ATLAS Status Report

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124th Open LHCC Session

December 2nd 2015

Outline:

- Short status on measurements and searches
- Wrap up of 2015 Operations and data taking
- Detector status and performance
- Year End Technical Stop and 2016 preparations

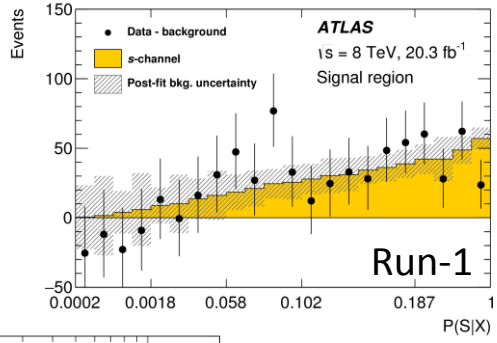
Run 1 and first Run 2 Measurements

Run 1 a Harvest of results: 487 Papers Submitted

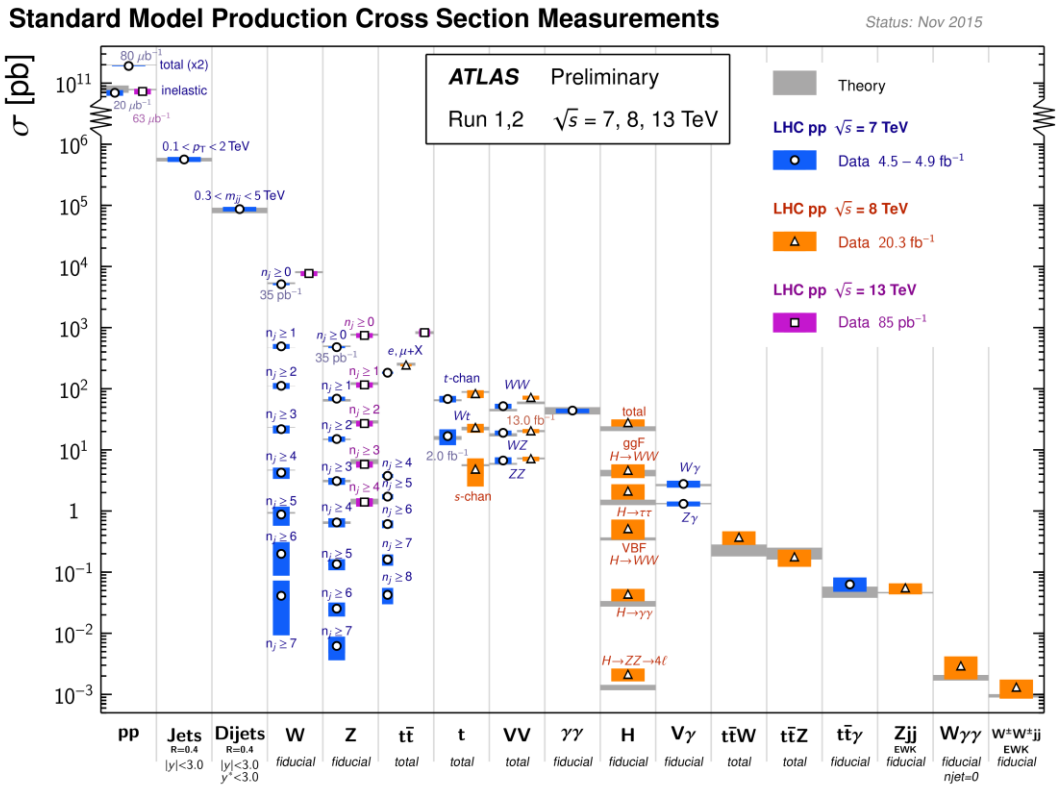
Run 2 fantastic start: 1 Paper submitted and 15 CONF Notes

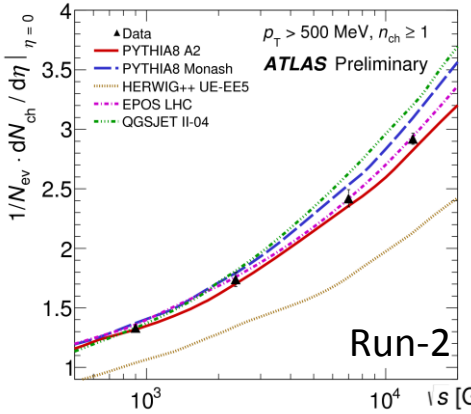
Many more new and updated measurement and search results with the full 2015 dataset are expected in 2 weeks time

Evidence for s-channel single top quark production

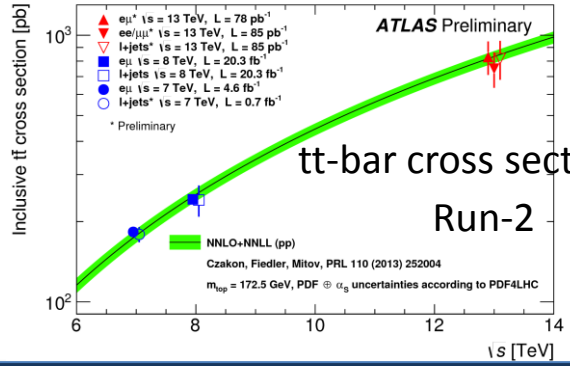


Measurement results with up to O(80) pb^{-1} of Run 2 13 TeV Data





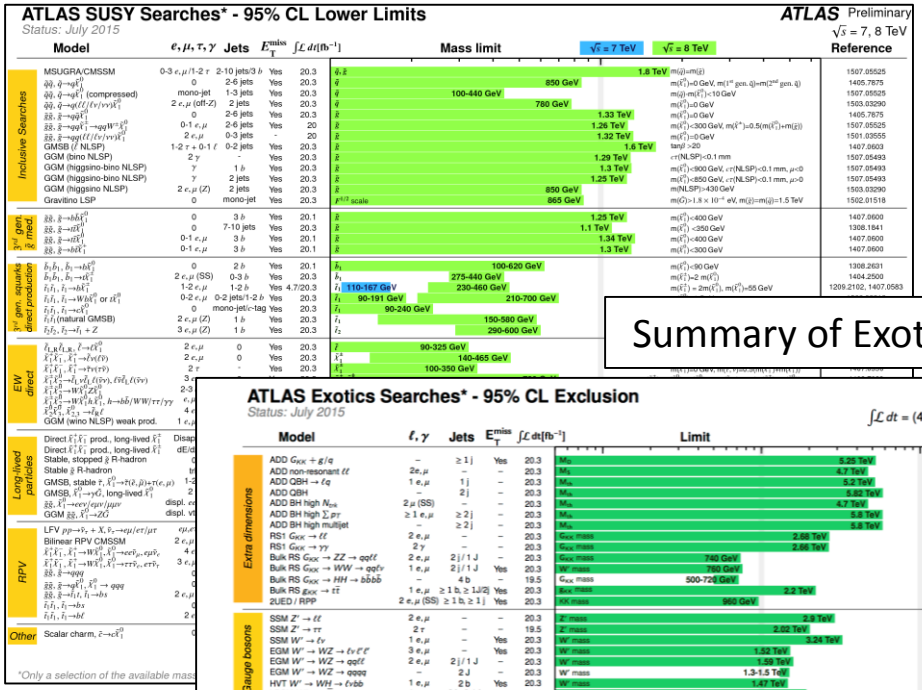
Minimum bias at different √s



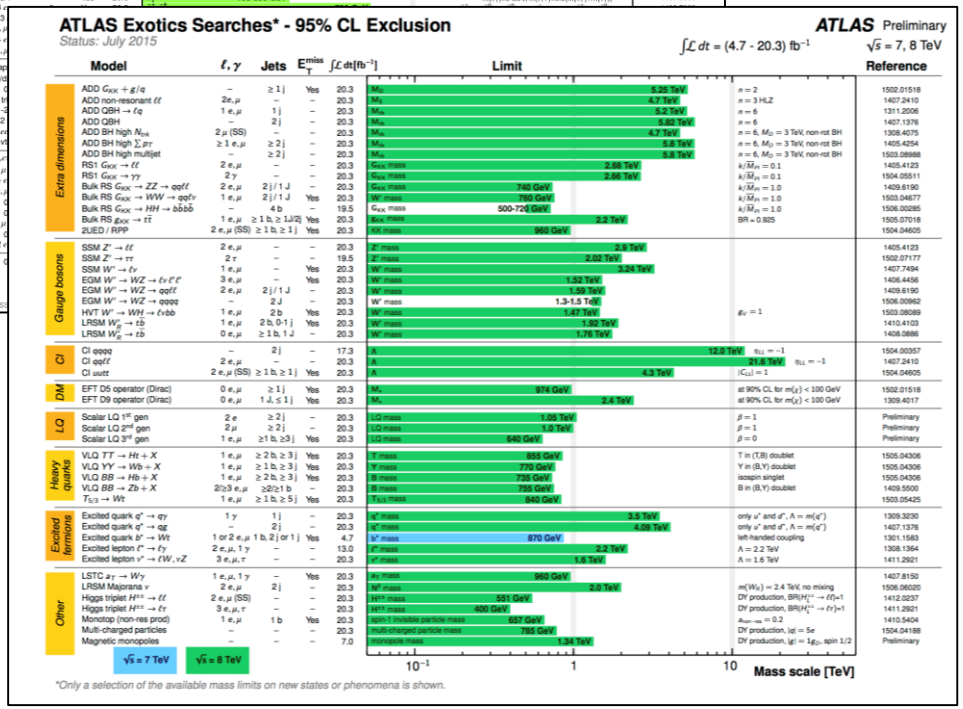
tt-bar cross section

Run 1 and first Run 2 Searches

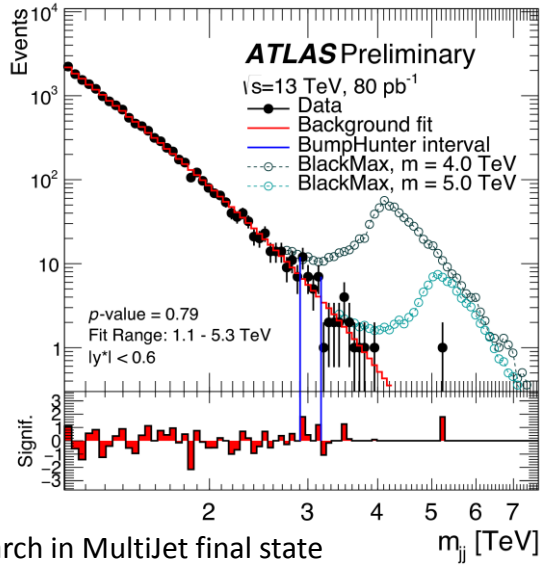
Summary of SUSY Searches



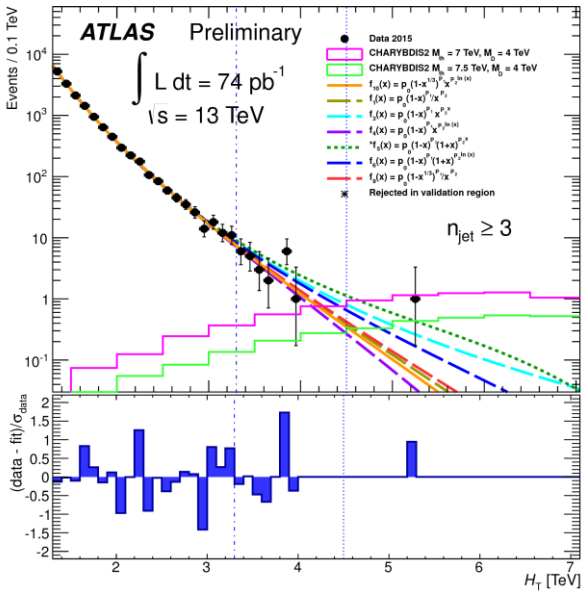
Summary of Exotic Searches



Search for dijet resonance (and non resonant production) ATLAS-CONF-2015-042



Search in MultiJet final state ATLAS-CONF-2015-043



… Many more searches (e.g. w/ Higgs and unconventional signatures)

Run 1 and first Run 2 Searches

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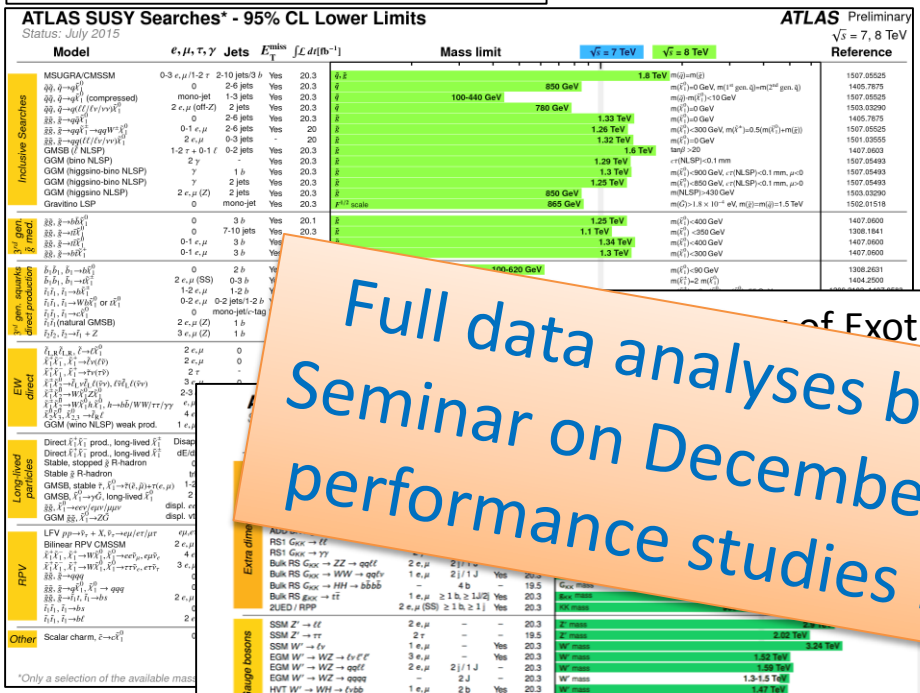

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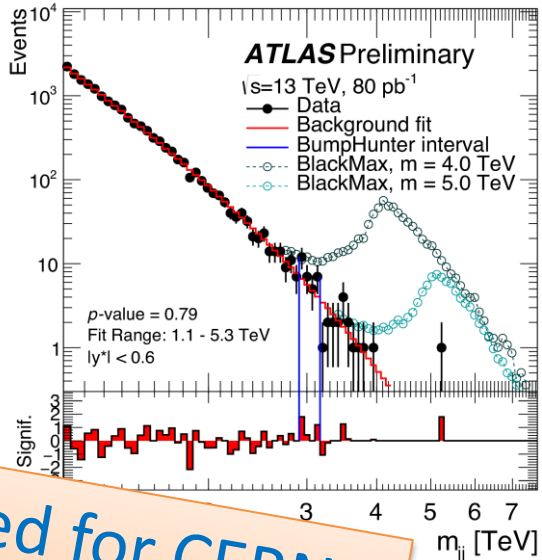
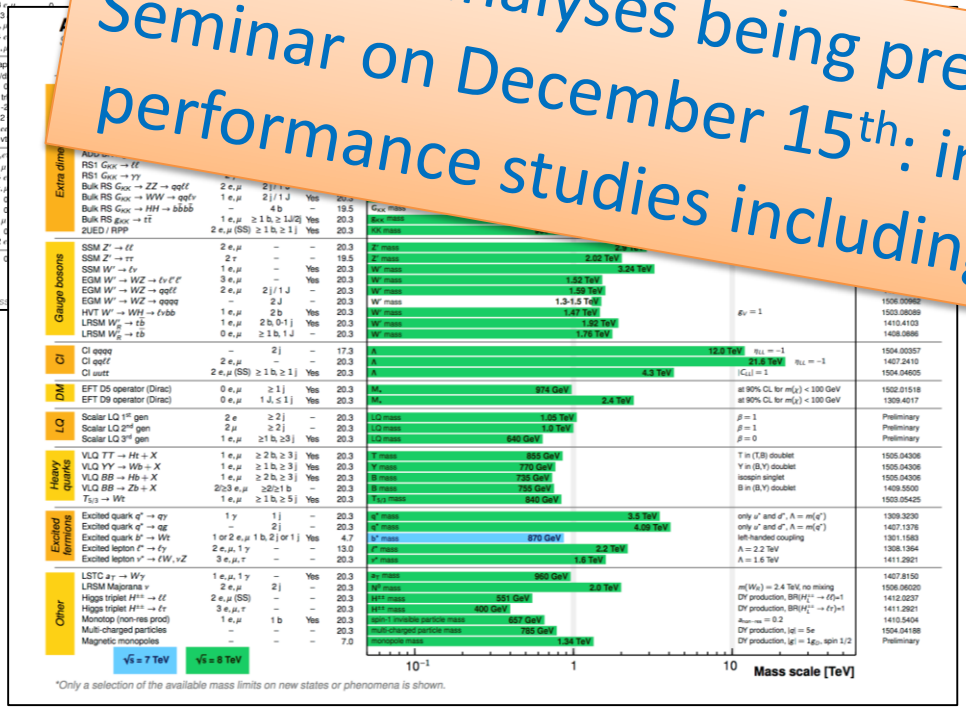
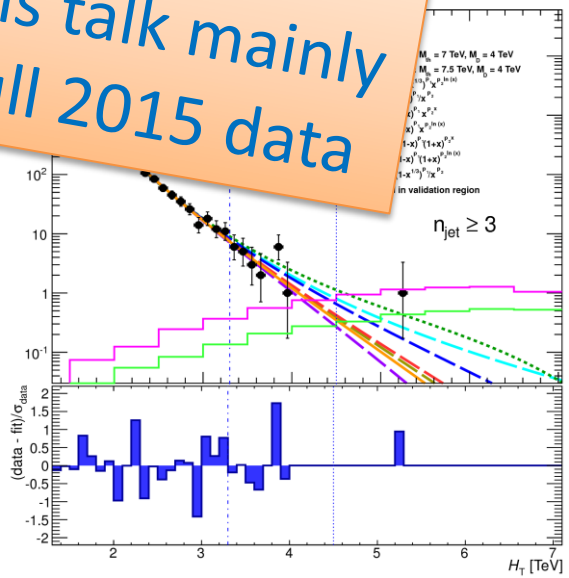


