SENSOR TESTS AND PLANS (BeamCal)

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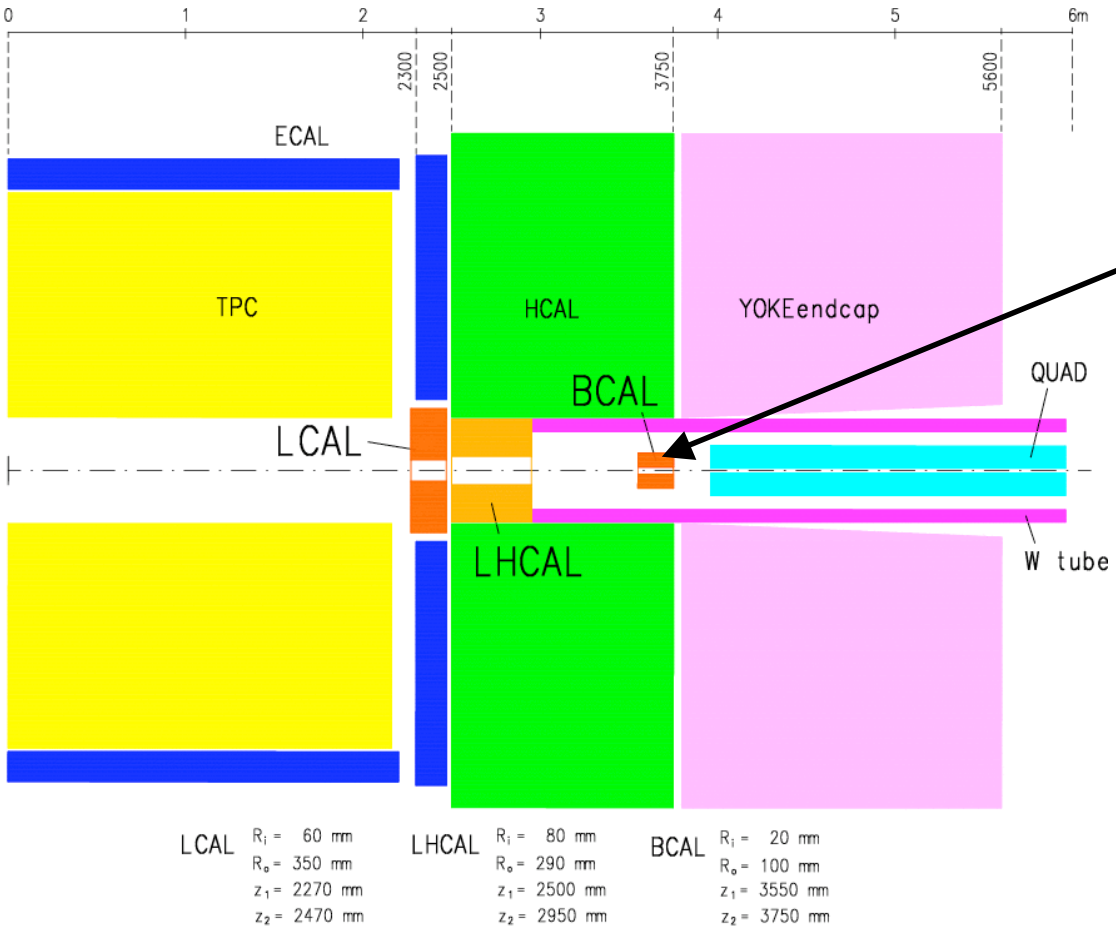
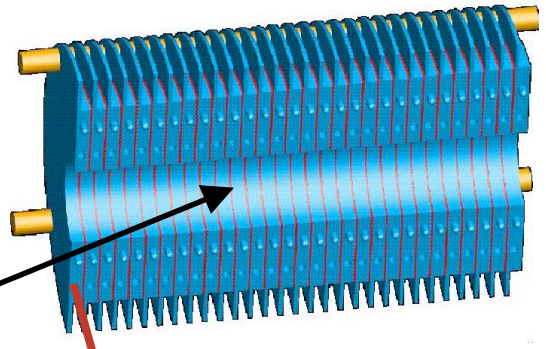
OUTLINE OF THIS TALK

1. Introduction
2. Methods / Infrastructure
3. Measurements
    1. Silicon
    2. CVD Diamonds
    3. Gallium Arsenide
4. Conclusions

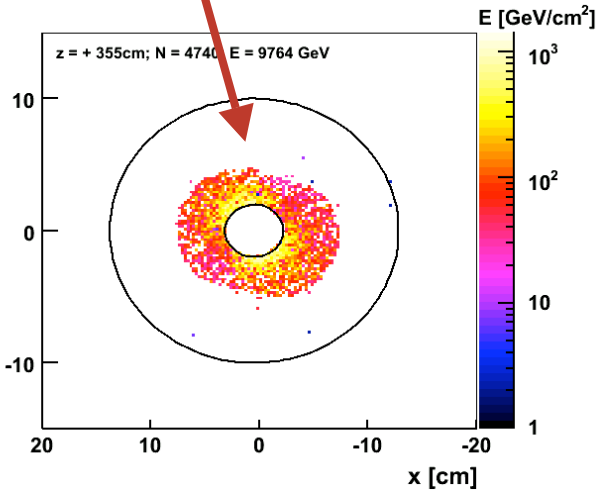
INTRODUCTION





BeamCal

30 layers of
W / rad hard sensors
5 < ***ANGLE*** < 28 mrad



Energy deposition from beamstrahlung pairs in BeamCal:

Dose of up to 10 MGy/a

METHODS

How can we characterize a sensor?

