ATLAS status

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A truly titanic task

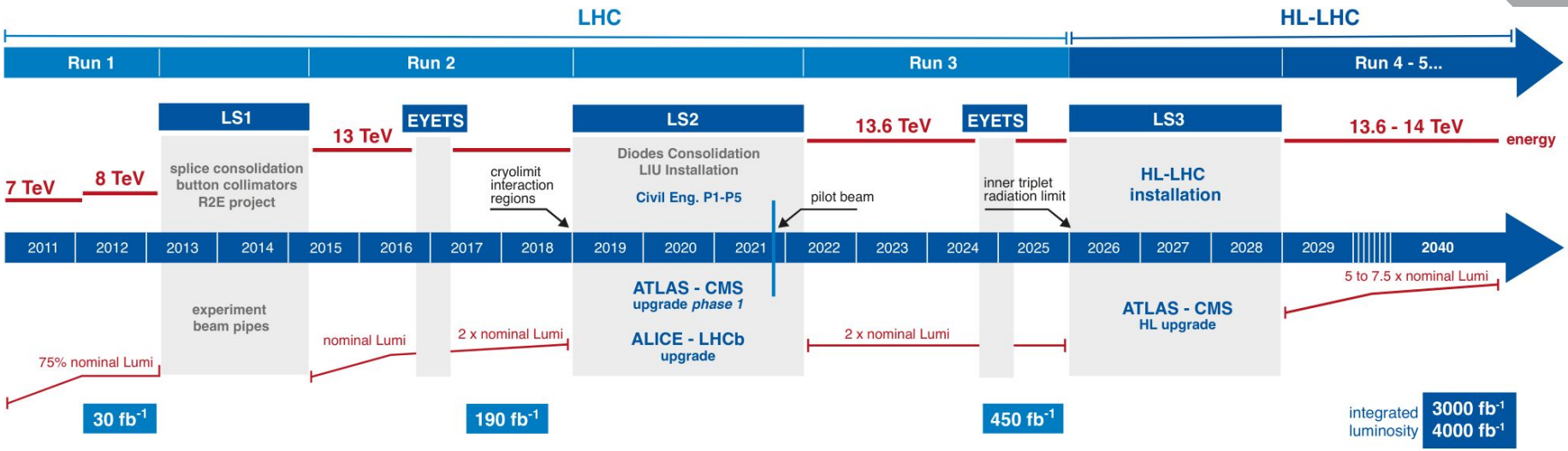
Summarizing ***everything ATLAS*** in 20 minutes is a pipe dream

- A short overview of how run 3 data taking is going
- Some 2023 analysis **highlights** I've chosen in a fully biased way
- A brief snapshot of how we are preparing for the HL-LHC

"It's a dangerous business, Frodo, going out your door. You step onto the road, and if you don't keep your feet, there's no knowing where you might be swept off to."

Where are we?

The Collaboration is hard at work with run 3 data-taking…

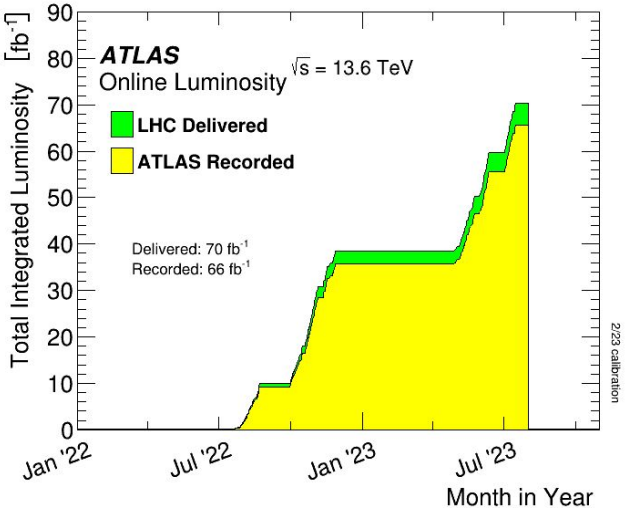


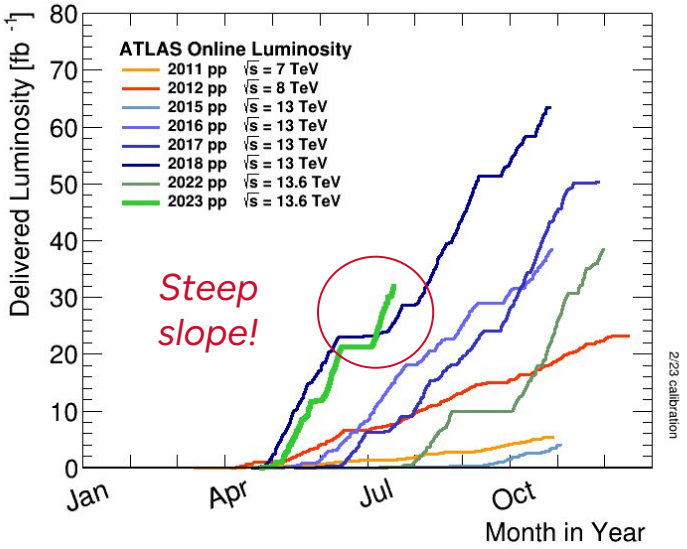
… while preparing for the HL-LHC!

Strong push to finalize the ongoing run 2 publications !

Two years into run 3

2023 in numbers:
pp 13.6 TeV: 29.9 fb-1
PbPb 5.36 TeV: 1.75 nb-1





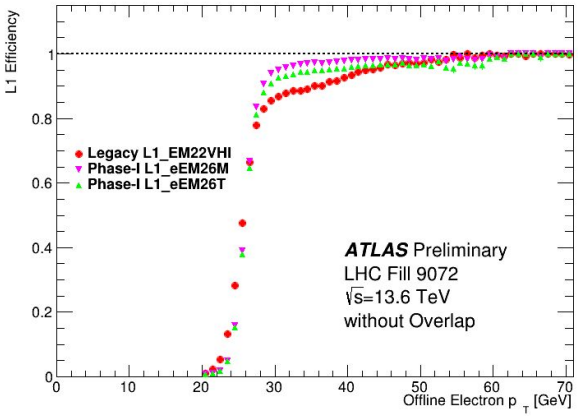
Shortened 2023 data taking lead to lower pp integrated luminosity that what we would have liked but the excellent data taking rate during the last period is good news for 2024 and 2025

Evolving detector

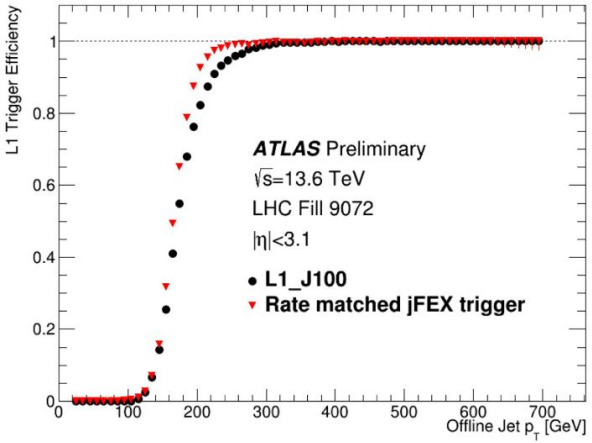
Continue the integration of Phase I items

eFex now fully the primary EM trigger, no more legacy

Focus switched to the rest of the L1Calo systems, Jfex jet trigger very near full deployment when data taking ended



