Instrumentation of the very Forward Region of a Linear Collider Detector

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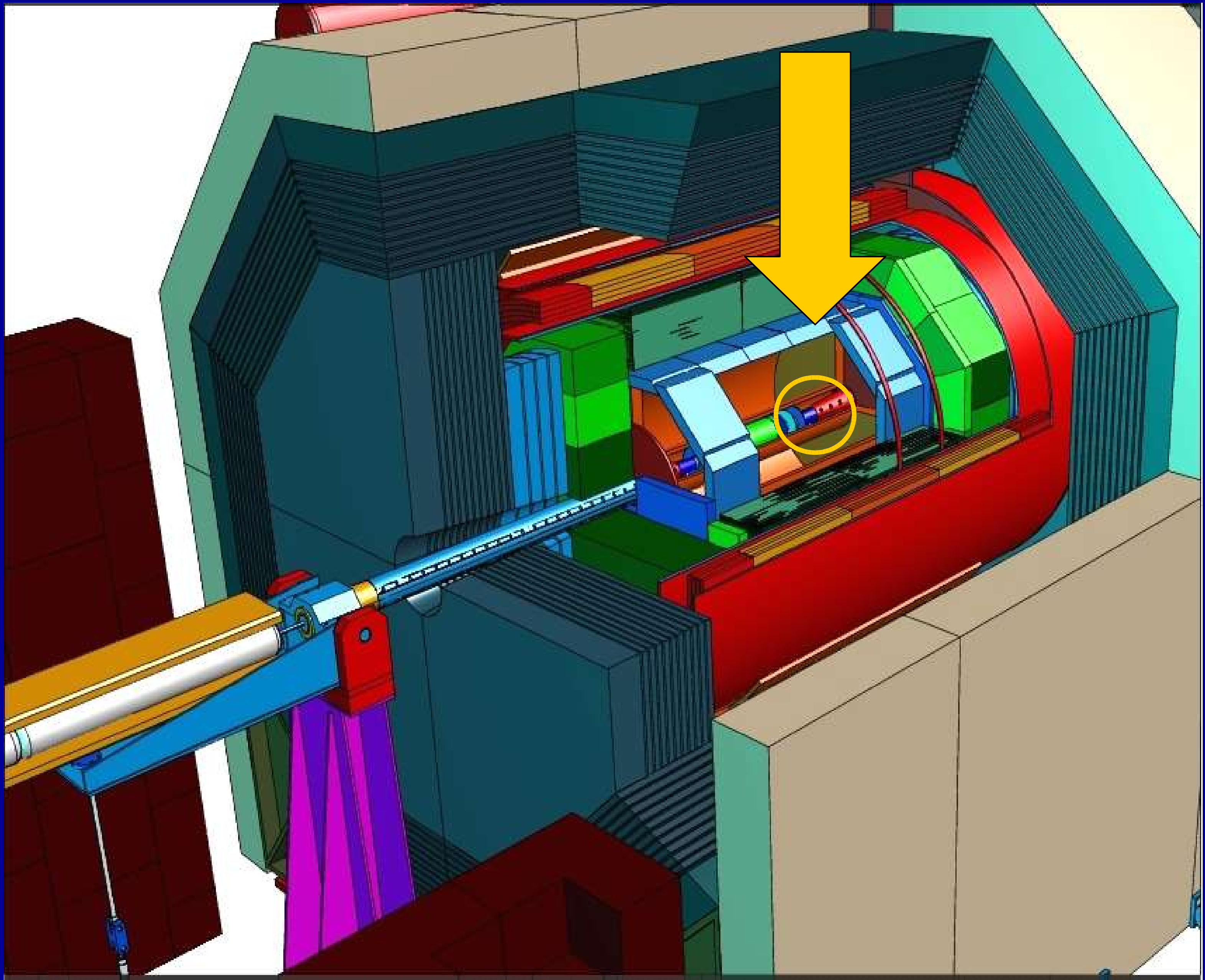
Colorado, Cracow, DESY(Zeuthen), JINR Dubna, London (UC), Minsk (BSU), Prague, Protvino (IHEP), Tel Aviv
Collaboration

The very Forward Calorimeter Collaboration

see: PRC R&D 01/02

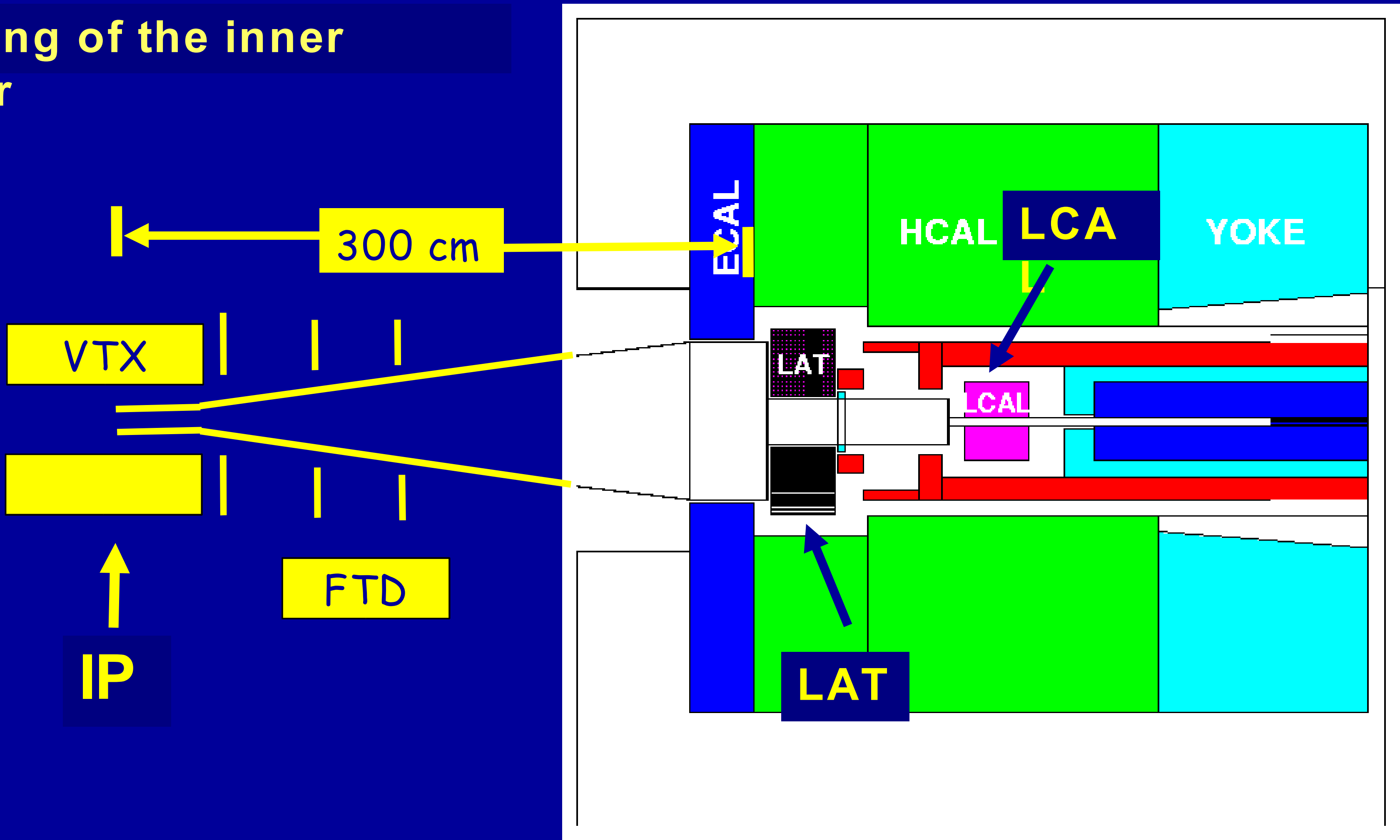
The TESLA Detector



Functions of the very Forward

- **Measurement of the Luminosity (LAT)**
- **Fast Beam Diagnostics (LCAL)**
- **Shielding of the inner Detector**

- **Detection of Electrons and Photons at very low angle – extend hermiticity**



•Measurement of the Luminosity

Gauge Process: $e^+e^- \longrightarrow e^+e^- (\gamma)$

Goal: 10^{-4} Precision (LEP: $3.4\otimes 10^{-4}$ exp.; $5.4\otimes 10^{-4}$ theor.)

