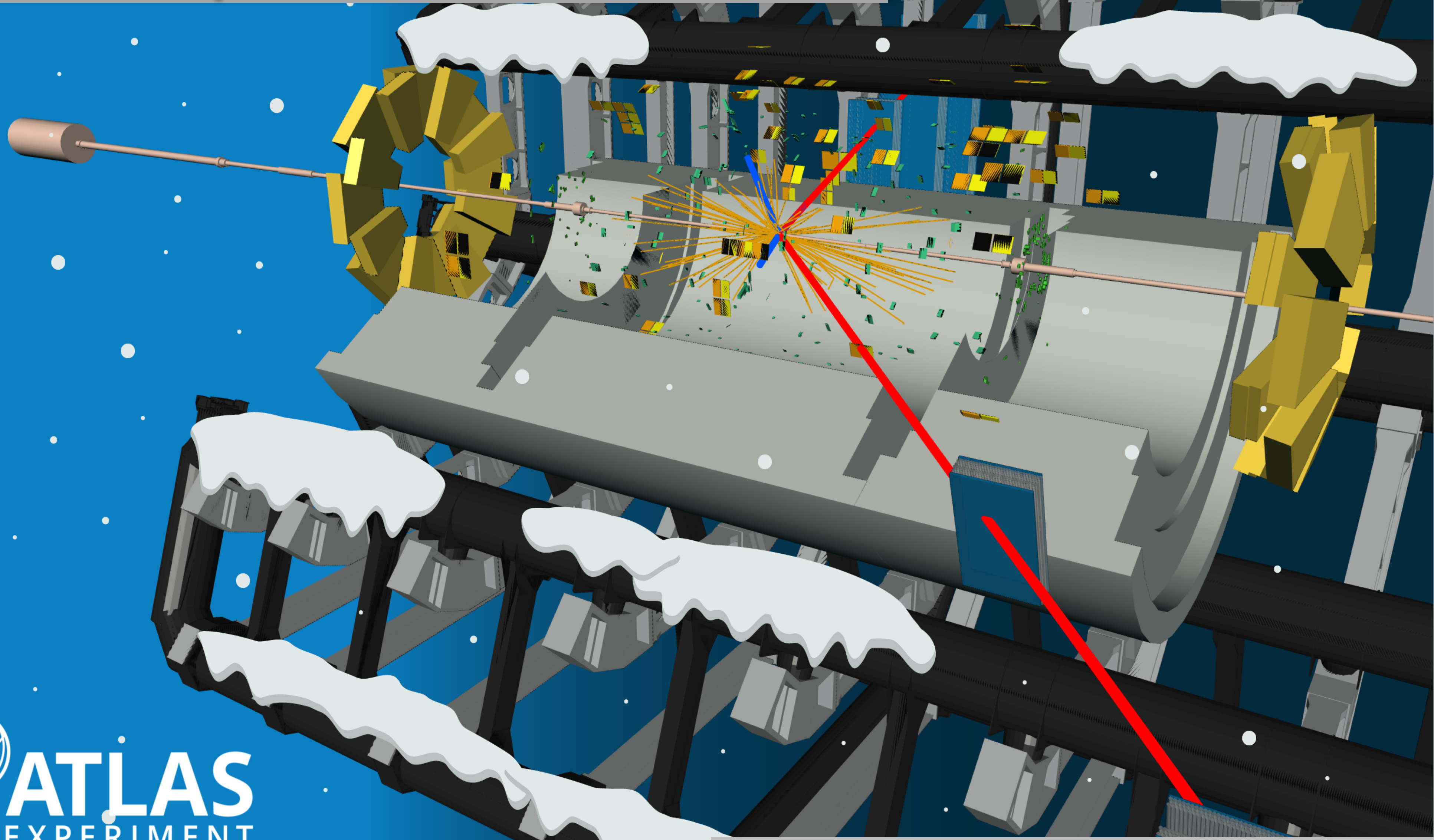
Эксперимент ATLAS



ATLAS EXPERIMENT

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

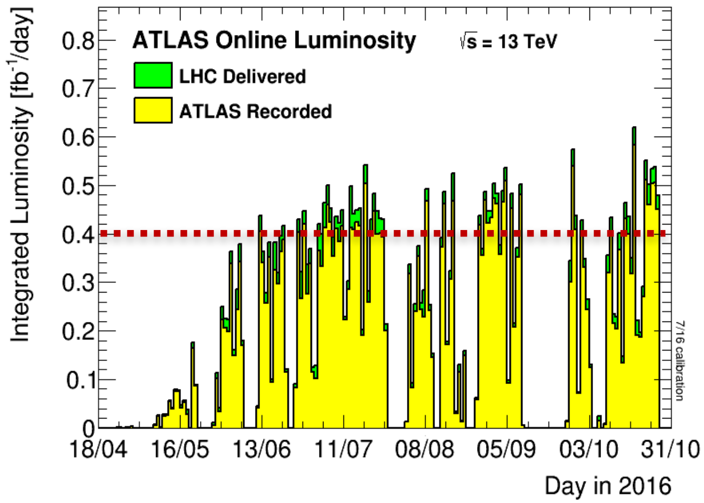
Научная сессия ученого совета ОФВЭ ПИЯФ
27 декабря 2016 года

Олег Федин

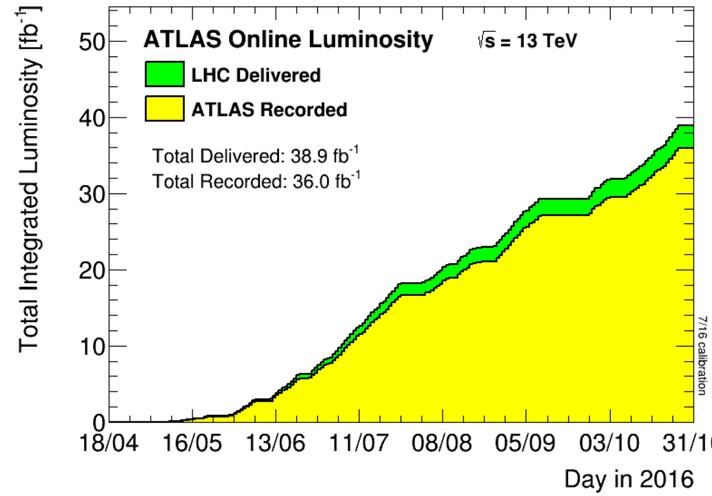
This Year's Data

- Set a record for the highest integrated luminosity (we got more data in 2016 than in all of Run1).

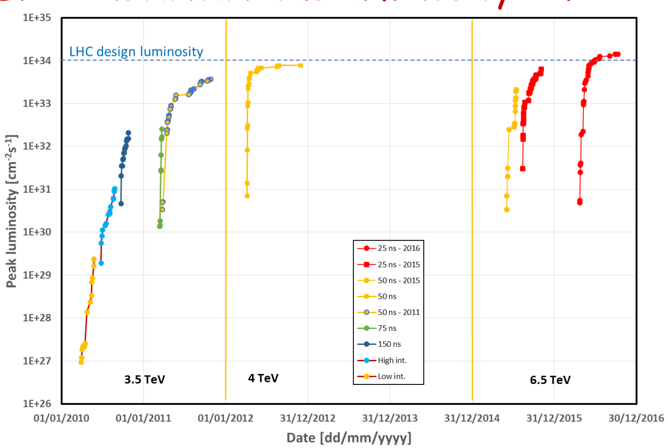
0,4 fb^{-1} per day ! (in RUN-1 ~1 fb^{-1} per week)

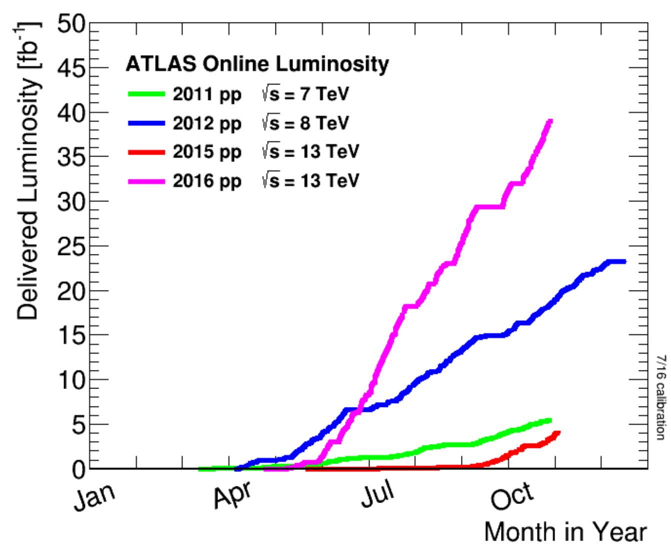


Total dataset recorded around 36 fb^{-1}.
Good for physics: 93-95% (33.3-33.9 5 fb^{-1})



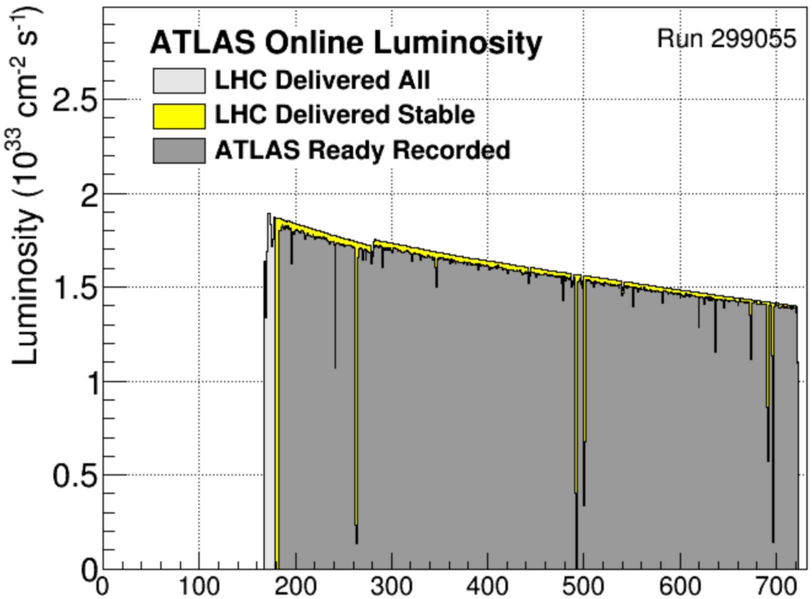
LHC Instantaneous luminosity ~1.3 10^{34} $cm^{-2}c^{-1}$



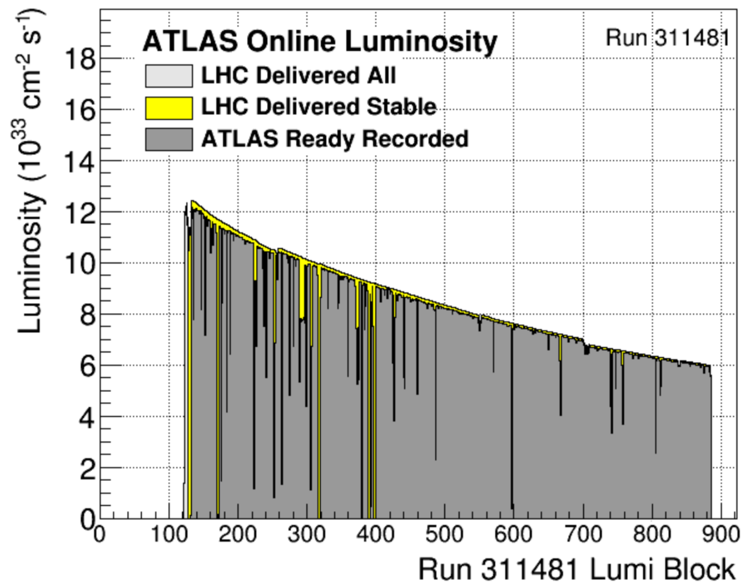


High luminosity problem

Max Lumi 1.87 10^{33}
Efficiency 96.6%

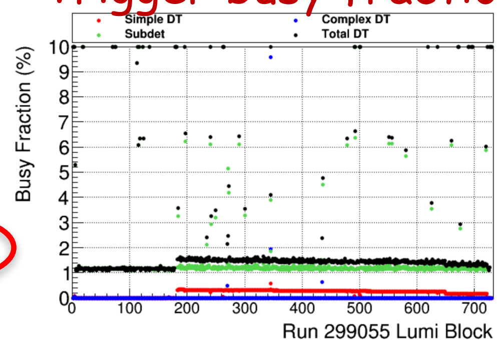


Max Lumi 12.4 10^{33}
Efficiency 94.4%



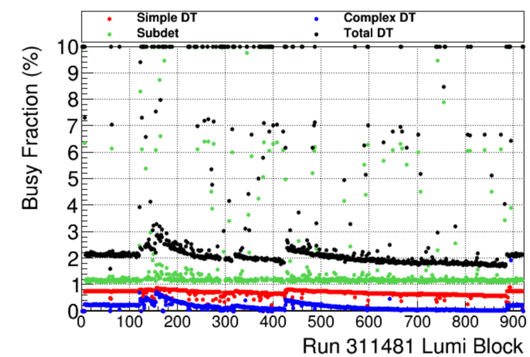
Peak Stable Lumi	1.87×10^{33} cm^{-2} s^{-1}	
Peak <Events>/BX	22.6	
Avg <Events>/BX	19.5	
	Lumi (pb^{-1})	Percent
Physics Beams Del.	51.59	100.0%
ATLAS Ready Del.	51.19	99.2%
ATLAS Ready Rec.	49.81	96.6%
Del. after Warmstop	0.0	0.0%

