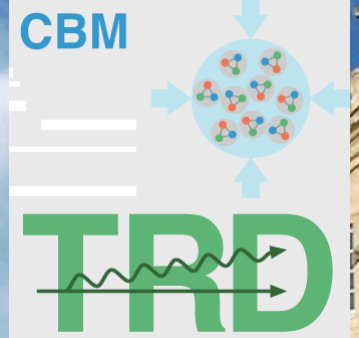




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# Detector Performance Tests for the CBM TRD



Martin Kohn  
martinkohn@uni-muenster.de  
DPG Tagung  
Münster 2017





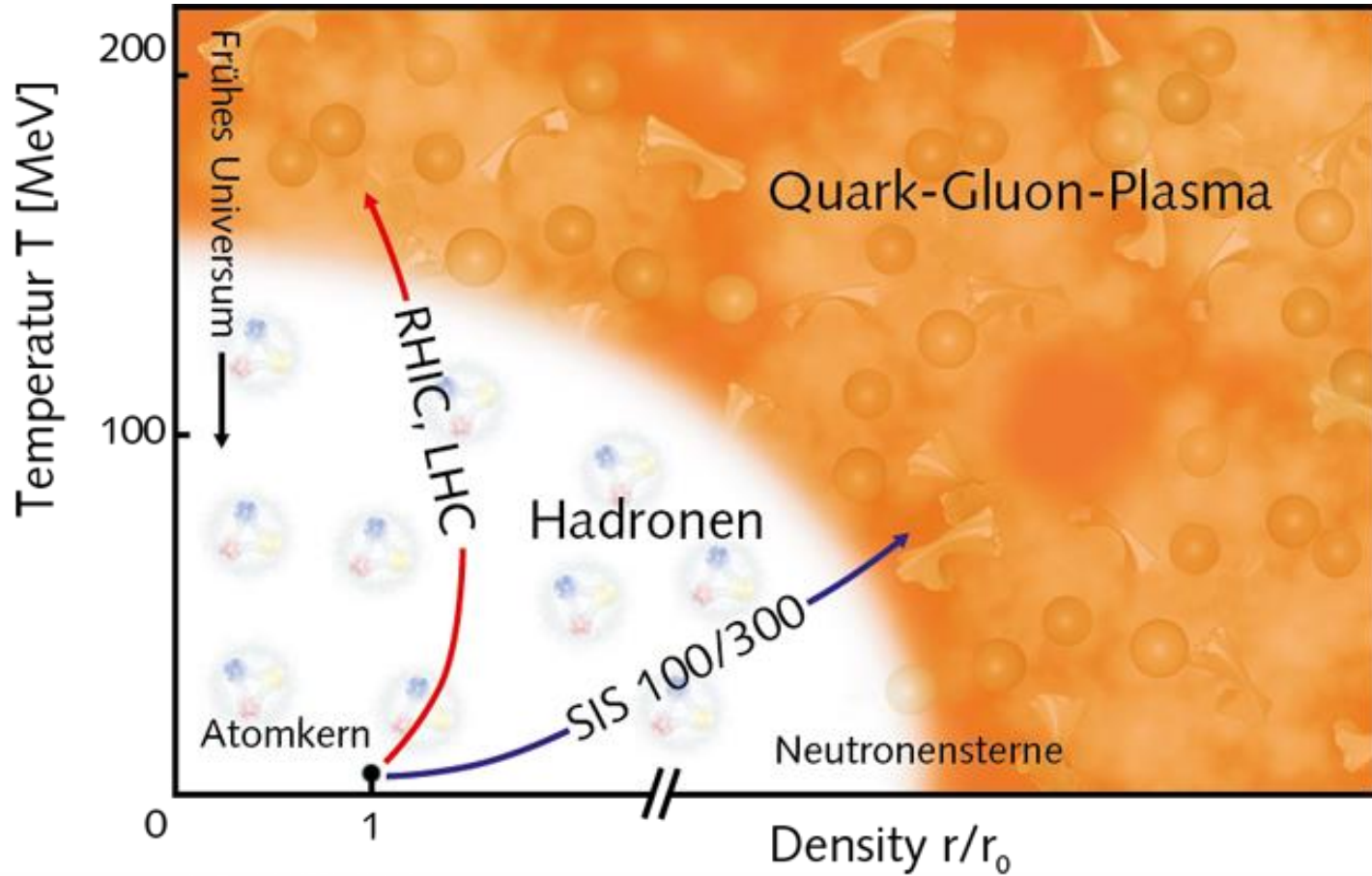
## Introduction to CBM TRD

## Performance Tests

## Selected Results

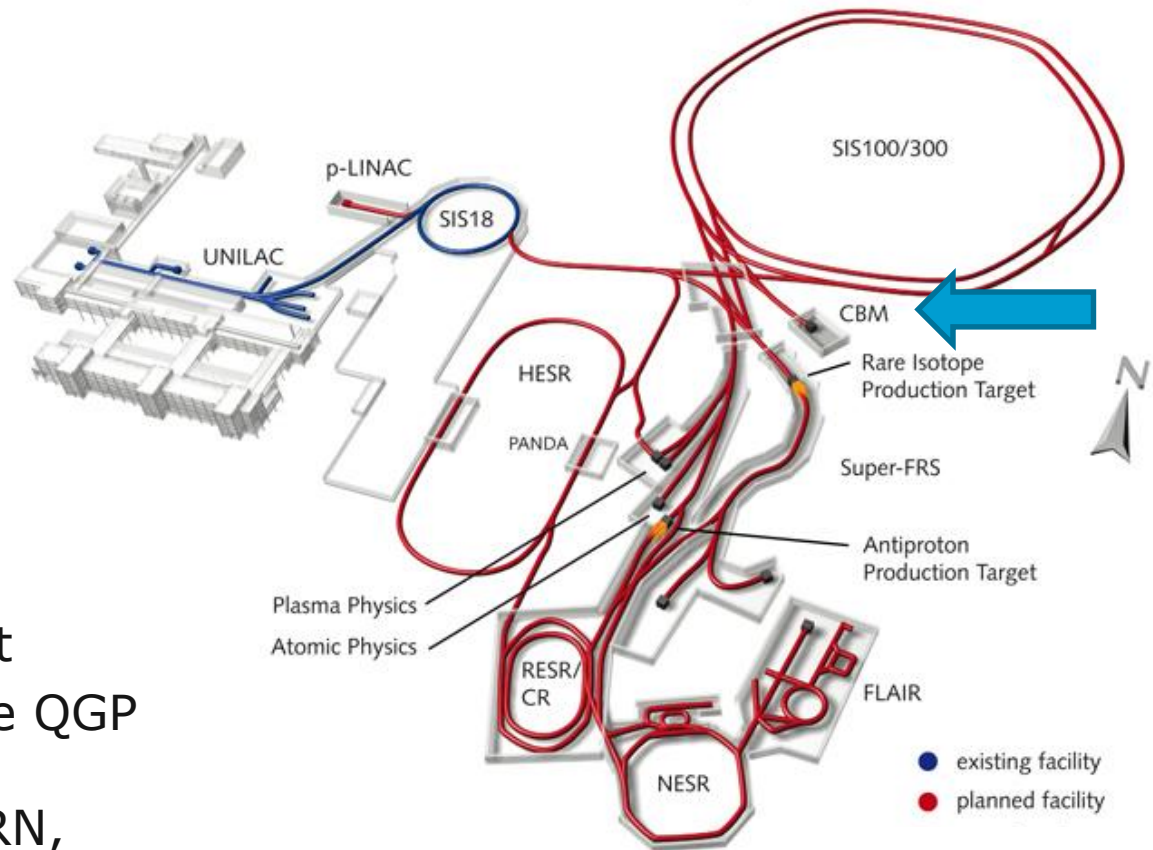
- |       |         |   |
|-------|---------|---|
| 14:45 | HK 62.4 | Detector performance tests for the CBM TRD — •MARTIN KOHN for the CBM collaboration   |
| 15:00 | HK 62.5 | Construction of large full-size MWPC prototypes for the CBM-TRD — •SUSANNE GLÄESSEL and FLORIAN ROETHER for the CBM collaboration |
| 15:15 | HK 62.6 | Development of a Gas System Prototype for the CBM-TRD — •FELIX FIDORRA for the CBM collaboration                                  |
| 15:30 | HK 62.7 | An instrumented analysis and supply gas system prototype for the CBM TRD — •PHILIPP MUNKES for the CBM collaboration              |
| 15:45 | HK 62.8 | Spectra and Position Reconstruction on CBM-TRD Data from CERN-SPS Testbeam 2016 — •PHILIPP KÄHLER for the CBM collaboration       |

