Studies of radiation field impact of microstrip sensors for the CBM Silicon Tracking System

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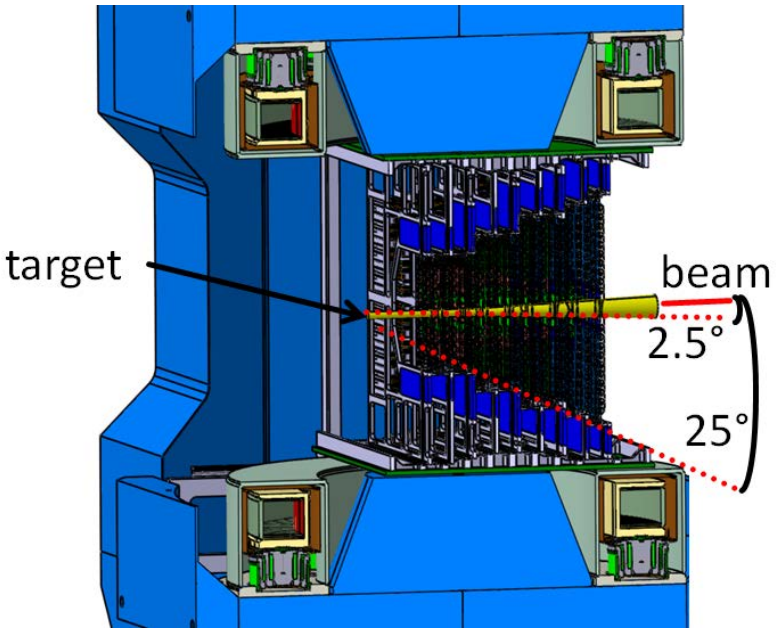
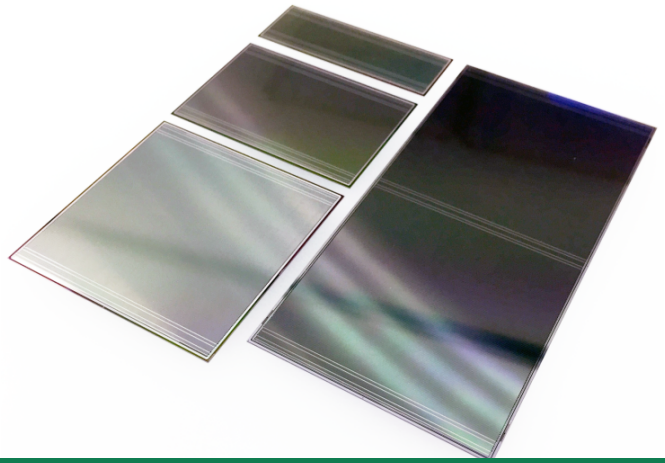
Silicon Tracking System @CBM experiment [Mon, 17:00 HK 9.2, O.Bertini]



- 8 tracking stations
- double-sided sensors, p-n-n structure
- sensors: 6×2, 6×4, 6×6, 6×12 cm^2
- 1024 strips per side (58 μm pitch)
- stereo angle on p side 7.5 deg
- radiation tolerance up to 1×10^{14} 1 MeV n_{eq}/cm^2
- S/N $\geq$ 10 for the hit reconstruction efficiency $\geq$ 98%

- Momentum resolution $\Delta p/p \sim 1.5$ %
- Hit spatial resolution $\sim$ 25 μm
- Material budget $\sim$ 1% X_0/station

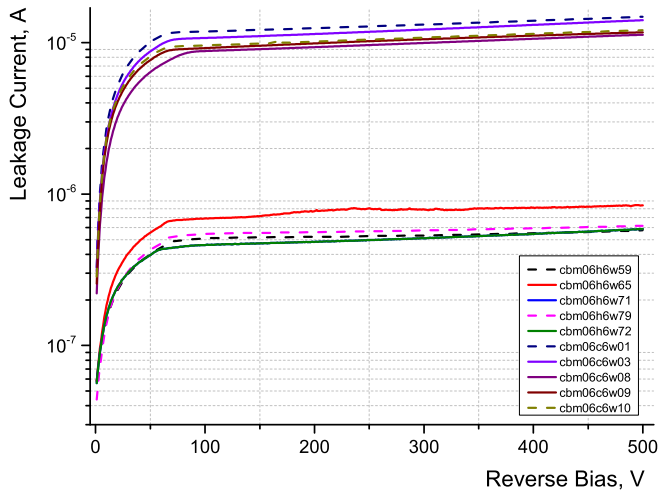


Irradiation Plan 2017

Fluence, 1 MeV n_{eq} / size	**6 × 6 cm^2**	**6 × 4 cm^2**	**6 × 2 cm^2**
2×10^{14}	2 × vendor	2 × vendor	1 × vendor
1×10^{14}	2 × vendor	1 × vendor	1 × vendor
5×10^{13}			1 × vendor
0 - reference sensor	1 × vendor	1 × vendor	1 × vendor
In total to study: 36 sensors			

