Module Characterization with a Beta Source Setup in Freiburg

8th RD 50 workshop

26.06.2006

Susanne Kühn, University of Freiburg

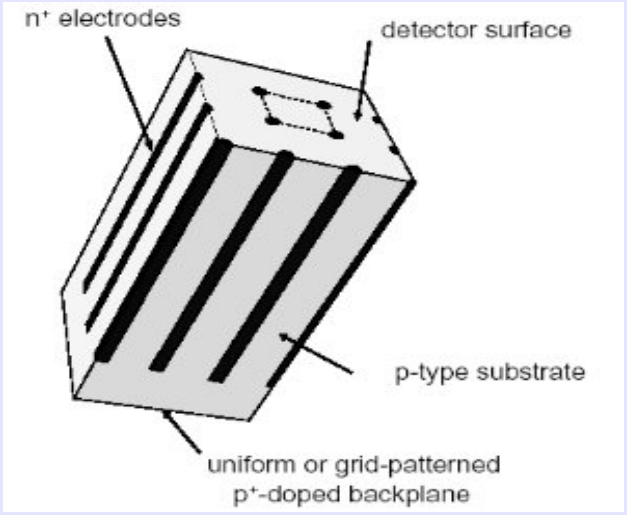
• M. Boscardin [2], G.-F. Dalla Betta [2], S. Eckert [1], T. Ehrich [1], K. Jakobs [1], M. Maassen [1], U. Parzefall [1], C. Piemonte [2], A. Pozza [2], S. Ronchin [2], N. Zorzi [2]
• 1 University of Freiburg, 2 ITC-irst, Trento

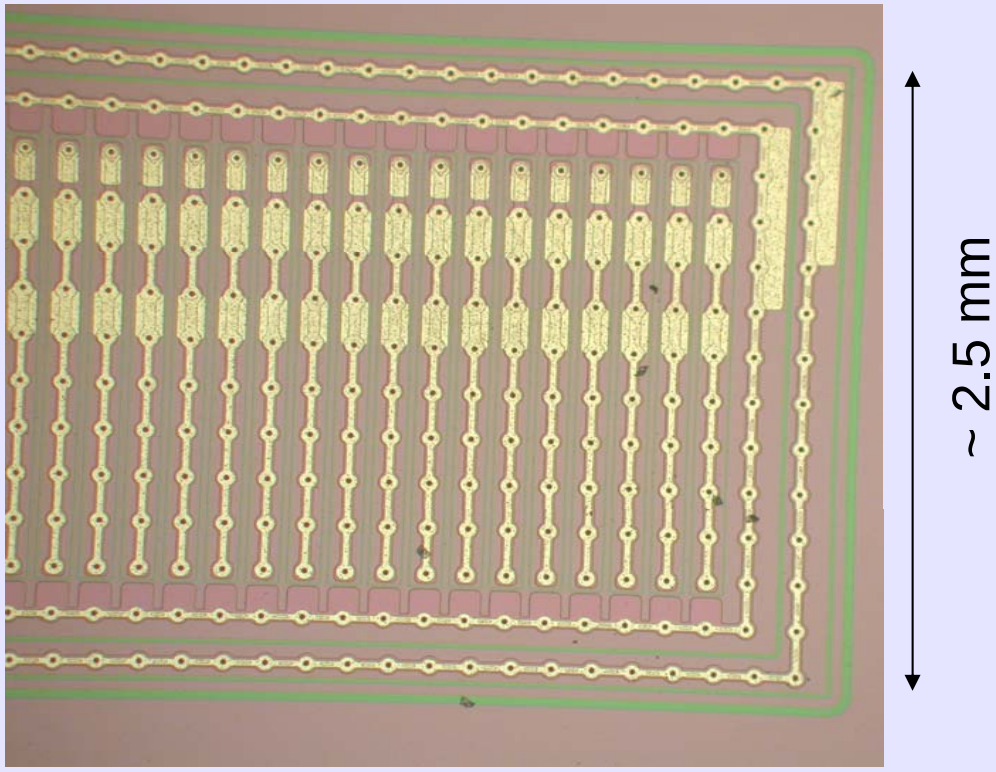
Outline

- Assembly of 3D prototype modules
- Description of the beta source test set-up
- Calibration and first tests with the set-up
- Summary and Outlook

New sensors in Freiburg

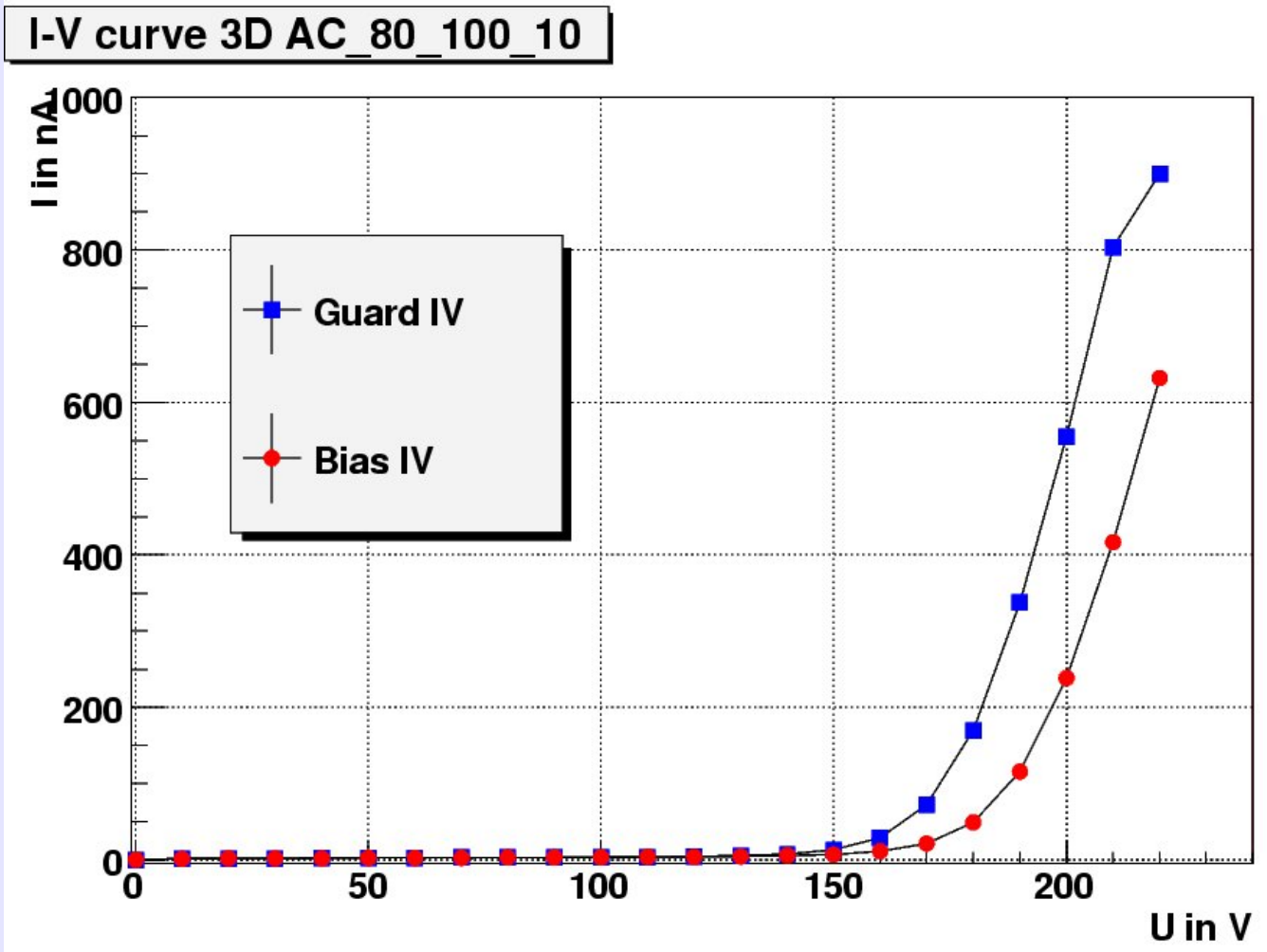
- 3D-stc n-in-p ministrip device from ITC-irst, Trento





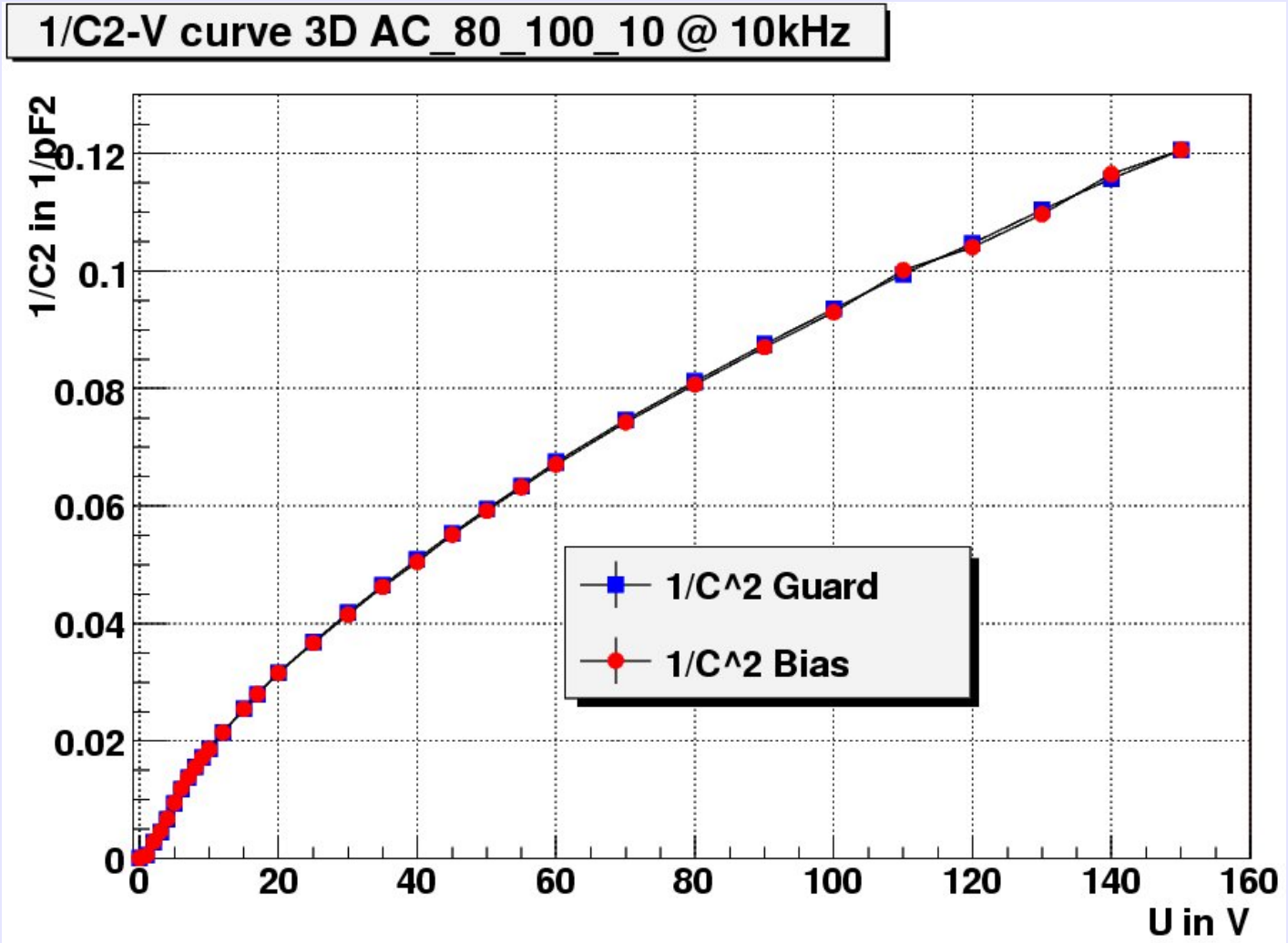
- Czochralski p-in-n sensors from Jaakko Härkönen, Helsinki, see talk of Thies Erich

IV measurments



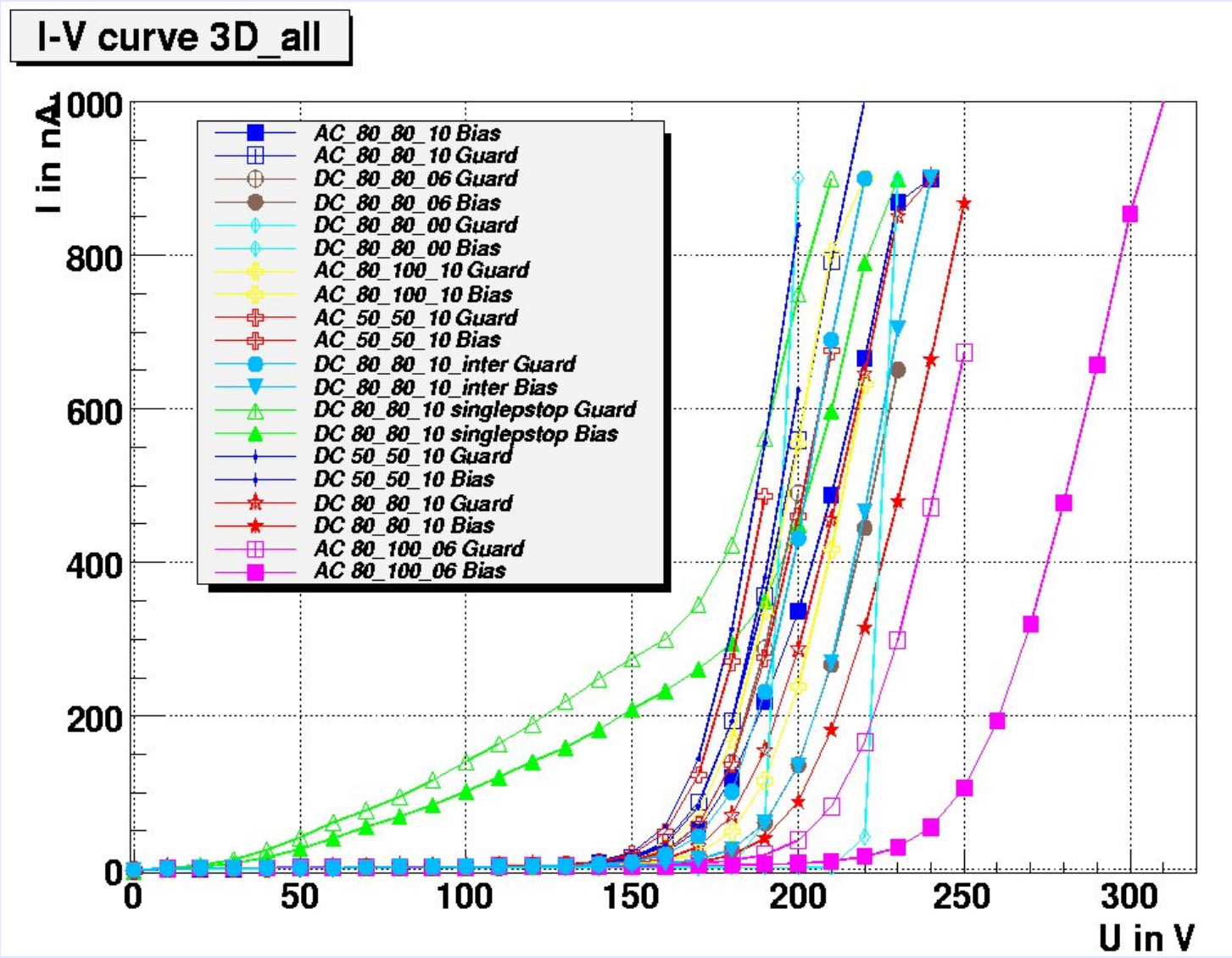
- IV-Kurven show breakthrough at V_{Bias} ~ 150V → functional sensor

