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2016 ATLAS and LHCf overview

CERN Council Open Session

Federico Meloni

ATLAS
EXPERIMENT

To the LHC and injector teams

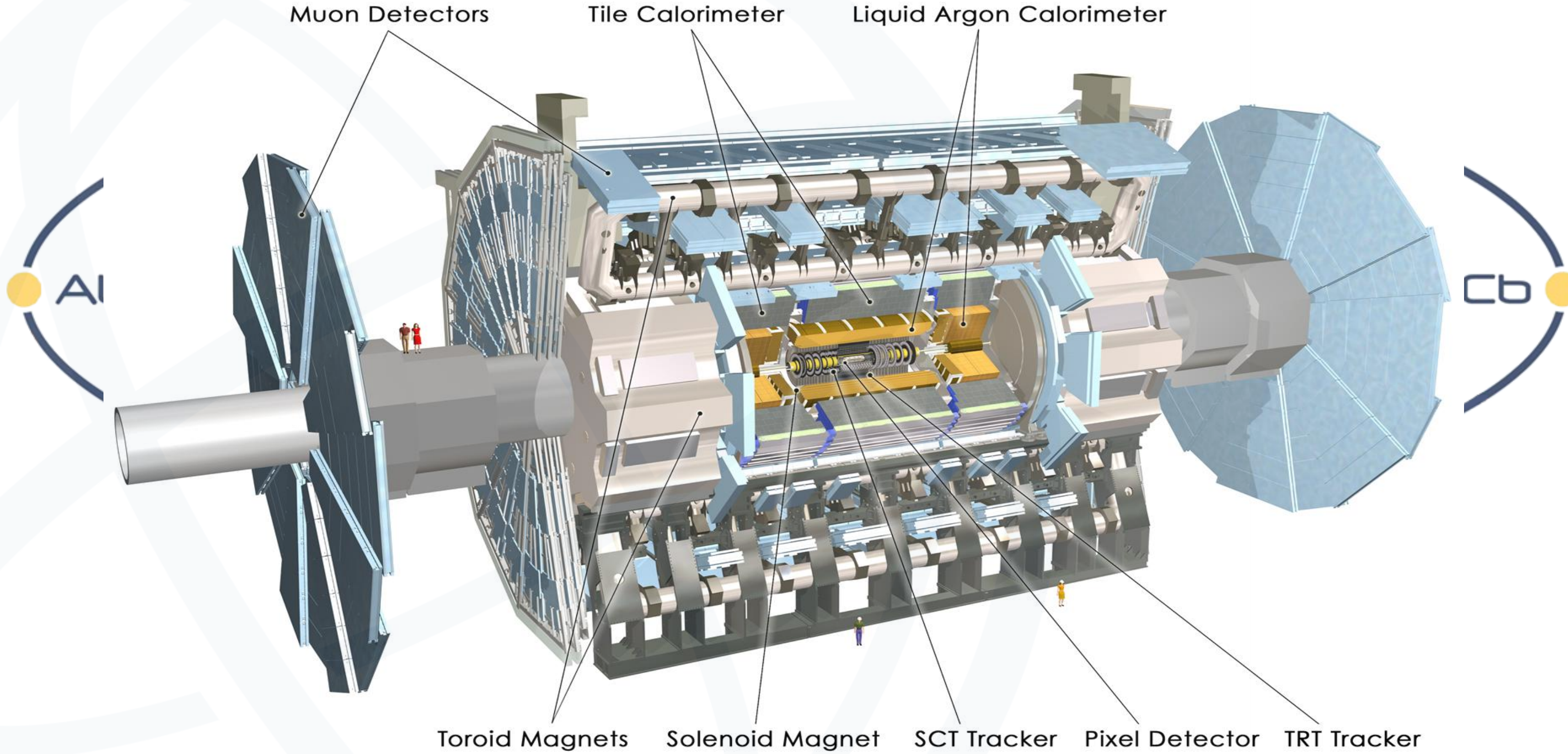
ALICE

LHCb

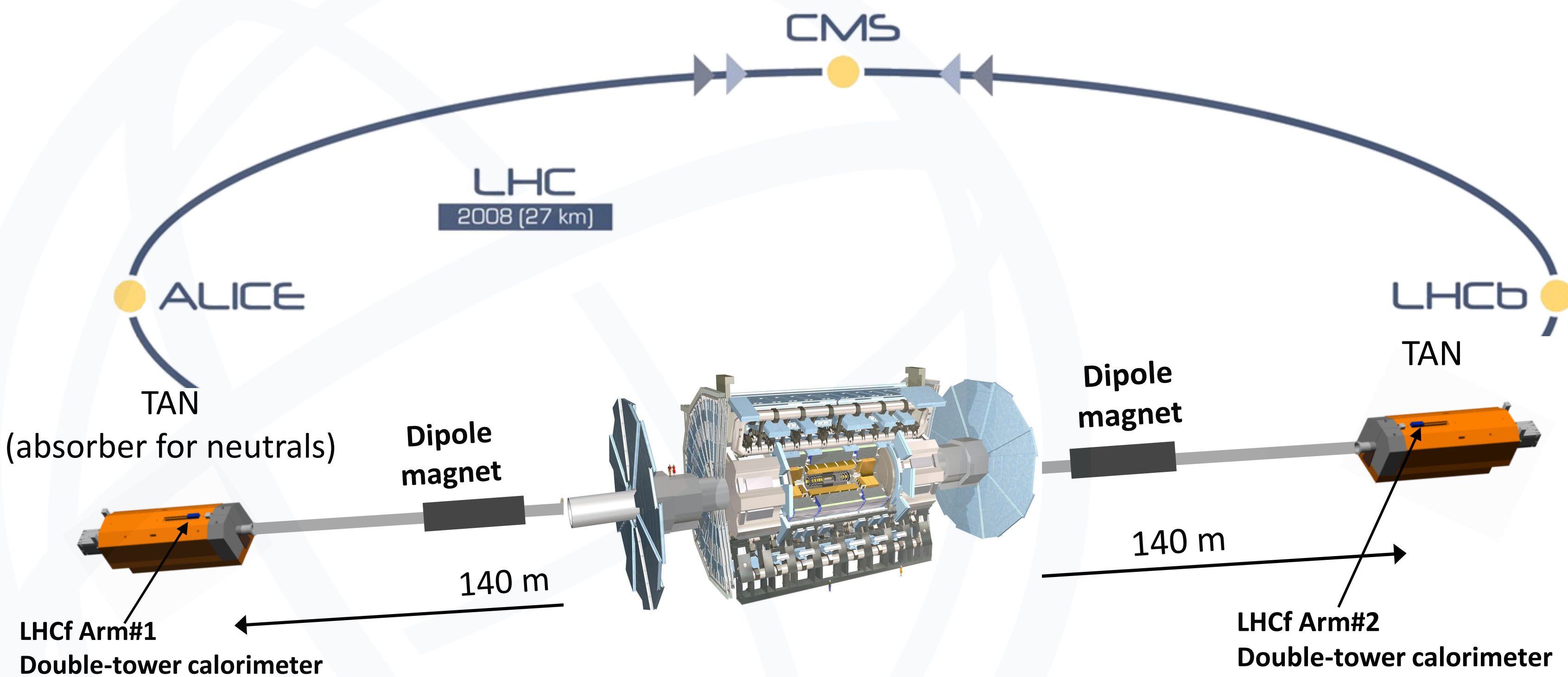
ATLAS

Thanks a lot for the fantastic dataset you delivered!

Physics around LHC Point 1



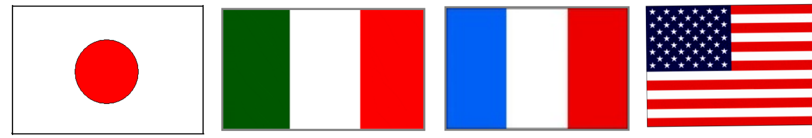
Physics around LHC Point 1



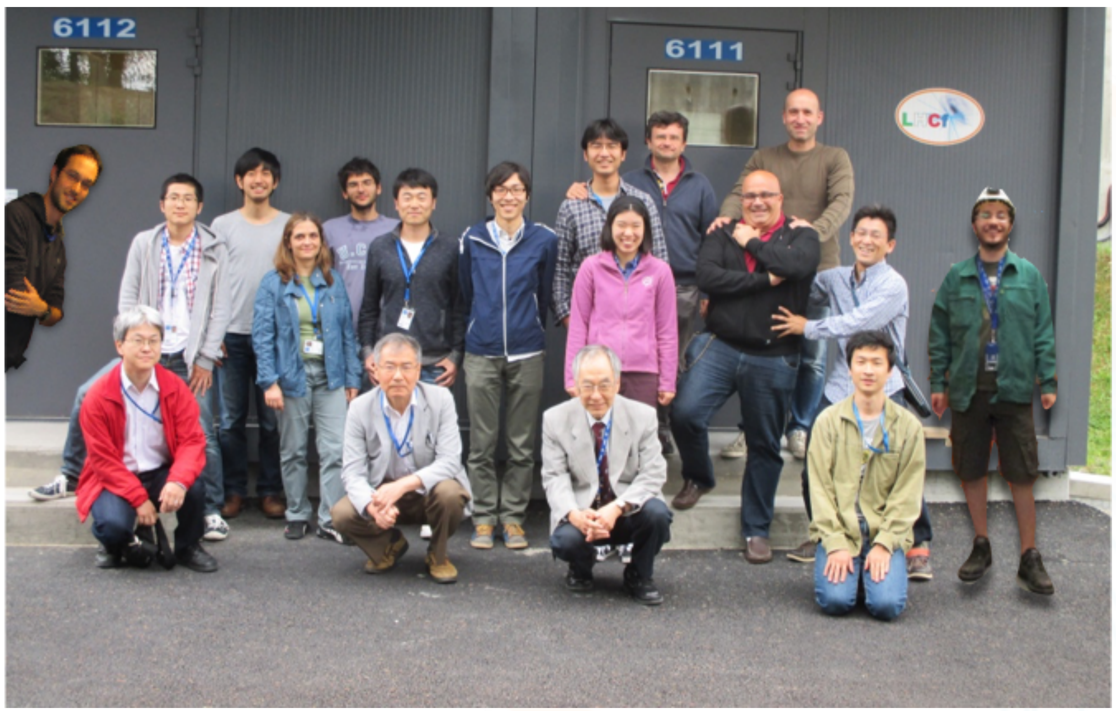
Two very different, but complementary experiments

The LHCf Collaboration

O. Adriani, E.Berti, L.Bonechi, M.Bongi, R.D'Alessandro, M.Haguenauer, Y.Itow, T.Iwata, K.Kasahara, Y.Makino, K.Masuda, Y.Matsubara, E.Matsubayashi, H.Menjo, Y.Muraki, P.Papini, S.Ricciarini, T.Sako, K.Sato, N.Sakurai, Y.Shimitsu, M.Shinoda, T.Suzuki, T.Tamura, A.Tiberio, S.Torii, A.Tricomi, W.C.Turner, M.Ueno, K.Yoshida, Q.D.Zhou

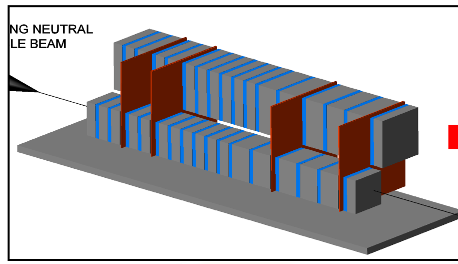


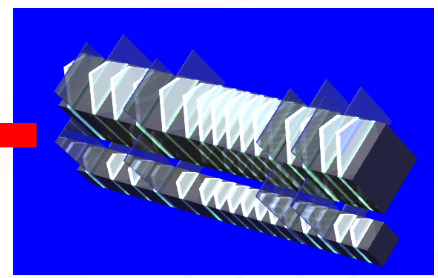
4 countries
14 institutions
~10 students



The LHCf detector

Position resolution: < 200 μm (Arm1) and 40 μm (Arm2)
Energy resolution: < 5% for photons; 30% for neutrons
Pseudo-rapidity range: $\eta > 8.7$ @ zero crossing angle
$\eta > 8.4$ @ 140 μrad



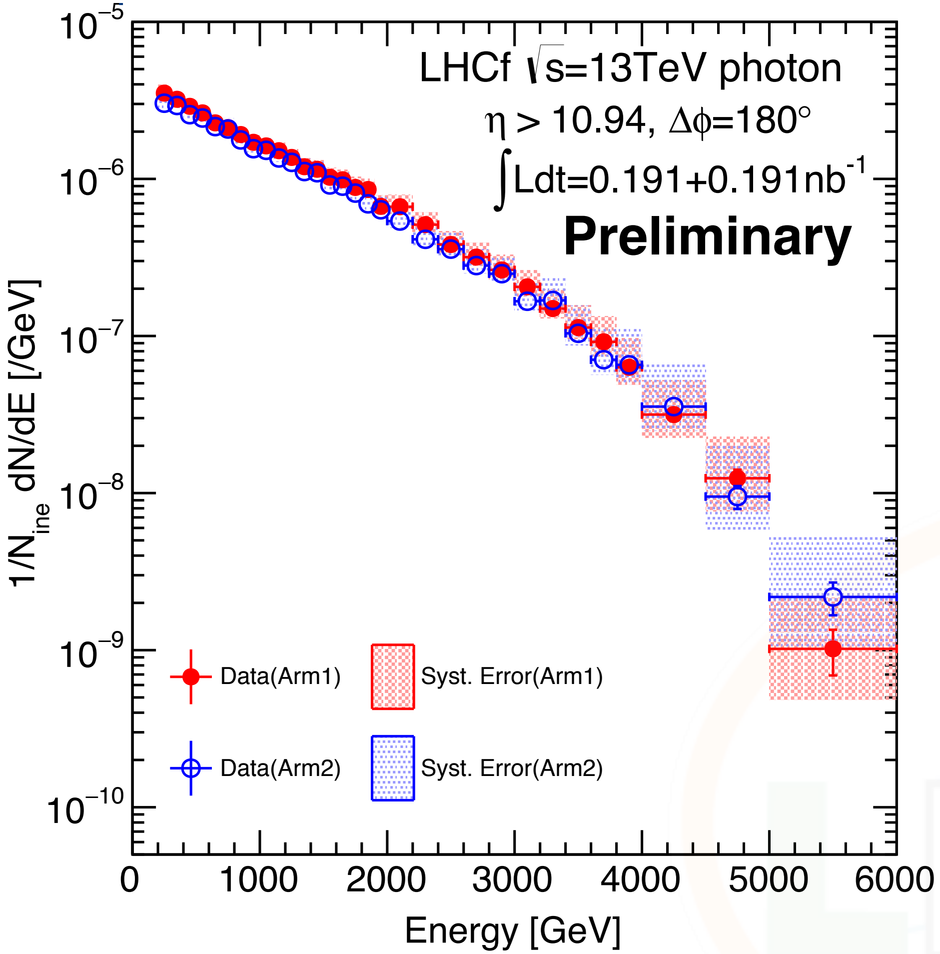


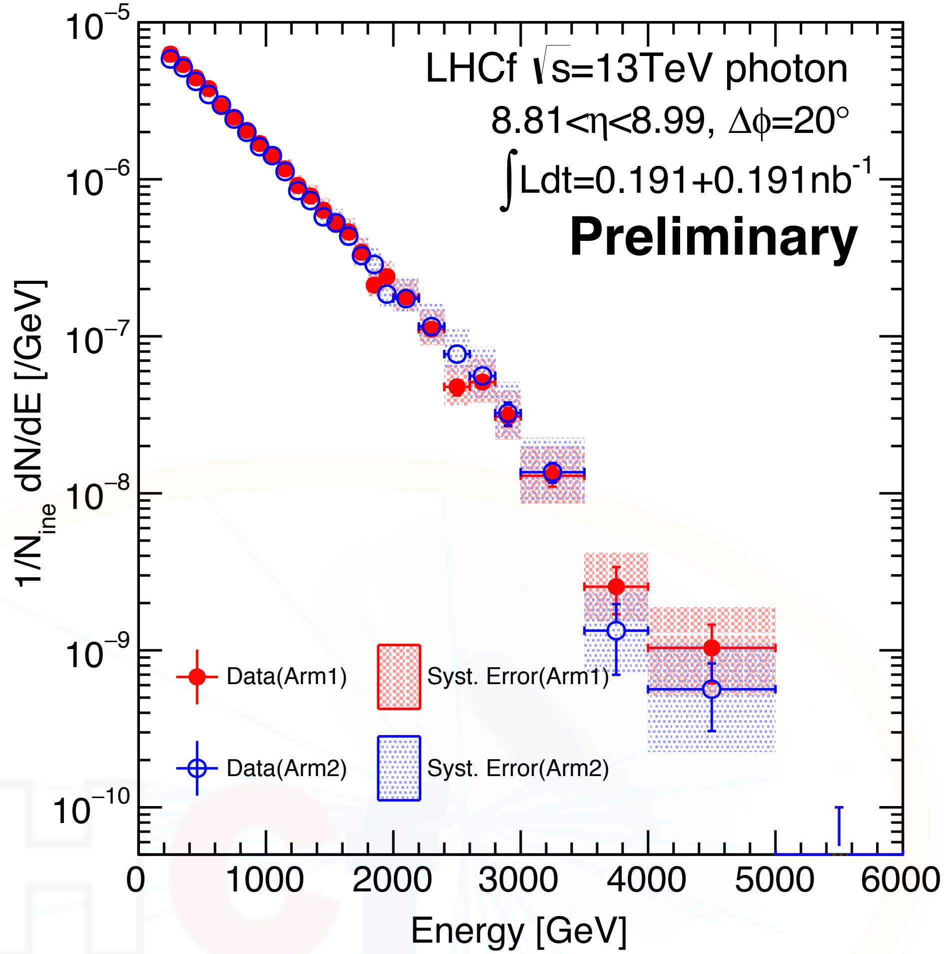
Arm1 Detector
2cm x 2cm + 4cm x 4cm
GSO tiles (e.m. calorimeter)
4 X-Y tracking layers
(GSO bars)

