Standard Model Measurements at the ATLAS Experiment

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3/27/2018

TCHOU Symposium

LHC

Swiss Alps

Particle Physics experiment at the world highest energy.

proton-proton collisions at $\sqrt{s} \leq 14$ TeV

2010 First Collisions in LHC

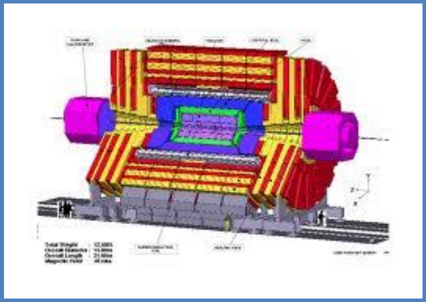
2011-12 Run 1. 25 fb^{-1} at $\sqrt{s}$ = 7 - 8 TeV.

2012 Discovery of the Higgs boson at ATLAS/CMS.

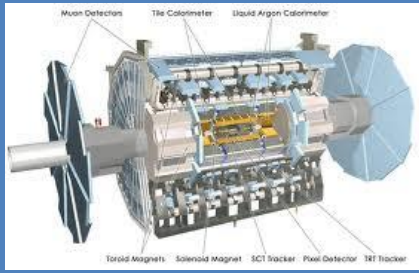
2015-18 Run 2 at $\sqrt{s}$=13 TeV.

Geneve

CMS



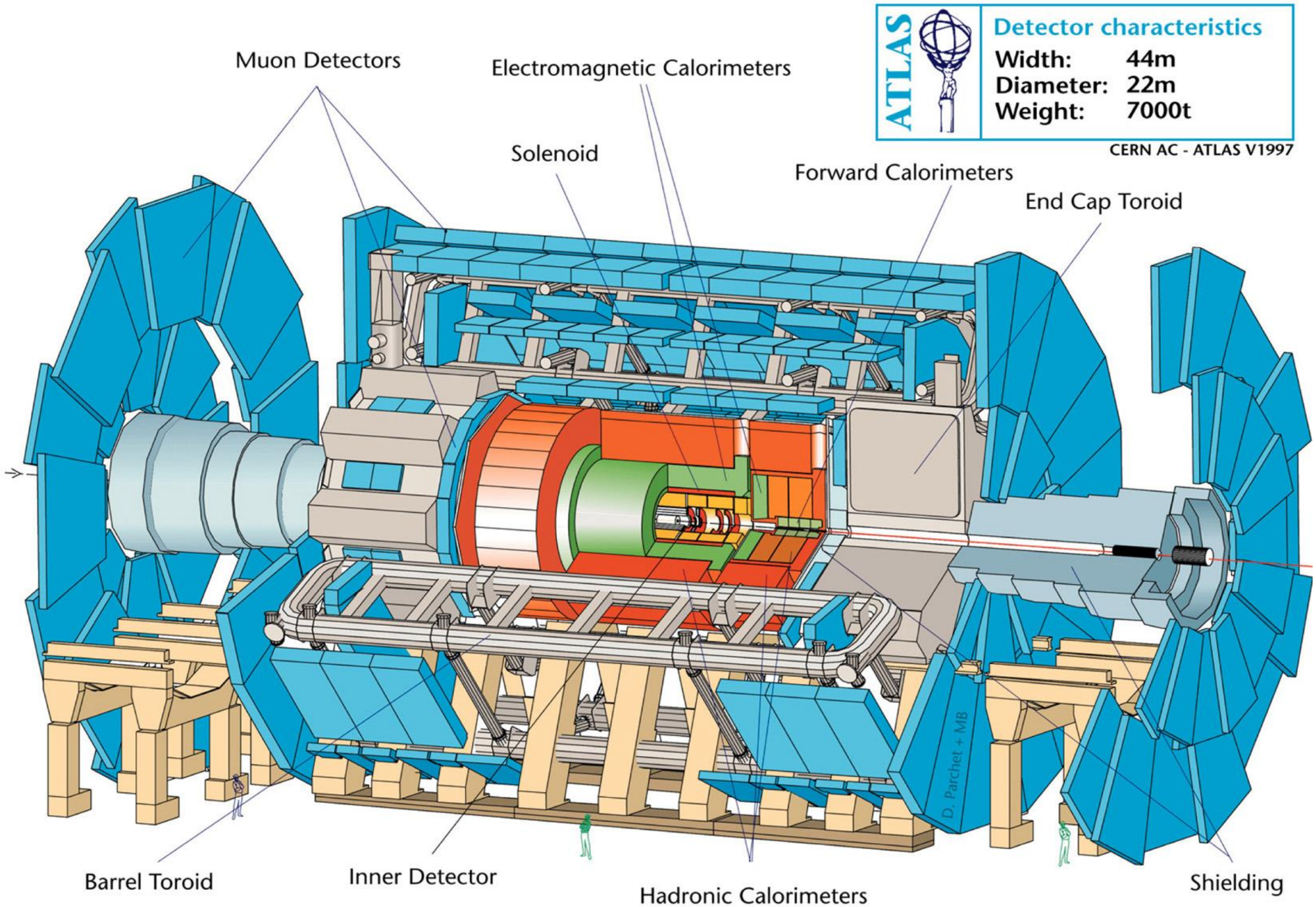
ATLAS



Circumference 27km

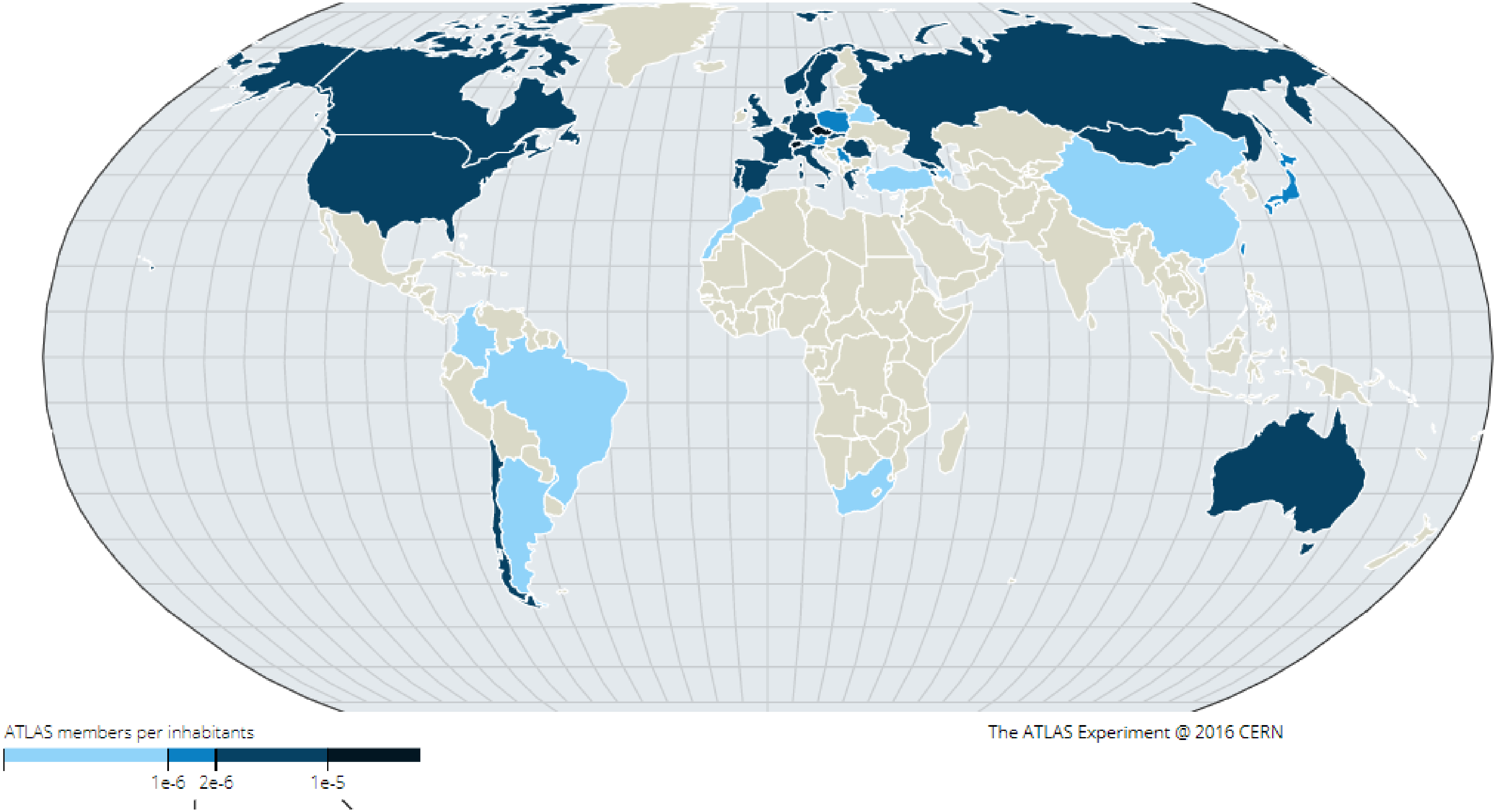
ATLAS Detector

Total weight: 7,000 t



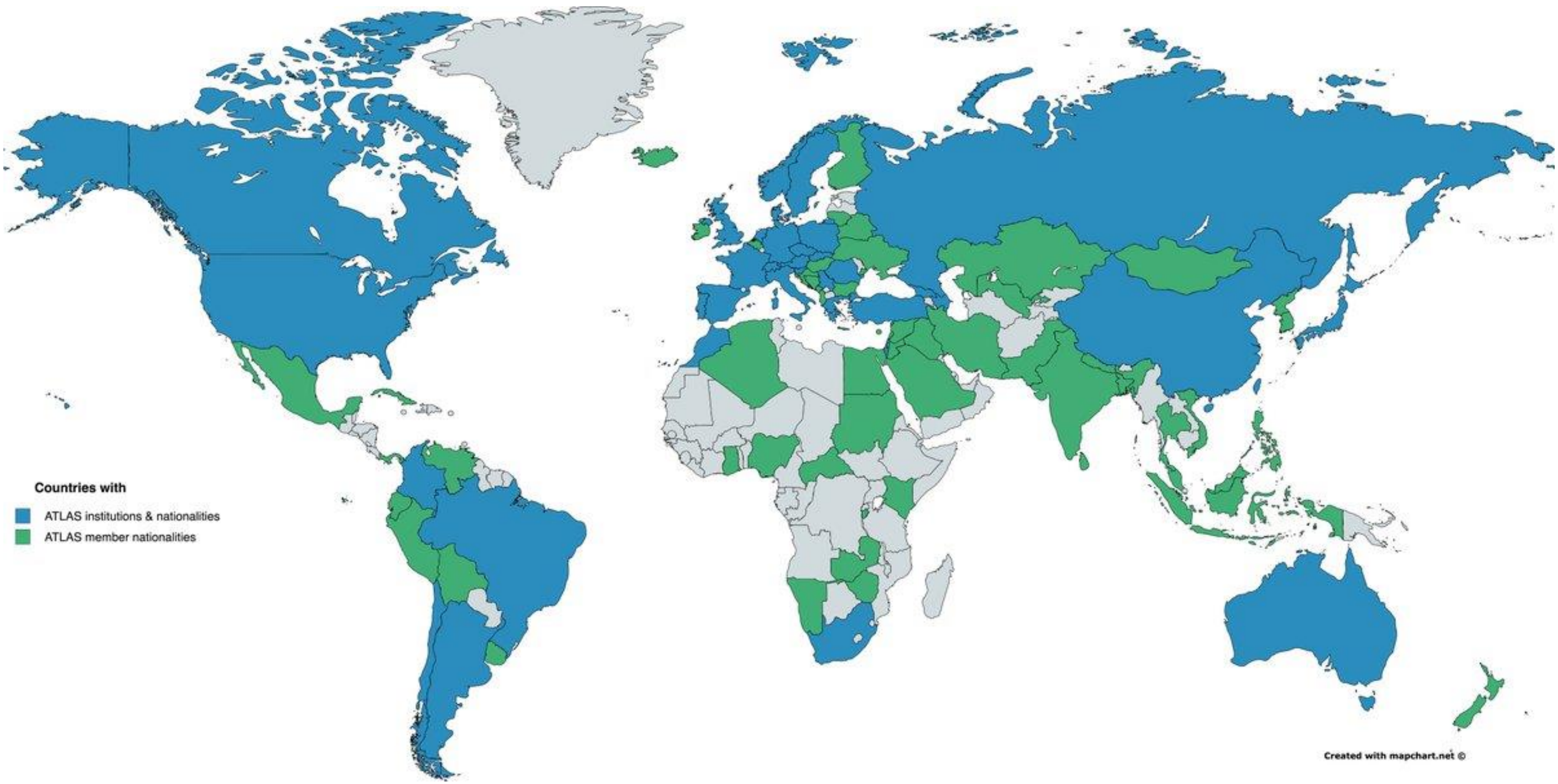
ATLAS Collaboration

- About 3000 scientific authors from 182 institutions in 38 countries.



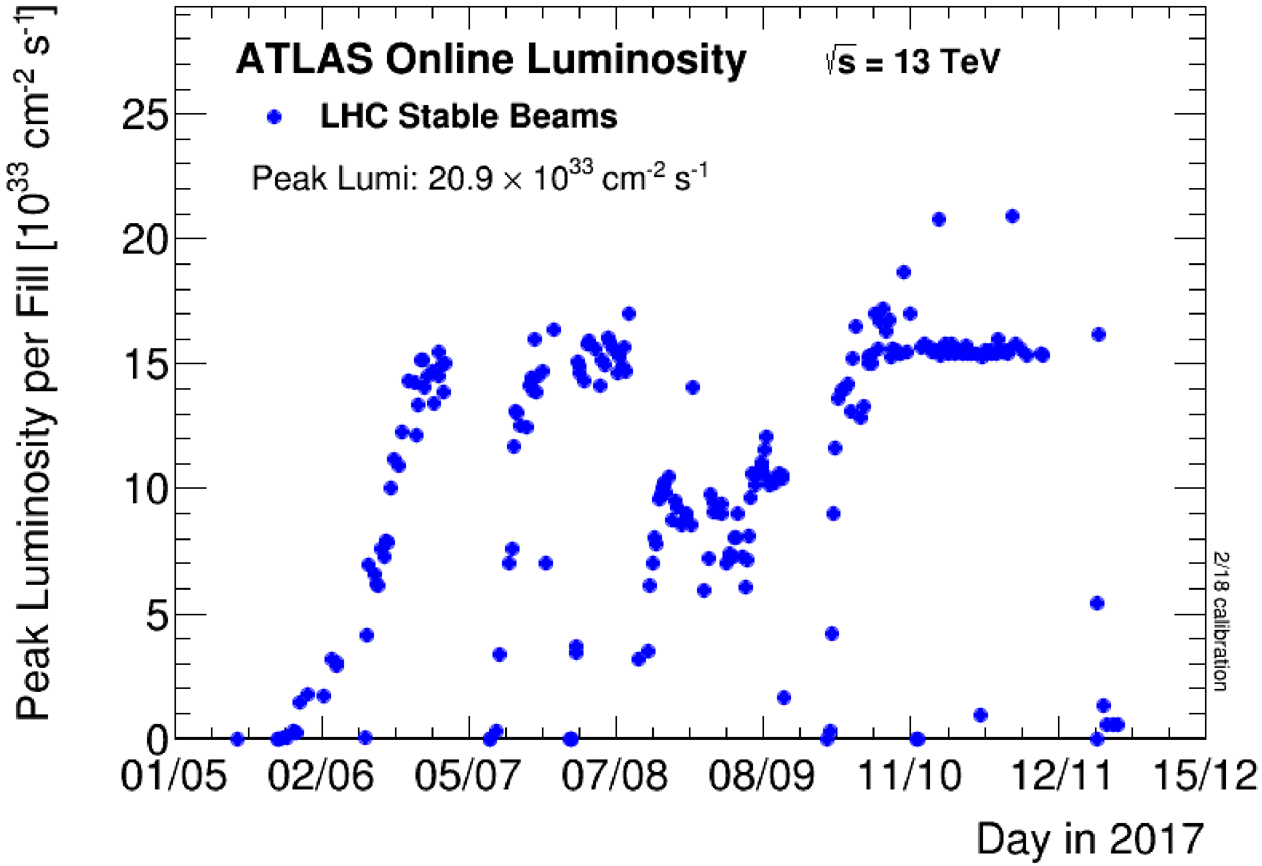
ATLAS Collaboration

- About 3000 scientific authors from 182 institutions in 38 countries. 94 different nationalities!!



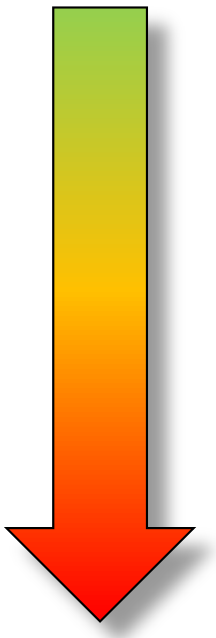
LHC Luminosity going high

- In 2018, the ATLAS trigger system could not keep up with the increase of instantaneous luminosity.
- The accelerator division had to introduce Luminosity leveling.