CV measurments

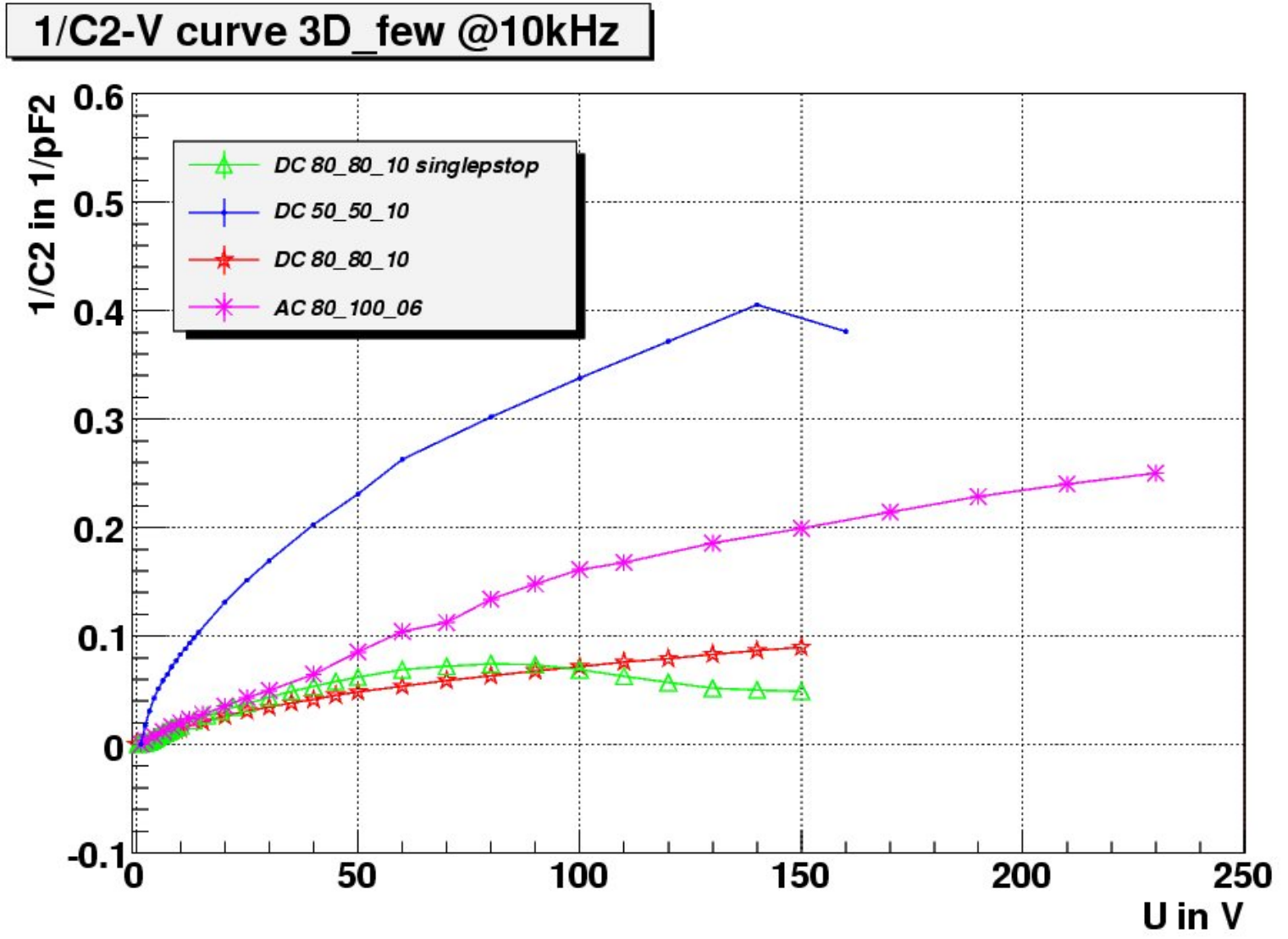


- sensor not fully depleted

IV measurments

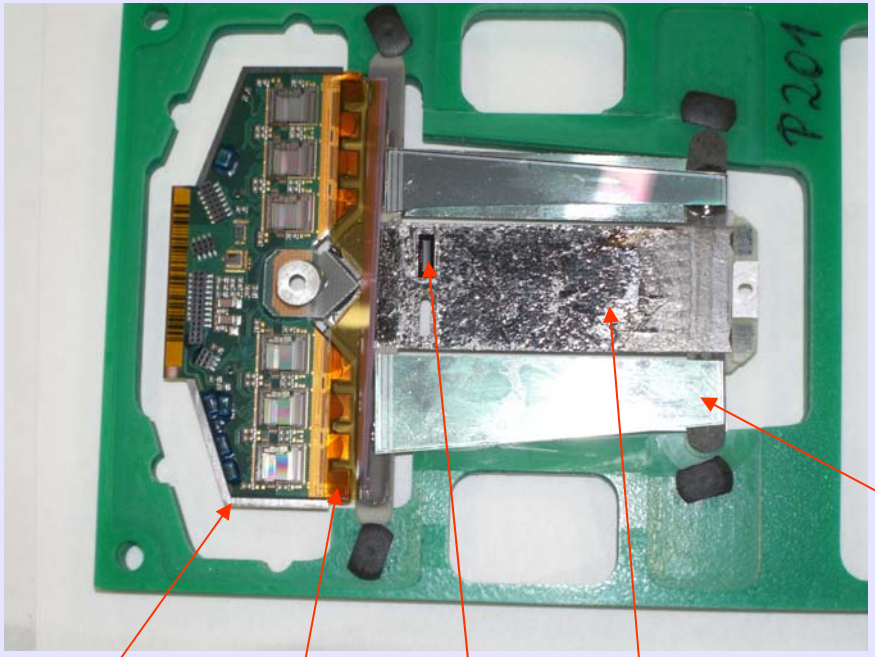


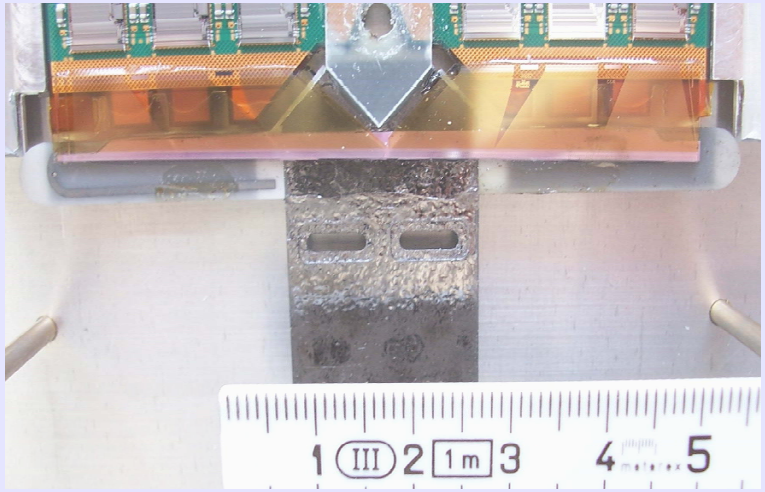
CV measurments



Assembly of 3D modules

- 3D-stc sensors size: 3mm x 7mm , thickness: 500µm, strip pitch: 80/100 µm
- Fan-ins from middle SCT modules (pitch = 92µm) and SCT hybrids
- re-use of old spines and milled edges in TPG material





Old Si for stabilization

SCT hybrid

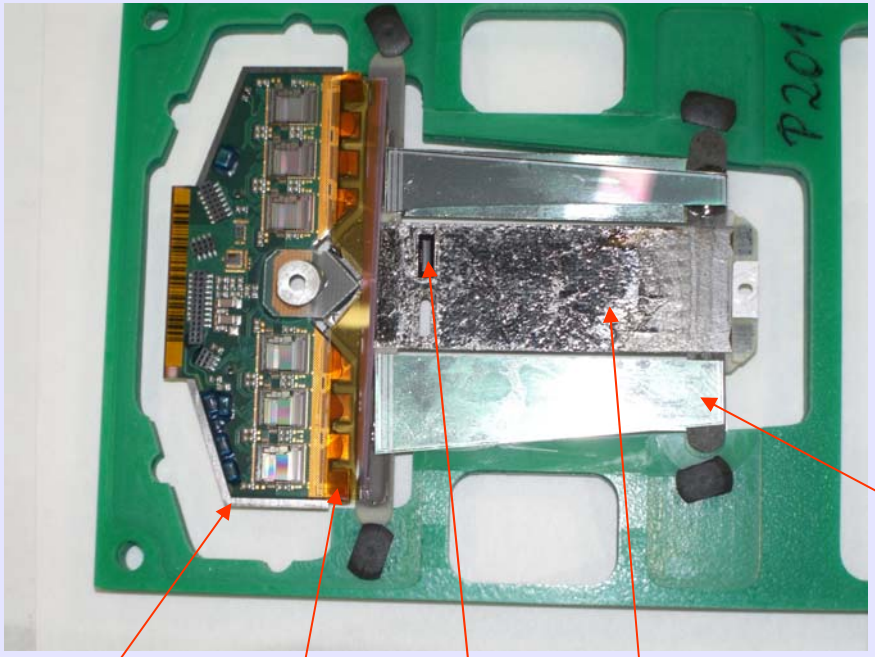
Fan-in

3D-sensor

TPG for cooling

Assembly of 3D modules

- 3D-stc sensors size: 3mm x 7mm , thickness: 500µm, strip pitch: 80/100 µm
- Fan-ins from middle SCT modules (pitch = 92µm)
- re-use of old spines and milled edges in TPG material



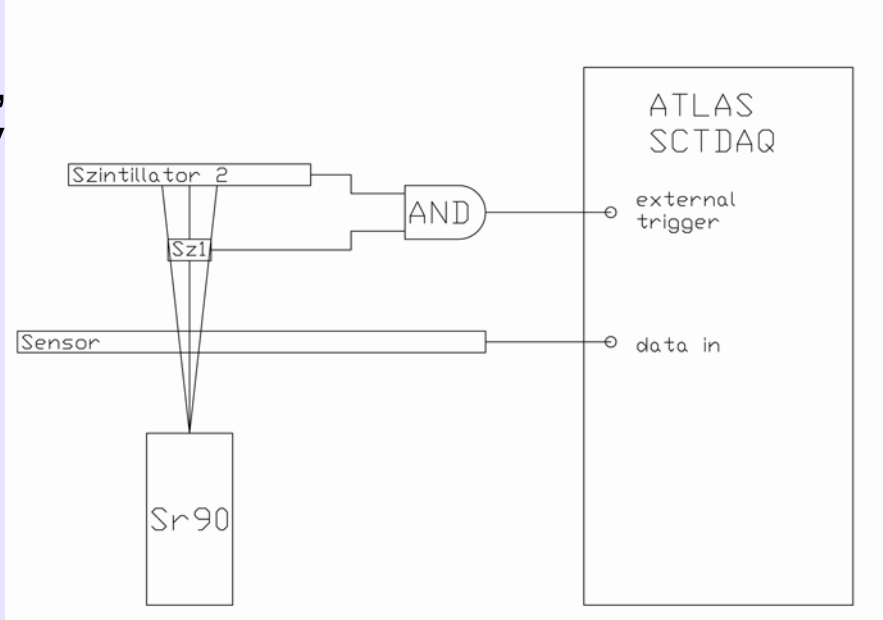
Sensor:
AC_80_100_10

The Beta source set-up

- Sr^{90} source,
$Sr^{90} \rightarrow Y^{90} \nu_e e^-$ with $E_{kin,max,e^-} = 0.546MeV$,
$Y^{90} \rightarrow Zr^{90} \nu_e e^-$ with $E_{kin,max,e^-} = 2.283MeV$
2 sources with 110kBq and 2MBq

- trigger logic: coincidence of 2 plastic scintillators connected to Hamamatsu PMT and clock give trigger input

- sensor readout with SCT DAQ test electronics



Advantages:

- measure charge collection efficiency of MIPs. Only electrons with $\gamma \sim 4\text{-}5$ (~ 2MeV) give trigger signal. dE/dx in scintillator 1 ~ 0.76MeV

- measure signal/noise

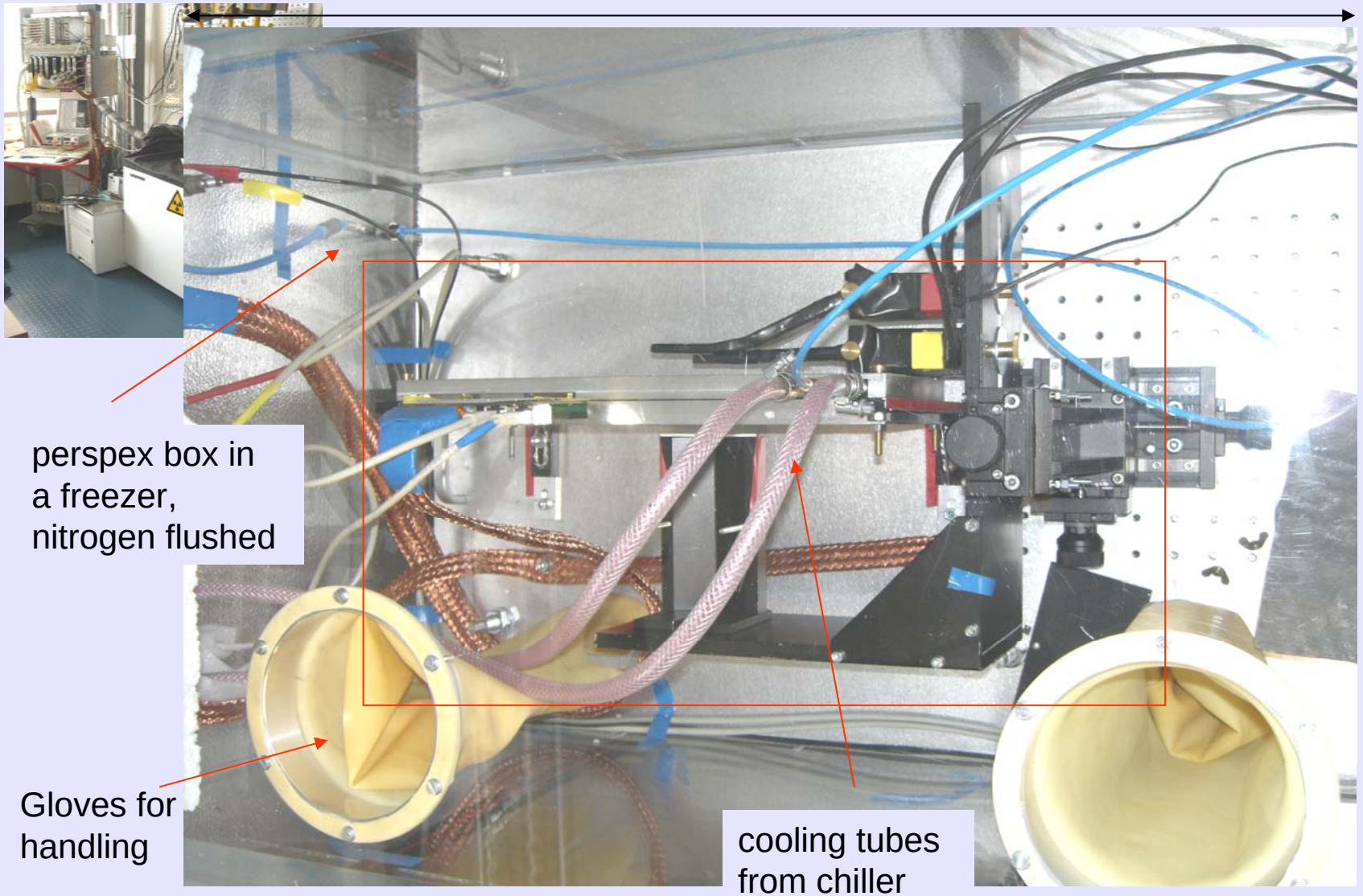
- modules tested with real ATLAS hybrids and electronics

- spatial width only ~ 4mm

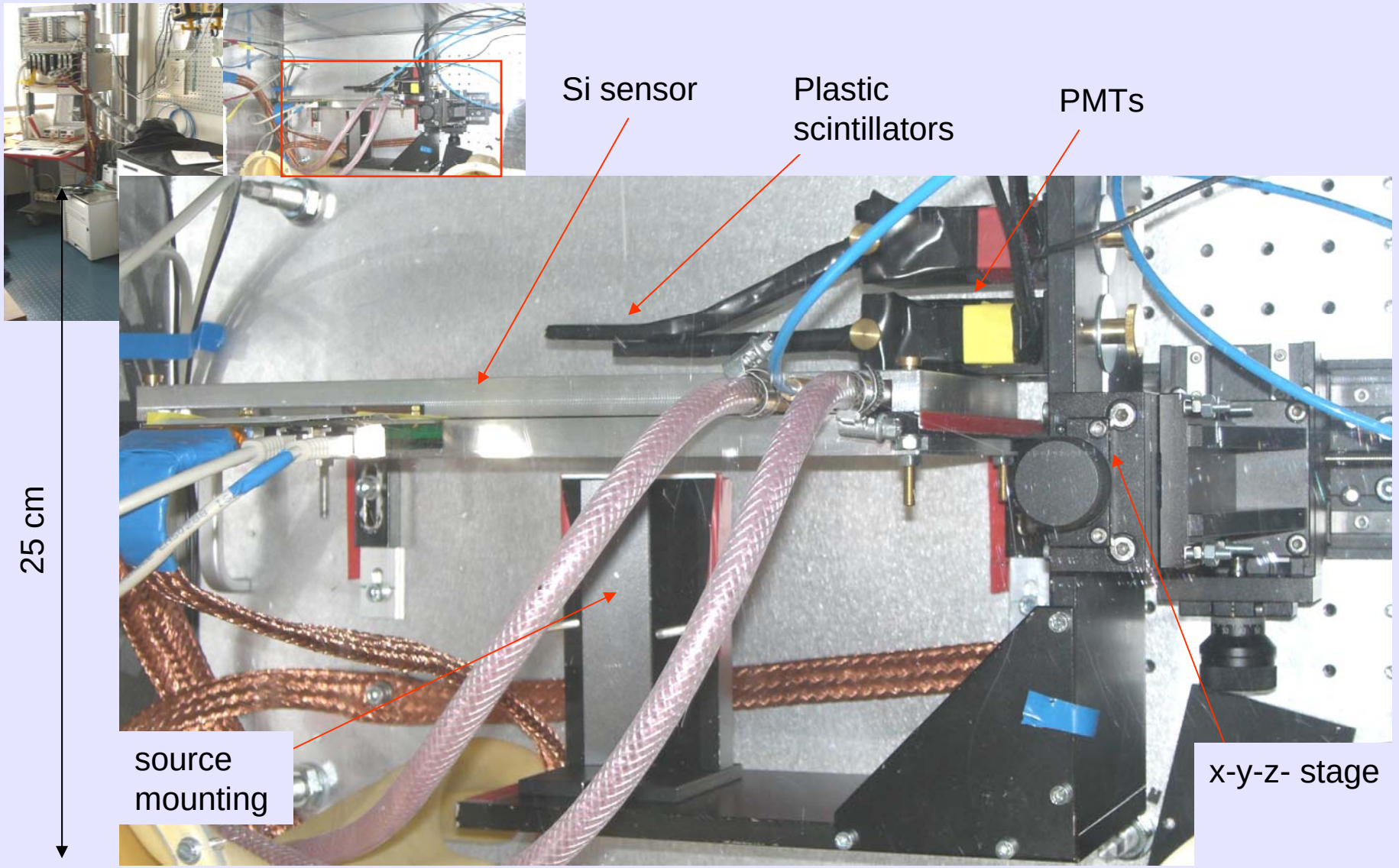
Pictures of the set-up

- set-up stands in a nitrogen flushed freezer (T = -18°C) and hybrid is cooled with a chiller (T = -25°C)

