Diamond Detector Developments at DESY

and

Measurements on homoepitaxial sCVD Diamond

Christian Grah - DESY Zeuthen

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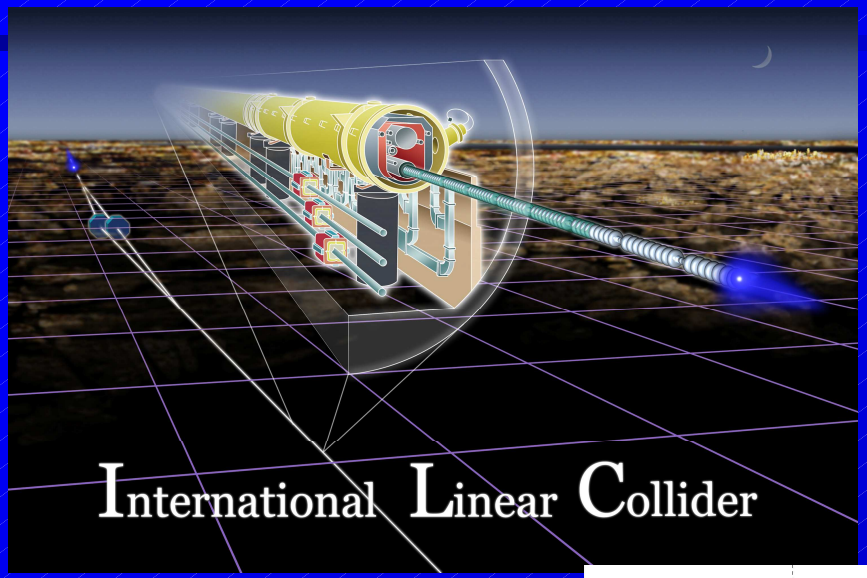
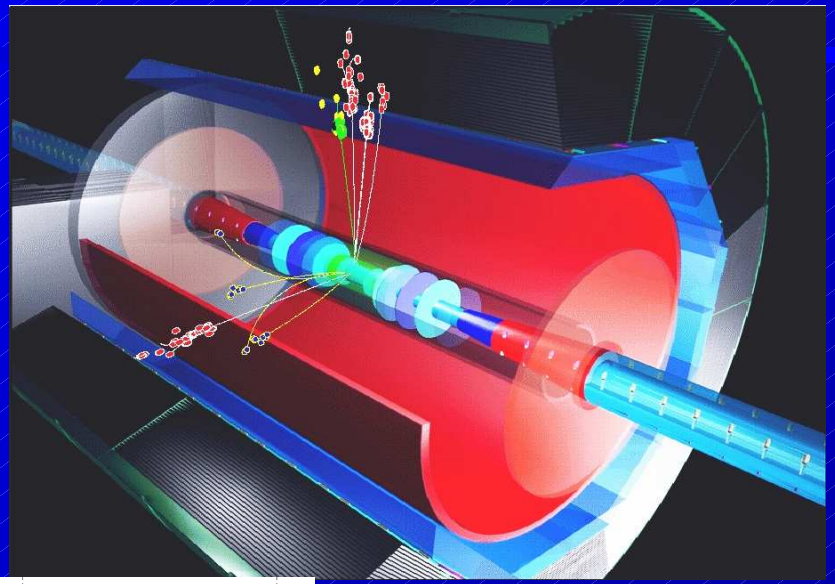
Contents

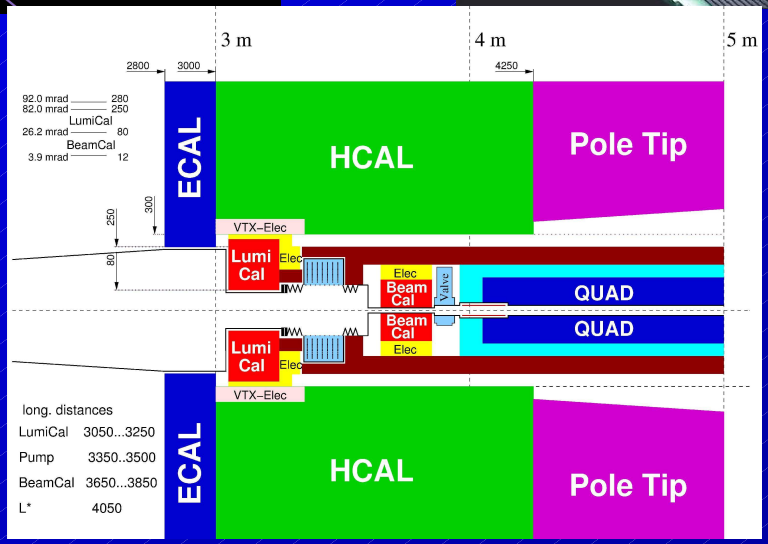
- Diamond Activities at DESY - Motivation
- Activities – investigation of sCVD diamond from Augsburg (->Schreck et. al.)
- I-V characteristics
- MIP spectrum
- Alpha source spectrum
- Summary & outlook