Full data analyses being prepared for CERN Seminar on December 15th: in this talk mainly performance studies including full 2015 data

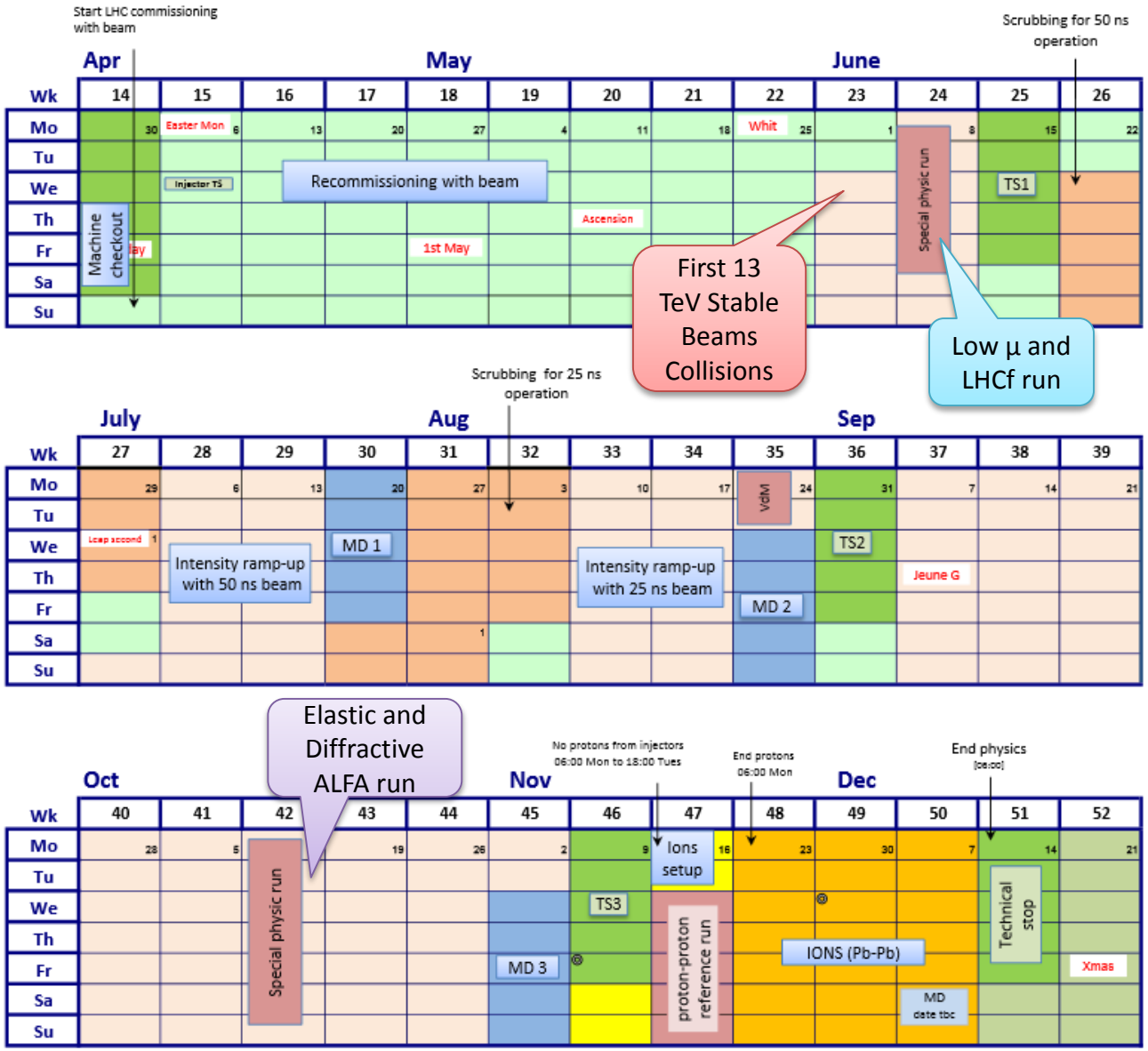




… Many more searches (e.g. w/ Higgs and unconventional signatures)

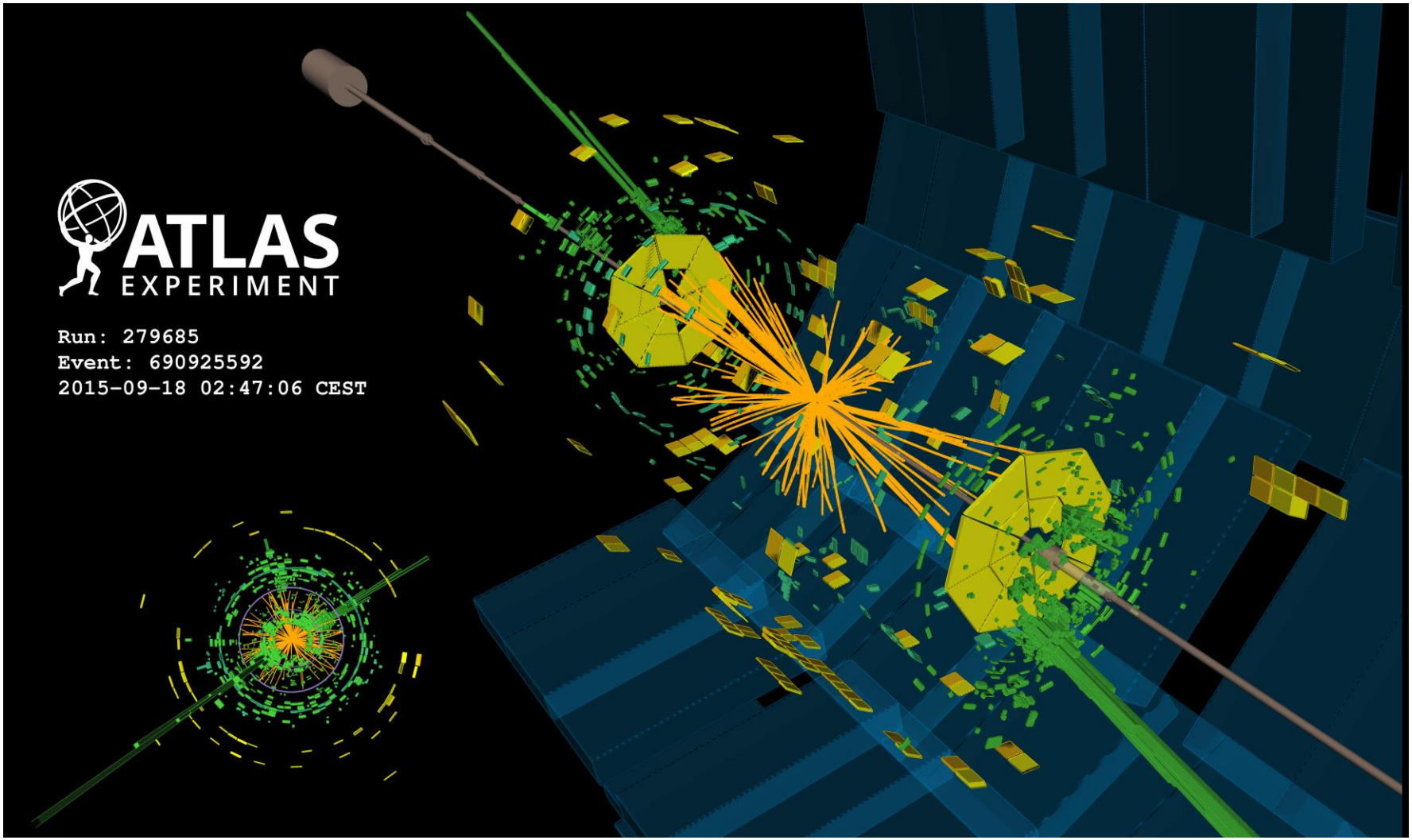
LHC in 2015

- Very rich and eventful period with diverse running conditions
  - 13 TeV
  - From few up to 2400 bunches
  - 50 ns, 25 ns, intensity ramp up
  - Limits on trigger rate for partially filled machine to avoid fixed frequencies (wire bond resonances on silicon detectors)
- Special Runs:
  - low pileup runs,
  - special combined trigger/running with LHCf
  - elastic and diffractive running with ALFA roman pots
- pp reference 5.02 TeV center of mass energy
- Heavy Ions 6.37*Z TeV



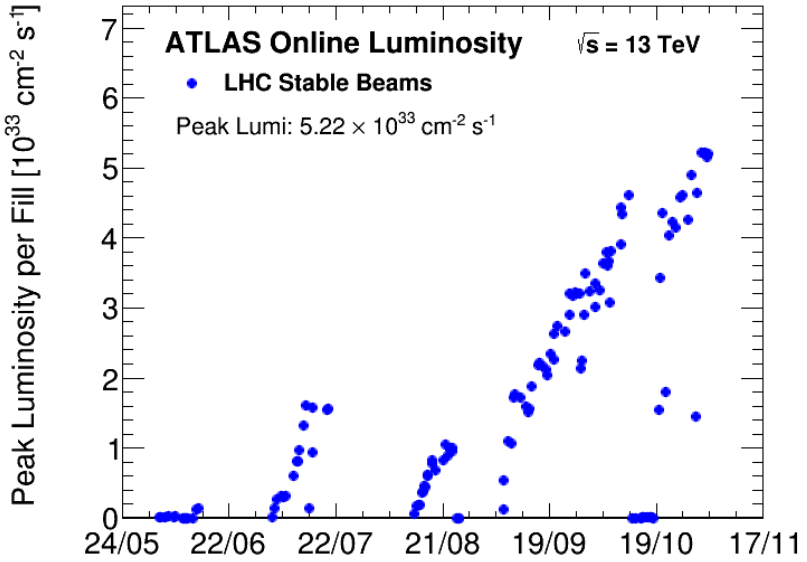
End of 13 TeV Run

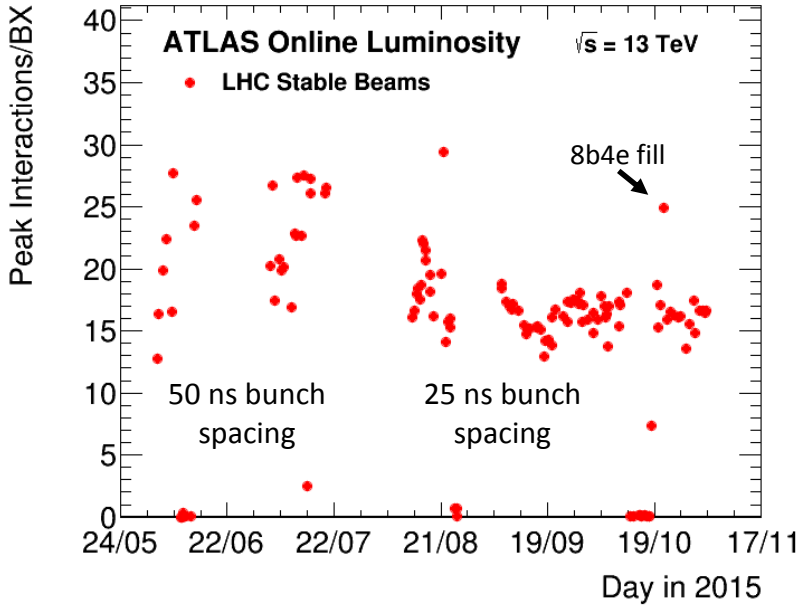
Unprecedented Centre of Mass Energy

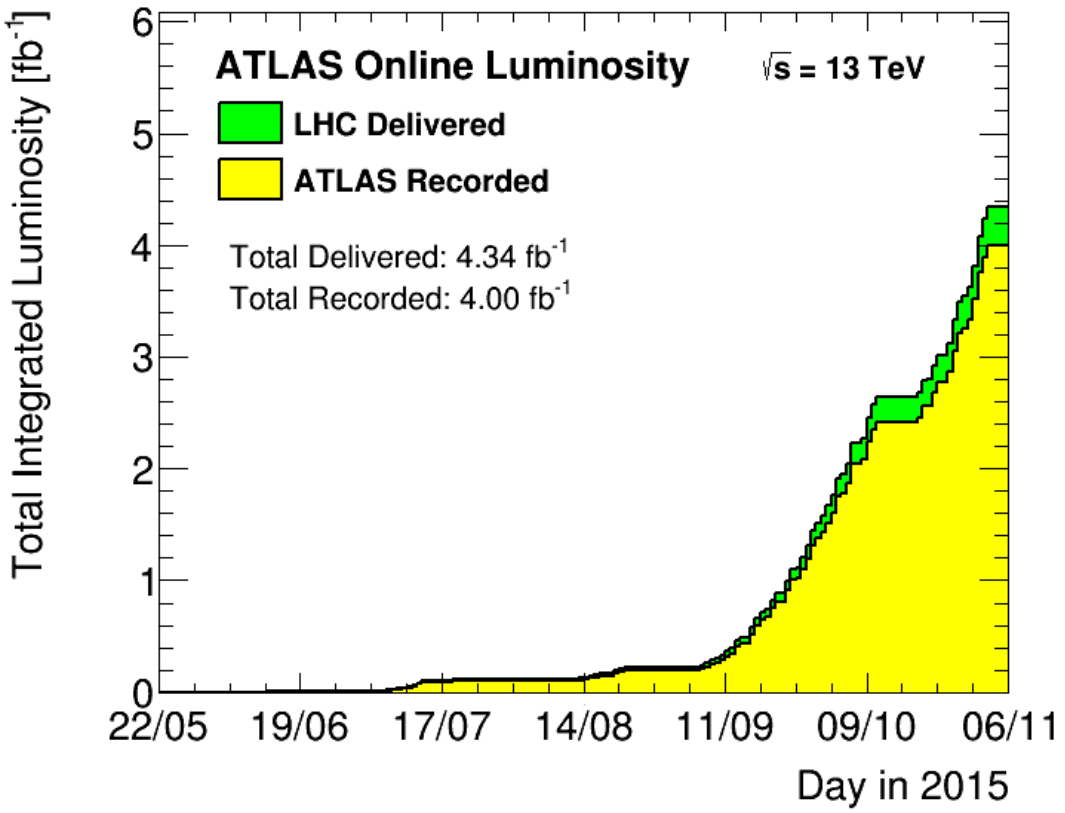


A high-mass dijet event collected by ATLAS in September, 2015. The two central high-p_T jets have an invariant mass of 8.8 TeV, the highest-p_T jet has a p_T of 810 GeV, and the sub-leading jet has a p_T of 750 GeV. The missing transverse energy for this event in 60 GeV.

pp run at 13 TeV



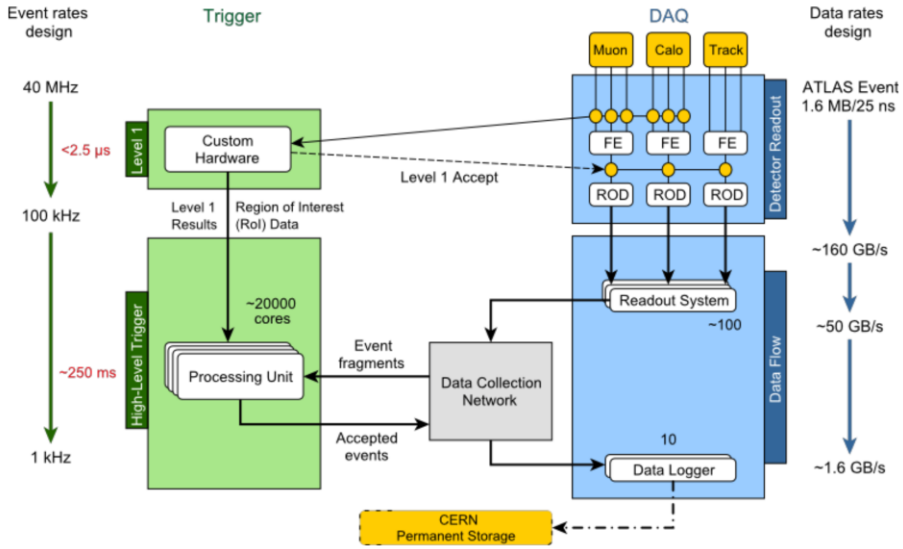




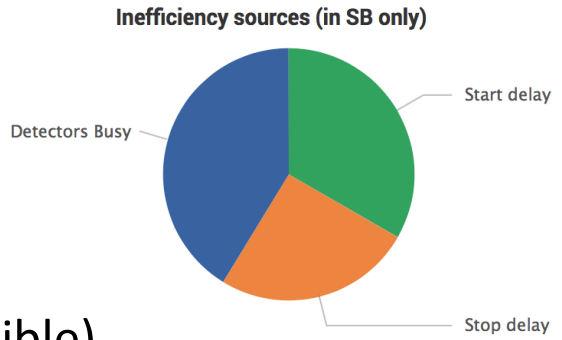
Typical Run-2 stable beams data taking efficiency: 90-96% <92.1%>

Trigger/DAQ System in Run 2

- TDAQ system redesigned for Run-2 to improve:
  - Read-Out Buffers
  - Data flow network performance
  - High level trigger (HLT)
  - Online calibration farm
  - Control & Operational monitoring
  - Trigger rate up to 100 kHz at L1, on average 1kHz HLT



- Run-2 pp data taking over, with over 90% efficiency
  - HLT farm ~25K cores, partially used for simulation jobs during Technical Stop and Machine Development periods.
  - ~730 hours of stable beams since June 1st, 2015.
    - largest busy contribution from holding triggers while "stop-less" recovering.



