Operation of the ATLAS Detector with First 7 TeV Collisions

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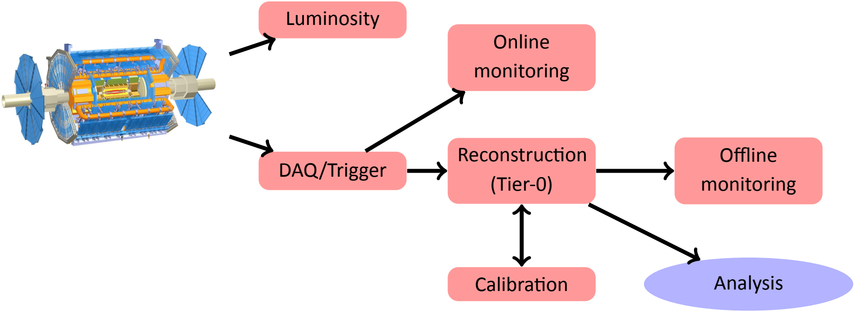
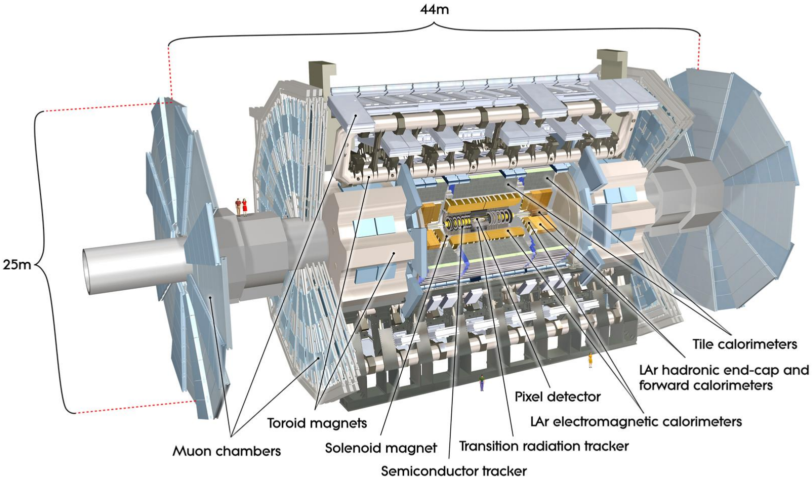
for the ATLAS Collaboration

ICHEP 2010, Paris

Topics

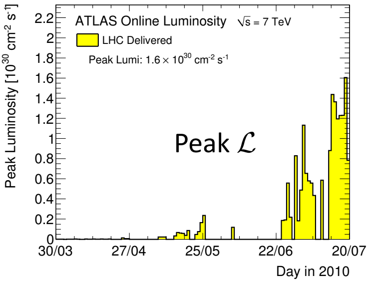

Luminosity
Online monitoring
DAQ/Trigger
Reconstruction (Tier-0)
Offline monitoring
Calibration
Analysis

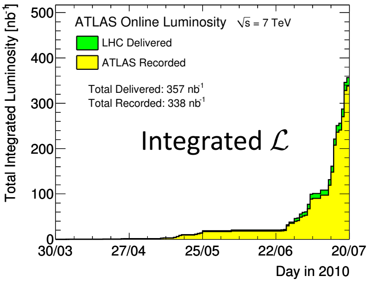
ATLAS



Not shown: forward detectors (see later)

