Characterisation of a 3D-stc p-type prototype module read out with ATLAS SCT electronics

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Physical Institute – University of Freiburg

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bmb+f - Förderschwerpunkt ATLAS

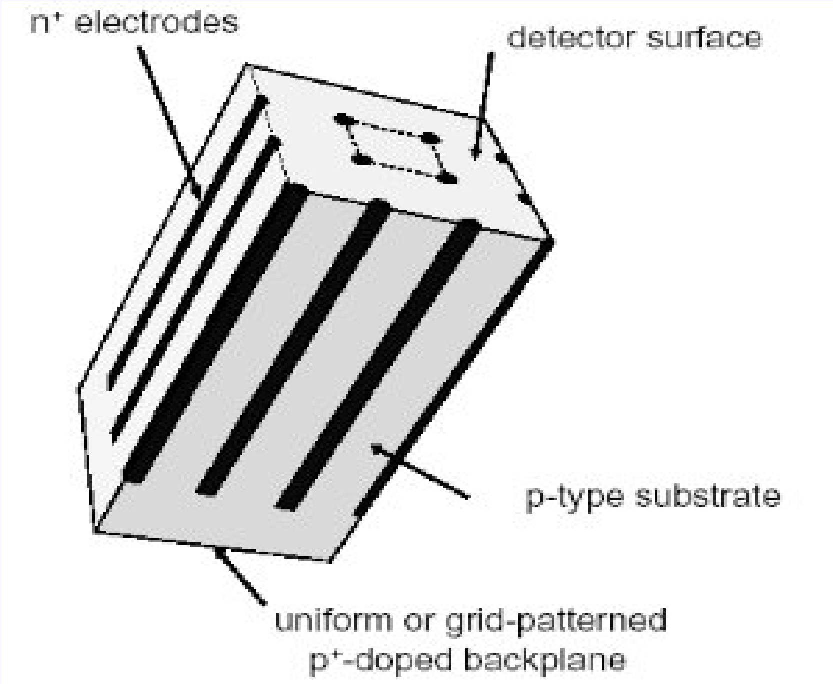
Großgeräte der physikalischen Grundlagenforschung

Outline

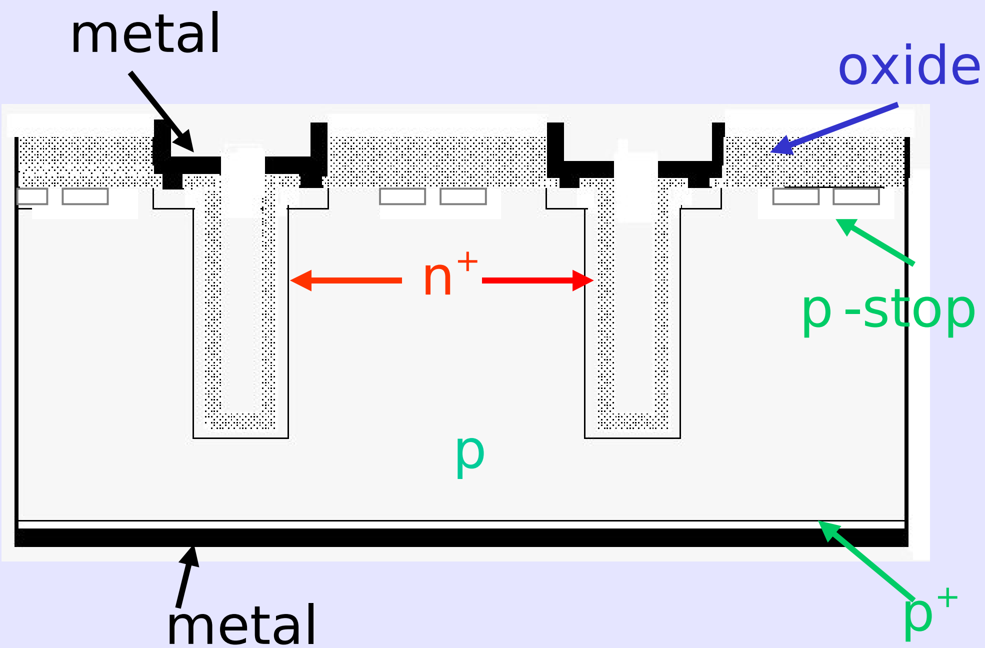
- Assembly of 3D prototype module
- Description of the laser test set-up
- Spatial measurements with laser test set-up
- Beta CCE measurements of irradiated stFZ module
- Summary and Outlook

3d-stc sensor

- 3D-stc FZ n^+-in-p micro strip device from ITC-irst, Trento



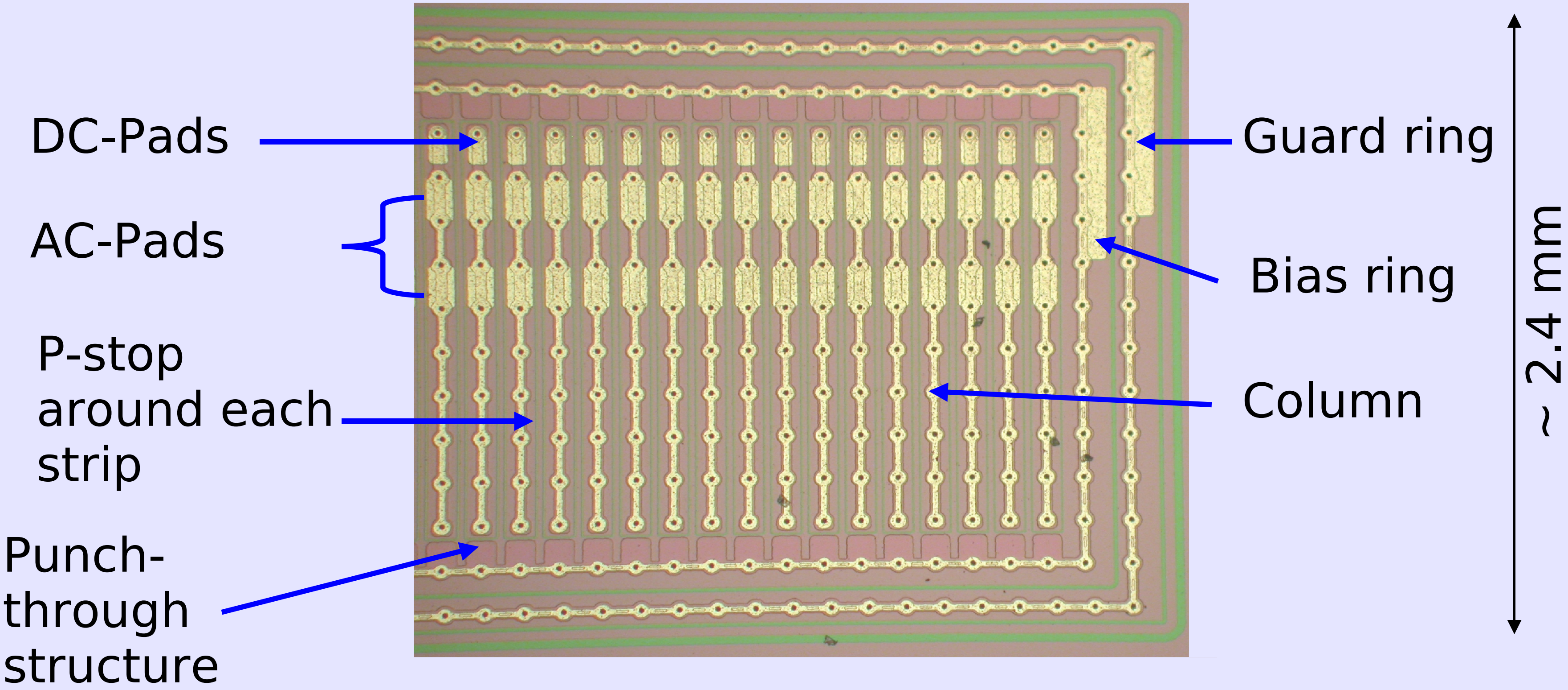
[C. Piemonte et al., NIM A 541 (2005) 441-448]