- YETS and 2016 Plans:
  - PC based Region of Interest Builder (faster and more flexible)

High Level Trigger

ATLAS Trigger Menu

Trigger	Typical offline selection	Trigger Selection		Level-1 Peak Rate (kHz)	HLT Peak Rate (Hz)
		Level-1 (GeV)	HLT (GeV)	$L = 5 \times 10^{33}$ cm^{-2}s^{-1}	
Single leptons	Single iso μ, $p_{\mathrm{T}} > 21$ GeV	15	20	7	130
	Single e, $p_{\mathrm{T}} > 25$ GeV	20	24	18	139
	Single μ, $p_{\mathrm{T}} > 42$ GeV	20	40	5	33
	Single τ, $p_{\mathrm{T}} > 90$ GeV	60	80	2	41
Two leptons	Two μ's, each $p_{\mathrm{T}} > 11$ GeV	2×10	2×10	0.8	19
	Two μ's, $p_{\mathrm{T}} > 19, 10$ GeV	15	18, 8	7	18
	Two loose e's, each $p_{\mathrm{T}} > 15$ GeV	2×10	2×12	10	5
	One e & one μ, $p_{\mathrm{T}} > 10, 26$ GeV	20 (μ)	7, 24	5	1
	One loose e & one μ, $p_{\mathrm{T}} > 19, 15$ GeV	15, 10	17, 14	0.4	2
	Two τ's, $p_{\mathrm{T}} > 40, 30$ GeV	20, 12	35, 25	2	22
	One τ, one μ, $p_{\mathrm{T}} > 30, 15$ GeV	12, 10 (+jets)	25, 14	0.5	10
	One τ, one e, $p_{\mathrm{T}} > 30, 19$ GeV	12, 15 (+jets)	25, 17	1	3.9
Three leptons	Three loose e's, $p_{\mathrm{T}} > 19, 11, 11$ GeV	15, 2×7	17, 2×9	3	< 0.1
	Three μ's, each $p_{\mathrm{T}} > 8$ GeV	3×6	3×6	< 0.1	4
	Three μ's, $p_{\mathrm{T}} > 19, 2 \times 6$ GeV	15	18, 2×4	7	2
	Two μ's & one e, $p_{\mathrm{T}} > 2 \times 11, 14$ GeV	2×10 (μ's)	2×10, 12	0.8	0.2
	Two loose e's & one μ, $p_{\mathrm{T}} > 2 \times 11, 11$ GeV	2×8, 10	2×12, 10	0.3	< 0.1
One photon	one γ, $p_{\mathrm{T}} > 125$ GeV	22	120	8	20
Two photons	Two loose γ's, $p_{\mathrm{T}} > 40, 30$ GeV	2×15	35, 25	1.5	12
	Two tight γ's, $p_{\mathrm{T}} > 25, 25$ GeV	2×15	2×20	1.5	7
Single jet	Jet ($R = 0.4$), $p_{\mathrm{T}} > 400$ GeV	100	360	0.9	18
	Jet ($R = 1.0$), $p_{\mathrm{T}} > 400$ GeV	100	360	0.9	23
$E_{\mathrm{T}}^{\mathrm{miss}}$	$E_{\mathrm{T}}^{\mathrm{miss}} > 180$ GeV	50	70	0.7	55
Multi-jets	Four jets, each $p_{\mathrm{T}} > 95$ GeV	3×40	4×85	0.3	20
	Five jets, each $p_{\mathrm{T}} > 70$ GeV	4×20	5×60	0.4	15
	Six jets, each $p_{\mathrm{T}} > 55$ GeV	4×15	6×45	1.0	12
b−jets	One loose b, $p_{\mathrm{T}} > 235$ GeV	100	225	0.9	35
	Two medium b's, $p_{\mathrm{T}} > 160, 60$ GeV	100	150, 50	0.9	9
	One b & three jets, each $p_{\mathrm{T}} > 75$ GeV	3×25	4×65	0.9	11
	Two b & two jets, each $p_{\mathrm{T}} > 45$ GeV	3×25	4×35	0.9	9
b−physics	Two μ's, $p_{\mathrm{T}} > 6, 4$ GeV plus dedicated b-physics selections	6, 4	6, 4	8	52
Total				70	1400

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- About 1.5 k high level trigger selections seeded by about 400 different Level-1 items.
  - Primary triggers, usually unprescaled;
  - Support and background triggers, usually prescaled;
  - Alternative triggers, using different algorithms
  - Backup triggers, using tighter selections;
  - Calibration triggers, usually providing partially built events.
- Maintained menu items and prescale strategy pretty stable through out 2015 data taking, to ensure continuity of trigger selections for physics analyses.

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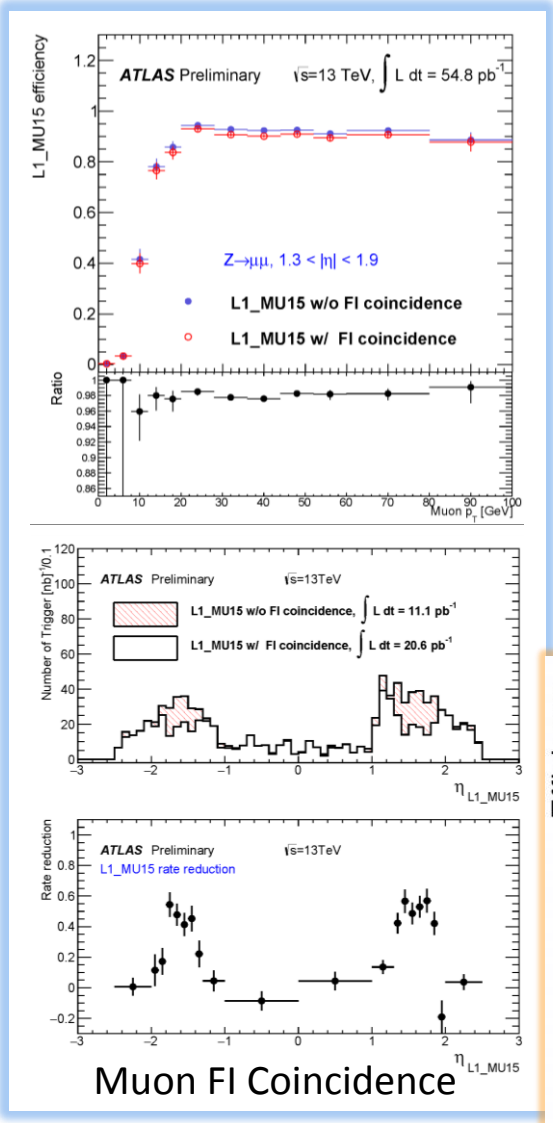
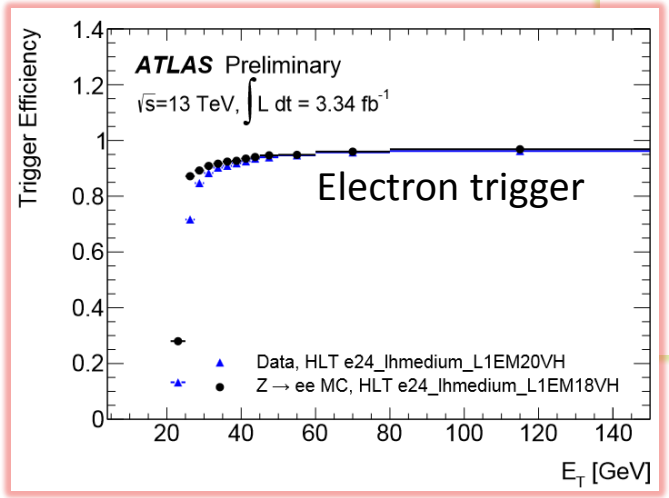
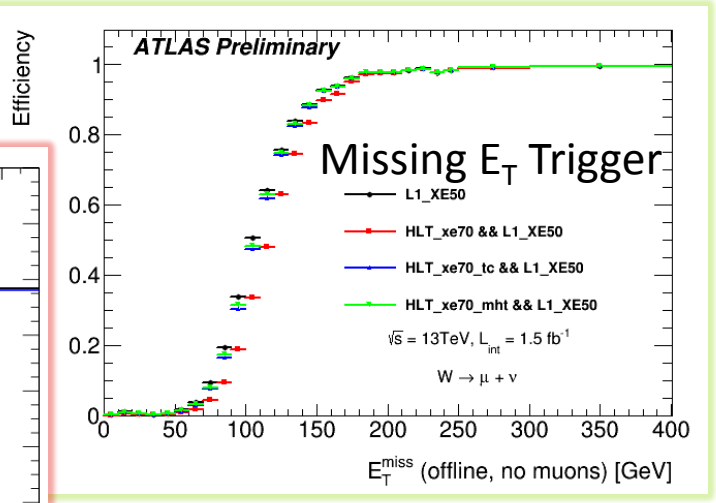
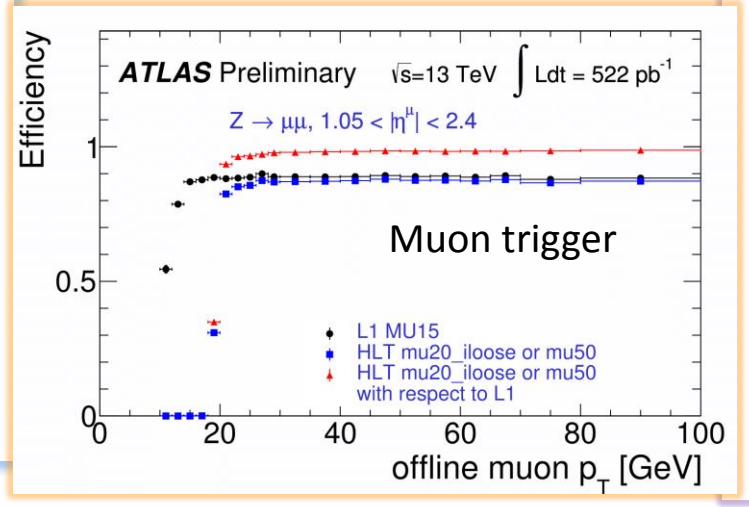
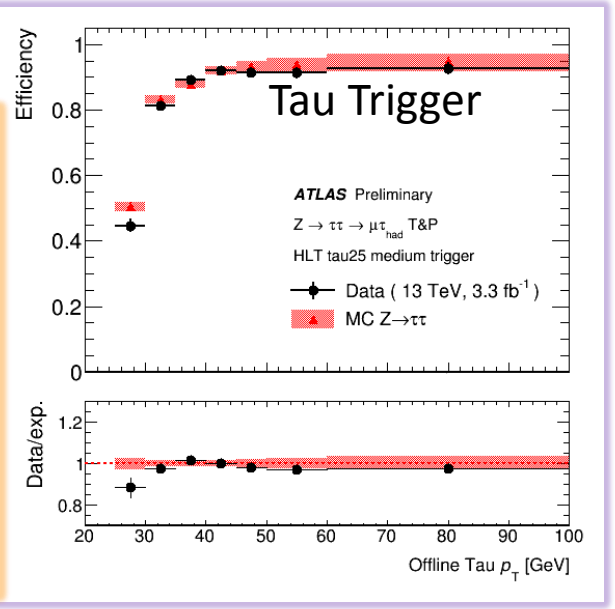
Trigger Performance











ATLAS Detector in 2015

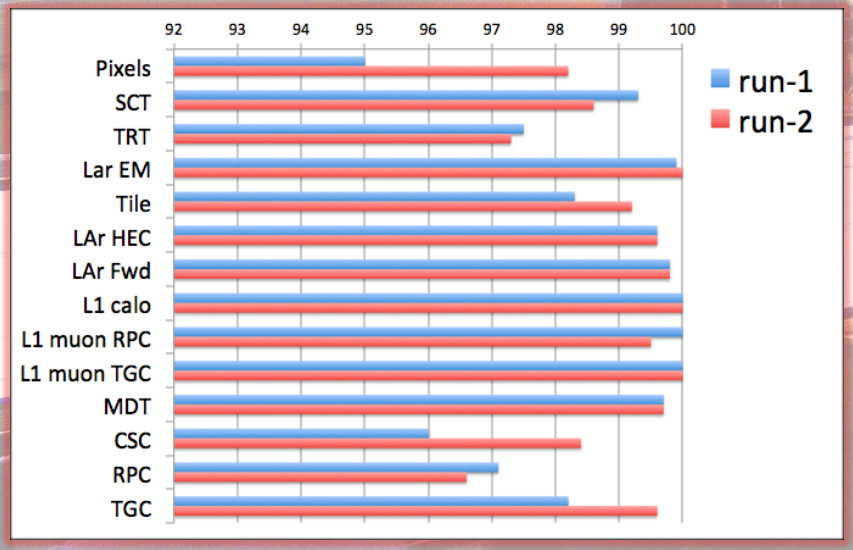
- Generally smooth running
- Fraction of live channels constant over the running period (ongoing Muon commissioning)
- Monitoring and adjusting the trigger following the LHC intensity ramp up
- Learned to operate the new detector

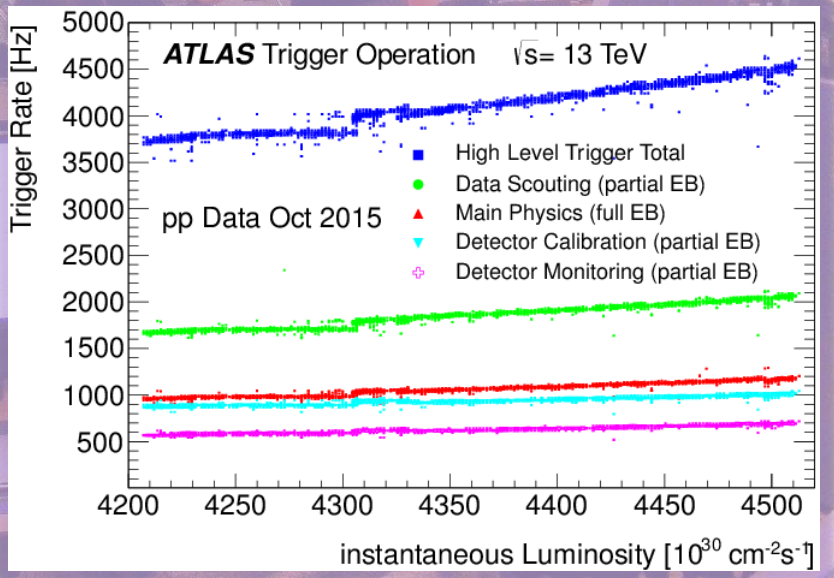
ATLAS pp run: August-November 2015

Inner Tracker			Calorimeters		Muon Spectrometer				Magnets	
Pixel	SCT	TRT	LAr	Tile	MDT	RPC	CSC	TGC	Solenoid	Toroid
93.5	99.4	98.3	99.4	100	100	100	100	100	100	97.8

All Good for physics: 87.4% (3.3 fb^{-1})

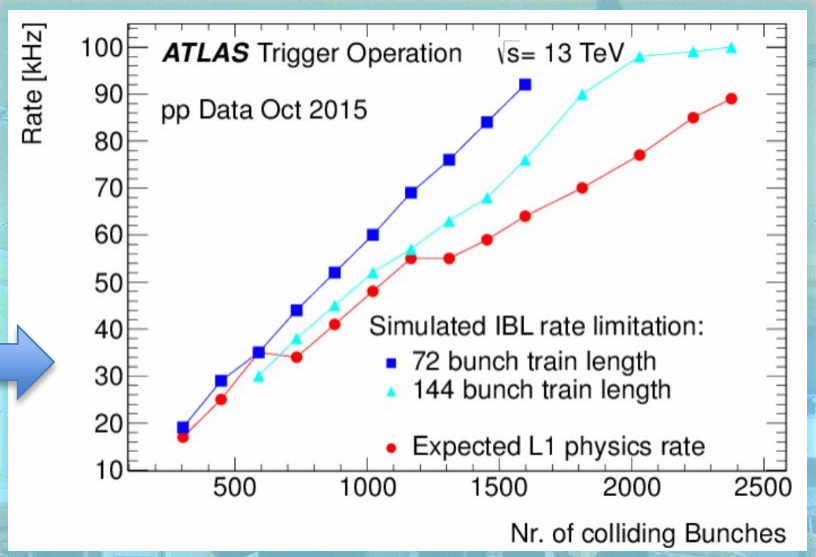
Luminosity weighted relative detector uptime and good data quality (DQ) efficiencies (in %) during stable beams in pp collisions with 25ns bunch spacing at √s=13 TeV between August-November 2015, corresponding to an integrated luminosity of 3.8 fb^{-1}. The lower DQ efficiency in the Pixel detector is due to the IBL being turned off for two runs, corresponding to 0.2 fb^{-1}. Analyses that don't rely on the IBL can use those runs and thus use 3.5 fb^{-1} with a corresponding DQ efficiency of 93.4%.

