CarADD
BeamCal for the ILC Detector

C.Grah

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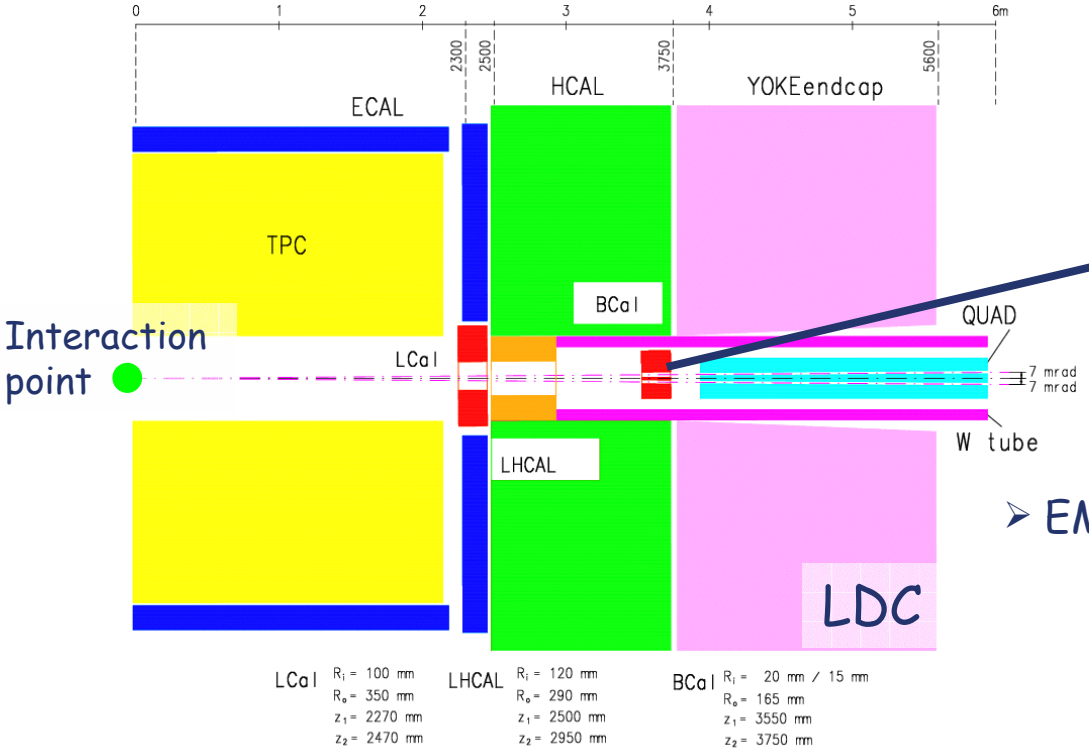
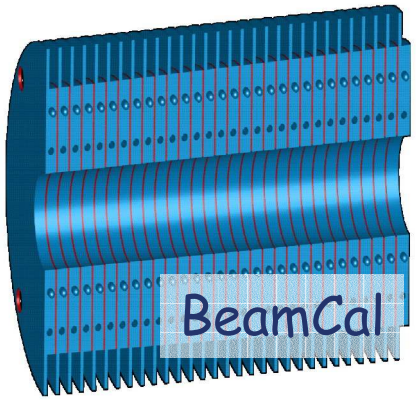
Very Forward Region of the ILC Detectors



