Westfälische Wilhelms-Universität Münster

Offline Event-Building with CBM-TRD Prototype FLES Data (CERN-SPS Beamtest 2015)

DPG-Frühjahrstagung 2016
2016, March 14th

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Bundesministerium für Bildung und Forschung
GSI
FAIR
Seventh Framework Programme
Study of Strongly Interacting Matter
HadronPhysics

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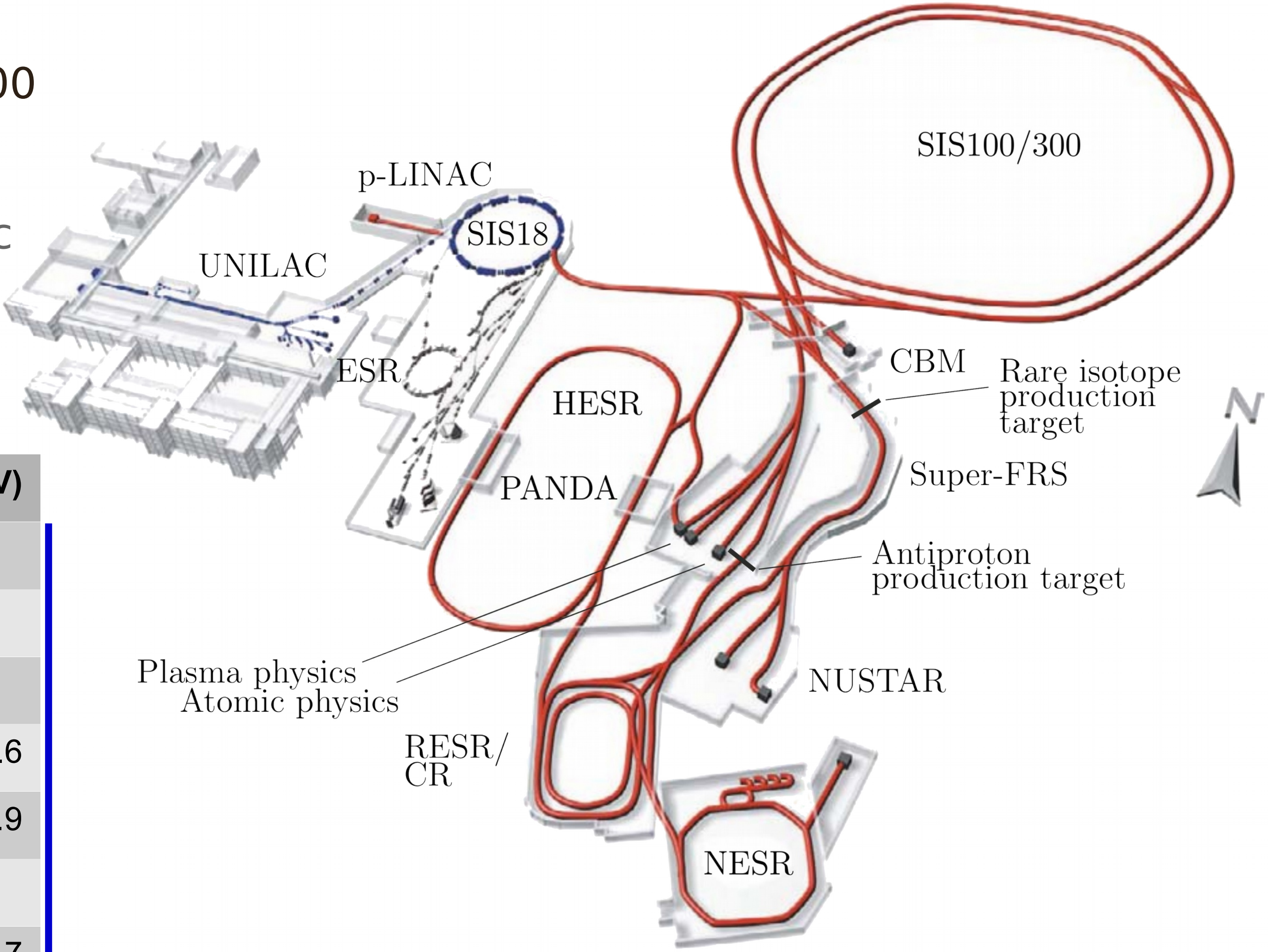
The CBM-TRD in FAIR

- In construction: SIS100 (magnetic rigidity of 100 Tm)
- **C**ompressed **B**aryonic **M**atter as one of the four pillars of FAIR
- Upgradeable: SIS300

beam	Z	A	E (AGeV)
p	1	1	29
d	1	2	14
Ca	20	40	14
Ni	28	58	13.6
In	49	115	11.9
Au	79	197	11
U	92	238	10.7

SIS100 energies



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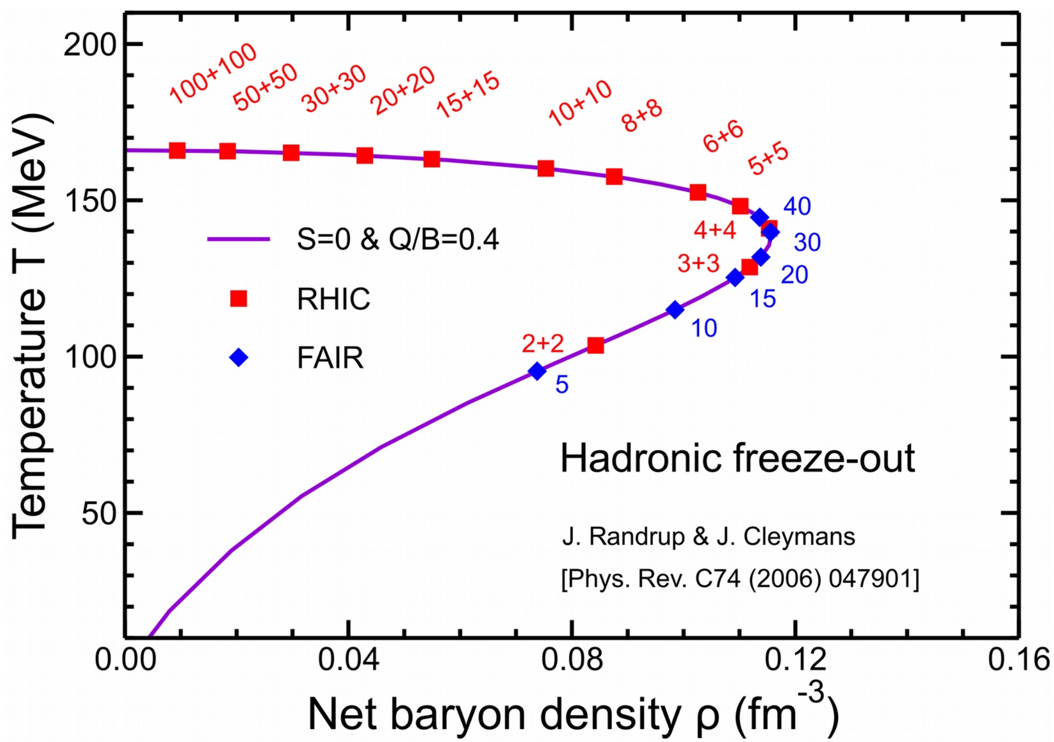

