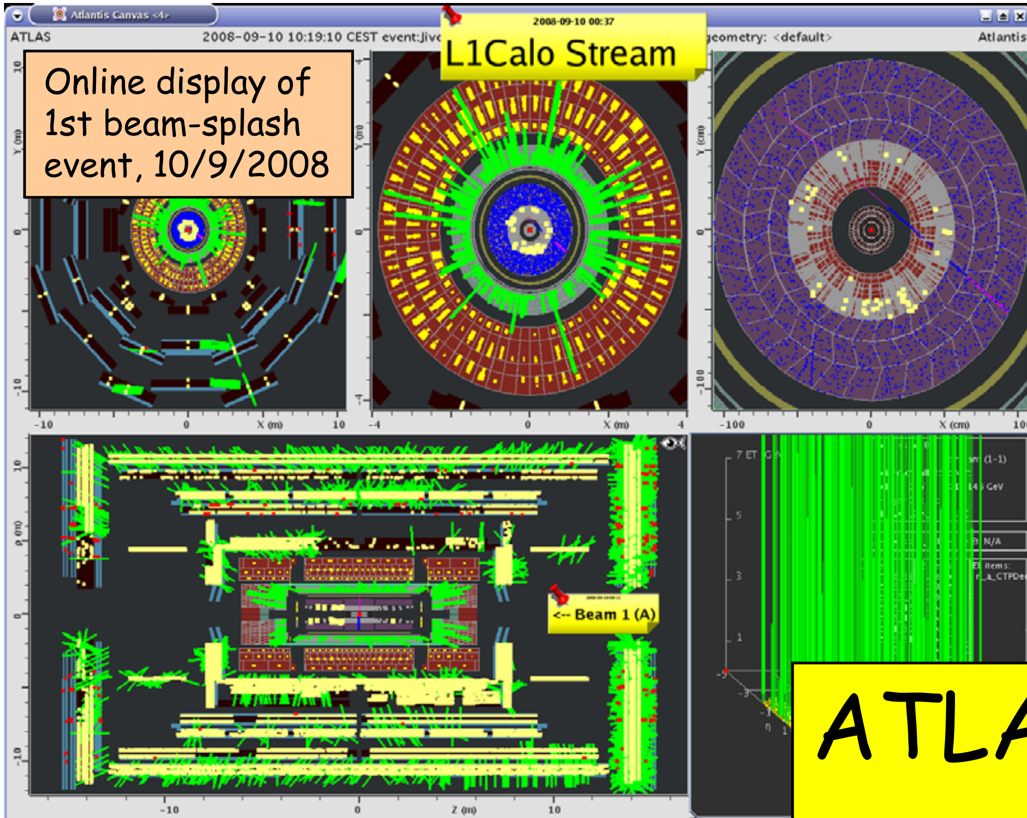
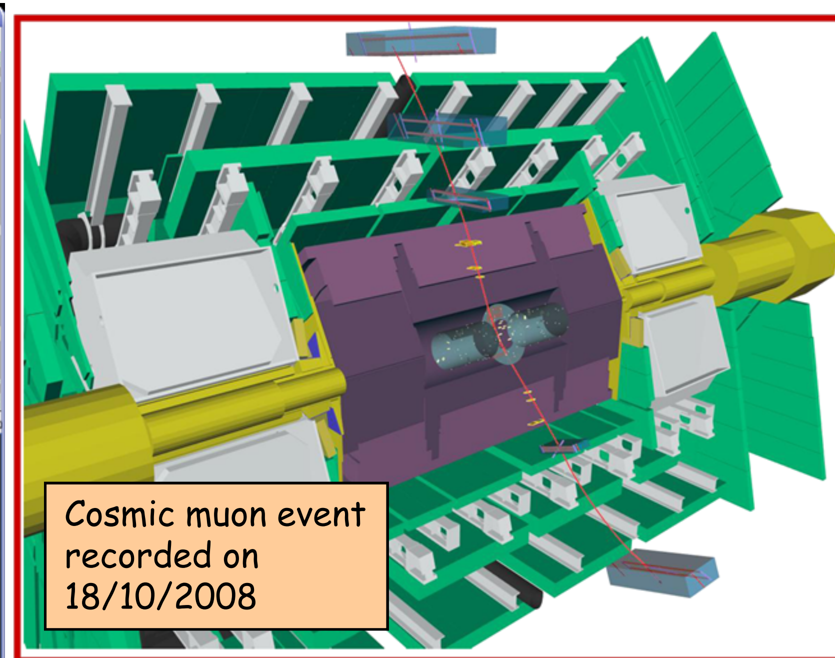
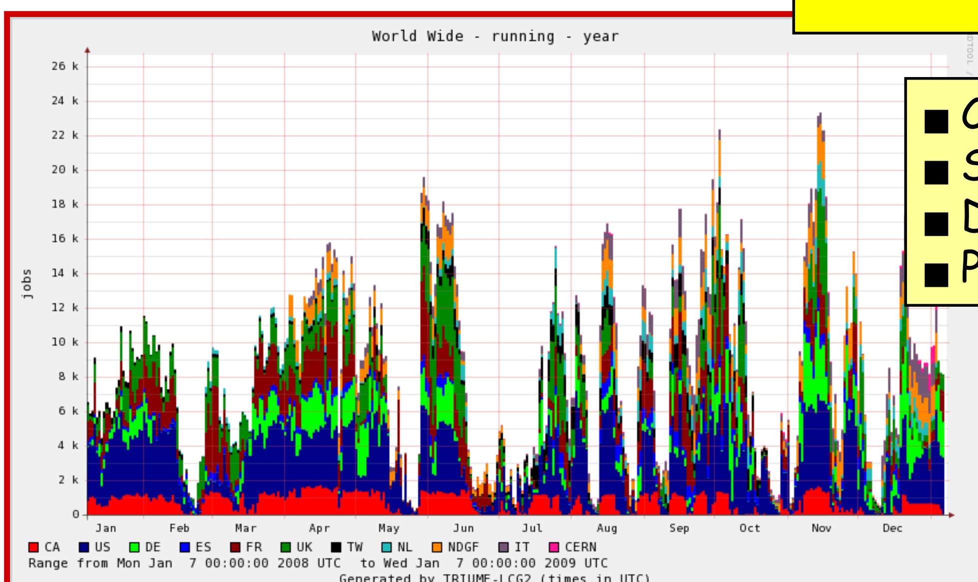



# ATLAS Progress Report
## (Part II)

- Collaboration, management, organization
- Status of Software and Computing
- Detector commissioning with cosmics data
- Physics-related activities




For the detector status, shut-down activities and upgrade see talk by M.Nessi

# Collaboration, Management, Organization

# ATLAS Collaboration

*(Status April 2009)*

**37 Countries**
**169 Institutions**
**2815 Scientific participants total**
**(1873 with a PhD, for M&O share)**


Albany, Alberta, NIKHEF Amsterdam, Ankara, LAPP Annecy, Argonne NL, Arizona, UT Arlington, Athens, NTU Athens, Baku, IFAE Barcelona, Belgrade, Bergen, Berkeley LBL and UC, HU Berlin, Bern, Birmingham, UAN Bogota, Bologna, Bonn, Boston, Brandeis, Brasil Cluster, Bratislava/SAS Kosice, Brookhaven NL, Buenos Aires, Bucharest, Cambridge, Carleton, CERN, Chinese Cluster, Chicago, Chile, Clermont-Ferrand, Columbia, NBI Copenhagen, Cosenza, AGH UST Cracow, IFJ PAN Cracow, UT Dallas, DESY, Dortmund, TU Dresden, JINR Dubna, Duke, Frascati, Freiburg, Geneva, Genoa, Giessen, Glasgow, Göttingen, LPSC Grenoble, Technion Haifa, Hampton, Harvard, Heidelberg, Hiroshima, Hiroshima IT, Indiana, Innsbruck, Iowa SU, Irvine UC, Istanbul Bogazici, KEK, Kobe, Kyoto, Kyoto UE, Lancaster, UN La Plata, Lecce, Lisbon LIP, Liverpool, Ljubljana, QMW London, RHBNC London, UC London, Lund, UA Madrid, Mainz, Manchester, CPPM Marseille, Massachusetts, MIT, Melbourne, Michigan, Michigan SU, Milano, Minsk NAS, Minsk NCPHEP, Montreal, McGill Montreal, RUPHE Morocco, FIAN Moscow, ITEP Moscow, MEPhI Moscow, MSU Moscow, Munich LMU, MPI Munich, Nagasaki IAS, Nagoya, Naples, New Mexico, New York, Nijmegen, BINP Novosibirsk, Ohio SU, Okayama, Oklahoma, Oklahoma SU, Olomouc, Oregon, LAL Orsay, Osaka, Oslo, Oxford, Paris VI and VII, Pavia, Pennsylvania, Pisa, Pittsburgh, CAS Prague, CU Prague, TU Prague, IHEP Protvino, Regina, Ritsumeikan, Rome I, Rome II, Rome III, Rutherford Appleton Laboratory, DAPNIA Saclay, Santa Cruz UC, Sheffield, Shinshu, Siegen, Simon Fraser Burnaby, SLAC, Southern Methodist Dallas, NPI Petersburg, Stockholm, KTH Stockholm, Stony Brook, Sydney, AS Taipei, Tbilisi, Tel Aviv, Thessaloniki, Tokyo ICEPP, Tokyo MU, Toronto, TRIUMF, Tsukuba, Tufts, Udine/ICTP, Uppsala, Urbana UI, Valencia, UBC Vancouver, Victoria, Washington, Weizmann Rehovot, FH Wiener Neustadt, Wisconsin, Wuppertal, Würzburg, Yale, Yerevan

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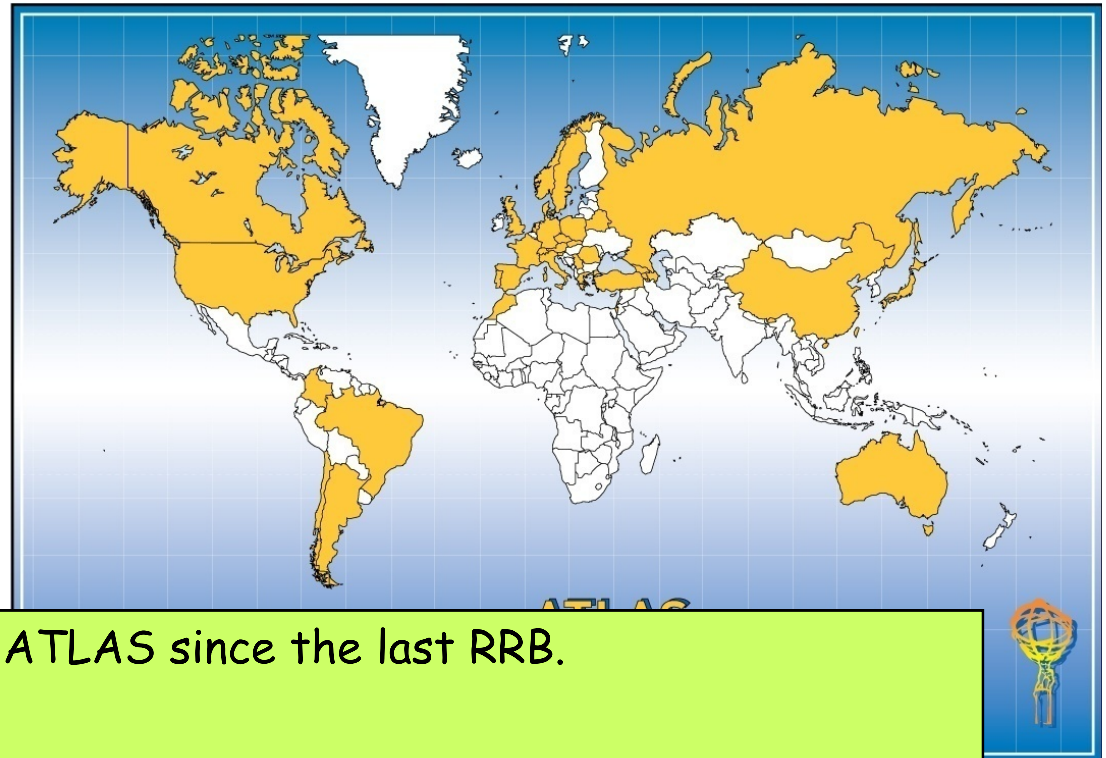


No new Institutions have joined ATLAS since the last RRB.

The following Institutes:

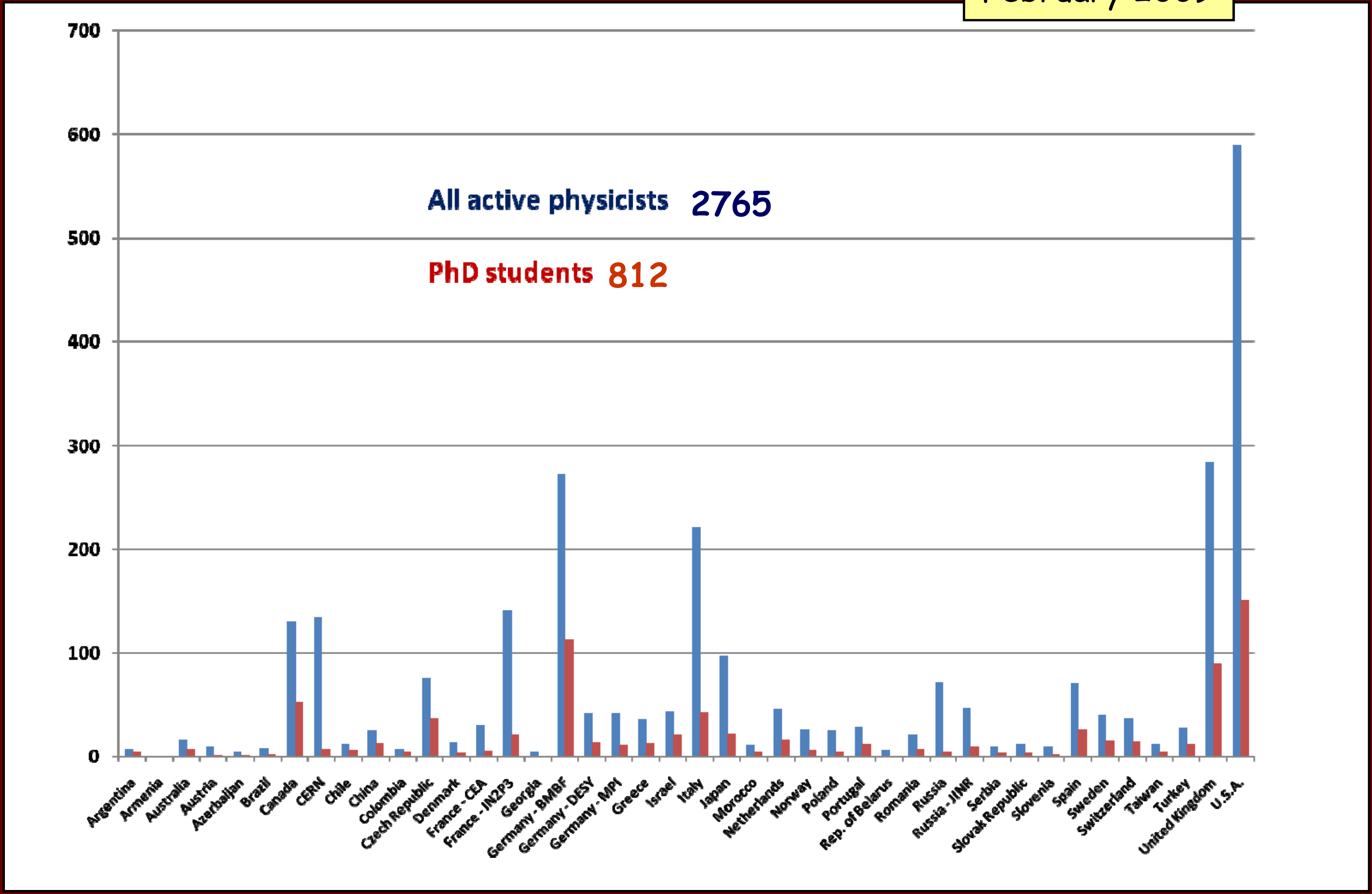
University of Granada, Spain
University Politehnica Bucharest, Romania
University of São Paulo, Brazil

have joined via "clustering" with existing Institutions.

