Challenges and prospects for the Silicon Tracking System of CBM in the first tests with heavy ions collisions

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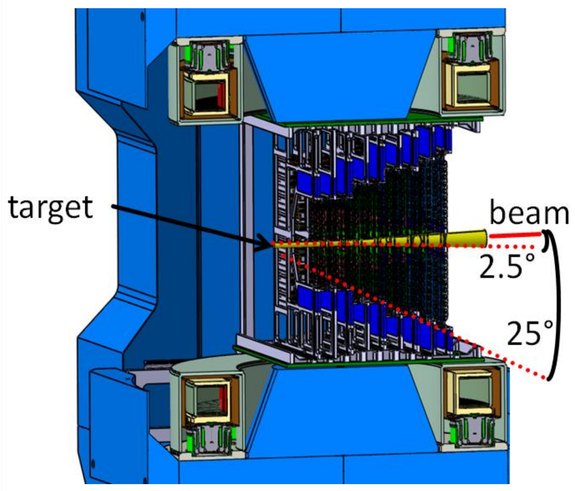
Compressed Baryonic Matter experiment at FAIR

STS for the CBM experiment

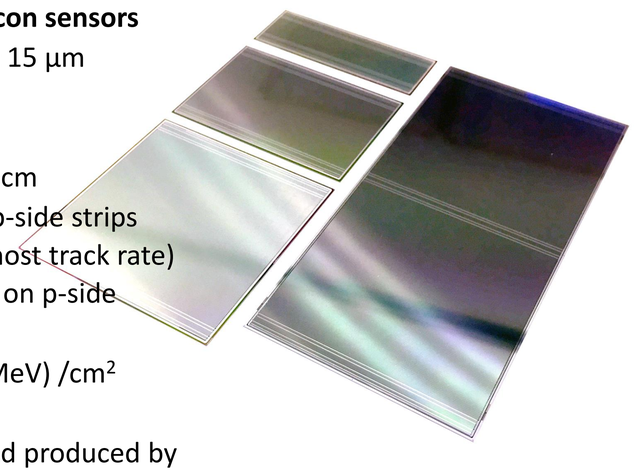


- track point measurement in high-rate collision environment: $10^5 - 10^7$/s (A+A), up to 10^9/s (p+A)
- physics aperture : $2.5° \leq \Theta \leq 25°$
- 8 tracking stations built with double-sided silicon microstrip sensors
- self-triggering front-end electronics
- material : ≈ 0.4% – 1.4% X_0 per station
- hit spatial resolution ≈ 25 µm
- $\Delta p/p \approx 1.8\%$ (p > 1 GeV/c, 1 Tm field)
- track (> 1 GeV/c) and single hit reconstruction efficiency 96% and 98%

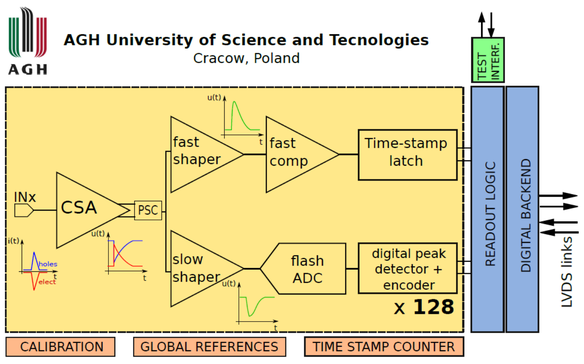
Silicon sensors

Double-sided n-type silicon sensors

- Thickness: 320 µm ± 15 µm
- 58 µm pitch
- 1024 strips/side
- strip length 2/4/6/12 cm
- 7.5° stereo angle for p-side strips (suppression of the ghost track rate)
- double-metal routing on p-side
- radiation tolerance: NIEL: 1×10^{14} n_{eq} (1 MeV) /cm^2 TID: 1 Mrad
- sensors developed and produced by Hamamatsu/Japan



Front-end electronics & STS module



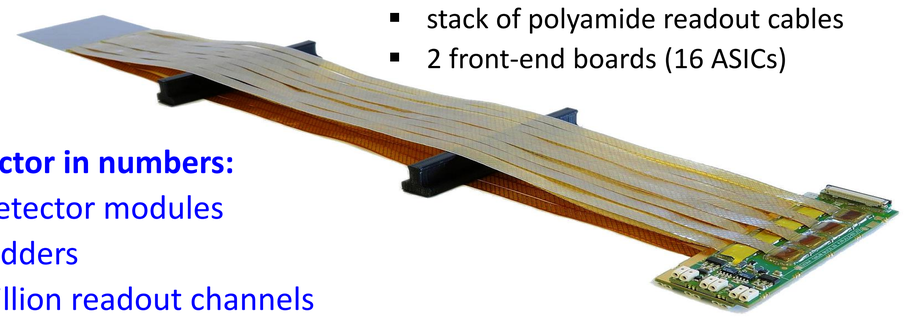
Block diagram of the STS-XYTER ASIC

STS-XYTER ASIC
STS + **X**, **Y** coordinates
Time and **E**nergy **R**esolution

- 128 readout channels
- time resolution < 5 ns
- 5 bit flash ADC/channel
- (14 fC dynamic range)
- hit rate/channel: >250 kHz
- radiation hard layout

