THE ROYAL SOCIETY

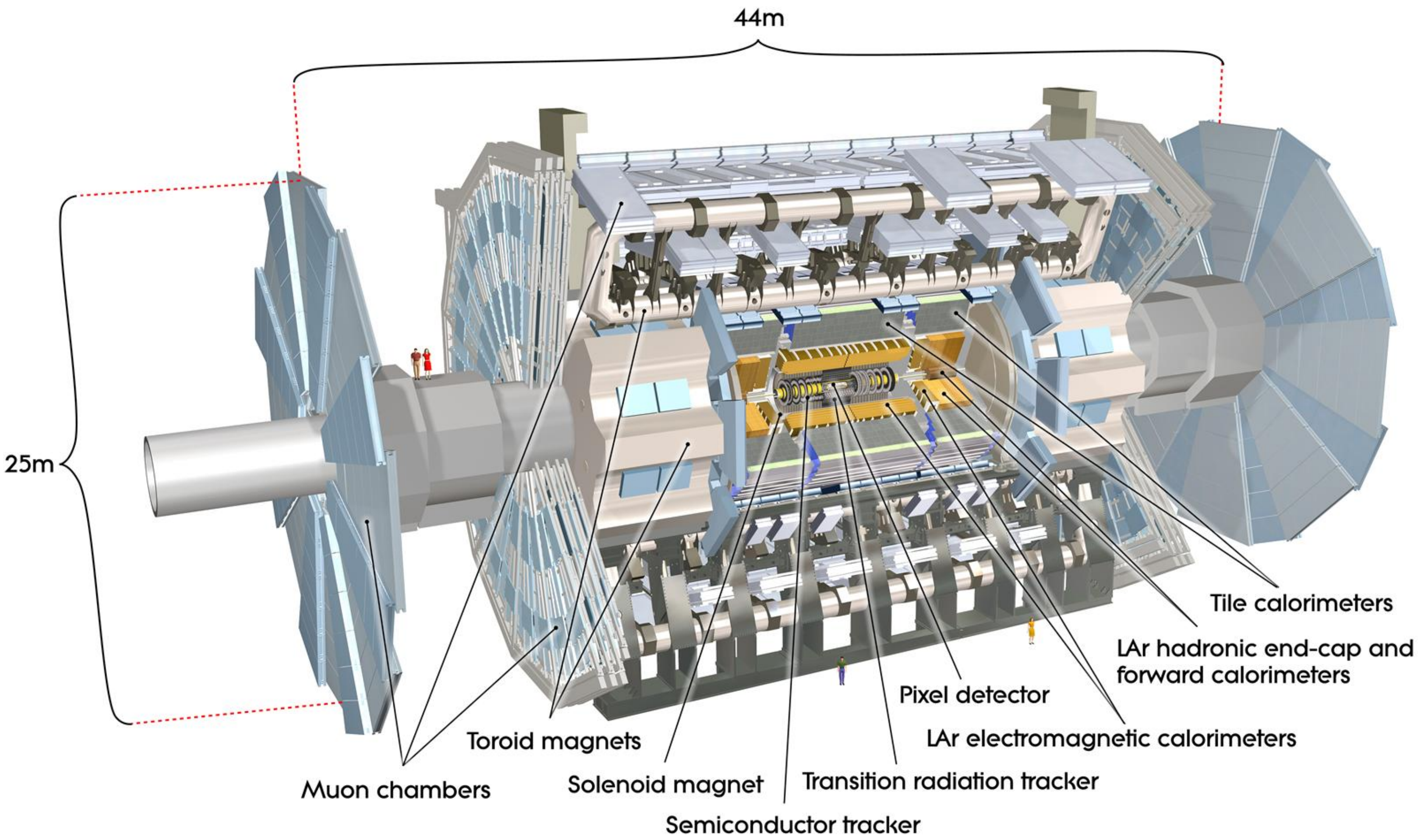
University of Glasgow

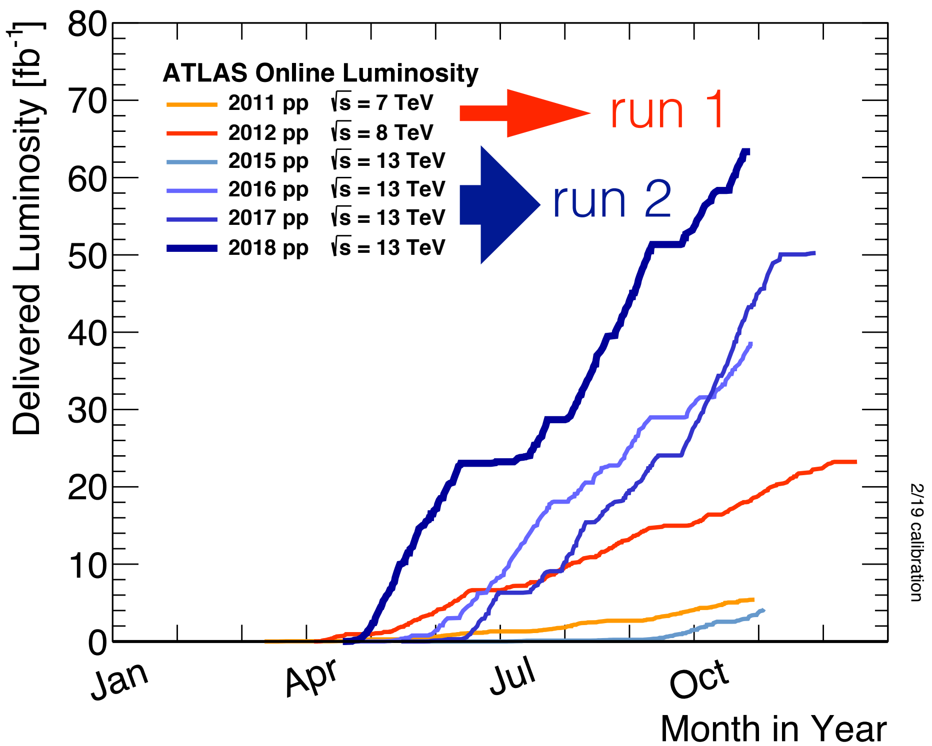
ATLAS

Mark Owen on behalf of ATLAS UK

PPAP Meeting 20 November 2020

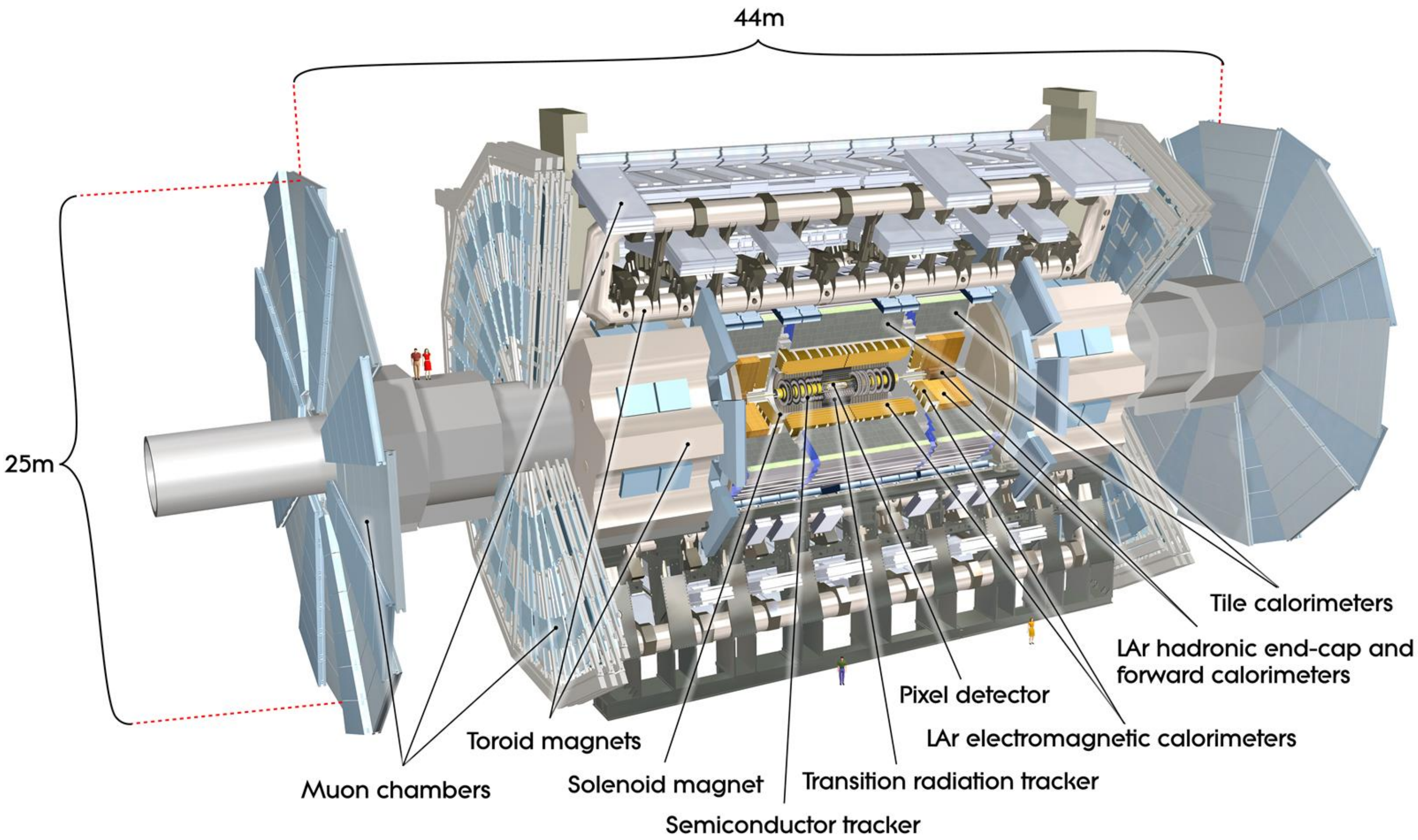
ATLAS

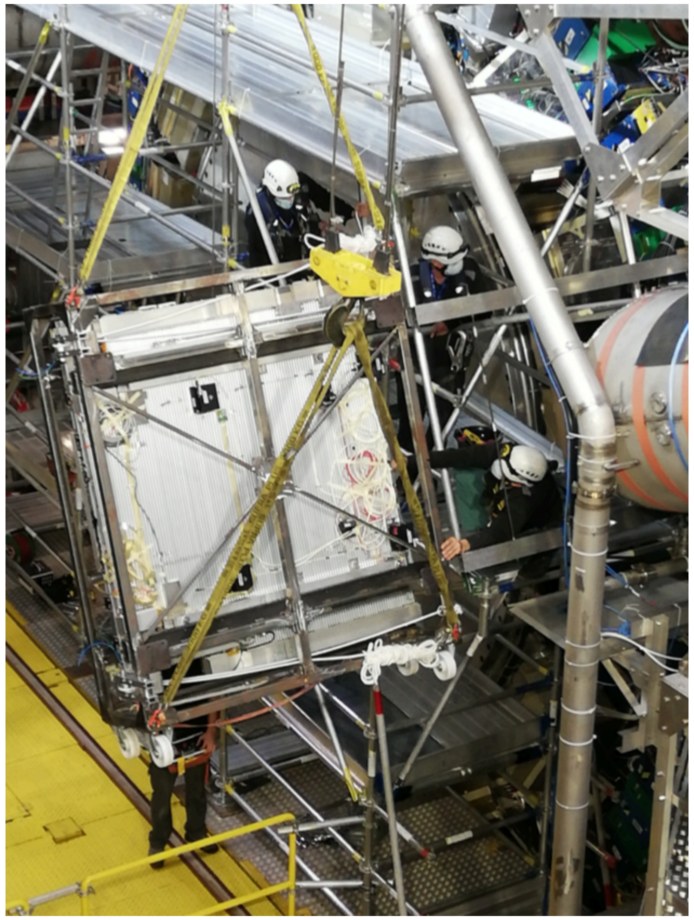




- General purpose detector with wide ranging physics programme: QCD, EW, Higgs, Top, B, Heavy Ion, Searches.
  - 968 papers to date (~7 / month).
  - Data analysis is not finished when the data is on tape - big effort ongoing to exploit the run-2 data (67 papers use the full run-2 dataset).
  - In parallel, preparing for run-3 and the upgrade of ATLAS for HL-LHC.

ATLAS





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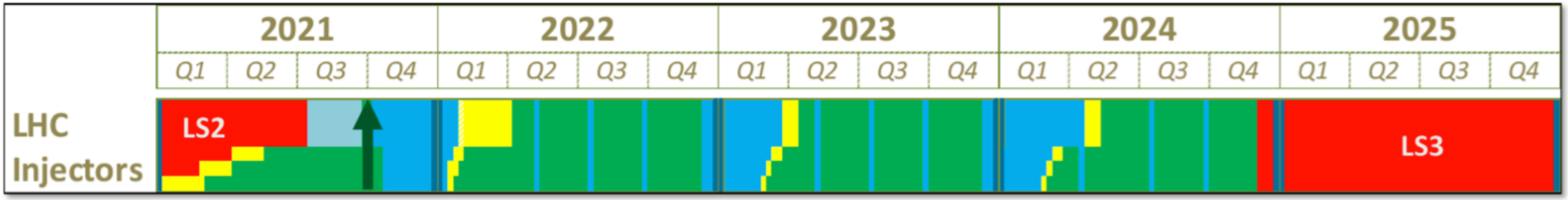
ATLAS UK

- UK is one of the leading countries in ATLAS.
- Consistently hold leadership roles across all areas of the experiment above our weight (10.5% of authors).
- Recent roles held by UK people in the last year:
  - Conveners of 6/10 physics groups (typically >200-300 physicists in each group).
  - Chair of collaboration board (~180 institutes).
  - Trigger coordinator.
  - ITK deputy project leader, ITK pixels project leader.
  - SCT project leader.
  - Deputy run coordinator.
- Impossible to cover the huge breadth of work done by >500 ATLAS UK people in 20 mins.