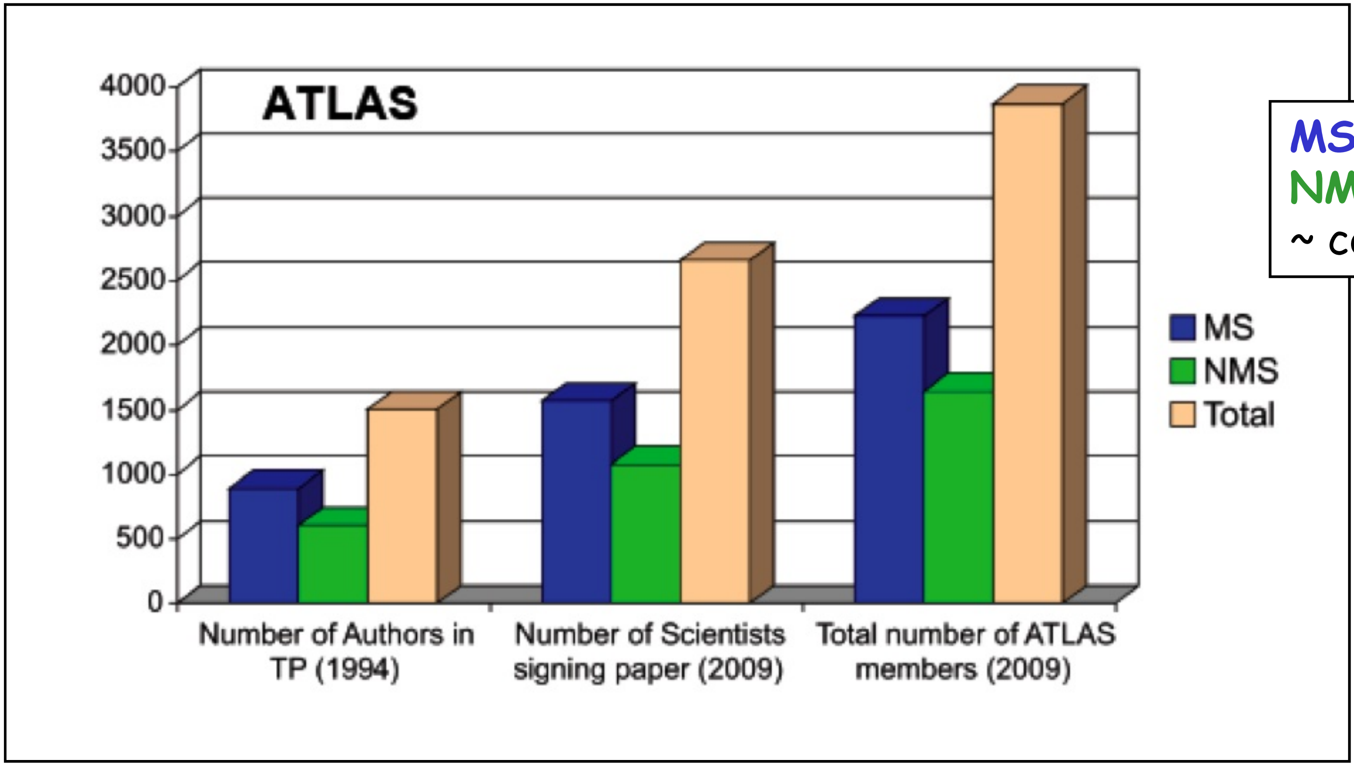
This does not change the institutional composition of the Collaboration Board nor the number of voting Institutions in the CB.

Alba ... ,
IFAE ... on,
Bran ... inese
Clus ...
UT D ... ngen,
LPS ... e UC,
Istan ... on,
RHE ... igan,
Mich ... ow,
MEF ... n, BINP
Novosibirsk, Ohio SU, Okayama, Oklahoma, Oklahoma SU, Olomouc, Oregon, LAL Orsay, Osaka, Oslo, Oxford, Paris VI and VII, Pavia, Pennsylvania, Pisa, Pittsburgh, CAS Prague, CU Prague, TU Prague, IHEP Protvino, Regina, Ritsumeikan, Rome I, Rome II, Rome III, Rutherford Appleton Laboratory, DAPNIA Saclay, Santa Cruz UC, Sheffield, Shinshu, Siegen, Simon Fraser Burnaby, SLAC, Southern Methodist Dallas, NPI Petersburg, Stockholm, KTH Stockholm, Stony Brook, Sydney, AS Taipei, Tbilisi, Tel Aviv, Thessaloniki, Tokyo ICEPP, Tokyo MU, Toronto, TRIUMF, Tsukuba, Tufts, Udine/ICTP, Uppsala, Urbana UI, Valencia, UBC Vancouver, Victoria, Washington, Weizmann Rehovot, FH Wiener Neustadt, Wisconsin, Wuppertal, Würzburg, Yale, Yerevan

February 2009



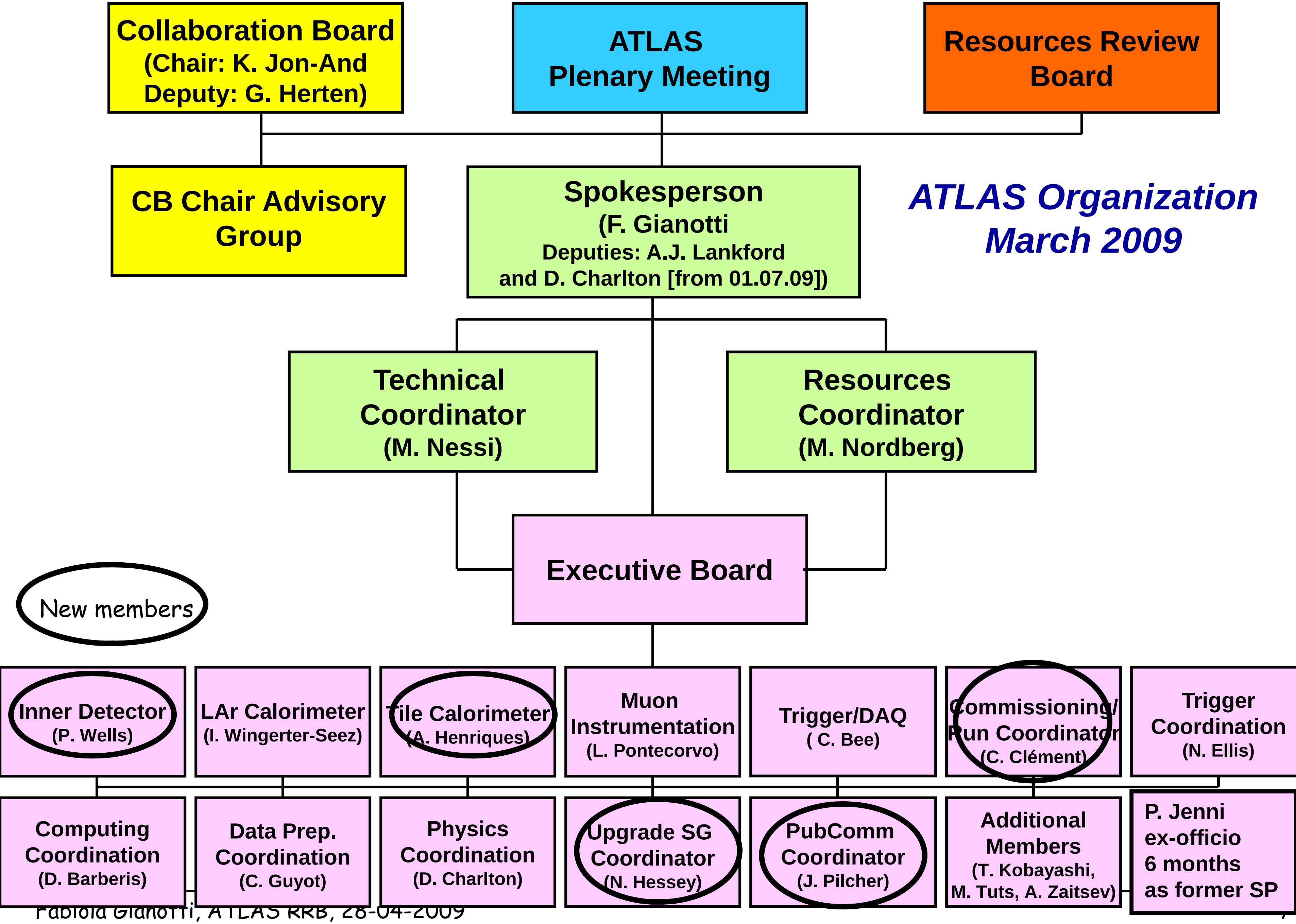

We are aware of the need to recognize the work of young people and give them visible positions. Several measures have been taken: talks, yearly rotation of conveners of Physics groups, etc. Other solutions being investigated (e.g. mechanism to record individual's contributions to e.g. a given analysis)

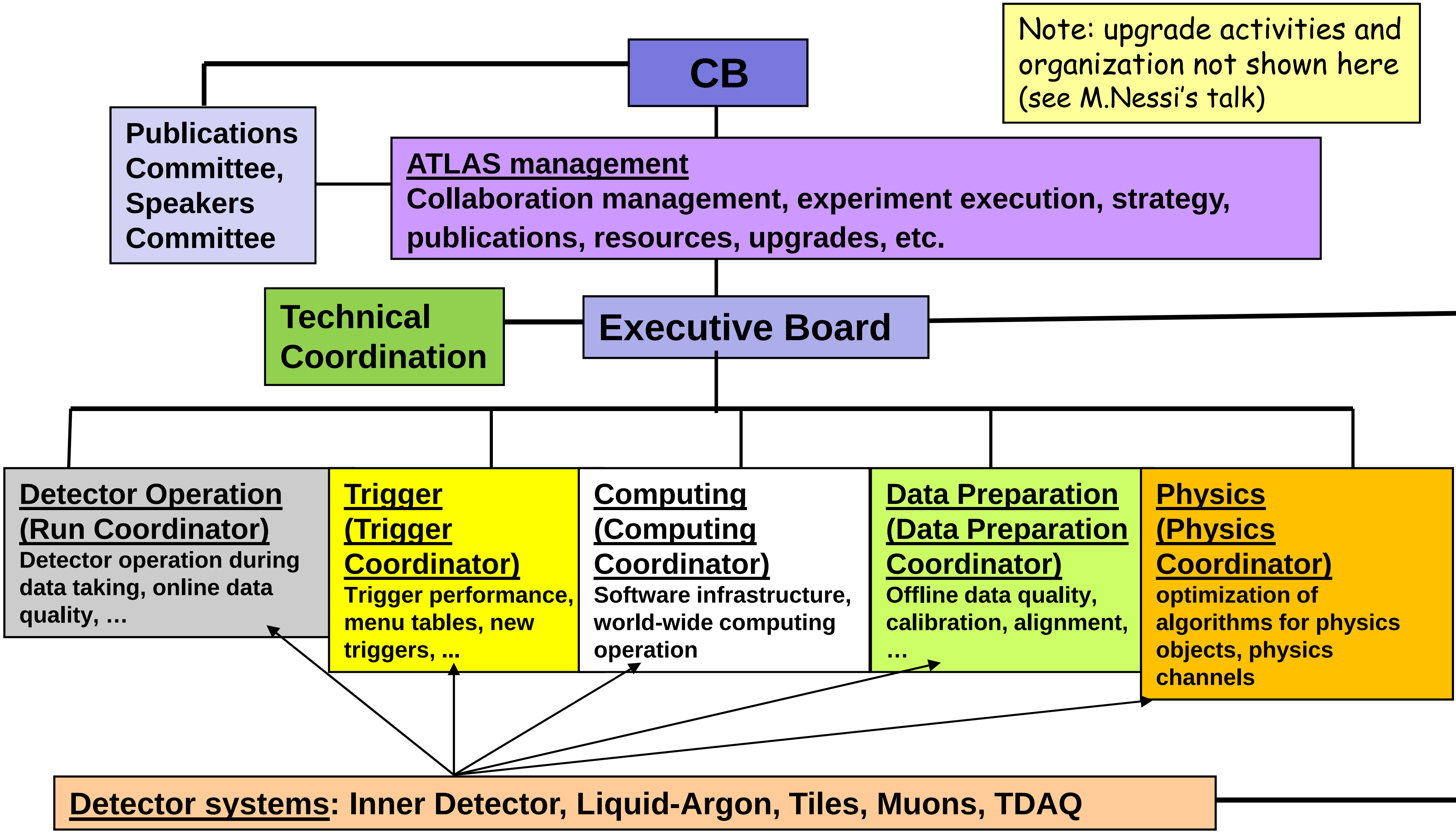



MS : ~ 60%
NMS : ~ 40%
~ constant with time

Collaborative tools (video-conferencing, etc.): CERN has set up an LHC Collaborative Environment Board (LCEB) with representatives from IT, LHC experiments and HEP labs to explore short and long-term solutions (EVO, etc.). ATLAS is well aware of the importance of this issue, and will pro-actively help find the most effective tools and a suitable funding mechanism

