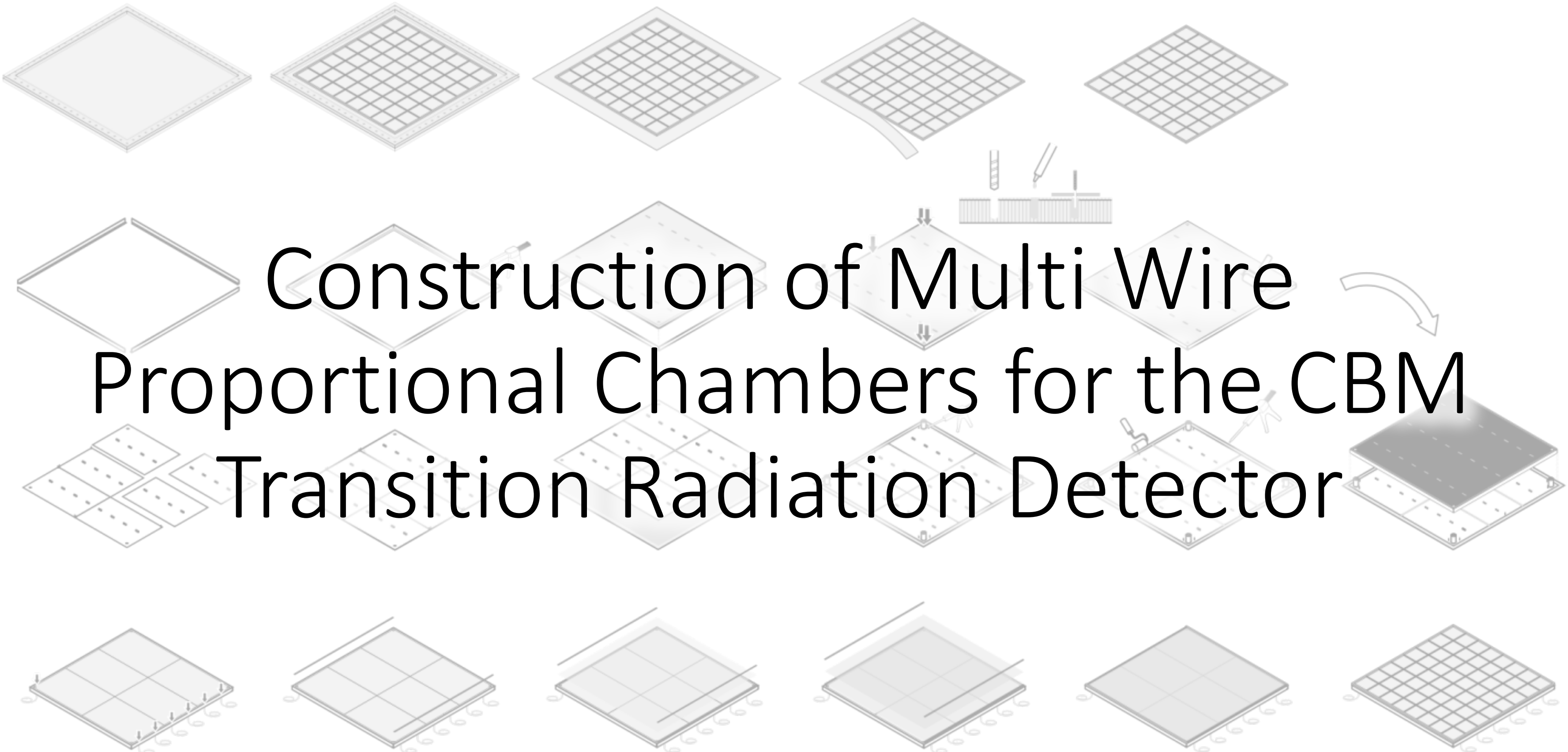
Construction of Multi Wire Proportional Chambers for the CBM Transition Radiation Detector



Bundesministerium für Bildung und Forschung

Florian Roether

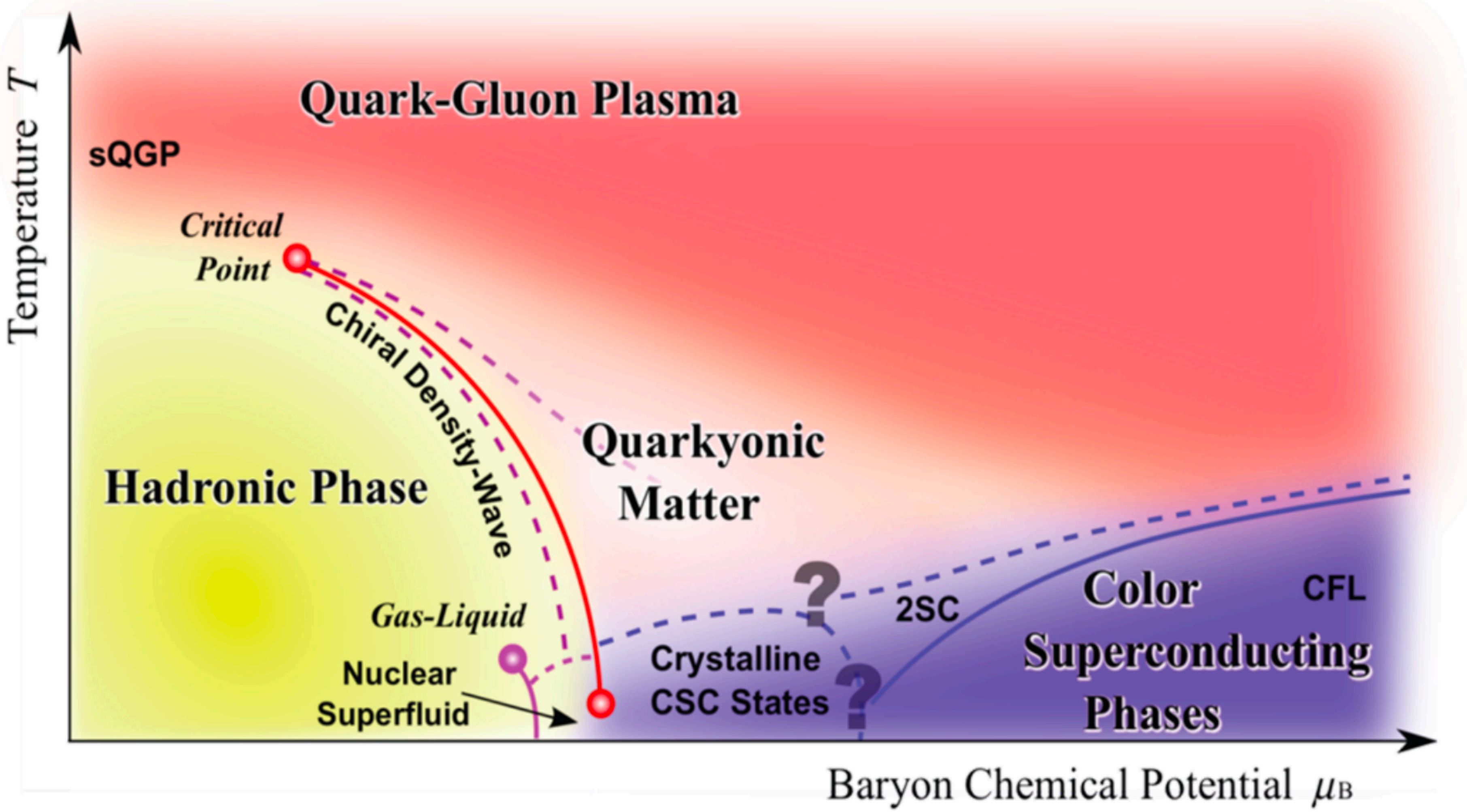
FAIRNESS 2.6.2017

IKF Institut für Kernphysik Frankfurt

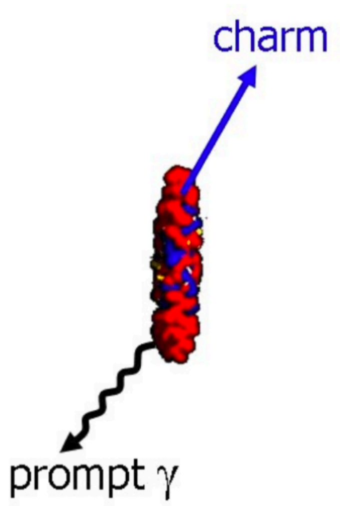
Outline

- Motivation
- The CBM experiment
- Physics objectives of the TRD
- Principle of operation
- Front end electronics
- Chamber construction

The phase diagram of nuclear matter

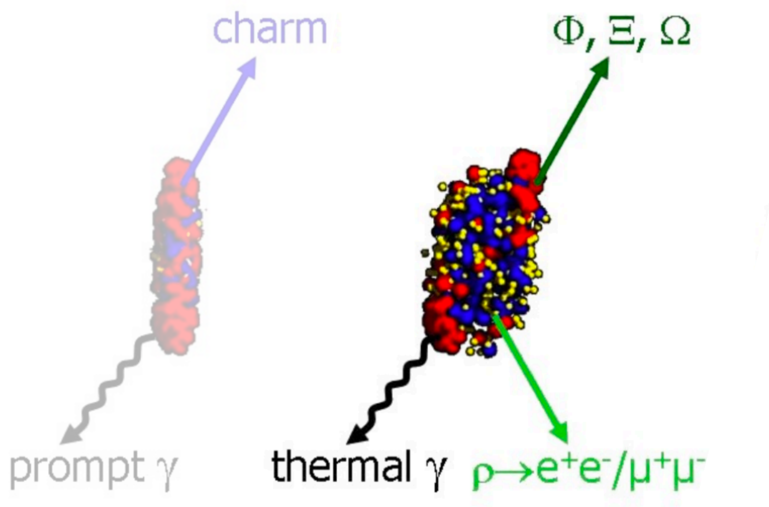


Diagnostic probes



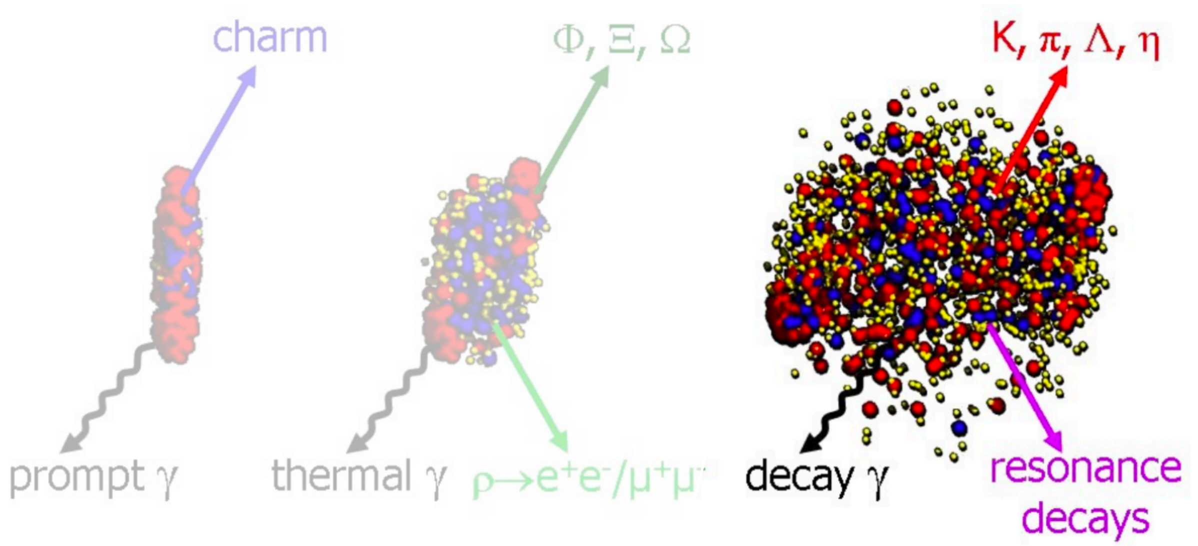
- D – mesons
- J/ψ – mesons
- promt ɣ

Diagnostic probes



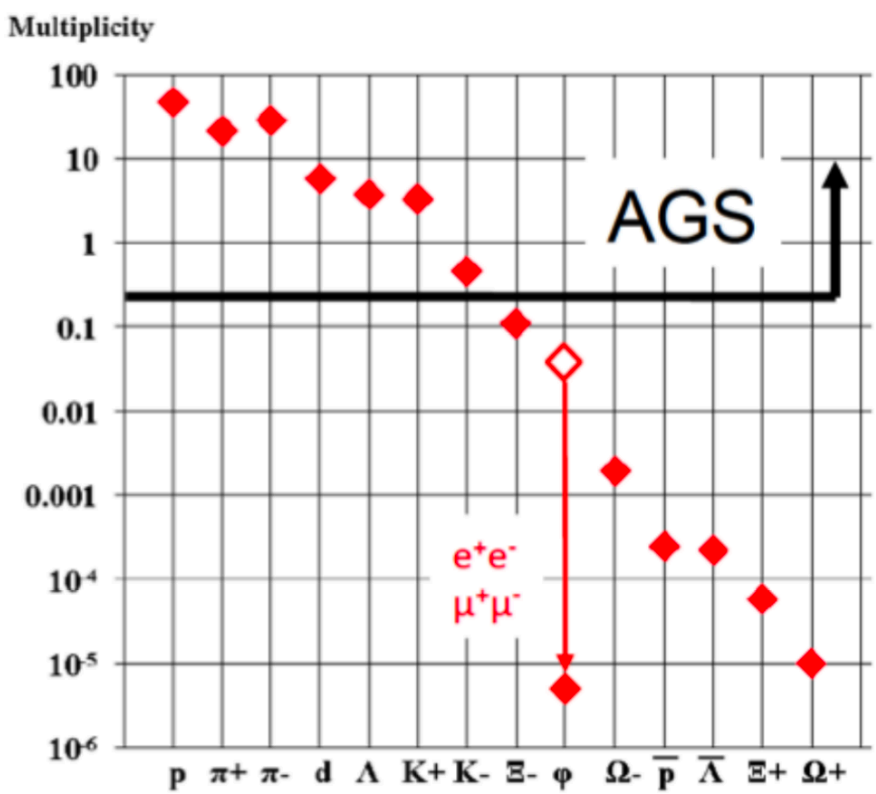
- vector mesons (ω,ρ,ϕ)
  → decay to mesons or dilepton pairs
- multi-strange hyperons (Ξ,Ω)
  → small hadronic cross section
- thermal ɣ

