



**Universität
Heidelberg**

The Transition Radiation Detector for ALICE at LHC

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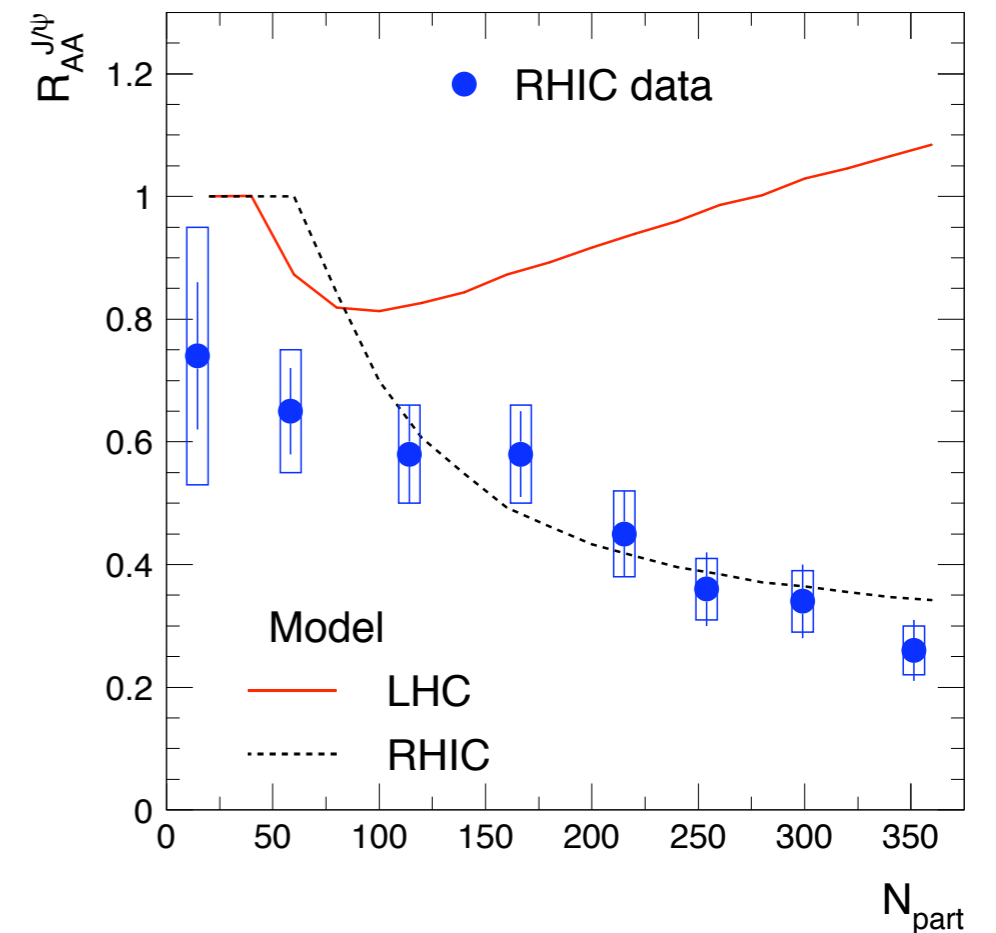
Quarkonia Production

J/ψ Suppression

- screening of color charges
- “melting” of $c\bar{c}$, $b\bar{b}$ bound state
- at SPS, RHIC, LHC

J/ψ Enhancement

- large abundance of c-quark at LHC
- statistical combination to J/ψ



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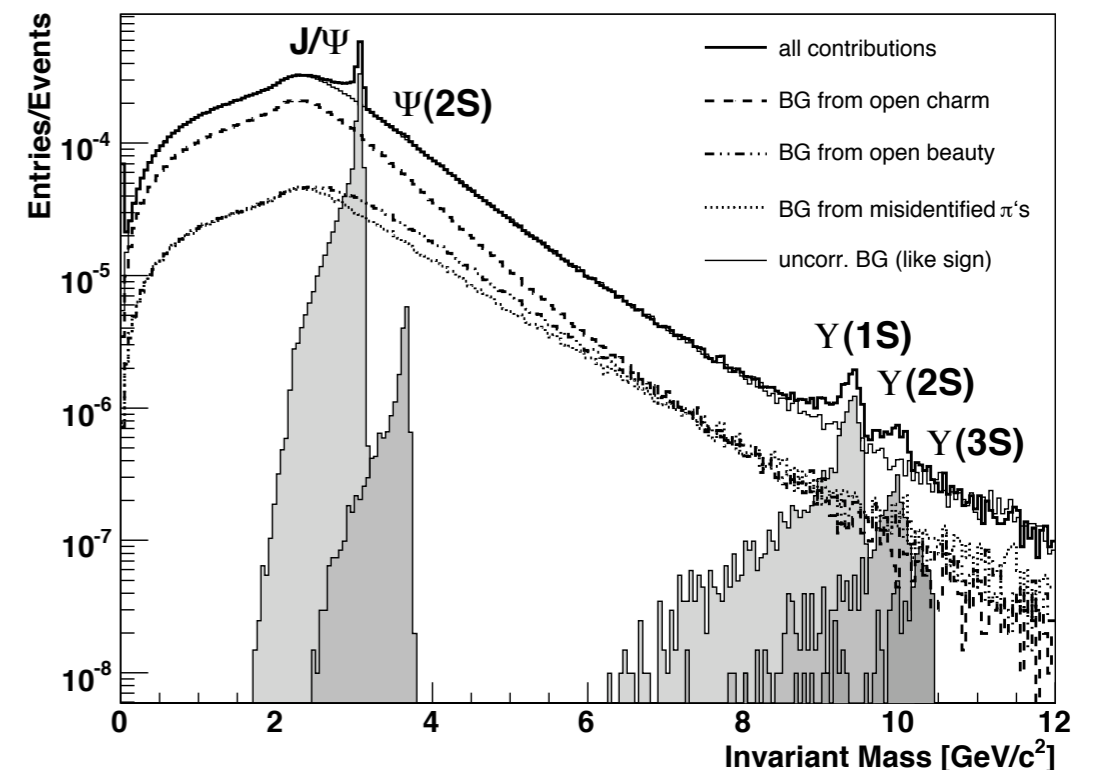
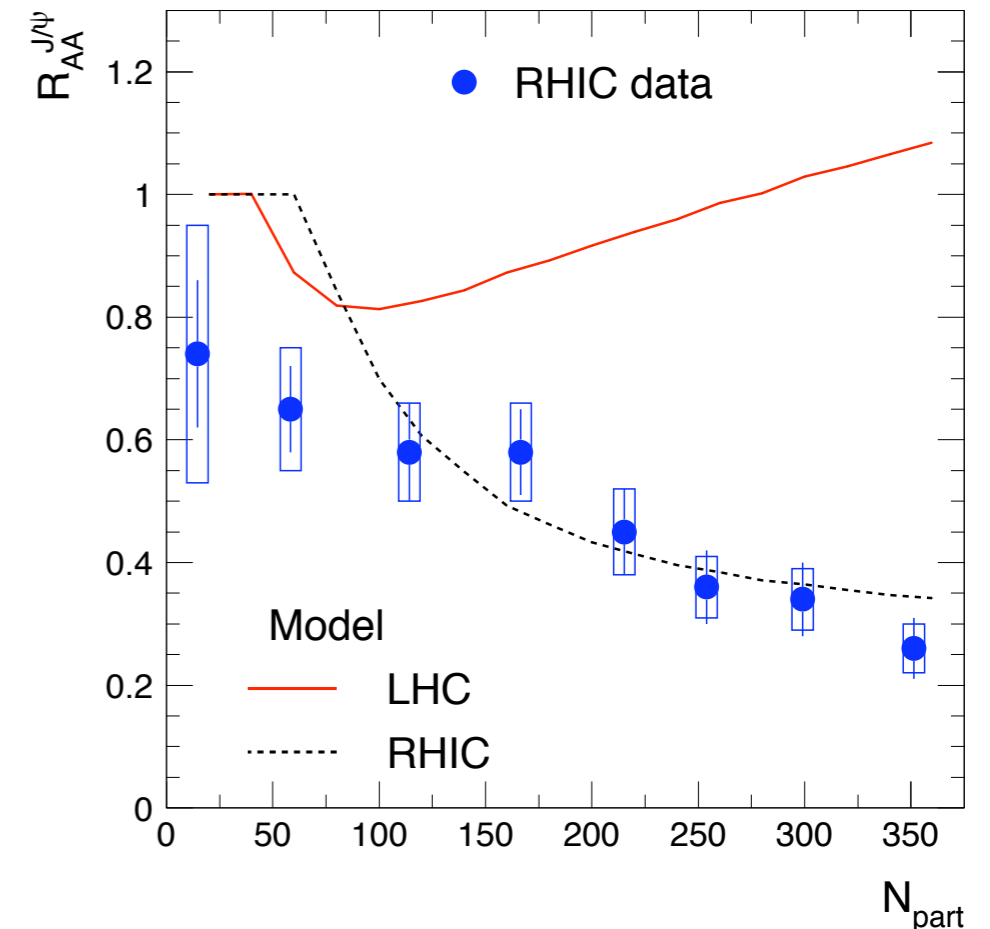
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Reconstruction: $J/\psi, \Upsilon \rightarrow e^+e^-$

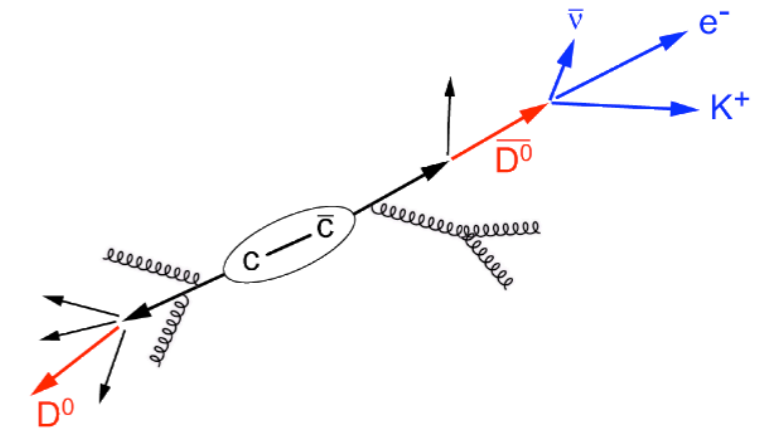
- good electron PID
- large acceptance



Physics Observables Accessible with the TRD

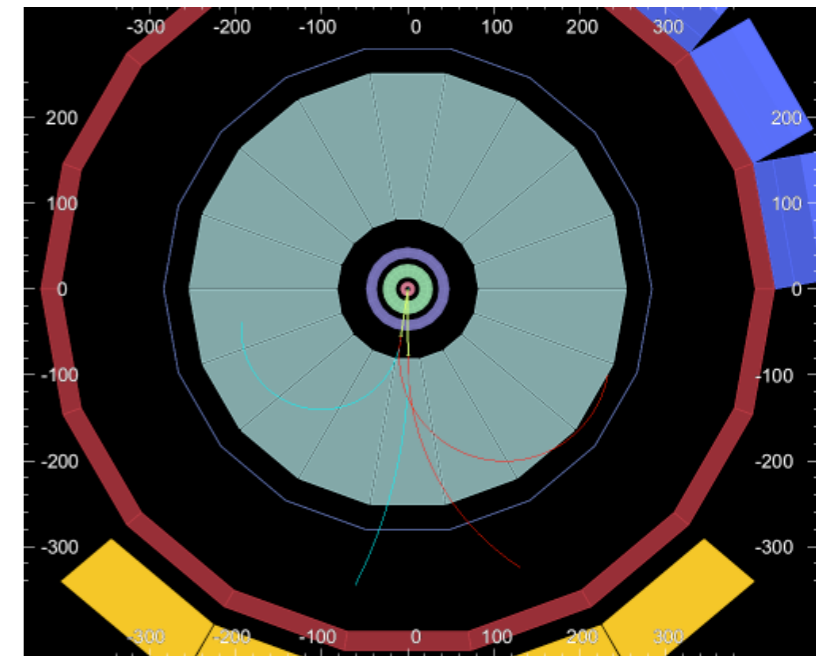
Open Heavy Flavor Electrons

- inclusive electrons
- open charm, beauty from semi-electronic decay
- charm, beauty cross-section