Physics Case: σ_Z for Giga-Z ,

Two Fermion Cross Sections at high Energy, Threshold Scans

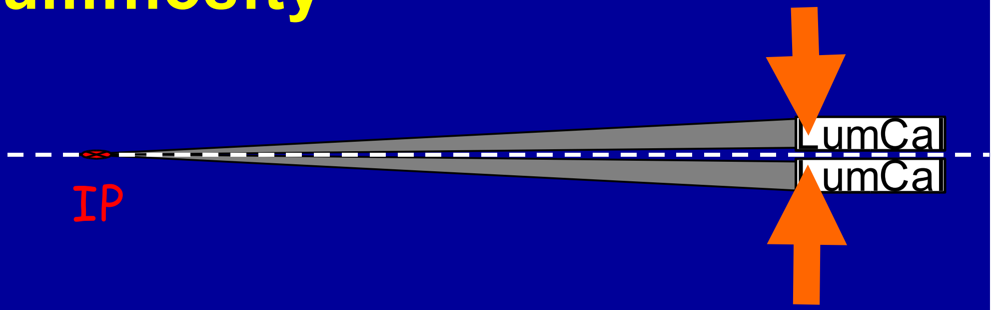
- Technology: Si-W Sandwich

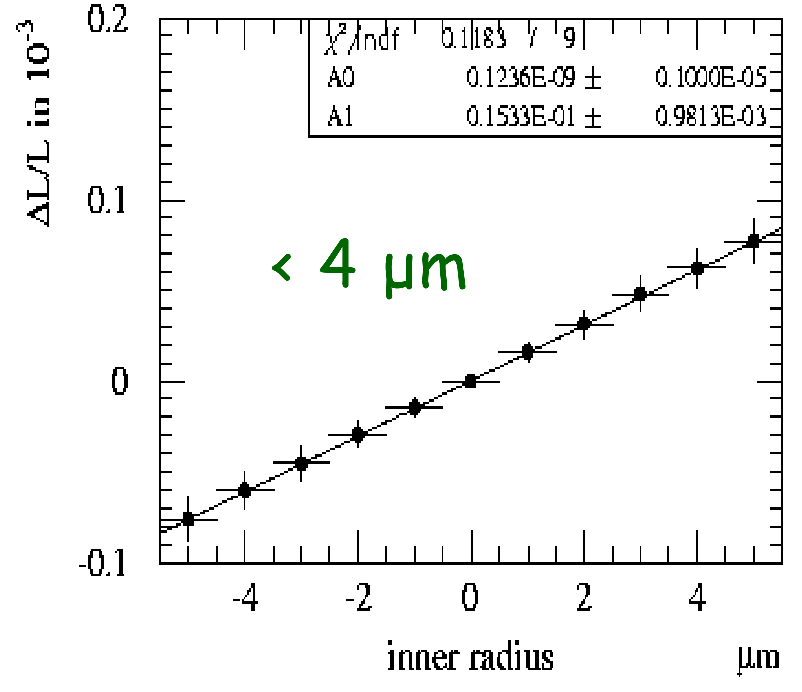
- MC Simulations → Optimisation of shape and segmantation

- Alignment with Laser Beams

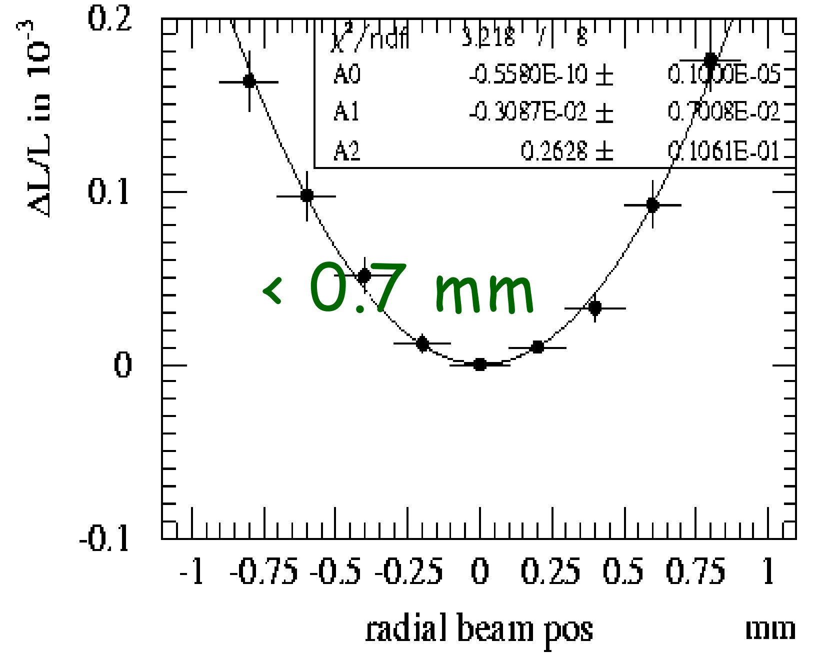
- Close contacts to Theorists (Cracow,

•Measurement of the Luminosity





Requirements on Alignment
and mechanical Precision
(rough Estimate)



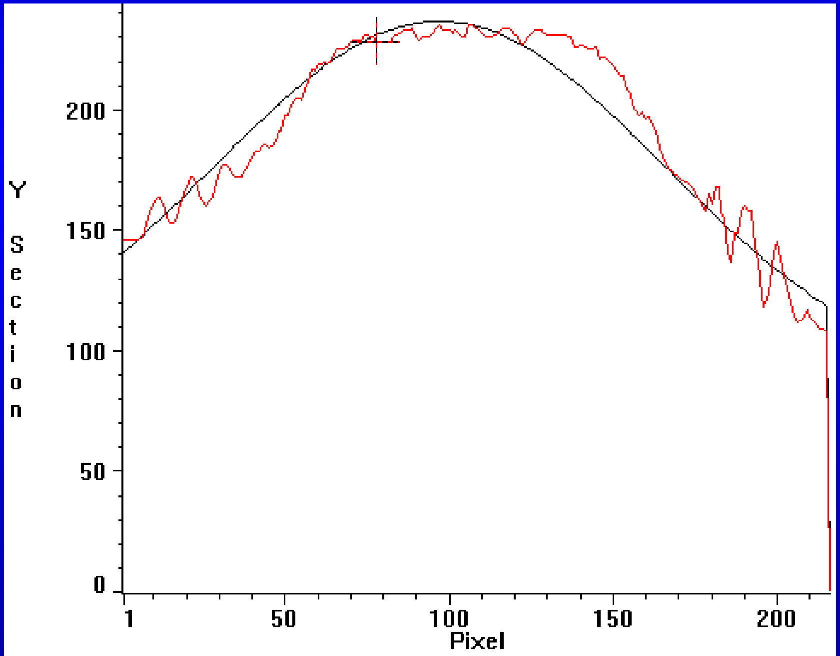
Beam Offsets:	**< 200 μm**
Inner Radius of Cal.:	**< 1-4 μm**
Distance of Cals.:	**< 60 μm**
Radial beam position:	**< 0.7**

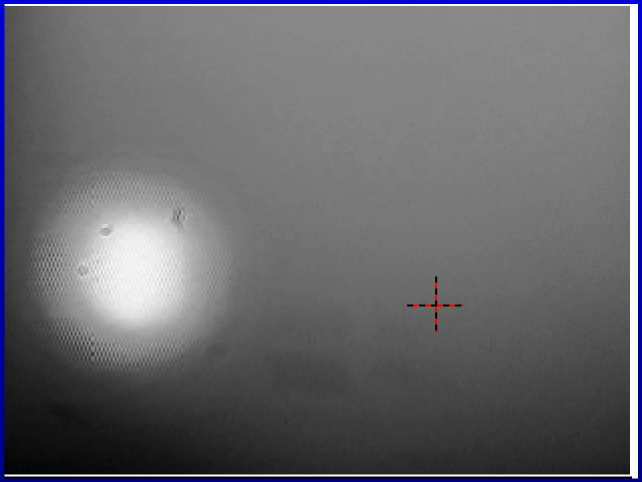
•Measurement of the Laser Alignment System

New collaborator: Jagiellonian Univ. Cracow
Photonics Group

Work just started:

reconstruction of Ne-Ne laser spot on CCD camera



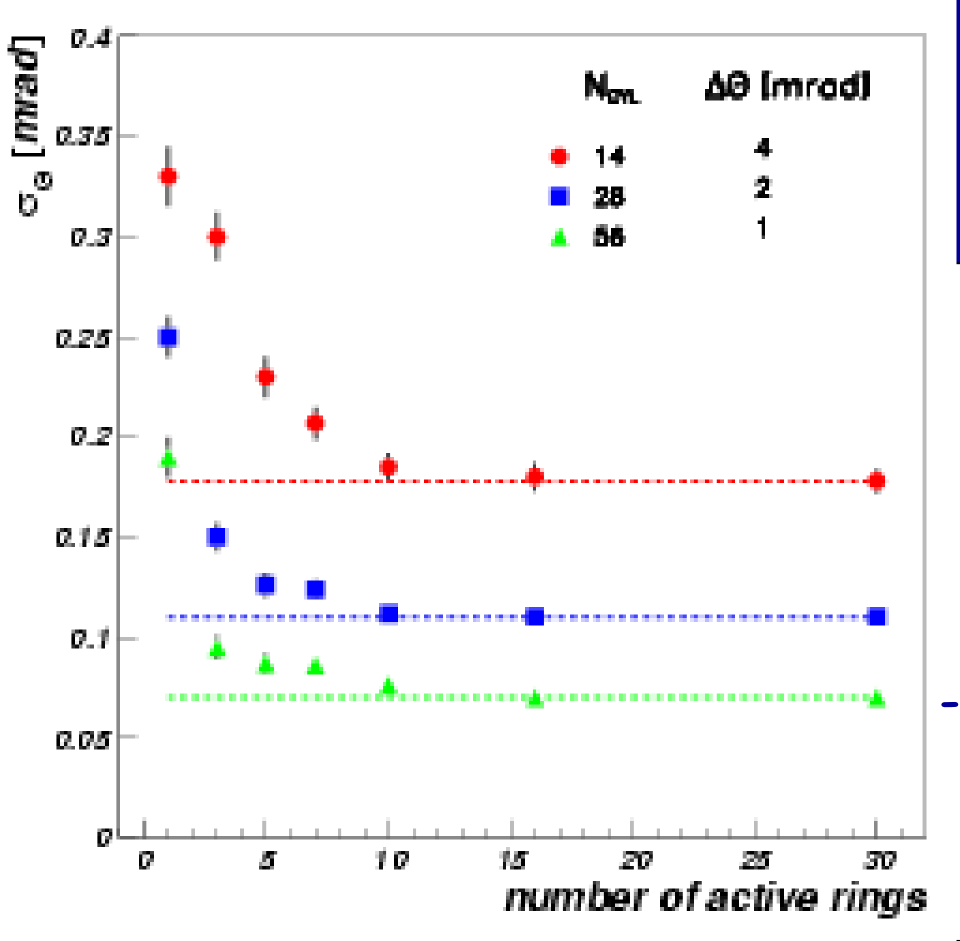


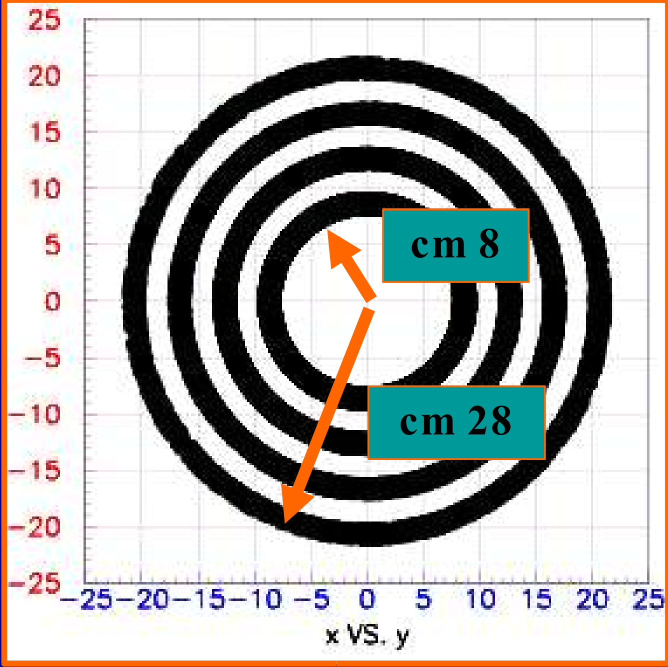
•Measurement of the Luminosity

$e^+e^- \longrightarrow e^+e^- (\gamma)$

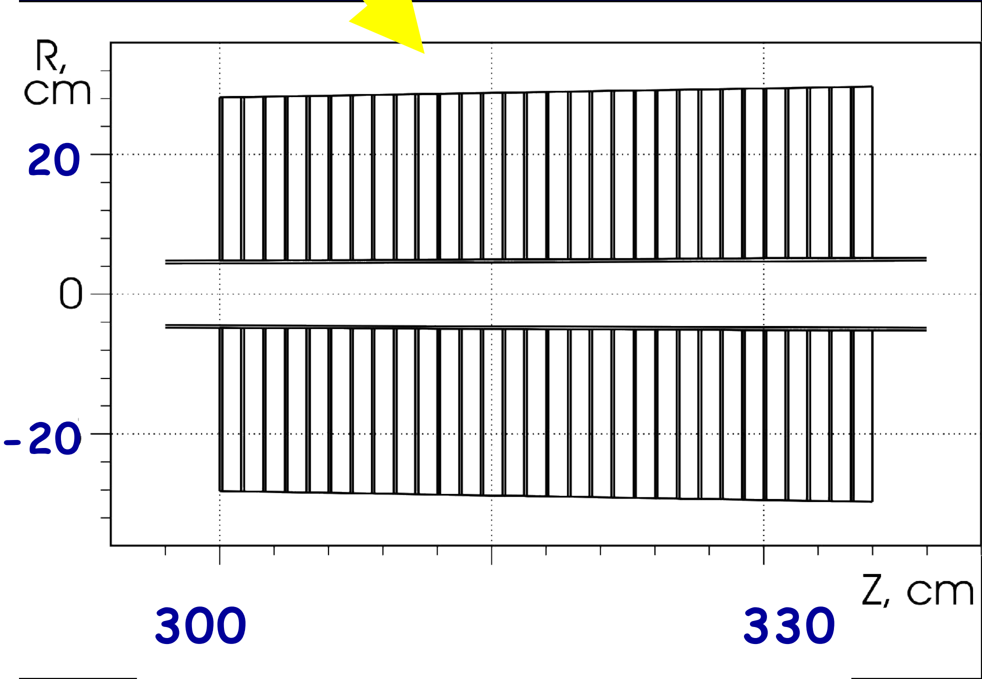
Simulations with BHWIDE

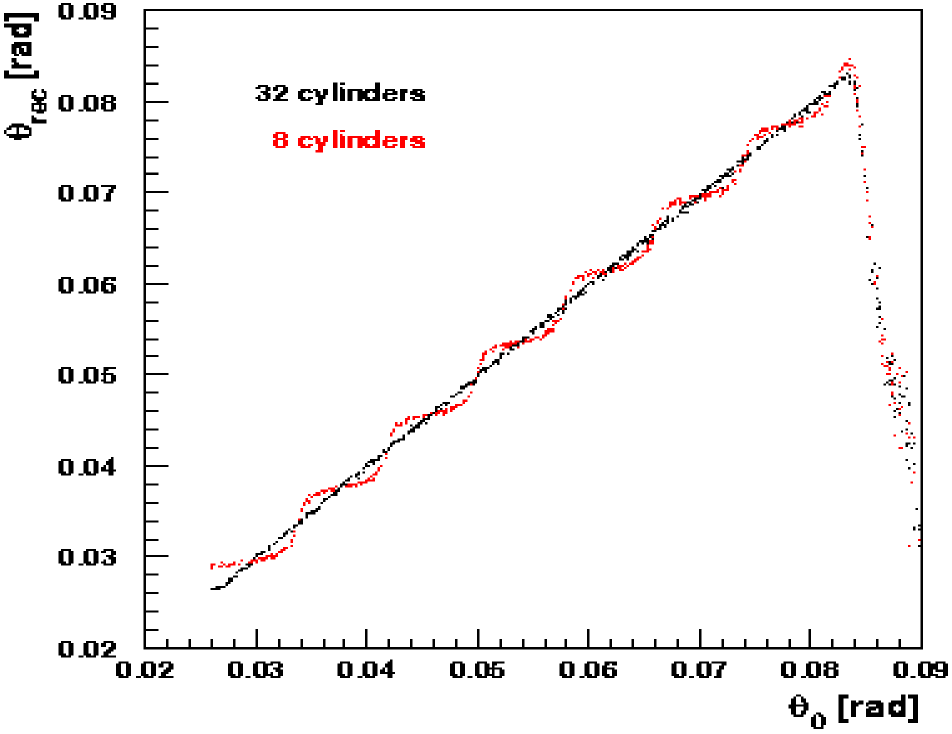
Θ Resolution as function of the depth



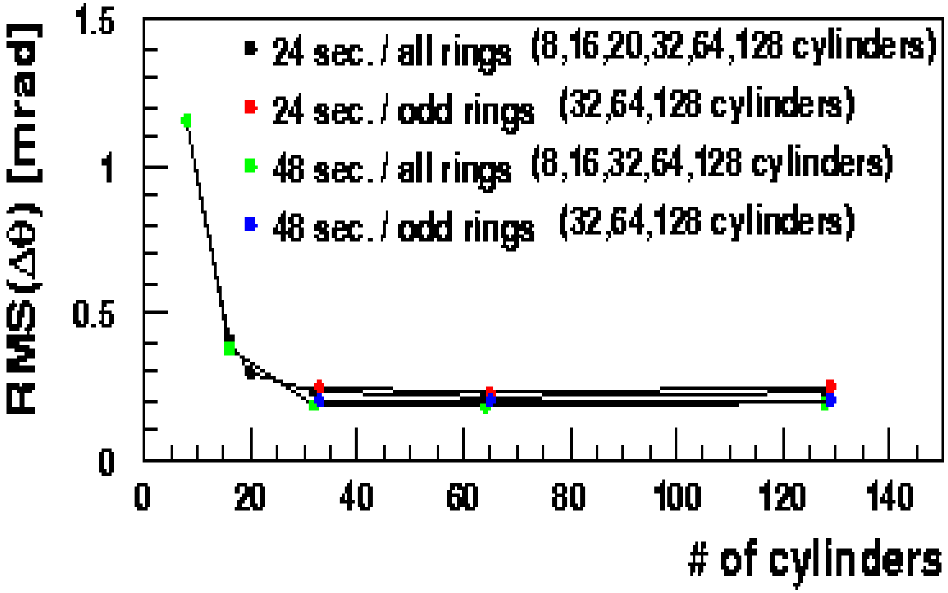


Rings



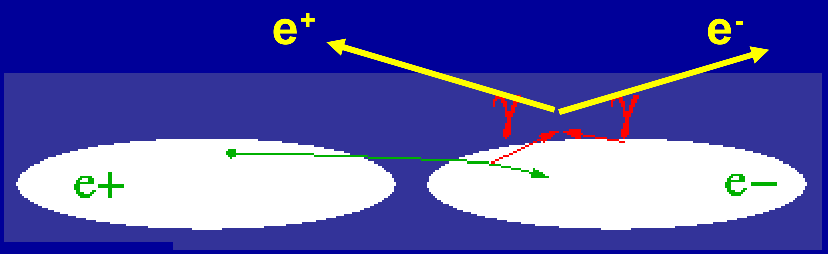


Some systematics in Θ Reconstruction



Θ Resolution as function of the number of cylinders

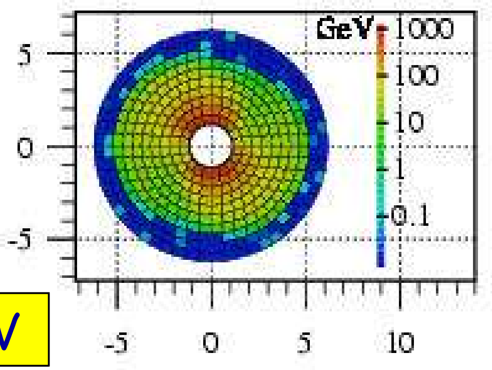
•Fast Beam Diagnostics (LCAL)



