ATLAS EXPERIMENT

Status Report

121st Open LHCC Session, 4th March 2015

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On behalf of the ATLAS Collaboration

UNIVERSITY OF MICHIGAN

Run-1 Publications

- Publications since last LHCC meeting on Nov. 19th 2014
  - 24 papers (3 published already)
  - 7 notes for conferences

- Only a few examples can be shown here

- Two key SM Higgs measurements submitted since Nov'14
  - $H \rightarrow WW^*$ arXiv:1412.2641 6.1σ observed (5.8 exp.)
  - $H \rightarrow \tau\tau$ arXiv:1501.04943 4.5σ observed (3.4 exp.)

Beyond Standard Model Higgs

arXiv:1501.03276

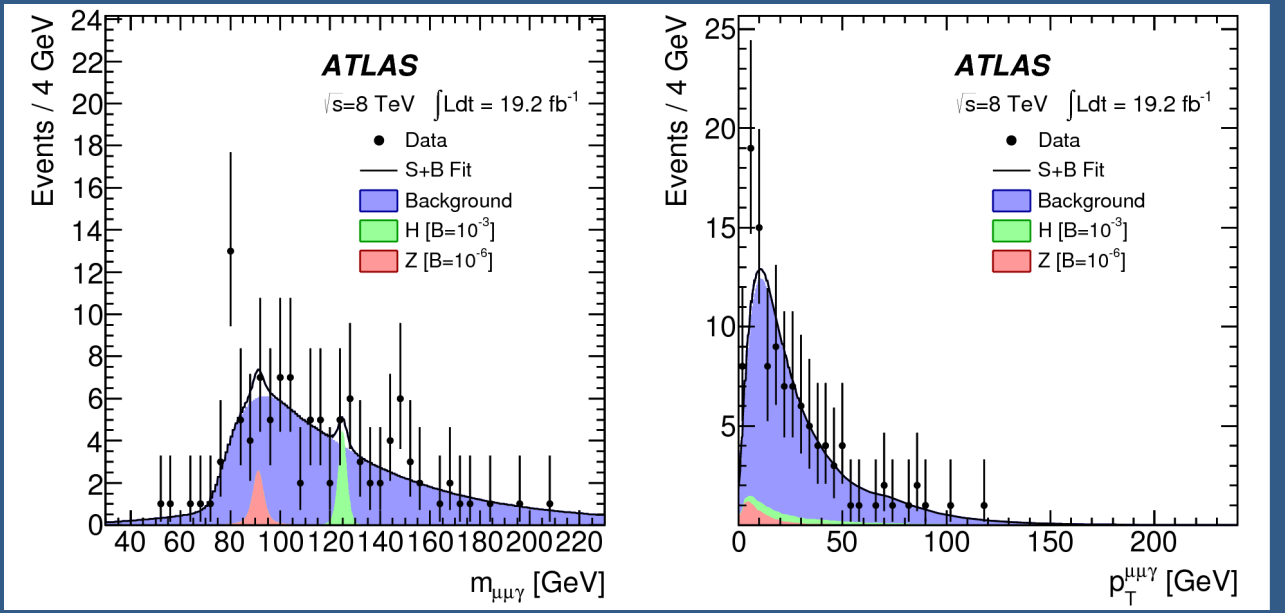
H→quarkonium+γ

Sensitive to magnitude and sign of Higgs coupling to (c, b) quarks

Sensitive to new physics e.g. in $Hc\bar{c}$ coupling

No significant excess above SM background

Upper limits on branching fractions obtained

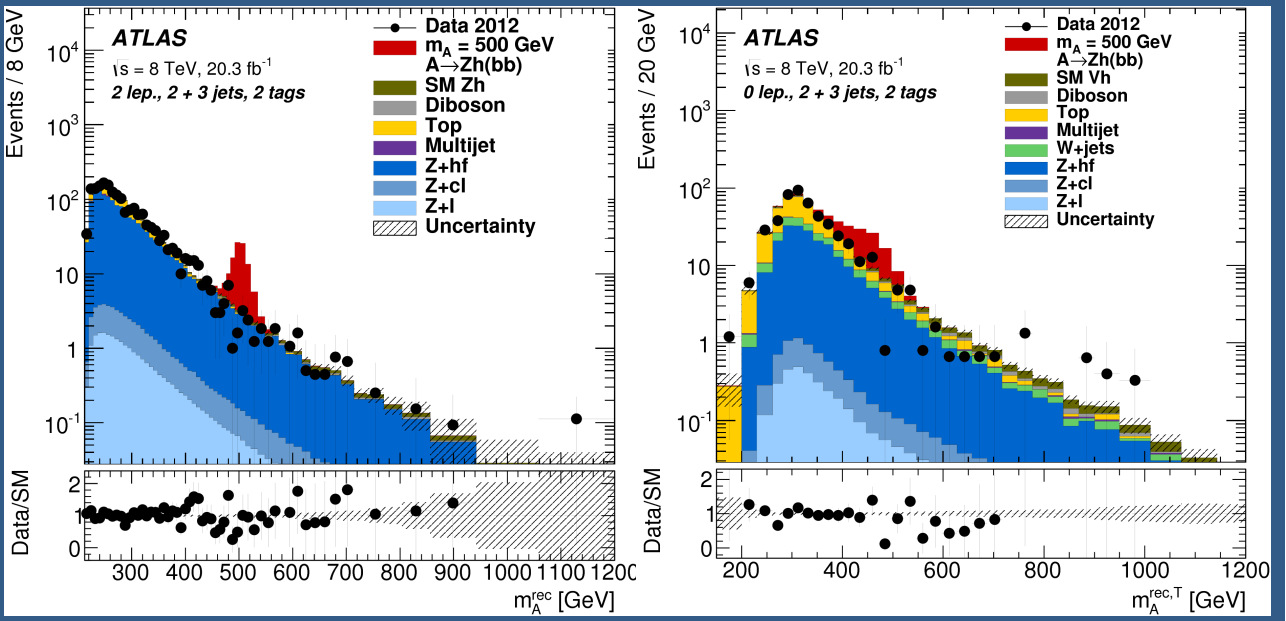


A→Zh arXiv:1502.04478

Higgs used as decay product

No deviation from SM background

Setting upper limits on branching fractions

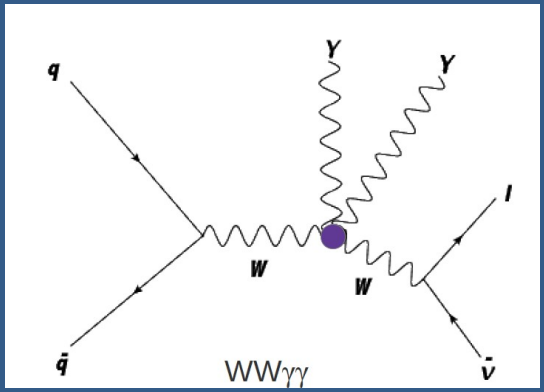


Standard Model Wγγ

Motivation

Test SM description of self-coupling between W and photon gauge bosons and sensitivity to new physics in anomalous quartic gauge couplings (aQGC)

Irreducible background to new physics searches and to future WH(→γγ) measurements



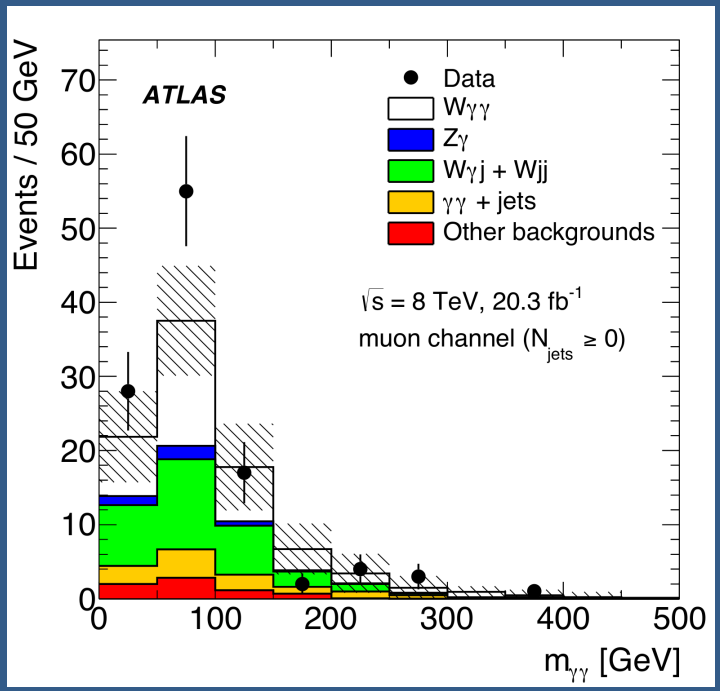
Wγγ cross-section measurements in W electron and muon decay channels in fiducial phase space, inclusively ($N_{jets} \geq 0$) and exclusively ($N_{jets}=0$) in associated jet multiplicity

Results

Cross-section compared with NLO prediction by MCFM
=> in agreement within 2σ uncertainties

aQGC limits performed for $m_{\gamma\gamma}$ > 300 GeV
=> improving f_{T0}/Λ^4

	σ^{fid} [fb]	σ^{MCFM} [fb]
Inclusive ($N_{\text{jet}} \geq 0$)		
$\ell\nu\gamma\gamma$	$6.1\ ^{+1.1}_{-1.0}$ (stat.) ± 1.2 (syst.) ± 0.2 (lumi.)	2.90 ± 0.16
Exclusive ($N_{\text{jet}} = 0$)		
$\ell\nu\gamma\gamma$	$2.9\ ^{+0.8}_{-0.7}$ (stat.) $^{+1.0}_{-0.9}$ (syst.) ± 0.1 (lumi.)	1.88 ± 0.20

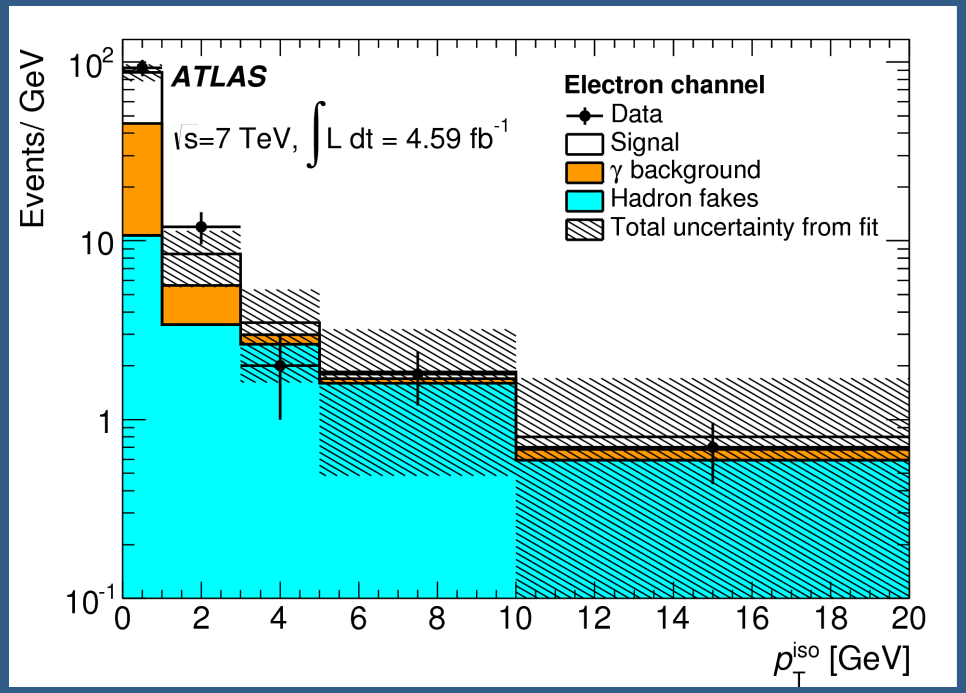


Top-antitop + Vector Boson Production

$t\bar{t}\gamma$ arXiv:1502.00586

Testing coupling of bosons to top quarks

Single lepton final state



Contribution	Total
Signal	152 ± 31
Hadrons	93 ± 46
Prompt photons	106 ± 10
Total background	199 ± 47
Total	351 ± 59
Data candidates	362

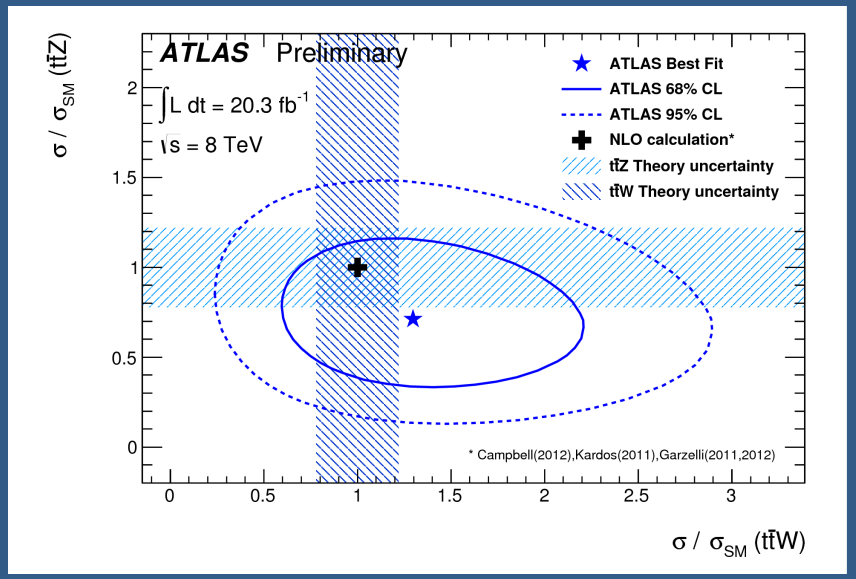
Observation 5.3σ

$\sigma^{fid}_{t\bar{t}\gamma} \times BR = 63 \pm 8(stat)^{+17}_{-13}(syst) \pm 1(lumi)$