- Use of standardized measurements: results can be compared.
  - I/V measurement with both polarities
  - C/V measurement (semiconductor (V_{dep} ?) or insulator?)
  - spectrum for MIPs (charge collection efficiency)
  - charge collection, leakage current etc. vs. irradiation dose
  - …
- Always check calibration, data integrity, repeatability
- Bookkeeping of data: from files to a data base

INFRASTRUCTURE (1)

Rooms:

two rooms with filtered air (10k), stabilized temperature and limited access, floor space ~ 50 m^2

- room 1: bonding and assembly
- room 2: all measurements without radioactive source
- 'neighbourship': both rooms can communicate through a window
- access only via a cell with two doors and a barrier

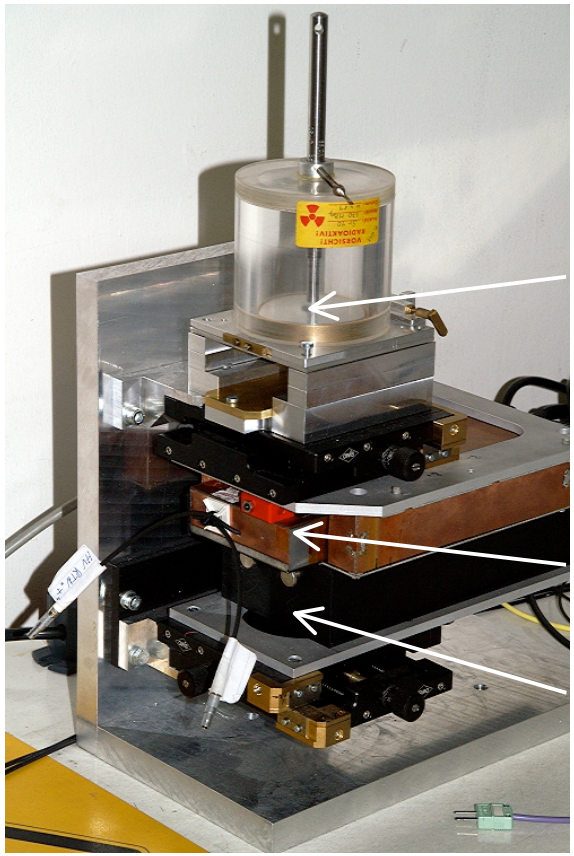
Instruments:

- manual prober in a shielded box (light, electrical screening)
- manual prober for probe cards (chip testing)
- microscopes with a large object distance
- manual bonding machine with x-y computer control
- glueing tools, oven etc.
- computer controlled instruments (I, C, V, V and I sources)

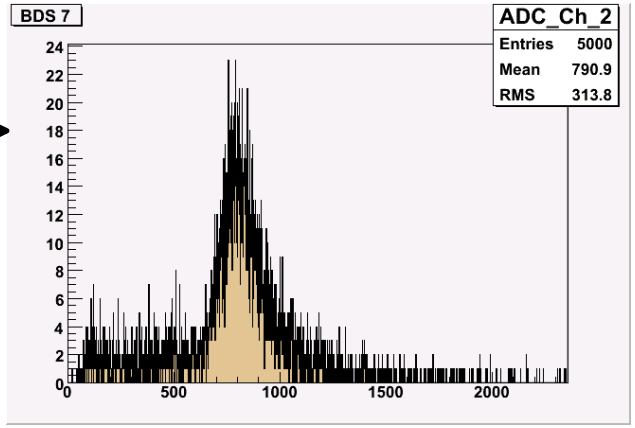
INFRASTRUCTURE (2)

Spectroscopic measurements - another lab room

- standard source ^{90}Sr with collimator and trigger system



Source (^{90}Sr)

