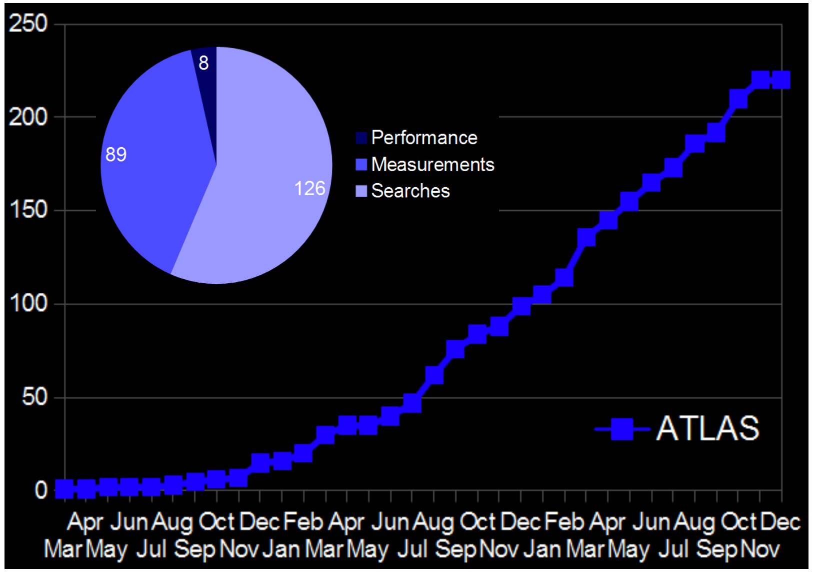
Status of the ATLAS Experiment

Recent (Selected) Highlights

Marumi Kado (LAL, Orsay)
On behalf of the ATLAS Collaboration

Preliminary Note and Disclaimer

As of yesterday December 12, 2012 :



- ATLAS produced 223 papers using collision data
  - 4% performance papers
  - 40% standard model measurements (including Heavy Ions)
  - 56% on searches for Higgs and new physics beyond the standard model
- 434 conference notes with preliminary results

+3 New results today

Most of these results were published in 2012, apologies for not covering them all

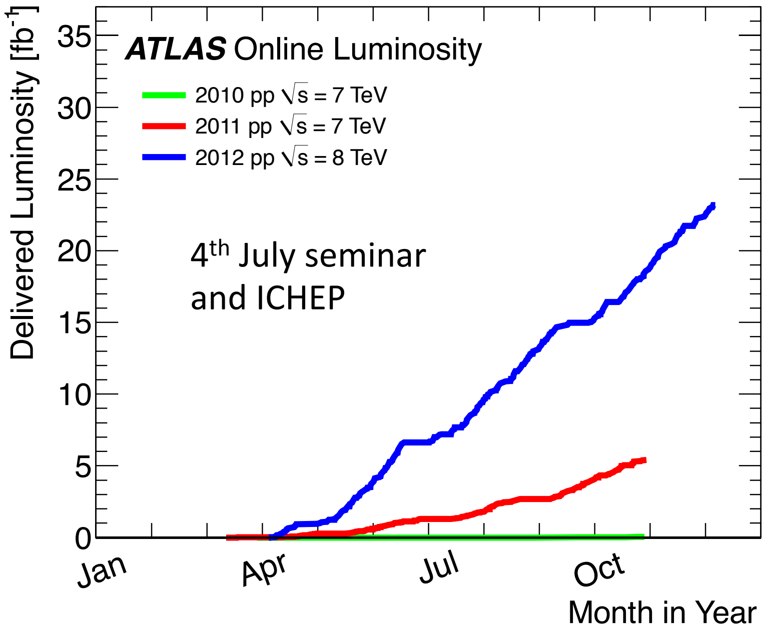
Only selected highlights will be presented here

All public documentation can be found at :
http://atlasresults.web.cern.ch/atlasresults

Three Years of data-taking at the Energy Frontier

In (a Nutshell) Review

Three Years of Remarkable LHC operations at the Energy frontier

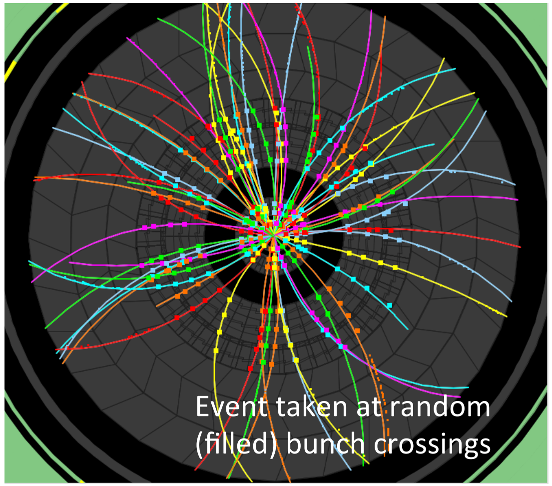


2010
0.05 fb^{-1}
at 7 TeV

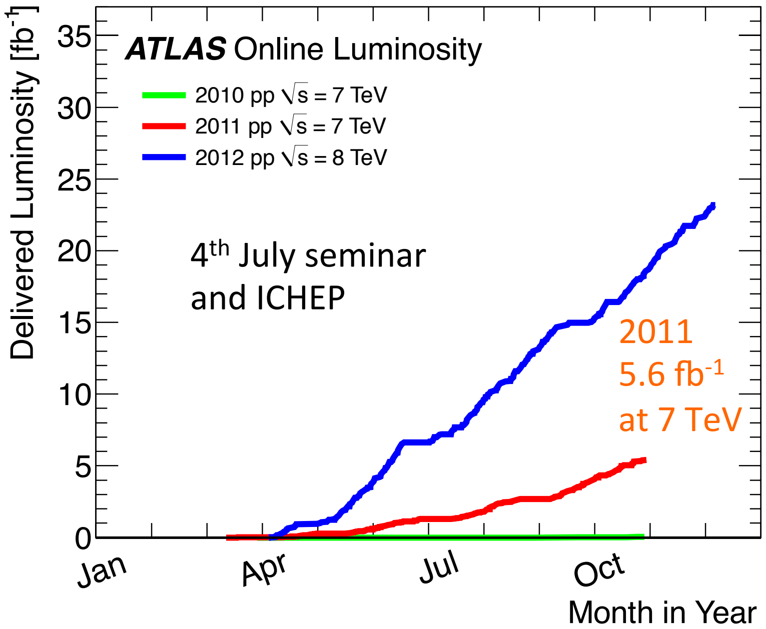
2010

O(2) Pile-up events

150 ns inter-bunch spacing



Three Years of Remarkable LHC operations at the Energy frontier



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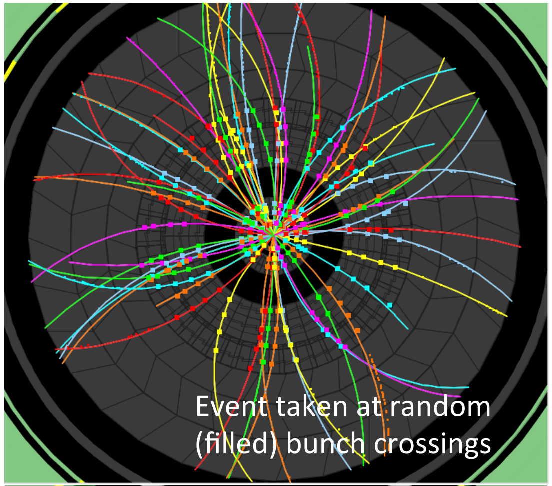
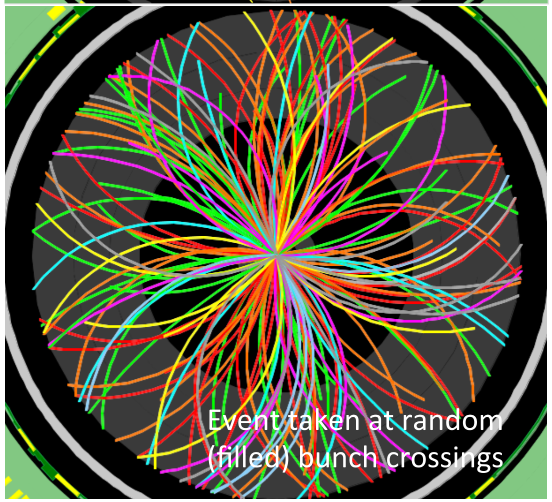


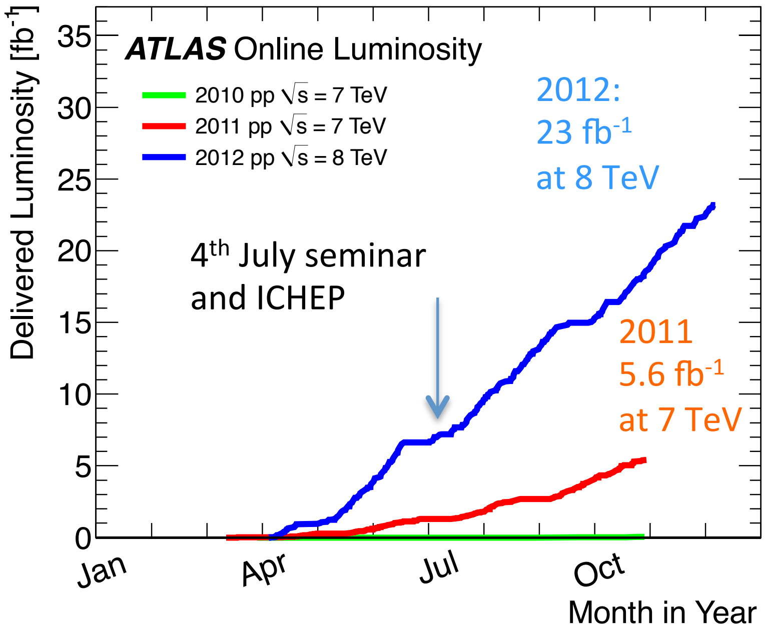
2011

O(10) Pile-up events

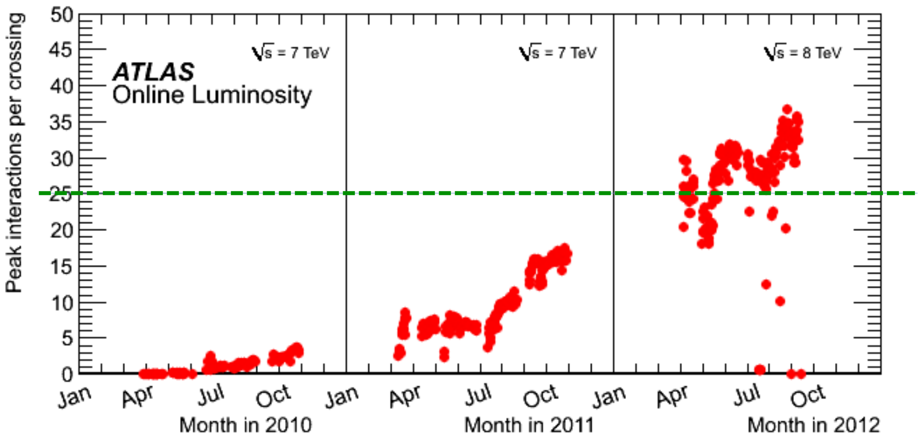
50 ns inter-bunch spacing



Three Years of Remarkable LHC operations at the Energy frontier



2010
0.05 fb^{-1}
at 7 TeV

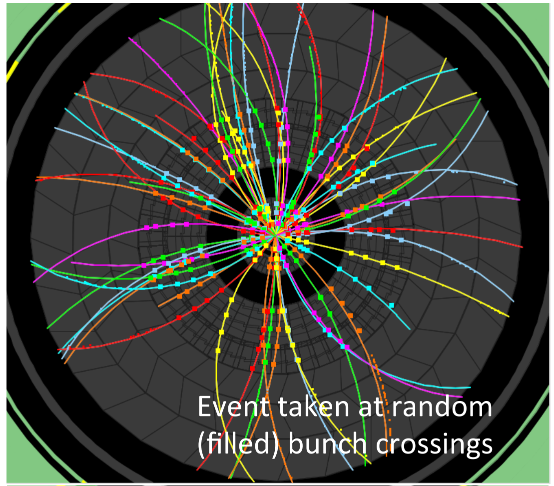


Design value (expected to be reached at L=10^{34} !)

2010

O(2) Pile-up events

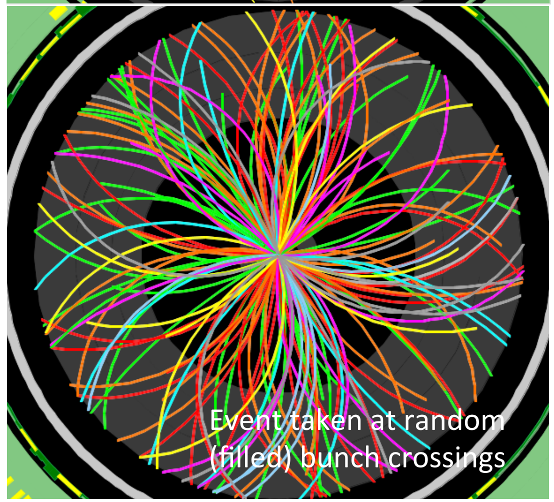
150 ns inter-bunch spacing



2011

O(10) Pile-up events

50 ns inter-bunch spacing



2012

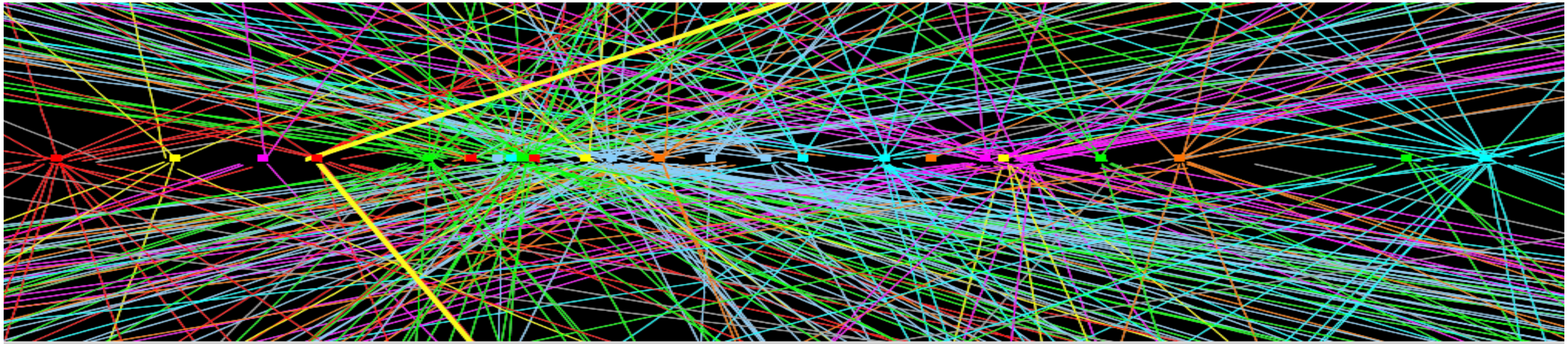
O(20) Pile-up events

50 ns inter-bunch spacing

To the entire LHC team

Congratulations and all our thanks for this splendid achievement !

High Luminosity and Pileup Challenges 2012



- Trigger Challenge : How to select 400 out of 20M events per second while keeping the interesting (including unknown) physics
- Computing Challenge : How to reconstruct, store and distribute 400 increasingly complex events per second

As of today processed and stored over 5 billion detector events
ATLAS has a total of 120 PB of data (data and simulation)

- Analysis Challenge : Maintain high (and as much as possible stable) reconstruction and identification efficiency for physics objects (e, μ, τ, jets, E^{T}_{mis}, b-jets) up to the highest pile-up

Trigger, Data Quality and Computing

Continued excellent performance of trigger even in High pile-up conditions

Inclusive unprescaled trigger thresholds within

5 GeV throughout large increase in luminosity

Average data taking efficiency: ~94%

Average data quality selection: ~94%

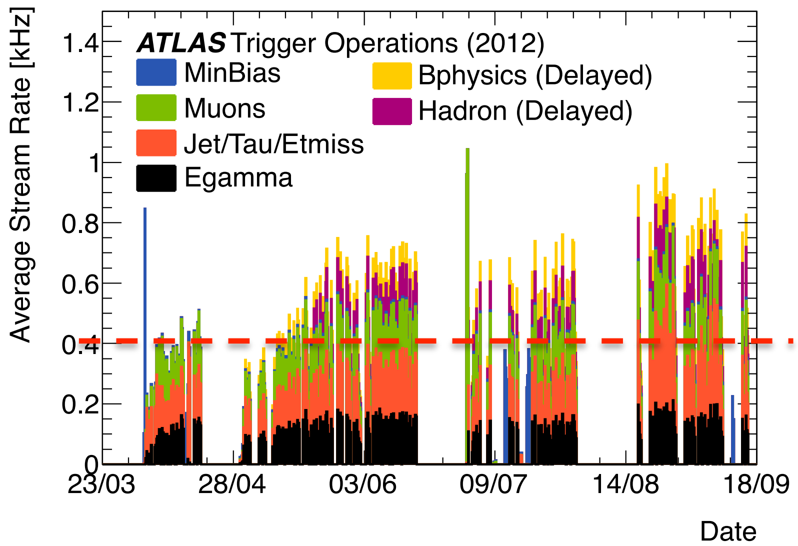
Very stable detector performance

Total efficiency (delivered → physics): ~90%

Example rates

Trigger	p_T Threshold	Rate (Hz) *
Inclusive e	24	70
Inclusive μ	24	45
ee	12	8
μμ	13	5
ττ	29,20	12
γγ	35,25	10
E_T^{mis}	80	18
5-jets	55	8

* At 5 10^{33} $cm^{-2}s^{-1}$

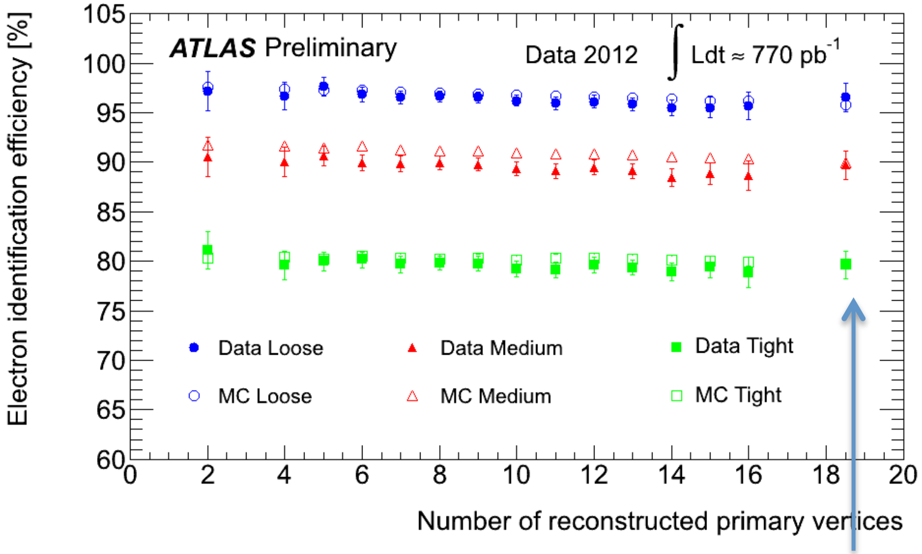


Average rate of 400 Hz
over 2012 run for prompt trigger streams

Use of grid has been critical to release physics results quickly and to allow people from all over the world to efficiently participate in the analysis effort

Robustness of Object Reconstruction and Identification vs Pile-up

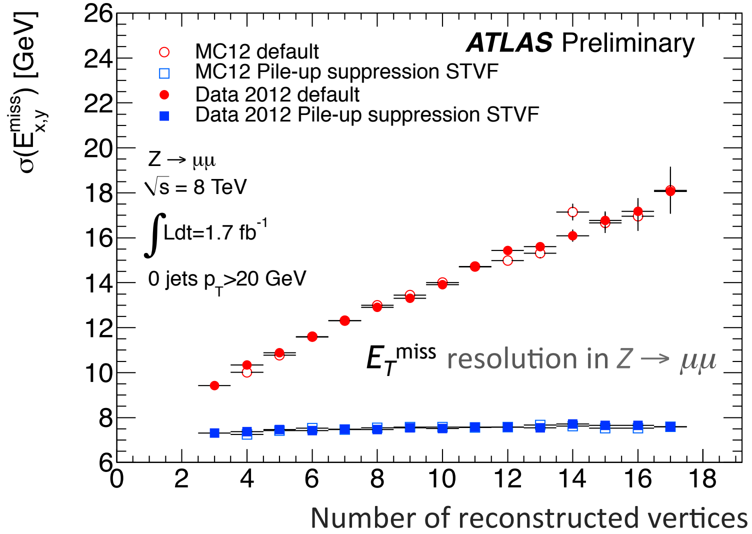
Robust electron reconstruction efficiency



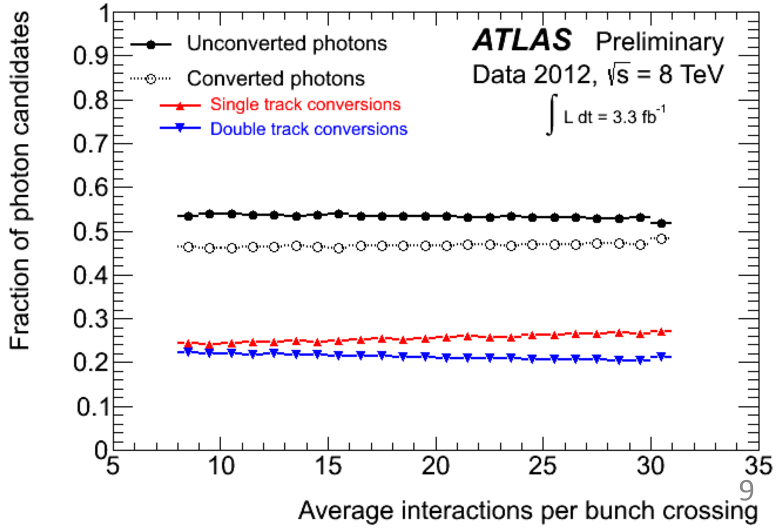
~30 Pile-up events

(60% reconstructed PV)

Improvement of E^{T}_{mis} resolution:
Including a track based soft-term fraction correction

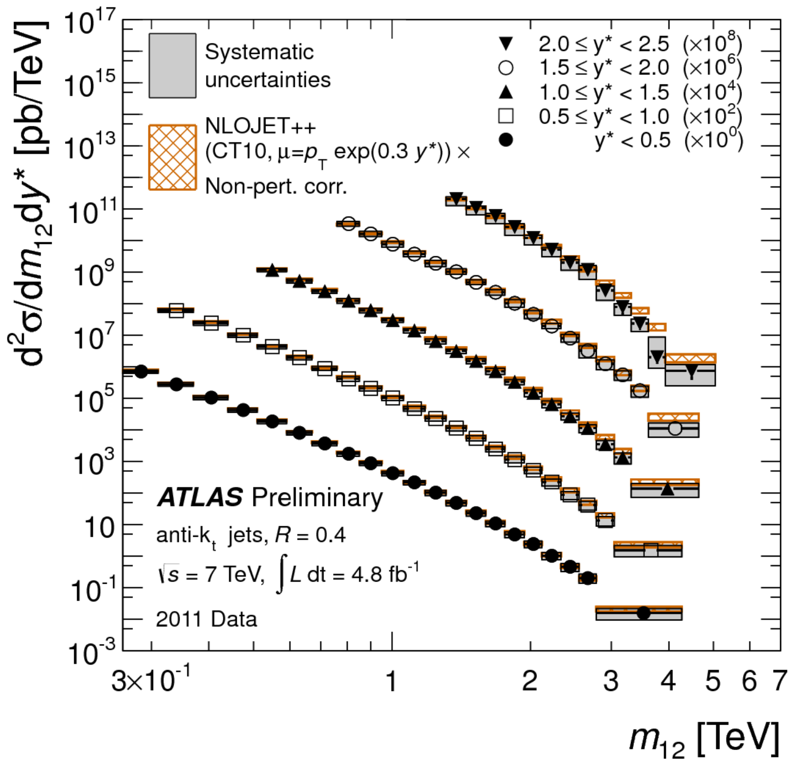


Fraction of photon candidates per conversion status



Jet Differential Cross Sections and DiJet Resonance Search

Testing predictions over
8 orders of magnitude !



