Measurements with an IR-laser

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bmb+f - Förderschwerpunkt
ATLAS
Großgeräte der physikalischen
Grundlagenforschung

Outline

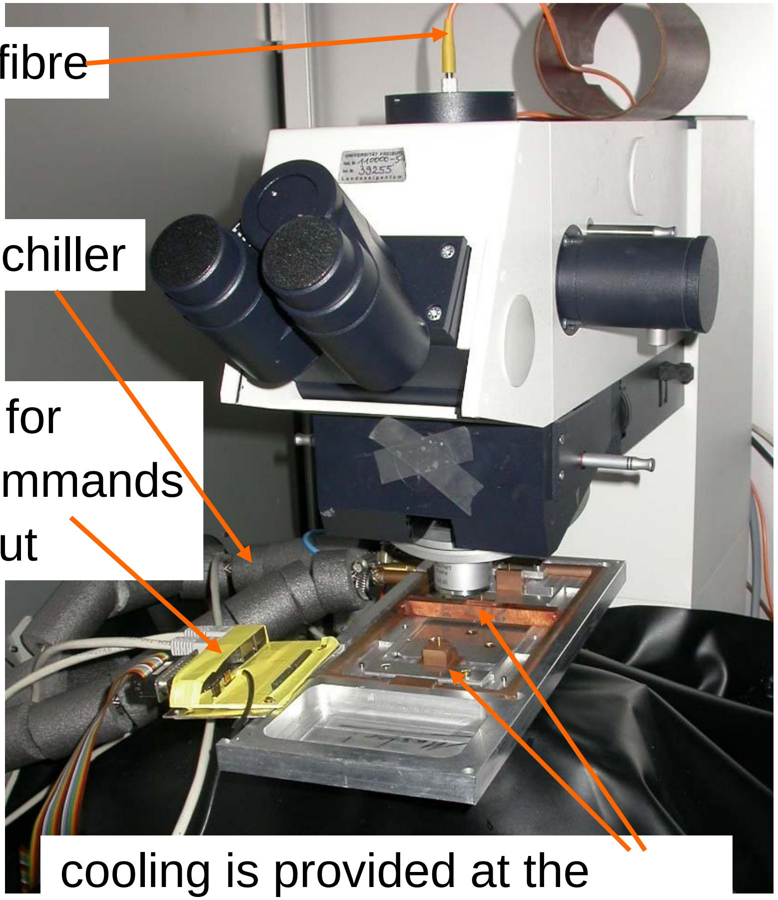
- The laser setup in Freiburg
  - Components
  - Focussing
  - Estimation of depletion voltages with CCE
  - Charge sharing effects of an irradiated Sensor.
- Cz-Module
  - Assembly procedure
  - First results
- Next steps

Laser Setup

We use a non standard setup, which

was independently built by our group.

- Penetration depth of photons ~100µm@982nm wavelength.
- Length of one pulse ~1-2ns.
- Focussing with the help of a microscope, laserspot ~ 4 µm (more later).
- Moving of the sensors in x-y plane via x-y stages. Moving in z by hand, but with µm accuracy.
- The sensor is put into a cooled testbox (possible to chill down the liquid to -30°C), flushed with nitrogen.
- The whole system is put into a box to protect the sensor from daylight.



optical fibre

tubes from chiller

patch card for
voltage, commands
and read out

cooling is provided at the
front and the end of the sensor

Pro/Contra Laser

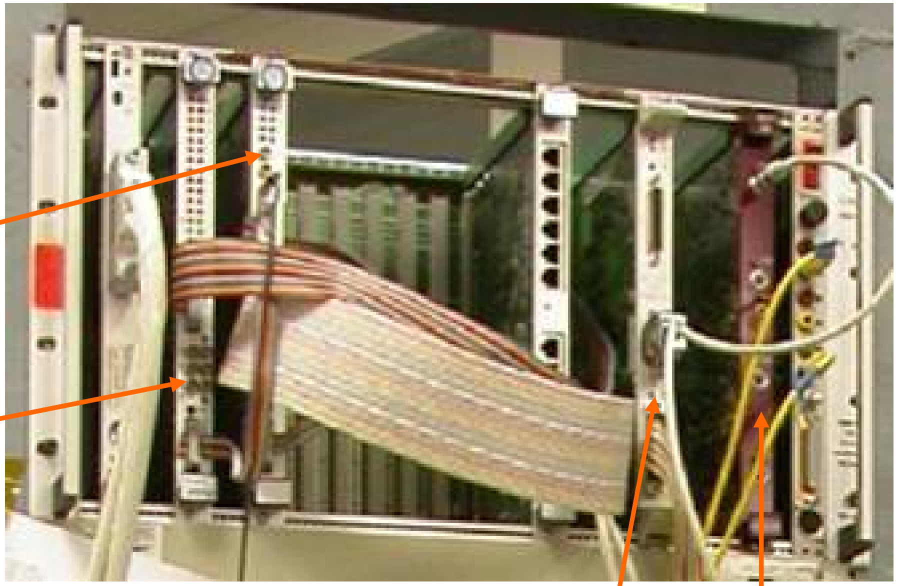
- High spacial resolution with the focussing of a microscope.
- Testing of individiual strips possible with x-y-stages.
- Investigation of charge-sharing effects possible.
- Easy triggering, good time resolution (pulse < 2ns).
- Quite homogenous charge injection into the sensor due to the long wavelength (982nm, penetration depth ~ 100µm).
- High rates (kHz), we have short measurement times with high statistics (limited only through DAQ).

- But: amount of absorbed energy differs with detectors (don‘t know refraction, reflexion indices).
- Therefore: only relative S/N measurement on the same sensor possible.
- The laser intensity is not stable and changes with temperature and time.

To simulate MIPs one should use betas (low rates), a testbeam (hardly available) or cosmics (very low rates).

