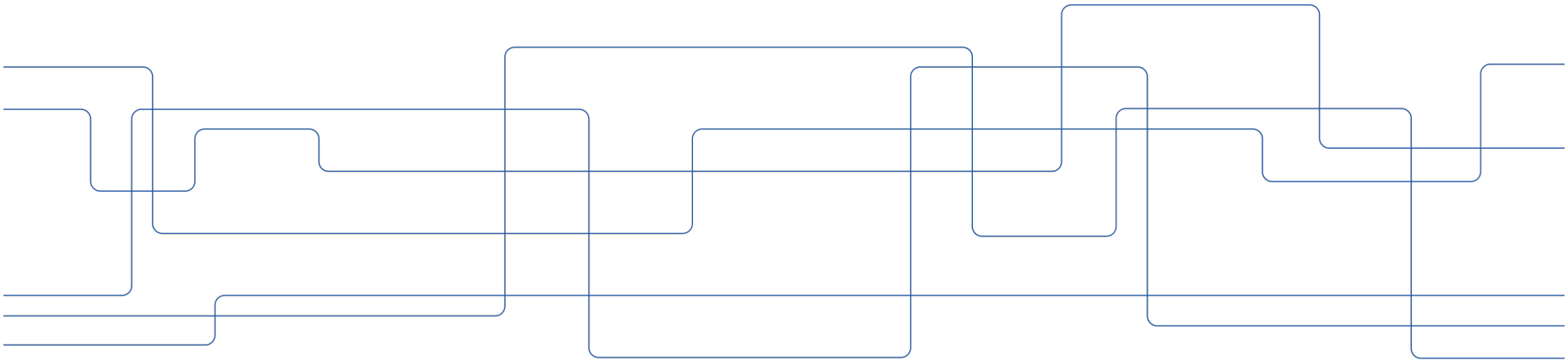
KTH ROYAL INSTITUTE OF TECHNOLOGY

Keeping ATLAS running

Olle Lundberg on behalf of ATLAS Sweden

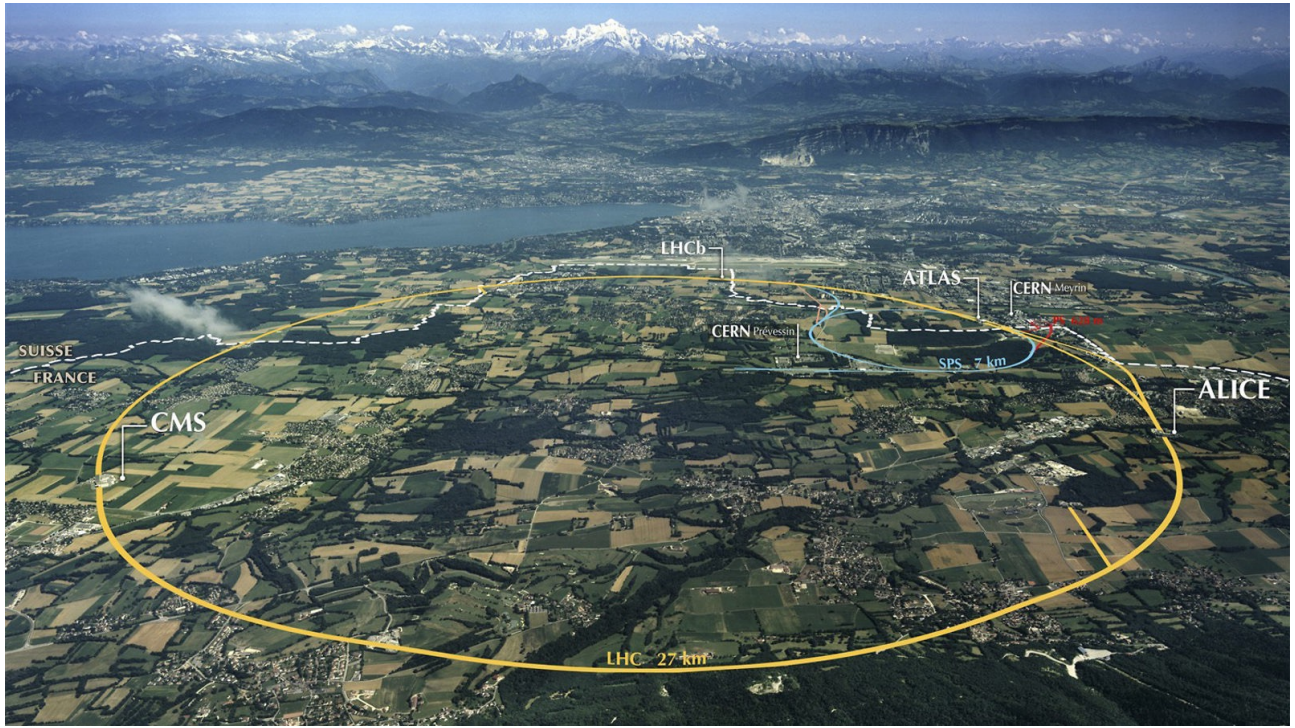


The Large Hadron Collider

The world's largest and highest energy particle collider

Proton-proton collisions at unprecedended 13.6 TeV center-of-mass energy

Four main experiments where beams are made to collide

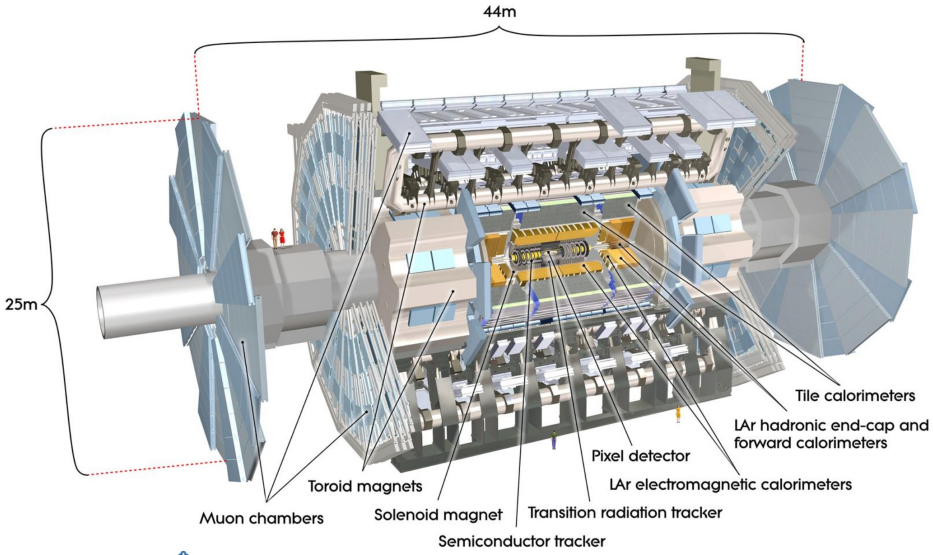


The ATLAS experiment

ATLAS: A multi-purpose detector constructed to maximize the physics potential offered by the LHC

(Almost) full solid-angle coverage, arranged in layers of detectors specialized in detecting various parts of the standard model spectrum