44 X_0
~1.5 λ_{int}

Arm2 Detector
2.5cm x 2.5cm + 3.2cm x 3.2cm
GSO tiles (e.m. calorimeter)
4 X-Y tracking layers
(silicon microstrip)

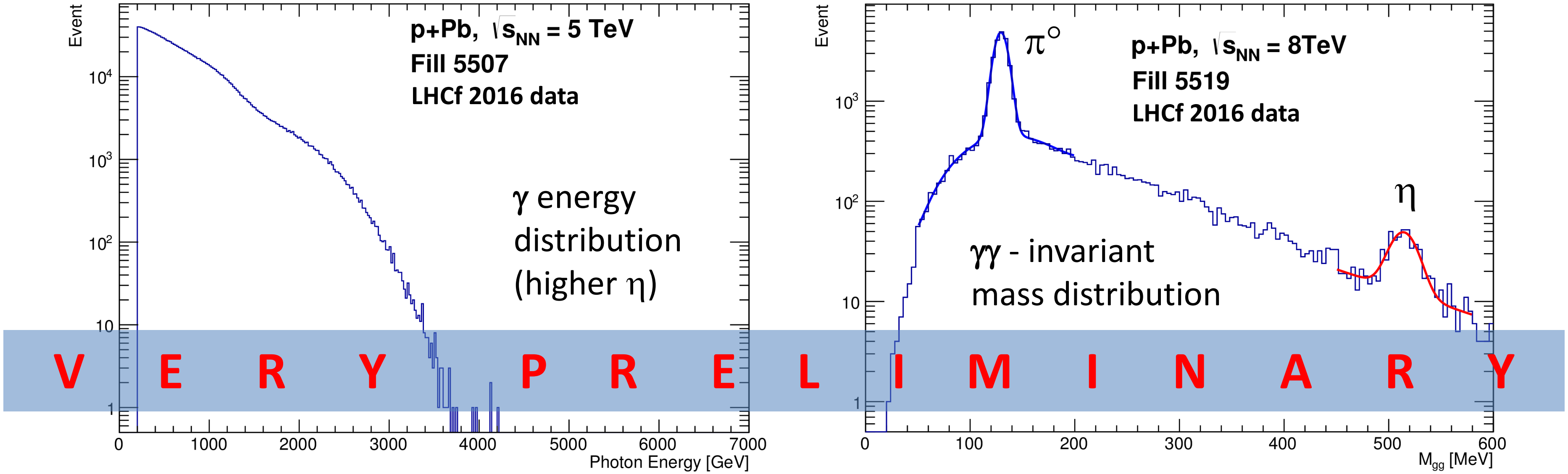
The LHCf performance





- **Arm1 and Arm2 spectra are consistent** within the estimated systematics (mostly energy scale and multi-hit correction)

The LHCf 2016 run



LHCf has taken data in combination with ATLAS

- Exploit the ATLAS tracker to separate the contributions from diffractive and non-diffractive collisions
- Various datasets (for $\sqrt{s_{pp}}$ = 13 TeV, $\sqrt{s_{pPb}}$ = 5 TeV and $\sqrt{s_{pPb}}$ = 8 TeV) available for combined analysis

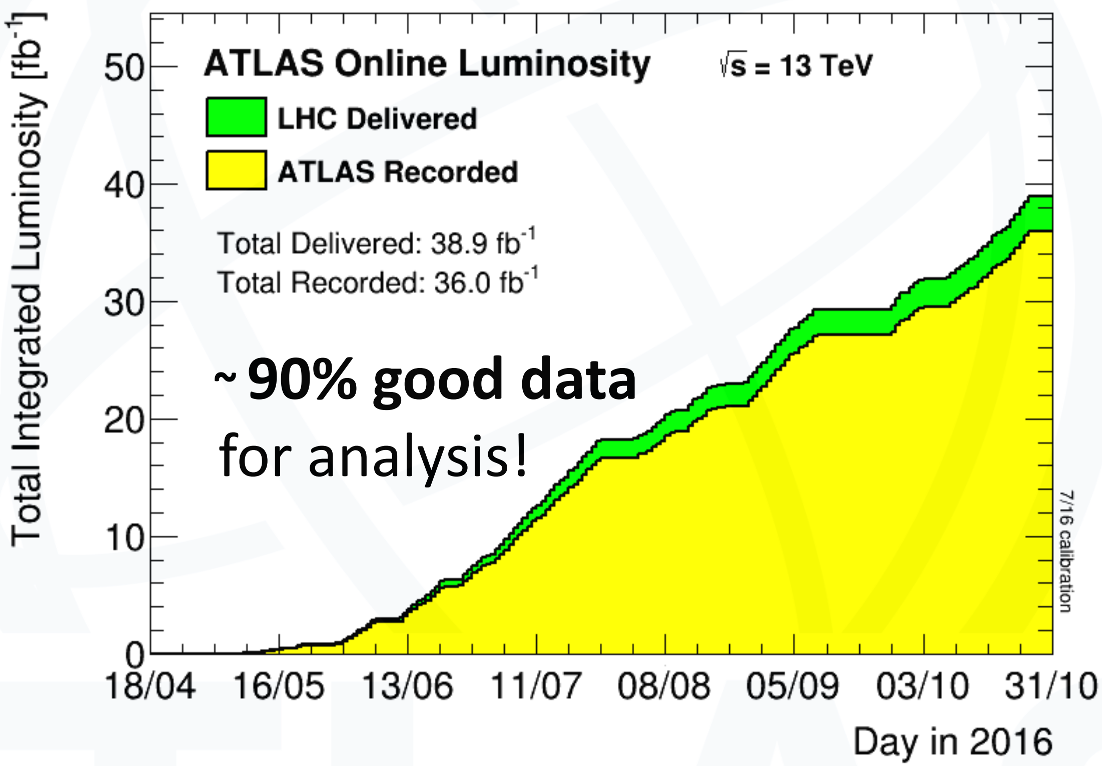
The LHCf Collaboration would like to thank the LHC Programme coordinators, the tunnel activities coordinator and all the people involved on the machine side for the final success of the 2016 run!!!

The ATLAS Collaboration

The ATLAS data taking

ATLAS has performed very well in 2016!

- New systems commissioned and operational
- **>96% working channels** (pixels, cells...)



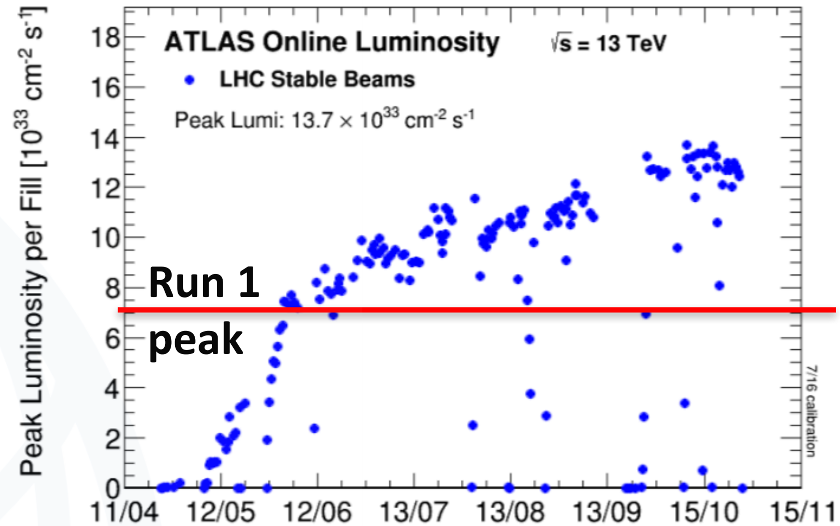
~ **90% good data**
for analysis!

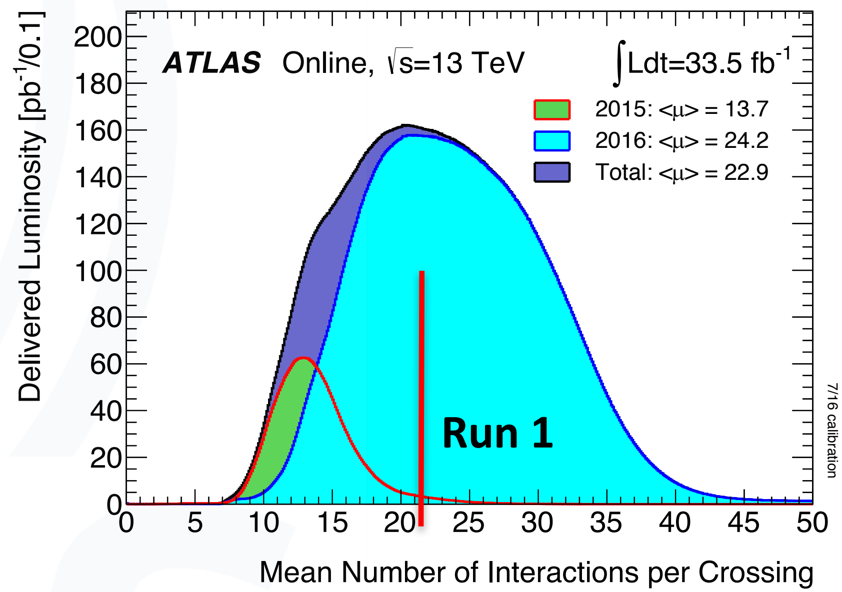
We have recorded more *pp* data in 2016 **than in all the previous years combined!**

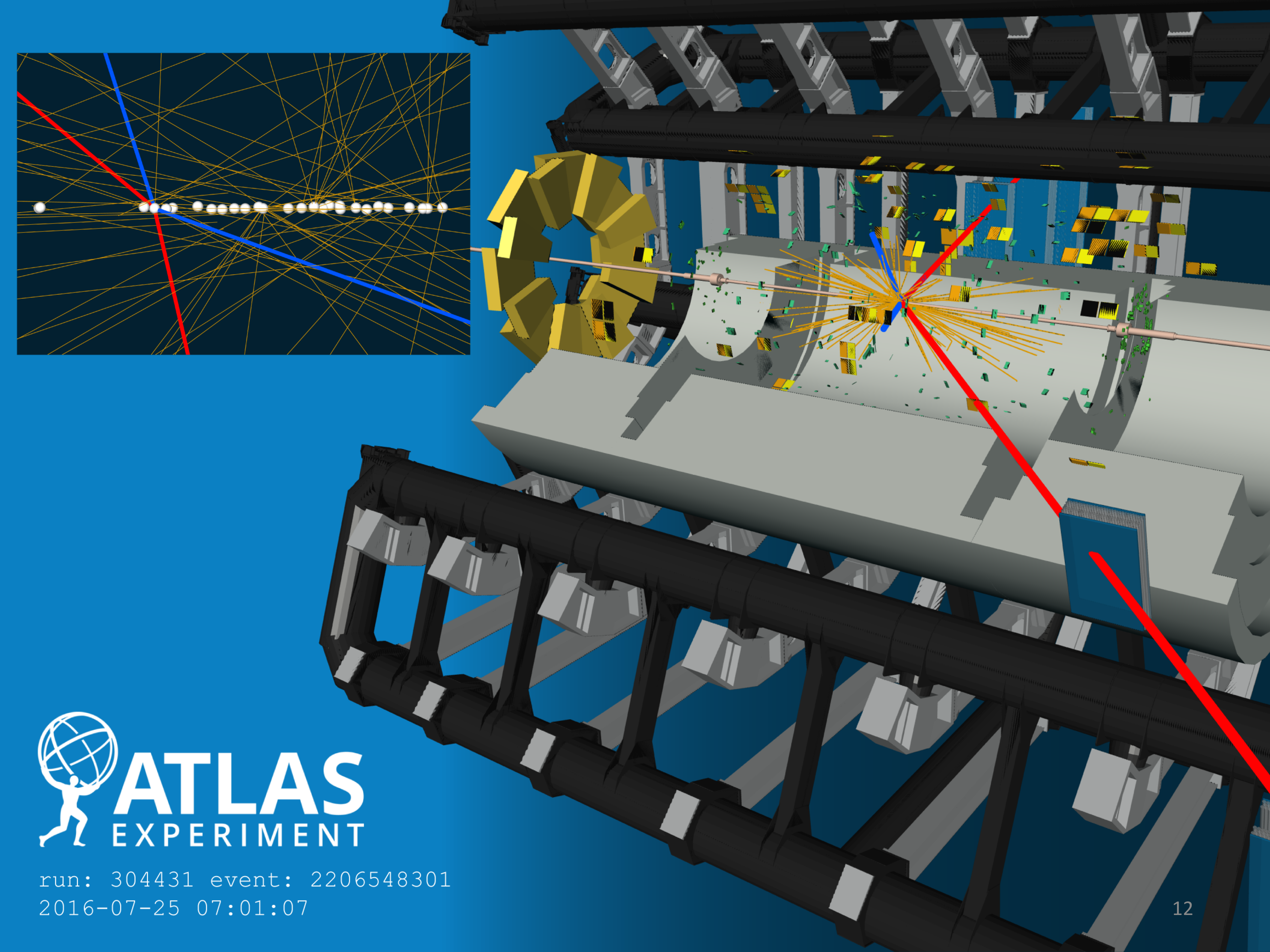
The pile-up challenge

We acquired data following the LHC beyond the design specifications

- **Twice as high luminosity as in Run-1!**
- Improved understanding of the detector and mitigated challenges as luminosity increased



