The Transition Radiation Detector for ALICE at LHC

MinJung Kweon
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for the ALICE TRD Collaboration

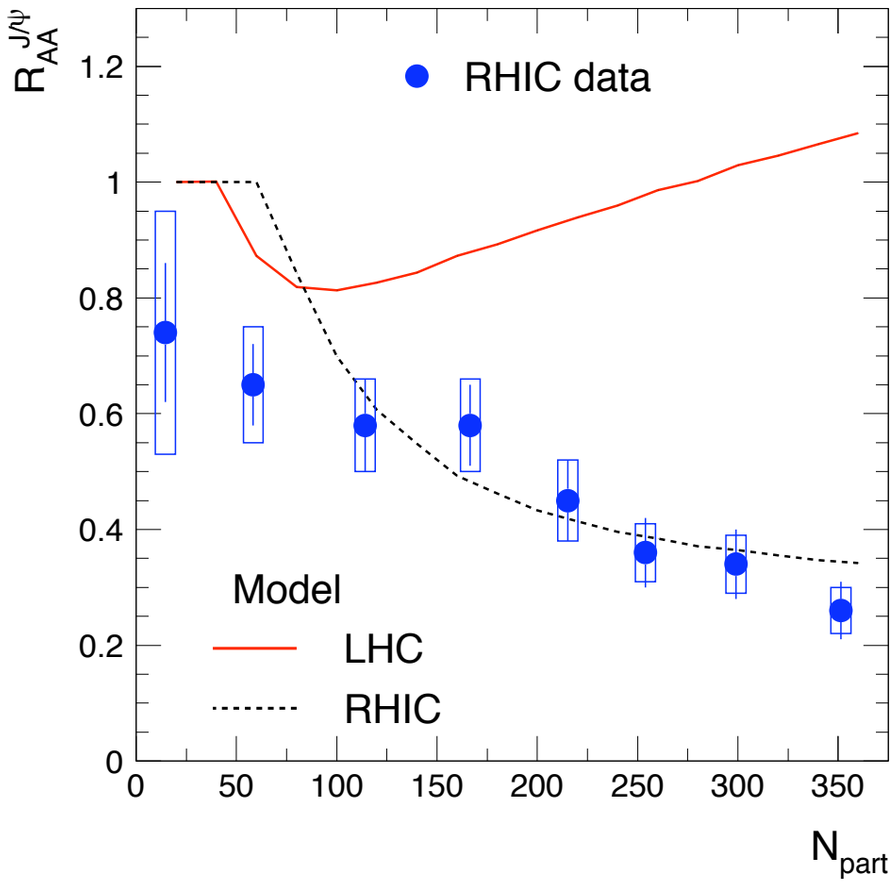
Outline

- Physics motivation of ALICE Transition Radiation Detector (TRD)
- Detector
- Production
- Installation
- Commissioning
- Summary and Outlook

Physics Observables Accessible with the TRD

J/ψ Production: Suppression or Enhancement?

- screening of color charges
  → "melting" of $c\bar{c}$ bound state



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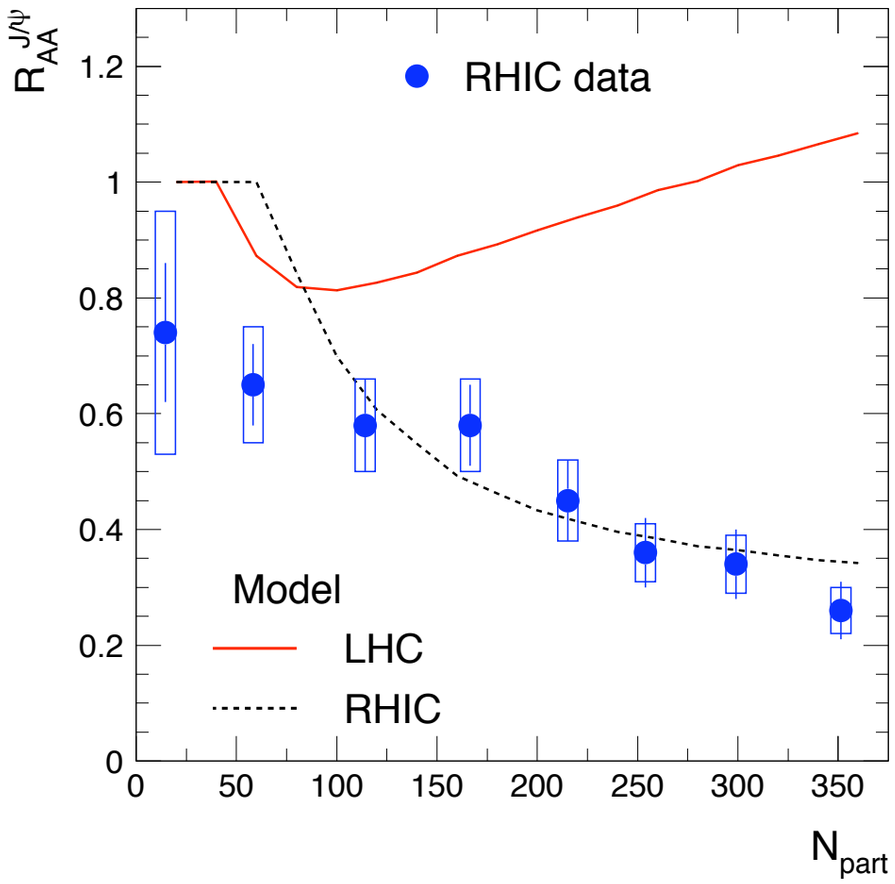
- large abundance of $c\bar{c}$ quarks at LHC
  → statistical combination to J/ψ



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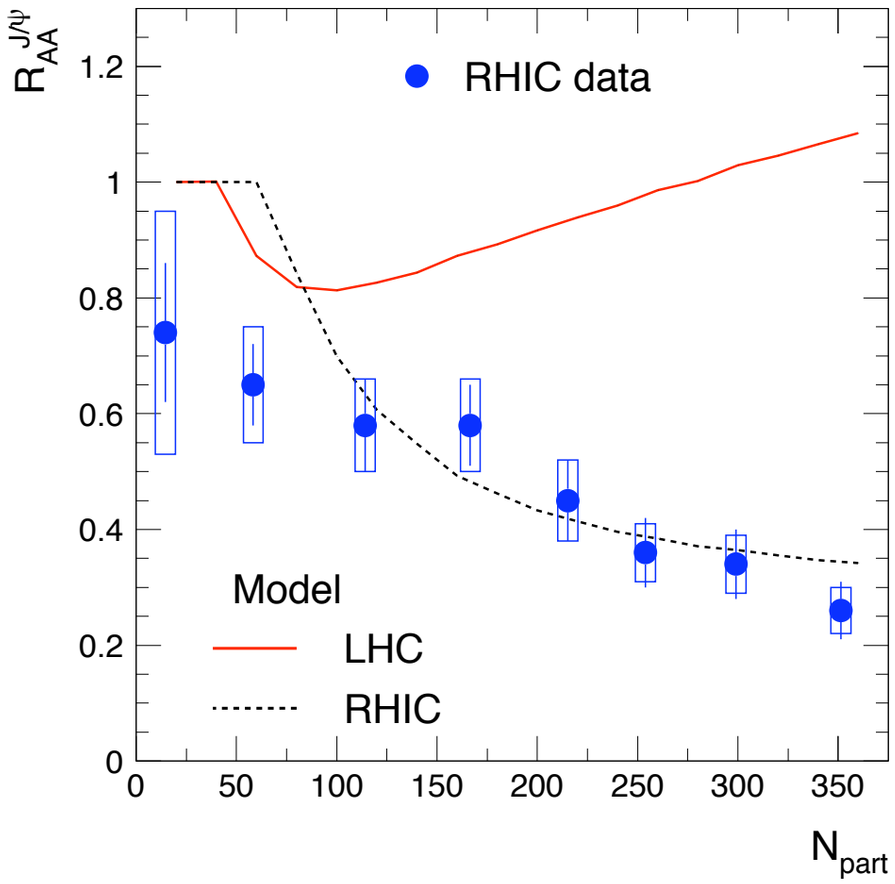
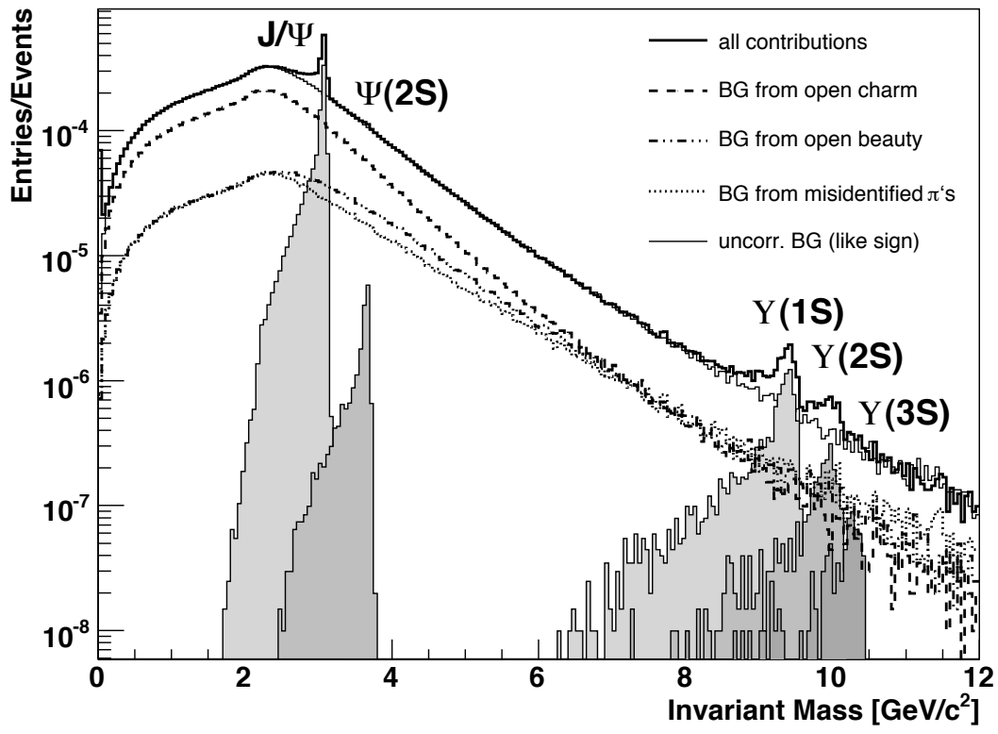


Requires good electron PID



Physics Observables Accessible with the TRD II

Open Heavy Flavor Electrons

- open charm, beauty from semi-electronic decays

  → charm, beauty cross-section

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- $\gamma + Z \rightarrow e^{+}e^{-} + Z$

  → direct γ , π^{0}, η

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Jets and High-p_T Hadrons

- trigger on high-p_T tracks

  → energy loss in QGP

  → medium-modified fragmentation functions

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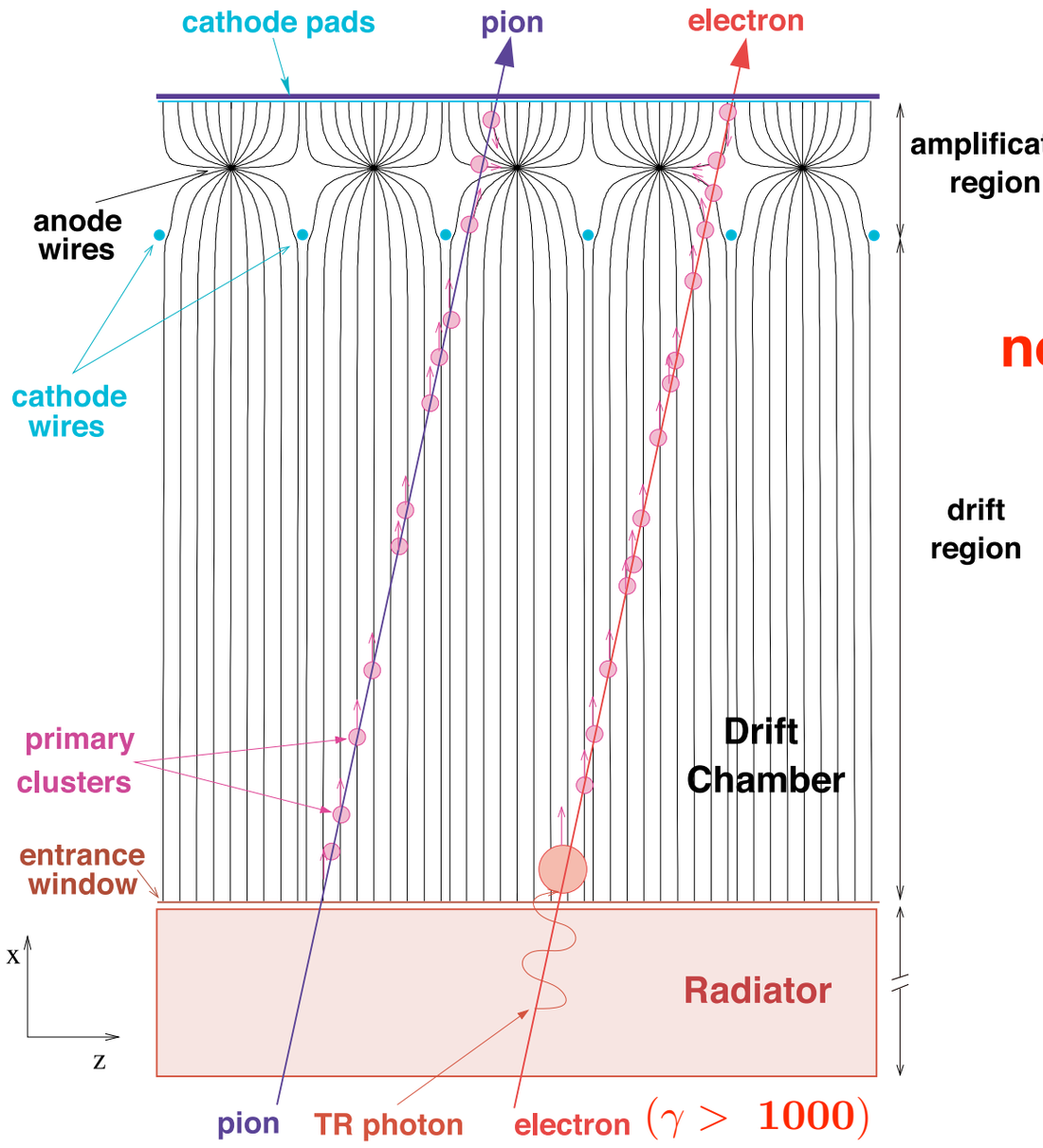
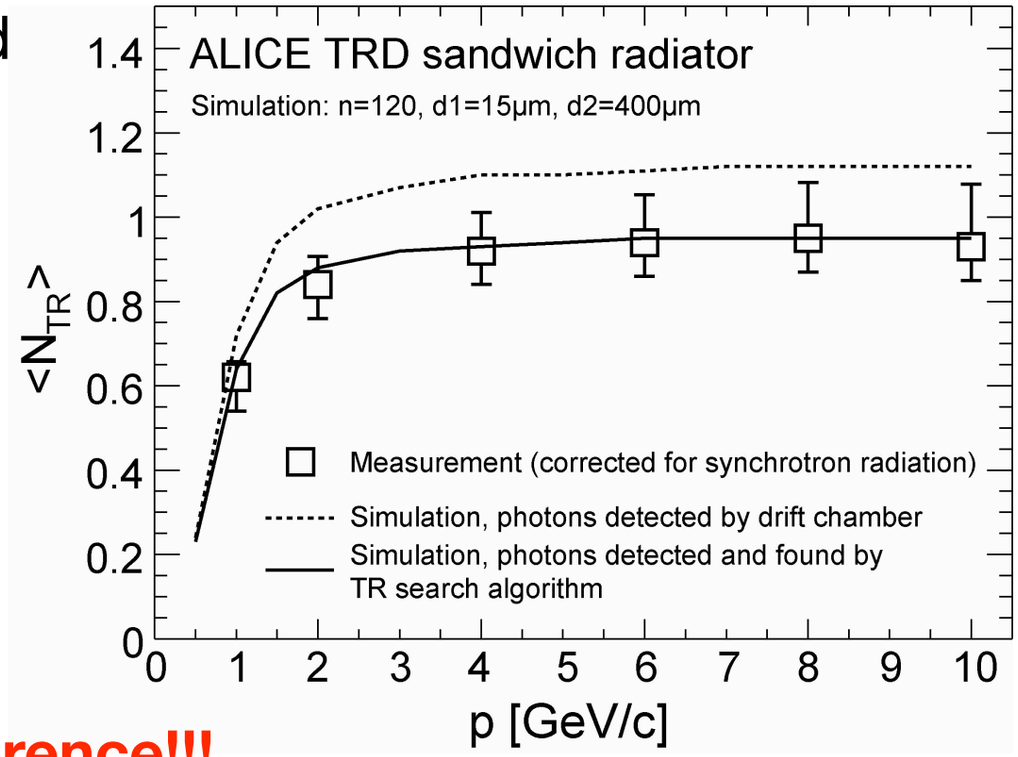
⇨ Requires:

- pion rejection by factor 100 for p > 1 GeV/c
- tracking capability
- trigger on cluster of high p_t tracks

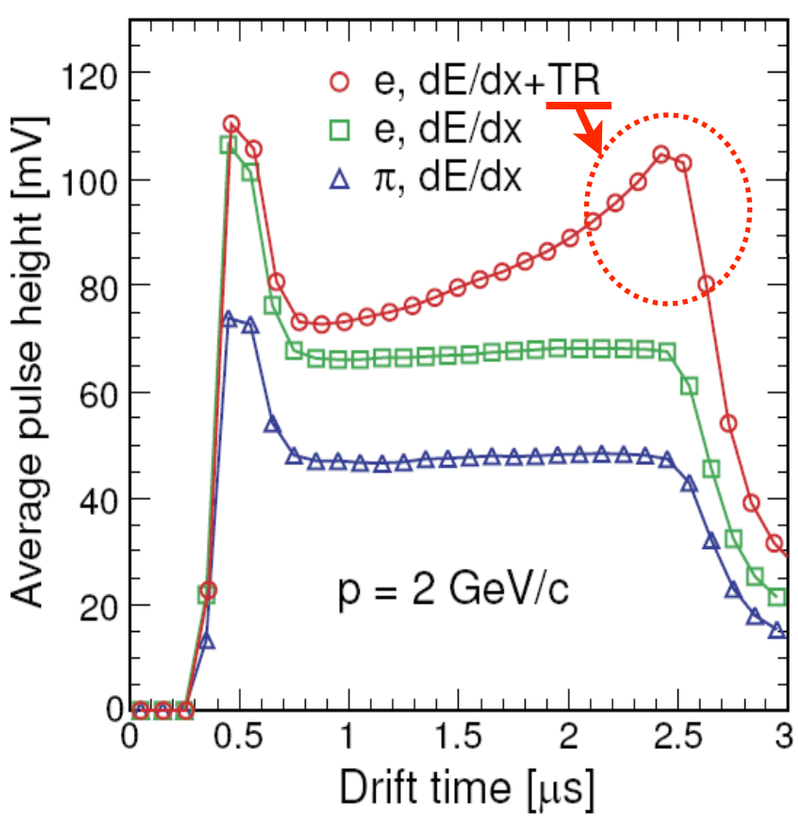
Working Principle of TRD

- Drift chambers with cathode pad readout combined with a fiber/foam sandwich radiator in front
- Transition Radiation (TR) photons are absorbed by high-*Z* gas mixture (Xe + CO_2)

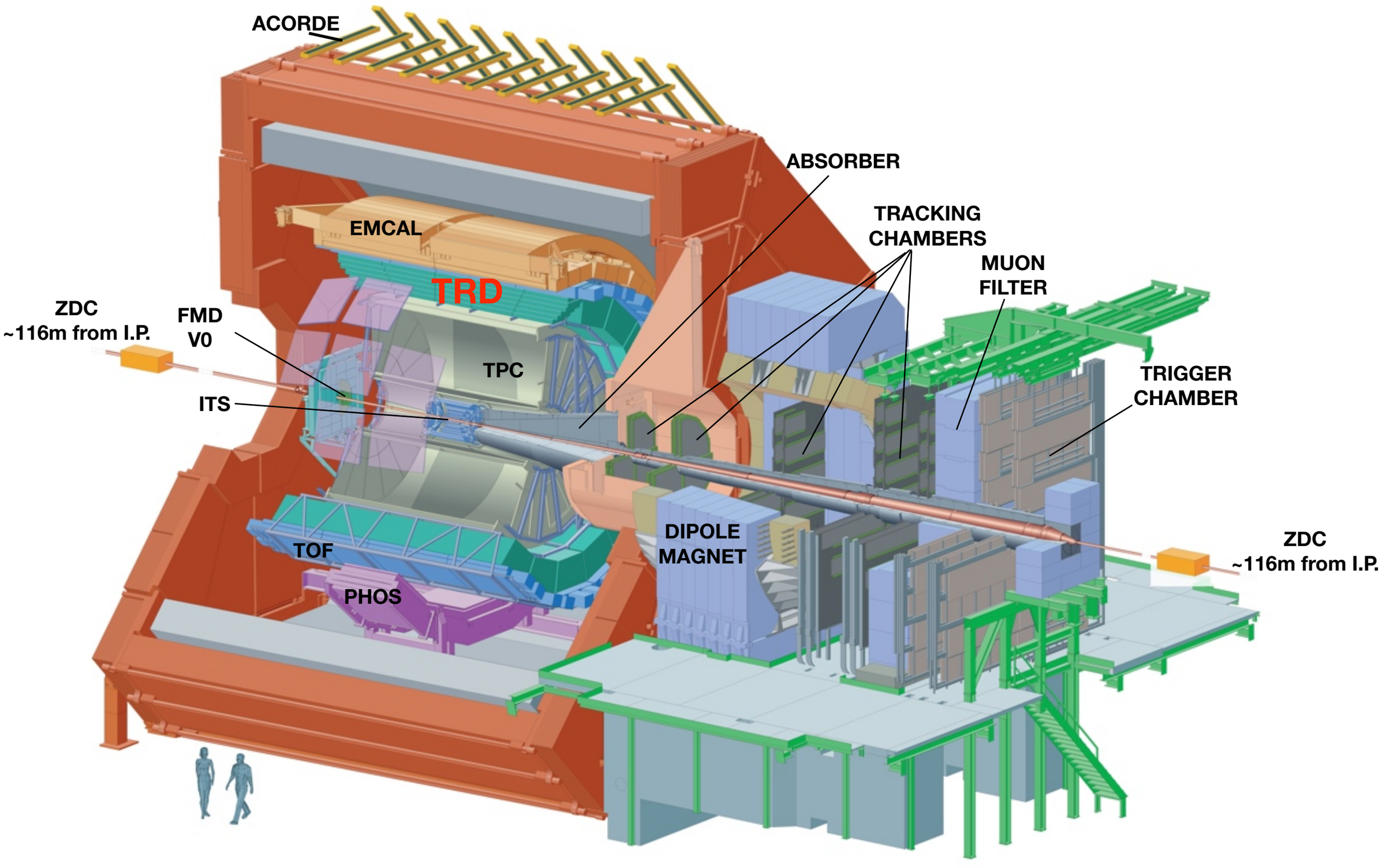




need reference!!!



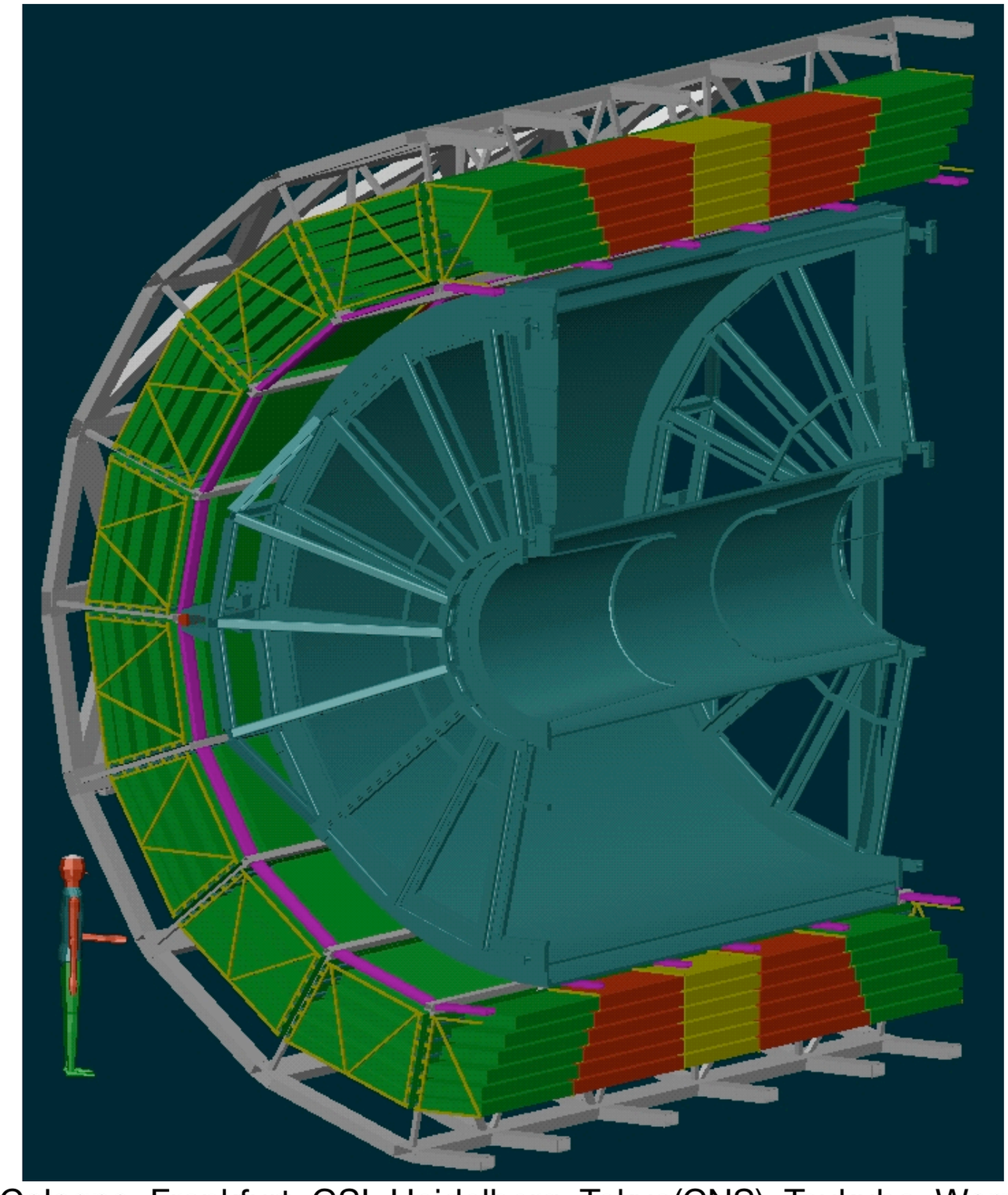
A Large Ion Collider Experiment



Collaboration: 31 countries, 109 institutes, > 1000 people

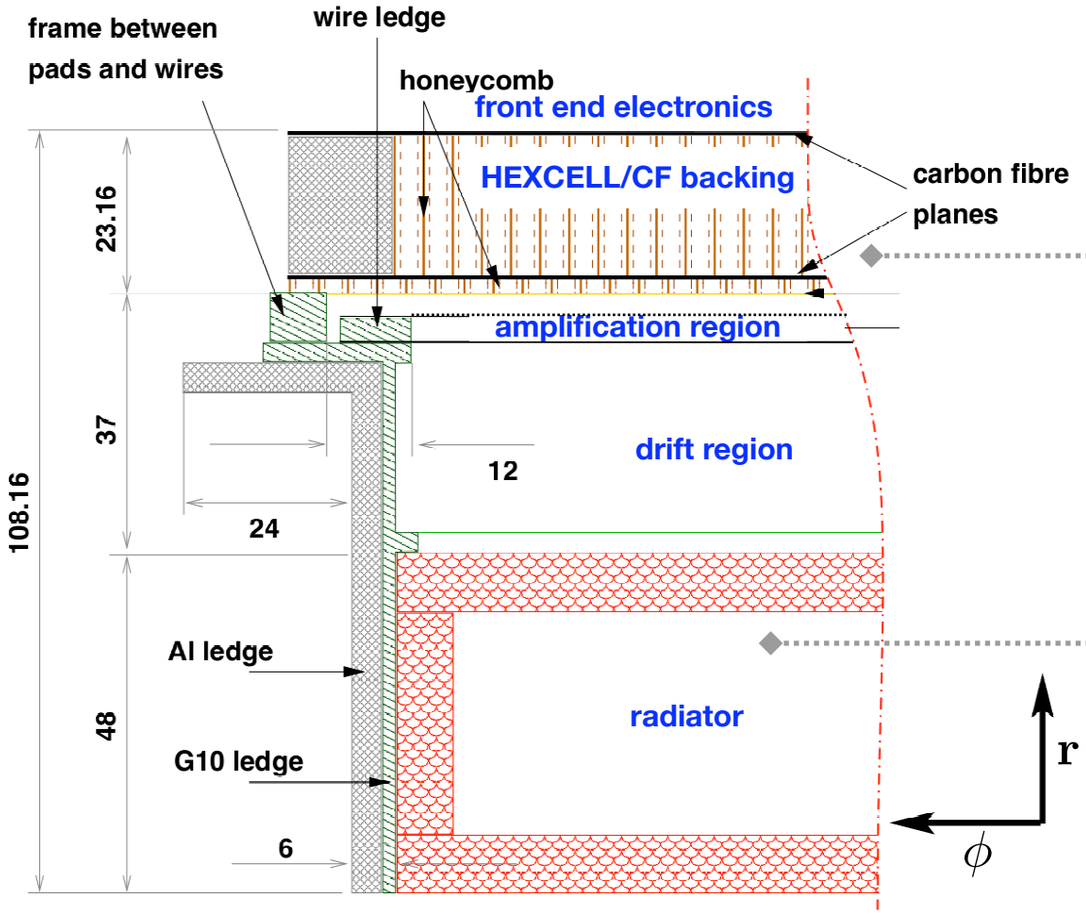
The ALICE TRD

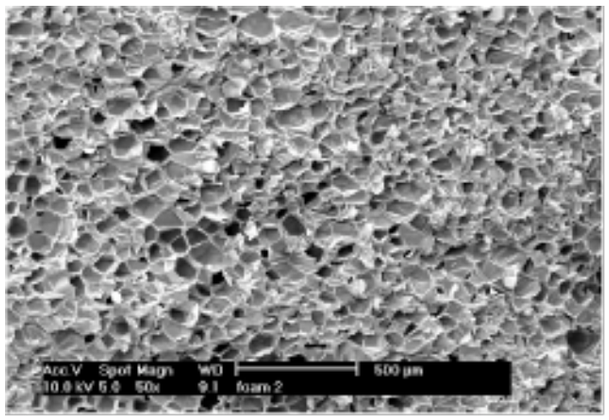
- Surrounds ALICE TPC
  - radial position 2.9 < *r* < 3.7 m
  - maximal length 7 m
  - full azimuthal coverage
  - $|\eta| < 0.9$
- 540 detector modules arranged in:
  - ϕ: 18 super modules
  - *r* : 6 layers
  - *z*: 5 stacks
- 694 m^2 active area
- 25.8 m^3 detector gas of Xe/CO_2
- $X/X_0 \sim 24$ %
- 30 tons
- 10 M Euro and 250 persons



