Automated assembly of large double-sided microstrip detectors for the CBM Silicon Tracking System at FAIR

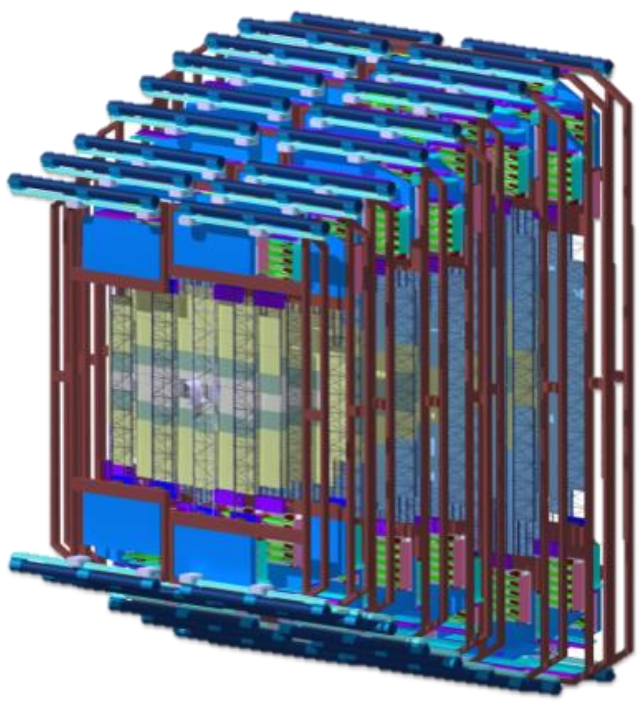
Patrick Pfistner, for the CBM collaboration

Contact: Patrick.pfistner@kit.edu

- **CBM** will be one of the major scientific pillars of the future **FAIR** facility
- Investigation of QCD phase diagram at highest baryon densities

Silicon Tracking System (STS)

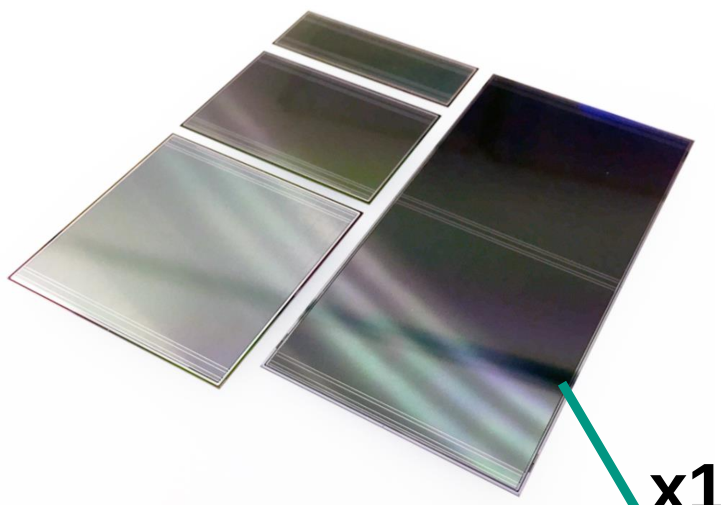
- One of the core detectors of CBM located inside the dipole magnet [1]
- Track reconstruction and momentum determination of charged particles
- Track mult. $\leq$ 700 per central Au+Au collision in aperture $2.5° < \theta < 25°$
- Momentum resolution $\Delta p/p$ < 2%
- Lifetime fluence up to $1 \times 10^{14} n_{eq}$ in innermost region