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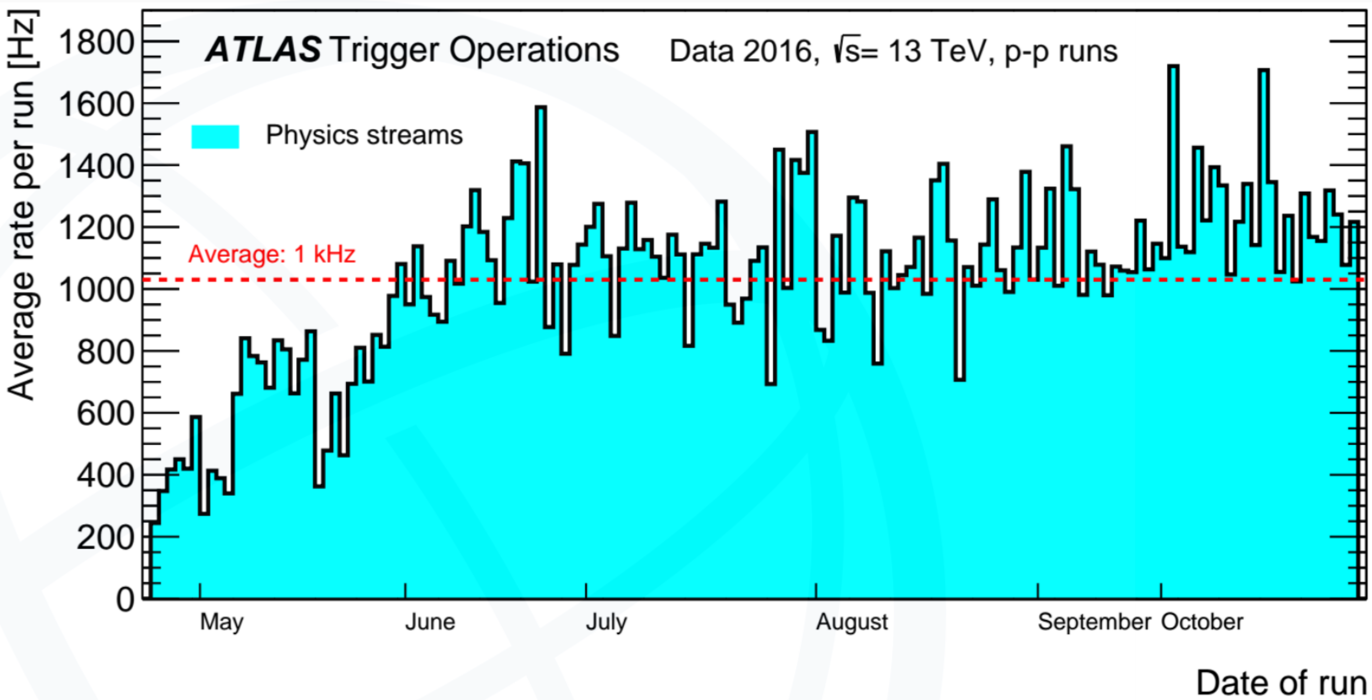
run: 304431 event: 2206548301
2016-07-25 07:01:07

Online event selection



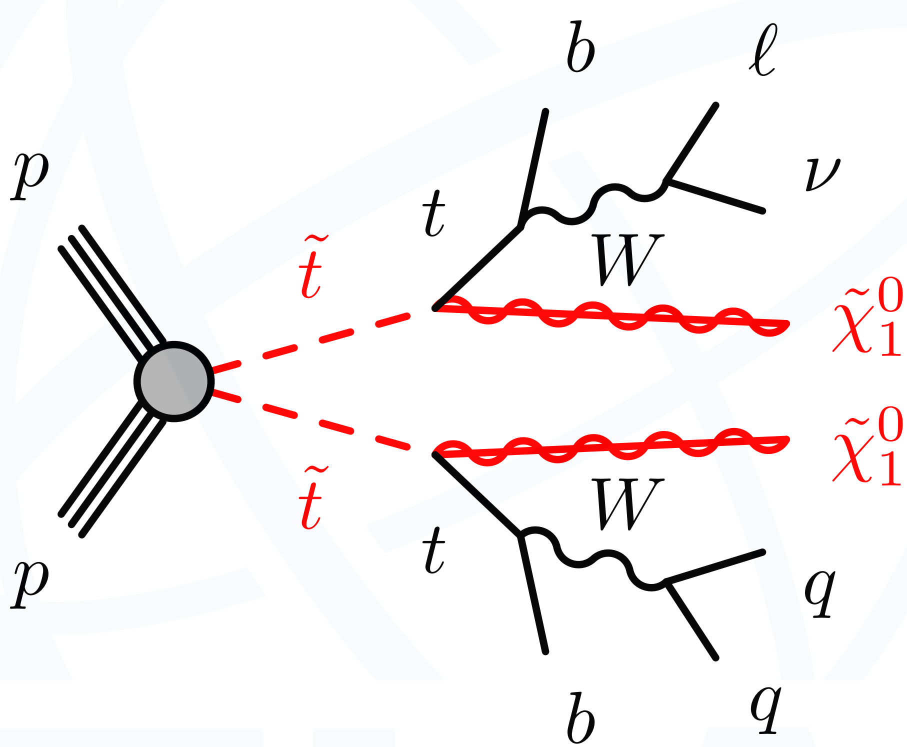
Online selections (triggers) nearly stable across the whole year despite the increasing luminosity

- **Coherent dataset across 2015 and 2016**

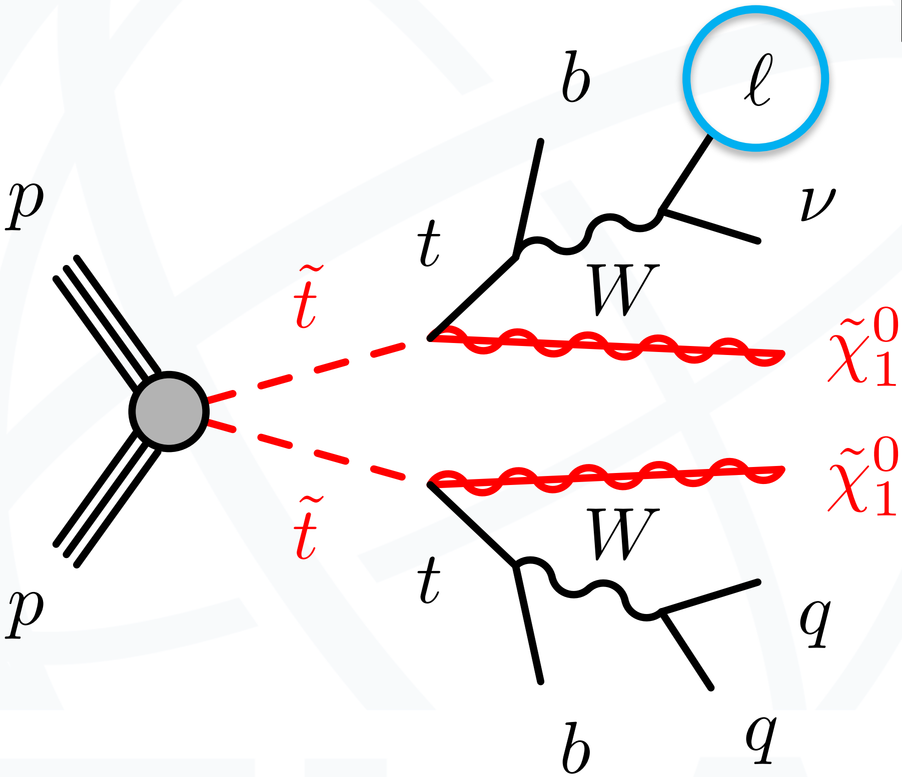
What to look for

One of the main goals of the 13 TeV run is to look for new physics

- This often implies understanding complex topologies

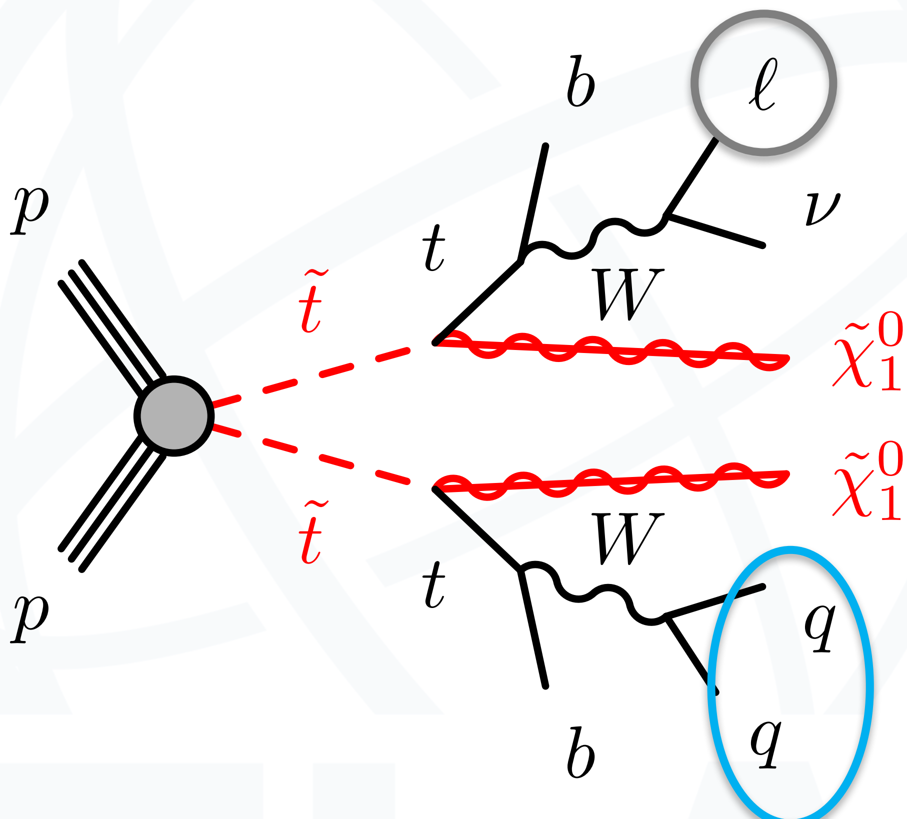


What to look for



Charged leptons!

What to look for



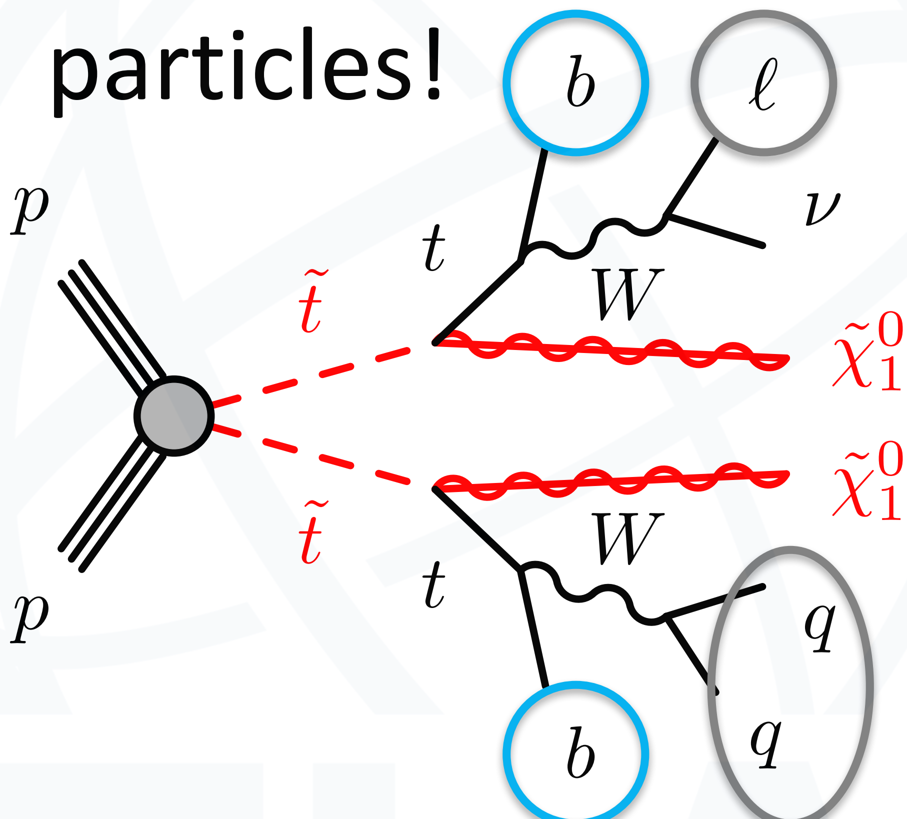
Charged leptons!

Jets!

What to look for

'Long lived' particles!

Charged leptons!

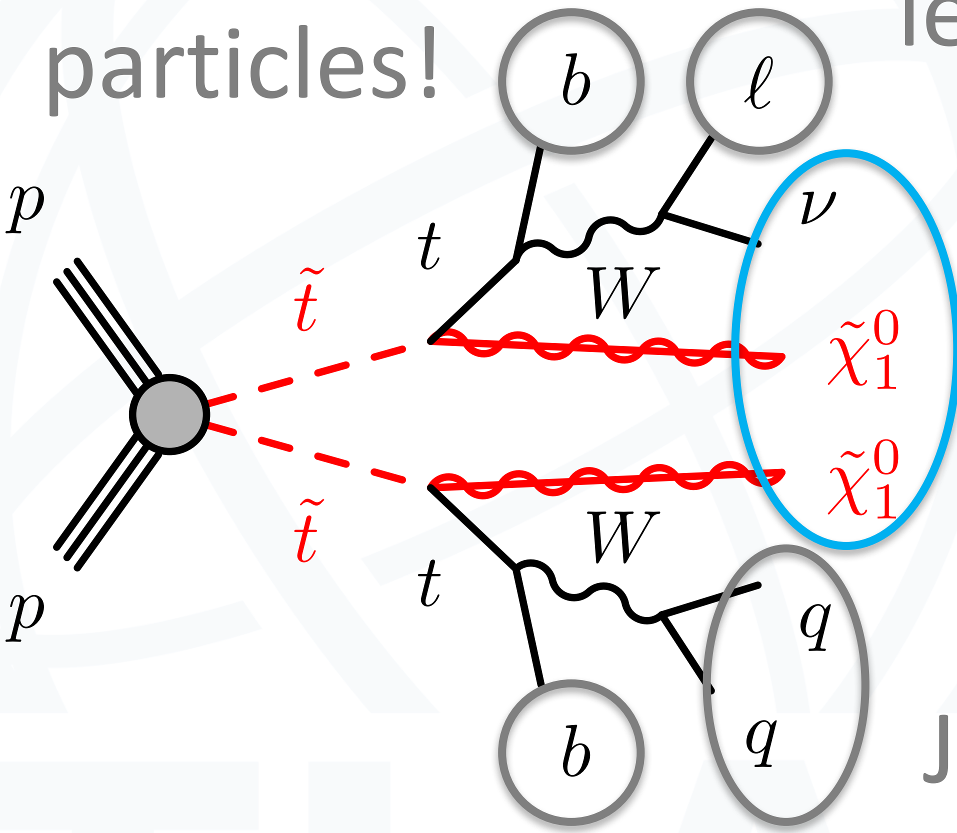


Jets!

What to look for

'Long lived' particles!

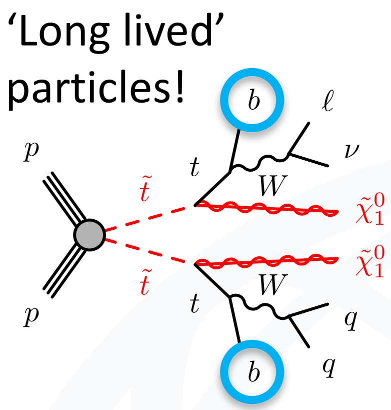
Charged leptons!



Invisible particles!

