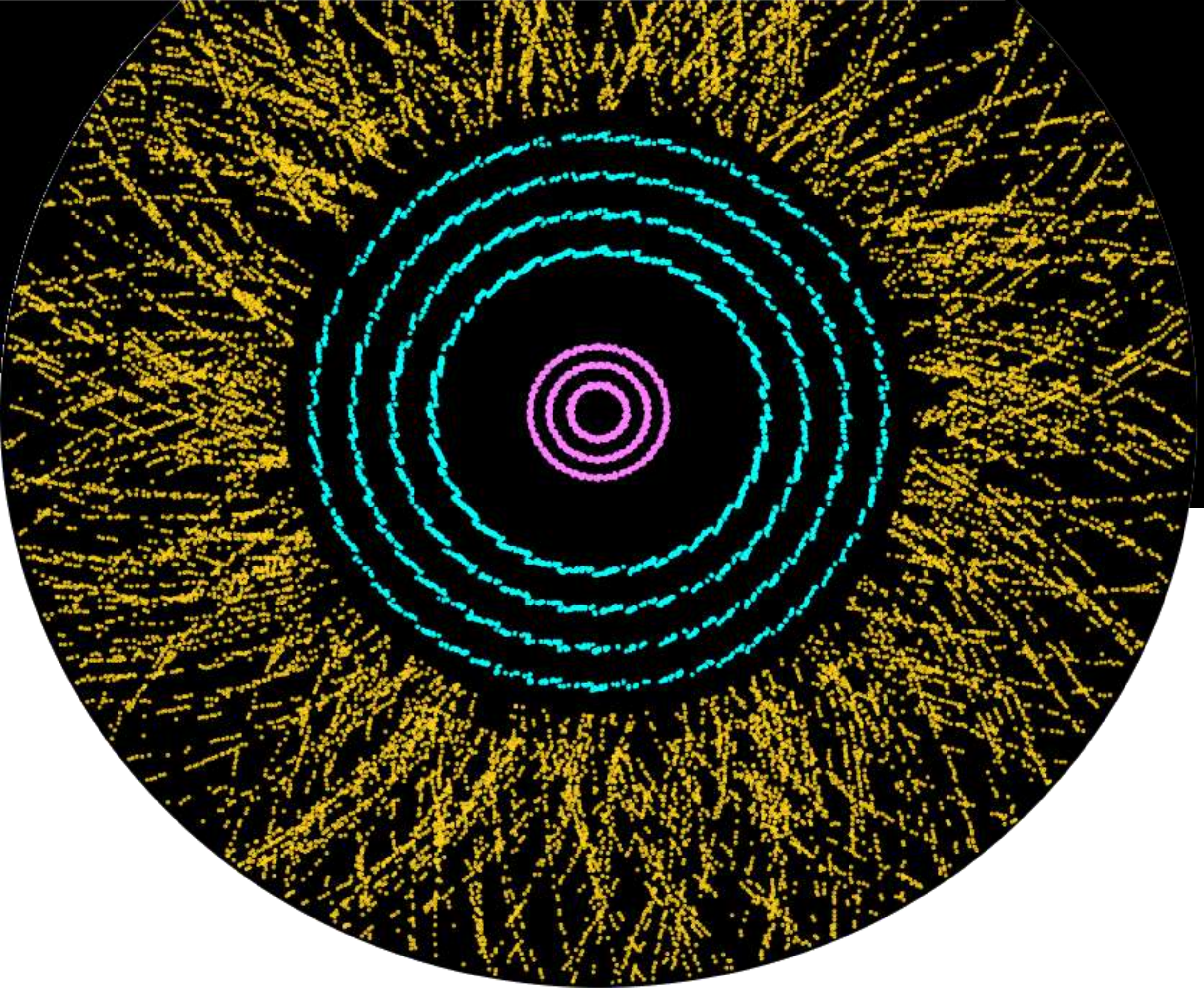
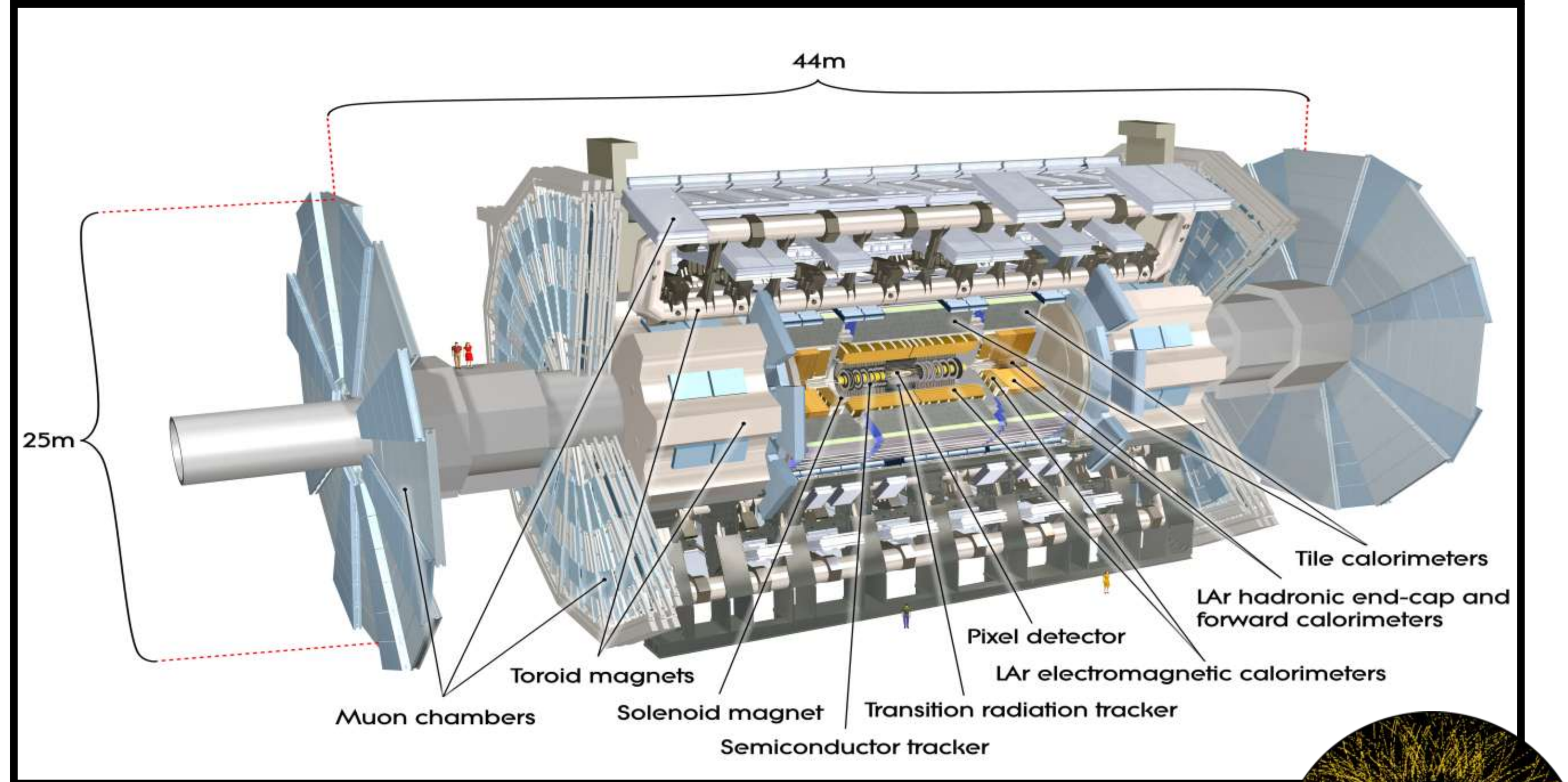
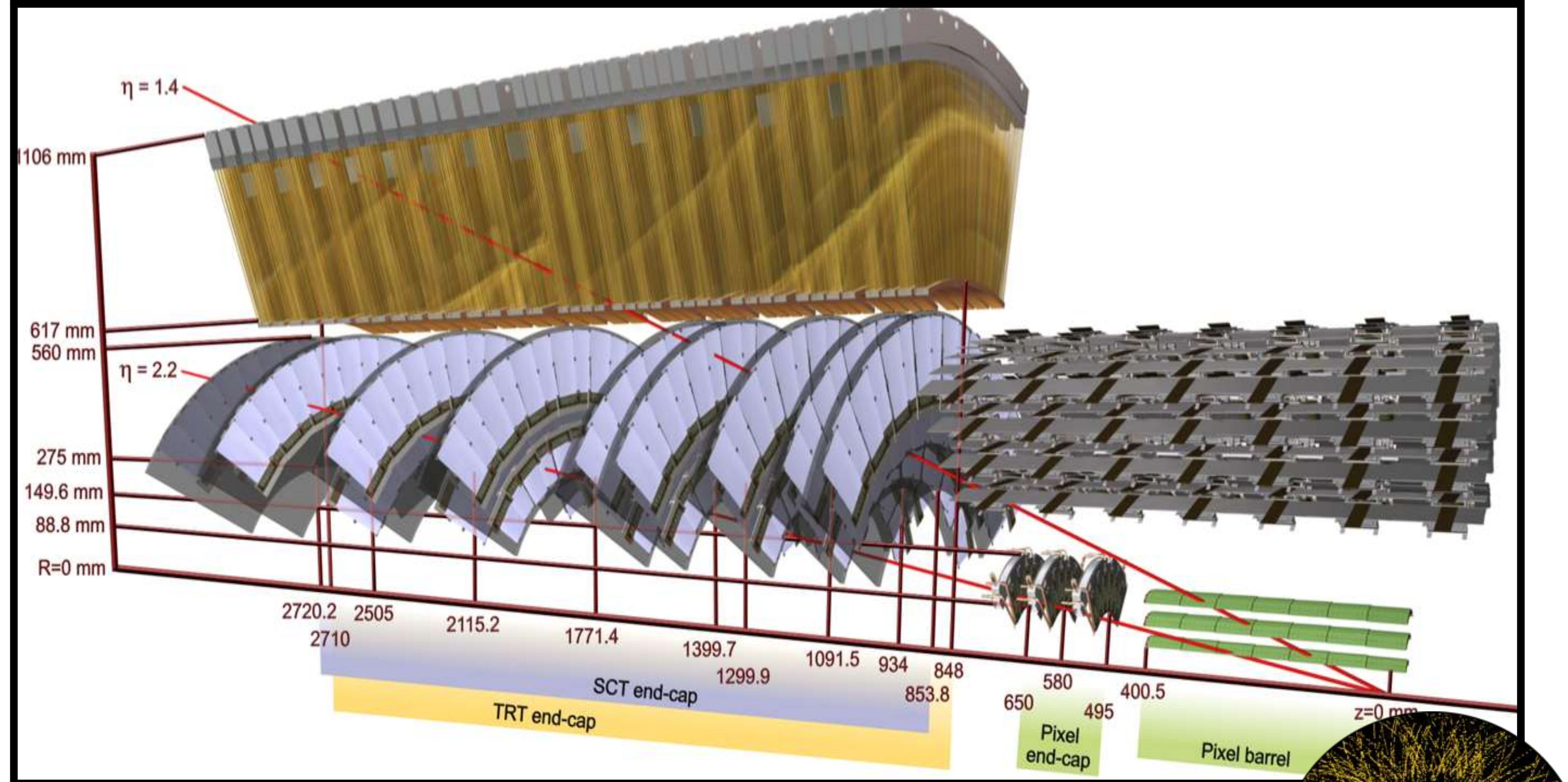


Commissioning and performance of the ATLAS Transition Radiation Tracker with first high energy pp and Pb-Pb collisions at LHC