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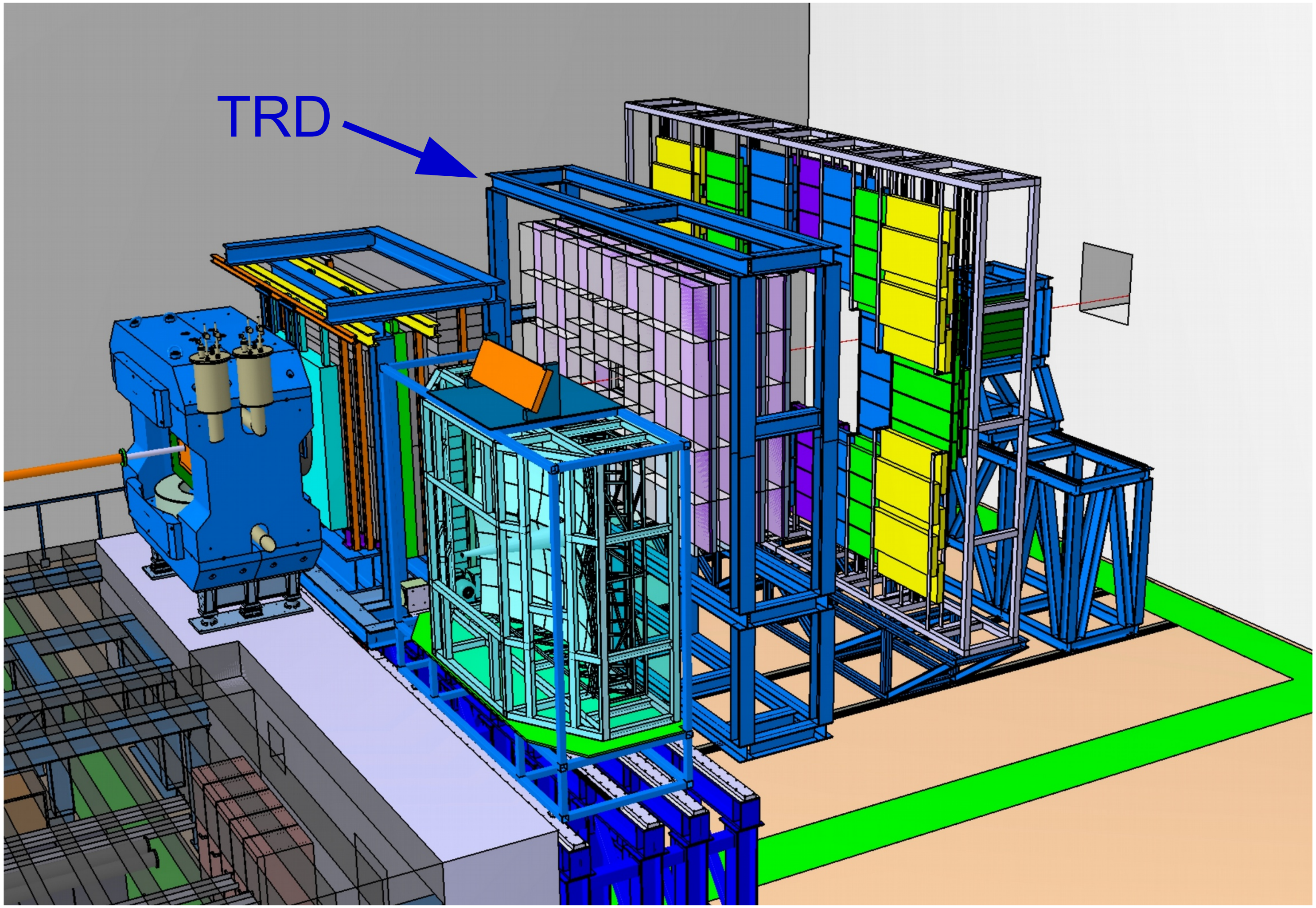
The CBM-TRD in FAIR

- MVD+STS
  Micro-Vertex Detector + Silicon Tracking Station
  magnetic field
- MUCH or RICH
  MuonChambers/ Ring imaging Cherenkov Detector
- TRD
  Transition Radiation Detector
- TOF
  Time Of Flight
- PSD
  Projectile Spectator Detector



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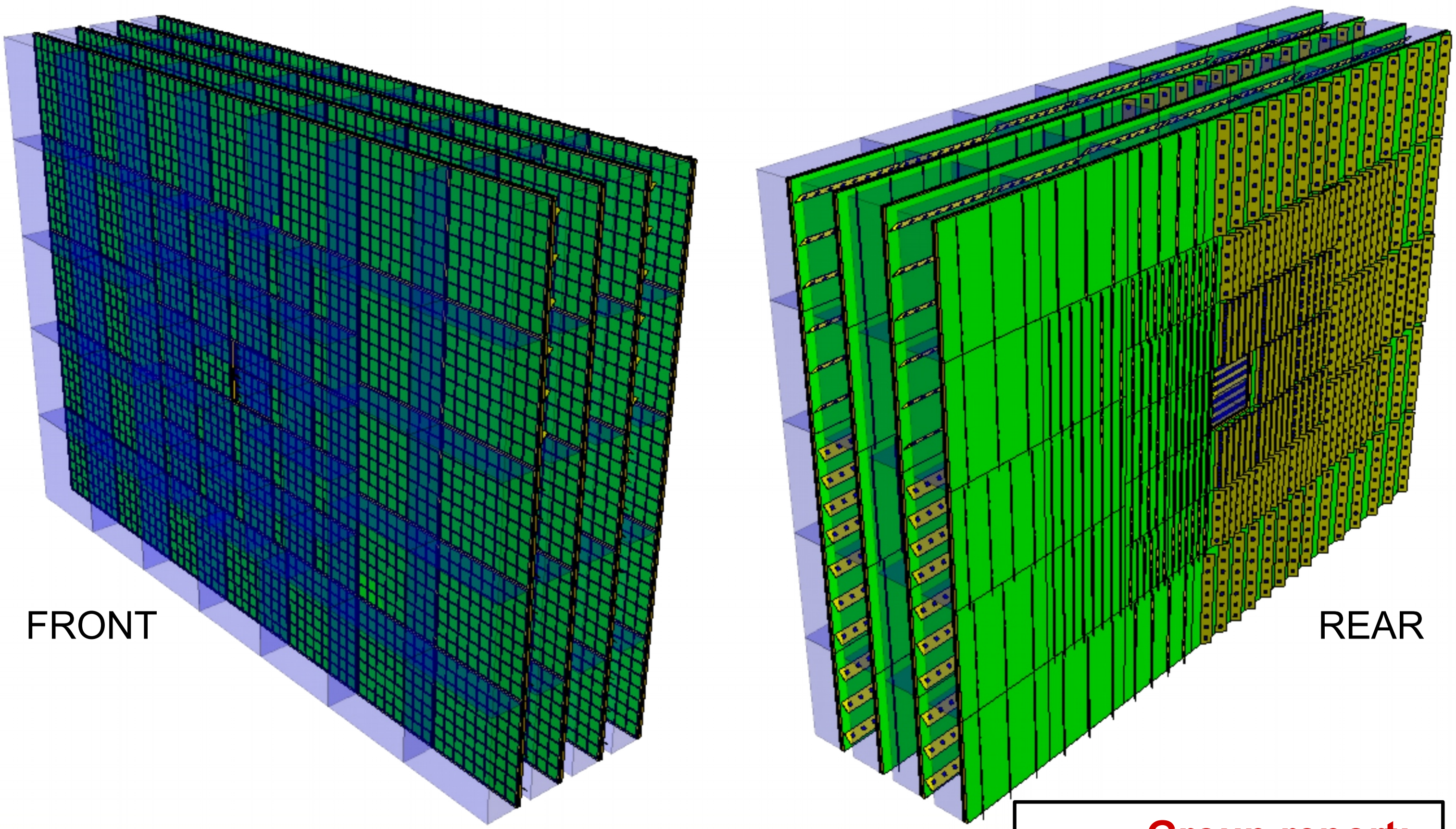
The TRD in CBM