Phase I trigger upgrades

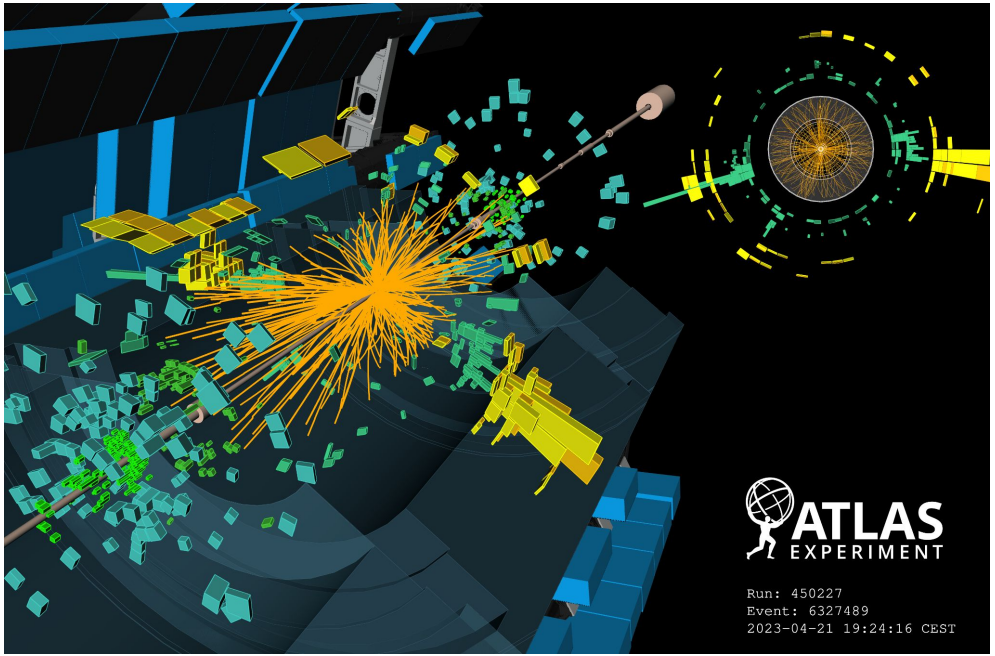


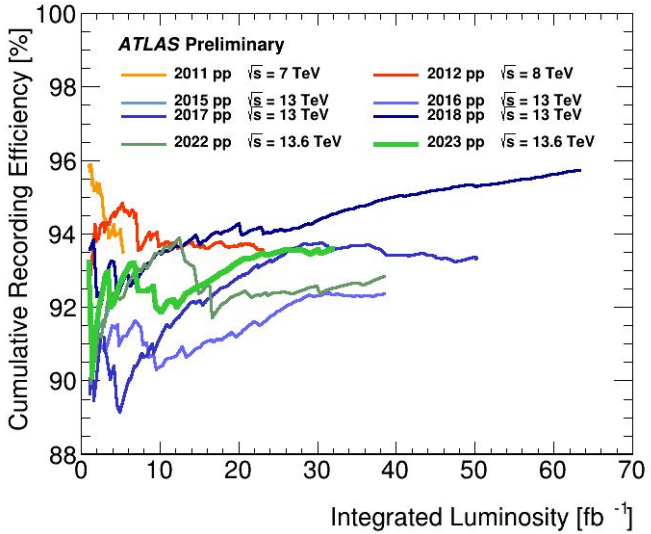
Commissioning while taking high quality data is really hard

Lots of work in improving DAQ stability of New Small Wheel

Despite the challenges...

A lot of nice data has been taken at a high efficiency

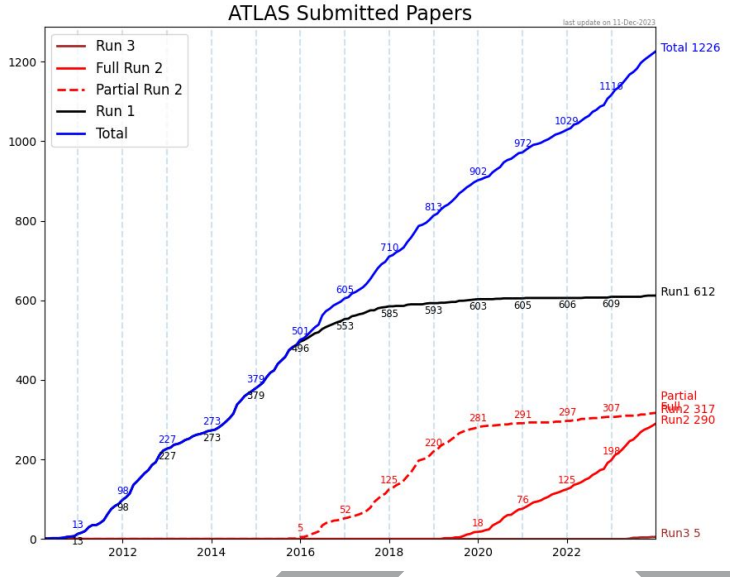




We couldn't do it without all of the experts and collaborators that give their time to operations.

A selection of 2023 public results

Run 2 publication efforts still in full swing



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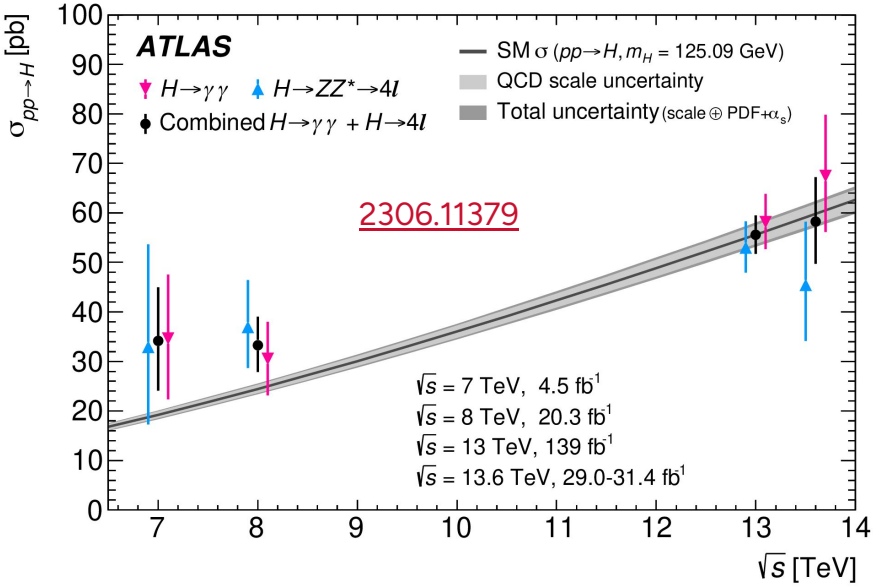
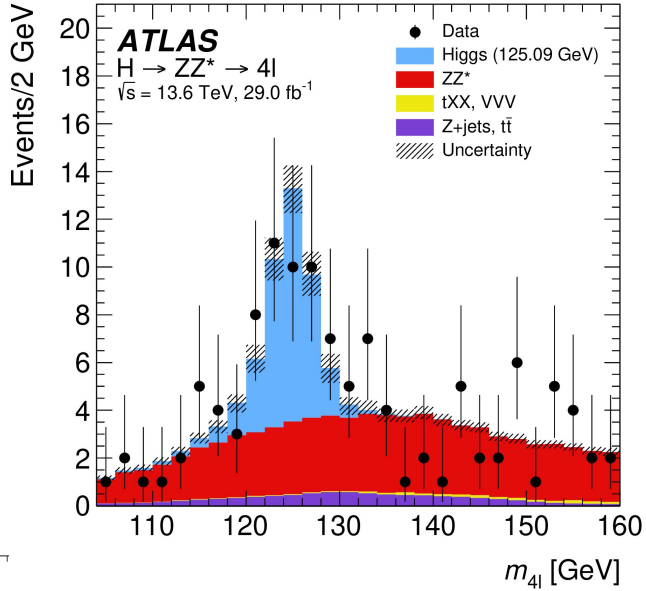
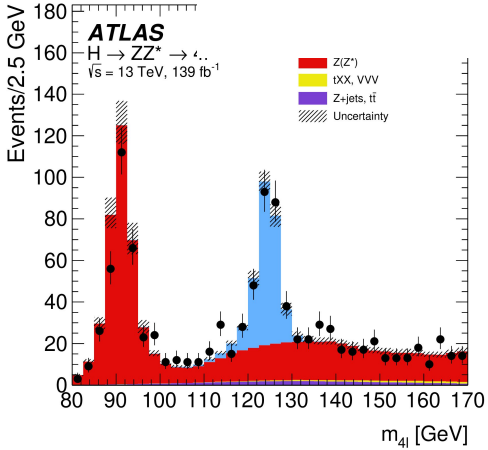
First 13.6 TeV public results!

