Analyse-Software in ATLAS

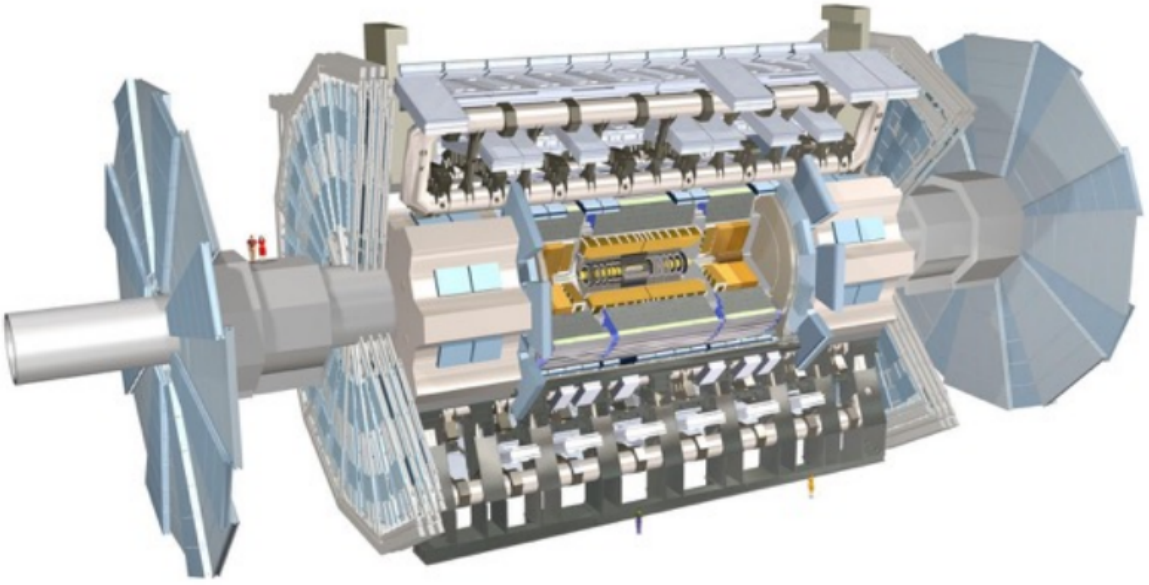
Wo kommen meine Daten her?

Nikolai Hartmann
(Slides von Federica 2017)

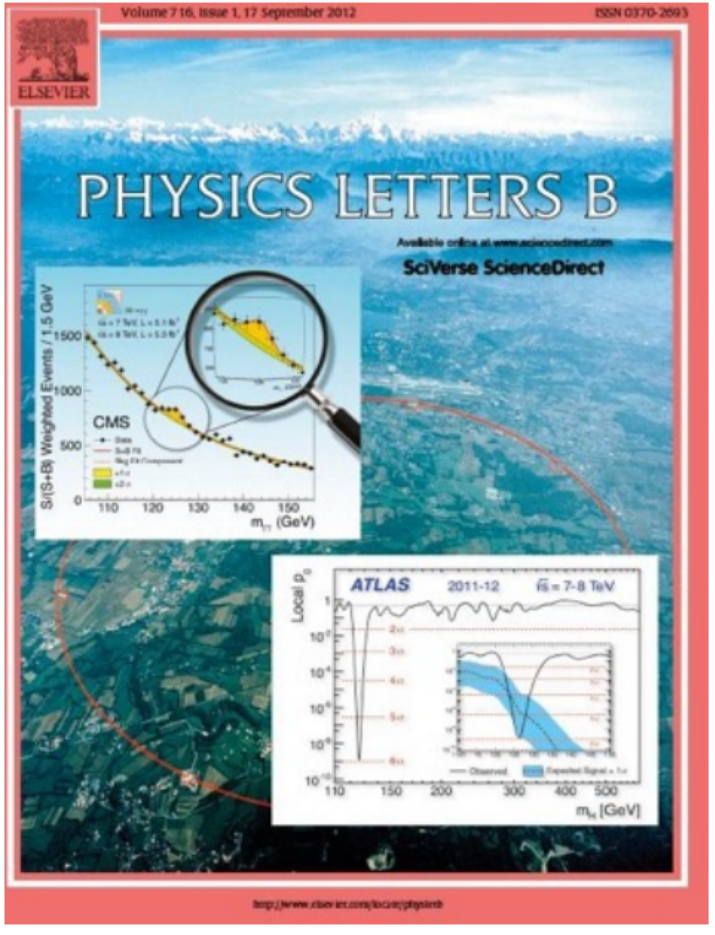
LMU Munich

May 3, 2019

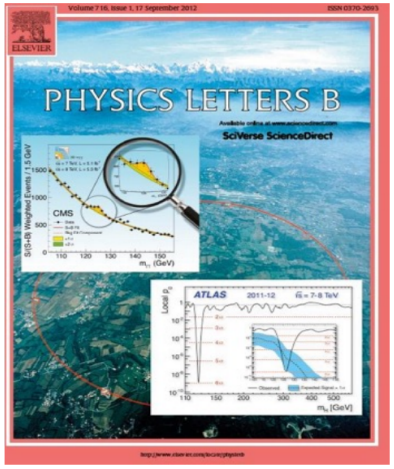
How do we get from this….

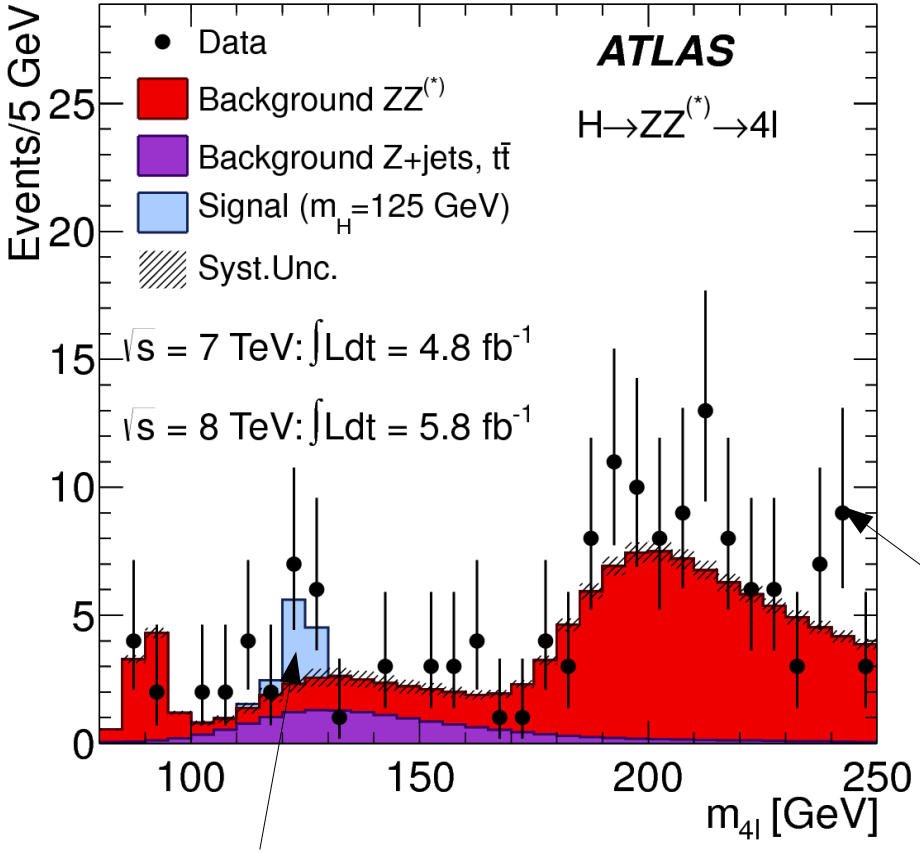


to this…?

