Westfälische Wilhelms-Universität Münster

CBM TRD

The CBM Transition Radiation Detector in Principle and First Time-Based Data Analysis

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Bundesministerium für Bildung und Forschung

GSI FAIR

Seventh Framework Programme

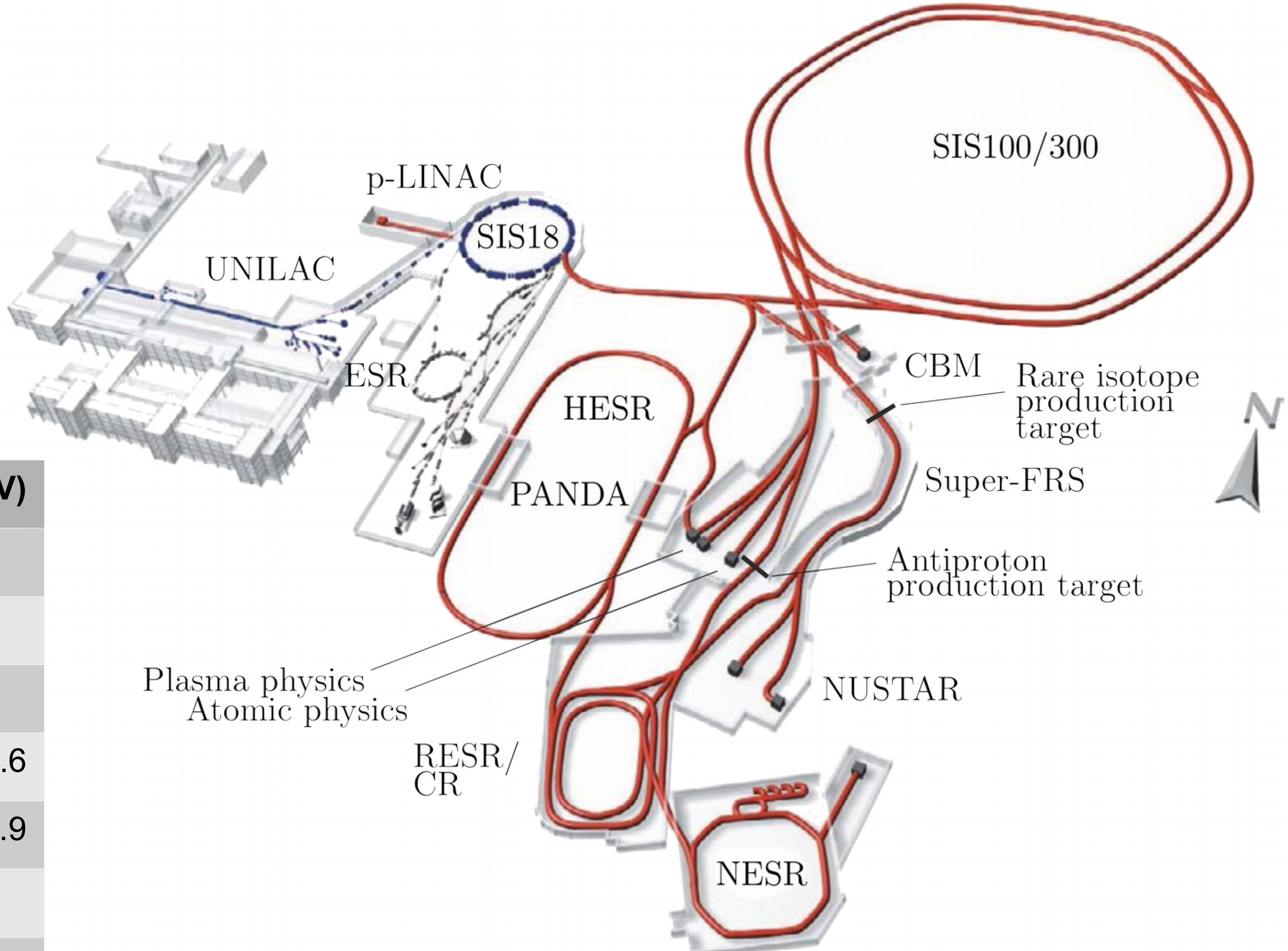
Study of Strongly Interacting Matter
HadronPhysics

The CBM-TRD in FAIR

- First goal: SIS100 (magnetic rigidity of 100 Tm)
- CBM as one of the four columns of FAIR
- SIS300 upgrade

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



The CBM-TRD in FAIR

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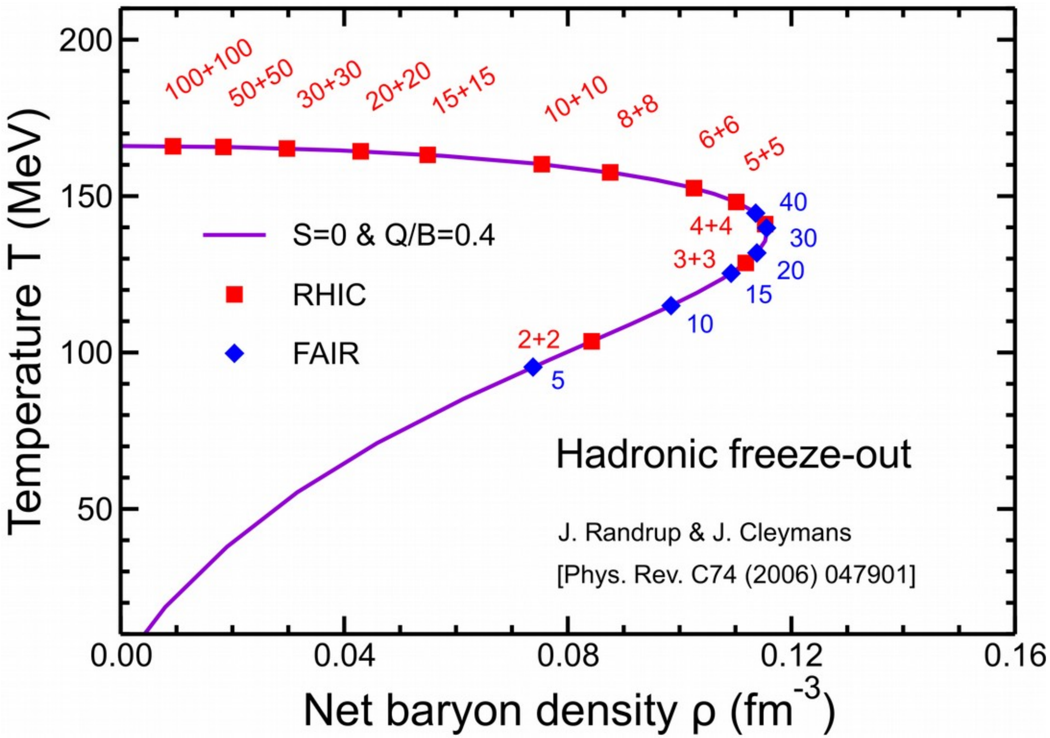
- CBM as one of the four columns of FAIR
- SIS300 upgradeable