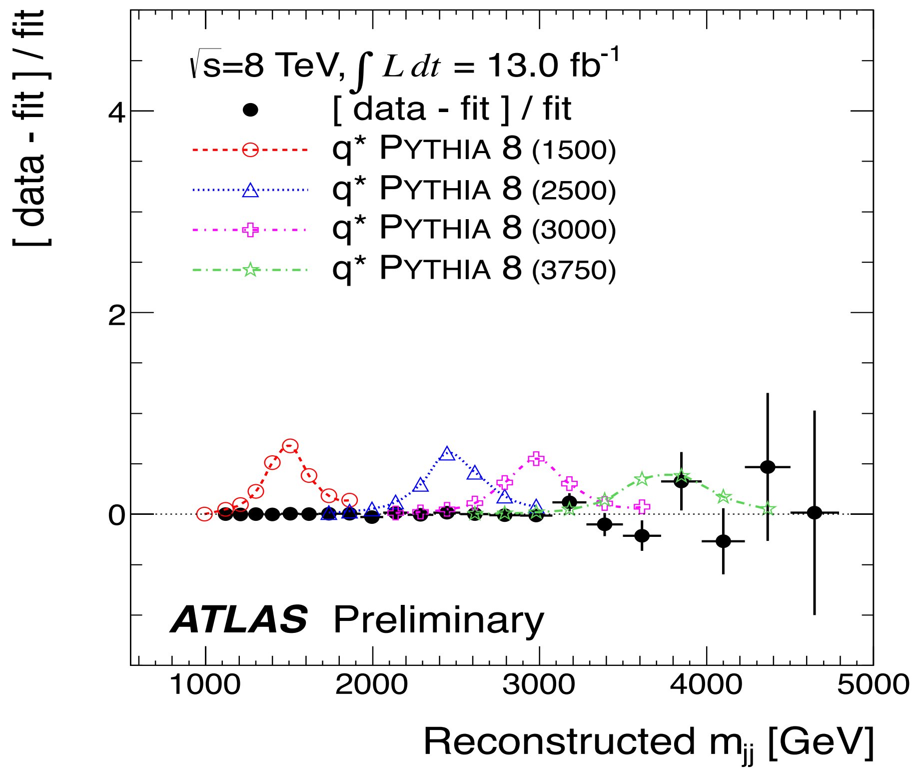
Di-jet mass differential cross section probing :

- Excellent performance and reconstruction
- NLO theory prediction of cross sections and PDFs

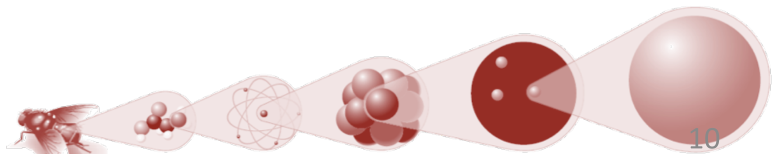
Di-jet Mass Resonance

ATLAS-CONF-2012-148

Data / fit ratio, compared to four q* models

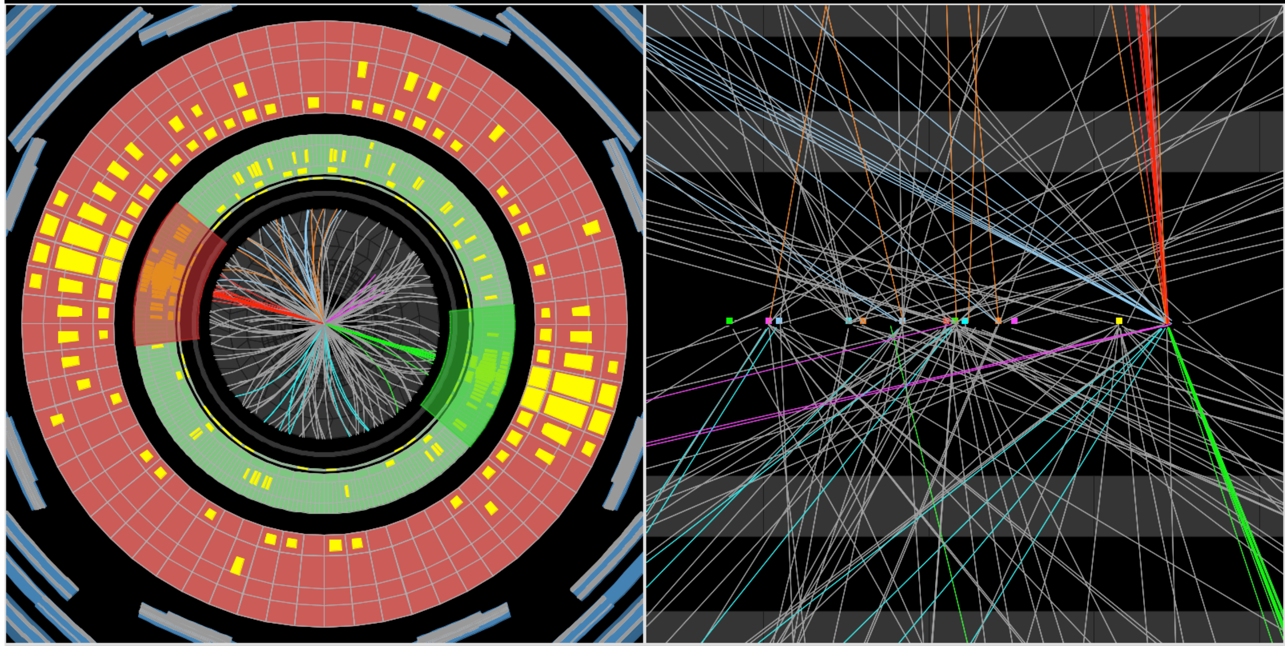


m(q*) > 3.84 TeV (95% CL)



Search for Compositeness

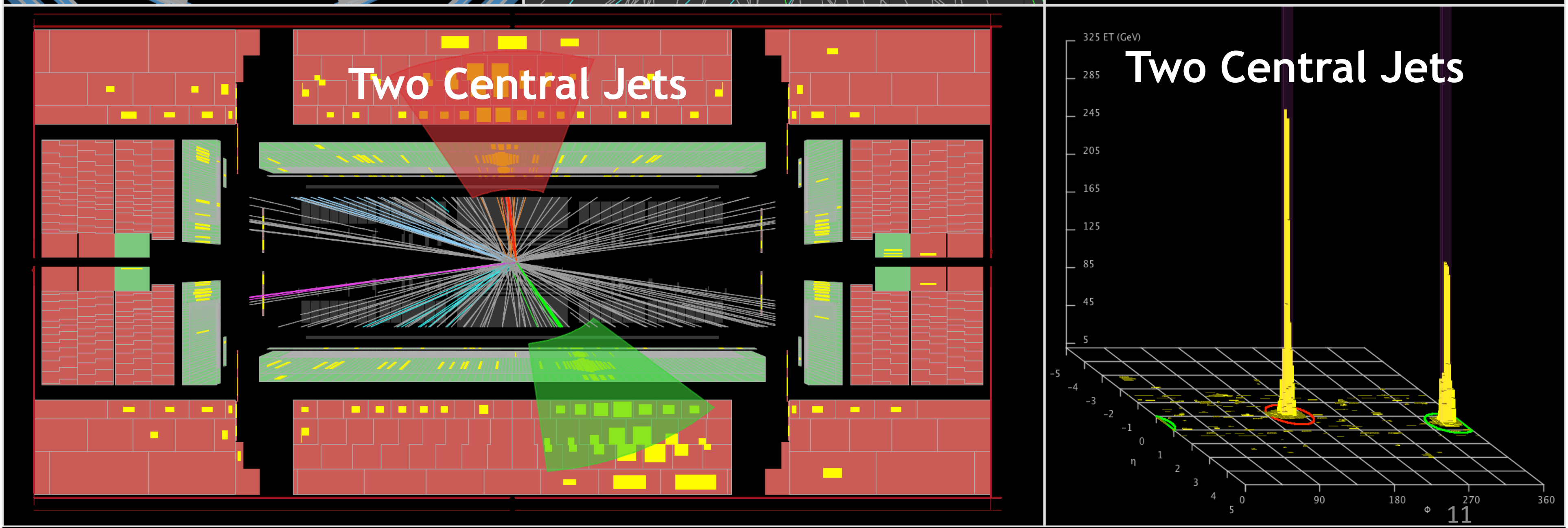
The highest-mass central dijet very well measured event. Two central jets with invariant mass of 4.7 TeV



ATLAS EXPERIMENT

m_{jj} = 4.7 TeV
p_T (j_1, j_2) = 2.3-2.2 TeV

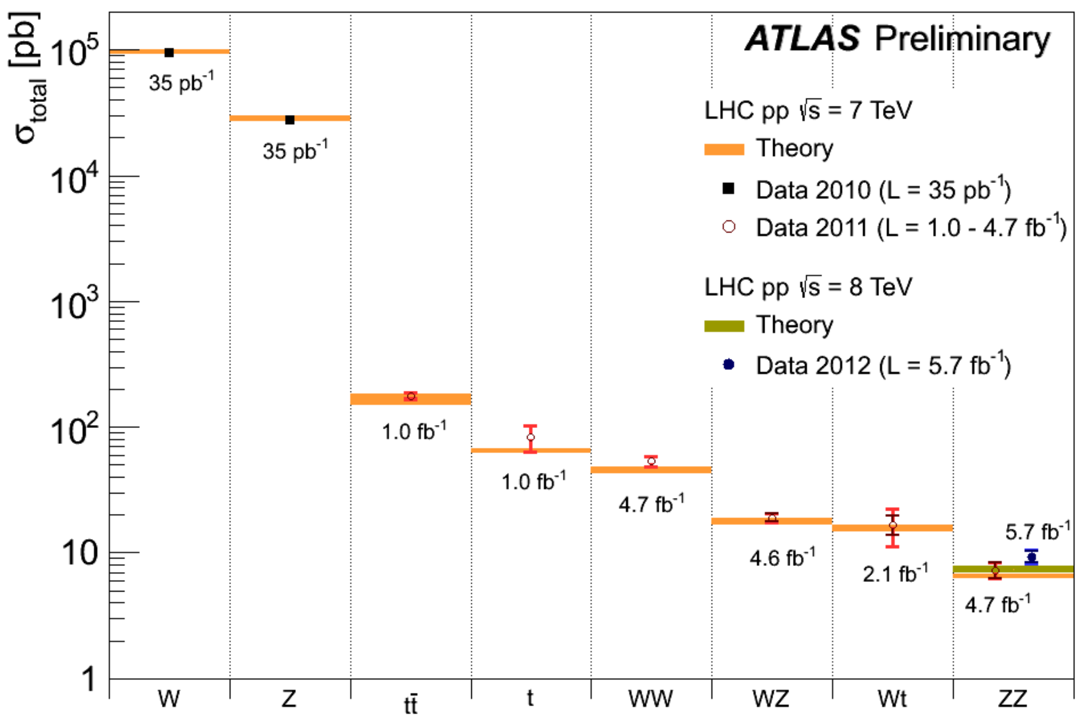
E_T^{miss} = 47 GeV



Overview of Cross Section of EW and top Processes

Tremendous progresses in theory calculations and simulation “Next-to… revolution” :

Processes are simulated to an unprecedented level of accuracy (and order of perturbation theory)



Number of events selected in full 2010-2012 dataset

W → lν ~ 100 M
Z→ ll ~ 10 M
tt → l+X ~ 0.4 M (top factory)

- Test Standard Model predictions at 7 and 8 TeV
- Search for new phenomena
- Calibrate the detector

Measuring the Top and Measuring with the Top

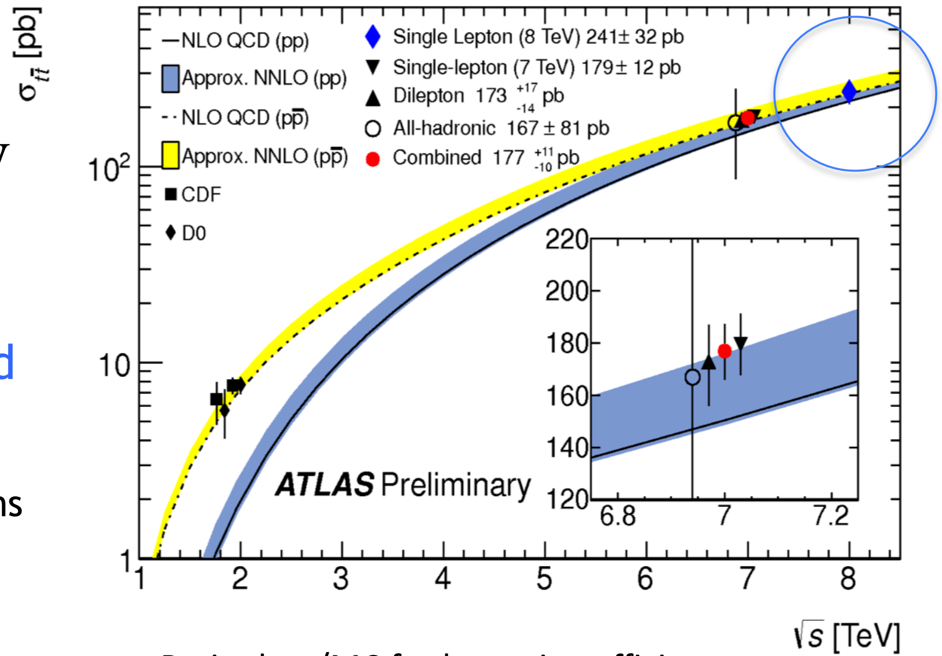
- Top quark mass measured (ATLAS+CMS):

$$m_{top} = 173.2 \pm 0.5\ (stat)\ \pm\ 1.3\ (syst)\ \text{GeV}$$

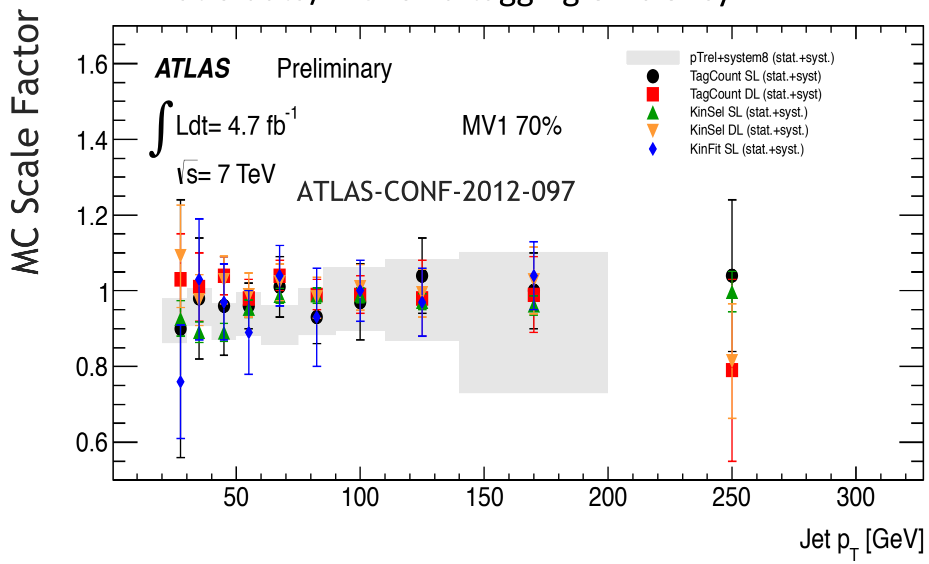
July 2012 ATLAS-CONF-2012-095

- Measuring top-pair cross sections at 7 and 8 TeV

Good agreement with Approx. NNLO theory predictions



Ratio data/MC for b-tagging efficiency

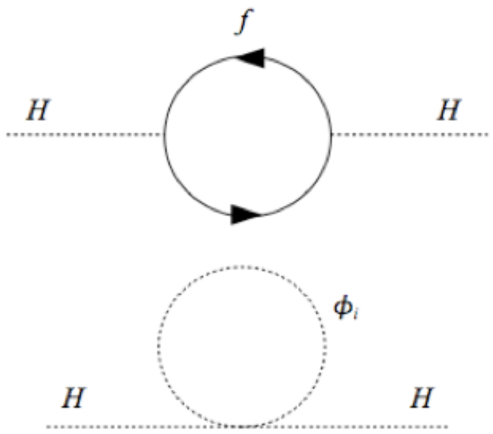


- Measuring b-tagging efficiency using top samples
    - Complementary to other methods → redundancy!
    - Extends measurement at high pT

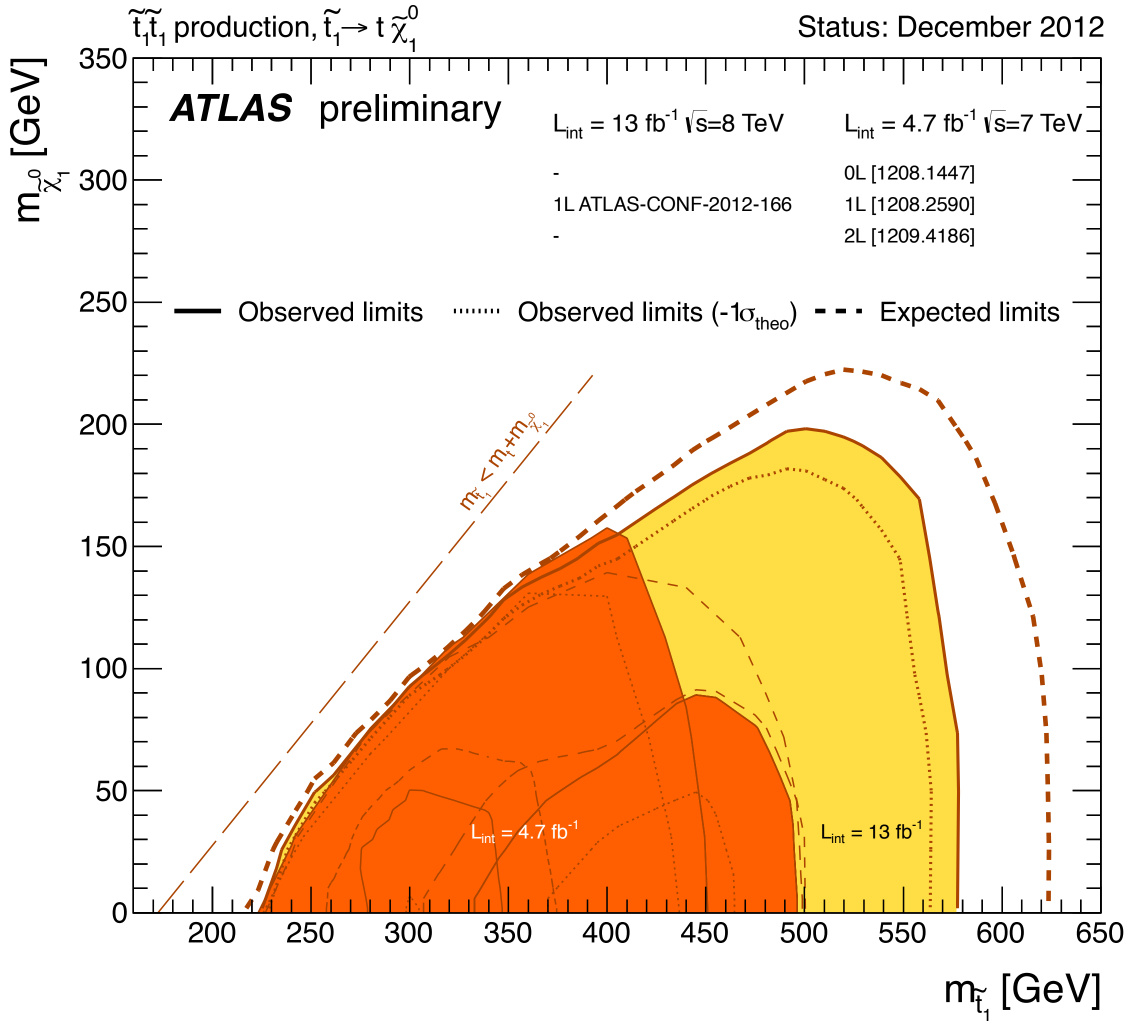
Searching for "natural" SUSY with Tops

ATLAS-CONF-2012-166
ATLAS-CONF-2012-167

Seeking solutions to stabilize the Higgs mass… Hierarchy problem



$$\tilde{t} \rightarrow t\chi$$

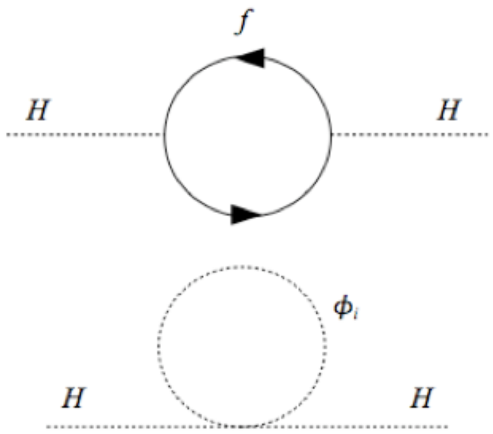


Significantly improved sensitivity at high stop masses with expected limits up to 620 GeV

Searching for SUSY with Tops

ATLAS-CONF-2012-166
ATLAS-CONF-2012-167

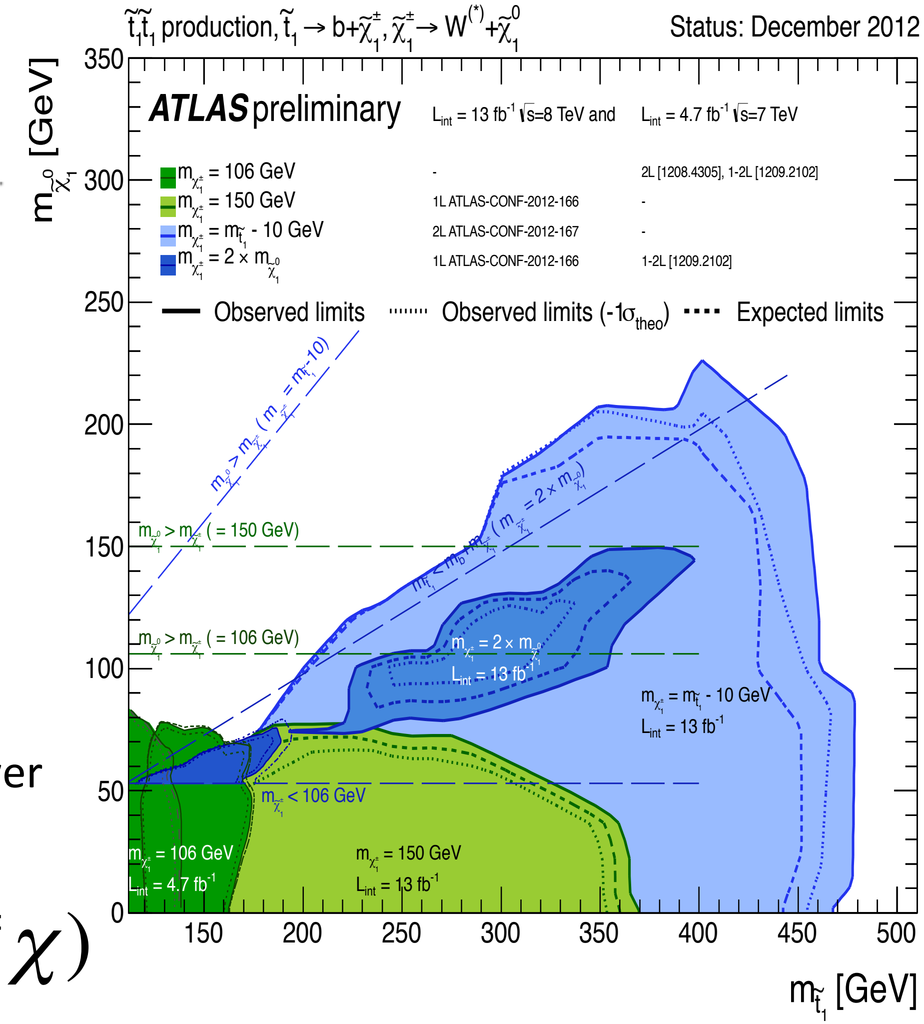
Seeking to Solve the Hierarchy Problem…



$$\tilde{t} \rightarrow t\chi$$

Complemented in the lower mass range by:

$$\tilde{t} \rightarrow b(\chi^{\pm} \rightarrow W^{\pm}\chi)$$

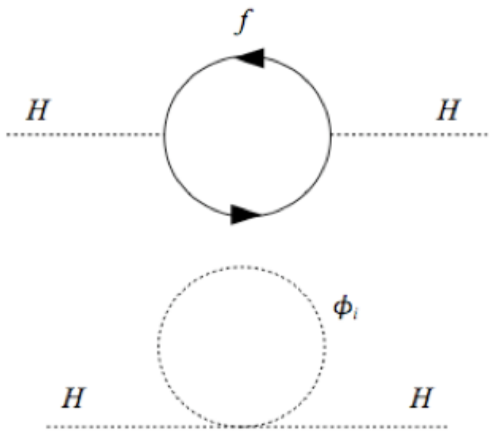


Significantly improved sensitivity at high stop masses with expected limits up to 620 GeV
Also, strongly enhanced sensitivity for lower mass stop decaying into *b* + chargino

Searching for SUSY with Tops

ATLAS-CONF-2012-166
ATLAS-CONF-2012-167

Seeking to Solve the Hierarchy Problem…



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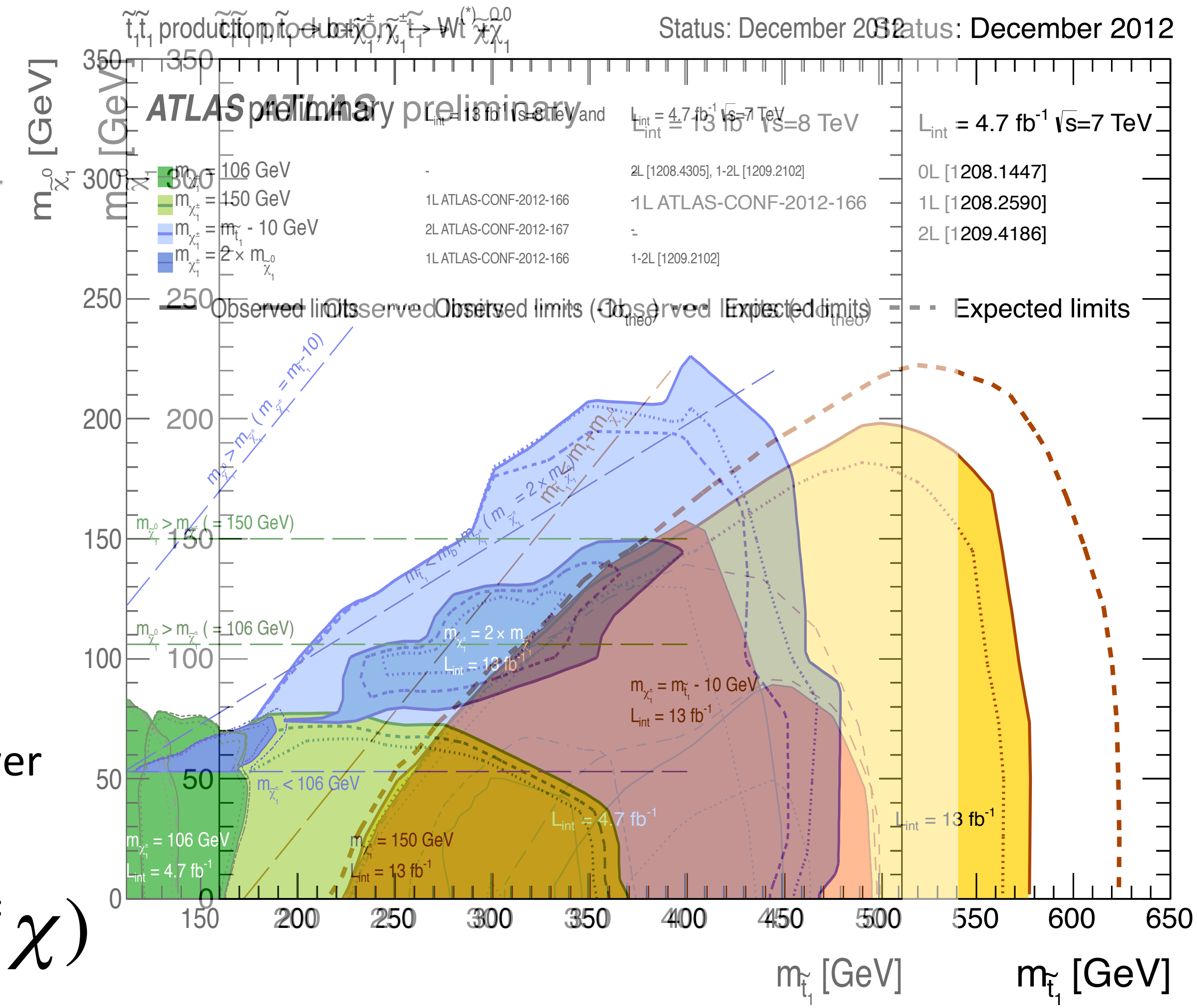


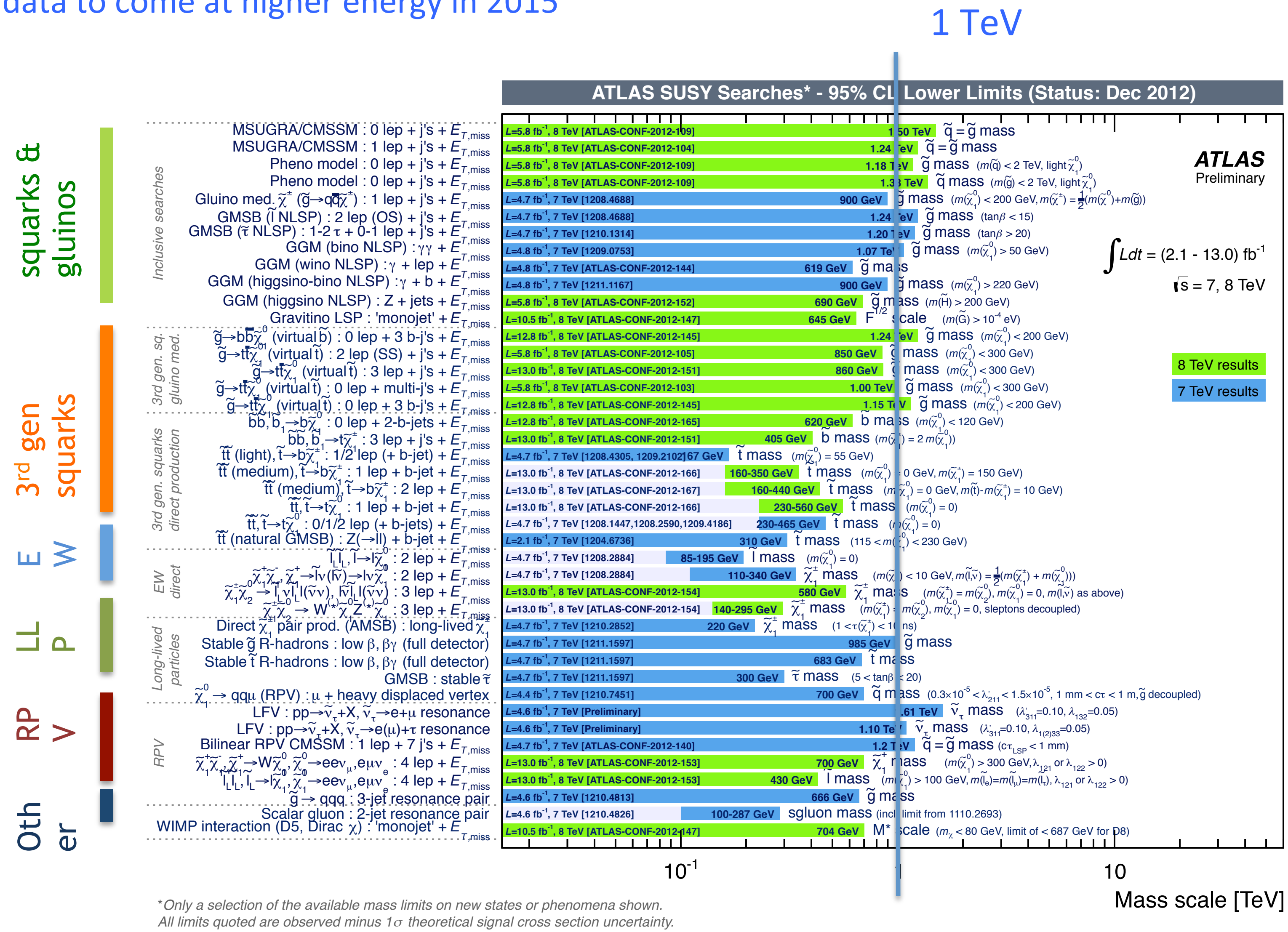
Significantly improved sensitivity at high stop masses with expected limits up to 620 GeV

