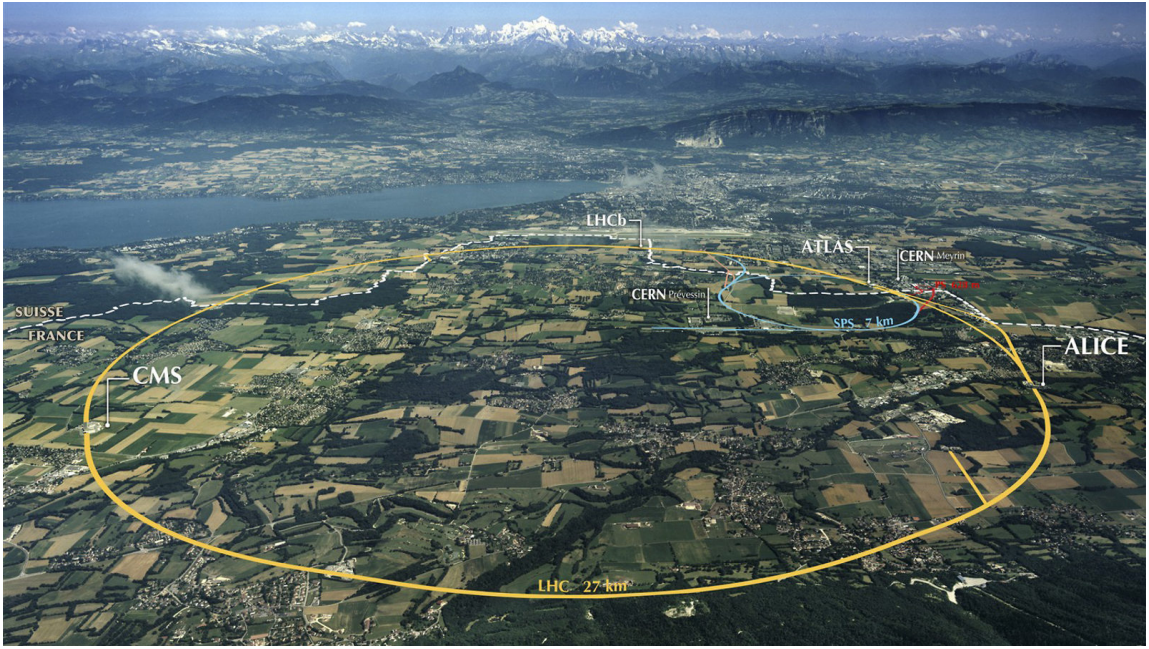
Science & Technology Facilities Council
Rutherford Appleton Laboratory