Trigger busy fraction



Peak Stable Lumi	1.24×10^{34} cm^{-2} s^{-1}	
Peak <Events>/BX	40.1	
Avg <Events>/BX	28.5	
	Lumi (pb^{-1})	Percent
Physics Beams Del.	368.0	100.0%
ATLAS Ready Del.	366.2	99.5%
ATLAS Ready Rec.	347.3	94.4%
Del. after Warmstop	0.0	0.0%

Trigger busy fraction

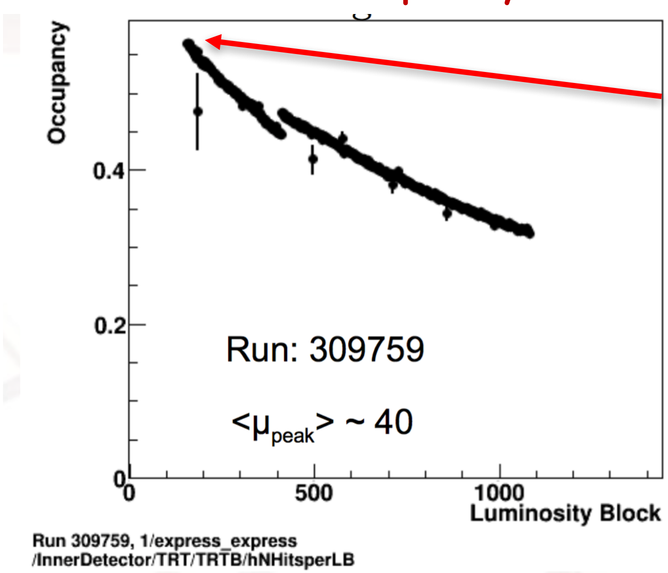


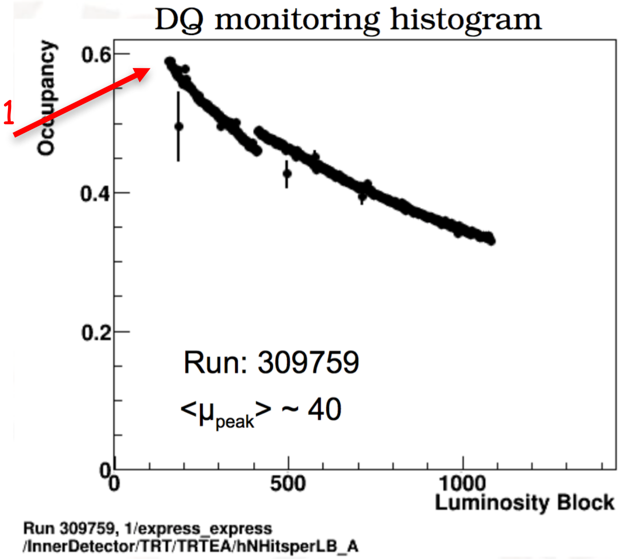
High luminosity and TRT detector

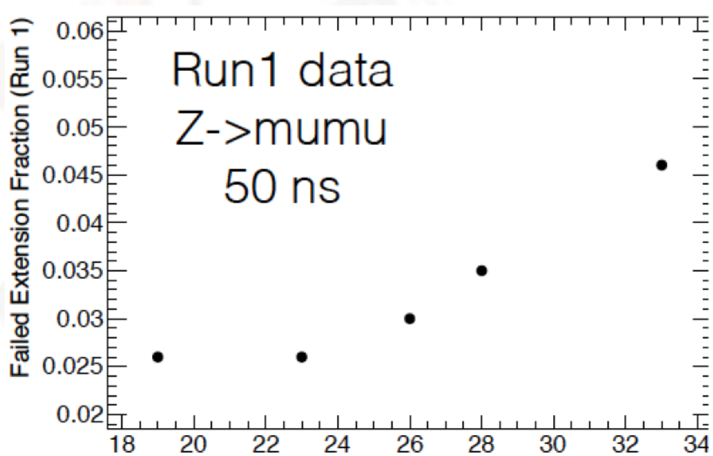
TRT Barrel Occupancy vs lumi

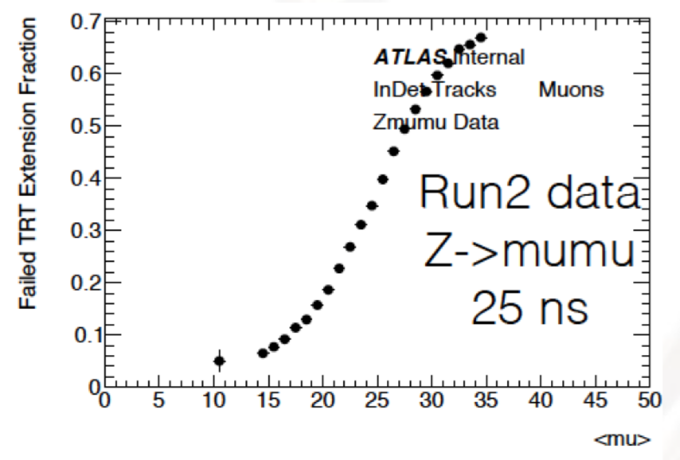
TRT End-cap Occupancy vs lumi

6.98×10^{33} cm^{-2} s^{-1}





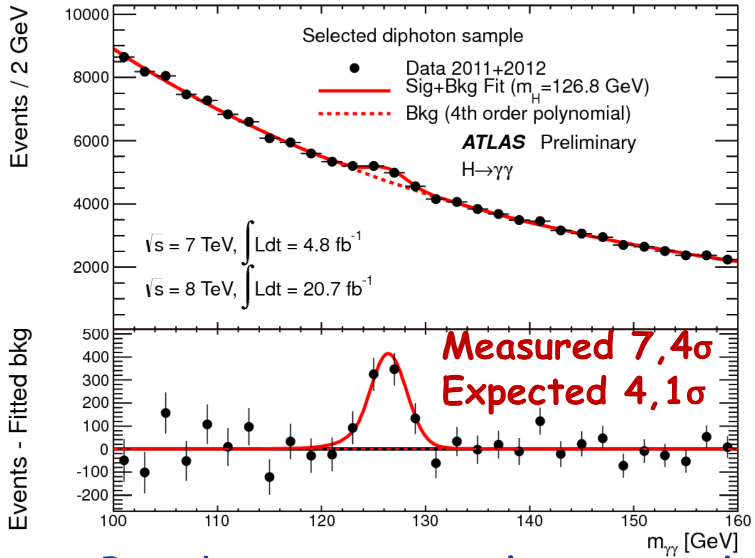




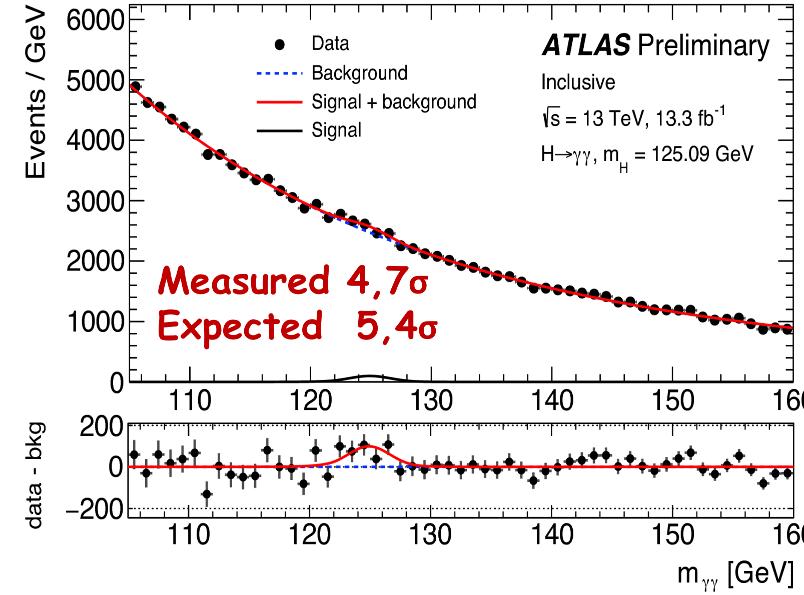
H→γγ

ATLAS-CONF-2013-012

Run I



Run II

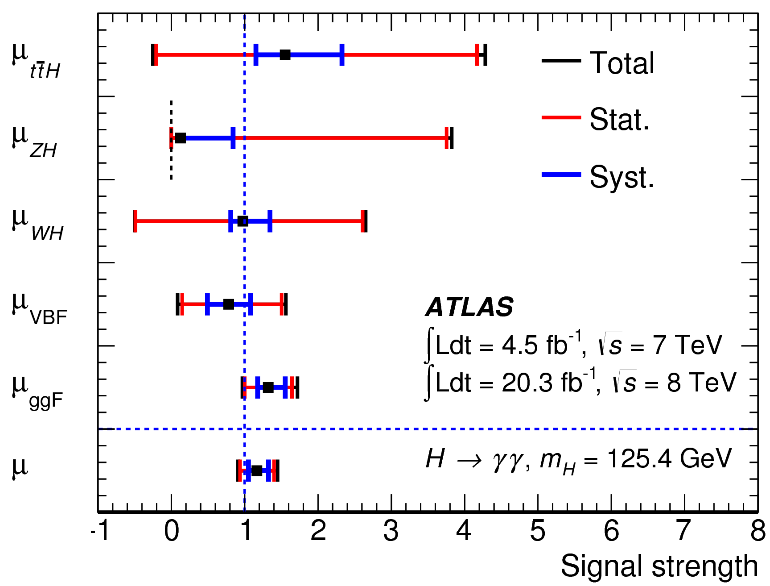


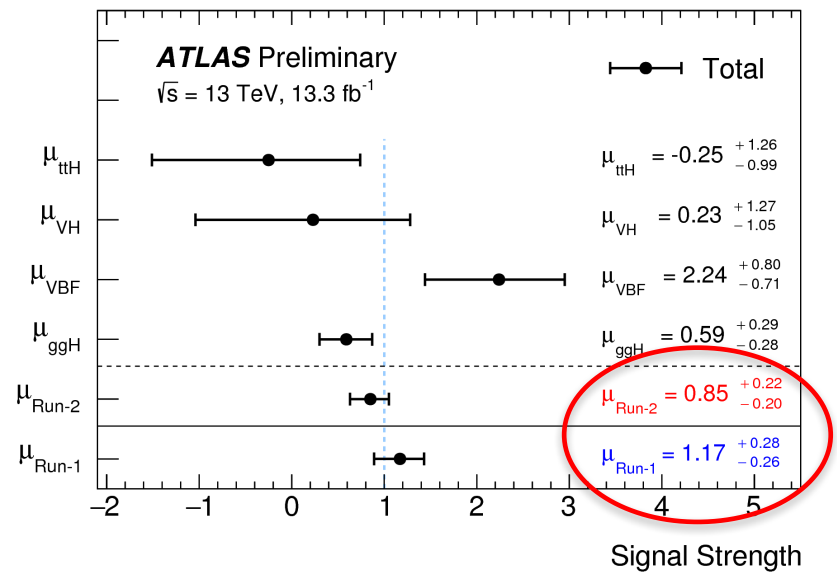
ATLAS-CONF-2016-067

Production signal strength

$$\mu_i = \frac{\sigma_i}{(\sigma_i)_{SM}}$$

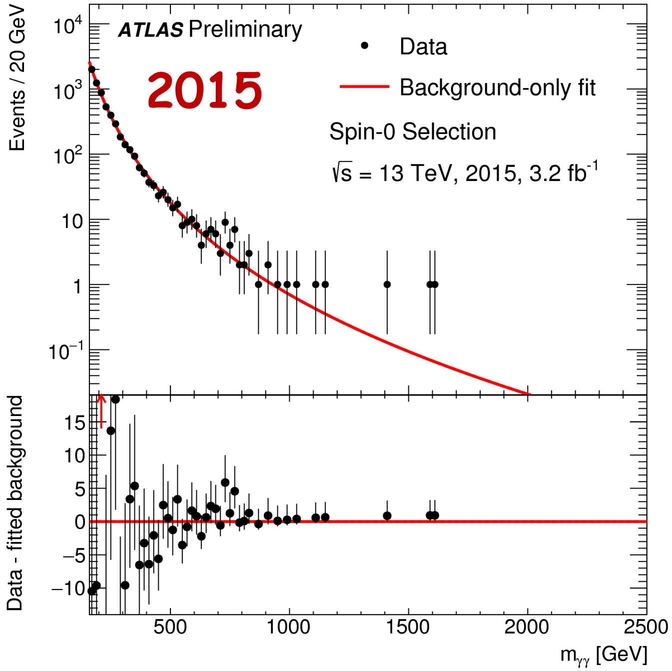
Phys. Rev. D. 90, 112015 (2014)