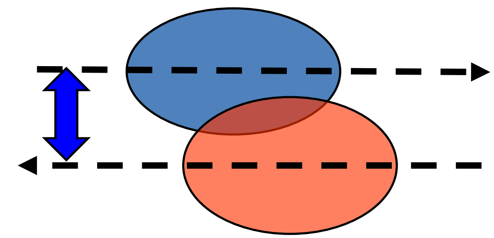
Luminosity levelling

- In certain conditions and depending on the experiments request, it is desirable to adapt the luminosity dynamically with beams in collision – **levelling**
- Each levelling technique has its advantages and drawbacks

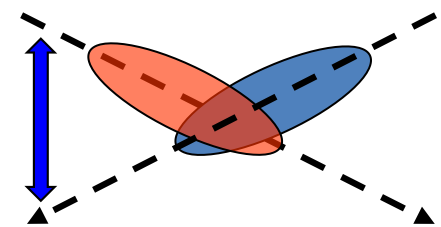


Complexity

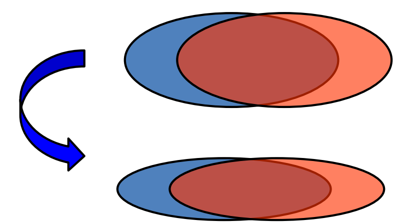
Levelling by beam offset / separation



Levelling by crossing angle



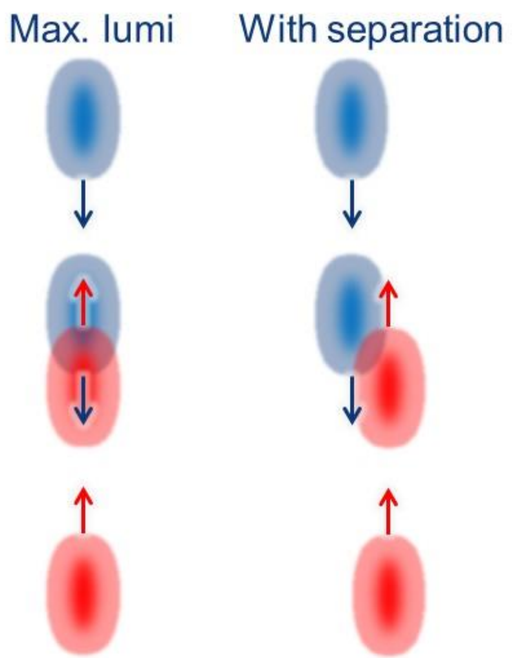
Levelling by β^* (= beam size at IP)

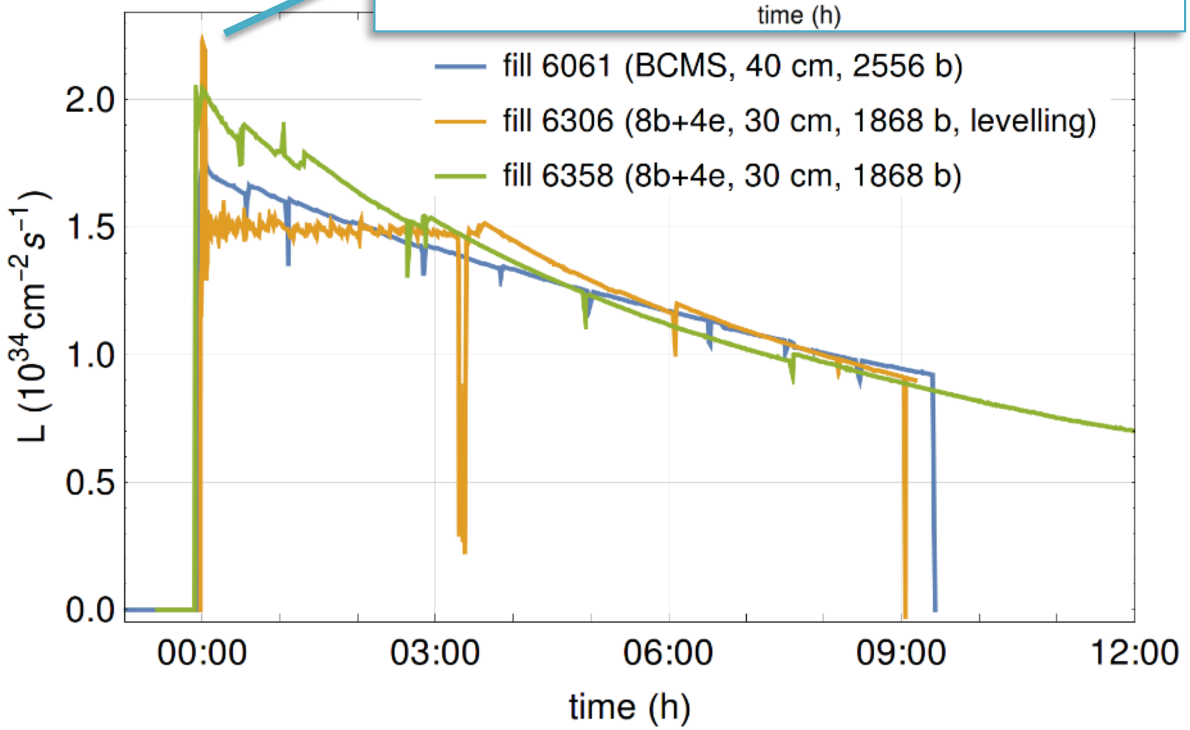


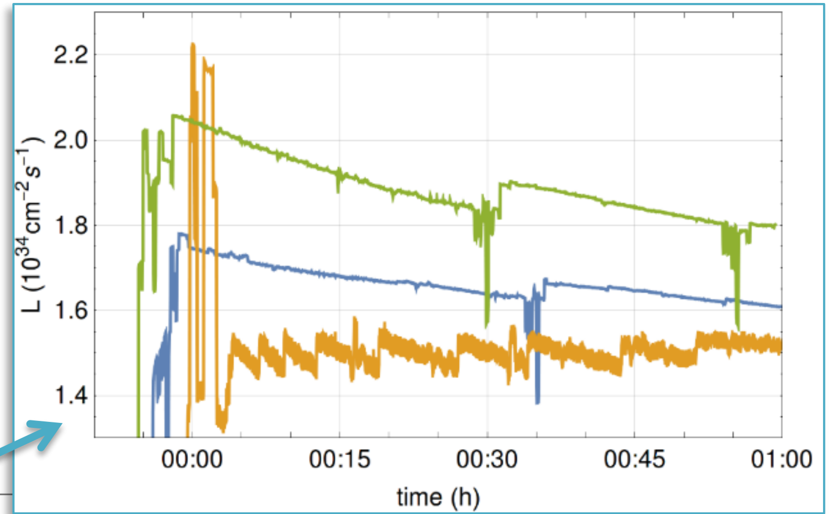
Bordry, Moriond QCD 2018

LHC 2017 : separation levelling

- Introduced separation levelling for all experiments (Separation levelling is used since many years for ALICE and LHCb)
- Dynamic orbit bump changes overlap of colliding bunches
- Initial spike before leveling reaching 2.2×10^{34} $cm^{-2}s^{-1}$







Bordry, Moriond QCD 2018

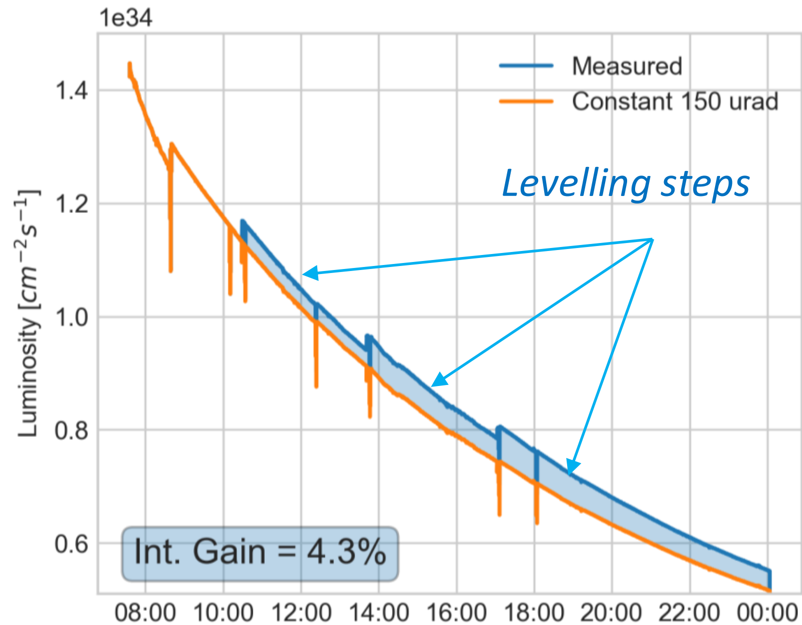
Anti-Levelling by Crossing Angle

Crossing angle anti-levelling operational

- Observed luminosity gain of **3-4 %**
- Steps of -10 µrad at stable beams

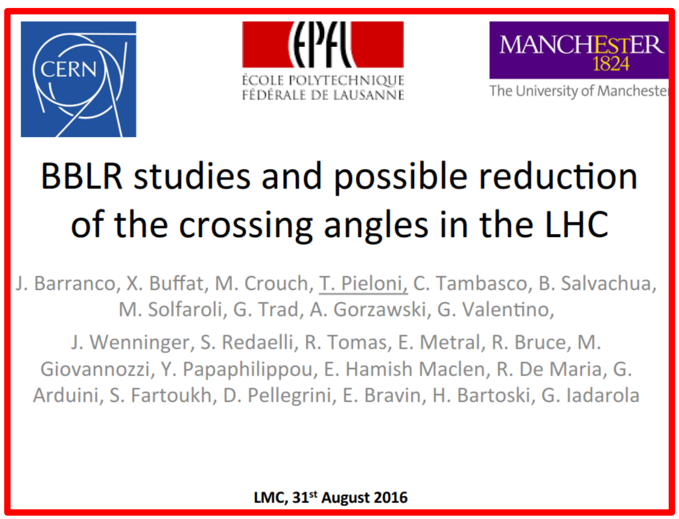
  after 2h, 4h, 8h

  150 → 140 → 130 → 120 µrad



Fill 5872

ATLAS Luminosity



BBLR studies and possible reduction of the crossing angles in the LHC

J. Barranco, X. Buffat, M. Crouch, T. Pieloni, C. Tambasco, B. Salvachua, M. Solfaroli, G. Trad, A. Gorzawski, G. Valentino,

J. Wenninger, S. Redaelli, R. Tomas, E. Metral, R. Bruce, M. Giovannozzi, Y. Papaphilippou, E. Hamish Maclen, R. De Maria, G. Arduini, S. Fartoukh, D. Pellegrini, E. Bravin, H. Bartoski, G. Iadarola

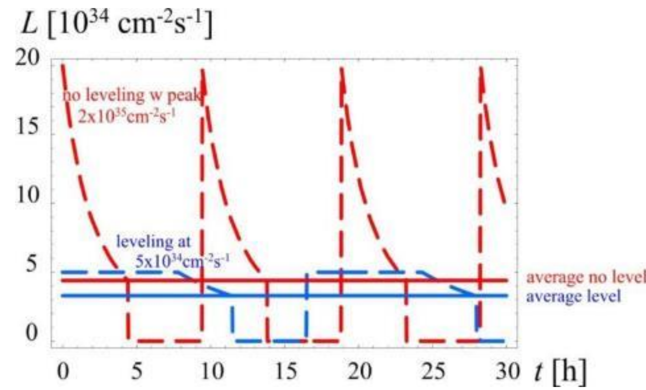
LMC, 31st August 2016

MD in 2016

Bordry, Moriond QCD 2018

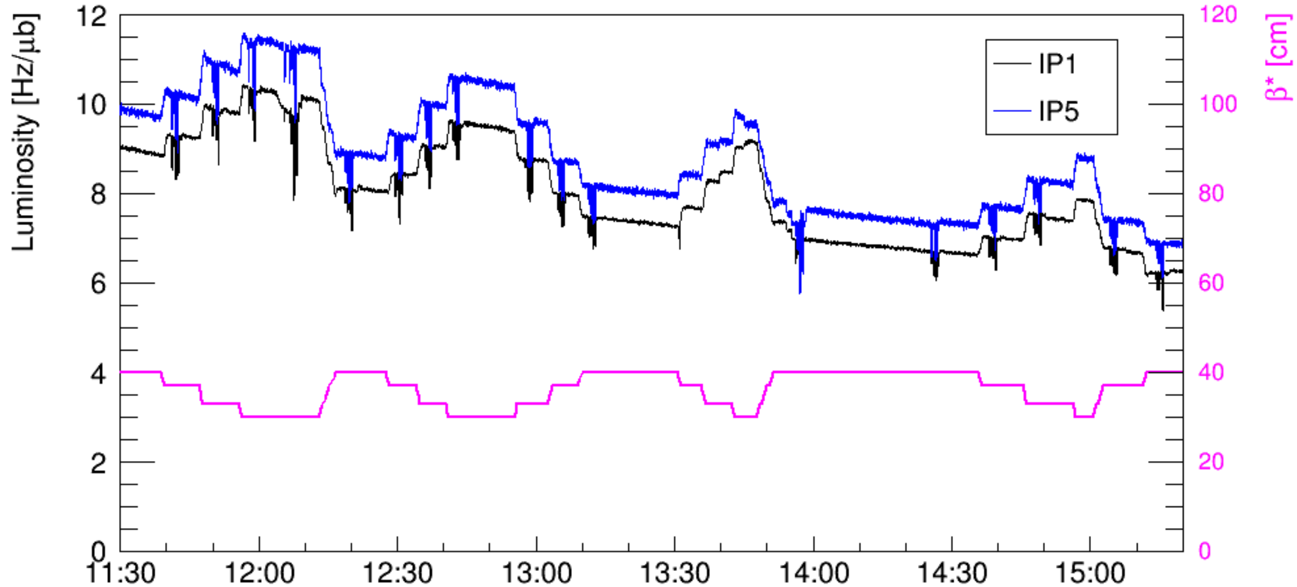
MDs on β* levelling

Levelling luminosity by β* should be the main levelling technique for HL-LHC



β* levelling in the last LHC MD: a possible tool for 2018 operation

Aimed for final β*: 27-25 cm

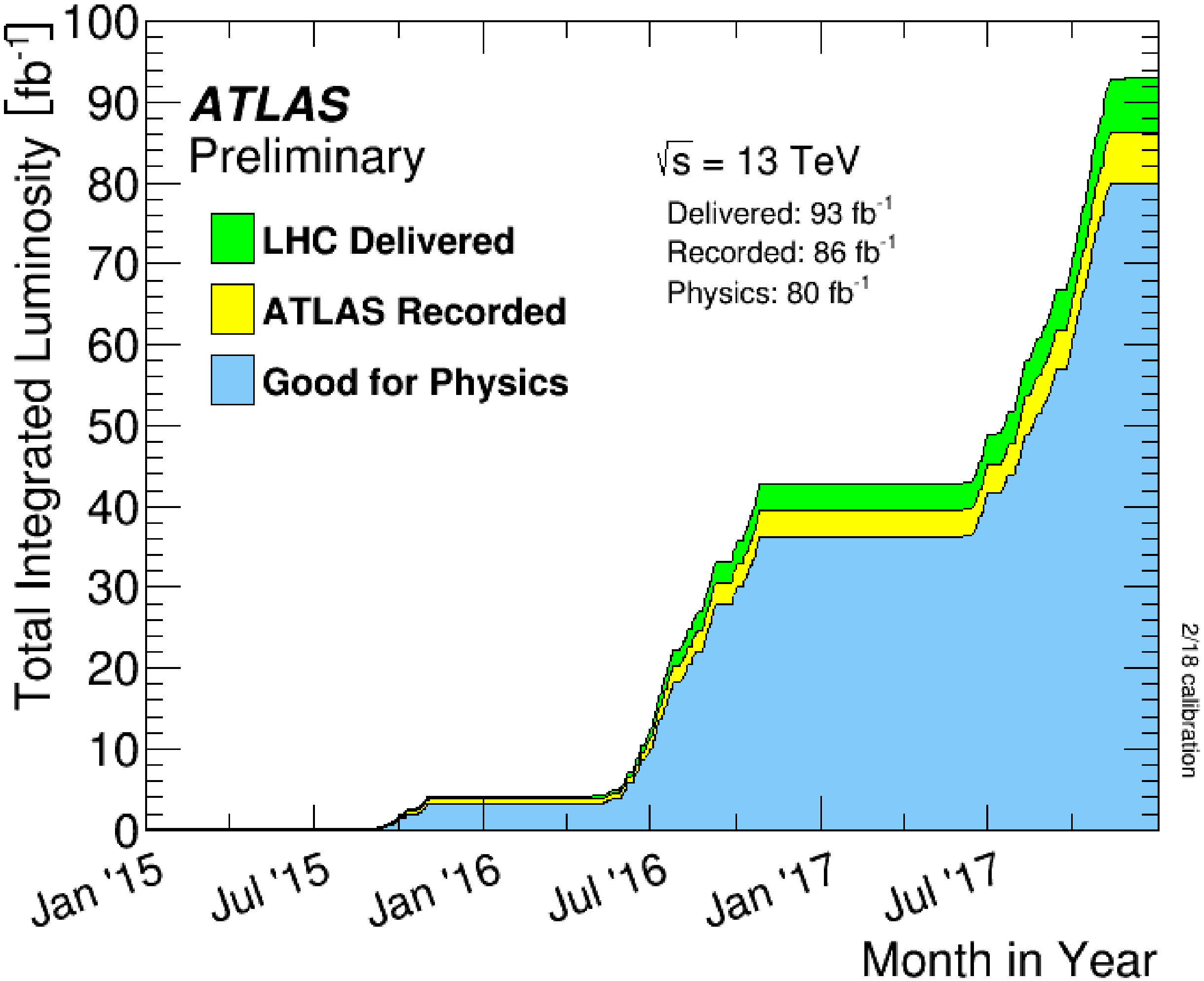


Luminosity evolution during β levelling, moving back and forth between 30 cm and 40 cm. The beams remained head-on* ***within ~ 2 µm*** *!*

Bordry, Moriond QCD 2018

ATLAS Run-2 Detector Status (from July 2017)

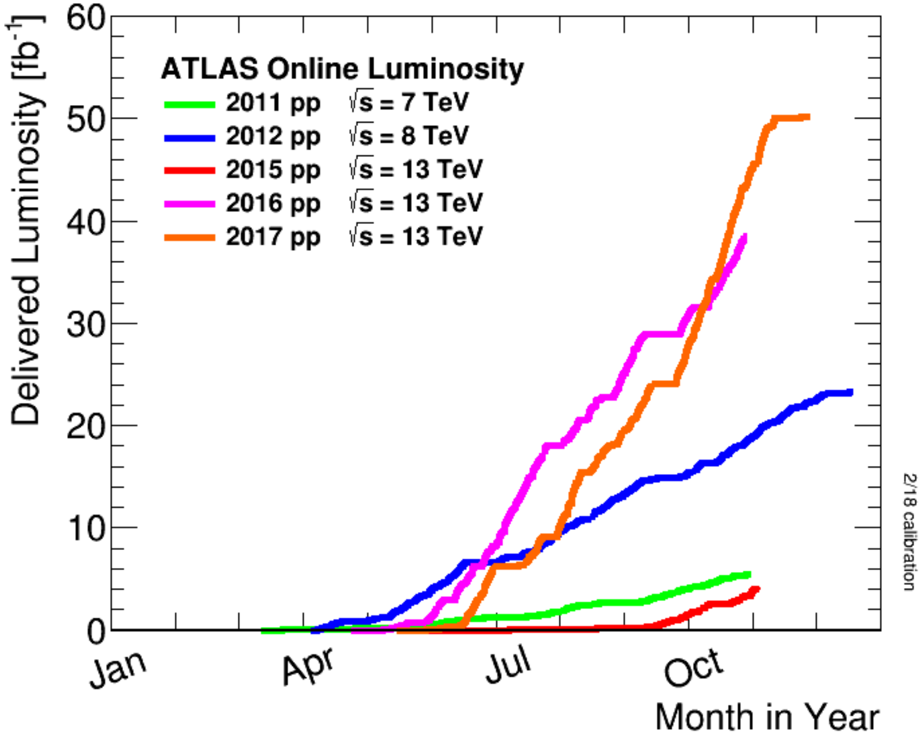
Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	92 M	97.8%
SCT Silicon Strips	6.3 M	98.7%
TRT Transition Radiation Tracker	350 k	97.2%
LAr EM Calorimeter	170 k	100 %
Tile Calorimeter	5200	99.2%
Hadronic End-Cap LAr Calorimeter	5600	99.5%
Forward LAr Calorimeter	3500	99.7%
LVL1 Calo Trigger	7160	99.9%
LVL1 Muon RPC Trigger	383 k	99.8%
LVL1 Muon TGC Trigger	320 k	99.9%
MDT Muon Drift Tubes	357 k	99.7%
CSC Cathode Strip Chambers	31 k	95.3%
RPC Barrel Muon Chambers	383 k	94.4%
TGC End-Cap Muon Chambers	320 k	99.5%
ALFA	10 k	99.9%
AFP	430 k	93.8%



- 2018 alone:

Total Delivered: 50.2 fb^{-1}
Total Recorded: 46.9 fb^{-1}
Data taking efficiency~93%