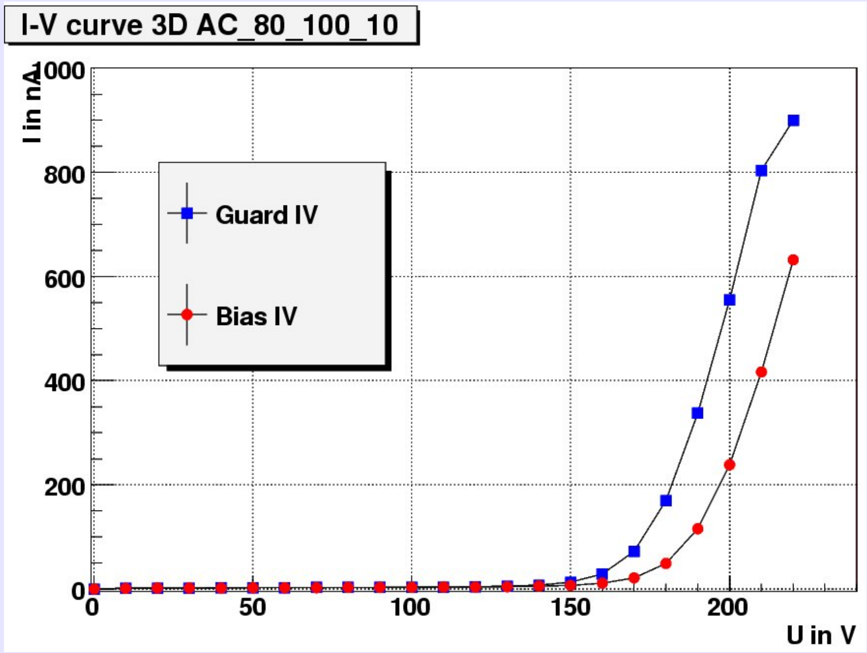
- sensor size: 2.4 mm x 7 mm , thickness: 500 µm, strip pitch: 80/100 µm
- 64 strips with each 10 columns, columns connected by n-doped layer
- resistivity 5 kOhm

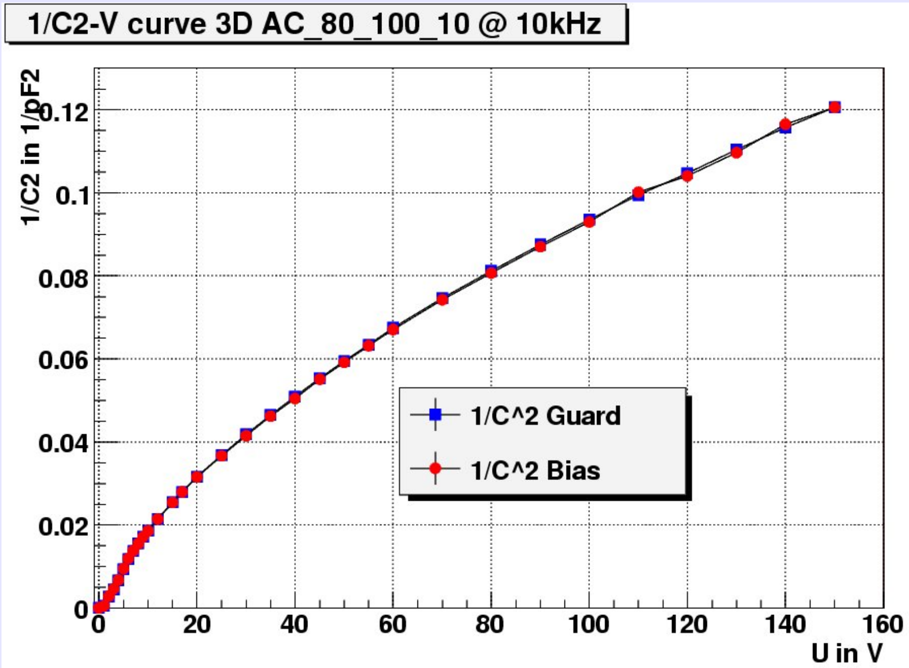
3d-stc sensor: AC_80_100_10

- AC coupling, punch-through structure
- strip pitch: 80 µm, interstrip pitch: 100 µm, hole diameter 10 µm
- common p-stop for each strip



IV and CV measurements





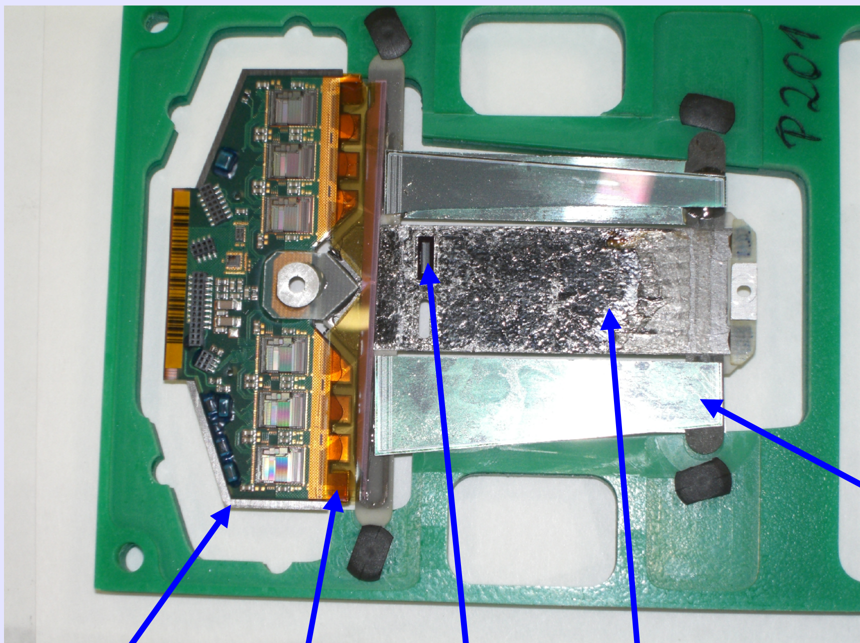
- IV-curves show breakthrough at $V_{bias} \approx 150$ V

