Test of the STS-XYTER2 frontend ASIC for the CBM Silicon Tracking System

Adrian Rodriguez Rodriguez for the CBM Collaboration

DPG Spring meeting

Muenster, March 31st, 2017

Outline

1 → Introduction to the CBM Silicon Tracking System

2 → STS-XYTER v2 first tests summary.

3 → Develop and test an ADC trim calibration procedure.

4 → Test beam results evaluating SEU in the STS-XYTERv2 at COSY beam time.

5 → Towards noise studies with the STS-XYTERv2.

6 → Summary & outlook

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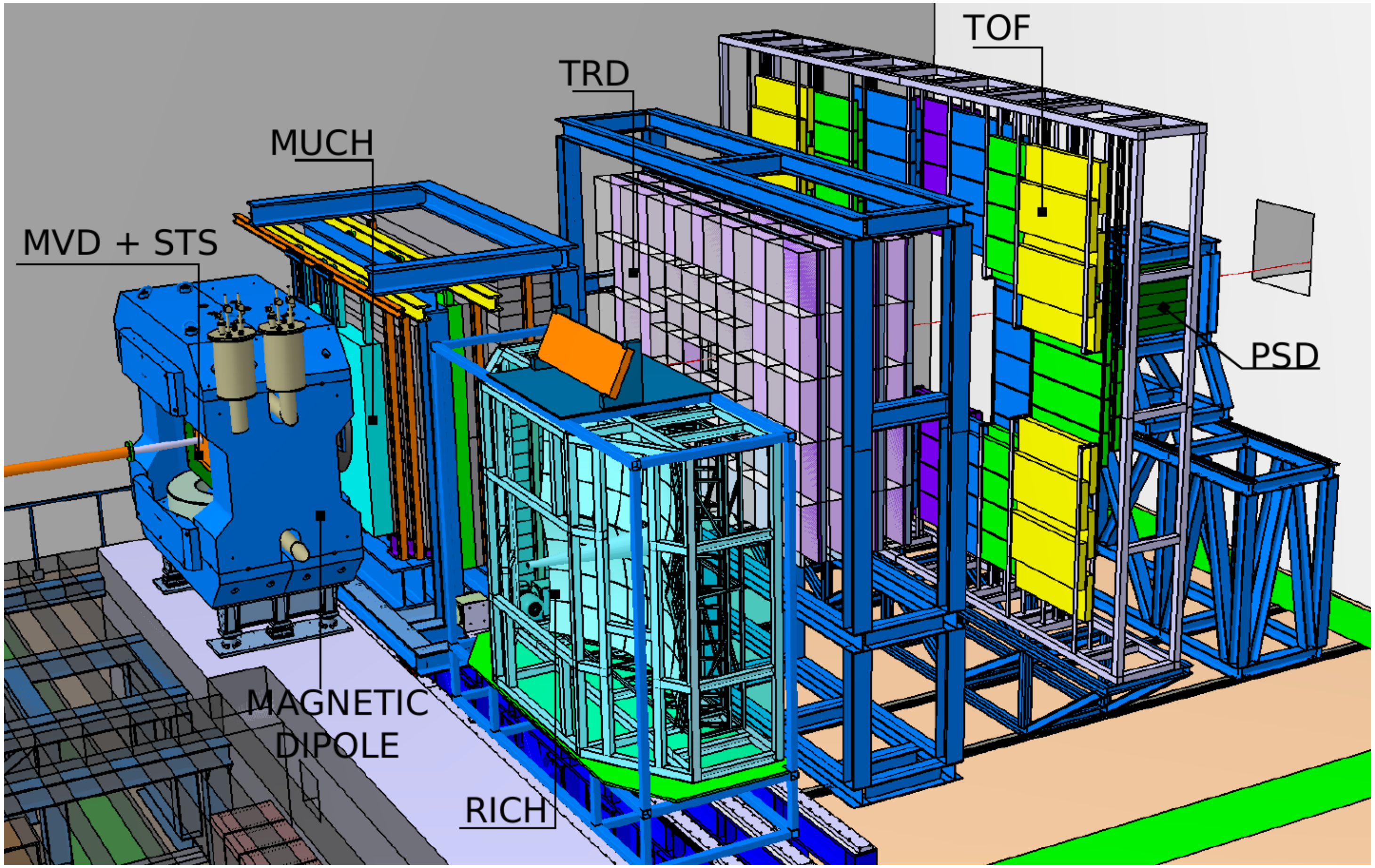
The Compressed Baryonic Matter experiment (CBM) at FAIR

Exploring the QCD phase diagram at high net baryon densities



→ 10^5-10^7 A+A collisions/s
→ Fast and radiation hard detectors
→ Self-triggering electronics
→ 4D event reconstruction.