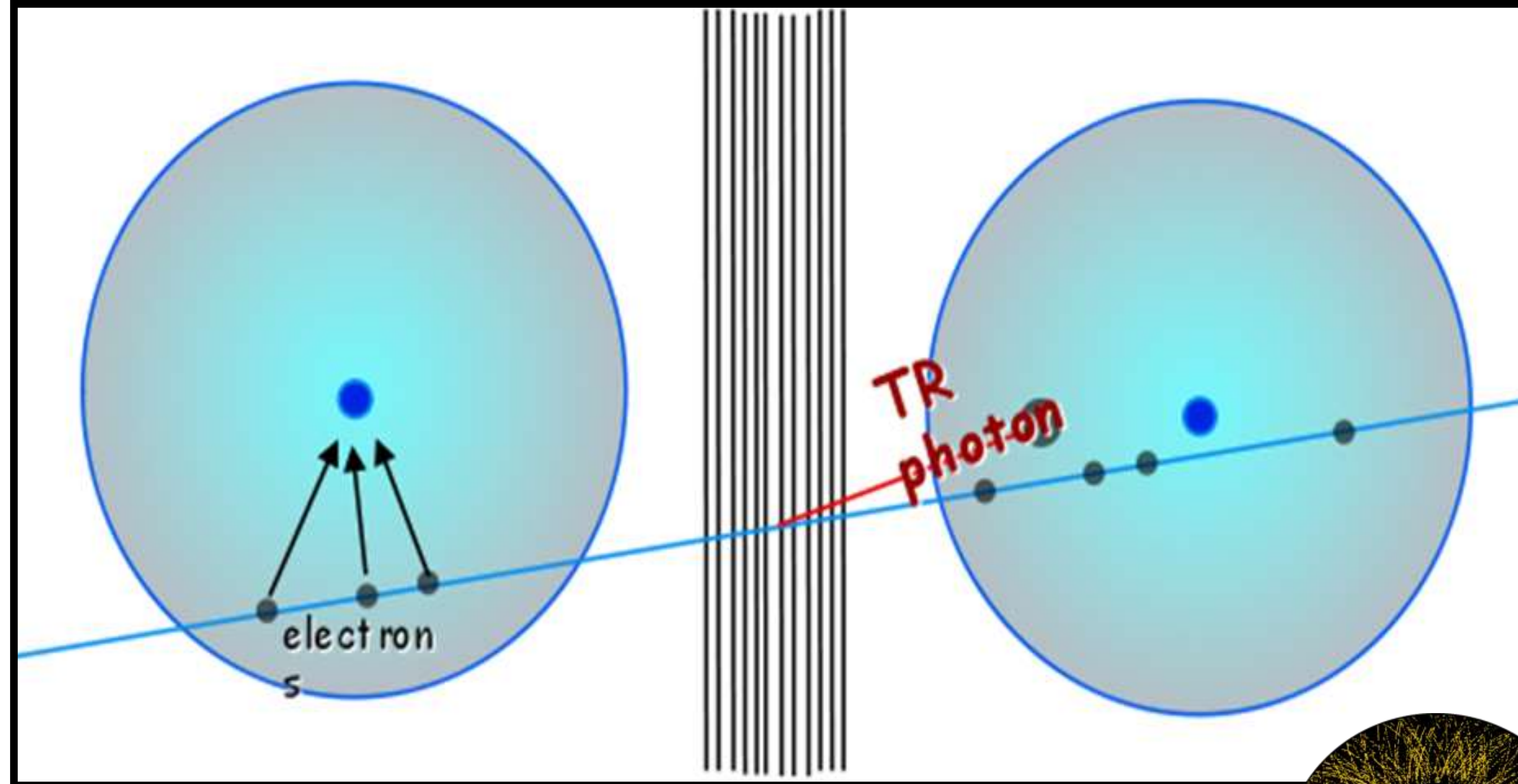
Introduction



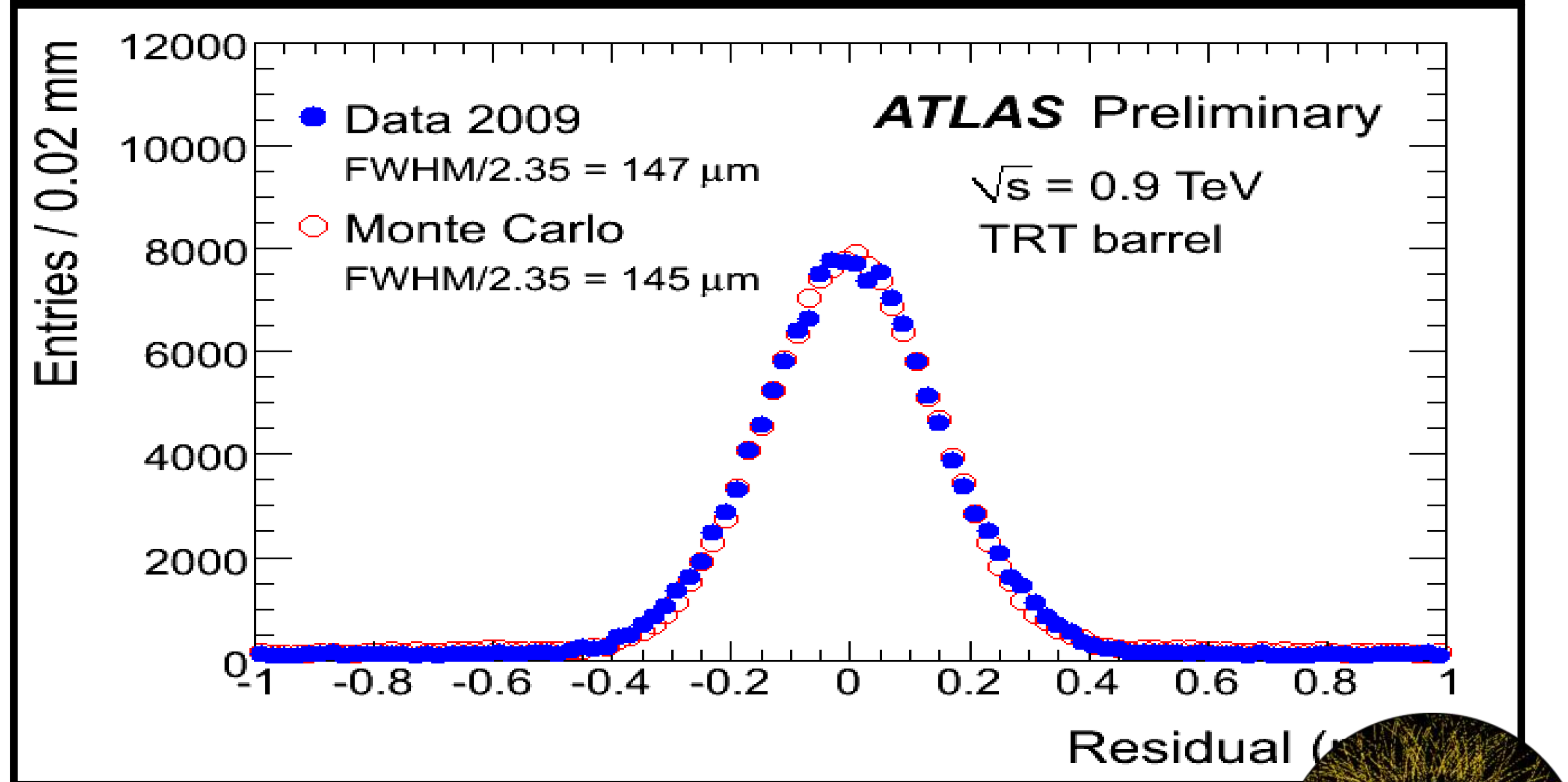
The ATLAS TRT



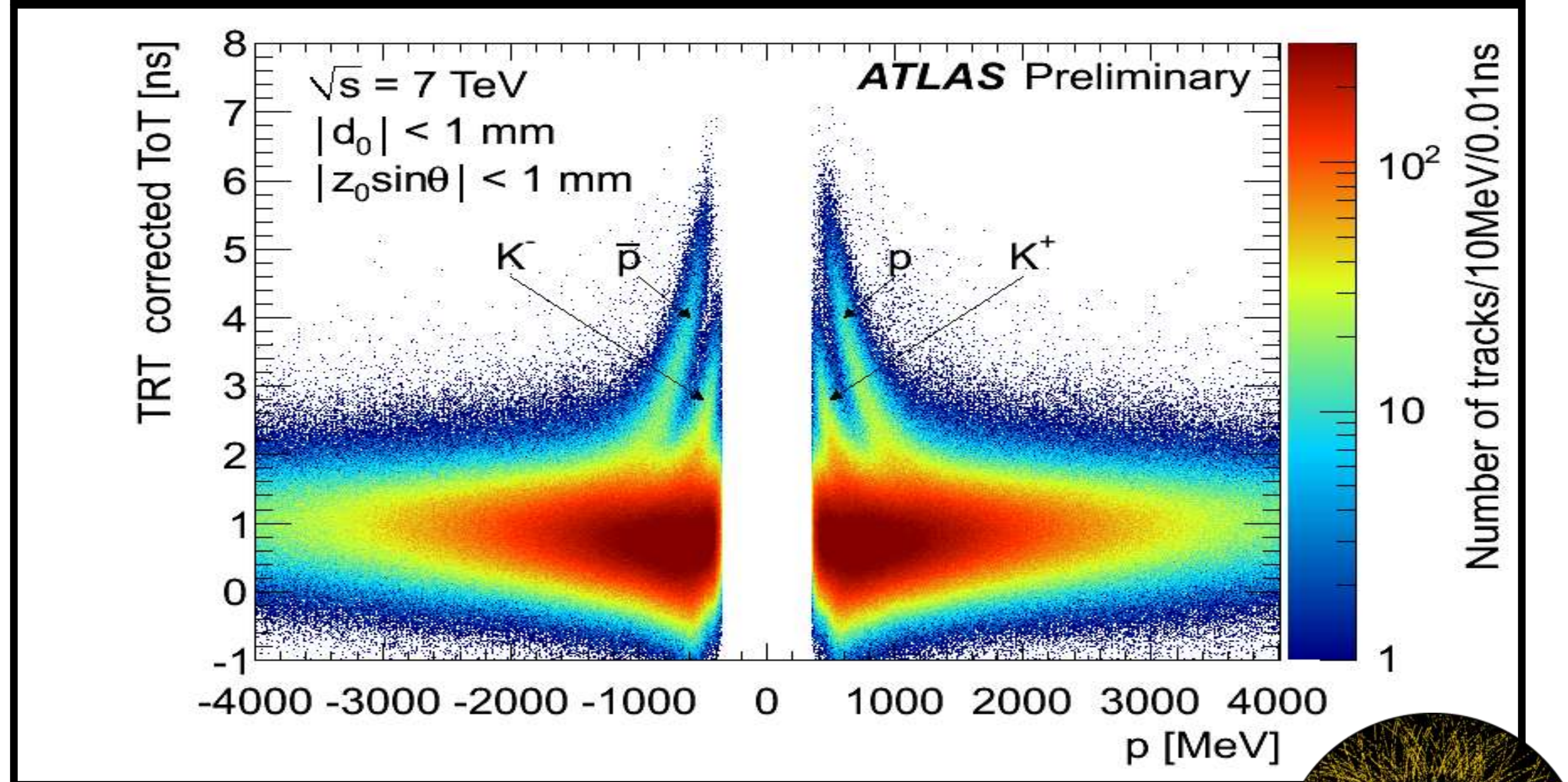
How the TRT works



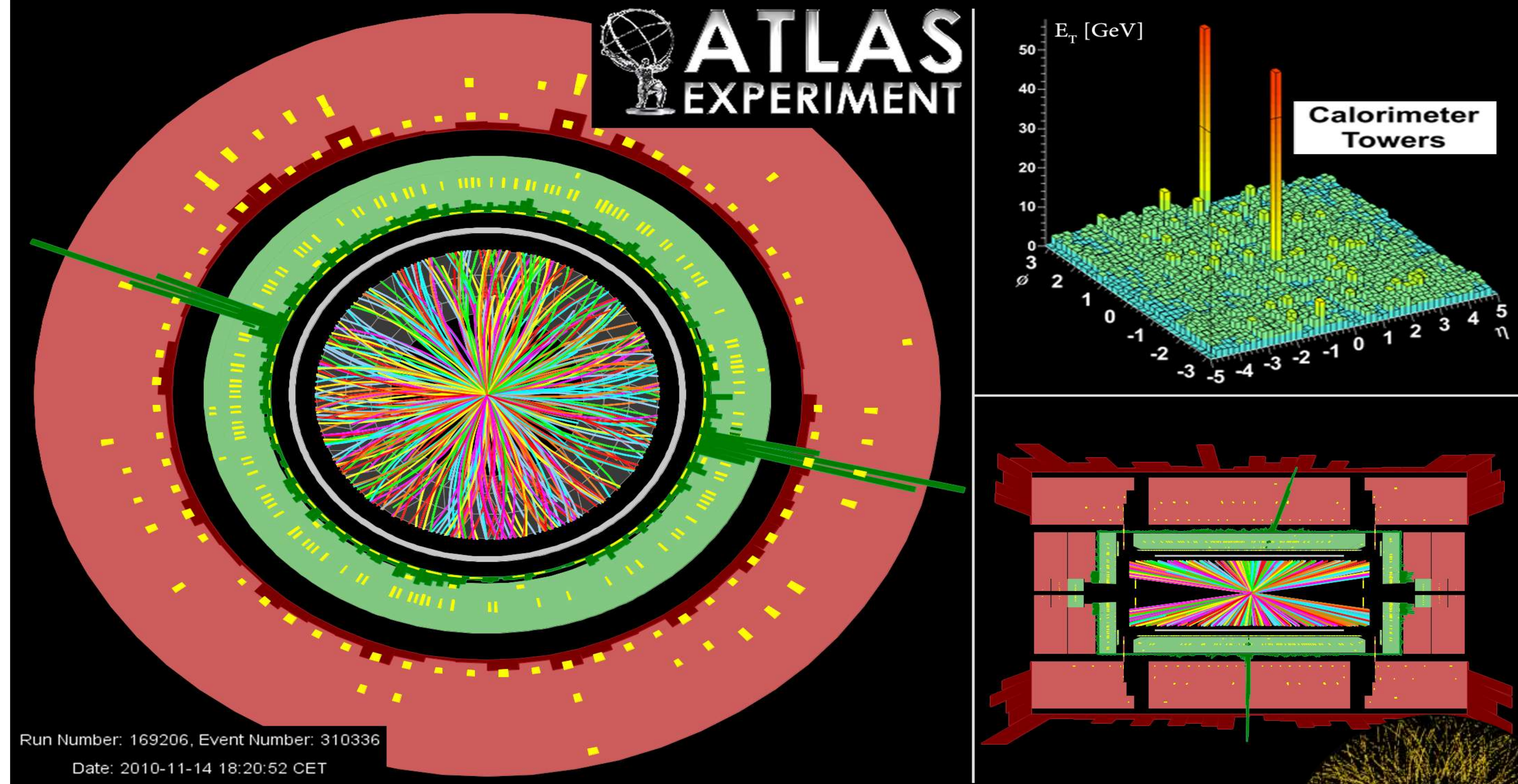
TRT performance



Particle ID

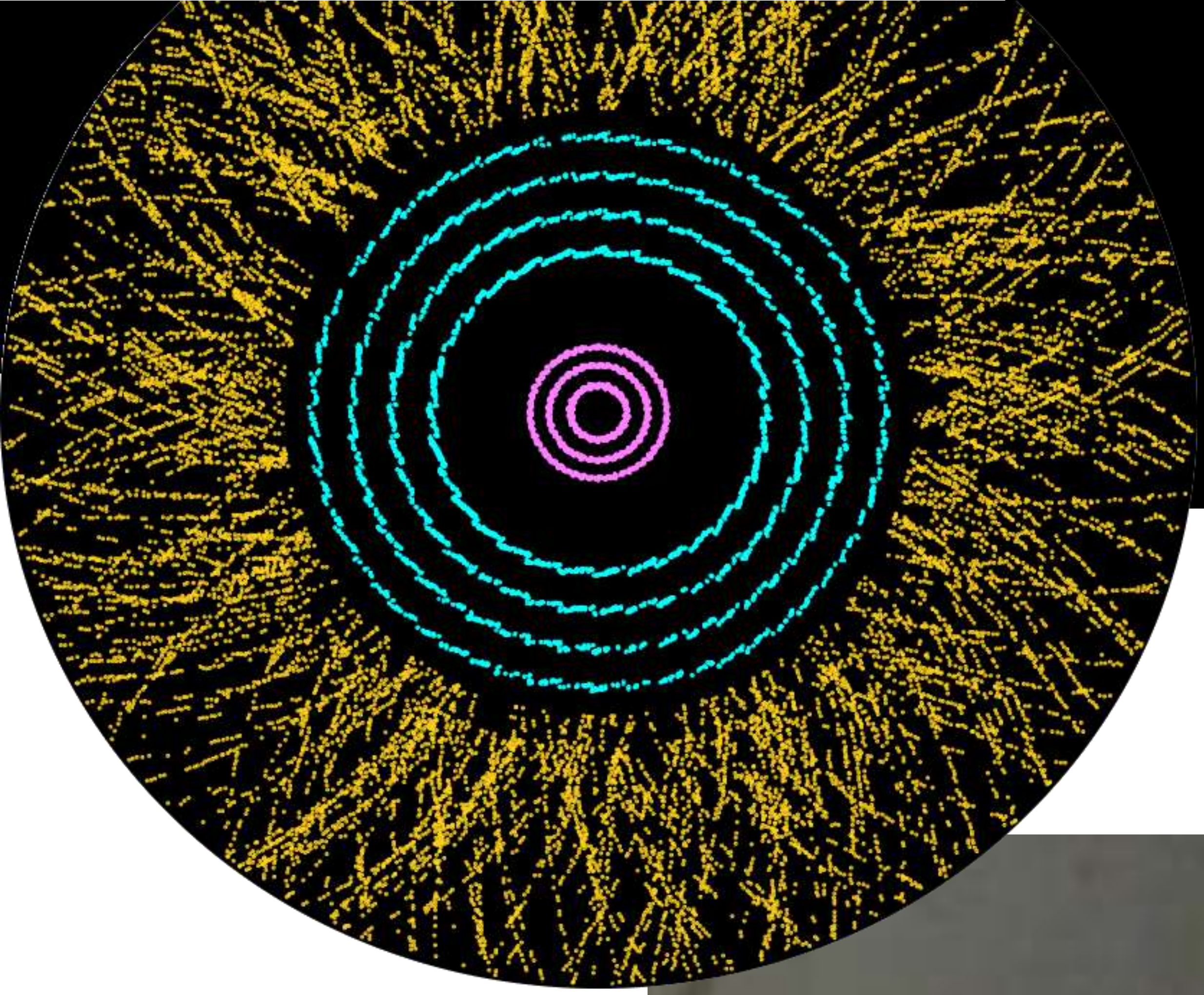


Heavy Ion running



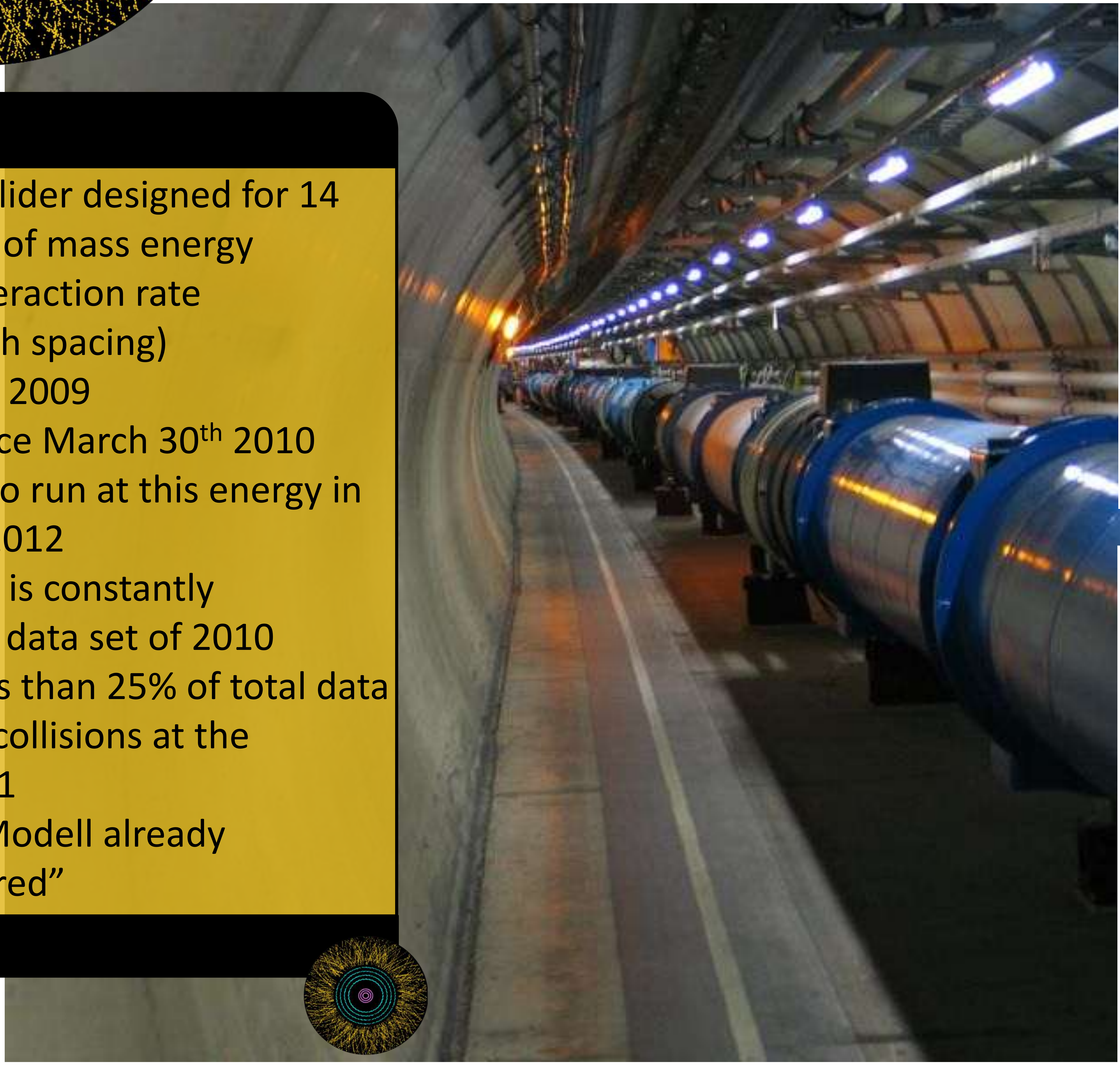
ANIMMA 2011, Ghent

Steffen Schaepe, for the ATLAS collaboration

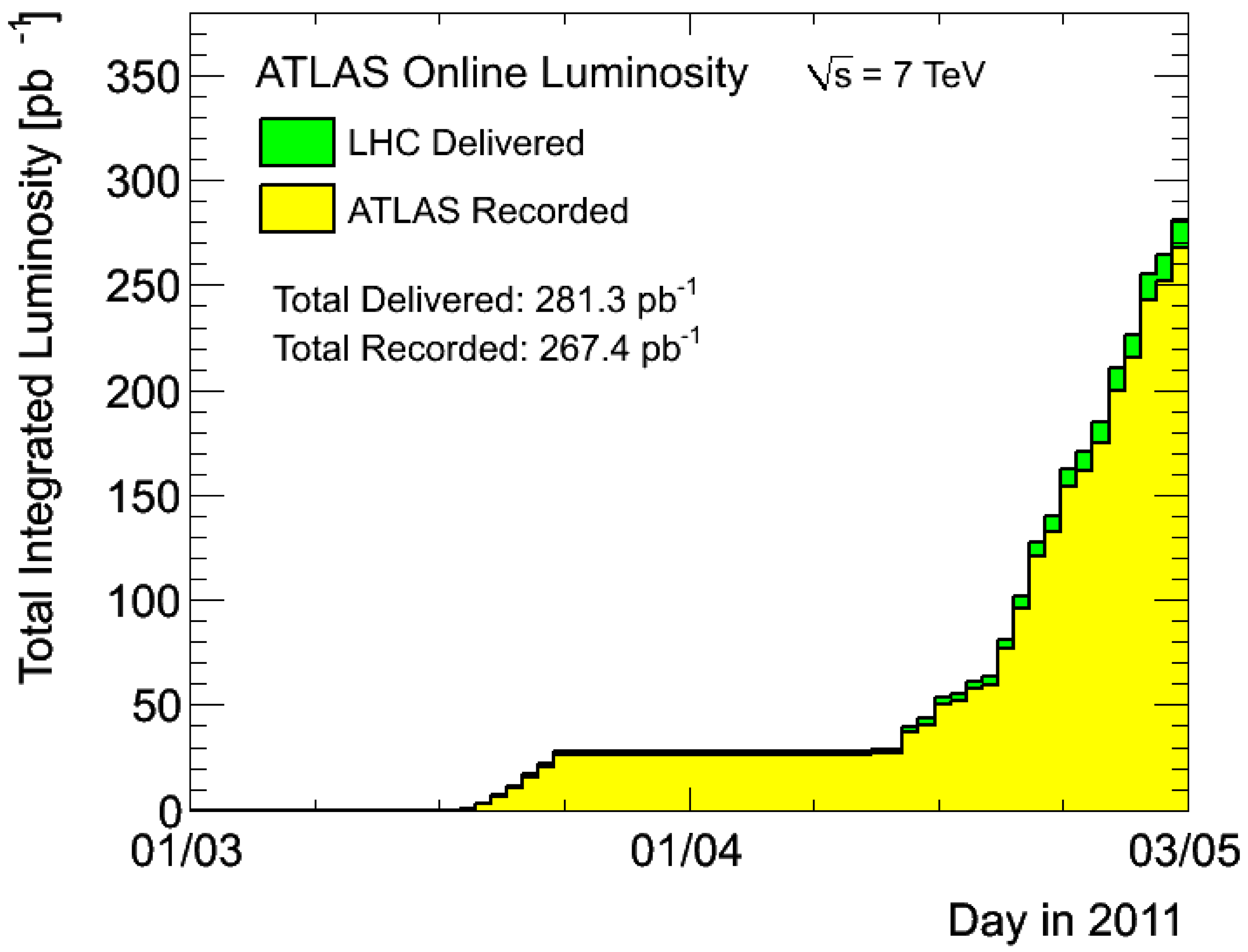


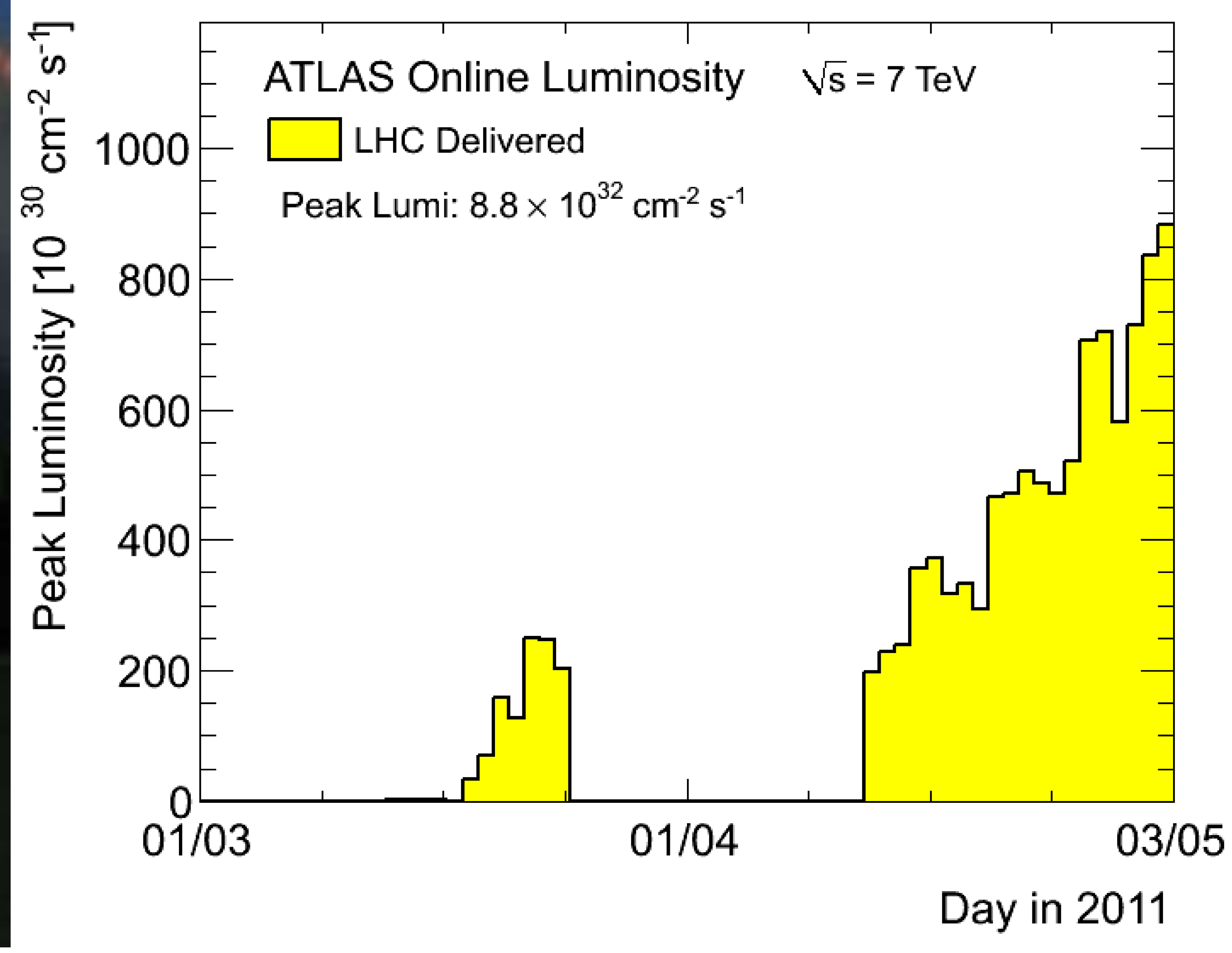
Commissioning and performance of the ATLAS Transition Radiation Tracker with first high energy pp and Pb-Pb collisions at LHC

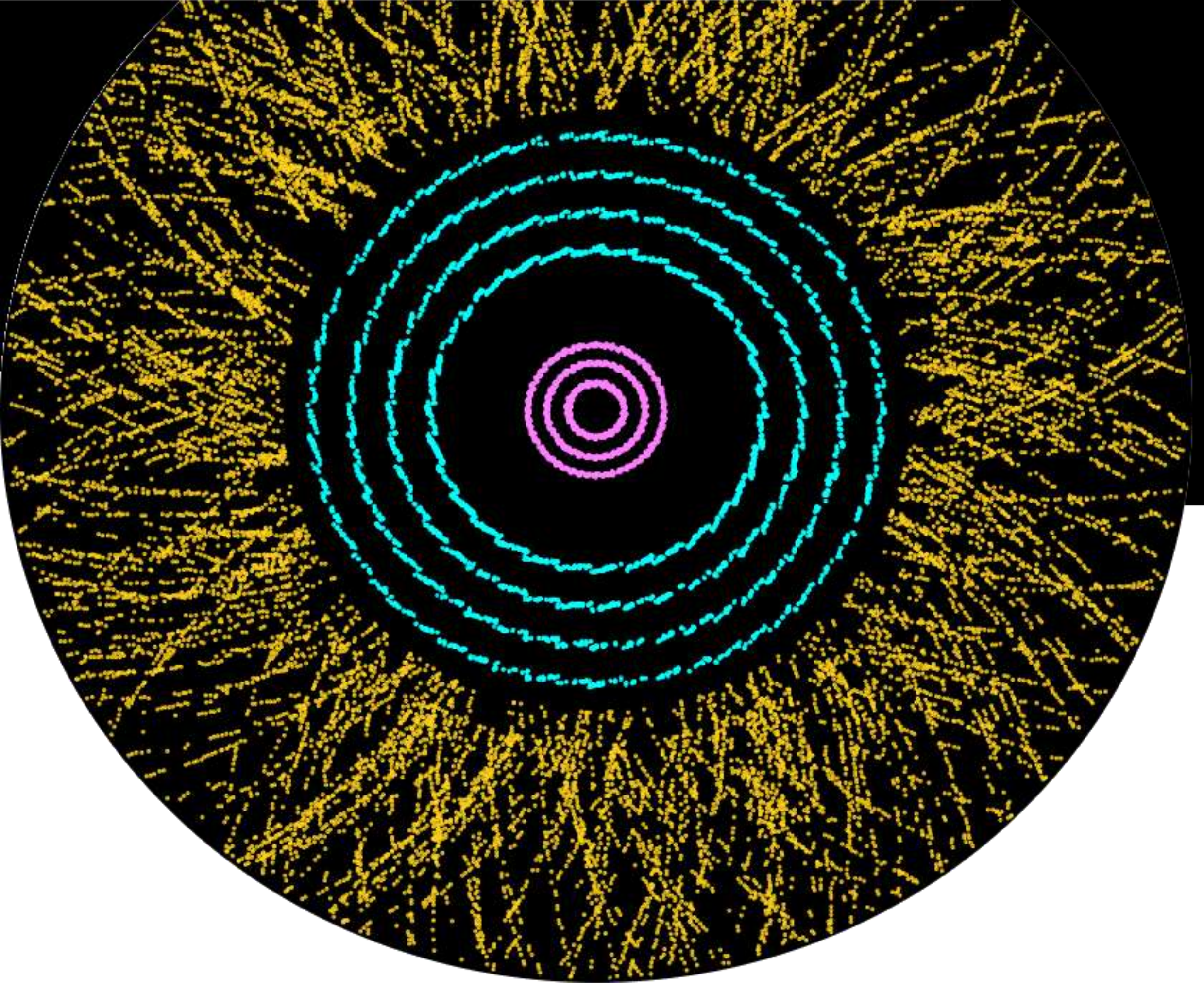
The LHC status



- Hadron collider designed for 14 TeV center of mass energy
- 40MHz interaction rate (25ns bunch spacing)
- 900 GeV in 2009
- 3.5 TeV since March 30th 2010
- Projected to run at this energy in 2011 and 2012
- Luminosity is constantly increasing: data set of 2010 already less than 25% of total data
- Heavy Ion collisions at the end of 2011
- Standard Modell already "rediscovered"

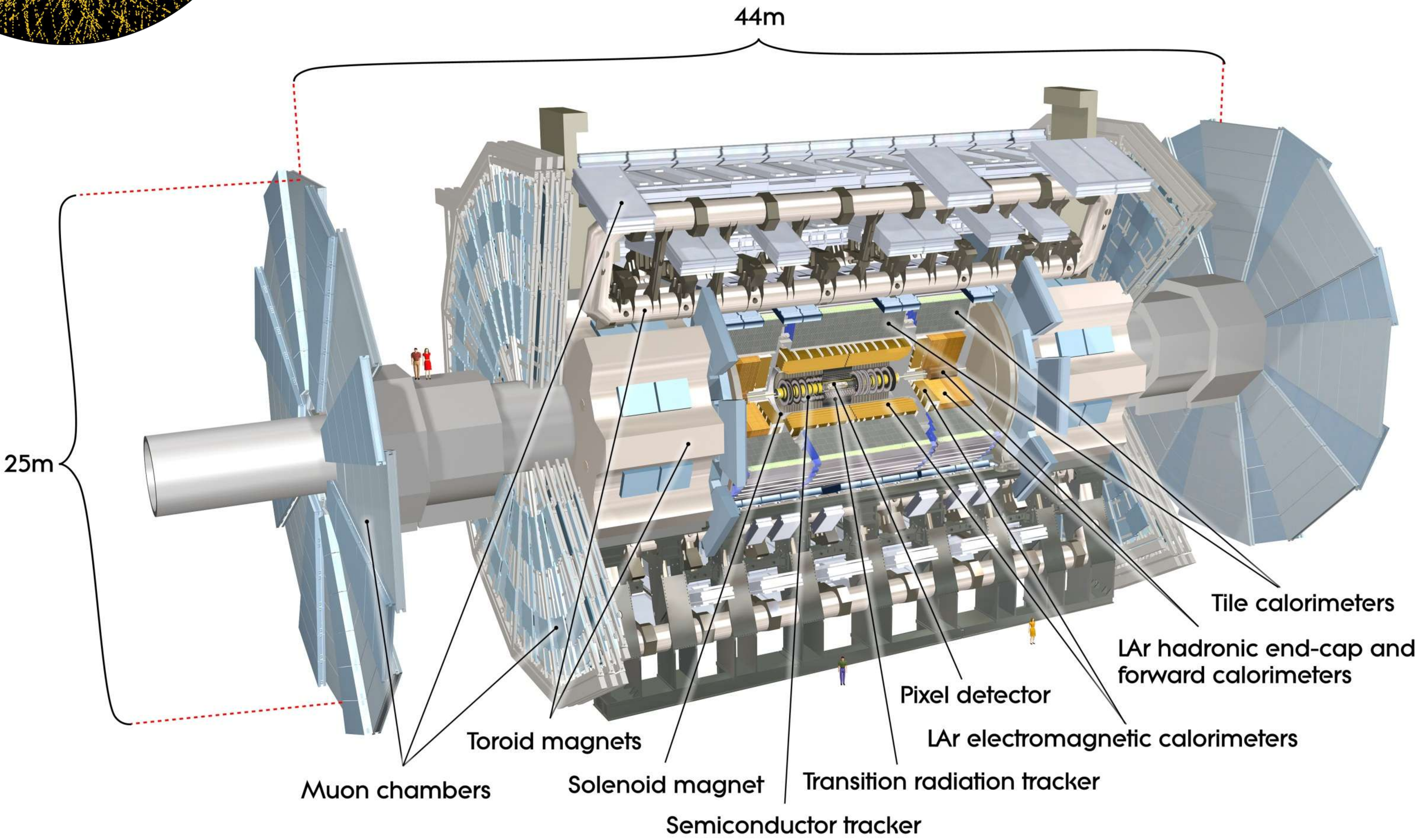




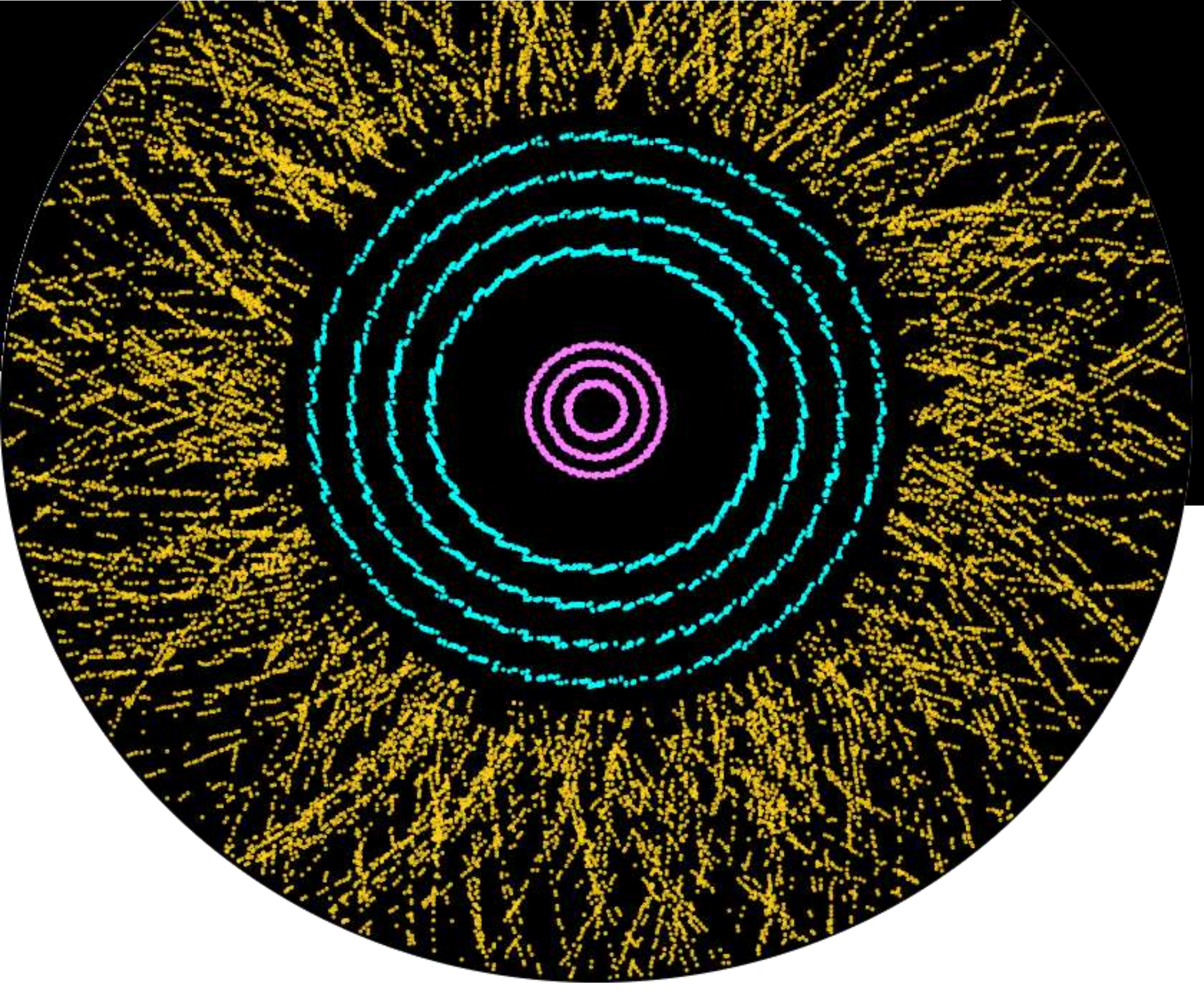


Commissioning and performance of the ATLAS Transition Radiation Tracker with first high energy pp and Pb-Pb collisions at LHC