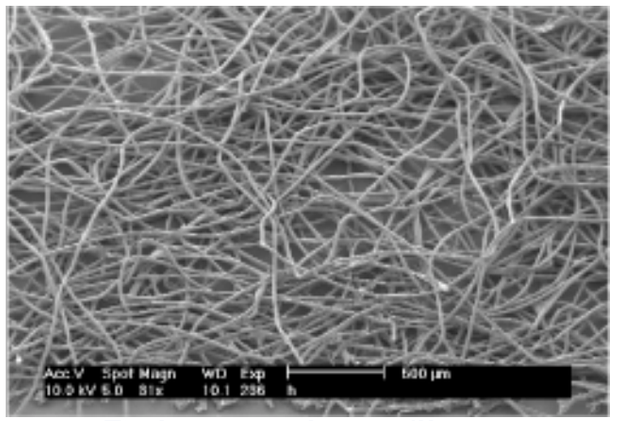
Collaborations for TRD: Bucharest, Darmstadt, Dubna, FH Cologne, Frankfurt, GSI, Heidelberg, Tokyo(CNS), Tsukuba, Worms

TRD Readout Chamber





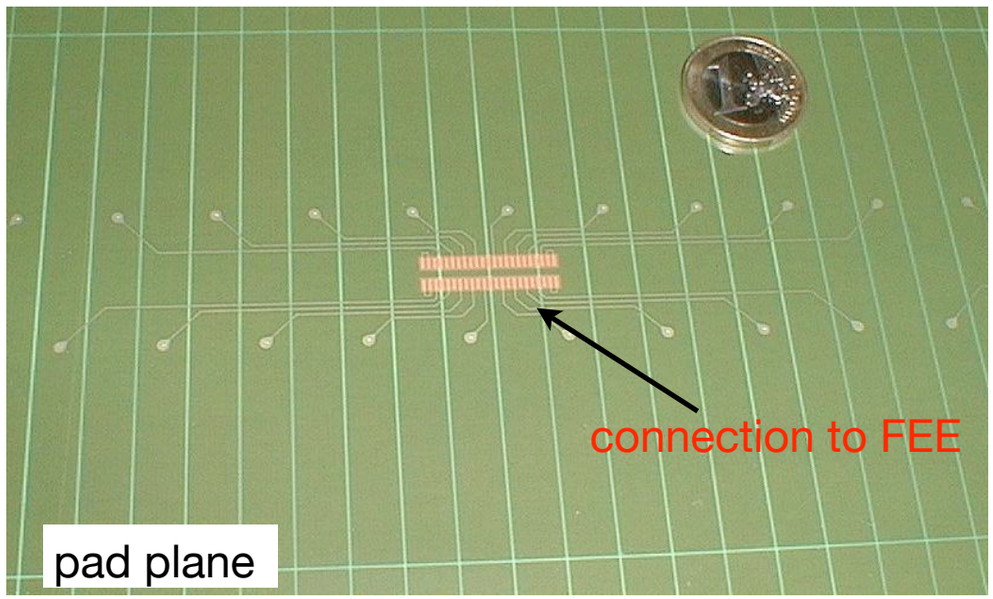
Rohacell



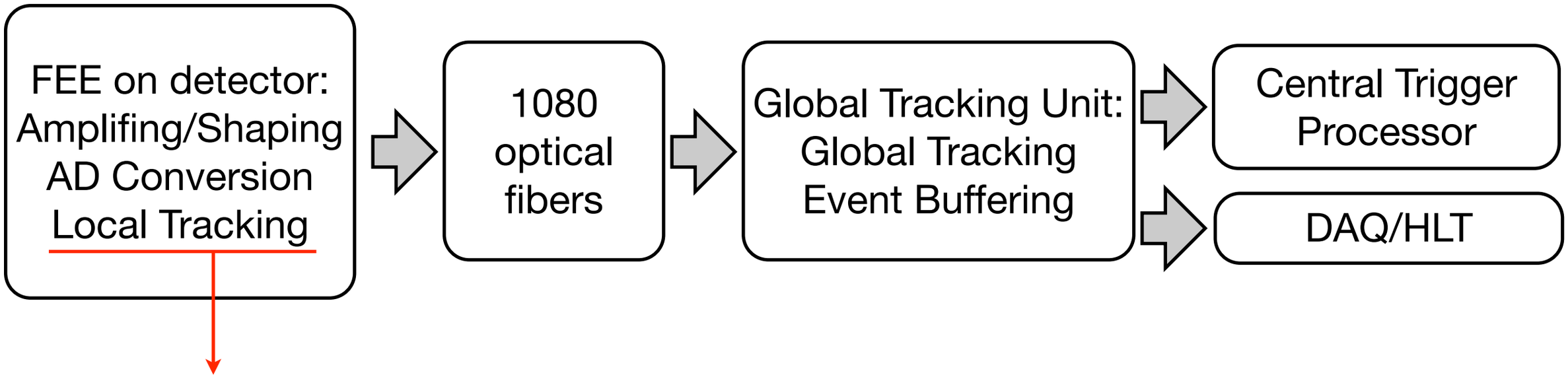
Polypropylene fibers

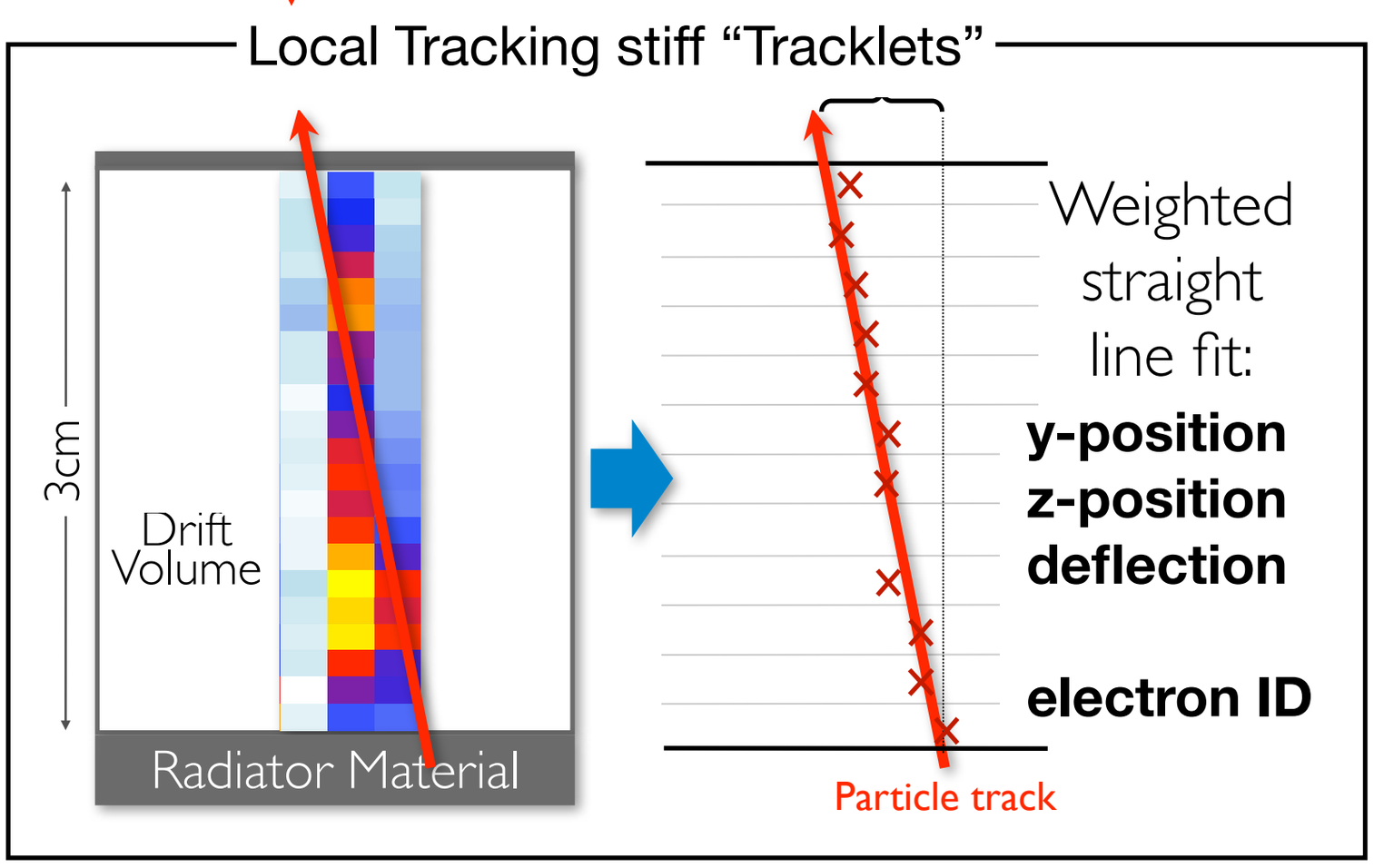
- Electronics directly on detector
- Detector needs to be very thin in radiation lengths

  , but at the same time very strong (keep gain uniformity better than 20%)



Front-End Electronics Design





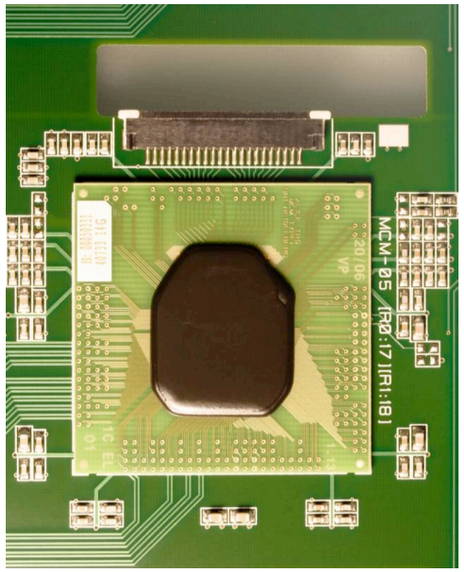
Provide a trigger capability:

- fast track reconstruction and electron PID
- trigger decision available at L1 (6.5 μs)
- pretrigger required before ALICE L0

Readout Chamber Electronics

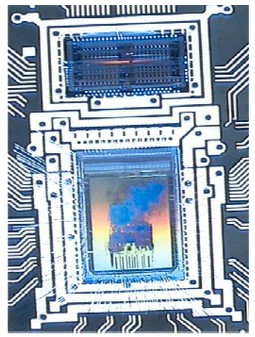
Multi Chip Module (MCM)

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



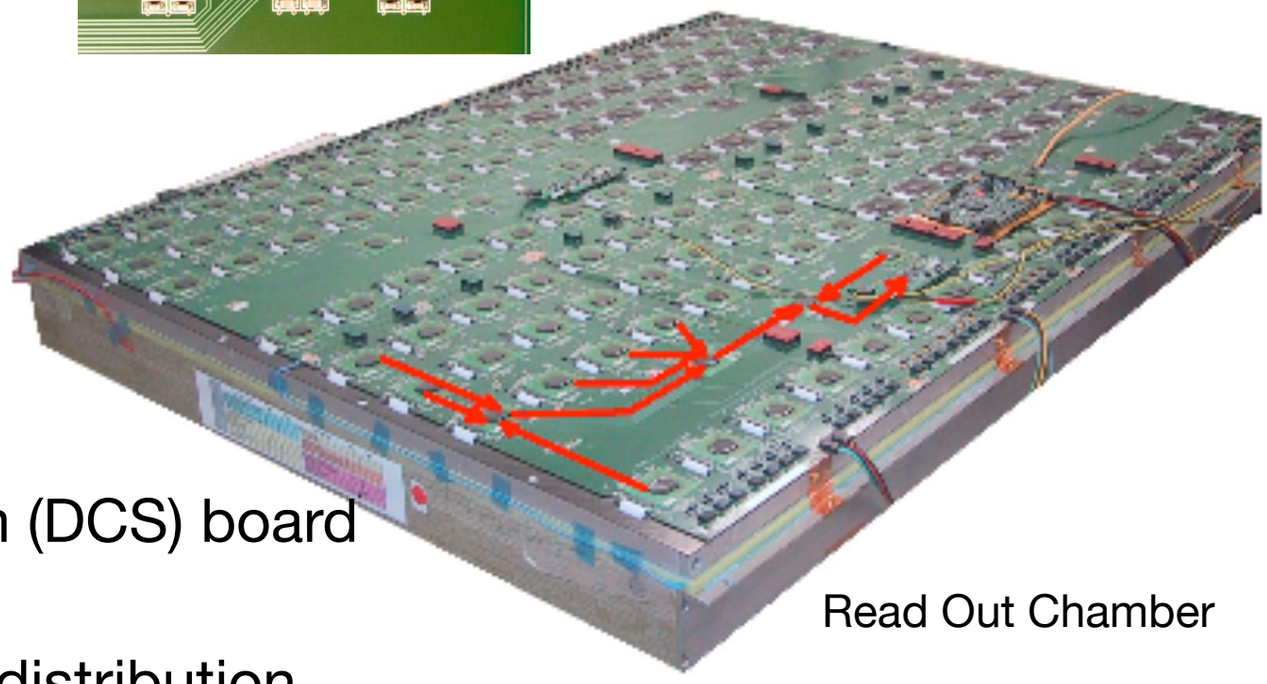
MCM

PASA



Read Out Chamber (ROC)

- 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



Read Out Chamber

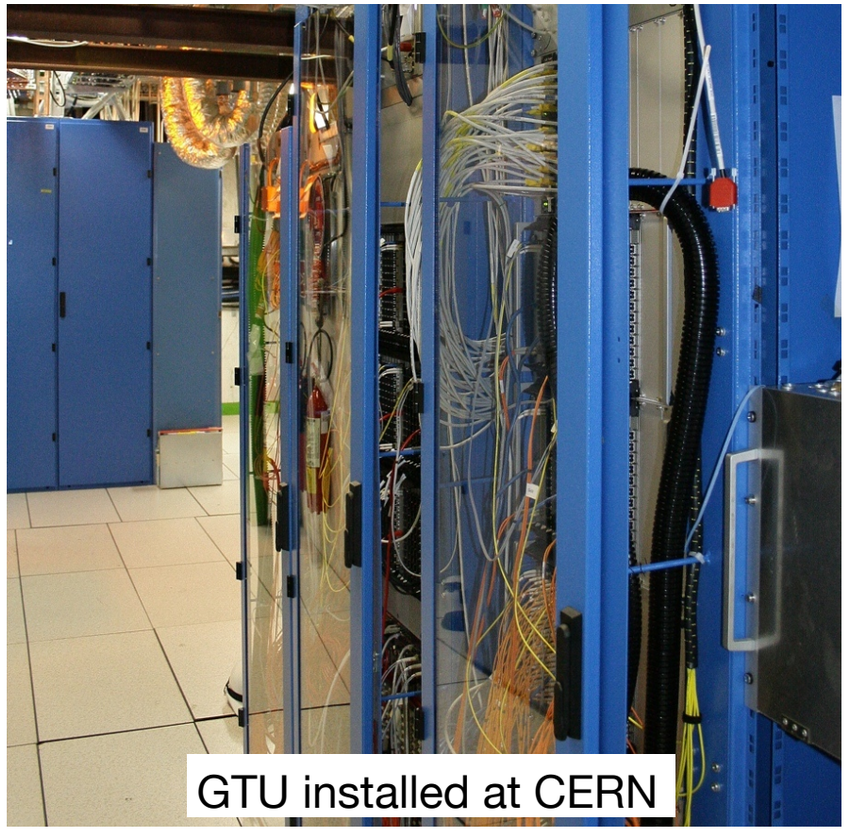
Data readout done in tree structures

Send data via ORI to Global Tracking Unit (GTU)