Wednesday, March 29th, 2017, 16:45-17:15, HK30.1
The Compressed Baryonic Matter experiment at FAIR
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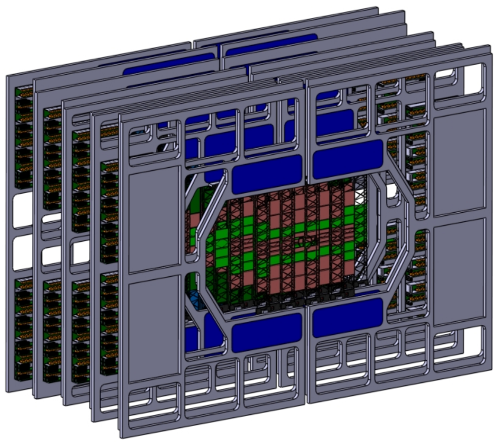
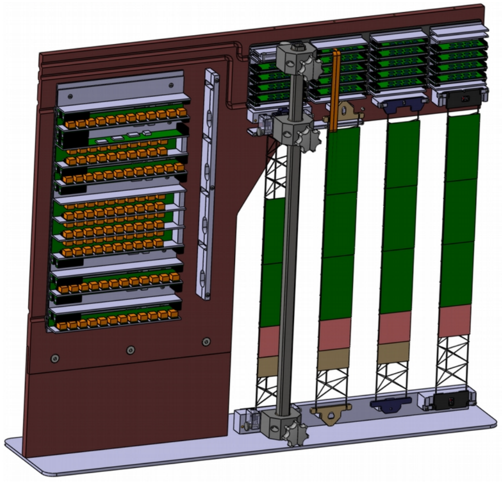
Joerg Lehnert for the CBM collaboration

The Silicon Tracking System (STS) of the CBM experiment





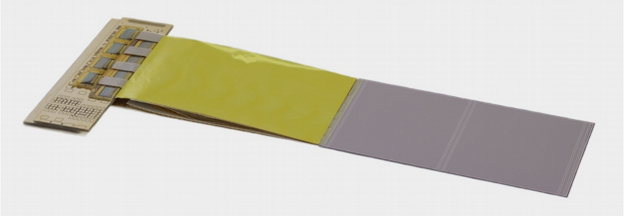
Requirements:

→ High detection efficiency.
→ Spatial hit resolution: 25 µm
→ Momentum resolution: <2%
→ Tracking up to 1000 charged particles/collision.
→ Low material budget 0.3%-1.0% X_o per station.
→ Radiation hard sensors: 1 x 10^{14} 1 MeV n_{eq}/cm^2
→ Ionizing dose at the electronics place ~200 krad/yr.
→ Heat dissipation ~40 kW.

Design:

→ 8 tracking stations inside 1T magnetic field.
→ Geometrical acceptance: $2.5^0 \leq \theta \leq 25^0$
→ Based on ~ 900 double-sided Si sensors with 4 different sizes:
- 2x6 cm^2, 4x6 cm^2, 6x6 cm^2,12x6 cm^2.
- 7.5^o stereo-angle for the p-side strips

→ 1.8 millions of channels::~14 000 ASICs.
→ Built as a functional module:
- 1 Si sensor + microcables + 2 FEB.
- 1 FEB carry 8 ASICs (1024 channels).



Monday, March 27th, 2017, 17:00–17:30, HK9.2
The Silicon Tracking System of the CBM Experiment at FAIR
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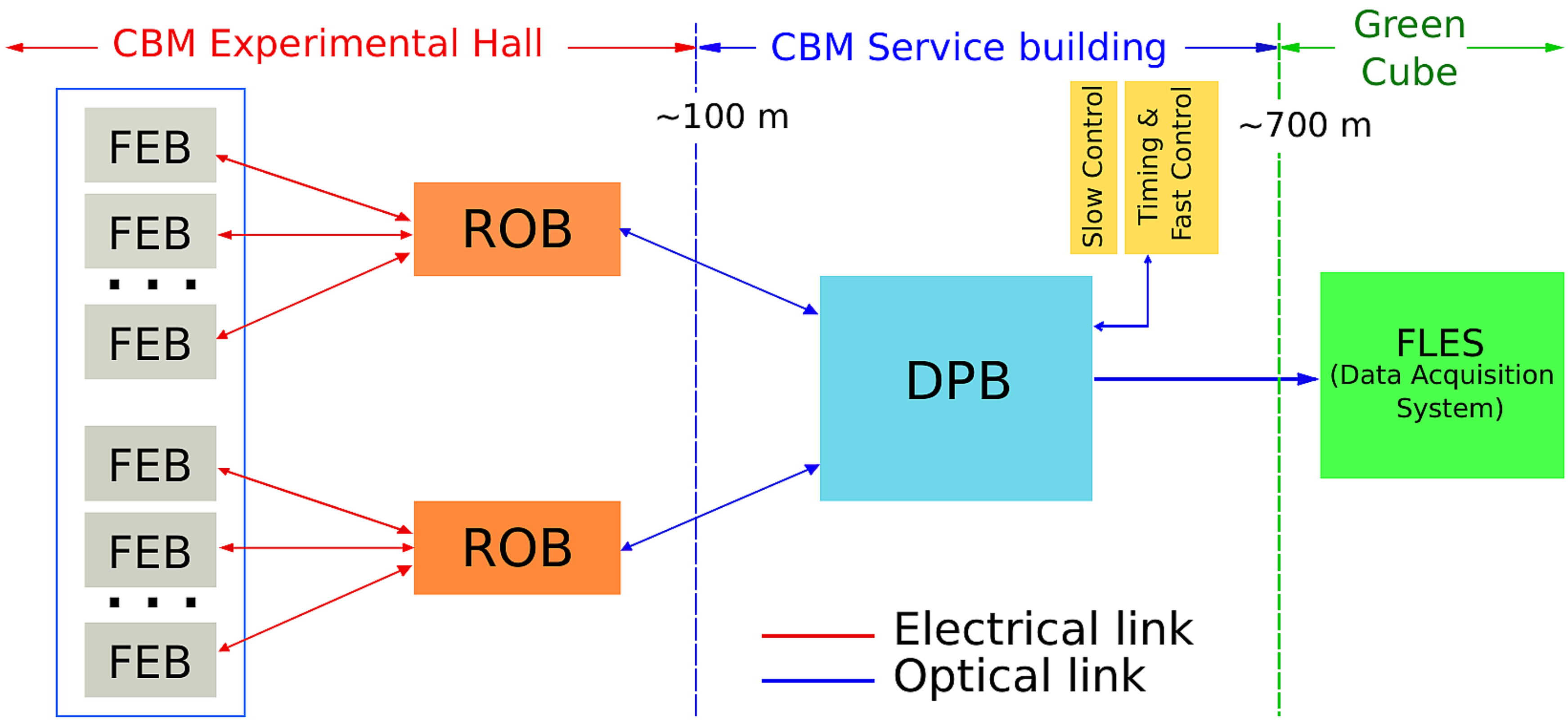
Olga Bertini for the CBM collaboration

