ATLAS EXPERIMENT

LHC Paperfest 26th May 2022

UNIVERSITY OF OXFORD

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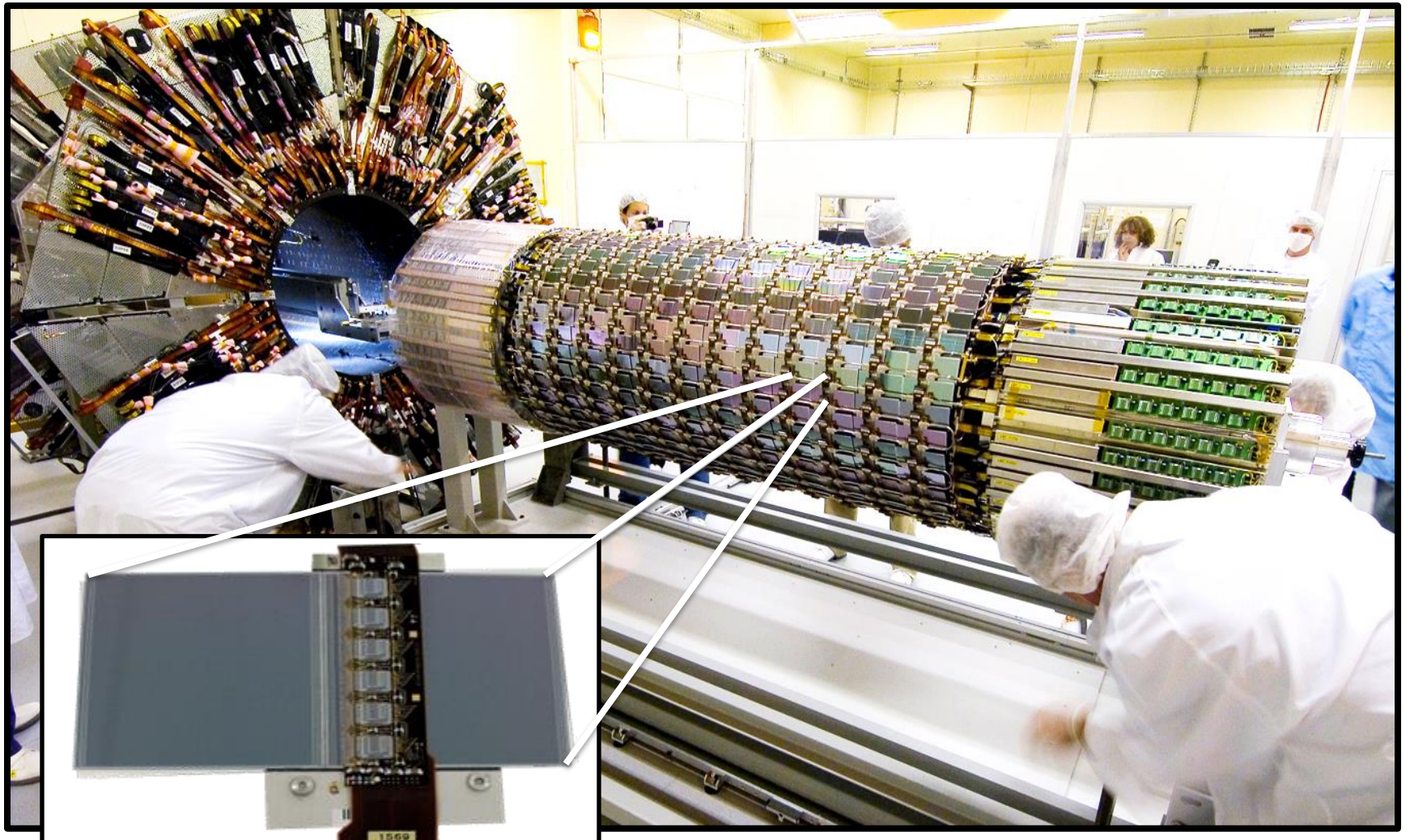
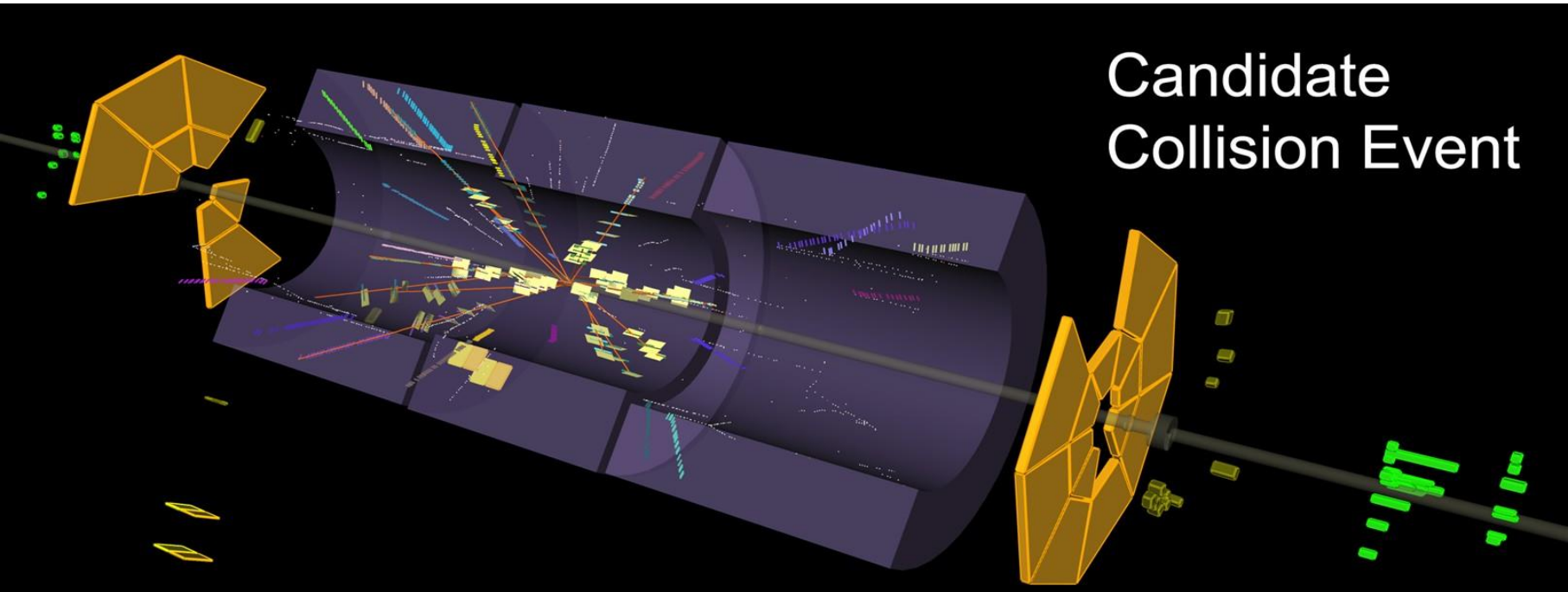
"Operation & performance of the ATLAS Semiconductor Tracker"