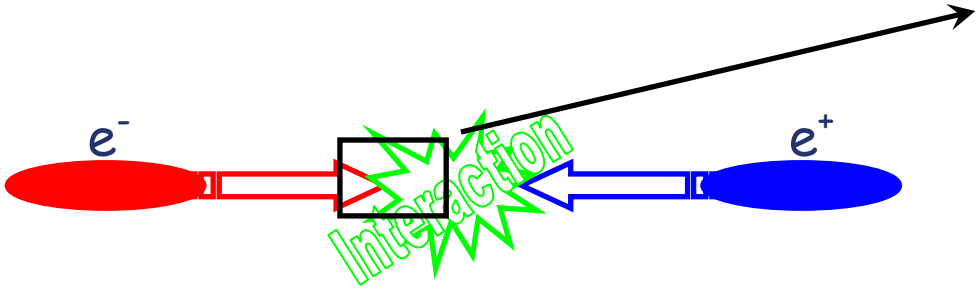


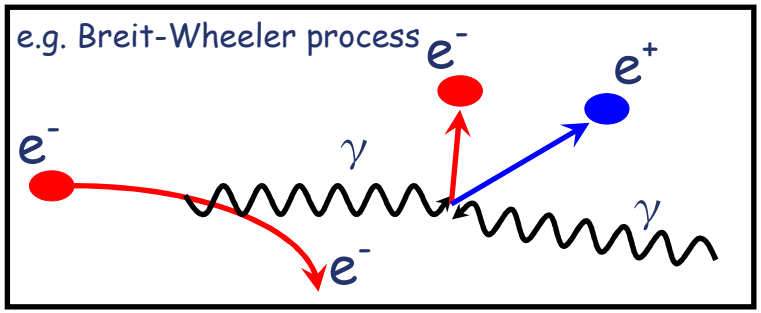
- EM calorimeter with sandwich structure:
  - 30 layers of 1 X_0
    - 3.5mm W and 0.3mm sensor
  - Angular coverage from 5mrad to 28 mrad
  - Moliére radius $R_M \approx$ 1cm
  - Segmentation between 0.5 and 0.8 x R_M

- The purpose of the instrumentation of the very forward region is:
  - Hermeticity: increase the coverage to polar angles > 5mrad
  - Optimize Luminosity

The Challenges for BeamCal

Creation of beamstrahlung at the ILC

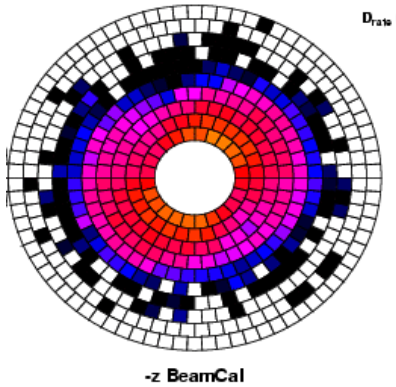




- e+e- pairs from beamstrahlung are deflected into the BeamCal
- 15000 e^+e^- per BX

=> **up to 10 MGy per year** strongly dependent on the beam and magnetic field configuration

=> radiation hard sensors

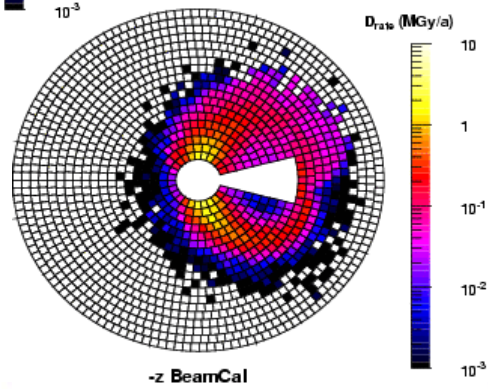


≈ 1 MGy/a

- Detect the signature of single high energetic particles on top of the background.