The **STS** readout chain



→ **F**ront **E**nd **B**oards: Part of a functional module; it carries 8 STS-XYTER ASIC/FEB

→ **R**ead **O**ut **B**oard: Based on CERN-GBTx and Versatile links components.

Tuesday, March 28th, 2017, Poster session
The common GBTx based prototype board for CBM
•
Joerg Lehnert for the CBM collaboration

→ **D**ata **P**rocessing **B**oard:FPGA based, interface for Timing and Control and data preprocessing

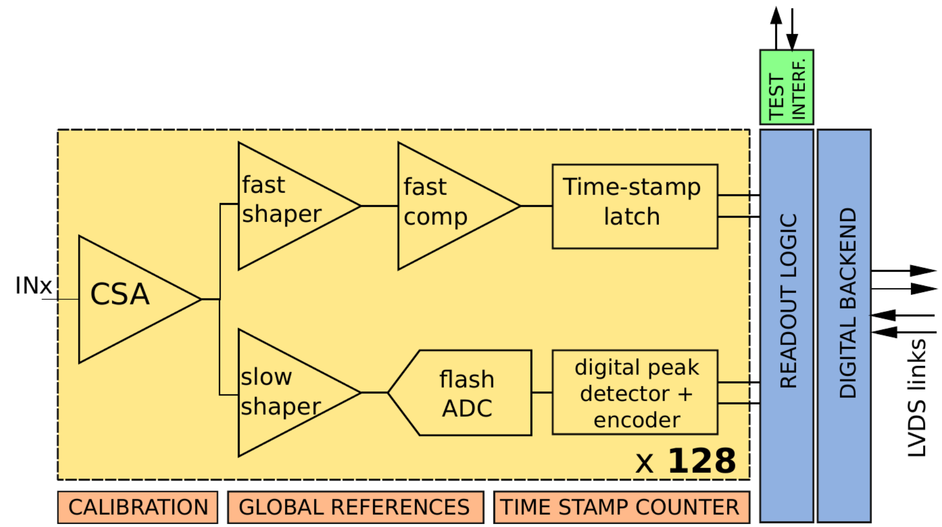
The **STS-XYTER** ASIC

STS+X,Y coordinate, Time and Energy Resolution
Low power, self triggering ASIC dedicated for reading out the double-sided Si sensors.

STS-XYTERv2 available since fall 2016

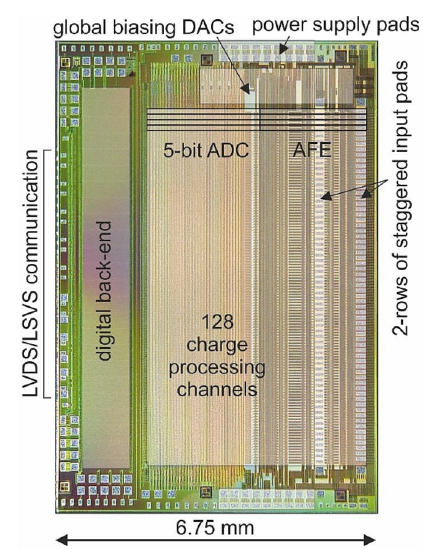
Designed by AGH University of Science and Technology
Cracow, Poland.
(Scziegiel, Kasinski et al)