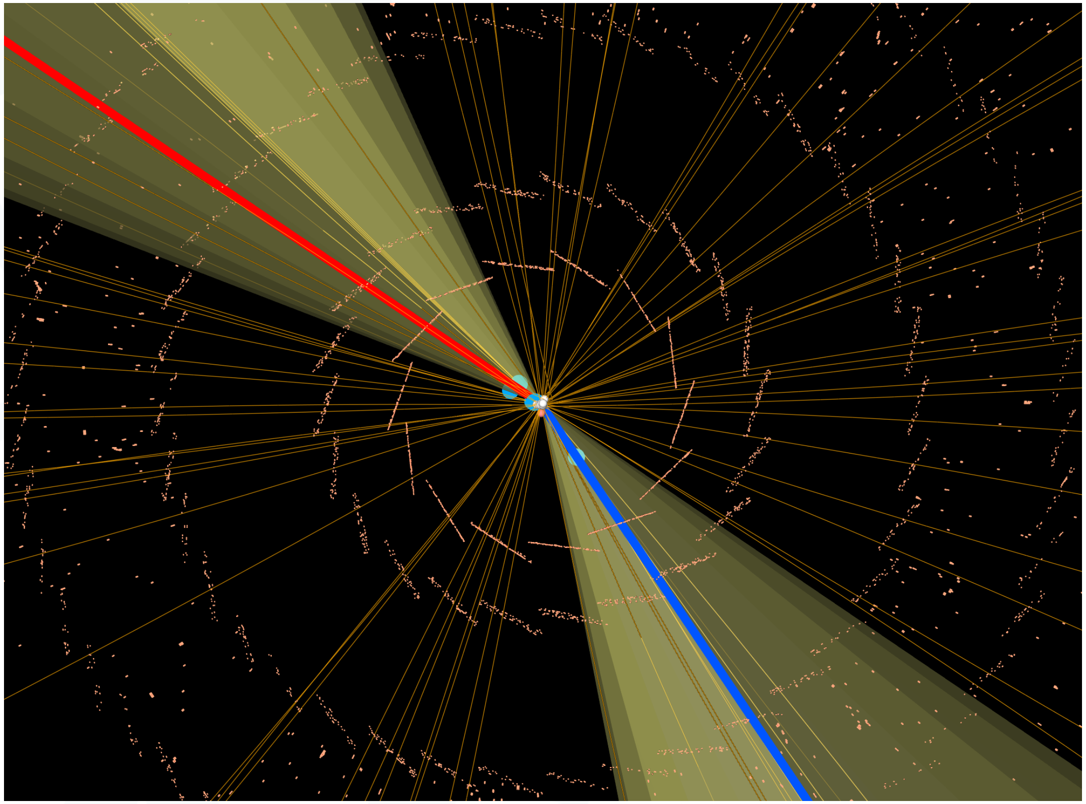
Jets!

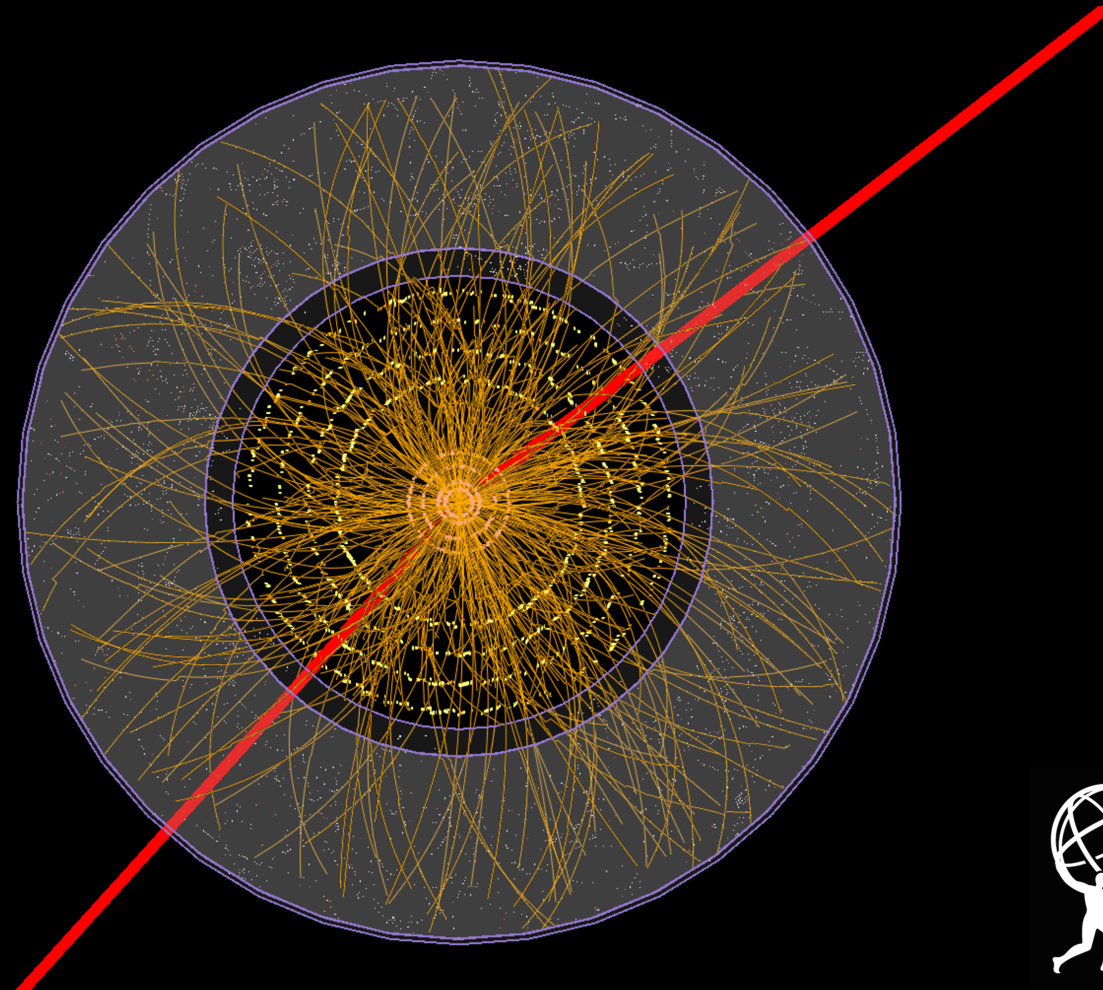
Flavour Tagging



Heavy flavour quarks form intermediate particles that travel away from the interaction before decaying.

- We are able to **identify them by looking for displaced vertices**





ATLAS EXPERIMENT

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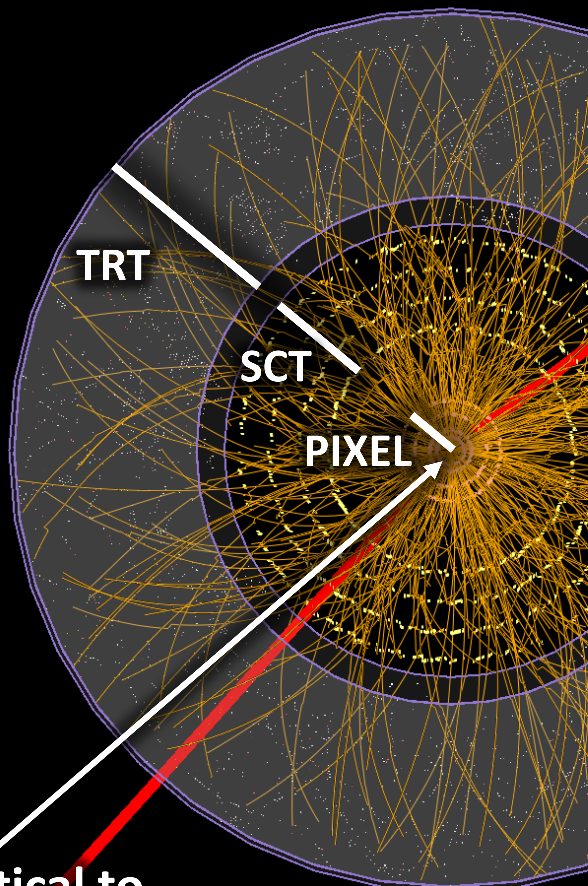
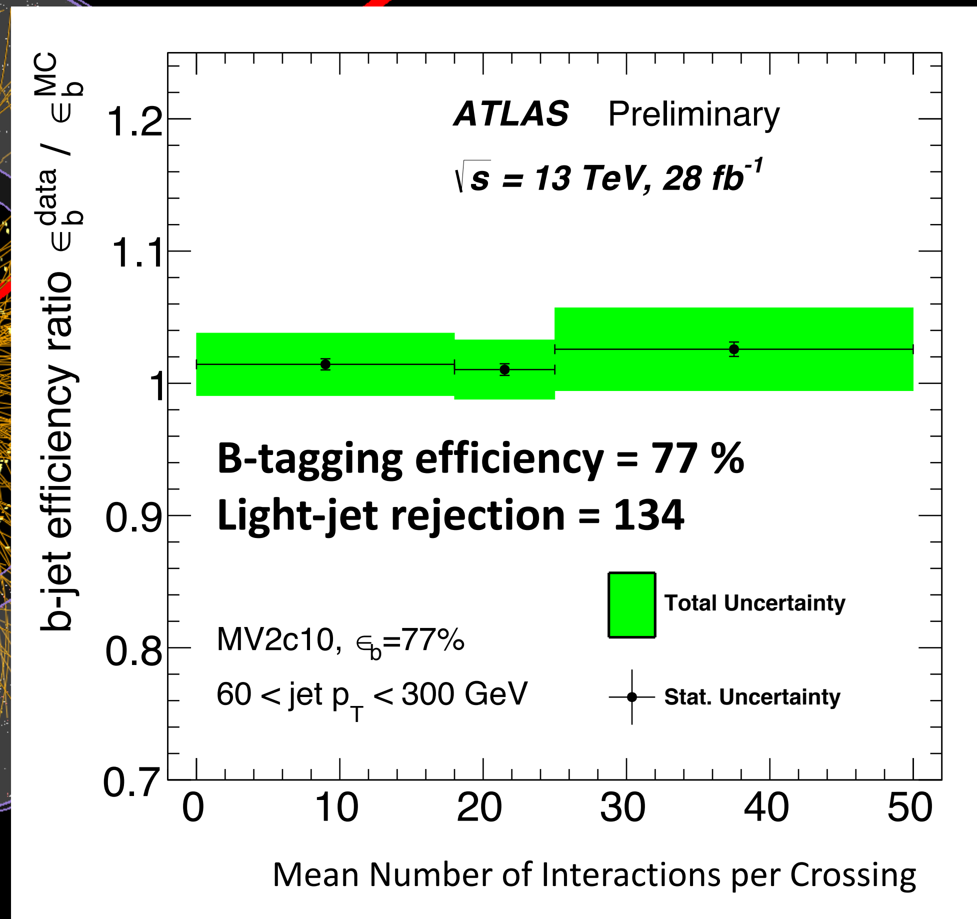
Event: 242090708
2015-06-14 01:01:14 CEST

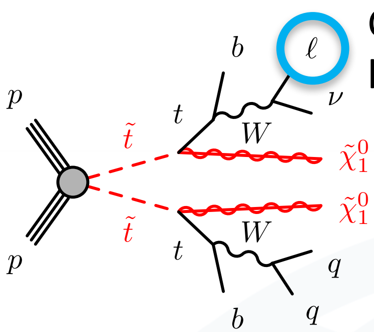
Flavour Tagging





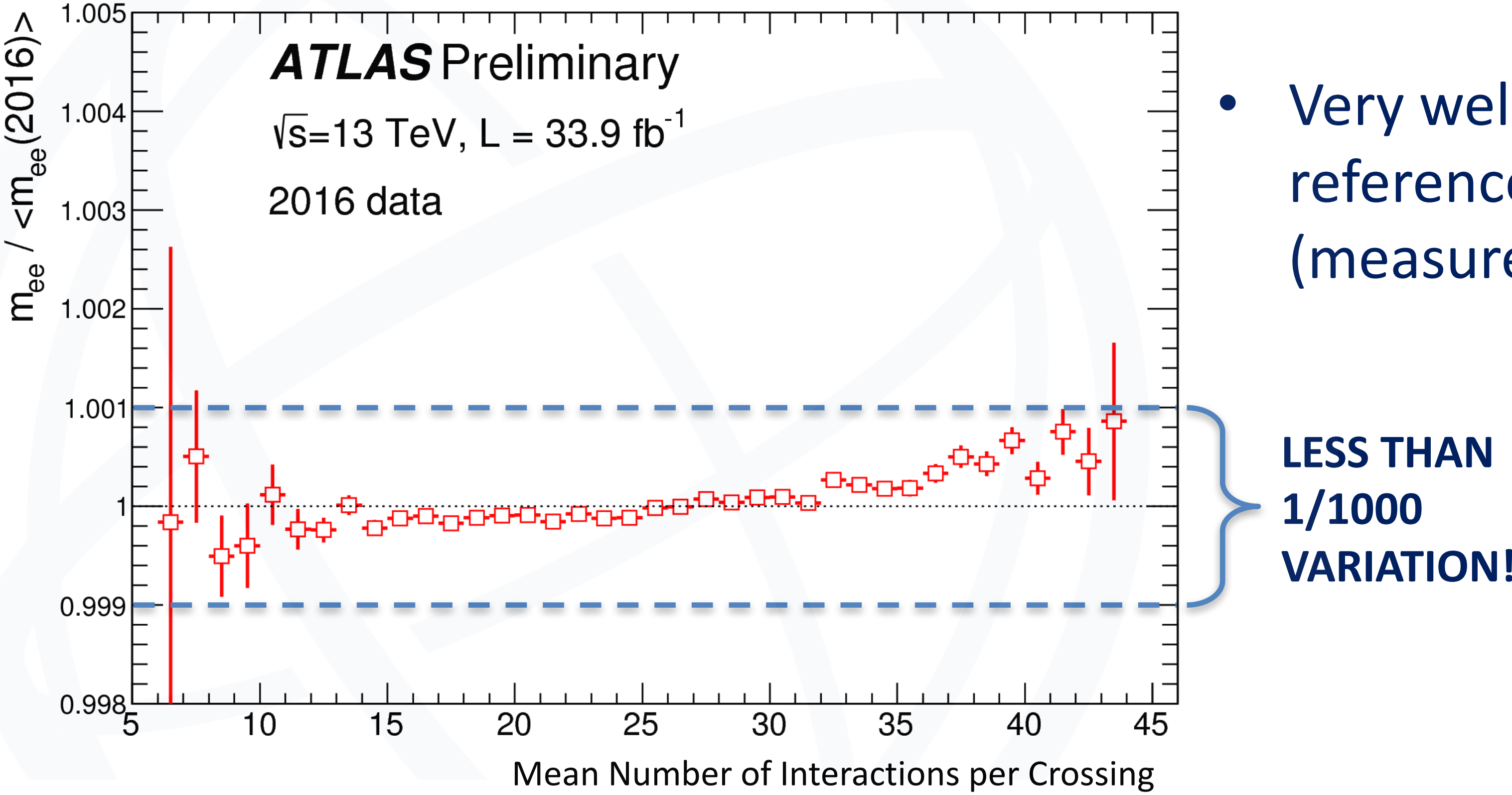
IBL: critical to achieve this performance!

