



# ATLAS Status Report

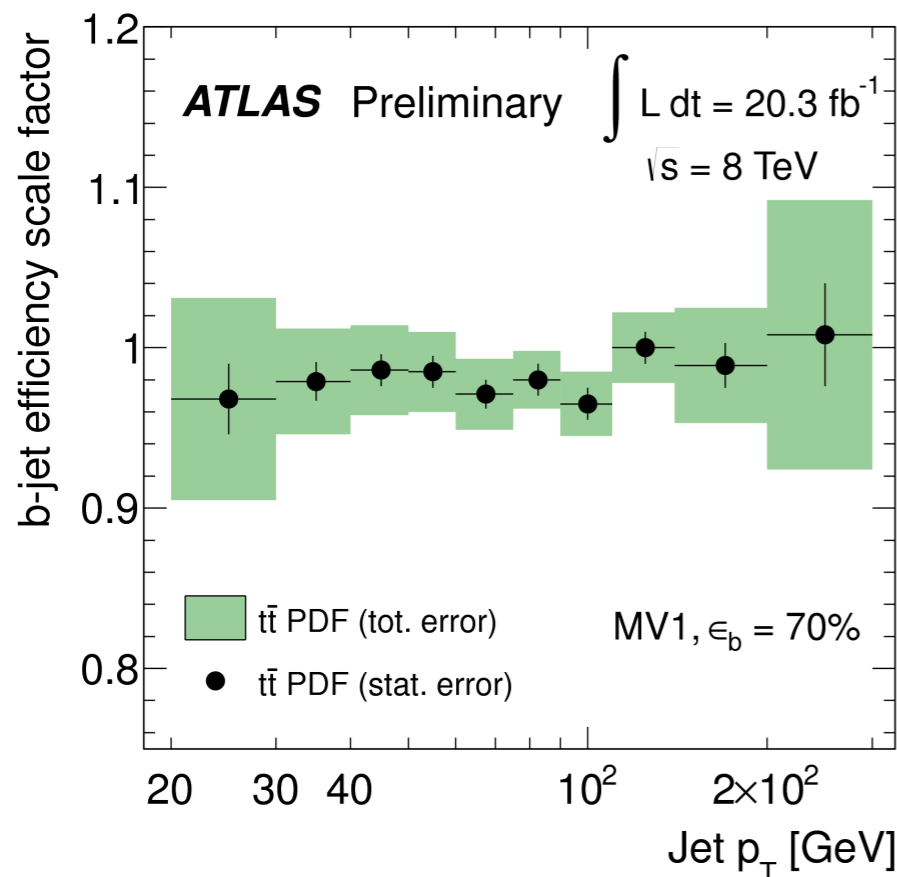
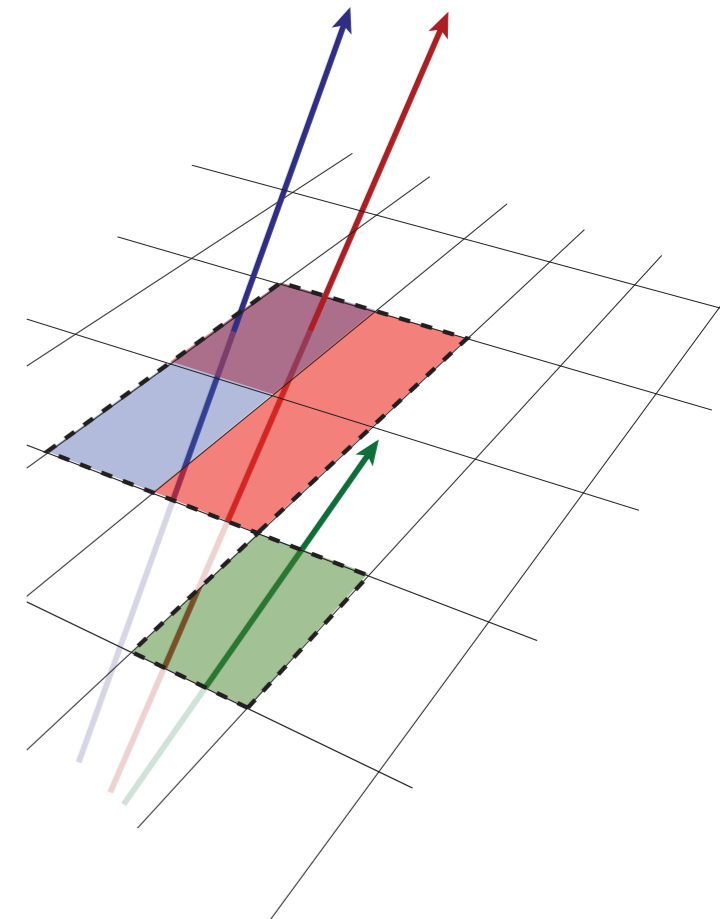
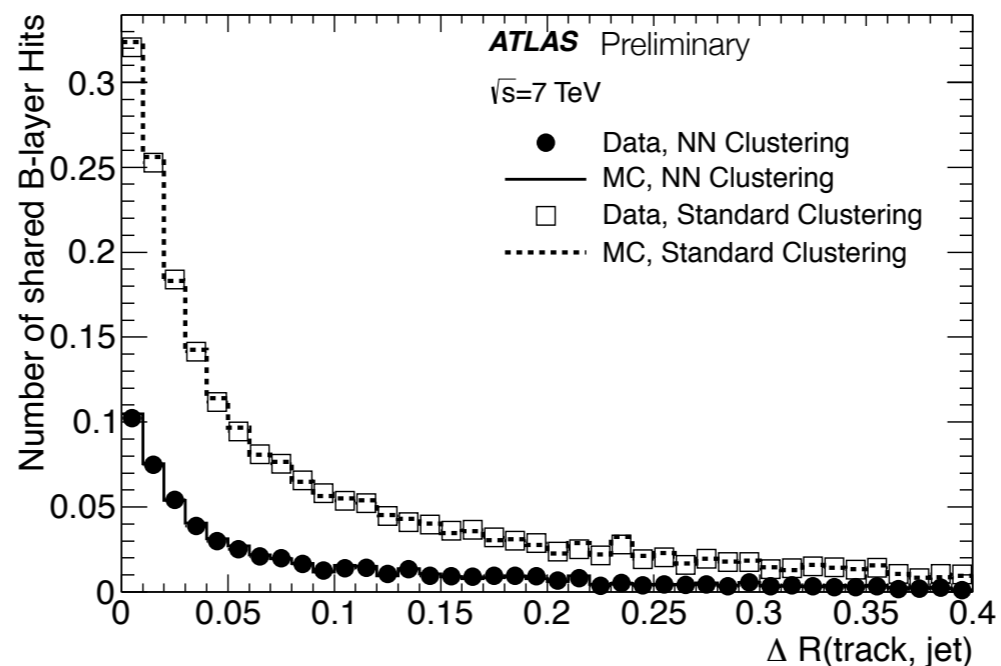
117<sup>th</sup> OPEN LHCC Session, 5<sup>th</sup> of March 2014  
Andreas Salzburger (CERN)

# Detector Performance

## Neural network-based pixel cluster splitting

- ▶ detect and split pixel clusters created by multiple particles using a set of neural networks

- reduces number of shared hits in dense jet cores by factor 3



## b-tagging calibration

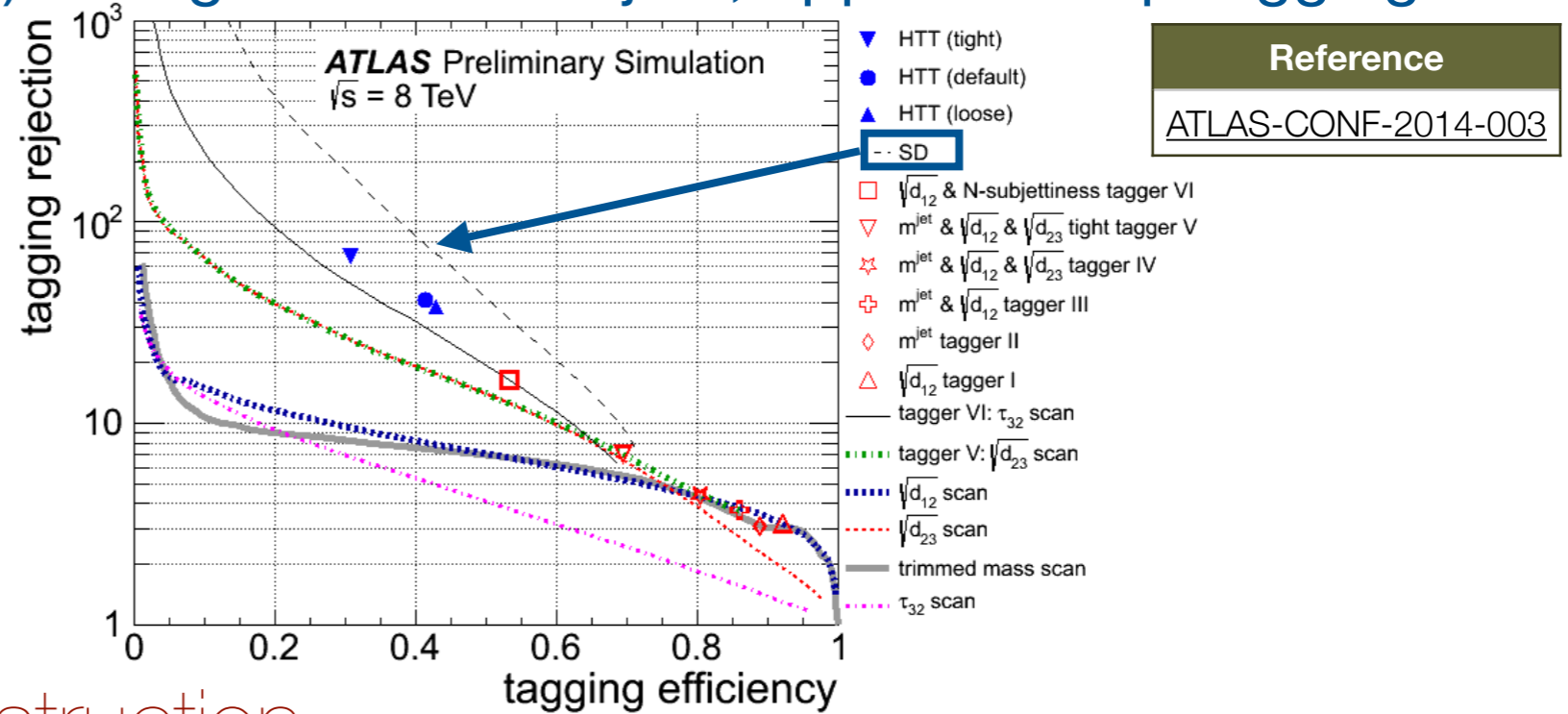
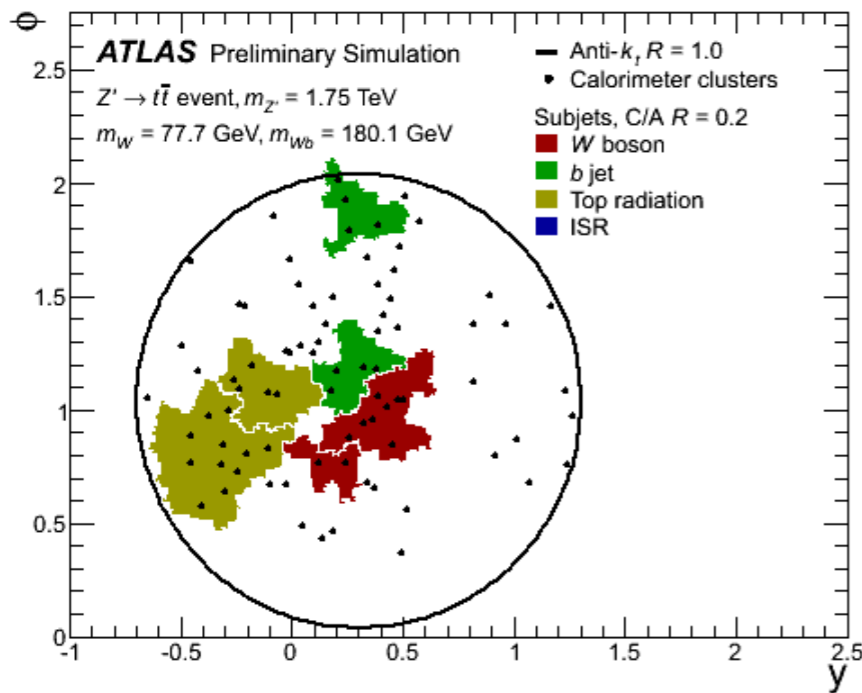
- ▶ using di-leptonic  $t\bar{t}$  events

- requiring both b quarks to decay semi-leptonically  
 - event-based b-tagging calibration using a PDF combining flavour correlations  
 - reduces uncertainties on data/MC scale factors to **2%** at around 100 GeV jet  $p_T$

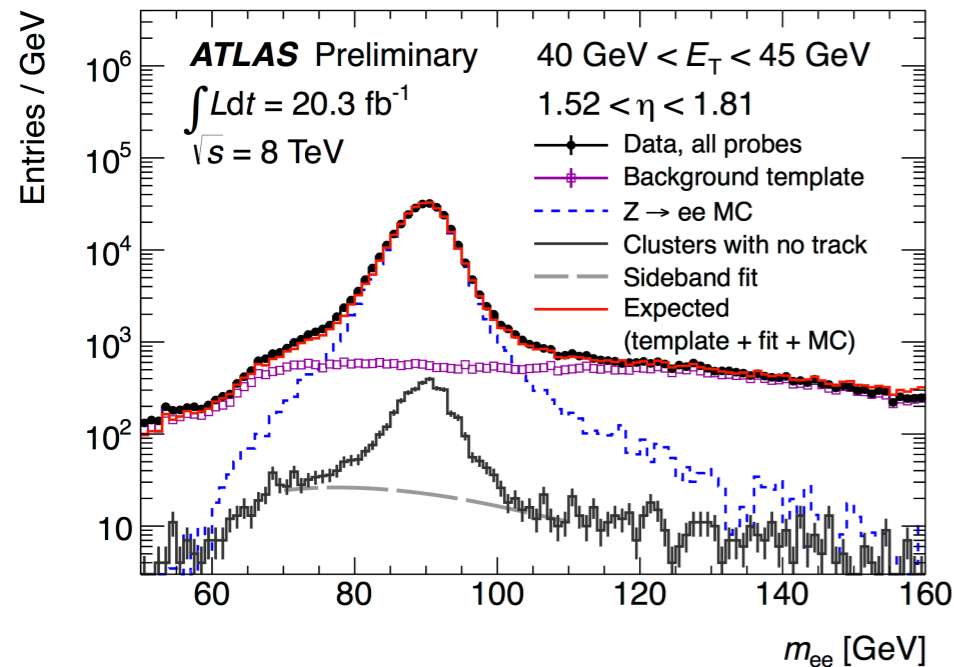
Reference
ATLAS-CONF-2014-004

# Jet substructure analysis

- ▶ shower deconstruction (SD) of large  $R=1$  anti- $k_t$  jets, applied to top tagging



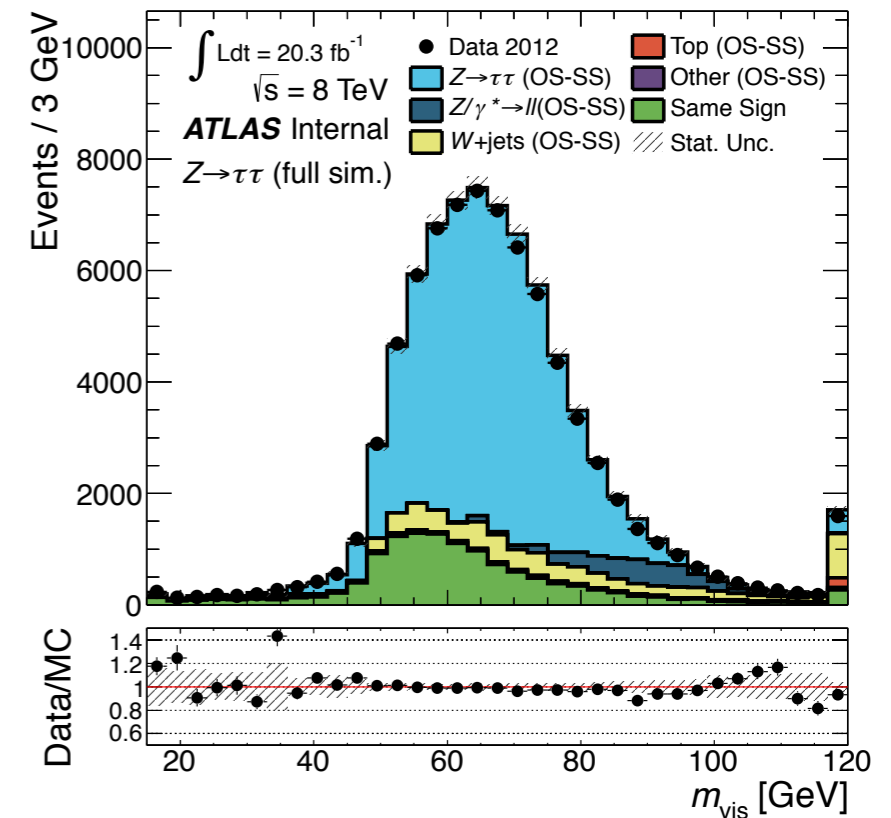
# Lepton & photon reconstruction



- ▶ tag & probe electron reconstruction eff.
- ▶ tau energy scale estimation

LPCC Simulation WS  
 March 18/19

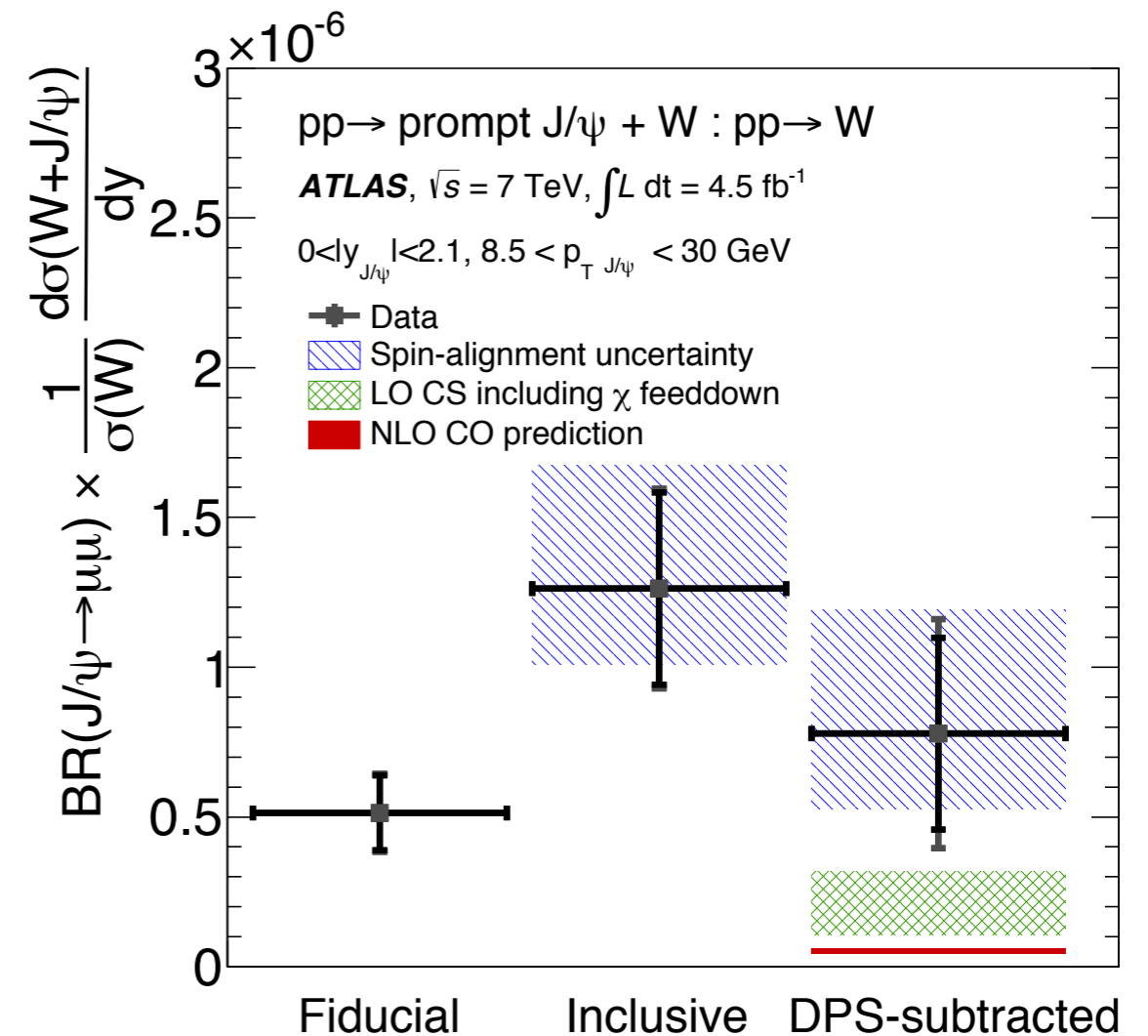
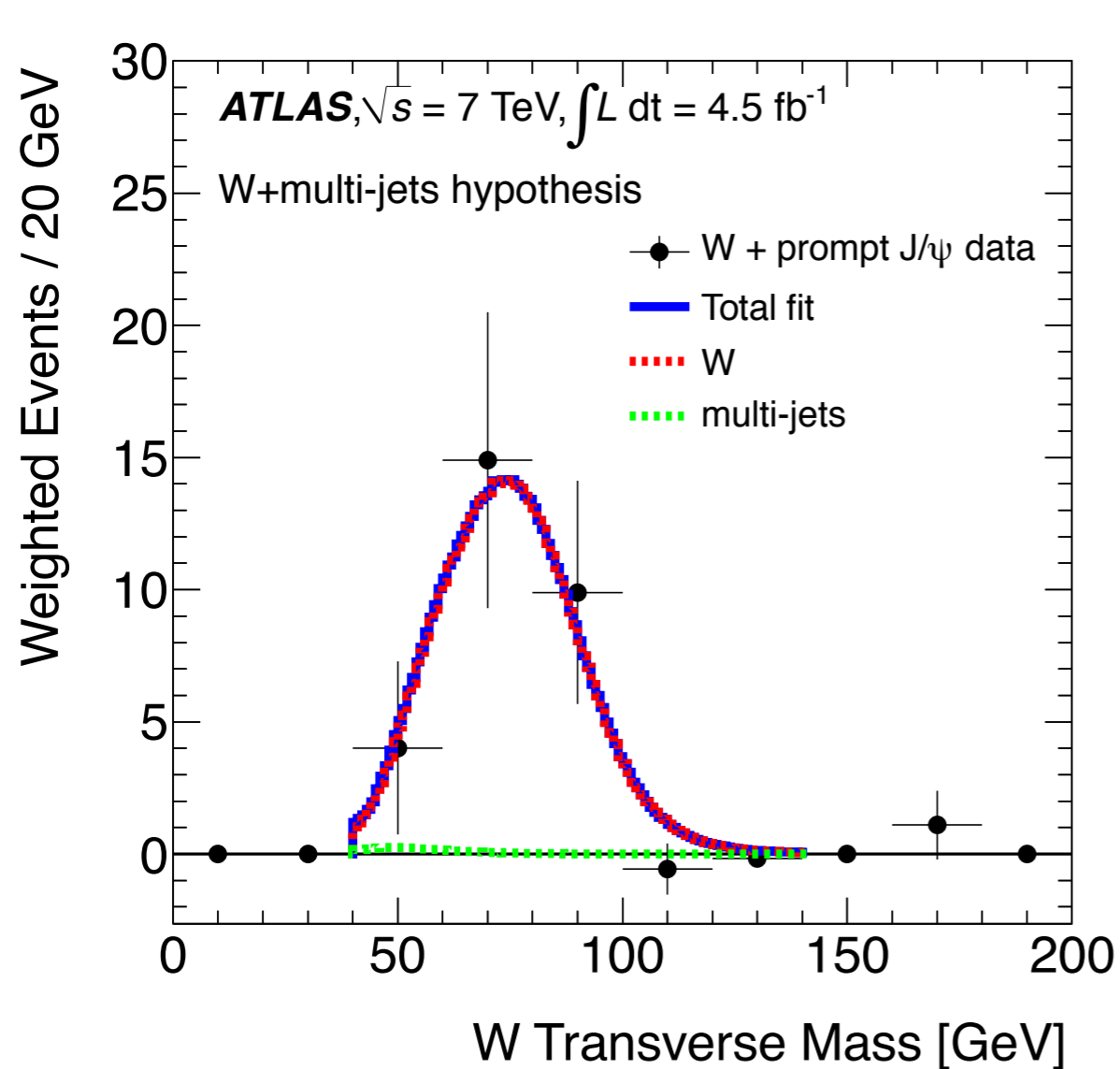
- ▶ high precision of EM scale and tracker momentum scale almost final