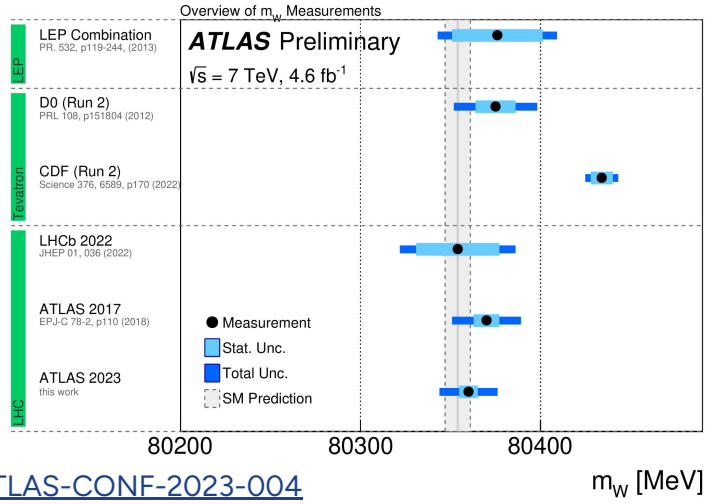






Combined diphoton and 4l measurement. One of the first results coming out of run 3!!

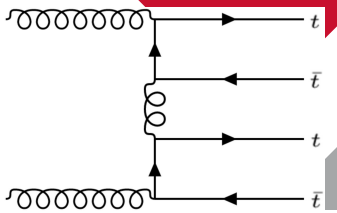
Old and new SM measurements



ATLAS-CONF-2023-004

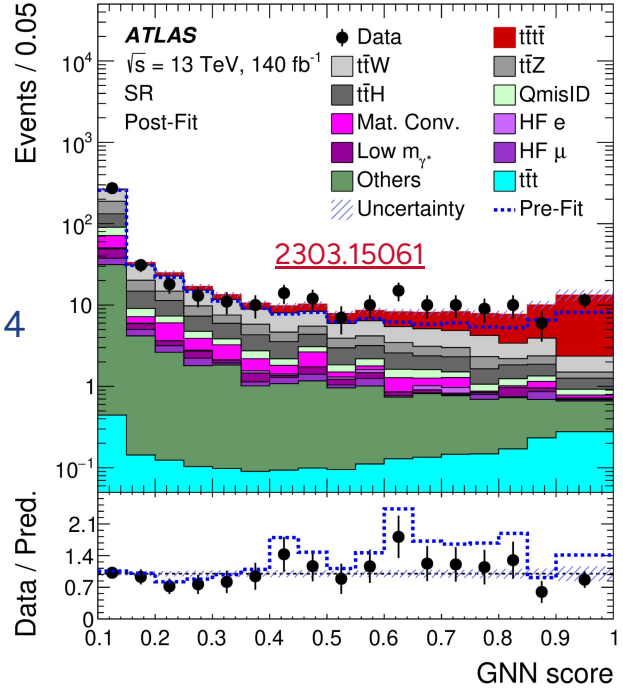
Following the excitement of the CDF results last year ATLAS has published a new result with 7 TeV data

Profile likelihood fit with Mw as parameter using transverse mass of the W and the Pt of the lepton, more precise than previous analysis, compatible with SM

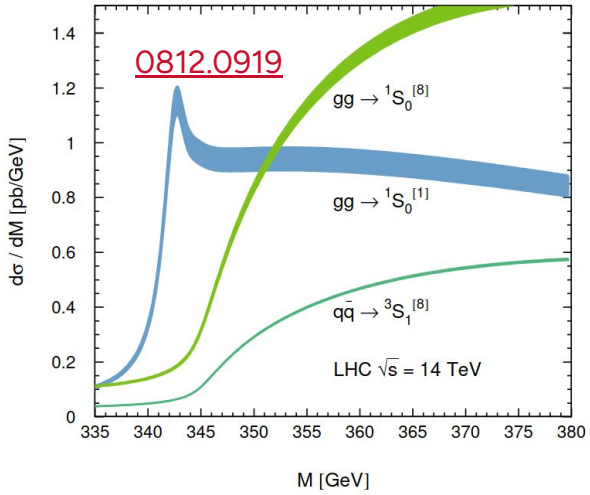


Near simultaneous publication of the observation (6-5 σ) of 4 top production by ATLAS and CMS

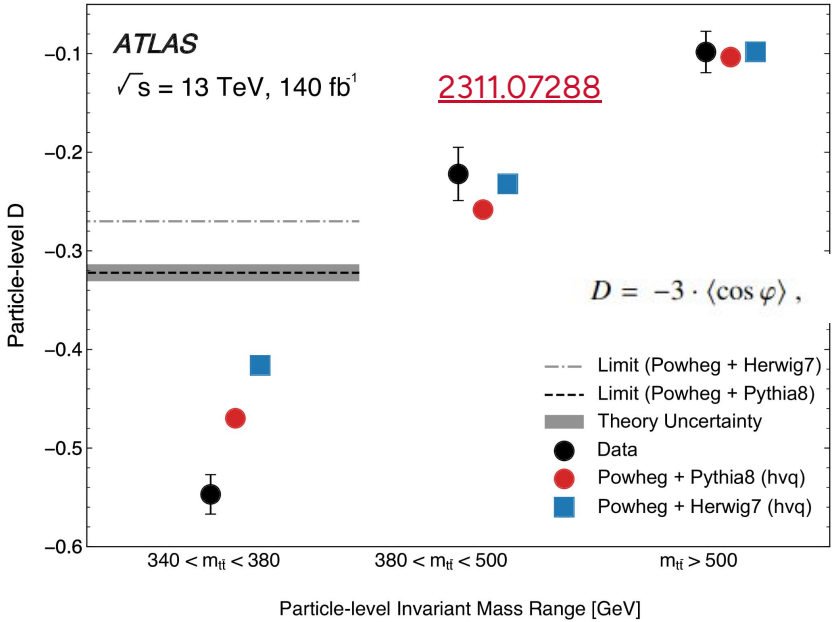
Excess with respect to standard model expectation (around 2 σ)



~~Old~~ and new SM measurements



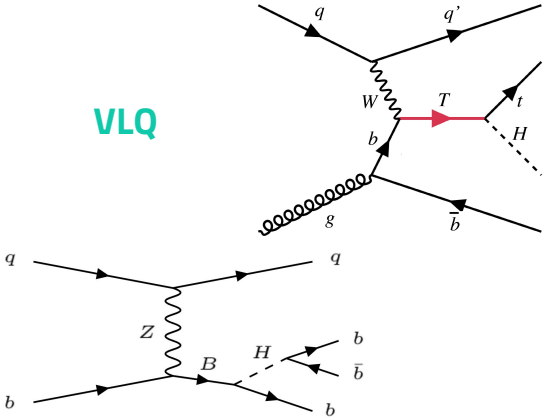
Top-quark pairs produced near threshold arise from a spin-singlet state that is maximally entangled

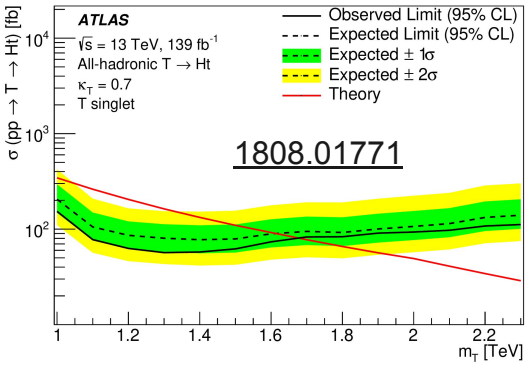


First observation of entanglement between a pair of quarks and the highest-energy measurement of entanglement.

