Development and characterization of high-density interconnection technologies for the CBM Silicon Tracking System at FAIR

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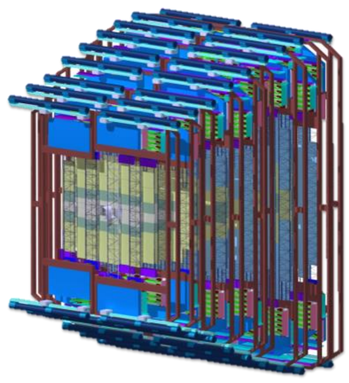
CBM experiment at FAIR

Compressed Baryonic Matter

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

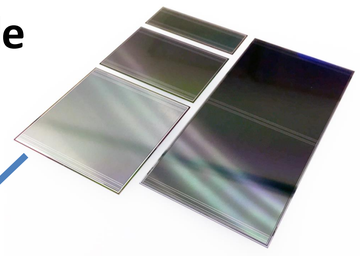


STS conception

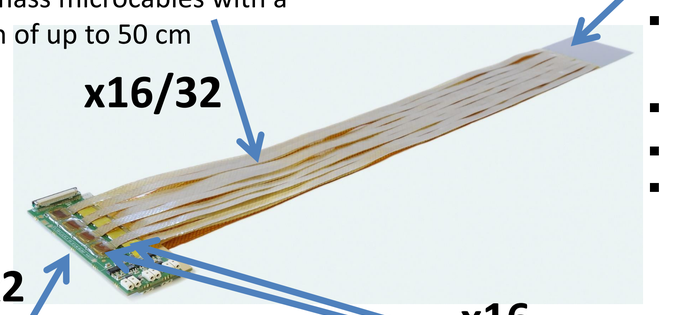
- Eight tracking stations 0.3 m to 1 m downstream of the target
- 896 detector modules arranged in 106 ladders of 23 variations
- Readout electronics in periphery
- Complex module structure

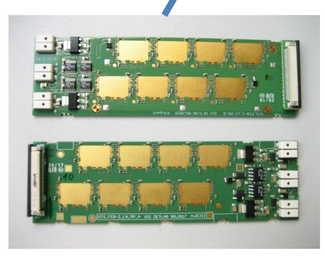
STS detector module

- Low-mass microcables with a length of up to 50 cm

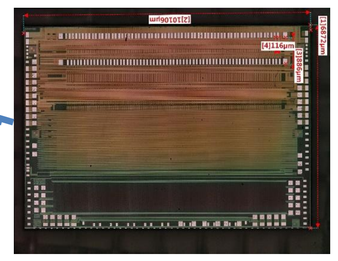


- Four main sensor sizes: 62 mm x 22, 42, 62, 124 mm
- Sensor thickness: 300 µm
- Strip pitch: 58 µm
- 2 x 1024 channels (p and n)





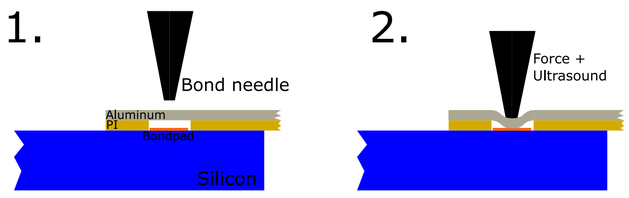
- Front-End Board-8 for p and n-side

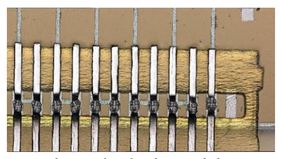


- STS-XYTER ASIC [2]

Microcable and interconnection technologies

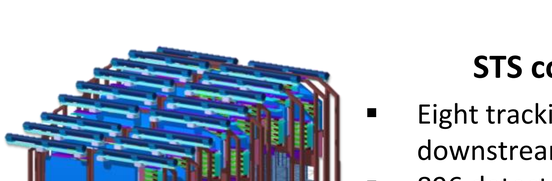
Aluminum microcable: TAB bonding [3]

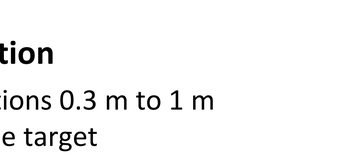


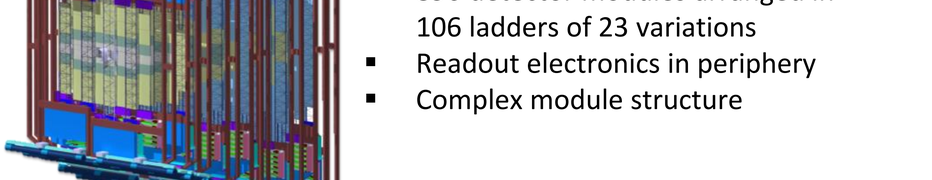


TAB-bonded alu cable

Copper microcable: gold bump – solder flip-chip bonding [3,4]