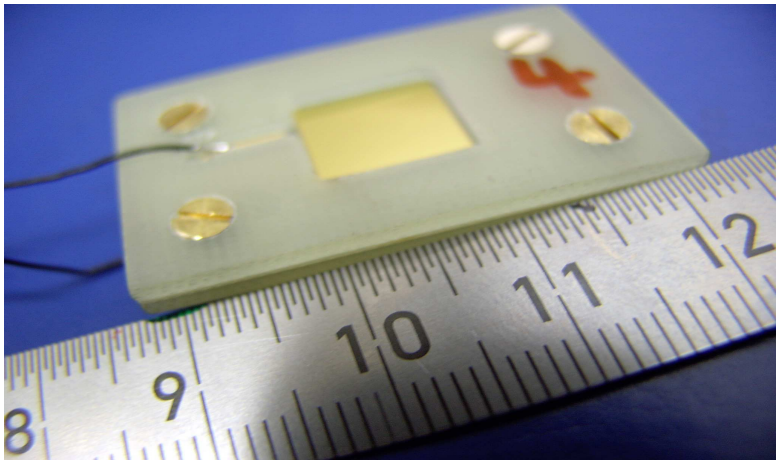
=> high dynamic range/linearity

≈ 5 MGy/a

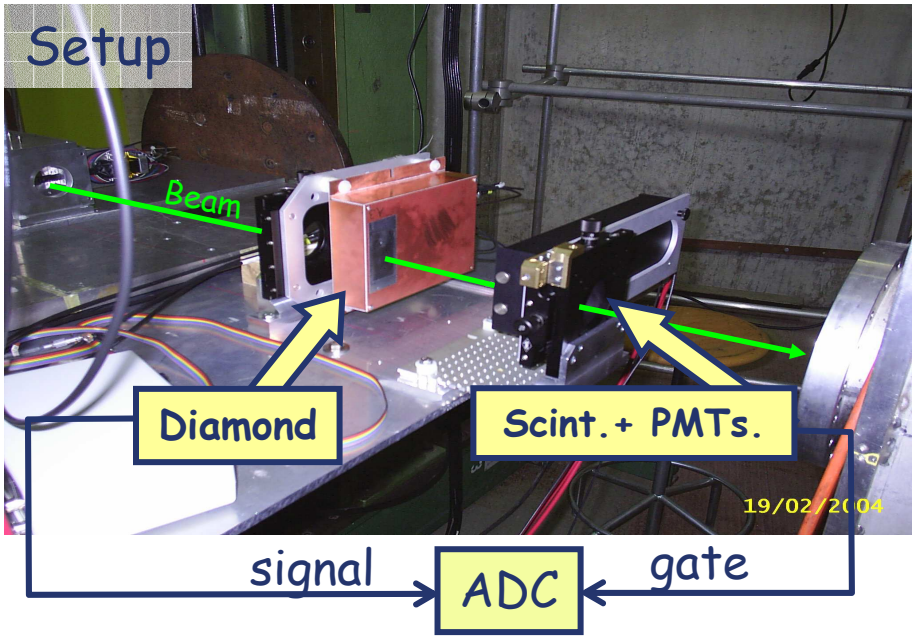


Chemical Vapour Deposited Diamonds

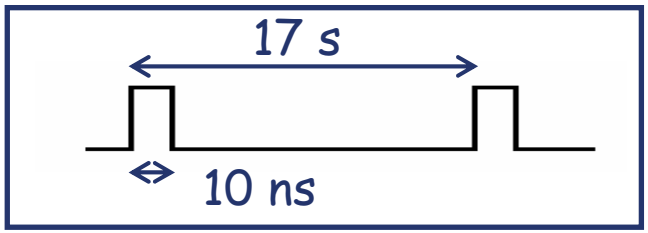
- CVD diamonds are an interesting material:
  - radiation hardness (e.g. LHC pixel detectors)
  - advantageous properties like: high mobility, low $\varepsilon_R = 5.7$, thermal conductivity
  - availability on wafer scale



Linearity Test at CERN PS

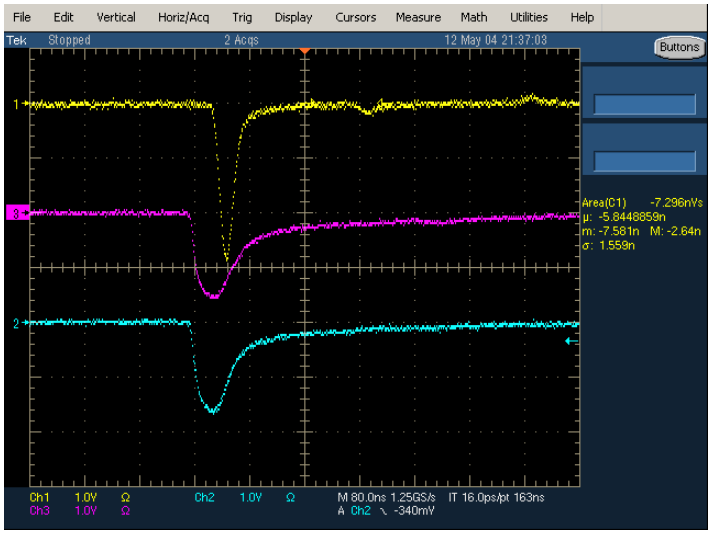


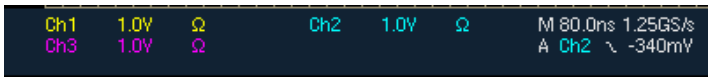
Hadronic beam, 3 & 5 GeV
Fast extraction mode
~10^4-10^7 particles / ~10 ns