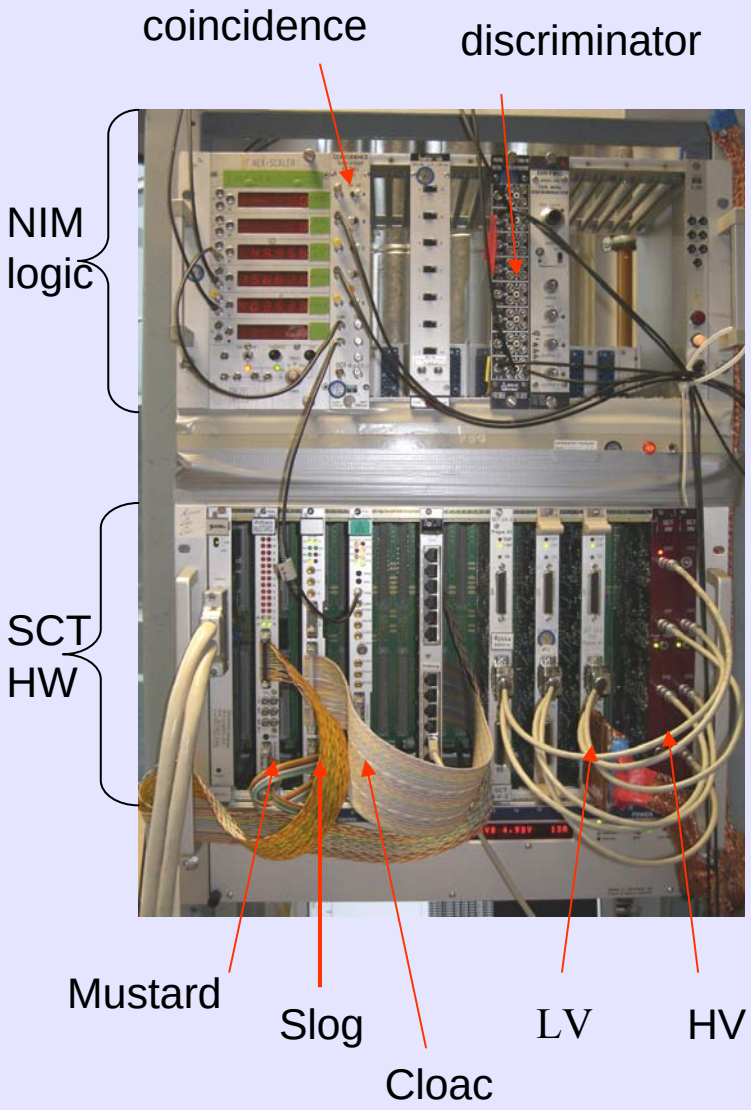
Pictures of the set-up



Pictures of the set-up



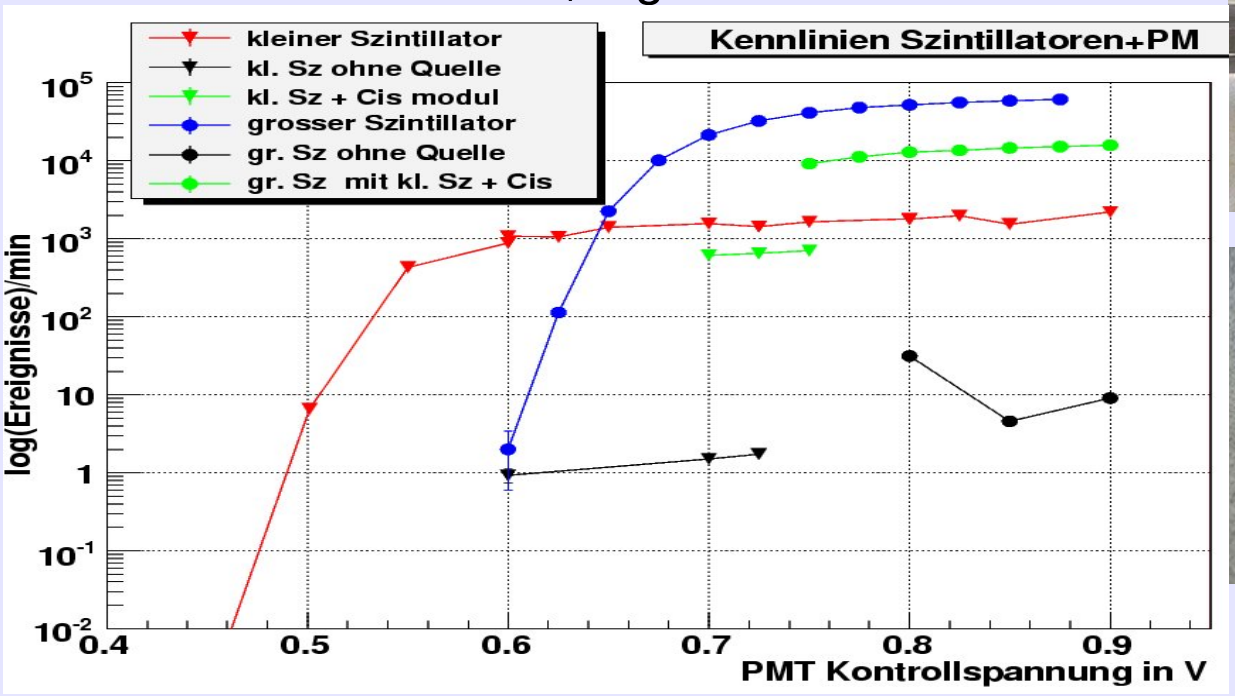
Pictures of the set-up

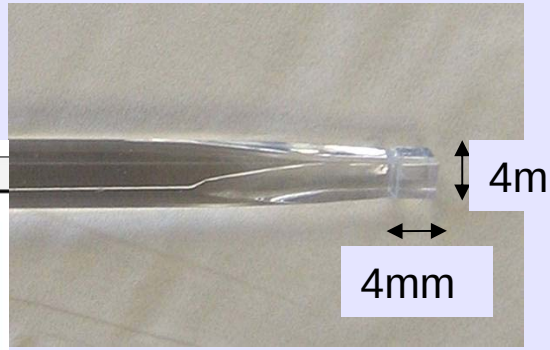


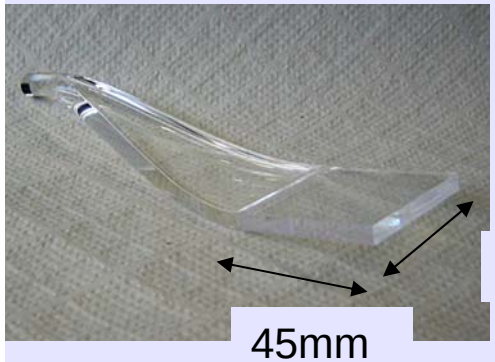
Calibration of the set-up

- plateau curves for the scintillators

small scinti. 4x4x4mm^3, big scinti. 45x45x4mm^3





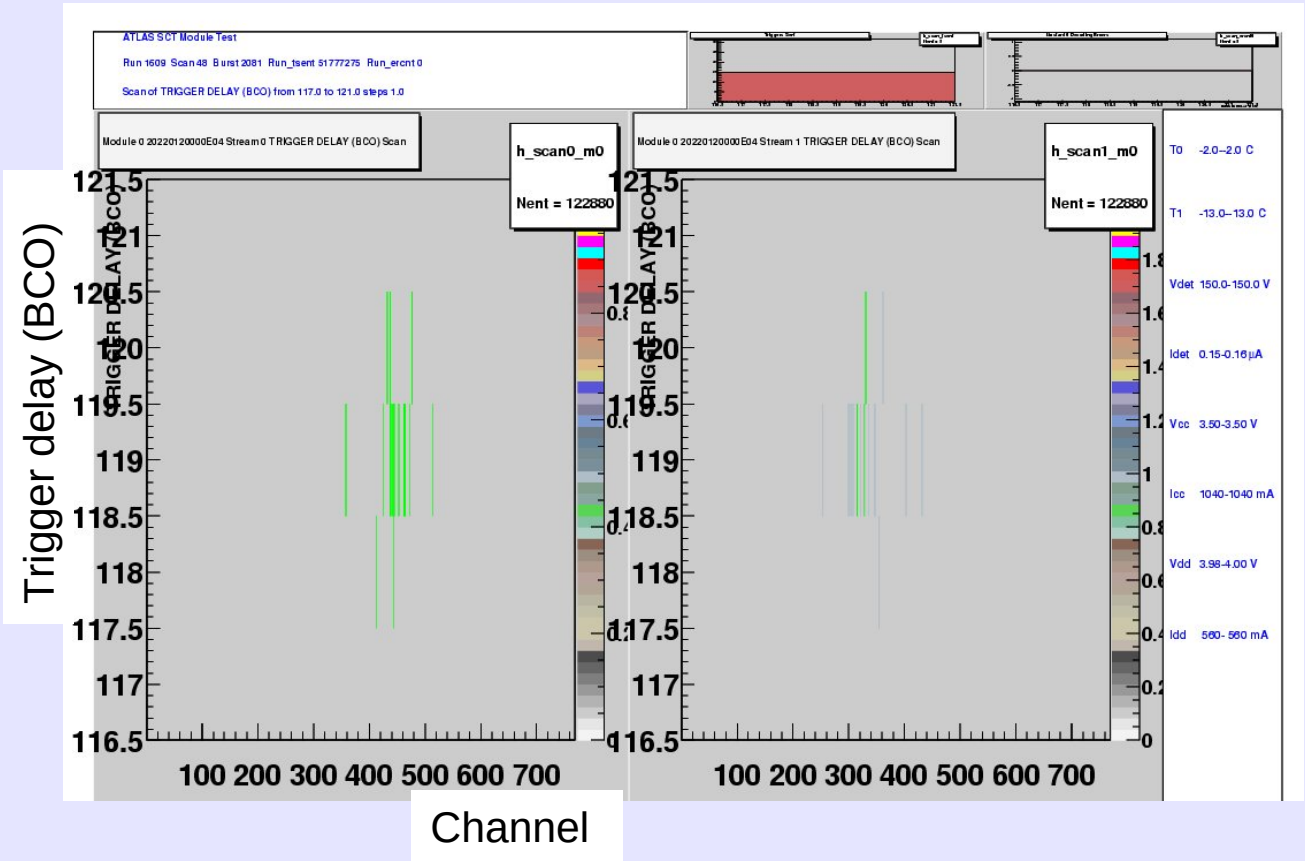


	small Sz in Hz	big Sz in Hz	coincidences in Hz
Strong source (2MBq) + SCT module	18.0±0.1	305.3±0.5	0.75±0.02
Noise	0.029±0.002	0.523±0.008	0.0042±0.0007

Calibration of the set-up

Calibration with a SCT-prequalification module

- T_{hybrid} = -6°C, humidity < 7%
- locate signal in correct time bin: to maximize signal (thanks to Pavel Reznicek)



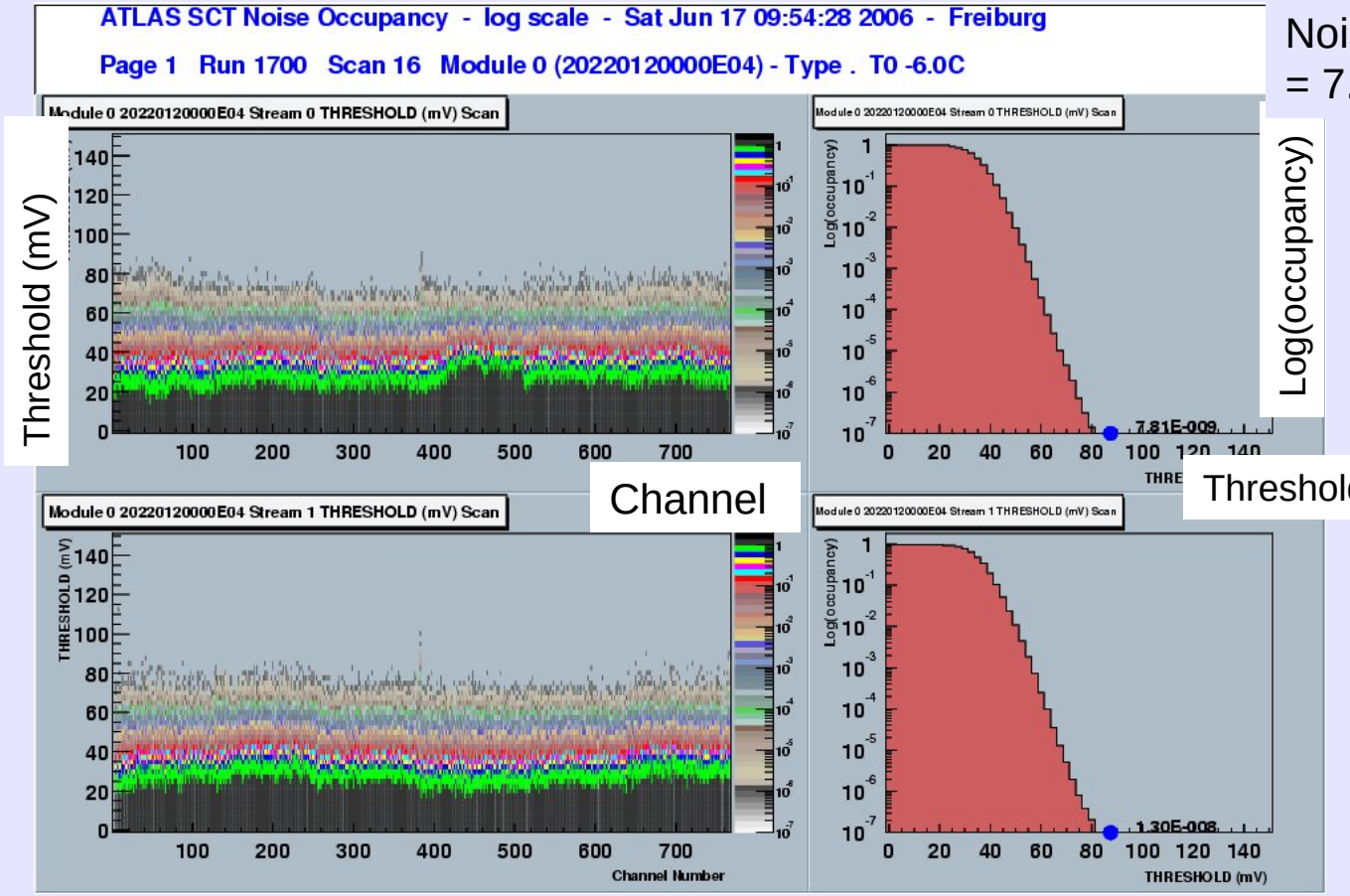
Trigger delay (BCO)