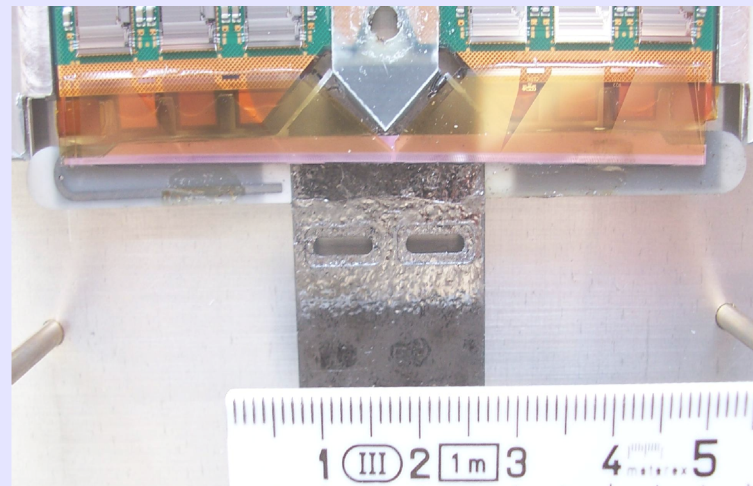
→ functional sensor

- lateral depletion around 7 V expected

Assembly of 3D module

- 3D-stc sensor AC_80_100_10
- Fan-ins from middle SCT modules (pitch = 92 µm) and SCT hybrid
- re-use of old spine: TPG material with slots for 3D-sensor





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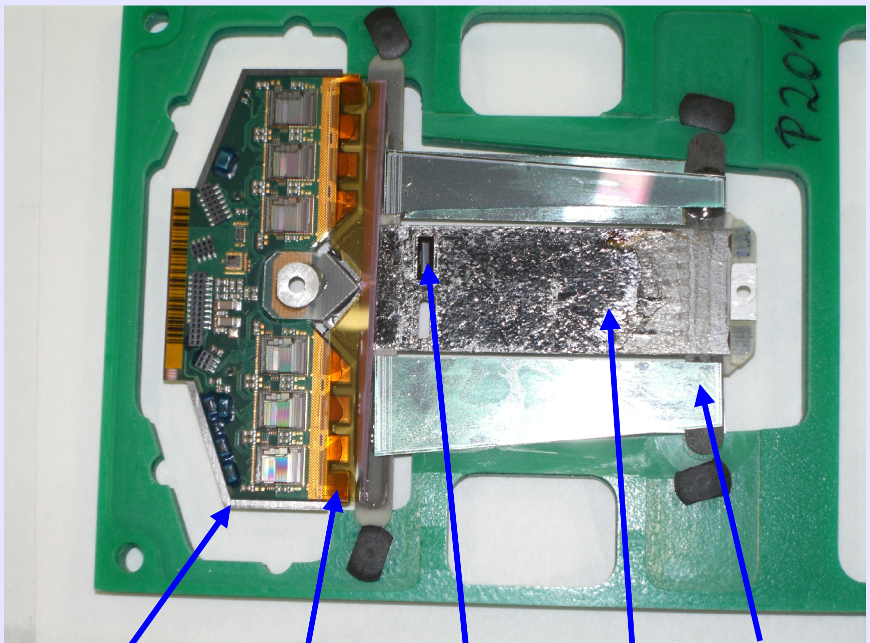
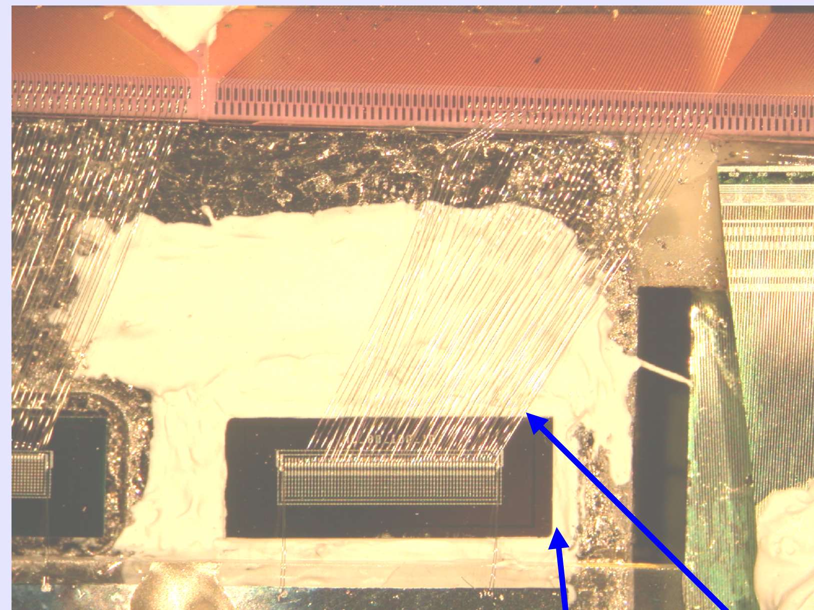
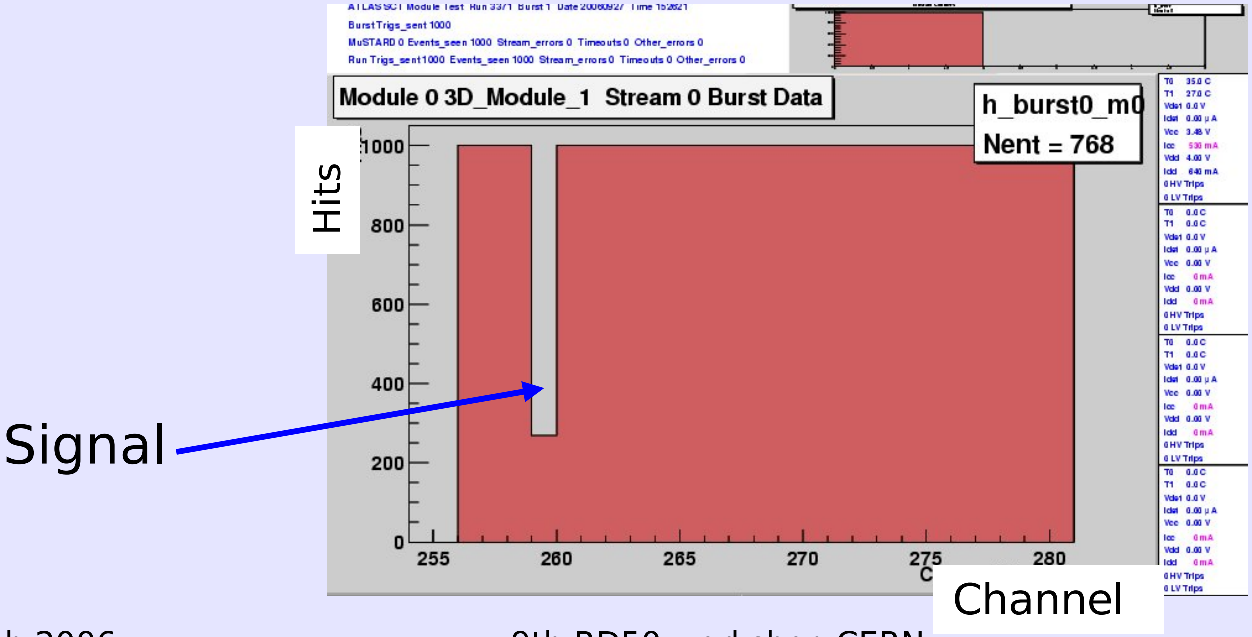