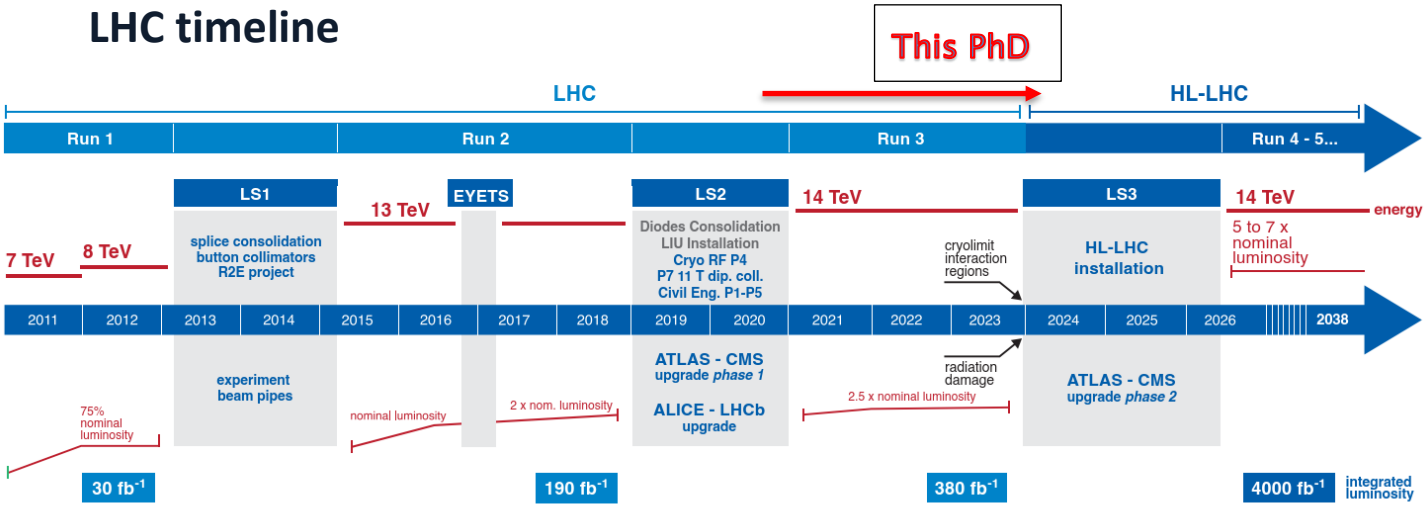
Particle Physics

ATLAS studentship at RAL

Particular emphasis on preparation of upgraded ATLAS High Level Trigger for LHC Run 3



LHC timeline



LHC first started serious data taking in 2011

Run 1, ran at up to 75% nominal luminosity, culminated in discovery of Higgs boson

LHC Run 2 finished at end of 2018

Reached 2 times nominal luminosity, delivered over 5 times data of Run 1

Now in Long Shutdown 2 for upgrade for Run 3

Machine consolidation, Phase-I upgrades to ATLAS

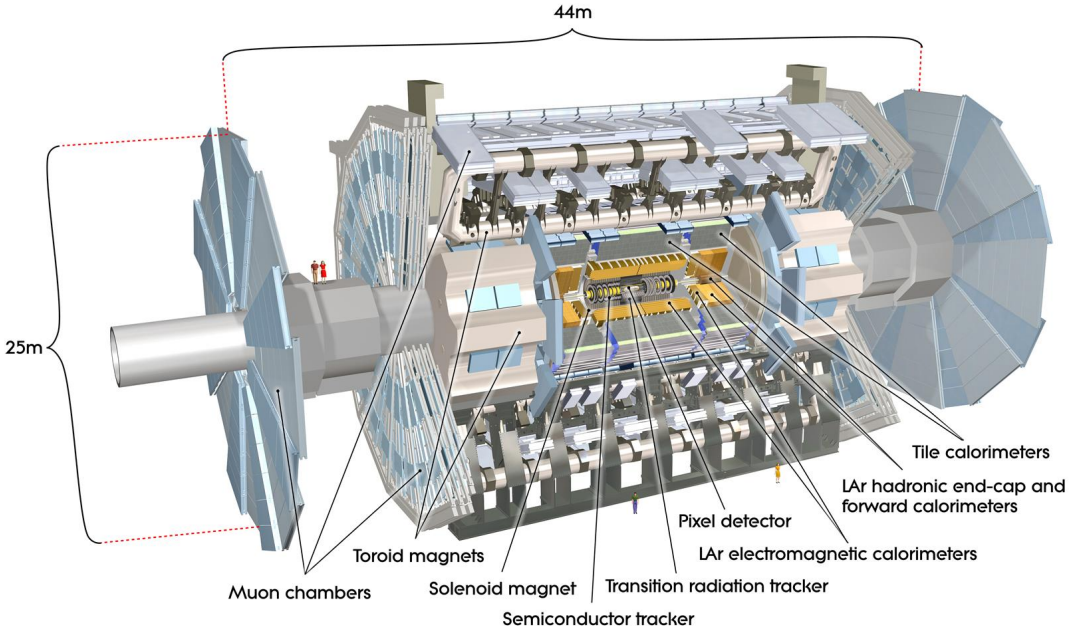
Further Long Shutdown 3 starting in 2024 for upgrade to HL-LHC