ATLAS: 5 year view



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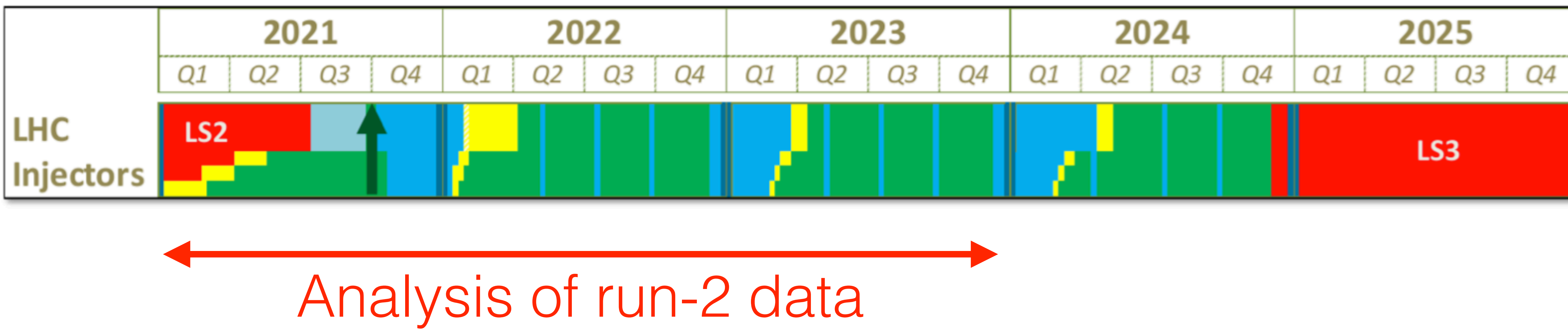
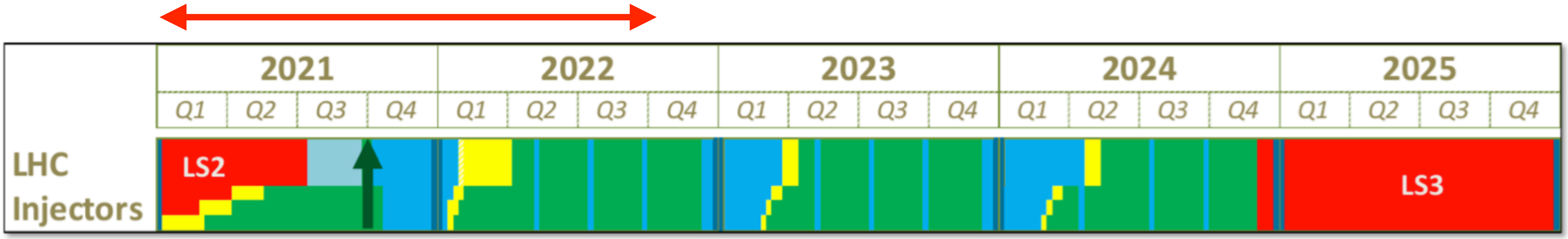


ATLAS: 5 year view

Install & commission phase-1 upgrades

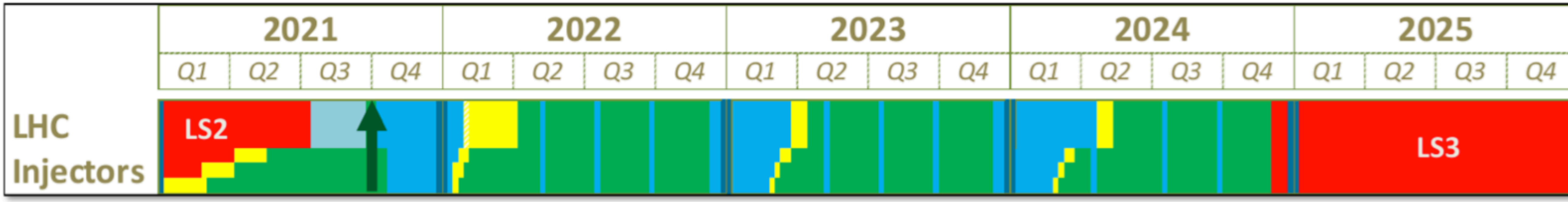


Analysis of run-2 data

ATLAS: 5 year view

Maintain & operate detector

Install & commission phase-1 upgrades



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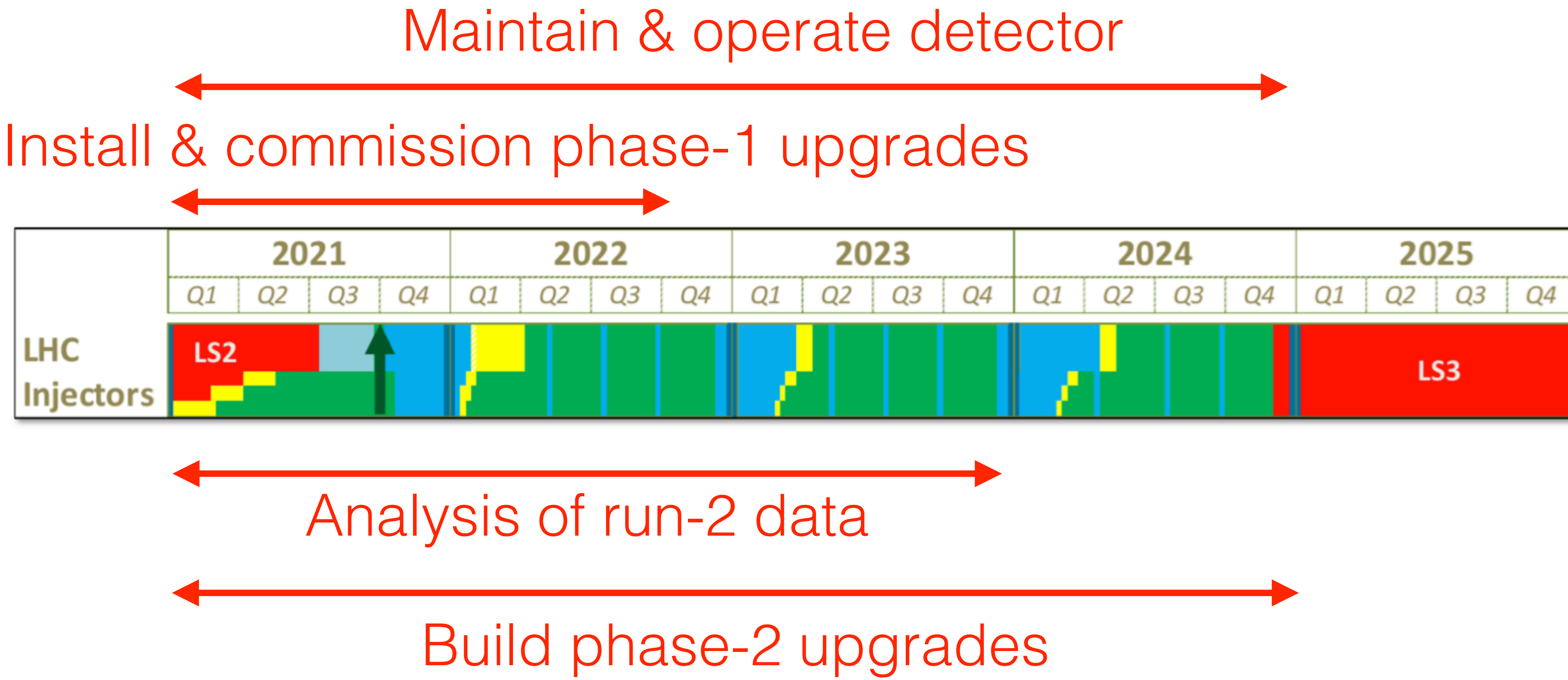
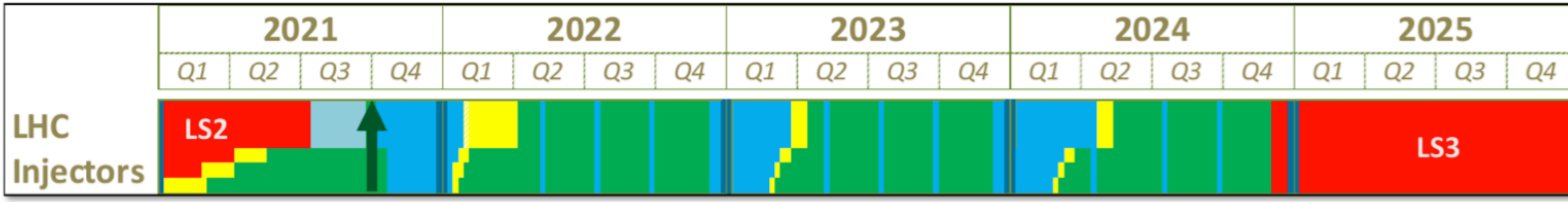


ATLAS: 5 year view

Maintain & operate detector

Install & commission phase-1 upgrades



Analysis of run-2 data

Build phase-2 upgrades

Analysis of run-3 data

Outline

- Recent physics highlights
- Preparations for run-3
- Upgrading ATLAS for HL-LHC

UK continues to lead many activities in the experiment

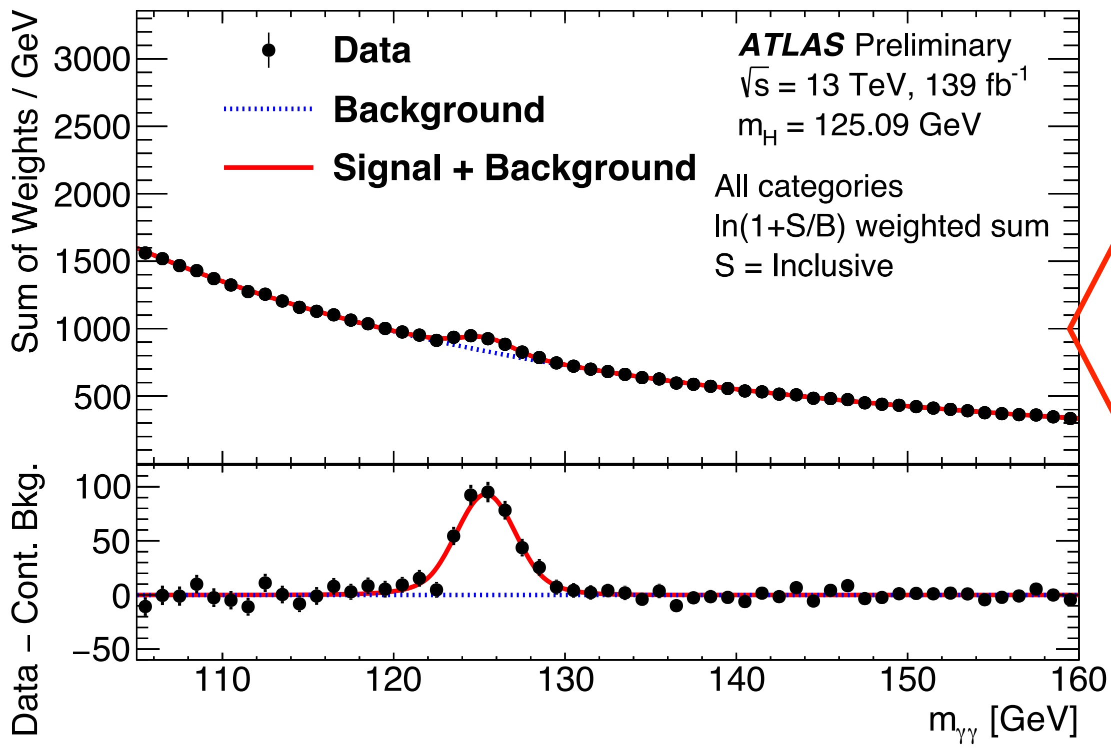
Everything shown here has strong UK leadership

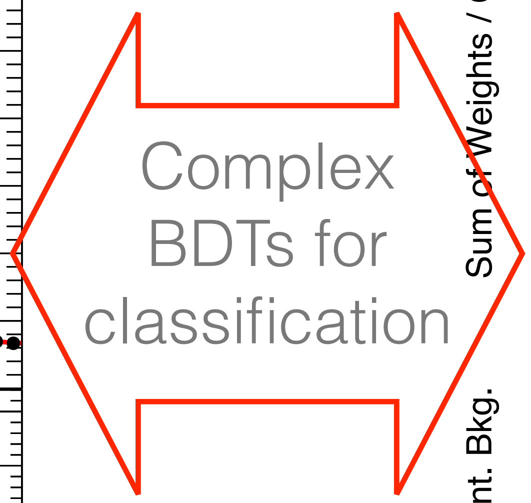
Physics highlights

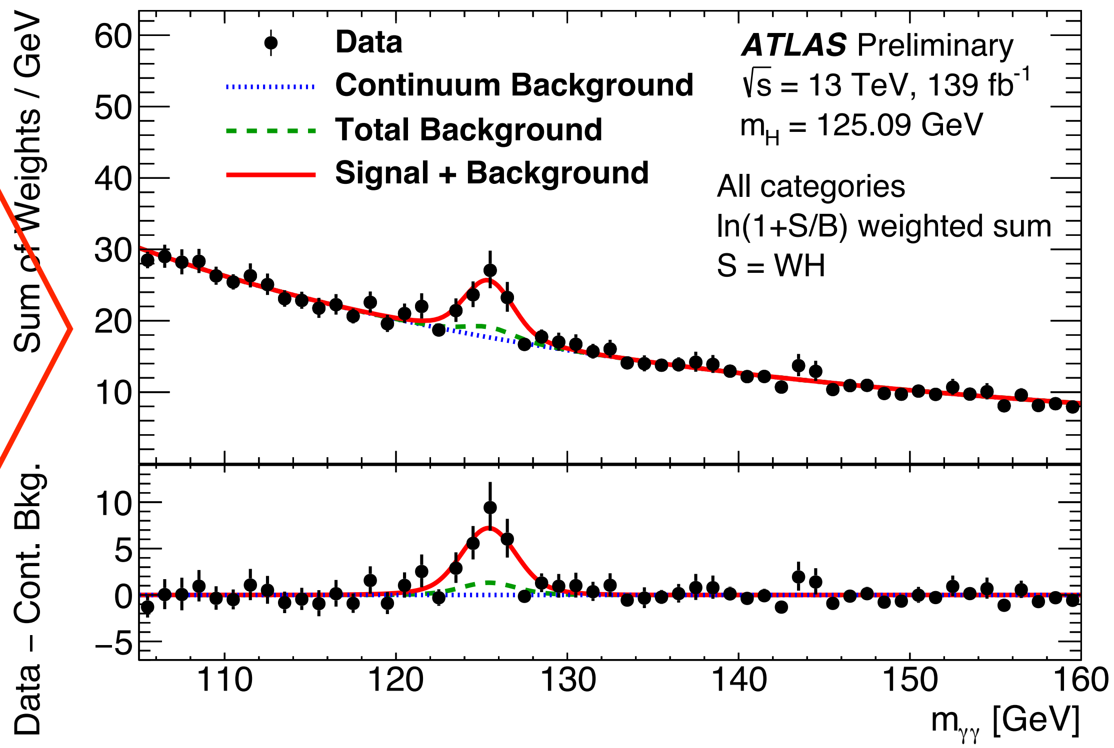
H→γγ

ATLAS-CONF-2020-026

- Full dataset allows us to probe the different Higgs production modes:







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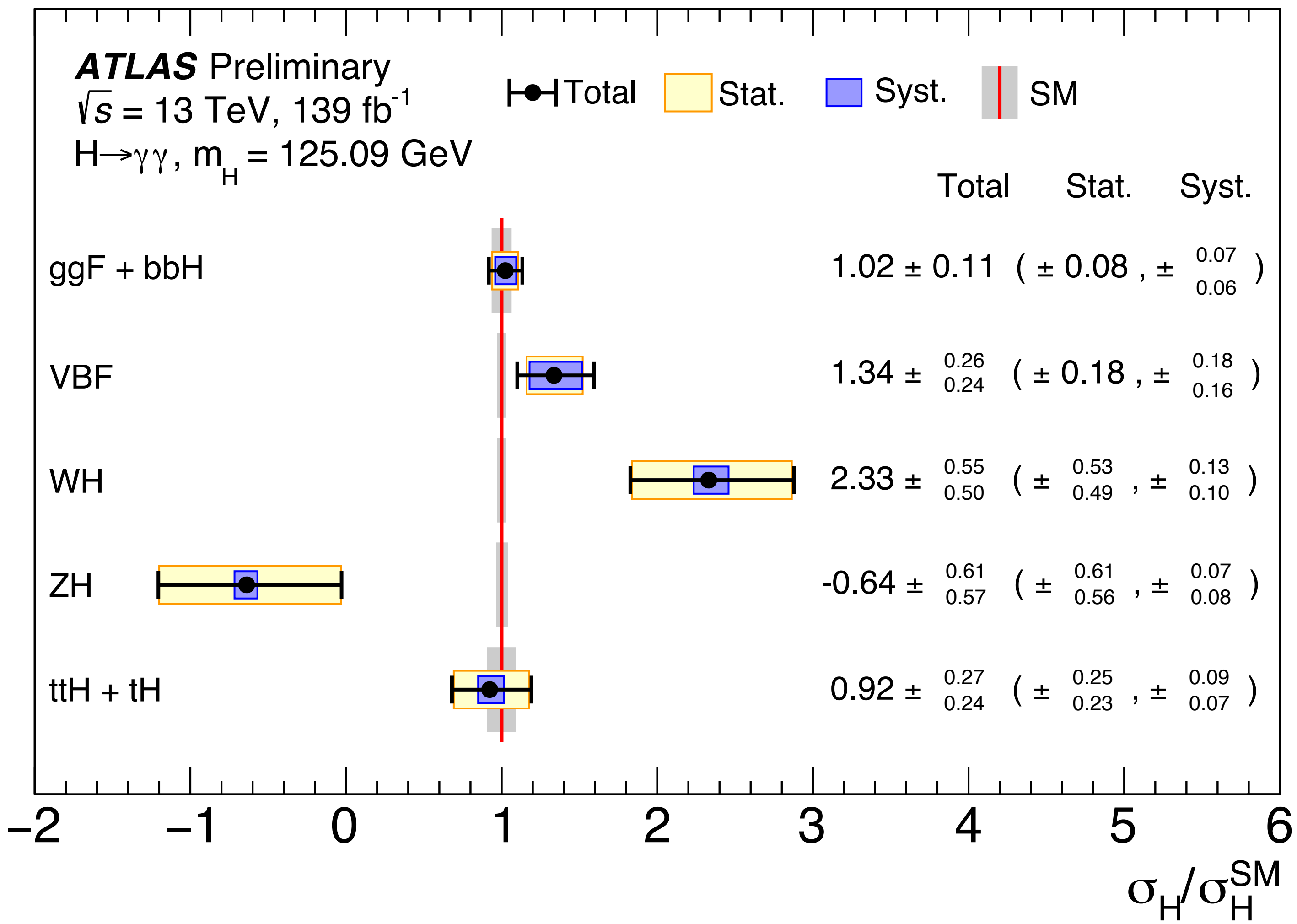


