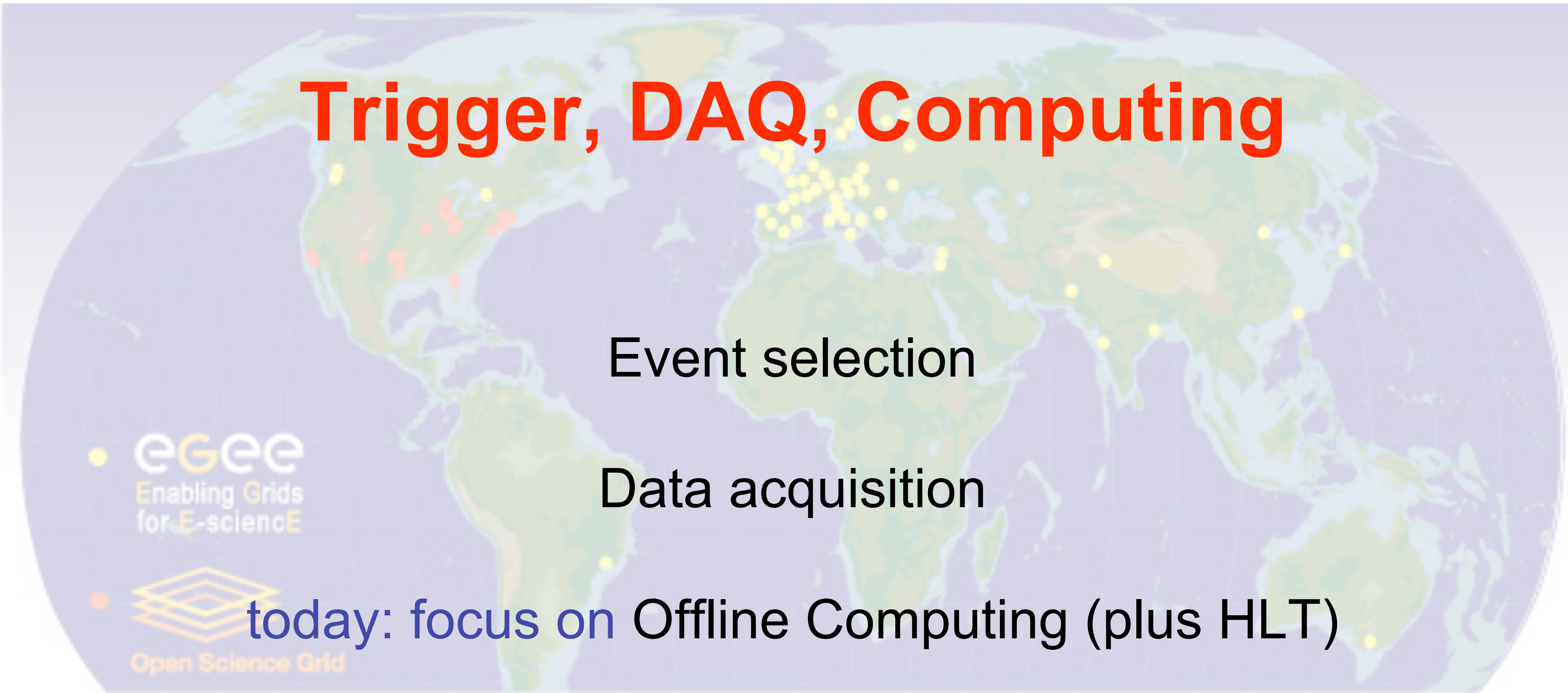
Trigger, DAQ, Computing

Event selection

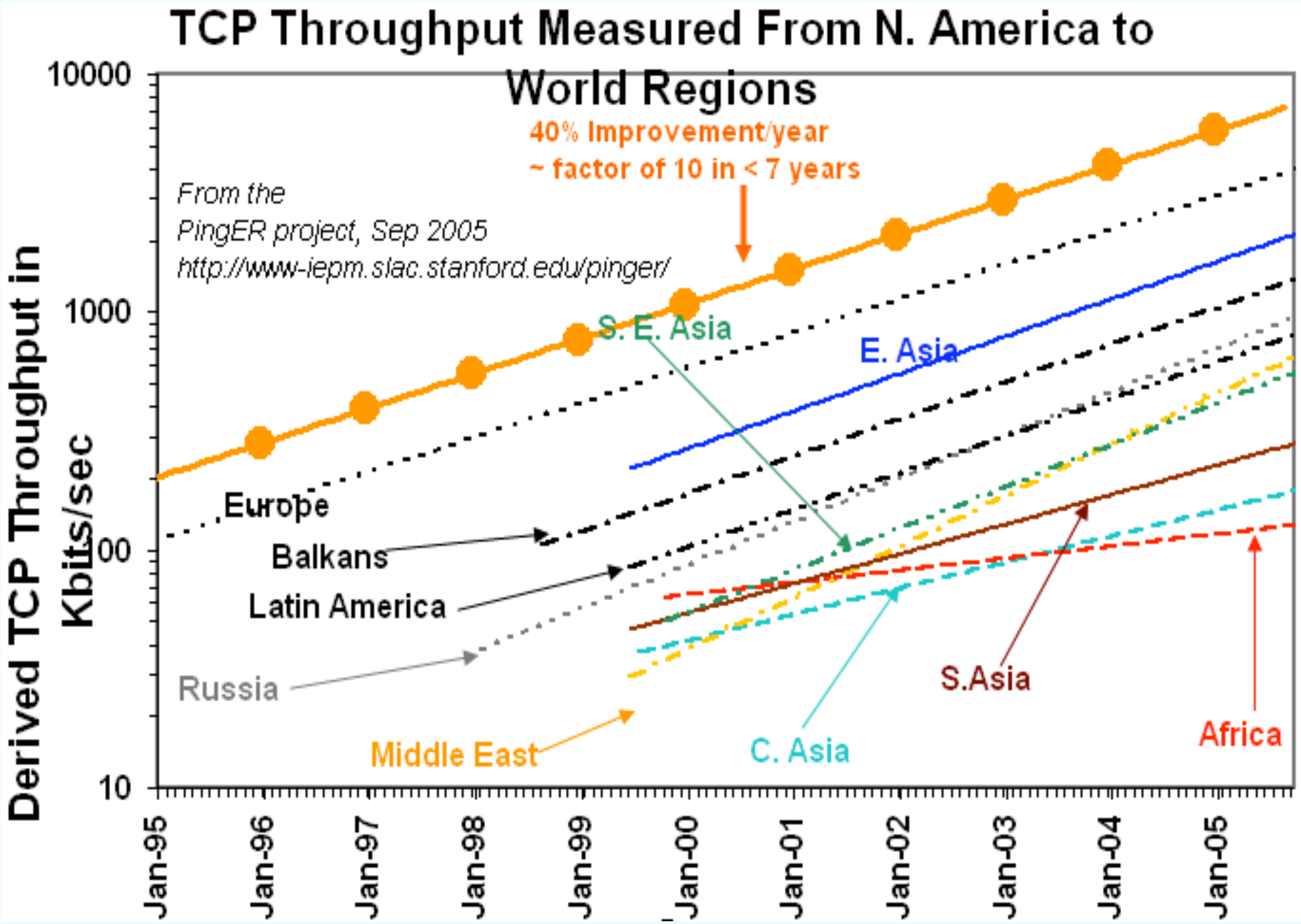
Data acquisition

today: focus on Offline Computing (plus HLT)



A map of the worldwide LCG infrastructure operated by EGEE and OSG.

Wide area networking - development since 1995



40% annual growth

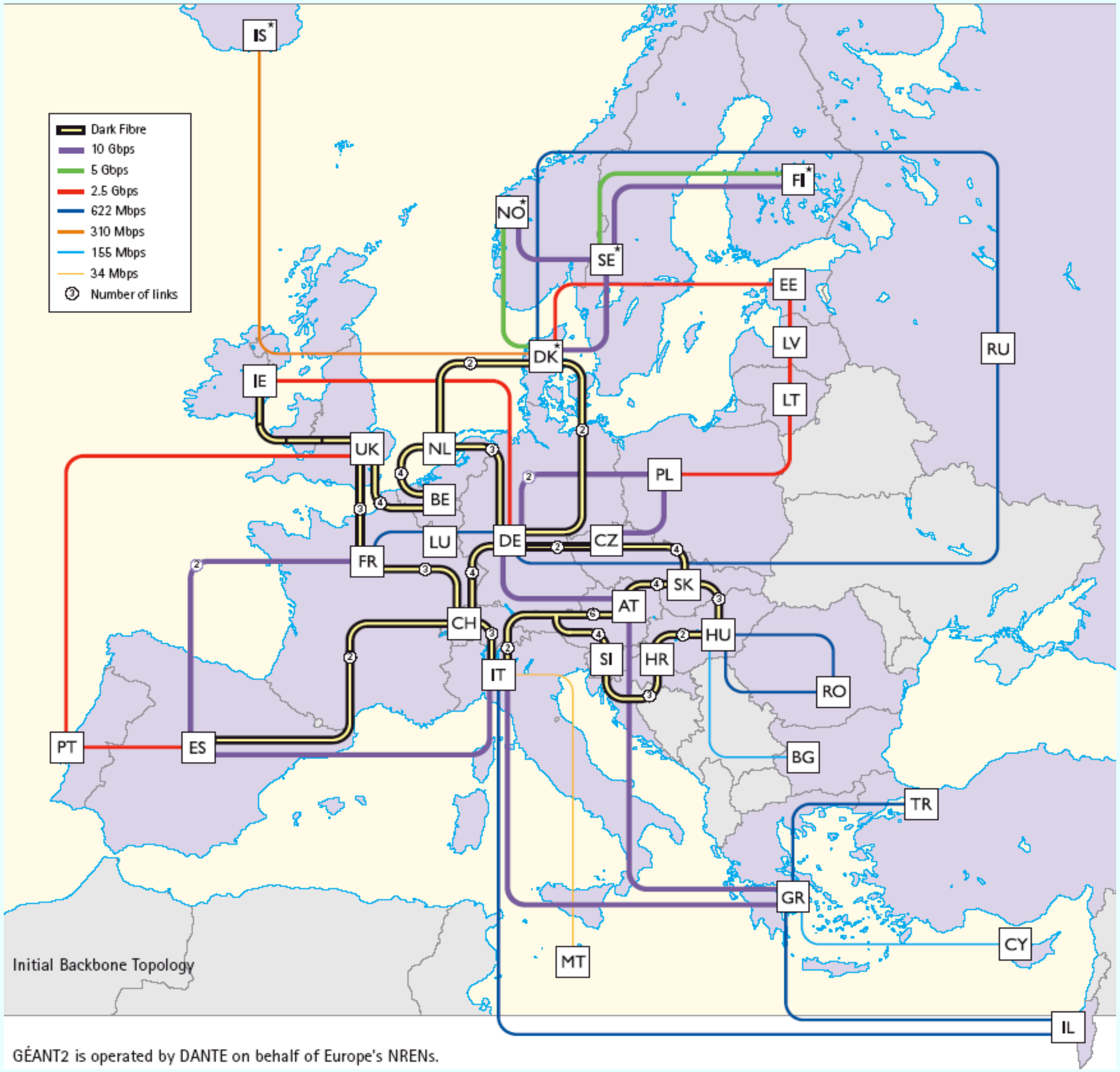
Years behind Europe:

