Analysis of 2.7 GeV proton-beam measurements with the STS detector for the CBM experiment

Patrick Pfistner[1], for the CBM collaboration

[1] *Karlsruhe Institute of Technology KIT*

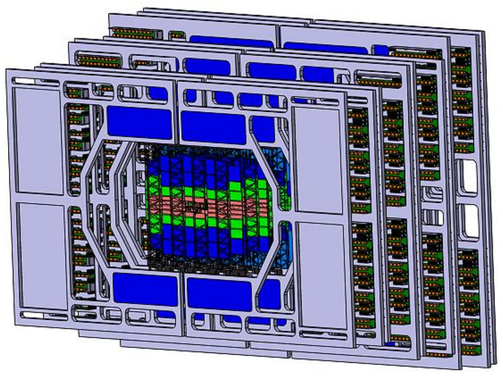
Compressed Baryonic Matter experiment at FAIR

Motivation

- COoling SYnchrotron (COSY) at Research Center Juelich provides well-defined experimental conditions with pencil-like fixed-energy proton beam
- First operation of a fully functional and noise-optimized STS module in beam
- Great tool for characterization of full CBM-STS electronic readout chain + sensor

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. ≤ 700 per central Au+Au collision in aperture $2.5° < \theta < 25°$
- Momentum resolution Δp/p < 2%
- Lifetime fluence up to $1 \times 10^{14} n_{eq}$ in innermost region

