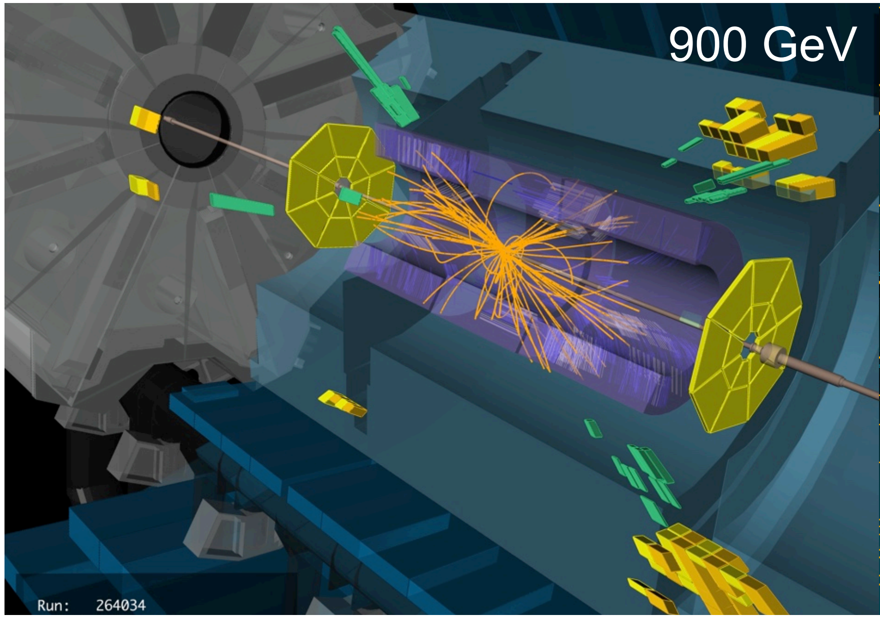
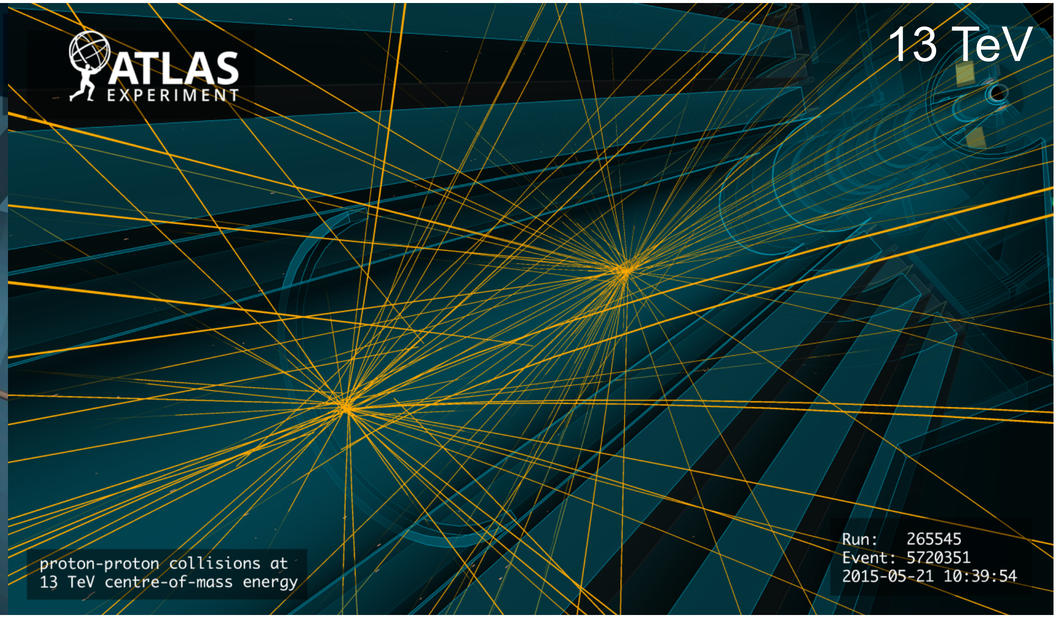




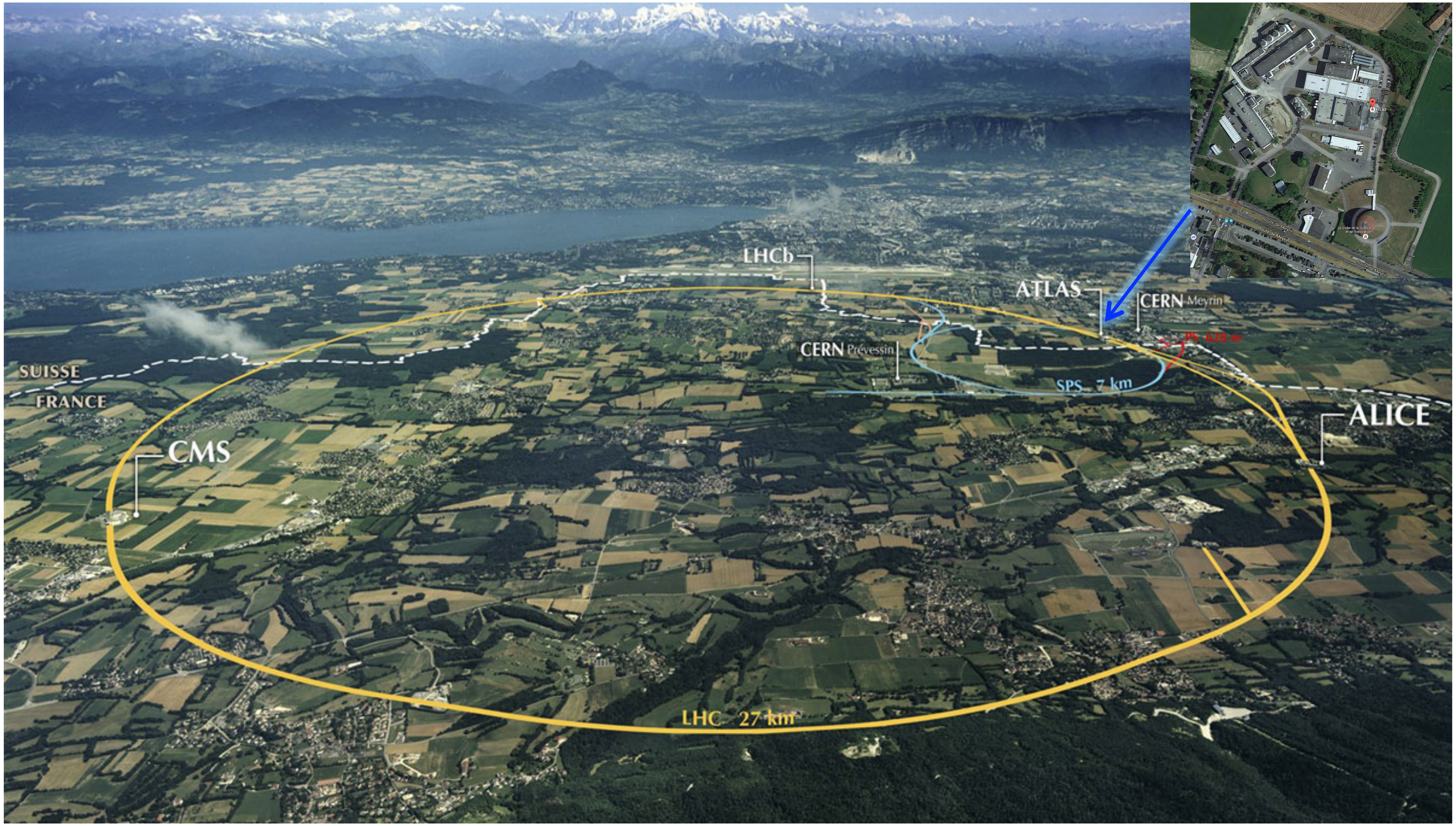
Preparation and Commissioning of ATLAS for the Run-II of LHC

Beniamino Di Girolamo – CERN

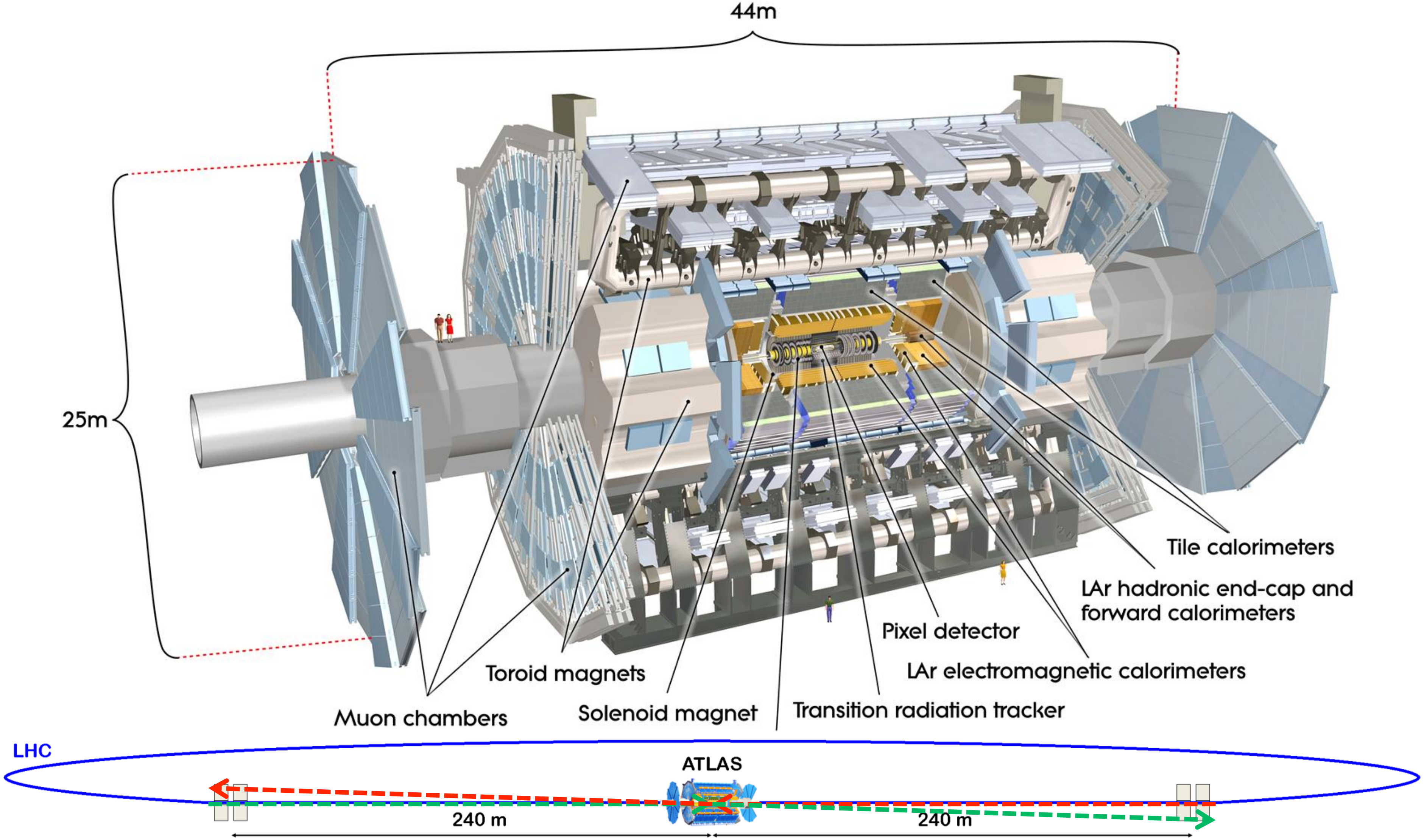
Outline

- The ATLAS Detector
- Preparation: Long Shutdown 1 work
    - Infrastructural work
    - Detector improvements and new installations
- Commissioning for the Run II
    - Integration and cosmic rays
    - Beam splashes
    - Collisions at 900 GeV
    - Collisions at 13 TeV
- Conclusions