6 Yrs Russia, Latin America
7 Yrs Mid-East, SE Asia
10 Yrs South Asia
11 Yrs Cent. Asia
12 Yrs Africa

Central Asia and Africa fall farther behind

"Digital Divide" mostly remained

GÉANT2 - now being implemented

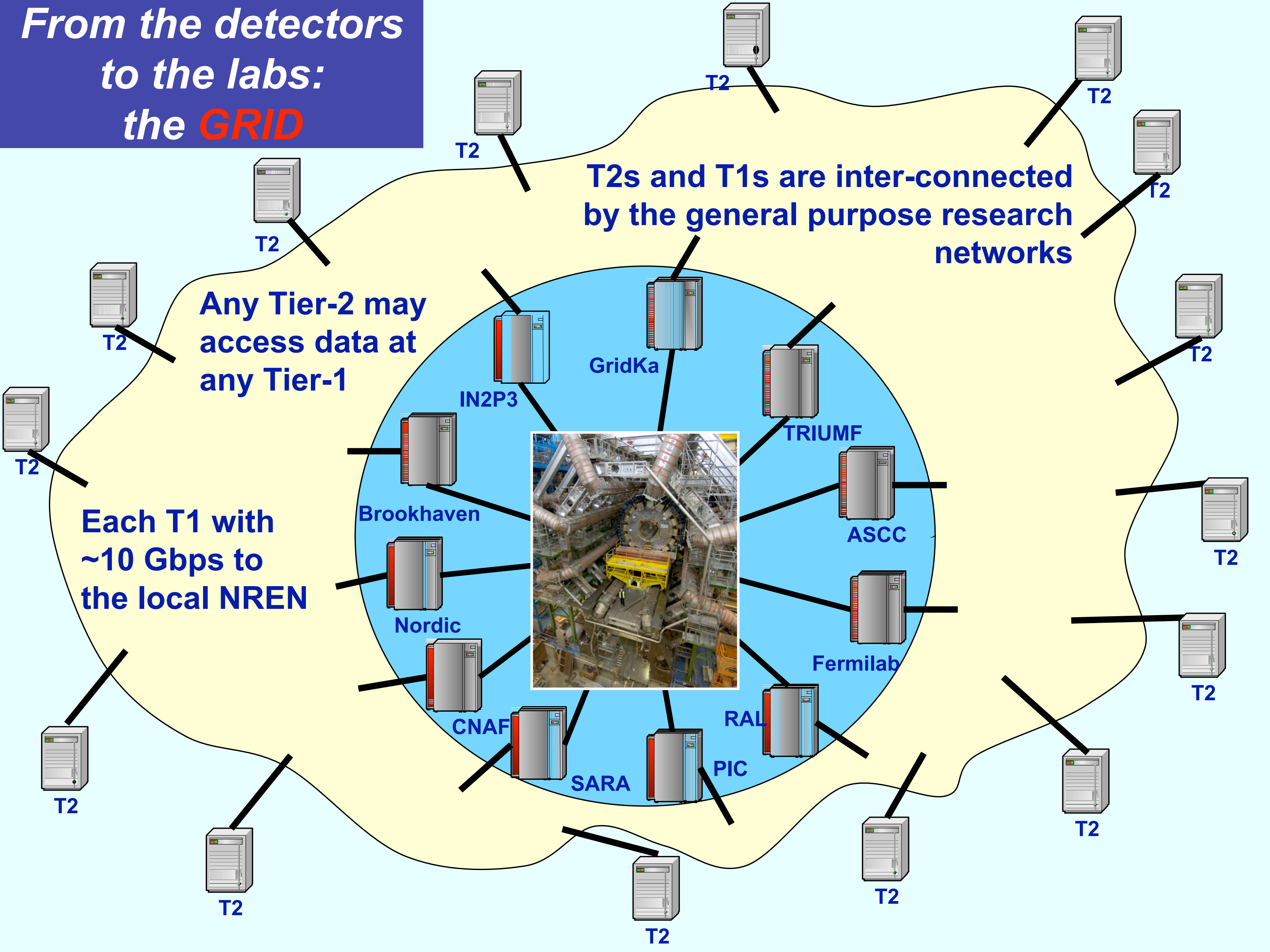


Multi-Wavelength Core + 0.6-10G Loops

Dark Fiber Connections
<u>Among 16 Countries:</u>

- Austria
- Belgium
- Bosnia-Herzegovina
- Czech Republic
- Denmark
- France
- Germany
- Hungary
- Ireland
- Italy,
- Netherland
- Slovakia
- Slovenia
- Spain
- Switzerland
- United Kingdom

From the detectors to the labs: the GRID

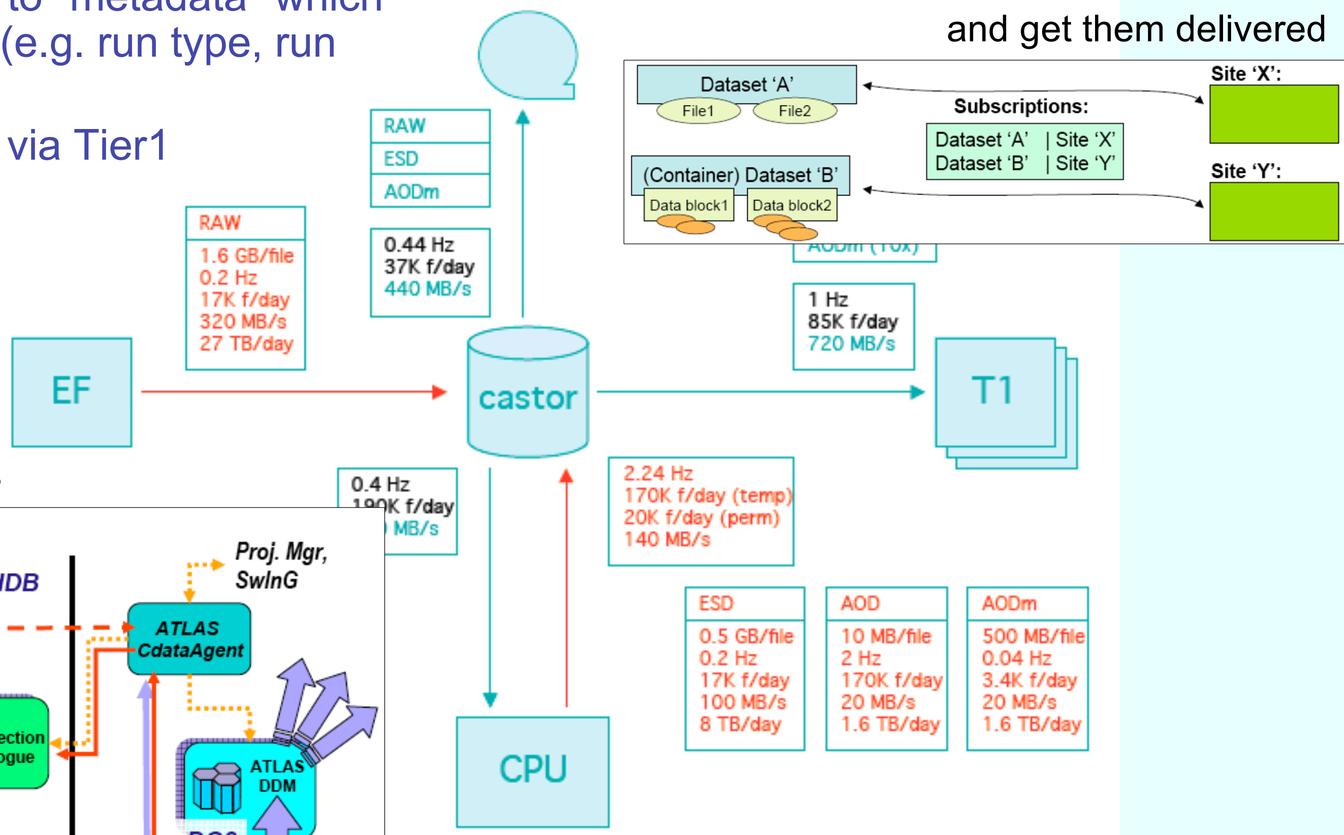


The "first mile" and further

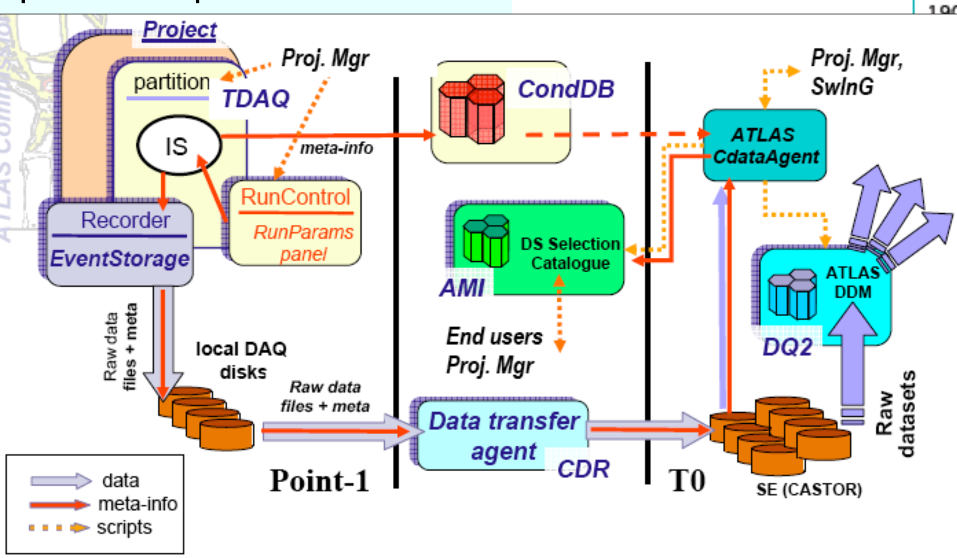
Data from the detector site (Point1)

- are copied to the CERN computing centre (Tier0)
- are recorded on permanent storage at Tier0
- are catalogued according to "metadata" which accompany with the data (e.g. run type, run number...)
- are distributed to the labs via Tier1 and Tier2 centres

labs subscribe to the data and get them delivered



present implementation at ATLAS



Brief overview of Offline Software, Databases, Monitoring

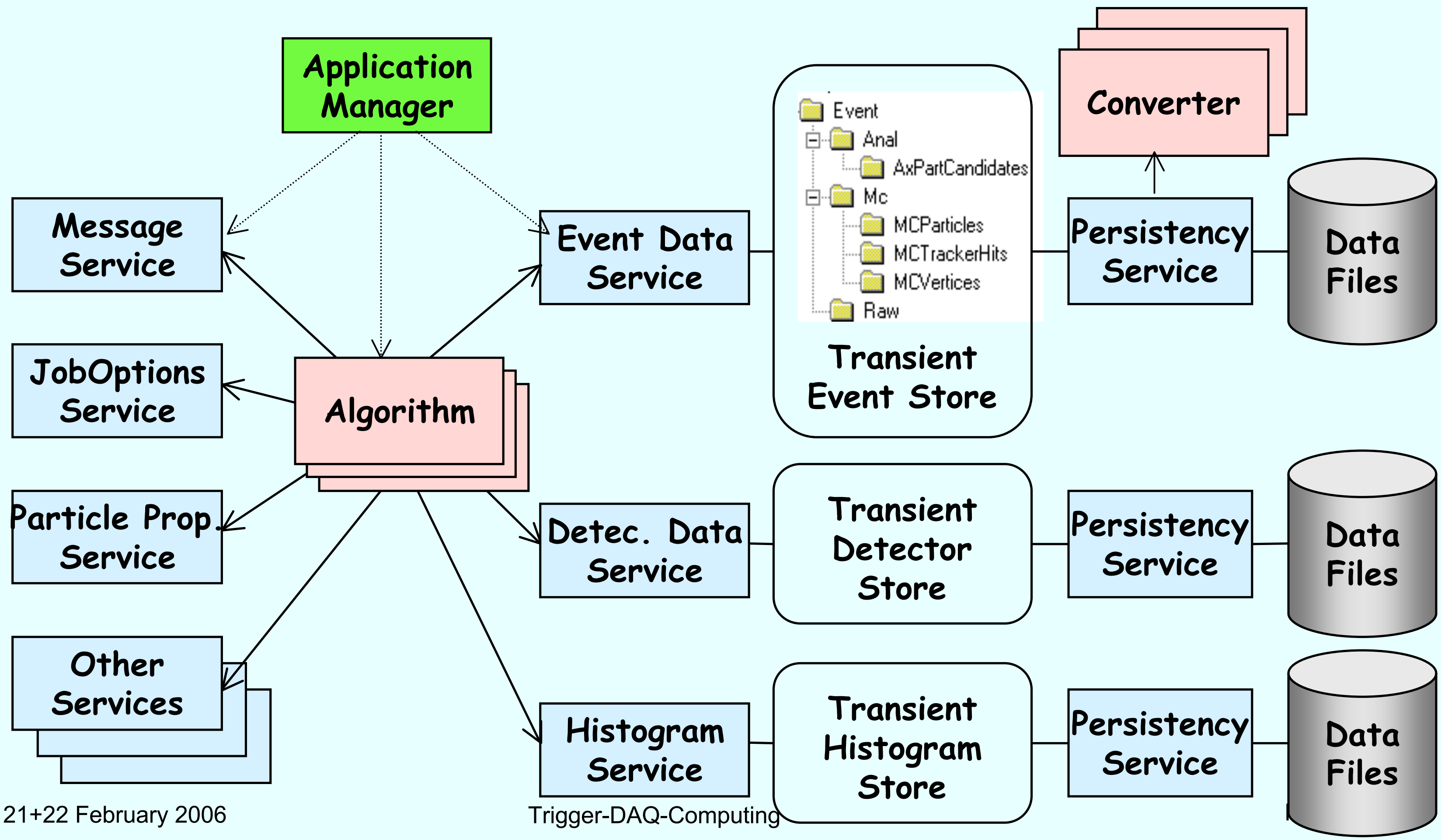
(using ATLAS as example)