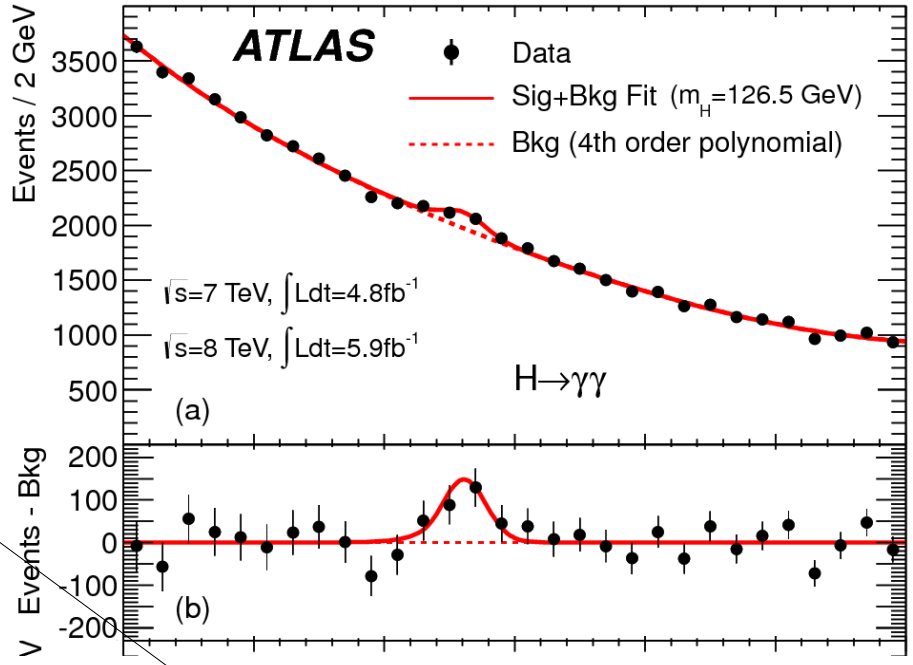


What's in ?

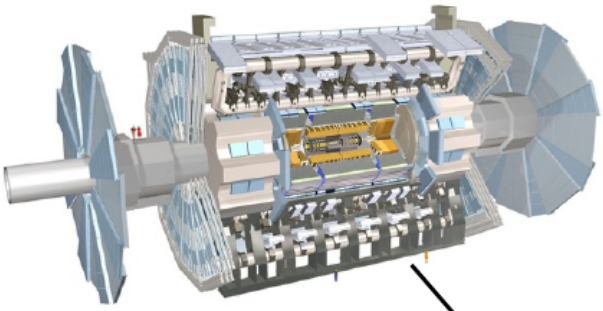




Monte Carlo data



LHC data



Data

GENERATION

SIMULATION

DIGITIZATION

RECONSTRUCTION

DERIVATION

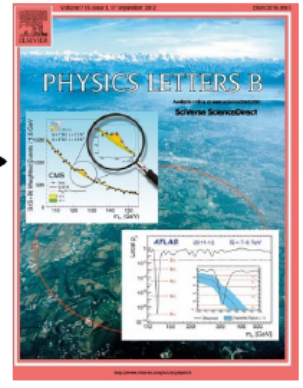
Monte Carlo

TRIGGER

RECONSTRUCTION

DERIVATION

ANALYSIS

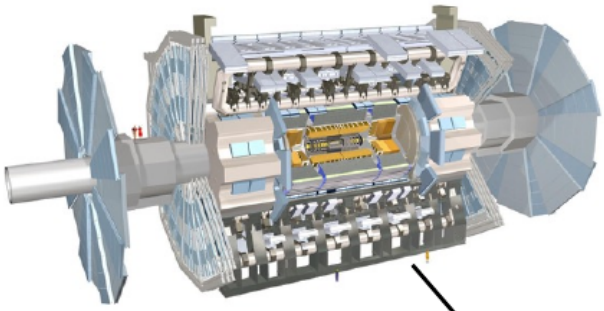


Online

Tier-0

Grid

Local



Data

GENERATION

SIMULATION

DIGITIZATION

RECONSTRUCTION

DERIVATION

Monte Carlo

TRIGGER

RECONSTRUCTION

DERIVATION

ANALYSIS

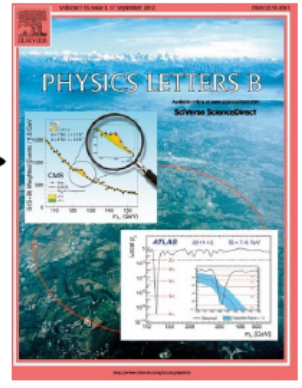
YOUR BACHELOR THESIS

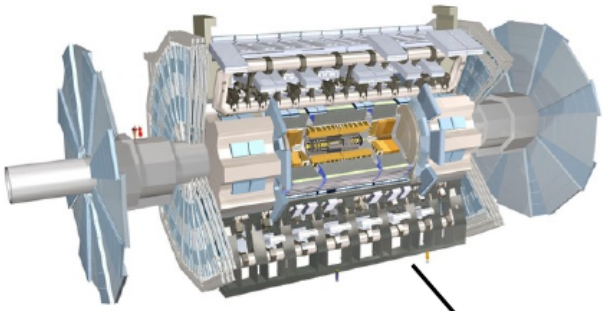
Online

Tier-0

Grid

Local





Data

TRIGGER

RECONSTRUCTION

DERIVATION

GENERATION

SIMULATION

DIGITIZATION

RECONSTRUCTION

DERIVATION

Monte Carlo

Online

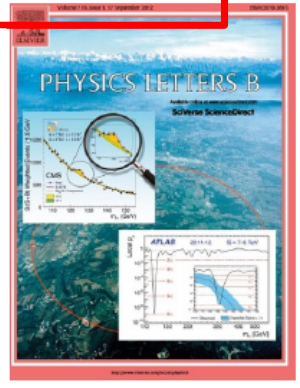
Tier-0

Grid

Local

THIS LECTURE

If time allows



Bulk reconstruction

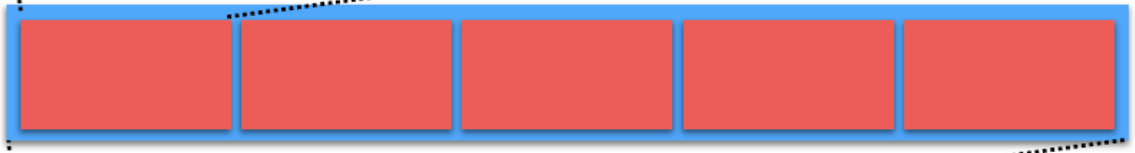
- Bulk reconstruction uses the majority of the Tier0 resources
- Processes the RAW data using updated calibrations determined in the Prompt Calibration
- Produces many outputs used for a variety of purposes, the most important being the AOD

How data is divided up in ATLAS

EVENT: record in data of bunch crossing that activated trigger.
Basic unit of data taking. Defines a single cycle of Athena. Approximately 1K per second.
Demarkation: integer number, re-sets with each new run (see below)

LUMINOSITY BLOCK: about 1 minute of data taking. Unit of known luminosity.
~100K events
Demarkation: integer number, re-sets with each new run

RUN: continuous period of ATLAS data recording. Usually corresponds to a single LHC fill, e.g. hours of data taking. ~1000 luminosity blocks.
Demarkation: integer number. Never resets → each event can be uniquely specified by its run and event number



SUB-PERIOD: group of runs taken with very similar conditions (e.g. trigger, LHC).
~5-10 runs
Demarkation: letter and number (e.g. E5)

PERIOD: group of sub-periods taken with similar conditions, or during some period (e.g. increments after technical stop)
~5-10 sub periods
Demarkation: letter (e.g. E); resets each year

LHC RUN: long period of data taking, between shutdowns. 2009-2012 was Run 1, we are now in Run II, and Run III will start in 2021. Typically 20-30 periods per LHC run.