Theory: 48±10fb

Completes the already presented:

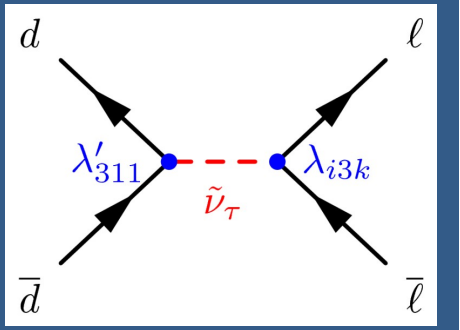
$t\bar{t}V$ ATLAS-CONF-2014-038



Search for eμ, eτ, or μτ Resonances

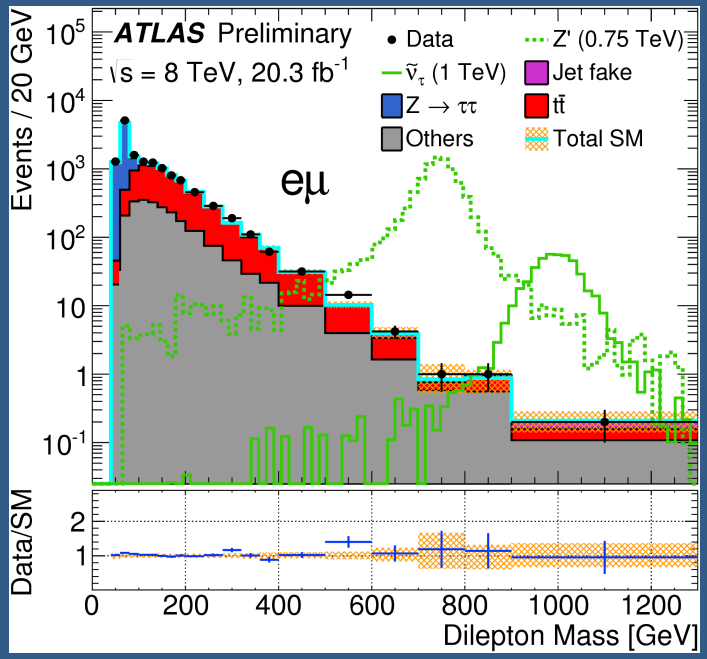
Preliminary

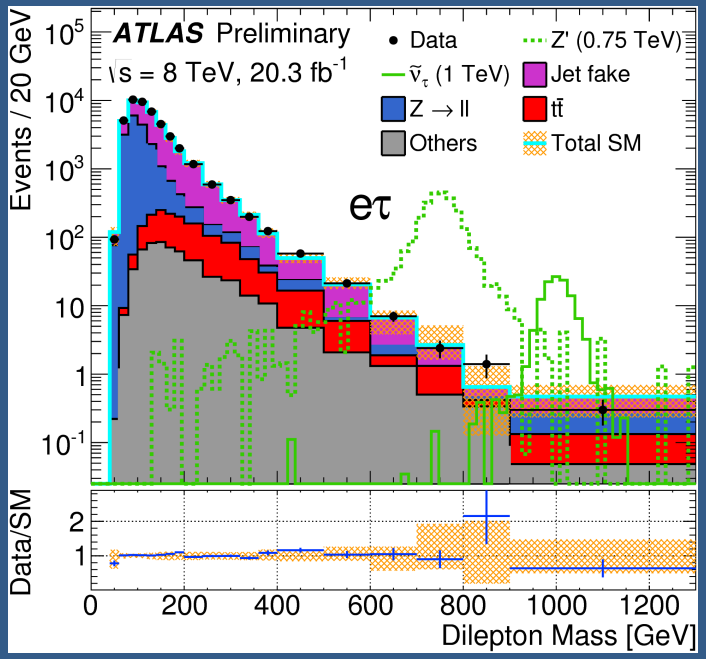
Following on from a search for lepton flavour violating Z-boson decays ($B(Z\rightarrow e\mu) < 7.5 \times 10^{-7}$, arXiv:1408.5774)

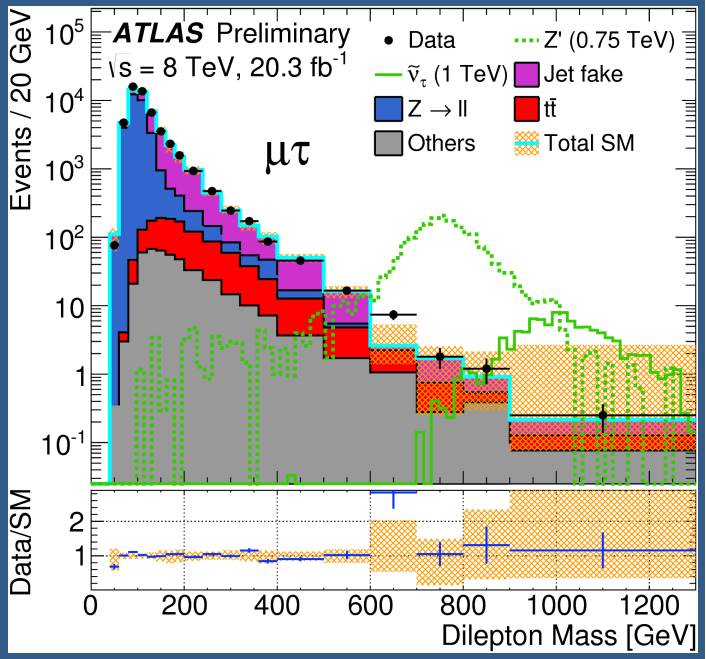


Now search in the high mass region for:
- R-parity violating decays of the τ sneutrino
- Lepton flavour violating decays of a Z'

Excess searched for in mass ranges compatible with signal resolution
Setting mass limits in the range of 1.7 - 2.0 TeV for sneutrinos and
2.2 - 2.5 TeV for Z'

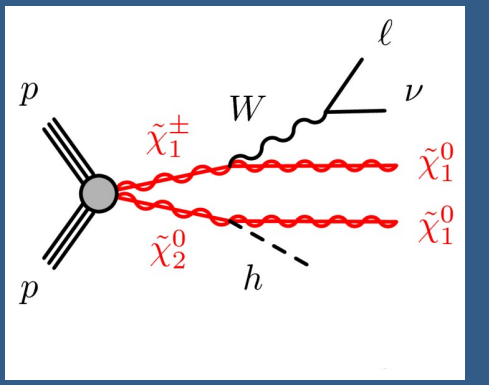






Search for EWKinos Decaying via Higgs

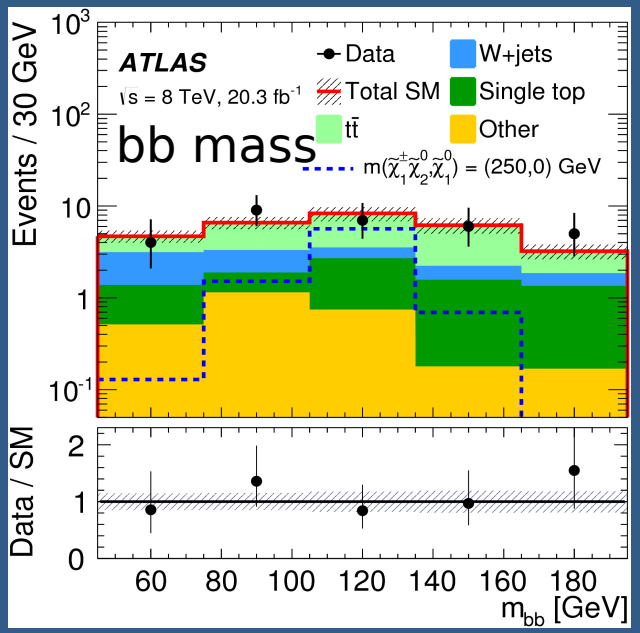
arXiv:1501.07110

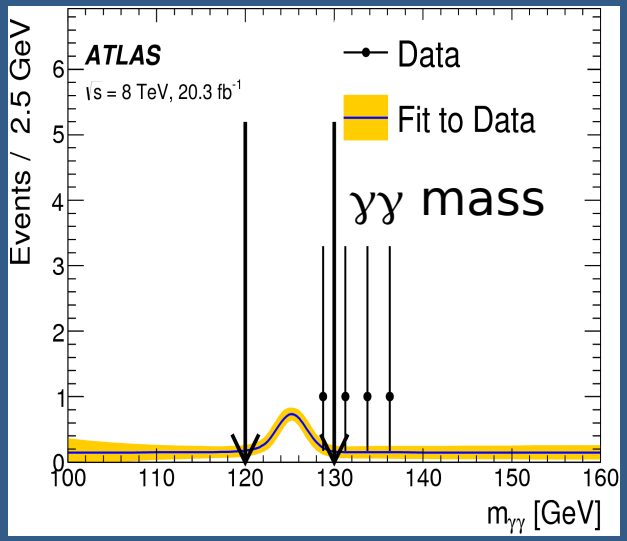


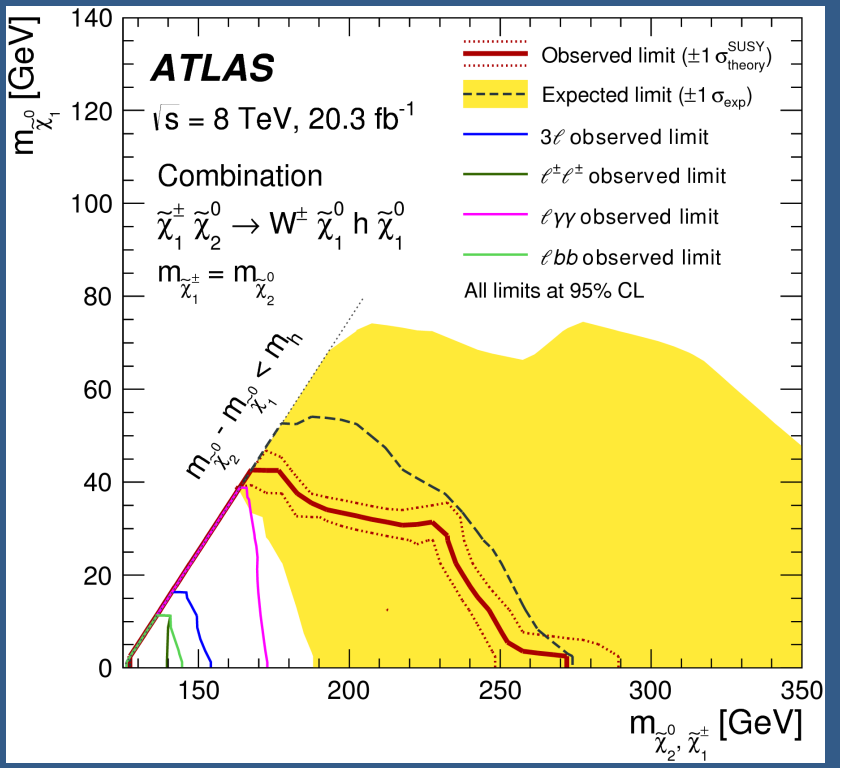
Heavier neutralino can decay via Z-boson or Higgs
Z cases already exploited in earlier analyses, here consider Higgs case

Include Higgs decays to $\gamma\gamma$, bb, WW, and $\tau\tau$
Starting to become sensitive, more statistics needed