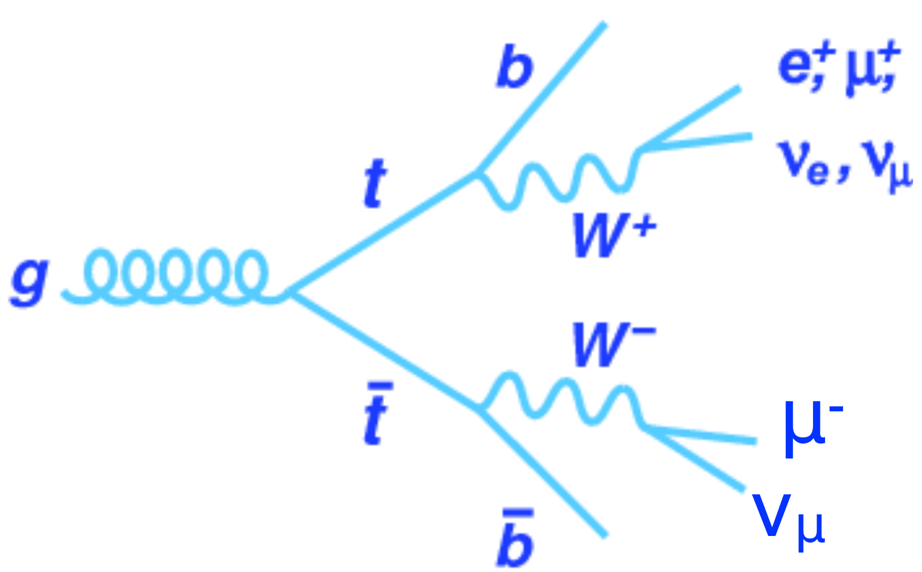
2x improvement in sensitivity above luminosity increase for VH and top.

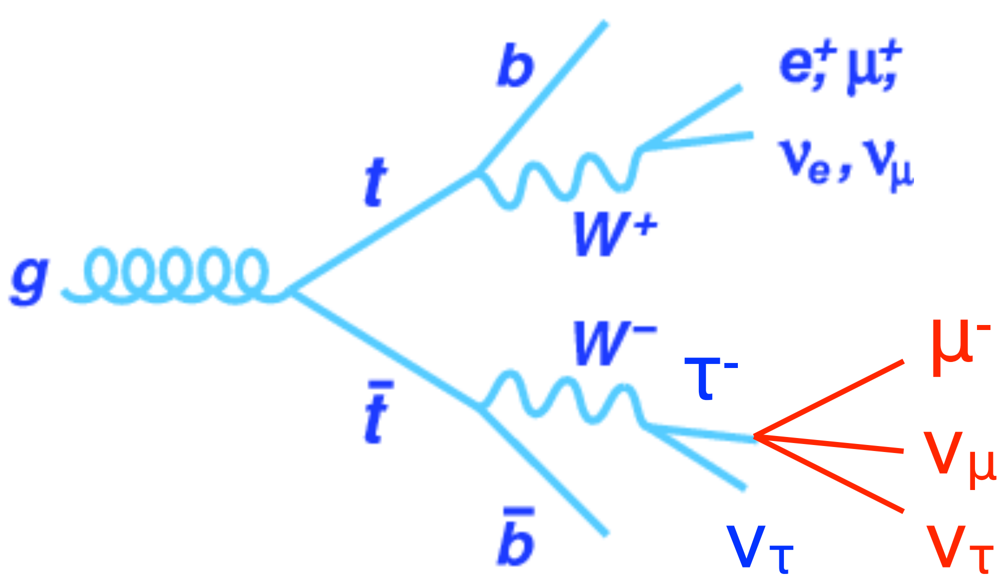
Vital to have strong level of effort to exploit the run-2/3 data.

Lepton Universality

arXiv:2007.14040, submitted to Nature Physics

- Legacy result from LEP:
  - Br(W→τν)/Br(W→μν)=1.070 ± 0.026
  - 2.7σ away from 1.
- Exploit huge LHC tt production rate to get sample of 500k muons.





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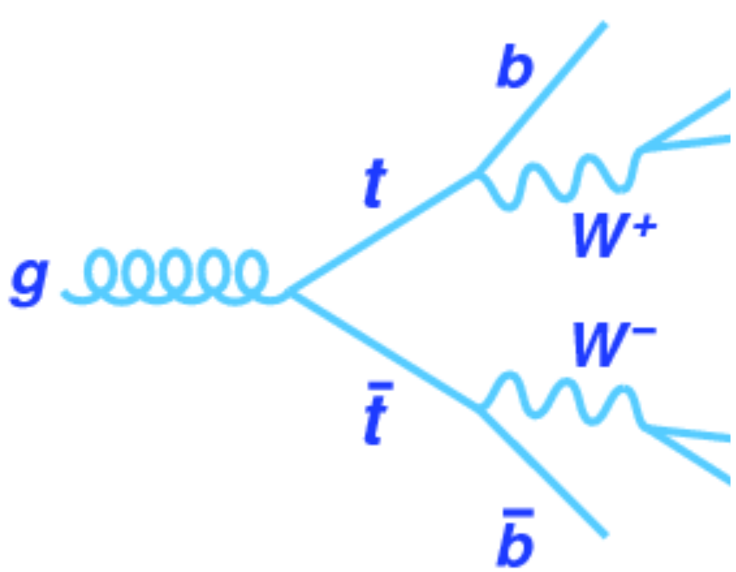

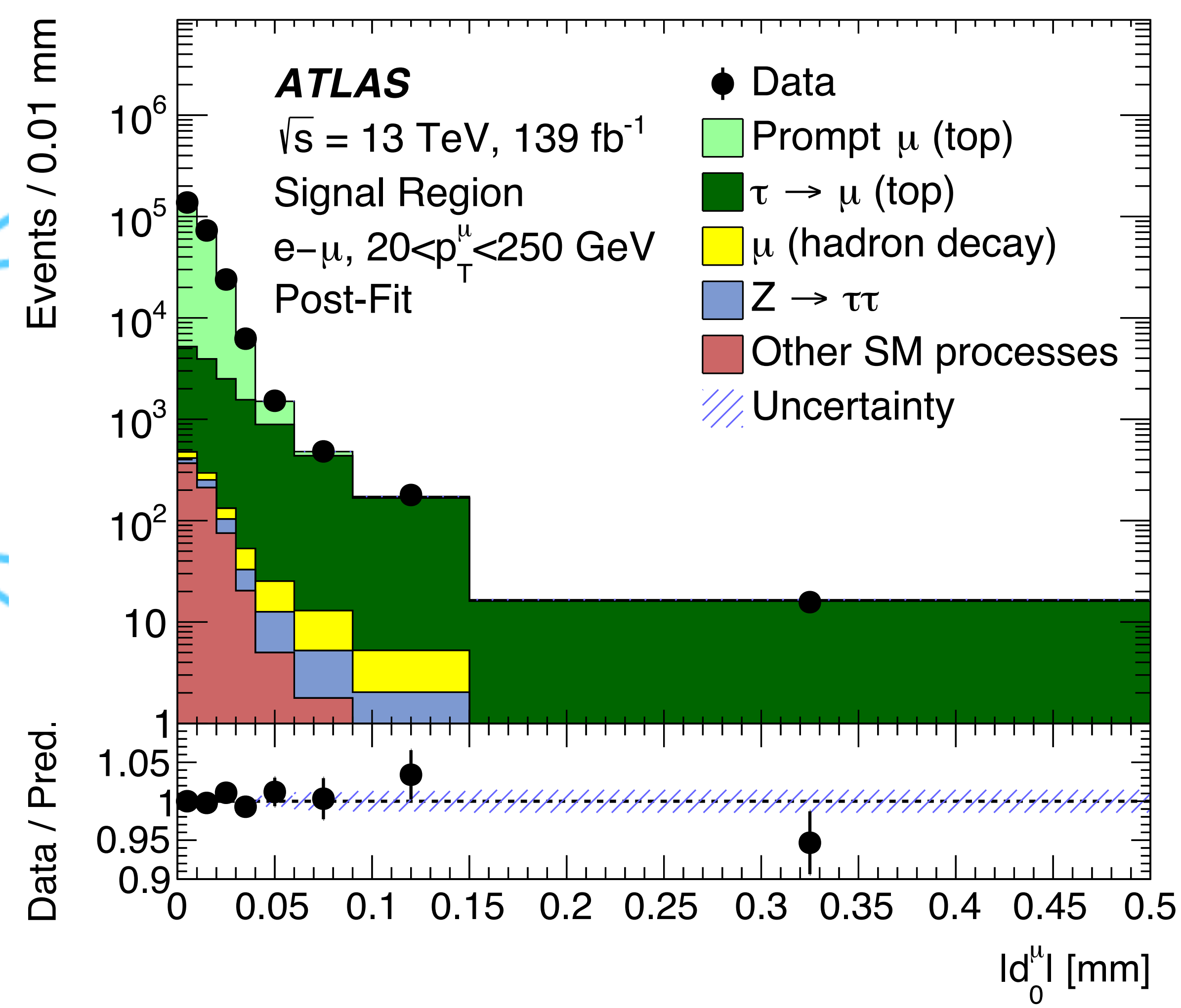

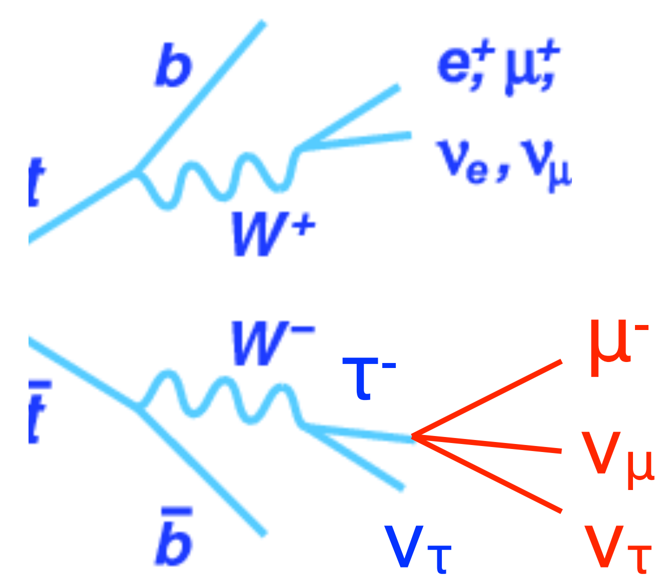

d_0 resolution from silicon tracker, UK experts provide main expertise on DAQ, DCS & operations.

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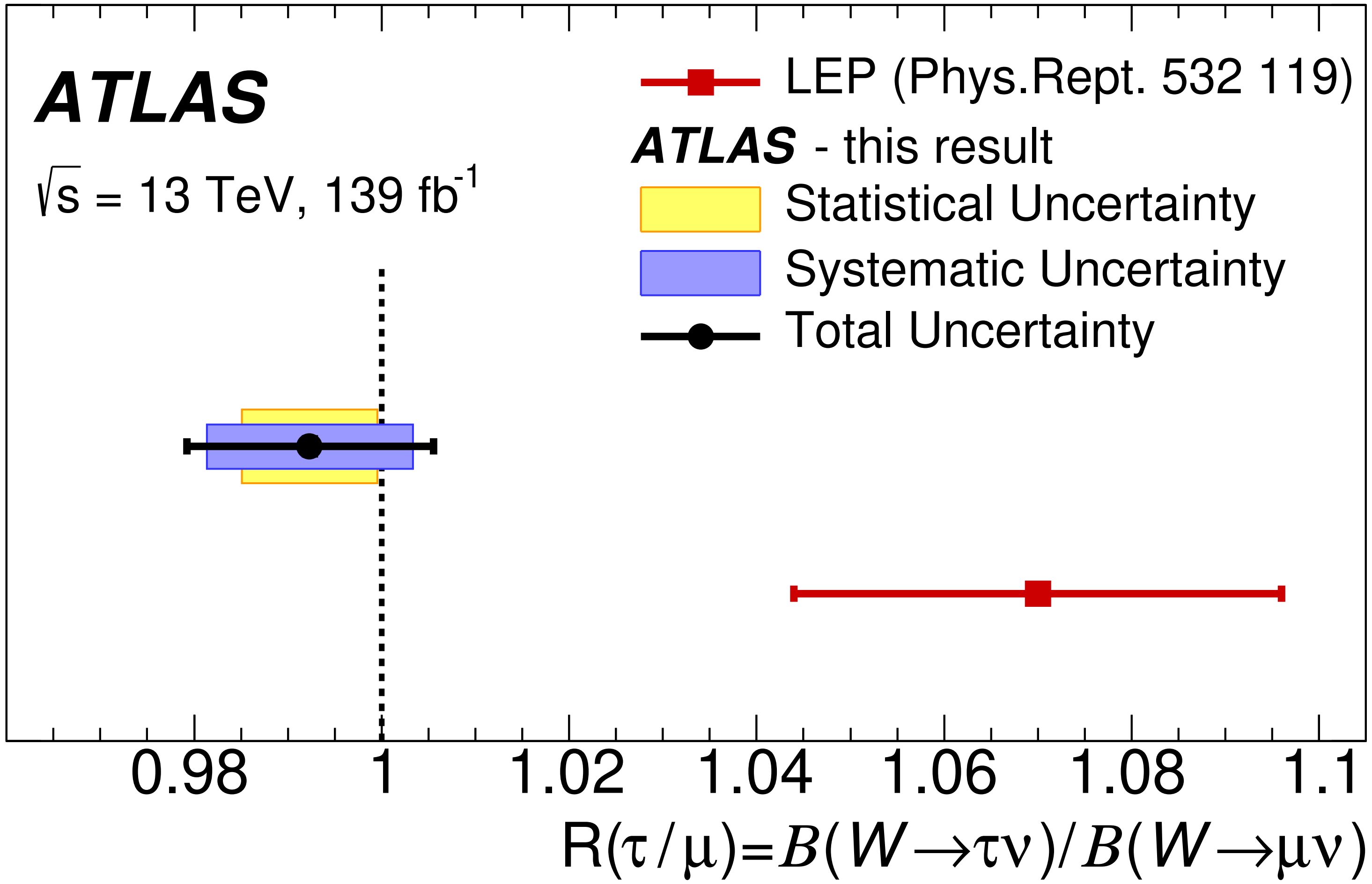
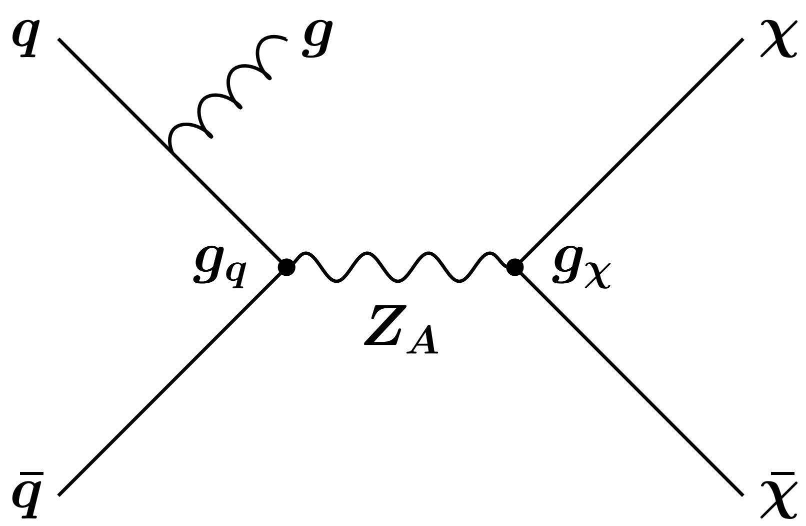