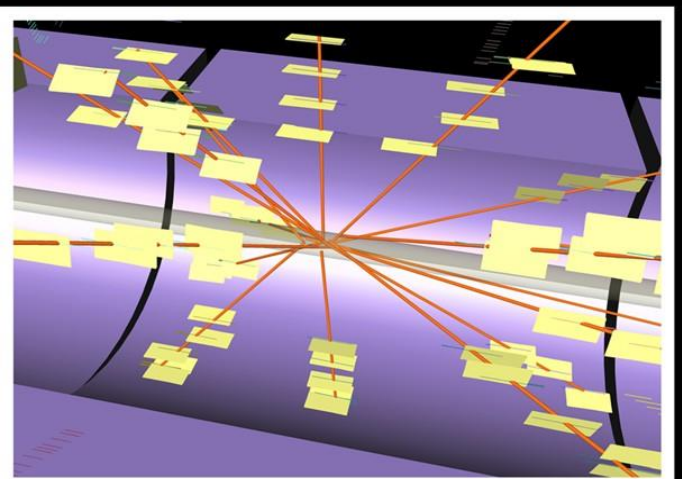
Alan Barr, University of Oxford

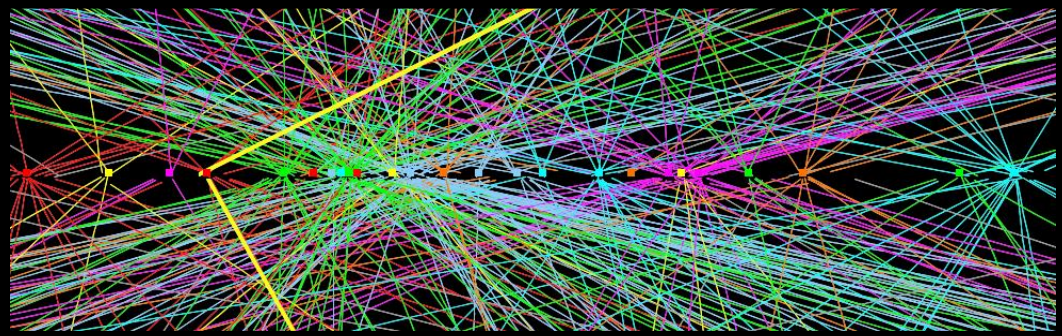


Module
Length ~ 12 cm

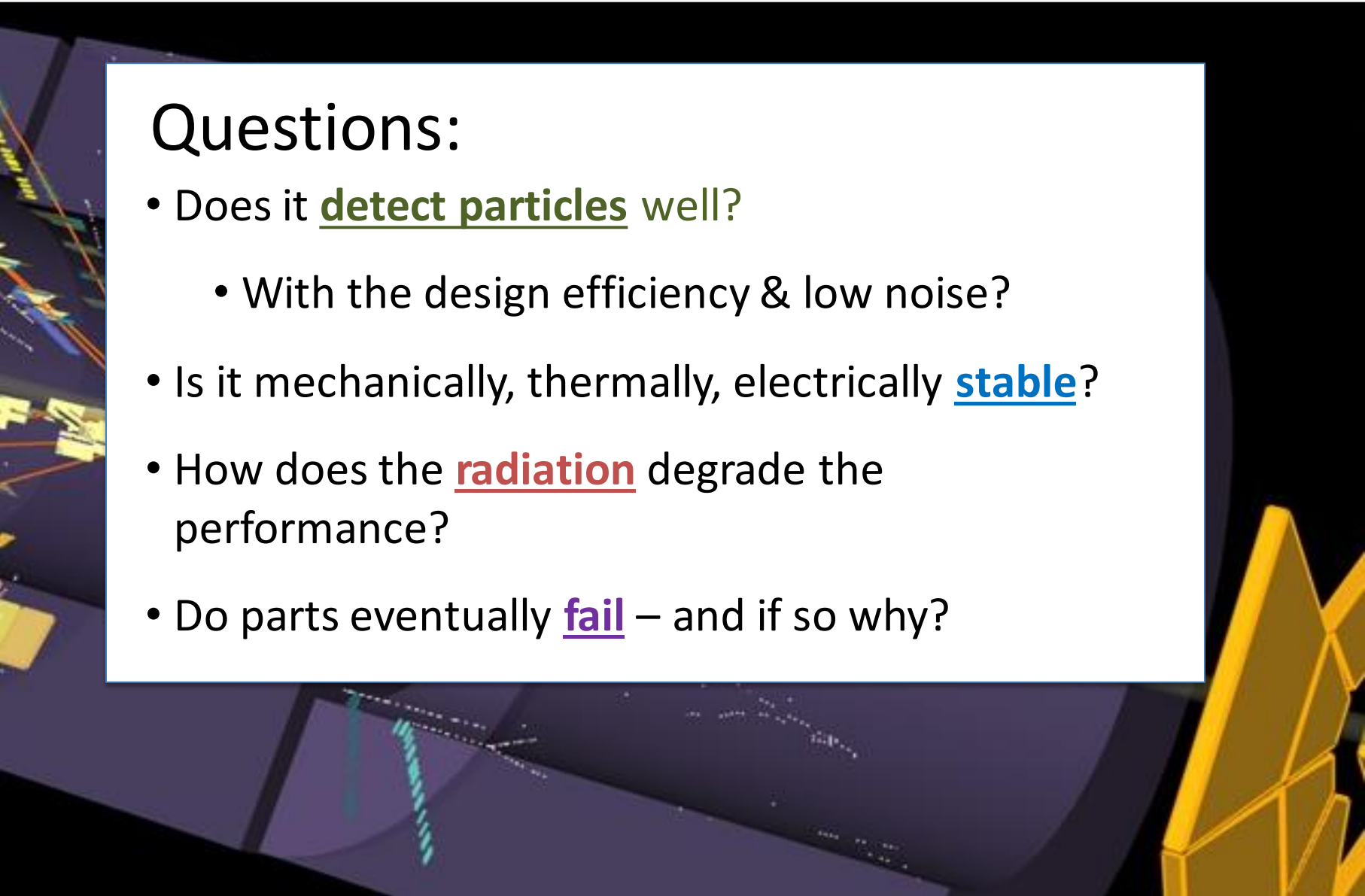
July 2005







http://atlas.web.cern.ch/Atlas/public/EVTDISPLAY/events.html



Questions:

- Does it **detect particles** well?
  - With the design efficiency & low noise?
- Is it mechanically, thermally, electrically **stable**?
- How does the **radiation** degrade the performance?
- Do parts eventually **fail** – and if so why?

Jinst

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Operation and performance of the ATLAS semiconductor tracker

April 2014
After the first LHC run

The ATLAS collaboration

E-mail: atlas.publications@cern.ch

ABSTRACT: The semiconductor tracker is a silicon microstrip detector forming part of the inner tracking system of the ATLAS experiment at the LHC. The operation and performance of the semiconductor tracker during the first years of LHC running are described. More than 99% of the detector modules were operational during this period, with an average intrinsic hit efficiency of (99.74±0.04)%. The evolution of the noise occupancy is discussed, and measurements of the Lorentz angle, δ-ray production and energy loss presented. The alignment of the detector is found to be stable at the few-micron level over long periods of time. Radiation damage measurements, which include the evolution of detector leakage currents, are found to be consistent with predictions and are used in the verification of radiation background simulations.

KEYWORDS: Solid state detectors; Charge transport and multiplication in solid media; Particle tracking detectors (Solid-state detectors); Detector modelling and simulations I (interaction of radiation with matter, interaction of photons with matter, interaction of hadrons with matter, etc)

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2014 JINST 9 P08009

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Q: Radiation effects?