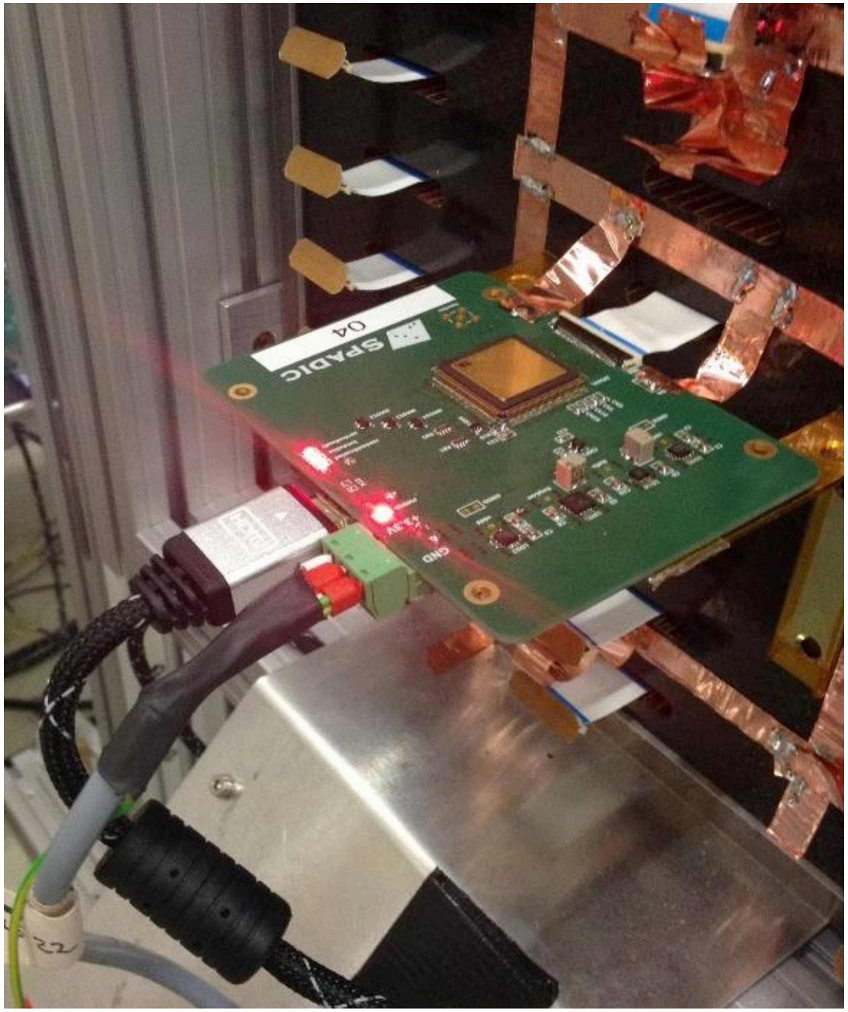
- TRD in total:
  4 layers with 2 MWPChamber sizes (central regions: higher rates)
  - Plus <u>radiator</u>: irregular type, foam (polyethylene)



Group report: Cyrano Bergmann, HK 44.1, Wed 16:30

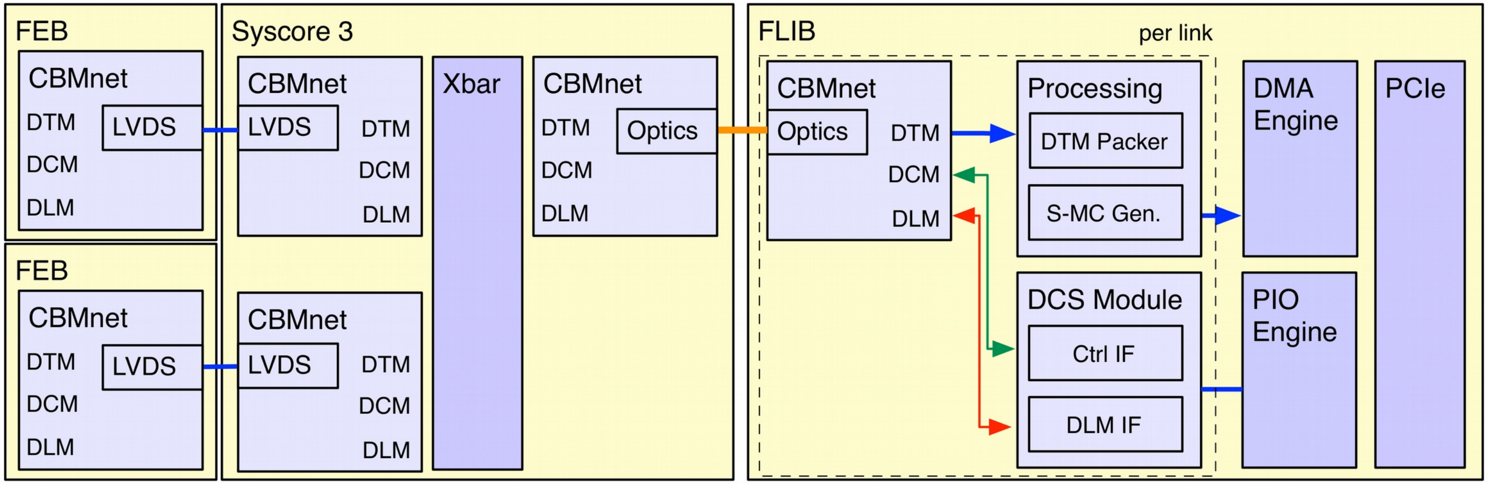
CBM-TRD Readout: SPADIC

- Readout of the cathode pads with *Self-triggered Pulse Amplification and Digitization ASIC* (SPADIC)
- Charge-sensitive amplifier with 32 channels
- Free-streaming
- Digitising 32 samples, 40 ns each
- Forced neighbour readout (sensitivity despite high trigger thresholds)
- Digital filter implemented: time shortening by tail cancellation
- Ongoing development



CBM-TRD Readout: DAQ Chain

- *Front End Board* (FEB): SPADIC
- *SysCore* boards streaming hit messages of 6 SPADICs to PC port
- *First Level Event Selector* (FLES) processes messages into data containers