ATLAS offline software system: Athena

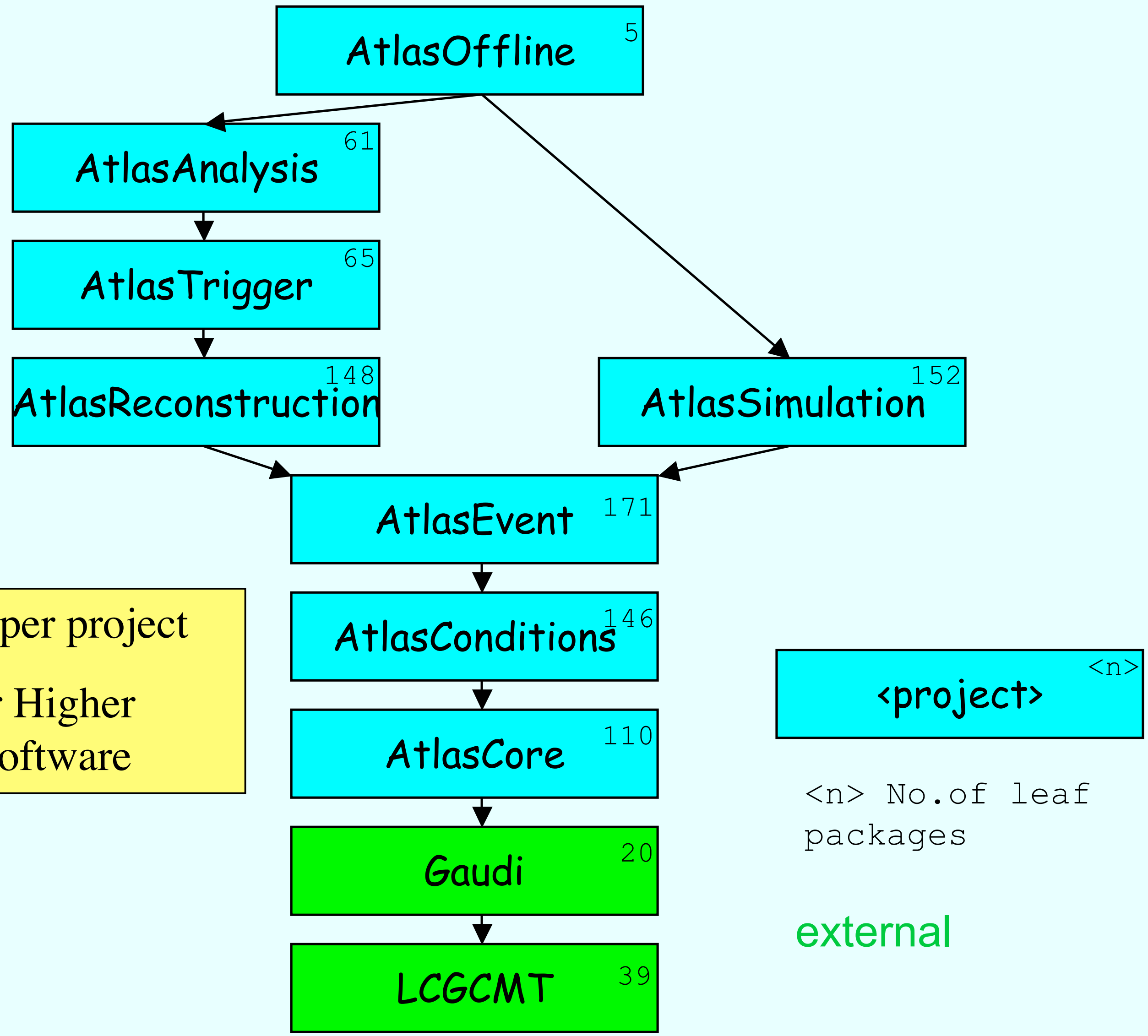
- Organized in software packages (~1000)
  - written by ATLAS, plus many external packages e.g. by LCG
  - each package contains
    - algorithm code (C++, some Java, some Fortran wrapped in C++)
    - configuration code (“job options”, Python)
    - interactive analysis making more extensive use of Python
    - scripts for building and setting up (CMT requirements, shell scripts)
- Grouped into “projects” (7 by now)
  - from Core to Analysis, unidirectional dependency
- Documentation based on Twiki
  - https://uimon.cern.ch/twiki/bin/view/Atlas/WorkBook

Athena overview

- Athena is largely based on the Gaudi framework developed in LHCb
- Athena has many extensions, e.g. changed blackboard mechanism for transient stores
- Gaudi architecture document: http://lhcb-comp.web.cern.ch/lhcb-comp/Frameworks/Gaudi/Gaudi_v9/GUG/GUG.pdf



Athena packages grouped in “projects”



Individual **release cycles** per project

Plus the release cycles for Higher Level Trigger and DAQ software

Access to Athena sources etc.

- All stored in CVS
- Browsing can start here: http://atlas-sw.cern.ch/cgi-bin/viewcvs-atlas.cgi/offline/

- Configutation management tool [cmt](#) used on top of CVS

- [pacman](#) used to distribute and install the software

CVS Tags: **MonRun-00-00-03, HEAD**
Changes since **1.1: +34 -31 lines**

```
Full jobOptions for Event Filter Monitoring used in 2004
```

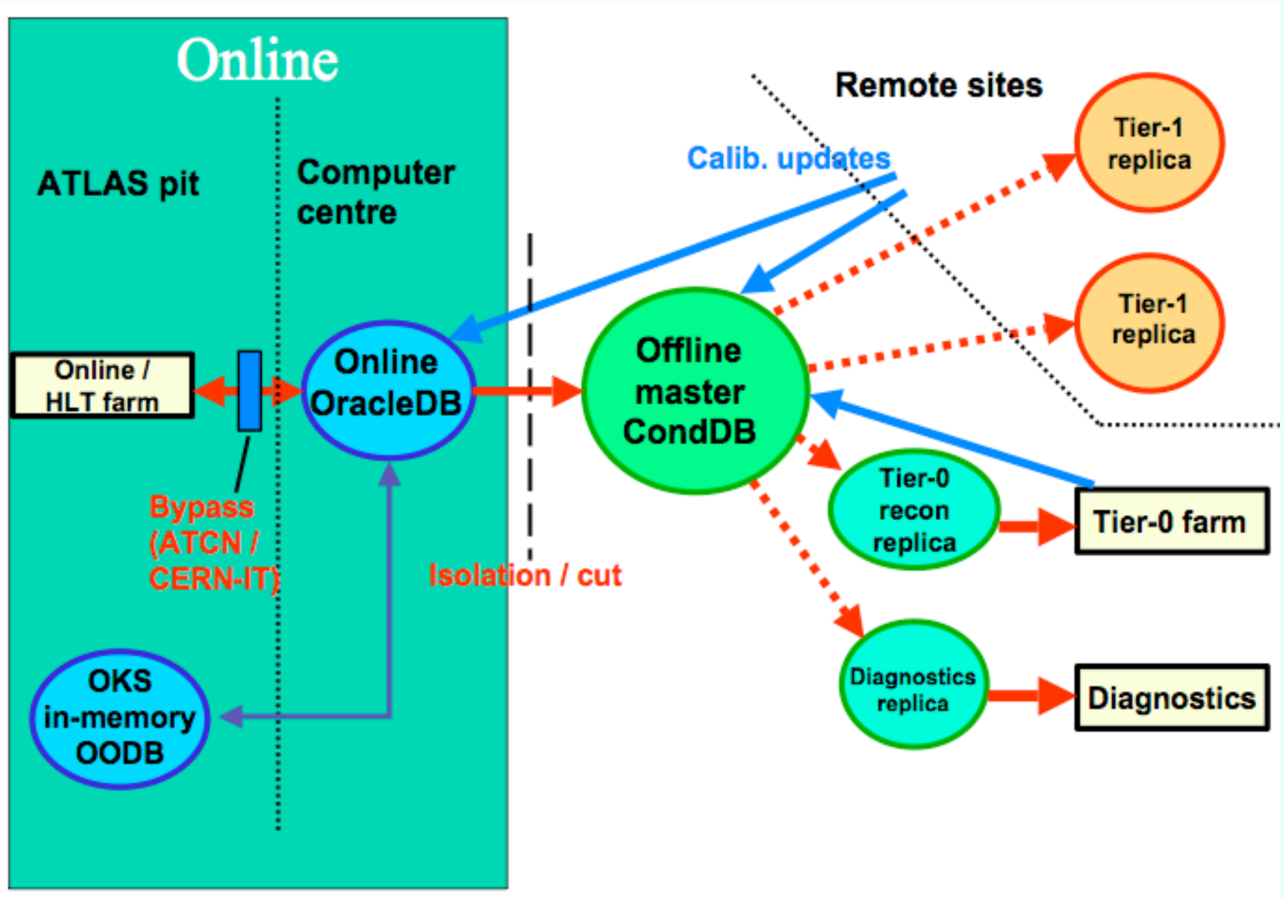
```
DetDescrCnvSvc.DetectorManagers+= ["CaloTTDescrManager"]
DetDescrCnvSvc.DetectorManagers+= ["CaloTTDescrManager"]
DetDescrCnvSvc.DetectorManagers += [ "CaloMgr" ]

LArCondCnvDbServer = 'atlobk01.cern.ch'
#---- LAr BS Reading & Reconstruction
#theApp.TopAlg += ["FakeLArOFCs"]
#include("LArTBRec/LArTBRec_H8_Simple_jobOptions.py")
include("LArTBRec/LArTBRec_H8_HalfSimple_jobOptions.py")
#include("LArTBRec/LArTBRec_H8_TimeCheck_jobOptions.py")
#include("LArTBRec/LArTBRec_H8_jobOptions.py")
#LArRawChannelSimpleBuilder.RecoMode     = "CUBIC"
#LArRawChannelSimpleBuilder.OutputLevel=DEBUG
#LArRawChannelBuilder.OutputLevel=DEBUG
theApp.DLLs+=["LArTools"]
include( "LArDetMgrDetDescrCnv/LArDetMgrDetDescrCnv_H8_jol

# TileCal reconstruction
# the fastest Flat Filter method selected
doTileFlat = True
doTileFit = False
doTileOpt = False

# init DetDescr and load conditions data
include( "TileTBRec/TileTBConditions_jobOptions.py" )
```

Relational databases used

Databases usage

Online: for configuration and to store conditions (including the actual configuration)

Offline: for retrieval / update of conditions and to prepare future configurations



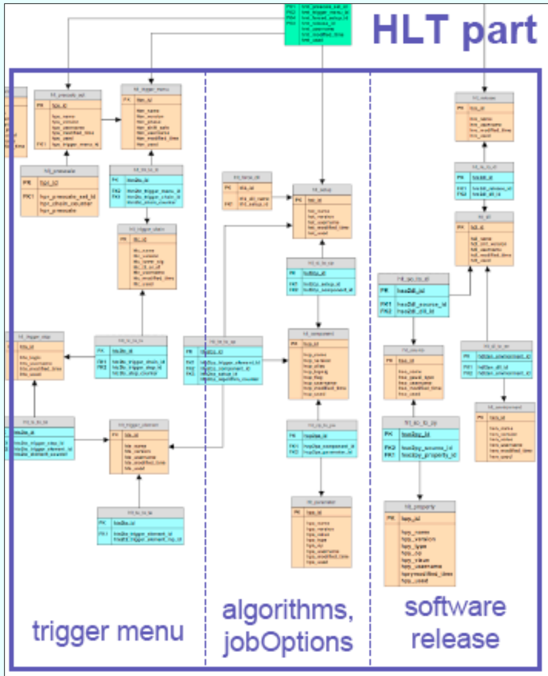
Conditions database (COOL):

Contents addressed by Run/Event number or by time (Interval of Validity mechanism)

Based on Oracle or MySQL RDBs with CORAL as interface layer

Data may be external to COOL: useful for large objects, files, additional relational tables