Identification efficiency robust against presence of additional interactions



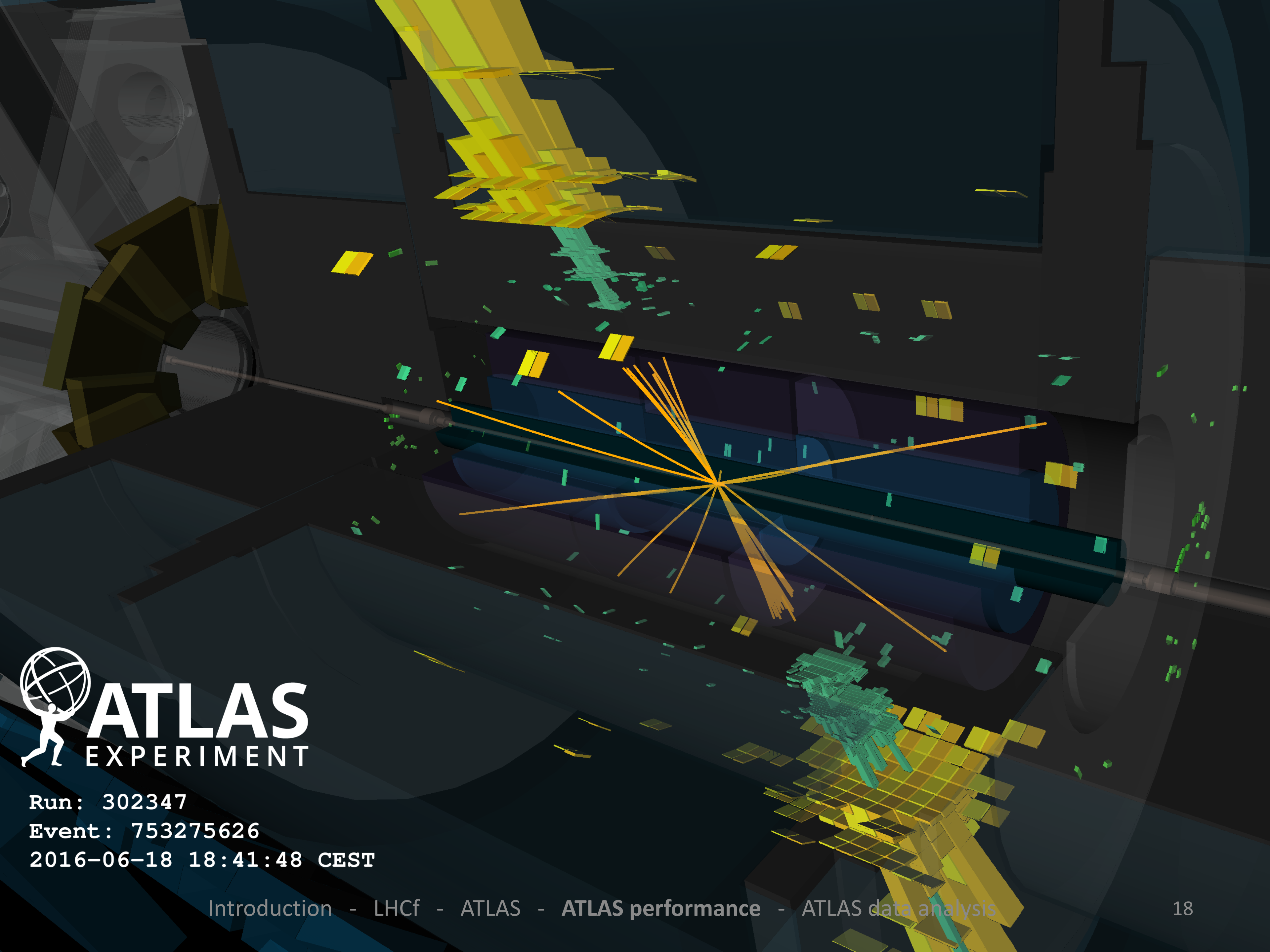
Electrons

The leptonic decays of the Z boson are used to monitor the electron energy calibration.



- Very well known reference mass (measured at LEP)

- Impressive stability of electron energy calibration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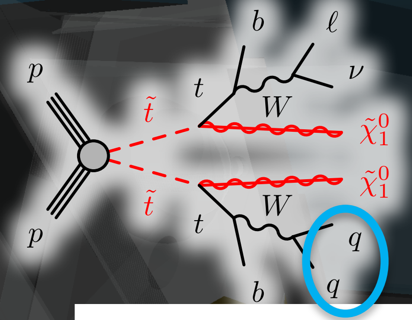
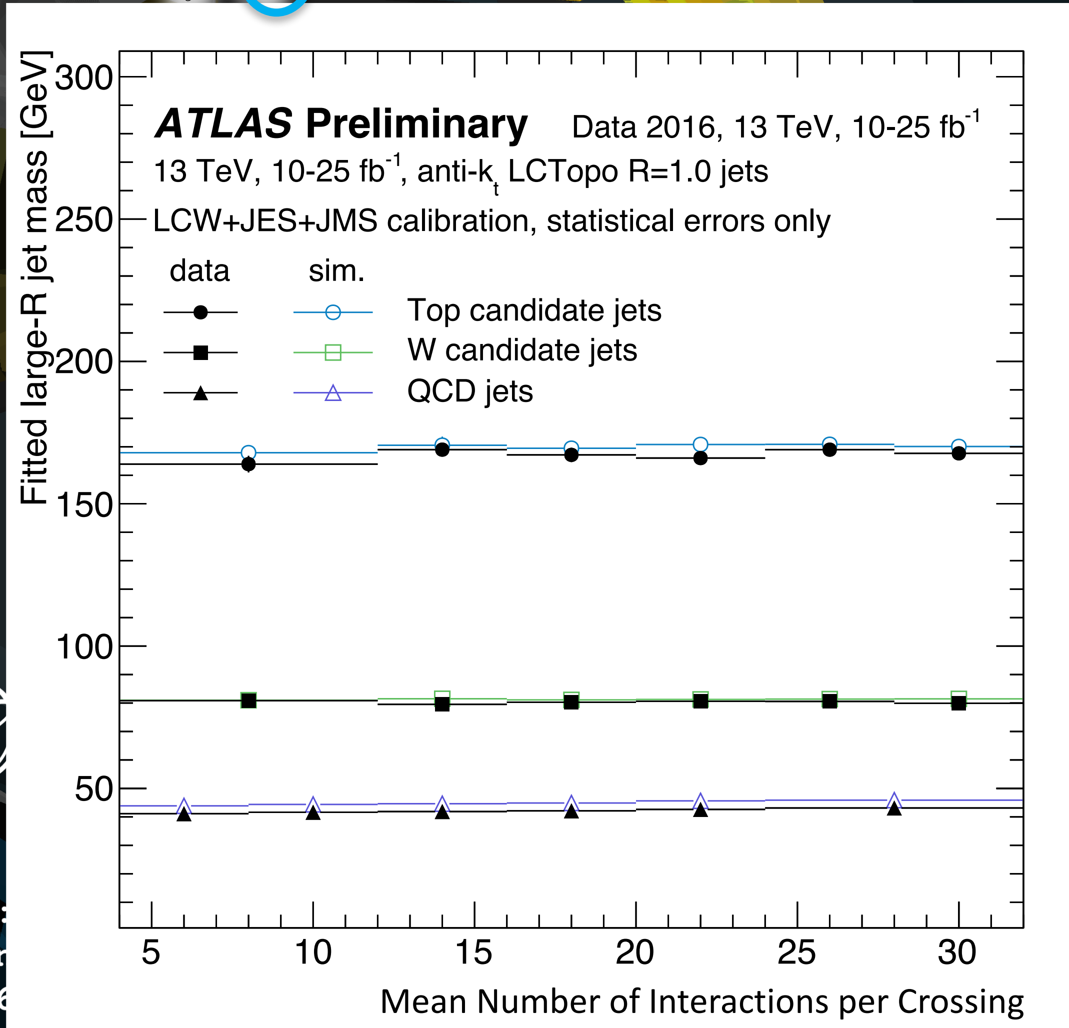
Run: 302347
Event: 753275626
2016-06-18 18:41:48 CEST

Jets



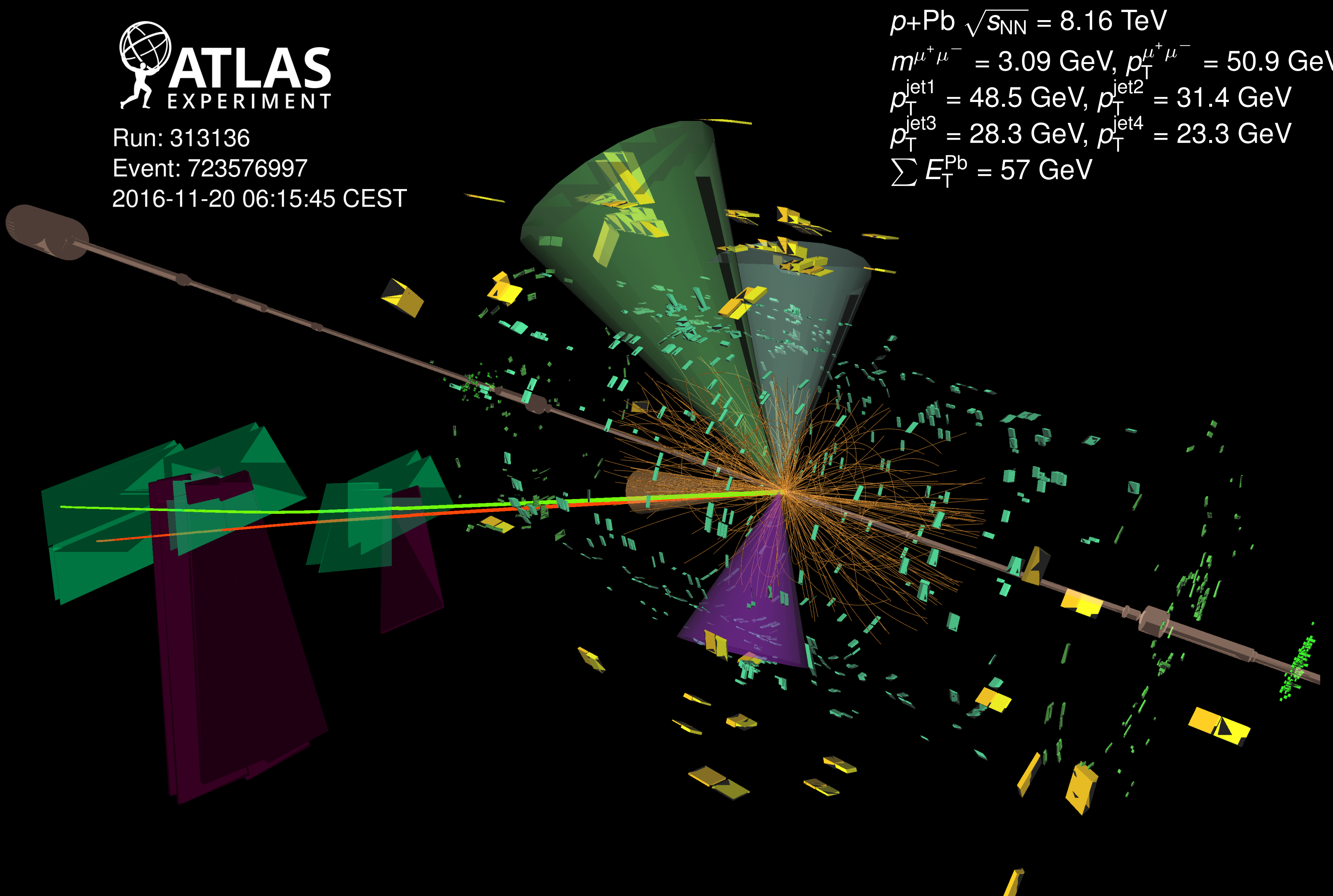
Jets!



The decay products of highly energetic W bosons and top quarks tend to be close to each other.

- **They can be reconstructed as a single jet**
- **We can measure the mass of these jets to monitor our calibration**
- **Impressive stability**

Run :
Even
2016


ATLAS EXPERIMENT
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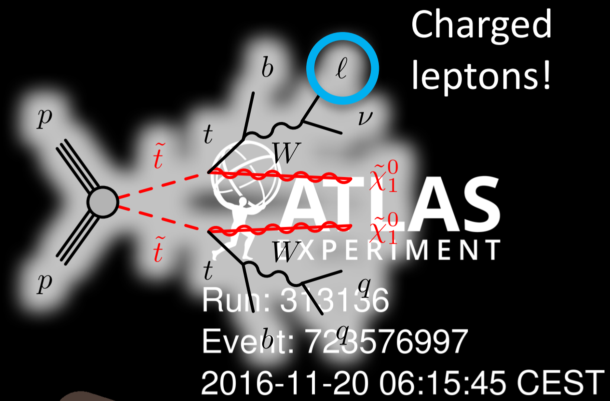
Event: 723576997
2016-11-20 06:15:45 CEST
p+Pb $\sqrt{s_{NN}}$ = 8.16 TeV
$m^{\mu^+\mu^-}$ = 3.09 GeV, $p_T^{\mu^+\mu^-}$ = 50.9 GeV
p_T^{jet1} = 48.5 GeV, p_T^{jet2} = 31.4 GeV
p_T^{jet3} = 28.3 GeV, p_T^{jet4} = 23.3 GeV
$\sum E_T^{Pb}$ = 57 GeV

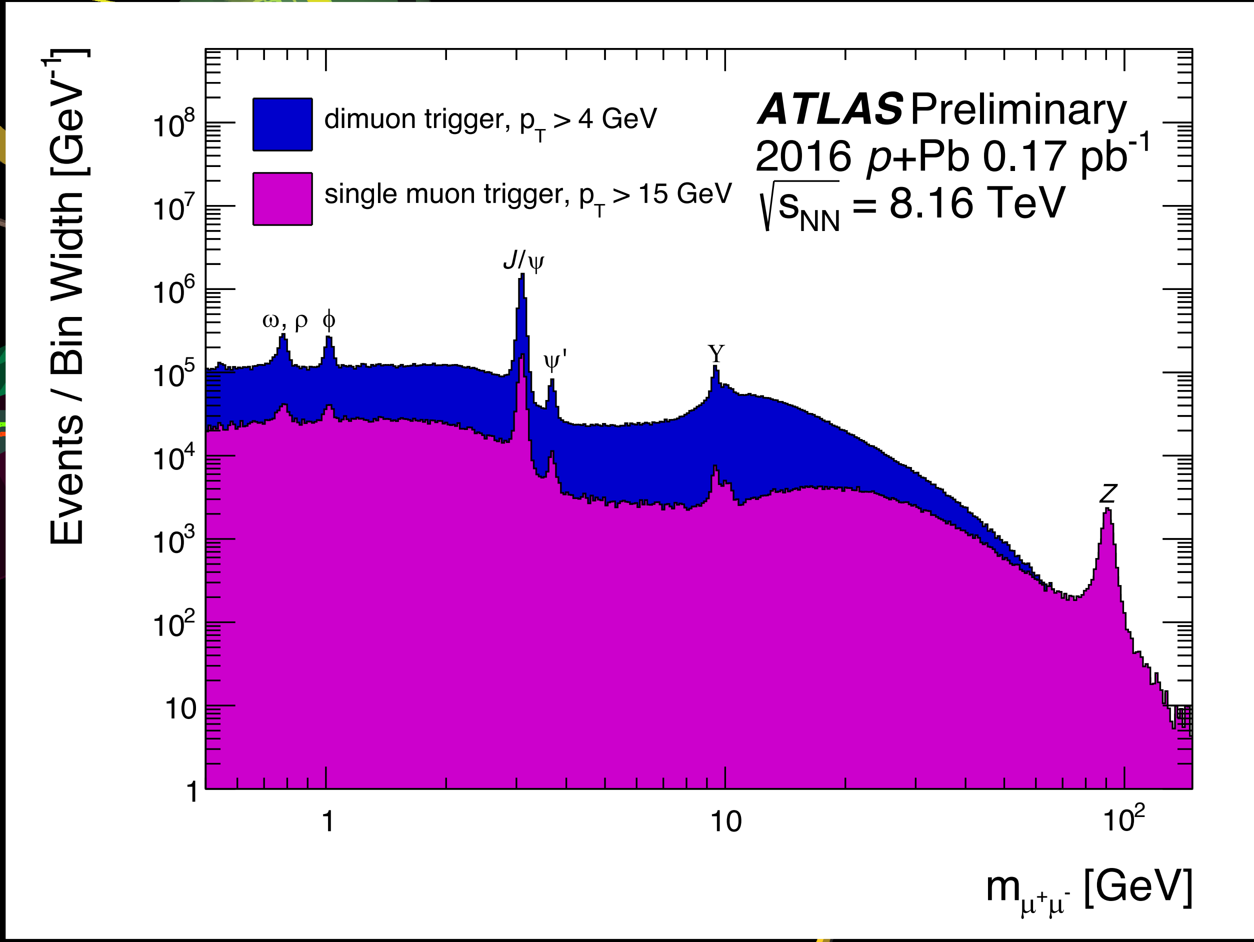


Muons

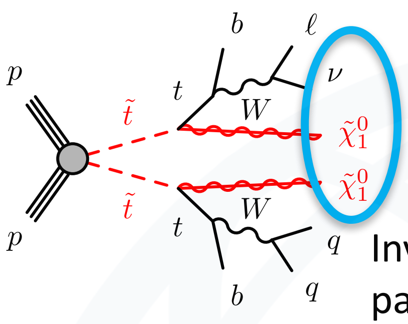
p+Pb $\sqrt{s_{NN}}$ = 8.16 TeV
$m^{\mu^+\mu^-}$ = 3.09 GeV, $p_T^{\mu^+\mu^-}$ = 50.9 GeV
p_T^{jet1} = 48.5 GeV, p_T^{jet2} = 31.4 GeV
p_T^{jet3} = 28.3 GeV, p_T^{jet4} = 23.3 GeV
$\sum E_T^{Pb}$ = 57 GeV

Decades of particle physics, in heavy ion collisions.