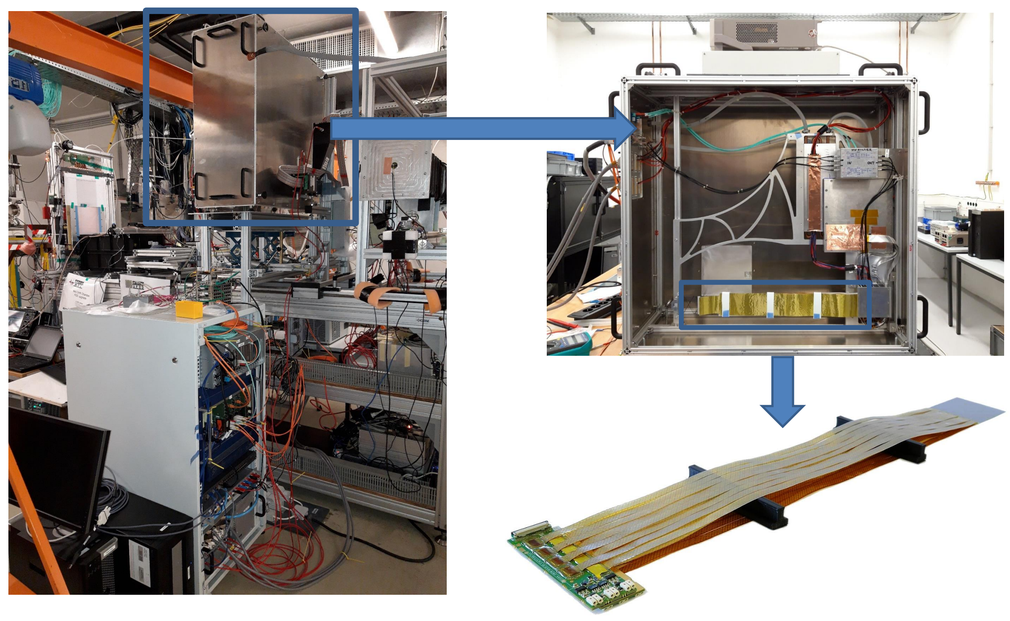


STS concept

- 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

COSY beamtime setup

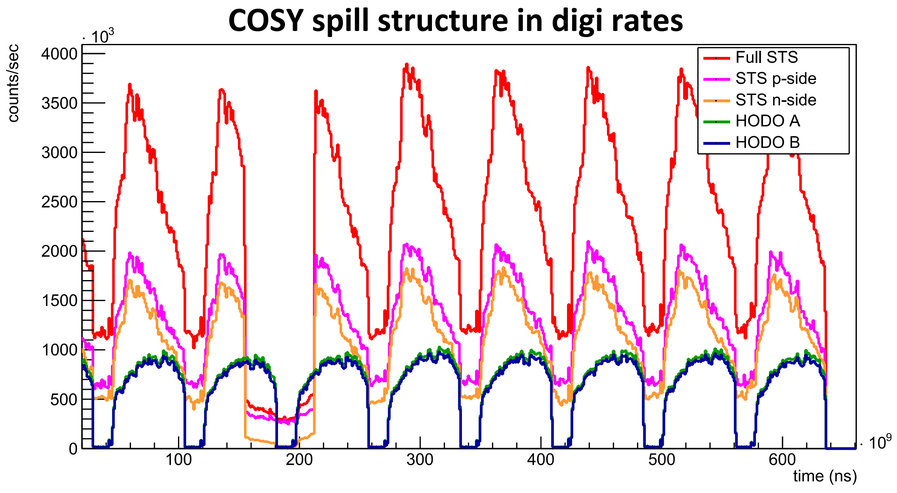
- STS module box hosting a C-frame, the module, electronics and cooling infrastructure
- One STS module with 6x6 cm^2 sensor, 45 cm aluminum microcables, two FEB-8 and 16 STS-XYTER v2.1 readout ASICs
- Scintillating fiber hodoscopes (64 channels in X and Y direction) in front and behind STS
- STS sensor: double-sided microstrip sensor with a 7.5° stereo angle on the p-side
- Full prototype CBM data-driven read-out chain



Beamtime parameters

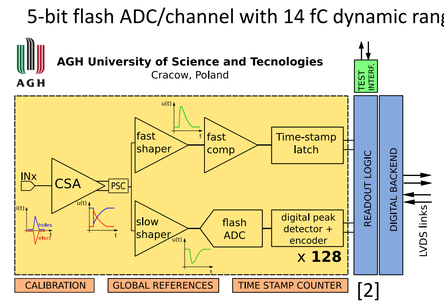
- 2.7 GeV/c proton beam ($E_{kin} = 1.92\ GeV$)
- Peak data rate: 4×10^6 digis/s/16ASICs
- Performed beam intensity, beam position and threshold scans
- Reconstruction chain: digis (electronic signal) → clusters → hits

COSY spill structure in digi rates



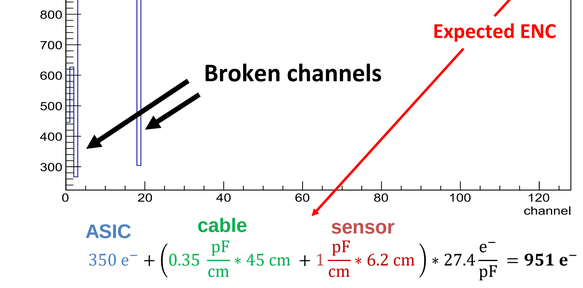
Performance of electronics

- STS-XYTER ASIC
  - STS + X, Y coordinates Time and Energy Resolution
  - Self-triggered front-end electronics
  - 128 readout channels
  - Time resolution < 5 ns
  - 5-bit flash ADC/channel with 14 fC dynamic range

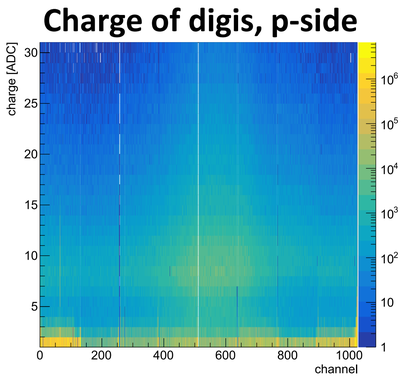


[2]