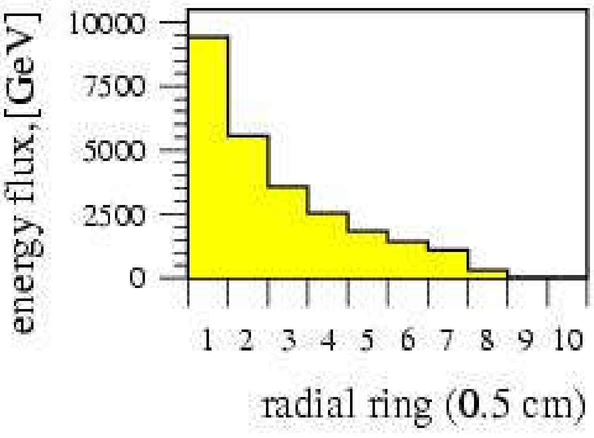
- e^+e^- pairs from beamstrahlung are deflected into the LCAL

- 15000 e^+e^- per BX ⟶ 10 – 20 TeV

- 10 MGy per year ⟶ Rad. hard sensor



GeV



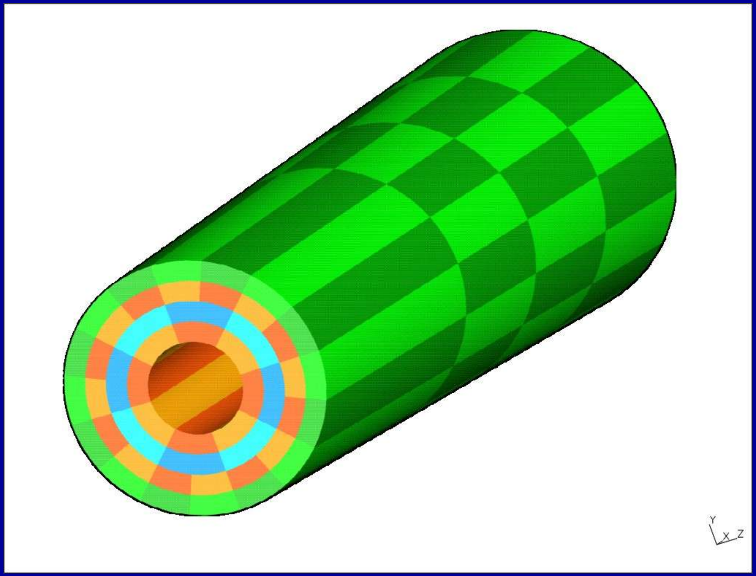
Technologie **Diamond-W Sandwich**

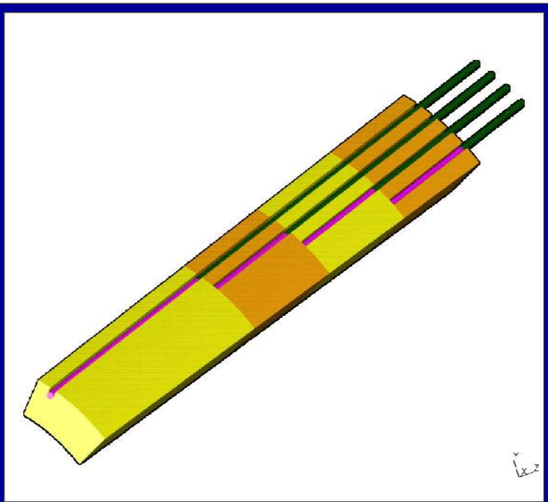
Scintillator crystals

Gas ionisation cham

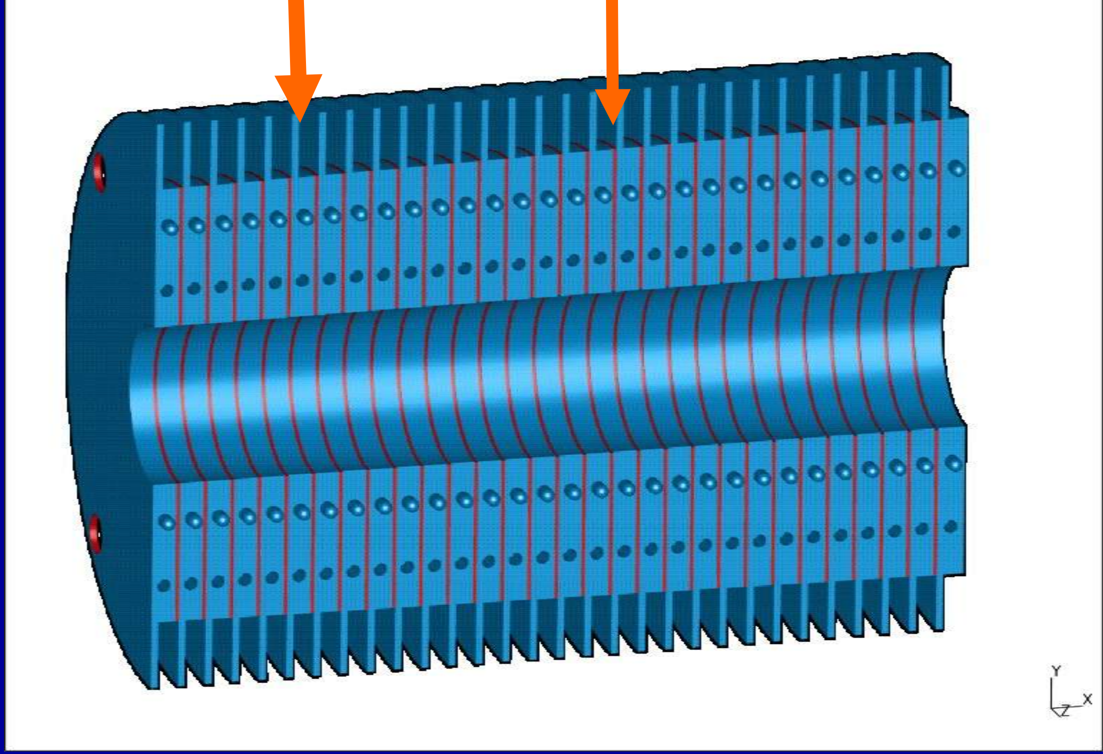
Schematic

Heavy crystals





W-Diamond sandwich



Space for electronics

sensor

•Fast Beam Diagnostics (LCAL)

1st Results:Single Parameter Analysis

detector: realistic segmentation, ideal resolution
single parameter analysis, bunch by bunch resoluti

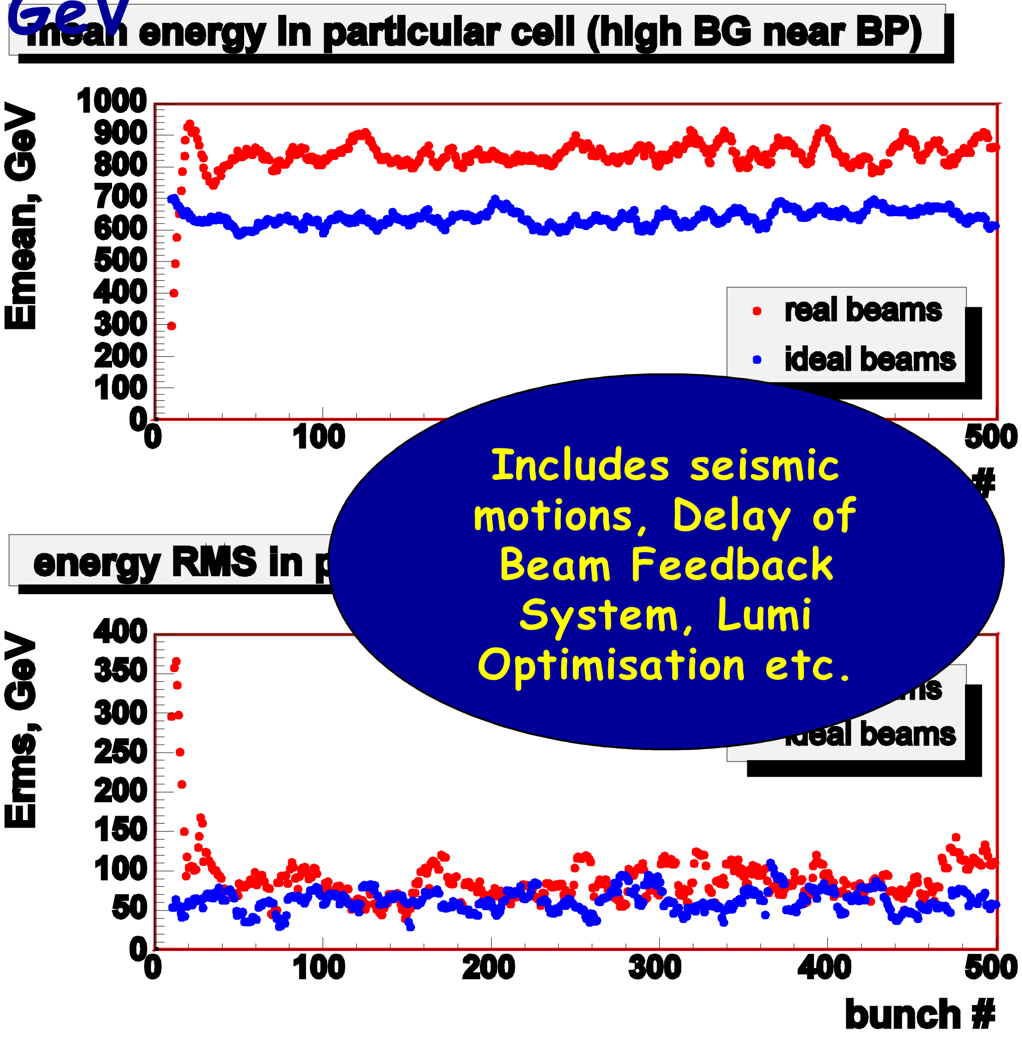
		nominal	our precision	Beam Diag.
Bunch width x	Ave. Diff.	553 nm	1.2 nm 2.8 nm	~ 10 % ~ 10 %
Bunch width y	Ave. Diff.	5.0 nm	0.1 nm 0.1 nm	Shintake Monitor
Bunch length z	Ave. Diff.	300 µm	4.3 µm 2.6 µm	~ 10 % ~ 10 %
Emittance in x	Ave. Diff.	10.0 mm mrad	1.0 mm mrad 0.4 mm mrad	? ?
Emittance in y	Ave. Diff.	0.03 mm mrad	0.001 mm mrad 0.001 mm mrad	? ?
Beam offset in x Beam offset in y		0 0	7 nm 0.2 nm	5 nm 0.1 nm
Horizontal waist shift Vertical waist shift		0 µm 360 µm	80 µm 20 µm	None None

