CBM detector and electronics tests at COSY in 2017 and Q1/2018

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for the CBM Collaboration

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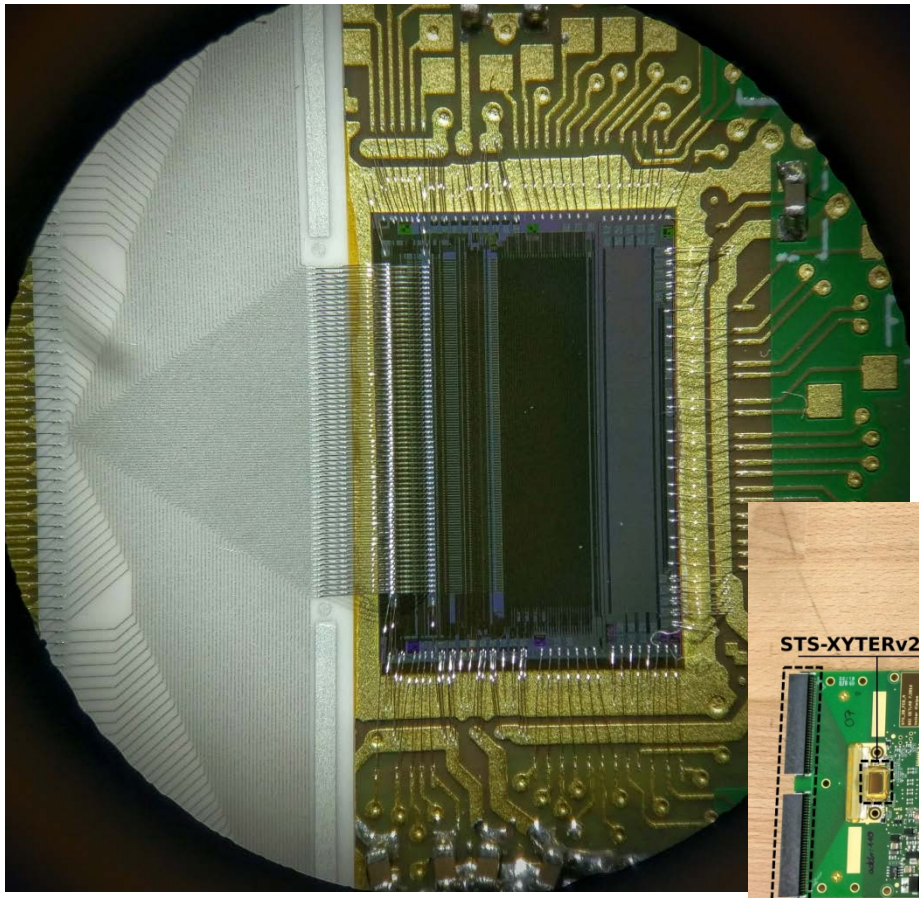
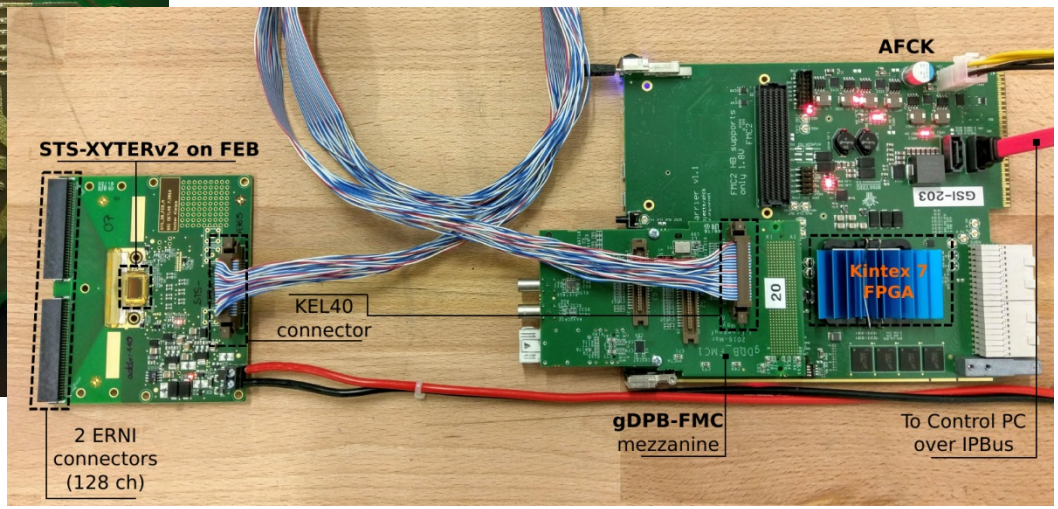
Outline