scheme from Dirk Hutter, 23rd CBM Coll. meeting

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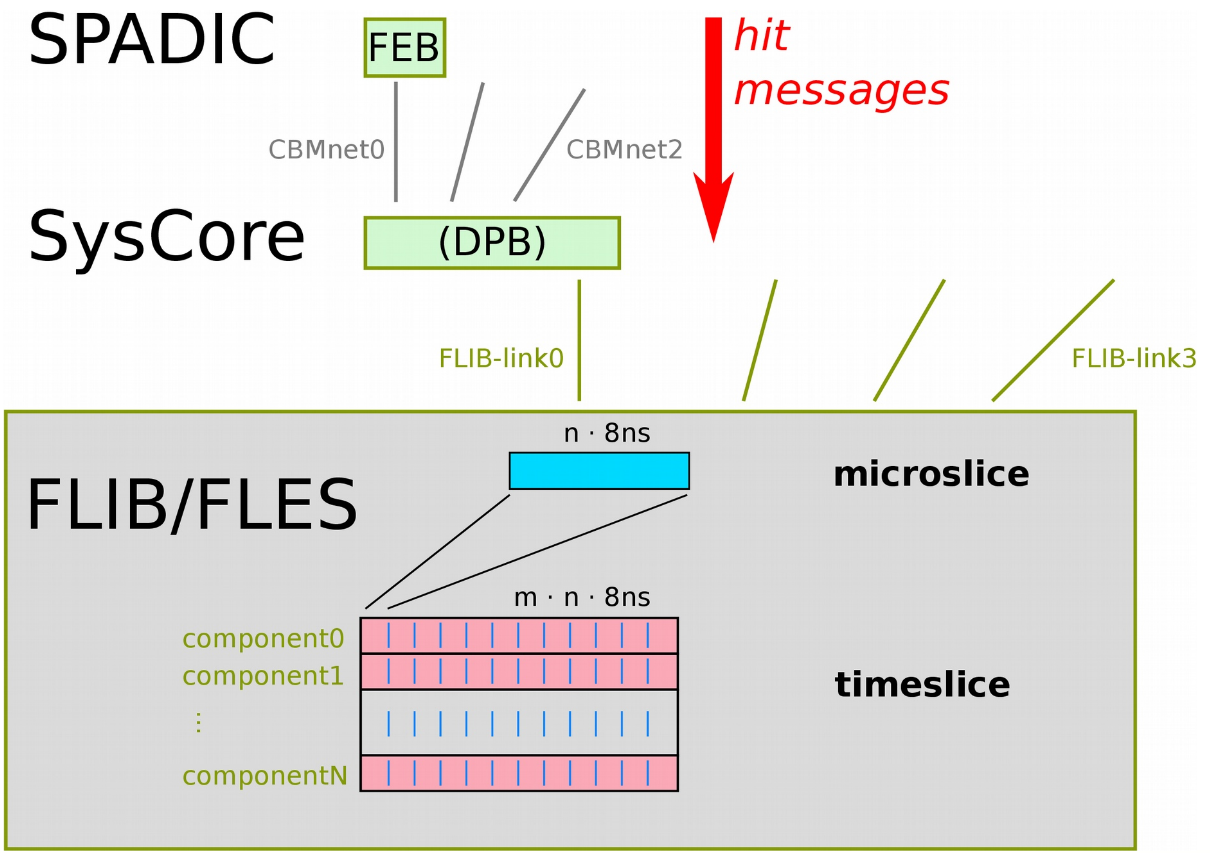
CBM-TRD Readout: DAQ Chain

- Principle allows various microslice sources
- Ringbuffers minimize memory consumption, maximise throughput

Towards event-building:

- The SPADIC-unpacker *extracts hit messages* from the timeslices

- Full-time calculation currently in validation



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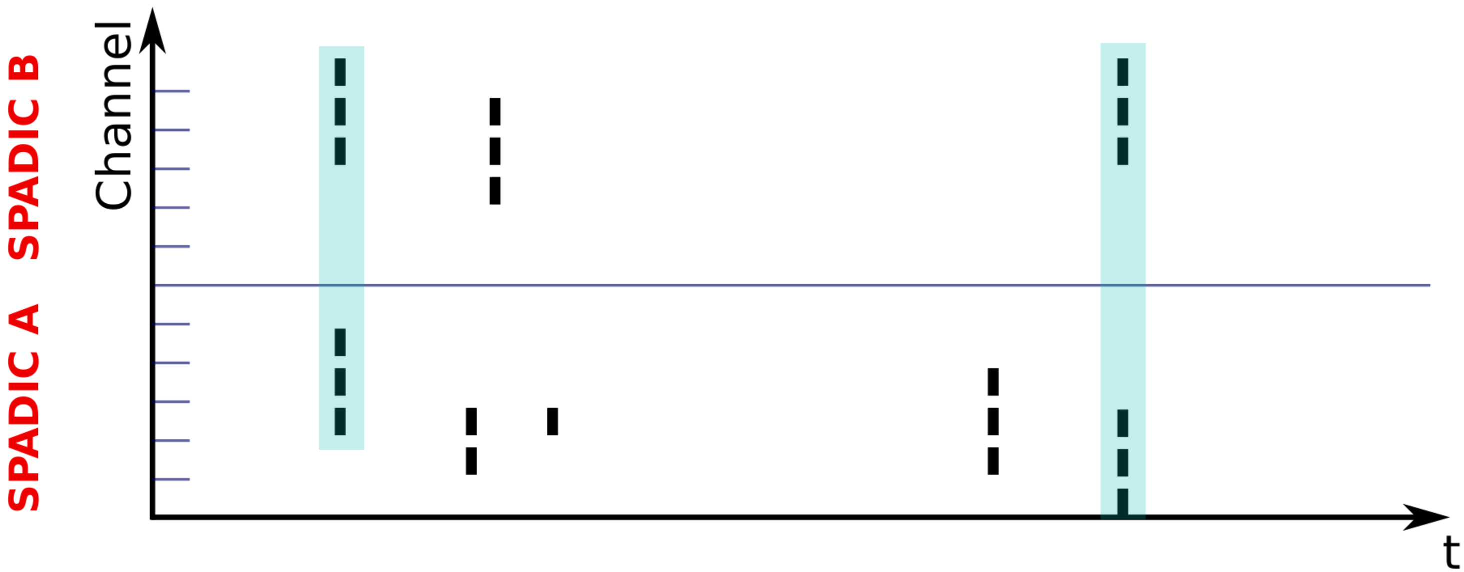
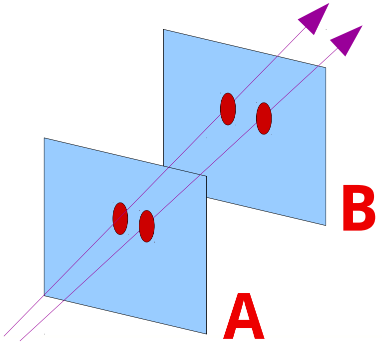
Starts of Data Analysis: Spatial Correlation





- Let SPADIC A and SPADIC B be projective behind target
- Hits from one event to be correlated

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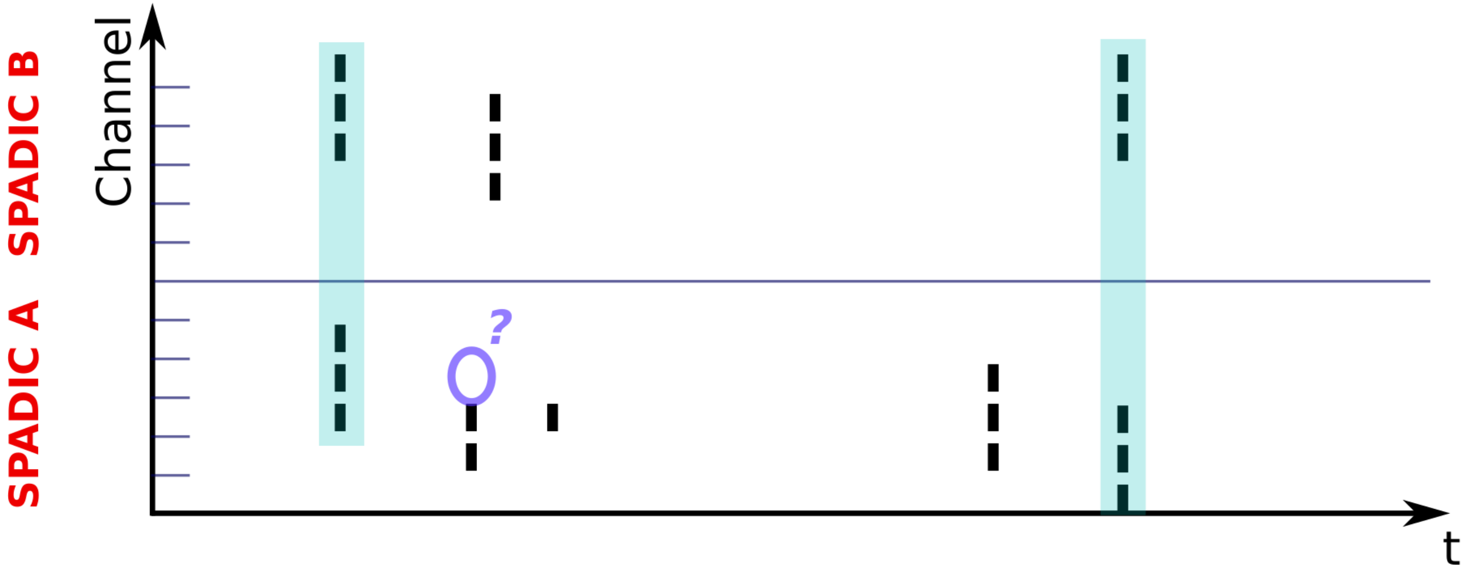