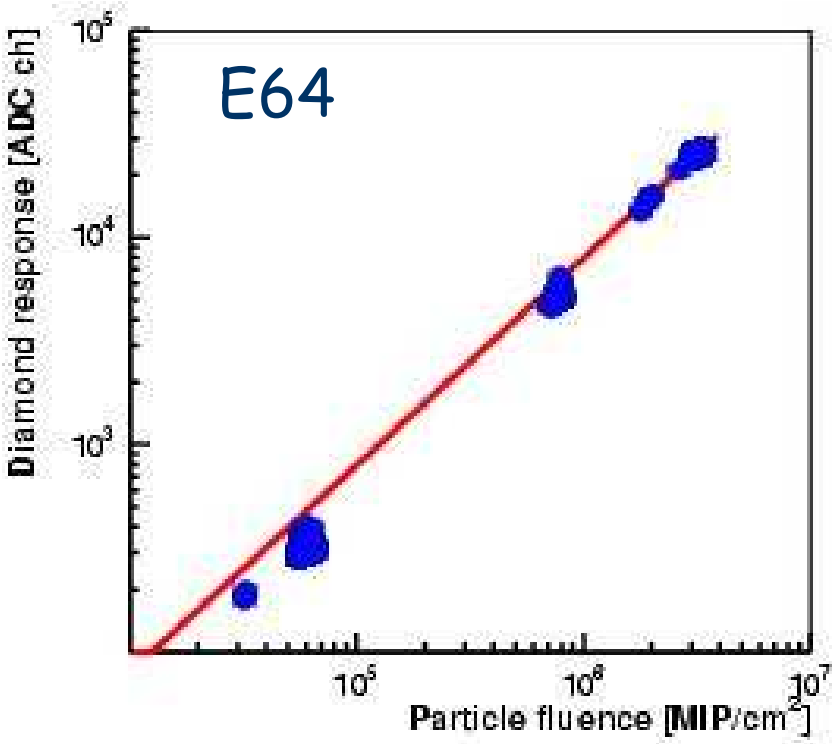
Response of diamond sensor to beam particles (no preamplifier/attenuated)