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SIS100 energies

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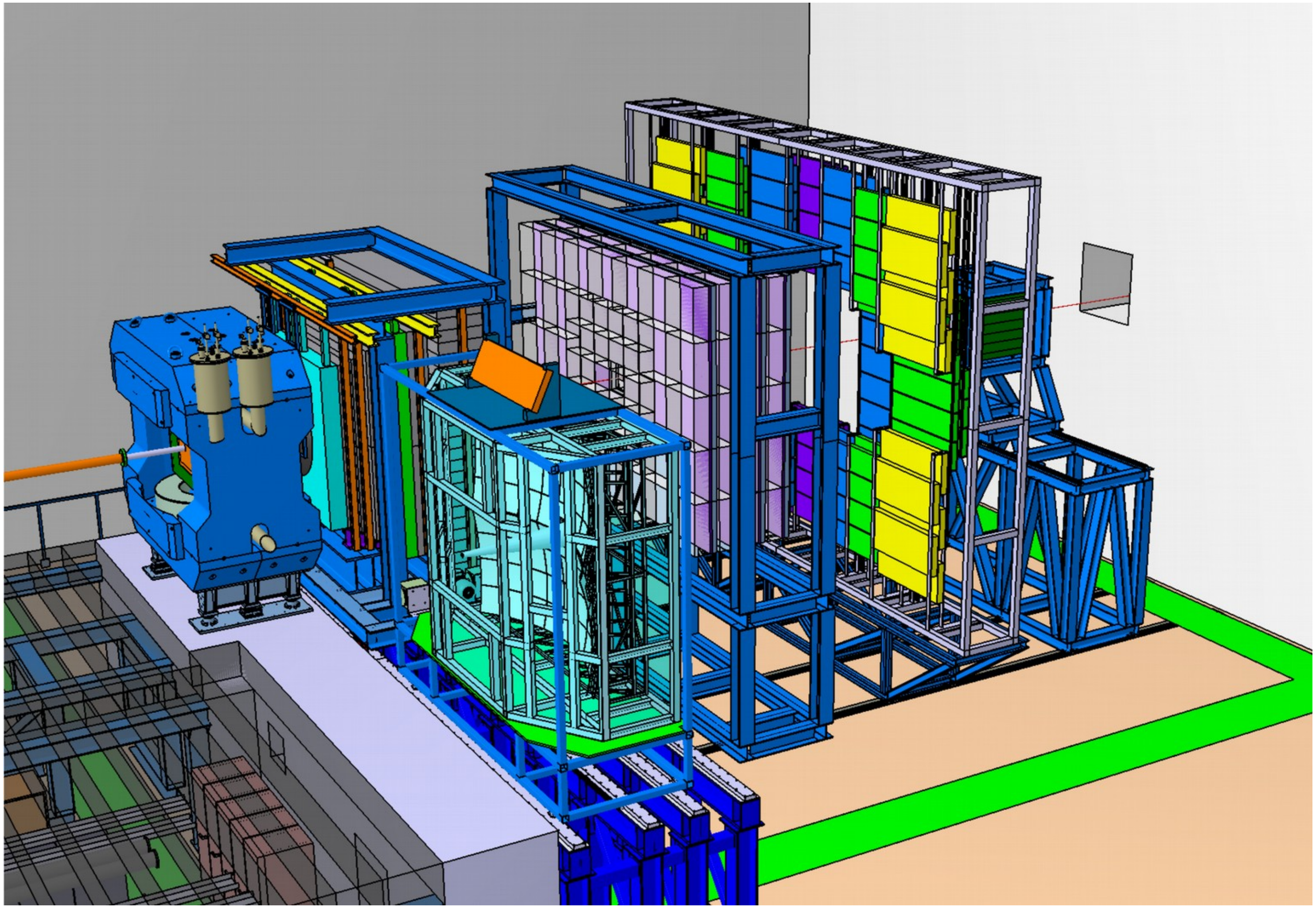
The CBM-TRD in FAIR

- 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



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 x 10^6 Hz & realistic multiplicities
  - Tracking of muons … high track matching with the MUCH

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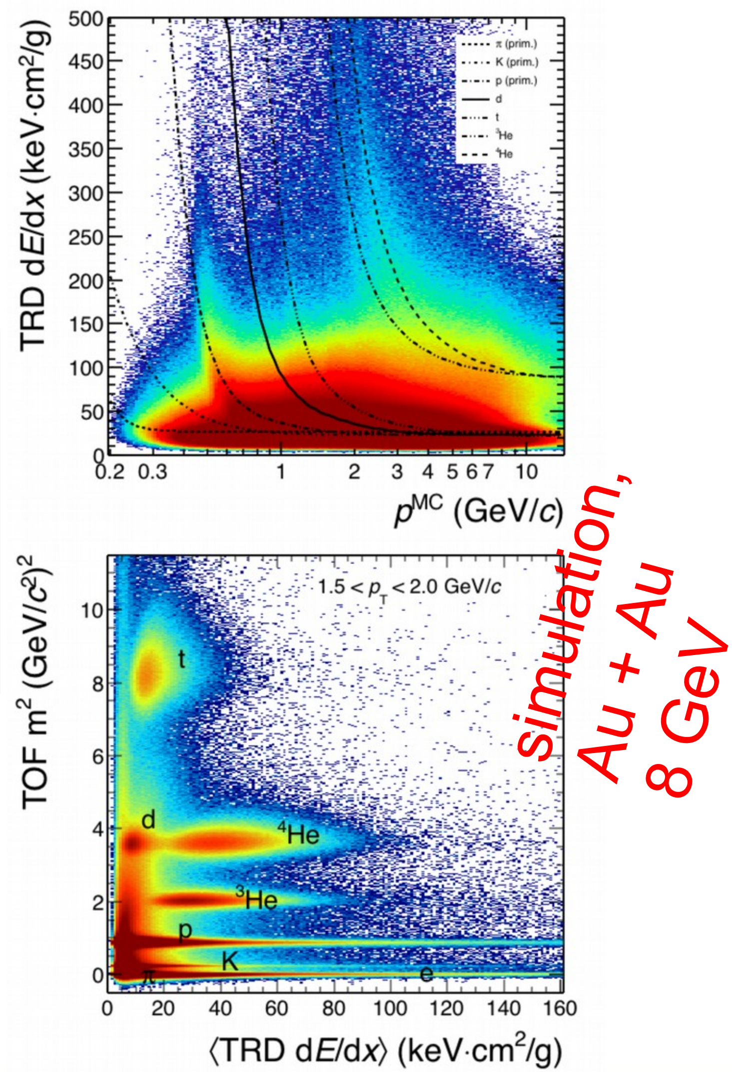
$${}^{6}_{\Lambda\Lambda}\mathrm{He} \rightarrow {}^{5}_{\Lambda}\mathrm{He} + p + \pi^-$$