## Densities of matter



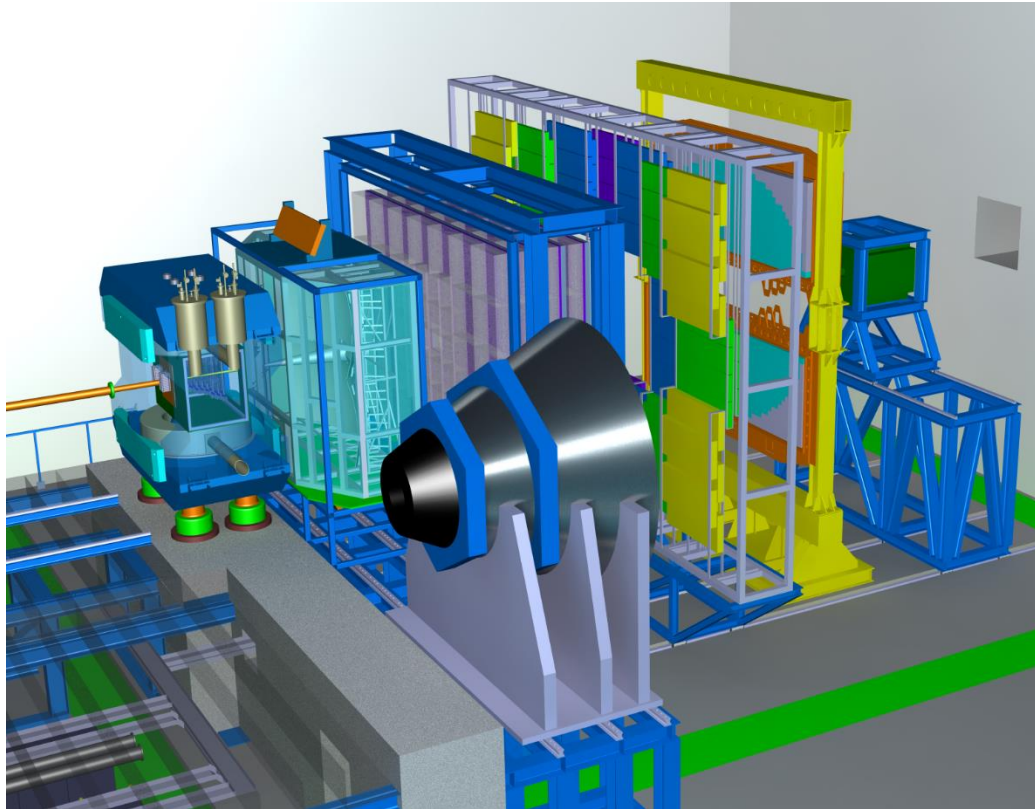
## CBM Overview

- Planned at FAIR@GSI in Darmstadt
- Built to investigate the QGP at different parameters compared to ALICE/CERN, higher densities in Nucleus-Nucleus collisions
- High collision rates cause high interaction rates, these make demands on the readout rate and sensitivity of detector/electronics



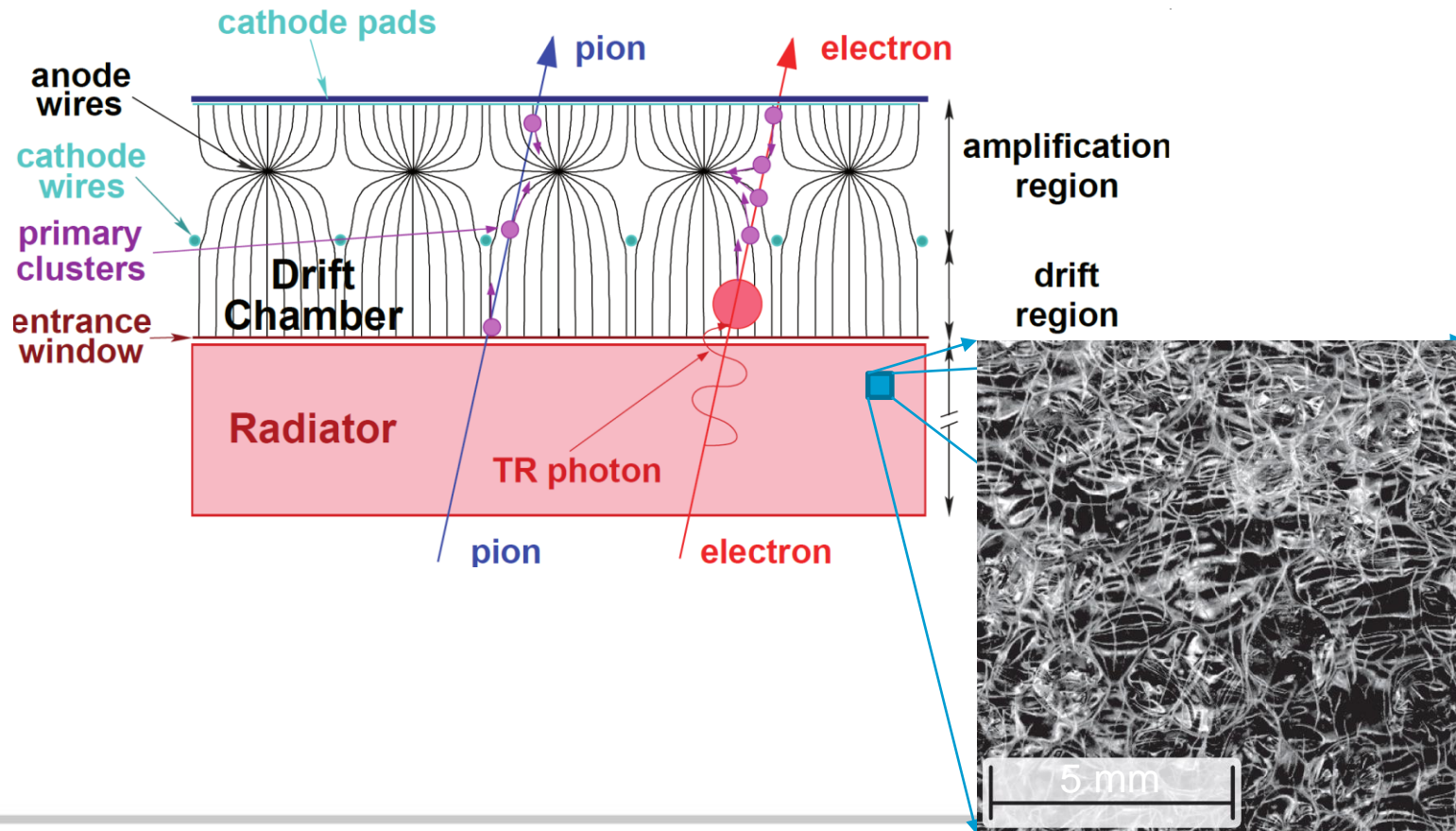
# Planned TRD Setup of the CBM Experiment at SIS 100

## TRD properties:



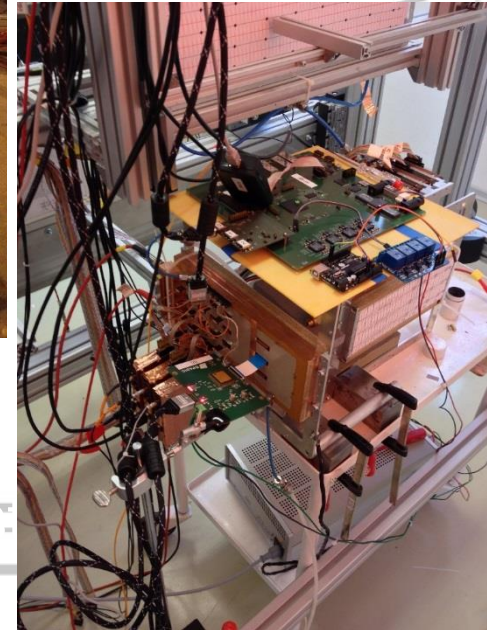
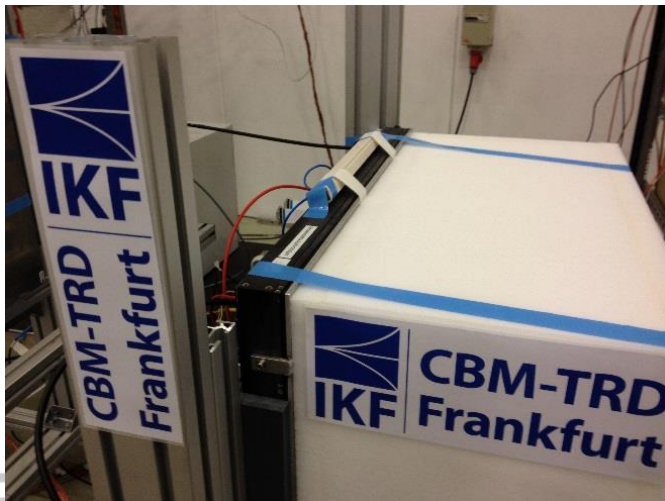
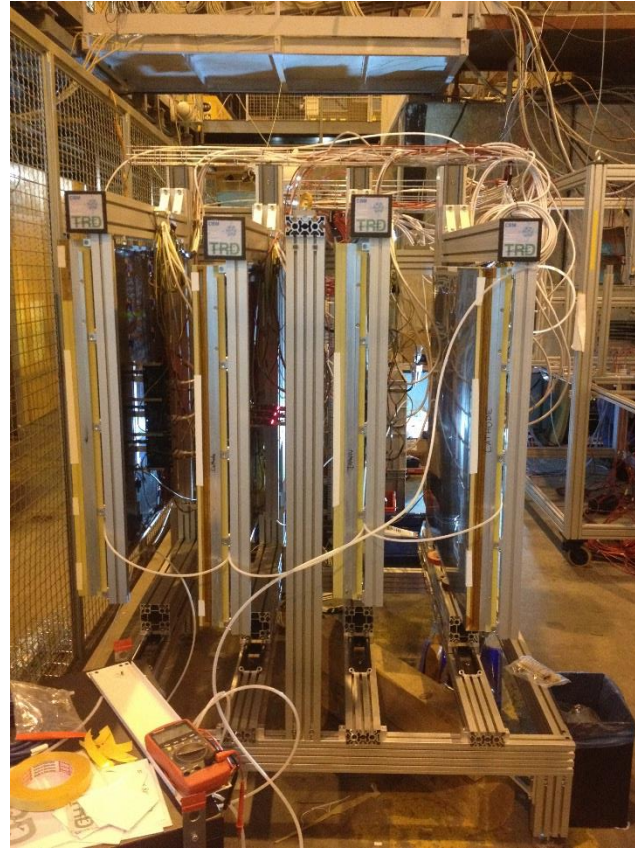
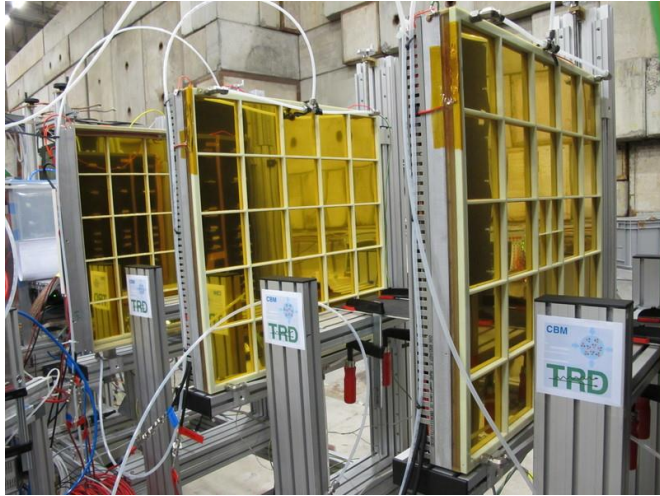
- **Geometry**
  - 4 layers in 1 stations
- **Electron Identification**
  - Pion suppression:  $\sim 10$
  - @ 90% electron-efficiency
- **Tracking all charged particles**
  - Position resolution:  $\sim 200\text{-}300 \mu\text{m}$
  - @ high rates ( $>100 \text{ kHz/cm}^2$ )
  - and high multiplicities