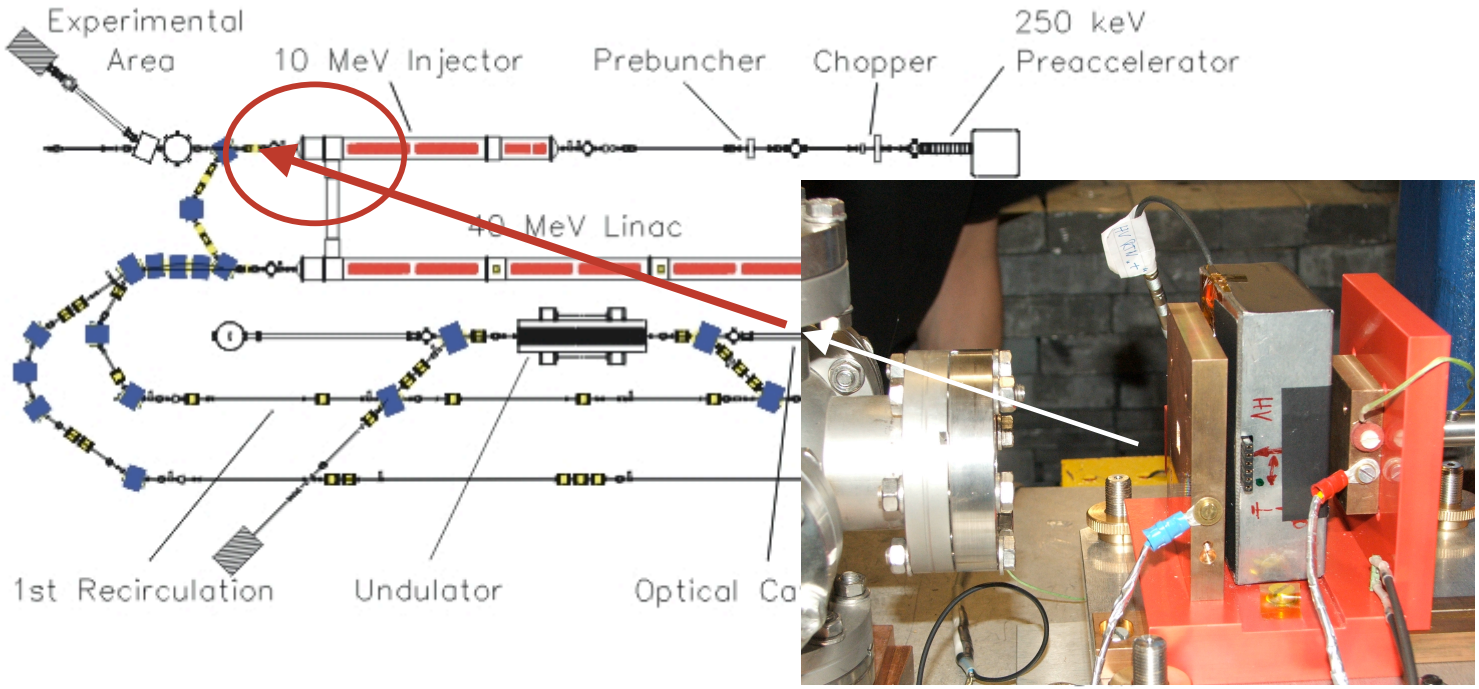


Sensor, Preamp

Trigger

INFRASTRUCTURE (3)

Irradiation facility (e^-): S-Dalinac



Using the injector line of the S-DALINAC:

10 ± 0.015 MeV and possible beam currents from ***1nA to 50µA***

INFRASTRUCTURE (4)

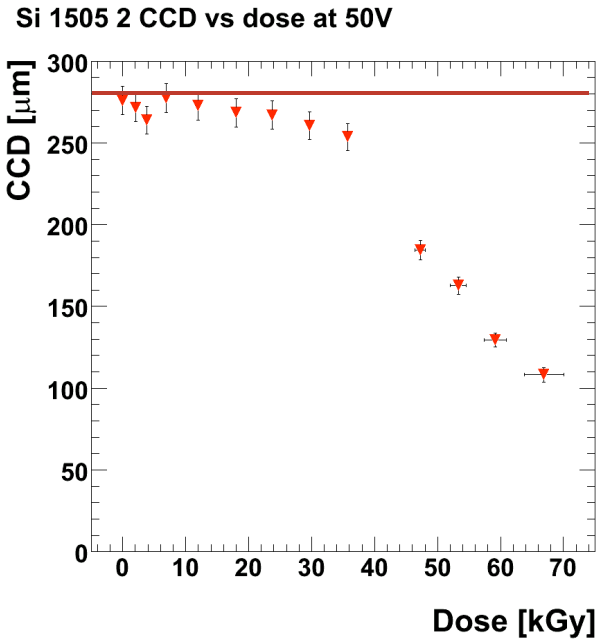
Test beam - DESY HH, beam lines 22 to 24

- energies up to ~ 5 GeV, beam controllable by user
- scanning of sensors (vs. position, borders, gaps etc)
- ‘under construction’

EXAMPLES - SILICON

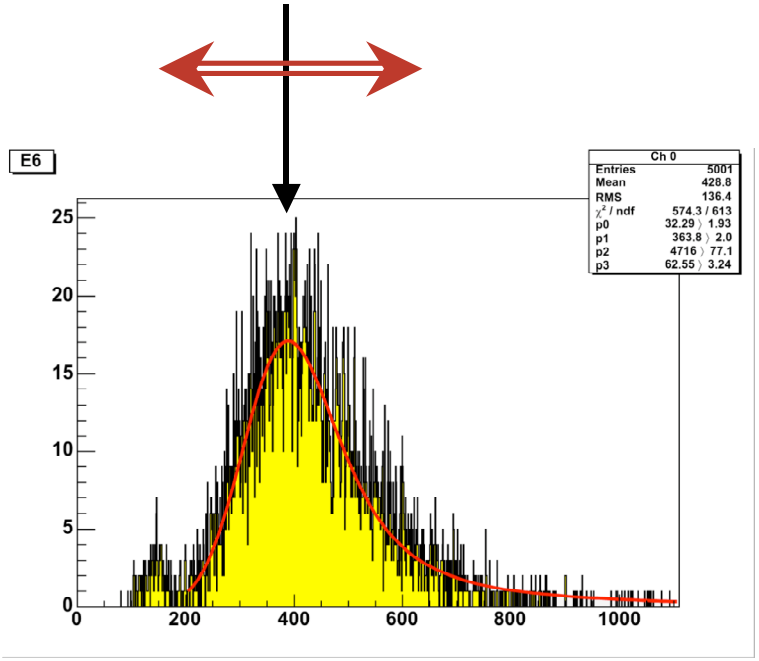
- measurement of regular silicon (fully depleted pn junction):
- “reference measurements”
- Problem: radiation hardness:

Sample irradiated with e^-:
Thickness = 280 µm
Initial CCD = 280 µm
(100% collection efficiency)

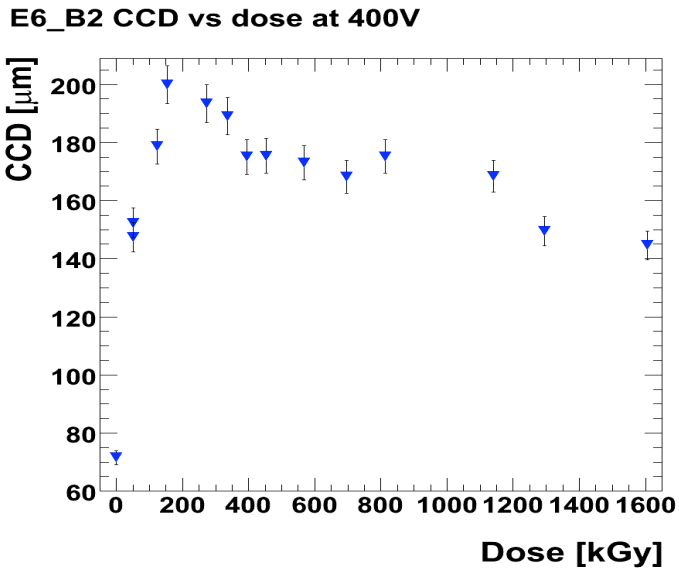


EXAMPLES - pCVD DIAMONDS

- operated as ‘solid state ionization chamber’



spectrum (^{90}Sr electrons)



charge collection efficiency vs. dose (S-Dalinac)

pCVD DIAMONDS (2)