1) Results from in-beam test, February 2017
2) Request for re-scheduled beamtime, May 2017
   I. *October 2017 (1 week)*
3) Application for beamtime in Q1/2018:
   I. *Electronics tests: Feb. 2018 (1 week)*
   II. *Detector tests: Feb./March 2018 (1 week)*

(1) Results from in-beam test, February 2017



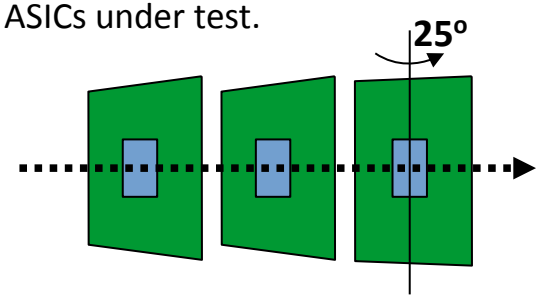
STS-XYTERv2 ASIC – Test for single-event effects in JESSICA Cave

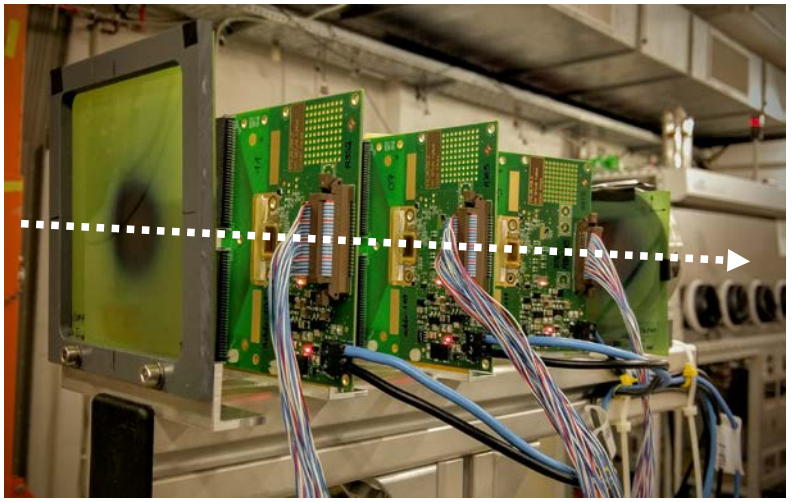


SEU Test Setup@COSY Feb.2017

Two different architectures:

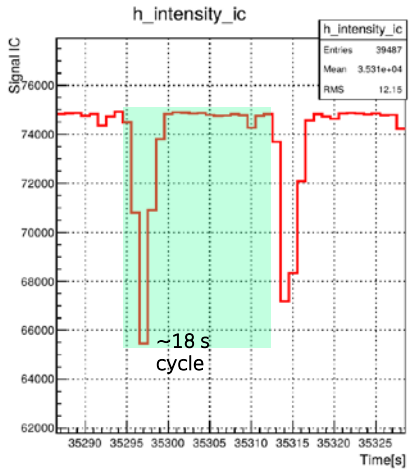
→ DICE cells: 31744 bits (ADC trim DACs)
→ Flip-flops: 47616 bits (ADC disc counters)
→ 3 ASICs under test.





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.