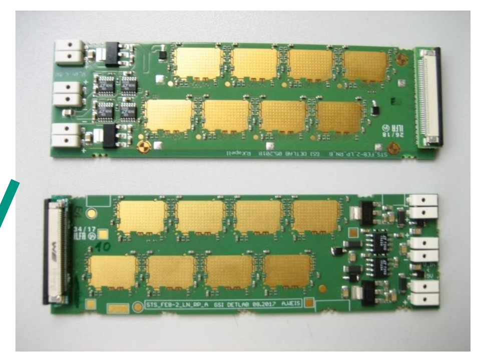


STS conception

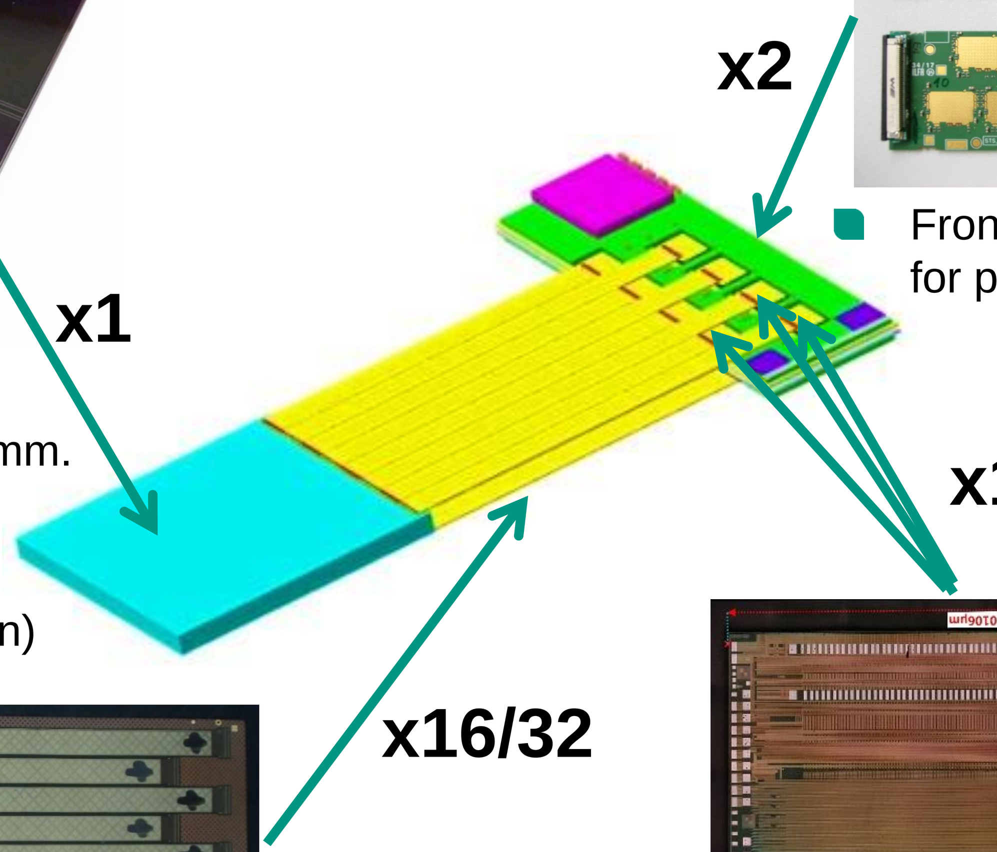
- Eight tracking stations 0.3 m to 1 m downstream of the target
- 896 detector modules arranged in 106 ladders of 23 variations
- Readout electronics located in the periphery
- Module structure is rather complex

STS detector module



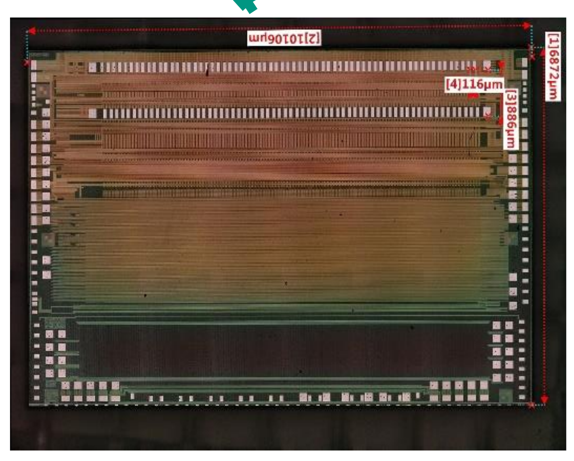


- Front-End Board-8 for p and n-side



- Four main sensor sizes: 62 mm x 22, 42, 62, 124 mm.
- Sensor thickness: 300 µm
- Strip pitch: 58 µm
- 2 x 1024 channels (p and n)

