SENSOR DEVELOPMENTS (BeamCal)

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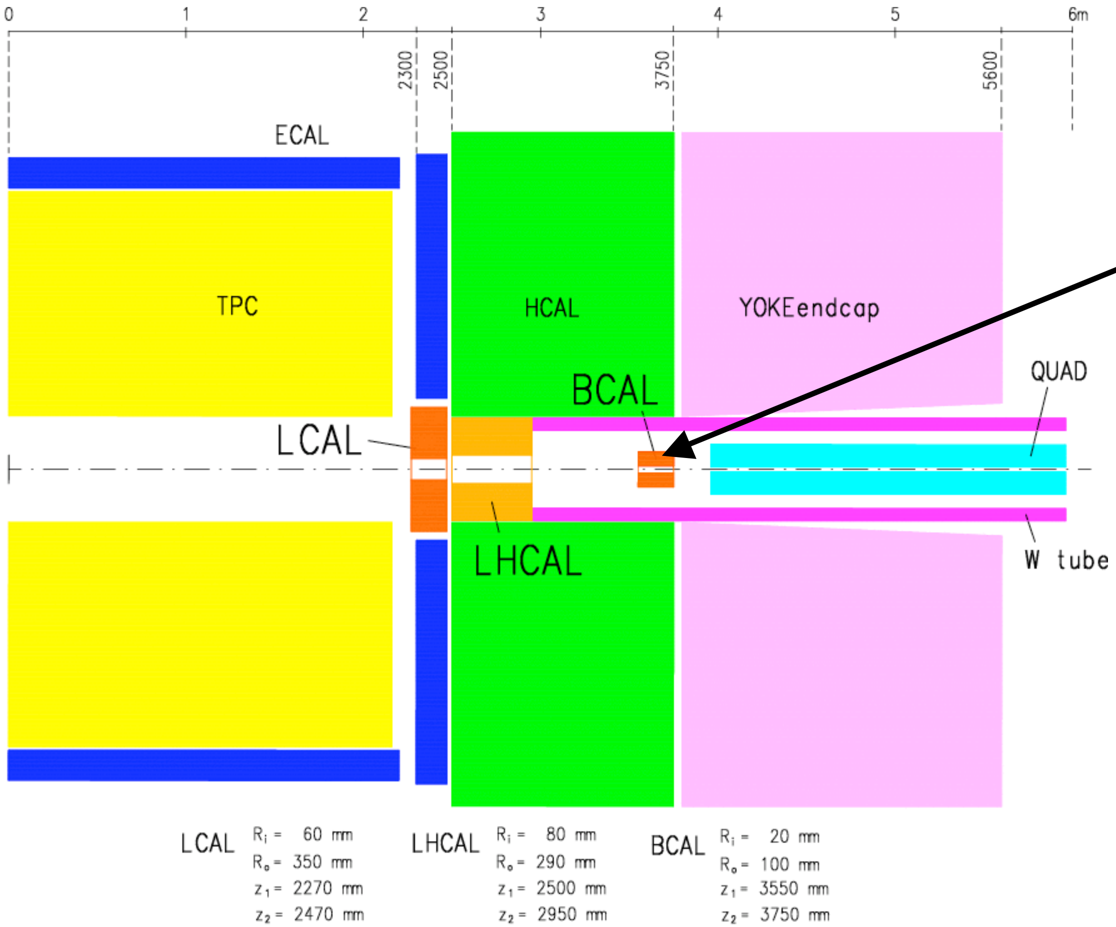
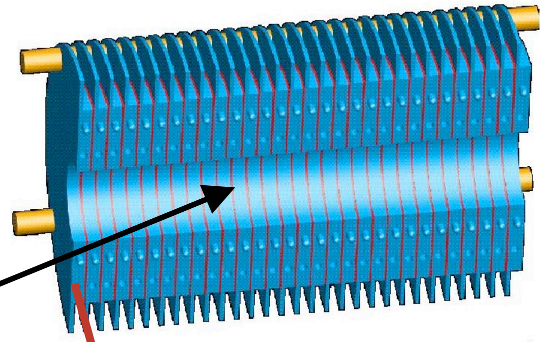
OUTLINE OF THIS TALK

1. Introduction
2. Silicon
3. CVD Diamonds
4. Gallium Arsenide
5. Silicon Carbide
6. Conclusions

INTRODUCTION





BeamCal

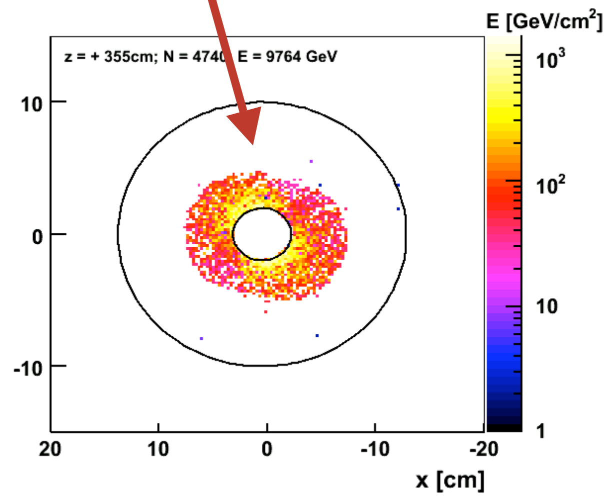
30 layers of

W / CVD diamond (?)