- signal yield depends on
  - material (sample)
  - conditioning (history, pumping, dose acquired)
  - actual conditions (dose rate)

- applications w/o threshold:
  spectrometry
  - *instant recalibration necessary*

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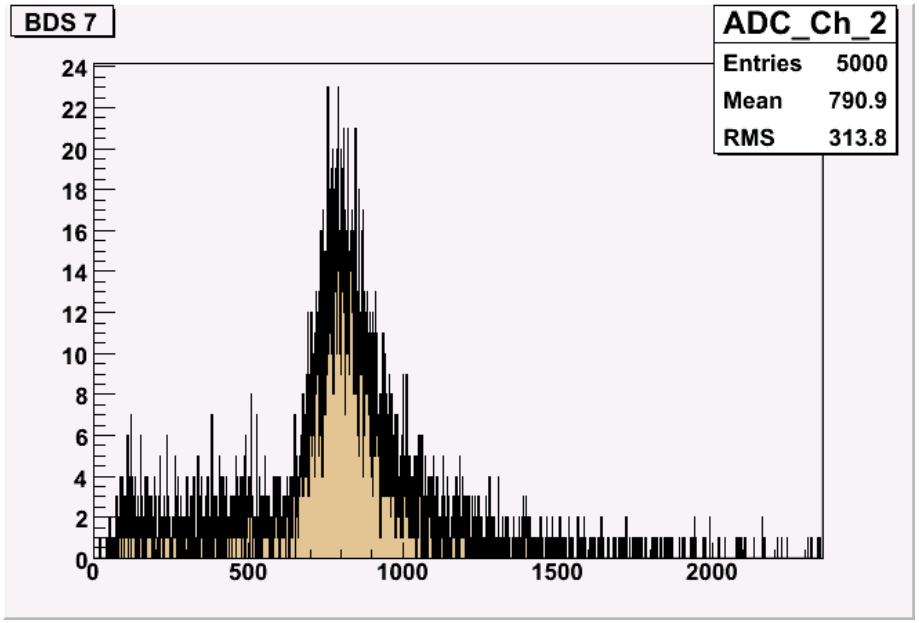
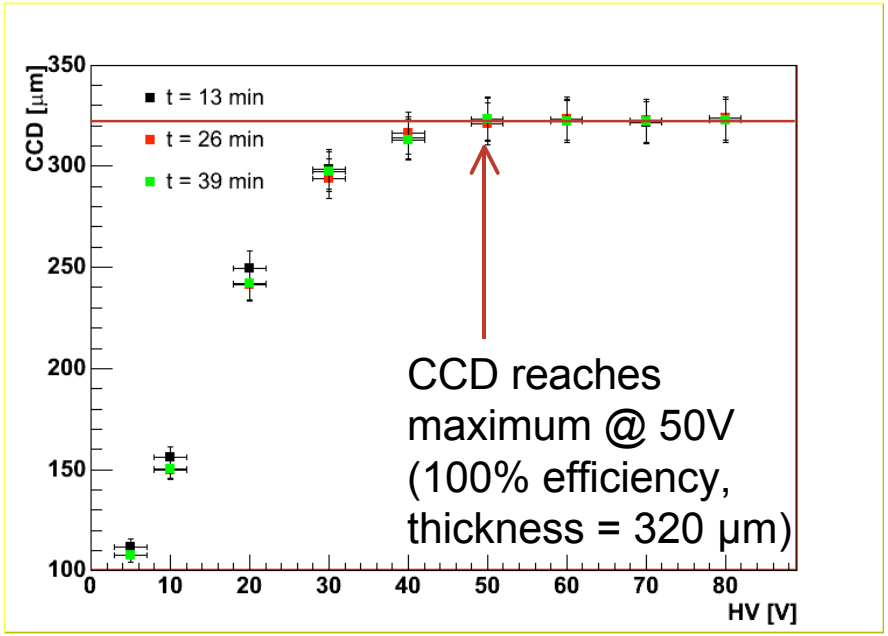
- applications with thresholds
  counting

Examples - sCVD DIAMONDS

- Single Crystal (CVD grown on substrate) by E6
- Size: 5 x 5 mm², metallization 3 mm in diameter, 320 μm thick