- Electrical tests (IV, CV) has to be made for all of sensors.
- 6 × 6 cm^2 and 6 × 4 cm^2:
  - irradiated;
  - tested in the lab with β source for CCE.
- 6 × 2 cm^2:
  - to be inserted inside a new PCB and bonded;
  - has to be tested with radioactive source before and after irradiation.
- Some of sensors ($\geqslant 8$):
  - will be tested with the proton beam @COSY;
  - study degradation of detection efficiency with irradiation.

Sensors 6×6 cm^2 – selection before irradiation



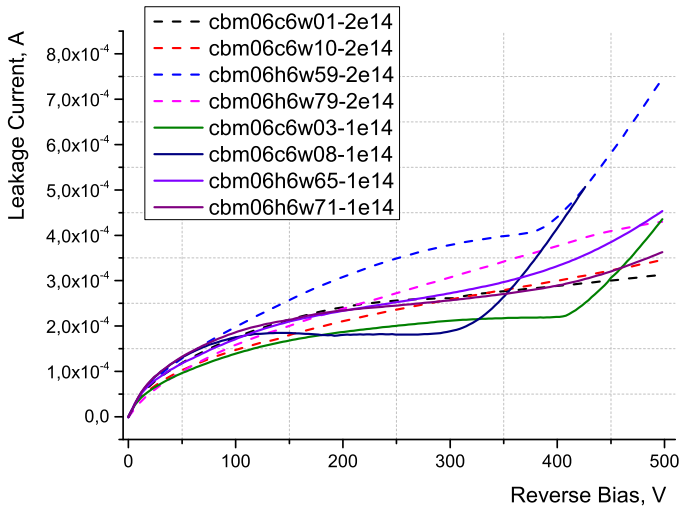
10 healthy sensors with breakdown at < 500 V were selected:

- CiS: w1, w3, w8, w9, w10;
- Hamamatsu: w59, w65, w71, w72, w79.

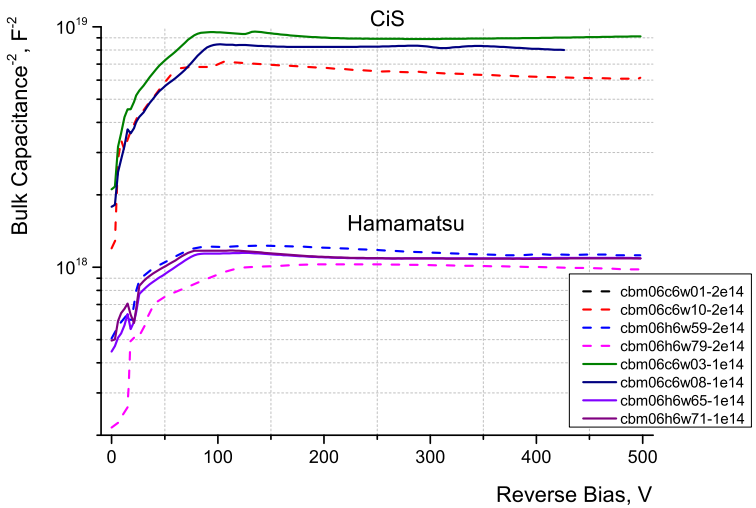
8 of them have been irradiated to doses 1×10^{14} & 2×10^{14} 1 MeV n_{eq}/cm^2, two used as a reference with 0 fluence.

Sensors 6×6 – after irradiation

Leakage current dependence on applied voltage.