5 < ***ANGLE*** < 28 mrad

Energy deposition from beamstrahlung pairs in BeamCal:

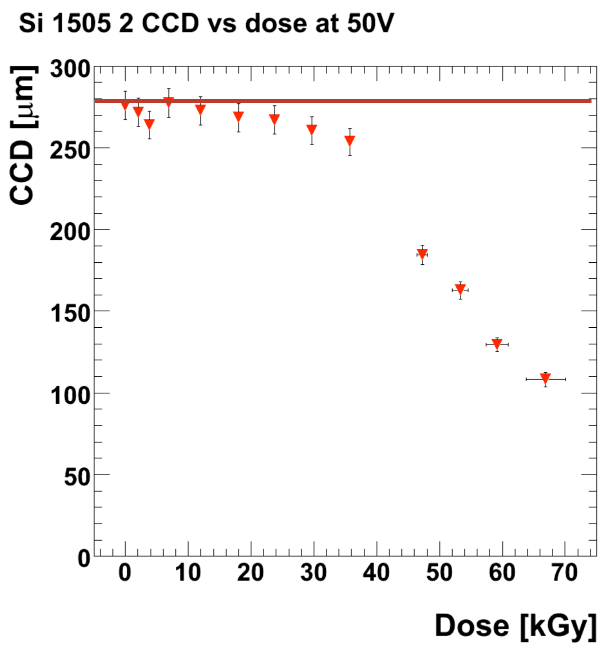
Dose of up to 10 MGy/a



SILICON

- operated as ‘extended’ pn junction -> depleted intrinsic material (bandgap 1.12 eV)
- The only material which is fully ‘under control’: ***reference material***
  - technology: availability, structuring, testing, assembly
  - properties: signal yield, stability, long term behaviour
- Problem: radiation hardness:

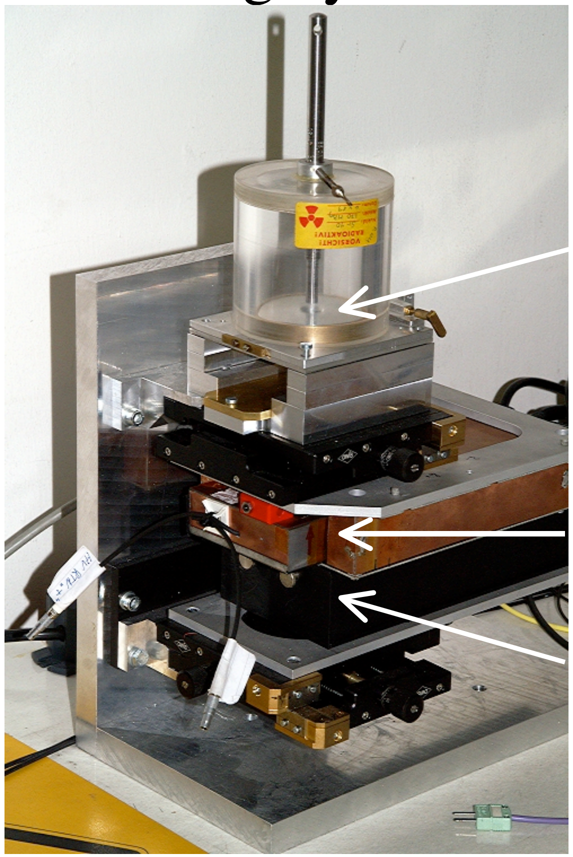
Sample irradiated with e^-:
Thickness = 280 μm
Initial CCD = 280 μm
(100% collection efficiency)



- will improve significantly
- still not sufficient for the inner radii of a planned BeamCal

CVD DIAMONDS - polycrystalline (1)

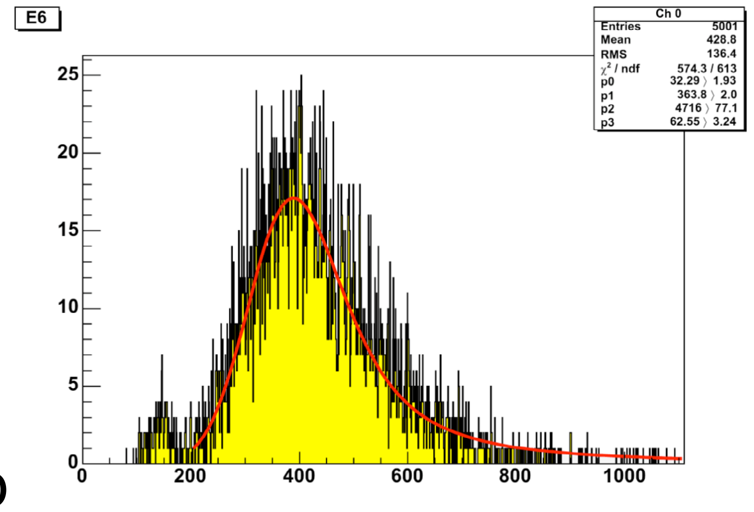
- operated as 'solid state ionization chamber' (bandgap ~ 5.5 eV)
- different sources: IAF (Fraunhofer, Freiburg), E6
- state of the art: 4" wafers, 6" possible -> sensor areas > 50 **x** 50 mm^2
- structuring by metallization ('coarse patterns') w/o photolithography



Source (Sr 90)