Luminosities in Run 2

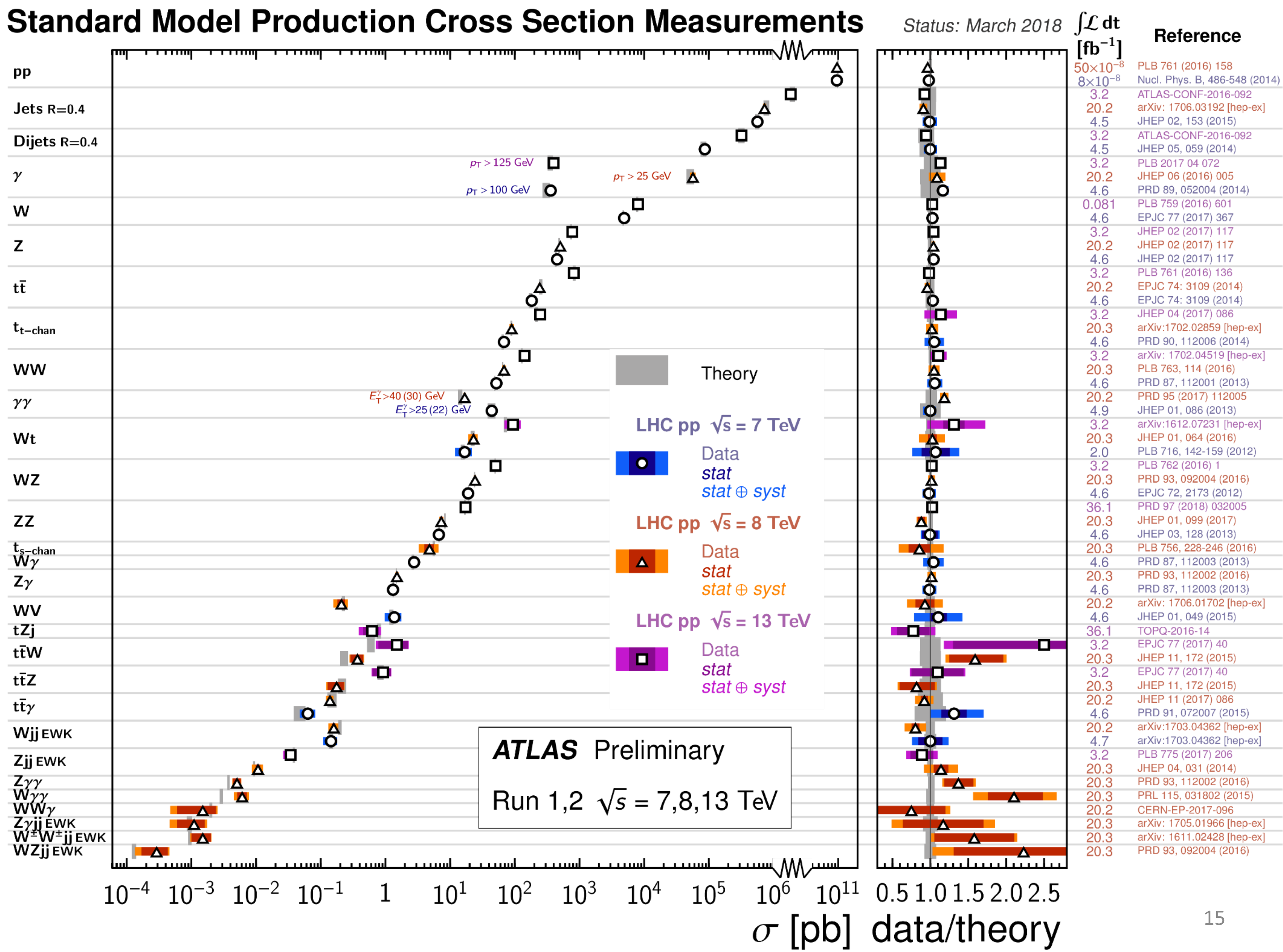


Run 1	E_{CM} (TeV)	integ lumi [fb^{-1}]
2011	7	～5
2012	8	～21

$E_{CM} = 13$ (TeV)

Run 2	Peak lumi E34 cm^{-2}s^{-1}	Days pp physics	Recorded integ lumi [fb^{-1}]
2015	0.5	56	3.9
2016	1.4	122	36.0
2017	2.1	150	46.9
2018	Similar to 2017	152	Similar to 2017

LHC long term schedule



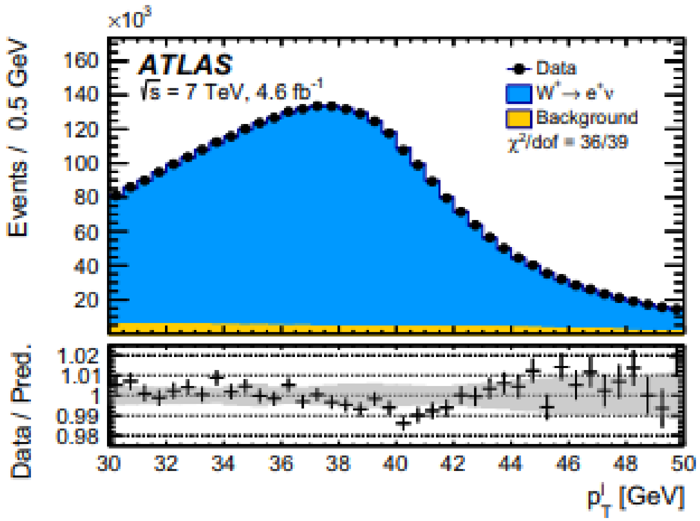
Standard Model Production Cross Section Measurements
Status: March 2018
∫ℒ dt [fb⁻¹]
Reference
pp
Jets R=0.4
Dijets R=0.4
γ
W
Z
tt̄
t t-chan
WW
γγ
Wt
WZ
ZZ
t s-chan
Wγ
Zγ
WV
tZj
tt̄W
tt̄Z
tt̄γ
Wjj EWK
Zjj EWK
Zγγ
Wγγ
WWγ
Zγjj EWK
W±W±jj EWK
WZjj EWK
pT > 125 GeV
pT > 100 GeV
pT > 25 GeV
E_T^γ>40 (30) GeV
E_T^γ>25 (22) GeV
Theory
LHC pp √s = 7 TeV
Data
stat
stat ⊕ syst
LHC pp √s = 8 TeV
Data
stat
stat ⊕ syst
LHC pp √s = 13 TeV
Data
stat
stat ⊕ syst
ATLAS Preliminary
Run 1,2 √s = 7,8,13 TeV
σ [pb]
data/theory
50×10⁻⁸ PLB 761 (2016) 158
8×10⁻⁸ Nucl. Phys. B, 486-548 (2014)
3.2 ATLAS-CONF-2016-092
20.2 arXiv: 1706.03192 [hep-ex]
4.5 JHEP 02, 153 (2015)
3.2 ATLAS-CONF-2016-092
4.5 JHEP 05, 059 (2014)
3.2 PLB 2017 04 072
20.2 JHEP 06 (2016) 005
4.6 PRD 89, 052004 (2014)
0.081 PLB 759 (2016) 601
4.6 EPJC 77 (2017) 367
3.2 JHEP 02 (2017) 117
20.2 JHEP 02 (2017) 117
4.6 JHEP 02 (2017) 117
3.2 PLB 761 (2016) 136
20.2 EPJC 74: 3109 (2014)
4.6 EPJC 74: 3109 (2014)
3.2 JHEP 04 (2017) 086
20.3 arXiv:1702.02859 [hep-ex]
4.6 PRD 90, 112006 (2014)
3.2 arXiv: 1702.04519 [hep-ex]
20.3 PLB 763, 114 (2016)
4.6 PRD 87, 112001 (2013)
20.2 PRD 95 (2017) 112005
4.9 JHEP 01, 086 (2013)
3.2 arXiv:1612.07231 [hep-ex]
20.3 JHEP 01, 064 (2016)
2.0 PLB 716, 142-159 (2012)
3.2 PLB 762 (2016) 1
20.3 PRD 93, 092004 (2016)
4.6 EPJC 72, 2173 (2012)
36.1 PRD 97 (2018) 032005
20.3 JHEP 01, 099 (2017)
4.6 JHEP 03, 128 (2013)
20.3 PLB 756, 228-246 (2016)
4.6 PRD 87, 112003 (2013)
20.3 PRD 93, 112002 (2016)
4.6 PRD 87, 112003 (2013)
20.2 arXiv: 1706.01702 [hep-ex]
4.6 JHEP 01, 049 (2015)
36.1 TOPQ-2016-14
3.2 EPJC 77 (2017) 40
20.3 JHEP 11, 172 (2015)
3.2 EPJC 77 (2017) 40
20.3 JHEP 11, 172 (2015)
20.2 JHEP 11 (2017) 086
4.6 PRD 91, 072007 (2015)
20.2 arXiv:1703.04362 [hep-ex]
4.7 arXiv:1703.04362 [hep-ex]
3.2 PLB 775 (2017) 206
20.3 JHEP 04, 031 (2014)
20.3 PRD 93, 112002 (2016)
20.3 PRL 115, 031802 (2015)
20.2 CERN-EP-2017-096
20.3 arXiv: 1705.01966 [hep-ex]
20.3 arXiv: 1611.02428 [hep-ex]
20.3 PRD 93, 092004 (2016)

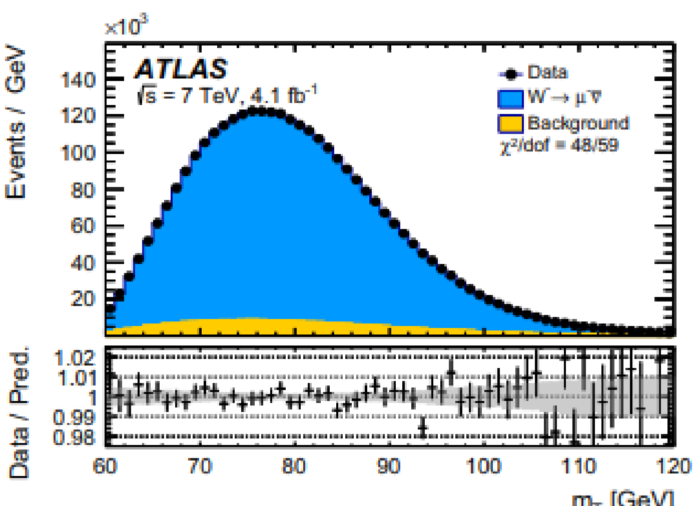
W mass at ATLAS

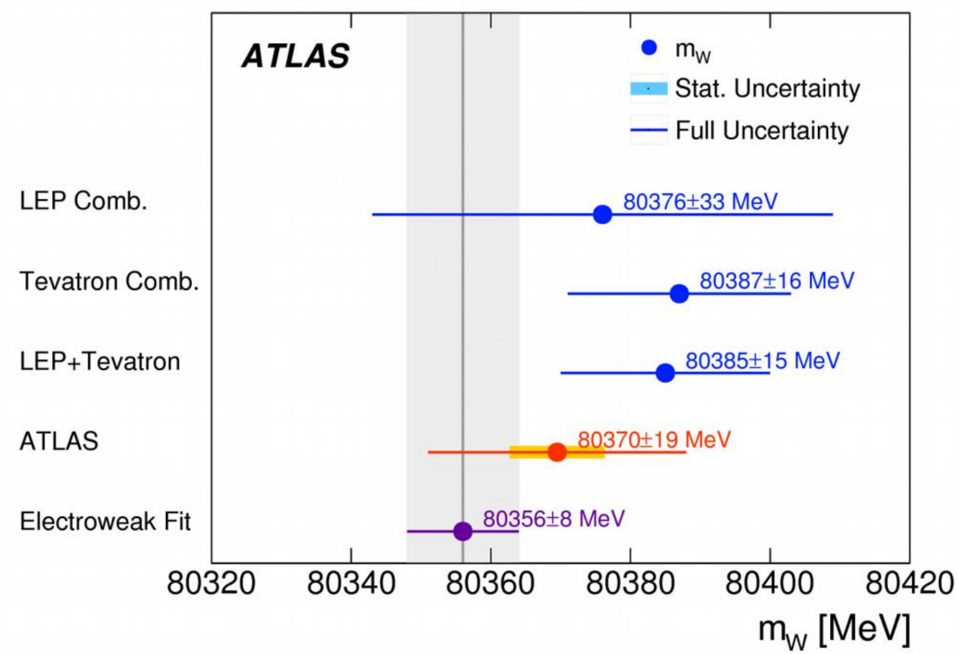
Eur. Phys. J. C 78 (2018) 110

- $M_W = 80370 \pm 19$ MeV.

- Consistent with LEP and Tevatron measurements.
- Compelling sensitivity.





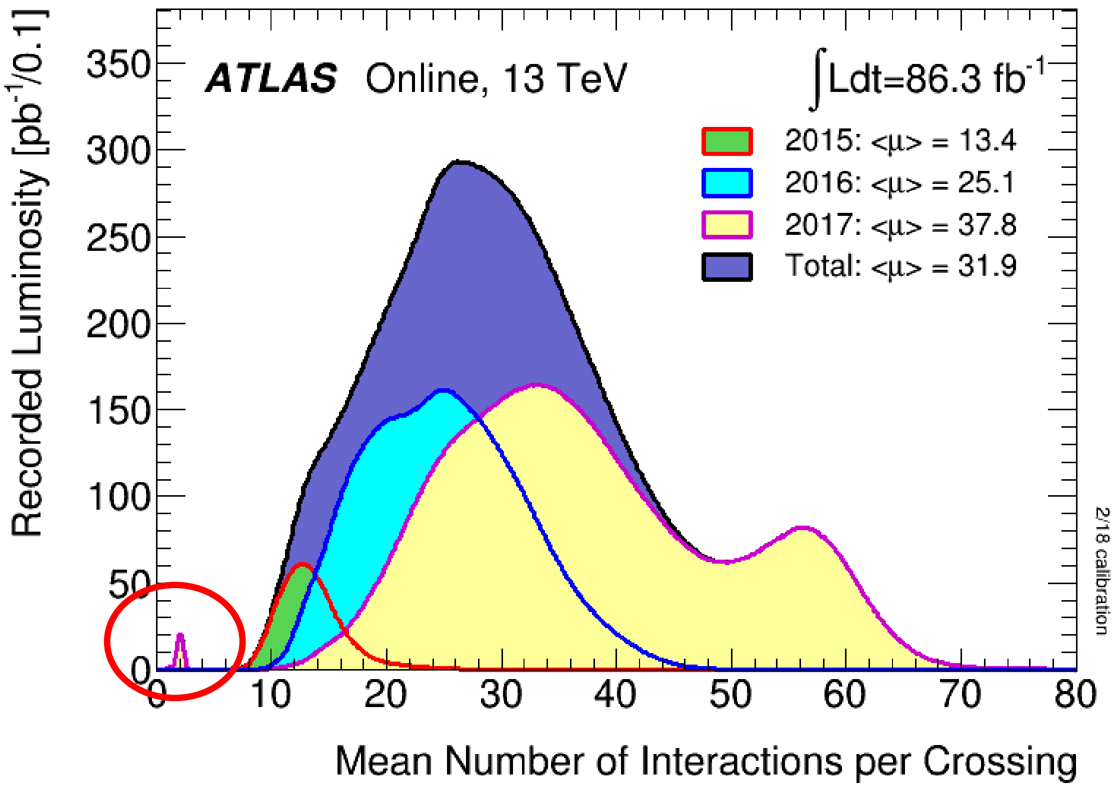


W mass measurement in 2017 run

- First result used 31/pb at 7 TeV from 2010 runs.
- Recent low-μ runs taken by ATLAS

  ~150 /pb at 13 TeV: 1.75M W, 220k Z

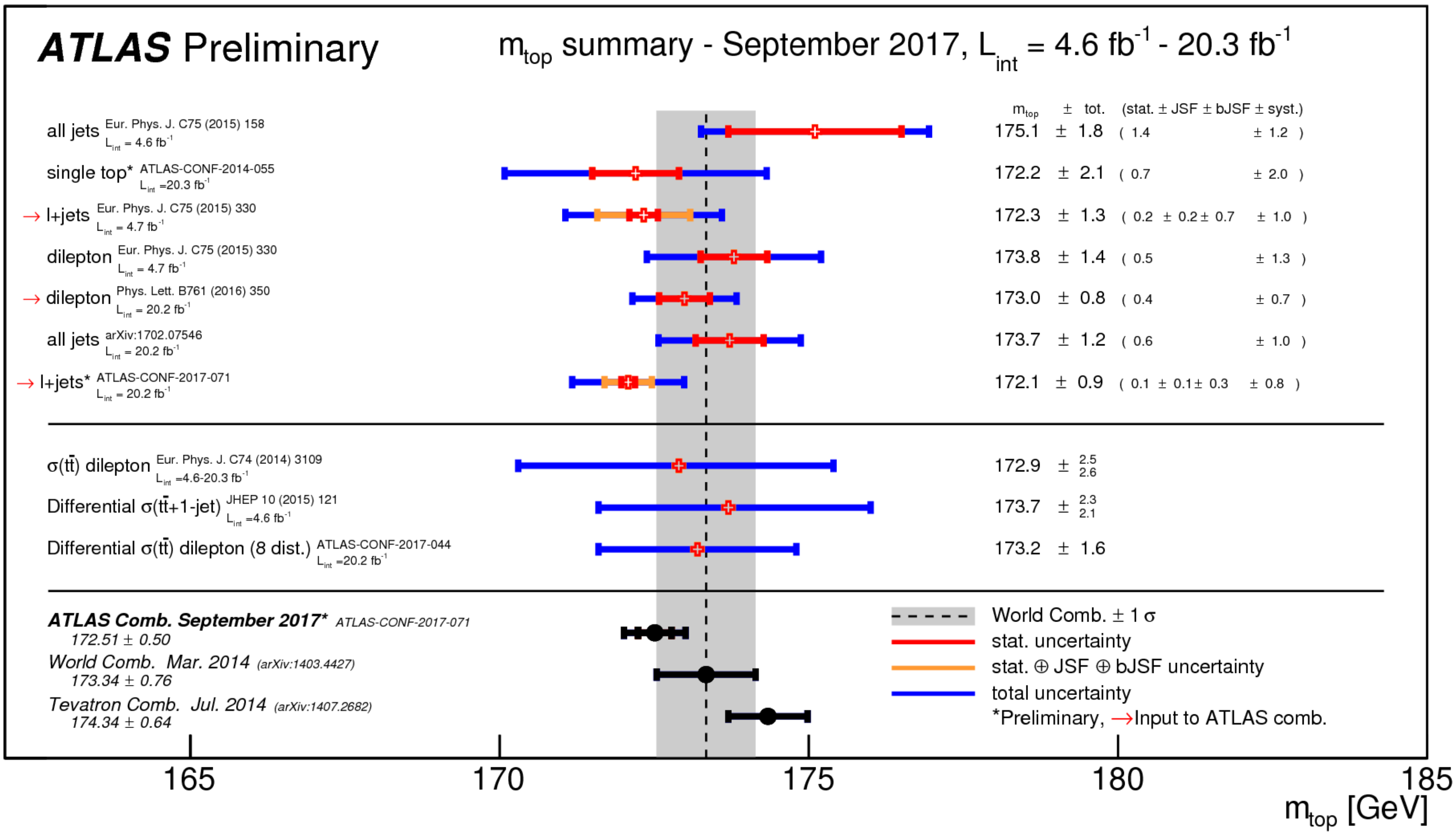
  ~270 /pb at 5 TeV: 1.3M W, 150k



ATLAS direct top mass measurements

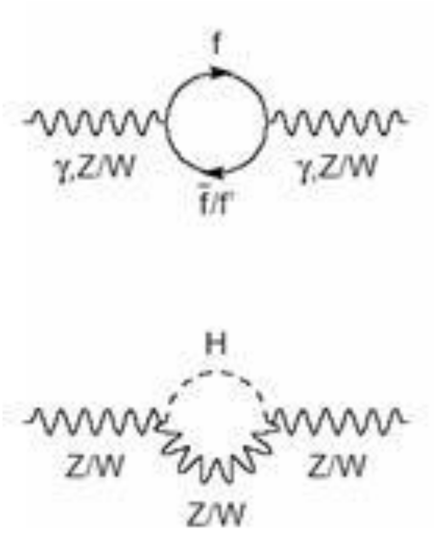
- New ATLAS combination:

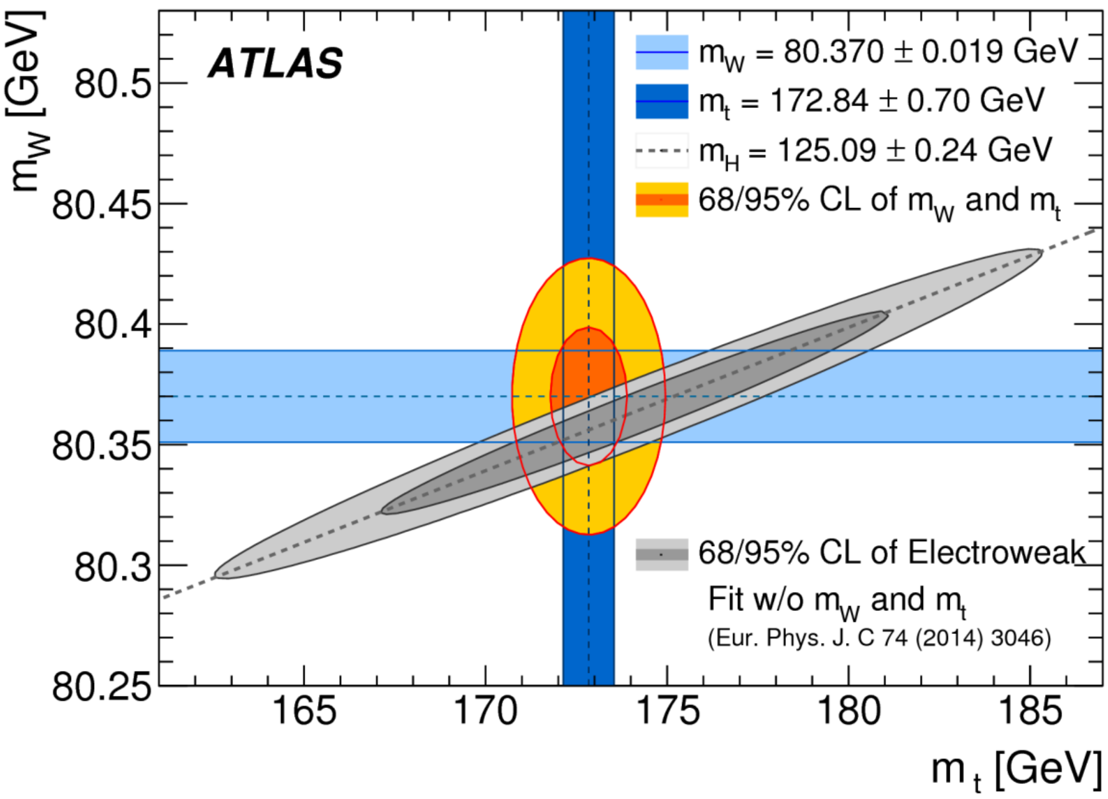
$$m_{top} = 172.51 \pm 0.50 \text{ (GeV)}$$



Radiative Correction

- Comparison of measured W, top and Higgs masses.

