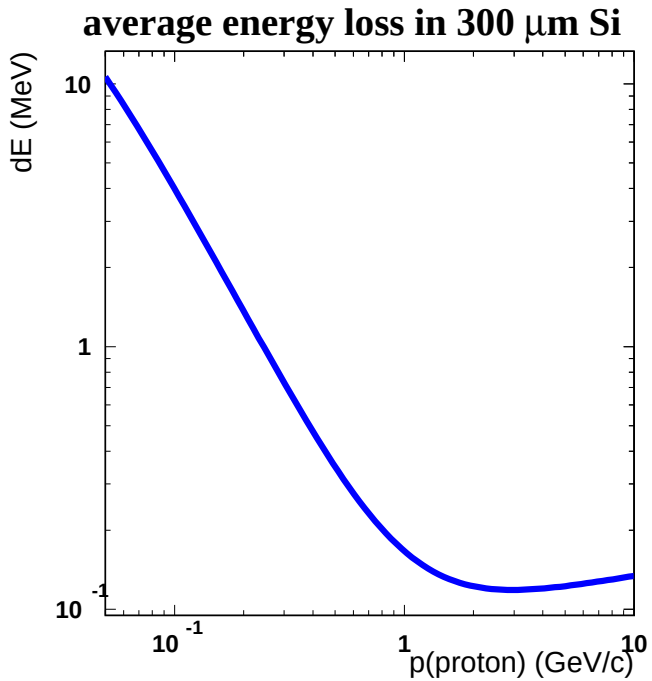
- Silicon measuring low momenta protons
- SciFi for momentum and tracking
- Photon detector to improve exclusivity
- Superconducting Magnet providing field for SciFi
- A new collimator to reduce background hits

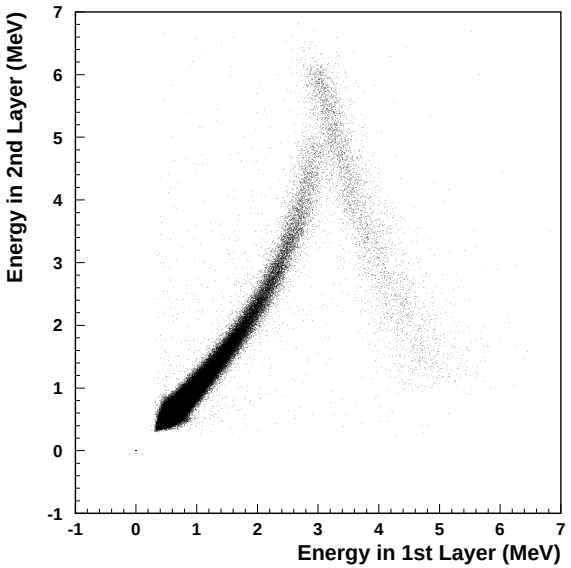
Recoil Silicon Detector

- Inside beam vacuum
- Diamond shape around target cell
- 2 layers of silicon
- 76 % of ϕ
- $23^o < \theta < 80^o$

- Project of DESY,Erlangen,Gent,Glasgow

Recoil Silicon Detector

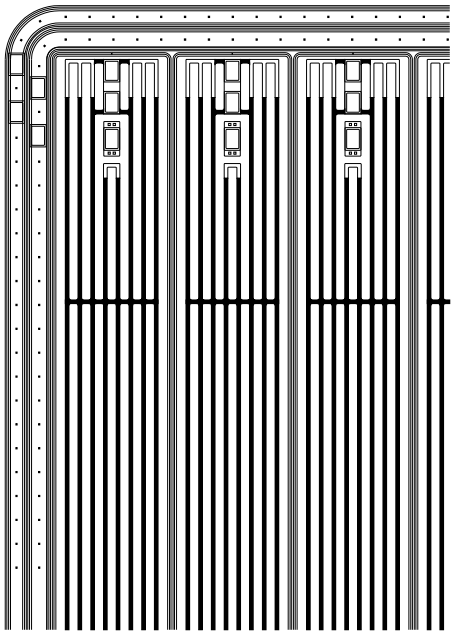


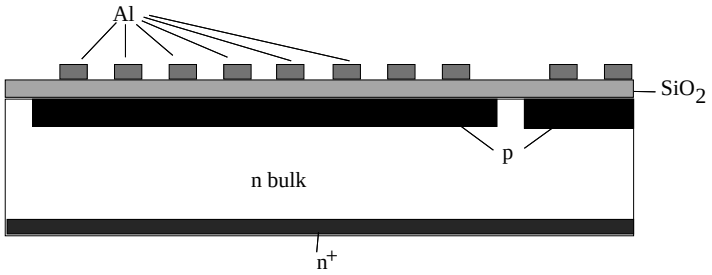


- Large Dynamic Range required
- Vacuum compatible components

Silicon Sensors

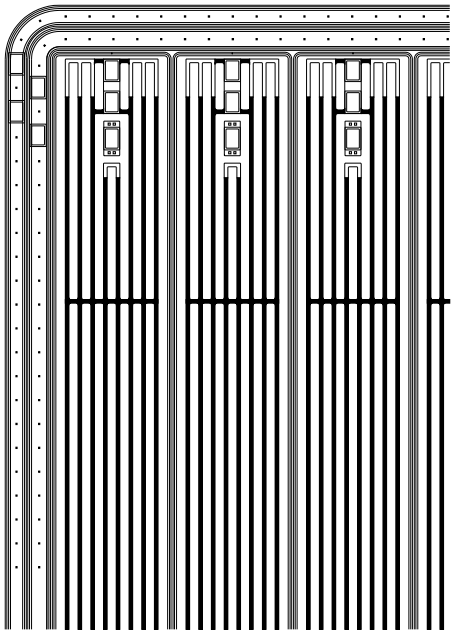
TIGRE sensors

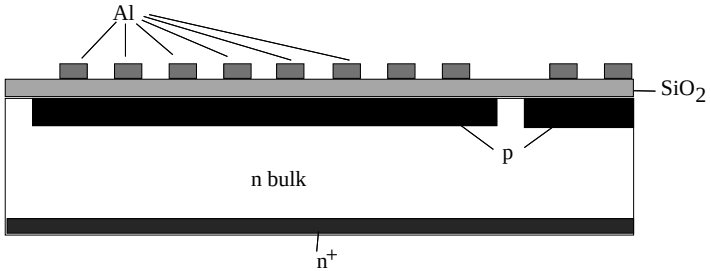




- Largest commercially available silicon sensor
- Double sided
- 99 $\times$ 99 mm^2, 300 μm thick
- 758 μm pitch
- Strip width: 702 μm
- SiO_2 layer ensures AC-coupling

TIGRE sensors





- Depletion voltage: 50 V
- Total capacitance p (n) : 52 pF (70 pF)
- Changes to original design:
  - Thicker SiO_2 layer
  - Bias Resistor $50\ M\Omega \rightarrow 6.5\ M\Omega$

TIGRE sensors

All TIGREs have been tested:

- Bias resistors p/n side for 3 strips
  - 3 strips: left, middle, right
- Interstrip resistance for 3 strips
- Coupling capacitor resistance for 3 strips
- Overall I/V–C/V characteristics: diode functionality, depletion voltage
- Long Term Test

The Holding Frame

A Holding Frame

Requirements for the holding frame:

- ➜ Sufficient stability
- ➜ Suitable for vacuum applications
- ➜ Thermal expansion coefficient close to that of silicon

A Holding Frame

	Silicon	Aluminium	Graphite	Shapal-M	Unit
Resistance	$10^{-4} - 10^{4}$	$5 \cdot 10^{-6}$	0.02	10^{12}	$\Omega \cdot cm$
Thermal Expansivity	2.6	23	7.4	4.4	$\frac{10^{-6}}{K}$
Modulus of Elasticity	170	70	15	160	GPa
Thermal Conductivity	150	130	65	100	$\frac{W}{m \cdot K}$
Outgassing Rate	n.a.	10^{-10}	$8 \cdot 10^{-11}$	$2.3 \cdot 10^{-11}$	$\frac{\text{mbar} \cdot l}{s \cdot \text{cm}^2}$
Costs per frame	n.a.	30	110	1200	€

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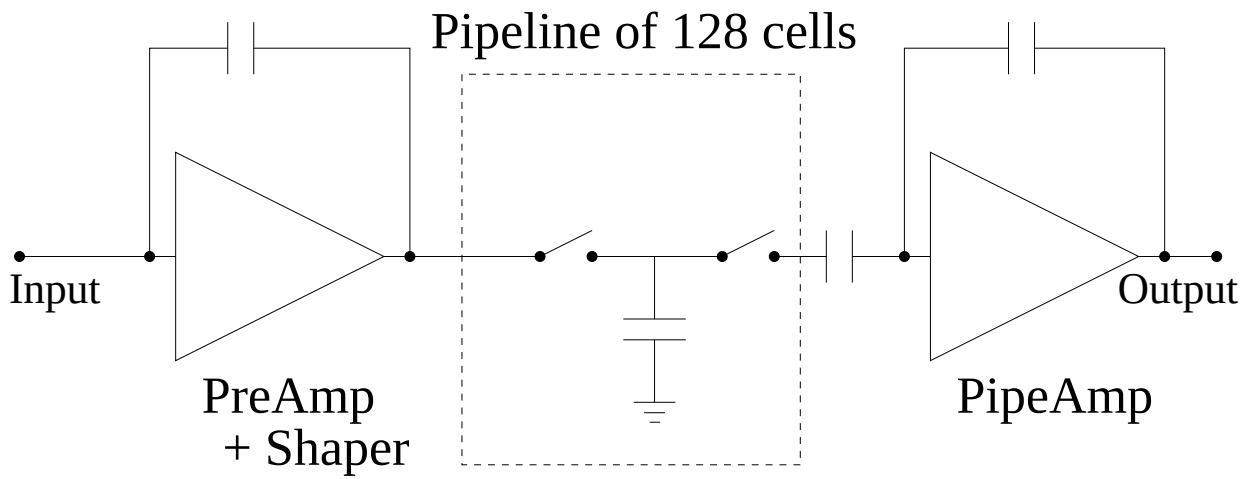
Go for Shapal-M

