

LHC Days in Split

1 - 6 October 2012

Diocletian's Palace / Palazzo Milesi

Split, Croatia



Overview of ATLAS results



Anna Di Ciaccio
On behalf of the ATLAS Collaboration

INFN and University of Roma Tor Vergata

LHC Days in Split 2012

1-6 October 2012

Split, Croatia



**UNIVERSITA' degli STUDI di ROMA
TOR VERGATA**

ATLAS experiment: 176 Institutions and 38 Countries, ~2900 physicists



20 years of history from conception to start of operation.

Main milestones:

1989: R&D starts

1999: ATLAS built

July 4th (CERN and Melbourne)



Maximum excess observed at

Local significance (including energy-scale systematics)

Probability of background up-fluctuation

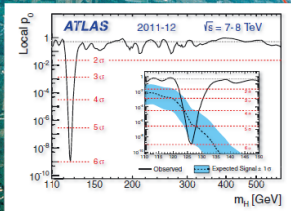
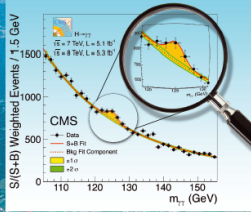
Expected from SM Higgs $m_H=126.5$

Global significance: 4.1-4.3 σ (for LEE over 110-600 or 110-150 GeV)

$m_H = 126.5$ GeV
5.0 σ
3×10^{-7}
4.6 σ



First observations of a new particle in the search for the Standard Model Higgs boson at the LHC



www.elsevier.com/locate/physletb

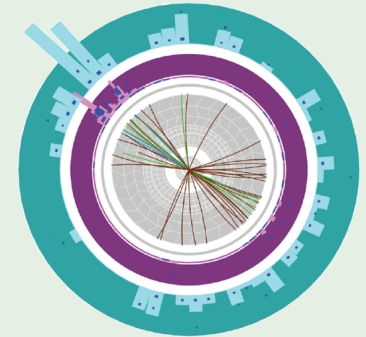
ATLAS submitted/published 192 papers, 401 CONF notes

All ATLAS results available at <https://twiki.cern.ch/twiki/bin/view/AtlasPublic>

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New Journal of Physics

The open-access journal for physics



is to certify that the article

is in dijet mass and angular distributions in pp collisions at $\sqrt{s}=7$ TeV measured with the ATLAS detector

by

The ATLAS Collaboration

Gad et al 2011 New J. Phys. 13 053044

by the editors of *New Journal of Physics* for inclusion in the series of 2011 collection. Papers are chosen on the basis of merit, novelty, scientific impact and broadness of appeal.

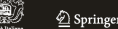
E. Bojesch

Professor Eberhard Bojesch

Editor-in-Chief

New Journal of Physics

www.njpp.org



Inclusive jet differential cross-section as a function of jet p_T integrated over the full region $|\eta| < 2.4$ for central production of the pair, as identified with $p_T > 10$ GeV. The data are compared to the NLO QCD calculation by which with QCD corrections have been applied. From the ATLAS Collaboration: Measurement of inclusive and dijet cross-sections in $\sqrt{s}=7$ TeV proton-proton collisions with the ATLAS detector



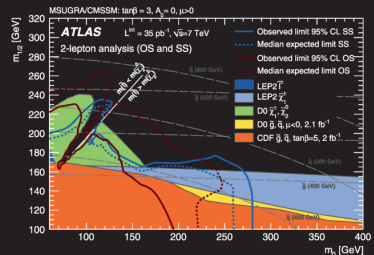
Volume 108, Number 11

The European Physical Journal volume 71 - number 7 - July - 2011

EPJ C

Recognized by European Physical Society

Particles and Fields



Exclusion in the $m_{\mu\mu}$ - $m_{\tau\tau}$ plane for $Z \rightarrow \mu\mu$, $Z \rightarrow \tau\tau$ and $\mu\tau$ together with existing limits. The expected (dashed line) and observed (solid line) 95% CL exclusion limits are shown for the opposite-sign (red line) and same-sign (blue line) analyses. From the ATLAS Collaboration: Search for supersymmetric particles in events with lepton pairs and large missing transverse momentum in $\sqrt{s}=7$ TeV proton-proton collisions with the ATLAS experiment

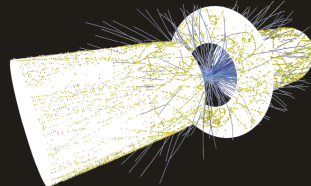


The European Physical Journal volume 70 - number 3 - December 1 - 2010

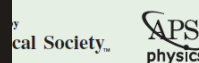
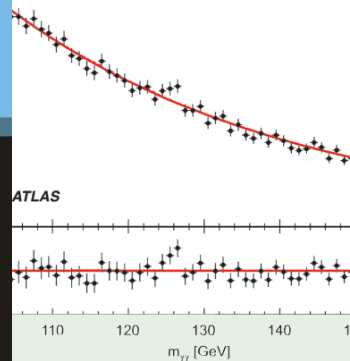
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Particles and Fields



Simulation of a Higgs boson decaying into four muons inside the ATLAS detector, with only the inner detector tracks and ATLAS simulation software. From the ATLAS Collaboration: The ATLAS Simulation Infrastructure



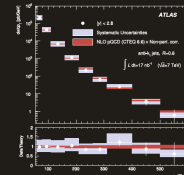
Volume 108, Number 11

The European Physical Journal volume 71 - number 2 - February - 2011

EPJ C

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Particles and Fields



Inclusive jet differential cross-section as a function of jet p_T integrated over the full region $|\eta| < 2.4$ for central production of the pair, as identified with $p_T > 10$ GeV. The data are compared to the NLO QCD calculation by which with QCD corrections have been applied. From the ATLAS Collaboration: Measurement of inclusive and dijet cross-sections in $\sqrt{s}=7$ TeV proton-proton collisions with the ATLAS detector



Volume 108, Number 11



- **Detector status and operation**
 - **Highlights on detector performance**
- **A few selected physics results**
 - **Precision tests of Standard Model**
 - **Higgs measurements**
 - **Supersymmetry searches**
 - **Exotics searches**
- **Many more results in the next ATLAS talks**
 - **I will list the speakers in the presentation**

ATLAS Talks at this Conference



Subject	Speakers
B Physics in ATLAS	Maren UGLAND
QCD ATLAS	James John LACEY
Top Physics in ATLAS	Jaroslava SCHOVANCOVA
W and Z physics in ATLAS	Mauro IODICE
Di-boson cross sections and limits on anomalous couplings	Andreas George PETRIDIS
Higgs ATLAS in ZZ/WW/2gamma	Efstathios PAGANIS
Higgs ATLAS in 2tau/2b + BSM	Yann COADOU
Higgs ATLAS SM combination + properties	Sven KREISS
Search for pair production of supersymmetric particles in R-parity conserving scenarios	Gabriella GAUDIO
Search for supersymmetry in events with resonances or long-lived particles	Lucian Stefan ANCU
Boosted physics at ATLAS	Dominique PALLIN
Overview of Exotica Physics in ATLAS	Mark Stephen COOKE
Upgrade and future of ATLAS	Sergey BURDIN

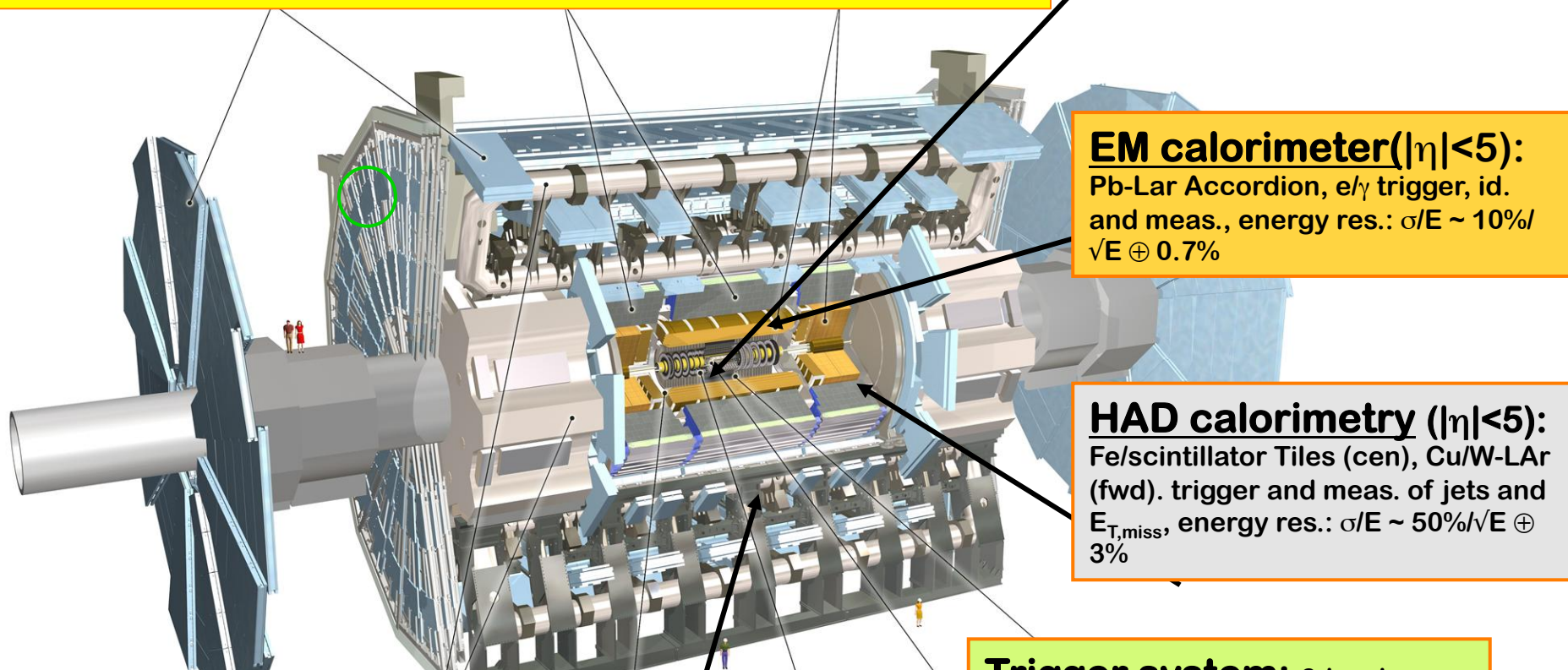
The ATLAS Detector

L ~ 46 m, \varnothing ~ 22 m, 7000 tons
~ 10^8 electronic channels

- Gigantic general purpose detector with well balanced performance on resolutions and high hermetic acceptance
- Emphasis on lepton measurements with excellent magnets

Inner Tracker ($|\eta| < 2.5$, B=2T):

Si Pixels, Si strips, Trans. Rad. Det.
Precise tracking and vertexing, e/π separation, momentum resolution:
 $\sigma/p_T \sim 0.04\% p_T$ (GeV) \oplus 1.5%



EM calorimeter ($|\eta| < 5$):

Pb-Lar Accordion, e/γ trigger, id. and meas., energy res.: $\sigma/E \sim 10\%/\sqrt{E} \oplus 0.7\%$

HAD calorimetry ($|\eta| < 5$):

Fe/scintillator Tiles (cen), Cu/W-Lar (fwd). trigger and meas. of jets and $E_{T,miss}$, energy res.: $\sigma/E \sim 50\%/\sqrt{E} \oplus 3\%$

Muon Spectrometer ($|\eta| < 2.7$): air-core toroids with gas-based muon chambers. trigger and meas. with momentum resolution $< 10\%$ up to $E_\mu \sim 1$ TeV

