# Processing, Calibration and Reprocessing of ATLAS Data from LHC Collisions at 7 TeV

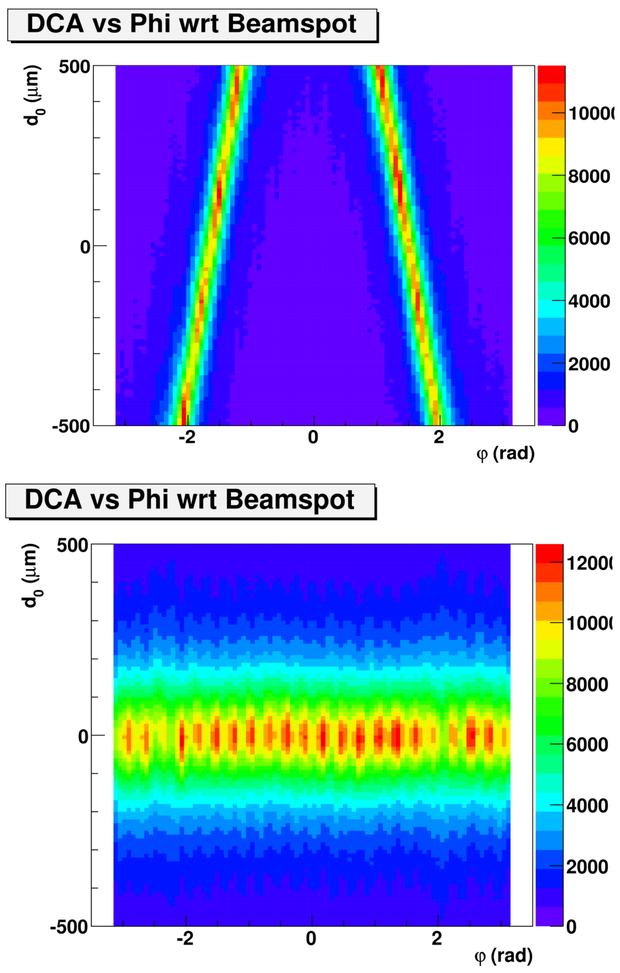
Michael Böhler[1] (Deutsches Elektronen-Synchrotron DESY)
on behalf of the **ATLAS** Collaboration

## Introduction

The ATLAS experiment has successfully **recorded, reconstructed,** and **analysed hundreds of millions of collision events** delivered by the LHC at a centre-of-mass energy of 7 TeV. Both, the early commissioning period and the stable data acquisition are run over large-scale data processing operations, which work remarkably well.
New data from the ATLAS detector is promptly processed at the CERN "Tier-0" computing farm which provides reconstructed **data samples** and a **variety of reduced datasets**.

Using these datasets, the **reconstruction software** was tuned and **calibration** and **alignment constants** were derived. The constants and software improvements have been used for a series of **centralised data reprocessings**, using world-wide distributed computing on the Grid.
These reprocessings were then run **consistently for real** and **simulated data samples.** Since April 2010, the **prompt reconstruction software was frozen** and each run was **pre-calibrated** during a so-called **calibration loop,** so that the new data samples produced by the Tier0 are **directly usable for physics analysis** and could be combined with the earlier reprocessed data, both real and simulated.

## Calibration




Track parameters d0 vs. phi before (upper plot) and after (lower plot) beam spot corrections from the calibration loop

The offline **calibration constants** are derived from **express** and dedicated **calibration stream** data.