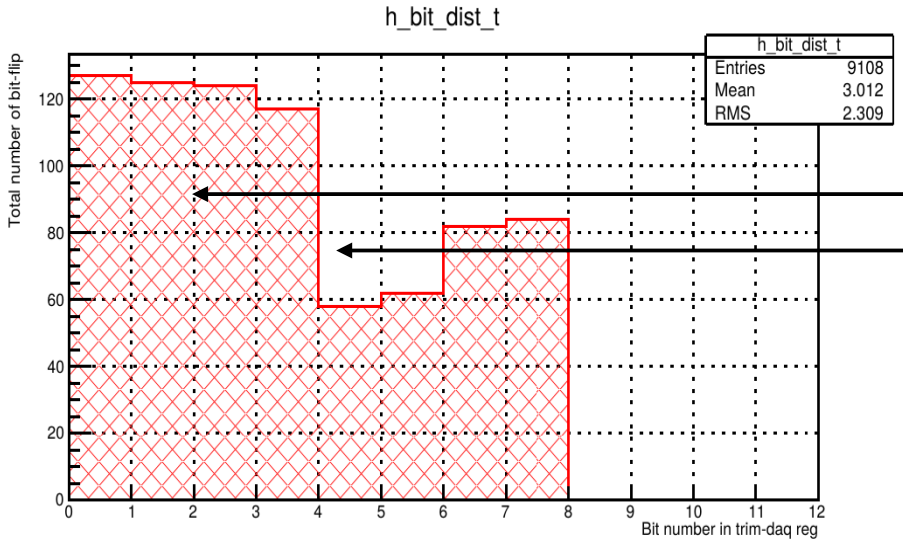


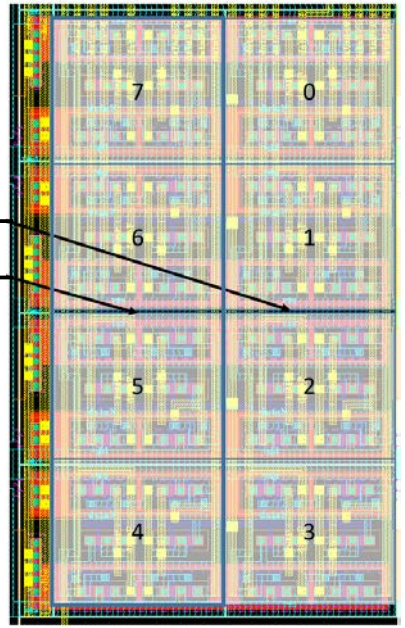
Beam monitoring:

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

Results (I)

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)

Results (II)

Two unexpected scenarios of malfunction observed during operation in test beam:

1) Potential latch-up in AFE (analog front end) control path

- Symptoms
  - Errors in read-back from registers in the AFE: counters, configuration registers
  - correlated with higher supply current (0.6 A → 0.8 A)
  - startup procedure (sync, reset, configure) does not cure
  - power cycle recovers from condition
- 4 occurrences during normal operation
- No effect seen in registers of digital backend

→ probably latch-up in row/column decoders of AFE registers

→ Possible means to fix: more contacts to bulk & wells - and add guard rings.

2) Randomly toggling bits in test counters

- some counter bits do not retain stable values: some bits toggle randomly
  - Symptom: inconsistent or erroneous read-back
- appeared at the same time in all 3 ASICs in beam during beam optimization at higher rates (> 8×10^9 p/spill)
- Permanent effect
- counters are not rad-hard → only used for monitoring in test phase, not critical
- Problem does not affect configuration registers
  - Possible remedy: applying similar changes as applied to the DICE registers may also solve counter problems:
    - better T-well & n-well contacts by guard rings

further investigations planned in February 2018

(2) Request for re-scheduled beamtime 2017

- In May 2017 we had the following tests scheduled (2 weeks):
  - Test of readout electronics for RICH-MAPMTs (DiRICH)
  - Diamond T0 tests with TRB3 read-out
  - Test of STS sensors (track reconstruction efficiency* → charge collection)
  - Test of new GEM detectors for MuCH*
  - Test of new DAQ chain* (n-XYTERv2 ASICs, front-end boards type F, AFCK read-out boards, prototype interface boards FLIB to FLES)

  ** cancelled due to dying/noise problem in n-XYTER front-end boards*
- We would like to carry out part of the tests in *October 2017*:
  - DiRich read-out study
  - Diamond T0 test / HADES MDC
  - power regulators – TID effects
  - Configuration Scrubbing via GBT-SCA chain

1 week of beamtime,
2nd half of October (weeks 42+)**
in JESSICA or BIG KARL cave

** due to CBM, HADES Collab. Meetings

Test of readout electronics for RICH-MAPMTs

Goals for COSY test beam:

First full system test with complete front end electronics:
12 MAPMTs, 2 backplanes, 24 ***DiRICH****, 2 DiRICH-Combiner*