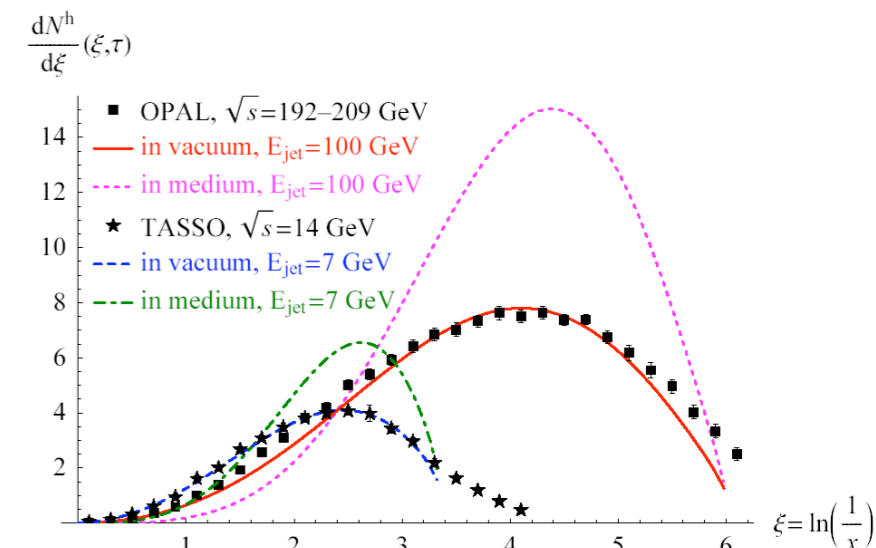
Photon Conversions

- $\gamma \rightarrow e^+e^-$
- direct γ , π^0 , η

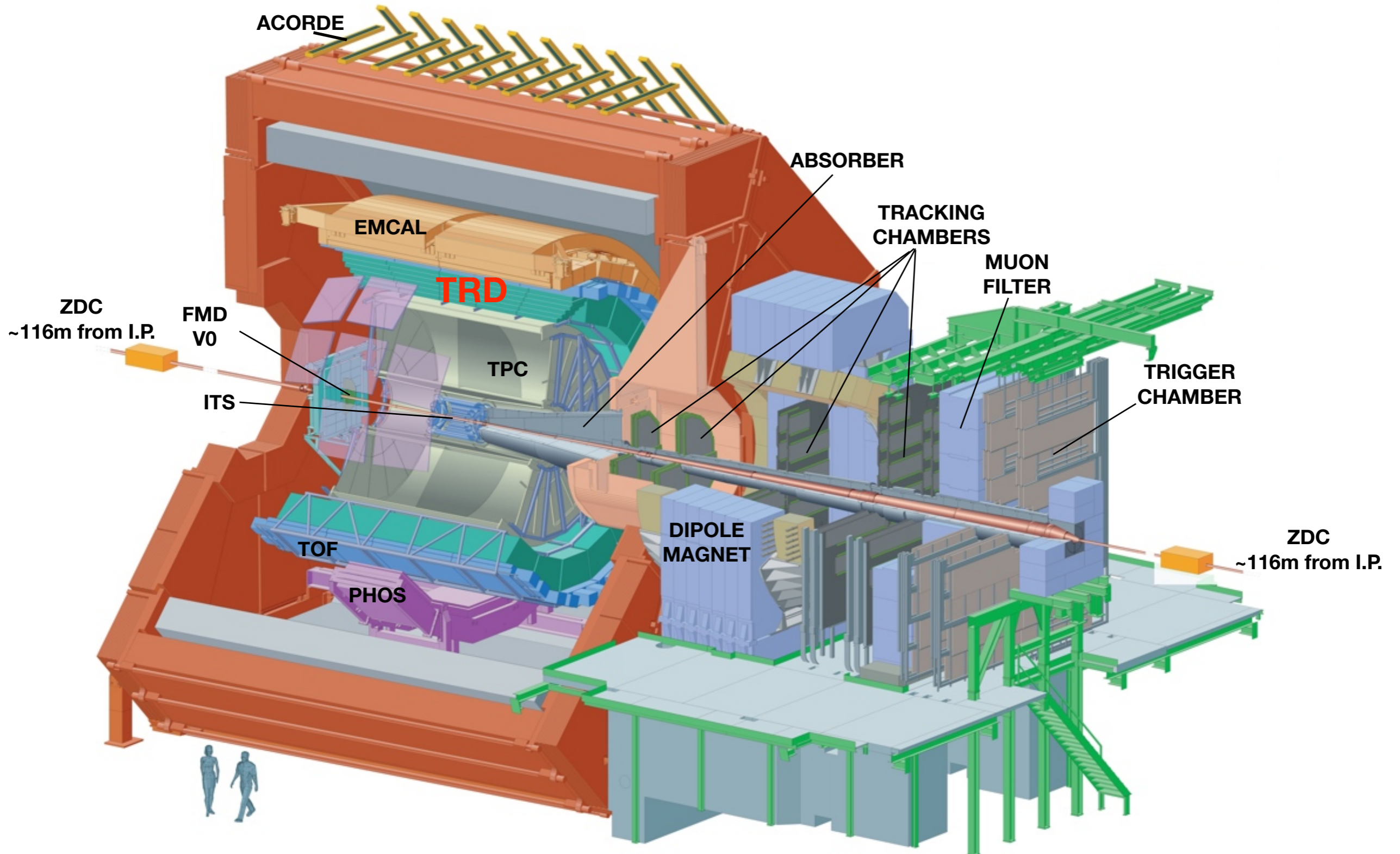


Jets and High- p_T Hadrons

- trigger on high- p_T tracks
- energy loss in QGP
- medium-modified fragmentation functions



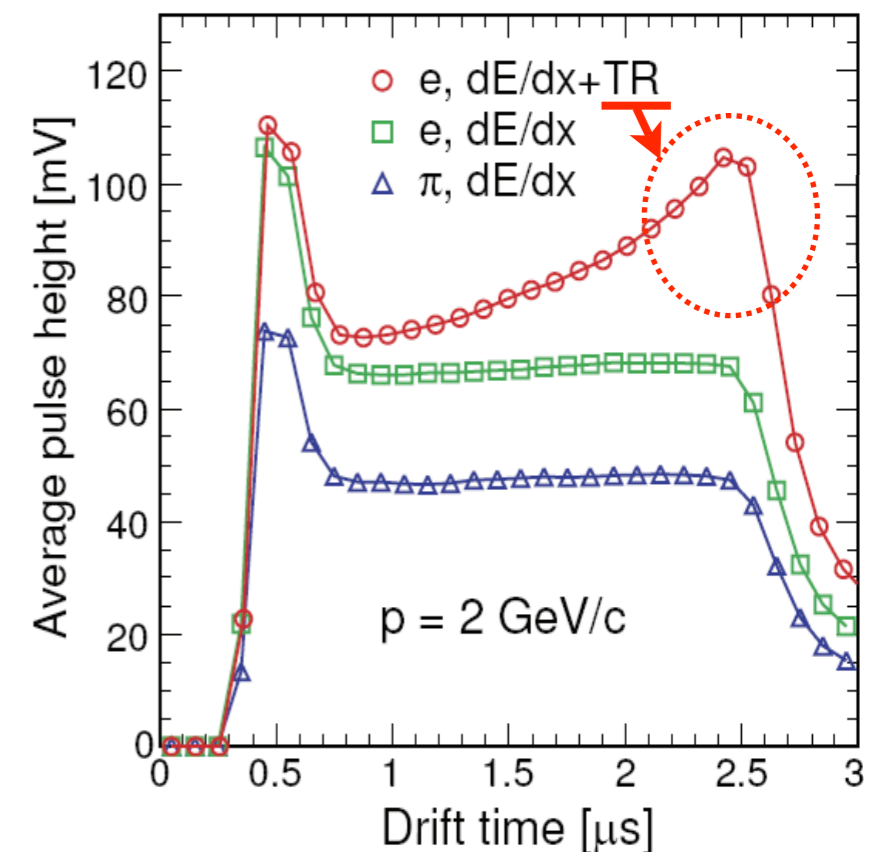
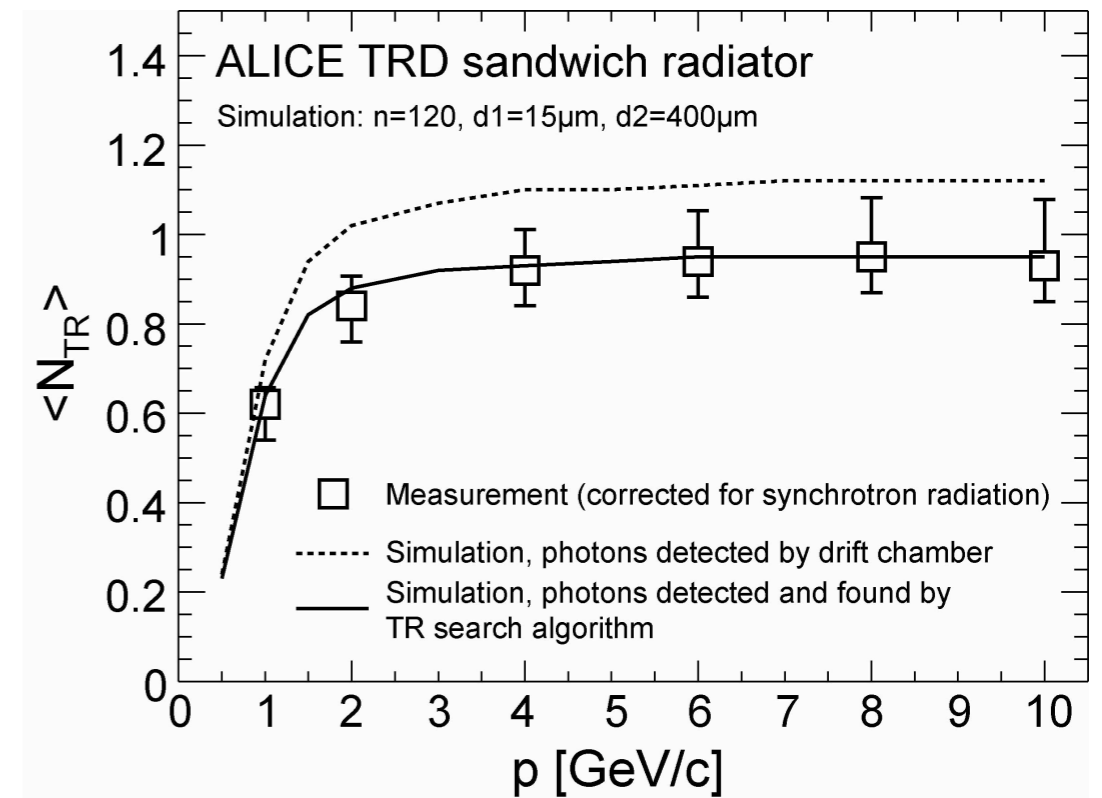
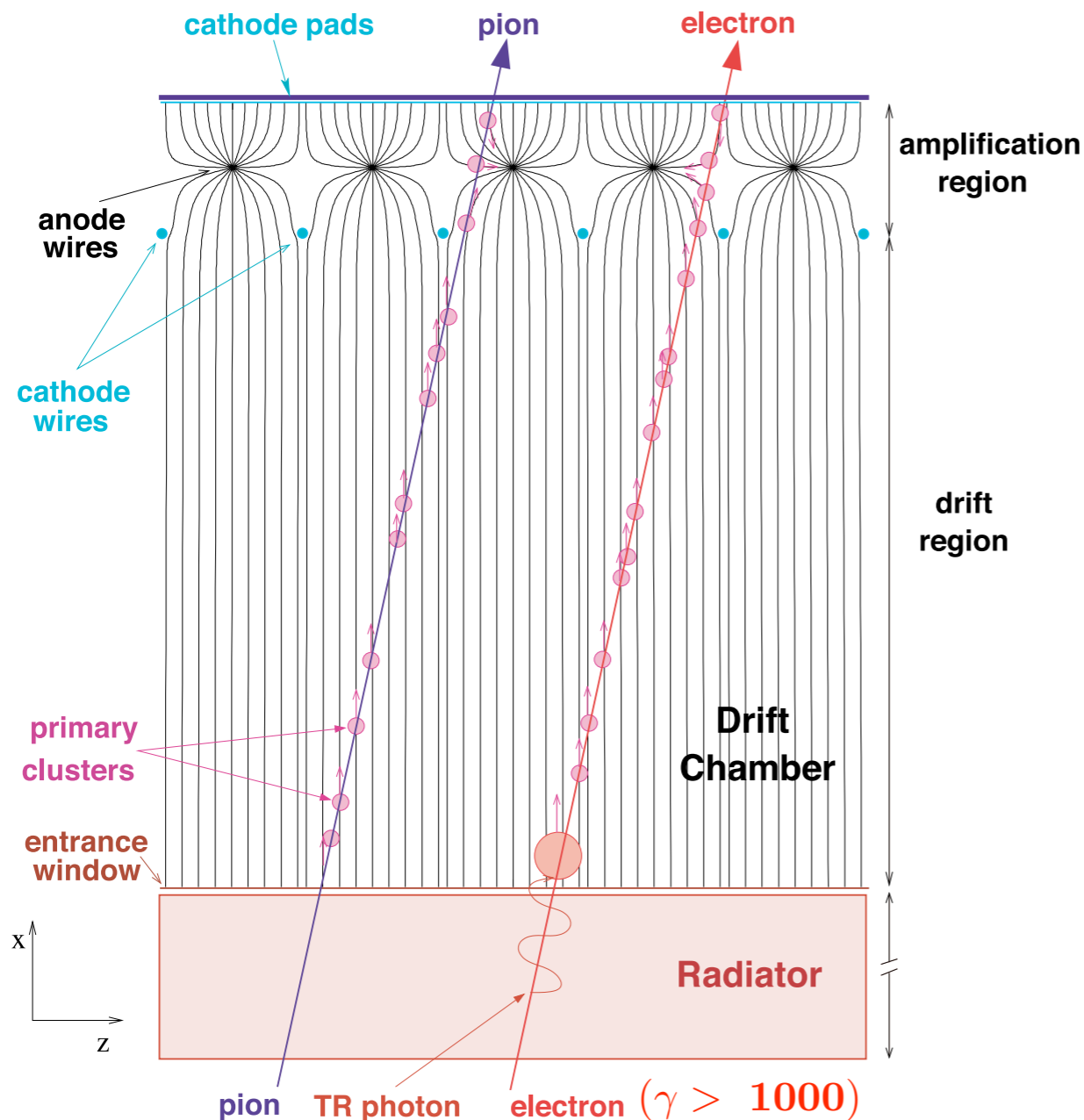
A Large Ion Collider Experiment



Collaboration: 31 countries, 109 institutes, > 1000 people

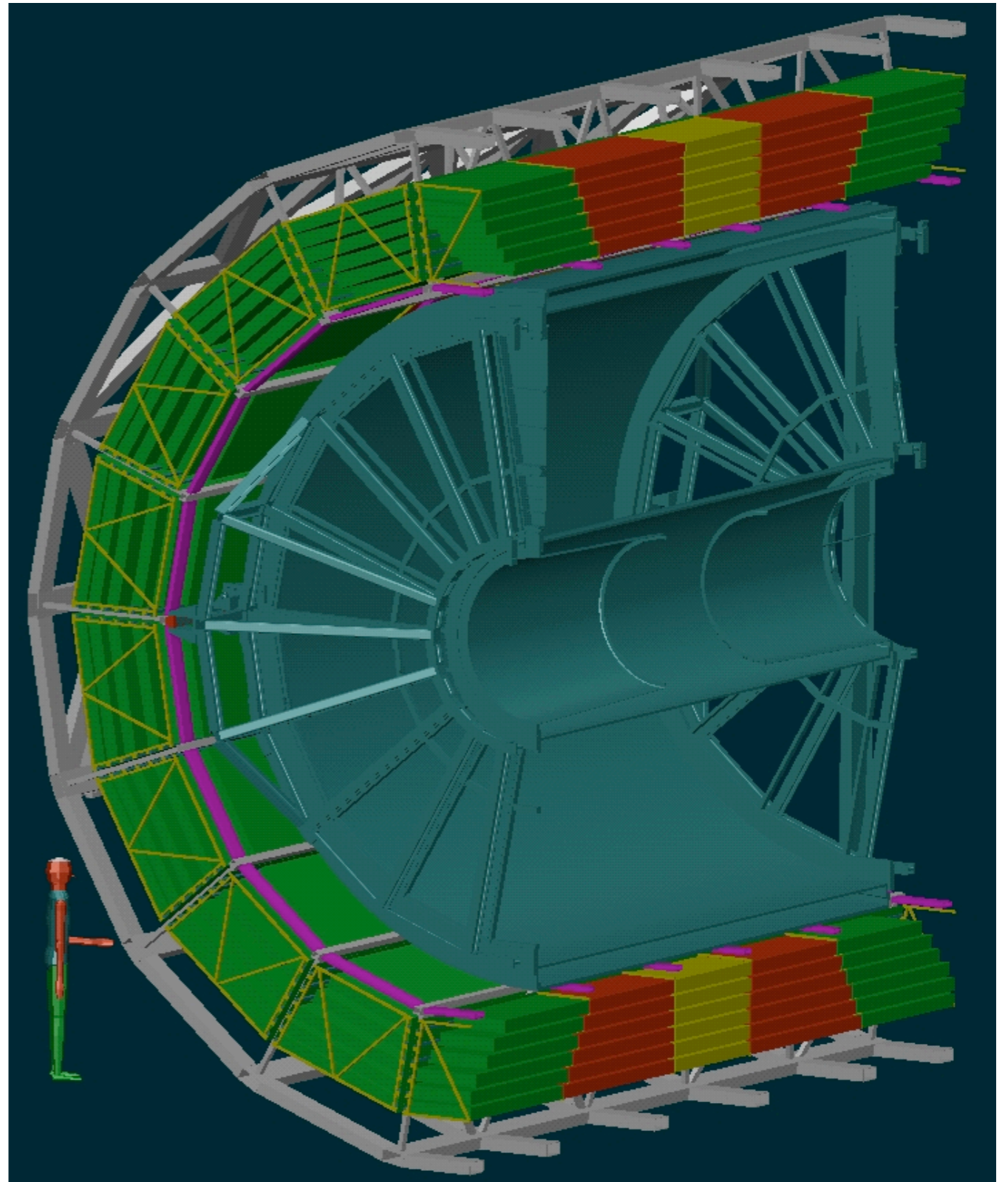
Working Principle of TRD (Transition Radiation Detector)