➠ Sensors are glued with two component epoxy glue at 150^{o}

Readout Hybrid

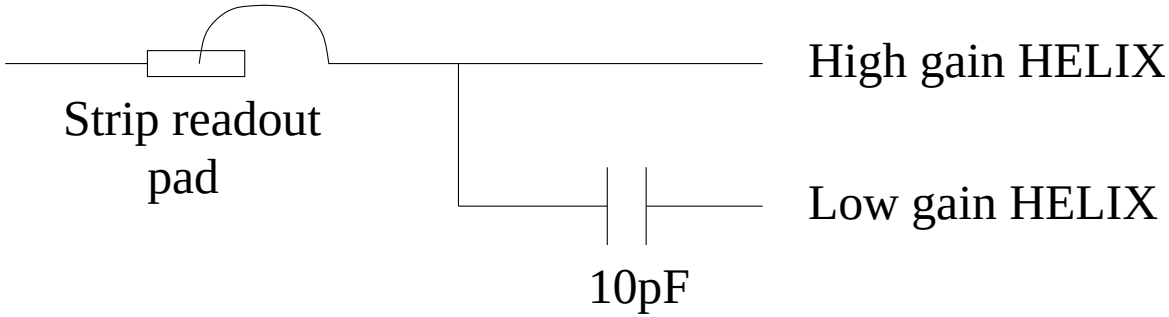
Readout Hybrid

Two readout chip candidates were tested: APC and HELIX128-3.0



Readout Hybrid

Extend Dynamic range with Charge division method:



Readout Hybrid

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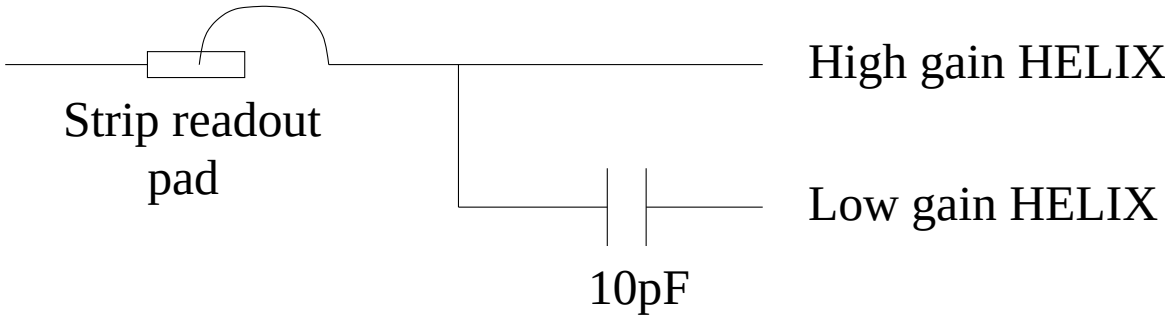
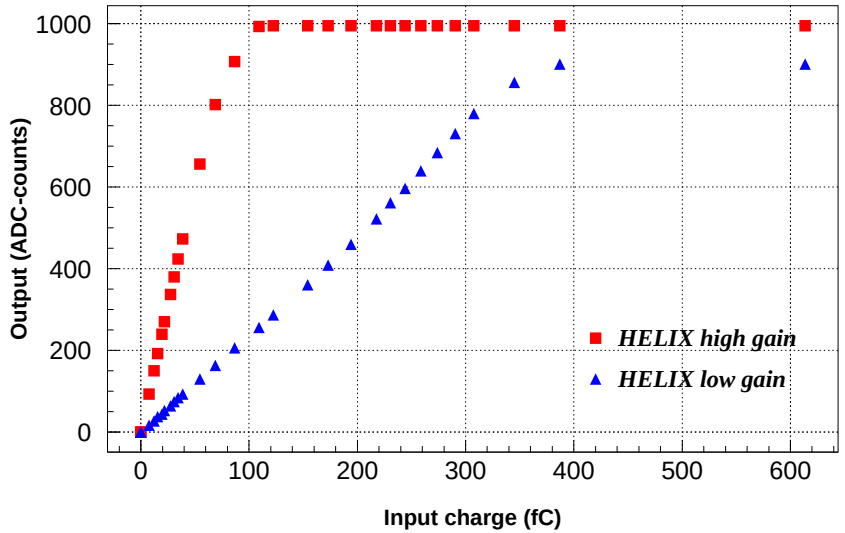
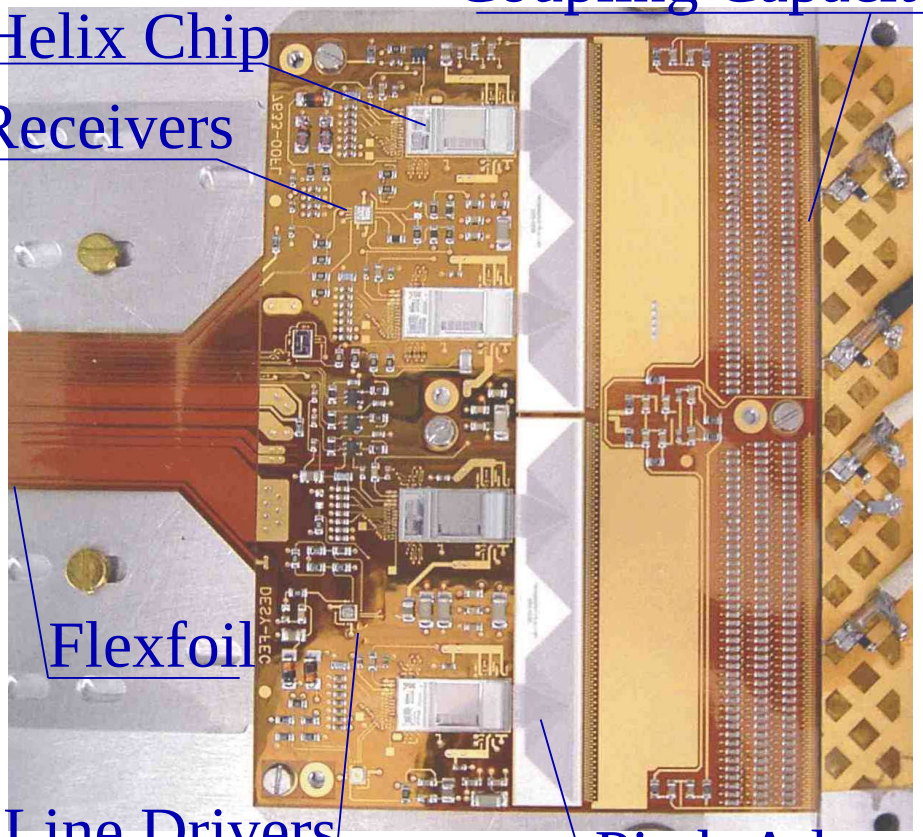