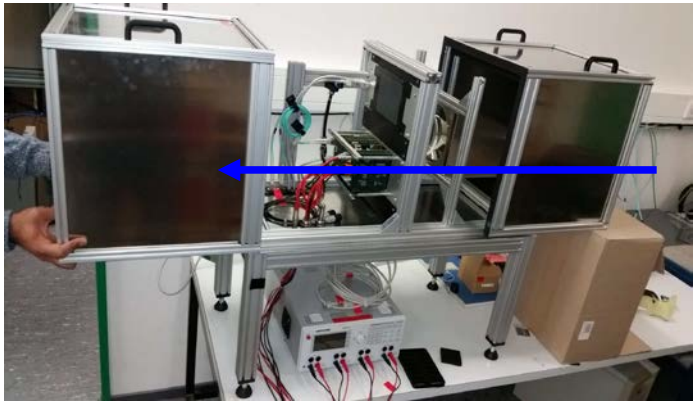
- Check stability and functionality of new readout chain
- Determine single photon detection efficiency with new DiRICH readout
- Test readout chain under realistic high rate conditions
- Test performance of new WLS coating

Status:

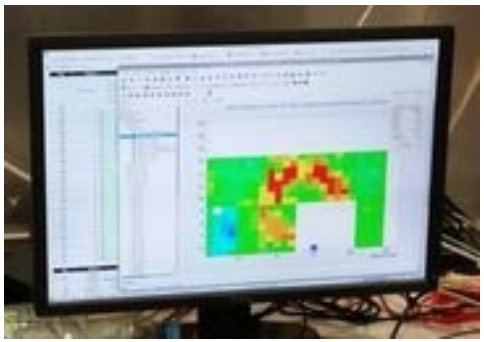
Second iteration of DiRICH front-end module
30x DiRICH2 produced, ready for testing
(2 full backplanes, 12 MAPMTs)

COSY prototype testbox ready for beam:
- Solid glass lense Cherenkov radiator
- with 2 modules: 12 MAPMTs, 24 DiRICH

Promising first tests at GSI with light pulser in preparation of COSY beamtime:

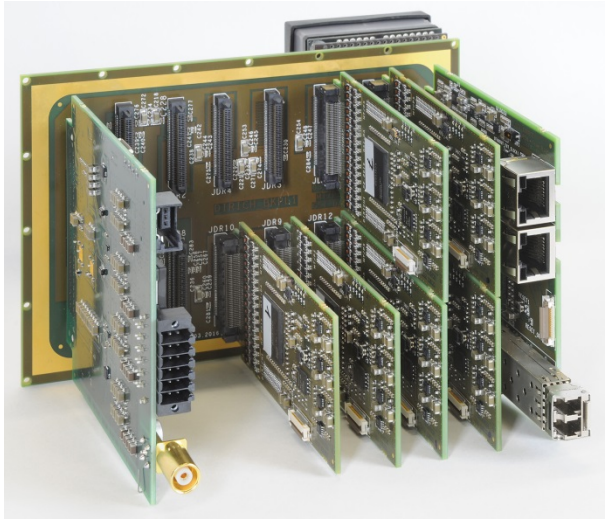


COSY Cherenkov prototype detector with lense radiator (right compartment), and 1 or 2 fully equipped readout modules (left compartment)