- Drift chambers with cathode pad readout at 10 MHz combined with a fiber/foam sandwich radiator in front
- Transition Radiation (TR) photons are absorbed by high-Z gas mixture (Xe + CO₂)



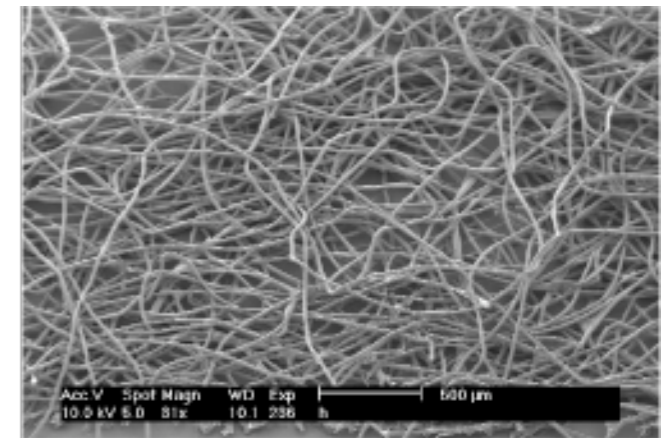
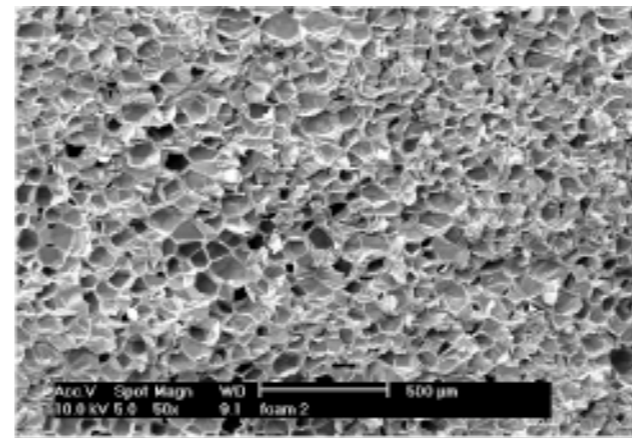
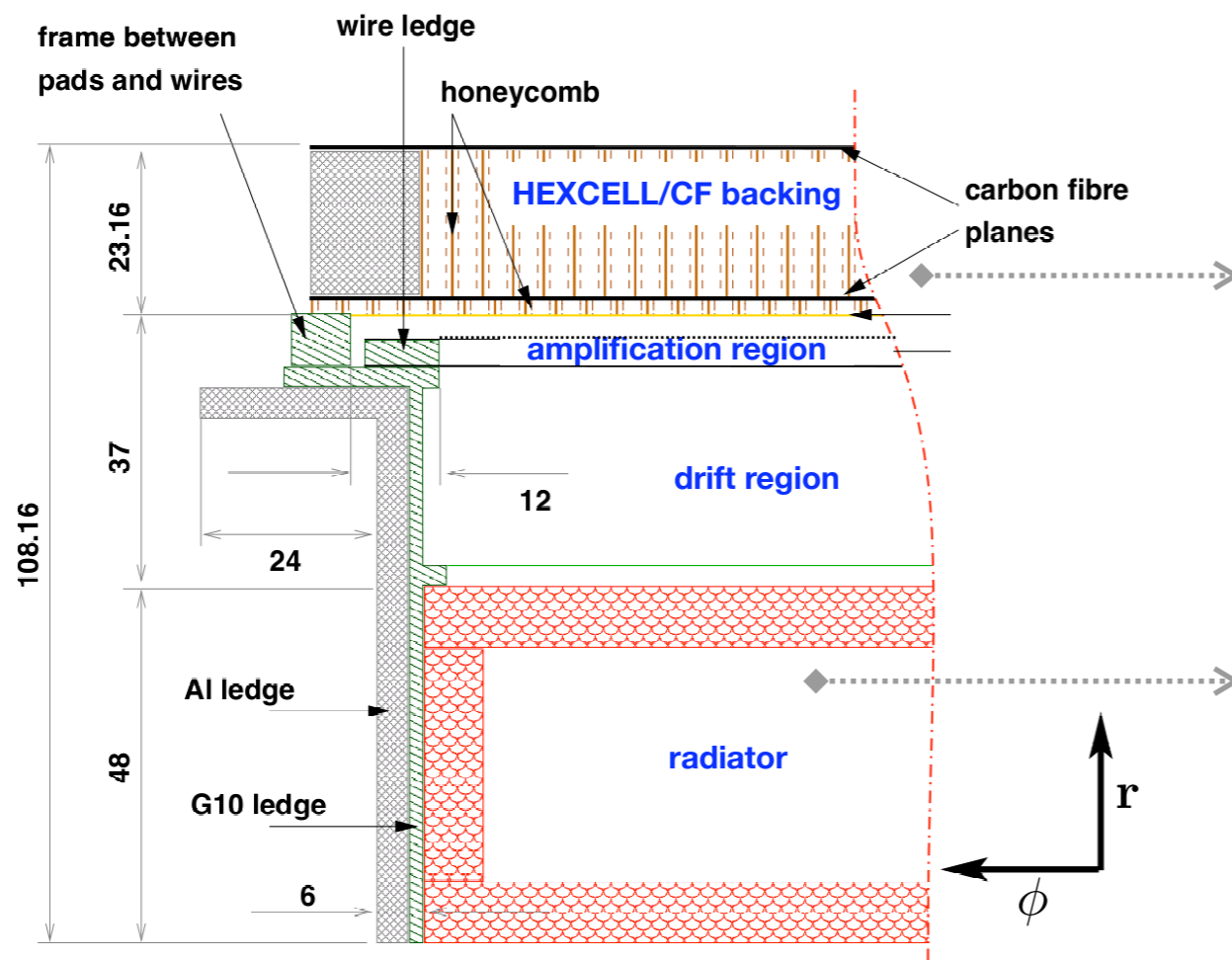
The ALICE TRD

- Surrounds ALICE TPC
 - radial position $2.9 < r < 3.7$ m
 - maximal length 7 m
 - full azimuthal coverage
 - $|\eta| < 0.9$
- 540 detector modules arranged in:
 - ϕ : 18 super modules
 - r : 6 layers
 - z : 5 stacks
- 750 m² active area
- 28 m³ detector gas of Xe/CO₂
- $X/X_0 \sim 24$ %
- 1.7 ton
- 0.5 M Euro per super module



Collaborations for TRD: Bucharest, Darmstadt, Dubna, FH Cologne, Frankfurt, GSI, Heidelberg, Tokyo(CNS), Tsukuba, Worms

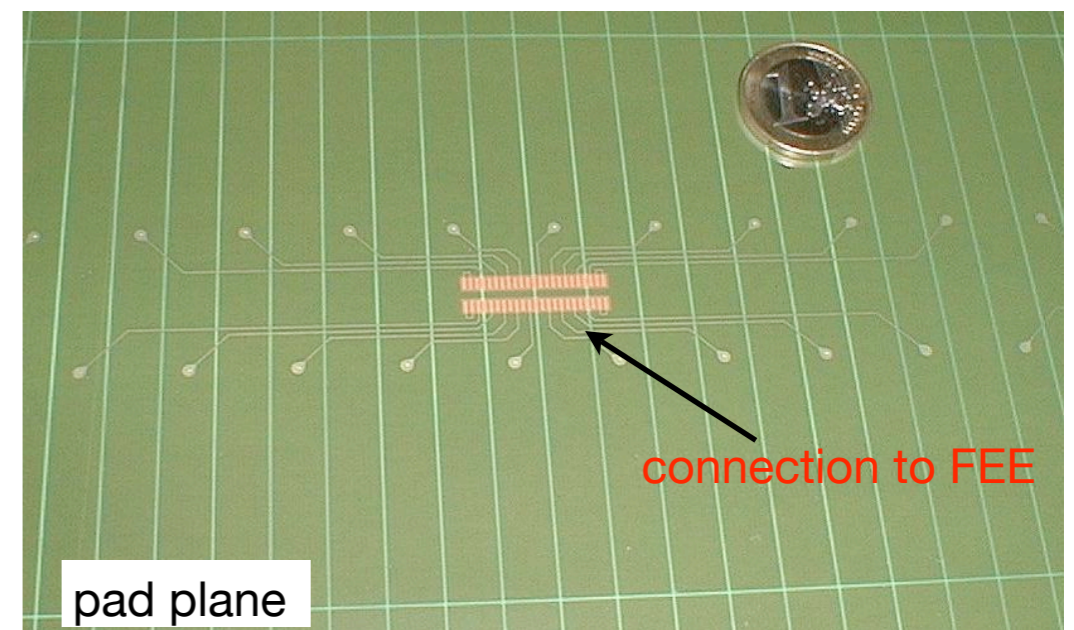
TRD Readout Chamber



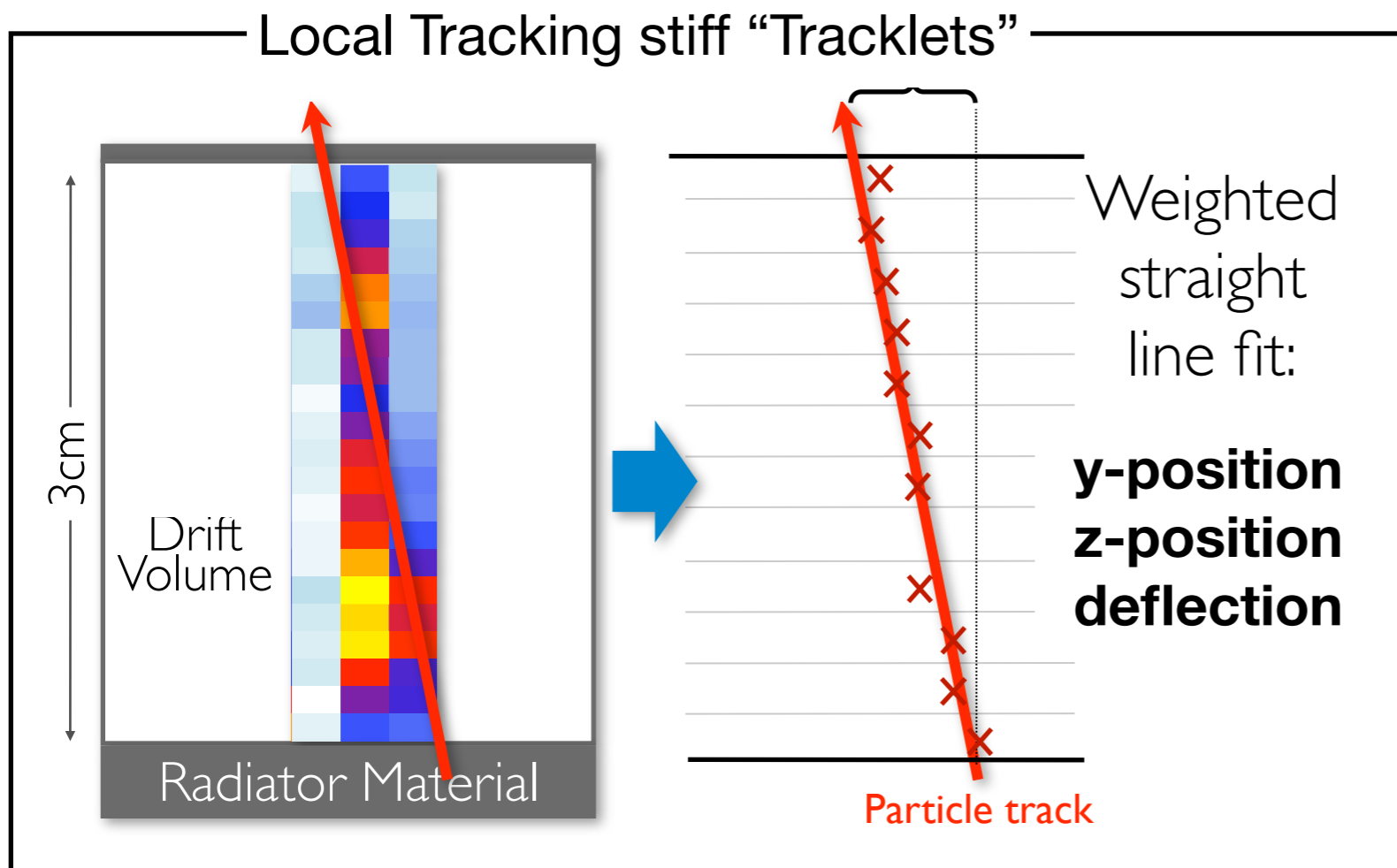
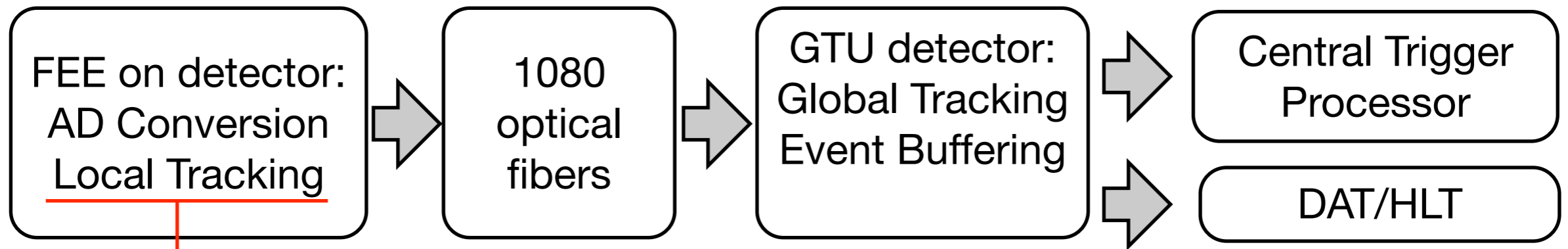
Polypropylene fibers

Designed to be:

- TR absorption length: 1 cm for 10 keV
- drift field: 0.7 kV/cm
- drift time: $2 \mu\text{s}$
- gas gain: 5000