Motivation



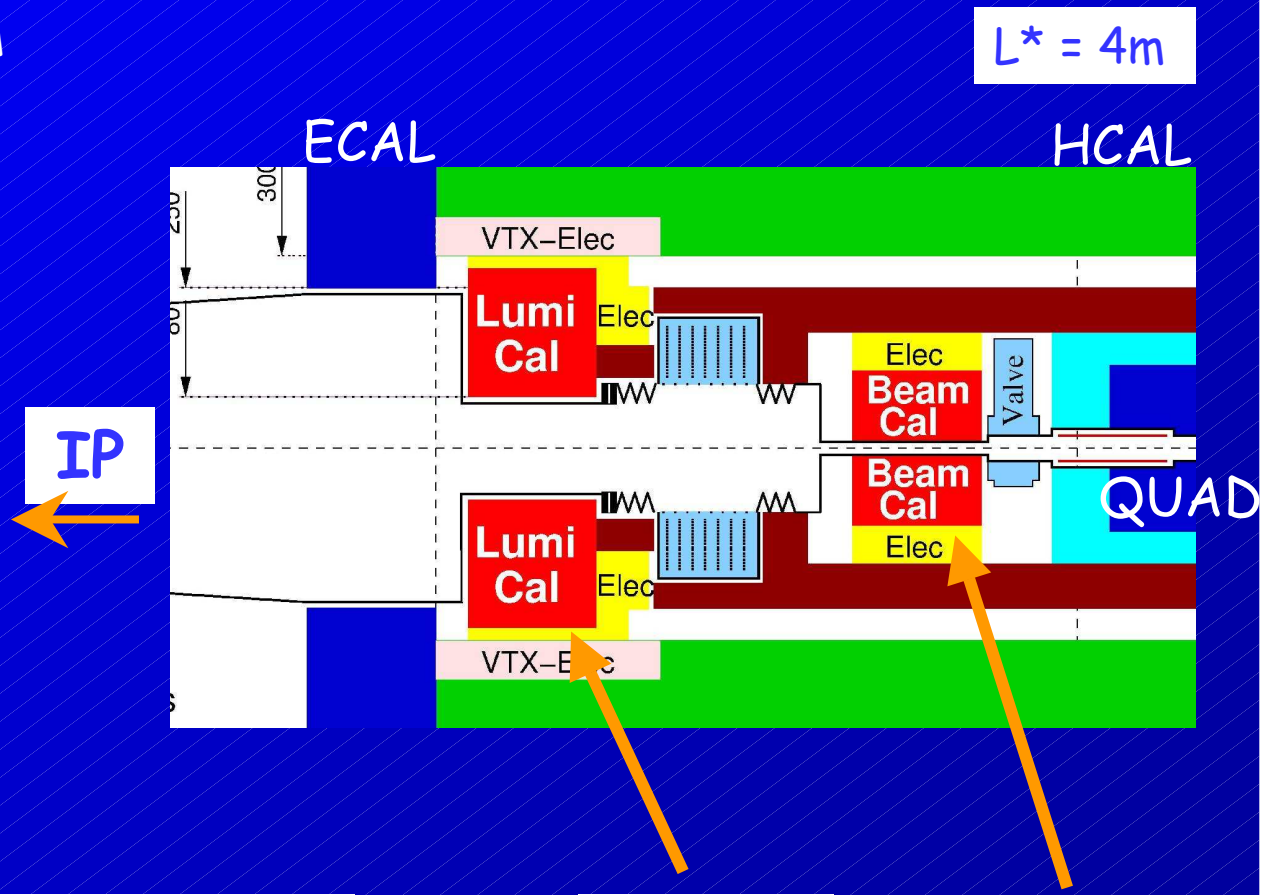


R&D for the Forward region of an ILC detector. (LDC based on the TESLA TDR)



Measure the background (beamstrahlung)

- Measure deposition from beamstrahlung pairs => determine beam parameters.
- Fast luminosity measurement from deposited energy.
- Measure single high energetic electrons/photons on top of that background.
- Shield the Inner Detector against backscattering.
- Precise luminosity measurement using LumiCal.