In Run 2 (2015-2018) ATLAS collected a total integrated luminosity of 140.1 fb^{-1} at $\sqrt{s}$ = 13 TeV. Run 3 ongoing!



Detector Work

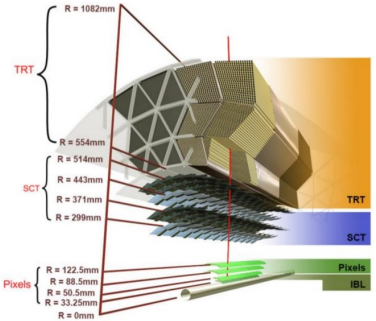
David Brunner, Lara Calic, Hannah Herde, Else Lytken, Torsten Åkesson, Lennart Österman

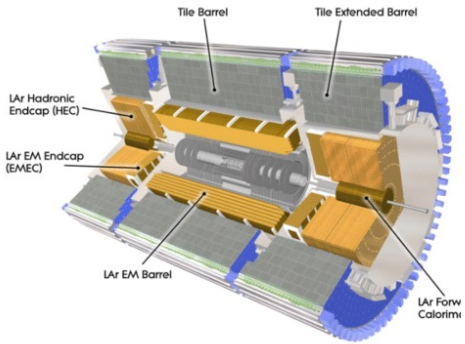
ATLAS Sweden part of running the Transition Radiation Tracker. For material on ongoing tracking studies, see poster by L. Calic

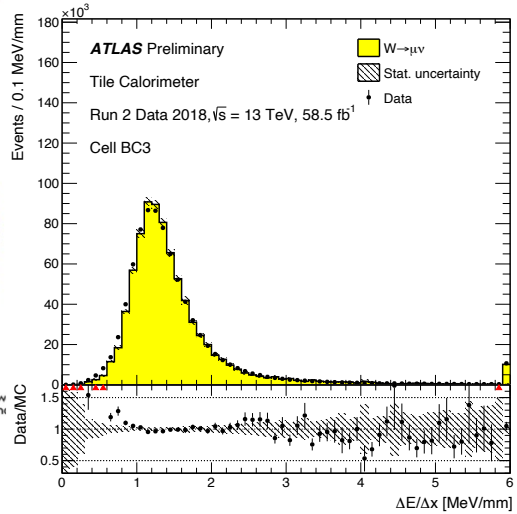
The Tile Calorimeter constitutes the bulk of ATLAS hadron calorimetry – more in talk by H. Herde on upgrade

Recent work – use of collision muons (W->μv) to measure:

- Cell energy deposit data-MC agreement over muon path length
- Cell response uniformity in azimuthal angle