Front-End Electronics Design



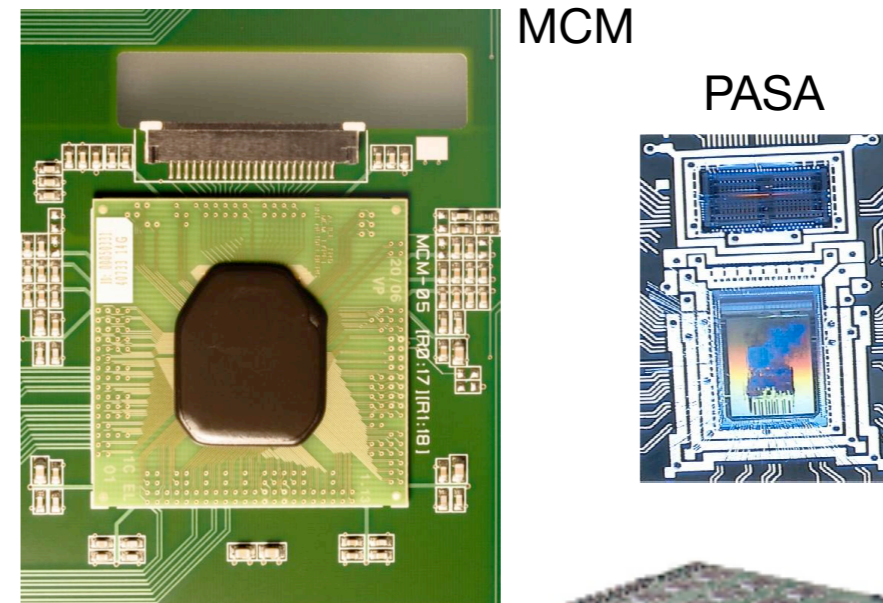
FERO makes TRD as a trigger detector

- fast track reconstruction and electron PID
- trigger decision available at L1 ($6.5 \mu\text{s}$)
- pretrigger required before ALICE L0

Readout Chamber Electronics

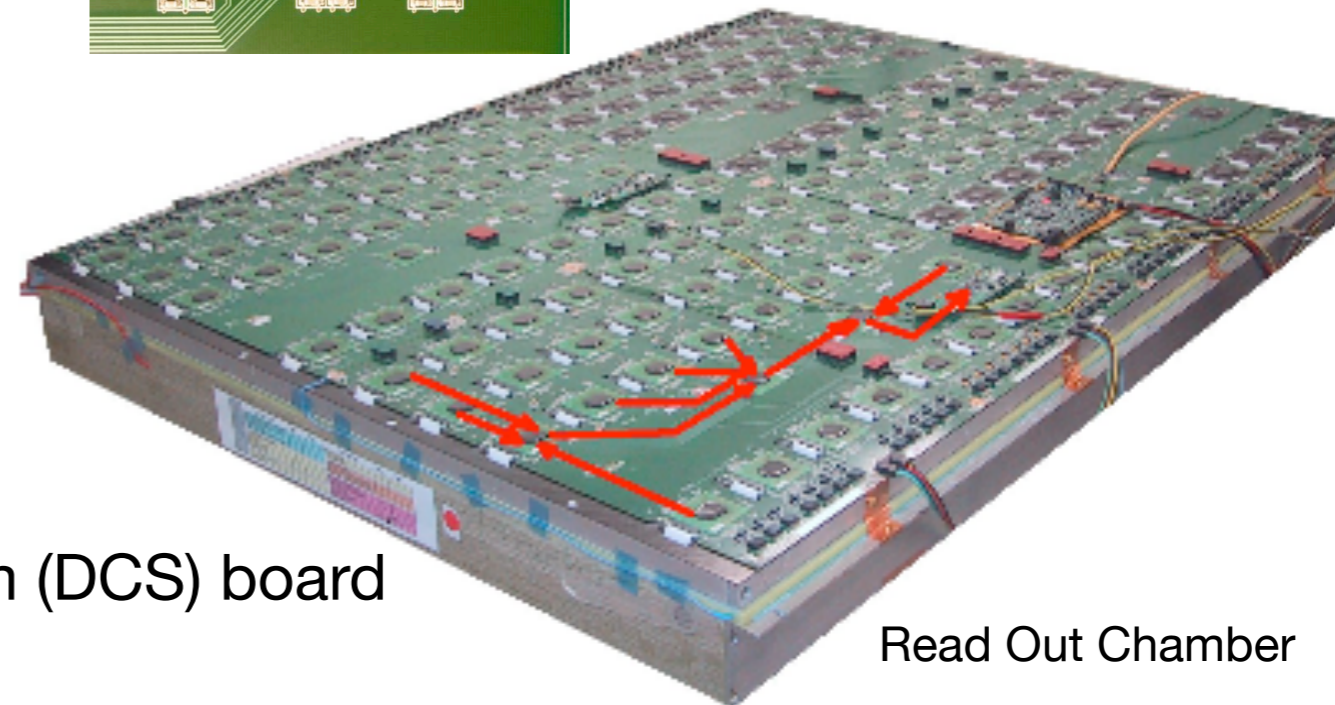
Multi Chip Module (MCM)

- PASA: PreAmplifier/ShAper
- TRAP: TRAcklet Processor
 - ADC, digital filter, clustering
 - tracklets calculation for trigger decision
 - raw data readout



Read Out Chamber

- 6/8 Read Out Boards (ROB)
 - MCMs equipped on ROB
- 1 linux based Detector Control System (DCS) board
 - configuration, FEE monitor
 - clock and trigger decoding and its distribution
- 2 Optical Readout Interfaces (ORI) for data shipping



Send data via ORI to Global Tracking Unit (GTU)

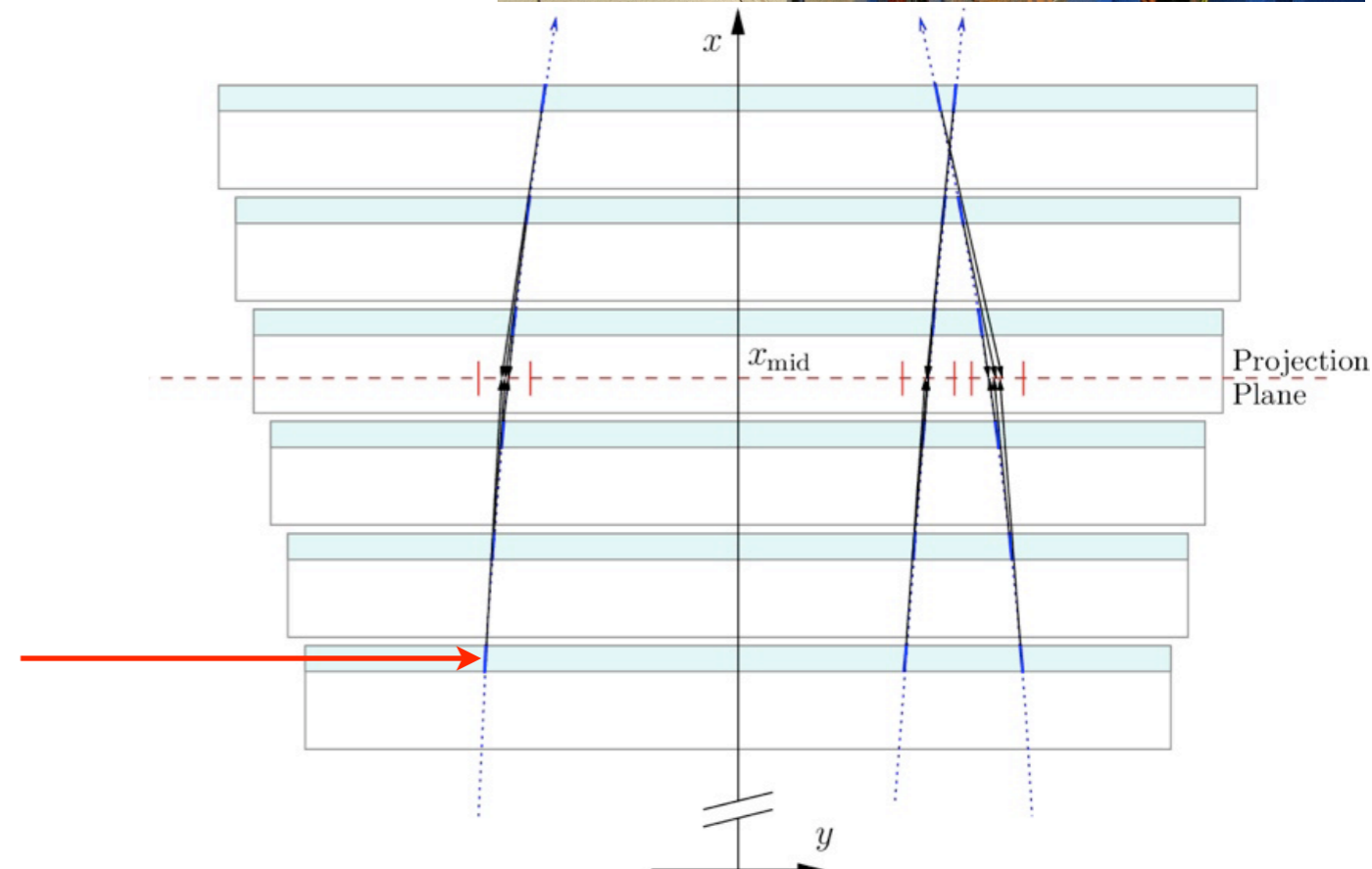
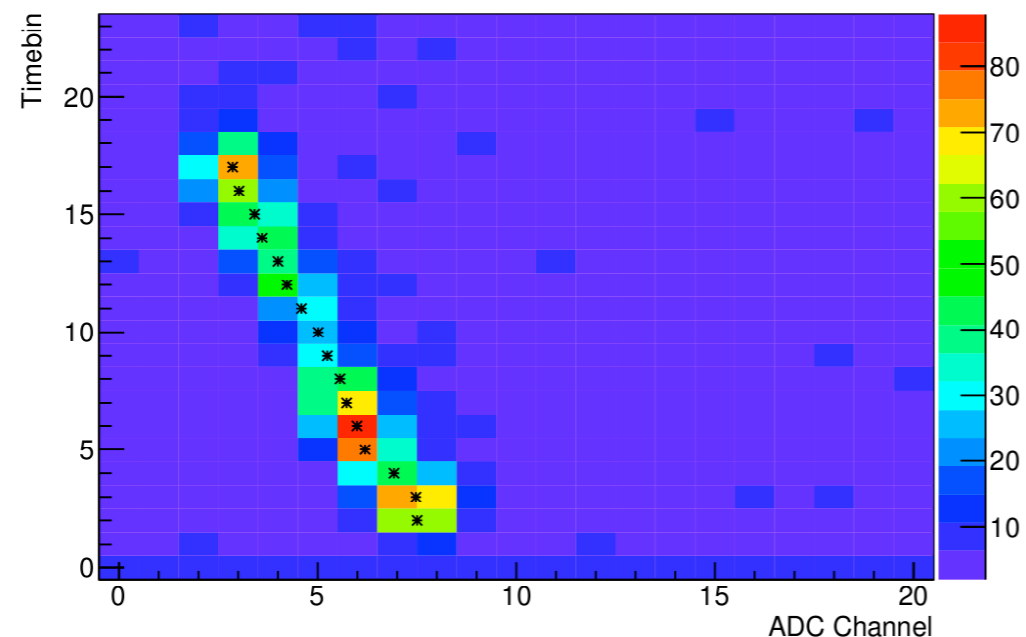
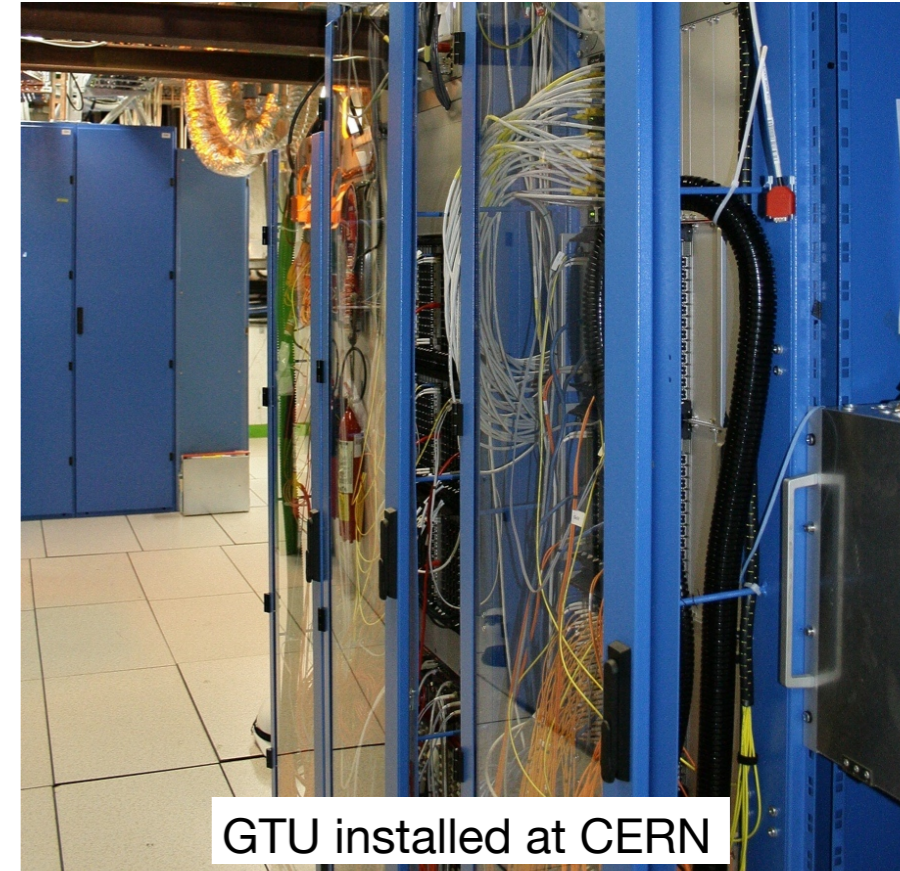
Global Tracking Unit

Trigger

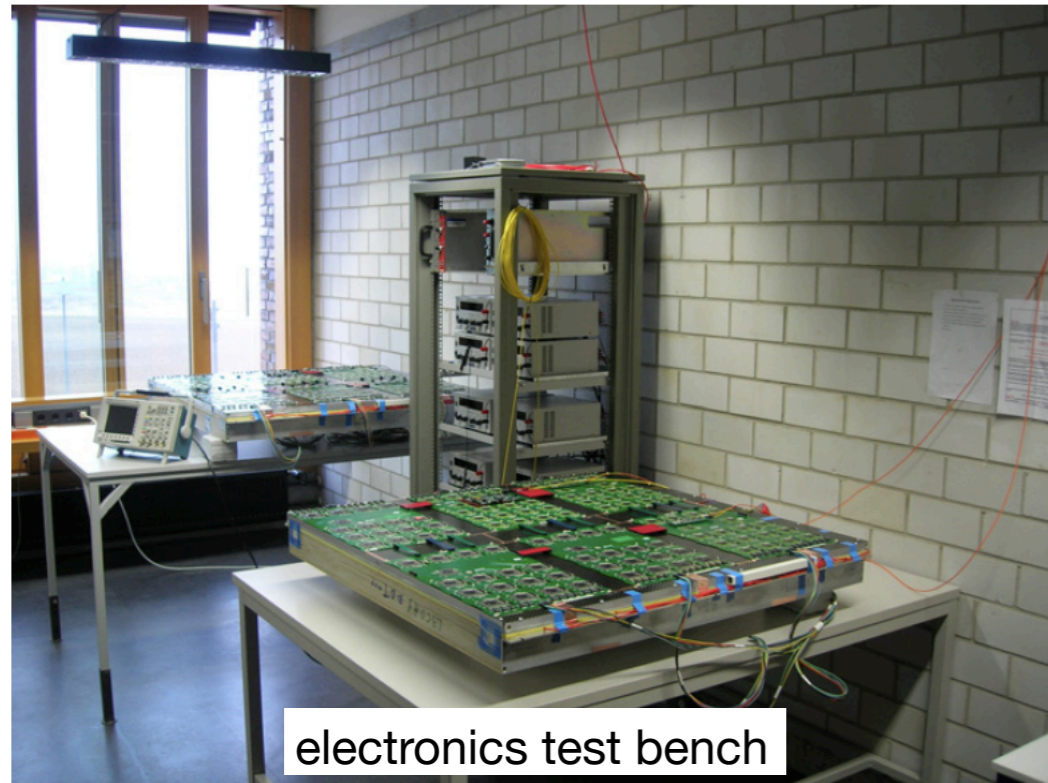
- find and reconstruct high- p_t tracks from “tracklets”
- calculate momentum
- apply various trigger schemes: di-lepton decay, jets, cosmics,...
- level-1 trigger decision after $6.5 \mu\text{s}$ from collision