The ATLAS Experiment

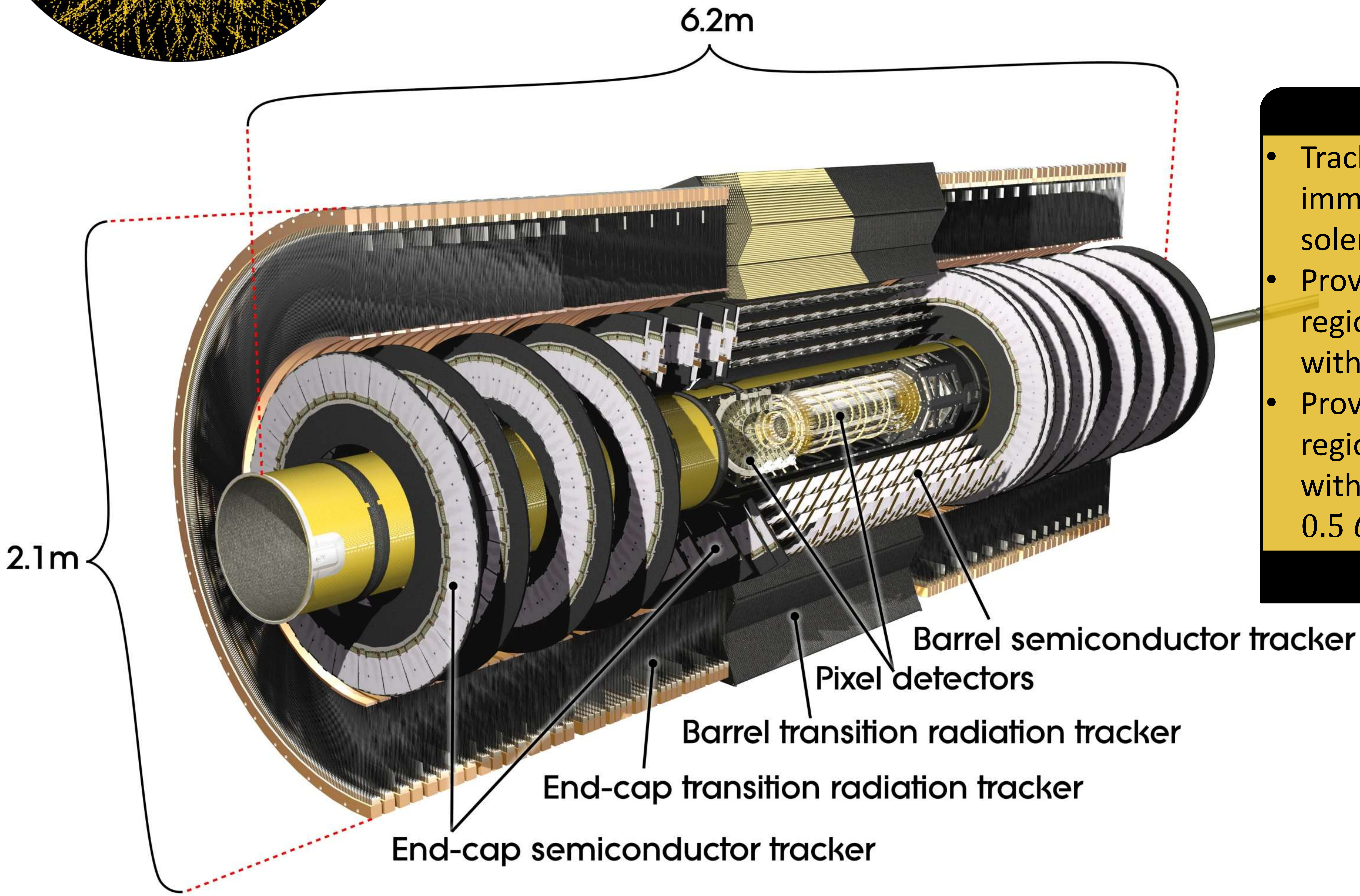


Steffen Schaepe, for the ATLAS collaboration

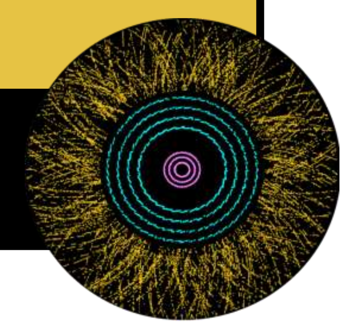


Commissioning and performance of the ATLAS Transition Radiation Tracker with first high energy pp and Pb-Pb collisions at LHC

The ATLAS Inner Detector



- Tracking detectors immersed in a 2T solenoidal field
- Provides tracking in the region $|\eta|$<2.5 for particles with $p_T > 0.1\ GeV$
- Provides electron ID in the region $|\eta|$<2 for particles with $150\ GeV > p_T >$ $0.5\ GeV$



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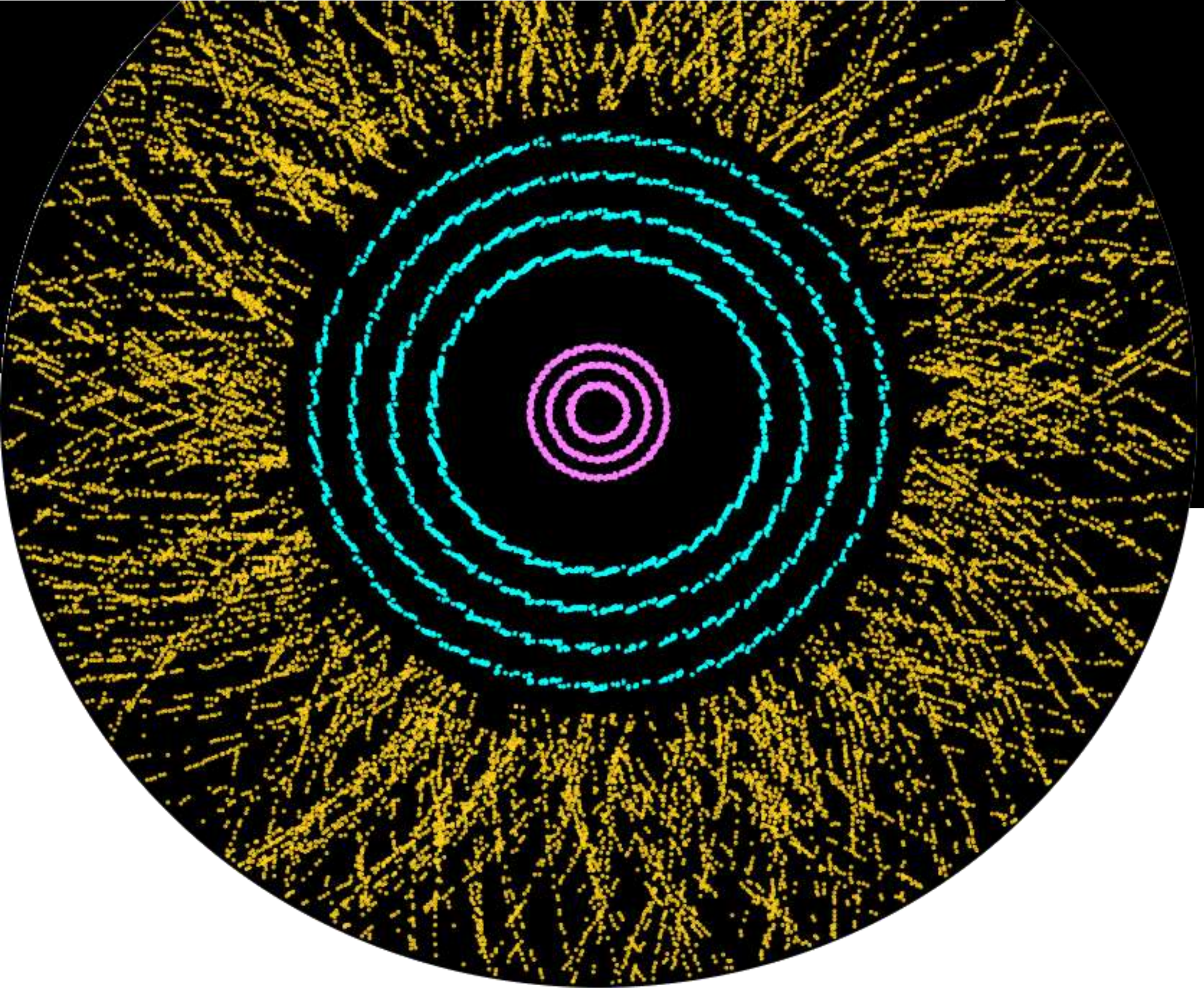
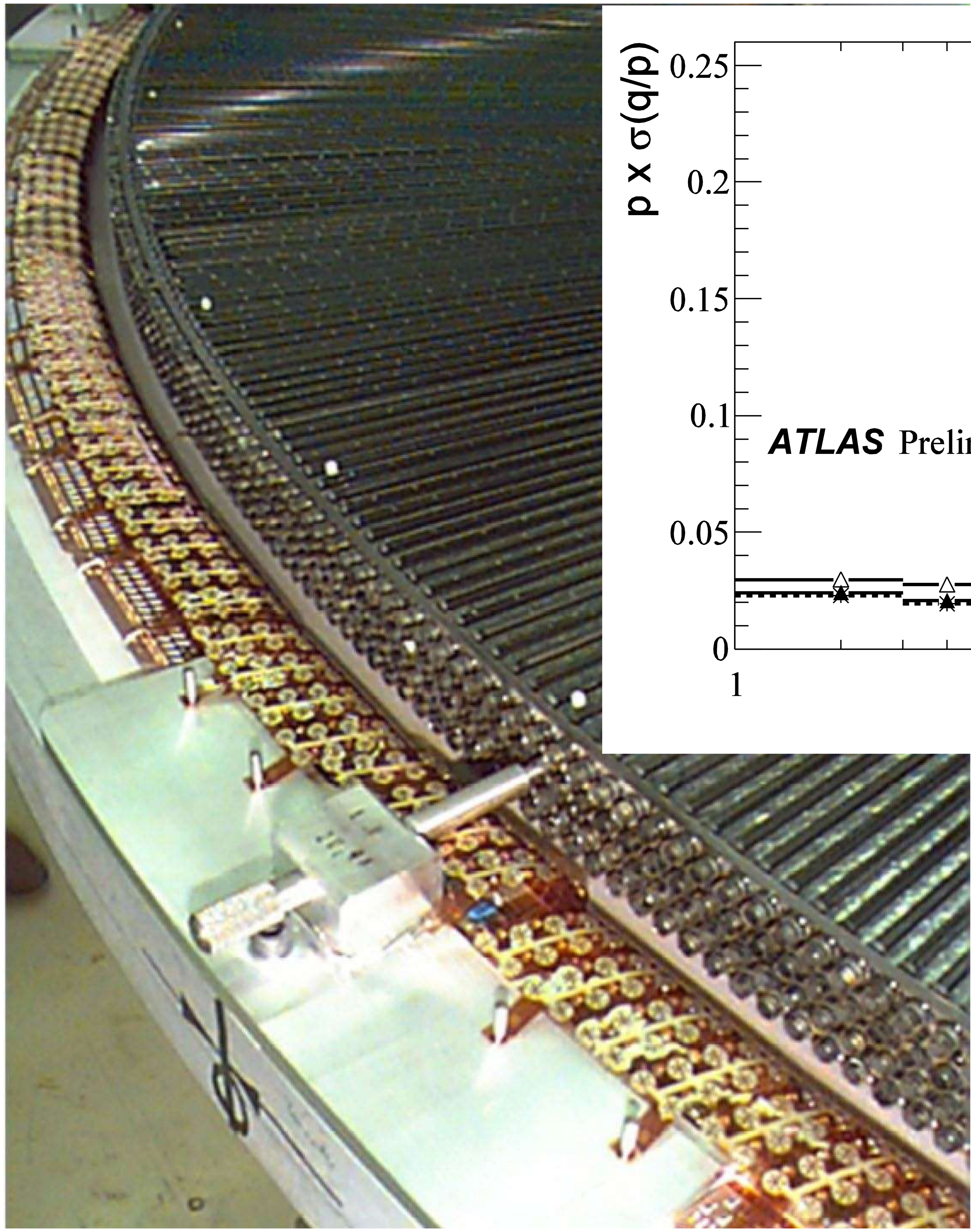


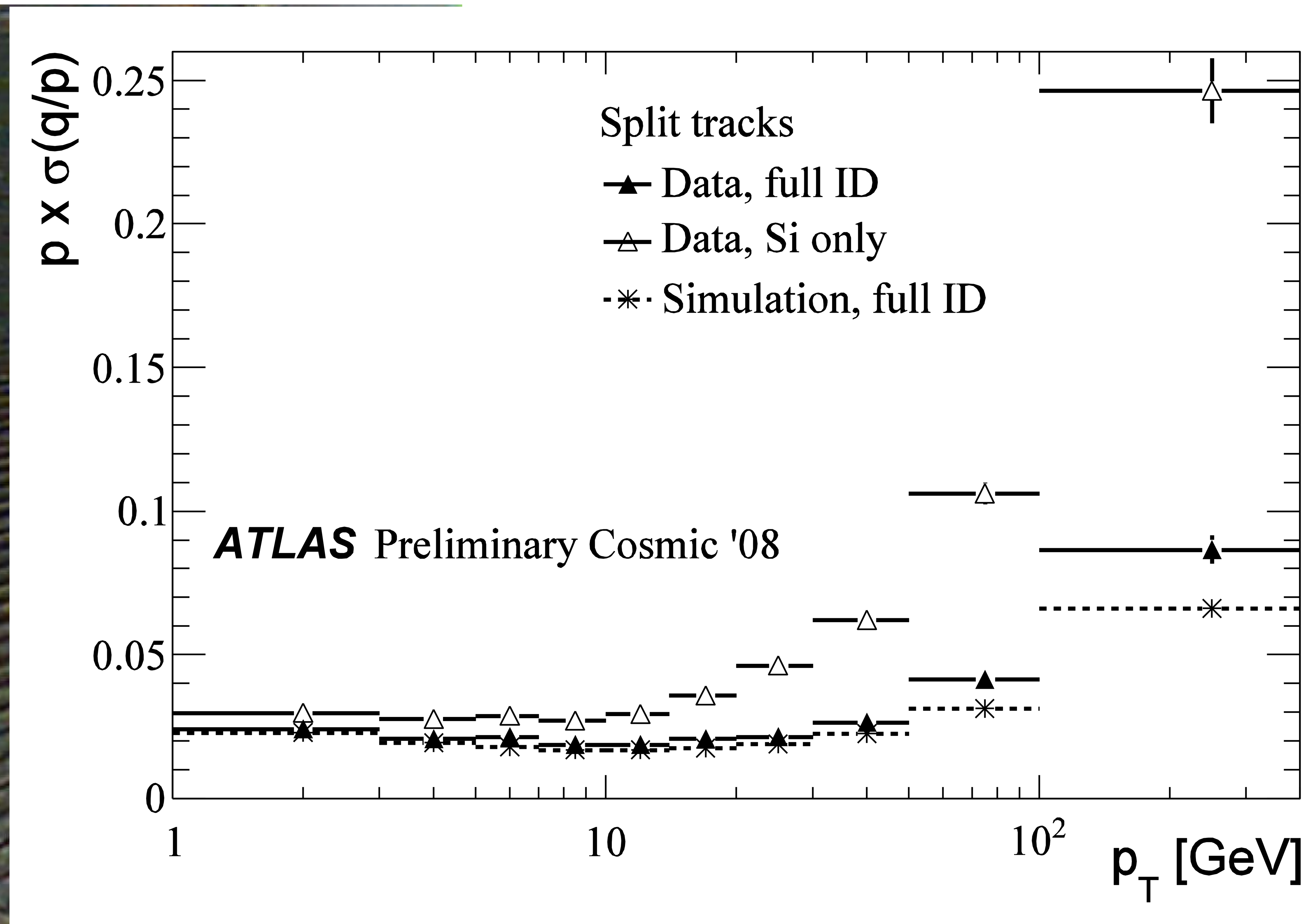
Commissioning and performance of the ATLAS Transition Radiation Tracker with first high energy pp and Pb-Pb collisions at LHC

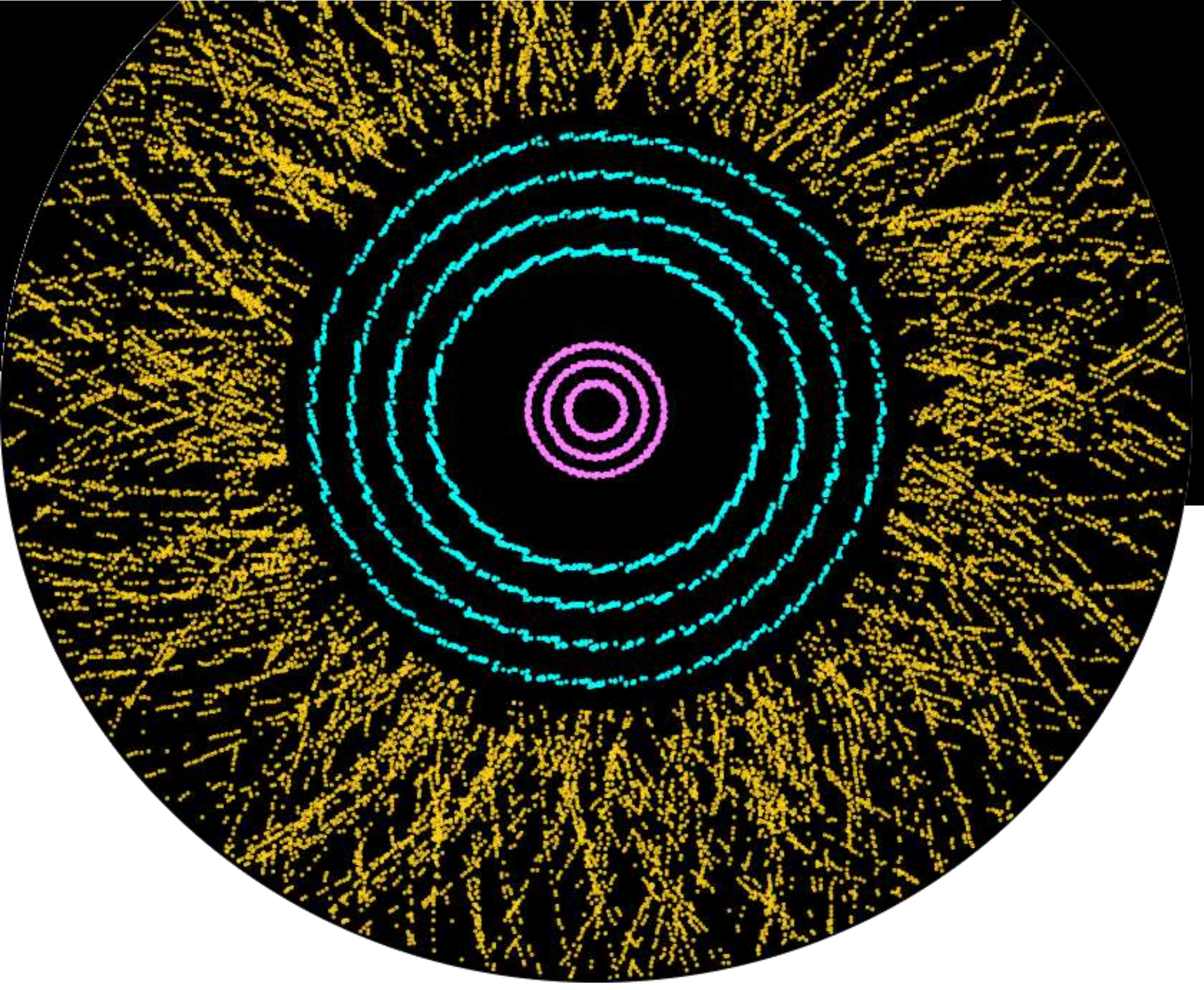
The ATLAS Transition Radiation Tracker

TRT Design goals

- Long arm for p_T measurement over wide range
- Continuous tracking = many (>30) hits per track
- Hit precision of ~130μm
- Electron identification
- High occupancies (up to 30%)
- High single straw rates (up to 20MHz)
- 25ns event-to-event time
- High radiation dose
- ➔ 4mm straw tubes (drift tubes)

