Characterization and operation of the front-end electronics of the CBM Silicon Tracking System

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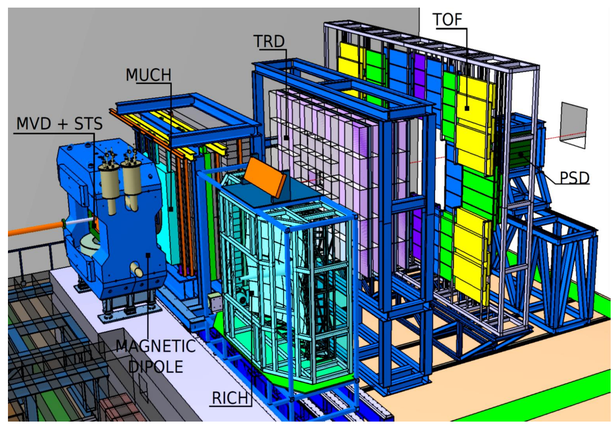
Compressed Baryonic Matter experiment at FAIR

The Compressed Baryonic Matter (CBM) experiment

The CBM experiment :

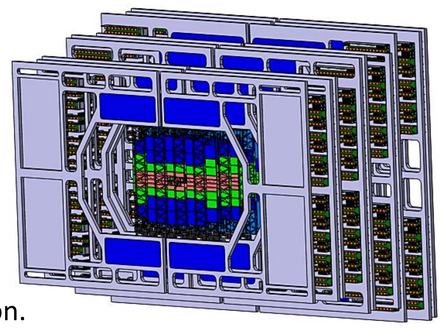
- Explore the QCD phase-diagram at moderate temperature and high density.
- Au + Au @ 2-11 AGeV (SIS100) at 10^5 -10^7 interactions/s.
- Fast self-triggering electronics and time-stamped readout.
- High speed data processing and acquisition system.
- 4D event reconstruction and fast selection algorithms.



The Silicon Tracking System (STS)

STS features & requirements :

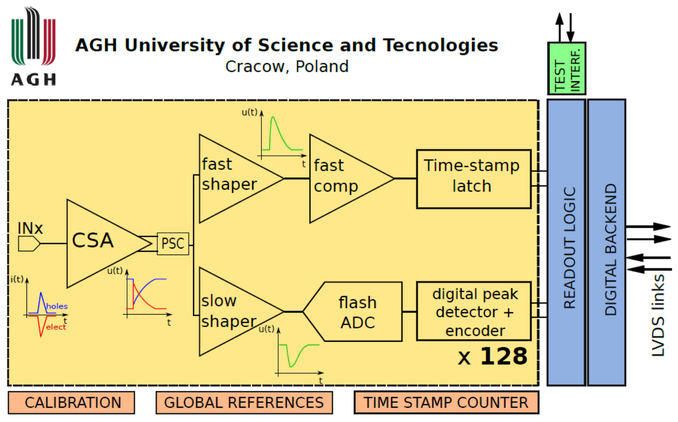
- 8 tracking stations inside 1~T field.
- Double-sided Si micro-strip sensors:
  - 320 µm thickness.
  - 7.5^0 stereo-angle between front and back side strips.
  - Radiation hardness: 10^{14} 1 MeV n_{eq}/cm^2.
- High efficiency and momentum resolution.
- Tracking up to 1000 charged particles/collision.
- Low mass: material budget per station in the range 0.4-1.4% X_0.



Front-end electronics

STS-XYTER ⟶ **S**TS + **X**, **Y** coordinates + **T**ime and **E**nergy **R**esolution

Low power, self-triggering ASIC dedicated for reading out the double-sided Si sensor

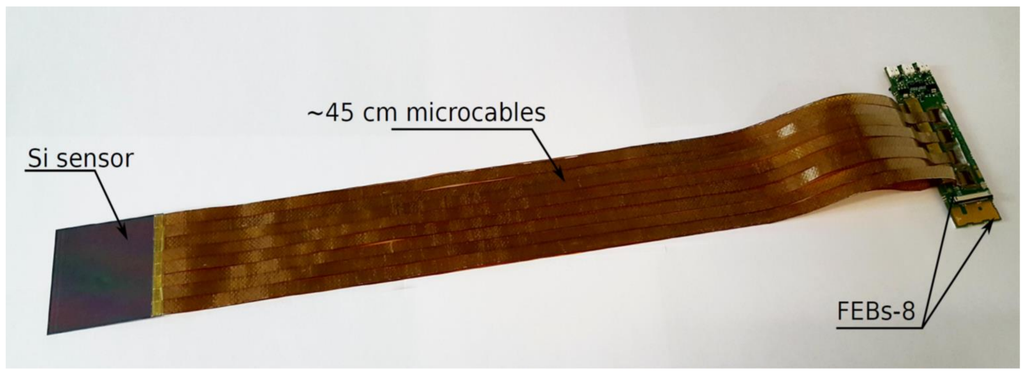


STS-XYTER features :