Raw Data Readout

- collect data from ROCs
- forward to DAQ

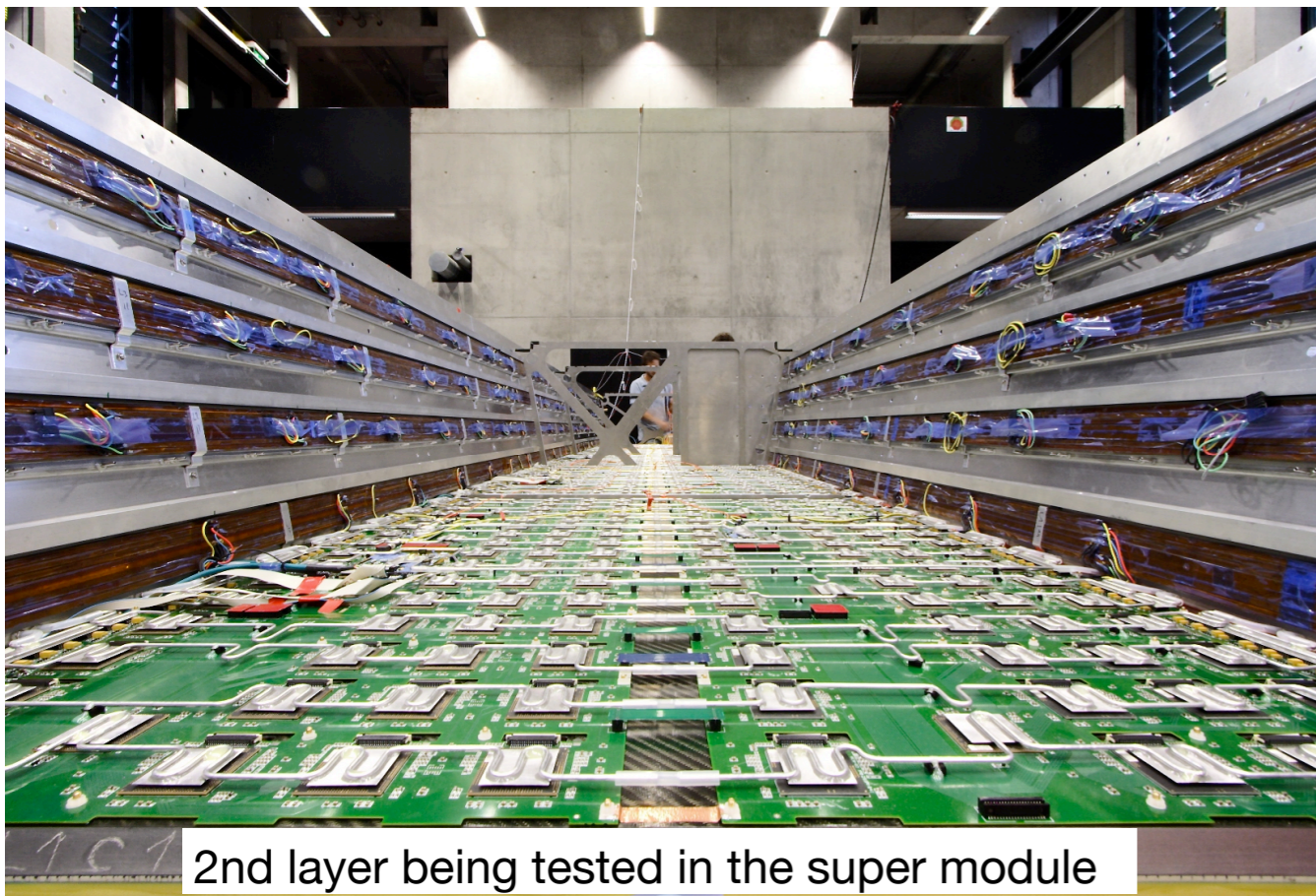


Electronics and Super module Integration

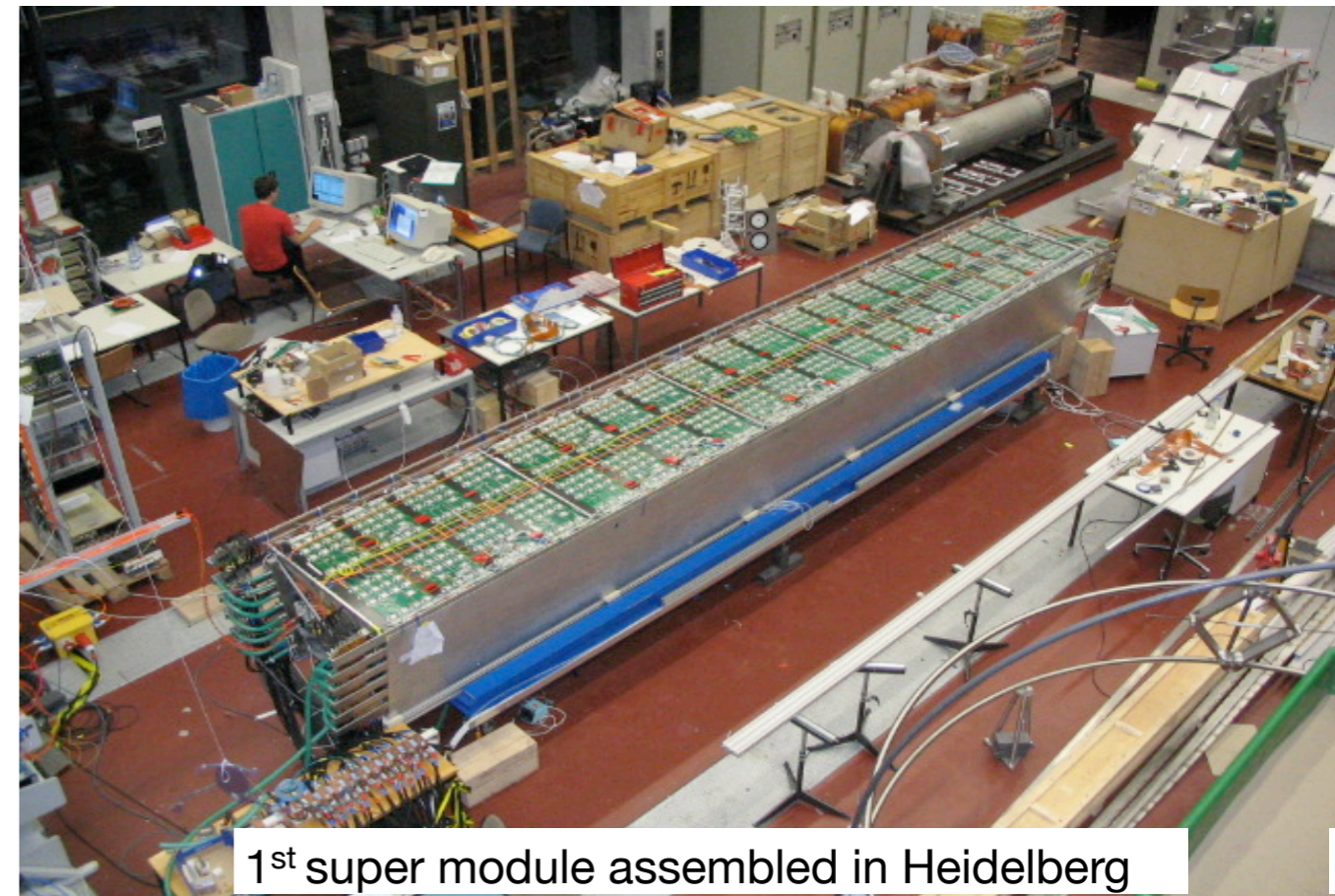


electronics test bench

- Installation of electronics and water cooling
- Electronics testing
- Assembled in Heidelberg (1st one) and Münster (from 2nd ~)



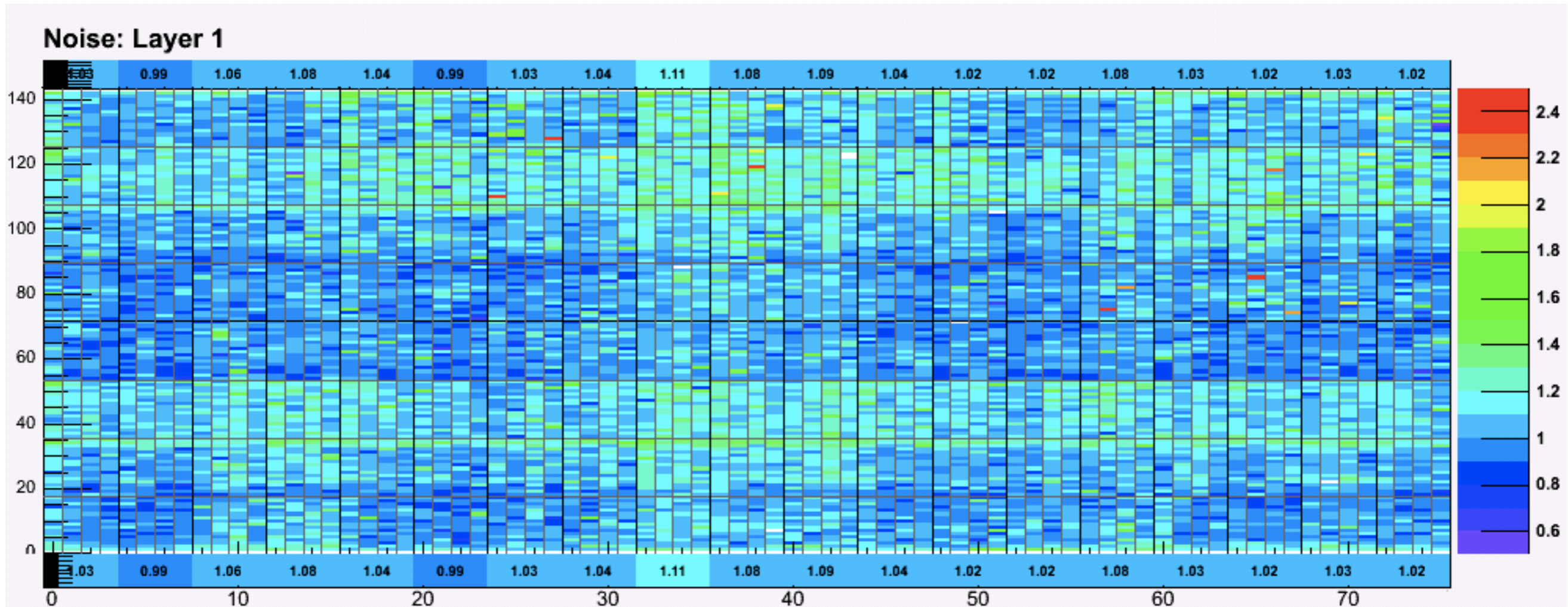
2nd layer being tested in the super module



1st super module assembled in Heidelberg

Electronics Noise

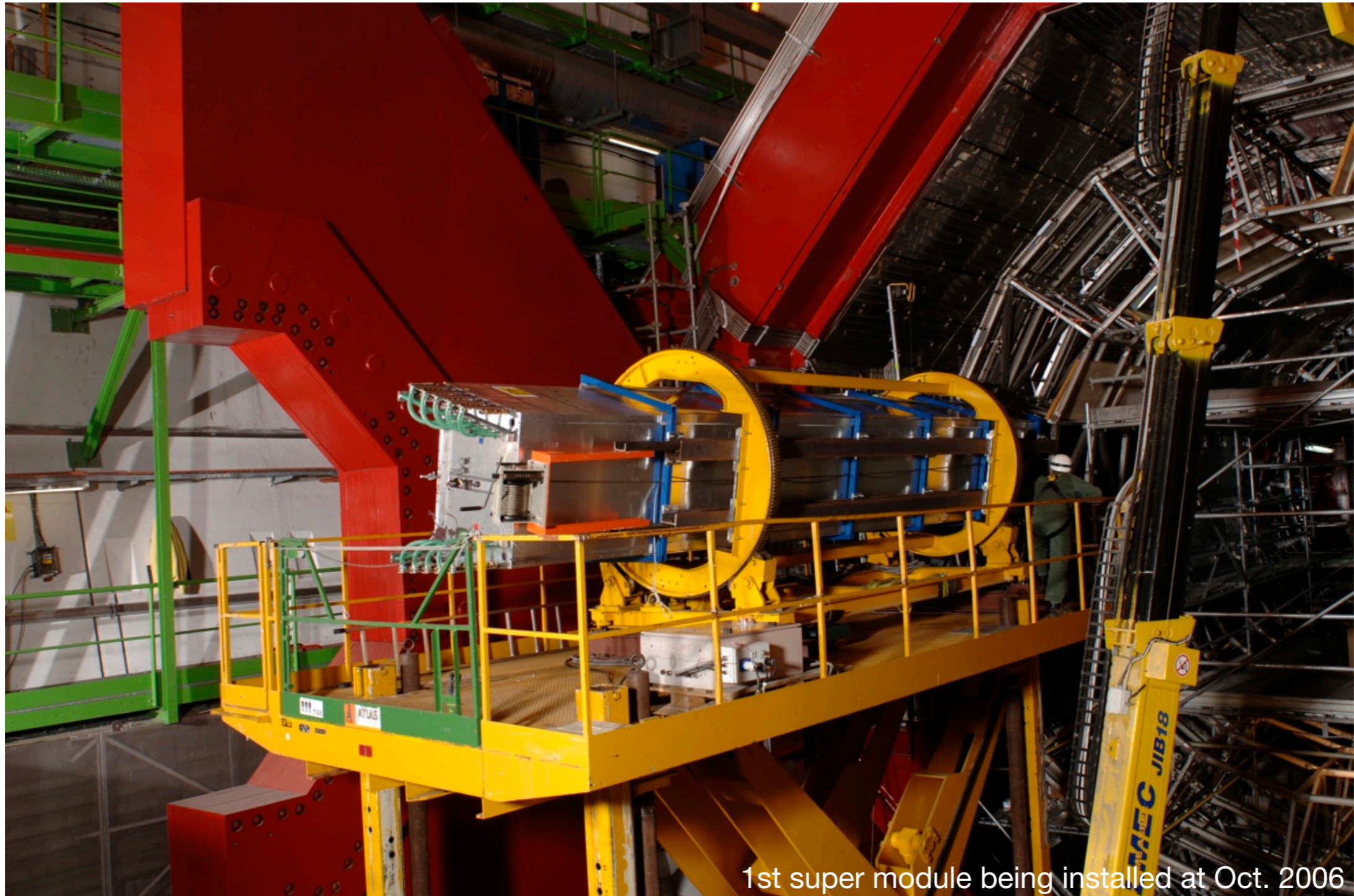
RMS noise map of one layer of a SM



Very close to design goal

- $1000 e \hat{=} 1 \text{ ADC}$
- dead channels $< 0.1 \%$

Installation at ALICE



- 1st TRD super module installed at October 2006
- 6th super module installed January 2009