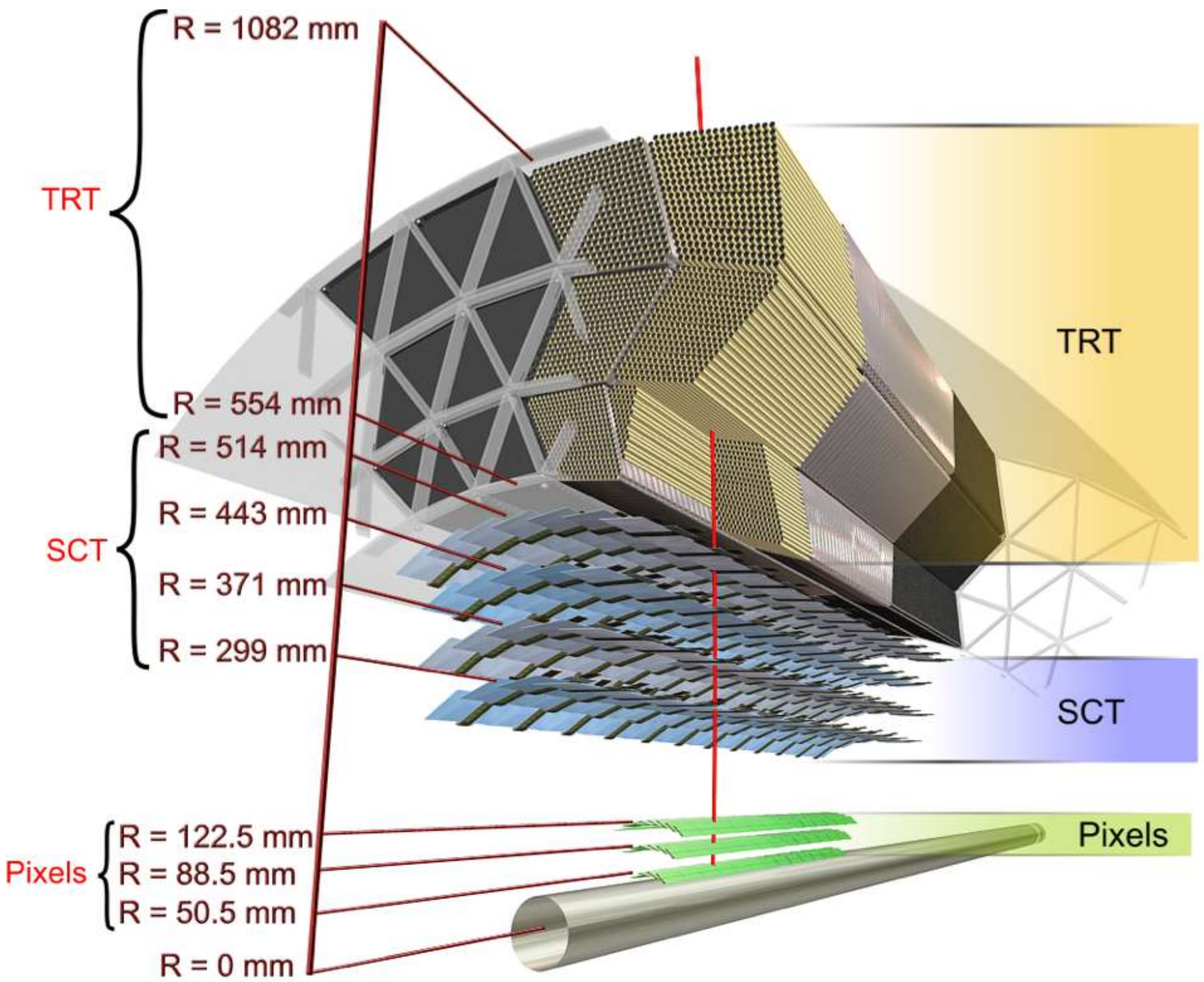


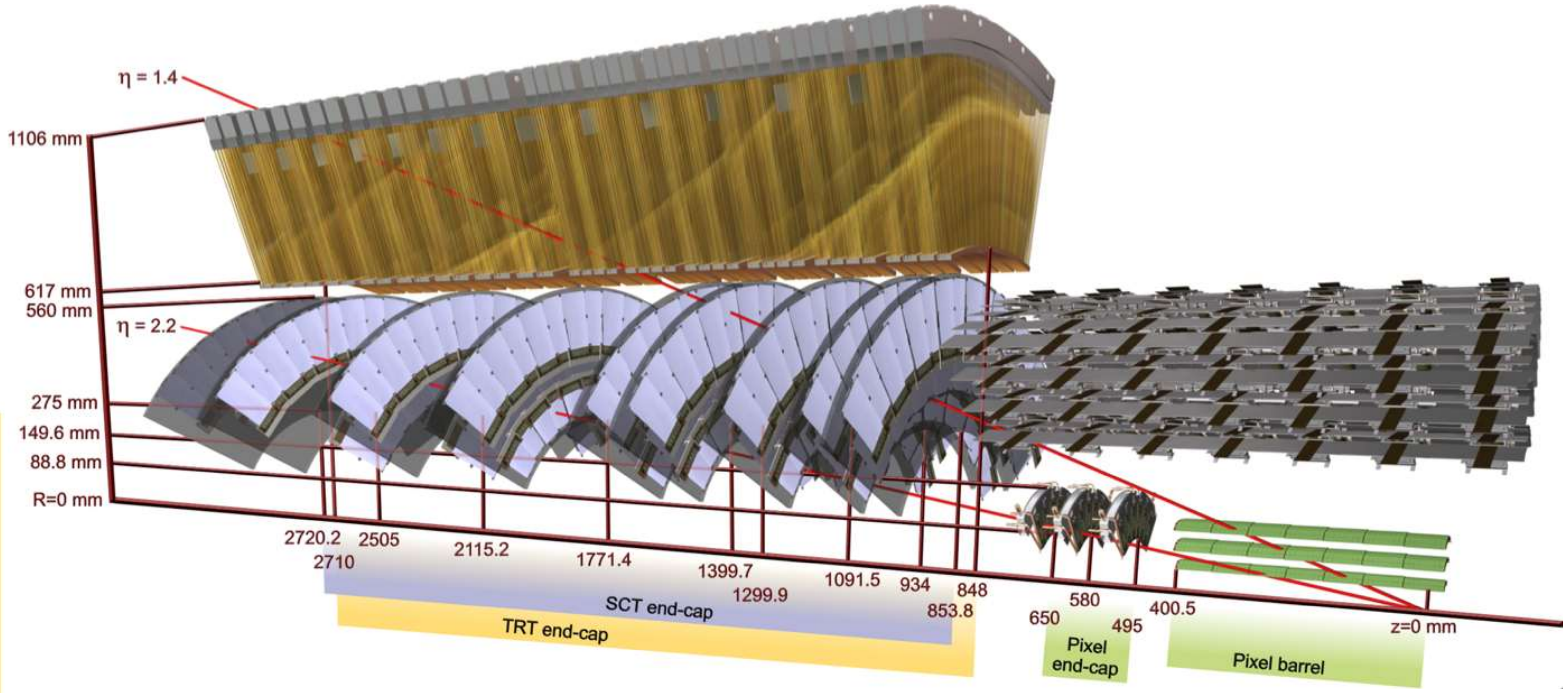




Commissioning and performance of the ATLAS Transition Radiation Tracker with first high energy pp and Pb-Pb collisions at LHC

The ATLAS Transition Radiation Tracker



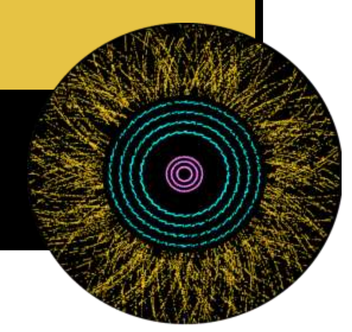


TRT Barrel

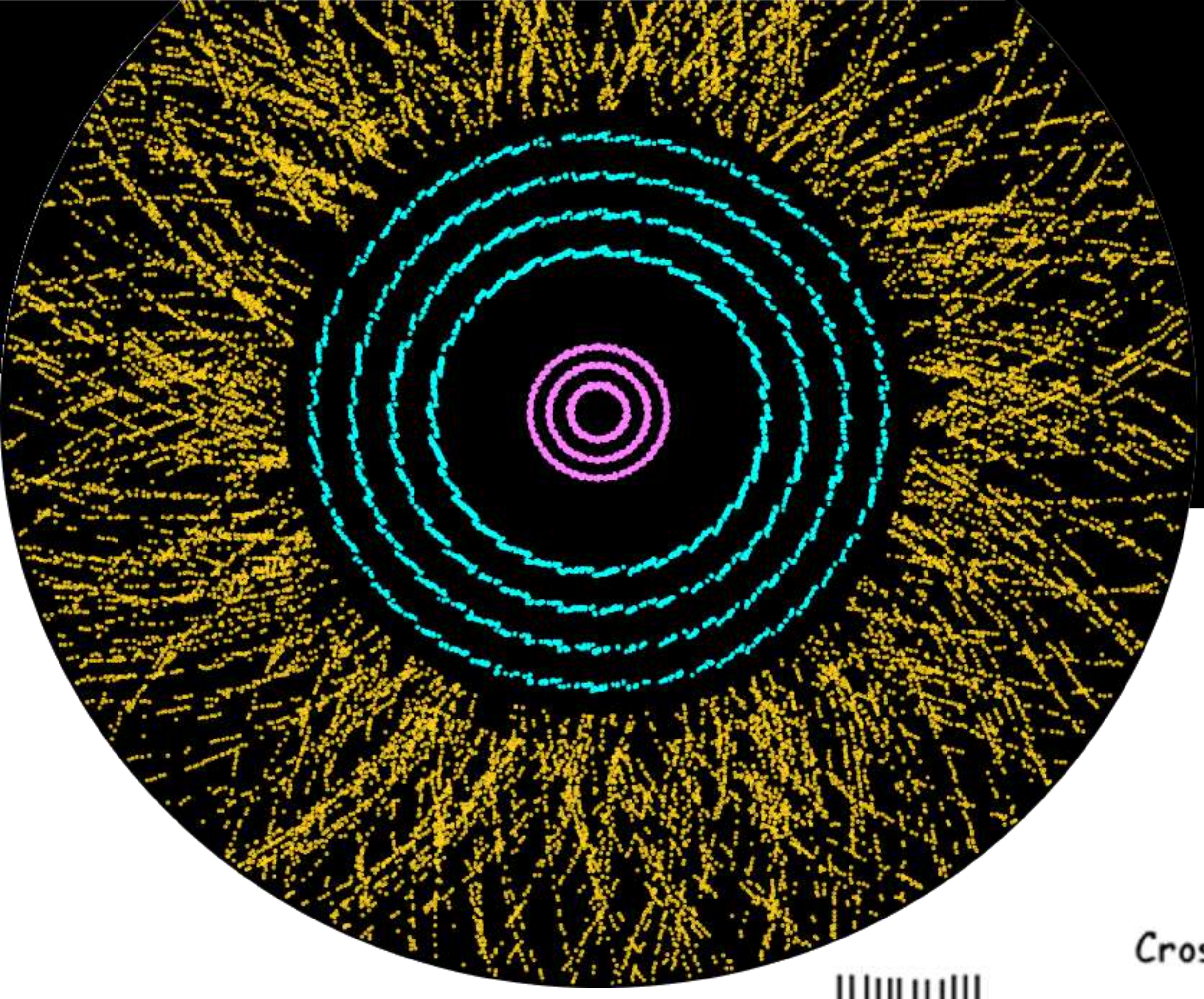
- 73 Layers of 144cm straws in the barrel region
- Straws parallel to beam axis
- Wires split in two, independent readout on both side
- 105088 readout channels
- Grouped in 3 layers of 32 modules

TRT Endcaps

- 160 Layers of 39cm straws in each endcap
- Straws radially oriented
- Readout at the outer end
- 122880 readout channels
- Grouped in 20 wheels of 8 layers

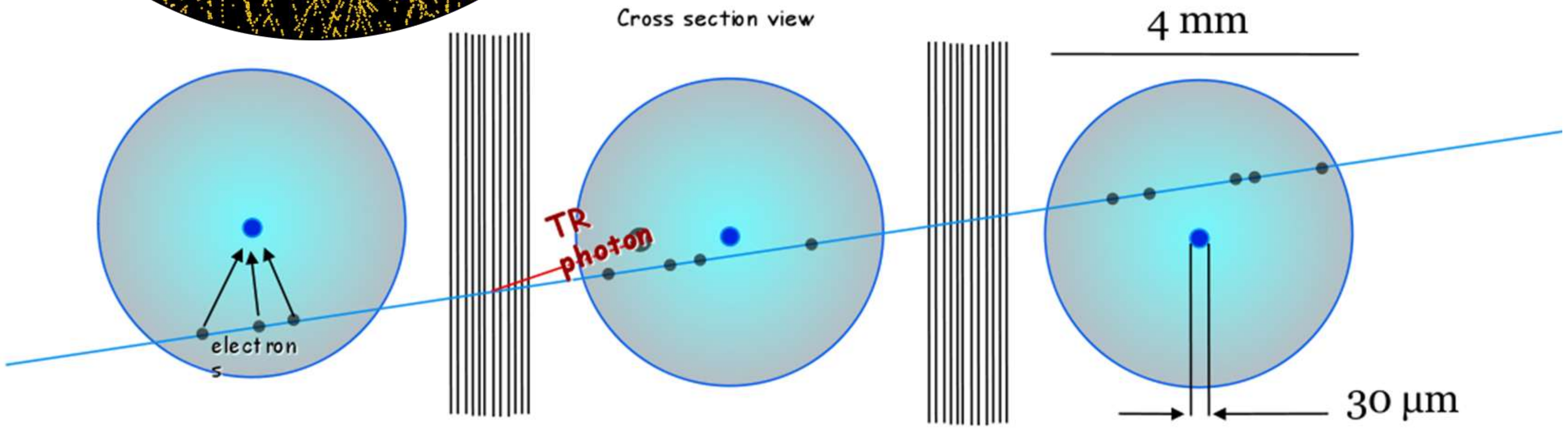


Steffen Schaepe, for the ATLAS collaboration



Commissioning and performance of the ATLAS Transition Radiation Tracker with first high energy pp and Pb-Pb collisions at LHC

How the TRT works

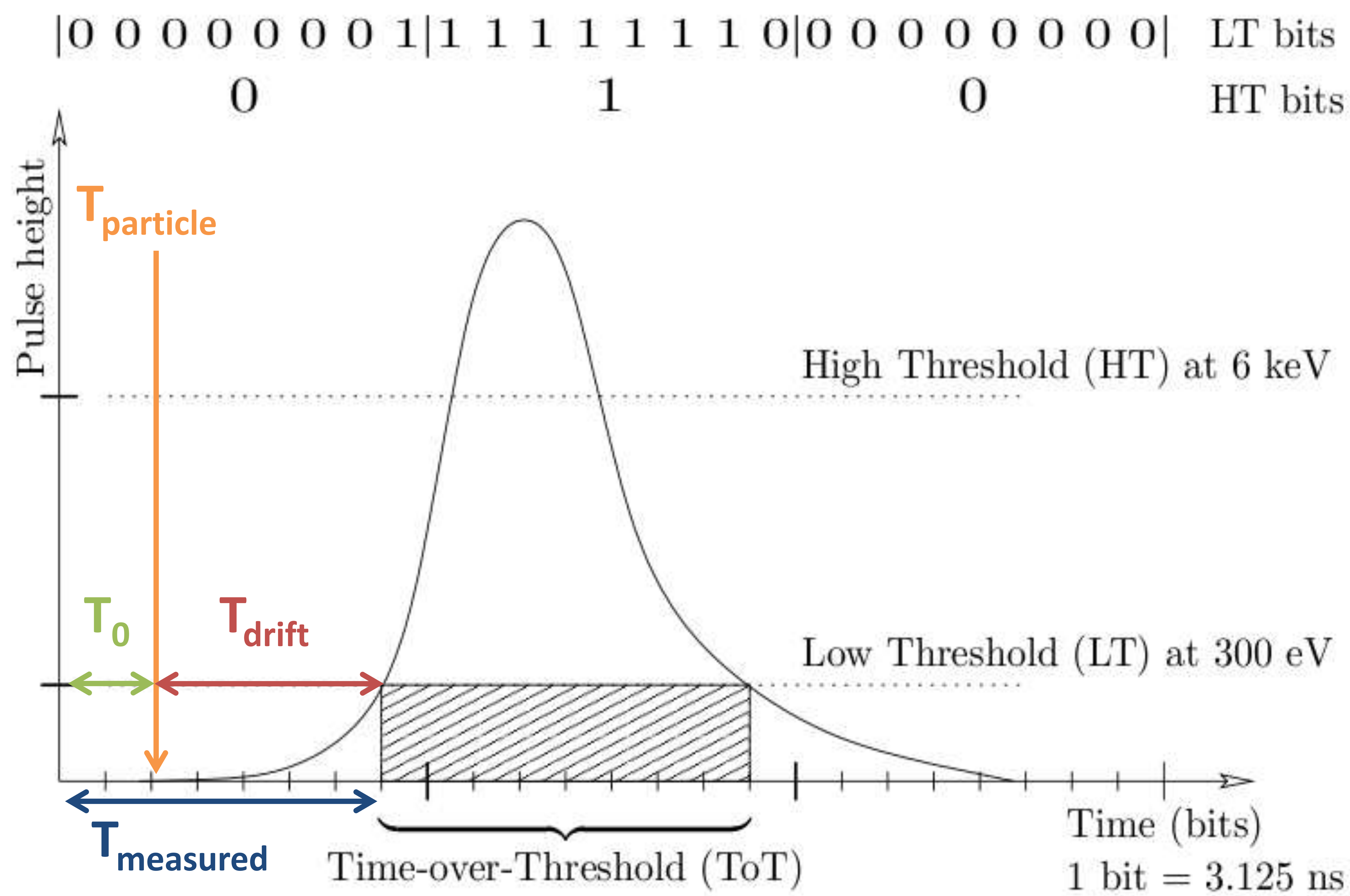


Signal Formation

- Ionisation generated by traversing charged particles and/or transition radiation photons in the soft X-ray regime
- Straw layers interleaved with foil stacks (endcap) and fibre structures (barrel) respectively to generate TR
- Only Electrons have a velocity high enough to generate TR
- TR photons generate much larger signals than ionizing particles
- ➔ Particle ID

Digitization

- Two discriminator thresholds for tracking and TR
- Digitization in bins of 25 ns (TR) and 3.125 ns (tracking)
- 75 ns read out per event
- Time-bit pattern stored ➔ Information on leading and trailing edge



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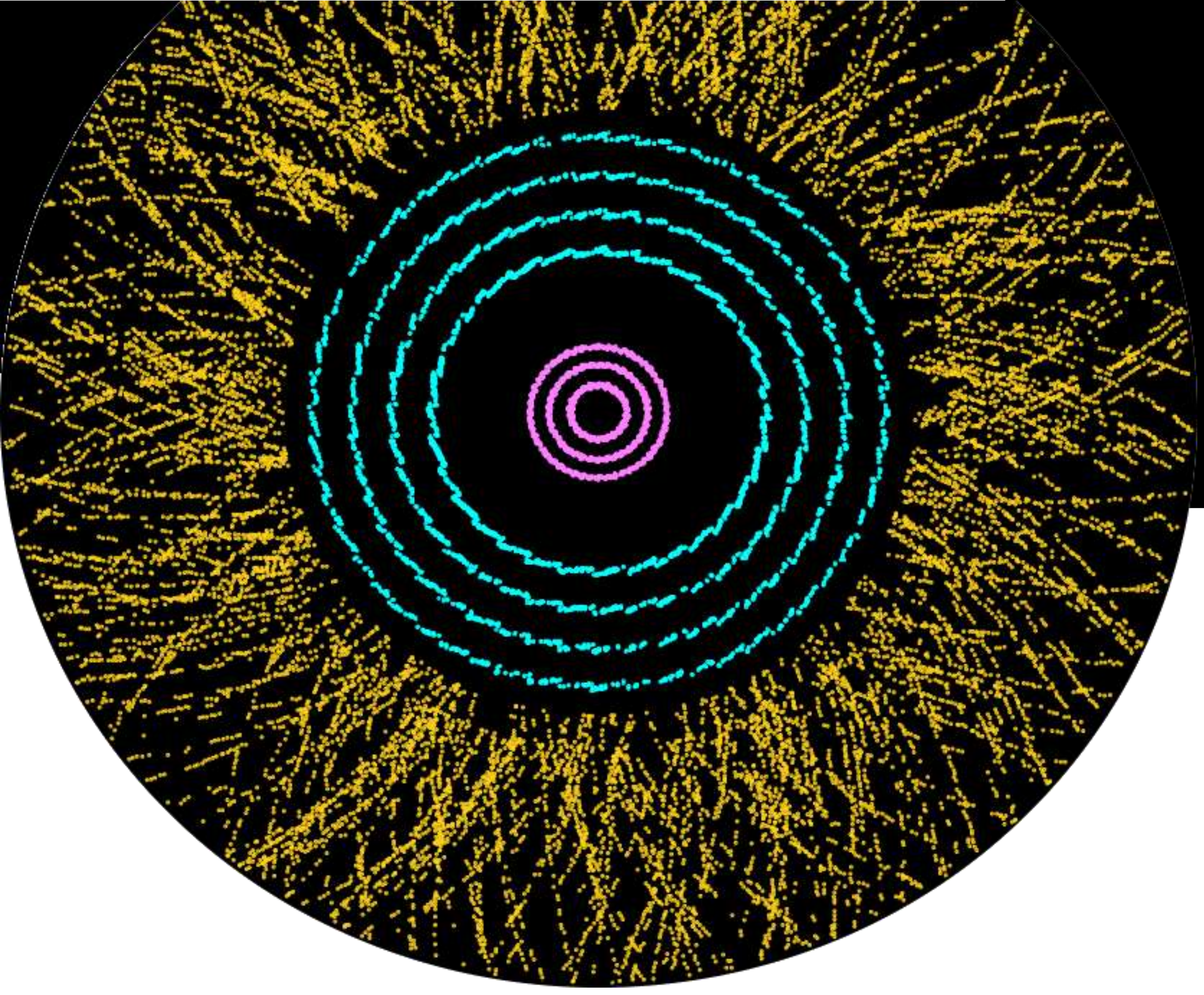
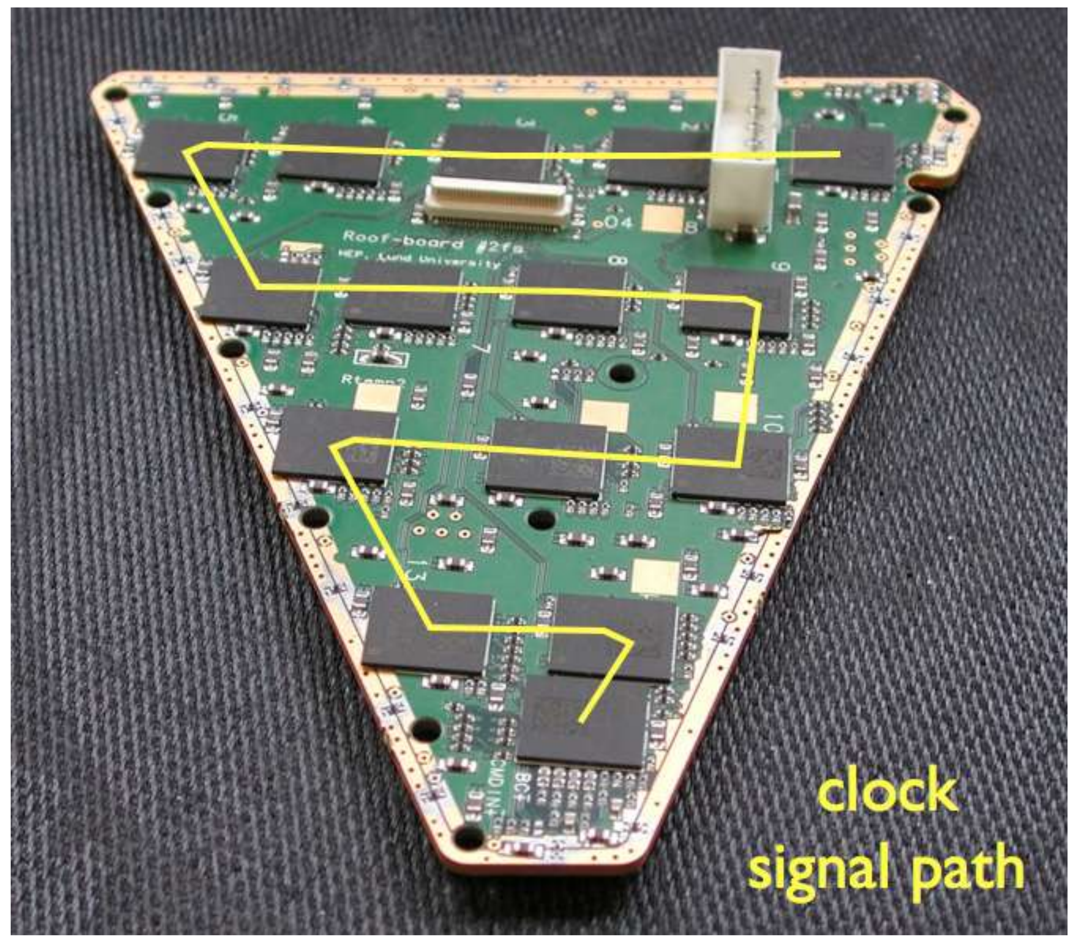


Commissioning and performance of the ATLAS Transition Radiation Tracker with first high energy pp and Pb-Pb collisions at LHC