Detector module as functional unit:

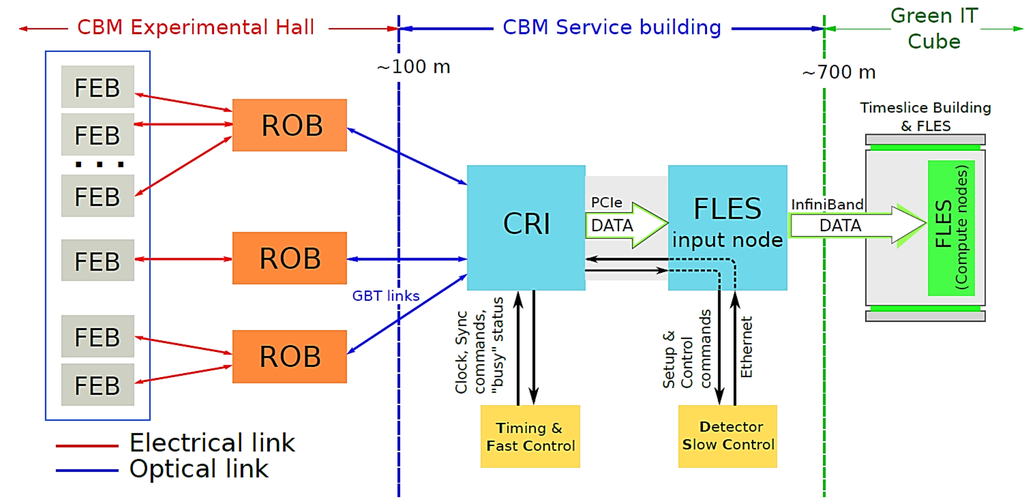
- silicon sensor
- stack of polyamide readout cables
- 2 front-end boards (16 ASICs)



STS detector in numbers:

- 896 detector modules
- 106 ladders
- 1.6 million readout channels

STS readout chain



Block diagram of the STS readout chain

High performance, free-streaming readout chain
Main components:
FEB: Front-end boards
ROB: Readout board
CRI: Common readout interface
TFC: Timing and fast control
DSC: Detector slow control
FLES: First level event selector

mCBM @ SIS18: First tests with heavy-ions collisions

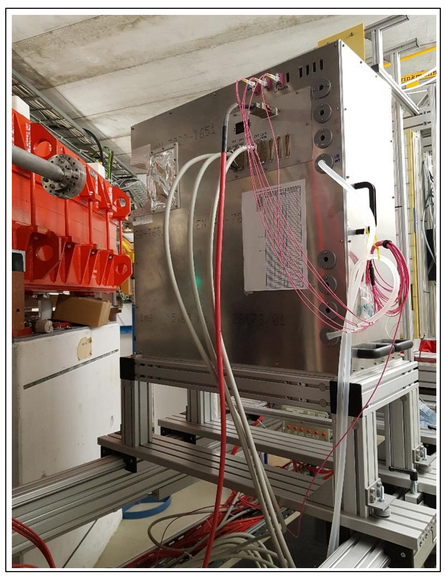
CBM full test setup for high rate, nucleus-nucleus collisions at GSI/FAIR

GOALS:

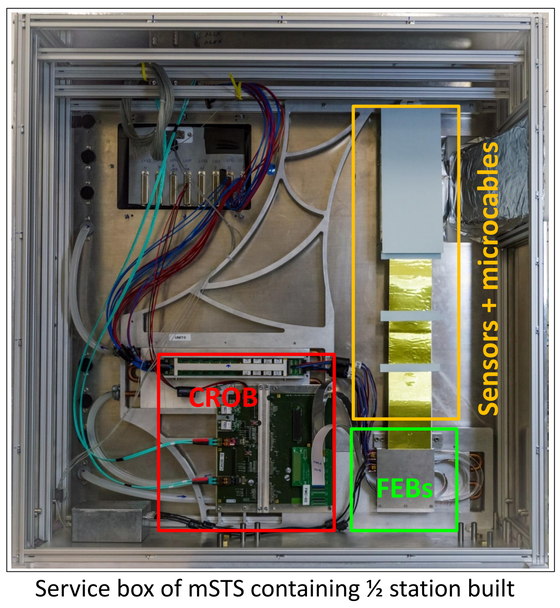
- demonstrator for full CBM data taking and analysis
- integrating prototype detector's modules into a common, free-streaming DAQ
- reconstructing physics observable (Λ reconstruction using Ni-Ni at 1.93 AGeV and Au+Au at 1.24 AGeV)