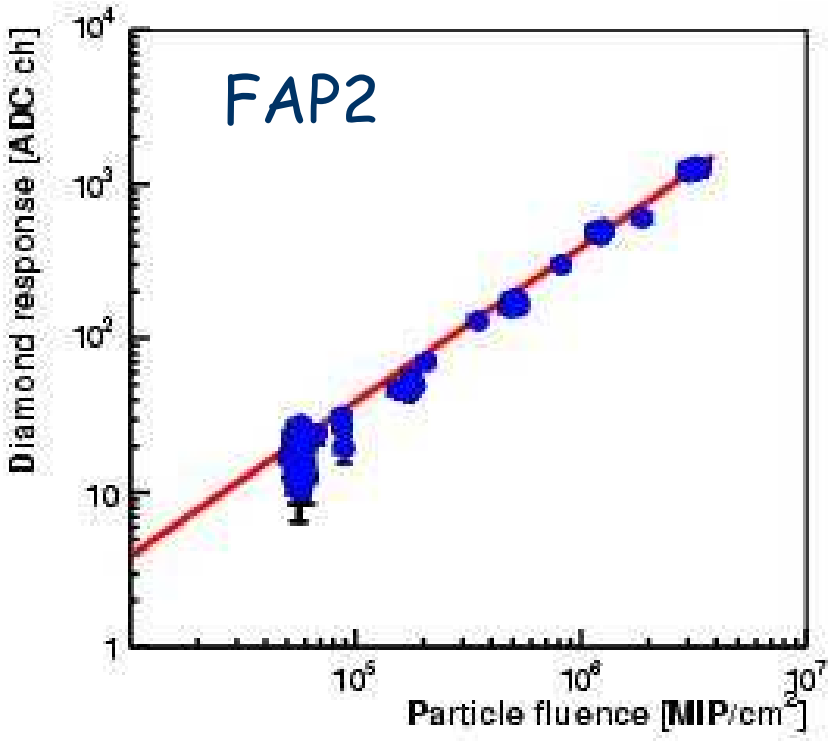
Photomultiplier signals





Response vs. Particle Fluence

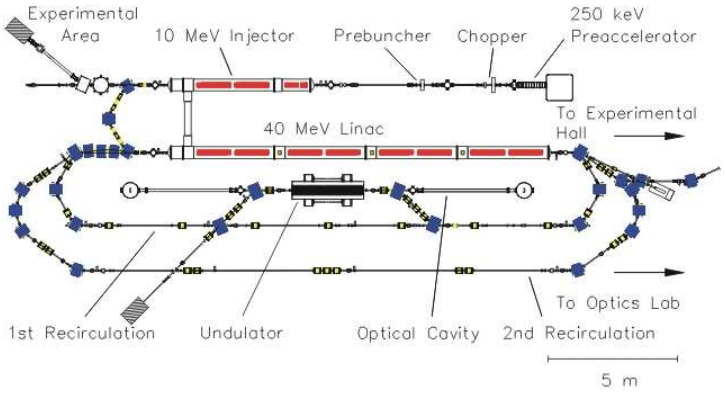




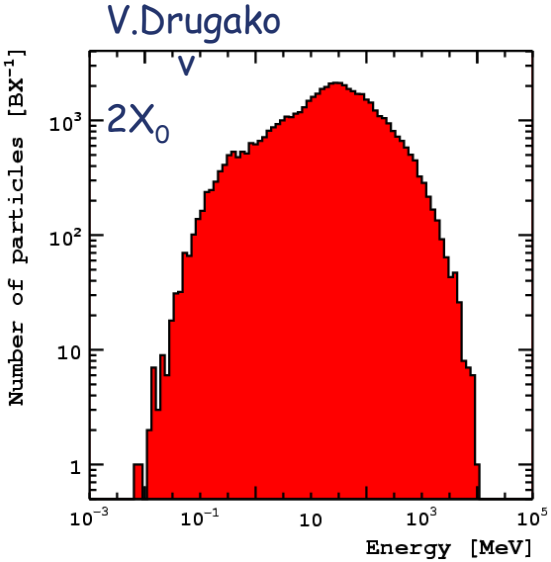
30% deviation from a linear response for a particle fluence
up to ~10^6 MIP/cm^2
The deviation is at the level of the systematic error of the fluence calibration.