Example: trigger configuration



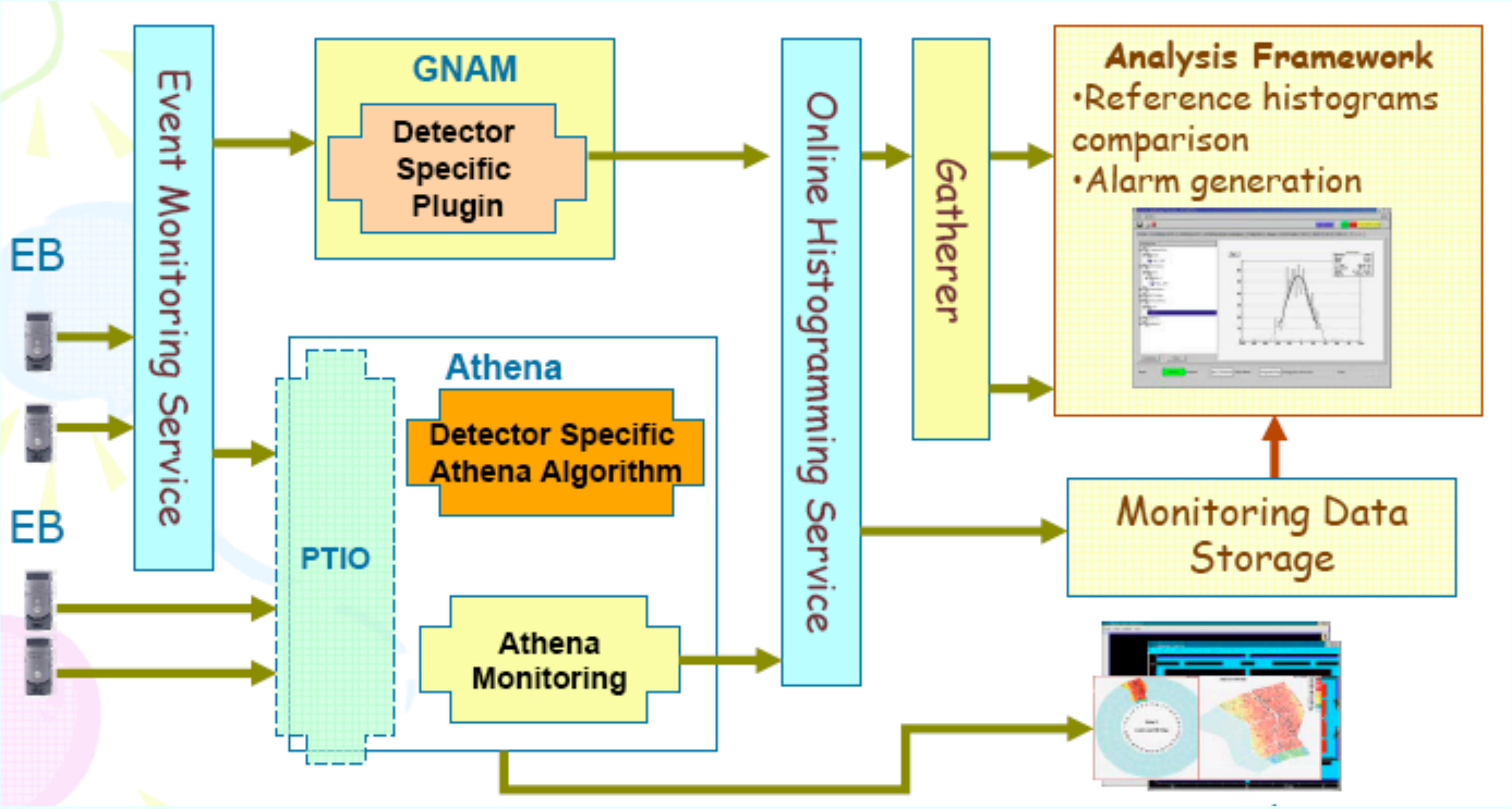
Online monitoring using Athena

Monitoring framework - Athena plugged into Online with PTIO

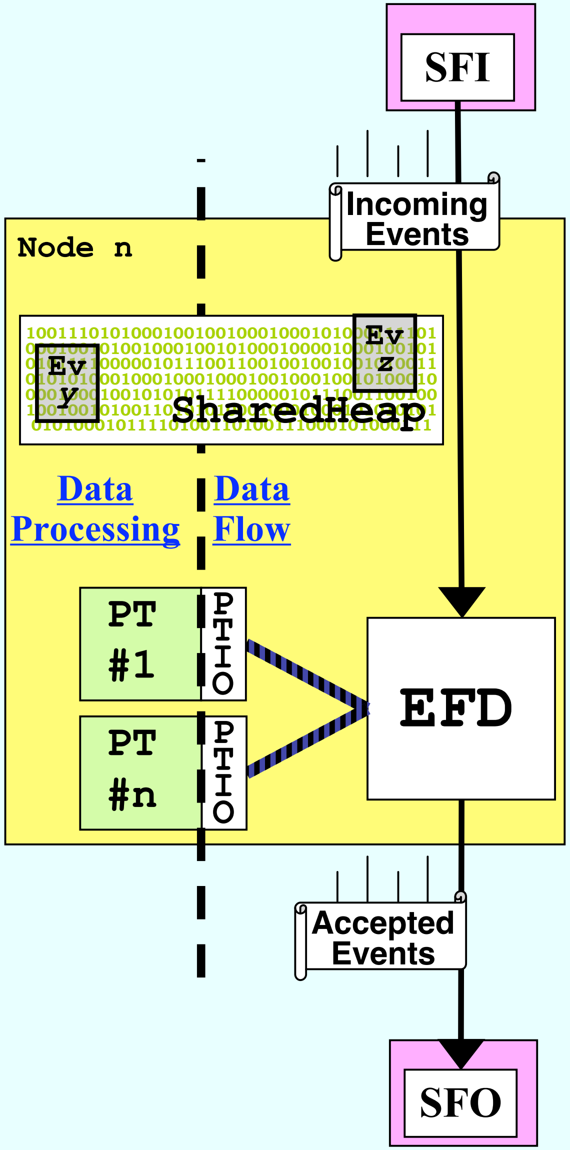
Online histograms generated with **Athena**, or with lightweight online histogrammer (GNAM**)**

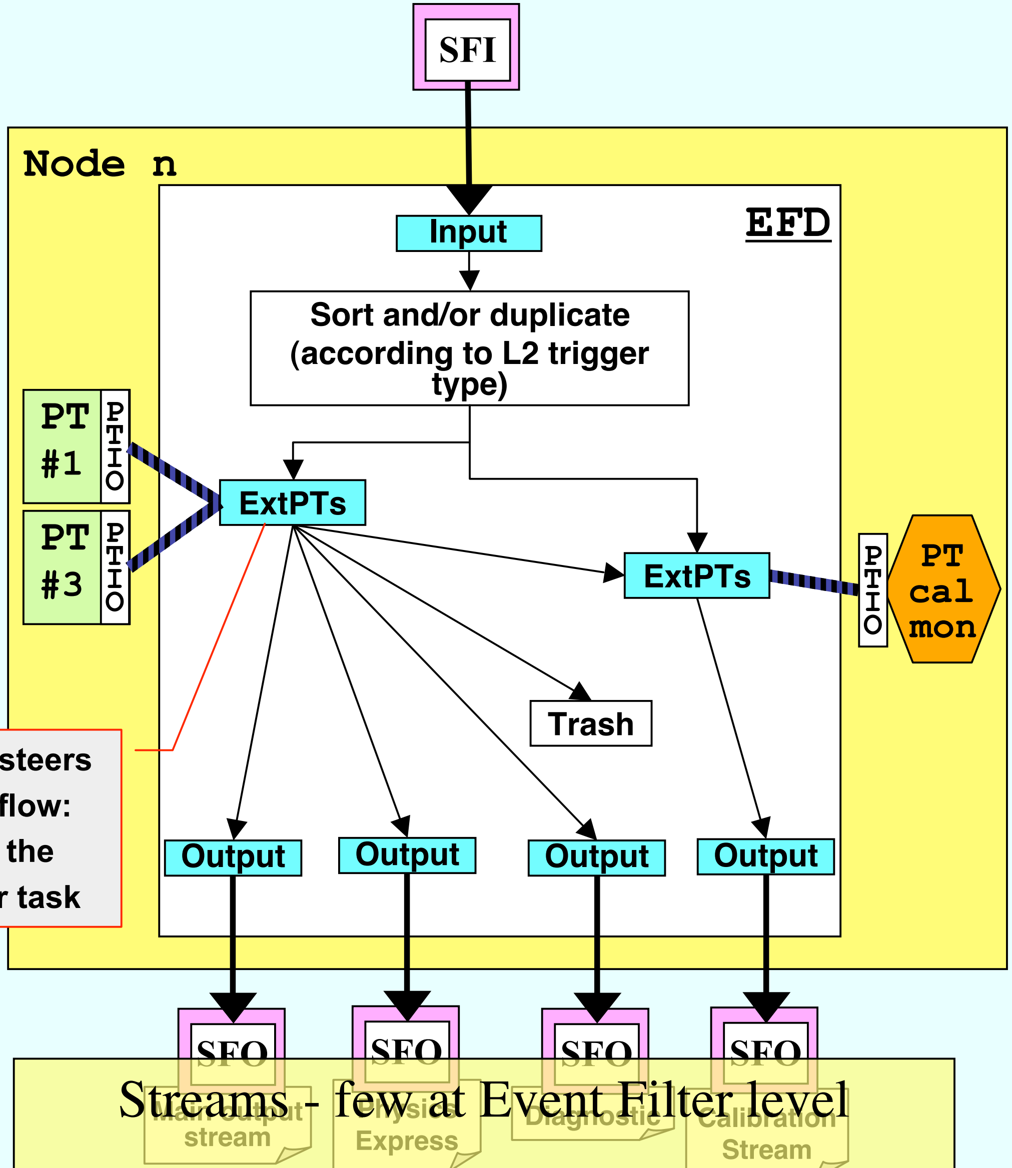
Presenter is **ROOT** based

Online event diaplays, 2D + 3D with **Athena**



Filtering, Calibration, Monitoring in the Event Filter



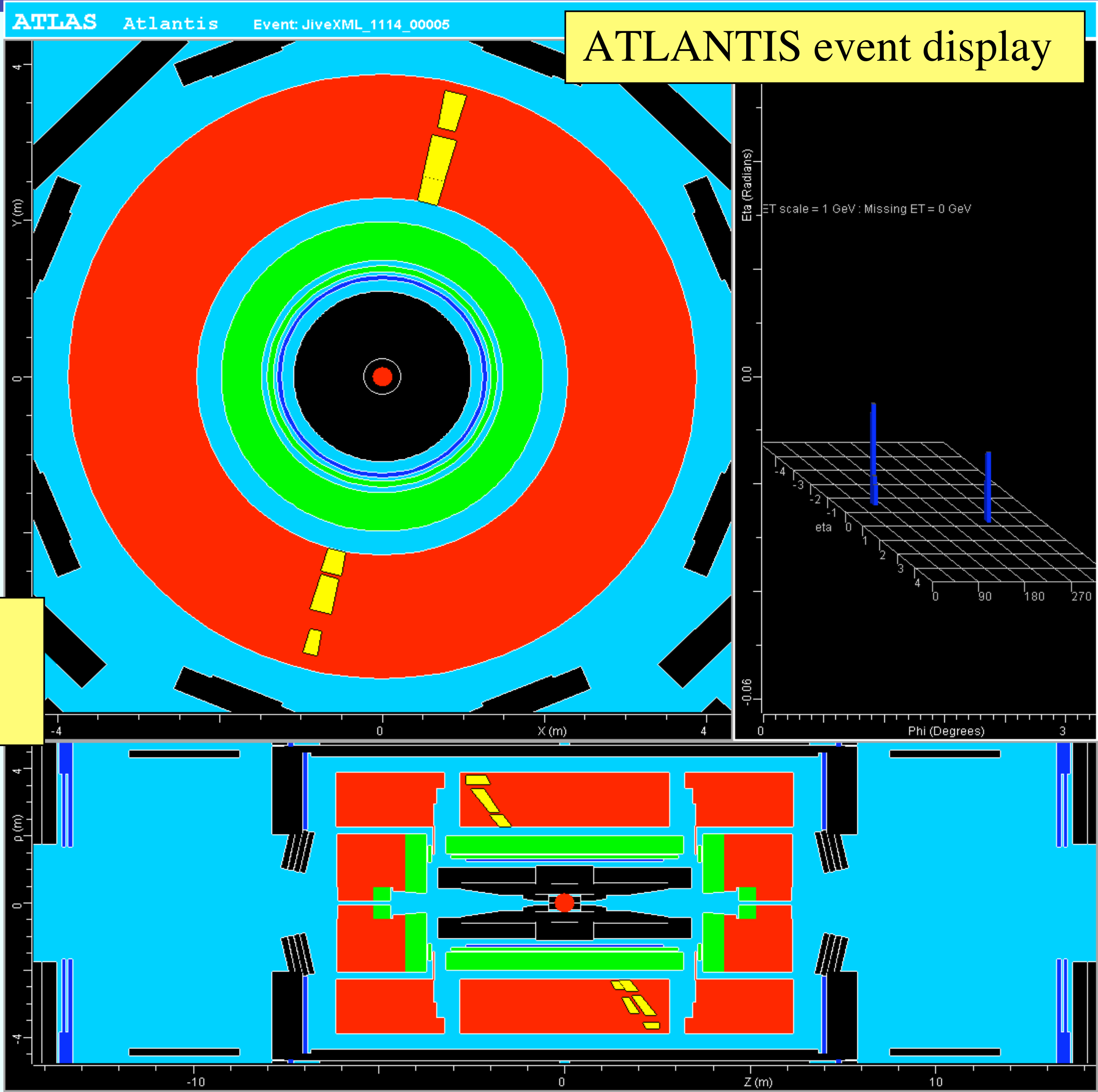


PT answer steers EFD dataflow: chooses the successor task

Streams - few at Event Filter level

More at full reconstruction level (Tier0)

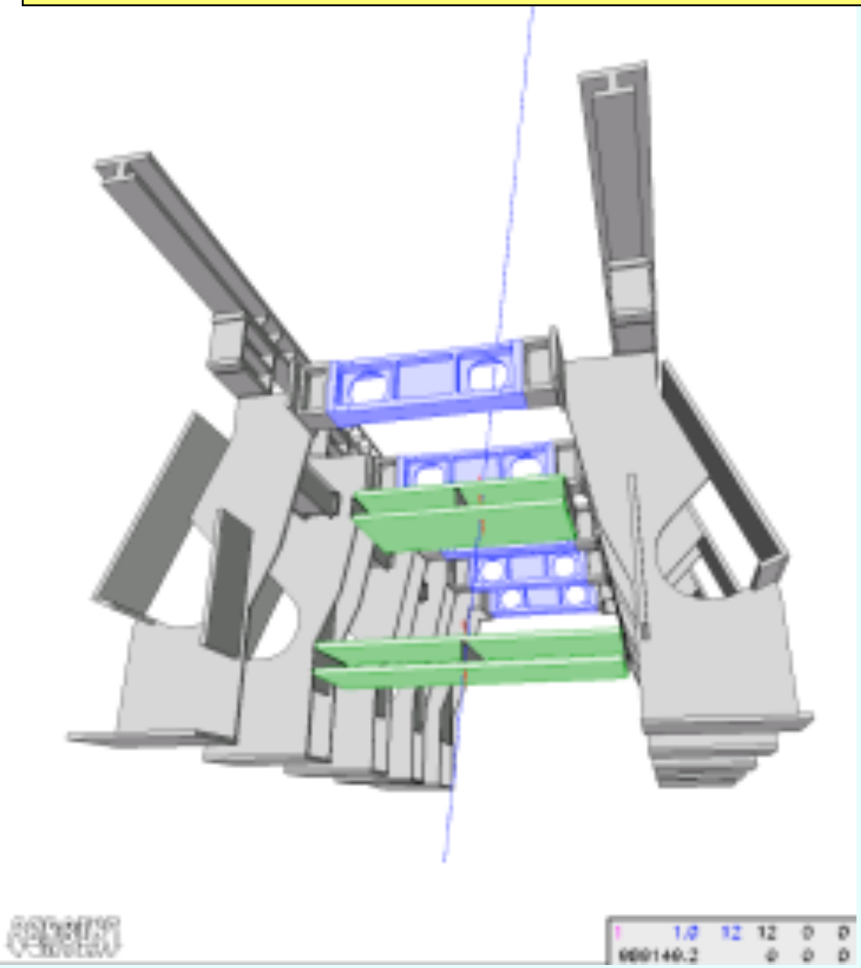
Event displays - several, used online and offline