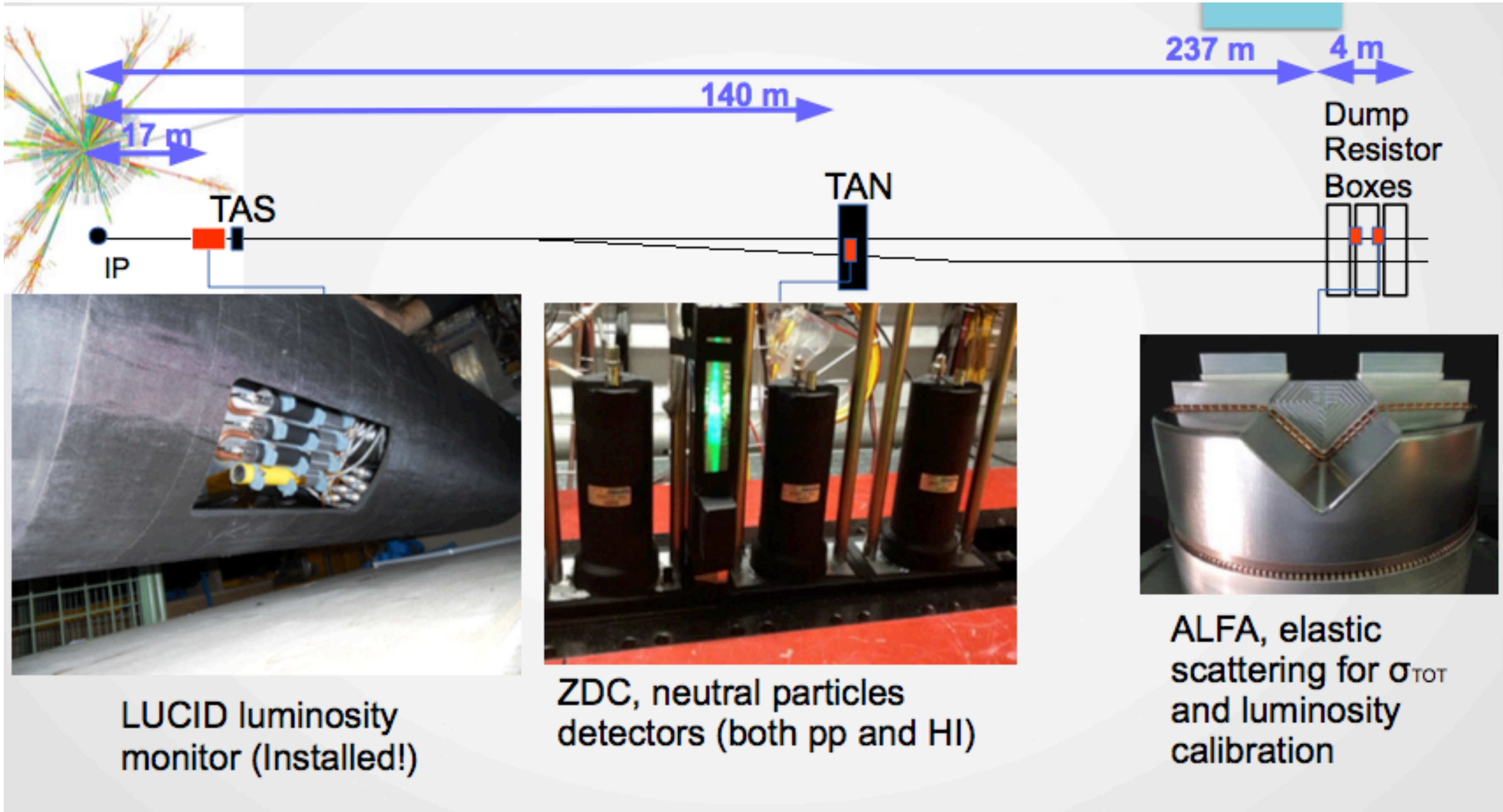
The ATLAS Site at LHC



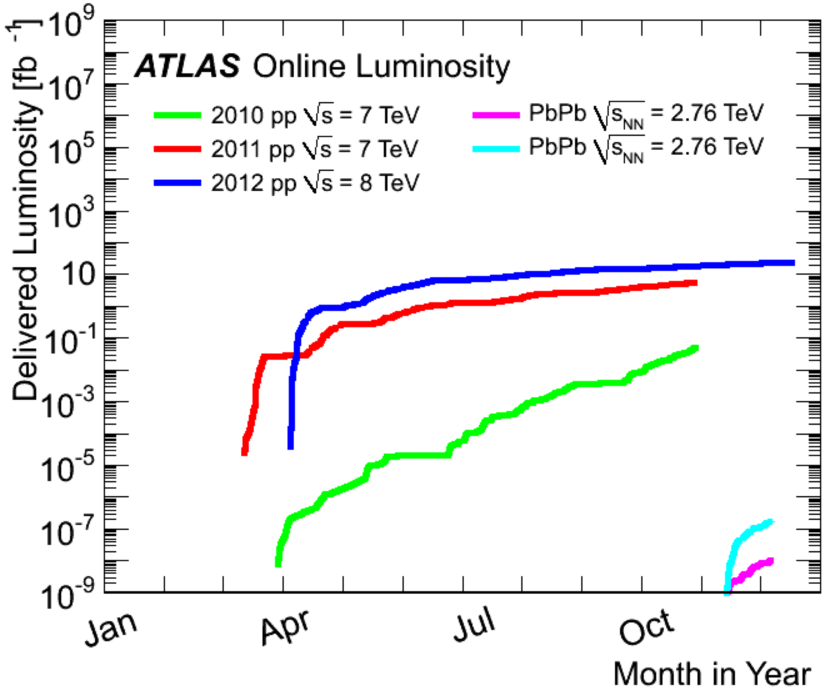
The ATLAS Detector

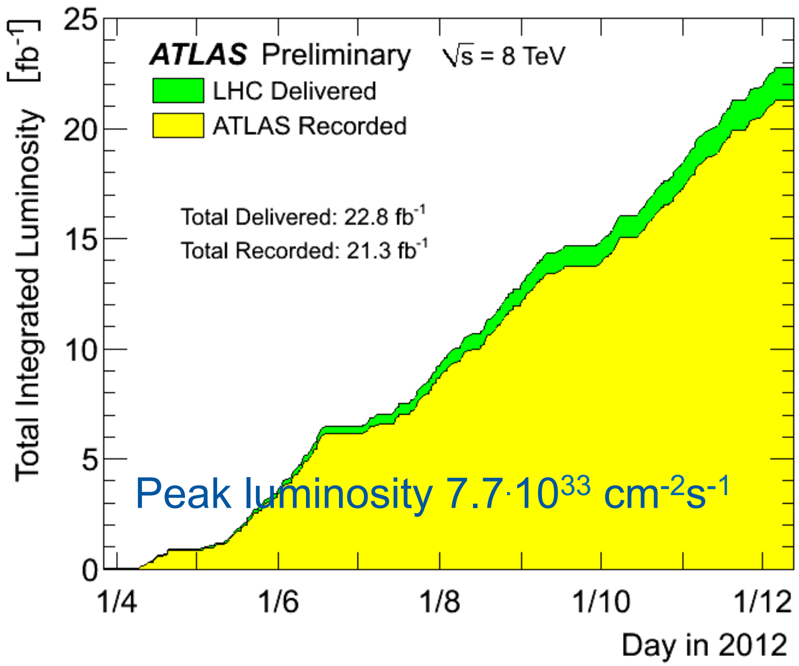


Forward detectors



Successful Run-I





Data quality			ATLAS 2012 p-p run							
Inner Tracker			Calorimeters		Muon Spectrometer				Magnets	
Pixel	SCT	TRT	LAr	Tile	MDT	RPC	CSC	TGC	Solenoid	Toroid
100	99.4	100	95.0	98.7	100	99.2	100	99.9	100	100

Luminosity weighted relative detector uptime and good quality data delivery during 2012 stable beams in pp collisions at $\sqrt{s}=8$ TeV between April 4th and May 31st (in %) – corresponding to 3.5 fb^{-1} of recorded data. The inefficiencies in the LAr calorimeter will partially be recovered in the future.

The Long Shutdown 1 (LS1)

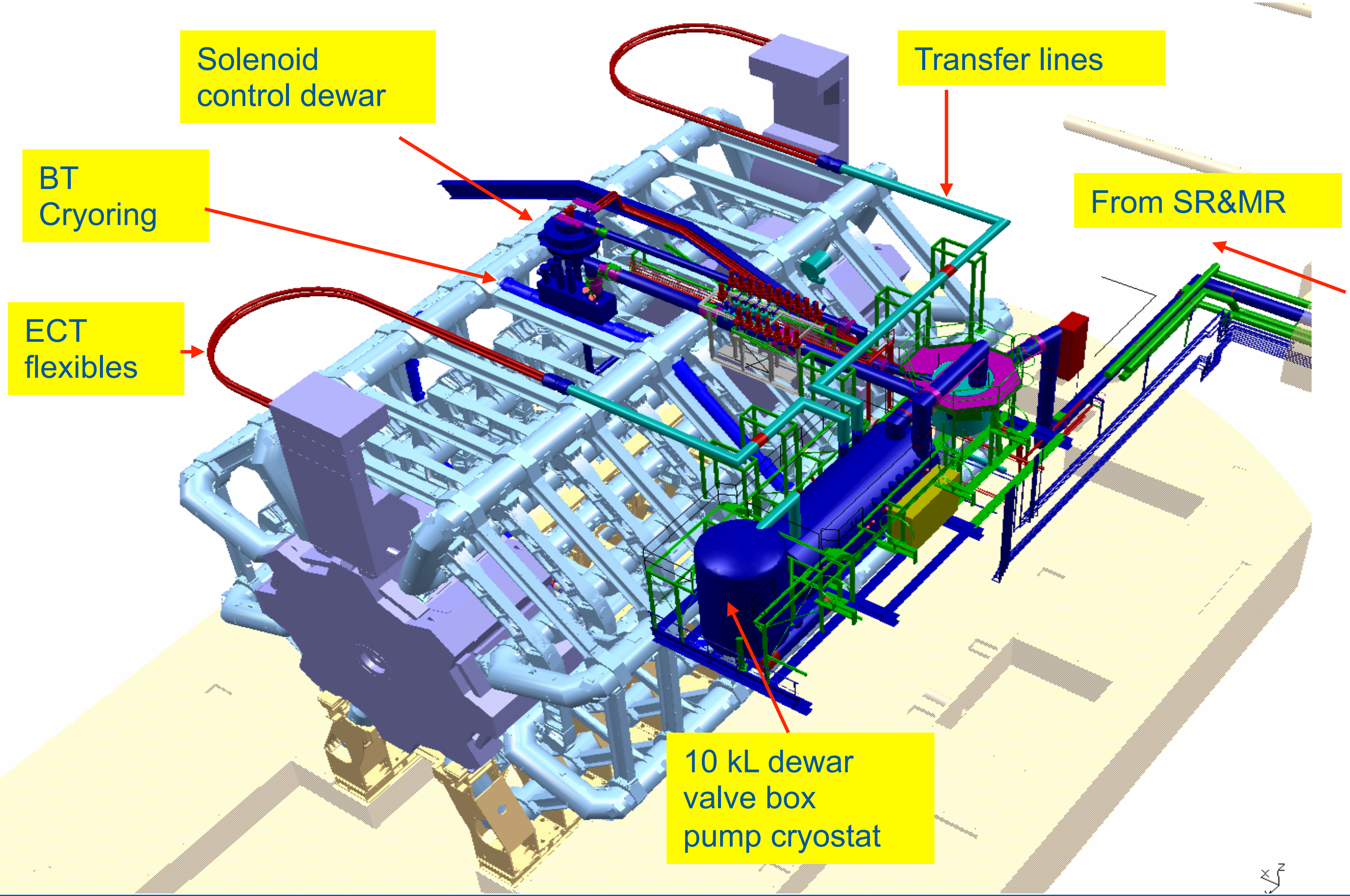
- Starting from February 2013 we entered a 2-years long maintenance period (a.k.a. LS1)
  - Addressing LHC interconnections and much more for the accelerators
  - Profiting in experiments to make improvements and new installations
    - Infrastructural work
    - Detector repairs and installations
- The shutdown is now over and we are on the starting blocks for physics

Infrastructure

LS1: Infrastructural work

- Addressing mainly issues experienced during the Run-I, but also work foreseen for the first possible long slot
- > 300 Work Packages (~ 3500 interventions)
- Few examples:
  - Separation of Solenoid and Toroid magnets operation
    - This will increase up-time for the detector in case of dumps
  - Implementation of UPS for the full experiment
    - Including parts that were not included before. The full experiment can withstand a black-out for 10 minutes to gracefully shutdown; it filters spikes.

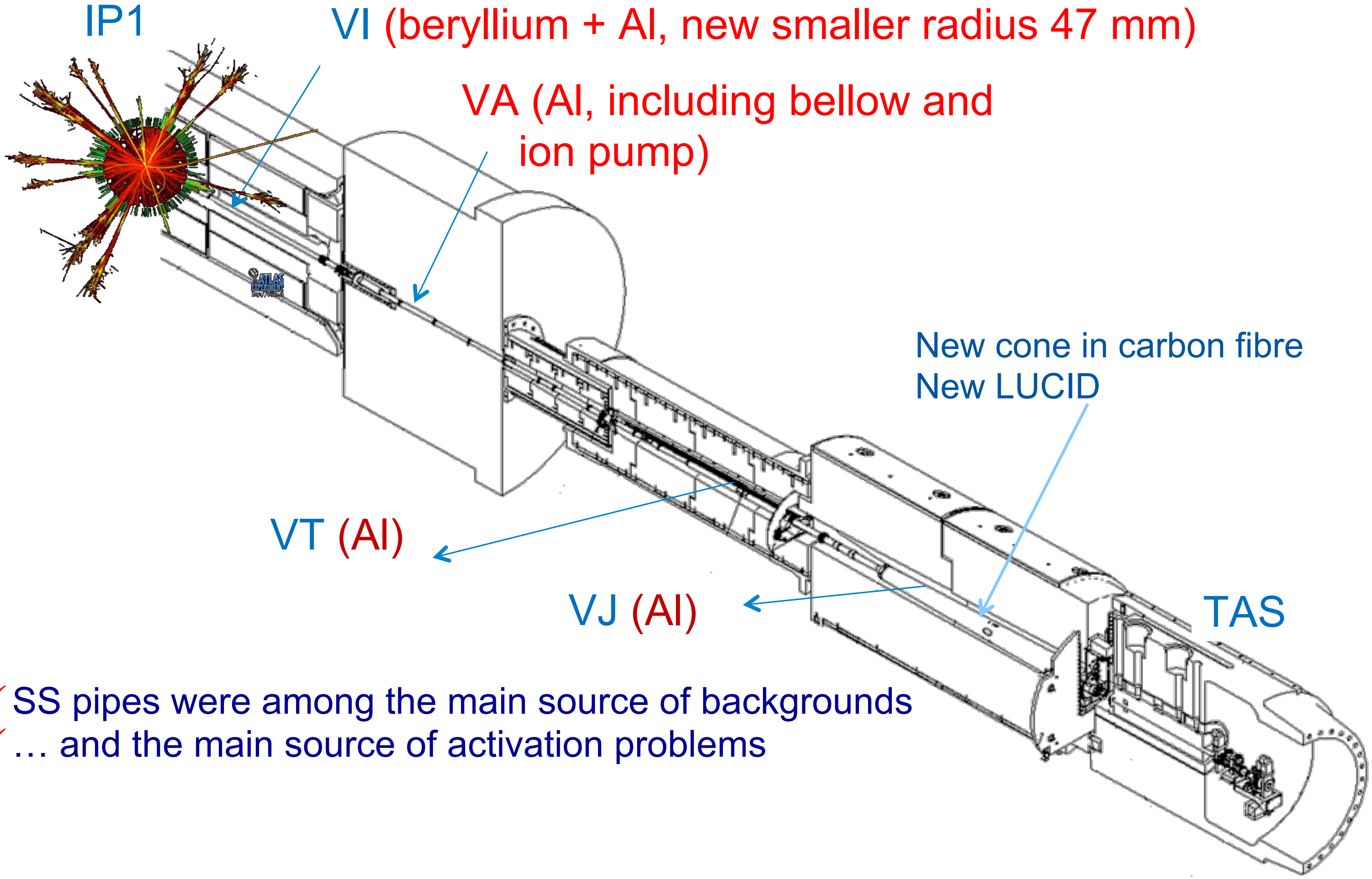
LS1: Magnet system



LS1: reducing background and doses

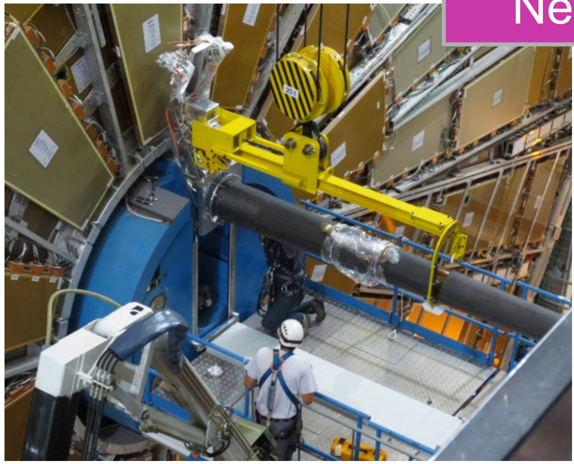
- Additional shielding to limit background in muon chambers
- Additional neutron shielding for personnel in counting rooms and above pits
- All beam pipes in Aluminum (7 m central section in Be) instead of stainless steel
- Extensive use of zero/low-activation materials
- Optimization of services routing and accessibility to reduce doses

All new beam pipes



- ✓ SS pipes were among the main source of backgrounds
- ✓ … and the main source of activation problems