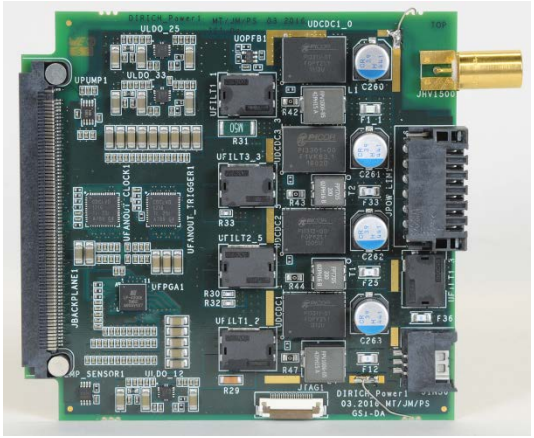


first DiRICH “ring” with light pulser + shadow mask at GSI

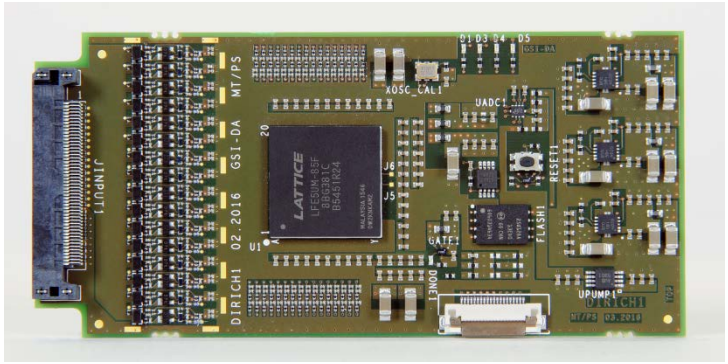
DiRICH read-out modules



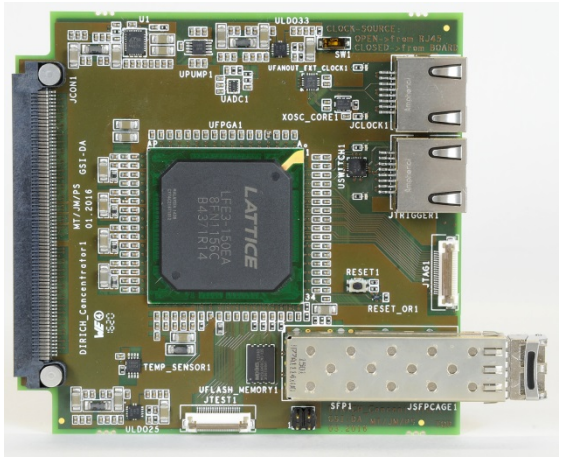
full backplane for 6 MAPMTs, 12 DiRICH + Combiner + Power module



DiRICH-Power module for LV and HV supply

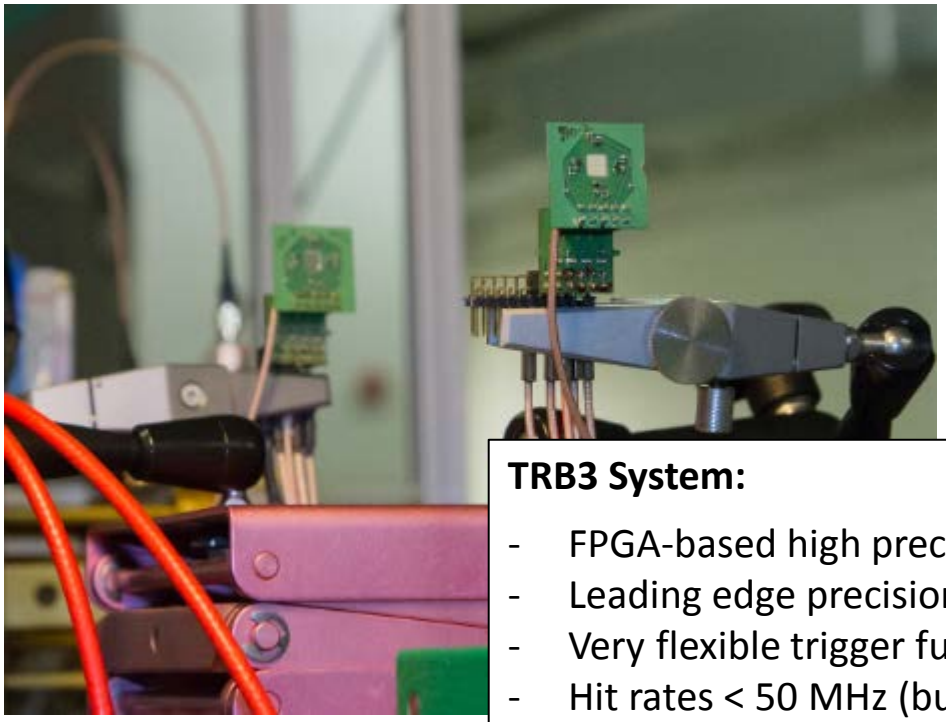


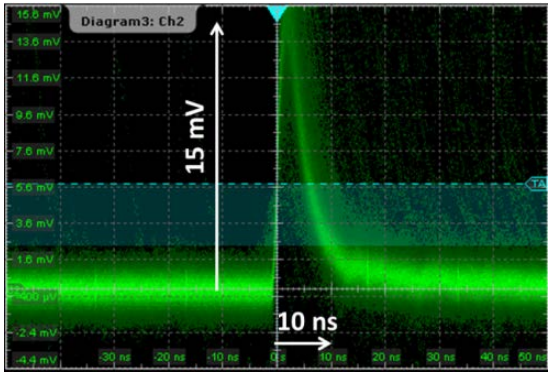
single DiRICH front-end module, 32 ch



DiRICH-Combiner module

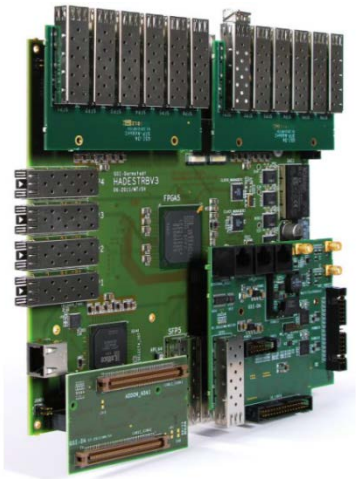
Diamond T0 tests with Scope/TRB3 read-out