- **2016 p+Pb data already being analysed!**



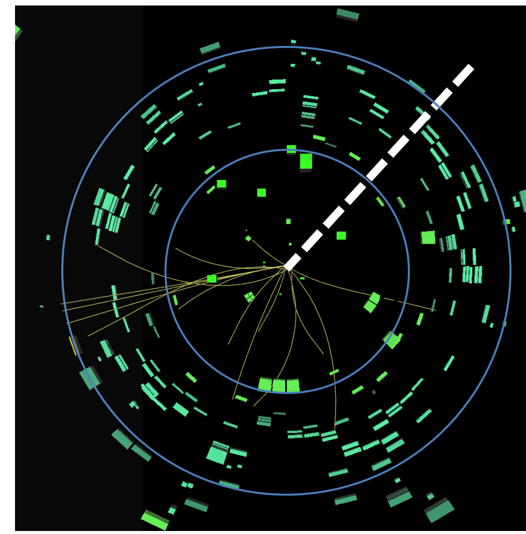
Missing Transverse Momentum

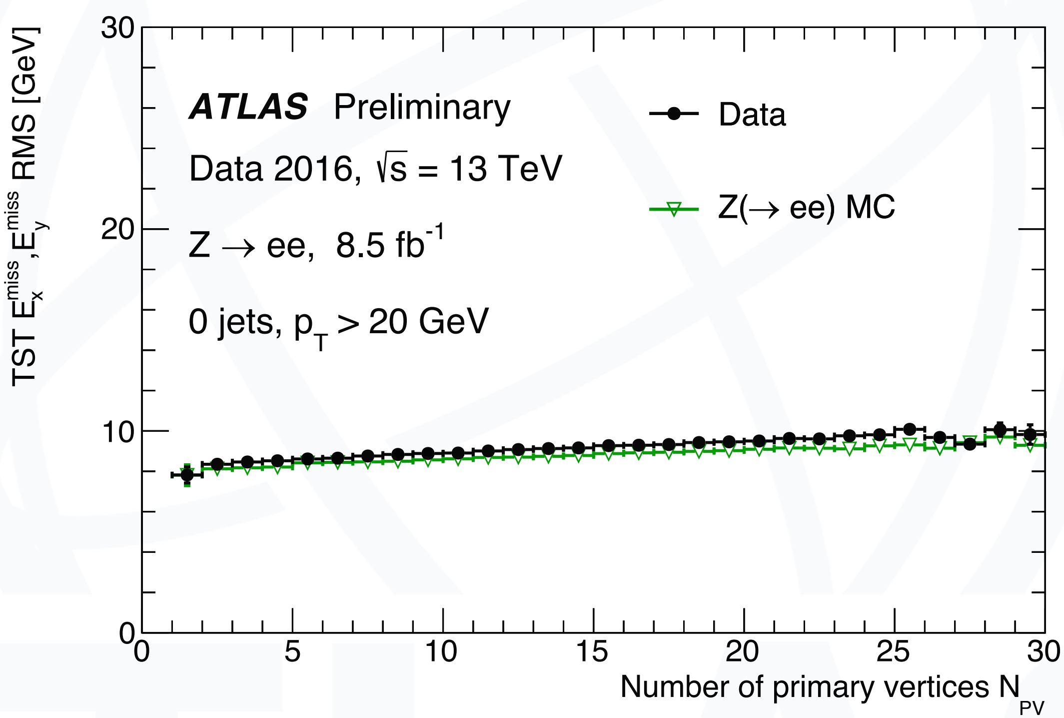


Invisible particles!

The momentum balance is known only in the transverse plane.

- Crucial to detect invisible particles



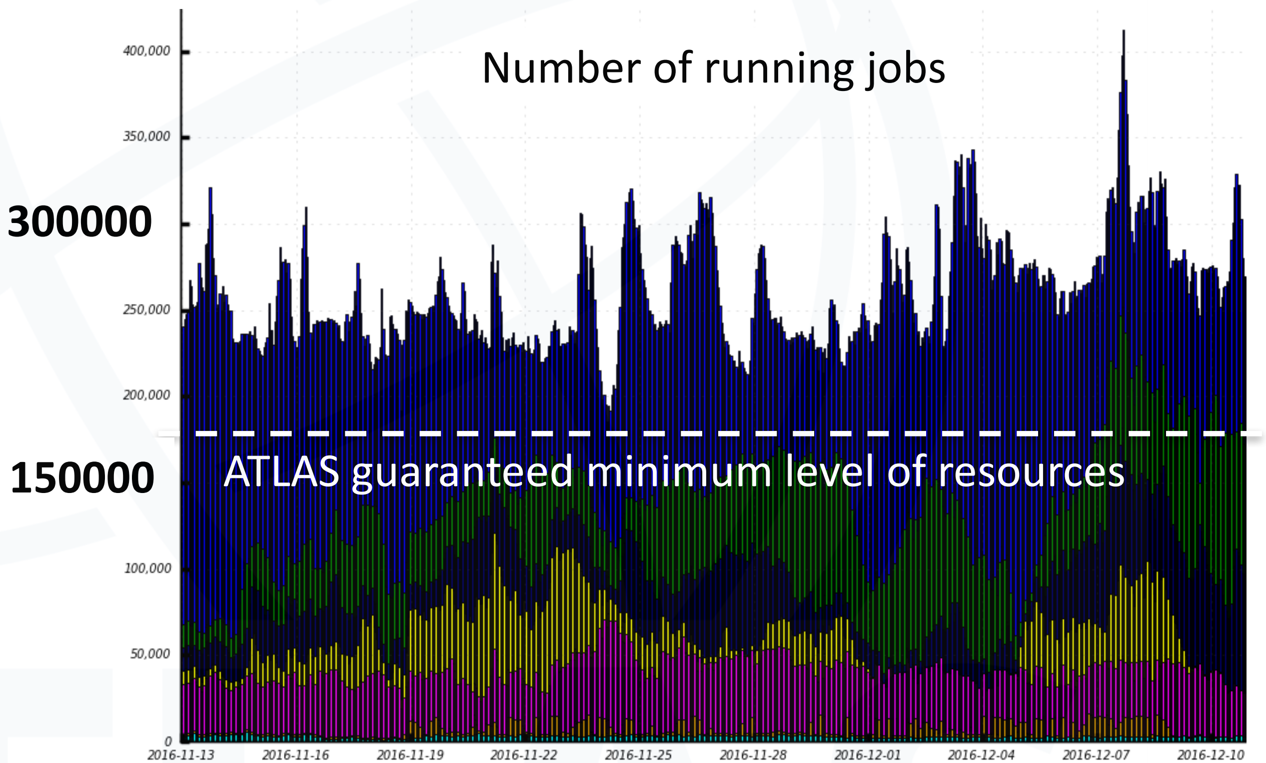


Combination of tracking and calorimetry to improve robustness.

Data Processing and Computing

Worldwide computing resources are crucial

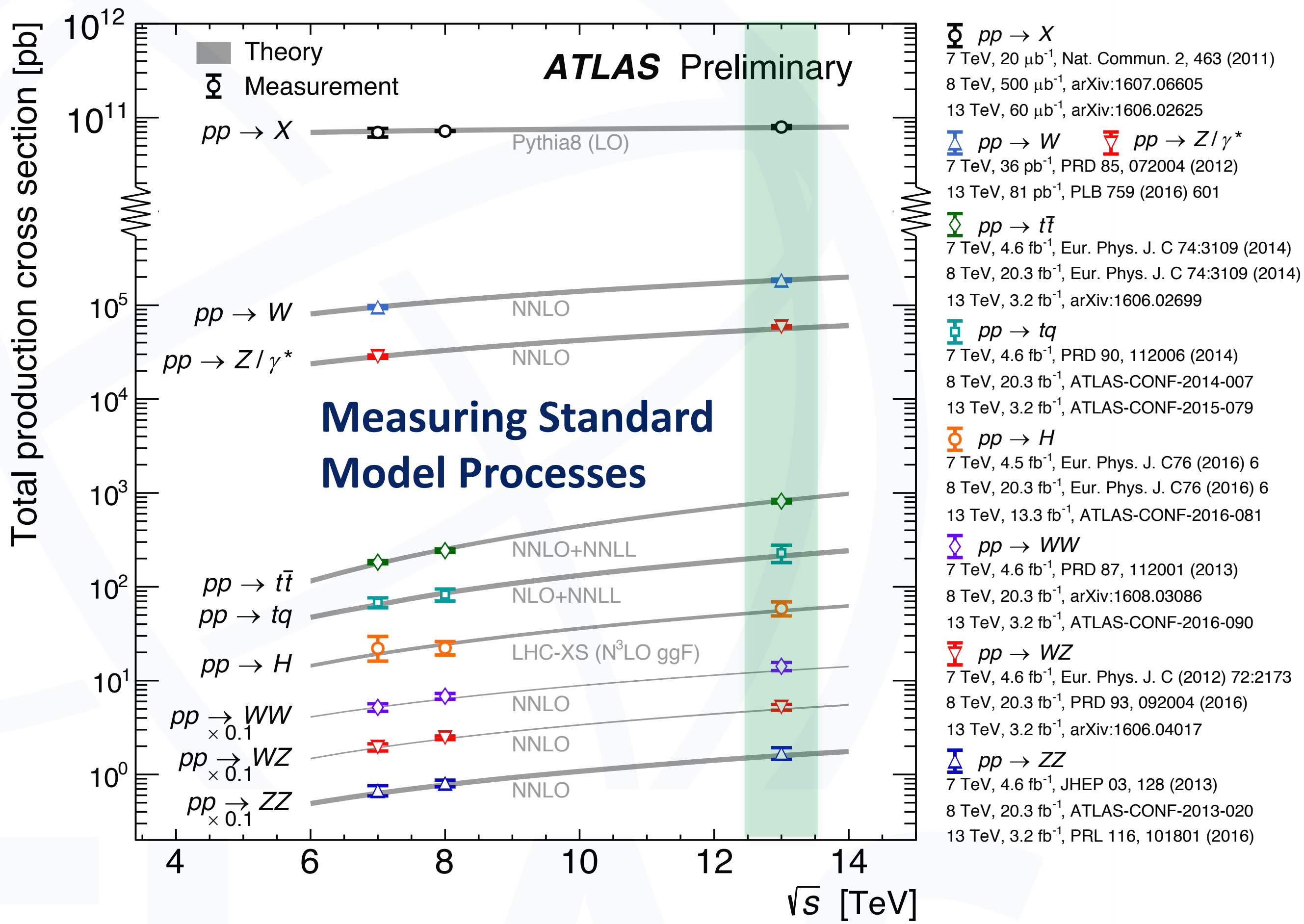
- The computing model continues to evolve: large simulation samples essential for detailed understanding of the data



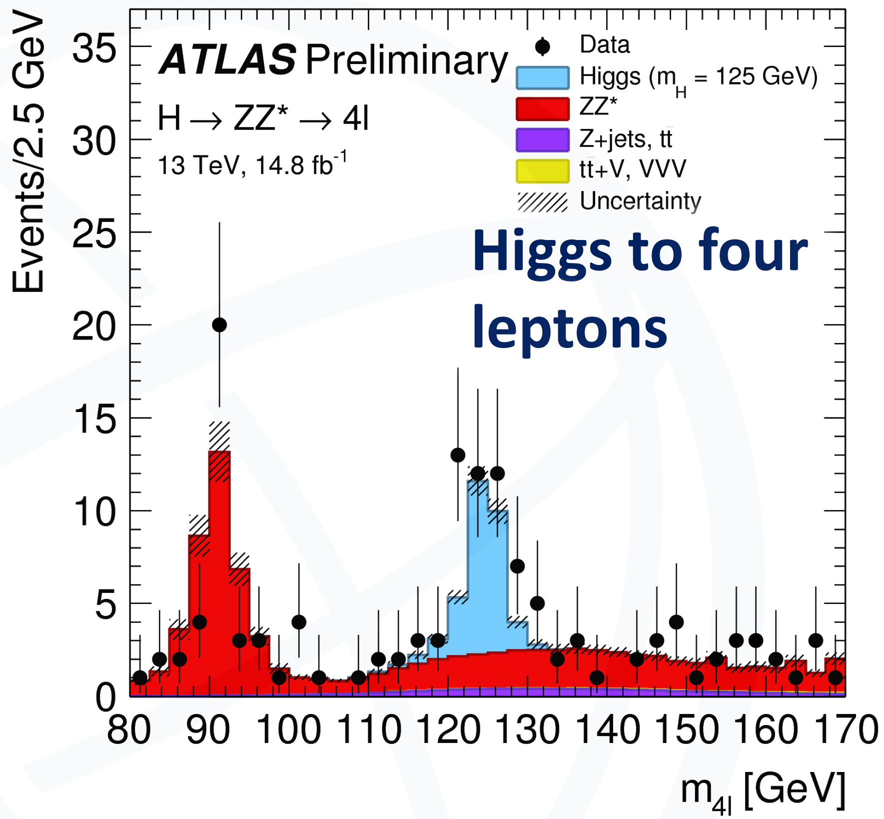
A 2016 milestone: ICHEP

Great achievement of the collaboration

- Results have been presented with data taken just two weeks before!