Sensor, Preamp

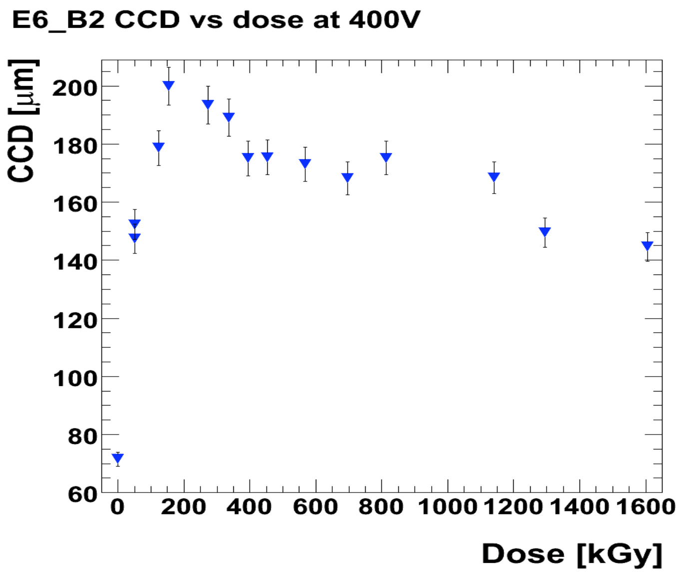
Trigger

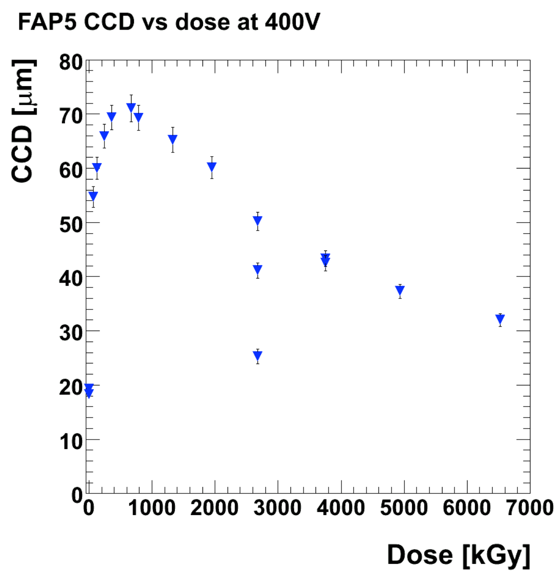


CCE measured:
(5 to 50)%

CVD DIAMONDS - polycrystalline (2)

- radiation hard (survival) but no stable and no predictible behaviour:
  - dependence of CCD on dose acquired (pumping / degradation)

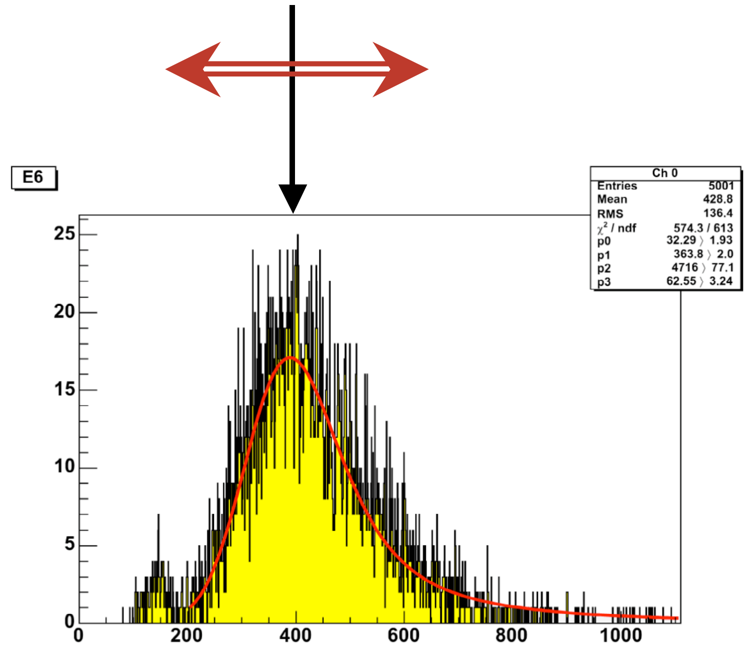




- dependence on pumping and degradation, on dose rate applied
- changes (vs irrad) observed: improvement, degradation
- actual properties time dependent (relaxation, recovery)

CVD DIAMONDS - polycrystalline (3)