Global Tracking Unit

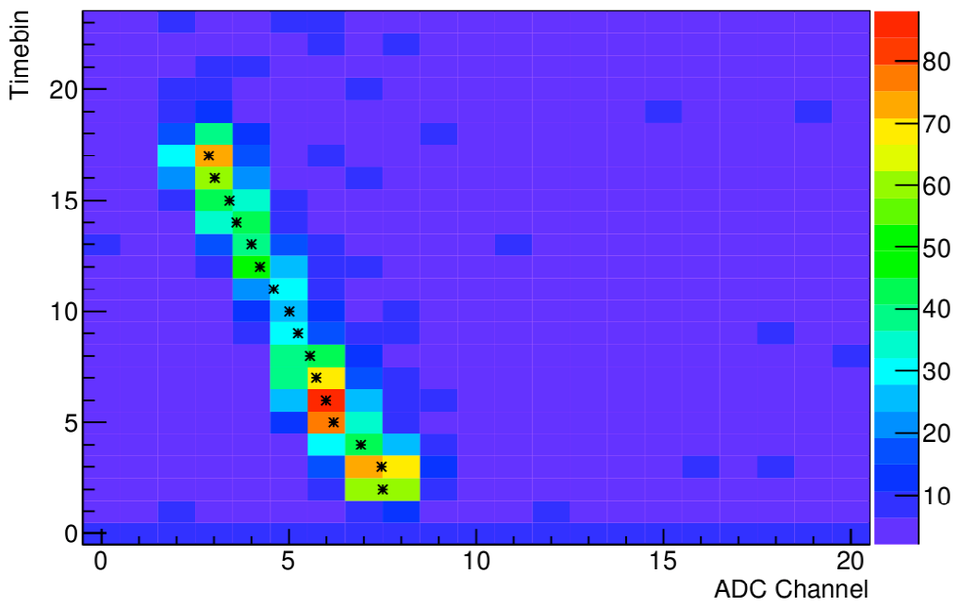
Trigger

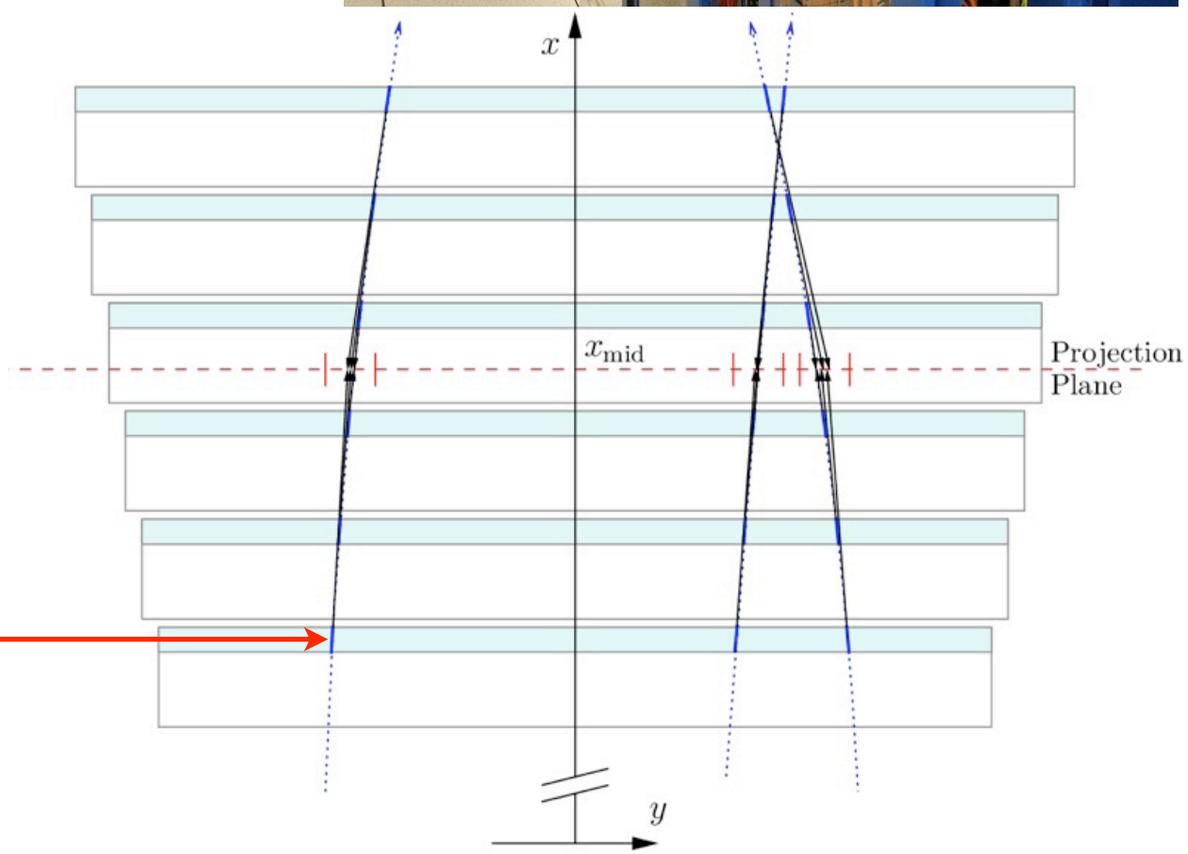
- merge tracklets from MCMs
- reconstruct tracks and calculate momentum
- find high-p_t tracks
- apply various trigger schemes: di-lepton decays, jets, cosmics,...
- level-1 trigger decision, done within 6.5 μs from collision


GTU installed at CERN

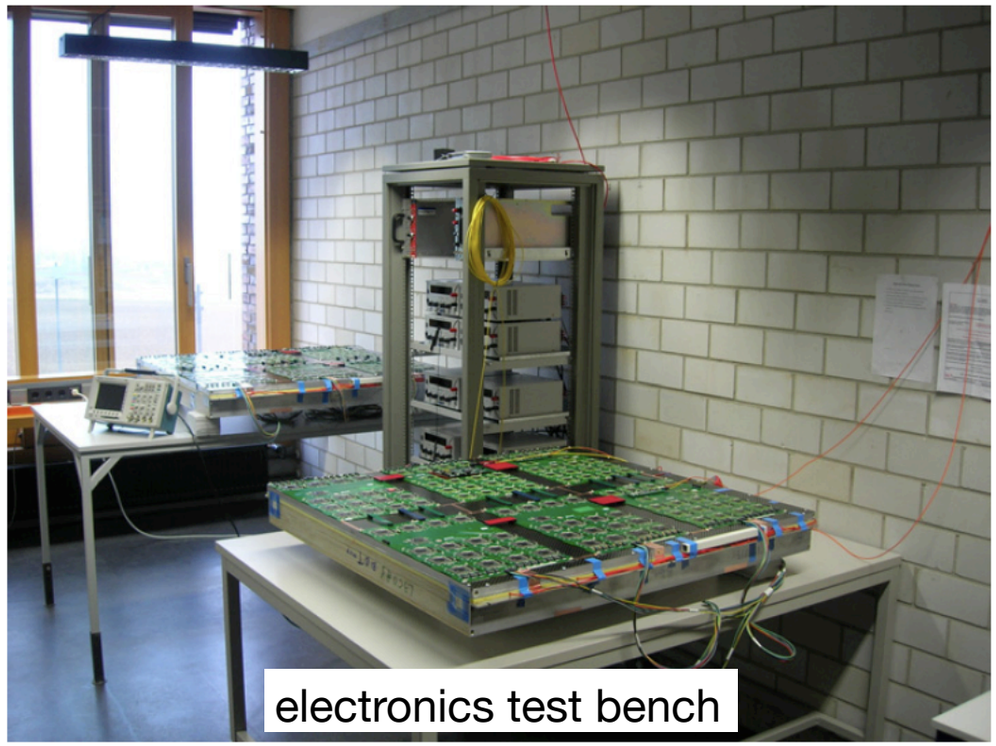
Raw Data Readout

- collect data from ROCs
- forward to DAQ



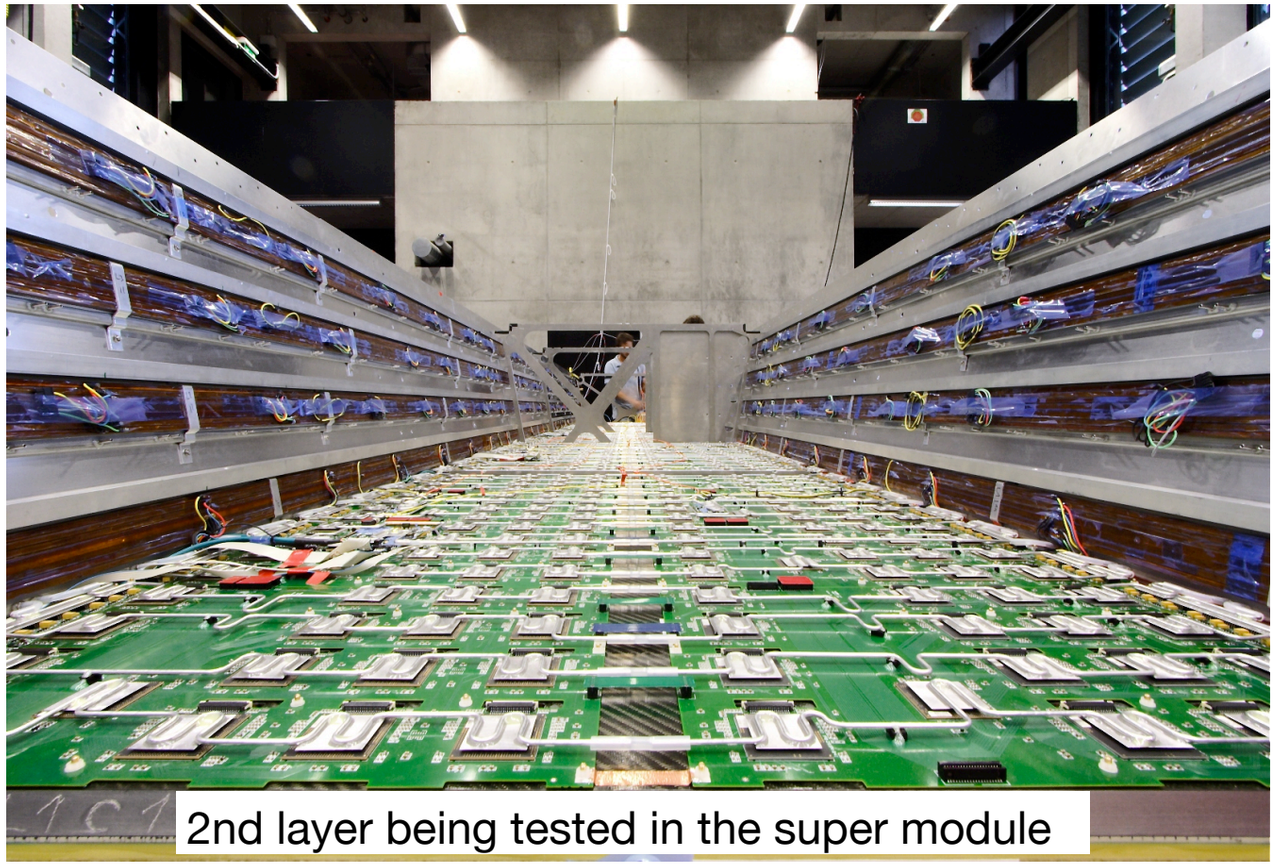


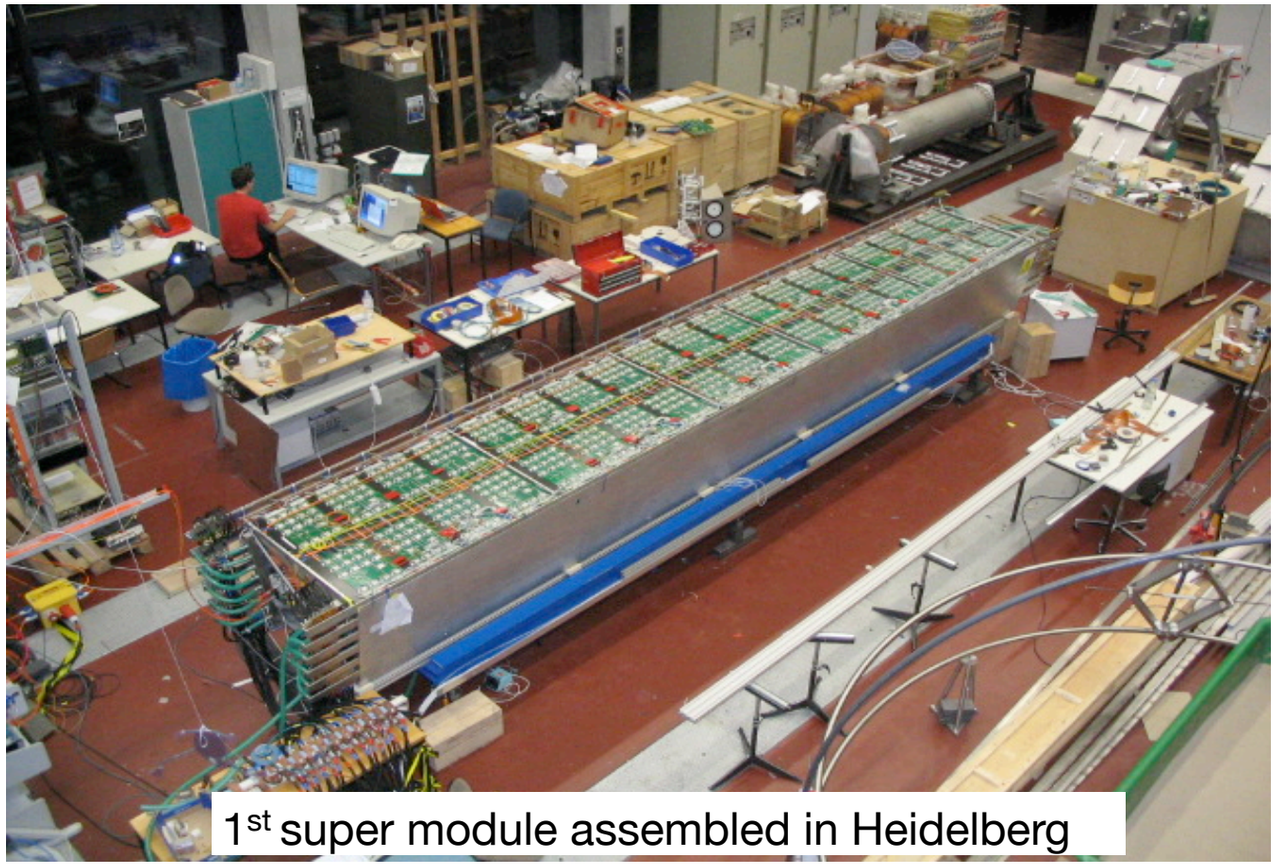
Electronics and Super module Integration


electronics test bench

- Installation of electronics and water cooling
- Electronics testing
- Assembles into one super module