# *ATLAS Organization March 2009*



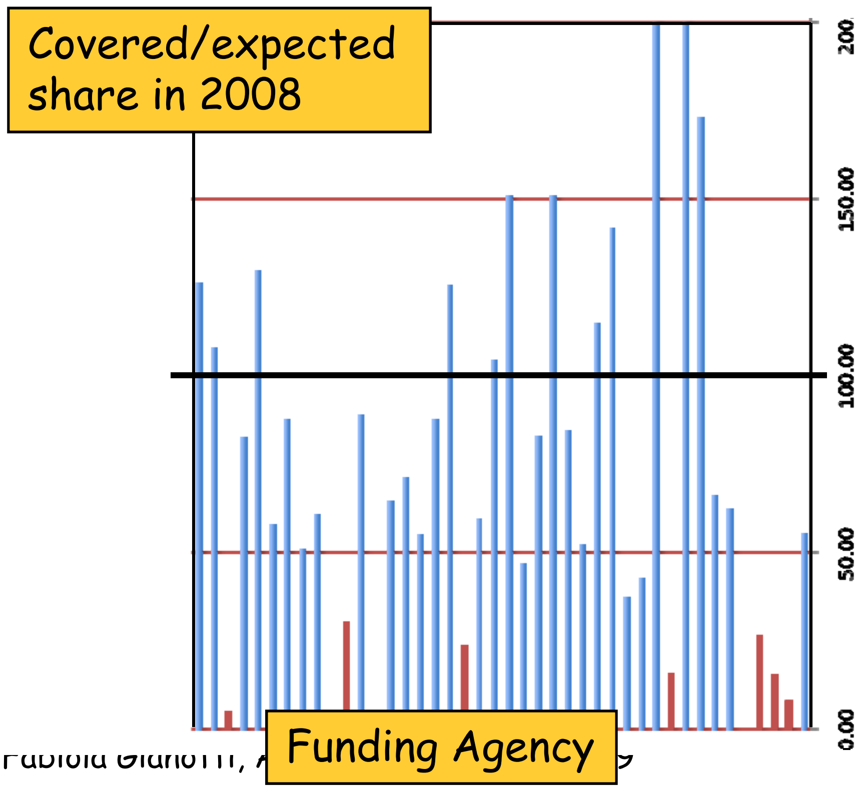



- 5 detector systems, 5 "horizontal" experiment-wide activities, plus upgrade (not shown here)
- Detector Project Leaders and Activity Coordinators: 2-year term.
  Each year a Deputy Activity Coordinator is appointed, who becomes Coordinator one year later for one year (this staggering mechanism ensures continuity)
- Experiment's execution reviewed monthly in the Executive Board: 1.5 day meeting (one day open to the full Collaboration followed by half day closed)

## Operation Task sharing system is being put in place (framework approved by CB in 2007)

ATLAS operation, from detector to data preparation and world-wide computing, requires 600-700 FTE (note: Physics is not an operation task):

- Shared in fair way by the Institutions: proportional to the number of authors
  - -- students are weighted 0.75
  - -- new Institutions contribute more the first two years (weight factors 1.5, 1.25)
- ~ 60% of these FTE tasks are CERN-based; efforts to reduce this fraction with time
- ~ 12% are shifts in the Control Room or on-call in 2009; increase remote monitoring with time
- Allocation made in two steps: shifts are distributed first, then other tasks
- Required FTE and FA contributions reviewed and updated yearly




Distribution per FA in 2008:
100% means covered=expected share

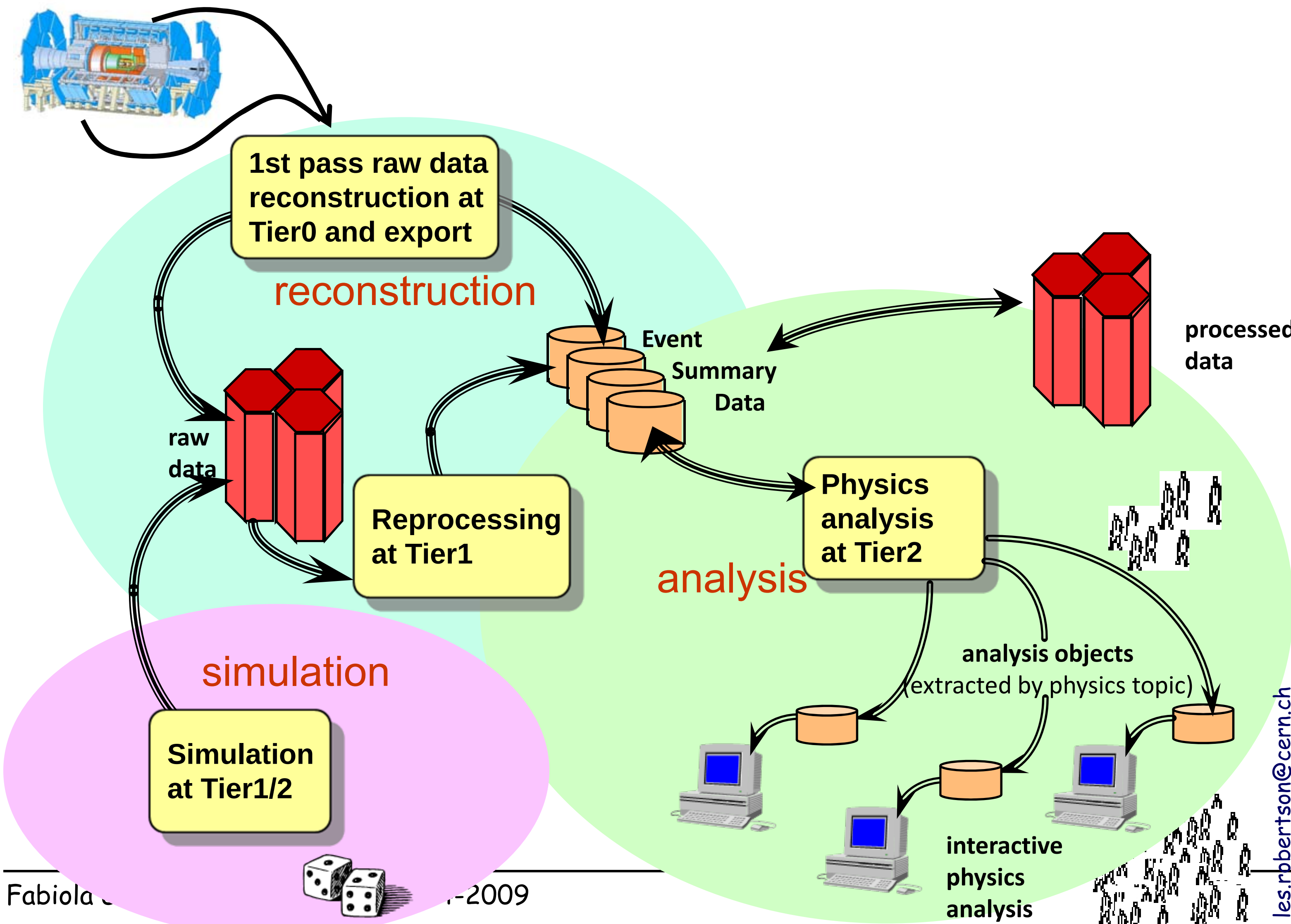
For illustration only: 2008 was the first exercise of the system. Plot shows that tracking tools are in place

# Status of Software and Computing

ATLAS wLCG world-wide computing: ~ 70 sites
(including CERN Tier0, 10 Tier1-s, ~ 40 Tier2 federations)

4 main computing operations according to the Computing Model:

- First-pass processing of detector data at CERN Tier0 and data export to Tier1-s/Tier2-s
- Data re-processing at Tier1-s using updated calibration constants
- Simulation of Monte Carlo samples at Tier1-s and Tier2-s
- (Distributed) physics analysis at Tier2-s and at more local facilities (Tier3-s)



# PETER JENNI - ATLAS Spokesperson 1992-2009

Peter Jenni has led the project for more than 20 years, from its conception to successful data taking with first beams. He has been the main actor in building a strong world-wide Collaboration. He has represented ATLAS in 27 RRB meetings, and chaired 134 ATLAS Executive Boards and about 60 ATLAS Collaboration weeks.

He will continue to be very active in ATLAS, and give his invaluable advice and help, in particular for Funding Agencies and RRB matters. He will also represent ATLAS in the CERN External Relations group

4 main computing operations according to the Computing Model:

- First-pass processing of detector data at CERN Tier0 and data export to Tier1-s/Tier2-s
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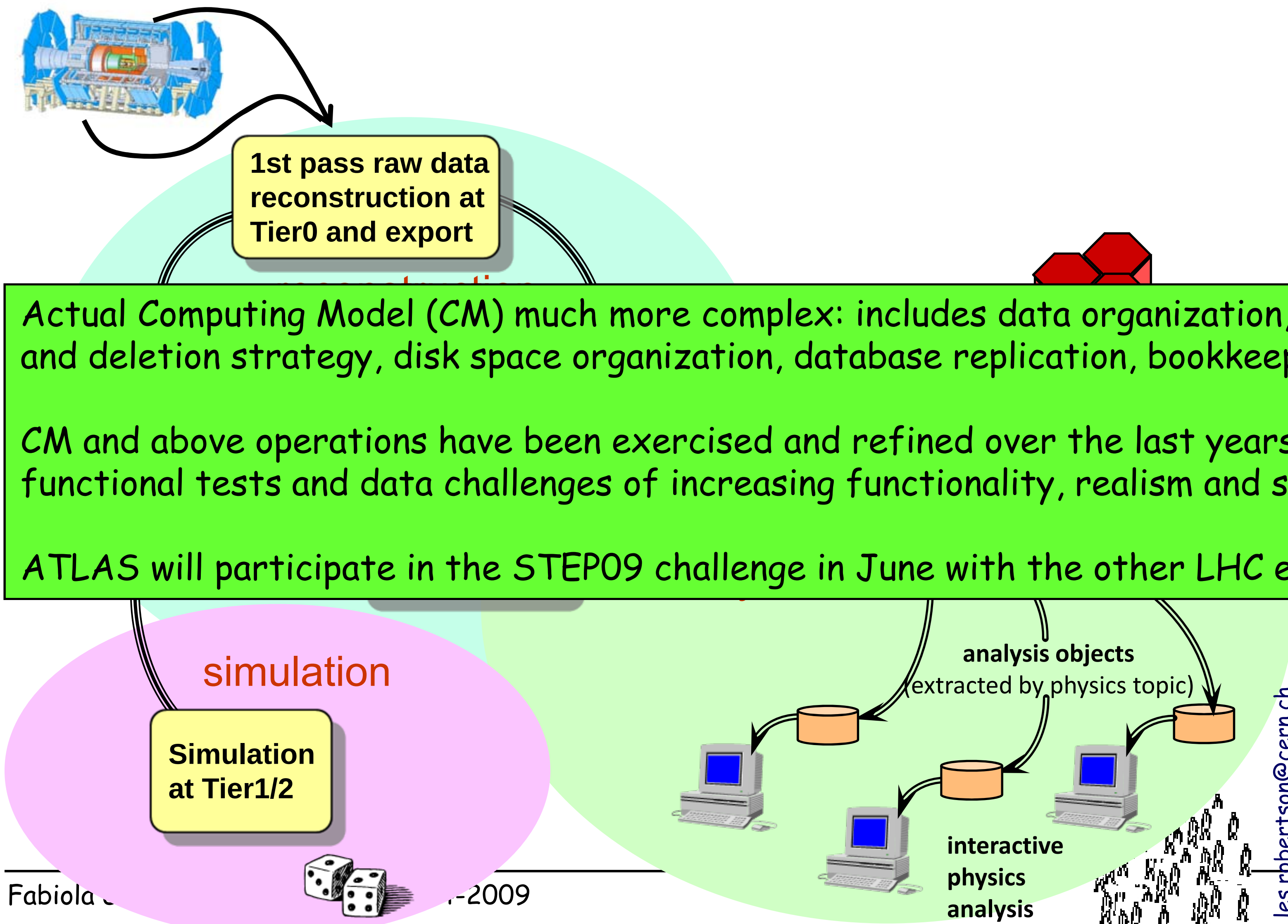
- (Distributed) physics analysis at Tier2-s and at more local facilities (Tier3-s)

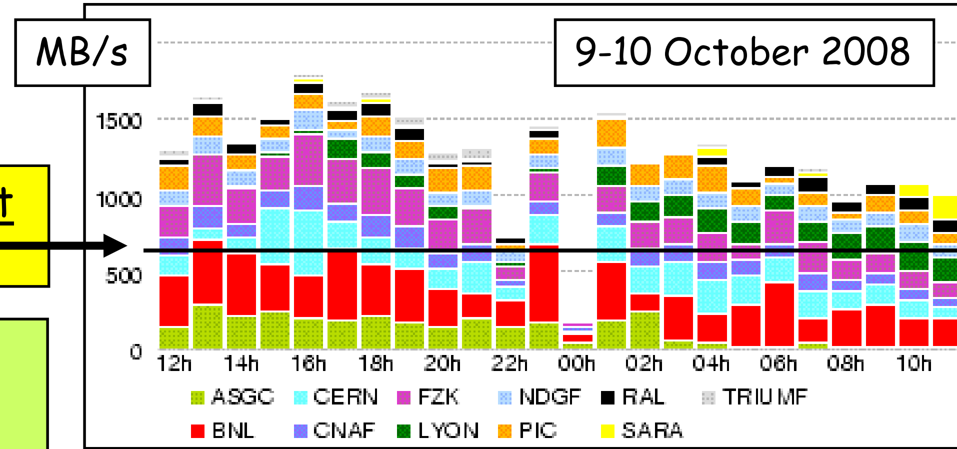
Actual Computing Model (CM) much more complex: includes data organization, placement and deletion strategy, disk space organization, database replication, bookkeeping, etc.

CM and above operations have been exercised and refined over the last years through functional tests and data challenges of increasing functionality, realism and size

ATLAS will participate in the STEP09 challenge in June with the other LHC experiments



# Most recent tests of these 4 operations and achievements




Tier0 →Tier1-s sustained <u>cosmics data export</u> larger than during LHC operation (~650 MB/s)

<u>Reprocessing of cosmics and single-beam data</u> recorded in Fall 2008 with full detector:

- 1st campaign at Tier1-s over Christmas
- updated calibration/alignment constants used
- 284M events, 0.5 PB of RAW data (> 25% of LHC data volume expected in 2009-2010)
- 0.1 PB of output data distributed world-wide
- very successful: improved detector results; several computing problems found and fixed
- second campaign (~ completed): problems fixed, more automatic procedures, testing tape-staging and conditions database access

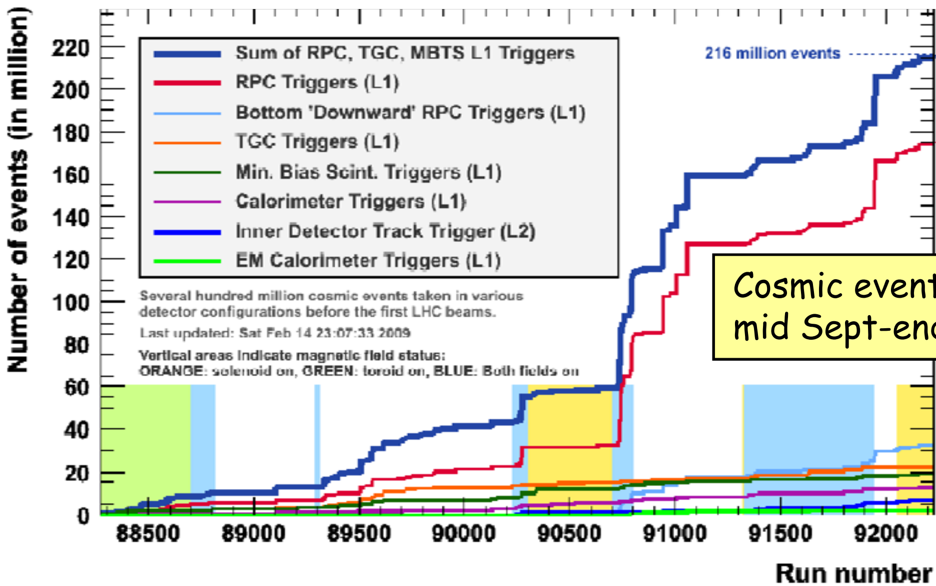
Continuous <u>simulation of MC physics samples</u>:

- made at Tier1-s and Tier2-s
- since last Summer (MC08): 250M Geant4-simulated events + 300M events with faster simulation
- new campaign (MC09): starting soon with software release for data taking