Stefio Yosse Andrean, Filip Backman, Christophe Clement, Dave Milstead, Alessandro Montella

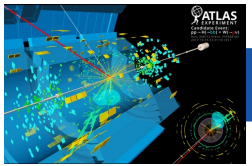
The ATLAS trigger systems

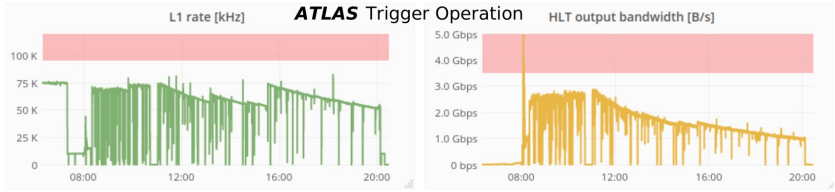
ATLAS has an output rate of 40 MHz, O(10-100 TB/s) → need a dedicated trigger system to safely reduce rates to what can be saved to disk.

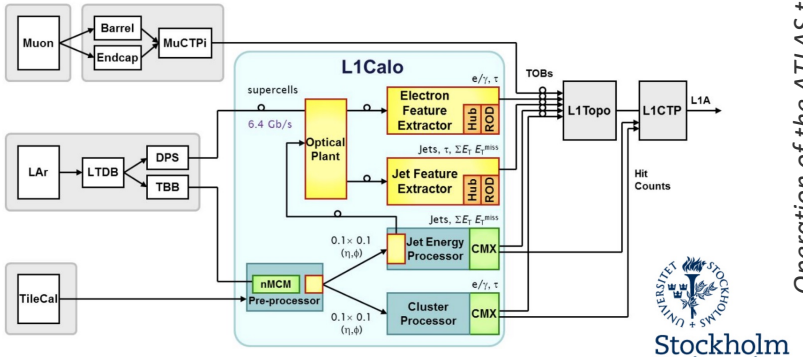
Two-level system: a firmware-based “Level 1” (L1) and software-based “high-level” trigger (HLT).

ATLAS Sweden works in the L1 Calorimeter trigger

- Uses reduced-granularity information to search for high-energy calorimeter objects and missing energy







Sten Hellman, Sam Silverstein

Stockholm University

Operation of the ATLAS trigger system in Run 2, The ATLAS Collaboration 2020 *JINST* **15** P10004

Trigger operations and data quality

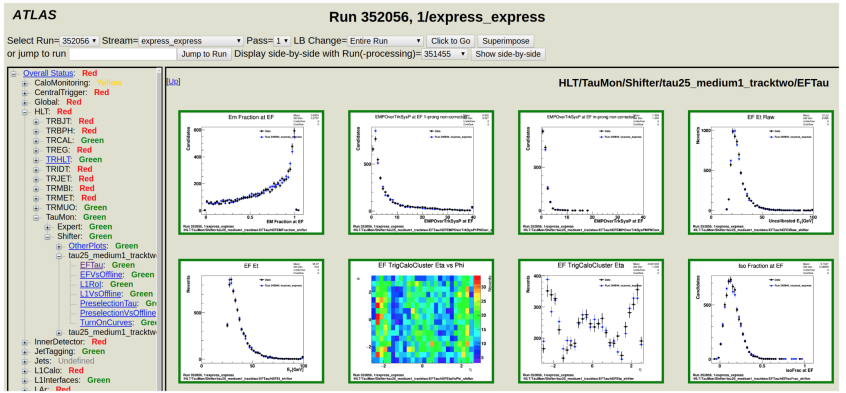
During data-taking, 18 people are on shift every day to ensure that the trigger system operates correctly.

Antonia Strübig (SU) coordinates parts of this operations work

L1 and trigger operators report to the ATLAS Data Quality group.

The Trigger Monitoring and Data Quality coordinator oversees this process and works on long-term trigger-related DQ issues. Elin Bergeås Kuutmann (UU) currently covers this role

Data Quality Offline webdisplay



ATLAS Data Quality operations and performance for 2015-2018 data taking
The ATLAS Collaboration 2020 *JINST* **15** P10004

Elin Bergeås Kuutmann, Antonia Strübig

Prompt Reconstruction and Data Quality

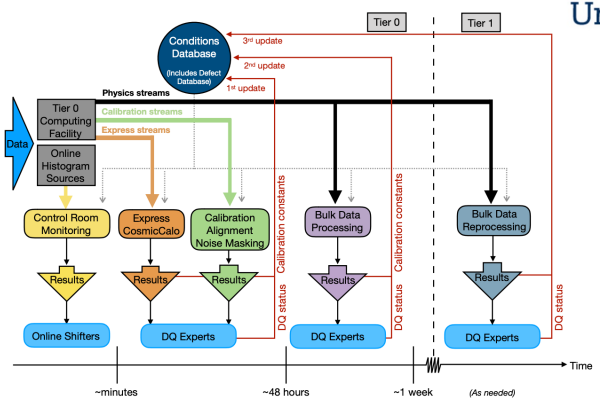
Prompt reconstruction on dedicated CERN ”Tier0” cluster – ”prompt” meaning non-delayed – *express* reconstruction is done in parallell to the data taking. Stefan Richter (SU) coordinated this effort until May 2023