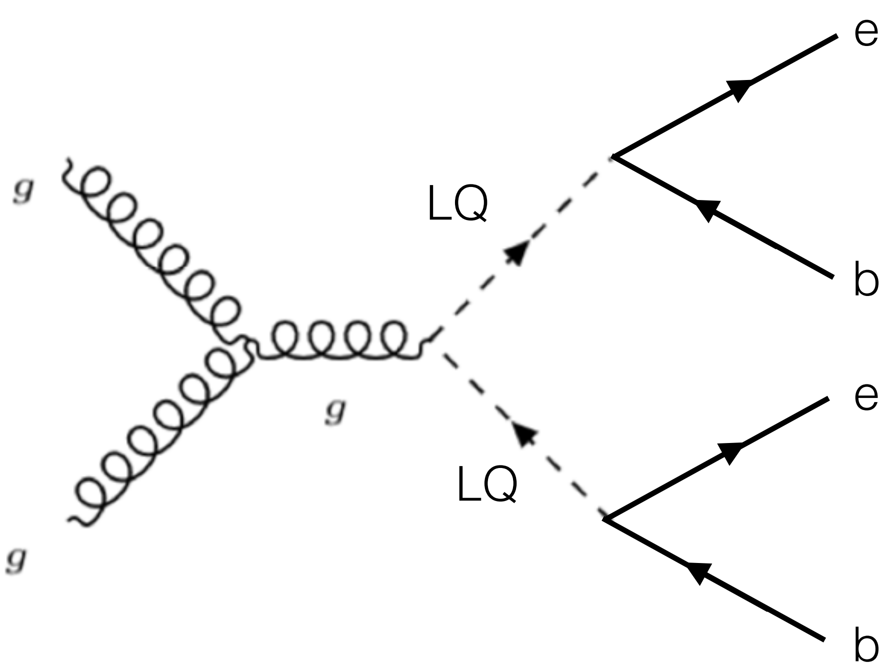
Factor 2 improvement in precision over LEP

Searching for new physics

- Two examples of recent ATLAS searches:



Search for new invisible particles in mono-jet events



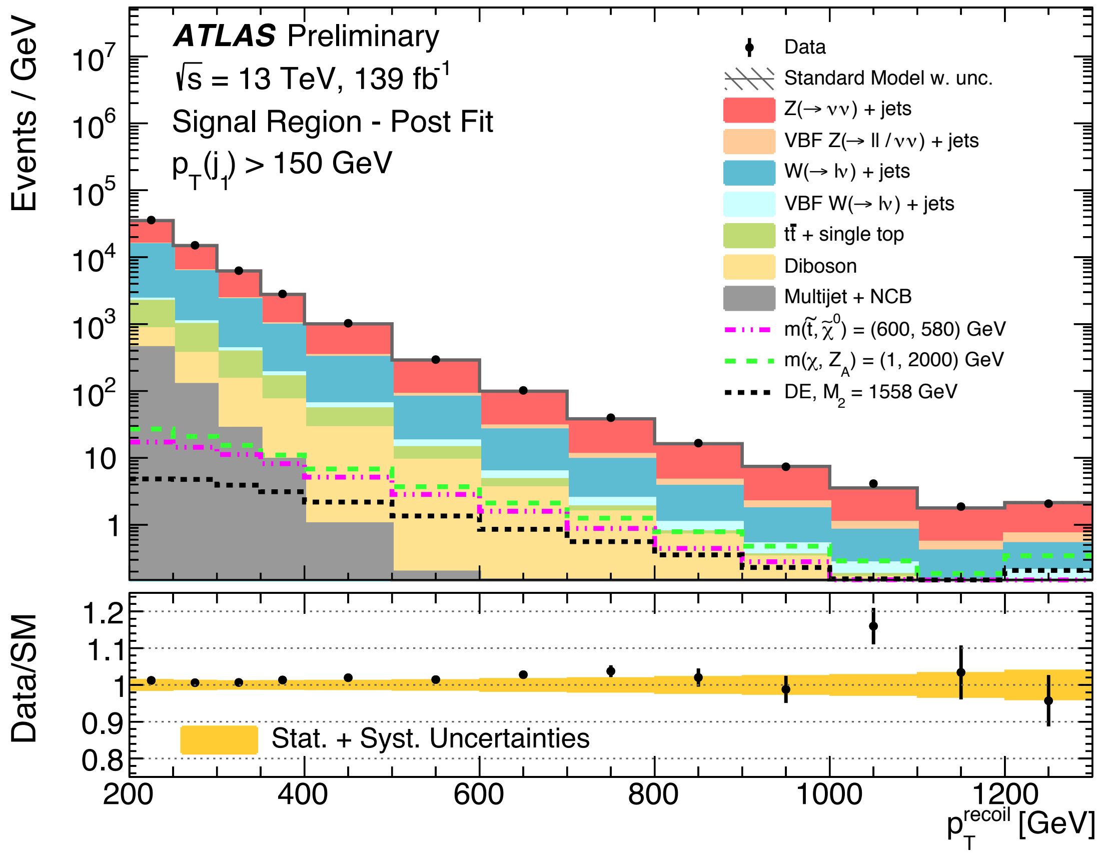
First time searching for lepto-quarks with “cross-generation” decays

ATLAS-CONF-2020-048
JHEP 10 (2020) 112

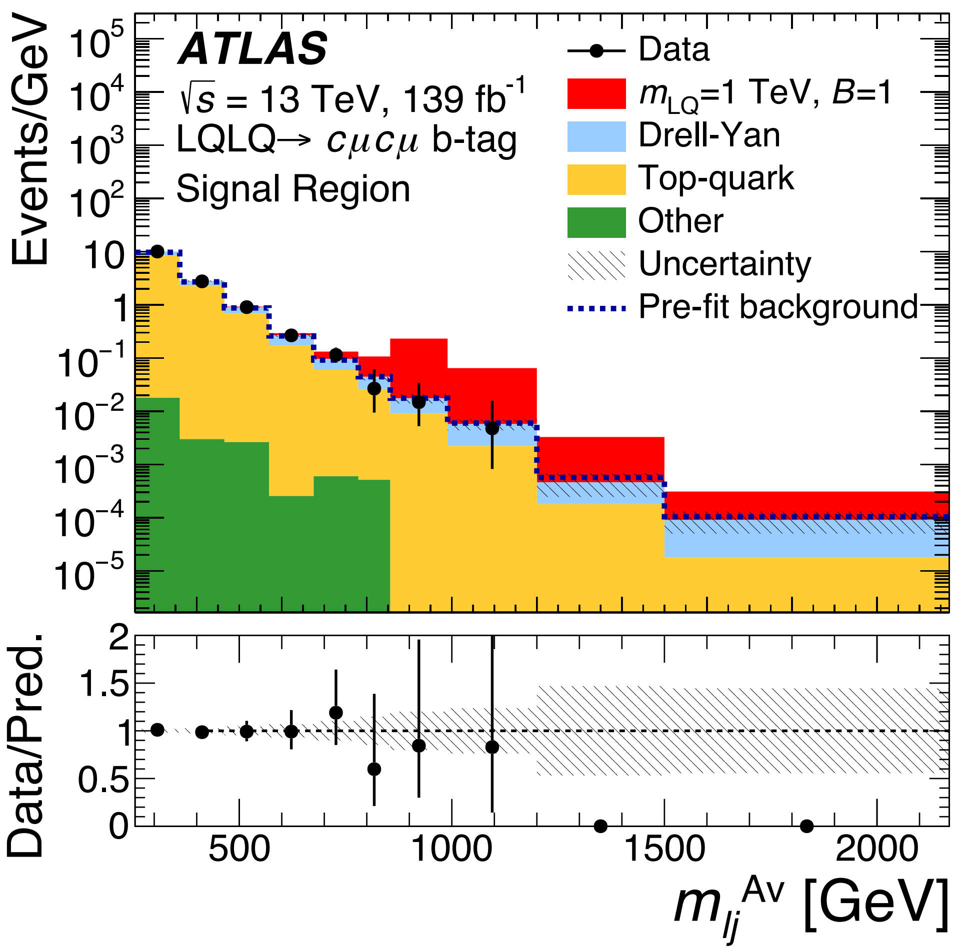
Searching for new physics

- Two examples of recent ATLAS searches:

Searching for new invisible particles in mono-jet events

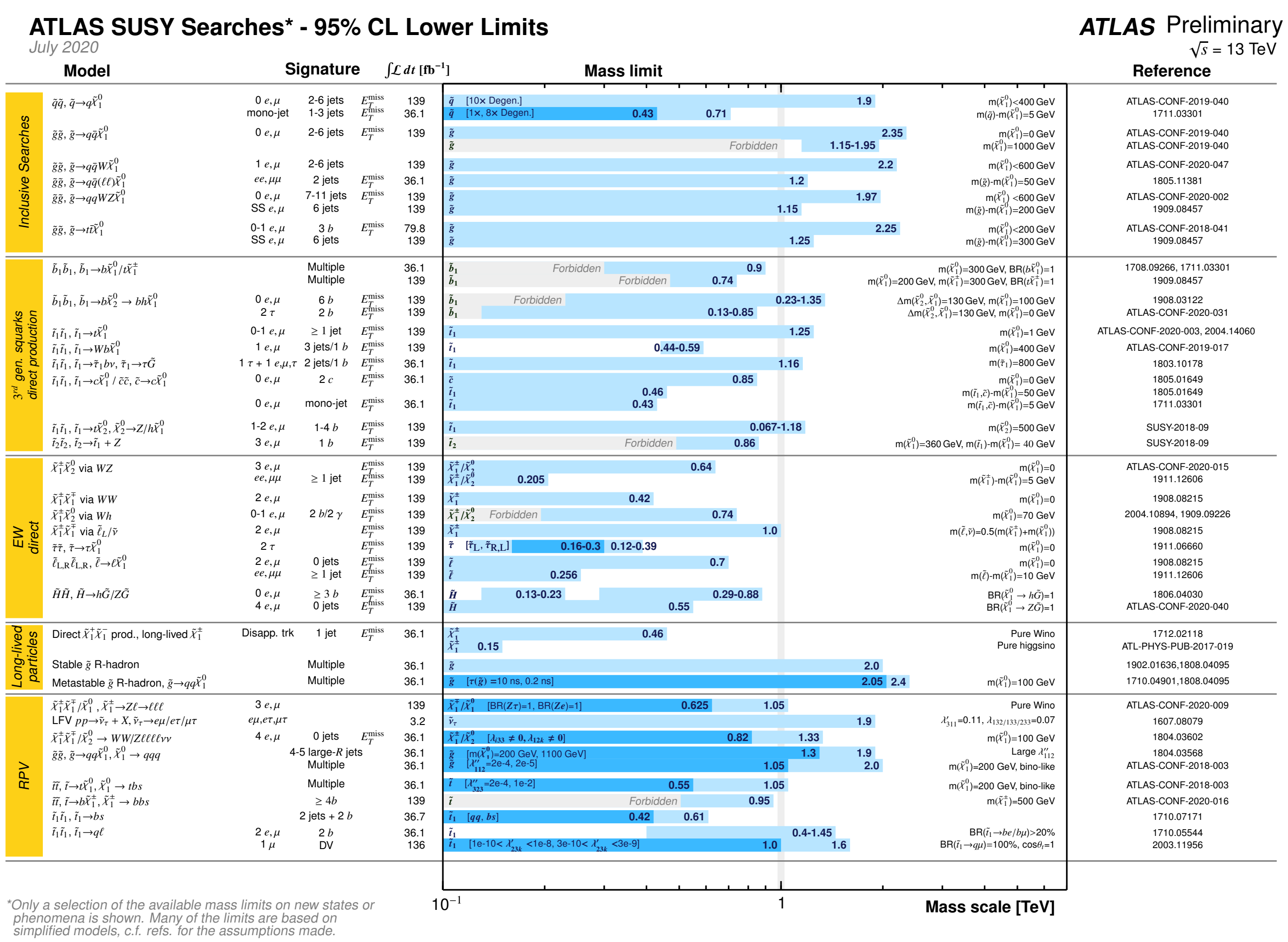


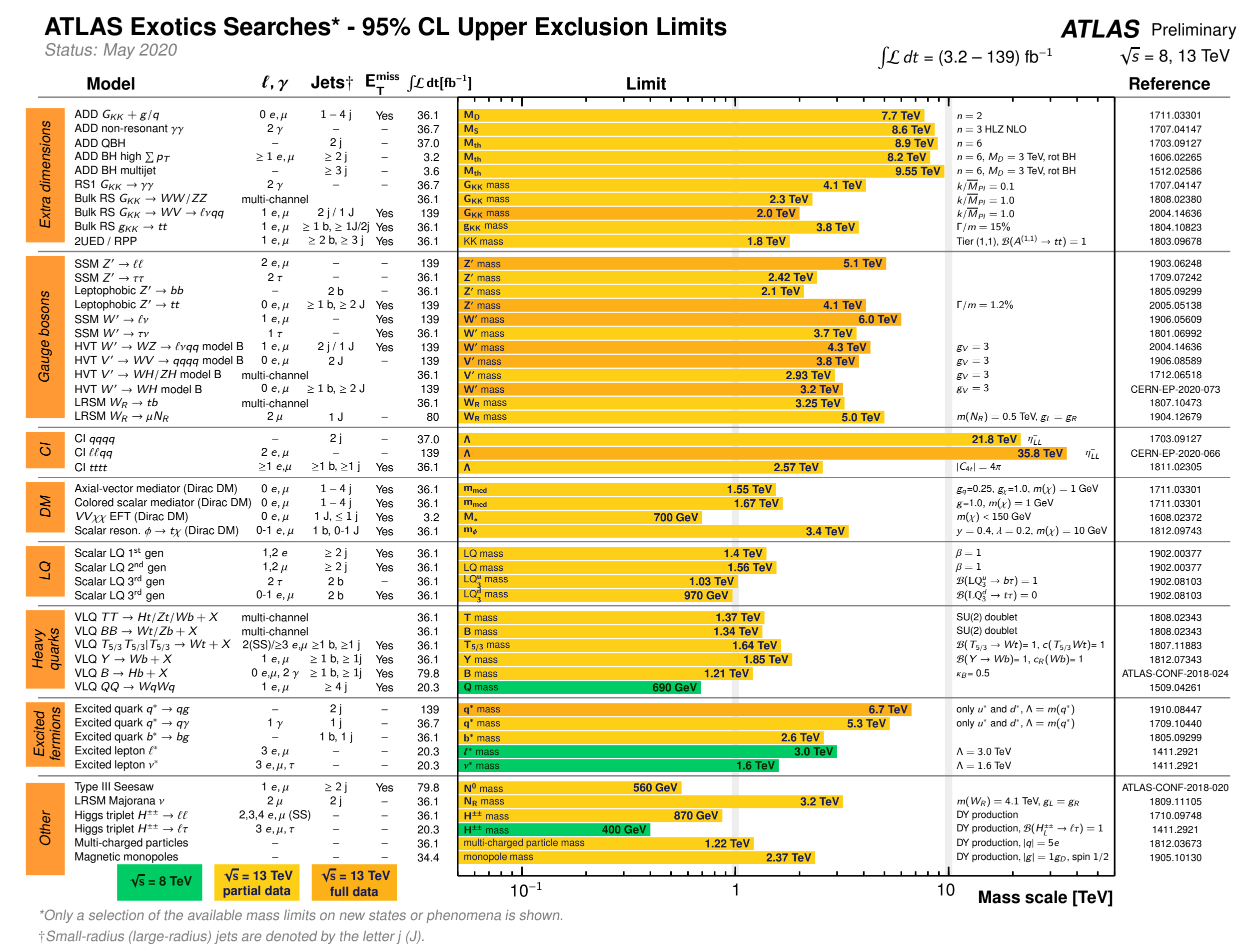
Searching for lepto-quarks with "cross-generation" decays



Searching for new physics

- No evidence yet for new physics, but many channels have only fully analysed 36 fb-1 - ~factor of 10 in luminosity to go to end of run-3.