Combination excludes chargino masses up to 250 GeV

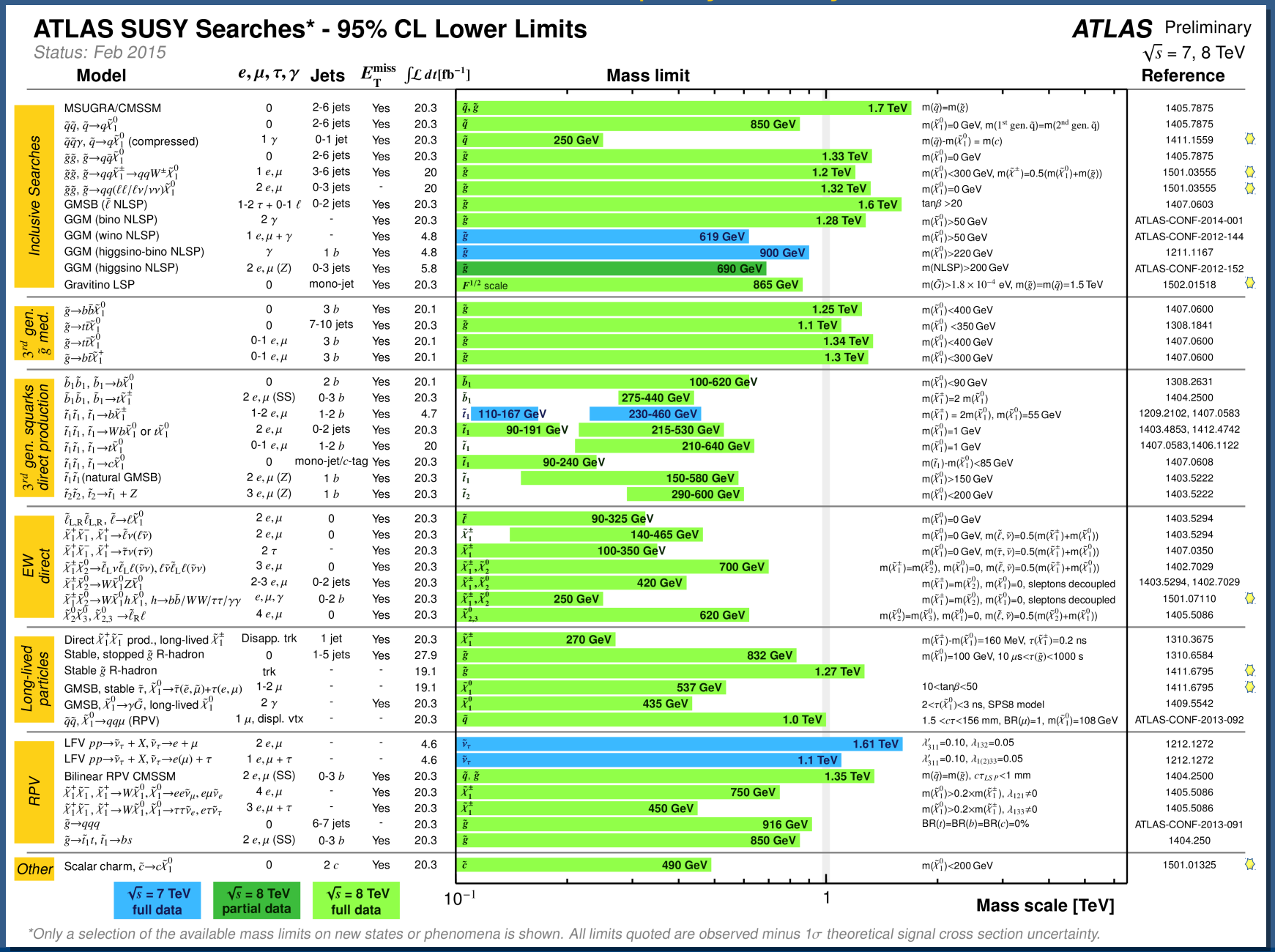






Run-1 SUSY program completing

https://twiki.cern.ch/twiki/bin/view/AtlasPublic/SupersymmetryPublicResults



Dark Matter Searches: MET+jet

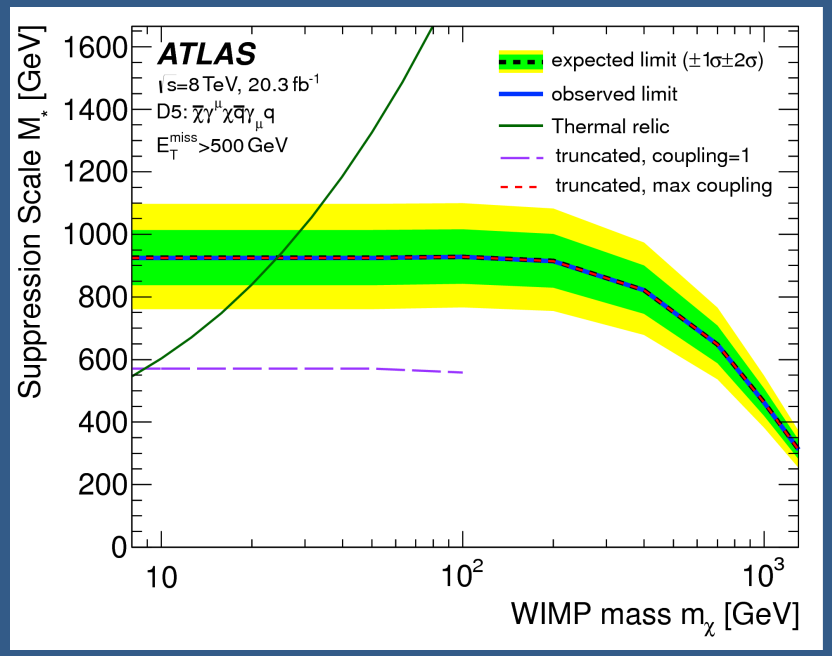
arXiv:1502.01518

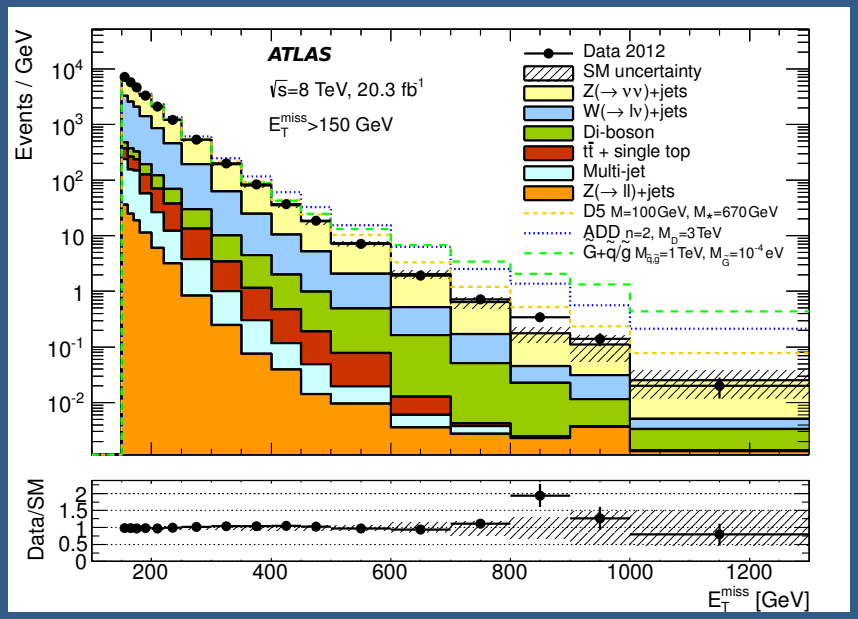
Clean signature for BSM searches

$p_{T,jet}$>120GeV, data-driven background

No evidence for signal

Model dependant exclusion limits obtained

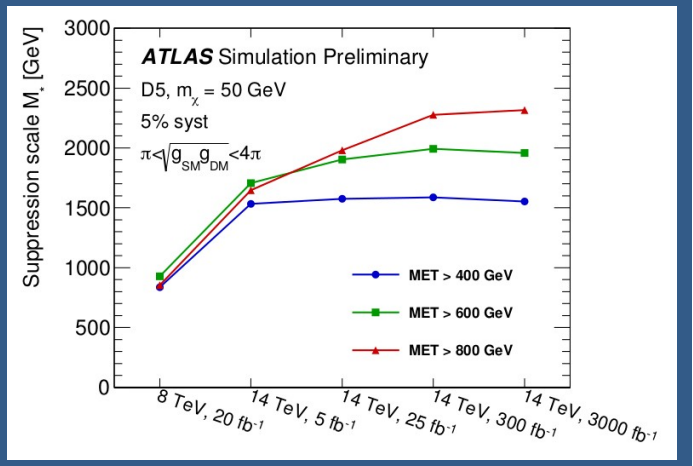




Expected sensitivity of MET+jet @run-2

ATL-PHYS-PUB-2014-007

5 fb^{-1} data can surpass 8 TeV result



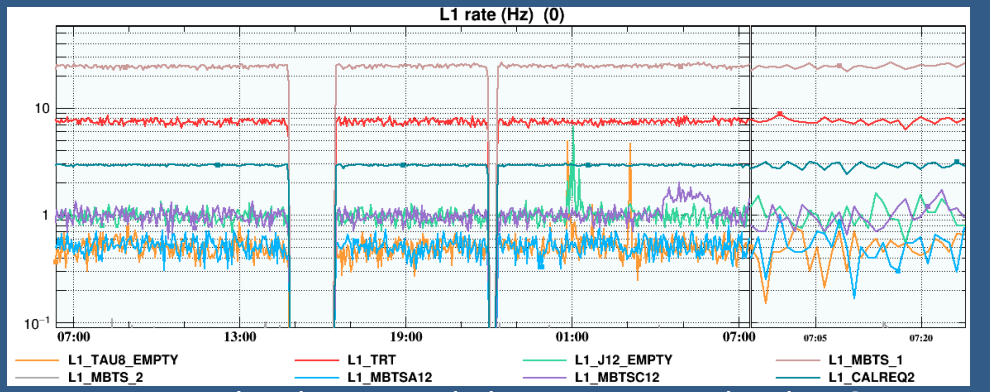
Other MET+X searches: no excess

MET+photon	PRD 91, 012008(2015)
Hadronic W,Z	PRL 112, 041802 (2014)
Leptonic W	JHEP 09 (2014) 037
Leptonic Z	PRD 90, 012004 (2014)
MET+Heavy flavour	arXiv:1410.4031

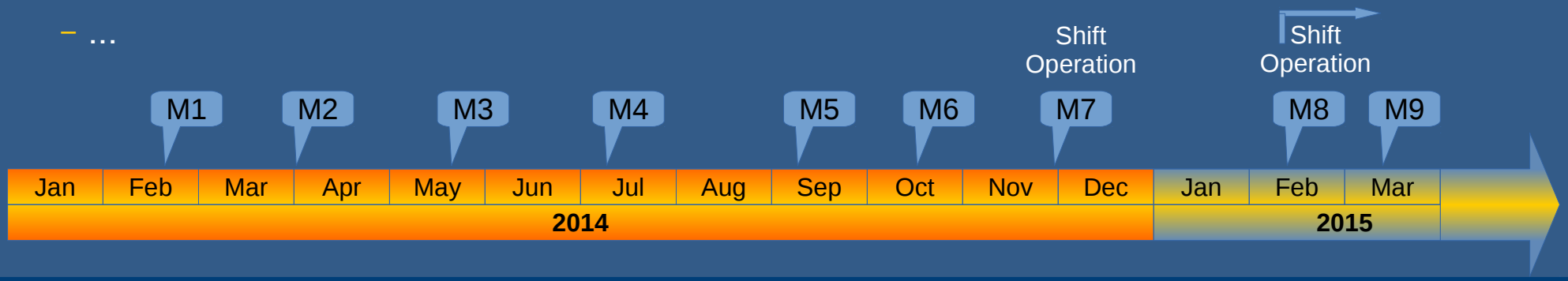
LS1 → Run-2

Milestone Runs

- M7 (Nov/Dec 2014)
  - First time with shifters back in the control room
  - Almost all sub-detectors in, some without HV
  - Solenoid and Toroid B-field on for part
- M8 (Feb 2015)
  - Testing of new DAQ and Trigger software
  - All sub-detectors integrated
  - Stable runs up to 20h
  - Start of continuous shift operation
  - Solenoid B-field on for part (Toroid off)
- M9 (Mar 2015)
  - Calibration and alignment cosmic data taking
  - Runs through to beam splashes
  - ...

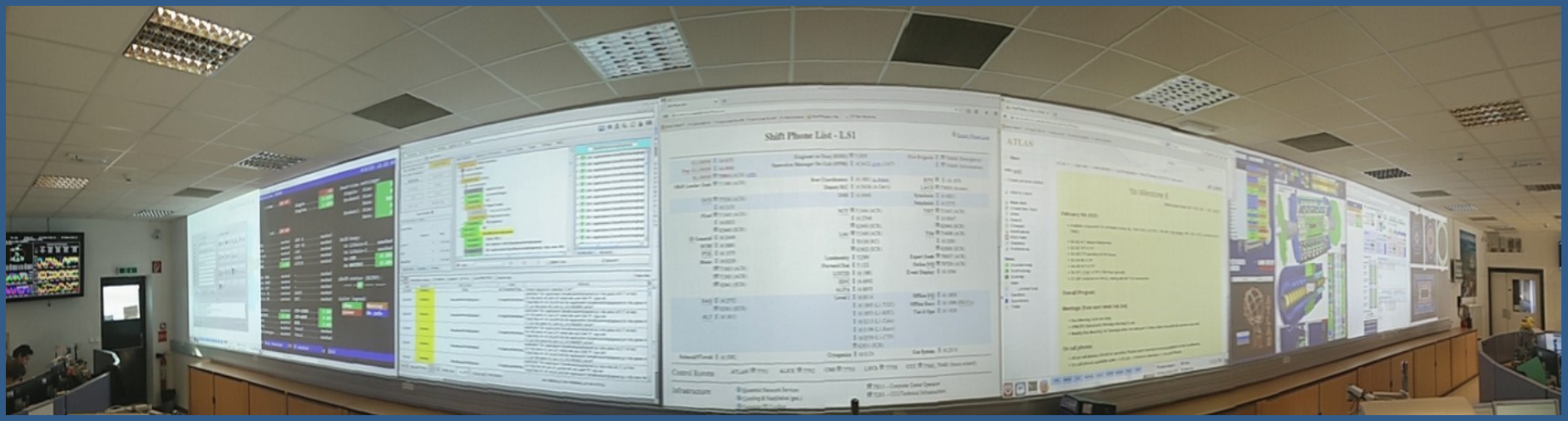


Level 1 trigger rate during some runs taken in M8



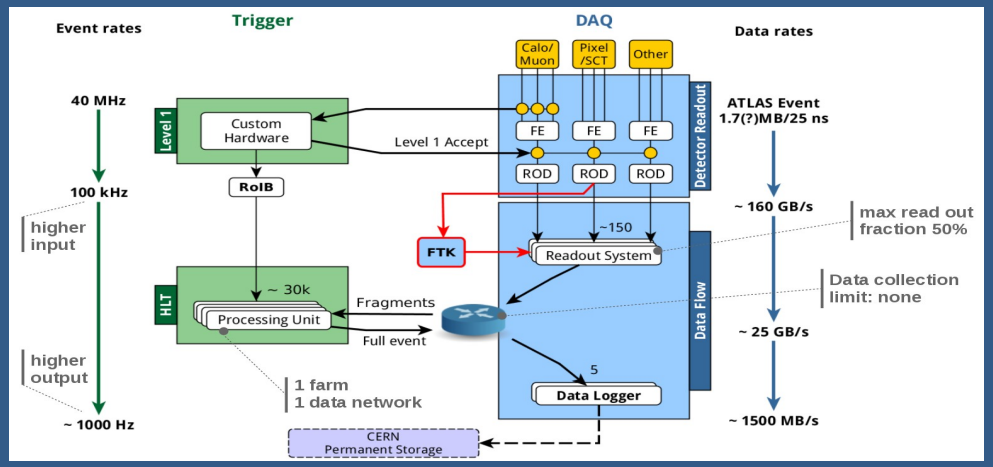
Preparation for Run-2

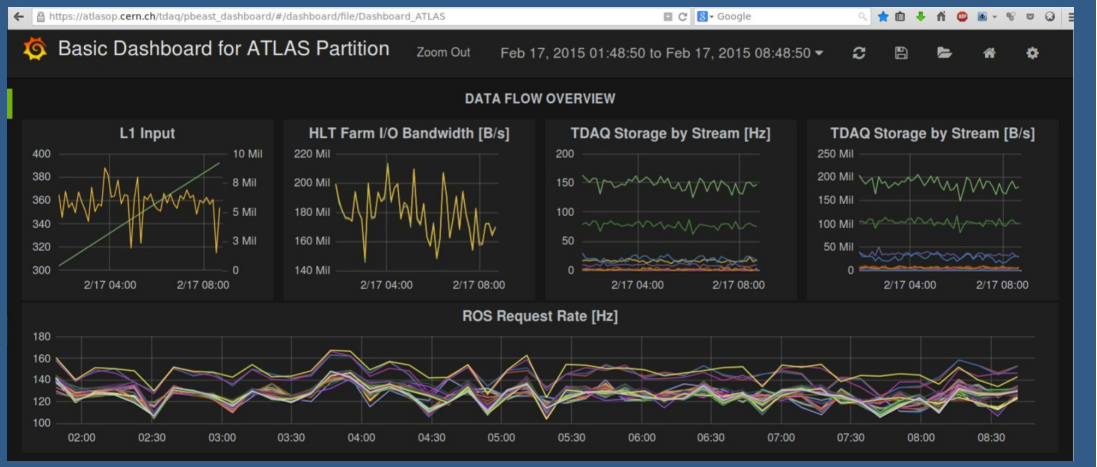
- It's a long time since run-1
  - Many new Shifters and Experts
- Regular shift training
  - Already done three times