Phase-II upgrades to ATLAS for 5 to 7 times nominal luminosity

ATLAS Experiment

ATLAS one of two general purpose detectors at the Large Hadron Collider

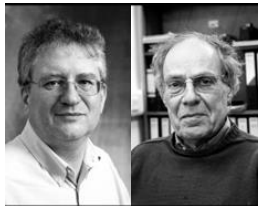
25 m high, 44 m in length, consisting of different subsystems wrapped concentrically in layers around collision point to record trajectory, momentum and energy of particles



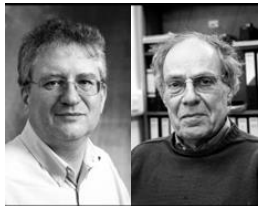
ATLAS Collaboration ~5000 scientists and engineers, 182 institutions, 38 countries

In UK 14 universities and Rutherford Appleton Laboratory (RAL group 22 people)

RAL ATLAS group



RAL ATLAS group



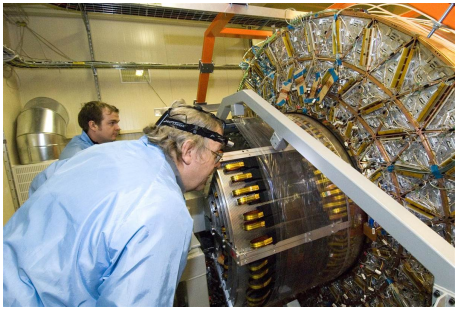
RAL involvement in ATLAS

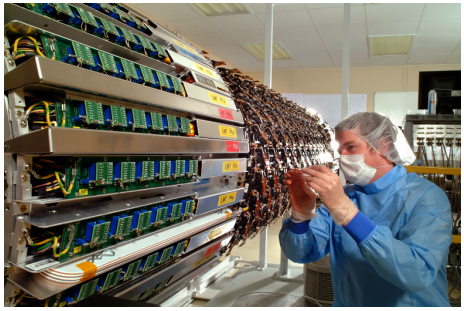
RAL group had responsibility for original construction

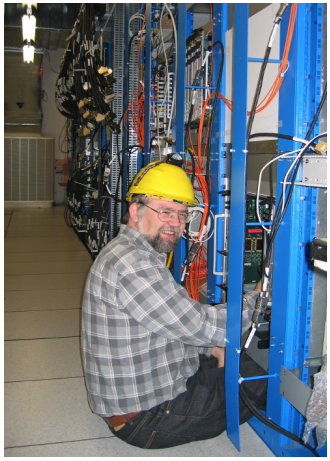
Level-1 Calorimeter Trigger

High Level Trigger

Semi-Conductor Tracker (SCT)







Since then operating the detector and contributing to the physics analysis

Including B physics, Higgs measurements and searches for heavy bosons

Now preparing for upgrades

Phase-I upgrades for installation this Long Shutdown

- Level-1 Calorimeter Trigger and High Level Trigger

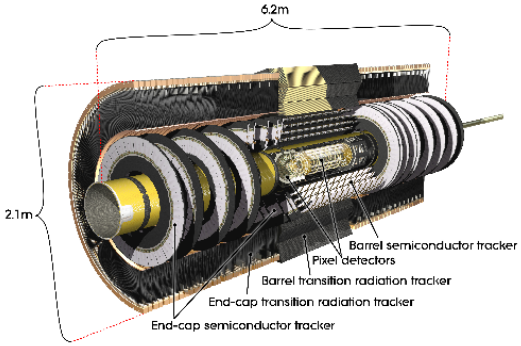
Phase-II upgrades for installation in next Long Shutdown starting in 2024

- Level-0 Global Trigger, Event Filter and new Inner Tracker (ITk)