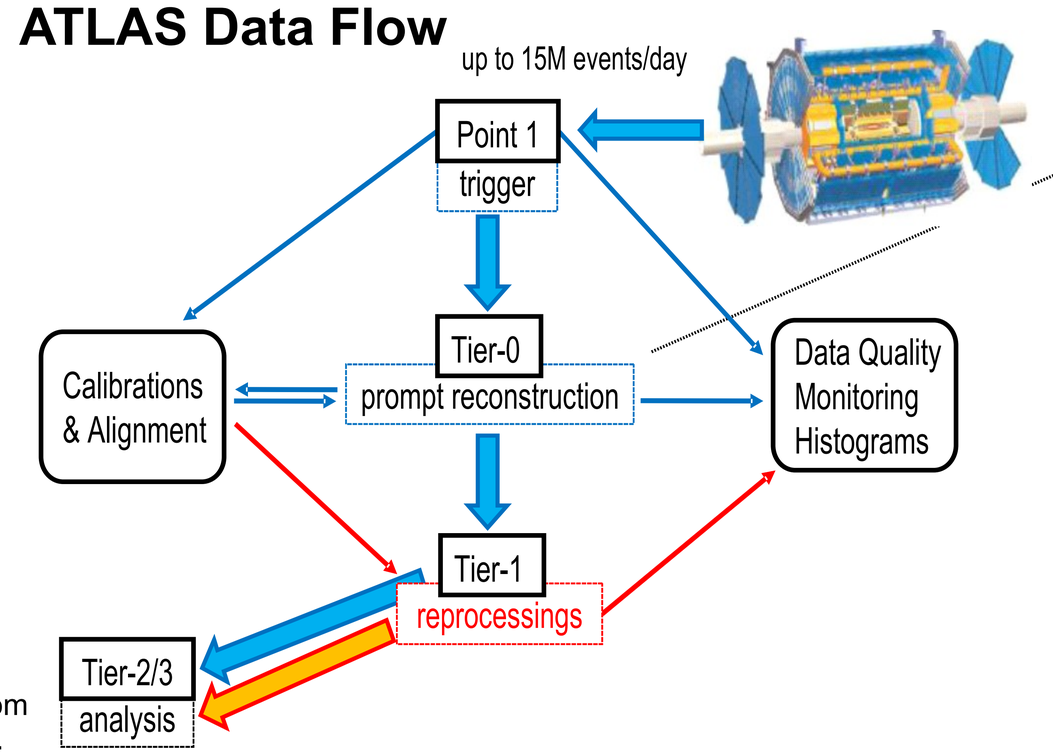
These are the usual steps:
1)Ntuples and data samples are produced from Tier0 reconstruction jobs for the express stream
2)Calibration constants are extracted
3)Constants are validated and uploaded to the conditions data base

Amongst others, the offline **calibration** checks for **noisy** and **dead channels** and **masks** them.
Very important is the **beam spot** determination. The beam spot position is already determined online. A second **offline determination**, using the offline reconstruction, is based on the **express stream data**. The **beam spot position** and **width** is determined for **five luminosity blocks** grouped (one luminosity block ~ 120 sec. data taking).

## Data Flow (in a nutshell)

1) Trigger interesting events
2) Run prompt reconstruction (express and calibration stream)
   - Determine calibration constants
   - Provide data quality histograms
3) Bulk reconstruction of physics streams with updated calibration constants
4) Re-reconstruct (reprocessing) raw data and MC simulation after major updates (e.g. software)

## ATLAS Data Flow



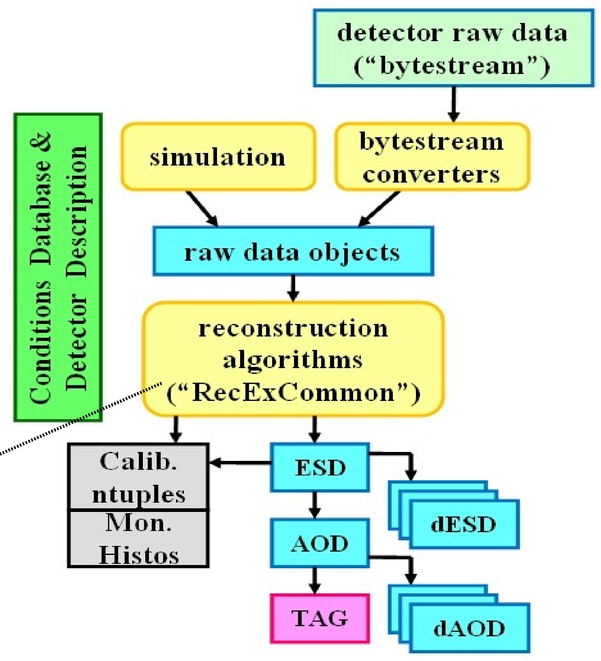

## Processing (➡)

The triggered events are reconstructed at the **Tier0 at CERN**. This is first done in a so called **express stream,** which calculates some calibration constants. After the calibration loop, which takes maximum 36 hours after a run has ended, the newly calculated constants are used for the bulk **reconstruction** of **physics streams**.

## Reprocessing (➡)

After software updates or new determinations of calibration and alignment constants, **data** and **Monte-Carlo samples** are re-reconstructed (**reprocessed**) with exactly the same setup. These reprocessing jobs are **run** on the world-wide distributed computing **Grid** at different Tier 1 centres.

