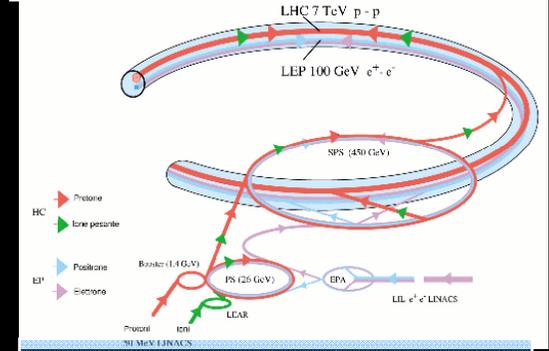


MDT Data Quality Assessment at the Calibration Centers for the ATLAS experiment at LHC

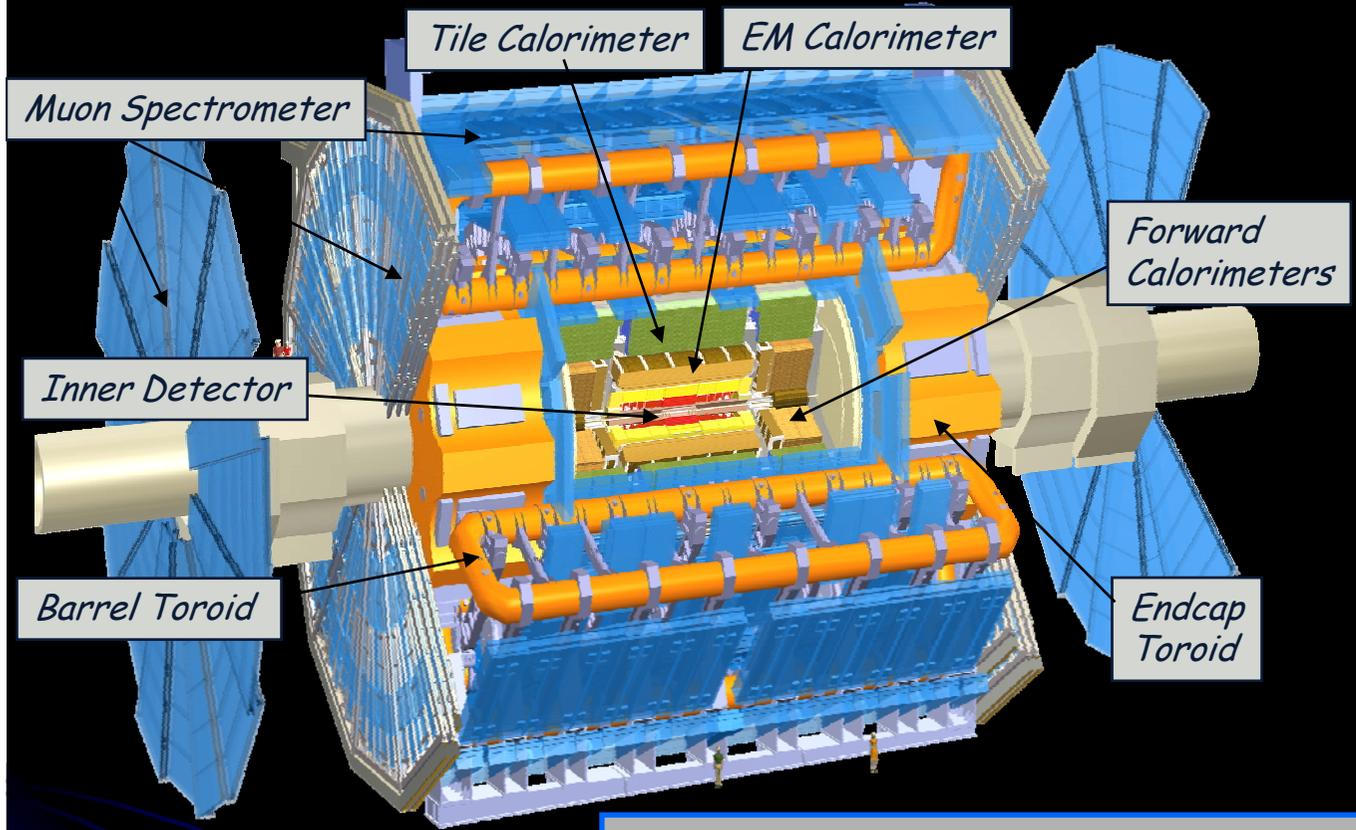
E.Solfaroli Camillocci and M.Verducci
(Università di Roma “La Sapienza” and INFN Roma)
on behalf of the ATLAS MDT DQA group

ATLAS @LHC

Large Hadron Collider



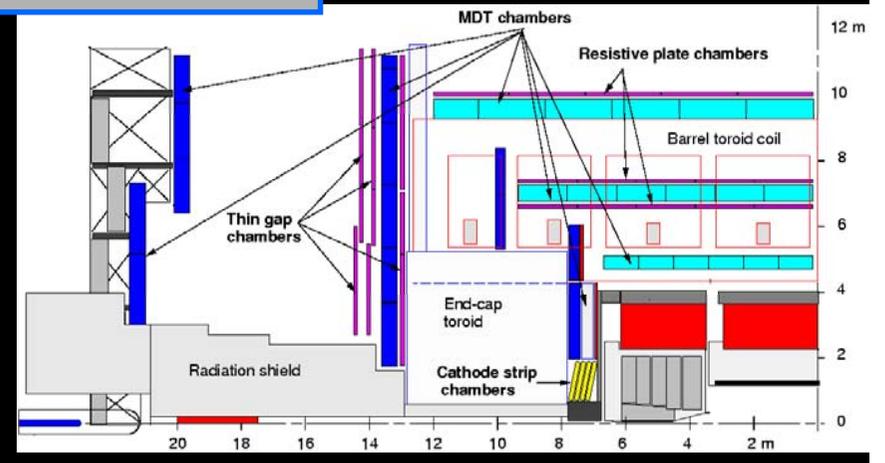
p-p collision @ $\sqrt{s} = 14 \text{ TeV}$
 Bunch Crossing every 25ns
 Luminosity $\sim 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$



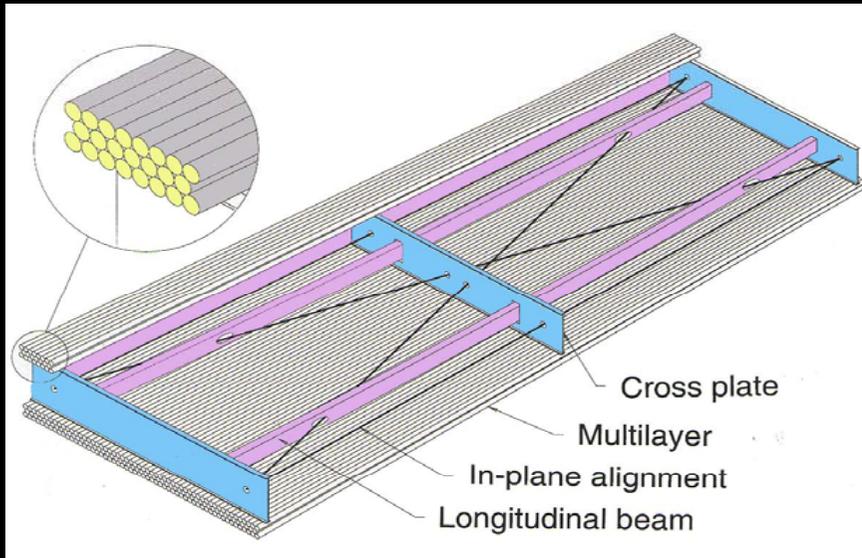
Muon Spectrometer

- Tracker Detectors
 - Monitored Drift Tube Chambers**
 - Cathode Strip Chambers
- Trigger Detectors
 - Resistive Plate Chambers
 - Thin Gap Chambers
- Toroidal magnetic field in air to minimize multiple scattering.
- Can operate as a **stand-alone detector**