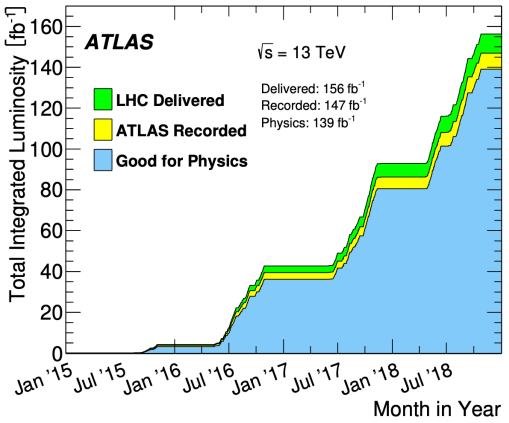
Status: Smooth, integration of ”New Small Wheel” muon detector still progressing

Sara Strandberg (SU) coordinates ATLAS Data Quality group

Responsible for monitoring the quality of the data, both online and offline, and compile the list of data taking periods that are good for physics analyses.

Stefan Richter, Sara Strandberg



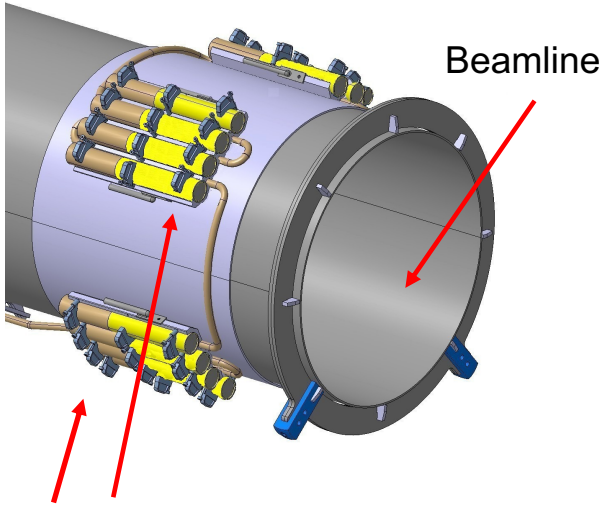


ATLAS Data Quality operations and performance for 2015-2018 data taking
The ATLAS Collaboration 2020 *JINST* **15** P10004

Luminosity

Luminosity – a measure of the overall interaction rate.

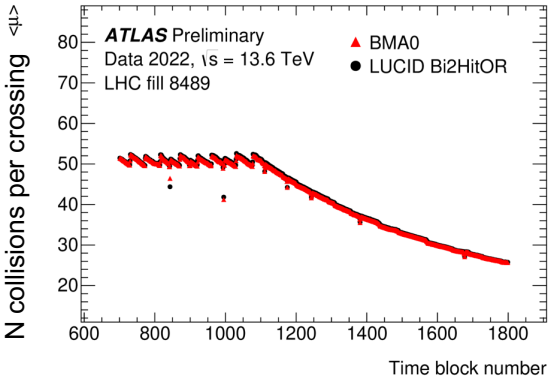
Crucial to have precise determination for all physics measurements. Full Run2 measurement published recently at https://arxiv.org/abs/2212.09379 (submitted to EPJC) with unprecedented precision in any hadron collider experiment.



LUCID: 4 Sets of PMTs

Luminosity hardware

- LUCID2 – the main ATLAS luminometer: PMTs positioned around beampipe with Quartz windows that act as Cherenkov medium. Long standing Swedish involvement.
- We're also involved in analyzing data from a new prototype (BMA) based on LGAD Si Pad detectors installed in forward shielding – two such detectors already in place in Run 3!



Vincent Hedberg, Jonas Strandberg, Magda vande Voorde

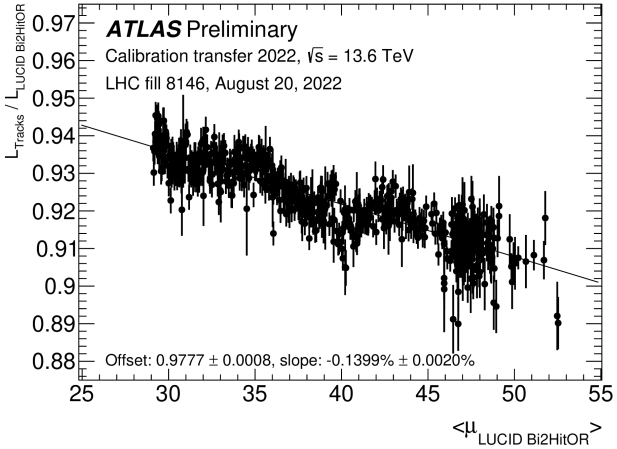
Alex Leopold, Xuanhong Lou, Giulia Ripellino, Rabia Shaheen, Jonas Strandberg, Sara Strandberg