Luminosity Profile

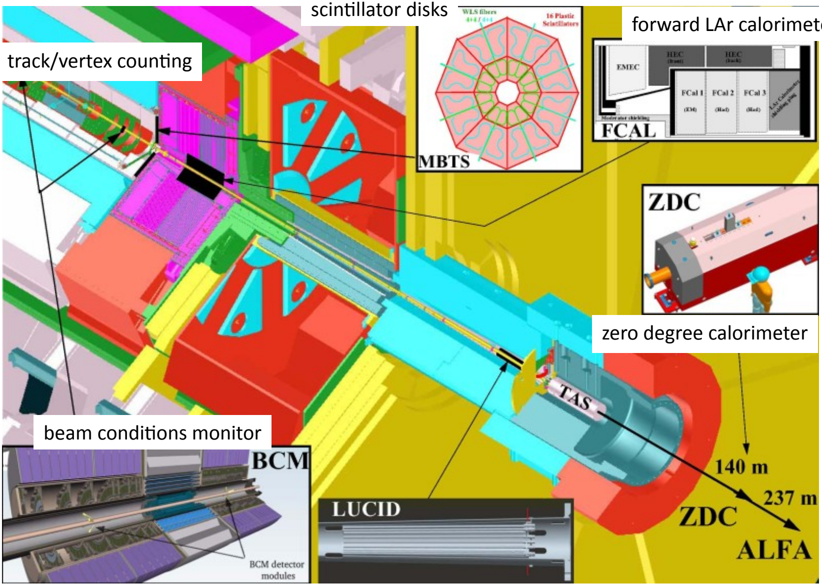




As of July 19:

- 357 nb^{-1} stable beam delivered
- 338 nb^{-1} recorded in full configuration
- Peak lumi 1.6×10^{30} cm^{-2} s^{-1}

Subdetectors Used For Luminosity

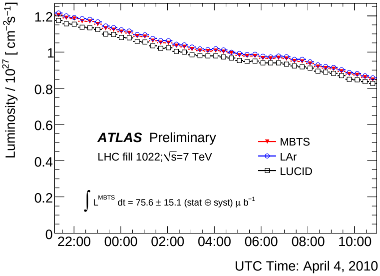


gas Cherenkov tubes

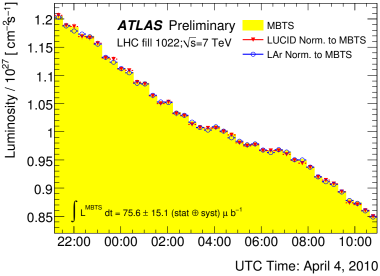
Luminosity Normalization — Monte Carlo

- For 900 GeV runs and early 7 TeV data used cross-sections and normalization from Monte Carlo
  - Uncertainty 20% dominated by MC cross-section

independent normalizations from MC



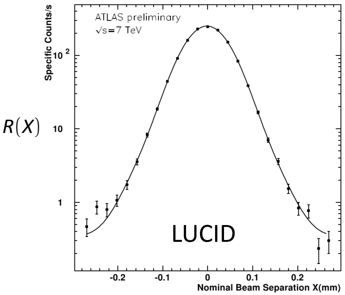
normalized to MBTS



Luminosity Normalization — van der Meer scans

- LHC provided three van der Meer scans
  - beams separated by known distances & interaction rate measured
  - measured transverse beam profile gives normalization from geometry
- Luminosity normalization now known to **11%**
  - Largest uncertainty from LHC beam current measurement (5% per beam)

Poster: *David Miller*



$$\mathcal{L} = \frac{n_b f_r I_1 I_2}{2\pi \Sigma_x \Sigma_y}$$

→ n_b: number of bunches

→ f_r: revolution frequency

→ $I_{(1,2)}$: particles per bunch in beams 1, 2

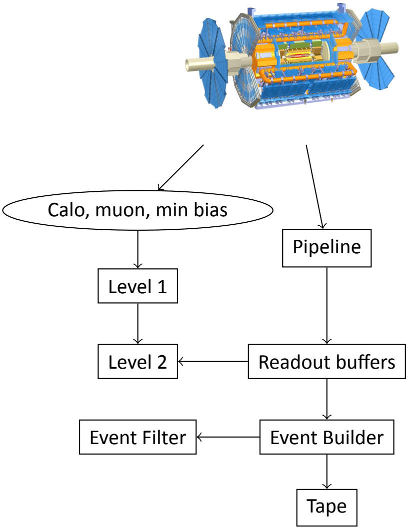
→ $\Sigma_{(x,y)}$: effective convolved width in x, y $= \int R(X)\, dX / (\sqrt{2\pi}\, R_{peak})$