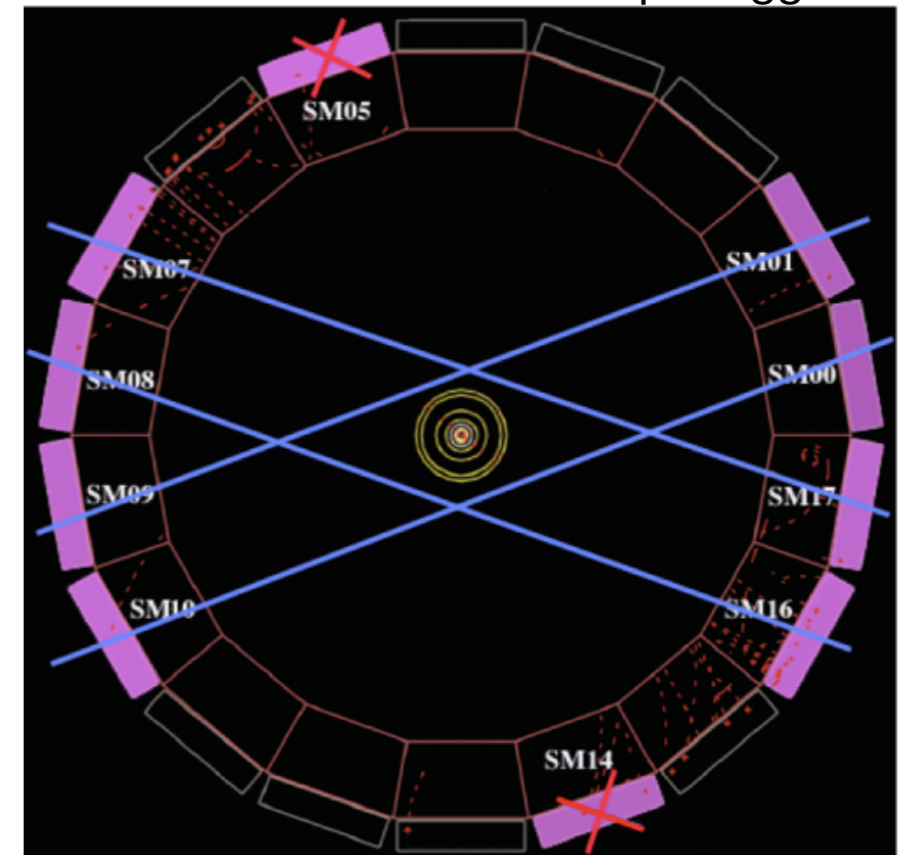
Commissioning

ALICE cosmic runs (Dec. 2007, Jul.~Oct. 2008)

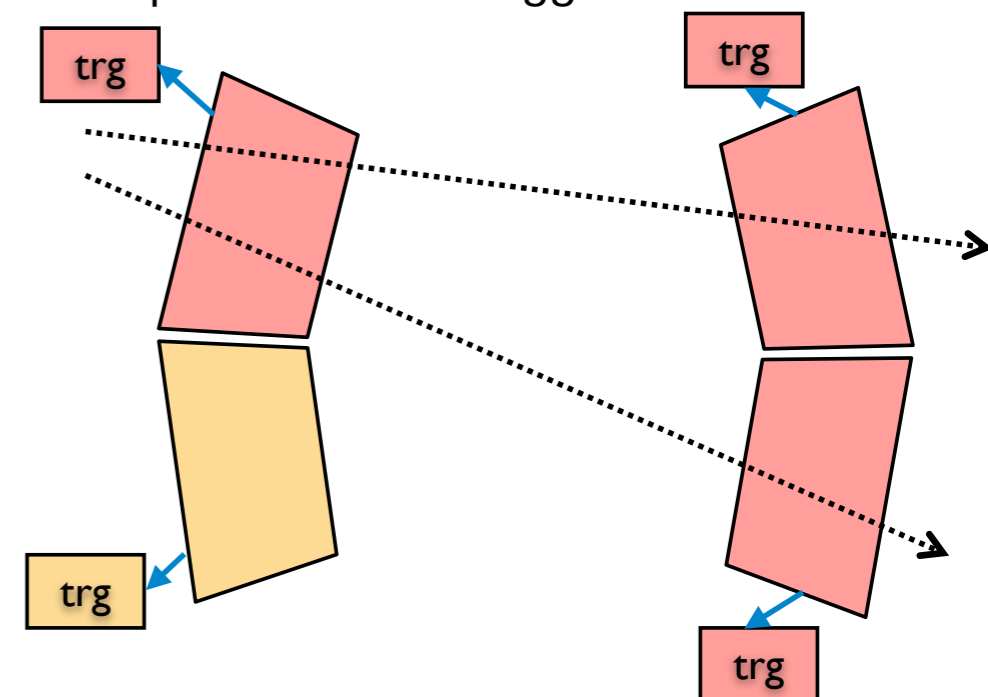
- 4-TRD super modules participated (total $\Delta\phi = 80^\circ$)
- combined running with other detectors
- TOF pretrigger
 - coincidence of two opposite modules
- GTU L1 trigger
 - 4 tracklets in one stack
 - single super module and one-to-many correlations between super modules
 - L1/L0 $\sim 1/20$, L1 rate 0.05 Hz
 - purity $> 85\%$
- 55 k events collected

TRD ready for beam in September 2008

Coincidence condition for pretrigger



Top level GTU L1 trigger condition



Detector Control System

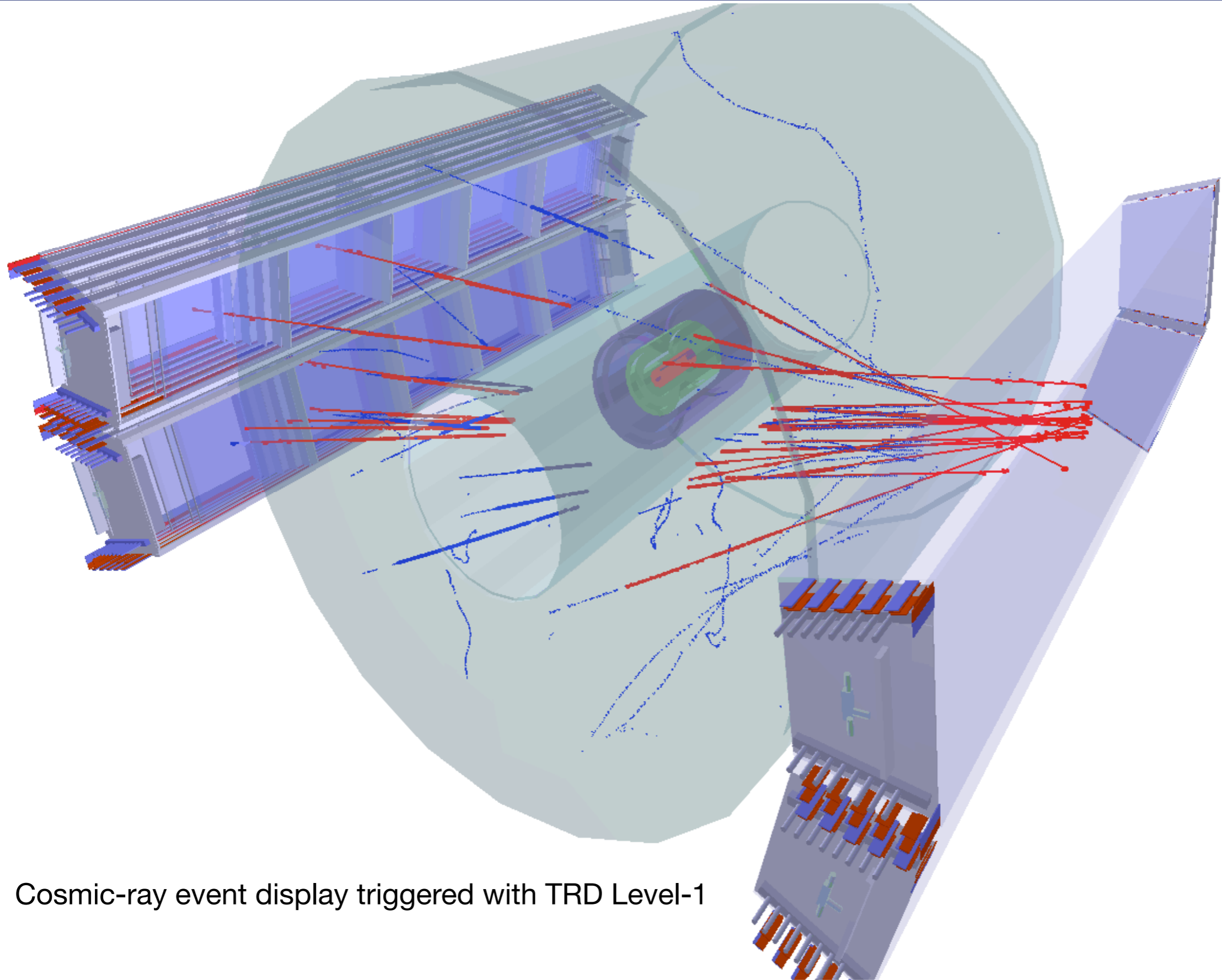
The screenshot displays the TRD Main Control Console interface. At the top, it shows the system status as 'READY' and 'NO CONNECT'. The central part features a 3D model of the detector's circular structure. On the left, a tree view lists various system components like SM00, SM08, SM09, and SM17 stacks. Below the 3D model, a detailed view for 'TRD_SM17' is shown, including a 3D stack of modules and a 'FED server monitor' table. The table shows temperature and configuration status for five stacks across five layers.

LAYER	STACK 0	STACK 1	STACK 2	STACK 3	STACK 4
LAYER 5	CONFIGURED 20.85 °C CONF	CONFIGURED 19.97 °C CONF	CONFIGURED 20.01 °C CONF	CONFIGURED 20.54 °C CONF	CONFIGURED 19.79 °C CONF
LAYER 4	CONFIGURED 20.46 °C CONF	CONFIGURED 22.01 °C CONF	CONFIGURED 20.33 °C CONF	CONFIGURED 21.75 °C CONF	CONFIGURED 20.87 °C CONF
LAYER 3	CONFIGURED 20.32 °C CONF	CONFIGURED 20.94 °C CONF	CONFIGURED 21.54 °C CONF	CONFIGURED 20.04 °C CONF	CONFIGURED 21.09 °C CONF
LAYER 2	CONFIGURED 20.07 °C CONF	CONFIGURED 21.68 °C CONF	CONFIGURED 22.44 °C CONF	CONFIGURED 21.33 °C CONF	CONFIGURED 21.59 °C CONF
LAYER 1	CONFIGURED 20.19 °C CONF	CONFIGURED 20.90 °C CONF	CONFIGURED 22.70 °C CONF	CONFIGURED 21.14 °C CONF	CONFIGURED 23.38 °C CONF
LAYER 0	CONFIGURED 22.57 °C CONF	CONFIGURED 22.51 °C CONF	CONFIGURED 23.62 °C CONF	CONFIGURED 22.04 °C CONF	CONFIGURED 22.00 °C CONF

DCS system for TRD

- User friendly detector control system based on PVSS-II
- Ensure safe/stable detector operation and monitor :
 - 90 power supplies
 - 1080 HV channels
 - 280 k on-detector CPUs
 - 1.2 M channels of preamplifiers and ADCs and digital filters
 - gas systems
 - cooling systems
 - trigger systems
- Based on tree structure of distributed Finite State Machines
- TRD can be operated by half a shift person