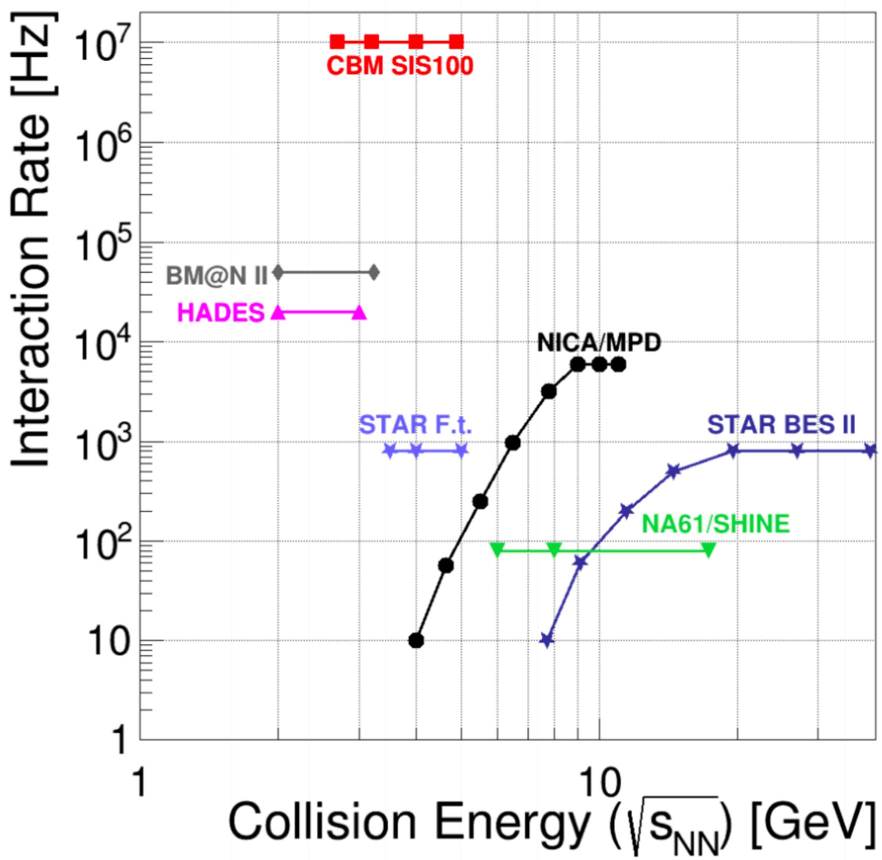
Diagnostic probes



- final stage "freeze out"
  → K, π, Λ, η
  → resonances
- decay ɣ

Diagnostic probes

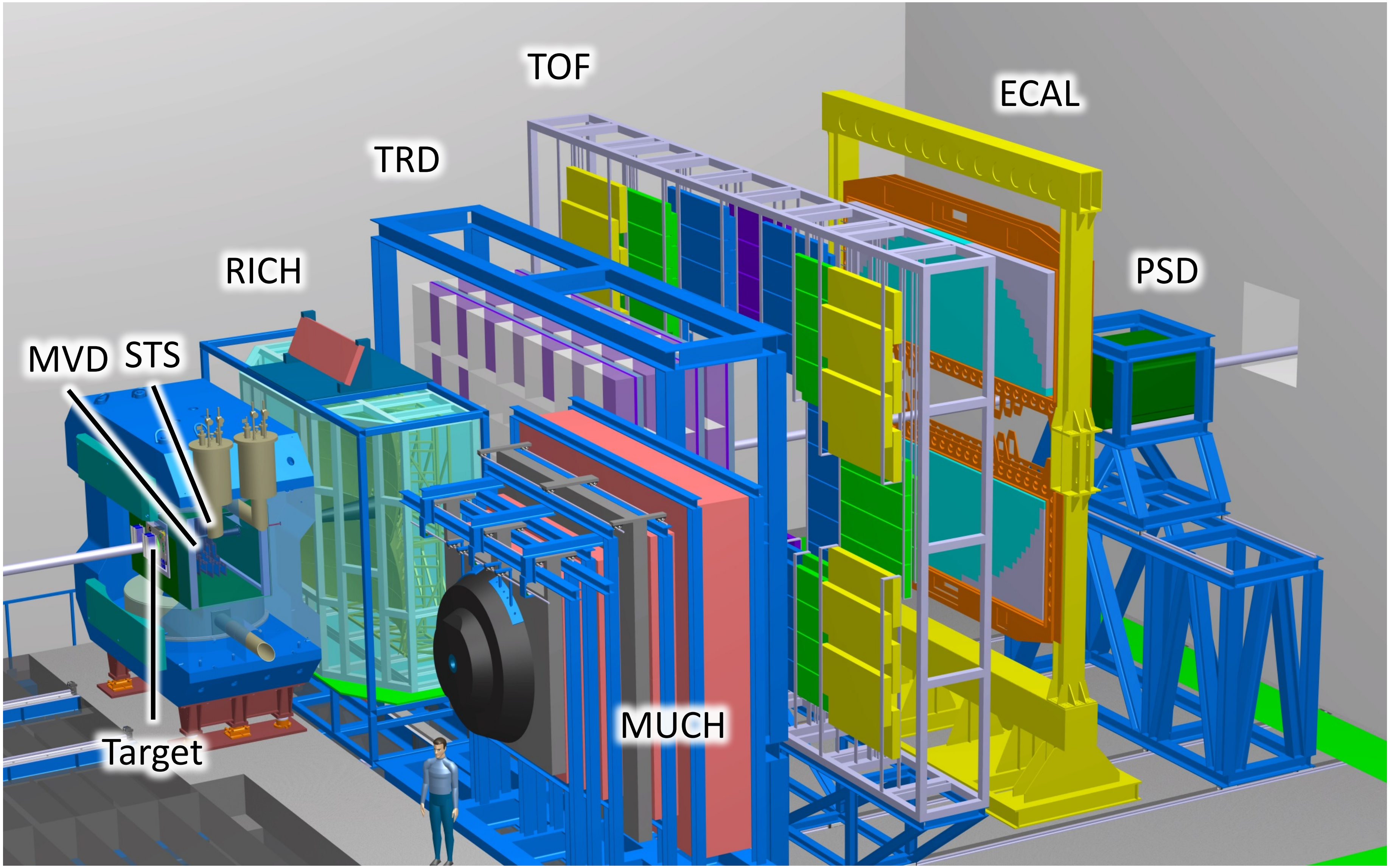




Physics cases and observables at CBM

- The equation-of-state of matter at neutron star densities.
- In-medium properties of hadrons.
- Phase transitions from hadronic matter to quarkyonic or partonic matter at high net-baryon densities.
- Hypernuclei, strange dibaryons and massive strange objects.
- Charm production mechanisms, charm propagation and in-medium properties of charmed particles in (dense) nuclear matter.

The Compressed Baryonic Matter experiment



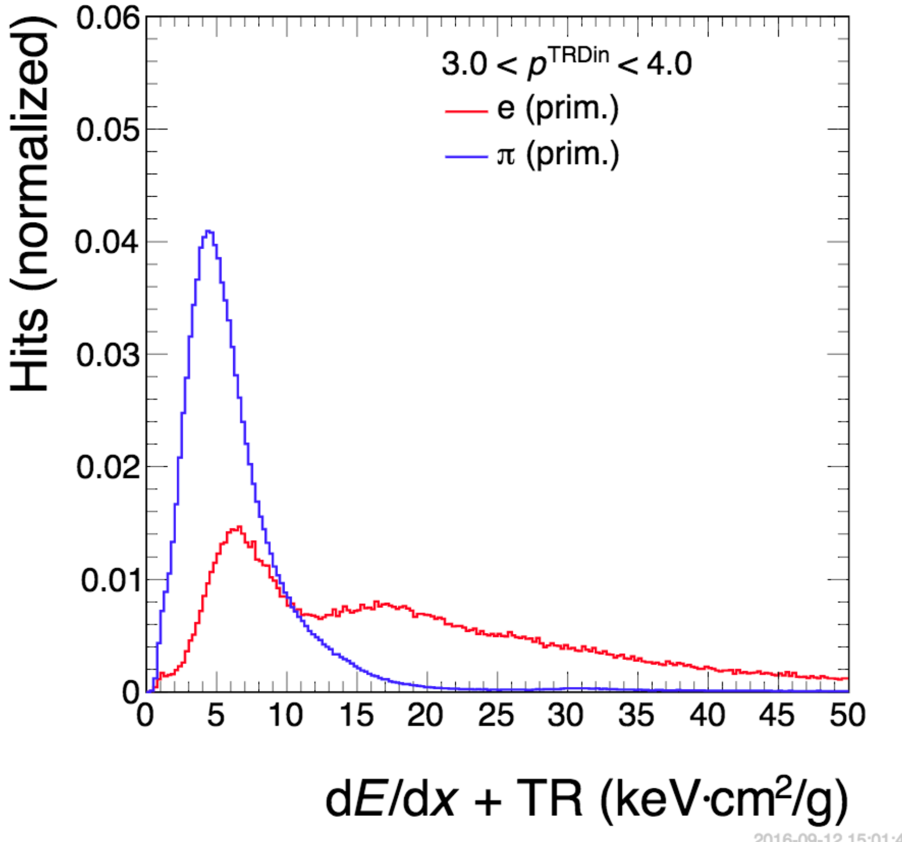
The Transition Radiation Detector

Design parameter (SIS100)	
Max. signal collection time	0.3 µs
Typical space point resolution	~ 300 µm
Pion suppression at 90 % electron efficiency and $p \geq 1.5$ GeV/c	10 - 20
dE/dx resolution above $p = 1$ GeV	~ 25 %
Detector radiation length (active area)	< 5% X_0 per layer
Pseudo-rapidity coverage	$0.89 < \eta < 3.74$
Azimuthal coverage	2π

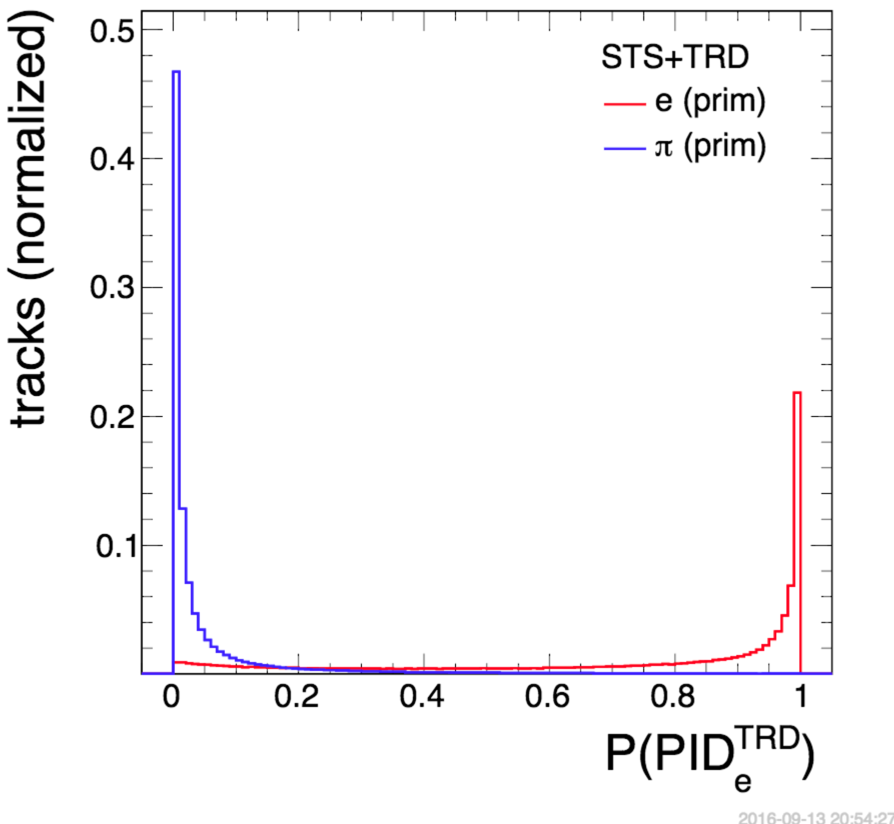
Physics objectives of the TRD

- **Intermediate mass dileptons**
  Provide access to thermal radiation from the hot and dense fireball.
- **Fragments**:
  Essential for the study of hyper- and anti-nuclei.
- **Quarkonia**:
  Quarkonia states, are probes for the presence of deconfined matter.
- **Low mass vector mesons:**
  Provides information on medium induced modification of the hadron spectral functions.
- **Photons:**
  Can provide information on the temperatures of the early stages in a heavy-ion collision.