Good runs lists

- Remember those luminosity blocks? ~ 1 minute of data taking
  - Several hundred lumi blocks per run; one or several lumi blocks per file
  - Some lumi block ranges will have *bad data quality* and should not be used for analysis

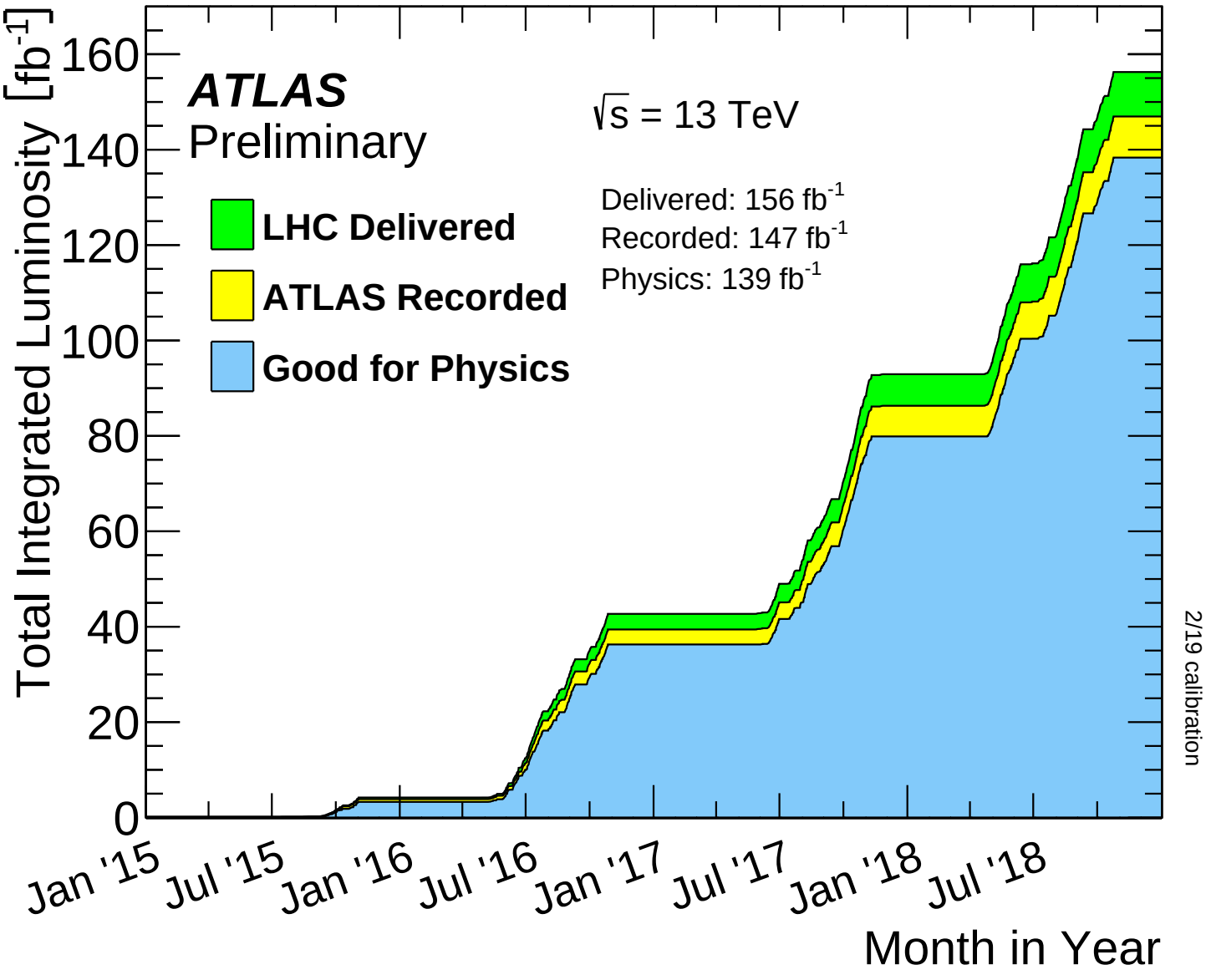
- The data quality flags are set in the data quality monitoring
- They are encoded in a database
- Different versions of the data quality flags get a different name, e.g. DetStatus-v61

Lumi blocks and analysis

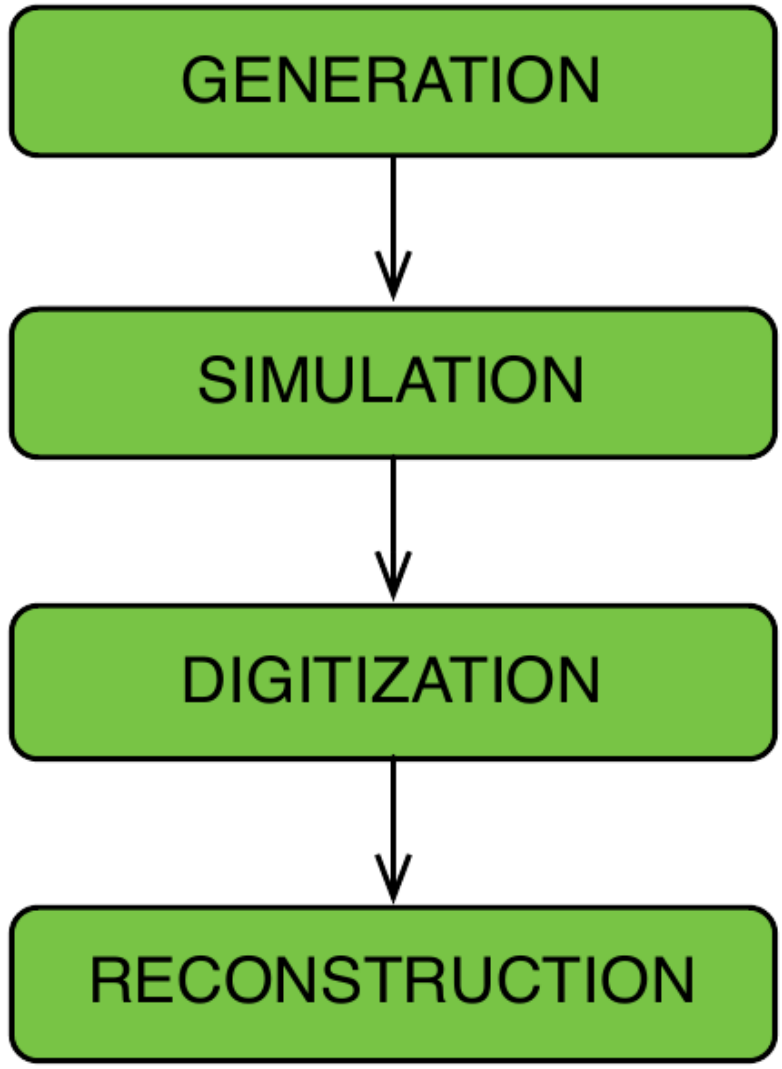
- When you do your analysis you need to filter out the bad lumi blocks
- This is done by means of a *good runs list (GRL)*
  - XML file listing each run and the range of good lumi blocks in each: read in by the analysis code