M. Verducci



The Monitored Drift Tube Chambers



The Muon Spectrometer uses
 • **~1200 MDT Chambers** to
 precisely measure muon tracks
 (→ **~350K drift tubes!**)

Challenges:

Wire positioning < 20 μ m r.m.s.
Required alignment < 40 μ m
Resolution < 80 μ m

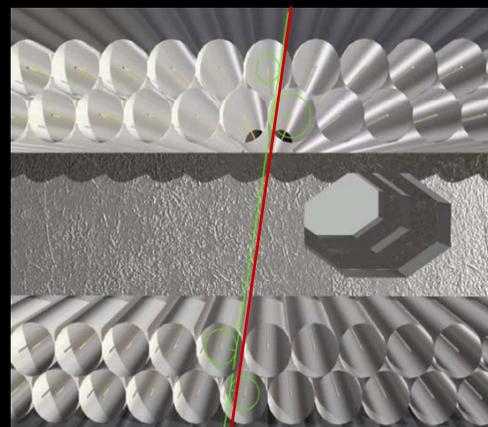
<i>Parameter</i>	<i>Value</i>
<i>Tube diameter</i>	29.970 \pm 0.015 mm (ext)
<i>Tube wall thick.</i>	0.4 mm
<i>Wire diameter</i>	50 μ m (tungsten-rhenium)
<i>Gas</i>	Ar:CO ₂ (93:7)
<i>Pressure</i>	3 bar absolute
<i>HV</i>	3100 V (Gas gain \approx 2 \times 10 ⁴)
<i>Discr. threshold</i>	60 mV (\approx 15 prim. Ioniz.)

The MDT Measurement

The nominal resolution of $80\mu\text{m}$ on a single hit is required in the coordinate orthogonal to the B-field

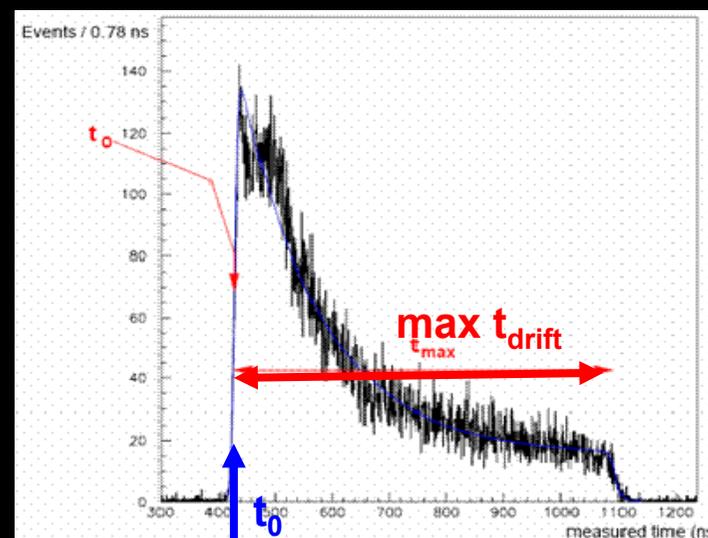
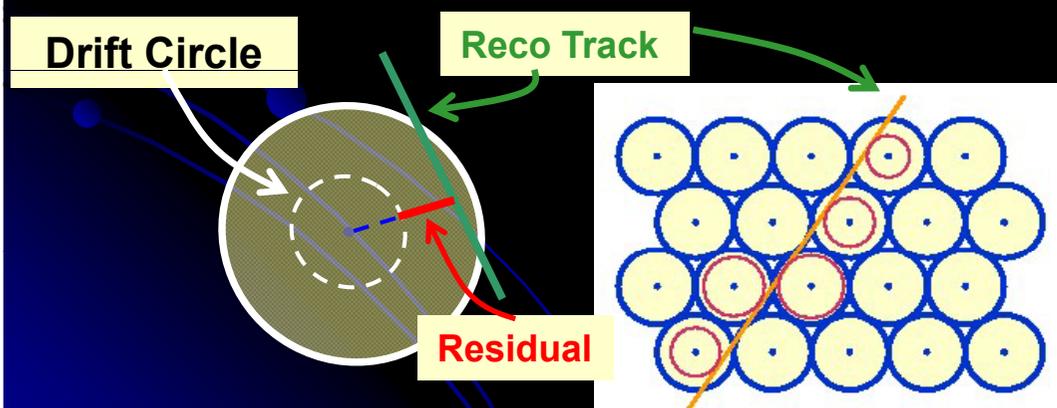
- ❖ Accuracy in the precision of the drift time measurement and of the detector mechanics.
- ❖ Knowledge of the space-time (r-t) relation

→MDT CALIBRATION



3 layers of tubes
(4 layers inner
ch.)

3(4) layers of
tubes (wire
position $10\mu\text{m}$)



Need of large number of muon tracks and a dedicated trigger stream!

Muon Calibration Stream Model

Continuous MDT calibration and alignment are needed to keep all effects (i.e. environmental parameter and geometry) under control

- ✓ Weekly computation of single tube t_0 (~20K muon tracks/tube)
- ✓ Daily determination of the **r-t relation** of each chamber

→ ~10⁸ muon tracks each day over the entire spectrometer!

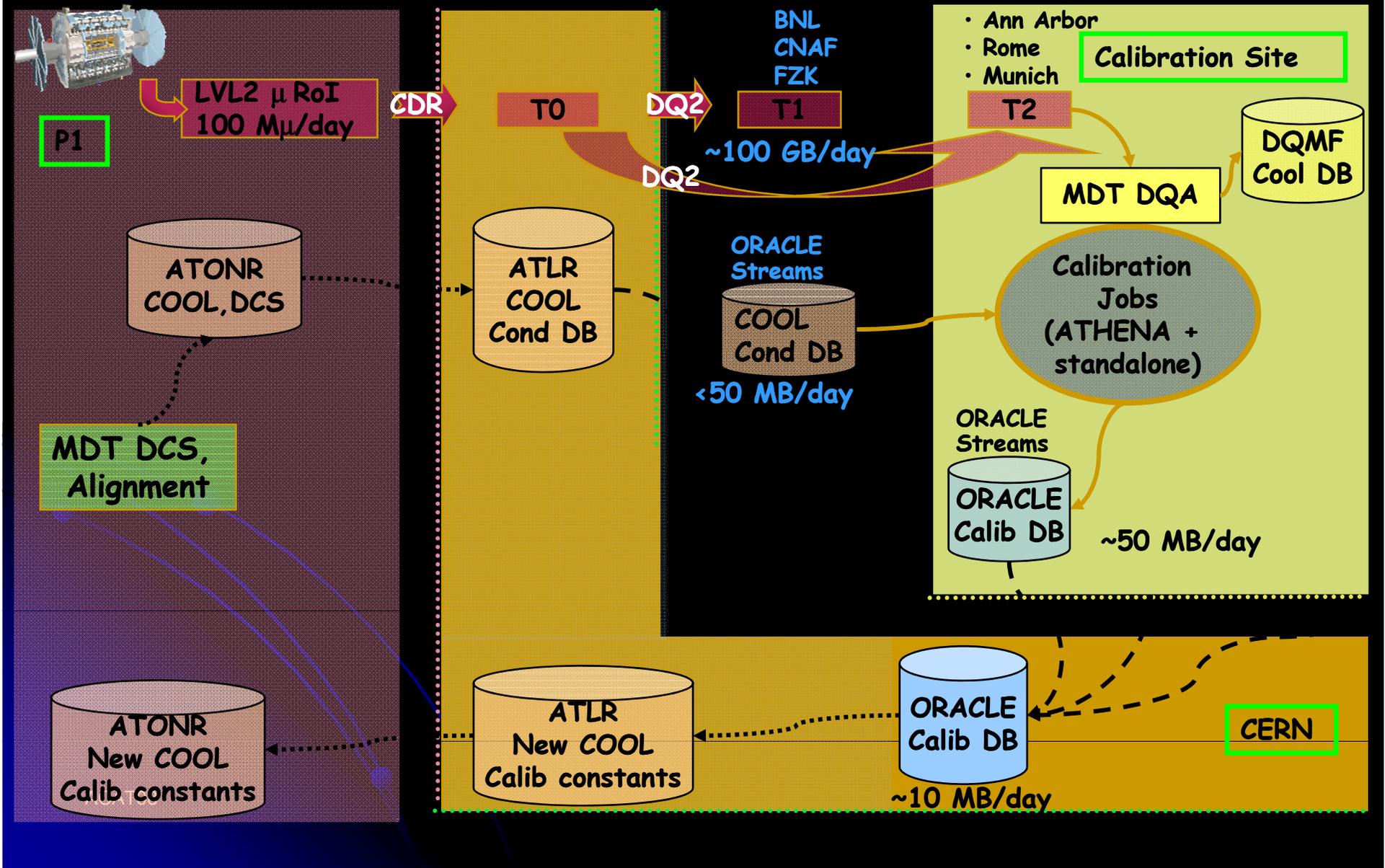
Not achievable using the standard ATLAS Data Flow (muon rate through the 3 trigger levels ~20Hz) → Need a dedicated Stream:

MUON CALIBRATION STREAM

- ✓ Muons are extracted from the second level trigger (LVL2), requiring a track in the MDTs pointing to the vertex (~1 KHz)
- ✓ Data are streamlined and processed in 3 Calibration Centres
 - ✓ Ann Arbor, Munich, Rome;
 - ✓ ~100 CPUs each.
- ✓ **~1 day latency for the full chain:**
 - ✓ data extraction,
 - ✓ calibration computation at the Centres,
 - ✓ storage of results in the Condition DB at CERN.

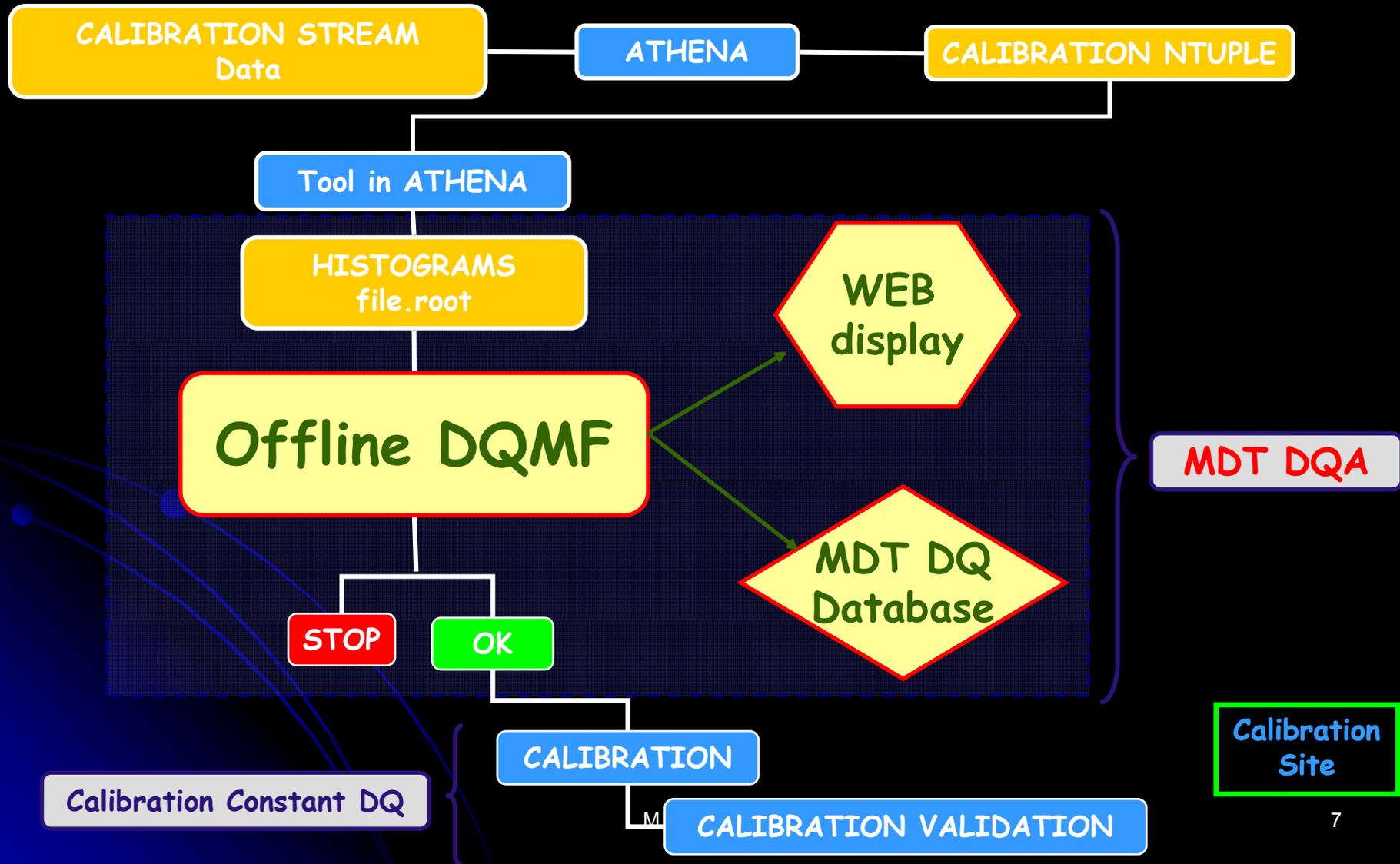
→ Need to carefully design the data flow and the DB architecture.