ATLAS SCT Readout

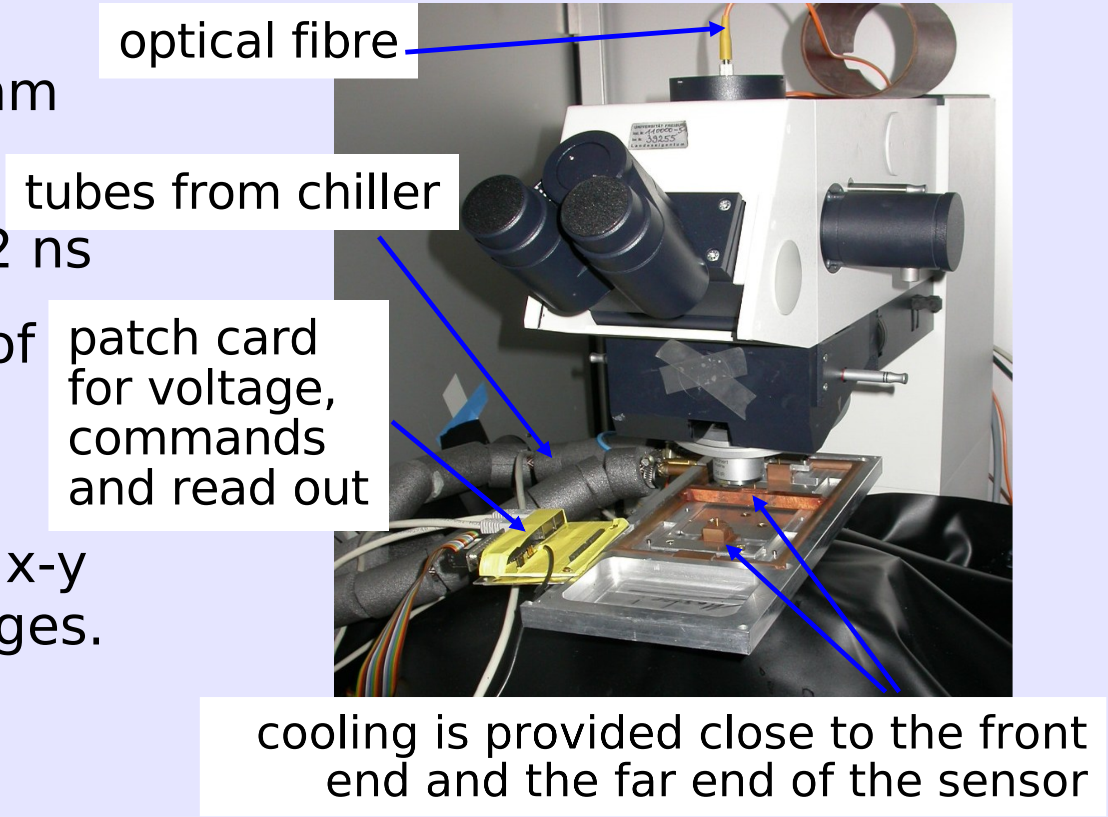
- We use SCTDAQ and standard SCT hardware (VME, NIM)
- 40 MHz binary readout
- Peaking time of shaper 20 ns
- SCT ABCD3T chip is mostly bipolar, but discriminator is not

→ signals from p-type sensors are negative → TrimDAC
→ “maximal” signal @ 0 fC threshold, corresponds to ≈ -4 fC charge



The Laser set-up

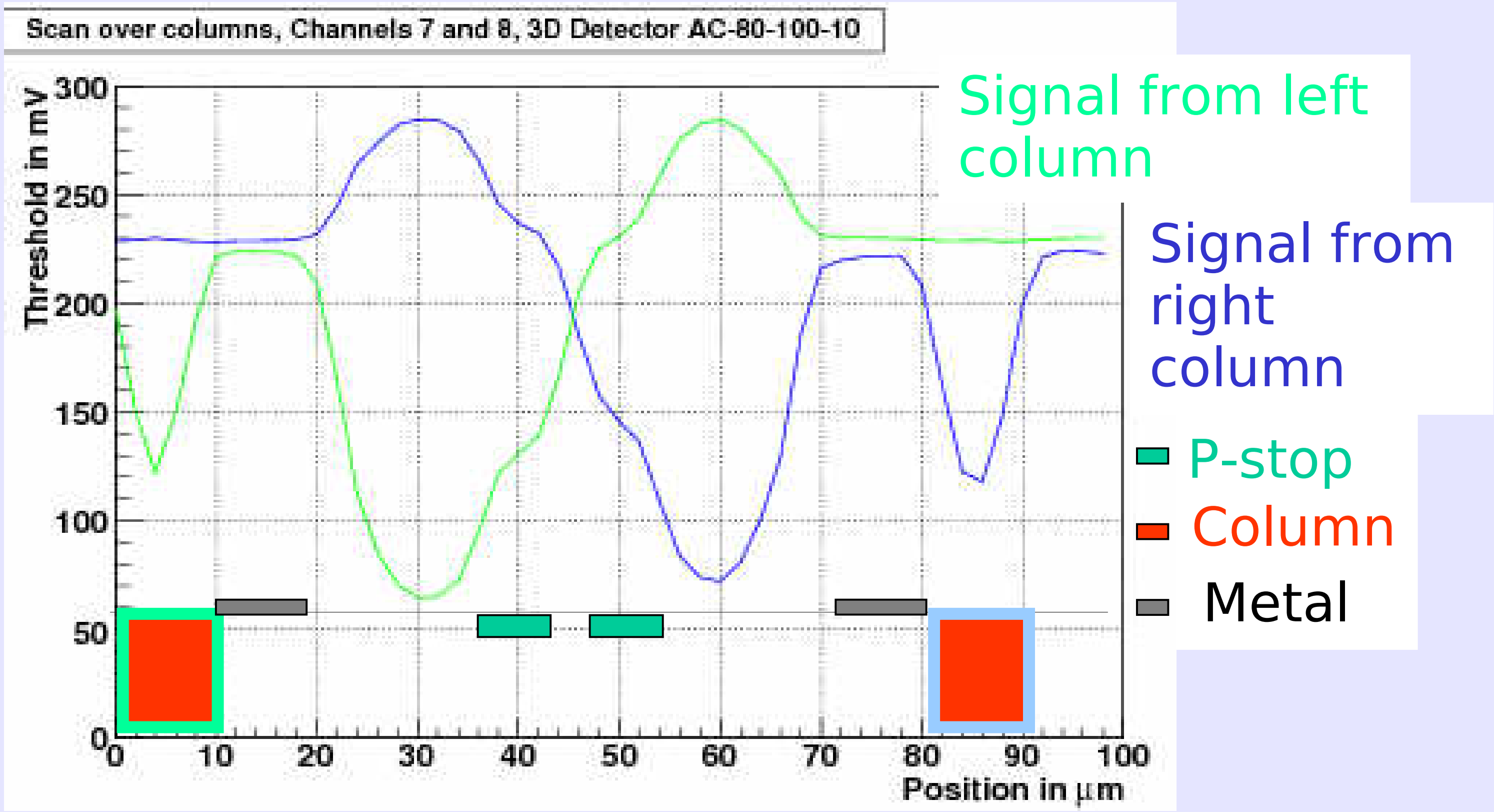
- Penetration depth of photons ~100 µm @ 982 nm wavelength
- Length of one pulse ~1-2 ns
- Focussing with the help of Leica-polyvar microscope, laserspot ~2-3 µm
- Moving of the sensors in x-y plane via motor-driven stages.
- Sensor is cooled to –5 °C
- built by Thies Ehrich