# Transition Radiation Detector



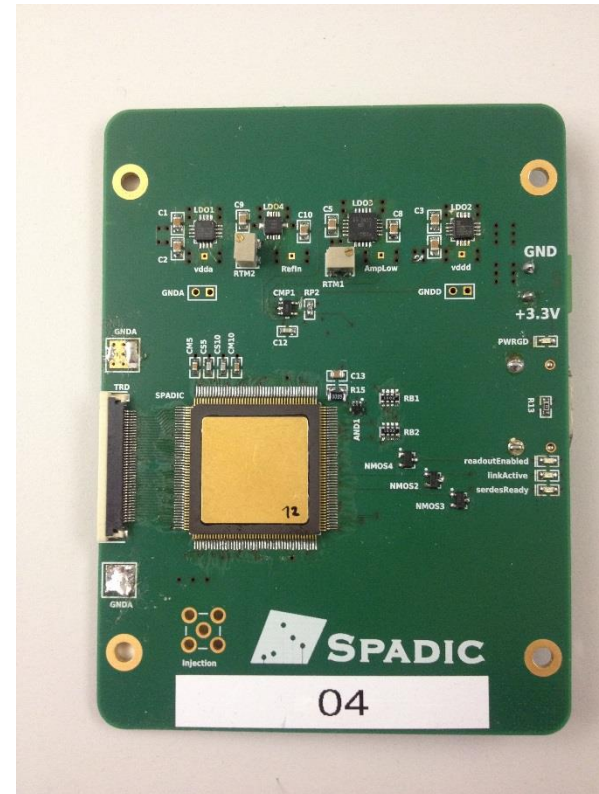


# Prototypes from Bucharest, Frankfurt and Münster



## SPADIC1.0

- Self-triggered *Pulse Amplification and Digitization asIC*
- *32 channel organized in two groups of 16ch each*
- Max 32 samples (time bins) of 57,14ns each per pulse
- ADC Range from -256 to 256
- Neighboring channels can trigger each other
- Free streaming data!!



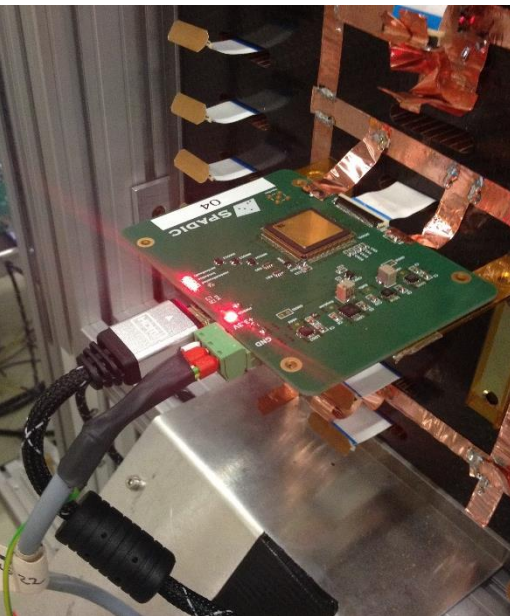


# Remainder: DAQ LEGACY Chain for beam tests and laboratory for SPADIC v1.0 and SPADIC v1.1

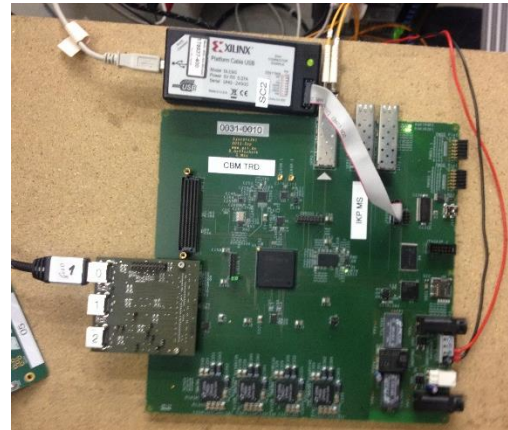
*SPADIC* :  
Self-triggered *Pulse*  
Amplification and  
*Digitization asIC*

SysCore v3.1:  
Data Concentrator  
Board

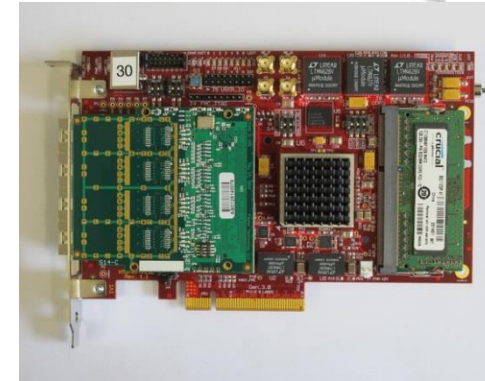
FLIB: **F**irst **L**evel  
**E**vent **S**elector  
(FLES) Interface  
Board



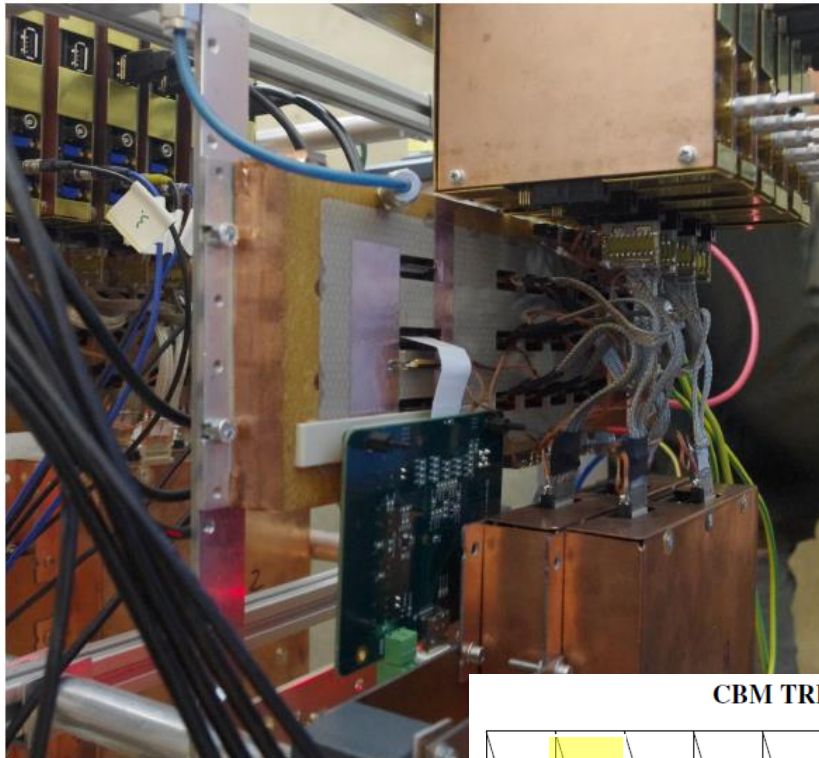
LVDS



Optical

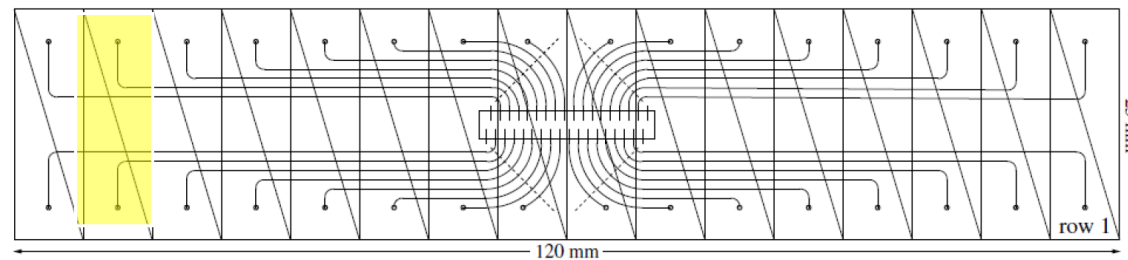


# Experimental Setup SPADIC v1.1 on Bucharest Chamber at SPS in beam test 2016



- One SPADIC v1.1 with 32 channels
- dynamic range:  $[-256, 255]$  ADC-values
- tested absolute and differential thresholds
- Baseline around -240 with Bucharest chamber