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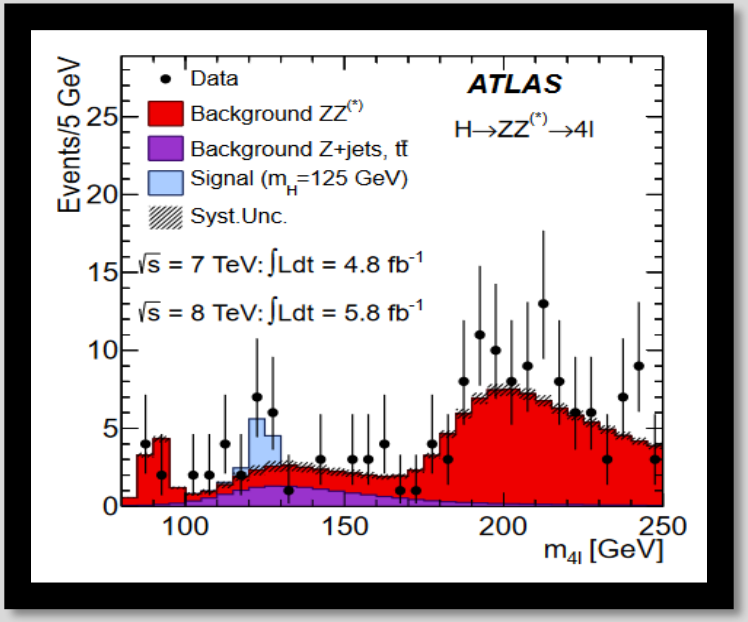
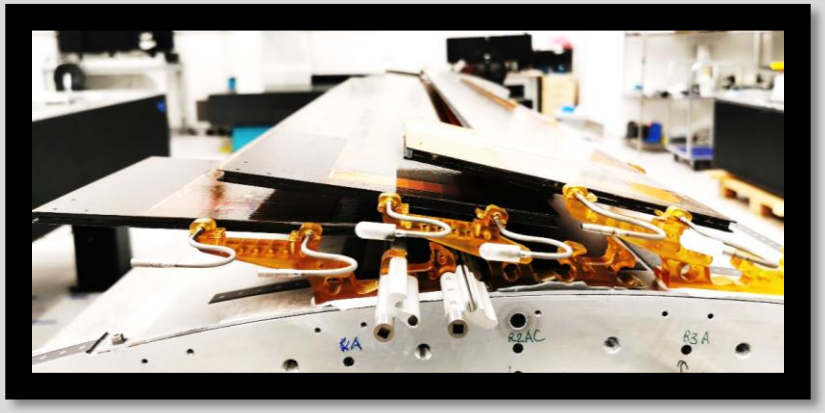
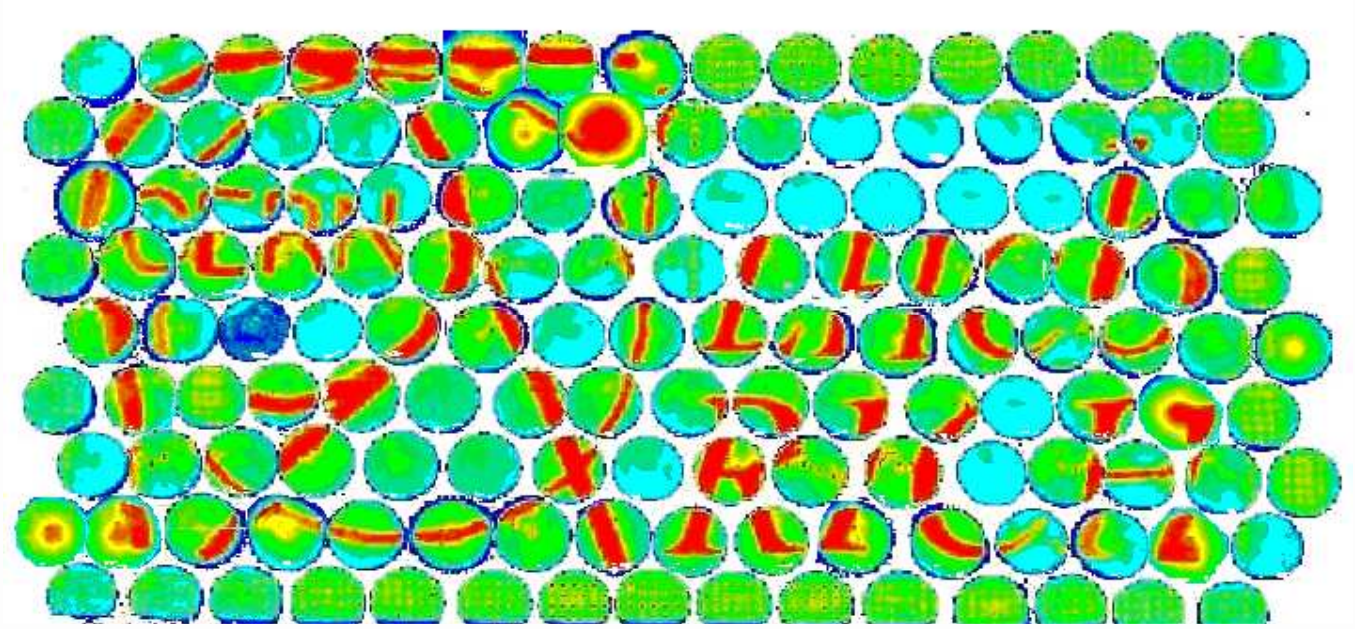

Data
Background ZZ(*)
Background Z+jets, tt̄
Signal (m_H=125 GeV)
Syst.Unc.
√s = 7 TeV: ∫Ldt = 4.8 fb-1
√s = 8 TeV: ∫Ldt = 5.8 fb-1
ATLAS
H→ZZ(*)→4l
Events/5 GeV
m4l [GeV]