<u>Distributed analysis</u>:

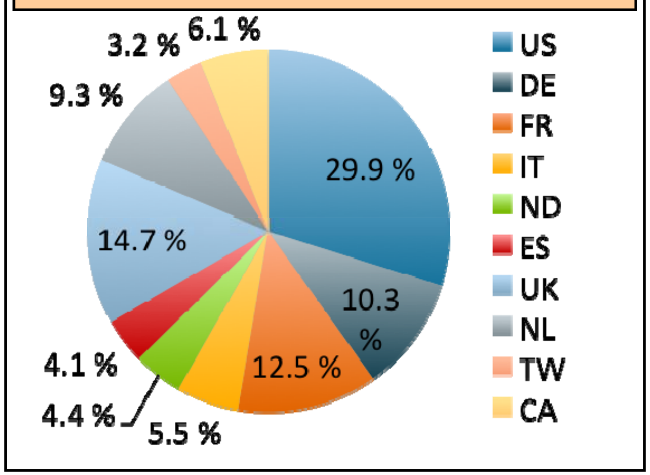
- takes place at Tier2-s and more local facilities
- challenging as more chaotic than scheduled production
- in place for a long time for analysis of simulated data, but stress on Tier2-s will be much higher with real data (more users, more types of analysis jobs)
- high-load robotic stress tests of 74 sites being done since November by computing experts
- several problems found and fixed → system is now ready for user participation in systematic large-scale Tier2-s tests

# Reprocessing of cosmics data




Cosmic events recorded mid Sept-end Oct 2008

Initial RAW data distribution for reprocessing according to CM



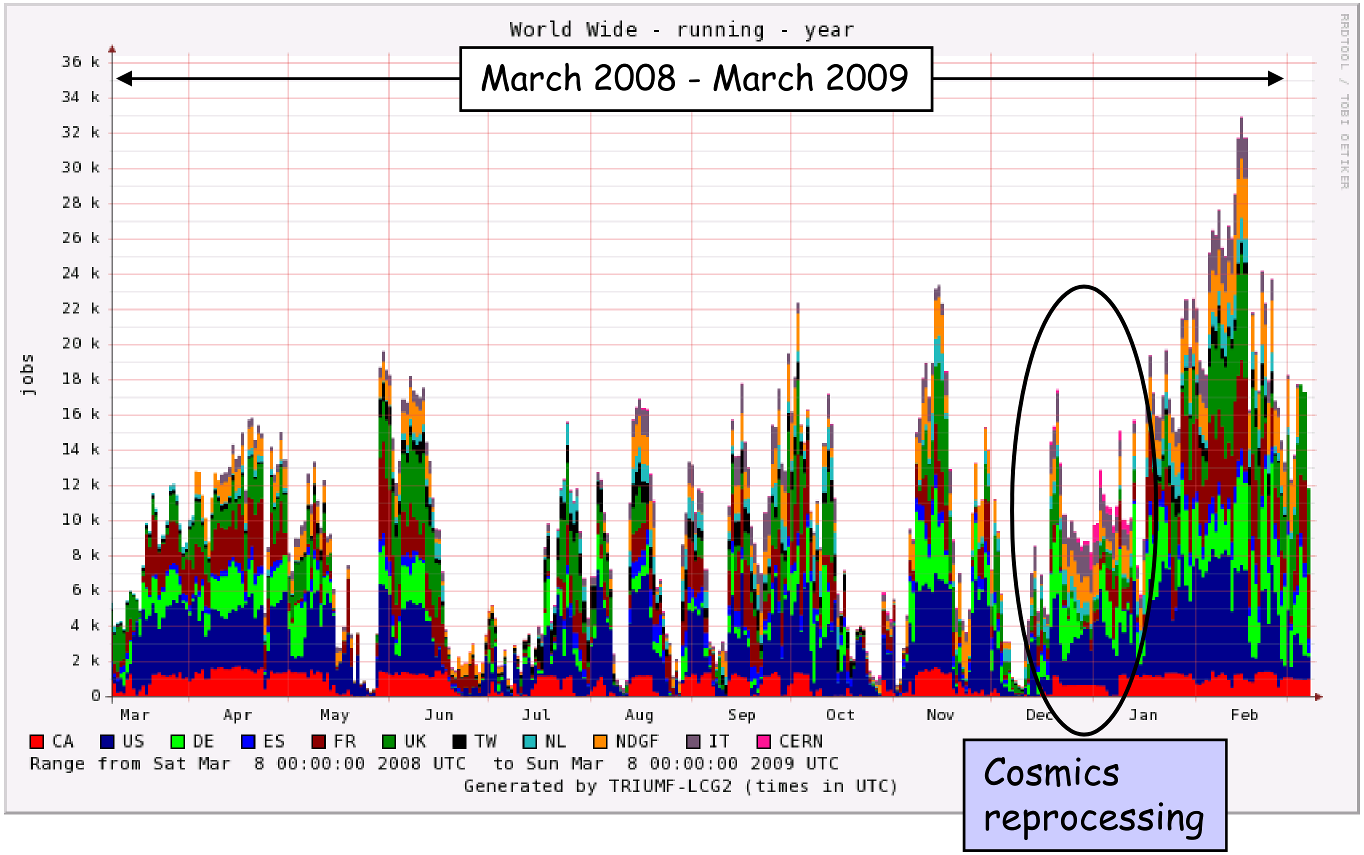

- Good runs signed off by Data Quality group (as for LHC data)
- Data from Tier1-s with problems re-distributed to other sites (useful test of vital feature of the system)
- Job failure rate : 3.5 % (1st campaign) → 0.3% (2nd campaign)

| Tier-1: | CERN | CA | ES | FR | IT | ND | NL | UK | US | Sum |
|---|---|---|---|---|---|---|---|---|---|---|
| Total jobs | 26348 | 20707 | 364 | 48288 | 13619 | 12561 | 23472 | 54360 | 128764 | 329609 |
| Done jobs | 26015 | 20150 | 364 | 46937 | 13018 | 12281 | 23167 | 51344 | 124667 | 317943 |
| Fraction [%] | 94.7 | 97.3 | 100 | 97.2 | 95.6 | 97.8 | 98.7 | 94.5 | 96.8 | 96.5 |
| Aborted jobs | 1459 | 557 | 0 | 1351 | 601 | 280 | 305 | 3016 | 4097 | 11666 |
| Fraction [%] | 5.3 | 2.7 | 0 | 2.8 | 4.4 | 2.2 | 1.3 | 5.5 | 3.2 | 3.5 |

1 job=1file
~1000 evts

See later for detector performance results

# Continuous production of MC samples for physics simulation studies




Main structures due to software release schedule and validation and time profile of simulation and/or reprocessing campaign

ATLAS production system in continuous operation mode since > 1 year:

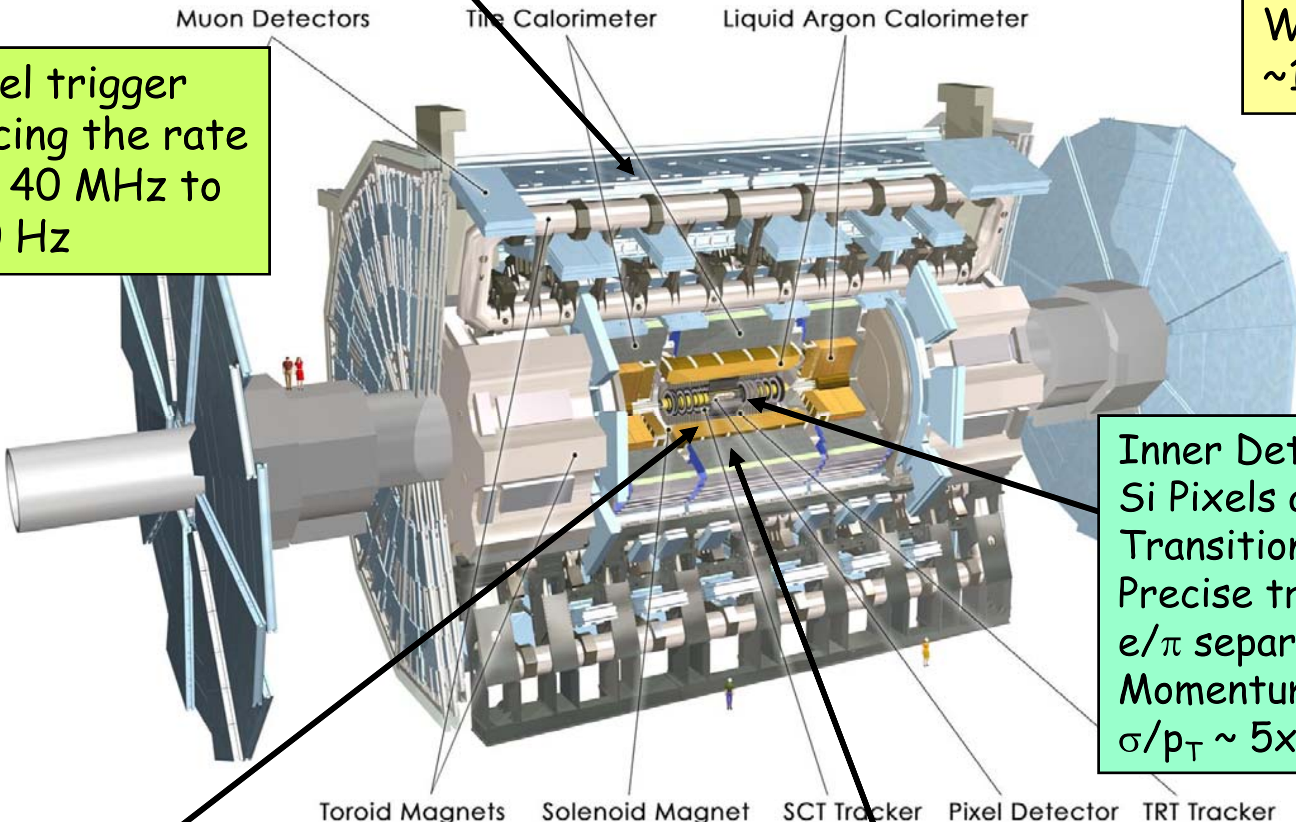
- up to ~ 30k jobs/day; 1.2 M fully-simulated (Geant4) events per day; 200 TB per week
- efficiency (#succeeded/#failed tasks): > 97% (half Grid, half ATLAS SW problems)
- ~ half of available CPU used; limited by storage (disk) space situation
- ATLAS software (simulation, reconstruction, infrastructure) increasingly more powerful, realistic and complete

# Detector commissioning with cosmics and single-beam data

Muon Spectrometer ($|\eta|<2.7$) : air-core toroids with gas-based chambers
Muon trigger and measurement with momentum resolution < 10% up to $E_\mu$ ~ TeV

Length : ~ 46 m
Radius : ~ 12 m
Weight : ~ 7000 tons
~$10^8$ electronic channels

3-level trigger reducing the rate from 40 MHz to ~200 Hz




Inner Detector ($|\eta|<2.5$, B=2T):
Si Pixels and strips (SCT) +
Transition Radiation straws
Precise tracking and vertexing,
$e/\pi$ separation (TRT).
Momentum resolution:
$\sigma/p_T \sim 5\times10^{-4}\, p_T\,(\mathrm{GeV}) \oplus 0.01$

EM calorimeter: Pb-LAr Accordion
$e/\gamma$ trigger, identification and measurement
E-resolution: ~ 1% at 100 GeV, 0.5% at 1 TeV

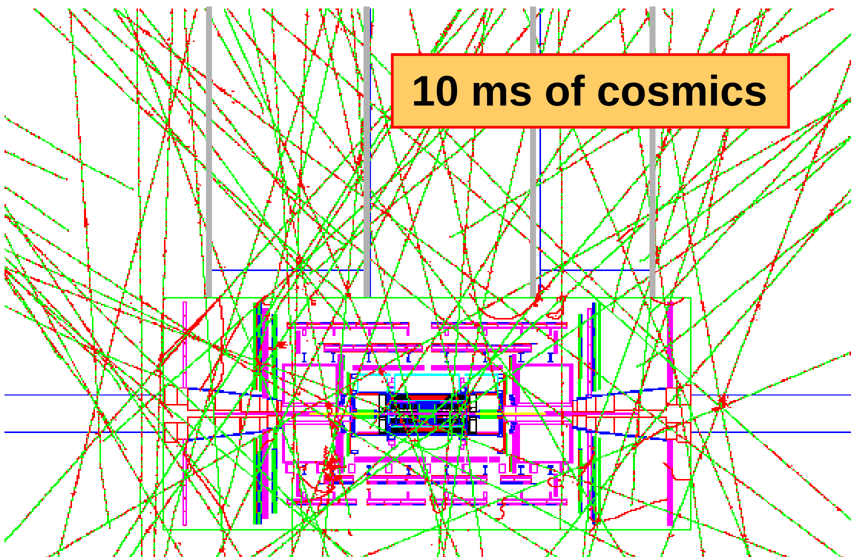
HAD calorimetry ($|\eta|<5$): segmentation, hermeticity
Tilecal Fe/scintillator (central), Cu/W-LAr (fwd)
Trigger and measurement of jets and missing $E_T$
E-resolution: $\sigma/E \sim 50\%/\sqrt{E} \oplus 0.03$

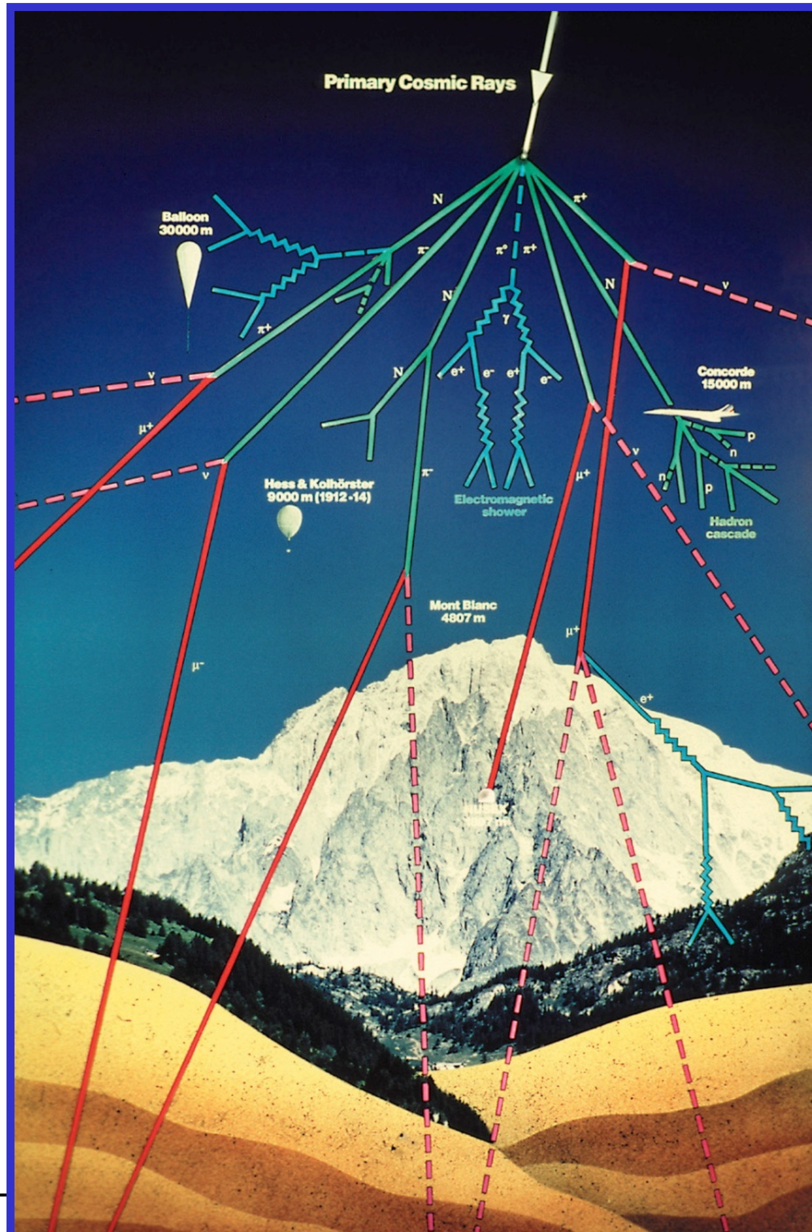
# Commissioning with cosmics in the underground cavern