DAQ

- Network overhaul
  - Redundancy implemented for all critical systems
- Data flow architecture
  - Redesigned to simplify resource management
- Tested in technical runs of central infrastructure
  - Followed by milestone runs with all sub-systems
- More Web based monitoring tools
  - Easier access for experts from remote

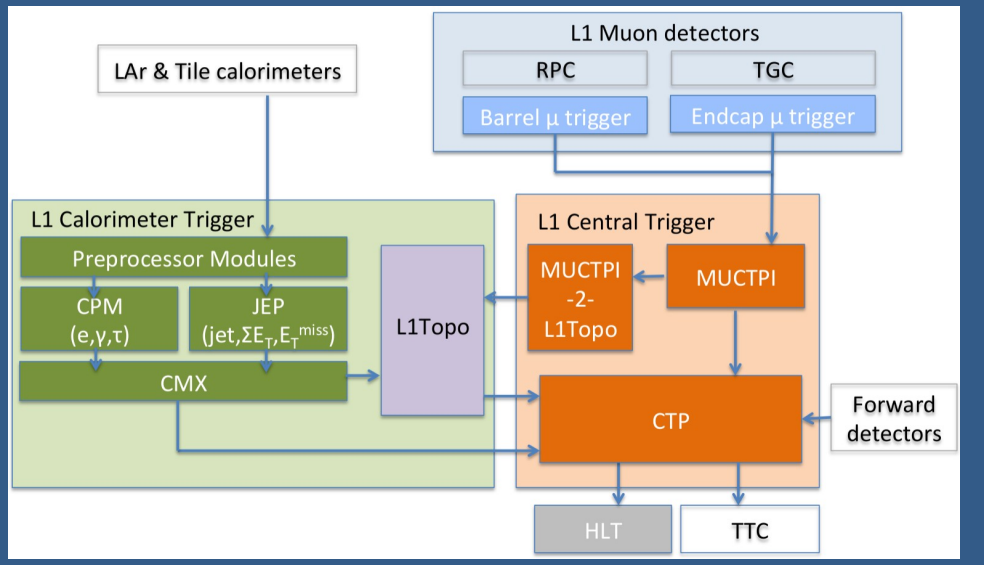




Trigger

Level 1 Trigger

- New central trigger processor installed and commissioned with all detector systems
  - Doubles number of trigger items and allows for new inputs from Topo processor and ALFA
- L1 Calo firmware and hardware upgraded
  - Relative isolation, correct for bunch train effects, provide more trigger items
- Max L1 rate 100 kHz
  - Was 75 kHz in run-1



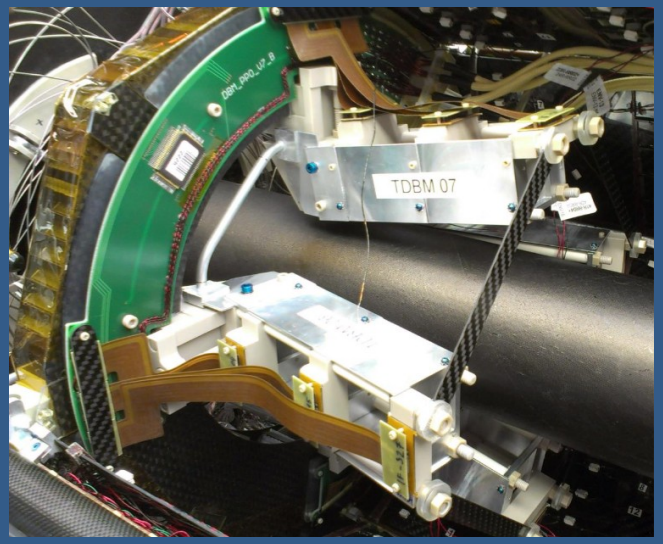
High Level Trigger

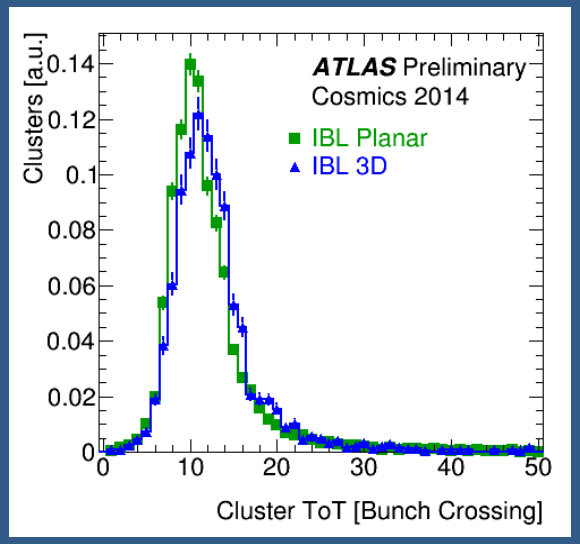
- New data flow architecture
  - Data read as needed from detector, no Level 2
- Run-2 trigger menu very close to final
  - Validation of trigger items ongoing
- Run-2 average HLT rate ~1kHz
  - Was 200-400 Hz in run-1

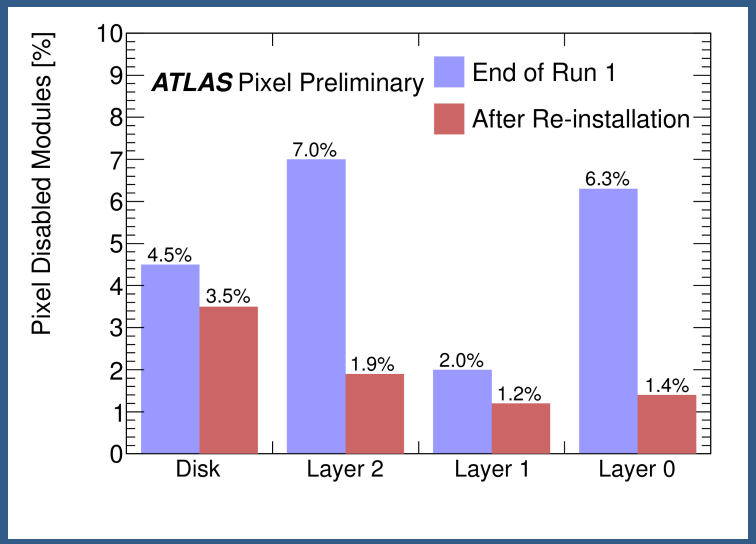
Pixel / Insertable B-Layer / Diamond Beam Monitor

- Pixel Calibration updated
  - Already performed end of 2014
- Pixel & IBL operation
  - More than 100 hours of data taking
- DBM currently running with 16 of 24 modules
  - First DBM hits seen during M8

Cosmic muon events	Solenoid On (Millions)	Total (Millions)
IDCosmic	2.5	9.2

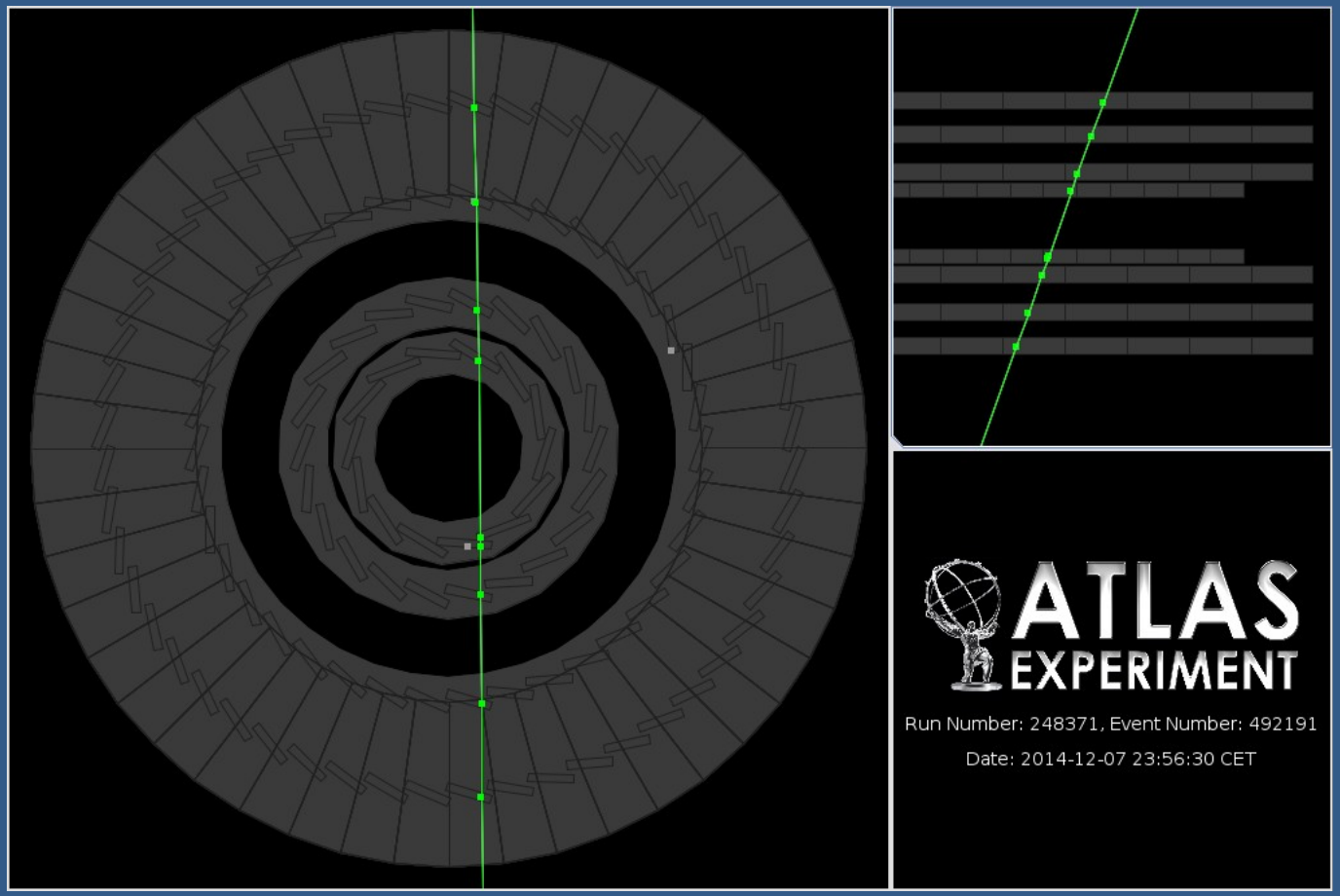






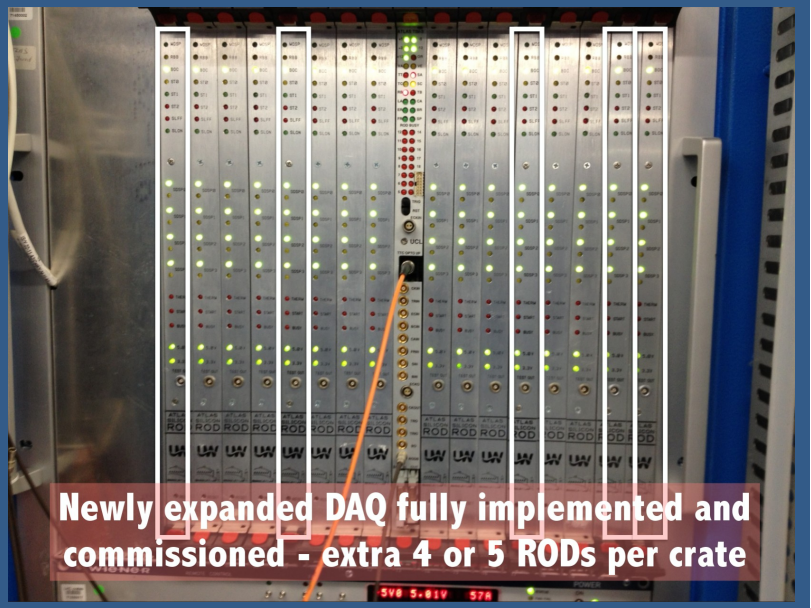
Pixel / Insertable B-Layer / Diamond Beam Monitor