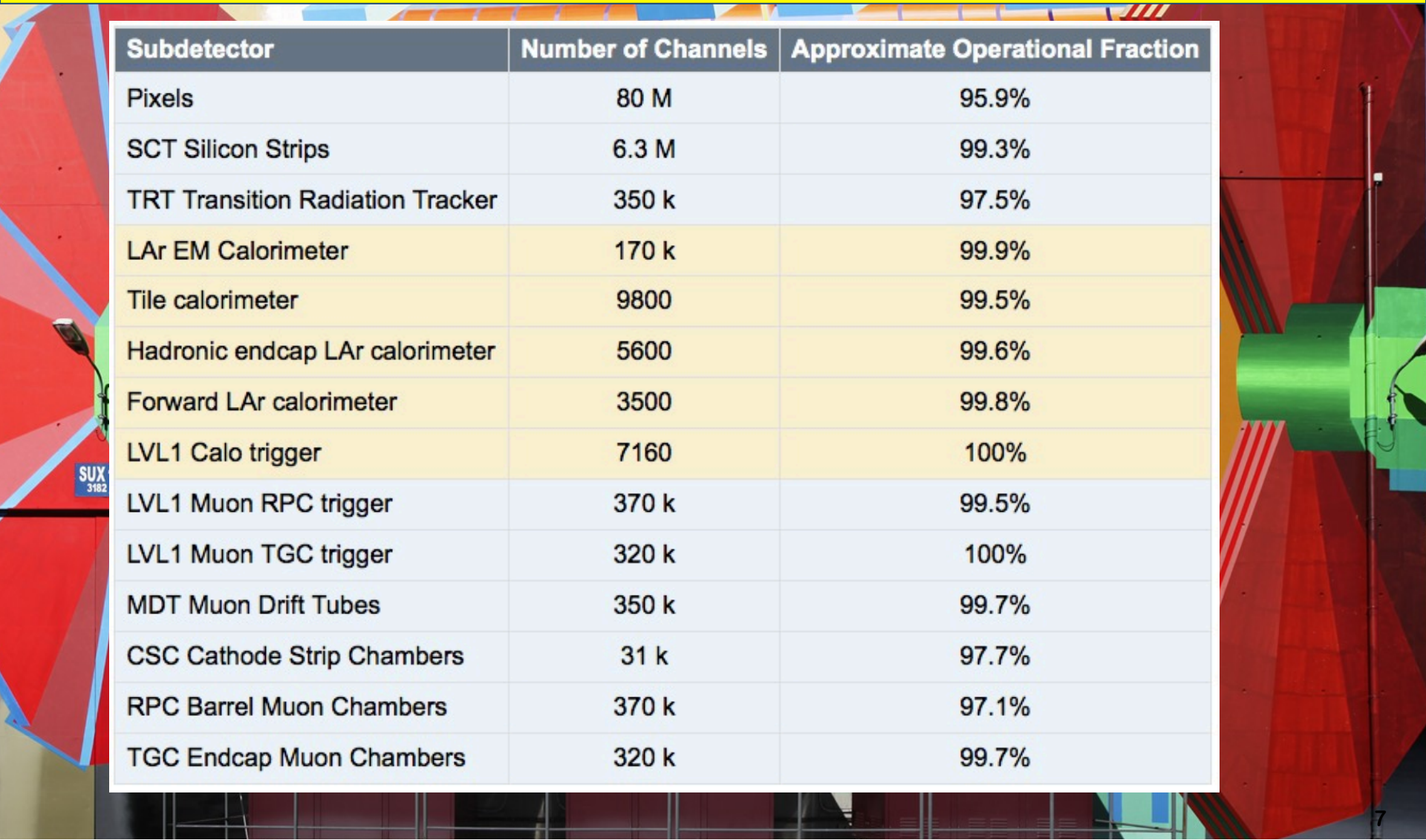
Trigger system: 3-levels reducing the rate from 40 MHz to ~200 Hz



ATLAS operation status

Fraction of operational channels near 100% for most of the subdetector systems !

Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	80 M	95.9%
SCT Silicon Strips	6.3 M	99.3%
TRT Transition Radiation Tracker	350 k	97.5%
LAr EM Calorimeter	170 k	99.9%
Tile calorimeter	9800	99.5%
Hadronic endcap LAr calorimeter	5600	99.6%
Forward LAr calorimeter	3500	99.8%
LVL1 Calo trigger	7160	100%
LVL1 Muon RPC trigger	370 k	99.5%
LVL1 Muon TGC trigger	320 k	100%
MDT Muon Drift Tubes	350 k	99.7%
CSC Cathode Strip Chambers	31 k	97.7%
RPC Barrel Muon Chambers	370 k	97.1%
TGC Endcap Muon Chambers	320 k	99.7%



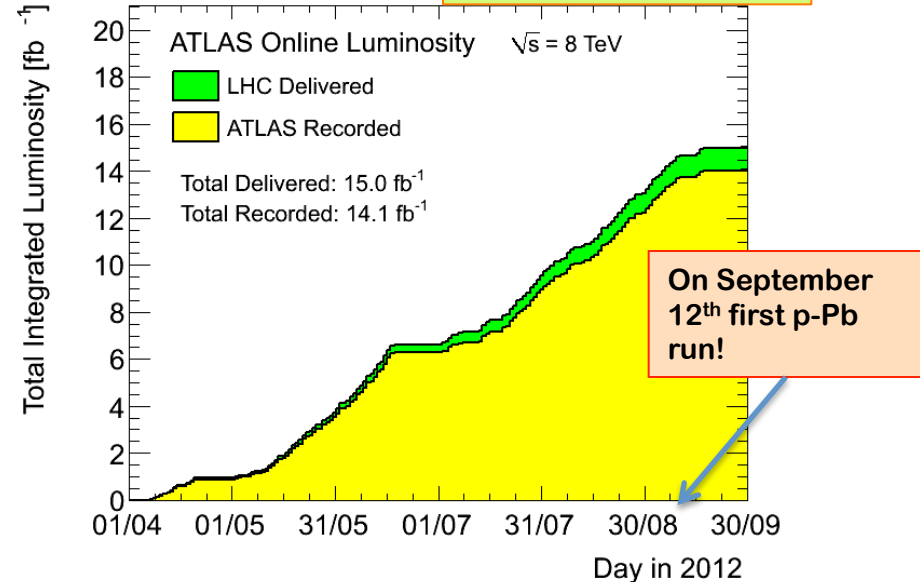
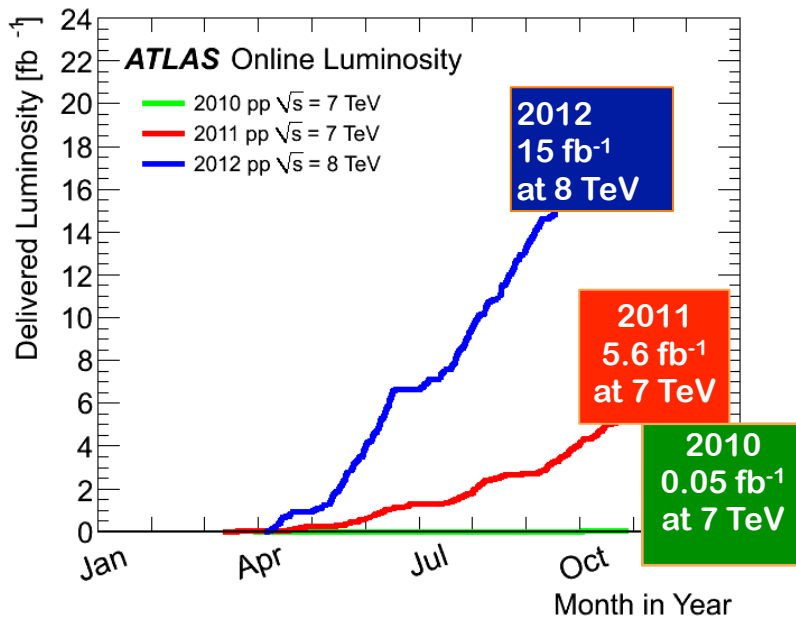
SUX
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Data Taking and data quality

Outstanding performance of LHC!

Peak Luminosity:
 $7.73 \times 10^{33} \text{ cm}^{-2} \text{ s}^{-1}$



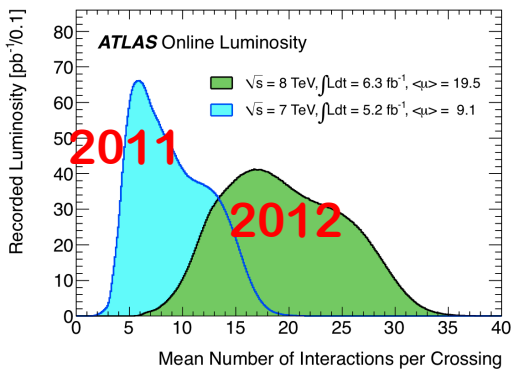
- **Data-taking efficiency = (recorded lumi)/(delivered lumi): ~ 93.7%**
 - **Fraction of data after data quality cuts used for analysis: ~ 94%**
 - **Fraction of delivery luminosity used for physics: ~ 90%**
- **excellent performance of data taking and data quality**

Inner tracking Detectors			Calorimeters				Muon Detectors				Magnets	
Pixel	SCT	TRT	LAr EM	LAr HAD	LAr FWD	Tile	MDT	RPC	CSC	TGC	Solenoid	Toroid
99.8	99.6	99.2	97.5	99.2	99.5	99.2	99.4	98.8	99.4	99.1	99.8	99.3



A challenge in 2012 : mastering pile up events

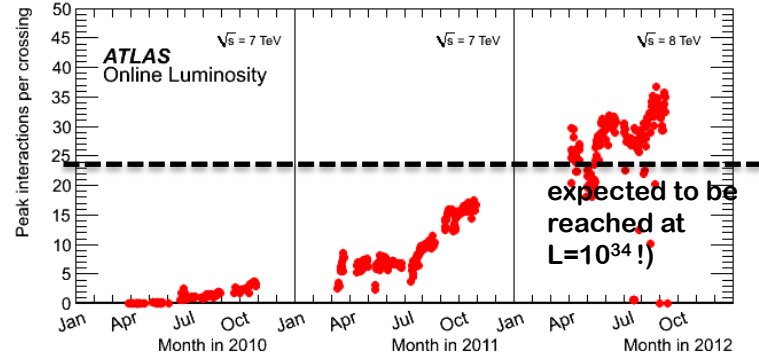
Numbers of interactions per bunch crossing



Huge efforts invested over the last months to minimise the impact of pile-up on physics

$$\mu = L \times \sigma_{inel} / (n_{bunch} \times f_r)$$

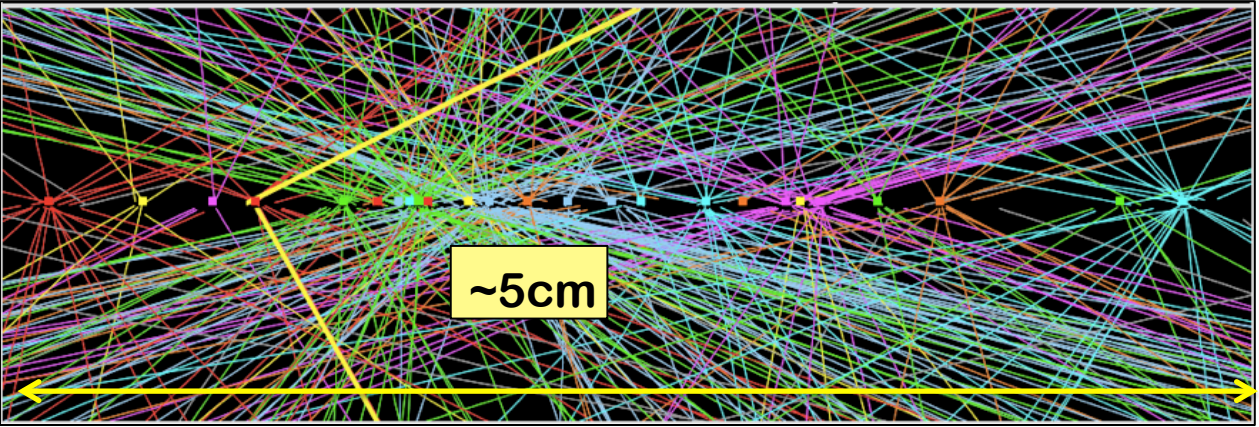
peak # collisions vs time



Strategy:

- Developed pile-up robust fast triggers
- Optimized reconstruction and identification of physics objects
- Precise modeling of in-time and out-of-time pile-up in simulation
- Flexible computing model to handle x2 trigger rate and x2 event size

Z → μμ event from 2012 data with 25 reconstructed vertices



Trigger in 2012



Menu optimised for $7 \times 10^{33} \text{ cm}^{-2}\text{s}^{-1}$ at 8 TeV:

- improvement of object selection, e.g. isolation, to keep single lepton threshold low (in spite of 2 x lumi and 2 x pile-up with respect to 2011)
- Pile-up robust algorithms close to offline selections

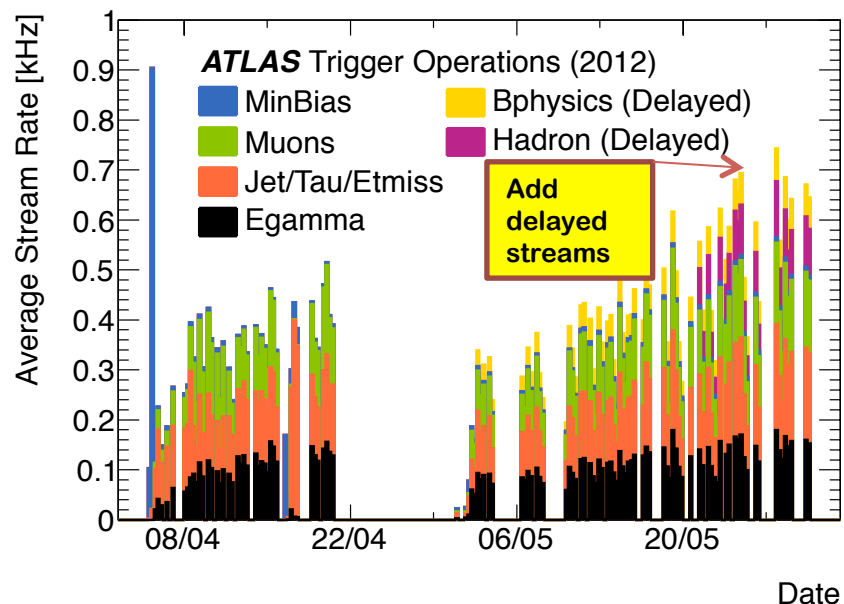
Operations in 2012 show trigger is coping very well (in terms of rates, efficiencies, robustness, ..) with harsh conditions while meeting physics requirements

Trigger rates:

- Level 1 rates ~ 65 kHz
- Level 2 rates ~ 5 kHz
- Event Filter (EF) rates ~ 400 Hz

Main triggers at $7 \times 10^{33} \text{ cm}^{-2}\text{s}^{-1}$

Offline (GeV)	L1 thr (GeV)	L1 rate (kHz)	EF thr (GeV)	EF rate (Hz) @ 5×10^{33}
$e > 25$	18	17	24	70
$\mu > 25$	15	8	24	45
dilepton	10-15	15	8-18	21
2γ 25-40	10-16	12	20-35	17
2τ 30-45	11-15	12	20-29	12
Jet > 360	75	2	2	5
MET 120	40	2	80	17

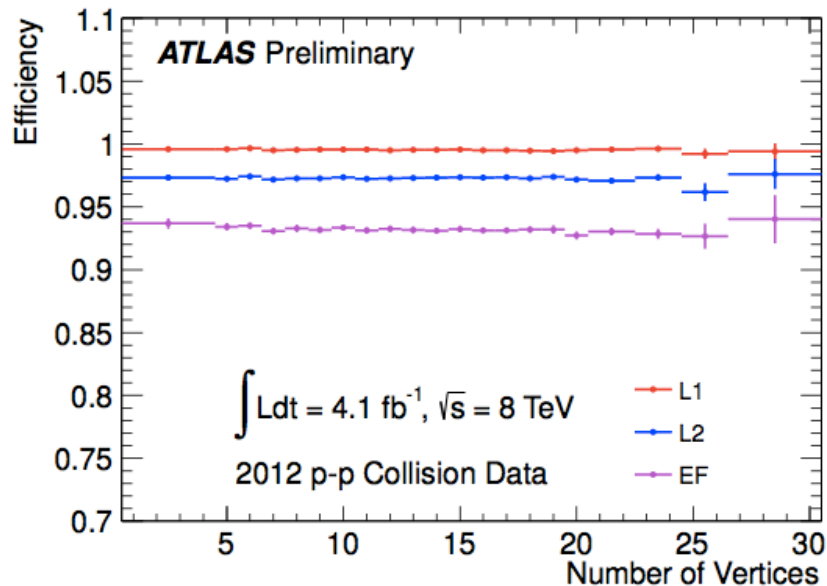


(*) Additional b-physics and hadronic triggers to 'delayed' streams for later processing



Trigger performance in 2012

Efficiency of Inclusive single electron trigger as a function of pile-up

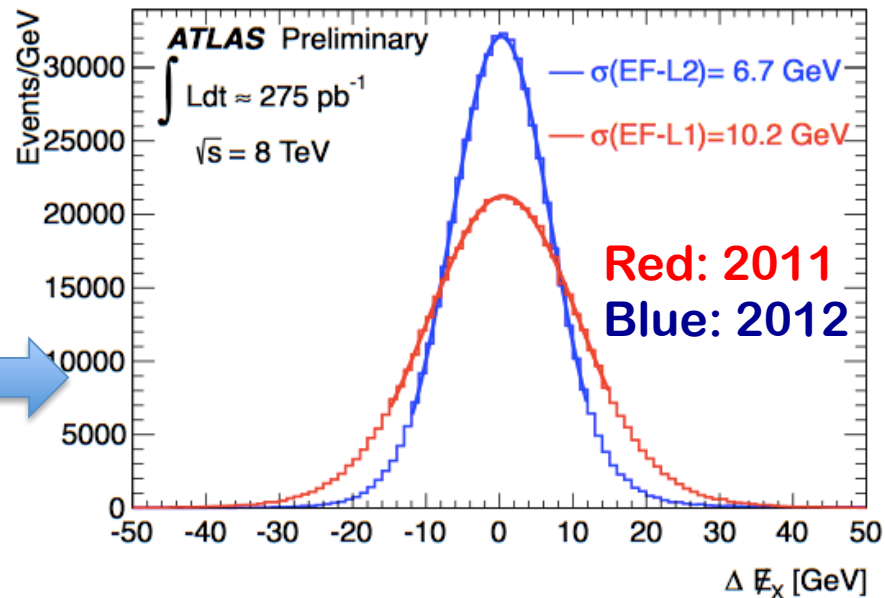


High efficiency for electrons with $E_T > 25 \text{ GeV}$ and $|\eta| < 2.47$ using isolation – independent of pile-up

E_T^{miss} threshold lower than 2011.
Better trigger resolution in 2012 thanks to:

- Noise cuts at L1 to suppress pile-up
- Fast Front End Board sums at Level 2
- Better algorithm at Event Filter

E_T^{miss} Trigger resolution



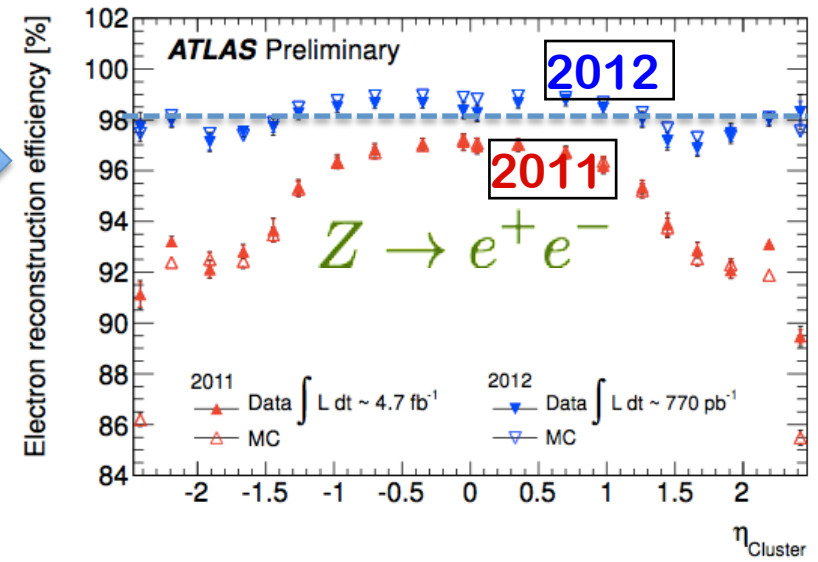


Electron Performance

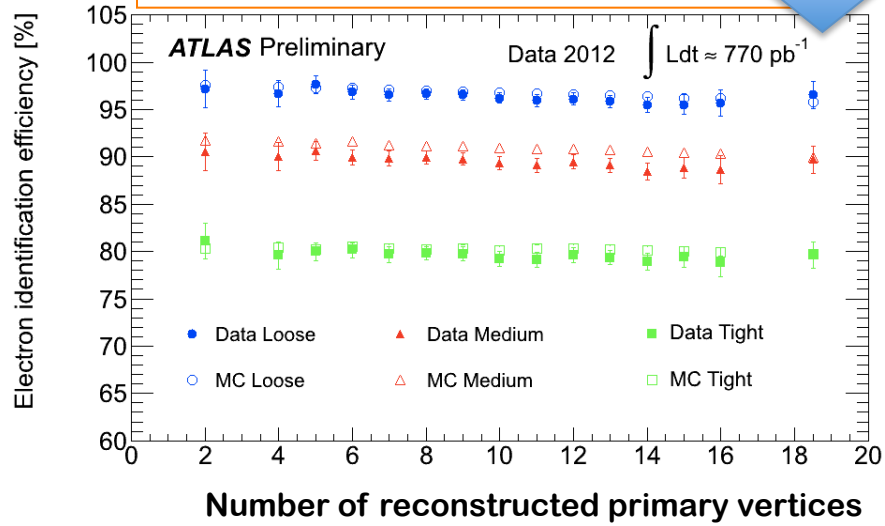
- **Electron reconstruction improved**
 - More performing track cluster matching
 - Track pattern recognition takes in account of bremsstrahlung losses
 - Achieved ~ 98% reconstruction efficiency, ~ flat vs η and E_T

- **Retuning of cuts (shower shape)**
 - Identification efficiency
 - achieved ~ 95%, ~ flat vs pile-up
 - excellent energy scale stability in time and as a function of pileup to better than 0.1%

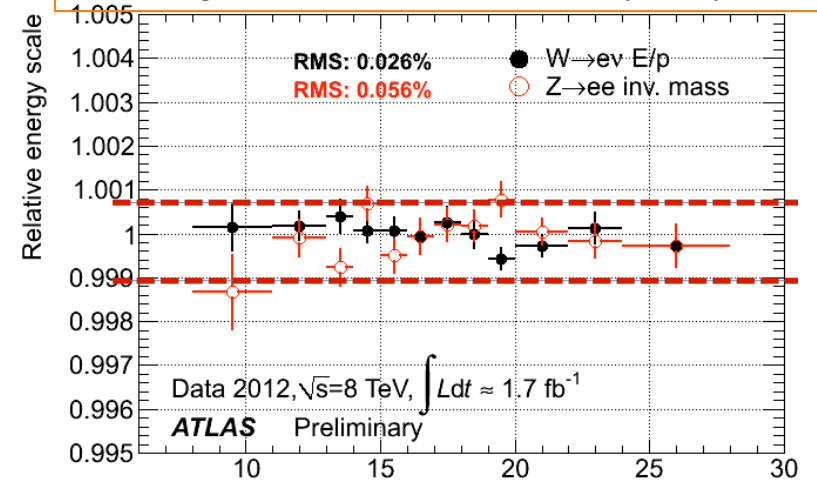
Results are from $Z \rightarrow ee$ data and MC tag-and-probe