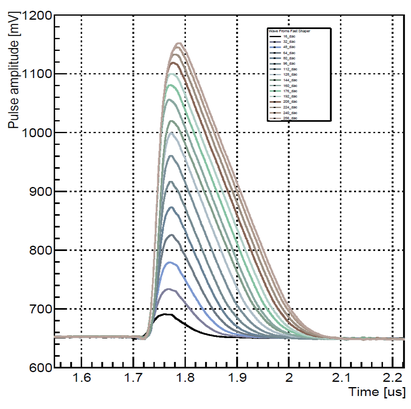
- 128 readout channels
- Time Resolution ~ 5ns
- 14 bits time stamp
- 5 bit flash ADC/channel
- 14 fC dynamic range
- Radiation hard layout
- Digital backend compatible with the CERN GBTx data concentrator

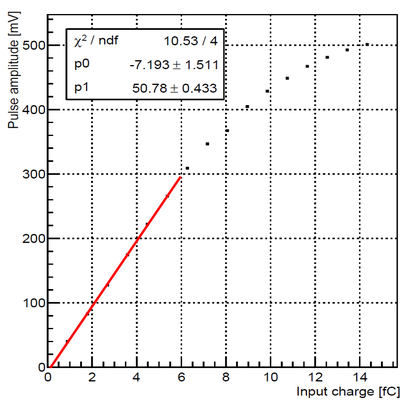
Detector module

Full detector module prototype ⟶ 6.2 × 6.2 cm^2 silicon micro-strip sensor + 45 cm microcable + 2 FEBs. Every FEB carries 8 STS-XYTER ASICs



Analog front-end

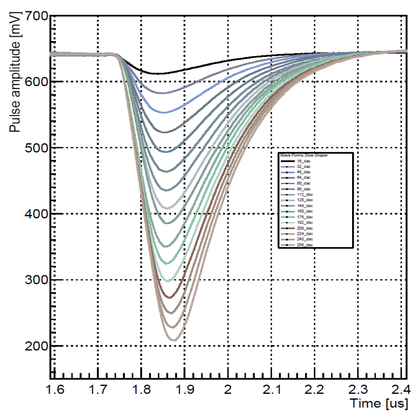


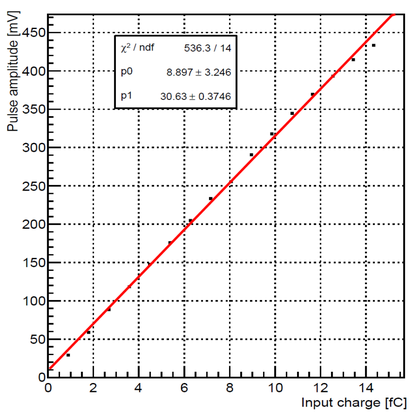


Waveforms & gain for fast shaper.

Tests of the analog front-end:

- Waveforms for different injected charges in the range (1-14.2) fC
- CSA gain @100 fF feedback capacitance: 8 mV/fC in STS mode.
- Fast shaper linearity up to 6 fC
- Gain fast shaper: 50 mV/fC
- Gain slow shaper: 30 mV/fC
- Fast reset functionality cheked



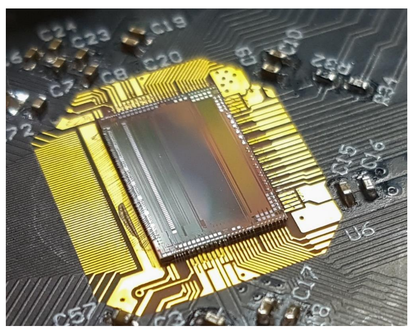


Waveforms & gain for slow shaper.