Also, strongly enhanced sensitivity for lower mass stop decaying into *b* + chargino

Overview of SUSY Searches

Vast number of SUSY models studied… Concentrating on the most « Natural » scenarios

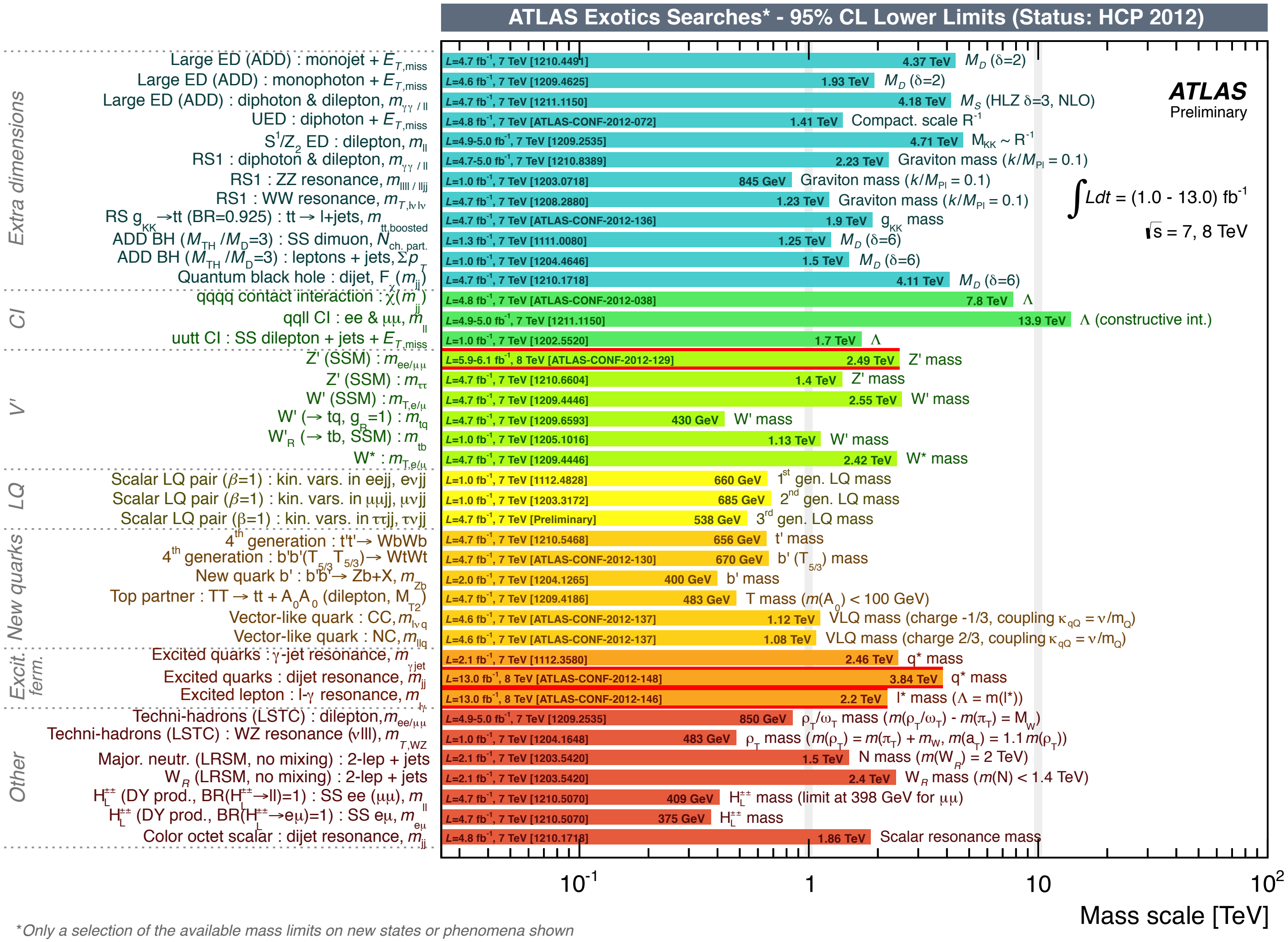
Still many analyses to be completed with 8 TeV data, surprises might be waiting in the present data, and/or data to come at higher energy in 2015



Overview of Searches at the Energy Frontier

Vast number of models investigated in large number of topologies… but only fraction of data investigated in various cases…

Surprises might be waiting in the present data, and/or data to come at higher energy in 2015



Exotics Models:

Extra dimensions:
- RS KK Graviton (dibosons, dileptons, diphotons)
- RS KK gluons (top antitop)
- ADD (monojets, monophotons, dileptons, diphotons)
- KK Z/gamma boosns (dileptons)

Grand Unification symmetries
- (dielectons, dimuons, ditaus)
- Leptophobic topcolor Z' boson (dilepton ttbar, l+j, all had)

S8- color octet scalars (dijets)
String resonance (dijets,)
Benchmark Sequential SM Z', W'
W' (lepton+MET, dijets, tb)
W* (lepton+MET, dijets)
Quantum Black Holes (dijet)
Black Holes (l+jets, same sign leptons)
Technihadrons (dileptons, dibosons)
Dark Matter
- WIMPs (Monojet, monophotons)

Excited fermions
- q*, Excited quarks (dijets, photon+jet)
- l*, excited leptons (dileptons+photon)

Leptoquarks (1st, 2nd, 3rd generations)
Higgs -> hidden sector
- (displaced vertices, lepton jets)

Contact Interaction
- llqq CI
- 4q CI (dijets)

Doubly charged Higgs (
- multi leptons, same sign leptons)

4th generation
- t'->Wb, t'->ht, b'-Zb, b'->Wt
- (dileptons, same sign leptons, l+J)

VLQ-Vector Like quarks
Magnetic Monopoles (and HIP)
Heavy Majorana neutrino and RH W

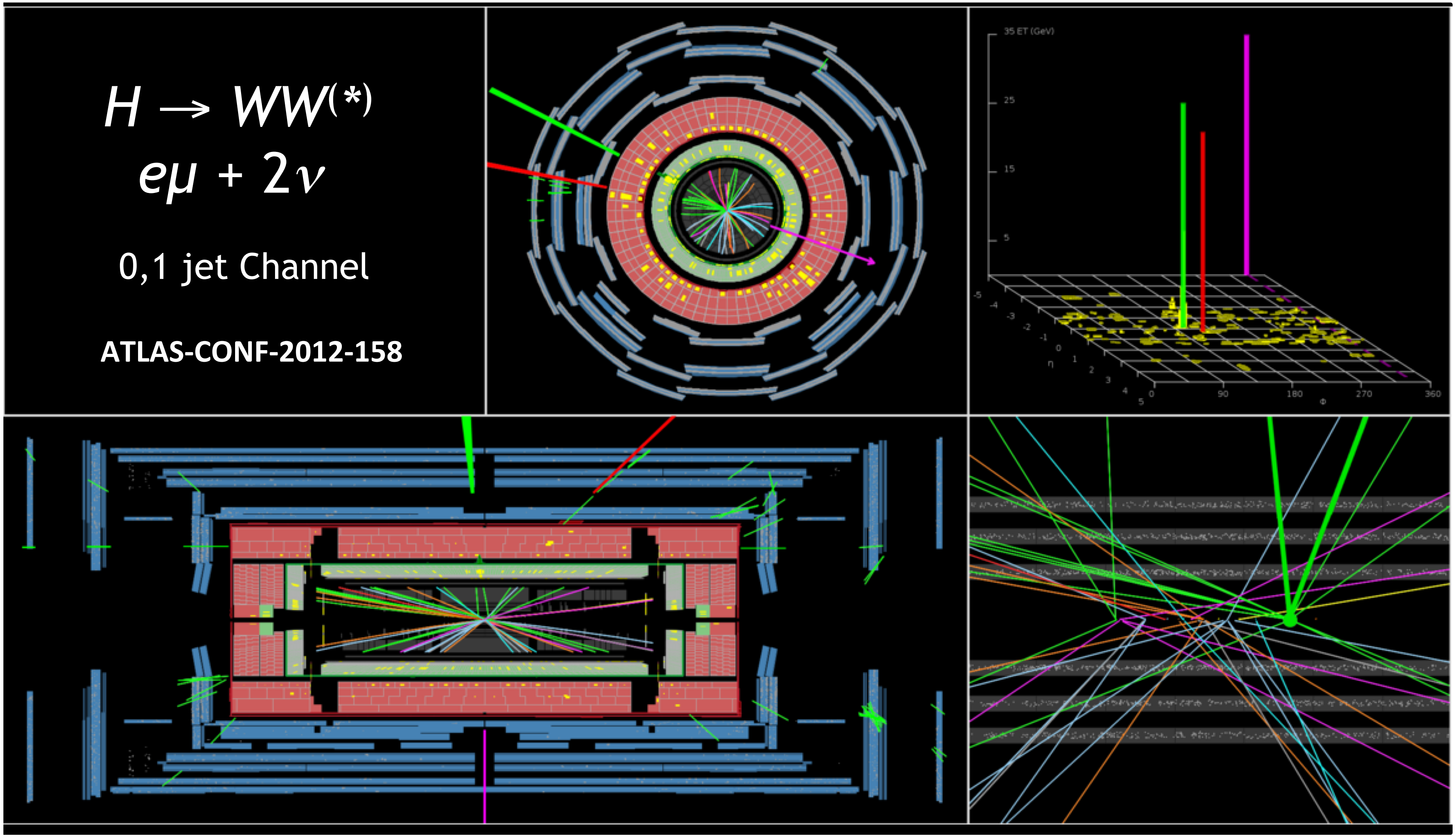
Highlights of Higgs Analyses

From Discovery to Measurements

I.- (nano) Review of Recent Results on Main SM Higgs Channels

II.- Update of Higgs analyses in $H \rightarrow \gamma\gamma$ and $H \rightarrow 4l$ Channels New !

III.- First Spin and Parity Studies New !

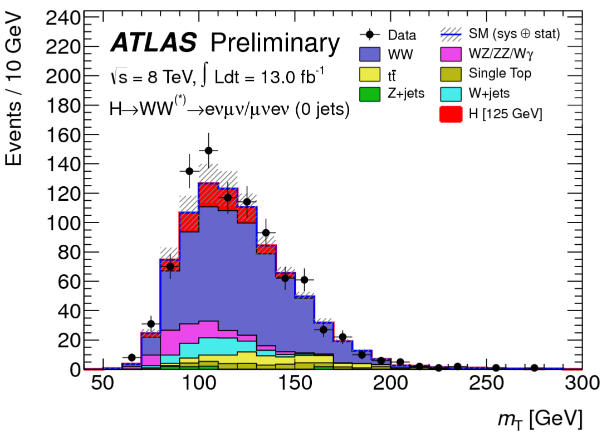


WW channel basic facts sheet :

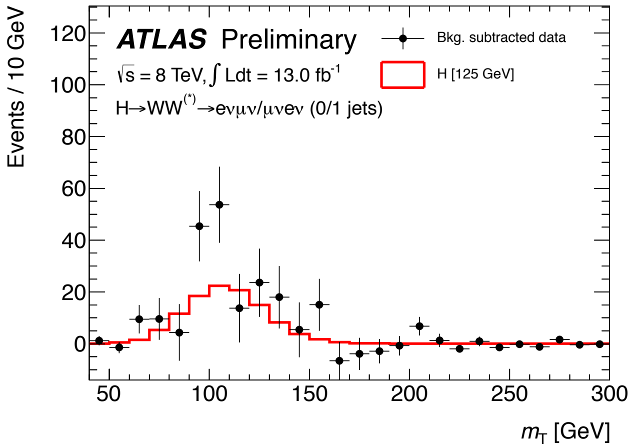
Signal	Signal purity s/b	Main backgrounds	Production	8 TeV $\int L\,dt$
~110	~10%	WW, W+jets, top, etc...	ggH	13 fb^{-1}

$H \rightarrow WW^{(*)} \rightarrow e\mu + 2\nu$

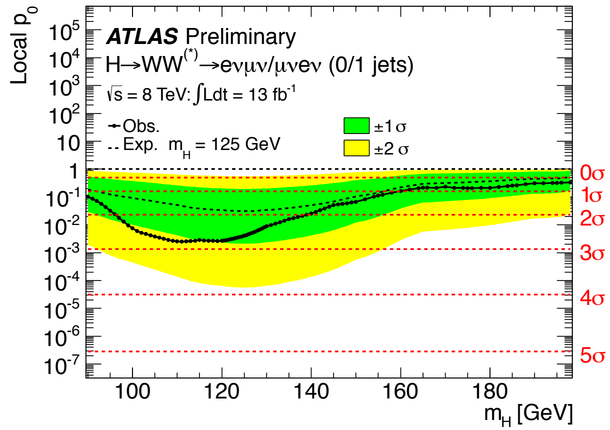
Different-flavour channel and 8 TeV (13 fb^{-1}) 0 and 1-jet



Transverse mass (signal region)



Background subtracted transverse mass



- Main discrimination with: m_{ll}, Δf_{ll}, m_T
- Main backgrounds estimated from control regions

μ

Signal strength:

Ratio of measured event yield to that expected from the Standard Model Higgs signal

μ(125 GeV) = 1.5 ± 0.6

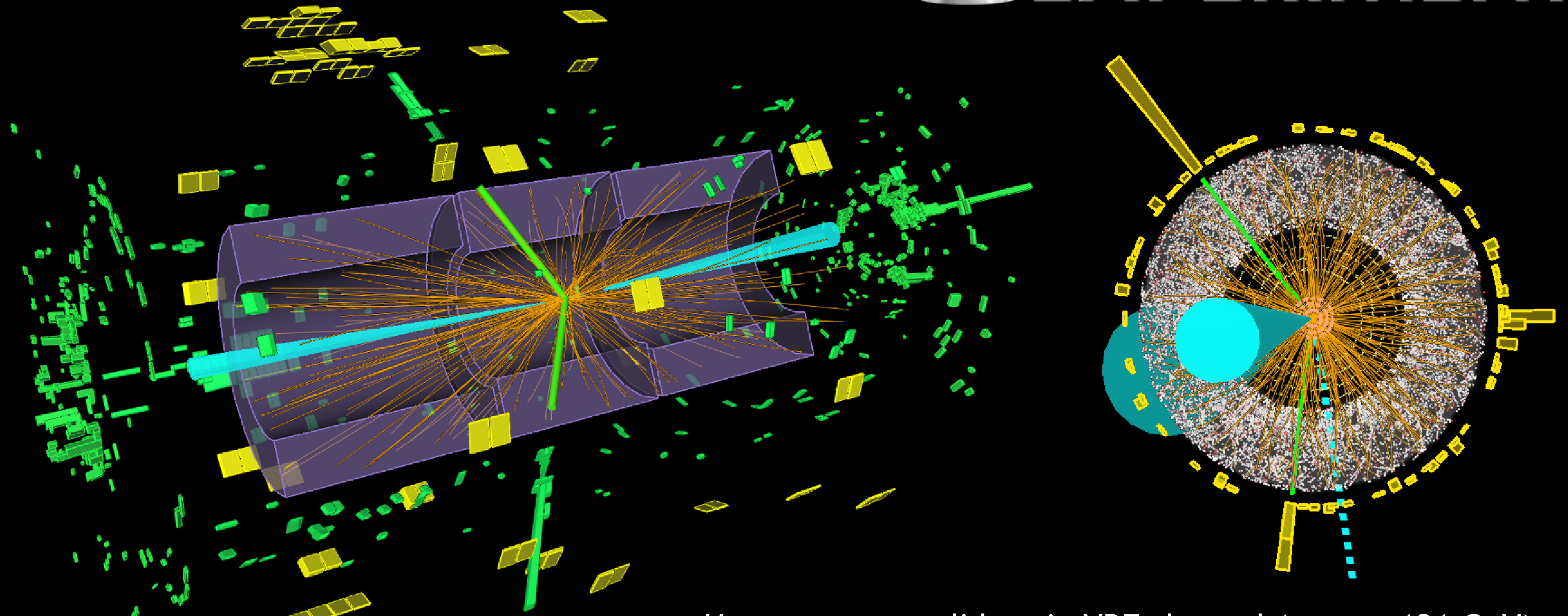
Observed Significance (125 GeV): 2.6σ

Expected Significance : 1.9σ

$H \rightarrow \tau\tau$

Reoptimised 7+8 TeV analysis

ATLAS-CONF-2012-160



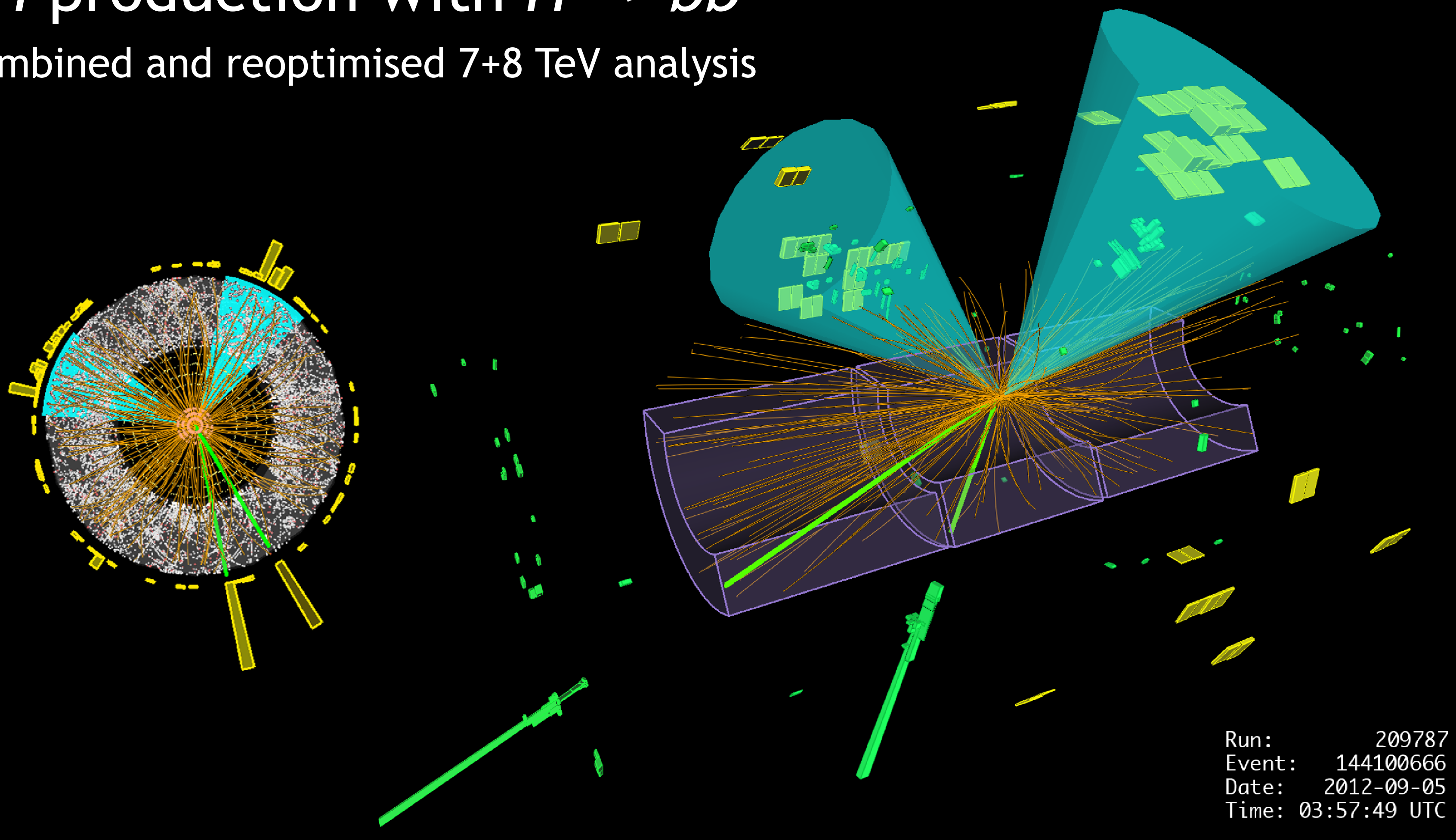
$H \rightarrow \tau_{had}\tau_{had}$ candidate in VBF channel (m_{MMC} = 131 GeV)

ττ channel basic facts sheet :

Signal (SM)	Signal purity s/b	Main backgrounds	Production	7 & 8 TeV $\int L\,dt$
~330	0.3% - 30%	ZZ, Z+jets, top	VBF, Hgg, VH	4.9 & 13 fb^{-1}

VH production with $H \rightarrow bb$

Combined and reoptimised 7+8 TeV analysis



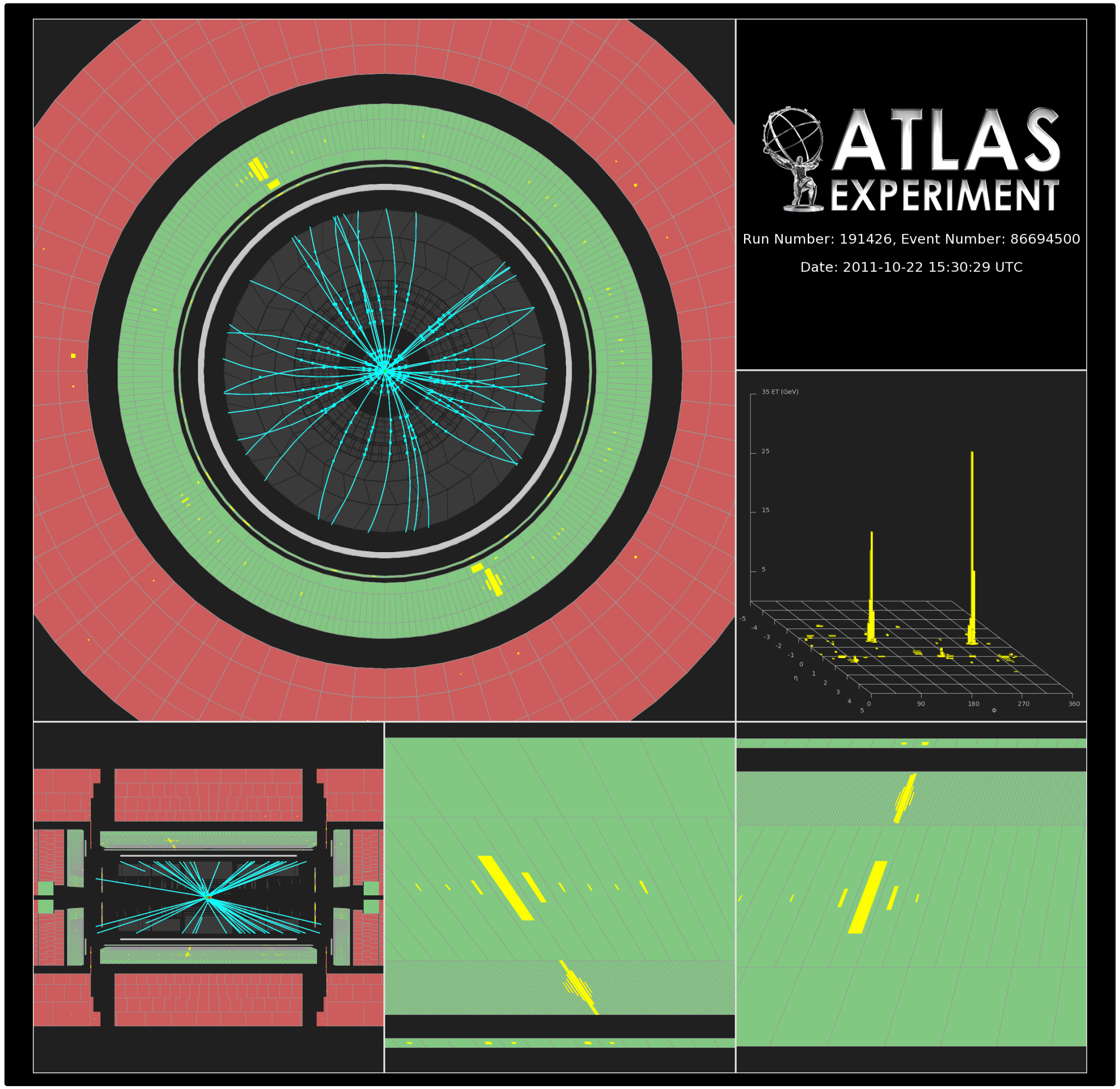
VH(bb) channel basic facts sheet :

Signal (SM)	Signal purity s/b	Main backgrounds	Production	7 & 8 TeV $\int L\,dt$
~50	~1% - 10%	Wbb,Zbb, top, etc…	VH	4.9 & 13 fb^{-1}

$H \to \gamma\gamma$ Update

Since "Discovery Paper" PLB 716

ATLAS-CONF-2012-168



γγ channel basic facts sheet :

Signal ($SM_{126\ GeV}$)	Signal purity s/b	Main backgrounds	Production	7 & 8 TeV $\int L\,dt$
~330	2% - 20%	γγ,γj and jj	Hgg, VBF, VH	4.9 & 13 fb^{-1}

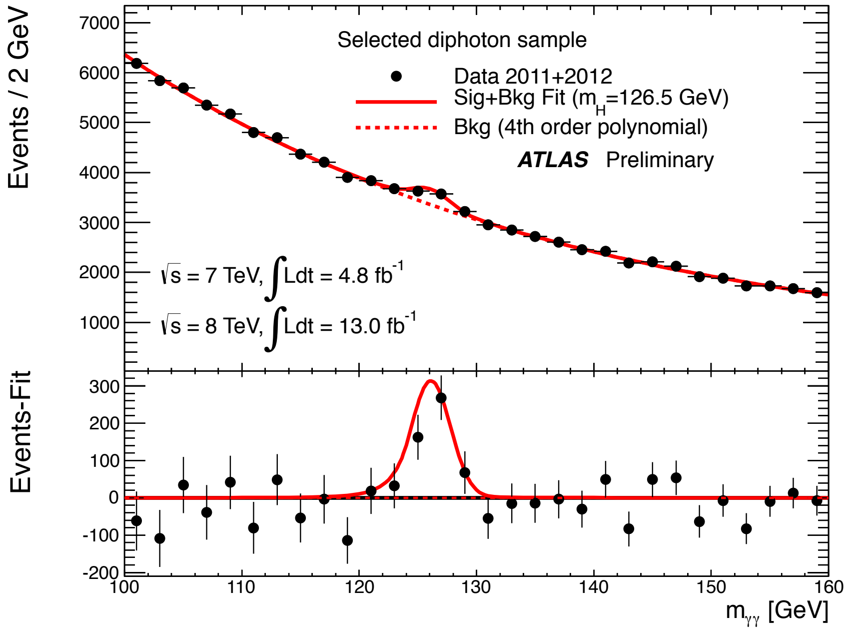
$H \to \gamma\gamma$ Update

Simple topology: two high-p_T isolated photons E_T (g_1, g_2) > 40, 30 GeV

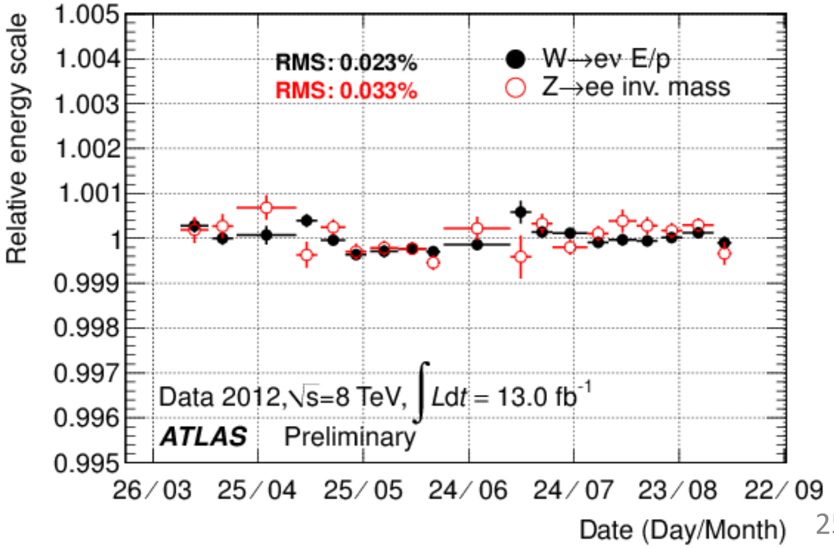
To increase sensitivity, overall and to specific production processes 12 exclusive categories:

- γ rapidity, converted/unconverted γ, p_{Tt}($p_T^{\gamma\gamma}$ perpendicular to $\gamma\gamma$ "thrust" axis)
- presence of 2 high-mass (m_{jj} 400 GeV) forward jets target VBF process
- 1 lepton $\to$ target W/Z/ttH
- Low-mass di-jet (60 <m_{jj}<100 GeV) jets $\to$ target W/ZH

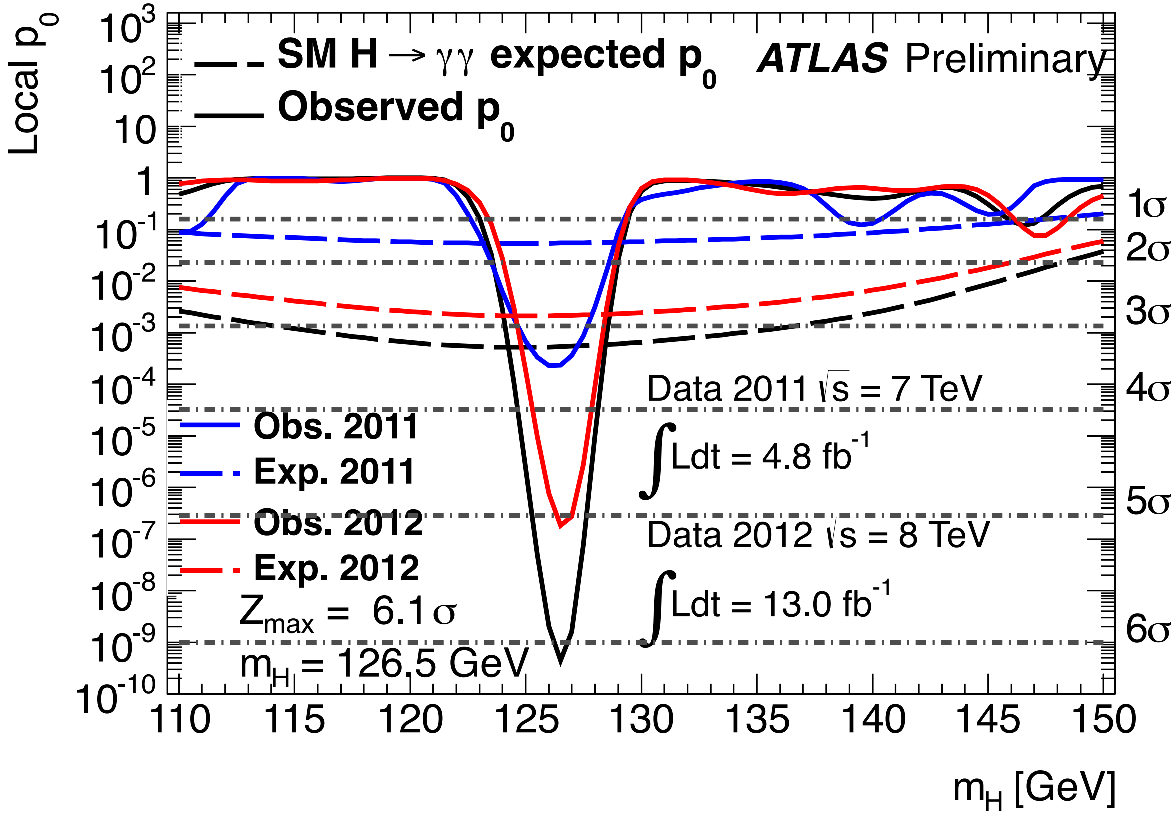
NEW since PLB716



Stability of EM calorimeter response vs time (and pile-up) <0.1%



$H \to \gamma\gamma$ Signal Confirmation and Single Channel Discovery!