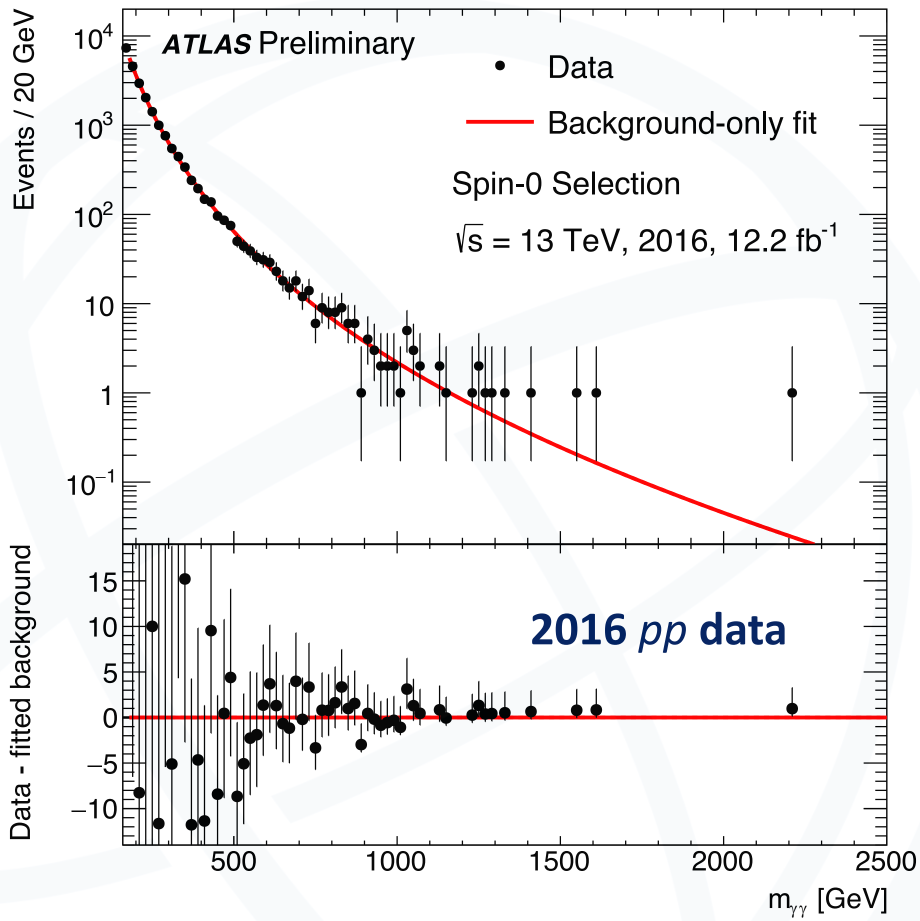


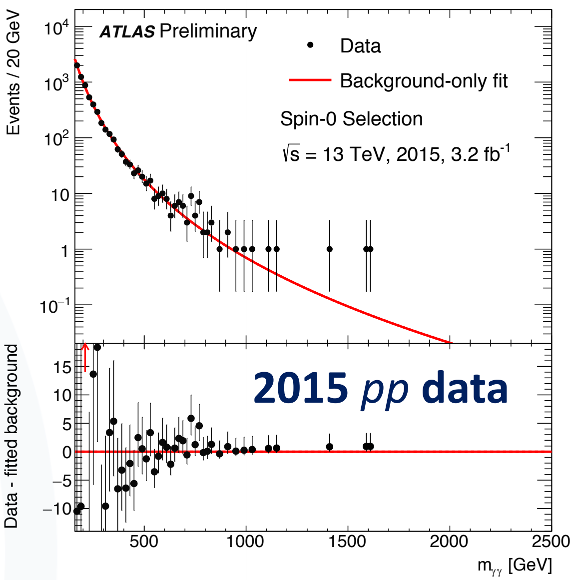
A 2016 milestone: ICHEP



We have been able to fully re-establish the observations of Run 1 …

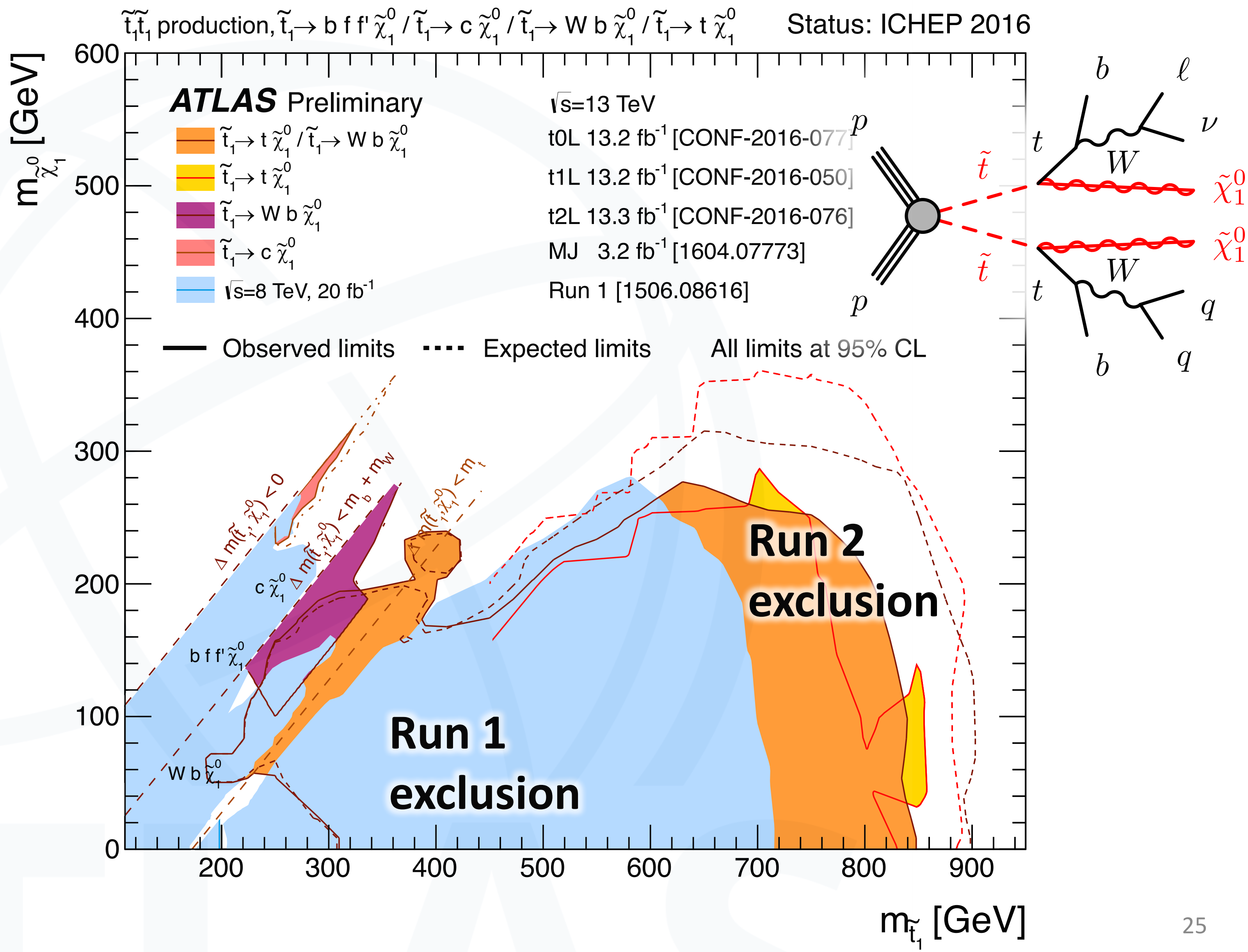
A 2016 milestone: ICHEP



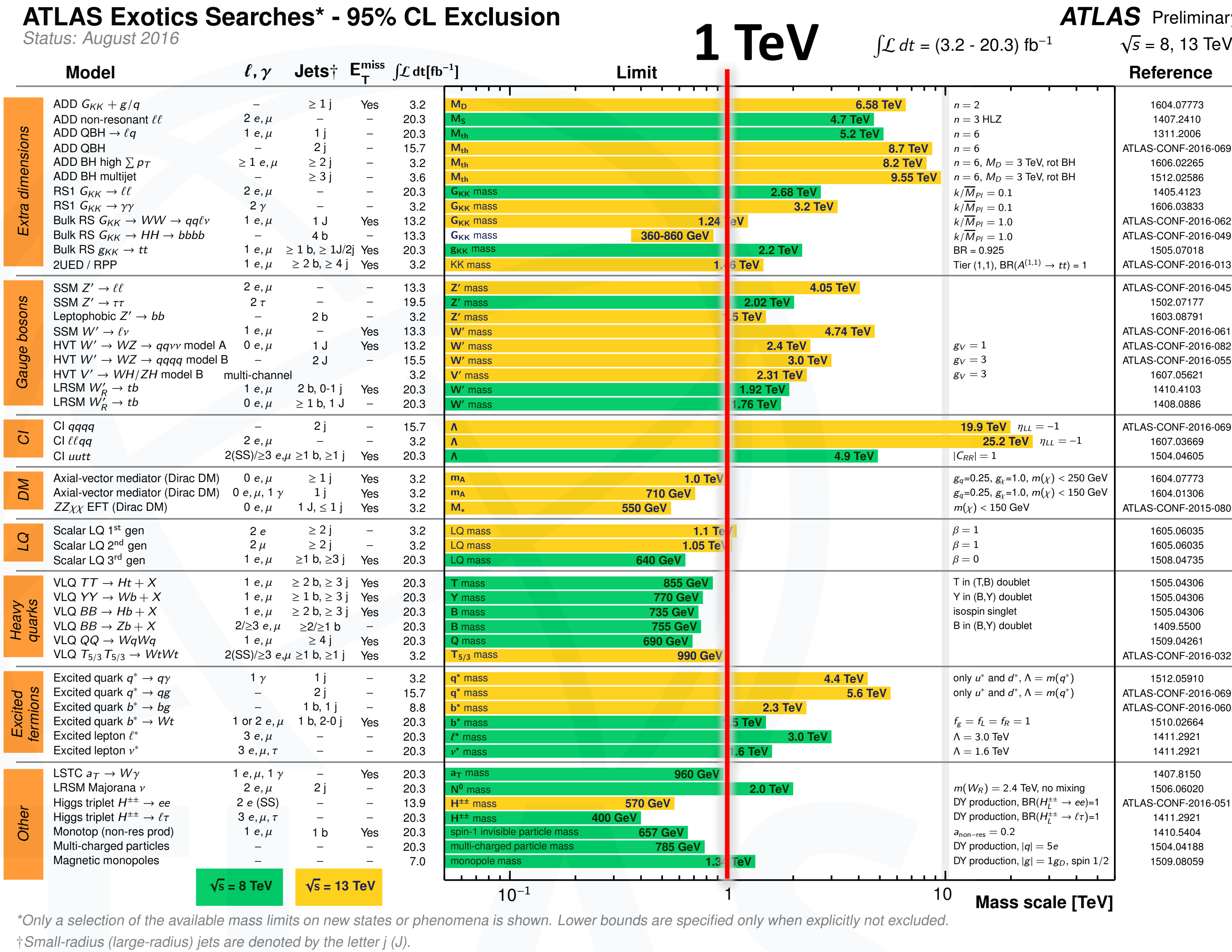


… and rule out some hints from 2015.

A 2016 milestone: ICHEP



A 2016 milestone: ICHEP

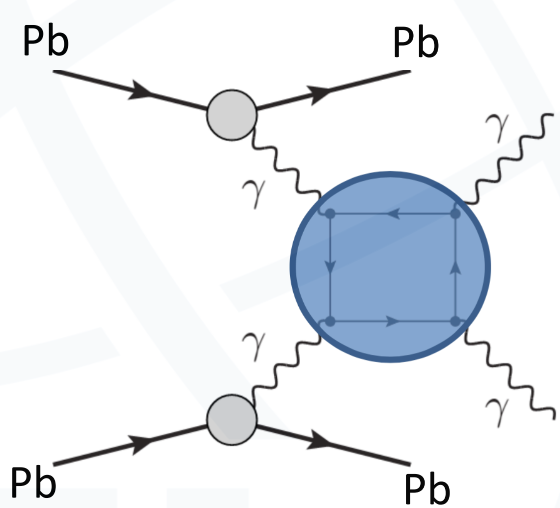


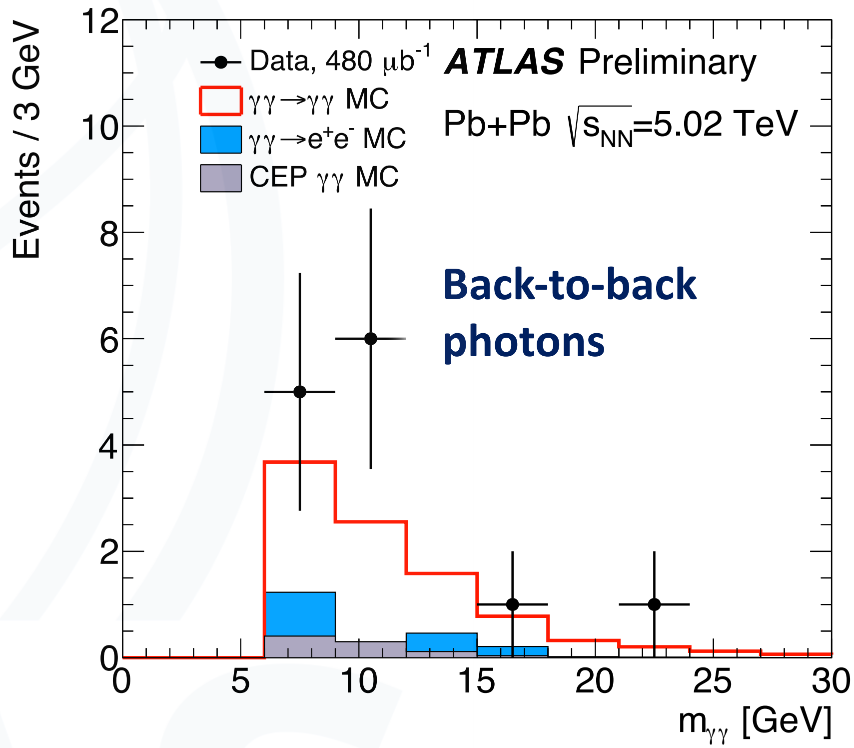
Light-by-light scattering

Based on 2015 Pb-Pb data (5.02TeV)

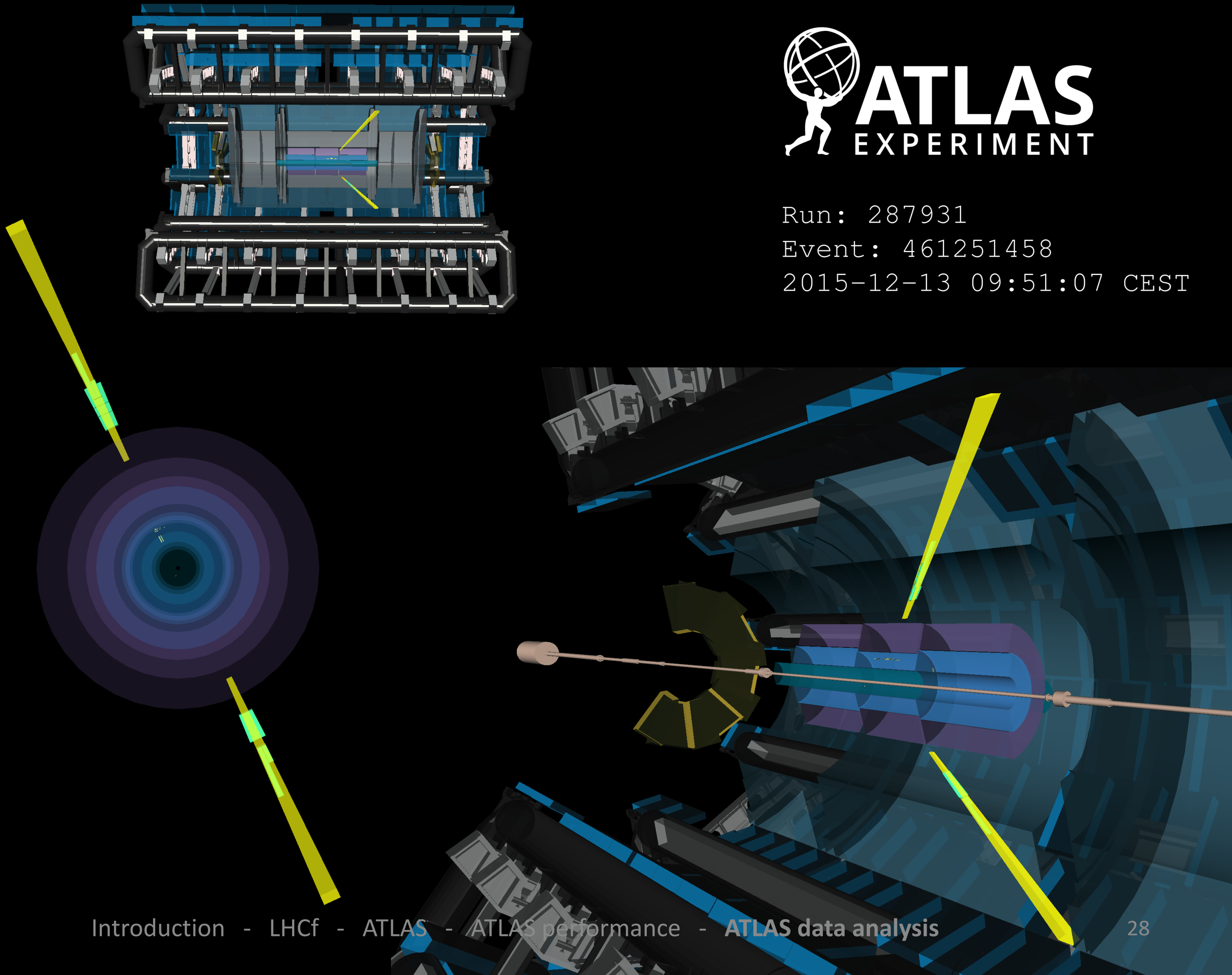
First evidence of quasi-elastic scattering of two photons at high energy!