Electron identification efficiency



Stability of EM calorimeter vs pileup





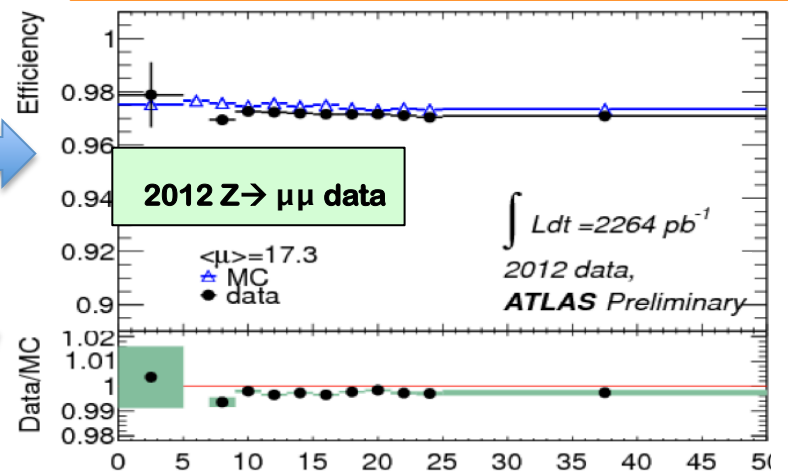
Muon Performance

ATL-COM-PHYS-2012-716

- Reconstruction efficiency ~ 97%,
 - ~ flat down to $p_T \sim 6$ GeV and over $|\eta| \sim 2.7$
 - not affected by pile-up
- Mass resolution, reconstruction and isolation efficiency well described by Monte Carlo

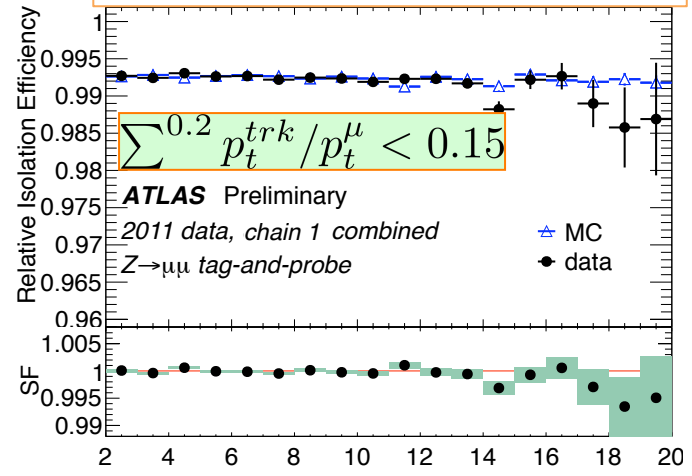


Reconstruction efficiency vs Nvtx



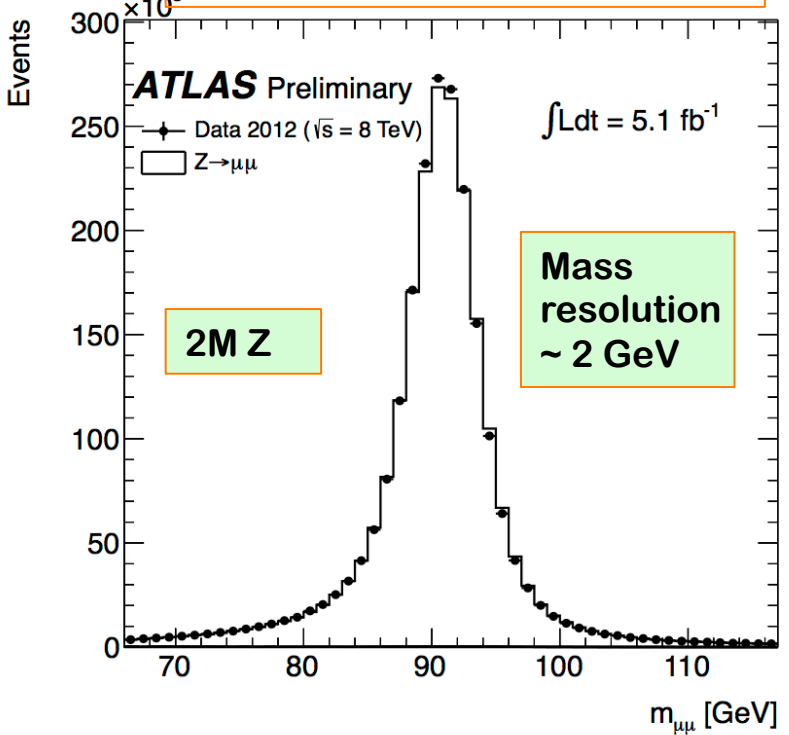
Number of reconstructed primary vertices μ

isolation efficiency vs Nvtx



Number of reconstructed primary vertices μ

2012 $Z \rightarrow \mu\mu$ mass peak



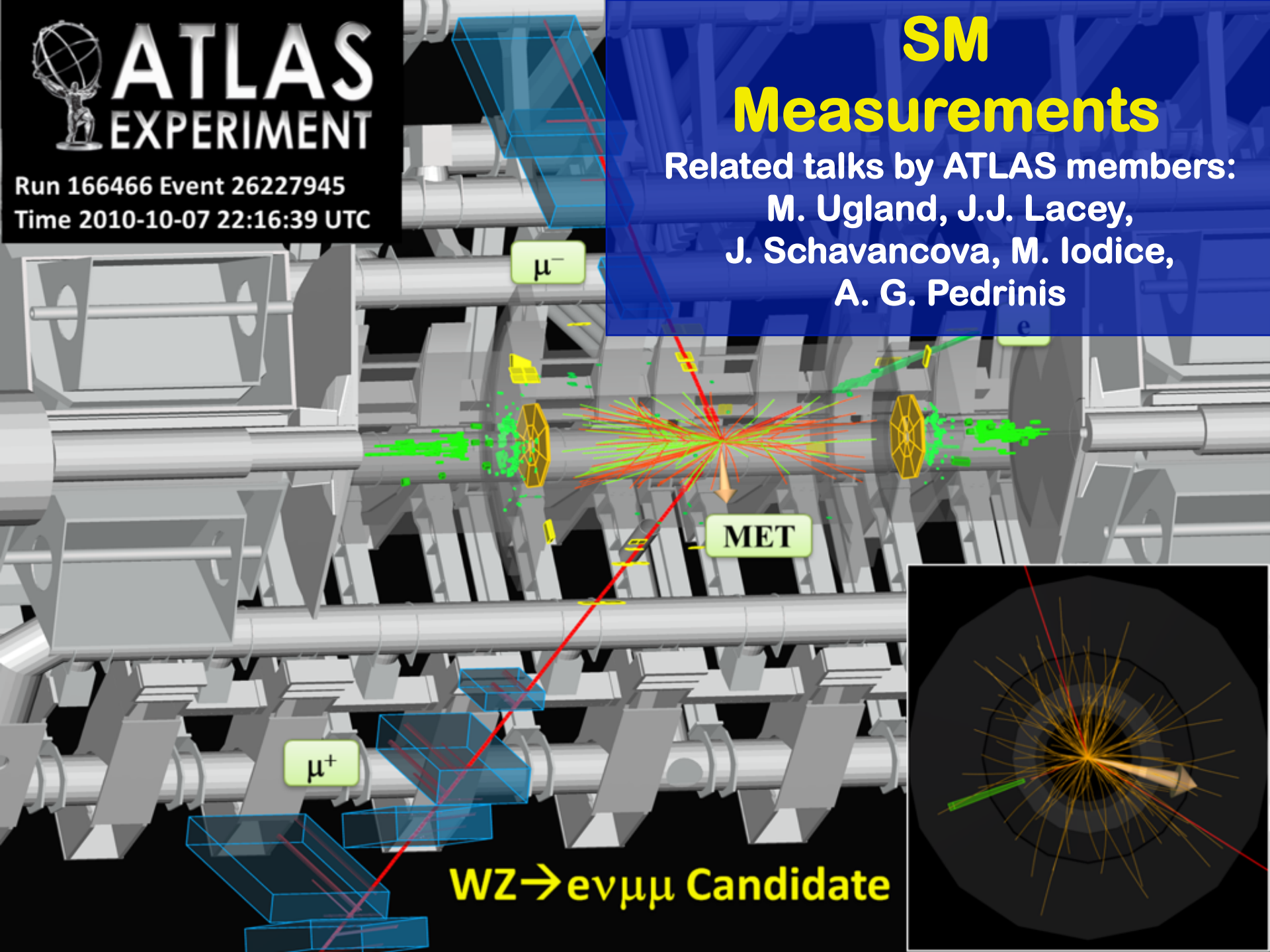
A few highlights of physics results

(at 7 and 8 TeV)

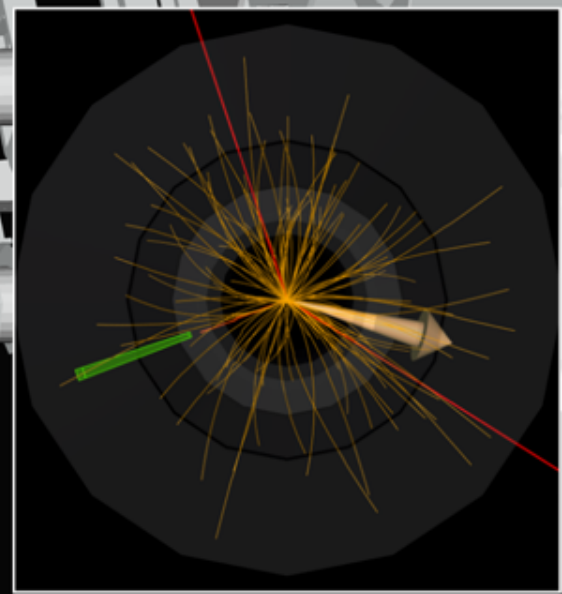
Measurements

Related talks by ATLAS members:

M. Ugland, J.J. Lacey,
J. Schavancova, M. Iodice,
A. G. Pedrinis



$WZ \rightarrow e\nu\mu\mu$ Candidate



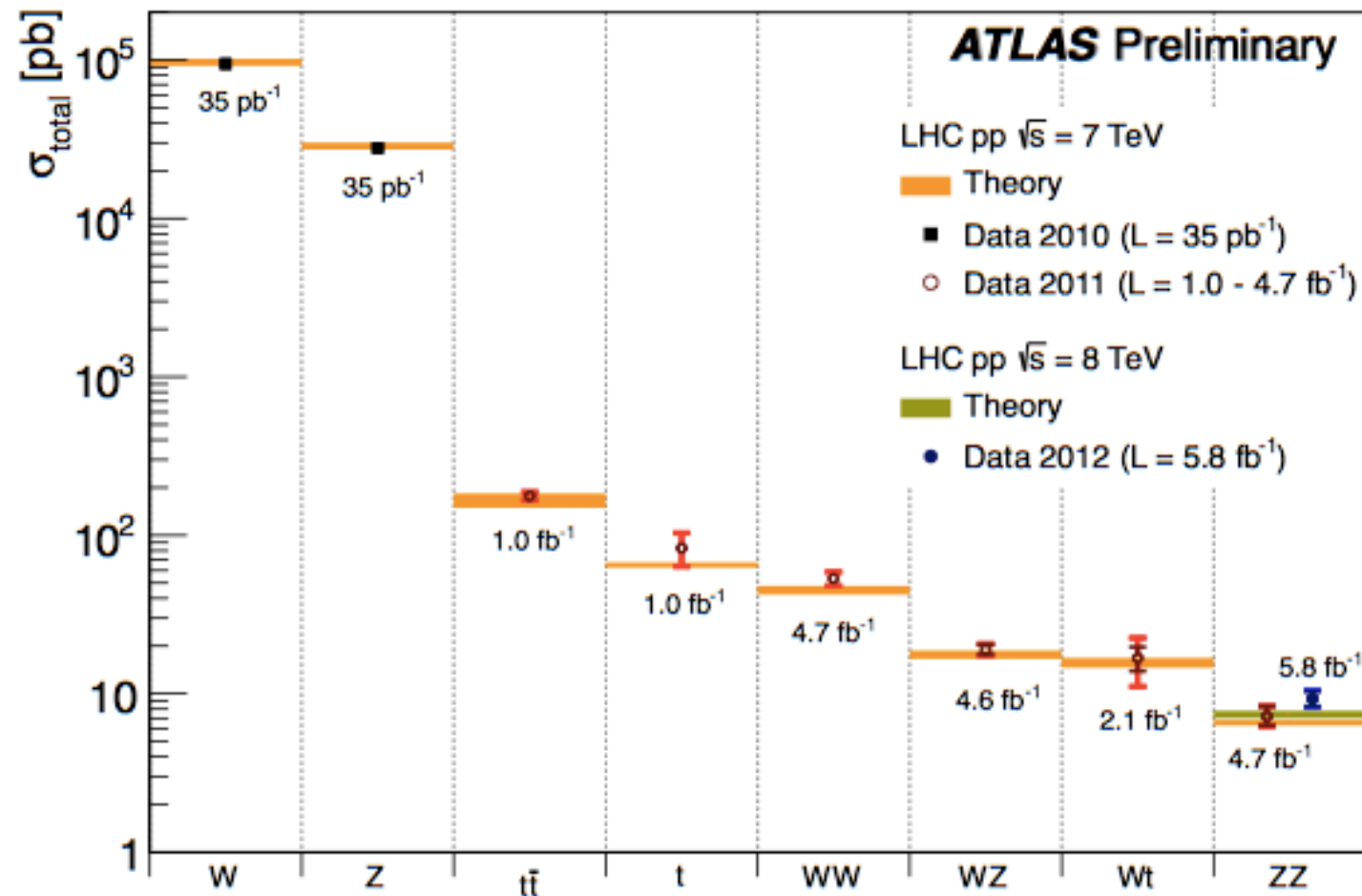


Standard Model Measurements

Cross-section measurements from inclusive W, Z to ZZ production. Foundation of SM.