Observed local significance:

6.1σ

Expected local significance:

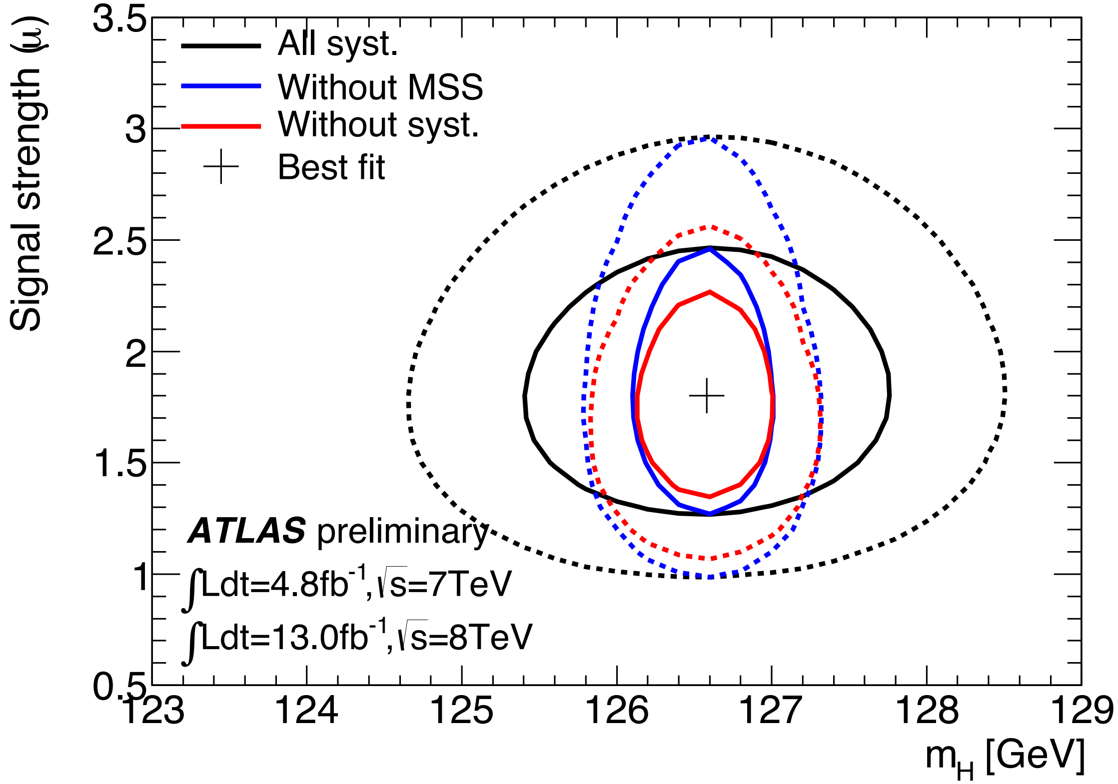
3.3σ

2011 126.0 GeV 3.5σ (exp. 1.6σ)
2012 127.0 GeV 5.1σ (exp. 2.9σ)

$H \to \gamma\gamma$ signal is confirmed

$H \rightarrow \gamma\gamma$ Mass Measurement

ATLAS-CONF-2012-168

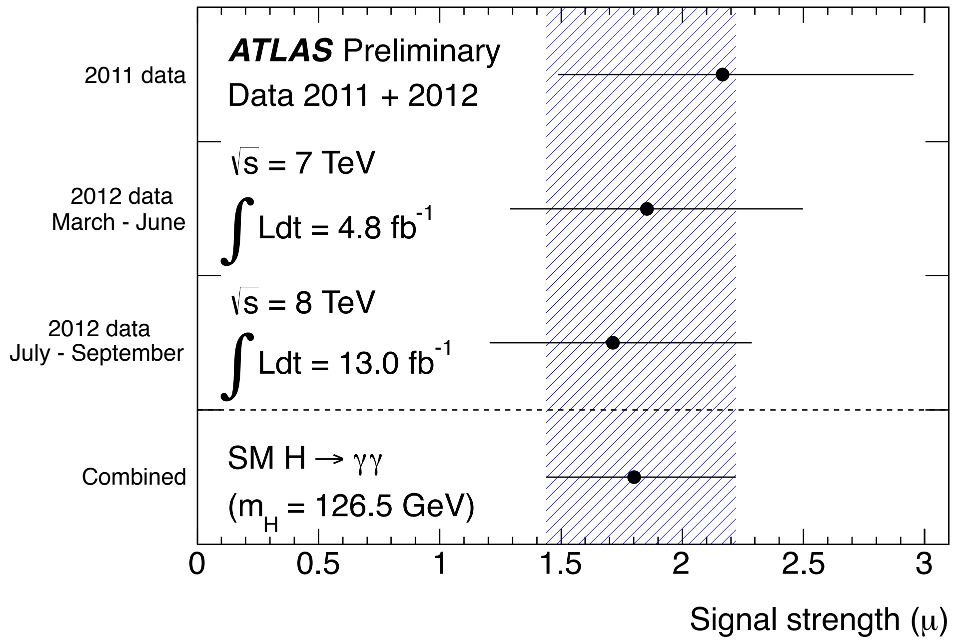


Measurement of narrow resonance mass :

$$m_H = 126.6 \pm 0.3\ (stat) \pm 0.7\ (syst)\ \text{GeV}$$

$H \rightarrow \gamma\gamma$ Signal Strength

ATLAS-CONF-2012-168



Measurement of signal strength :

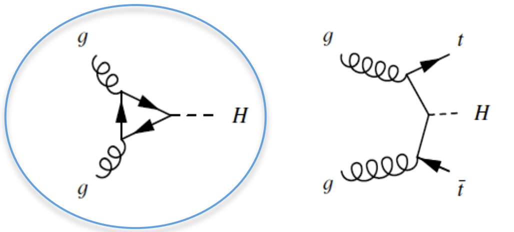
(at best fit mass 126.5 GeV)

$$\hat{\mu} = 1.8 \pm 0.3\ (stat)^{+0.29}_{-0.21}\ (syst)$$

Signal strength for different production modes :

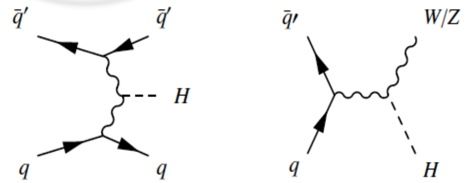
Fermion couplings dominated modes

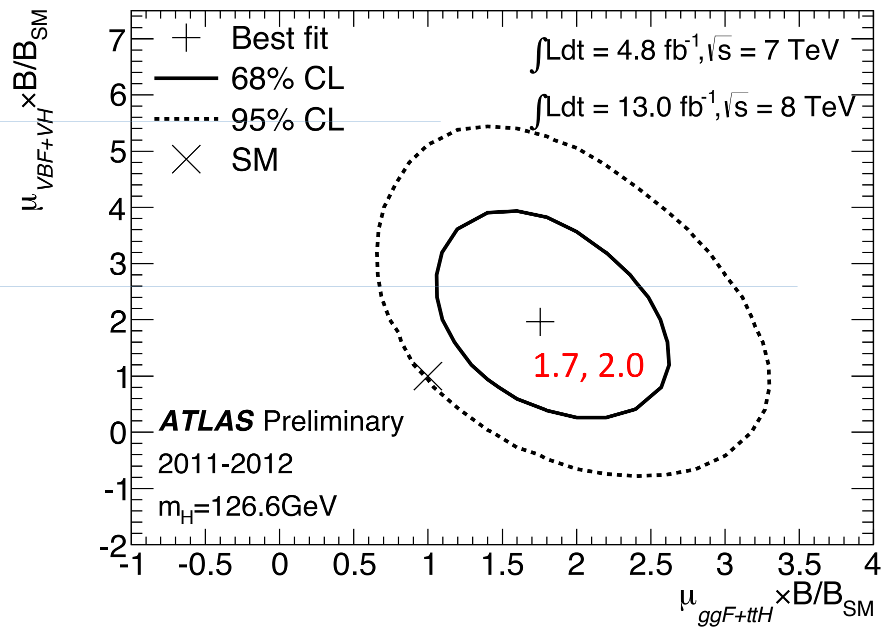
ggH+ttH

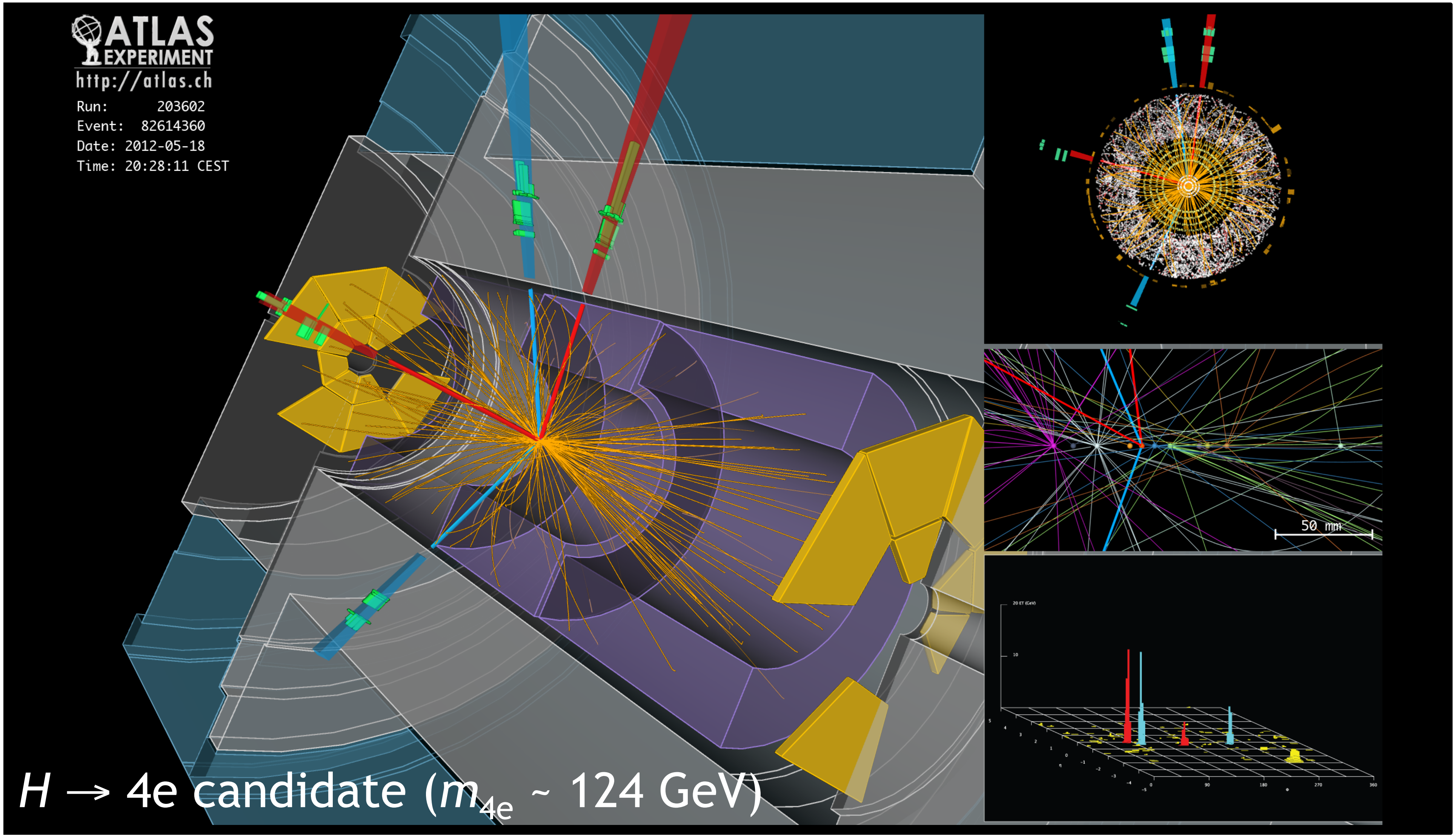


Vector boson dominated modes

VBF+VH







4l channel basic facts sheet :

Signal	Signal Purity s/b	Main backgrounds	Production	7 & 8 TeV $\int L\,dt$
~10	~1	ZZ, Z+jets, top	All inclusive	4.9 & 13 fb^{-1}

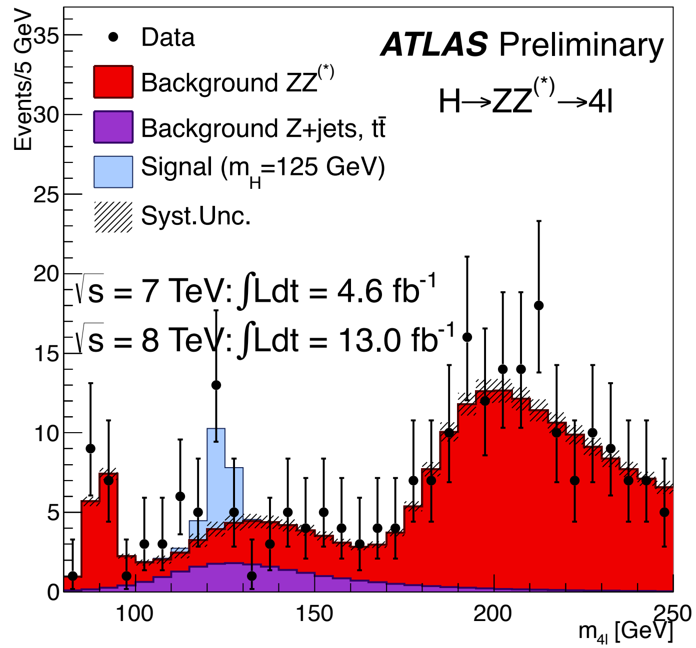
$H \rightarrow 4l$ Signal Confirmation

Simple selection :

- 4 leptons: $p_T^{1,2,3,4}$ > 20,15,10,7-6 (e-μ) GeV
- $50 < m_{12} < 106$ GeV
- $m_{34} > 17.5$ GeV

In the signal region 125 ± 5 GeV

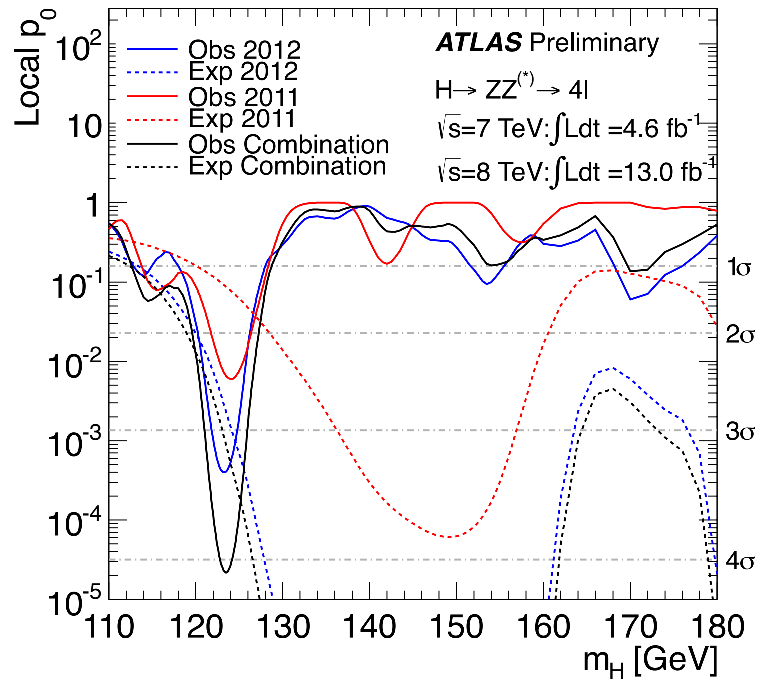
Observed	18 events
Expected from bkg only	8.3 ± 0.3
Expected from SM Higgs	9.9 ± 1.3



Observed local significance: 4.1σ

Expected local significance: 3.1σ

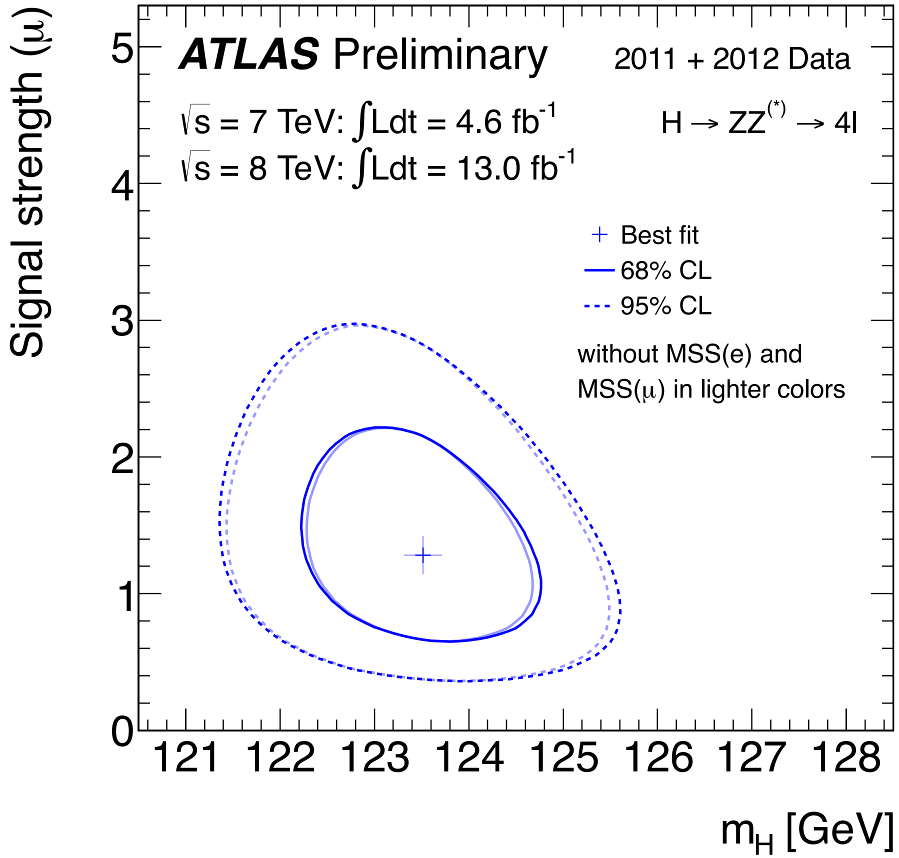
2011	124.1 GeV	2.5σ	(exp. 1.4σ)
2012	123.3 GeV	3.4σ	(exp. 2.8σ)



$H \rightarrow 4l$ signal is confirmed

ATLAS-CONF-2012-169

$H \rightarrow 4l$ Mass and Signal Strength Measurements



Measurement of signal strength

$$\hat{\mu} = 1.3 \pm 0.4$$

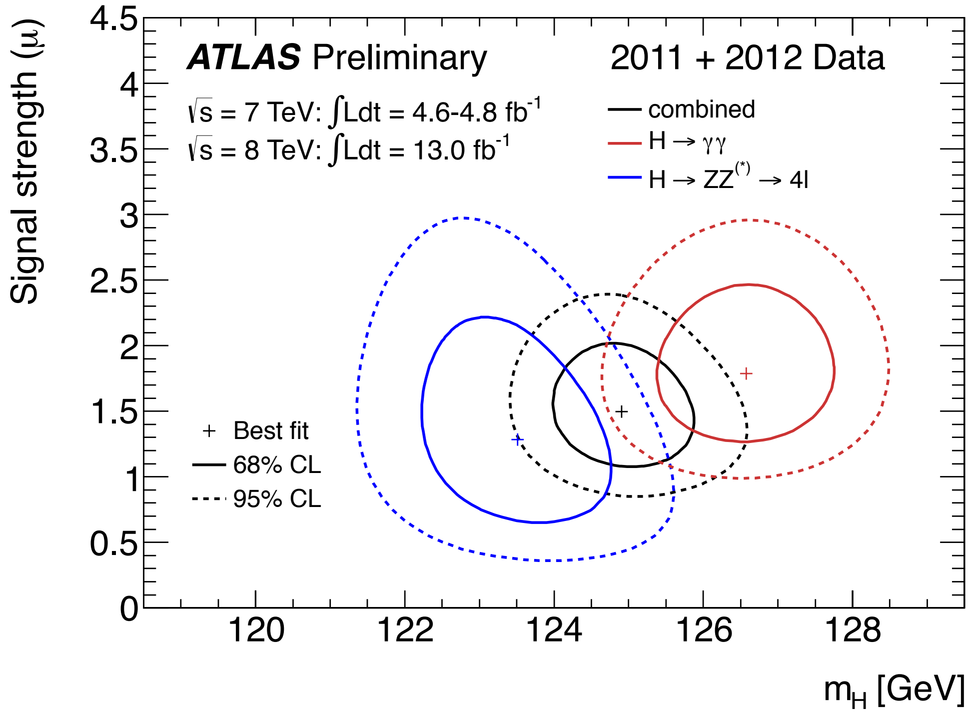
Measurement of narrow resonance mass

$$m_H = 123.5 \pm 0.9\ (stat)\ ^{+0.4}_{-0.2}\ (syst)\ \mathrm{GeV}$$

$H \rightarrow \gamma\gamma$ and $H \rightarrow 4l$ Combination

ATLAS-CONF-2012-170

Best fit signal strength $\hat{\mu} = 1.5^{+0.33}_{-0.29}$



Combined Mass Measurement :

$$m_H = 125.2 \pm 0.3\ (stat)\ \pm\ 0.6\ (syst)\ \mathrm{GeV}$$

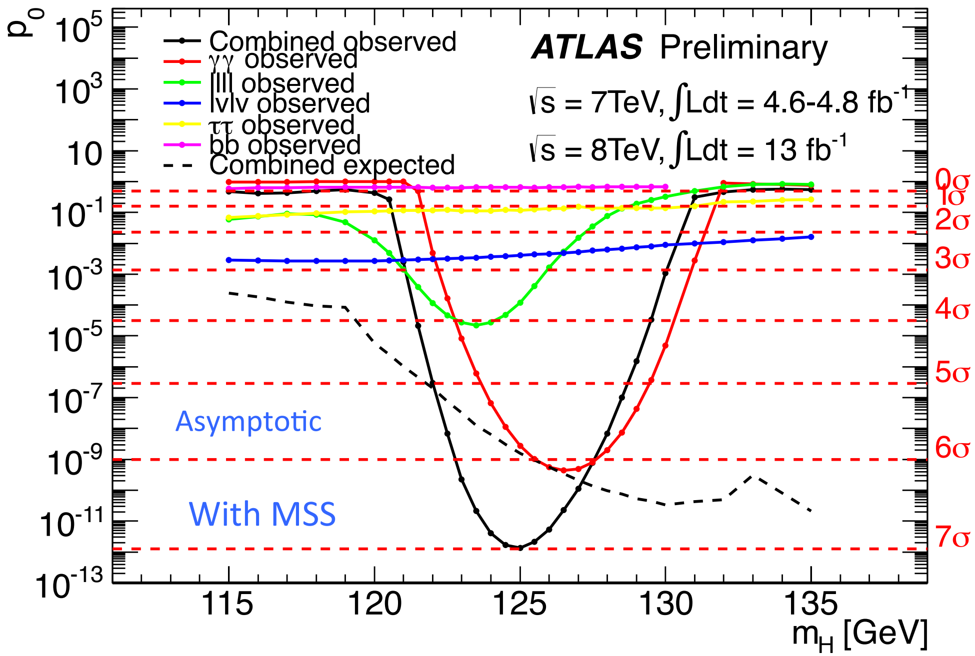
Taking mass scale systematic uncertainties and their correlations into account the compatibility of the two measurements is estimated to be at the 2.7σ level

An alternative treatment of systematic uncertainties yields a compatibility at the level of 2.3σ