New remote handling lifting beam



VJ + Lucid Services

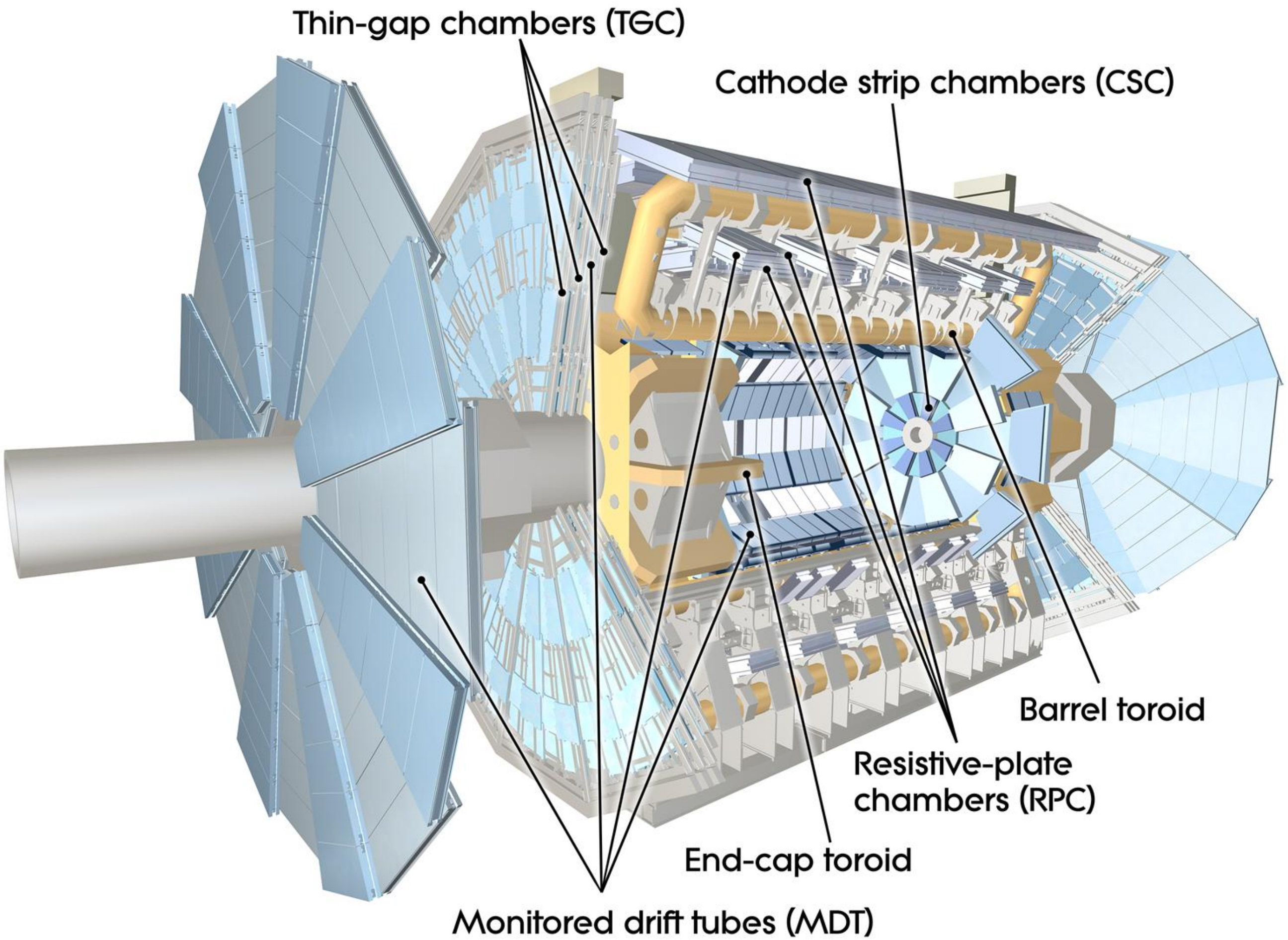
Old design

New design

Optimizations

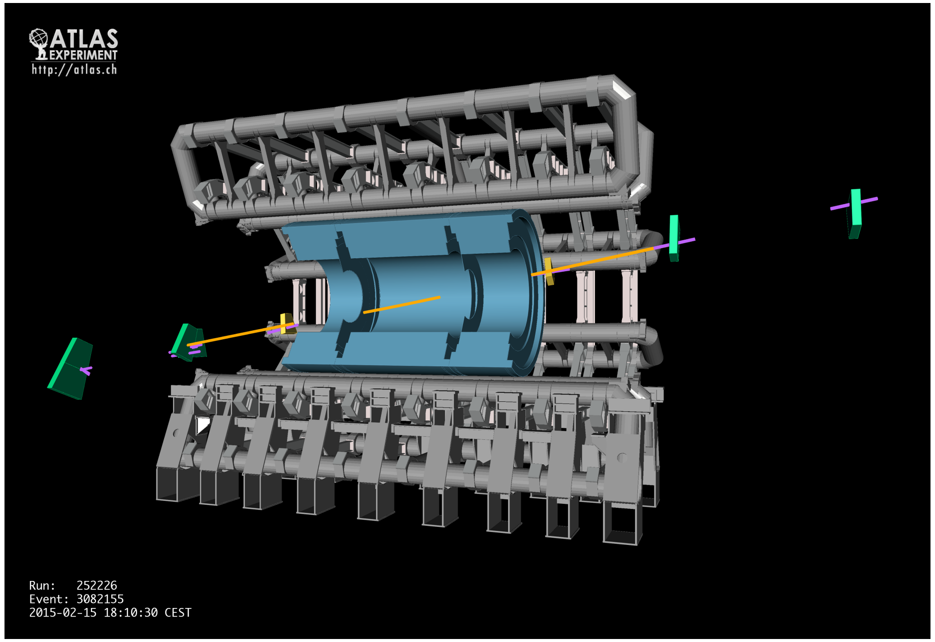
Cable trays and patch panels integrated into the structure

Muon Spectrometer

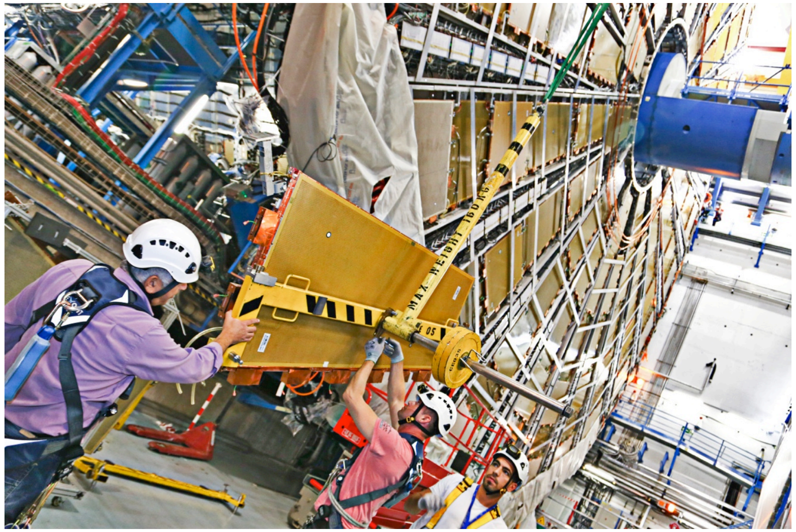


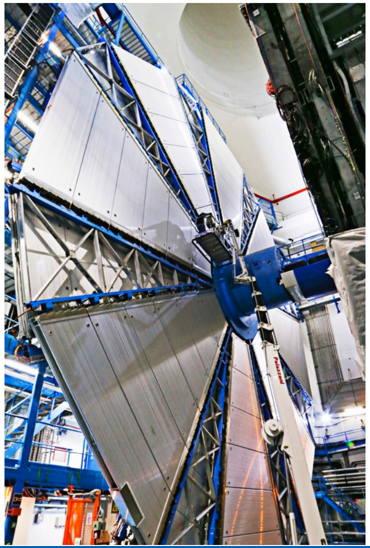
Muon Spectrometer: CSC chambers

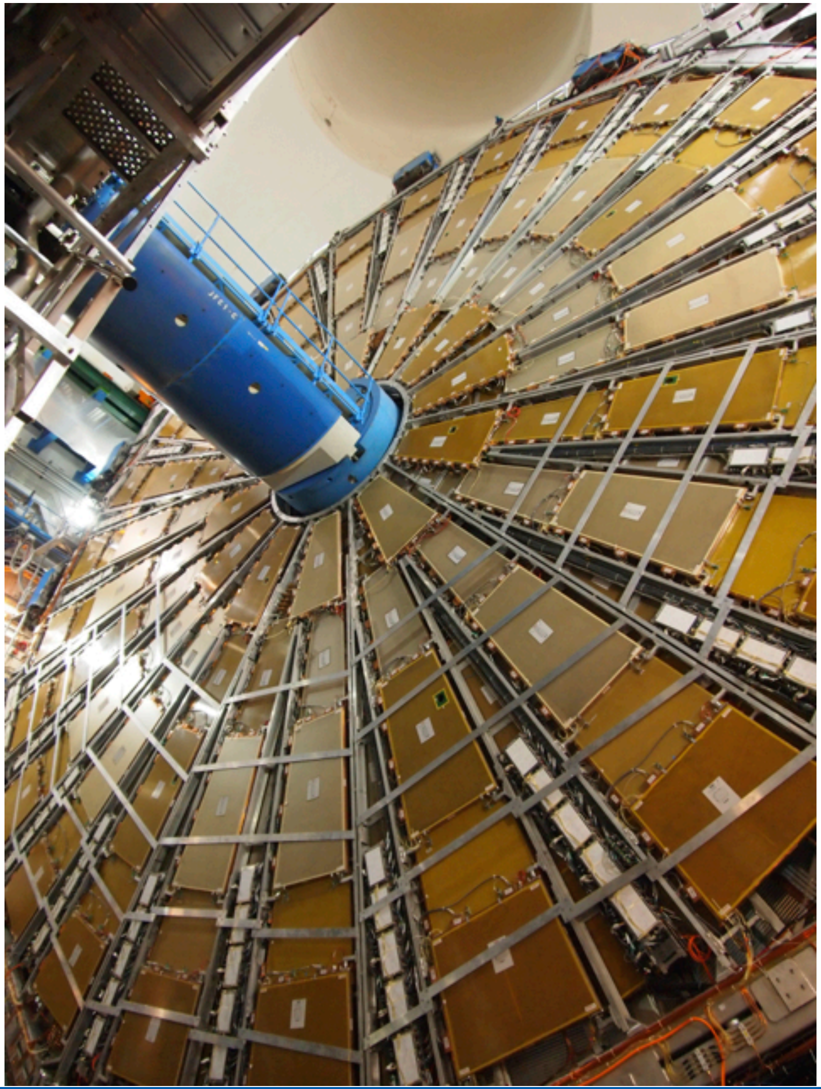
- One Small Wheel had to be extracted because of the Pixel extraction
  - Few chambers need to be repaired on both Wheels
- Readout improvements to reach 100 kHz LVL1 Trigger: new ATCA-based ReadOut Drivers



Muon Spectrometer: Big Wheels





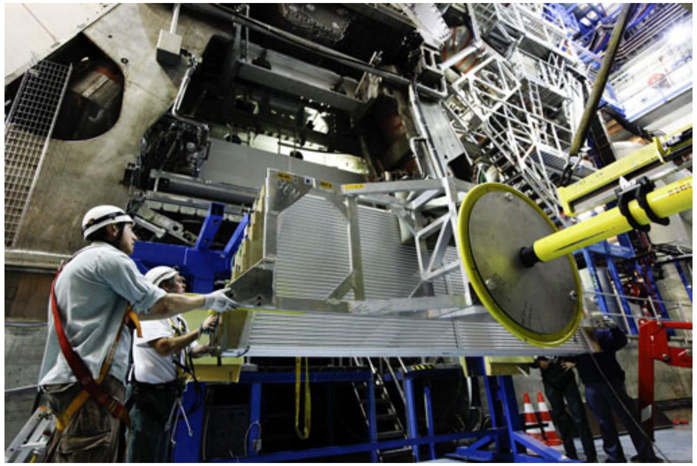


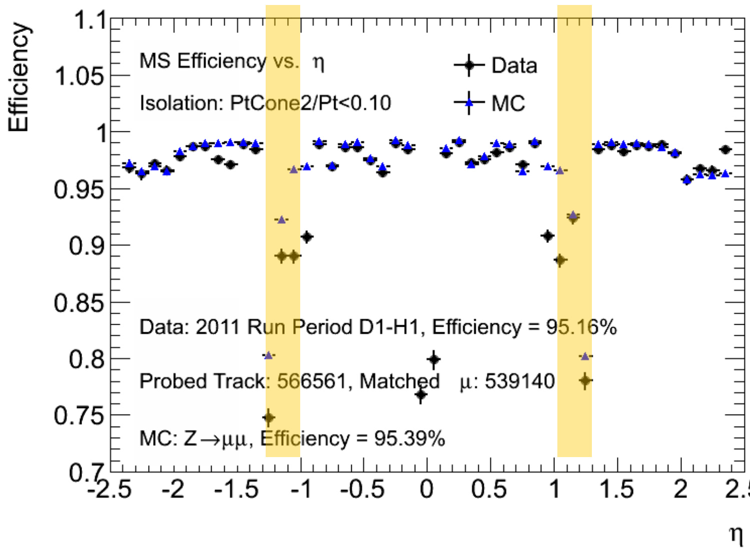
Muon Spectrometer: TGC chambers

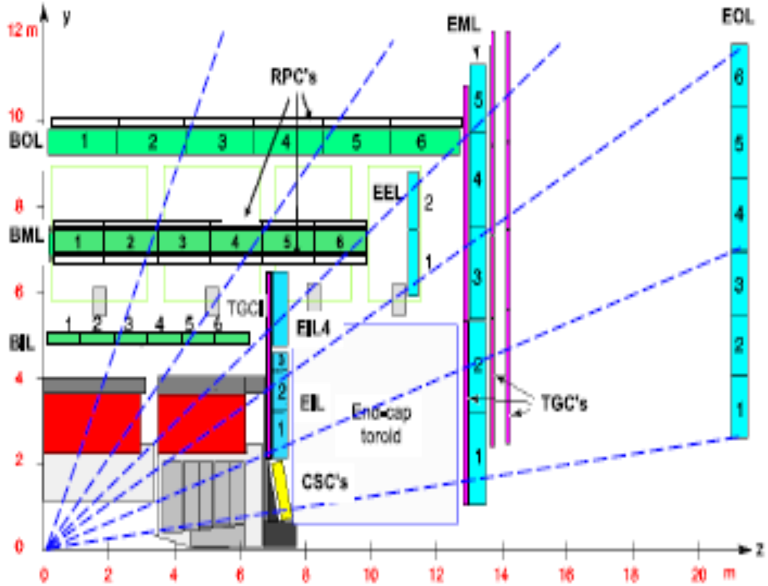
- Almost 30 chambers needed to be replaced because of failures
- A production of chambers was started in 2012 and we had a slot for installation at the end of 2014
  - Last interventions before closing the detector
- Acrobatic operations

Completion of the Muon Spectrometer: the EE chambers

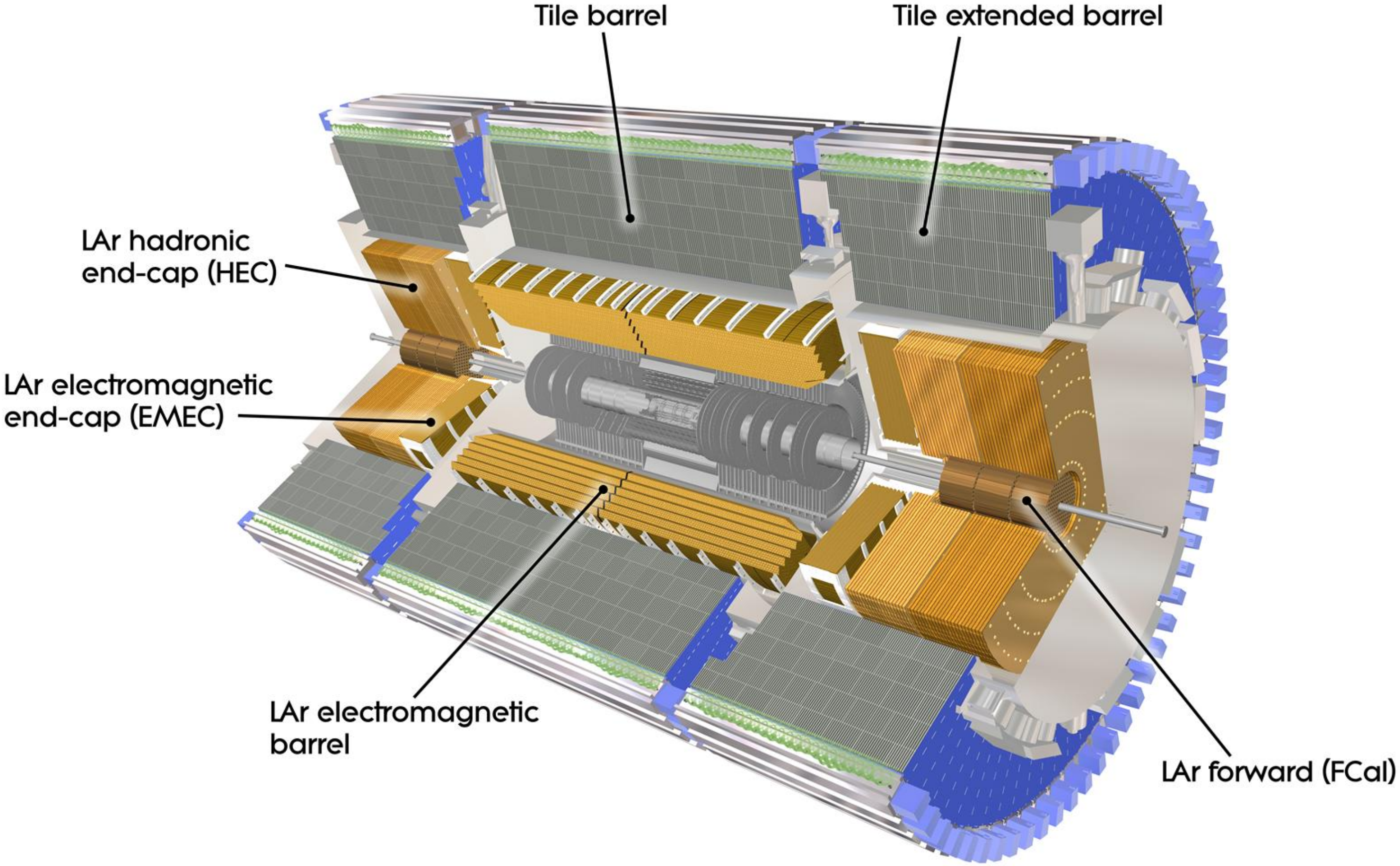
- The staged EE chambers
  - Installed during past shutdowns on Side C
  - Side A installation during LS1
- The Initial Design Muon Spectrometer is now completed
- EE = EndCap Extension
  - Range of the EE chambers is 1.0 < |η| < 1.3