- 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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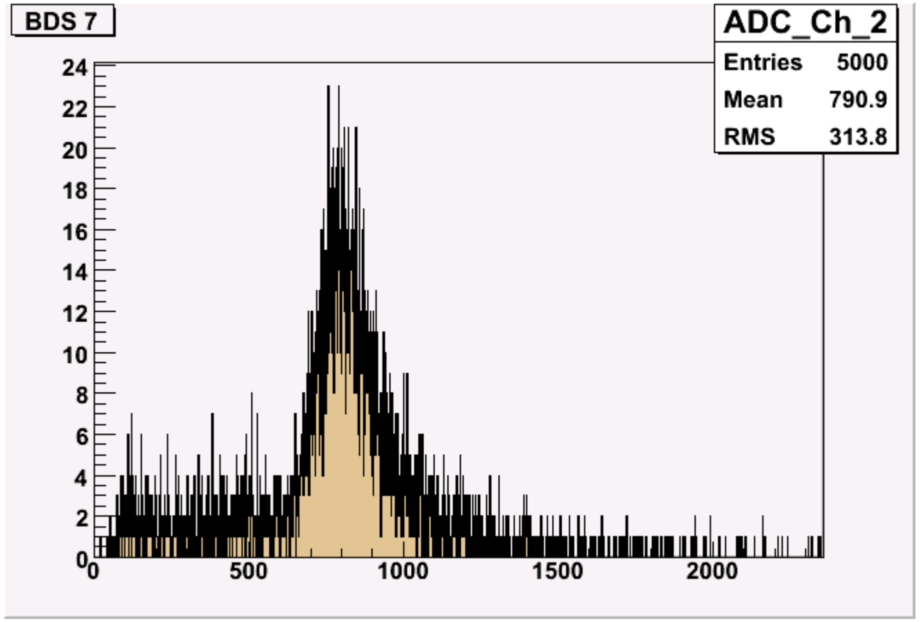
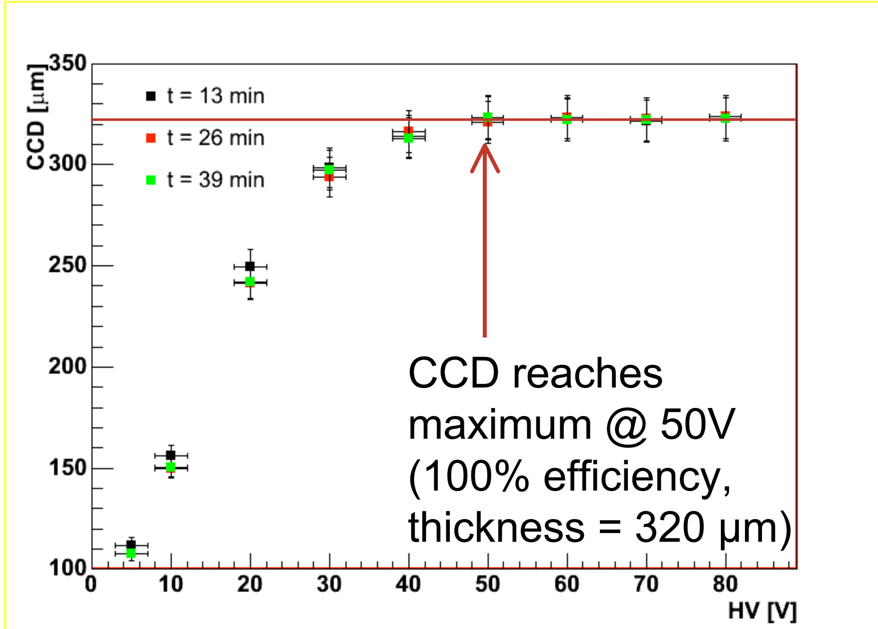
- applications with thresholds
  counting

CVD DIAMONDS - single crystals (1)

- Single Crystal (CVD grown on substrate) by E6
- Size: 5 x 5 mm^2, metallization 3 mm in diameter, 320 μm thick