Particle identification



Likelihood method



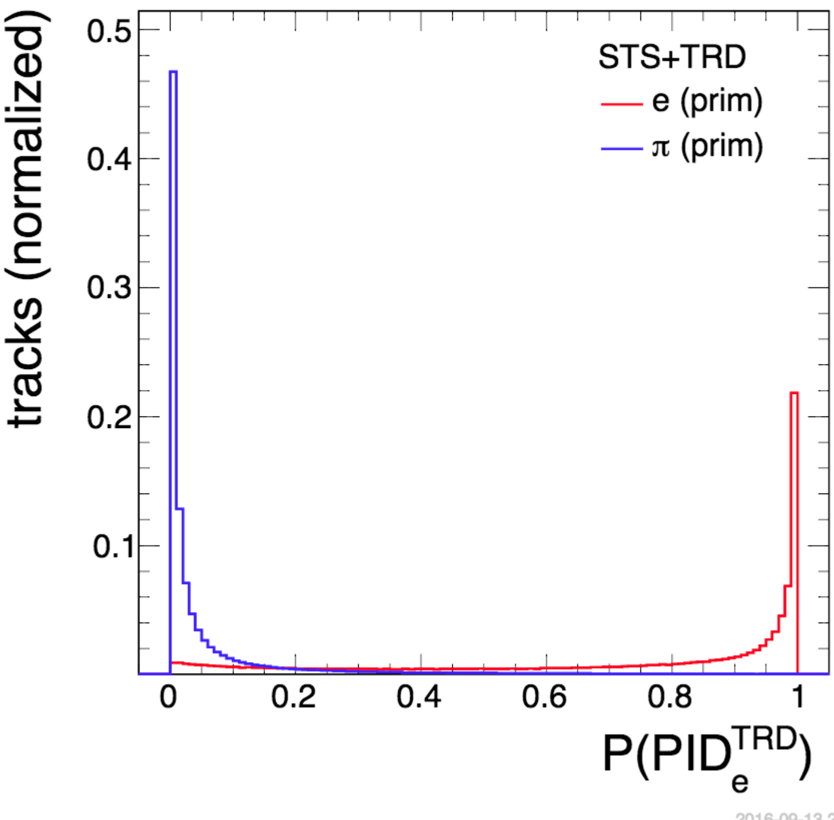
$$L_{el} = \frac{P_e}{P_e + P_\pi}$$

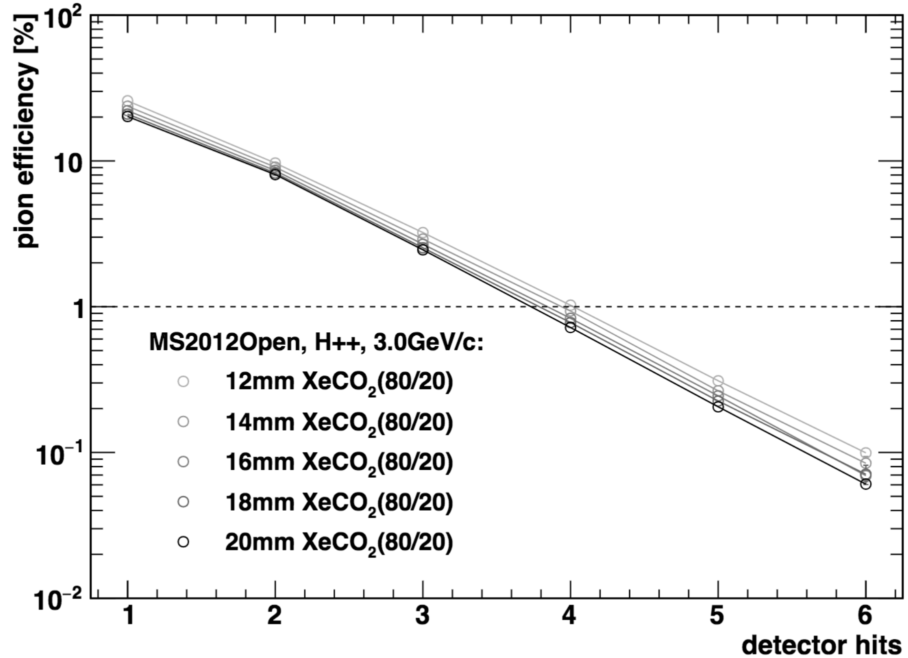
$$L_\pi = \frac{P_\pi}{P_\pi + P_e}$$

$$P_e = \prod_{i=1}^{N} P(E_i|e)$$

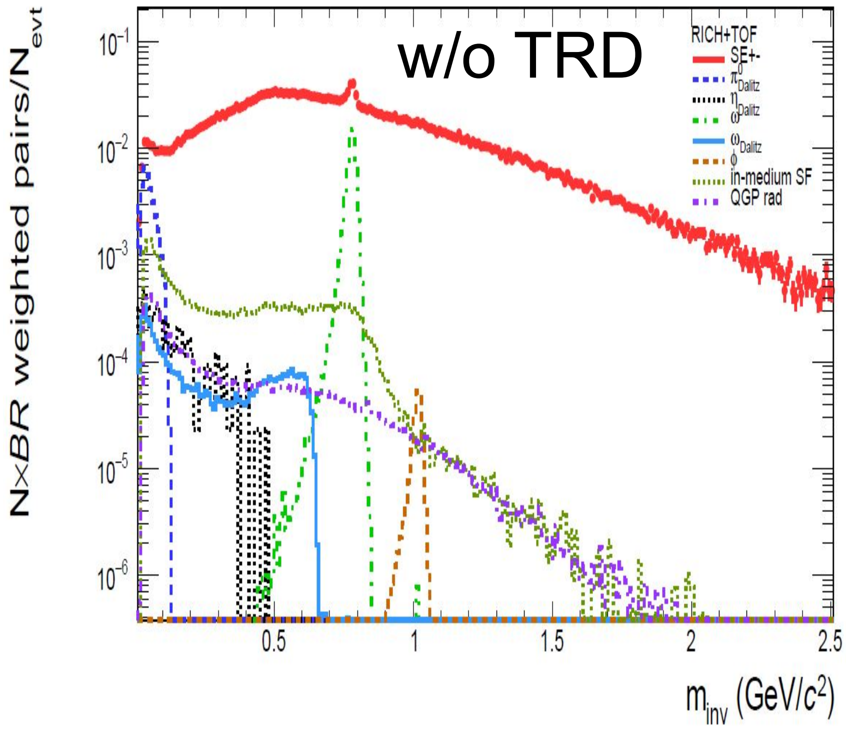
$$P_\pi = \prod_{i=1}^{N} P(E_i|\pi)$$

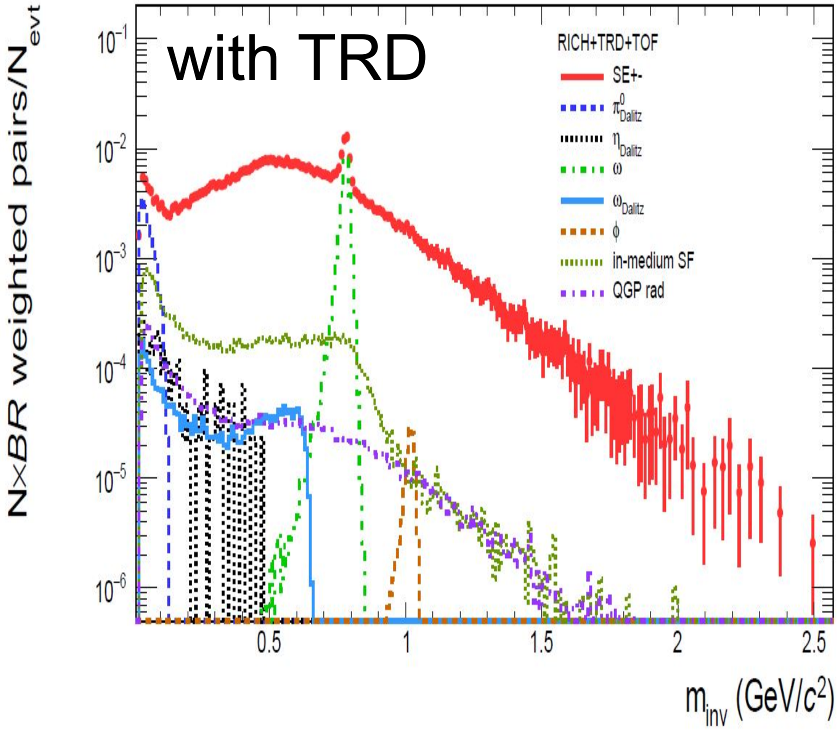
Likelihood method





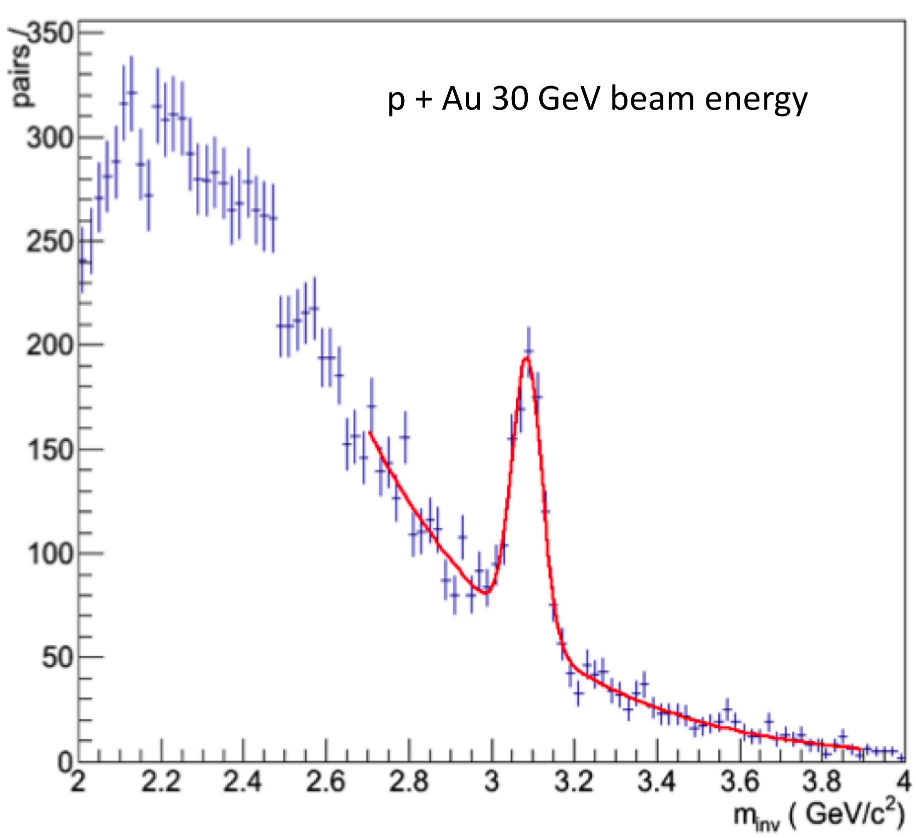
Dielectron reconstruction



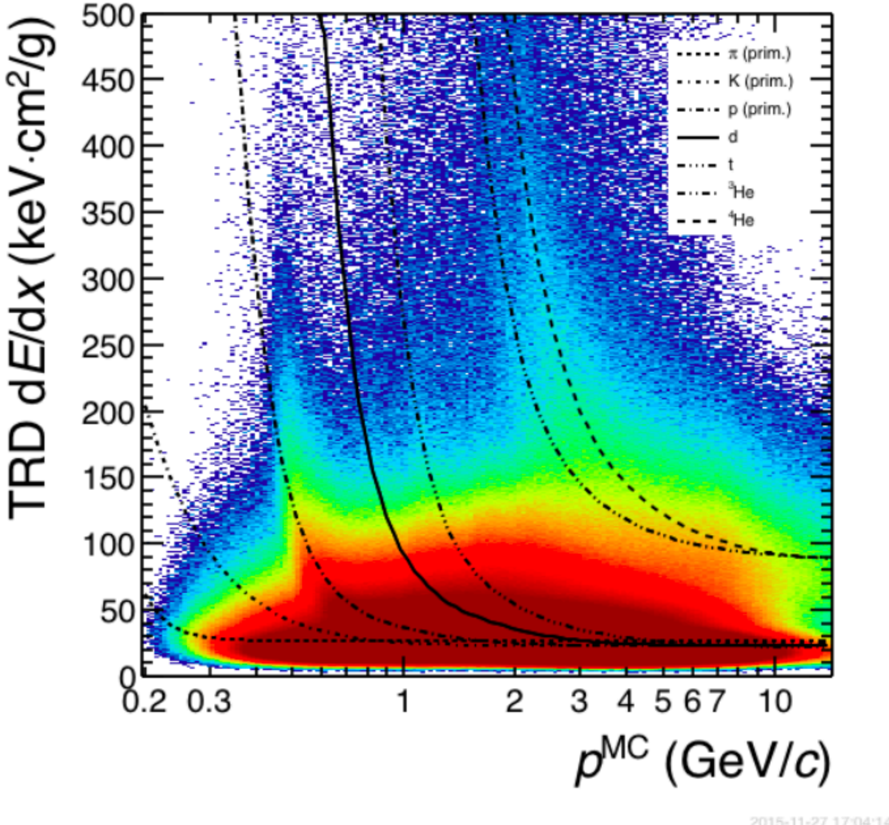


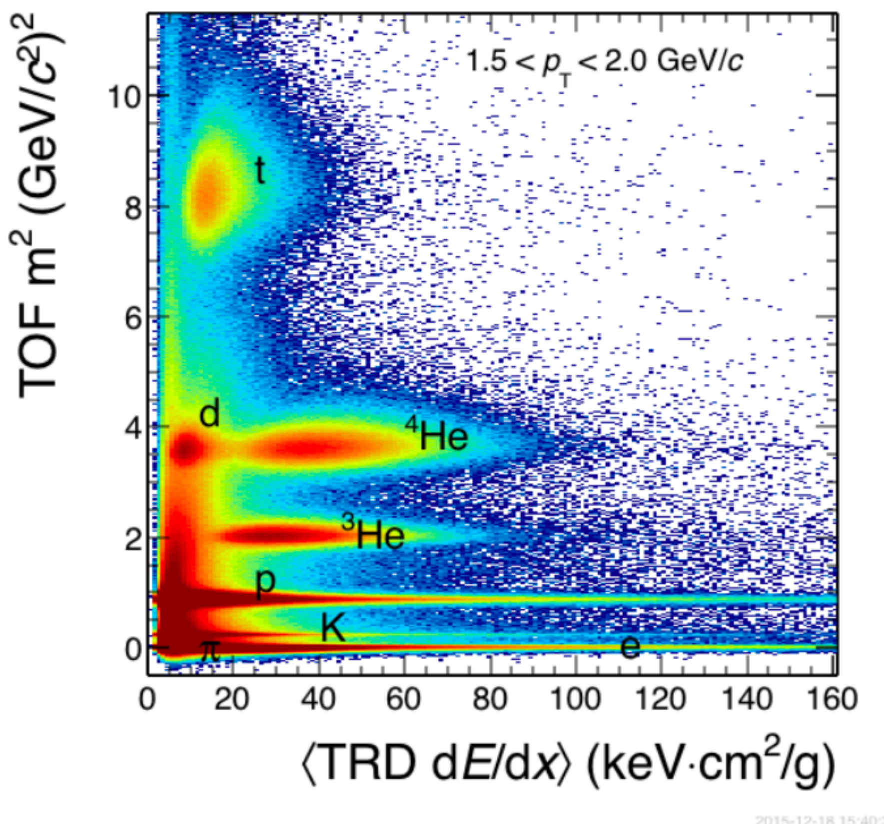
- Au+Au at 8AGeV (10% most central)
- 4 Layer TRD