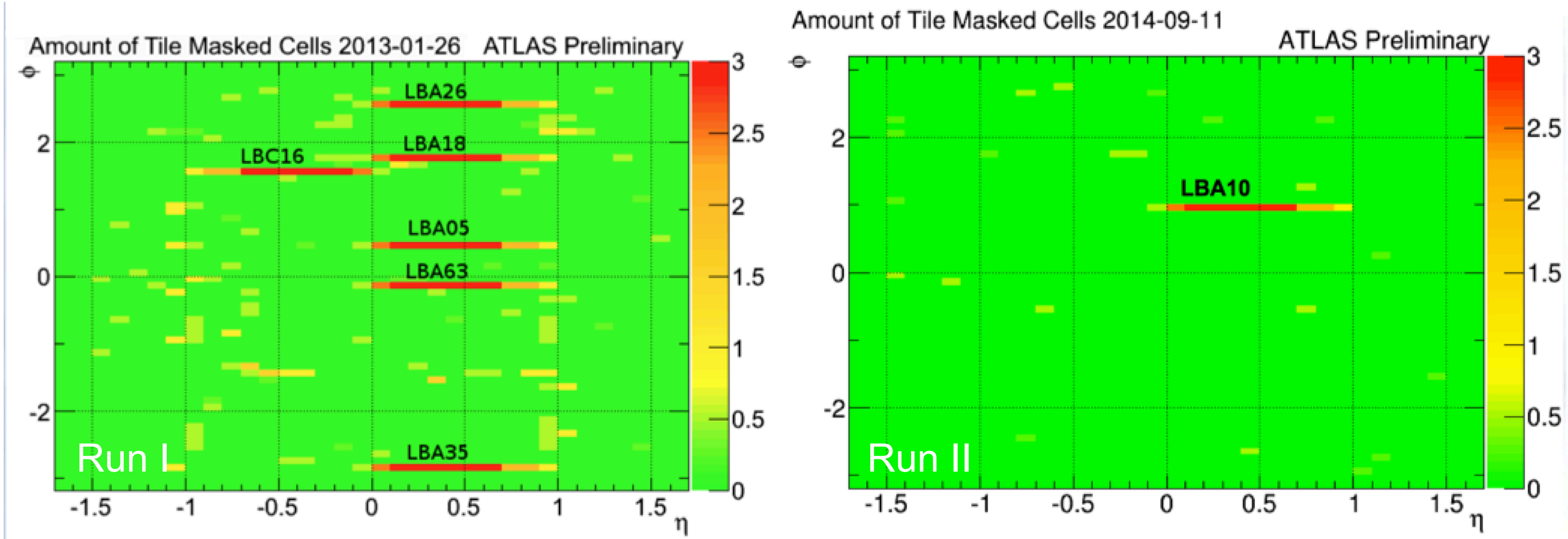


Calorimetry



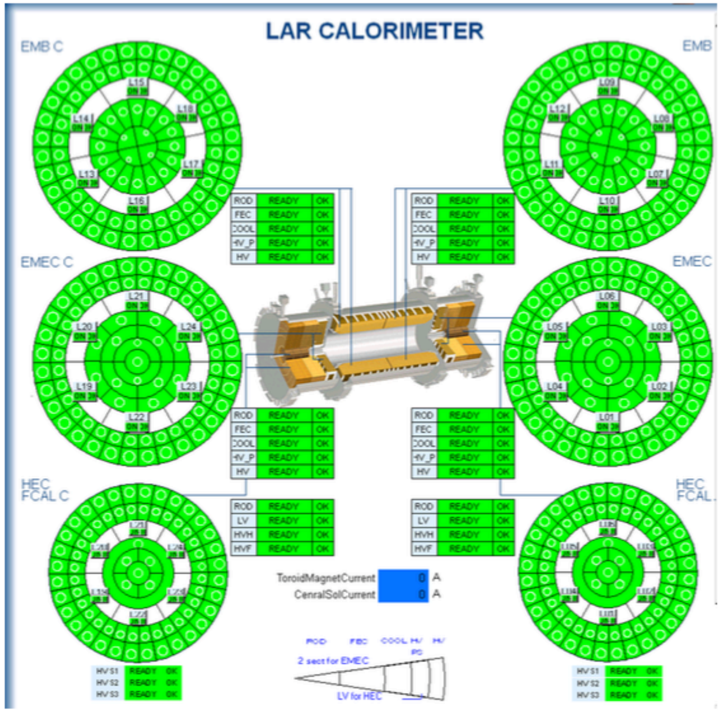
Hadronic calorimetry: Tilecal

- Tilecal Front-End electronics consolidation (connectors and cable almost 10 years old)
- 1 failure after repair that will be addressed at the next opening



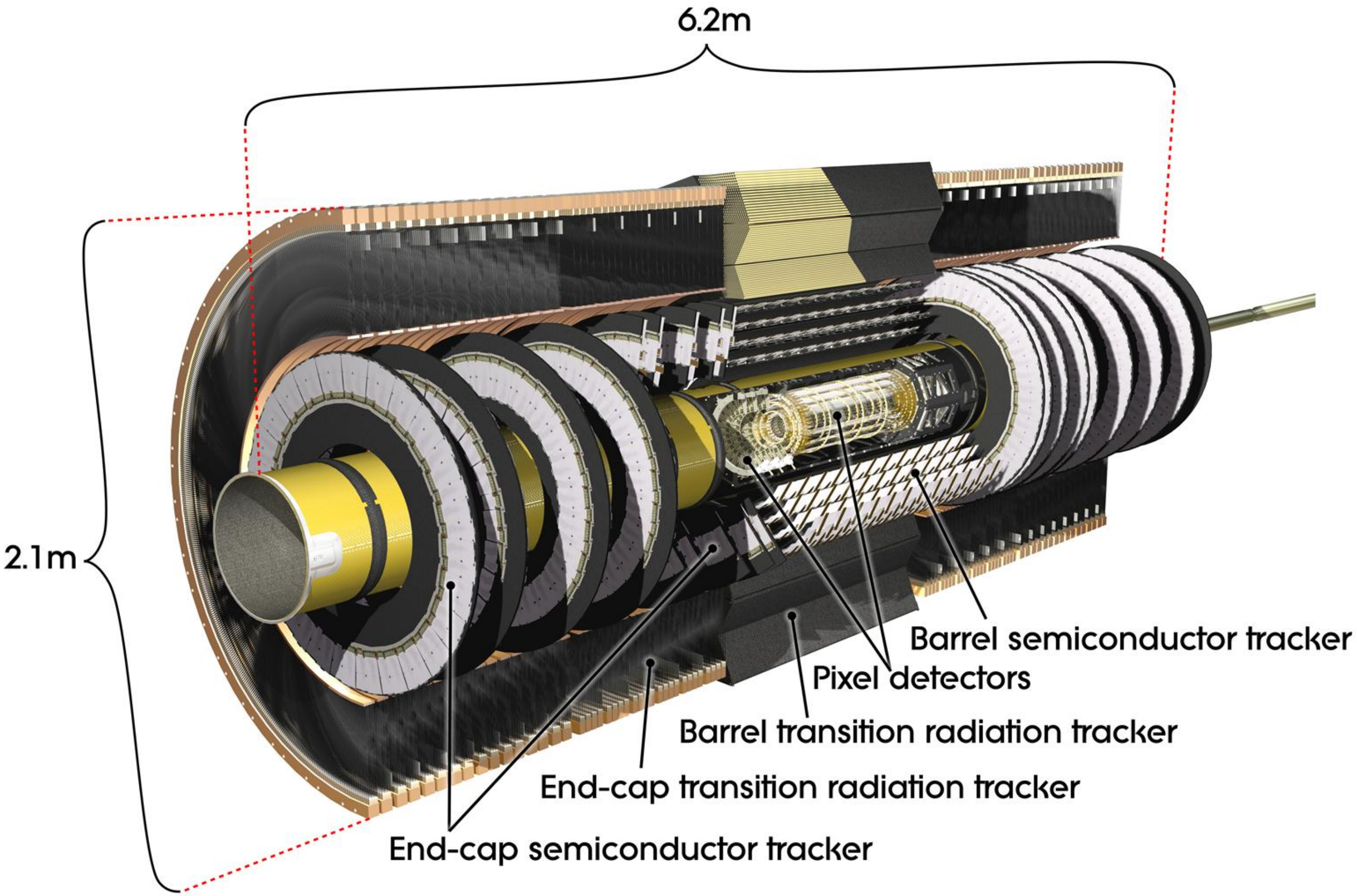
LAr

- Fixed all problems and back to green at 100%
- A grounding fault in one end-cap
  - Cause unknown so far
  - No problems in physics and noise runs
- Installed two demonstrator boards of the future trigger and readout upgrade (3 years to learn)



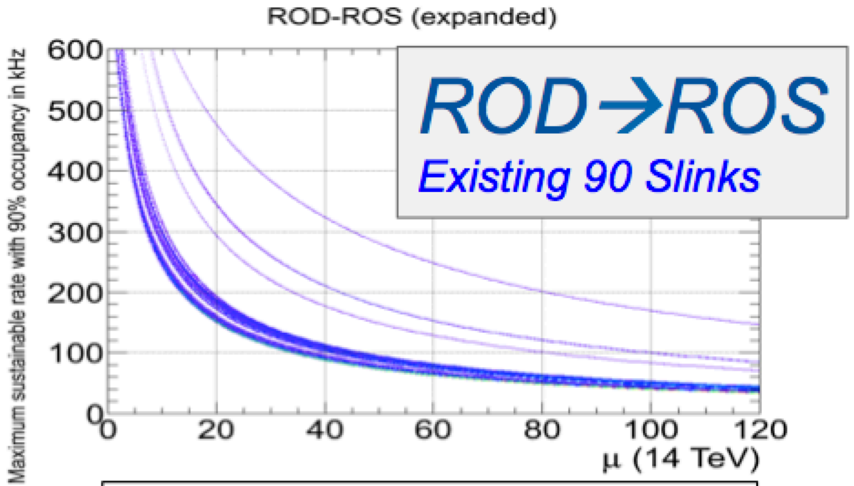
Recovered the usual "All-Green" status!

Inner Detector

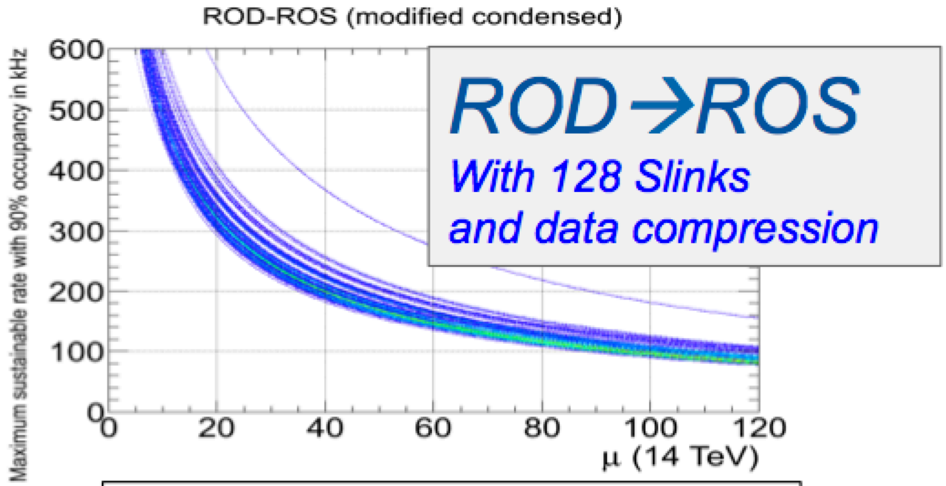


Inner Detector: SCT and TRT

- Improved data treatment to cope with 100 kHz LVL1 rate in Run-2 for TRT
- Addressed TRT gas leaks (at exhaust) to minimize Xe consumption
- SCT: improved readout capabilities to cope with higher pile-up



✗ 100kHz at μ~33



✓ 100kHz at μ~87

Pixel and IBL

INTERNATIONAL JOURNAL OF HIGH-ENERGY PHYSICS

CERNCOURIER

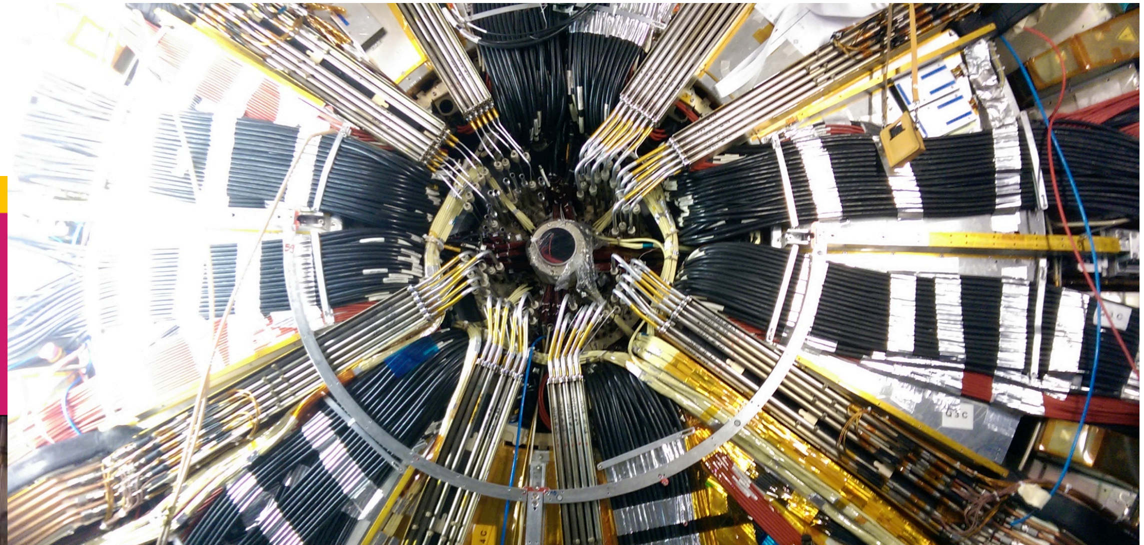
VOLUME 53 NUMBER 8 OCTOBER 2013

Revitalizing the heart of ATLAS

AMS-02
Results from the first two years on board the ISS
p22

LHC MAGNETS
First missions for long shutdown now accomplished
p5

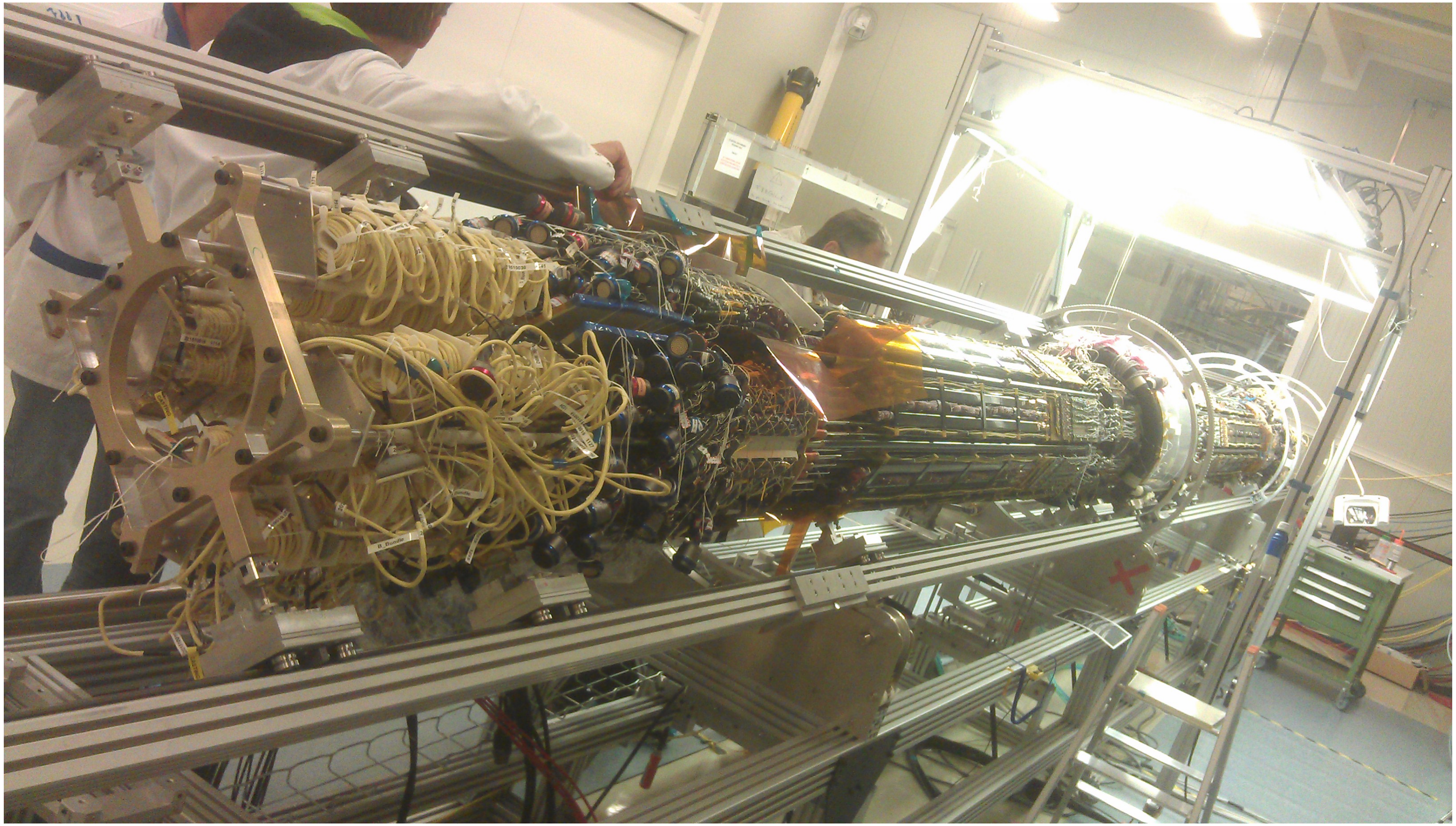
EPS-HEP 2013 CONFERENCE
Highlights from Stockholm p37