•Detection of Electrons and Photons

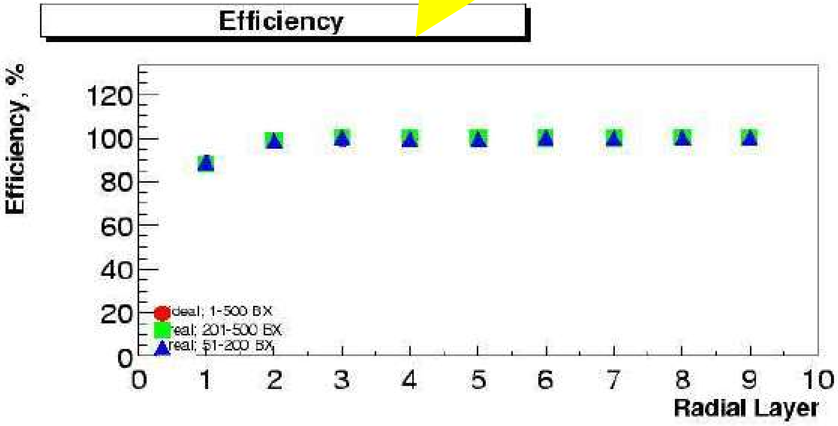
Realistic beam

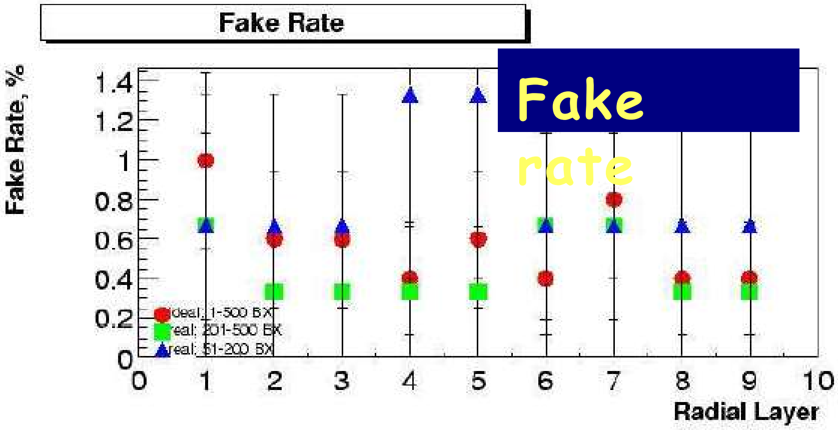
√s = 500 GeV

Efficiency to identify energetic electrons and photons



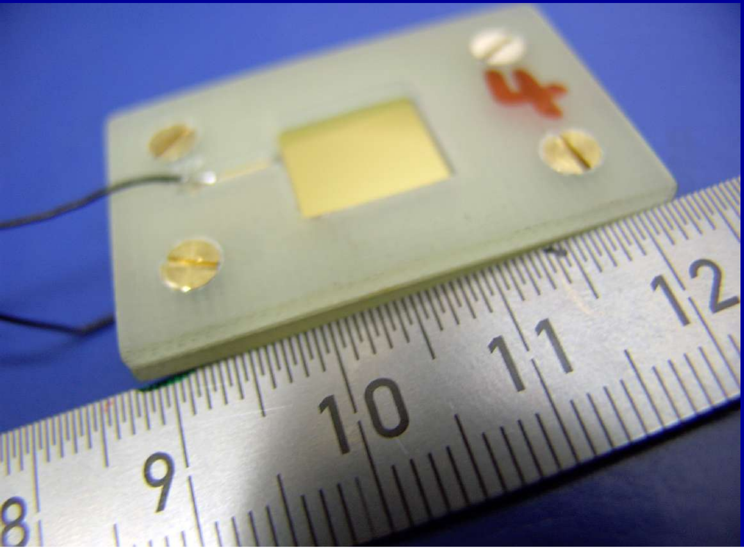
Includes seismic motions, Delay of Beam Feedback System, Lumi Optimisation etc.





Fake rate

Sensor prototyping, Diamonds



Different surface treatments :

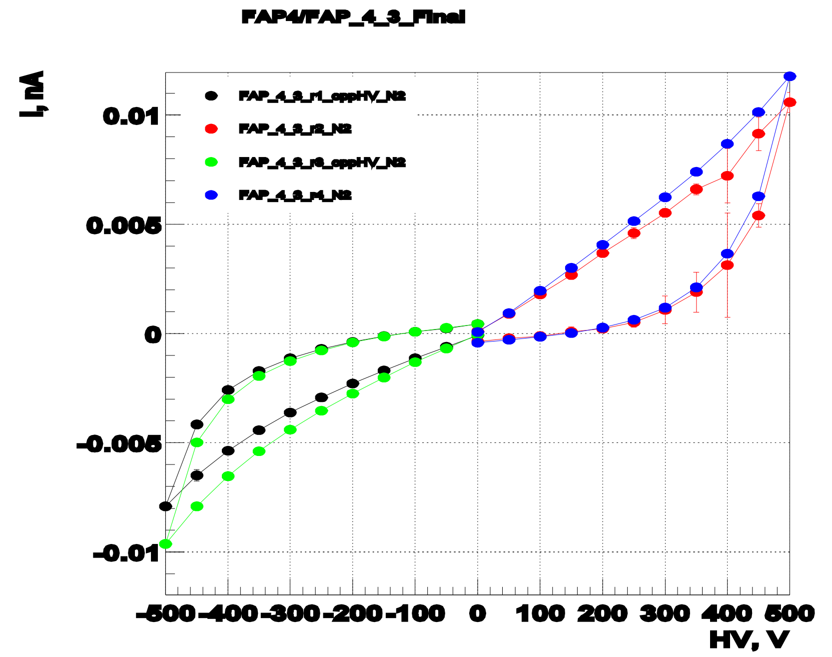
- #1 – substrate side polished; 300 um
- #2 – cut substrate; 200 um
- #3 – growth side polished; 300 um
- #4 – both sides polished; 300 um