CRACOW
AGH University of Science and Technology



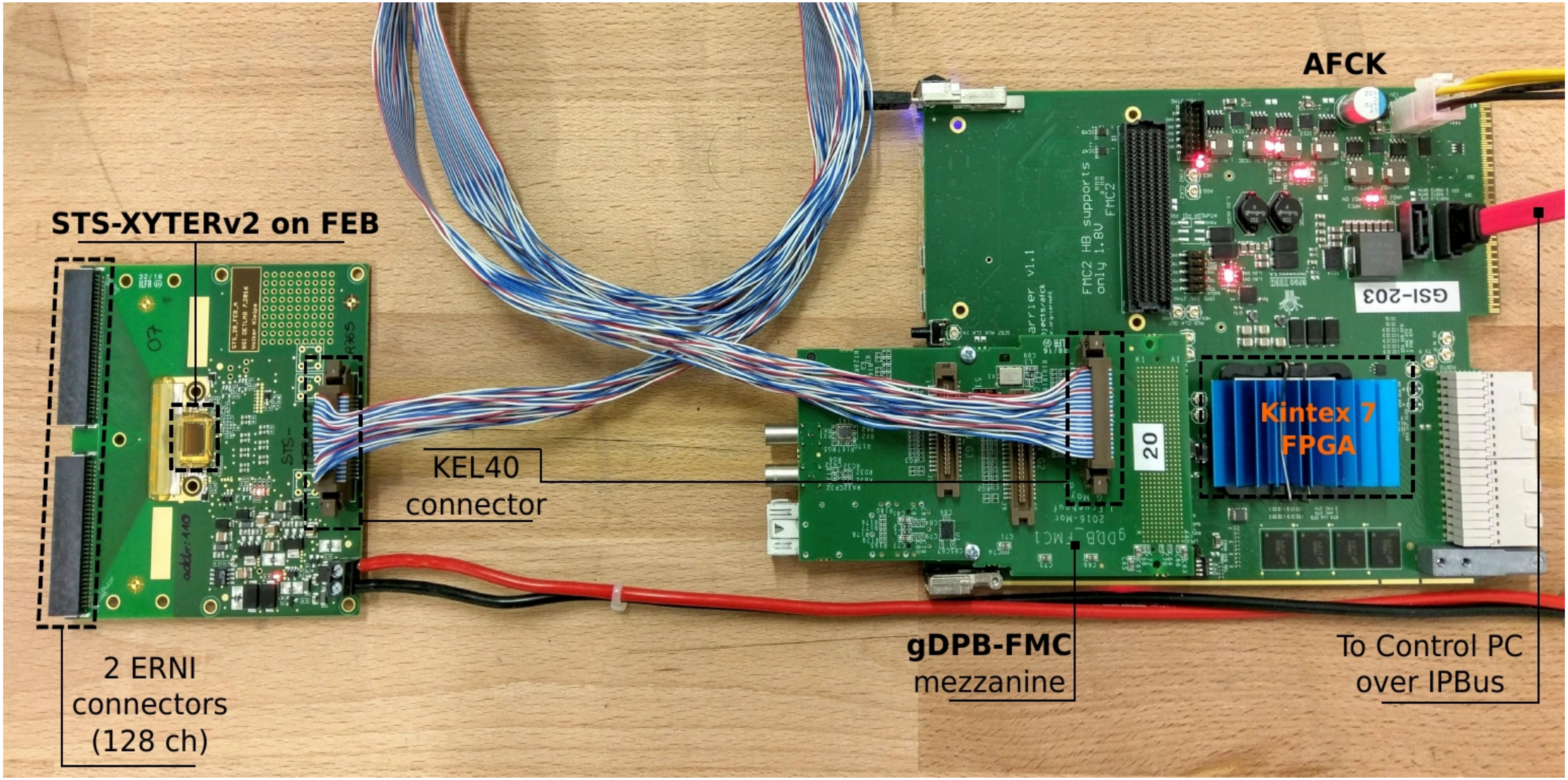
Features:

→ 128 channels + 2 test channels.
→ CSA with variable gain (STS/MUCh detectors)
→ Time resolution: ~5 ns.
→ 14 bit Time stamp.
→ 5 bit in-channel flash ADC.
→ ADC linearity range up to 15 fC.
→ Radiation hard layout.
→ Power consumption: <10 mW/ch
→ Digital backend compatible with the CERN-GBTx.



STS/MUCH-XYTER2 ASIC

The STS-XYTERv2 test setup at GSI



Test setup estblished at GSI and 3 other research institutes:
AGH, Poland; VECC, India; JINR, Russia

Digital backend implemented in the Kintex7 FPGA.
Firmware developed by W. Zabolotny (Warsaw University)

STS-XYTERv2 ASIC tests

ASIC functionalities test:

→ Links synchronization & masking. ✔

→ ASIC addressing. ✔

→ Register access R/W. ✔

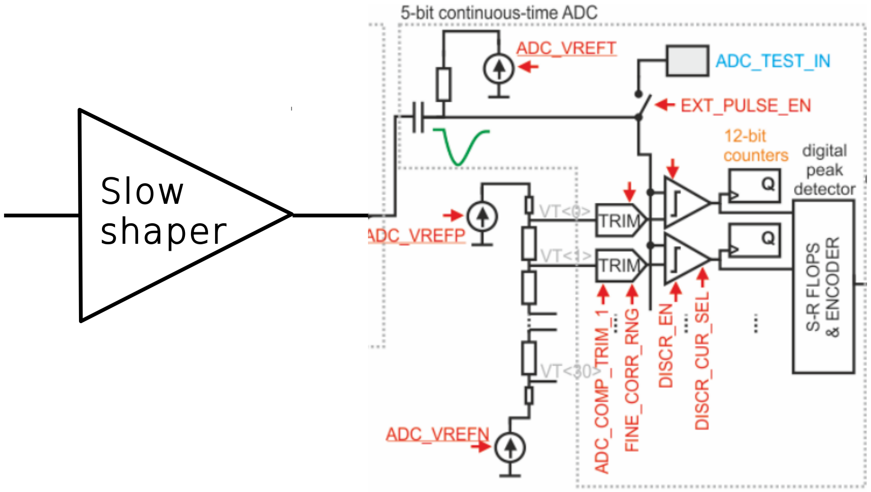
→ Hit generation by using test modes implemented in the ASIC. ✔

→ ADC trimming calibration. ✔

→ Single Event Upset (SEU) tests at COSY beam time. ✔

STS-XYTERv2 tests

Evaluating ADC by acquisition of S-curves with dedicated counters using the analog test-pulse generator .