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

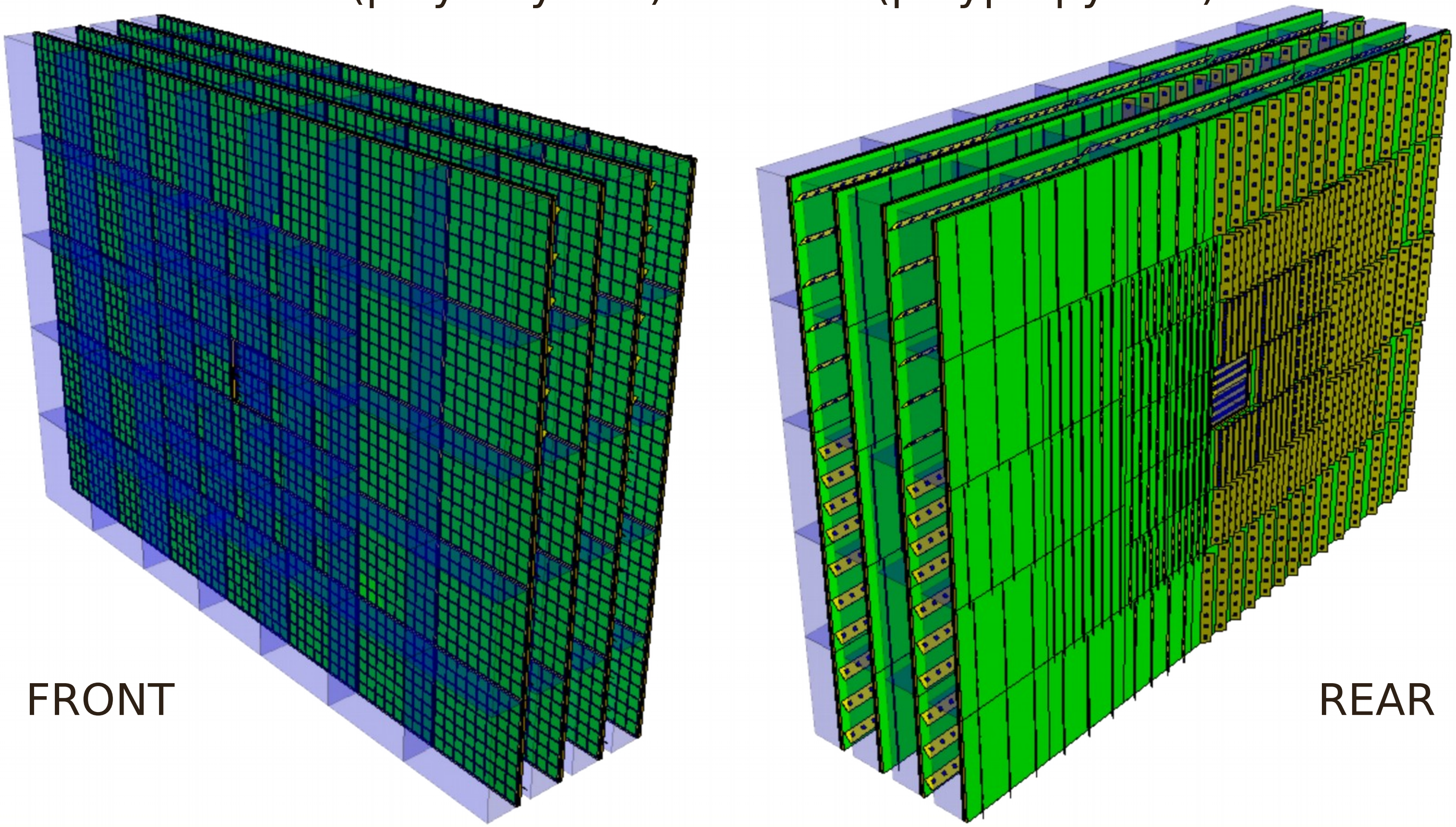
or

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



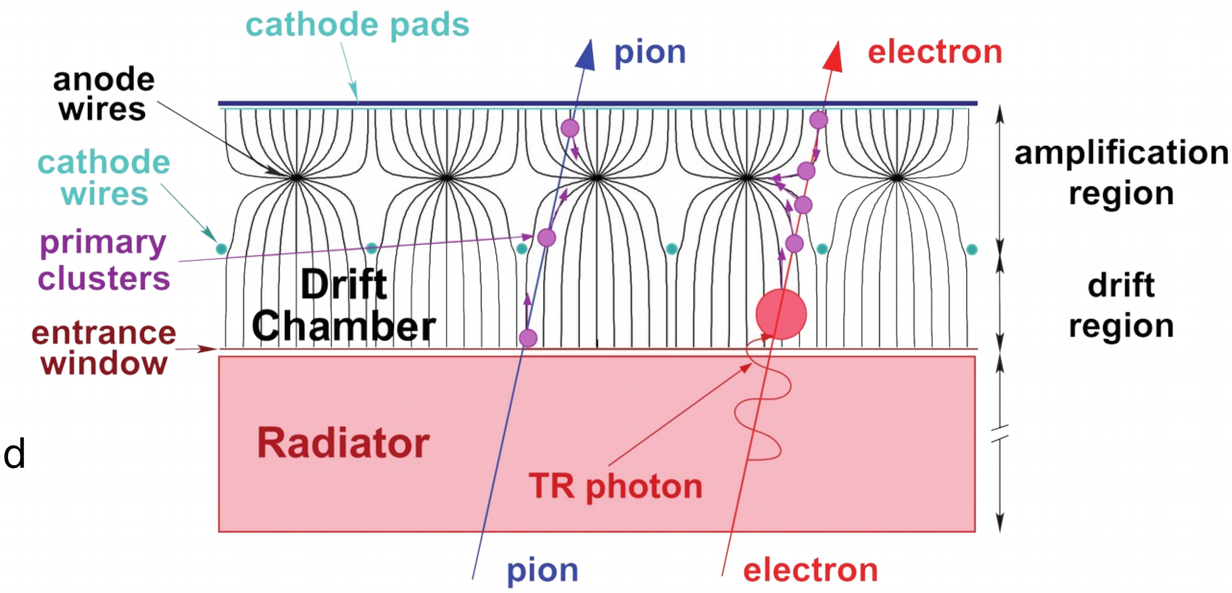
The TRD in CBM

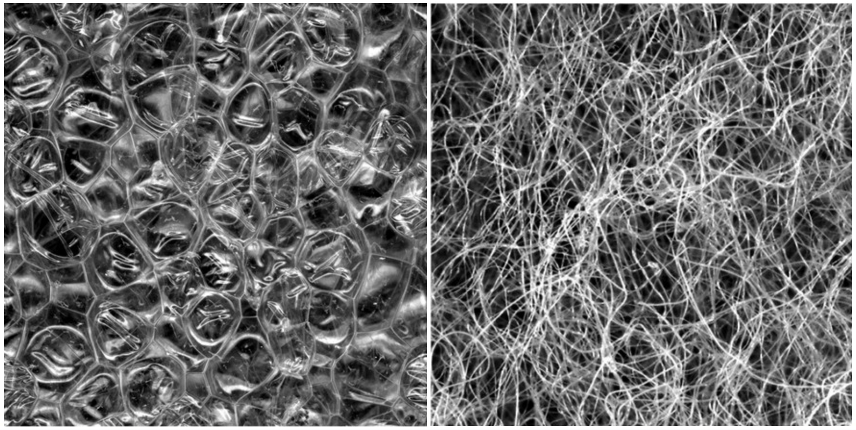
- TRD in total:
  4 Layers with 2 chamber sizes (central regions: higher rates)
  Plus radiator: irregular type, encapsulated or free-hanging,
  foam (polyethylene) or fibers (polypropylene)



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:

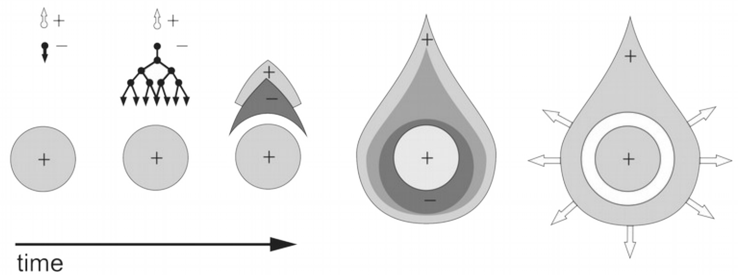
$$\left(\frac{d^2 N}{d\omega\, d\vartheta}\right)_{\text{interface}} = \frac{\alpha}{\pi}\cdot\left(\frac{\vartheta}{\gamma^{-2}+\vartheta^2+(\omega_{P,1}/\omega)^2} - \frac{\vartheta}{\gamma^{-2}+\vartheta^2+(\omega_{P,2}/\omega)^2}\right)^2$$