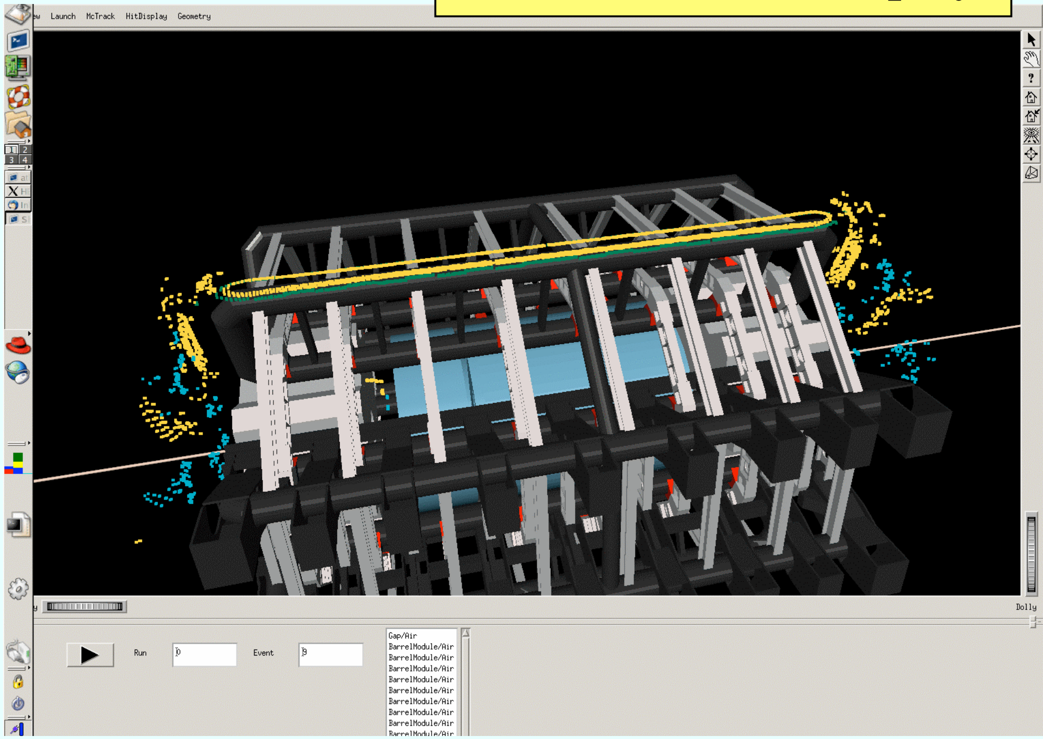
First cosmic from the Pit - Tiles (June 05)

3D event displays (online + offline)

First cosmic from part of the Muon spectrometer (December 05)

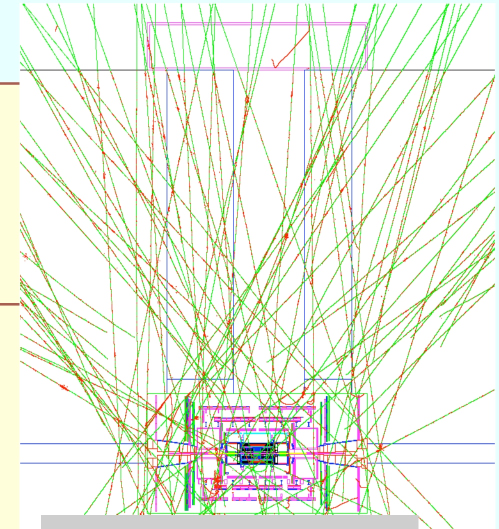


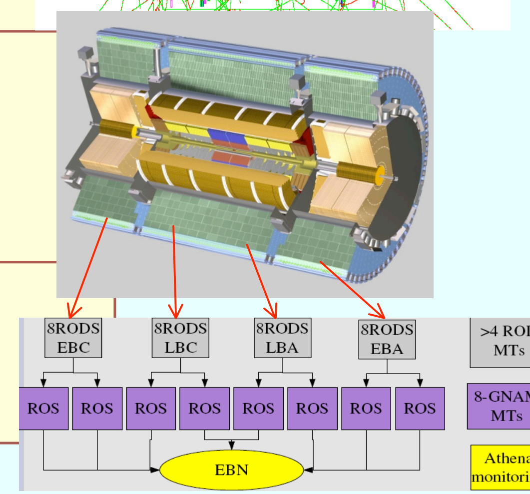
V-ATLAS event display



Detector commissioning

Phase 1 Standalone detector installation	Testing of electronics, DAQ, DCS, gas, power supplies	Summer 2005 to Summer 2006
Phase 2 Integrate systems into full ATLAS detector	Multi-detector DAQ, DCS, DB Calibration runs	Autumn 2005 to Autumn 2006
Phase 3 Cosmics with single and multiple detectors	Record / analyze data Ship data to remote sites	Autumn 2005 to Autumn 2007
Phase 4 Single beam, first collisions, full ATLAS	Minimum bias High rates	From Autumn 2007





LHC plans and status of software

LHC planning

Stage 1
Initial commissioning
43x43 to 156x156, N=3x10^{10}
Zero to partial squeeze

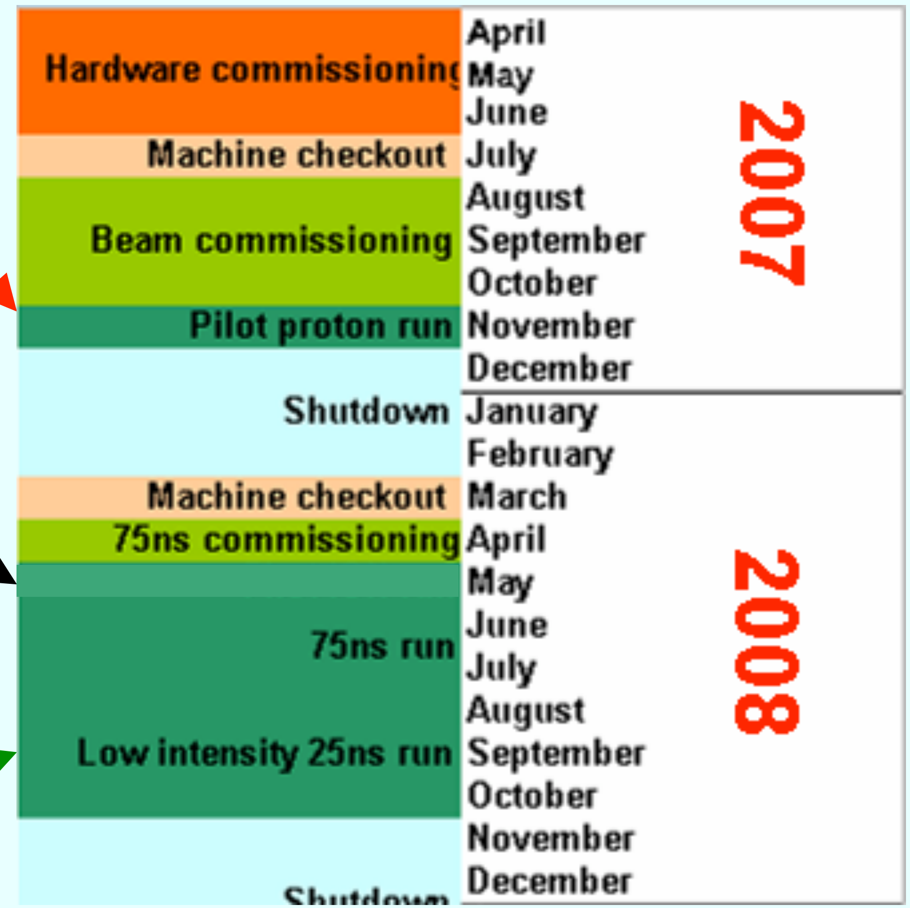
L=3x10^{28} - 2x10^{31}

Stage 2
75 ns operation
936x936, N=3-4x10^{10}
partial squeeze

L=10^{32} - 4x10^{32}

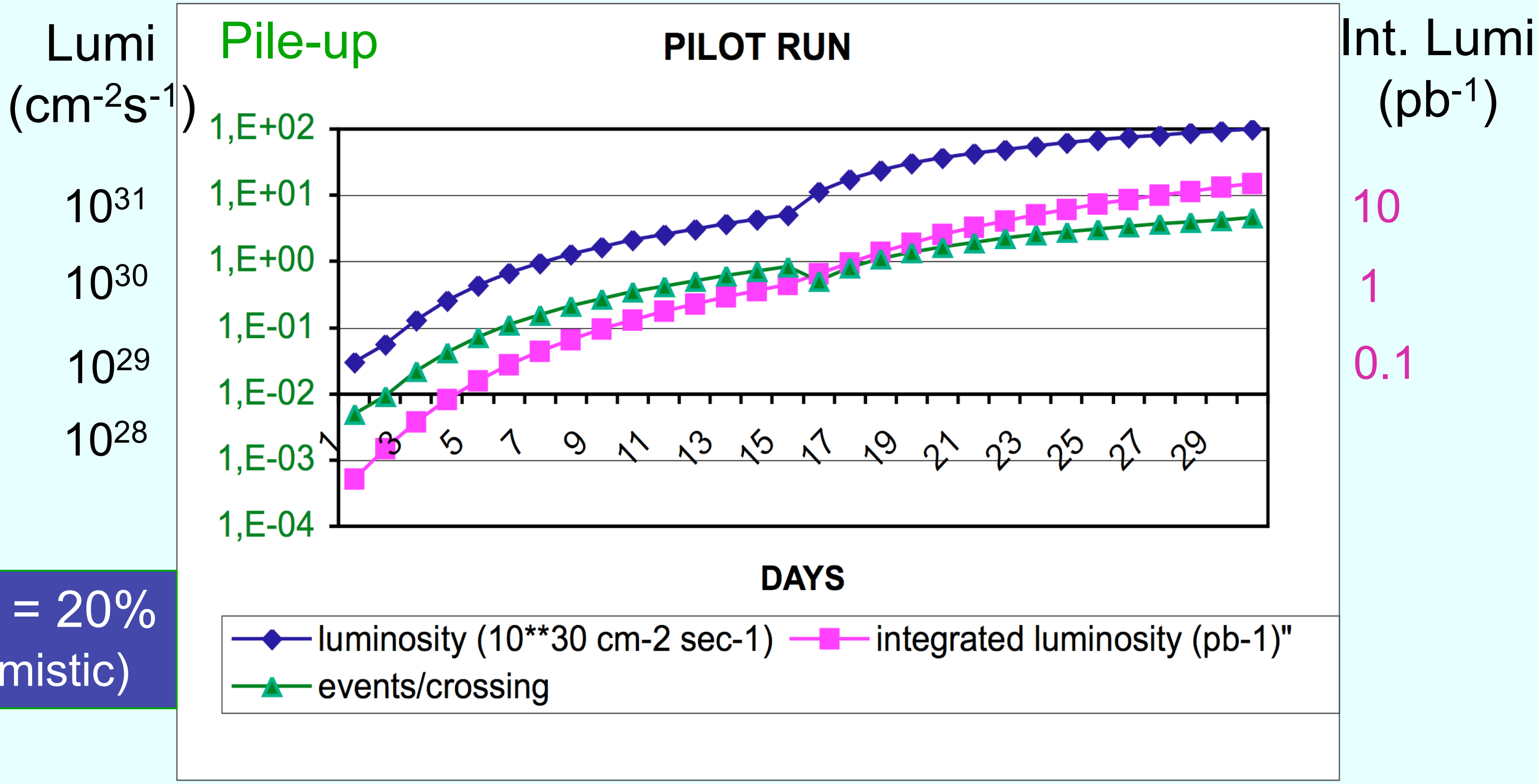
Stage 3
25 ns operation
2808x2808, N=3-5x10^{10}
partial to near full squeeze