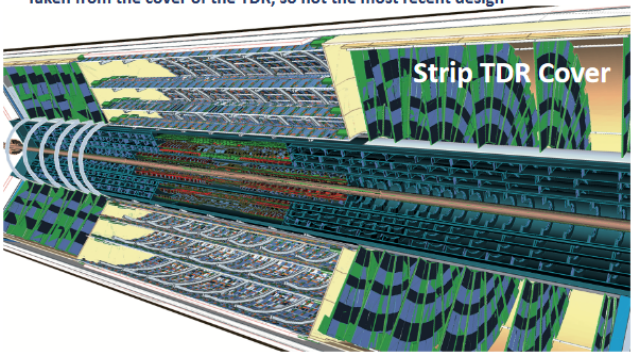
ITk

Original Inner Detector reaches its end of life in 2024

Will be replaced with new all silicon detector



Taken from the cover of the TDR, so not the most recent design



RAL involved in barrel strips and endcap pixels

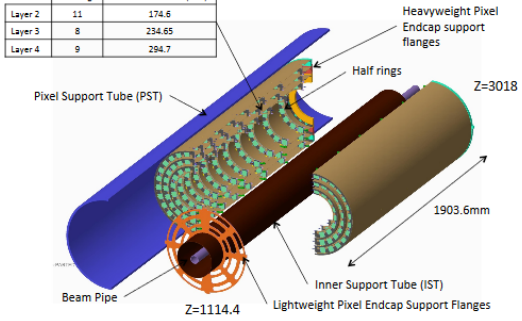
Strip R&D, including testing ASICs, leading into module production

- mounting modules onto staves

Pixel R&D wafer probing, development of HV multiplexing, DAQ and control systems

- production mounting onto half-rings in construction of endcap

	# of Rings	Mean active radius (mm)
Layer 2	11	174.6
Layer 3	8	234.65
Layer 4	9	294.7



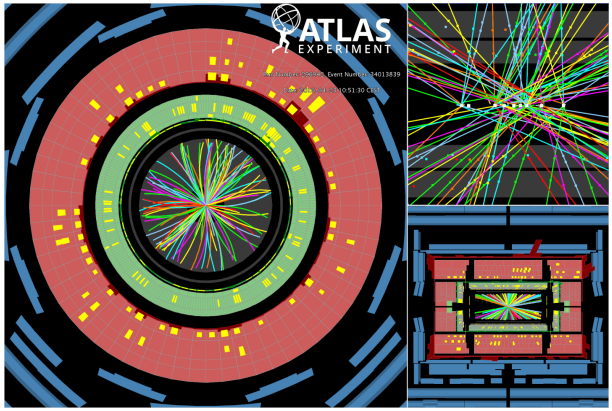
Triggering at the LHC

LHC collides bunched beams of protons 40 million times per second

Every time the bunches cross multiple protons collide

Real example from 2016 with 10 collisions

- *at end of Run 2 LHC delivering ~1 billion proton-proton collisions per second*



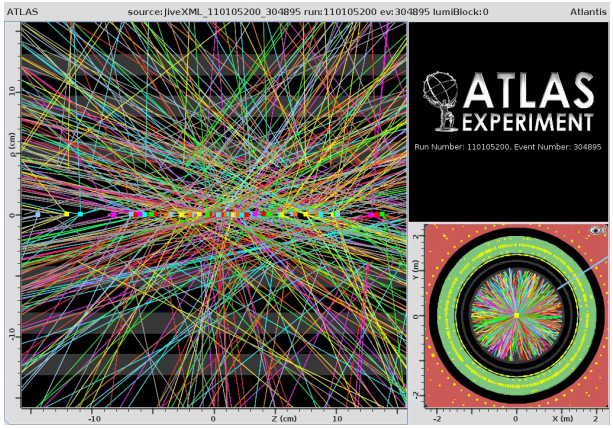
In Run 4 expect an average of 200 collisions each time bunches cross