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

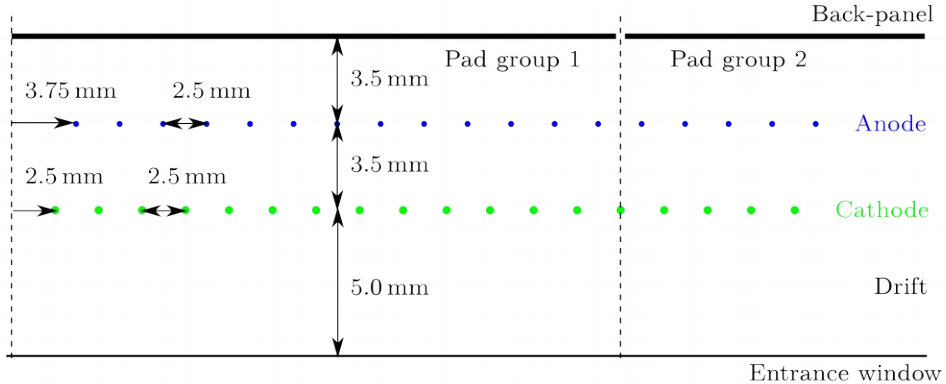
Development in progress

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

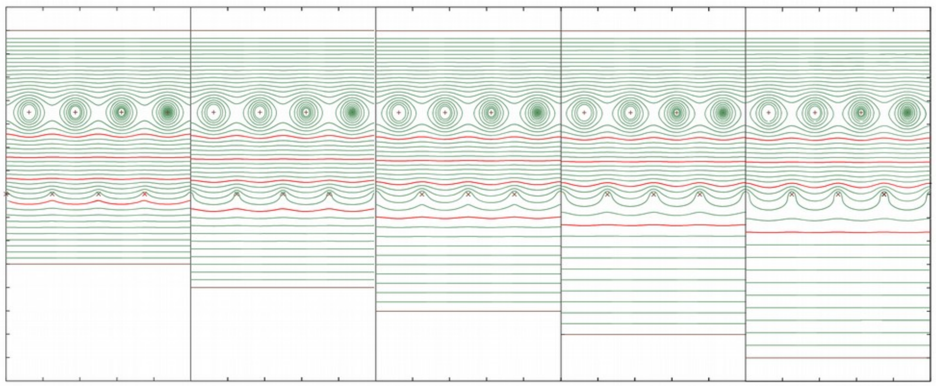


from F. Sauli, CERN lectures 1977

→ short ion drifts (3.5+5 mm)



Favoured Anode+Drift HV geometry



- Special conditions: flexible cathode (entrance window)

Field distortion by entrance window stretching (Garfield sim.)

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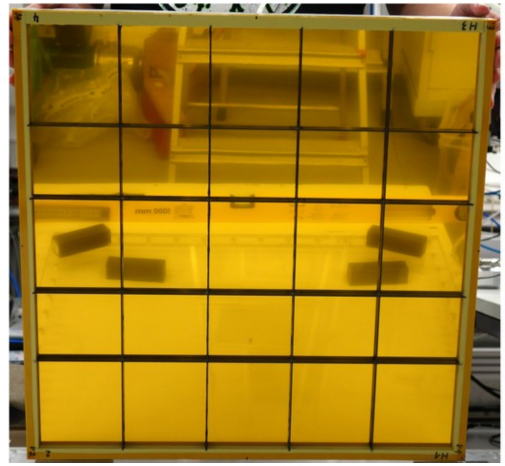
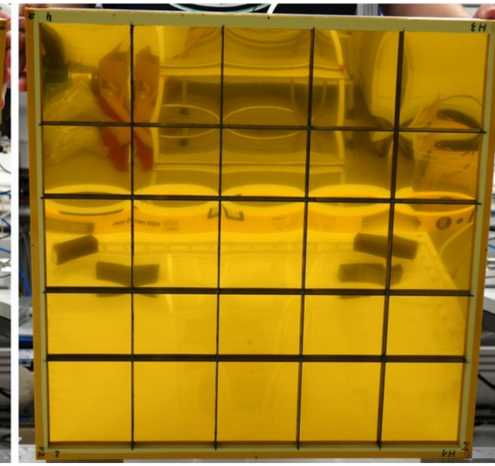
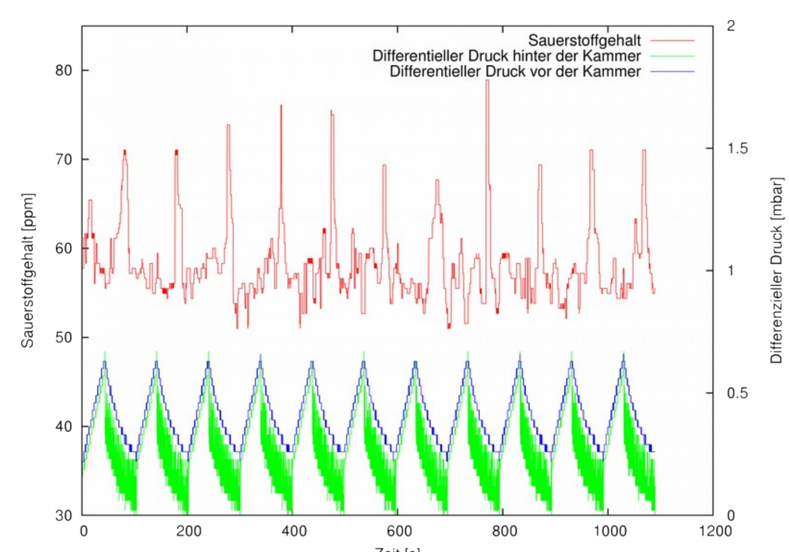
The TRD in CBM

Development in progress

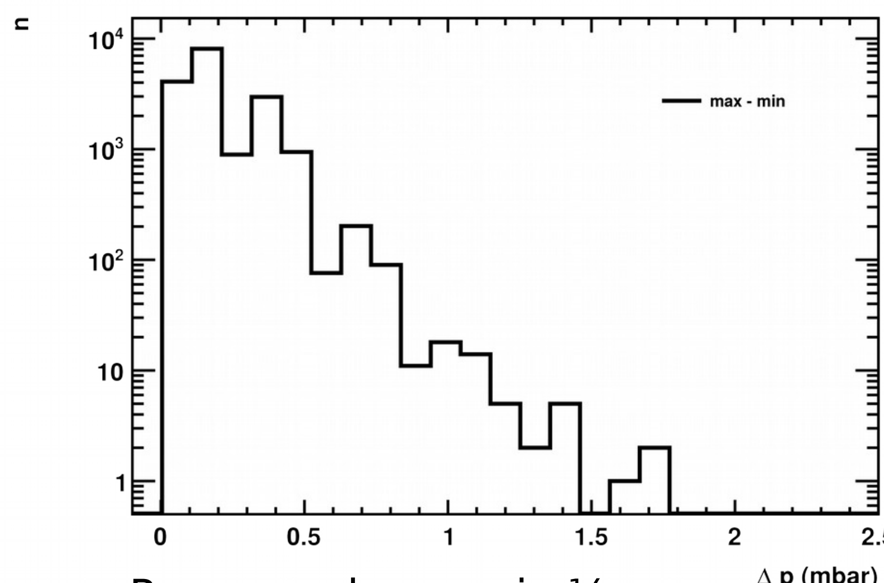
- Atmospheric pressure changes stress the entrance window
- Implied: Requirements to the gas system