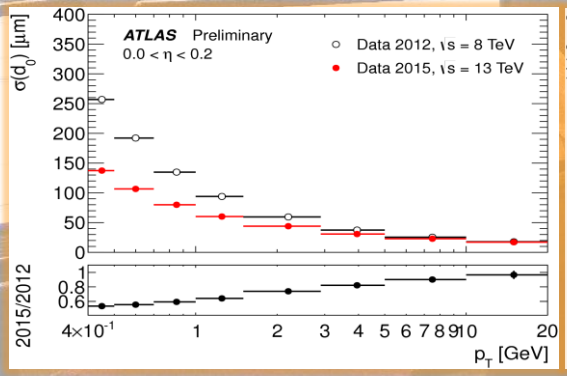


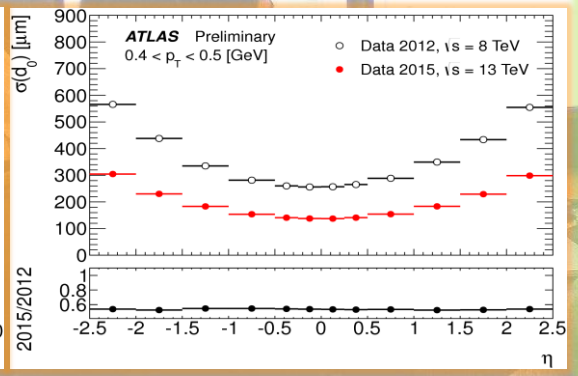


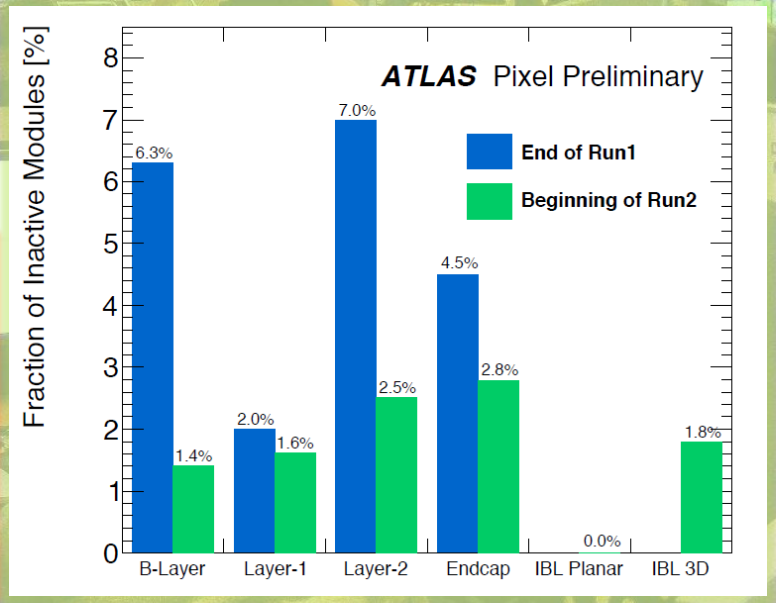
IBL and Pixel Operation

- Overall status of Pixels improved w.r.t. 2012 after LS-1 maintenance
- IBL Detector fully working and enhancing tracking close to IP
- IBL wire-bond protection against Fixed Frequency Trigger required careful trigger rate optimization
- IBL (next slides):
  - Front-End current increase
  - Temperature dependent bowing

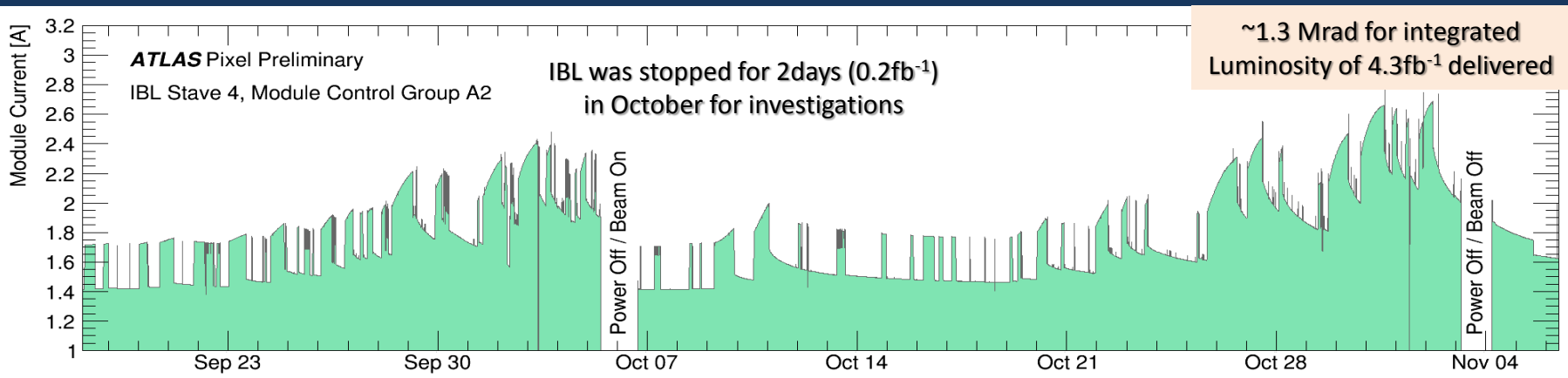






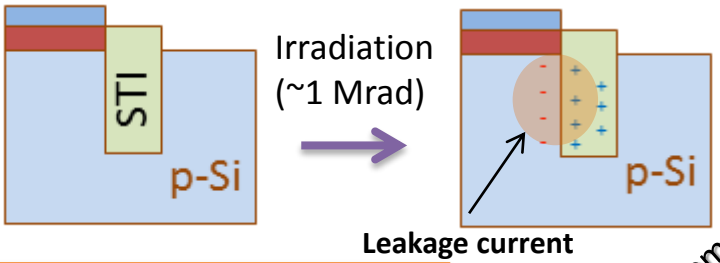


IBL - LV Front End current drift



- This effect was significantly visible since the end of September during data taking
- Immediate investigations were made together with FE experts and setting-up a Task Force (TF)
- Understood to be a FE N-MOS transistors leakage due to defects built-up at the Silicon Oxide (STI) interface and cumulated by ionizing dose → Known features but not tagged during construction
- At low dose rate effect is almost invisible – Negligible impact expected for HI runs
- Lab investigations are on going for next year operation

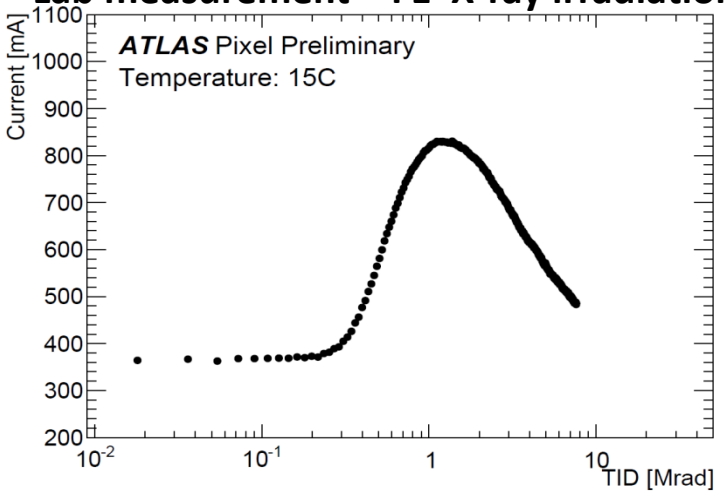
N-MOS transistor cross section



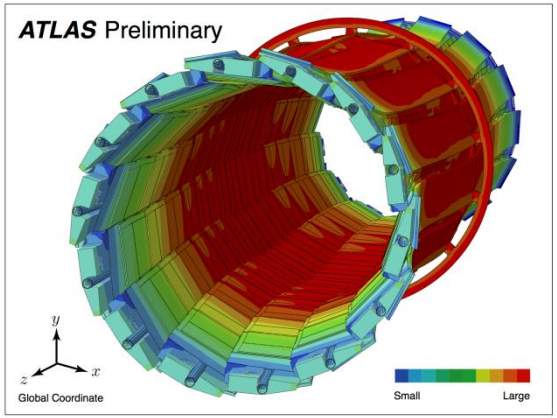
Consequences:
- Temperature increase
- Electrical failure risks

Lab measurement confirmed the phenomena
Issue expected to be relaxed after few Mrad

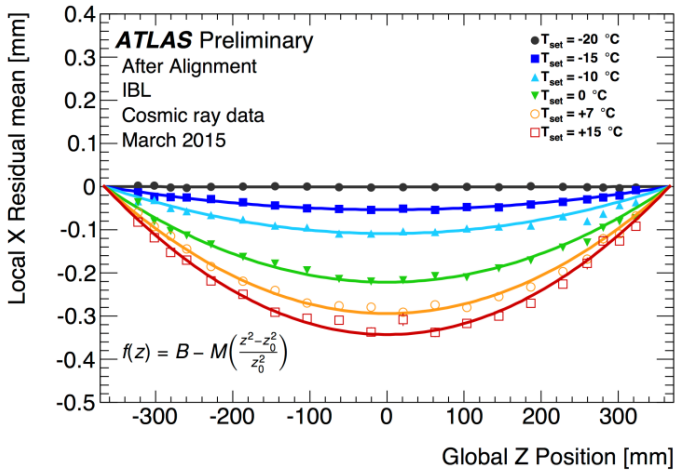
Lab measurement – FE X-ray irradiation



IBL – Thermomechanical Distortion

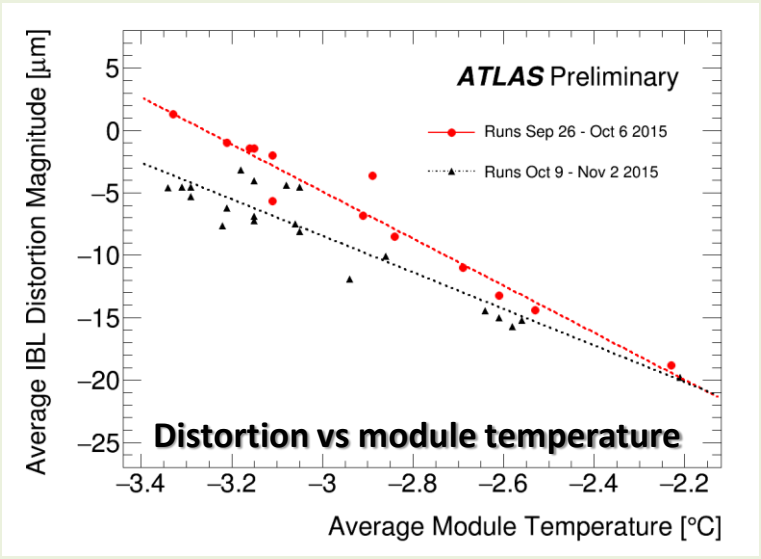


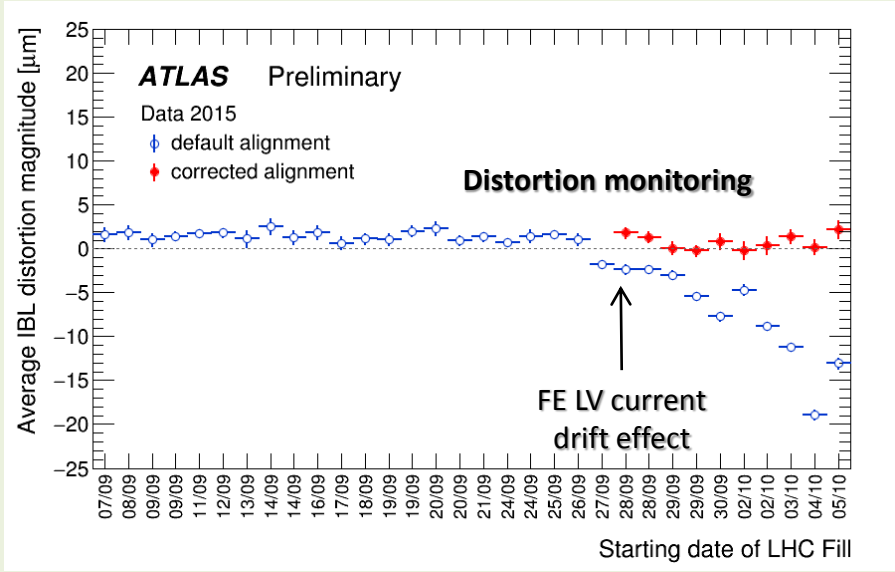
- Issue discovered early in 2015
- Temperature dependency exhibited - O(10 µm/K)
- Direct impact on the tracking performance
- Temperature and cooling stability ok until September
- Static alignment correction was sufficient to mitigate the effects



Current drift effect

- *Run by run alignment correction is necessary to recover the physics performances*
- *Dynamic change within a run is visible*

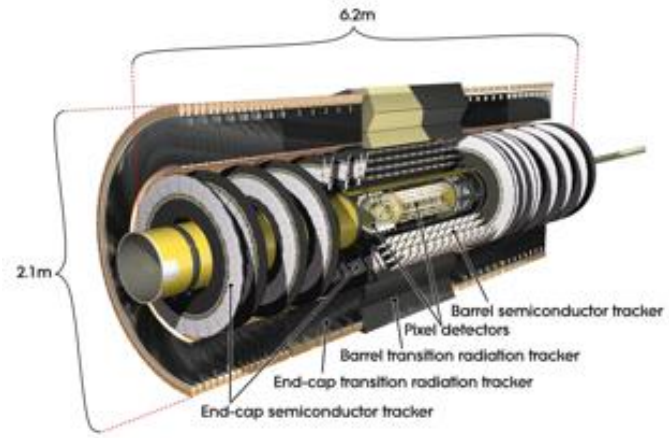




Semiconductor Tracker - SCT

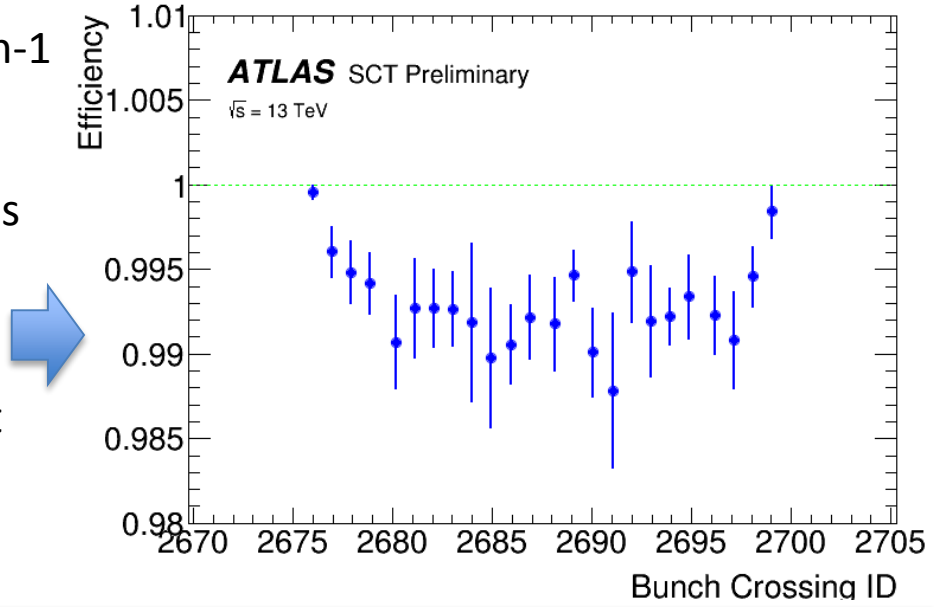
Operations

- Stable and reliable throughout 2015
- 98.6% of 6 million strips active for tracking
- Some minor DQ and data taking inefficiency due to ROD firmware requiring further tuning