The LHCb RICH detectors

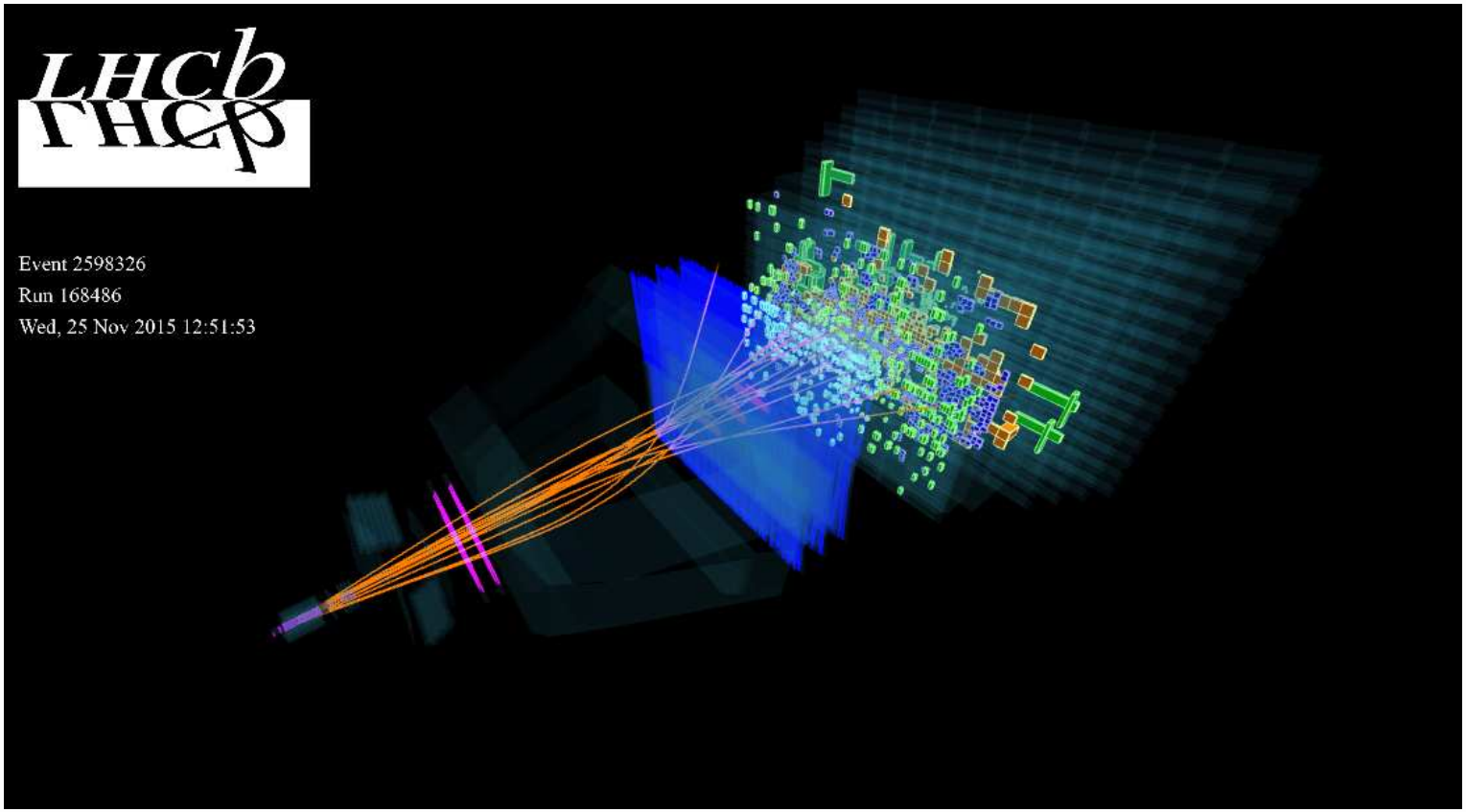
Silvia Gambetta

LHC Paperfest

Why hadron Particle identification?

Collisions at LHC $\Rightarrow$ observe processes by detecting particles generated $\Rightarrow$ detect tracks, measure energy, identify particles

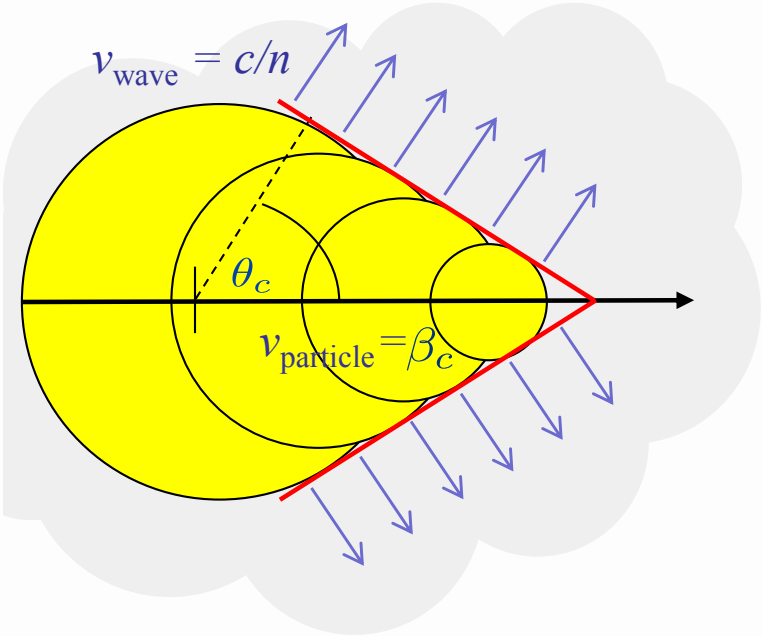
Particle identification is one of the key aspects of high-energy physics experiments: different techniques employed in different experiments