- The luminosity "seen" by your analysis depends on three things:
  - the luminosity blocks processed (from the GRL)
  - the trigger prescales applied
  - the level-1 trigger live-time (fraction of delivered luminosity that ATLAS recorded)

Delivered, recorded, good for physics



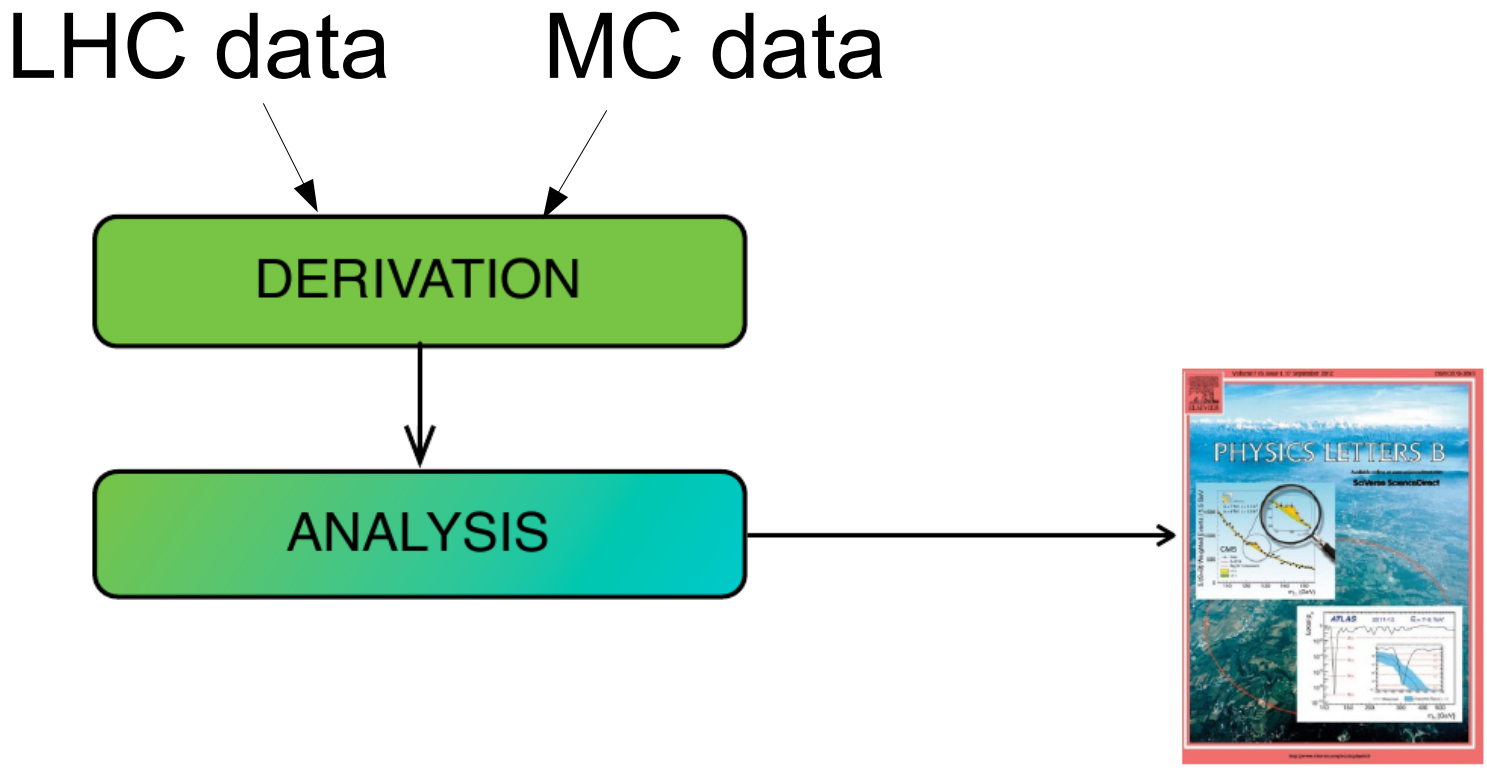
Monte Carlo Production



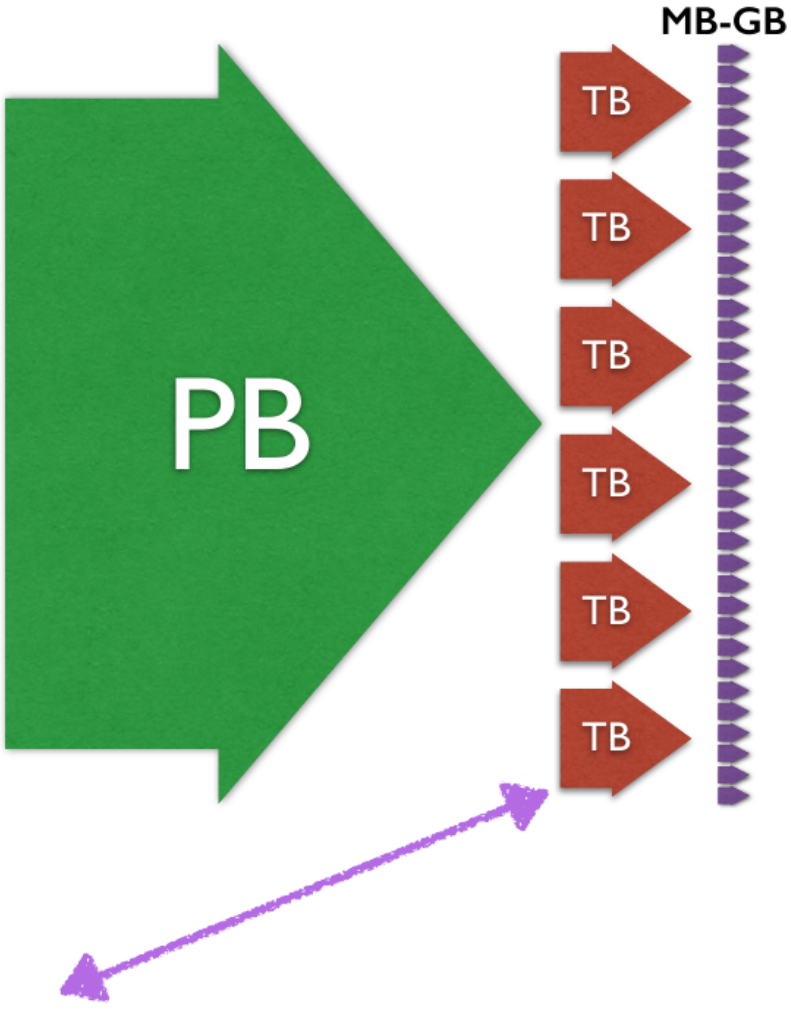
Monte Carlo production

- All official Monte Carlo production is done on the Grid
- Several-step process
  - *Event generation*: simulation of the interaction between the quarks and gluons in the colliding protons, the subsequent parton showering and hadronization and decays into stable particles
  - *Detector simulation:* calculation of how the particles from the generator interact with the detector material; how they shower into secondaries; how much energy they deposit in each sensitive element
  - *Digitisation*: turning the simulated energy deposits into a detector response that "looks" like the raw data from the real detector
  - After this step, the process is the same as for real data
- The analysis data for MC and real data looks the same, *except* that in MC the original generated events (the "truth") are available as well as the reconstructed objects
- Extra low momentum events must be injected into the chain to simulate the presence of multiple proton collisions ("pile-up") in a given LHC bunch crossing
  - Complication: the average number of collisions per bunch crossing is a function of the LHC parameters, and we typically do not know this when we start the Monte Carlo production
  - Monte Carlo events must be weighted in analysis to account for discrepancies between the real and simulated pile-up.