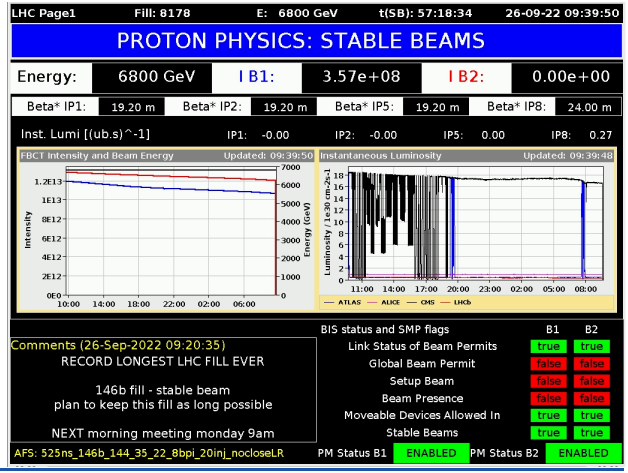
Luminosity

ATLAS Sweden has strong participation in the luminosity determination from *track counting*

Very linear response as function of pileup – used to correct LUCID measurements online & offline

We are also in charge of *Online Luminosity,* among other things making sure trigger systems and LHC have accurate, calibrated up-to-speed measurements while running

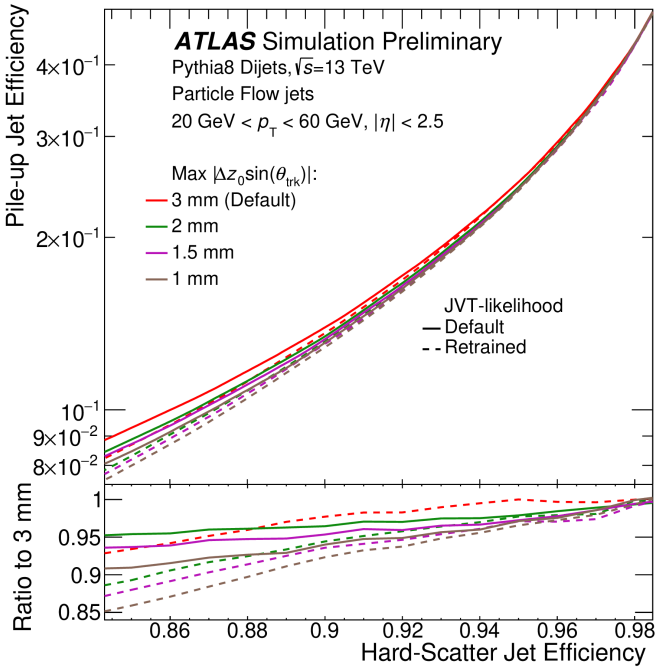




Karl Gellerstedt, Olle Lundberg, Christian Ohm

Jet pile-up correction

- Jet Vertex Tagger (JVT) – is used to discriminate between pile-up (contaminating additional jets) and jets from the hard interaction
- JVT is a multivariate combination of variables which quantify the amount of track pT of a jet that can be associated with the hard scatter vertex – thus discriminate against pile-up.
- Optimization recently performed with *pflow* jets, looking to improve the track-to-vertex association
- Current work ongoing to replace the k-nearest-neighbour algorithm with a Neural Network, and to see if other kinematic variables could improve the output.



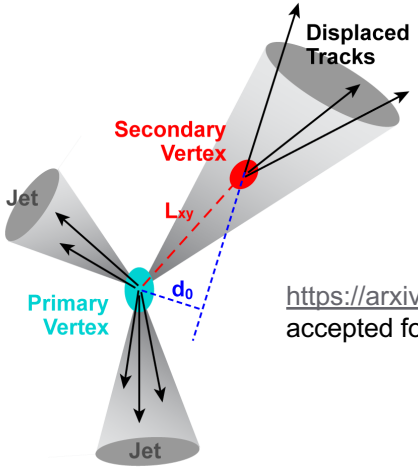
Stockholm University

Tom Ingebretsen Carlson, Christophe Clement

Flavour tagging

b-tagging: Identification of hadronic jets containing b-hadrons

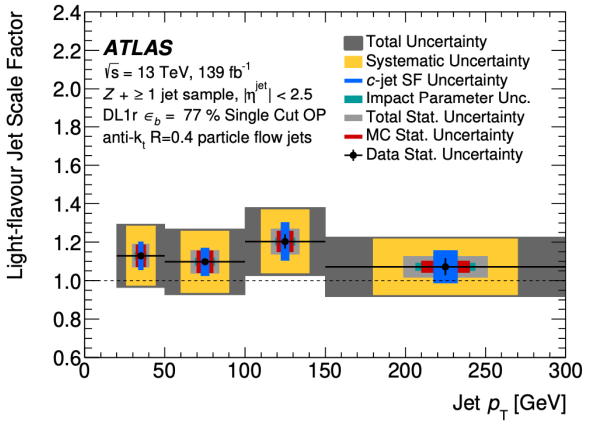
- Important since b-quarks dominate the decays of top quarks and Higgs bosons
- b-tagging algorithms need calibration with data since they are hard to model using simulations