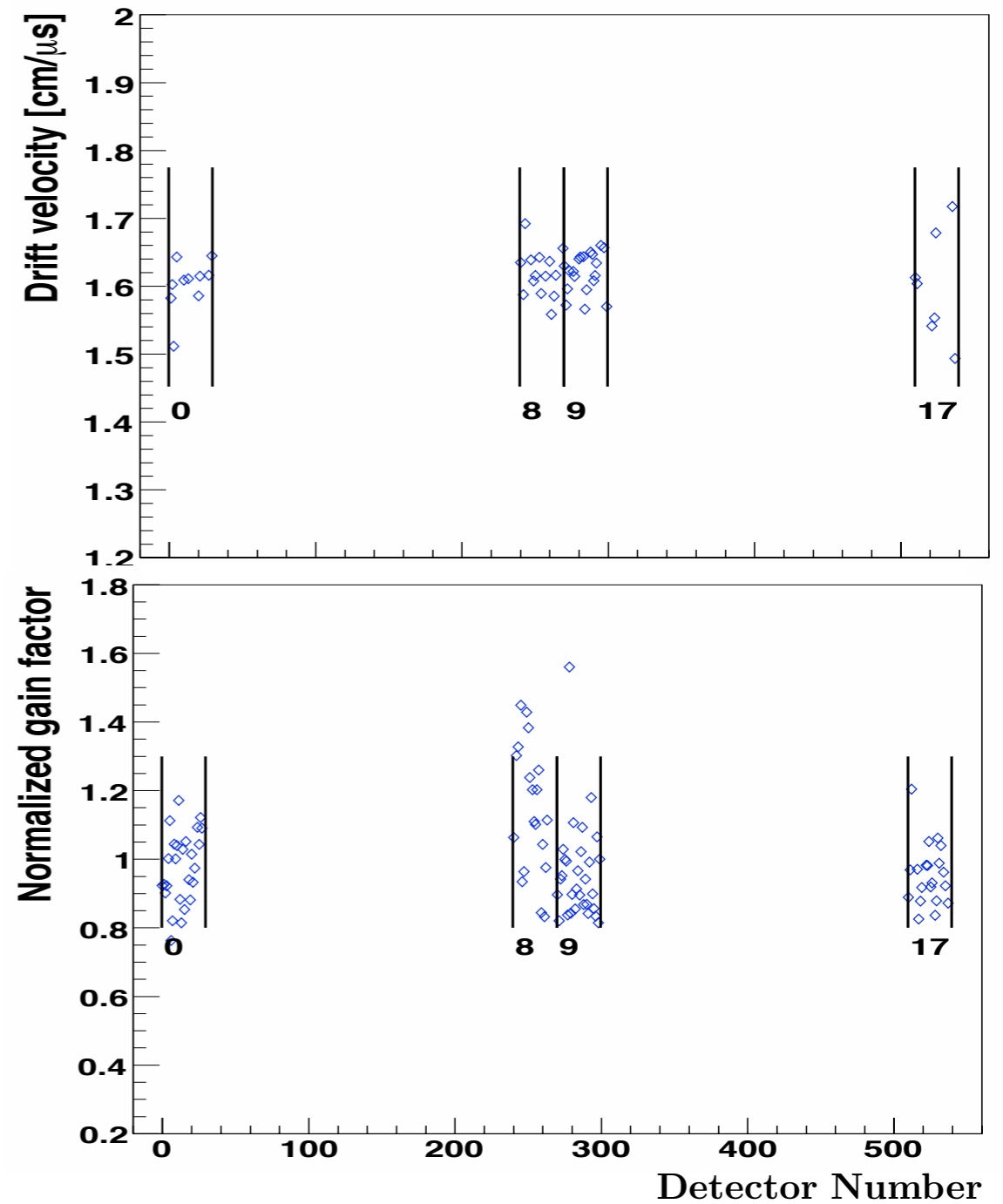
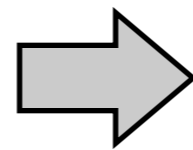
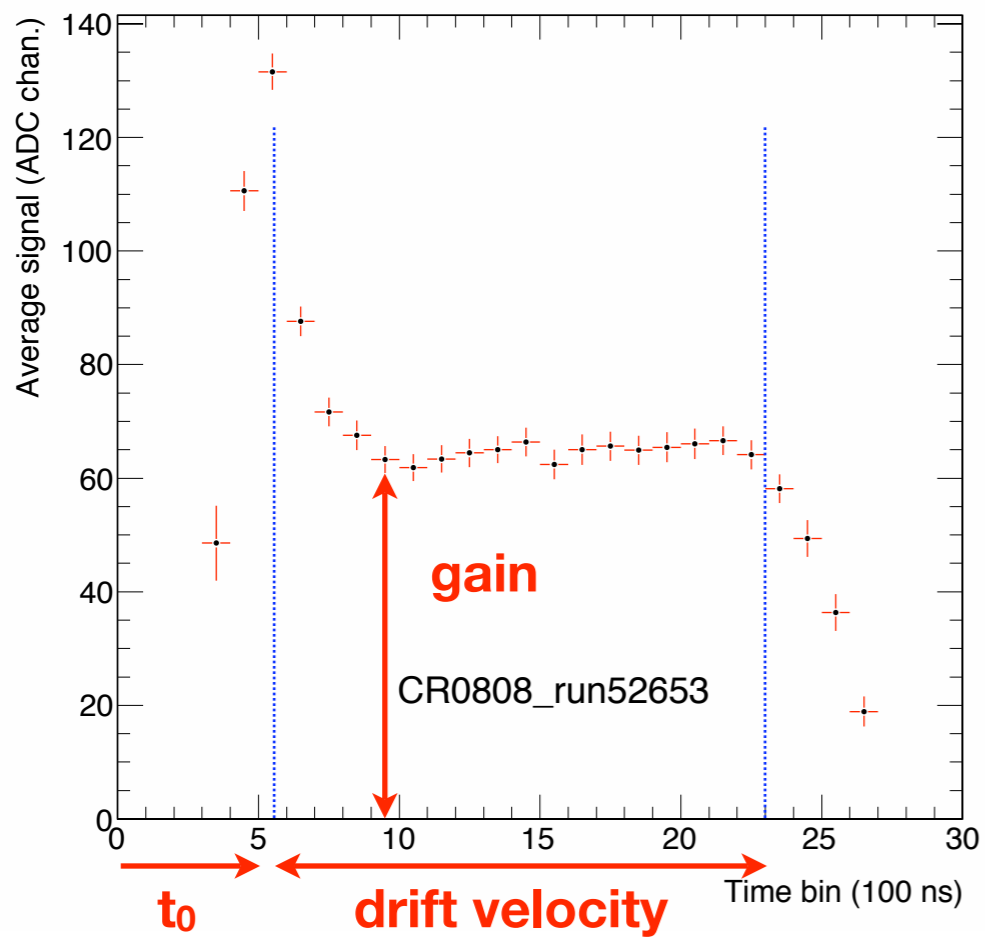
Cosmic Event Triggered



Cosmic-ray event display triggered with TRD Level-1

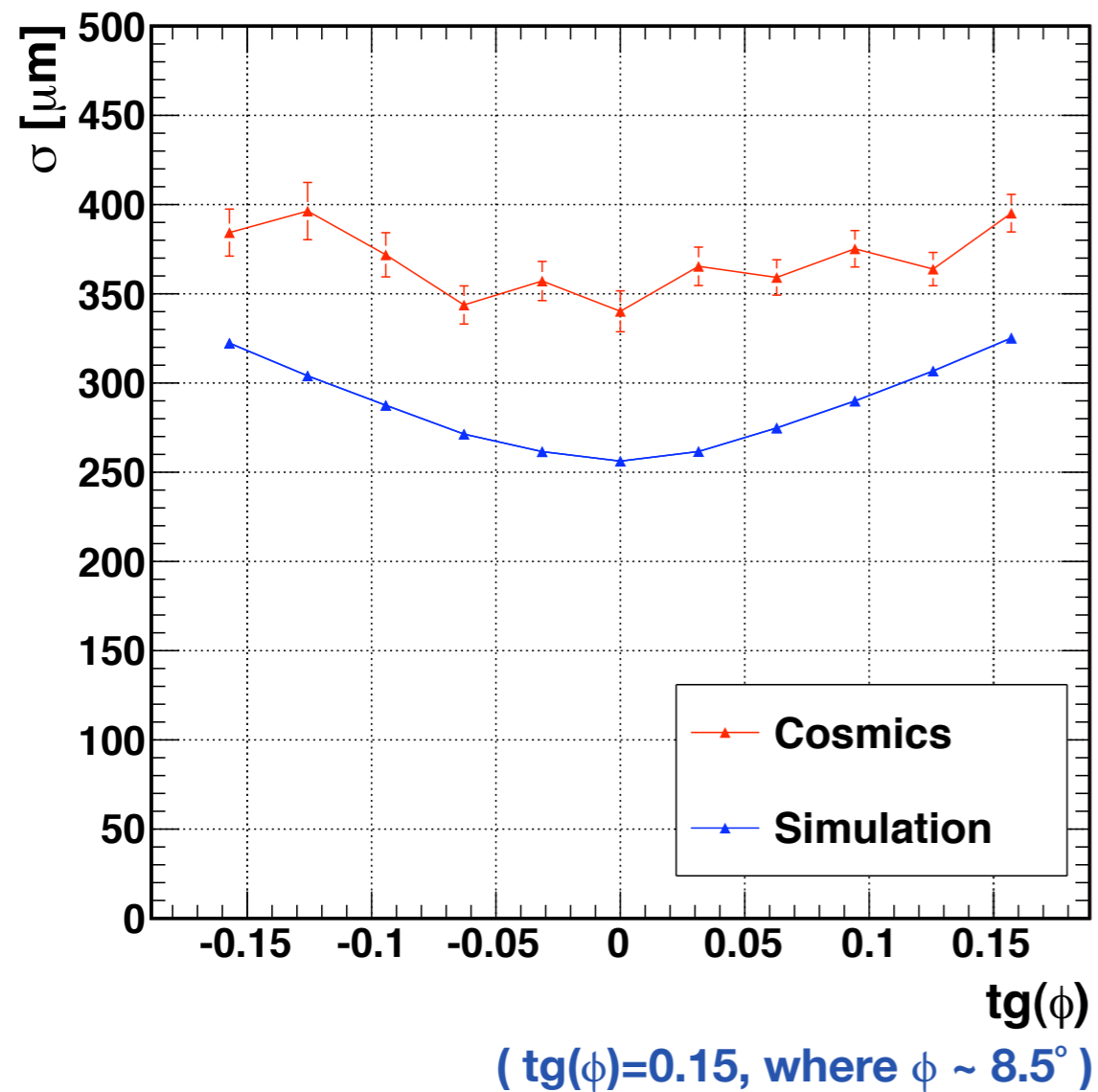
Calibration

	nominal conditions	cosmic run
gas	Xe, CO ₂ (15%)	Ar, CO ₂ (18%)
U _a (V)	1550	1450
U _d (V)	-2100	-1200
v _d (cm/μs)	1.5	1.61



- Drift velocity ≈ 1.62 cm/μs and variation ≈ 3.3 %, in the expected range from simulation
- Gain variation ≈ 16 %, better than the expected ± 20 % \rightarrow important for trigger

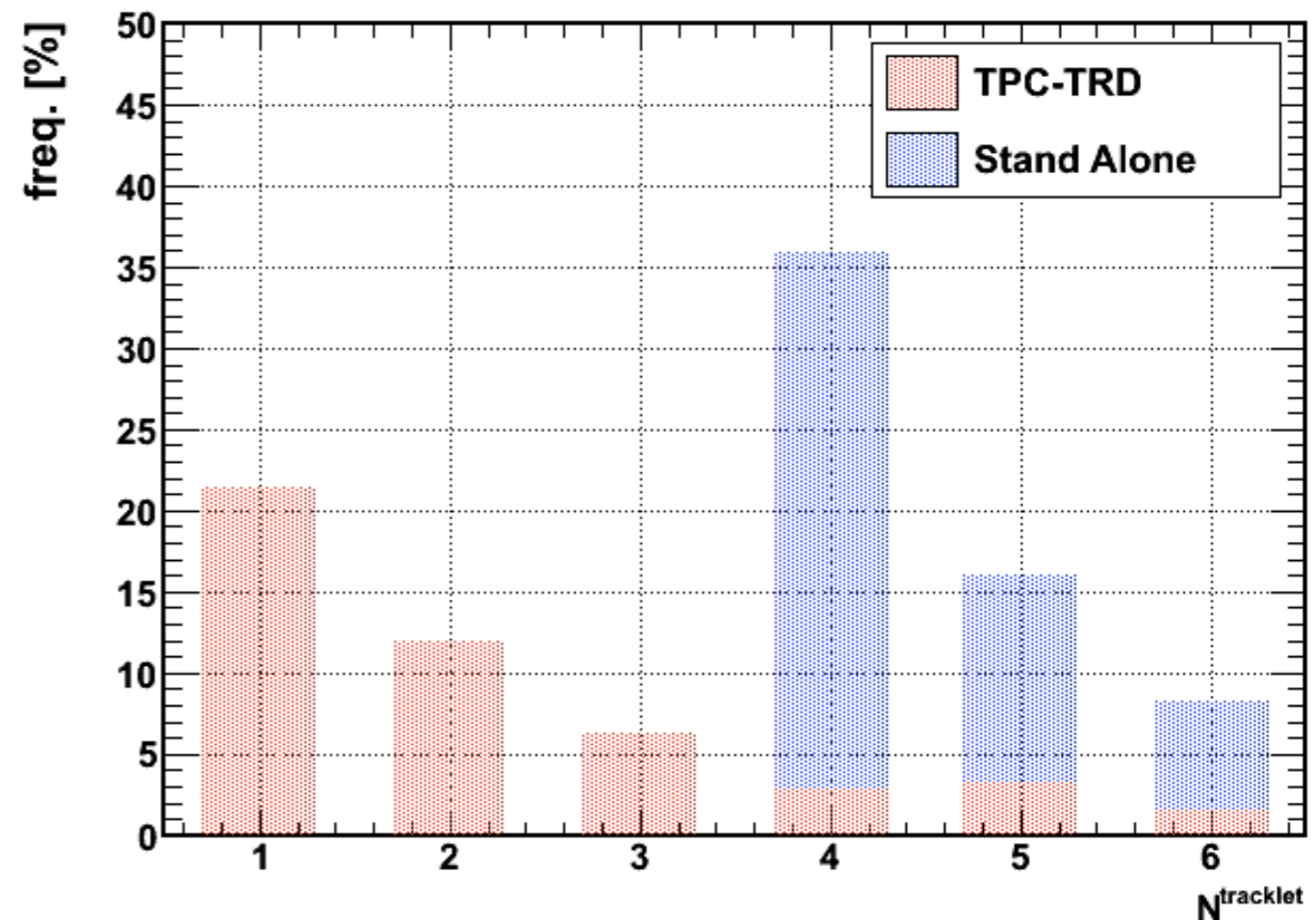
Tracking Performance



- $r\phi$ directional position resolution $\approx 350 \mu\text{m}$ at 0° incident angle

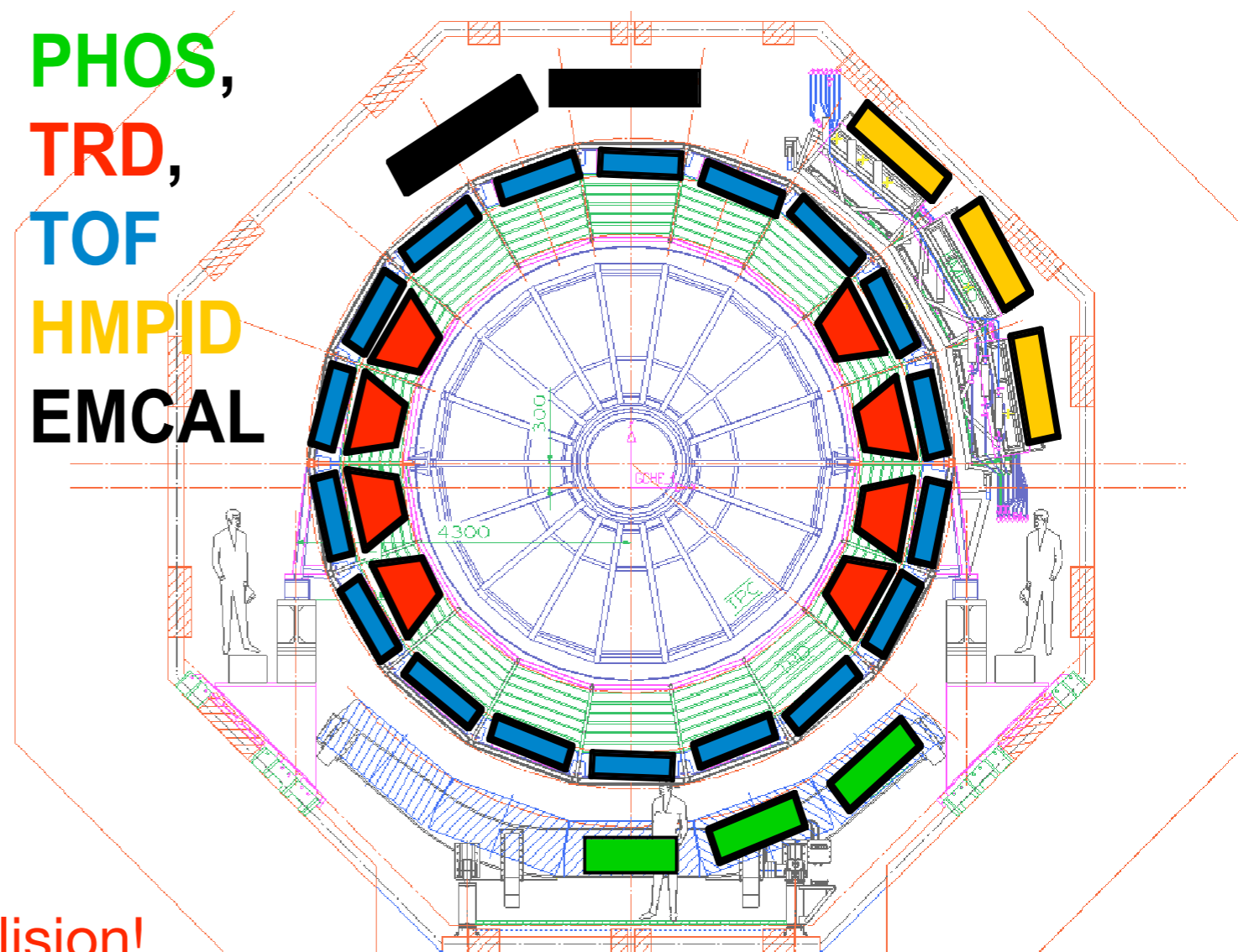
Various analysis on going:

- TPC-TRD track matching resolution
- alignment



Summary and Outlook

- TRD provide excellent electron identification and fast trigger capability
- 4-TRD super modules were commissioned successfully
- For 2009 LHC run, 8 super modules will be ready
- Full TRD will be ready for 2011 run



TRD is ready and waiting for real collision!