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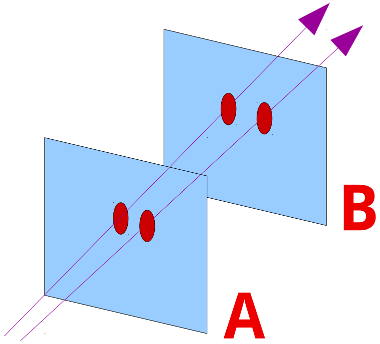

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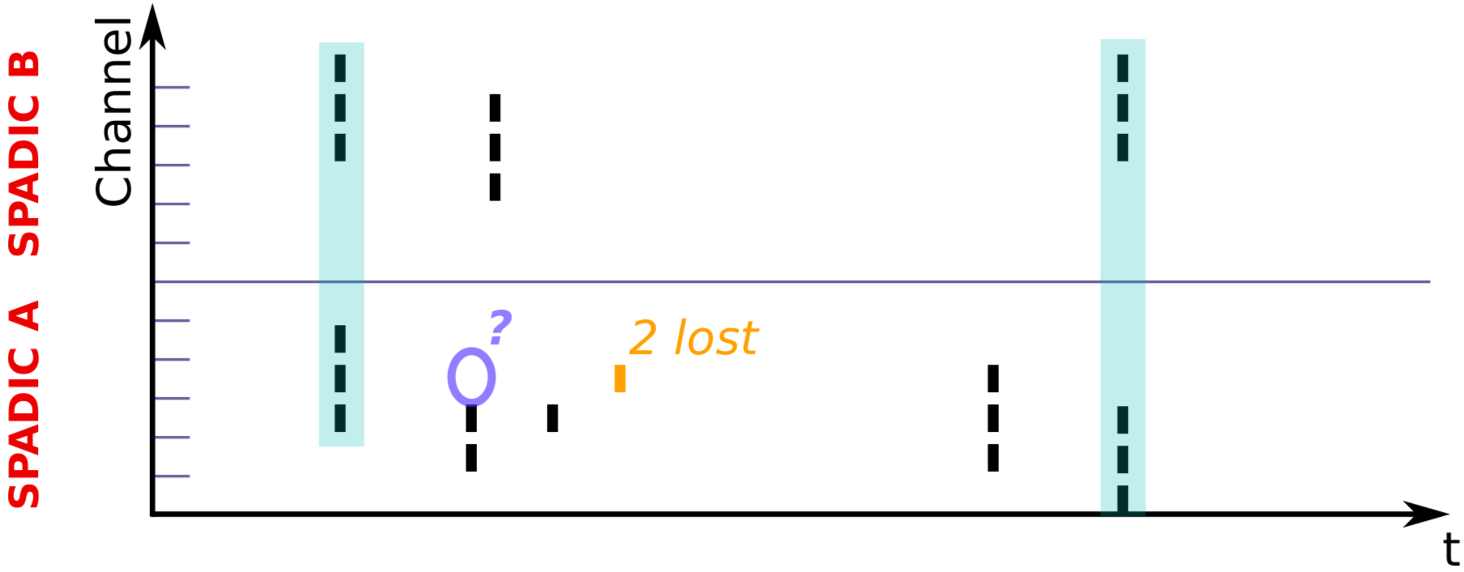
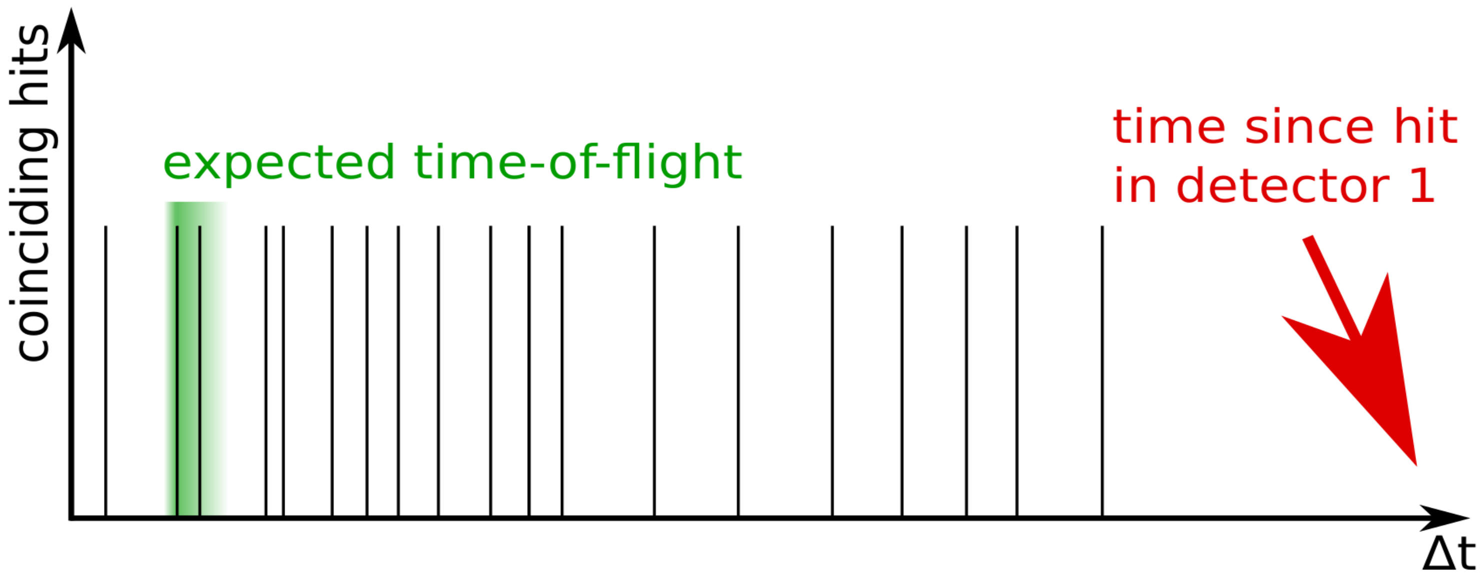


- Let SPADIC A and SPADIC B be projective behind target
- Hits from one event to be correlated
- Needed: Routines for message loss, e.g. caused by high-rate environment

Starts of Data Analysis: Time Correlation



- Let SPADIC A and SPADIC B be projective behind target
- Hits from one event to be correlated
- Needed: Routines for message loss, e.g. caused by high-rate environment
- Needed: Routines for association in time

Starts of Data Analysis: SPS 2015 Testbeam

- Testbeam at the CERN-SPS, Nov. 2015
- Pb 30 AGeV beam on Pb target
- SPADICv1.0 readout on 3 diff. prototypes,
  2 of them in line
- Interaction rates up to 10^5 Hz