Calibration

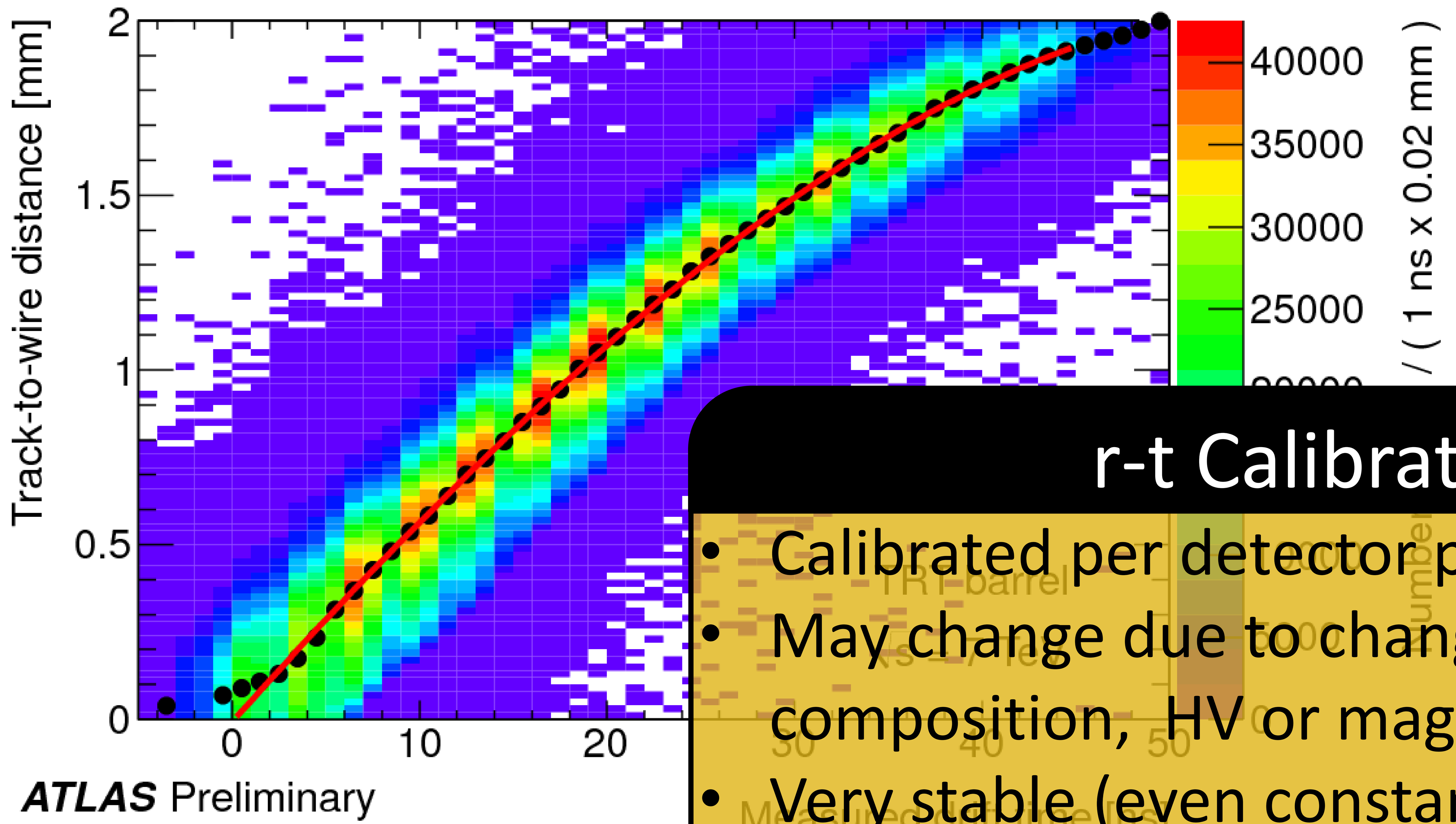
Calibration

- Calibration is crucial to ensure precise measurement of track parameters
- Calibration of discriminators thresholds in dedicated calibration runs once per week
- „Coarse“ timing calibration on hardware level indedicated runs once per week
- „Fine“ calibration on software level for every run with sufficient statistics
    - T_0 = time between start of readout and arrival of physical particle (time of flight + signal propagation + clock offset)
    - r-t relation = relation between measured drift time and distance of closest approach of the track to the wire



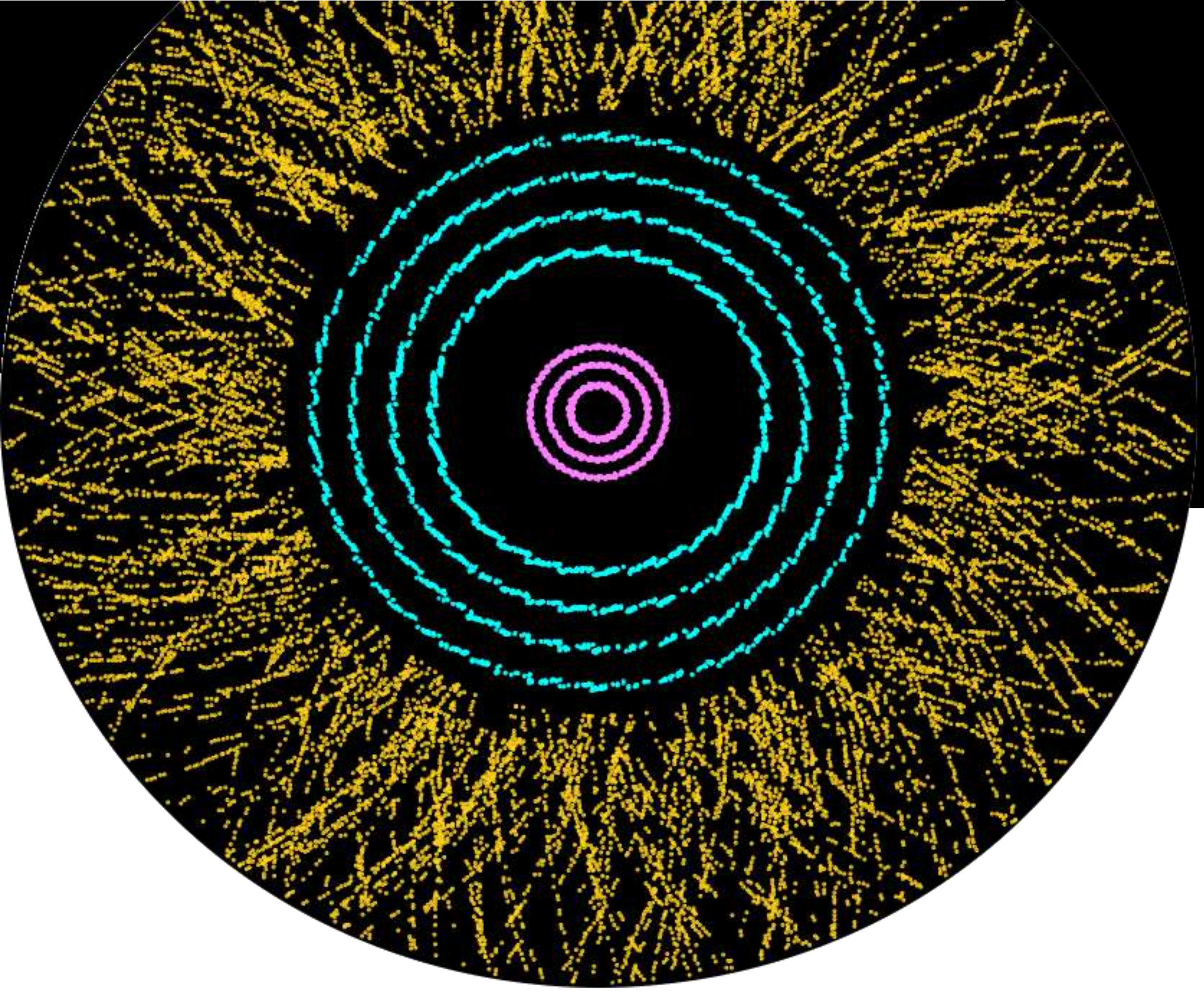
T_0 Calibration

- Calibrated per readout chip
- Sensitive on a 100ps level
- May change due to changes in clock timing, temperature drift etc.



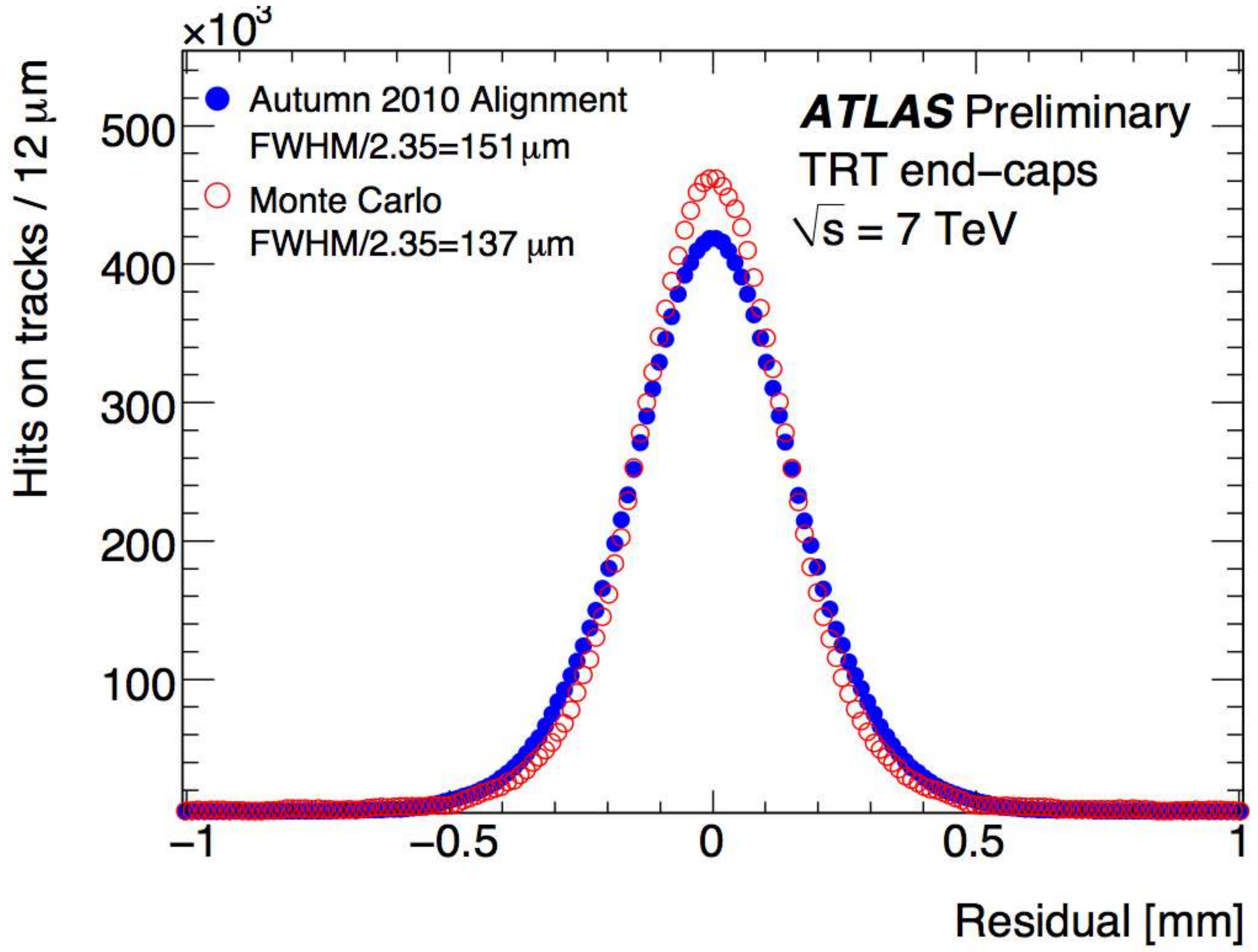
r-t Calibration

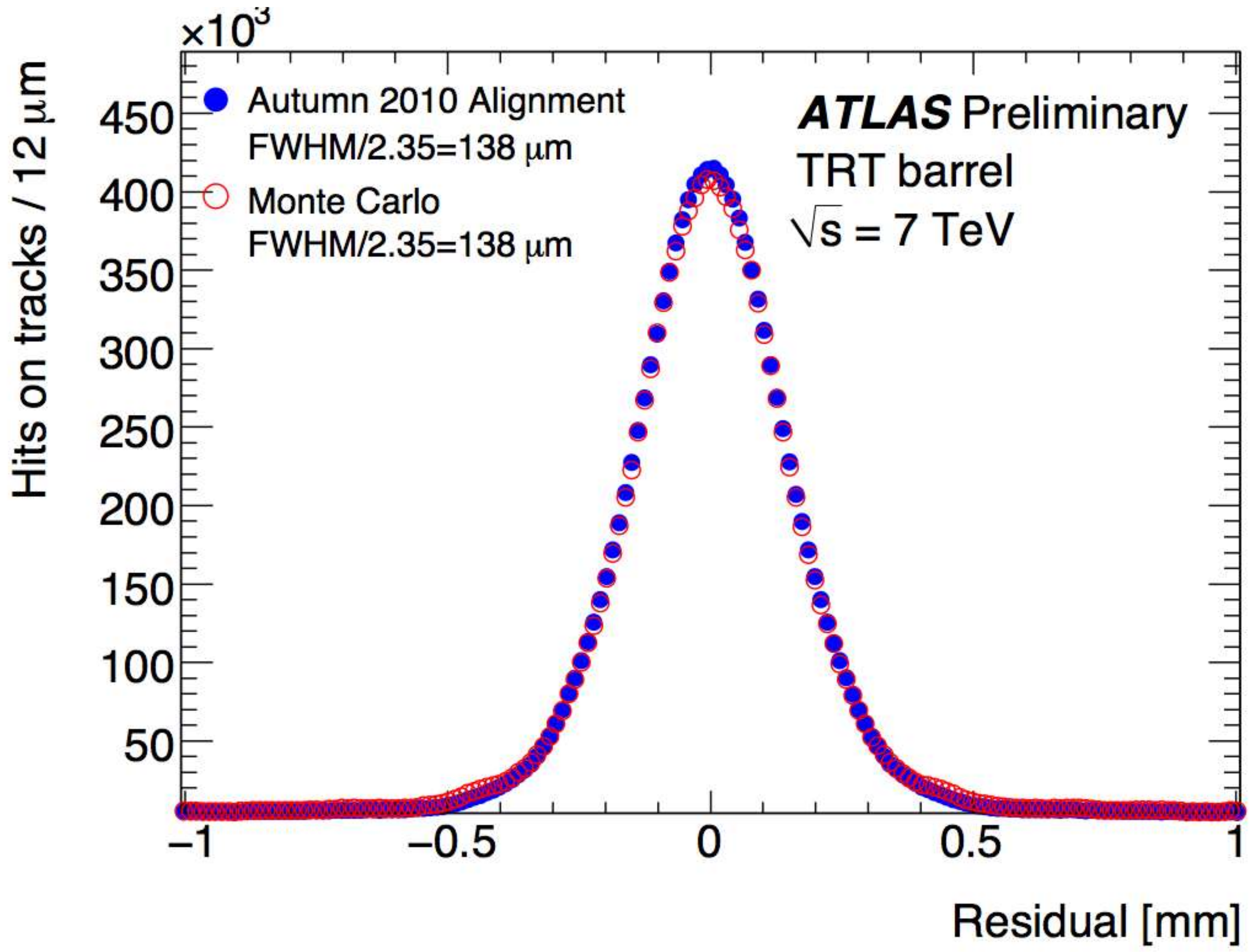
- Calibrated per detector partition
- May change due to changes in gas composition, HV or magnetic field
- Very stable (even constant for 900Gev/7TeV)



Commissioning and performance of the ATLAS Transition Radiation Tracker with first high energy pp and Pb-Pb collisions at LHC

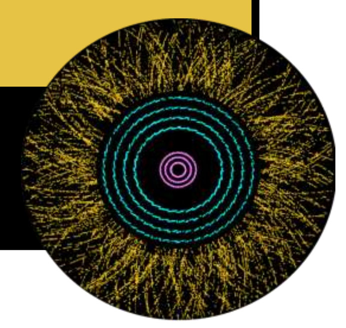
Point resolution

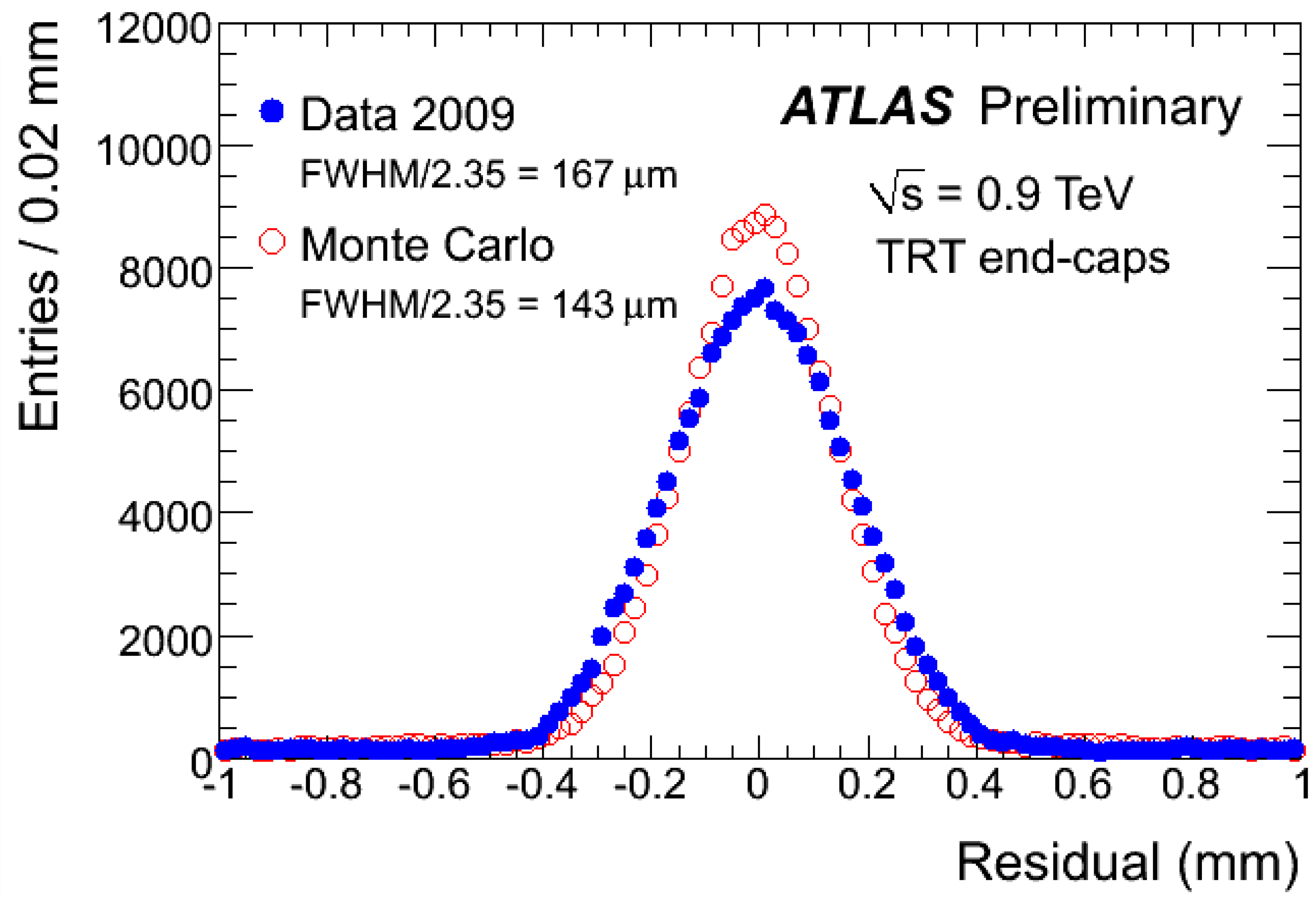


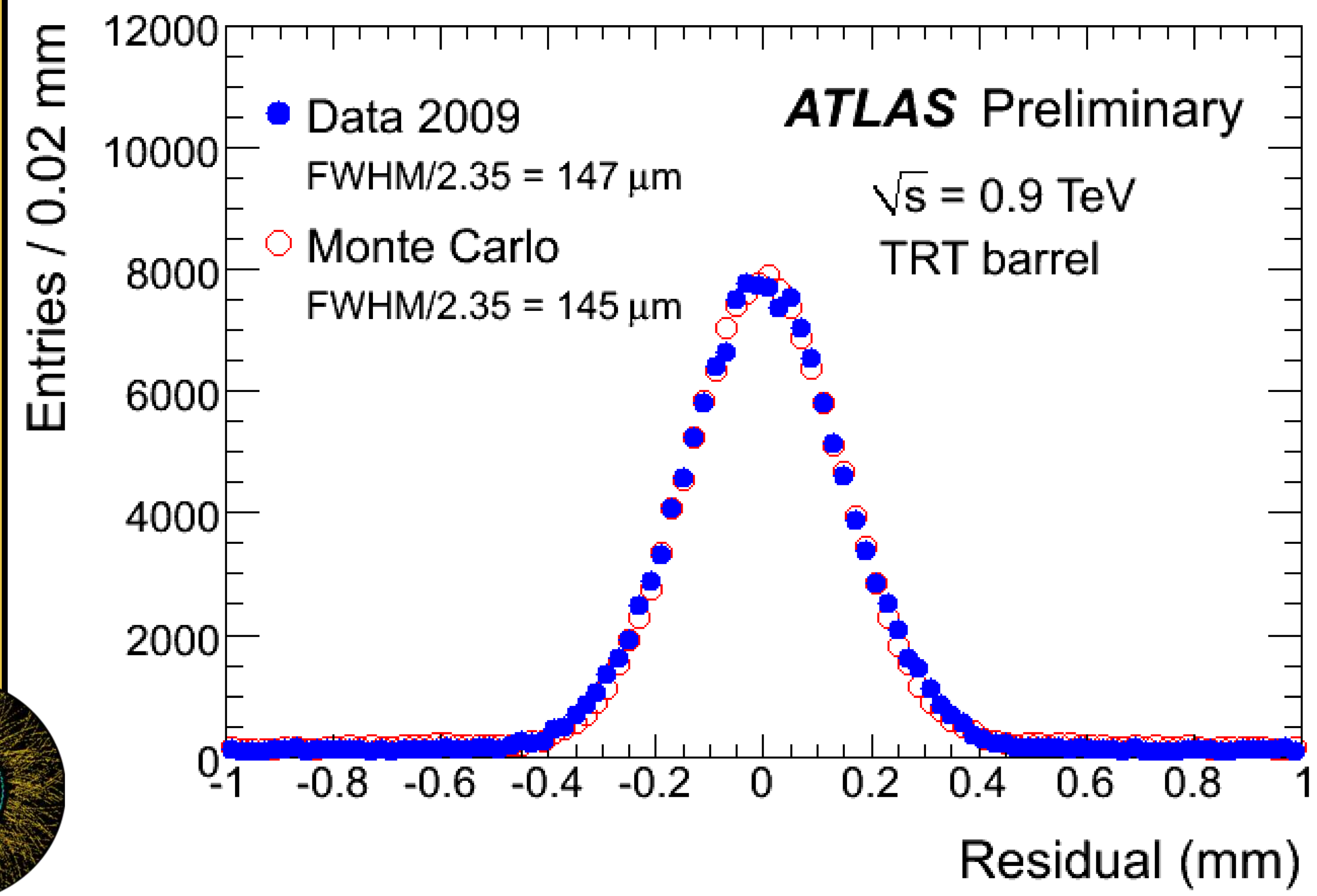


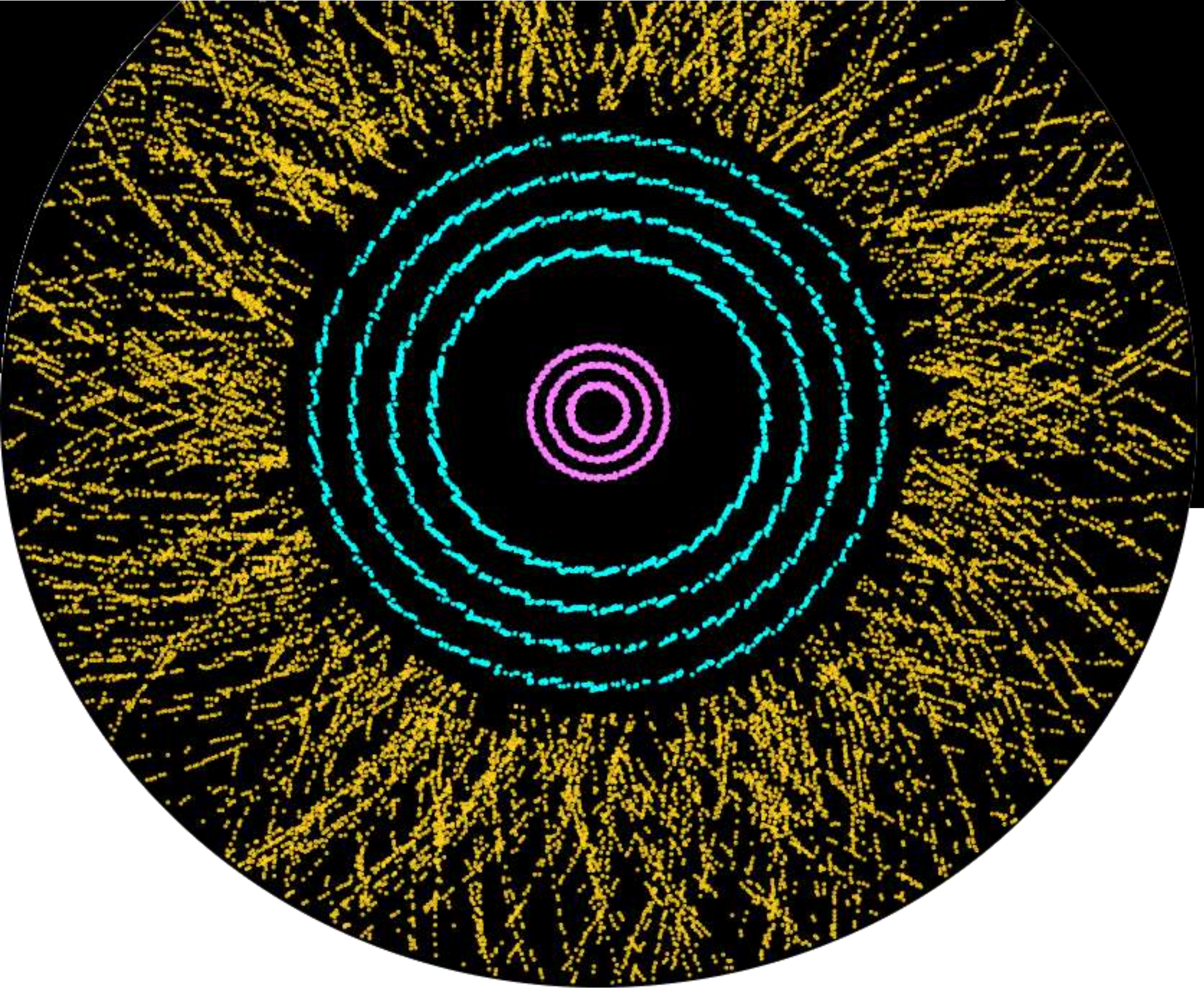
Resolution

- Residual distributions show the difference between the fitted track position and the measured track position for each hit on track
- Shows “point resolution” of the TRT straws
- Resolution improved in 7 TeV running
- ...among other facts due to improvements in alignment
- In the barrel desing resolution exceeded
- A bit worse in the end-caps
- Barrel benefits more from cosmic tracks
  ➔ One extra year of running
- Physical limitation nearly met