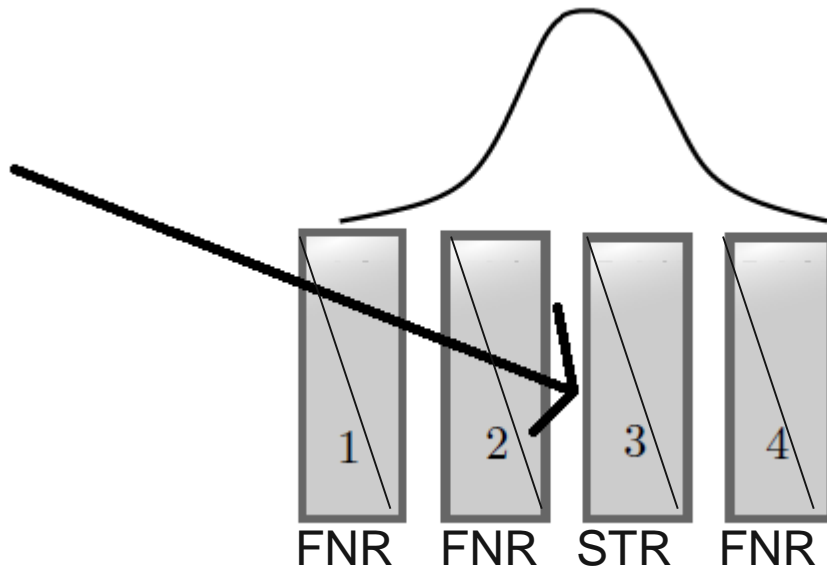
CBM TRD triangular pad plane interface to 32ch SPADIC



size of pads 7,5 mm x 25,0 mm / 2 (w x h)

by David Emschermann, 08.04.2011

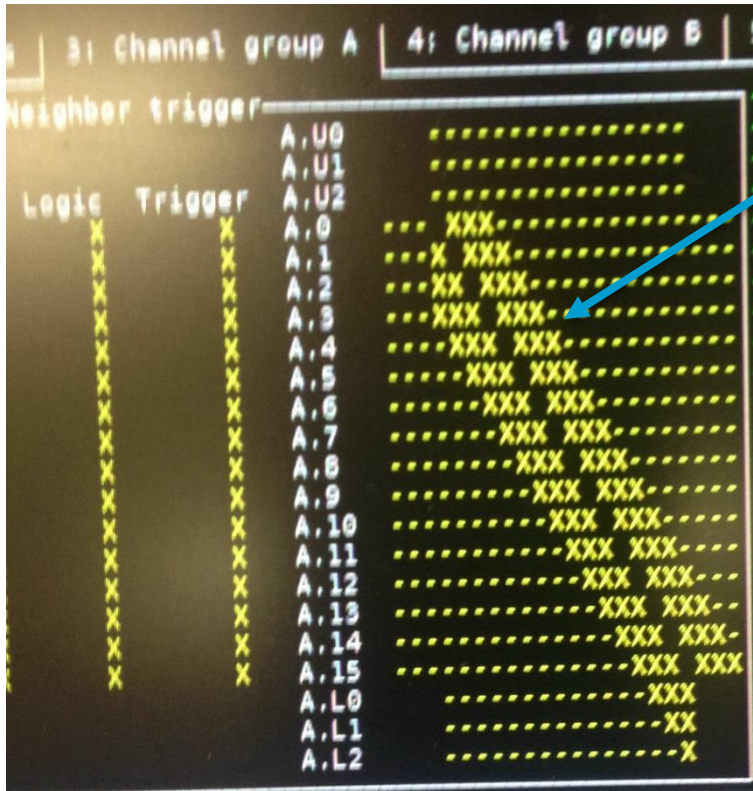
## Short Overview: Clustering, done in Software



FNR =forced neighbor  
readout  
STR =self triggered by  
threshold

work by Philipp Munkes

## Triggermatrix for neighbor triggered pads



- Not intuitive to read
- For example Channel A.3 is triggered by ch 0,1,2 and 4,5,6
- Used to gain position information in x and y coordinate later on
- mean of 7 pad cluster expected



Introduction to CBM TRD

Performance Tests

Selected Results

## Parameter for Performance of TRD

- **Electron Identification**

- Pion suppression:  $\sim 10$  PS 2014 data
- @ 90% electron-efficiency

- **Tracking all charged particles**

- Position resolution:  $\sim 200\text{-}300 \mu\text{m}$  SPS 2016 data PS 2012 with small size prototypes

- **High rate stability**

- high rates (  $>100 \text{ kHz/cm}^2$ ) and high multiplicities
  - **High Voltage-Stability** (Poster in HK 27.65 Measurements with CBM-TRD Prototypes at the CERN SPS in 2015 — •Patrick Schneider and Dennis Spicker for the CBM collaboration)
  - Readout SPS 2016 data

## Summary of all TRD in beam test campaigns starting from 2014

- 2014 PS with SPADIC v1.0 0.5 up to 3 GeV mixed beam of electrons, pions and muons
  - two 2014 small size prototypes each from Frankfurt and Münster
- 2015 SPS with SPADIC v1.0 Pb beam with 30 AGeV on Pb target
  - one 2014 small size prototype each from Frankfurt and Münster
  - readout of Bucharest 2010 Prototype with one SPADIC v1.0
- 2016 SPS with SPADIC v1.1 Pb beam with 15, 30 and 150 AGeV on Pb target
  - four 2016 large size prototypes first test of SPADIC v2.0
  - readout of Bucharest 2010 Prototype with one SPADIC v1.1