Detector Operational Channels

Subdetector	# of Channels	Fraction operational
Pixels	80 M	97.4%
SCT Silicon Strips	6.3 M	99.2%
TRT Transition Radiation Tracker	350 k	98.0%
LAr EM Calorimeter	170 k	98.5%
Tile calorimeter	9800	97.3%
Hadronic endcap LAr calorimeter	5600	99.9%
Forward LAr calorimeter	3500	100%
LVL1 Calo trigger	7160	99.9%
LVL1 Muon RPC trigger	370 k	99.5%
LVL1 Muon TGC trigger	320 k	100%
MDT Muon Drift Tubes	350 k	99.7%
CSC Cathode Strip Chambers	31 k	98.5%
RPC Barrel Muon Chambers	370 k	97.0%
TGC Endcap Muon Chambers	320 k	98.6%

$>$ 97% of channels operational for all subdetectors

DAQ/Trigger



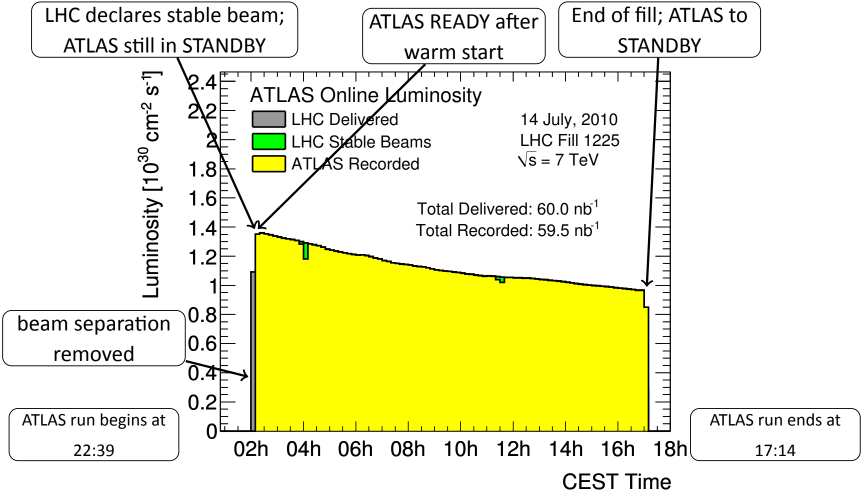
Rates

Eventual	**Typical***
75 kHz	2-3 kHz
$\sim$ 3 kHz	0.7–1 kHz
200 Hz	200 Hz

* = Physics menu, highest $\mathcal{L}$ run

1/3 of final L2+EF farm capacity installed

DAQ In An Example (Recent) Run



Luminosity-weighted DAQ efficiency for 7 TeV data: 97.2%

DAQ

- Event size is at target $\sim$ 1.6 MB/event
- Level 2 output is near design output rate (reached 2.5 kHz, design $>$ 3 kHz — full set of computing nodes not yet deployed)
- Event Filter (final trigger output) has surpassed design output rate (200 Hz)
  - The Tier-0 reconstruction farm processes 200 Hz successfully
- Techniques implemented to maintain high efficiency
  - "Stopless" removal/recovery: parts of readout can be dropped during run if causing problems, and reincluded when fixed
  - Automatic resynchronization to LHC clock
  - Silicon and muon detectors kept in intermediate standby state until stable beams declared ("warm start"): shortens ramp time without compromising safety
  - "Expert system" recognizes error/configuration conditions and takes appropriate action

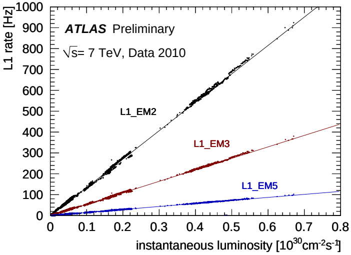
Trigger

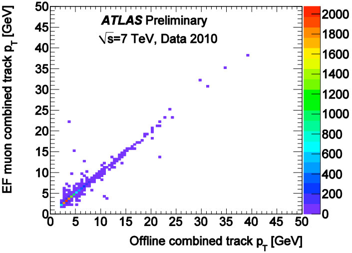
Talks: *John Baines, Simon George*

ATLAS separates Level 1 trigger (hardware) from High Level Trigger (software).

