



ATLAS Status Report

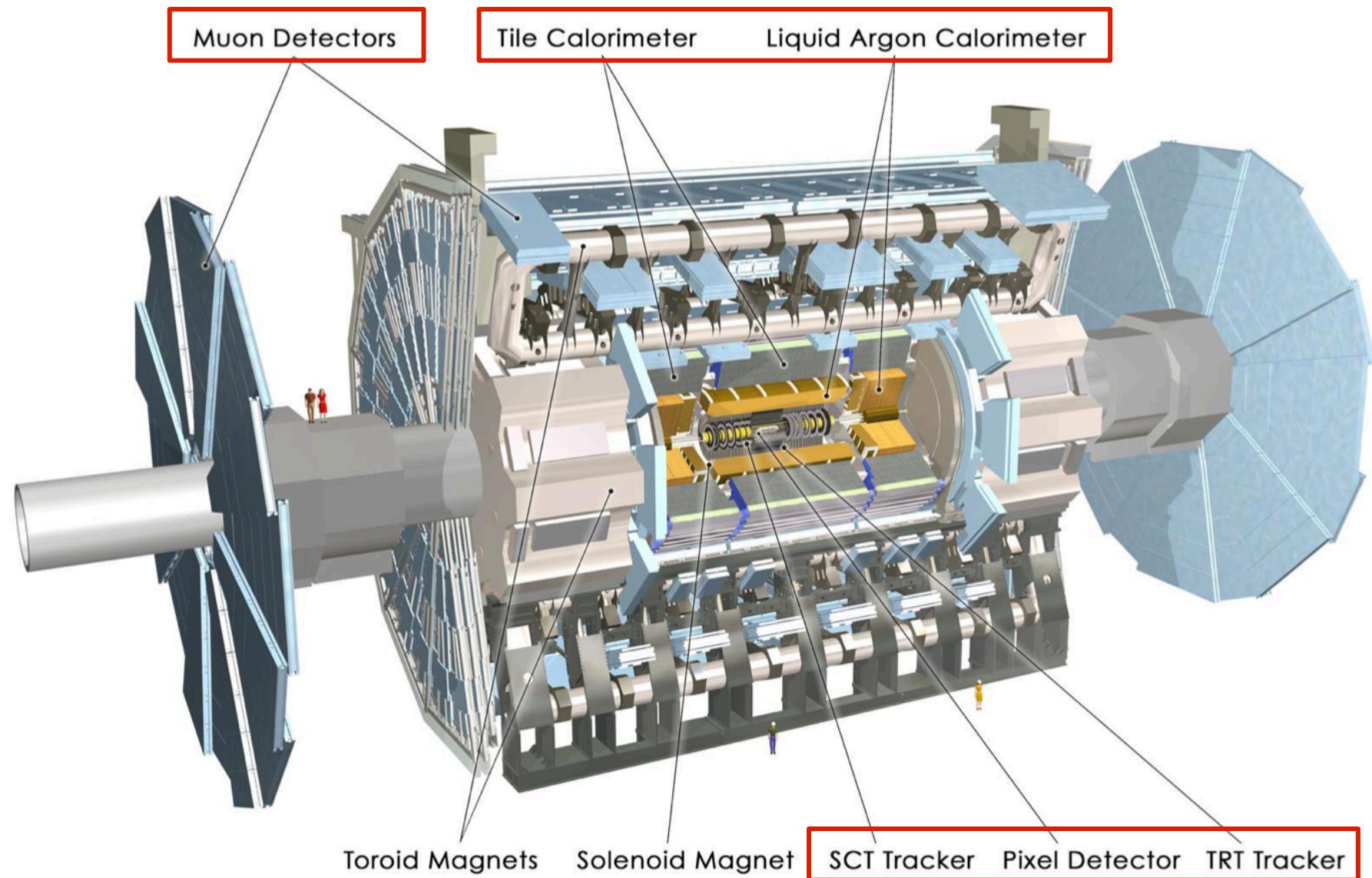
Yu Nakahama Higuchi (Nagoya University, KMI)
on behalf of the ATLAS collaboration

LHCC Open Session, 25th May 2016

Outline of this report

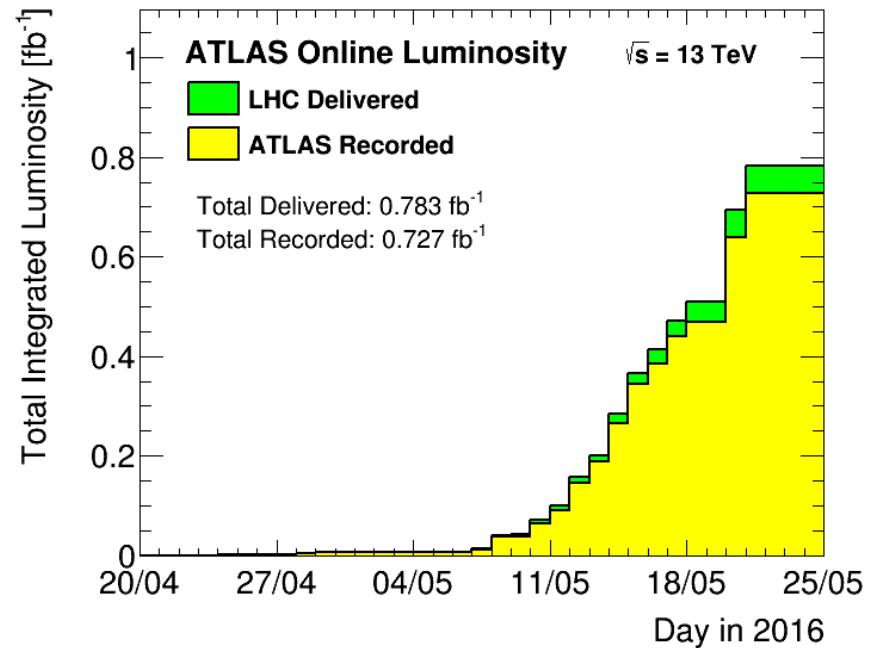
- Detector Commissioning in the 2016 startup
- Recent Physics Highlights
- ATLAS Upgrades Phase-1 and Phase-2

Detector Commissioning in the 2016 startup



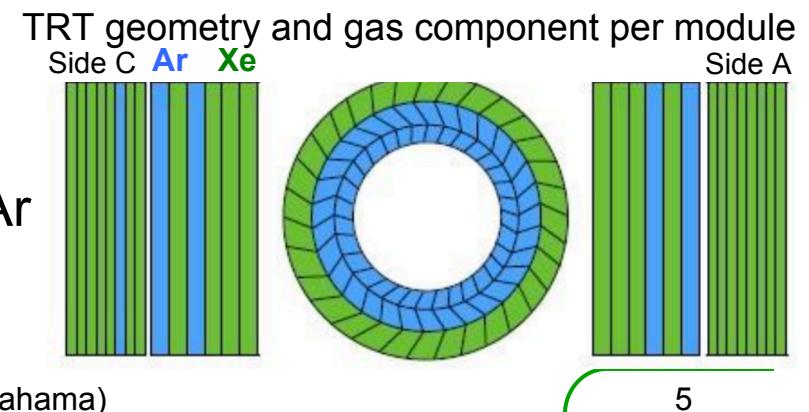
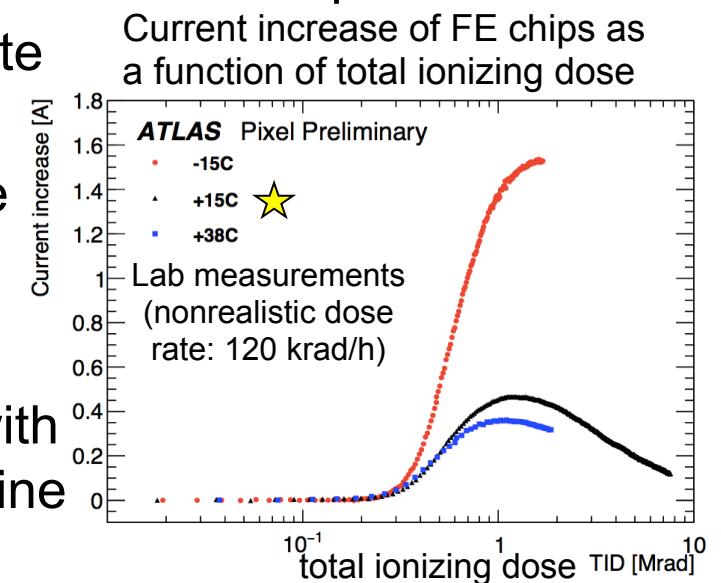
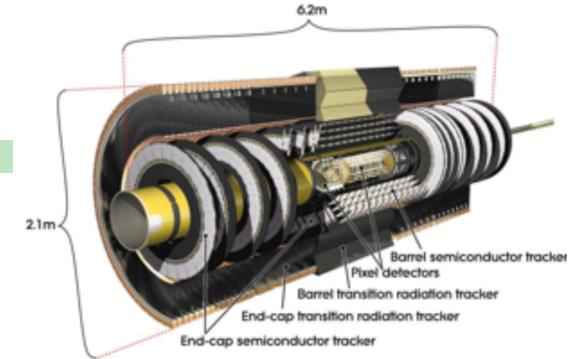
ATLAS pp data taking in 2016

- Quiet beams: on 12th Apr
- First stable beams: on 23rd Apr
- Intensity lumi ramp up: ongoing
 - Currently with 1200 bunch fill, at 3.6×10^{33} (peak), $\langle\mu\rangle \sim 20$
 - Completed various special runs in between
 - e.g. detector calibration runs in single bunch and early train runs, VdM scan + afterglow for luminosity measurement, and pressure bump test for non-collision background
 - **Re-commissioned the ATLAS detector successfully and in smooth operation already**
→ **Recorded 0.73 fb^{-1} with data-taking efficiency of 93 %**
 - Most of performance plots shown here used the early 2016 dataset



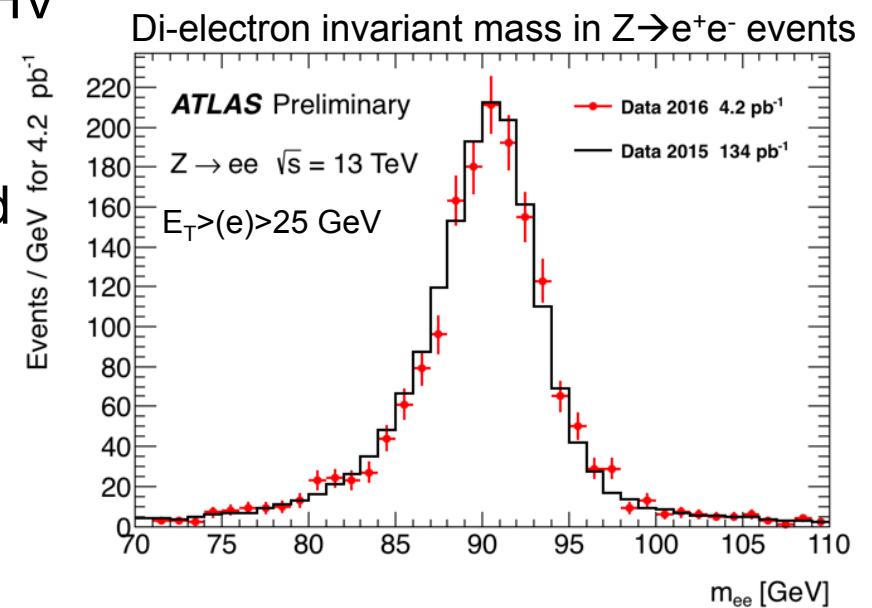
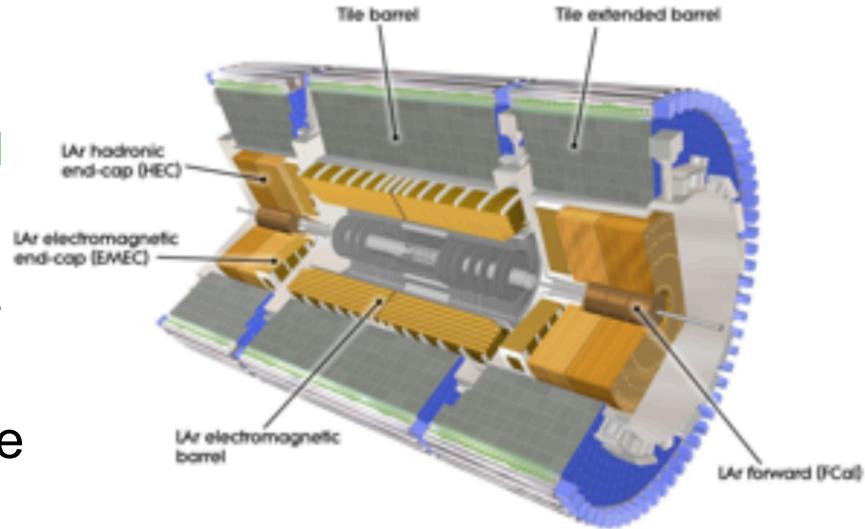
Inner Detectors: 2016 operation