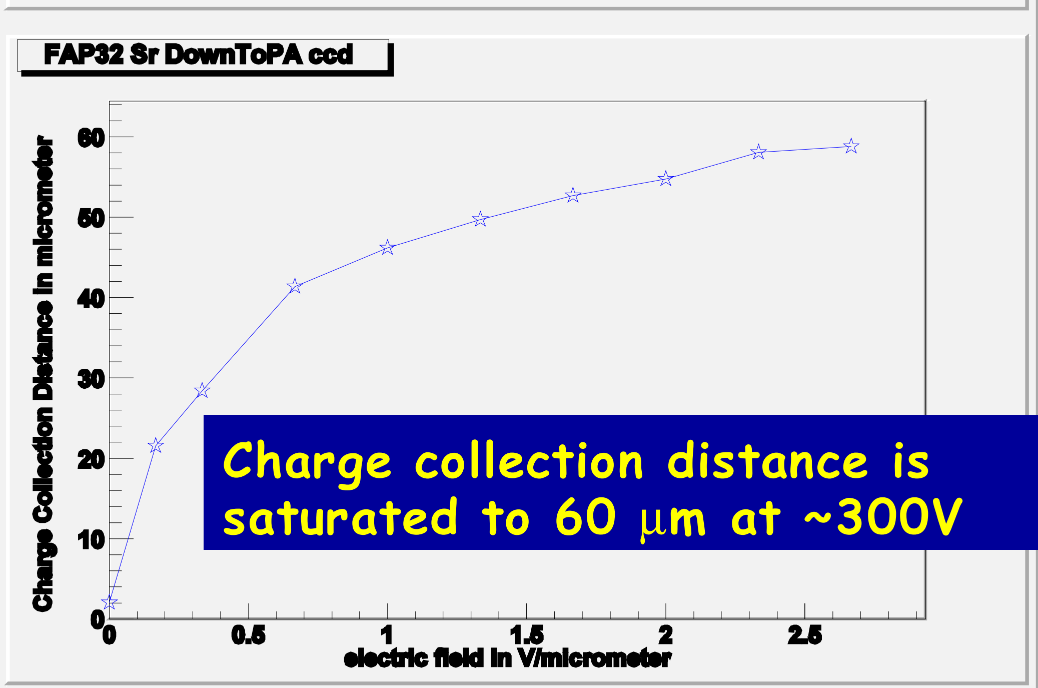
Diamond; Size: 12x12 mm ^{2}

Metallisation: 10 nm Ti + 400nm Au

Current (I) dependence on the voltage

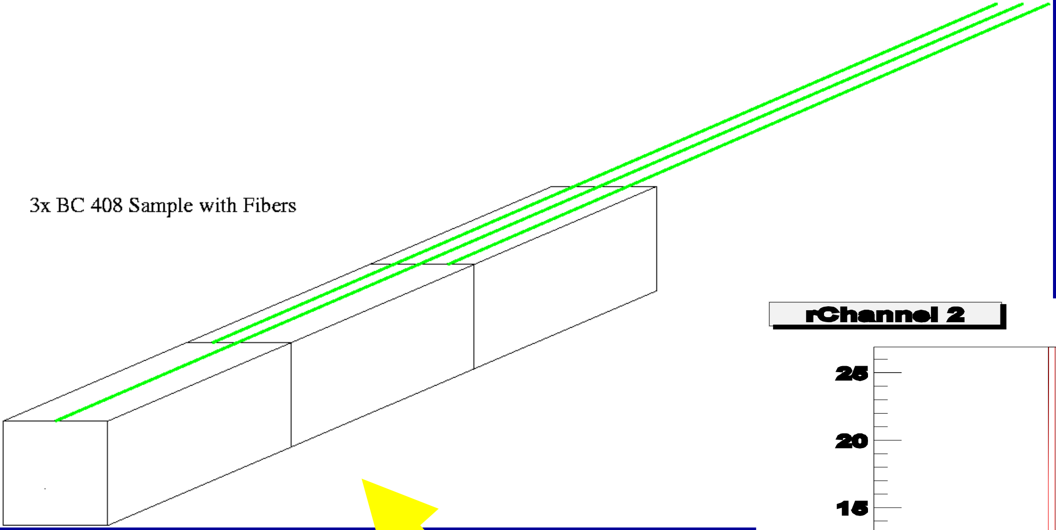
Ohmic behavior for ‘ramping up/down’, hysteresis





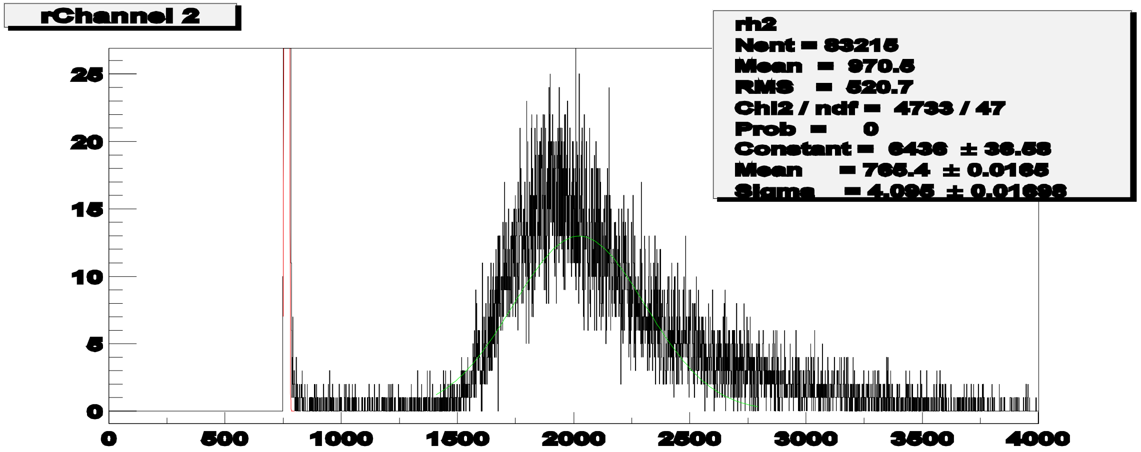
Charge collection distance is saturated to 60 μm at ~300V

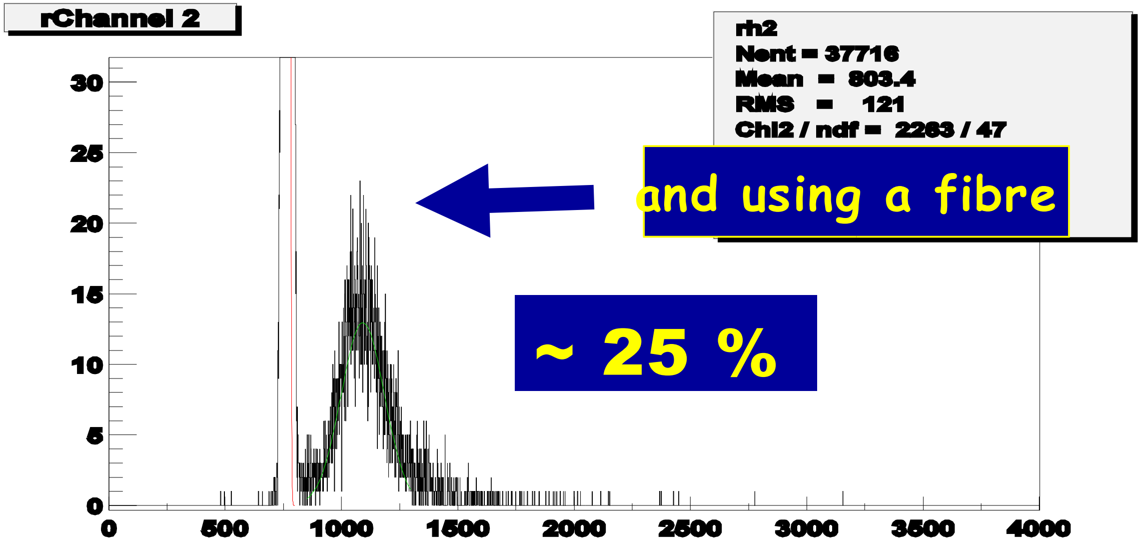
Sensor prototyping, Crystals



Plastic scintilator

ight Yield from direct couplin



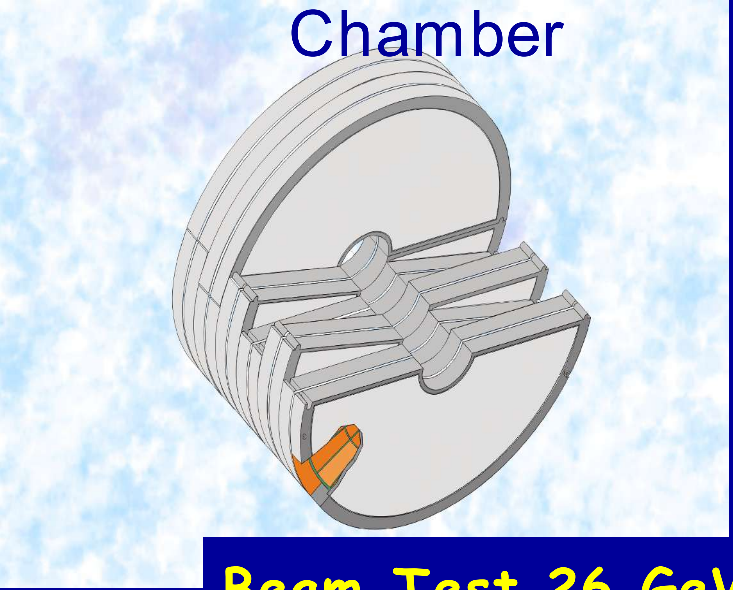


and using a fibre

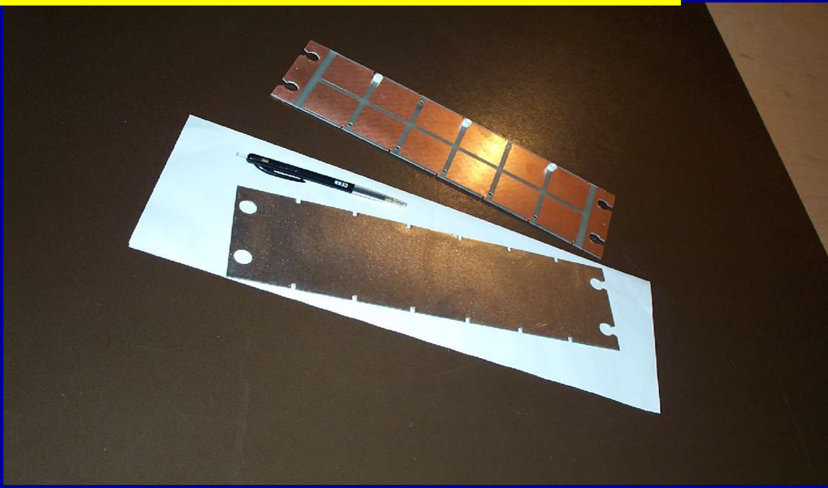
~ 25 %

Study with heavy crystals (Cerenkov light) is going on

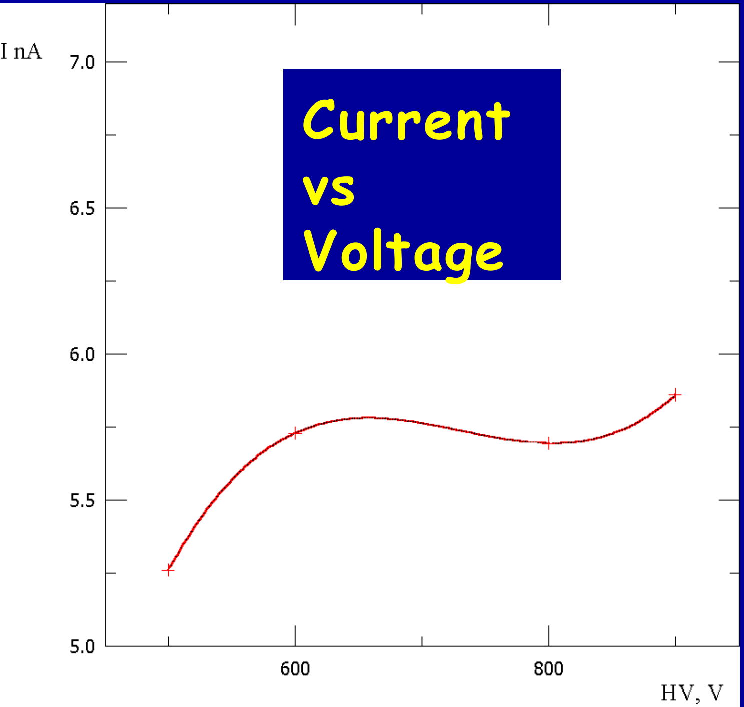
Sensor prototyping, C_3F_8 Gas Ionisation Chamber