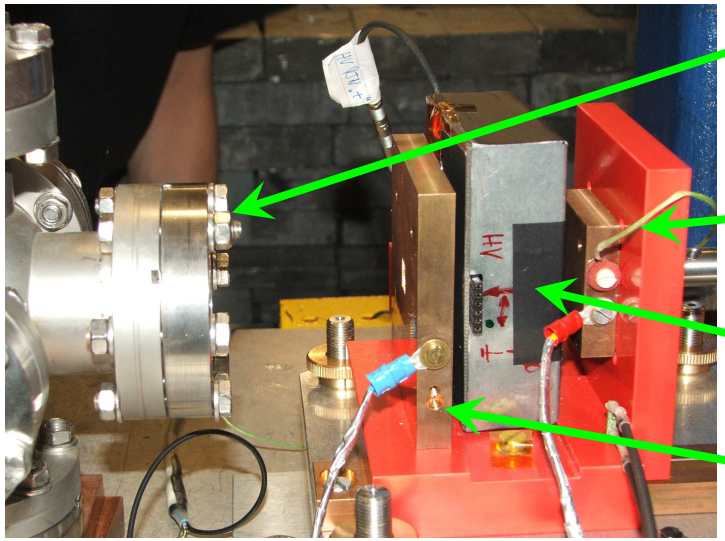
High Dose Irradiation

Superconducting DArmstadt LINear ACcelerator
Technical University of Darmstadt



Energy spectrum of shower particles in BeamCal





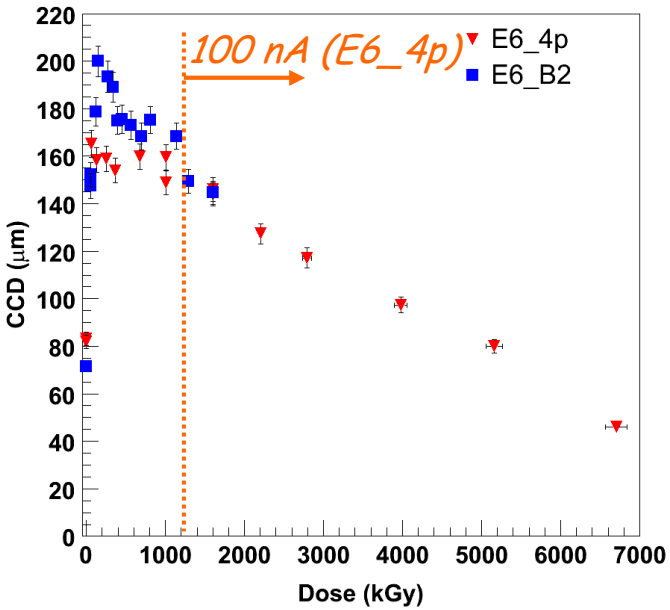
- Irradiation up to several MGy using the injector line of the S-DALINAC:
  10 ± 0.015 MeV and beam currents from 10 to 100 nA corresponding to about 59 to 590 kGy/h

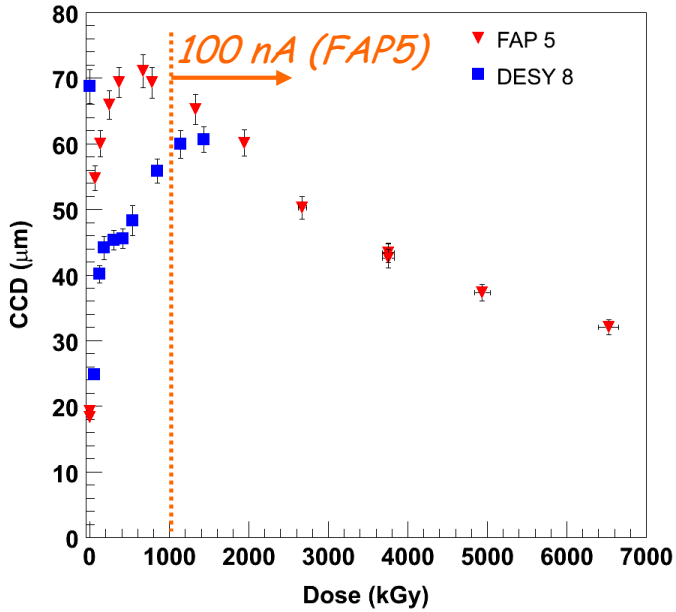
Results: CCD vs. Dose

CCD = $Q_{meas}/Q_{induced}$ x thickness
Bias voltage = 400V ≈> 1 V/ μ m

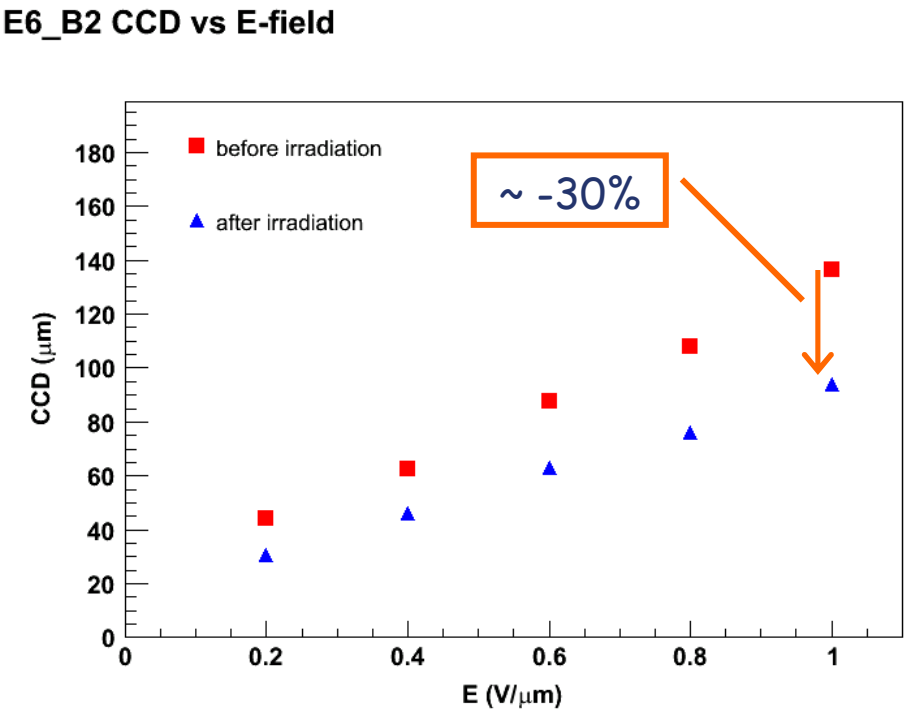
After absorbing 7MGy the CVD diamonds are still operational.