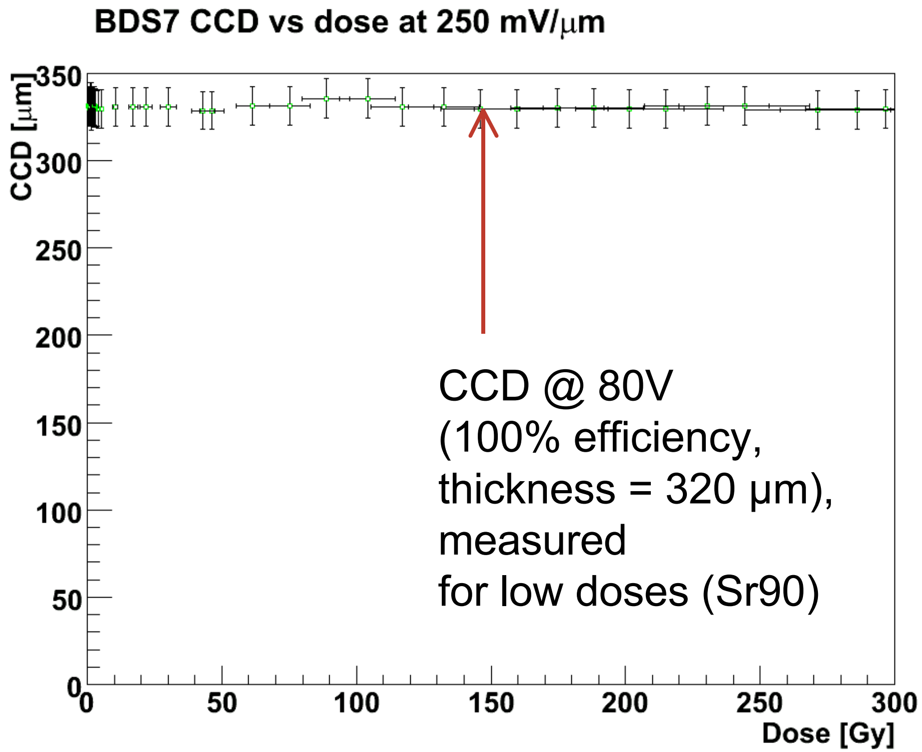


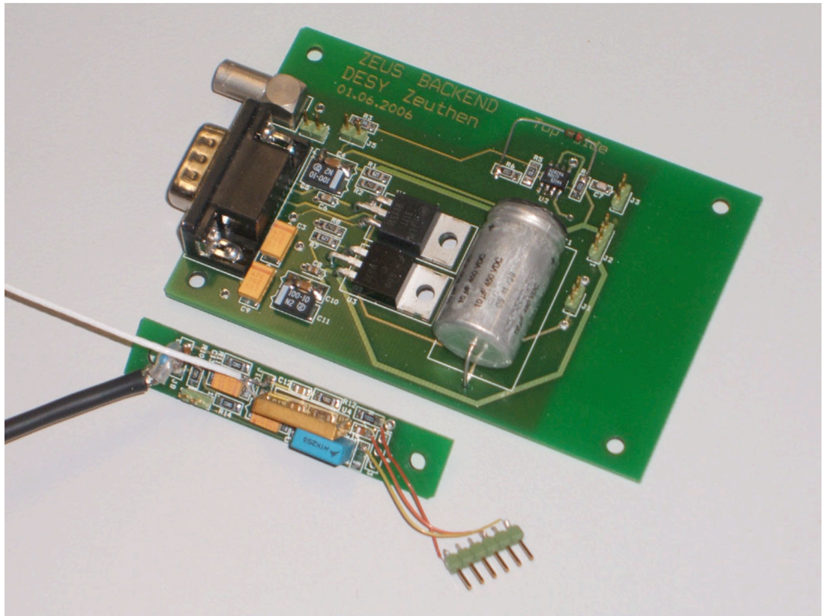


- Clearly separated spectrum of minimal ionizing particles
- 100% CCE, CCD = thickness, 1 mip results in 11.5 ke^- (1.84 fC)

CVD DIAMONDS - single crystals (2)

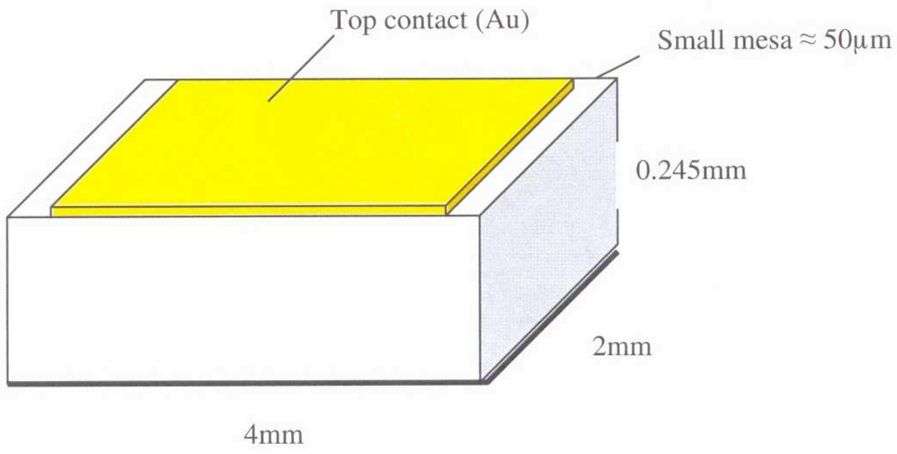
- Stable for low doses, further investigations needed (and planned)





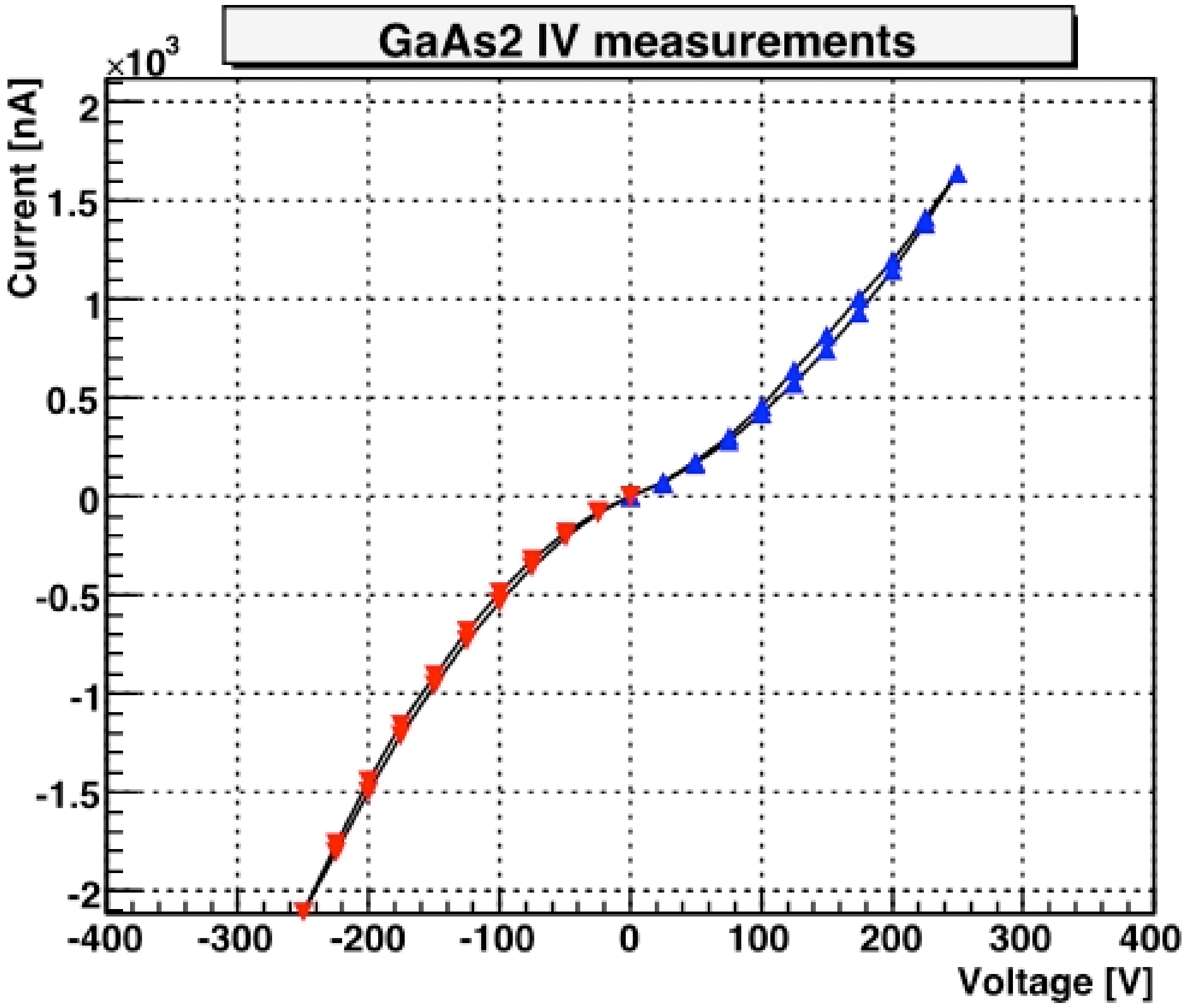
Gallium Arsenide (1)