TRB3 System:

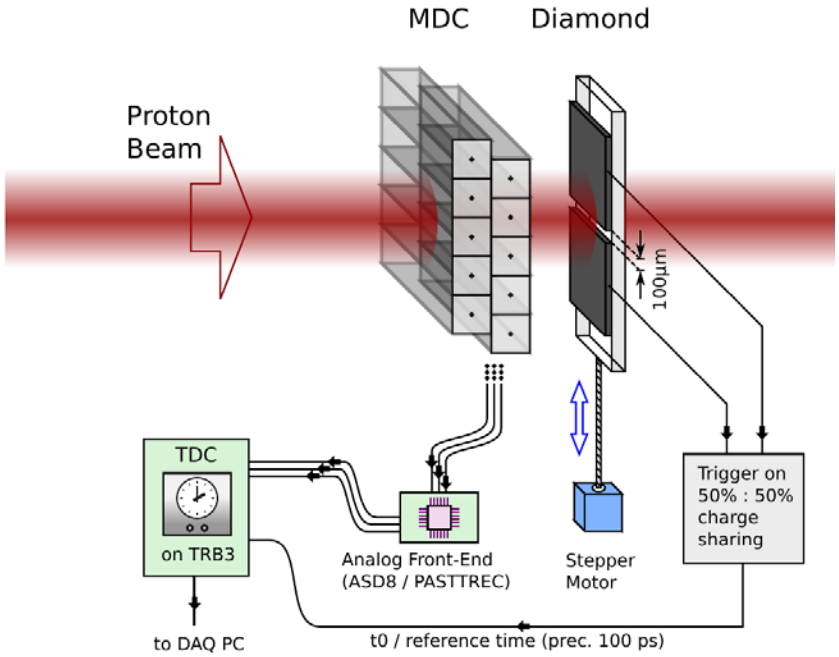
- FPGA-based high precision TDC measurement and DAQ in one
- Leading edge precision: 8-12ps (RMS)
- Very flexible trigger functionality (FPGA)
- Hit rates < 50 MHz (burst)



Used in many FAIR Projects:

- HADES (diamond/trigger/RICH/ECAL),
- CBM RICH,
- PANDA (Barrel-DIRC/Straw)
- and also outside of FAIR: MUSE, A1, ...

MDC & Diamond setup

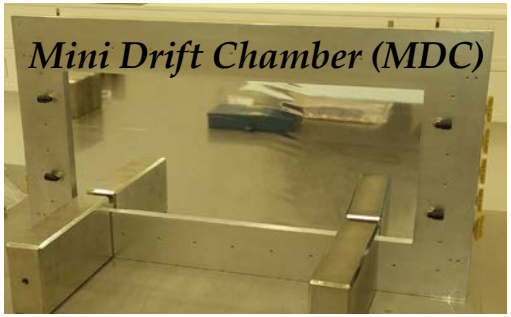


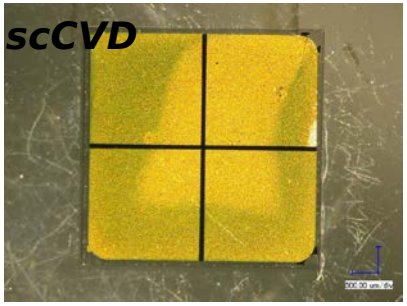
Goals:

- Study drift velocity map inside drift cell, gas mixture dependency
- Compare precision of old & future HADES analog ASICs
- Measure spatial resolution of full system: MDC + analog + digital electronics with standalone DAQ

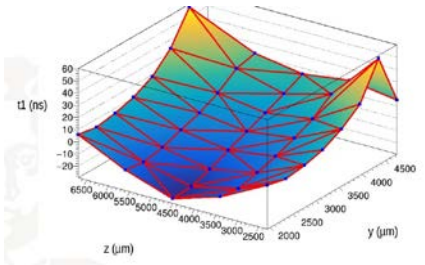
Setup:

- Mini Drift Chamber (MDC)
  - 50x20 cm² active area
  - 2 drift cell layers,
  - each 40 cells (5x5 mm²)
- reference / tracking by Diamond (scCVD) detector:
  - 4 channels, 100µm gap
  - time precision < 100 ps
  - movable (µm step precision)





drift time map inside a single drift cell (measured by laser ionization @ HZDR)



(3) Application for beamtime in Q1/2018

(a) One week of electronics tests in high-intensity proton beam (February 2018)

- STS-XYTER v2 ASIC: near-final chip before its mass production;

  carry out more detailed investigations of open questions:
  - verify single-event for register cells of different architectures
  - verify unexpected latch-up events observed previously
  - verify potentially dose-rate dependent failures at highest COSY intensities (> 7 × 10^9 protons/spill of 5 seconds)
- Test new custom-designed LDOs for effects of total ionizing dose and fast transients.
- Test robustness of new Fault Tolerant Local Monitoring and Control (FTLMC) board against SEU radiation effects
- Different FPGA electronics will be tested for single-event upsets and the effectiveness of data correction methods.

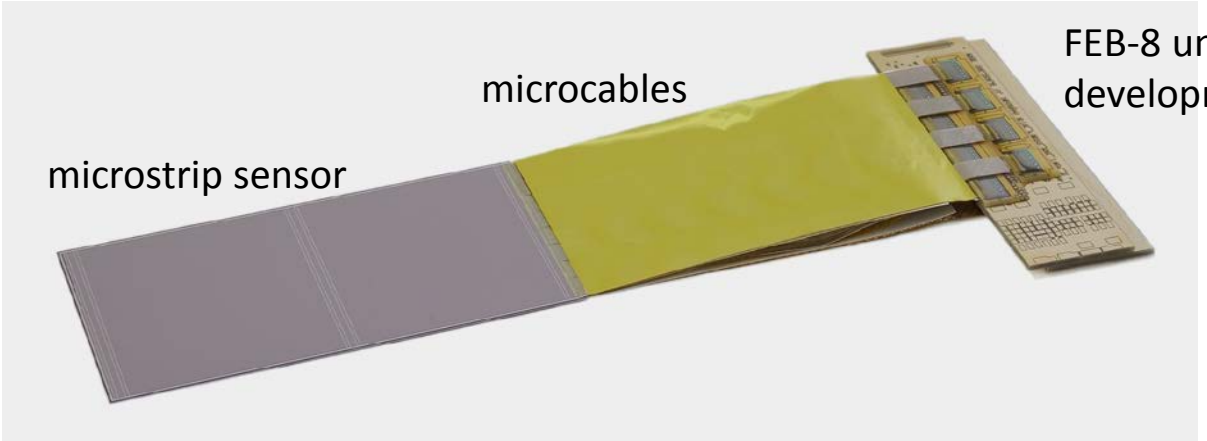
(3) Application for beamtime in Q1/2018

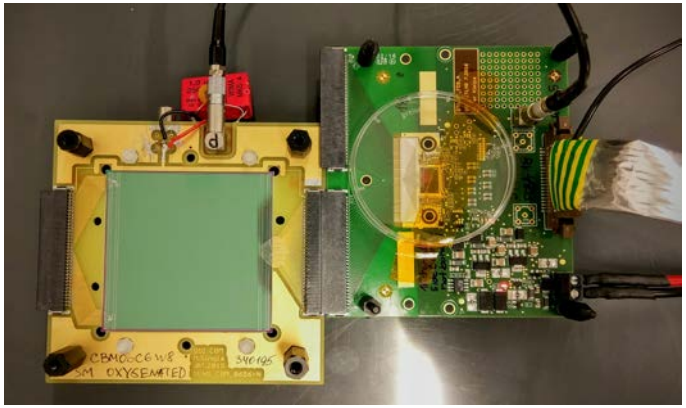
(b) One week of detector tests in mid-intensity, widened proton beam (February or early March 2018)

- Test of prototype STS modules read out with the STS-XYTER v2 ASIC
  - The module will employ the final prototype sensors and microcables bonded to STS-XYTER v2 ASICs mounted on a technical prototype of the front-end electronics board.
  - Several modules shall be tested for their detection performance in a particle beam covering a good fraction of the silicon sensors. Beam widened to the pipe diameter in the Big Karl cave (about 6 cm diameter) is well suited to such test.
- T0 Diamond detector test