Channel

Calibration of the set-up

Calibration with a SCT-prequalification module

- noise occupancy without source



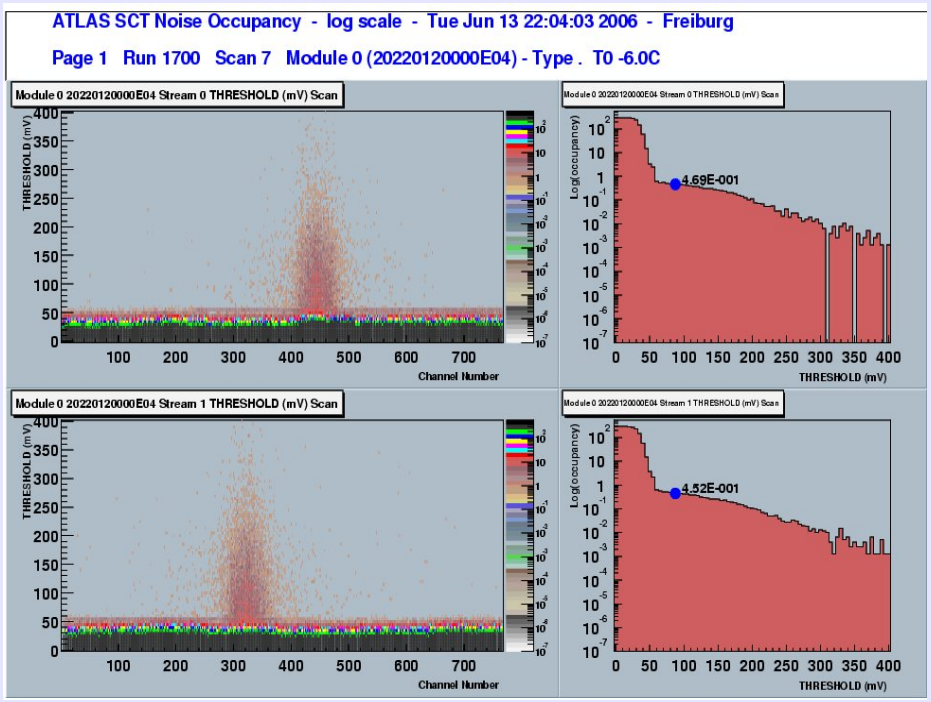
Noiseoccupancy = 7.8×10^{-9}

→ noise in all chips 900 - 1000e$^-$

First tests with the set-up

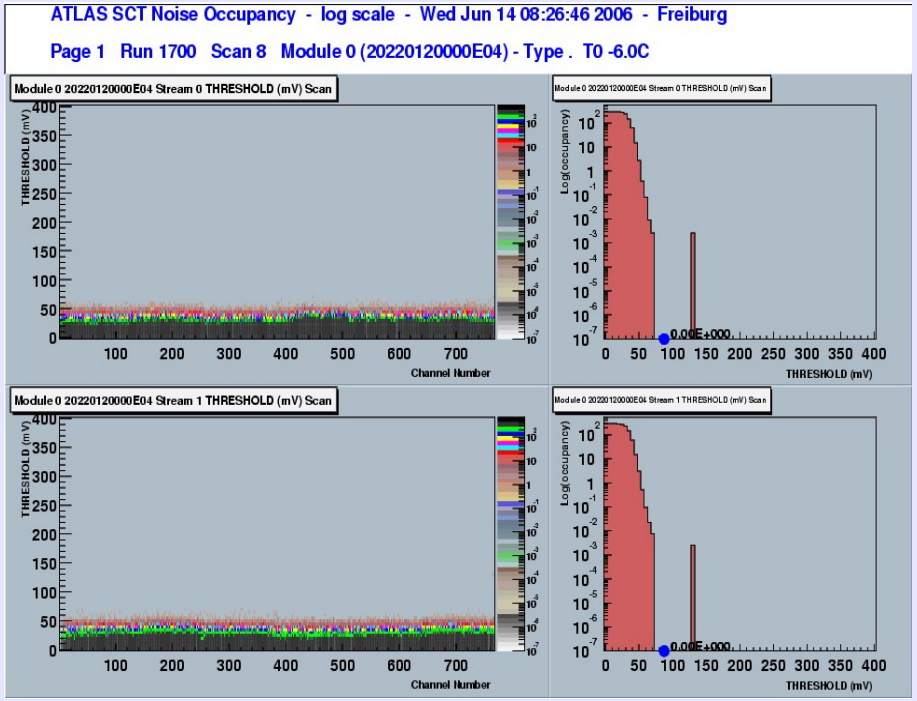
Noise occupancy scans of a SCT-module with external trigger, U_{bias}=150V

measurement with optimal delay (BCO 119)



→ source gives a ~ 65 channels broad signal, defined by the area of small scintillator

measurement with 230ns offset (BCO 110)

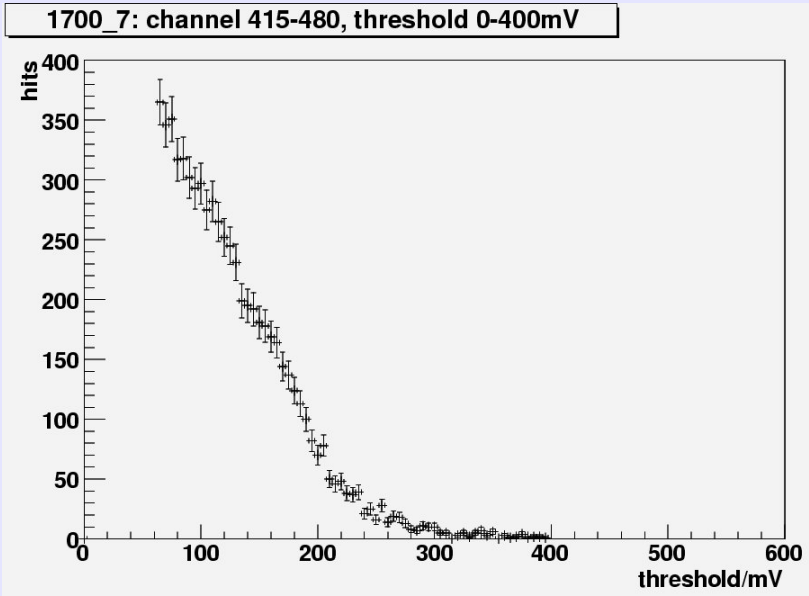


→ no random coincidences above noise

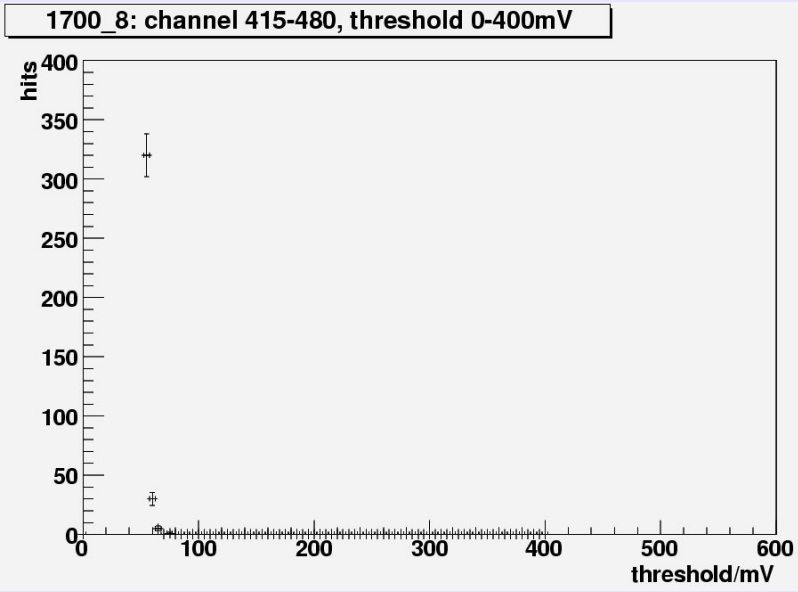
First tests with the set-up

Data analysis

- sum up the signal of 65 channels → integrated Landau convoluted with a Gaussian
- optimal delay (BCO 119)

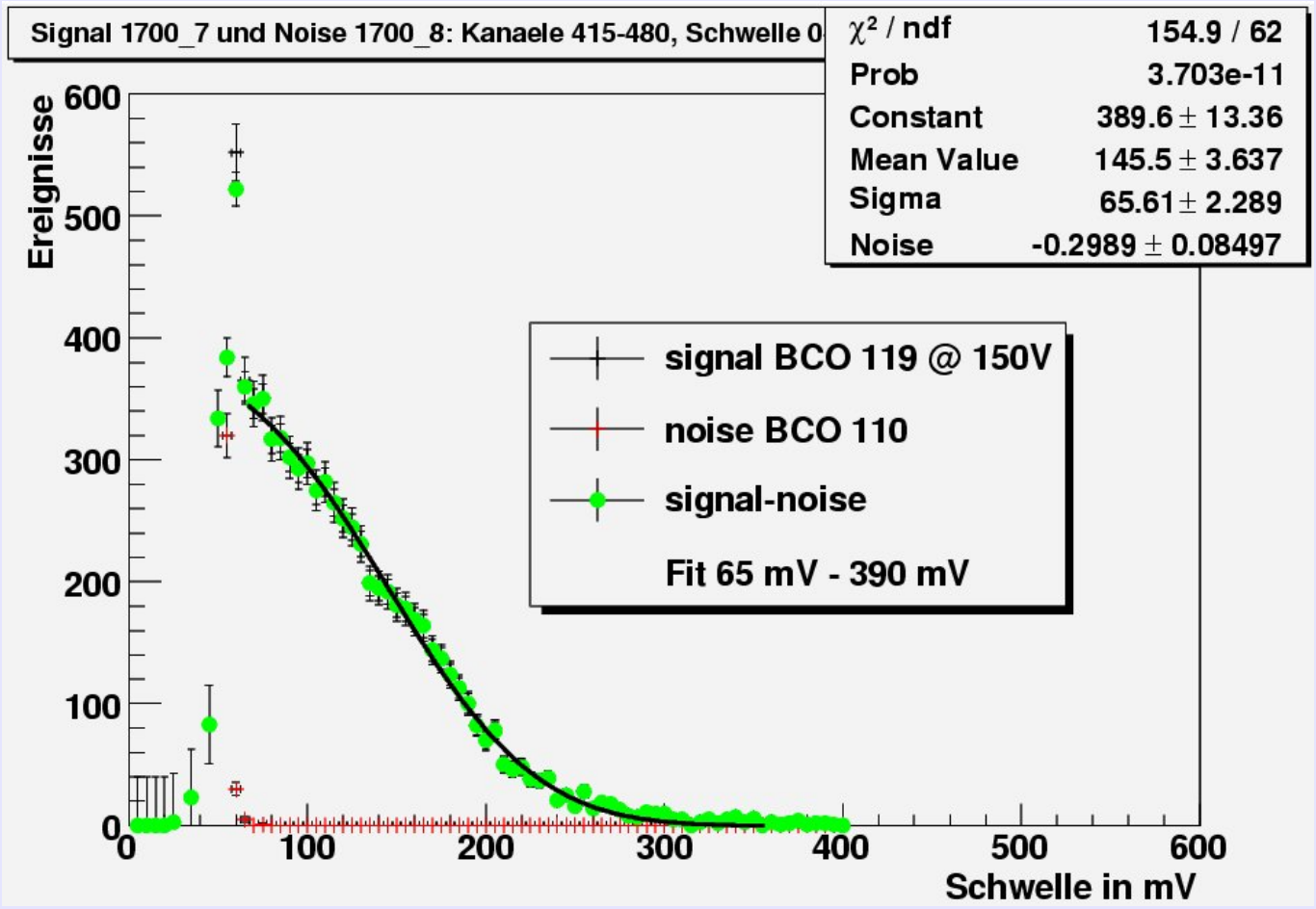


out-of-time (delay BCO 110)



First tests with the set-up

- fit with an error function → 50% point/median



- gain from response curve → median in fC

Summary and Outlook

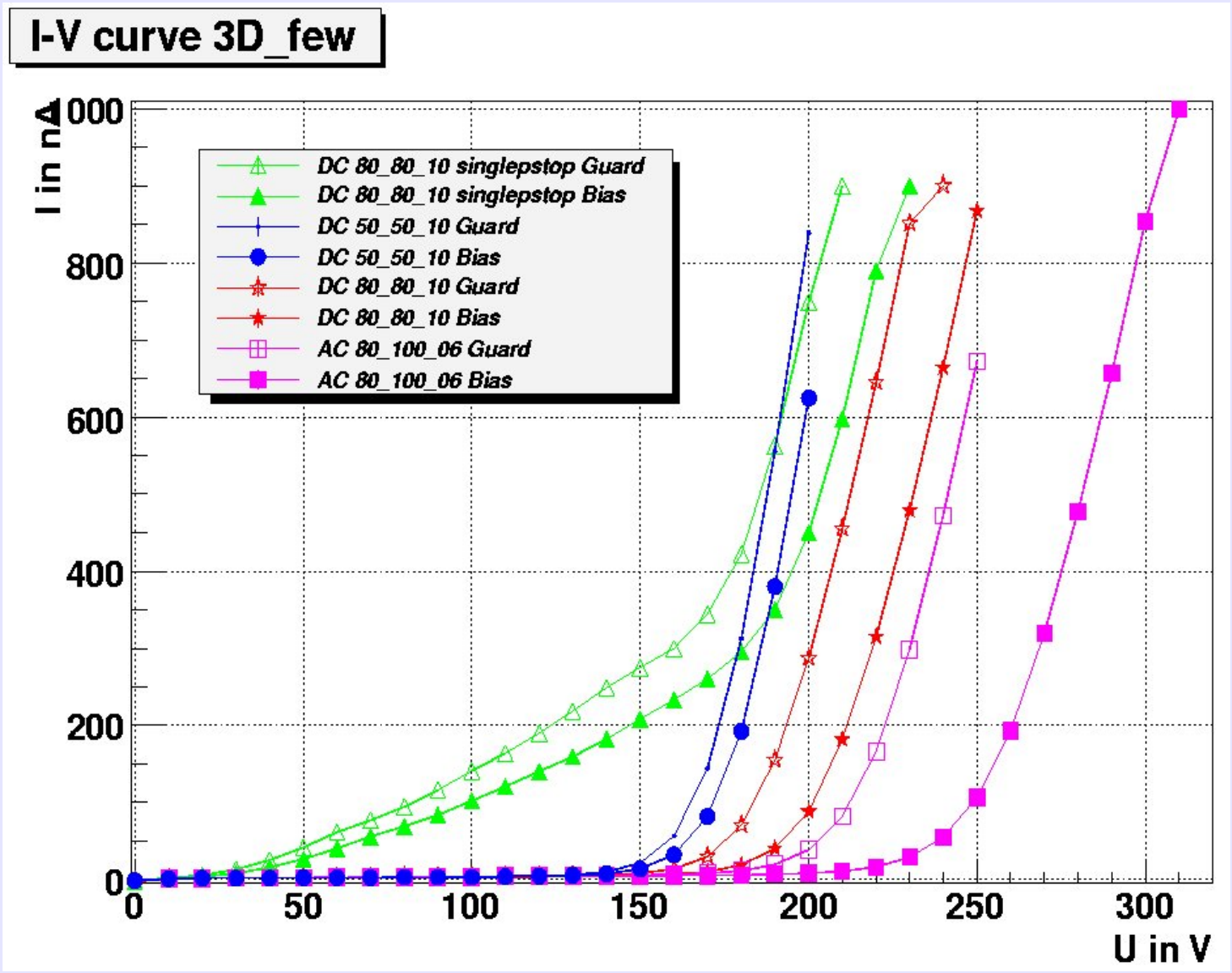
- fully functional beta source set-up designed and built up,
- set-up performance is good, low noise, signal from mips is measured

To do:

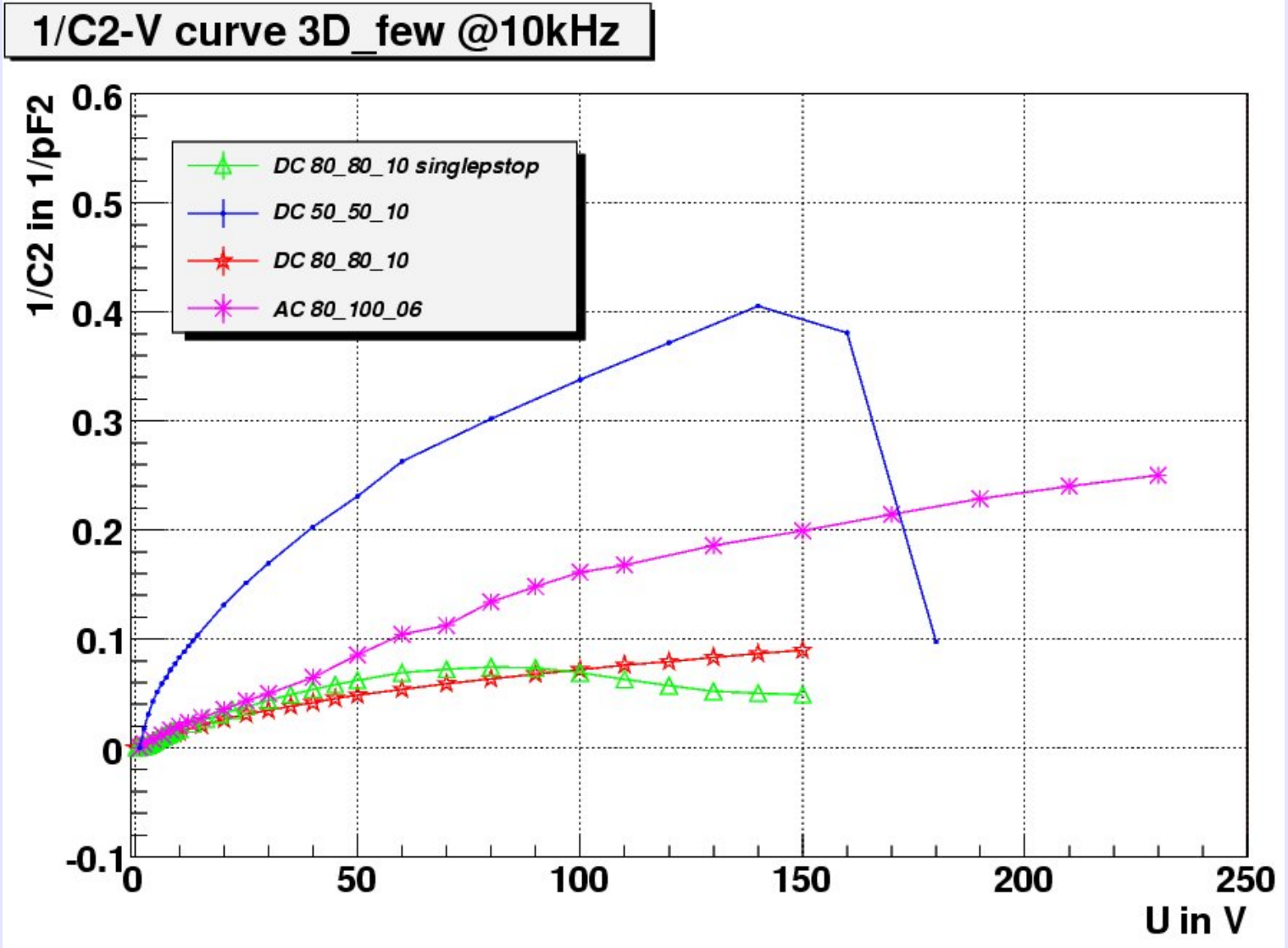
- fit with integrated Landau
- measure irradiated SCT sensors
- tests of prototype modules CZ, 3D
- irradiation of prototype modules

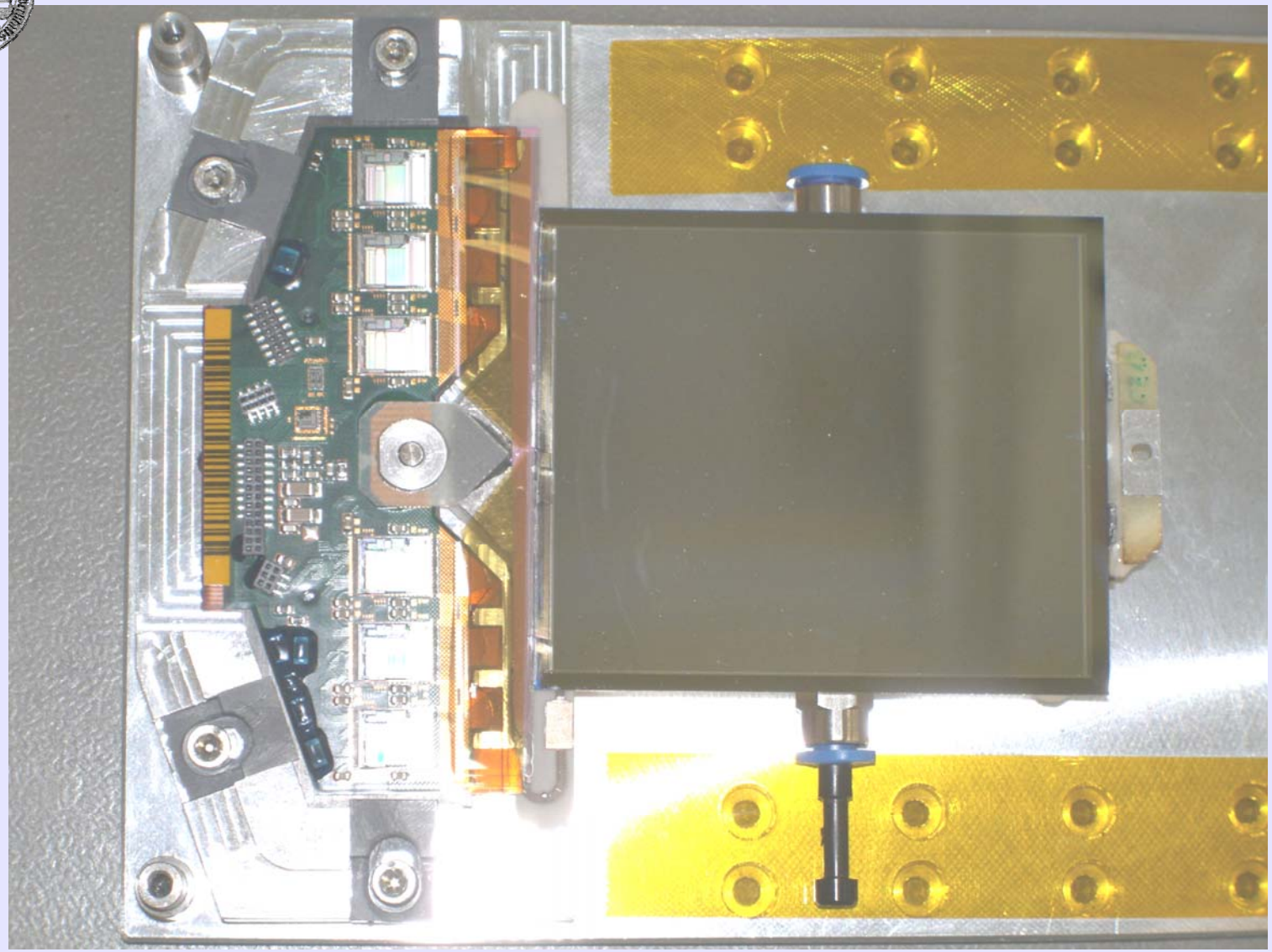
- Thanks to colleagues from IPNP Prague, MPI Munich, Helsinki Institut of Physics and IRST, Trento