J/ψ reconstruction

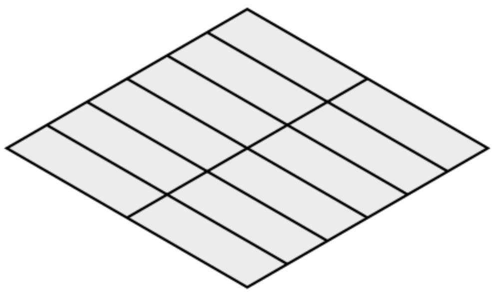


Fragment reconstruction





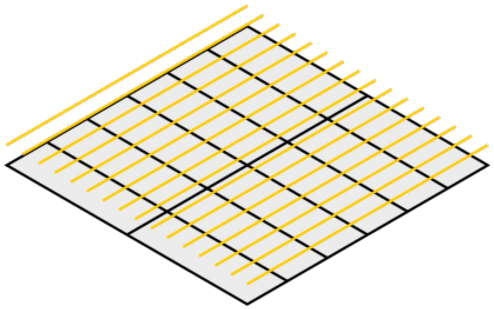
The Transition Radiation Detector



Pad plane:

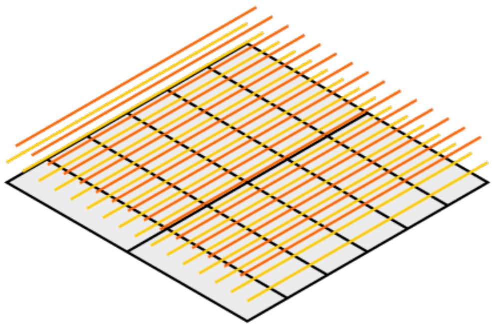
- PCB material (FR4)
- 35µm copper plated
- segmented into pads
- potential: 0V (ground)

The Transition Radiation Detector



Anode wire plane:
- Gold plated tungsten wires
- 20µm diameter
- potential: 1850 V

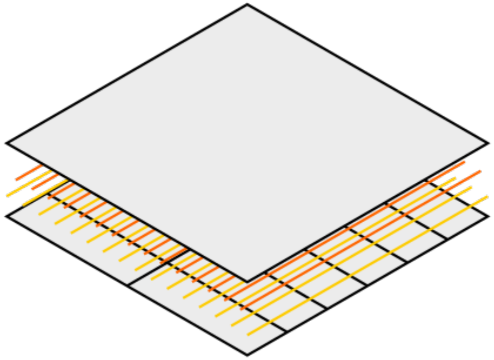
The Transition Radiation Detector



Cathode wire plane:

- Copper-Beryllium wires
- 79 µm diameter
- potential: 0 V (ground)

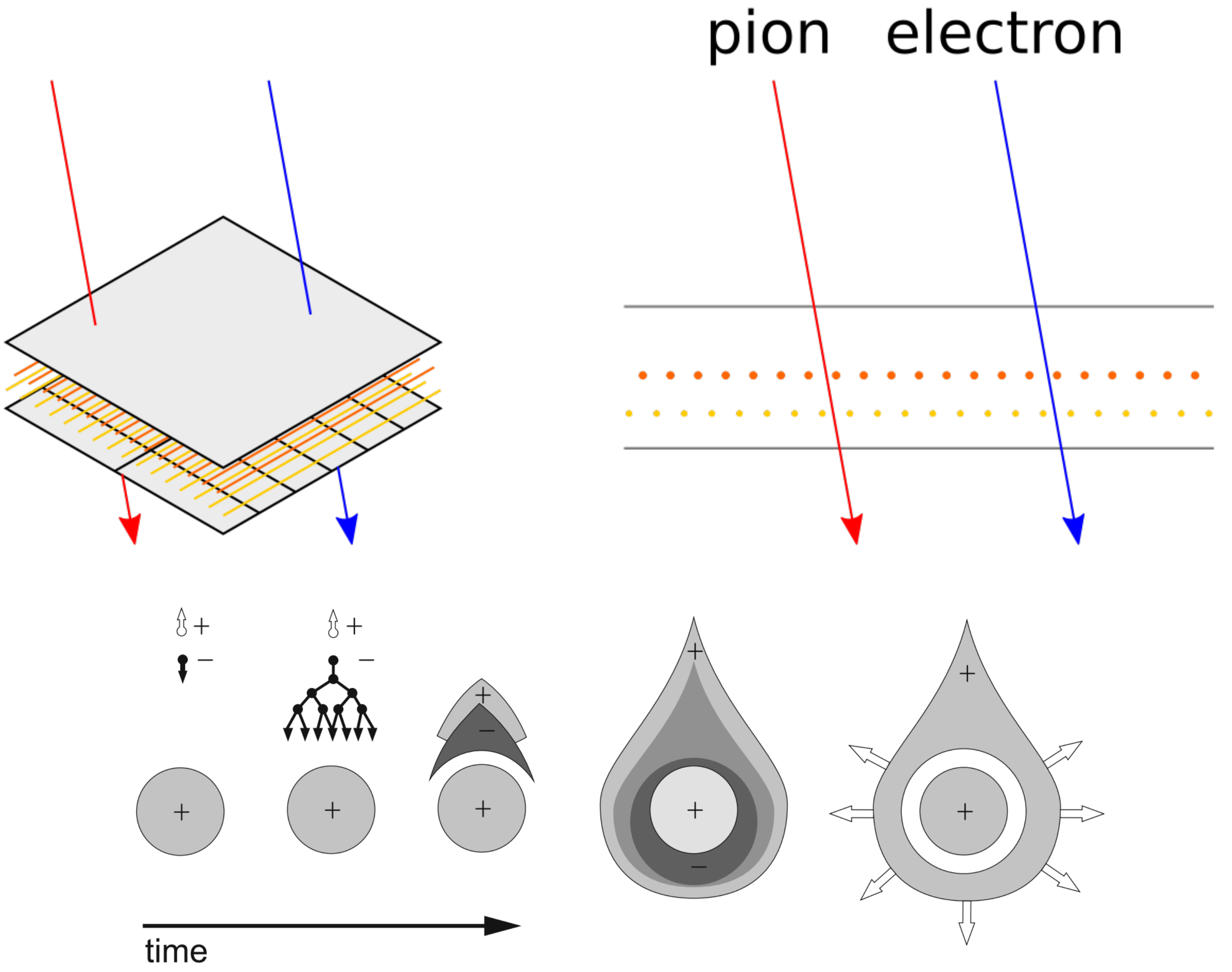
The Transition Radiation Detector



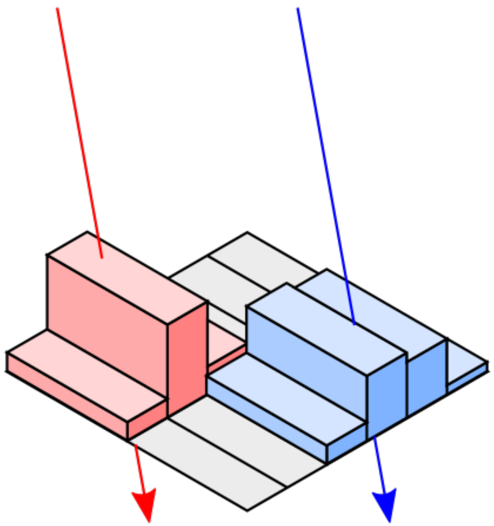
Entrance window:

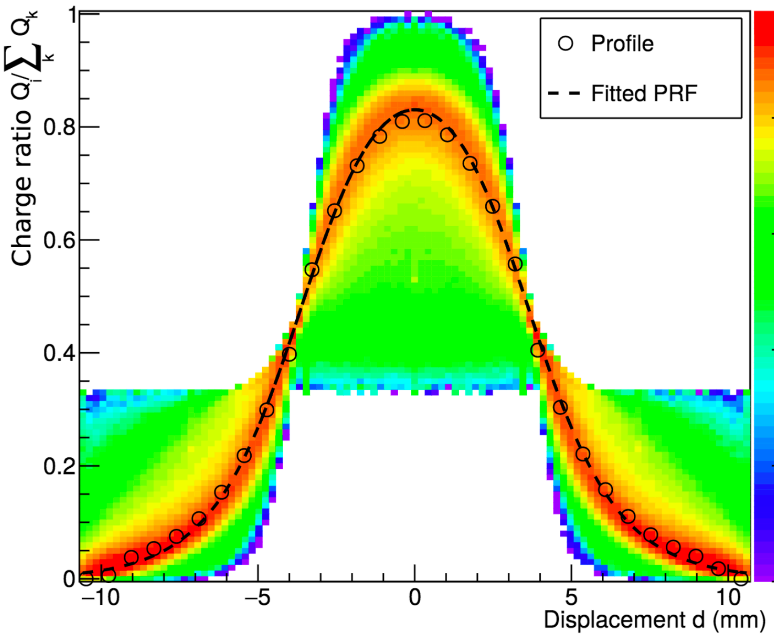
- 20µm Kapton foil
- aluminized
- potential: -150 V