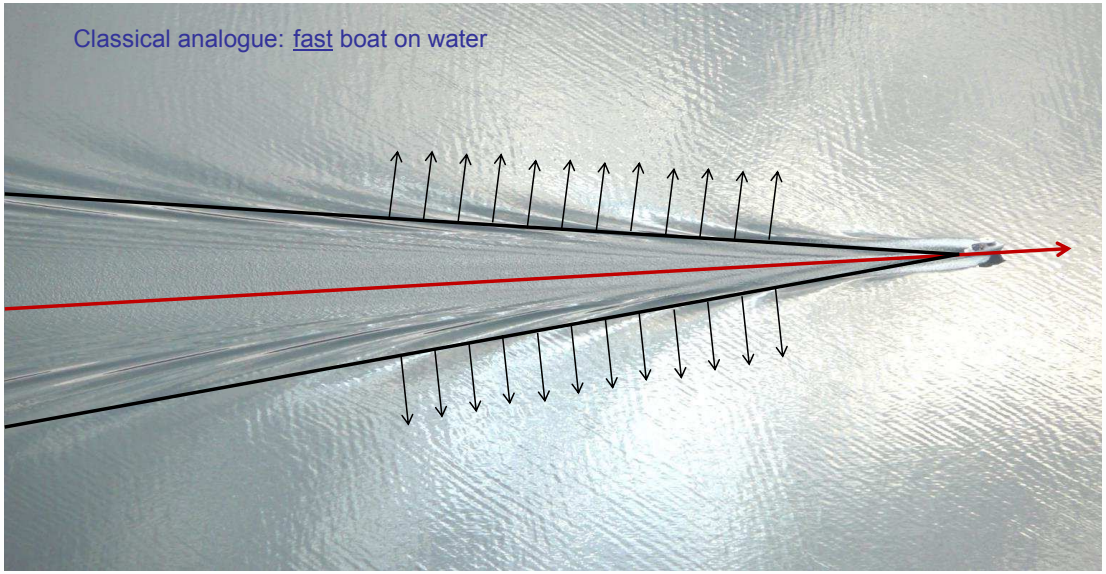


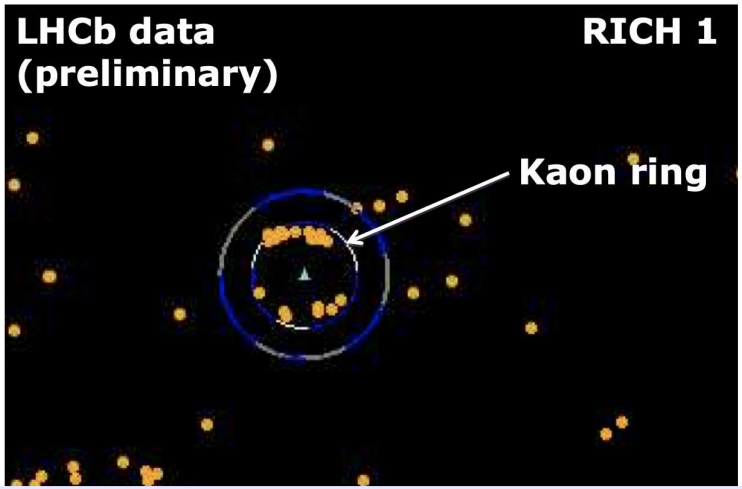
extreme precision needed in flavour physics to distinguish p, K and π in very crowded environment: distinguish final states of identical topology!

A Ring Imaging Cherenkov detector

A charged particle traversing a medium with a velocity v larger than the velocity of light in the medium emits light



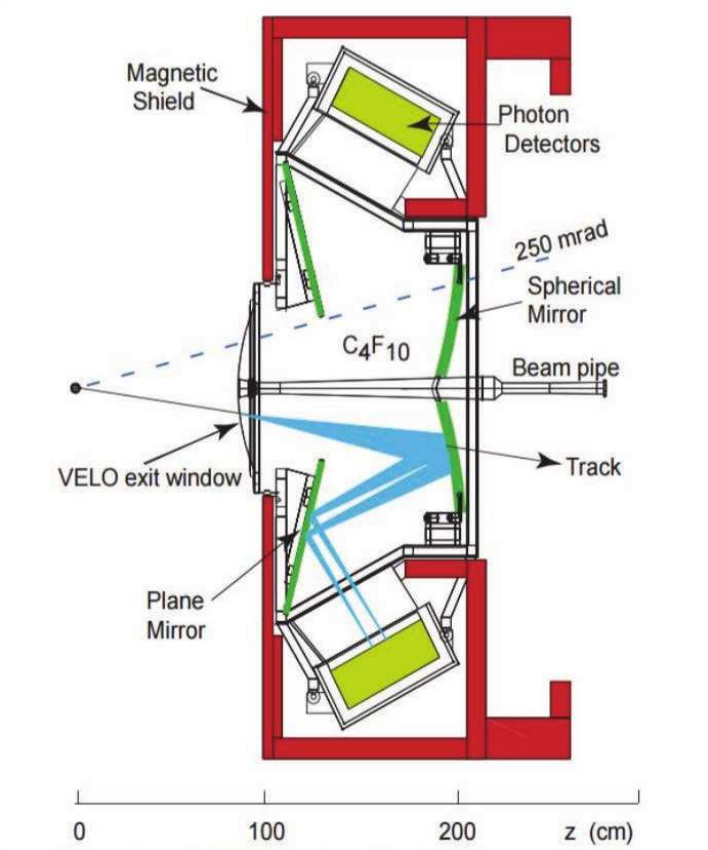


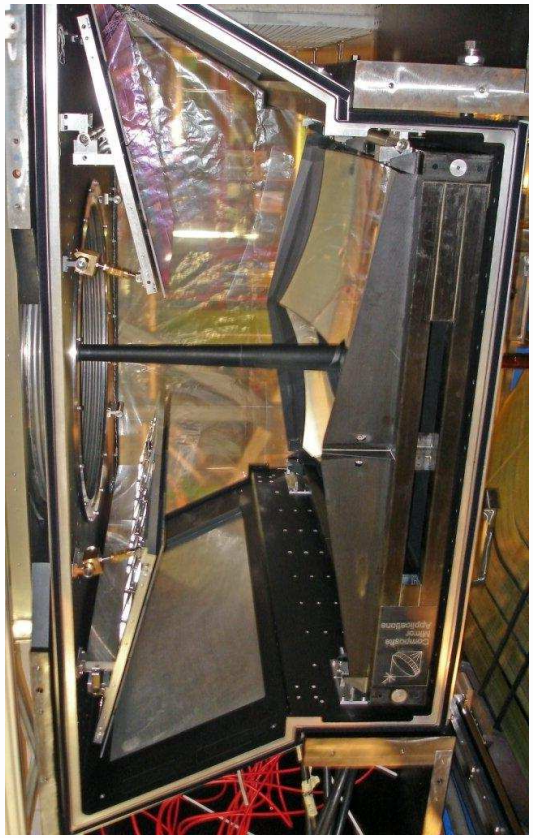


- the aperture of the cone depends on the type of particle
- a "slice" of the cone is a ring of photons
- rings can be imaged