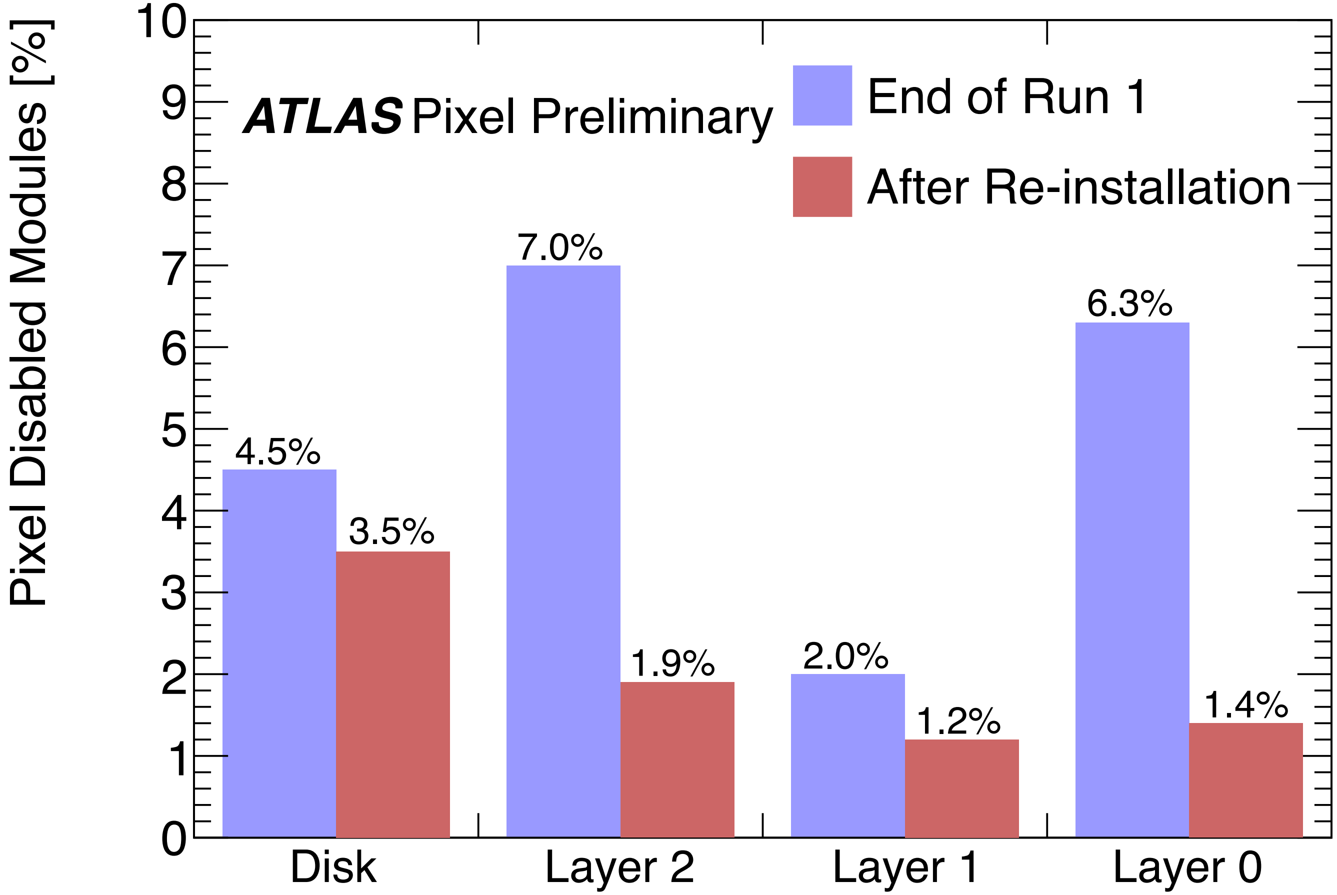
Pixel and IBL

- The 3-Layers Pixel extracted and repaired
  - Profiting to introduce higher bandwidth services for future Run II and III higher luminosity runs
- The IBL was a full challenge:
  - It was anticipated by 2 years
  - It suffered from wire-bonds corrosion
    - A number of modules reproduced in record time
  - Its installation was the central part of the full shutdown
    - Influencing every other detector
  - We did it!

Pixel services



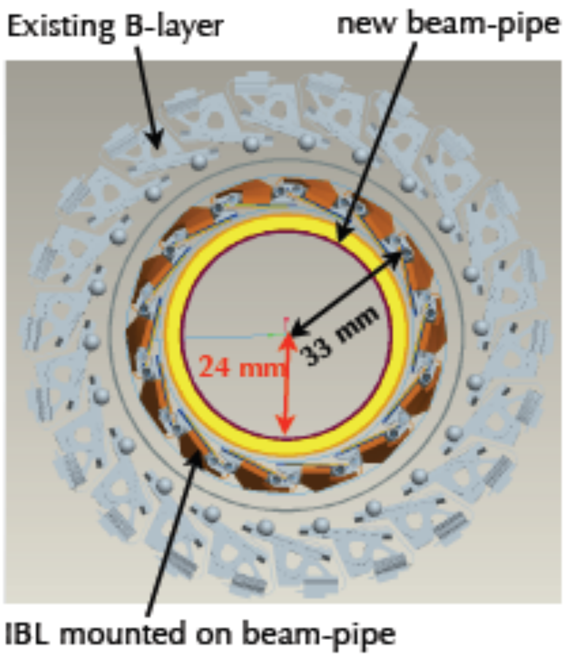
Pixel recovered modules



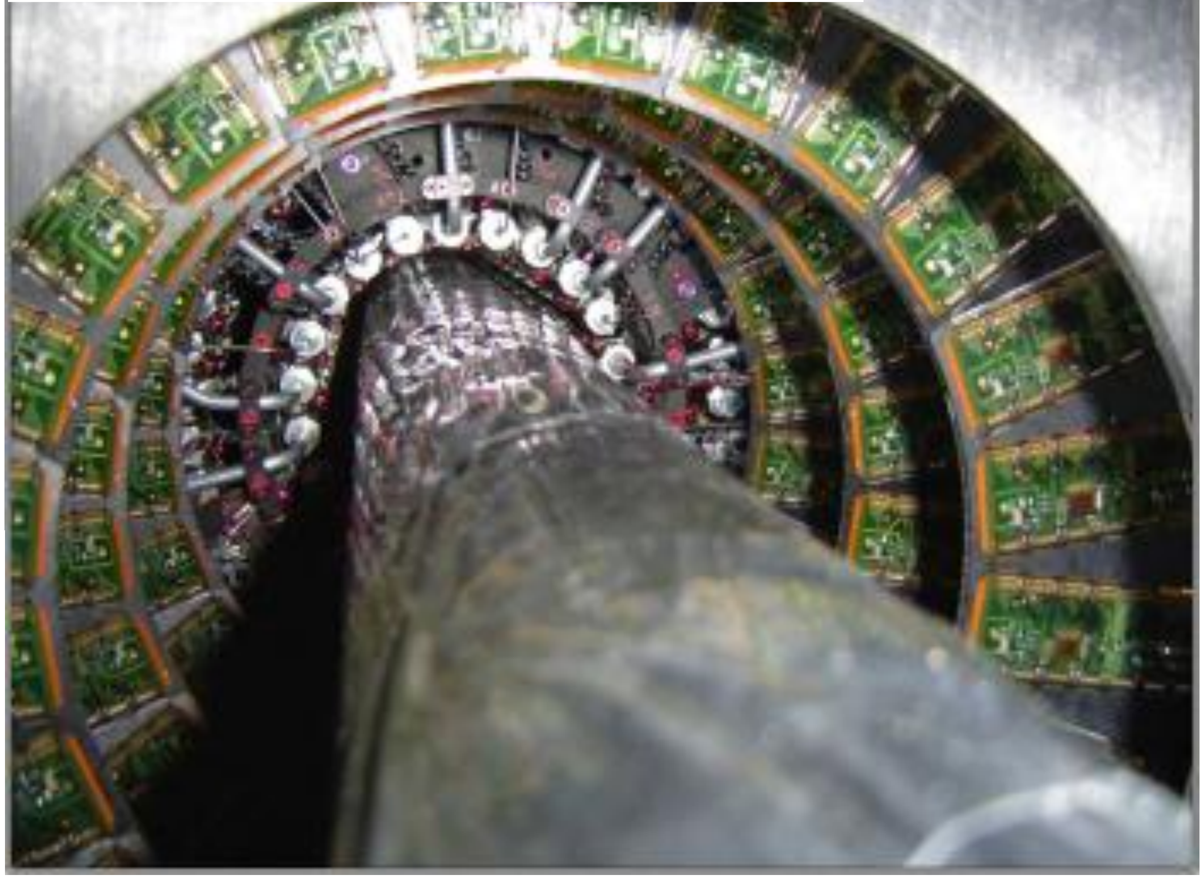
IBL

If you thought it was simple

47 mm diameter new beam pipe to create enough space

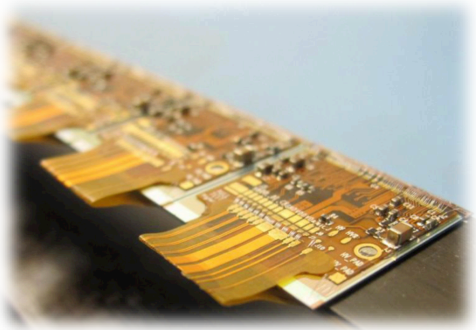


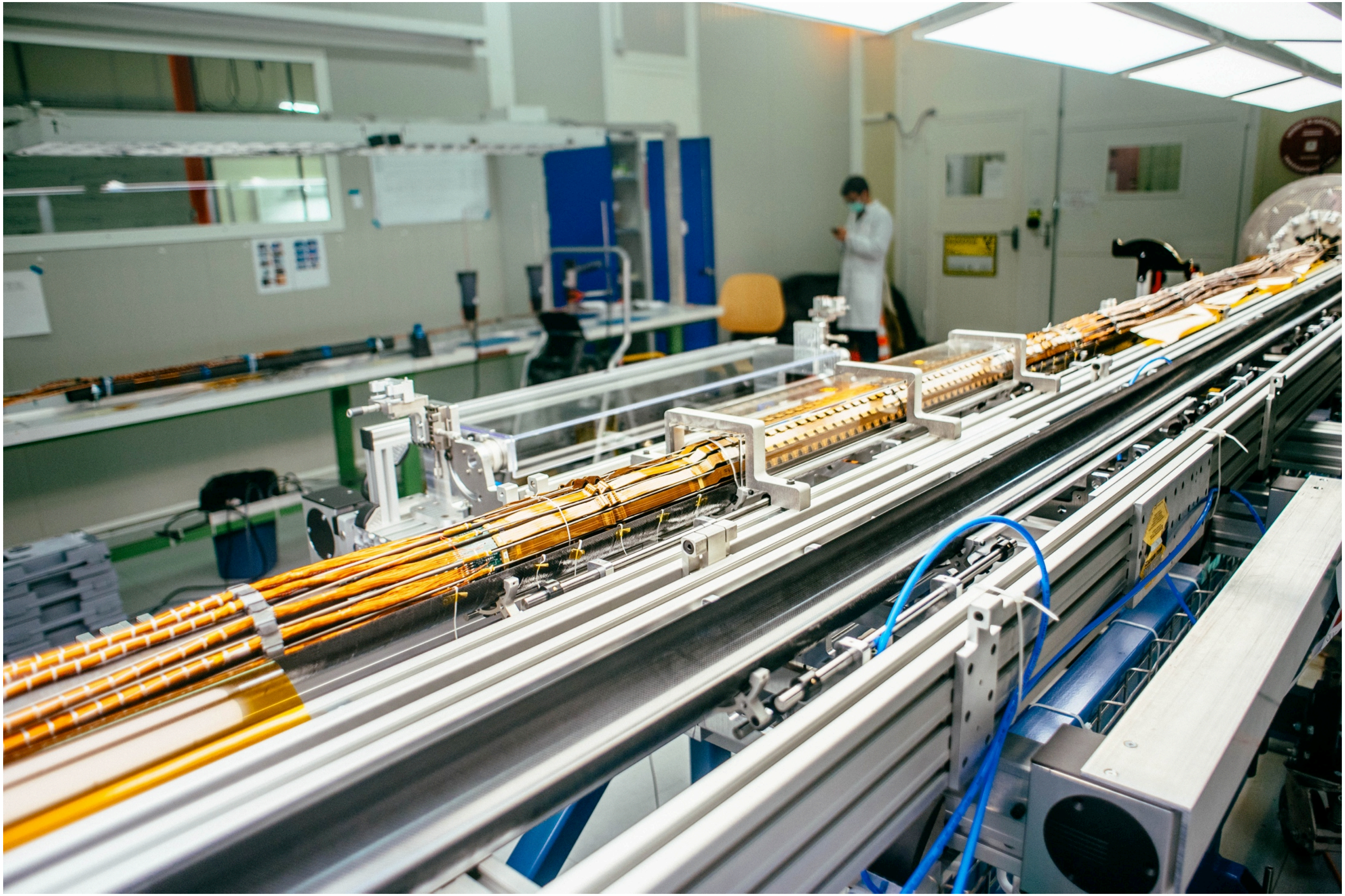
Original Pixel and previous beam pipe



An Inner Support Tube inserted at 2 mm from the Layer-0 modules.
Then the new VI beam pipe was instrumented with IBL