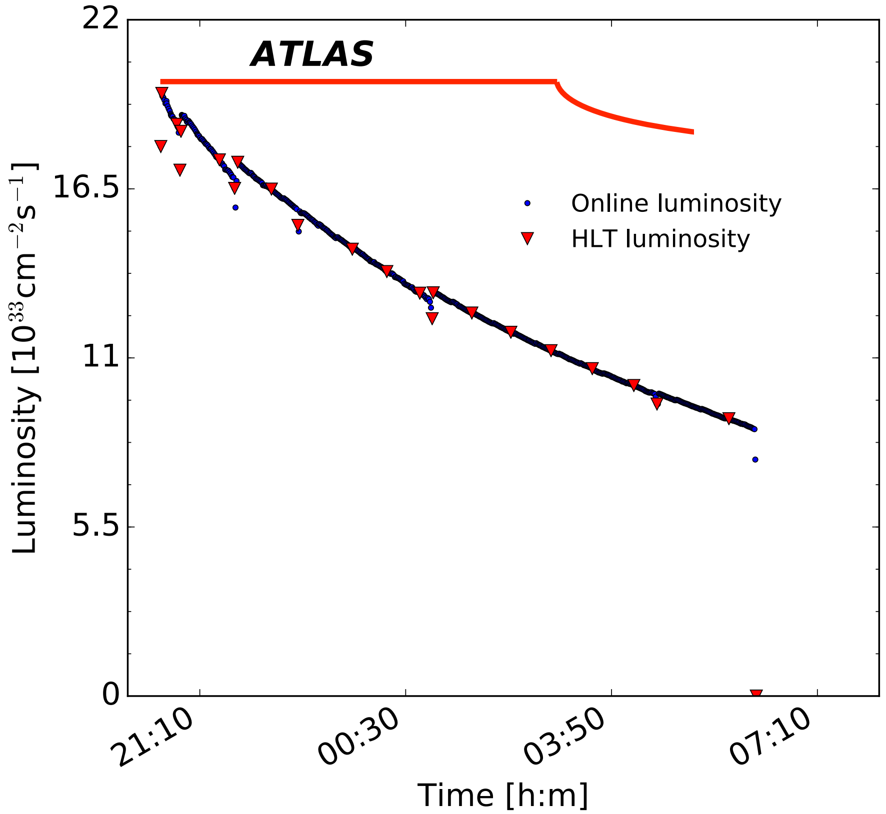
THE ROYAL SOCIETY

University of Glasgow

Preparing for run-3

Preparing for run-3

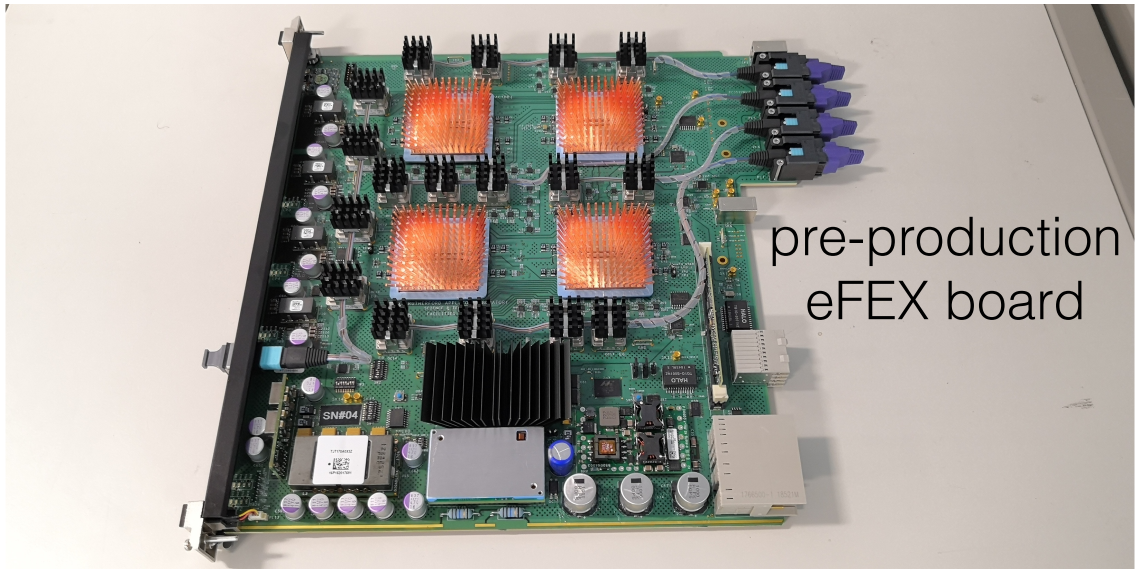
- Run-3: higher average pileup than run-2 & hopefully higher energy:
  - L1 calorimeter: all new hardware with better performance.
  - HLT & offline software: new framework for fully-parallel processing.
  - SCT: Maintenance & operation of ~16 year-old system.
  - Muon: new detectors to cope with trigger rates.

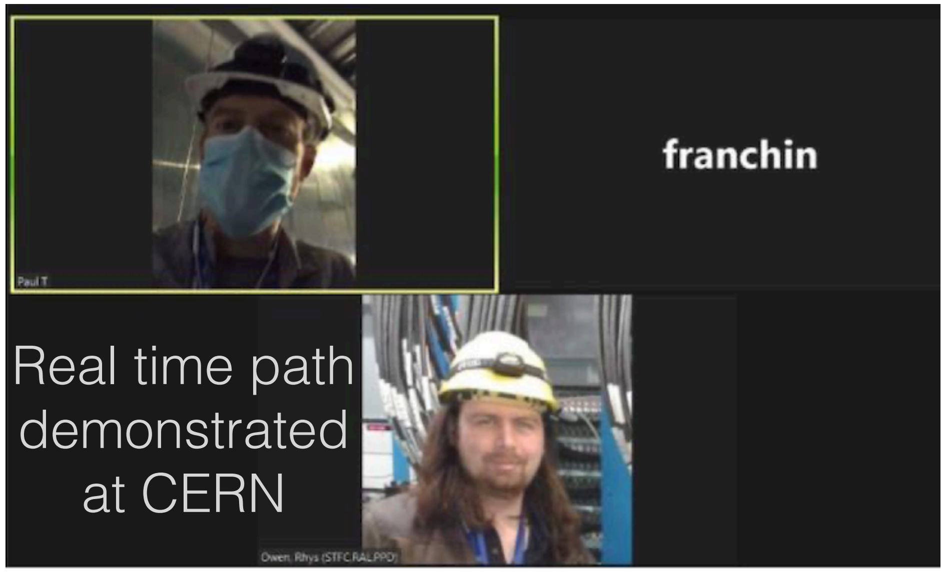


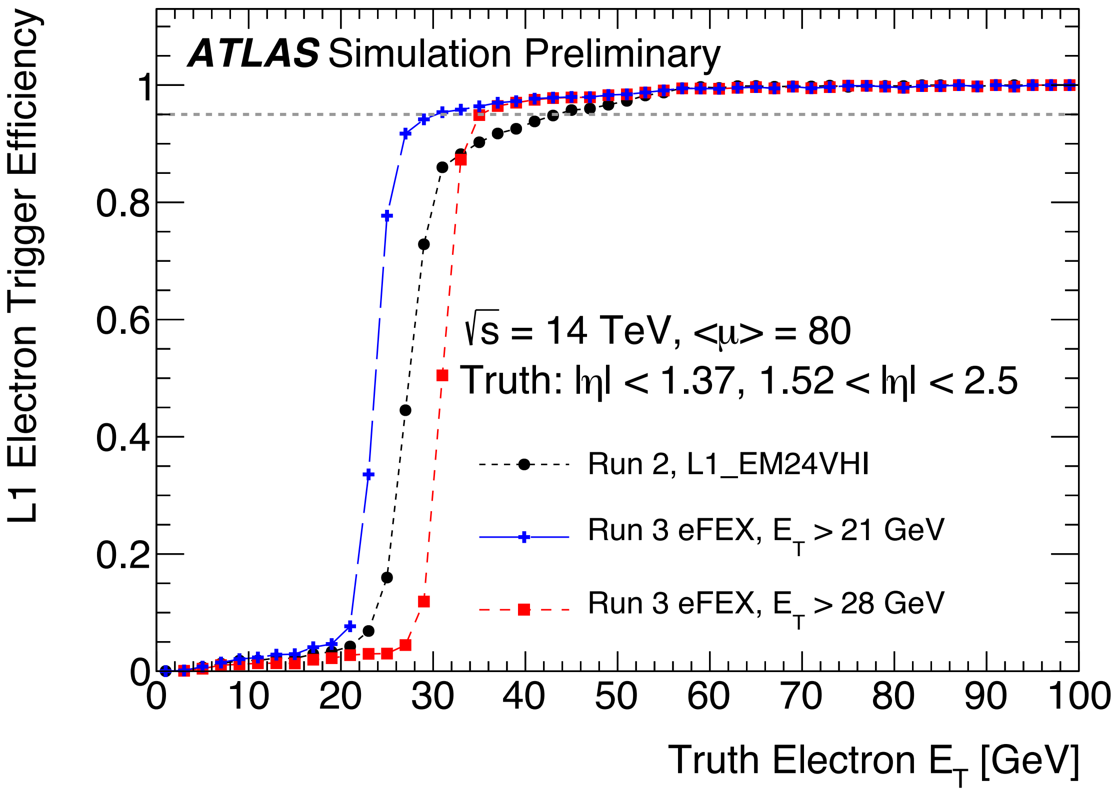
Run-2 typical
Run-3 plan

L1 Calorimeter Trigger

- Improved granularity of calorimeter data -> better performance.
- UK responsible for electron & tau finding board & readout modules for full system.



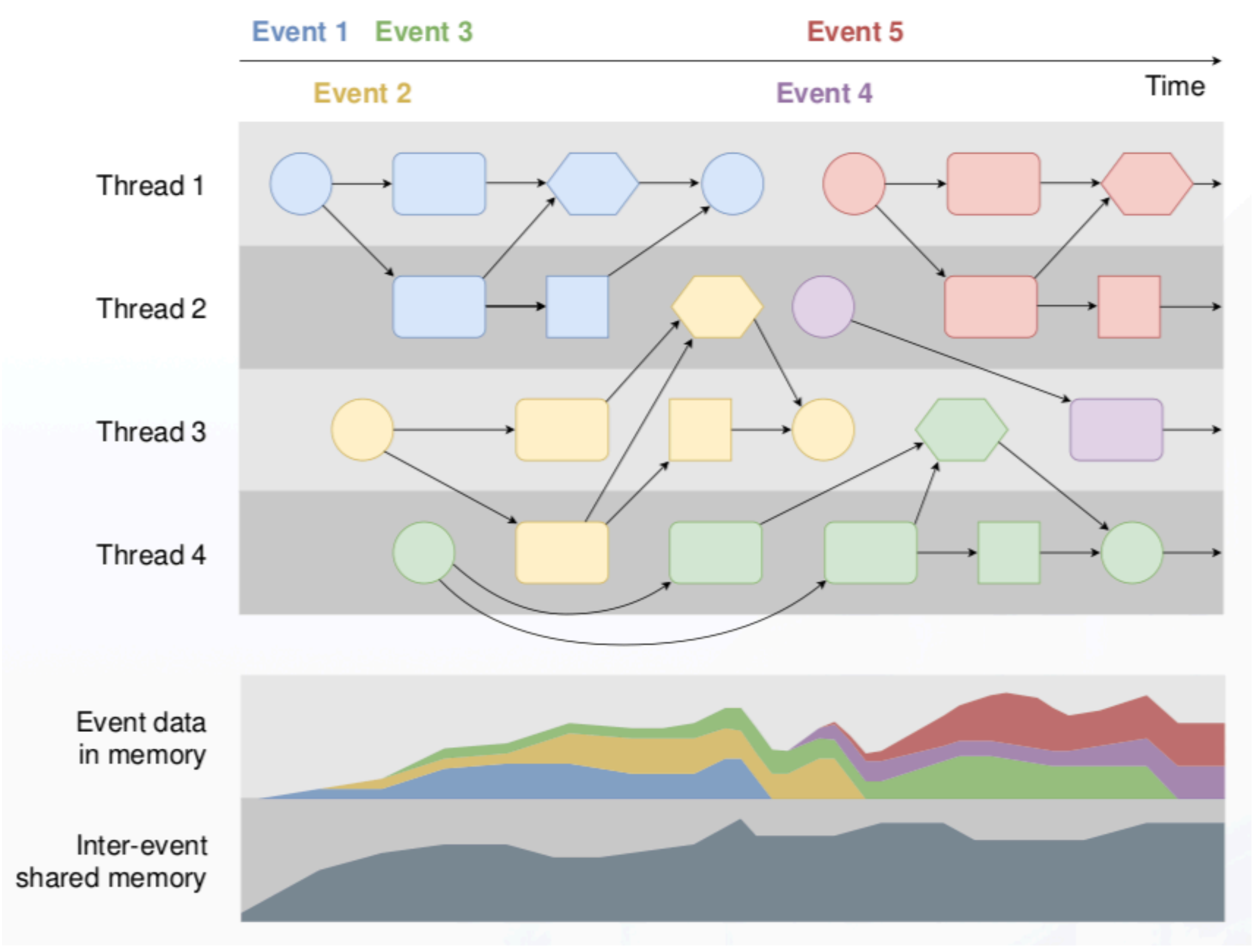




- Important to have sufficient effort for all the software needed to actually run the system!

Software trigger & offline computing

- Trend in modern computing: more cores and less memory / core.
- Motivated rewrite of software framework to support parallel processing.