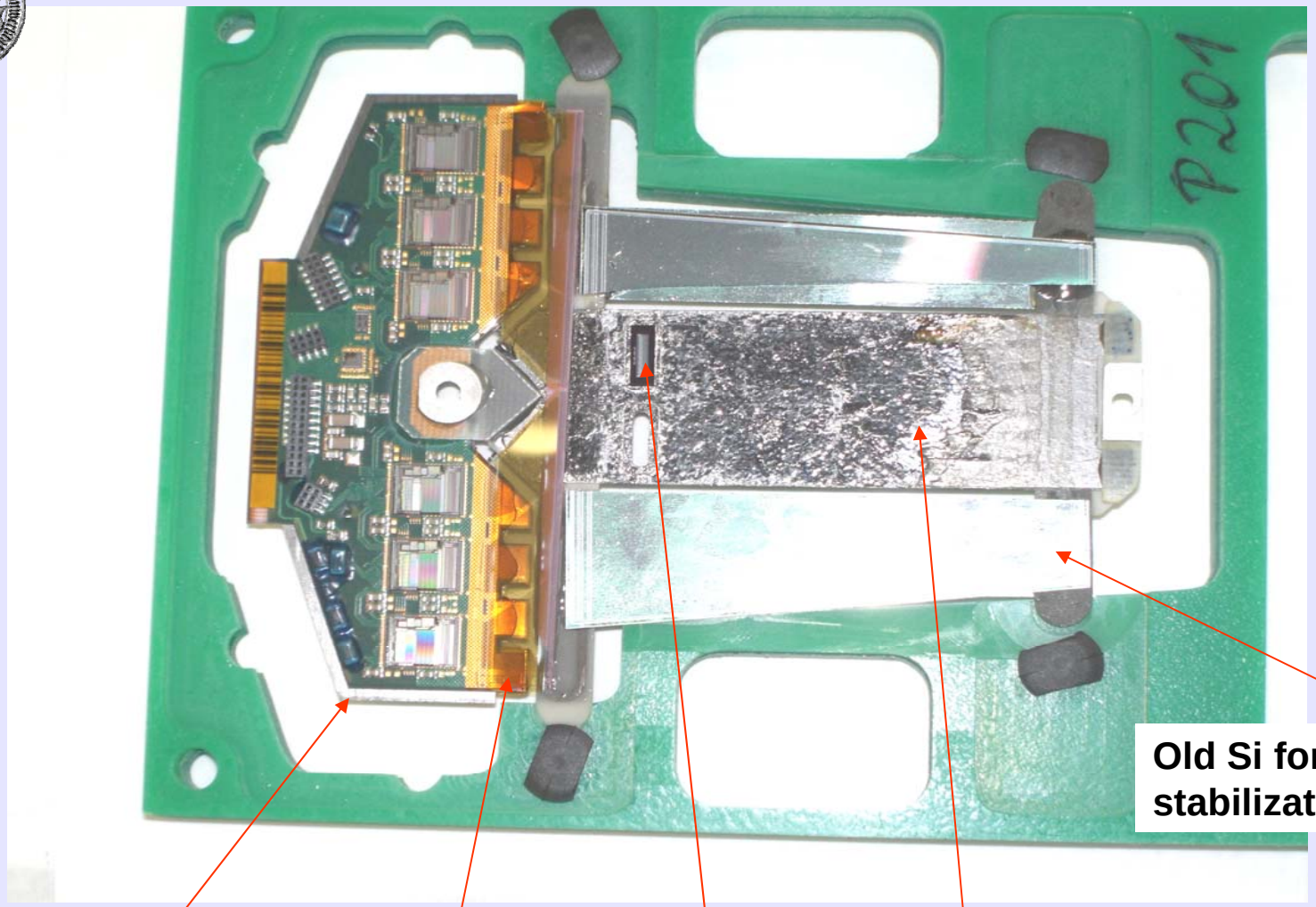
CV+IV measurments



CV+IV measurments







Old Si for stabilization

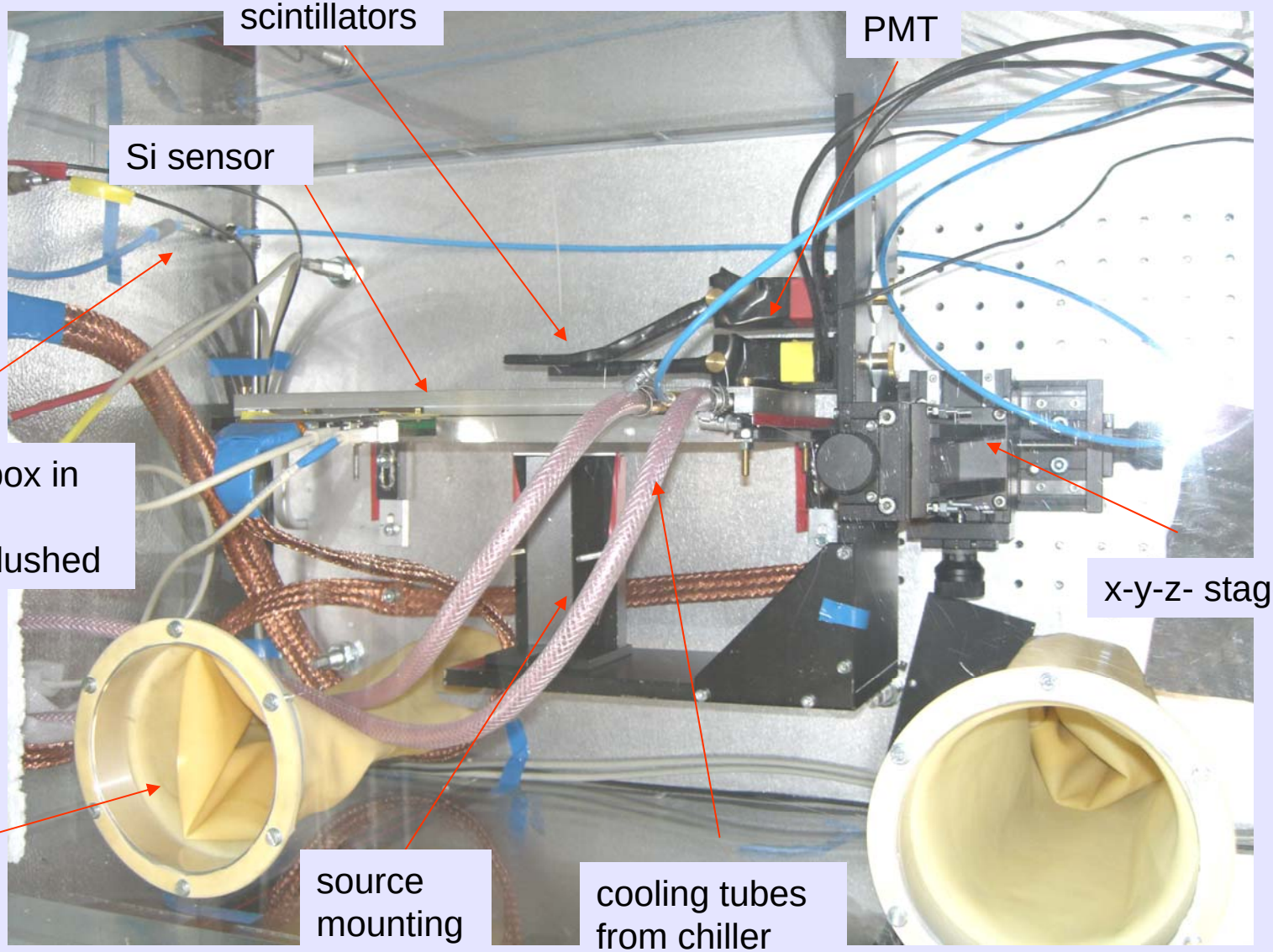
SCT hybrid

Fan-in

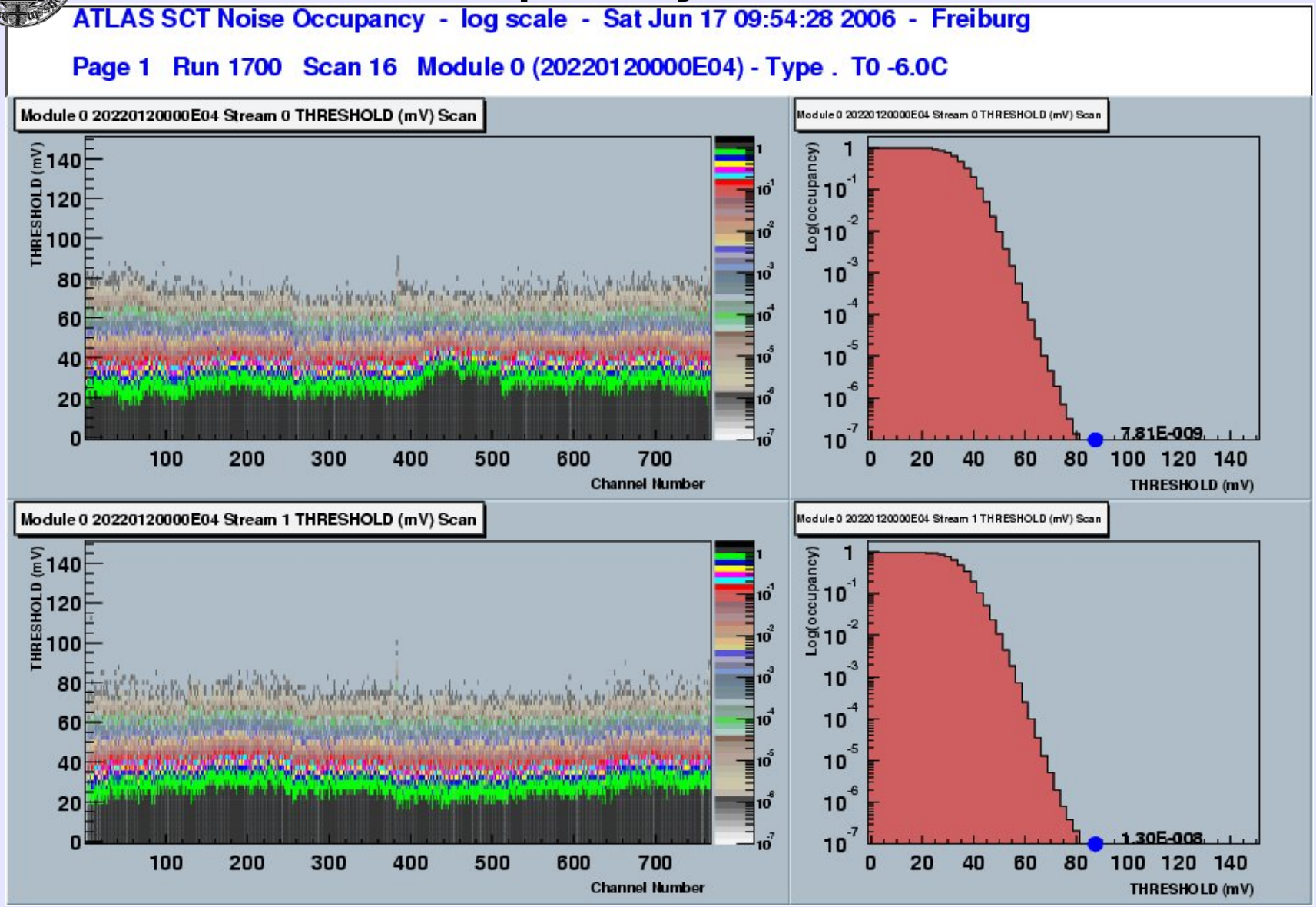
3D-sensor

TPG for cooling

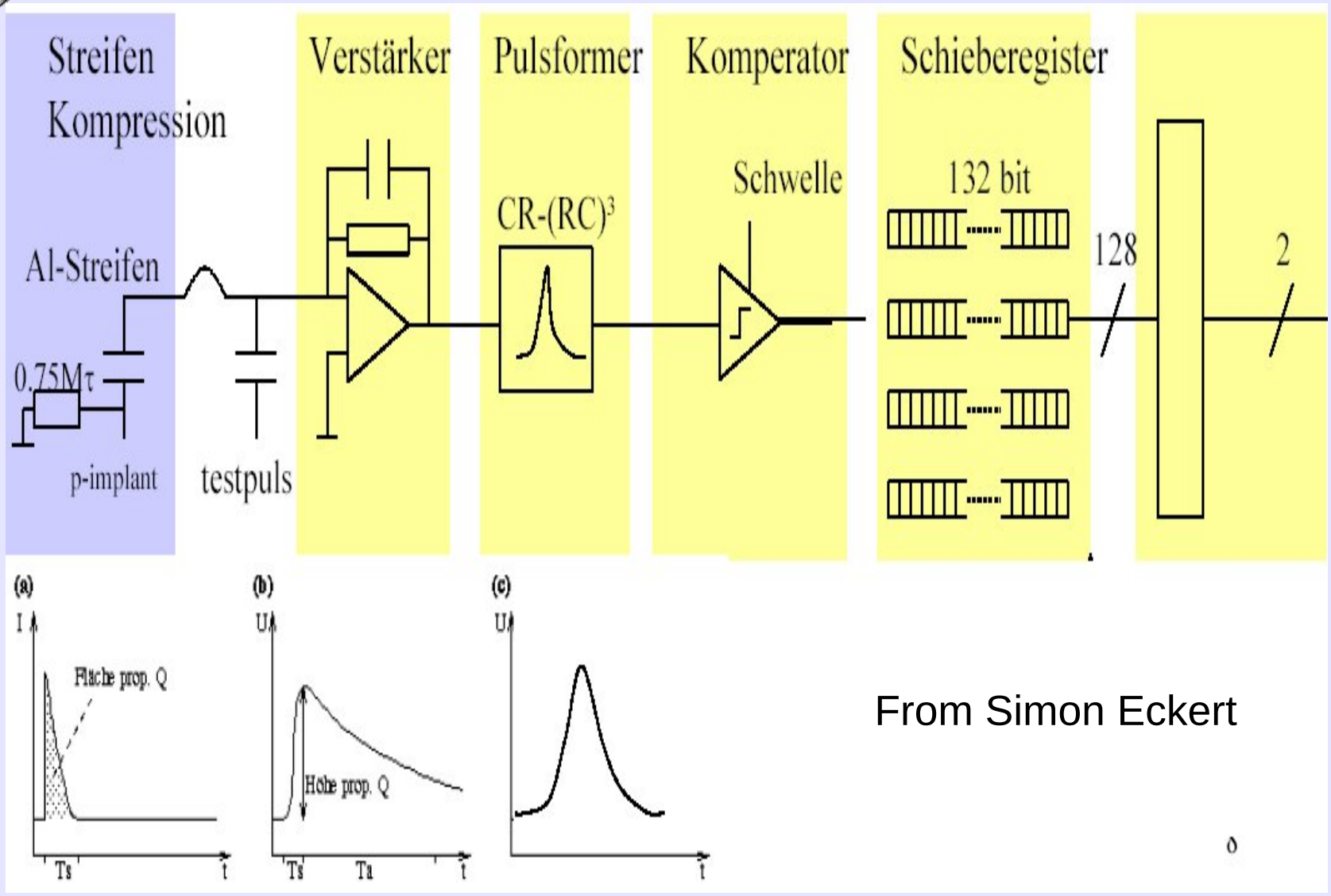
Pictures of the set-up



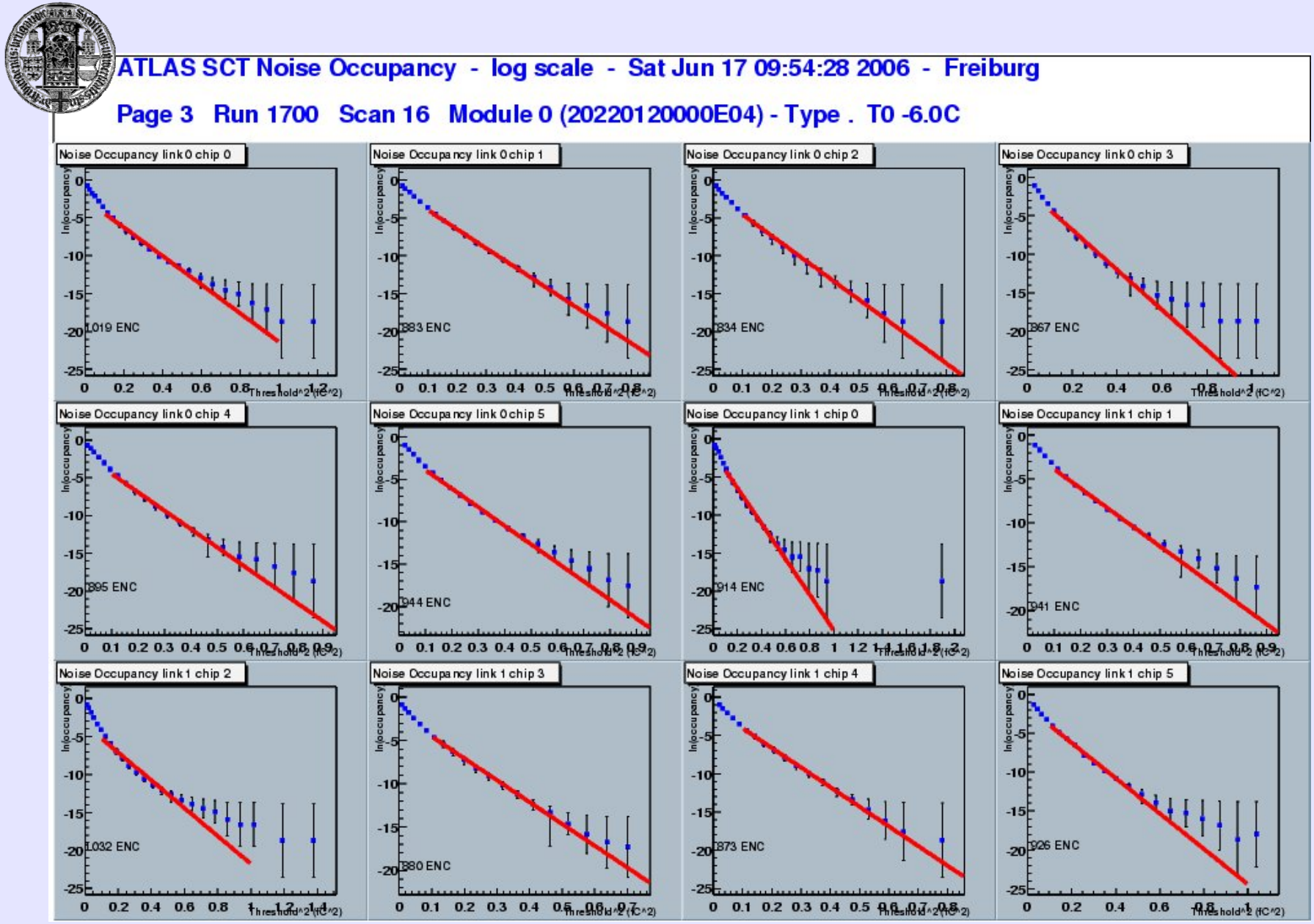
Noise occupancy without source



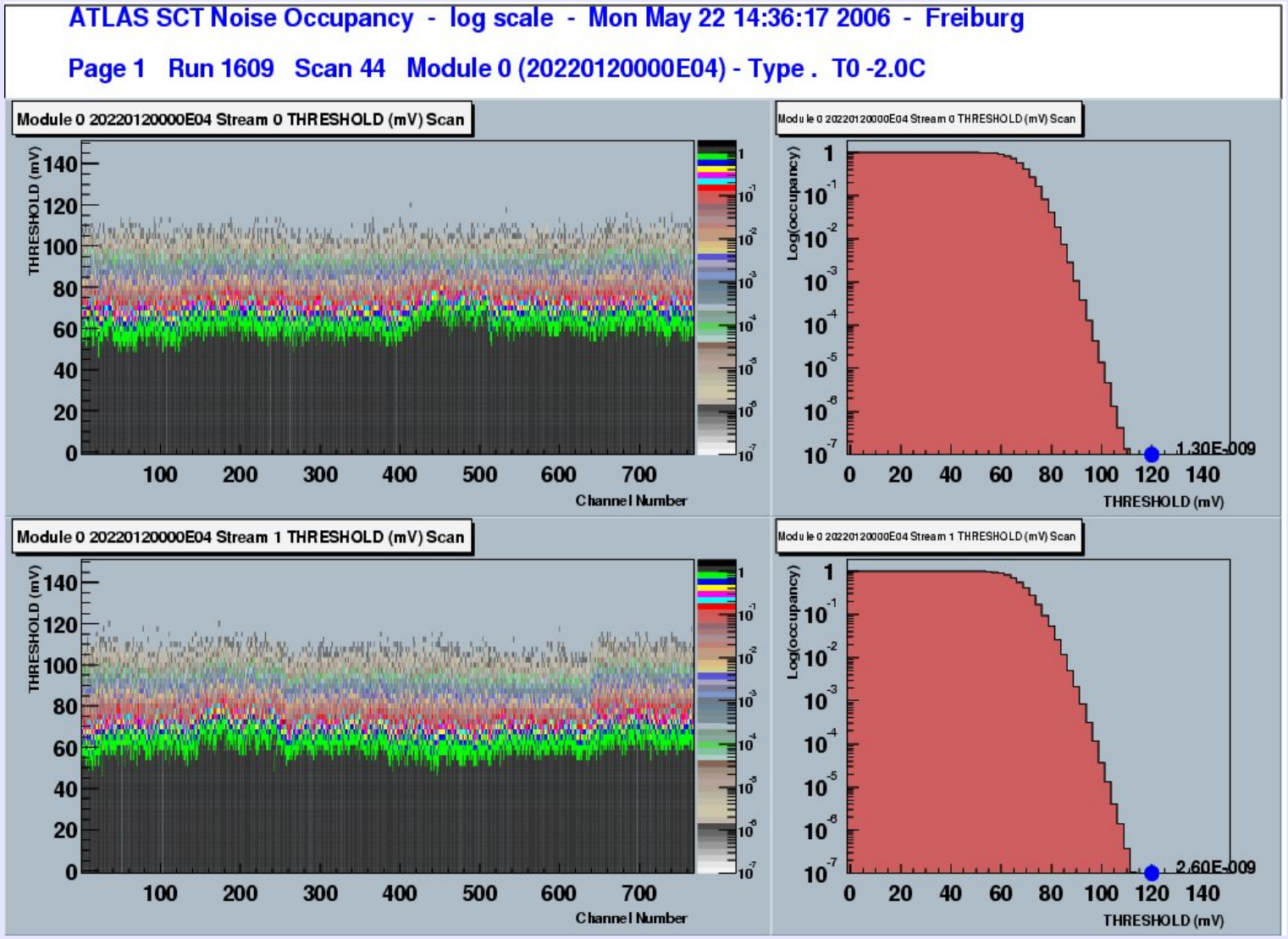
Binary readout

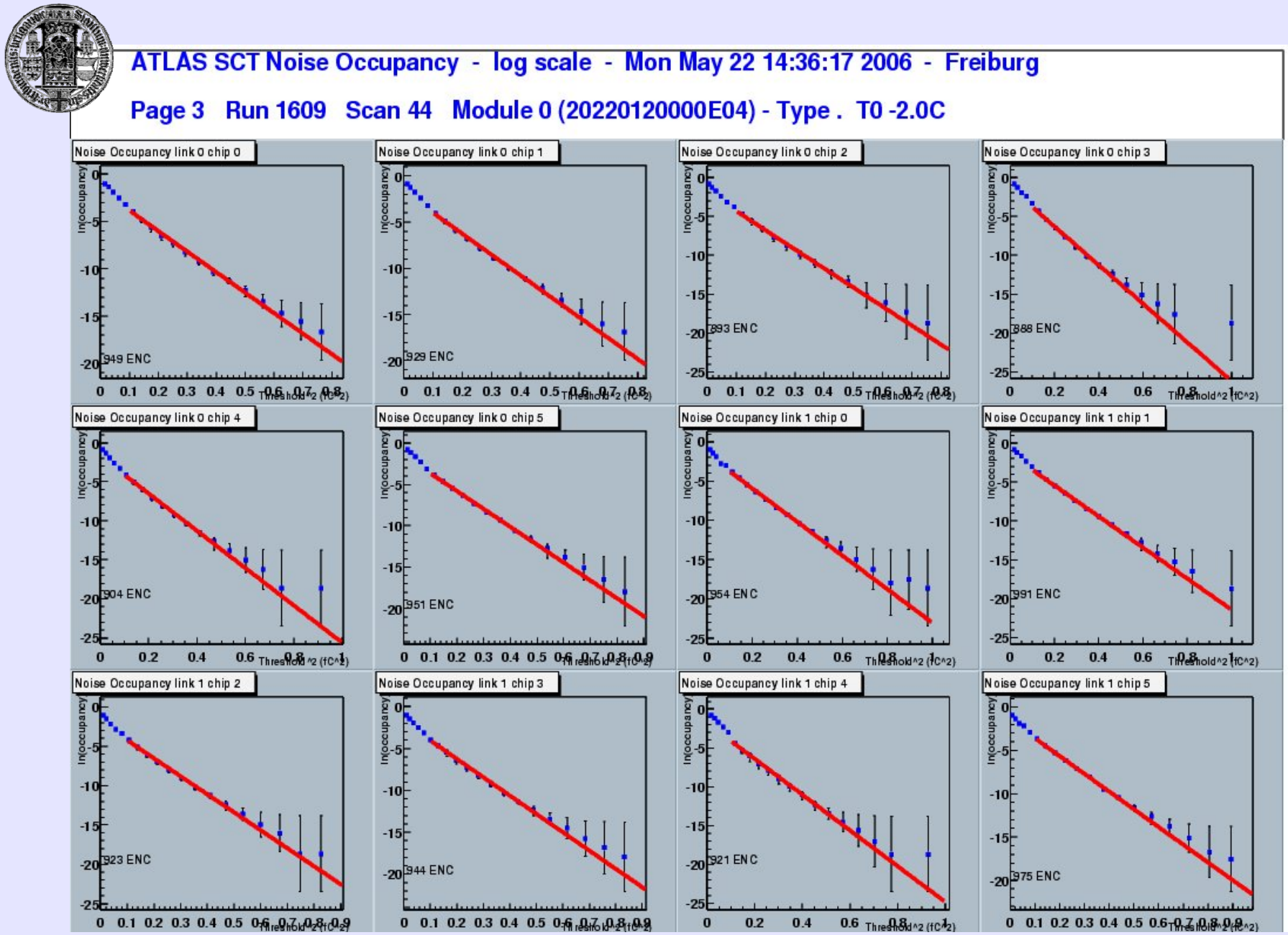


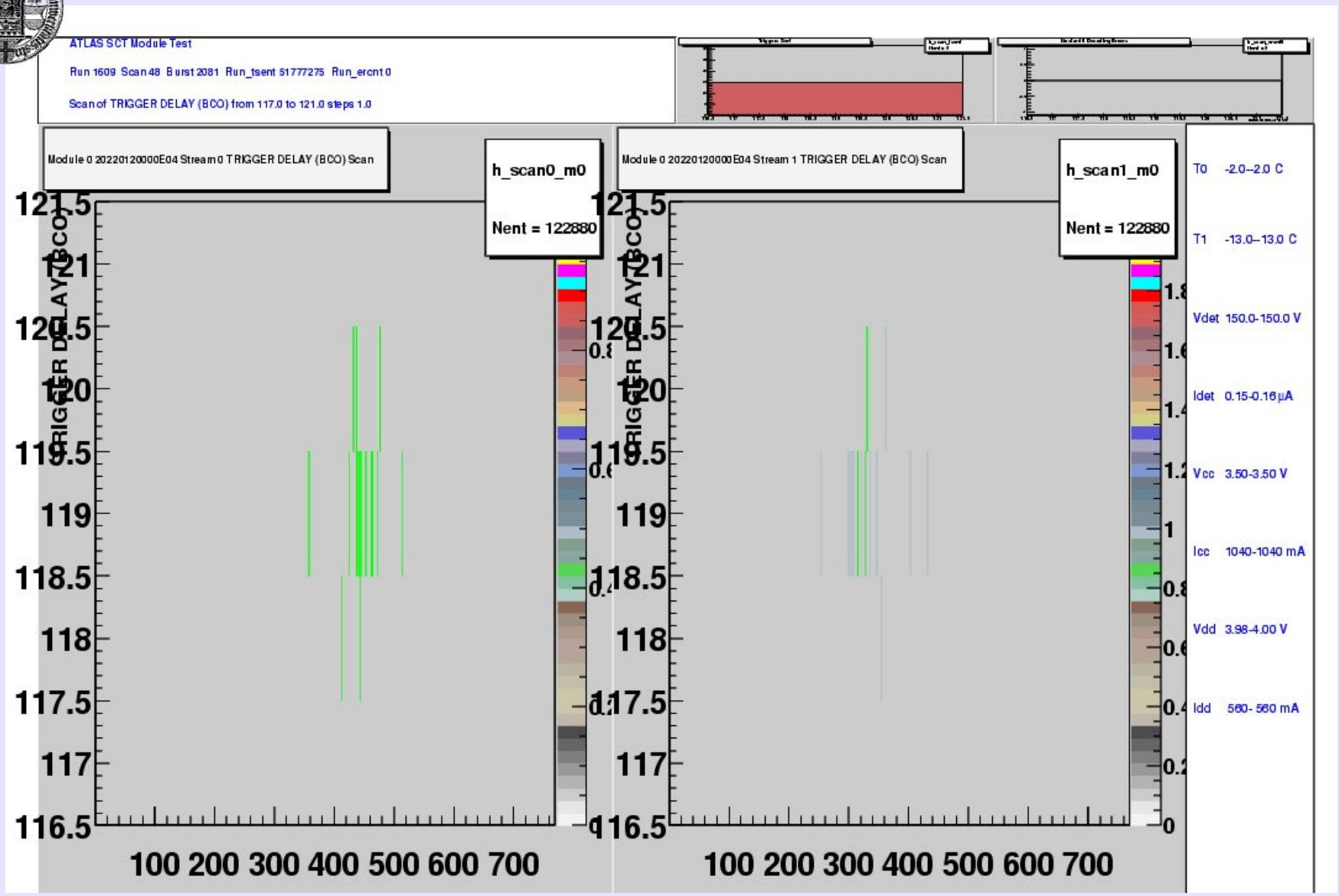
From Simon Eckert

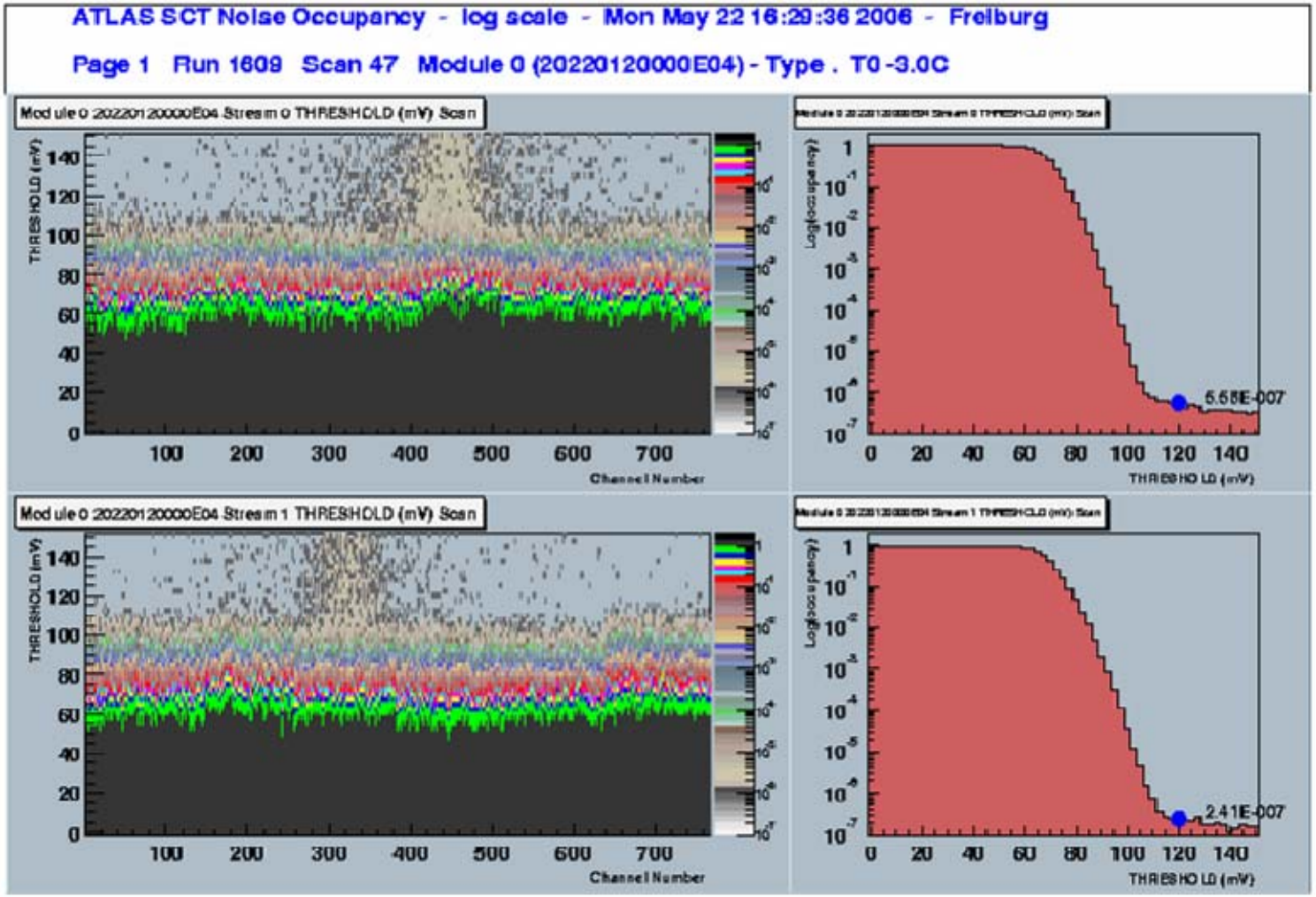

ATLAS SCT Noise Occupancy - log scale - Sat Jun 17 09:54:28 2006 - Freiburg
Page 3 Run 1700 Scan 16 Module 0 (20220120000E04) - Type . T0 -6.0C
Noise Occupancy link 0 chip 0
1019 ENC
Noise Occupancy link 0 chip 1
883 ENC
Noise Occupancy link 0 chip 2
834 ENC
Noise Occupancy link 0 chip 3
867 ENC
Noise Occupancy link 0 chip 4
895 ENC
Noise Occupancy link 0 chip 5
944 ENC
Noise Occupancy link 1 chip 0
914 ENC
Noise Occupancy link 1 chip 1
941 ENC
Noise Occupancy link 1 chip 2
1032 ENC
Noise Occupancy link 1 chip 3
880 ENC
Noise Occupancy link 1 chip 4
873 ENC
Noise Occupancy link 1 chip 5
926 ENC
ln(occupancy)
Threshold^2 (fC^2)

Beta source

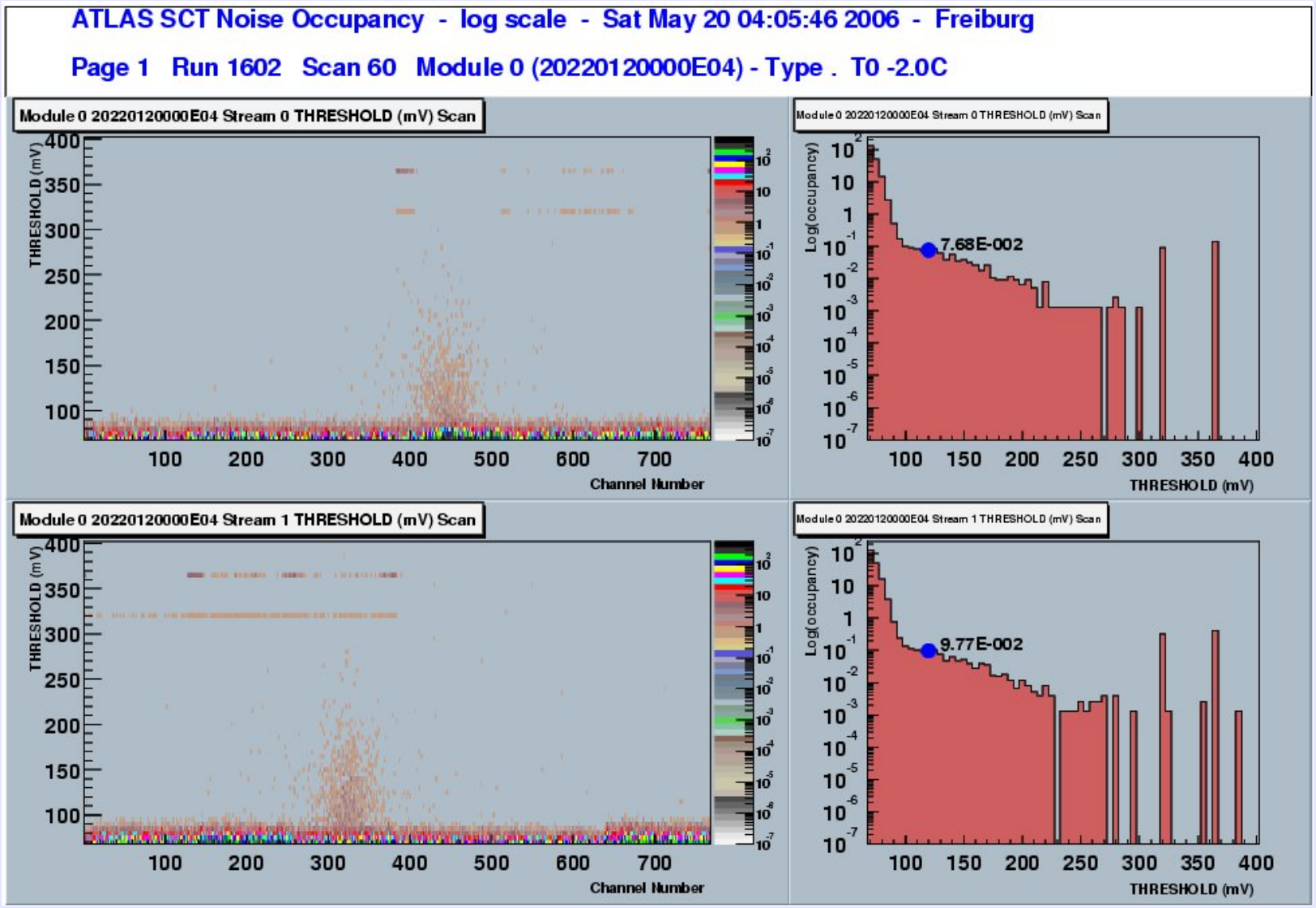

ATLAS SCT Noise Occupancy - log scale - Mon May 22 14:36:17 2006 - Freiburg
Page 1 Run 1609 Scan 44 Module 0 (20220120000E04) - Type . T0 -2.0C
Module 0 20220120000E04 Stream 0 THRESHOLD (mV) Scan
THRESHOLD (mV)
Channel Number