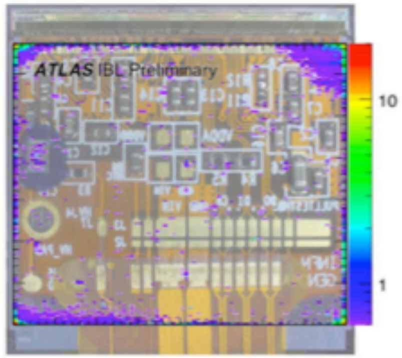
IBL images…



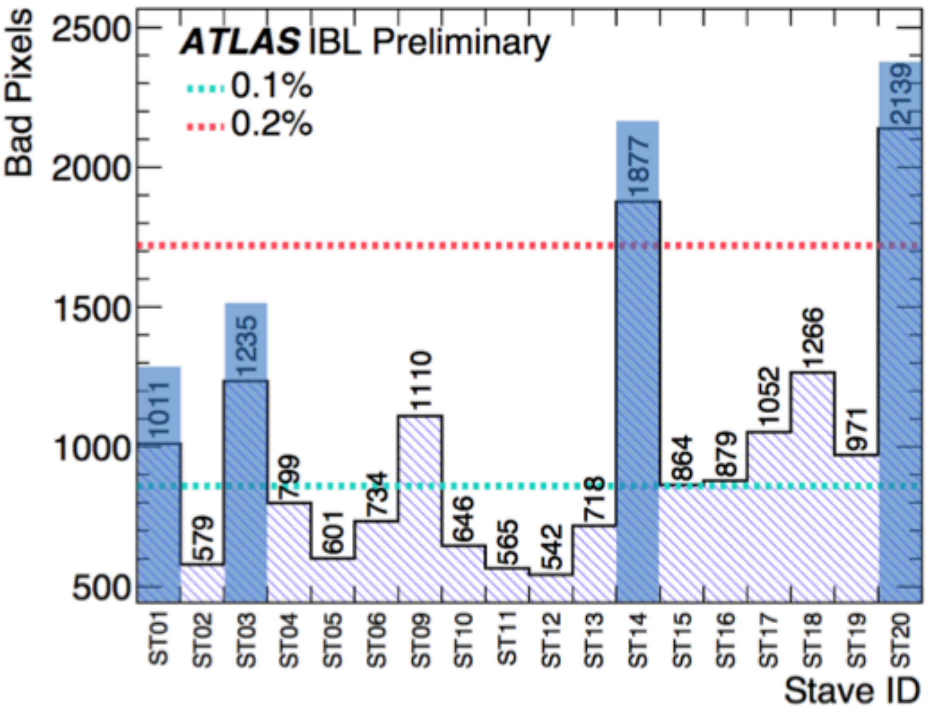


Overall IBL stave quality

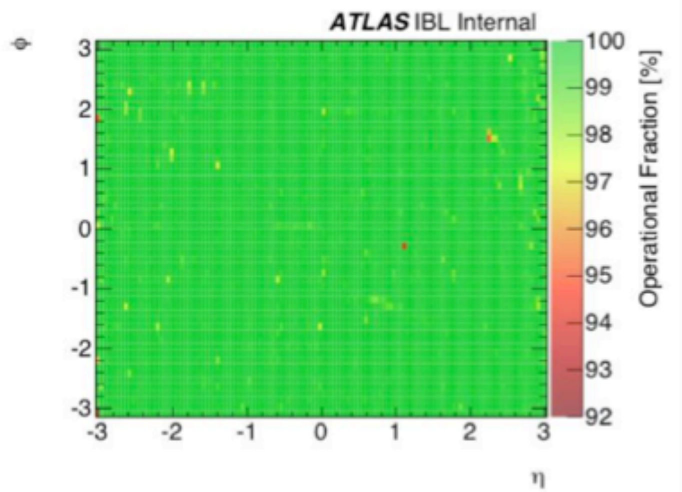
- Aim to have less than 1% dead pixels
- Actual detector has ~0.1 % dead pixels!
  - Disconnected pixels usually on sensor edges



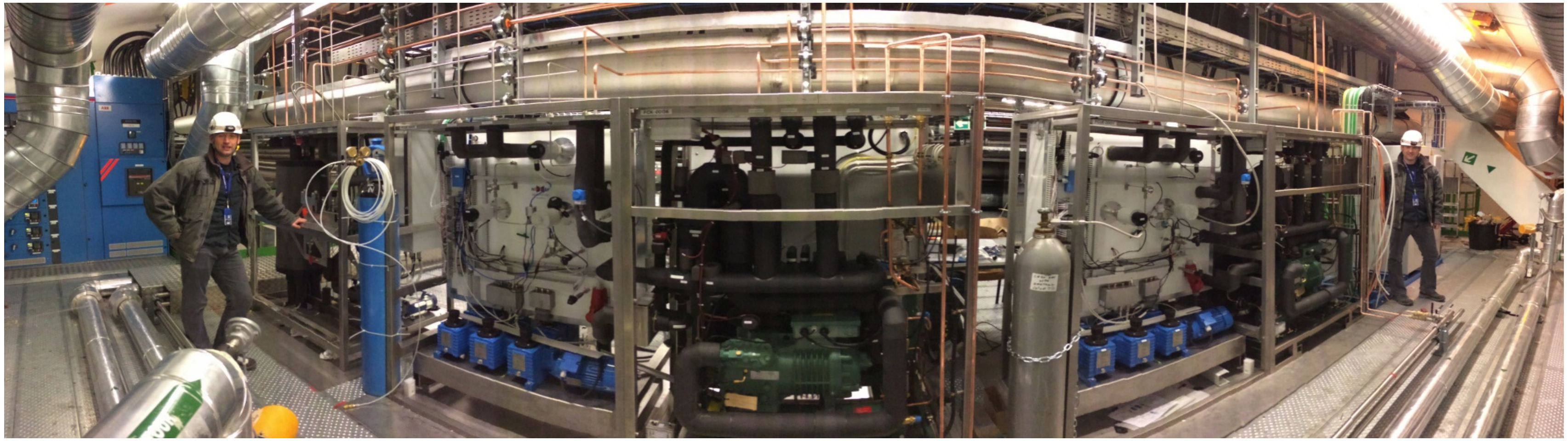
1 Stave has 860,000 pixels



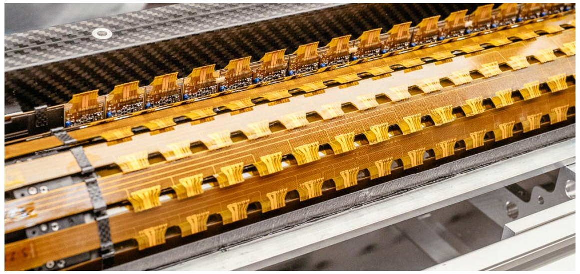
Arranged modules & staves in final IBL for uniform low η–ϕ distribution of dead pixels (particular for |η|<2)



IBL CO_2 cooling installation

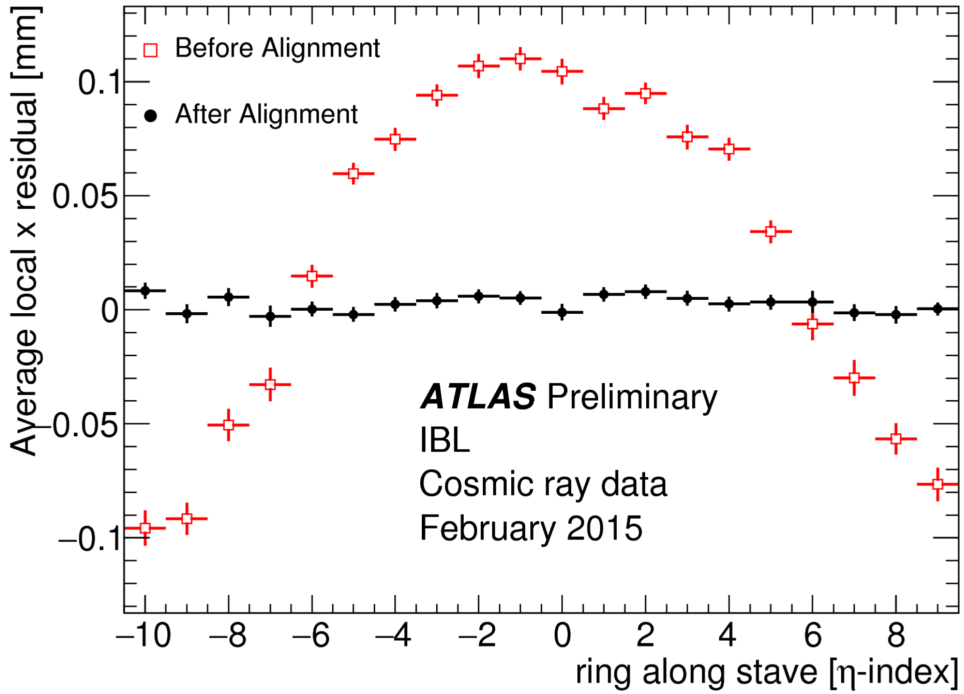


IBL



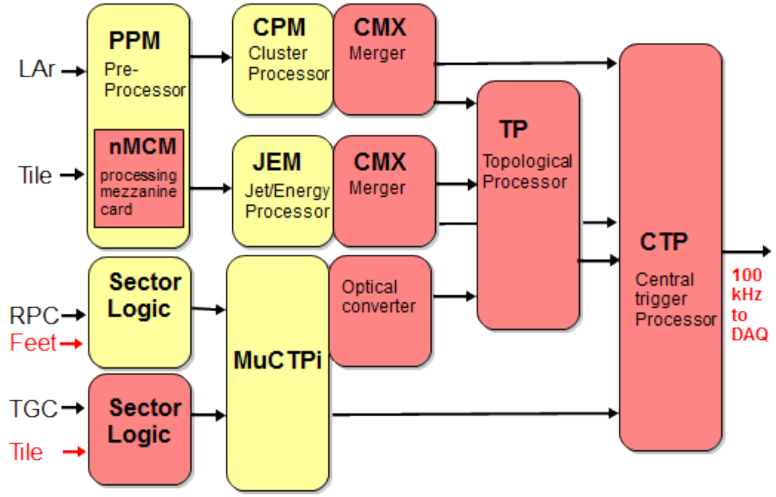
- A bowing issue

- We observe a larger than expected thermally-induced r-ϕ "twisting" of IBL staves: at the level of few μm/K
  - Mapped out well with large cosmic samples
  - It might require refinements to operating procedures, but we do not currently foresee any impact on costs or data quality
  - Expect to manage the effect via a careful temperature control at the level of ~ 0.2 K as recently measured

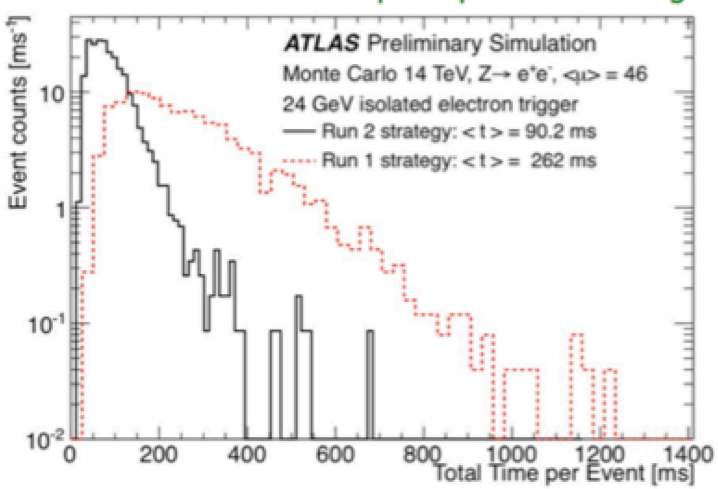


Trigger improvements

- Many improvements to LVL1 trigger
  - New calorimeter plugins (better handling of bunch trains)
  - New topological trigger processor
  - New Central Trigger Processor
- Restructuring of High-Level Trigger
  - Higher speed (> factor 2)
- Further improvements during Run-II with the introduction of the FTK Fast TracK finder



Speedup of HLT tracking



Detector status for Run II (Run I)

Subdetector	Number of Channels	Approximate Operational Fraction	
Pixels	92 M	(95.0%) 99.0%	
SCT Silicon Strips	6.3 M	(99.3%) 98.9%	temp
TRT Transition Radiation Tracker	350 k	(97.5%) 97.3%	
LAr EM Calorimeter	170 k	(99.9%) 100%	
Tile calorimeter	4900	(98.3%) 99.5%	
Hadronic endcap LAr calorimeter	5600	(99.6%) 99.6%	
Forward LAr calorimeter	3500	(99.6%) 99.8%	
LVL1 Calo trigger	7160	(100%) 100%	
LVL1 Muon RPC trigger	370 k	(100%) 95.8%	temp
LVL1 Muon TGC trigger	320 k	(100%) 100%	
MDT Muon Drift Tubes	357 k	(99.7%) 99.8%	
CSC Cathode Strip Chambers	31 k	(96.0%) 98.4%	
RPC Barrel Muon Chambers	370 k	(97.1%) 96.4%	temp
TGC Endcap Muon Chambers	320 k	(98.2%) 99.8%	

Milestone weeks

Sequence of "milestone (M) weeks" every ~6 weeks in 2014, and twice in 2015 (M8 & M9)

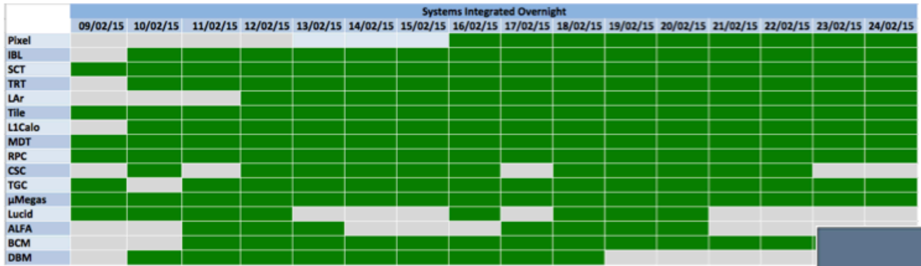
- Each week had a set of detectors to reintegrate into DAQ, DCS and further goals
- Cosmic data-taking during part of these weeks
- Also re-established offline activities – Tier-0 operations, data quality, alignment and detector conditions
- M8 & M9 (2015) had all systems included together with new CTP and latest software release
- Large samples of cosmics for calibration and alignment studies → module level alignment in pixel/IBL

Since M8 (9 Feb) ATLAS has been in 24/7 operations

2014 schedule plus M7 (all systems) Nov 24 - Dec 8

M-Week Schedule

	M1	M2	M3	M4	M5	M6
	Feb 17– Feb 23	Mar 31- Apr 4	May19- May 23	Jul 7- Jul 11	Sep 8- Sep 12	Oct 13- Oct 17
PIX				X^1, X^2	X^2	
IBL				X^1	X^2	
SCT				X	X^2	
TRT		X				
LAR				X		
TIL				X		
MBTS				X		
L1Calo	X^1			X^2	X^3	X^4
CSC	X^1				X^2	X^2
MDT	X					
RPC		X^1	X^1			
TGC	X^1					X^2
BCM		X				
ALFA						X
LUCID						
Lumi					X	

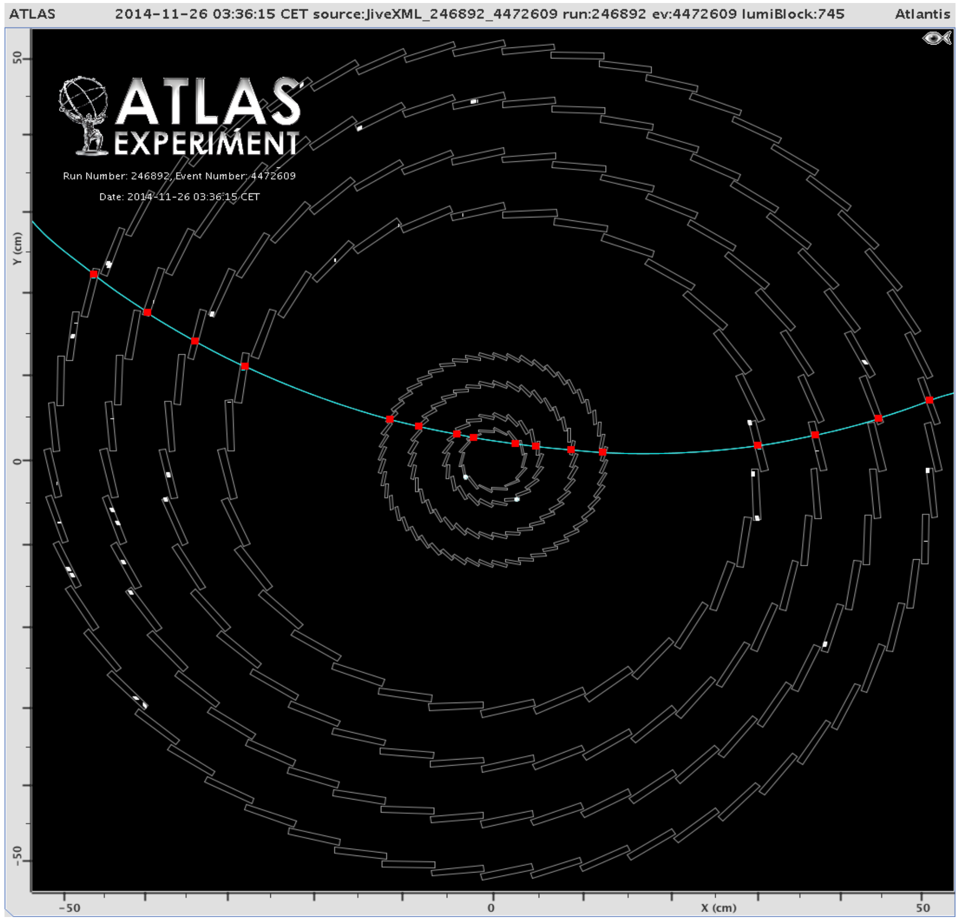


Detectors included in overnight runs, M8

M9 cosmic-ray data statistics (Mevents)