(the first real data in situ … )

Started more than three years ago. Very useful to:

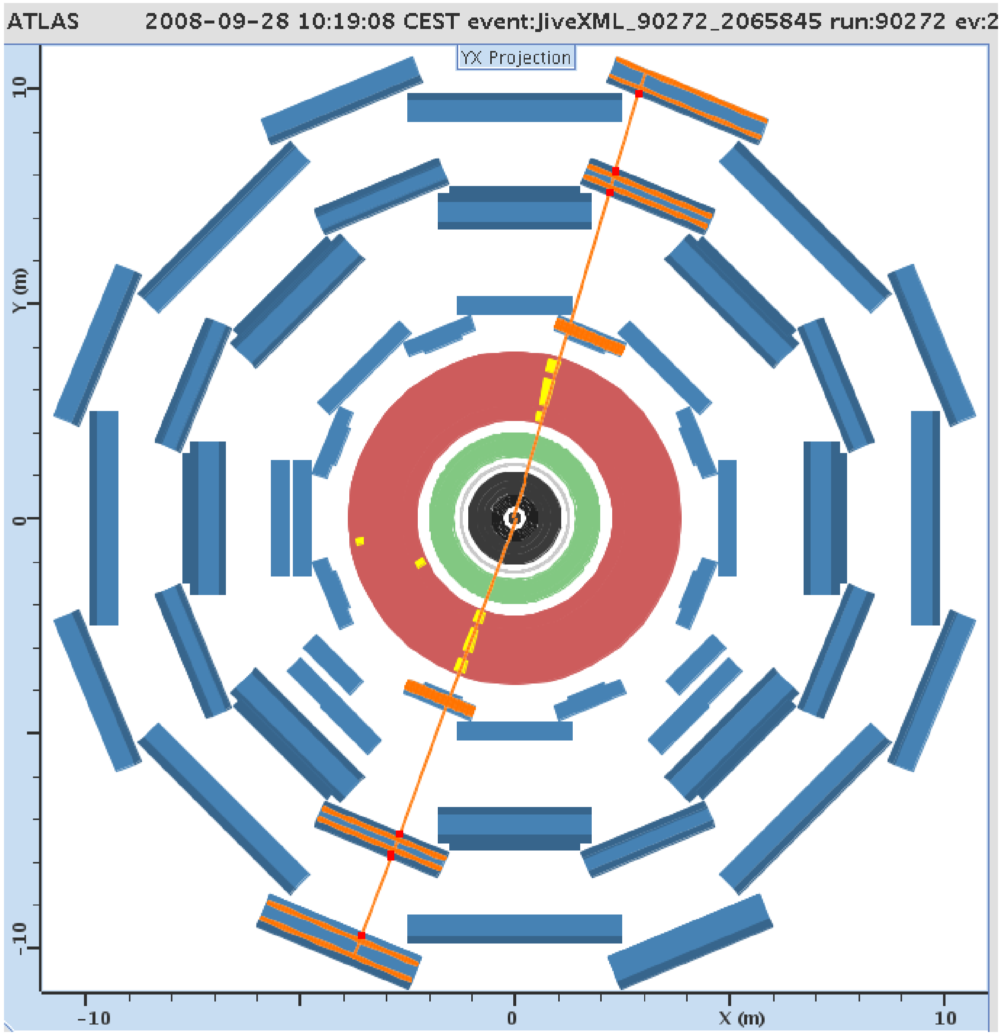
- Run an increasingly more complete detector with final trigger, data acquisition and monitoring systems. Data analyzed with final software
- Shake-down and debug the experiment in its final position → fix problems
- Perform first calibration and alignment studies
- Gain global operation experience in situ before collisions start

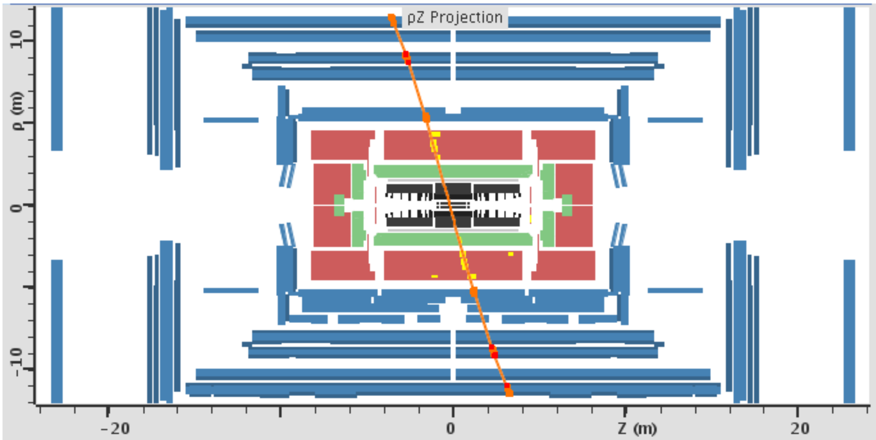


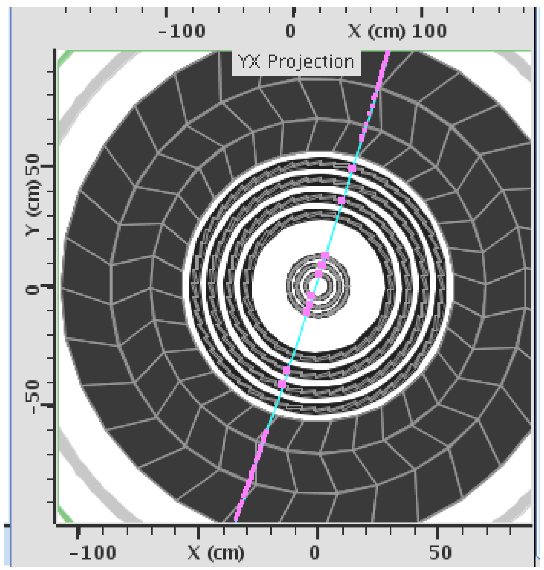




Rate of cosmics in ATLAS: 0.5-100 Hz
(depending on sub-detector size and location)

A cosmic muon traversing the whole detector.
Recorded on 28 September 2008



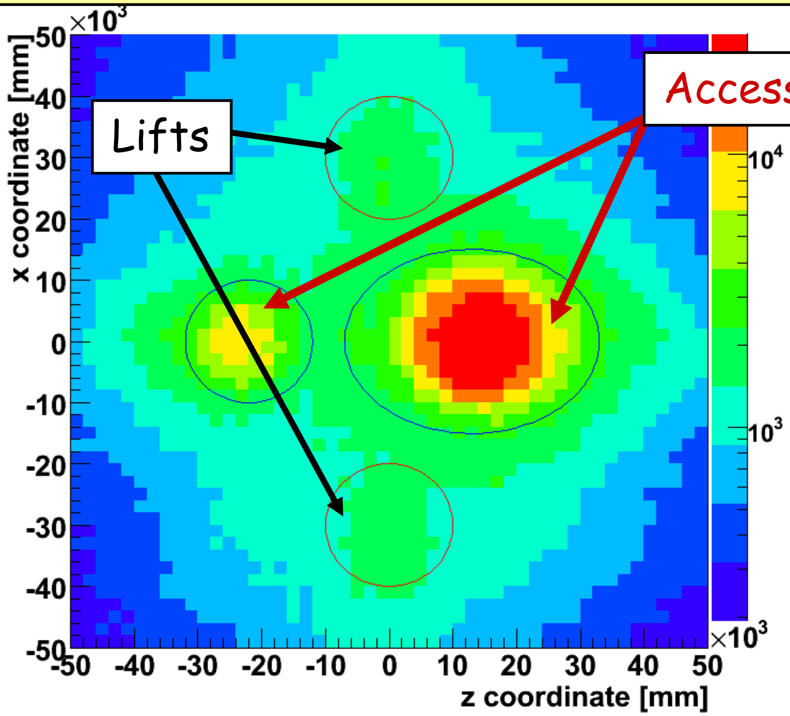



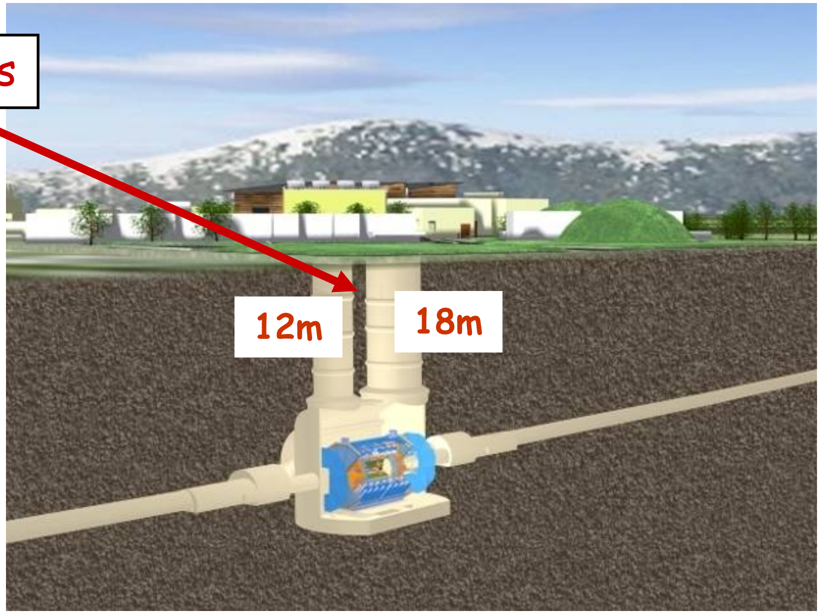

~ 500 million cosmics muons recorded August-November 2008 (1.2 PB raw data)

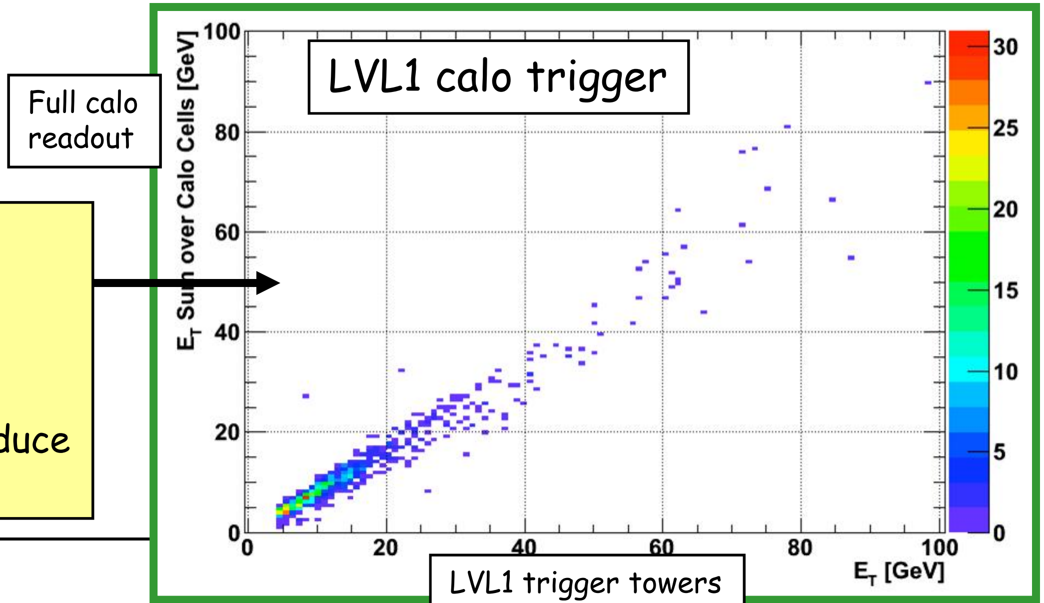
# Examples of trigger performance with cosmics data

ATLAS preliminary

Extrapolation to the surface of cosmic muon tracks reconstructed by RPC chambers



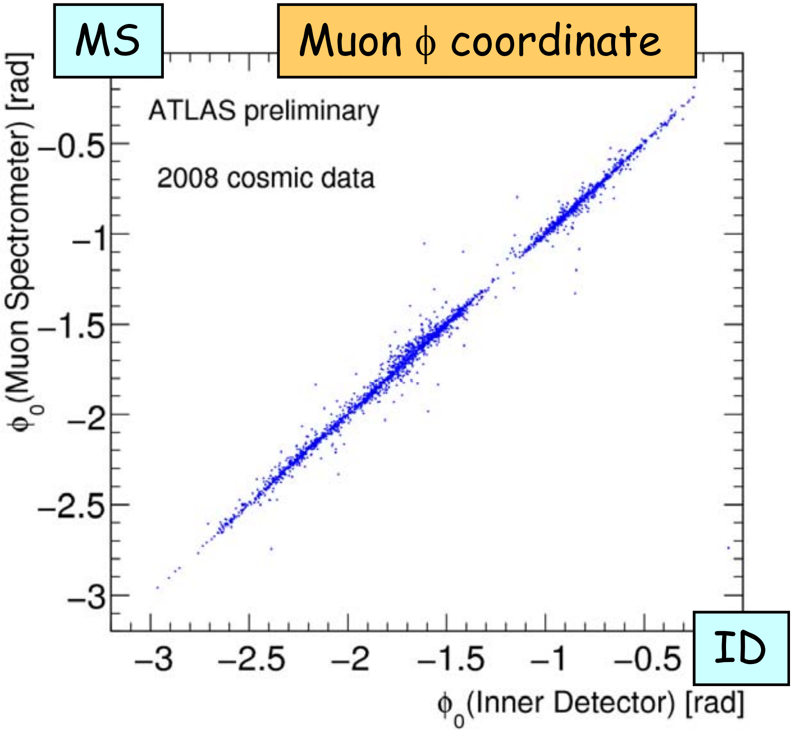



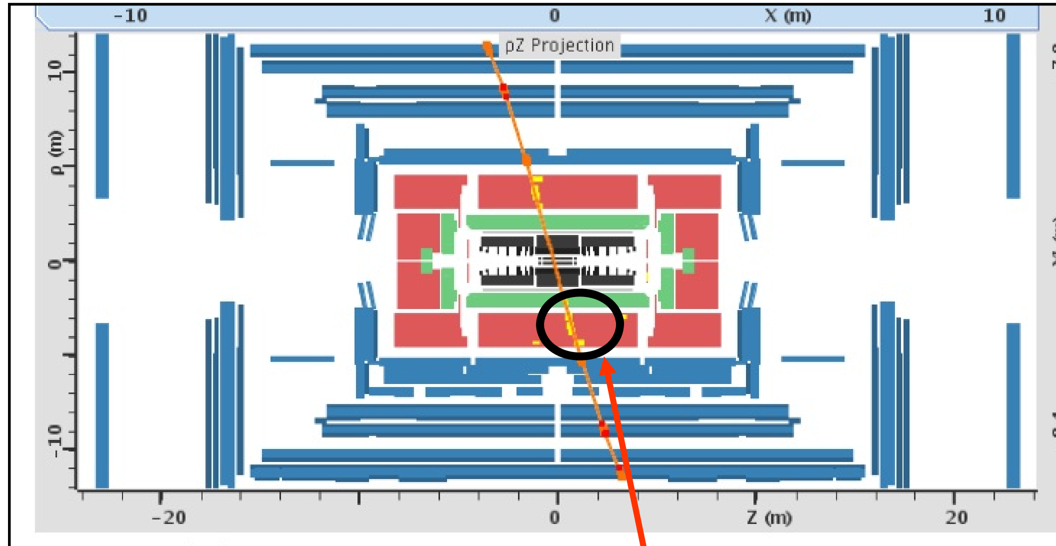




Muon (shower) energy measured with full calorimeter readout vs energy measured in trigger towers ($\eta\times\phi$=0.1x0.1) by LVL1 Calo trigger