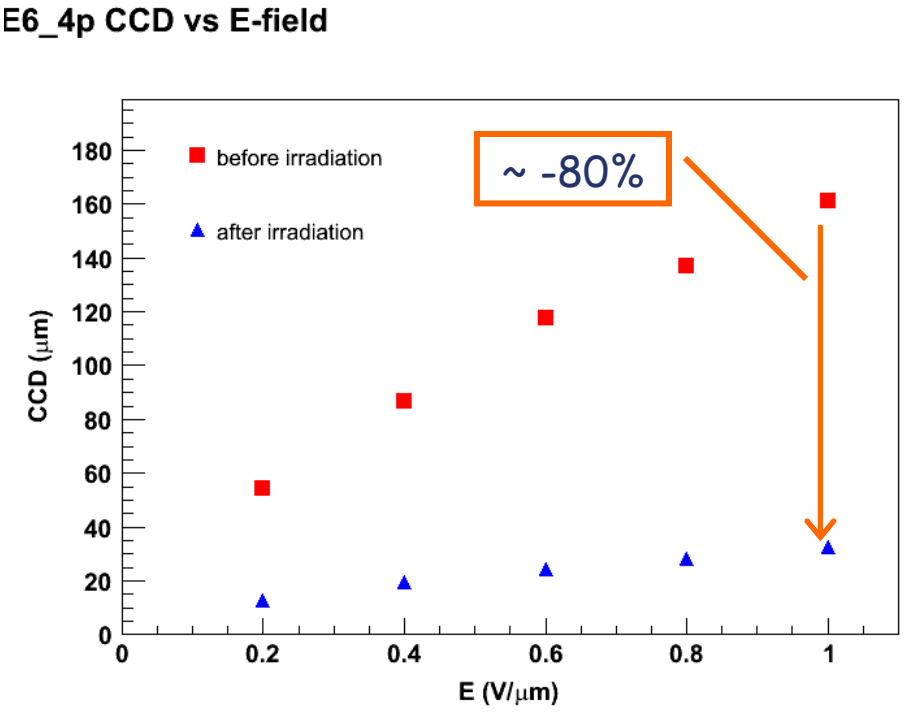
BUT large fluctuations in the signal size.