Read out

- For the read out we use the sct-daq and standard hardware (VME).
- SLOG-card: provides 40MHz clock, commands for the chips and sends synchronized triggers for the laser.
- Mustard-card: reads data from the front end electronics.
- For the read out we only have to set one delay (Trigger command – readout).
- Furthermore one should be careful with the cable length to ensure that the signal is in only one time bin (more next slide).



HV

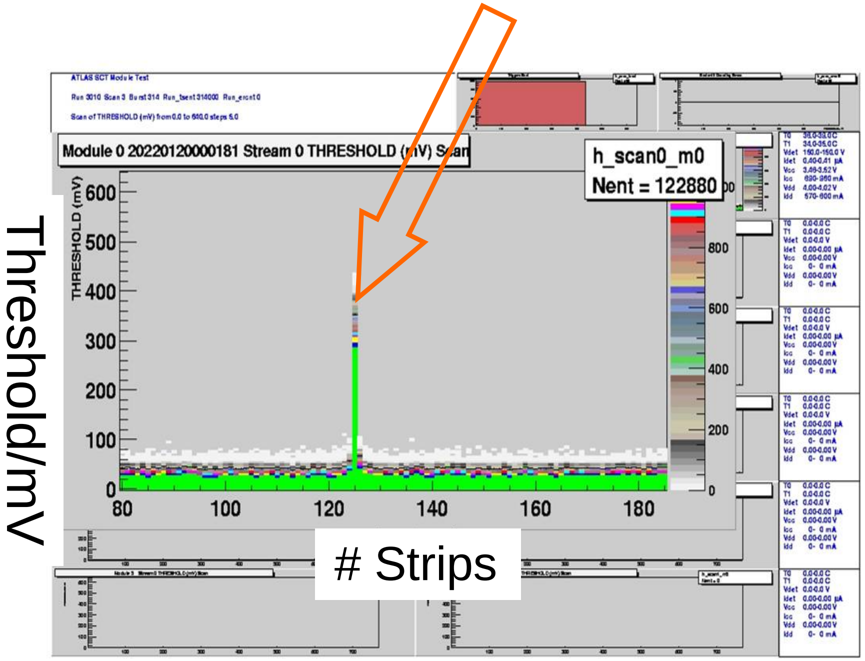
depletion

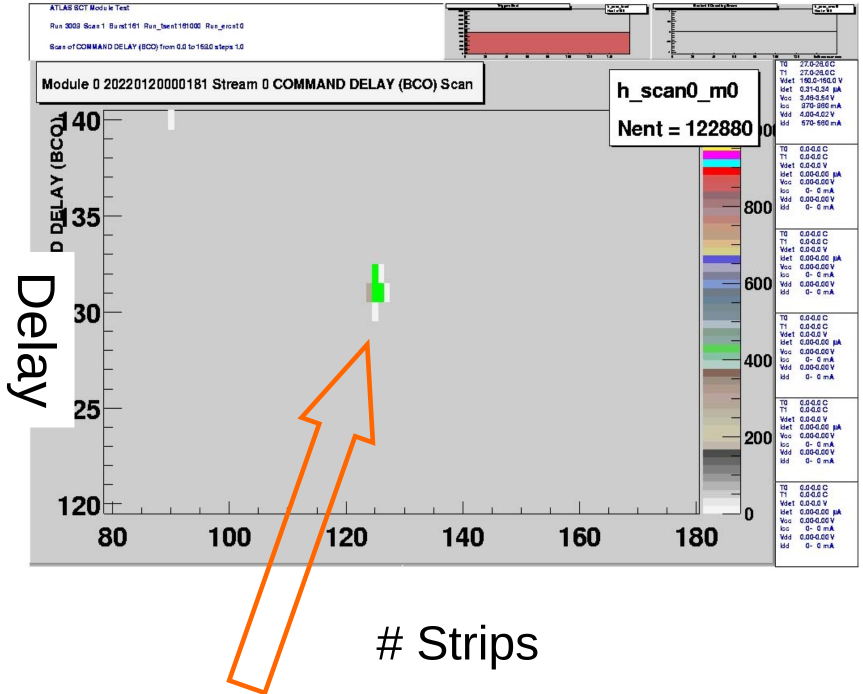
LV

front end electronics

First signals

- First tests were done with an failed ATLAS SCT module (has scratches on the backside).
- The ATLAS SCT read out electronics use *binary* chips.
- To evaluate the deposited charge, one has to do *threshhold scans*.