Bulk capacitance as a function of reversed bias

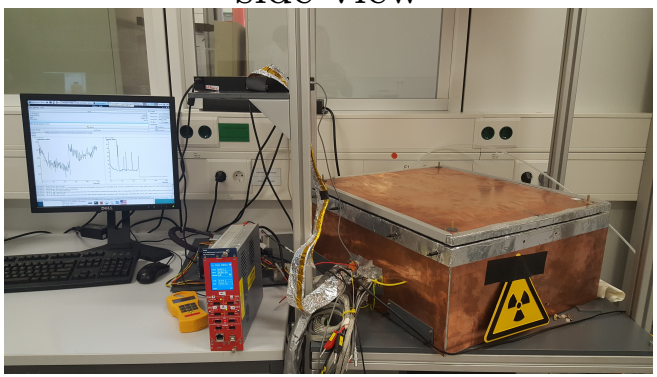


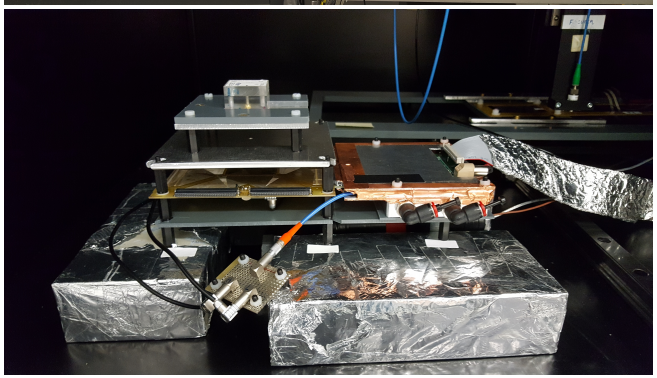
After irradiation:

- Leakage current increases by factor:
  - 500 for 10^{14} n_{eq}/cm^2;
  - 1000 for 2×10^{14} $_{eq}/cm^2$.
- Sensors kept constantly under cooled conditions:
  - to suppress current during measurement;
  - to avoid annealing during storage.

Set-up @STS lab

side view

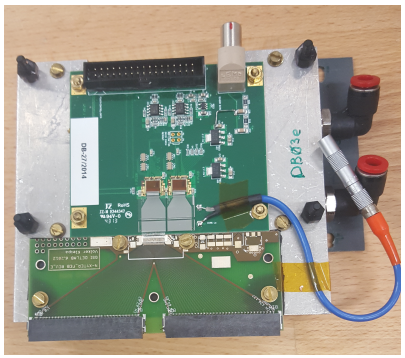


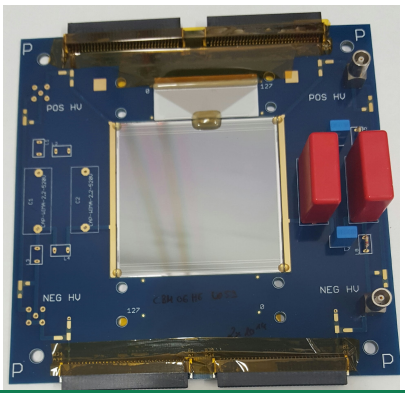


top view

Thermal enclosure:

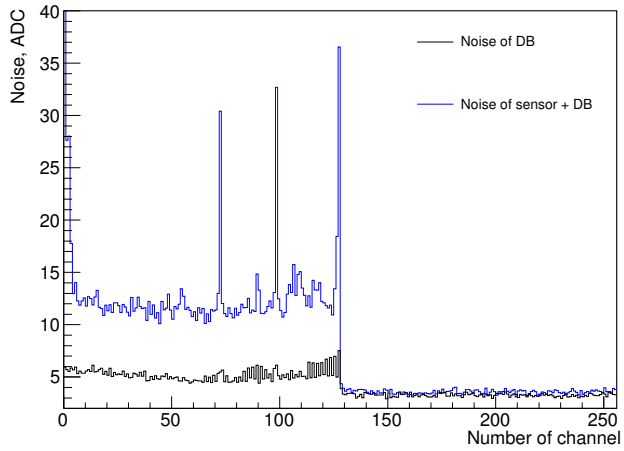
- cycle from +23°C to -11°C and back ∼ 2 h;
- cooling liquid: Ethylene Glycole +H_2O;
- 2 radiators; 6 fans.

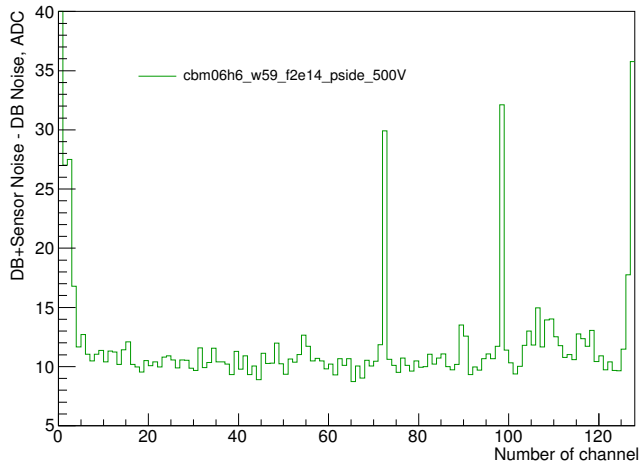




Source: ^{90}Sr (maximum e$^-$ energy 2.28 MeV)
Triggering and selection of MIPs: Scintillator (2.5 cm thick) + PM.