- Pixel system
 - Readout was upgraded for Layer-2 and 15% of Layer-1 in order to handle higher pileup w.r.t. the 2015 operation
 - IBL is operated at +15°C in order to mitigate the radiation-induced current increase
 - ID alignment is automated, updates before bulk Tier-0 reconstruction
- Semi Conductor Tracker
 - Nearly 99% of the modules are included with good data quality. The DAQ also running fine
- Transition Radiation Tracker
 - New gas configuration in order to reduce loss of xenon
 - 2 barrel + 5 endcap modules with Ar
 - Particle-ID reoptimised
→ Negligible impact on physics



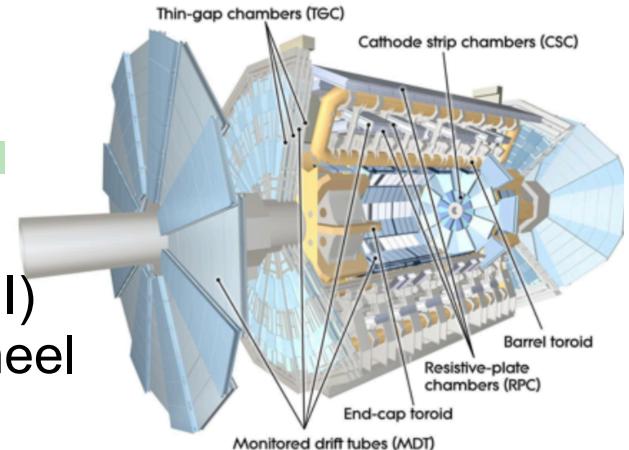
Calorimeters

- Liquid Argon Calorimeter
 - Repaired several Front-End Boards during the winter shutdown
 - Tuned some HV modules to mitigate hot cells
 - Switched off the LAr purity monitor HV in the endcaps to reduce frequency of long-standing noise bursts
 - From the Zee distribution, confirmed energy scale in the 2016 data is consistent with the 2015 one
- Tile Calorimeter
 - Recovered two dead modules and four partially operational drawers → 100% coverage
 - No significant hot spots are observed in 2016

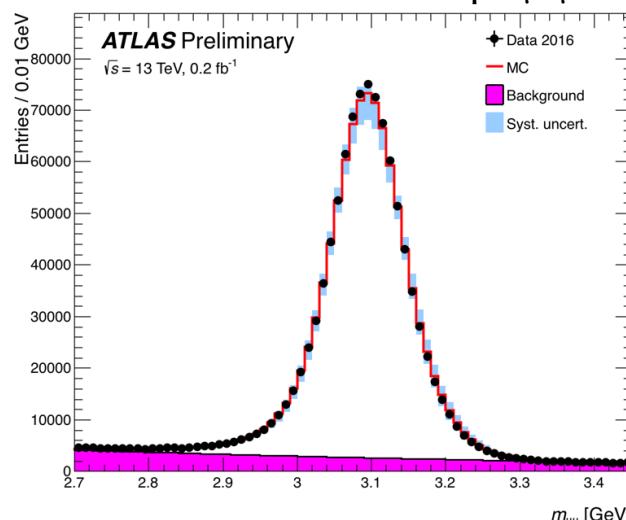


Muon Detectors

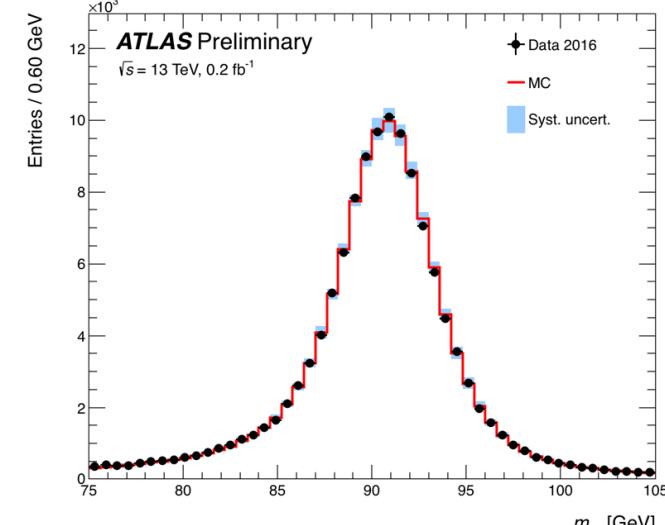
- Thin Gap Chambers (endcap)
 - Extending coincidences with inner chamber (EI) and optimising coincidence window for Big Wheel ($\rightarrow \sim 8\%$ rate reduction for L1 MU20)
- Resistive Plate Chambers (barrel)
 - Additional “feet” chambers fully functional for triggering ($\rightarrow 4\%$ larger acceptance)
- Muon Drift Tube and Cathode Strip Chambers
 - Working fine for precision tracking to reconstruct muons offline
 - The 2015 alignment is applied to the 2016 data



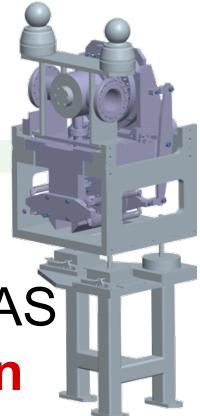
Di-muon invariant mass of $J/\psi \rightarrow \mu^+\mu^-$ events



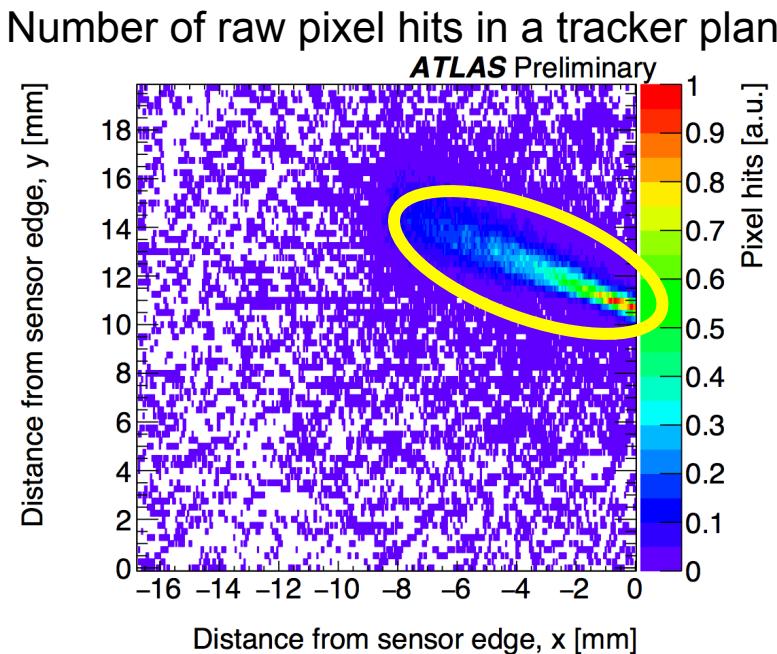
Di-muon invariant mass of $Z \rightarrow \mu^+\mu^-$ events



Forward Detectors

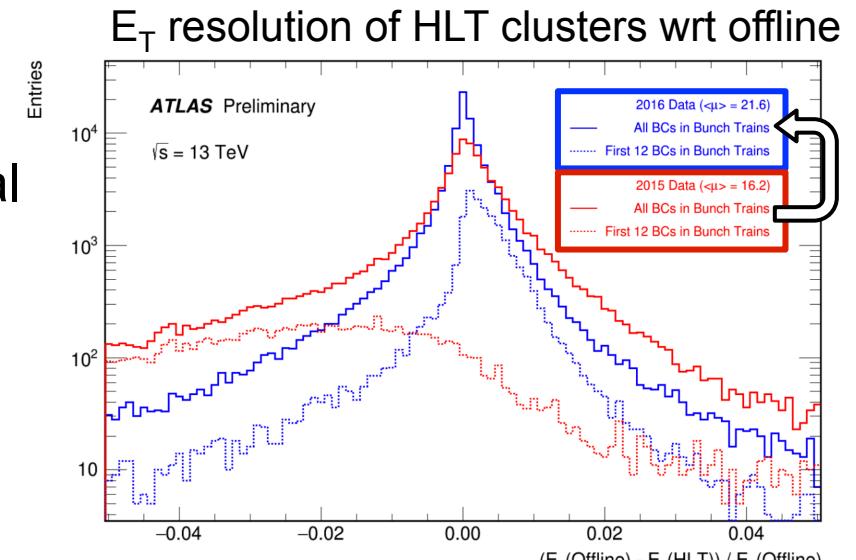


- New Detector AFP: ATLAS Forward Protons
 - Roman pots for one arm were installed with 200m from the ATLAS interaction point. **Integrated in the TDAQ. Included in 600b run**
 - Hit-pattern plots promising e.g. Observed “band” of diffractive protons as expected (in 300b run)
 - The other arm installation will be completed in 2016/2017 shutdown
- LUCID
 - new LUCID-2 detector provided the luminosity for ATLAS in 2015
 - Two more PMT with Bi-207 monitoring have been added for 2016
- ALFA and ZDC: operating fine



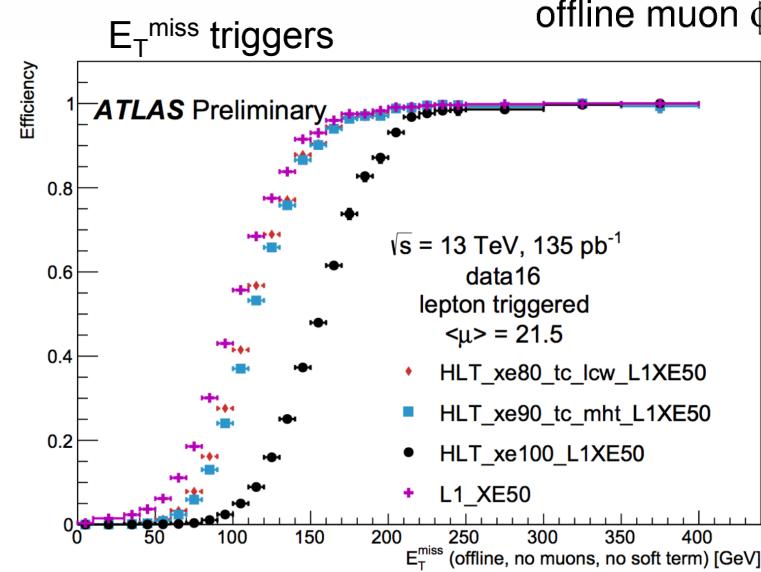
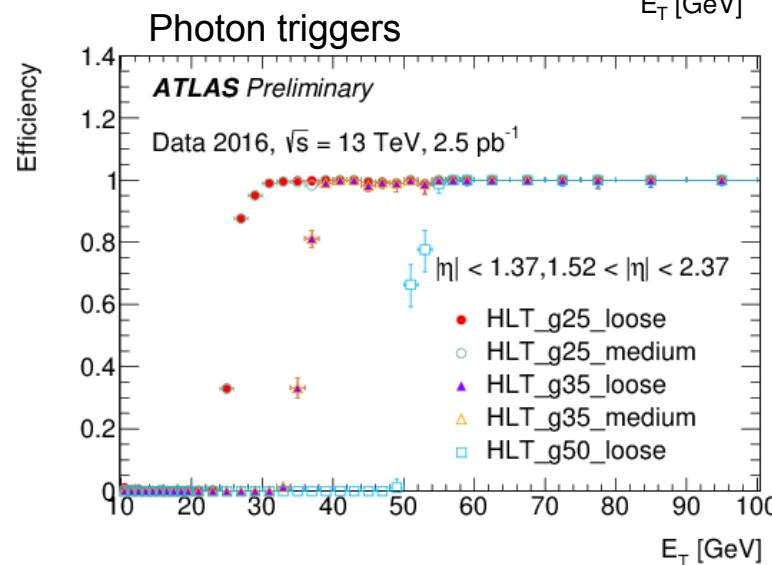
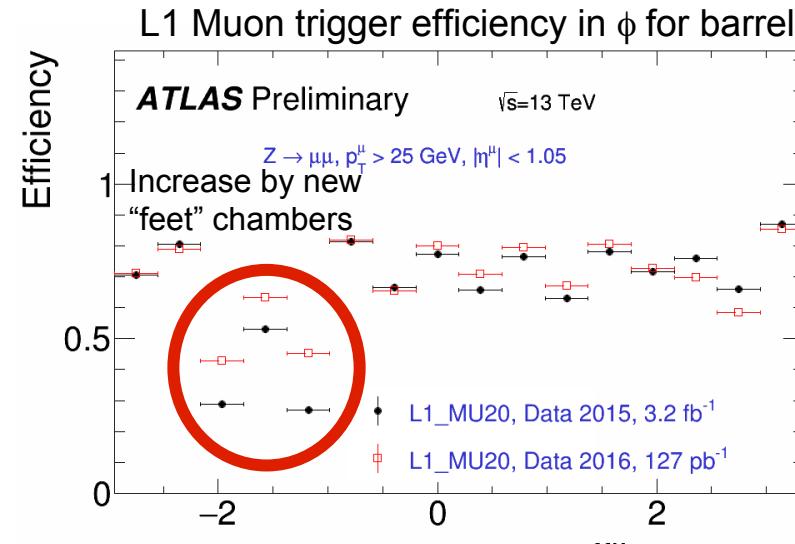
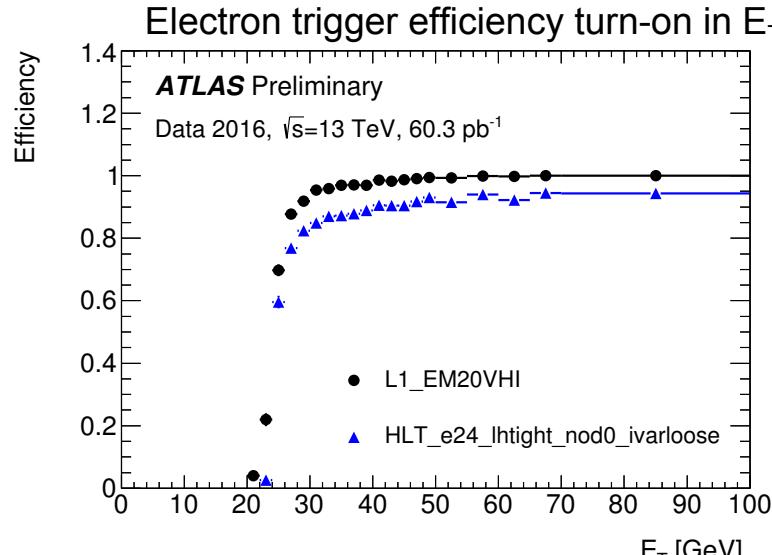
Trigger and DAQ: 2016 design and operation