- operated as
  - ‘solid state ionization chamber’ (bandgap: 1.42 eV) or as
  - ‘extended pn junction’: p-i-n structure



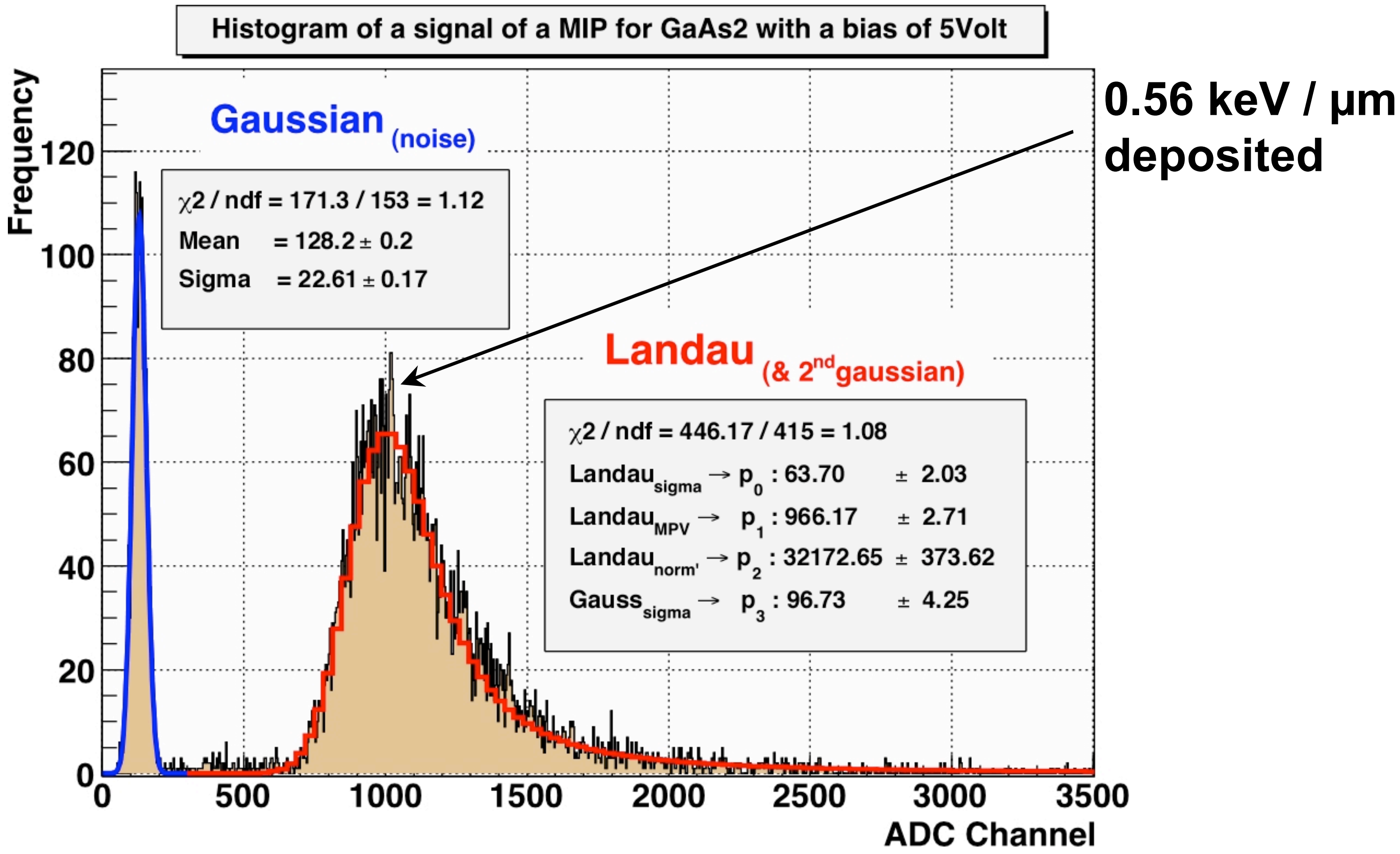
Gallium Arsenide (2)