MDT Calibration Chain



MDT DQA

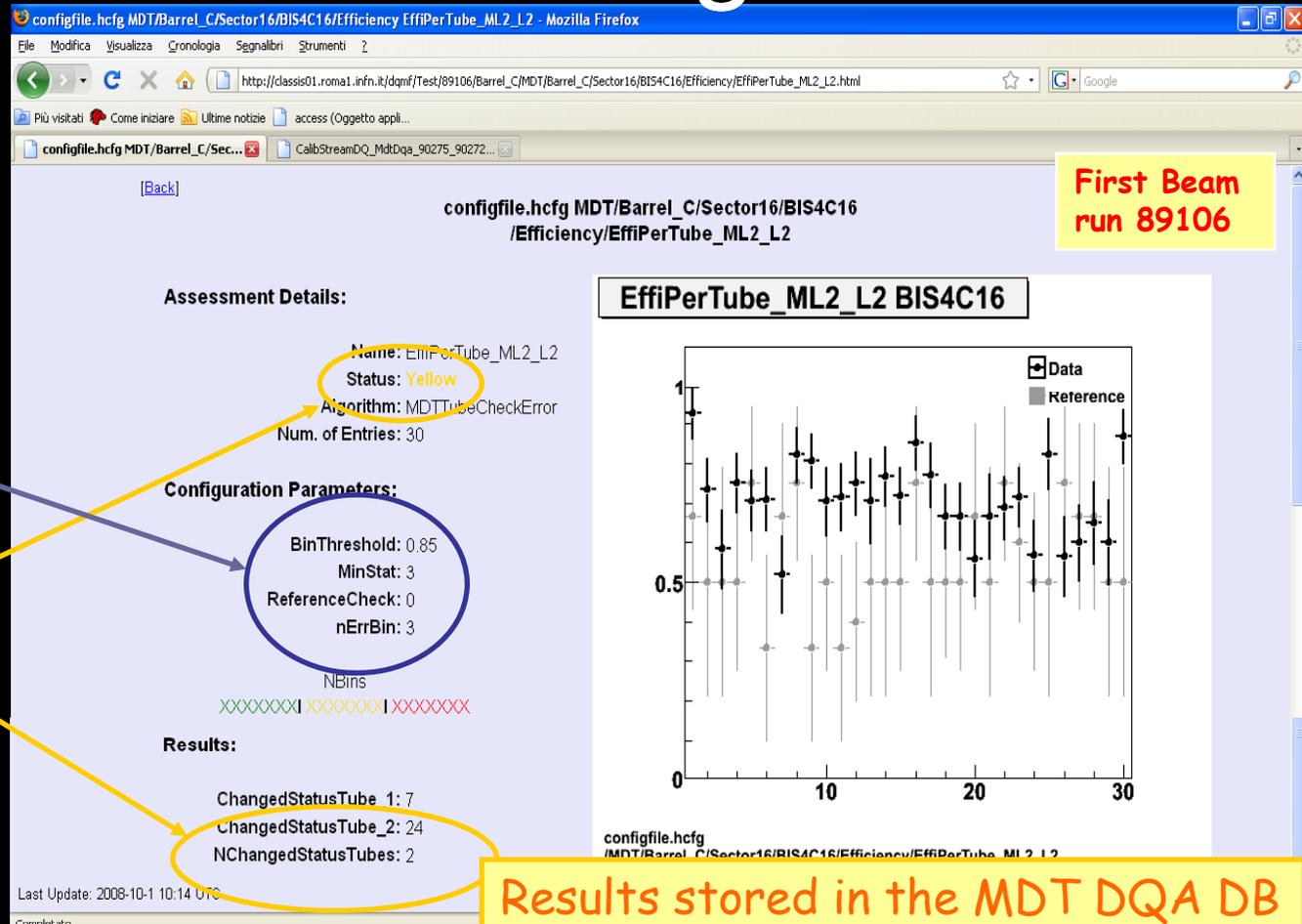
from stream to calibration



DQMF at Calibration Centers

- ✓ MDT Data Quality Assessment is performed using the “**offline DQMF**” package (**Data Quality Monitoring Framework**
<https://twiki.cern.ch/twiki/bin/view/Atlas/DQHistogramAnalyzer>)
- ✓ Algorithms are applied on ROOT histograms, from the Calibration Stream, in an automated way.
- ✓ Histograms are compared respect to a reference.
- ✓ “Standard” algorithms are implemented in the package, and algorithms specific to this analysis are being developed (available in CVS repository).
- ✓ **Results and summaries are**
 - ✓ published on **WEB**,
 - ✓ stored in a **dedicated Database**.
- ✓ DQMF is already used for MDT DQA by shifters at the calibration centers.

A MDT dedicated algorithm



Configuration Parameters

Results

Applied algorithm: AlgMDTCheckTubeError

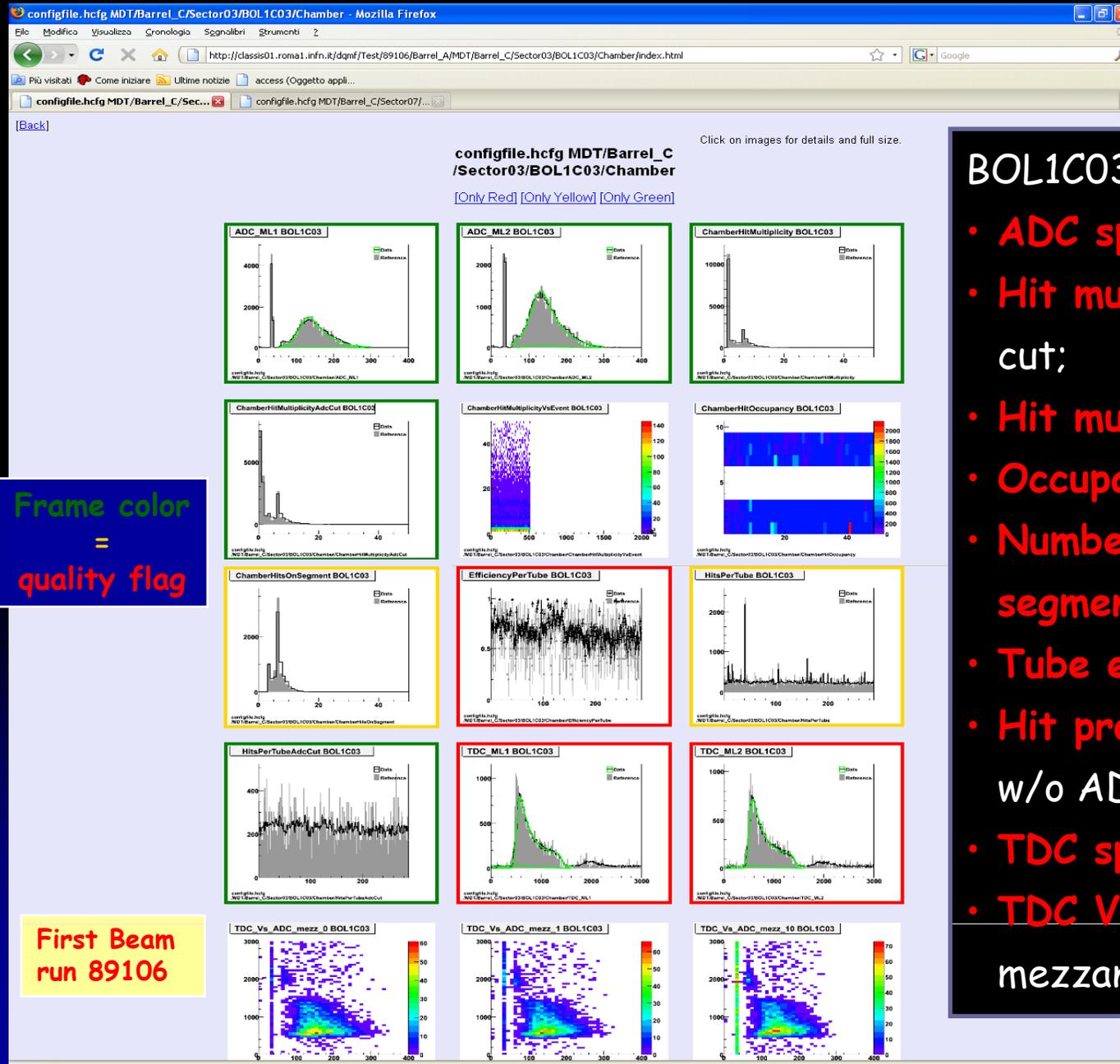
→ Search for bins with efficiency < 0.85 and compare with the reference histogram