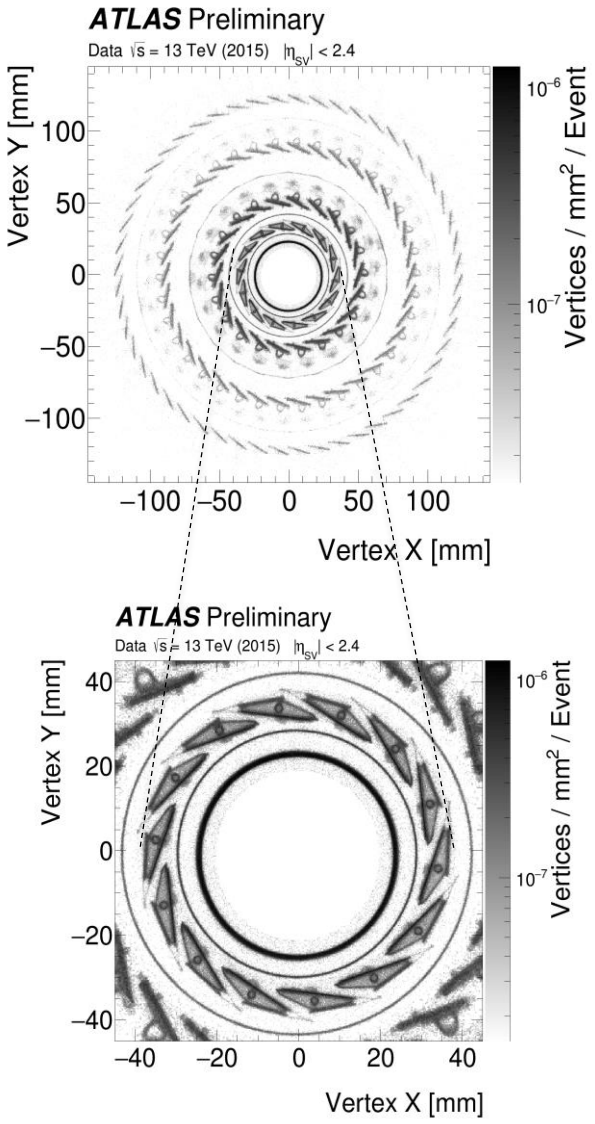
Detector Status & Tracking Performance

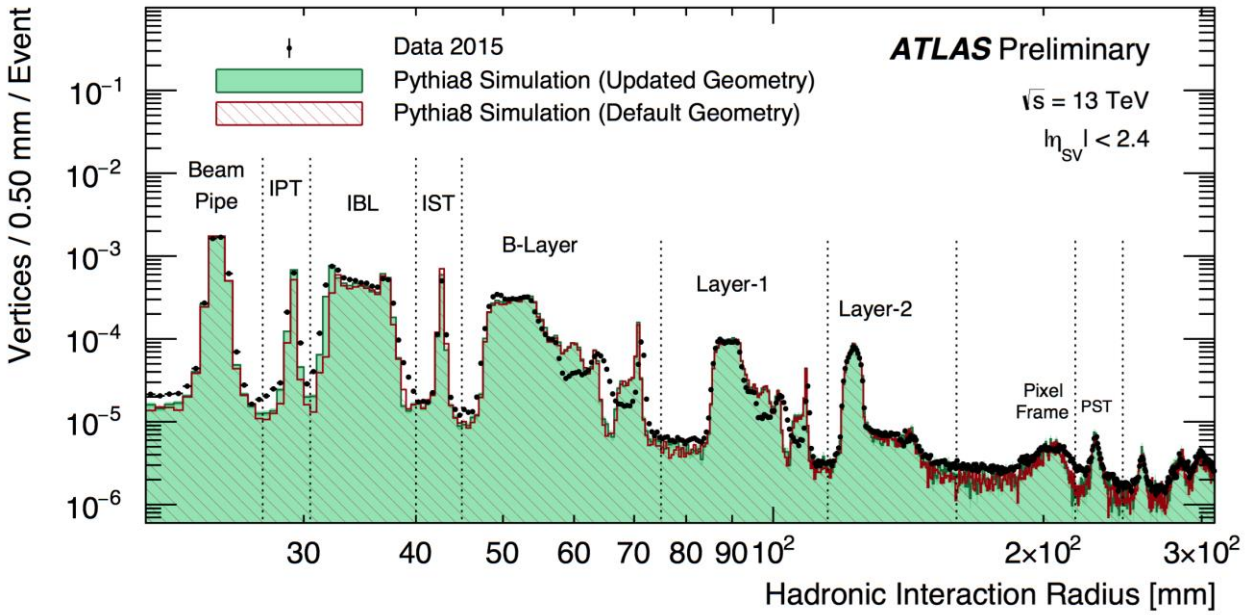
- Silicon leakage currents continue to closely match expectations from radiation damage
- In general, noise levels comparable with Run-1
- Tracking performance metrics comparable with Run 1
- Small (~0.5%) drop in hit efficiency with 25ns beams
  - Expected due to 01X requirement (veto hit from previous BC)
  - intrinsic hit efficiency still visible on first bunch
  - No impact on tracking performance



Inner Detector Material

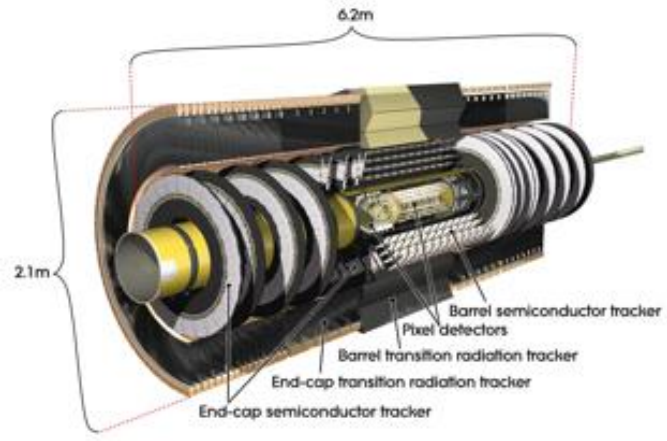
- Detailed mapping of material in Pixel detector using
  - Hadronic interactions
  - Photon conversions
- Simulation updated after comparison to improve geometry description



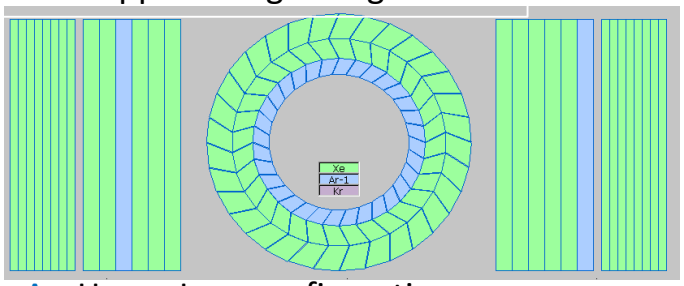


Transition Radiation Tracker

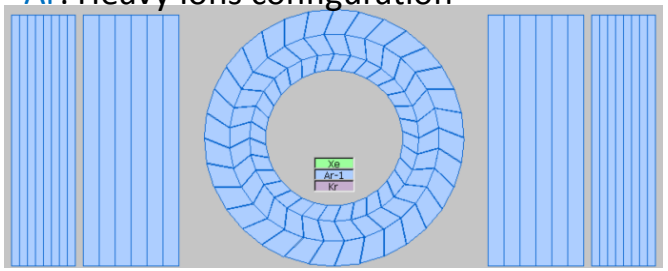
- TRT operates smoothly and provides high quality data
  - Proved to sustain 100 KHz at 50% occupancy
  - ROD spares under control
- Gas: one more leak developed in the exhaust active gas pipes.
  - Xe losses at the end of pp operation about 150 l/day
  - Measures to reduce the Xe leak rate will be taken during YETS
  - Scenarios with more modules running with Ar-mixture are under study, aiming to minimize performance loss.
- Using a Kr-based mixture instead of Ar-based one in some TRT modules is also under study
- Another focus now is to optimize TRT performance at large occupancies for μ>~40



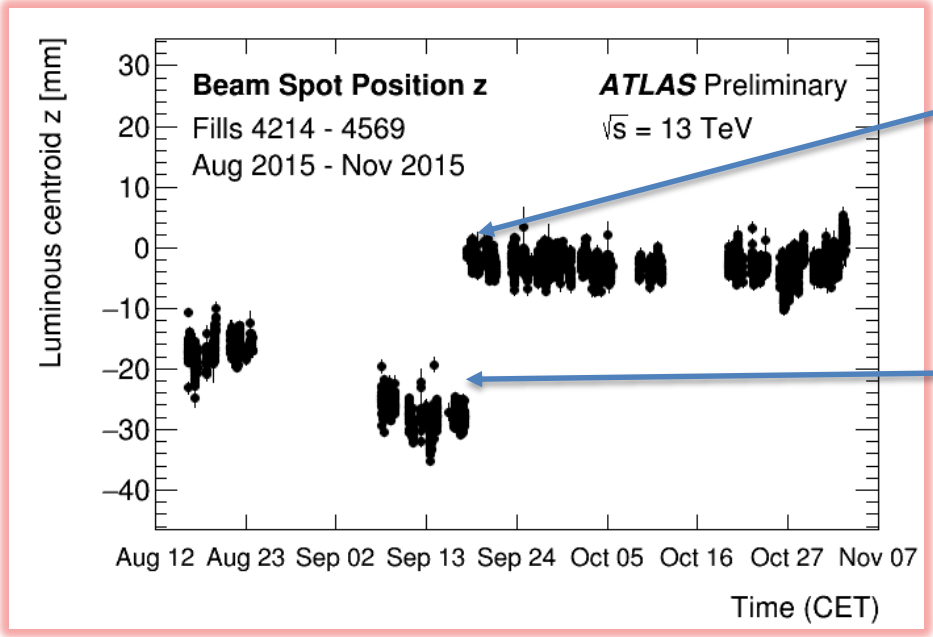
Xe+Ar: pp running configuration

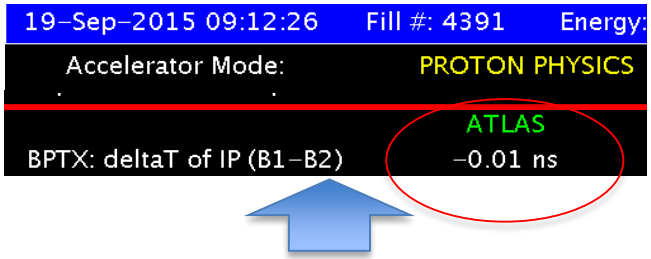


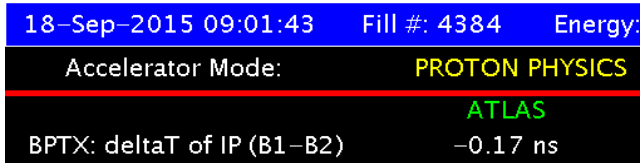
Ar: Heavy Ions configuration



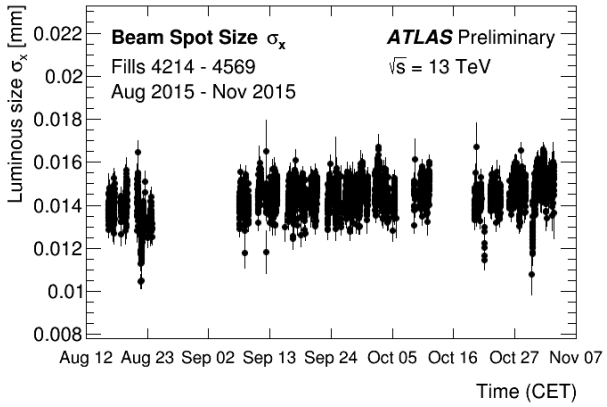
Beam Spot

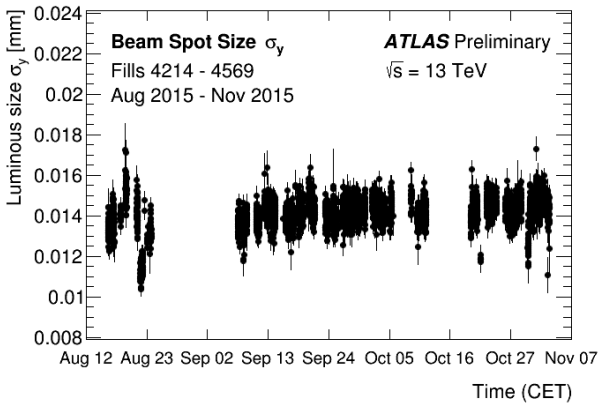


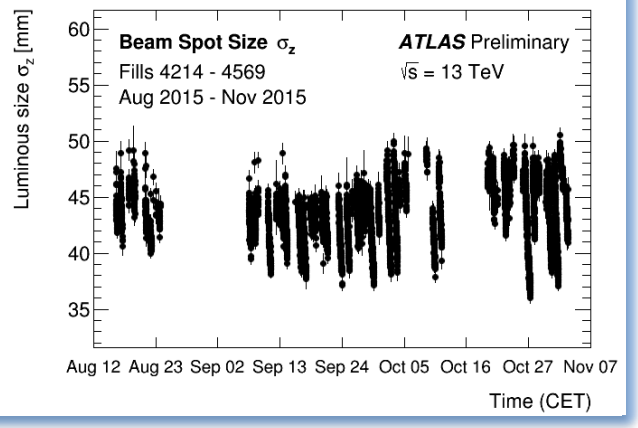




- Very stable beam spot for all 2015
- Performed once beam cogging to bring collisions in nominal position
- Very stable x,y,z beam sizes

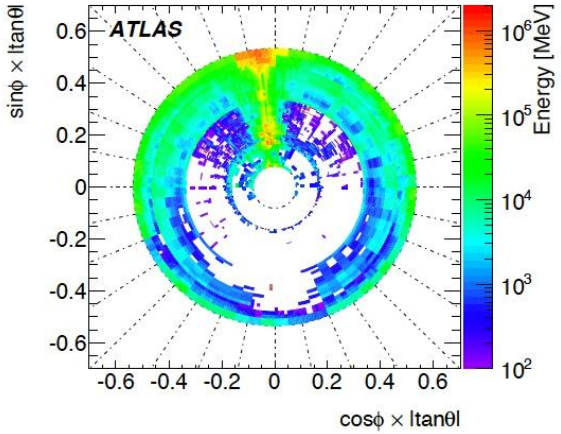




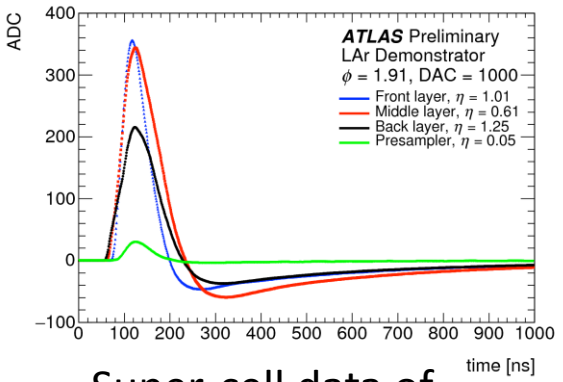


LAr Operation and Data Quality

- **Very smooth Running in 2015**
- **Some changes/improvements with respect to Run-1**:
  - LAr **4-sample read-out** to cope with 100kHz L1 accept rate (with 0% detector busy).
  - **Noise burst flagging** before the express stream working well. Big step: Correlation with HV of LAr purity probes has been established.
- **2015 Proton Run LAr DQ**: LAr data fraction that is good for physics: ~99.4%
  - Even better than during Run-1!
  - Biggest source of inefficiency: HV trips (0.4%), but also coverage, timing, calibration,…
  - New current controlled HV modules were installed for the EMEC during LS1 → tremendously improved situation in EMEC
  - → Decided to buy new current controlled modules for HEC (to be installed during YETS)
- Front-end timing has been derived and updated → During 2015, readout timed in with a precision of better than < 1 ns
- **LAr Phase I Upgrade demonstrator**: Installed during LS1
  - read-out implemented this year: data taking during physics and calibration runs → super-cell data at realistic LHC conditions



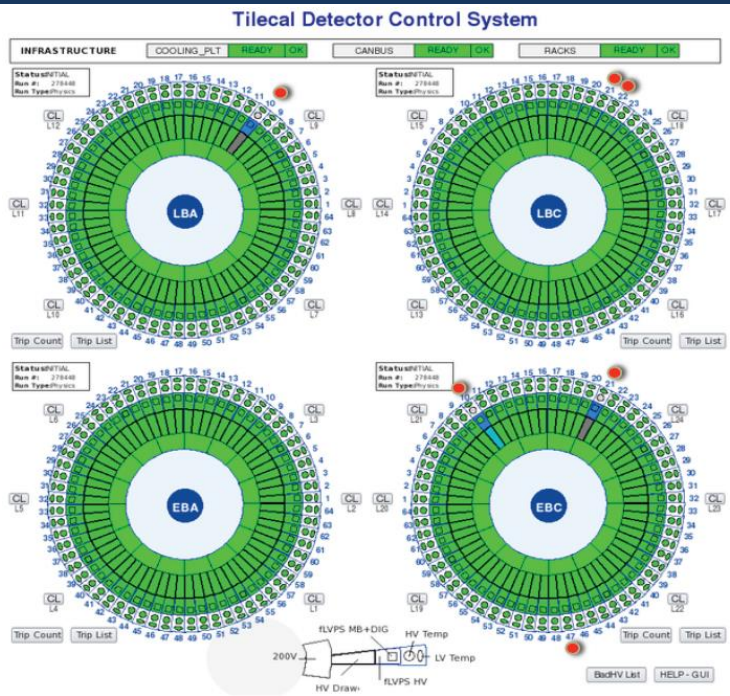
LAr noise burst



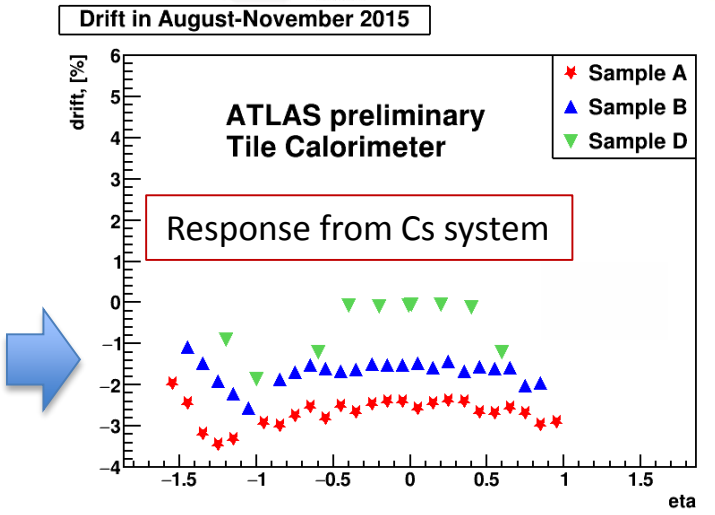
Super-cell data of Phase I demonstrator during a calibration run