Test features:

→ 128 channels.

→ 5 bit flash ADC:: 31 discriminators.

→ Every disc has 8 bit trimming DAC (DICE cells).

→ Internal test-pulse generator.
Scan over calibration pulse amplitude (8 bits)

→ Dedicated ADC disc counters (12 bits)

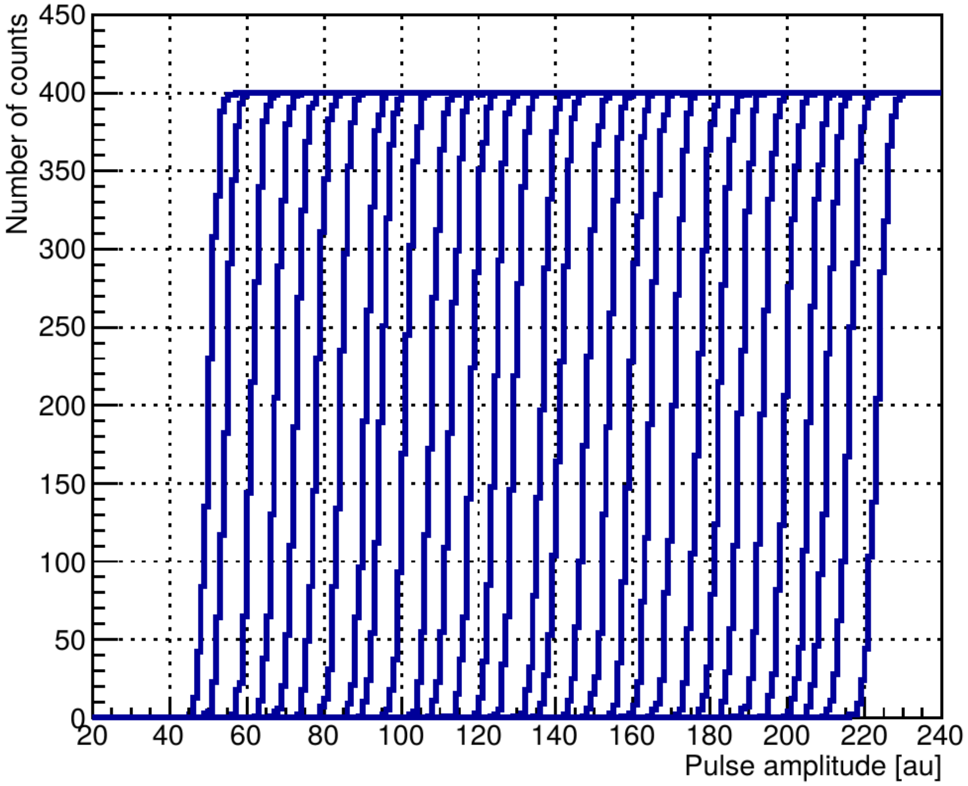
→ ADC Configuration registers implemented with DICE cells.

TASK → Developing and testing ADC trim procedure for calibration

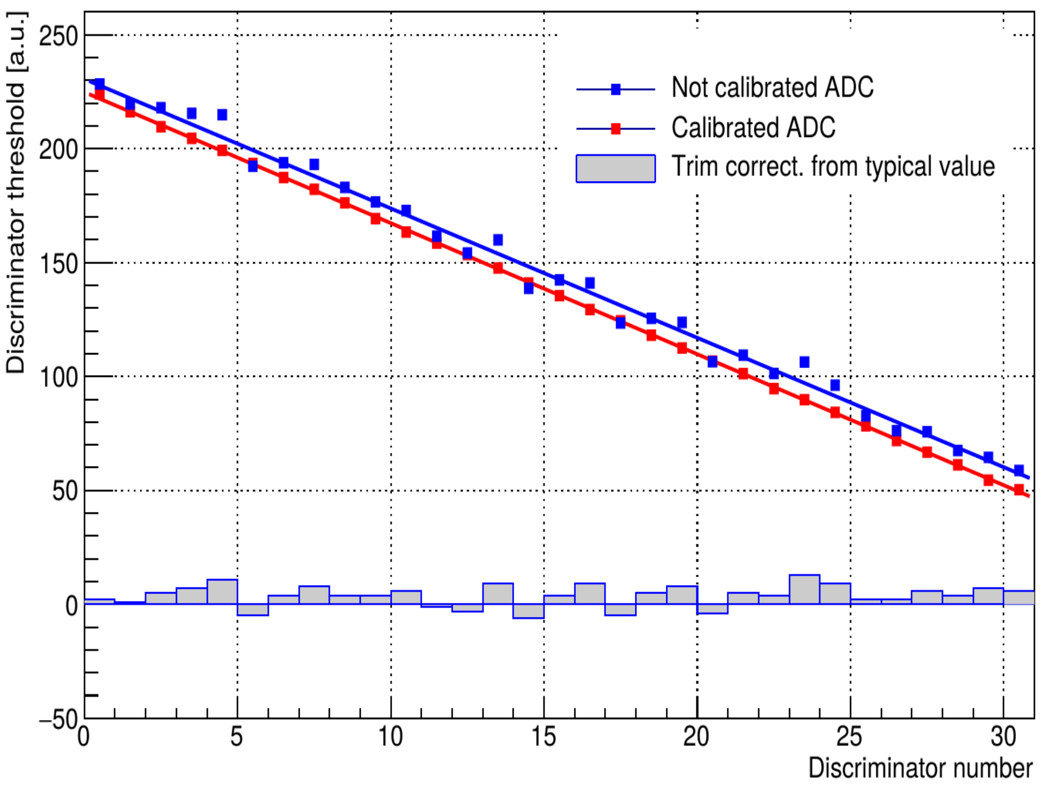
STS-XYTERv2 tests

Evaluating ADC by acquisition of S-curves with dedicated counters using the analog test-pulse generator .