The ATLAS Analysis Model and the xAOD



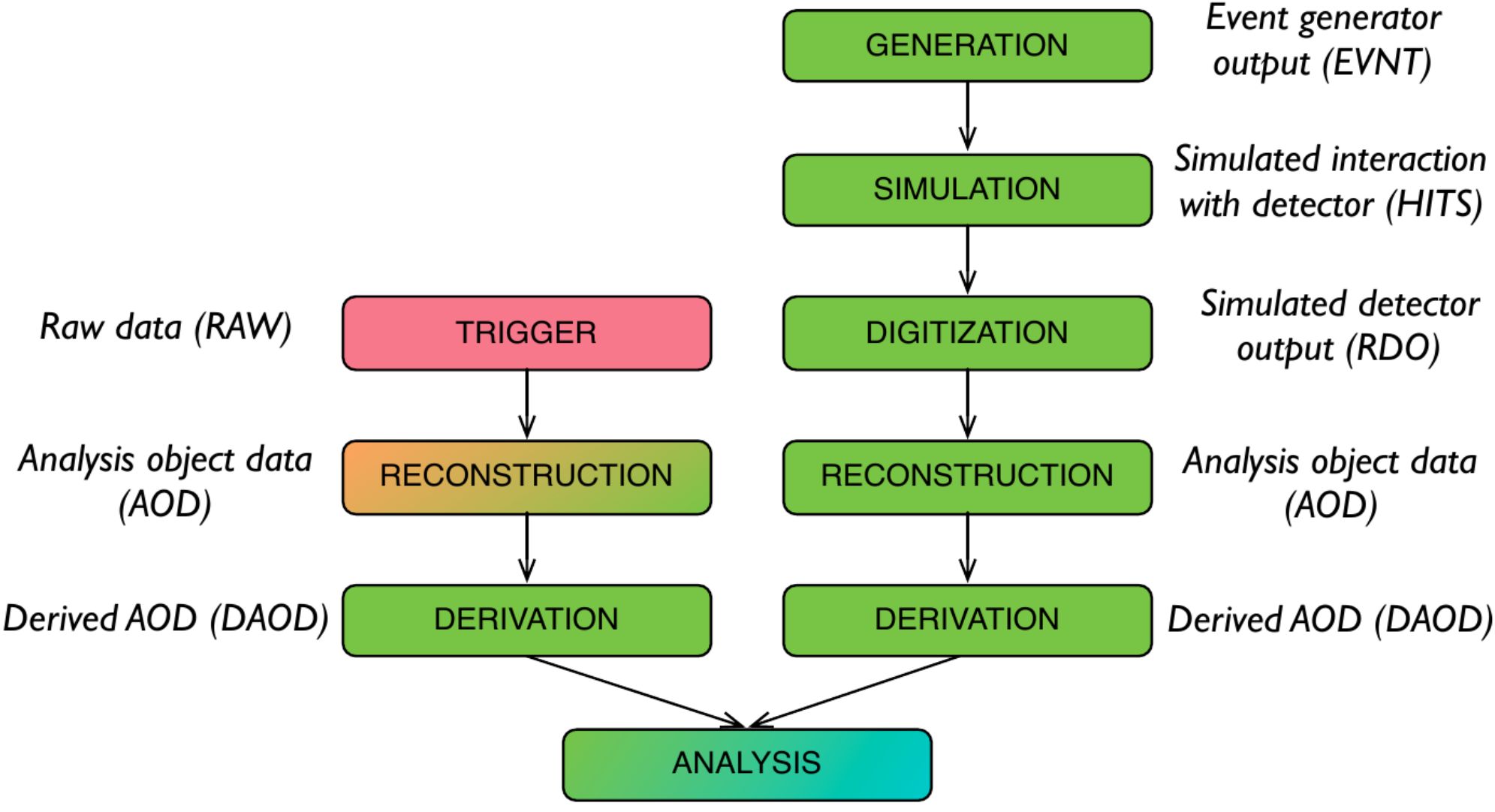
Derivation step



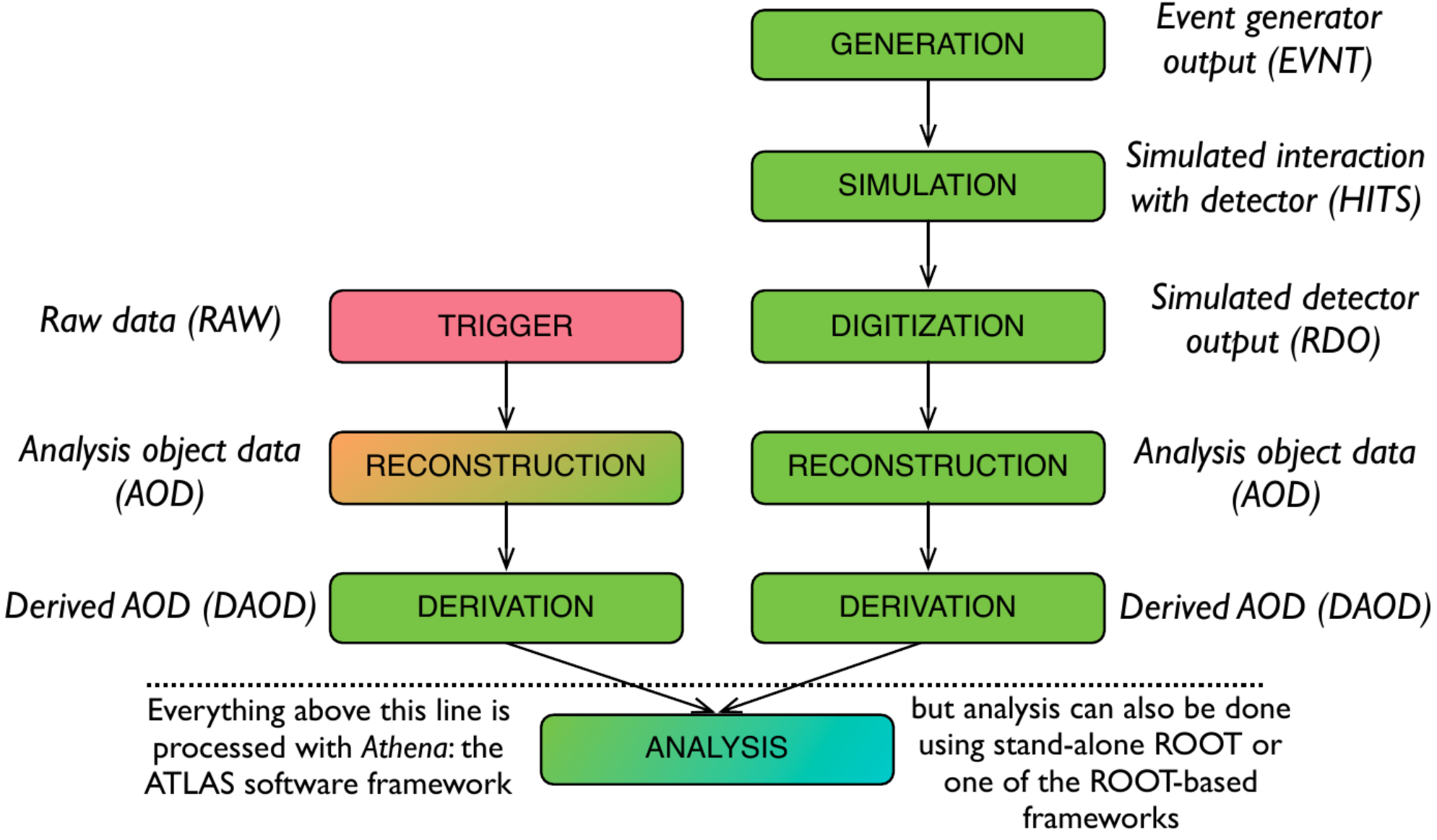
	Full output of reconstruction, ~PB size	One format
	Intermediate analysis format ~TB size	~100 formats
	Final n-tuple ~MB-GB size	~1000 formats