- Use heavy ions as source due to their large electromagnetic field
- Relevant to precision QED physics!



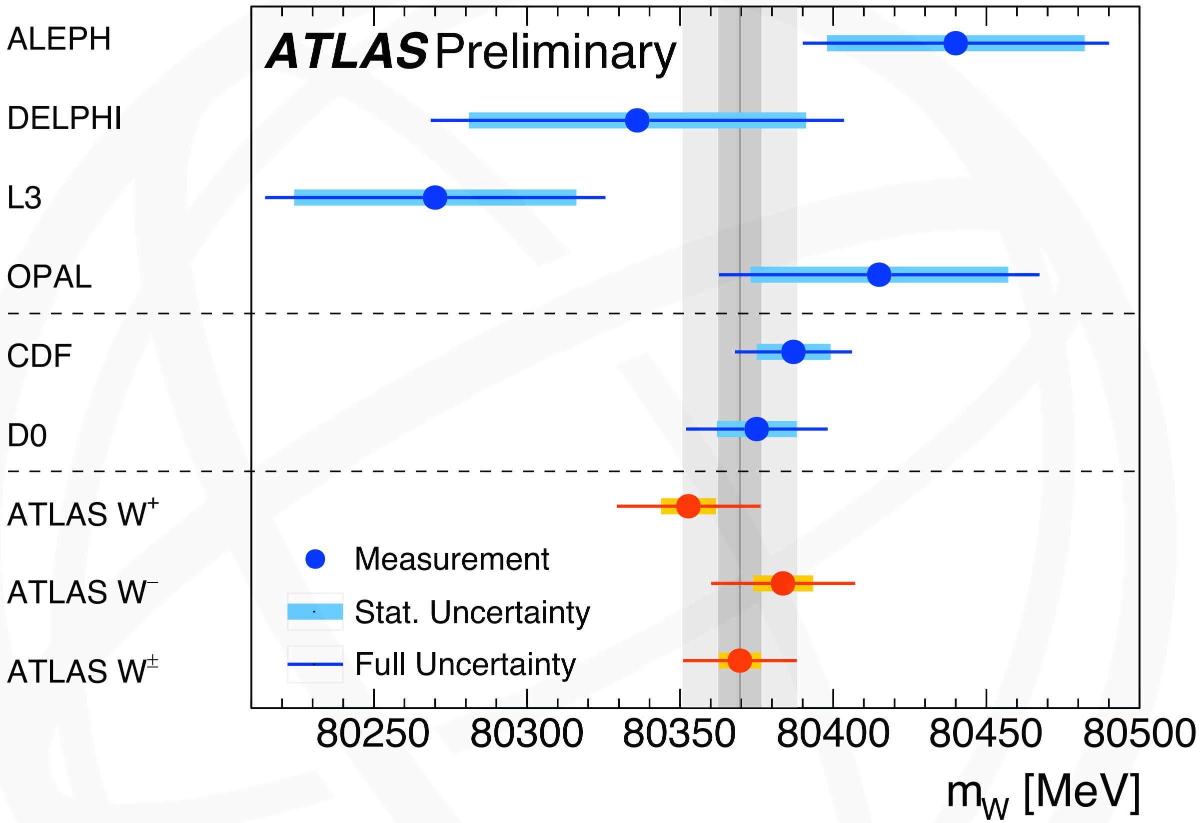


ATLAS-CONF-2016-111


ATLAS
EXPERIMENT
Run: 287931
Event: 461251458
2015-12-13 09:51:07 CEST

Measurement of the *W* -boson mass

ATLAS-CONF-2016-113

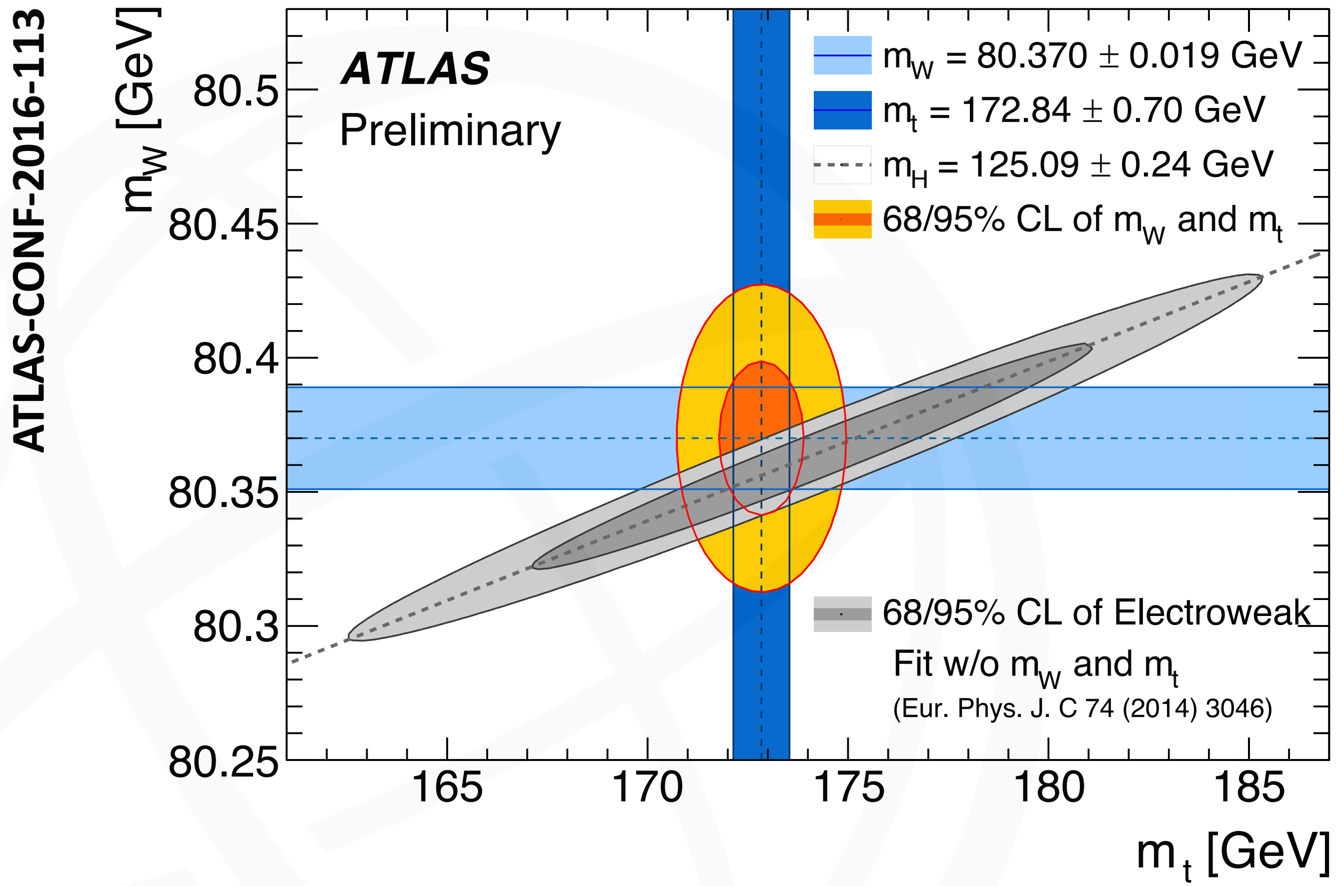


Just released result, based on 7 TeV data

- **Precision comparable with the currently leading measurements** performed by the CDF and D0 collaborations

$$
\begin{aligned}
m_W &= 80370 \pm 7\ \text{MeV}(\text{stat.}) \pm 11\ \text{MeV}(\text{exp. syst.}) \pm 14\ \text{MeV}(\text{mod. syst.}) \\
&= 80370 \pm 19\ \text{MeV}
\end{aligned}
$$

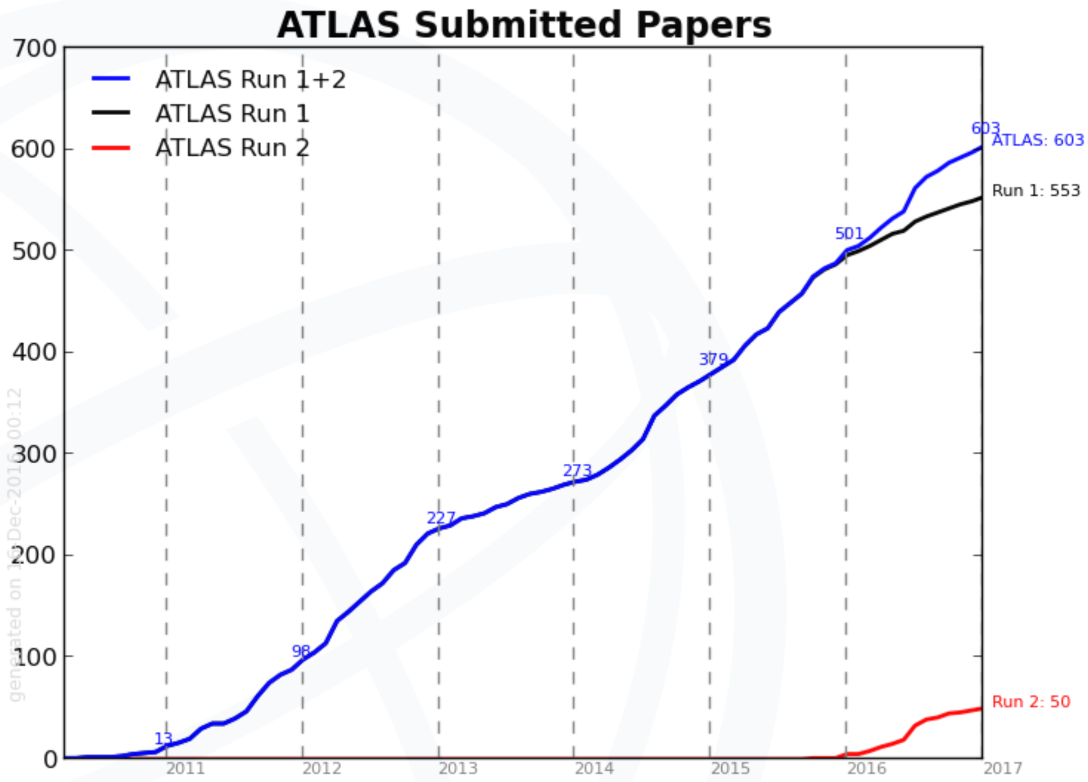
Measurement of the *W* -boson mass



In the Standard Model, m_W m_t and m_H are related to each other

- **Measuring them precisely provides an important consistency test**

ATLAS publication status

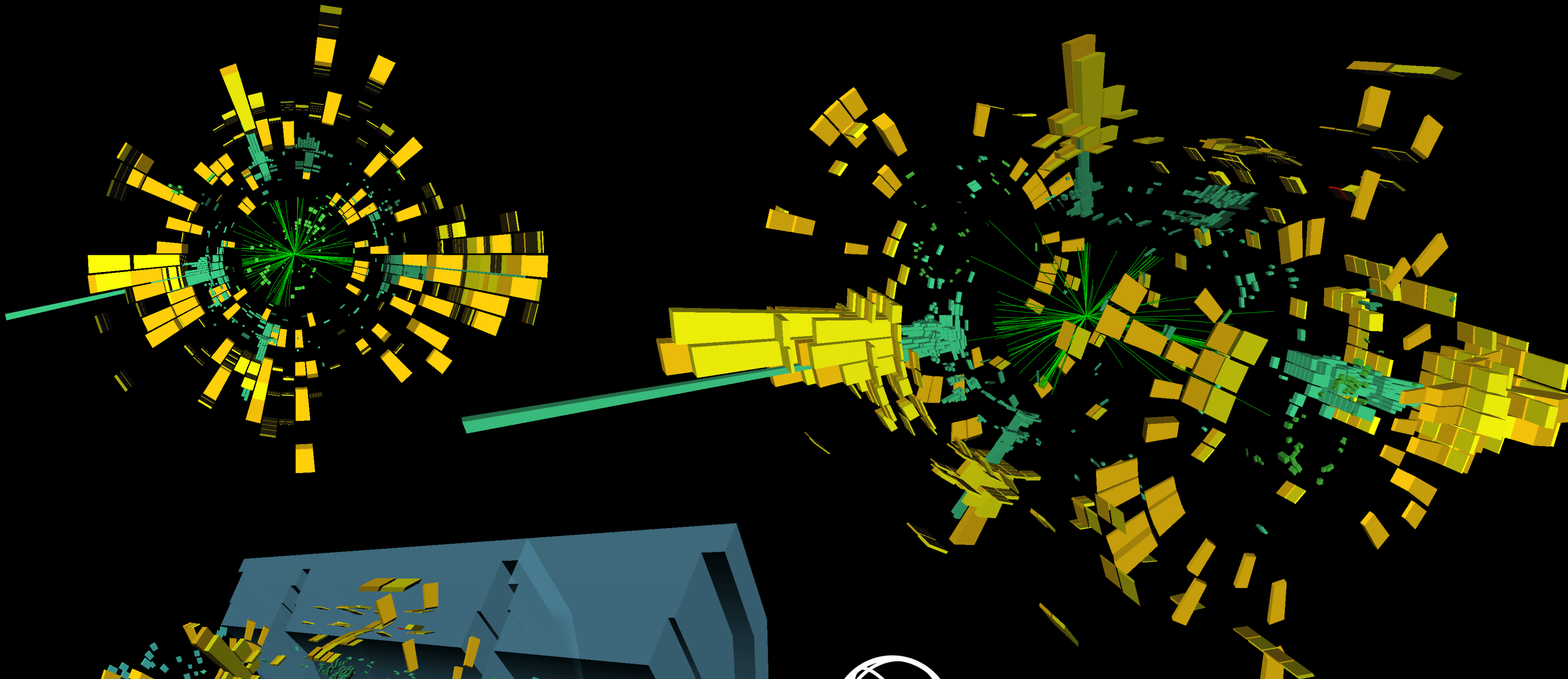


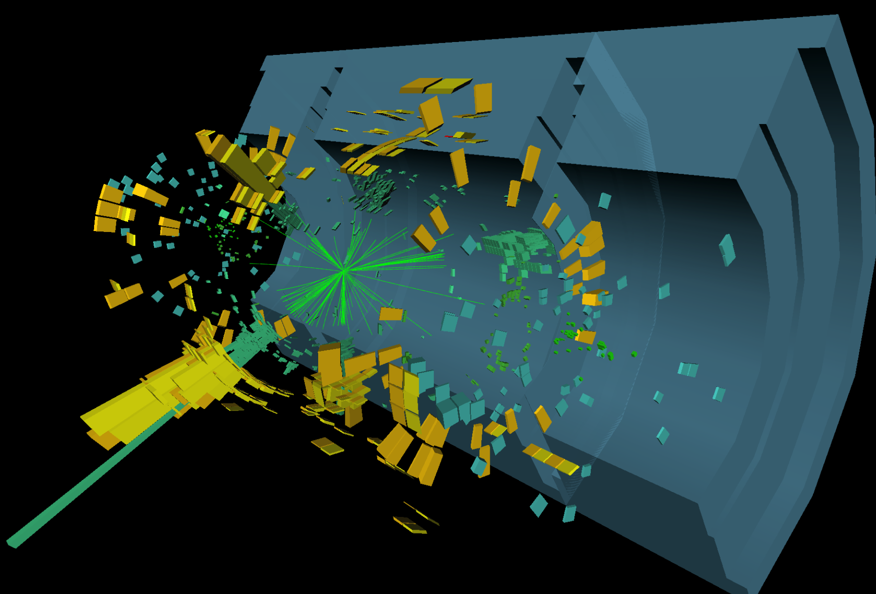
553 Run 1 and **49** Run 2 papers and counting…

Looking forward to more

Thanks to collaborating nations and funding agencies!

Thanks for your attention





ATLAS EXPERIMENT

Run: 300800

Event: 2418777995

2016-06-04 03:47:03 CEST