https://arxiv.org/pdf/2301.06319.pdf - accepted for publication in EPJC

Recent publication with strong Swedish involvement

- Looks at full Run 2 efficiency with which light jets are rejected by standard b-tagging algorithms, utilizing Z+jet events in data
- Drastically reduces uncertainties on these mistag rates
- Work now ongoing to use di-jet events to increase the range of the calibration



Laura Pereira Sánchez, Ellen Riefel, Sara Strandberg

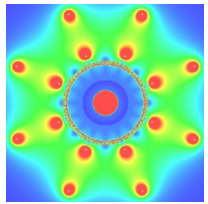
ATLAS Software and Computing

Three main areas:

- WLCG (grid) operations
  - > Nordic NeIC Tier1 (NeIC): Oxana Smirnova
  - > ARC software development: Balázs Kónya, Florido Paganelli, Oxana Smirnova
- ATLAS software optimization
  - > Parallelisation for GPUs, ML: Oxana Smirnova, Sten Åstrand
    - Activity is just starting
- The work with the more streamlined PHYSLITE data format for physics analysis: Olga Sunneborn Gudnadottir

O. Smirnova is currently the ATLAS International Computing Board chair

- – Overview of SW&C resource commitments (OTP, hardware, strategic directions)
- – SW&C publications committee



Balasz Konya, Florido Paganelli, Oxana Smirnova, Olga Sunneborn Gudnadottir, Sten Åstrand

Summary

For the physics program you will hear of in coming talks to be possible, we all contribute to keep ATLAS running and data taking smooth

ATLAS Sweden have or are developing key roles in areas such as

- Detector Operations (Tile, TRT, LUCID)
- Tracking performance & alignment
- Trigger (Hardware, operations and Data Quality)
- Luminosity (Detector work, track counting, online operations)
- Data Quality
- Jet calibration and flavour tagging
- Computing

Backup

- Stockholm University appointment: **Prompt Reconstruction Coordinator** Stefan Richter (September 2022 — May 2023)

- Manage reconstruction on Tier0 (dedicated cluster at CERN)
- "Prompt" as opposed to delayed or re-processing (on the Grid)

- Prompt reconstruction schema:

  - Data taken
  → **express reconstruction** (no alignment, no beamspot, …) of *express* data stream
  → **Calibration Loop:** per-run calibration/condition updates of the detectors
  → **bulk reconstruction** of *main* data stream

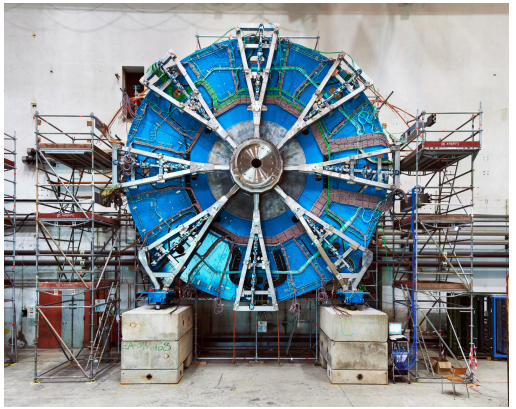
- Data quality checks are done both after express and bulk reconstruction

- ATLAS offline software: Athena

- Prompt reconstruction coordinators co-manage release branch for reconstruction

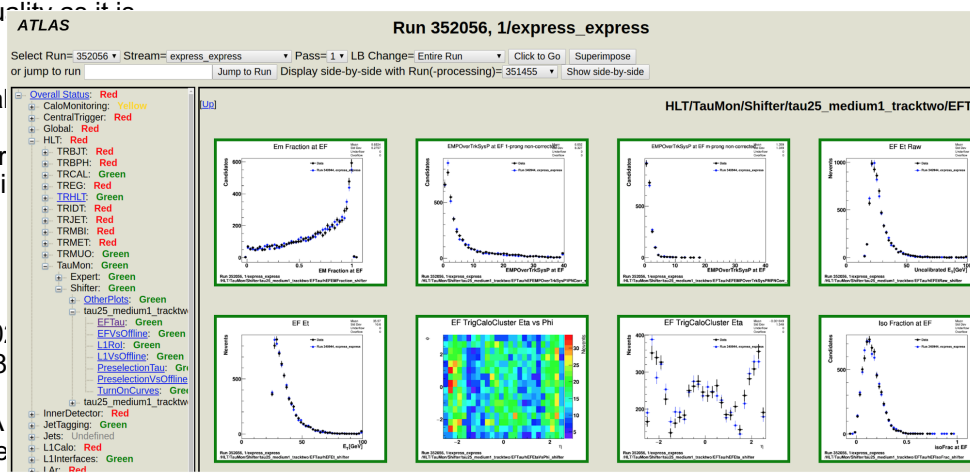
- Status of prompt reconstruction in 2023 so far:

- Overall smooth, some teething issues during ramp-up of data-taking after LHC Year End Technical Stop, detector conditions database migration, etc.
- Reconstruction code quality has been continuously improved
- Integration of New Small Wheel subdetector still requires work: reconstruction software performance improvements were/are required



- Trigger Monitoring and Data Quality Coordinator (Elin Bergeås Kuutmann, UU)

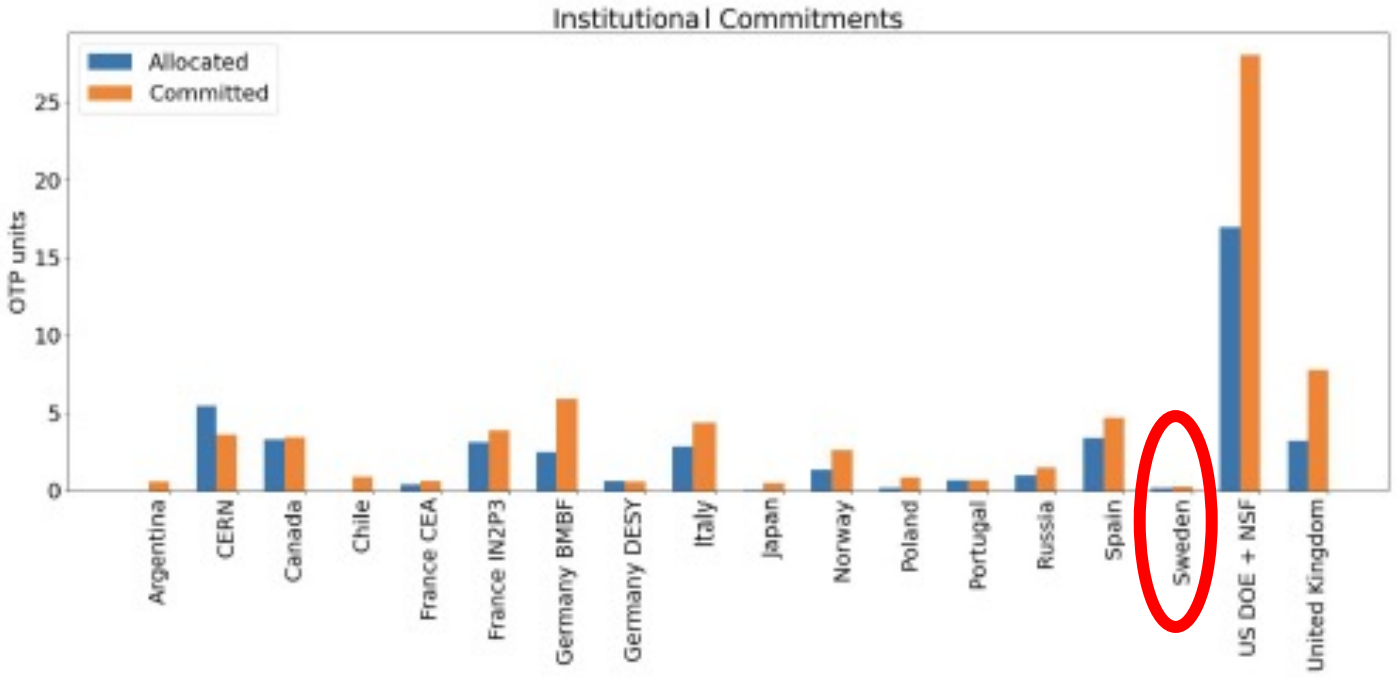
- Purpose of the (trigger) DQ monitoring:
  - *During a run*: Assure that the data we take are of the highest qu
  being collected, or immediately after.
  - *During shut-down periods:*
  Maintain and develop the tools, work on long-term DQ issues, val
  triggers.
  During the Long Shut-down 2 (2019-2022) the ATLAS software fr
  Athena was completely redesigned to process multiple threads si
  Affected the trigger software and DQ monitoring.