- Sufficient Dynamic Range
- HELIX already used in HERMES

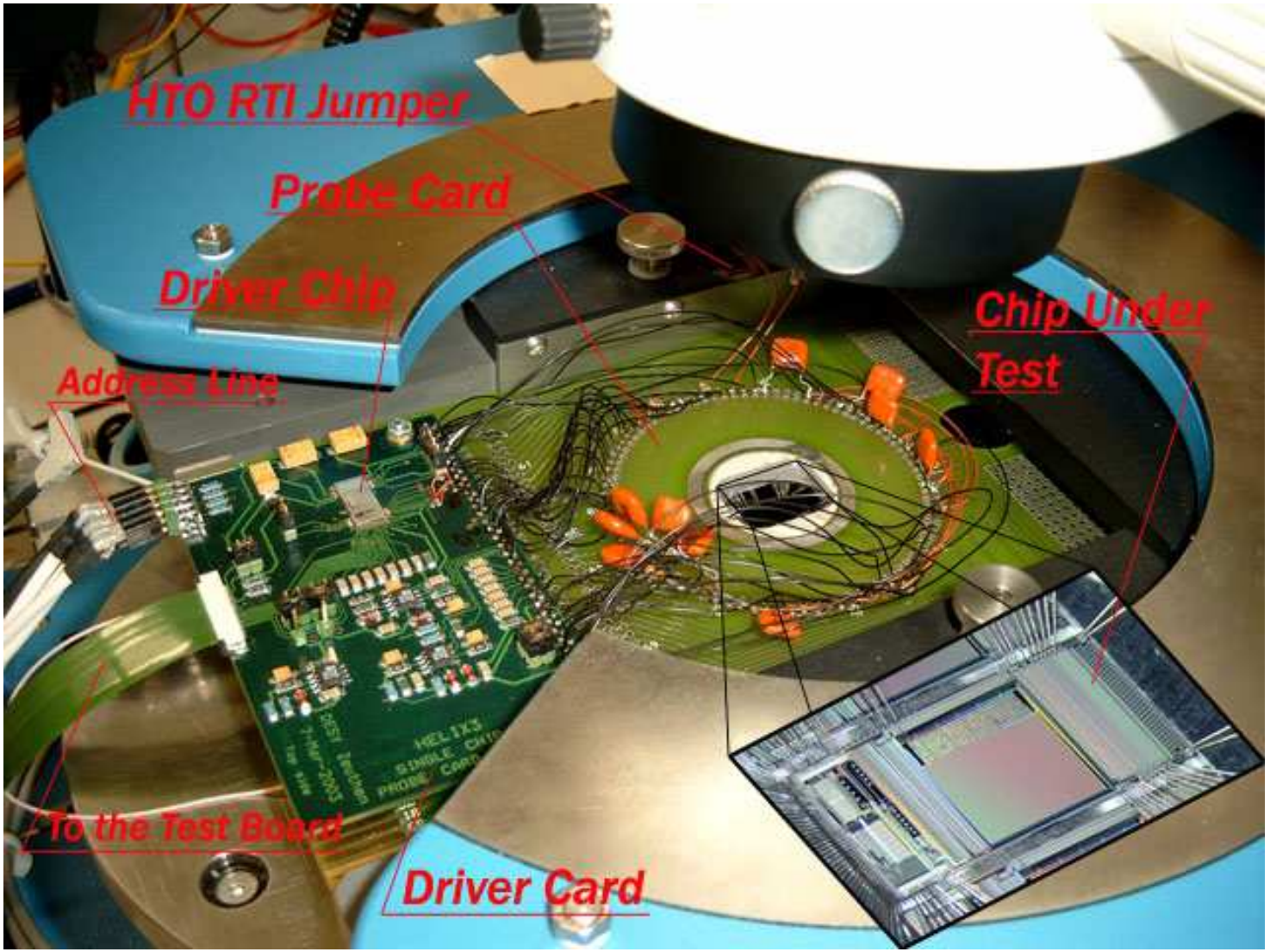


Readout Hybrid



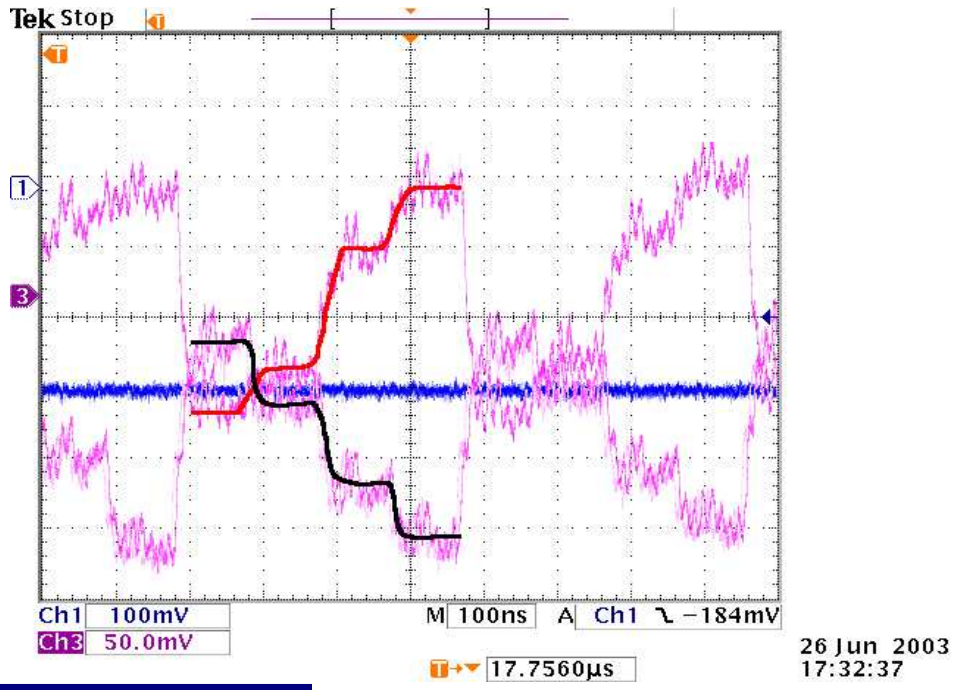
- 4 layers, with kapton cores
- Glued to aluminum heatsink

Chip Tests


HTO RTI Jumper
Probe Card
Driver Chip
Address Line
Chip Under Test
To the Test Board
Driver Card

Chip Tests

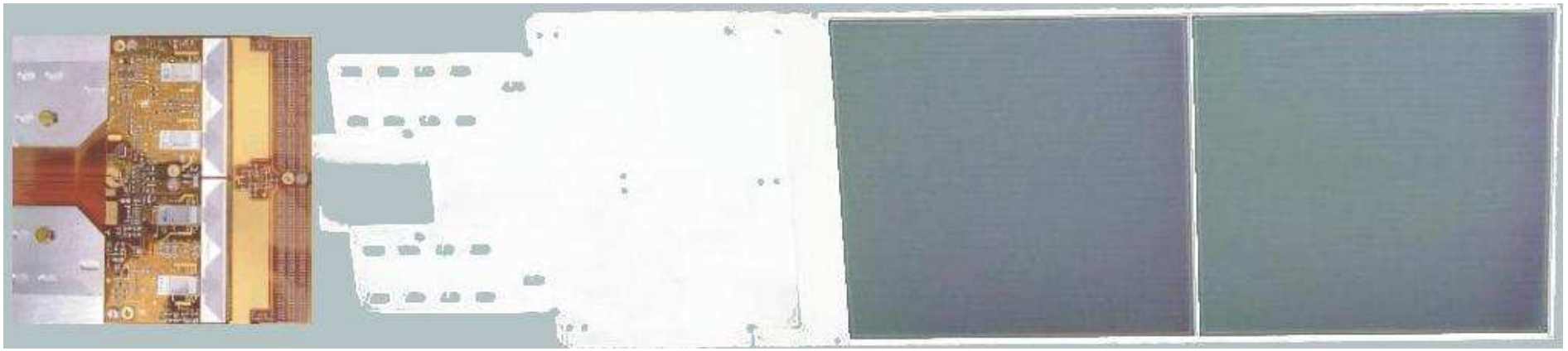
- Basic functionality (addressing, programming)
- Uniformity checked with internal testpulse



Chip Tests

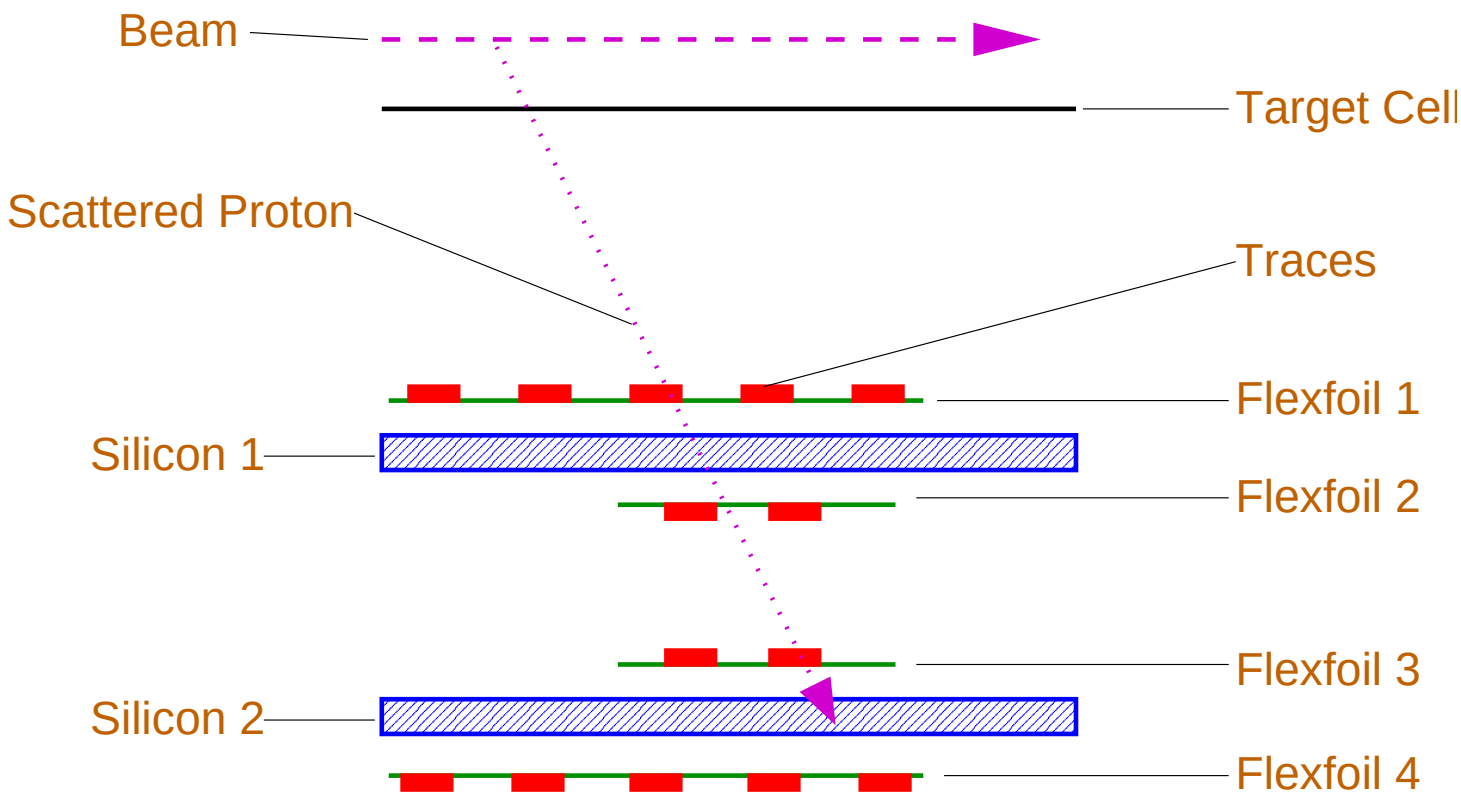
- 372 chips tested
  - 64 chips needed
  - 153 Class A chips
  - 100 Class A1

Kapton Readout foils



➵ Readout Foils needed !