LumiCal: 26 < θ < 82 mrad
BeamCal: 4 < θ < 28 mrad

W-Diamond Sandwich Calorimeter

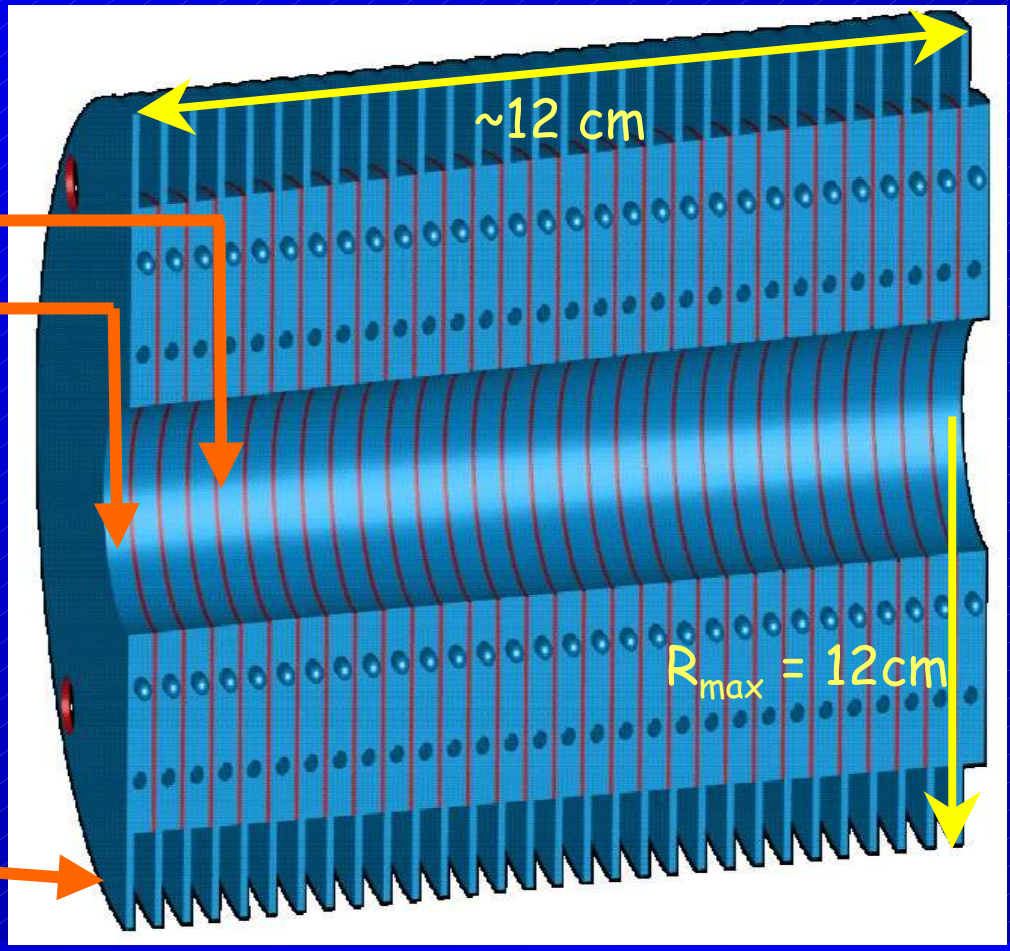
Length = 30 X_0

3.5mm W + .3mm diamond sensor

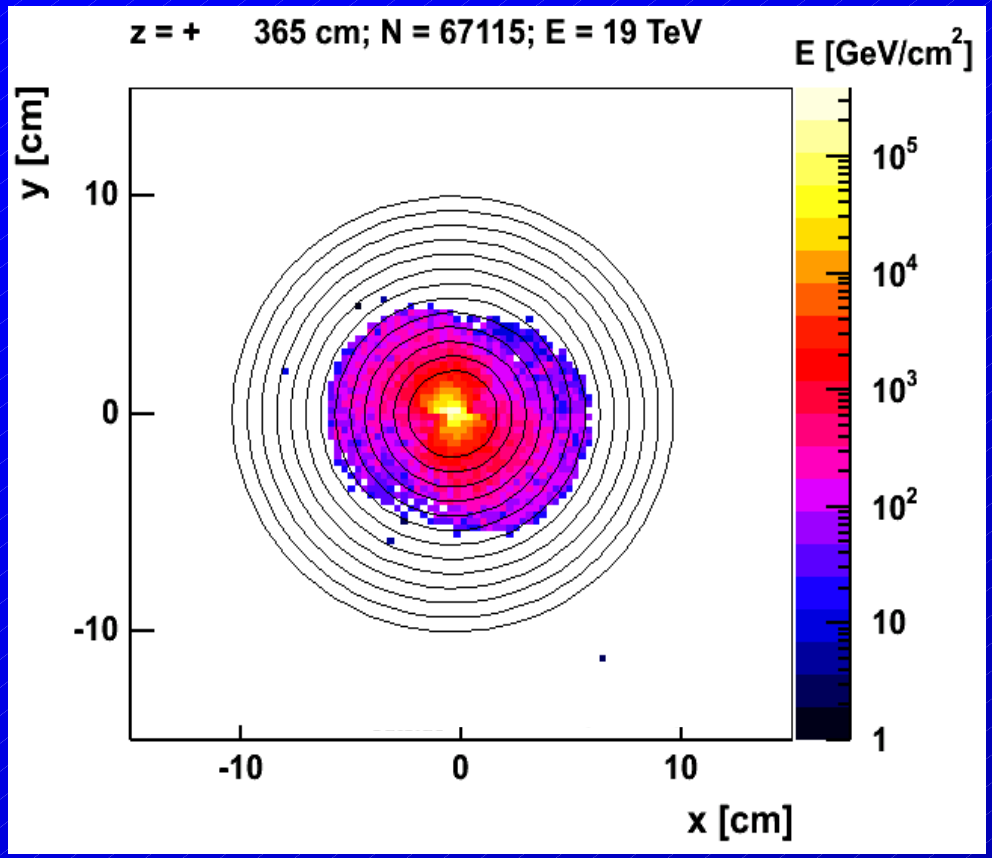
~ 15 000 channels
~ 0.5 x 0.5 cm^2 pad size/channel

~1.5 cm < R < ~10(+2) cm

Space for electronics



Why Diamond?



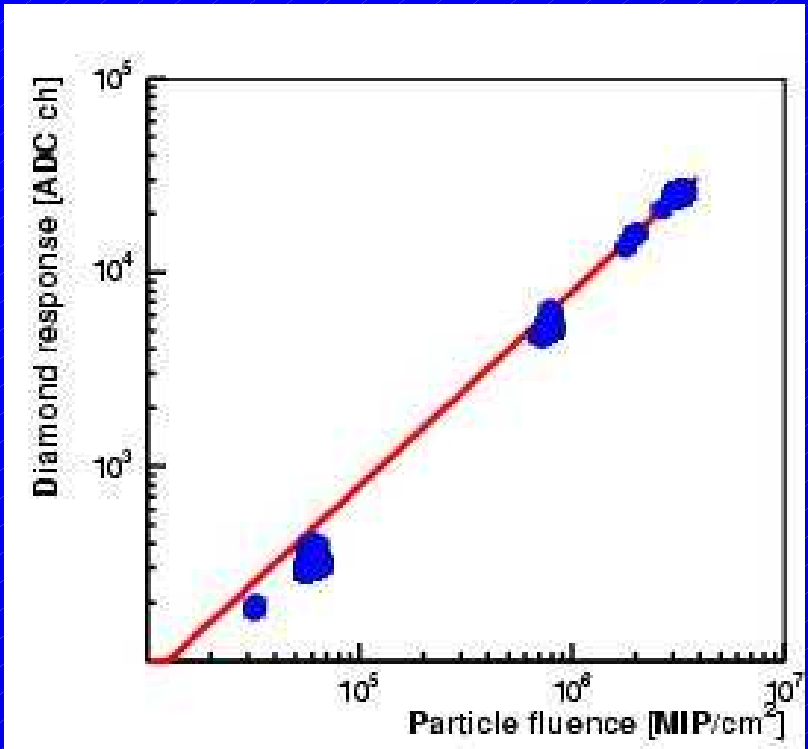
- Expect electron/positron hits of 10-20 TeV total energy in this region (14100/s).
- We expect ~ 10MGy/a dose rate in the "hot" region.
- Diamonds are the most promising candidate to do the job.

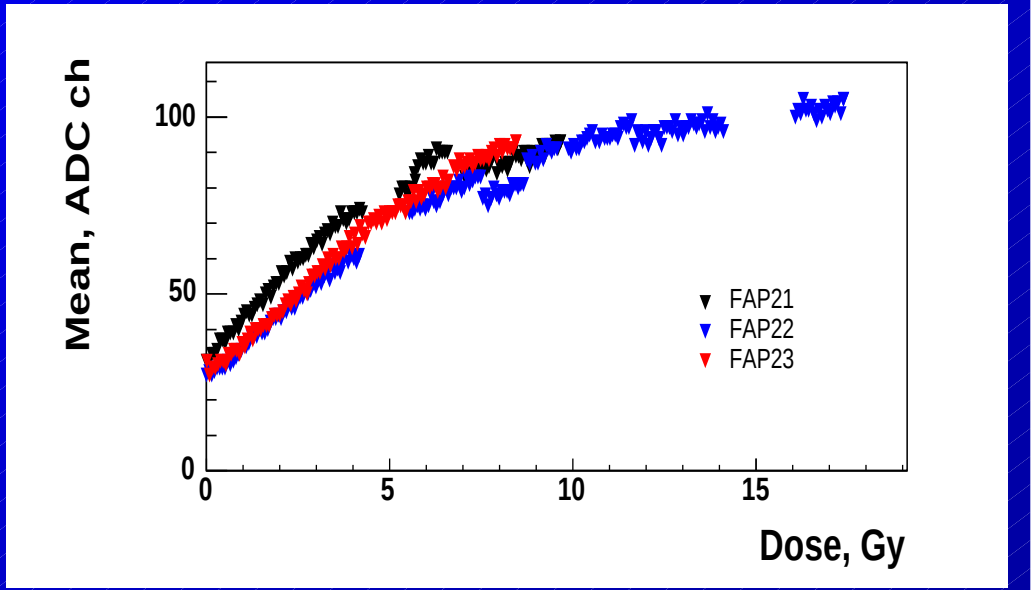
Sensors at Desy Zeuthen so far

- E6 – 2 samples
- Fraunhofer IAF, Freiburg - ~25 samples
- GPI Moscow – 3 samples
  These are polycrystalline CVD diamonds.

- Begin of 2005: 1 homoepitaxial sCVD diamond from Augsburg - "AB1".
  The following measurements were done on this sample!
- More features of AB1: ~ 350µm thick, single crystalline area in the center, small Ti/Pt/Au electrode of 2.5mm diameter on both sides.