GREEN: All channels are efficient and compatible with the reference histogram

YELLOW: up to 2 inefficient channels, new respect to the reference histogram

RED: > 2 inefficient channels, new respect to the reference histogram

Histograms of an MDT Chamber

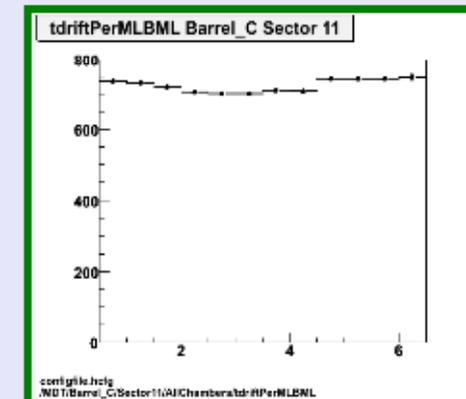
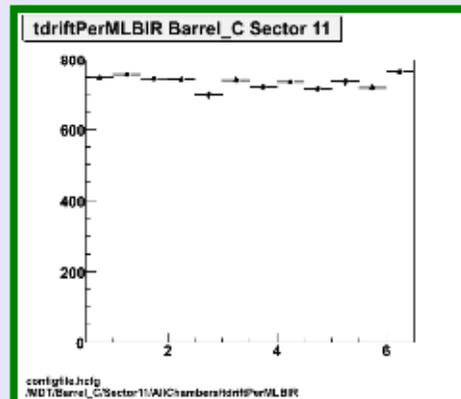
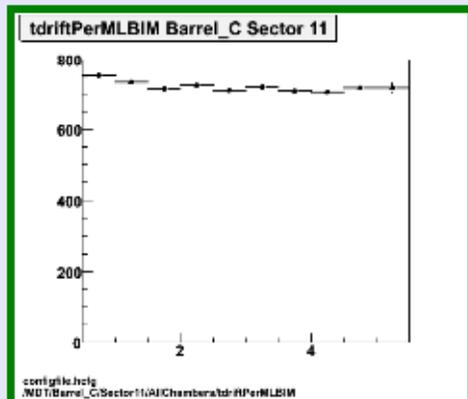
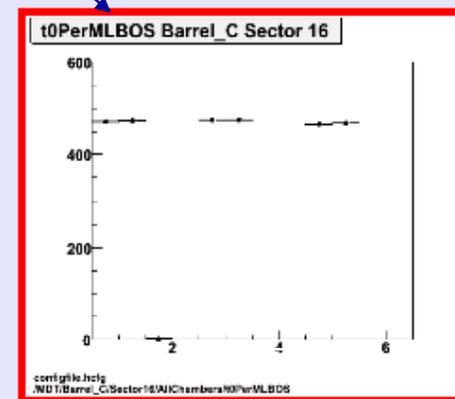
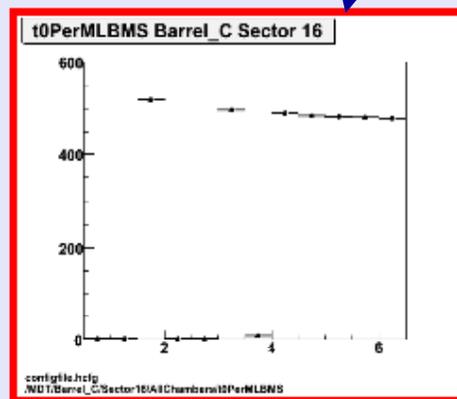
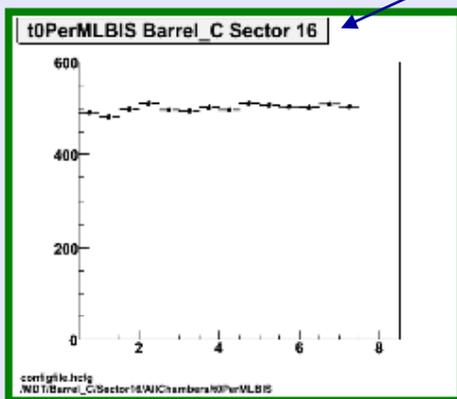
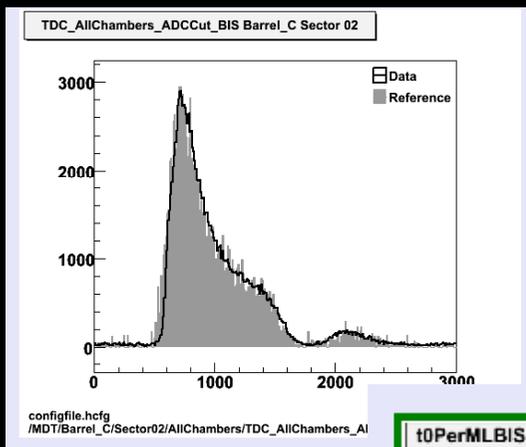
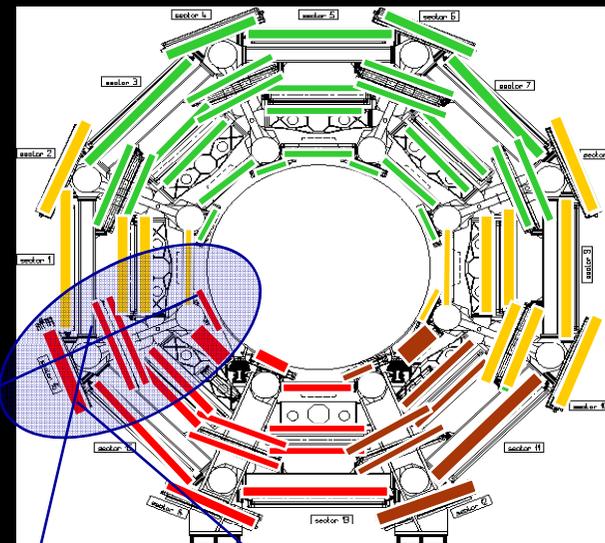


BOL1C03

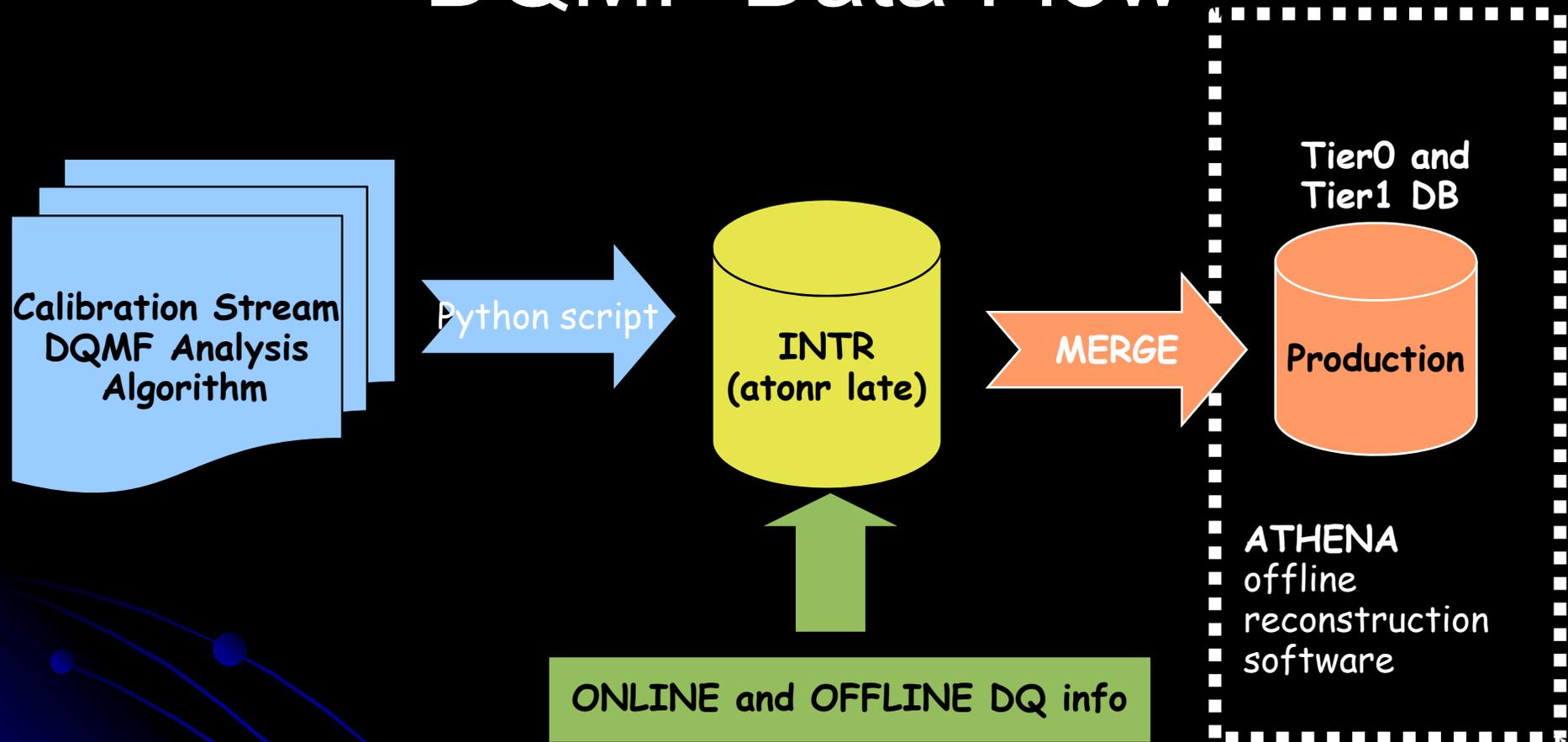
- ADC spectrum per ML;
- Hit multiplicity w/o ADC cut;
- Hit multiplicity VS event;
- Occupancy map;
- Number of hits per segment;
- Tube efficiency;
- Hit profile per chamber w/o ADC cut;
- TDC spectrum per ML;
- TDC VS ADC per mezzanine.