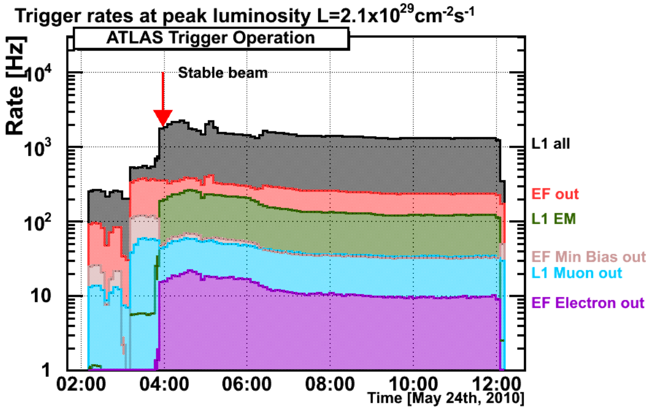
HLT operation was phased in:

- For brief initial period HLT did not run any algorithms on events
- Very quickly HLT algorithms began to run, but did not reject any events (events were just tagged with whether they passed triggers or not). Minimum bias rate handled via prescales.
- For recent higher luminosity ($> 10^{29}$) some HLT triggers are now in rejection mode
- Physics menu was deployed at 1.6×10^{30} cm^{-2} s^{-1}



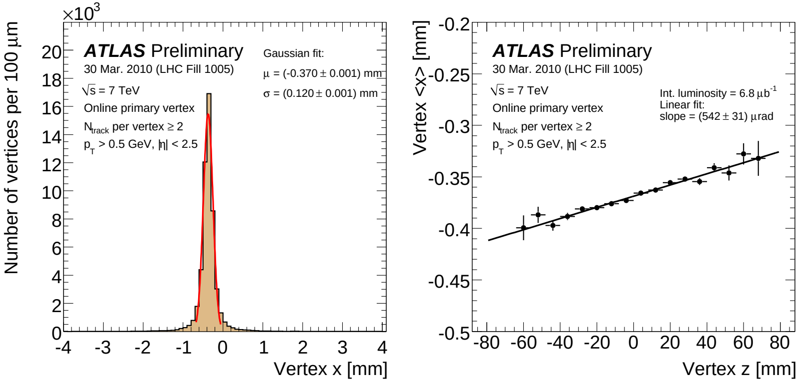


Trigger Operation



- Trigger configuration change after stable beams visible
- L1 EM rates would saturate recorded bandwidth; therefore improve rejection by using EF algorithms

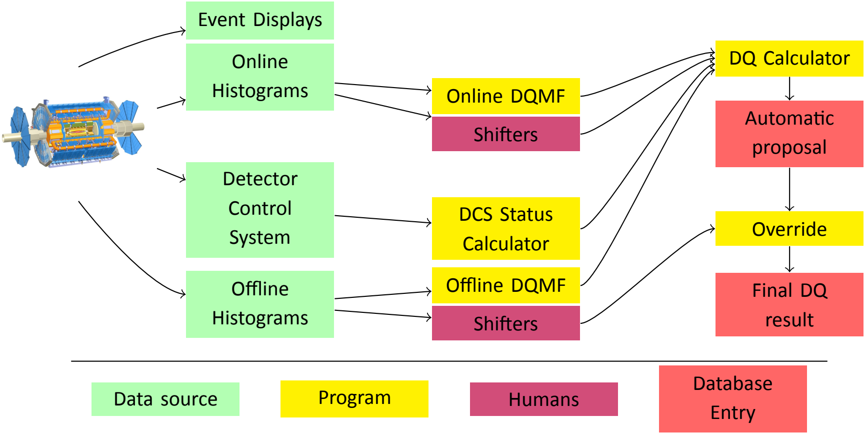
Monitoring in HLT



Trigger monitoring is important part of monitoring chain

- e.g. can determine beamspot parameters online in high level trigger — will feed this back to displaced vertex triggers

Monitoring/Data Quality Flow



Online Monitoring

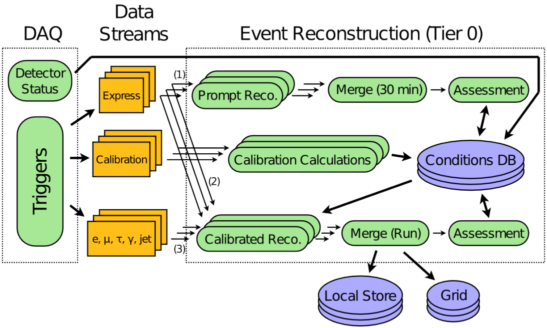
Many tools for online monitoring:

- Detector Control System and LHC interface tools
- An extensive suite of trigger rate monitoring tools
- Several event analysis frameworks provide histograms
  - Raw data fragments
  - HLT monitoring
  - Full event reconstruction (also feeds event displays)
- Selected histograms are analyzed and flagged good/caution/bad automatically
- Histograms archived at end of run

Systems are distributed programs, makes overall system more robust

Developing/improving remote monitoring tools

Reconstruction, Calibration, Distribution



Full cycle (first reconstruction pass, calibration, second reconstruction pass, data quality assessment) generally complete in 3–4 days

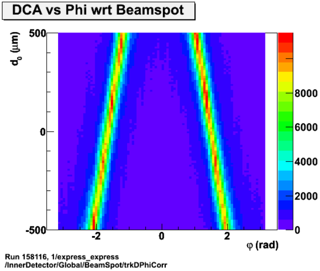
Poster: *Michael Boehler;* **Talk:** *Graeme Stewart*

Calibration Loop

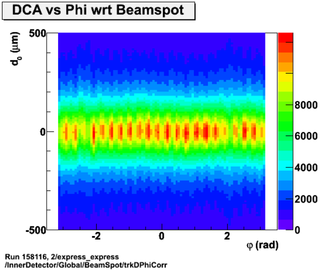
- Calibration occurs immediately after prompt reconstruction of express data (finished within hours after a run ends) and before "bulk" reconstruction of all events ($\sim$ 36 hours after run ends)
- Typical updates:
  - Beamspot (determined on $\sim$ 10 minute intervals)
  - Calorimeter hot channels, noise distributions
  - Straw tube t_0 and distance-time relations
  - Silicon noise masks
- Muon detectors will join at higher luminosity

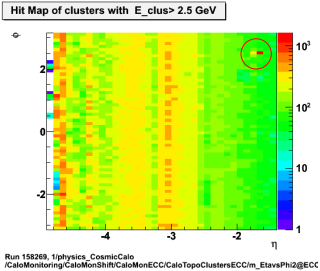
Impact of Calibration Loop

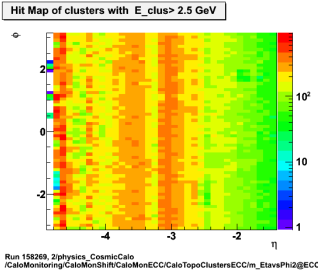
Before



After







Data Quality

- Input to data quality decisions comes from shifters, slow control information, and automated tests on distributions
- Preliminary DQ decision within 36 hours, finalization of decisions for initial Tier-0 processing within 92 hours of data taking
- Good interaction with calibration loop

Inner Tracking Detectors			Calorimeters				Muon Detectors			
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	TGC	CSC
97.1	98.2	100	93.8	98.8	99.1	100	97.9	96.1	98.1	97.4

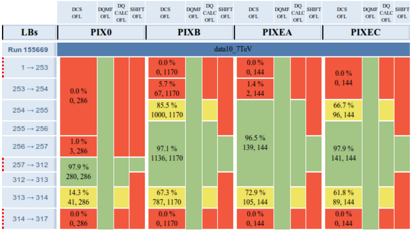
Luminosity weighted relative detector uptime and good quality data delivery during 2010 stable beams at $\sqrt{s}$=7 TeV between March 30th and July 16th (in %)

Poster: *Peter Waller*

DQ Complications

Quality of ATLAS data can change significantly during a run. . .

- Standby/Ready transition
- Power supply trips
- Coherent noise bursts
- Removal/readdition of fractions of the detector



DQ evaluated with luminosity block granularity ($\sim$ 2 minutes)

Conclusion

- ATLAS has begun its 7 TeV data taking very successfully
  - During LHC stable beams, DAQ efficiency of $\sim$ 97% and good data efficiency of $\sim$ 94%
- Commissioning of all essential data-taking systems proceeding well
- Fast monitoring and calibration provides high-quality data for analysis