<u>Measurements:</u>

- SPADIC read-out
- HV-currents recorded with 2.5 Hz

Photo: David Emschermann

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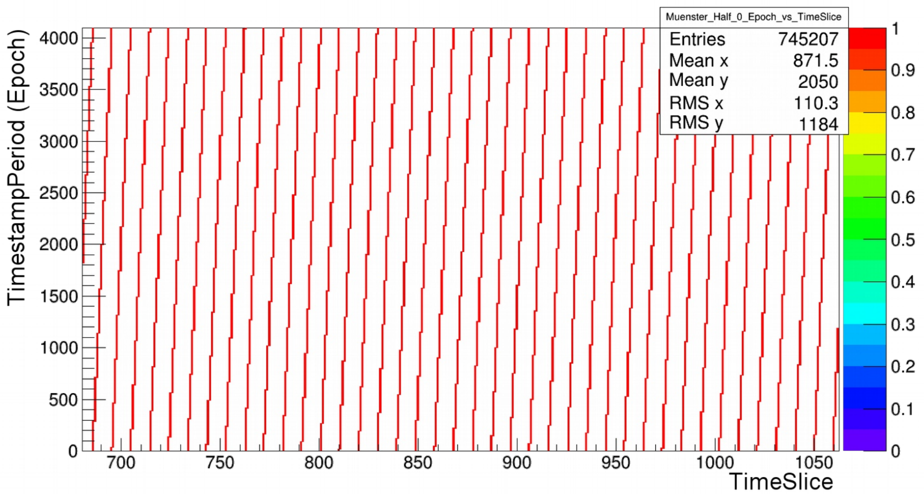
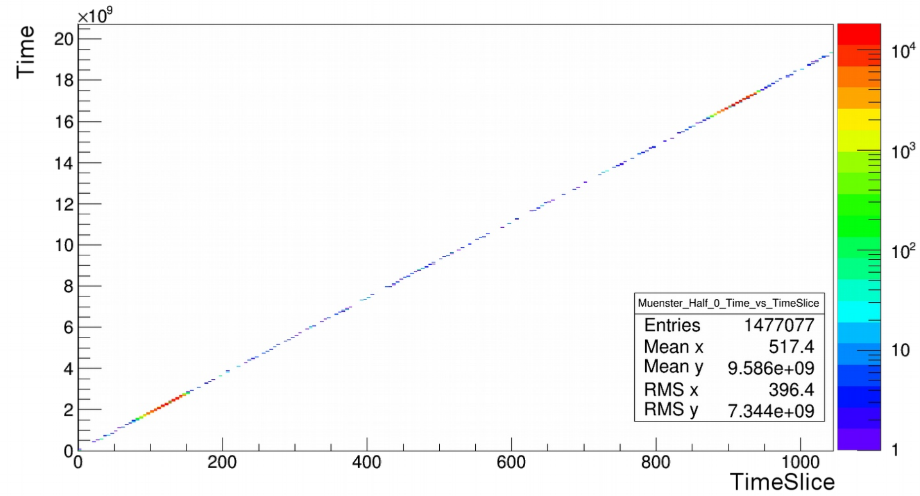
Starts of Data Analysis: Timing Validation

- Work in progress: Validation of time reconstruction



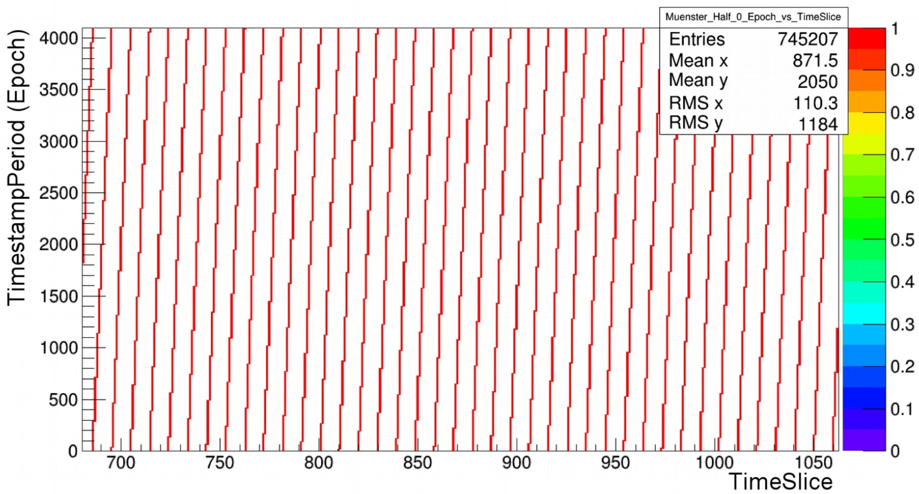


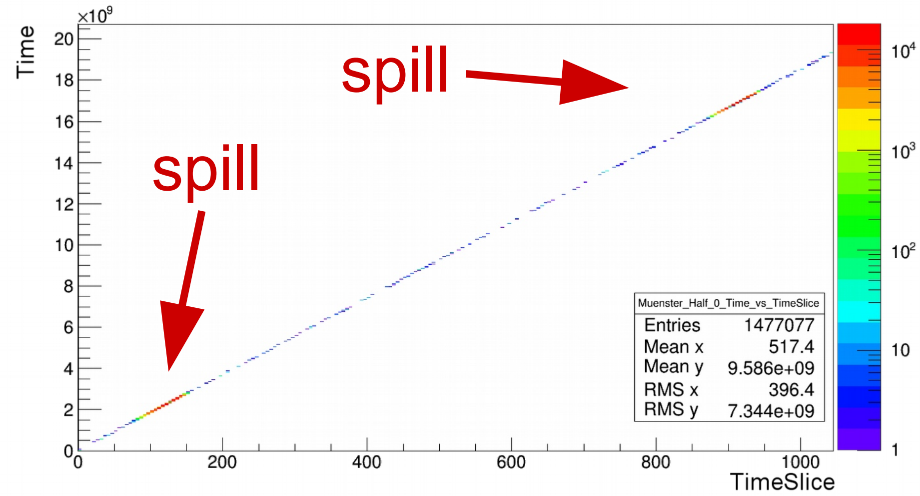
real time vs. processing (recording) time

- time is counted in the SPADIC as:
  - timestamp (12 bit, unsigned) with clock derived from outer frequency
  - timestamp periods are “epochs”