Combination of All Channels

ATLAS-CONF-2012-170

Updated with 13 fb^{-1} of 2012 8 TeV data

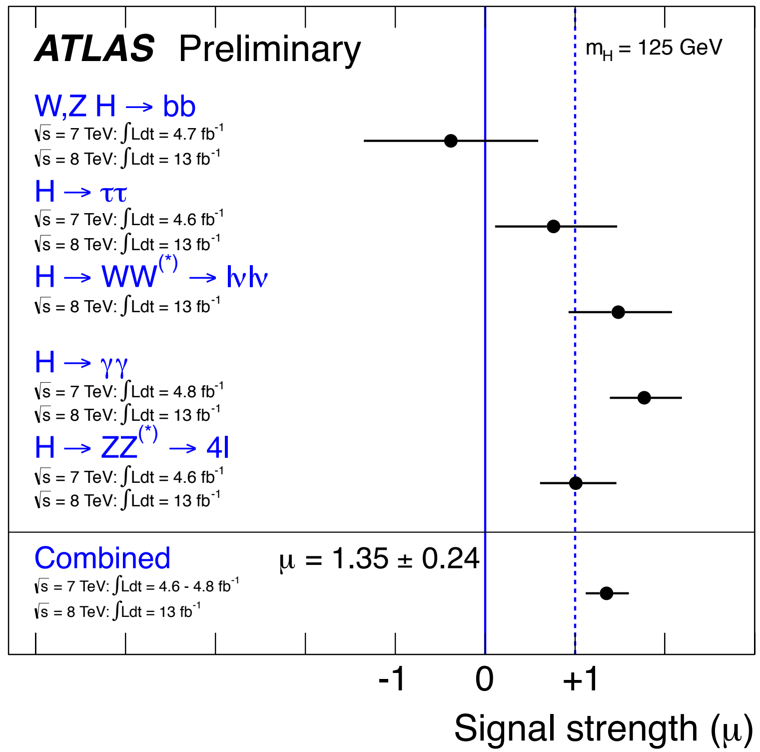


Observed local significance (w/ MSS): 7.0σ

Without MSS: 6.6σ

Expected local significance: 5.9σ

Summary of the signal strength in all SM Higgs search channels



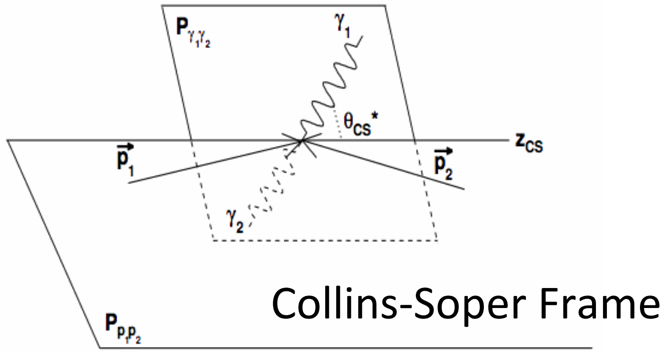
$$\hat{\mu} = 1.35 \pm 0.19\ (stat) \pm 0.15\ (syst)$$

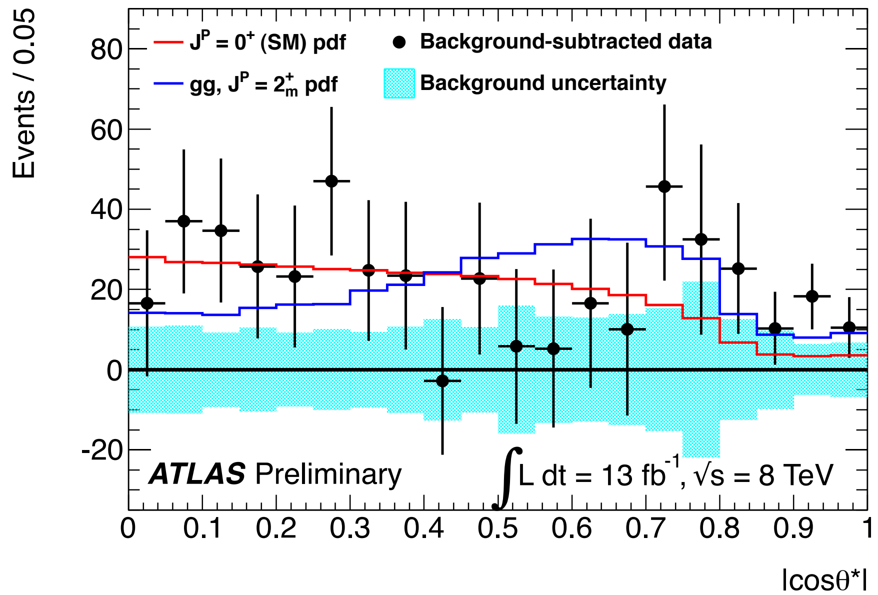
Overall agreement with the SM Higgs boson hypothesis

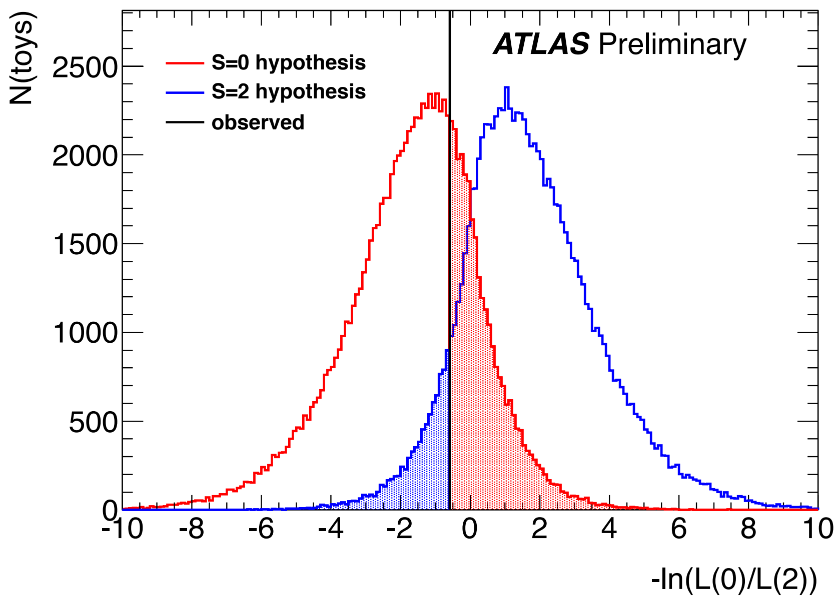
First Analysis of Spin in the $H \rightarrow \gamma\gamma$ Channel

Using the inclusive analysis

- Sensitive variable is dihoton cos θ* distribution
- Use events within 1.5σ of the peak (m_H=126.5 GeV)







- Expected sensitivity: exclusion of the spin 2^+ hypothesis at the 97% CL
- Observed exclusion of spin 2^+ hypothesis at the 91% CL

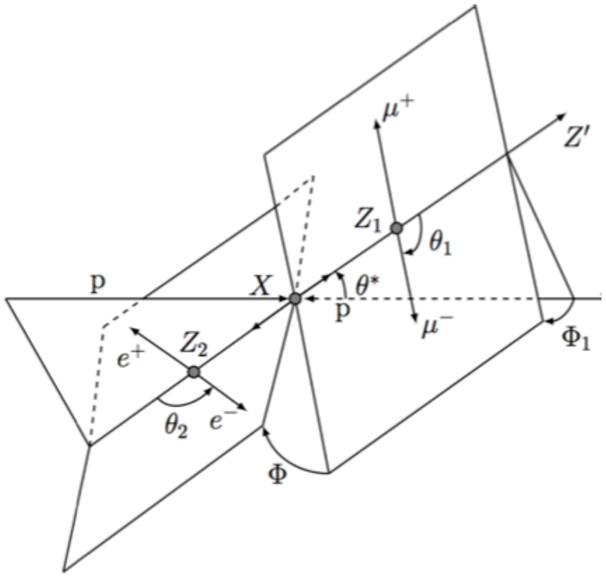
  Observation compatible with spin 0 (within 0.5σ)

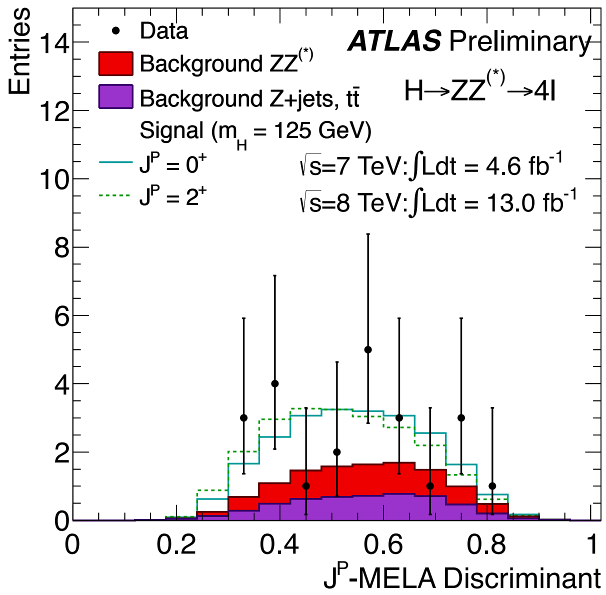
ATLAS-CONF-2012-168

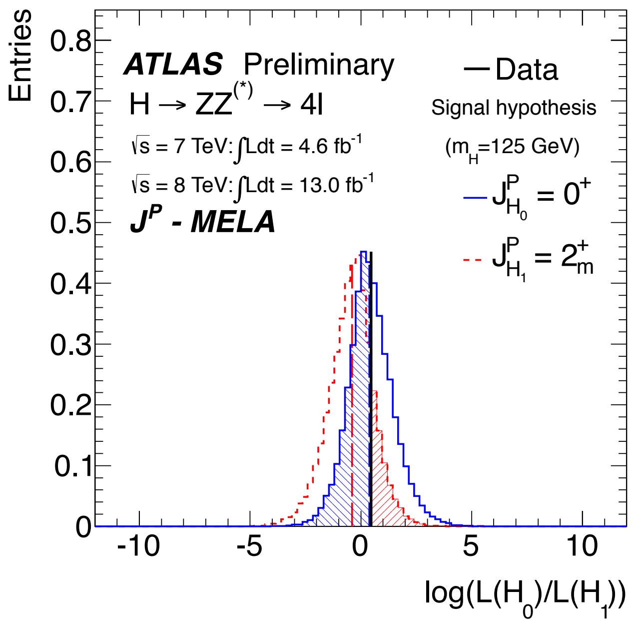
Analysis of Spin in the $H \rightarrow 4l$ Channel

ATLAS-CONF-2012-169

Using the distributions of 5 production and decay angles combined in BDT or Matrix Element (MELA) discriminants







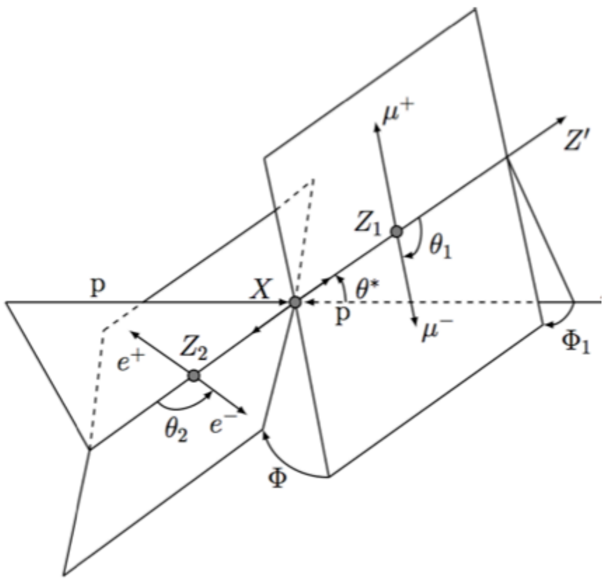
- 0^+ vs 2^+ : (Low) Expected Exclusion of 2^+ at the 80% CL
- Observed exclusion of spin 2^+ at the 85% CL

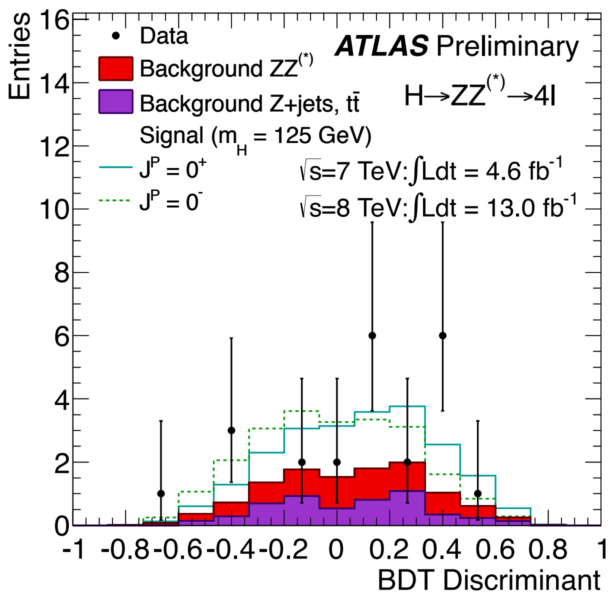
Observation fully compatible with spin 0 (within 0.18 σ)

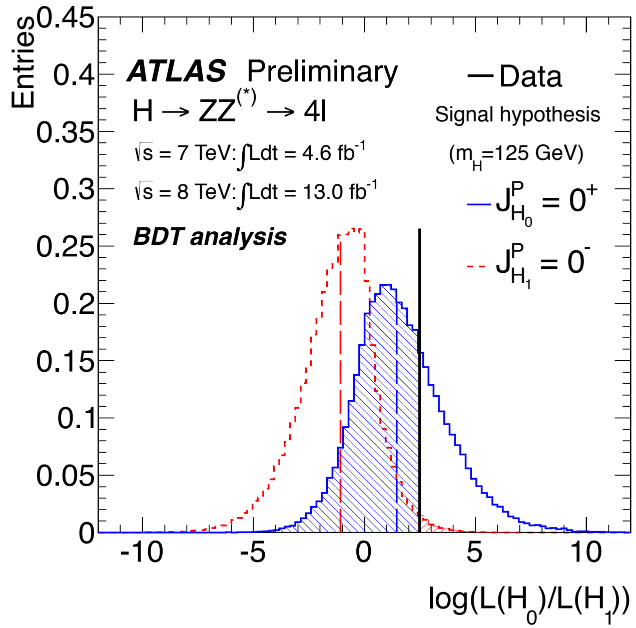
Analysis of Parity in the $H \rightarrow 4l$ Channel

ATLAS-CONF-2012-169

Using the distributions of 5 production and decay angles combined in BDT or Matrix Element (MELA) discriminants







- 0^+ vs 0^- : Expected Exclusion of 0^- at the 96% CL
- Observed exclusion of 0^- at the 99% CL

Observation fully compatible with spin 0 (within 0.5 σ)

Summary and Conclusions

- The first LHC run has ended; ATLAS has recorded altogether ~27 fb^{-1} of *pp* data.

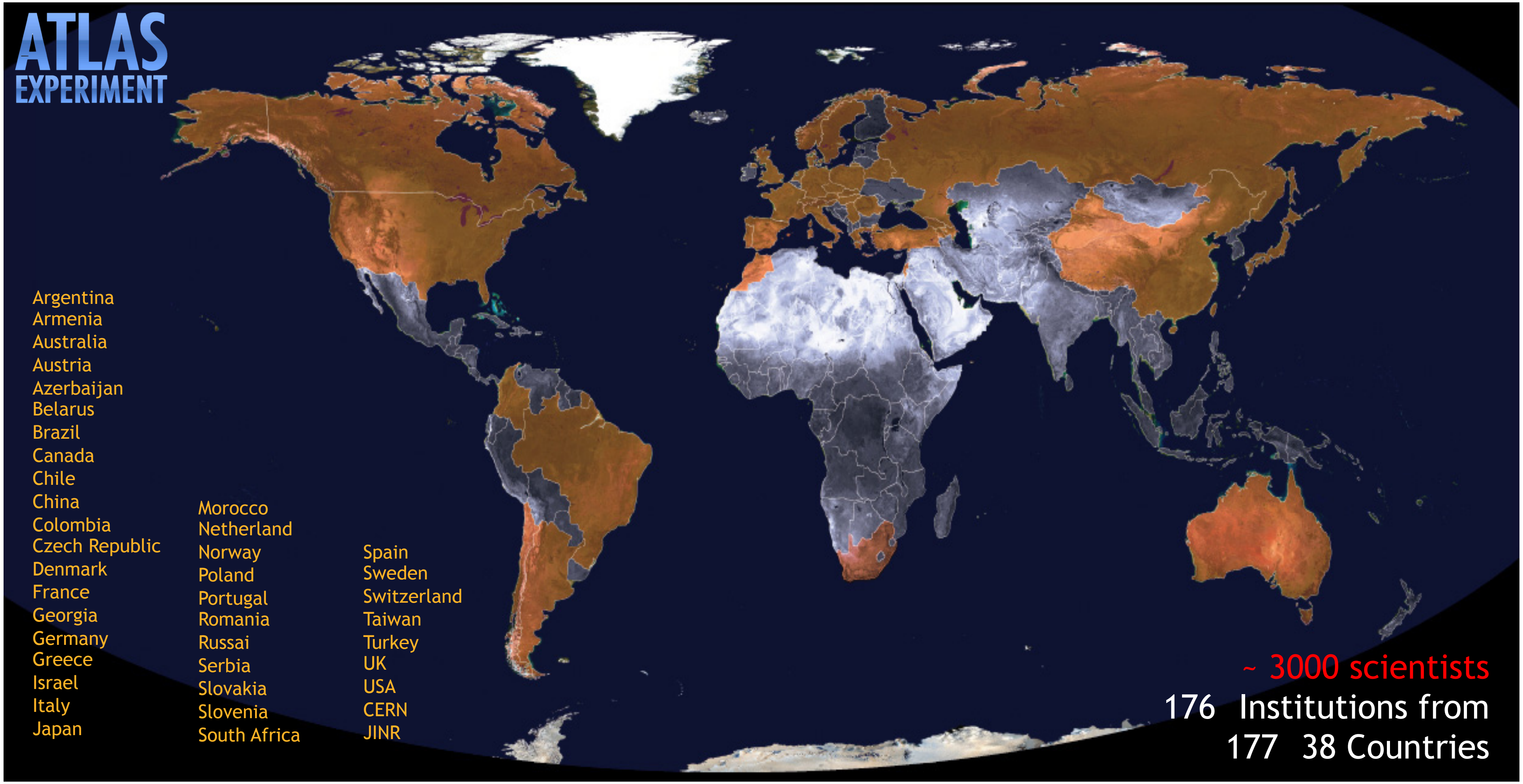
- Three very successful years at the energy frontier :

  - Effective operation of the experiment in all its components (from detector to physics)
  - A wealth of nice measurements of Standard Model processes at 7 TeV and 8 TeV
  - Studies of Heavy Ion collisions with many results on quenched/unquenched hard probes
  - Searches for new physics in a vast number of topologies and theoretical scenarios, but only a fraction of data has been investigated in several cases… surprises might be hiding in the present data and data to come at higher energy in 2015

- The discovery of a very special particle

  - This discovery is fully confirmed today in all its most sensitive channels
  - First measurements of its coupling properties and its mass
  - First indications that a spin 2 scenario is disfavored by angular analyses in the $H \rightarrow \gamma\gamma$ and $H \rightarrow 4l$ channels

Best Wishes for 2013



from The ATLAS Collaboration

Backup Slides

$H \rightarrow \gamma\gamma$ and $H \rightarrow 4l$ Mass Scale Systematic Uncertainties

Main Mass Scale systematic uncertainties (considered in also ICHEP studies) :

Source	Relative Mass Scale Effect
Absolute Energy scale calibration from Z	0.3%
Upstream material simulation inaccuracies	0.3%
Pre-Sampler energy scale	0.1%

Further investigation and extensive checks lead to find additional sources of systematic uncertainties :

- LAr Strips relative calibration (0.2%)
- Photon energy resolution (0.15%)
- Calibration of the high gain (0.15%)
- Mis-classification due to fake conversions (0.13%)
- Backgound modeling (0.1%)
- Lateral shower development simulation (0.1%)
- Effect of PV choice (0.03%)

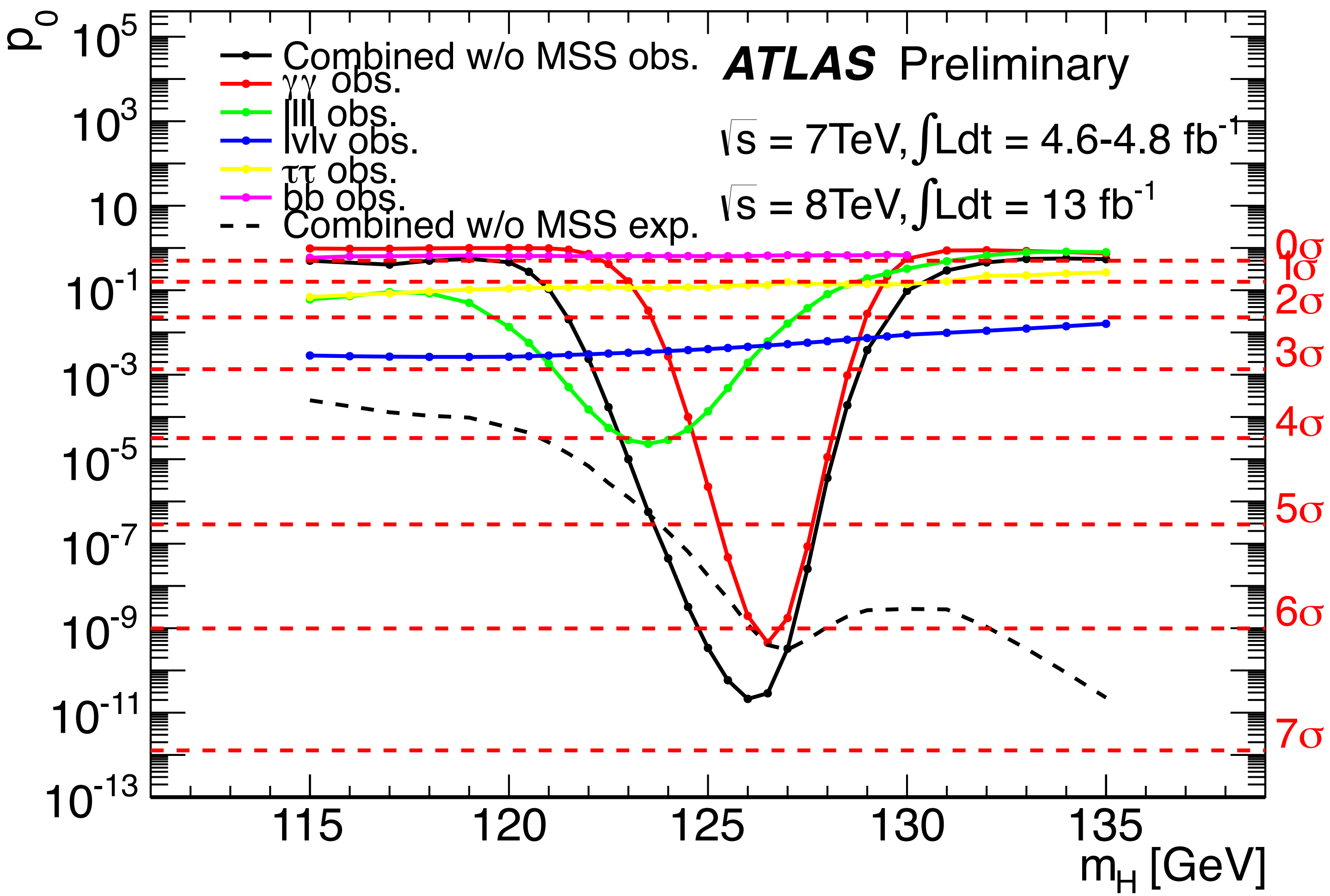
$\rightarrow$

Main 4l Mass Scale systematic uncertainties :

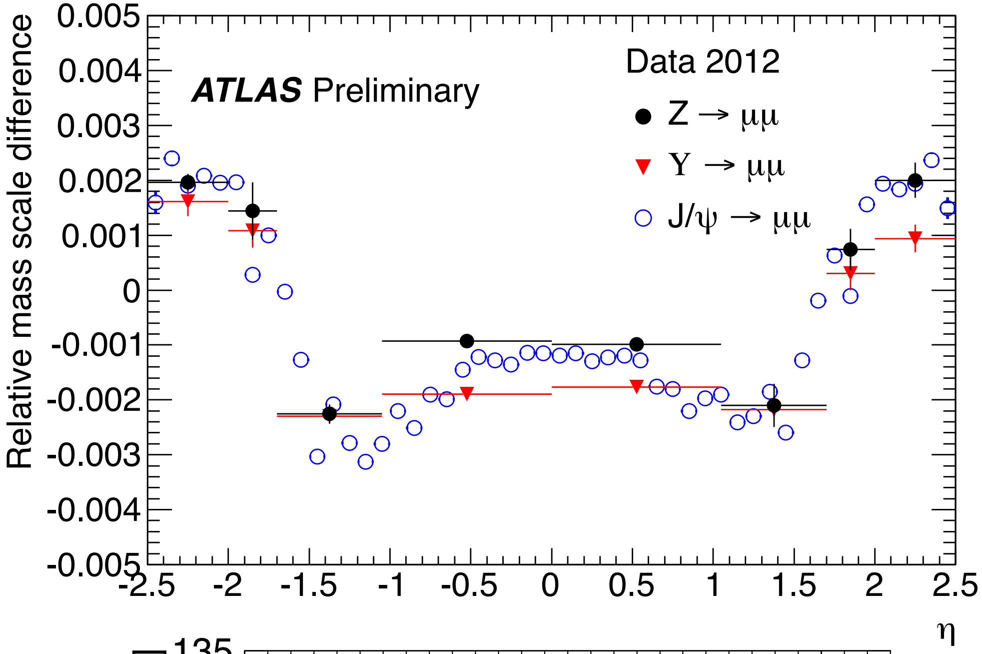
Source	Relative Mass Scale Effect
Absolute Energy scale calibration from Z	0.4%
Low transverse energy electrons	0.2%
Muon momentum scale	0.2%

Further investigation and extensive checks have not lead to additional substantial sources of systematic uncertainty :

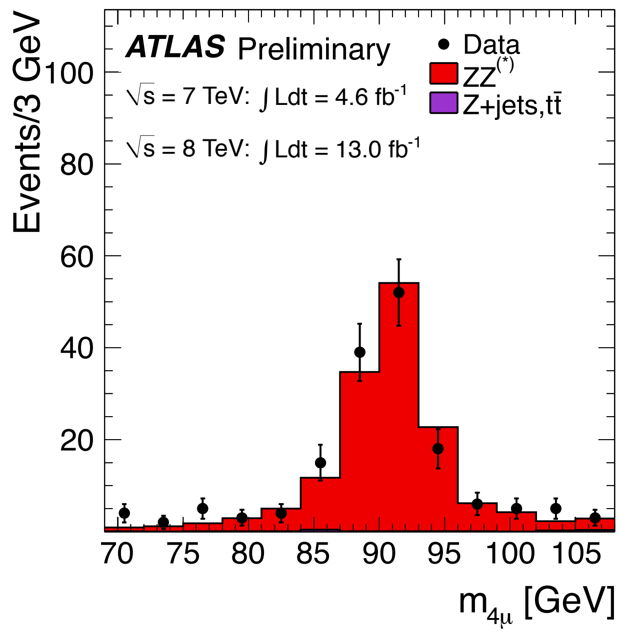
- Measurement with MS and ID alone
- Local detector biases checked event by event
- Local resolution effects checked using event-by-event error;
- kinematic distributions in agreement with expectation
- FSR simulation
- Different mass reconstruction using Z-mass constraint (+400 MeV shift)



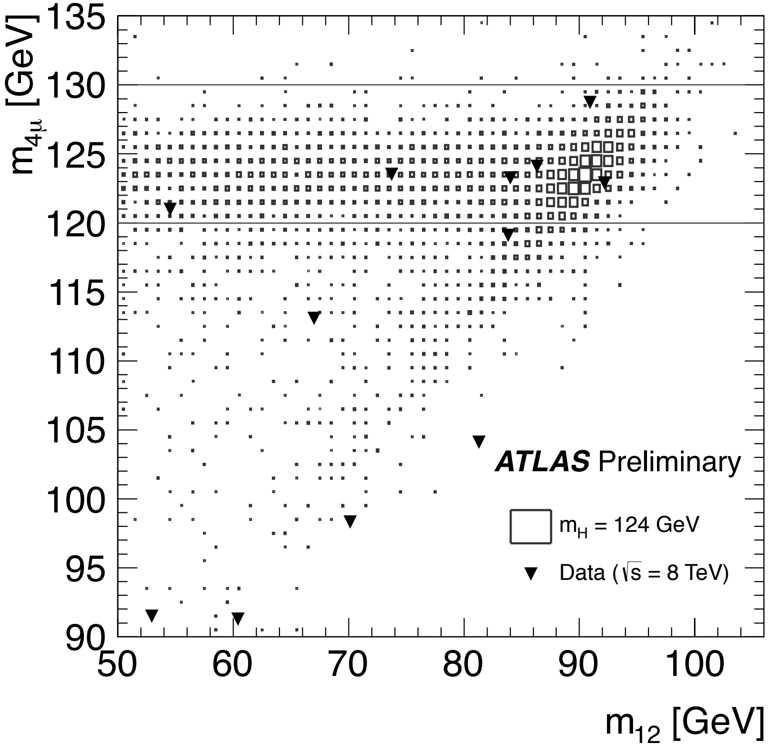
p_0
Combined w/o MSS obs.
γγ obs.
llll obs.
lνlν obs.
ττ obs.
bb obs.
Combined w/o MSS exp.
ATLAS Preliminary
√s = 7TeV, ∫Ldt = 4.6-4.8 fb^-1
√s = 8TeV, ∫Ldt = 13 fb^-1
0σ
1σ
2σ
3σ
4σ
5σ
6σ
7σ
10^5
10^3
10
10^-1
10^-3
10^-5
10^-7
10^-9
10^-11
10^-13
115
120
125
130
135
m_H [GeV]