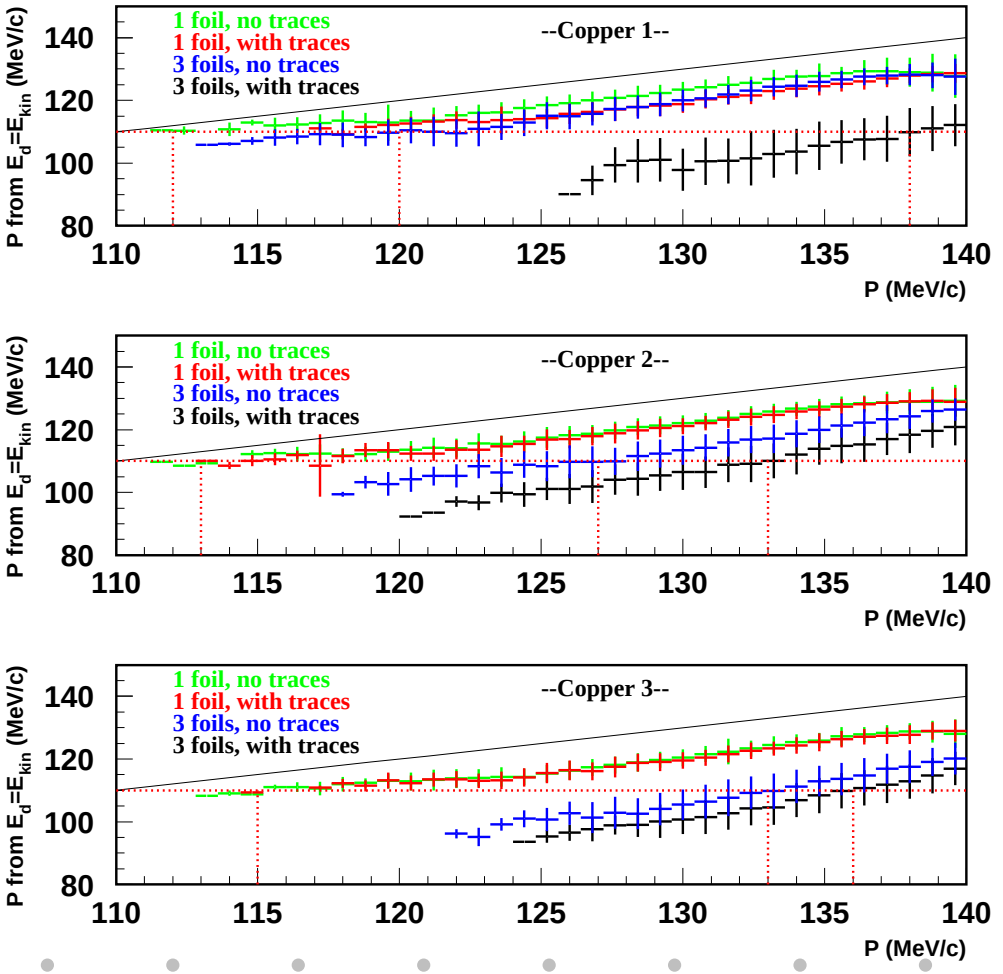
Kapton Readout foils



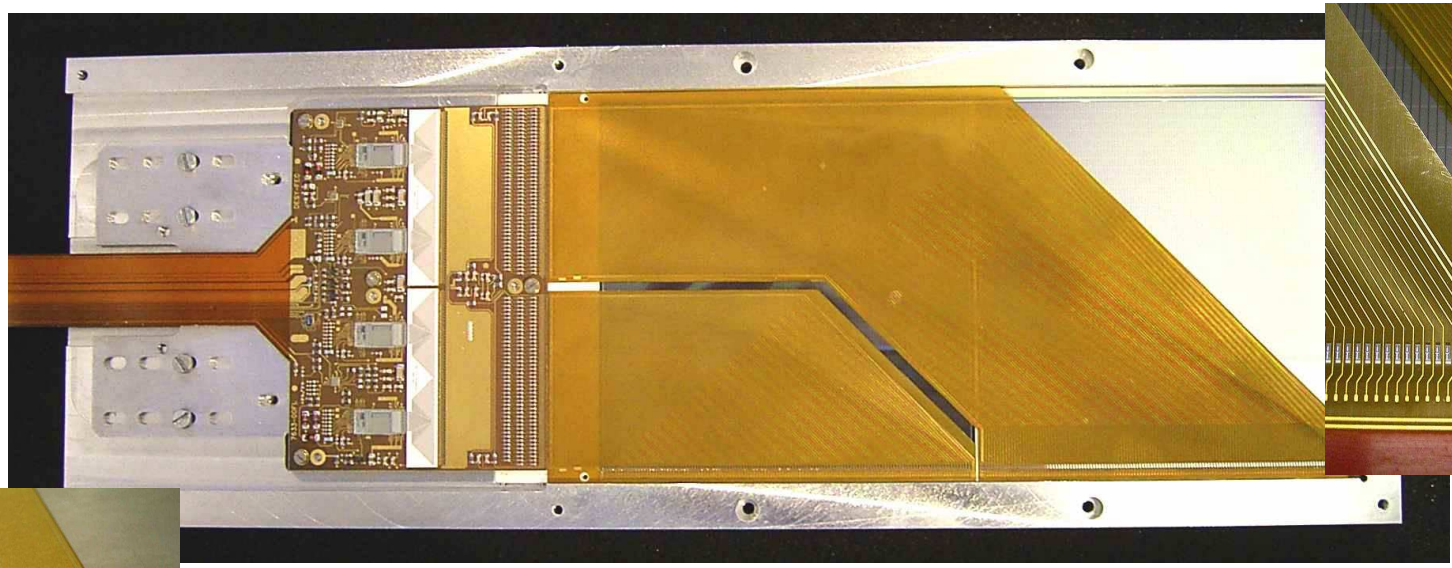
Kapton Readout foils

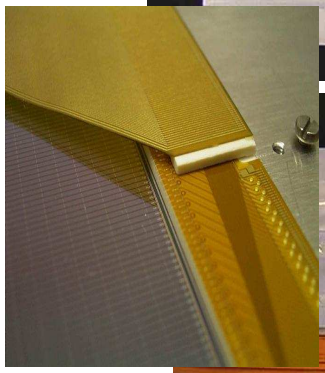
➟ Different designs: (μm)

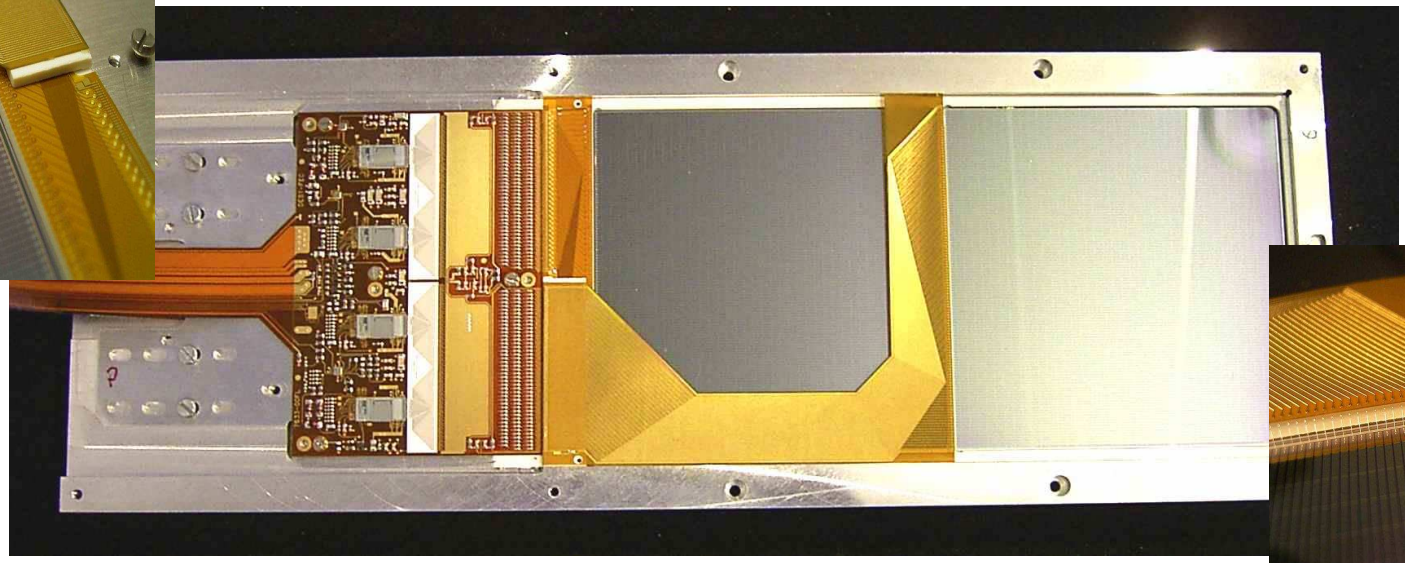
	C1	C2	C3
Kapton	25	50	50
Copper	17	5	5
Nickel	5	5	–
Gold	0.1	0.1	–
Kapton2	–	–	25

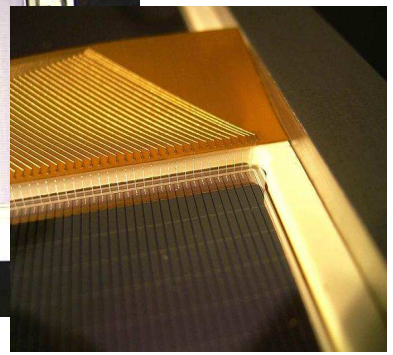


An SRD Module

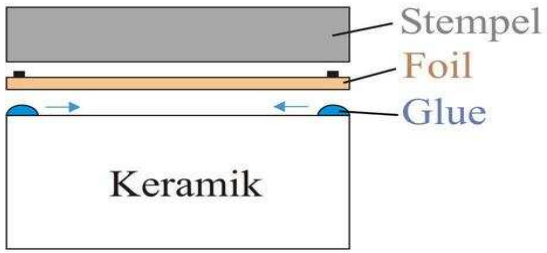




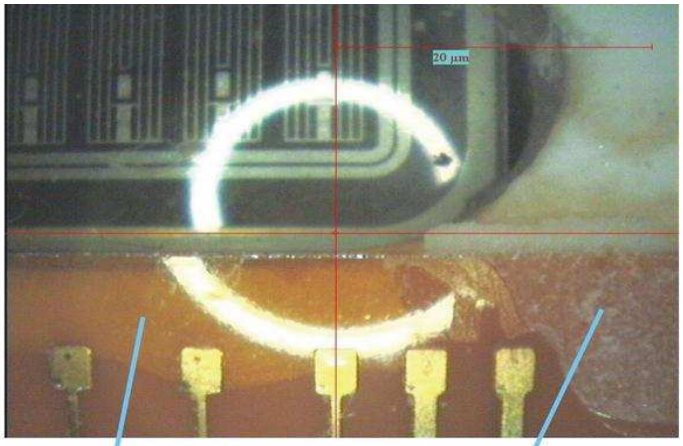




Assembly-Glueing

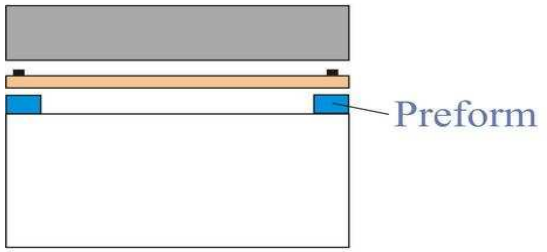


Glue : 2-Component Epoxy
Epotek H77 (Polytec)