	Solenoid Off	Solenoid On	Magnets Ramping	All On	Total (Millions)
Period	B1/B3	B2	B4	B5	B
IDCosmic	1.1	1.5	0.1	0.8	3.5
CosmicCalo	1.5	0.41	0.04	0.8	2.7
CosmicMuons	26.8	38.6	2.0	29.0	96.4
express	1.6	1.3	0.1	1.0	4.0

Cosmic rays

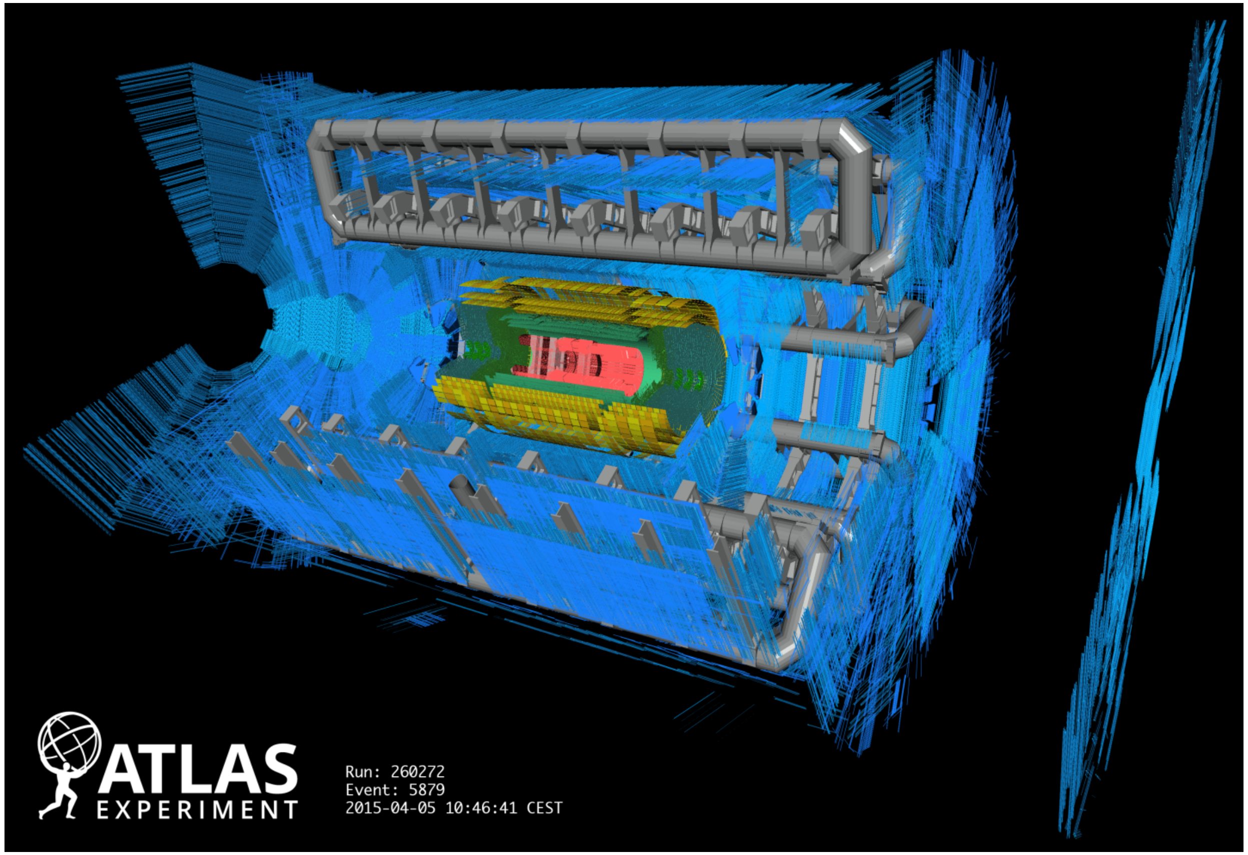


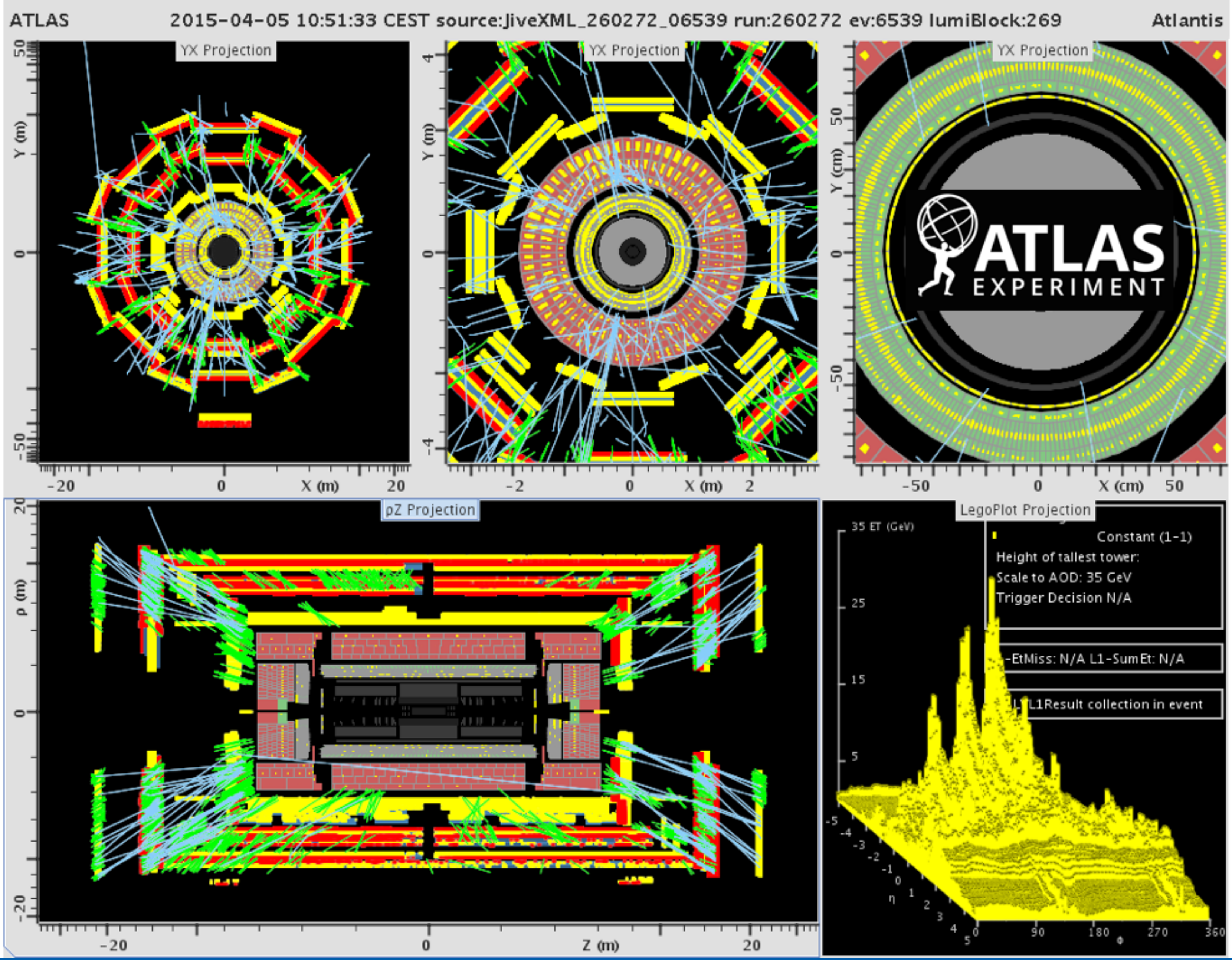
The ATLAS Smile

First event display with the 4-Layers Pixel in magnetic field

LHC is back!

- First traditional step: the beam splashes

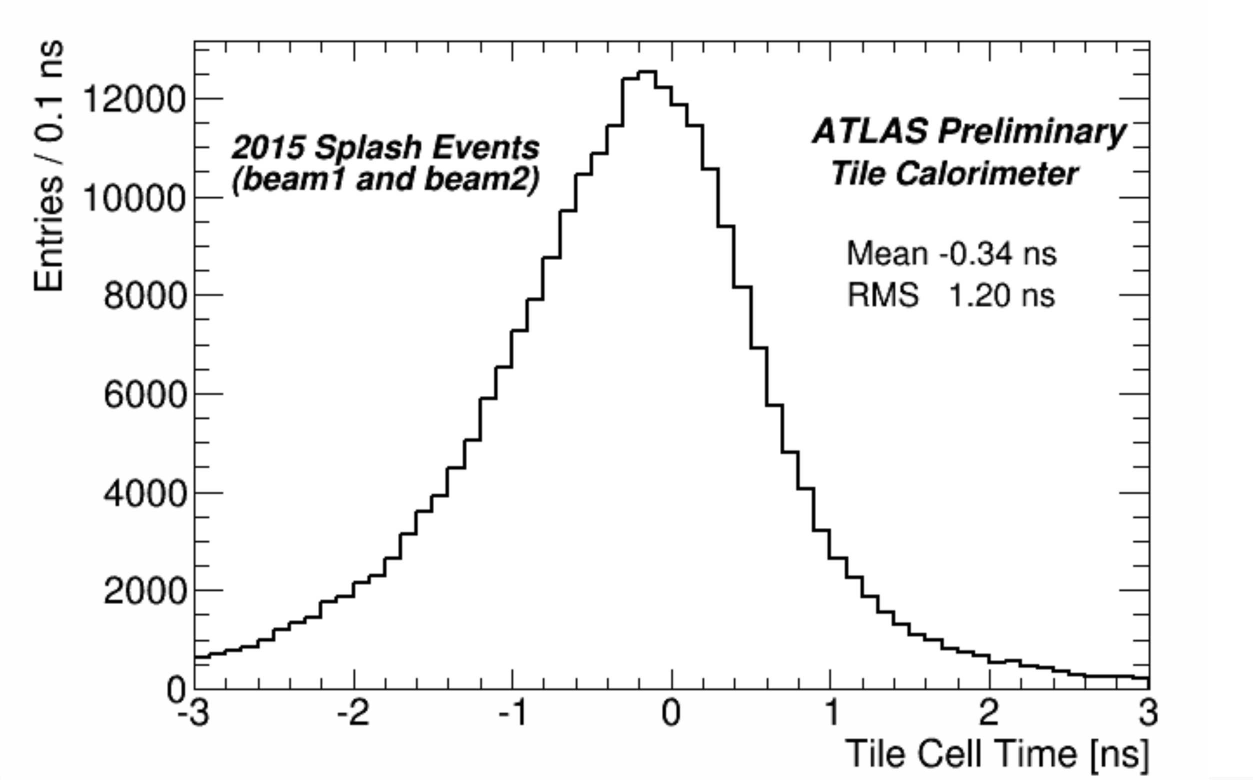



ATLAS
2015-04-05 10:51:33 CEST source:JiveXML_260272_06539 run:260272 ev:6539 lumiBlock:269
Atlantis
YX Projection
YX Projection
YX Projection
ATLAS EXPERIMENT
ρZ Projection
LegoPlot Projection
35 ET (GeV)
Constant (1-1)
Height of tallest tower:
Scale to AOD: 35 GeV
Trigger Decision N/A
-EtMiss: N/A L1-SumEt: N/A
L1Result collection in event
Y (m)
X (m)
Y (cm)
X (cm)
ρ (m)
Z (m)
η
φ

Not as many people in the ATLAS Control Room as for first beam in 2008,
but still quite a crowd for the morning of Easter Sunday!