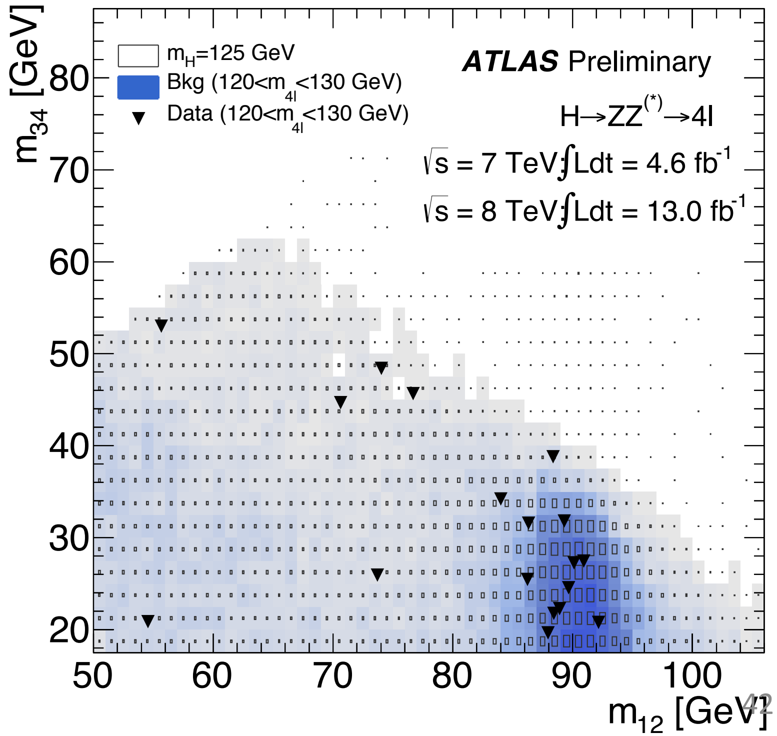
ATLAS Preliminary
Data 2012
Z → μμ
Υ → μμ
J/ψ → μμ
Relative mass scale difference
η



ATLAS Preliminary
√s = 7 TeV: ∫Ldt = 4.6 fb-1
√s = 8 TeV: ∫Ldt = 13.0 fb-1
Data
ZZ(*)
Z+jets,tt̄
Events/3 GeV
m4μ [GeV]

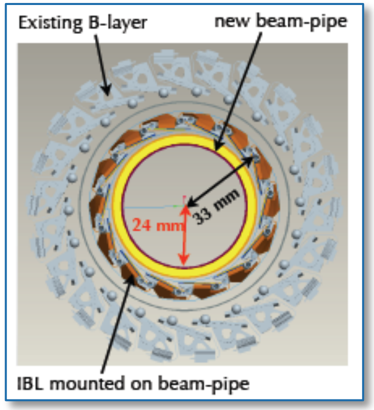


ATLAS Preliminary
mH = 124 GeV
Data (√s = 8 TeV)
m4μ [GeV]
m12 [GeV]



mH=125 GeV
Bkg (120<m4l<130 GeV)
Data (120<m4l<130 GeV)
ATLAS Preliminary
H→ZZ(*)→4l
√s = 7 TeV∫Ldt = 4.6 fb-1
√s = 8 TeV∫Ldt = 13.0 fb-1
m34 [GeV]
m12 [GeV]

LS1 and more



LS1 consolidation and upgrade work

- New Insertable Pixel *B*-layer (IBL)
  [installation either on surface (preferred) or in situ / decision end of Jan 2013]
- New Pixel service quarter panels (nSQP) [***if IBL installed on surface***]
- New ID evaporative cooling plant
- New Al forward beam pipe
- New calorimeter LVPS
- Consolidation of other detectors and infrastructure
- Complete muon spectrometer (EE, RPC, feet)
- Add specific muon shielding
- Upgrade magnet cryogenics
- Detector readout for Level-1 100 kHz rate

Towards the Phase-1 upgrade

- LoI submitted Marc 2012 / received strong support from LHCC
- Work for TDRs in full swift: four (new μ SW, FTK, LAr+Tiles, TDAQ) expected to be completed in 2013, AFP in 2014

LHC timeline

2009 Start of LHC

Run 1, 7+8 TeV, ~25 fb^{-1} int. lumi

2013/14 LS1: prepare LHC for design *E* & lumi

Collect ~30 fb^{-1} per year at 13/14 TeV

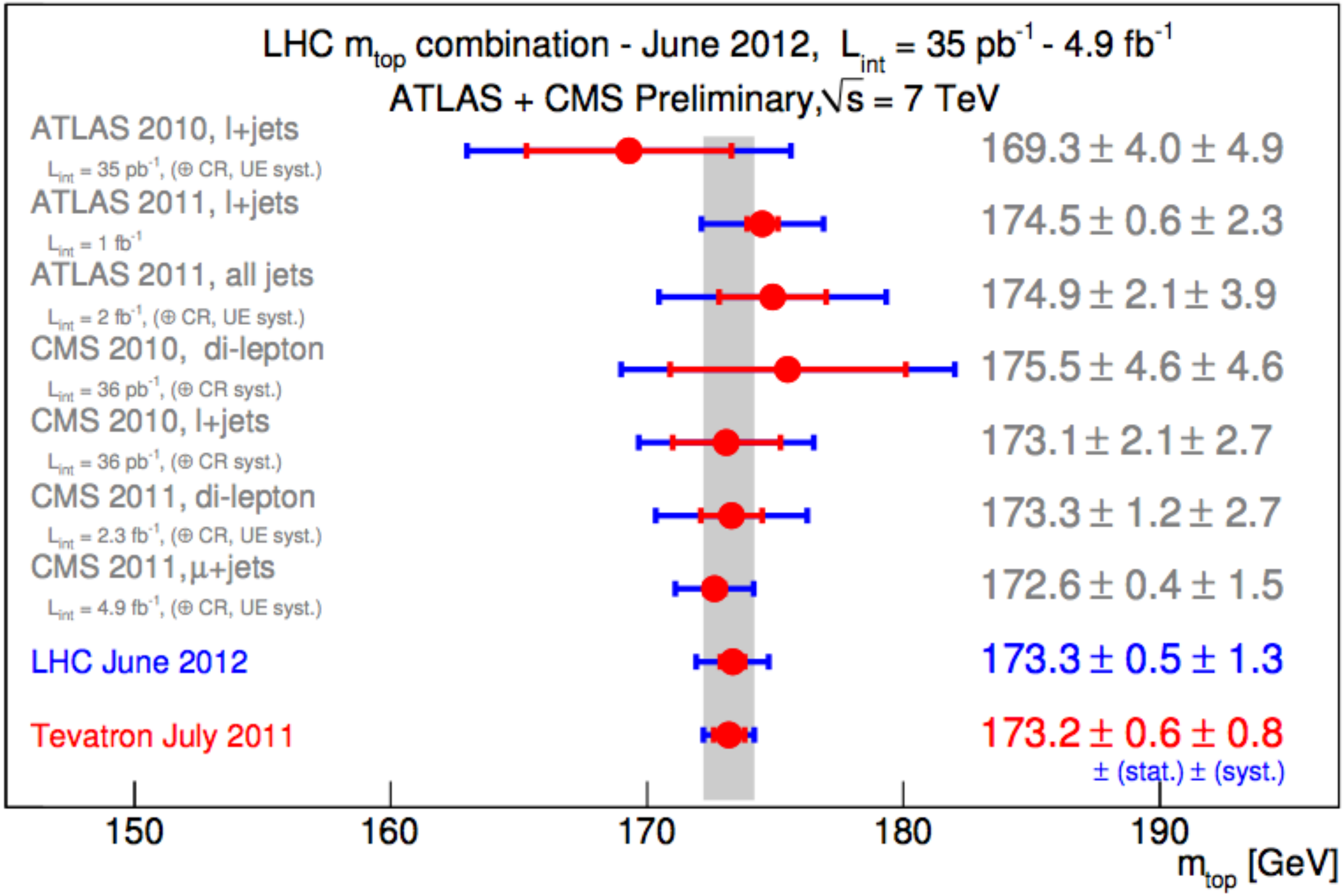
2018 Phase-1 upgrade for ultimate lumi

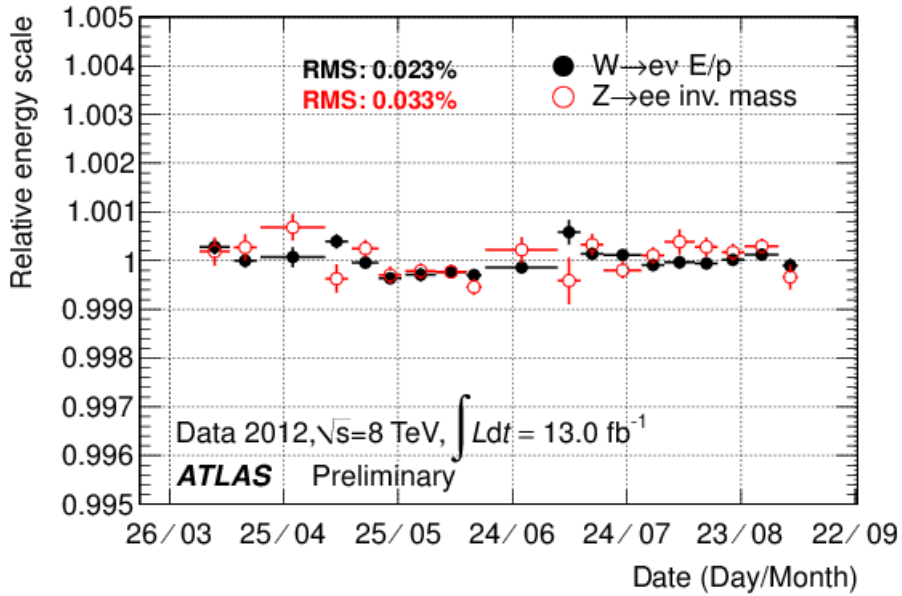
Twice nominal lumi at 14 TeV, ~100 fb^{-1} per year

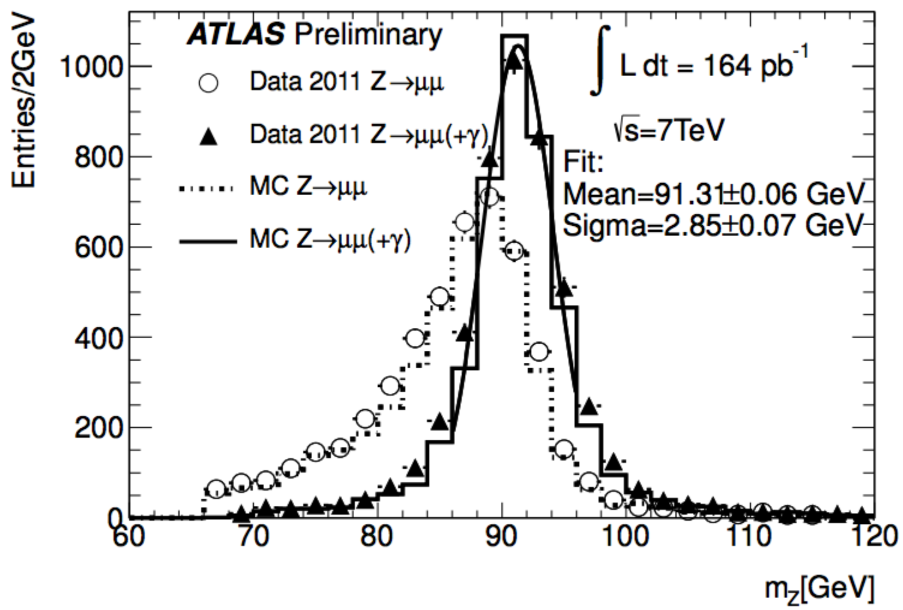
~2022 Phase-2 upgrade to HL-LHC

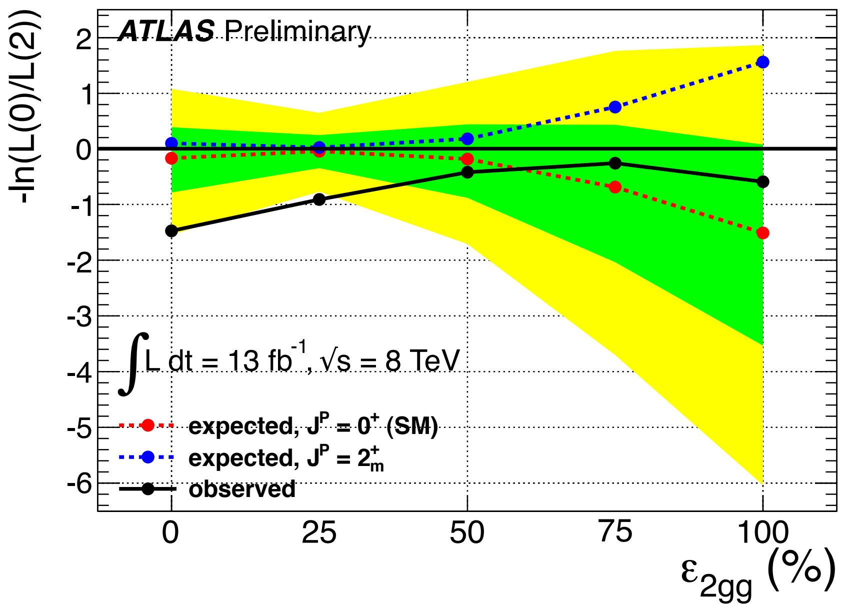
~300 fb^{-1} per year, run up to > 3 ab^{-1} collected

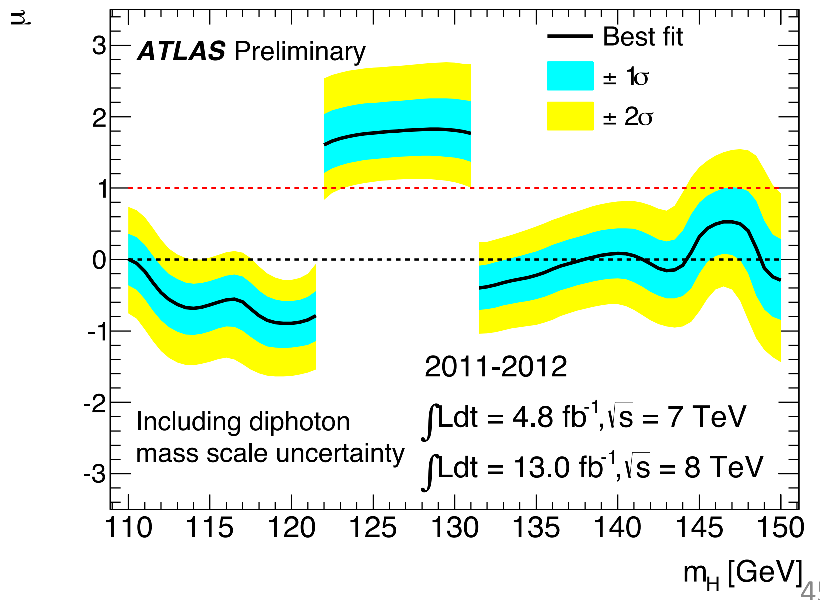
~2030


LHC m_top combination - June 2012, L_int = 35 pb^-1 - 4.9 fb^-1
ATLAS + CMS Preliminary, √s = 7 TeV
ATLAS 2010, l+jets
L_int = 35 pb^-1, (⊕ CR, UE syst.)
169.3 ± 4.0 ± 4.9
ATLAS 2011, l+jets
L_int = 1 fb^-1
174.5 ± 0.6 ± 2.3
ATLAS 2011, all jets
L_int = 2 fb^-1, (⊕ CR, UE syst.)
174.9 ± 2.1 ± 3.9
CMS 2010, di-lepton
L_int = 36 pb^-1, (⊕ CR syst.)
175.5 ± 4.6 ± 4.6
CMS 2010, l+jets
L_int = 36 pb^-1, (⊕ CR syst.)
173.1 ± 2.1 ± 2.7
CMS 2011, di-lepton
L_int = 2.3 fb^-1, (⊕ CR, UE syst.)
173.3 ± 1.2 ± 2.7
CMS 2011, μ+jets
L_int = 4.9 fb^-1, (⊕ CR, UE syst.)
172.6 ± 0.4 ± 1.5
LHC June 2012
173.3 ± 0.5 ± 1.3
Tevatron July 2011
173.2 ± 0.6 ± 0.8
± (stat.) ± (syst.)
150
160
170
180
190
m_top [GeV]


Relative energy scale
RMS: 0.023%
RMS: 0.033%
W→eν E/p
Z→ee inv. mass
Data 2012,√s=8 TeV, ∫Ldt = 13.0 fb-1
ATLAS Preliminary
Date (Day/Month)


Entries/2GeV
ATLAS Preliminary
∫ L dt = 164 pb-1
√s=7TeV
Data 2011 Z→μμ
Data 2011 Z→μμ(+γ)
MC Z→μμ
MC Z→μμ(+γ)
Fit:
Mean=91.31±0.06 GeV
Sigma=2.85±0.07 GeV
mZ[GeV]

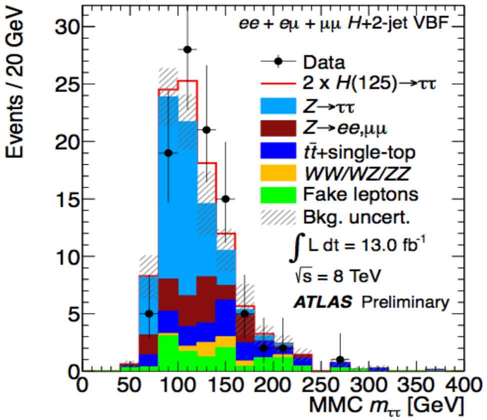

-ln(L(0)/L(2))
ATLAS Preliminary
∫L dt = 13 fb-1, √s = 8 TeV
expected, JP = 0+ (SM)
expected, JP = 2+m
observed
ε2gg (%)

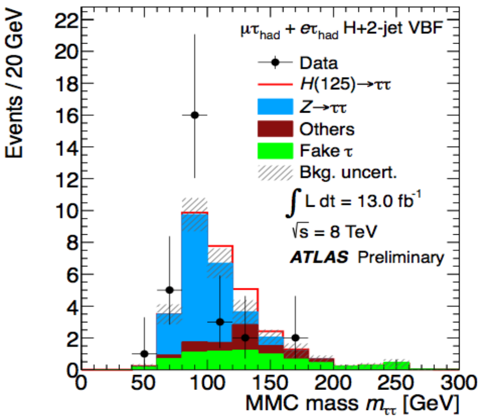

μ
ATLAS Preliminary
Best fit
± 1σ
± 2σ
2011-2012
Including diphoton
mass scale uncertainty
∫Ldt = 4.8 fb-1,√s = 7 TeV
∫Ldt = 13.0 fb-1,√s = 8 TeV
mH [GeV]

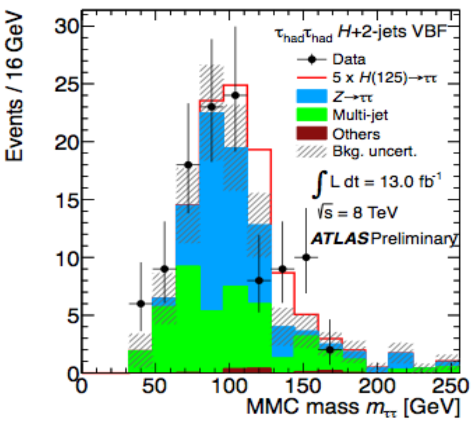
$H \rightarrow \tau\tau$

Reoptimised 7+8 TeV analysis

- Search in exclusive categories: lep-lep, lep-had, had-had and jets: 0, 1 (boosted or not), 2 (VBF, VH)



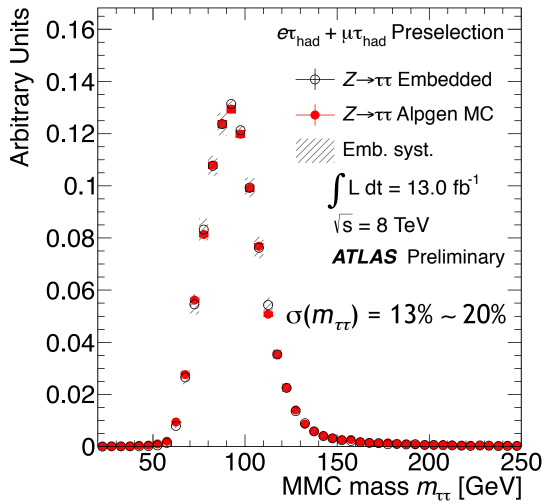




- Background modeling is critical especially in specific environments such as VBF production : Use embedding

- Use of MMC mass

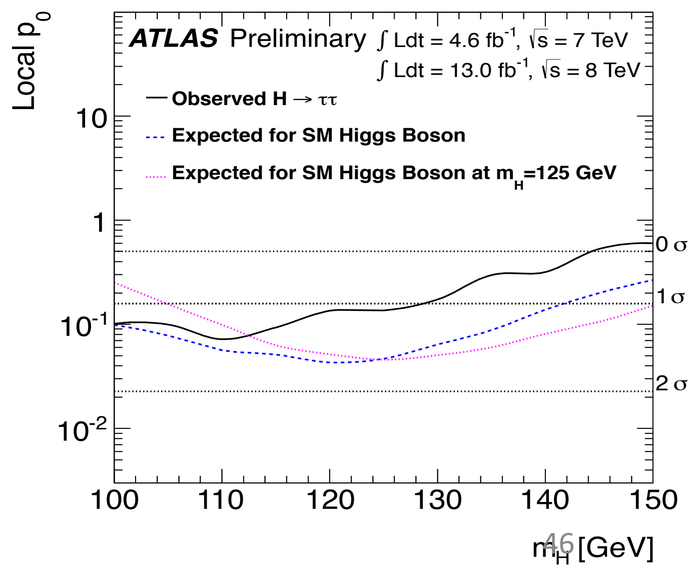
- Most powerful channel VBF



$\mu(125) = 0.7 \pm 0.7$

95% CL limit (125): 1.9 [exp: 1.2] × SM

Significance (125): 1.1σ [exp: 1.7σ]



$H \to \gamma\gamma$ Normalization Systematic Uncertainties

Main systematics on Yield and Migration

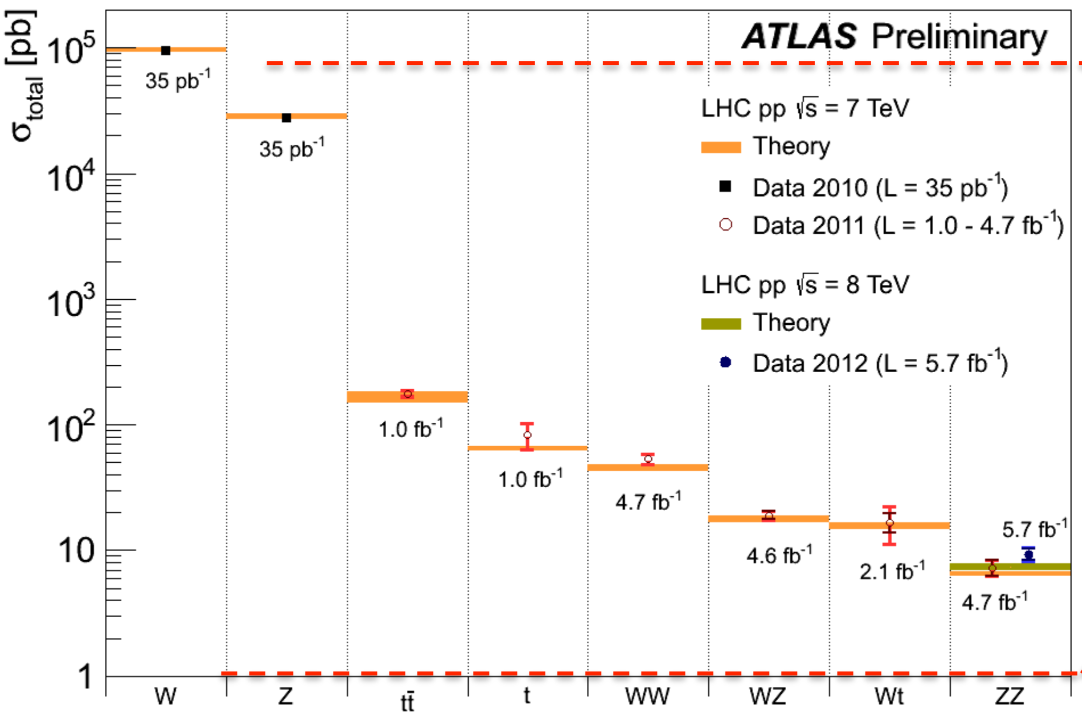
Theory (PDF, scales, a_s)	~12% (overall)
g Efficiency	5.3%
Background Model	~3%
Luminosity	3.9% and 3.6%
Trigger	0.5%
Isolation	1%
Energy Scale	0.5%
JES	4% - 19% (HM 2-jets)
pTt Modeling	0.8%
Material mis-modeling	~4%
UEPS	7% - 30% (LM HM 2-jets)
Leptons	~2%

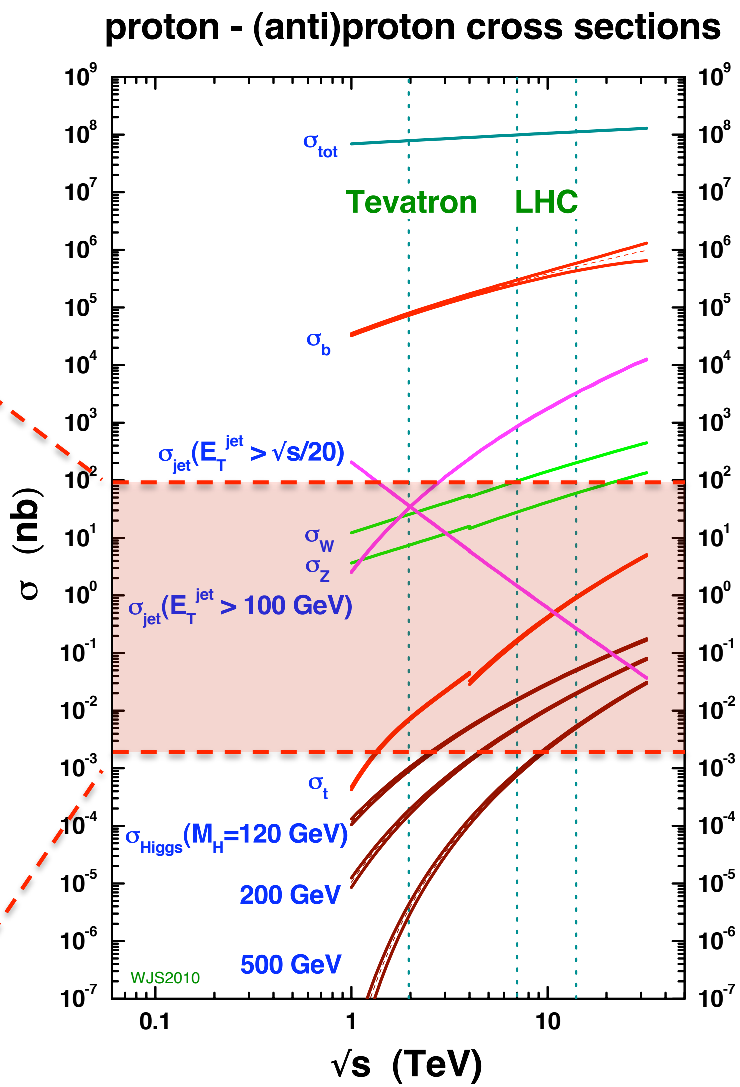
Overview of Cross Section

Staged throughout running (and PU) periods

Theory and simulation "Next-to…" revolution :

- NNLO PDFs sets
- Calculations at unprecedented order in P-theory
- Parton Shower (and Matrix Element matching) improvements





No PU

Data taking efficiency and Computing Performance

Continued excellent performance of detector, trigger and reconstruction

Average data taking efficiency: ~94%

Stable detector performance

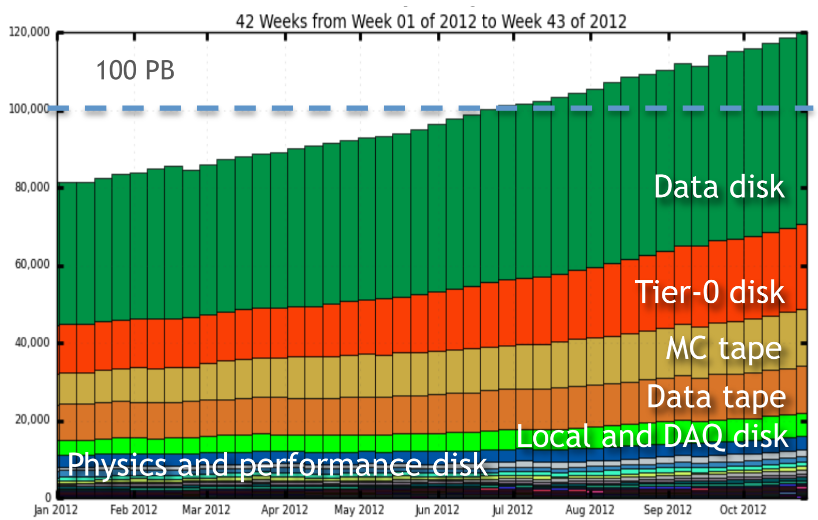
Total efficiency (delivered → physics): ~88%

ATLAS p-p run: April-Sept. 2012										
Inner Tracker			Calorimeters		Muon Spectrometer				Magnets	
Pixel	SCT	TRT	LAr	Tile	MDT	RPC	CSC	TGC	Solenoid	Toroid
100	99.3	99.5	97.0	99.6	99.9	99.8	99.9	99.9	99.7	99.2
All good for physics: 93.7%										

Luminosity weighted relative detector uptime and good quality data delivery during 2012 stable beams in pp collisions at √s=8 TeV between April 4th and September 17th (in %) – corresponding to 14.0 fb^{-1} of recorded data. The inefficiencies in the LAr calorimeter will partially be recovered in the future.