- tests of the SM & probing new physics
- backgrounds for searches and precision measurements

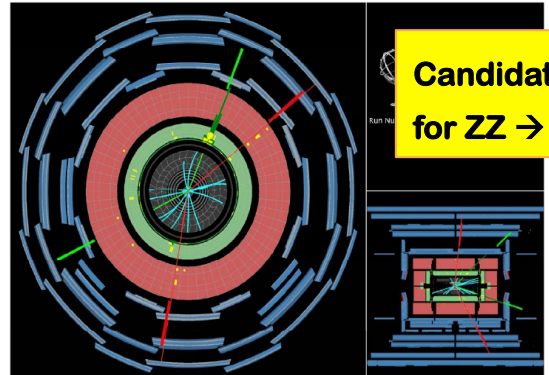
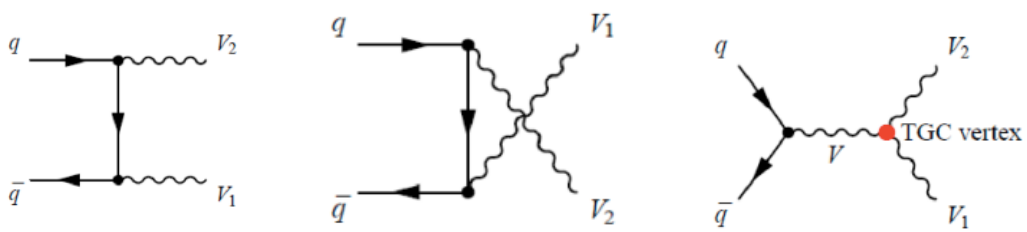
<https://twiki.cern.ch/twiki/bin/view/AtlasPublic>



- Plenty of interesting results
→ presented in detail in next ATLAS talks
- Only a few will be presented in the next slides
 - Di-bosons
 - Single top



Di-Boson Productions (WW, WZ, ZZ, W γ , Z γ)



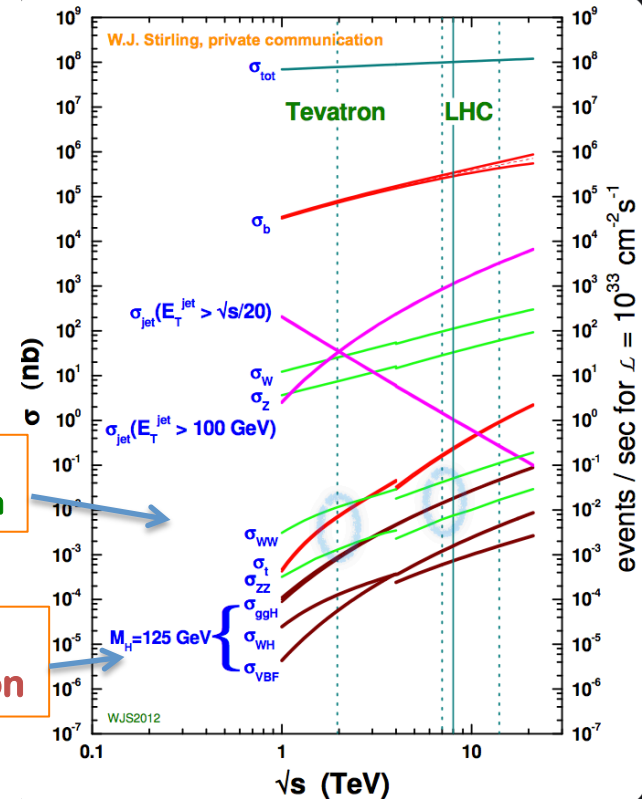
Candidate event for ZZ \rightarrow ee $\mu\mu$

Importance of di-boson measurements

- Sensitive to Triple Gauge Couplings (TGC): fundamental test of SM
 - WW γ and WWZ allowed;
 - ZZ γ , Z $\gamma\gamma$ and ZZZ forbidden at tree level
- Search for physics beyond SM
 - \rightarrow anomalous coupling measurements and resonances
- Irreducible Background to Higgs processes and SUSY and Exotica searches

Diboson production

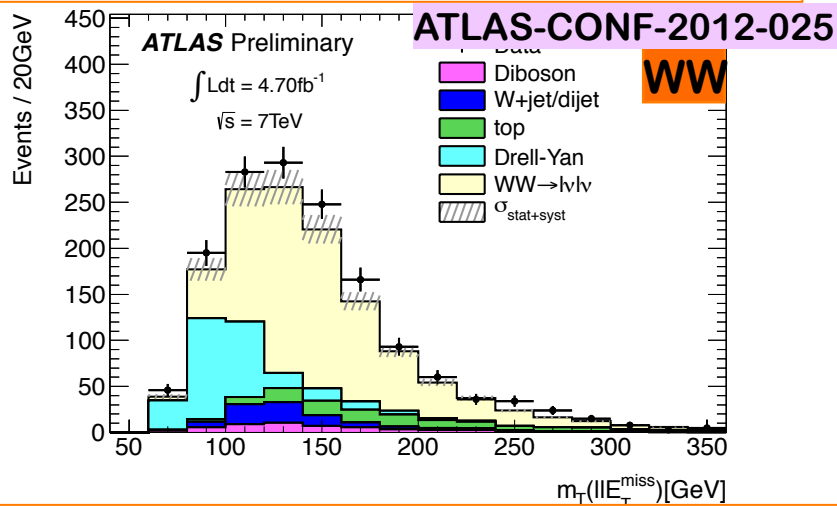
Higgs production



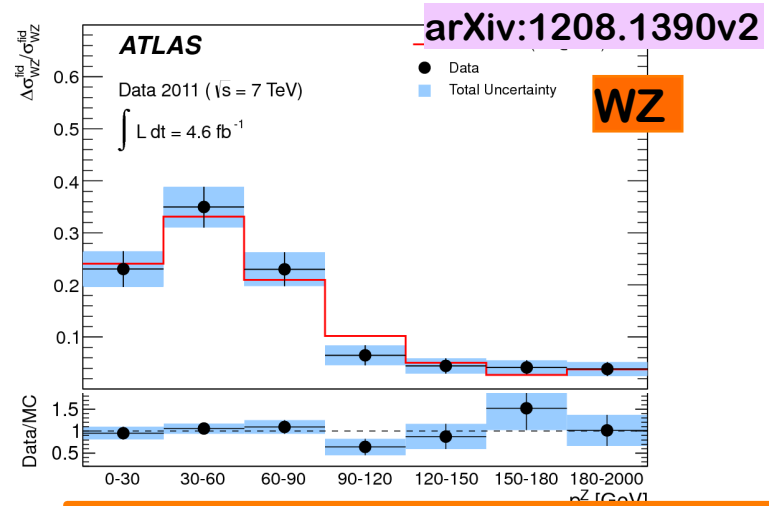


Di-boson (WW, WZ, ZZ) cross-sections

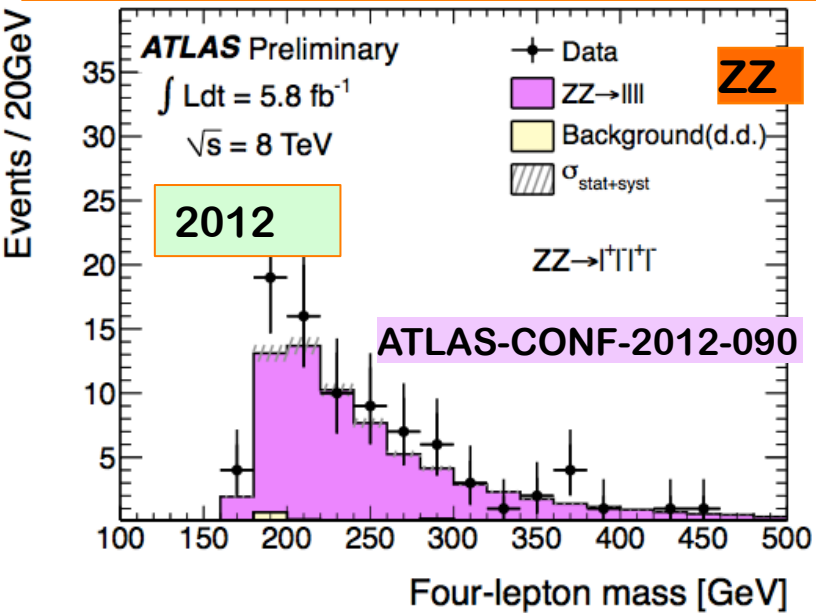
Measure cross section in WW→2l2ν channel



Measure cross section in WZ→3l1ν channel



Measure cross-section in channels: ZZ→4l and ZZ→2l2ν



Dedicated talk: A. G. Pedrinis

Process	σ_{meas} (pb)	σ_{NLO} (pb)	\sqrt{s}
WW	$53.4 \pm 2.1 \pm 4.5 \pm 2.1$	45.1 ± 2.8	
WZ	$19.0^{+1.4}_{-1.3} \pm 0.9 \pm 0.4$	$17.6^{+1.1}_{-1.0}$	7 TeV
ZZ	$7.2^{+1.1}_{-0.9} \pm 0.4 \pm 0.3$	$6.5^{+0.3}_{-0.2}$	
ZZ	$9.3^{+1.1}_{-1.1} \pm 0.4 \pm 0.3$	7.4 ± 0.4	8 TeV

- Good agreement with SM prediction
 - Di-boson cross-sections are calculated up to NLO with uncertainty of about 5%



Limits on Charged Triple Gauge Coupling

- Set limits to the anomalous couplings assuming an effective Lagrangian with EW gauge and CP invariance

$$\frac{\mathcal{L}_{WWV}}{g_{WWV}} = i \left[g_1^V (W_{\mu\nu}^\dagger W^\mu V^\nu - W_{\mu\nu} W^{\dagger\mu} V^\nu) + \kappa^V W_\mu^\dagger W_\nu V^{\mu\nu} + \frac{\lambda^V}{m_W^2} W_{\rho\mu}^\dagger W_\nu^\mu V^{\nu\rho} \right]$$

- CP invariance + EM gauge invariance → 5 independent couplings: $g_1^Z, k_\gamma, k_Z, \lambda_\gamma, \lambda_Z$
 In SM: $g_1^Z=1, k_\gamma=k_Z=1, \lambda_\gamma=\lambda_Z=0$

arXiv:1208.1390v2

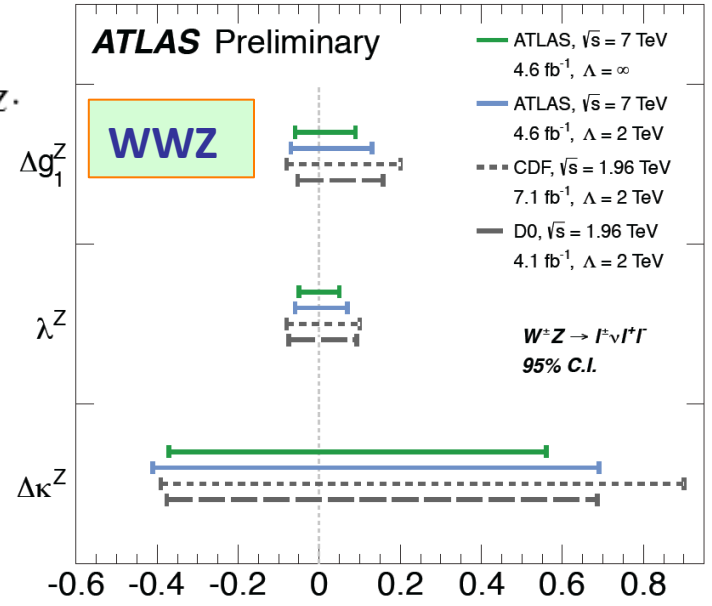
- TGC are studied as deviation wrt SM → 5 'Anomalous Coupling':

$$\Delta g_1^Z \equiv g_1^Z - 1, \quad \Delta \kappa_\gamma \equiv \kappa_\gamma - 1, \quad \Delta \kappa_Z \equiv \kappa_Z - 1, \quad \lambda_\gamma, \quad \text{and} \quad \lambda_Z.$$