# Observation of $W$ with a prompt $J/\psi$

## ► analysis of 2011 p-p dataset using 3 muons in final state

- new test of quarkonium production with contributions from colour singlet and octet
- background-only hypothesis excluded with  $5.1 \sigma$

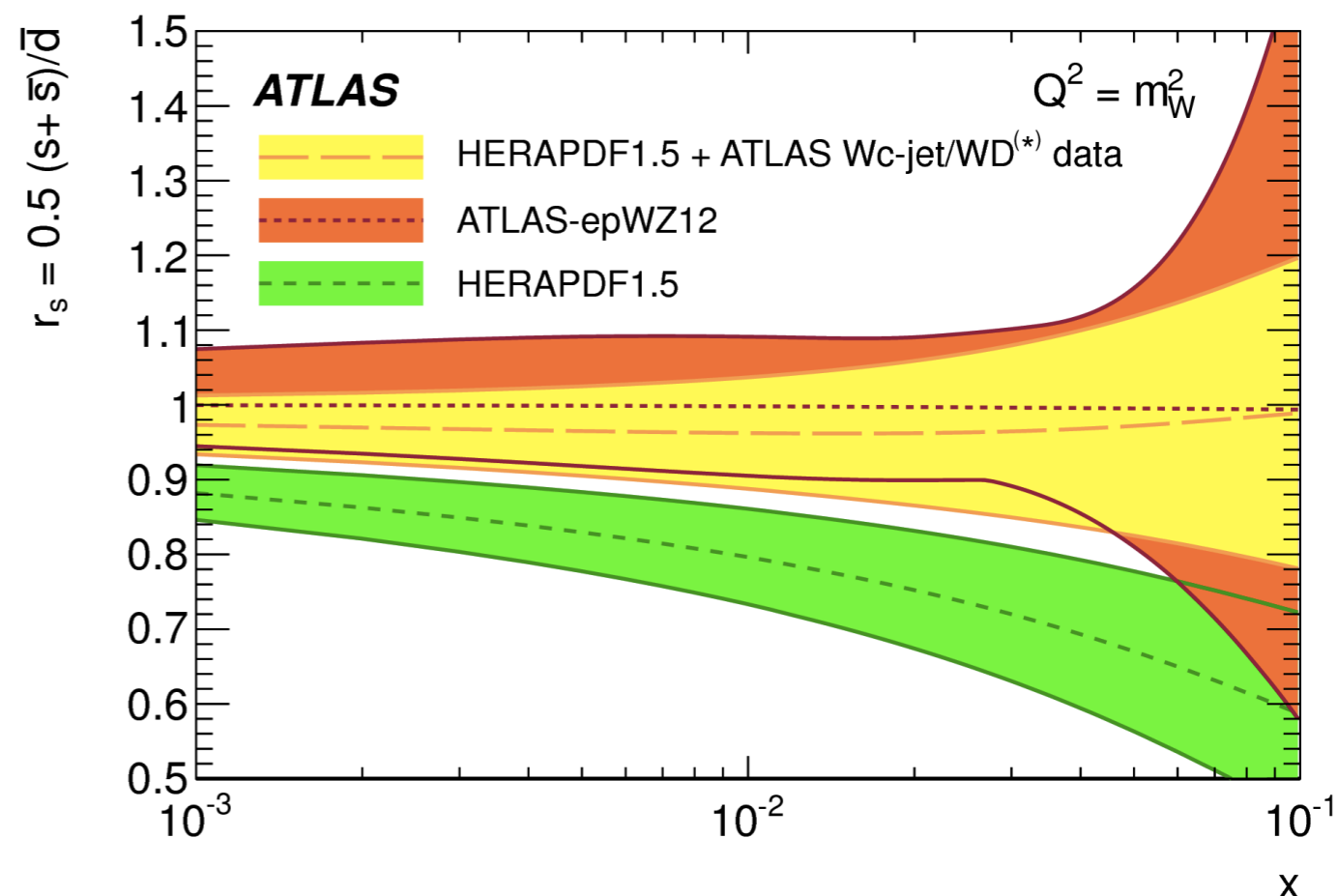
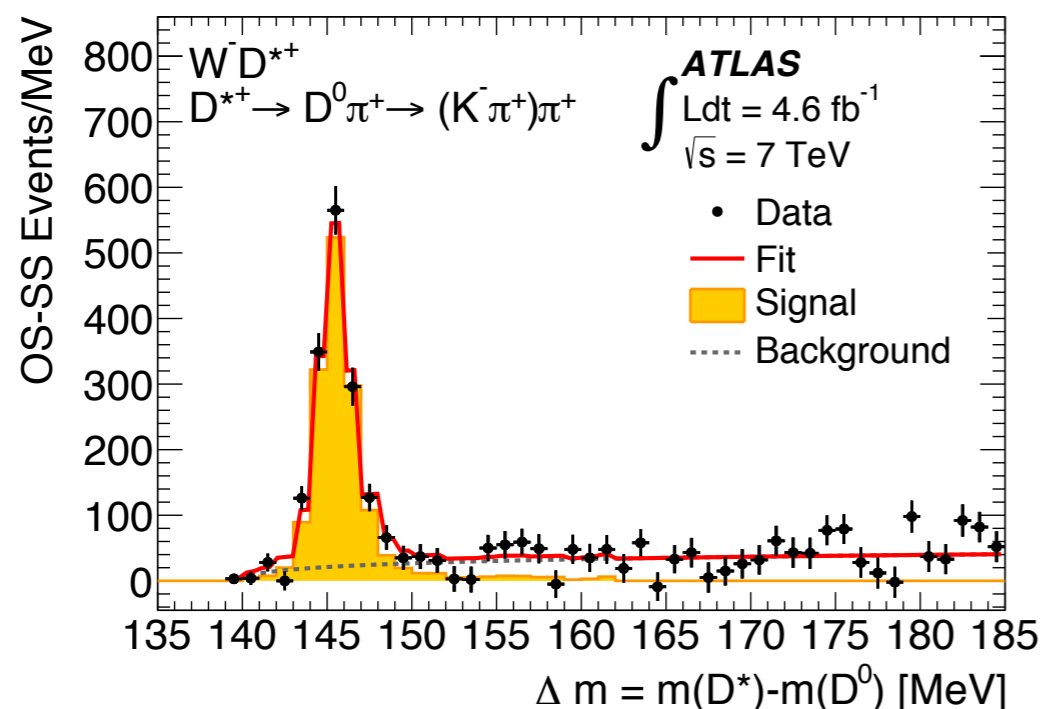


Short title	Journal	$\sqrt{s}$ (TeV)	Run (yr)	Lumi
Associated production of prompt $J/\psi$ and W	<a href="https://arxiv.org/abs/1401.2831">arXiv:1401.2831</a>	8 TeV	2011	$4.6 \text{ fb}^{-1}$

# W production in association with a single charm

- probes strange quark distribution function in proton
- c-jet tag using decay to  $\mu$  and  $D^{(*)}$  decay chain reconstruction

- measured by subtracting opposite sign (OS) to same sign (SS) final state



- ratio of the strange-to-down sea-quark distributions

$$r_s \equiv 0.5(s + \bar{s})/\bar{d} = f_s/(1 - f_s) = 0.96^{+0.16}_{-0.18} {}^{+0.21}_{-0.24}$$

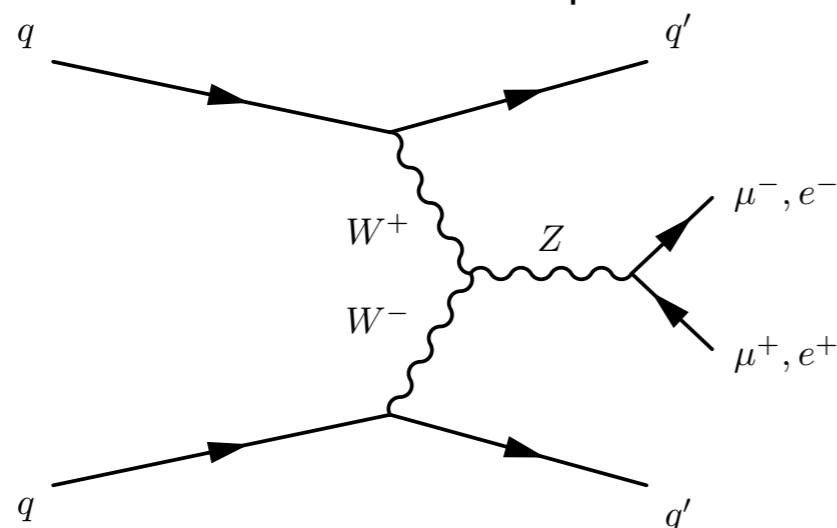
ATLAS measurement prefers symmetric light quark sea

Short title	Journal	$\sqrt{s}$ (TeV)	Run (yr)	Lumi
W + c-quark production	<a href="https://arxiv.org/abs/1402.6263">arXiv:1402.6263</a>	7 TeV	2011	$4.6 \text{ fb}^{-1}$

# More Standard Model highlights

## Electroweak $Zjj$ production

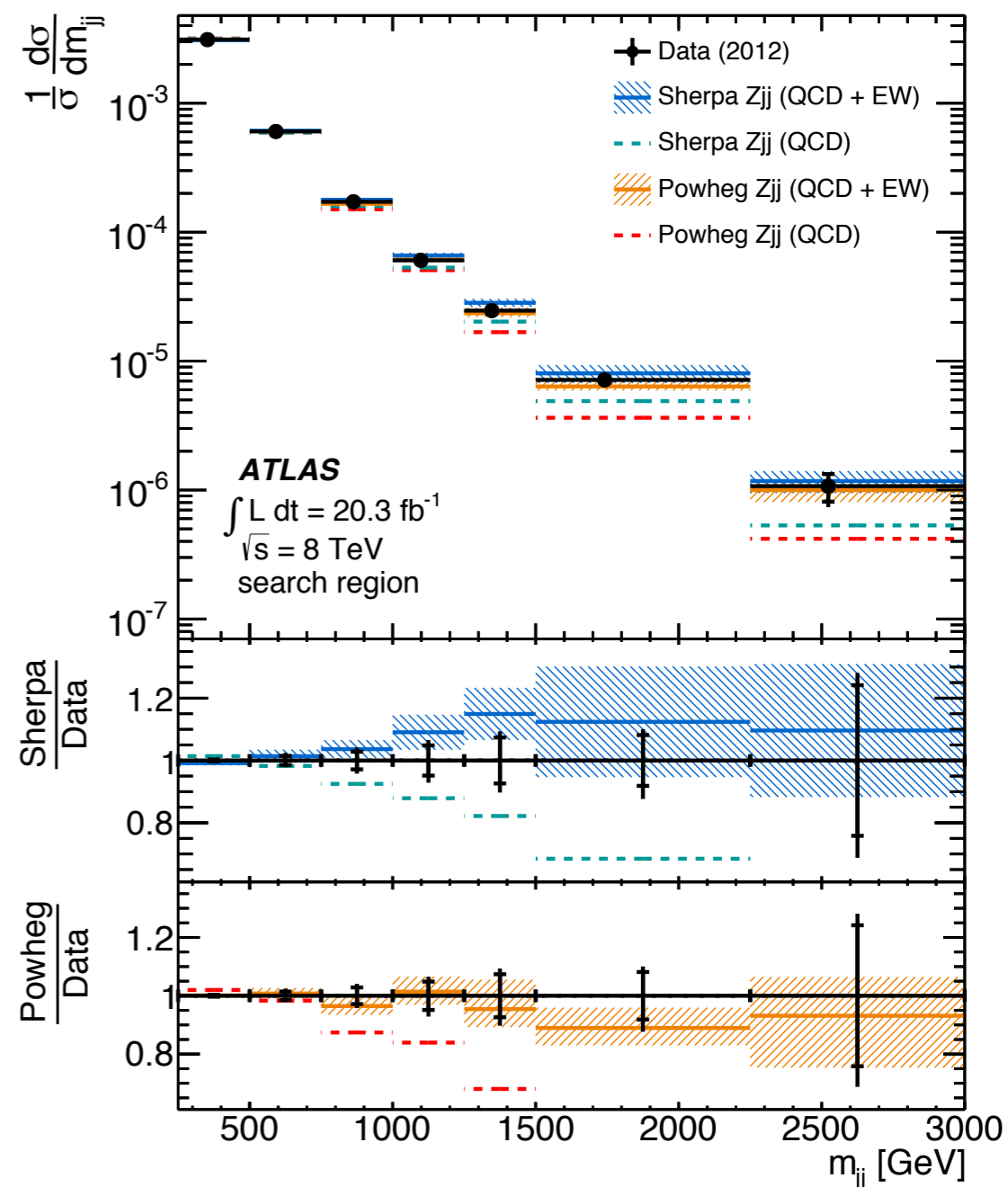
- rare production mode w.r.t. Drell Yan + jets
- probes vector boson fusion process



- background-only hypothesis excluded above  $5 \sigma$

fiducial  $\sigma_{EW} = 54.7 \pm 11.5 \text{ fb}$   
 (Powheg  $46.1 \pm 1.0 \text{ fb}$ )

- limits set for anomalous triple gauge couplings

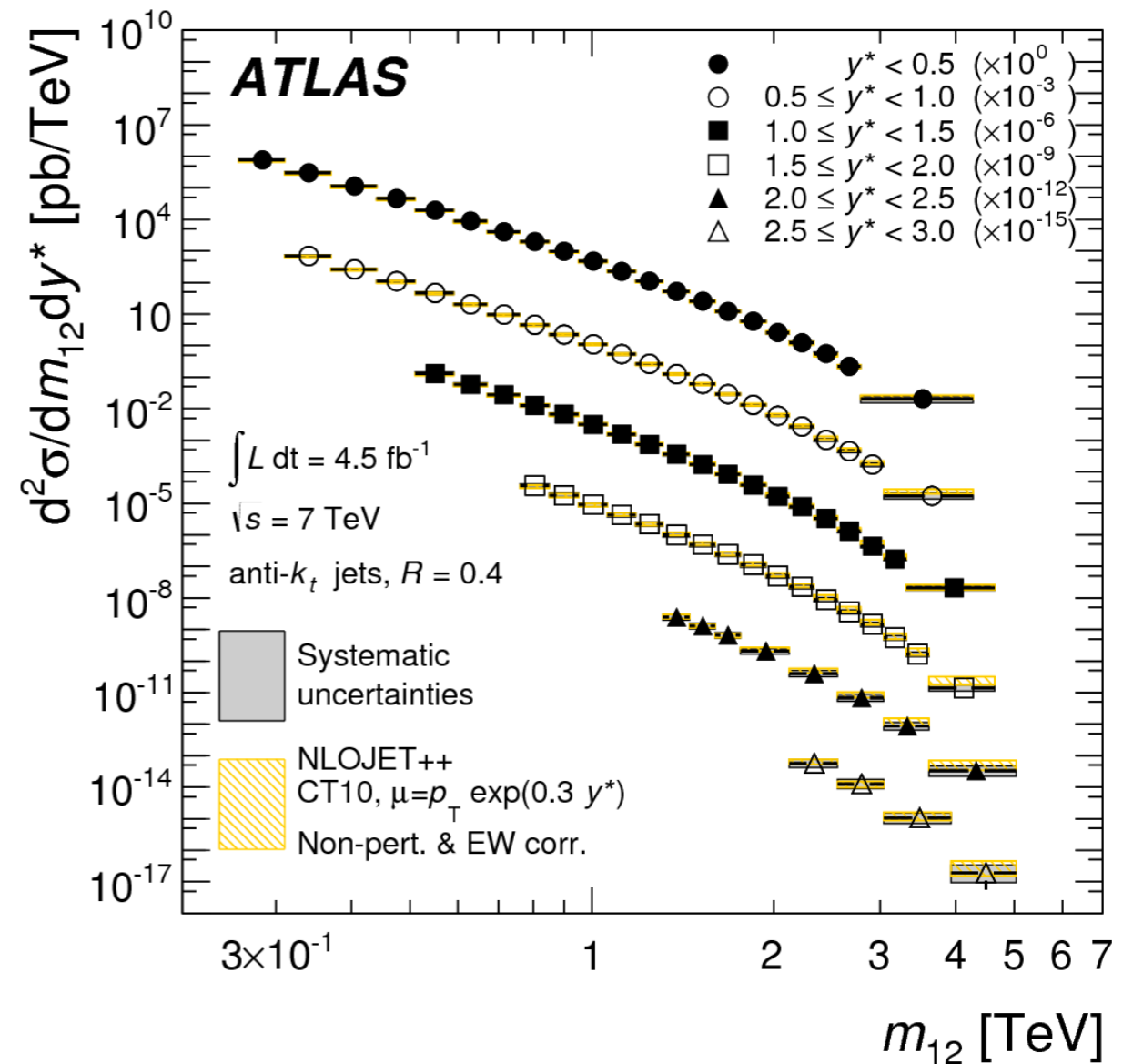
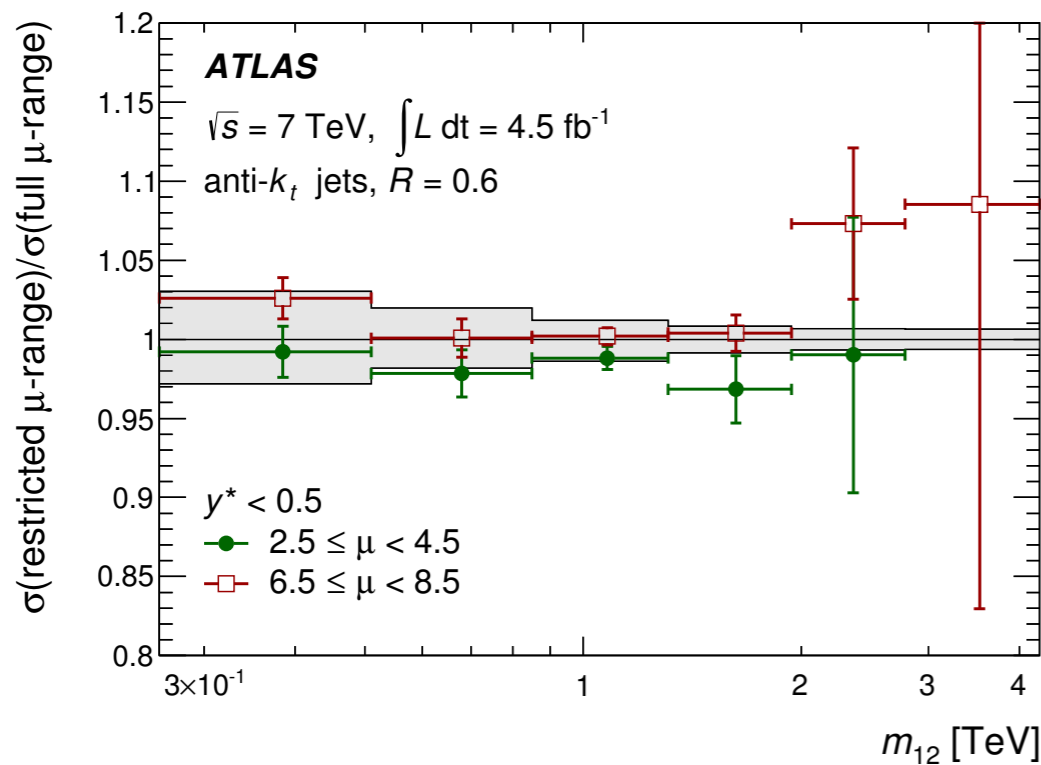


Short title	Journal	$\sqrt{s}$ (TeV)	Run (yr)	Lumi
Electroweak production of Z bosons	<a href="https://arxiv.org/abs/1402.6263">arXiv:1402.6263</a>	8 TeV	2012	$20.3 \text{ fb}^{-1}$

# Di-jet cross section in 7 TeV data

## ▶ double differential di-jet cross section

- measured as functions of di-jet mass  $m_{12}$  and rapidity gap  $y^*$
- for both  $R = 0.4$  and  $R = 0.6$  anti- $k_t$  jets
- unfolded to particle level



Short title	Journal/Reference	$\sqrt{s}$ (TeV)	Run (yr)	Lumi
Di-jet cross sections in pp collisions	<a href="https://arxiv.org/abs/1312.3524">arXiv:1312.3524</a>	7 TeV	2011	$4.6 \text{ fb}^{-1}$
Production of Phi mesons	<a href="https://arxiv.org/abs/1402.6162">arXiv:1402.6162</a>	7 TeV	2010	$383 \mu\text{b}^{-1}$
Sensitivity to the proton parton distributions of the inclusive photon production cross section	<a href="https://arxiv.org/abs/ATL-PHYS-PUB-2013-018">ATL-PHYS-PUB-2013-018</a>	7 TeV	2011	$4.6 \text{ fb}^{-1}$

# Higgs status

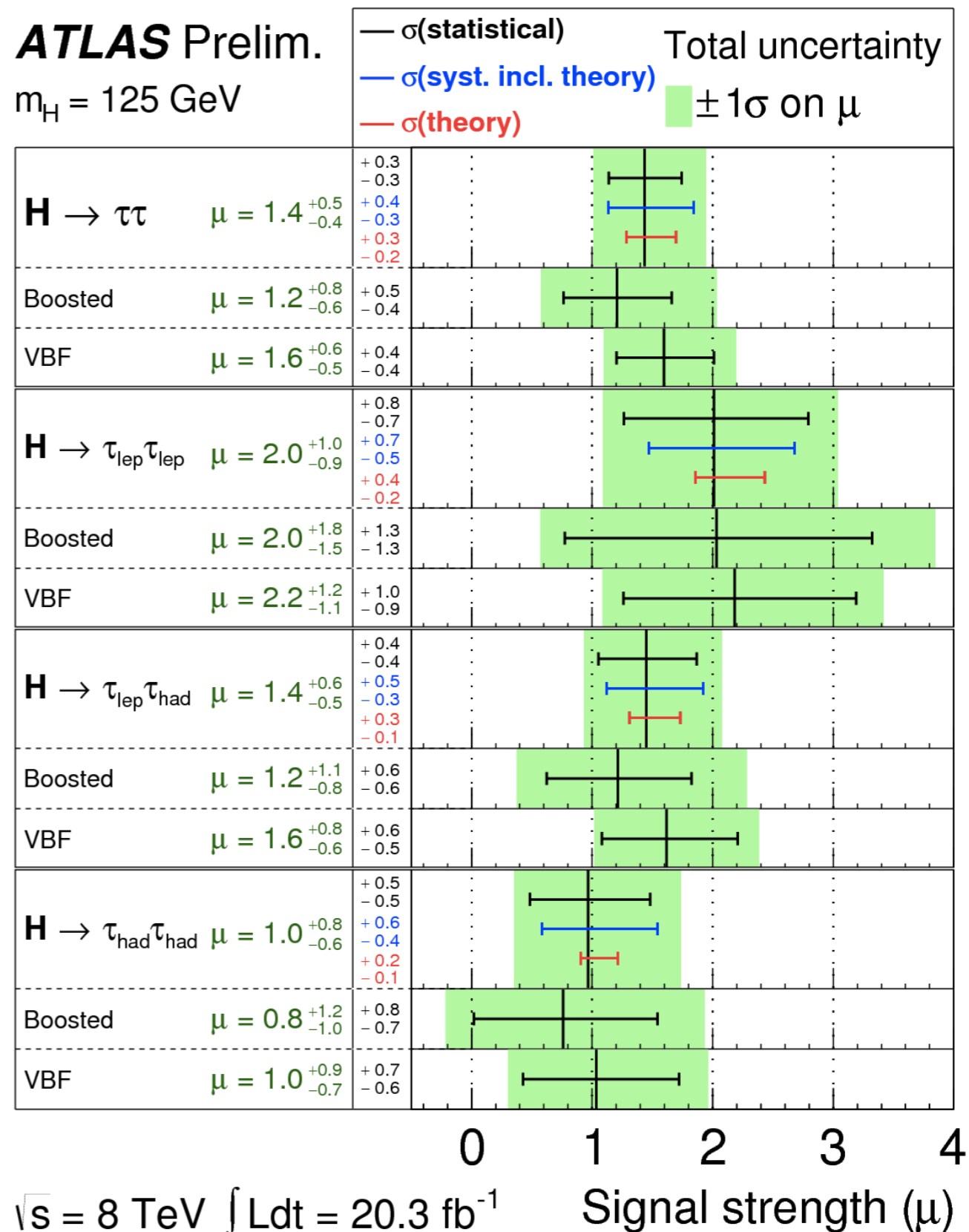
## ▶ $H \rightarrow \tau\tau$ preliminary results released end of November 2013