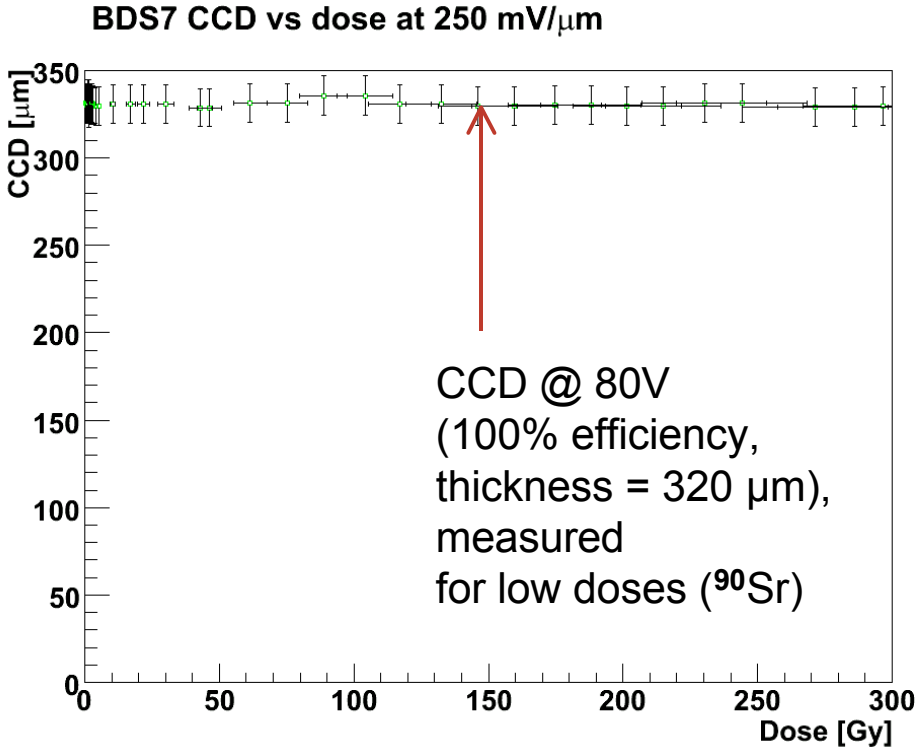


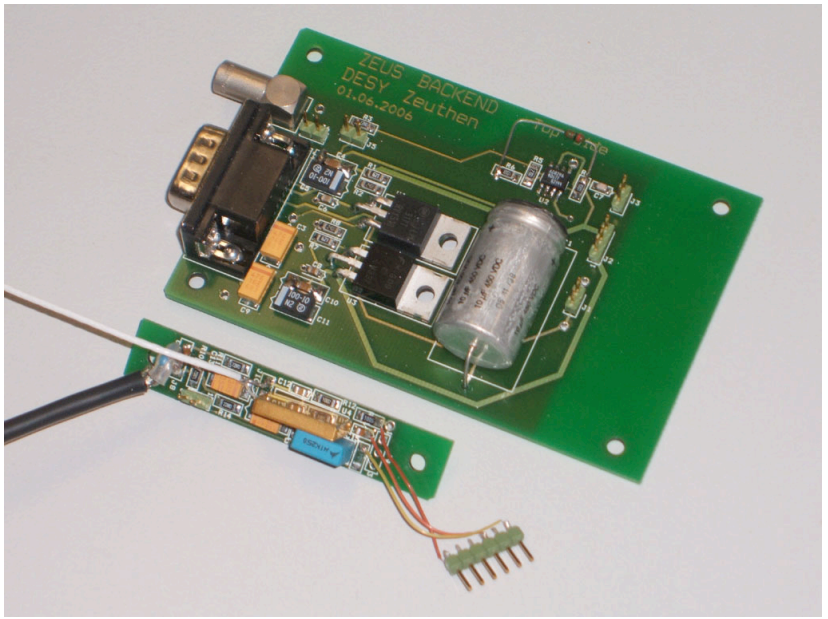


- Clearly separated spectrum of minimal ionizing particles
- 100% CCE, CCD = thickness, 1 mip results in 11.5 ke$^-$ (1.84 fC)

sCVD DIAMONDS (2)

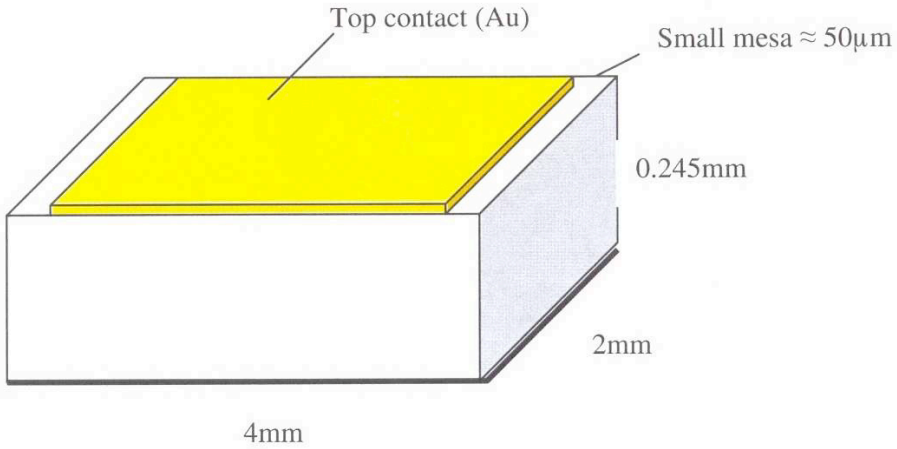
- Stable for low doses, further investigations needed (and planned)