- static measurements (I/V)



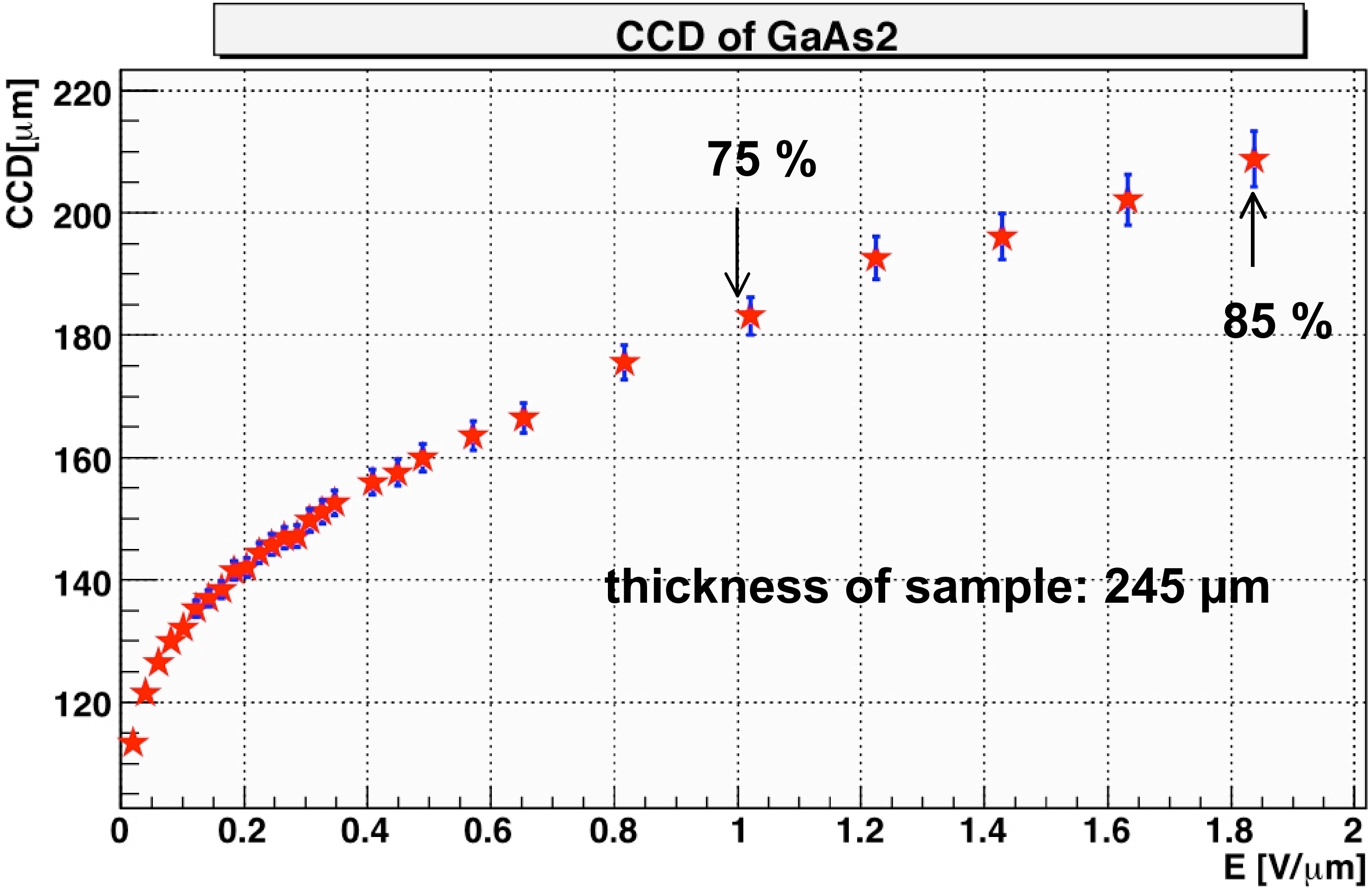
Gallium Arsenide (3)

- Spectroscopic measurements (Sr 90)