Some Results

Monitoring the t_0 and t_{drift} stability



DQMF Data Flow



The DQMF flags are included in the overall Muon Conditions Data Available for the reconstruction in the Production DB.

Conditions Database

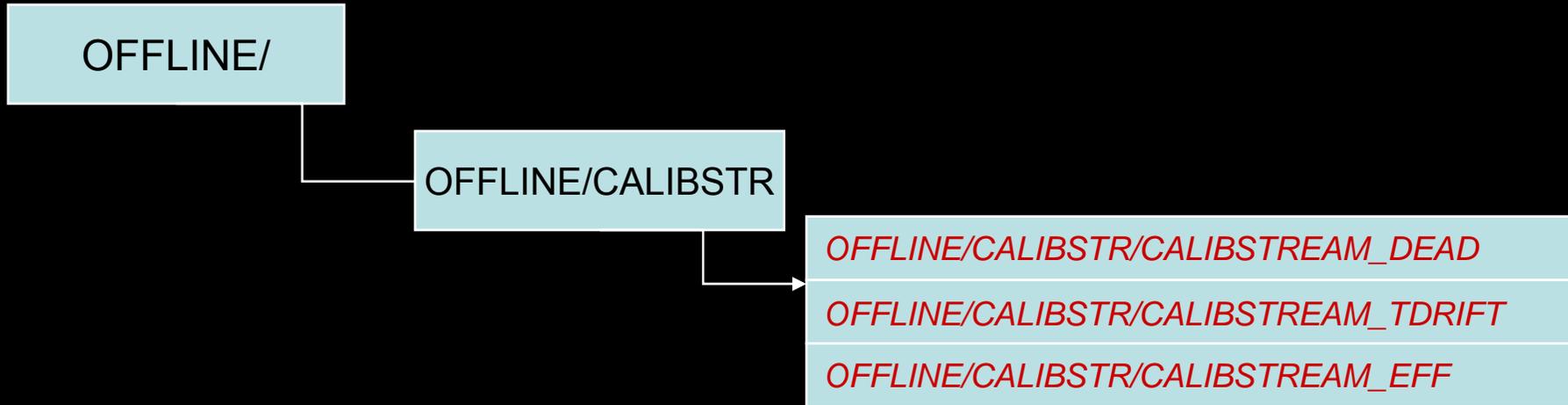
The DQMF output is part of the most general Conditions Data largely used in the ATLAS offline reconstruction.

- ✓ The Conditions Data are 'non-event' data that :
 - ✓ **Vary with time;**
 - ✓ **Exist in different versions;**
 - ✓ **Come from both offline and online.**
- ✓ and are used for
 - ✓ **Diagnostic by detector experts;**
 - ✓ **Calibration and Alignment;**
 - ✓ **Event Reconstruction and analysis.**

The technology used is COOL (COnditions Objects for LHC), it is a database scheme optimized for IOV retrieval & look-up. This is an example scheme of the folder:

Since	Until	ChannelId	Payload	Tag
<i>(Time)</i>	<i>(Time)</i>	<i>(Integer)</i>	<i>(Data)</i>	<i>(String)</i>

DQMF Database



The folder structure (for example, the dead tube folder):

OFFLINE/CALIBSTREAM/CALIBSTREAM_DEAD

Number&list of dead ML,
 Number&list of dead Mezzanine,
 Number&list of dead tubes. } 3 columns varchar2(4000)

since	until	Channel	Dead ML	Dead	Dead
		Chamber	MultiLay	Mezz	tube

Conclusions

- ✓ **Offline DQMF is already used by MDT calibration shifters for DQ assessment.**
- ✓ **Some MDT dedicated DQMF algorithms were developed and are available in CVS.**
- ✓ **Results are daily published on web in <http://classis01.roma1.infn.it/dqmf/> and stored in the MDT DQA COOL database.**

NEXT STEPS

- ✓ **Complete the optimization of the algorithms for the MDT dedicated analysis.**

Backup

ATLAS Data Volume @LHC

Bunch-crossing frequency: 40 MHz
 ~ 20 collisions p-p per bunch crossing

10^9 events/s => 1GHz
 1 event ~ 1MB (~PB/s)

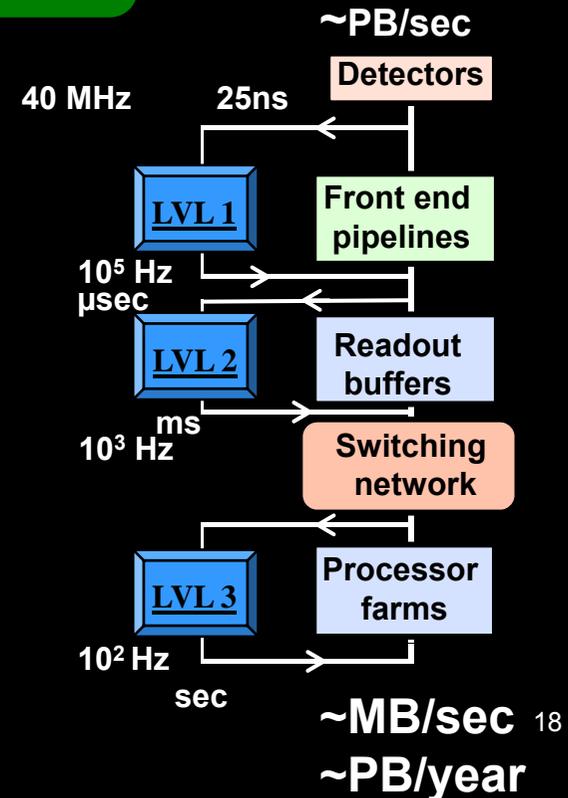
Hierarchical trigger system
 ~MB/sec
 ~PB/year raw data

Reduction of the events via 3 Levels of Trigger into 4 different output streams (200Hz, 320 MB/s):

- ✓ **Primary stream:** 5 sub-streams based on trigger info: e,m,jet.
- ✓ **Calibration and Alignment Stream** (10%).
- ✓ **Express Line Stream:** rapid processing of events, also included in the Primary Stream (30 MB/s, 10%).
- ✓ **Pathological events:** events not accepted by

EF.
 ACAT08

M.Verducci

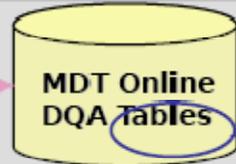


MDT Data Quality Schema

P1

Online in the TDAQ DataFlow: GNAM, DAQ, DQMF...

COOL



Common Variables
...
...
Online Variables
...
...

T0

Offline DQMF (on Express Stream)

COOL

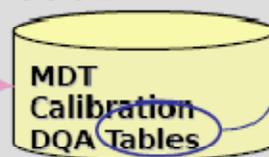


Common Variables
...
...
Offline Variables
...
...