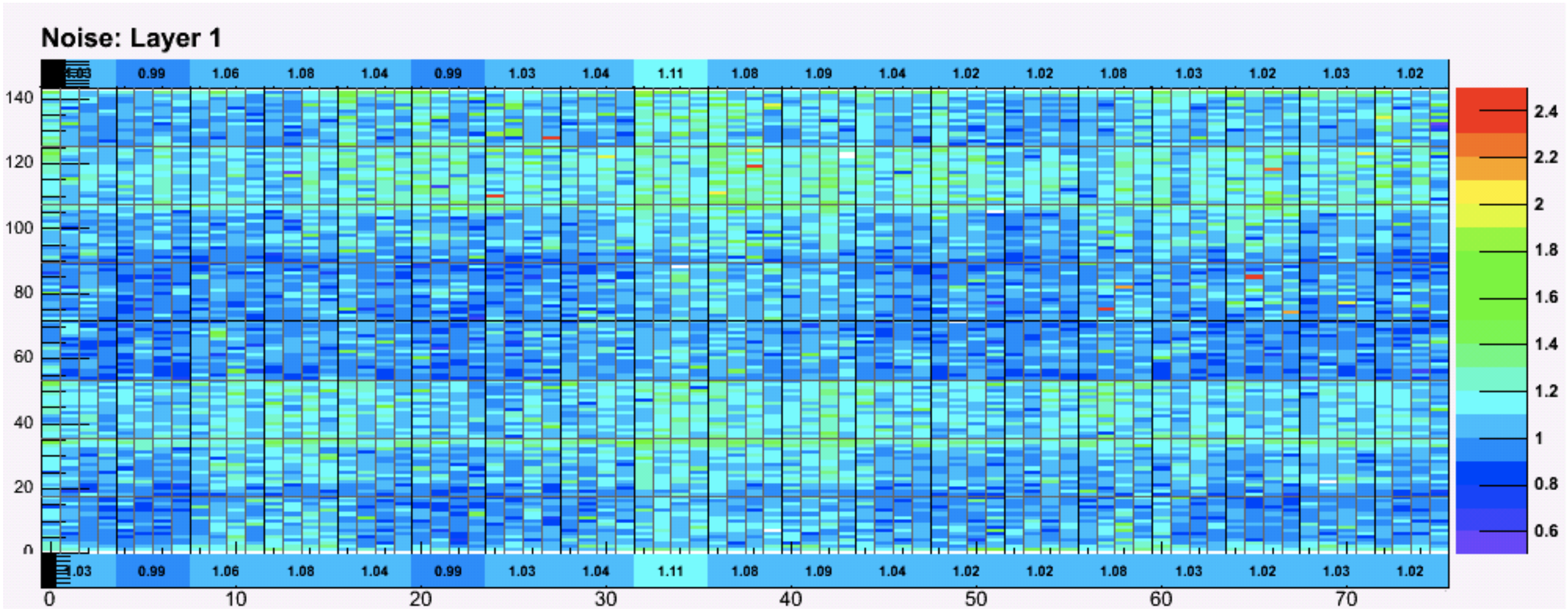
- Assembled in Heidelberg (1st one) and Münster (from 2nd ~)


2nd layer being tested in the super module


1st super module assembled in Heidelberg

Electronics Noise

RMS noise map of one layer of a super module

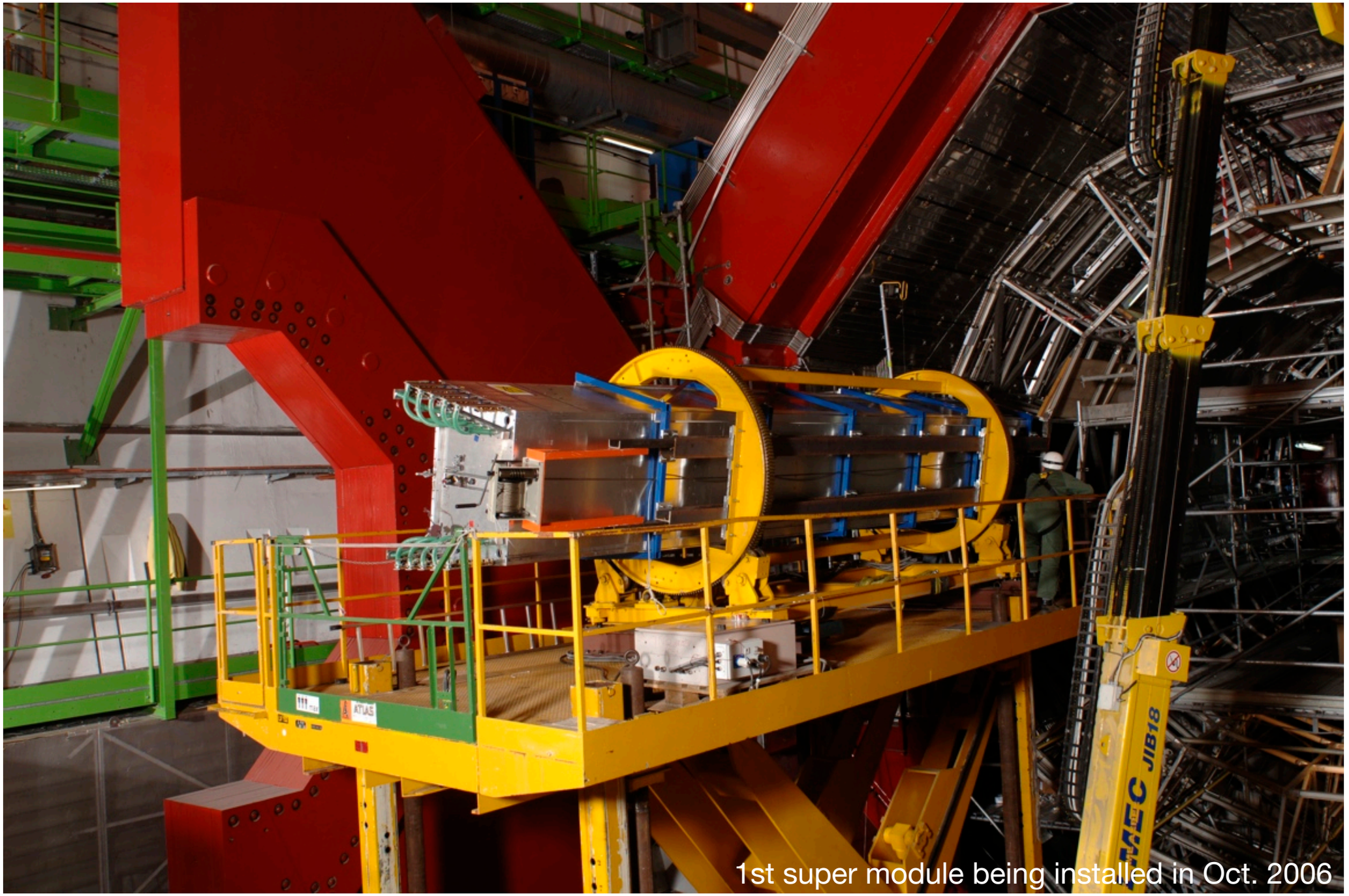


Very close to design goal

- 1000 *e* ≙ 1 ADC
- dead channels < 0.1 %

Performance

Installation at ALICE



1st super module being installed in Oct. 2006

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

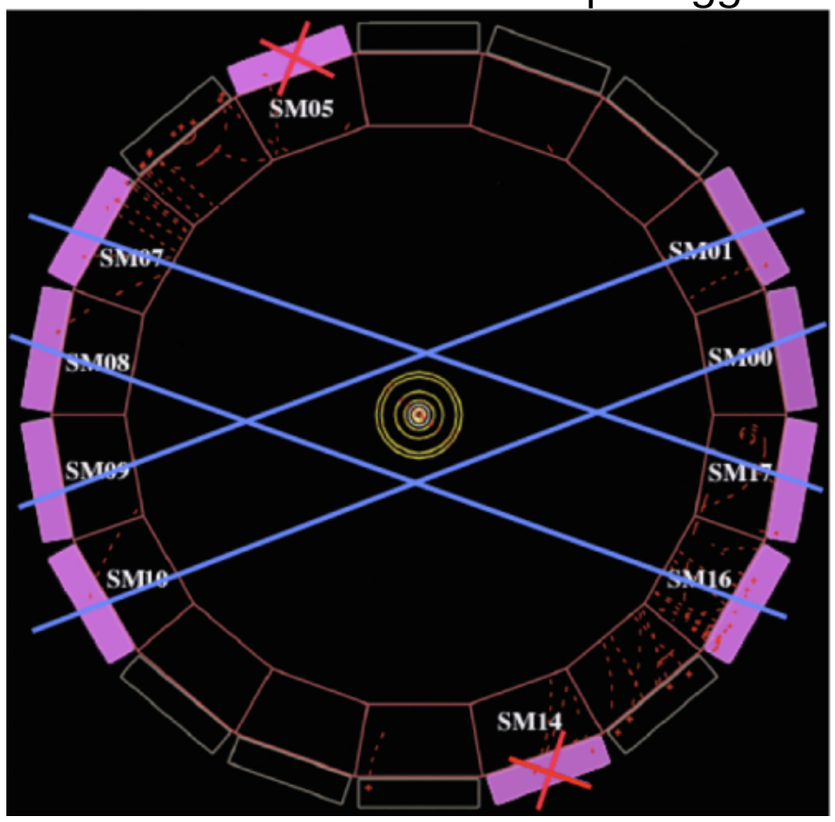
Commissioning

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

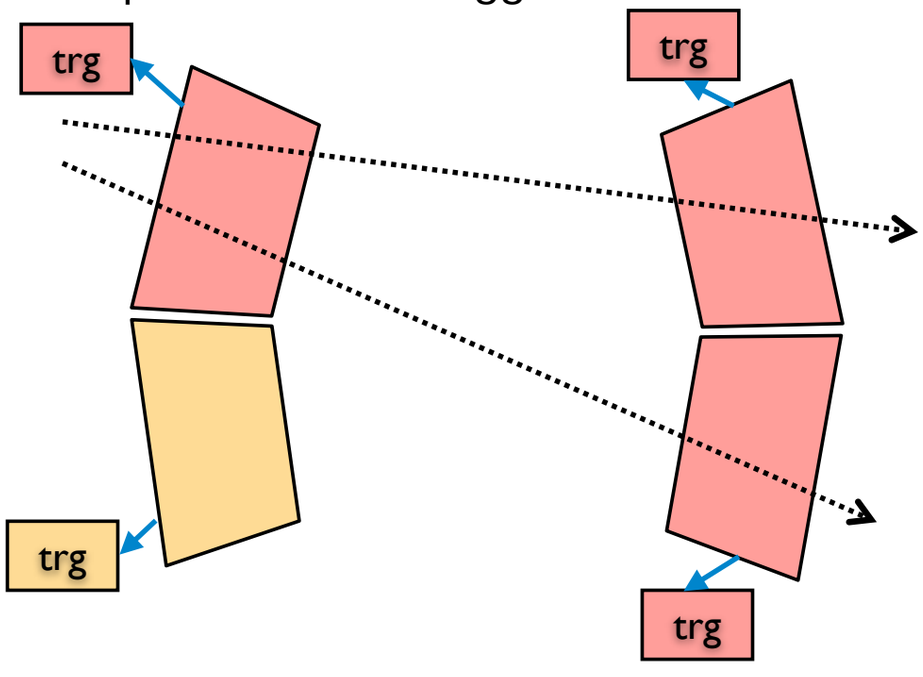
- 4-TRD super modules participated
  (total $\Delta\phi = 80^\circ$)
- combined running with other detectors
- TOF pretrigger
  - coincidence of two opposite modules
- GTU L1 trigger
  - 4 tracklets in one stack
  - single super module and one-to-many correlations between super modules
  - L1/L0 ~ 1/20,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