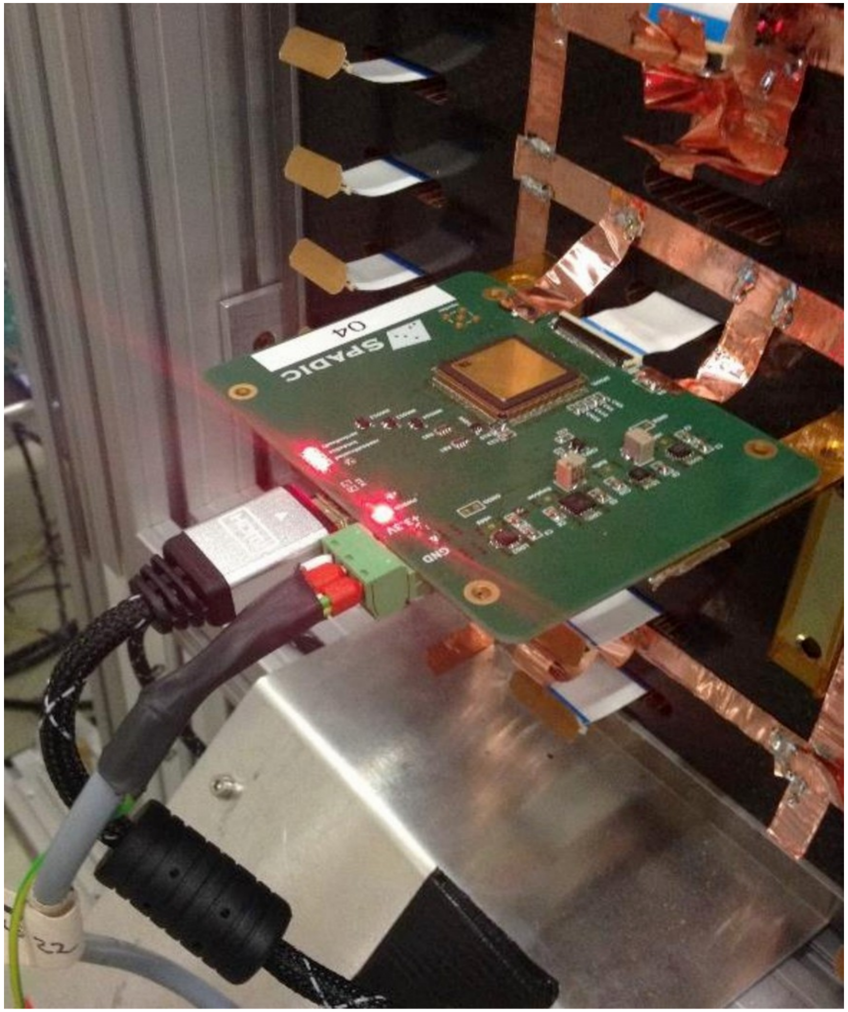
from Felix Fidorra, Bachelor th.



Pressure changes in ½ year

CBM-TRD Readout: SPADIC

- Readout of the granular cathode pads with the Self-triggered Pulse Amplification and Digitization ASIC
- Charge-sensitive amplifier on 32 channels
- Free-streaming
- Digitising 32 samples, 1.28 µs each
- Neighbour readout to enable good sensitivity using high trigger thresholds
- Digital filter implemented: time shortening by tail cancellation
- Ongoing development



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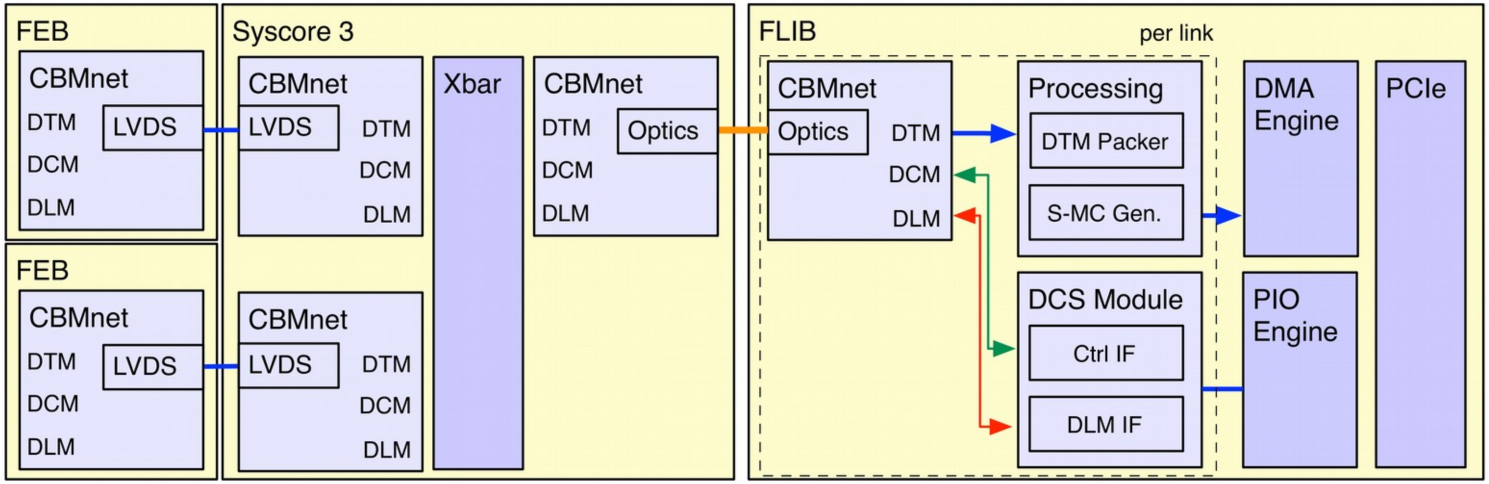
CBM-TRD Readout: DAQ Chain

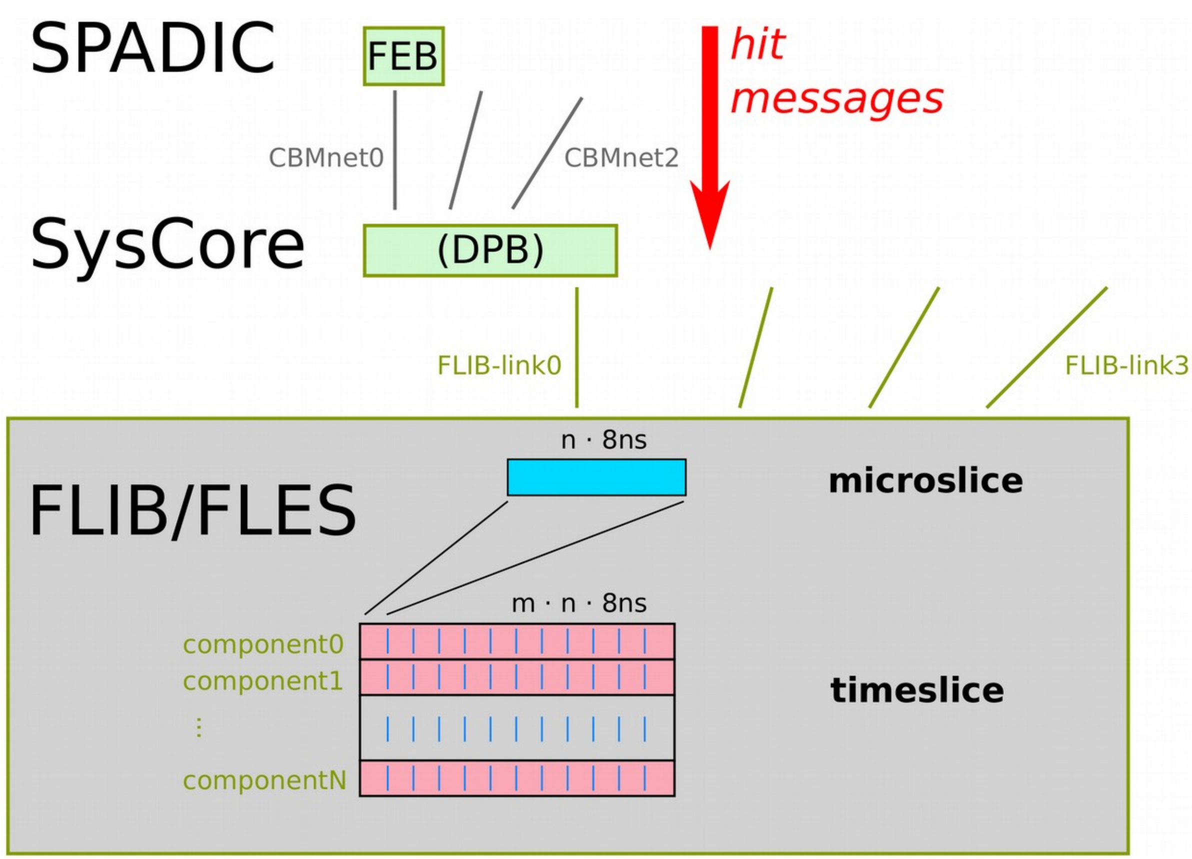
- Front end board: SPADIC
- SysCore boards streaming hit messages of 6 SPADICs to PC port
- First Level Event Selector processing messages into container format