- IBL calibration applied
  - First time performed in the cavern
- IBL integration into DCS being completed
- IBL Safe For Beam (SFB)
  - Under commissioning



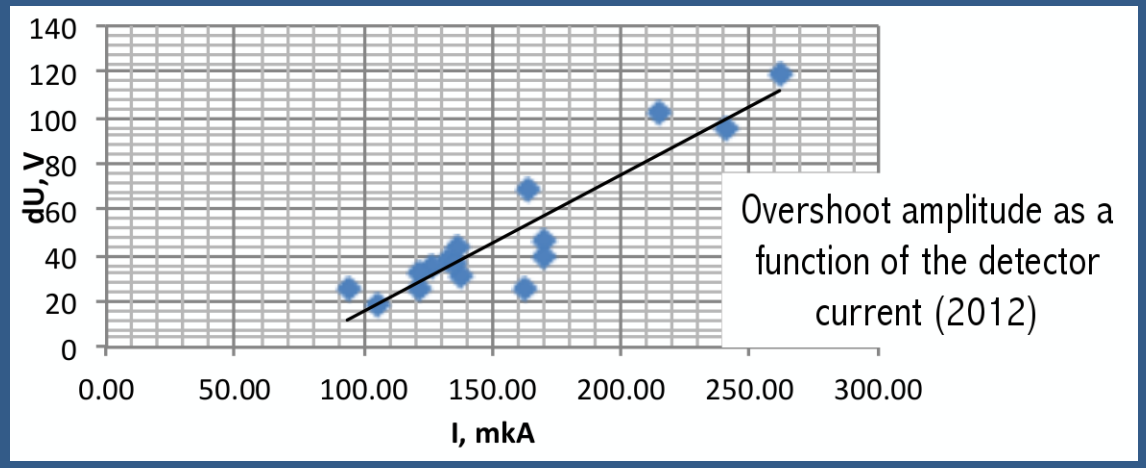
Semiconductor Tracker

- Expansion of DAQ to cope with higher pileup
  - Increased number of ROD/BOC from 90 to 128
  - Pile-up limit well above run-2 expectation
- Running smoothly during M8
  - Validated Run-2 fibre mapping
  - First round of calibrations performed
- Off-detector optical transmitters TX
  - Many failures during run-1
  - Some crates equipped with new LTx
  - Running with TX and LTx in 2015 for lifetime studies

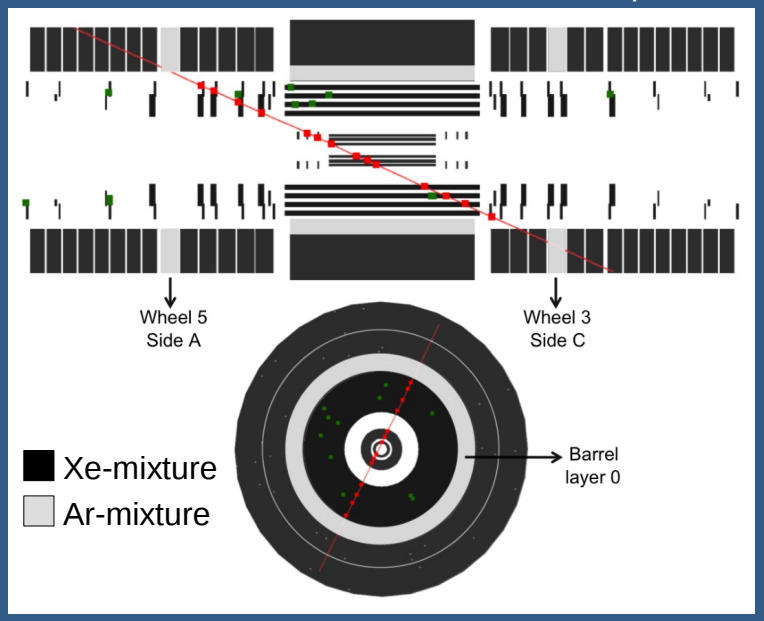


Transition Radiation Tracker

- High voltage ON in the entire detector
  - Successfully tested operation at 100 kHz with up to 50% occupancy
  - FastOR trigger in stable use during cosmic ray runs
- New active gas system
  - Leaks can lead to contamination into active gas volume
  - New system allows to remove accumulated nitrogen
  - Baseline for 2015: operating part of the detector with Argon mixture instead of Xenon
  - Impact on e/γ-identification small after algorithm updates
- HV overshoot at beam dump in run-1
  - Amplitude depends linearly on detector current
  - Solution found: under preparation (for summer 2015)

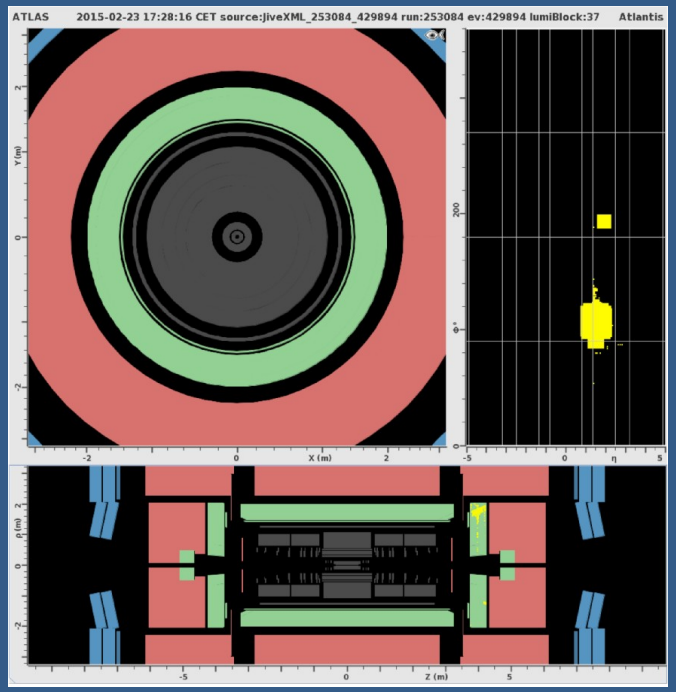


Baseline scenario for 2015 operation



Liquid Argon Calorimeter

- All planned hardware maintenance work finished
  - In January HV modules replaced on EMEC outer wheel and FCal
    - Quick re-ramping after trips and precision current reading
  - Nominal HV for M8
- Some improvements in LAr online software and DQ assessment
  - Since M7 data taking with 4-sample mode up to 100 kHz
  - Online flagging of noise bursts
    - successfully tested during M8 with HV-ramp-induced noise bursts
  - Automatic flagging of hot cells in trigger towers
- LAr Cryostat grounding
  - Reminder: grounding inadvertently changed during LS1
  - No impact on LAr noise and noise bursts seen so far

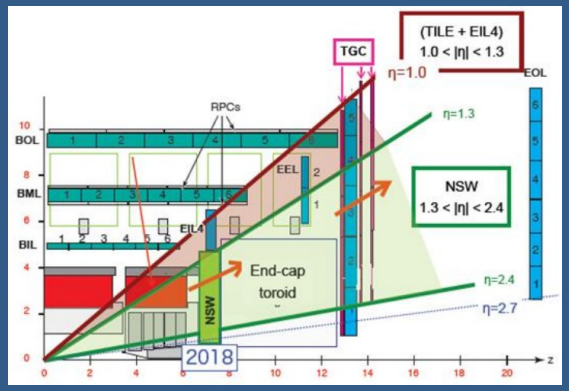


HV-ramp-induced noise burst

Hadronic Tile Calorimeter

- New Laser-II system under commissioning
  - Improve long term stability control of the system
- First Cs scans performed and HV settings updated
  - Preserve absolute EM scale as in run-1
- Minimum Bias Trigger Scintillators replaced
  - Finalising commissioning
- Tile-Muon-Trigger
  - Coincidence between Tile and TGC
  - Trigger rate reduction in $1<|\eta|<1.3$
    - Expected reduction with E(Tile)>500MeV: ~82%
  - First Tile-Muon Digitizer Boards available
  - To be tested soon

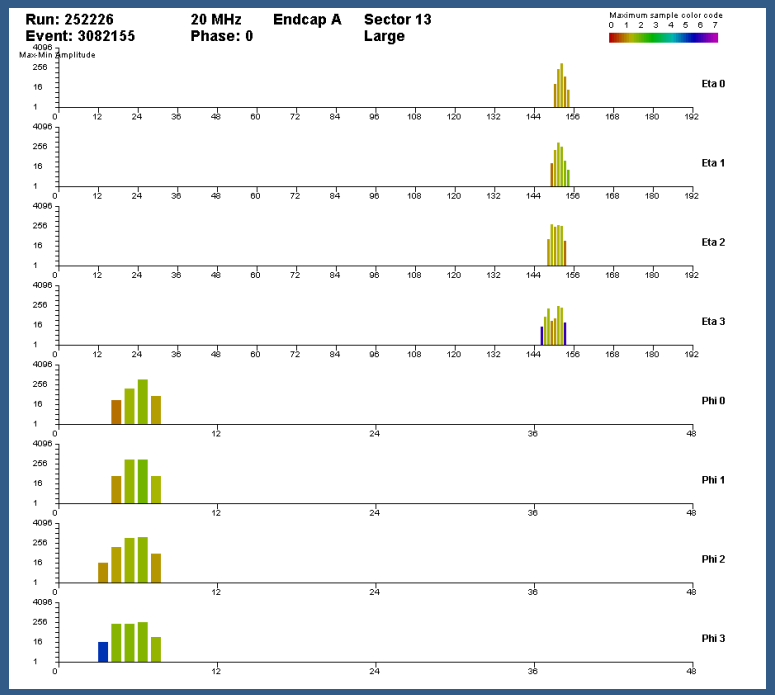
Laser-II

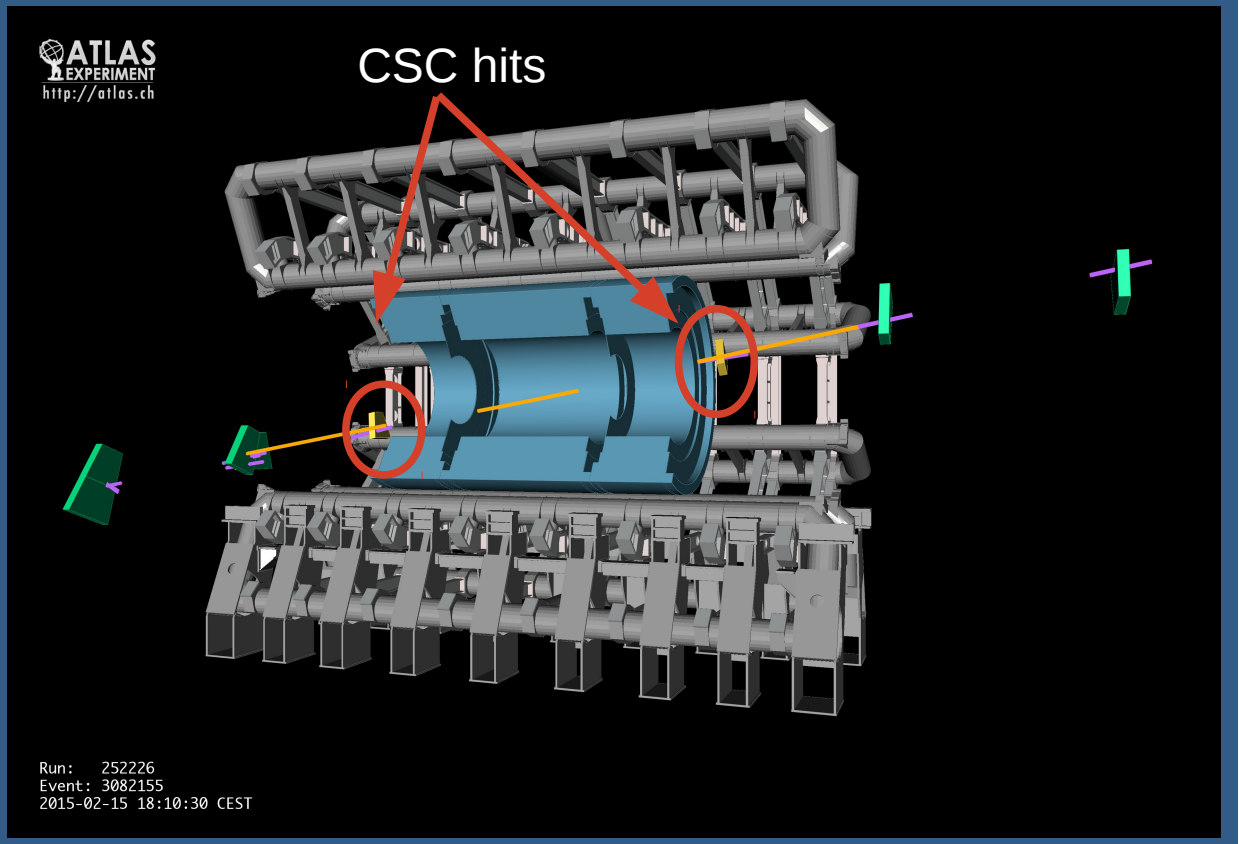


Tile-Muon Digitizer Board

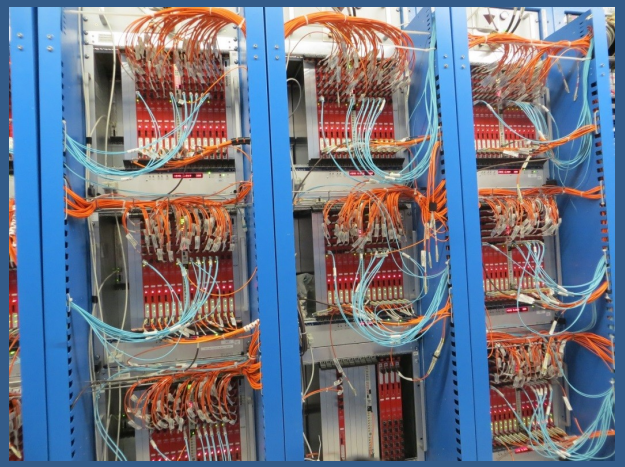
Cathode Strip Chambers

- New ROD complex fully integrated
  - Old system had rate limitations not adequate for run-2
- Running up to 100 kHz achieved
  - Ongoing development to improve stability at higher occupancy
- Readout system housed in ATCA shelf
  - First ATCA based system in ATLAS DAQ
  - Monitored and controlled via DCS