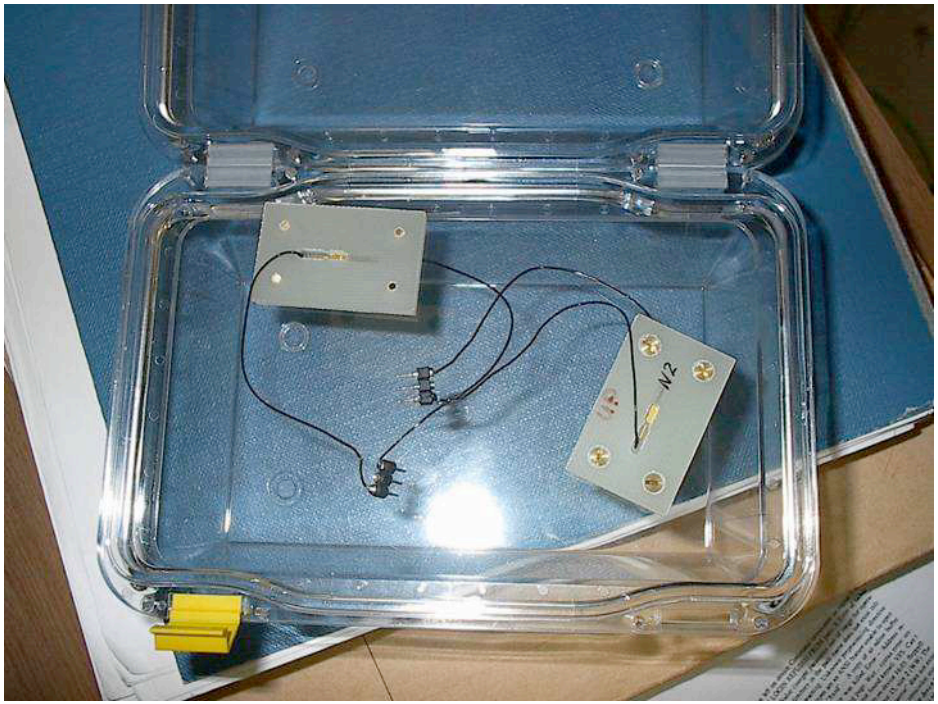




Examples - Gallium Arsenide (1)

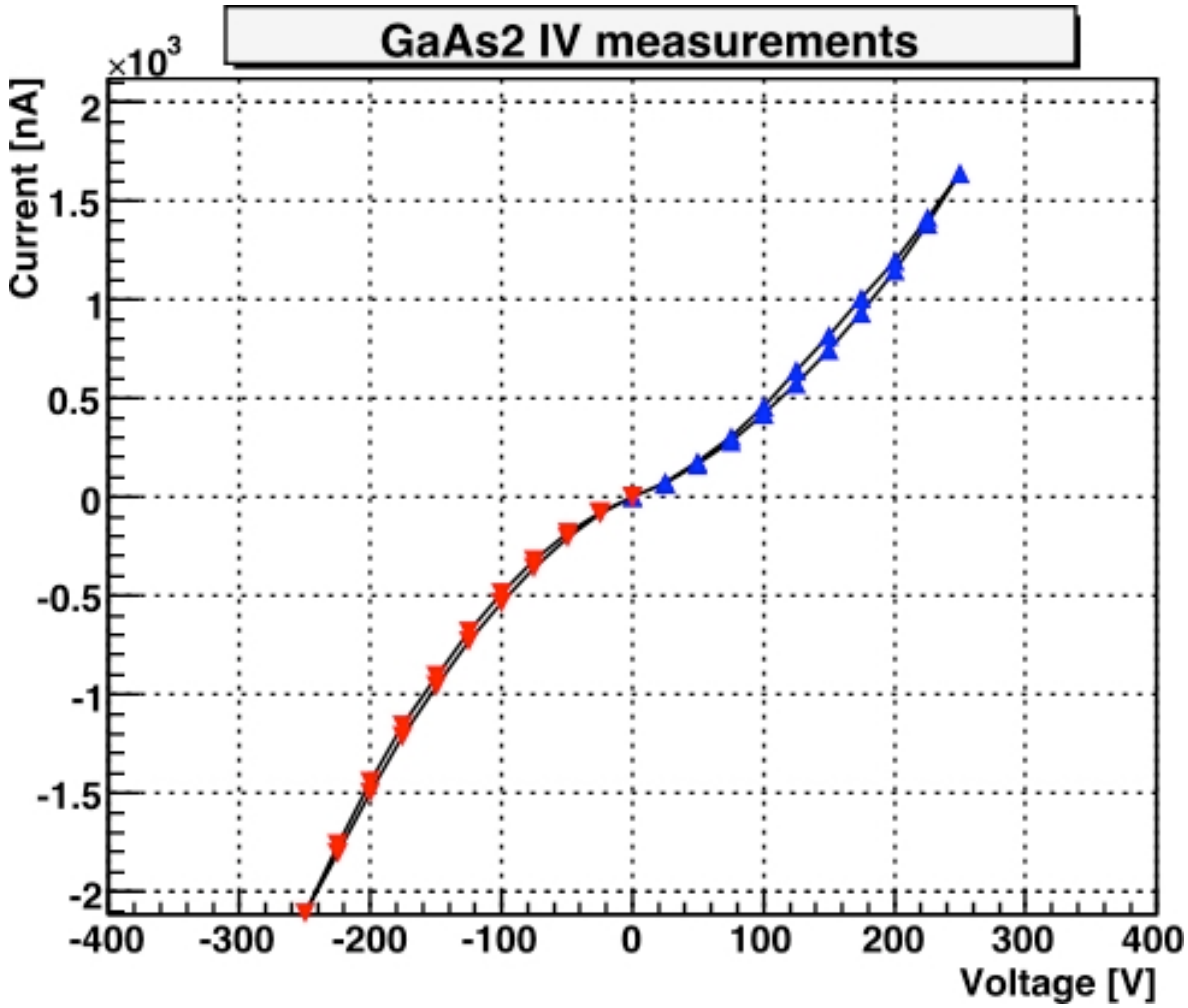
- operated as ‘solid state ionization chamber’