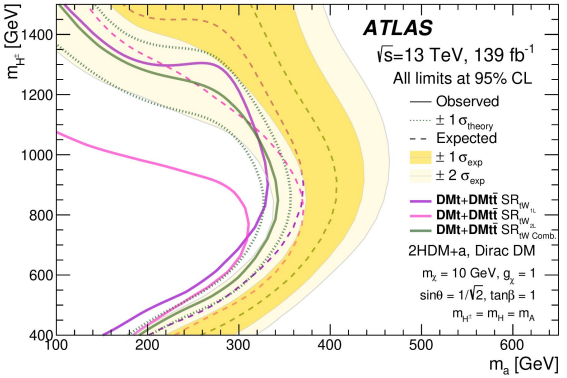
Extended the range of plenty of searches

VLQ

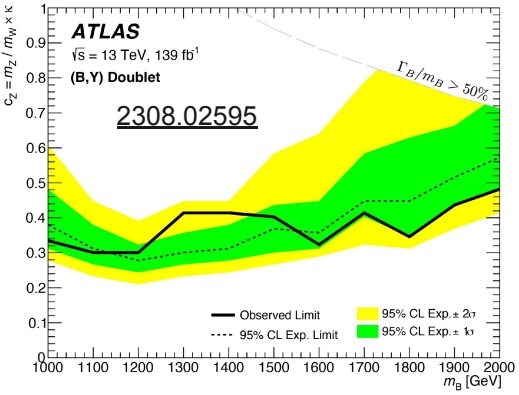




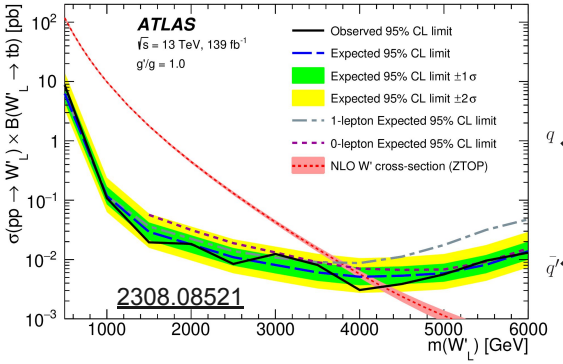
1808.01771



2011.09308

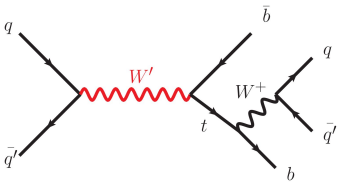


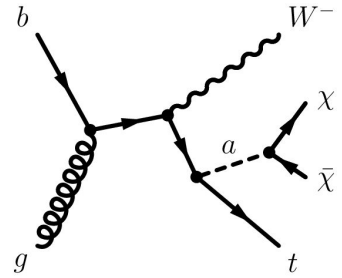
2308.02595



2308.08521

Vector Resonance



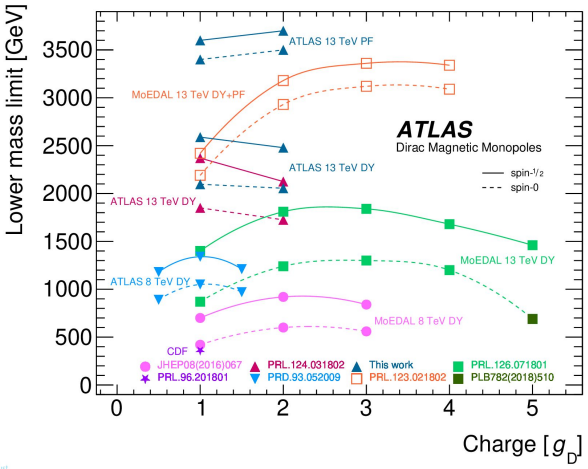


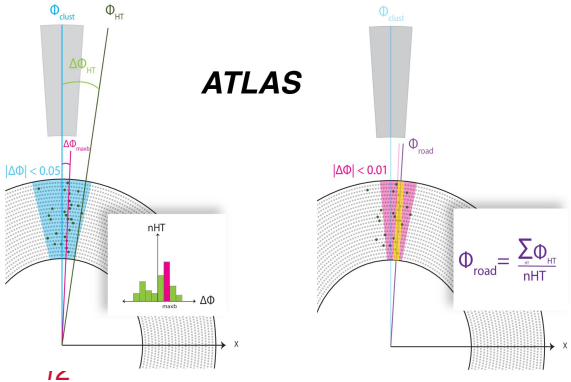
Dark Matter

Tried new techniques

Magnetic monopoles and particles with high electric charges

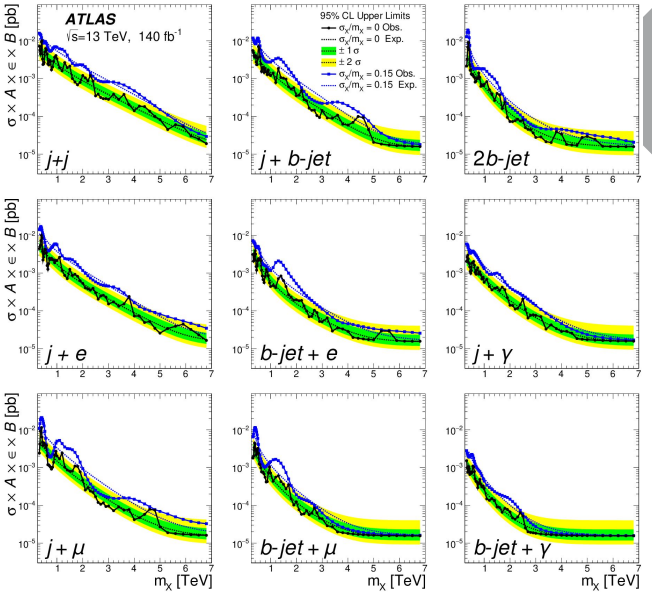
2308.04835





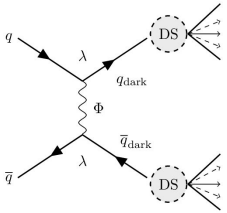
Dedicated reconstruction techniques in TRT and Calorimeters

2307.01612



Event level anomaly detection for the first time in an ATLAS analysis
Events with at least one lepton