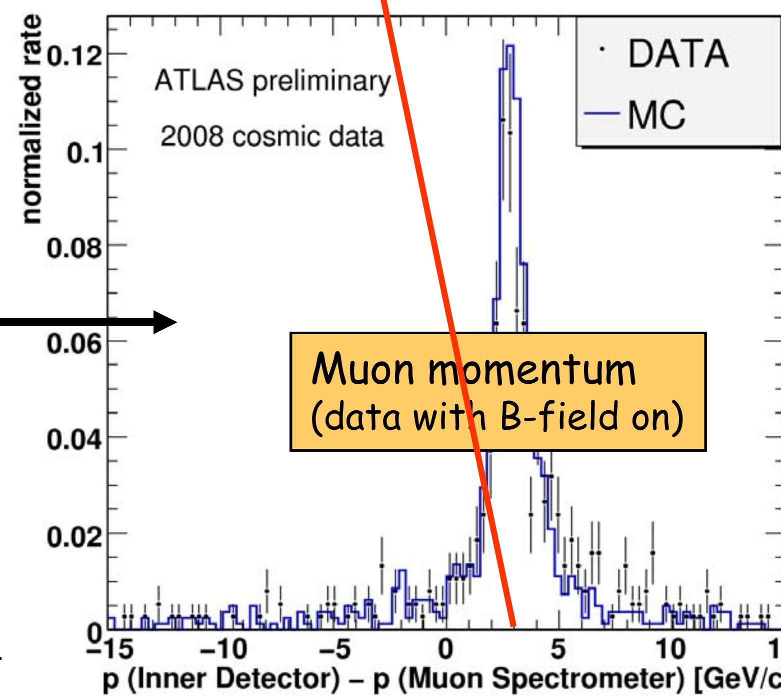
With initial calibration (final calibration will reduce the spread)

# Correlation between measurements in the Inner Detector and Muon Spectrometer



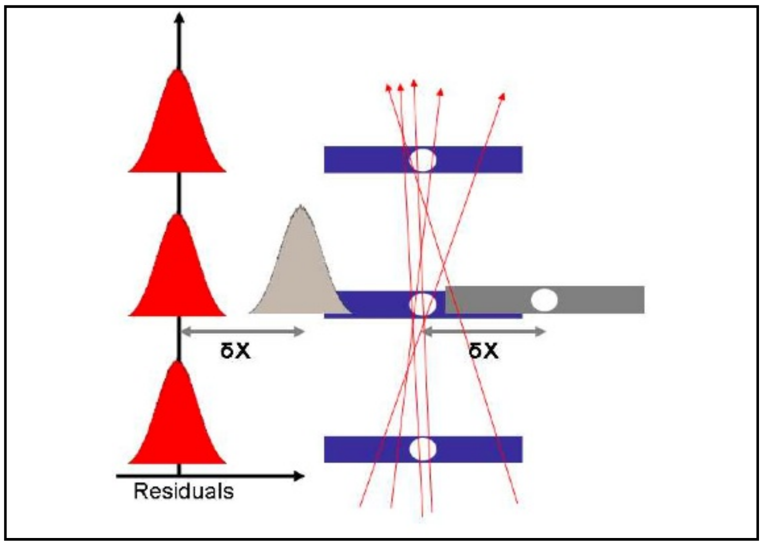




Difference between the muon momentum measured in the ID and in the MS for tracks in the bottom part of the detector (~ 3 GeV energy loss in the calorimeter)

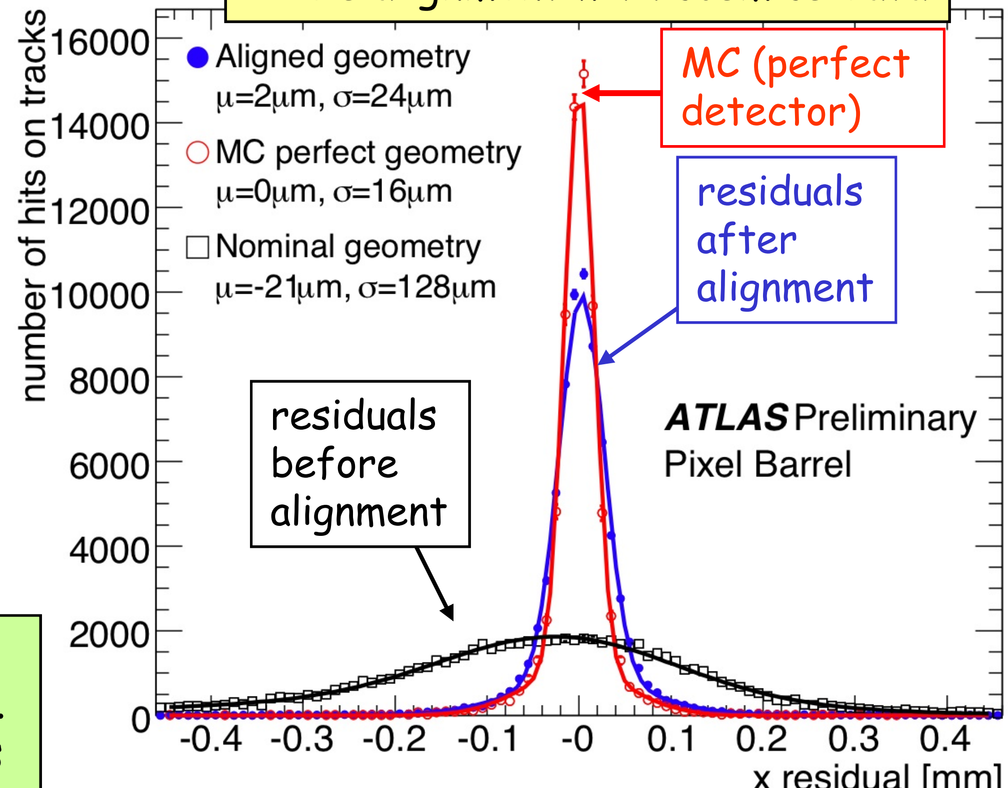


# Precision studies: alignment of the Inner Detector

The positions ("alignment") of the Pixels and SCT detector modules must be known to a few microns for a precise reconstruction of the track parameters
The detector alignment is performed using tracks (from cosmics now, pp collisions later) and an iterative procedure that minimizes the hit residuals globally
~ 36000 degrees of freedom: 6000 detector modules x 6 unknown (3 position coordinates + 3 rotation angles per module)




Pixels alignment with cosmics data



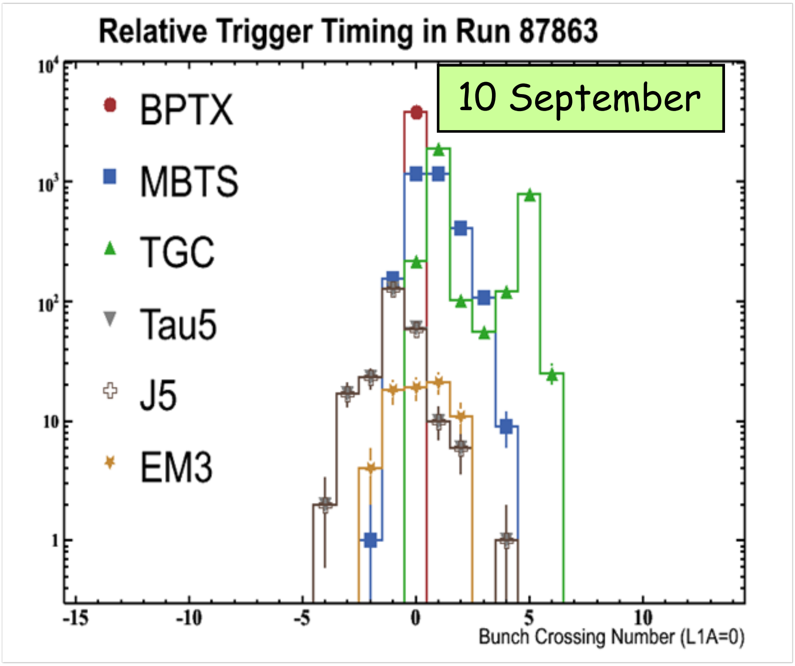

Residuals: distance between the fitted track and the hits in the individual layers. After alignment: distribution of residuals peaks at zero with σ compatible with detector resolution

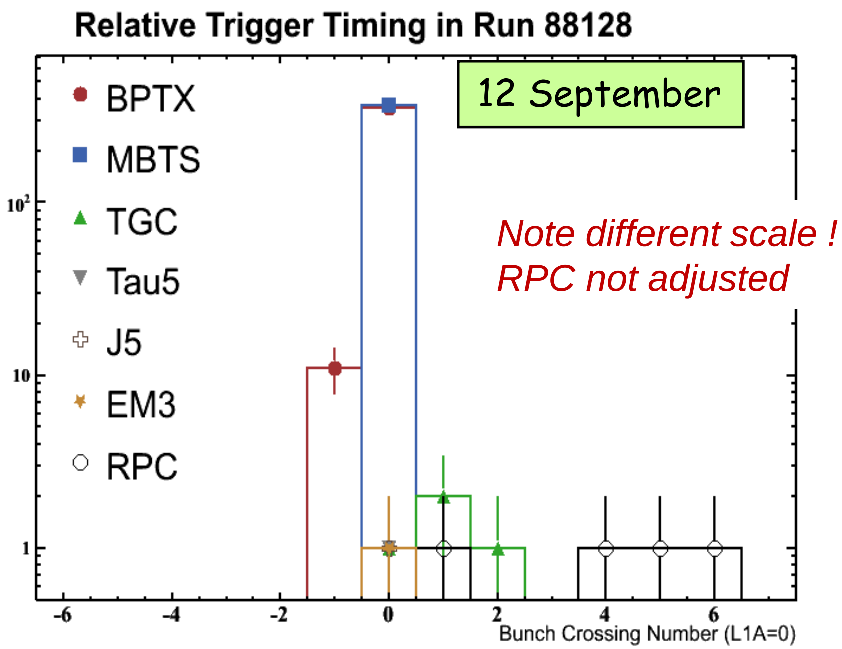
Achieved in best illuminated modules: 24 μm

# First beams September 10-12 very useful to synchronize the various sub-detectors, in particular to start timing-in the trigger

ATLAS preliminary

- Timing of the various components (sub-detectors, trigger system) synchronized with respect to beam pick-ups (BPTX) reference
- Signal times of various triggers adjusted to match the BPTX reference
- Plots show improvement from 10 September to 12 September




1 bunch crossing number = 25 ns

# Physics-related activities

# Organization of the Physics activities (sketch)

5 Combined Performance Working Groups

e/γ, Muon Combined, Tau, Jets/ETmiss, Flavour-tagging

8 Physics Working Groups

Standard Model, B-physics, top-physics, Higgs SUSY, Exotics, Heavy-ions, MC generators

2 conveners per WG, 2-year (staggered) term → 13 conveners replaced every year
(frequent rotation gives opportunities to young people)
Conveners of Combined Performance groups appointed by detector Project Leaders

**Physics Coordination (chair: Physics Coordinator)**
**Includes also representations from Trigger, Computing, Data Preparation**

Publication policy and procedure recently reviewed and adapted to data-taking phase.
Each analysis will have 2-3 reviewers (mixture of young and senior people; mixture of experts of that topic and people from Collaboration at large to bring broader view).
Reviewers will also be the core of the editorial board for that paper.
Two-fold advantage: scrutiny of each analysis from different perspectives; involvement of more and more people from the Collaboration at large in the physics activities

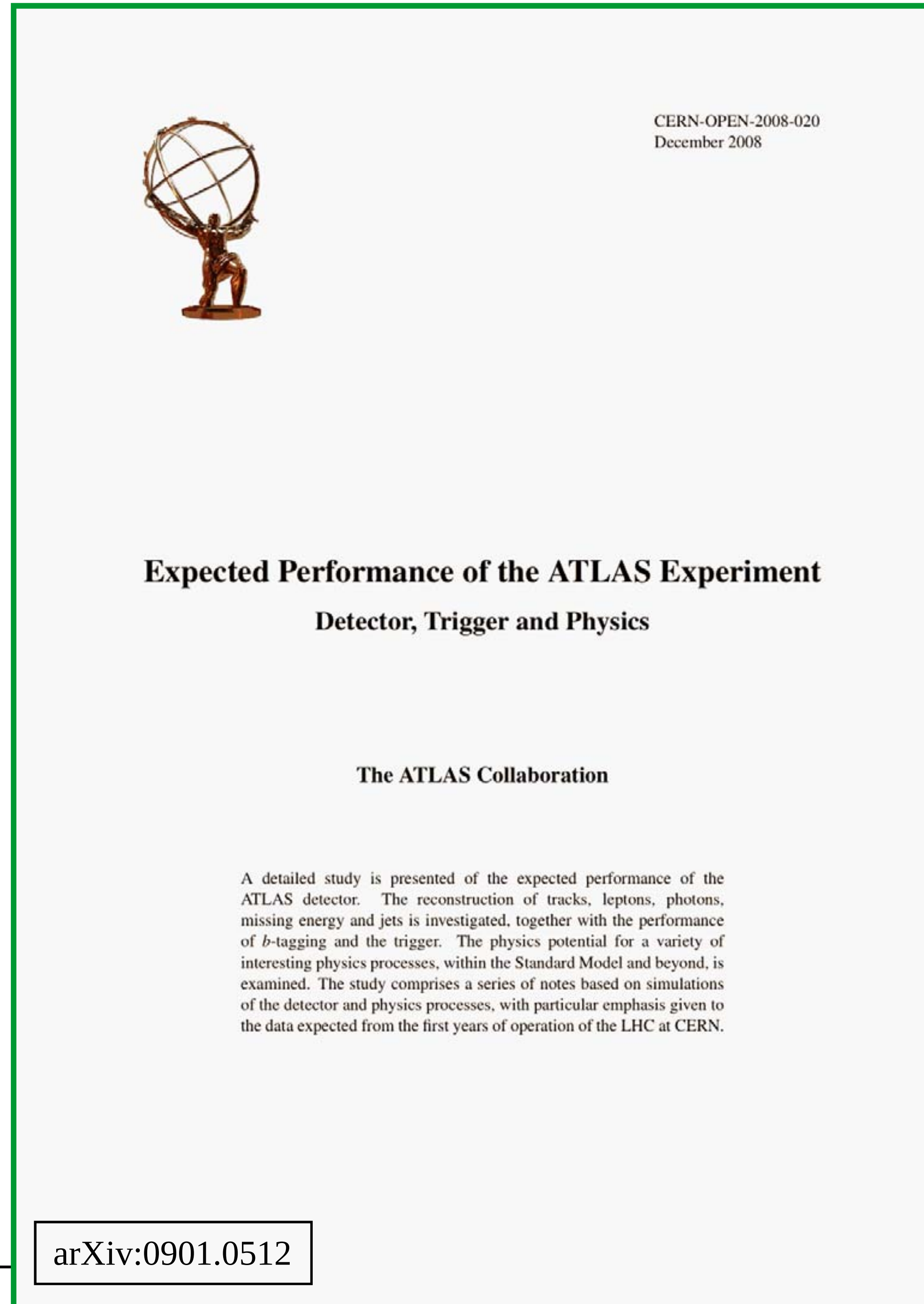
December 2008: "CSC book" (CSC=Computing and Software Commissioning) released