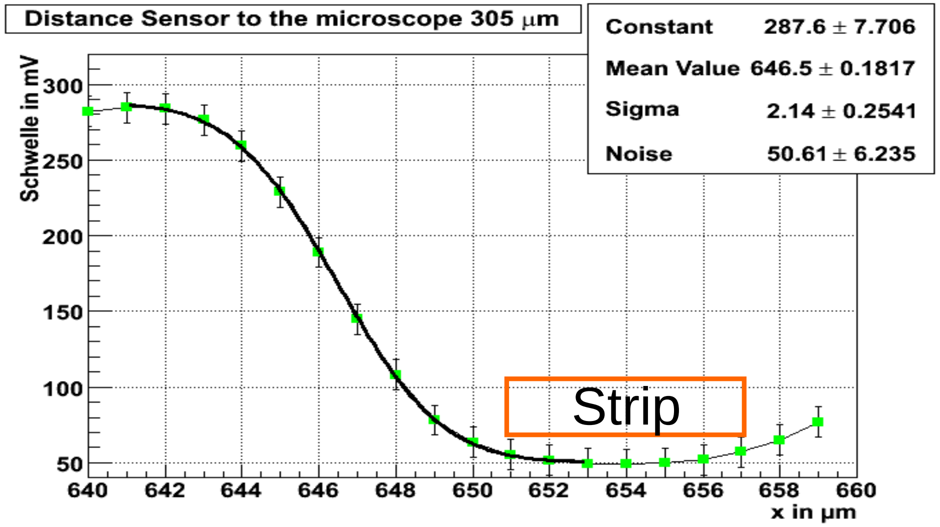


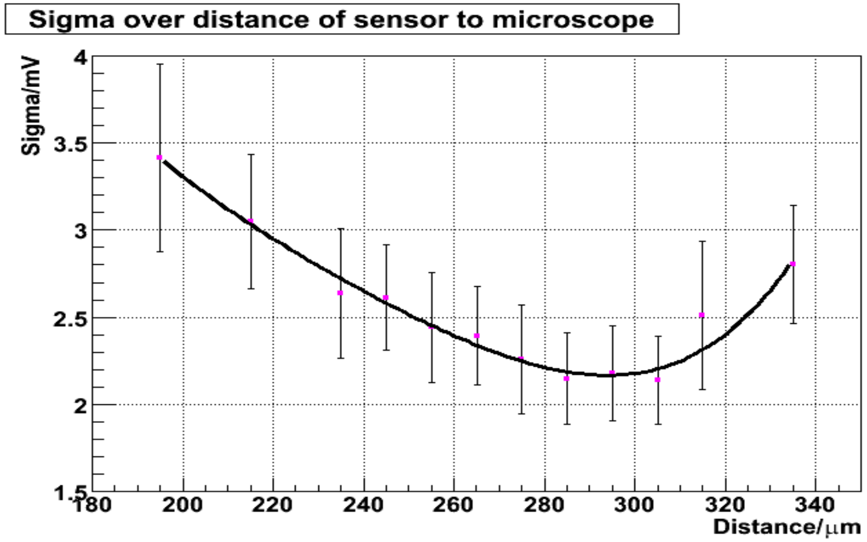
In this example we see the laser in more then one time bin (=25 ns)

→ the signal has to be shifted in time with cables.

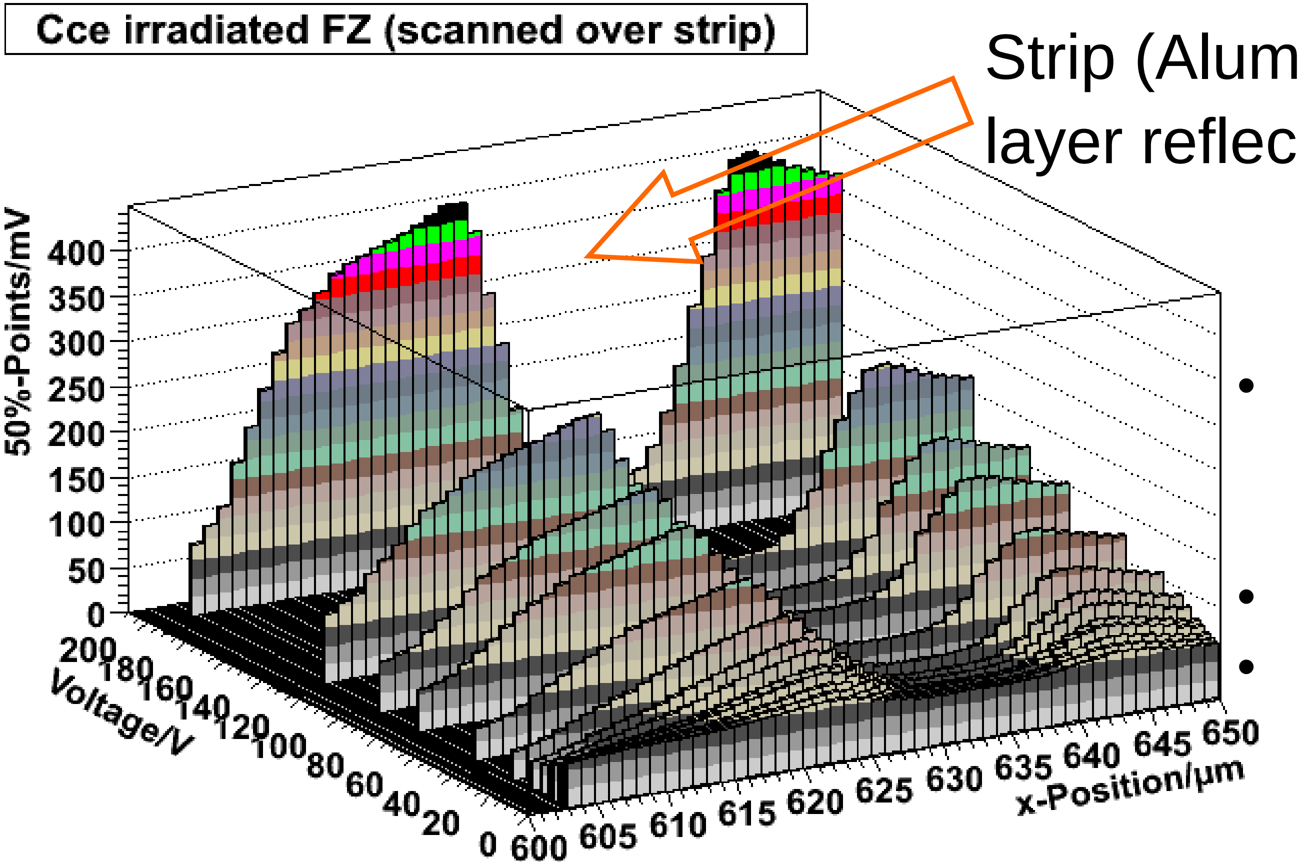
Focussing

- Main procedure: maximise the gradient of deposited energy when scanning one strip.
- Since the beam profile is Gaussian (2D), one expects an error function.
- Use sigma of this fit as spatial resolution.
- Best laser spot has a width of ~4.2µm.





