QA tests of the CBM Silicon Tracking System sensors with an infrared laser

Maksym Teklishyn **for the CBM Collaboration**

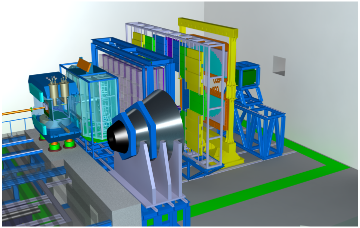
FAIR, Darmstadt; KINR, Kyiv

March 14, 2016

Introduction

Silicon Tracker System design:

- Detector acceptance
  - rapidities from centre-of-mass to beampipe
  - angular coverage $2.5^\circ < \Theta < 25.0^\circ$
- Low mass large area detector
  - readout electronics away from the acceptance
  - double sided 300 μm thick silicon sensors (8 stations)
  - material budget $\simeq 1\% X_0$/station
  - low scattering, high momentum resolution
  - track matching in MVD and RICH/MUCH

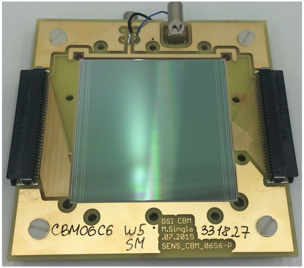


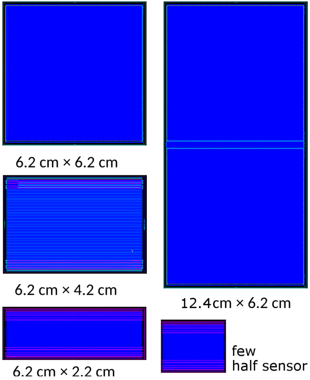
- $\Delta p/p \simeq 1.5\%$
- up to $\simeq 25\,\mu\text{m}$ single hit resolution

- To fulfil requirements above — well understanding of our sensors is needed
- See A. Lymanets, Mo HK15 talk for more details

Microstrip sensor prototypes

- Double-sided n-type silicon sensors
  - $58\,\mu m$ pitch
  - 1024 strips per sensor
  - AC-coupling, aluminium strips
  - 7.5° stereo angle for p-side (suppression of the ghost track rate)
- Sensor inside a sandwich PCB frame:



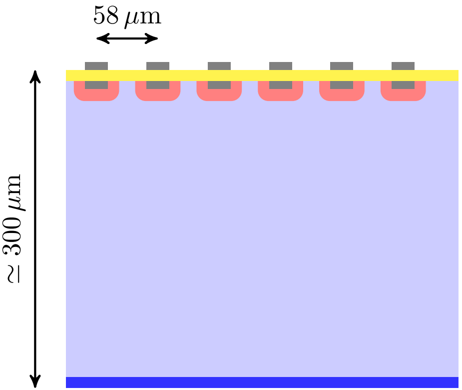


- radiation tolerance up to $10^{14}\,\mathrm{n_{eq}/cm^2}$
- signal transfer to r/o electronics by microcable (polyimide $10\,\mu m$, aluminium $14\,\mu m$ thick)

Charge collection in the sensor medium

interaction with MIP

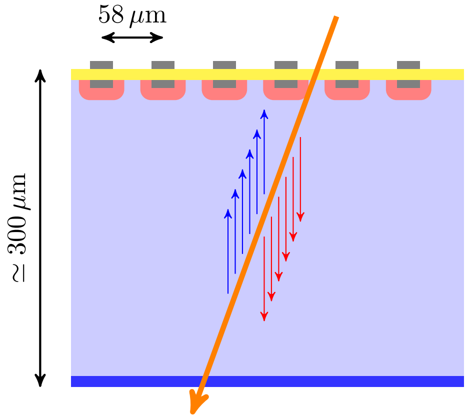
- MIP (Minimum Ionising Particle) penetrates silicon sensor
- Deposited charge drifts along $\vec{E}$ field to the electrodes