Introduction to CBM TRD

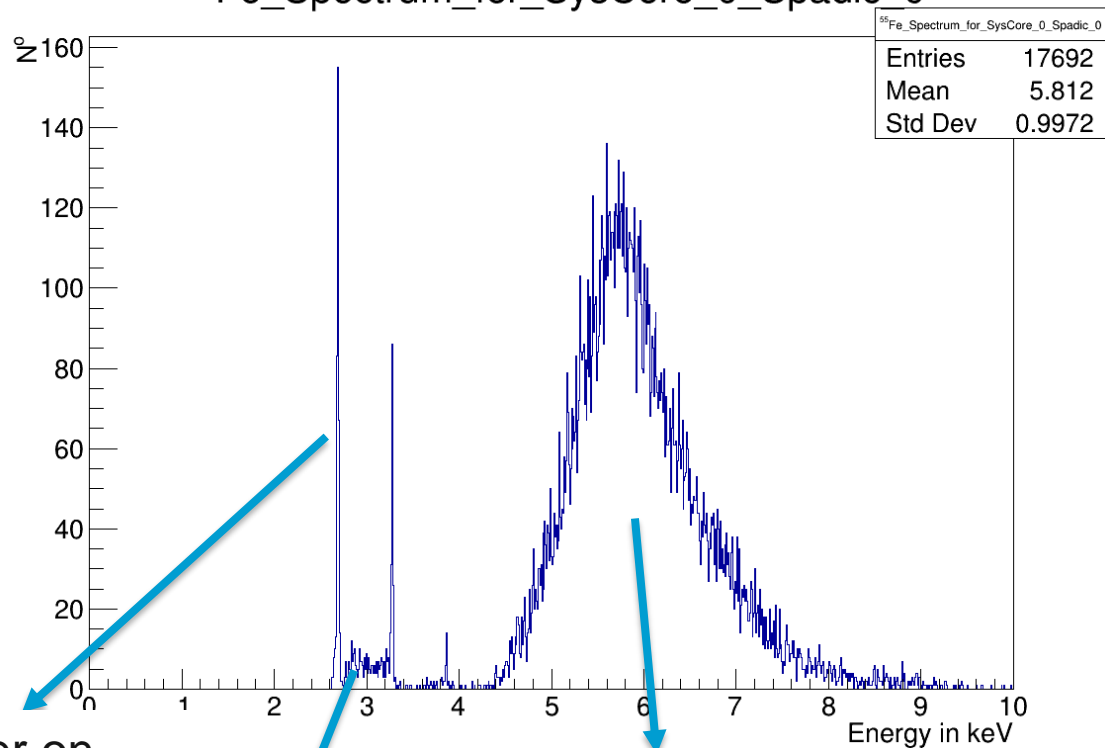
Performance Tests

Selected Results



# Reference for energy calibration and electronic tests in laboratory

$^{55}\text{Fe}$ \_Spectrum\_for\_SysCore\_0\_SpadiC\_0



energy resolution of  
fe55 peak approx.  
10,5%

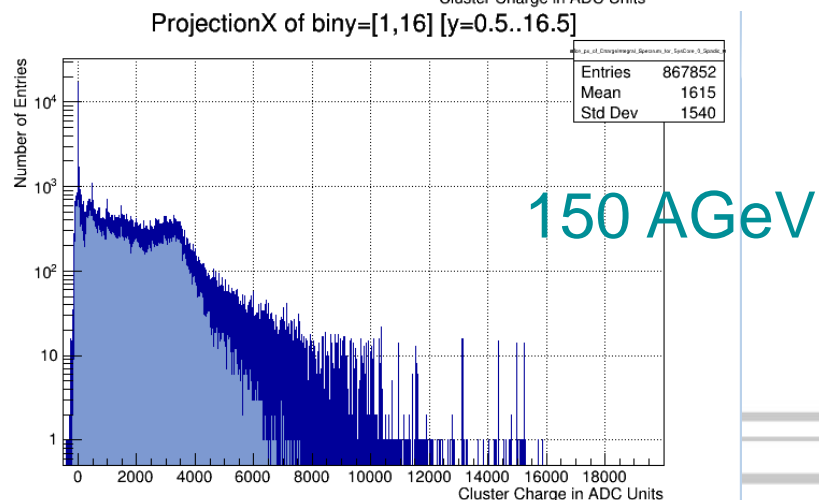
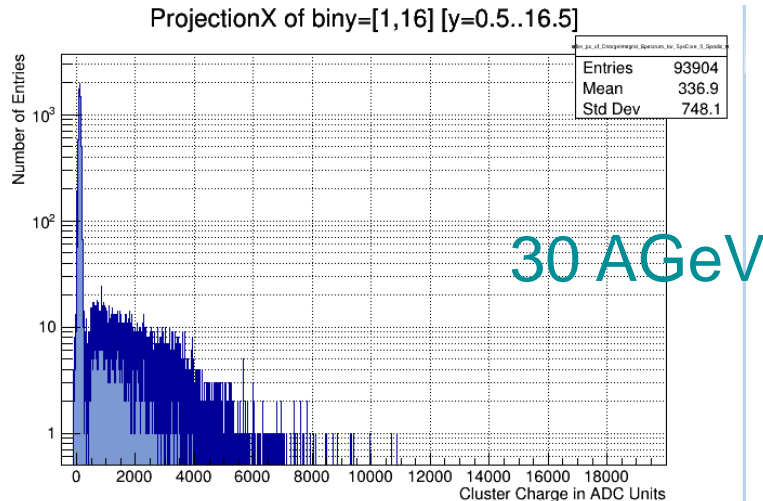
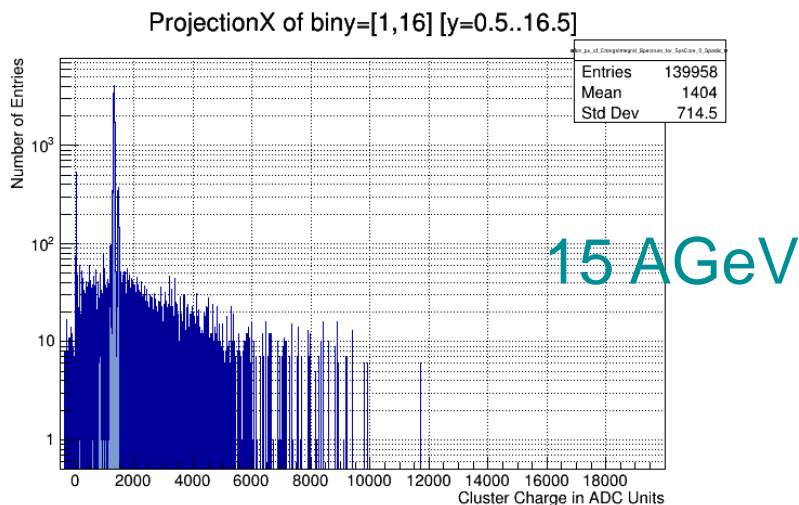
preliminary result!!!

pulser on  
anode wires?

escape peak

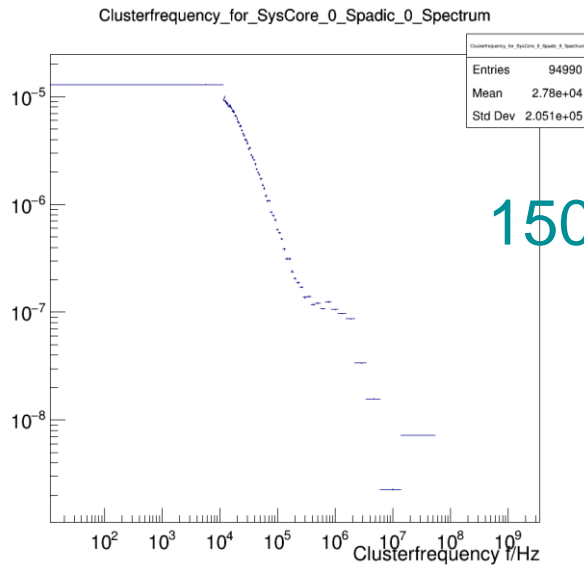
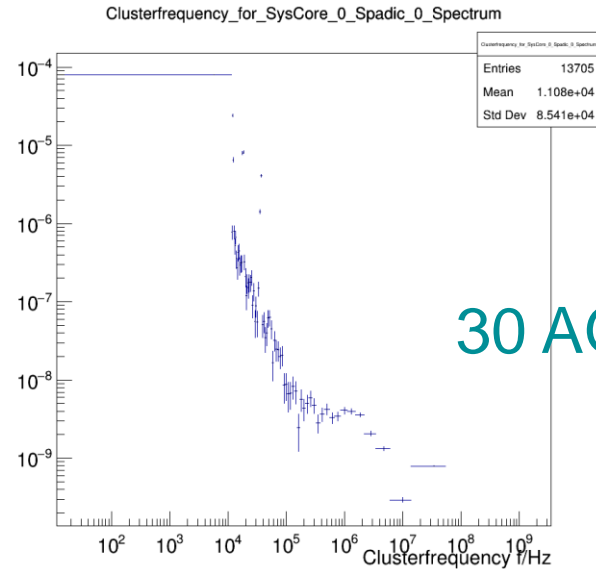
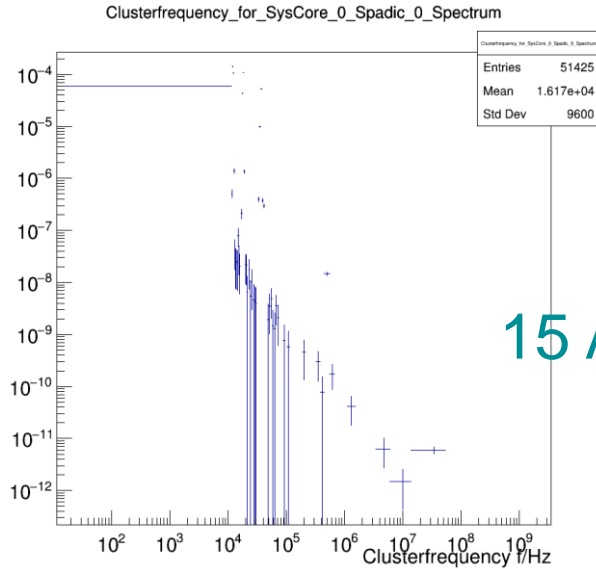
fe55

# Comparison of cluster charge for different beam energies



Observed increase of deposited charge per cluster with higher beam energy

# Comparison of cluster frequency spectrum



Max of frequency for all energies the same, still under investigation

## Outlook

- Analysis ongoing
- Comparison with simulations
- Comparisons between different chamber prototypes
- Hit rates not yet archived in comparison to expectations from SIS100, GIF++ test this year
- SPADIC v1.1 data with electron measurements  
-> DESY in beam test this Year

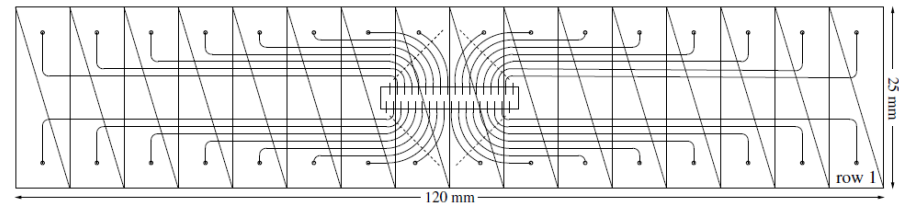


Thank you!

## TRD Prototype Bucharest

- TRD10A from 2010
- Differences to Prototypes from Münster and Frankfurt
- 2\*4mm amplification region
- 4mm drift region
- 25 $\mu$ m aluminized Kapton foil for Drift electrode on 8mm Rohacell
- Readout electrode of 300 $\mu$ m thickness PCB
- Anode wires are Au coated W wires of 20 $\mu$ m diameter 3mm pitch
- Cathode wires are 75 $\mu$ m Cu/Be alloy with 1,5mm pitch
- Rectangular pads split on diagonal for a triangular shape

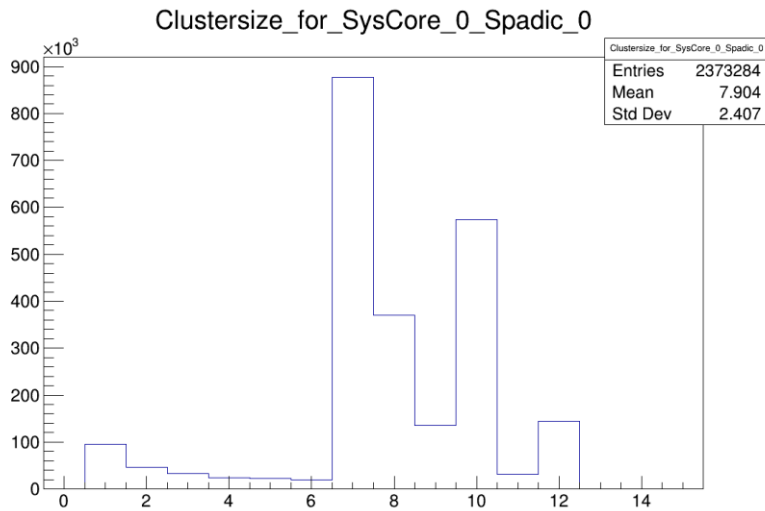
CBM TRD triangular pad plane interface to 32ch SPADIC



size of pads 7,5 mm x 25,0 mm / 2 (w x h)