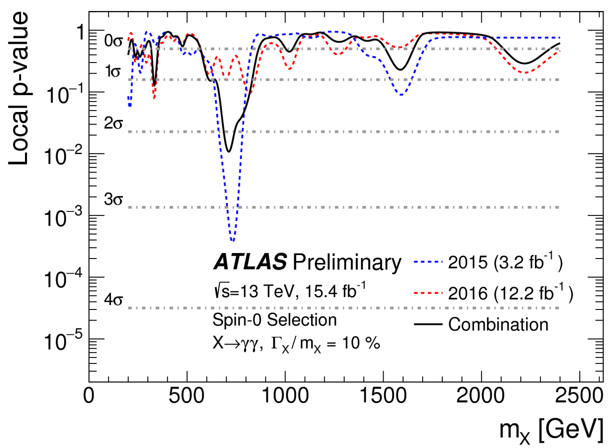




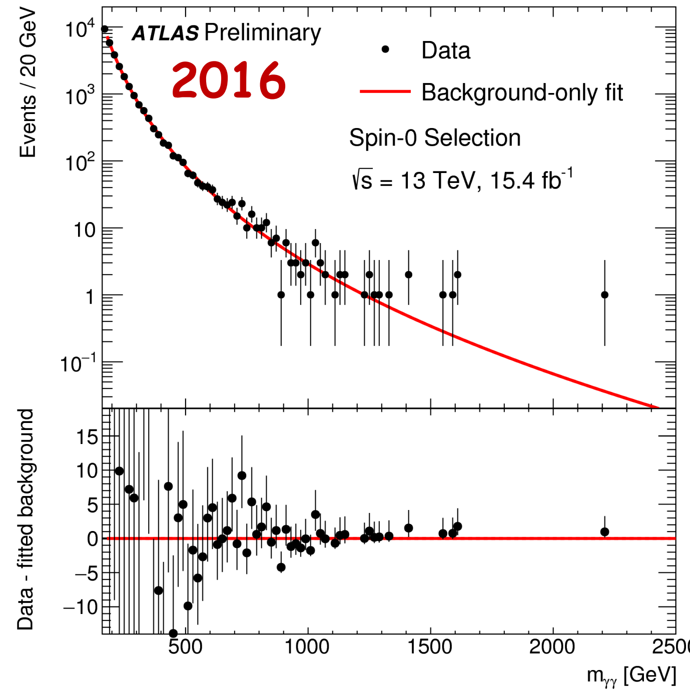
$H \to \gamma\gamma$

2015: 3,4σ local significance @730 GeV





2016: No significant excess observed with four times larger statistics.

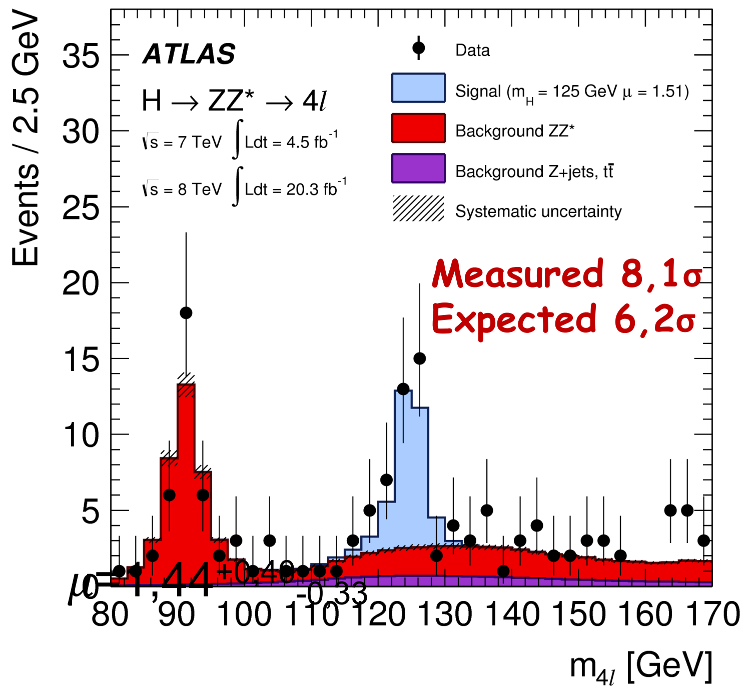


2016: Data consists with SM hypothesis. Global significance of excess <1σ

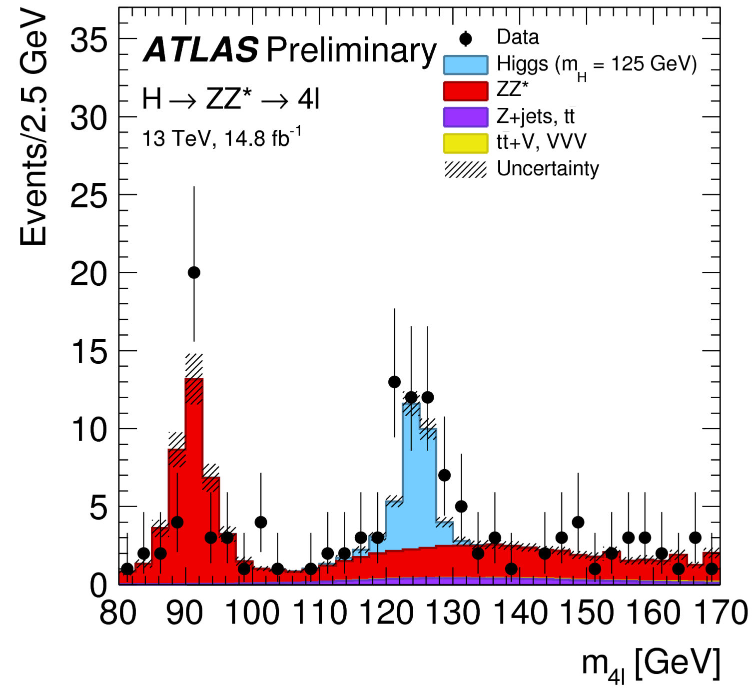
H→ZZ →4l

Phys. Rev. D 91, 012006 (2015)

Run I



Run II

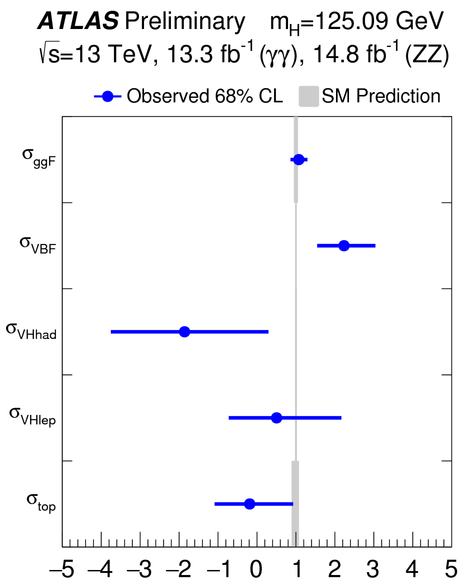


37 events observed in 120-130 GeV
Expected background: 10,3±0,4 events
Expected signal at 125 GeV: 16,2 events

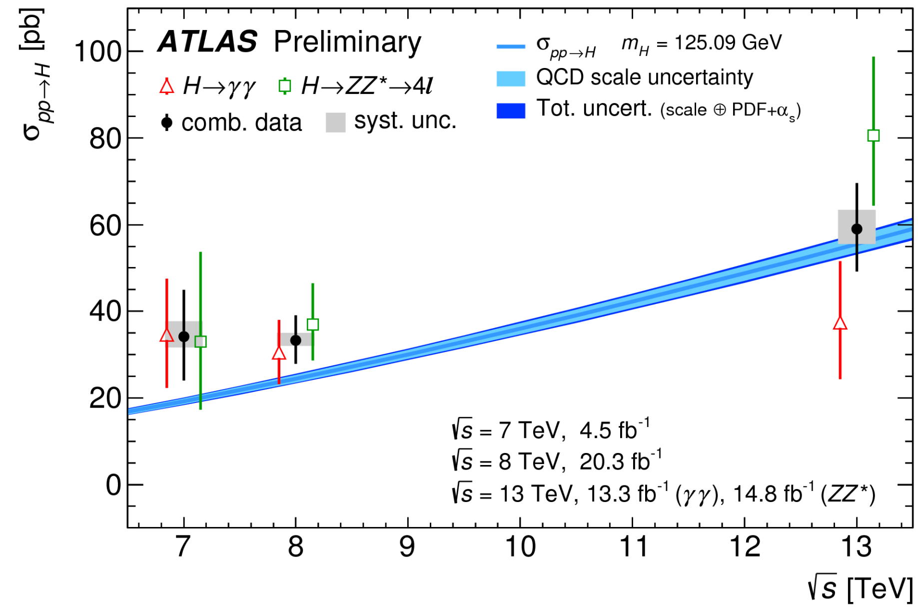
44 events observed in 118-129 GeV
Expected background: 9,7±0,8 events
Expected signal at 125 GeV: 22,3 events

Combined $H \to \gamma\gamma, ZZ$ @13 TeV

- Higgs production is seen with local significance 10σ (8,6σ expected)
- Evidence for VBF H production is about 4σ (1,9σ expected)
- $\sigma(pp \to H+X) = 59^{+9,7}_{-9,2}(stat)\ ^{+4,4}_{-3,5}(stat)$ is determined from fiducial measurements and combined with older results at 7 and 8 TeV