scheme from Dirk Hutter, 23rd CBM Coll. meeting

CBM-TRD Readout: DAQ Chain

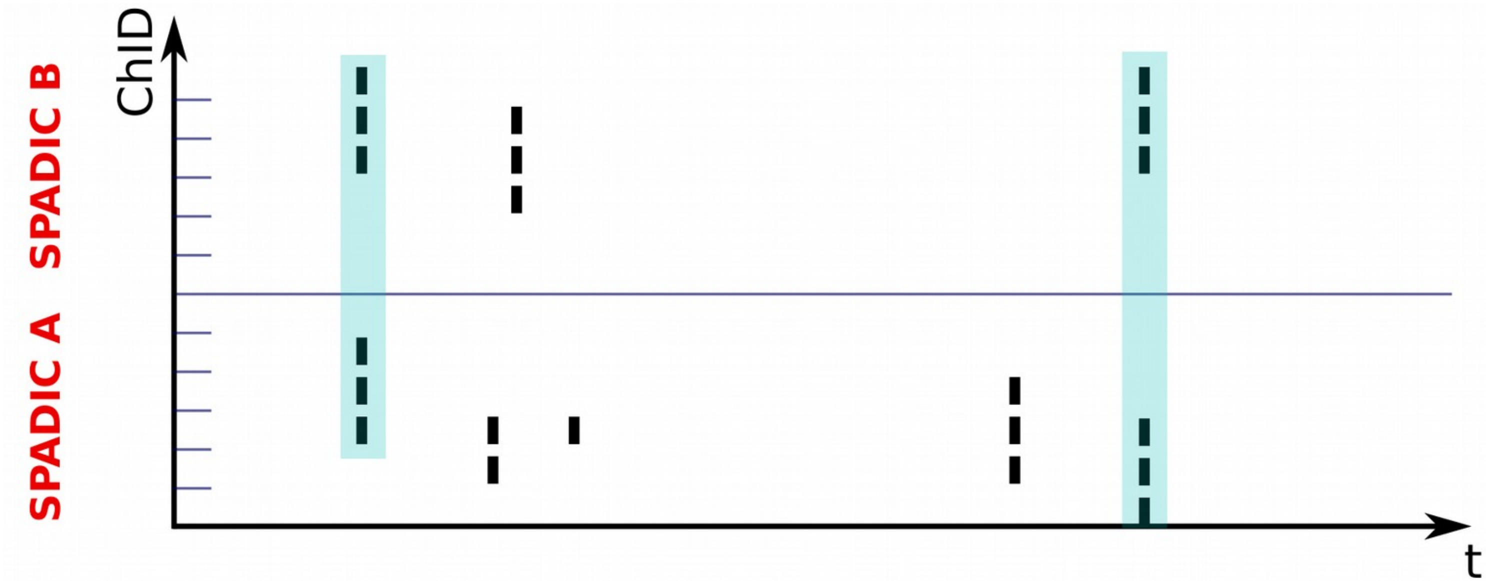
- Principle allows various microslice sources
- Ringbuffer minimize memory consumption, maximise throughput



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

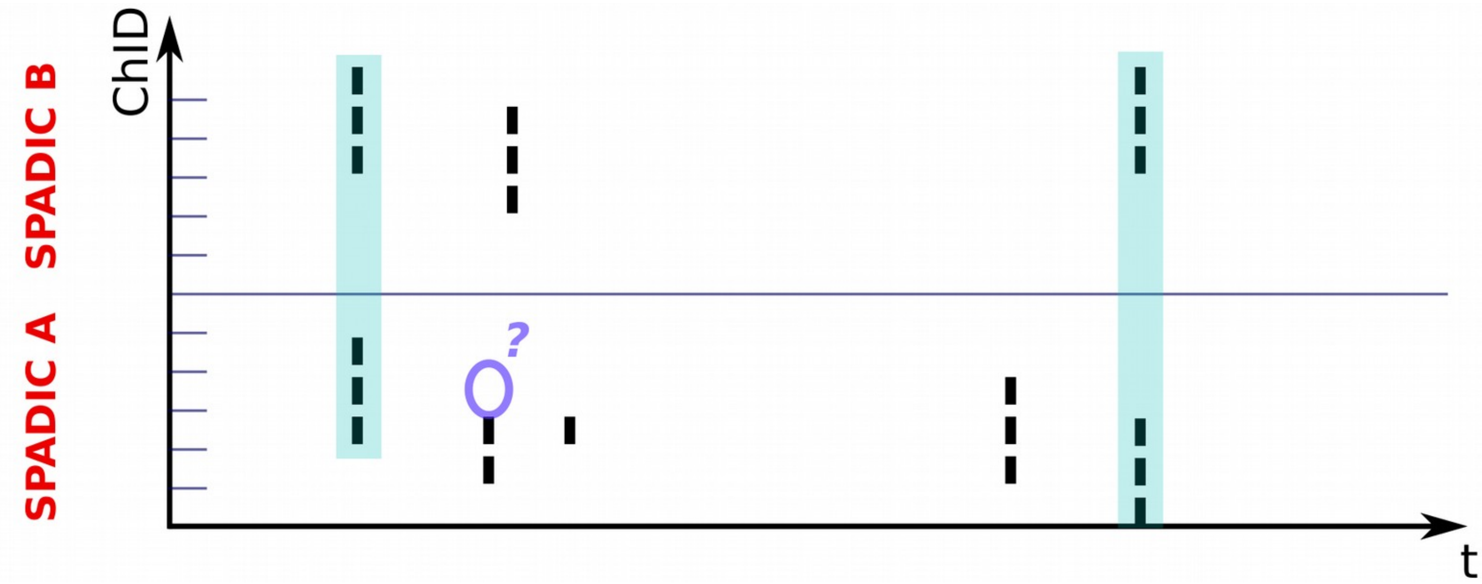
- full-time calculation currently in approvement

Starts of Data Analysis: Spatial Correlation



- Let SPADIC A and SPADIC B be in one line
- Simultaneous events can be correlated