This a simulated example with 200 collisions

- *up to 10 billion collisions per second*

Interesting collisions at much much lower rate

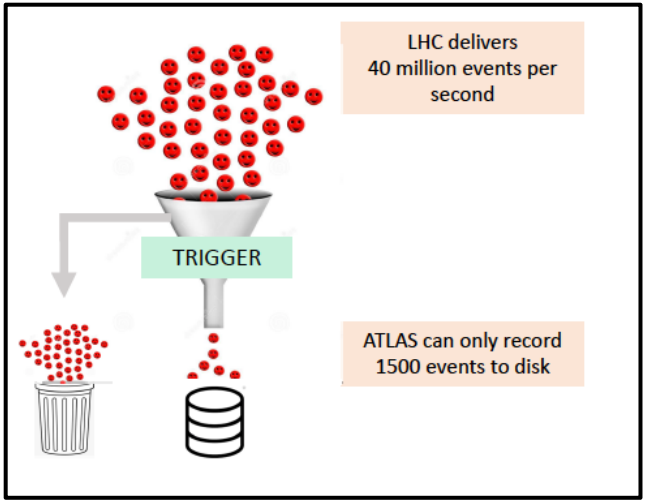
- 1 Higgs boson per 10 billion collisions, some analyses a handful of collisions per year



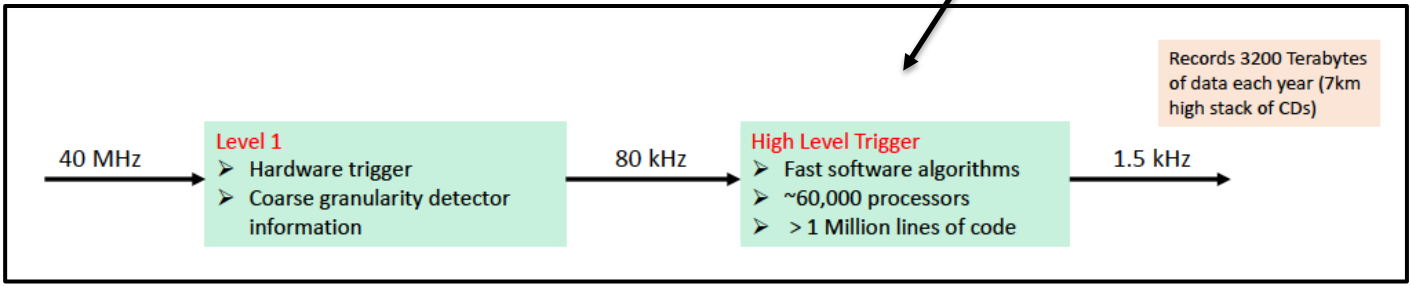
We want just the interesting collisions

Sitting in a sea of 'pileup' collisions

Triggering in ATLAS



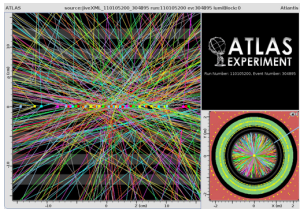
This project is on High Level Trigger



High Level Trigger upgrade for Run 3

During LS2 re-write entire trigger software – Multi-threaded, uses more "standard" offline algorithms

RAL involvement :



- Tracking – using Machine Learning techniques to find tracks quickly and efficiently
- Core trigger software – flow of events/algorithms, control room tools, analysis tools, etc.
- Validation of trigger software – are we finding the events we want efficiently? Resource usage – memory and CPU time?

Physics

Perform an exciting measurement or search in the Higgs sector

The Higgs boson, discovered in 2012, is still largely unknown

Can the Higgs sector explain some of the mysteries of particle physics?

Dark Matter : Measure the Higgs boson coupling for boosted Higgs events

Baryon Asymmetry : Search for an additional source of CP violation in HVV coupling

Flavour puzzle – Is the Yukawa Matrix diagonal?

Search for Lepton-Flavour violation in $H \rightarrow \tau\mu/\tau e$

Studentship project

Start at Warwick (~6 months)

Academic and computing courses

Start work on HLT – gain familiarity with project

Some time at RAL and then 12 - 18 months at CERN

Hands-on experimental experience commissioning/operating HLT system during Run 3

- including control room shifts and providing first-line expert support

Join physics analysis group, foundation for physics analysis component of thesis

Return to RAL

Physics analysis and write thesis