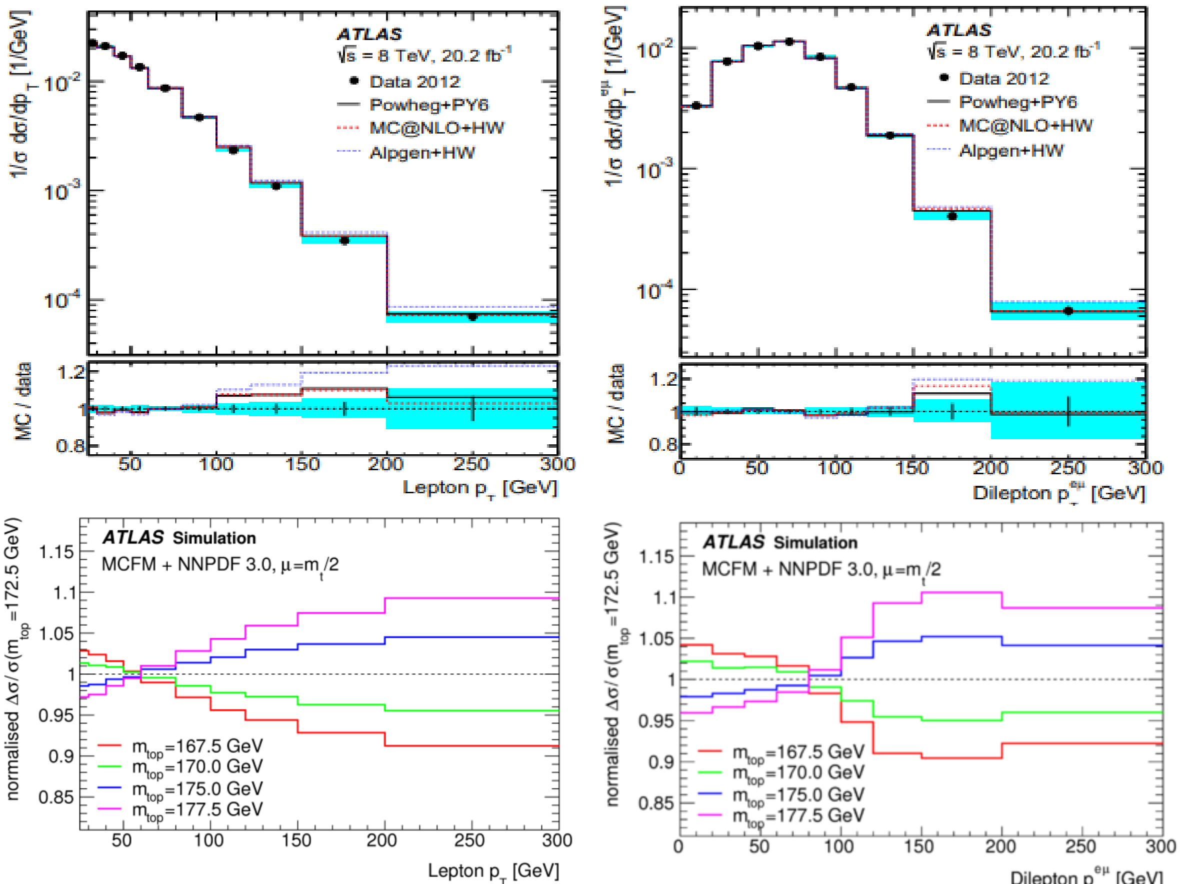




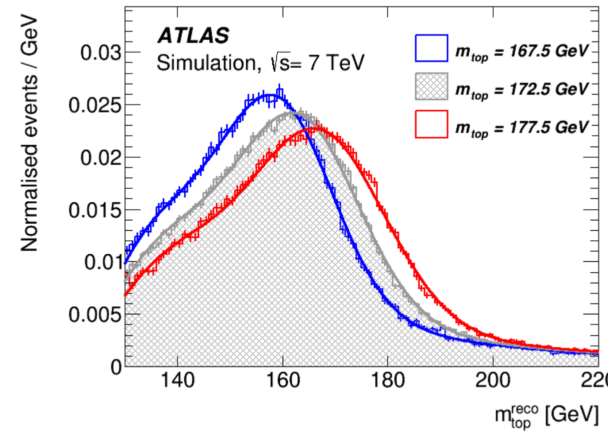
Eur. Phys. J. C 77 (2017) 804

Top Pole Mass Measurement

- Difficult to relate the directly measured top mass to well defined theoretical parameter because of non-perturbative effects.
- Fit lepton kinematics in ttbar events.



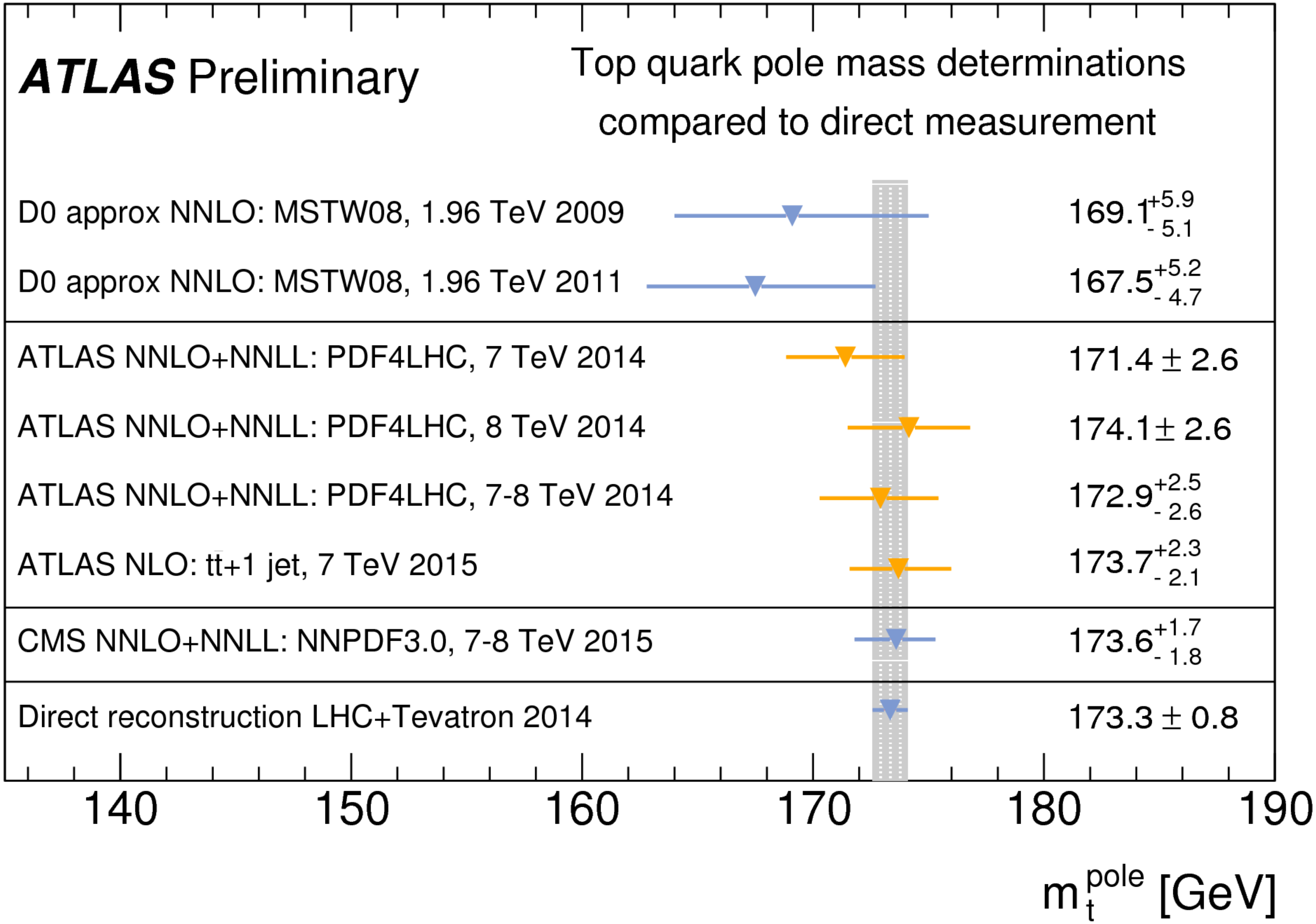
Reconstructed top mass in l+jets analysis



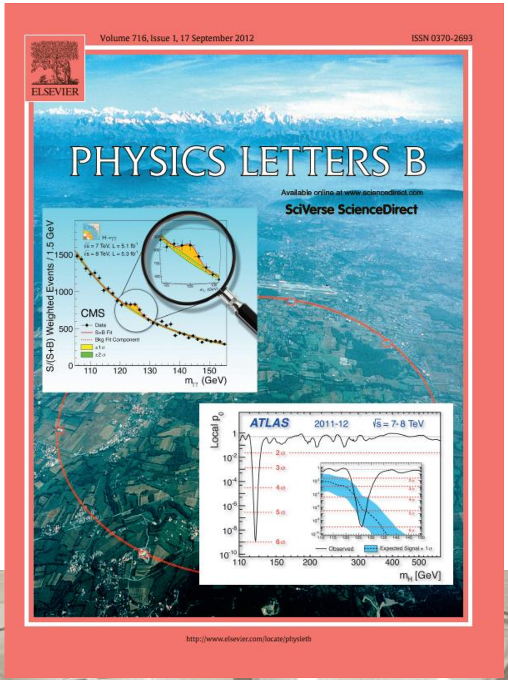
Eur. Phys. J. C75 (2015) 330

m_{pole}^{top}=173.2±0.9(stat)±0.8(syst)±1.2(theory) GeV

Top Pole Mass Measurements



Discovery of Higgs Boson

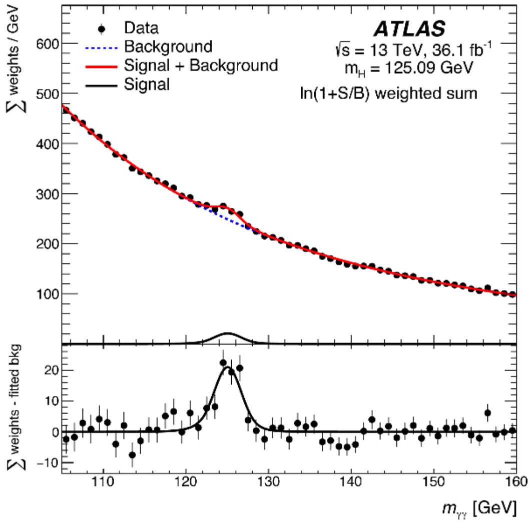


July 4, 2012 CERN seminar on Higgs discovery by ATLAS/CMS

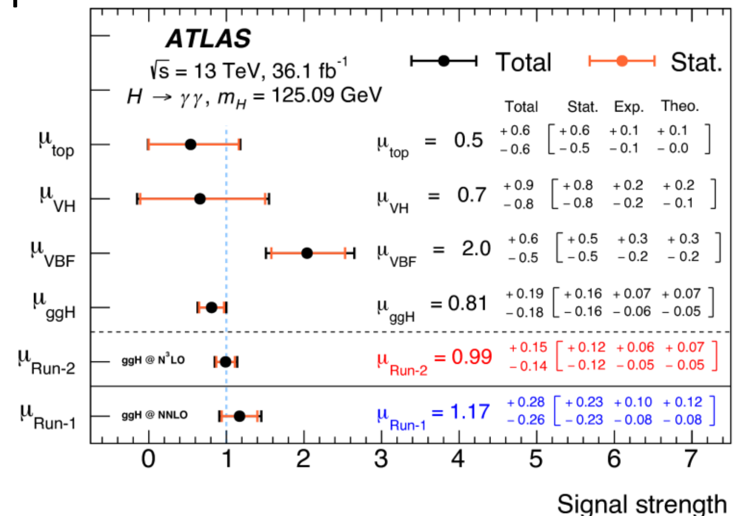
$H \rightarrow \gamma\gamma$

arXiv:1802.04146

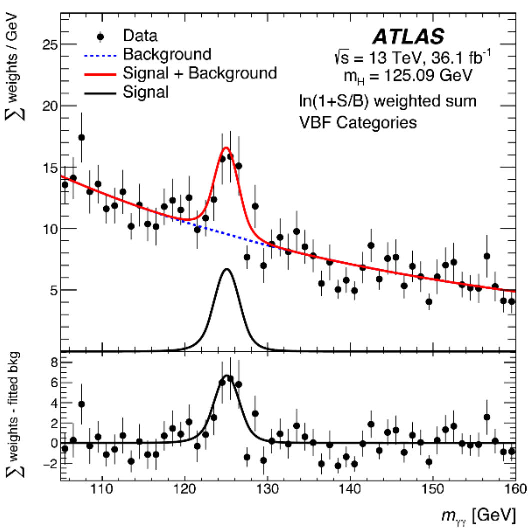
Subcategorizes the events into different regions → sensitivity to separate production modes.



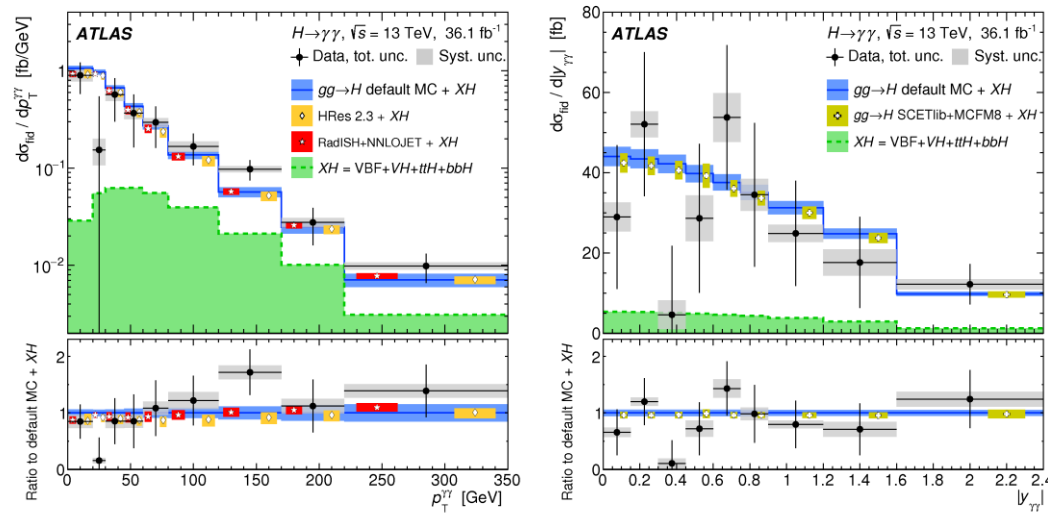
Cross section measurement by production modes



VBF Enriched region



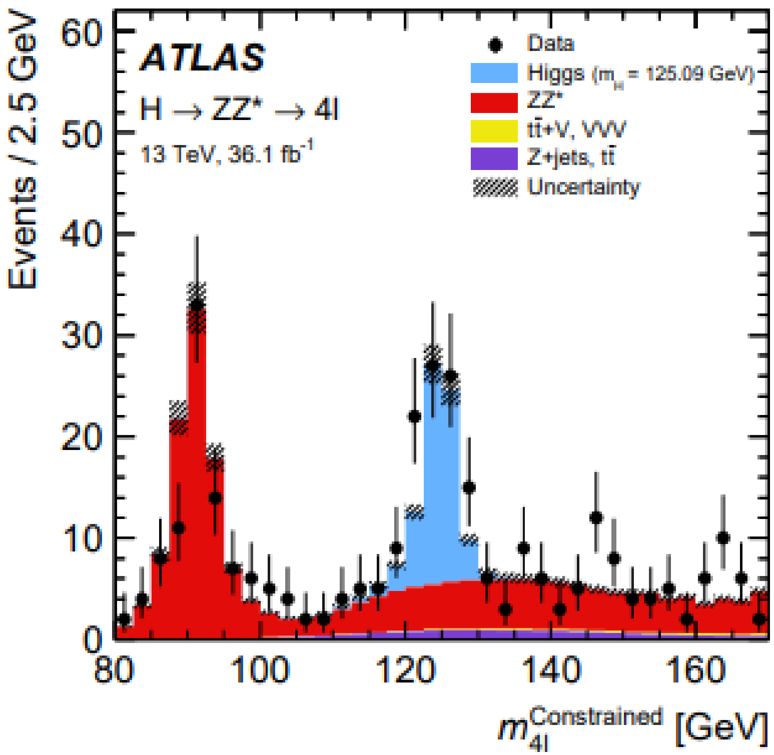
Differential cross sections



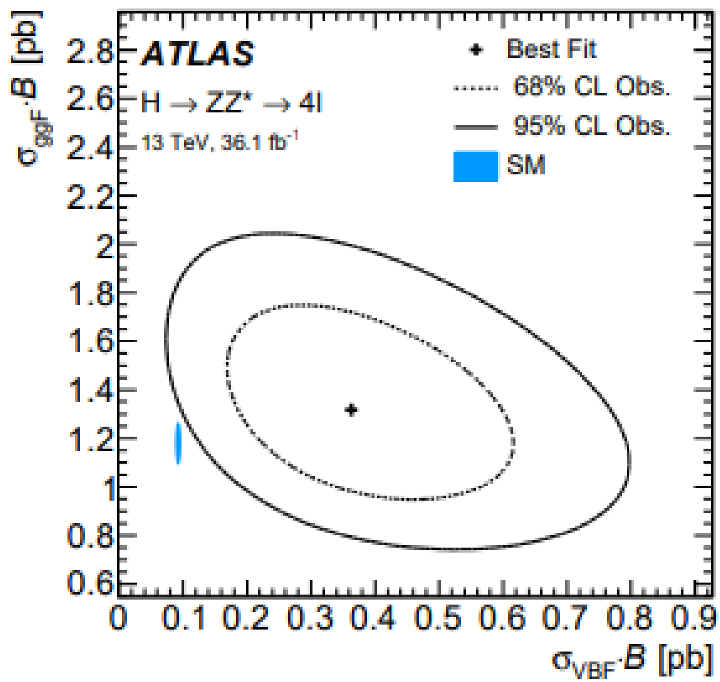
$H \to ZZ^* \to 4\ell$

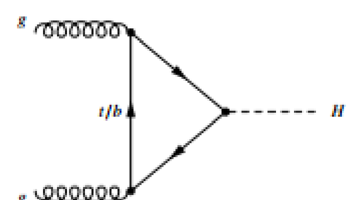
arXiv:1712.02304

Subcategorizes the events into different regions, train → sensitivity to separate production modes.