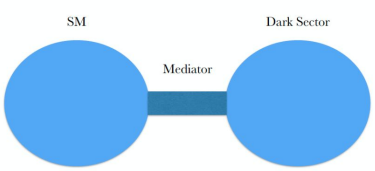
Looked into dark sectors

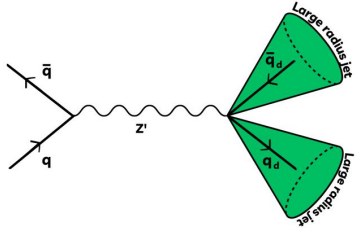


Jets with Mixture of SM and DS hadrons Events with jets and missing Et

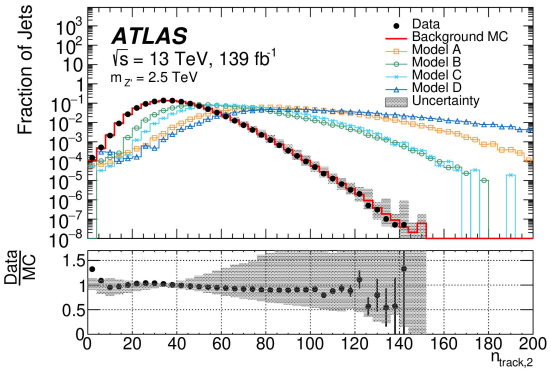
Earlier this year

2305.18037

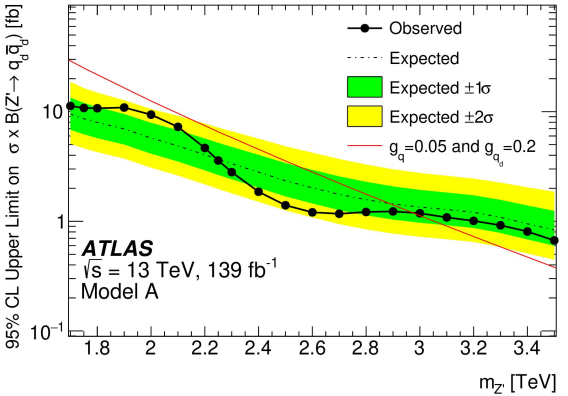




Wider jets with more charged particles than SM jets



2311.03944



HL-LHC, the new frontier

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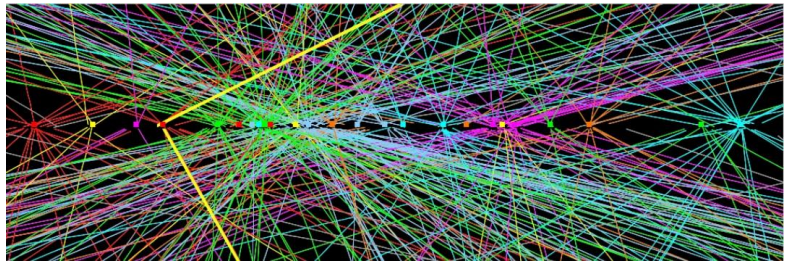
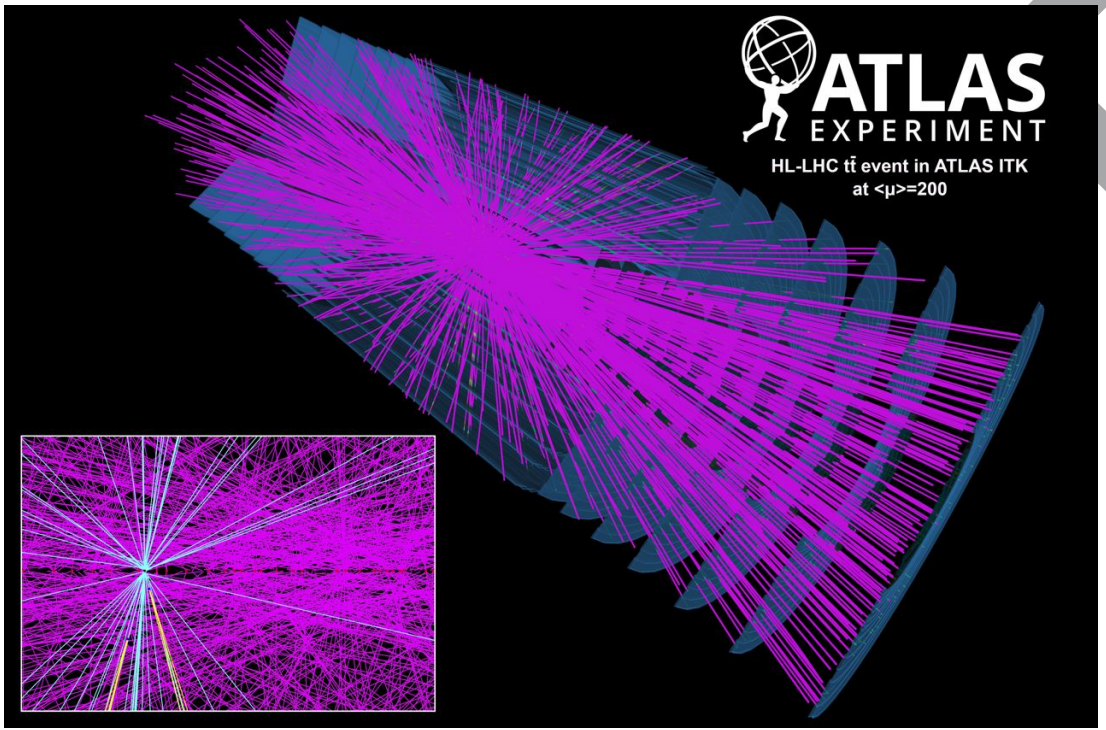
The challenge of the HL-LHC



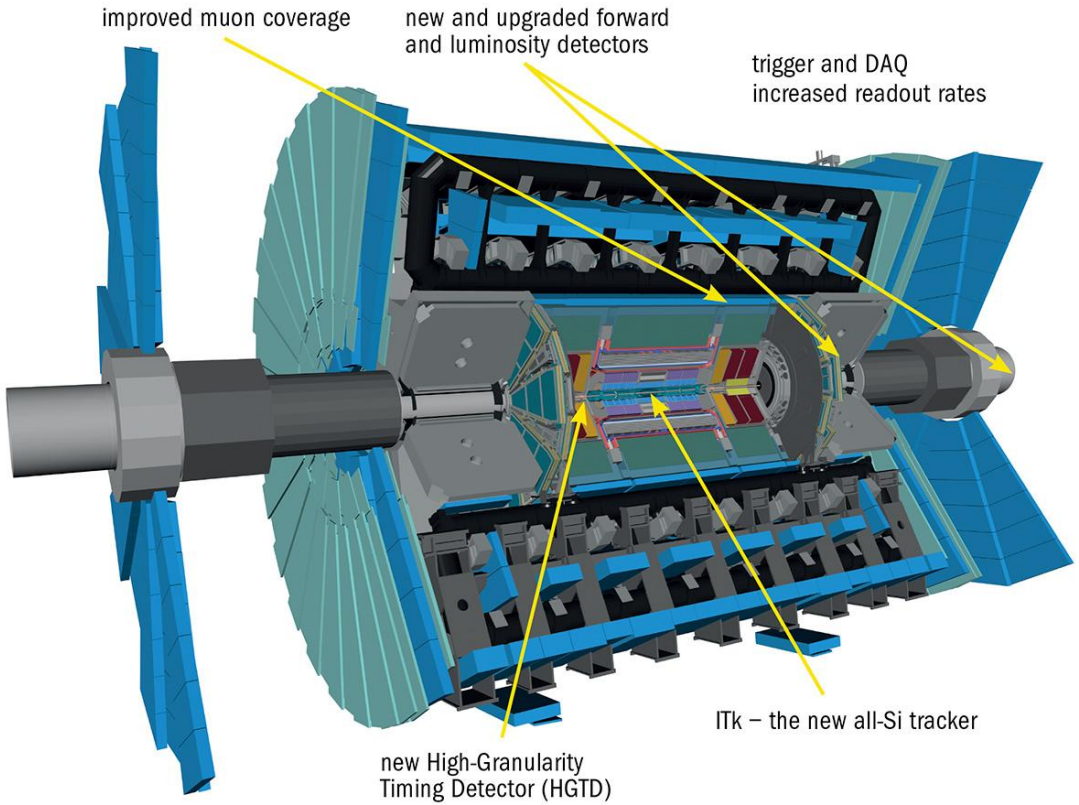


At HL-LHC we expect ~200 Average interactions per crossing (2022-2023 average is 44)

Lots of tracks, lots of vertices, lots of radiation, lots of everything !

The experiments will also need to upgrade… no other option !

ATLAS Phase 2 upgrades



Improved luminosity and forward detectors

New muon chambers and electronics

ITK: All silicon with 9 layers up to $\eta = 4.0$

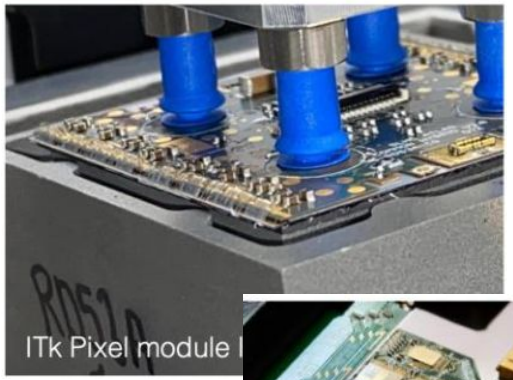
HGTD: 30 ps precision track timing in the forward region

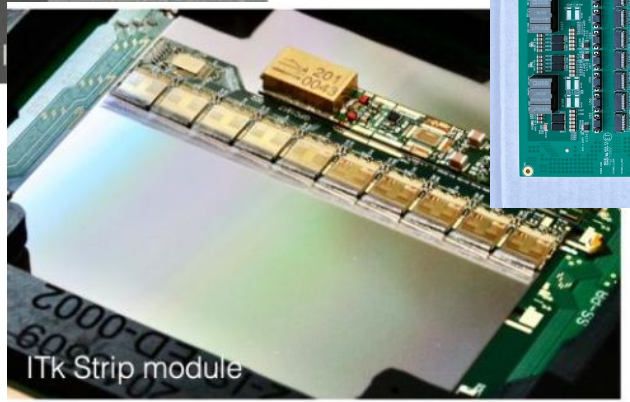
Improved trigger and DAQ system, L0 output @ 1MHz, Full calorimeter granularity, Heterogeneous EF system @ 10 KHz