Starts of Data Analysis: Timing Validation

- Work in progress: Validation of time reconstruction





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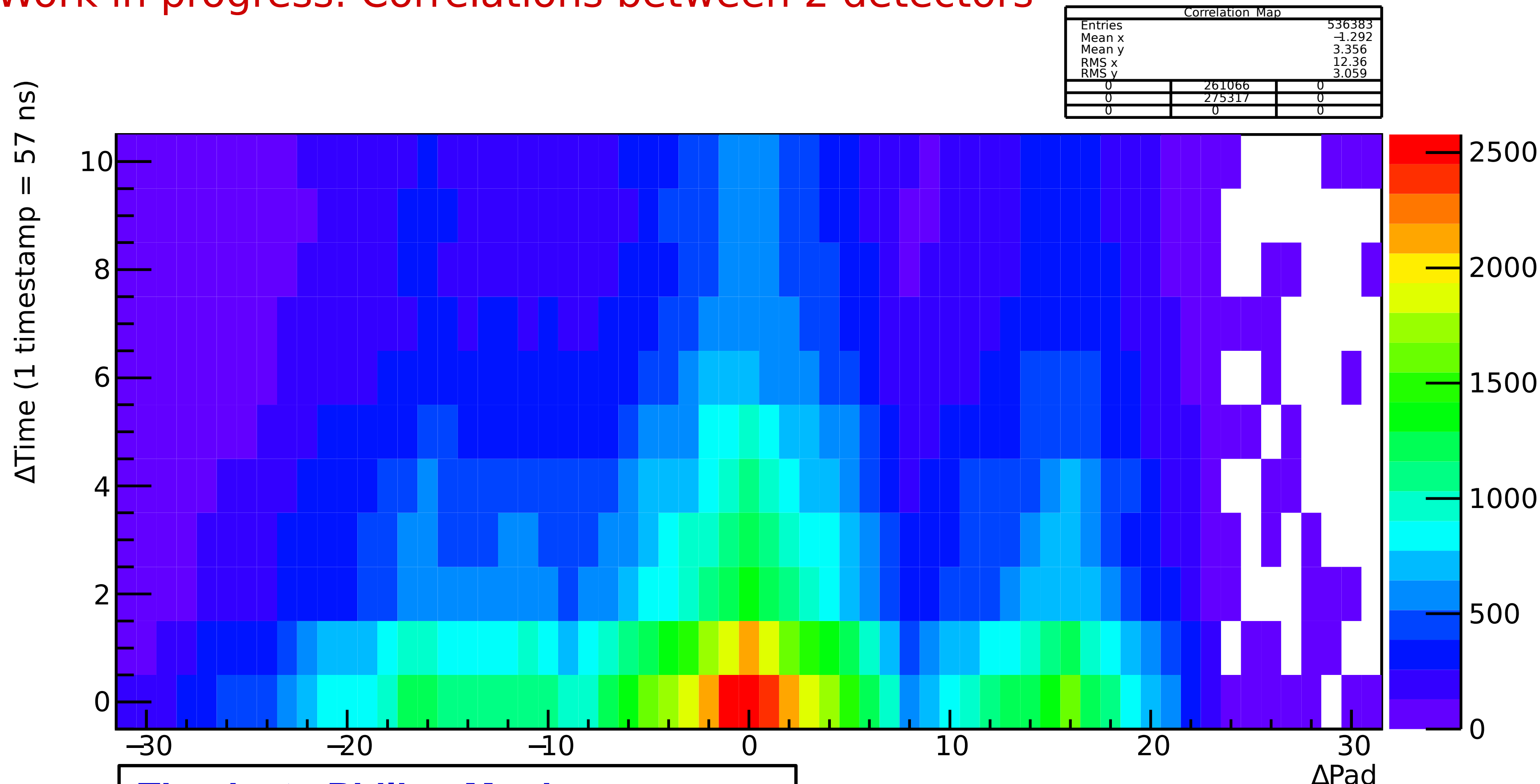
Starts of Data Analysis: Correlation

- Work in progress: Correlations between 2 detectors



Thanks to Philipp Munkes for works on an efficient clusterizer

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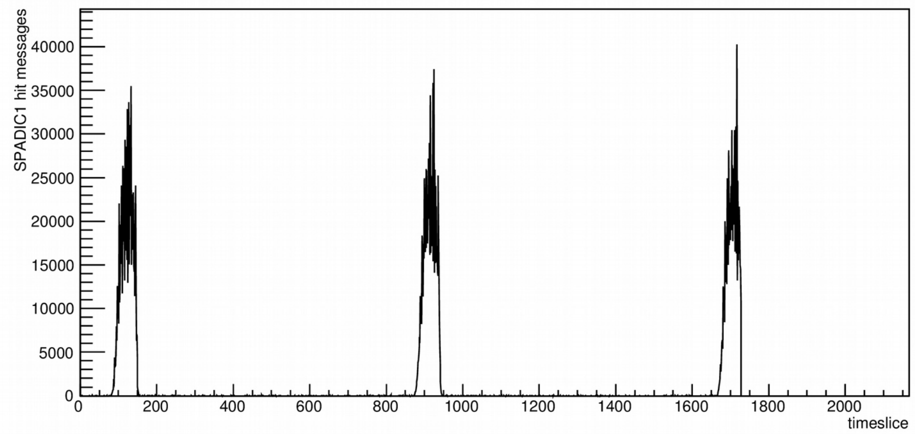
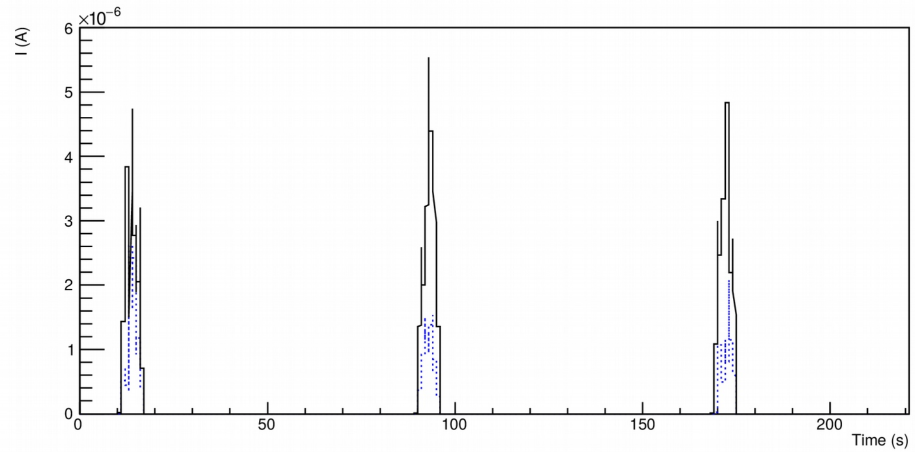
Outlook and Summary

- Next local steps:
  - Proceed in spatial and time correlation
  - Optimise SPADIC settings for high rate capabilities
  - Systematically analyse HV behaviour



FLES

- And more global:
  - Production of 4 large-sized prototypes
  - Release + test of the SPADICv1.1 chip