Examples of Investigated Diamond

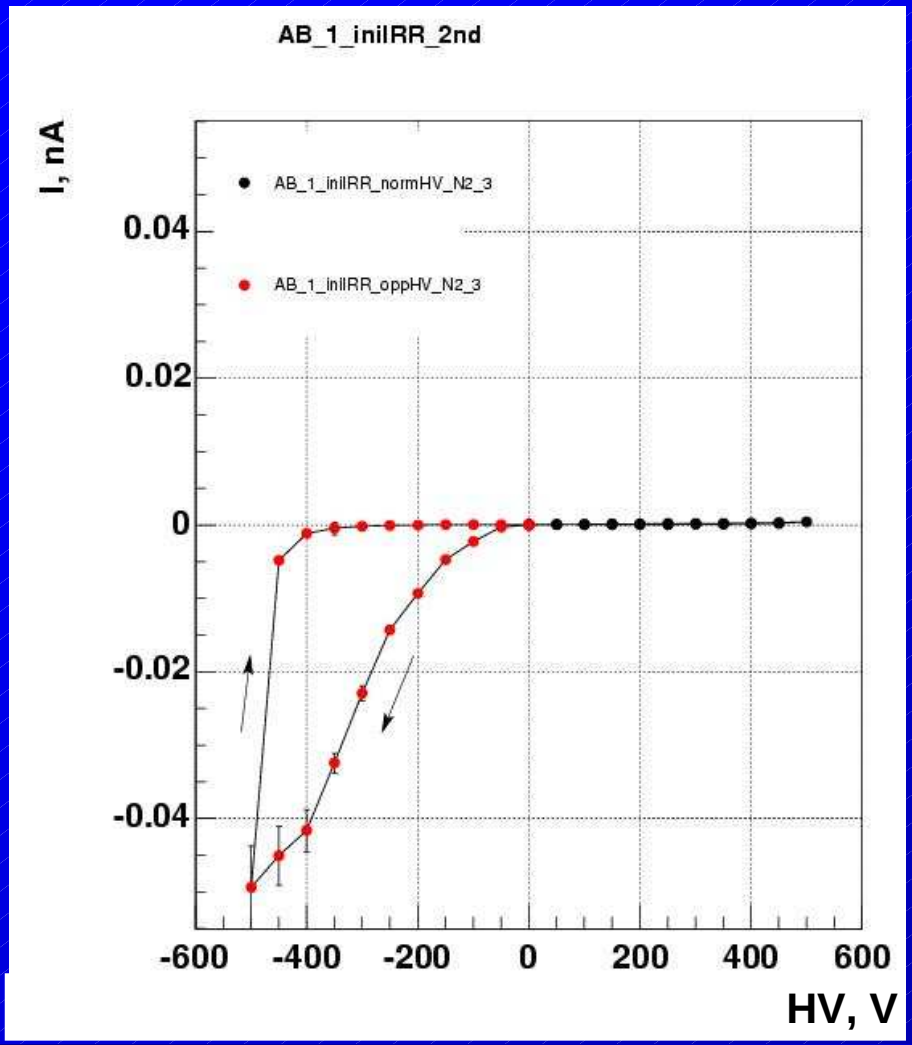




linearity over a wide range
(testbeam measurement,
5GeV hadrons)

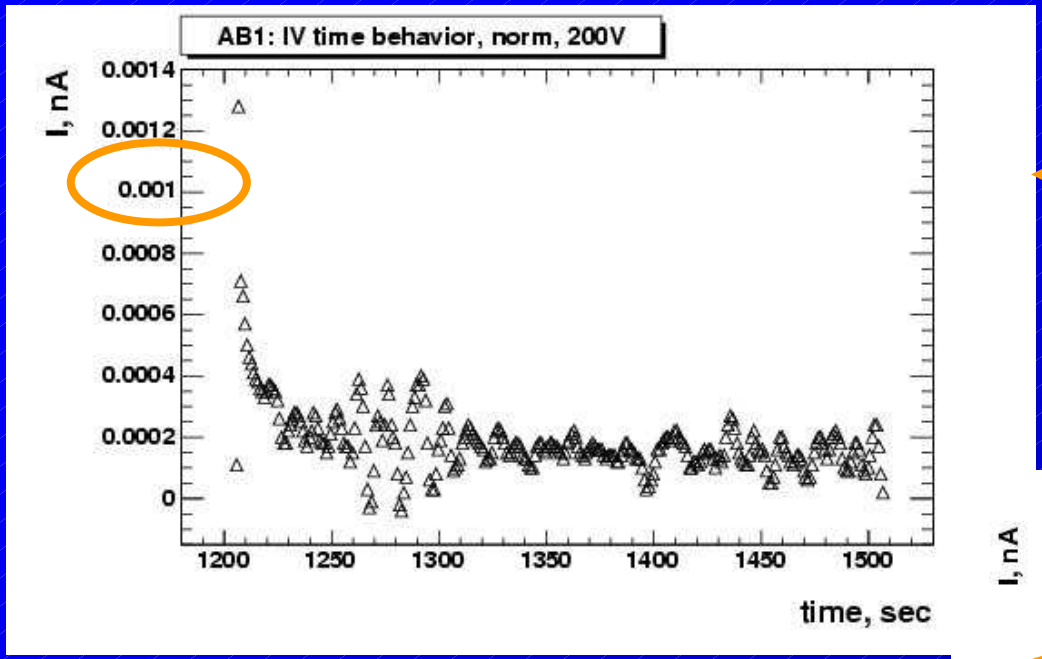
uniform behavior of signal size vs dose

Current-Voltage Characteristics



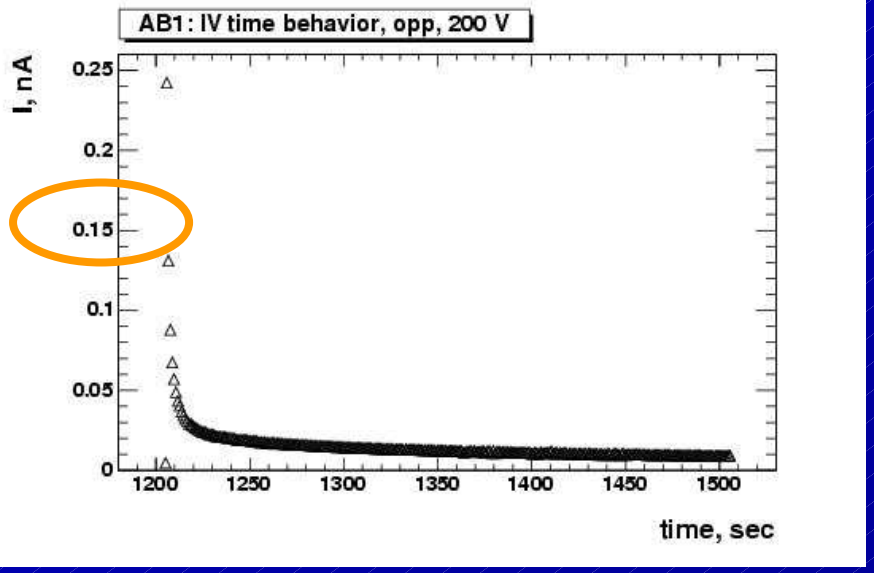
- Setup for measuring the current O(10^{-12} A) as a function of the applied voltage (up to 500 V). (good shielding, Pico Ampere meter, Nitrogen flow)
- Hysteresis (standard behavior for pCVD) and polarity dependence.
- Diode-like behavior.