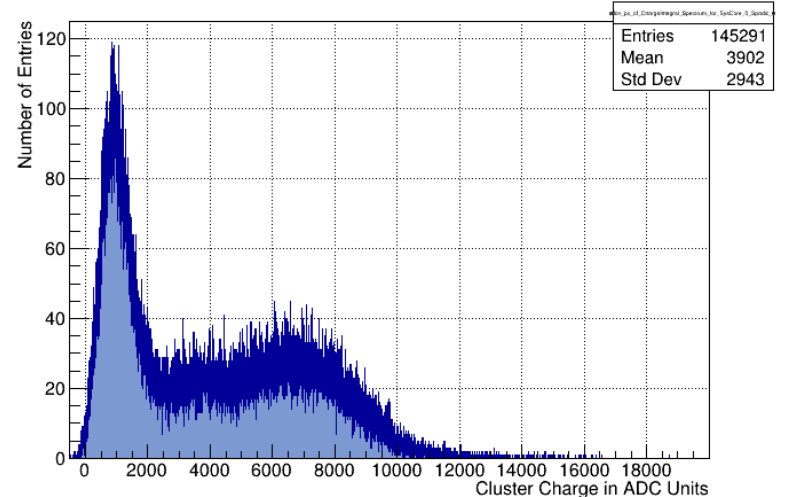
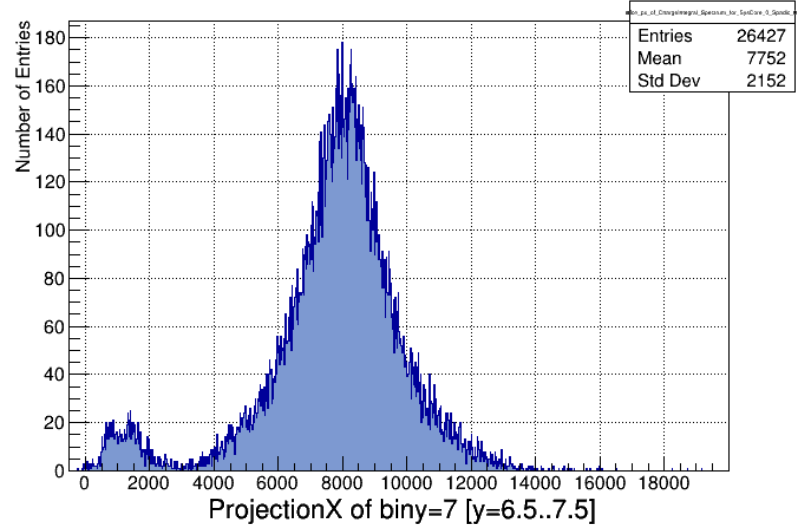
by David Emschermann, 08.04.2011

# Artefacts up to 12pad cluster

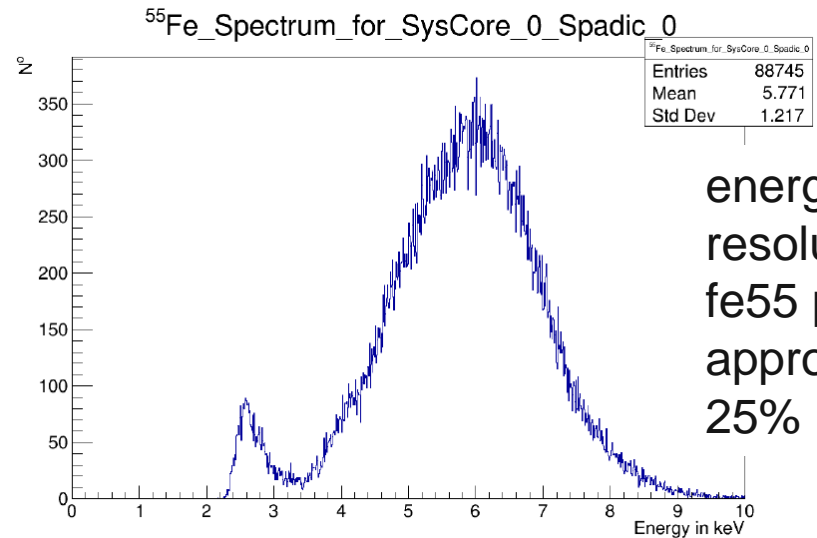
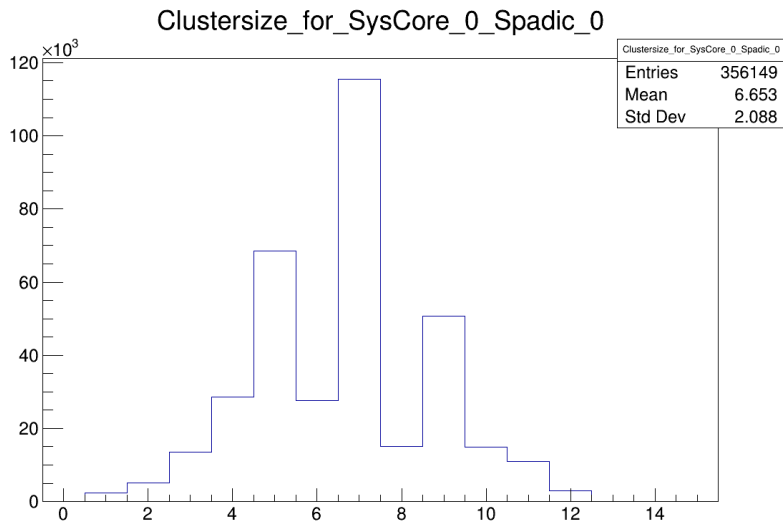


run237 threshold1=-155

ProjectionX of biny=12 [y=11.5..12.5]



# First calibrated $^{55}\text{Fe}$ spectrum

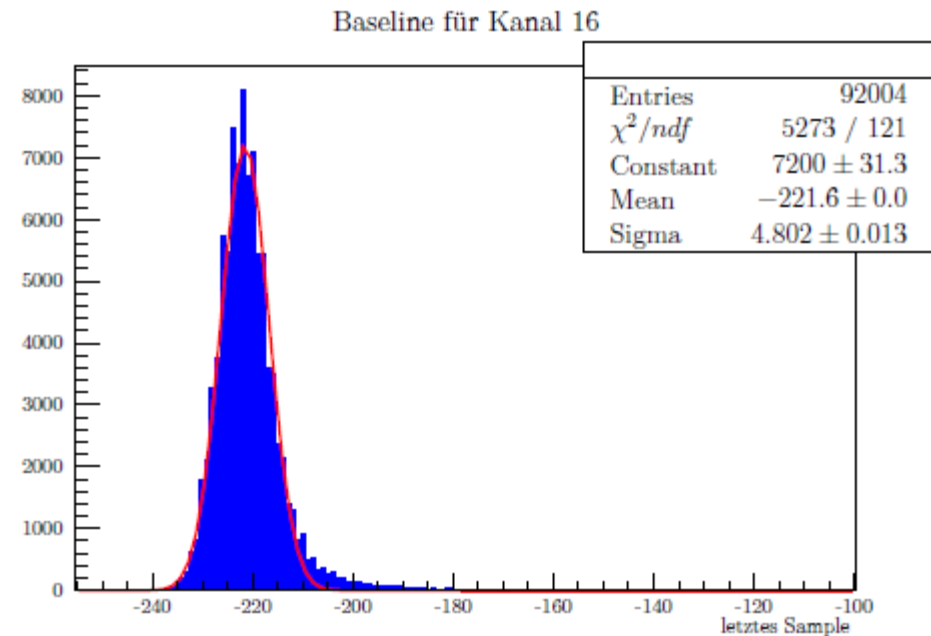
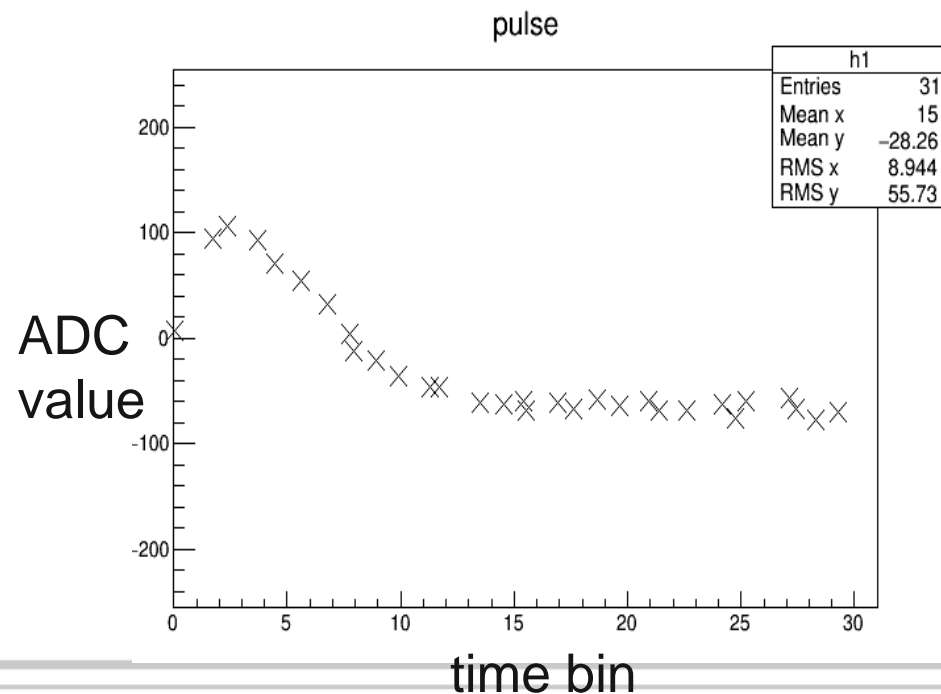


run 241, differential thresholds 20 / 20 only 7 pad cluster selected



# Channel dependent baseline (Two Pass) – Source of statistical fluctuations at large cluster size?

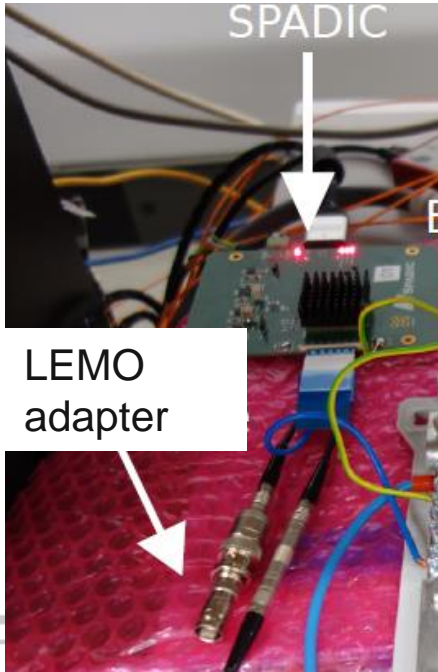
- Take the last bin, calculate the average value over a whole file
- The average value from a Gaussian fit is used to normalize the signal in the second run