L=7x10^{32} - 2x10^{33}



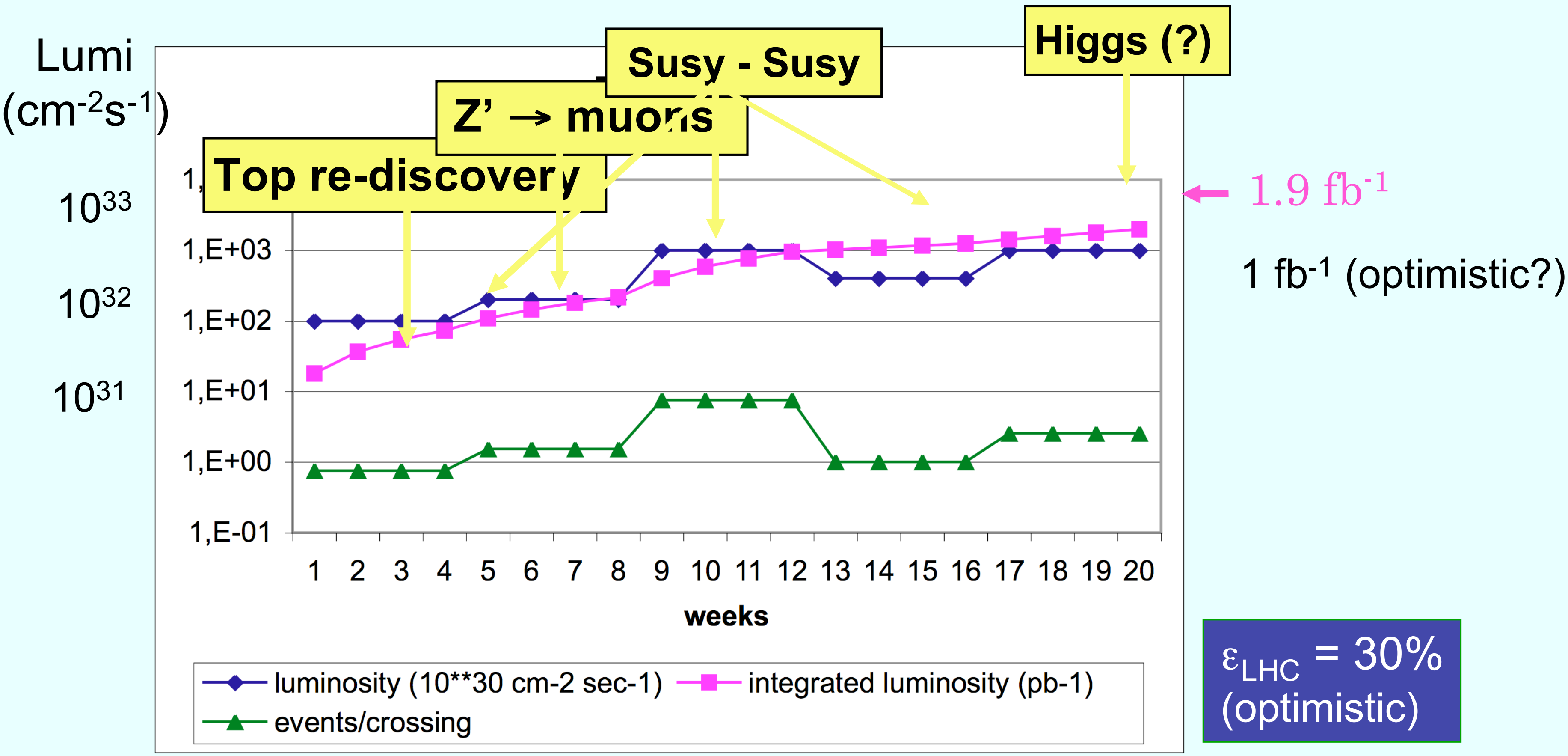
Pilot Run: Luminosity

– 30 days; maybe less; 43*43 bunches, then 156*156 bunches



ε_{LHC} = 20% (optimistic)

Integrated luminosity with the current LHC plans



ε_{LHC} = 30% (optimistic)

Startup plan

Physics rush:

- ALICE: minimum-bias proton-proton interactions
  - Standard candle for the heavy-ion runs
- LHCb: B_S mixing, sin2β repeat
  - If the Tevatron has not done it already
- ATLAS + CMS: measure jet production
  in 15 pb^{-1} will have 30K W's and 4K Zs into leptons
  - Measure cross sections and W and Z charge asymmetry
    - Luminosity?

Startup plans: Software needed

- Turn-on is fast
  - Pile-up increasing rapidly
  - Timing (43x43 to 75ns to 25 ns) evolution
  - Lots of physics
- For all detectors:
  - Commission detector and readout
  - Commission trigger systems
  - Calibrate/align detector(s)
  - Commission computing and software systems
  - Rediscover the Standard Model

- Simulation
- Reconstruction
- Trigger
- Monitoring
- Calibration/Alignment
  - calculation
  - application
- User-level data objects
  - selection
- Analysis
- Documentation

Need it all !

Frameworks

ALICE: AliROOT; ATLAS+LHCb: Athena/Gaudi

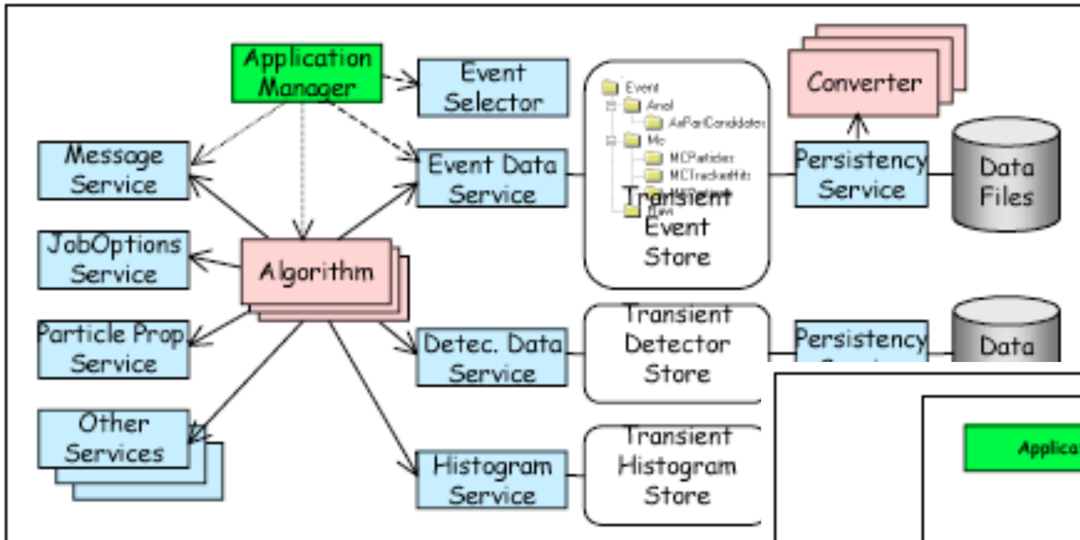


Figure 2.1 Gaudi Architecture Object Diagram

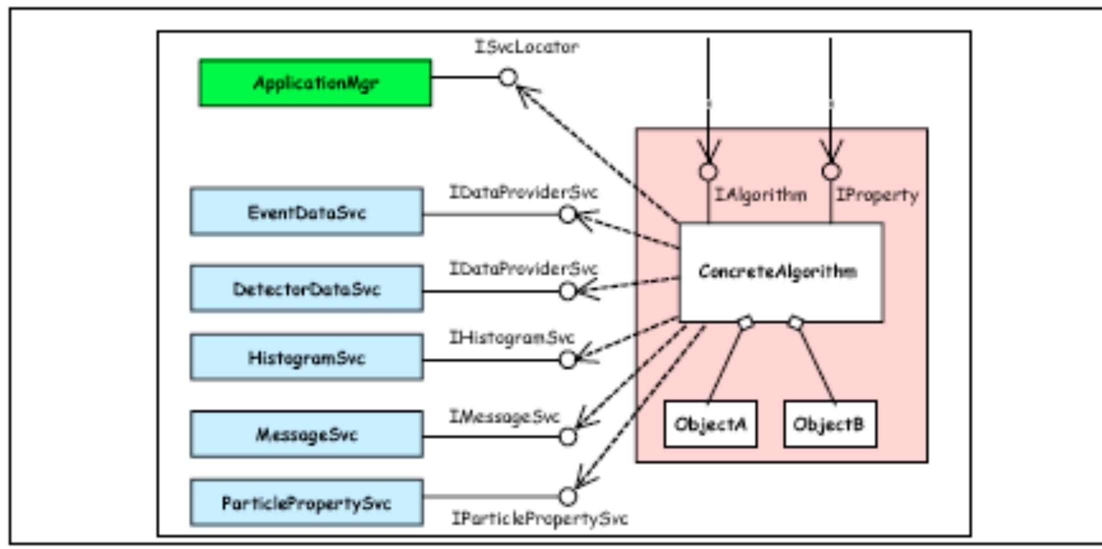
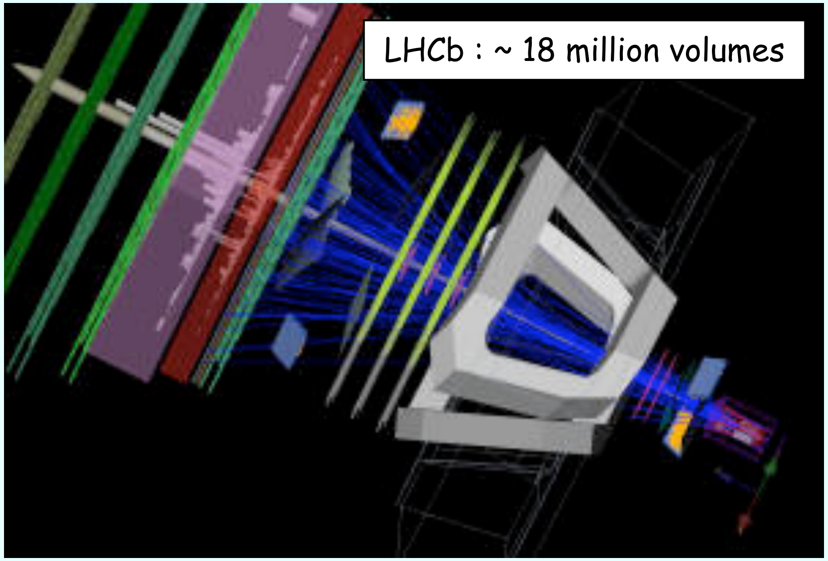


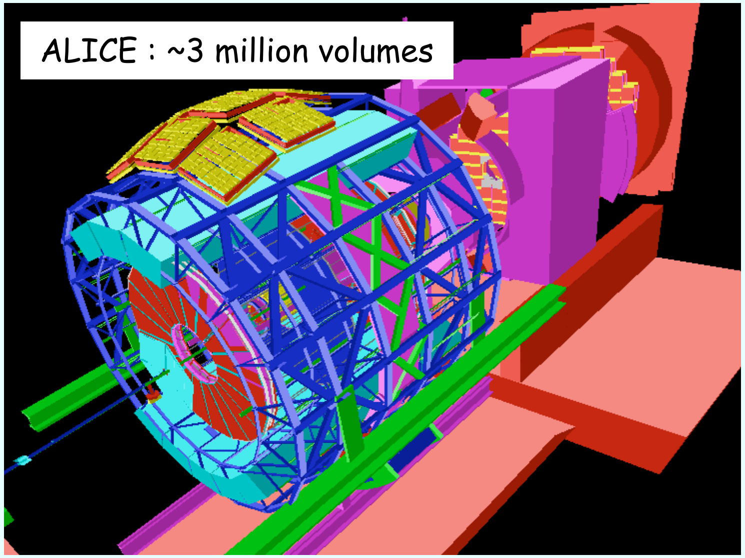
Figure 2.2 The main components of the framework as seen by an algorithm object

CMS: moved to a new framework; in progress

Simulation

- Geant4: deployed by all experiments
  - Functionality essentially complete. Detailed physics studies performed by all experiments
    - reliable in production (better than 1:10^4)
  - Good collaboration between experiments and Geant4 team
  - Lots of feedback on physics (e.g. from testbeams)





Fast simulation

- Different levels of “fast” simulation at the four experiments
  - CMS extreme: swimming particles through detector; include material effects, radiation, etc. Imitate full simulation – but much faster (1Hz).
  - ATLAS: particle-level smearing. VERY fast (kHz)
  - LHCb: generator output directly accessible by the physics application programs
- But: ongoing work in bridging the gap
  - For example, in shower-parametrization in the G4 full simulation (ATLAS)
- Common goal of all: output data at AOD level

Reconstruction, trigger, monitoring

- General feature: all based on corresponding framework (AliRoot, Athena, Gaudi, CMSSW)
  - Multi-threading is necessary for online environment
  - Most Algorithms & Tools are common with offline
- Two big versions
  - Full reconstruction
  - “seeded”, or “partial”, or “reconstruction inside a region of interest”
    - This one used in HLT
- Online monitoring and event displays
  - “Spying” on Trigger/DAQ data online
    - But also later in express analysis
- Online calibrations

A huge challenge; large rejection factor

Lvl-1 (HW)

HLT (SW)

	ATLAS/CMS	LHCb	ALICE
interaction rate	10^9 Hz	10^7 Hz	10^4 Hz
HLT input	100 kHz	1 MHz	1 kHz
HLT accept	100-200 Hz	200 Hz	~50 Hz

In practice: startup will use smaller rates

- CMS example: 12.5 kHz (pilot run) and 50 kHz (10^{33} cm^{-2}s^{-1})
- Real startup conditions (beam, backgrounds, expt) unknown
  - Startup trigger tables: in progress
  - ATLAS/CMS have prototypes
  - Real values: when beam comes