Pulse amplitude scan in the range 50-220 au



S-curves from a typical calibrated channel



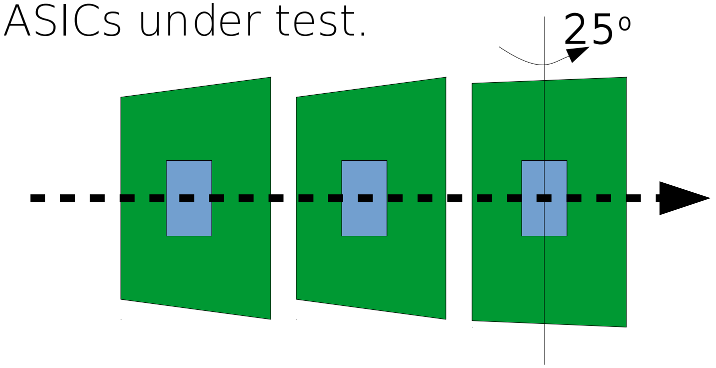
ADC linearity (before and after calibration)
Blue curve → typical trim value (128)

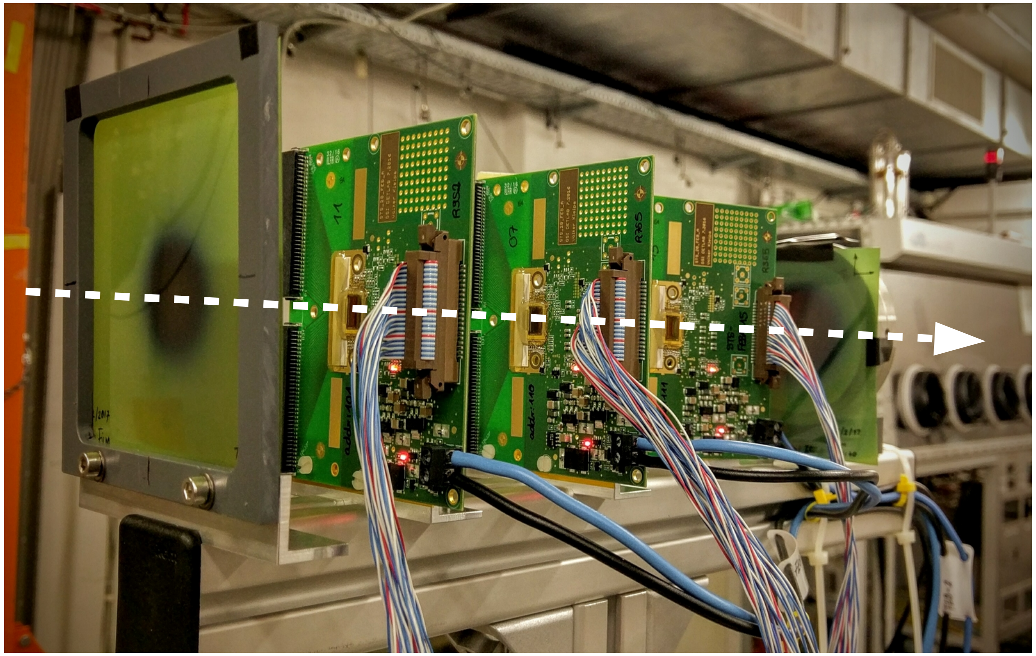
Redo process with external pulser

STS-XYTERv2 SEU test

Two different architectures:

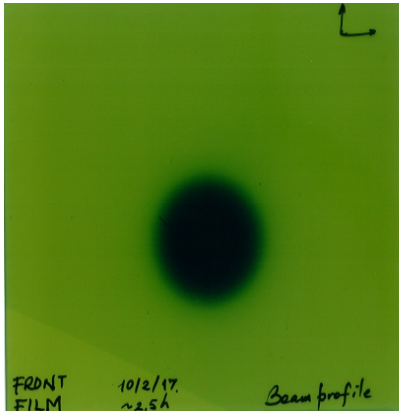
→ DICE cells:31744 bits (ADC trim DACs)
→ Flip-flops: 47616 bits (ADC disc counters)
→ 3 ASICs under test.