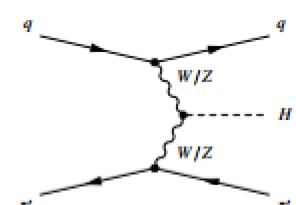


Cross section measurement by production modes





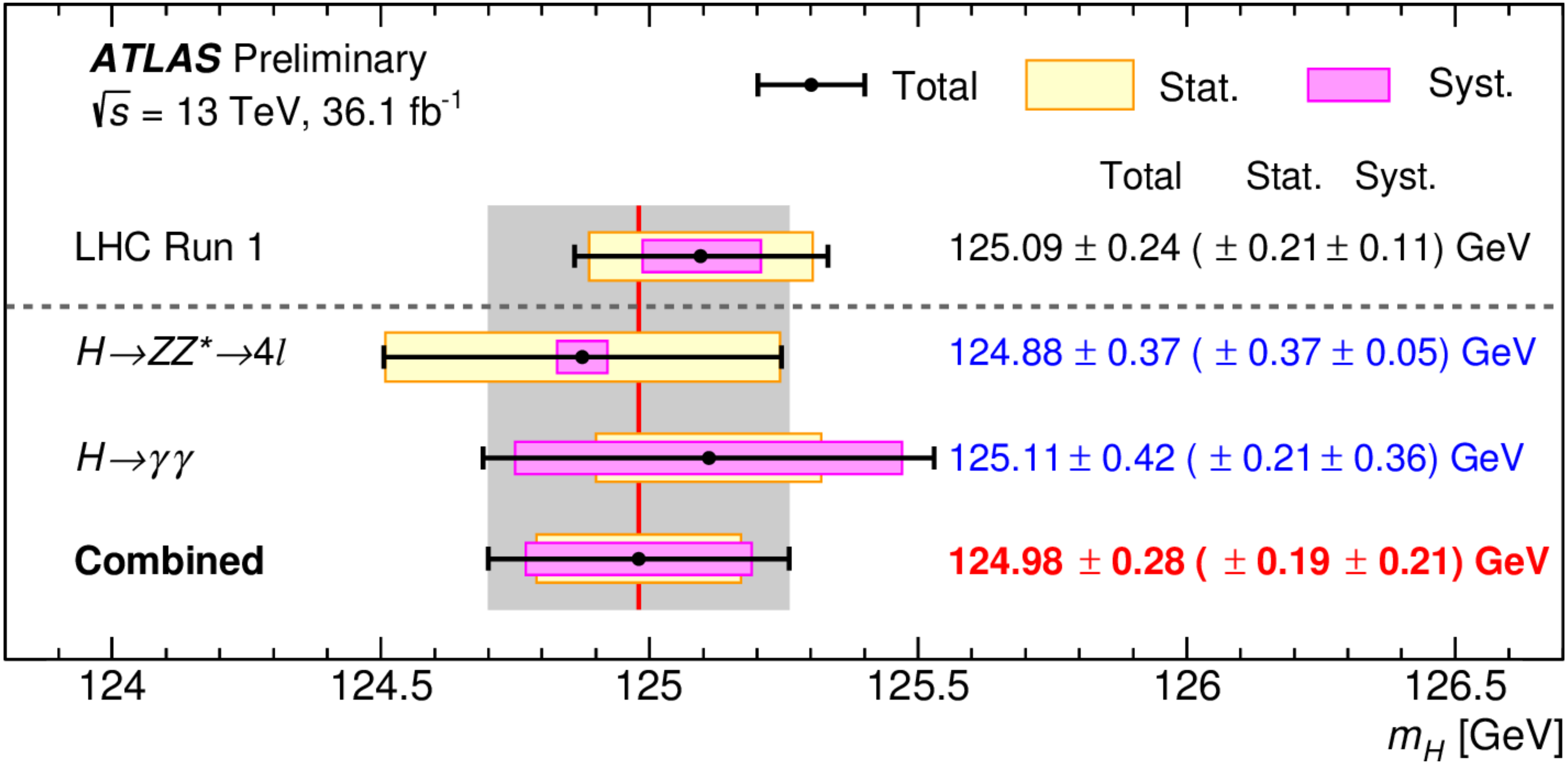
ggF



VBF

Higgs Mass

ATLAS-CONF-2017-046



Signal Significance in Run 1 Analyses

ATLAS and CMS separately

Channel	References for individual publications		Signal strength [μ] from results in this paper (Section 5.2)		Signal significance [σ]	
	ATLAS	CMS	ATLAS	CMS	ATLAS	CMS
$H \to \gamma\gamma$	[92]	[93]	$1.14^{+0.27}_{-0.25}$ $\left(^{+0.26}_{-0.24}\right)$	$1.11^{+0.25}_{-0.23}$ $\left(^{+0.23}_{-0.21}\right)$	5.0 (4.6)	5.6 (5.1)
$H \to ZZ$	[94]	[95]	$1.52^{+0.40}_{-0.34}$ $\left(^{+0.32}_{-0.27}\right)$	$1.04^{+0.32}_{-0.26}$ $\left(^{+0.30}_{-0.25}\right)$	7.6 (5.6)	7.0 (6.8)
$H \to WW$	[96, 97]	[98]	$1.22^{+0.23}_{-0.21}$ $\left(^{+0.21}_{-0.20}\right)$	$0.90^{+0.23}_{-0.21}$ $\left(^{+0.23}_{-0.20}\right)$	6.8 (5.8)	4.8 (5.6)
$H \to \tau\tau$	[99]	[100]	$1.41^{+0.40}_{-0.36}$ $\left(^{+0.37}_{-0.33}\right)$	$0.88^{+0.30}_{-0.28}$ $\left(^{+0.31}_{-0.29}\right)$	4.4 (3.3)	3.4 (3.7)
$H \to bb$	[101]	[102]	$0.62^{+0.37}_{-0.37}$ $\left(^{+0.39}_{-0.37}\right)$	$0.81^{+0.45}_{-0.43}$ $\left(^{+0.45}_{-0.43}\right)$	1.7 (2.7)	2.0 (2.5)
$H \to \mu\mu$	[103]	[104]	$-0.6^{+3.6}_{-3.6}$ $\left(^{+3.6}_{-3.6}\right)$	$0.9^{+3.6}_{-3.5}$ $\left(^{+3.3}_{-3.2}\right)$		
ttH production	[78, 105, 106]	[108]	$1.9^{+0.8}_{-0.7}$ $\left(^{+0.7}_{-0.7}\right)$	$2.9^{+1.0}_{-0.9}$ $\left(^{+0.9}_{-0.8}\right)$	2.7 (1.6)	3.6 (1.3)

3σ : "Evidence"
5σ : "Discovery"

- Some production and decay processes have been discovered in Run 1.
- ttH and $H \to bb$ will be searched for in Run 2.
- Precision of Higgs property measurements to be improved in Run 2, putting SM to stringent test.

arXiv:1606.02266

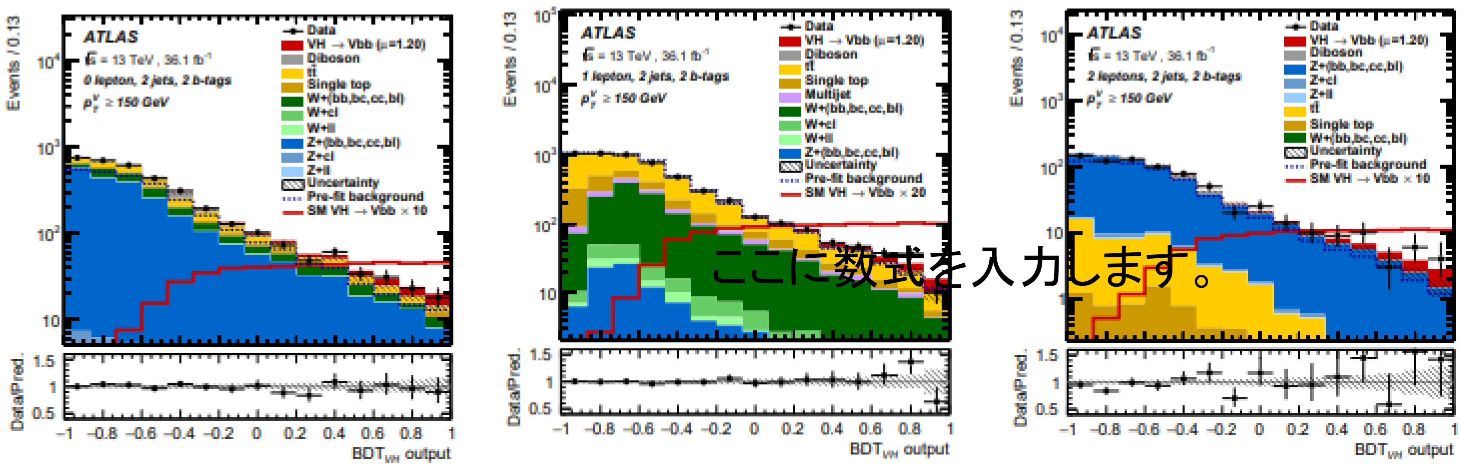
ATLAS+CMS

Production process	Measured significance (σ)	Expected significance (σ)
VBF	5.4	4.6
WH	2.4	2.7
ZH	2.3	2.9
VH	3.5	4.2
ttH	4.4	2.0
Decay channel		
$H \to \tau\tau$	5.5	5.0
$H \to bb$	2.6	3.7

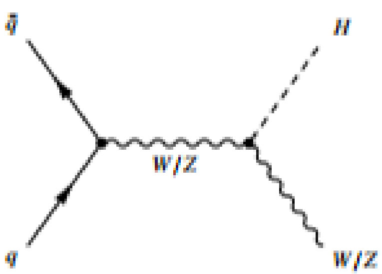
arXiv:1708.03299

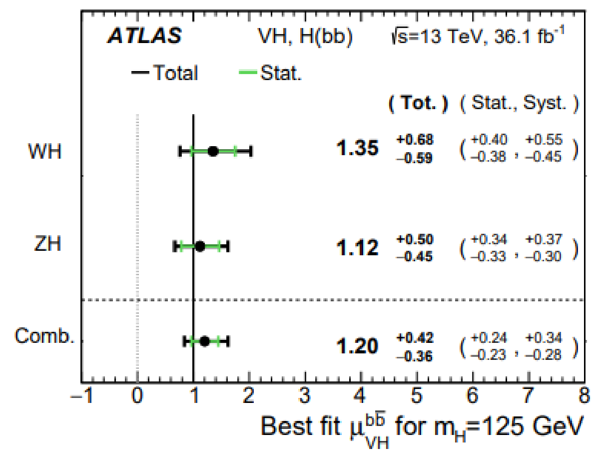
$H \to bb$

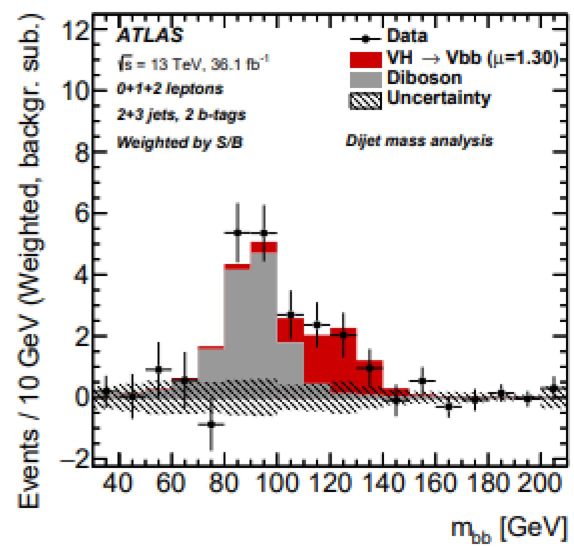
- Search for WH, ZH production, with $W \to \ell\nu, Z \to \ell\ell/\nu\nu$
- Train BDTs in 0, 1 and 2 lepton categories.



ここに数式を入力します。



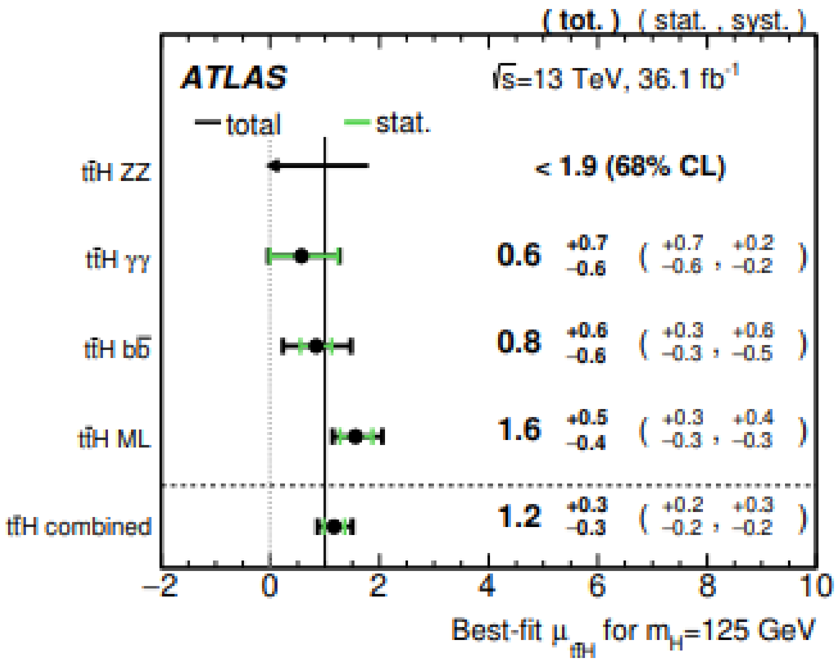




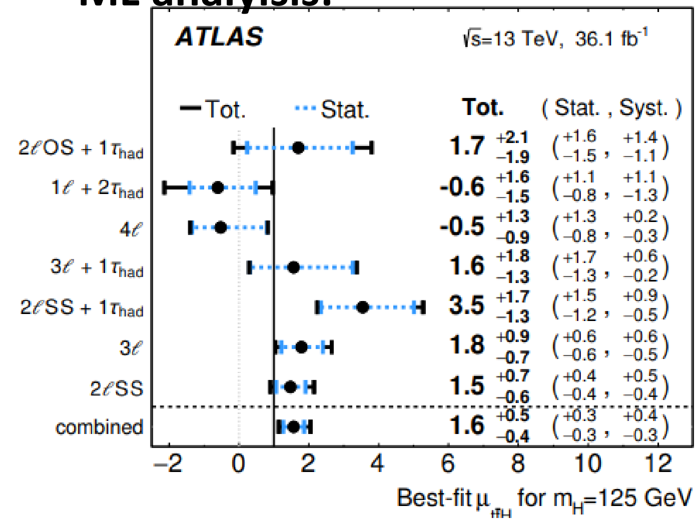
Significance: 3.5σ (exp: 3.0σ)

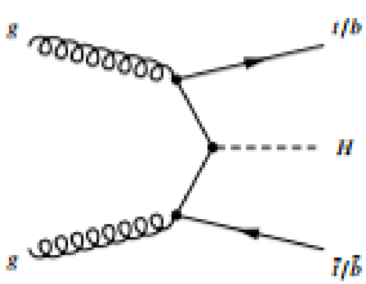
$t\bar{t}H$ production

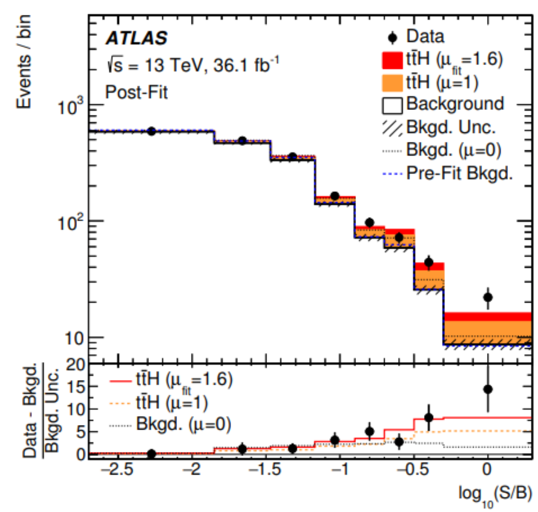
- Combination of analyses on $H \rightarrow \gamma\gamma, bb, ML(\tau\tau, WW, ZZ)$.
- BDT as S/B separator in most subchannels.