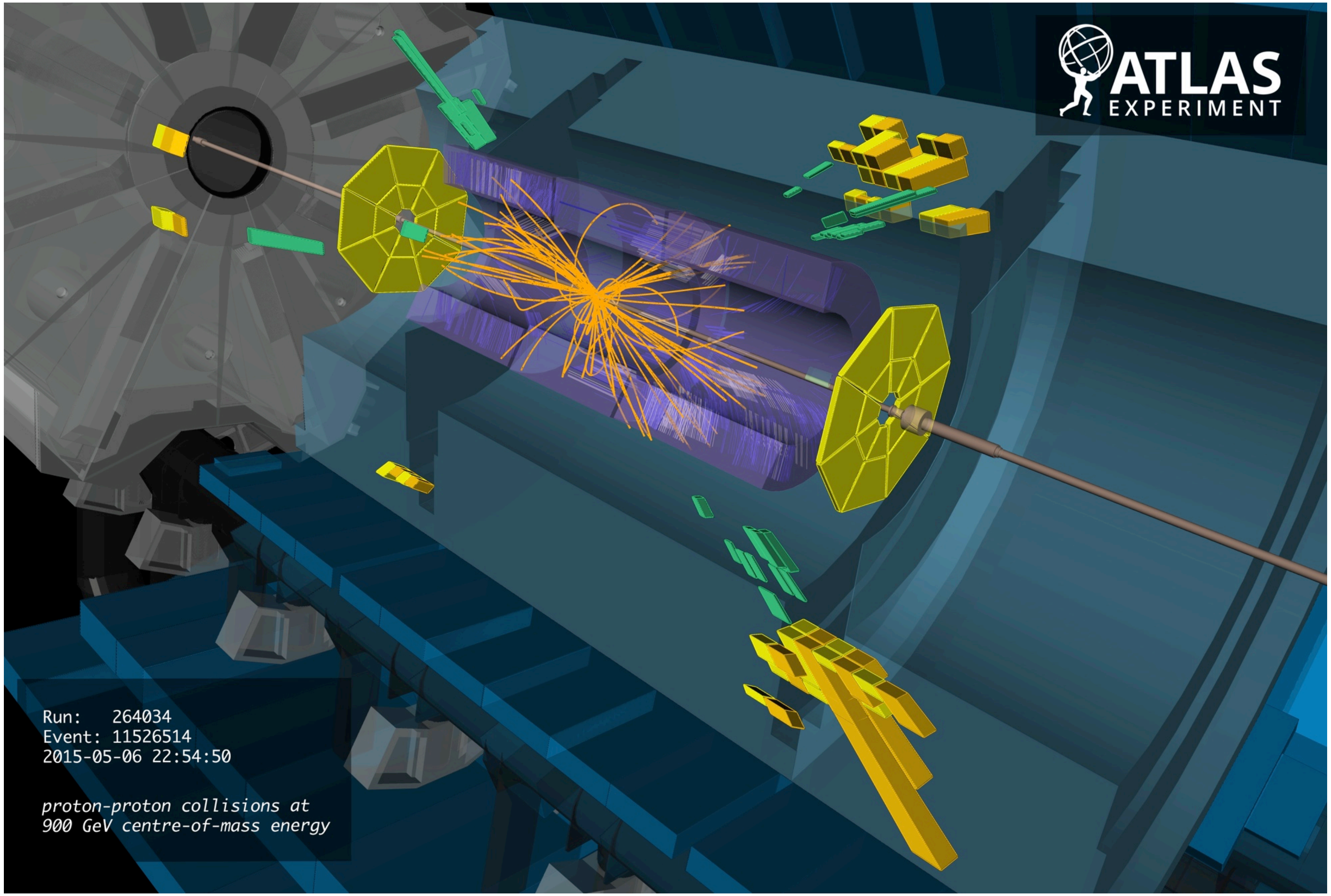
Time Distribution

Using splashes: TILECAL

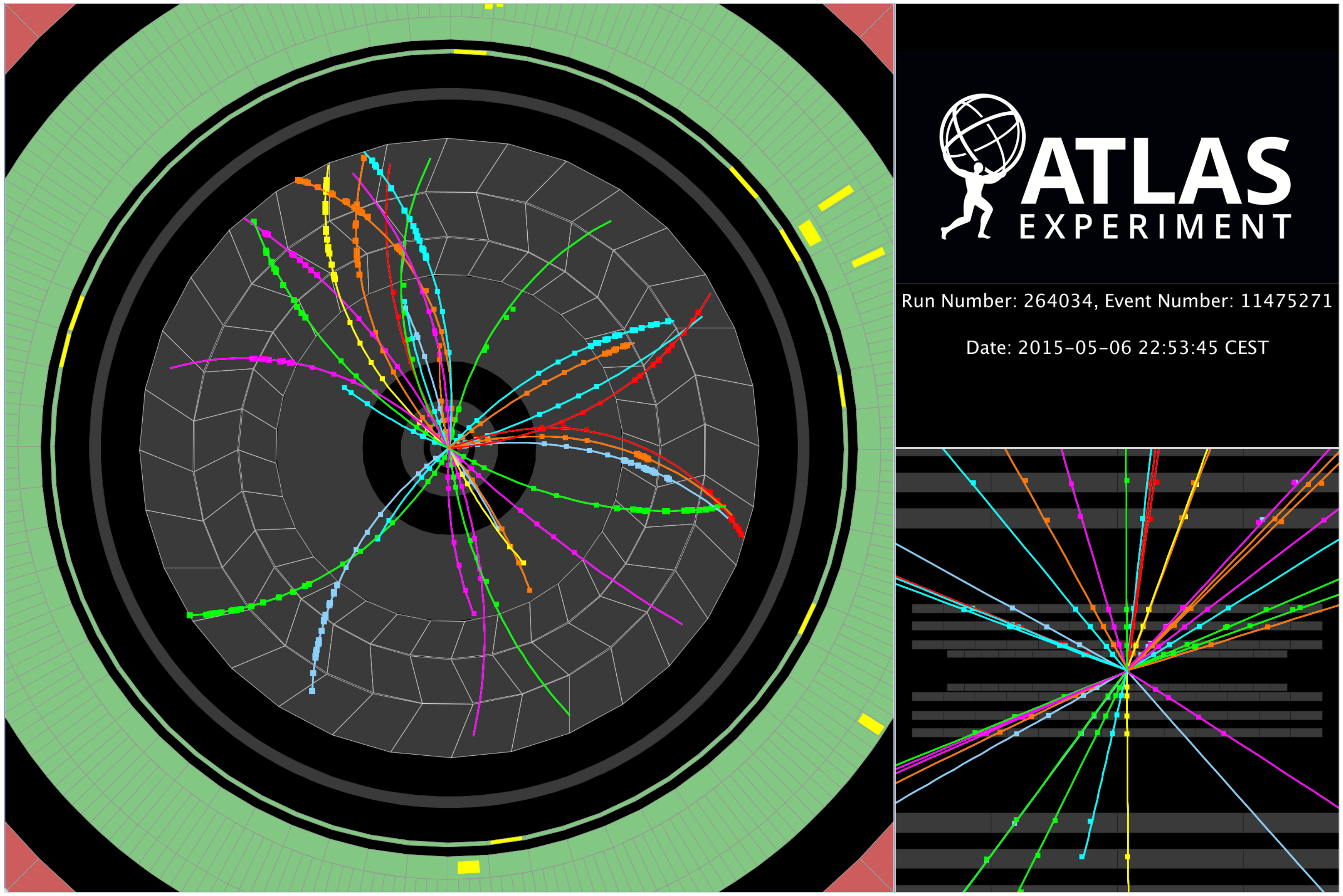


Timing of ATLAS TileCal signals recorded with single beam data on April 2015 (Beam 1, entering A-side, Z>0 and Beam 2, entering C-side, Z<0, splash events). Cell time distribution over several events, after removing ~2% of cells without a proper time calibration (mean=-0.34ns , RMS=1.20ns). Entries below -3ns and above 3ns are not shown, but all entries enter in the calculation of the mean and RMS of the distribution. The values of the mean and RMS reflect the replacement of the electronics happened during the maintenance work of the Long Shutdown. The timing offsets measured with splash events will be introduced in the ATLAS condition database and used in the reconstruction of the TileCal signals.

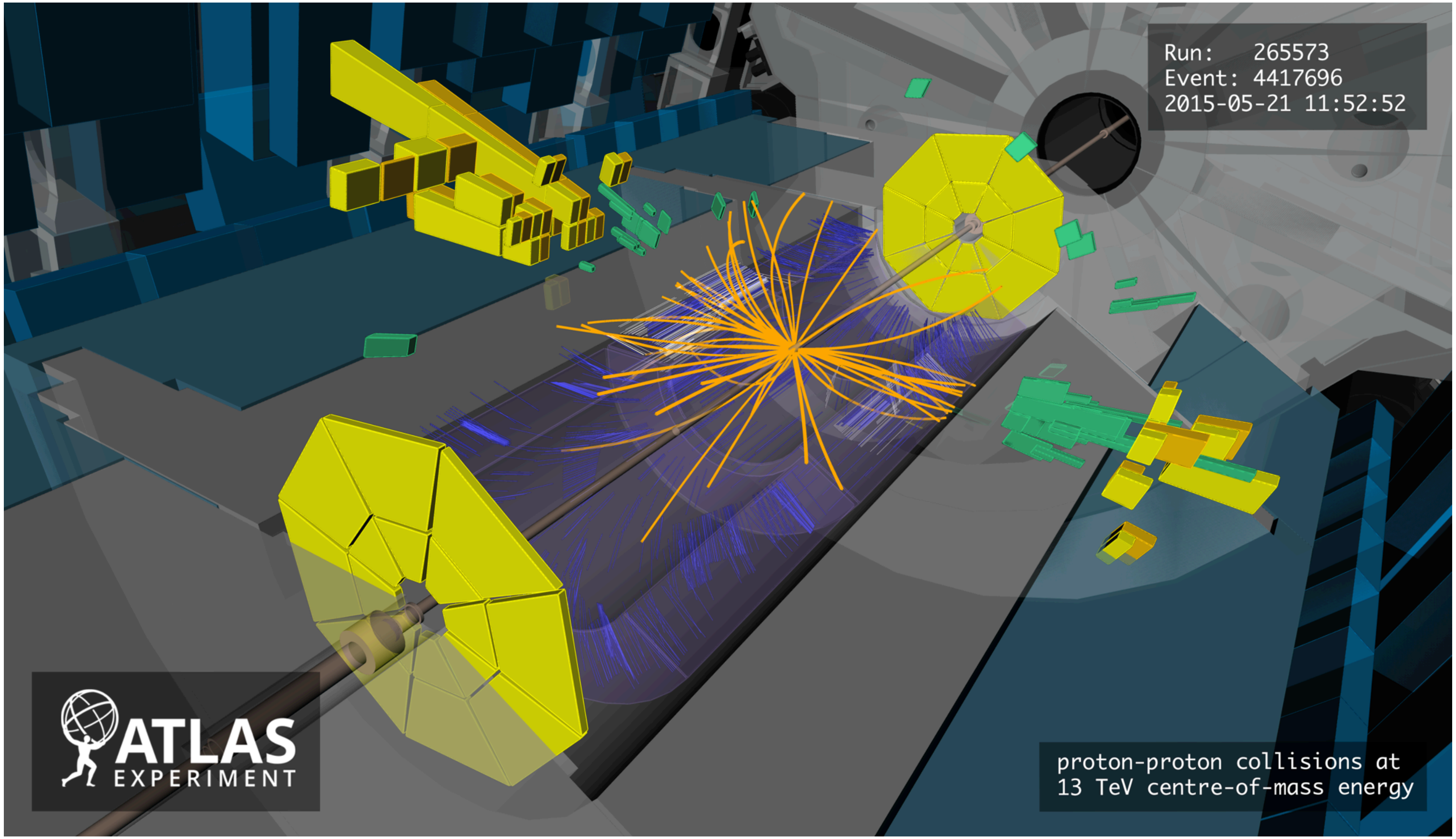
Collisions at 900 GeV



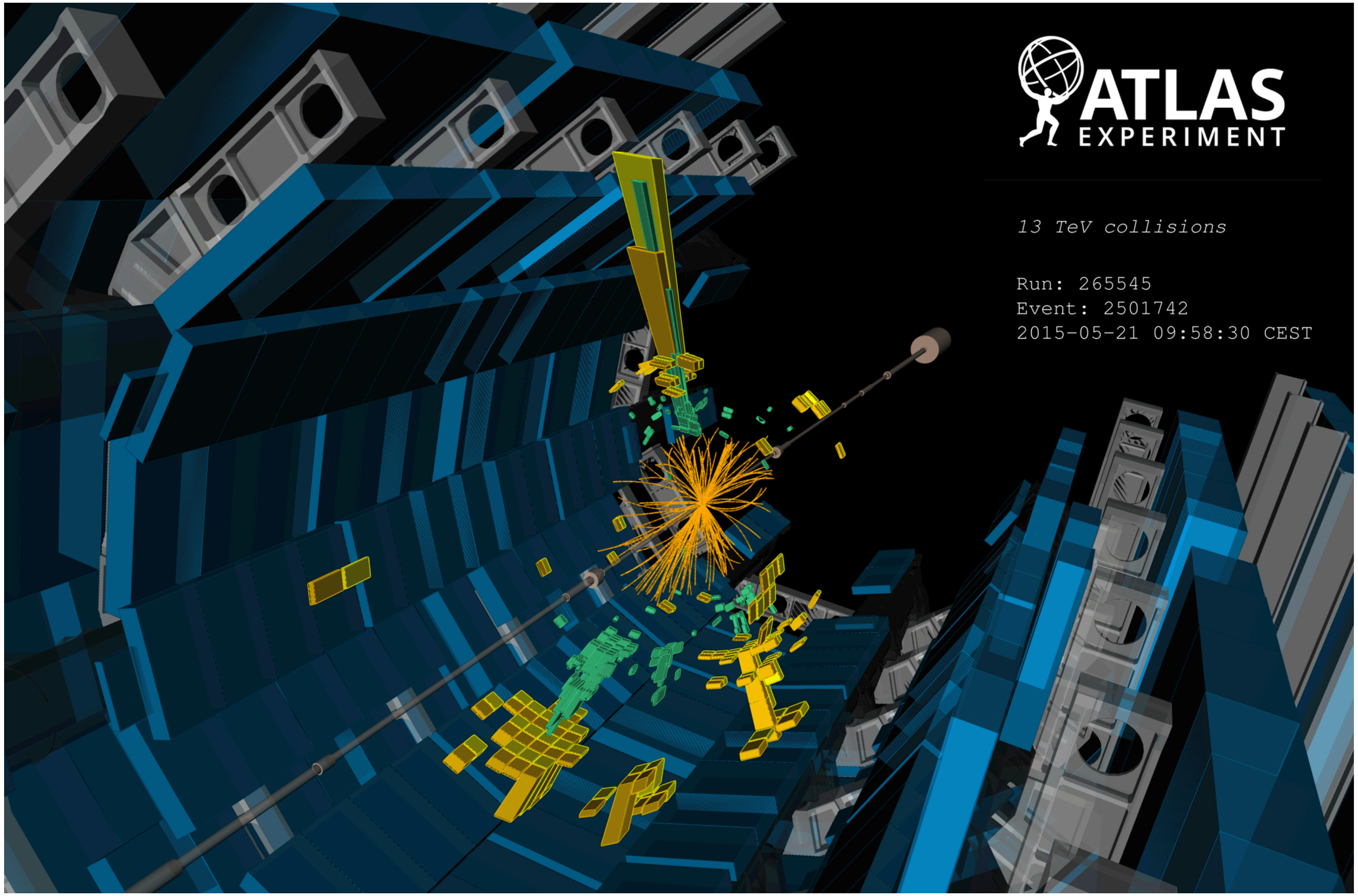
Collisions at 900 GeV: full tracker ON



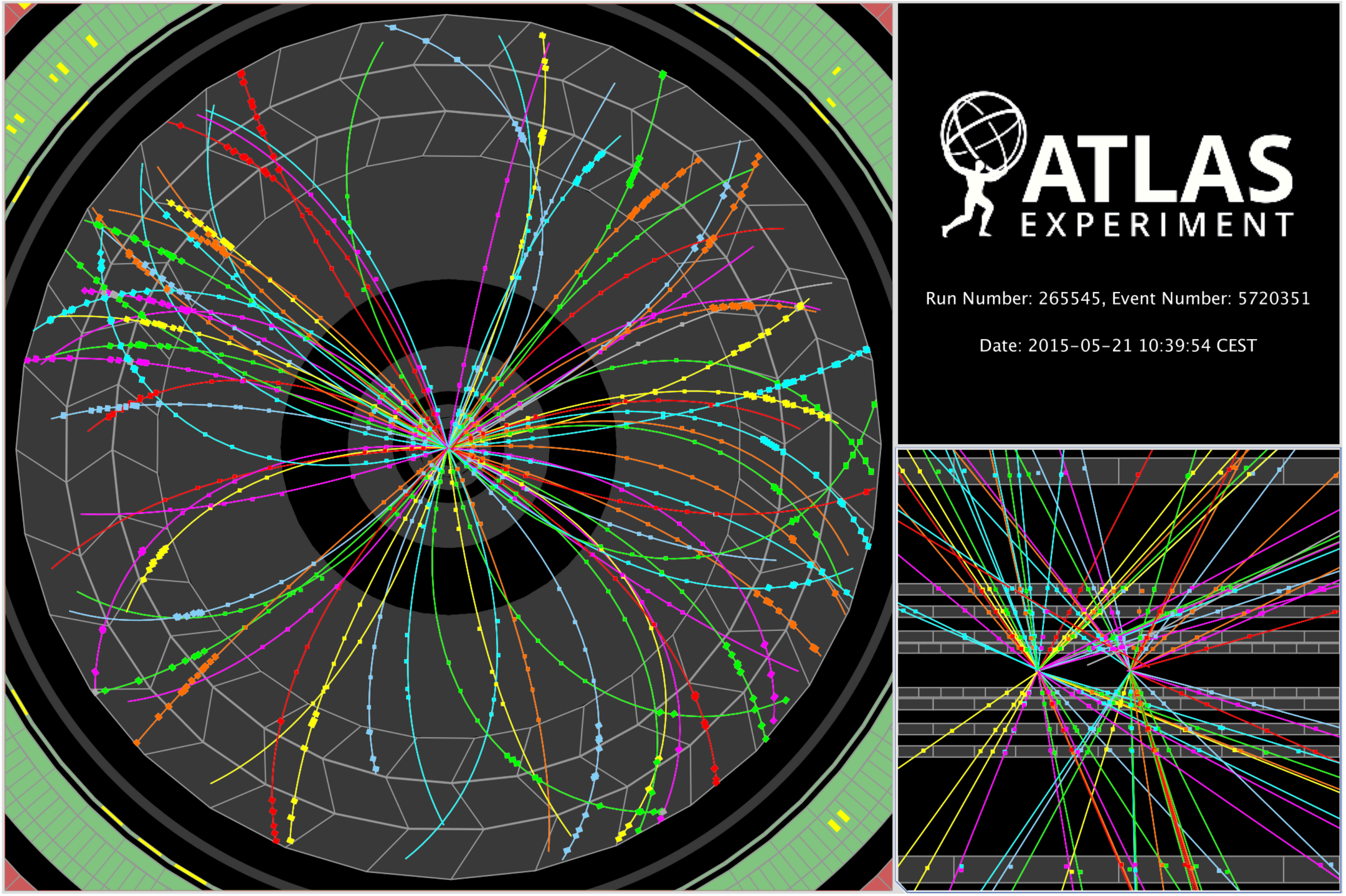
Collisions at 13 TeV: di-jet event



Collisions at 13 TeV: 4-jets event



Collisions at 13 TeV: pile-up



Conclusions

- After two long years to improve the Detector in all corners…
  - Addressing issues and improving infrastructure
  - Installing more channels: EE chambers and IBL
  - A refurbished Pixel detector: 4-Layers from now on, 92 M channels
- …it is time to full exploit it at higher energy and higher luminosity
- Looking in all possible directions with an improved detector for Run-II