- These formats tend to be specific to a single analysis or group of analyses
- Calibrations and common object selections are often applied as they are made
- They generally need to contain all variables needed for calculating systematics

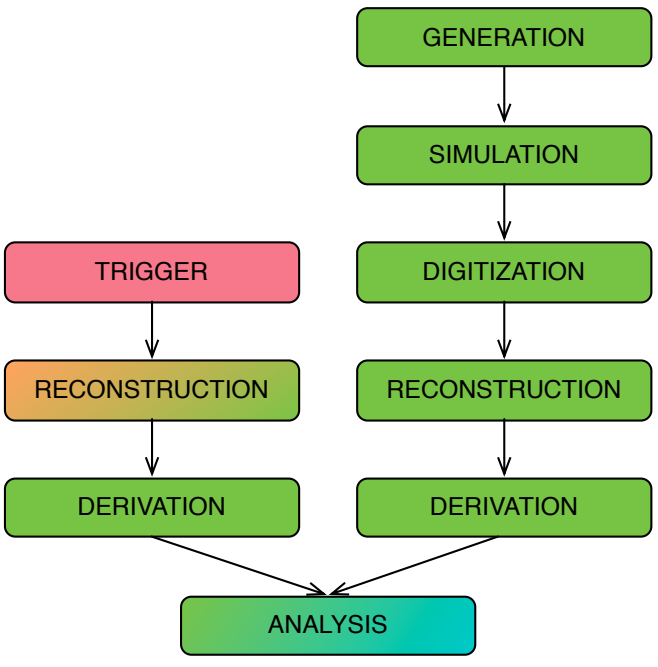
Data formats in ATLAS

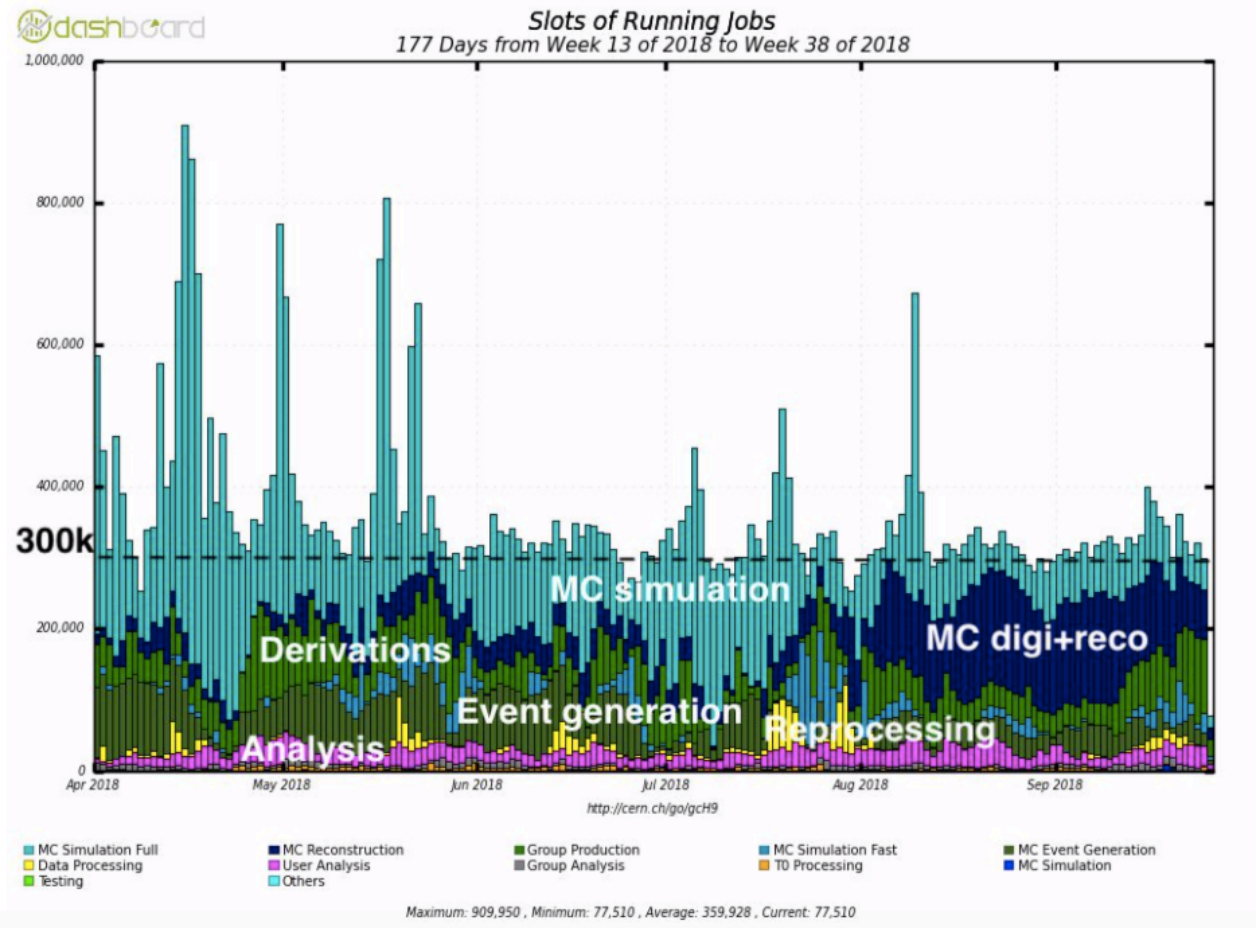


Data formats in ATLAS