ML analylsis:







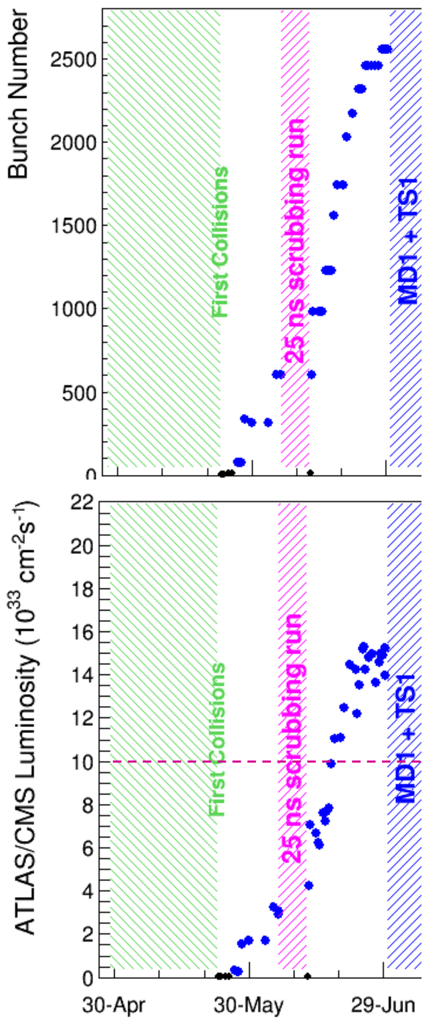
Significance: 4.1σ (exp: 2.8σ)

Summary

- LHC and ATLAS continues successful operation.
- Wide variety of measurements at ATLAS put SM to stringent test.
  - Cross sections of many different physics processes are measured to be consistent with SM.
  - W, top and Higgs masses are measured at high precision.
  - Higgs production and decay rates are extensively studied.
    - Evidence of $H \to bb$ decay and ttH production

BACKUP

LHC Physics Run 2017: Ups and Downs



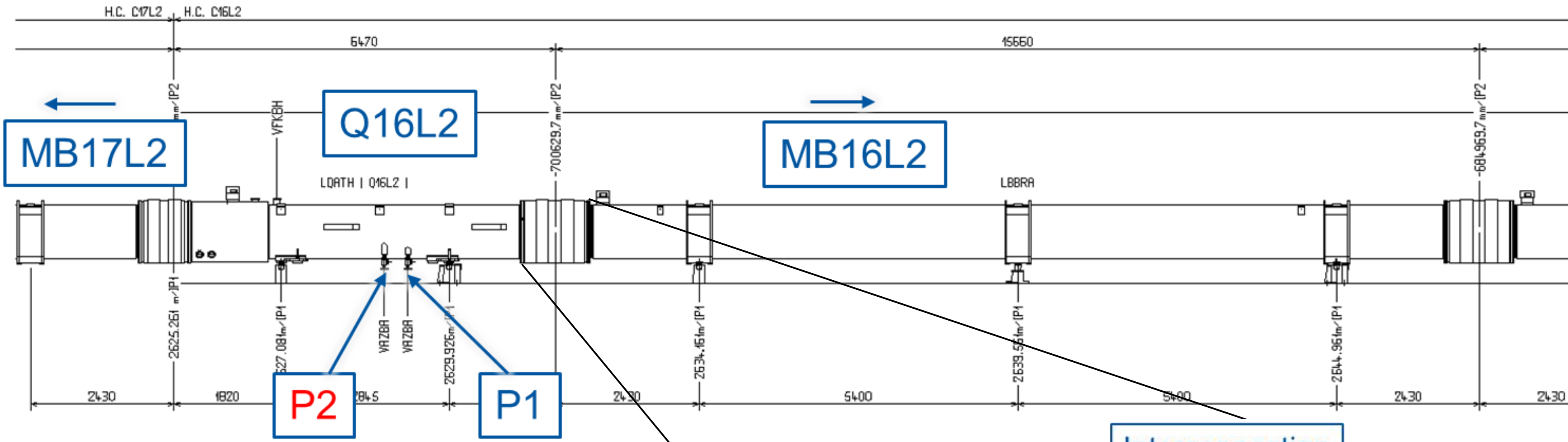
- Very fast and efficient start-up of the LHC, quickly reaching 2556 bunches at 6.5 TeV
- Loss burst appeared however in one cell '**16L2**' on both beams, operation continuously interrupted by beam dumps.
- Fortunately stable operation could be resumed with the **8b4e** low electron cloud beam

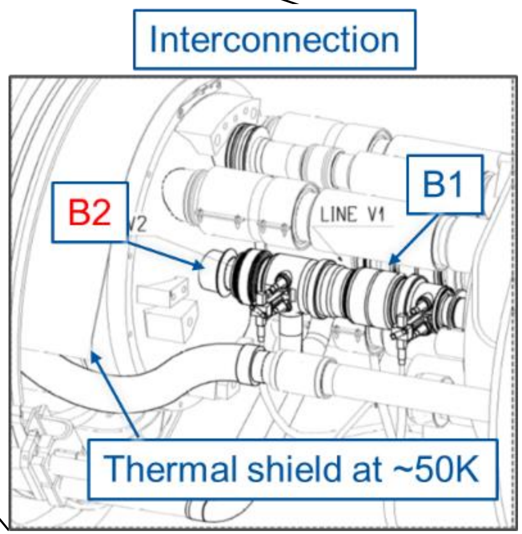
Smooth operation with high availability
Only a few dumps from 16L2

Luminosity pushed in ATLAS/CMS
- Smaller β*
- Crossing angle reduction during a fill
- Larger bunch intensity

And luminosity levelling !

LHC “16L2”: Air inlet as “most probable” cause





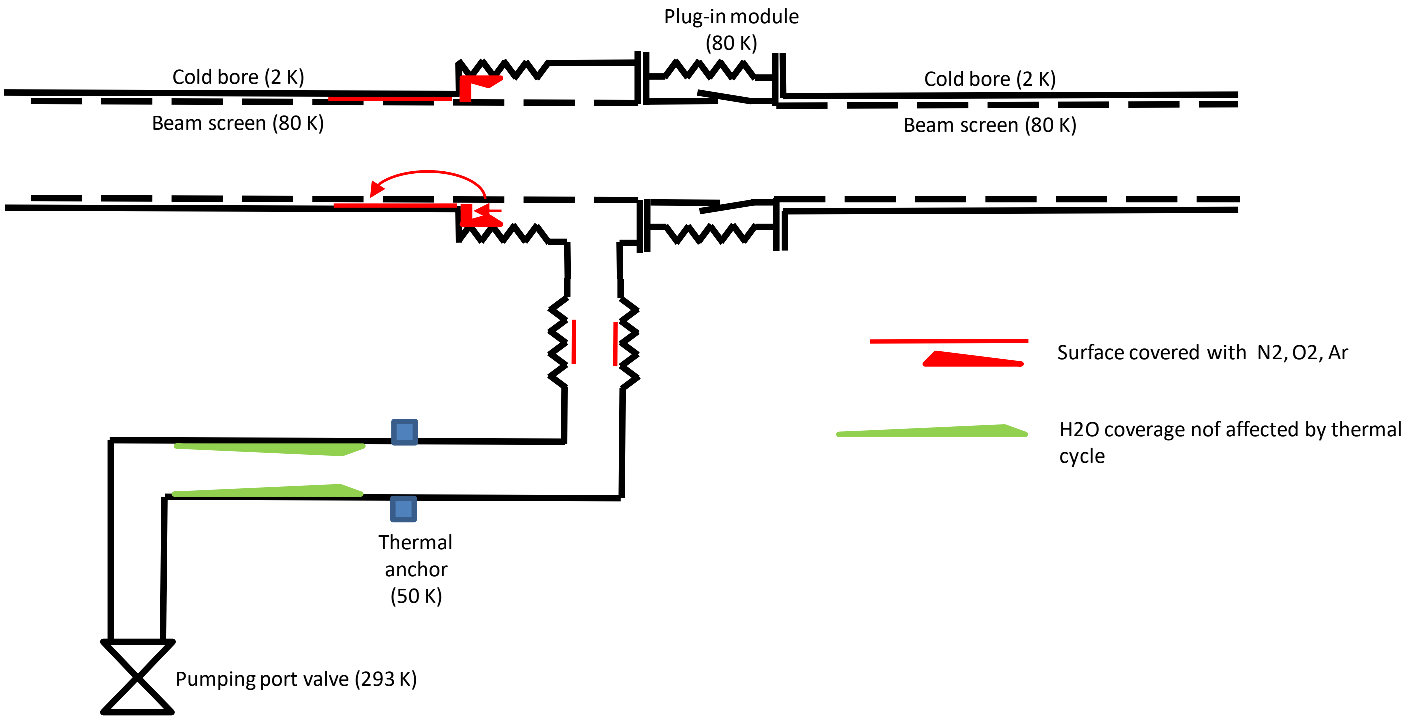
Air inlet through **both** pumping ports while magnet cold masses, beam screens and thermal shields already at operating cryogenic temperature.

To be noted that gasses have a reduced mobility at those temperatures, explain why was not immediately identified.

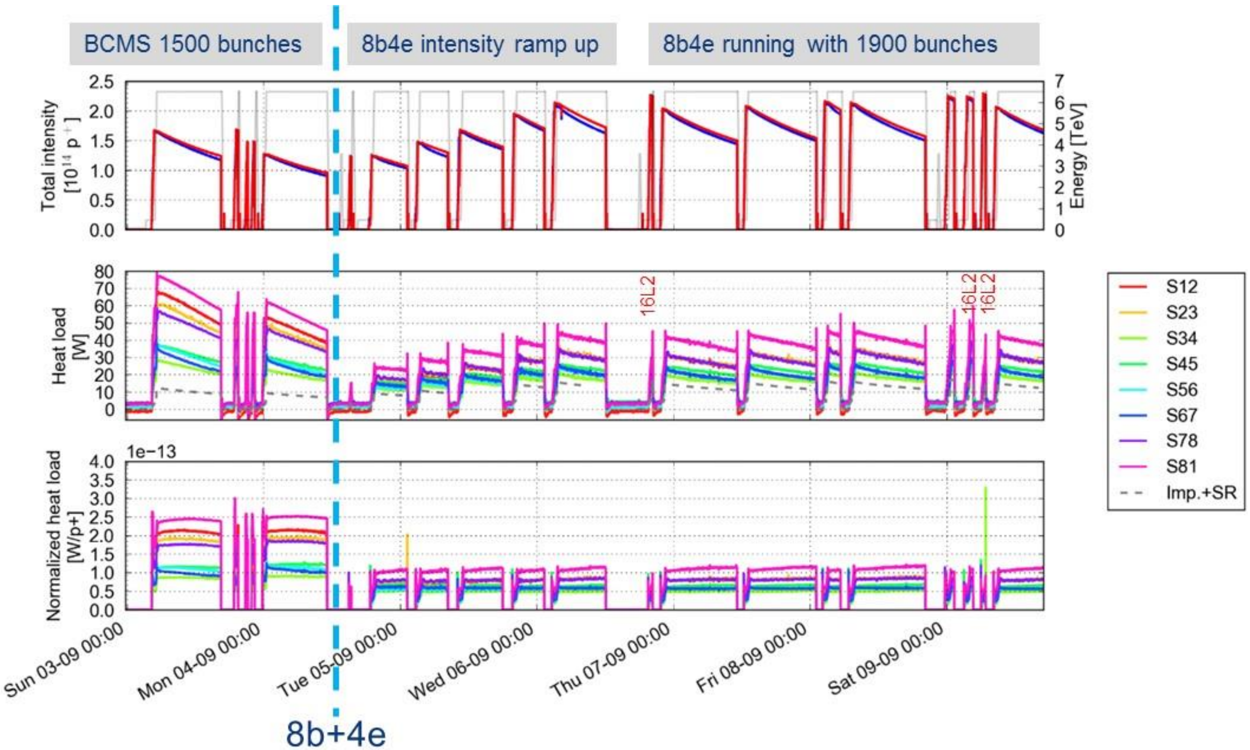
LHC “16L2”: Air inlet as “most probable” cause

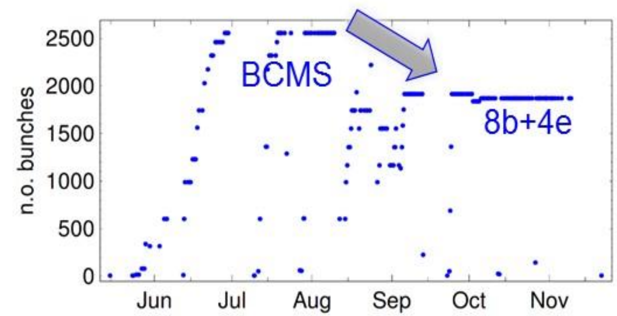
Situation at the end of first BS thermal cycle to 80 K

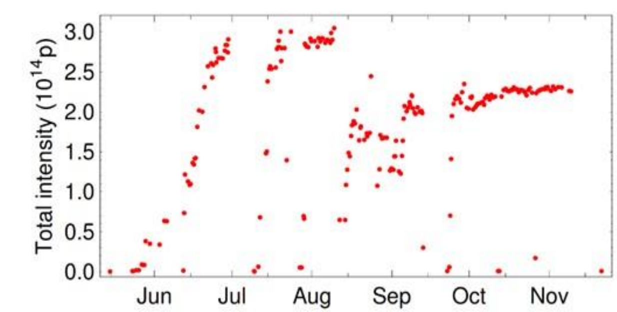
(No pumping though pumping port)

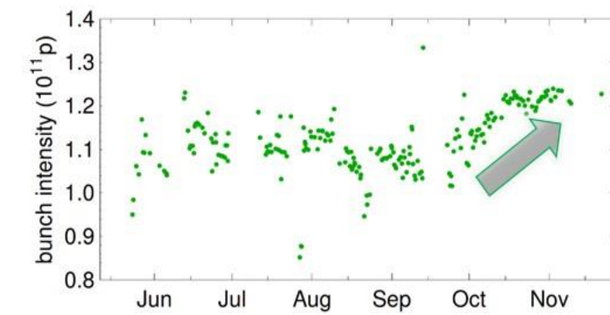


LHC: Cryogenics Heat Load BCMS versus 8b4e









8b4e = **8 b**unches + **4 e**mpty buckets

For same LHC bunch intensity PSB bunch intensity and transverse emittance is ~50% of standard scheme

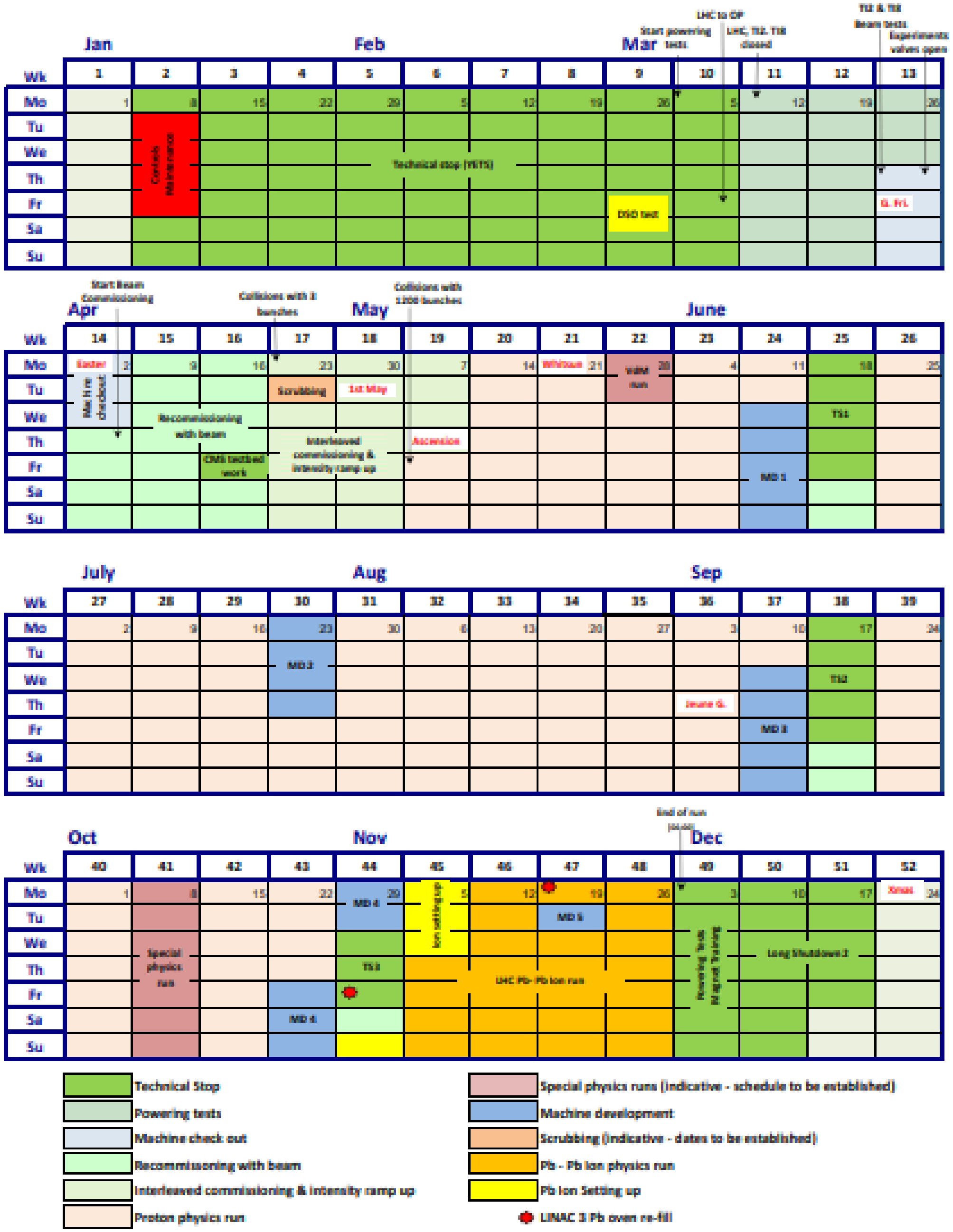
but limitation on the bunch numbers and pile-up

RS

February 7, 2018
ver. 1.1

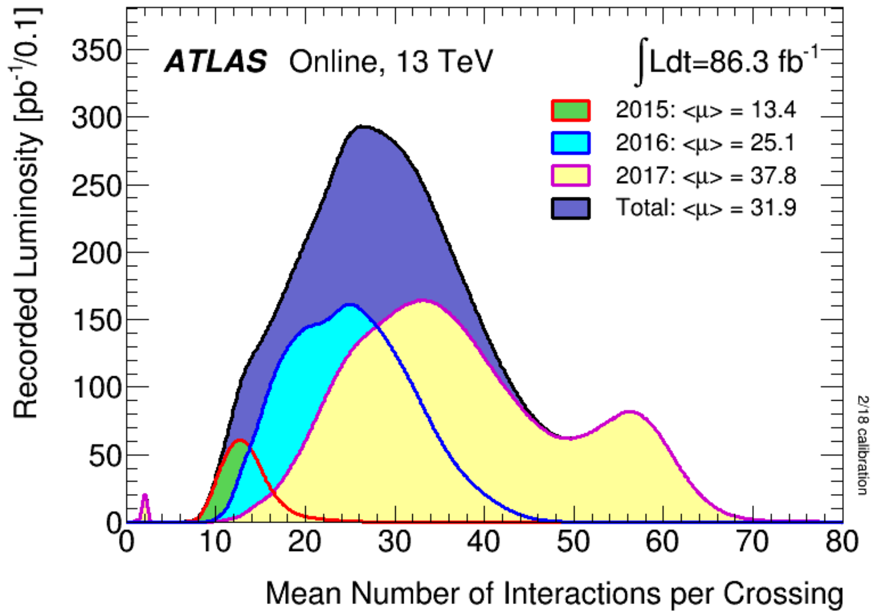
LHC Schedule 2018

Approved by Research board on 06.12.2017



ATLAS Run-2 Detector Status (from July 2017)

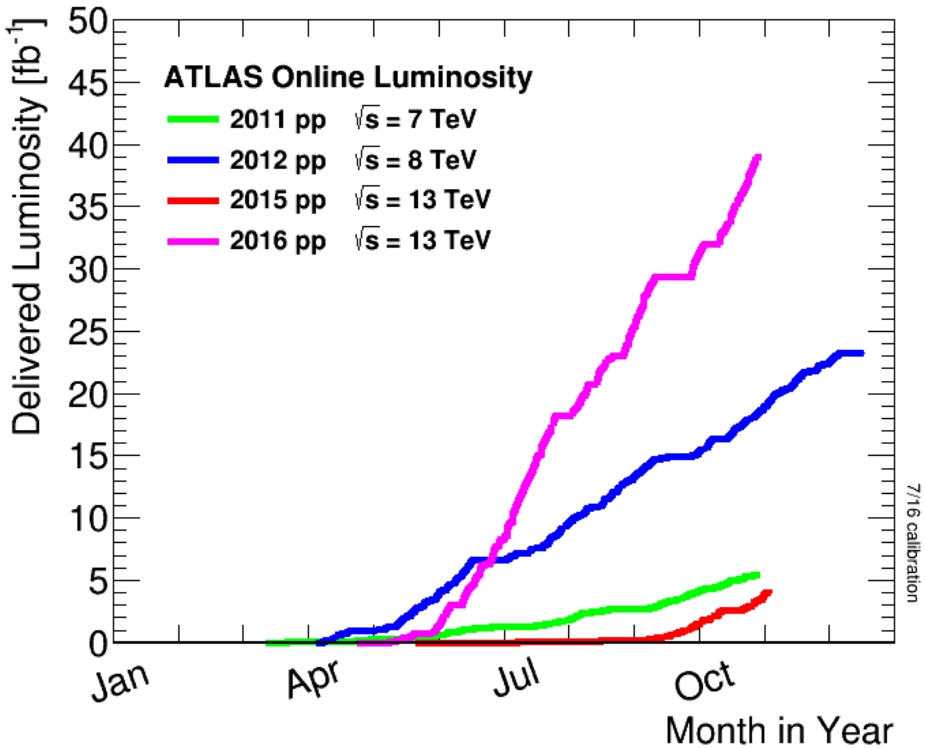
Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	92 M	97.8%
SCT Silicon Strips	6.3 M	98.7%
TRT Transition Radiation Tracker	350 k	97.2%
LAr EM Calorimeter	170 k	100 %
Tile Calorimeter	5200	99.2%
Hadronic End-Cap LAr Calorimeter	5600	99.5%
Forward LAr Calorimeter	3500	99.7%
LVL1 Calo Trigger	7160	99.9%
LVL1 Muon RPC Trigger	383 k	99.8%
LVL1 Muon TGC Trigger	320 k	99.9%
MDT Muon Drift Tubes	357 k	99.7%
CSC Cathode Strip Chambers	31 k	95.3%
RPC Barrel Muon Chambers	383 k	94.4%
TGC End-Cap Muon Chambers	320 k	99.5%
ALFA	10 k	99.9%
AFP	430 k	93.8%