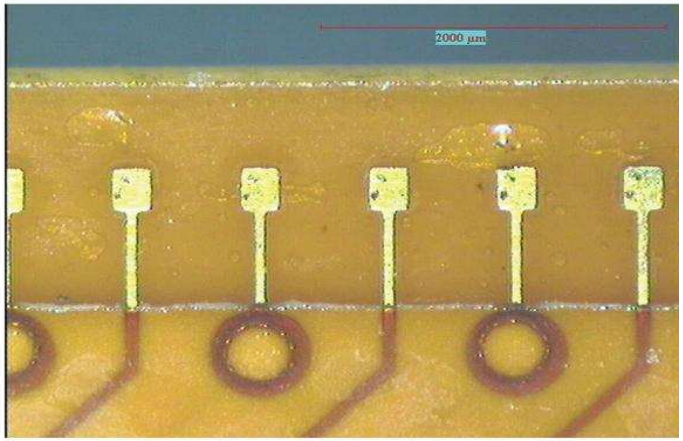


Air bubbles below bondpads

Glue on foil

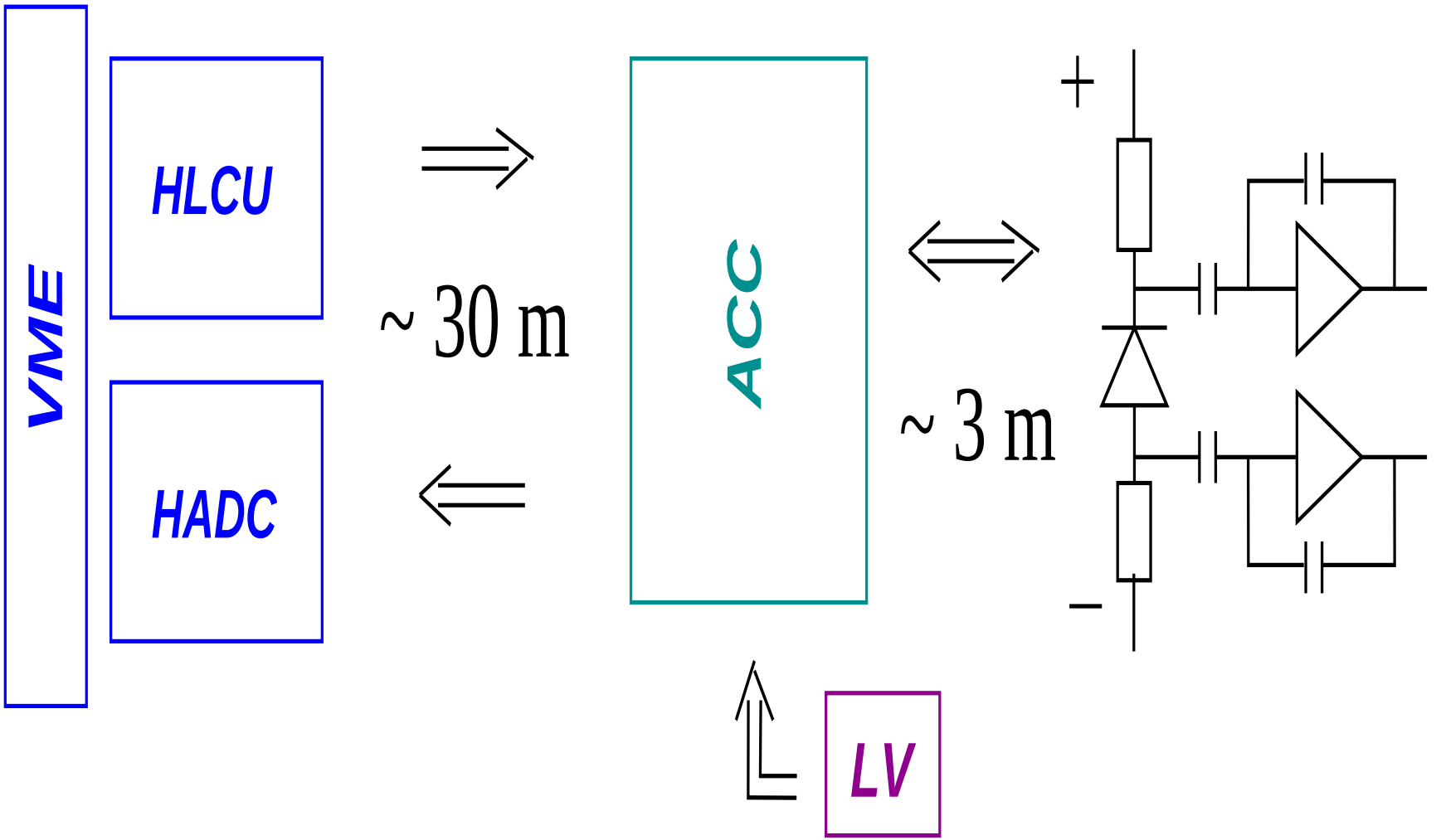


Preform : Woven material filled
with Epoxy Glue.
Polytec TFT D18-1 SP4



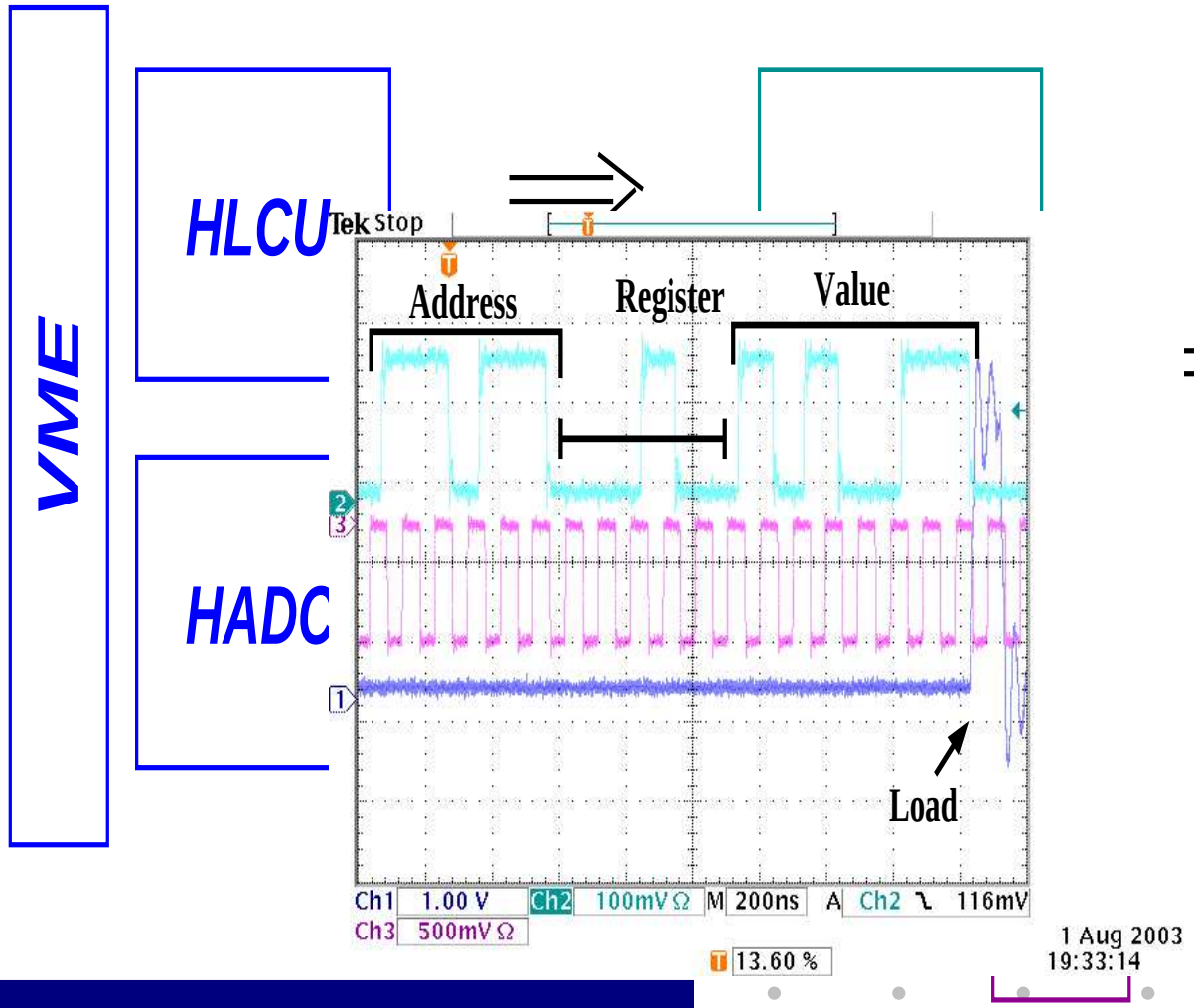
Readout Scheme

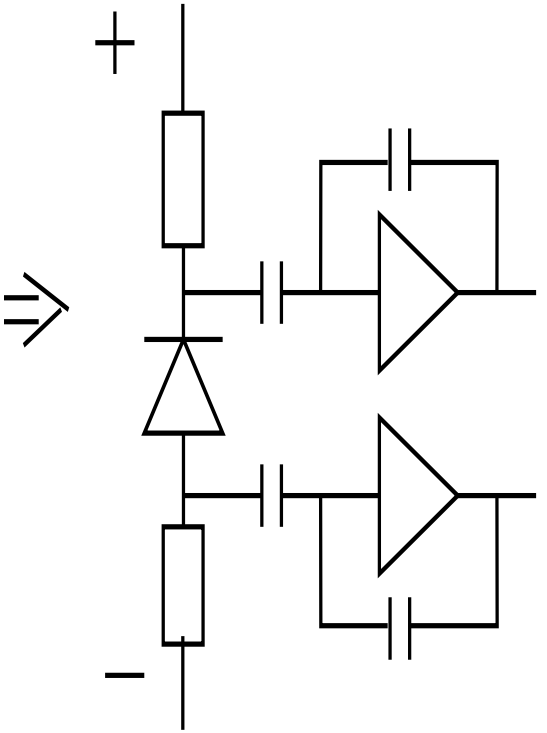
Readout Scheme



Readout Scheme

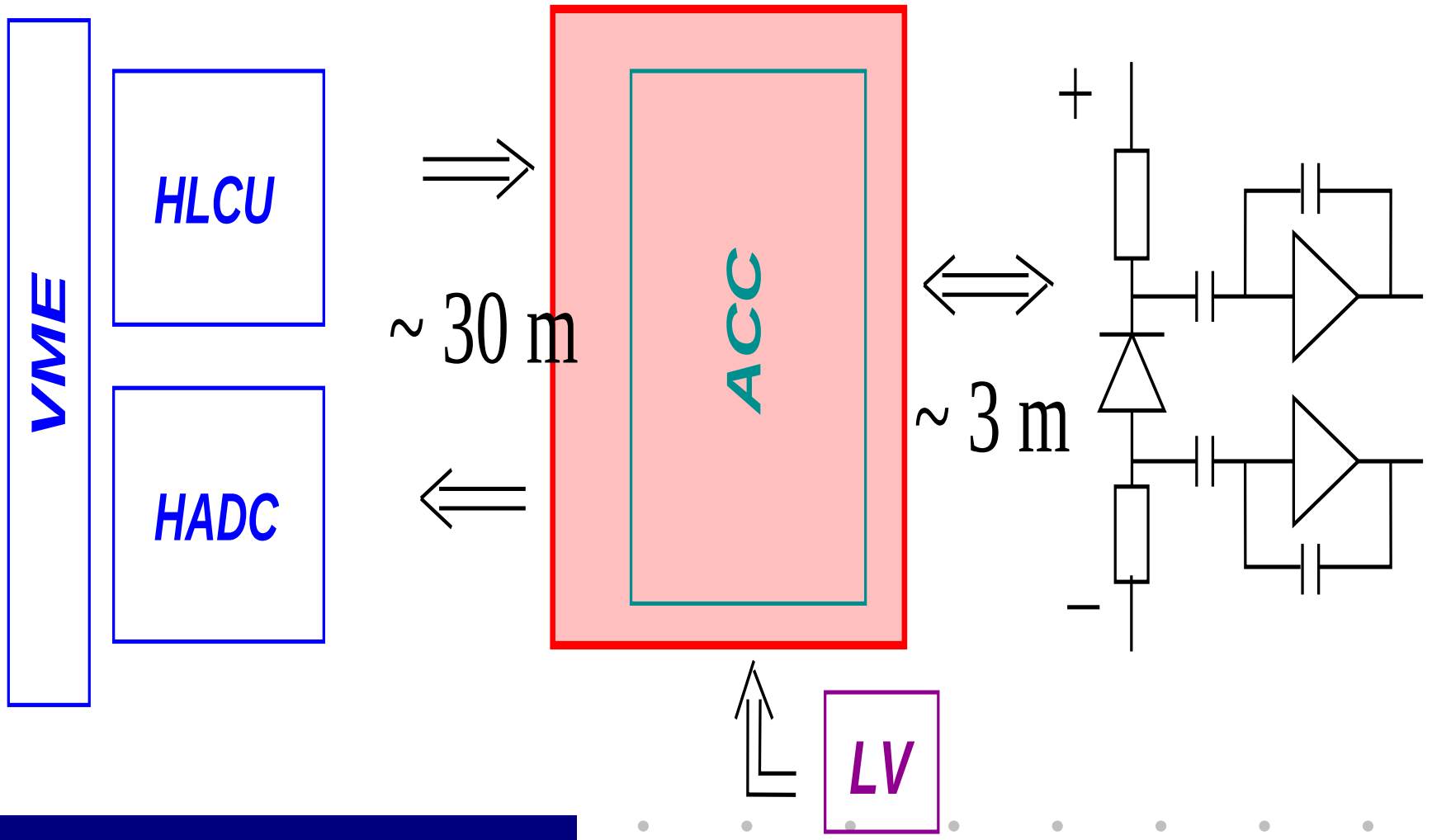
HLCU: Programming,Clock,Triggering