- Good progress: both trigger and offline reconstruction are running with n(threads) > 1.
- Computing system must be as efficient as possible to cope with run-3 demands.
- Run-4 will mean a step-change for computing - need additional effort – looking to meet this through SWIFT-HEP bids and working in collaboration through IRIS-HEP

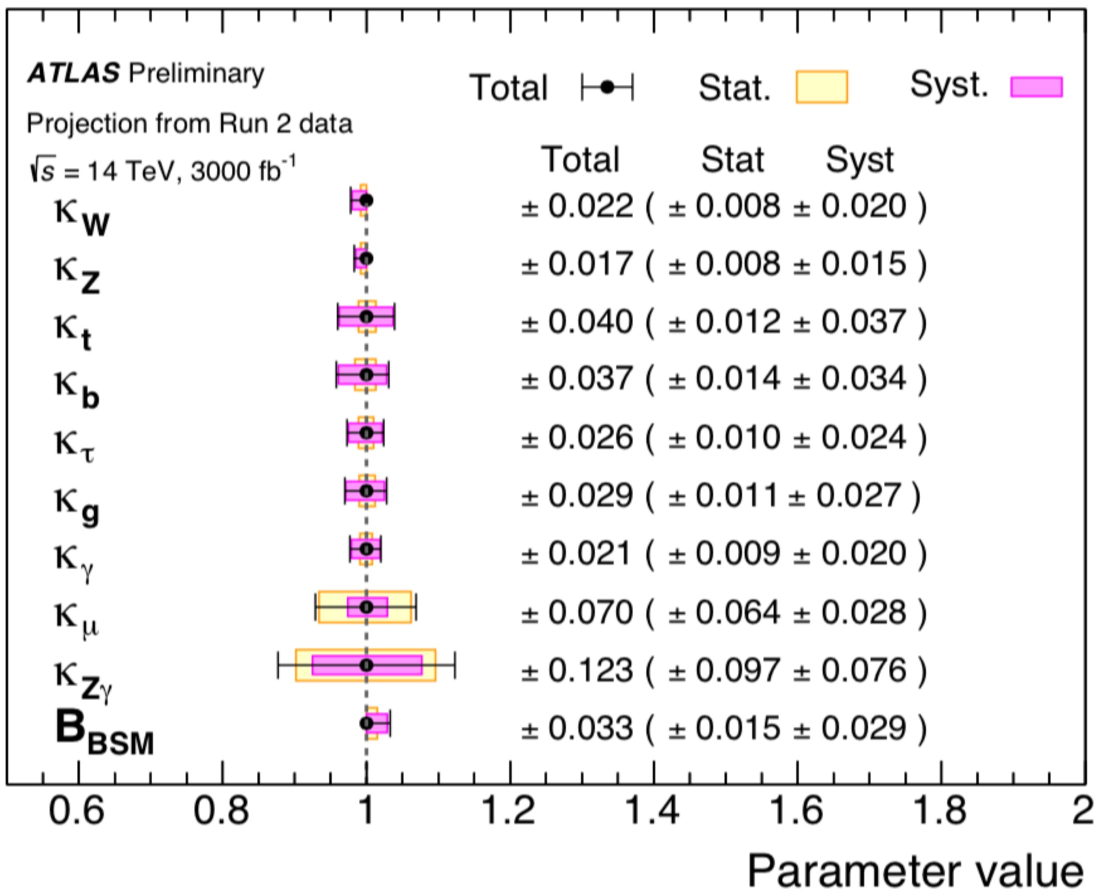
Upgrading ATLAS for HL-LHC

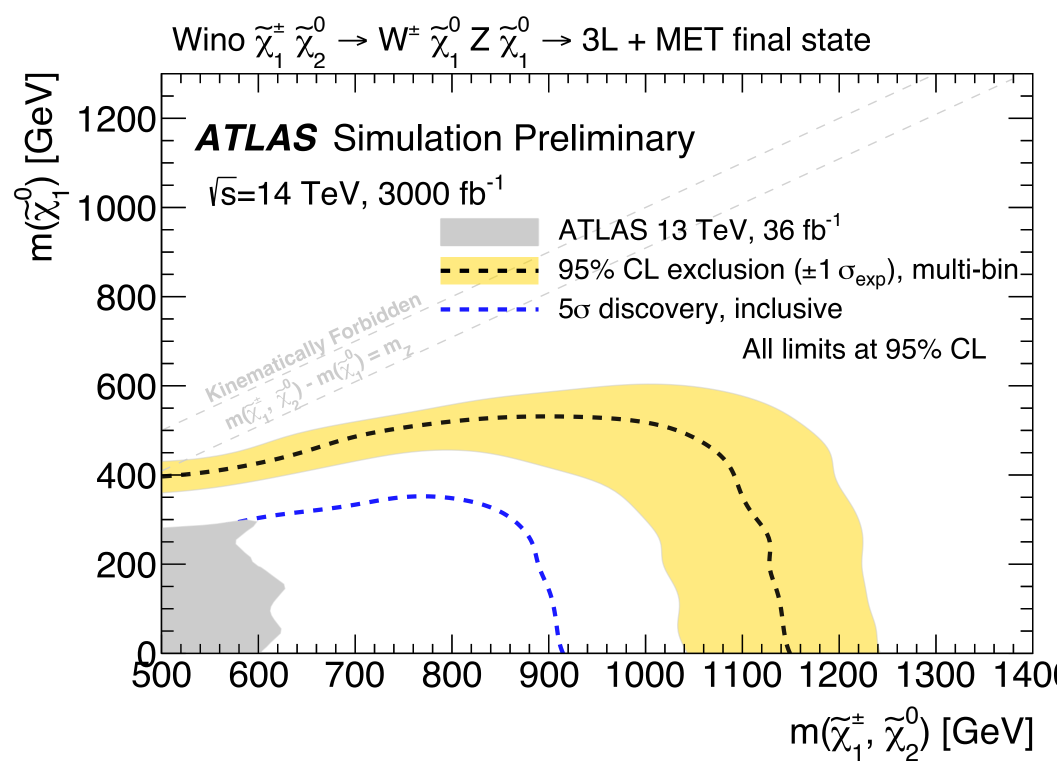
The successful completion of the high-luminosity upgrade of the machine and detectors **should remain the focal point of European particle physics**, together with continued innovation in experimental techniques. The full physics potential of the LHC and the HL-LHC, including the study of flavour physics and the quark-gluon plasma, should be exploited.

(European strategy update 2020)

Physics at HL-LHC with ATLAS

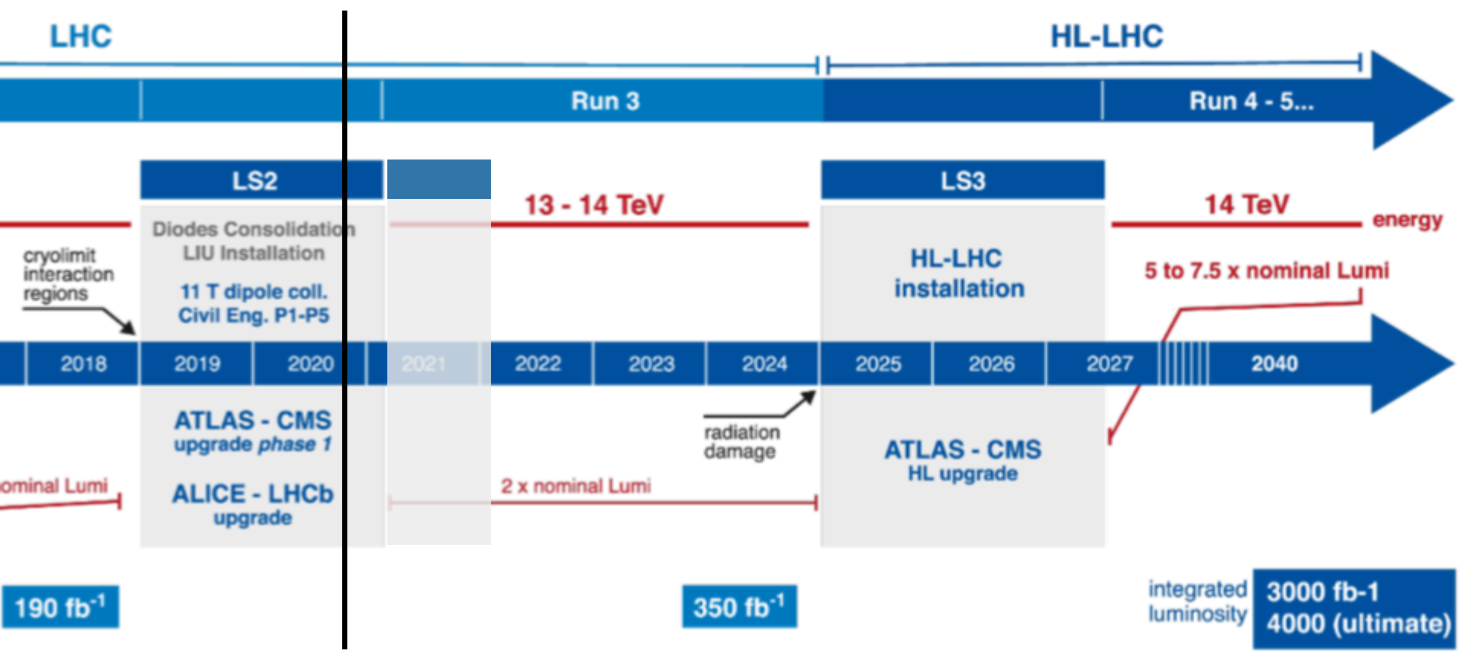
- HL-LHC aims to provide 10x more luminosity than LHC.
- Headline goals are Higgs self-coupling, precision Higgs measurements and extending new physics search reach.





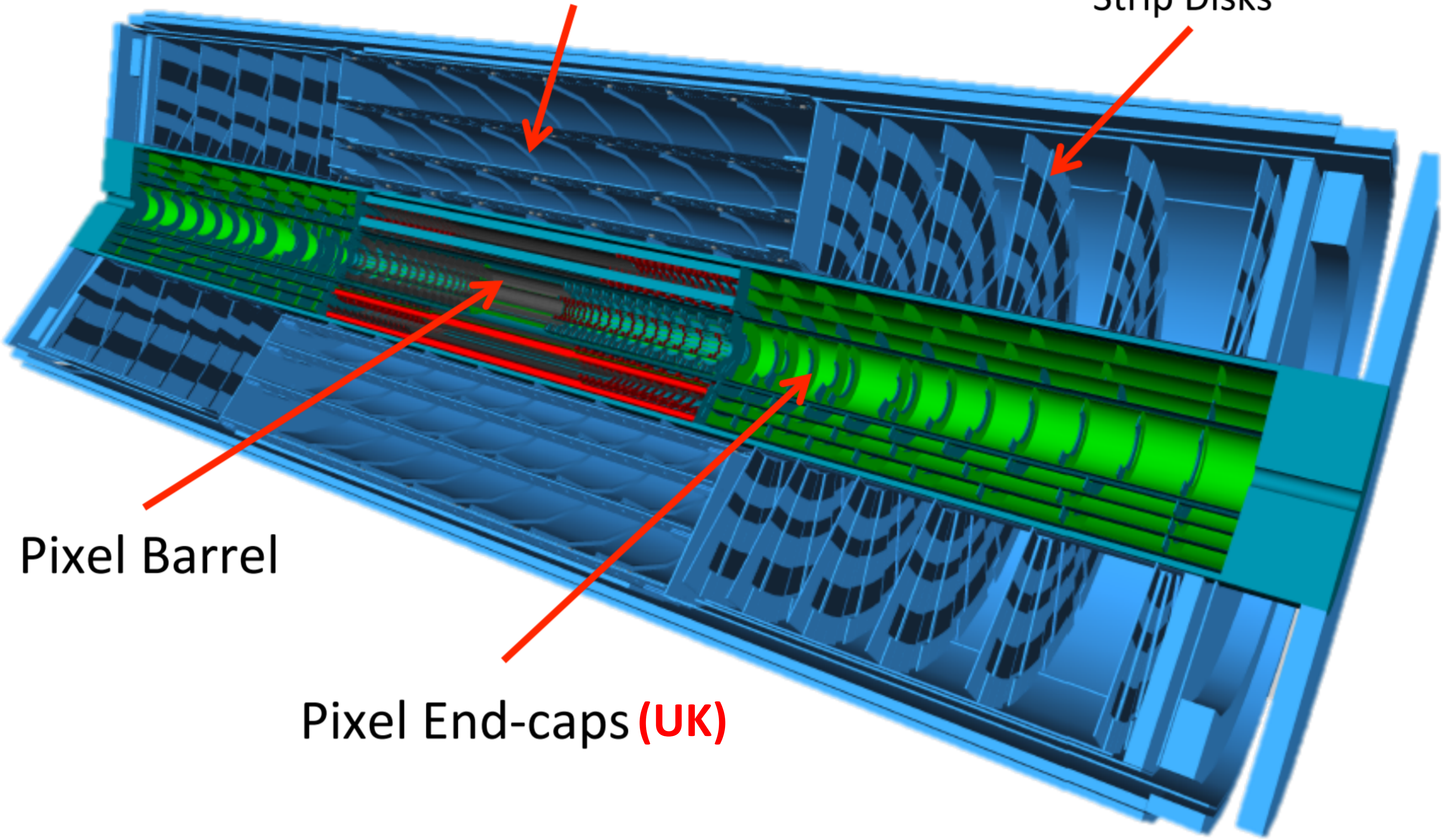
- Requires a detector performing as well as current ATLAS, in much higher pile-up environment.

Upgrading for HL-LHC



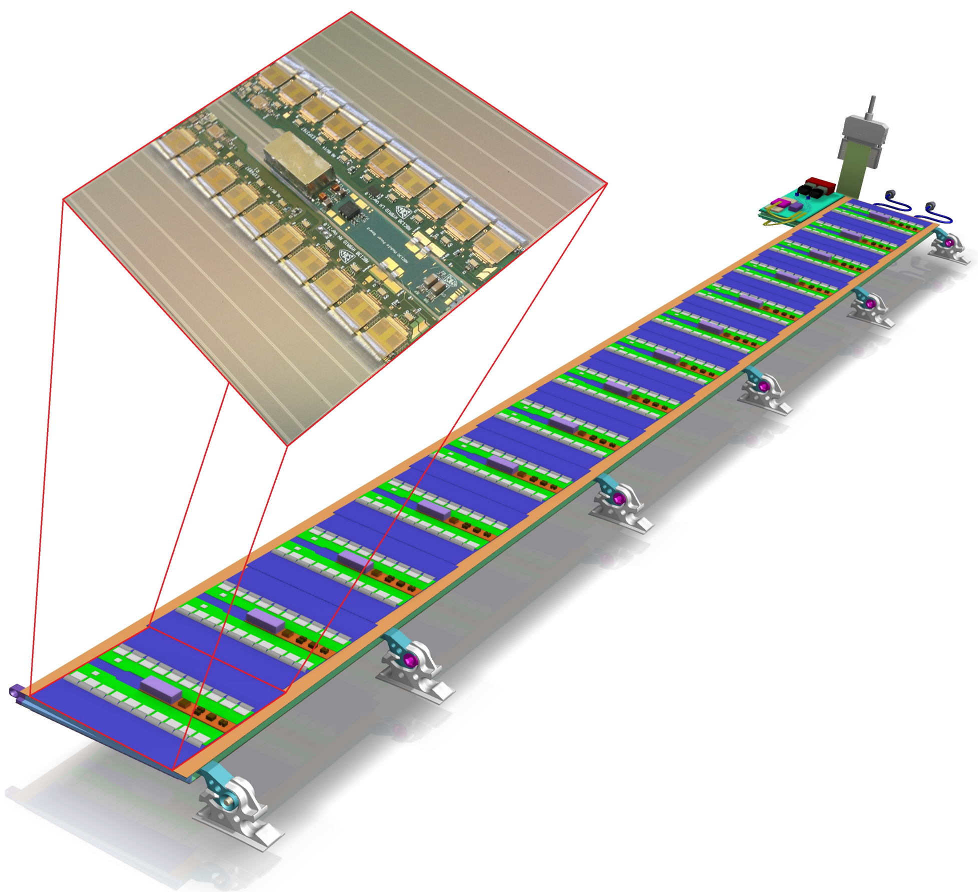
- **All new Inner Tracking Detector ITk**
  - **Strips and Pixels**
- Muon system upgrade.
- Upgrades to the LAr & Tile Calorimeters
  - & **associated Triggering**
- **Upgraded TDAQ System**
  - **DAQ**
  - **Event triggering & filtering,**
- **Computing**
  - **Offline software**
  - **Simulation & reconstruction**
- High Granularity Timing Detector HGTD