RICH detectors combined with tracking detectors provide the mass of the particle with high precision

The LHCb RICH detectors



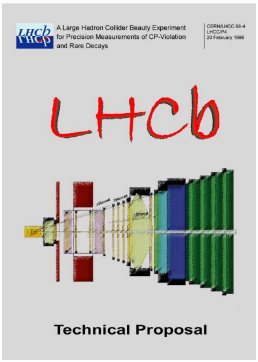


how to build a RICH detector:

- a volume of radiator (gas) to generate photons from charged particles
- a system of mirrors to focus and reflect the photons
- a plane of photon detectors to detect single photons imaged in rings

Two RICH detectors built and installed in LHCb: particle identification over large momentum range (2-100 GeV) in unprecedented conditions ($\sim$100 tracks per primary vertex)

The LHCb RICH system



1998 The LHCb Technical Proposal Approved: CERN-LHCC-98-004

2000 RICH Technical Design Report submitted and approved: CERN LHCC 2000-037

2005-2007 The RICH system gets installed in the LHCb cavern

2008-2010 The RICH system begins operations!

2010-2018 LHCb Run1 and Run2 $\rightarrow$ a rich production of exciting physics results

"The LHCb Detector at the LHC" (JINST 3 S08005)

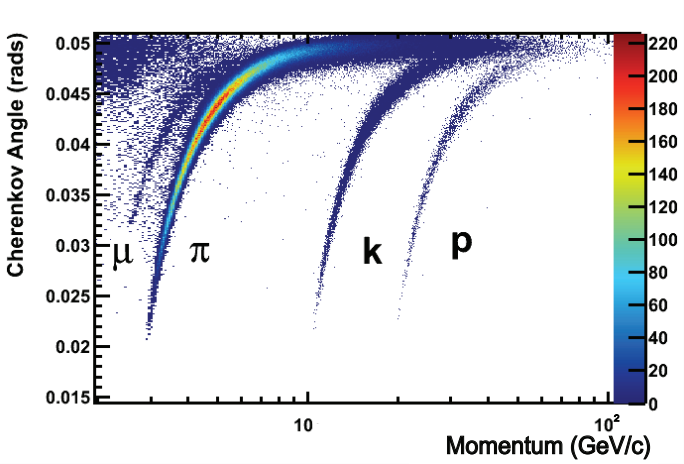
custom developed photon detectors: HPD in both RICH1 and RICH2

carbon fibre mirrors: 1.5% radiation length in RICH1

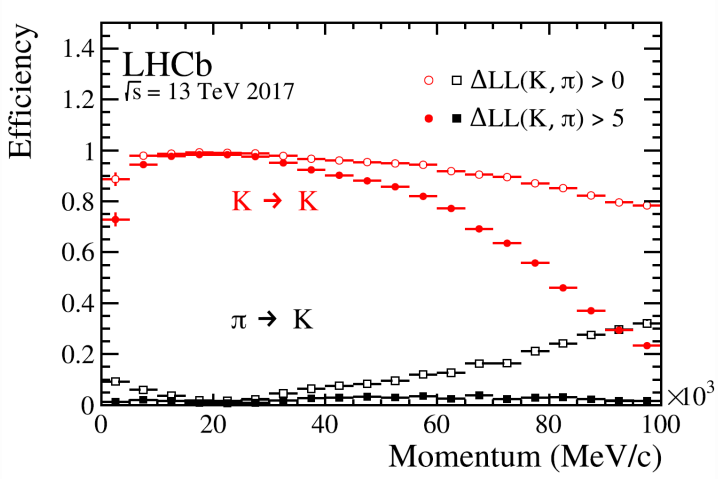
RICH2: the biggest detector lowered "in one piece" in the LHCb cavern

The RICH detectors performance

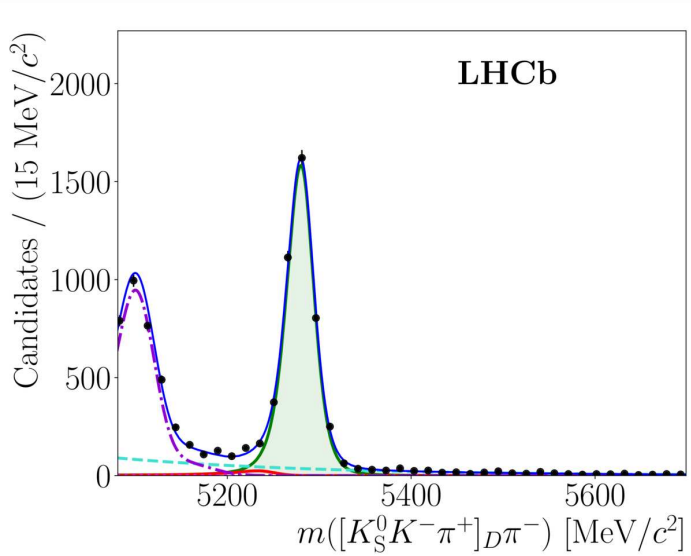
"Performance of the LHCb RICH detector at the LHC"
(Eur. Phys. J. C 73 (2013) 2431)