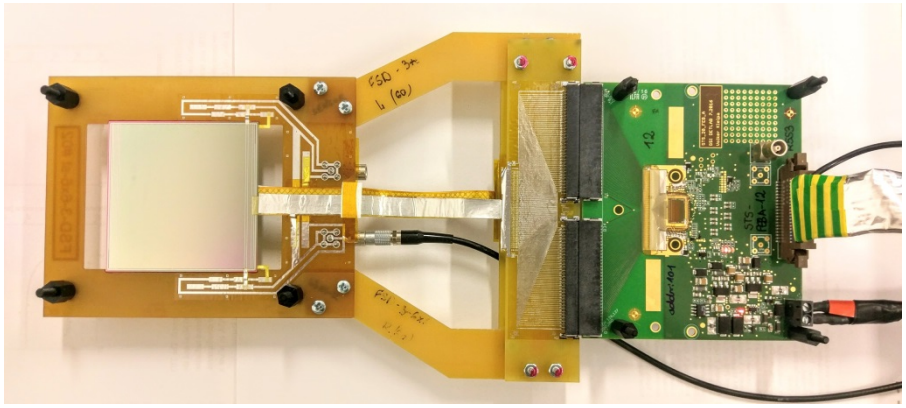
Prototype STS module read out with the STS-XYTER v2 ASIC

dummy module from assembly trials





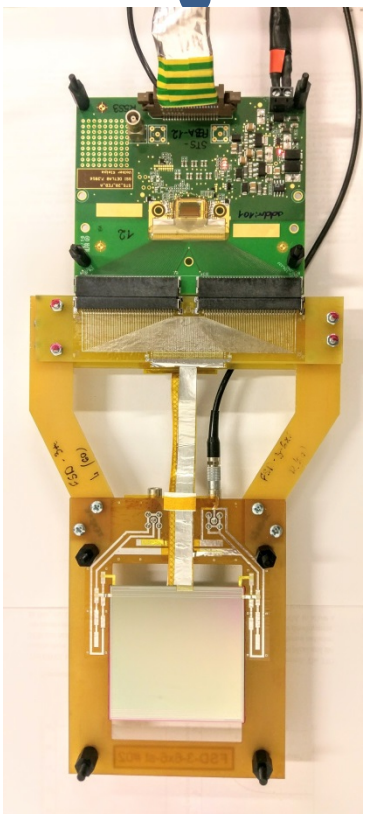
STS-XYTERv2 test board connected to a silicon microstrip sensor



prototype module with STS-XYTERv2 read-out under preparation

Prototype STS module read out with the STS-XYTER v2 ASIC

STS-XYTER FEB (r/o front + back) 2x 128 chs



2 x 1 E-Link

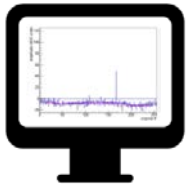
AFCK-DPB

key issue to be addressed:
S/N as function of micro cable length

IP bus

FLES node

FLIB



CBM request October 2017 summarized

Total number of particles and type of beam (p,d,polarization)	Momentum range (MeV/c)	Intensity or internal reaction rate (particles per second)	
		minimum needed	maximum useful
p	p ~ 2700 p ~ 400	~ 10^4	up to 10^6
Experimental area	**Safety aspects (if any)**	**Earliest date of installation**	**Total beam time (No.of shifts)**
JESSICA or Big Karl Cave	**None**	**October 2017** **Detector tests:** **DiRICH readout, T0**	**7 days around the clock** **(installation of equipment in advance of the beamtime week advantageous)**

CBM application Q1/2018 summarized

Total number of particles and type of beam (p,d,polarization)	Momentum range (MeV/c)	Intensity or internal reaction rate (particles per second)	
		minimum needed	maximum useful
p	p ~ 2700	~ 10^4 – 10^6 (detector tests)	up to 10^9 (electronics tests)
Experimental area	**Safety aspects (if any)**	**Earliest date of installation**	**Total beam time (No.of shifts)**
JESSICA or Big Karl Cave	**None**	**February 2018** **electronics tests: front-end ASIC STS-XYTERv2, power regulators,control boards, FPGA**	**7 days around the clock** **(installation of equipment during the beamtime week is sufficient)**
Experimental area	**Safety aspects (if any)**	**Earliest date of installation**	**Total beam time (No.of shifts)**
Big Karl Cave	**None**	**February/early March 2018** **detector tests: prototype STS module with STS-XYTERv2 read-out , T0**	**7 days around the clock** **(installation of equipment during the beamtime week is sufficient)**