- ***Publications:***
  - “Operation of the ATLAS trigger system in Run 2“ JINST 15 (20
  - “ATLAS data quality operations and performance for 2015-2018
  JINST 15 (2020) P04003
  - “The ATLAS Experiment at the CERN Large Hadron Collider: A
  the Detector Configuration for Run 3” arXiv:2305.16623, submitte
  (not about operations or DQ)

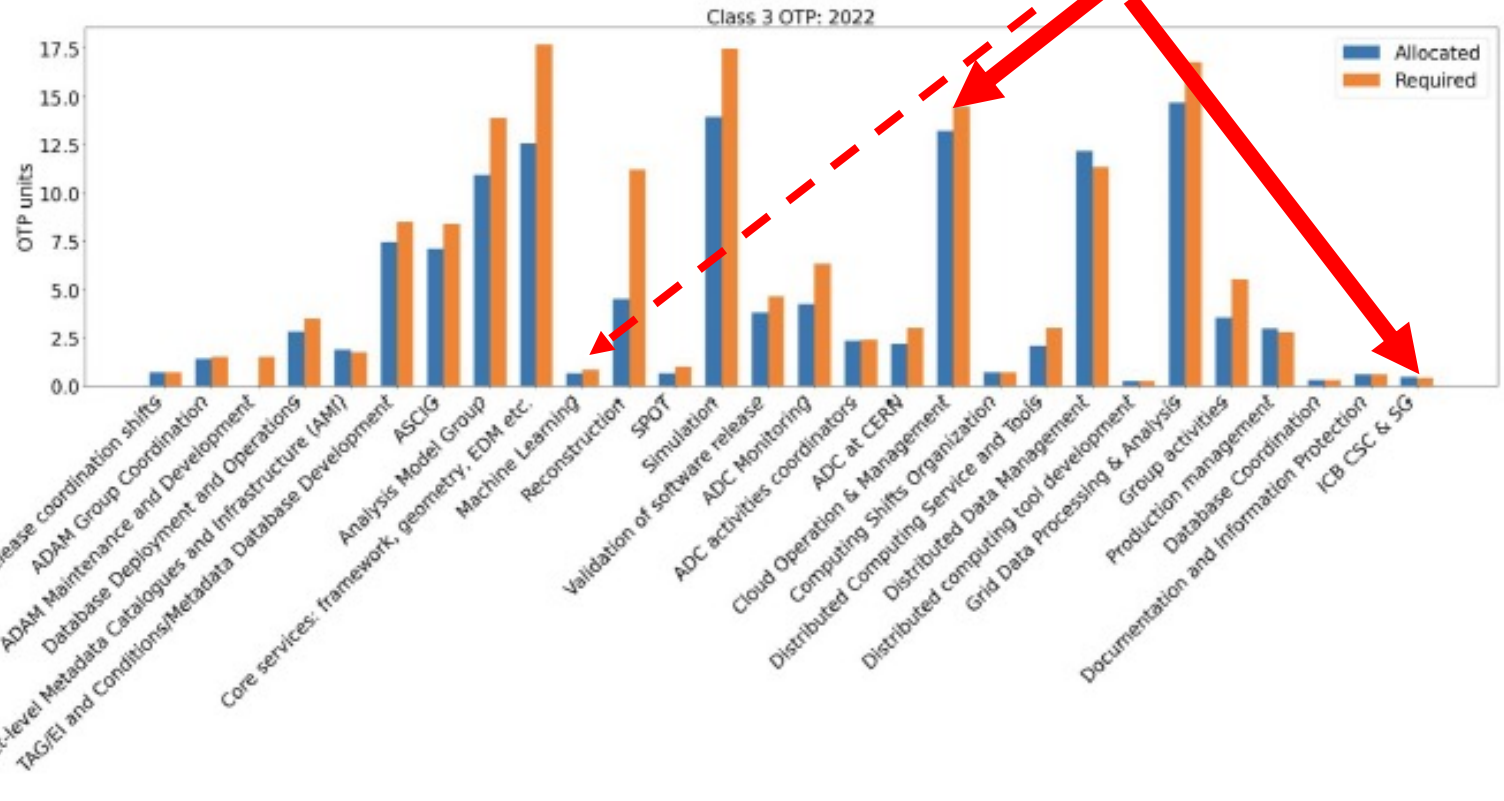
Overview of ATLAS SW&C commitments per country

A rather modest contribution from Sweden overall



Overview of ATLAS SW&C tasks

Lund contributions
(dashed line: just starting)



Trigger operations and DQ

- The ATLAS trigger is a two-level system: a hardware-based “Level 1” (L1) nad a software-based “high-level” trigger (HLT).
- During data-taking, 18 people are on shift every day to ensure that the trigger system operates correctly.
- 6 of these people are directly involved in data quality checks, representing various HLT signatures (egamma, tau, jet, MET, Calo, b-jet, ID, B-physics, muons, minbias) and L1, as well as the coordinating DQ/debug expert.
- After each run, monitoring histograms are carefully checked to make sure that the trigger algorithms are running correctly and that the hardware is fully functional.
- The various trigger signatures and L1 report to the DQ/debug expert, who in turn reports to the ATLAS Data Quality group.
- The Trigger Monitoring and Data Quality coordinator oversees this process and works on long-term trigger-related DQ issues.

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