- 4.1 (3.2)  $\sigma$  observed (exp.) @125 GeV
- presented in detail at the 116th Open LHCC (5/12/2013)

Reference
ATLAS-CONF-2013-108

## ▶ Re-analysis of full 2011/2012 dataset well on the way

- including new mass measurements in  $H \rightarrow \gamma\gamma$ ,  $H \rightarrow ZZ^{(*)} \rightarrow 4\ell$  channels
- highly reduced systematic uncertainties for photon energy and lepton momentum scale



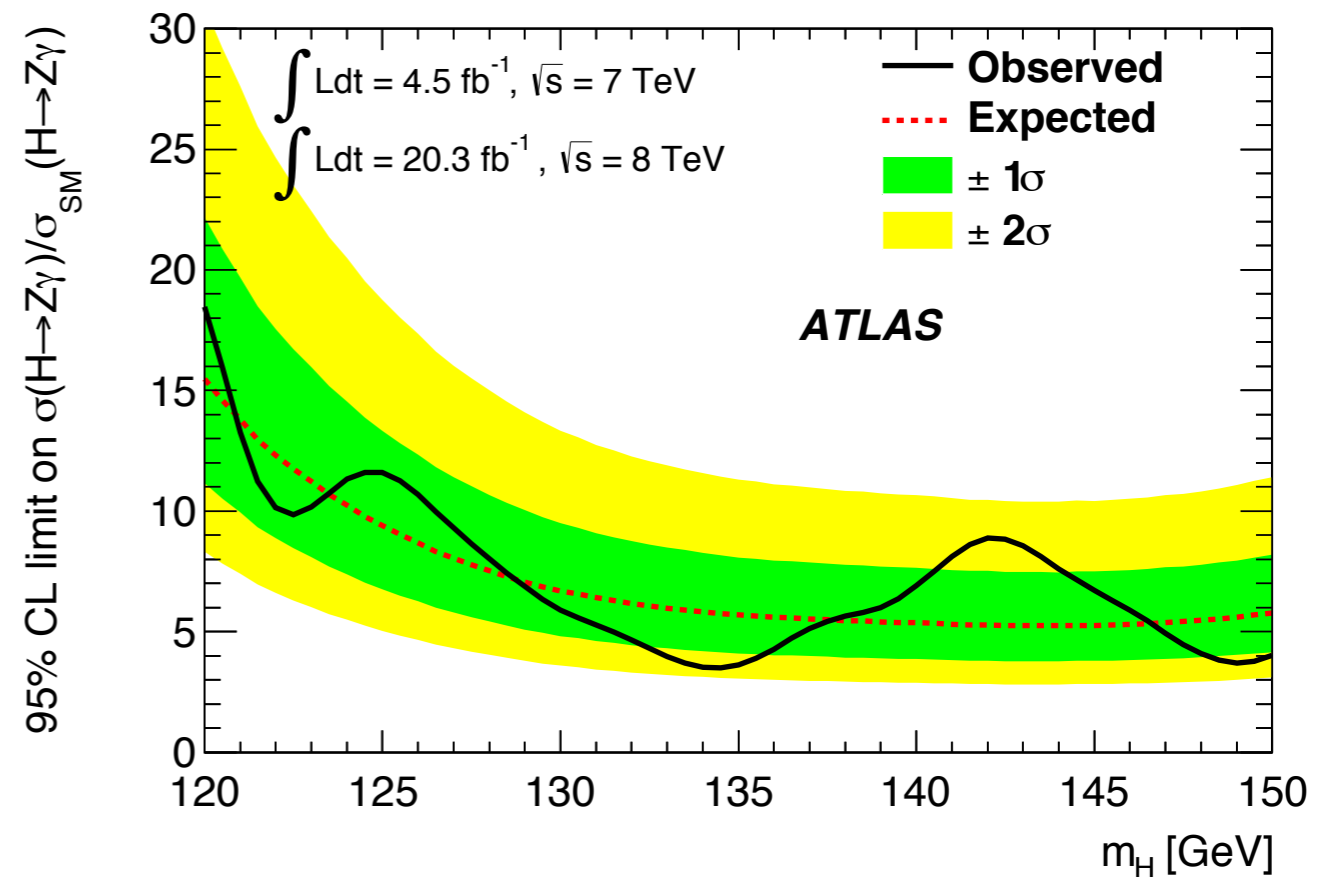
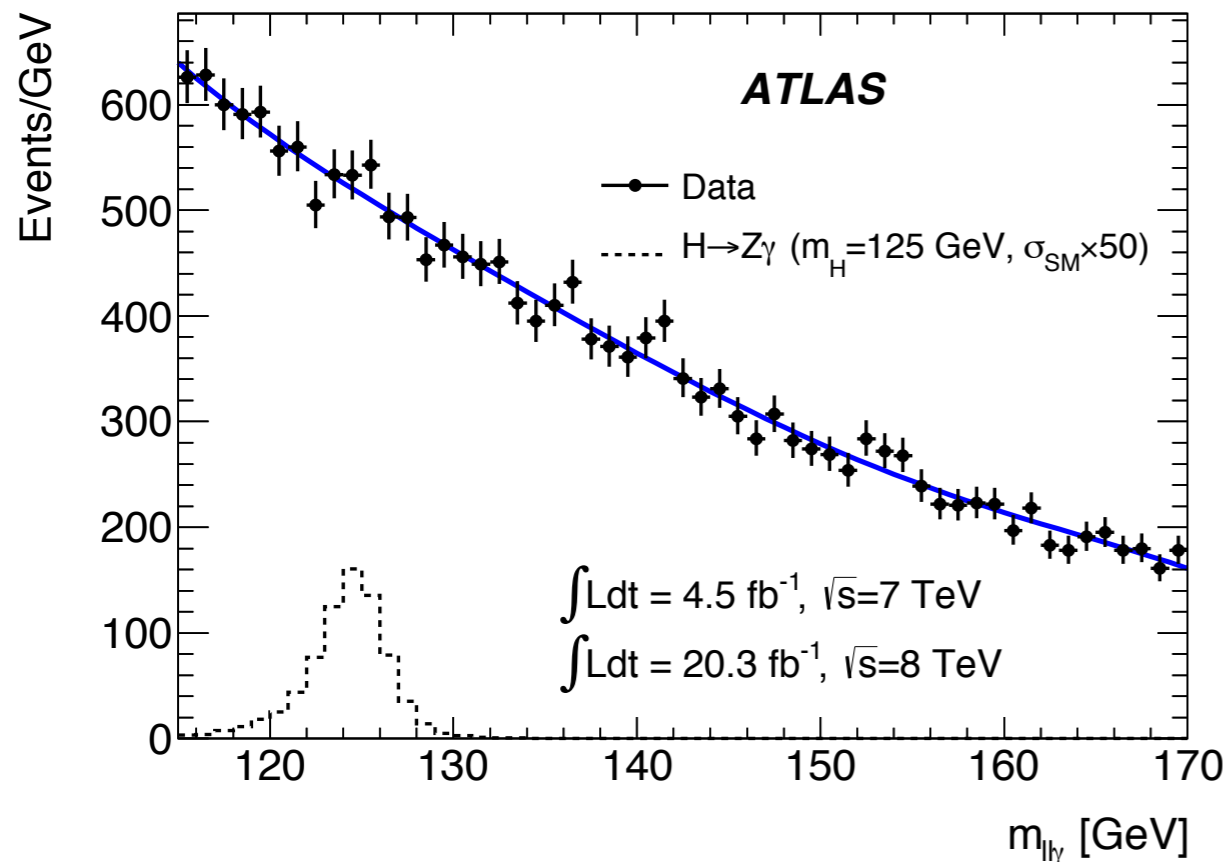


# More recent Higgs results

## $H \rightarrow Z\gamma$ search in full Run-1 dataset

### ▸ testing SM character of Higgs

- via leptonic (muon, electron) decay of Z



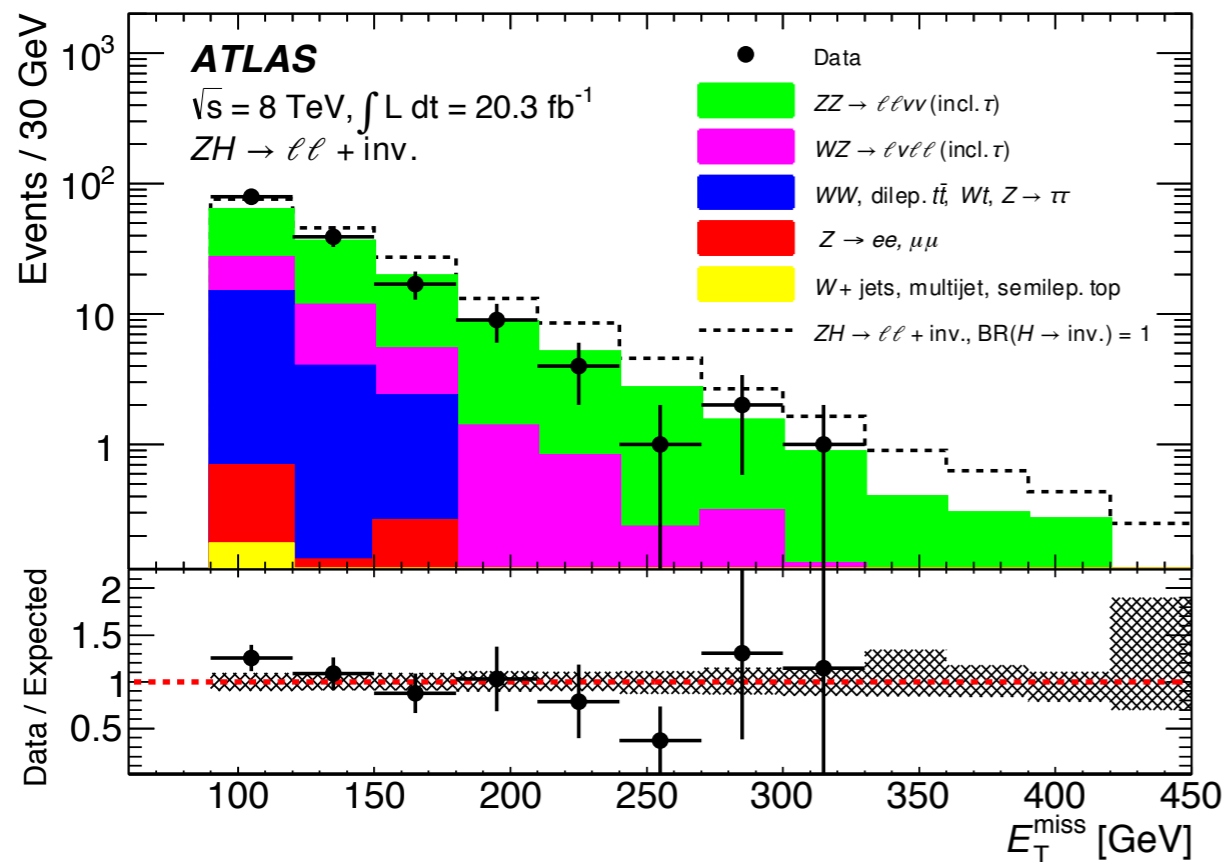
Observed (expected) limit @ 125 GeV : 11 (9) x Standard Model

Title	Reference	$\sqrt{s}$ (TeV)	Run (yr)	Lumi
Search for the Standard Model Higgs boson decay to a photon and a Z boson in pp collisions at $\sqrt{s} = 7$ and 8 TeV with the ATLAS detector	<a href="https://arxiv.org/abs/1402.3051">arXiv:1402.3051</a>	7/8 TeV	Run-1	24.8 fb <sup>-1</sup>

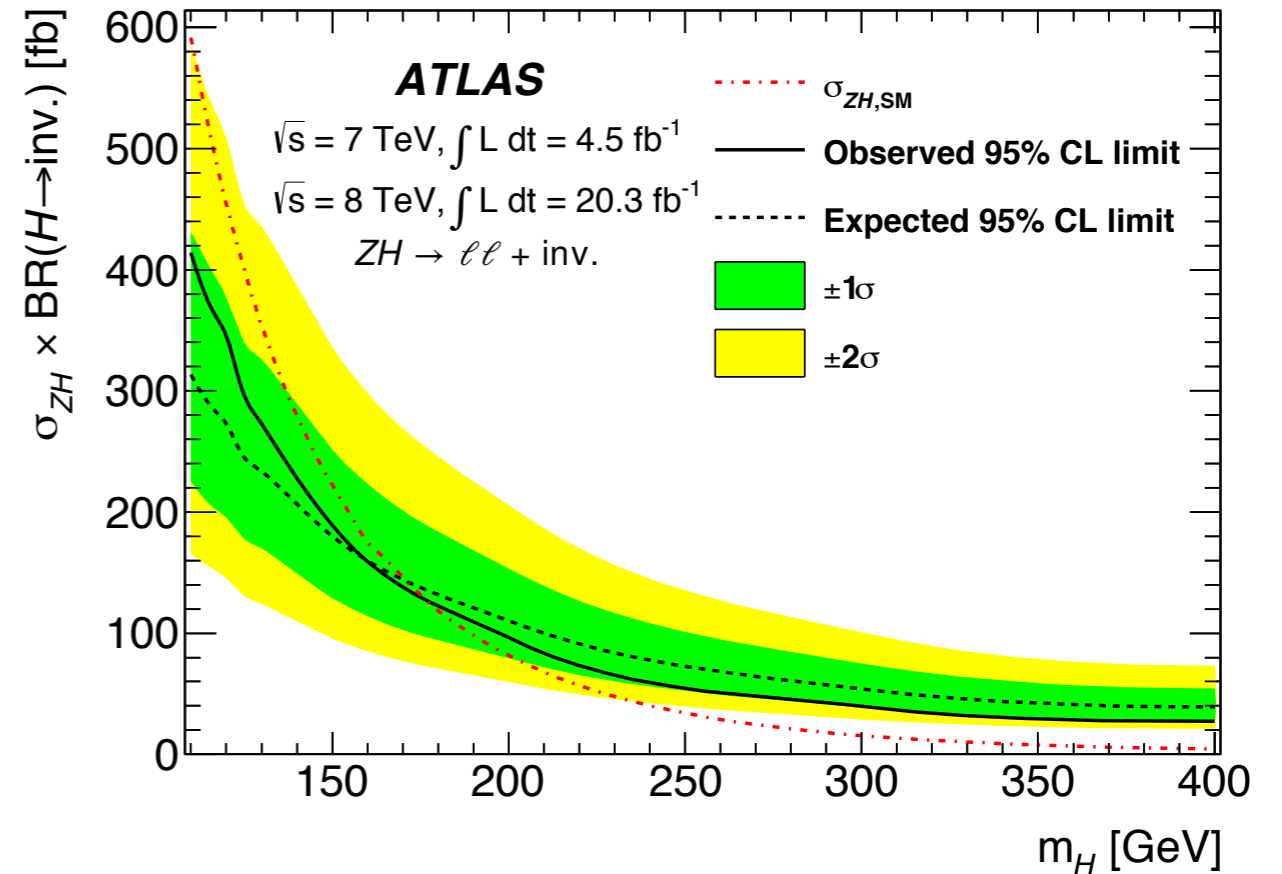
# ZH → ℓℓ + invisible

▸ search for invisible products of the Higgs boson

- in association with a Z decaying to leptons and large missing transverse energy



signal shown assuming SM rate ZH production and 100 % BR to invisible

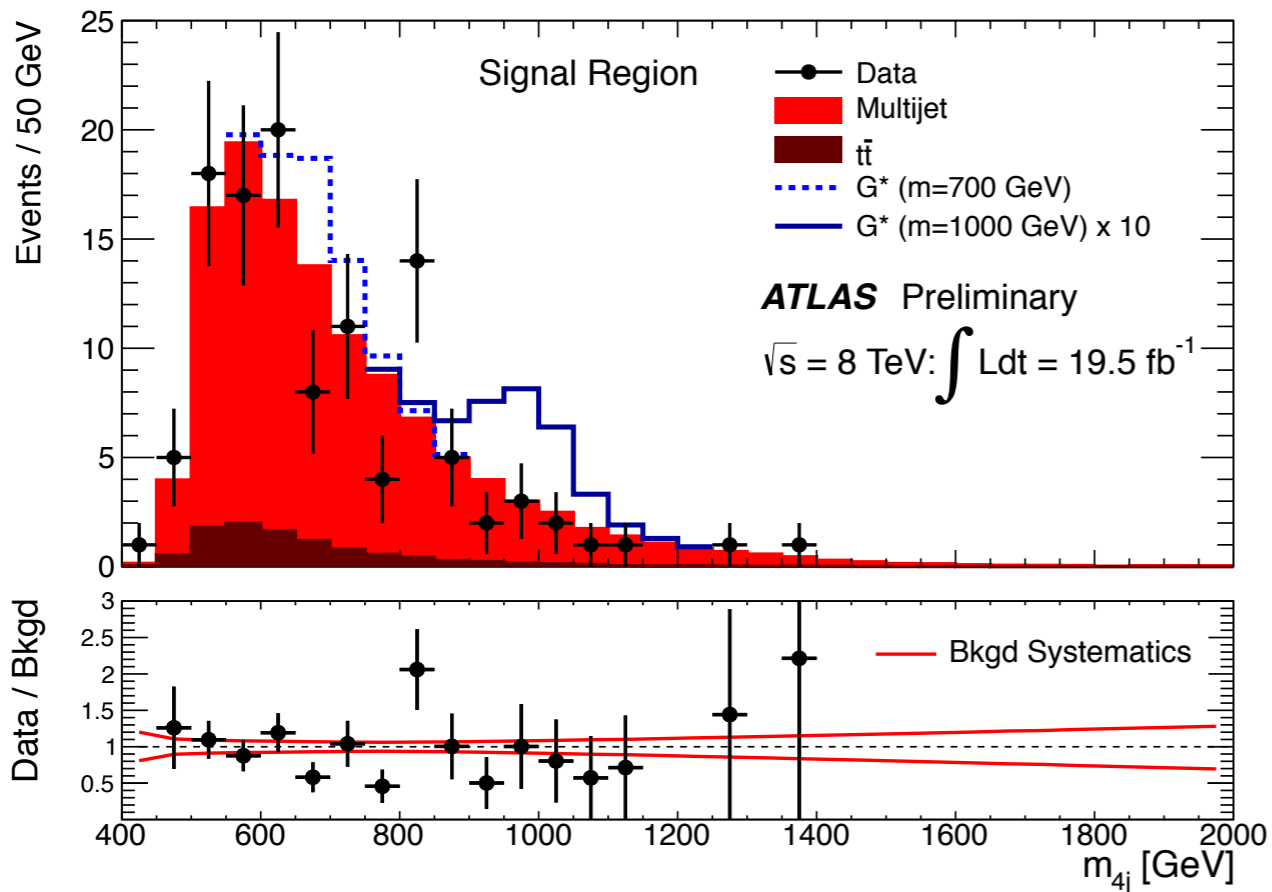
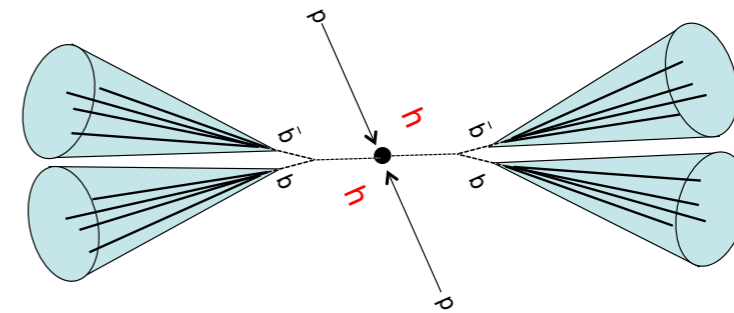


Obs. (exp.) upper limit at 95 % CL on the allowed invisible BR: 75 (62)%

Title	Journal	$\sqrt{s}$ (TeV)	Run (yr)	Lumi
Search for Invisible Decays of a Higgs Boson Produced in Association with a Z Boson in ATLAS	<a href="https://arxiv.org/abs/1402.3244">arXiv:1402.3244</a>	7/8 TeV	Run-1	24.8 fb <sup>-1</sup>
Search for a Multi-Higgs Boson Cascade in W+W- b̄b̄ events with the ATLAS detector in pp collisions at $\sqrt{s} = 8 \text{ TeV}$	<a href="https://arxiv.org/abs/1203.3546">PhysRevD.89.032002</a>	8 TeV	2012	20.3 fb <sup>-1</sup>

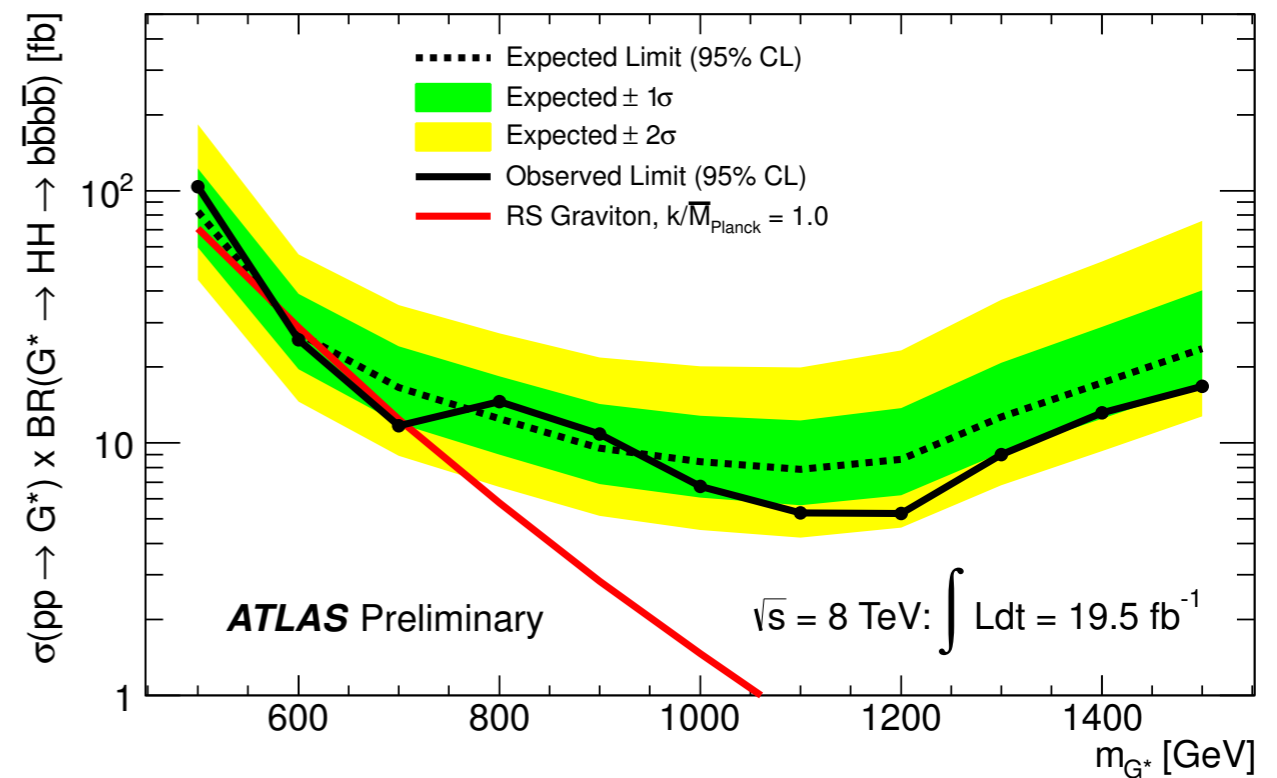
# Exotics: $X \rightarrow HH \rightarrow b\bar{b}b\bar{b}$