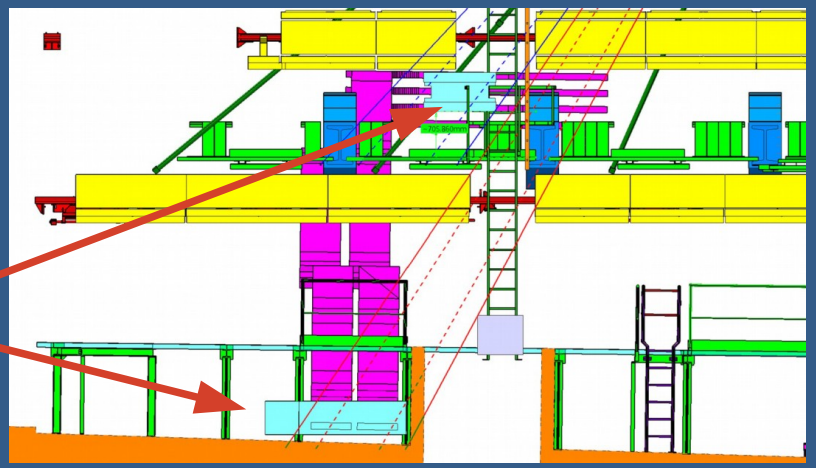




Monitored Drift Tube Chambers

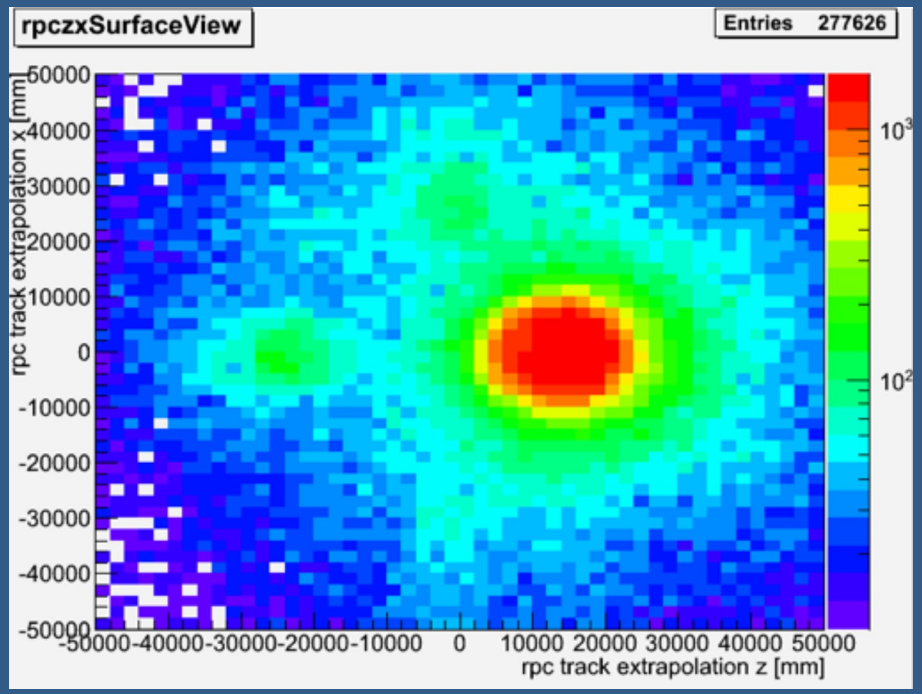


- Various small repairs performed
  - Exchange of some broken on chamber electronics
  - HV/LV problems
  - Gas leak repairs
- MROD Double Read-out
  - Remove potential bandwidth bottleneck in endcap inner region
  - Converted (by firmware update) 1 of 6 inputs into an additional output
- New chambers installed and integrated
  - Covering holes (0.9%) due to elevator shafts in in bottom sectors
  - First sMDT (small tube MDT) chambers
    - Tube diameter half of standard MDT tube



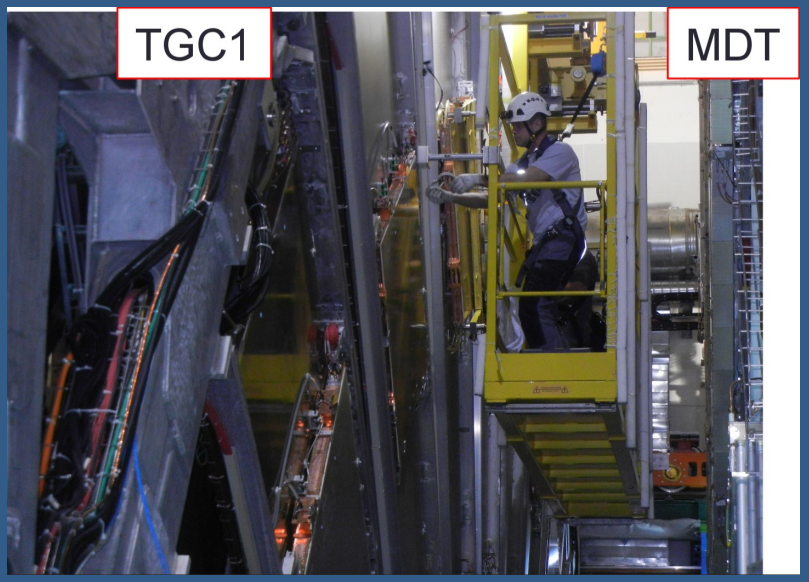
Resistive Plate Chambers

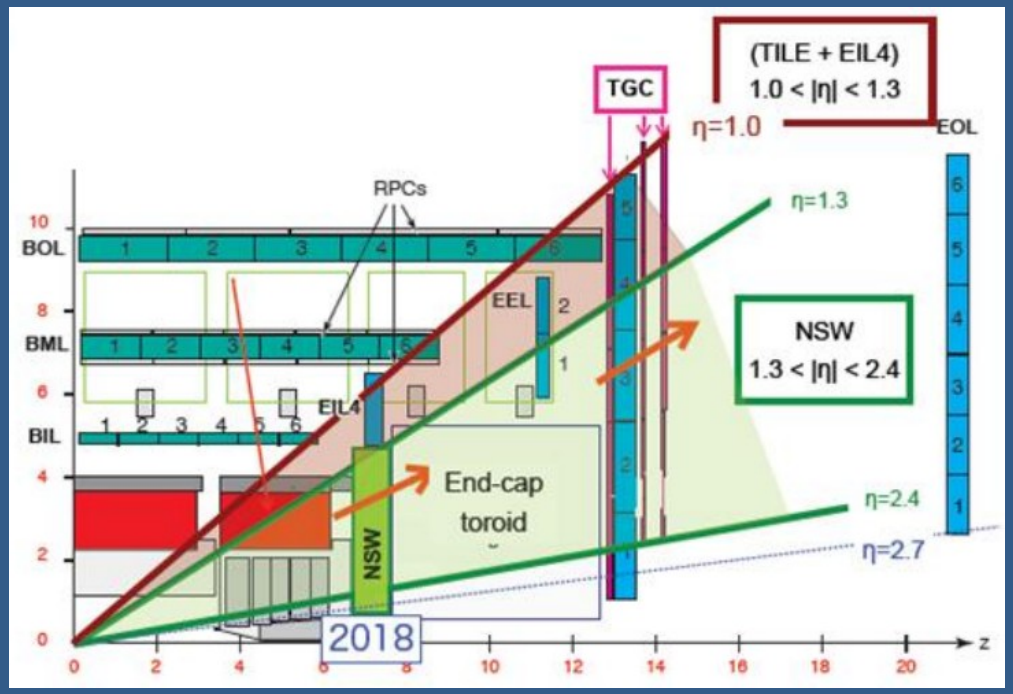
- Gas system upgrade
  - Repair of cracked inlets (2 teams nearly full-time in 2014)
  - New flowmeters and impedances (during 2015)
- RPC chambers in bottom sectors
  - Cover holes in BM layer due to feet (2.8%)
  - Cover holes due to elevator shafts (0.9%)
    - New type 1mm-gap RPC



Thin Gap Chambers

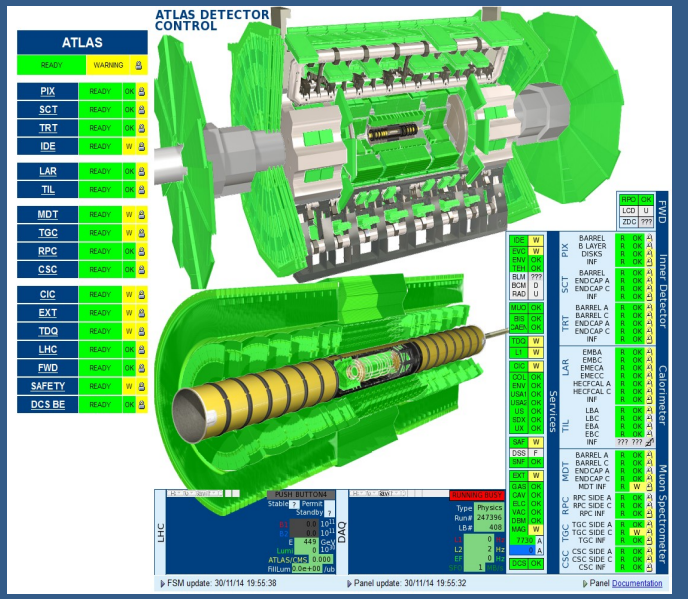
- Nominal gas back since few weeks ago
  - Successfully replaced 27 chambers
  - Participated in M8 with HV on
  - Sending trigger signals
- Inner coincidence
  - Inner chambers added to coincidence with big wheel
  - Timing adjustments ongoing





Detector Control System

- Major migration of all sub-systems
  - Last few sub-system upgrades finalising
- Several new sub-detector components integrated
  - IBL, DBM, new MDT/RPC chambers, ...
- LHC-handshakes tested during dry-runs
  - No major issues observed
  - Time(Stable Beam → Ready for Physics) improved by factor ~2
- Detector experts working hard to get “all green”



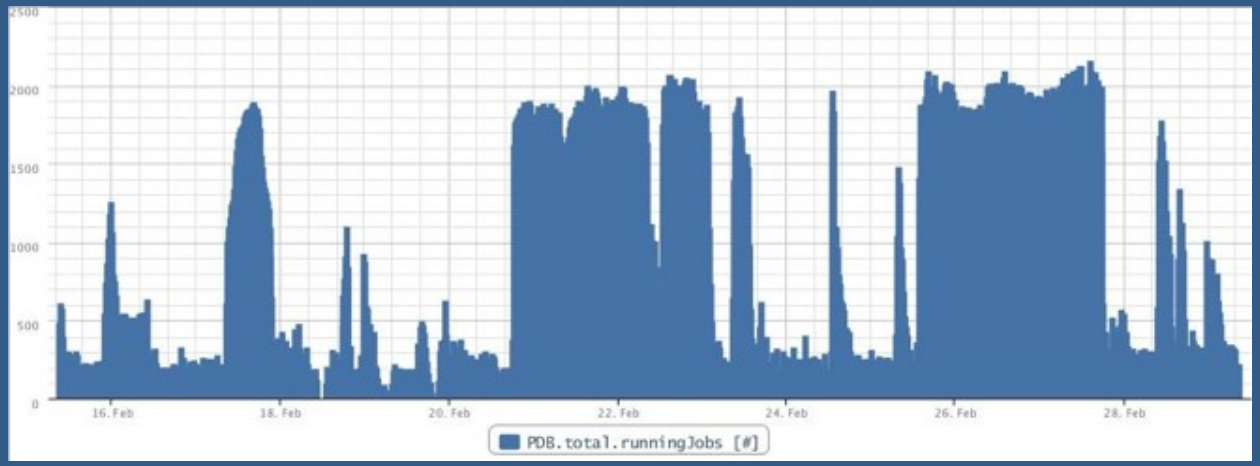
Data Preparation

- Exercising DataPreparation workflow since M7
  - Automatic Tier0 reconstruction
  - 48 hour calibration loop
  - Detector conditions uploads
  - Data Quality assessment and shifts
  - Data replication to grid

	Solenoid On (Millions)	Total (Millions)
IDCosmic	2.5	9.2
CosmicCalo	8.3	31.5
CosmicMuons	52.9	186.2