Current vs. Time



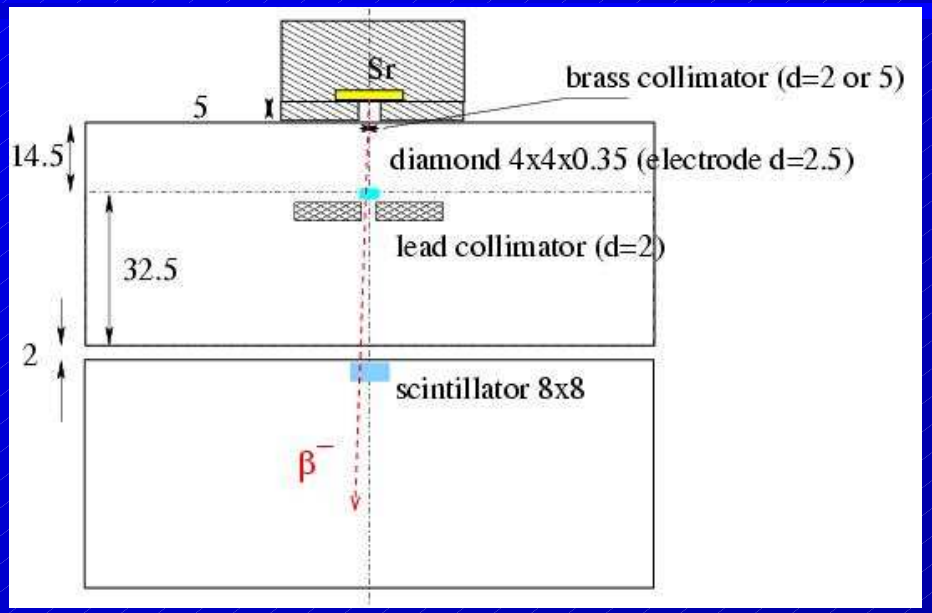
Positive polarity

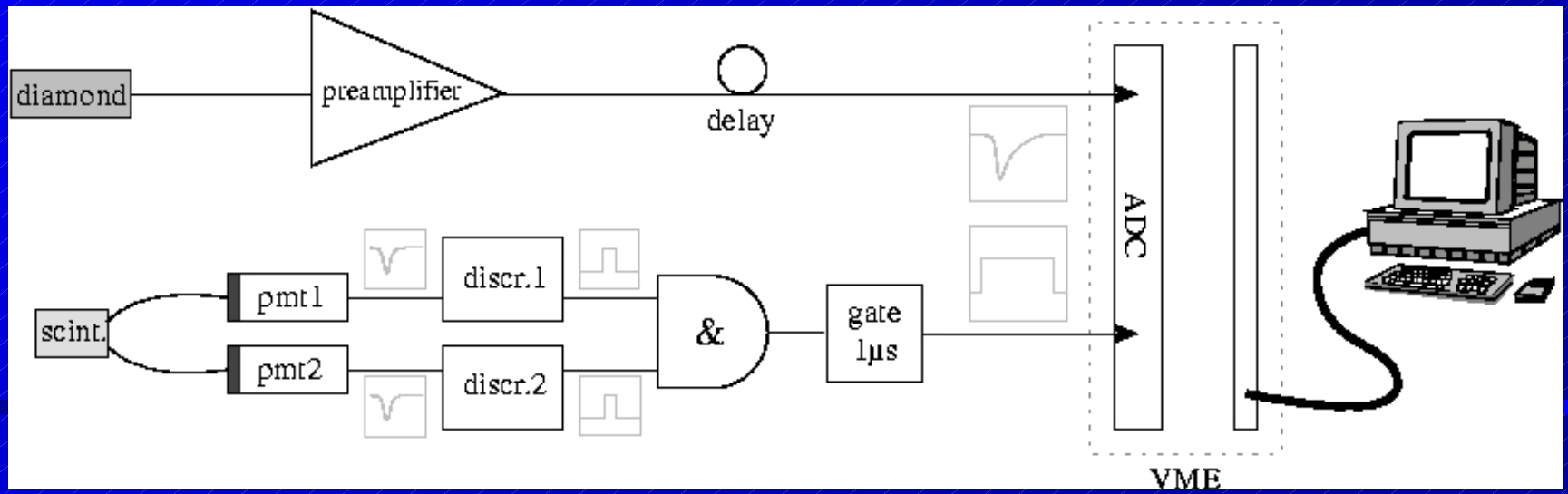
Negative polarity



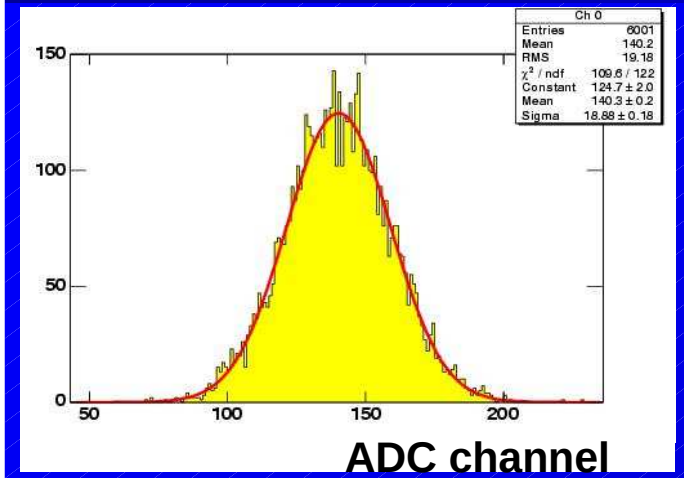
Spectra of MIPs: Setup

- β-particles from the ^{90}Sr are supposed to be a Minimum Ionizing Particle if they generate a signal in the scintillator (trigger).
- Low signal rate of AB1 due to small electrode.