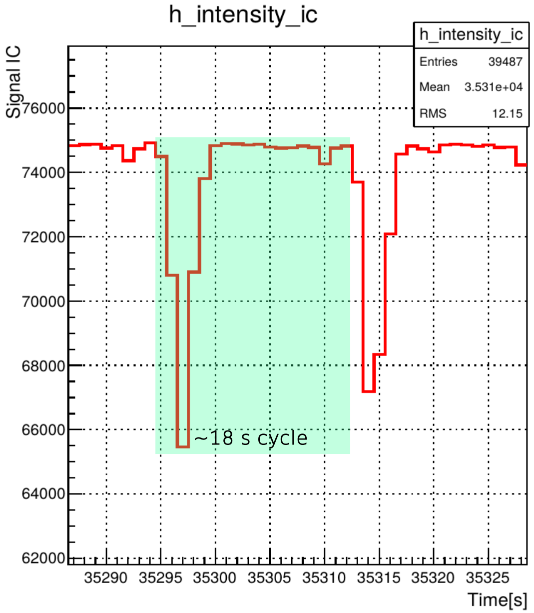




Beam features:

→ 1.6 Gev/c momentum (Info from AT).
→ 18 s duty cycle.
→ 4 – 5 s spill length.
→ Average intensity per spill > 4 x 10^9 p
→ Effective irradiation time: ~ 45 hours.
→ Integral intensity: ~ 3.7 x 10^{13} p.



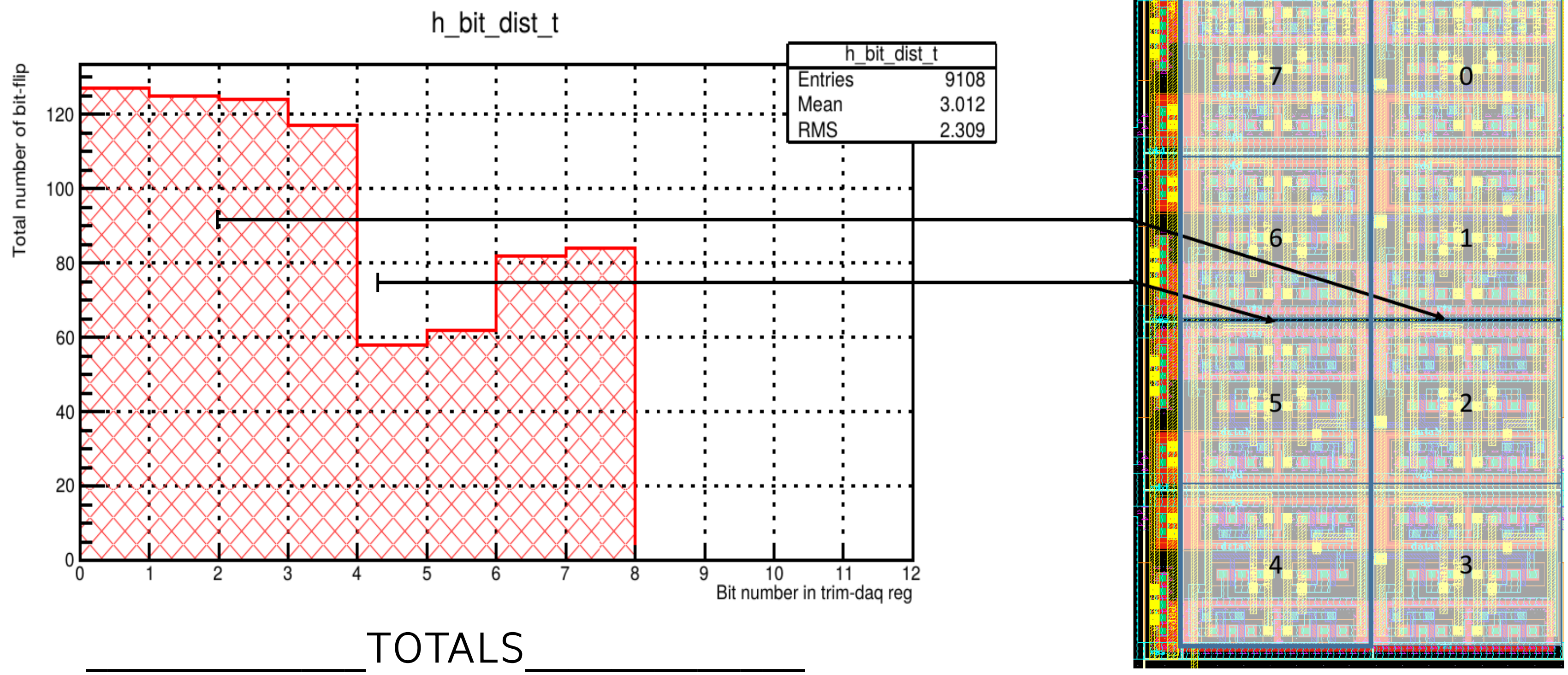


Beam monitoring:

→ Ionization chamber (IC) for beam intensity.
→ Gafchromic films for beam position and beam profile.

STS-XYTERv2 SEU test

SEU in DICE cells (8 bits).