- in SM: $\Delta g_1^Z=0, \Delta \kappa_\gamma=\Delta \kappa_Z=0, \lambda_\gamma=\lambda_Z=0$

- MC@NLO is used to generate WZ events with non-SM TGC**
 - Amplitude grow with energy and eventually violate tree level unitarity → introduce a cutoff scale
- Anomalies appear as enhanced rates and modify event kinematics**
- To extract AC:**
 - fit p_T^Z differential distribution

Anomalous TGC limits at 95% confidence level



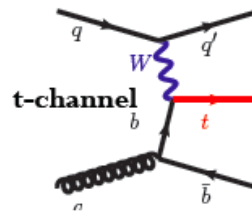
- Consistent with SM
- LHC limits are surpassing Tevatron



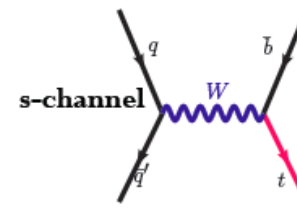
Single top t-channel at 7 and 8 TeV

- Background to Higgs and other searches
- Difficult to extract signal from $t\bar{t}$ and W +jets backgrounds
 - requires “advanced” analysis techniques (NN)

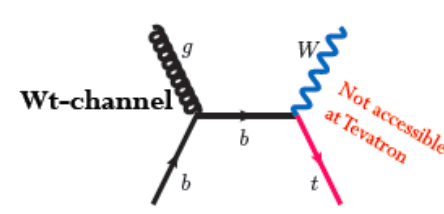
ATLAS-CONF-2012-132



Theory 7TeV $64.6 \pm 2.4 \text{ pb}$
 ATLAS 7TeV $83 \pm 20 \text{ pb}$

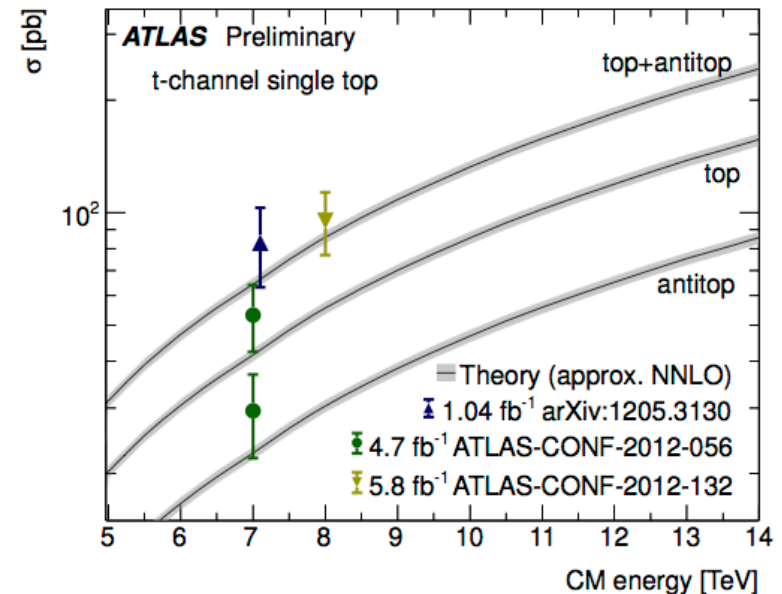
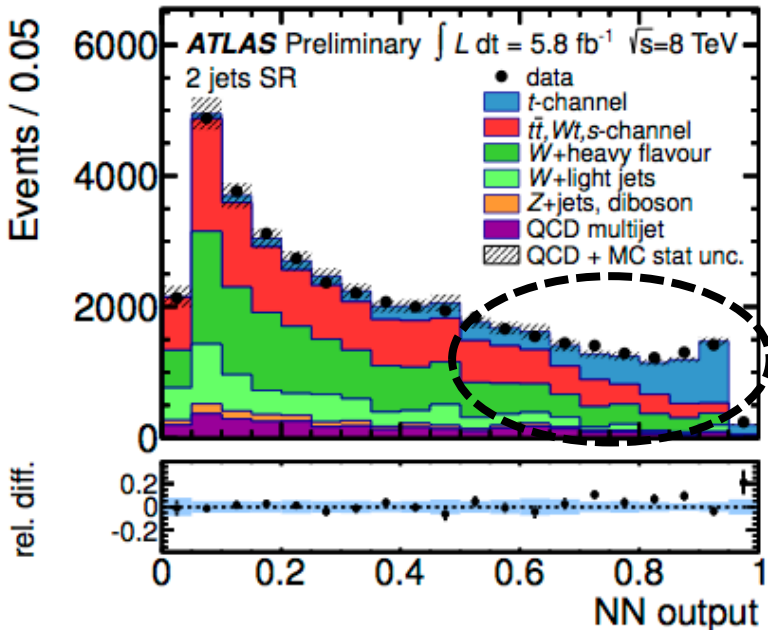


$4.6 \pm 0.2 \text{ pb}$
 $< 26.5 \text{ pb}$



$15.7 \pm 1.1 \text{ pb}$
 $17 \pm 6 \text{ pb}$ @3.3 σ

Single top t-channel x-sections at 7 and 8 TeV



At 8 TeV $\sigma_t(t) = 95.1 \pm 2.4 \text{ (stat.)} \pm 18.0 \text{ (syst.) pb}$

$$|V_{tb}| = 1.04^{+0.10}_{-0.11}$$

Theory (8 TeV) $\sigma_t(t) = 87.8 \pm 3.4 \text{ pb}$

$$|V_{tb}| < 1 \quad \rightarrow \quad |V_{tb}| > 0.80 \text{ at 95\% CL}$$

Dedicated talk: J. Schavancova

μ



μ

μ

Search for the SM Higgs Boson

Related ATLAS talks:
E. Paganis, Y. Coadou, S.Kreiss

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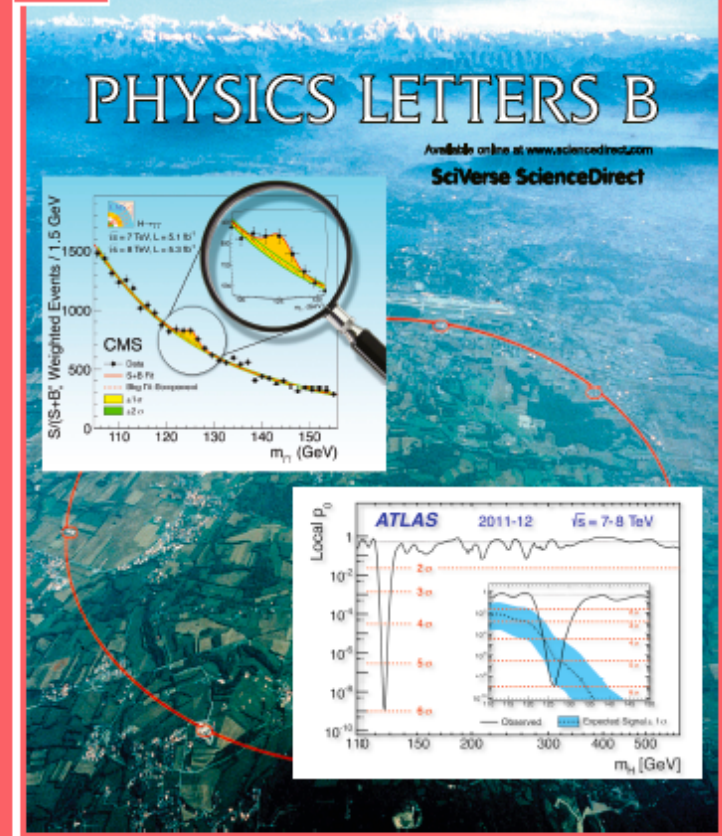
PHYSICS LETTERS B Vol. 716 (2012) 1-294

ELSEVIER

Volume



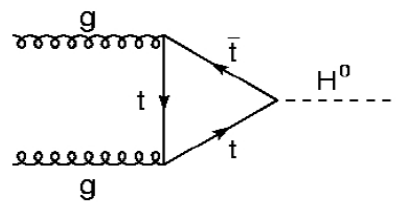
ATLAS and CMS papers
Phys. Lett. B716 (2012)



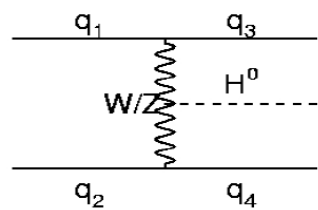


Higgs production and decay rates at $\sqrt{s} = 8$ TeV

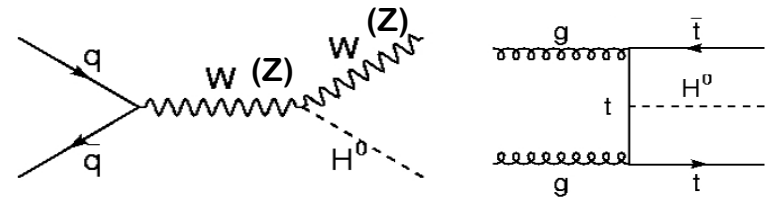
Gluon Fusion
 $pp \rightarrow H$



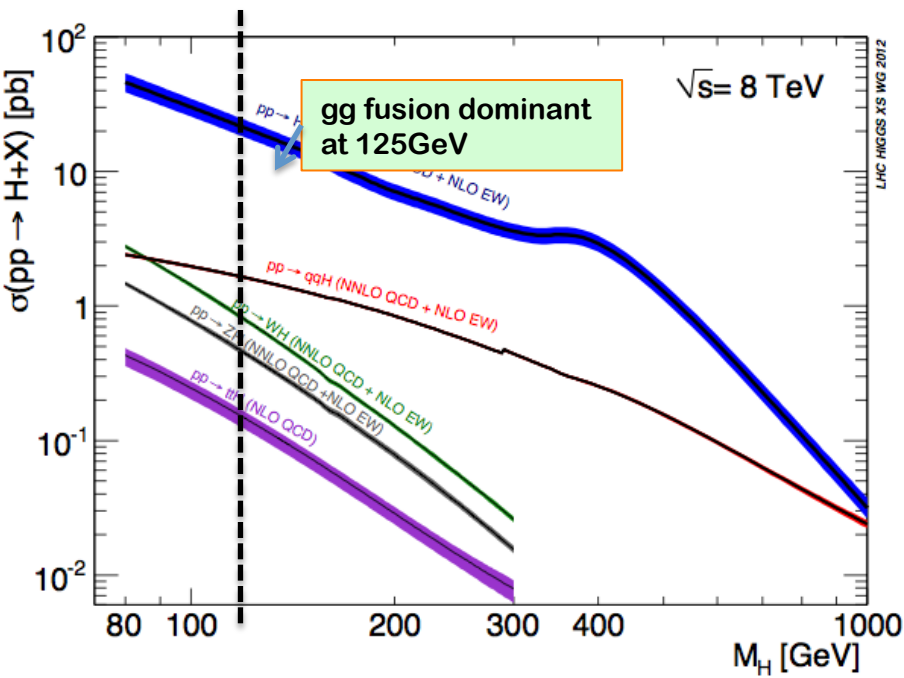
Vector Boson Fusion:
 $pp \rightarrow qqH$