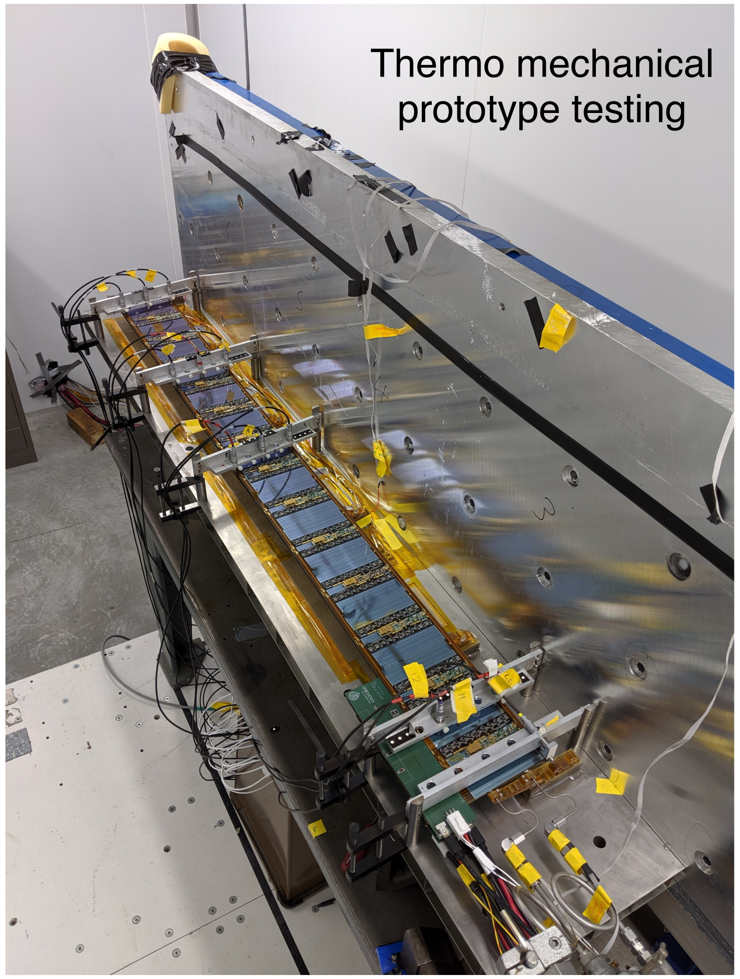
ITK



ITK Strips

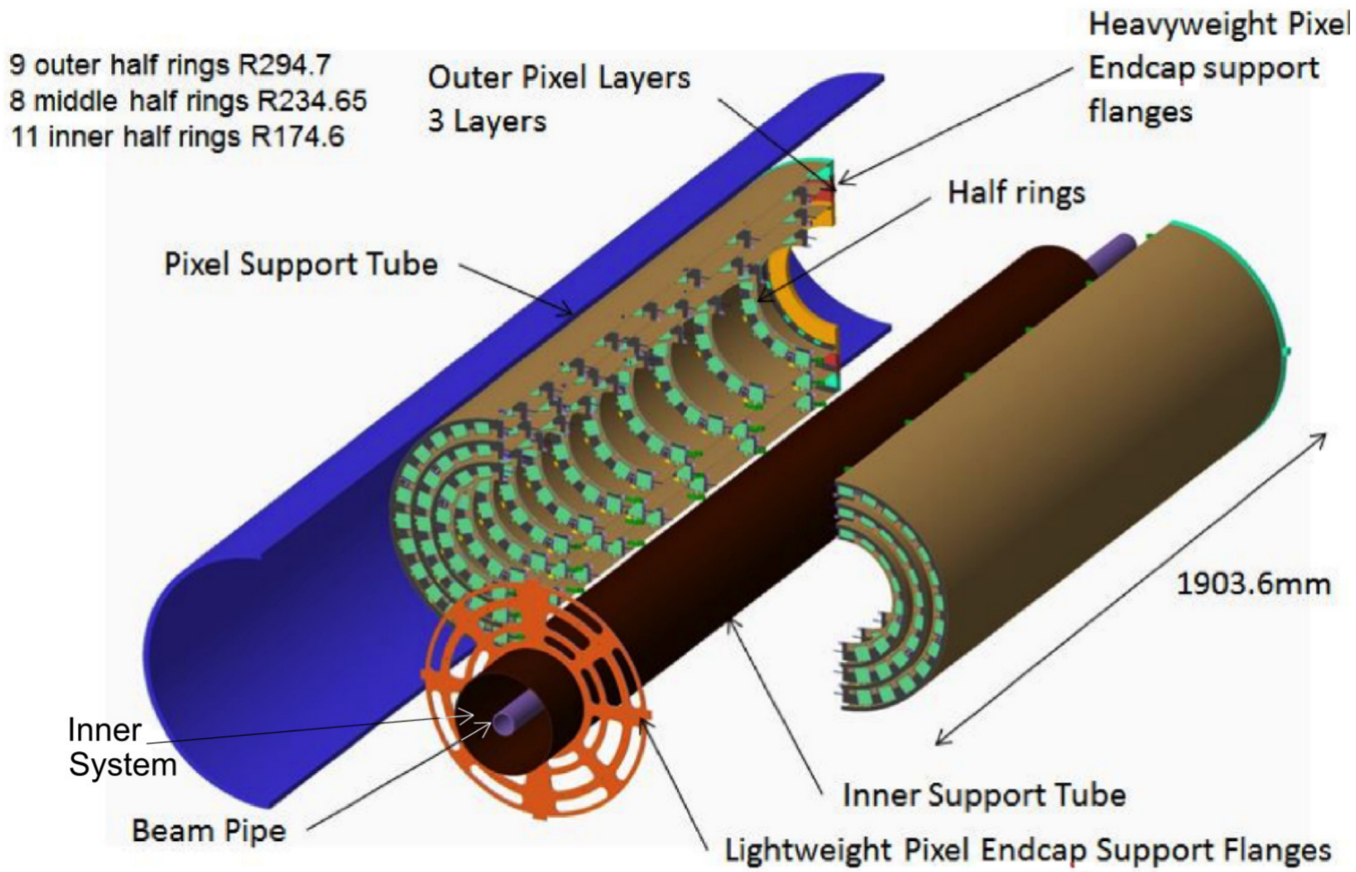
- Barrel strip detector constructed of staves, with ~10x10cm modules, strip pitch ~70μm. UK responsible for ~220 (half) of the staves.
- Design & prototyping largely complete, pre-production next year.



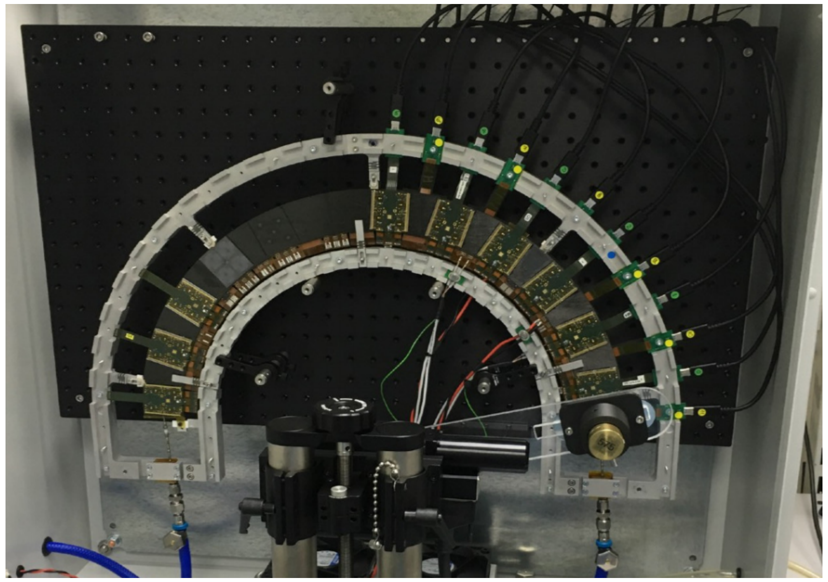


ITK Pixel

- Pixel end-cap detectors constructed from half-rings, cell size 50 x 50 μm² or 25 x 100 μm². UK responsible for 1 of 2 endcaps.



Outer Endcap

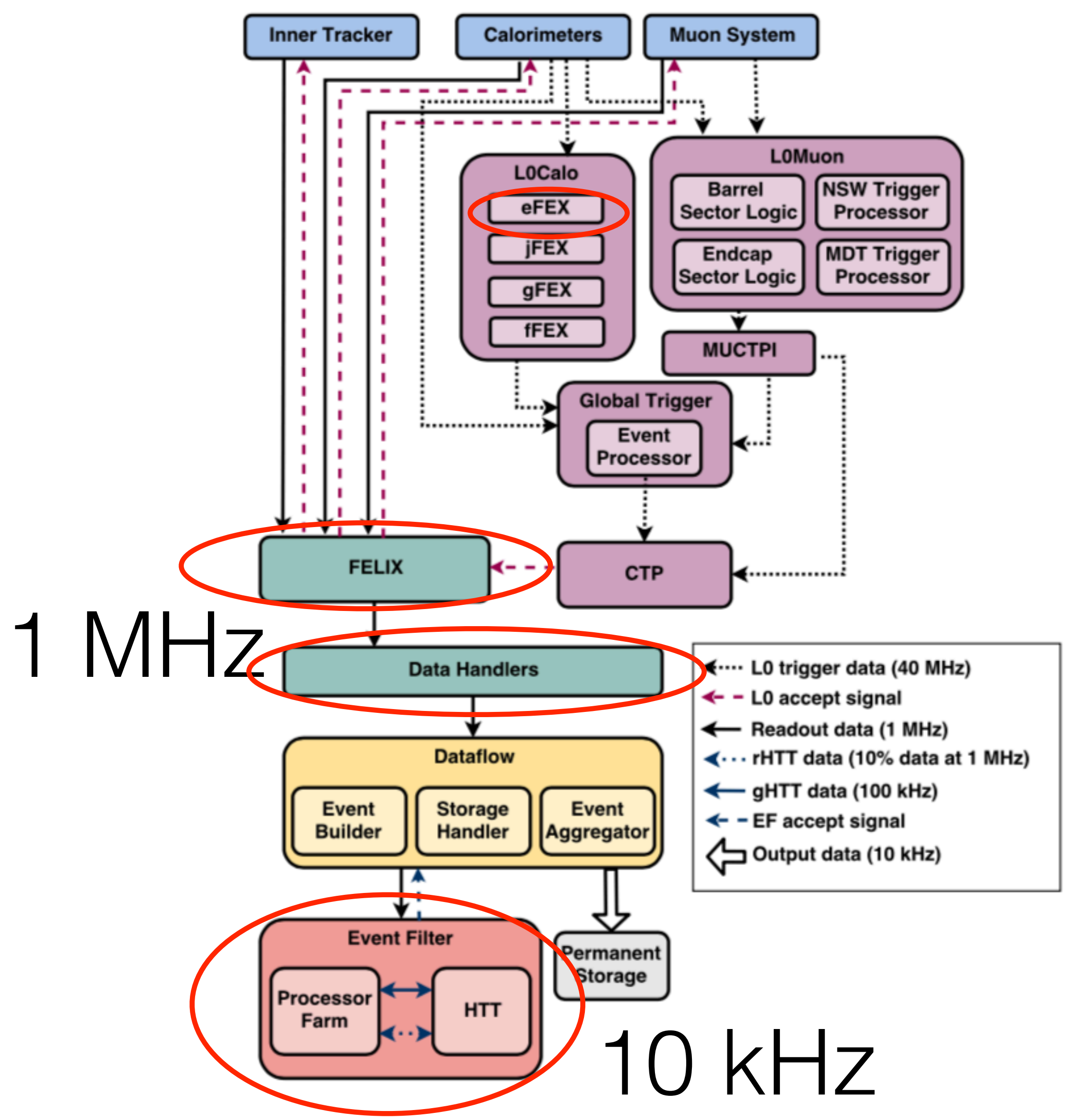


- Prototype ring-0 built & operated. Lessons learned incorporated into final design.

- Various design features under study & final chip is to be produced.

Trigger & Data Acquisition

- Keep two level trigger system, output rates up by x10.
- Need improved hardware and software triggers to cope with rates:



UK responsibilities & leadership

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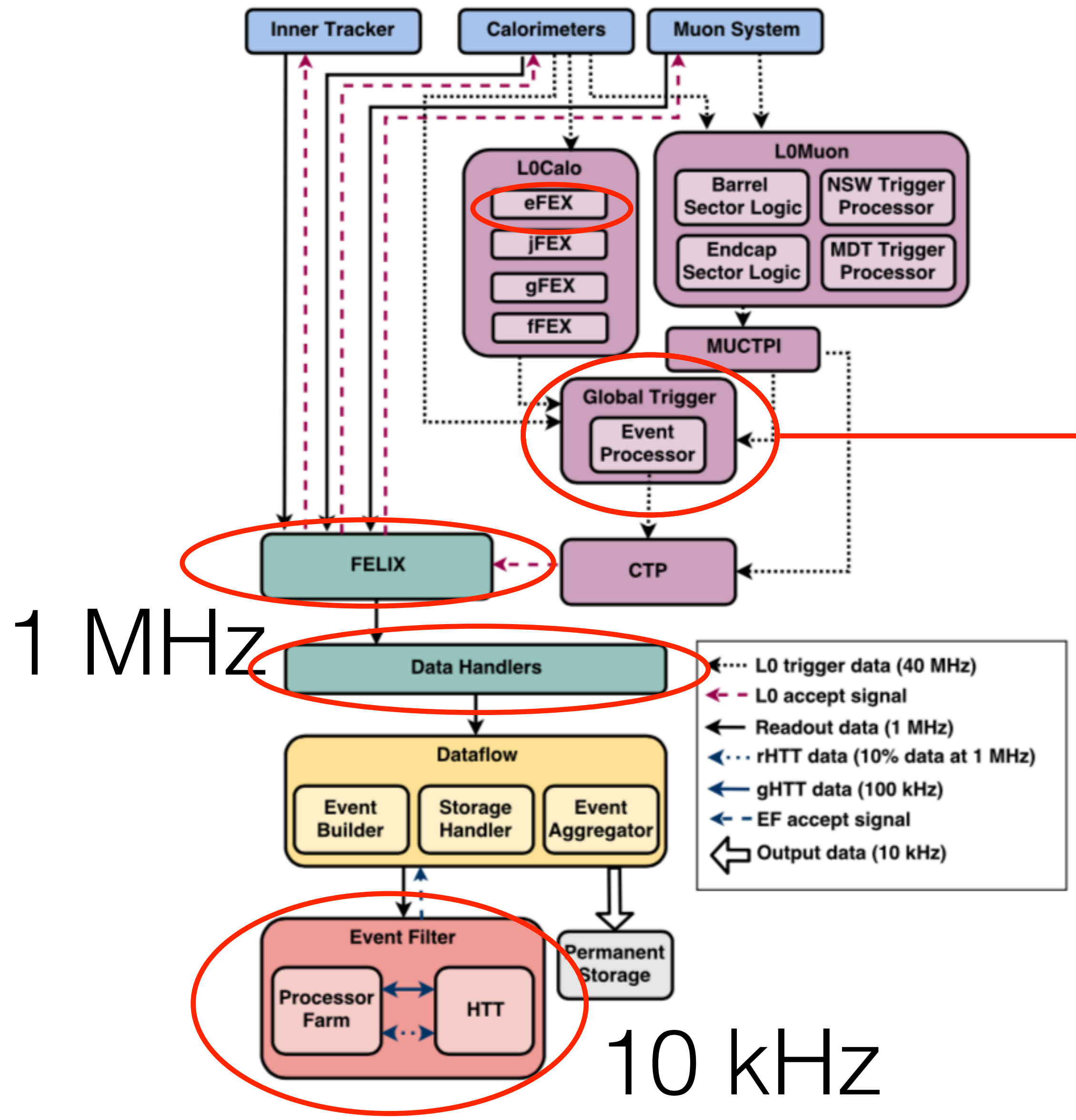
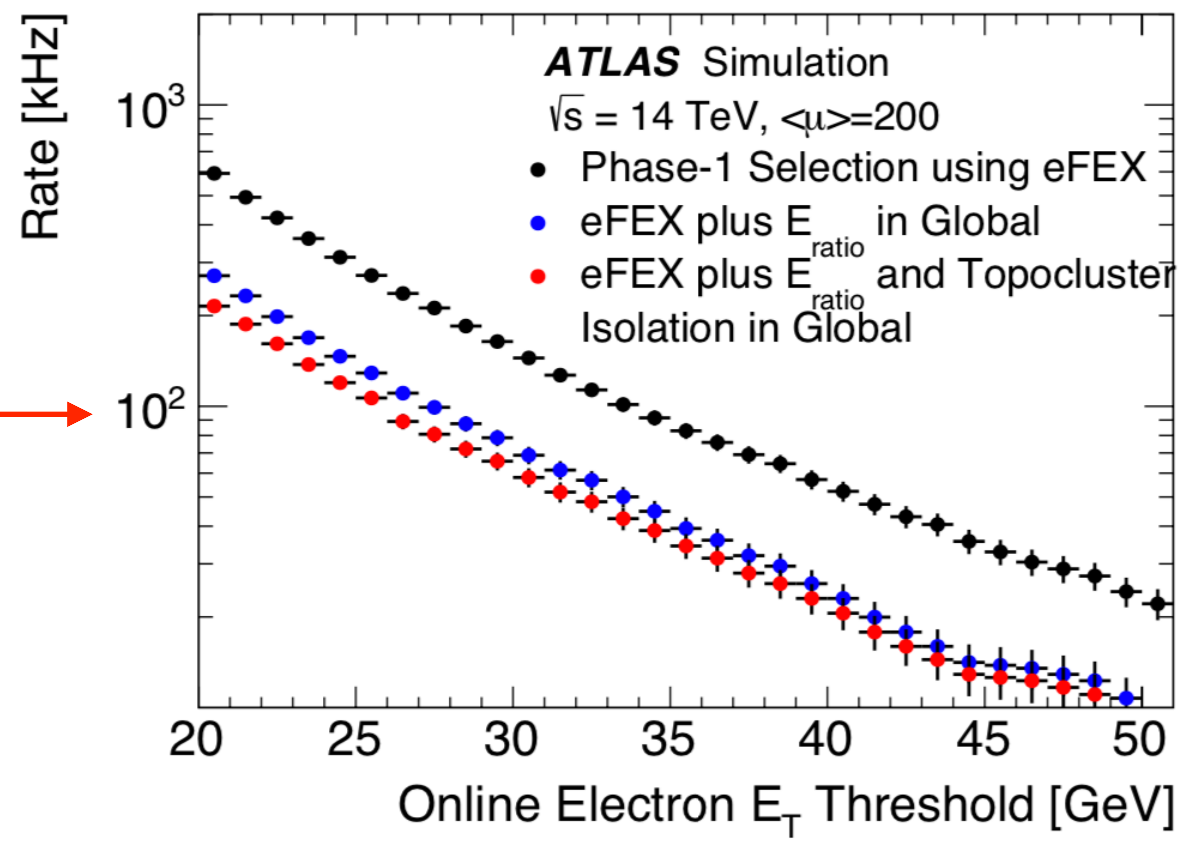