The Transition Radiation Detector

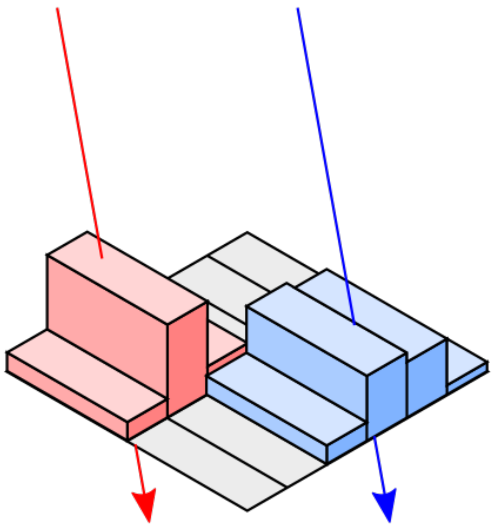


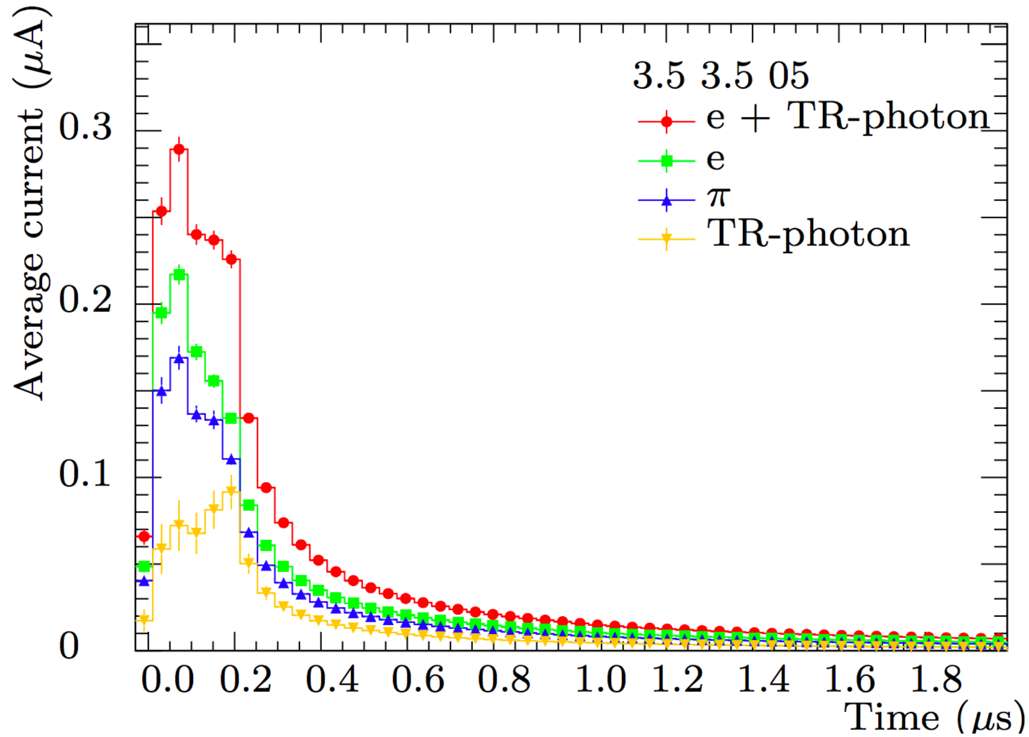
Pad response function



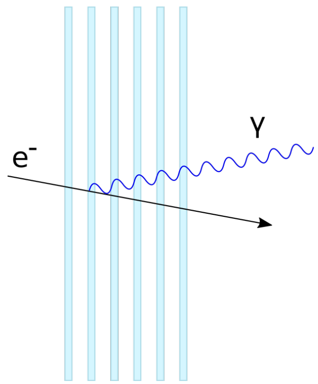


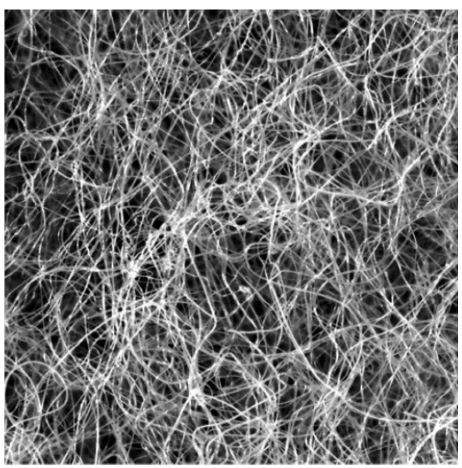
Induced signal on pad plane

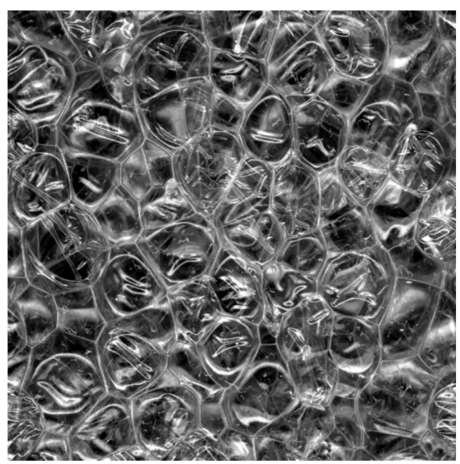


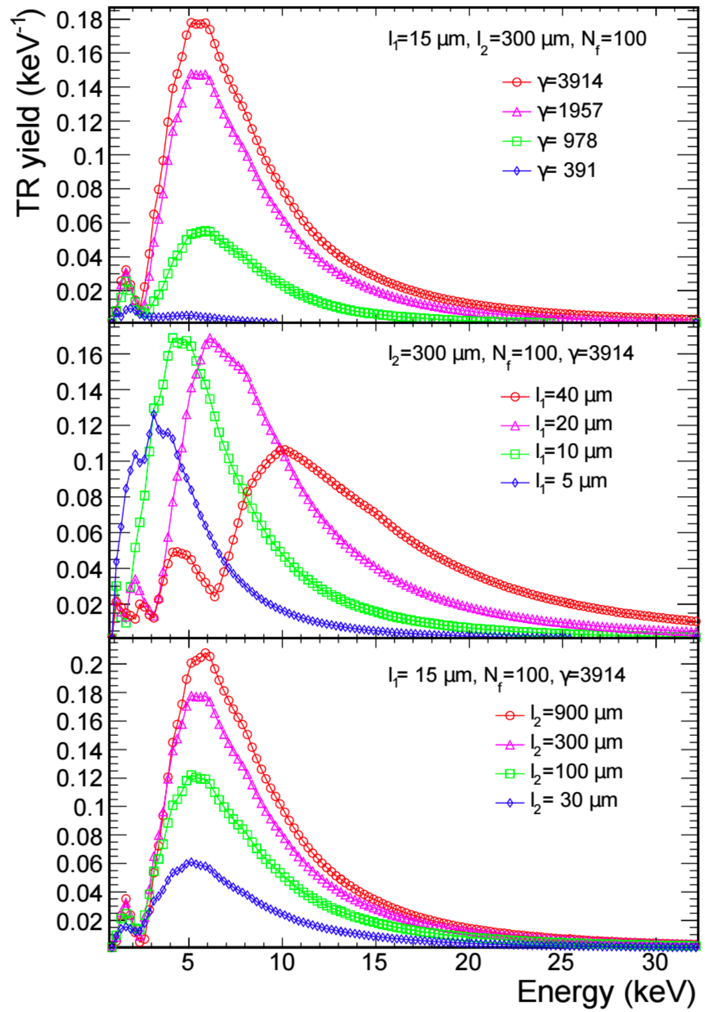


Transition Radiation

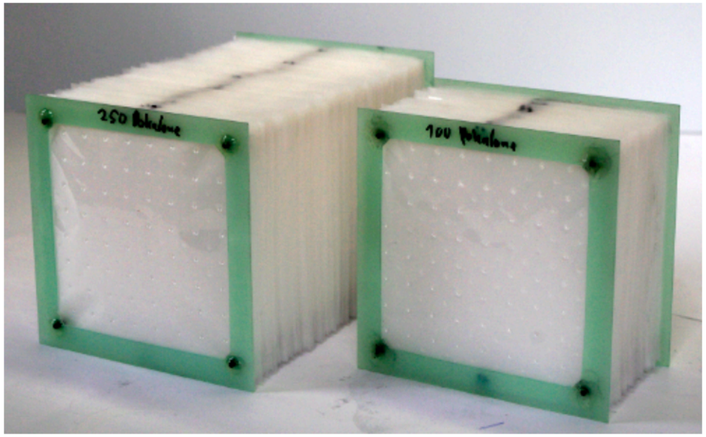


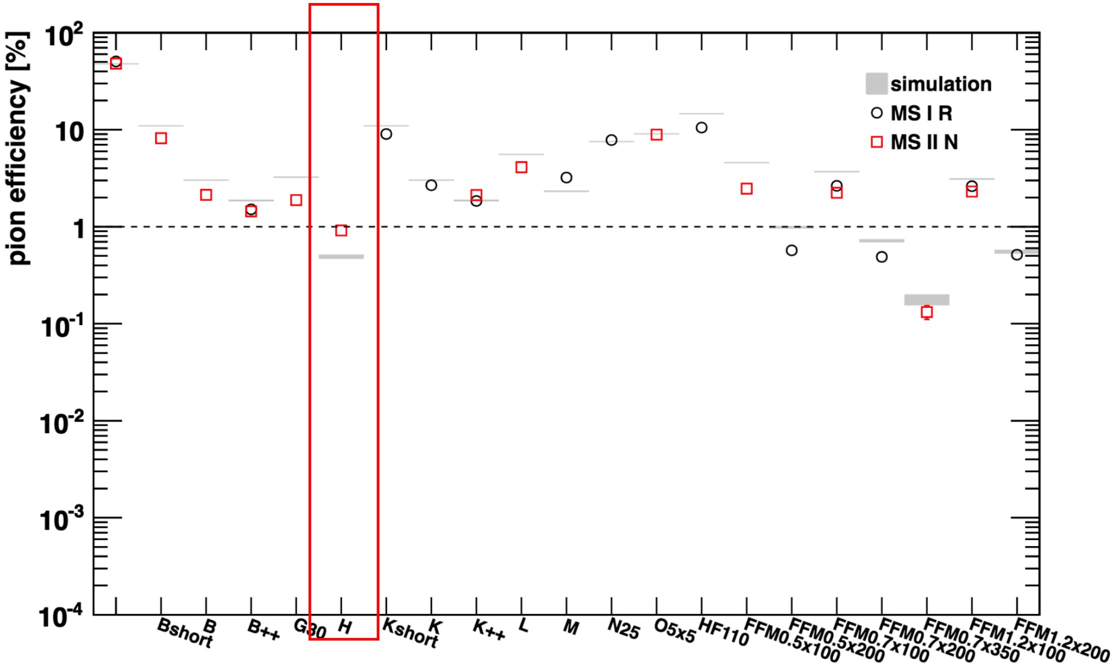




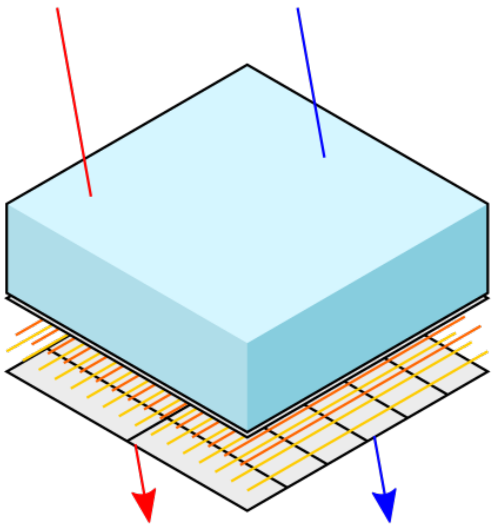


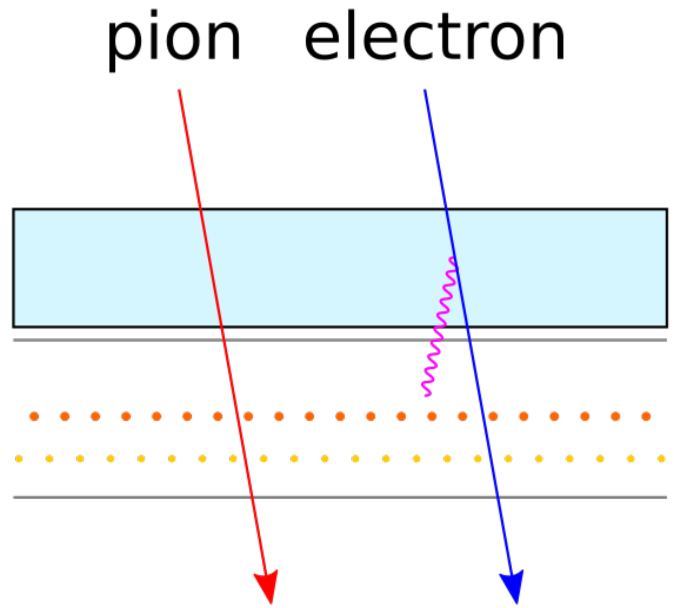
Test of different radiators