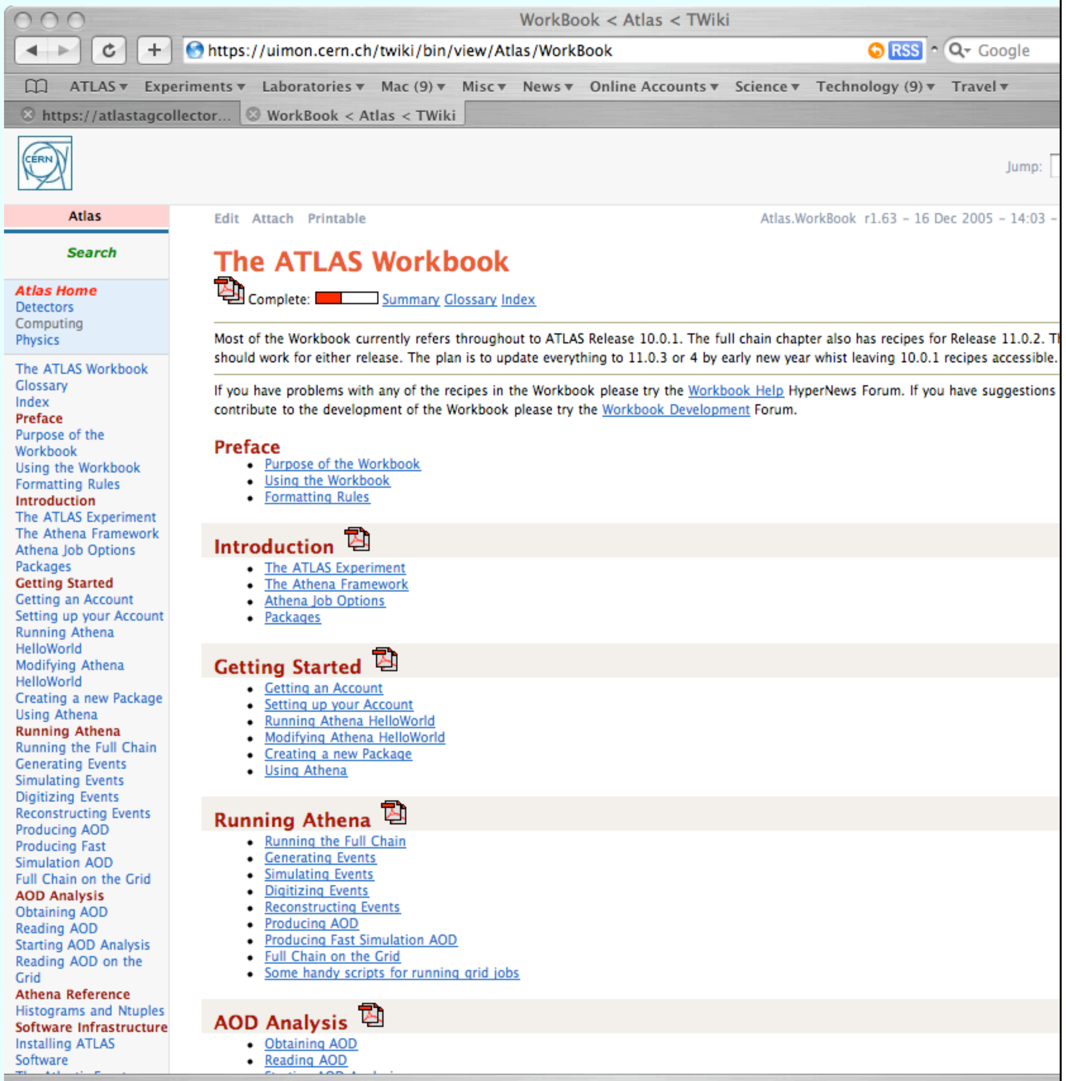
Calibration and alignment

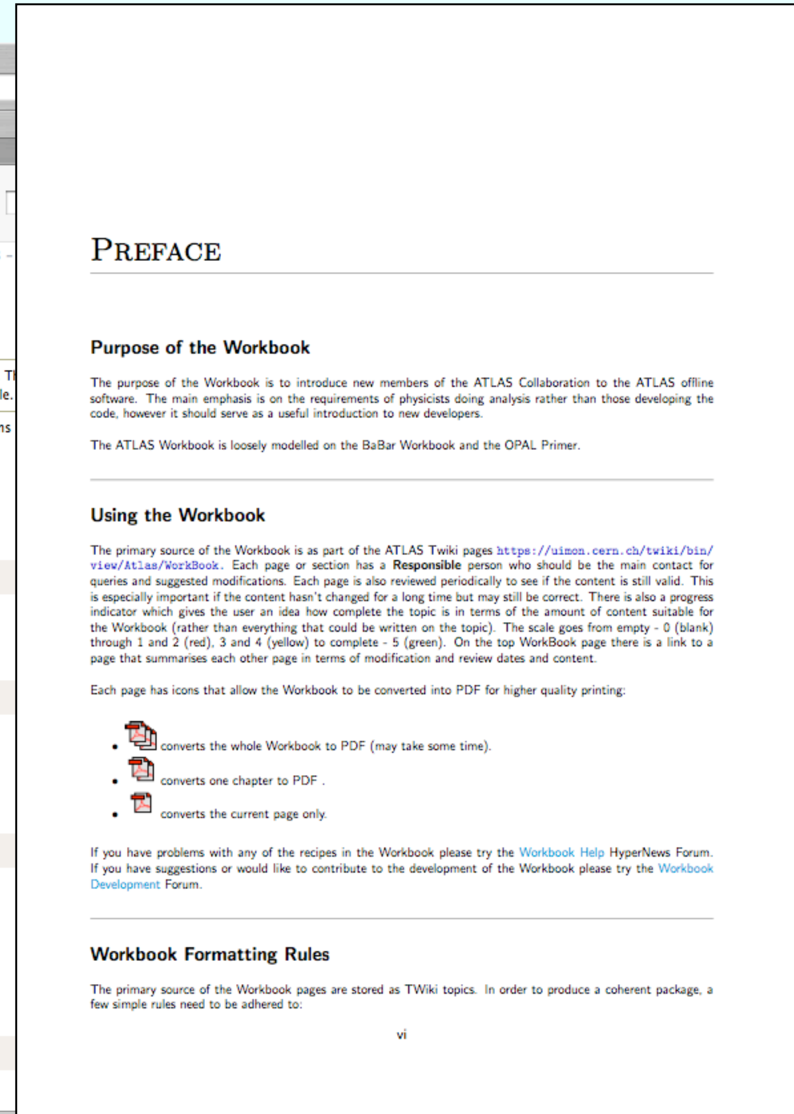
- Key part of commissioning activities
  - Dedicated calibration streams part of HLT output (e.g. calibration stream in ATLAS, express-line in CMS; different names/groupings, same content)
- What needs to be put in place
  - Calibration procedure; what, in which order, when, how
  - Calibration “closed loop” (reconstruct, calibrate, re-reconstruct, re-calibrate…)
    - Conditions data reading / writing / iteration
    - Reconstruction using conditions database
- What is happening
  - Procedures defined in many cases; still not “final” but understanding improving
  - Exercising conditions database access and distribution infrastructure
    - With COOL conditions database, realistic data volumes and routine use in reconstruction
    - In a distributed environment, with true distributed conditions DB infrastructure

Documentation

ATLAS Workbook (Twiki)

https://uimon.cern.ch/twiki/bin/view/Atlas/WorkBook





PREFACE

Purpose of the Workbook

The purpose of the Workbook is to introduce new members of the ATLAS Collaboration to the ATLAS offline software. The main emphasis is on the requirements of physicists doing analysis rather than those developing the code, however it should serve as a useful introduction to new developers.

The ATLAS Workbook is loosely modelled on the BaBar Workbook and the OPAL Primer.

Using the Workbook

The primary source of the Workbook is as part of the ATLAS Twiki pages `https://uimon.cern.ch/twiki/bin/view/Atlas/WorkBook`. Each page or section has a **Responsible** person who should be the main contact for queries and suggested modifications. Each page is also reviewed periodically to see if the content is still valid. This is especially important if the content hasn't changed for a long time but may still be correct. There is also a progress indicator which gives the user an idea how complete the topic is in terms of the amount of content suitable for the Workbook (rather than everything that could be written on the topic). The scale goes from empty - 0 (blank) through 1 and 2 (red), 3 and 4 (yellow) to complete - 5 (green). On the top WorkBook page there is a link to a page that summarises each other page in terms of modification and review dates and content.

Each page has icons that allow the Workbook to be converted into PDF for higher quality printing:

- converts the whole Workbook to PDF (may take some time).
- converts one chapter to PDF .
- converts the current page only.

If you have problems with any of the recipes in the Workbook please try the Workbook Help HyperNews Forum. If you have suggestions or would like to contribute to the development of the Workbook please try the Workbook Development Forum.

Workbook Formatting Rules

The primary source of the Workbook pages are stored as TWiki topics. In order to produce a coherent package, a few simple rules need to be adhered to:

vi

Analysis

- Common understanding: early analysis will use Event Summary Data ESD as input
  - ESD(ATLAS/CMS) ~(0.25-0.5) MB; ALICE/LHCb ~0.04 MB
  - The reconstructed quantities; frequent reference to RAW data
    - At least until basic understanding of detector, its response and the software will be in place
- Later, use Analysis Object Data AOD
  - Reduction of factor ~5 wrt ESD format
  - Crucial: definition of AOD (what’s in it); functionality
  - Prototypes exist in most cases
    - Sizes and functionality not up to specification yet
- Is there a need for a TAG format (1kB summary)
  - ATLAS has one, in a database; CMS not

Analysis flow: example

At Tier 0/ Tier1

At Tier 1/ Tier2

At Tier 2

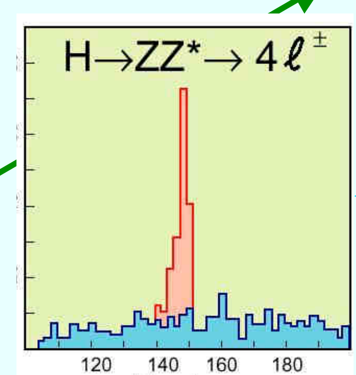
ESD → Datasets → AOD → pre → AOD, Cand → pre → Cand, User Data

AOD → pre → AOD, Cand → pre → Cand, User Data

Signal dataset

Background dataset(s)

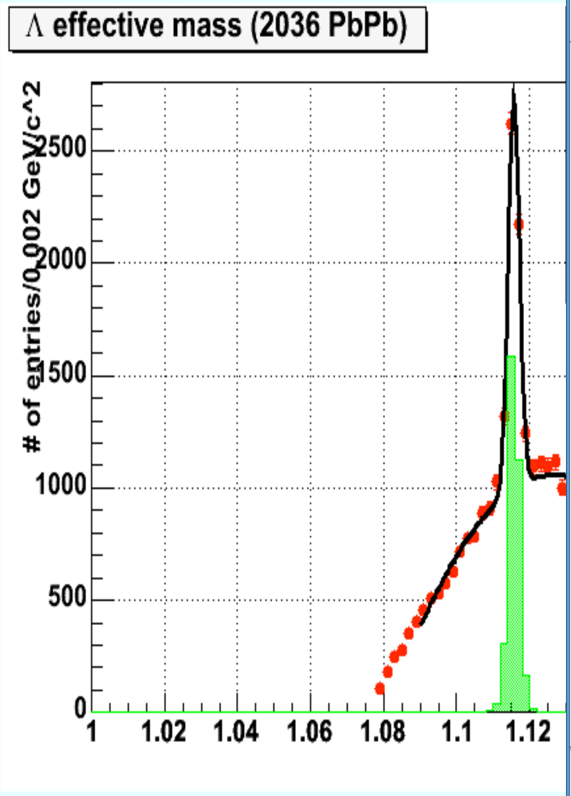
Example numbers: 500 GB, 50 GB

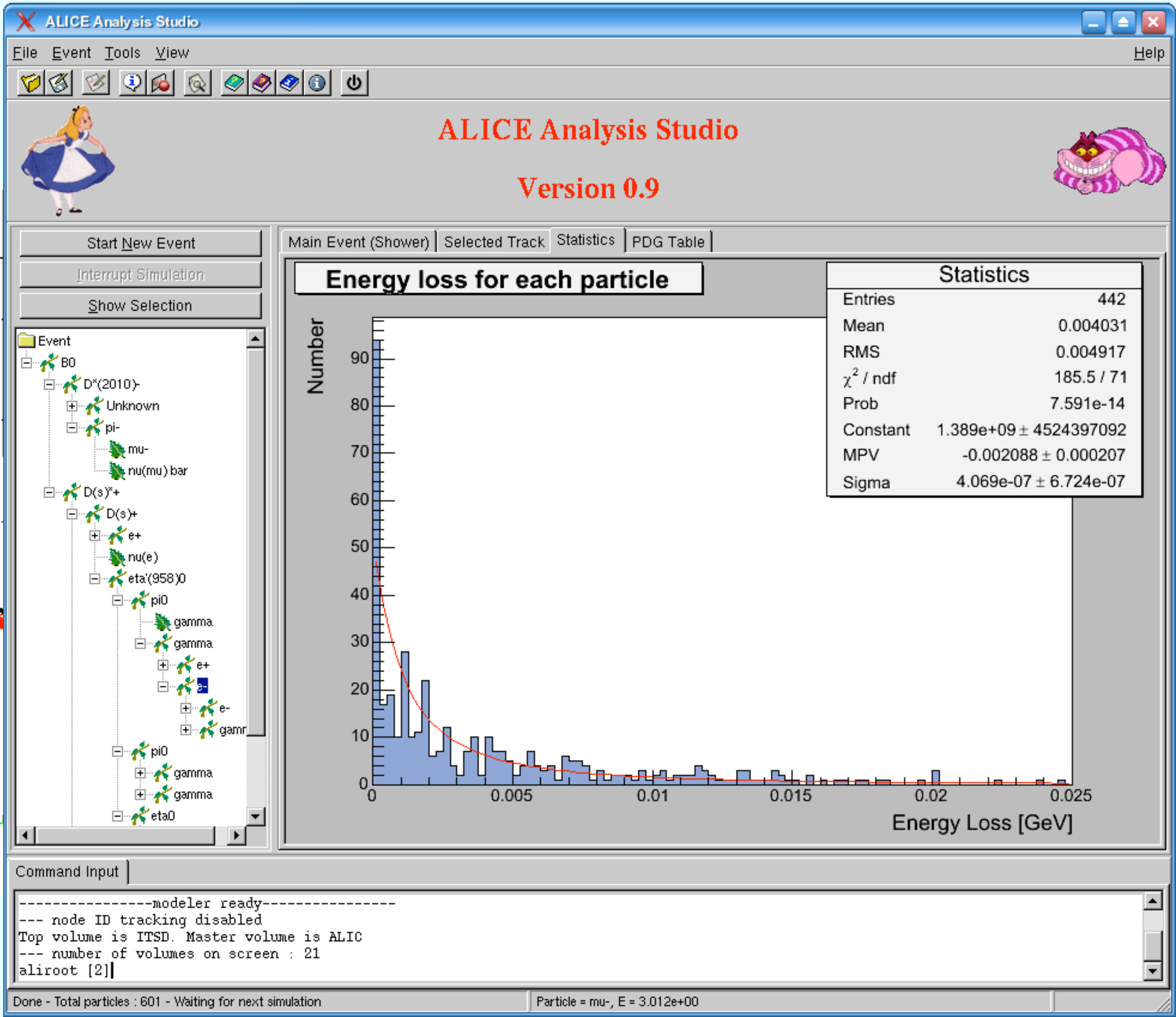


Laptop ?