T2

Calibration DQA at Calib Sites

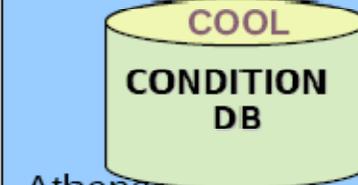
COOL



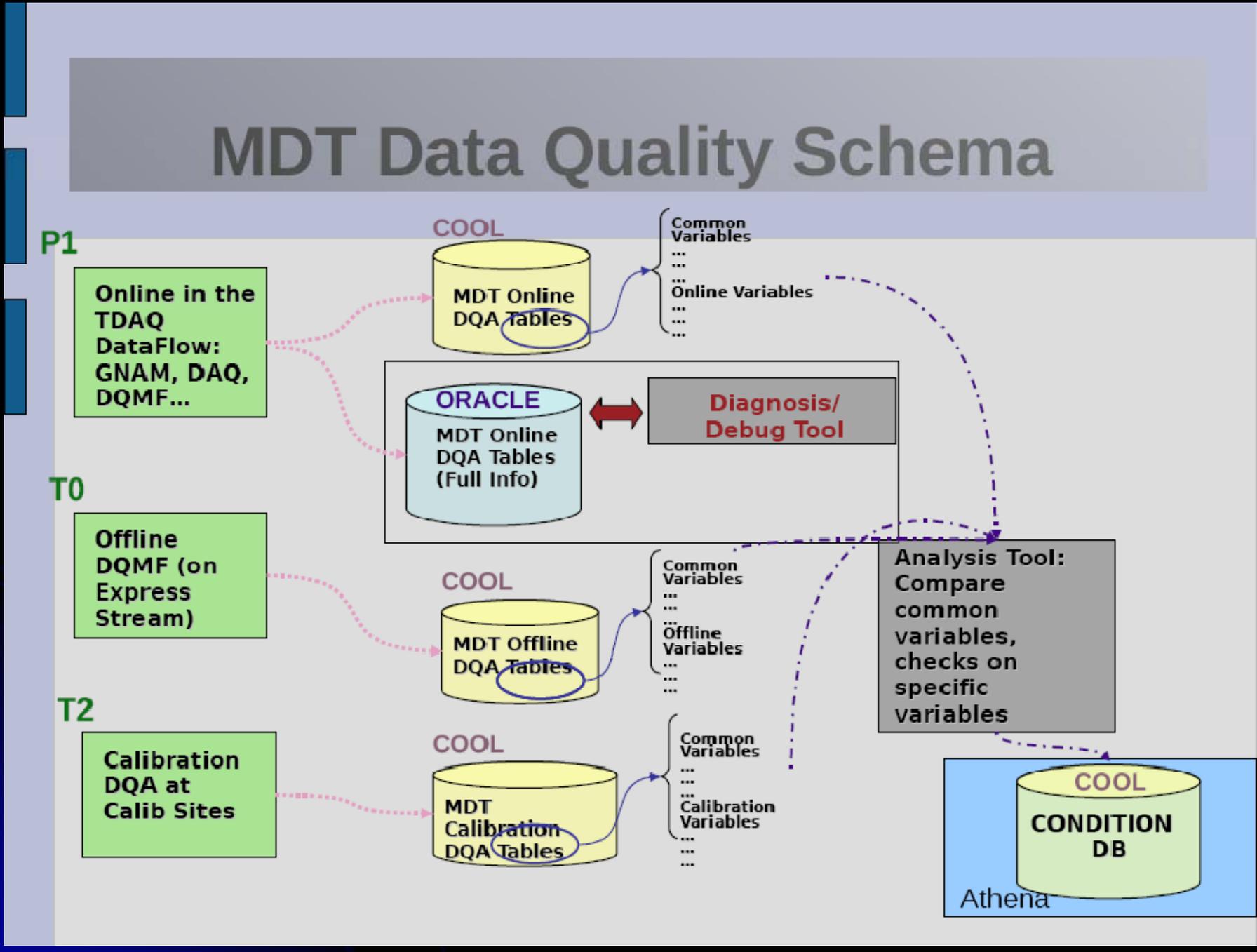
Common Variables
...
...
Calibration Variables
...
...

Diagnosis/
Debug Tool

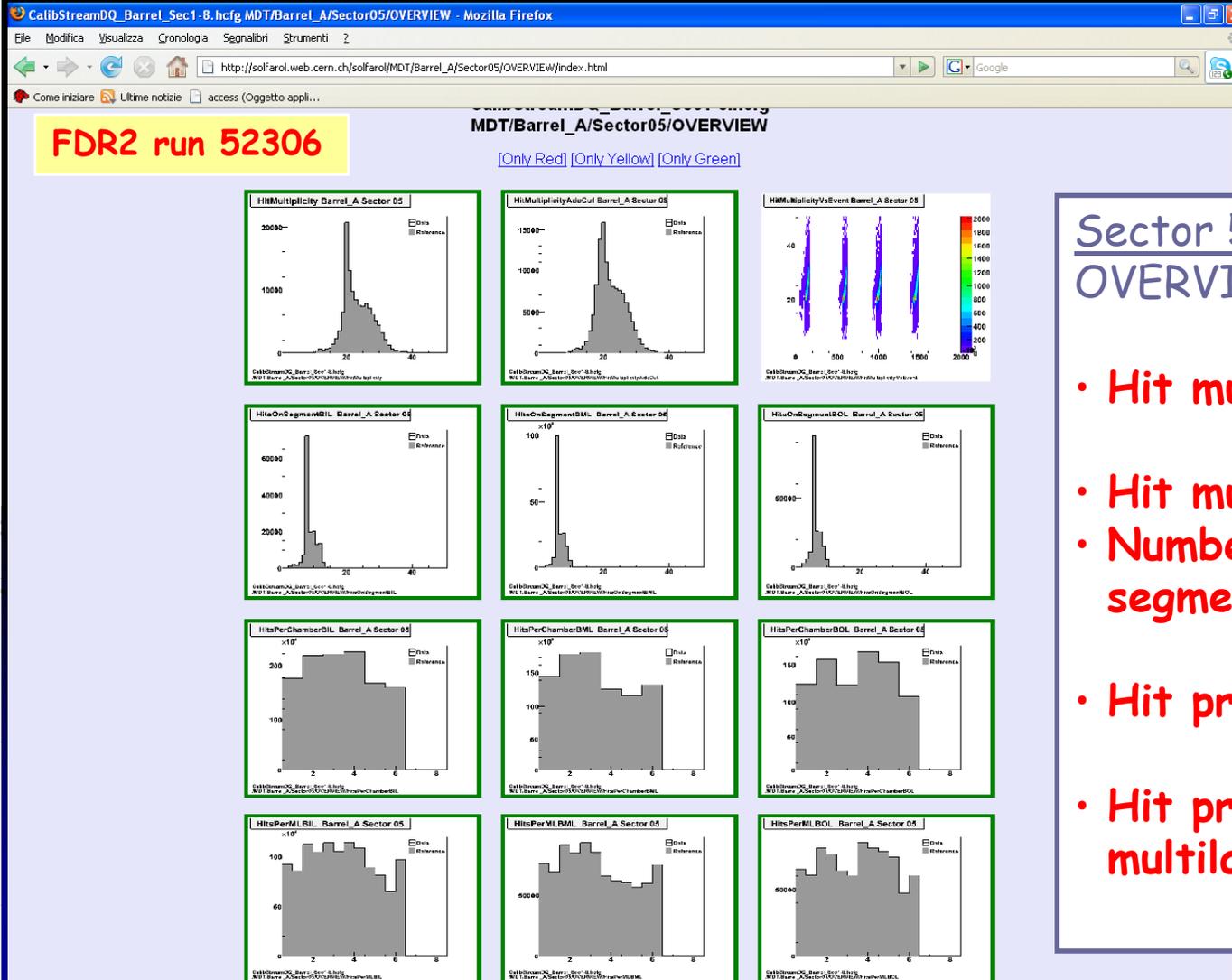
Analysis Tool:
Compare common variables, checks on specific variables