Noise





$$\mathrm{Noise}_{\mathrm{sensor}} = \sqrt{\mathrm{Noise}^2_{\mathrm{DB+sensor}} - \mathrm{Noise}^2_{\mathrm{DB}}}$$

Non-irradiated @ $\mathrm{U}_{\mathrm{bias}}$=150V

	p-side, ADC	n-side, ADC
cbm06c6 w09	8.78 ± 0.15	10.58 ± 0.17
cbm06h6 w72	9.11 ± 0.16	10.45 ± 0.22

Irradiated to 1×10^{14} n_{eq}/cm^2 @ $\mathrm{U}_{\mathrm{bias}}$=300V

cbm06h6 w65	12.28 ± 0.48	11.94 ± 0.22
cbm06h6 w71	11.73 ± 0.25	13.5 ± 0.26
cbm06c6 w03	11.71 ± 0.11	–
cbm06c6 w08	11.71 ± 0.25	9.77 ± 0.25

Irradiated to 2×10^{14} n_{eq}/cm^2 @ $\mathrm{U}_{\mathrm{bias}}$=500V

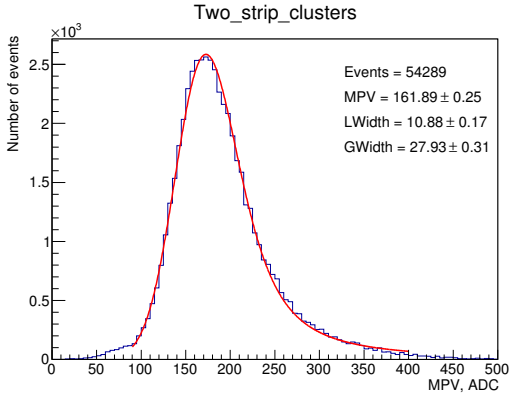
cbm06c6 w01	10.87 ± 0.10	10.29 ± 0.49
cbm06c6 w10	–	9.67 ± 0.08
cbm06h6 w59	10.5 ± 0.10	11.36 ± 0.10
cbm06h6 w79	to be bonded	

Sensors 6×6 cm^2 – after irradiation. Preliminary result.

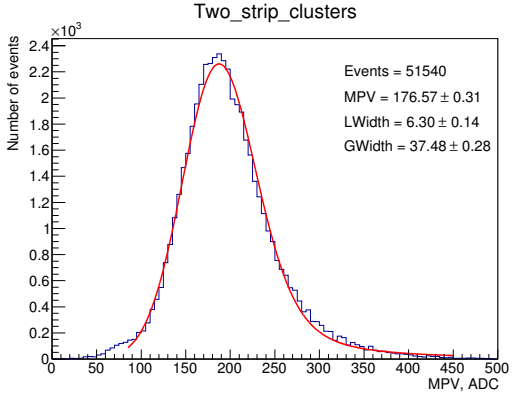
Example: spectra of 2 strip cluster.
Assume, our noise is uniform: $S/N_{cluster} = S/(\sqrt{2} \times N)$