Analysis à la ALICE

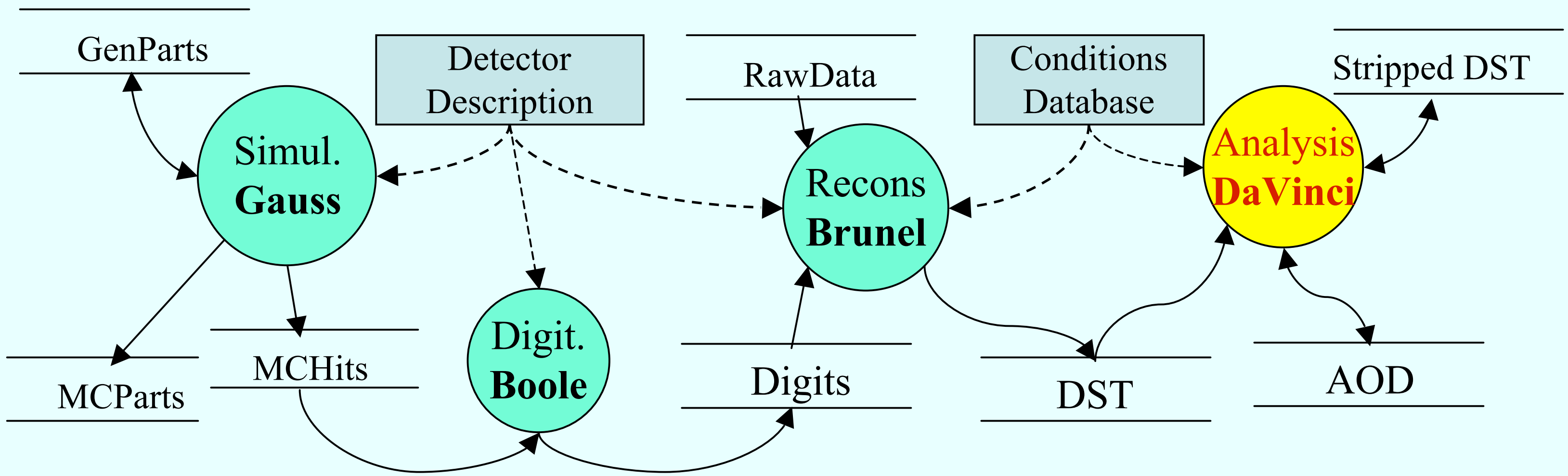
All-ROOT: ALICE

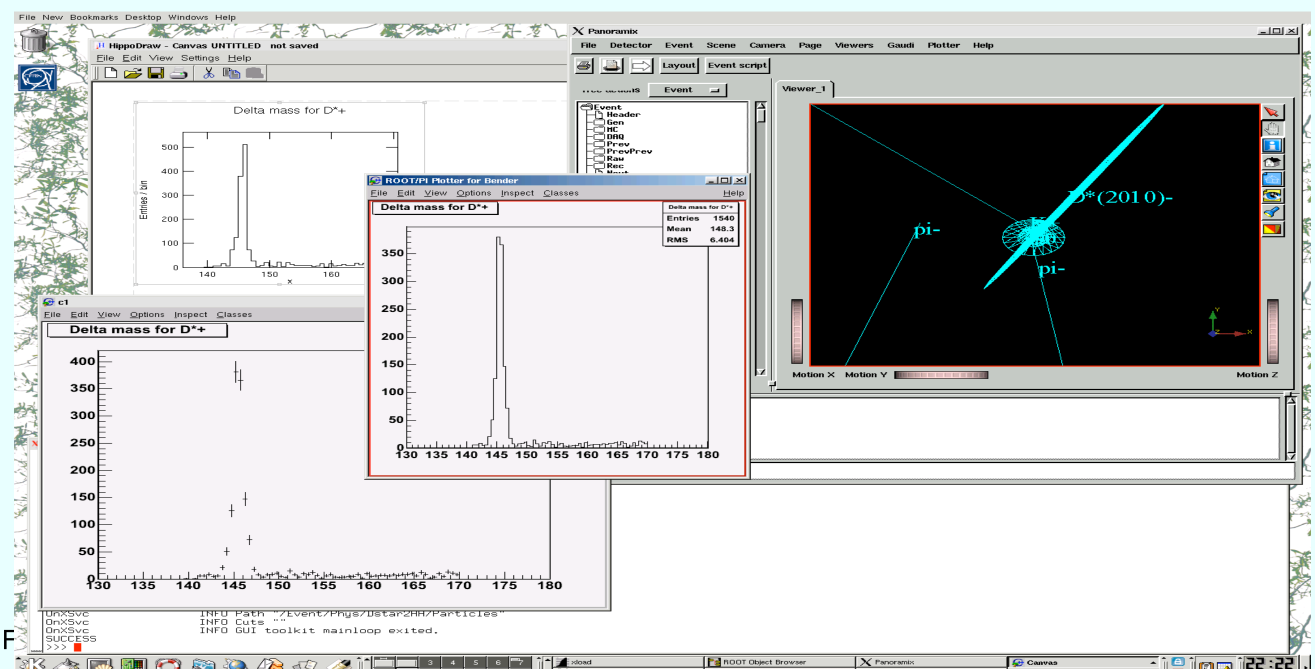




Analysis à la LHCb

Python

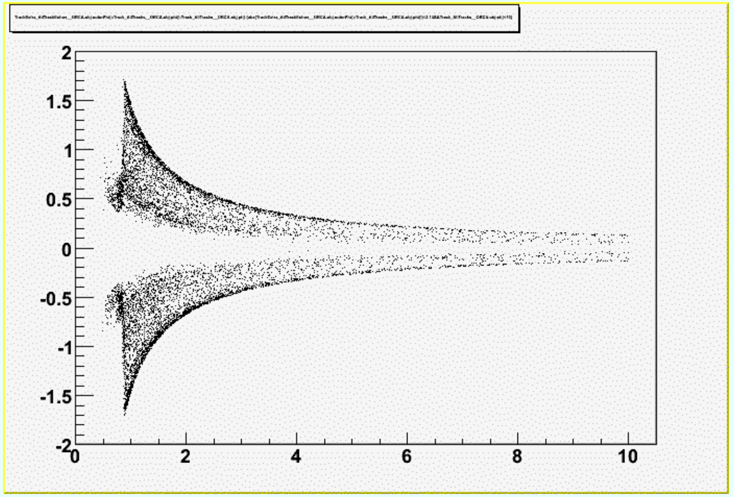




Analysis à la CMS

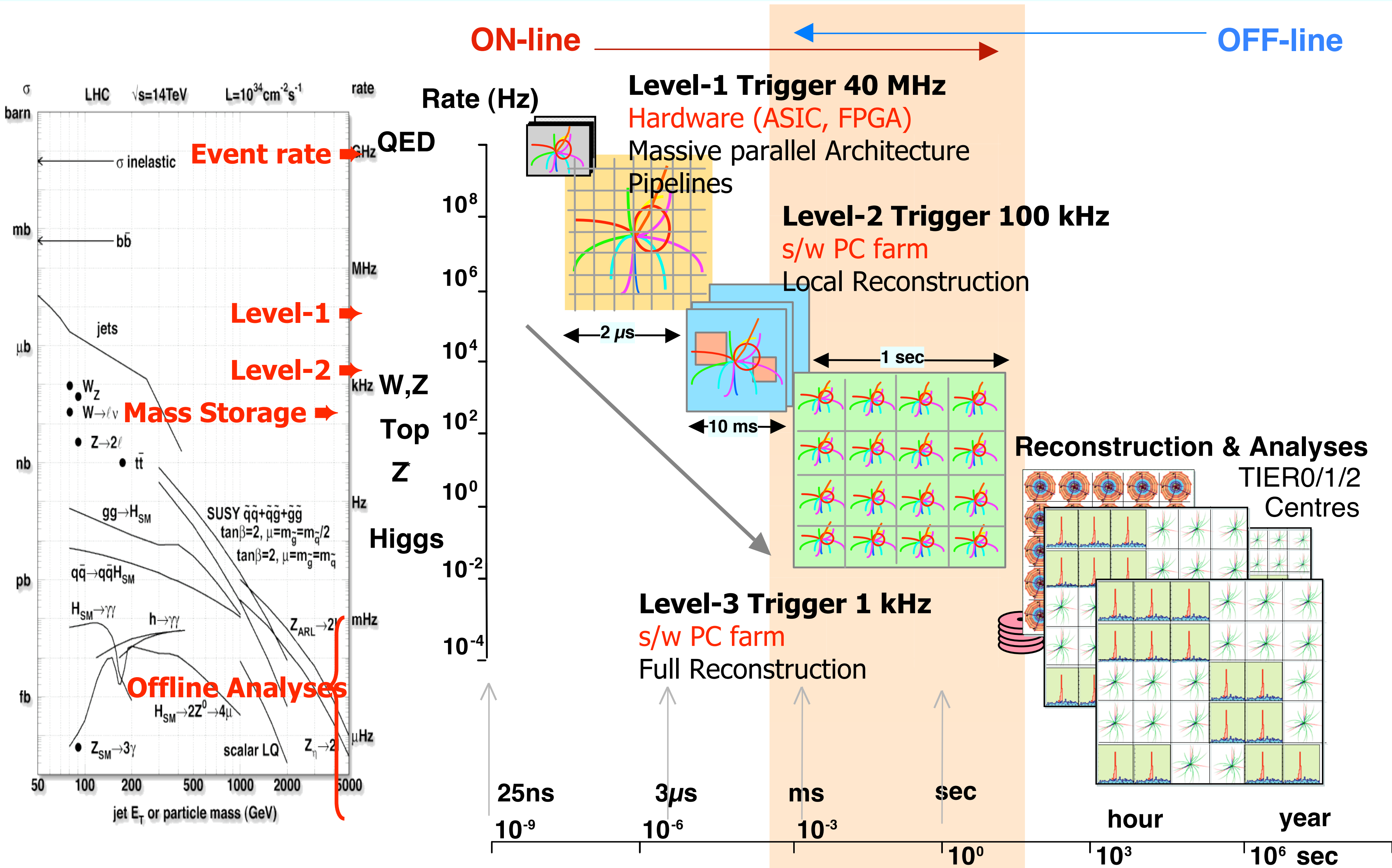
- Goal: one format, one program for all (reconstruction, analysis)
  - Store "simple" structures that are browsable by plain ROOT

```
gSystem>Load("libPhysicsToolsFWLite")
AutoLibraryLoader::enable()
TFile f("reco.root")
Events.Draw("Tracks.phi()-
TrackExtra.outerPhi():
Tracks.pt()",
"Tracks.pt()<10",
"box")
```

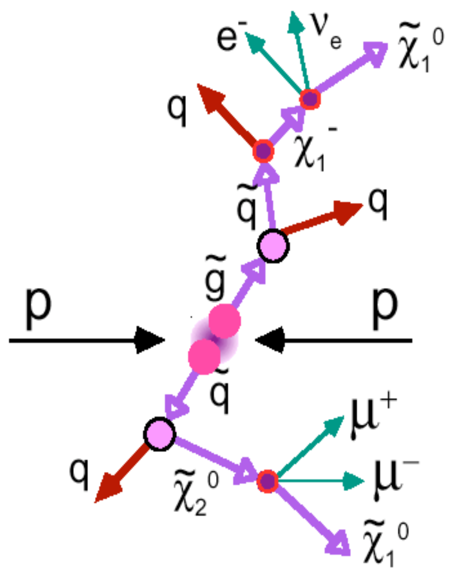


- And then: load CMSSW classes and act on data as in a "batch"/"reconstruction" job
  - Same jet-finding; muon-matching code; cluster corrections
  - Issue is what data is available (RAW, ESD, AOD)

From Bunch Crossings to Physics Analyses



LHC software outlook



Still some way to go before some of the more complicated analyses are possible.

Meanwhile, busy with: readout, calibration / alignment, HLT, reconstruction, AOD, measurement of Standard Model…

Many thanks to

- Paris Sphicas
- Beat Jost
- Sergio Cittolin
- Hanspeter Beck
- Les Robertson
- Harvey Newman
- Michael Hauschild