- Trigger was prepared for higher luminosity and pileup condition anticipated and has been operated smoothly since the beginning
 - **Trigger menu designed up to 1.2e34**
 - with detailed pre-scales strategy for a huge set of ~2000 triggers.
 - Most bandwidth still given to generic triggers as in Run-1 and 2015
 - e.g. single isolated electron and muon triggers with > 24-26 GeV
 - multi-object and dedicated triggers added
 - e.g. VBF triggers, dedicated triggers for slow particles
 - e.g. HLT calorimeter-cluster energy resolution was improved
 - to be more robust against pedestal changes due to out-of-time pileup
 - by introducing BCID/ $\langle\mu\rangle$ -based energy corrections at cell level



Trigger performances with the 2016 data

- Observed good performances: e.g. efficiencies



2016 Detector Status

- Fraction of operational channels

Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	92 M	98.2%
SCT Silicon Strips	6.3 M	98.7%
TRT Transition Radiation Tracker	350 k	97.2%
LAr EM Calorimeter	170 k	100%
Tile calorimeter	5200	100%
Hadronic endcap LAr calorimeter	5600	99.6%
Forward LAr calorimeter	3500	99.7%
LVL1 Calo trigger	7160	100%
LVL1 Muon RPC trigger	383 k	99.8%
LVL1 Muon TGC trigger	320 k	100%
MDT Muon Drift Tubes	357 k	99.7%
CSC Cathode Strip Chambers	31 k	98.4%
RPC Barrel Muon Chambers	383 k	96.6%
TGC Endcap Muon Chambers	320 k	99.6%
ALFA	10 k	99.9 %
AFP	188 k	98.8 %

Change w.r.t. 2015

+0.8%

+13k channels

+13k channels

(for all other subdetectors
change by < ±0.1%)

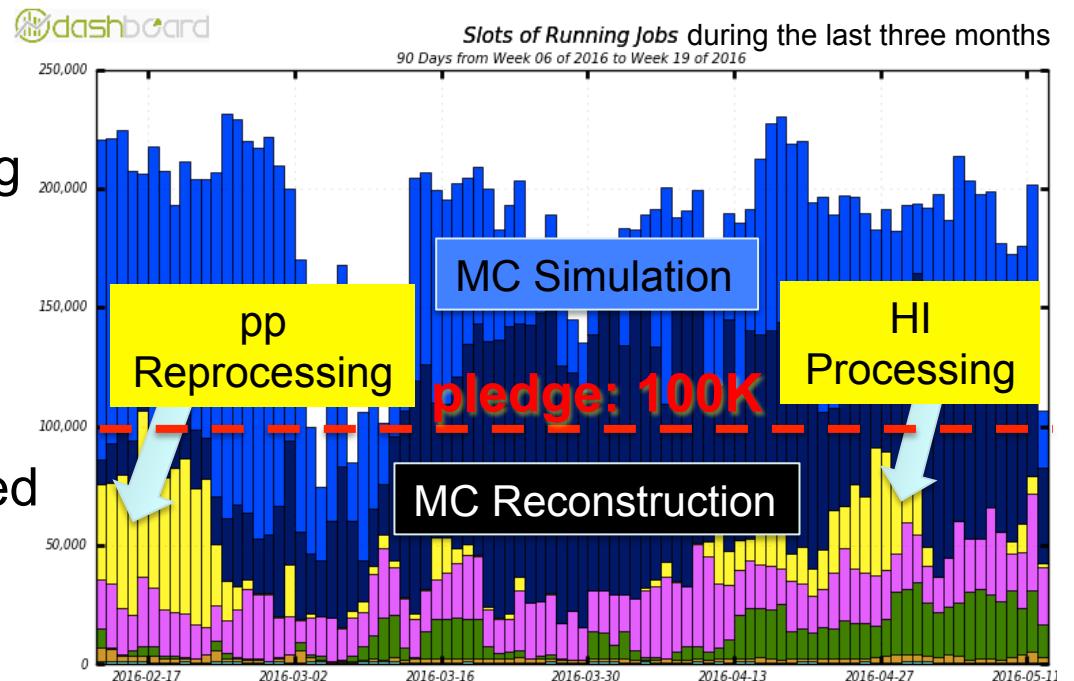
Notes:

- For the Pixel status: 3-Layers Pixel (80 M channels) - 98%; IBL (12 M channels) - 99.5%
- Now includes the 36 new trigger towers for Sector 12 and 14 on the outer layer.
- For Tilecal we indicate the number of cells (including gap and crack counters) that is more accurate for the status
- Detectors with fewer than 100 channels are not reported

(from May 2016)

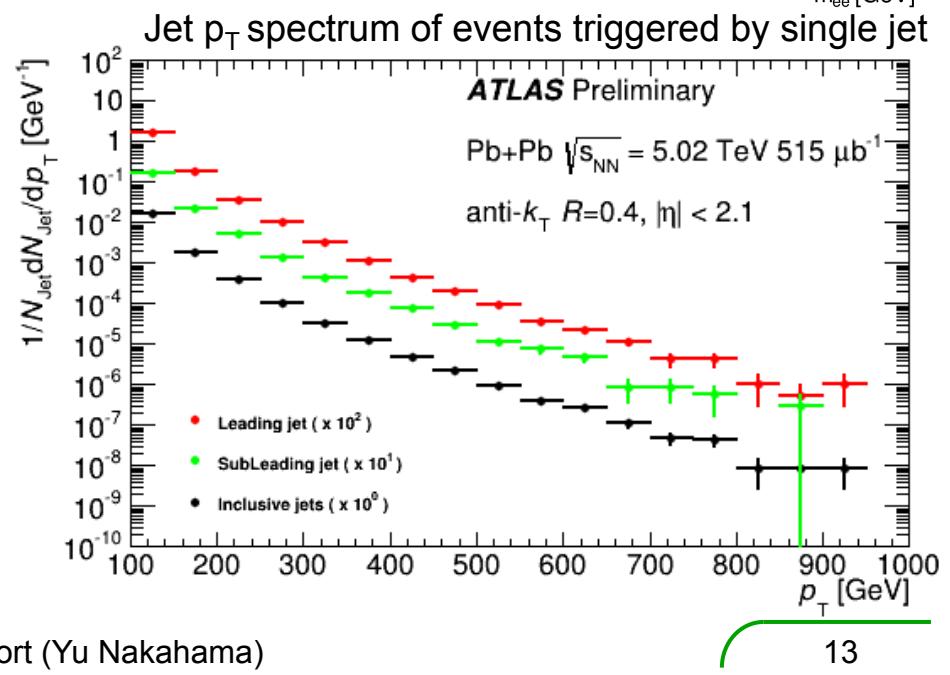
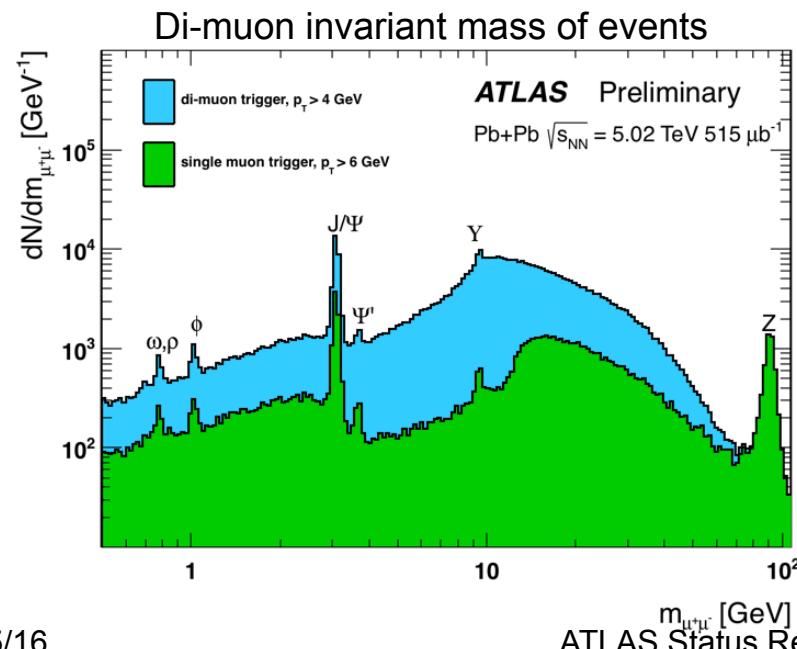
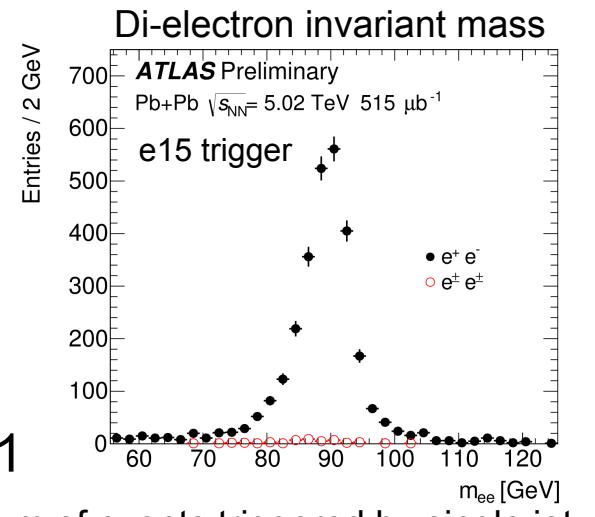
Software and Computing: Status and Plan

- Software
 - New offline software (athena 20.7) was delivered in the first quarter of 2016. Is being used in 2016
 - Athena 21 in preparation (builds now with CMake)
- Computing
 - Data and MC sample processing is stably running beyond the pledge
 - All 2015 pp data and MC samples were reprocessed with the new software
 - 2015 HI data was processed in May after major improvements in CPU time and memory usage
 - First 2016 data processed by Tier-0 and available on the Grid as usual