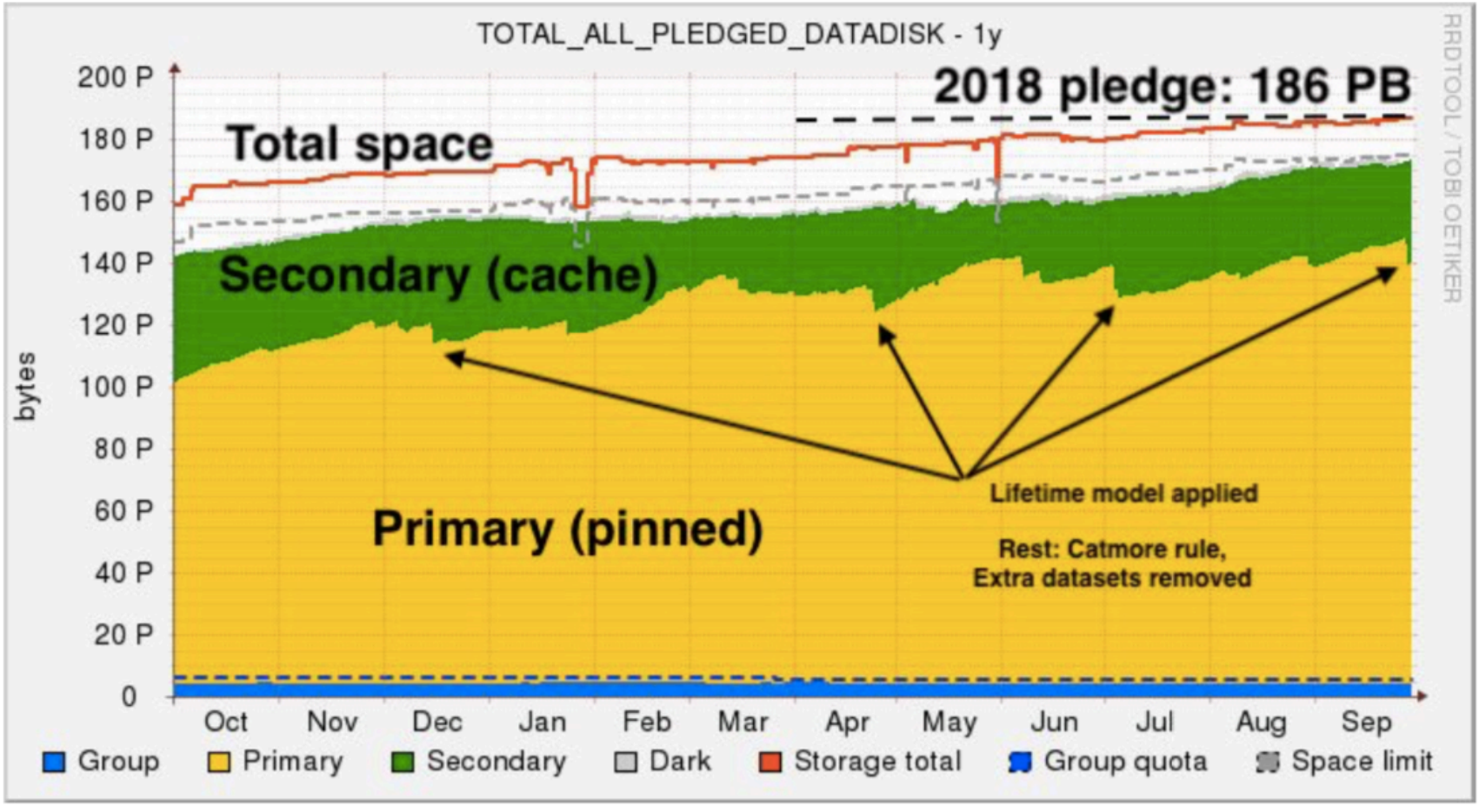


What are we running?

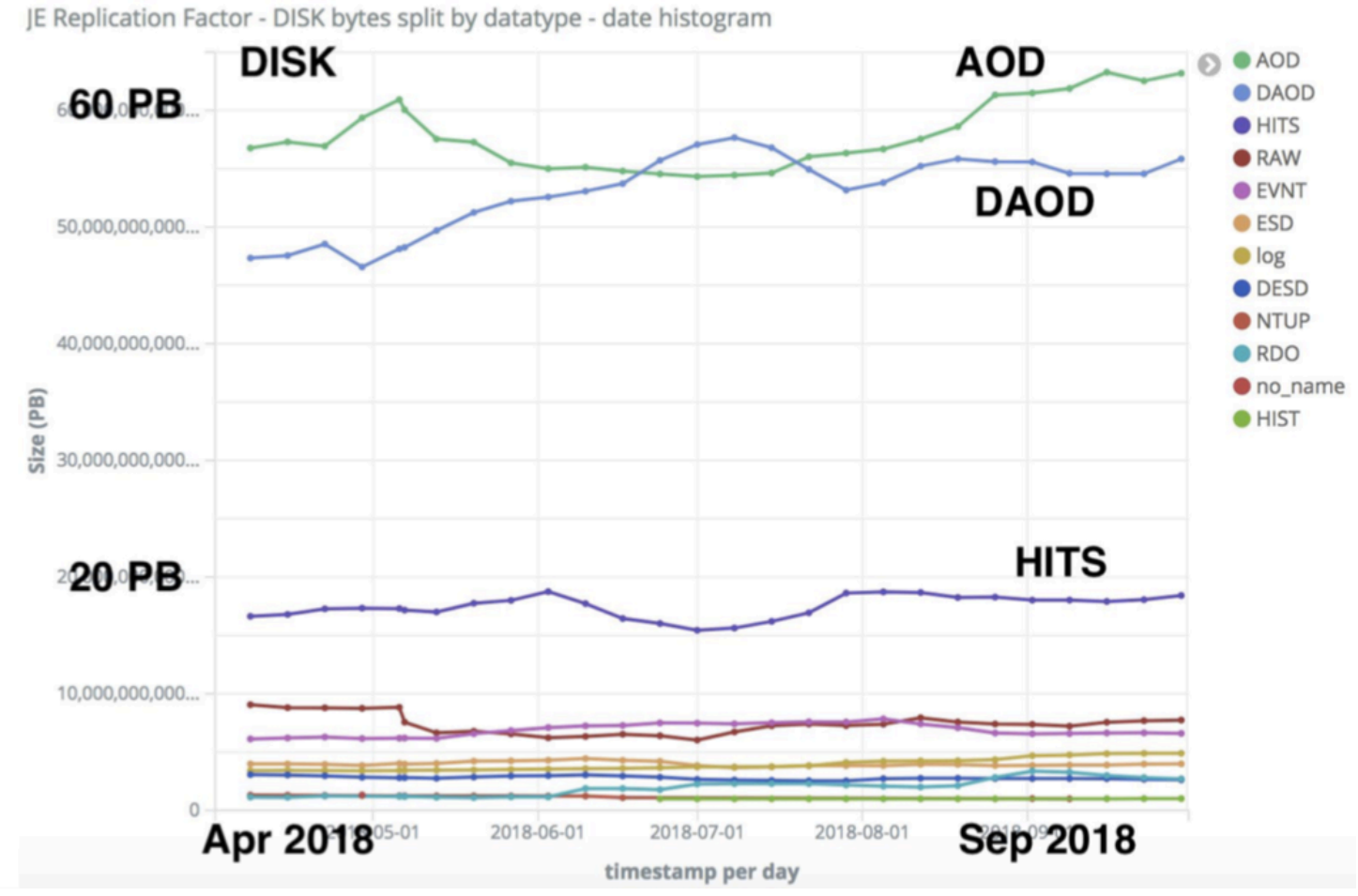




Our computing resources aren't infinite…



… and analysis takes up most of the space

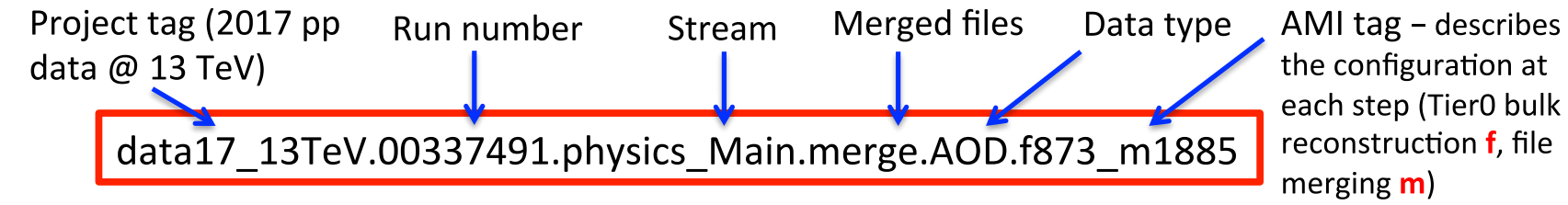


Message: don't assume that computing resources are infinite. Keep disk space usage in mind when planning your work.