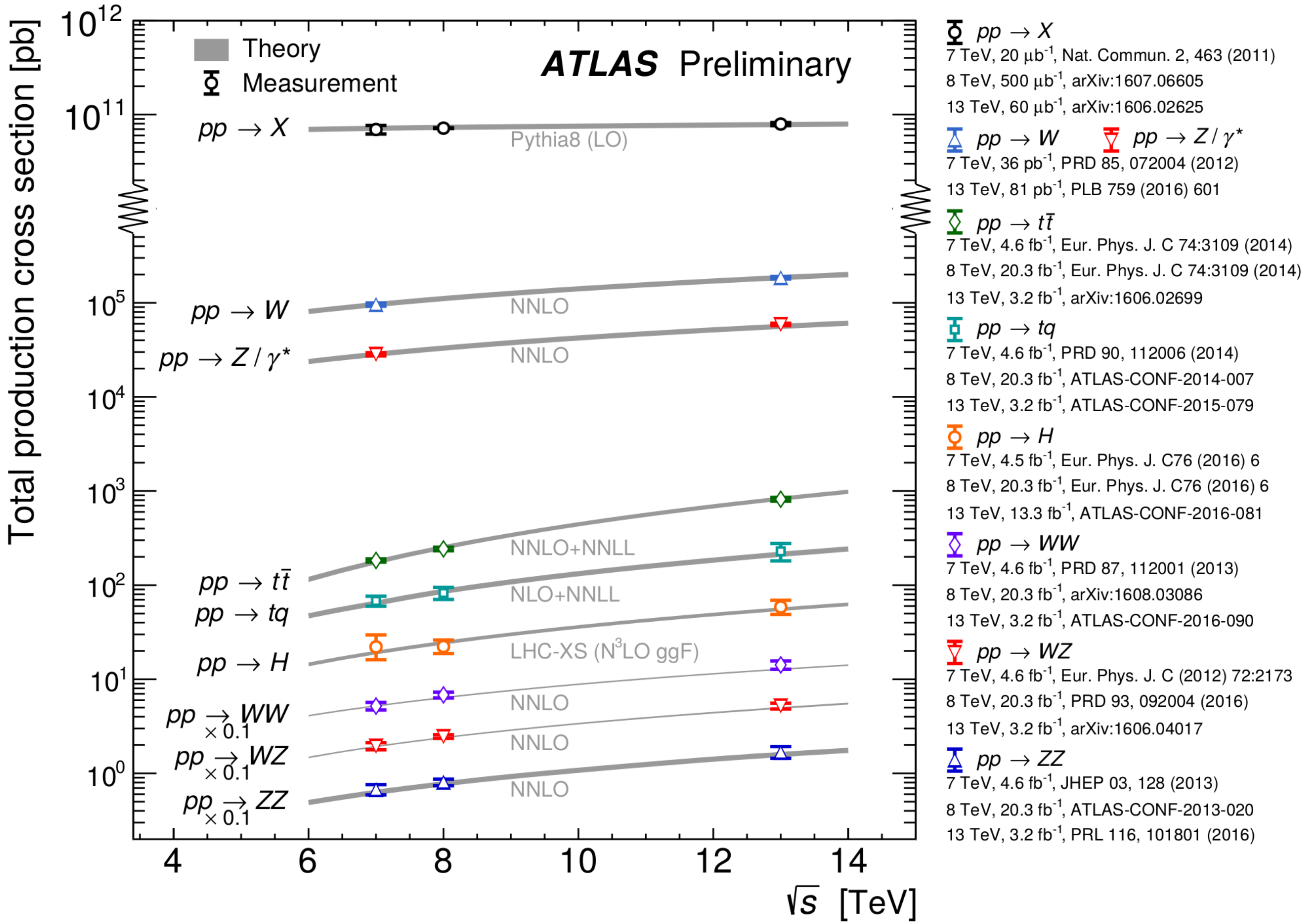


$\mu=\sigma_{meas}/\sigma_{SM}$=1,13±0,18



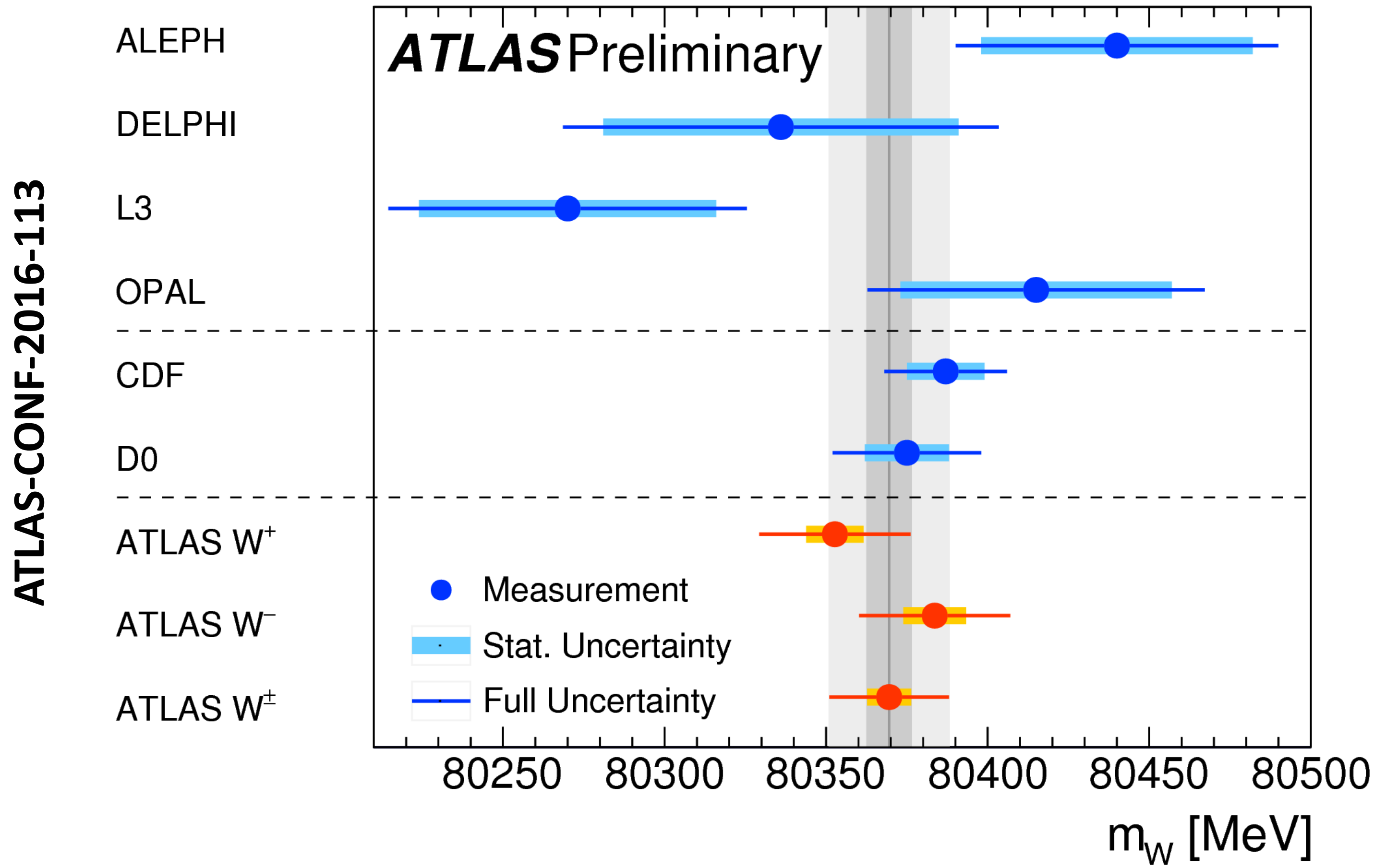
Decay channel	Total cross section ($pp \to H+X$) $\sqrt{s}$ =7 TeV	$\sqrt{s}$ =8 TeV	$\sqrt{s}$ =13 TeV
$H \to \gamma\gamma$	35^{+13}_{-12} pb	$30.5^{+7.5}_{-7.4}$ pb	37^{+14}_{-13} pb
$H \to ZZ^* \to 4\ell$	33^{+21}_{-16} pb	37^{+9}_{-8} pb	81^{+18}_{-16} pb
Combination	34 ± 10 (stat.) $^{+4}_{-2}$ (syst.) pb	$33.3^{+5.5}_{-5.3}$ (stat.) $^{+1.7}_{-1.3}$ (syst.) pb	$59.0^{+9.7}_{-9.2}$ (stat.) $^{+4.4}_{-3.5}$ (syst.) pb
SM predictions [7]	19.2 ± 0.9 pb	24.5 ± 1.1 pb	$55.5^{+2.4}_{-3.4}$ pb

Total production cross section



Measurement of the W-boson mass

Result based on 7 TeV data. Precision comparable with the currently leading measurements performed by the CDF and D0 collaboration.

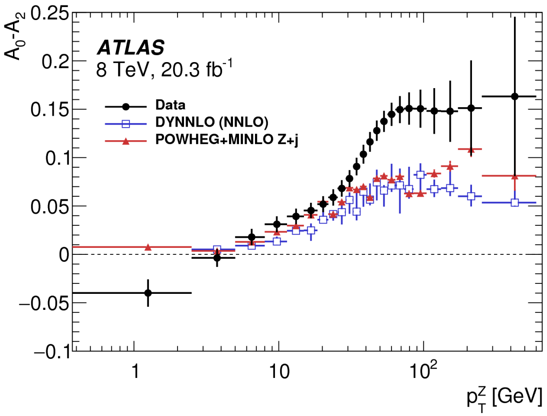


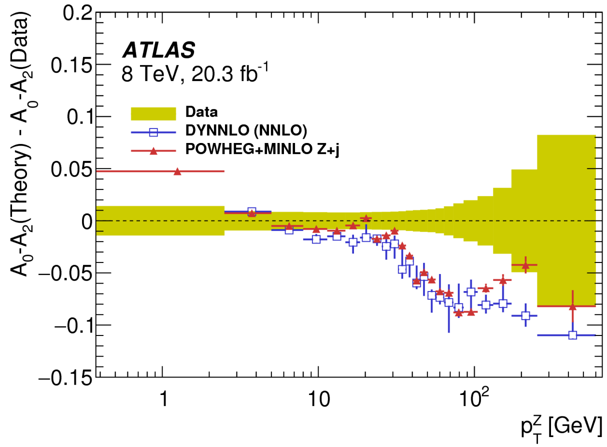
$$
\begin{aligned}
m_W &= 80370 \pm 7\ \text{MeV(stat.)} \pm 11\ \text{MeV(exp. syst.)} \pm 14\ \text{MeV(mod. syst.)} \\
&= 80370 \pm 19\ \text{MeV}
\end{aligned}
$$

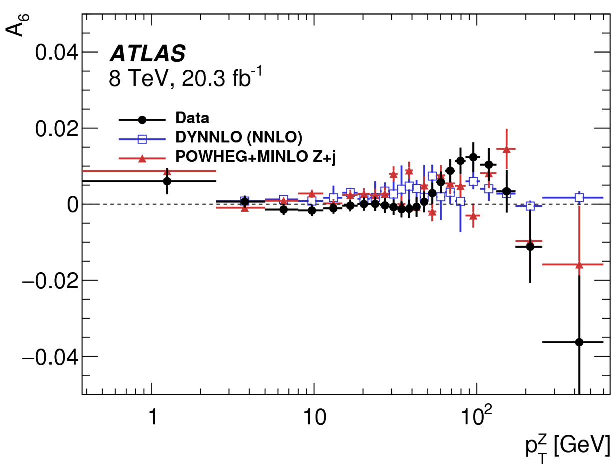
Angular coefficients in Z→ ll events

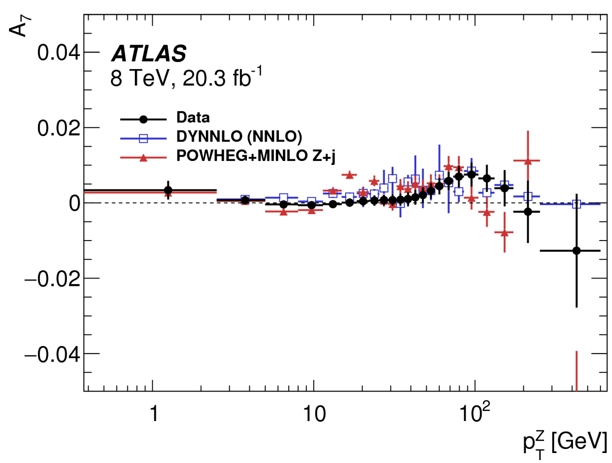
$$\frac{d\sigma}{dp_T^Z\, dy^Z\, dm^Z\, d\cos\theta\, d\phi} = \frac{3}{16\pi}\frac{d\sigma^{U+L}}{dp_T^Z\, dy^Z\, dm^Z}$$
$$\{(1+\cos^2\theta) + 1/2\, A_0(1-3\cos^2\theta) + A_1\, \sin 2\theta\, \cos\phi$$
$$+1/2\, A_2\, \sin^2\theta\, \cos 2\phi + A_3\, \sin\theta\, \cos\phi + A_4\, \cos\theta$$
$$+A_5\, \sin^2\theta\, \sin 2\phi + A_6\, \sin 2\theta\, \sin\phi + A_7\, \sin\theta\, \sin\phi\}.$$

Вклад ПИЯФ - анализ мюонного канала, теоретические расчеты коэффициентов…: А. Ежилов, О.Федин







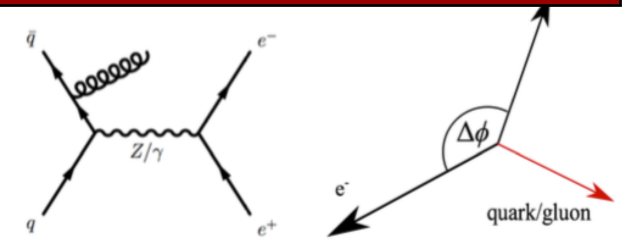


- Measured the full set of angular coefficient as a function of p_T^Z
- The measurements are compared to the most precise fixed-order calculations currently available $O(\alpha_s^2)$) and with theoretical predictions embedded in Monte Carlo generator
- The measurements are precise enough to probe QCD corrections beyond the formal accuracy of these calculations and to provide discrimination between different parton-shower models.
- A significant deviation from the $O(\alpha_s^2)$ predictions is observed for A_0-A_2.
- Evidence is found for non-zero $A_{5,6,7}$, consistent with expectations.