CCD Behaviour after Irradiation





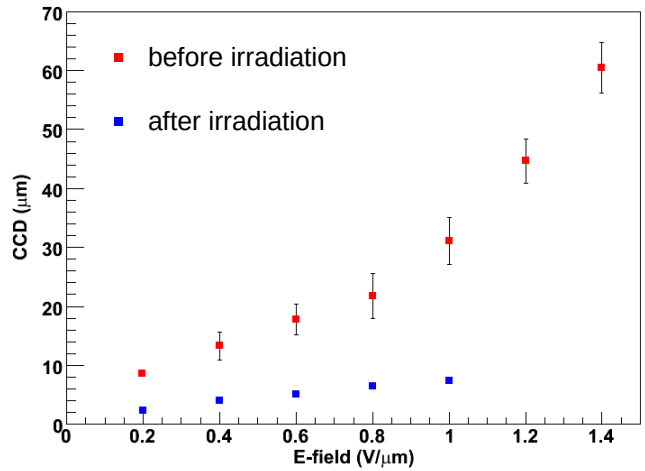
after 1.5 MGy

after 7 MGy

After Irradiation: IAF Sample

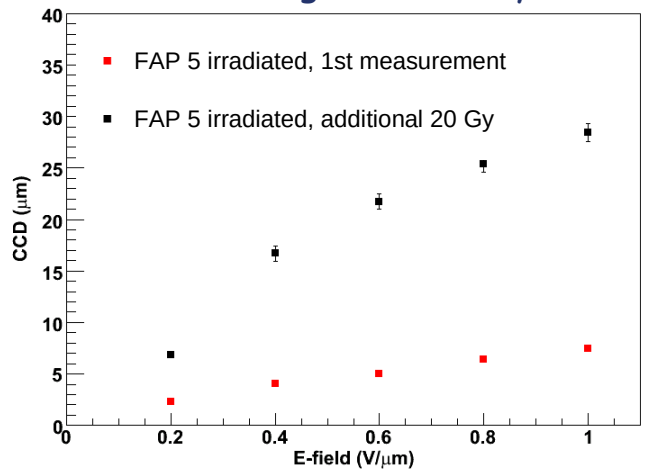
FAP 5 CCD vs E-field

before/after ~ 7MGy

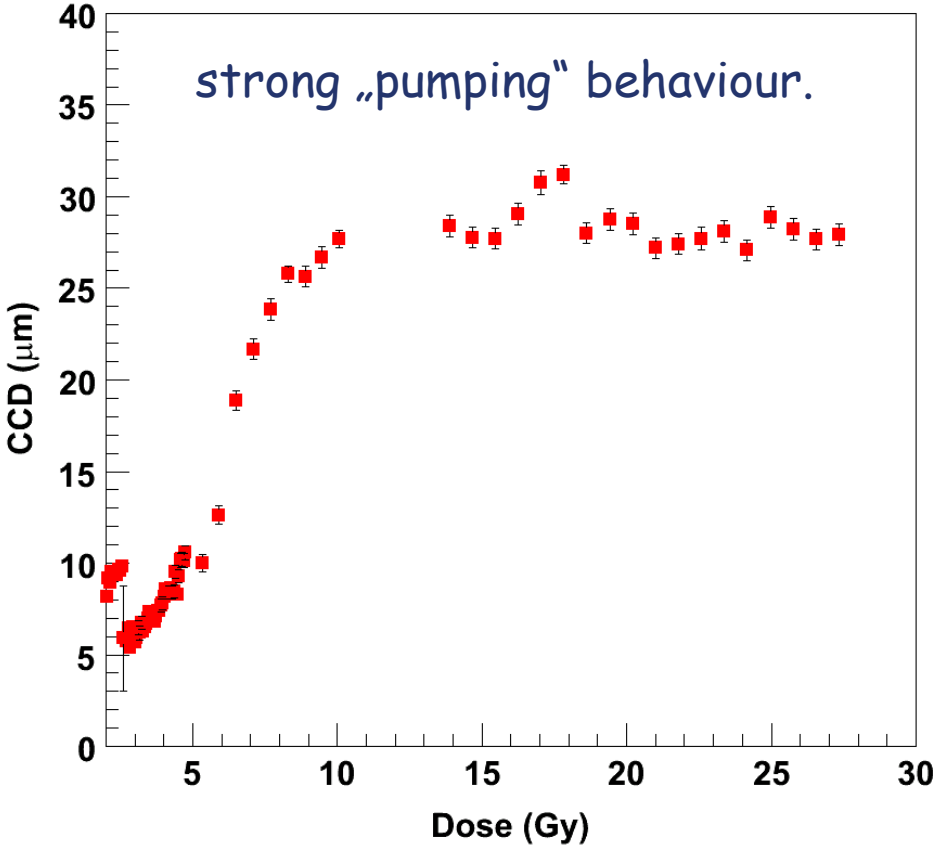


FAP 5 CCD vs E-field

signal recovery after 20 Gy



strong „pumping" behaviour.



Summary

- For the BeamCal of the ILC detector we need:
  - radiation hard sensors (proven for diamond)
  - linear over a large dynamic range (proven for diamond)
  - available on wafer scale (so far only polycrystalline CVD diamond)
- Polycrystalline CVD diamonds lack the following requirements:
  - stability and predictibility and sample to sample fluctuations.
- We therefore support the CarADD proposal and would like to contribute in the fields of:
  - Lab investigations (e.g. MIP spectra, IV measurements) of large area CVD diamond
  - Testbeam investigations (linearity, radiation hardness)
  - Prototyping of full system (small scale BeamCal prototype)

http://www-zeuthen.desy.de/ILC/fcal/

Request

- We request:
  - 1 PhD for 3 years: 96k
  - travel costs for 3 years: 6k
  - consumables for 3 years: 50k
  - => total 152k

- Contribution from DESY:
  - FTE & consumables for 3 years: 200k