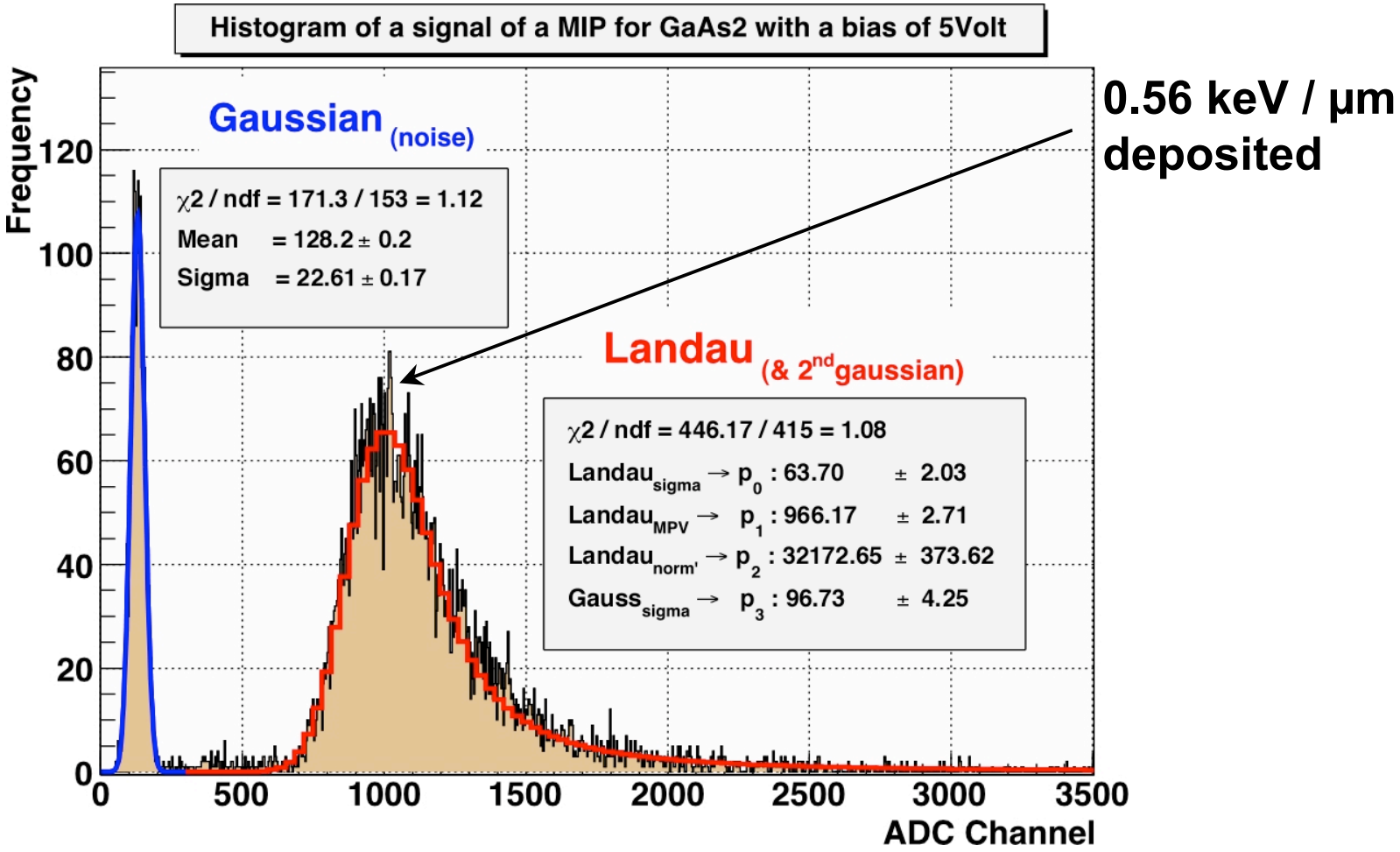
Gallium Arsenide (2)

- static measurements (I/V)



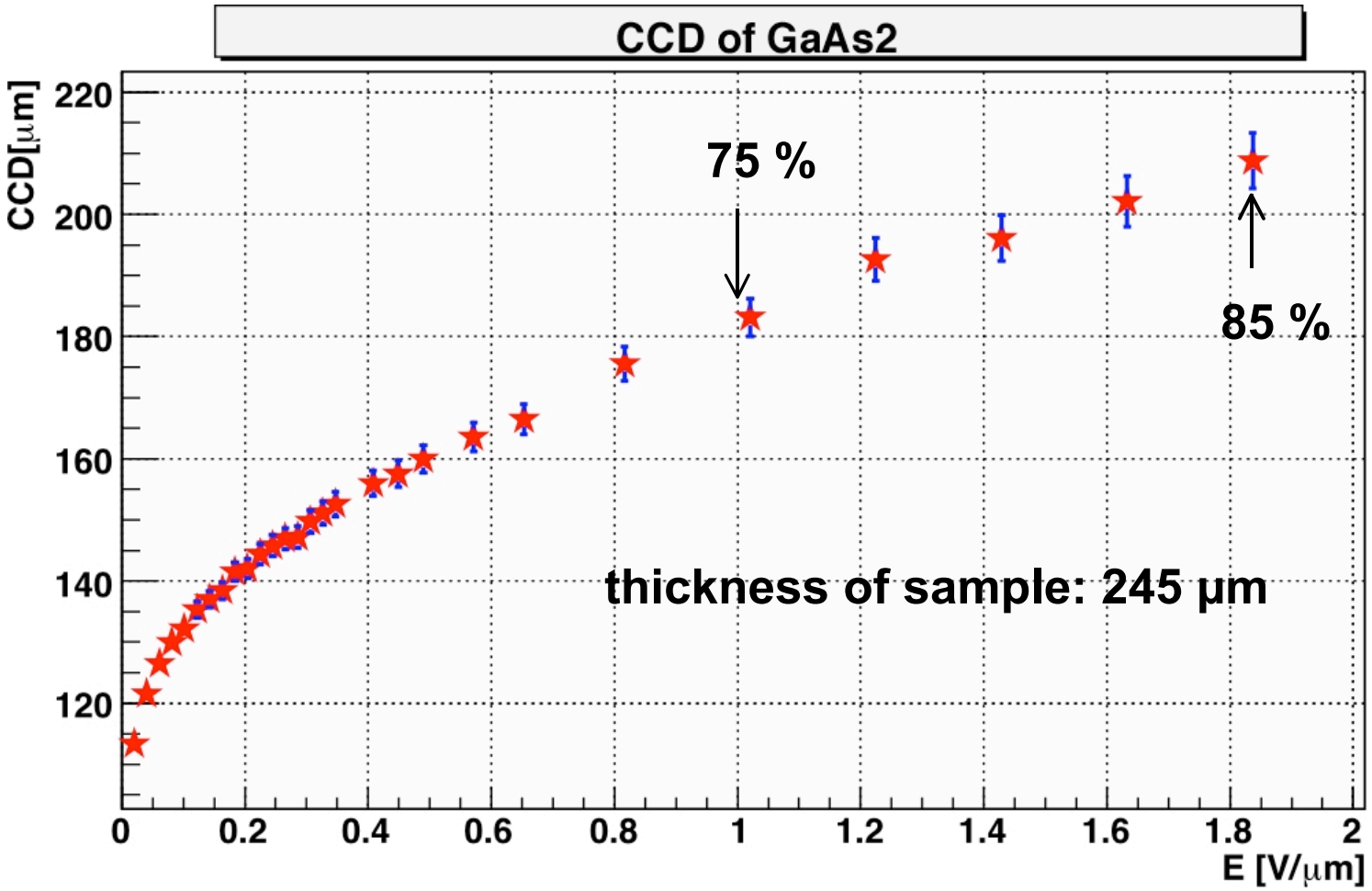
Gallium Arsenide (3)