- ▶ 4 b-tagged R=0.4 anti- $k_t$  jets
  - multi-jet and dedicated b-tag triggers
- ▶ requiring  $m(X) > 500$  GeV and SM Higgs, with  $m(2j) \sim 125$  GeV



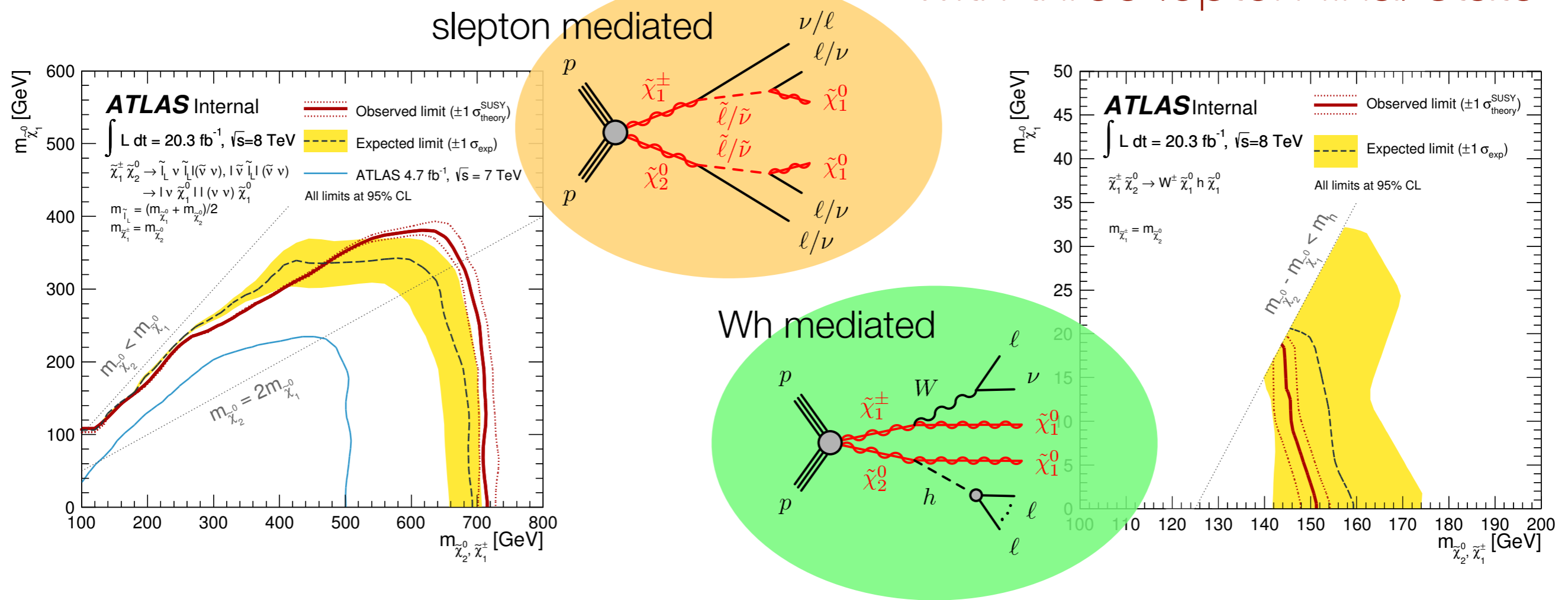
- ▶ assuming KK excited Graviton  $G^*$  excluded [500,700 GeV] @ 95 % CL

Sample	search region
QCD	$109 \pm 5$
tt	$10 \pm 6$
Z+jets	$0.7 \pm 0.2$
<b>TOTAL bkg</b>	<b><math>120 \pm 8</math></b>
<b>Data</b>	<b>114</b>



Title	Reference	$\sqrt{s}$ (TeV)	Run (yr)	Lumi
Search for a resonant Higgs-pair production in the bbbb final state	<a href="#">ATLAS-CONF-2014-005</a>	8 TeV	2012	$19.5 \text{ fb}^{-1}$

# SUSY direct production of charginos and neutralinos with three lepton final state

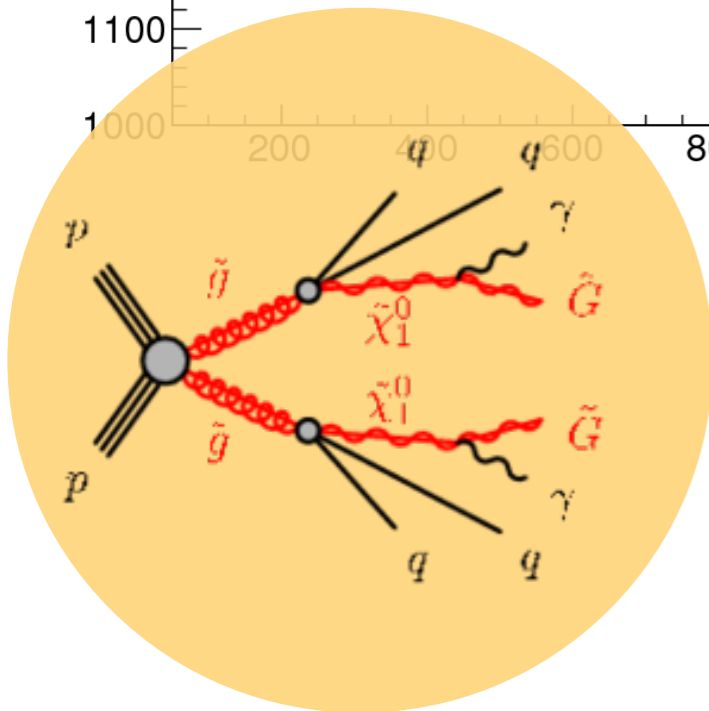
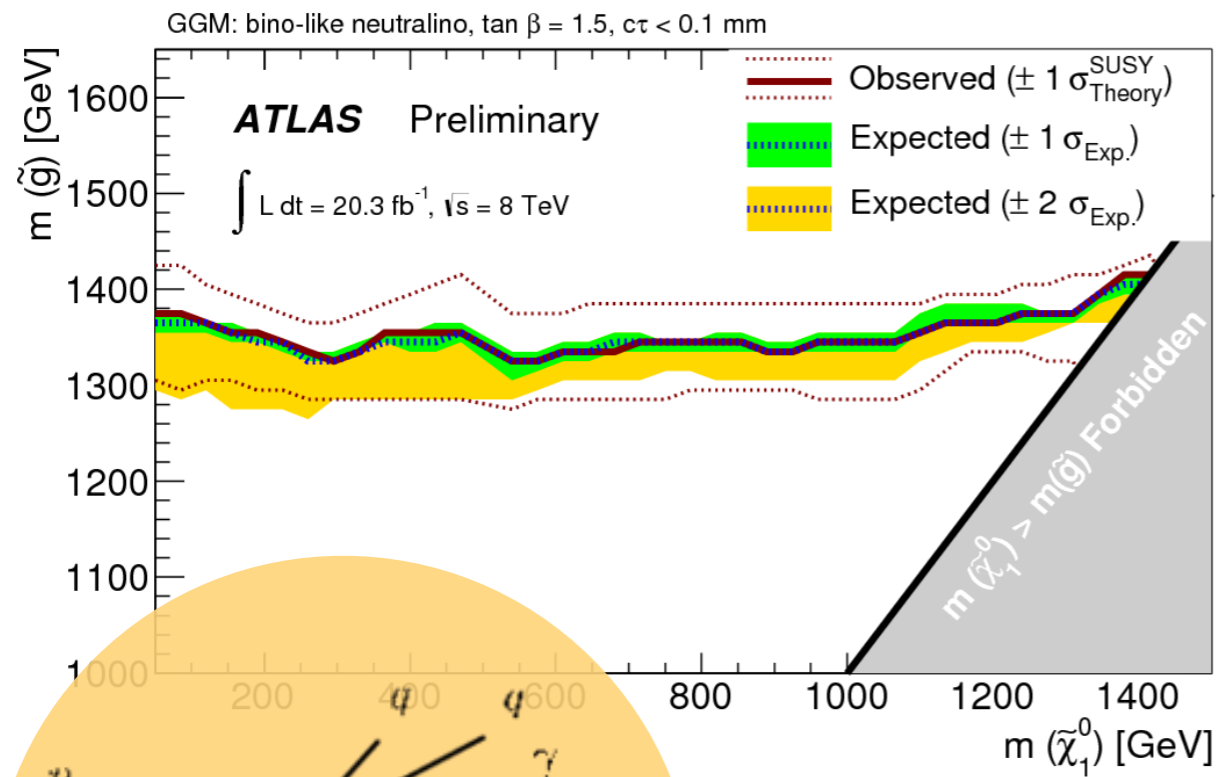


- Search performed in slepton, stau, WZ & Wh mediated categories
- full 2012 dataset used for this analysis

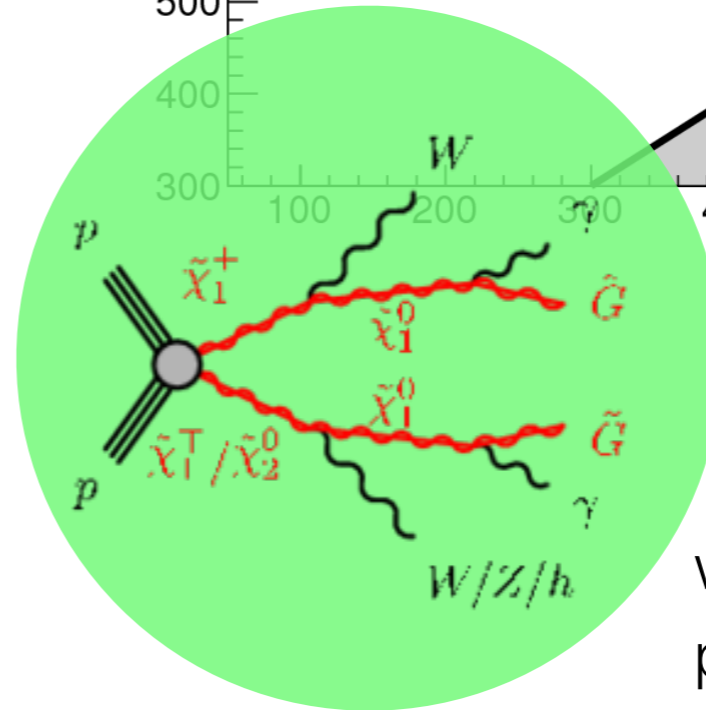
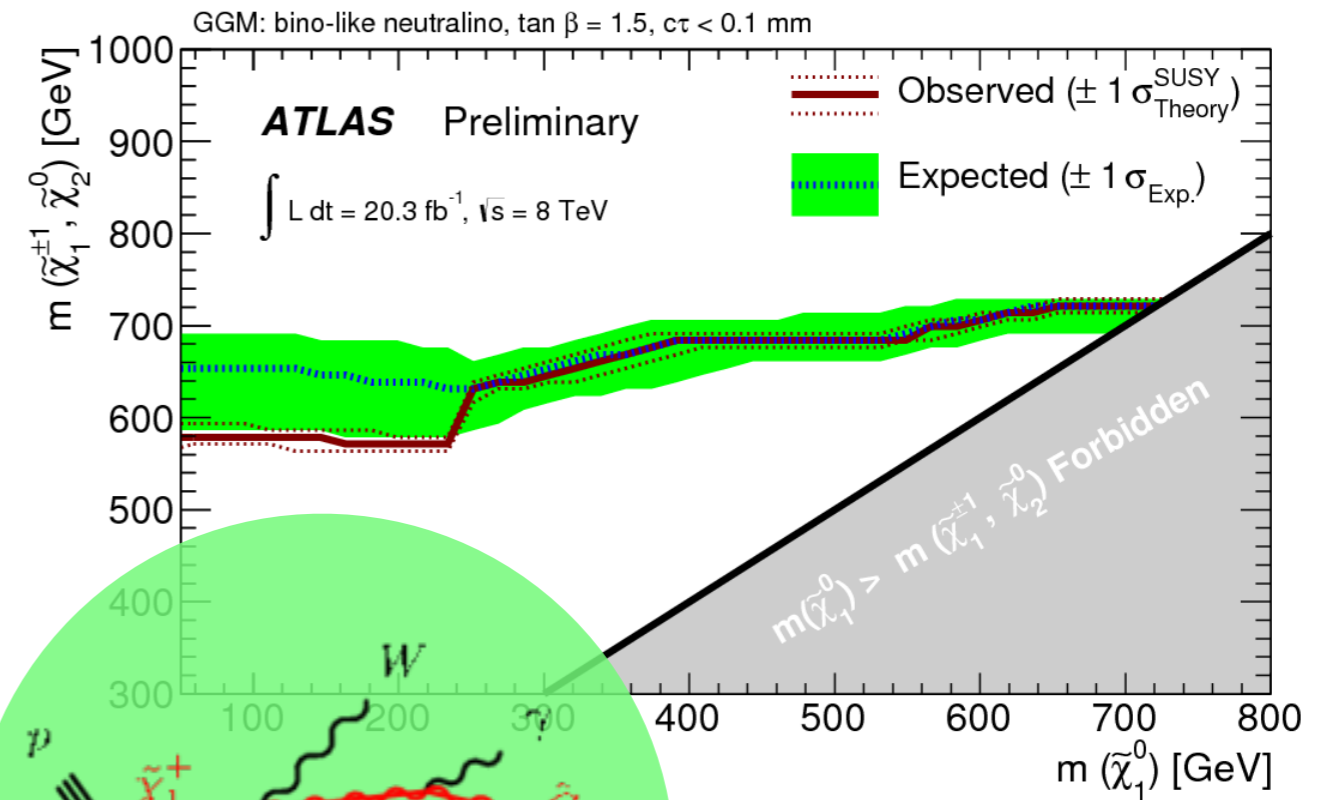
Title	Reference	$\sqrt{s}$ (TeV)	Run (yr)	Lumi
Search for direct production of charginos and neutralinos in events with three leptons and missing transverse momentum in $\sqrt{s} = 8 \text{ TeV}$ pp collisions with the ATLAS detector	<a href="https://arxiv.org/abs/1402.7029">arXiv:1402.7029</a>	8	2012	$20.3 \text{ fb}^{-1}$
A general search for new phenomena with the ATLAS detector in pp collisions at $\sqrt{s} = 8 \text{ TeV}$	<a href="#">ATLAS-CONF-2014-006</a>	8	2012	$20.3 \text{ fb}^{-1}$

# SUSY

## Search for Gauge mediated SUSY in 2 photons + MET final states



strong  
production



weak  
production

Title	Journal	$\sqrt{s}$ (TeV)	Run (yr)	Lumi
Search for Supersymmetry in Diphoton Events with Large Missing Transverse Momentum in 8 TeV pp Collision Data	ATLAS-CONF-2014-001	8 TeV	2012	$20.3 \text{ fb}^{-1}$

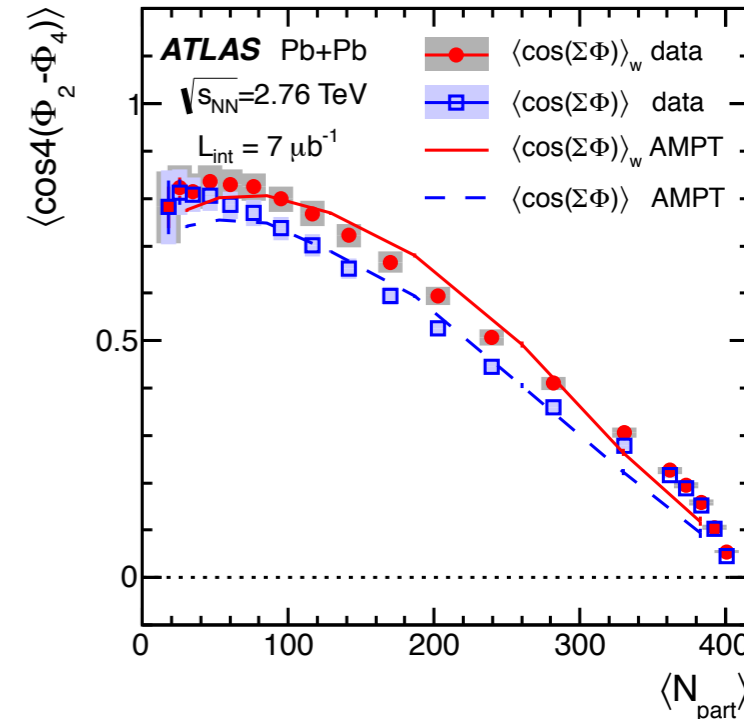
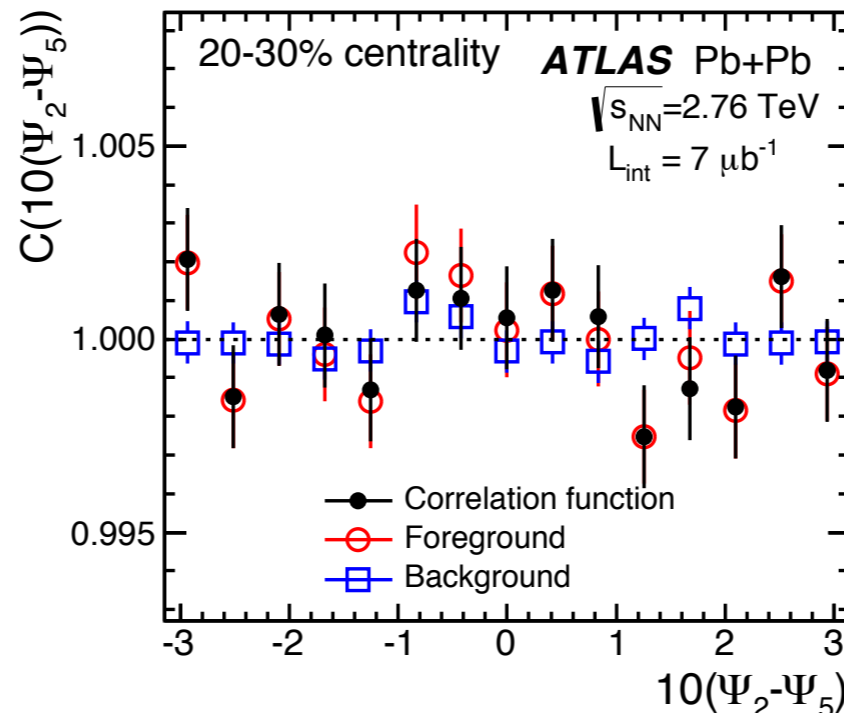
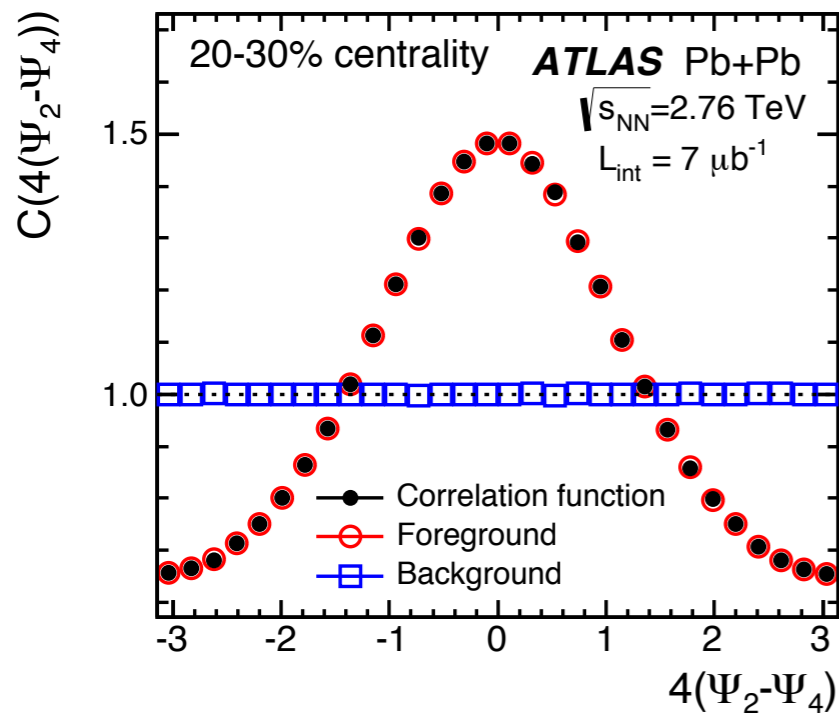
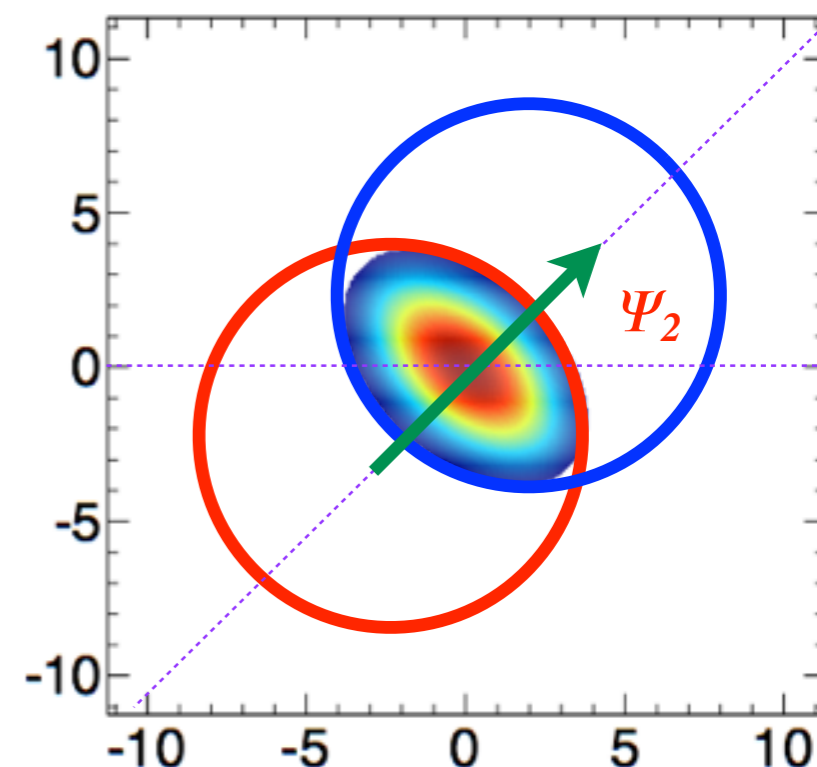
# Heavy Ion collision: event plane correlations

## ▶ Non-central Pb-Pb collisions create elliptical nucleus interaction region

- creates pressure gradients resulting into flow directions
- can be described in a Fourier series

$$\frac{dN}{d\phi} \propto 1 + 2 \sum_{n=1}^{\infty} v_n \cos n(\phi - \Phi_n)$$

- 2<sup>nd</sup> order dominant (elliptical), but higher orders exist
- precise measurement of correlations in 2D and 3D