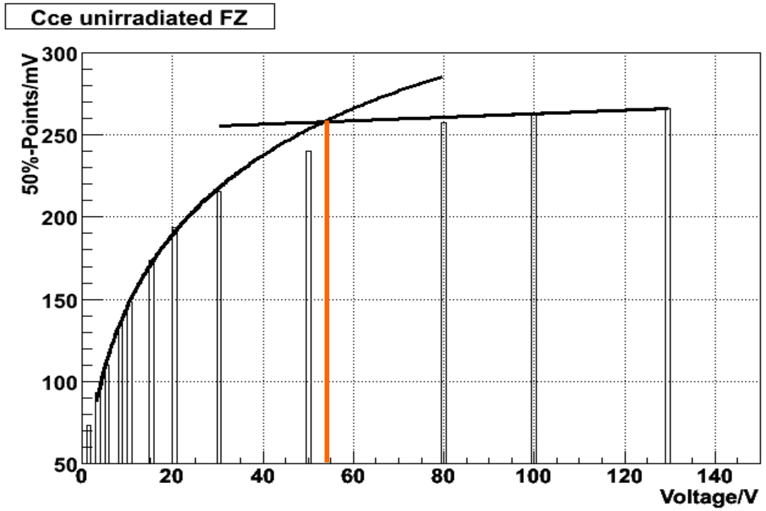
CCE of one channel

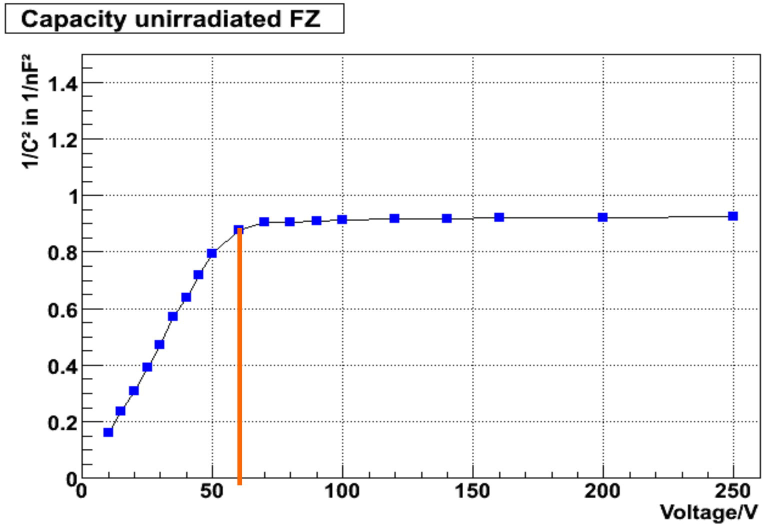


Strip (Aluminium layer reflects light)

- *Failed* CiS SCT Module (bad IV), it was used for irradiations.
- Strip width ~16µm
- Pitch ~60-70µm

Estimation of the depletion voltage





- To measure the full depletion one should take into account the *exponential intensity drop* of light (k~100µm@982nm) in silicon.

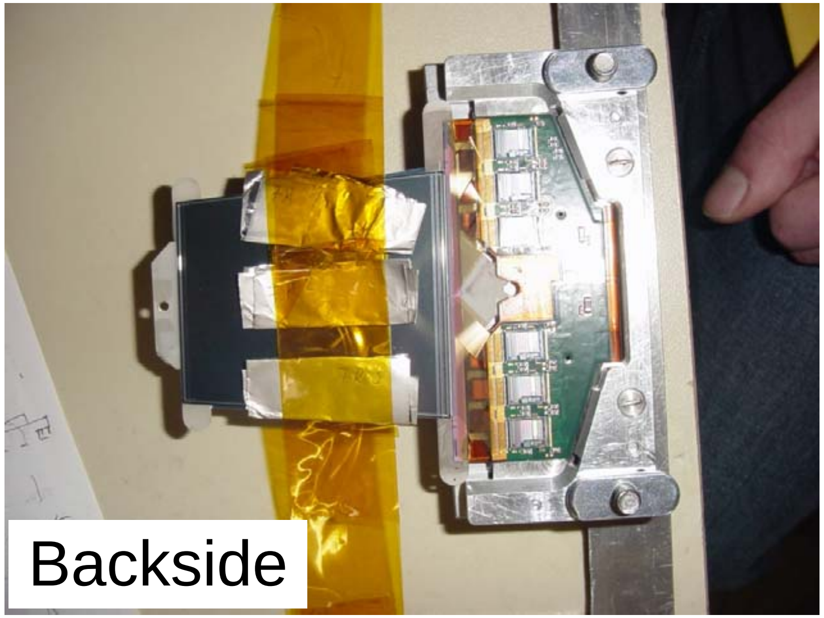
$$Signal = \int_{0}^{x} C \cdot exp(-kx)dx$$

and $x \sim \sqrt{U}$

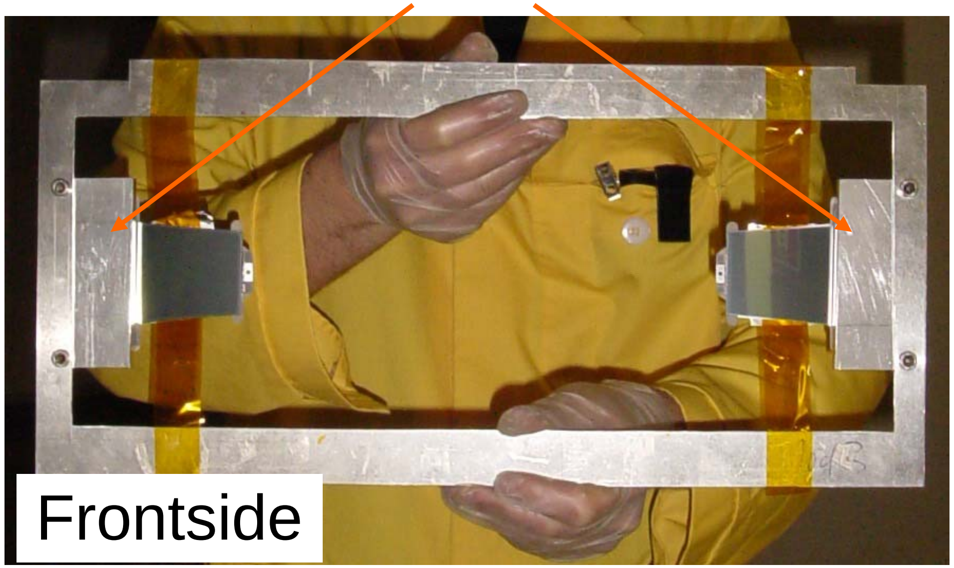
The V_{FD} from C-V seems to be slightly higher.