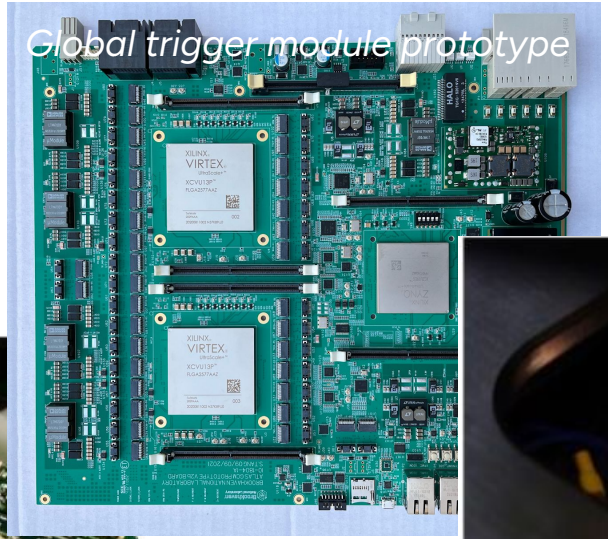
We are in a critical period

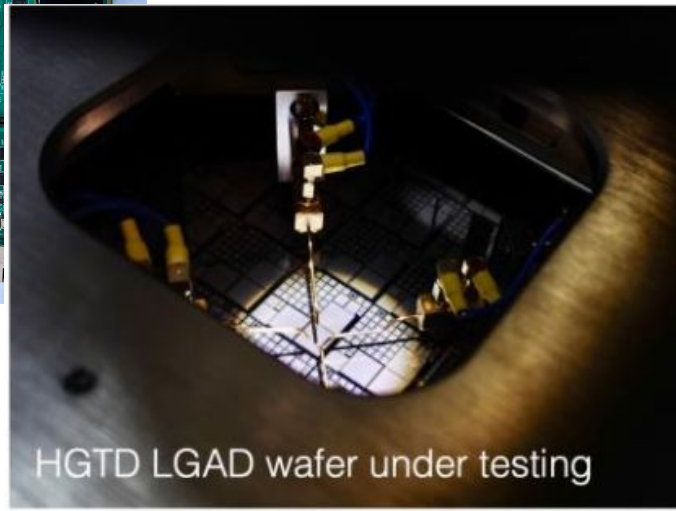
Many ATLAS Upgrade projects are moving into production

Many procurements and technical achievements









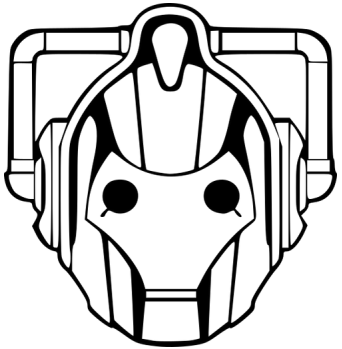
Challenges and next steps

- *Few remaining technical issues under intense scrutiny before we move to production*
- *All of the projects undergoing a comprehensive sets of reviews, both internal and external*
  - *A lot of them planned for 2024 (Final design reports, Production readiness reviews)*
    - *30 just for ITK!*
- *Tight schedules for many projects, but a lot of work going on to find ways to gain contingency and increase robustness.*

Beyond production, large parallel effort to get CP and DAQ ready for commissioning and data taking. LS3 is approaching and we want to be ready as soon as possible

Very active R&D period, many new ideas being explored

Upgrading is compulsory!



Conclusions

- Despite the shortened 2023 pp data taking period, ATLAS detector was able to take a lot of nice data that is already making its way into publications
- A strong push to wrap up ongoing run 2 data analyses
- Plenty of new ideas and approaches to squeeze the potential of run 2 and run 3 data
- The upgrade of ATLAS for the HL-LHC is entering a critical period
  - Supported by a lot of work and a comprehensive review process
  - Intensive period of R&D with lots of cool ideas, we hope to tell you all about it very soon

The road ahead is filled with exciting physics and new challenges, looking forward to 2024

Backup

There is still much to do

As we attempt to cover the full phase space possible for searches and push the sensitivity of the run 2 and run 3 datasets, new approaches are rising to the challenge

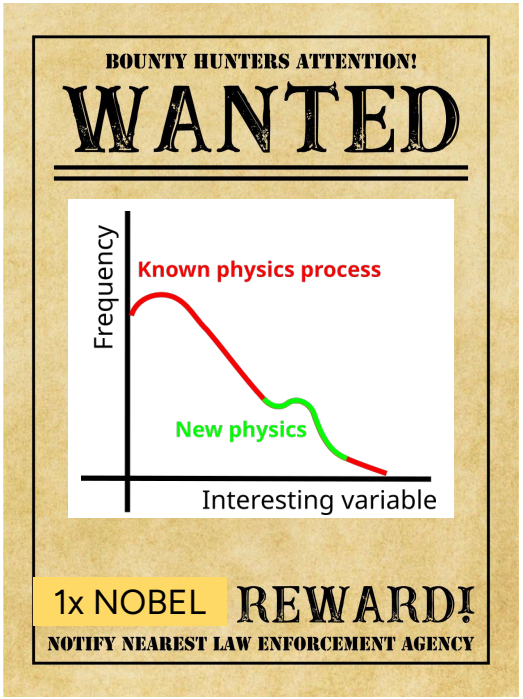
Combinations

Unsupervised learning

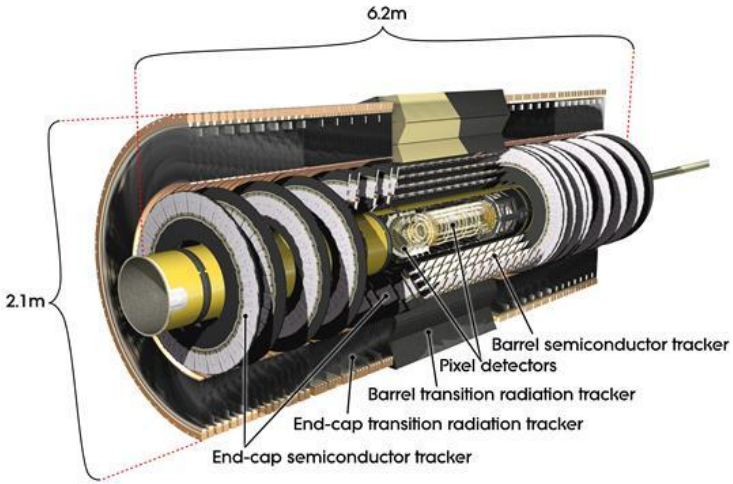
New triggers

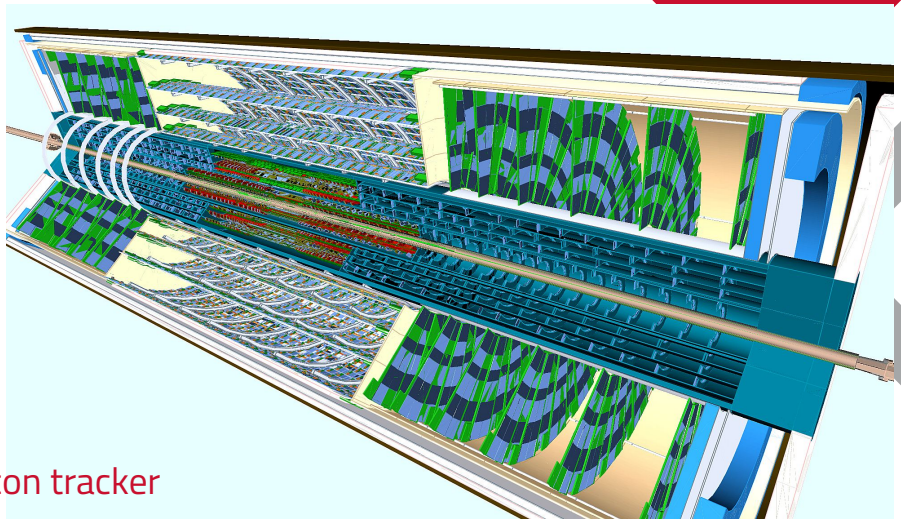
Exciting new models

We are looking everywhere, I swear



Inner detector -> ITK



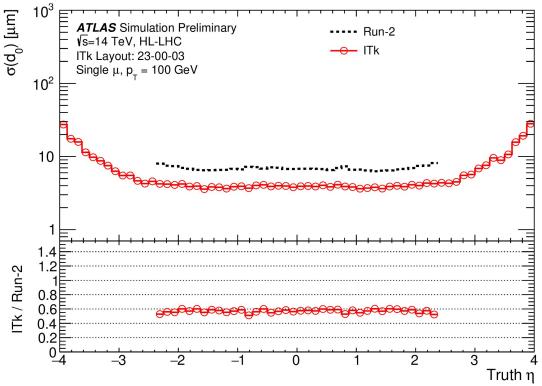


All silicon tracker

Reduced segmentation and material

Extended coverage (η = 2.5 to η= 4)