Module 0 20220120000E04 Stream 0 THRESHOLD (mV) Scan
Log(occupancy)
1.30E-009
THRESHOLD (mV)
Module 0 20220120000E04 Stream 1 THRESHOLD (mV) Scan
THRESHOLD (mV)
Channel Number
Module 0 20220120000E04 Stream 1 THRESHOLD (mV) Scan
Log(occupancy)
2.60E-009
THRESHOLD (mV)


ATLAS SCT Noise Occupancy - log scale - Mon May 22 14:36:17 2006 - Freiburg
Page 3 Run 1609 Scan 44 Module 0 (20220120000E04) - Type . T0 -2.0C
Noise Occupancy link 0 chip 0
949 ENC
Noise Occupancy link 0 chip 1
929 ENC
Noise Occupancy link 0 chip 2
893 ENC
Noise Occupancy link 0 chip 3
888 ENC
Noise Occupancy link 0 chip 4
904 ENC
Noise Occupancy link 0 chip 5
951 ENC
Noise Occupancy link 1 chip 0
954 ENC
Noise Occupancy link 1 chip 1
991 ENC
Noise Occupancy link 1 chip 2
923 ENC
Noise Occupancy link 1 chip 3
944 ENC
Noise Occupancy link 1 chip 4
921 ENC
Noise Occupancy link 1 chip 5
975 ENC
ln(occupancy)
Threshold^2 (fC^2)

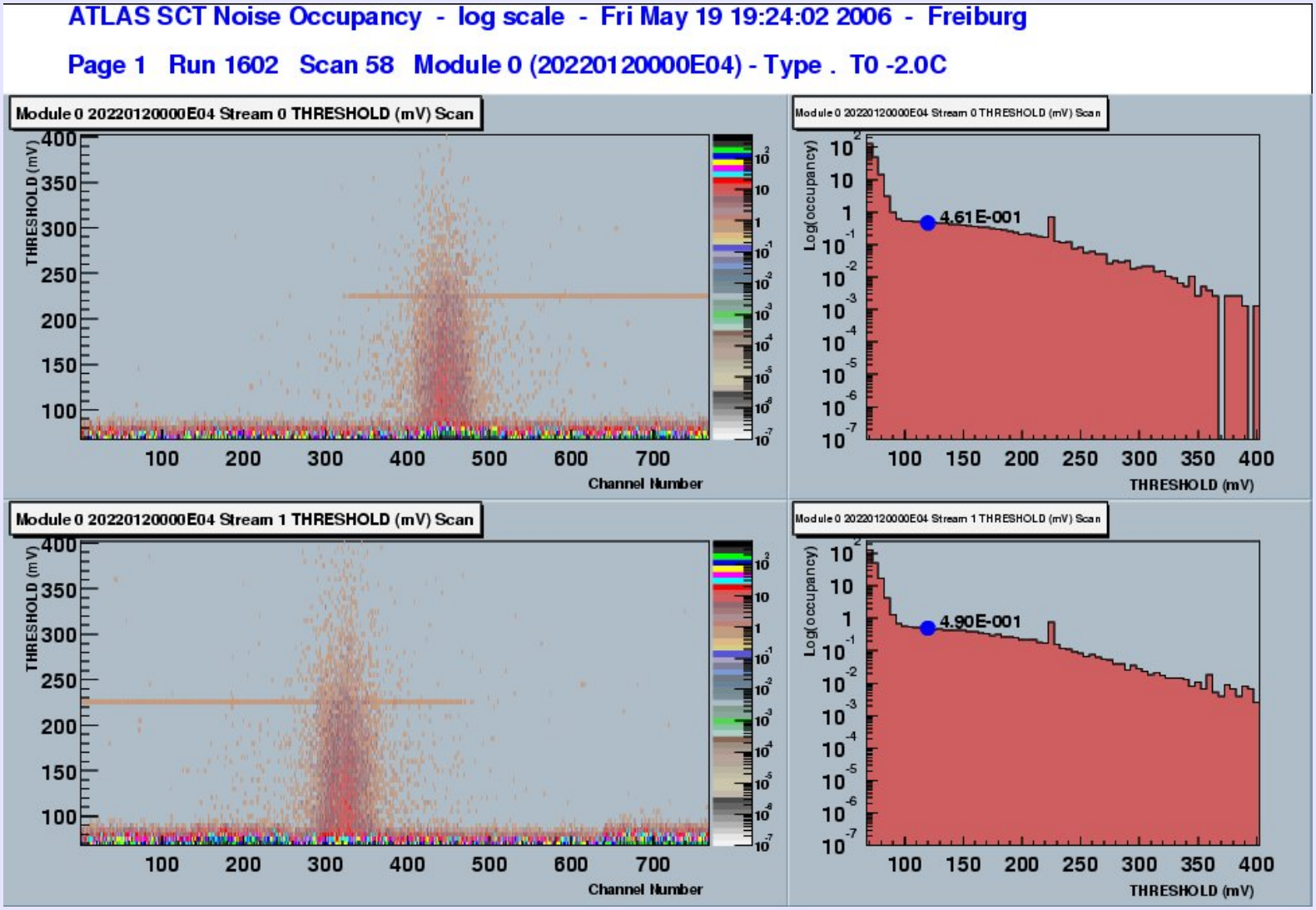

ATLAS SCT Module Test
Run 1609 Scan 48 Burst 2081 Run_tsent 51777275 Run_ercnt 0
Scan of TRIGGER DELAY (BCO) from 117.0 to 121.0 steps 1.0
Module 0 20220120000E04 Stream 0 TRIGGER DELAY (BCO) Scan
h_scan0_m0
Nent = 122880
Module 0 20220120000E04 Stream 1 TRIGGER DELAY (BCO) Scan
h_scan1_m0
Nent = 122880
TRIGGER DELAY (BCO)
121.5
121
120.5
120
119.5
119
118.5
118
117.5
117
116.5
100 200 300 400 500 600 700
T0 -2.0--2.0 C
T1 -13.0--13.0 C
Vdet 150.0-150.0 V
Idet 0.15-0.16 µA
Vcc 3.50-3.50 V
Icc 1040-1040 mA
Vdd 3.98-4.00 V
Idd 560- 560 mA