A wide-angle, high-angle photograph of a large industrial facility, likely a particle accelerator. The central focus is a large, octagonal structure with a complex internal framework of metal beams and supports. The structure is surrounded by massive, reddish-brown metal walls. In the foreground, a yellow robotic arm is visible on the right side, positioned on a concrete base. The scene is illuminated by bright overhead lights, creating a high-contrast environment. A white banner with black text is overlaid across the middle of the image.

Thank you for your attention!

BACKUP - Different version of plots or pictures

The image shows the interior of the ALICE Transition Radiation Detector (TRD) at the Large Hadron Collider (LHC). The detector is a large, complex structure with a central cylindrical core. The core is surrounded by a dense network of blue and silver components, likely the radiator and detector layers. The entire structure is housed within a large, red-painted metal frame. The background shows the industrial environment of the LHC tunnel, with various pipes, cables, and structural elements visible. The lighting is bright, highlighting the intricate details of the detector's construction.

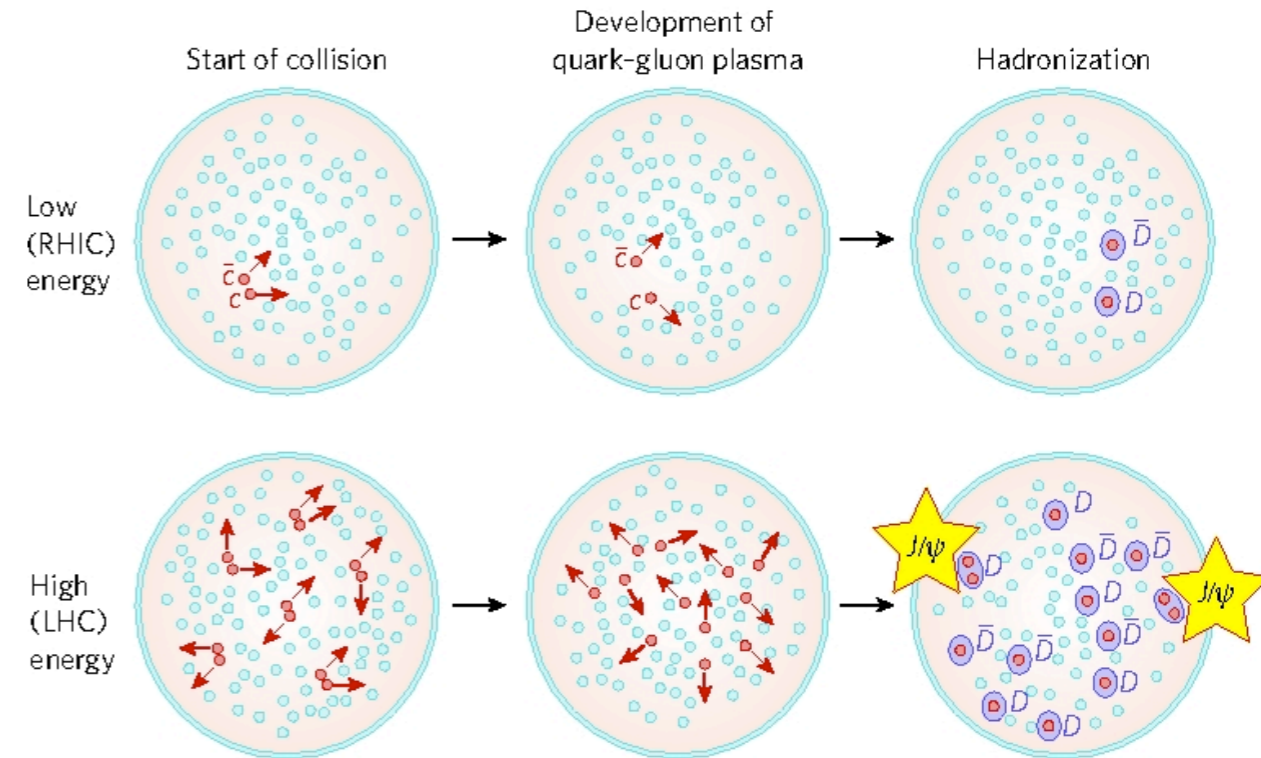
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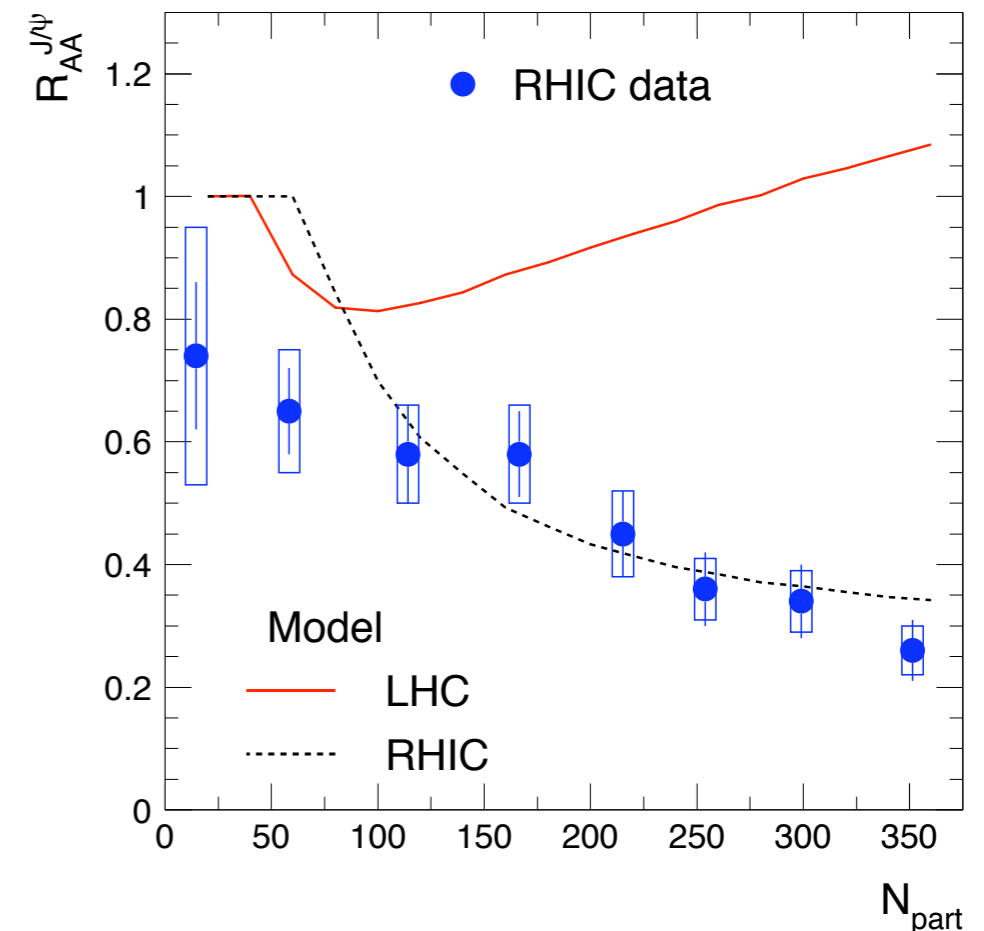


J/ψ Enhancement

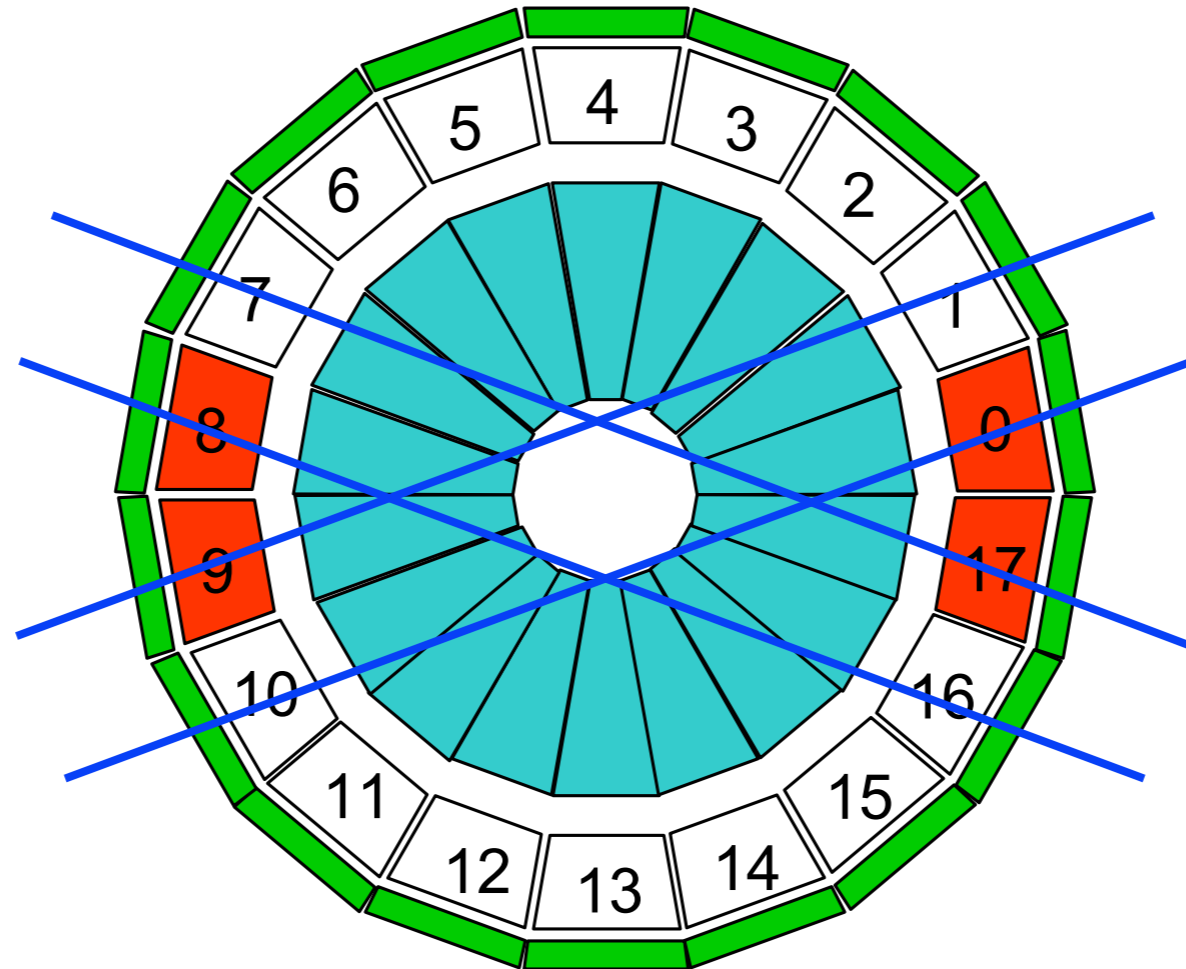
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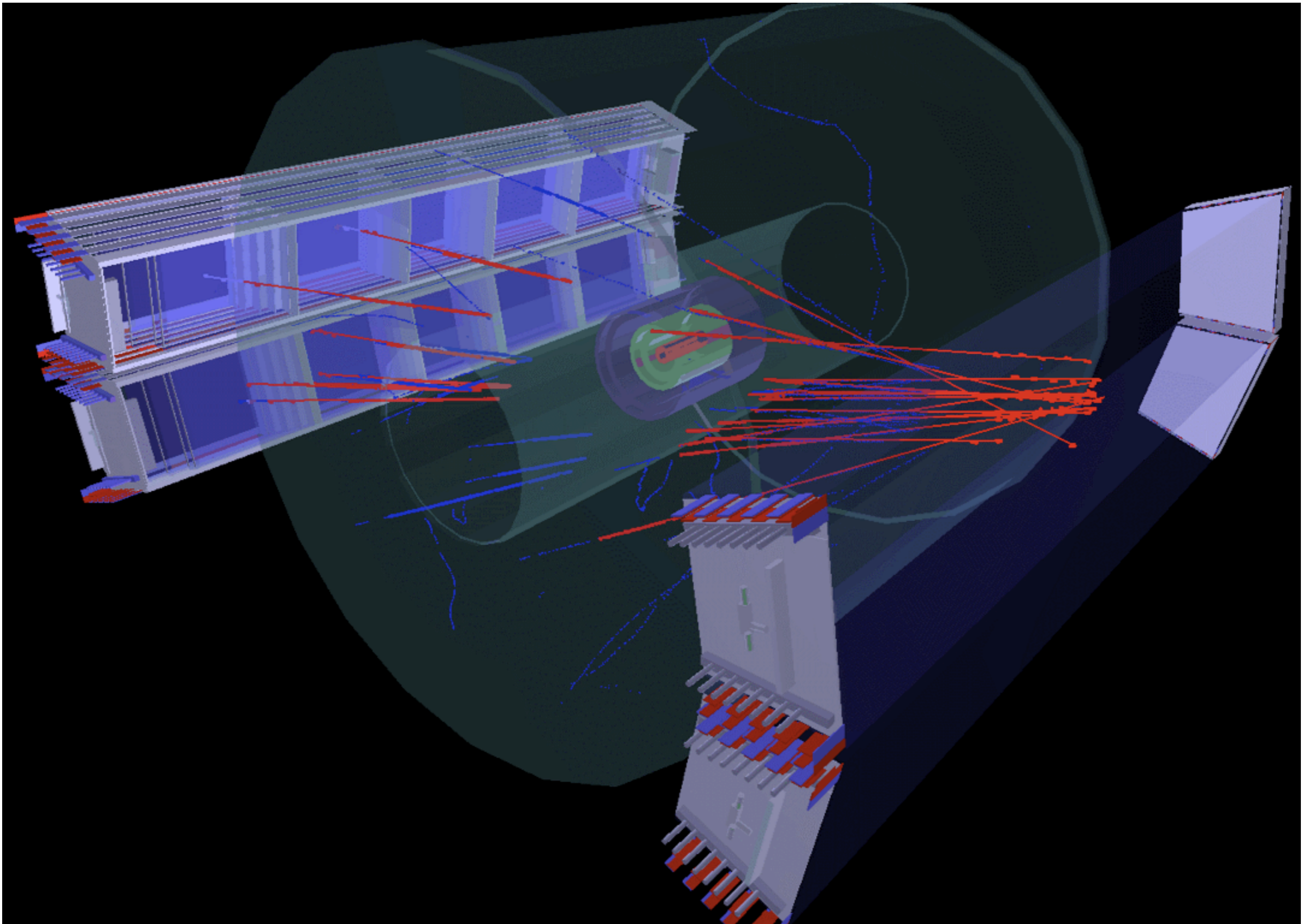
- good electron PID
- large acceptance



- TOF pre-trigger setup



Cosmic Event Triggered



Cosmic Event Triggered