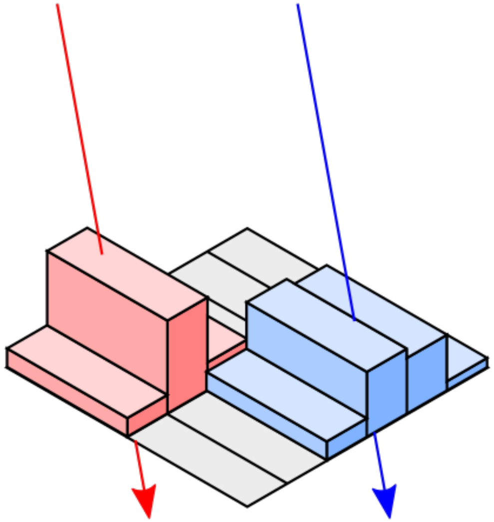


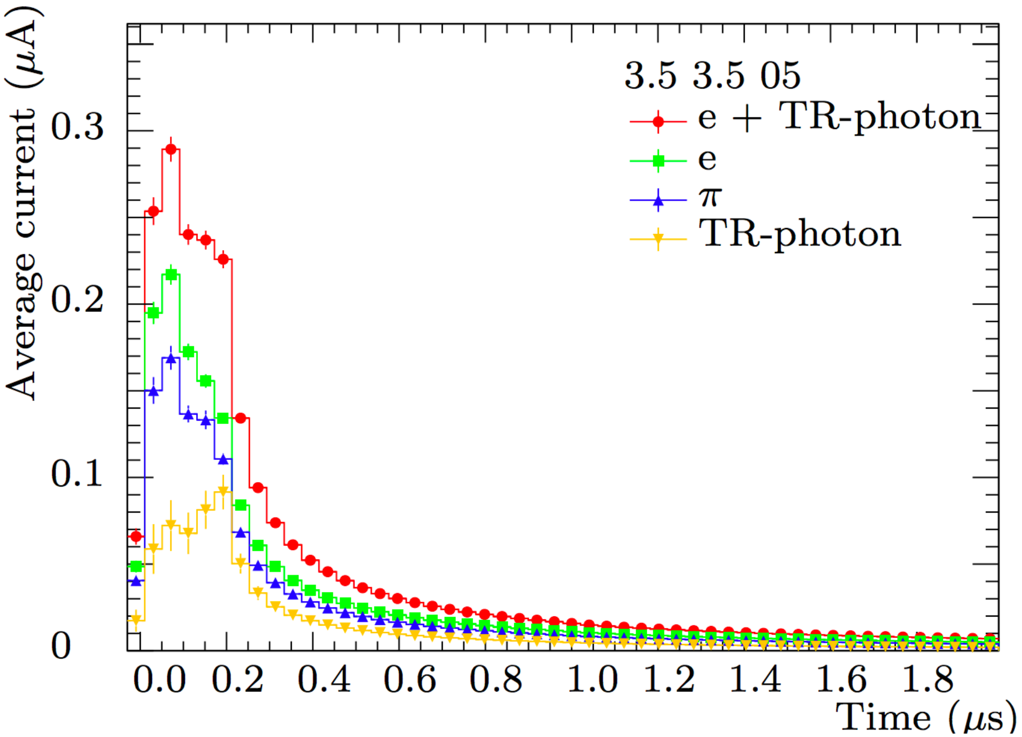
The Transition Radiation Detector



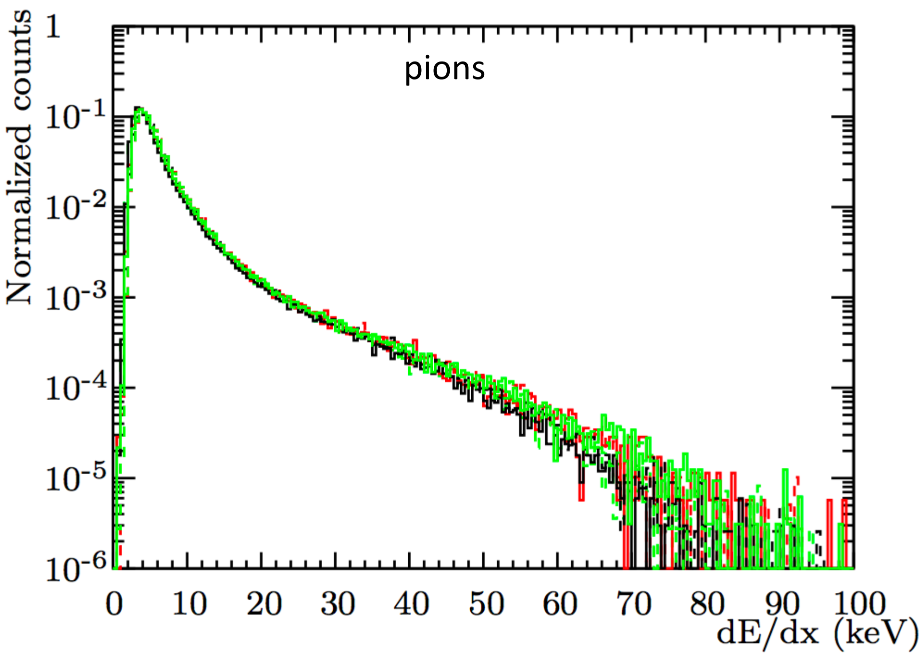


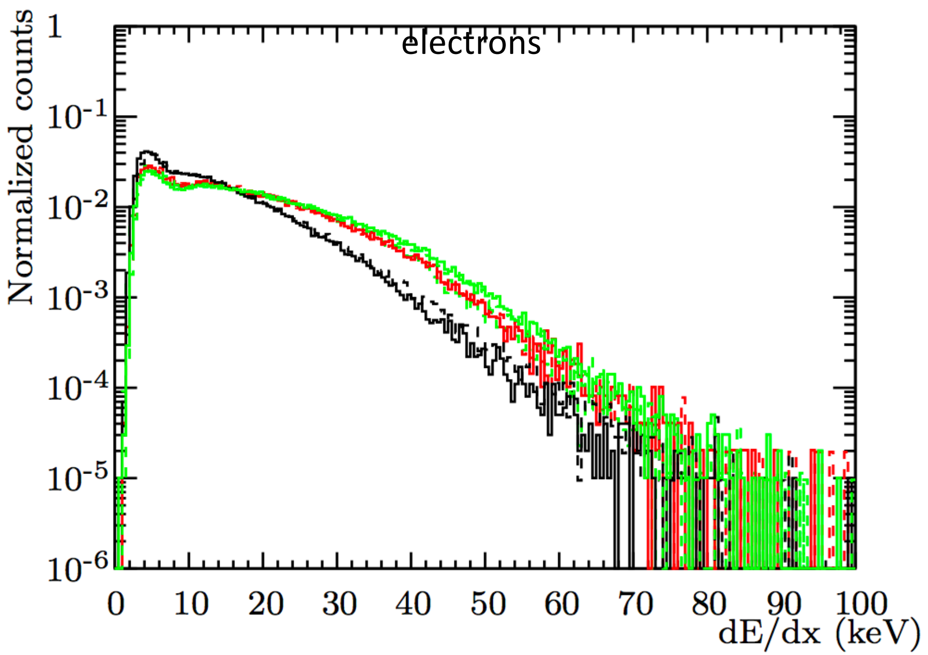
Induced signal on pad plane



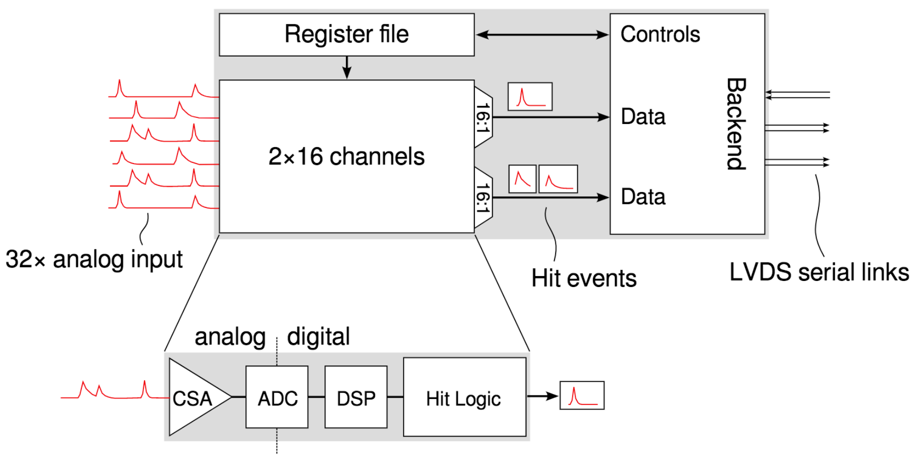


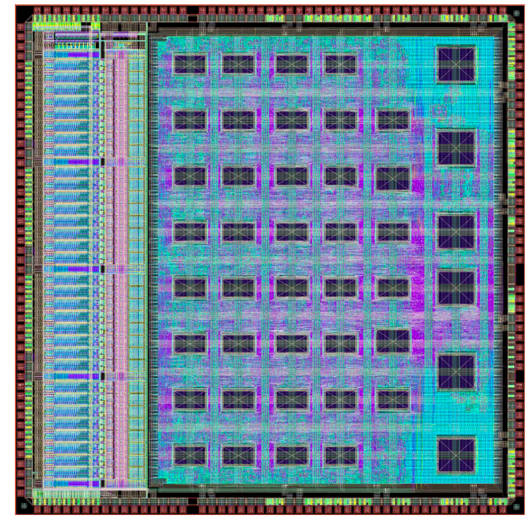
dE/dx spectra for pions and electrons

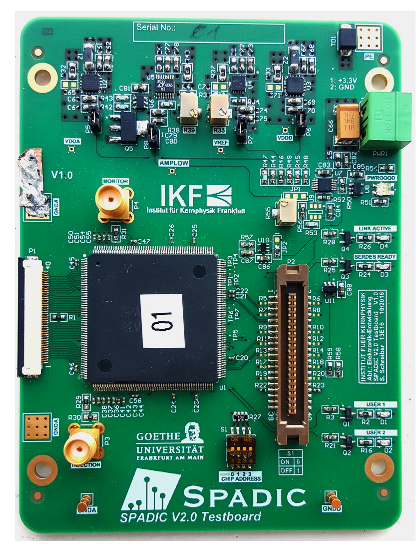




Front end electronics



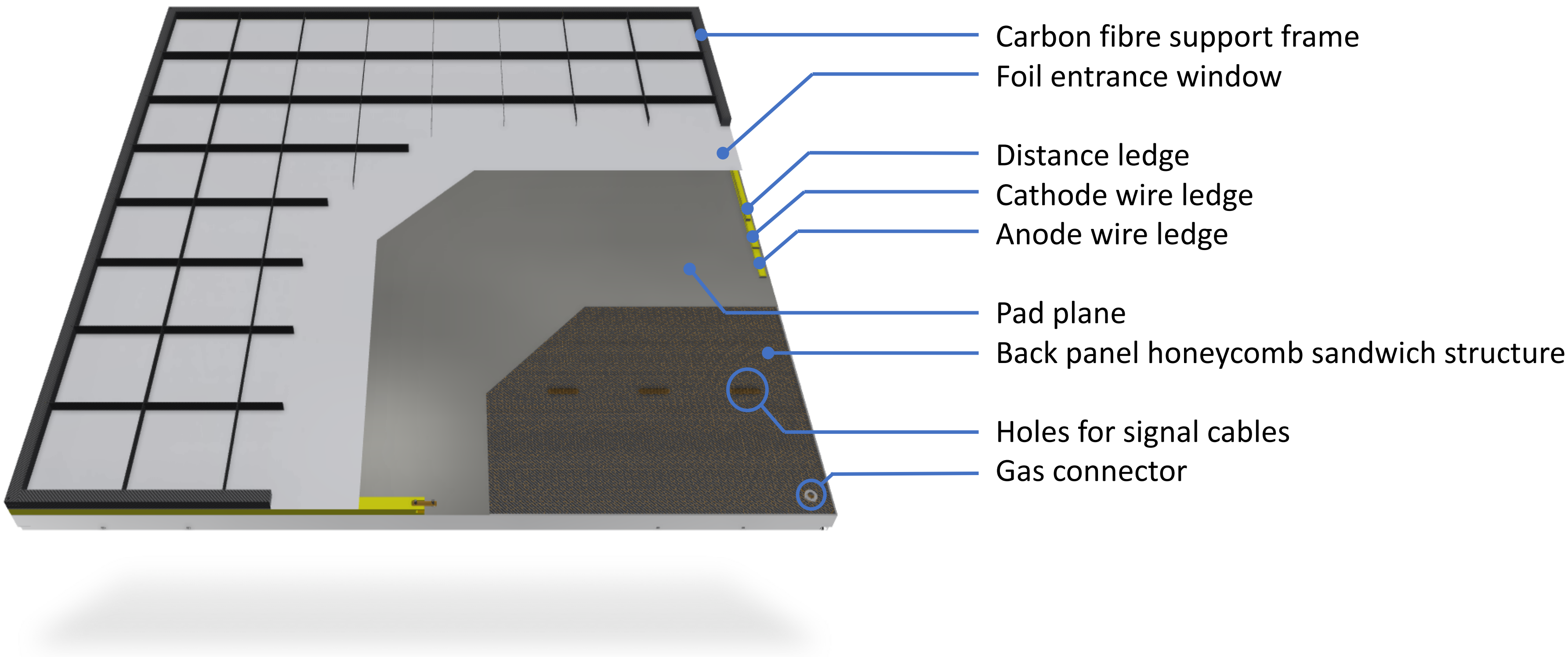




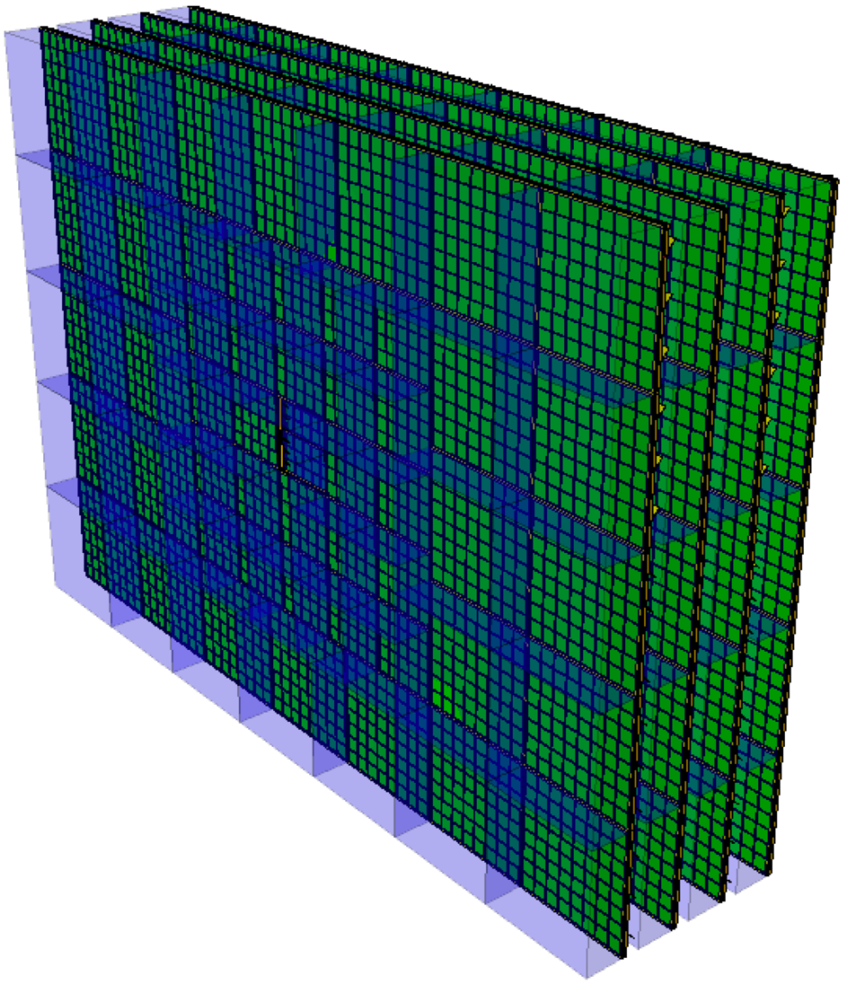
SPADIC (Self-triggered Pulse Amplification and Digitization asIC)