Precision studies of p_T and φ* of Z-boson

Вклад ПИЯФ – анализ электронного канала: А. Ежилов Д. Пуджа
мюонный канал: Д. Майстришен

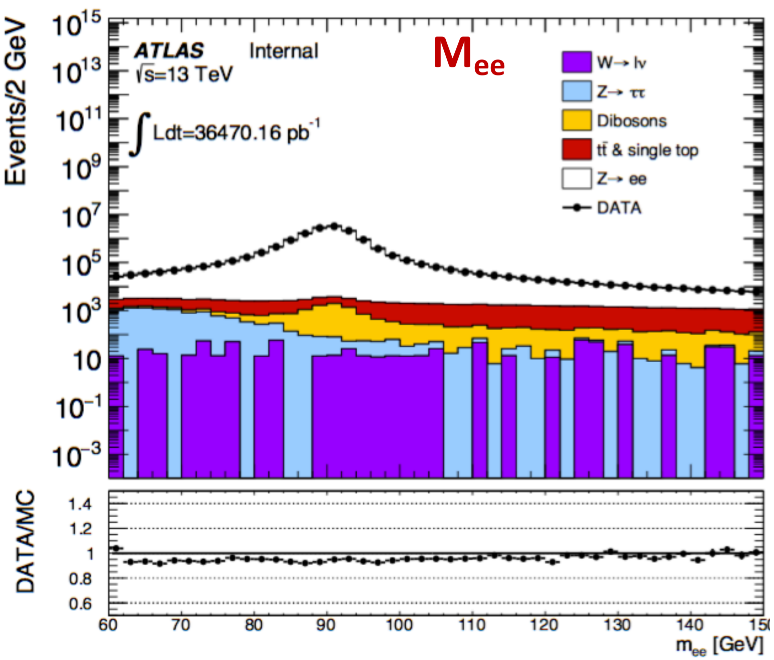
- Test predictions of
  - QCD predictions in all order of α_s complimented with Parton Showers(PS)
  - Soft-gluon resummation and hard jet emission
  - Non-pertubative effects (initristic parton transverse momentum)
- Results can be used for
  - Tune Monte-Carlo generators
  - Improve re-summed analytical calculations
  - measurement of electroweak observables (e.g. W boson mass)

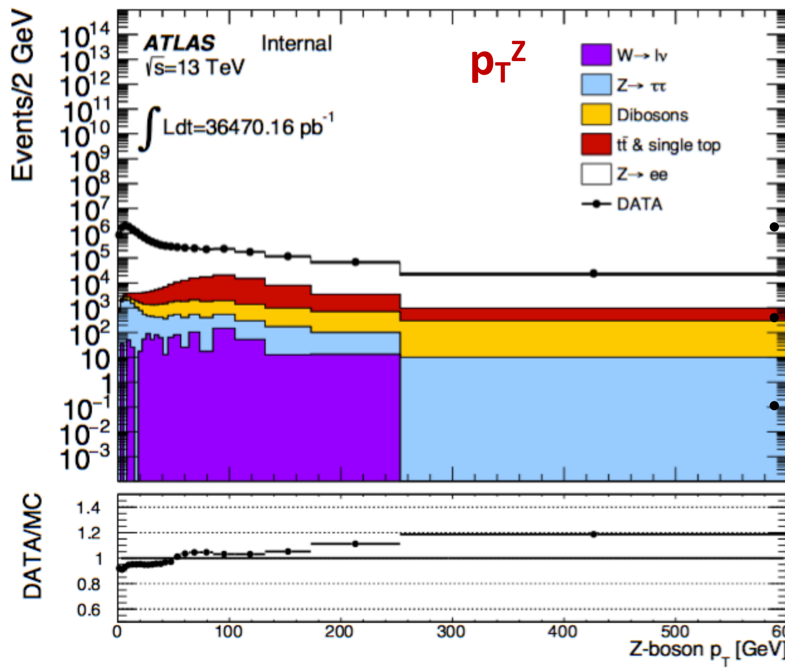


$$\phi_\eta^* = \tan\left(\frac{\pi - \Delta\phi}{2}\right)\cdot\sin(\theta_\eta^*)$$

$$\theta_\eta^* = \arccos\left(\tanh\left(\frac{\eta^- - \eta^+}{2}\right)\right)$$

$$\sqrt{2}m_z\phi_\eta^* \approx p_T^{ll}$$



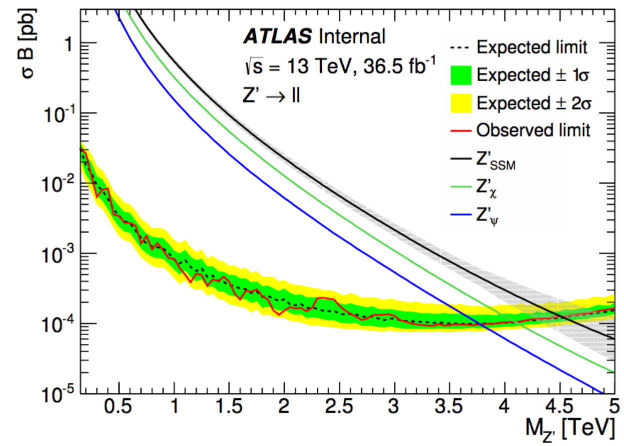


Analysis started in October '16
First results shown at the end of November
PNPI team will participate in all activities for both channels (for ATLAS contribution the main channel - electrons)

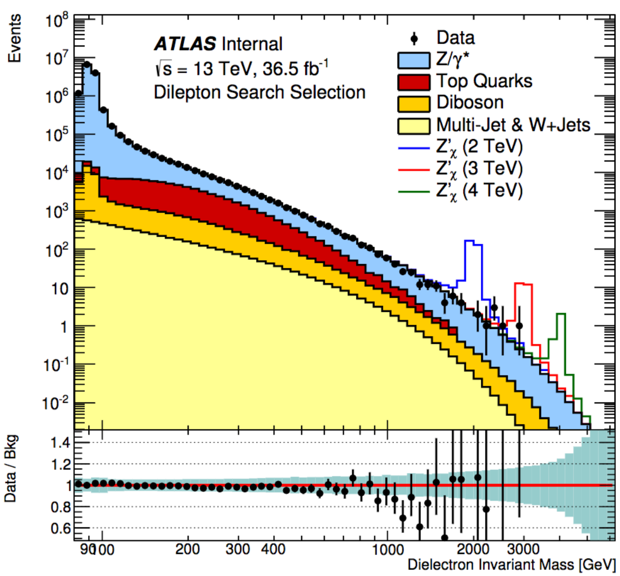
Search for heavy neutral Z′-boson (1)

Вклад ПИЯФ - анализ электронного канала: В. Малеев, М. Левченко, В.Пацера

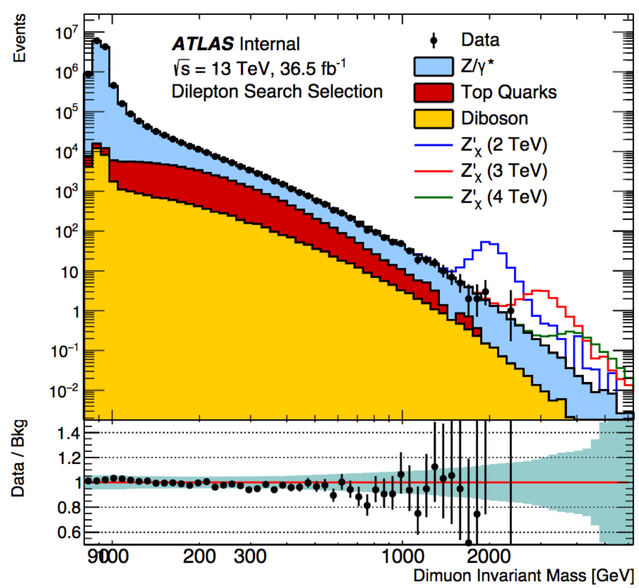
- Many models predict additional heavy bosons that decay to dilepton. Use Sequential Standard Model (SSM) Z′ as benchmark model
- Search for high mass states with dilepton: Z′ → ll
- Observable – dilepton invariant mass
- The major not reducible background: Z/γ*→ ll
- The search uses 36.5 fb^{-1} of proton–proton collision data, collected at s=√13 TeV during 2015 and 2016 years



Electrons



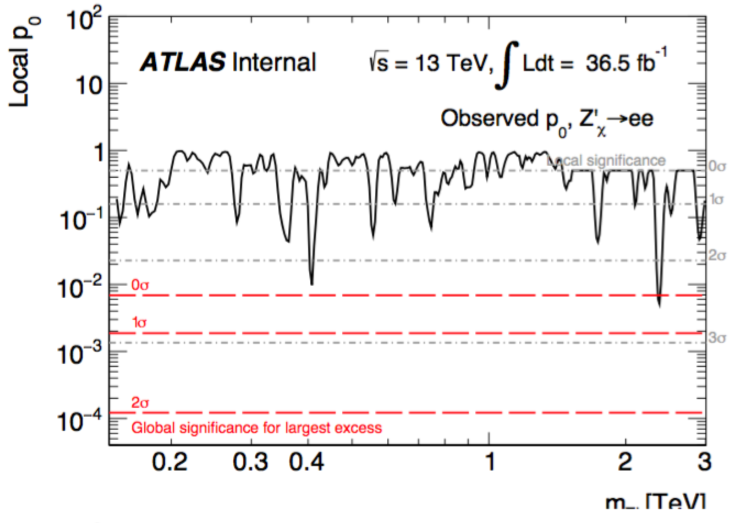
Muons

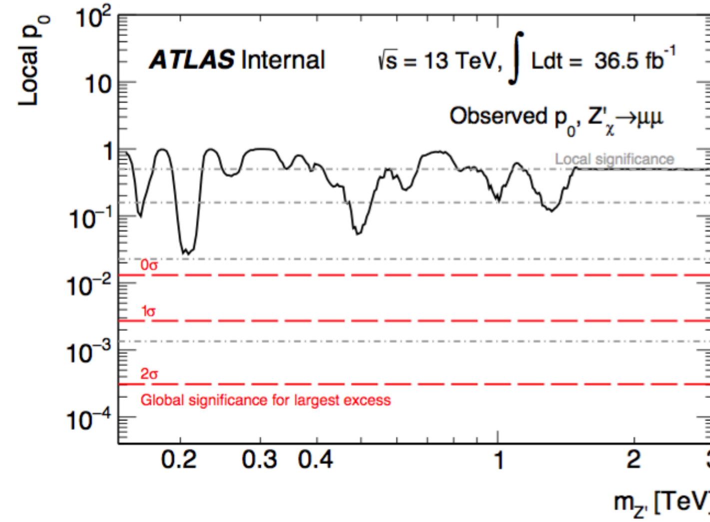


Model	Z'_{SSM}	
Год	Набл.(ТэВ)	Ожид. (ТэВ)
2010	1.048	1.088
2011	2.22	2.25
2012	2.9	2.87
2015	3.11	3.19
2016	4.53	4.52

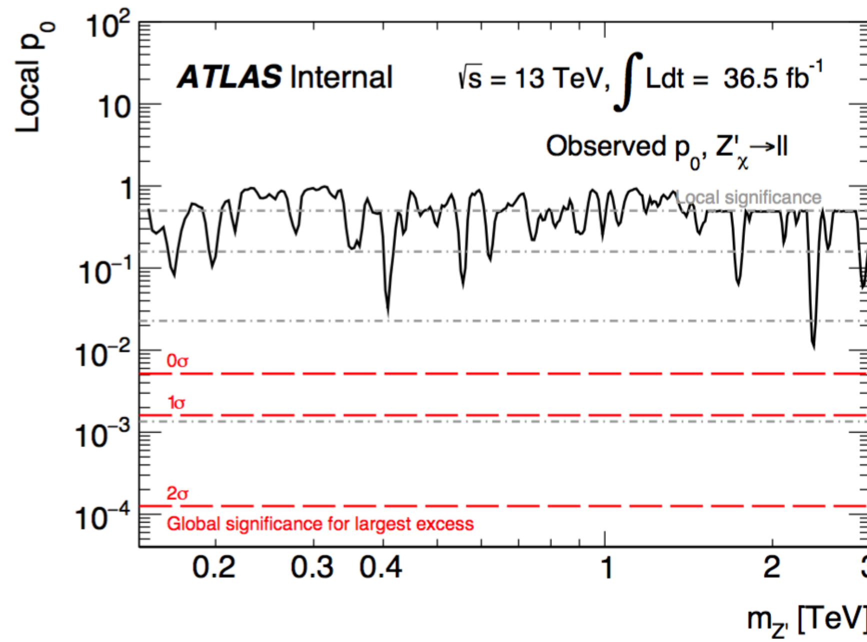
In the absence of any signal set the limit on cross-section (σB) with the CL 95%