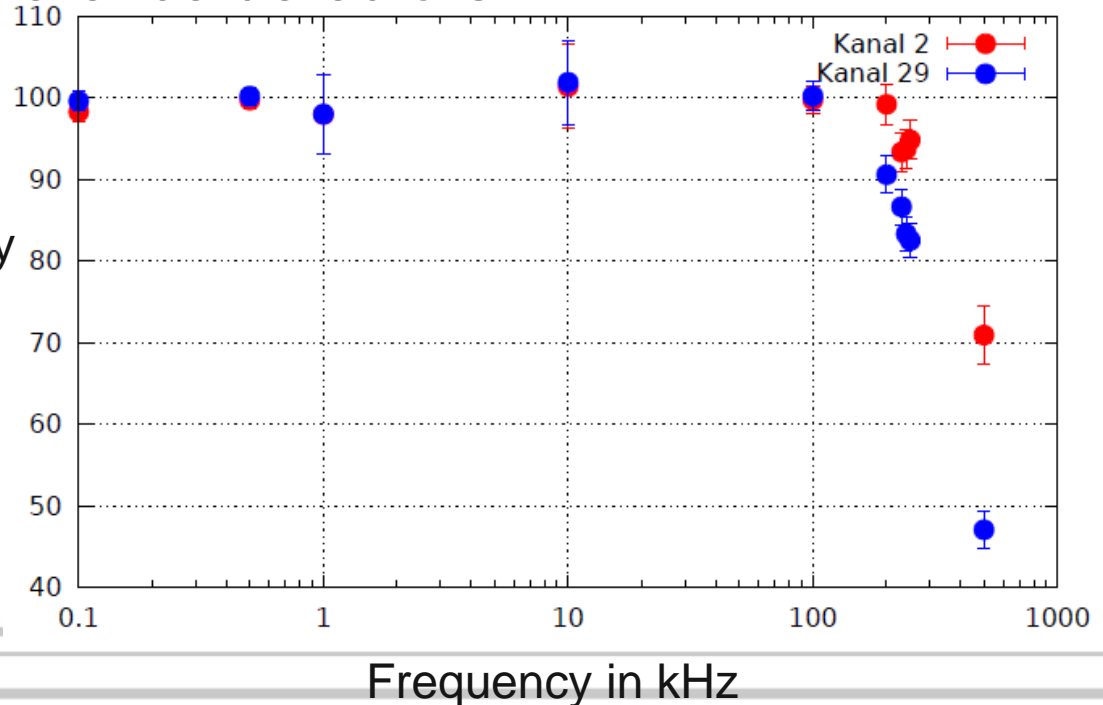
# Spadic test with pulse generator

Preparation for Spadic 1.1 testing, pulses  $0,02\mu\text{s}$  rise time,  $0,05\mu\text{s}$  fall time,  $400\text{mV}$  Amplitude, one channel with signal only

Usable for readout of reference detectors

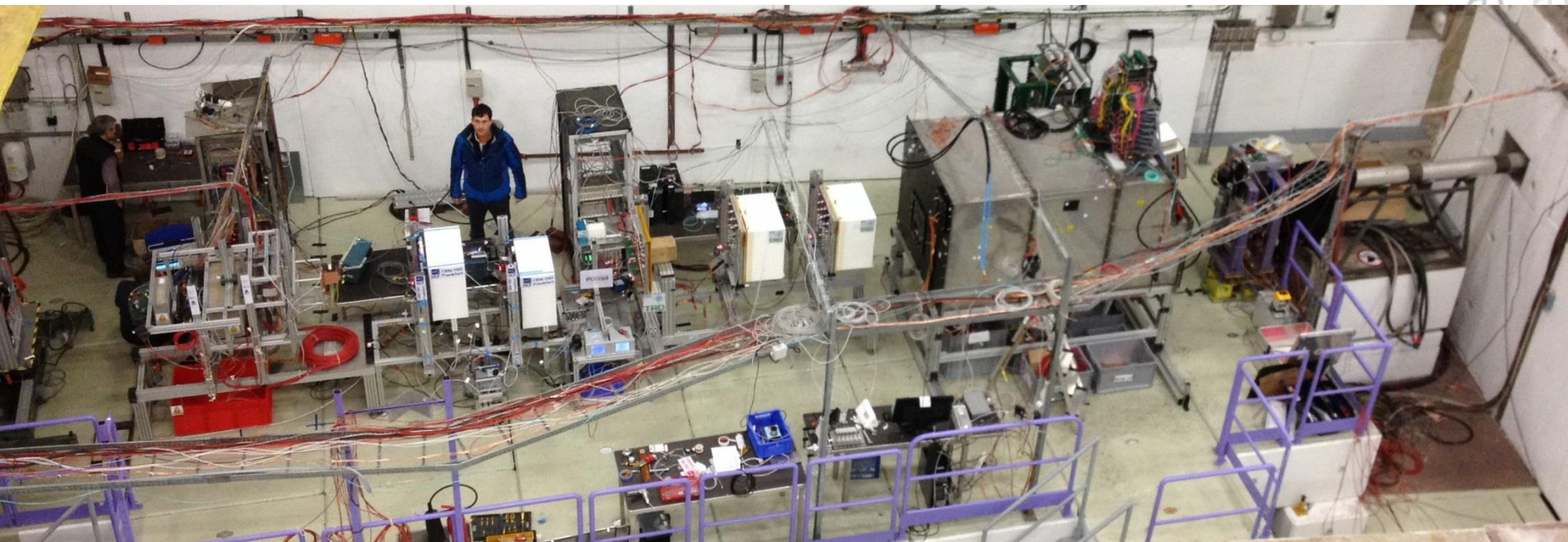


Efficiency  
in %



## In Beam Measurement CERN PS Nov. 2014

- Mixed electron/pion/muon beam up to 3 GeV
- 2 prototypes from Münster (construction in 2012), 2 prototypes from Frankfurt (construction in 2014) with a SPADIC 1.0 chip each



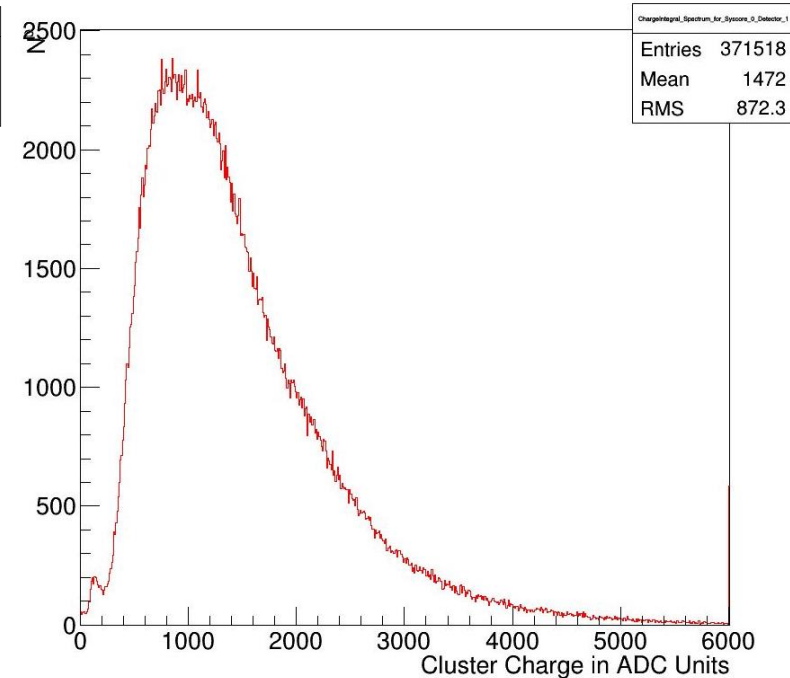
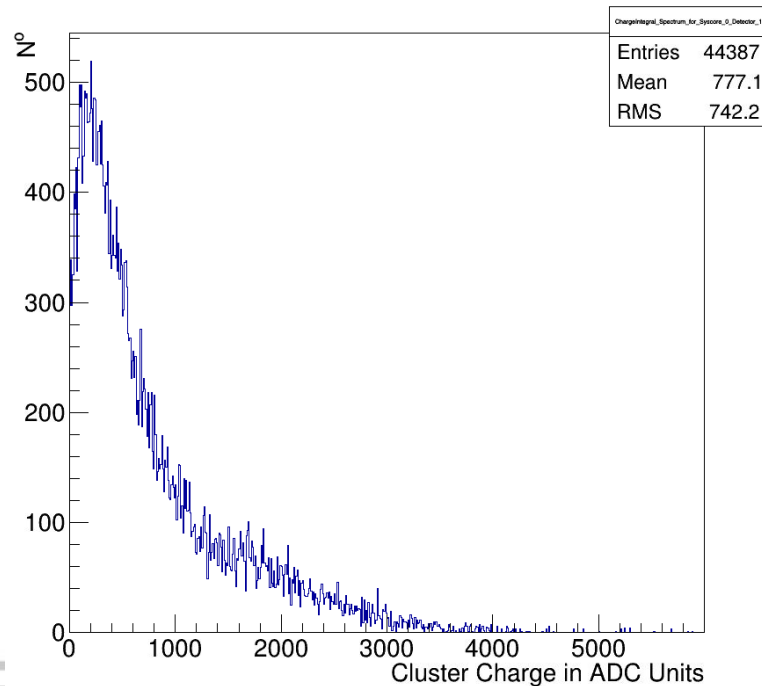
## In Beam Measurement CERN SPS Nov. 2015

- Pb 30GeV per nucleon
- SPADIC1.0 on first Bucharest Chamber
- Two independent DAQ Systems for the SPADICs, one for Bucharest and one for Münster/Frankfurt Prototype