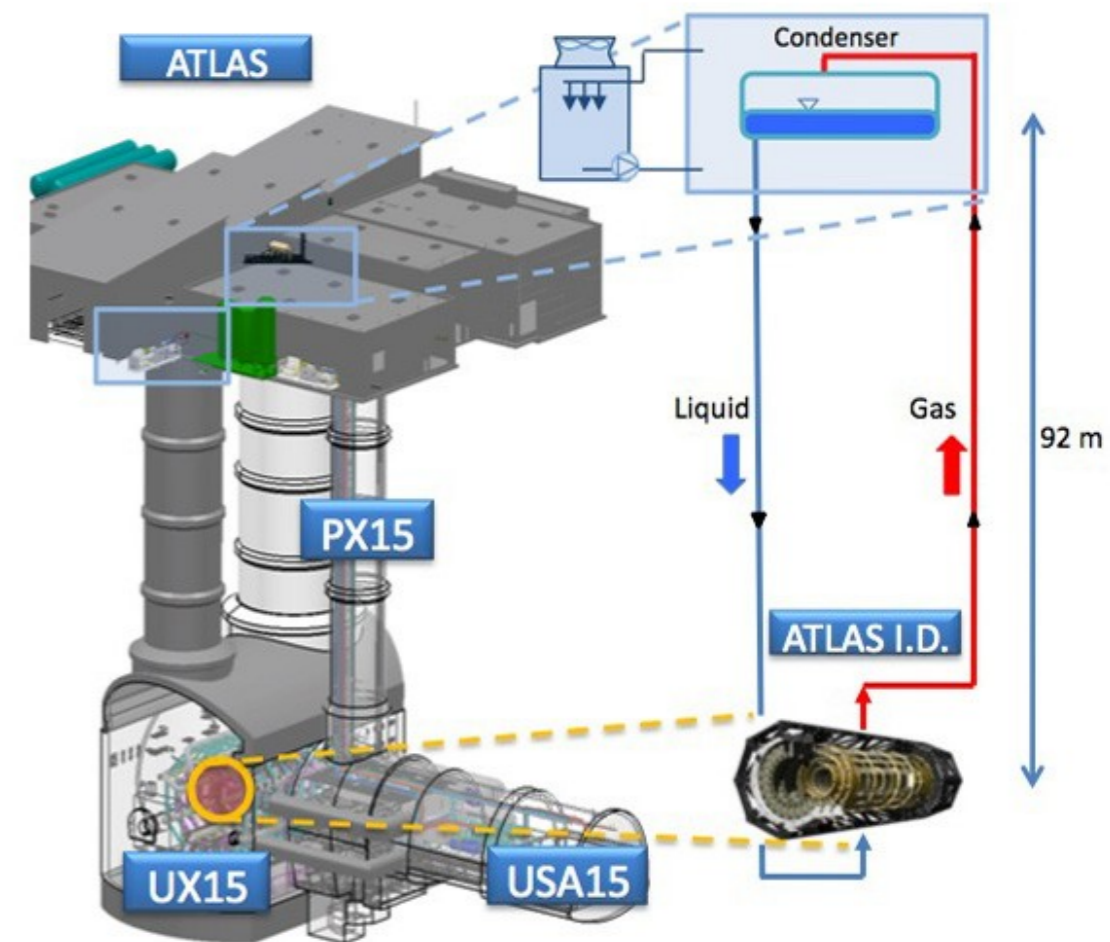
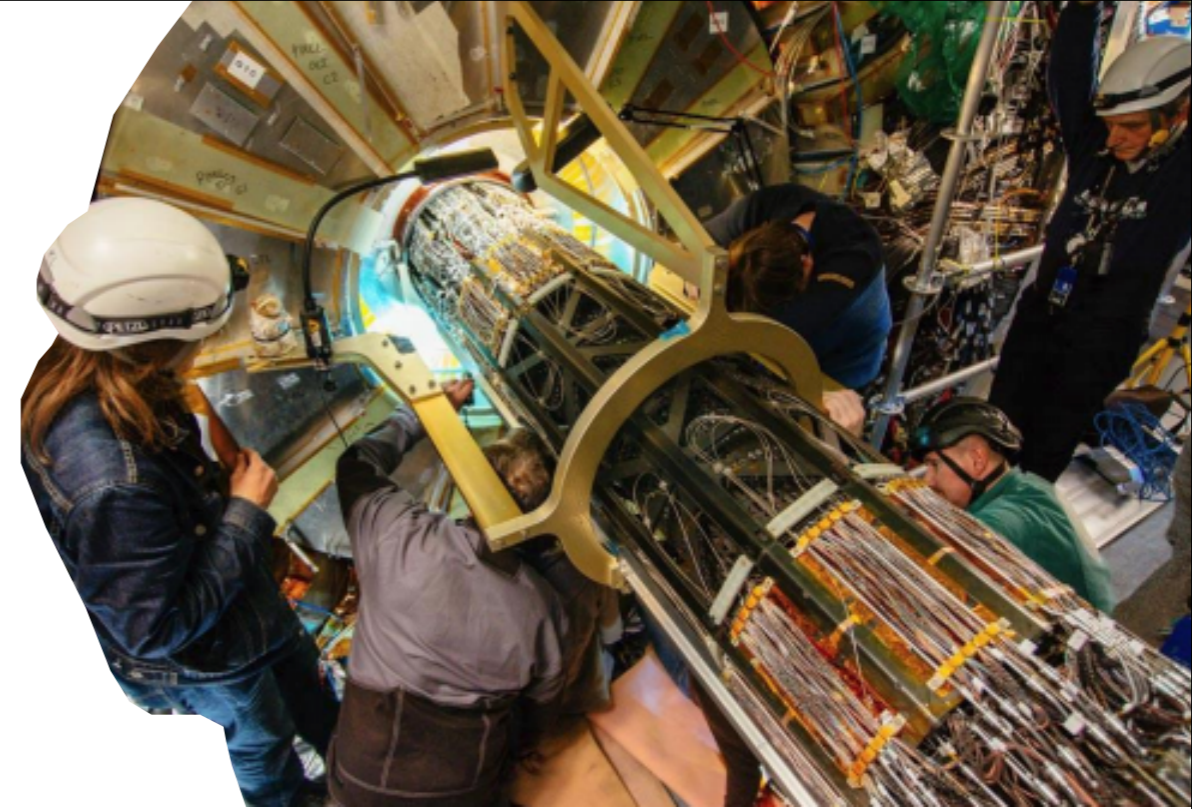
Title	Journal	$\sqrt{s}$ (TeV)	Run (yr)	Lumi
Measurement of event-plane correlations in $\sqrt{s_{NN}} = 2.76$ TeV lead-lead collisions with the ATLAS detector	<a href="https://arxiv.org/abs/1403.0489">arXiv:1403.0489</a>	2.76	2011	$7 \mu\text{b}^{-1}$

# Run-2 Preparation



# Recent Inner Detector activities

- ▶ Pixel detector has been extracted, repaired and reinserted (12/2013)
  - recovery of operational detector readout fraction to **98.8%** (from 95%)
  - cabling started last month, also for newly-installed diamond beam monitors
- ▶ Dual output for Fast Track Trigger (FTK) installed for Pixel and SCT
- ▶ Cooling system
  - new evaporative cooling system replacing the compressor system, corrosion found on internal welds, repair plan with company fixed, compressor system as back-up in the meantime
  - CO<sub>2</sub> cooling units for IBL installed
- ▶ DAQ: detectors prepare for 100kHz rate





# Insertable B-layer (IBL)

- ▶ **Corrosion on wire bonds**

- staves have been reworked, replacing affected wire bonds

- ▶ **No conclusive evidence for origin found**

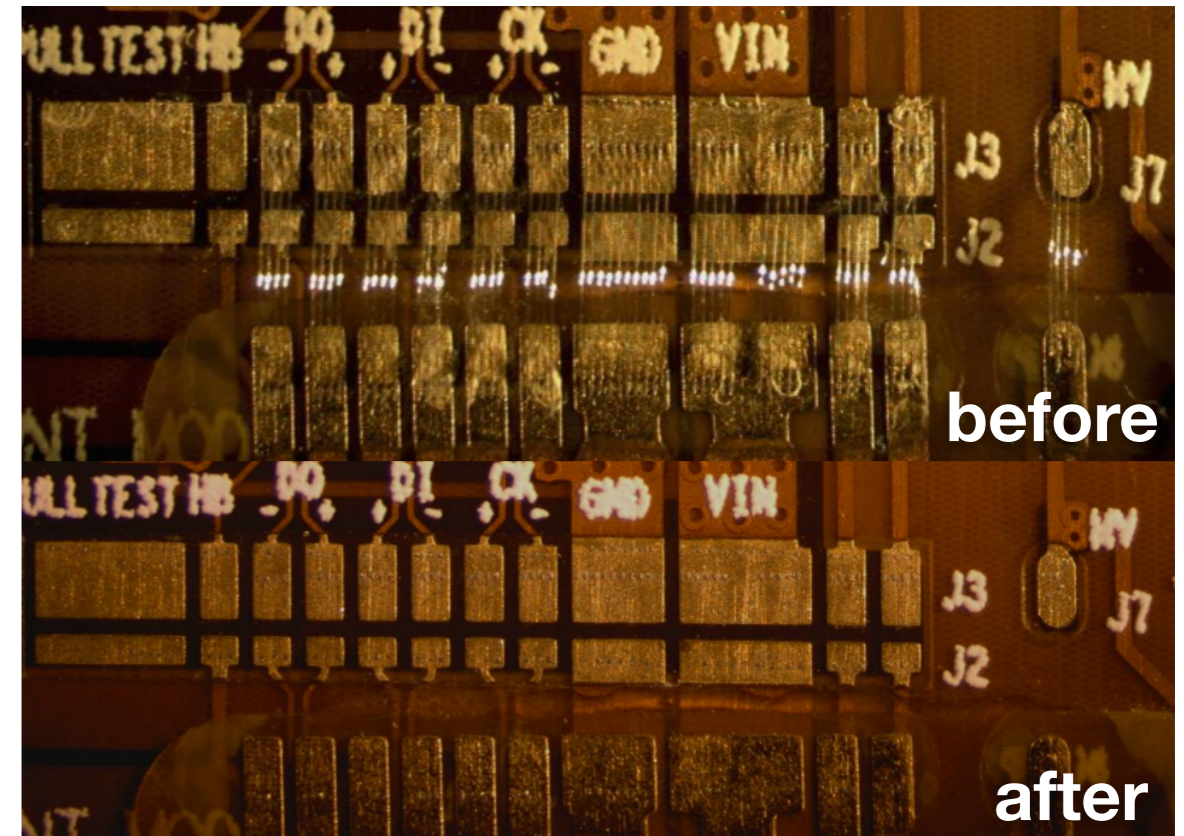
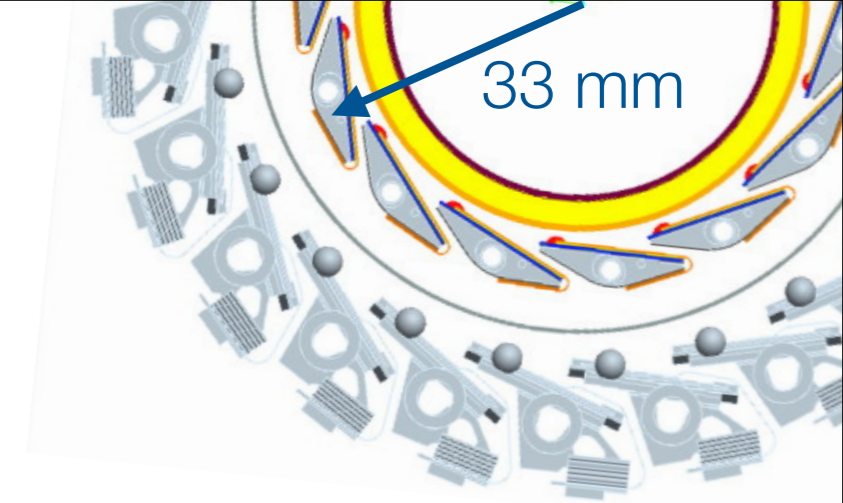
- no sign of corrosion in dry environment
  - 2 initially affected staves kept for tests and further analyses

- ▶ **20 staves are completed**

- 12 are ready for installation (14 needed)

- ▶ **First four staves mounted onto Inner Pixel Tube (IPT)**

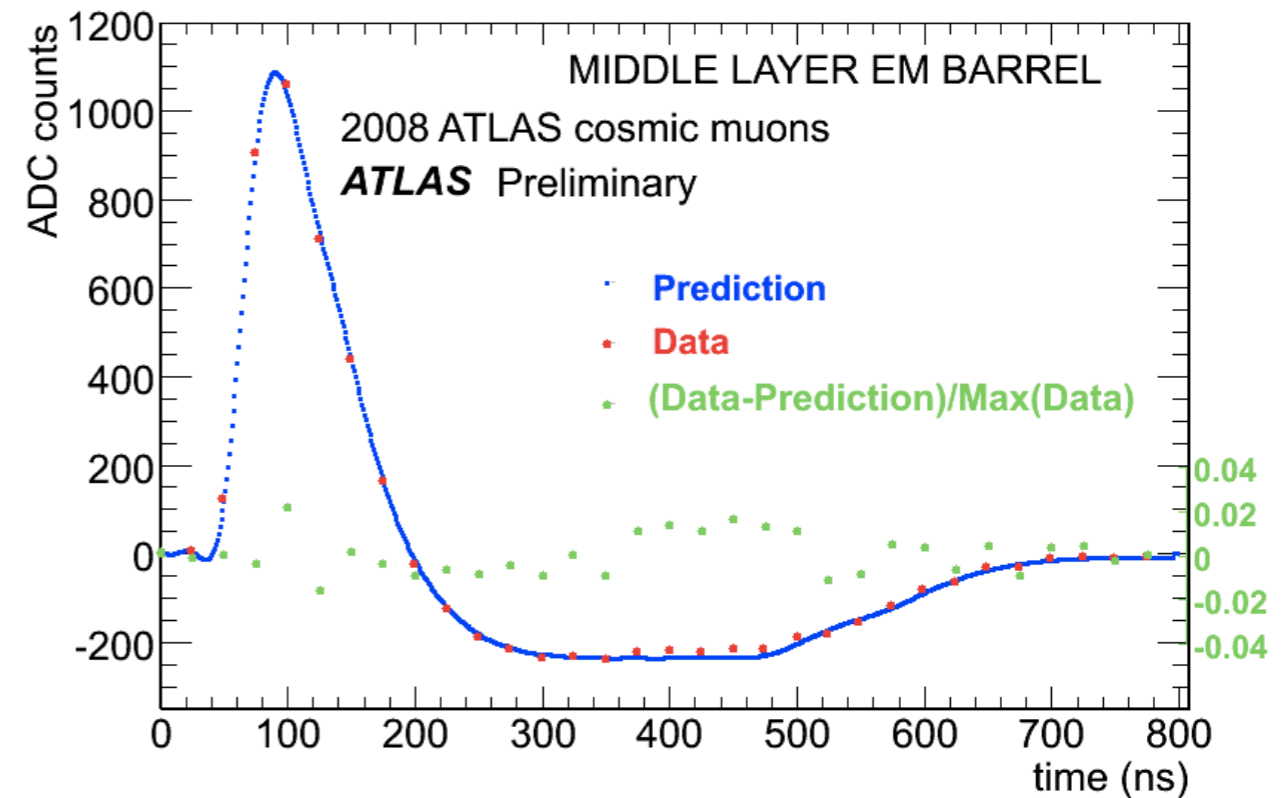
- ▶ **Installation (exp. 05/2014) is being exercised in 1-to-1 scale mock-up to train experts and optimise procedures**



first IBL staff mounted on IPT in 02/2014

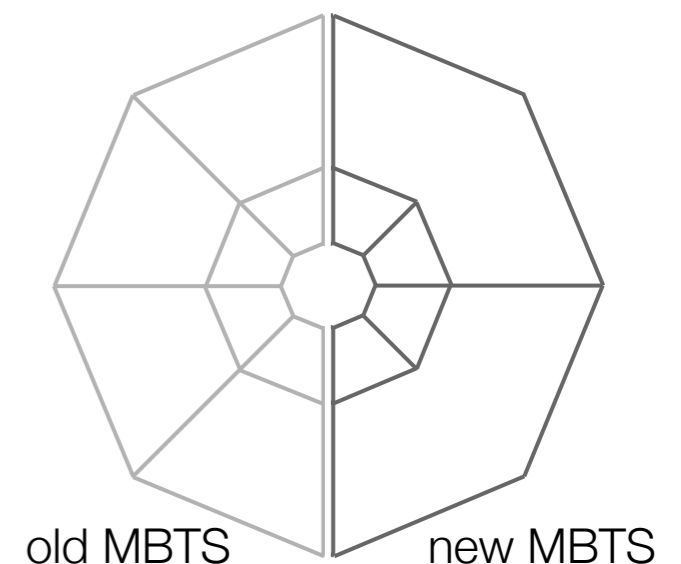
# Liquid Argon Calorimeter

- ▶ Installation and rework of Wiener low voltage power supplies (LVPS) finished
- ▶ Weekly calibration runs during LS1, regular checks ramping HV to 200 V
- ▶ DAQ: new 4-sample readout mode to cope with 100 kHz L1 acceptance
  - exercised in test run 12/2012
  - optimal choice of readout schema, small performance and DQ impact being evaluated



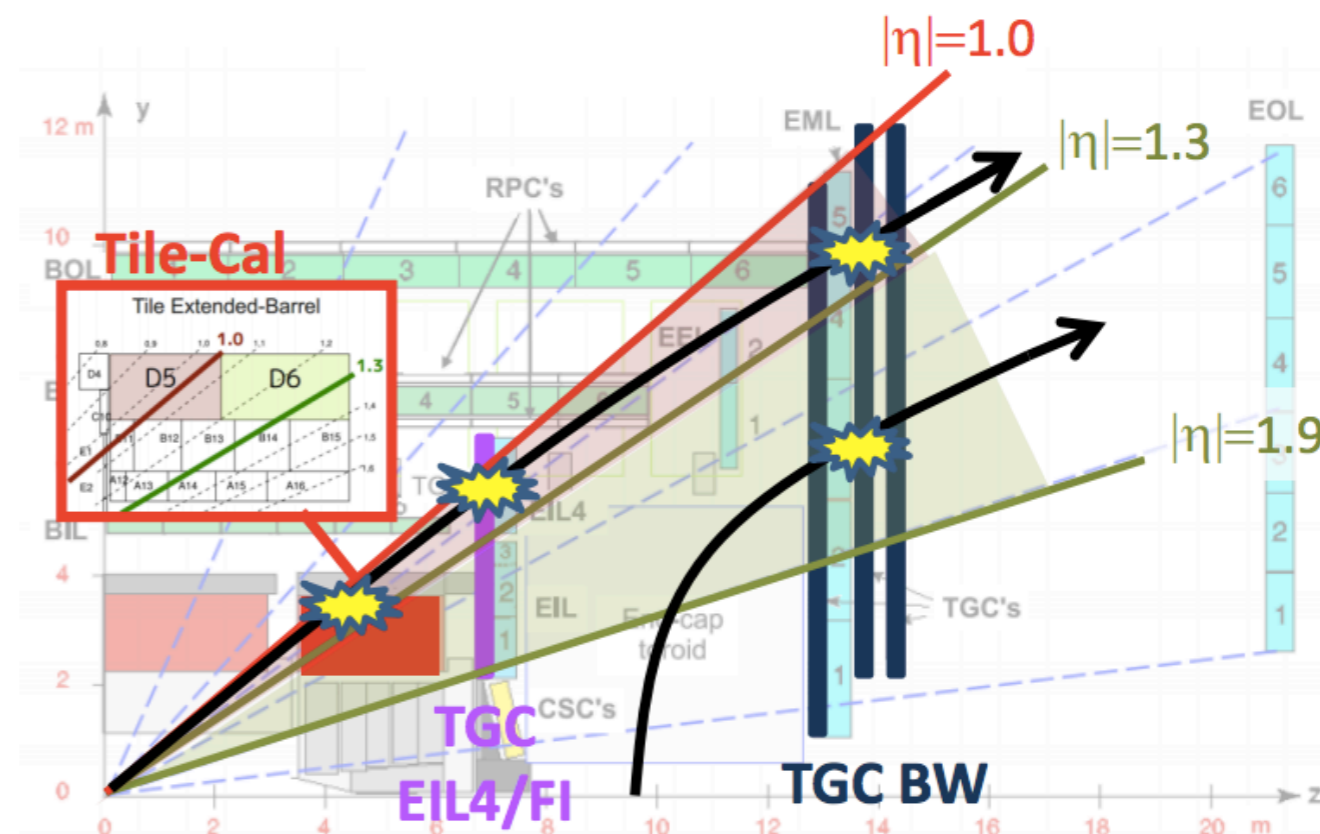
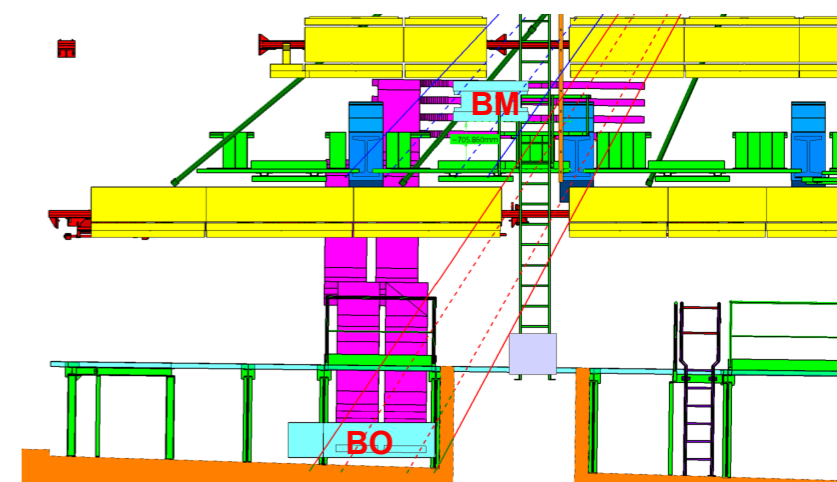
# Tile Calorimeter

- ▶ General repairs for all modules well underway
  - replace LVPS, check of HV boards
  - 212/256 drawers reworked
- ▶ New Minimum Bias Trigger Scintillators (MBTS) installation
  - 24 instead of 32 PMTs, channels used for completed Tile
  - slightly less light yield in outer, more yield in inner cells compared to extracted MBTS (irradiated)



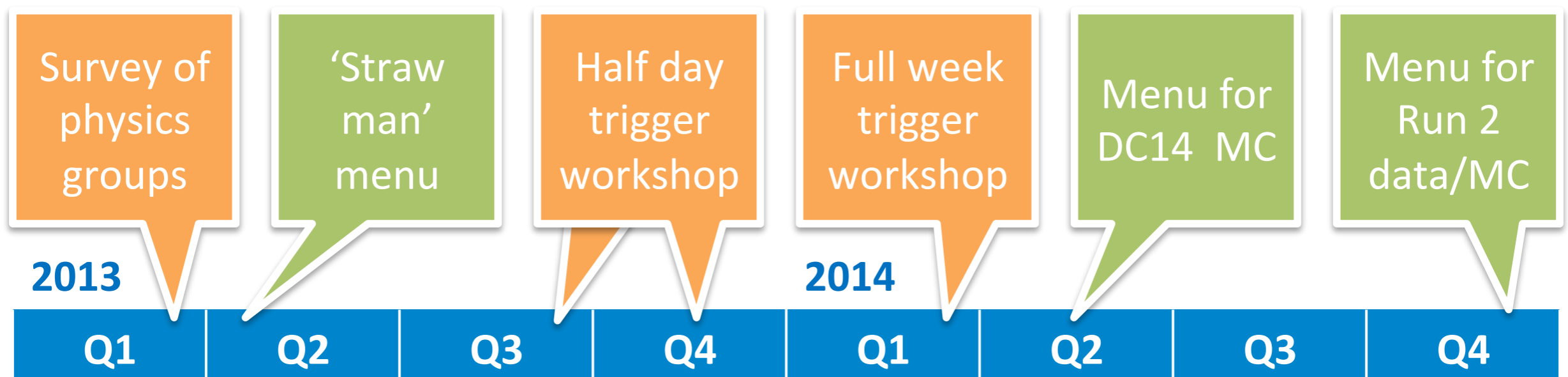
# Recent Muon Spectrometer work

- ▶ Maintenance work on RPC ongoing with increased pace
- ▶ Repair of 2 CSC sectors
- ▶ MDT/RPC chambers (BME) installation
  - arriving in March, installation in April
  - increase of trigger coverage
- ▶ Installation of additional alignment sensors ongoing
- ▶ CSC, MDT and TGC successfully included in first milestone week M1
- ▶ Combining Tile-Cal and TGC small wheel coincidence triggers
  - reduction of about 30% of L1 muon fake rates
  - new Small Wheel will solve this in the entire end-cap region (2018)