TRD ready for beam in September 2008

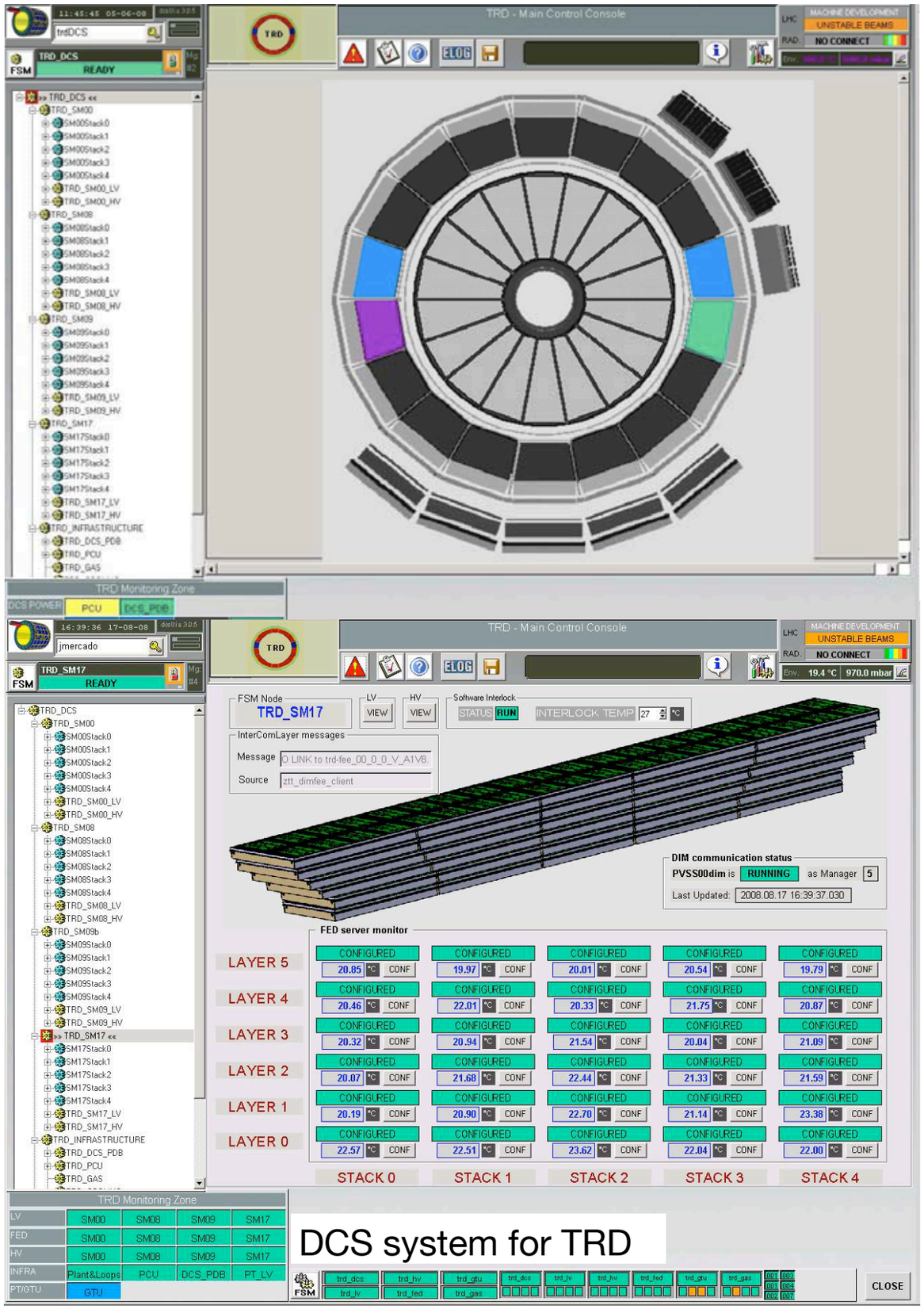
Coincidence condition for pretrigger



Top level GTU L1 trigger condition



Detector Control System



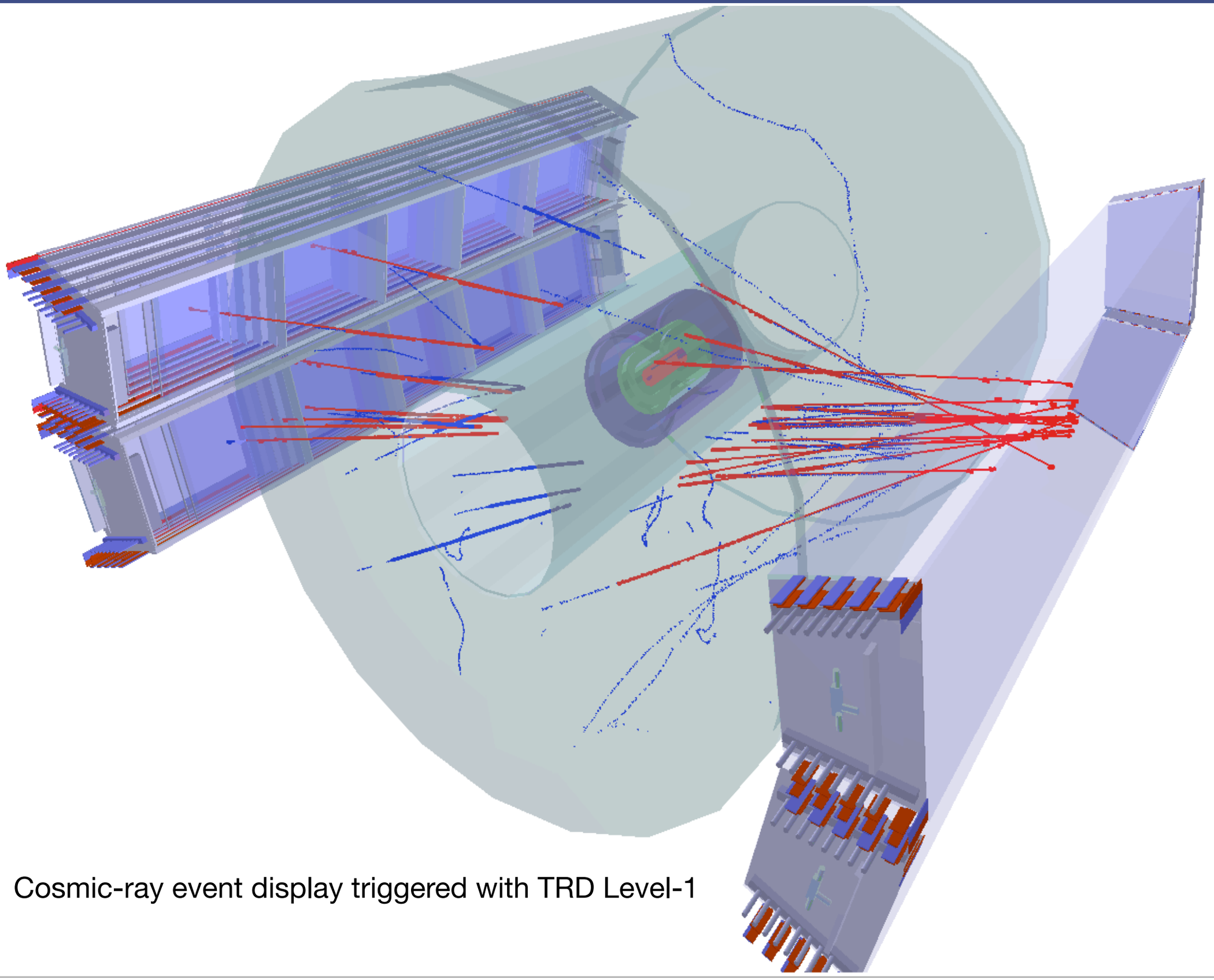
- User friendly detector control system based on PVSS-II

- Ensure safe/stable detector operation and monitoring:
  - 90 low voltage 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 (combined shift with other detectors)

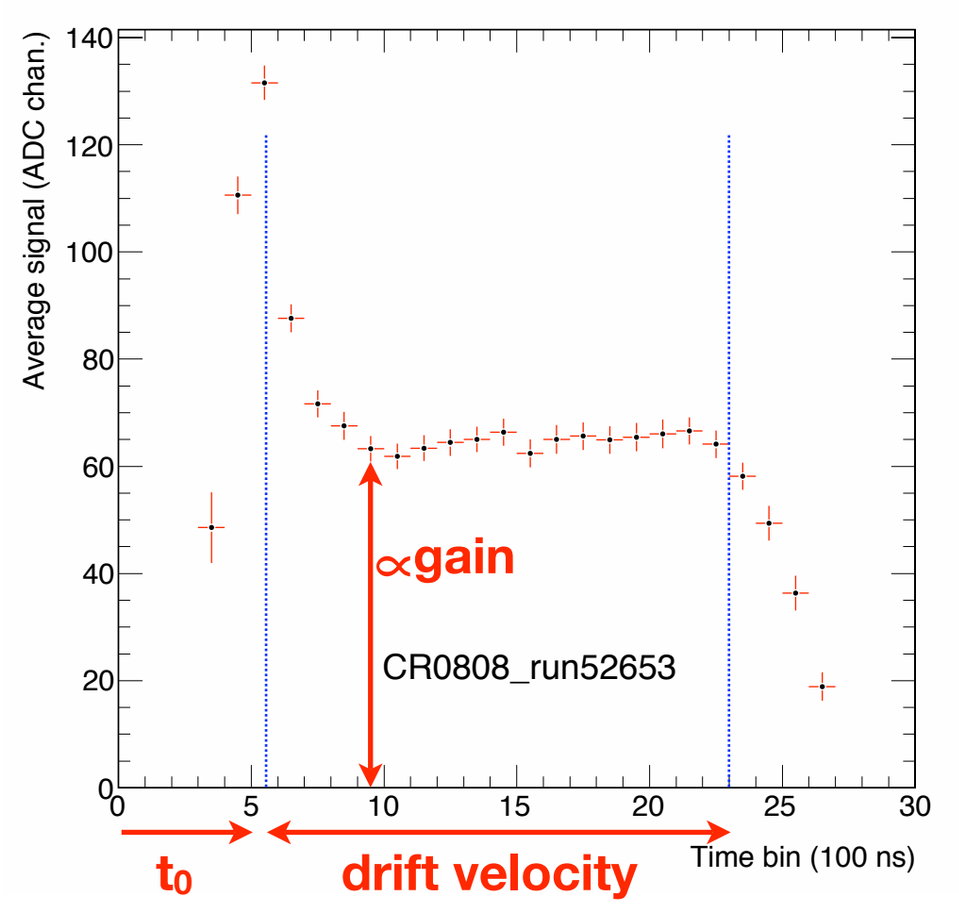
Cosmic Event Triggered

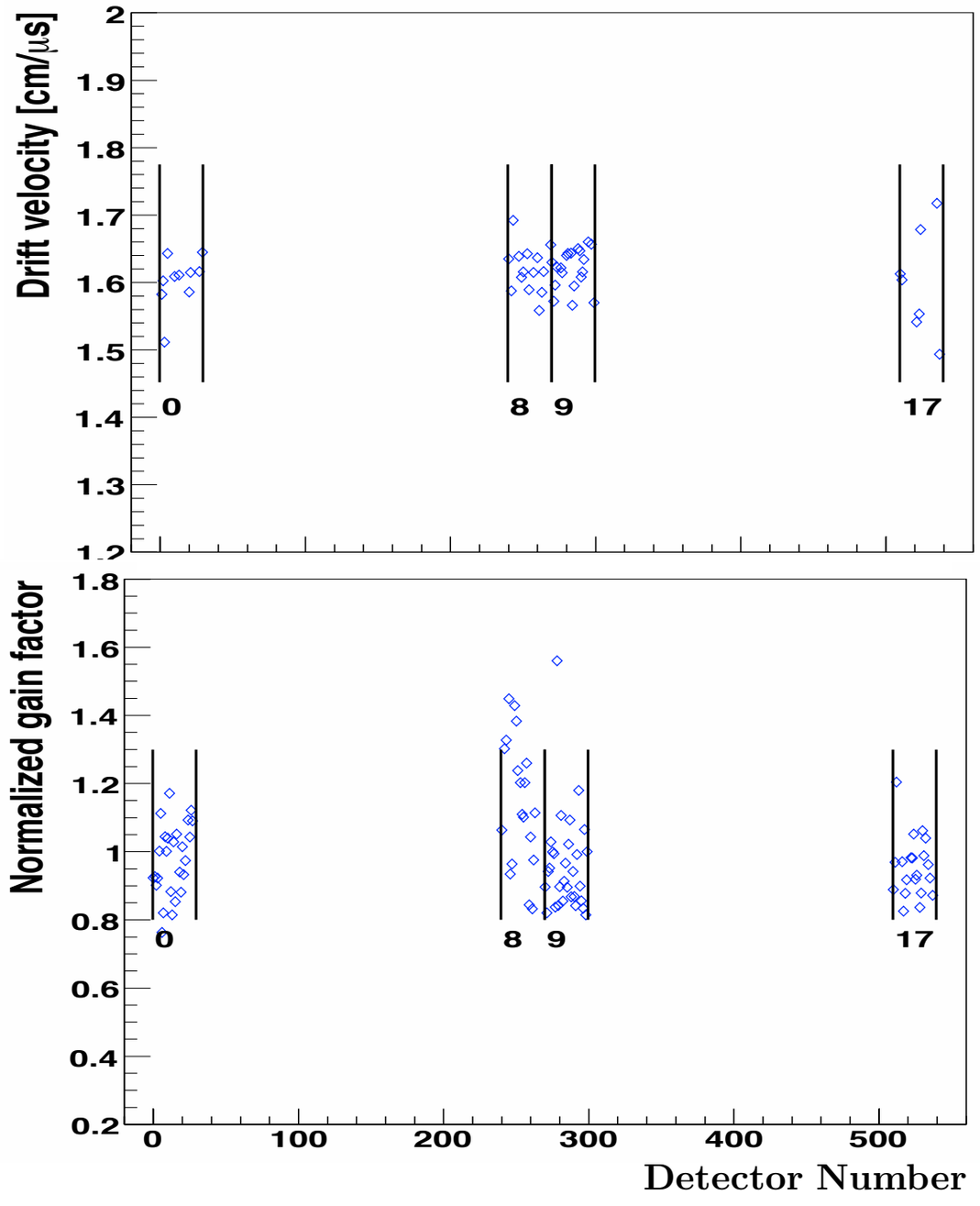


Cosmic-ray event display triggered with TRD Level-1

Calibration

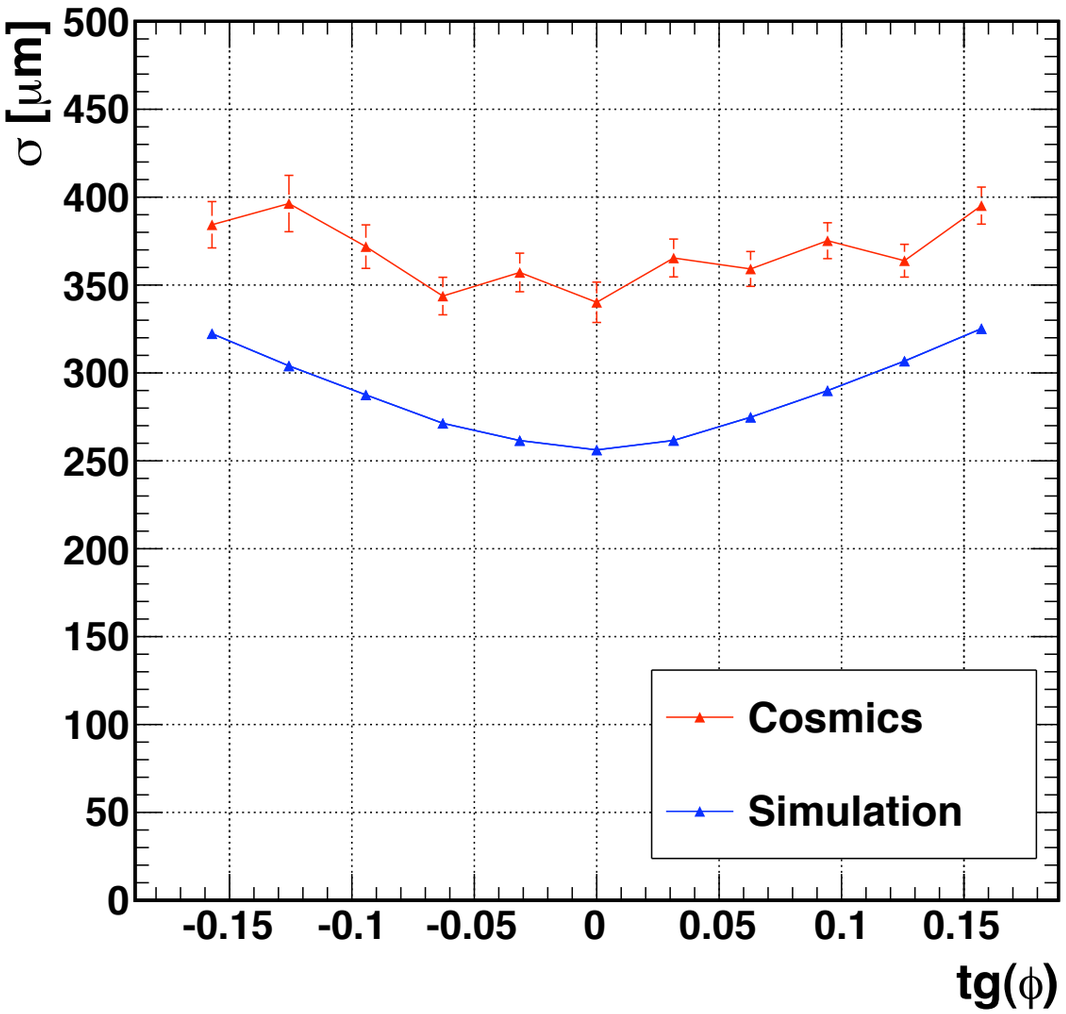
	nominal conditions	cosmic run
gas	Xe, CO_2 (15%)	Ar, CO_2 (18%)
U_a (V)	1550	1450
U_d (V)	-2100	-1200
v_d (cm/μs)	1.5	1.61