HI Pb+Pb data in 2015

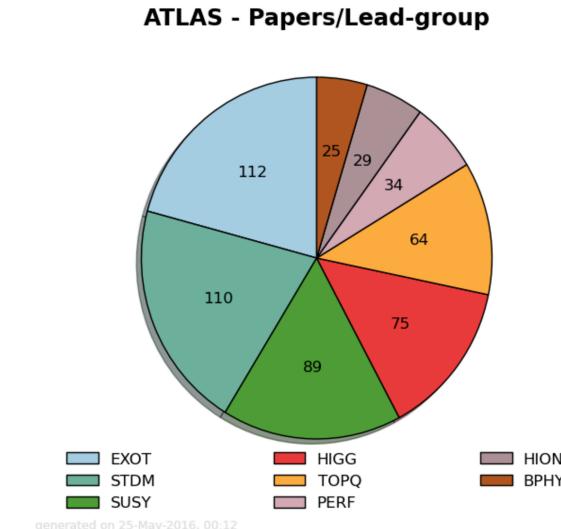
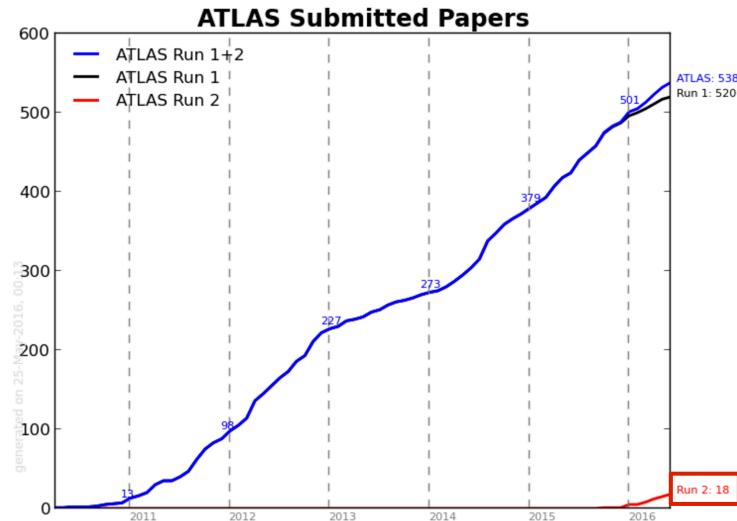
- Recorded $550 \mu\text{b}^{-1}$ of Pb+Pb data at $\sqrt{s_{\text{NN}}}=5.02 \text{ TeV}$
- Analyses of hard-probe data with high- p_{T} electrons, muons and jets are ongoing
 - di-electron events around the Z-mass peak
 - di-muon events with clear peaks from ω/ρ to Z
 - jet events with p_{T} from 100-1000 GeV
- big increase in hard-probe statistics w.r.t. Run-1



- Physics Results

Physics Results

- ATLAS submitted 538 papers in total
 - including 18 papers on the 2015 data

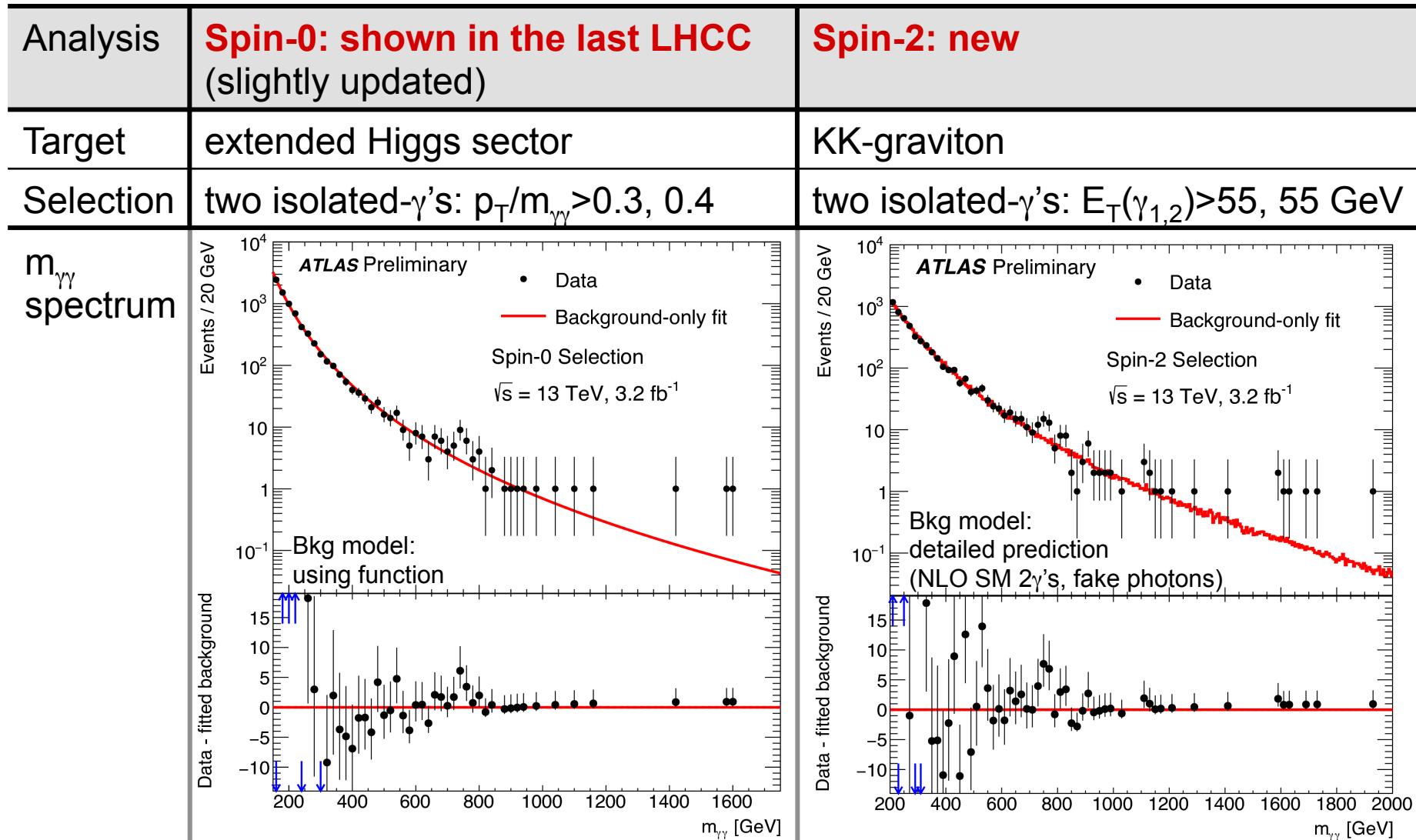


- 25 papers and 20 CONF notes since the last LHCC
- the full list here: <https://twiki.cern.ch/twiki/bin/view/AtlasPublic>
- Following slides present a few selected highlights
 - 2015 searches
 - 2015 measurements
 - Run-1 measurement

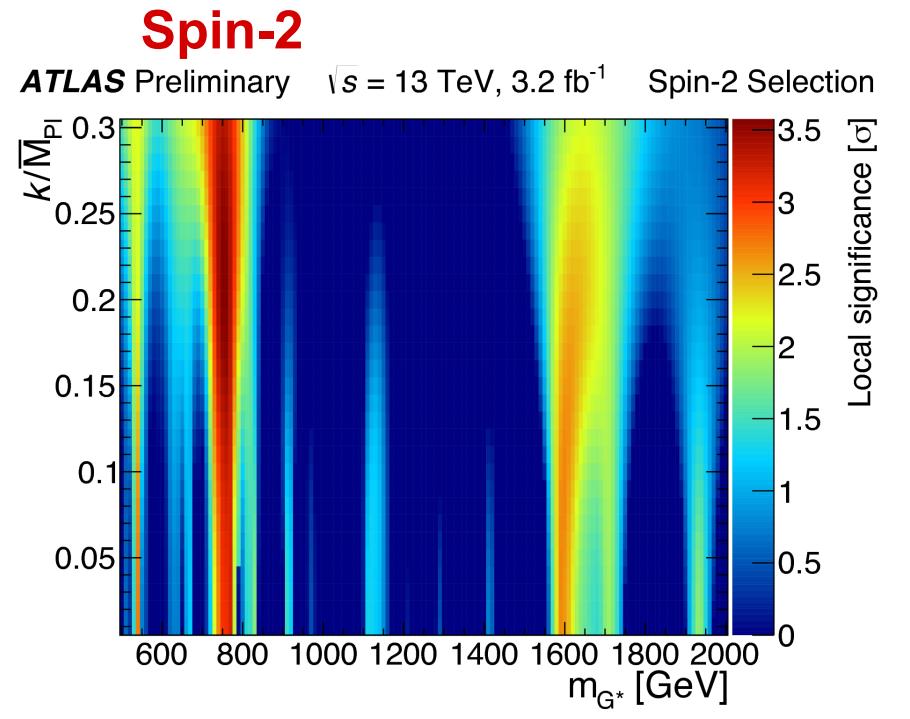
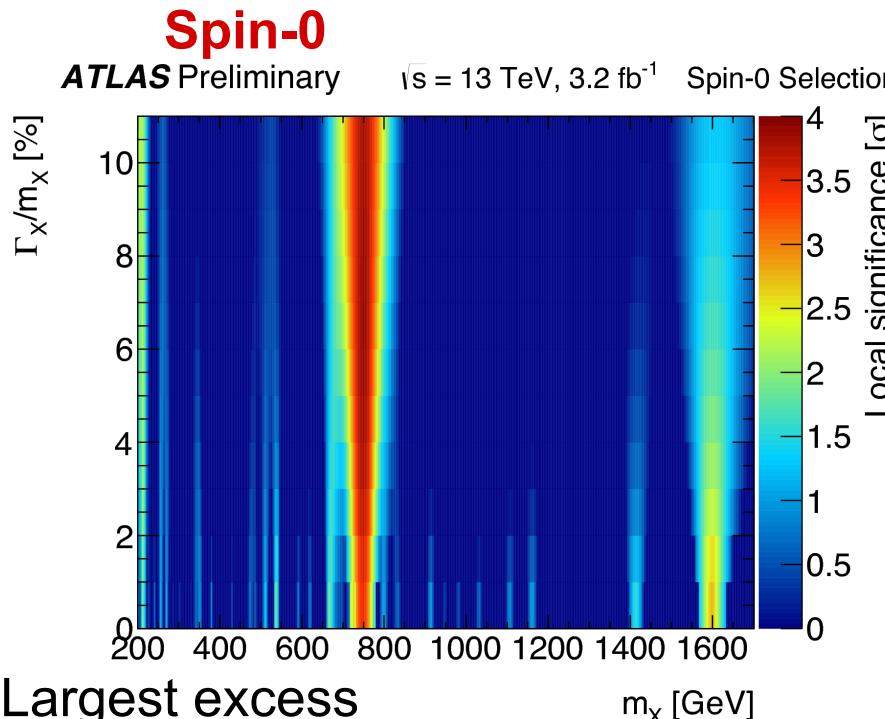
Search for di-photon resonance: $m_{\gamma\gamma}$ spectrum

ATLAS-CONF-2016-018

- Search for excess in di-photon invariant mass spectrum



Search for di-photon resonance: significance

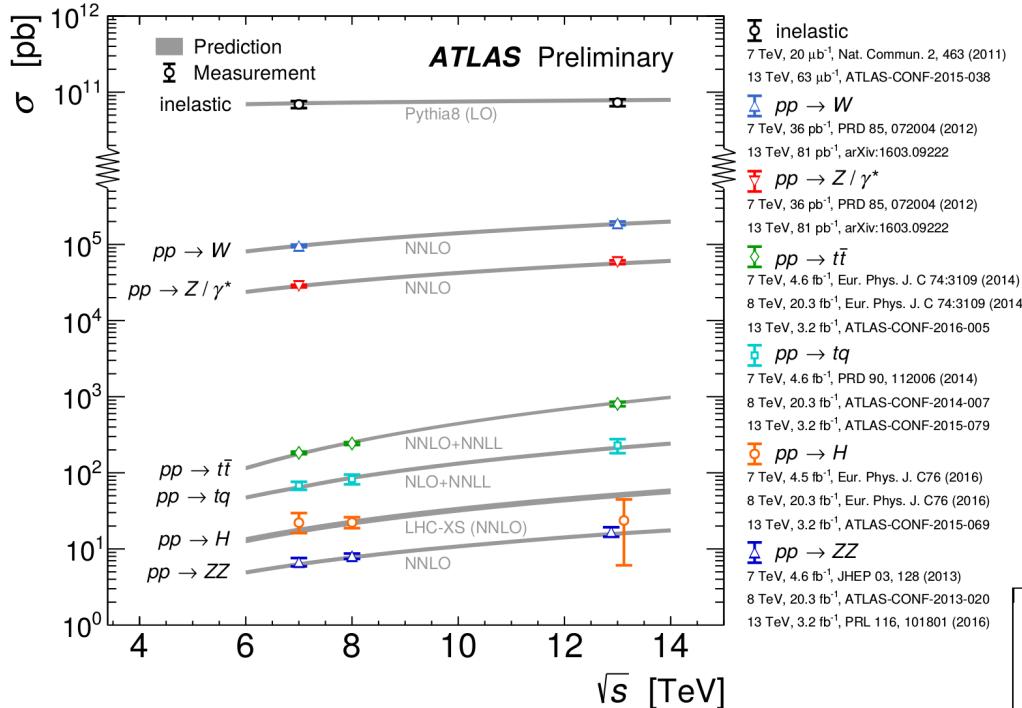


- Significances intriguing but not compelling at this point
- Studied compatibility of 13 TeV sample with 8 TeV data
 - 1.2σ for spin-0
 - 2.7σ for spin-2