Tile Calorimeter

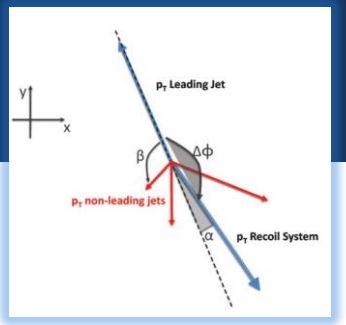
- The detector has been performing stably with no data-taking and data quality losses.
- The calibration systems allow preserving the cell EM scale at a stability of ~0.5%.
  - The new laser calibration system is commissioned and has proven a <1% precision.
- Commissioning of the Tile-Muon trigger for $1.0<|\eta|<1.3$ is in its final stage.
- Running with 2 Modules OFF (LBA10, EBC21).
- Given the fact that Tile will be accessed on the C-side (negative η) during YETS, 5 modules will be repaired:
  - One off due to LVPS
  - One with no possibility of HV regulation on PMTs
  - Three with no HV in ¼ of the PMTs

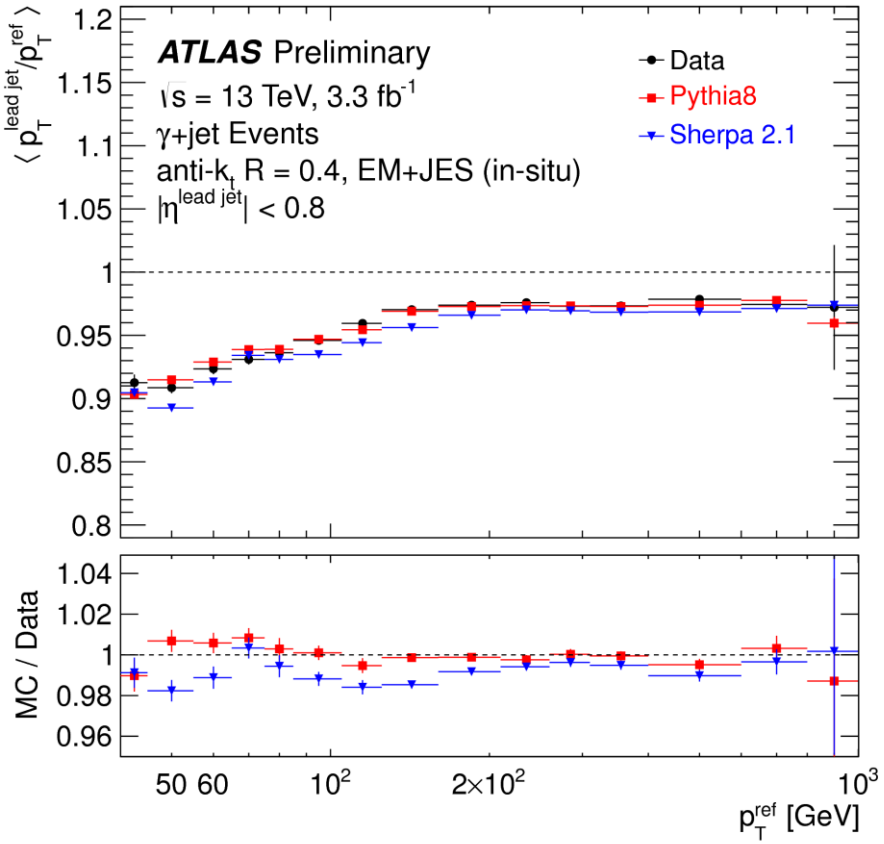


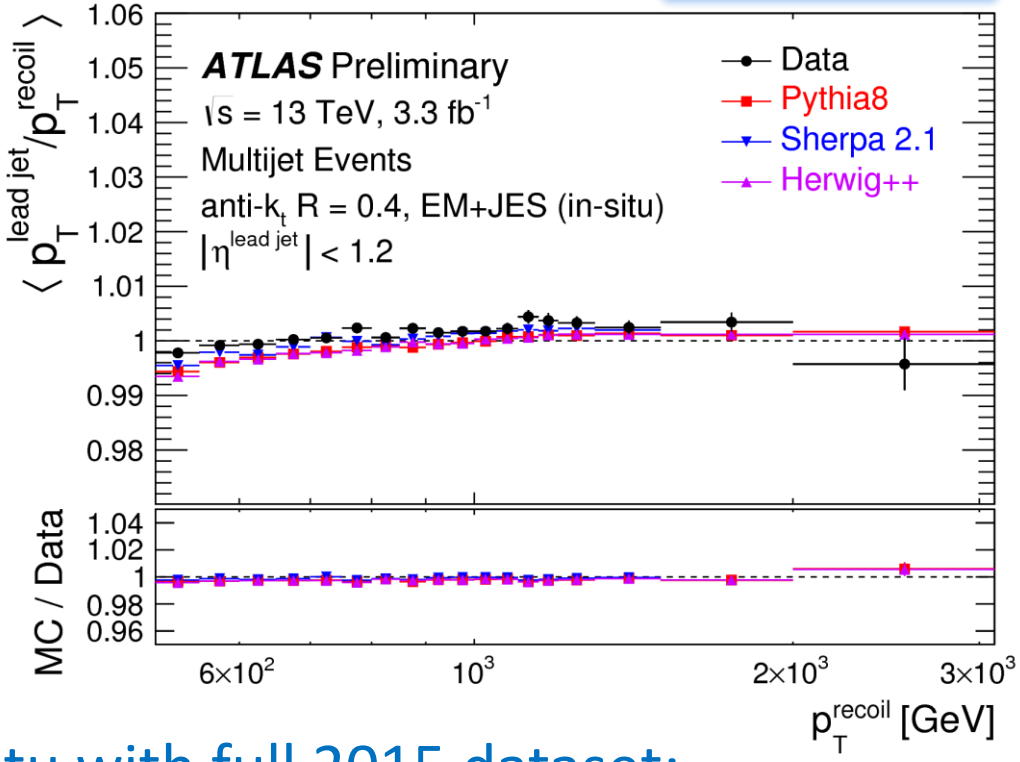
Known drifts from PMTs under illumination and there is recovery when there are no collisions



Jet Energy Scale

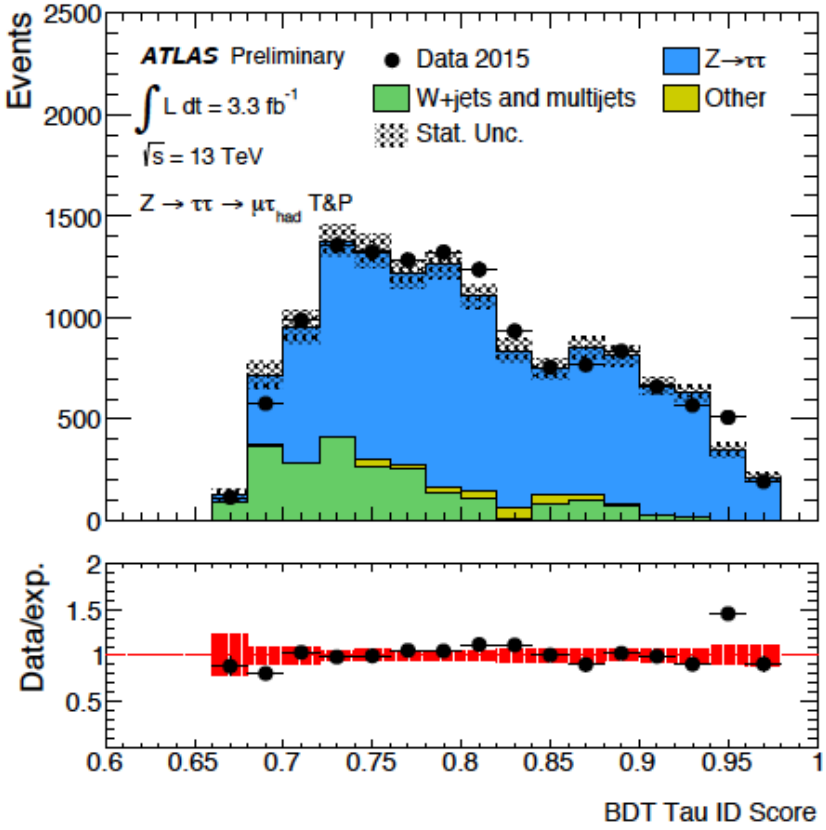


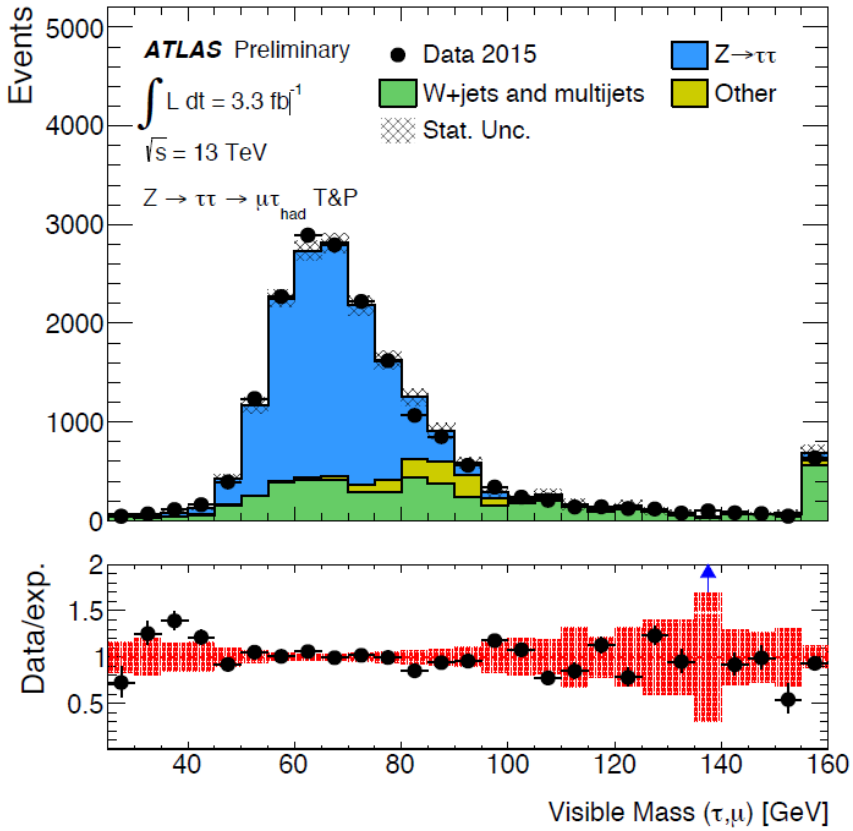




- Jet energy scale studied in-situ with full 2015 dataset:
  - Photon-jet balance
  - Multi-jet balance
- Agreement between data and MC better than 2% up to 3 TeV

Taus

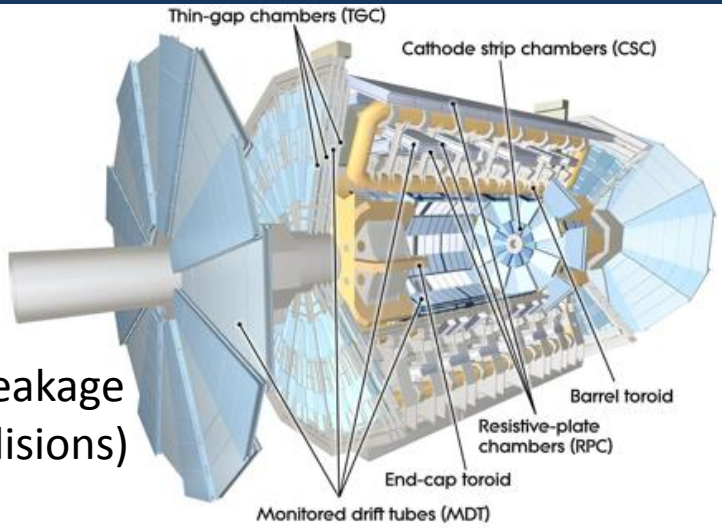


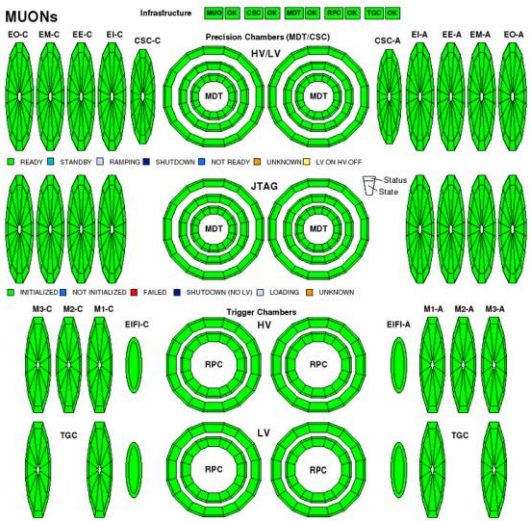


- Hadronically decaying taus identified using boosted decision tree offline and online
  - Performance measured using Z-> ττ candidates
  - Identification and trigger efficiency in data well reproduced by simulation

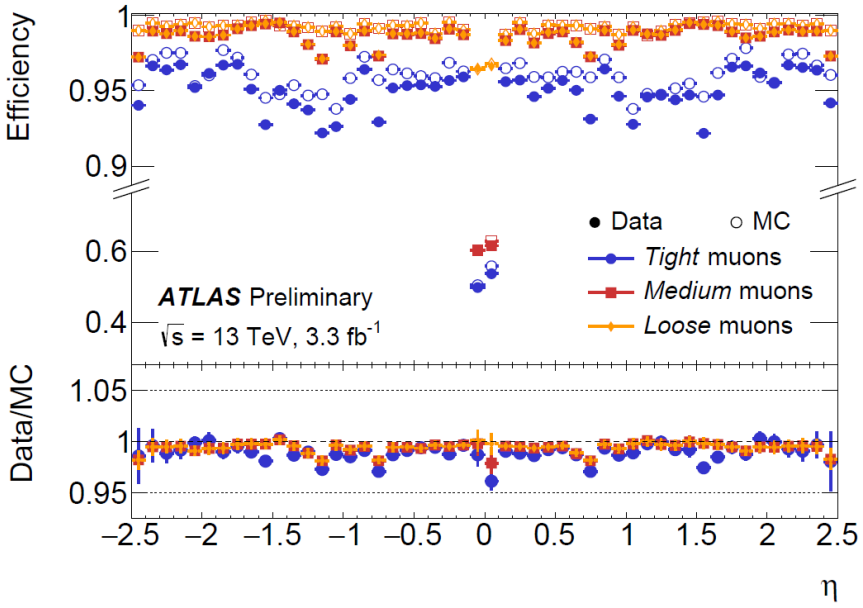
Muons

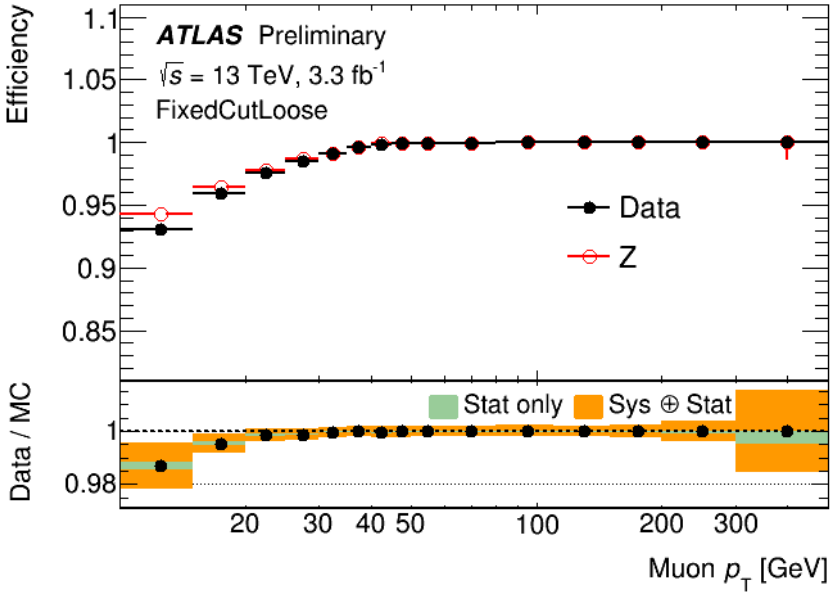
- Muon Spectrometer overall running smoothly
- CSC:
  - new ATCA-based CSC readout operating nicely
  - tested up to L1 rates above 100kHz
  - detectors: two chambers have broken wires, 1 (of 4) layers lost
  - post-mortem showed high spark rate before wire breakage
  - found another O(10) layers sparking (only during collisions) ➔ reduced HV (typically -60V) to stop sparking
- MDT:
  - MDT MROD double readout implemented, working fine
- RPC:
  - commissioning of new trigger towers (feet region) ongoing,
  - Since TS3 all towers included in trigger and readout
- TGC:
  - TGC features to reduce rate and load partially in
  - TGC instabilities have been observed above $5*10^{33}$ (as expected and already seen in Run-1), situation should be improved once the burst stopper is activated (was running in monitoring mode), investigations ongoing.