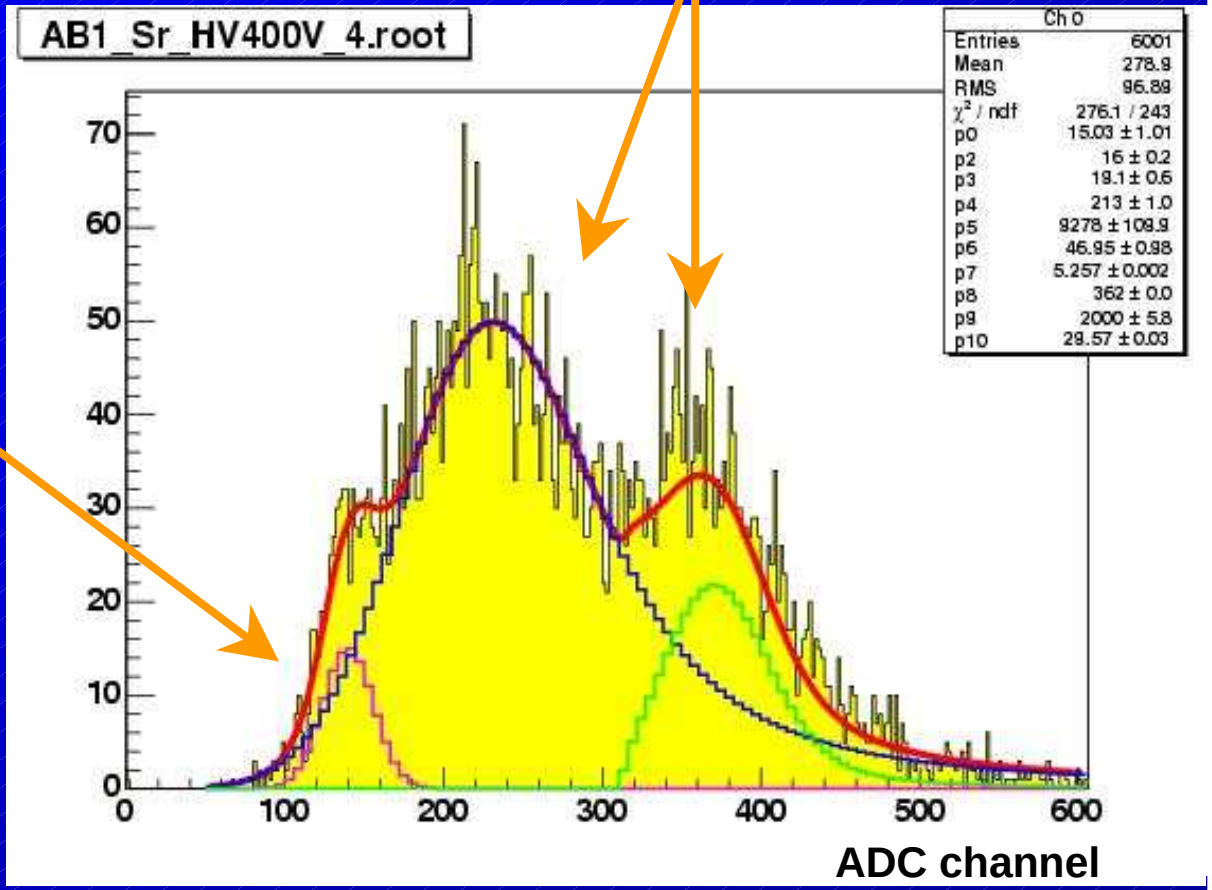


Typical Result

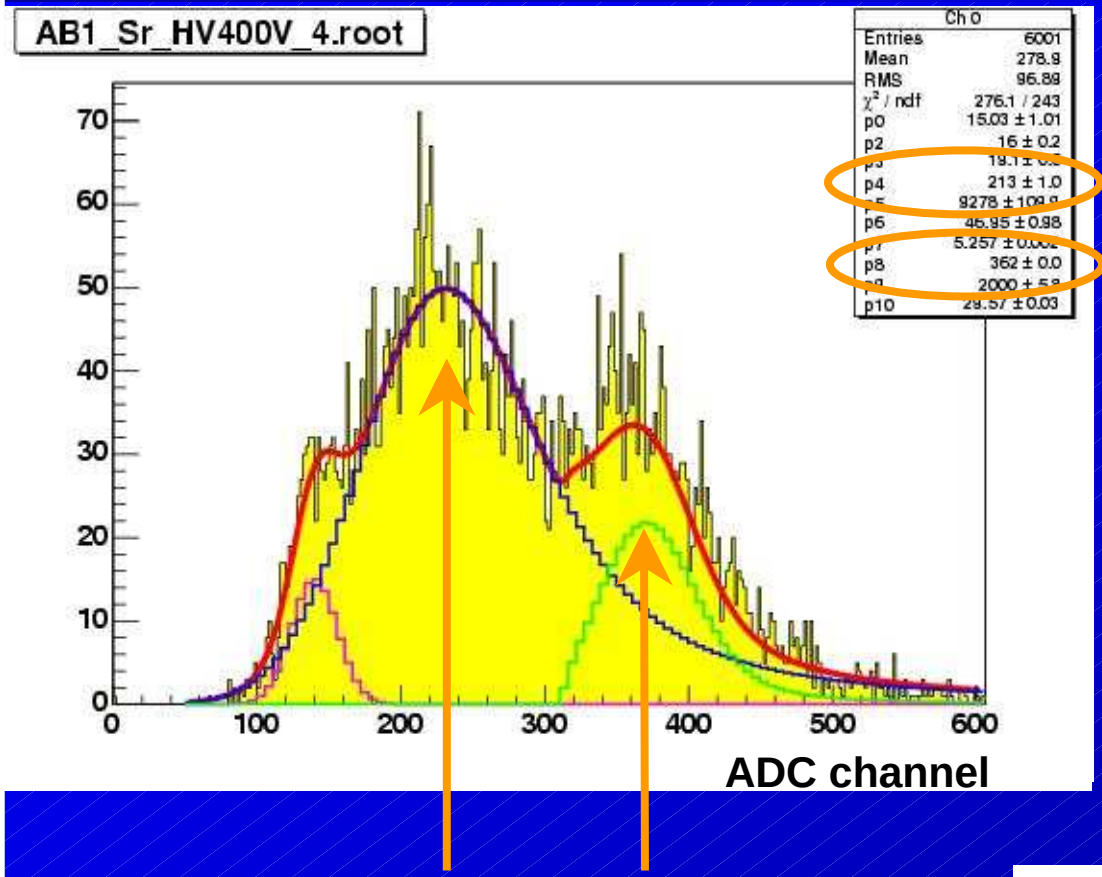


Pedestal

2 signals !