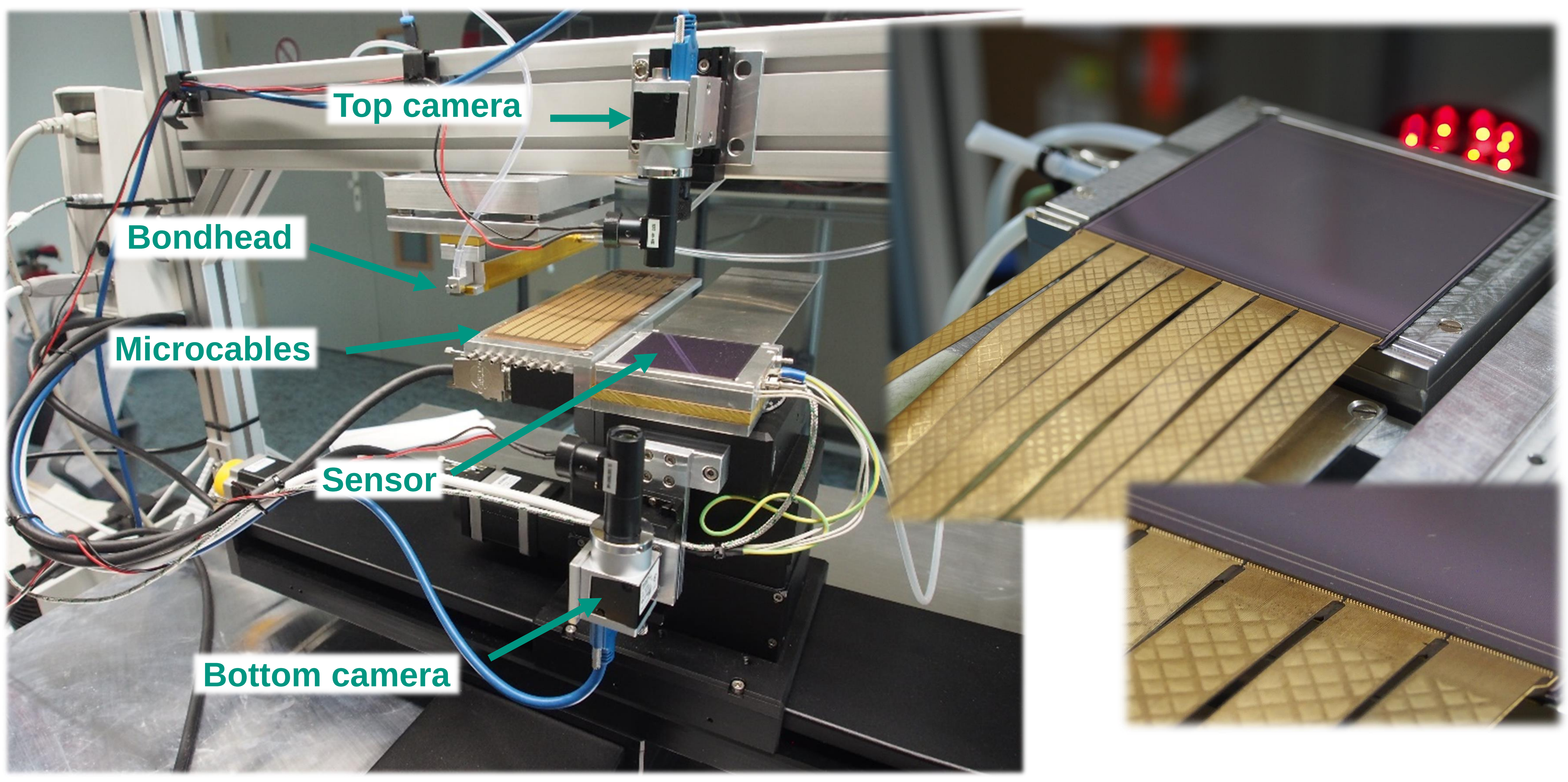
- Low-mass microcables with a length up to 50 cm for innermost modules