Starts of Data Analysis: Spatial Correlation



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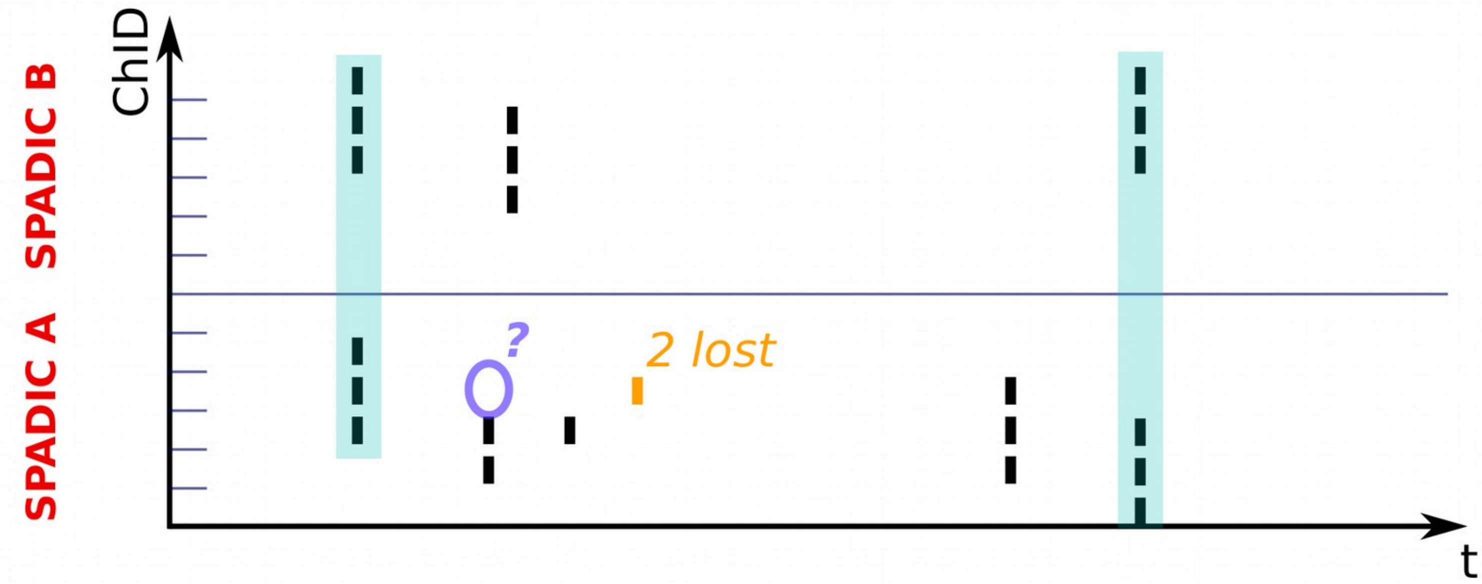

- Let SPADIC A and SPADIC B be in one line
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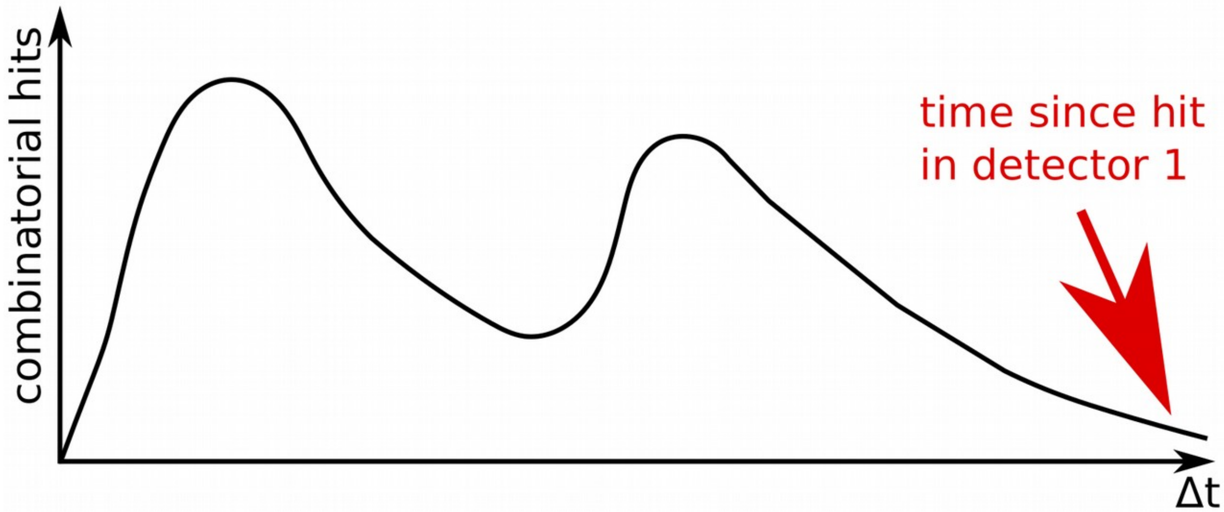
- Needed: Routines for message loss, e.g. rate-related

Starts of Data Analysis: Time Correlation



- Let SPADIC A and SPADIC B be in one line
- Simultaneous events can be correlated
- Needed: Routines for message loss, e.g. rate-related
- Needed: Routines for association in time

Starts of Data Analysis: SPS 2015 Beamtime

- Self-triggered experiment: common beamtimes wished!
- Beamtime with the CBM-TOF detector at the CERN-SPS, Nov. 2015
- Pb+Pb with 30 AGeV beam
- SPADIC readout on 3 diff. prototypes
- High rates:
  - SPADIC rate capabilities
  - HV-currents recorded with 2 Hz

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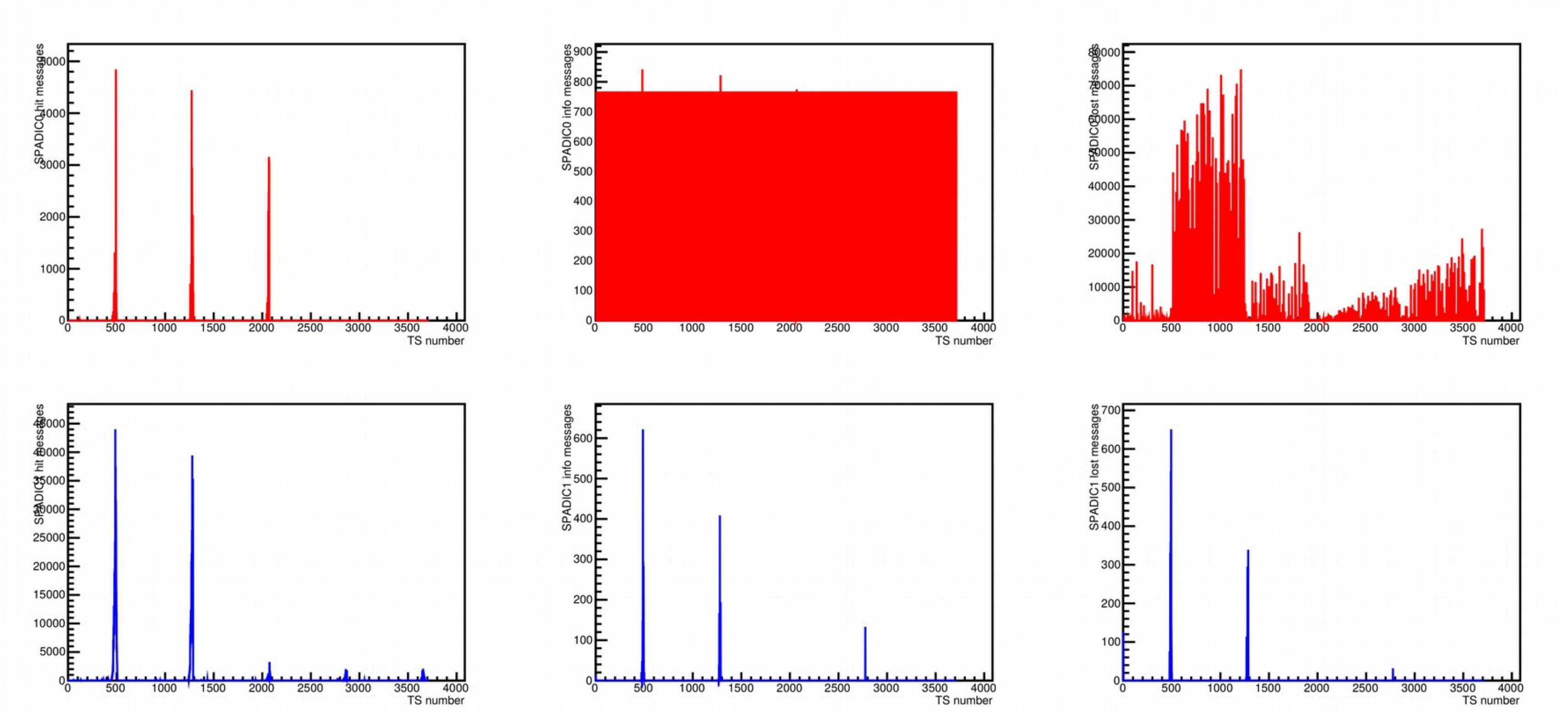
Starts of Data Analysis: SPS 2015 Beamtime