→ Testing of individual strips and interstrip area possible with automated x-y-stages, easy triggering, good time resolution (pulse < 2 ns)

Laser measurements

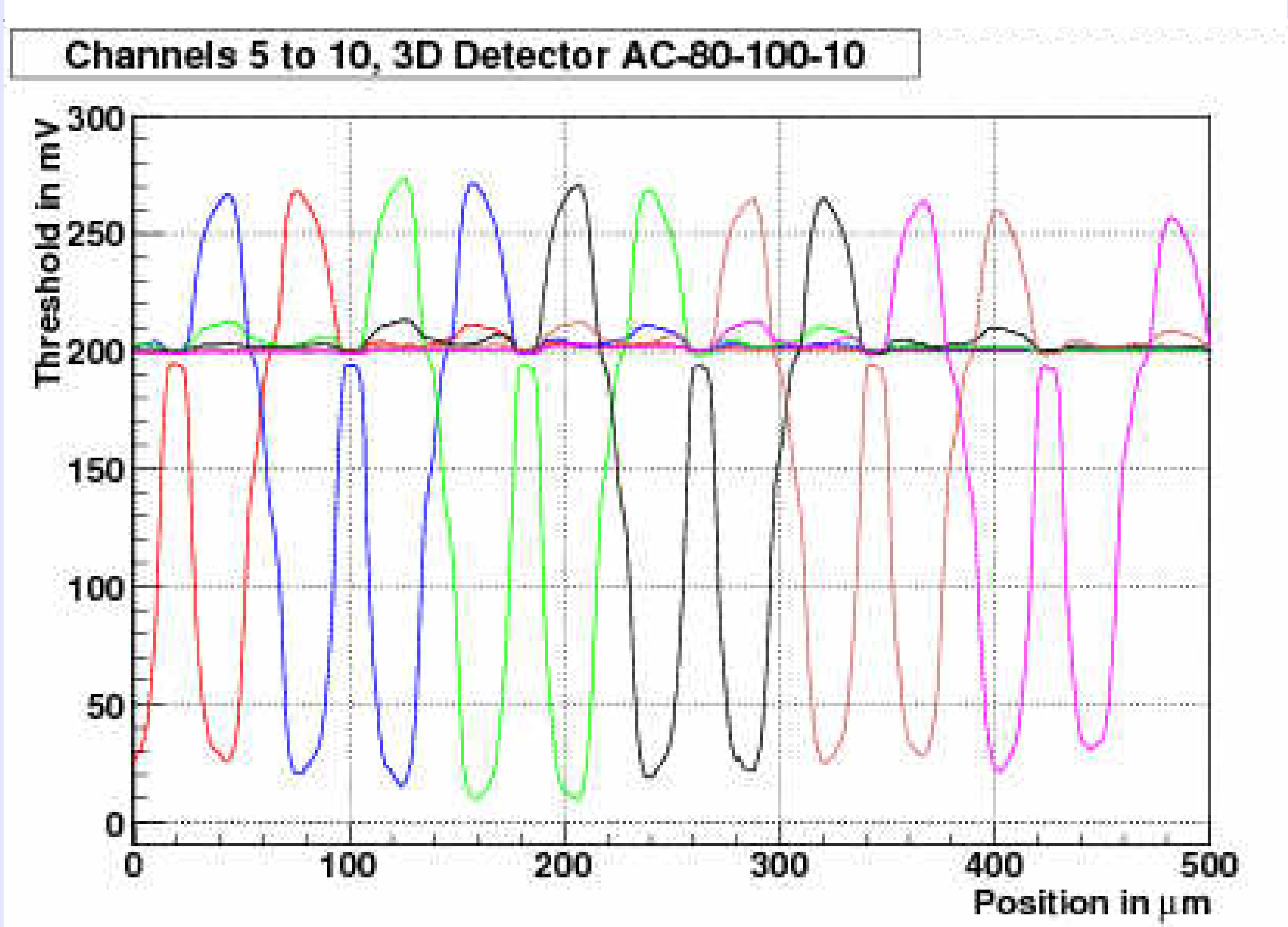
- Scan over two columns at V_{bias} = 12 V:



- positive signal on neighbouring strips
- p-stop structure can be seen

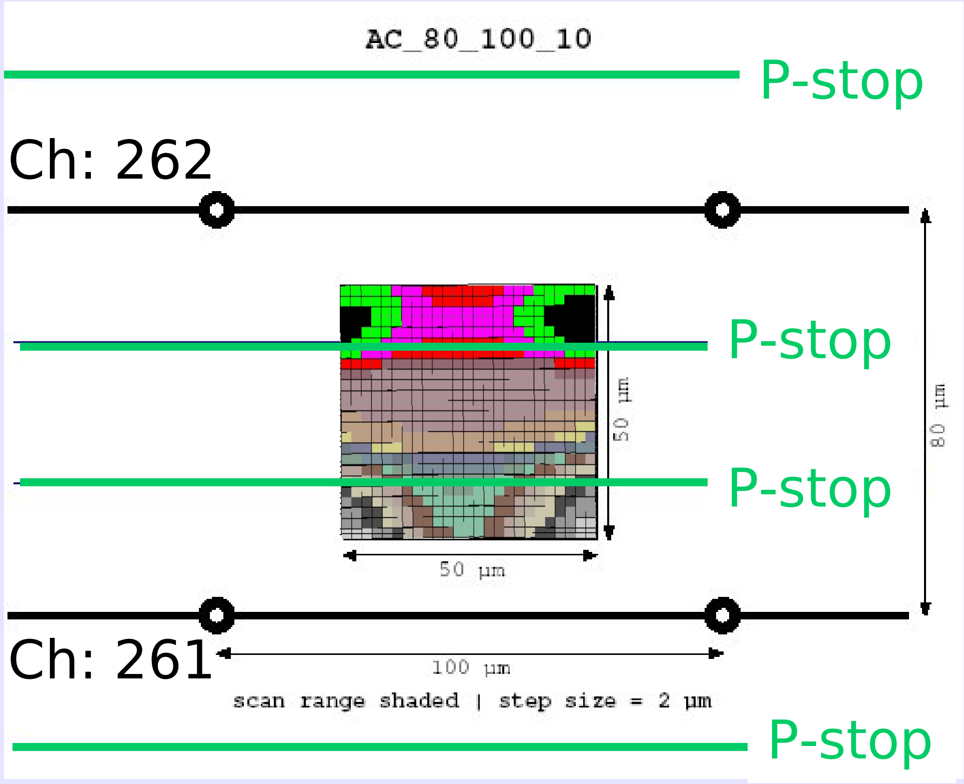
Laser measurements

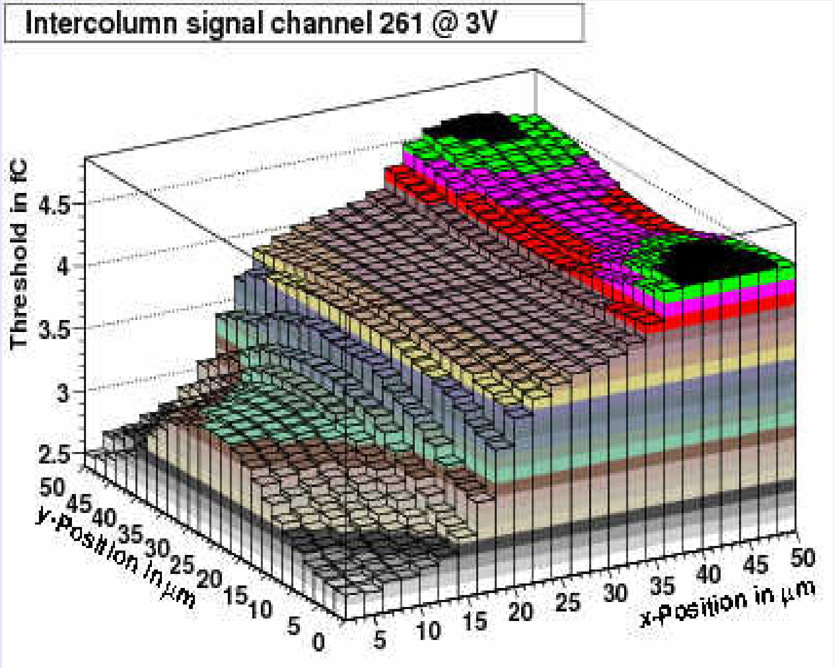
- Scan over 6 columns at V_{bias} = 12 V:



Spatial measurements

- Scan over 50µm x 50µm region between two strips for several bias voltages:

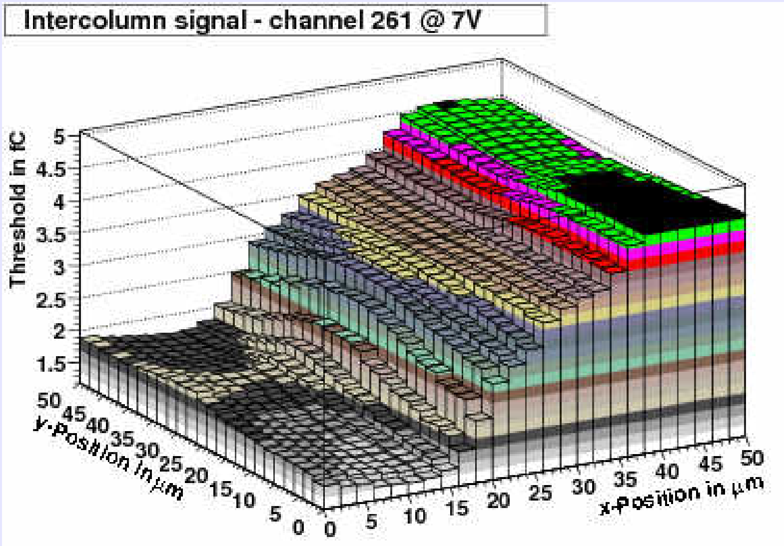




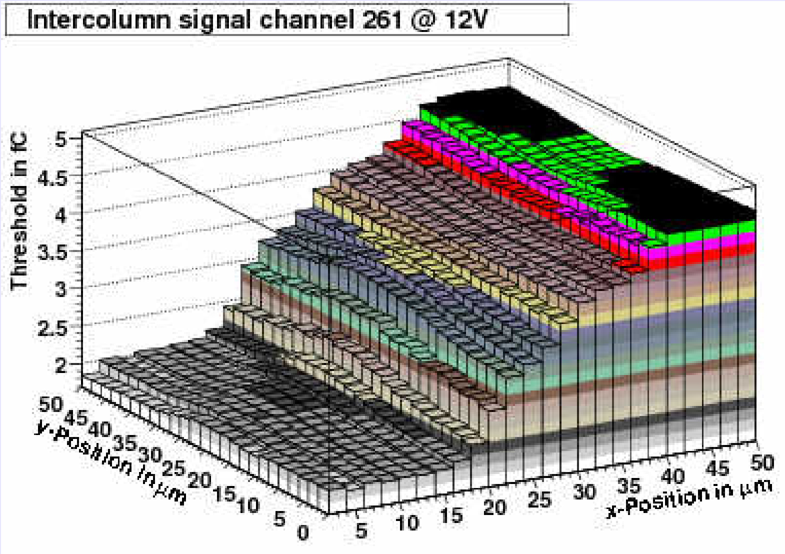
$V_{bias} = 3$ V

Spatial measurements

V_{bias} = 7 V:



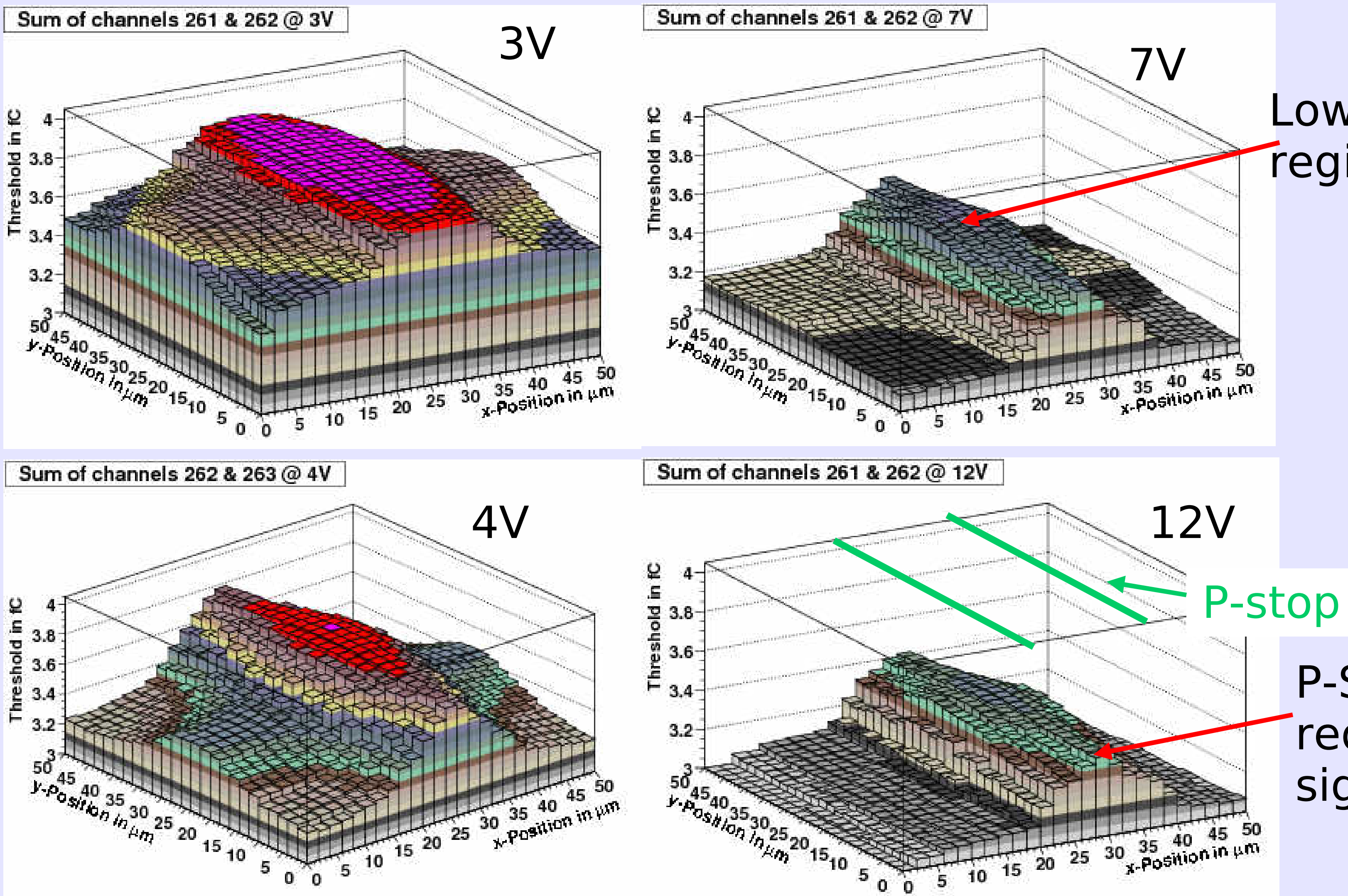
V_{bias} = 12 V:



- Noise: Nearly same amplitude as unbonded channels, can not be measured → low interstrip capacitance because of short strips

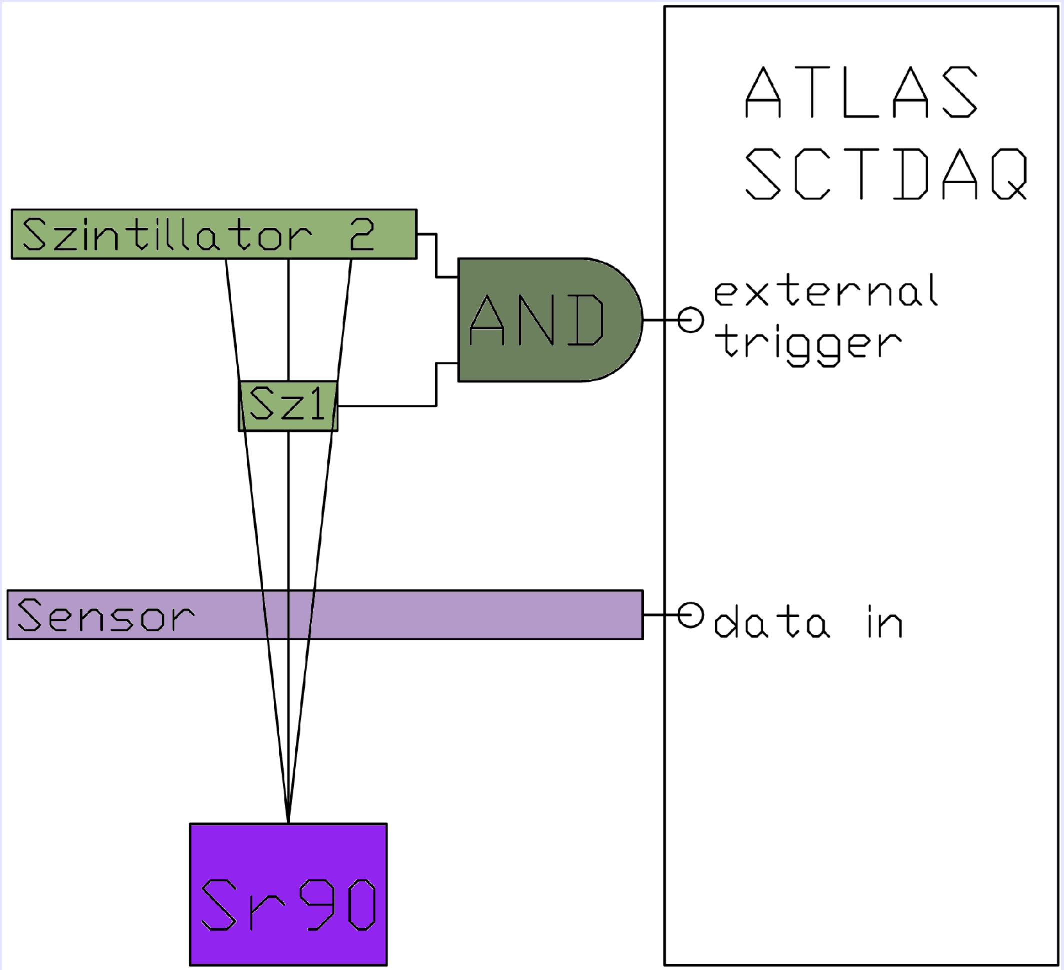
Spatial measurements

- Scans from 2 channels added



Beta source set-up

- 2.4 MBq ^{90}Sr source
- Sufficiently high energy electrons simulate MIPs
- Binary readout
- 40 MHz clock
- 20 ns peaking time of shaper
- Temperature < -11°C (hybrid thermistor)