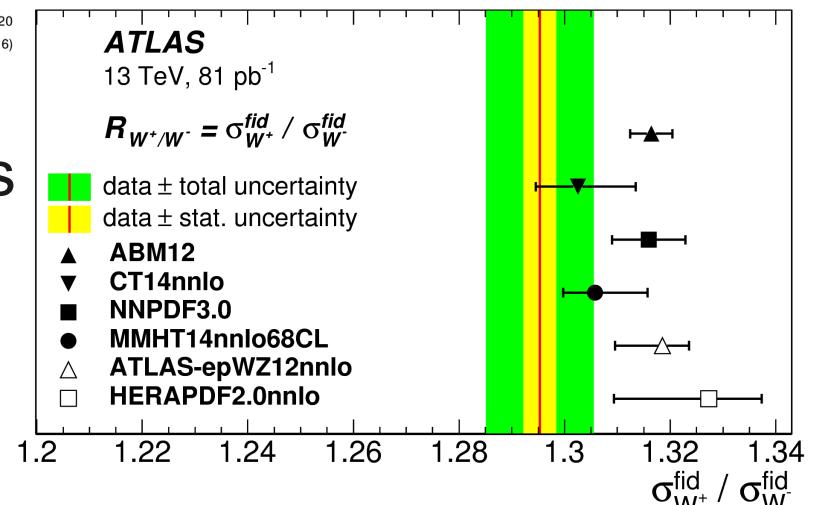
→ One analysis we are watching carefully in 2016

2015 measurements

- Wide range of cross-section measurements performed



arXiv:1603.09222

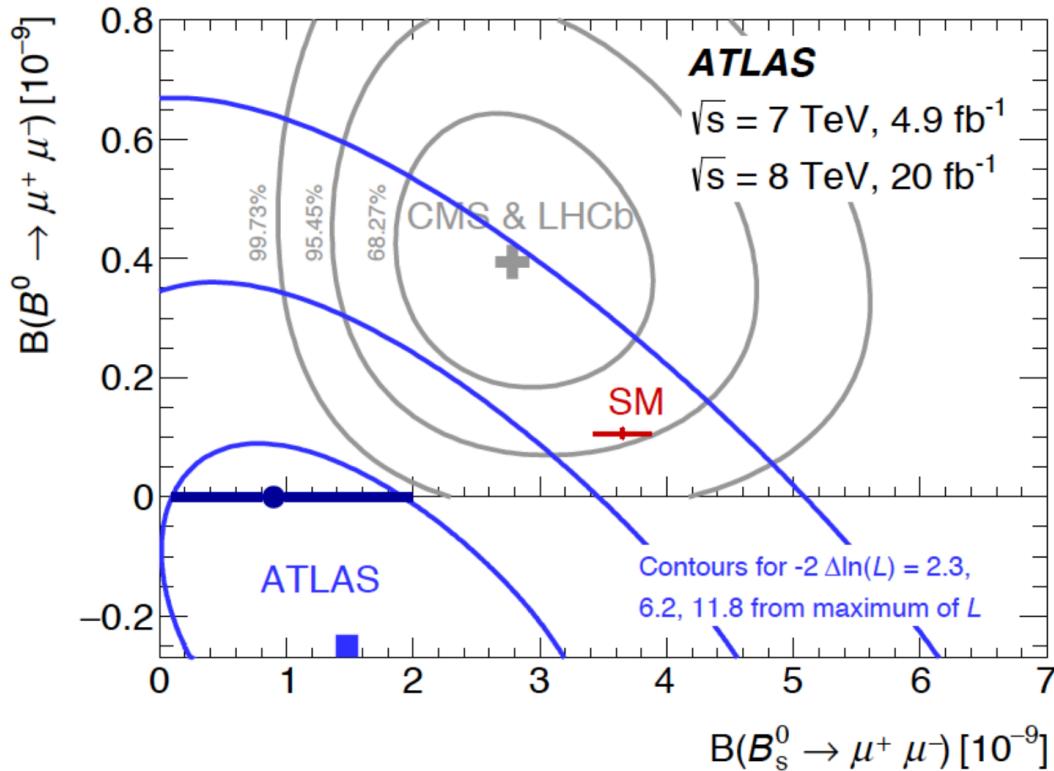


- e.g. ratio of W^+ to W^- cross sections in a fiducial region
 - measured with a precision of 0.8%
 - 1-2 σ lower than the various predictions based on different PDFs

Measurement of $B_{d/s} \rightarrow \mu^+ \mu^-$ decays

<http://arxiv.org/abs/1604.04263>

- Used 25 fb^{-1} of the 7 TeV and 8 TeV data in Run-1

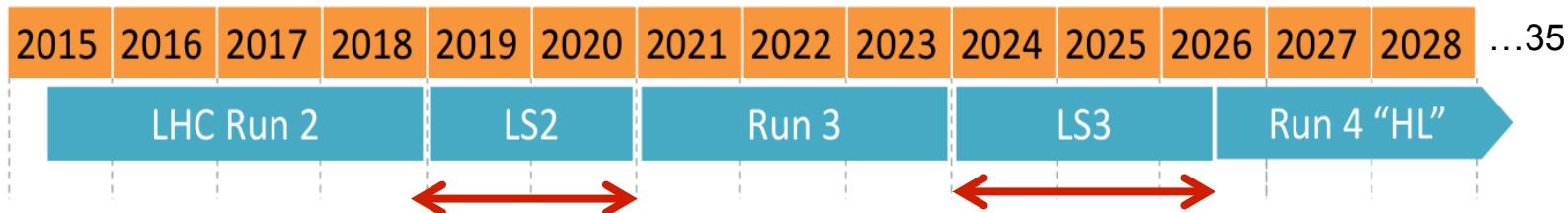


$$\begin{aligned}\mathcal{B}(B_s^0 \rightarrow \mu^+ \mu^-) &= (0.9^{+1.1}_{-0.8}) \times 10^{-9} \\ \mathcal{B}(B_s^0 \rightarrow \mu^+ \mu^-) &< 4.2 \times 10^{-10} \quad \text{at 95% CL}\end{aligned}$$

- Consistent with the SM prediction at 2.0σ
- Also consistent with zero

- ATLAS Upgrades: Phase-1 and Phase-2

ATLAS Upgrade Timeline

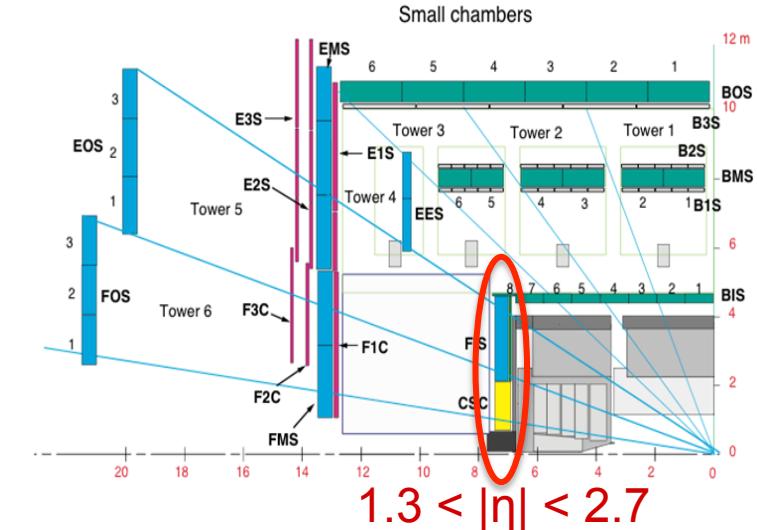
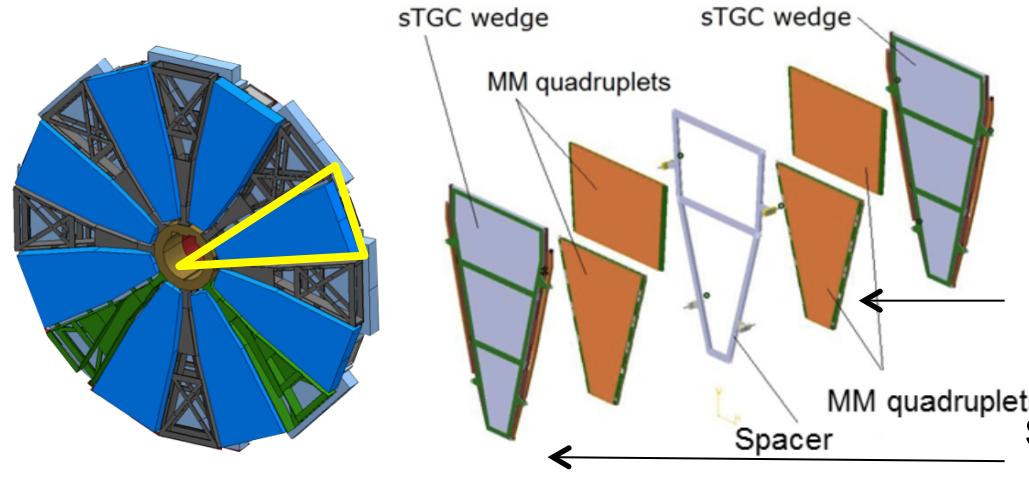


Phase-1 Upgrade	Phase-2 Upgrade
$L = 2e34 (\mu\sim 60)$ int $L = 200 \text{ fb}^{-1}$	$L = 7.5e34 (\mu\sim 200)$ int $L = 3000 \text{ fb}^{-1}$
<ul style="list-style-type: none">• New Muon Small Wheel (NSW) ★• Fast Track Trigger (FTK) ★• TDAQ Phase-1• LAr Calorimeter Electronics• ATLAS Forward Protons (AFP) <p>★ : covered in the following slides</p>	<ul style="list-style-type: none">• All new Tracking Inner Detector (ITk-Strip/Pixel)• Calorimeter Electronics Upgrade• New Forward Calorimeter• Muon System Upgrade• TDAQ Phase-2

Phase-1: New Muon Small Wheels (NSW)

TDR: <http://cds.cern.ch/record/1552862>

- NSW is targeted at replacing the present Small Wheels
 - for more precise tracking and angle resolution at L1 triggering
 - using two new chamber technologies



Micro-mesh gaseous detectors
(Micro-megas, MM)

small-strip thin gap chambers
(sTGC)

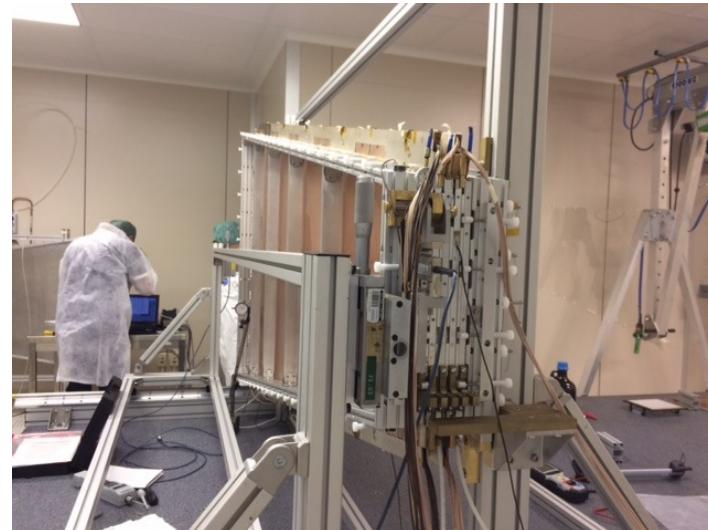
- Major challenges are sTGC and MM chamber production, on-detector ASICs, and mechanics
 - Submitted full prototypes of 3 of 4 ASICs
 - Mechanics procurement starts later this year

NSW: Construction

- The sTGC detector
 - First module-0 chamber construction is nearly completed in Chile, China, Canada and Israel. Production Readiness Review will take place in June
- The Micro-Megas detector
 - The first module-0 chamber was completed by the Italian construction consortium. Final Design Review and PRR to be completed this year for all sites



Micro-Megas module-0 (SM1 type)