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

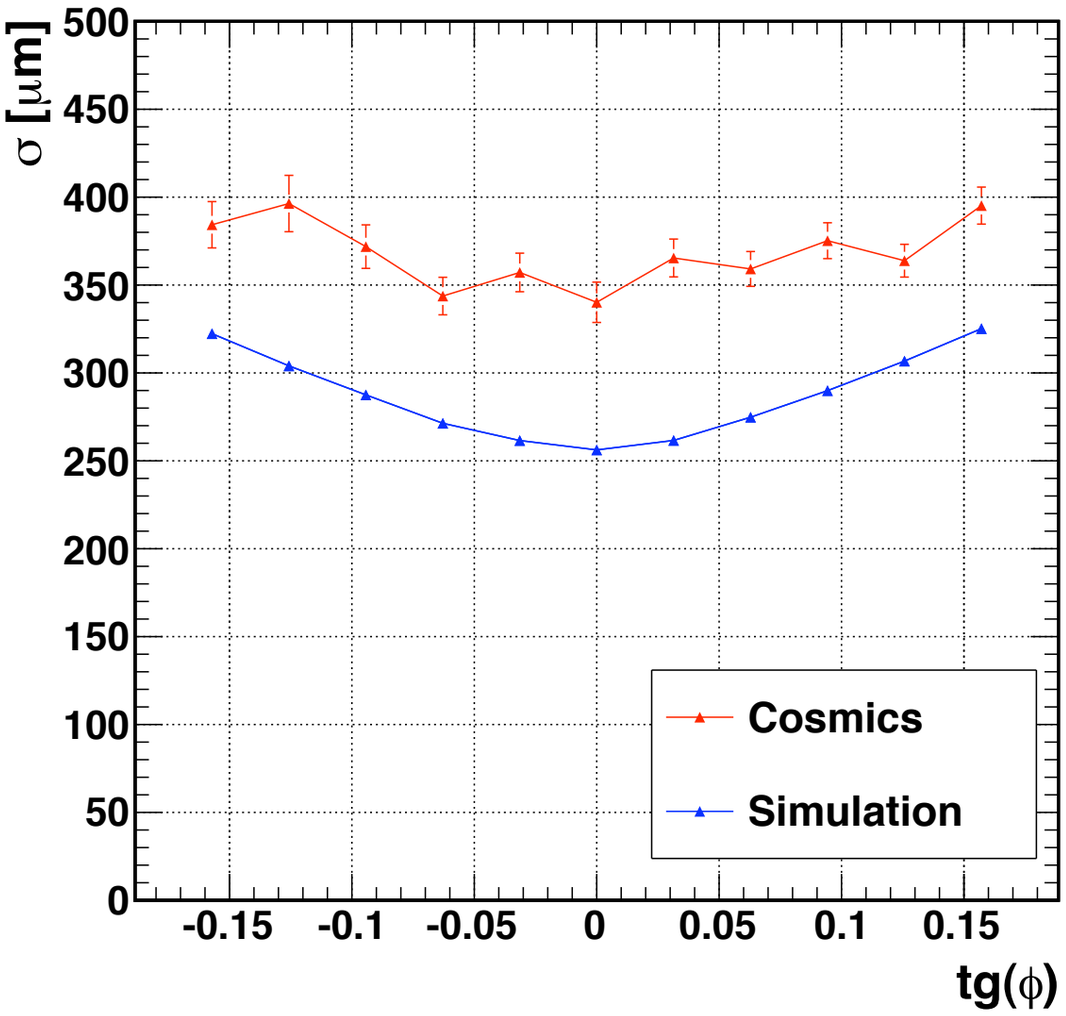
Tracking Performance



(tg(ϕ)=0.15, where ϕ ~ 8.5°)

- $r\phi$ directional position resolution ≈ 350 μm at 0° incident angle
- position resolution close to design goal

Tracking Performance



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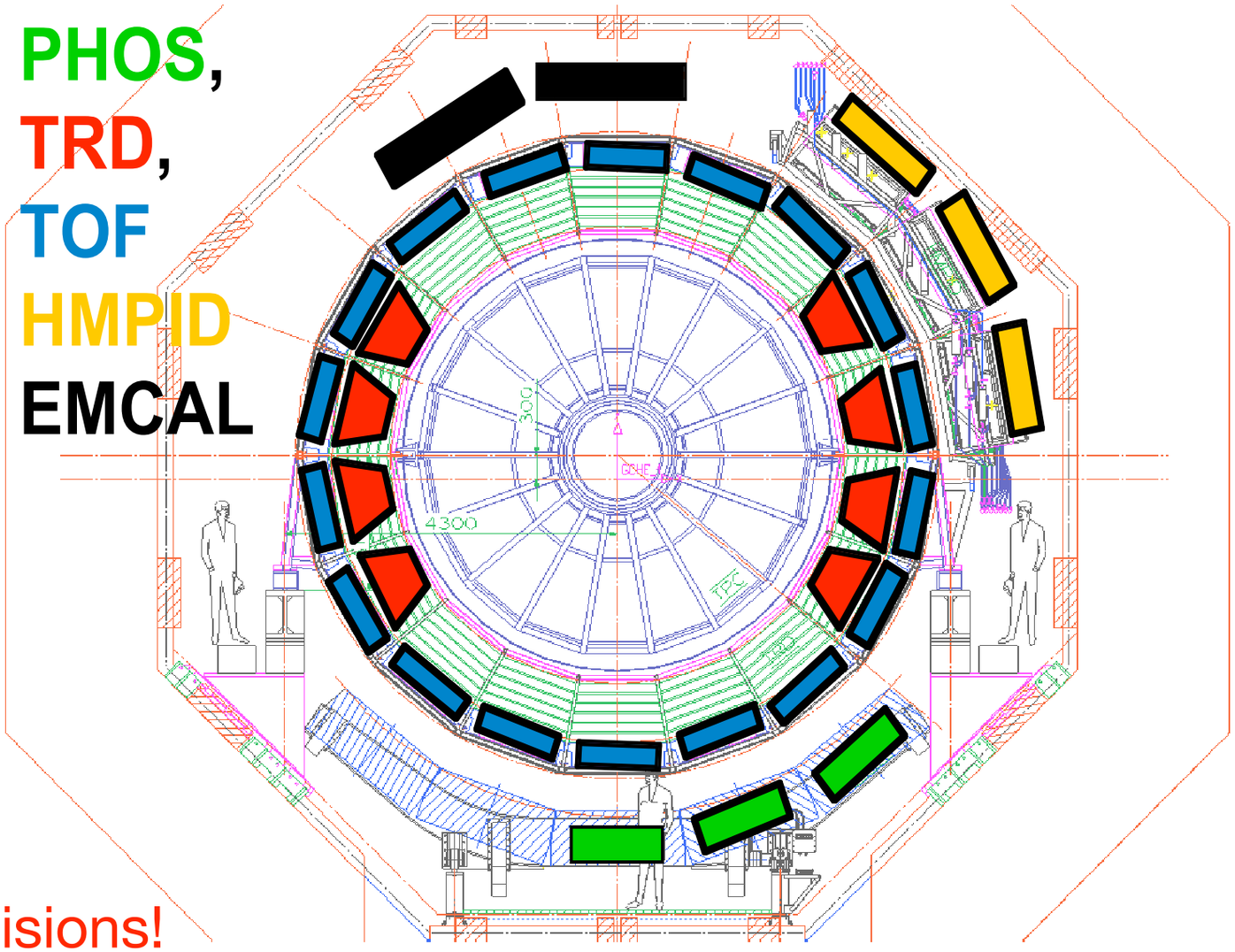
Various analysis on going:

- TPC-TRD track matching resolution
- alignment

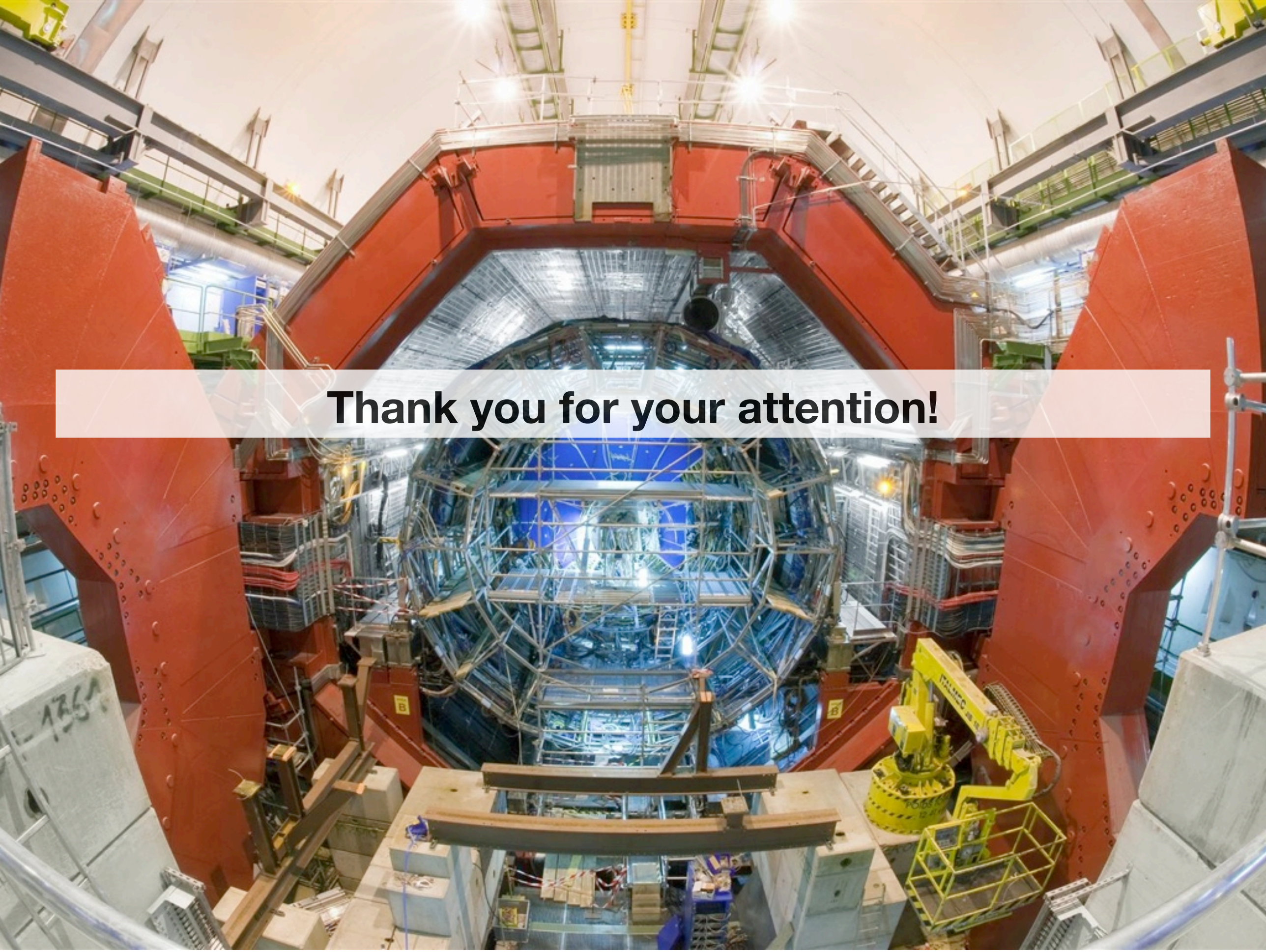
Summary and Outlook

- TRD provides 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 collisions!



Thank you for your attention!

BACKUP - Different version of plots or pictures

The Transition Radiation Detector for ALICE at LHC

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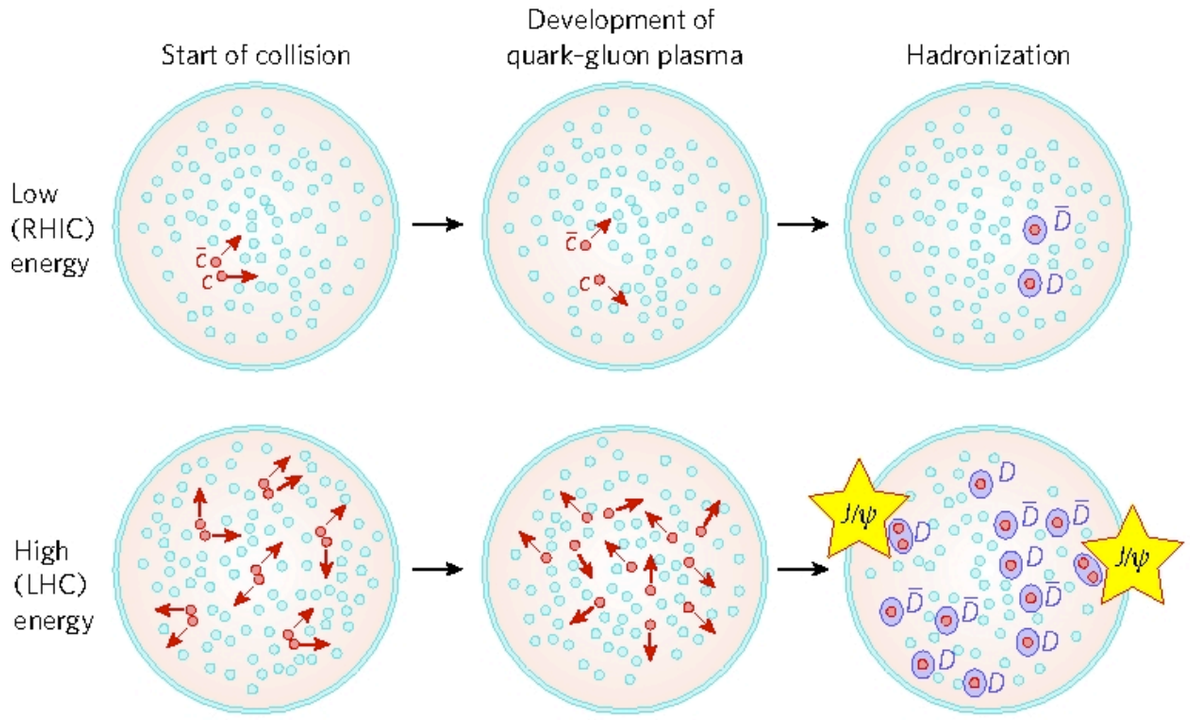
for the ALICE TRD Collaboration
Physikalisches Institut, Universität Heidelberg

Quarkonia Production

J/ψ Suppression

- screening of color charges
- "melting" of *cc*, *bb* bound state
- at SPS, RHIC, LHC