Pads for charge collection



Beam Test 26 GeV e^- beam, $10^3 s^{-1}$



Current vs Voltage

Pressure vessel

Summary

- The Instrumentation of the Very Forward Region of a LC is a challenging Topic

- MC Simulations to optimise the Design are progressing
- Different Detector Technologies for LCAL are studied
- Tests with Sensor Prototypes have been started

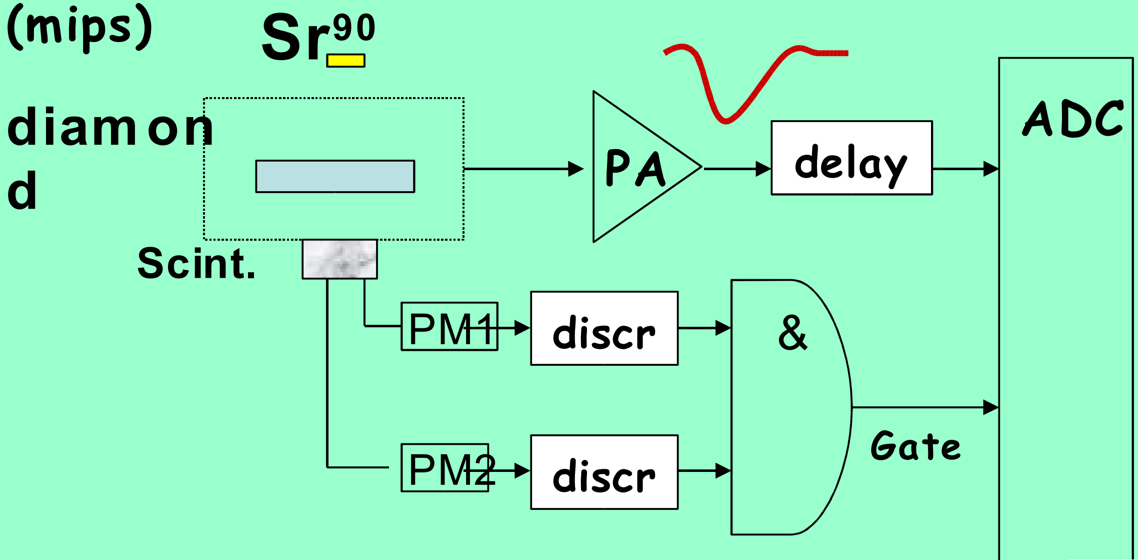
- After about two years we will present a Design

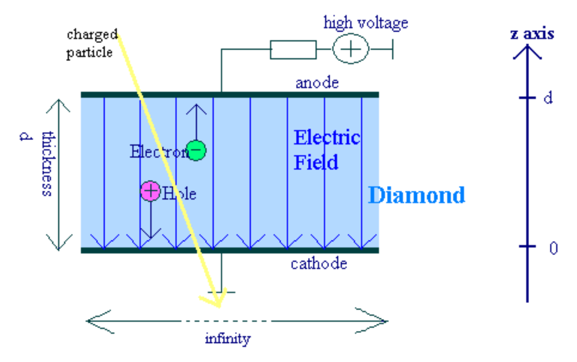
- The goal is to start after with the construction and test of a prototype

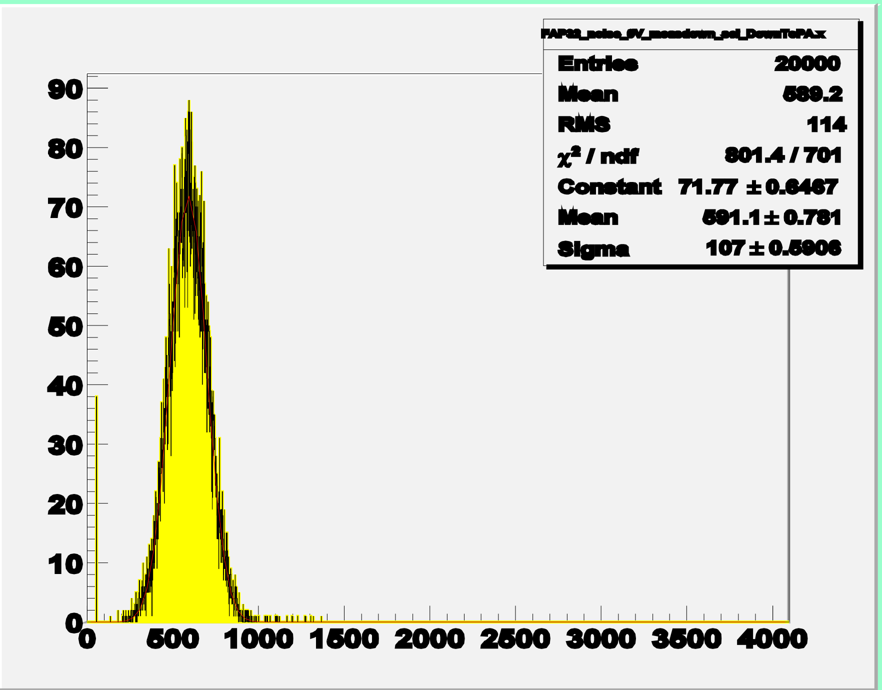
Charge collection distance measurements

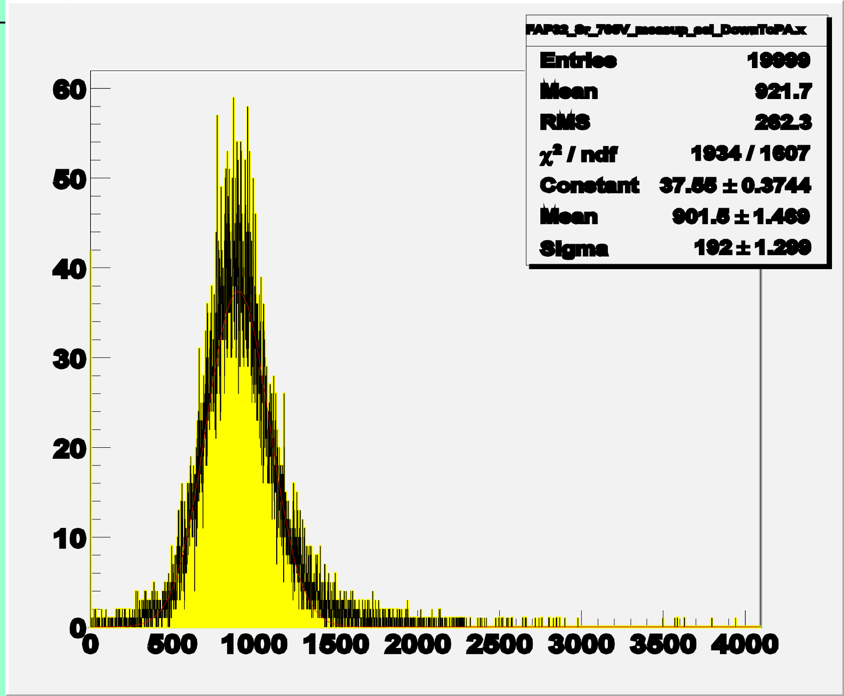
$$Q_{meas.} = Q_{created} \text{ x ccd / L}$$

Using electrons from a Sr^{90} source (mips)