Thickness of this detector: 285µm

Irradiations in Karlsruhe


Backside

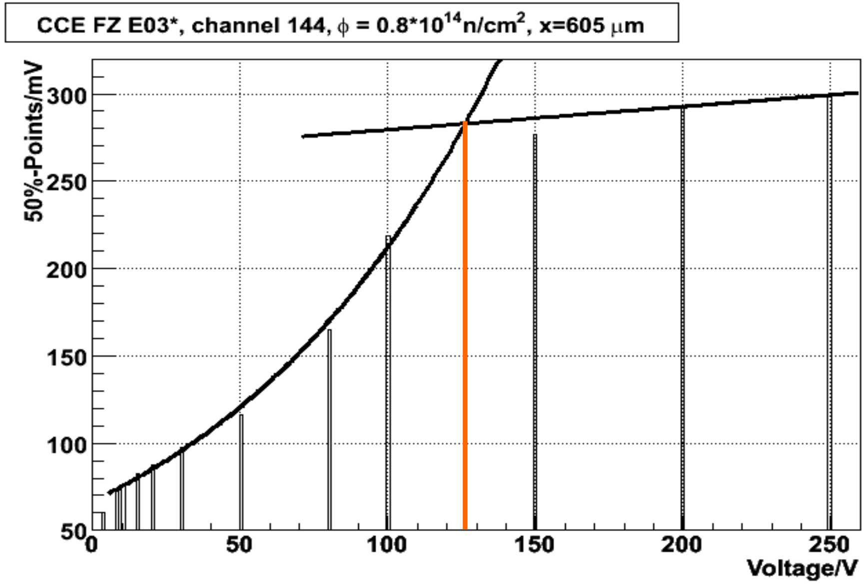
The hybrids were protected with 1cm Aluminium


Frontside

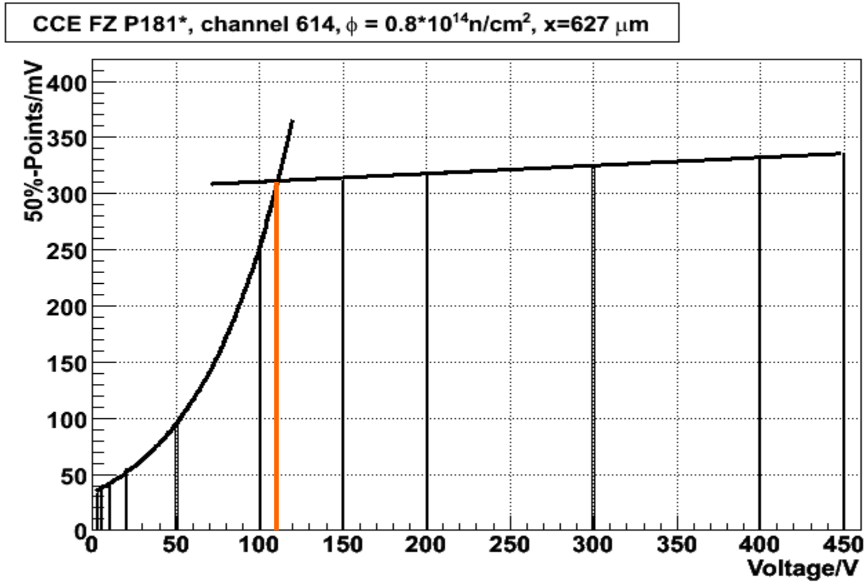
- For the irradiation we took the same two failed ATLAS SCT modules, that were used for previous tests.
- Irradiation was done in Karlsruhe with 26MeV Protons.
- Each sensor was irradiated with three fluences:

$$
\begin{aligned}
\phi_1 &= 0.8 \cdot 10^{14} n/cm^{-2} \\
\phi_2 &= 1.0 \cdot 10^{14} n/cm^{-2} \\
\phi_3 &= 2.8 \cdot 10^{14} n/cm^{-2}
\end{aligned}
$$