# Trigger preparation for Run-2

- ▶ Rates will increase by factor of 5 (energy & luminosity increase), maximum L1 rate during Run-1 was 70kHz
  - full effort on the way to run at 100kHz, needed for  $L = 2 \times 10^{34} \text{ cm}^2\text{s}^{-1}$
  - Run-1 single lepton thresholds will exceed HLT output rate:  
update from 400 Hz to 500/1000Hz -> pressure on offline software components
- ▶ Rising thresholds as one possibility, compromise in physics (low mass H)
- ▶ Introduction of combined & topological triggers
- ▶ Level-1 Central Trigger processing and output
  - upgrade from 160 (Run-1) inputs to 320 + 192 (topological)



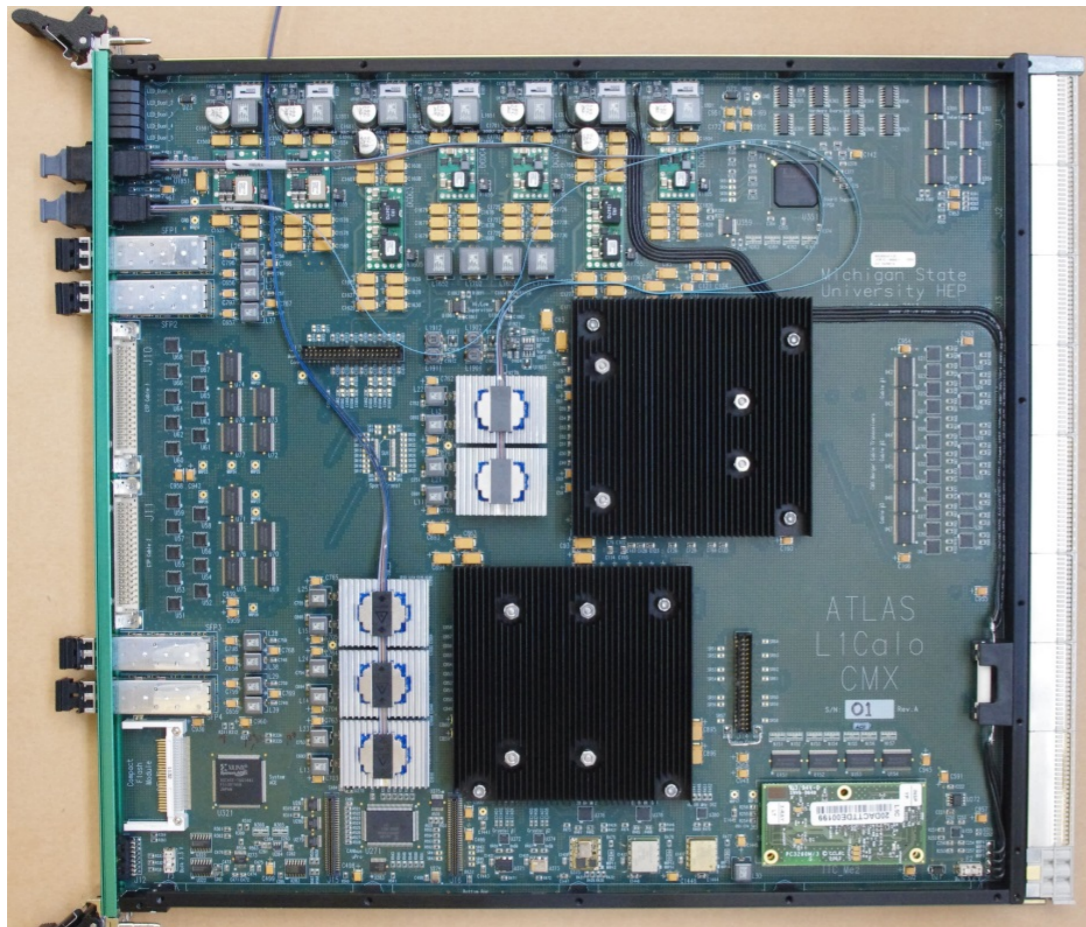
# Trigger/DAQ - Hardware updates

## ▶ 3<sup>rd</sup> generation ReadOut System (ROS)

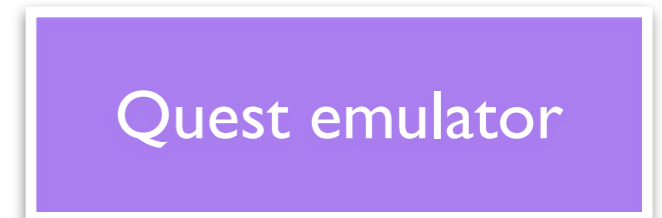
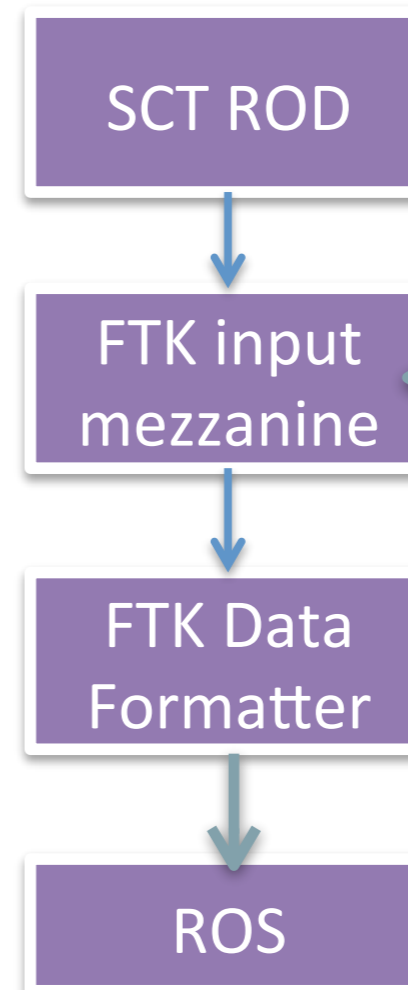
- sustains L1 rate up to 120 kHz, including new PCIe boards, factor 10 bandwidth, about 270 additional ReadoutLinks

## ▶ FTK demonstrated data flow chain

- from Quest emulator and SC ROD through FTK boards to ROS



**L1Calo progress: CMX prototype board**



# Milestone weeks

- ▶ get all sub detectors up and running for Run-2
- ▶ 6 milestone weeks foreseen until October 2014
  - some detectors in two steps, generally
    - (1) TDAQ integration
    - (2) test with detector front-end, detector cold, with operation gas
- ▶ First week completed **(two weeks ago)**
  - **all 4 detectors were successfully integrated in ATLAS, cycled through TDAQ and were running**
- ▶ Detectors taking part in M1 will also continue in MX weeks with extended tests
- ▶ *SLIMOS: “ ... all the peace is gone.”*

	M1	M2	M3	M4	M5	M6
	Feb 17– Feb 23	Mar 31– Apr 4	May 19– May 23	Jul 7– Jul 11	Sep 8– Sep 12	Oct 13– Oct 17
PIX			X <sup>1</sup>	X <sup>2</sup>		
IBL			X <sup>1</sup>		X <sup>2</sup>	
SCT				X		
TRT		X				
LAR			X			
TIL				X		
MBTS				X		
L1Calo	X <sup>1</sup>	X <sup>2</sup>		X <sup>3</sup>		
CSC	X <sup>1</sup>					X <sup>2</sup>
MDT	X					
RPC		X <sup>1</sup>				
TGC	X <sup>1</sup>					
BCM		X				
ALFA					X	
LUCID						X
Lumi					X	



# Offline computing - preparation for Run-2

- ▶ **Resource projections for Run-2 follows expectation of “flat budget”**

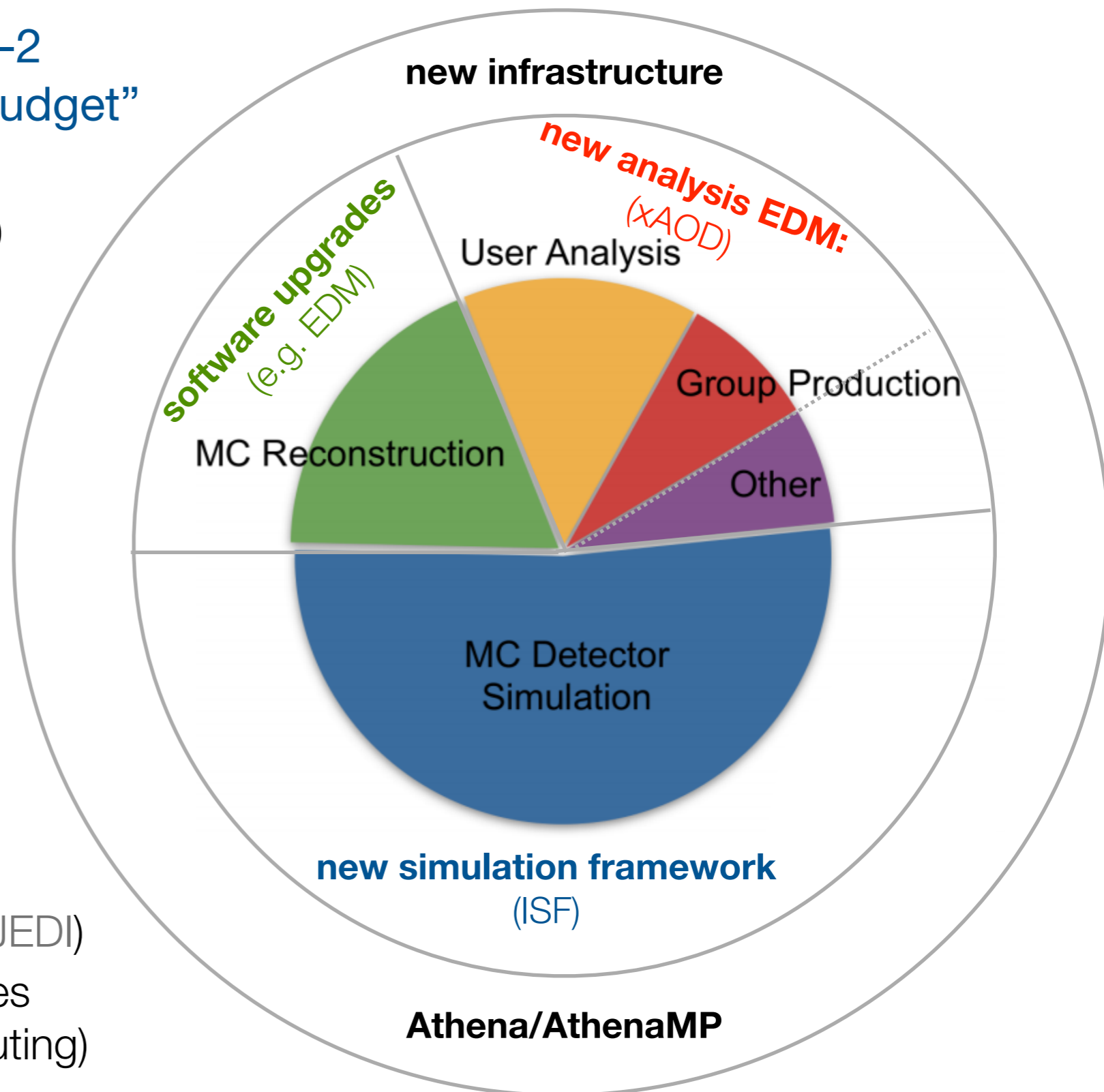
- update to 1kHz HLT rate
- expected pile-up increase to 40
- increased demands of MC statistics

- ▶ **Need to optimise all across software and computing**

- CPU, disk size, workflow

- ▶ **New GRID infrastructure**

- new data management system (Rucio) which scales beyond expected Run-2 data volumes
- new workflow definition and job management system (Deft/JEDI)
- exploring opportunistic resources (cloud/high performance computing)

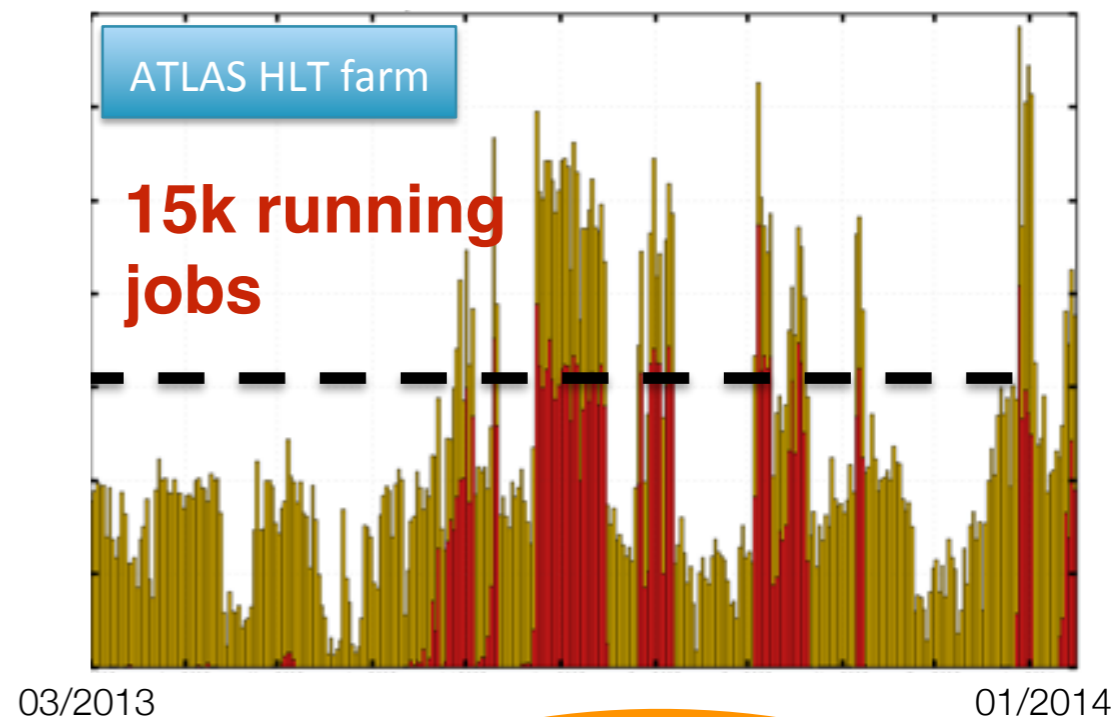
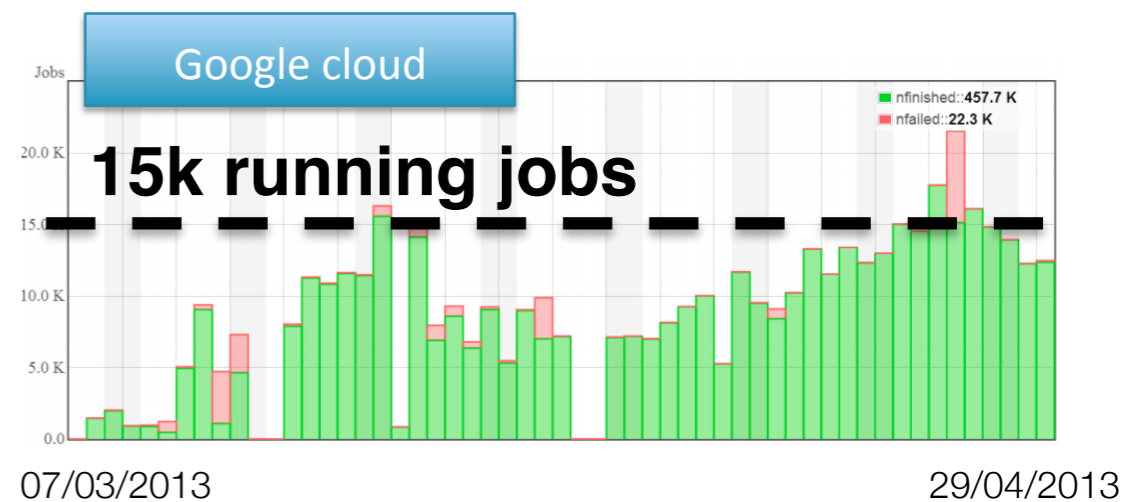


**to be exercised in data challenge 2014 (DC14)**

MC/group production and user analyses averaged over all ATLAS grid sites (T0/T1/T2/T3)

# Optimising resources

- ▶ **Opportunistic Resources (OR) through cloud computing integration**
  - “Free” OR: academic facilities offer free resources, **HLT farm** used for MC production
  - Commercial OR: amazon/**google**
- ▶ **High performance computing - using free cycles**
  - working group for interfacing systems with ATLAS software
- ▶ **Volunteer computing - ATLAS@Home**
  - outreach project turning private PCs into MC simulation stations
- ▶ **Disk resources are a major concern**
  - new dataset replication and deletion policy for Run-2
  - effort to decrease persistent data size (xAOD) in reconstruction and analysis format



03/2013

01/2014

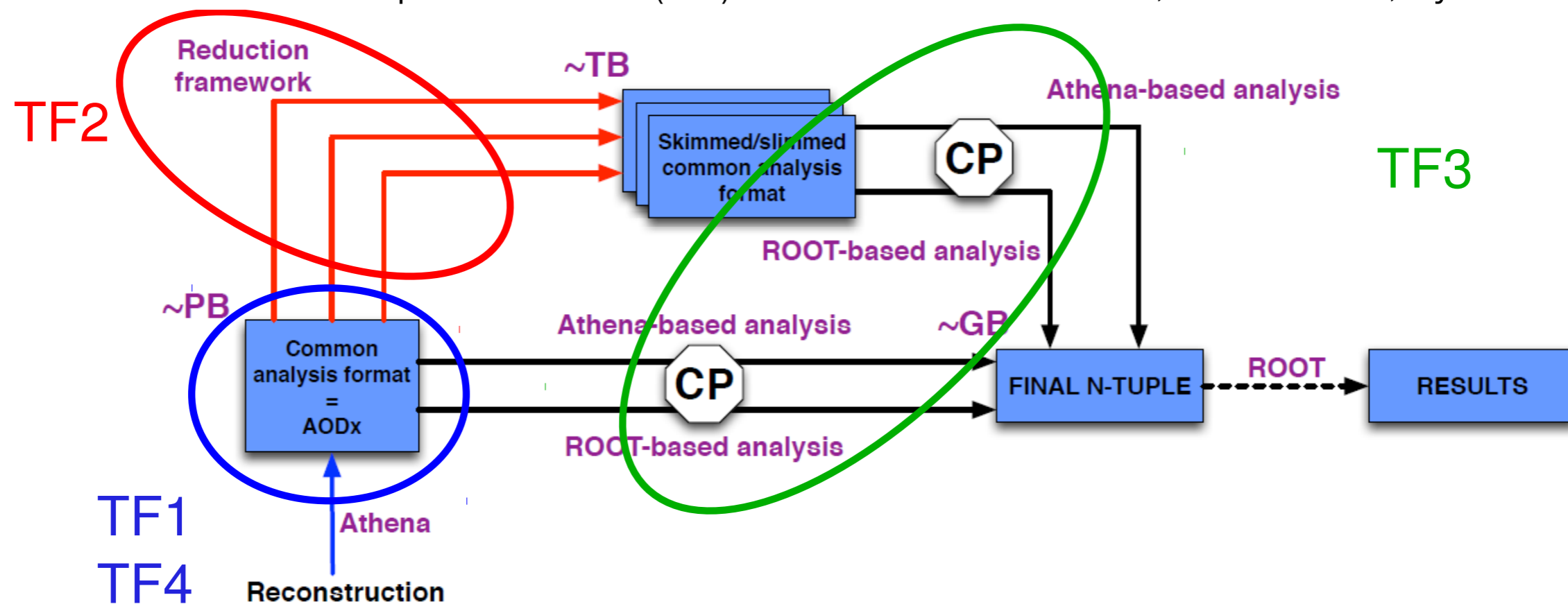




# New analysis data model: xAOD

## ▸ xAOD is a completely new analysis data format (replaces AOD format)

- **ROOT**-browsable format that supports partial read (also ATHENA-readable)
- comes with a reduction framework based on train model (one input, many outputs)
- new analysis release model based on ROOT, including an analysis framework
- dual-use combined performance (CP) tools for scale factors, efficiencies, systematics



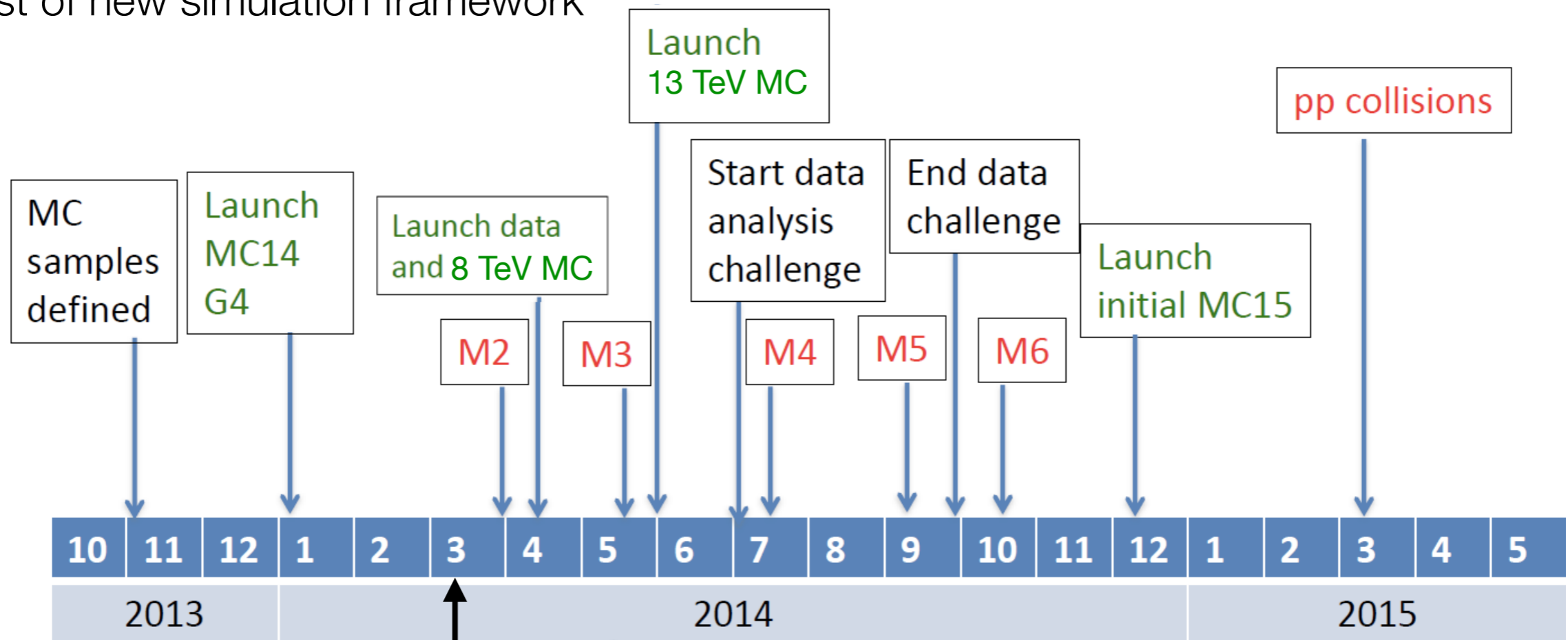
## ▸ Four ATLAS-wide task forces work on the realisation

- **TF1** (xAOD object definition, alongside with object harmonisation effort)
- **TF2** (reduction framework), **TF3** (analysis framework)
- since december 2013: **TF4** for reconstruction code migration