Most recent evaluation of expected detector performance and physics potential based on present software (Physics TDR in 1999 used old fortran software)

Huge effort of the community: ~2000 pages, collection of ~ 80 notes

Very useful reference for studies with LHC data

Exercised also internal review and editorial procedure in preparation for future physics papers



CERN-OPEN-2008-020
December 2008

# Expected Performance of the ATLAS Experiment

## Detector, Trigger and Physics

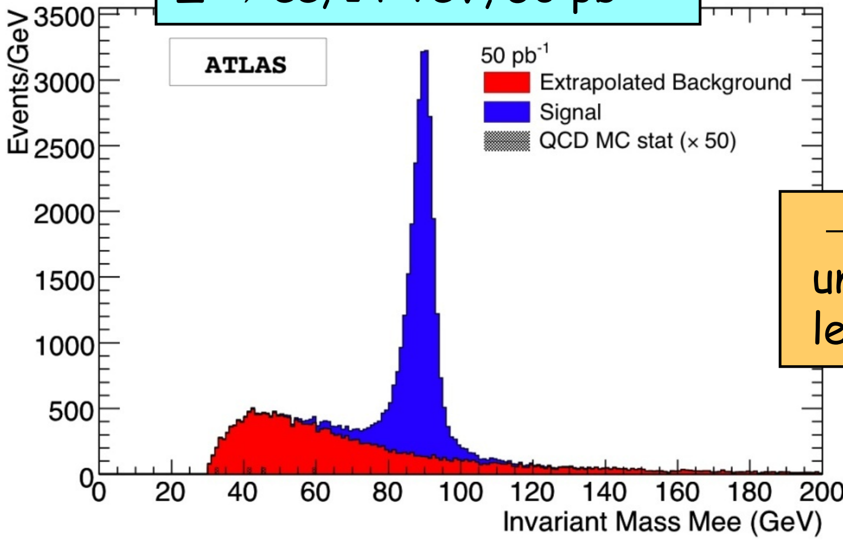
The ATLAS Collaboration

A detailed study is presented of the expected performance of the ATLAS detector. The reconstruction of tracks, leptons, photons, missing energy and jets is investigated, together with the performance of *b*-tagging and the trigger. The physics potential for a variety of interesting physics processes, within the Standard Model and beyond, is examined. The study comprises a series of notes based on simulations of the detector and physics processes, with particular emphasis given to the data expected from the first years of operation of the LHC at CERN.

arXiv:0901.0512

# Early "signals": J/ψ, W, Z, top, the so-called "candles"

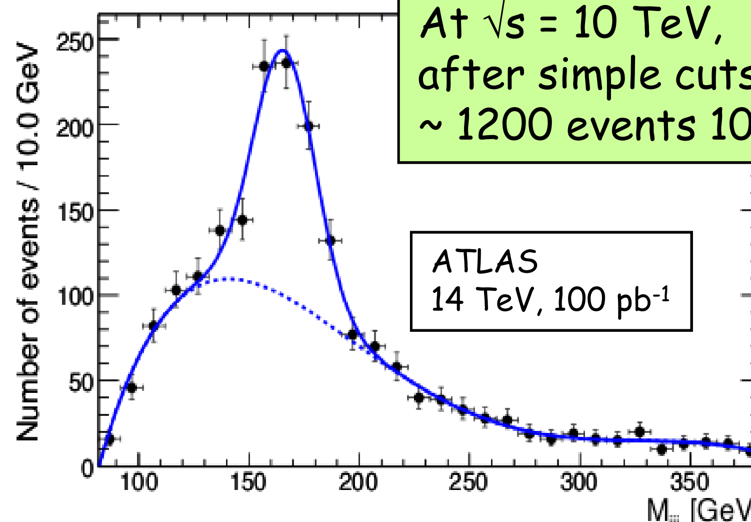
$Z \rightarrow ee$, 14 TeV, 50 $pb^{-1}$



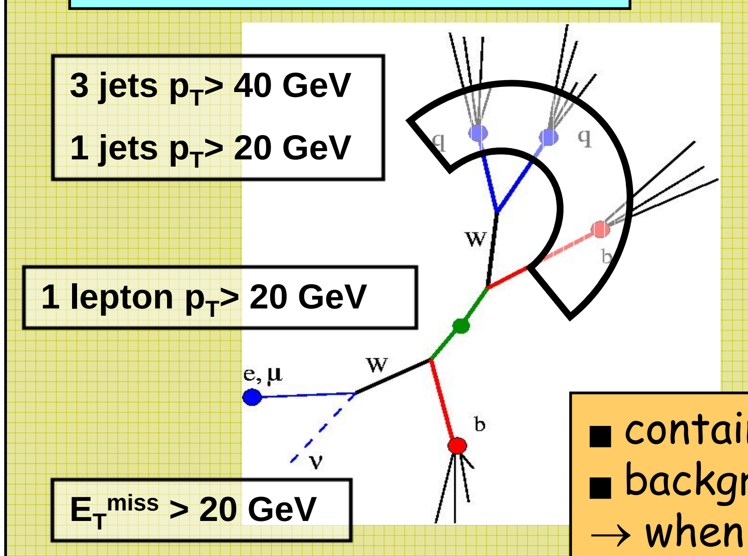

$\sqrt{s}$ = 10 TeV, after cuts:
~ 200 $Z \rightarrow ee, \mu\mu$ per day at L = $10^{31}$
~ 40000 events 50 $pb^{-1}$

→ Muon Spectrometer alignment, EM calo uniformity, energy/momentum scale of full detector, lepton trigger and reconstruction efficiency, …

At $\sqrt{s}$ = 10 TeV,
after simple cuts:
~ 1200 events 100 $pb^{-1}$




$t\bar{t} \rightarrow bW\,bW \rightarrow bl\nu\,bjj$




- contain most physics objects: leptons, jets, $E_T^{miss}$, b-jets
- background to ~ all searches

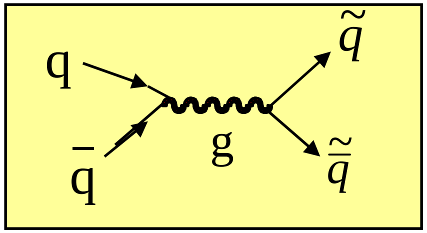
→ when top measured, experiment is ready for discovery phase

# First discoveries: Supersymmetry ?

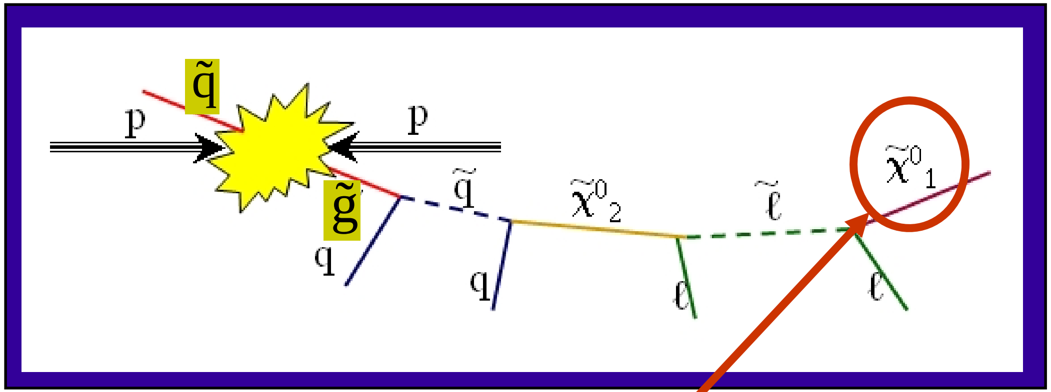
If it is at the TeV mass scale, it should be found "quickly" …. thanks to:

- Huge production rate for $\tilde{q}\tilde{q}, \tilde{g}\tilde{q}, \tilde{g}\tilde{g}$ production

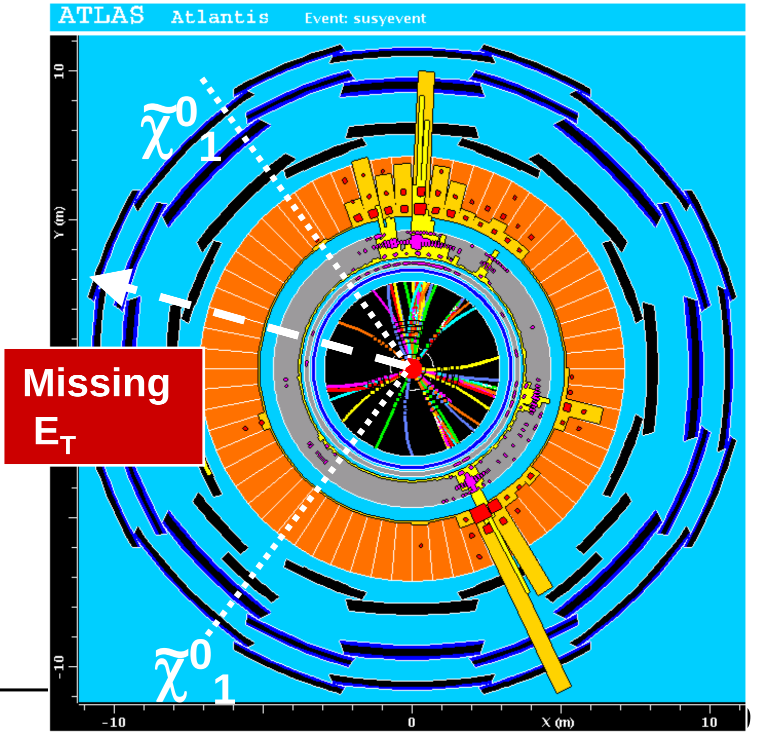
  For $m(\tilde{q},\tilde{g}) \sim 1$ TeV
  expect 1 event/day at $L=10^{31}$ $cm^{-2}$ $s^{-1}$




- Spectacular final states (many jets, leptons, missing transverse energy)

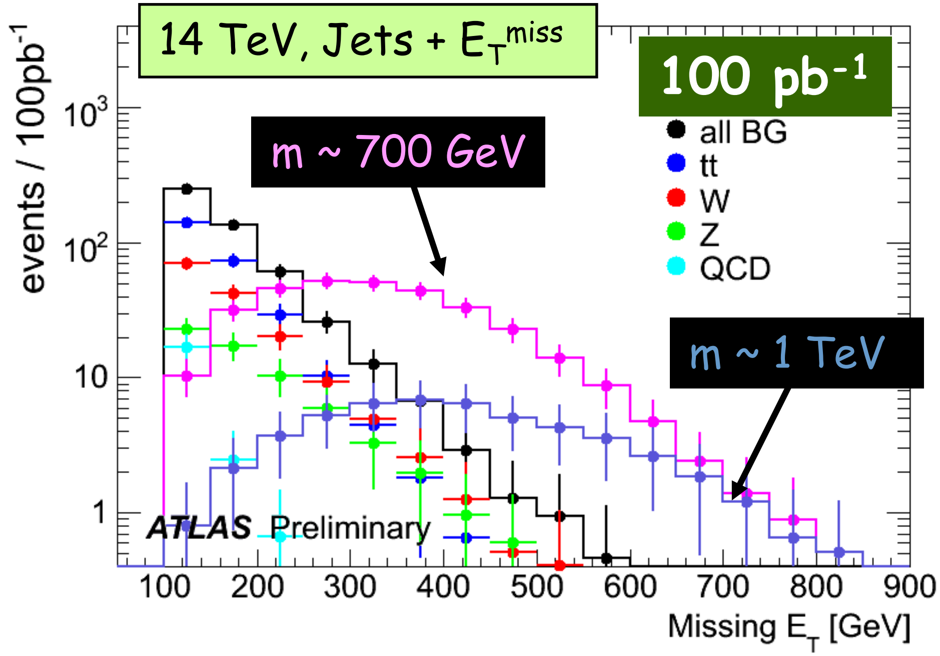



This particle (lightest neutralino) is stable, neutral and weakly interacting → escapes detection (like ν) → apparent missing energy in the final state



## LHC reach for gluino mass

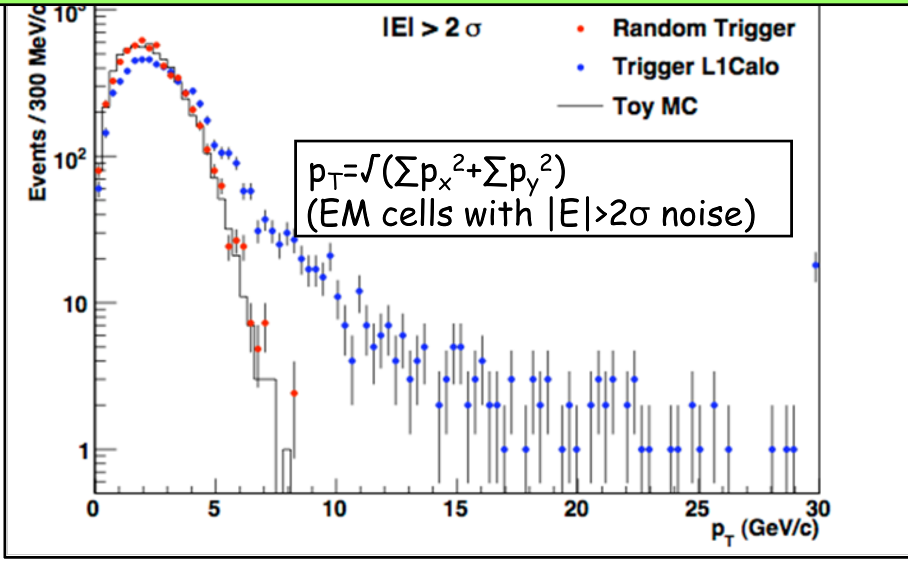
| ∫Ldt of well understood data | Discovery (95% C.L. exclusion) |
|---|---|
| 0.1-1 $fb^{-1}$ (2010-2011) | ~1.1 TeV (1.5 TeV) |
| ≥1 $fb^{-1}$ (≥2011) | ~1.7 TeV (2.2 TeV) |
| 300 $fb^{-1}$ (ultimate) | up to ~ 3 TeV |