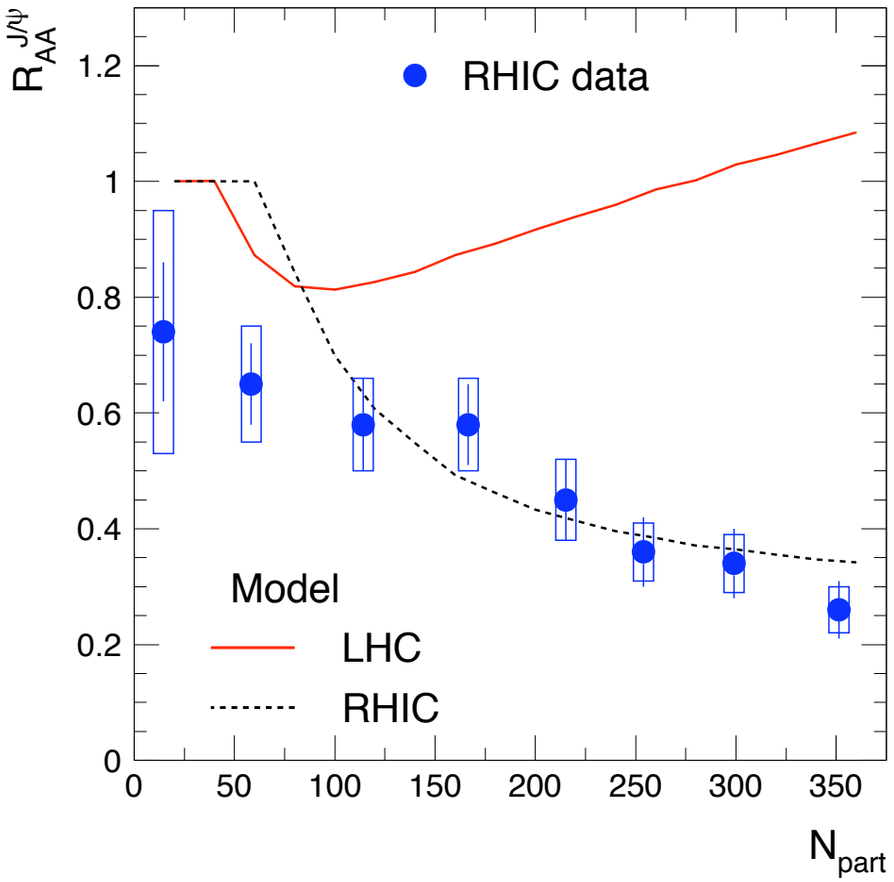


J/ψ Enhancement

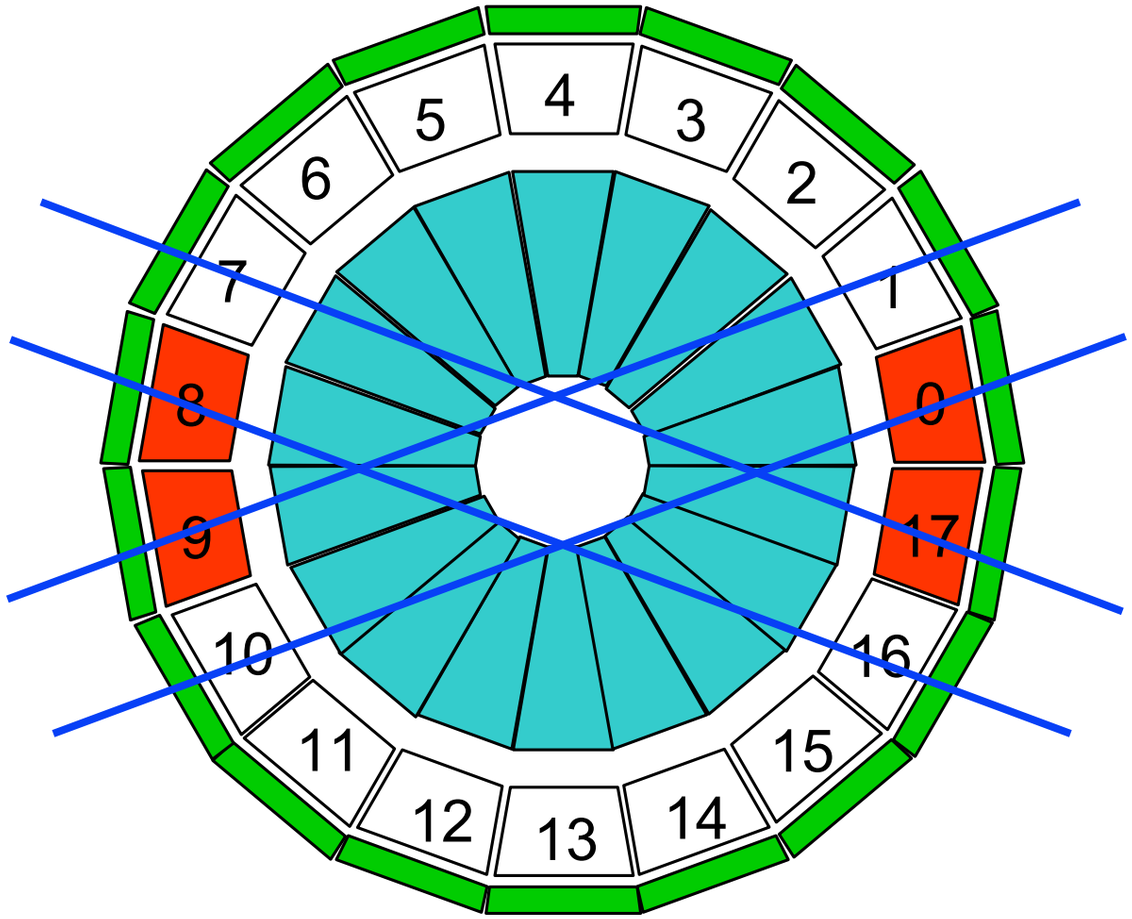
- large abundance of c-quark at LHC
- statistical combination to J/ψ

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

- good electron PID
- large acceptance



- TOF pre-trigger setup



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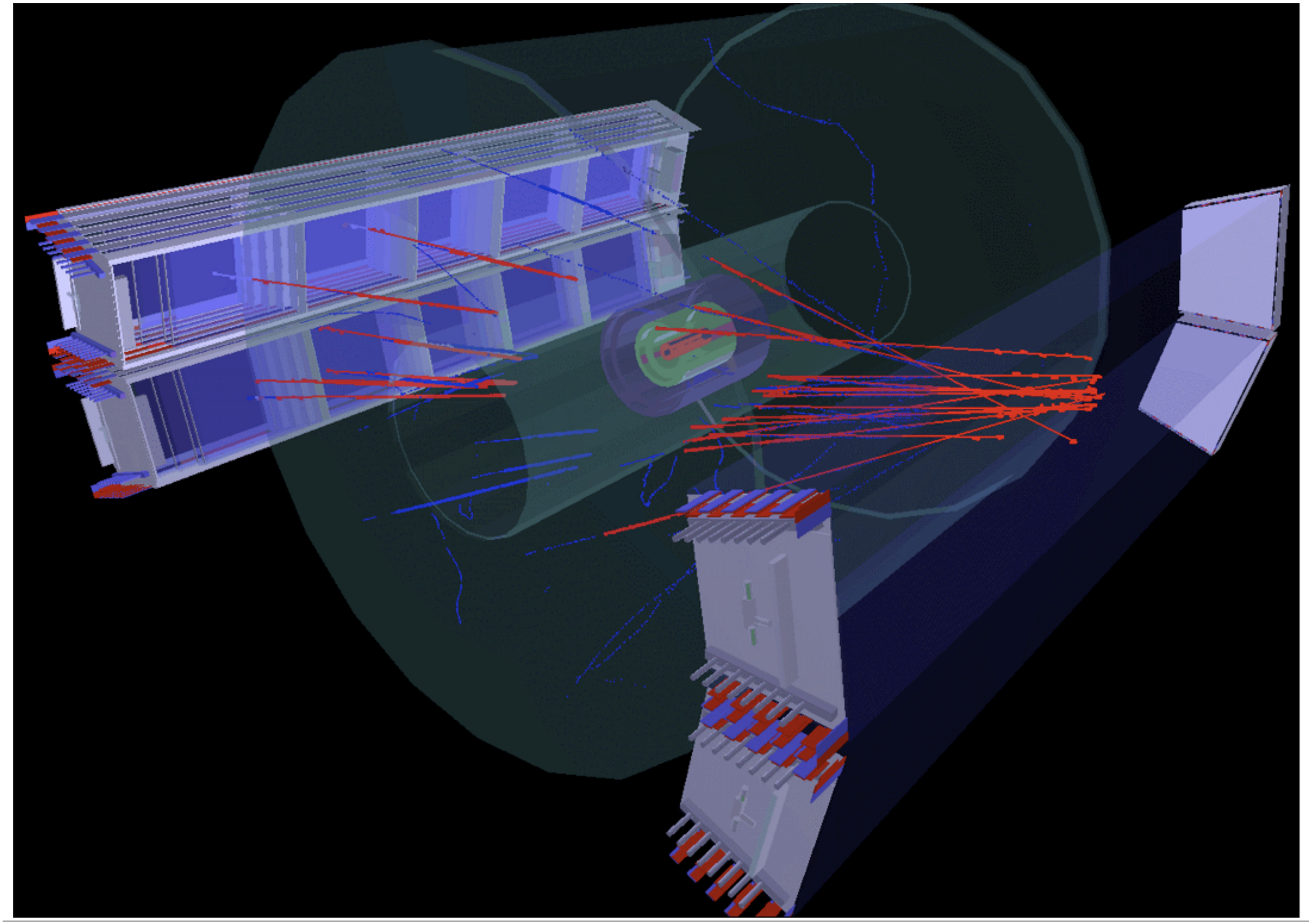

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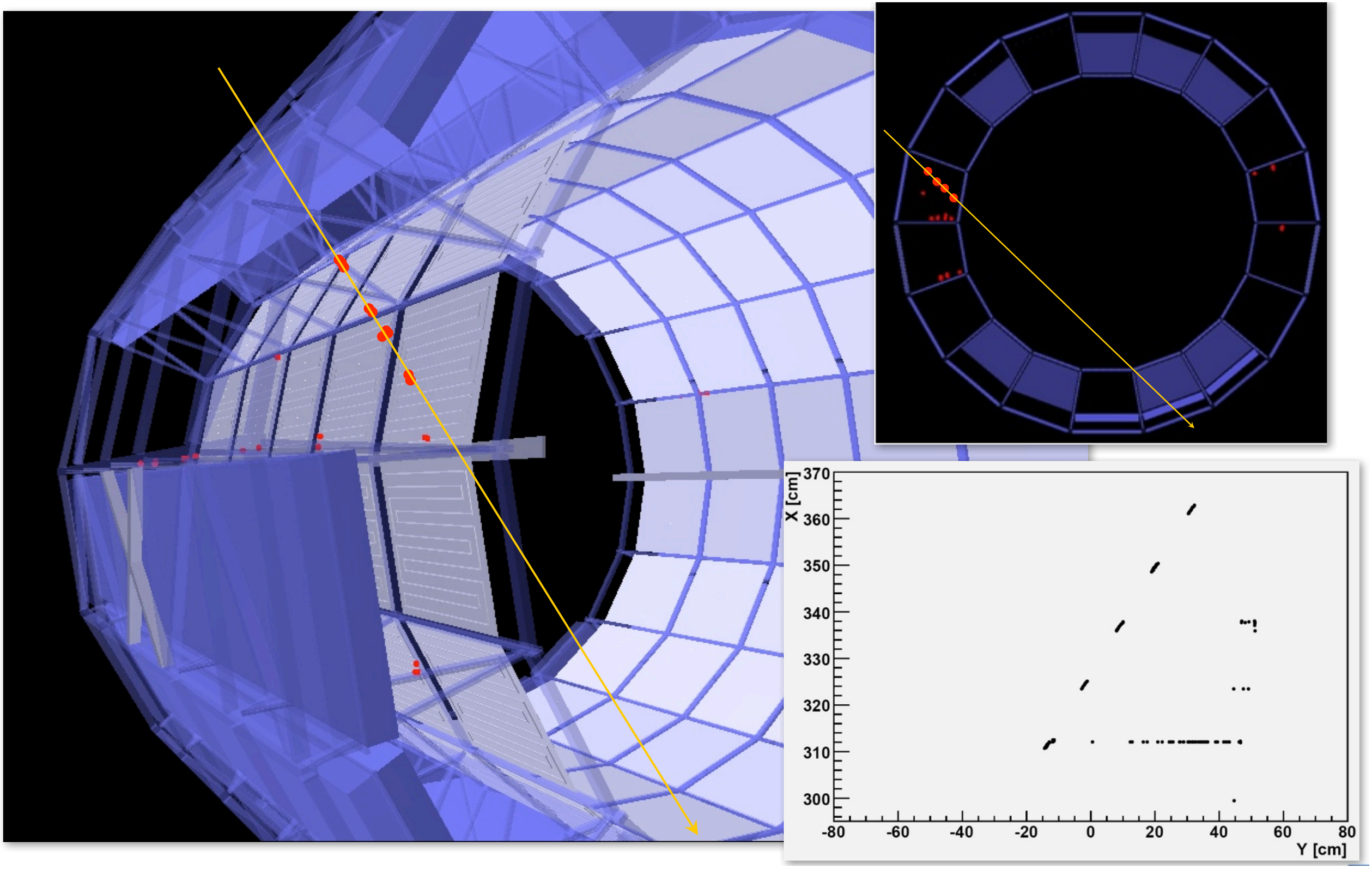


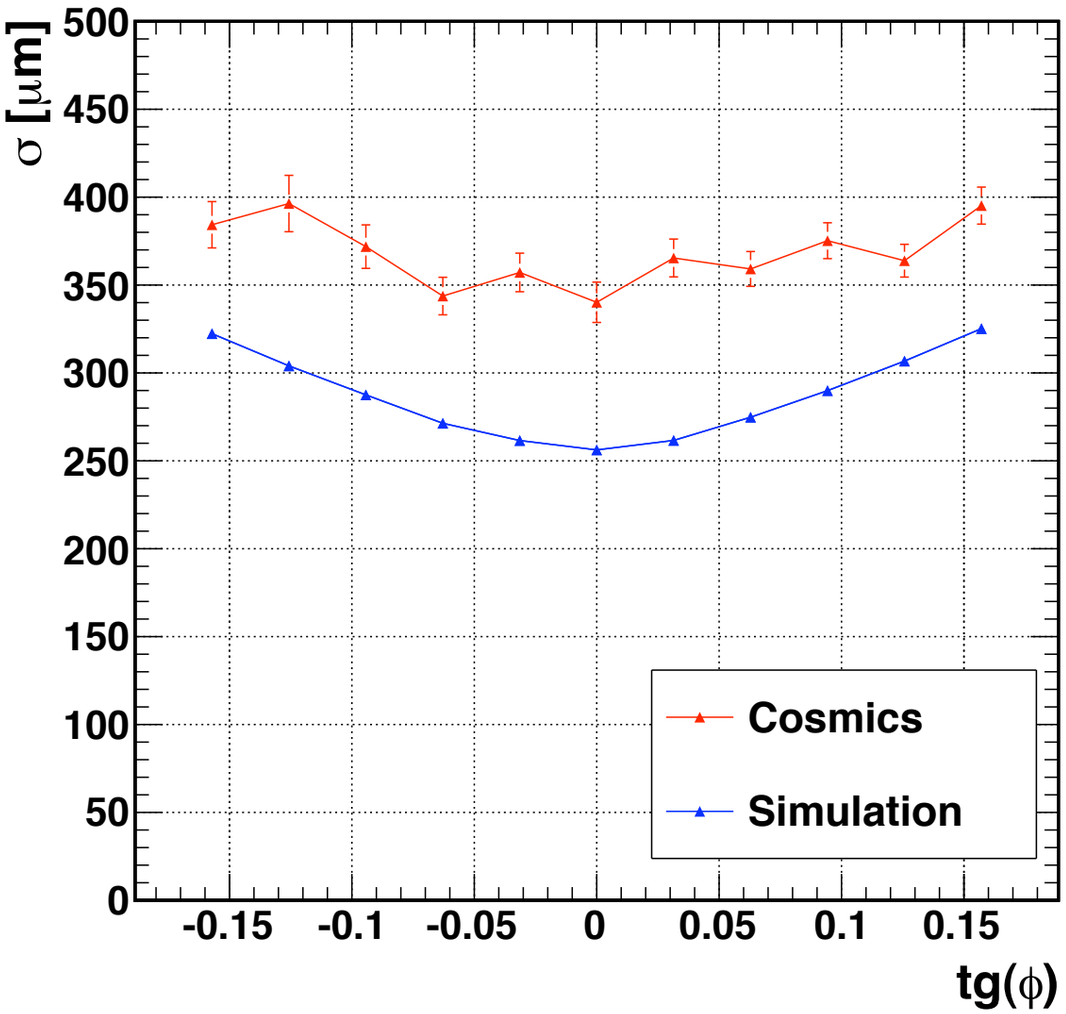
- typical chamber size:

≈ 1.35 x 1.03 m^2

≈ 12 cm thick (incl. radiators and electronics)

- in total 1.16 million read-out channels

Tracking Performance



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