## ATLAS Data Formats



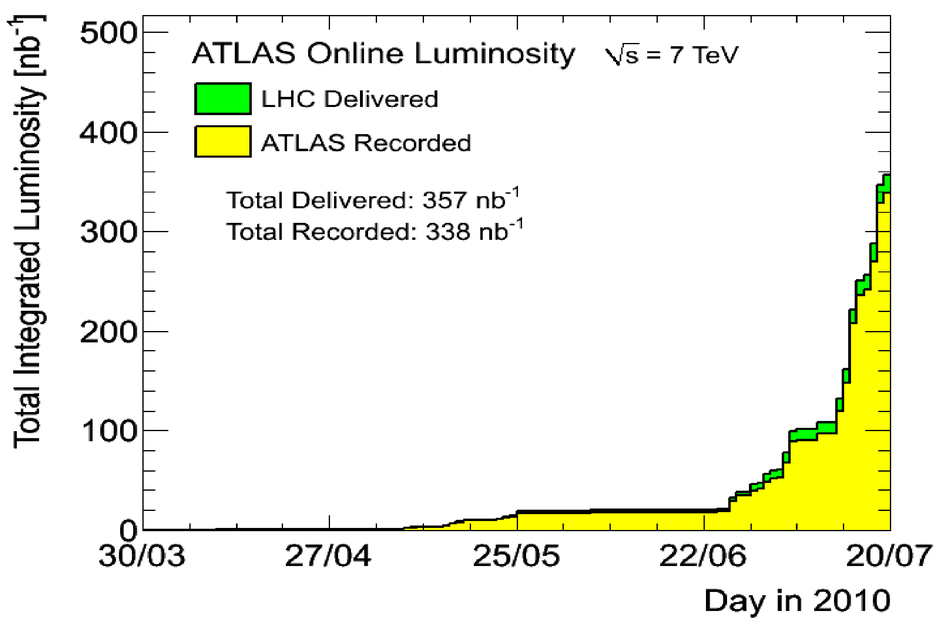

The **ATLAS Event Data Model** (EDM) foresees **different data formats** with different **levels of detail** and different event filter criteria:

- **Detailed** reconstructed objects are written in Event Summary Data (**ESD**) files, for **detector & reconstruction performance studies**.
- Smaller Analysis Object Data (**AOD**) files are derived from ESD, for **physics analysis**.
- **TAG, dESD & dAOD** files are provided for further **data reduction**. **TAG** allows to **select** individual **events quickly**. **dESD/dAOD** have analysis-specfic event **filtering**.

## Frozen Tier-0 software

**Freezing** the software means that during a data taking period, only updates which do **not change the physics content** of the data are allowed to be added to the Tier0 software, for instance monitoring software updates**.**
It allows **new data** to be **immediately combined** with already **reprocessed data samples** and **simulated data** from the **latest reprocessing** campaign.

## Total Integrated Luminosity




**Cumulative luminosity** versus day **delivered** to (green), and **recorded** by ATLAS (yellow) during **stable beams** and for 7 TeV centre-of-mass energy. Given is the luminosity as **determined from counting rates** measured by the **luminosity detectors**. These detectors have been **calibrated** with the use of the **van-der-Meer beam-separation** method. The **systematic uncertainty** of the luminosity measurement is estimated to be **11%**, dominated by the uncertainty in the beam current product (10%).

## Summary

The ATLAS experiment has successfully recorded, reconstructed and analysed **hundreds of millions of events**. During the **commissioning phase**, the **prompt reconstruction** was run **without** a **calibration** loop. The **calibration constants** were derived from the reconstructed data sets and used afterwards for the **reprocessing campaigns**.

By **April 2010**, the **software release** has been **frozen** and a **pre-calibration** is performed on each run. This allows the **new data** to be **directly combined** with the **latest reprocessed data** sets, both real and simulated.

So far, the **ATLAS** experiment has recorded data for a **total integrated luminosity** of **338 nb$^{-1}$**.

## Further reading:

[1] The ATLAS Collaboration, G. Aad et al., The ATLAS Experiment at the CERN Large Hadron Collider. JINST 2 (2008) S08003.
[2] The ATLAS Collaboration, ATLAS Computing: Technical Design Report (TDR) 2005 CERN-LHCC-2005-02
[3] Adams, D and Barberis, D et al. The ATLAS Computing Model.. CERN-LHCC-2004-037-G-085 2004
[4] González de la Hoz, S and Sánchez, et al. ATLAS Data Challenge 2: A massive Monte Carlo production on the GRID, ATL-SOFT-PUB-2005-001 2005
[5] The ATLAS collaboration, Characterization of Interaction-Point Beam Parameters Using the pp Event-Vertex Distribution Reconstructed in the ATLAS Detector at the LHC, CERN, ATLAS-CONF-2010-027

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1) michael.boehler@cern.ch