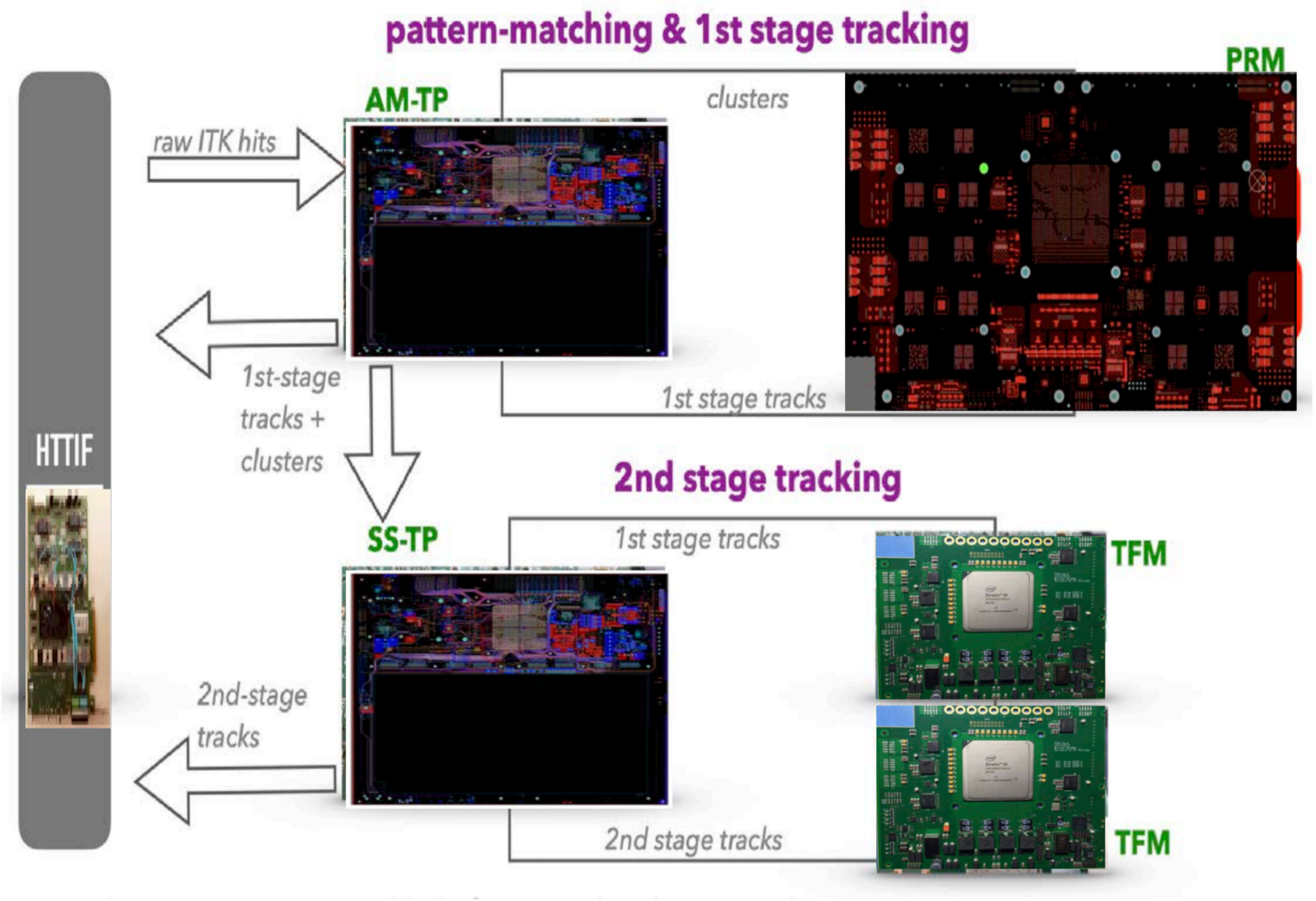


UK responsibilities & leadership

Hardware Track Trigger

- Track finding implemented in AM ASICs will provide tracks to be used in the software stage of the trigger (EF).

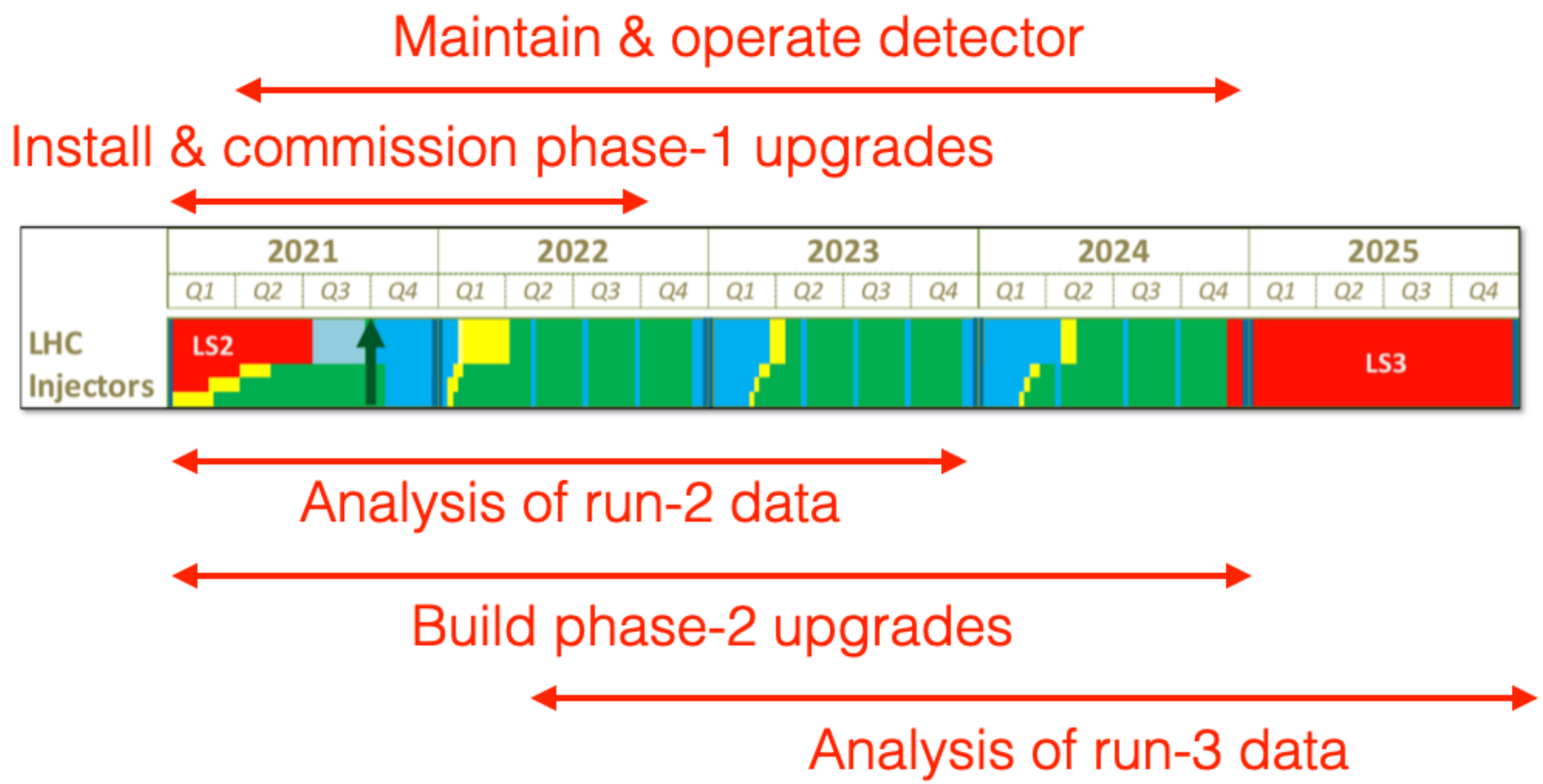
- Goals:
  - Regional: 10% of detector @ 1 MHz
  - Global: full detector @ 100 kHz



- Status: testing HW demonstrators and submitting smaller but fully functional version of final ASIC.

Summary

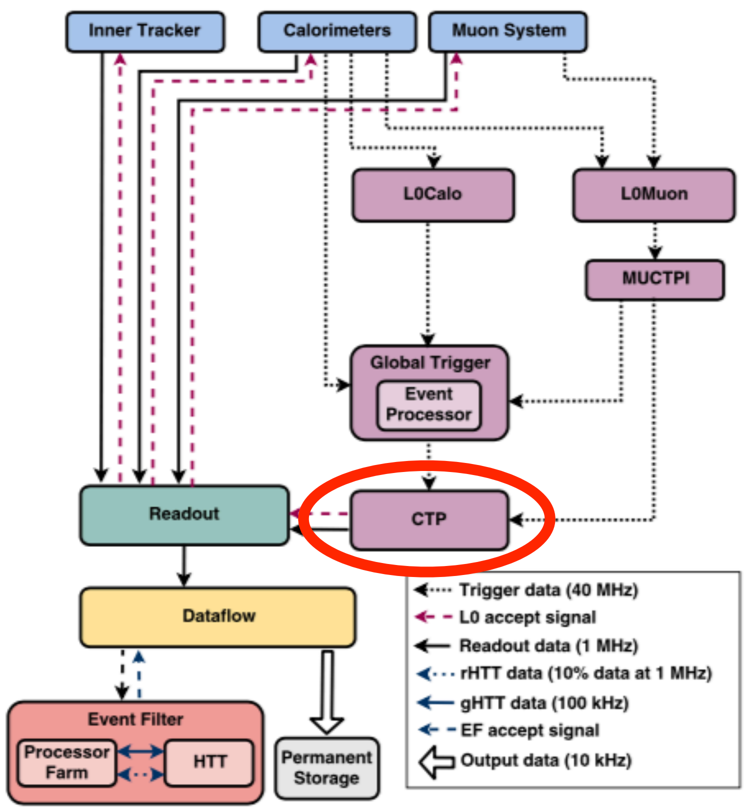
- ATLAS UK continues to produce important physics results & make vital contributions to the future of ATLAS.
- Next 5 years look to be as busy as any 5 before.

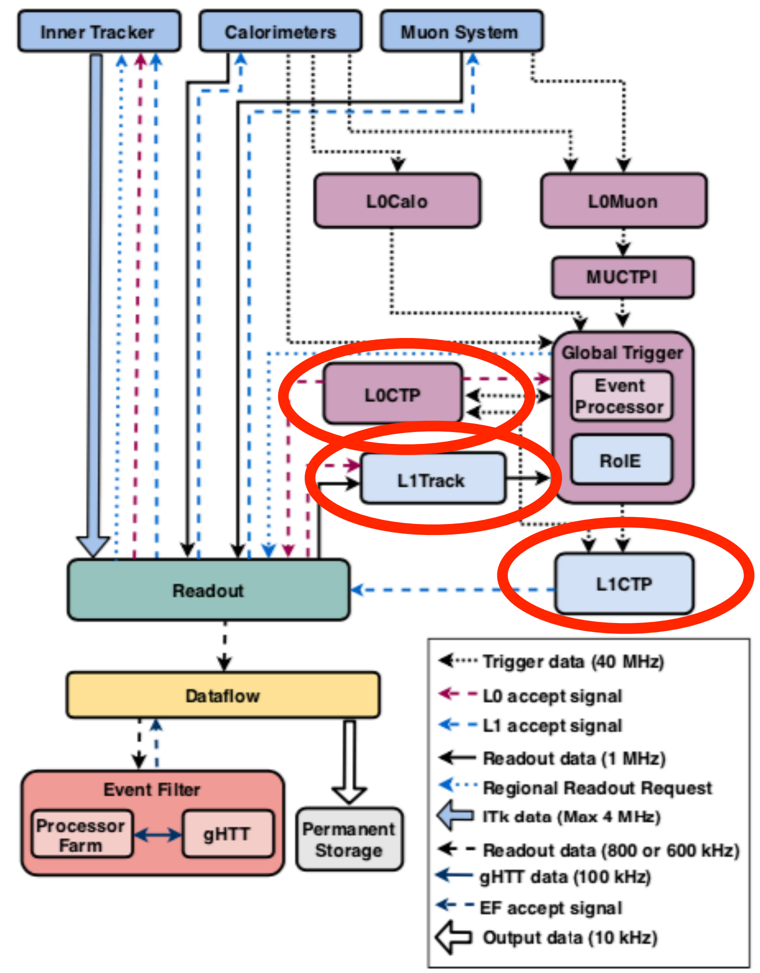


Backup

L1 evolution decision

- TDR included potential evolution from L0+HLT to L0+L1+HLT system, with tracks reconstructed at L1.





- Recent decision: do not proceed with the evolved setup, will build only the baseline system.