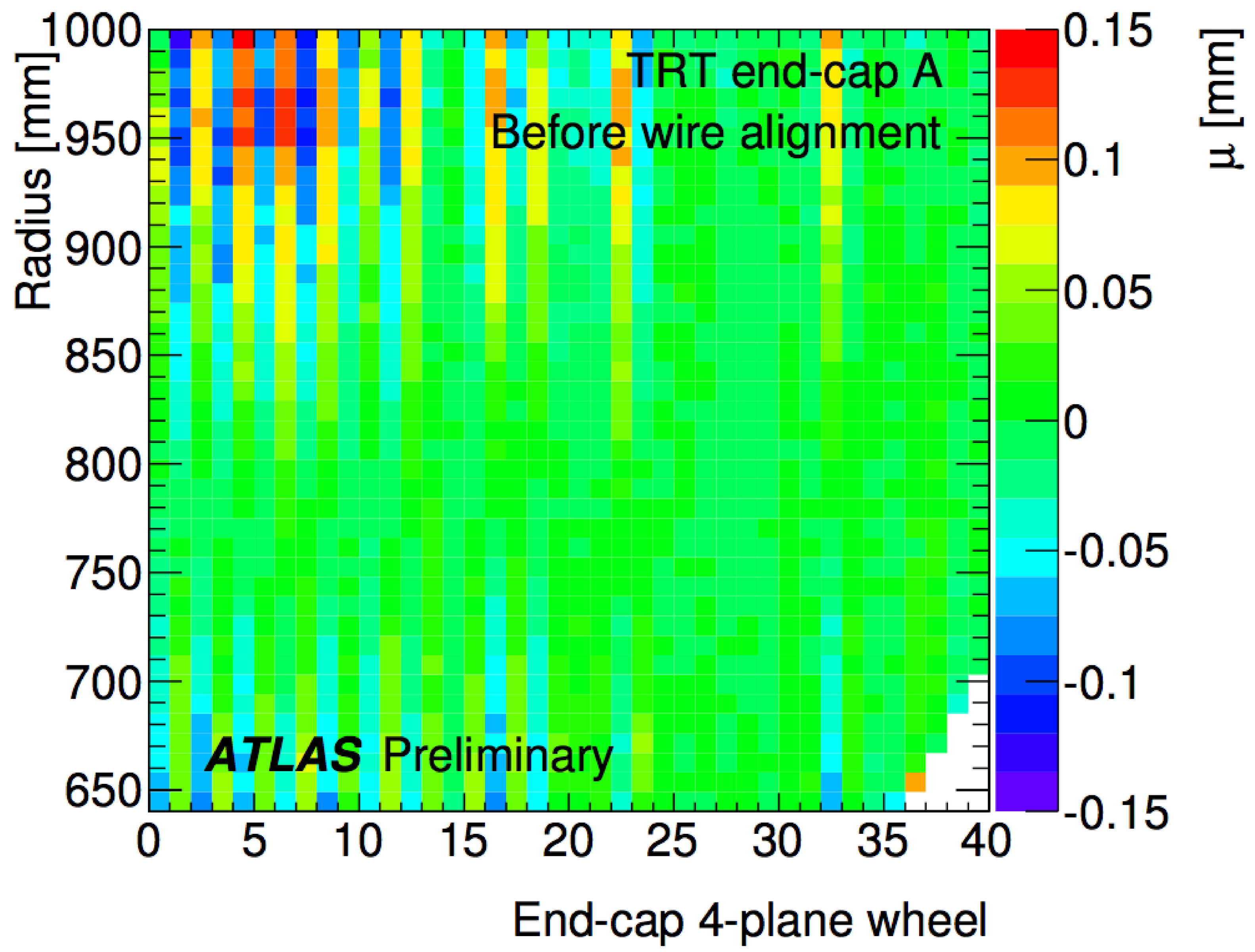


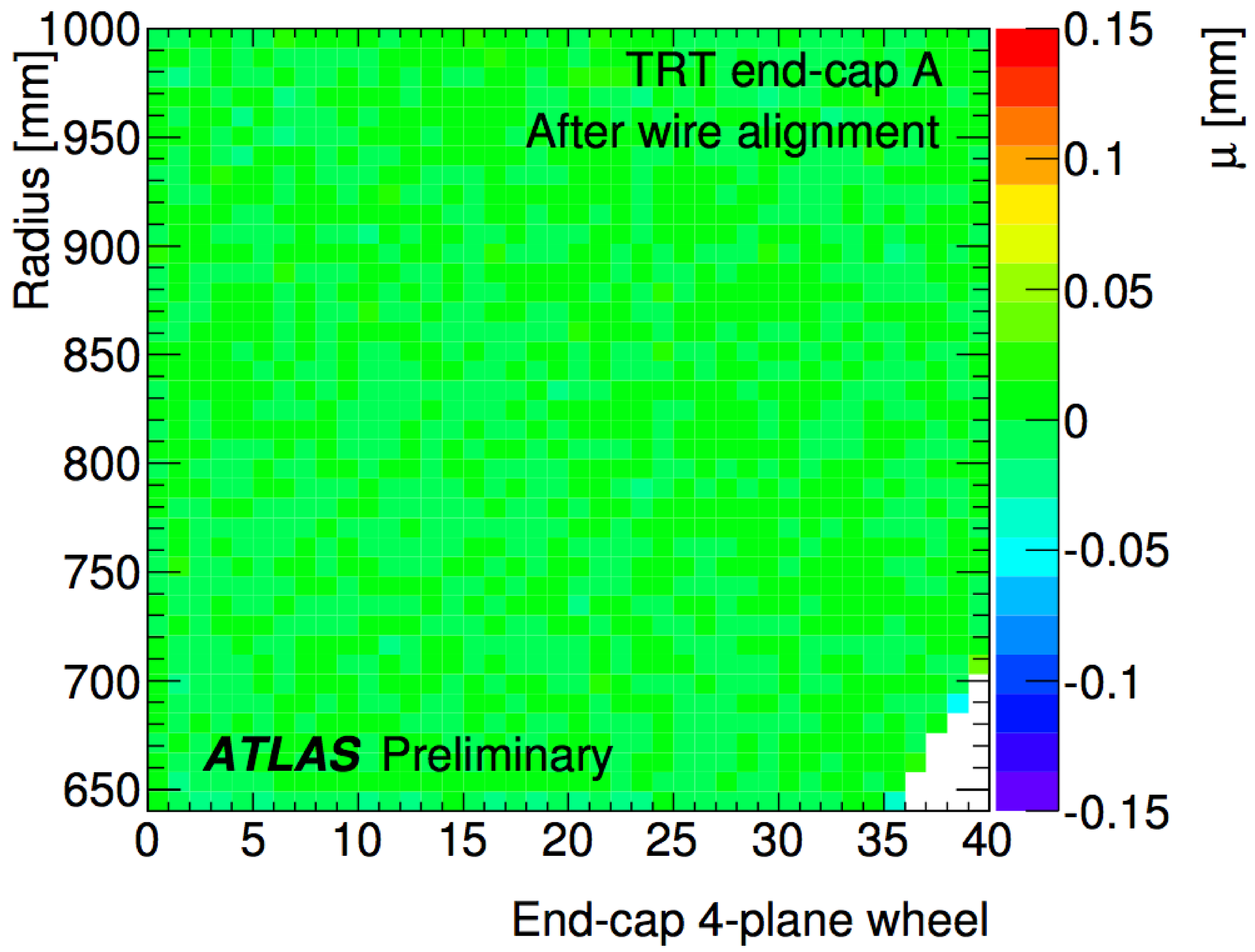




Commissioning and performance of the ATLAS Transition Radiation Tracker with first high energy pp and Pb-Pb collisions at LHC

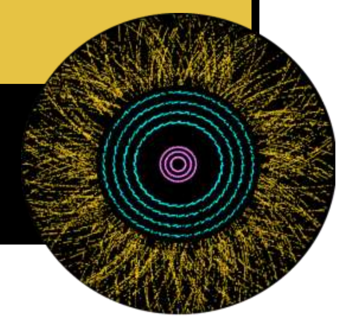
Alignment

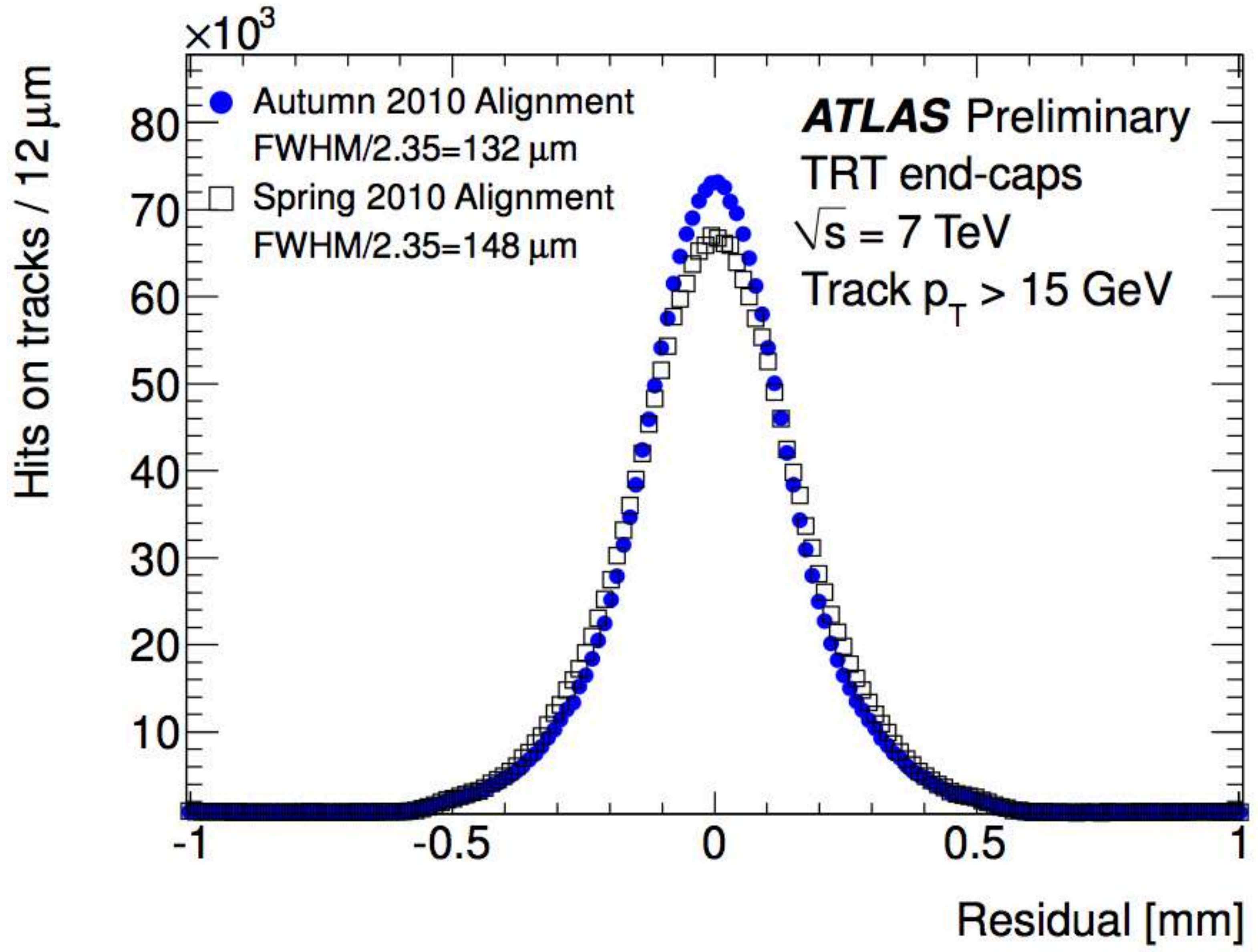


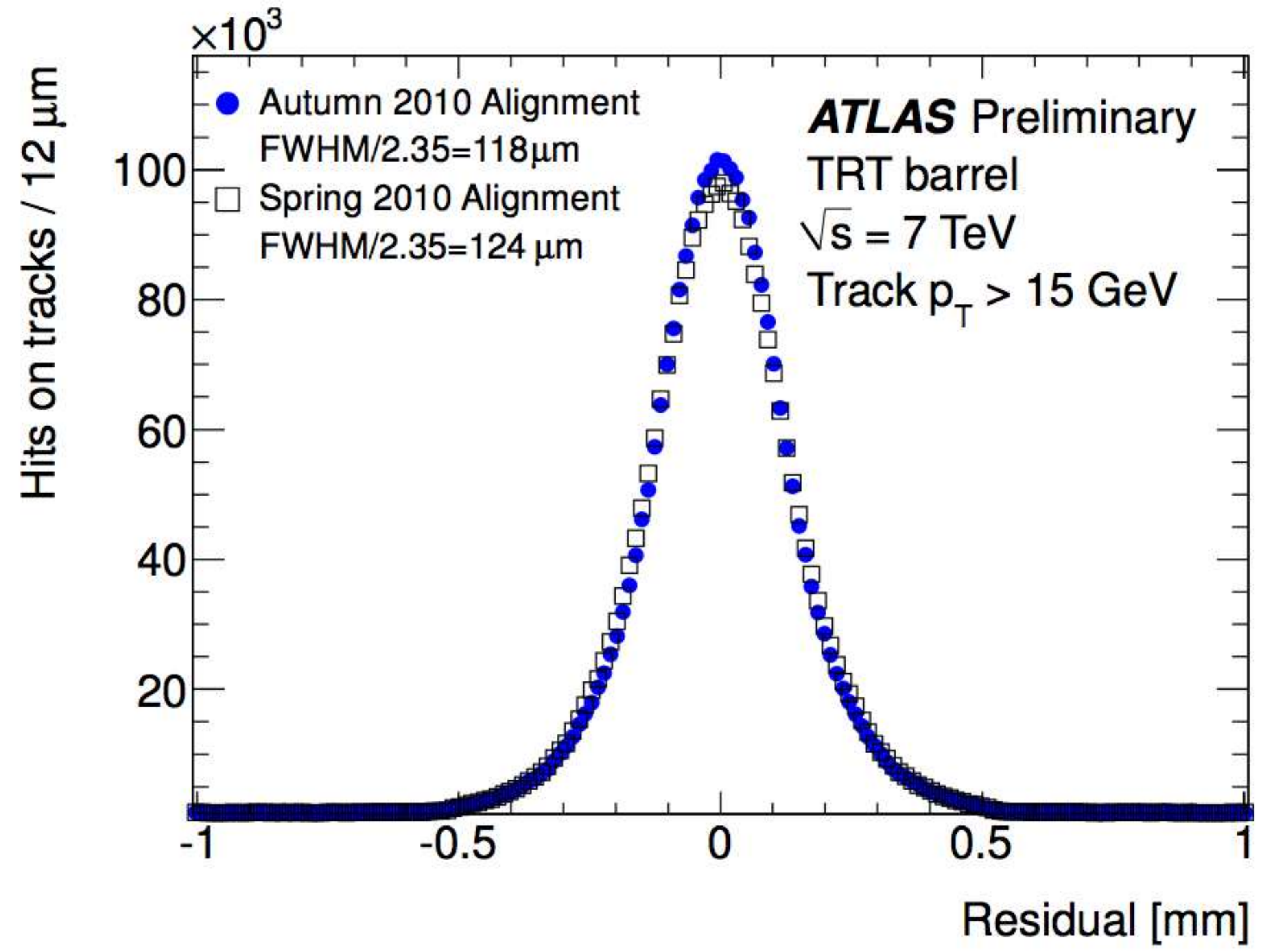


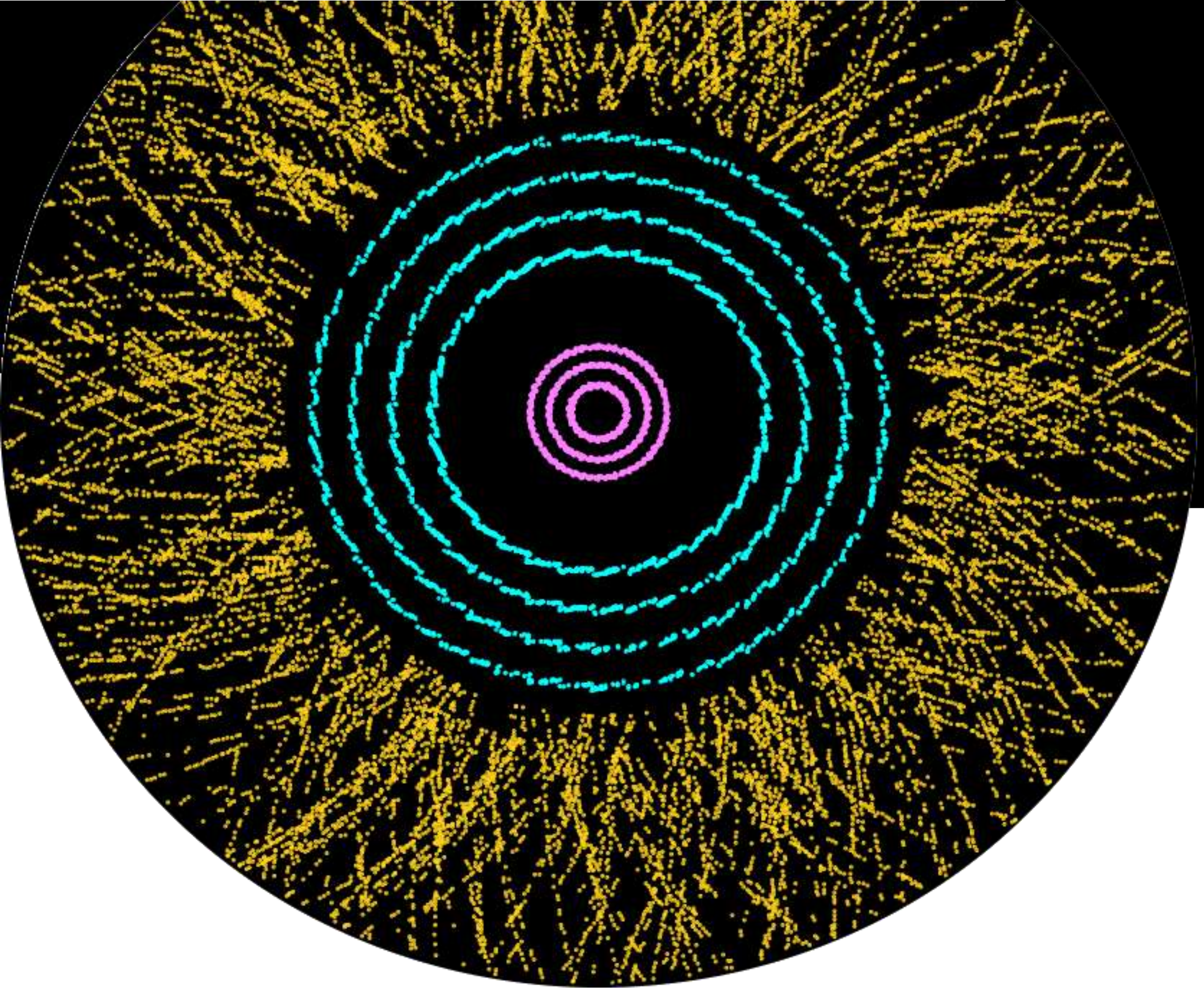
Alignment

- Alignment crucial to every tracking detector
- Alignment done using cosmic and collision tracks
- 3 Levels: Sub-detectors, sub-structures and individual sensors
- Data of 2010 contained enough information to perform a wire by wire alignment in the whole TRT
- 701696 degrees of freedom
- Boosted overall tracking performance
- Especially improved uniformity throughout the detector
- Handle on specific deformations