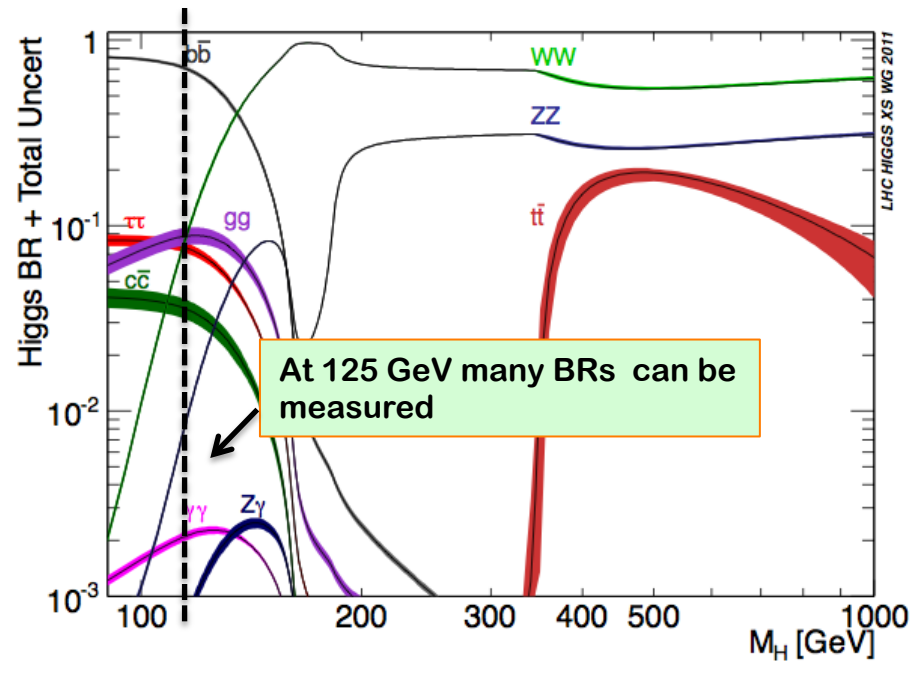
Associated Production:
 $pp \rightarrow WH, ZH, ttH$



Higgs production cross-section vs M_H



Higgs decay channels: BRs depend on Higgs mass



$\sqrt{s} = 7 \rightarrow 8$ TeV: Higgs cross-section increases by ~ 1.3 for $m_H \sim 125$ GeV

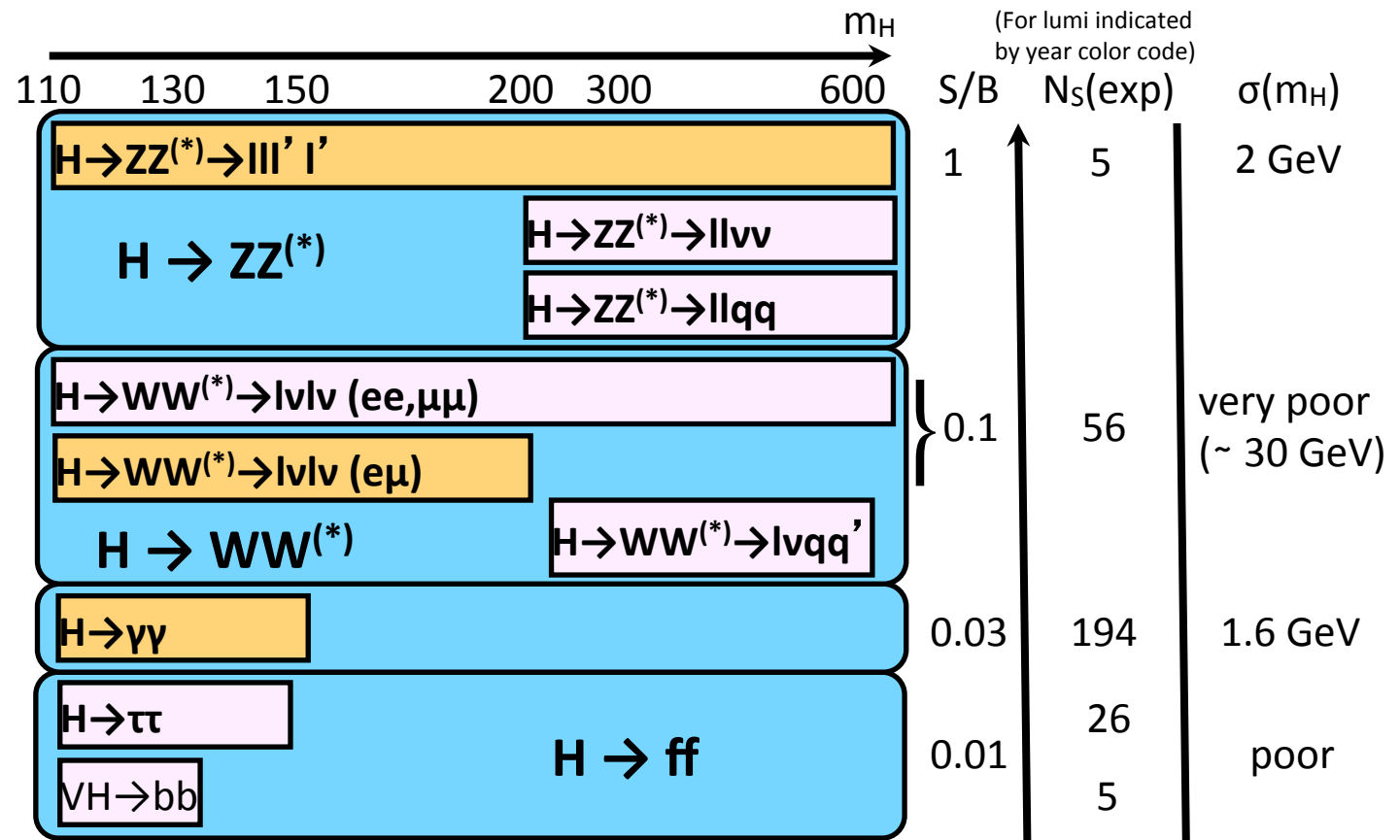


Standard Model Higgs Search Channels

- Channels and luminosity currently used in **2011** and **2012** ATLAS Higgs Combination
- In 2012 analyses re-optimised for high pileup and to enhance sensitivity to low m_H (i.e. improvement in the electr. reconstruction and identification)
- All selections and analysis techniques fixed before looking at 2012 data : blinded analysis

2011 only:
~ 4.9 fb⁻¹

2011+2012:
~ 4.9+5.9 fb⁻¹



numbers are for $m_H = 125$ GeV

Dedicated talk: E. Paganis



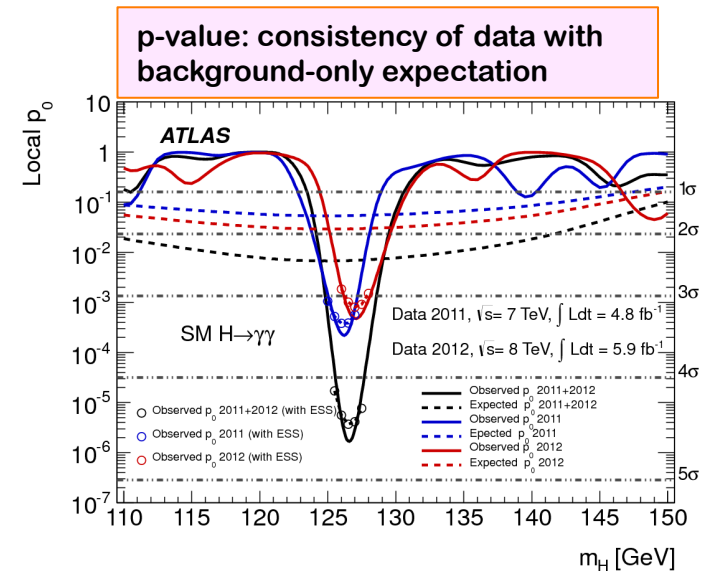
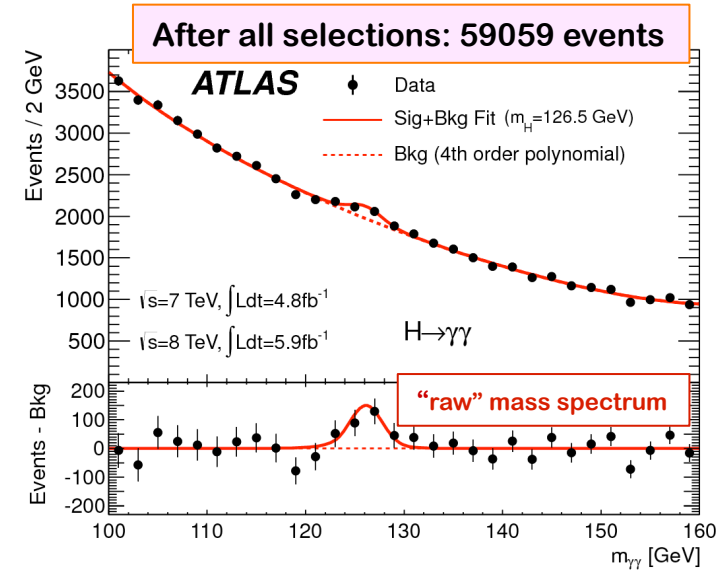
H → $\gamma\gamma$ channel search

Production and decay through loops: sensitive to t/W Higgs couplings and to new physics

- Select 2 isolated photon events ($E_T > 40, 30$ GeV)
- Look for narrow peak in the $m_{\gamma\gamma}$ distribution
 - Very large irreducible (continuum di-photons) and reducible (γ -jet, jet-jet) backgrounds
 - Background extrapolated from sidebands using data
 - Signal is extracted by fitting $m_{\gamma\gamma}$ in 10 categories with different S/B ratio and $m_{\gamma\gamma}$ resolution
 - new category (in 2011+2012) with 2 forward jets (sensitive to VBF)
 - Signal only visible if excellent mass resolution (1.6 GeV) → reconstruct angles and energies of photons
 - energy resolution below 1%
 - photon direction resolution below 5 mrad (i.e. vertex res. < 1.5 cm)

Most significant deviation from background-only hypothesis at $m_H = 126.5$ GeV

- Local significance of 4.5σ (expected 2.5σ)



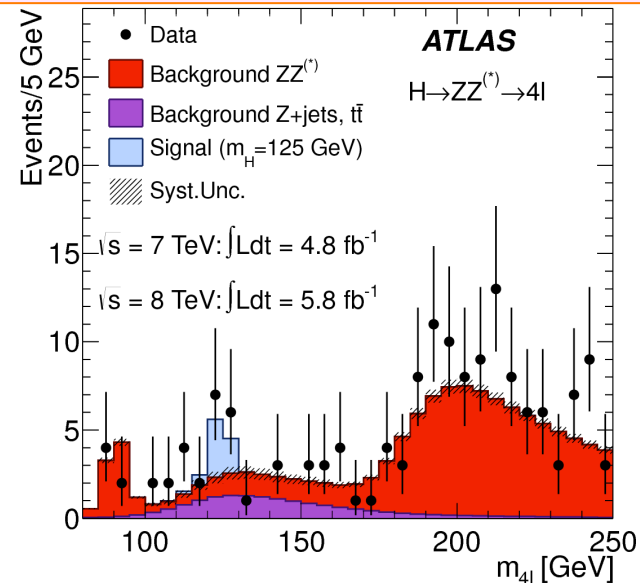


H → ZZ(*) → 4l (l=e,μ) search

The golden channel – very few events but S/B ~1!