CCE of irradiated FZ



$$U_{dep} = 127V$$



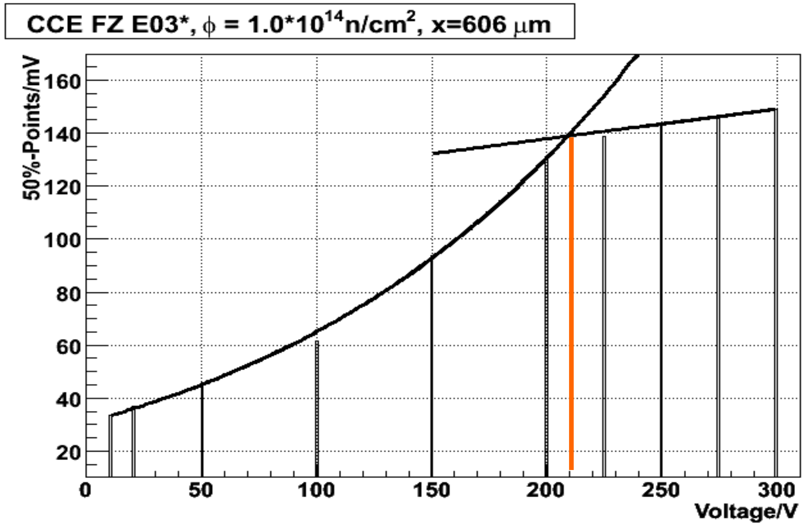
$$U_{dep} = 111V$$

$$\phi_1 = 0.8 \cdot 10^{14} n/cm^{-2}$$

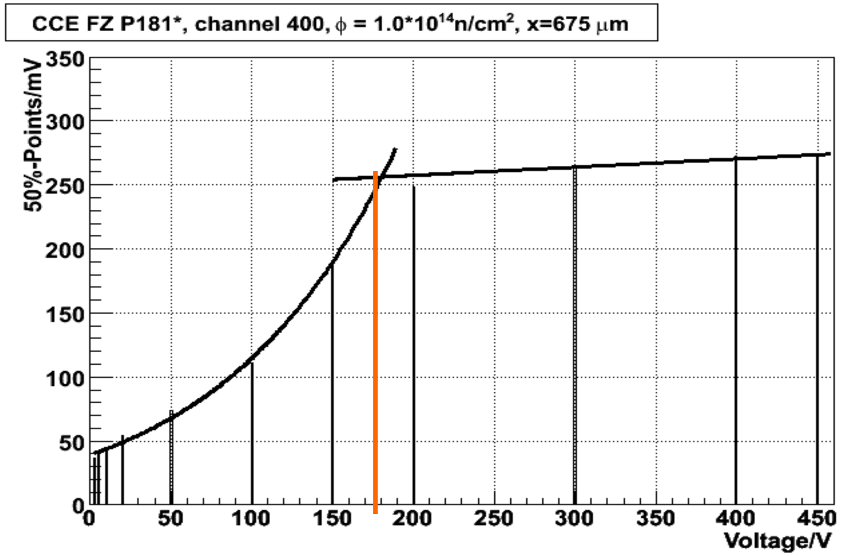
- Fitted quasi-exponential rise (sensor should deplete from the backside).
- The leakage current was always kept below 1mA.