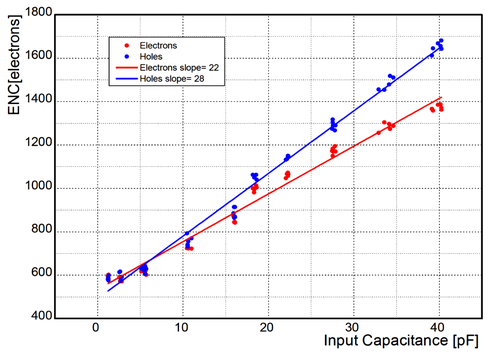
ASICs and modules tests

STS-XYTER Equivalent **N**oise **C**harge (**ENC)** & stability tests:

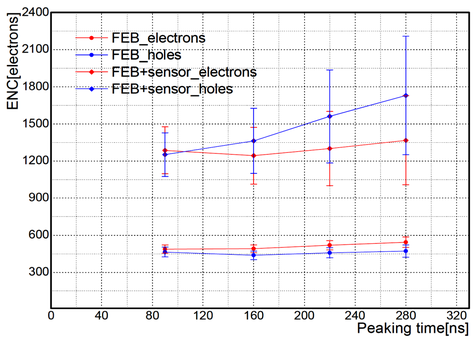
For a free-streaming experiment with self-triggered electronics , low noise performance is one of the key design parameters.



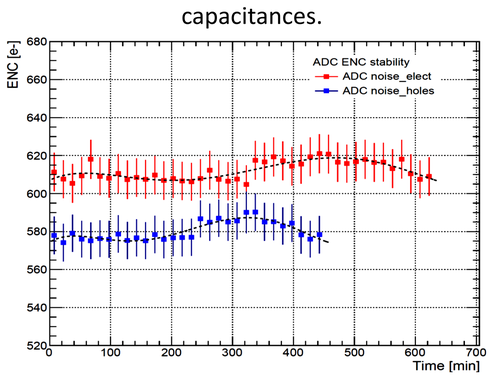
STS-XYTERv2.1 ASIC bonded onto a prototype FEB.



ENC contribution for different load capacitances.



ENC dependence for different slow shaper peaking times .



STS-XYTERv2.1 ENC long-term stability test.

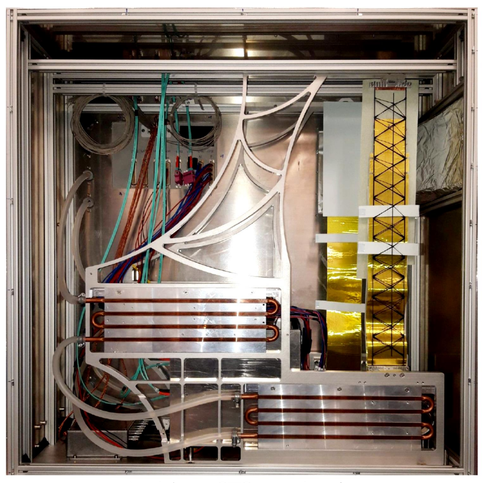
mSTS ⟶ **STS** demonstrator in the context of **CBM** phase 0 activities using the existing FAIR/GSI accelerator facilities.

Test & goals:

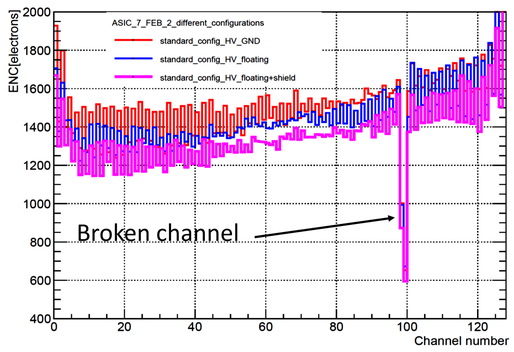
- Integration of the full detector modules
- Test of the full readout chain
- Study of the system noise performance
- Optimization of the ground and biasing scheme

March 2019.

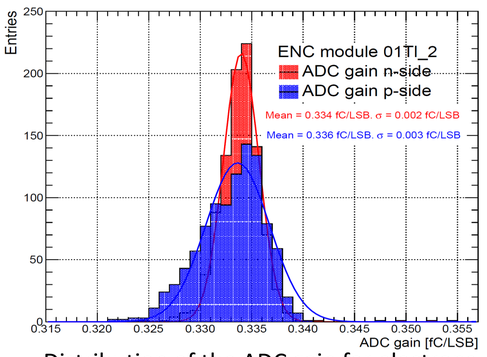
One tracking station built with 4 detector modules.



Inside mSTS service box



Example of noise performance for a single ASIC with different biasing.



Distribution of the ADC gain for electrons & holes.

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)*