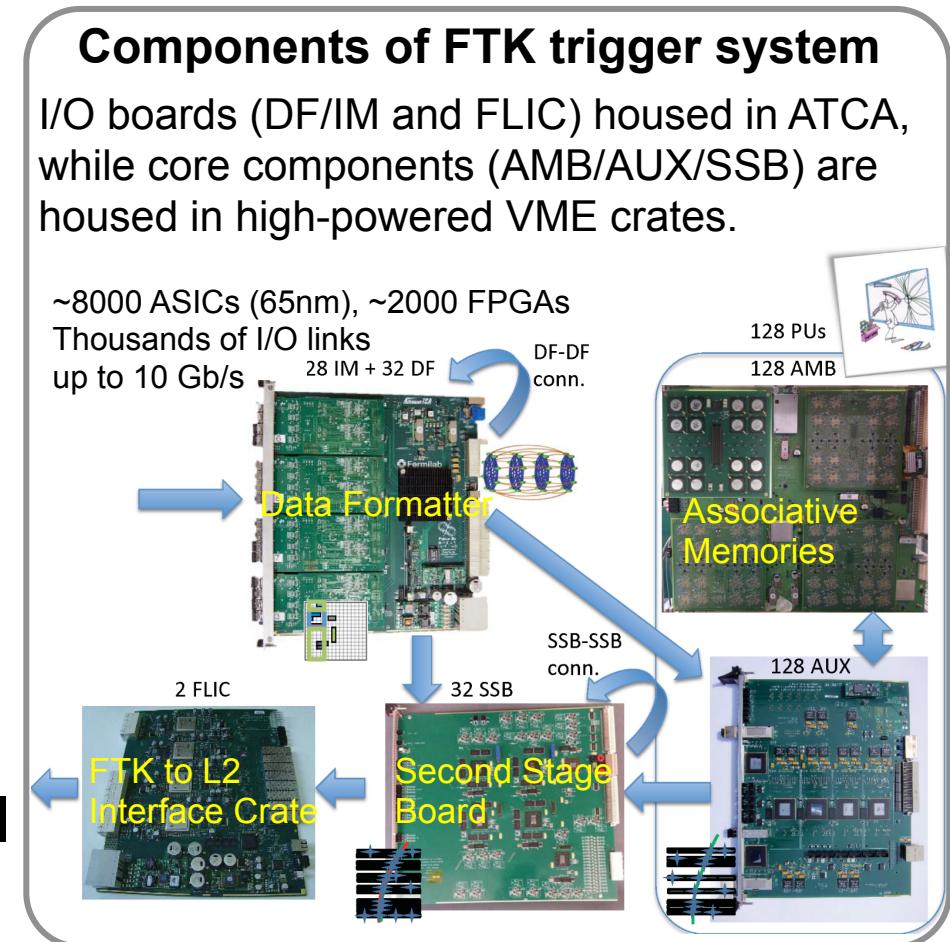


→ Good progress in all areas towards NSW installation in 2019

Phase-1: Fast Track Trigger

TDR: <https://cds.cern.ch/record/1552953>

- FTK performs pattern recognition and track fitting using pixel and strip data after L1 using associative memories and FPGAs
 - Hardware production for the FTK barrel-only system
 - Tested 50% of ASICs needed
 - Expect associative memories (AMB) and fitting (SSB) hardware at CERN by July
 - System integration at P1
 - Hardware and software infrastructure in place
 - Expect full slice test in July:
DF → AMB/AUX → SSB → FLIC
- Good progress towards the goal of commissioning full barrel system from Oct 2016



Phase-2: milestones and outlook for 2016

- Milestones scheduled in 2016/2017 (see Scoping Document)

Upgrade project	Initial Design Review (IDR)	Technical Design Report (TDR)
ITk Strip ITk Pixel	Q4 2014	Q4 2016 Q4 2017
LAr	Q4 2016	Q3 2017
TileCal	Q4 2016	Q3 2017
Muon	Q2 2016	Q2 2017
TDAQ	Q1 2016	Q4 2017

- Progress and Outlook for 2016
 - TDAQ IDR formal review on 18th April, report being finalised
 - Muon IDR formal review expected in September
 - LAr and TileCal IDRs expected in Q4 2016
 - R&D to establish technical designs
 - Preparing for major design decisions this year (sFCAL, muon options, TDAQ architecture, ...)
 - On track for the first TDR submission (ITk Strip) in December 2016

Role of CERN RD projects in Phase-1/Phase-2

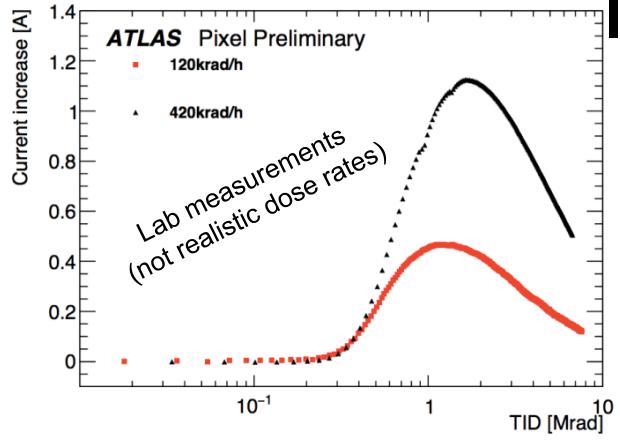
- There are four relevant RD programs for the ATLAS upgrades:
 - RD42: use of CVD diamond detectors in high-luminosity colliders
 - RD50: design and development of silicon detectors for HL-LHC
 - RD51: development of micro-pattern gaseous detectors
 - RD53: pixel readout ASICs for extreme rates and radiation levels
- We have used RD42 in a modest way in present Beam Condition Monitors and Diamond Beam Monitors. Contributions for Phase-2 are not yet clear
- We rely deeply on RD50 (and its predecessor RD48) for rad-hard silicon sensors in the present ID and for the Phase-2 ITk Strip and Pixel systems. It is also of interest for high-precision timing detectors
- We have relied on RD51 (and its predecessor RD28) for development of the Micro-Megas technology used in NSW
- We rely on RD53 for developing the 65nm CMOS knowledge base and IP blocks needed for our Pixel FE chip for the ITk

Conclusions

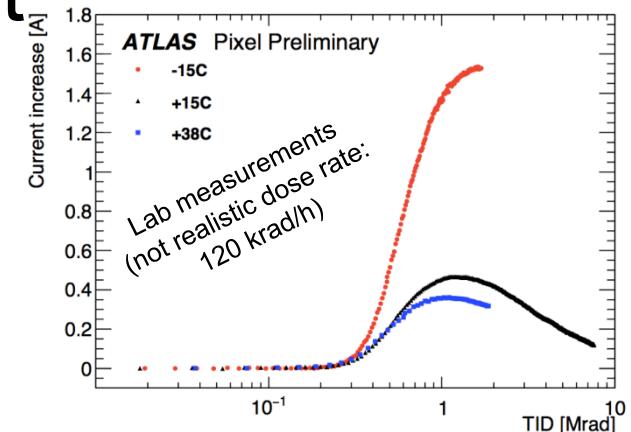
- Recommissioning of ATLAS this year has been going smoothly
 - including improved detectors, trigger and software
→ ATLAS is ready for the large sample expected in 2016
- Many new physics results released in the last few months
 - both on searches (Run-2) and measurements (Run-1 and Run-2)
 - just a tiny fraction could be shown here
- Steady progress on upgrades
 - Phase-1: NSW approaching production; FTK preparing full barrel system to start commissioning in late 2016
 - Phase-2: IDRs & preparation of design choices, towards TDRs from the end of 2016
- Many thanks to the LHC team for the efficient restart of the accelerator – we're looking forward to much more data soon!

- Backup slides

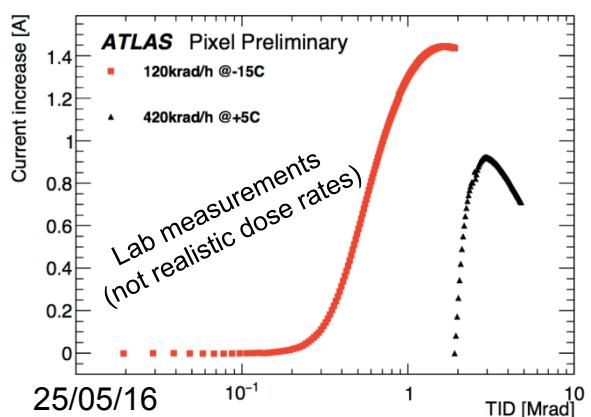
IBL LV current drift



IBL now running at +15°C



- Higher dose rate as expected with increased peak luminosity this year will worsen the effect
- A mitigation of the effect was discovered thanks to lab measurements when increasing the temperature of the module
- Pixel investigated the consequences of running warm as +15°C → no show stopper found but it is not recommended to operate too long for Si-sensor wrt radiation damage
 - New irradiator purchased will allow to make measurements at realistic dose rate and anticipate operational conditions



Monitoring of IBL before MD1/TS1 and additional lab measurements may lead to reduce the operational temperature



List of recent public results

2015 data results for 2016 winter

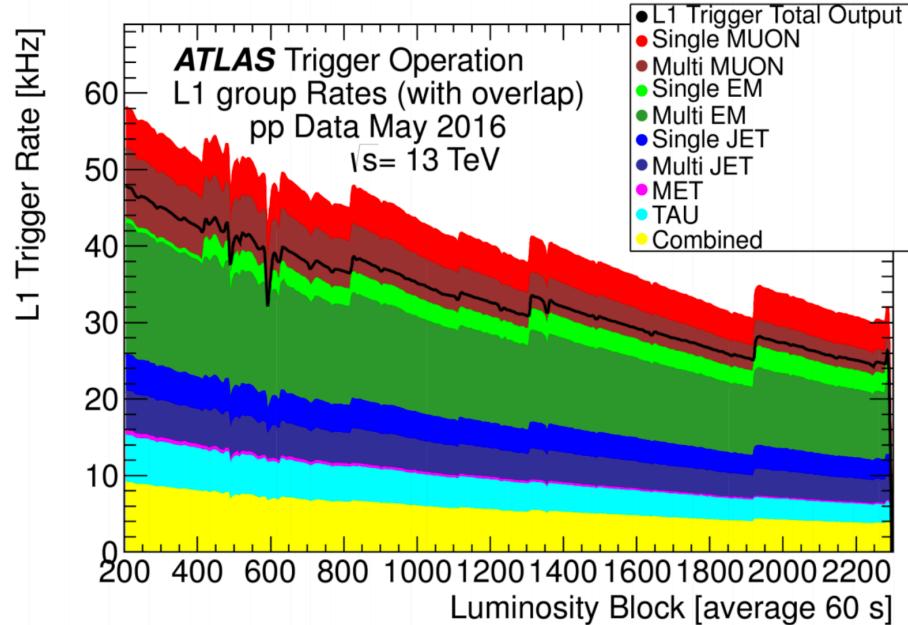
Topic	Document type	Short title	Reference and Link	Release conference
Top physics	Conference Note	tV cross section at 13 TeV	ATLAS-CONF-2016-003	Moriond EW
Top physics	Conference Note	tbar cross section in the e+mu channel at 13 TeV	ATLAS-CONF-2016-005	Moriond EW
Higgs physics	Conference Note	HH to bb+2 photons	ATLAS-CONF-2016-004	Moriond EW
Higgs physics	Conference Note	Search for 2 photons + MET	ATLAS-CONF-2016-011	Moriond EW
Higgs physics	Conference Note	Search for H>ZZ>llnn	ATLAS-CONF-2016-012	Moriond EW
Higgs physics	Conference Note	Search for A>Zh	ATLAS-CONF-2016-015	Moriond EW
Higgs physics	Conference Note	Search for H>ZZ>llqq	ATLAS-CONF-2016-016	Moriond EW
Higgs physics	Paper	Search for charged H->tau n produced in association with top quarks	arXiv:1603.09203	Moriond QCD
SUSY	Conference Note	Direct stop production in the 1-lepton channel	ATLAS-CONF-2016-007	Moriond EW
SUSY	Conference Note	Direct stop production in the 2-lepton channel	ATLAS-CONF-2016-009	Moriond EW
SUSY	Paper	Search for SUSY in the 2 same-sign lepton and 3 lepton channels	arXiv:1602.09058	Moriond EW
SUSY	Paper	Search for SUSY with large jet multiplicities and MET	arXiv:1602.06194	Moriond EW
Exotics	Conference Note	lepton+jets TeV-gravity	ATLAS-CONF-2016-006	Moriond EW
Exotics	Conference Note	Z+gamma resonances	ATLAS-CONF-2016-010	Moriond EW
Exotics	Conference Note	Search for vector like quarks in lepton+jets	ATLAS-CONF-2016-013	Moriond EW
Exotics	Conference Note	Search for high mass tbar resonances	ATLAS-CONF-2016-014	Moriond EW
Exotics	Conference Note	HH->4b search	ATLAS-CONF-2016-017	Moriond EW
Exotics	Conference Note	Search for resonances in diphoton events	ATLAS-CONF-2016-018	Moriond EW
Exotics	Conference Note	Search for dark matter produced with a Higgs boson decaying to b quarks	ATLAS-CONF-2016-019	DM@LHC
Exotics	Paper	Search for resonances in two b-jet events	arXiv:1603.08791	Moriond QCD
Exotics	Conference Note	Search for 4-top production in the lepton + jets channel	ATLAS-CONF-2016-020	DIS
Standard Model physics	Paper	Measurement of charged particle multiplicities	arXiv:1602.01633	Moriond EW
Standard Model physics	Paper	Measurement of W and Z production	arXiv:1603.09222	Moriond QCD