CCE of irradiated FZ

$\phi_2 = 1.0 \cdot 10^{14} n/cm^{-2}$

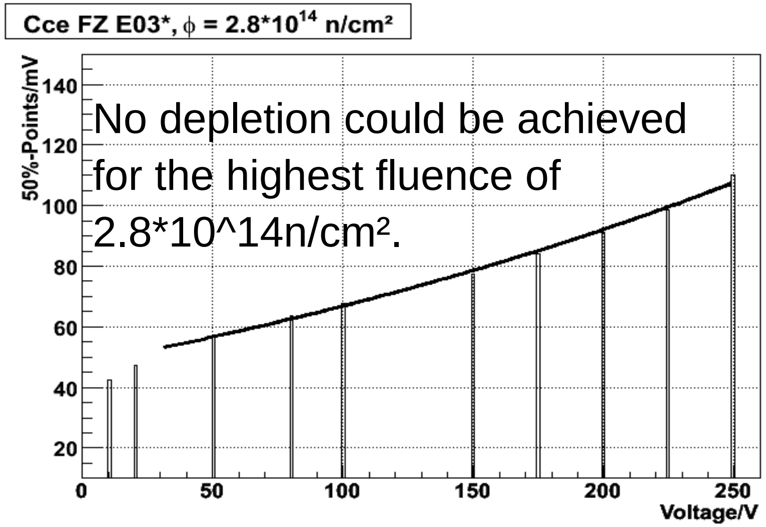


$U_{dep} = 209V$

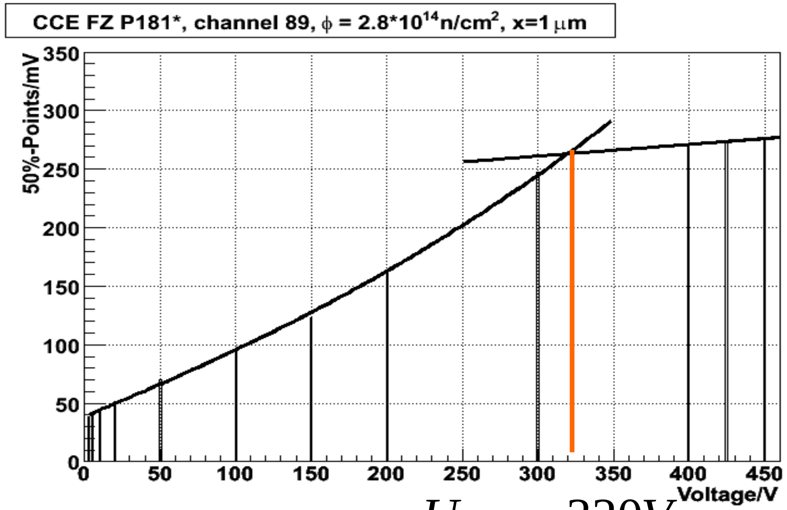


$U_{dep} = 180V$

$\phi_3 = 2.8 \cdot 10^{14} n/cm^{-2}$



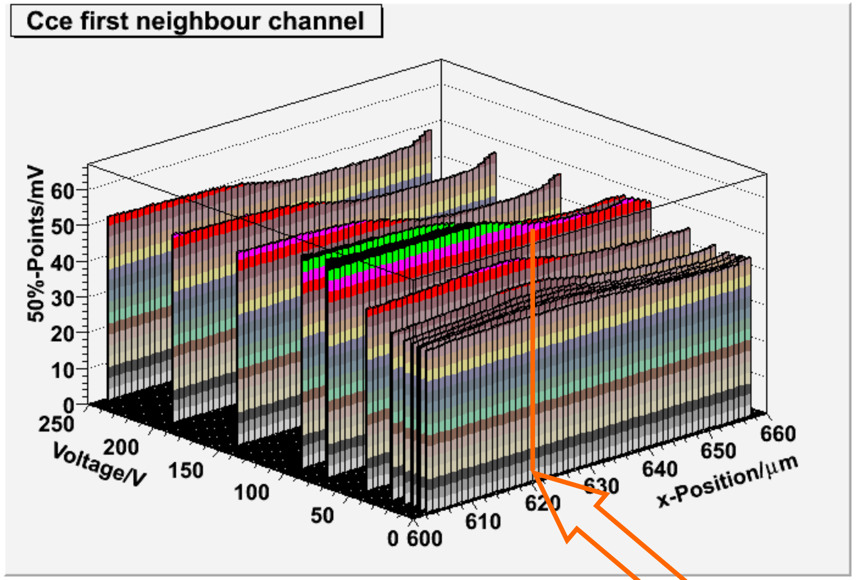
No depletion could be achieved for the highest fluence of 2.8*10^14n/cm².



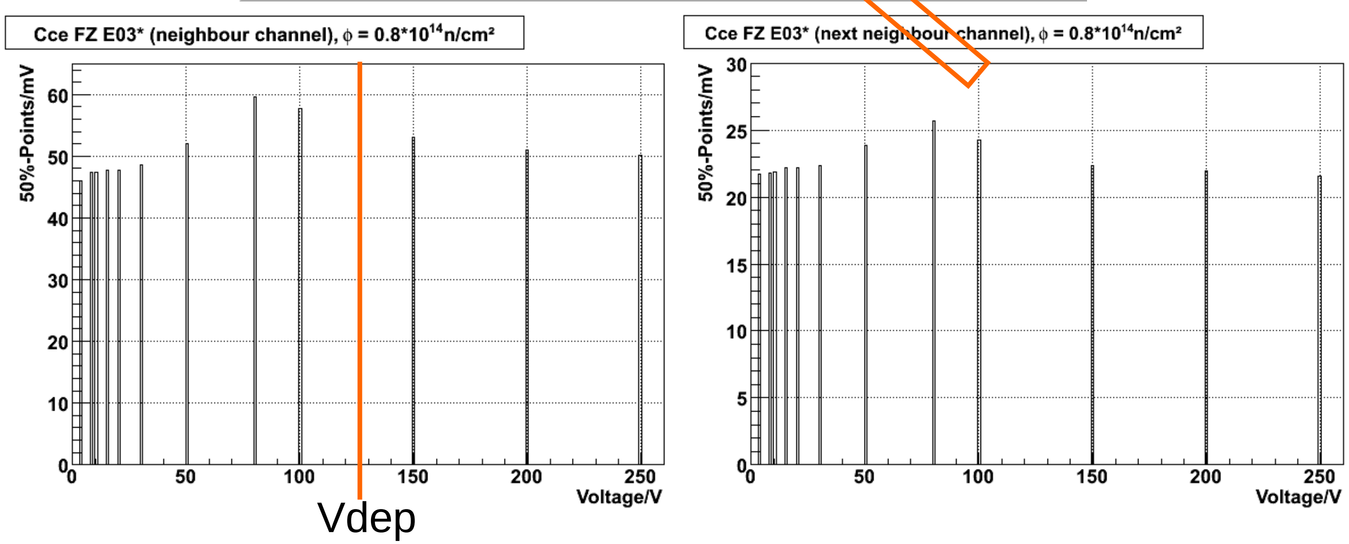
$U_{dep} = 320V$

Charge sharing in irradiated detectors

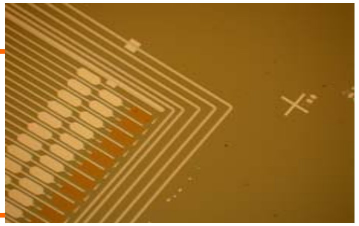
At irradiated and undepleted detectors we see signals at two/three neighbour channels.