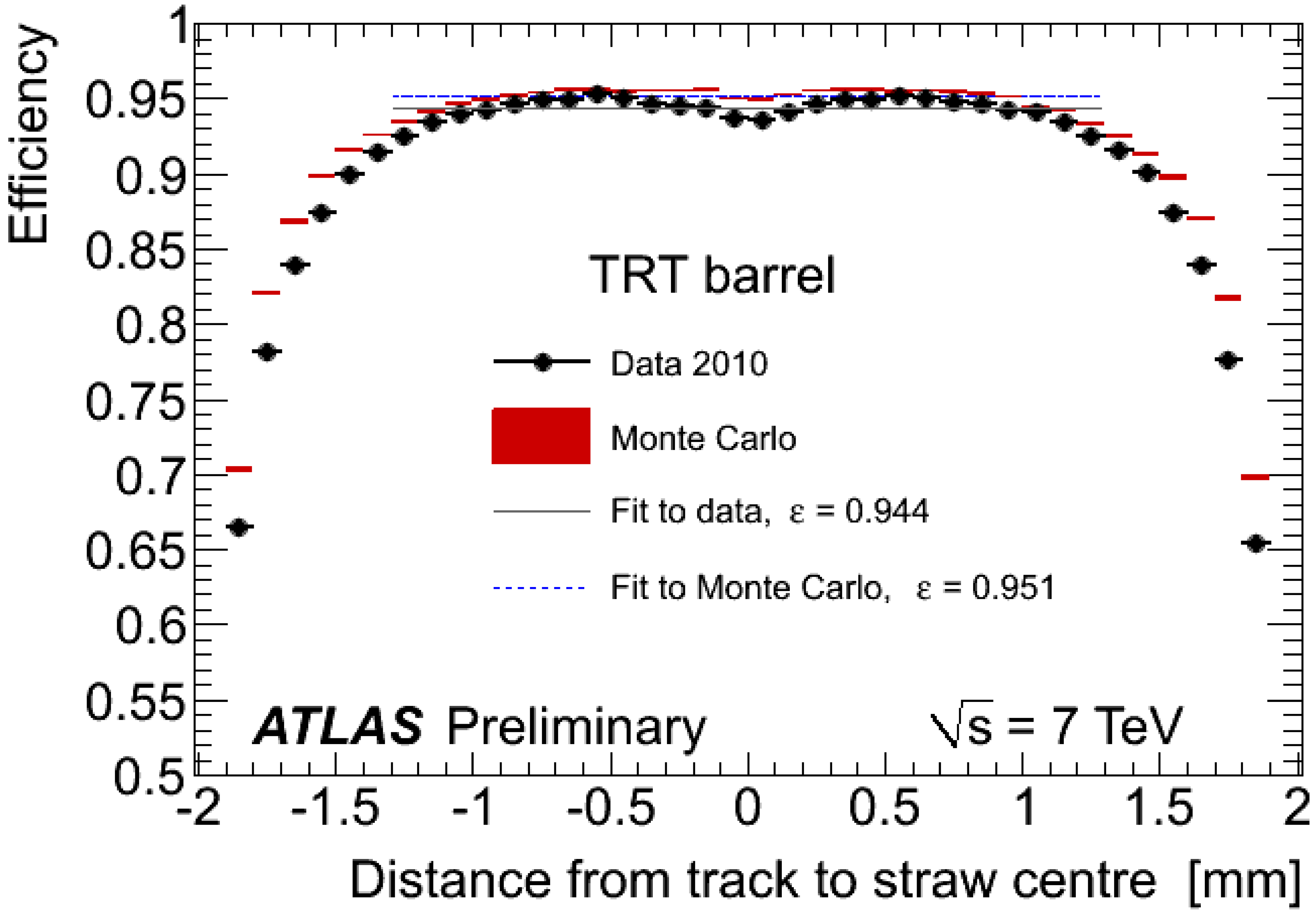


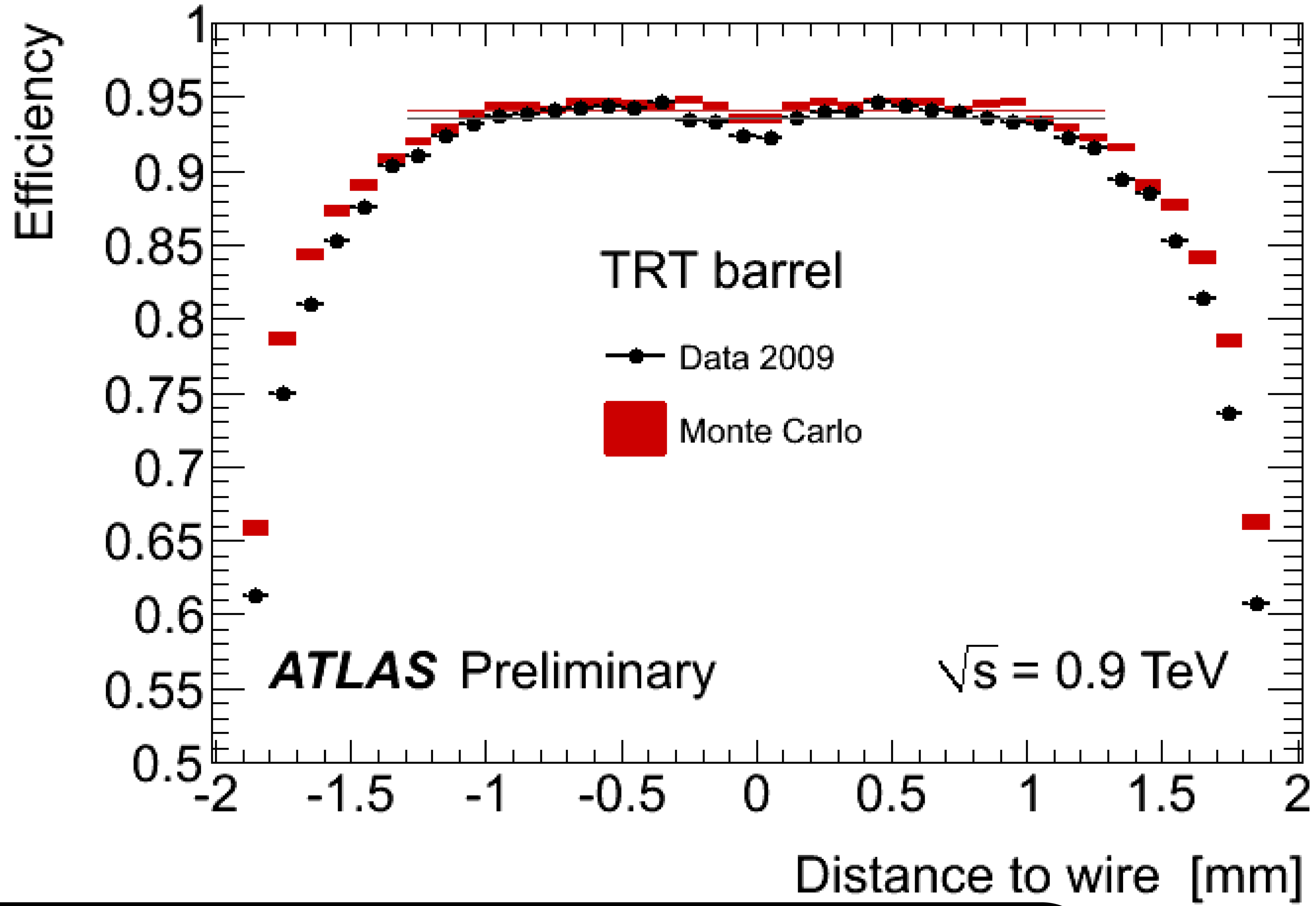




Commissioning and performance of the ATLAS Transition Radiation Tracker with first high energy pp and Pb-Pb collisions at LHC

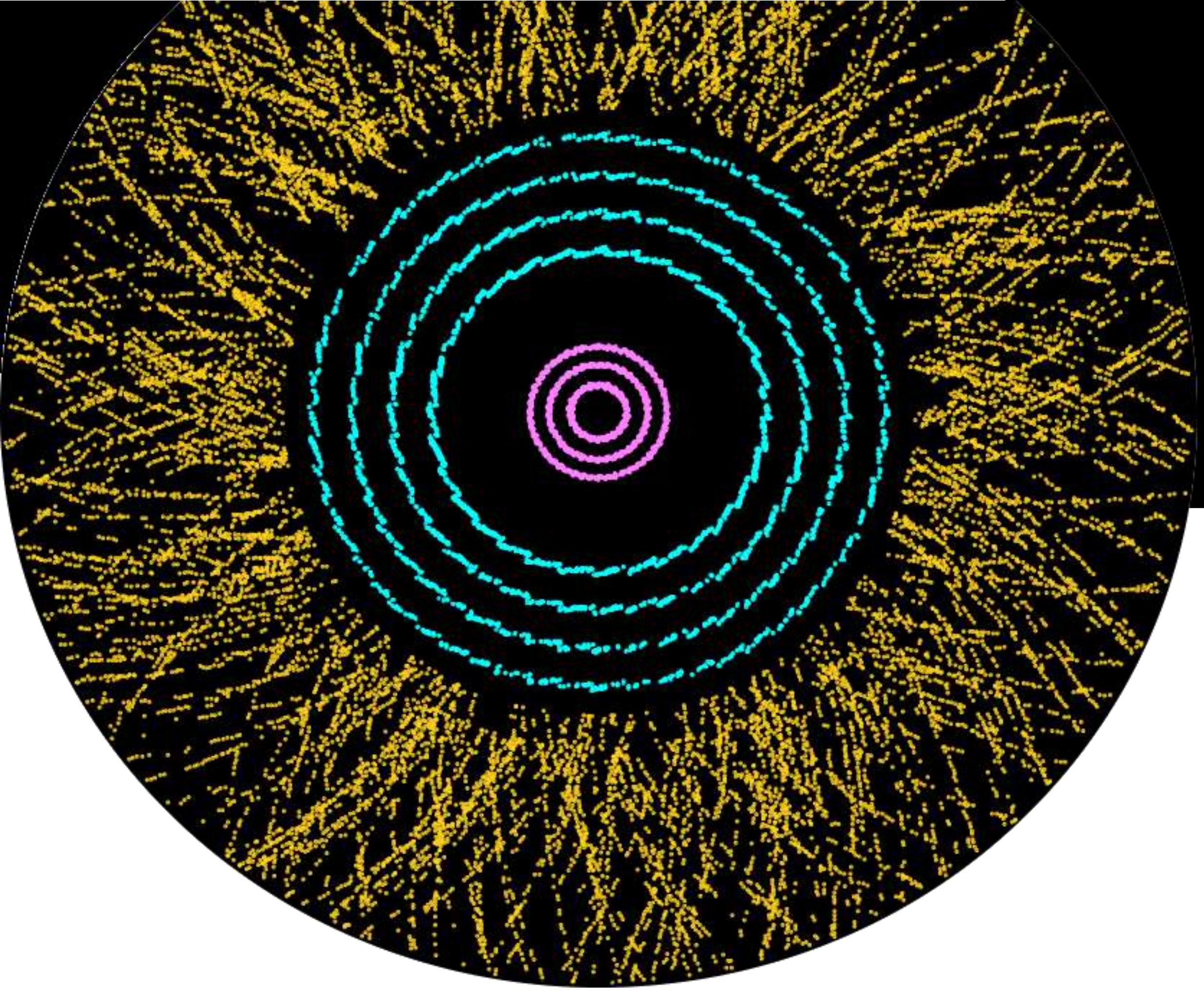
Efficiency





Efficiency

- Efficiency is calculated averaged over all straws in a detector partition
- Dead straws (~2%) excluded
- Efficiency better than 94% in the plateau
- Drops outside the plateau due to geometrical and reconstruction effects
- Identical for 900GeV and 7TeV data

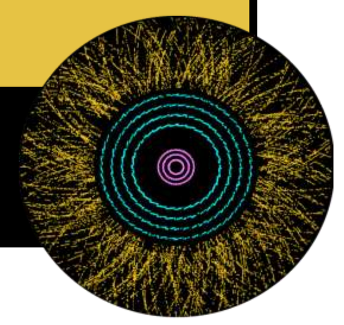


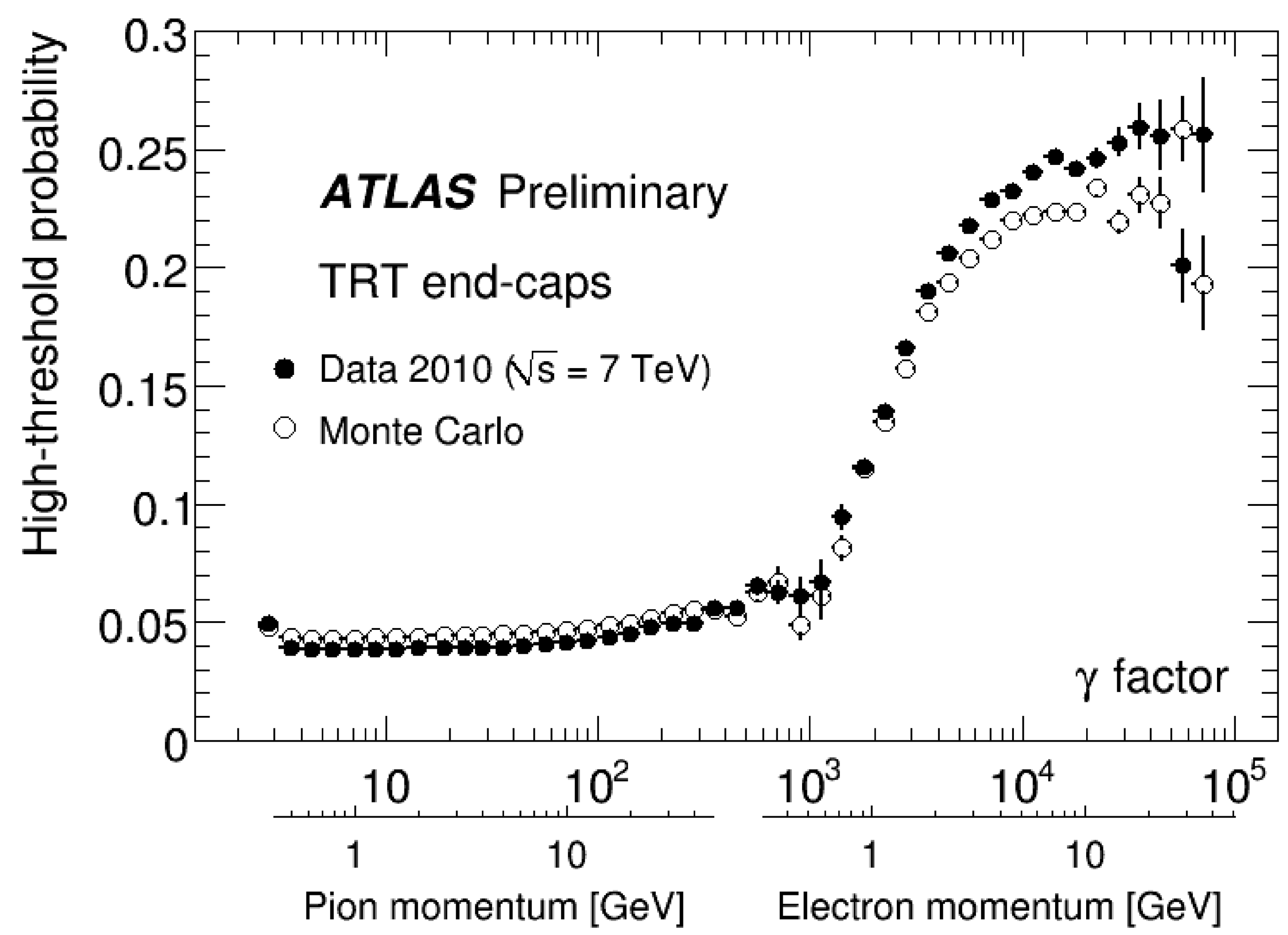
Commissioning and performance of the ATLAS Transition Radiation Tracker with first high energy pp and Pb-Pb collisions at LHC

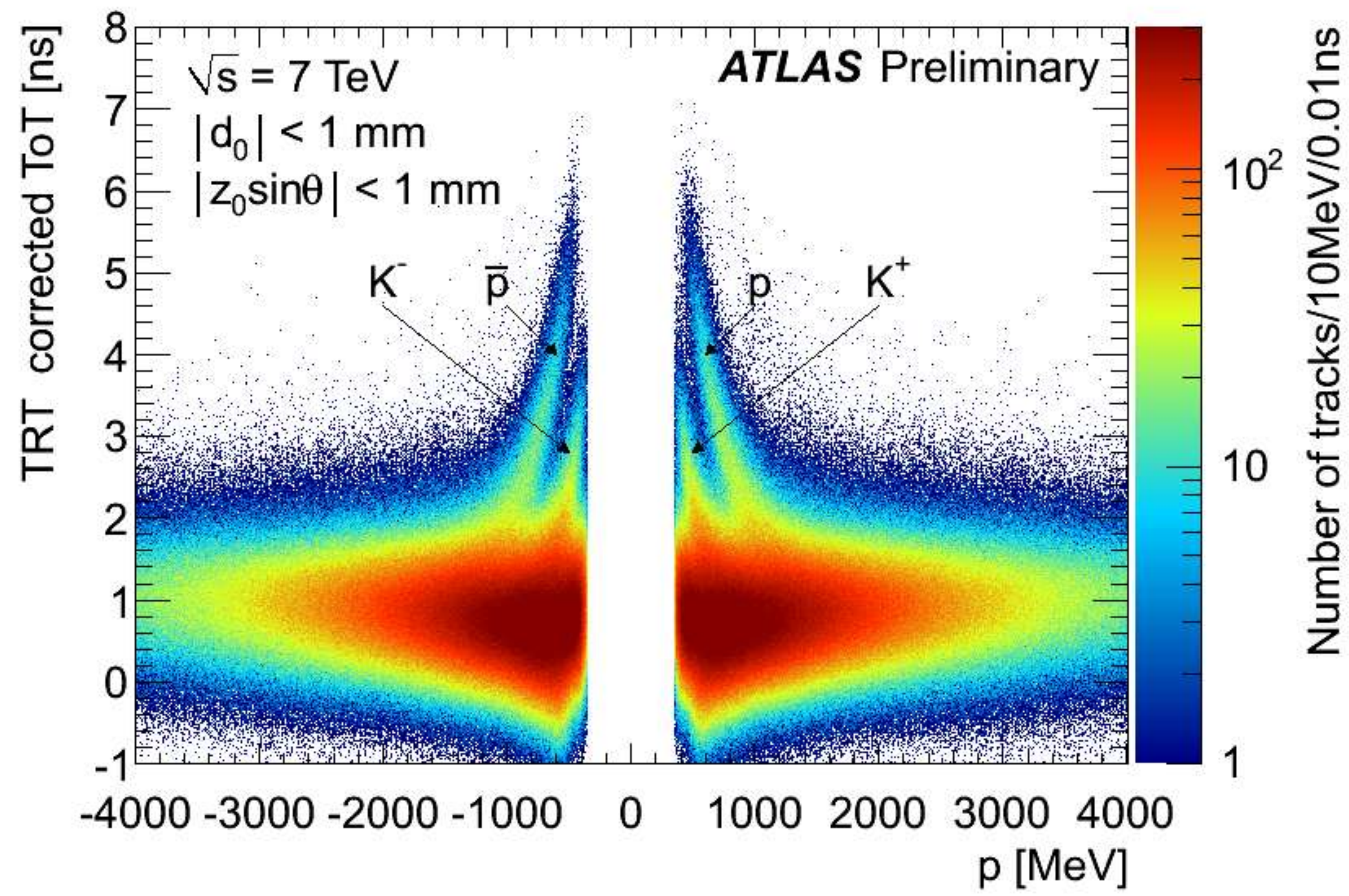
Particle identification

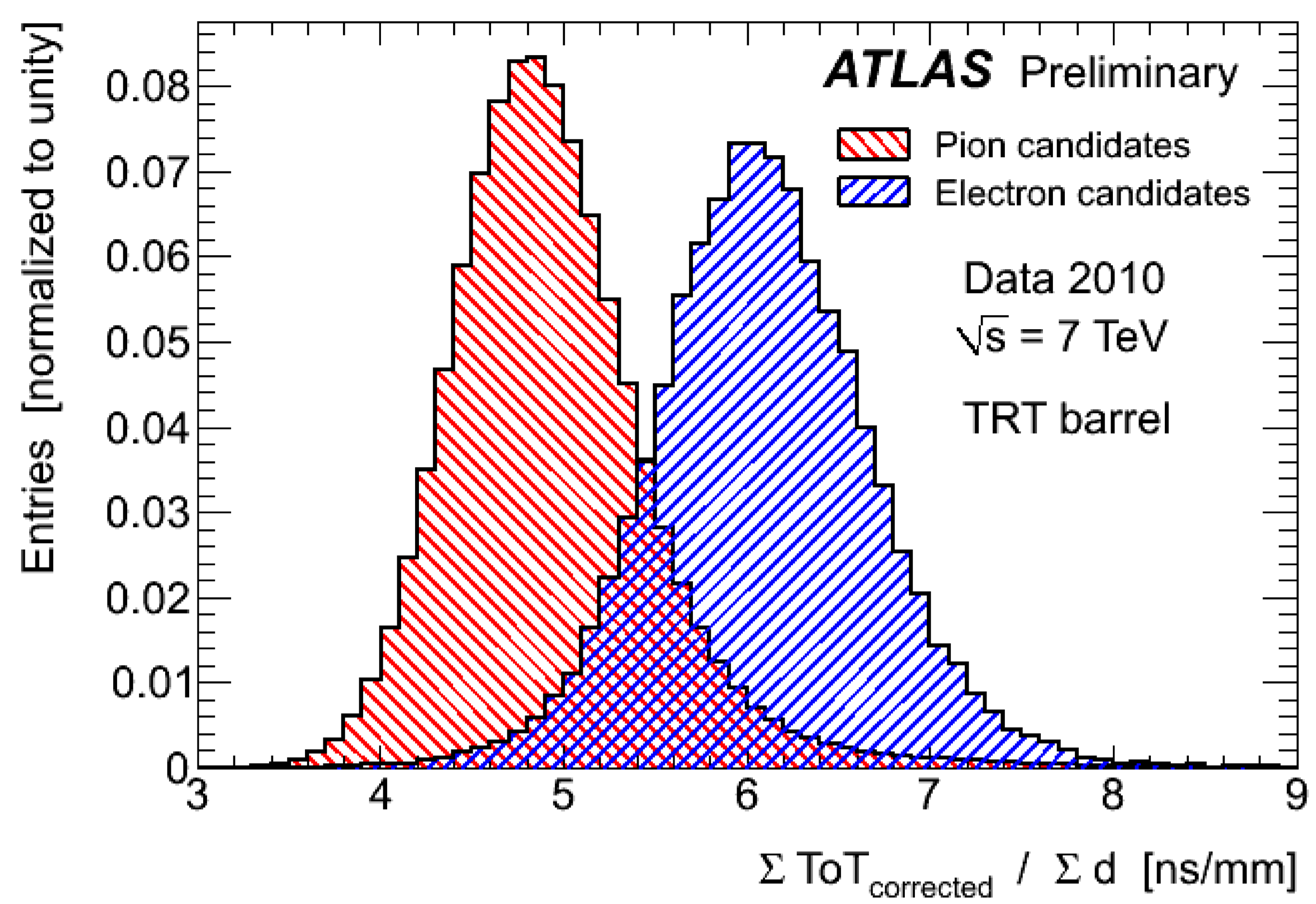
Particle ID

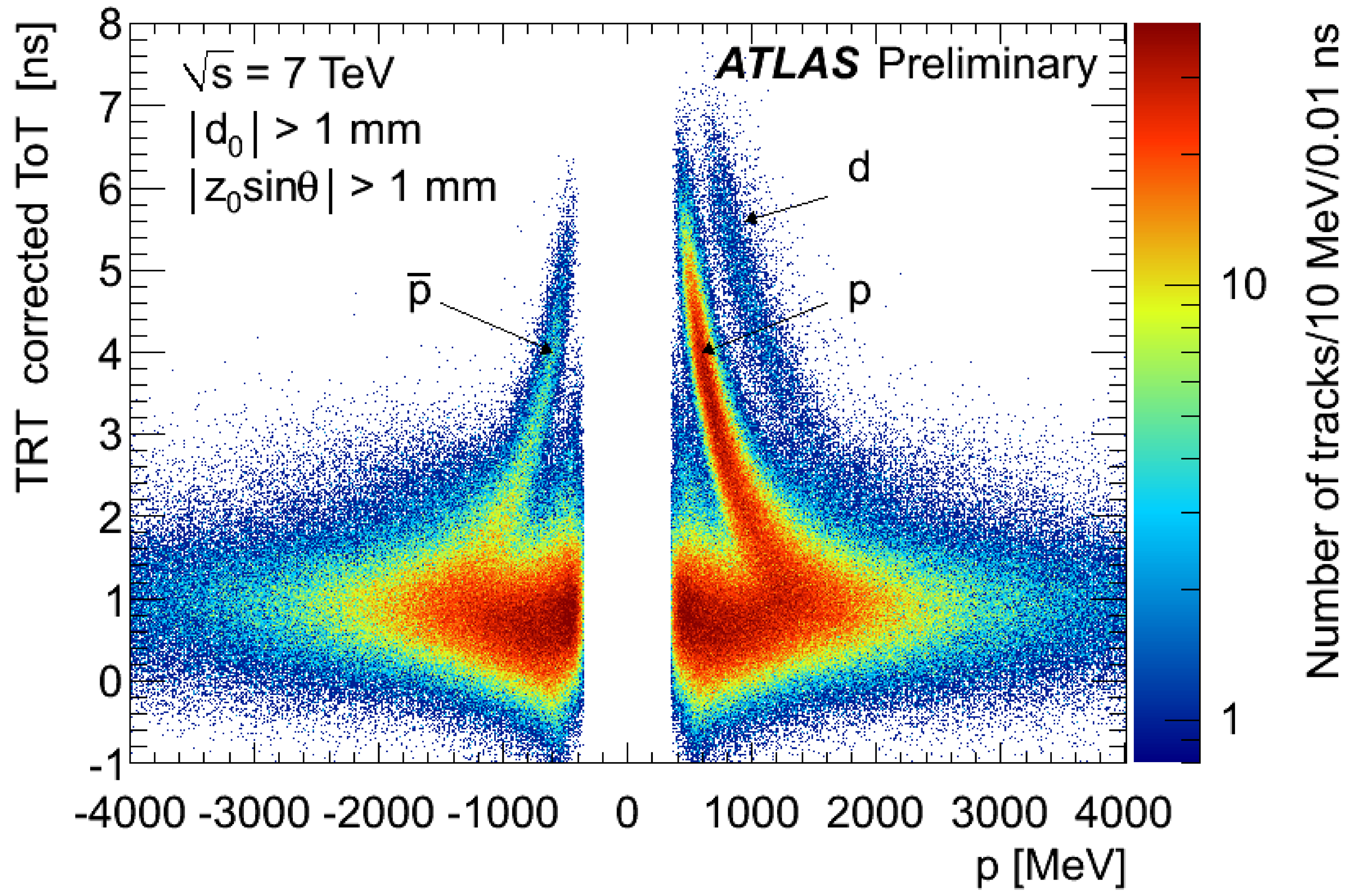
- Probability to get High Threshold hits on tracks and the measured time over threshold serve as electron discriminator
- For performance studies: Electron sample obtained from photon conversion, all hadrons treated as pions
- Combining both information a fake rate of well below 10% is obtained for a electron efficiency of 90% (depending on η and p_T)
- Significant improvements to be expected in preparation
- Hadron ID possible by using ToT as an estimator for dE/dx