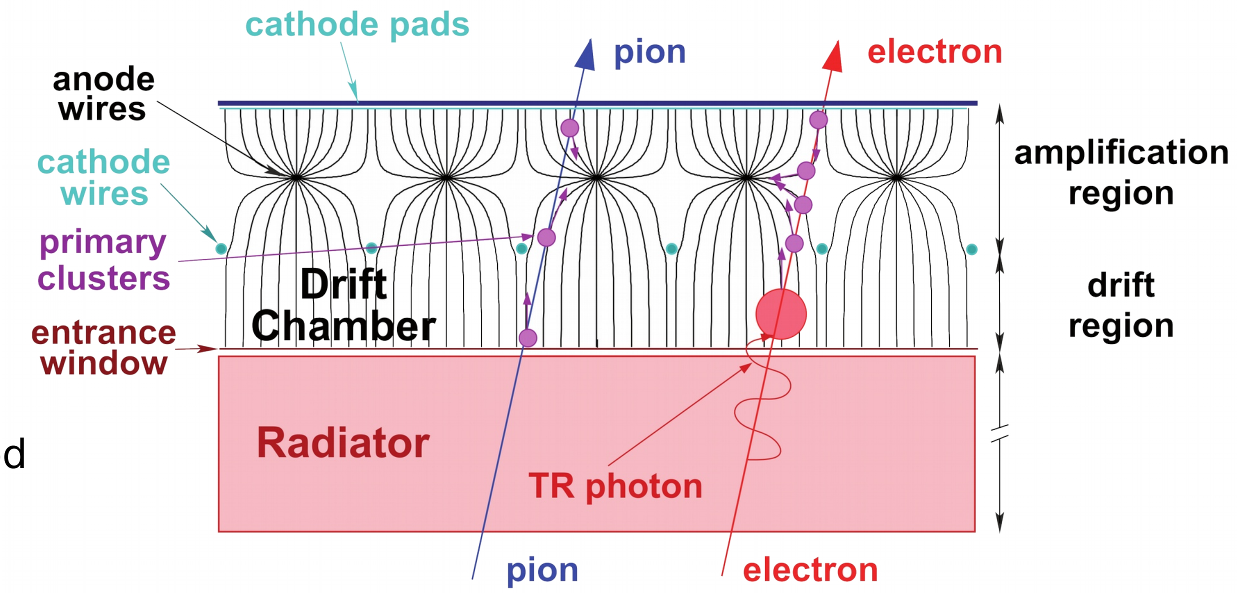
HV currents

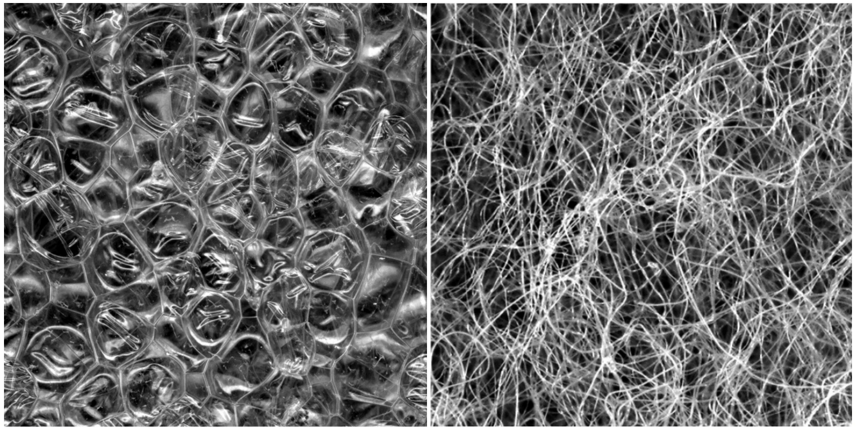
→ Fully equipped beamtime measurements with large acceptance (improved correlation)

BACKUP

The TRD in CBM

- TRD in principle:
  - Multi-wire proportional chamber-based
  - Transition radiation emitted at ε-transitions
  - Intensity of TR is ~ γ (idealised)
  - e/π-sep. e.g. by likelihood
- Regular and irregular radiators: foil, foam, fibers





Transition radiation at <u>one</u> ε-interface:

$$\left(\frac{d^2 N}{d\omega\, d\vartheta}\right)_{\text{interface}} = \frac{\alpha}{\pi} \cdot \left(\frac{\vartheta}{\gamma^{-2}+\vartheta^2+(\omega_{P,1}/\omega)^2} - \frac{\vartheta}{\gamma^{-2}+\vartheta^2+(\omega_{P,2}/\omega)^2}\right)^2$$

ω: photon frequency

$\omega_{P,i}$: plasma frequency of material i

α: fine structur constant

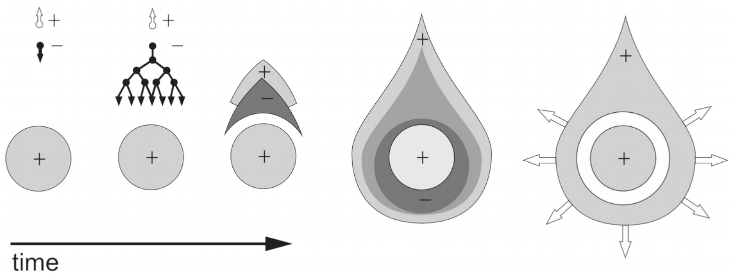
ϑ: emission wrt. particle motion

γ: Lorentz factor

The TRD in CBM

Development in progress

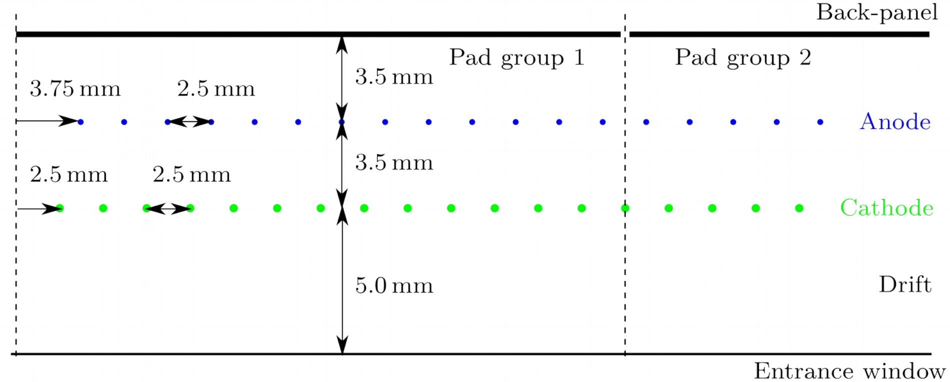
- High-voltage wire geometries in comparison: different prototypes
- Proportional chamber: rate limits



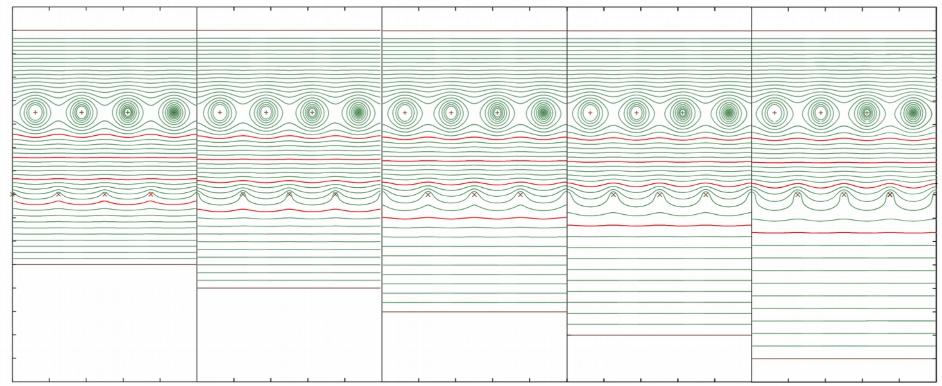
from F. Sauli, CERN lectures 1977

→ short ion drifts (3.5+5 mm)

- Special conditions: flexible cathode (entrance window)



Favoured Anode+Drift HV geometry



Example: Field distortion by entrance window stretching (Garfield sim.)

The CBM-TRD in FAIR

- Physics objectives
  - Intermediate mass di-leptons … continuum from thermal sources (1…3 GeV)
  - Fragments … hyper- and anti-nuclei
  - Quarkonia … are probes for deconfined matter
  - Low mass vector mesons … medium-modified spectra
  - Direct Photons … inverse slope fits as thermometer
- Design considerations
  - Pion rejection capability … pion suppression up to 50 and 10^4 with RICH
  - (Charged) Particle identification … dE/dx resolution below 30%
  - Tracking capabilities … track resolution below 300 µm (pad granularity)
  - High interaction rates … optimised: 5×10^6 Hz & realistic multiplicities
  - Tracking of muons … high track matching with the MUCH

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- Physics objectives
  - Intermediate mass di-leptons
  - Fragments
  - Quarkonia
  - Low mass vector mesons
  - Direct Photons

$^{6}_{\Lambda\Lambda}He \rightarrow {}^{5}_{\Lambda}He + p + \pi^-$

$^{5}_{\Lambda}He \rightarrow {}^{4}He + p + \pi^-$

or

$^{3}_{\Lambda}He \rightarrow d + p + \pi^-$

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