Tracking performance comparable or better at much higher pile-up conditions



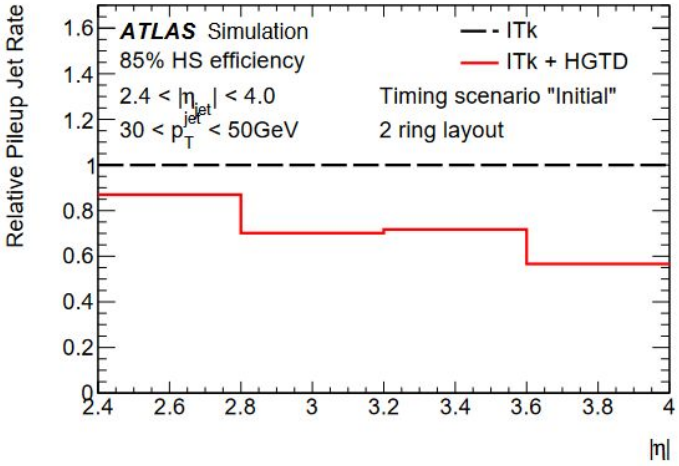
Inner parts of ITK pixel replaceable

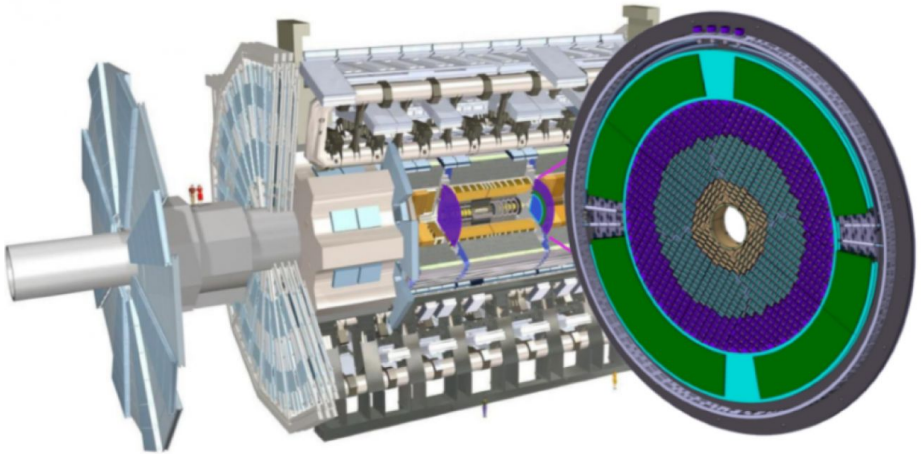
High Granularity Timing Detector (HGTD)

2 endcap wheels between ITK and calorimeters (in space currently occupied by the MBTS)

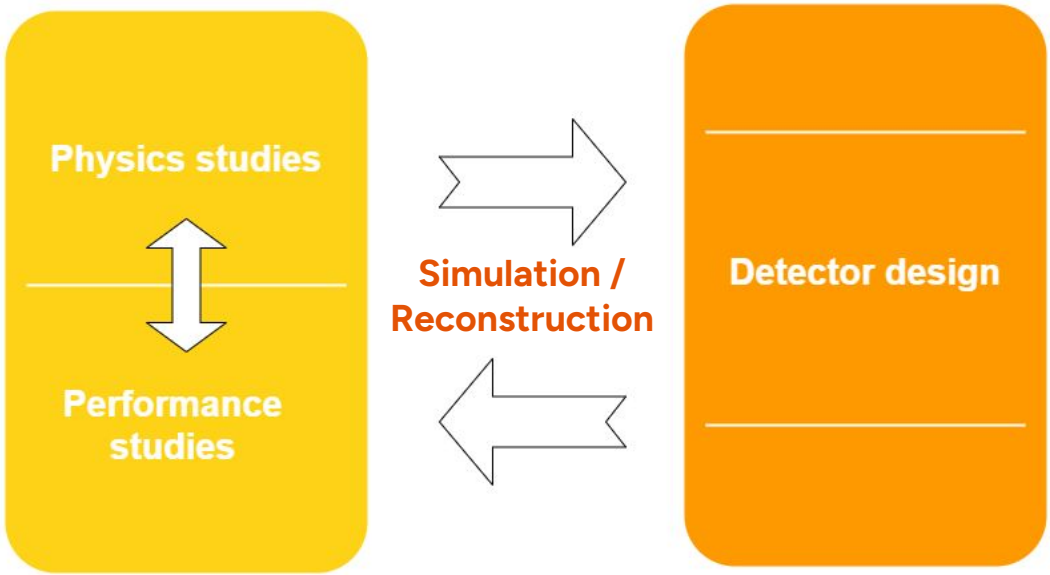
Timing resolution of 30ps per track
Four layers of silicon detector modules covering $2.4 < |\eta| < 4$

Improved vertex reconstruction and pileup rejection in the forward region





The feedback loop is essential

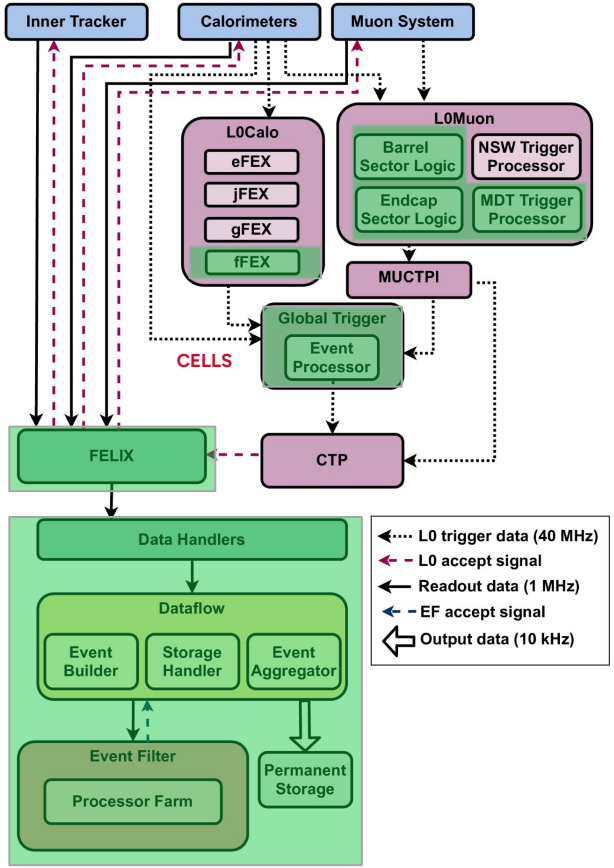


The upgrade is still an **moving target**

Huge amount of work by **software and computing groups** to make studies possible

Detector design and physics/performance studies don't live in isolation, they inform each other as the system evolves and we approach final designs