Submitted 25 papers since the last LHCC

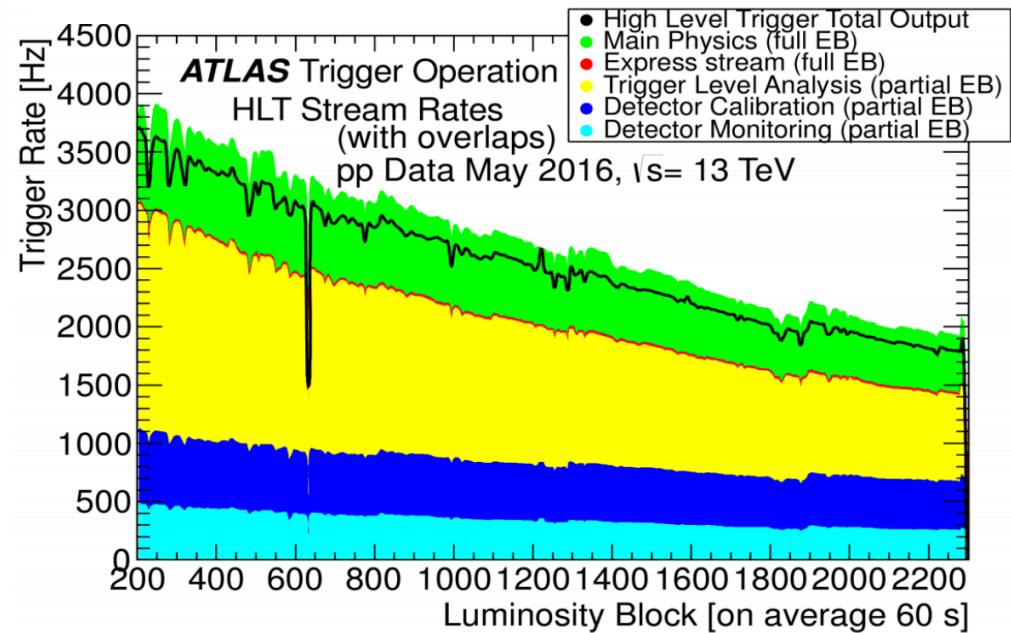
Full Title
[NEW] Measurement of the relative width difference of the \$B^0-\bar{B}^0\$ system with the ATLAS detector
[NEW] Transverse momentum, rapidity, and centrality dependence of inclusive charged-particle production in \$\sqrt{s_{NN}}=5.02\$ TeV p+Pb collisions measured by the ATLAS experiment
[NEW] Search for scalar leptoquarks in \$pp\$ collisions at \$\sqrt{s}=13\$ TeV with the ATLAS experiment
Search for gluinos in events with an isolated lepton, jets and missing transverse momentum at \$\sqrt{s}=13\$ TeV with the ATLAS detector
Search for squarks and gluinos in final states with jets and missing transverse momentum at \$\sqrt{s}=13\$ TeV with the ATLAS detector
Measurement of the inclusive isolated prompt photon cross section in \$pp\$ collisions at \$\sqrt{s}=8\$ TeV with the ATLAS detector
Search for lepton-flavour-violating decays of the Higgs and Z bosons with the ATLAS detector
Search for new phenomena in final states with an energetic jet and large missing transverse momentum in \$pp\$ collisions at \$\sqrt{s}=13\$ TeV using the ATLAS detector
Measurements of the charge asymmetry in top-quark pair production in the dilepton final state at \$\sqrt{s}=8\$ TeV with the ATLAS detector
Measurements of \$Z_\gamma\$ and \$Z_{\gamma\gamma}\$ production in \$pp\$ collisions at \$\sqrt{s}=8\$ TeV with the ATLAS detector
Search for metastable heavy charged particles with large ionization energy loss in \$pp\$ collisions at \$\sqrt{s}=13\$ TeV using the ATLAS experiment
Study of the rare decays of \$B_s^0\$ and \$B^0\$ into muon pairs from data collected during the LHC Run 1 with the ATLAS detector
Search for the Standard Model Higgs boson decaying into \$b\bar{b}\$ produced in association with top quarks decaying hadronically in \$pp\$ collisions at \$\sqrt{s}=8\$ TeV with the ATLAS detector
Measurement of fiducial differential cross sections of gluon-fusion production of Higgs bosons decaying to \$WW^*\rightarrow e\nu\mu\nu\$ with the ATLAS detector at \$\sqrt{s}=8\$ TeV
Search for new phenomena in events with a photon and missing transverse momentum in \$pp\$ collisions at \$\sqrt{s}=13\$ TeV with the ATLAS detector
[PUBLISHED] Beam-induced and cosmic-ray backgrounds observed in the ATLAS detector during the LHC 2012 proton-proton running period
Measurement of \$W^\pm\$ and Z-boson production cross sections in \$pp\$ collisions at \$\sqrt{s}=13\$ TeV with the ATLAS detector
Search for charged Higgs bosons produced in association with a top quark and decaying via \$H^\pm\rightarrow\tau\nu\$ using \$pp\$ collision data recorded at \$\sqrt{s}=13\$ TeV by the ATLAS detector
Search for resonances in the mass distribution of jet pairs with one or two jets identified as \$b\$-jets in proton-proton collisions at \$\sqrt{s}=13\$ TeV with the ATLAS detector
Muon reconstruction performance of the ATLAS detector in proton-proton collision data at \$\sqrt{s}=13\$ TeV
Topological cell clustering in the ATLAS calorimeters and its performance in LHC Run 1
Identification of high transverse momentum top quarks in \$pp\$ collisions at \$\sqrt{s}=8\$ TeV with the ATLAS detector
Charged-particle distributions in \$pp\$ interactions at \$\sqrt{s}=8\$ TeV measured with the ATLAS detector at the LHC
[PUBLISHED] Measurements of \$W^\pm Z\$ production cross sections in \$pp\$ collisions at \$\sqrt{s}=8\$ TeV with the ATLAS detector and limits on anomalous gauge boson self-couplings
Measurement of total and differential \$W^+W^-\$ production cross sections in proton-proton collisions at \$\sqrt{s}=8\$ TeV with the ATLAS detector and limits on anomalous triple-gauge-boson couplings

Trigger rates in a fill (2016 May operation)