# LS1 software and computing campaign

## ▸ Data challenge 2014

- *reference*: part of Run-1 data reprocessed ( $\sim 5 \text{ fb}^{-1}$ ), and 300 M new 8 TeV MC
- 13 TeV MC being produced as first test for simulation for Run-2
- large scale test of the new analysis EDM, Run-1 and Run-2 analyses exercised
- test of new simulation framework



**today:** M1 week successfully passed,  
first xAOD release built with mainly conversion from AOD  
reconstruction software migrated to new EDM/Eigen

# Simulation

## ▶ ATLAS Integrated Simulation Framework (ISF) in development since 2011, **baseline** for 2014 MC

- centrally managed simulation framework combining full and fast simulation engines even within **one** event (e.g. based on event topology)

\*relative CPU gain to ATLAS Geant4 application

Run-1 MC

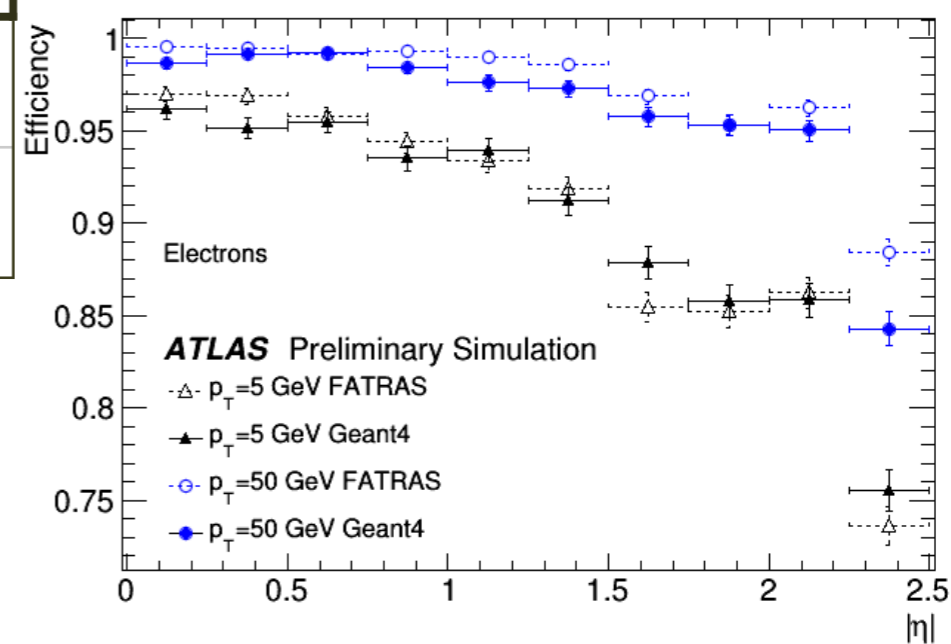
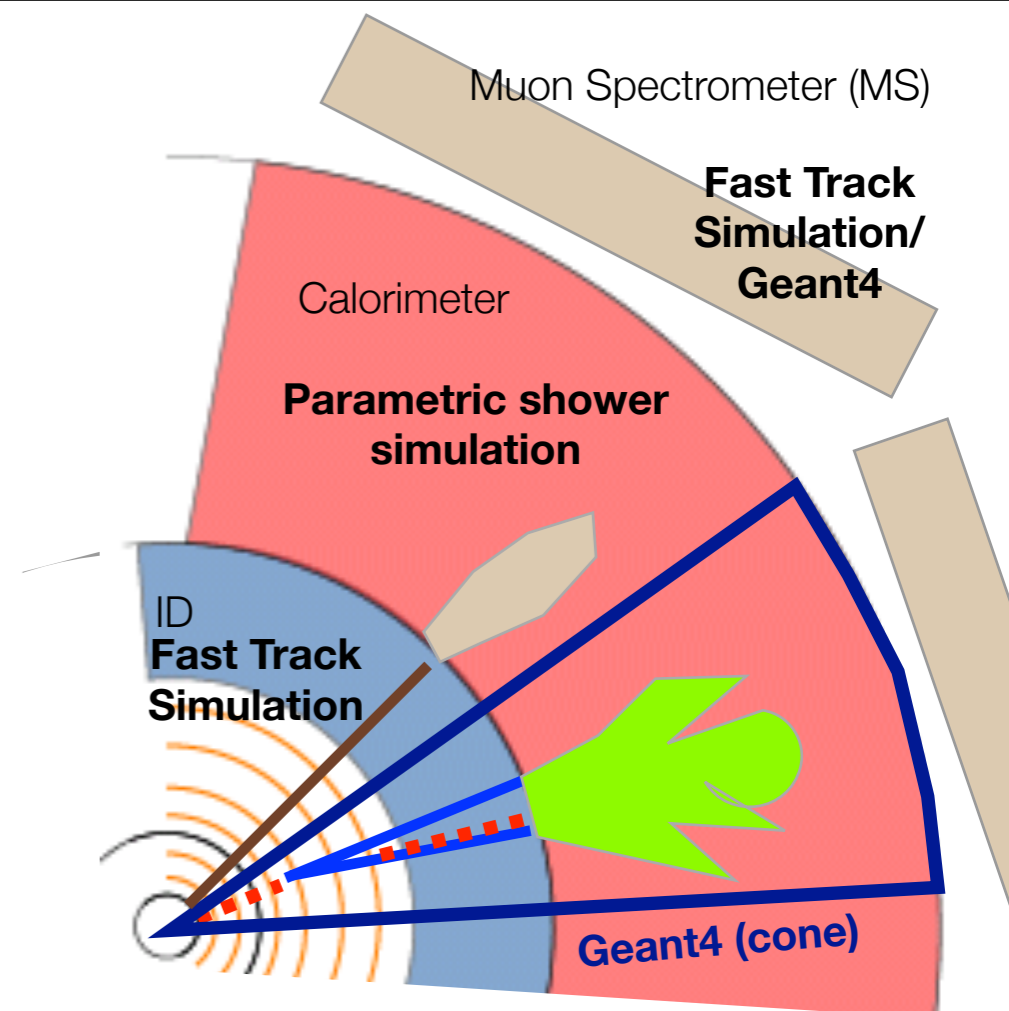
Flavor	Description	Status	CPU*
ISF_Geant4	Geant4 in full detector, frozen showers in forward Calorimeter	<b>validated</b>	1.02
ISF_AF2	G4 in ID & MS, parametric shower simulation in Calorimeter	<b>validated</b>	0.1
ISF_AF2F	like ISF_AF2, but Geant4 in ID replaced by Fast Track Simulation	<b>validation ongoing</b>	0.01
ISF_cone	like AF2F, but Geant4 in cone around e/g (sample H->gg)	<b>validation ongoing</b>	0.05

## ▶ Geant4 9.6 default (FTFP\_BERT physics list)

## ▶ MC/data overlay being currently validated

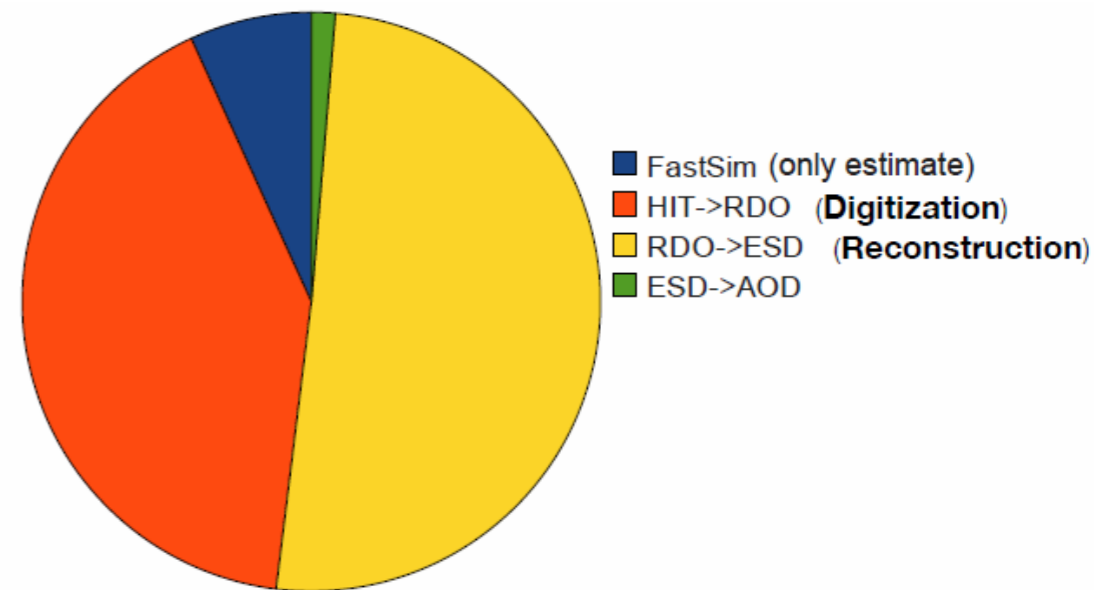
## ▶ Ongoing developments on fast simulation engines

- G4 hadronic interactions in fast track simulation, new parameterisation for fast calorimeter



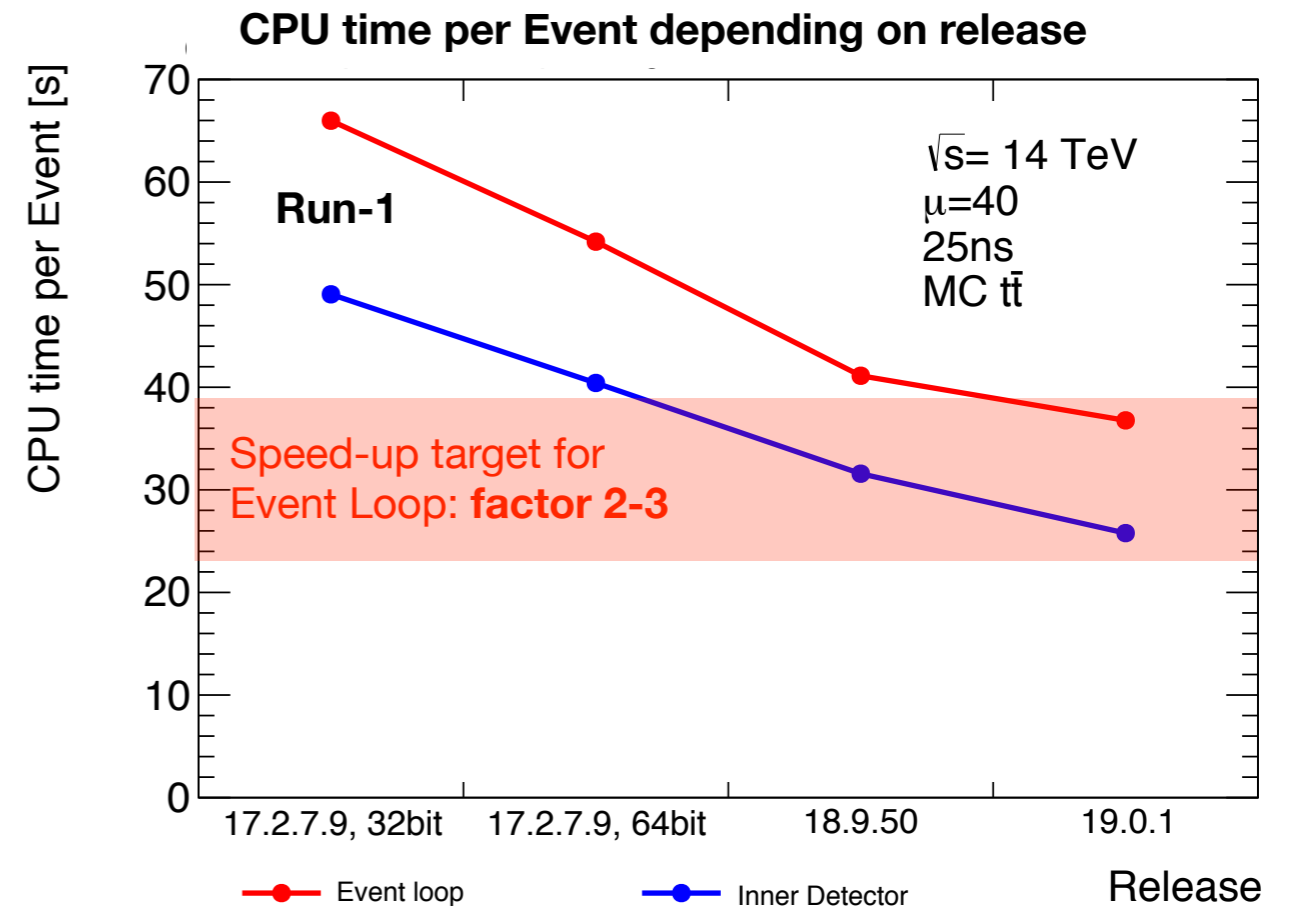
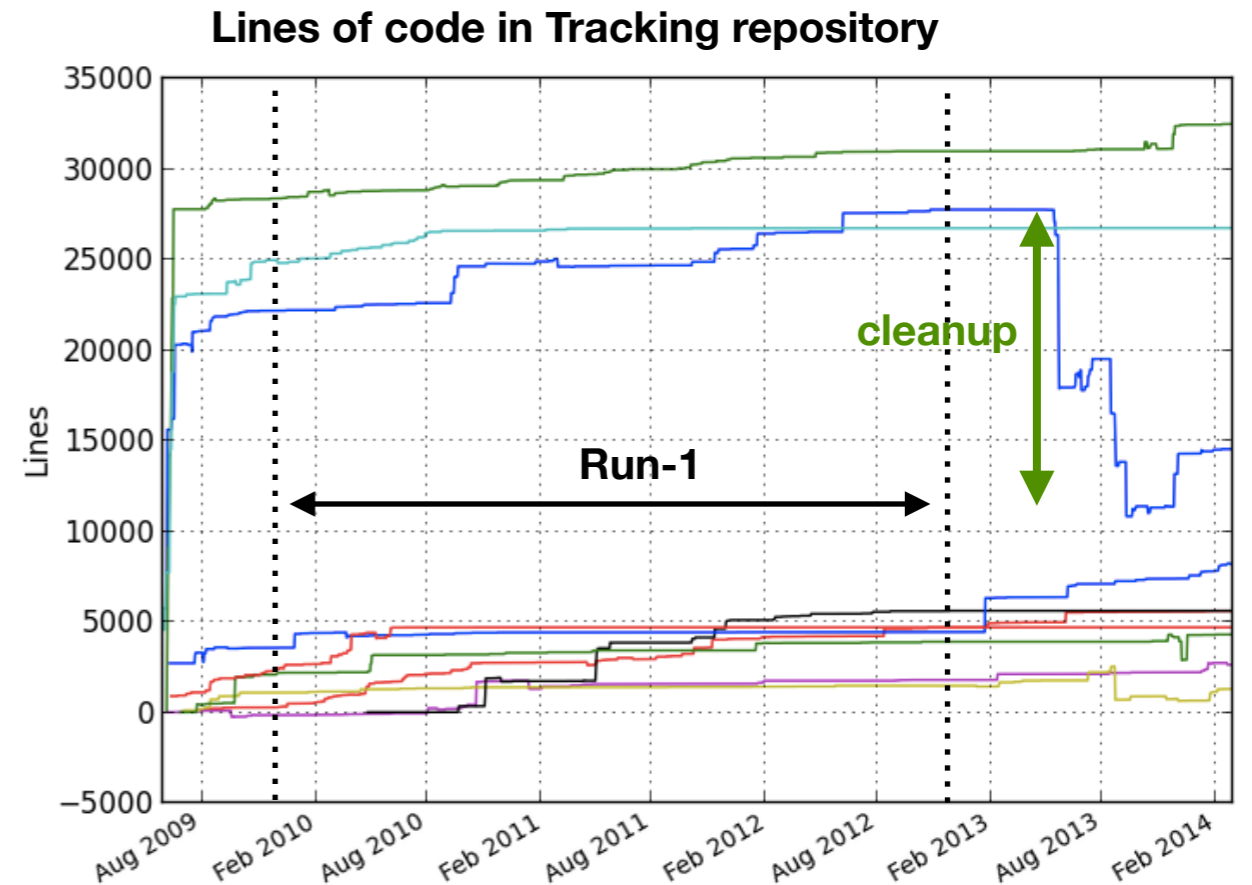
# Very fast Monte Carlo production

- ▶ **speed improvements through fast simulation**
  - digitisation and reconstruction main consumers
- ▶ **Very fast MC prototype in development**
  - pile-up on event generator level (emulation of out-of-time by in-time)
  - fast/mixed simulation using ISF
  - fast digitisation modules for Inner Detector
  - truth assisted reconstruction for Inner Detector
- ▶ **Current prototype**
  - full simulation, digitisation, reconstruction for hard-scatter event
  - fast simulation, fast digitisation and truth assisted reconstruction for pile-up particles
- ▶ **Ambitious target: few seconds/event**
  - while keeping it useful for physics !



# Optimising CPU needs

- ▶ Large-scale software cleanup and optimisation program on the way
  - `flat EDM` structure to remove overhead
  - replacement of algebra/geometry library, many alternatives to CLHEP tested, finally Eigen library chosen
- ▶ Main single CPU consumer reduced by **factor 2** compared to Run-1 release
  - accumulating changes from 32bit->64bit, new magnetic field service with enhanced caching, Eigen integration
- ▶ Replacement standard math library
  - candidates are (VDT, Intel)
- ▶ First release with new EDM (19.0.0) built late january
  - > **1000 packages** reworked



# Upgrade Projects



300126  
2AF3

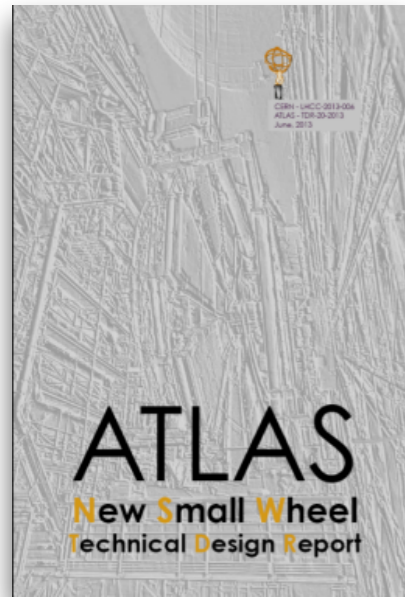
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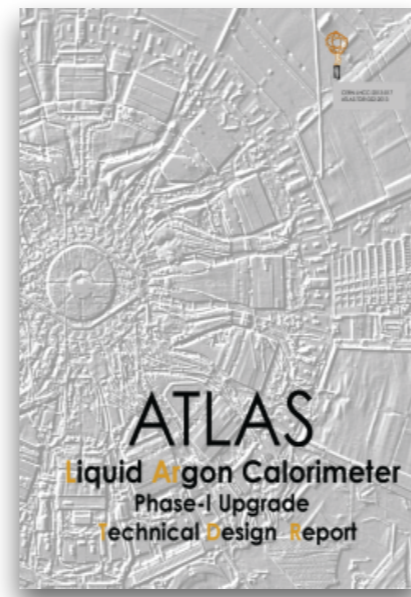
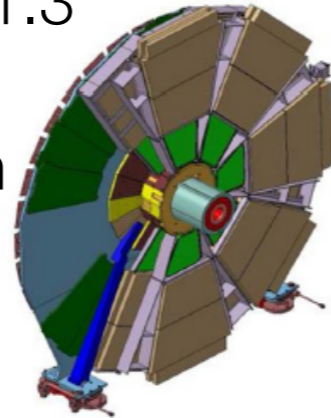
# Phase 1 Upgrade: TDRs released in 2013

and endorsed by LHCC



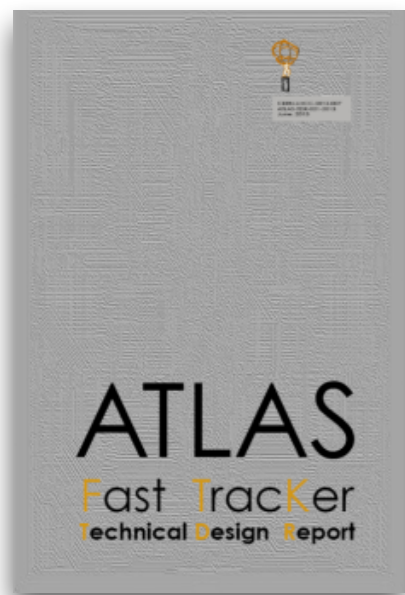
## ▶ New Small Wheel

- improved muon tracking above  $\eta > 1.3$
- reduction of L1 muon fakes



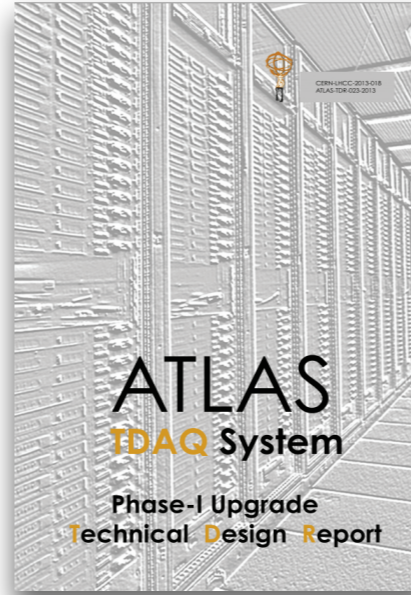
## ▶ Liquid Argon Electronics

- high granularity information at L1 for low threshold EM trigger significantly above LHC design luminosity



## ▶ Fast Track Trigger

- hardware base tracking system with performance close to offline at L1 rates



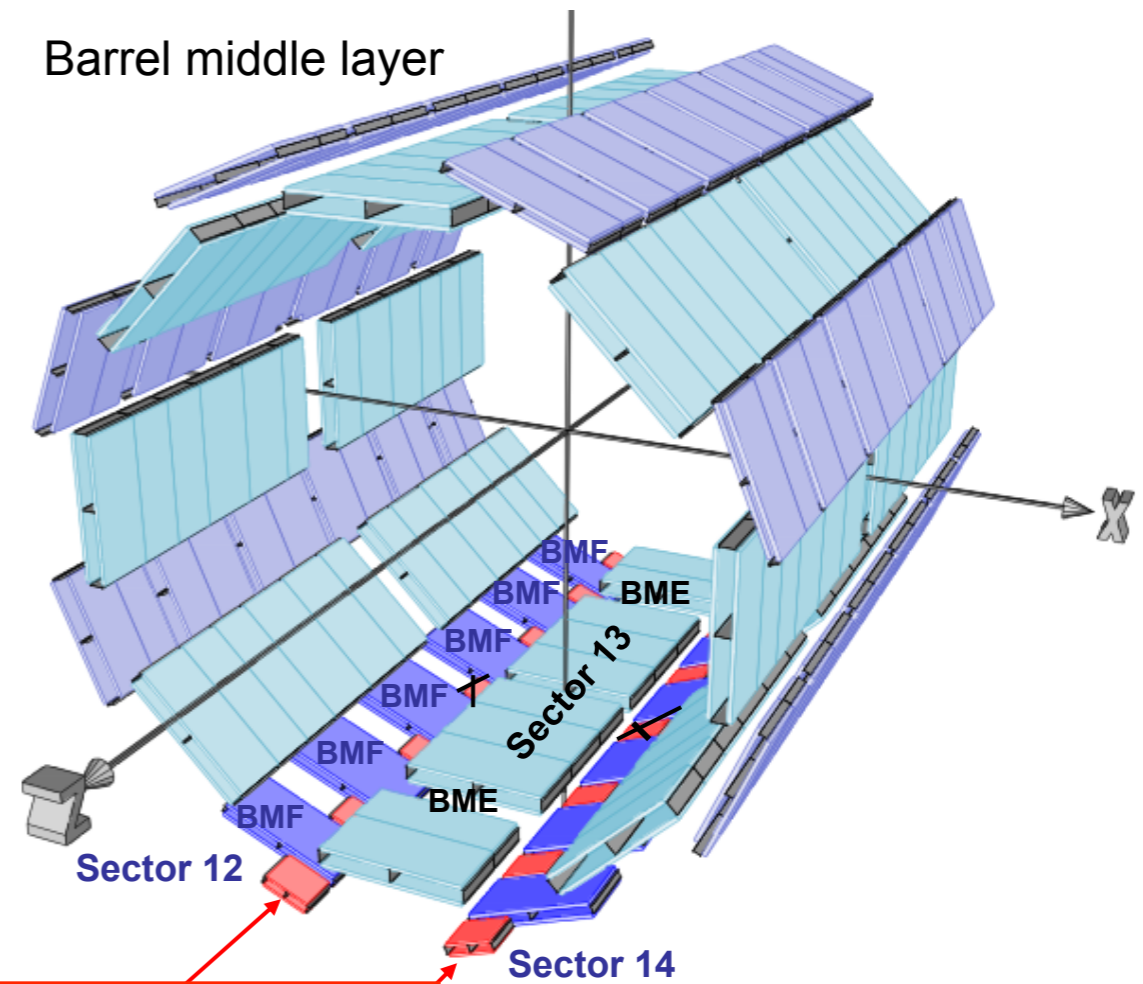
## ▶ TDAQ System

- many new components for operation well beyond design luminosity

**Memoranda of understanding being finalised for all 4 projects**

► Collaboration approved project to installation 12 new small MDT chambers

- schedule foresees install in winter shutdown 2016/2017
- significant improvement of the barrel acceptance by 2.6 %