STS GETTING READY (mSTS) GOALS:

- operation of full STS modules in a high-rate heavy-ion data taking scenario
- 13 STS sensor modules grouped in 2 tracking stations (5 ladders)
- 208 STS-XYTER ASICs (~26600 readout channels)



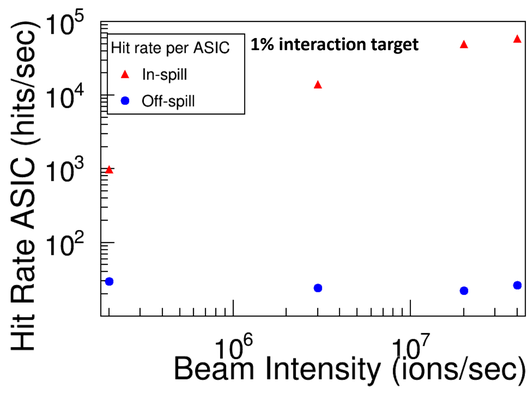
Installation of mSTS in the beam line at SIS18



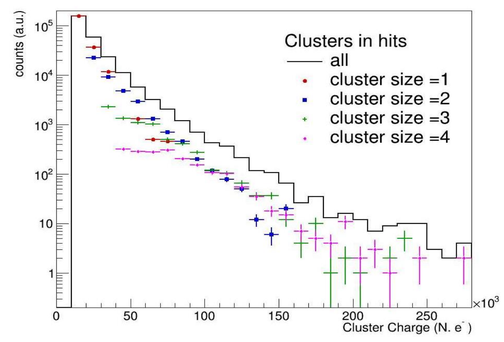
Service box of mSTS containing ½ station built with 2 modules

Preliminary results from March 2019 run

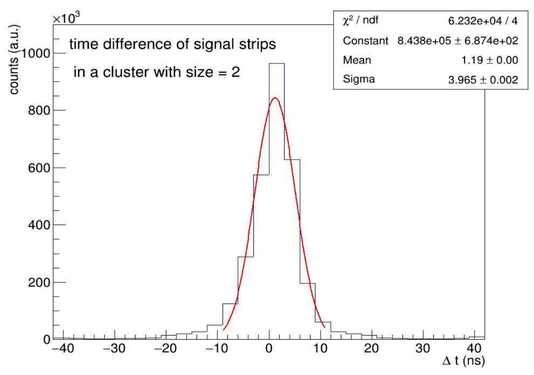
- 2 detector ladder with 4 modules installed
- Ag+Au collisions at 1.58 AGeV.
- Up to 10^7 ions/s in a 1% and 10% interaction target



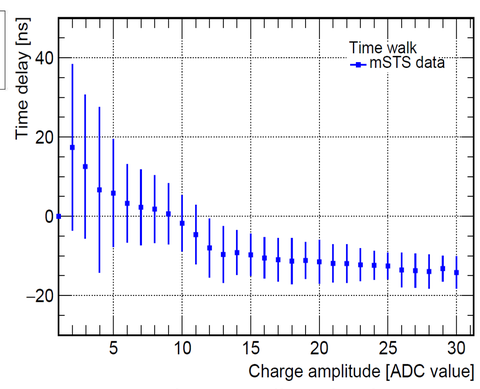
Hit rate in a single ASIC vs beam intensity



Charge distribution of hit-clusters



Time resolution between signals from channels in 2 strip-clusters



Measured time-walk in the detector, with reference in T0 detector

Key participant institutes:
GSI *(Darmstadt, Germany)*, JINR *(Dubna, Russia)*, Univ. Tübingen *(Germany)*, KIT (*Karlsruhe*, *Germany*), AGH (*Krakow*, *Poland*), JU *(Krakow, Poland)*, WUT *(Warsaw, Poland)*, Goethe University *(Frankfurt, Germany)*

Timeline:

- Detector construction: 2020– 2025

Assembly Centers: *GSI-FAIR, JINR-VBLHEP, KIT*

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