ATLAS SCT Noise Occupancy - log scale - Mon May 22 16:29:36 2006 - Freiburg
Page 1 Run 1609 Scan 47 Module 0 (20220120000E04) - Type . T0 -3.0C
Module 0 20220120000E04 Stream 0 THRESHOLD (mV) Scan
THRESHOLD (mV)
Channel Number
Occupancy
THRESHOLD (mV)
5.58E-007
Module 0 20220120000E04 Stream 1 THRESHOLD (mV) Scan
THRESHOLD (mV)
Channel Number
Occupancy
THRESHOLD (mV)
2.41E-007

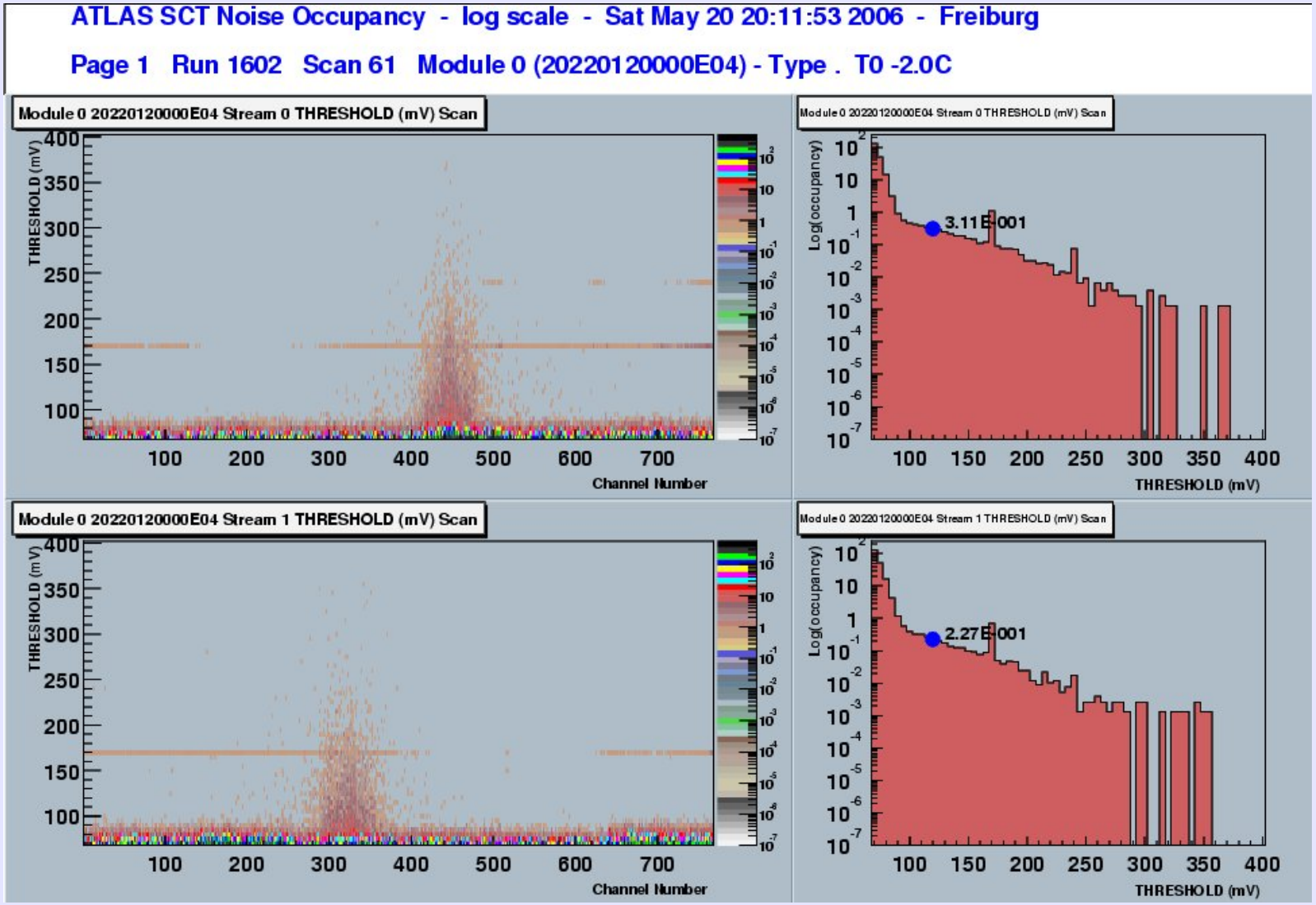
Noise occupancy BCO 118



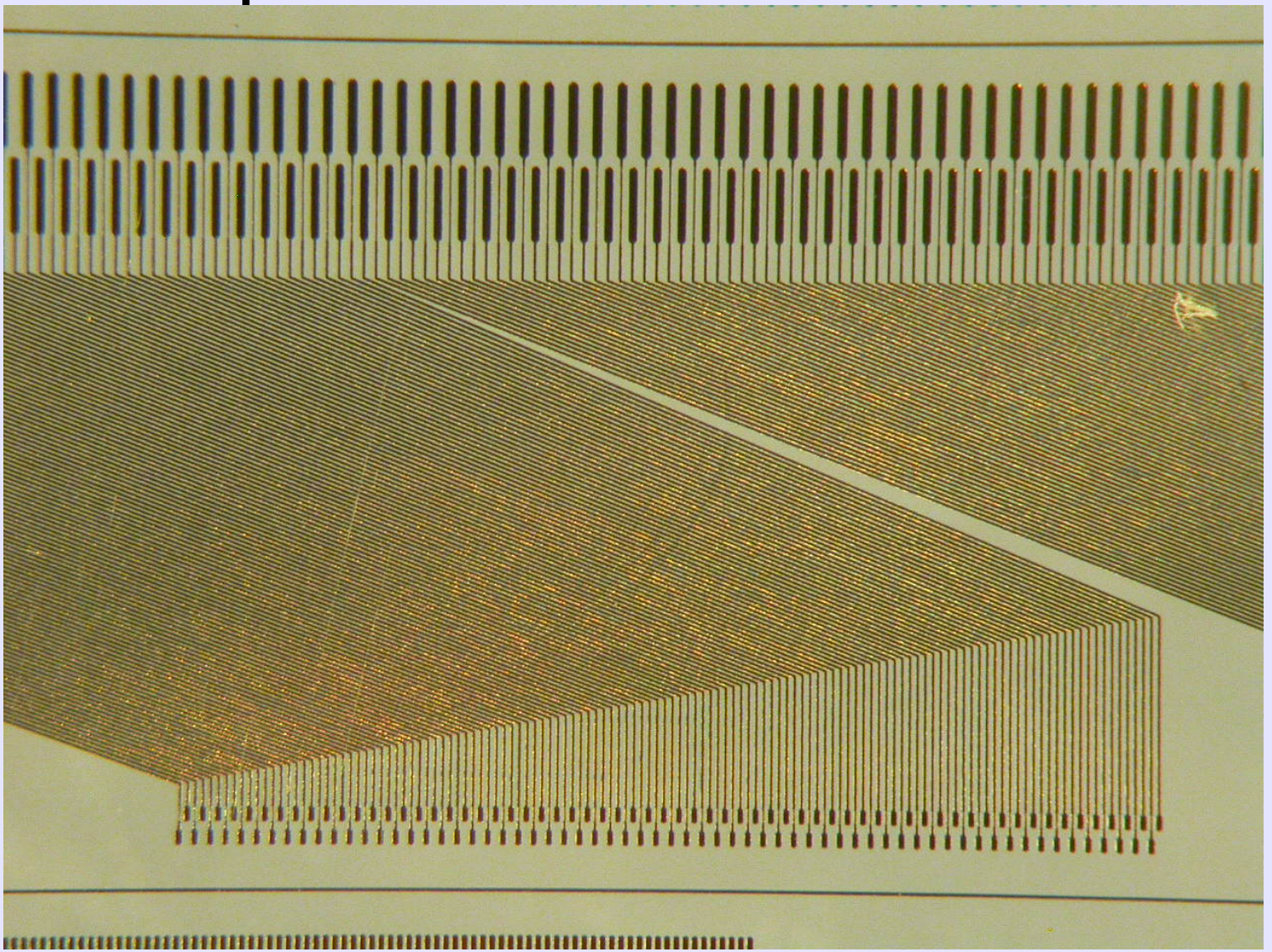
Noise occupancy BCO 119



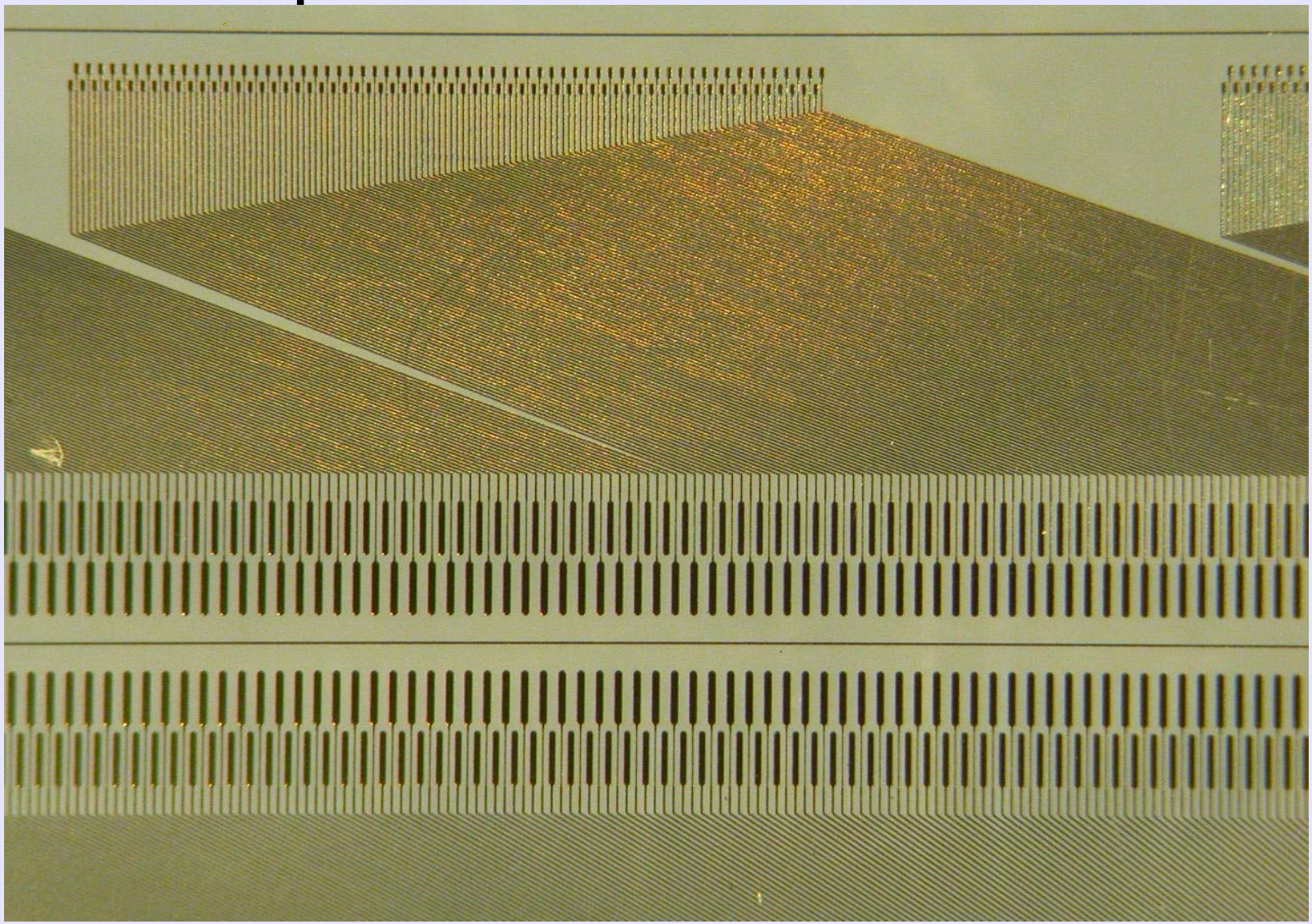
Noise occupancy BCO 120



Development of rebondable fan-ins



Development of rebondable fan-ins



Motivation

- LHC Upgrade

LHC: $800\,fb^{-1}$ $2\cdot10^{14}\,\frac{Neq}{cm^2}$, SLHC: $2500\,fb^{-1}$ $1\cdot10^{15}\,\frac{Neq}{cm^2}$

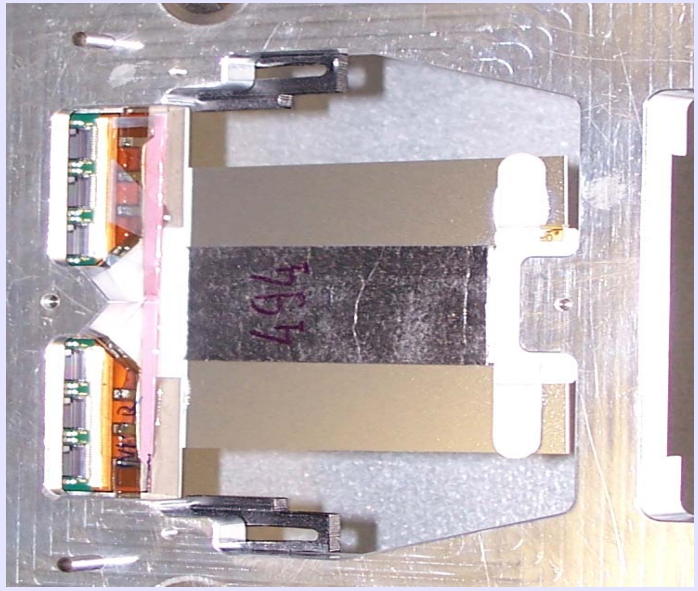
- Problem for semiconductor detectors:

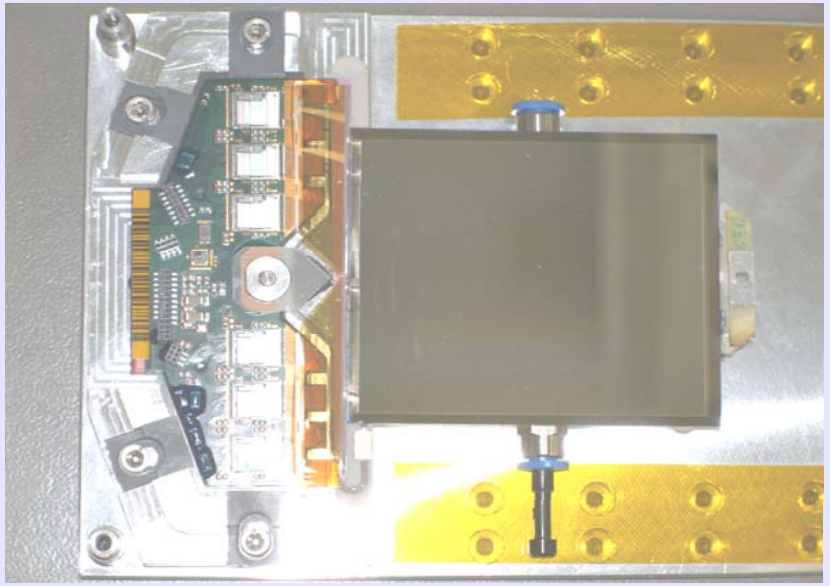
irradiation → defects: recombination /generation centers

  - Increase of leakage current,
  - Generation of charged centres changes effective doping concentration → type inversion: n-type material becomes p-type
  - Increase of depletion voltage
  - Centres act as trapping centres affecting the cce

Assembly of CZ modules

- CZ data: pitch = 50µm, size = 55x65mm^2, thickness = 380µm
- CZ with breakthrough at V_{bias}=140V (we have one more with $V_{bias} \approx V_{FD}$=400V)
- Fan-ins from middle SCT modules (pitch =92µm) and SCT hybrids used
- Extension of old SCT Spine for cooling, because $I_{irrad,leak}$ ~ mA





→ readout with SCT electronics and comparison with SCT modules possible

Irradiation of SCT modules in Karlsruhe

- irradiation of one CiS SCT-module and one Hamamatsu SCT-module in Karlsruhe (thanks to Alex Furgeri)
- 3 fluences: 0.86×10^{14} Neq, 1.02×10^{14} Neq, 2.8×10^{14} Neq on each sensor
- modules will be tested with the beta-source set-up and with the laser tester (done by Thies Ehrich)

  → comparison of different fluences on one sensor

  → comparison with 2 set-ups