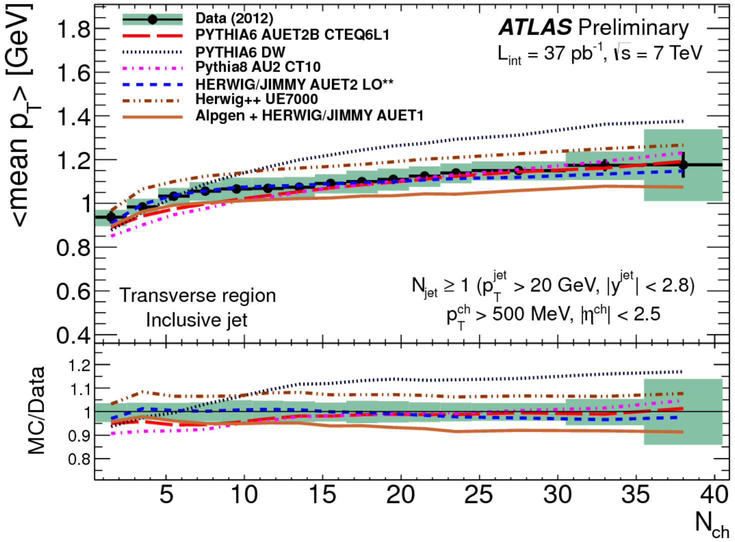
- Storage : Each LHC experiment produces ~ 10 PB of data per year (1 PB=10^6 GB)
  This corresponds to ~ 20 million DVD (a 20 km stack …)

Stored data (TB)

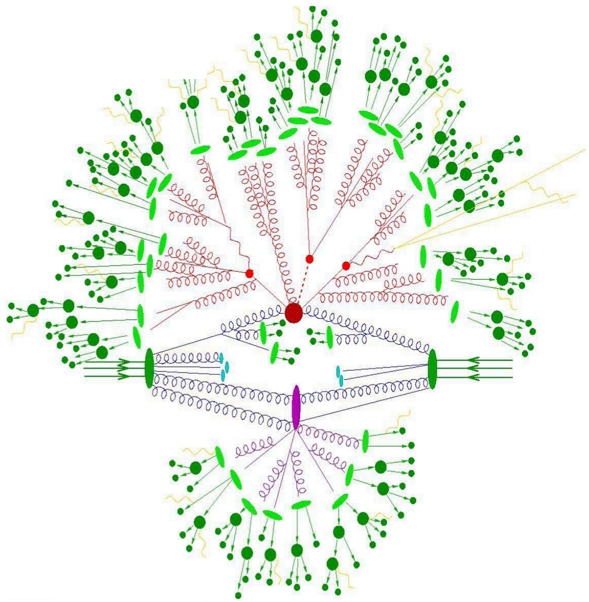


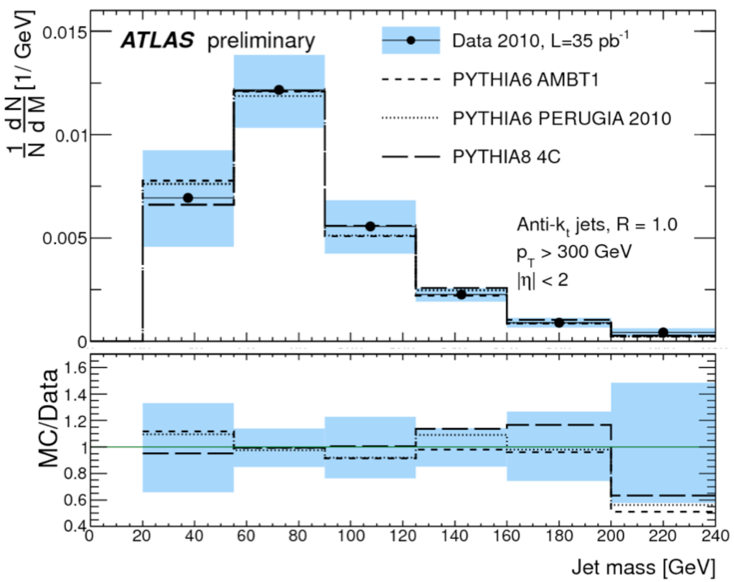
Underlying Event and Parton Shower Modeling

Tuning the underlying event and Parton Shower



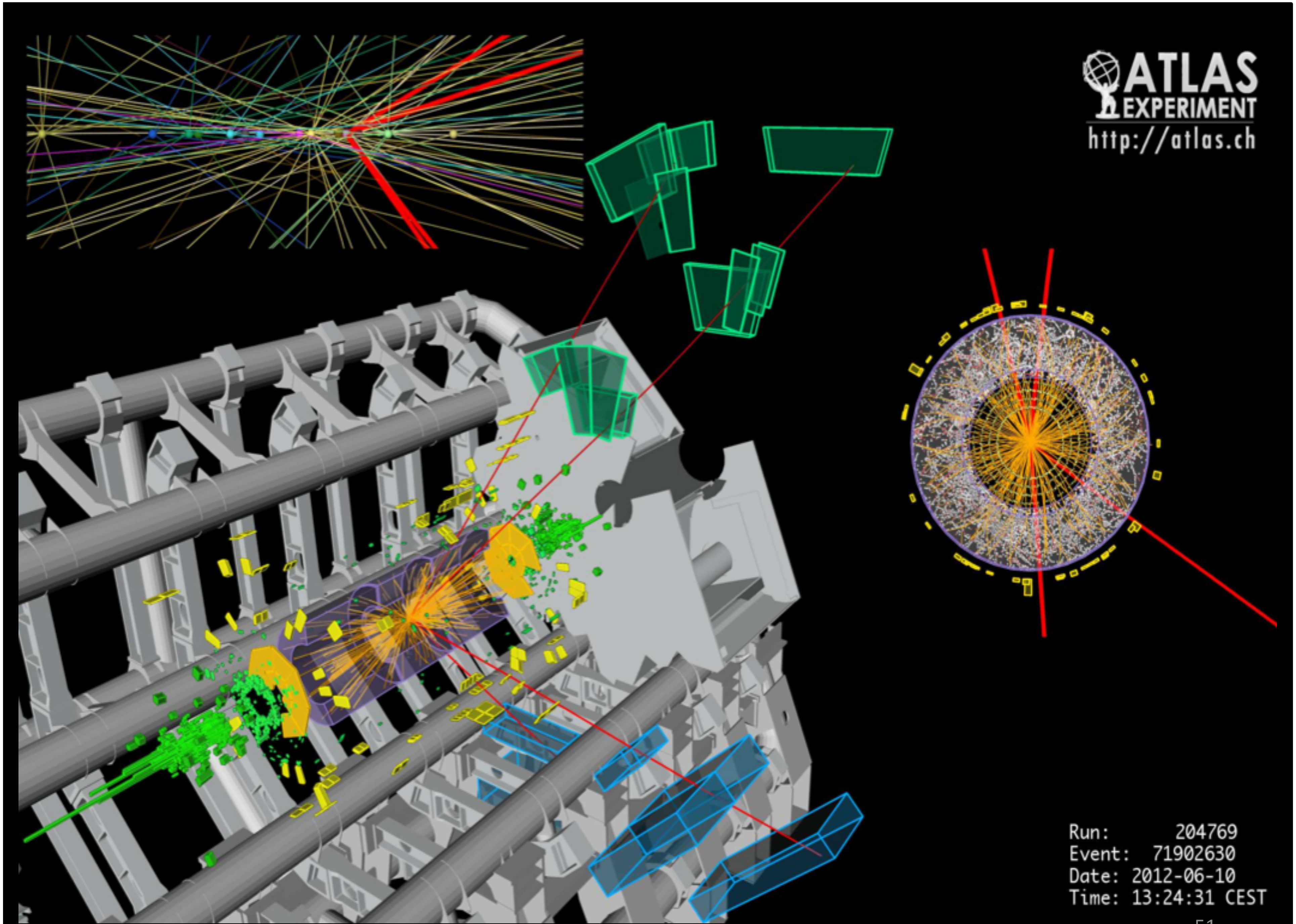
Testing UE in events with Jets





Testing PS models for Boosted variables in jet sub-strucutre …

In general UE and PS are very important to most analyses in ATLAS

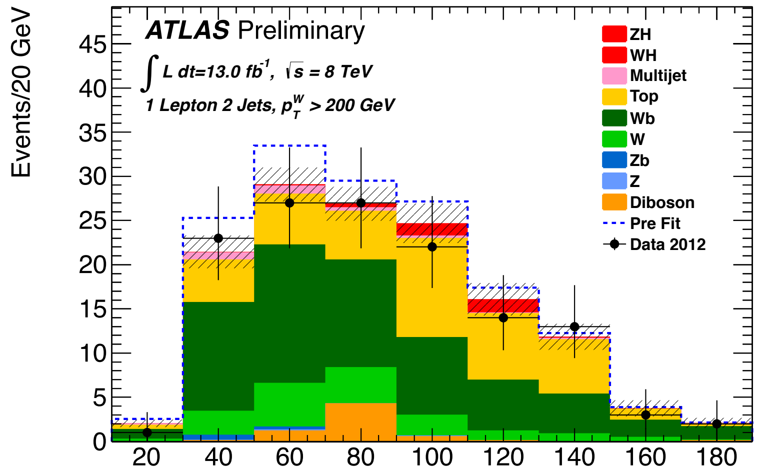

ATLAS
EXPERIMENT
http://atlas.ch
Run: 204769
Event: 71902630
Date: 2012-06-10
Time: 13:24:31 CEST

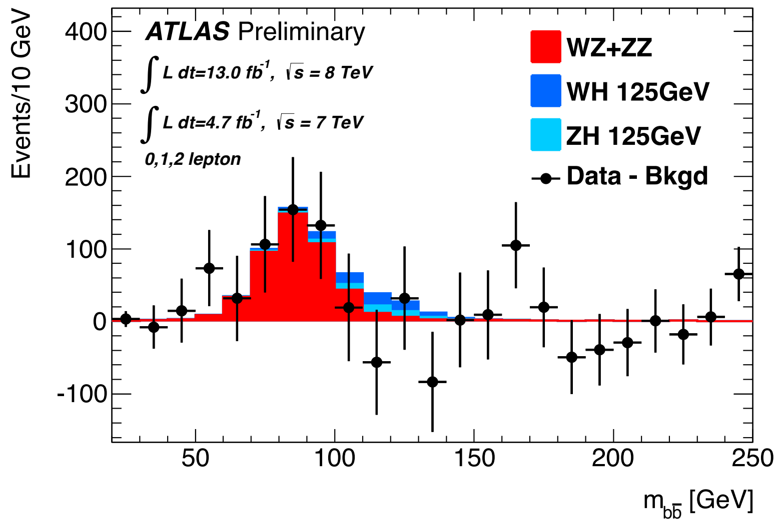
VH production with $H \to bb$

Reoptimised 7+8 TeV analysis

ATLAS-CONF-2012-161

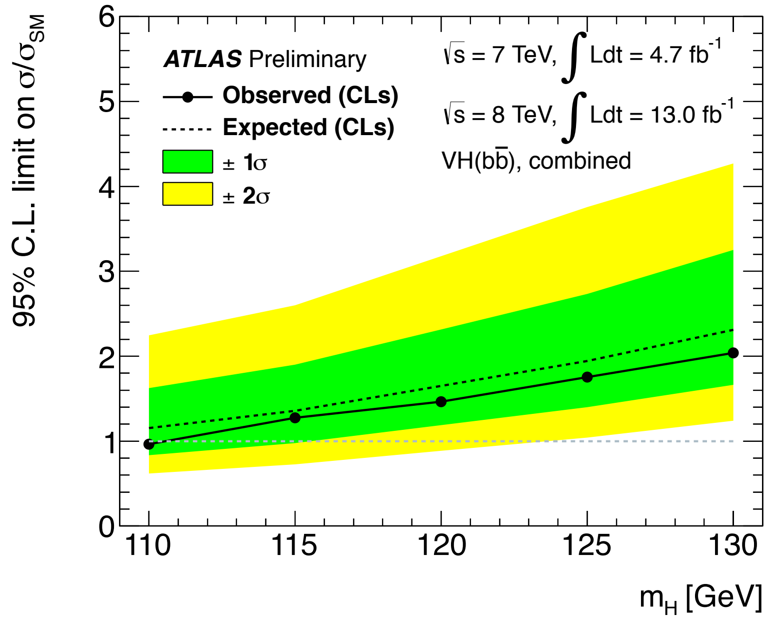
Also new 7 TeV analysis of tt+H, with H → bb [ATLAS-CONF-2012-135]





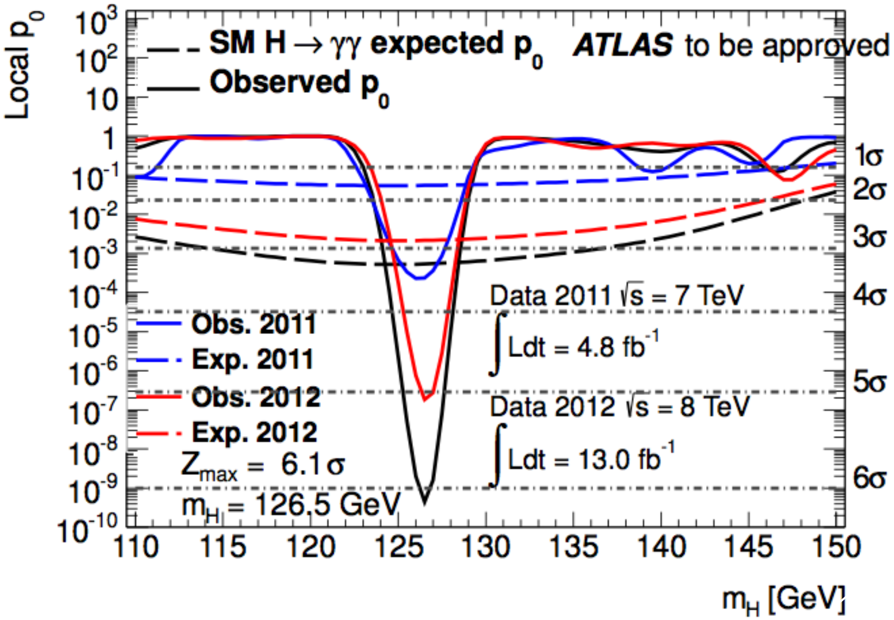
$\mu(125) = -0.4 \pm 0.7(\text{stat}) \pm 0.8(\text{syst})$
95% CL limit (125): 1.8 [exp: 1.9] × SM

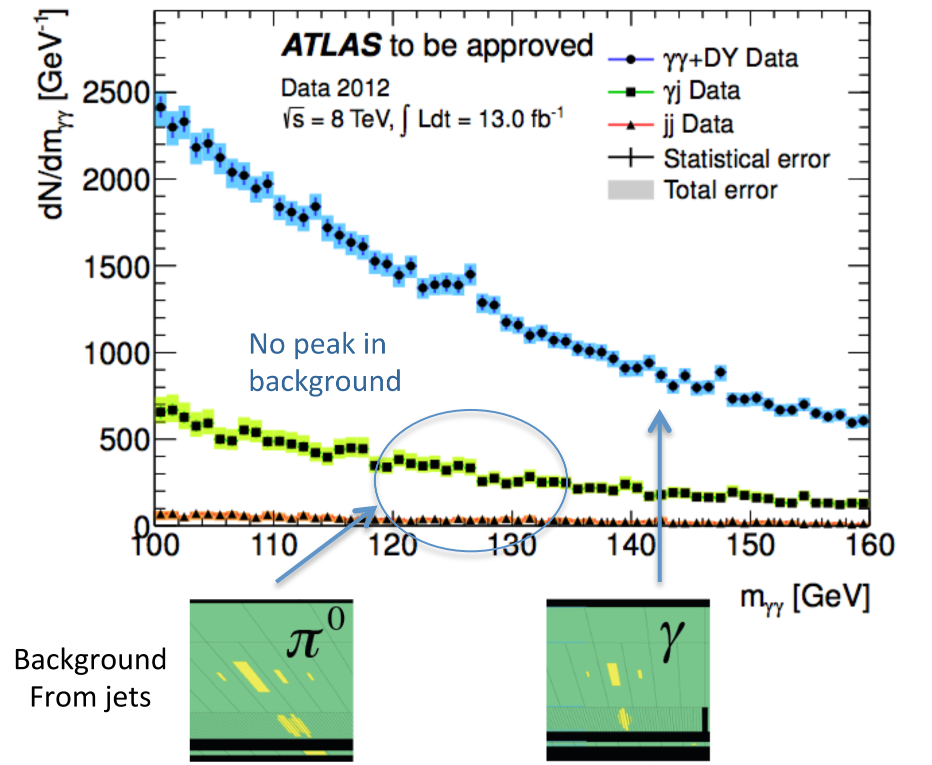
- Require 2 *b*-tags and distinguish 0, 1, 2 lepton channels
- Higgs discrimination based on m_{bb}, resolution of ~16%, improved by including muons and partial neutrino correction
- Categories in boost (w/o sub structure)



$H \rightarrow \gamma\gamma$ Signal Confirmation and Single Channel Discovery!

Since July 4th 2012 (ICHEP and PLB 716)





Observed local significance: 6.1σ

Expected local significance: 3.3σ

2011	126.0 GeV	3.5σ (exp. 1.6σ)
2012	127.0 GeV	5.1σ (exp. 2.9σ)

Main background: irreducible $\gamma\gamma$ continuum (very large rejection R_j ~ 5000)

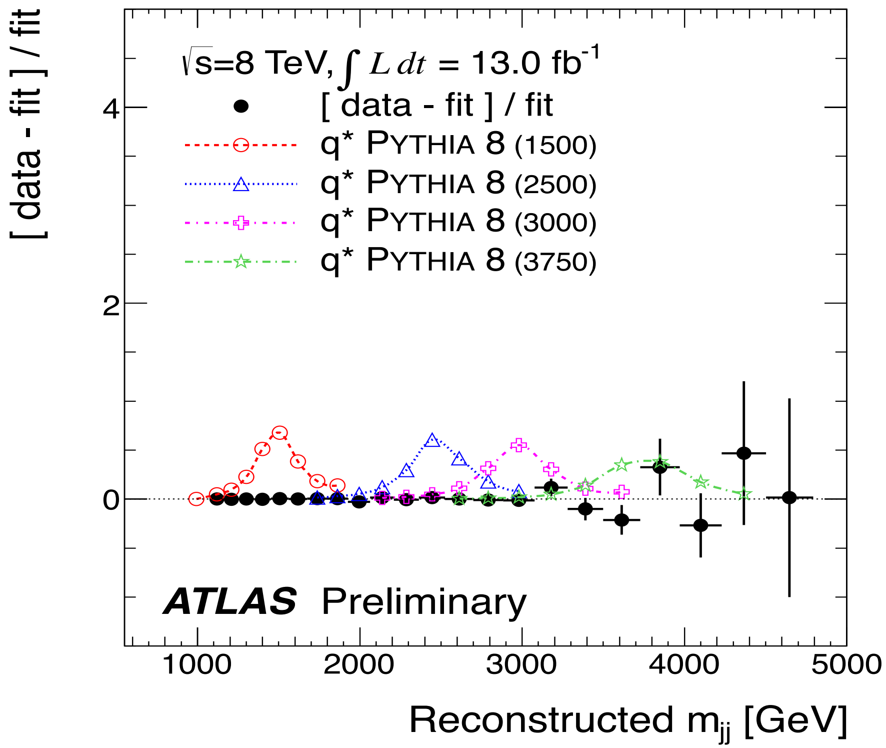
- Photon efficiency ~ 85%
- Background composition (data-driven): ~75 % γγ (~ 22% γj, 3% jj)

Seeking New Physics in Jet Signatures

Di-jet Mass Resonance

ATLAS-CONF-2012-148

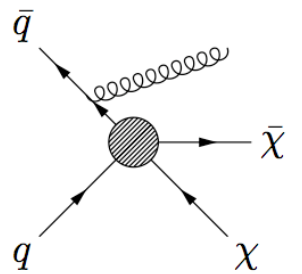
Data / fit ratio, compared to four q* models



$m(q^*) > 3.84$ TeV (95% CL)

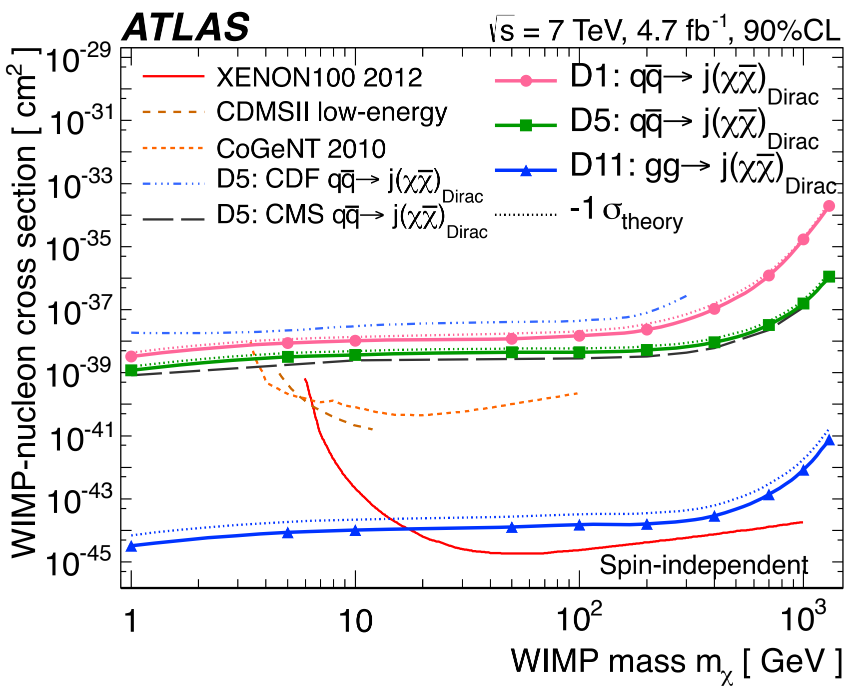
Composite

HE mono-jet searching for WIMPS



Energetic gluon/photon radiation in the initial sate

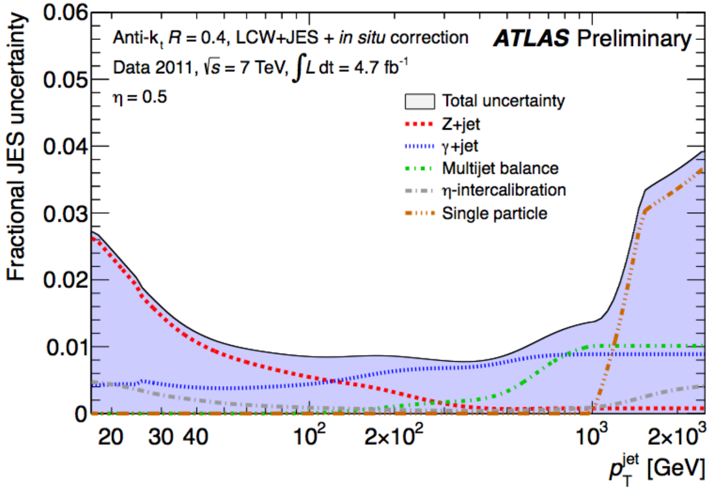
1210.4491, ATLAS-CONF-2012-147



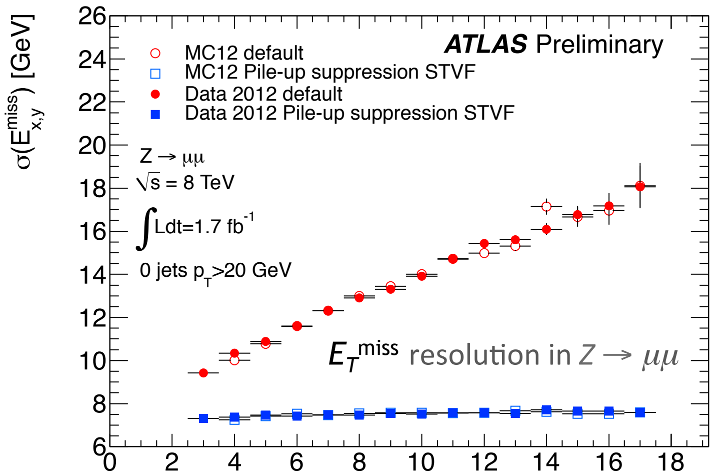
Complementarity between accelerator-based and underground based direct searches

Challenges to Object Reconstruction (Jets, E_T^{miss} and tau)

JES uncertainty data-driven w/ 2011 data typically ~1% and within 4%



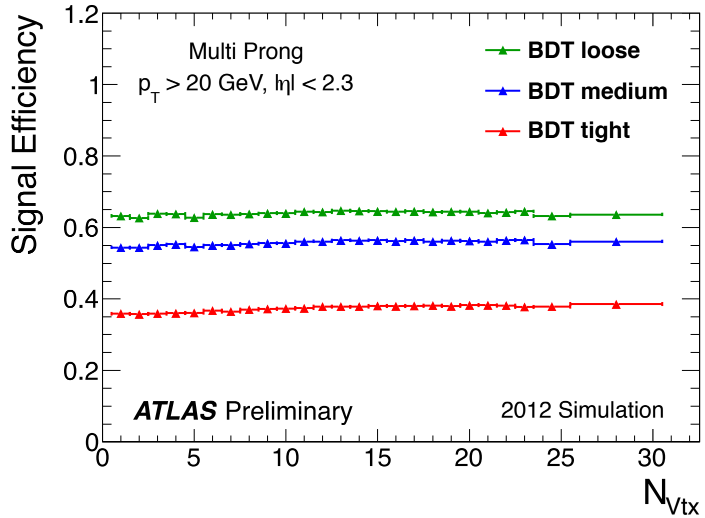
Including tracking information to correct for PU