Notes:

- For the Pixel status: 3-Layers Pixel (80 M channels) - 97.5%; IBL (12 M channels) - 99.3%
- For Tilecal the number of cells (including gap and crack counters) are included
- For CSC, the number of alive channel is lower than before due to the failure of the cooling of one chamber that cannot be operated and the presence of one layer with a broken wire in another chamber
- For RPC, most inactive channels are due to HV channels that cannot be turned on because one (of several) gas gaps connected to that channel cannot be operated. Some of the disconnected channels are actually operable and can be made to work by an intervention in the cavern during TS1.
- The number of channels for AFP has doubled since last year after the installation of the second arm
- Detectors with fewer than 100 channels are not reported

Luminosities in Run 2



Run 1	E_{CM} (TeV)	integ lumi [fb^{-1}]
2011	7	～5
2012	8	～21

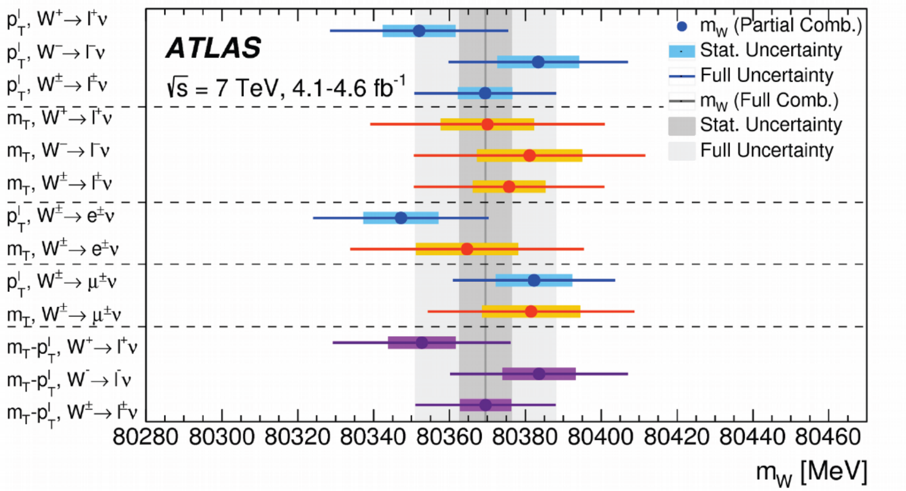
いまのところ、2016年夏に～13 fb^{-1} を使ったRun 2データの物理結果が発表されている

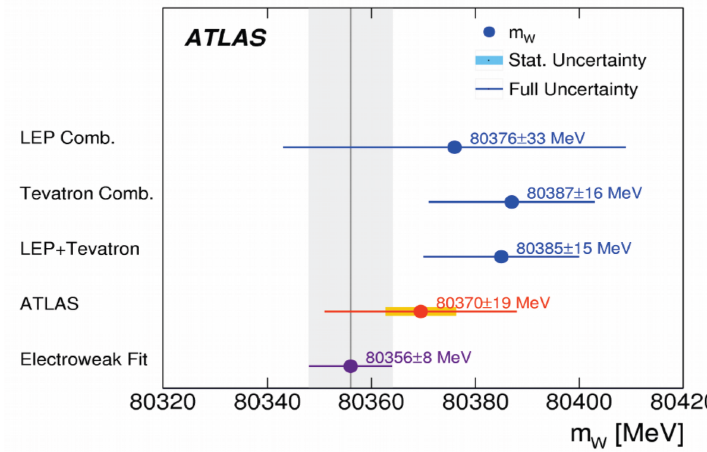
$E_{CM} = 13$ (TeV)

Run 2	Peak lumi E34 cm^{-2}s^{-1}	Days pp physics	Recorded integ lumi [fb^{-1}]
2015	0.5	56	3.9
2016	1.4	122	36.0
2017	>~1.7	150	40-60
2018	Similar to 2017	152	Similar to 2017

Measurement

Moriond QCD Jung's slide

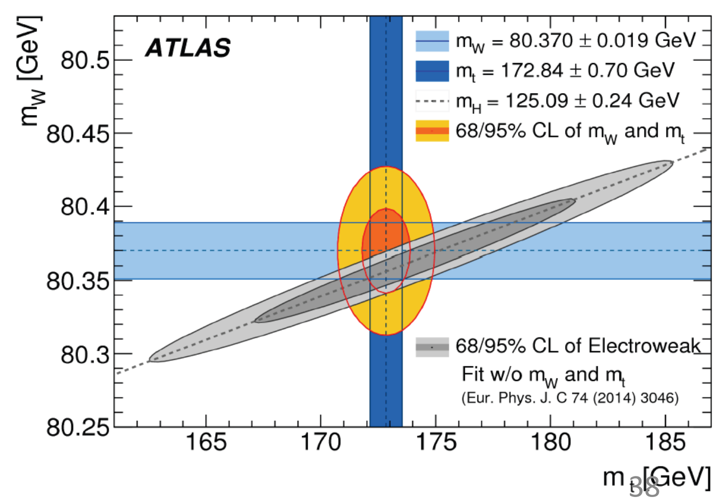




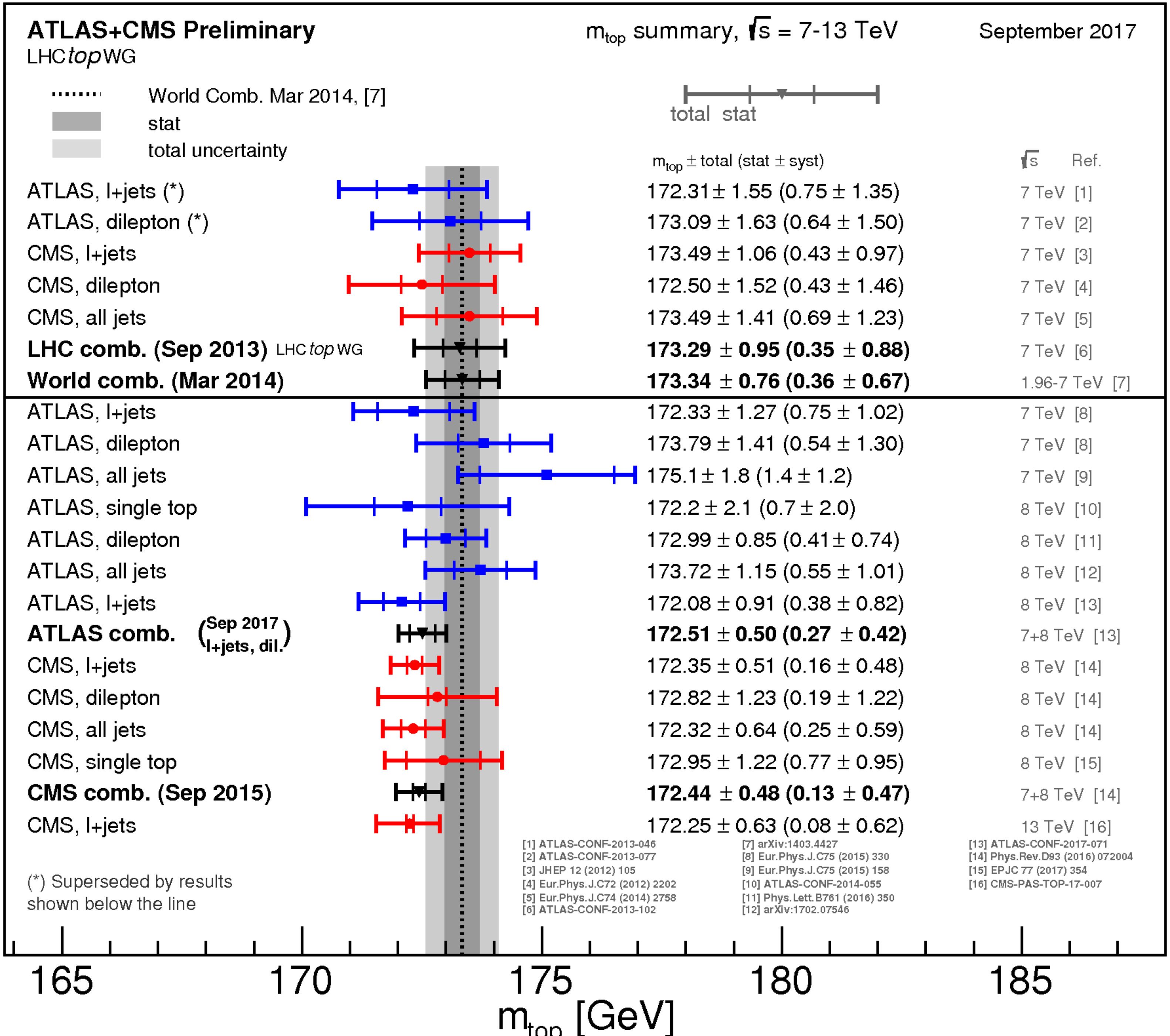
$$M_W = 80370 \pm 7\,(\text{stat}) \pm 11\,(\text{exp. syst.}) \pm 14\,(\text{model. syst.})\ \text{MeV} = 80370 \pm 18.5\ \text{MeV}$$

Combined categories	Value [MeV]	Stat. Unc.	Muon Unc.	Elec. Unc.	Recoil Unc.	Bckg. Unc.	QCD Unc.	EW Unc.	PDF Unc.	Total Unc.	χ^2/dof of Comb.
m_T-p_T^ℓ, $W^\pm$, e-μ	80369.5	6.8	6.6	6.4	2.9	4.5	8.3	5.5	9.2	18.5	29/27

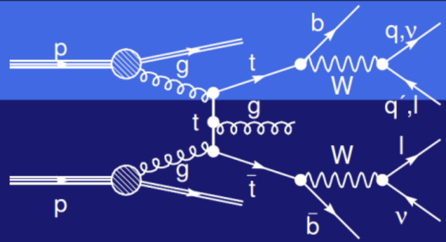
- Measurement consistent:
  - Between the different categories!
  - With previous LEP+Tevatron measurement!
  - Similar sensitivity as Tevatron!
- Measurement sys. dominated, with large uncertainty on the model (PDF & p_{TW}).



Louis Helary (represented by M. Schott)

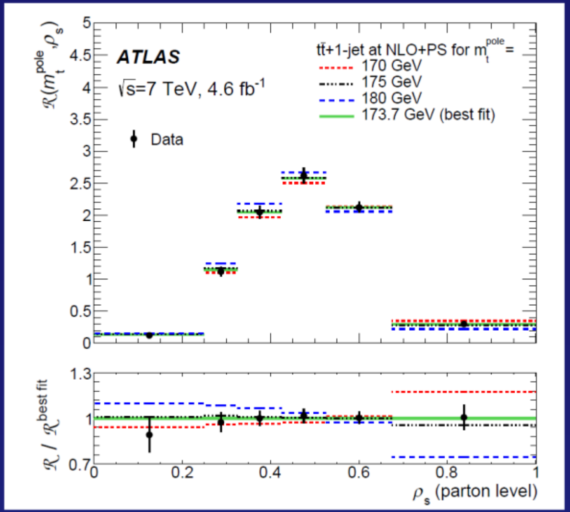

ATLAS+CMS Preliminary
LHC top WG
m_top summary, √s = 7-13 TeV
September 2017
World Comb. Mar 2014, [7]
stat
total uncertainty
total stat
m_top ± total (stat ± syst)
√s
Ref.
ATLAS, l+jets (*) 172.31 ± 1.55 (0.75 ± 1.35) 7 TeV [1]
ATLAS, dilepton (*) 173.09 ± 1.63 (0.64 ± 1.50) 7 TeV [2]
CMS, l+jets 173.49 ± 1.06 (0.43 ± 0.97) 7 TeV [3]
CMS, dilepton 172.50 ± 1.52 (0.43 ± 1.46) 7 TeV [4]
CMS, all jets 173.49 ± 1.41 (0.69 ± 1.23) 7 TeV [5]
LHC comb. (Sep 2013) LHC top WG 173.29 ± 0.95 (0.35 ± 0.88) 7 TeV [6]
World comb. (Mar 2014) 173.34 ± 0.76 (0.36 ± 0.67) 1.96-7 TeV [7]
ATLAS, l+jets 172.33 ± 1.27 (0.75 ± 1.02) 7 TeV [8]
ATLAS, dilepton 173.79 ± 1.41 (0.54 ± 1.30) 7 TeV [8]
ATLAS, all jets 175.1 ± 1.8 (1.4 ± 1.2) 7 TeV [9]
ATLAS, single top 172.2 ± 2.1 (0.7 ± 2.0) 8 TeV [10]
ATLAS, dilepton 172.99 ± 0.85 (0.41 ± 0.74) 8 TeV [11]
ATLAS, all jets 173.72 ± 1.15 (0.55 ± 1.01) 8 TeV [12]
ATLAS, l+jets 172.08 ± 0.91 (0.38 ± 0.82) 8 TeV [13]
ATLAS comb. (Sep 2017 l+jets, dil.) 172.51 ± 0.50 (0.27 ± 0.42) 7+8 TeV [13]
CMS, l+jets 172.35 ± 0.51 (0.16 ± 0.48) 8 TeV [14]
CMS, dilepton 172.82 ± 1.23 (0.19 ± 1.22) 8 TeV [14]
CMS, all jets 172.32 ± 0.64 (0.25 ± 0.59) 8 TeV [14]
CMS, single top 172.95 ± 1.22 (0.77 ± 0.95) 8 TeV [15]
CMS comb. (Sep 2015) 172.44 ± 0.48 (0.13 ± 0.47) 7+8 TeV [14]
CMS, l+jets 172.25 ± 0.63 (0.08 ± 0.62) 13 TeV [16]
(*) Superseded by results shown below the line
[1] ATLAS-CONF-2013-046
[2] ATLAS-CONF-2013-077
[3] JHEP 12 (2012) 105
[4] Eur.Phys.J.C72 (2012) 2202
[5] Eur.Phys.J.C74 (2014) 2758
[6] ATLAS-CONF-2013-102
[7] arXiv:1403.4427
[8] Eur.Phys.J.C75 (2015) 330
[9] Eur.Phys.J.C75 (2015) 158
[10] ATLAS-CONF-2014-055
[11] Phys.Lett.B761 (2016) 350
[12] arXiv:1702.07546
[13] ATLAS-CONF-2017-071
[14] Phys.Rev.D93 (2016) 072004
[15] EPJC 77 (2017) 354
[16] CMS-PAS-TOP-17-007
165
170
175
180
185
m_top [GeV]

Indirect mass measurements ► $t\bar{t} + 1\text{jet}$

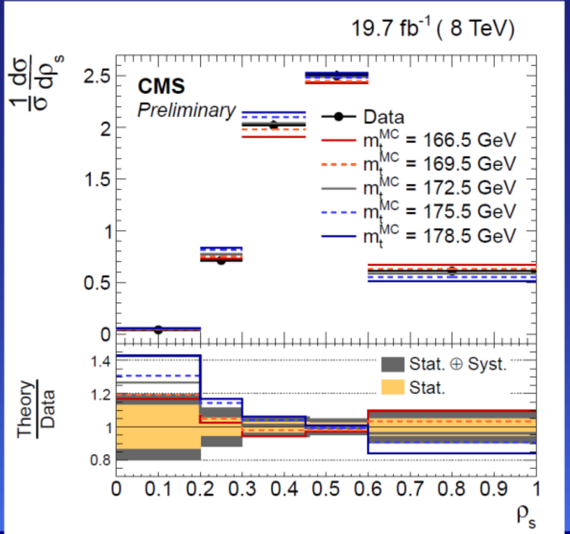


JHEP 10(2015)121

- ► m_{top}^{pole} from differential cross section observable in $t\bar{t} + 1\text{jet}$:
  - Di-Lepton channel for CMS@8 TeV
  - Lepton+Jets channel for ATLAS@7 TeV
- ► Event selection
  - First select $t\bar{t}$ candidates like in the lepton+jets (ATLAS) or di-lepton (CMS) channel
  - Leading unused jet combined with $t\bar{t}$ to reconstruct ρ_s
- ► Unfolding of distribution in ρ_s
  - Compare to calculations in NLO with parton showering
  - m_{top}^{pole} extracted from χ^2-fit to theory with regularized covariance matrix in unfolded $\rho_s \in [0.25, 1]$ (ATLAS) and $\rho_s \in [0.2, 1]$ (CMS)
  - Most sensitive regions are the low and high ρ_s-bins
  - Validation with MC samples with different top-quark masses



CMS-PAS-TOP-13-006



$$m_{top}^{\text{pole, ATLAS}} = 173.7 \pm 1.5_{\text{stat}} \,{}^{+1.0}_{-0.5}\,{}_{\text{theo}} \pm 1.4_{\text{sys}}$$

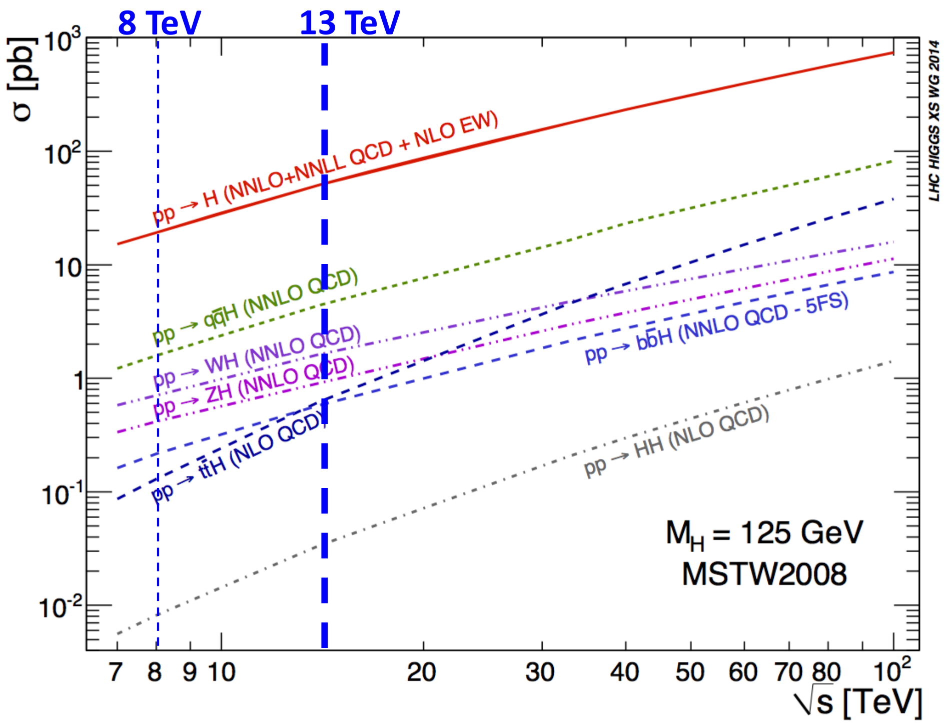
$$(0.9_{\text{JES+bJES}} \oplus 0.7_{\text{ISR/FSR}} \oplus 0.5_{\text{PDF}} \oplus \ldots)\ \text{GeV}$$

$$m_{top}^{\text{pole, CMS}} = 169.9 \pm 1.1_{\text{stat}} \,{}^{+3.6}_{-1.6}\,{}_{\text{theo}} \,{}^{+2.5}_{-3.1}\,{}_{\text{sys}}$$

$$({}^{+1.0}_{-2.8}\,{}_{\text{Scale}} \,{}^{-0.1}_{+1.6}\,{}_{\text{Jet-Parton Match}} \oplus 1.0_{\text{Bkgd}} \oplus \ldots)\ \text{GeV}$$

ヒッグス粒子の性質(標準理論の計算)

- 生成断面積



	σ(14TeV)/σ(8TeV)
gg→H	**2.6** (M_X=M_H)
qq→qqH	**2.6** (probes high M_X)
qq→VH	**2.1** (M_X=M_V+M_H)
gg→ttH	**4.7** (phase space+M_X)

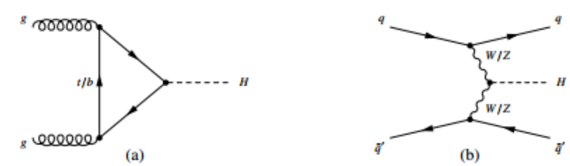


Figure 1: Leading-order Feynman diagrams for Higgs boson production via the (a) ggF and (b) VBF production processes.