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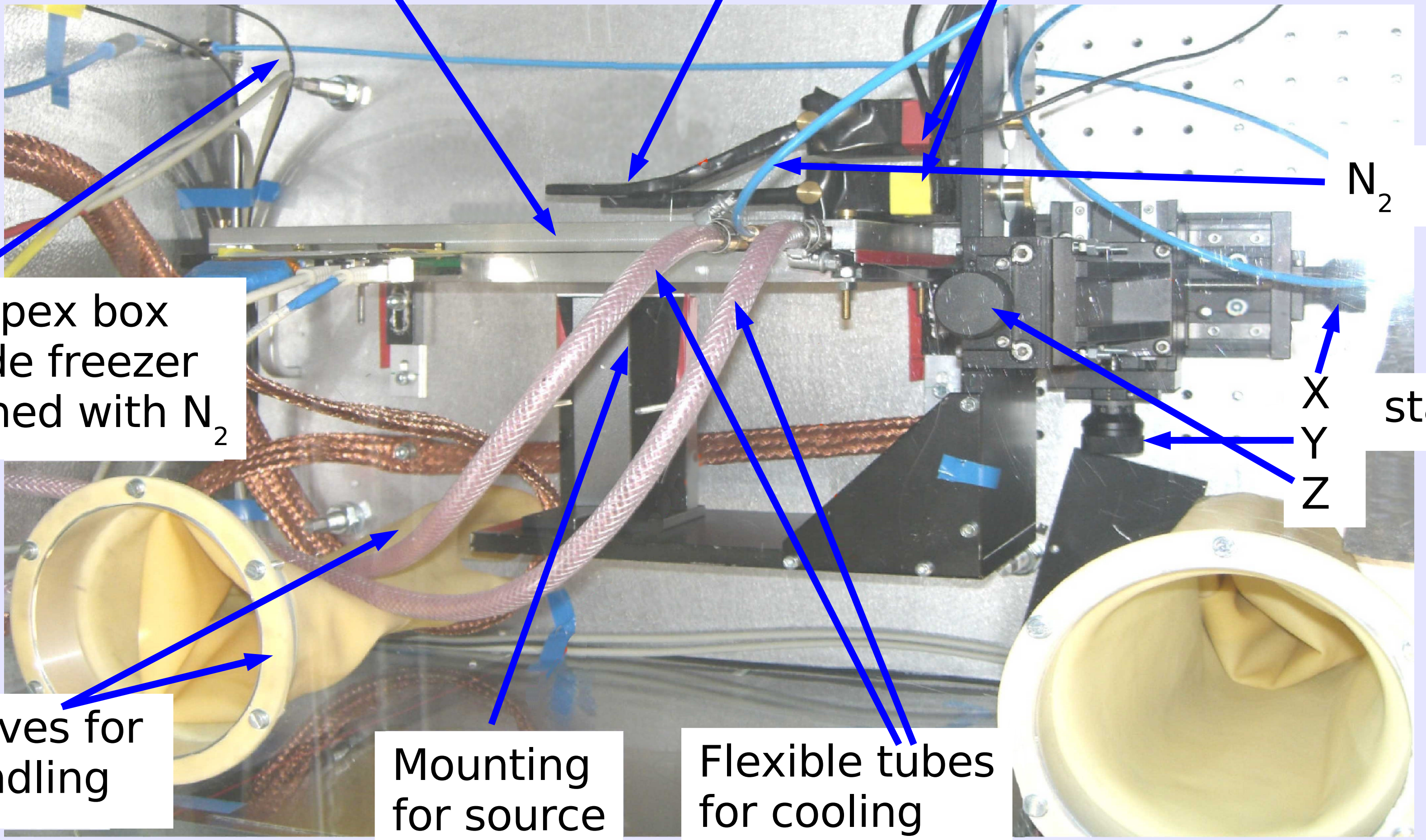
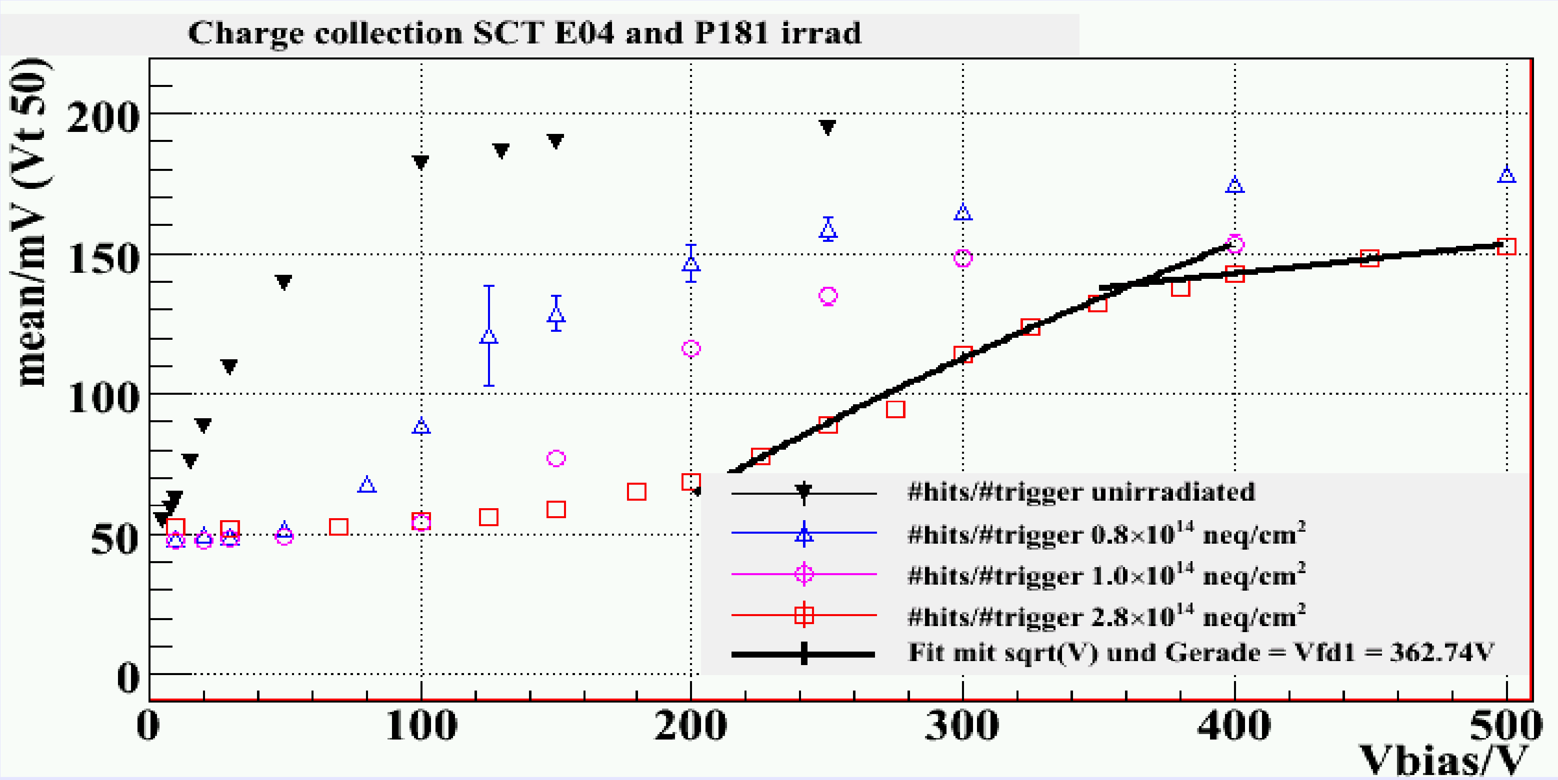


Beta measurements with stFZ p-in-n sensors



Irradiation done with 26 MeV protons in Karlsruhe
Thanks to A.Furgeri

Unirradiated → V_{fd} = 89 V

$\phi_1 = 0.8 \cdot 10^{14}$ neq/cm^2 (± 10%) → V_{fd} = 180 V

$\phi_2 = 1.0 \cdot 10^{14}$ neq/cm^2 (± 10%) → V_{fd} = 257 V*

$\phi_3 = 2.8 \cdot 10^{14}$ neq/cm^2 (± 10%) → V_{fd} = 363 V

Summary and Outlook

- Absolute and relative CCE measurements possible
- For stFZ S/N decreases from 25 to 16 (un-irradiated hybrid)

- 3D module:
- first measurements with LHC-speed electronics of 3D-stc sensor
- large (15 μm) low-field region between columns

- P-stops may have impact on electric field → signal reduced

To do for 3D module:

- measure charge collection efficiency with beta source set-up
- measure sensors with different p-stops
- irradiate sensors, then re-characterise

Thanks to colleagues from IRST, Trento, MPI Munich and Prague