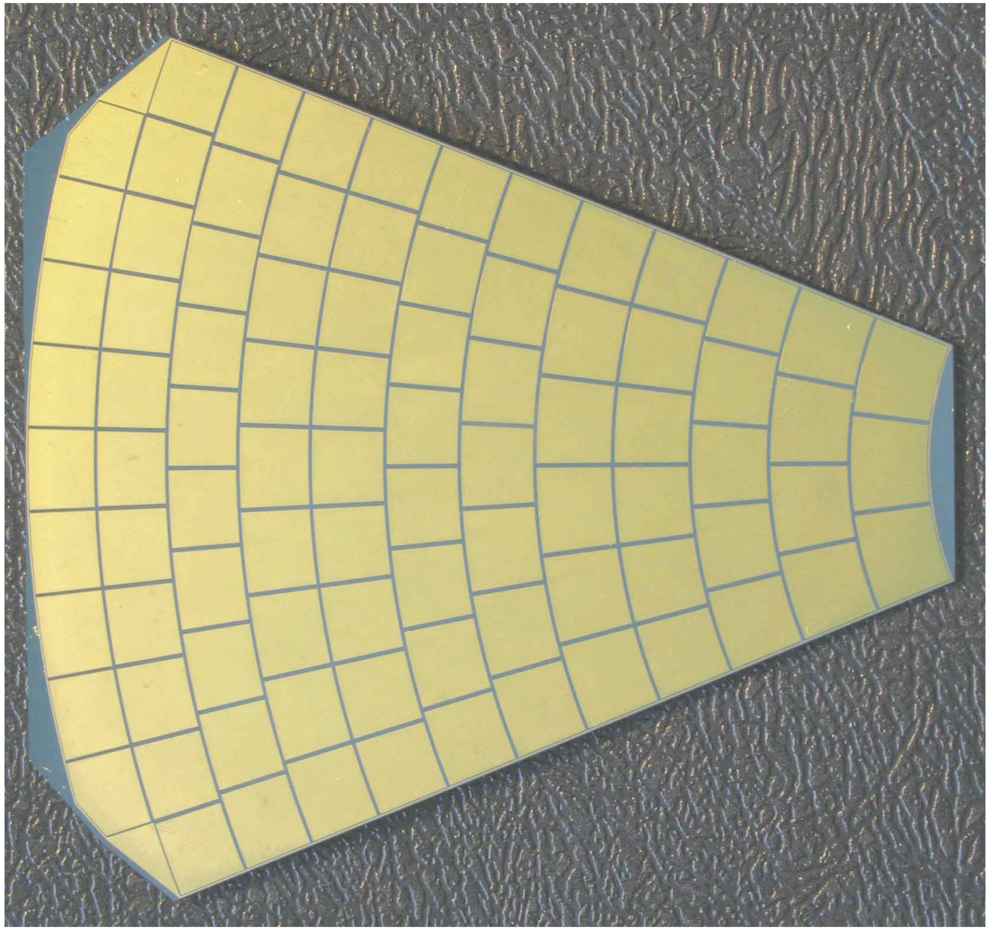
Gallium Arsenide (4)

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



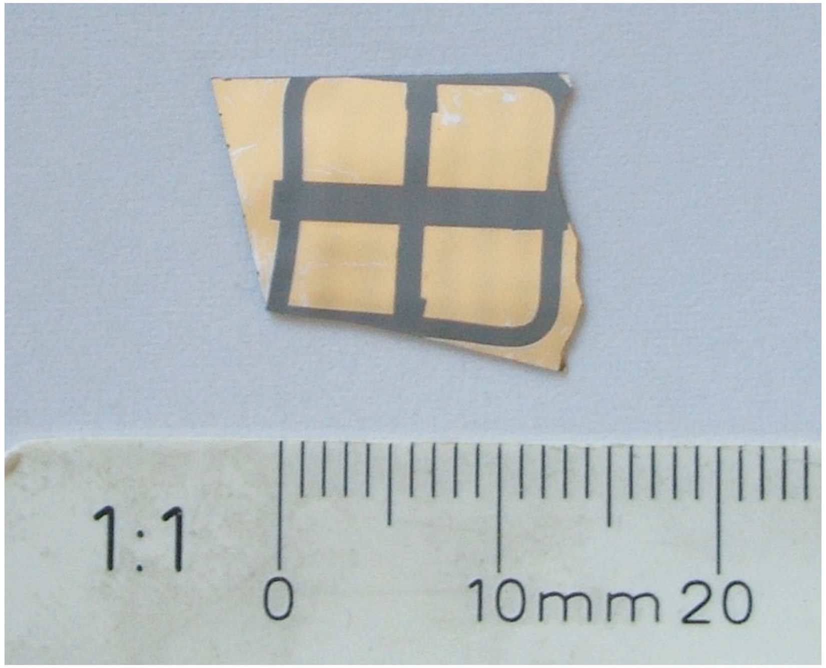
Gallium Arsenide (5)

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



Silicon Carbide (1)

- wide bandgap material: ~ (3…3.35) eV
  -> solid state ionization chamber
- normally produced as epi layer (CVD) on silicon (industry!)
- SiC at wafer scale up to 75 mm (3")
- still high defect densities (15 to 30 'micropipes' per cm^2)
- cost per cm^2: (150 … 300) Euro
- metal deposition ->
  - Schottky contact
    -> annealing @ high T ->
    ohmic contacts
- planned collaboration
  with BTU Cottbus



CONCLUSIONS

- harsh environment (irradiation) demand new detector materials
- current silicon does not survive the high radiation levels
    - but it's still got potential for improvement (LHC, X-ray etc)
    - watch the development
- GaAs: growing knowledge and experience (LHC etc)
    - promising detector capabilities
    - samples to be investigated
- CVD diamonds survive high doses
    - current samples are not (long term) stable (as detectors)
    - recommended only for counting applications
- Silicon Carbide has promising radiation hardness (literature)
    - already used by industry (power and high voltage devices)
    - detection properties to be measured…