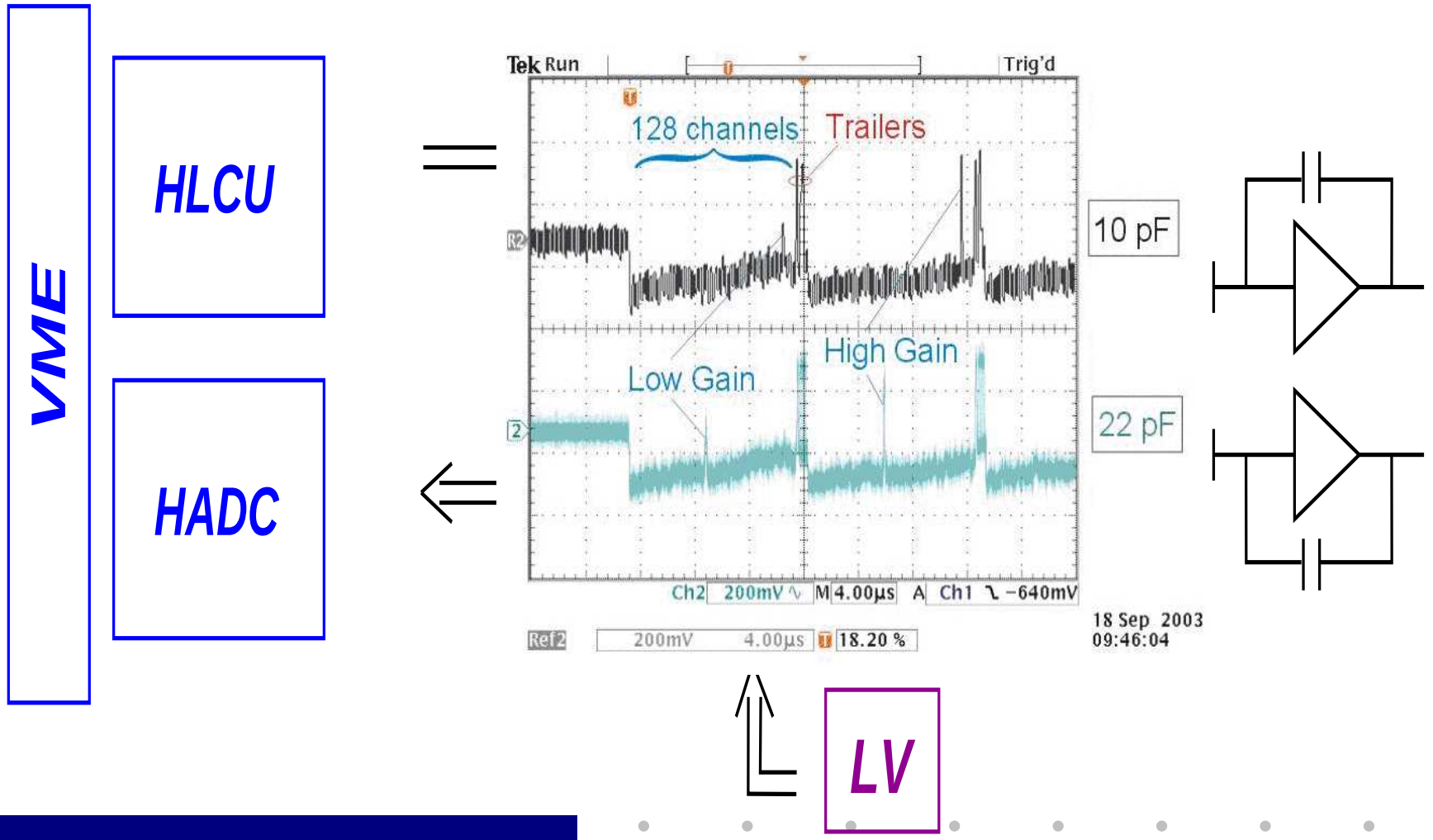
Readout Scheme

ACC: Repeater board, drivers/receivers



Readout Scheme

HADC: ADC, CMC, Zero Suppression



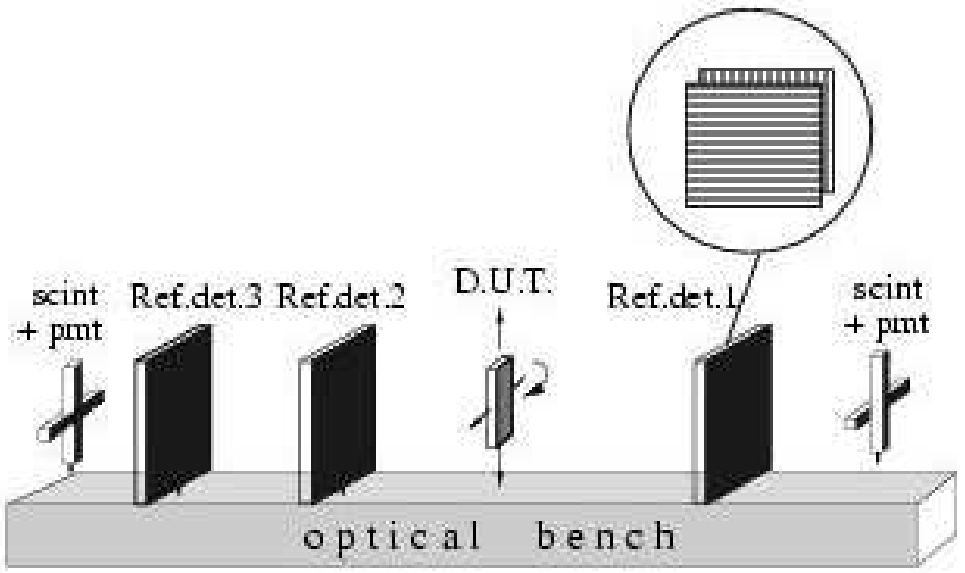
Prototype Testing

Prototype testing

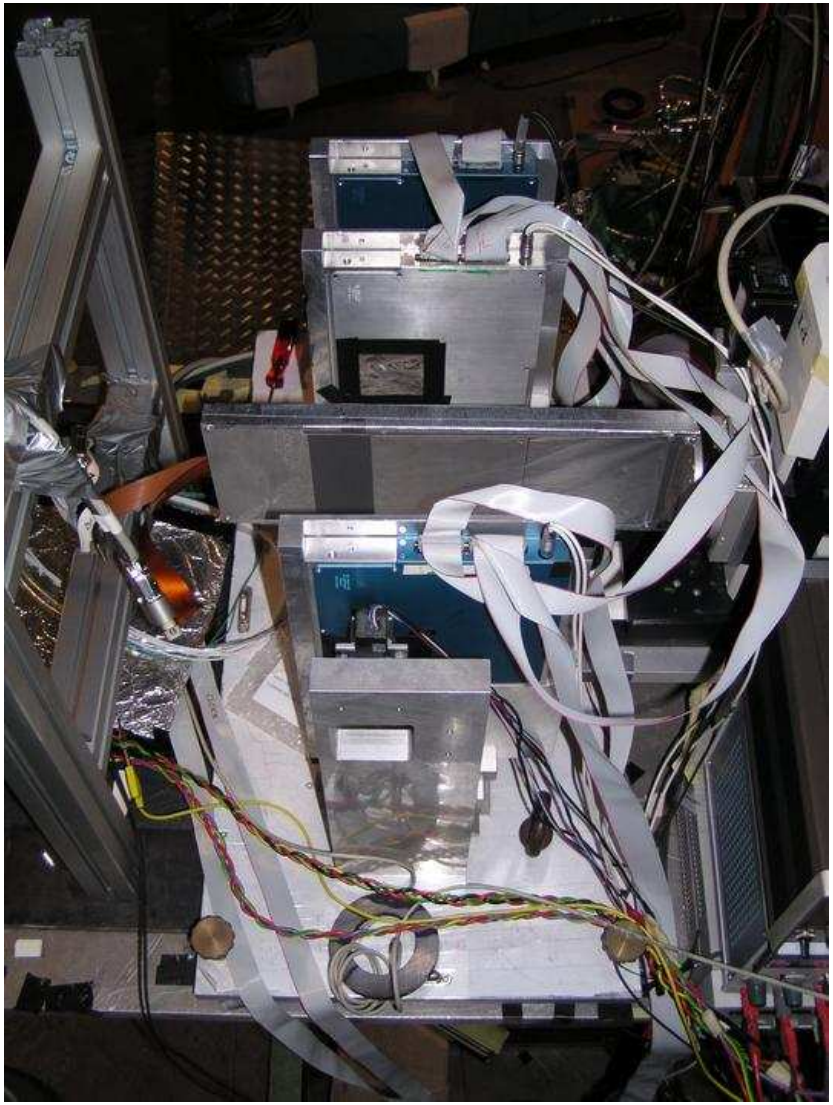
- Testbeams
  - DESY: MIP
  - Erlangen: Low Energy protons
- Laser Test Stand
- Detailed noise optimisation