Events collected during M8

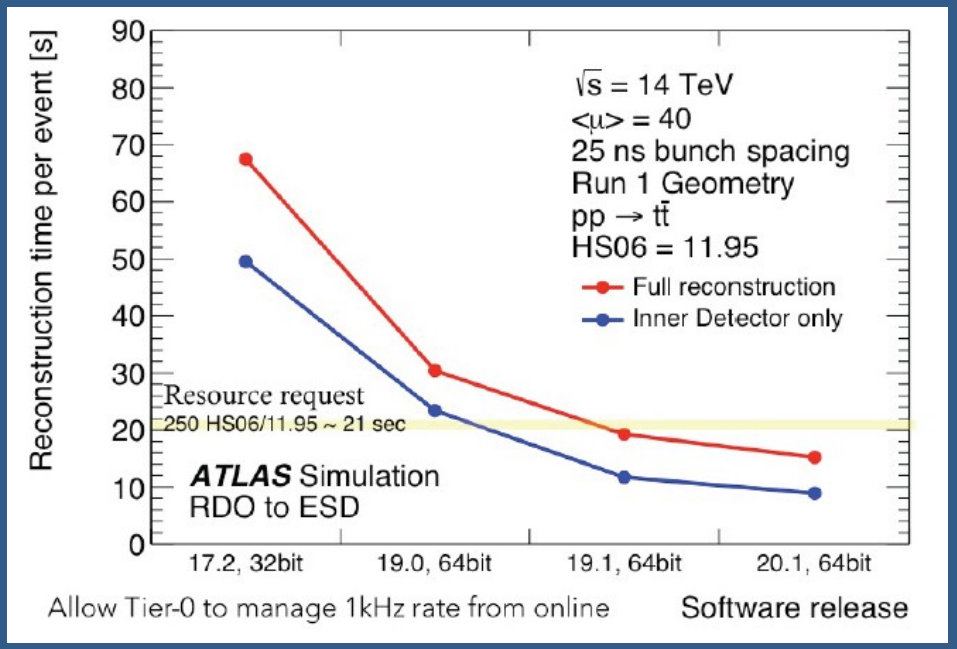
- Collecting cosmic data for detector alignment
  - First ID alignments including IBL done
  - Muon barrel alignment started, full sample in M9



Tier0 jobs running over 2 weeks during M8

Computing and Software

- Distributed Data Management
  - DQ2 → Rucio: scalability for run-2 and beyond (in operation)
- Distributed Workload Management
  - ProdSys → ProdSys2 (in operation)
- New Data Management
  - All data assigned lifetime, delete when expired (automatic during 2015)
- Software
  - New Analysis Workflow and Framework (in use)
  - Reconstruction: factor of ~4x faster at high μ

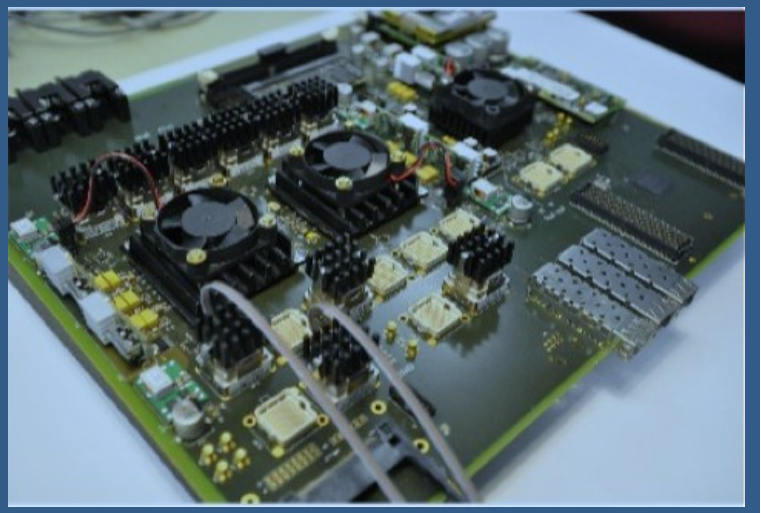


Upgrade

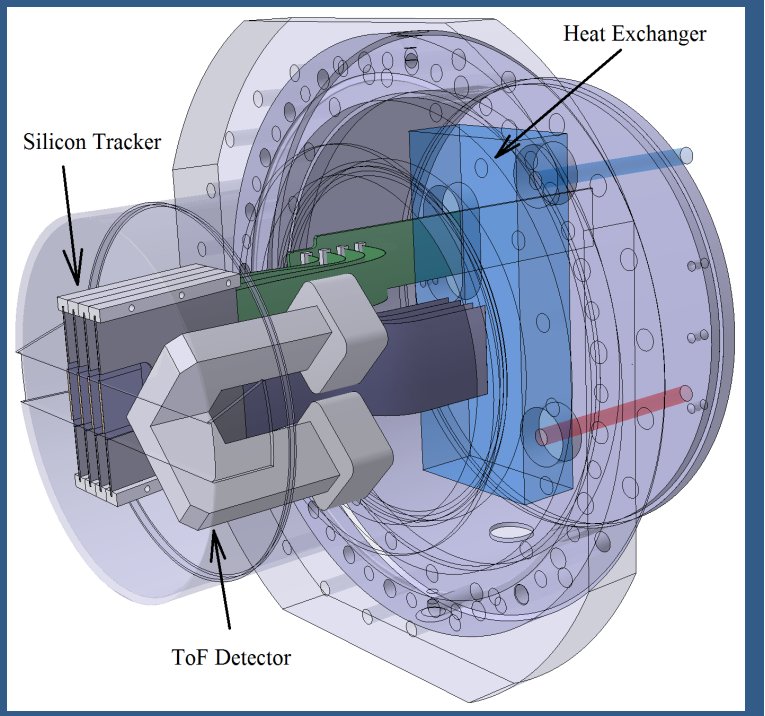
Upgrade: Phase I

- Four main projects
  - New muon small wheel, FastTracker, LAr trigger electronics and TDAQ
  - TDRs approved by LHCC in 2013 & Research Board in March 2014
  - Some parts are installed early for run-2 (e.g. L1Topo)
  - Remainder approaching production for installation during run-2 (FTK) or in LS2
  - LAr “Demonstrator” crate backplane and modules installed for run-2
  - First comprehensive LHCC annual review in Nov 2014

- ATLAS Forward Physics (“AFP”)
  - Roman pots at 210m, close to ALFA stations
  - Project now approved by ATLAS as part of the upgrade programme
  - Proceeding towards a TDR for next LHCC
  - Discussed yesterday in LHCC Upgrade Session



First L1Topo production module

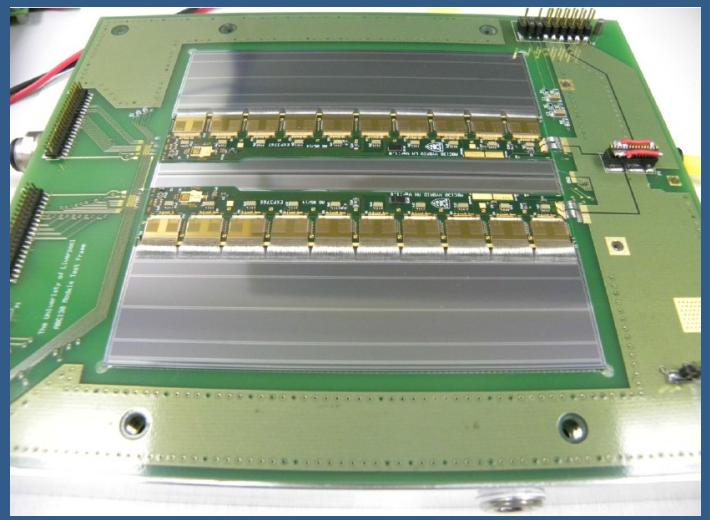


One (of four) AFP Roman Pot setup

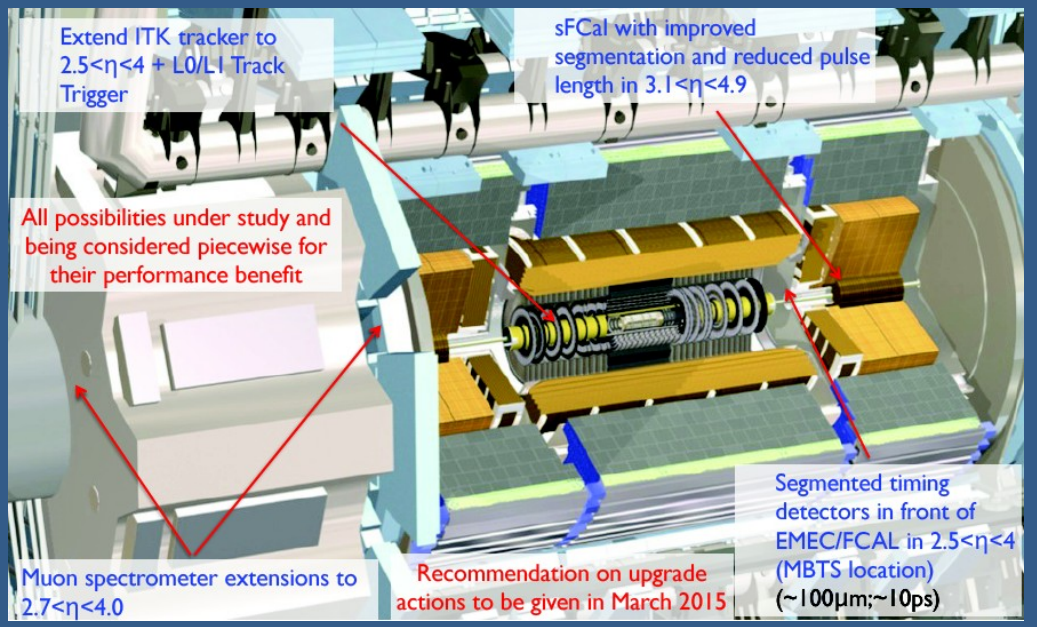
Upgrade: Phase II

- New inner tracker (ITK)
  - Approved by ATLAS as an upgrade project (Feb 2015)
  - ~95 institutions
- Huge range of R&D ongoing for all phase-II projects
  - Overall summary being prepared for April RRB
- Three scenarios being prepared
  - For study and inclusion in “Scoping Document” for LHCC and UCG consideration this summer
    - Informed by outcome of “high-eta task force” which is close to completion

Strip module with ABC130 chips



Options being considered by high-eta task force



Summary

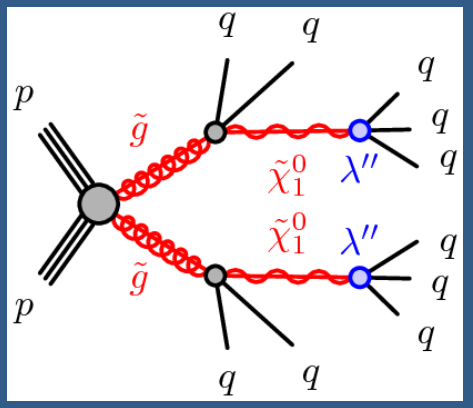
- Ongoing finalisation of run-1 analyses
  - Searches ~done, measurements continue
- ATLAS has been fully closed since December
  - Still access for some final repairs ongoing
- Several new detector components successfully integrated
  - IBL, DBM, additional muon chambers, ...
- Many other small changes 'behind the scene' during LS1
  - Recommissioning ATLAS close to complete
  - New shifters and experts training fast
- ATLAS is looking forward to beams and low and high intensity collisions at 13 TeV!

Backup

Hadronic Gluino Decays with R-Parity Violation

arXiv:1502.05686

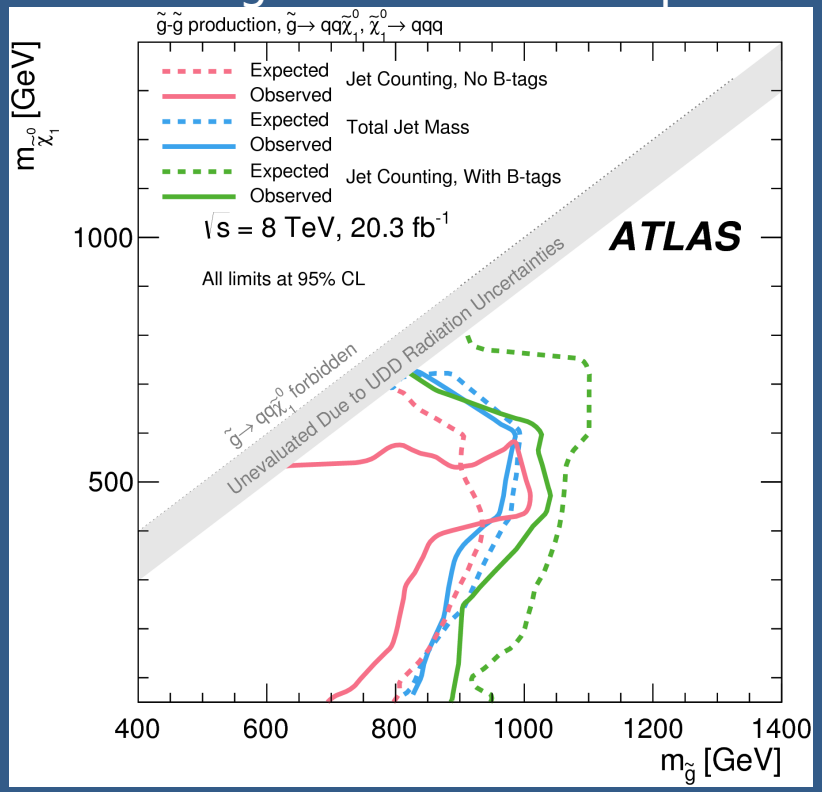
In RPV SUSY gluino can decay to many-jet final states with no missing energy
Challenging to separate signal from huge multi-jet background