Search for heavy neutral Z′-boson (2)





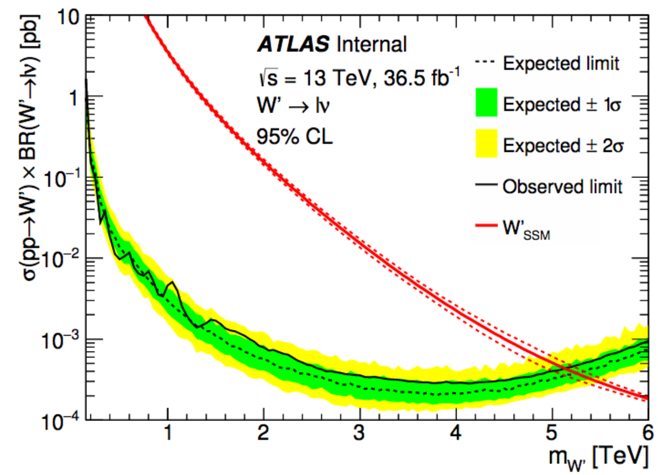
- Largest excess found in the electron channel at 2.3 TeV: 2.57σ local (0.29σ global)



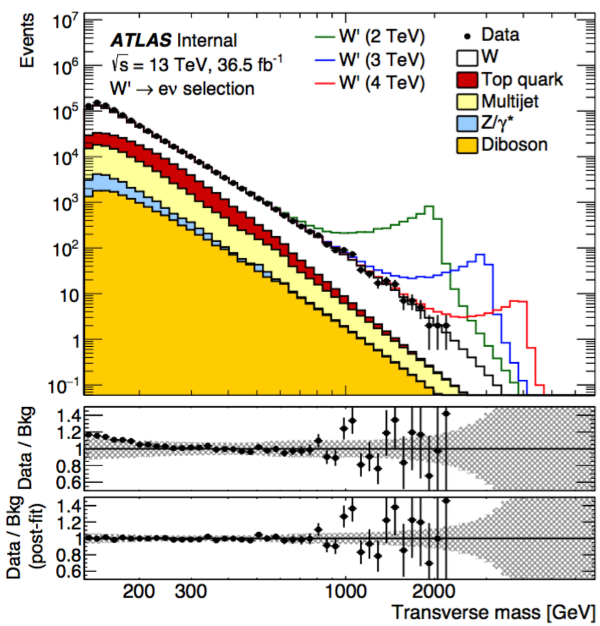
Search for heavy charged W'-boson (1)

- Many models predict additional heavy bosons that decay to lepton and neutrino. Use Sequential Standard Model (SSM) W' as benchmark model
- Search for high mass states with lepton plus missing ET
- The observable is transverse mass $m_T = \sqrt{2 p_T^l E_T^{miss} (1 - \cos\varphi_{l\nu})}$
- Look for excess above background – counting experiment!!

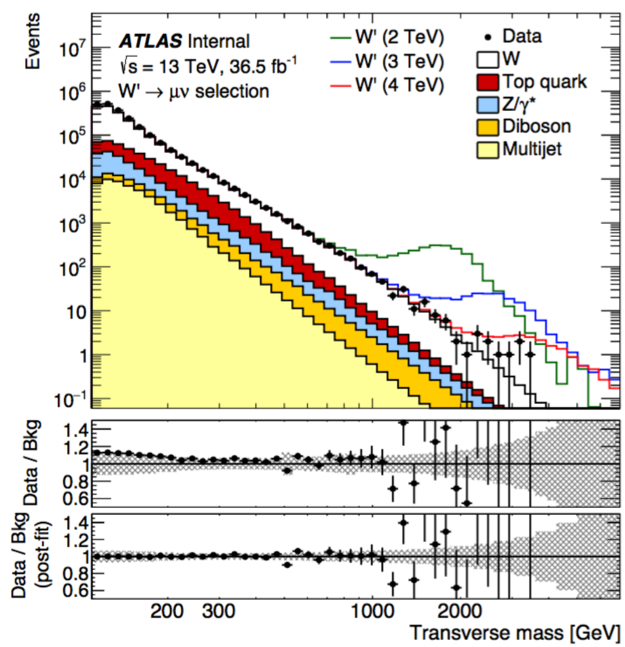
Вклад ПИЯФ - анализ электронного канала: В. Соловьев



m_T - electrons



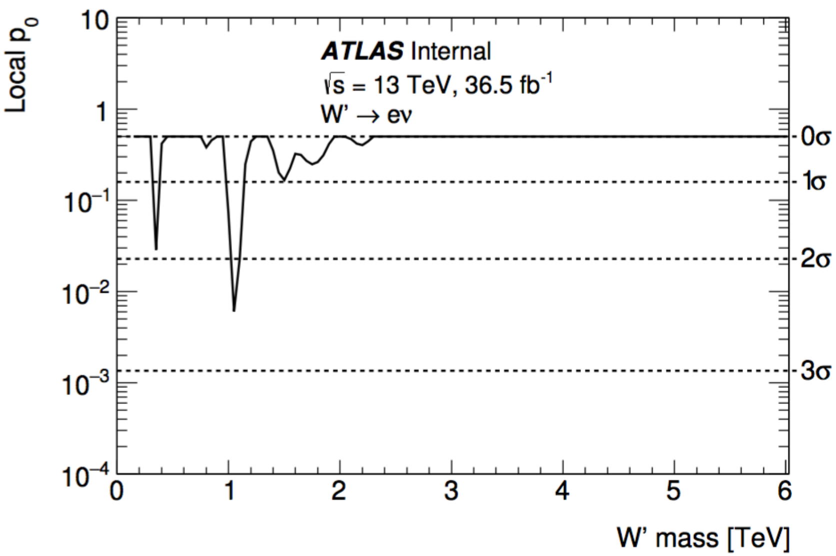
m_T - muons

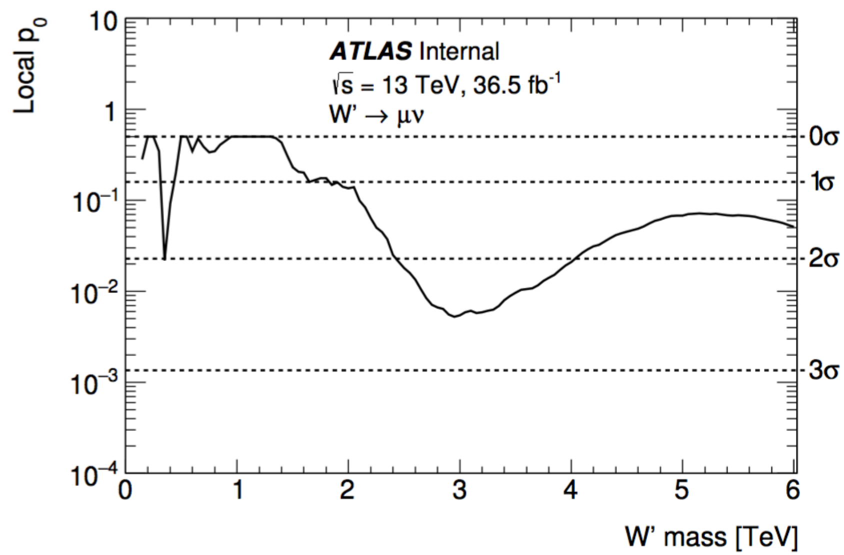


Модель	W'	
Год	Набл.(ТэВ)	Ожид.(ТэВ)
2010	1.49	1.45
2011	2.55	2.55
2012	3.17	3.24
2015	4.14	4.21
2016	5.13	5.25

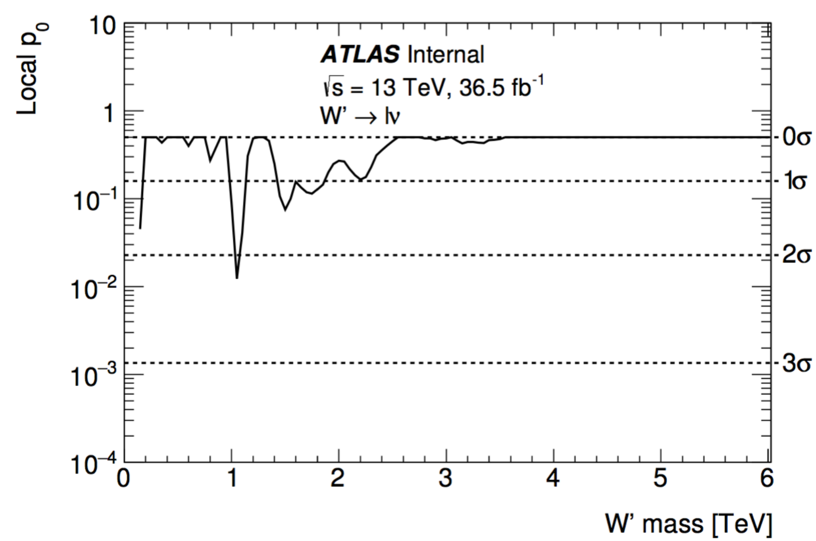
In the absence of any signal set the limit on cross-section (σB) with the CL 95%

Search for heavy charged W'-boson (2)

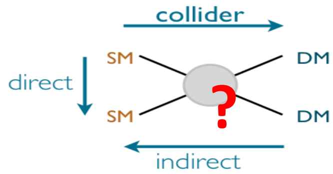


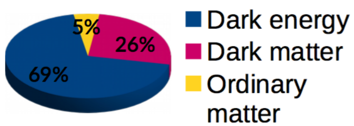


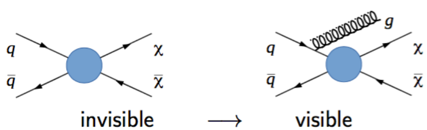
- Electron channel: largest excess found at 1.0 TeV: 2.5σ local significance
- Muon channel: wide excess in the muon channel due to various events above 2 TeV in mT Working with MCP to understand these events at high mT tail in the muon channel
- Combined: working to understand fit behavior and underlying physics reason for excess to vanish