- RF tests $\rightarrow$ Z. Ye's talk (T401.5)
- Parameter tests $\rightarrow$ I. Hristova's talk (T301.8)

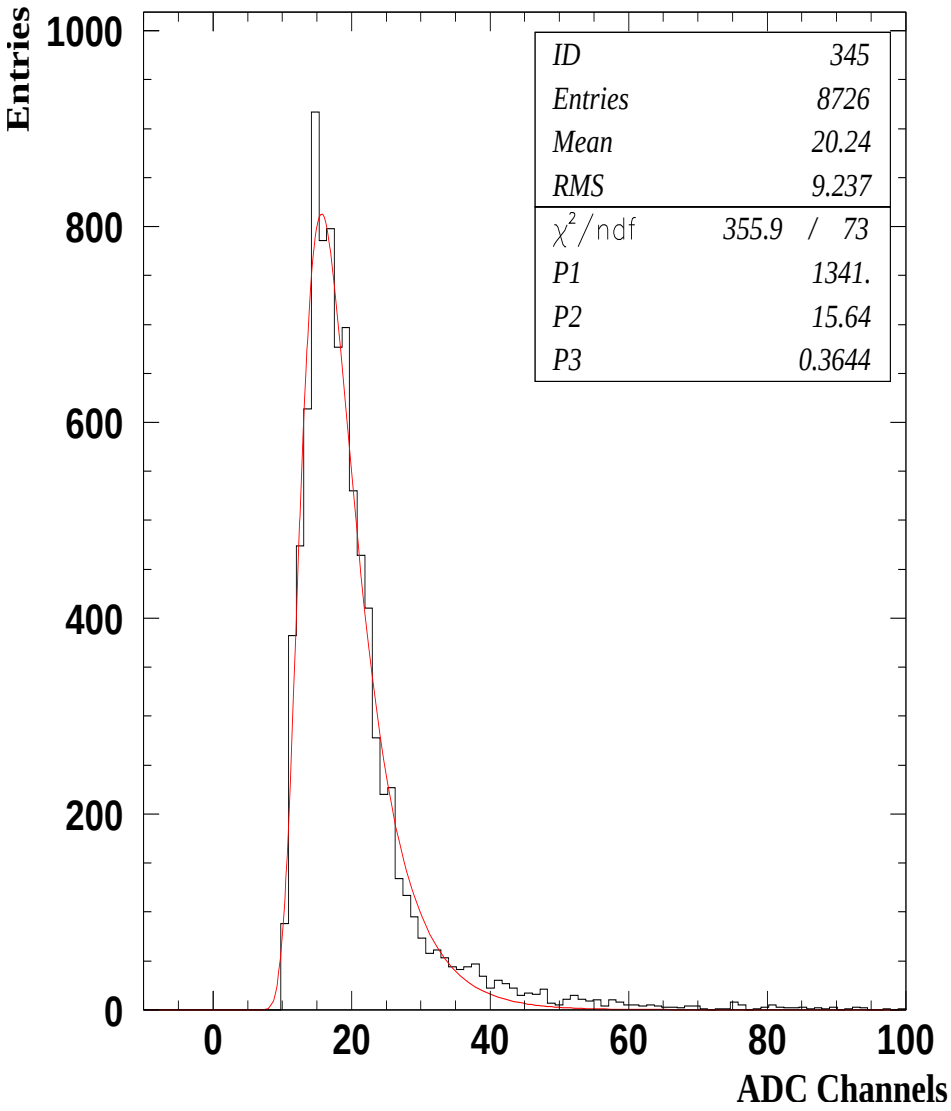
Testbeam at DESY

- Electrons from pre-accelerator DESYII (1-6 GeV)
- Use Zeus Telescope
  - 6 Reference detectors
  - $\frac{S}{N} > 60$
  - pitch 25 (50) μm

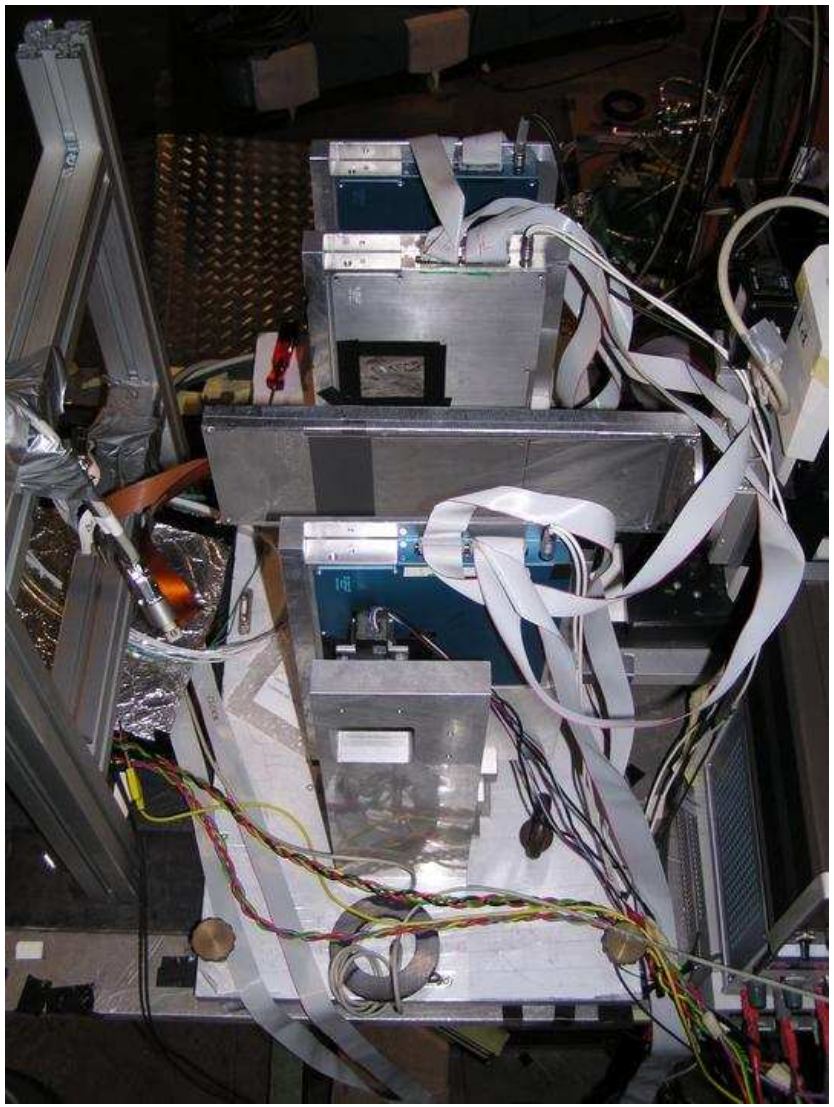


Testbeam at DESY





Testbeam at DESY



'*Pre*' Prototype:

- ➜ $\frac{S}{N} = 7.5$
- ➜ $\epsilon = 99.73 \pm 0.04\%$

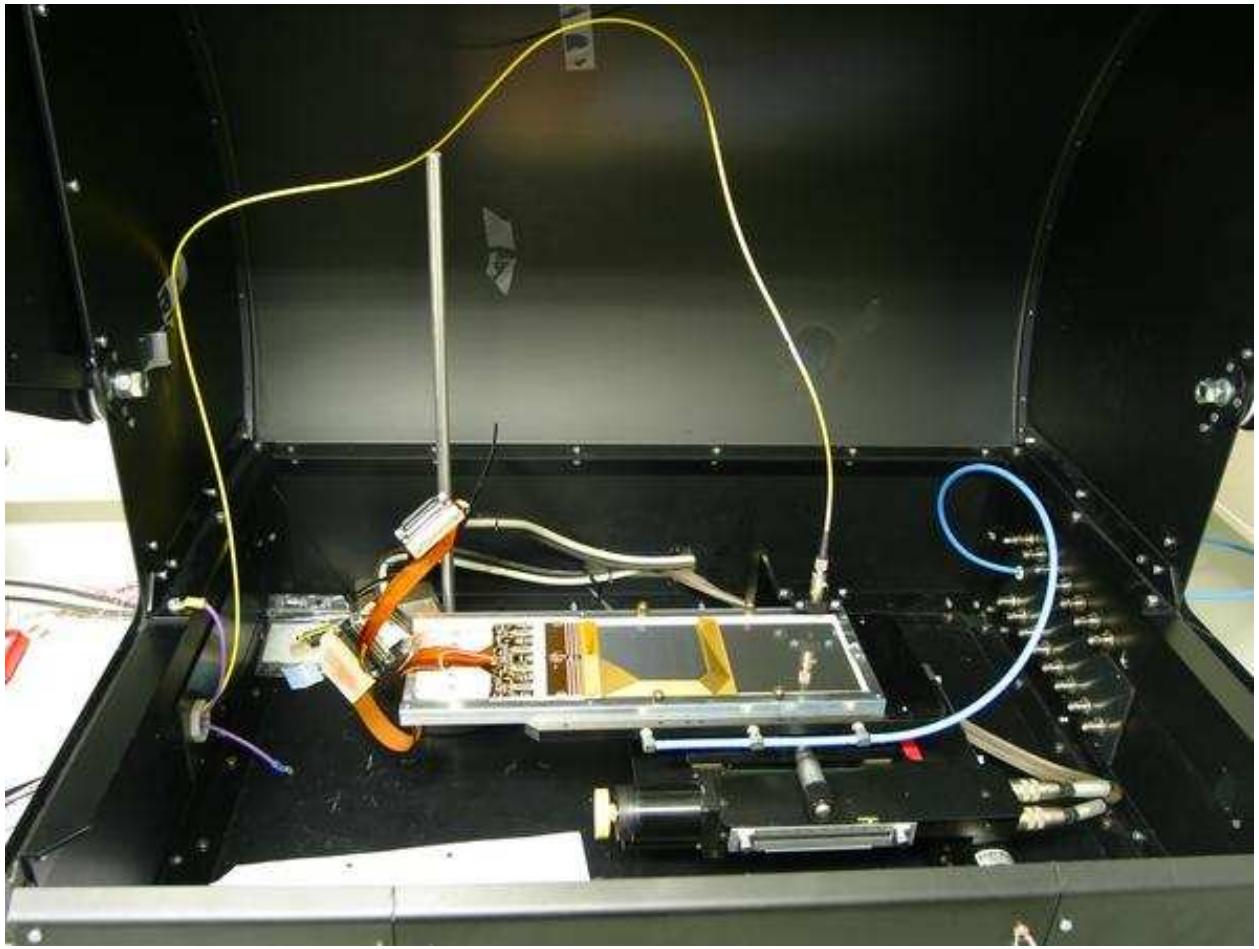
'*Final*' Prototype:

- ➜ $\frac{S}{N} \sim 6.2$

Erlangen Testbeam

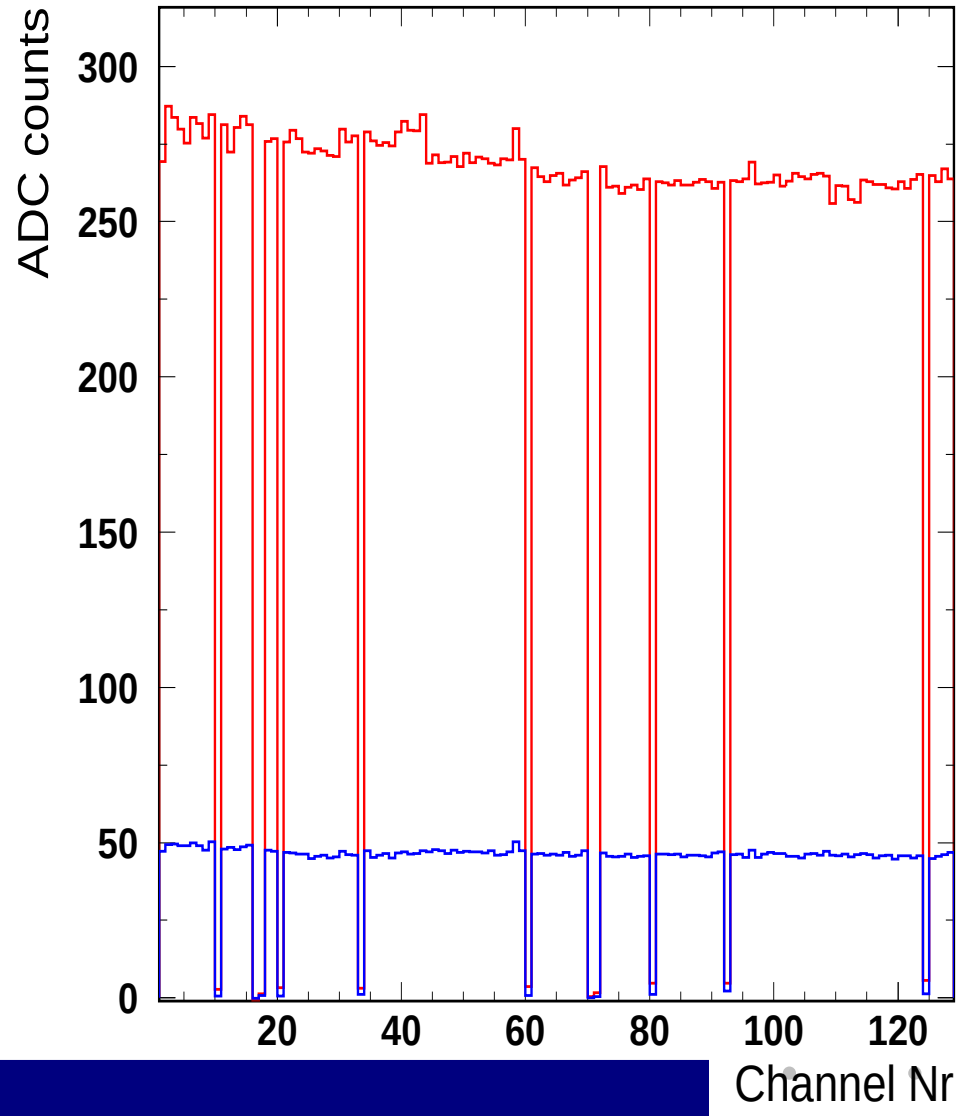
- Double Van De Graaff Accelerator
- Protons up to 11 MeV
- First tests being analysed

Laser Test



- Black Box
- Red Laser
- X-Y Table
- Spot $\sim 20\mu m$

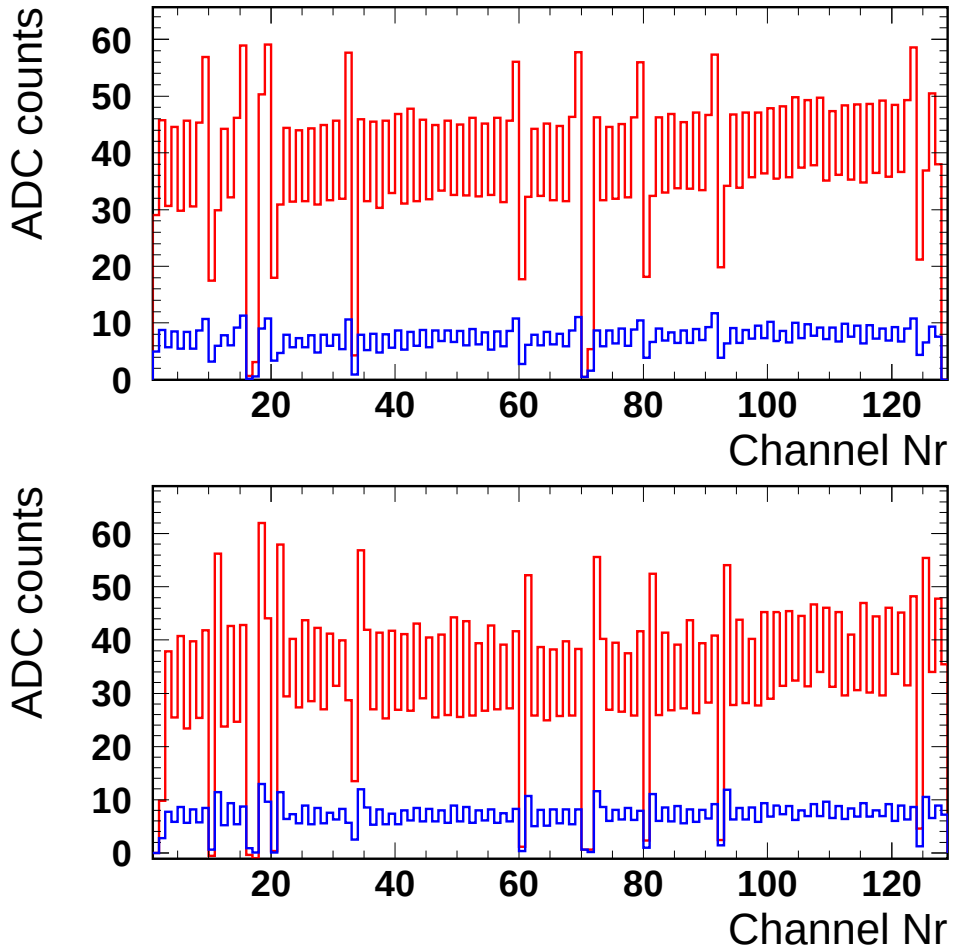
Laser Test



- Uniformity
- Linearity
- Pipe Spread

Laser Test

Asymmetric Crosstalk $\sim 5.1\%$



➠ Similar as reported by other groups

Summary

- Development of a Silicon Recoil Detector for HERMES
- Mechanical construction fixed and working
- First SRD module being tested and optimised
- Test installation in 2004