TOTALS

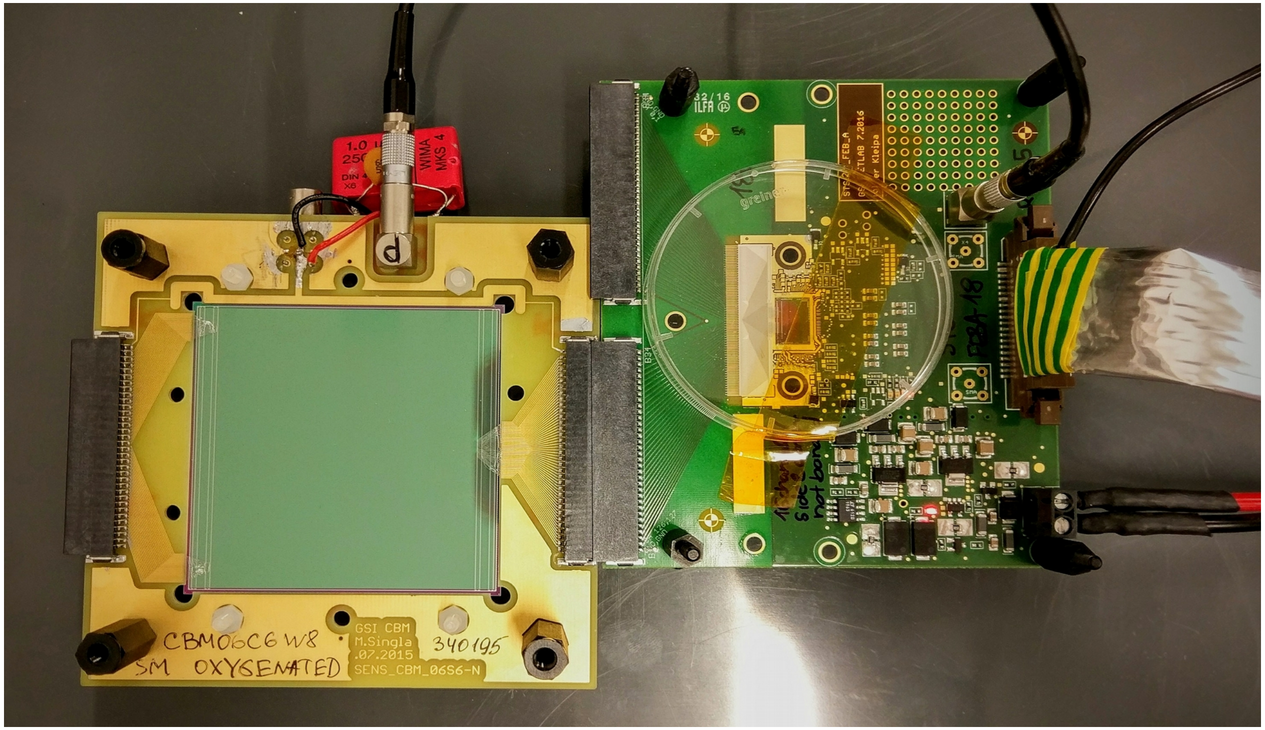
	No. of bits	SEU
Flip-Flops:	47616	75057
DICE cells:	31744	759
FF/DICE	1.5	66

Findings:

→ Improvement in the radiation hardness of the DICE cells architecture relative to the STS-XYTERv1 as expected.

→ Hint for further enhancement (cells 4 to 7)

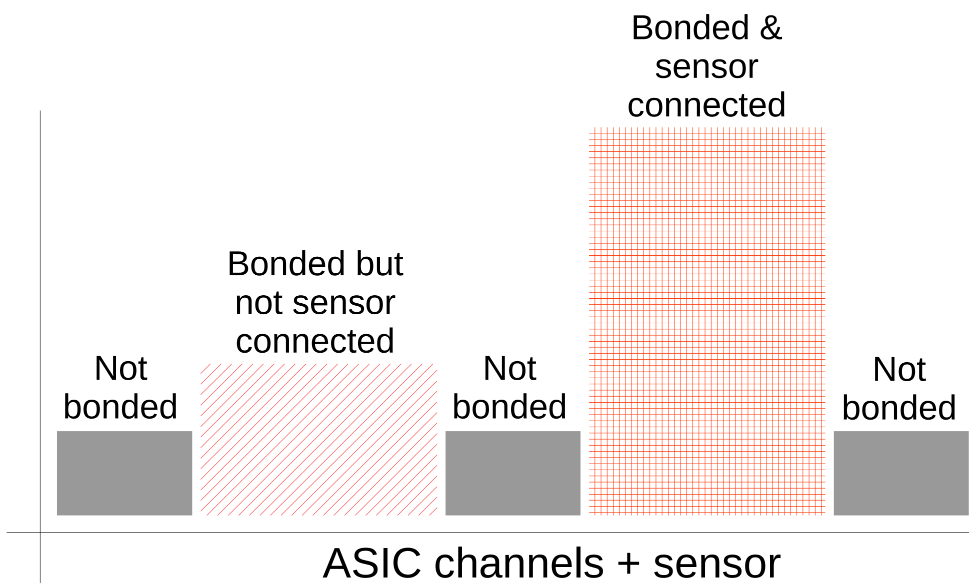
Sensor readout setup using the STS-XYTERv2



INSIDE SHIELDING BOX

→ Si sensor: 64 connected strips.

→ STS-XYTERv2 ASIC in prototype FEB (80 connected channels)



Summary and Outlook

→ Experimental setup to evaluate STS-XYTER ASIC functionalities have been set up at GSI and other research institutes (AGH, Poland, VECC, India, JINR, Russia)

→ ADC trim calibration procedure has been developed and tested.

→ Successful test-beam campaign at COSY in February 2017.
- ASIC has shown an improvement in terms of SEU for the DICE cells architecture.

Towards sensor readout and noise studies with the STS-XYTERv2

→ Sensor read out using the STS-XYTER v2.

- Investigate and reduce noise sources and ground loops contribution.
- First look into the system noise levels using (6x6 cm^2 sensor, sensor module).
- Detector response to radioactive sources.

→ Preparation of a standalone sensor readout for the beam time campaign (May 2017).

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Thanks for your attention!