Search of the DM (WIMP) particle

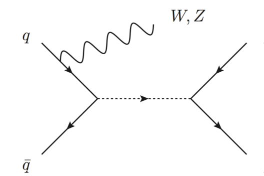


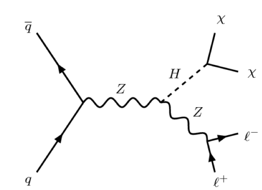


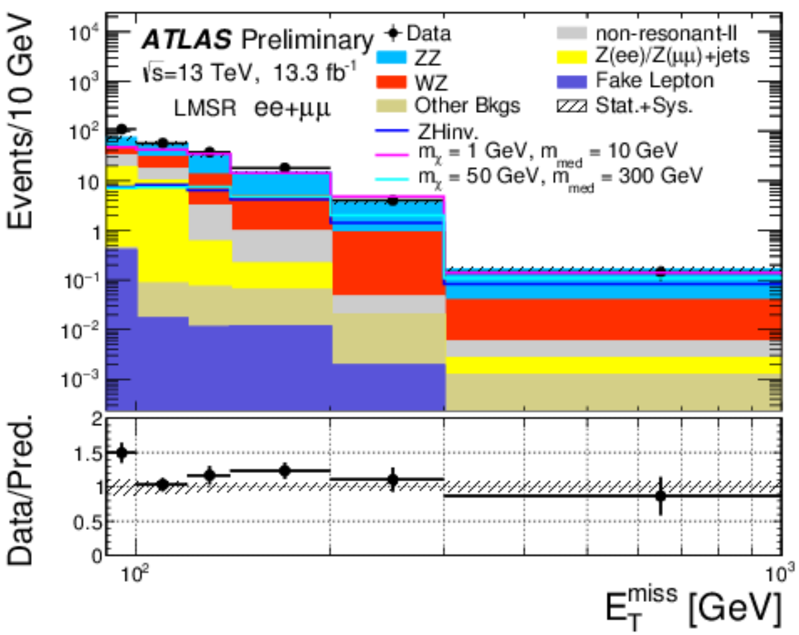


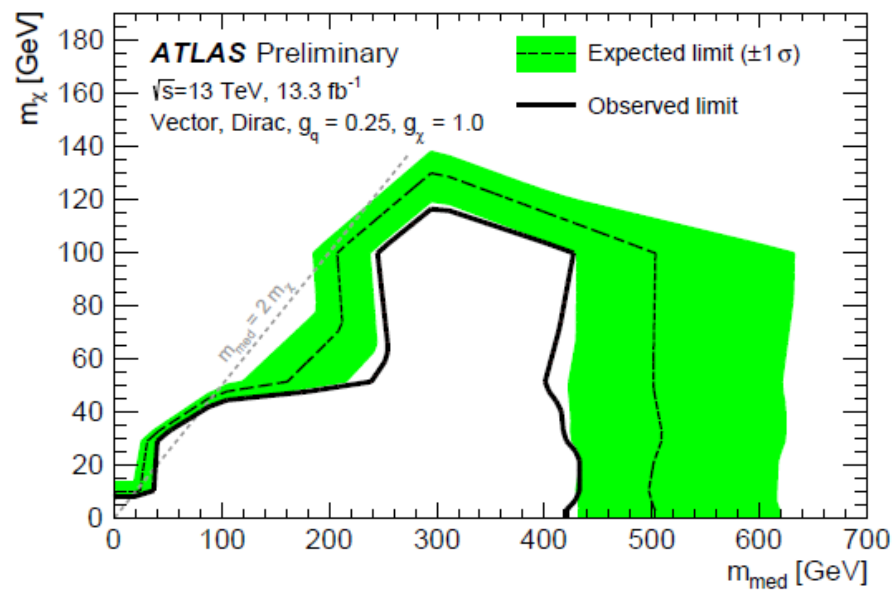
- DM can't be directly observed (doesn't interact with the detector
- Production of DM pairs can be identified via presence of an imbalance in transverse momenta ("missing energy") in the plane transverse to the beam line
- Hermetic calorimetric coverage of the ATLAS detector provides a good measurement of E^{t}_{miss}
- Mono-X (DM recoiling against X): $pp \rightarrow E^{t}_{miss}+X$, where X=jet,γ,W/Z(lept,jets)
- Commonly used in Run II simplified model (Run I – Effective field theory $Q^2 \ll M_{med}^2$): DM and SM particle interact via mediator=>small number of parameters ($M_{med}, m_{\chi}, g_{\chi}, g_q$)

Вклад ПИЯФ - анализ электронного канала: А.Басалаев, Ю.Нарышкин





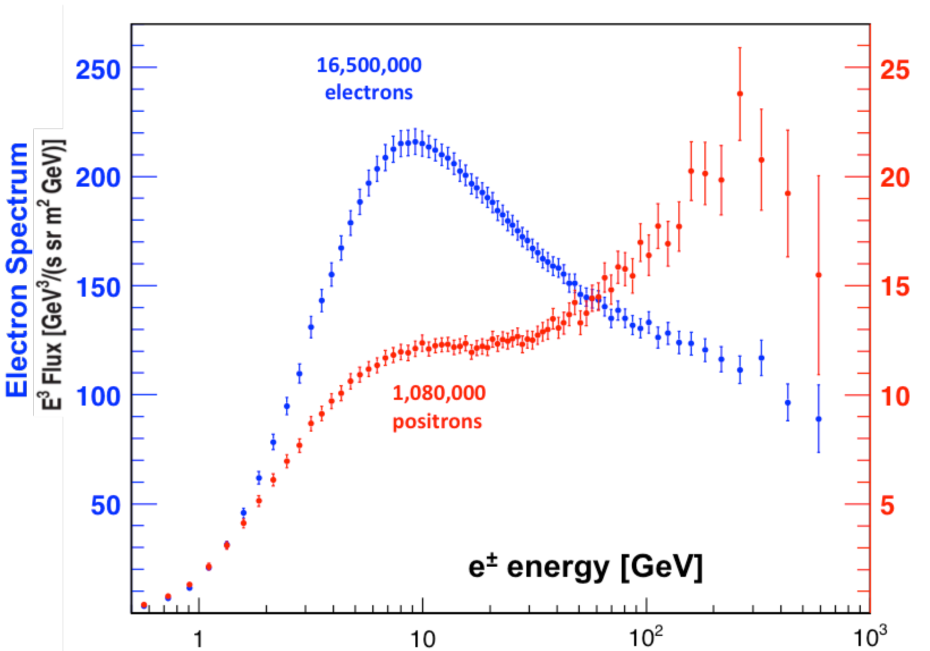




DM AMS-02 results

- *AMS has observed that the electron flux and positron flux display different behaviors both in their magnitude and in their energy dependence.*
- *The positron spectrum after rising from 8 GeV above the rate expected from cosmic ray collisions, the spectrum exhibits a sharp drop off at high energies in excellent agreement with the dark matter model predictions with a mass of ~1 TeV.*

Prof. Samuel Ting Thursday 8 Dec 2016



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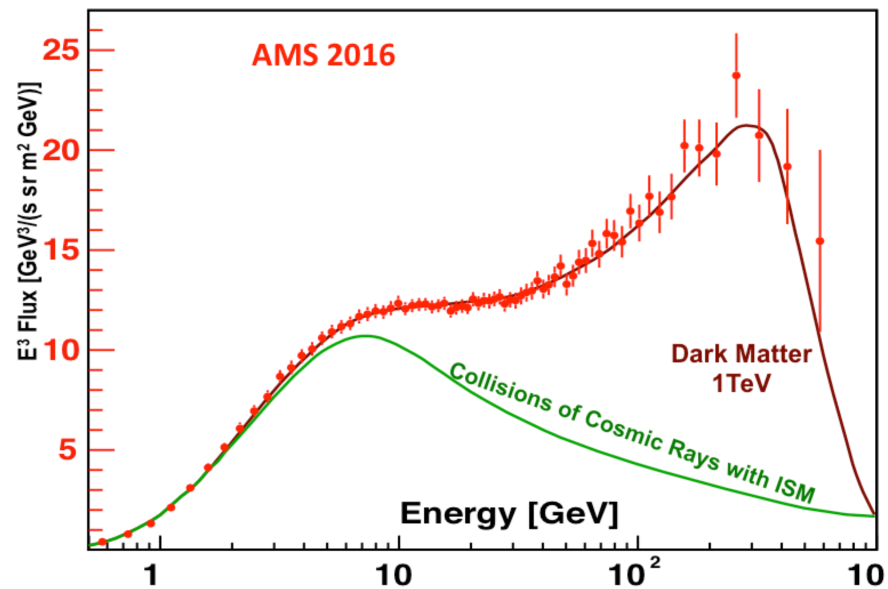
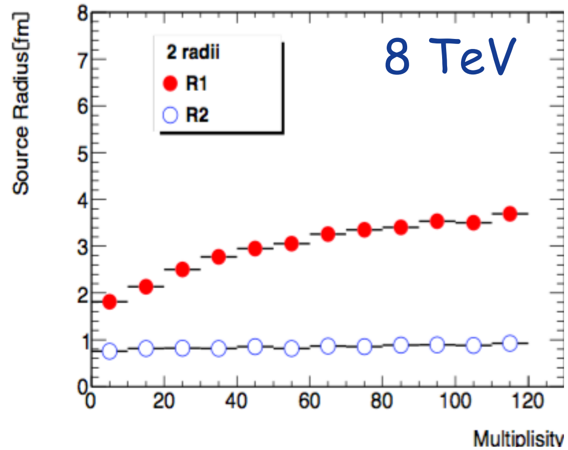


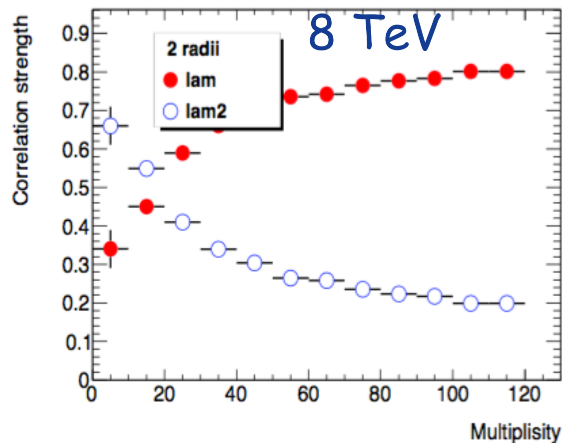
https://indico.cern.ch/event/592392/

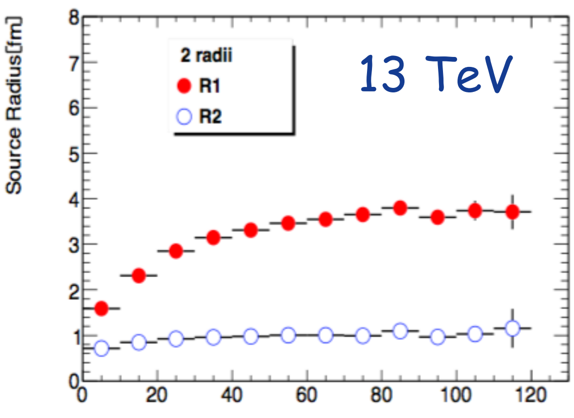
BEC

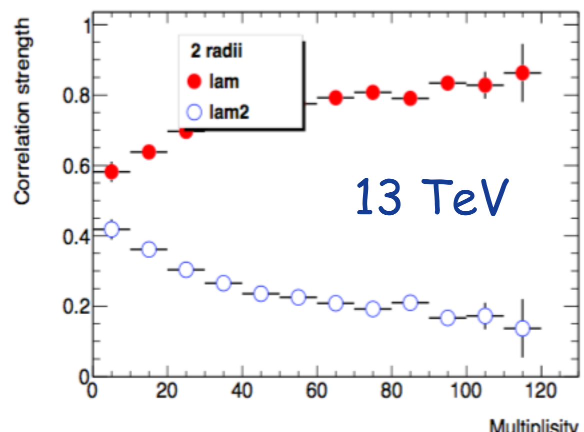
В.А. Щегельский и М.Г. Рыскин

Effective radius — **Correlation strength parameter λ:**









- The BEC effect is usually described by a function with two parameters: the effective radius parameter R and the correlation strength parameter λ:

$$R(Q) = \lambda e^{-RQ} + a + bQ$$

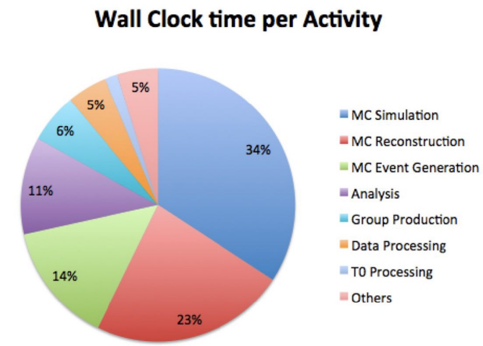
- However it was argue (V.A. Khoze, A.D. Martin, M.G. Ryskin and V.A. Schegelsky, Eur.Phys.J. C76 (2016) 193) that the secondaries produced in high energy hadron collisions may be radiated by *small size* sources distributed over a much larger area of the proton-proton interaction.

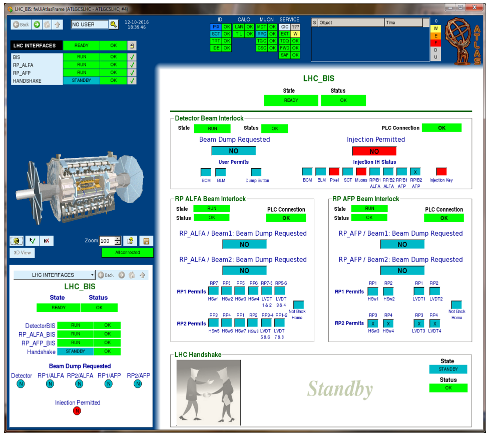
$$R(Q) = \lambda\, e^{-\bar{r}_1 Q} + (1-\lambda)\, e^{-\bar{r}_2 Q} + a + bQ$$

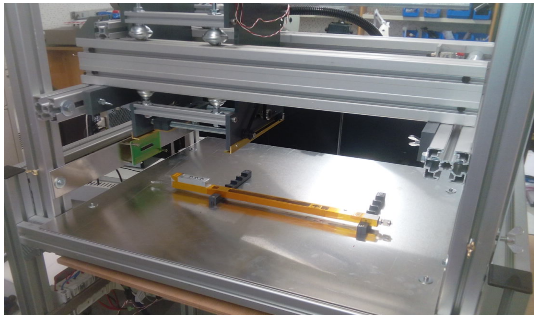
The first time observe in BEC that the secondaries are produced by a number of *small* size sources (hot spots) of the radius $r_2 \sim R_\pi$ (or smaller) with a much larger separation $r_1 \sim 2R_N$ between the individual sources (hot spots). These sources may be considered as the individual Pomerons or as some excitations of QCD vacuum medium. The small size, r_2, measured this way may be interpreted as the size of the individual vacuum excitation. Note also that the value of r_2 is independent on the LHC beam energy, i.e. this object is a universal one.