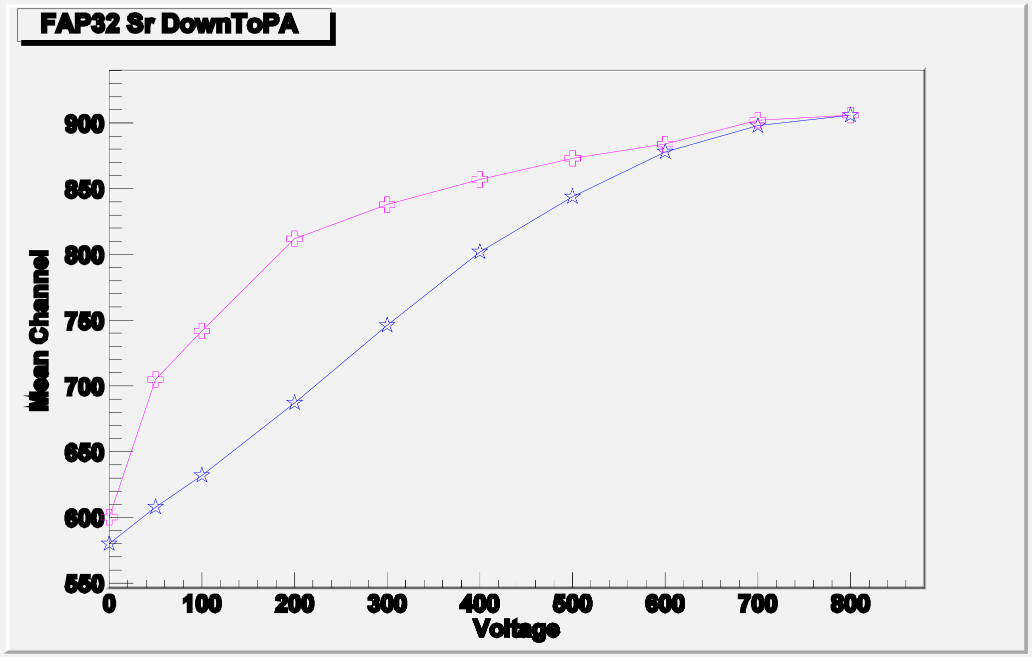


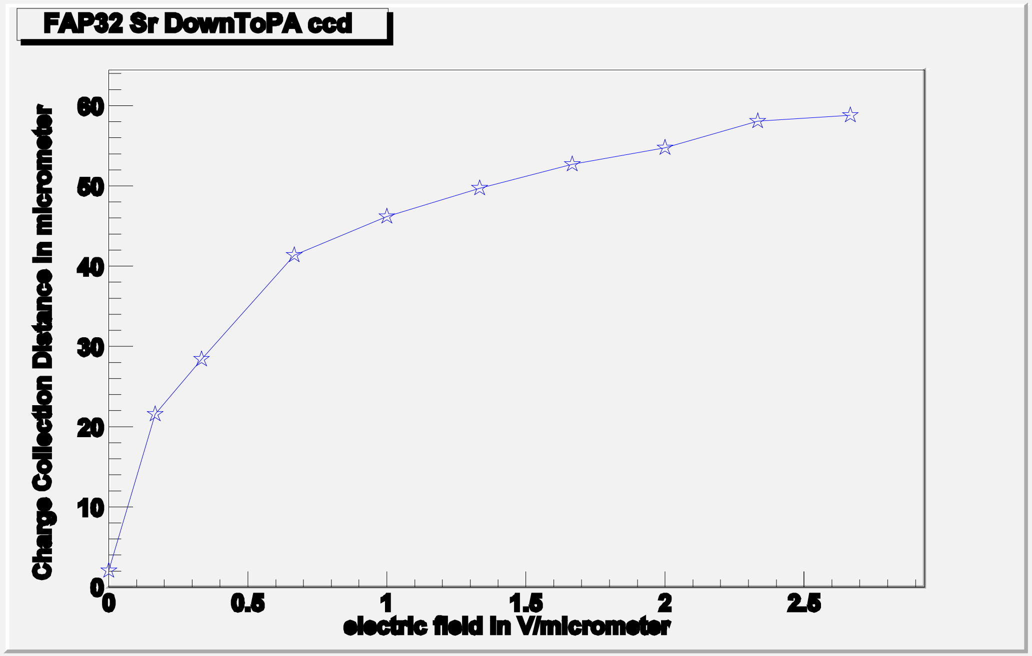
Charge collection distance measurements

The sensors are not irradiated

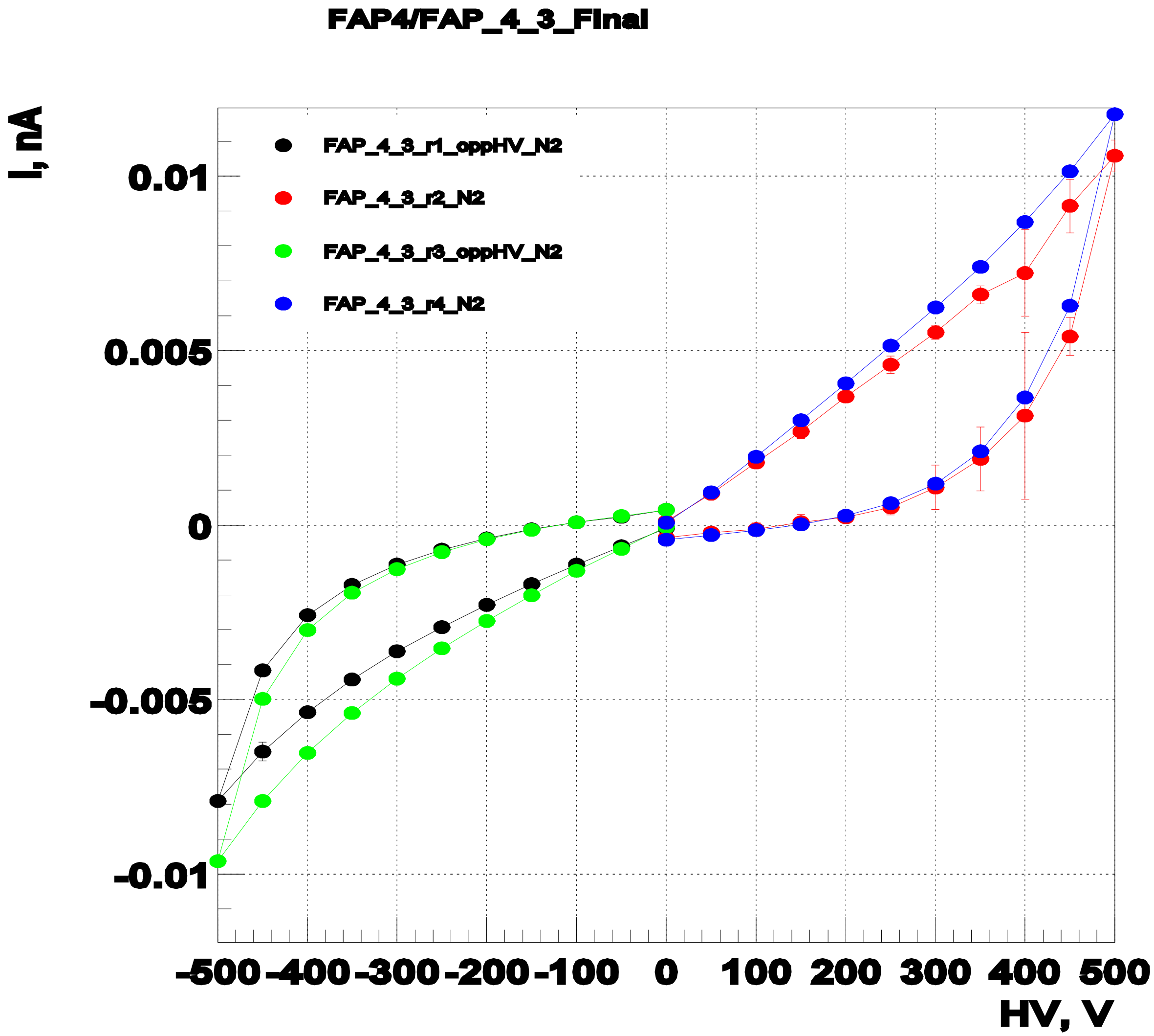
Upper curve is ramping up HV,
Lower ramping down.

Charge collection distance is saturated to 50 μm at ~300V





Sensor prototyping and lab tests



Current (I) dependence on the voltage (V)

Ohmic behavior for 'ramping up/down', hysteresis

Resistance in the order of 100 TOhm

Current decays with time
After 24 h nearly 1/2

Detection of Electrons and Photons

- essential parameters:

  Small Molière radius

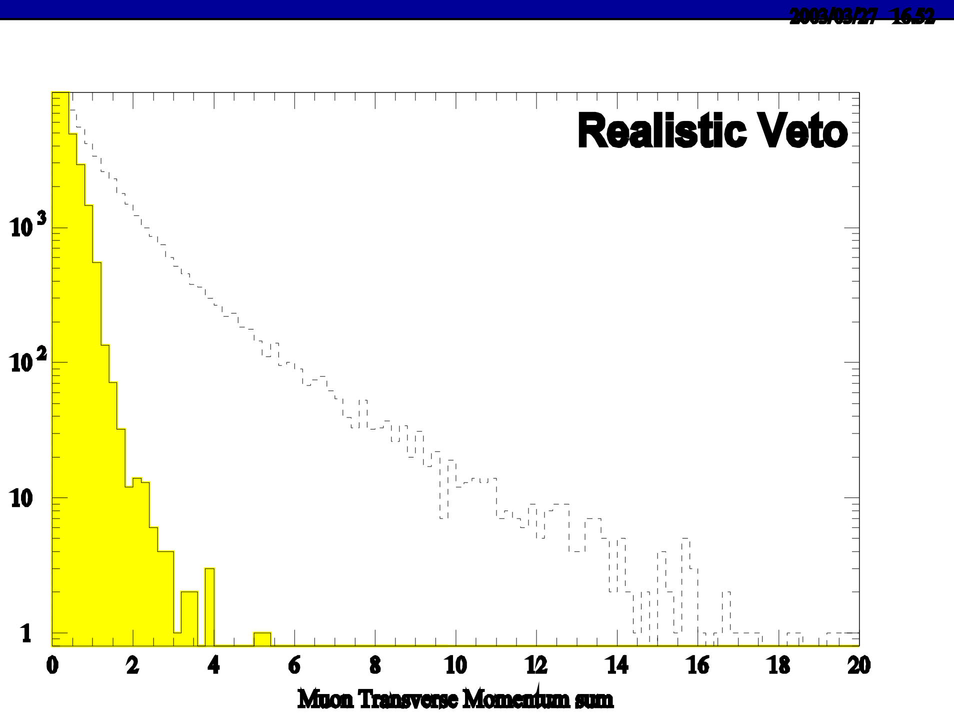
  High granularity

  Longitudinal segmentation

- Two photon event rejection

$e^+e^- \longrightarrow e^+e^- \mu^+\mu^-$

(Severe background for particle searches)



- Electromagnetic fakes

  1% from physics 2% from fluctuations