Athena



MDT sector



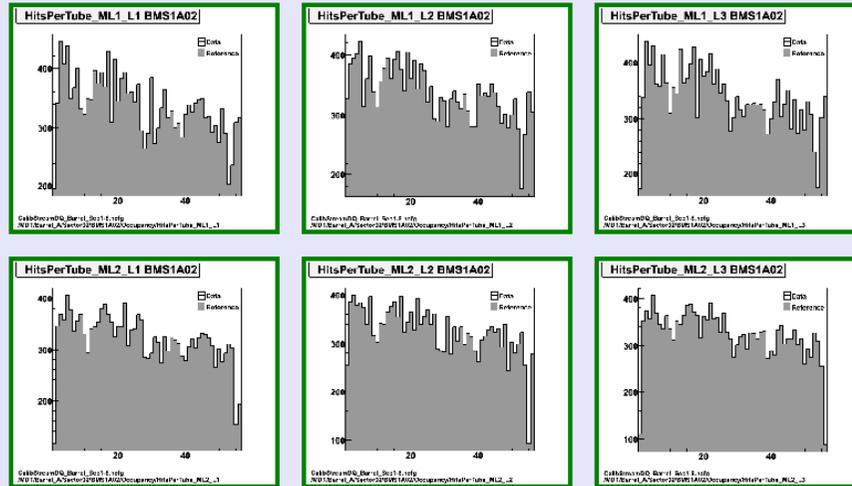
Sector 5 Barrel A OVERVIEW

- Hit multiplicity
- Hit multiplicity VS event;
- Number of hits per segment
- Hit profile VS η
- Hit profile VS η per multilayer

MDT chamber: in the directories

CalibStreamDQ_Barrel_Sec1-8.hcfcfg
MDT/Barrel_A/Sector02/BMS1A02/Occupancy

[\[Only Red\]](#) [\[Only Yellow\]](#) [\[Only Green\]](#)

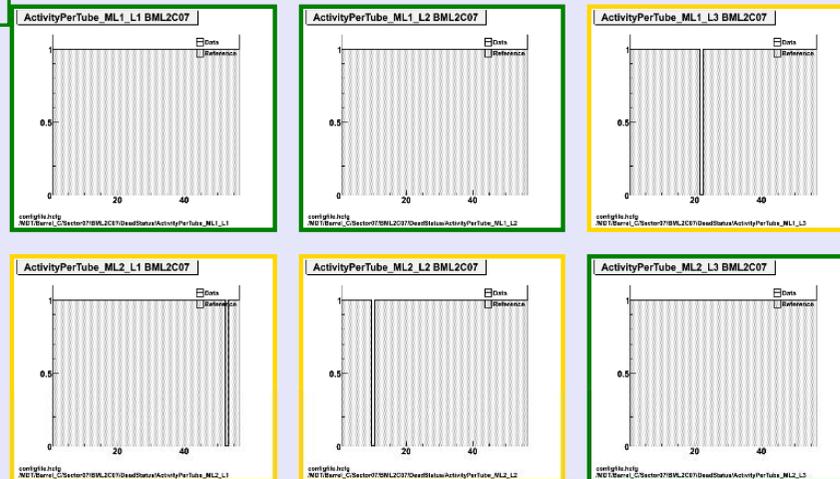


FDR2 run 52306
Calibration Stream

Hit profile
BMS1A02 each layer

configfile.hcfcfg MDT/Barrel_C
/Sector07/BML2C07/DeadStatus

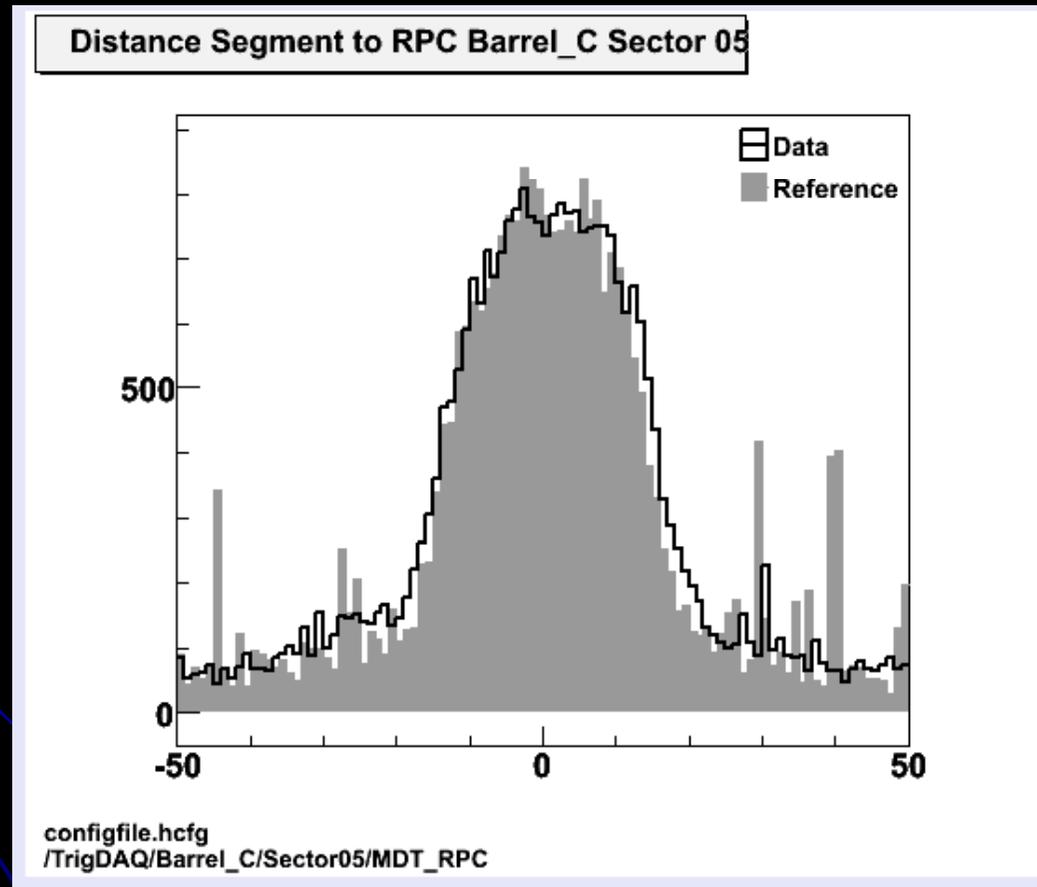
[\[Only Red\]](#) [\[Only Yellow\]](#) [\[Only Green\]](#)



Dead Tubes
BML2C07 each layer

First Beam
run 89106

MDT VS RPC tracks



COOL Technology

COOL = COnditions Objects for LHC

✓ COOL:

- ✓ Tight integration with other LCG software components (SEAL, POOL)
- ✓ Different (Oracle, MySQL and SQLite) implementations
- ✓ Within ATLAS, the master conditions database at CERN will be stored using Oracle, as will all Tier-1 replicas.
- ✓ COOL provides a C++ API, and an underlying database schema to support the data model.

✓ Once a COOL database has been created and populated, it is possible for users to directly interact with the database, using lower-level database tools

✓ COOL implements an **interval of validity database**

- ✓ objects stored or referenced in COOL have an associated start and end time between which they are valid.
- ✓ times are specified either as run/event, or as absolute timestamps in agreement with the meta-data stored.

✓ COOL data are stored in folders (**tables**)

- ✓ Database = set of folders
- ✓ Within each folder, several objects of the same type are stored, each with their own interval of validity range