- STS-XYTER ASIC [2]

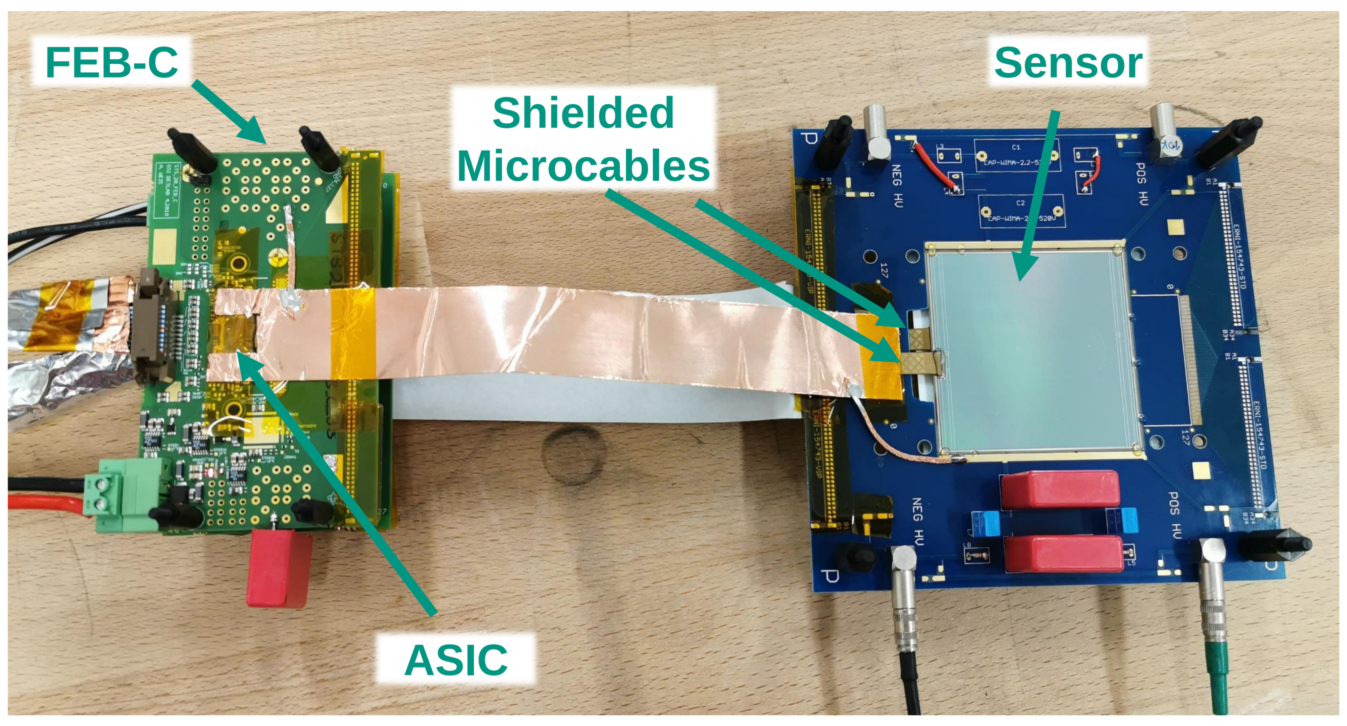
Automated bonder machine developed at KIT

- Complementing the established Al TAB bonding interconnection technology based on an aluminum microcable, a novel high-density interconnection technology based on a gold stud – solder paste flip chip process and a copper microcable has been developed at KIT [3]. To fully exploit its automation capabilities, an in-house bonder machine has been developed in parallel.
- **Cable bonder characteristics**
  - Four stepper motors in x, y, z, phi with sub-micron step resolution to achieve alignment accuracy $\leq$ 8 µm
  - Dual-camera system including calibration mechanism for precise alignment of microcable and sensor
  - Specialized mechanics for the handling of STS module components
  - Valve island for automated pneumatic control
  - Heatable bondhead and sensor plate with automated temperature control
  - Pressurized air cooling