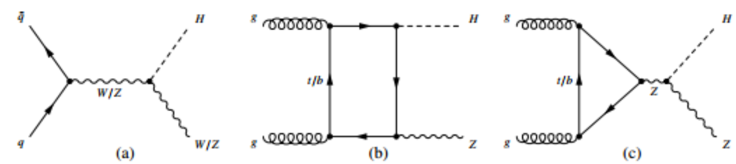


Figure 2: Leading-order Feynman diagrams of Higgs boson production via the (a) $q\bar{q} \to VH$ and (b,c) $gg \to ZH$ production processes.

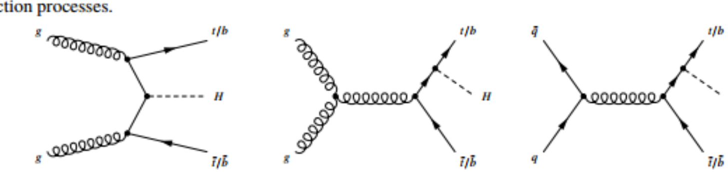


Figure 3: Leading-order Feynman diagrams of Higgs boson production via the $q\bar{q}/gg \to t\bar{t}H$ and $q\bar{q}/gg \to bbH$ processes.

ヒッグス粒子の性質(標準理論の計算)

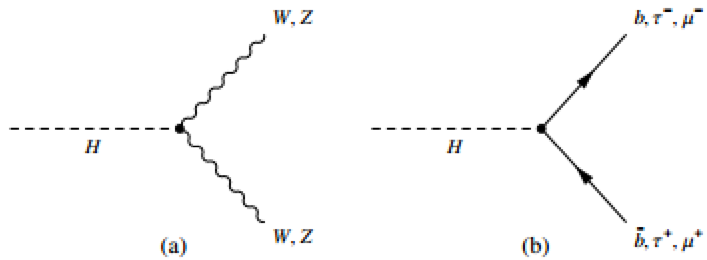


Figure 5: Leading-order Feynman diagrams of Higgs boson decays (a) to W and Z bosons and (b) to fermions.

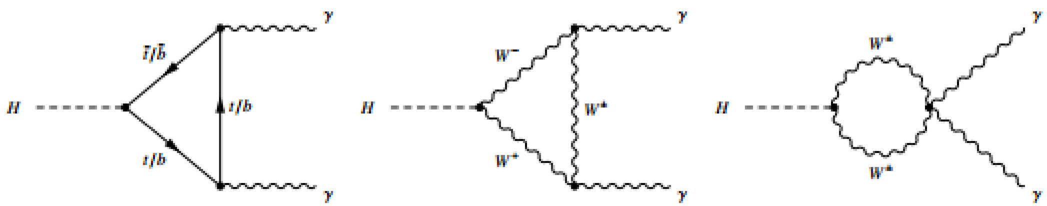


Figure 6: Leading-order Feynman diagrams of Higgs boson decays to a pair of photons.

さまざまな生成・崩壊モード

- **さまざまな測定を行い、標準理論を検証できる。**
- **標準理論からのずれをさがす。ずれがあれば、そこに新物理があるはず。**

重心エネルギー8 TeV⇒13 TeV

- 生成断面積は、2-5倍。
- Run2では、たくさん作ってじっくり研究する。

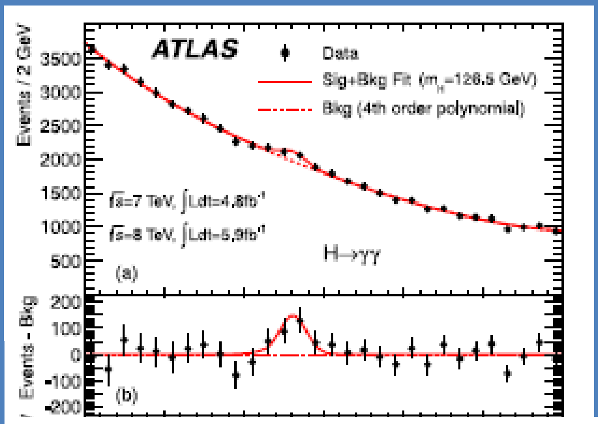
- 崩壊分岐比 $(m_H = 125\ \mathrm{GeV})$

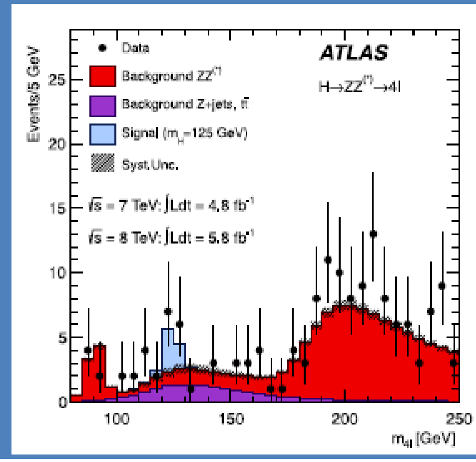
$H \to b\bar{b}$	$H \to \tau^+\tau^-$	$H \to \mu^+\mu^-$	$H \to c\bar{c}$
57.7%	6.32%	0.022%	0.029%

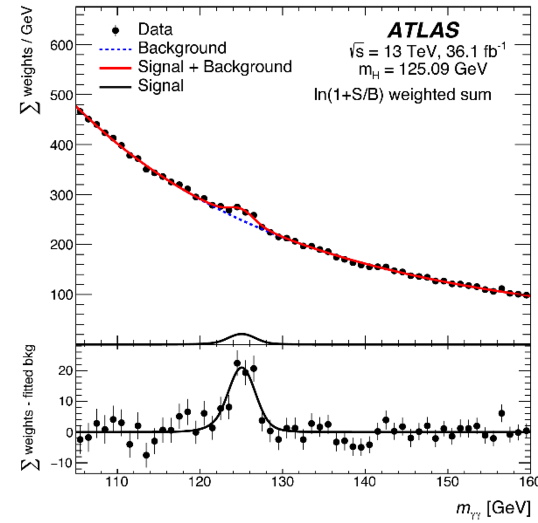
$H \to gg$	$H \to \gamma\gamma$	$H \to Z\gamma$	$H \to WW$	$H \to ZZ$	Γ_H [MeV]
8.6%	0.23%	0.15%	21.5%	2.64%	4.07

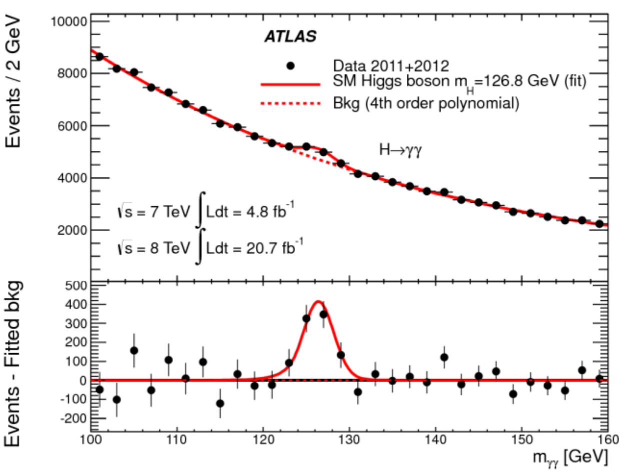
2012年末まで全データでのアップデート

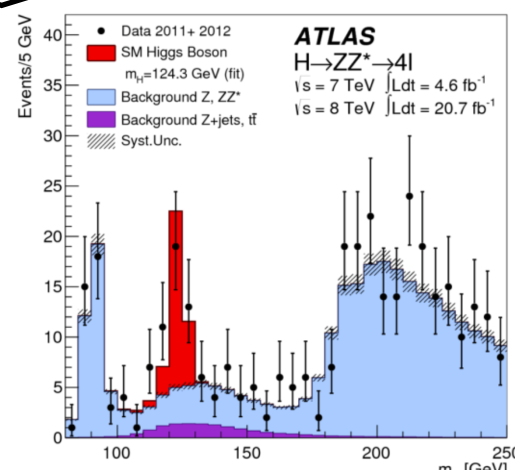
2012年夏の結果





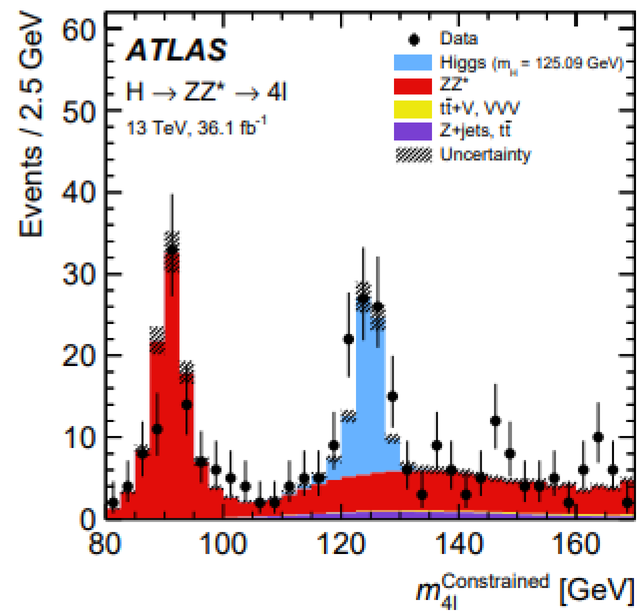






Signal significance:
Observed: 7.4 σ
Expected: 4.3 σ

Significance:
Observed: 6.6σ
Expected: 4.4σ

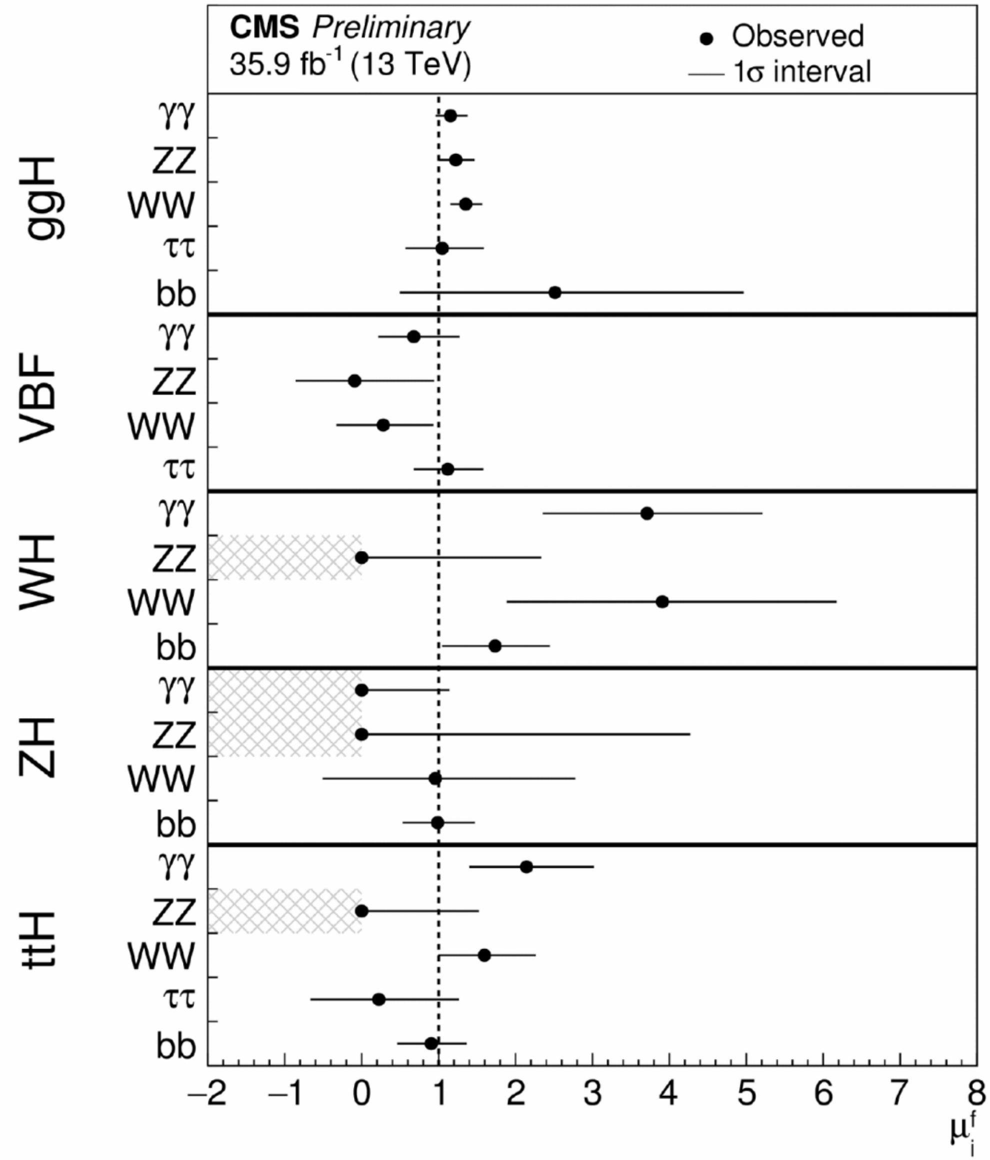


Combination

New

- Combine analyses sensitive on 22 from 25 possible production and decay modes
  - Missing to be added soon

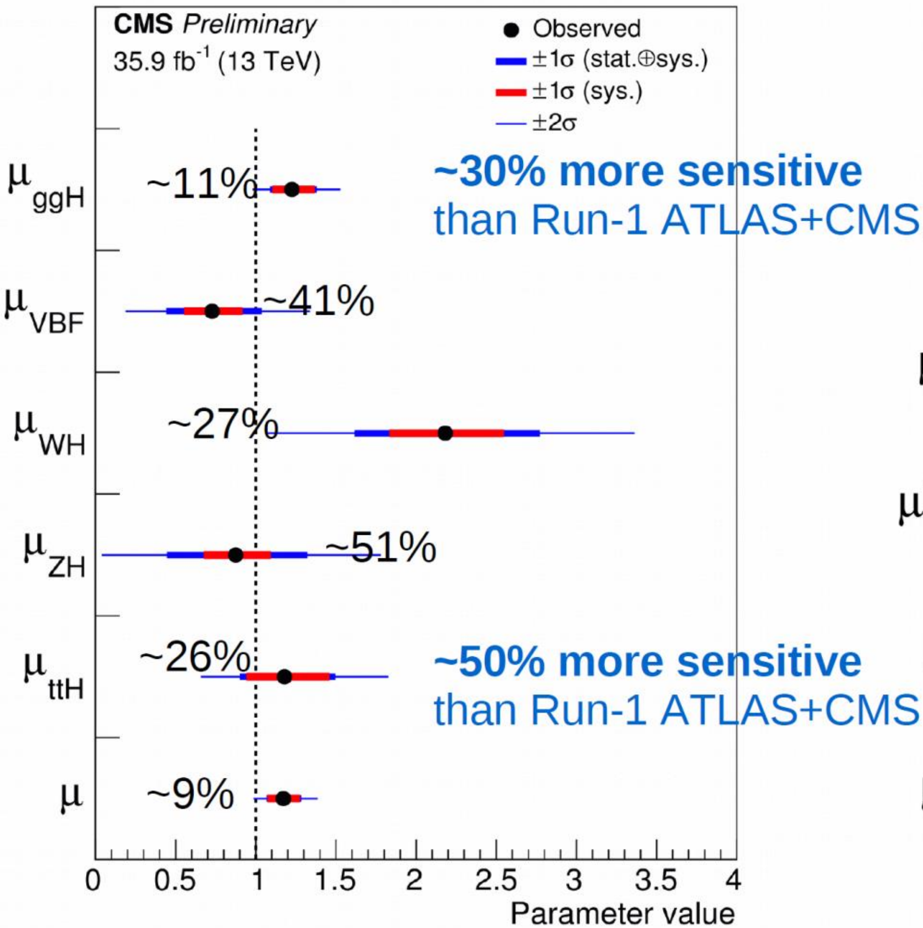
- Higher sensitivity of several measurements than with the Run-1 ATLAS+CMS combination...



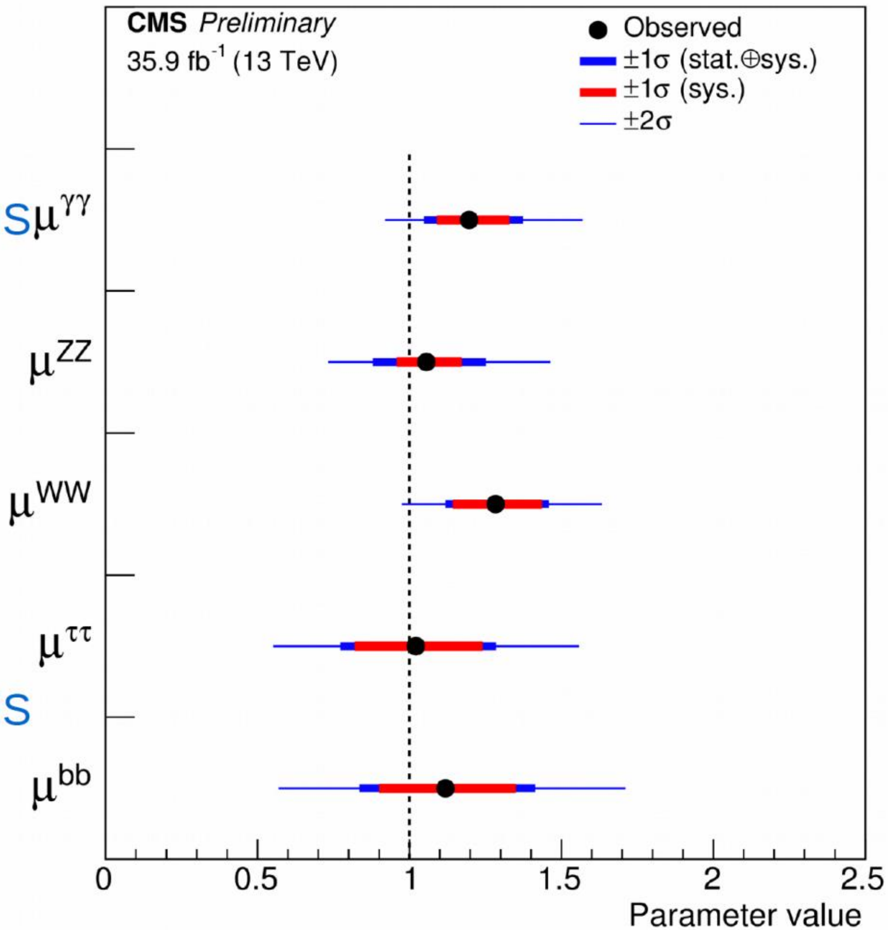
Production & decay modes

New

Per production mode



Per decay mode



Combined: $\mu = 1.17^{+0.10}_{-0.10} = 1.17^{+0.06}_{-0.06}\,(\text{stat.})\,^{+0.06}_{-0.05}\,(\text{sig. th.})\,^{+0.06}_{-0.06}\,(\text{other sys.})$