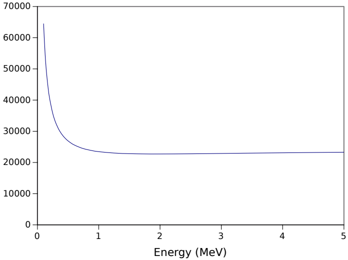
Charge collection in the sensor medium

interaction with MIP

- MIP (Minimum Ionising Particle) penetrates silicon sensor
- Deposited charge drifts along $\vec{E}$ field to the electrodes



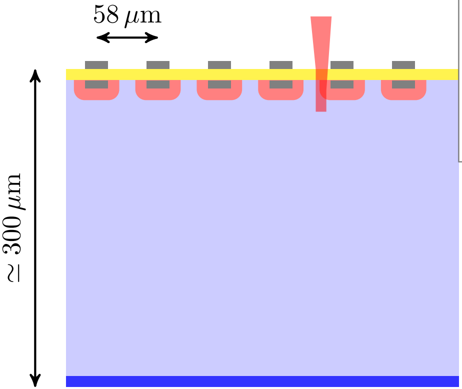
- $\Delta E = 3.79 \pm 0.01\,\text{eV}$ per one e-h pair got from
  - [C. Bussolati *et al.* Phys. Rev. 136, A1756]
- Δ_p is found for 300 μm silicon
- $\Delta_p \simeq 23 \times 10^3$
- this value depends on many input parameters

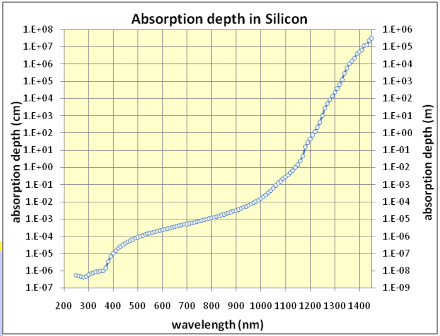


Charge collection in the sensor medium

interaction with (infra)red laser

- (Infra)red laser can be used to mimic MIPs
- Deposited charge drifts along $\vec{E}$ field to the electrodes



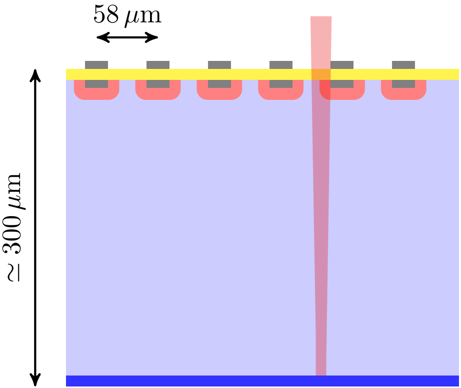


- Silicon absorption depth [Green MA, Keevers MJ. 1995;3:189 - 192.]:
  - red light $(660\,\mathrm{nm})$ $4\,\mu\mathrm{m}$
  - infrared light $(1060\,\mathrm{nm})$ $901\,\mu\mathrm{m}$

Charge collection in the sensor medium

interaction with (infra)red laser

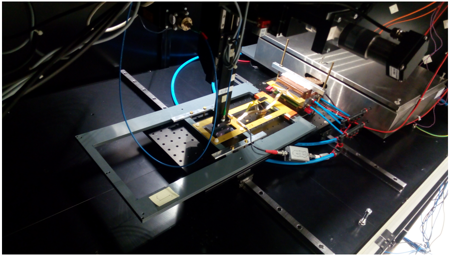
- (Infra)red laser can be used to mimic MIPs
- Deposited charge drifts along $\vec{E}$ field to the electrodes