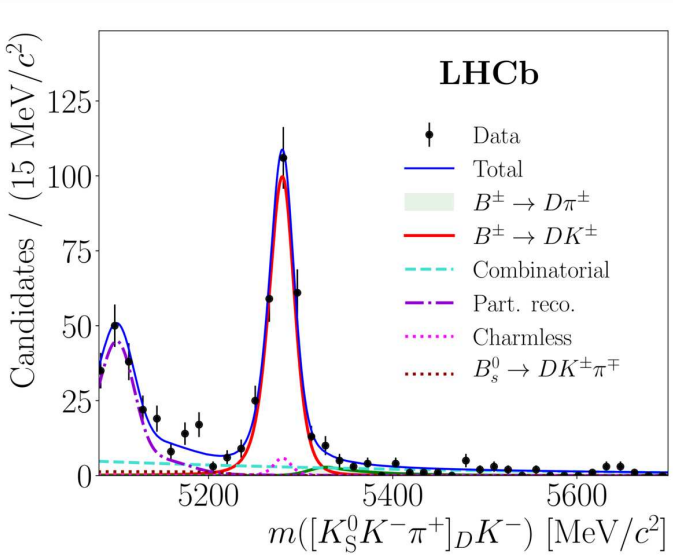


"Performance of the LHCb RICH detectors during LHC Run 2"
(accepted by JINST)



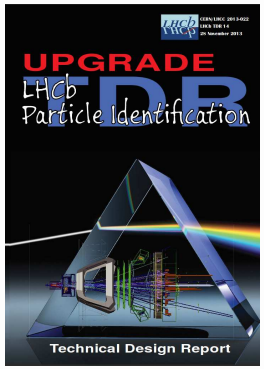
Example of matter-antimatter asymmetry study only possible thanks to the identification of K vs π (JHEP, 06:58, 2020)





excellent particle identification performance of p, K, π: key in all areas of physics programme of LHCb!

What's next?



2012 LHCb Upgrade Technical Design Report: CERN-LHCC-2012-007

2014 RICH Upgrade Technical Design Report submitted and approved: CERN-LHCC-2013-022

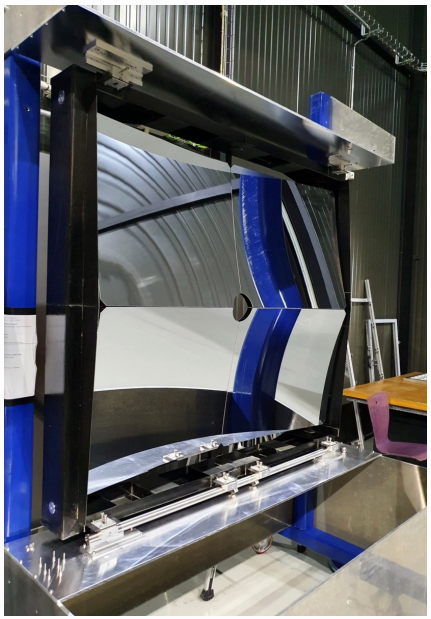
2021 The RICH Upgrade system gets installed in the LHCb cavern

2021 First collisions observed during LHC beam test

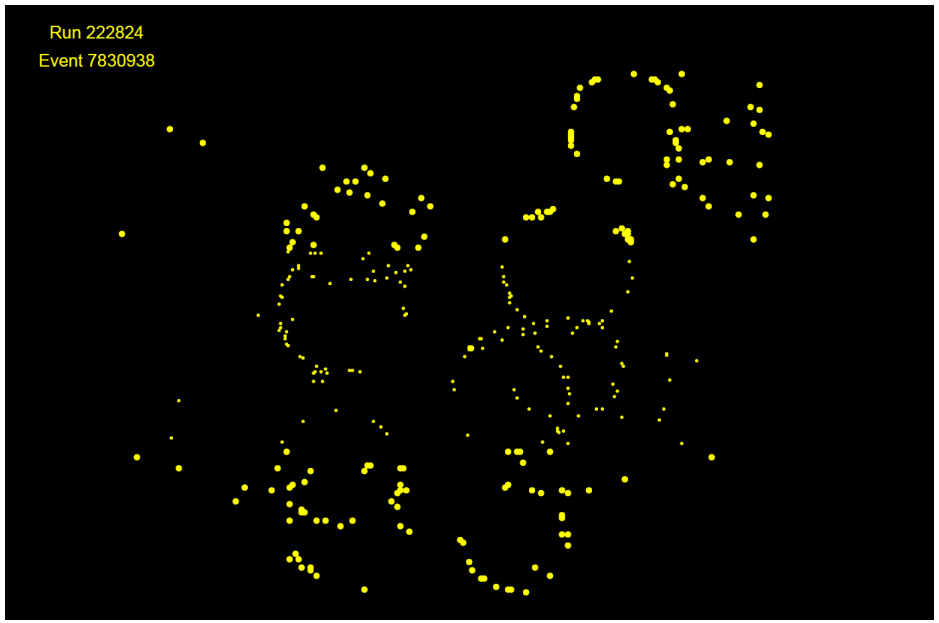
2022 Run3 is about to start! first stable beams tomorrow and first high energy collisions on 5 July!

"The LHCb Upgrade Detector construction paper": coming soon!

new photon detectors: MaPMTs in RICH1 and RICH2



new optics and mechanics in RICH1



first rings detected in the new RICH2 in 2021!

getting ready for a new season of successes!