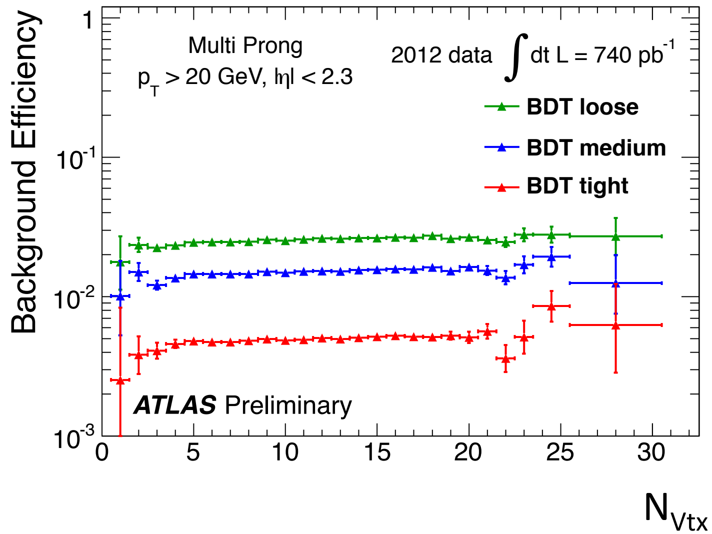


E_T^{miss} resolution in $Z \rightarrow \mu\mu$

Number of reconstructed vertices

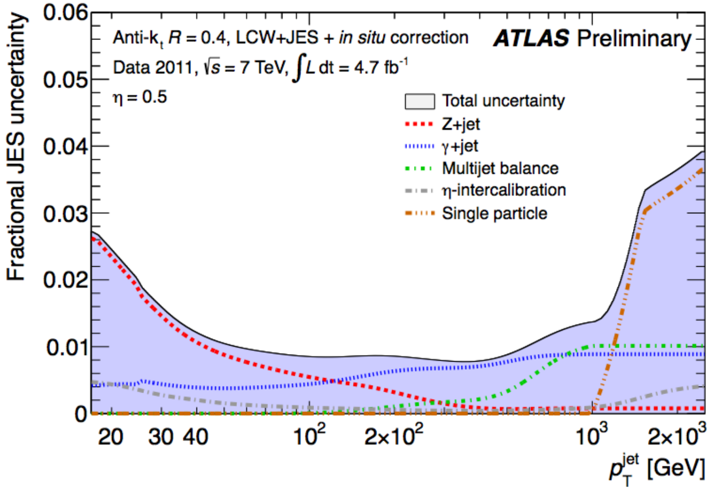
Tau BDT reconstruction efficiencies versus number of vertices



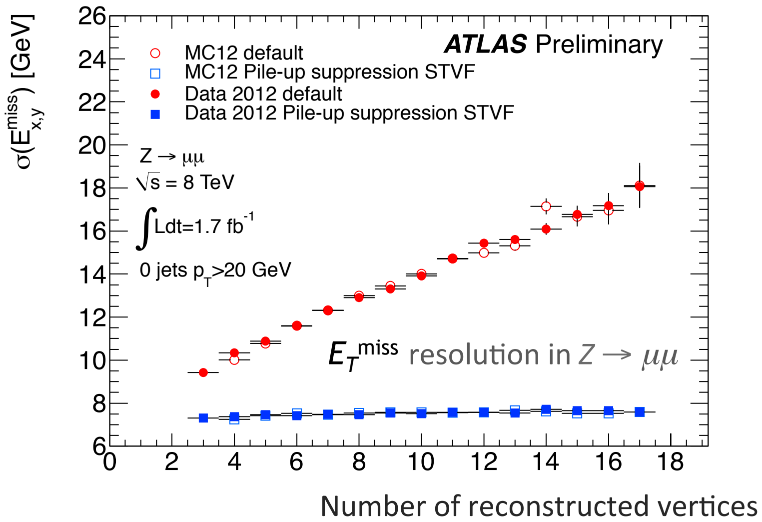


Challenges to Object Reconstruction (Jets, E_T^{miss} and tau)

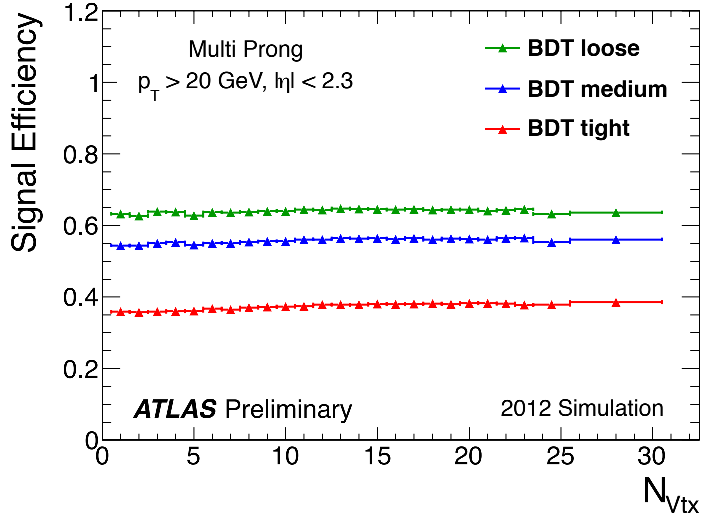
JES uncertainty data-driven w/ 2011 data typically ~1% and within 4%

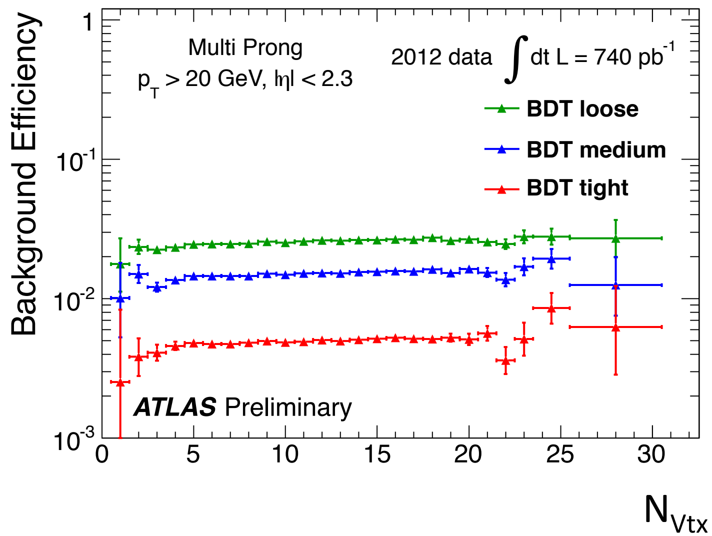


Including tracking information to correct for PU



Tau BDT reconstruction efficiencies versus number of vertices



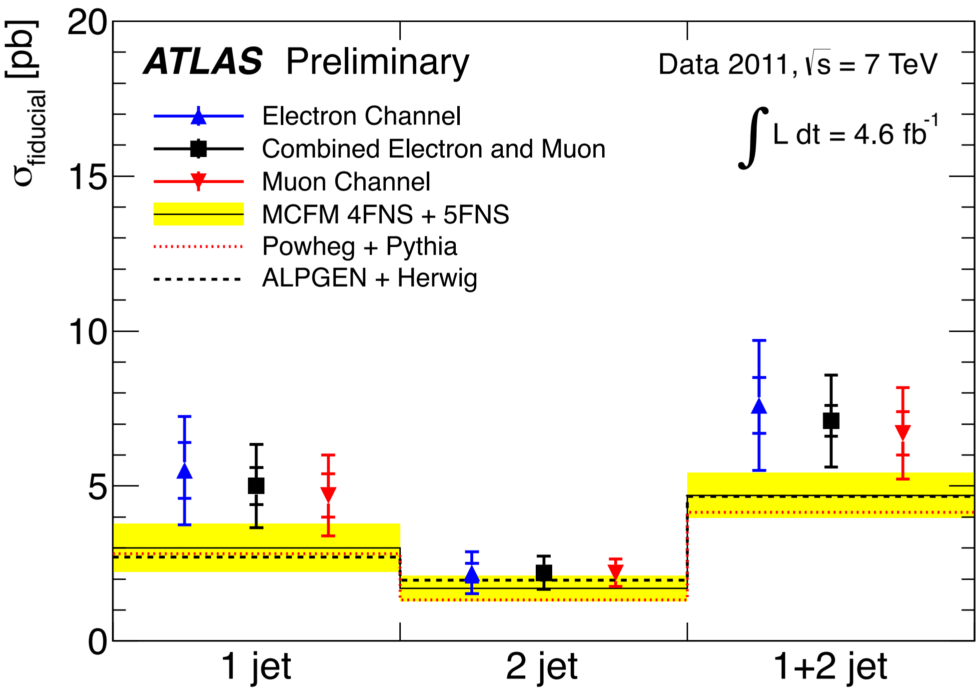


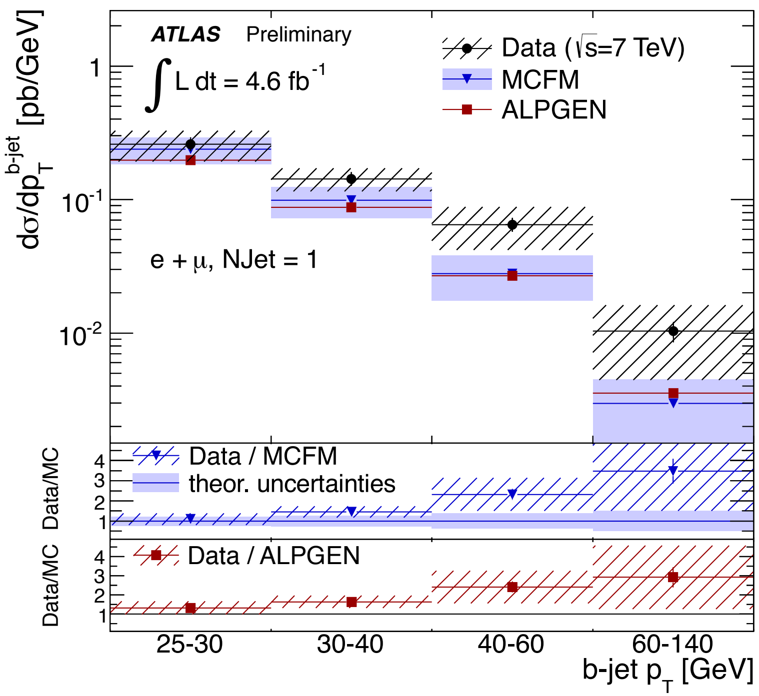
W and *Z* with Heavy Flavour Jets

ATLAS-CONF-2012-156

Large statistics allows precise tests of generators/theory, PDFs and bkg to searches

Measurement of *W* + *b*-jets fiducial (p_T > 25 GeV, $|\eta|$ < 2.1) & differential cross section





Fiducial cross section within 1.5σ of theory prediction

p_T spectrum harder in data, but compatible within uncertainties with generators

Measurements very important for the intricate search for the Higgs boson in the bb channel

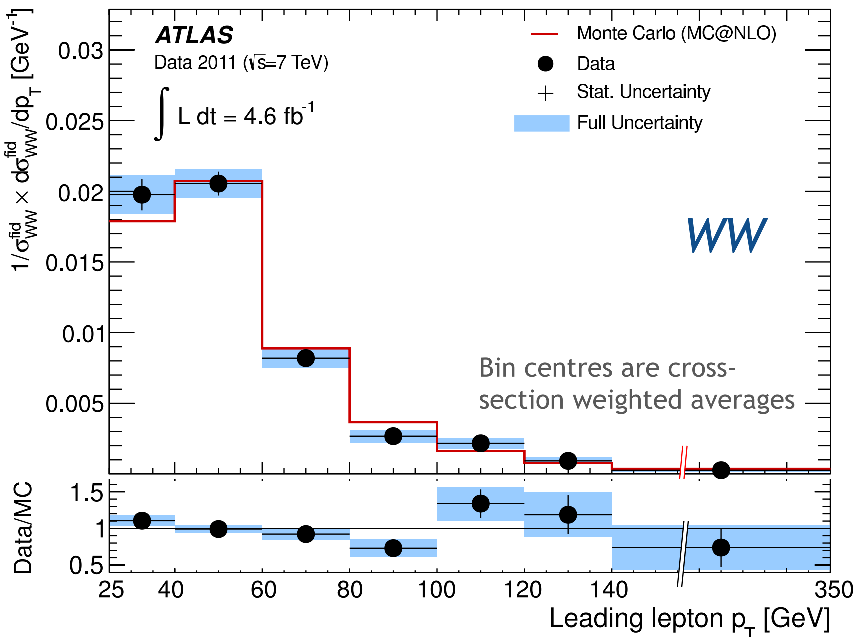
Diboson physics: *WW*, *WZ*, *ZZ*, *W*γ, *Z*γ, $\gamma\gamma$

ATLAS performed total, fiducial & differential diboson cross-sections measurements

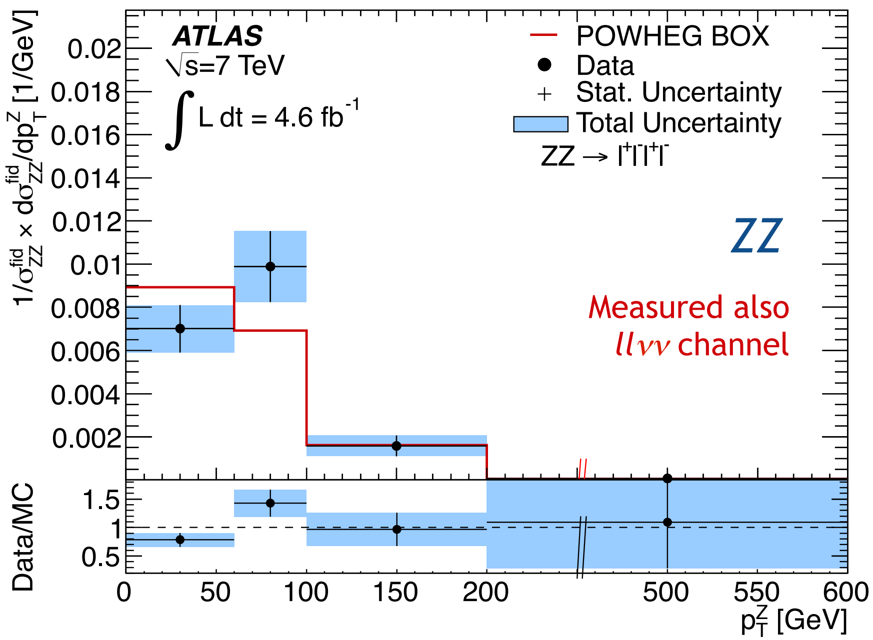
Measured 11 diboson fiducial cross-sections: most are slightly above theory expectation (but syst. and theo. errors correlated)

Examples for differential cross section measurements: *WW*, *ZZ* (7 TeV, 4.6 fb^{-1})

Normalised fiducial differential cross-section (→ unfolded)



Normalised fiducial differential cross-section



Satisfying agreement with NLO generators, also for mass spectra. Same for *WZ*

Also searched for diboson resonance production (*ZZ* [8 TeV, ATLAS-CONF-2012-150], *W*γ, *Z*γ)

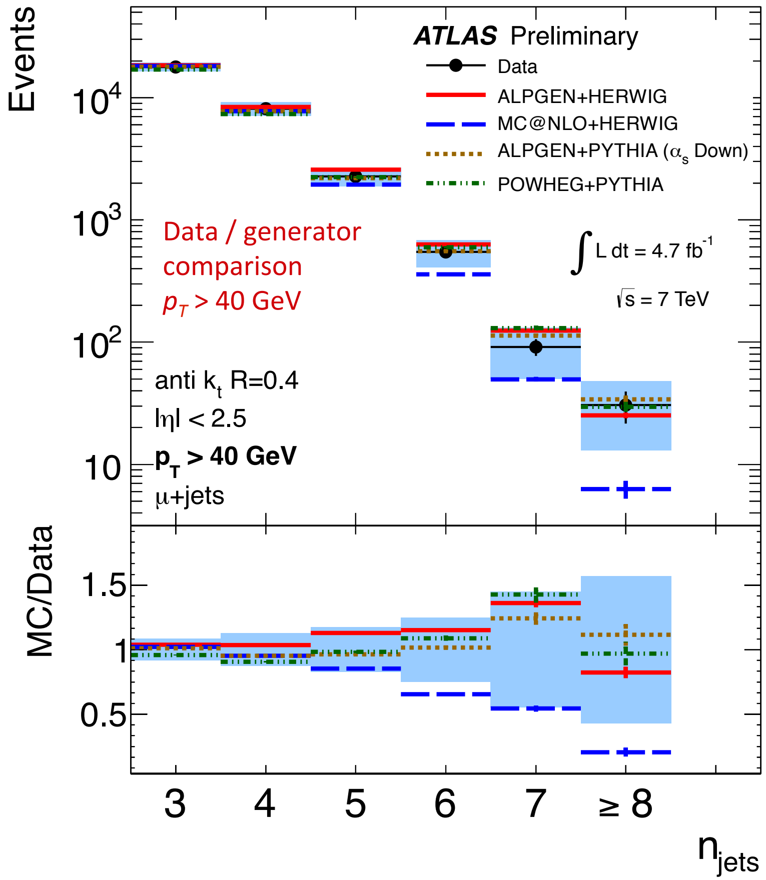
Measurements very important for the intricate search for the Higgs boson in the WW channel

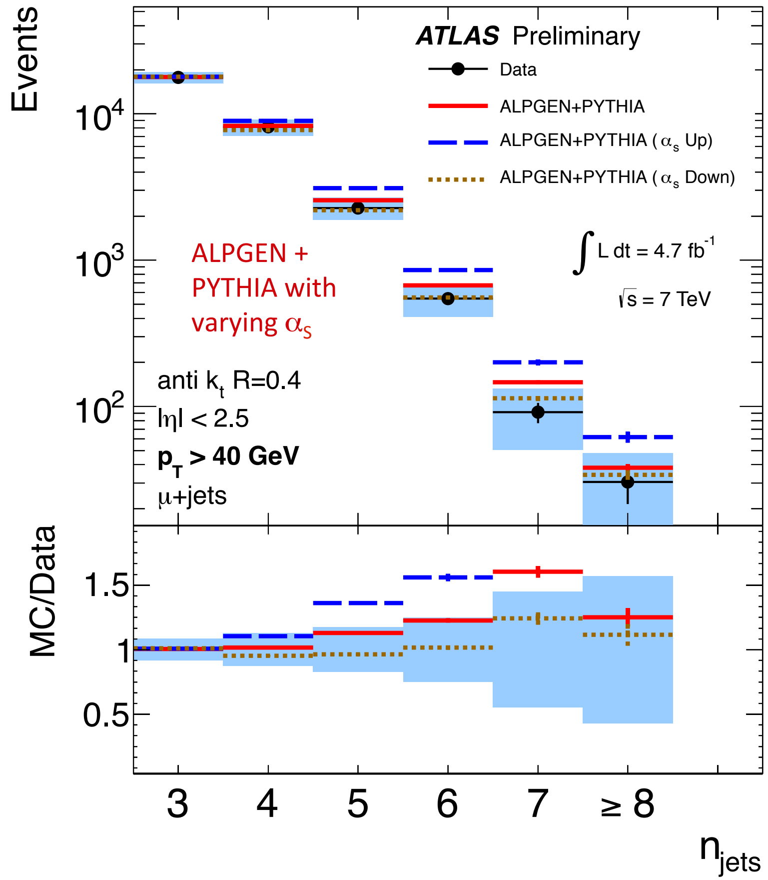
Top Differential Cross Sections

Prelim. measurement of fiducial jet multiplicity in tt production (lepton+jets) at 7 TeV (4.7 fb^{-1})

MC scaled to approx. NNLO inclusive prediction

ATLAS-CONF-2012-155, see also: 1203.5015





Measurements very important in many Higgs analyses

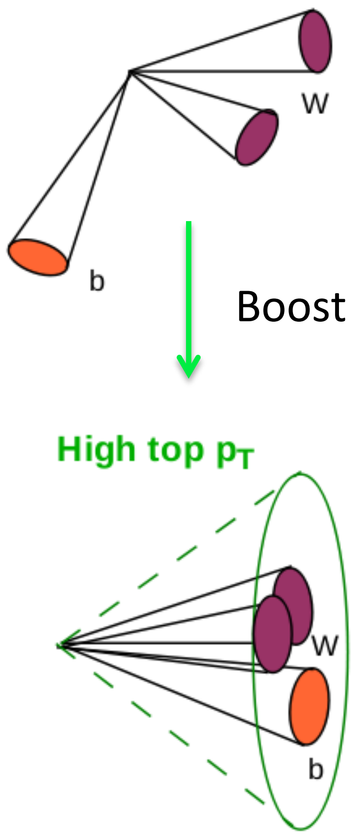
Searching for Exotic top pair Resonances

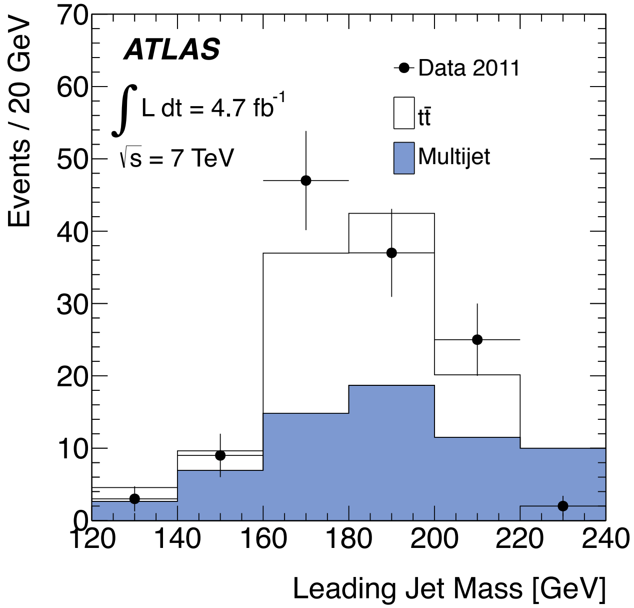
With fully boosted analyses

1211.2202
Lepton+jets analysis see : ATLAS-CONF-2012-136

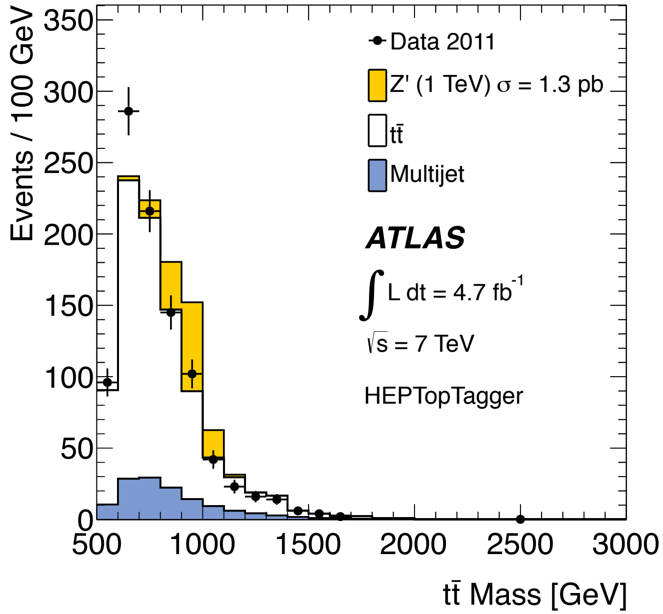
Two methods identify merged hadronic top decays

- ***HEP-Top-Tagger*** uses substructure of "fat jets"
- ***Top-Template-Tagger*** uses calorimeter templates (higher pT)





Jet mass of leading jets in Top-Template-Tagger signal region

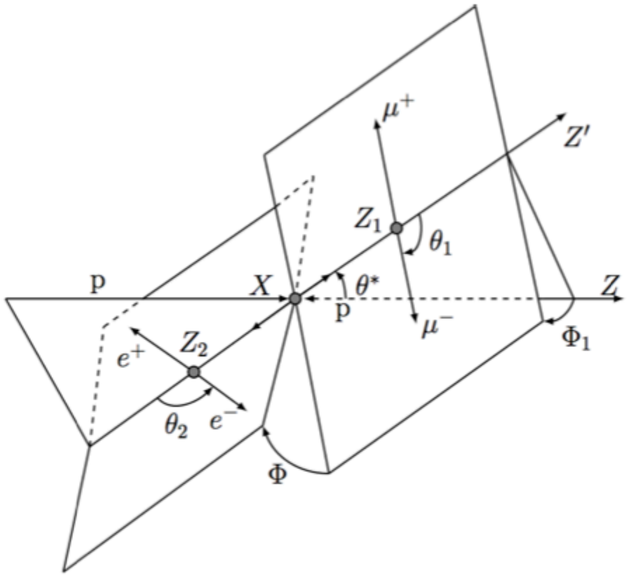


m(*tt*) after HEP-Top-Tagger identification

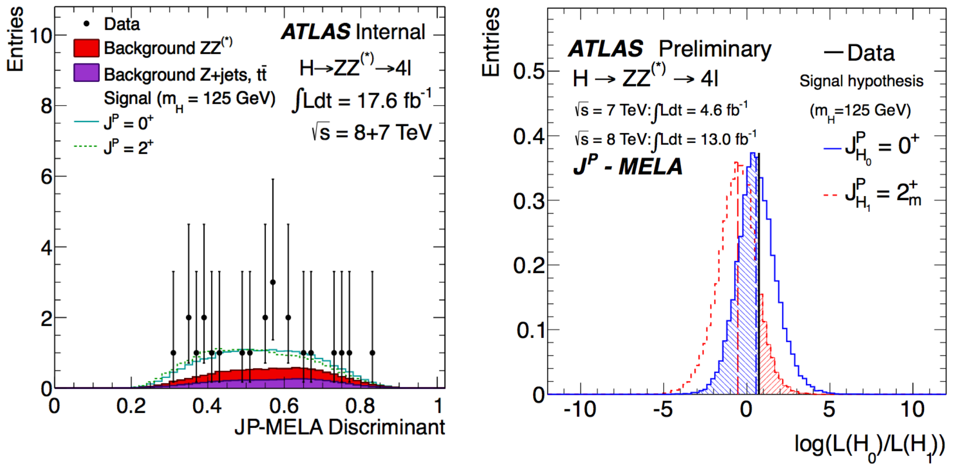
(Leptophobic topcolour) *Z'* excluded up to 1 TeV at 95% CL

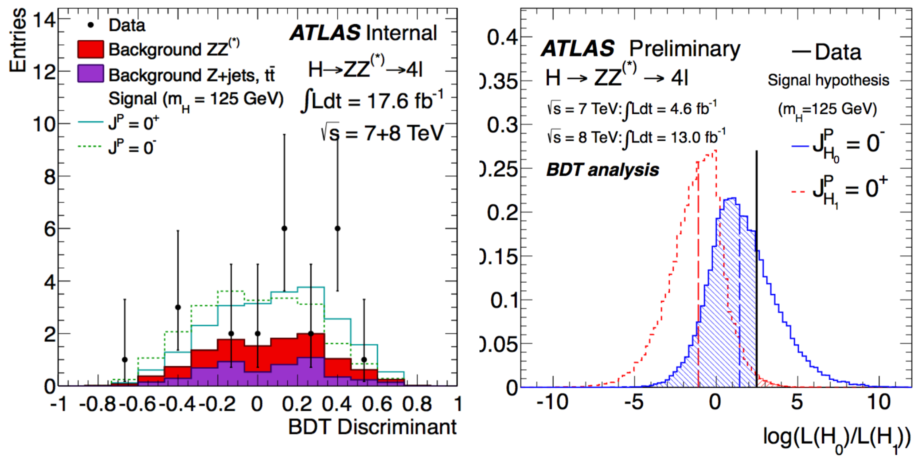
Analysis of Parity in the $H \rightarrow 4l$ Channel

ATLAS-CONF-2012-169



Using the distributions of 5 production and decay angles combined in BDT or Matrix Element (MELA) discriminants





- 0^+ vs 2^+ : (Low) Expected Exclusion of 2^+ at the 80% CL
- Observed exclusion of spin 2^+ at the 85% CL

Observation fully compatible with spin 0 (within 0.18 σ)

- 0^+ vs 0^- : Expected Exclusion of 0^- at the 96% CL
- Observed exclusion of 0^- at the 99% CL

Observation fully compatible with spin 0 (within 0.5 σ)