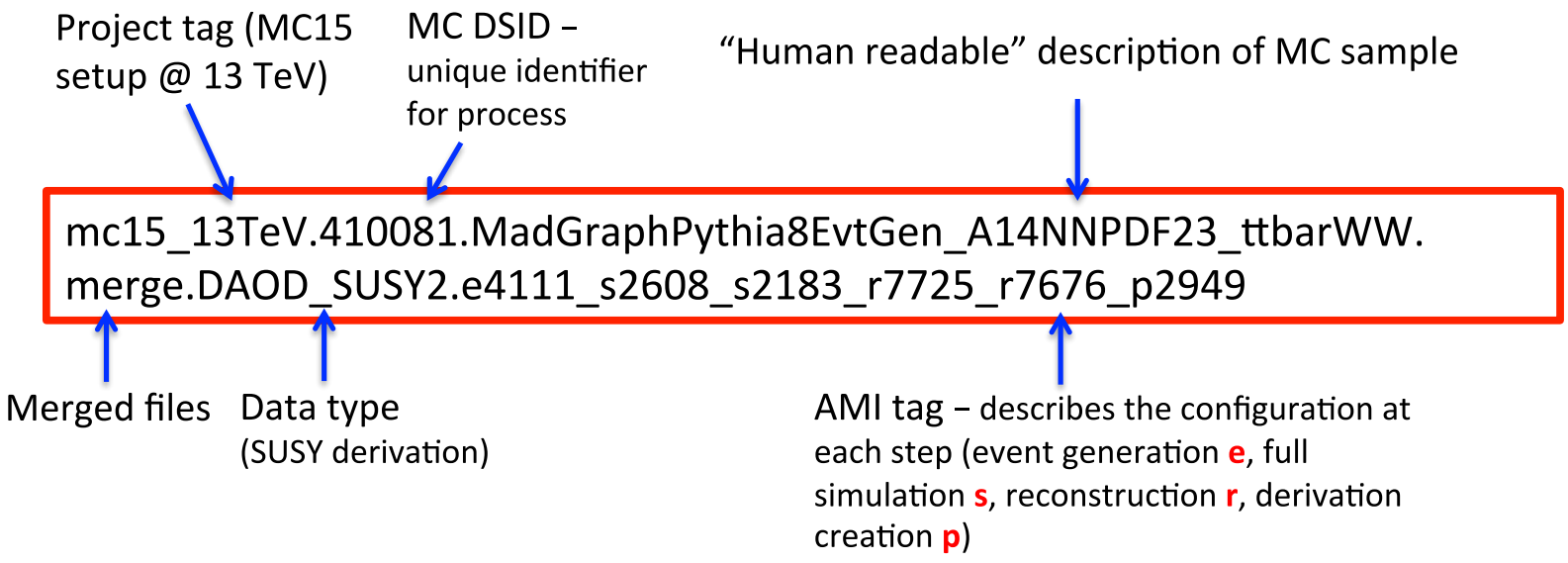
Computing is a shared resource.

Dataset nomenclature

Data:



Simulation:



Zusammenfassung

- Die ersten Schritte der Datenanalyse laufen zentral
  - Datenanalyse läuft in mehereren Schritten - auf gleiche Weise für simulierte Daten wie Monte Carlo
  - Datenmenge zu groß für lokale Speicherung/Prozessierung
    $\rightarrow$ Weltweit verteilt im Grid
  - Rekonstruktion bzw. Detektorsimulation für Monte Carlo zu einem Objektorientierten Datenformat (AOD)
  - Reduktion der Datenmenge durch "Derivations" für verschiedene Analysekategorien (DAOD)
- Prozessieren der DAOD Formate pro Analyse (mehr dazu später)

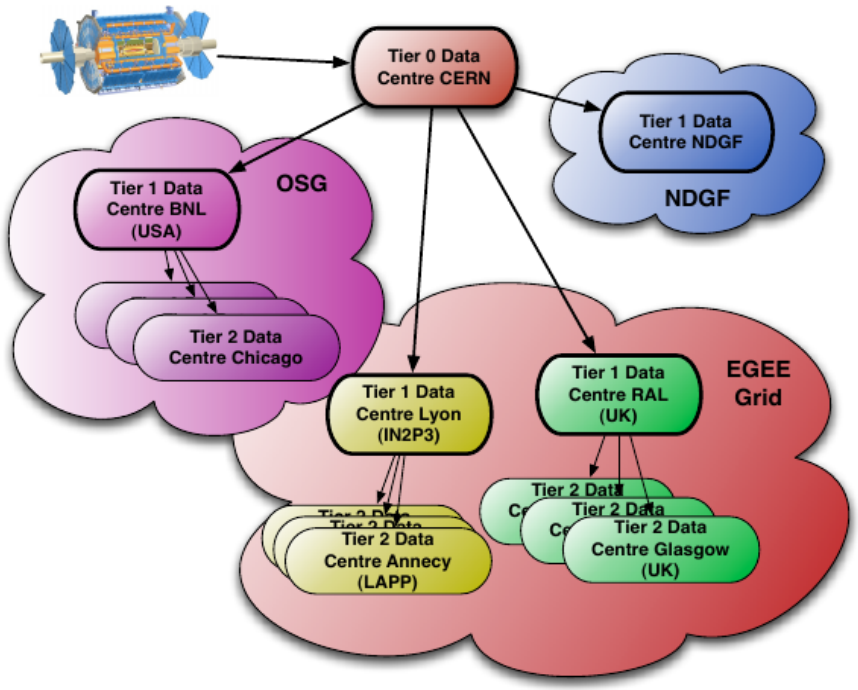
Backup

What's all this grid nonsense then?

- Recognition in the early planning of LHC computing that a single centre would not supply enough resources for the LHC experiments
  - Mainly because no one would fund a central computing facility

- In fact ATLAS uses three grids:
  - EGI in Europe, Asia and Canada (UMD middleware)
  - OSG in USA (OSG stack)
  - NorduGrid in Nordic countries (ARC middleware)
- All badged as "Worldwide LHC Computing Grid compatible"

Computing Model Cartoon



- 1 Tier-0: CERN
- 10 Tier-1: National Computing Centres (BNL, RAL, IN2P3, ...)
- 40 Tier-2: Regional Computing Centres (ScotGrid, Frascati, Toronto, ...)
- Composed of multiple individual sites
  - ~100 Analysis queues in PanDA

- T0: prompt reconstruction
- T1s/T2s: reprocessing, MC production, derivation production, analysis (mainly at T2s)
- T3s: analysis only

ATLAS Grid Architecture

- Distributed Data Management System (DDM): Data movement and catalog system, policy engines
- Other databases and data book keeping (AMI, GRL, Coma for metadata; conditions data in distributed Oracle + frontier; Event Index; etc.)
- Production System (PanDA)
- Distributed Analysis Interfaces (ganga + pathena)

New version for Run 2: Rucio

New for for Run 2: JEDI and DeFT

DDM Rucio

- Data management is at the core of all ATLAS grid activities
  - All data organised as datasets
    - Which contain multiple files
  - Datasets are the ‘work units’ on the grid
    - So the DDM central catalog records the location of datasets on the grid, as well as the content of each dataset
    - Datasets are also the basic input to an analysis
  - DDM also moves data between sites on the grid

https://twiki.cern.ch/twiki/bin/view/AtlasComputing/RucioClientsHowTo

Send in the Jobs!

- To run ATLAS jobs on the grid you need an distributed analysis framework which
  - Understands the ATLAS data model
  - Understands the grid
  - Understands the analysis code
- Distributed Analysis Interfaces (ganga + pathena)

https://twiki.cern.ch/twiki/bin/view/AtlasComputing/DistributedAnalysis