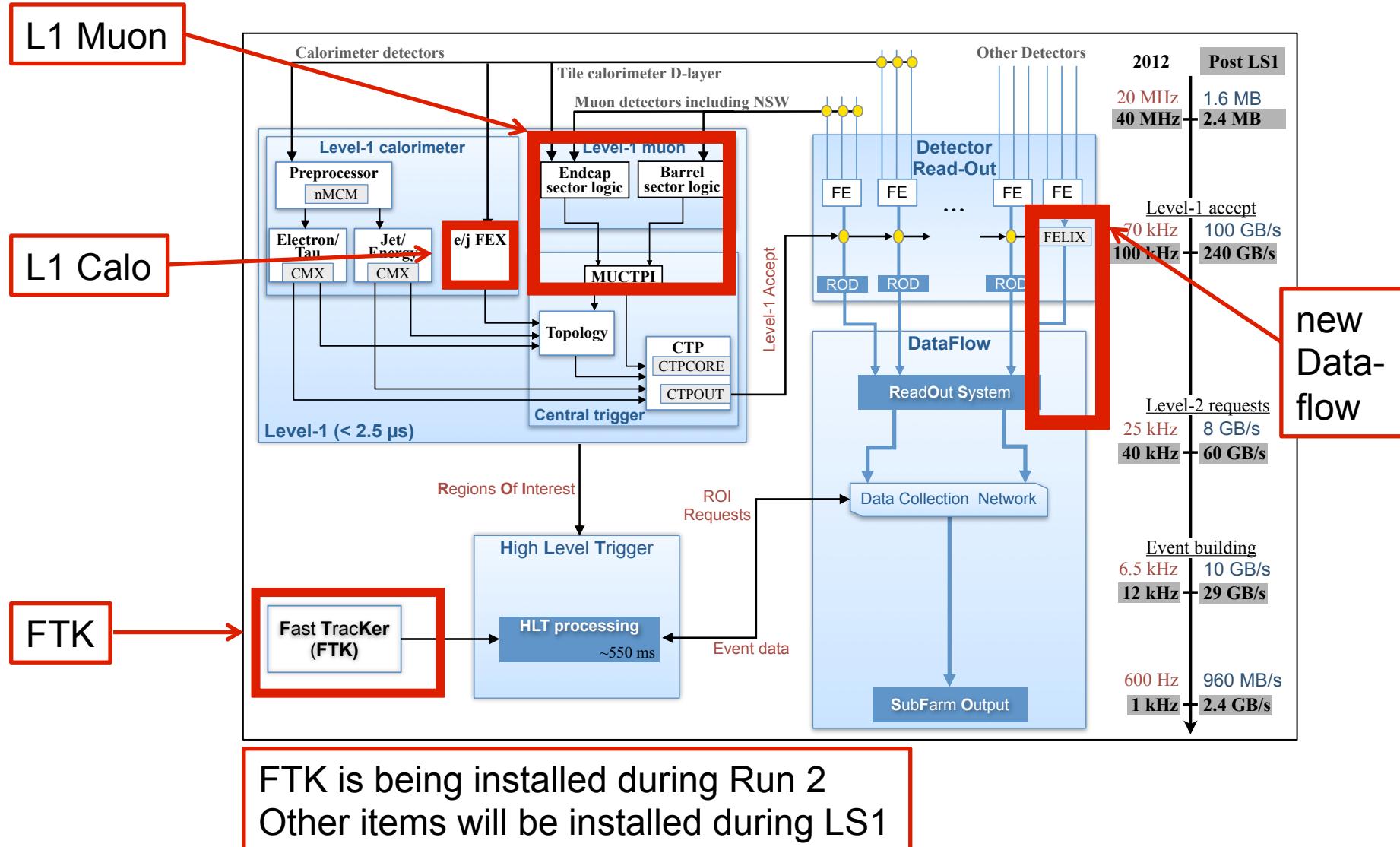
Level-1 trigger group rates



HLT stream rates

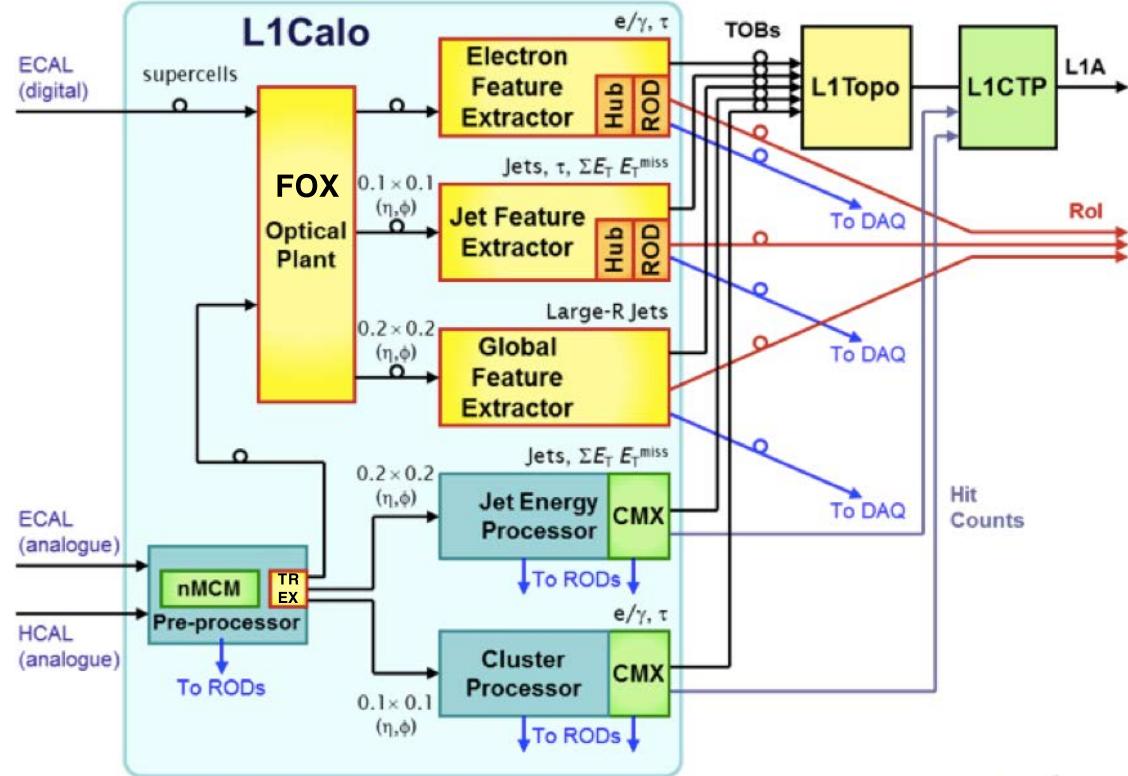


Phase-1 TDAQ Upgrade: Items to be completed



Focus on Phase-1 L1Calo

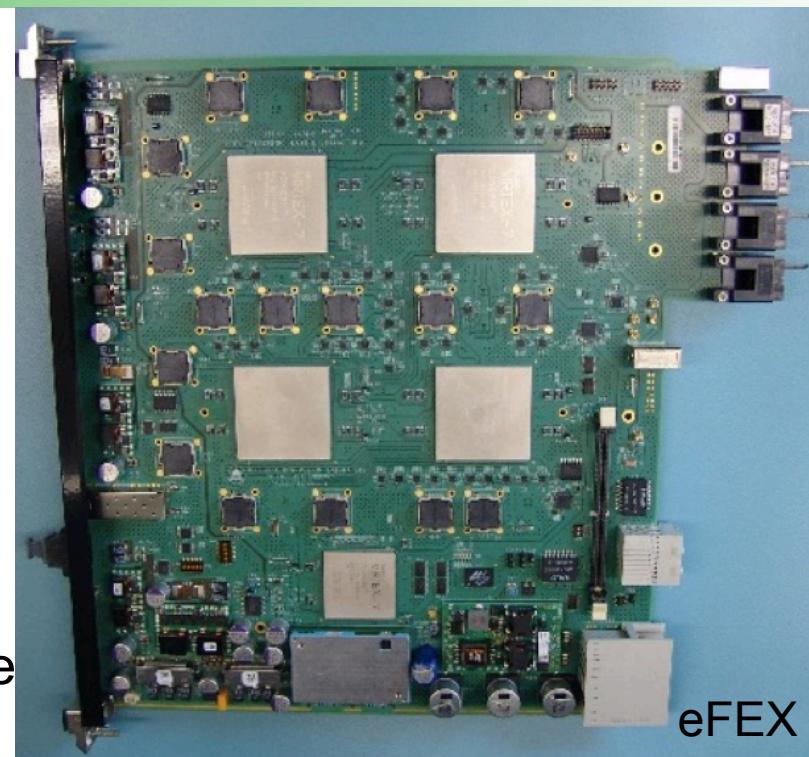
- Phase 1 L1Calo upgrade increases trigger granularity by a factor of 10 over original design
- Three feature extractors:
 - **eFEX** ($e/\gamma, \tau$),
 - **jFEX**(jets, τ , ΣE_T , ΣE_T^{Miss})
 - **gFEX** (large jets and other global objects)
- Additional supporting modules and infrastructure (FOX, ROD, HUB, L1Topo,TREX)



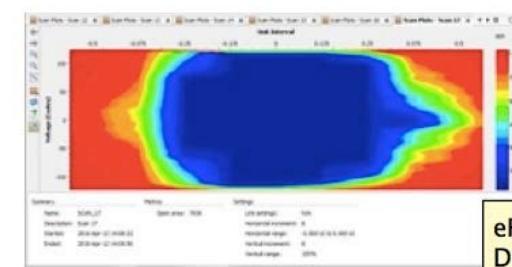
- L1Calo Phase 1 items are shown in yellow and orange (modified version of Run 2 topo will be used in Phase 1) and will be installed in LS2
- Items shown in green have already been installed during LS1

L1 Calo link speed tests successful

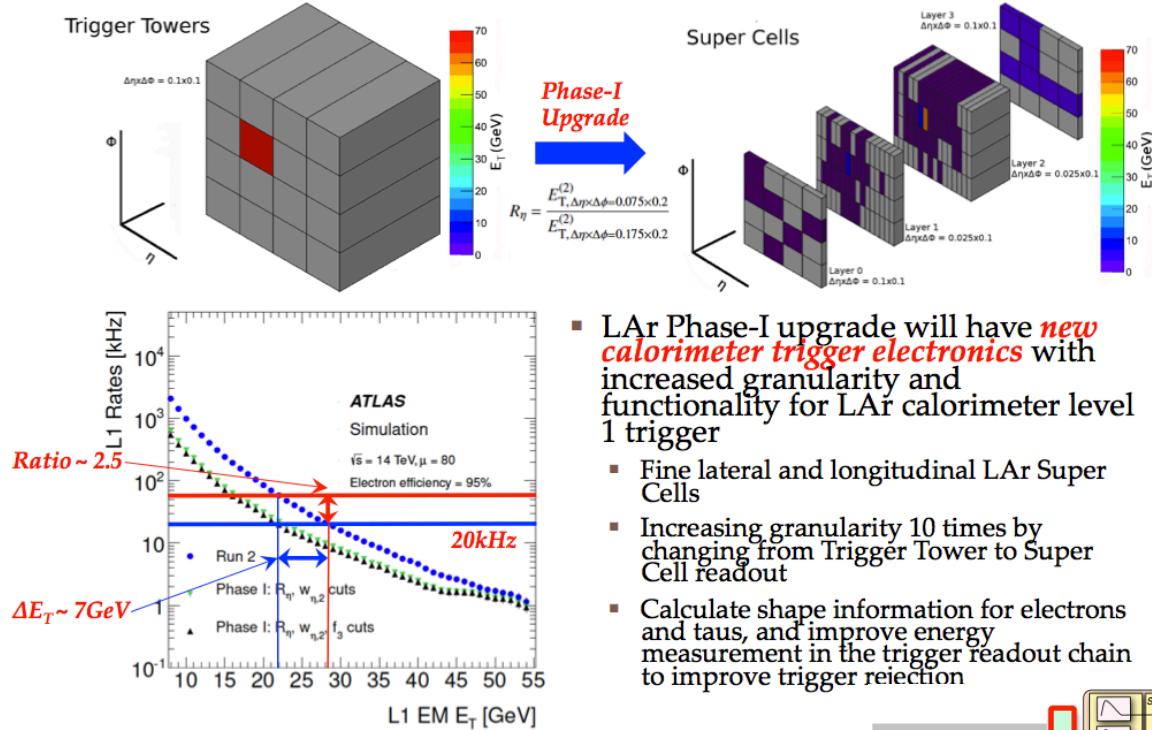
- Full-feature eFEX prototype successfully passed link speed test at 11.2 Gb/s
 - Layout of eFEX is the most complex of all FEXes.
- Full-feature jFEX prototype submitted for manufacture in April (ahead of revised schedule)
- gFEX prototype passed link speed test in January (full-feature prototype submitted for manufacture in April).
- **Link-speed decision: re-baselined to 11.2Gb/s**
 - 9.6Gb/s under consideration, 12.8 GB/s to be explored
- Sufficient progress to allow fiber mapping to be finalized for the ~6000 links



eFEX



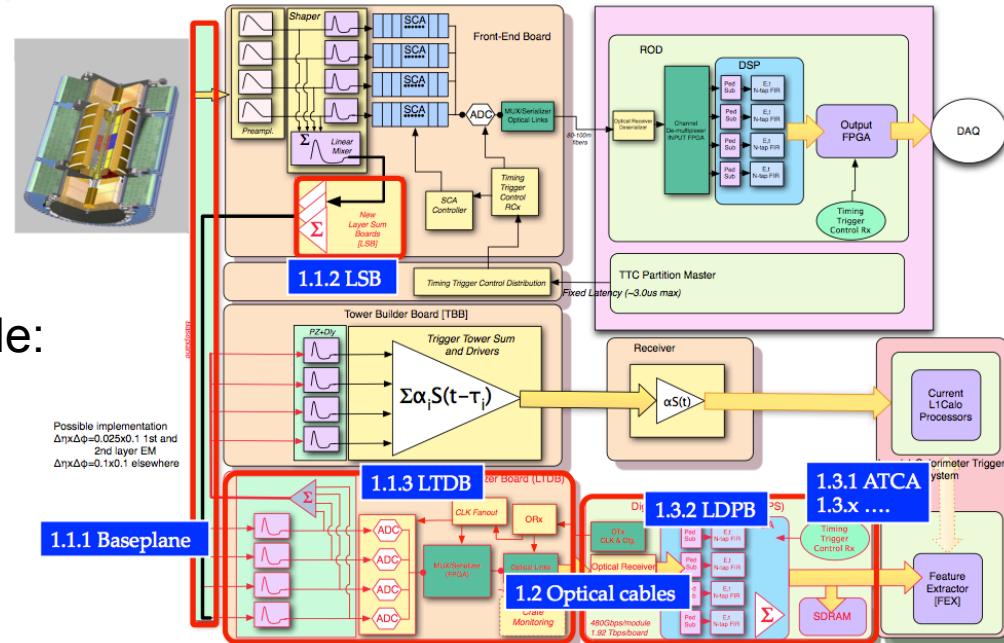
eFEX Eye
Diagram at
11.2 Gb/s



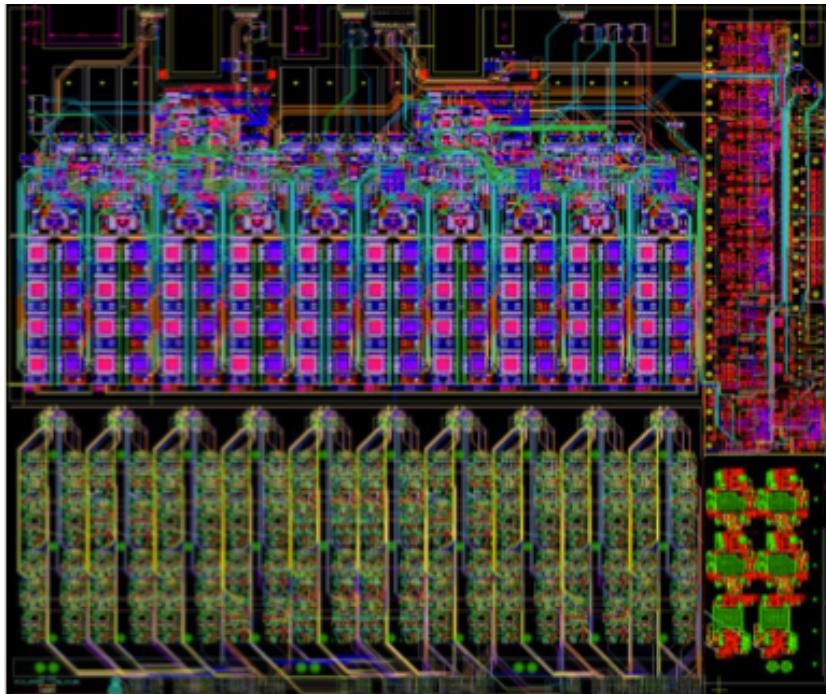
- LAr Phase-I upgrade will have **new calorimeter trigger electronics** with increased granularity and functionality for LAr calorimeter level 1 trigger
 - Fine lateral and longitudinal LAr Super Cells
 - Increasing granularity 10 times by changing from Trigger Tower to Super Cell readout
 - Calculate shape information for electrons and taus, and improve energy measurement in the trigger readout chain to improve trigger rejection

LAr Phase-1 Upgrade: principle

LAr trigger electronics is modified to increase granularity in Level-1 Calorimeter trigger, in order to keep the EM rates under control



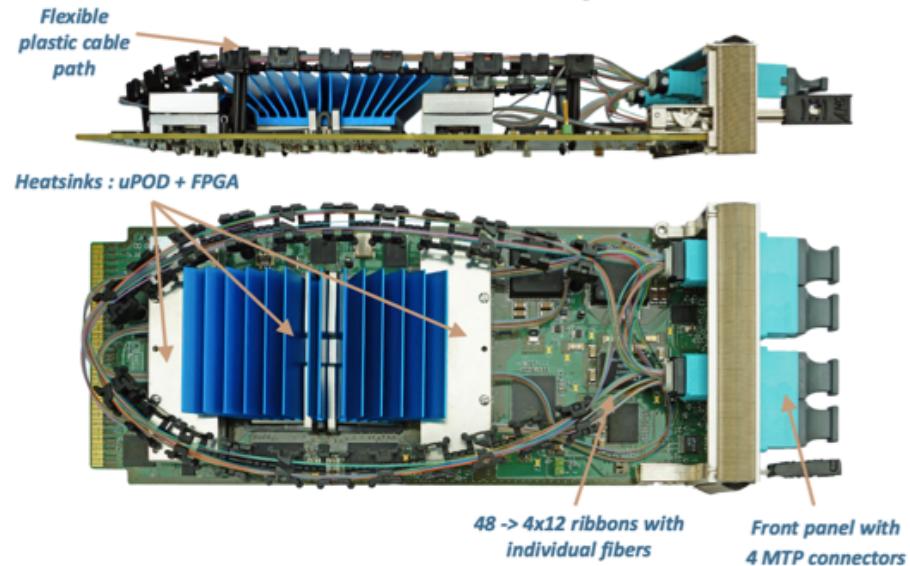
Deliverables for LAr Phase-1 Upgrade: Electronic boards



FE main board
LTDB pre-prototype in fabrication
ASICS (ADC+ serializer) close to series

Link speed test LAr-L1Calo
Successful : baseline 11.2 Gbps

BE main board
Main FPGA Altera Arria10
First prototype tested OK



LATOME – Optical link tests with gFEX