This effect seems to be *quite small.*



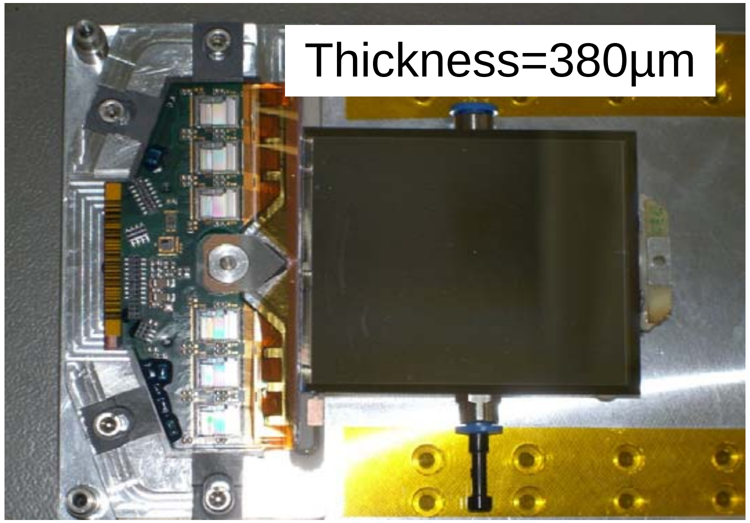
Czochralski-Modules



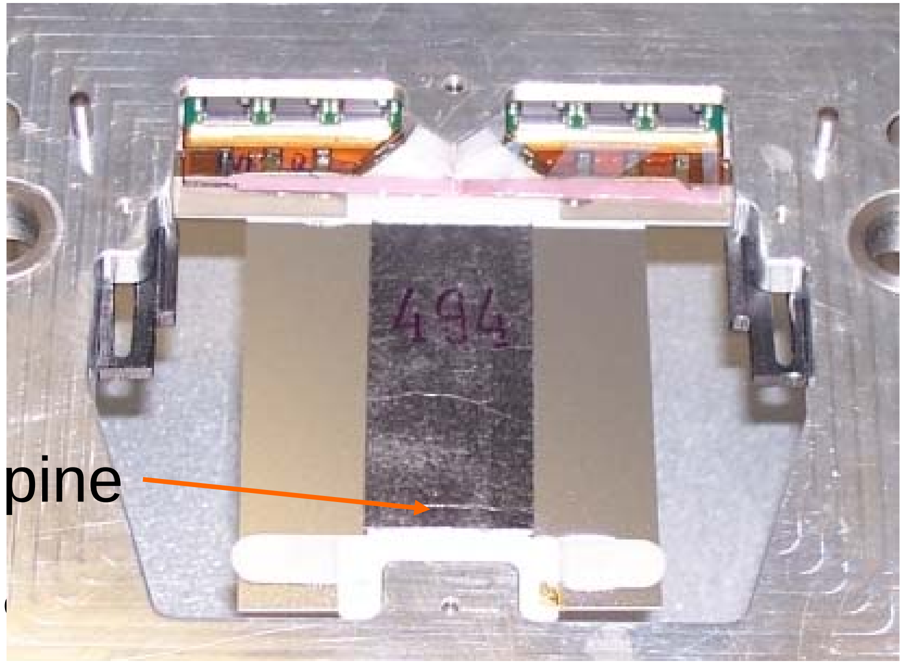
Idea: recycle rejected or failed ATLAS SCT components to build prototype modules with radiation hard sensors to read them out with LHC speed electronics.

By now one Cz-Sensor (Helsinki) is glued to a spine and bonded to the electronics.

The first 3D-Detector (ITC-Irst) is also glued to a spine and will be bonded very soon (will be shown in the talk of S. Kühn).



Thickness=380µm



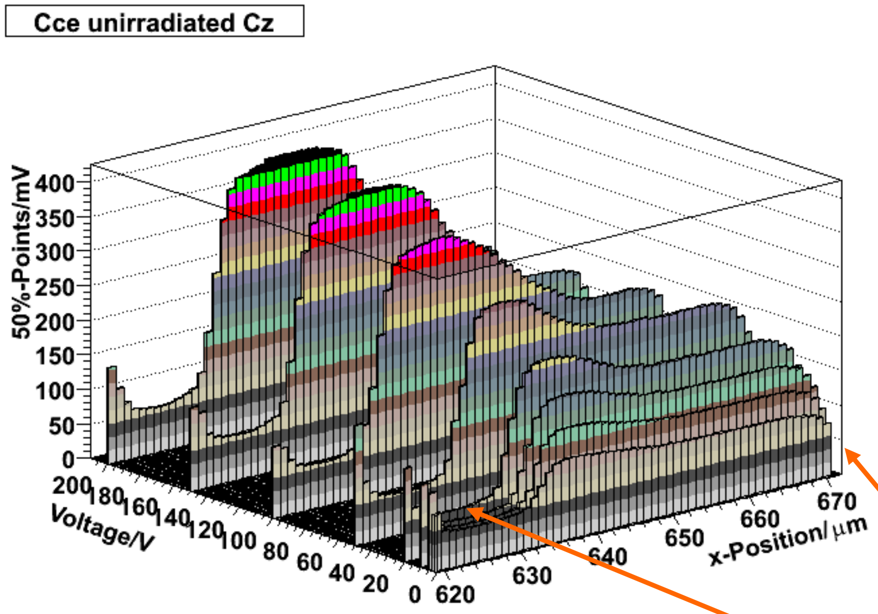
Longer spine

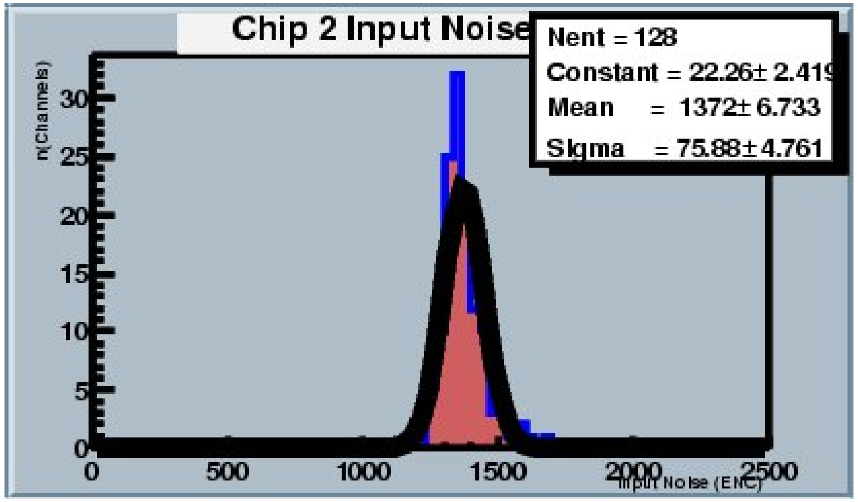
Signals and Noise of Cz-Module

Strip width = 10µm

Pitch = 50µm

Every 2nd channel bonded





Noise~1300-1400 electrons

For comparison: ATLAS SCT W12: ~900 electrons

unbonded strip

read out strip

Unfortunately the sensor could not be further depleted, previous studies report V_{FD}~ 420 V.

To Do:

- Irradiation of Cz detector with several fluences.
  - Irradiation at the compact cyclotron in FZ Karlsruhe (26 MeV).
- Test 3D sensors by ITC-irst, especially CCE from midstrip area (see next talk by S. Kühn).
- Many thanks to Peter Kodys,Jaakko Härkönen and Claudio Piemonte for discussion, help and detectors.