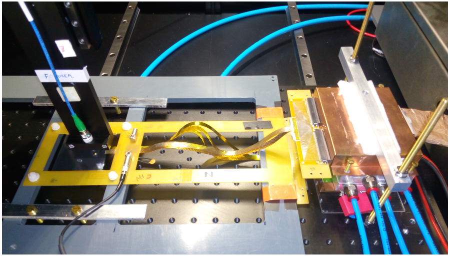


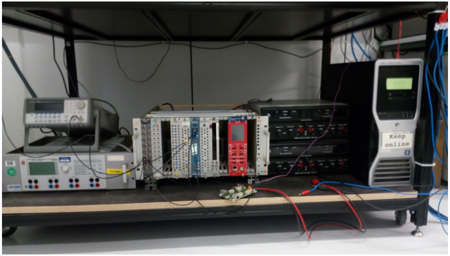
- Laser:
  - infrared $1060\,$nm
  - triggered by external puls generator
- Focuser:
  - focusing distance $10 \pm 1\,$mm
  - beam size $12 \pm 2\,\mu$m
- Step motor
  - controlled by EPICS
  - positioning precision $\simeq 1\,\mu$m
- Data acquisition
  - DABC over optical channel (ver. 2012)
  - GO4 online monitoring

Laser test stand

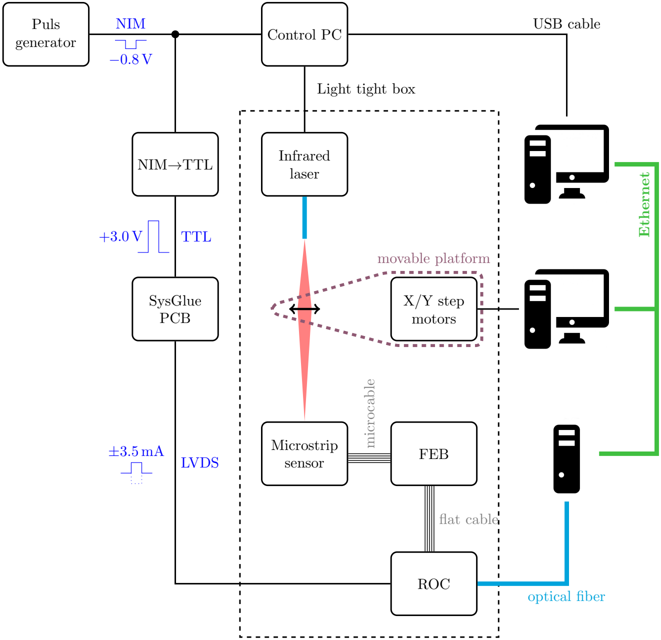
- Constructed for studies of the sensor properties with a laser
- Sensor + readout + laser in a light tight box
- Readout controllers additionally shielded







Laser test stand scheme

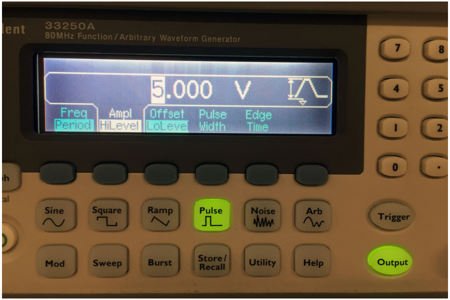


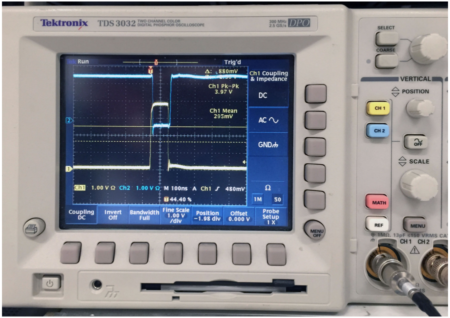
- **Windows machine**
- Laser control soft
  - amplitude
  - internal pulse gen.
- EPICS GUI
  - movement along the pattern