- Spectroscopic measurements (^{90}Sr)



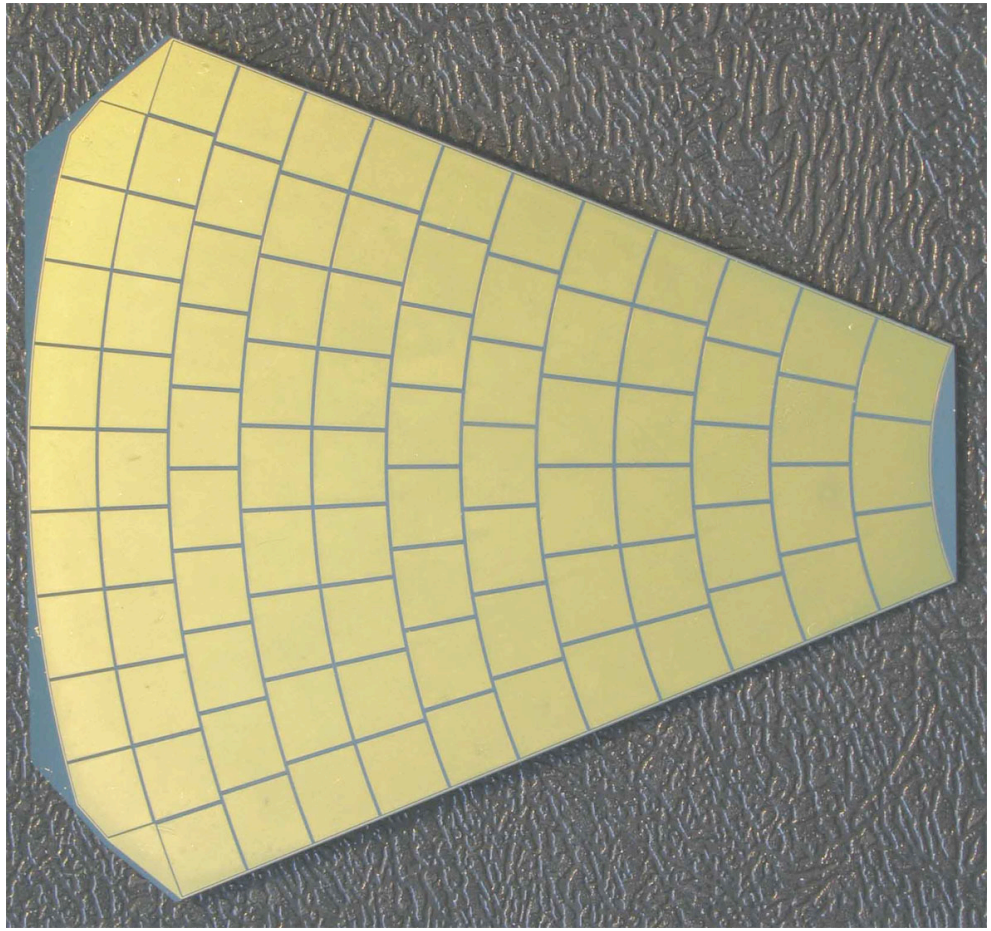
Gallium Arsenide (4)

- Spectroscopic measurements (^{90}Sr) vs. voltage -> CCD



Gallium Arsenide (5)

- first detector sample with BeamCal geometry (Dubna)
- we're looking forward to investigating these samples



CONCLUSIONS

- we developed in the framework of Eudet:
  - operational lab for all detector measurements w/o sources (to be completed until summer 2007)
  - standardized measurement with a ^{90}Sr source (CCD setup)
- we found collaborators for irradiation studies
  - S-Dalinac of TU Darmstadt
- we measured different detector materials
  - Silicon as reference material
  - different types of polycrystalline CVD diamond material
  - one singlescrystalline CVD diamond
  - several samples of GaAs material
- work to be continued as sketched…