- 32 channels
- 9-bit ADC
- Self-triggered (two trigger modes)
- Digital shaper

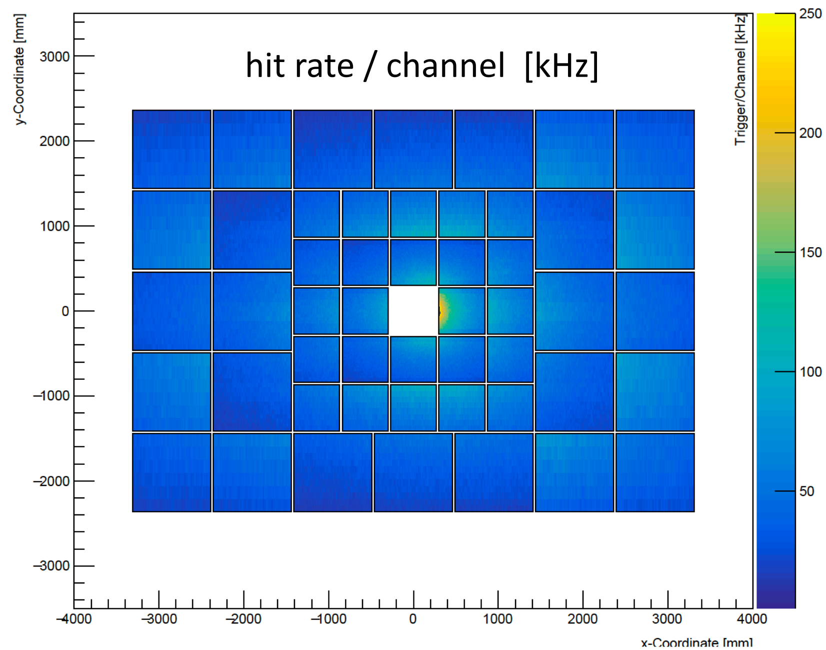
Chamber design



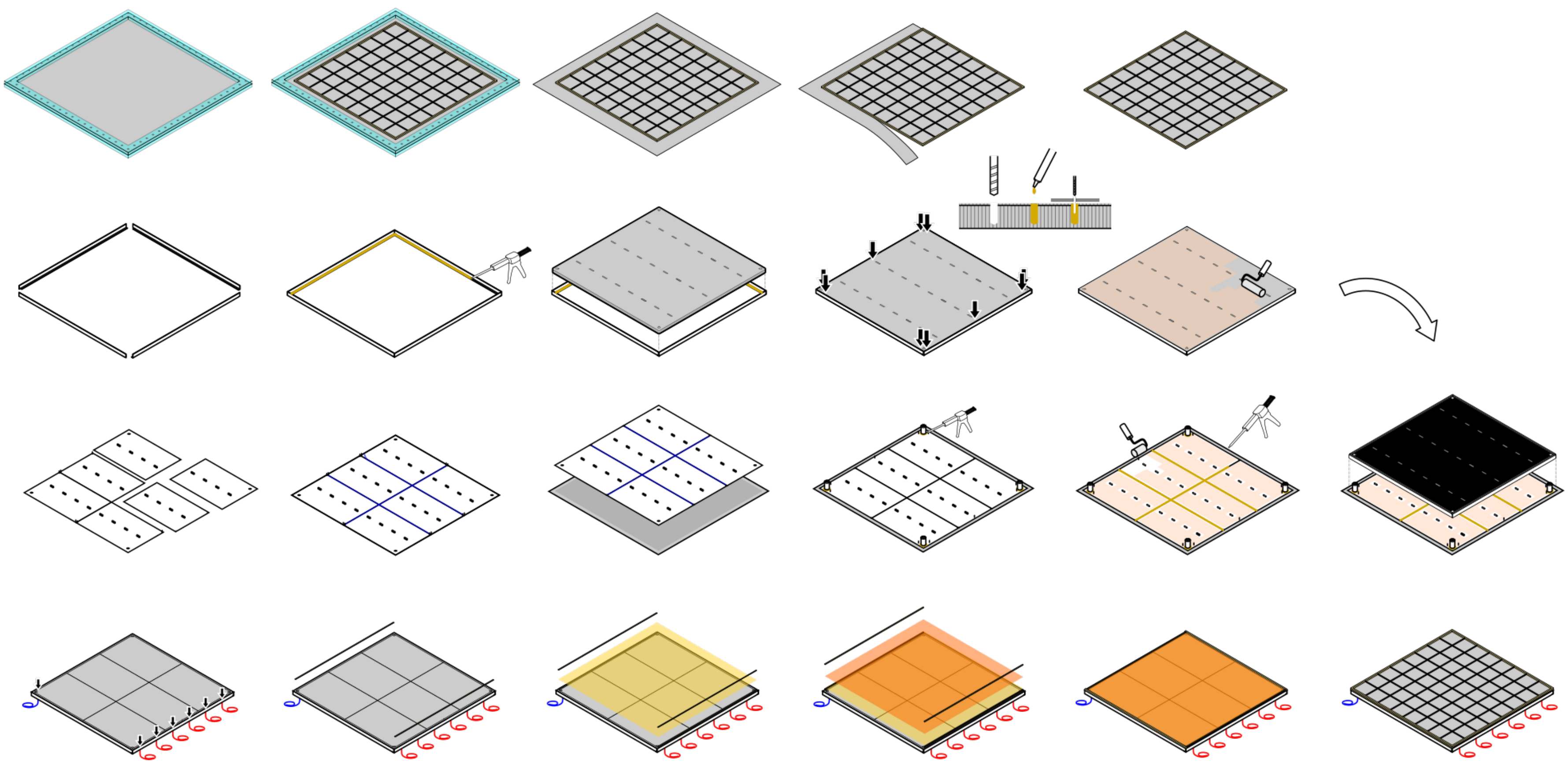
Station layout



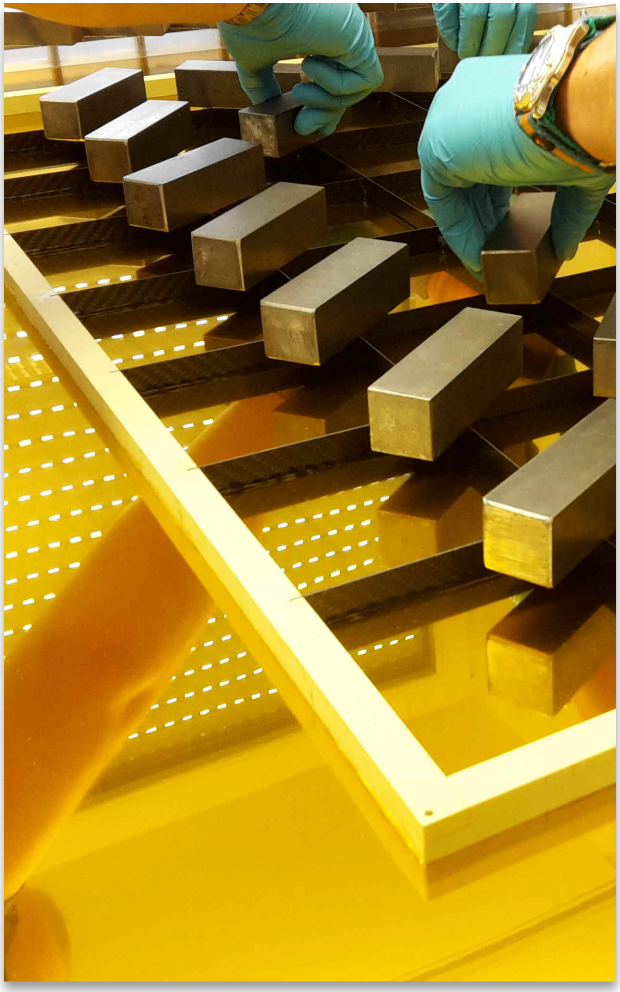
- Three large chamber types ($95x95cm^2$)
- Three small chamber types ($57x57cm^2$)
- 50 chambers per detector layer



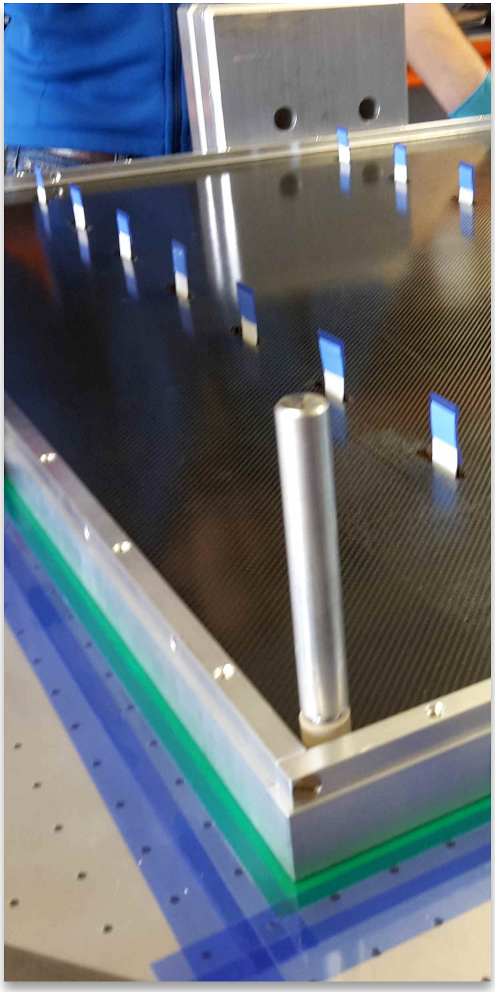
Chamber construction



First large prototypes



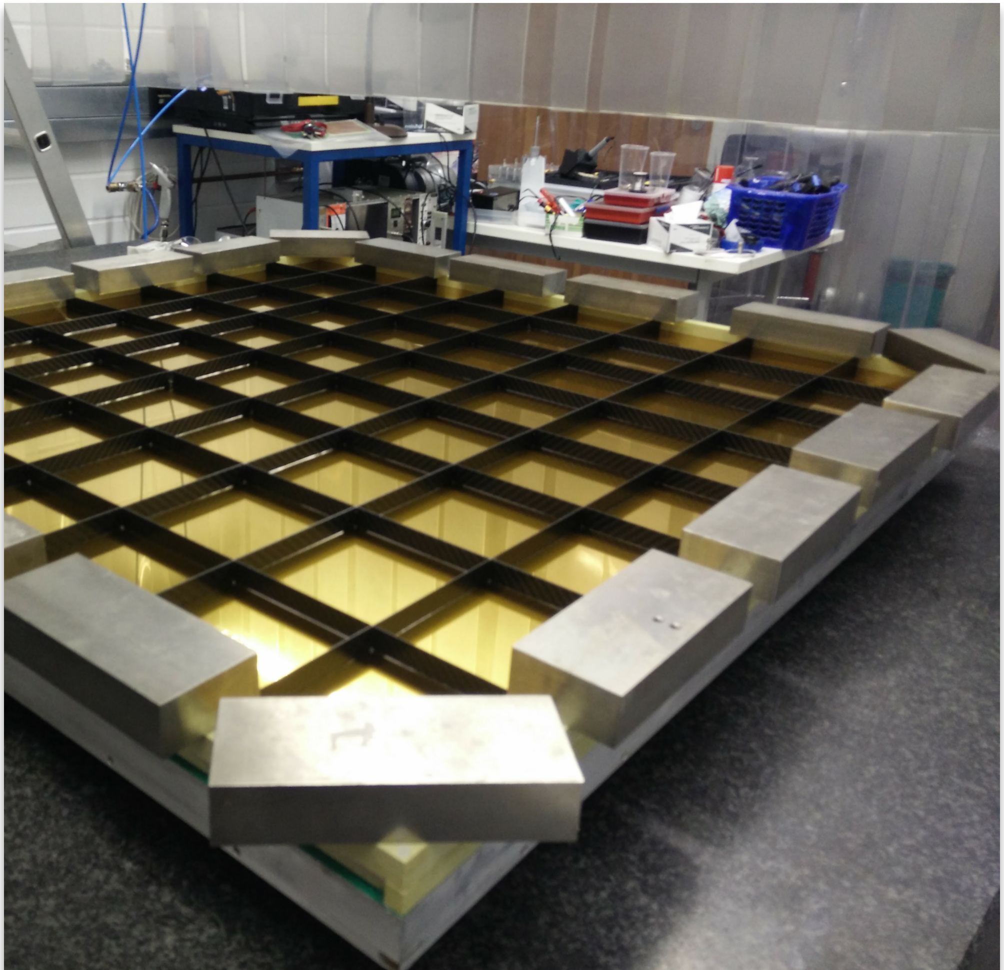
Entrance window



Back panel

Wire ledges with anode- and cathode-wire planes

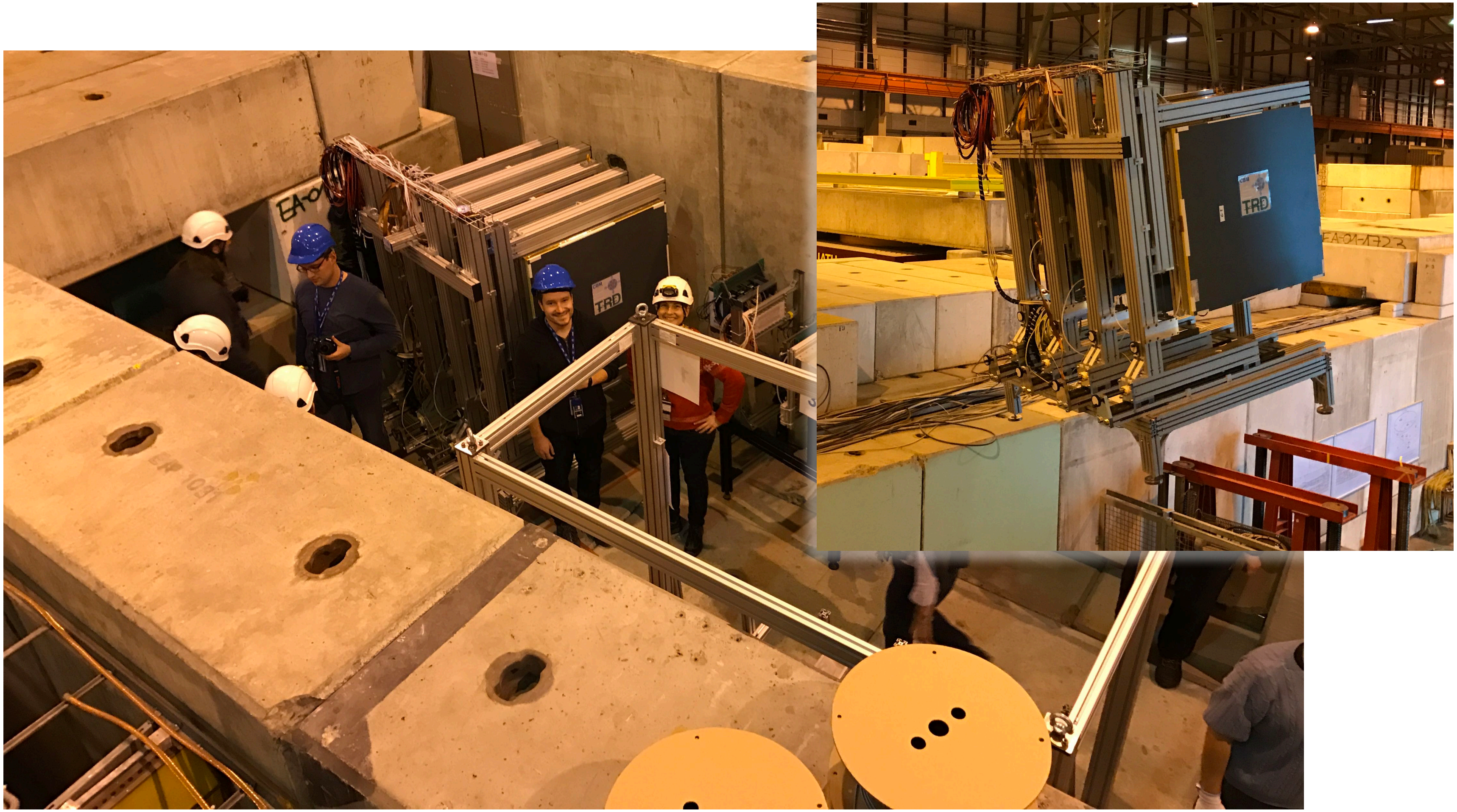
First large prototypes



Final chamber

Beam table

Test beam campaign at SPS



Outlook

Upcoming test beams:

GIF++

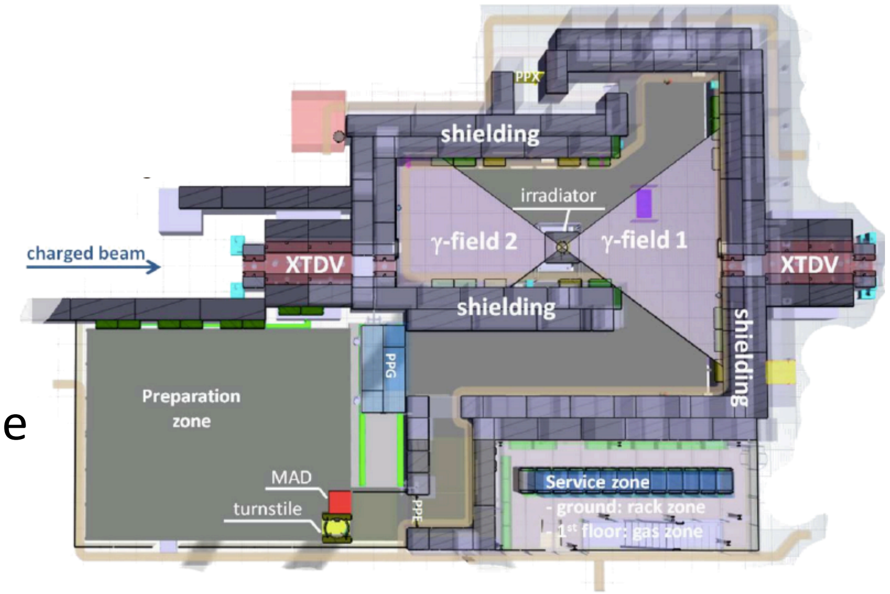
High-rate performance of MWPCs

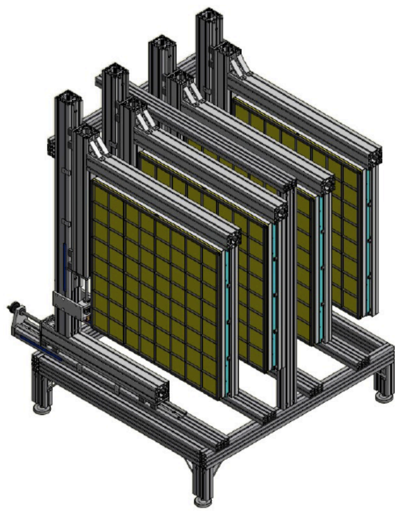
137Cs Source (13.7 TBq)

µ-Beam

DESY

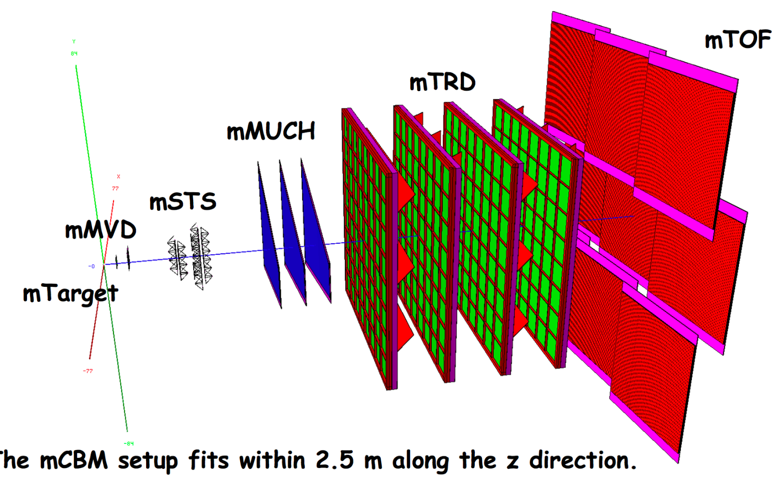
Systematic characterization of module performance





Mini-CBM:

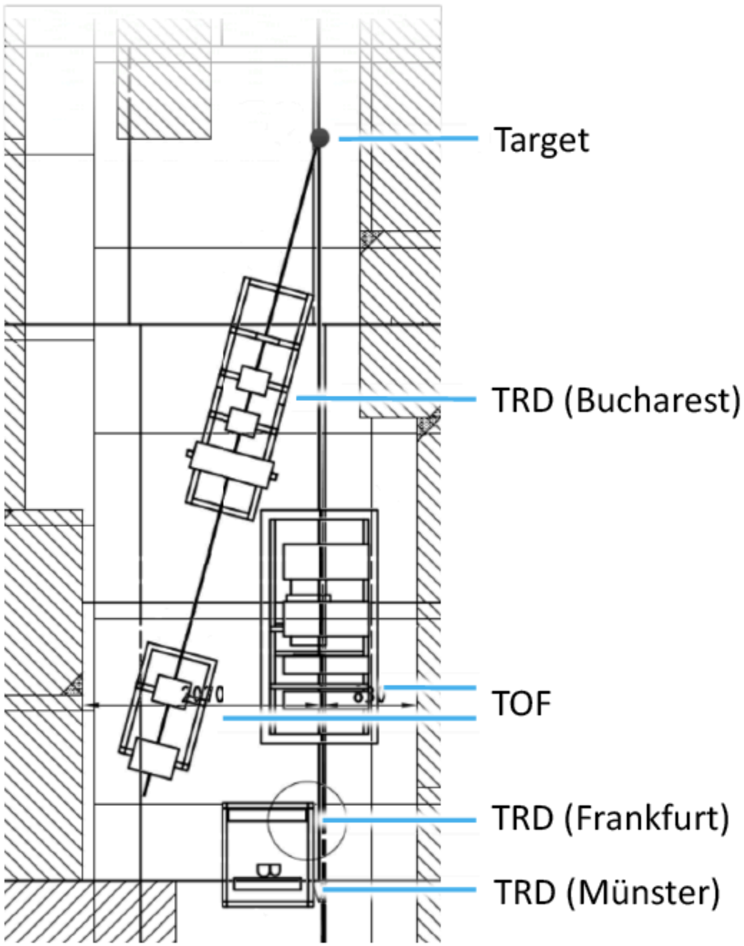
DAQ test system



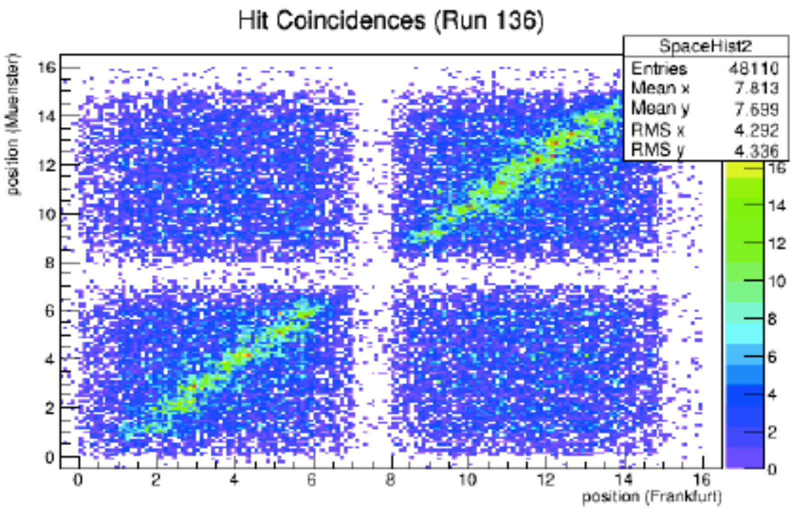
Thank you

BACKUP

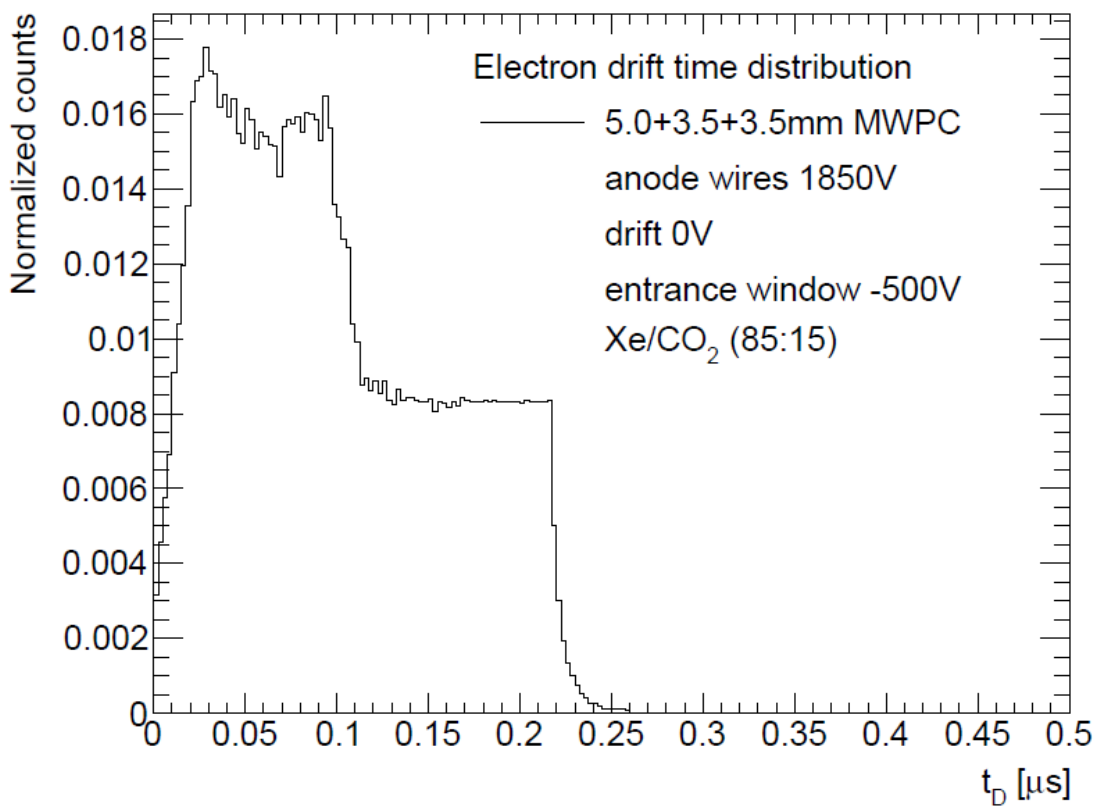
Testbeam 2015 at SPS

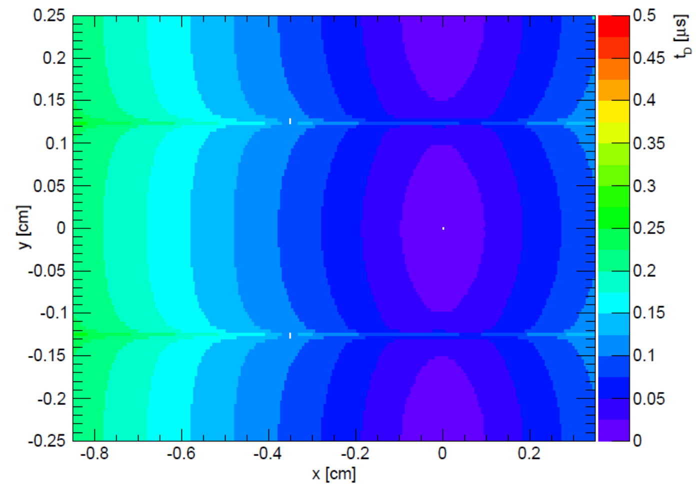


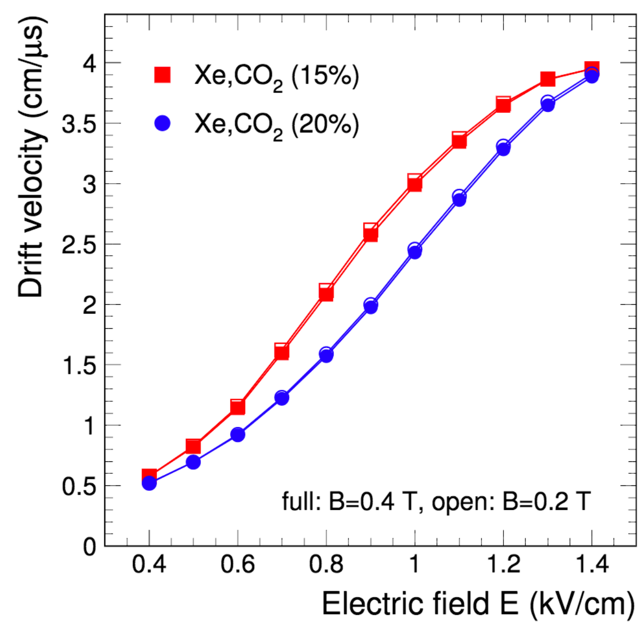
- moderate hit rates of up to 2 kHz/cm^2
- clear correlation between both detectors
- to extract precise information on position resolution an external reference detector is needed



Electron drift time distribution







Fragment separation