f = 0

cbm06c6 w09, S/N ∼ 14.3

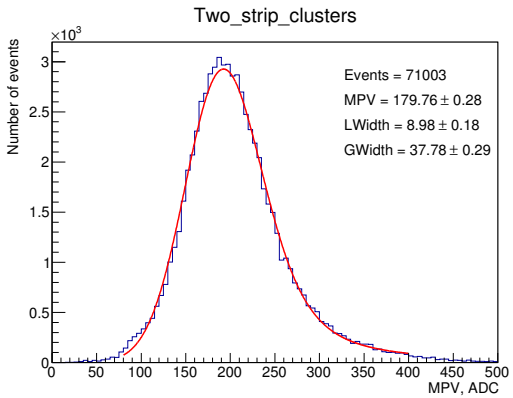


cbm06h6 w72, S/N ∼ 13.8

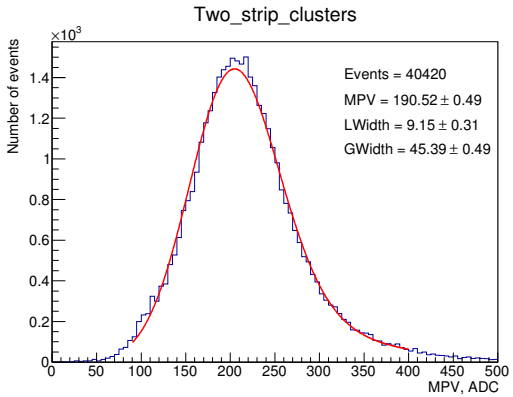


f = 1×10^{14} n$_{eq}$/cm^2

cbm06c6 w08, S/N ∼ 10.9

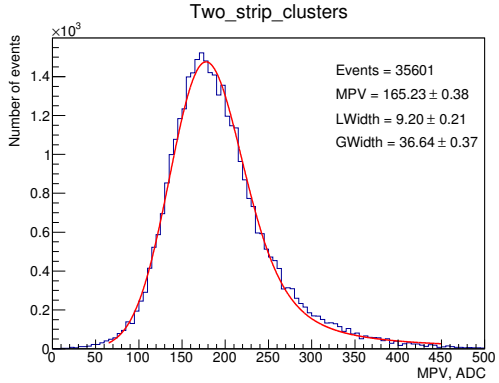


cbm06h6 w71, S/N ∼ 11.

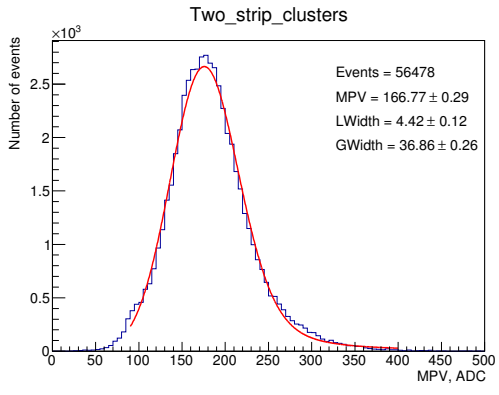


f = 2×10^{14} n$_{eq}$/cm^2

cbm06c6 w01, S/N ∼ 10.8



cbm06h6 w59, S/N ∼ 11.3



Conclusion/Outlook

Conclusion:

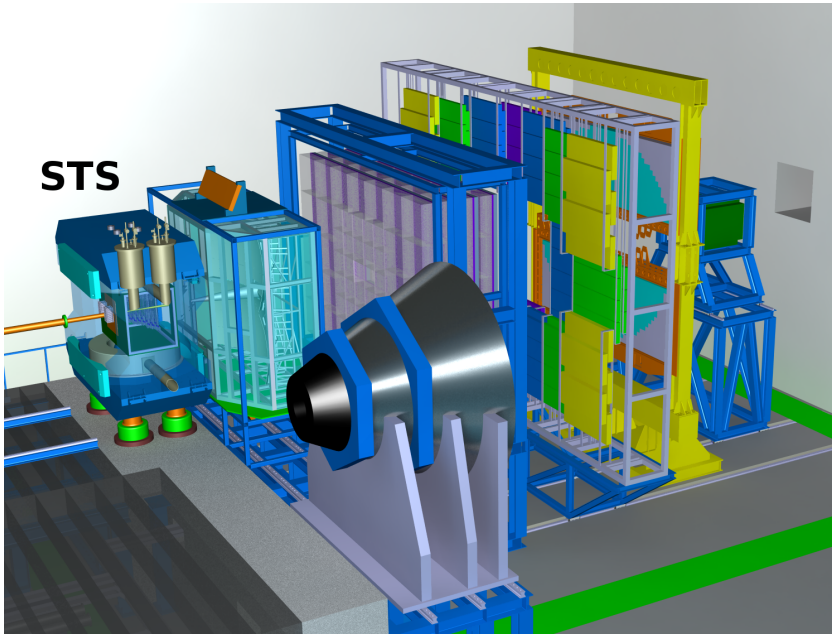
- 6×6 cm^2 sensors:
  - have been already irradiated and tested for IV, CV;
  - charge collection efficiency studies are in progress.
- 6×4 cm^2 sensors:
  - ready for the next irradiation.
- 6×2 cm^2 sensors:
  - have to be fully measured before irradiation and then irradiated.

Outlook:

To understand S/N of system:

- modules need to be tested;
- CCE & noise component to be finished;
- final read out chain based on STS XYTER to be used.

The CBM experiment [Wed, 16:45 HK 30.1 J.Lehnert]



Goal:
To study the QCD phase diagram at high net baryon densities and moderate temperatures

SIS100 collision energies 2÷11 A GeV

physics program @SIS100:

- Strangeness;
- Lepton pairs;
- Collective flow, correlations and fluctuations;
- Hypernuclei and hypermatter;
- Charm-anticharm quark pairs.