The run 4 trigger system



Improved Muon trigger

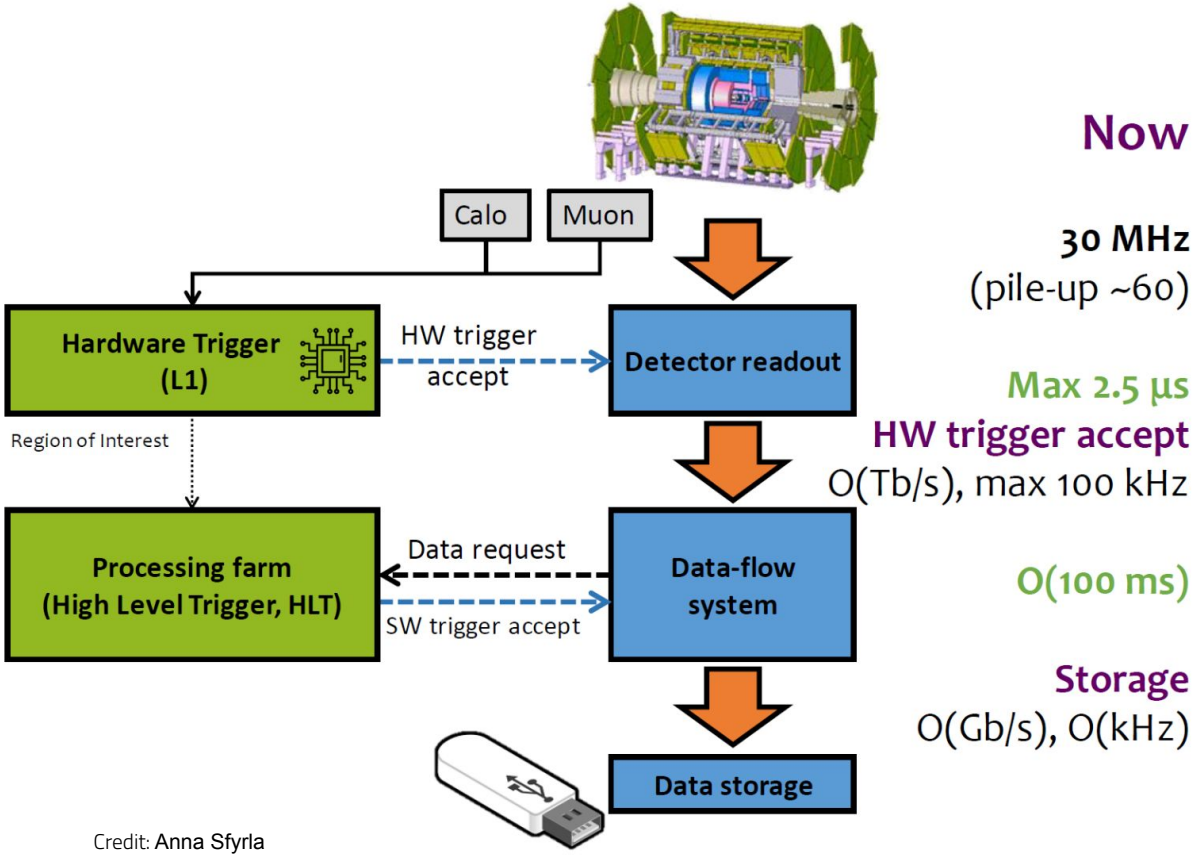
New Fex (fFex) especialized in dealing with the forward region

New global trigger with access to full calorimeter granularity and inputs from L0Calo and L0Muon

New Event filter: Heterogeneous* commercial farm including tracking

**Not necessarily one type of hardware, technology decision to be taken in 2025*

Trigger evolution From run 3...



Now

30 MHz
(pile-up ~60)

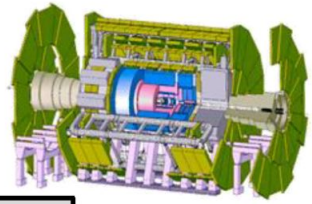
Max 2.5 µs
HW trigger accept
O(Tb/s), max 100 kHz

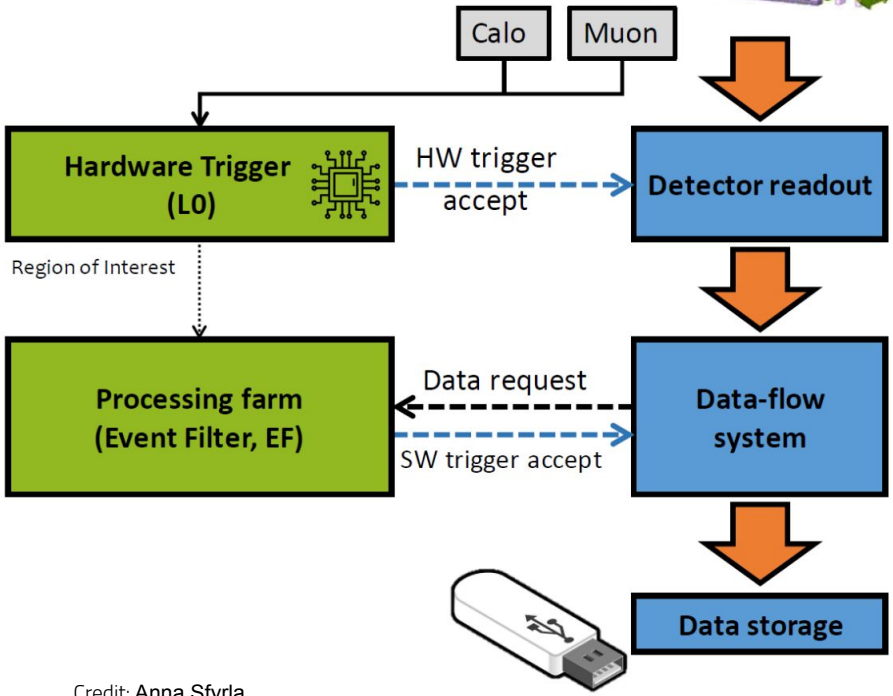
O(100 ms)

Storage
O(Gb/s), O(kHz)

Credit: Anna Sfyrla

… to run 4





In HL-LHC

40 MHz
(pile-up ~200)

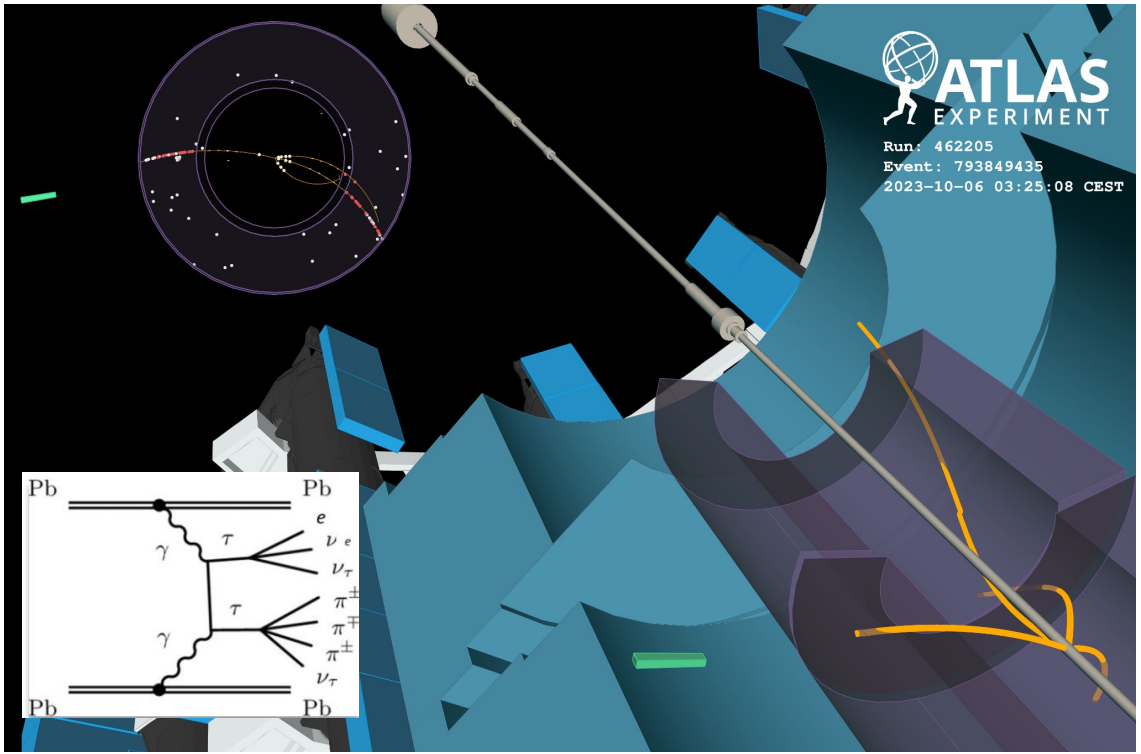
Max 12.5 μs
HW trigger accept
Max 1 MHz

O(100 ms)

Storage
O(10 kHz)

Credit: Anna Sfyrla

Very successful PbPb campaign



High data taking efficiency

Deployment of new tools such as L1 Trigger for UPC events