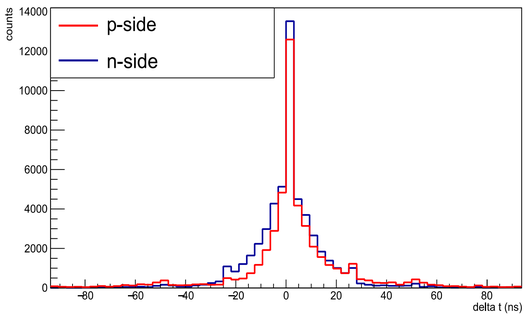
Noise per channel for one ASIC



Charge of digis, p-side

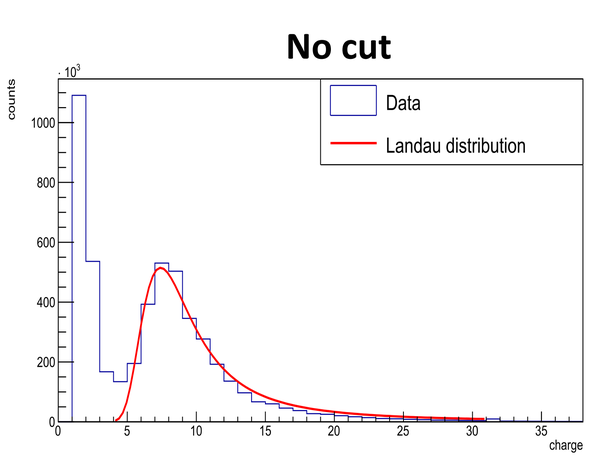


Time difference digis in 2-strip clusters

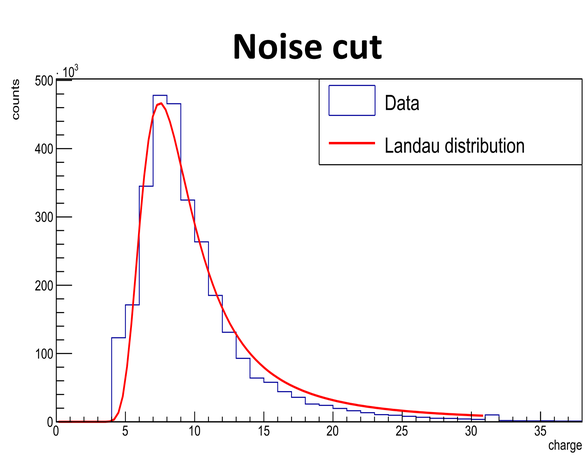


Charge distribution 1-strip clusters

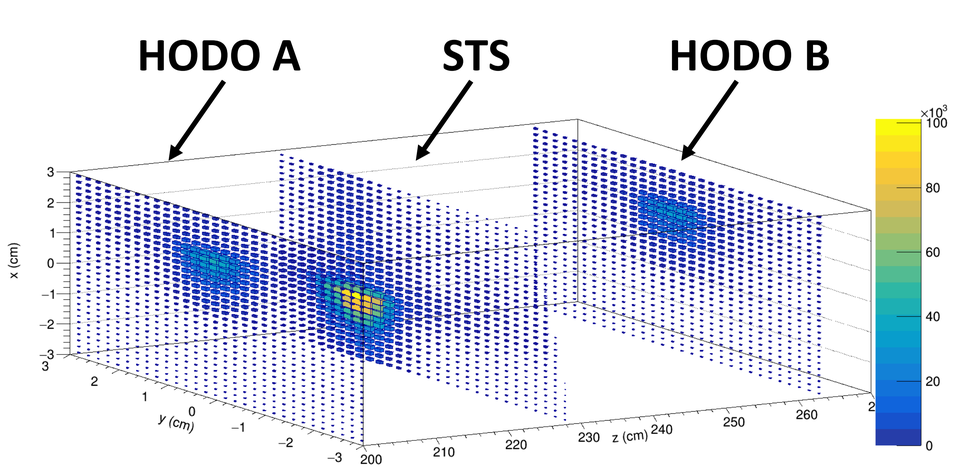
No cut



Noise cut



Hit map



- STS sensor displaced in x and y

Summary

- COSY beamtime campaign was immensely helpful in commissioning of online reconstruction software (cluster finder, hit finder) and full electronic readout chain
- The targeted STS system noise of around 1000 e- was achieved
- Charge distributions show clear separation between noise and proton peak
- Successful beam spot reconstruction
- Results and experience gained highly valuable for upcoming mCBM campaigns

Outlook

- ADC calibration
- Determine detector efficiency with hodoscopes as reference
- mCBM heavy ion beam tests in 2020

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)