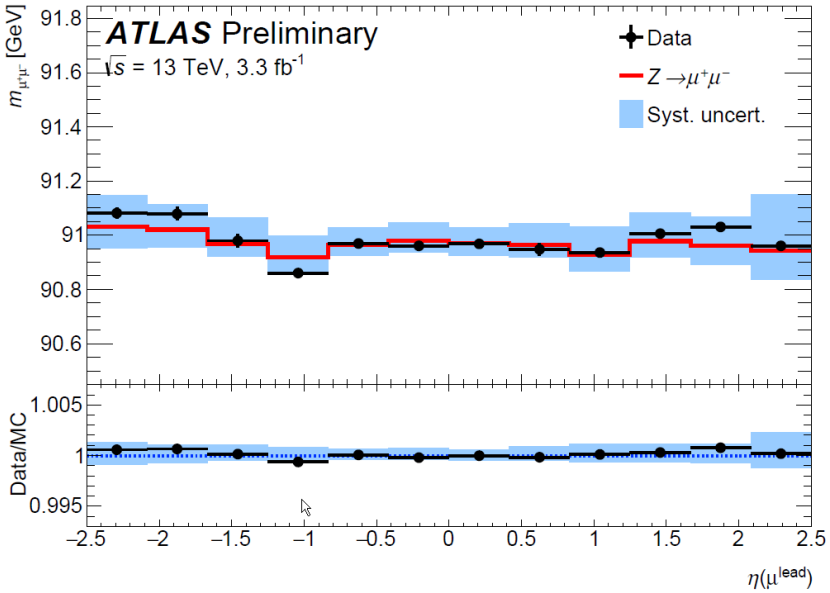


Muon efficiencies and momentum measurement

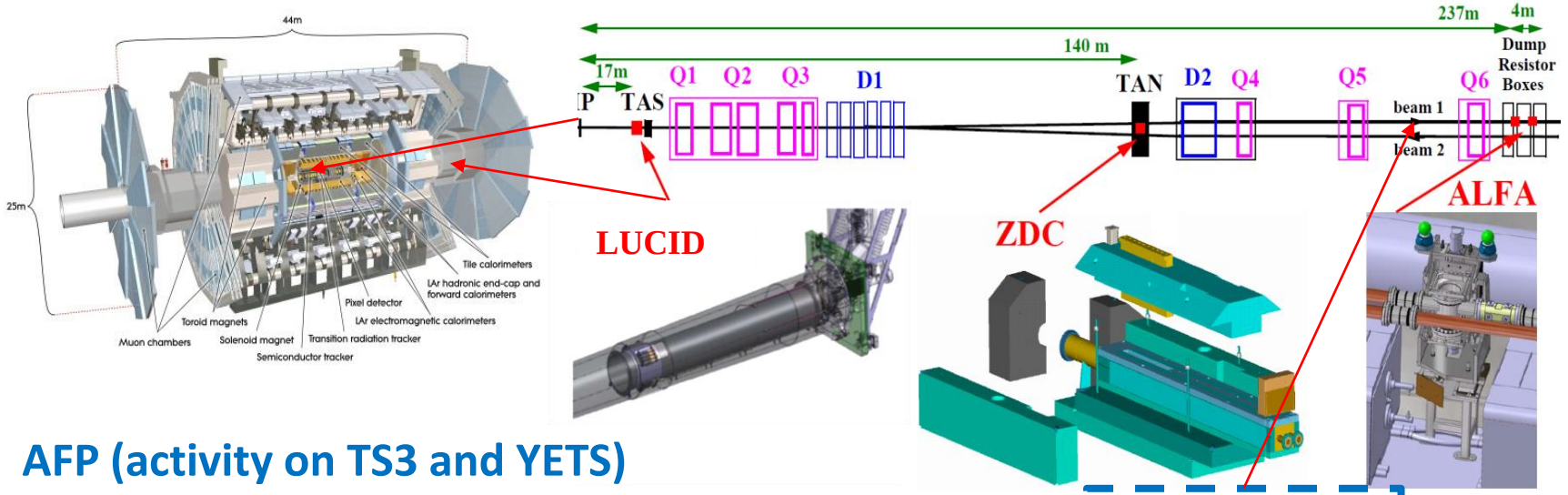




- Muon performance studies with full 2015 dataset
  - Reconstruction efficiencies
  - Muon momentum scale and resolution
  - Isolation efficiency
- Good agreement between data and simulation
  - Correction factors applied to correct for remaining differences



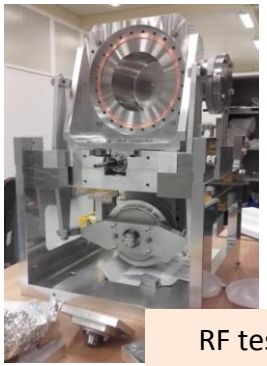
Forward Detectors (i)



- **AFP (activity on TS3 and YETS)**
  - Install infrastructures
    - Cabling
    - Modify exterior vacuum chamber between Q5 and Q6
  - Aim to install during YETS 2015 two stations (one of the two detector arms) in C6R1

2 Stations at Vakuum Praha

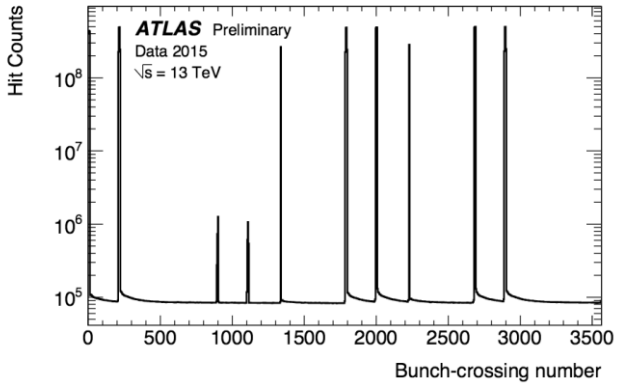
He Leak Test: OK

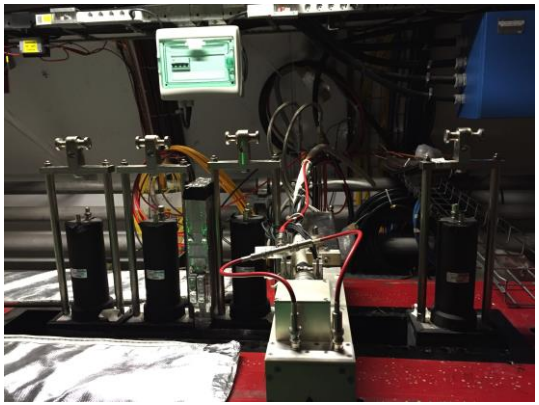


RF test 1st Station: OK

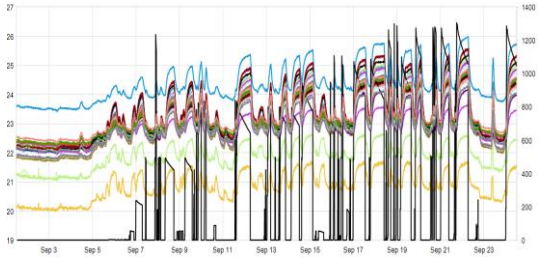
Forward Detectors (ii)

- **LUCID**
  - RUN 2:
    - Working well as luminosity monitor
  - YETS:
    - Substitute 4+4 PMTs with ^{207}Bi calibrated ones
- **ZDC**
  - RUN 2:
    - Detector refurbished taking successfully data during the Heavy Ions run
  - YETS:
    - Remove the detectors and place them in the Buffer Zone for testing and refurbishment
- **ALFA**
  - RUN 2:
    - Total cross section
    - Diffractive Physics
  - YETS:
    - Change of noisy LVDT (was responsible for a beam dump)





Temperature well under control, did not exceed 26 °C (Run1 max. ~45 °C)
Good news also for AFP!

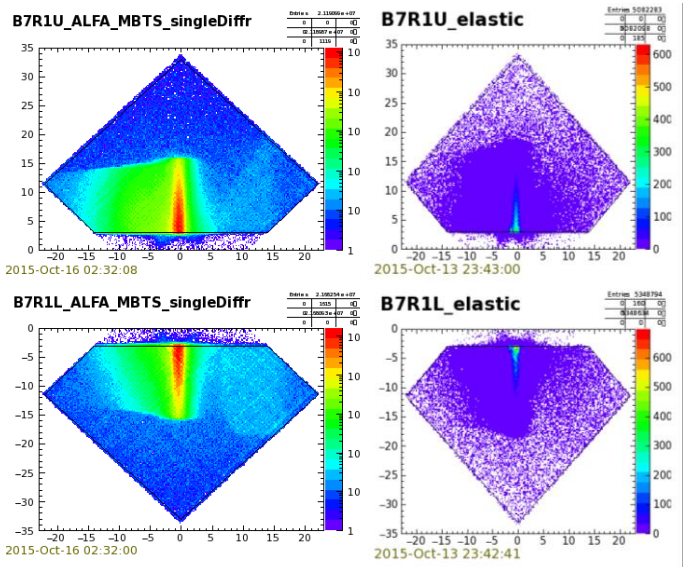


ALFA Elastic and Diffractive Program

Data taken between October 12th and 18th

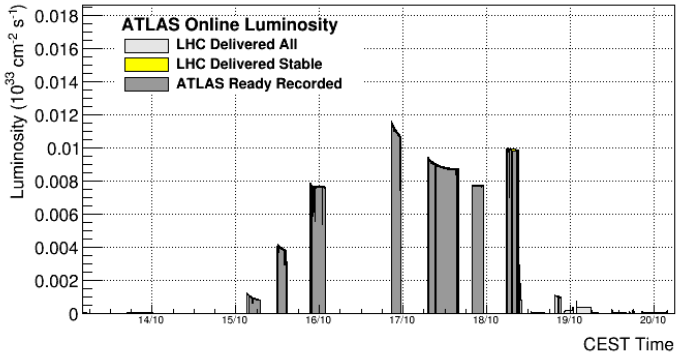
Elastic Program for total cross-section determination:

- Fill for loss maps and ALFA data taking without crossing angle.
- The ALFA detectors positioned at 5.5 $\sigma_{nominal}$.
- Online track reconstruction as check of data quality.
- About 2 + 4.5 hours of data taking in “quiet beam” mode:
- ~17 + 40 million “physics events” was stored.
- ~6.5 + 11 million of the “physics events” had an elastic trigger (large fraction expected to be background).
- ~45 + 450 million ALFA calibration events stored for efficiency, alignment etc.
- Triggers for vertex based luminosity and inelastic cross section with MBTS.



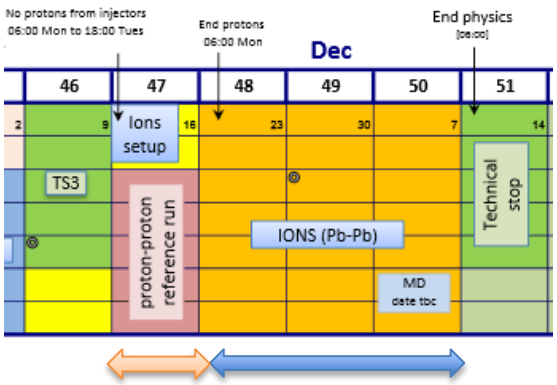
The diffractive programs was spread over many fills:

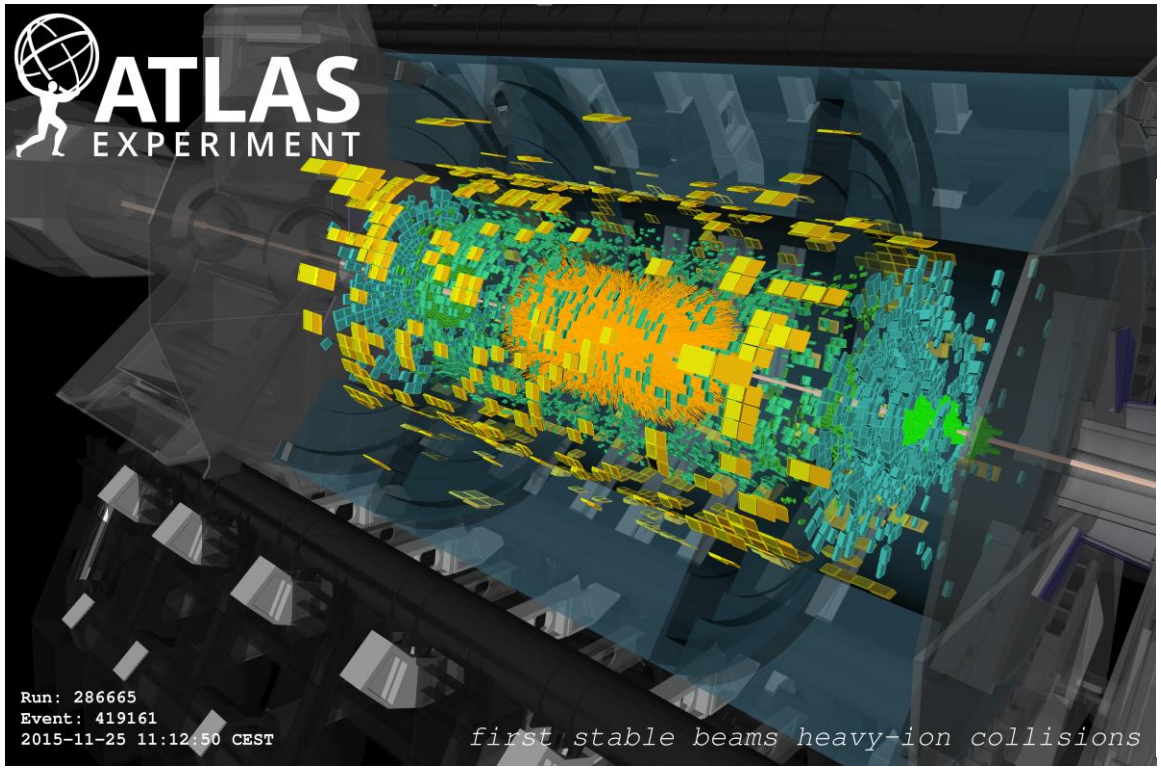
- The ALFA detectors positioned at 10 $\sigma_{nominal}$.
- Online track reconstruction as check of data quality (here single diffractive events).
- Integrated luminosity: LHC delivered: 0.74 pb^{-1}
- ATLAS+ALFA in position recorded: 0.65 pb^{-1} (88.7% efficiency)
- ATLAS+ALFA optimal: ~0.6 pb^{-1} (~82 % efficiency)
- Analysis ongoing, data quality in general good.