Analysis of the Data

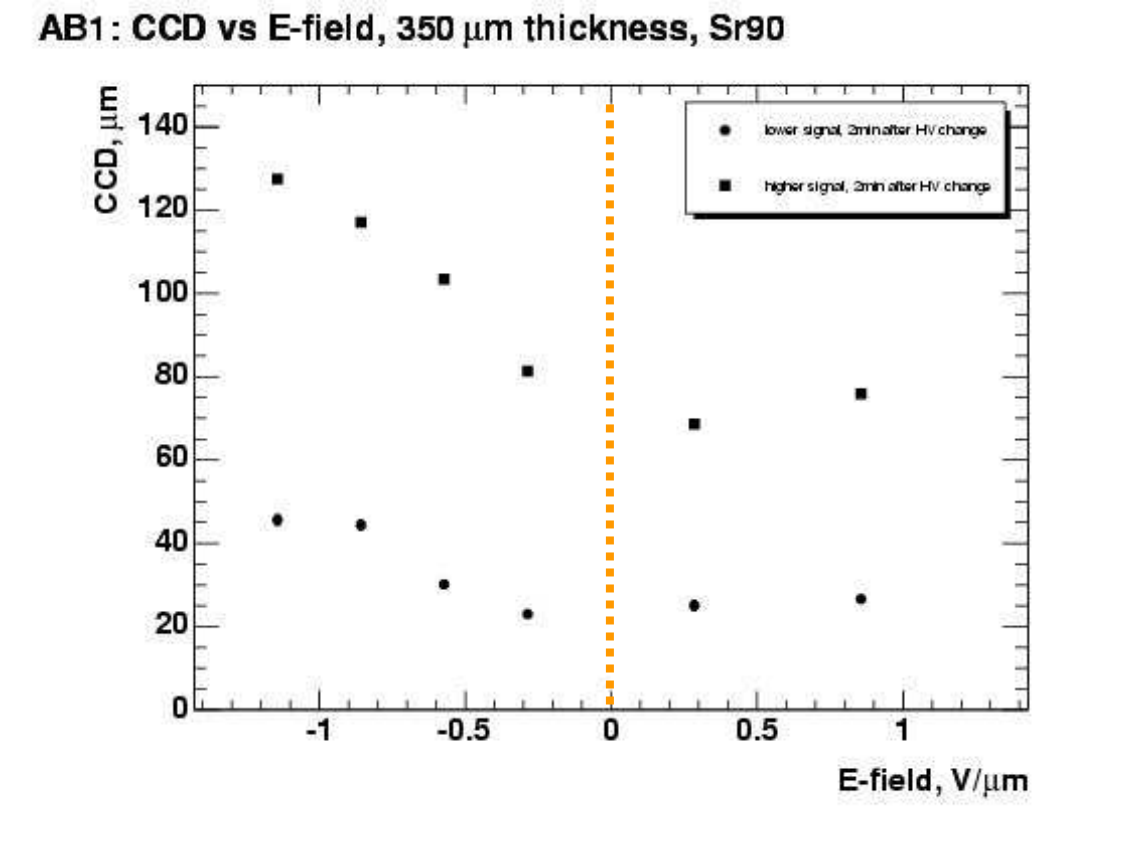


Time consuming fit routine of the order of hours.

$signal_{low}$ $signal_{high}$ →

$$CCD_{low,high} = k_{calib} \frac{signal_{low,high} - pedestal}{36 \cdot e^{-}/\mu m}$$

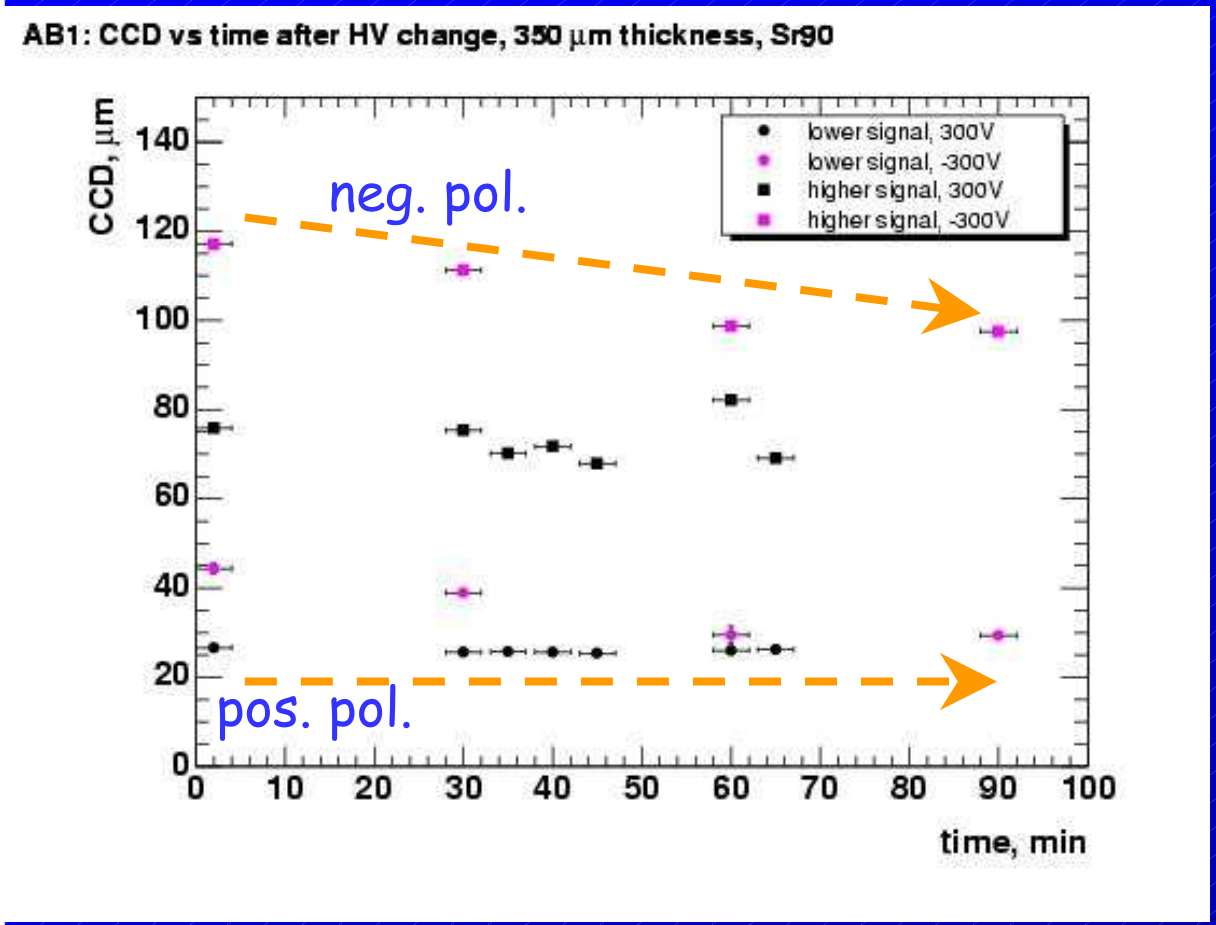
CCD as a function of the applied E-field



Measured CCD of up to 130 µm.

Again: difference between the two polarities.