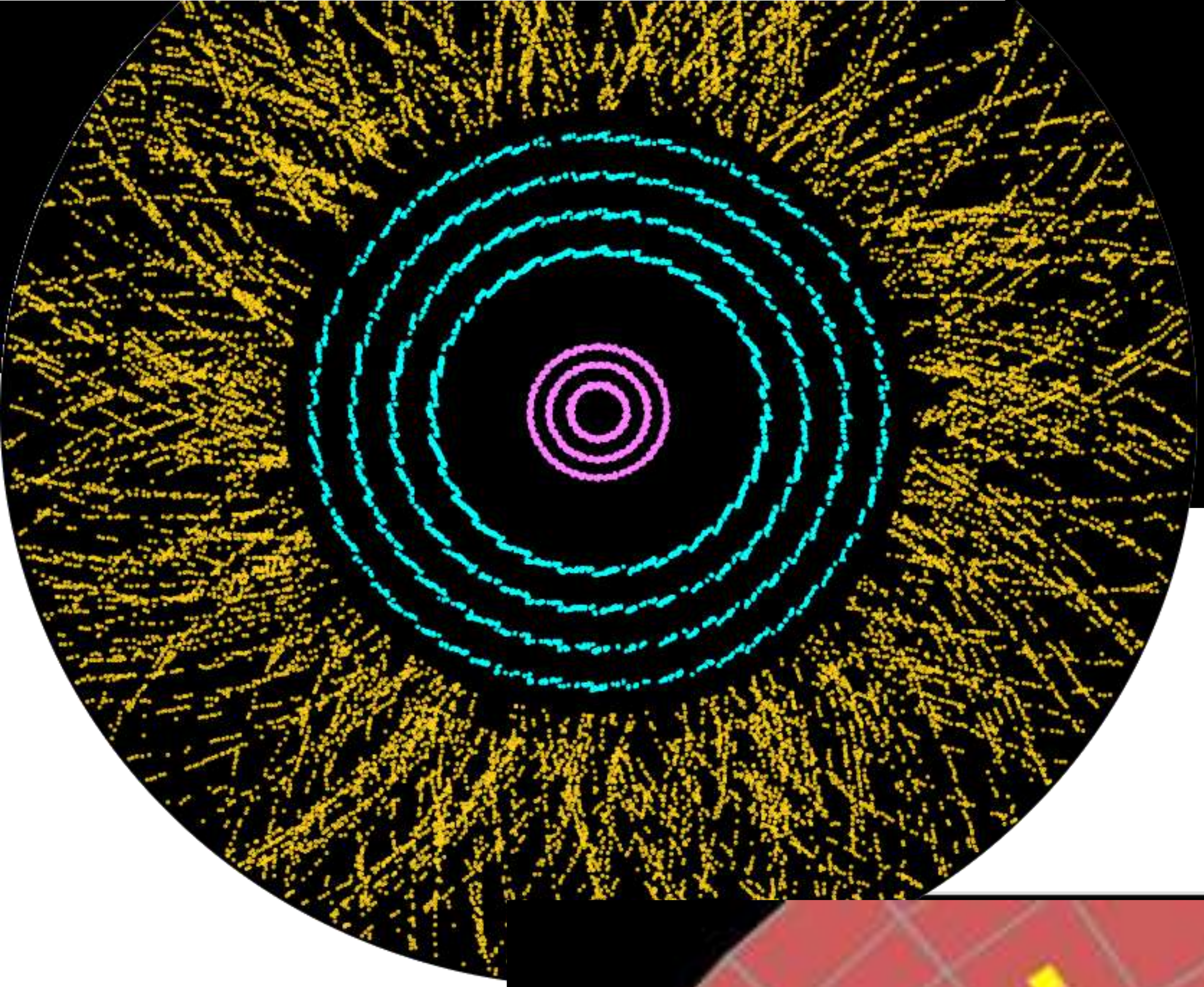






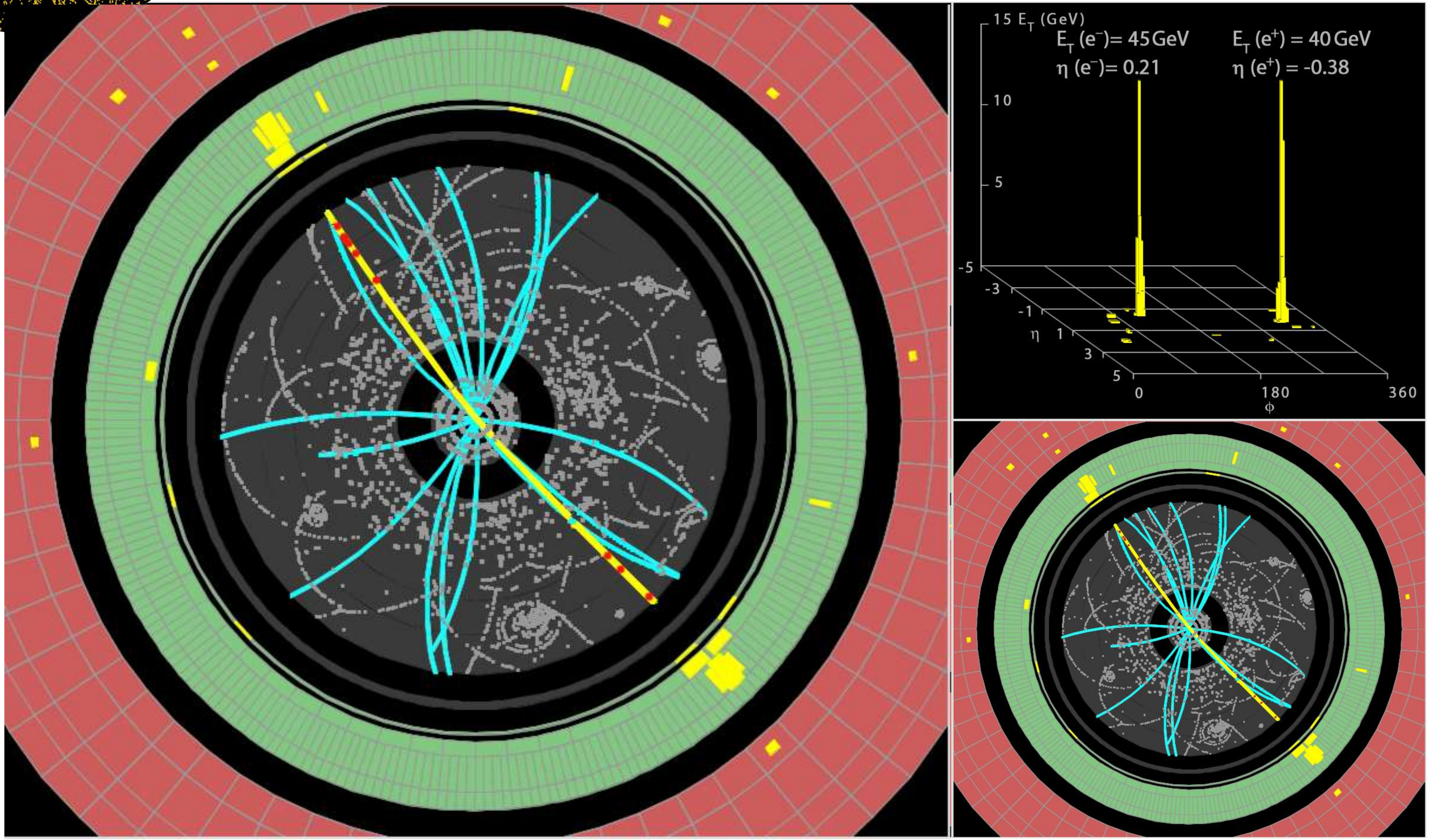


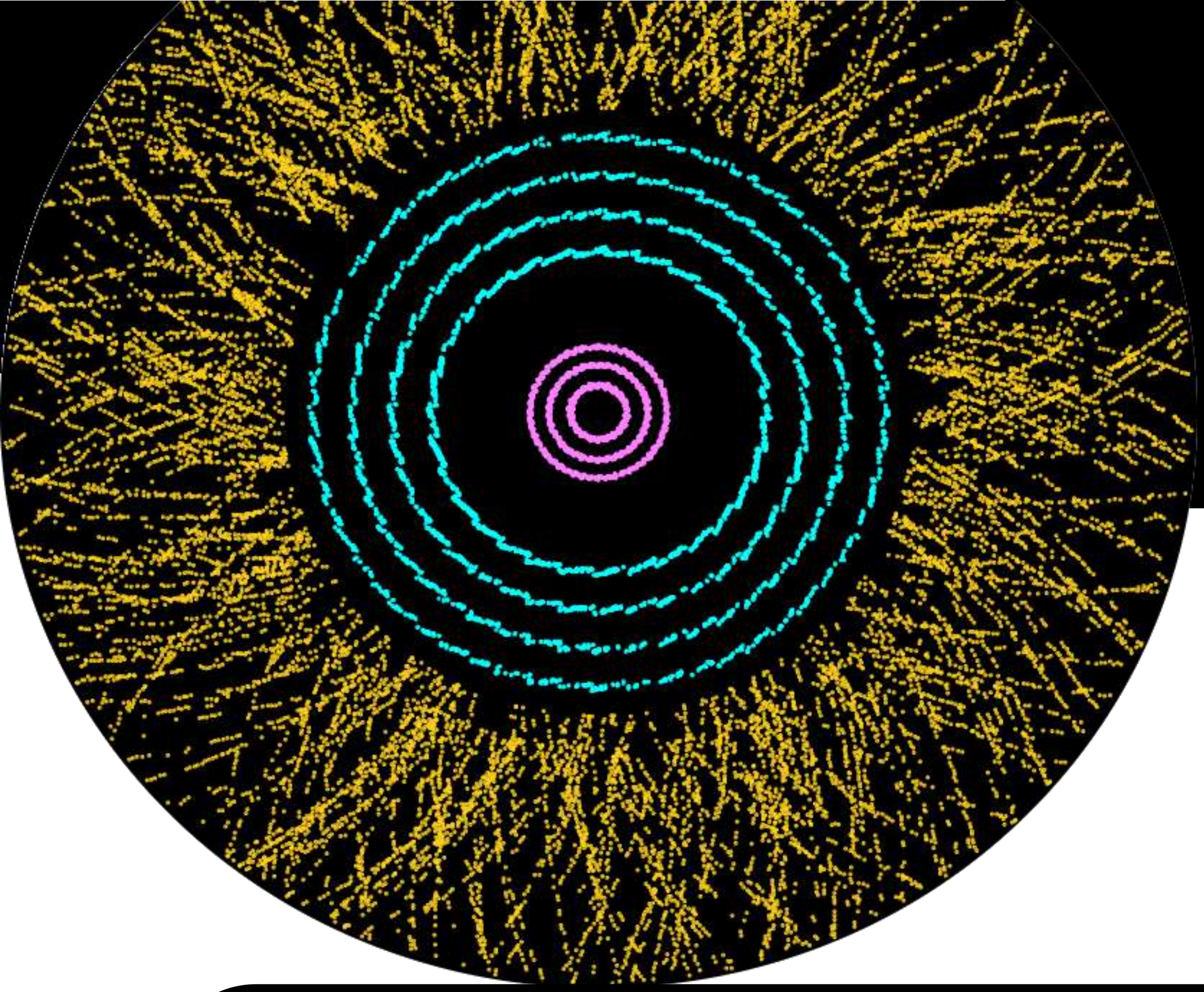
Steffen Schaepe, for the ATLAS collaboration



Commissioning and performance of the ATLAS Transition Radiation Tracker with first high energy pp and Pb-Pb collisions at LHC

Particle identification: Z -> ee candidate



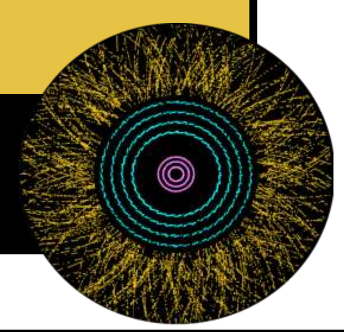


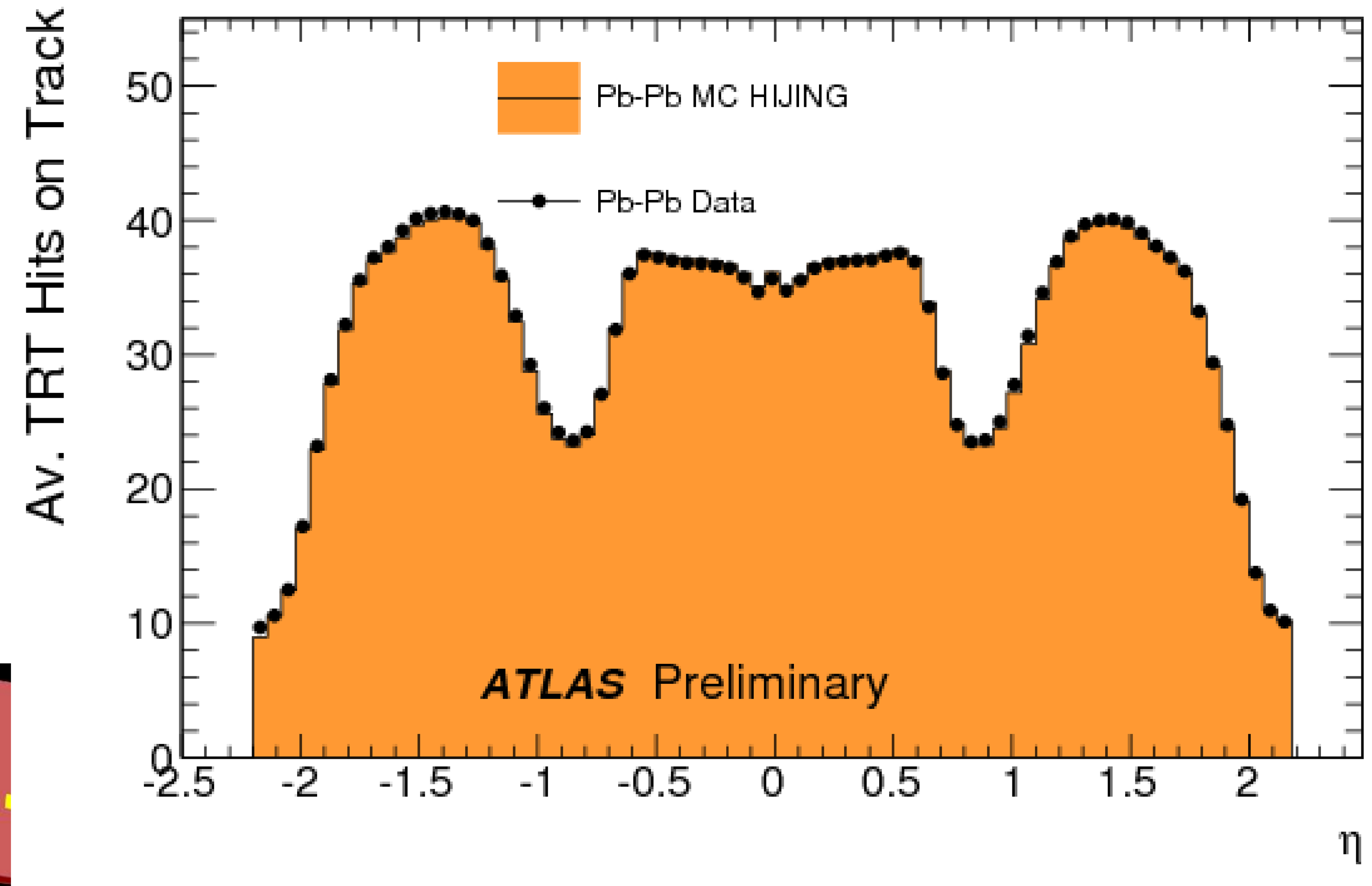
Commissioning and performance of the ATLAS Transition Radiation Tracker with first high energy pp and Pb-Pb collisions at LHC

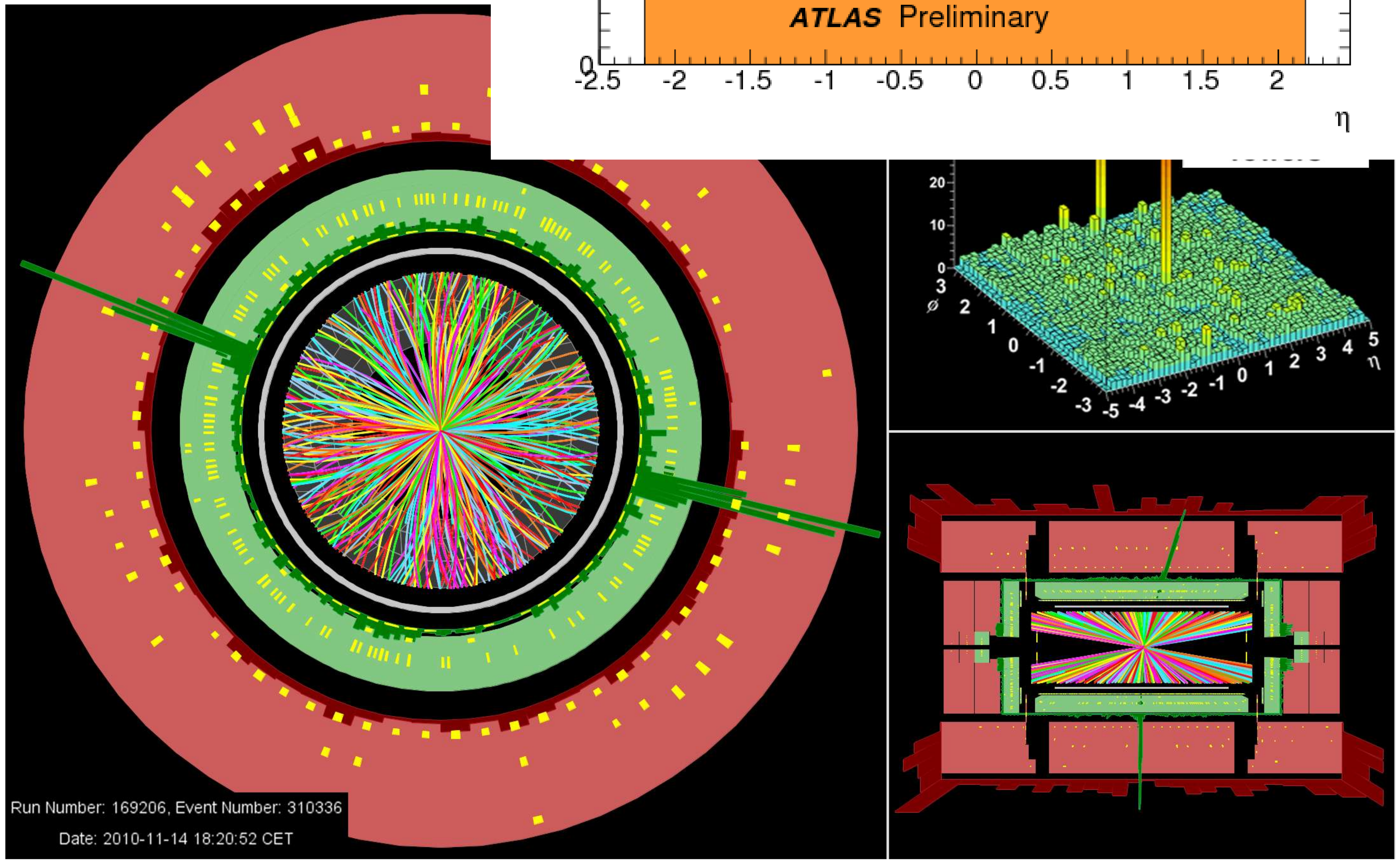
Heavy Ion collisions

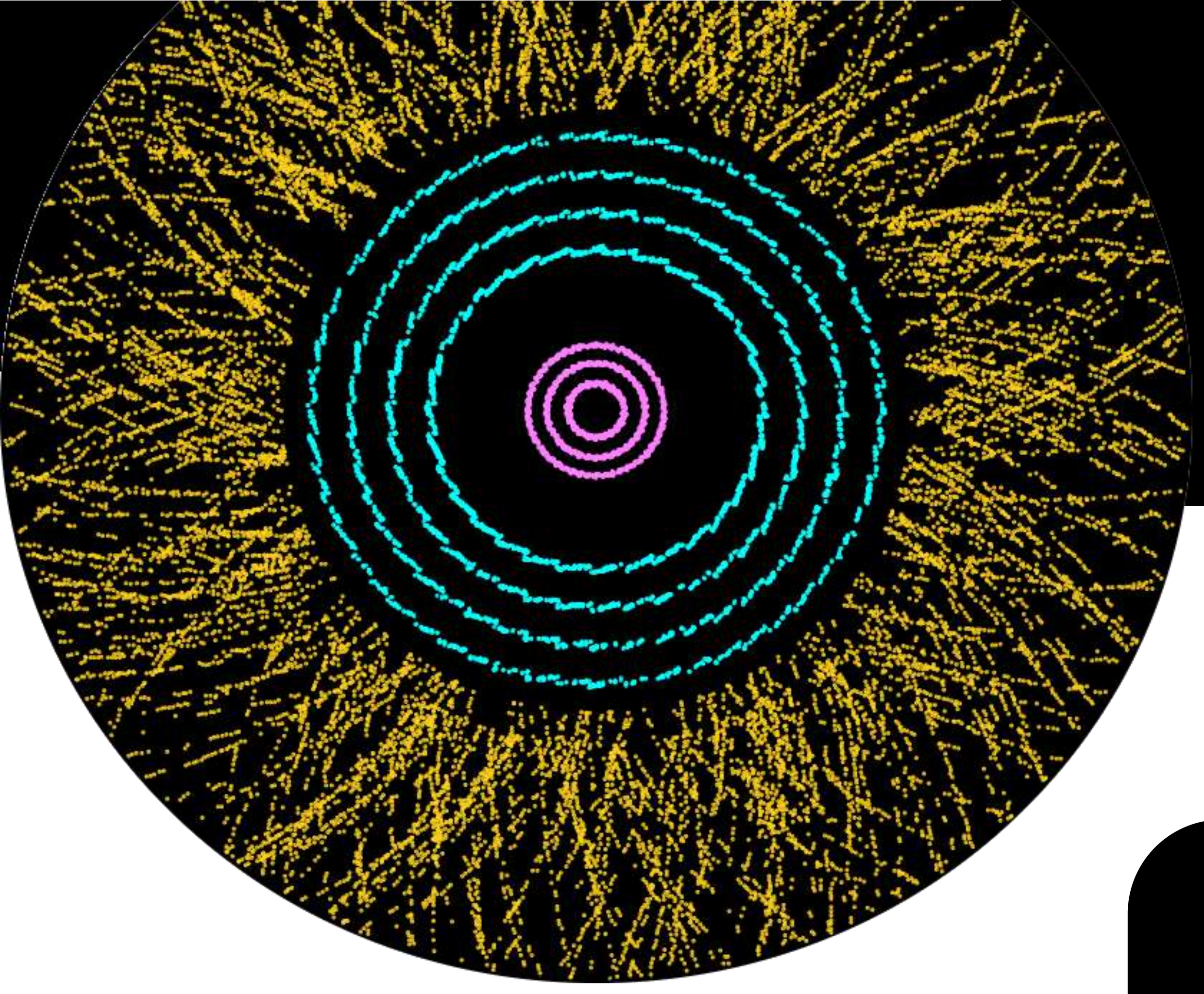
Heavy Ion collisions

- Several weeks of HI running at the end of 2010
- Very productive: First new results published as the data was still being recorded
- Very challenging environment: occupancies up to 90%, several thousands of tracks per event
- Tracking and reconstruction modified to accommodate for this environment
- Method of extension from tracklets in the Si detectors into the TRT have been adapted for HI
- TRT significantly improves momentum resolution and track finding over the full centrality and p_T range









Commissioning and performance of the ATLAS Transition Radiation Tracker with first high energy pp and Pb-Pb collisions at LHC

Conclusion

- The TRT is a very effective instruments for recording and measuring charged tracks at the ATLAS experiment
- In smooth 24/7 operation since September 2009 with a 100% uptime
- ➔ Thanks to the many devoted TRT enthusiast making this possible!!!
- Very good understanding of the detector already at this early stage of the ATLAS project
- Many improvements in development
- ➔ Performance will be pushed further towards the physical limits
- Important contribution to many physics analysis
- HI runs proof the TRT is ready for high occupancies as to be seen with full LHC intensity
- We are ready for at least 10 more years of data taking!

Inner Tracking Detectors			Calorimeters				Muon Detectors			
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	CSC	TGC
99.1	99.9	100	90.7	96.6	97.8	100	99.9	99.8	96.2	99.8

Luminosity weighted relative detector uptime and good quality data delivery during 2010 stable beams in pp collisions at $\sqrt{s}$=7 TeV between March 30th and October 31st (in %). The inefficiencies in the LAr calorimeter will partially be recovered in the future.

Steffen Schaepe, for the ATLAS collaboration