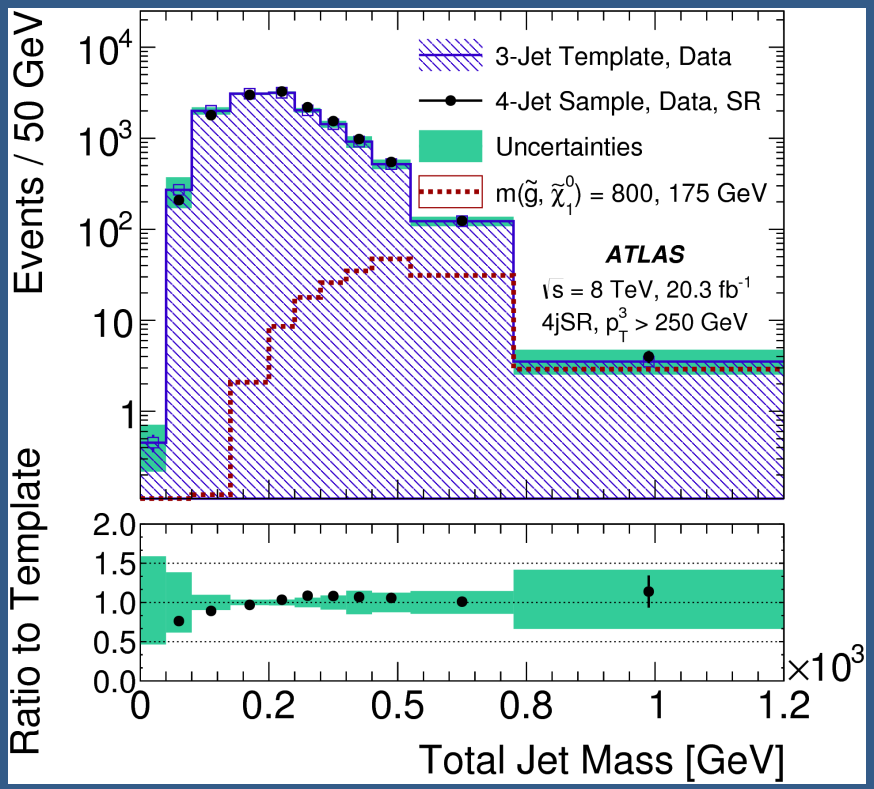


Two complementary techniques used:

- Scaling number of jets above p_T cut from lower jet multiplicities
- Using total jet mass of 4 large-R jets in event

Exclude gluinos of mass up to 1 TeV

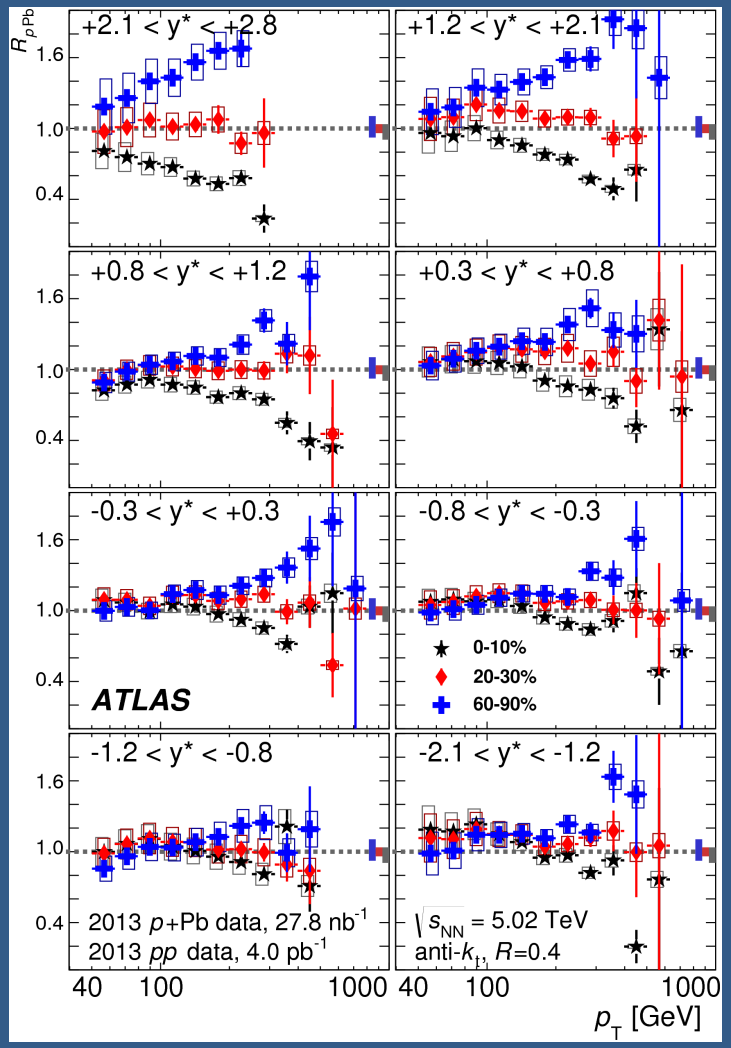




Heavy Ion: Inclusive Jet Production

arXiv:1412.4092

Centrality and rapidity dependence

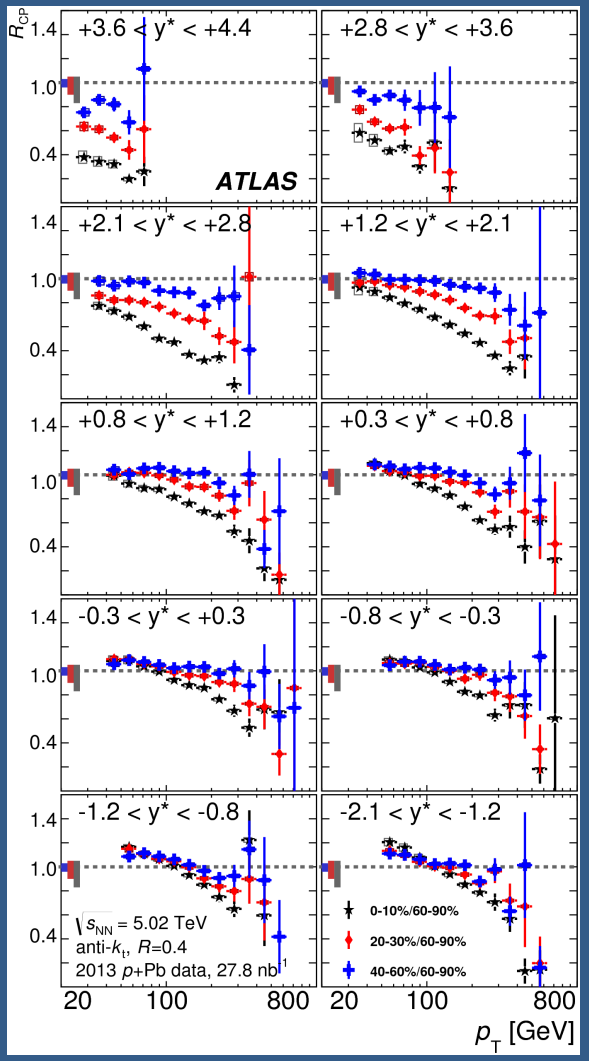


Nuclear modification factor R_{pPb}:

Quantifies absolute modification of jet rate
relative to geometric expectation

Central-to-peripheral ratio R_{CP}:

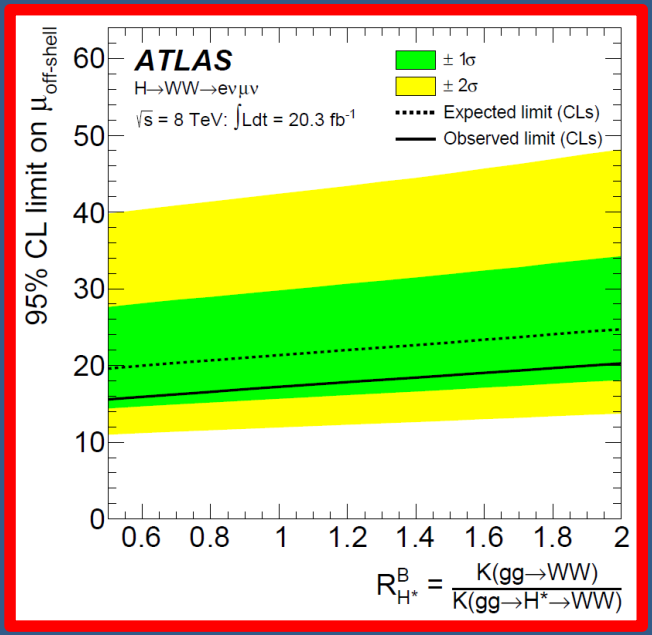
Sensitive to relative deviations in jet rate
from geometric expectation
between event centralities

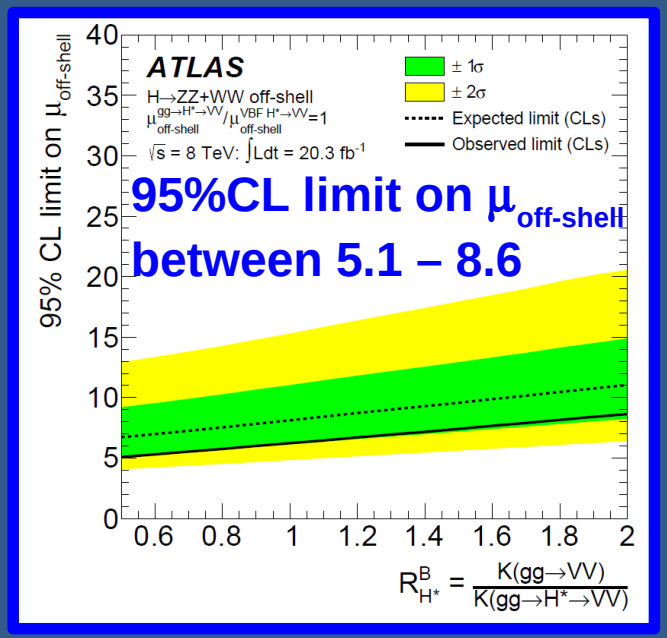


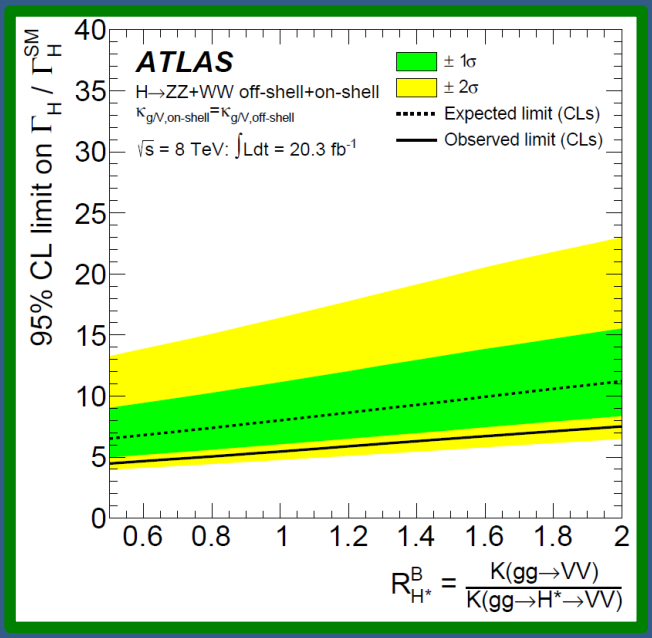
CERN-PH-EP-2015-026

Higgs off-shell analysis searches for large Higgs couplings for the off-shell Higgs at large virtualities (mass) m_{VV}

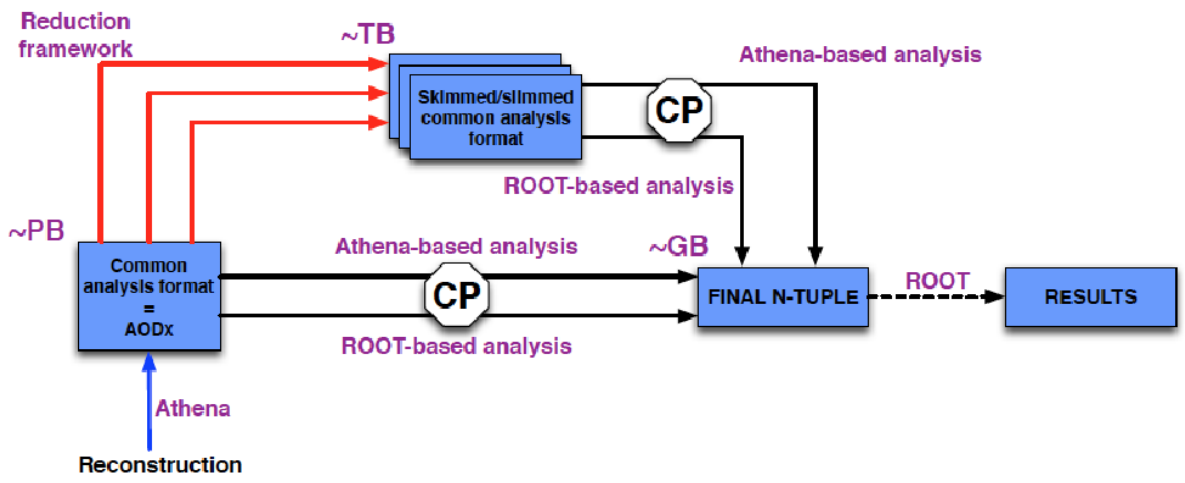
- Use high mass channels $H^* \rightarrow ZZ \rightarrow 4l+2l2\nu$;
  added $H^* \rightarrow WW \rightarrow l\nu l\nu$ for this paper
- Because of unknown QCD effects, all analysis done **inclusive in jets** and depending on the **unknown K-factor for the gg → VV bkg.**
- Combination with on-shell analysis @ 125GeV allows interpretation as measurement of total width Γ_H







New Analysis Model



Central pieces:

- New, dual Athena/ROOT format for reconstruction output "xAOD"
  - Fully defined and commissioned
- New derivation framework for efficient data reduction
  - So far: 22 derivations for performance groups, 39 for physics analysis
  - Total size of derivations roughly half of original xAOD size
  - Production of derivations in "trains" reliable and fast in new prodsys
- New analysis tools for implementation of harmonised physics objects
  - Most analysis tools available, tested during DC14
  - Update for CP pre-recommendations using newest MC15 production expected for April