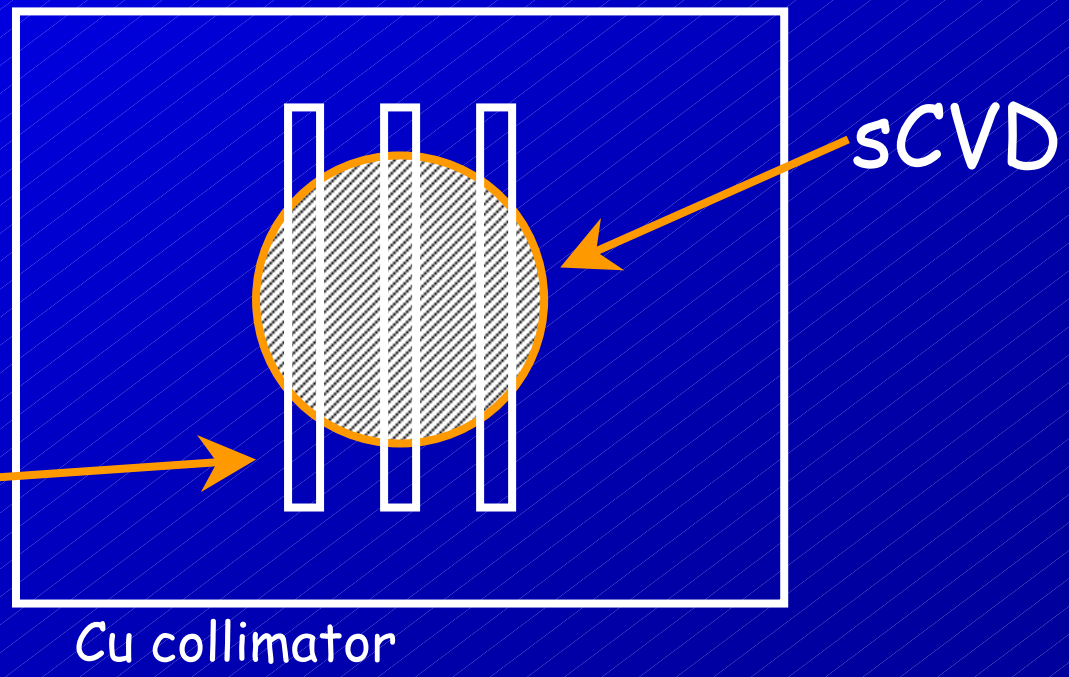
CCD as a function of time after changing the E-field



Time behavior of the signal's MPV is quite stable for positive polarity. Decrease of CCD with time for negative polarity.

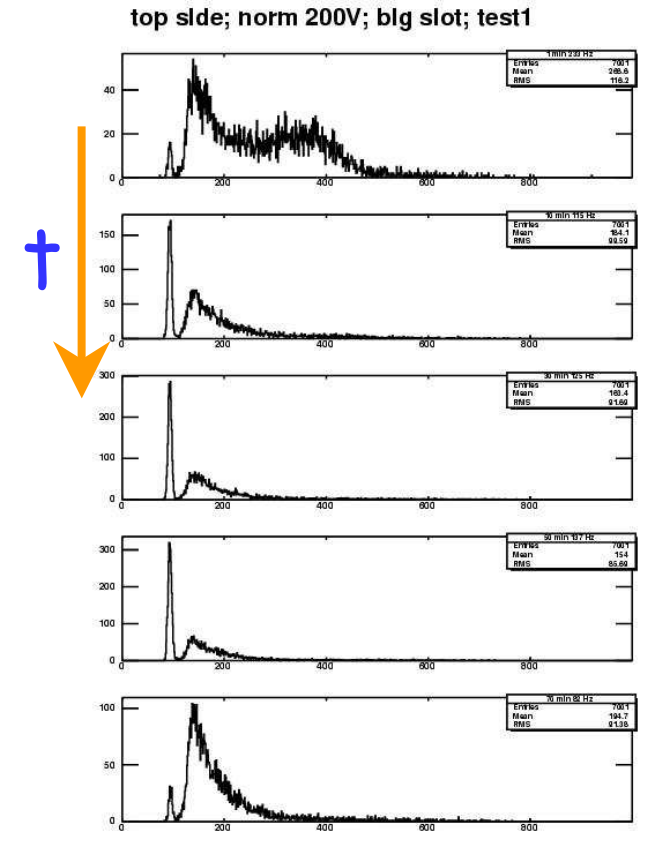
Alpha measurements

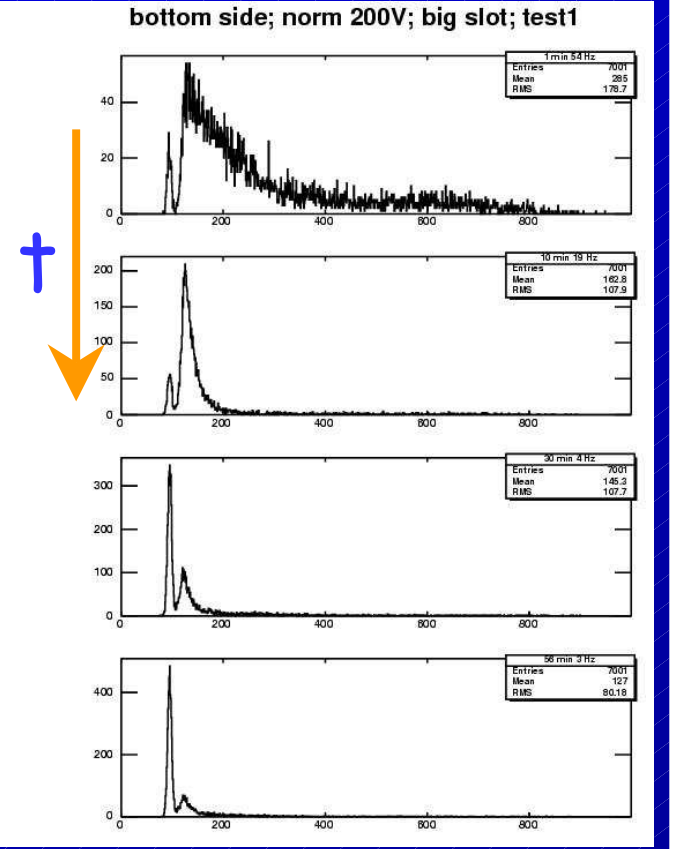
Self triggering mode.
Sensitive only to a small surface region (some µm).
By using a structured collimator a 'scan' over the sensor was done.



Result from Alpha measurement

Only in one position a clear second peak was observed.
In the other positions no second peak could be identified.





Summary

- For the BeamCal of the ILC a W:CVD sandwich diamond calorimeter is under investigation.
- Also studied sCVD Diamond from Augsburg.
- Observed diode-like IV.
- Observed a 2-peak structure in the MIP spectra and in the alpha measurements.
- Observed an inhomogeneity of the diamond (surface/bulk?).

Outlook

- Single crystals:
  - Looking forward to test more samples.
- Polycrystalline diamonds:
  - Will extent our irradiation studies to highest doses.
- Gathering ideas for readout/mechanics to develop a full detector architecture and a detector prototype.