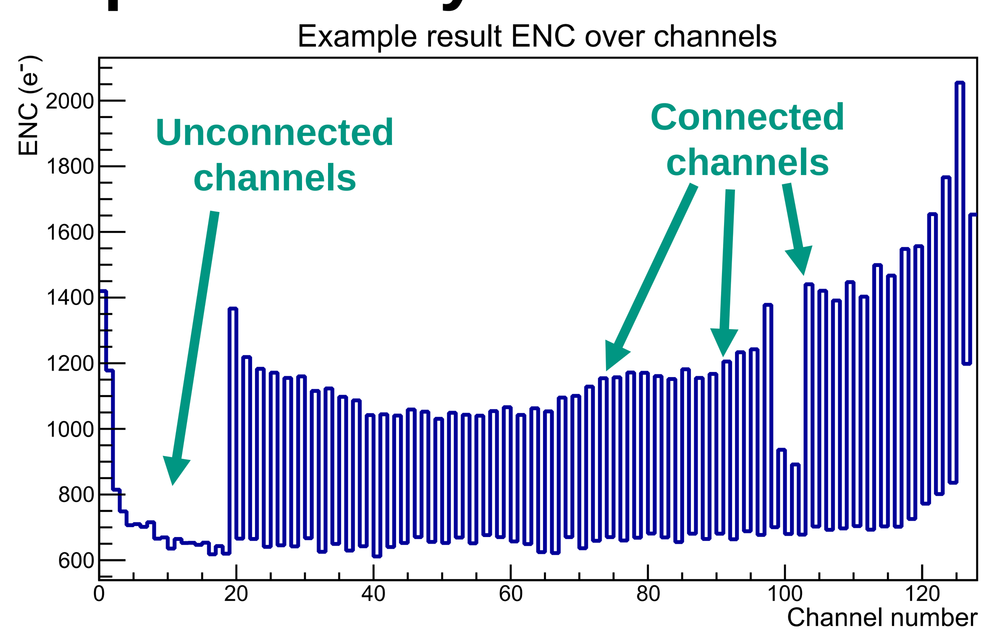
Test setup

- $6.2 \times 6.2\ cm^2$ double-sided sensor biased at $\pm$150 V
- One copper microcable for n-side and p-side
- Two Front-End Boards type C (FEB-C), each hosting one STS-XYTER readout ASIC
- Readout via AFCK board hosting Kintex7 FPGA controlled by IPbus
- Full noise analysis performed inside aluminum shielding box with the help of STS-XYTERs internal test pulsing capability



Noise analysis: preliminary results

- ENC analysis is essential for the QA of detector modules during R&D as well as production
  - Identification of possible bad connections on sensor or ASIC side
  - Comparison between interconnection technologies
  - Influence of different cable and sensor sizes
  - Optimization of shielding and grounding



- Expected ENC

$$460\ e^-(ASIC) + \left(0.44\ \frac{pF}{cm} * \ 20\ cm\ (cable) + 1.52\frac{pF}{cm} * 6.02\ cm\ (sensor)\right) * 27.4\frac{e^-}{pF} = 952\ e^-$$

- Measured ENC for connected channels
  - P-side: $1000 \pm 80\ e^-$
  - N-side: $1100 \pm 80\ e^-$
- Preliminary results are comparable to aluminum TAB bonding technology.

References:

[1] The CBM collaboration,*Technical Design Report for the CBM STS*, Darmstadt, 2013

[2] K. Kasinski et al., *Characterization of the STS/MUCH-XYTER2, a 128-channel time and amplitude measurement IC for gas and silicon microstrip sensors*, NIM A, **Vol. 30 Issue 9 (**2018)

[3] P. Pfistner et al., *Novel production method for large double-sided microstrip detectors of the CBM Silicon Tracking System at FAIR*, PoS(TWEPP2018)144 (2018)