# Spectrum Münster Chamber

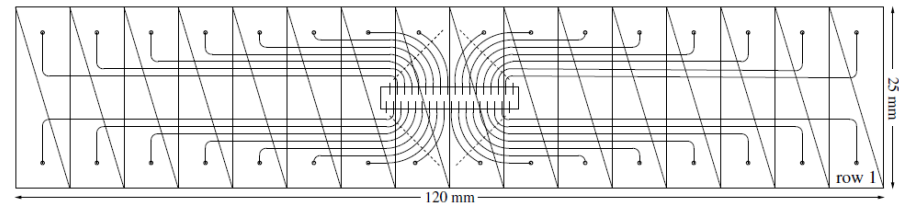
- Charge Spectrum, integrated over the whole signals of a cluster
- Not calibrated but same chamber type and same HV conditions
- Blue PS
- Red SPS



## TRD Prototype Bucharest

- TRD10A from 2010
- Differences to Prototypes from Münster and Frankfurt
- 2\*4mm amplification region
- 4mm drift region
- 25 $\mu$ m aluminized Kapton foil for Drift electrode on 8mm Rohacell
- Readout electrode of 300 $\mu$ m thickness PCB
- Anode wires are Au coated W wires of 20 $\mu$ m diameter 3mm pitch
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CBM TRD triangular pad plane interface to 32ch SPADIC



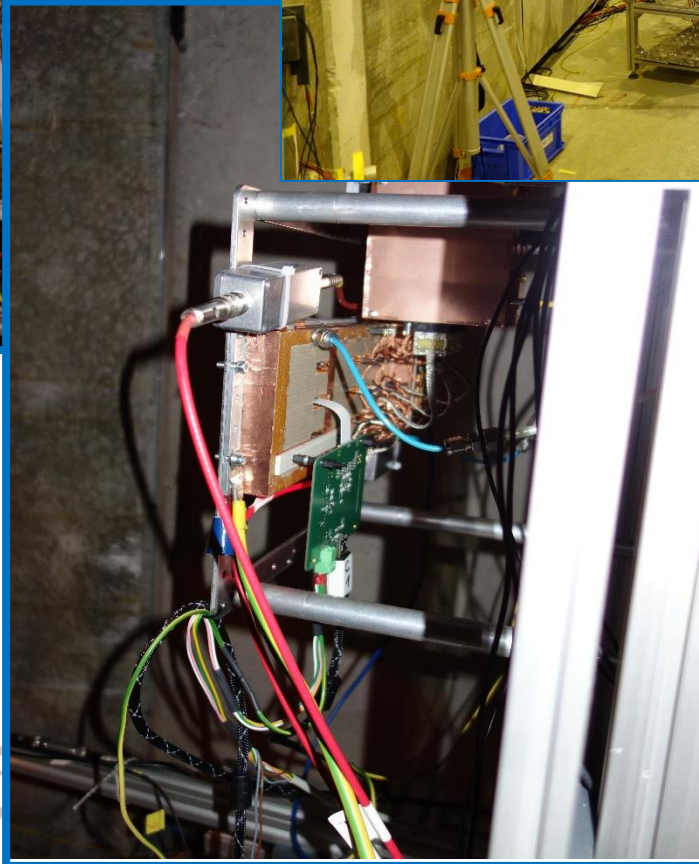
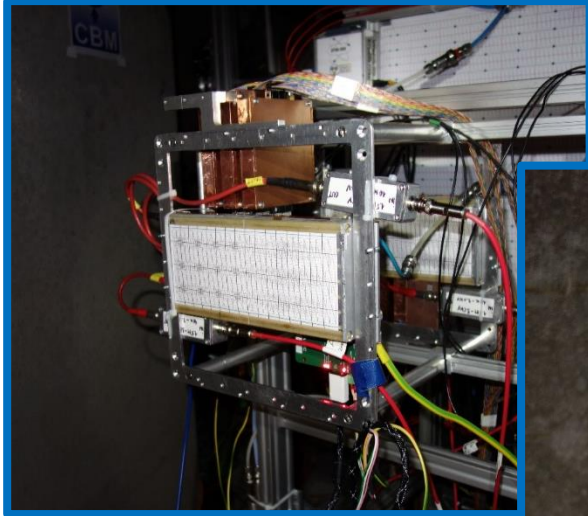
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by David Emschermann, 08.04.2011

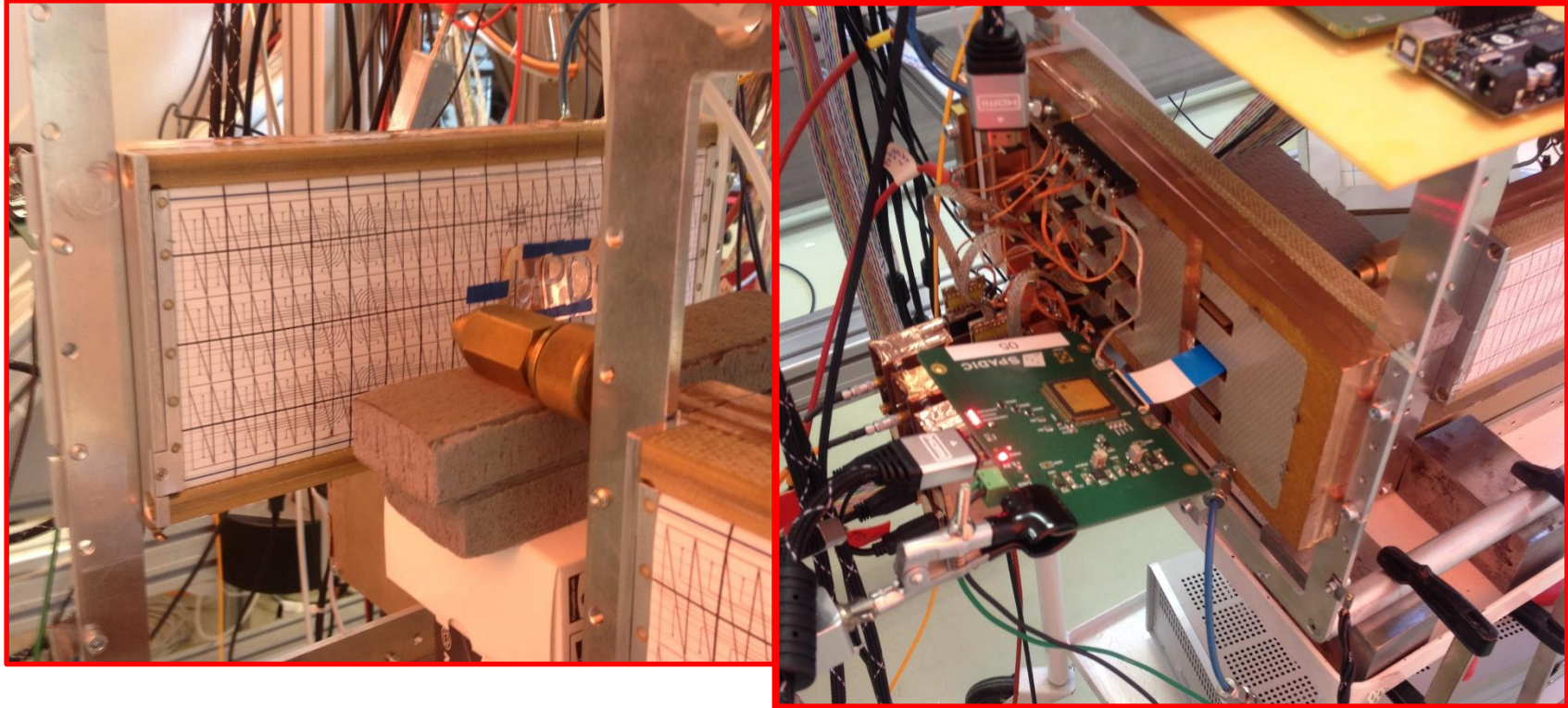


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## Setup at CERN SPS 2015

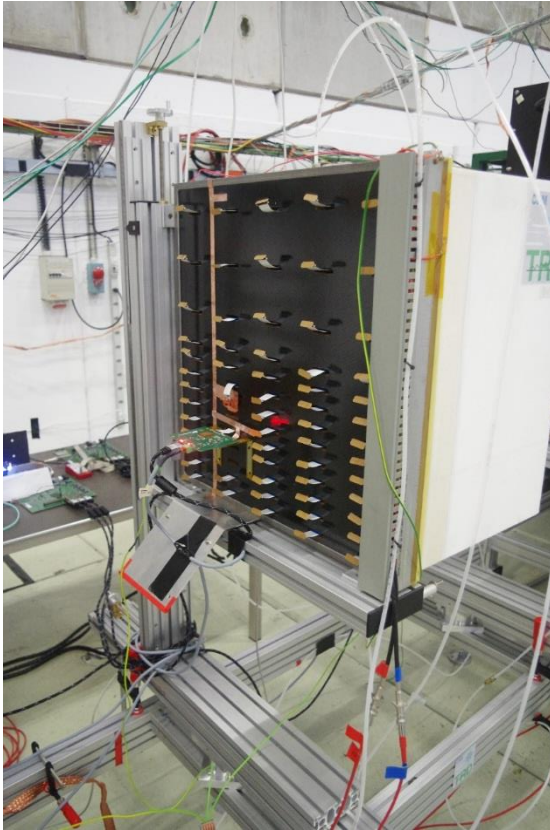


## First Readout of Bucharest Prototype with SPADIC1.0 and signal from $^{55}\text{Fe}$ Source ( $\approx 3\text{MBq}$ )





## TRD Chamber close-up



- Size: 60 \* 60 cm
- Radiator length: ca 35cm PE foam with density of  $0.026 \text{ g/cm}^3$  and 4mm mechanical structure of Rohacell
- Pad size: 7.124mm \* 75mm



## Fe-55

•  $K_{\alpha 1} = 5,89 \text{ keV}$

• Escape peak in Argon

K-alpha 2.95700002

K-beta 3.19199991

• Weighted both at 50% -> 3.08 keV