Other technical tasks…..

- Development of Fast Simulation s/w. (A.Basalaev)
- Validation of electron/photon identification s/w (M.Levchenko, A. Ezhilov)
- Отдел информационных технологий и автоматизации ПИЯФ (A. Kazarov, V. Filimonov, V. Khomutnikov):
  - Expert support and exploitation of TDAQ s/w at Point 1 (ATLAS).
  - TDAQ On-call experts.
  - DAQ s/w librarian.
  - Central ATLAS DCS
- Setup to check the purity of the gas system components for TRT detectors (S. Katunin)
- Construction of the sTGC chambers for forward part of ATLAS muon spectrometer (Phase-1 upgrade)
- Participation in the construction of ITk tracker- Phase-2 upgrade (I. Ilyashenko)





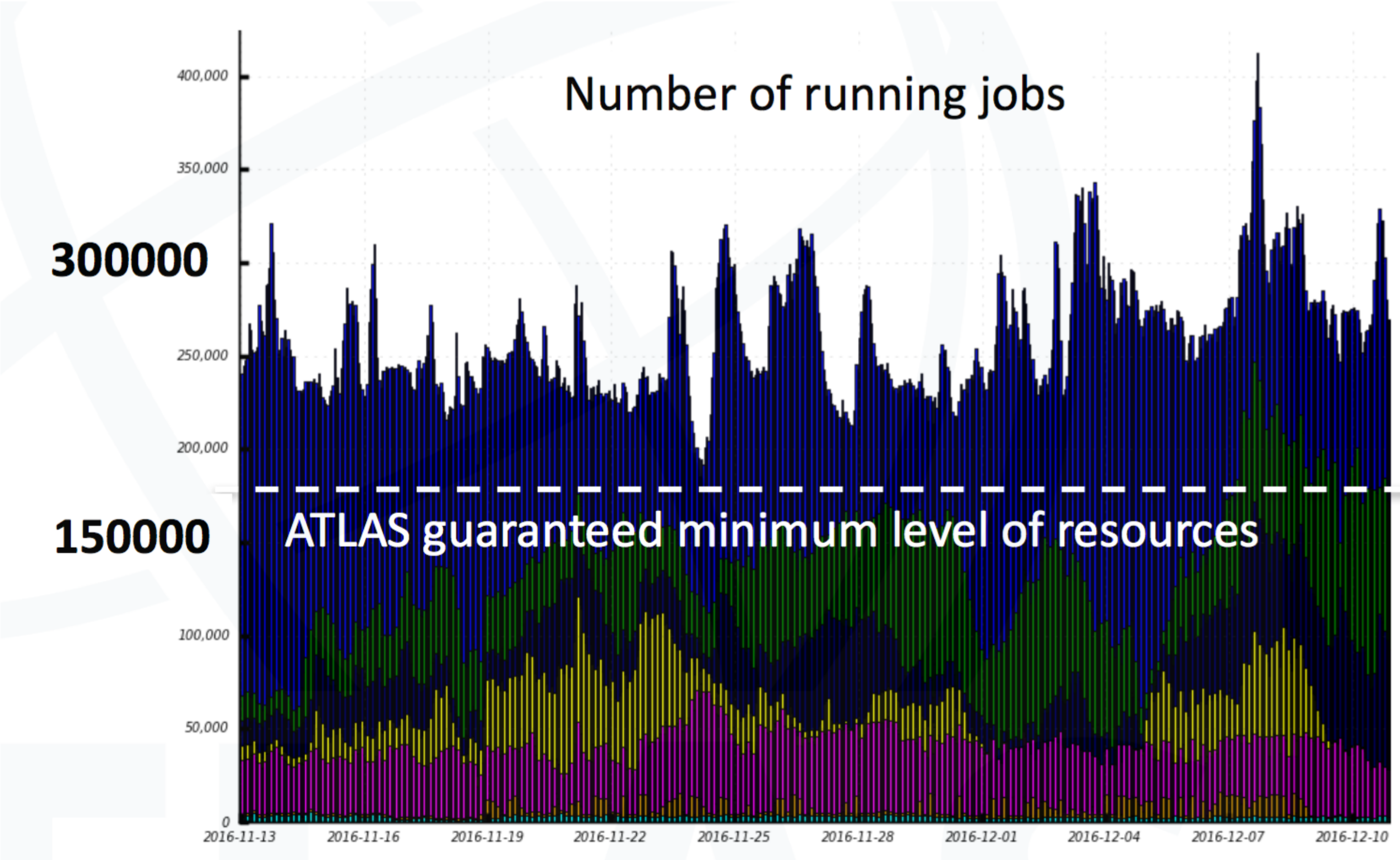


Back Up slides

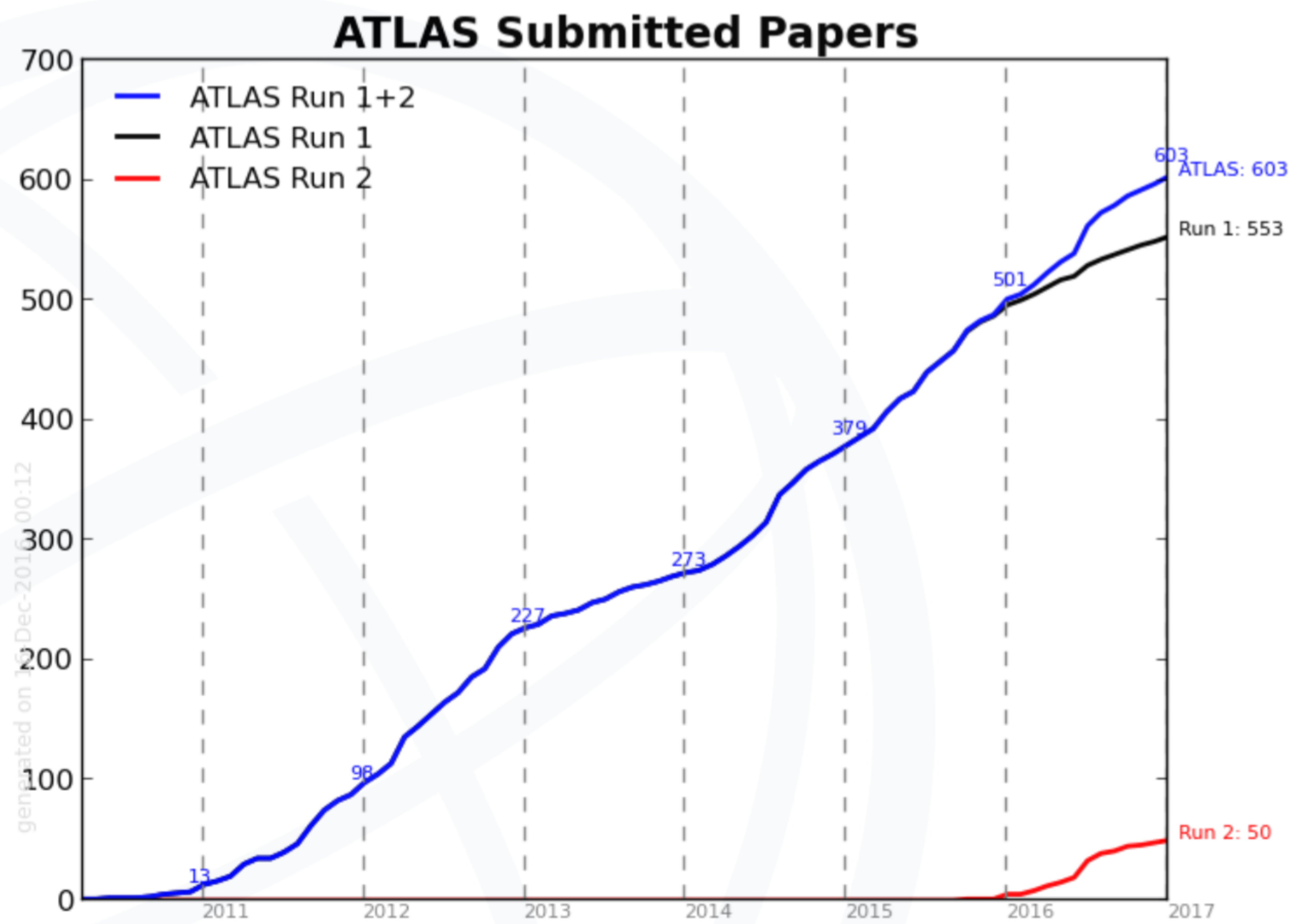
Data Processing and Computing

Worldwide computing resources are crucial

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



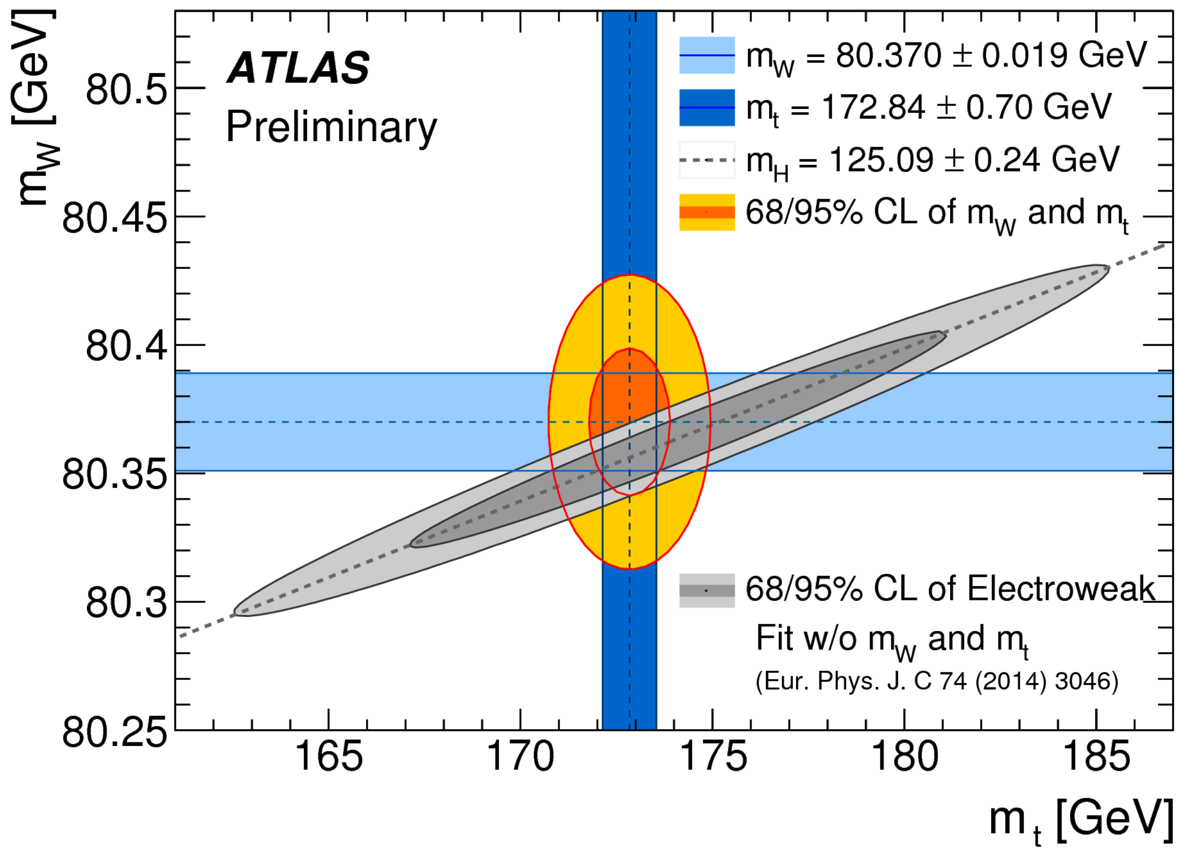
ATLAS publication status



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

Measurement of the W-boson mass

ATLAS-CONF-2016-113



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

Measuring them precisely provides an important consistency test