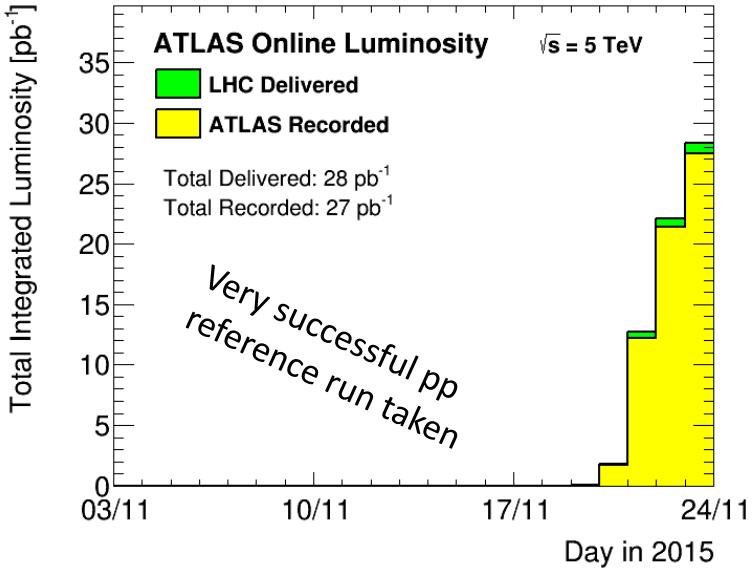


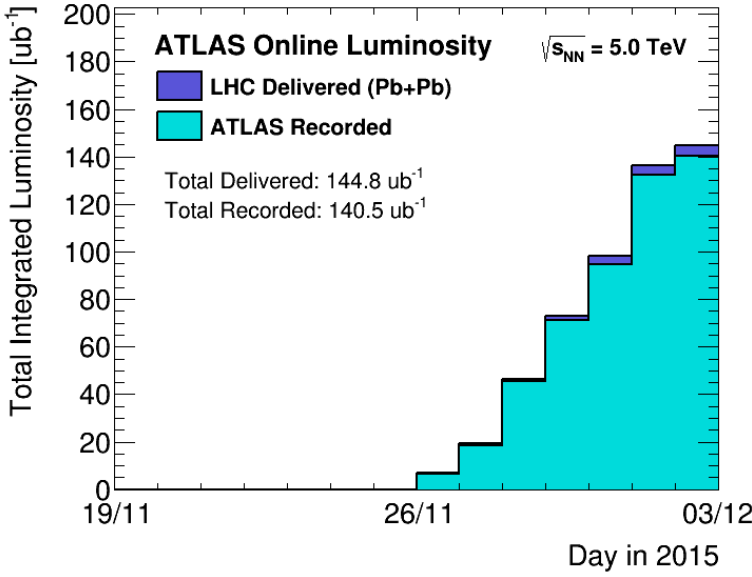
5.02 TeV pp and Heavy Ions Runs

Stable Beams data taking efficiency always above 96%



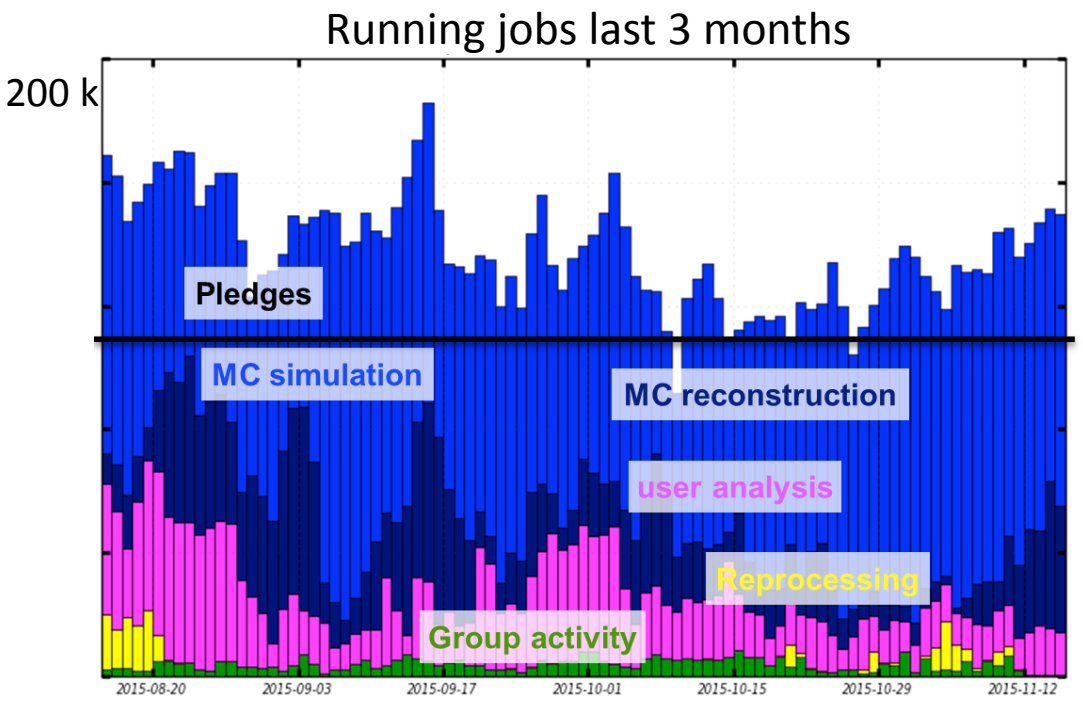


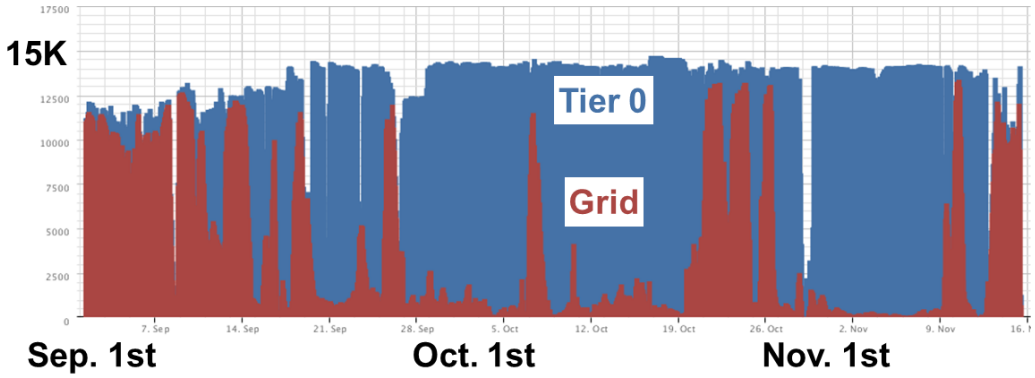




Computing

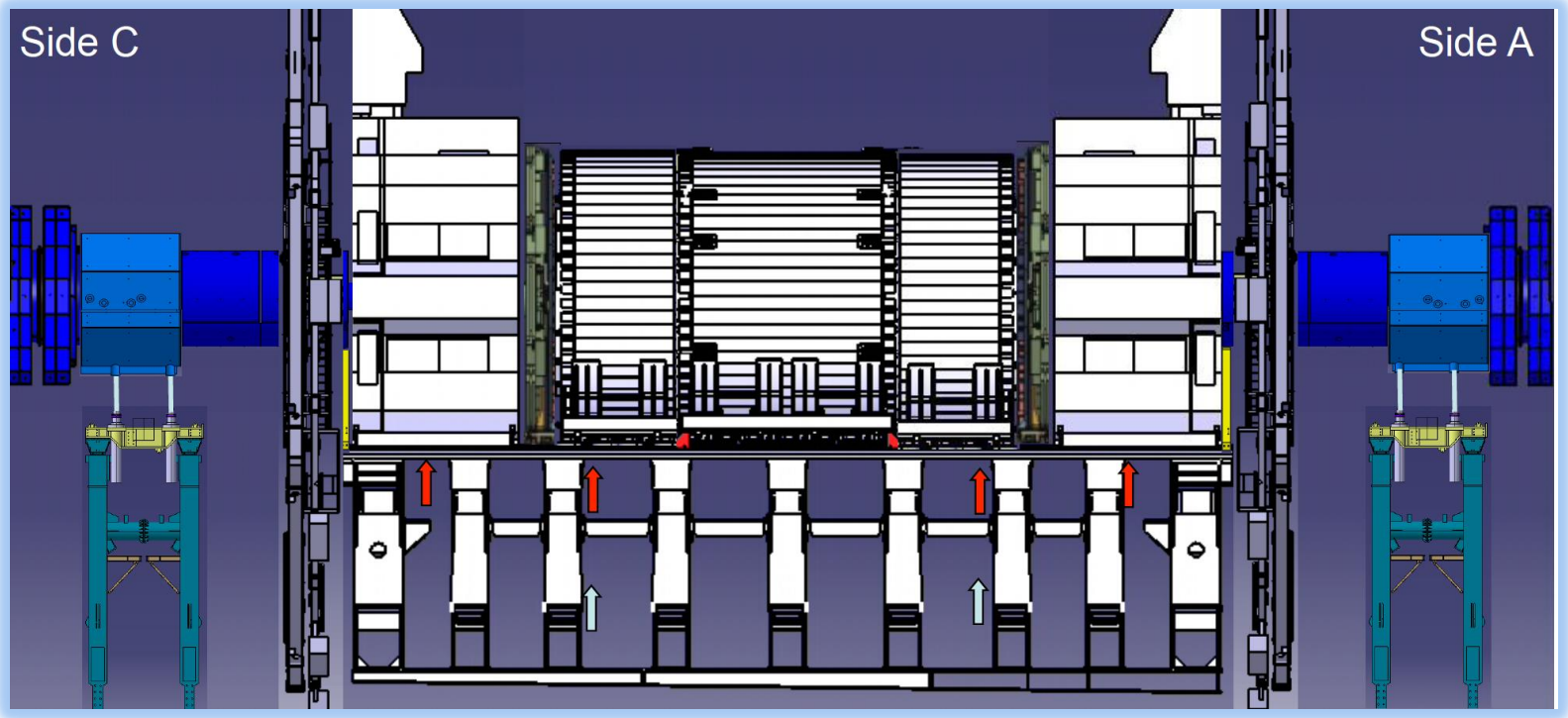
- Grid utilization at full
- No issue with data transfer and data processing
- Tier 0 farm used for grid processing when no data processing activity. Spill-over to Tier 1 sites validated
- Reprocessing of 2015 data (and MC) planned for the end of 2015 (early 2016)
- Major software update for summer 2016
- Evaluation of computing needs for ATLAS upgrade TDRs ongoing
- Collaboration on multi-threaded software frame-work for Run-3 on track





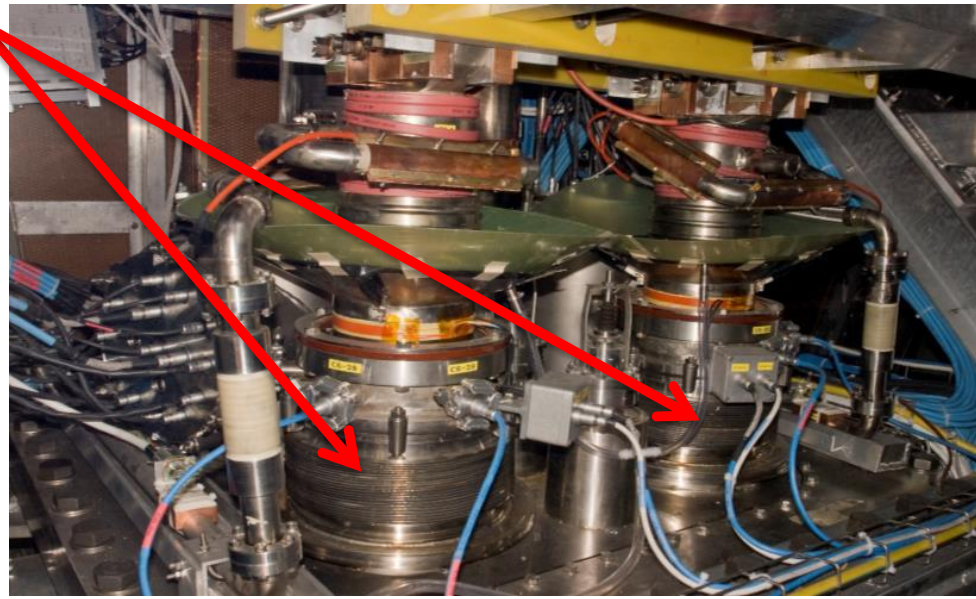
Repair Scenario during the YETS

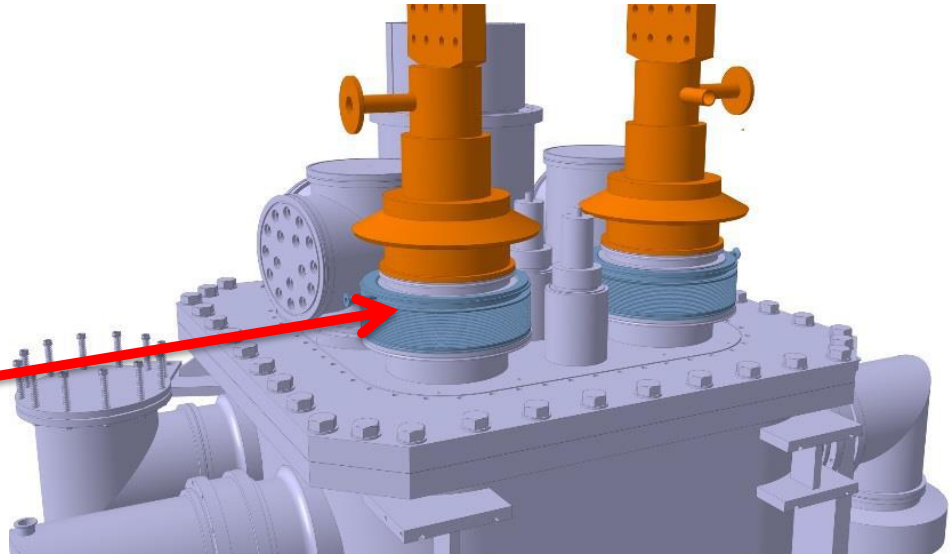
- Open fully Side C (starting from December 14th)
  - Main activity: repair of the End Cap Toroid Side C
  - Other Sub-detectors can profit from the opening for repairs
- Side A: Move only the Big Wheel in open position to allow maintenance for TGC chambers (19 January TBC)
- Start opening on the 14 December (detailed plan prepared, work in two shifts up to 23 December)



Damage to Endcap Toroid Bellow

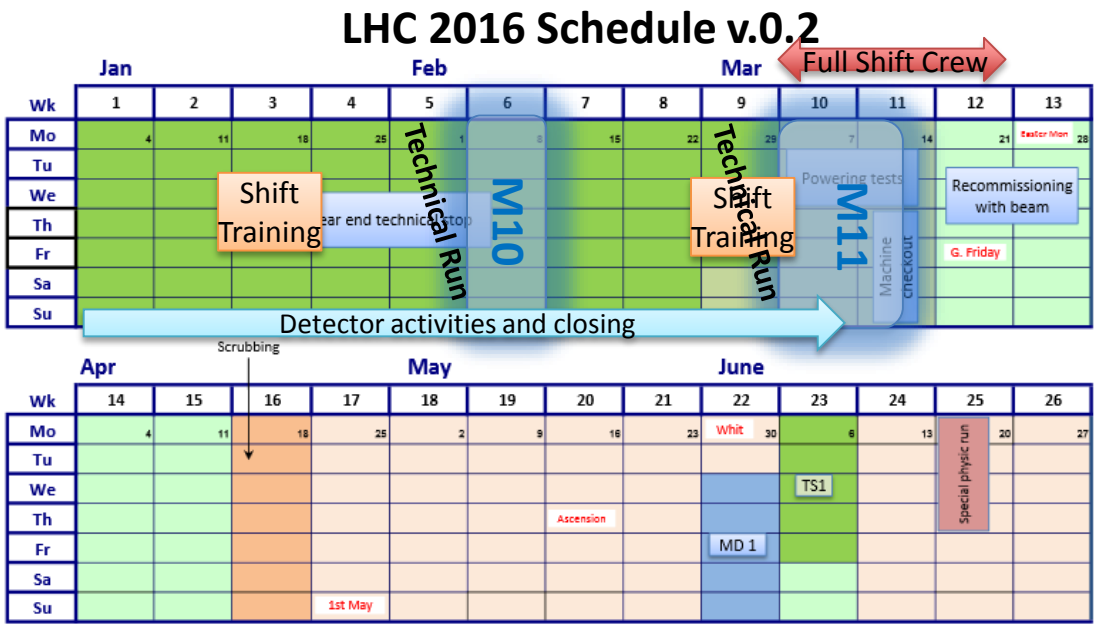
- Recently damage was discovered on the 2 bellows closing the vessel around the current leads of End Cap Toroid C.
  - Systems possibly affected: vacuum and current leads
- No impact on the ECT-C functioning (since 26 Feb. 2013), despite cool down, fast dump, and cycles of ramping up and down the field
  - The ECT has been leak tested and no leaks has been detected
- Preparations started to be ready to deploy the proposed solution during the forthcoming YETS
  - After ECT warm-up Inspection, via endoscope, of the current leads to check for internal damages
- Decision if internal repair needed (end of January)
  - In this case ATLAS will need 4 extra weeks on the YETS.
- Final repair of the damaged bellow by deploying two new larger bellows around on top of the damaged ones





Detector Closing

- Side A closing procedure 3/2 – 4/3
  - Allow some time during closing procedure for LUCID PMT refurbishment and for Muon Chamber gas leak fixes
- Side C closing procedure 5/2 – 3/3
  - All the time needed to move big objects (Calorimeters, Small Wheel ECT, Big Wheel)
  - In the shadow Muon Chamber gas leak fixes
- Detector closed by end of YETS



- Other activities:
  - **Pixel and IBL:**
    - The readout system of Layer-2 is planned to be replaced by the IBL one during this winter shutdown (ROD, BOC, opt-board).
    - Major effort underway to prepare hardware, firmware and software.
  - **SCT:**
    - Significant hardware and firmware updates to BackOfCrate Cards in barrel
  - **TRT:**
    - Gas Racks and Marathon Power supply maintenance
  - **MDT(Barrel and End-Cap):**
    - Standard maintenance on electronics cards, Repair of Gas Leaks on EO wheel
    - Elevator Chambers commissioning
  - **RPC(Barrel):**
    - Installation of flowmeters to to better monitor gas leaks development
    - installation of impedances to match the gas flow to the hit rate profile
  - **CSC(Small Wheel-C) :**
    - Dismounting of two chambers for repair and re-installation (TBD)
  - **TGC (Big Wheels):**
    - Replacement of 11 Chambers (Side C and Side A)
  - **All sub-systems:**
    - New SBC hardware (new trigger/DAQ release 64 bit only)
  - **Overall service yearly maintenance**

Conclusions

- The restart after the long shutdown and data taking through out 2015 has been very successful
- Despite the challenging conditions, the data taking efficiency and system stability has already reached a level comparable to last part of Run-1
- This result would not have been possible without the dedication of the subsystem and activities experts who have been working often all around the clock
- Analysis of the 2015 data is proceeding full steam – full data results will come soon
- While completing heavy-ion data taking, ATLAS is also getting ready and looking forward to more data in the coming years

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Thank You!