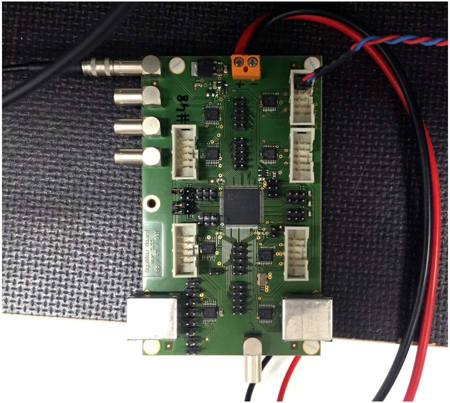
- **Linux machine**
- EPICS core (motor run)

- **Linux machine** (controlled via ssh)
- DAQ run
- DABC+EPICS stream combining

External triggering system

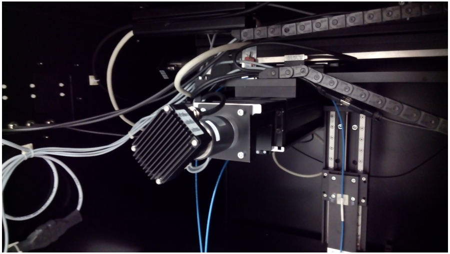


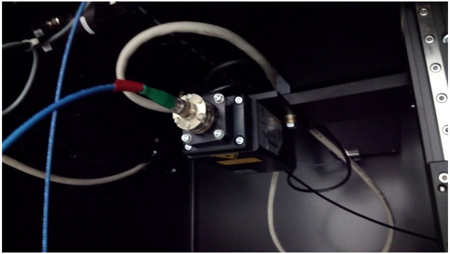


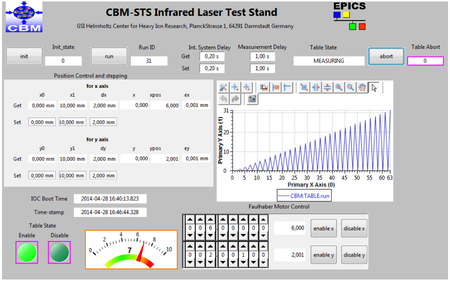


1. NIM signal is generated $(-0.8\,\mathrm{V})$
2. signal to Laser control PC
3. converted to TTL signal $(+3\,\mathrm{V})$
4. TTL → LVDS (current signal) → Read-out controller

Positioning system

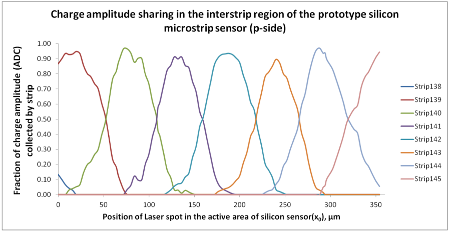




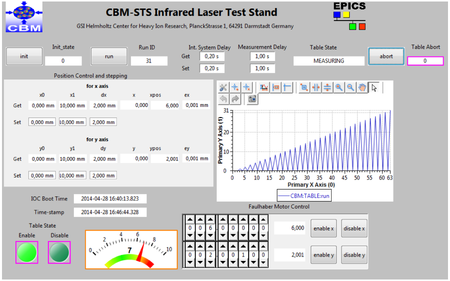


- Automated X/Y positioning
- Accuracy up to 1 μm
- Scanning along predefined pattern with EPICs based software
- Vertiacal positioning is manual

Online monitor and data processing



[Pradep Ghosh PhD thesis]



- Charge sharing between neighbouring strips
- Focusing is complicated with manual z-positioning
- External trigger forces to r/o all 128 channels per pulse

Conclusions and outlook

- Infrared laser is a good tool to test silicon sensor prototypes
- Red laser may be used for cross-check/surface effect studies
- Laser test stand is ready for operation
- Application of the external triggering allows go deep below the noise

Things we still missing:

- Motorised z-positioning for the focusing purposes
- Online feed-back from data stream for the pattern correction:
  - misalignment correction
  - automatic focusing
- Remote control for hardware components: bias voltage, pulse generator...
- Automatise the procedure **for the QA during the mass producrion**