- Learned a lot from this early recording:
  - Handling of lost messages, noise reduction, grounding issues, …

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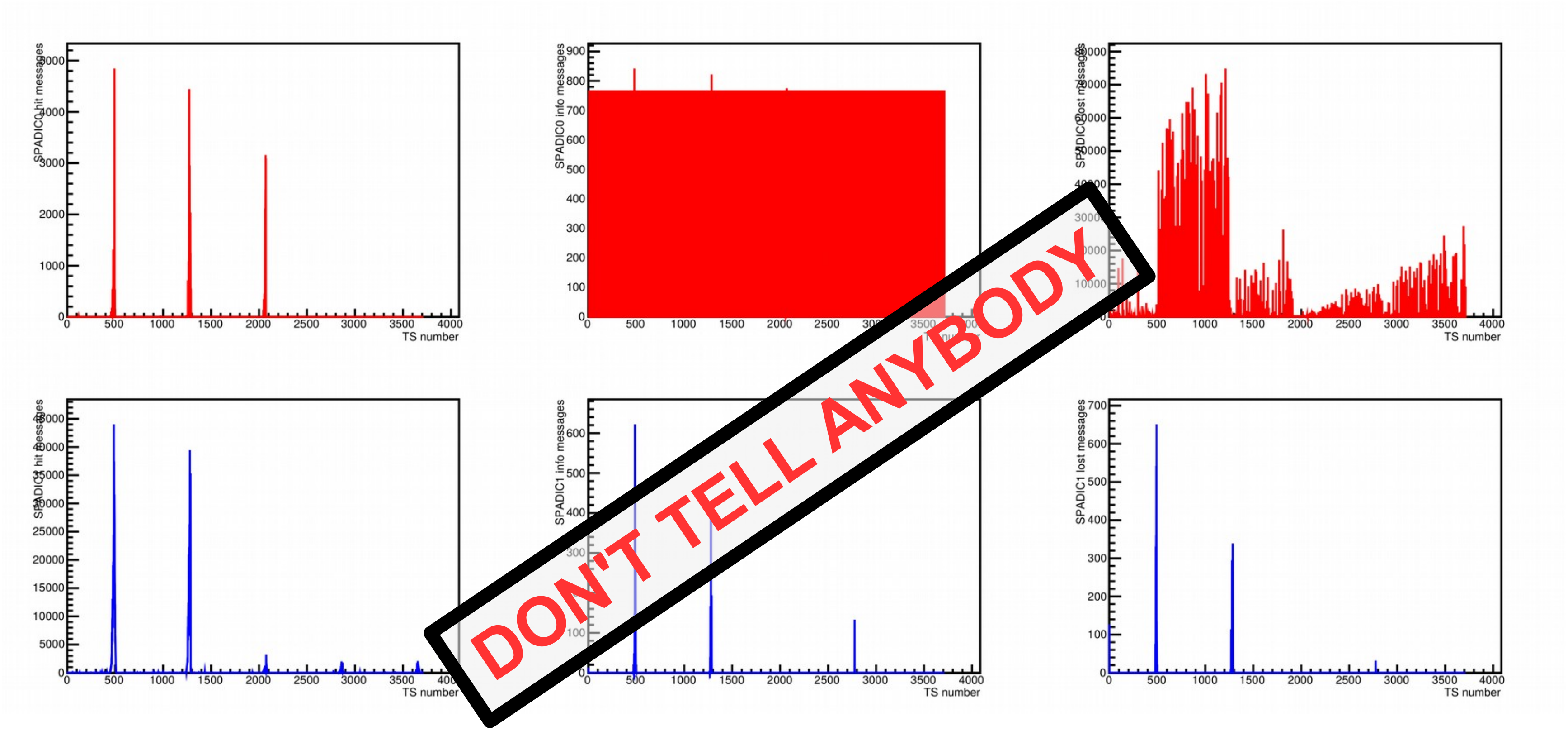

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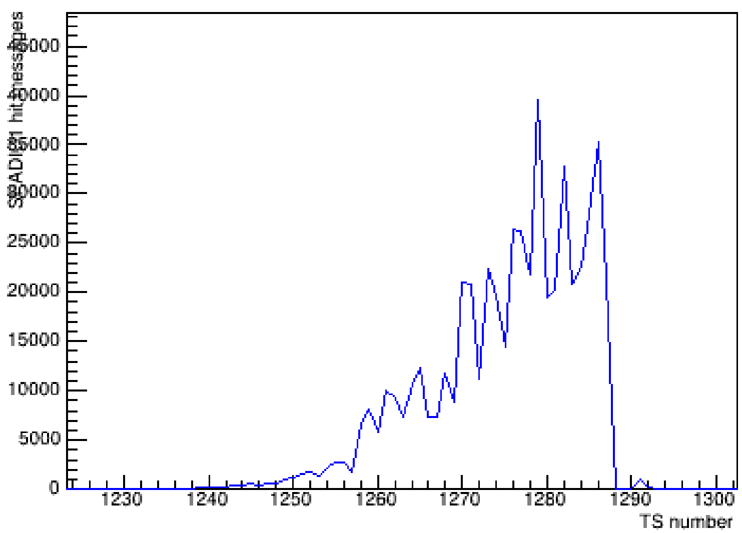

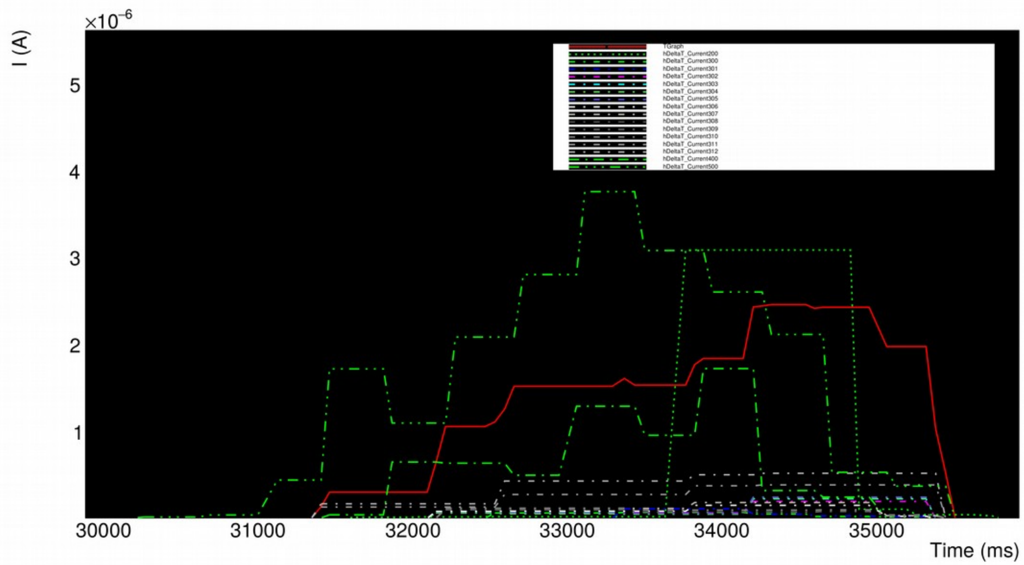

- Next local steps:
  – Full-time reconstruction from SPADIC messages
  – Establish spatial and time correlation for the TRD
  – Optimise SPADIC settings for high rate capabilities
  – Systematically analyse HV behaviour
- And more global:
  – Production of 4 large-sized prototypes
  – Release of the SPADIC 1.1 chip

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