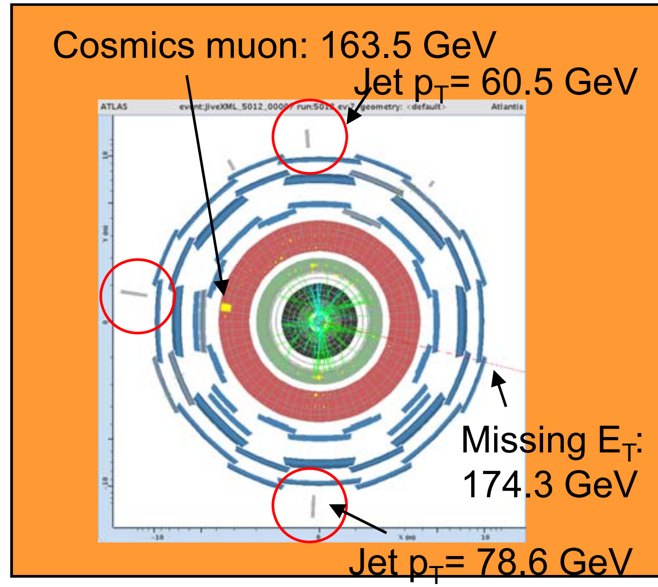



Hints up to m~1 TeV can show up with 100-200 $pb^{-1}$, but understanding the (tricky) backgrounds, in particular fake missing energy coming from instrumental effects, will take time

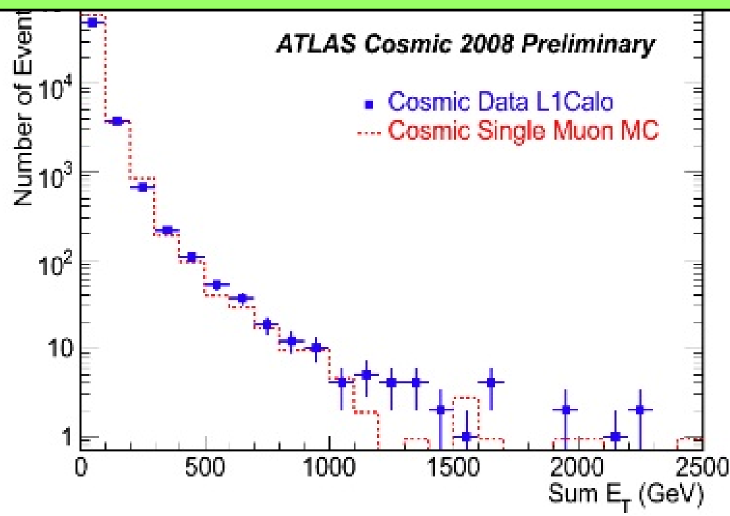
Background of fake missing energy from calorimeter noise and cosmics events being already studied with cosmics data

EM calorimeter noise distribution is as expected

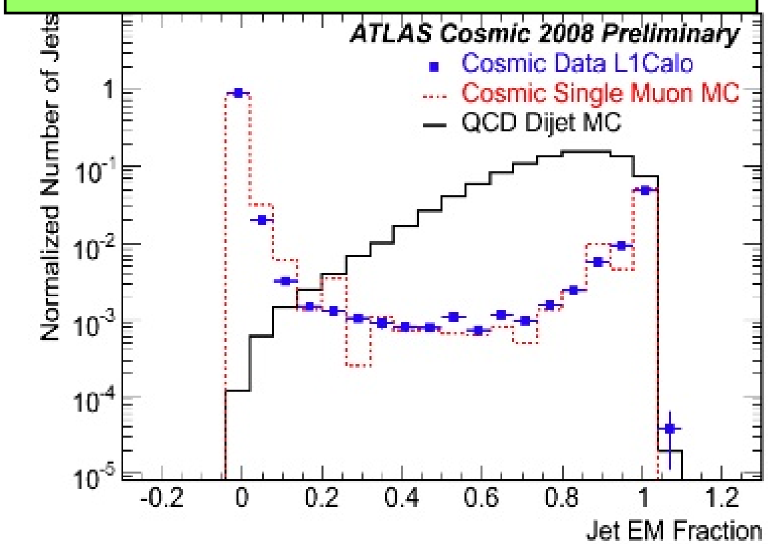



Total $E_T$ in calorimeters: comparison of cosmics data to simulation




Cosmics background rejection being studied with data



# Conclusions

The ATLAS experiment (from detector, trigger and data acquisition at the pit to data quality and calibration, data processing and world-wide distribution) has performed with high efficiency in 2008. More than 200M cosmics events were collected with the full detector operational, as well as single-beam data in Sept 2008.

Shut-down activities focused on repairs of few known problems and consolidation work. Expect to resume cosmics running in Summer 2009 with detector efficiency larger than 98% in most cases. Main concern for the 2009-2010 (long) run: long-term behaviour of "delicate" components: Inner Detector cooling, liquid-argon LVPS and front-end boards.

Software and Computing have demonstrated to be able to cope with massive simulations as well as real detector and real (cosmics) data, and with the complexity of a world-wide distributed system. They are also being consolidated.

Physics preparation is in full swing, both with simulated data and analysis of cosmics. Detailed trigger menus and strategies vs luminosity are being prepared. Approval procedure for physics results is also being exercised extensively.

A solid, coherent and well-tested organization of the experiment's activities is in place since a long time. System to scrutinize and assign Operation Tasks implemented.

Upgrade activities are ramping up and evolving from a collection of R&D activities to a coherent project, in order to prepare for a 20-year long (exciting !) physics program.

The project proceeded within the framework of the accepted 2002 Completion Plan. All resources requested in that framework are needed to cover the costs of the initial detector now installed.

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**ATLAS is very grateful to all Funding Agencies for their huge contributions to the success of the experiment and their continuous support during more than 15 years.**

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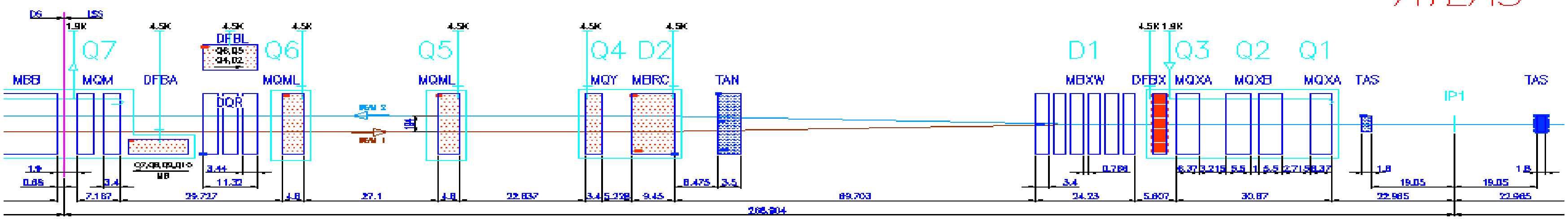
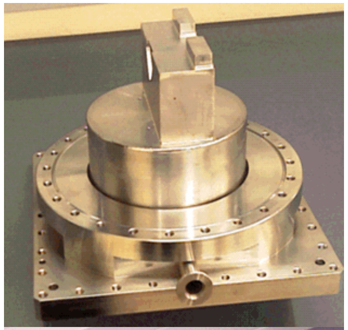
# Back-up

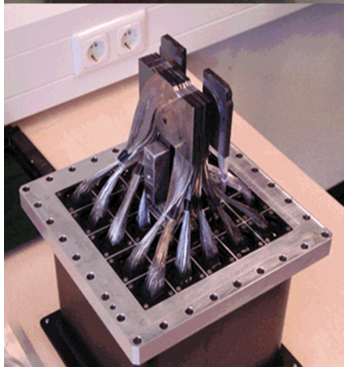
# Forward detectors

ATLAS

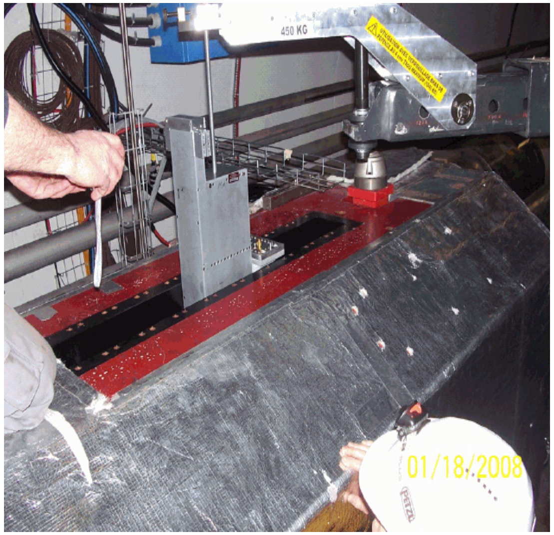



**ALFA at 240 m**



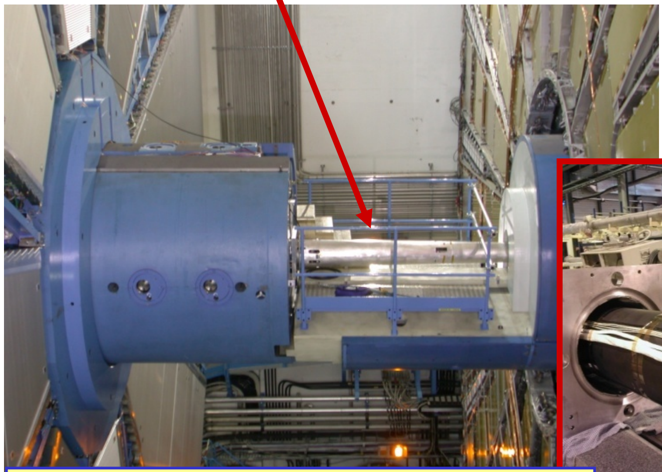


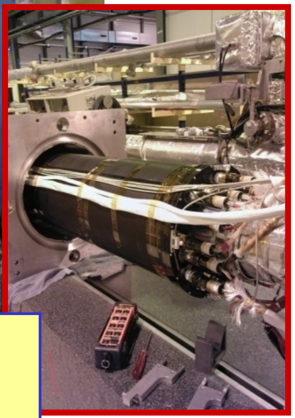
**ZDC at 140 m**




**Zero Degree Calorimeter**
(Data taking in 2009)

**LUCID at 17 m**

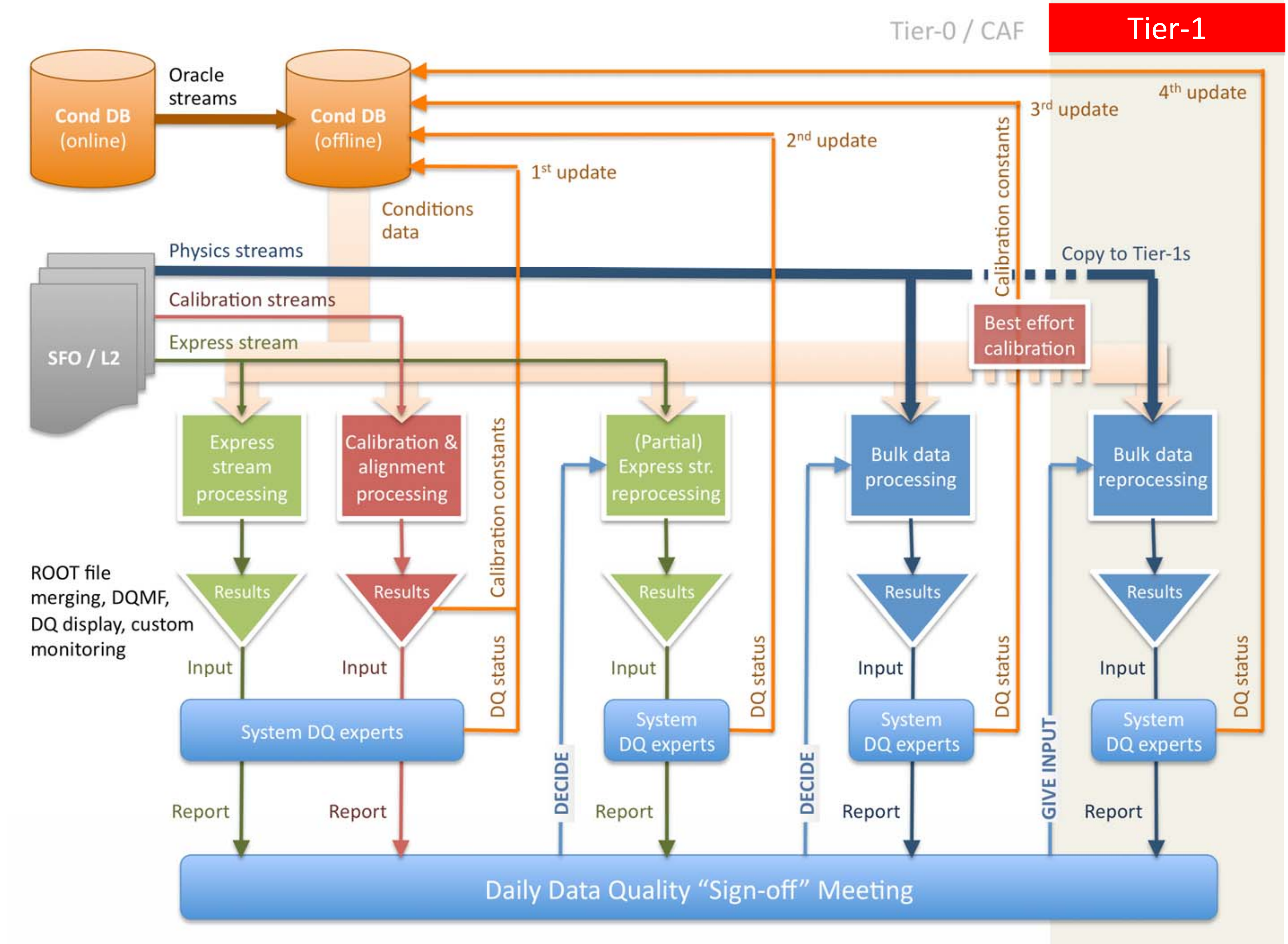




**Luminosity Cerenkov Integrating Detector**
(Phase 1 operational since 2008)

**ALFA: Absolute Luminosity for ATLAS**
(Installation in 2010)

**LoI for Forward Proton detectors at 220 and 420 m (AFP): ongoing ATLAS review**


Tier-0 / CAF
Tier-1
Cond DB
(online)
Oracle
streams
Cond DB
(offline)
4th update
3rd update
2nd update
1st update
Conditions
data
Calibration constants
Physics streams
Copy to Tier-1s
SFO / L2
Calibration streams
Express stream
Best effort
calibration
Express
stream
processing
Calibration &
alignment
processing
Calibration constants
(Partial)
Express str.
reprocessing
Bulk data
processing
Bulk data
reprocessing
ROOT file
merging, DQMF,
DQ display, custom
monitoring
Results
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Input
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DQ status
DQ status
DQ status
DQ status
System DQ experts
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System
DQ experts
DECIDE
DECIDE
GIVE INPUT
Report
Report
Report
Report
Report
Daily Data Quality "Sign-off" Meeting