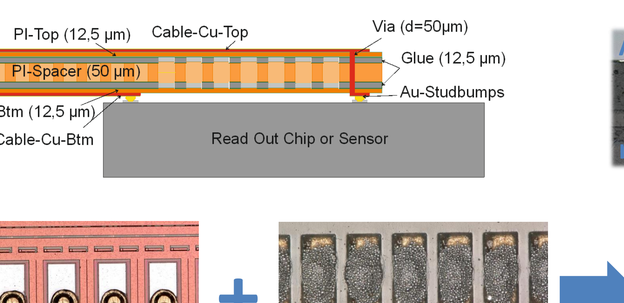
Cable technology	Alu	Copper
# of channels	64	128
stiffness	Low	High
Capacity (pF/cm)	0.346	0.384
X/X_0 of cable stack (%)	0.091	0.129

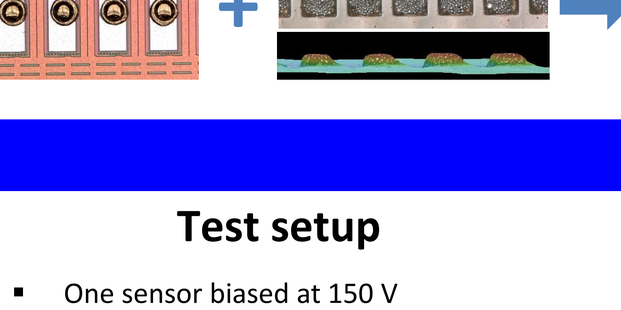
Material budget simulation for full STS geometry

- Both technologies within specification of X/X_0 < 1% per station
- Copper technology better suited for more peripheral modules

Test setup

- One sensor biased at 150 V
- 2 x alu/copper microcable for n- and p-side
- 2 x FEB-C hosting one STS-XYTER v2.0 each
- Readout via AFCK hosting Kintex7 FPGA and IPbus



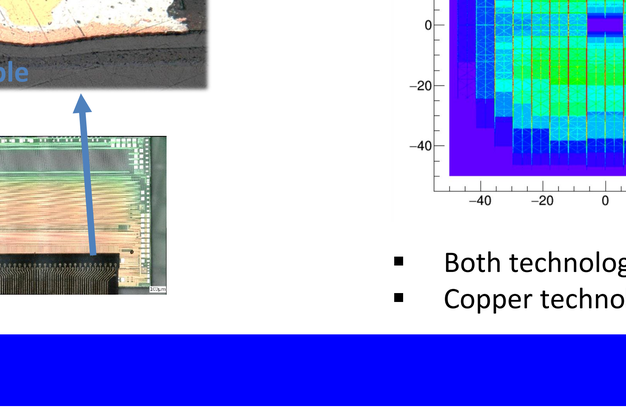


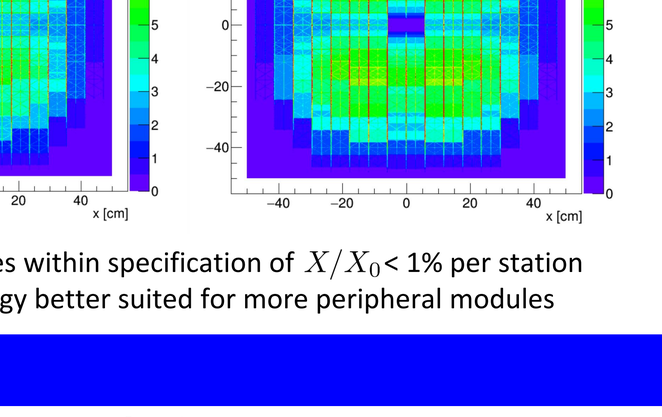
Noise analysis

Expected ENC

	ASIC	cable	sensor
Aluminum	$460\ e^- + \left(0.35 \frac{pF}{cm} * 25\ cm + 1.52/1.74 \frac{pF}{cm} * 4.2\ cm\right) * 27.4 \frac{e^-}{pF} = \mathbf{875/900\ e^-}$		
Copper	$460\ e^- + \left(0.38 \frac{pF}{cm} * 20\ cm + 1.52/1.74 \frac{pF}{cm} * 6.2\ cm\right) * 27.4 \frac{e^-}{pF} = \mathbf{926/964\ e^-}$		

Noise measurements





- Comparable ENC for aluminum and copper microcables
- Deeper investigation for copper microcables needed
- Outlook: Build, characterize and compare test modules with STS-XYTER v2.1

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 high-density interconnection technology for the CBM Silicon Tracking System*, JINST **Vol. 14 Issue 9** (2019)
[4] P. Pfistner et al., *Novel production method for large double-sided microstrip detectors of the CBM Silicon Tracking System at FAIR*, PoS(TWEPP2018)144 (2019)