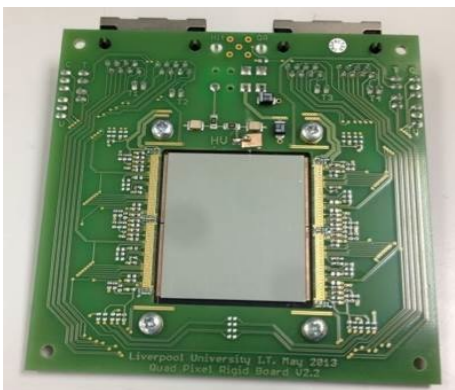


new BMG chambers

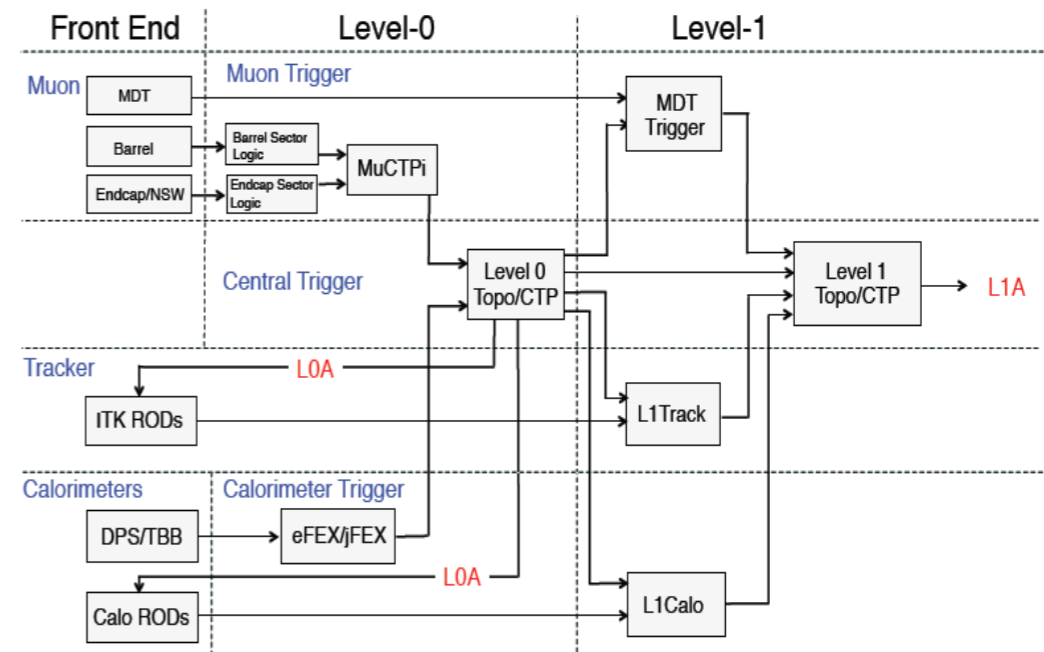
## Phase 2 Upgrade

► Preparing for a very different environment

- levelled luminosity of  $5 \times 10^{34} \text{ cm}^2\text{s}^{-1}$ , pile-up of 140 (as high as 200)
- R&D projects in several areas ongoing



Quad-Pixel module with 4 FE-I4 chips (IBL) with  $4 \times 4 \text{ cm}^2$  and  $50 \times 250 \mu\text{m}^2$



Plans of using new L0/L1 trigger to allow for refined tracking, calorimeter and muon information at L1

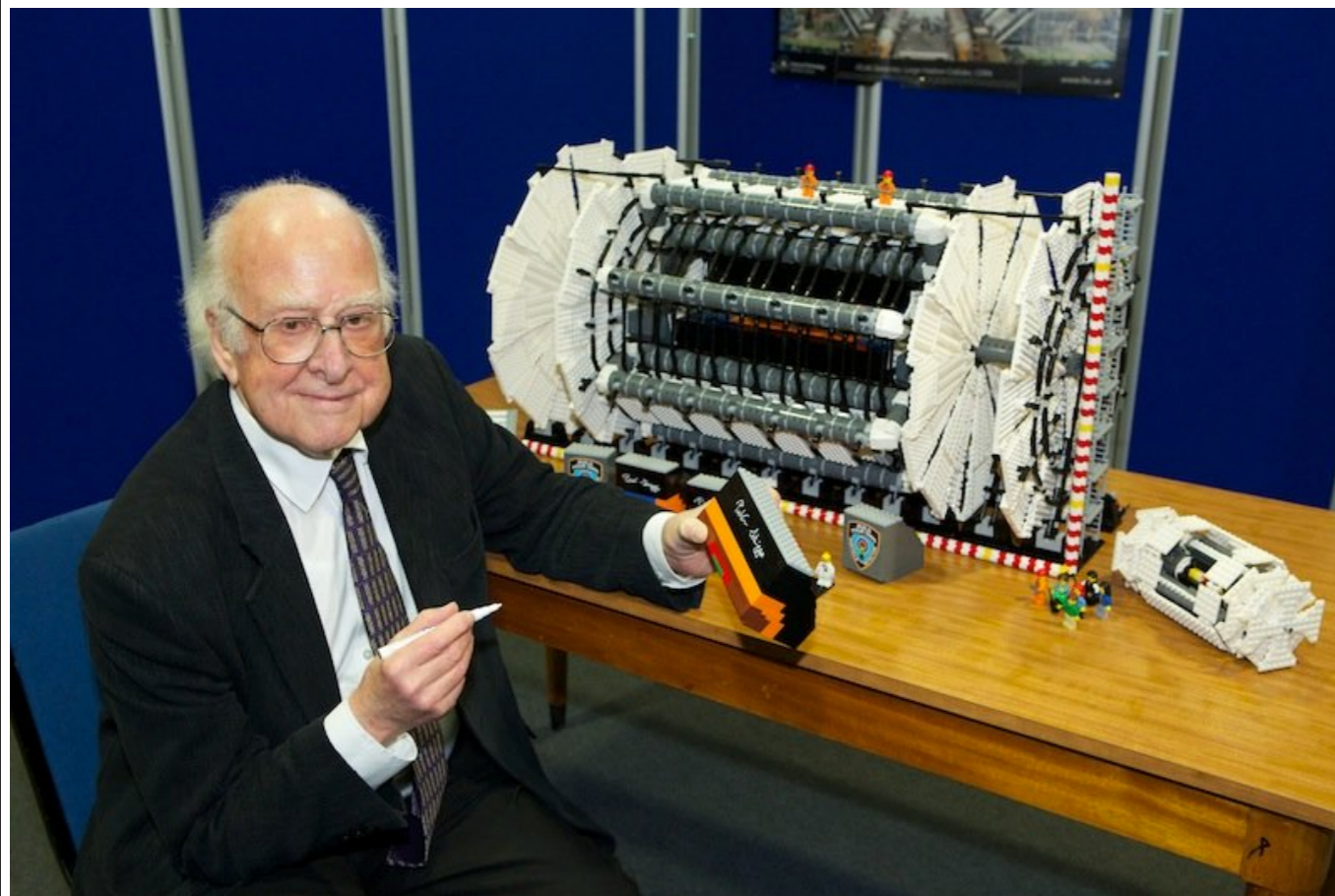


# Conclusion

- ▶ **ATLAS is making strides towards completing high-quality Run-1 analyses**
  - detector performance understanding substantially improved and being documented
  - many papers being completed and in approval
- ▶ **Detector and data-taking preparation for Run-2 is on schedule**
  - detector maintenance/consolidation proceeding well (IBL installation planned for 05/2014)
  - ATLAS schedule foresees completion of cavern work by November
- ▶ **Software, Computing and analysis preparation for Run-2**
  - big overhaul of computing/software infrastructure to cope with Run-2 data in progress
  - large reduction in CPU time for simulation and reconstruction achieved
  - data challenge 14 project will shake down new analysis model and prepare analyses for the new data



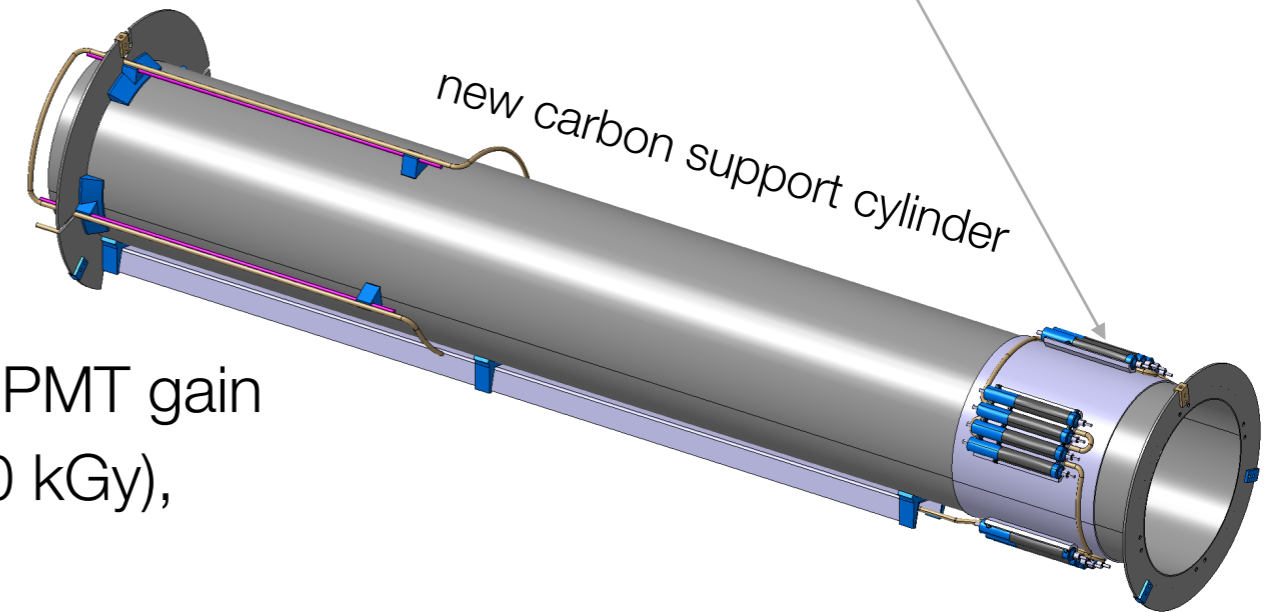
# Bonus slides



# Forward detectors

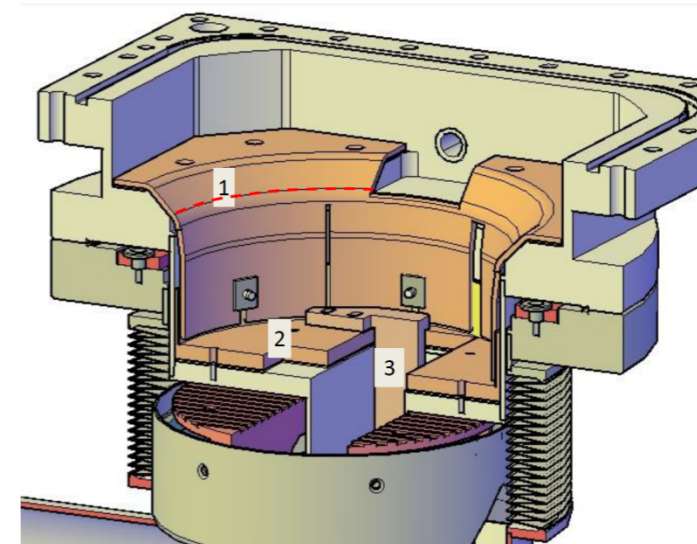
## ▶ LUCID

- possible problem at high luminosity: saturation of algorithm, PMT ageing
- solution: reduction of acceptance, smaller PMT: 10 instead of 15 mm, lower PMT gain
- PMTs passed radiation hardness test (200 kGy), all ordered, all 40 expected until 06/2014



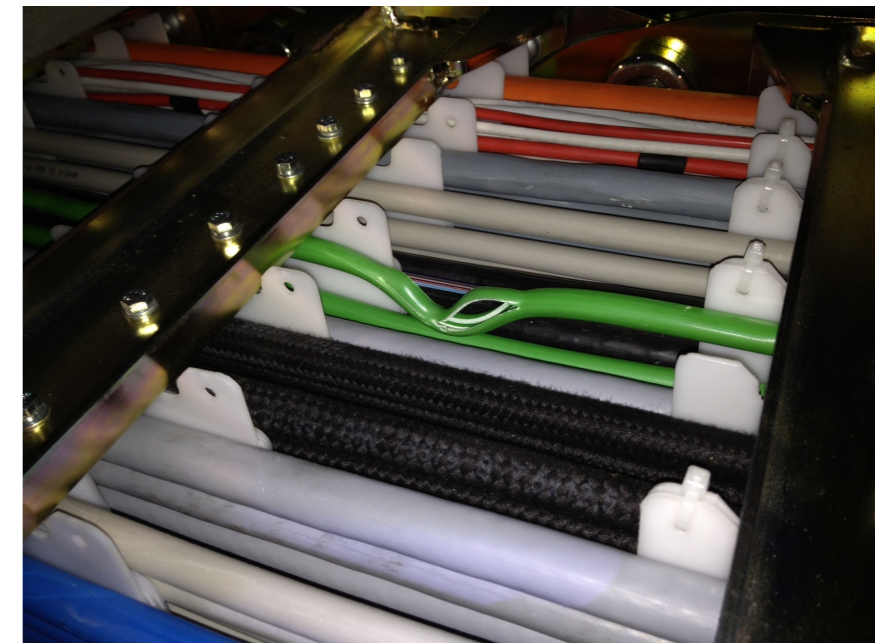
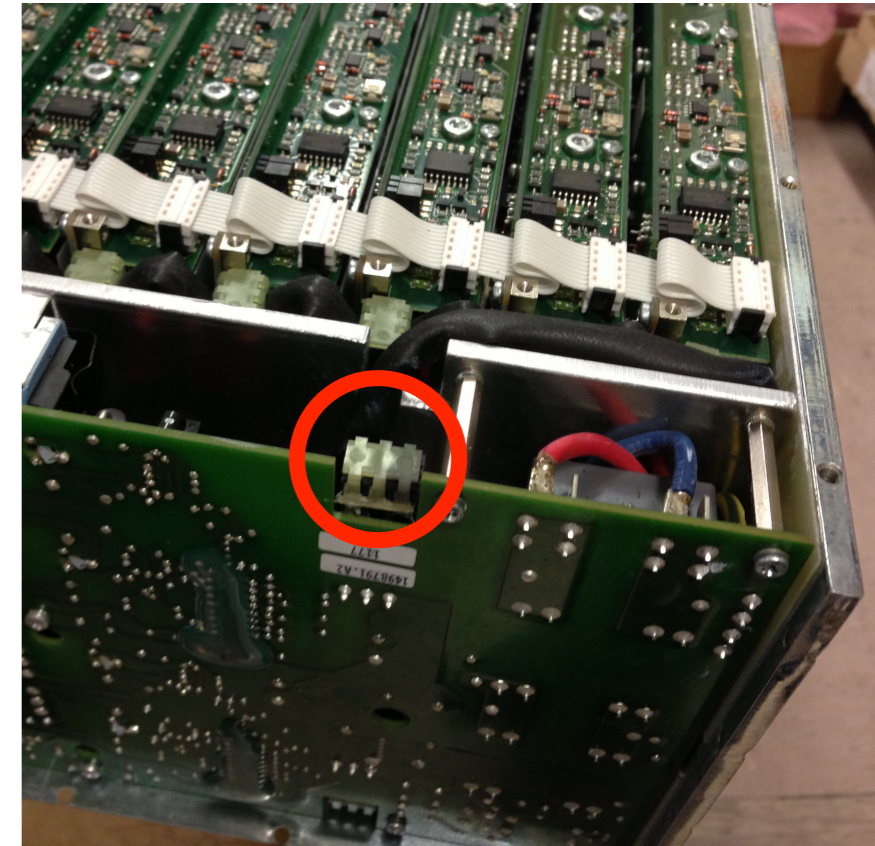
## ▶ ALFA: detector heating up above 40 degrees in Run-1 with RF impact ~20 W

- can increase during Run-2 to critical temperature and RF impact
- new Roman-pot fillers to reduce RF loss
- new heat distribution system, carbon coating
- all stations are on surface for rework, tight schedule until end of 03/2014



# Liquid Argon calorimeter

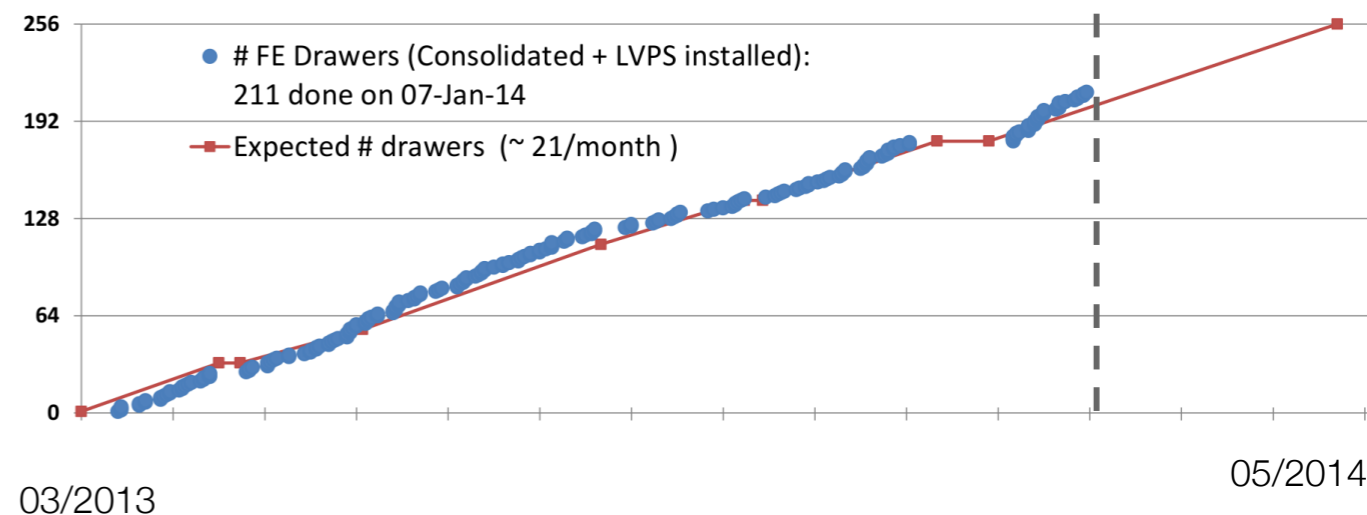
- ▶ **Installation and rework of Wiener low voltage power supplies (LVPS) finished**
  - one LVPS failed due to a **burned connector**, identified as single point of failure
  - LVPS have been brought to surface and refurbished with soldered connection (jan/feb 2014)
  - all LVPS are now re-installed and in operation
- ▶ **One optical read-out fibre got damaged during move of end cap C cryostat**
  - replacement and spare fibre cables ordered
  - installation foreseen 03/2014
- ▶ **Extraction and repair of max 20 out of 1524 front end boards foreseen for 03/2014**
- ▶ **DAQ: new 4-sample readout mode to cope with 100 kHz L1 acceptance (test run in 12/2012)**
  - small performance and DQ impact being evaluated



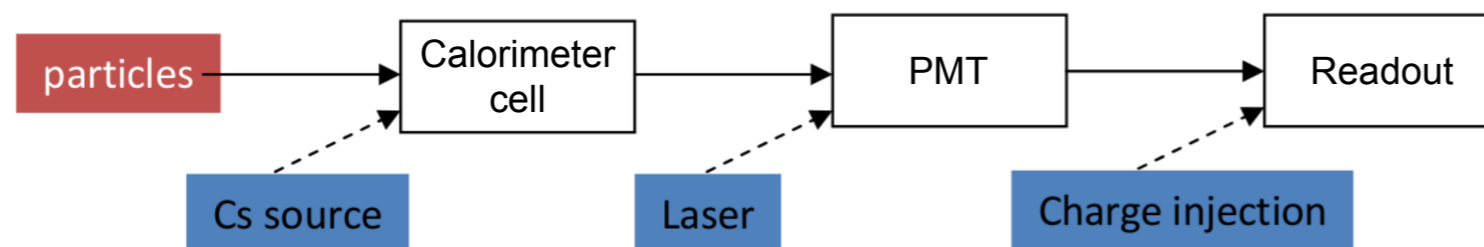
# Tile calorimeter

## ► General repairs for all modules

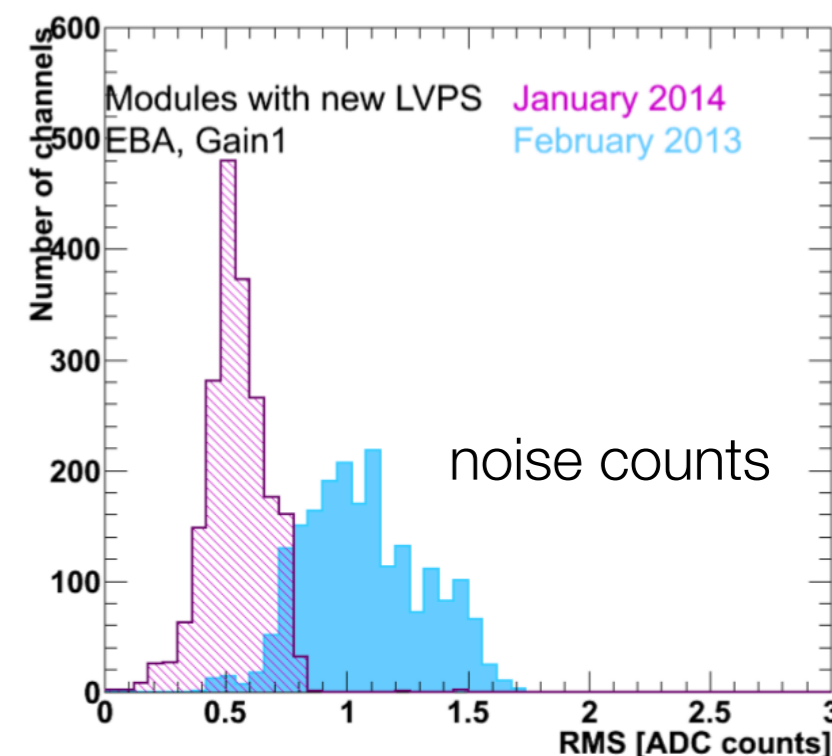
- replace LVPS, check of HV boards
- fix inactive/noisy/non-stable channels
- 212/256 drawers reworked
- removed noise levels and non-gaussian tails



## ► Calibration system updates



- upgrade Cs garage with new gaskets, water drains and leak sensors
- consolidation of the laser system



## ► New Minimum Bias Trigger Scintillators (MBTS) installation

- 24 instead of 32 PMTs, channels used for completed Tile
- slightly less light yield in outer, more yield in inner cells compared to extracted MBTS (irradiated)