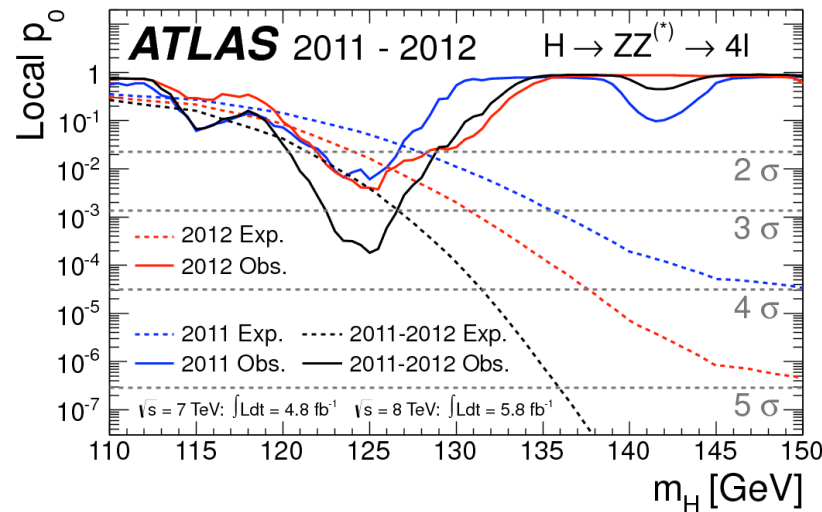
- Select four isolated leptons
- Main backgrounds:
 - Irreducible bkg: continuum ZZ*
 - Reducible bkg (low mass): Z+bbar, Z+ light jets, ttbar with two leptons from b-jets or q-jets
- Key-points:
 - Very high lepton reco/ID efficiency needed: down to low p_T and largest possible coverage
 - Excellent mass resolution
 - improved by using Z-constraint on leading lepton pair

Reconstructed 4l mass spectrum after all selections



Most significant deviation from background-only hypothesis at $m_H=125$ GeV.

- Local p_0 -value corresponding to 3.6σ (2.7σ expected)
- Both, 2011 and 2012 data contribute to excess in the same mass range.

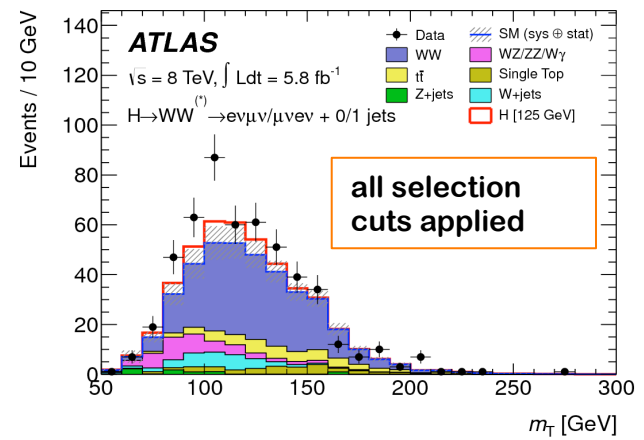
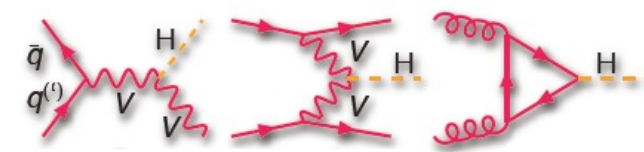




H → WW(*) → |ν|'ν search

Large cross-section but 2ν in final state → mass peak cannot be reconstructed → “counting channel”

- Higher pile-up in 2012: higher Drell-Yan background for same flavour final state
→ **2012 result only for different flavour final state (H → eνμν)**
- Different signal productions lead to different kinematic signatures and jet multiplicities
- Backgrounds different for each jet multiplicity:
 - H+0 jet: WW, Z/W+jets
 - H+1 jet: WW, top (ttbar, Wt, single top)
 - H+≥2 jets: ttbar, single top
 → analysis carried out in different jet multiplicity bins
- Main handles to fight backgrounds:
 - WW: spin correlations and topological cuts,
 - top bkg: b-tagging veto

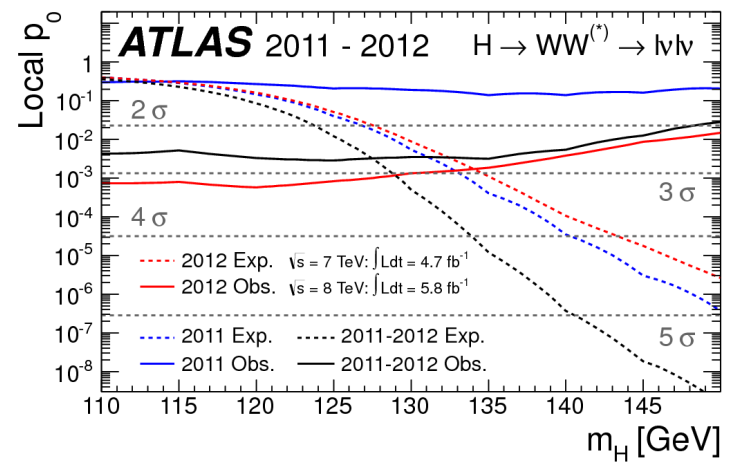


Transverse mass is the discriminant used :

$$m_T = \sqrt{(E_T^{\ell\ell} + E_T^{\text{miss}})^2 - |\mathbf{p}_T^{\ell\ell} + \mathbf{E}_T^{\text{miss}}|^2}$$

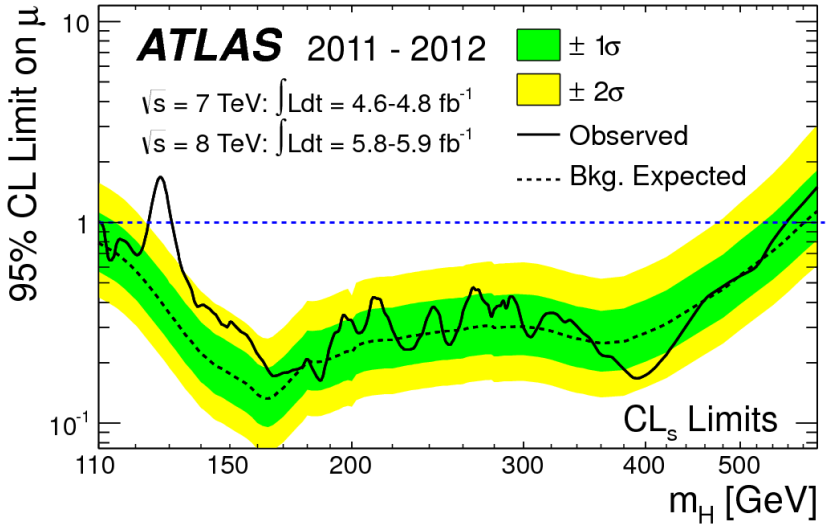
Final results obtained from binned likelihood fits to m_T distribution:

- Broad excess observed (due to poor mass resolution)
- **Significant deviation from background-only hypothesis:**
 - e.g. at $m_H=125$ GeV observed 2.8σ
- (2.3 σ expected)



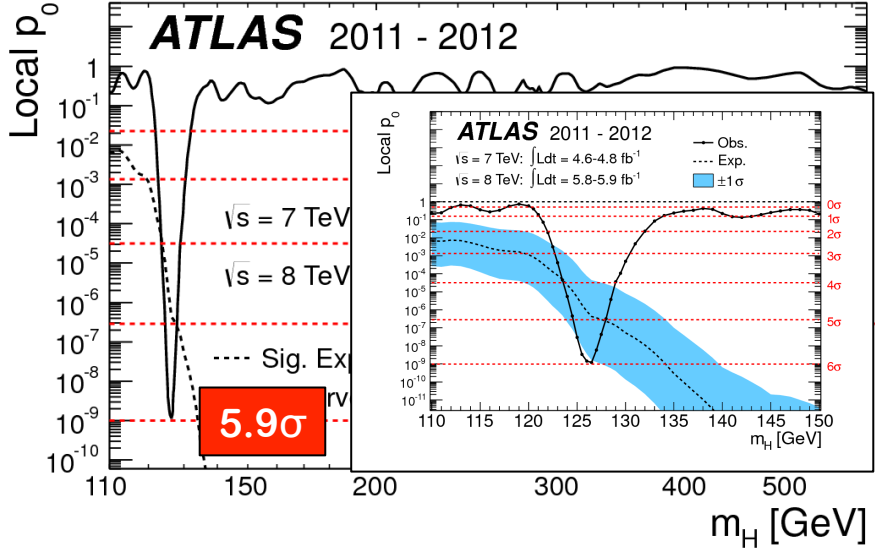


Higgs Searches Combination (2011+2012)



Excluded masses at 95% CL :

- Observed : 112-122 GeV and 131-559 GeV
- Expected : 110 GeV to 582 GeV



Maximum excess observed at $m_H=126.5 \text{ GeV}$

- Local significance **5.9 σ**
- Expected: 4.9 σ

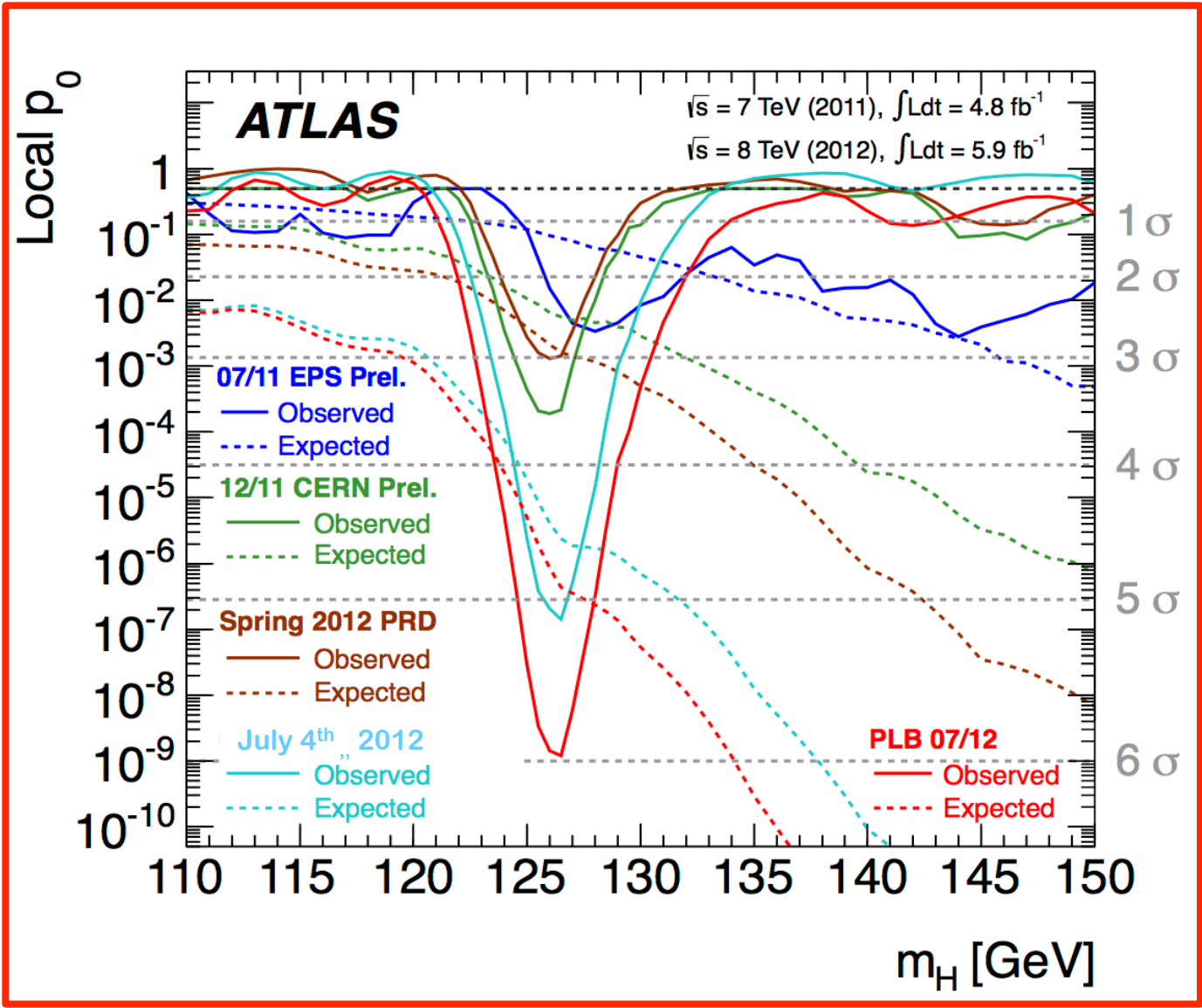
(Global significance: $\sim 5.2 \sigma$)

- Probability of background fluctuation to the observation: 1.7×10^{-9}

Dedicated talk : Sven Kreiss



Evolution of the excess with time



Significance increase from 4th July to the PLB from including $H \rightarrow WW^*$ search for 2012 data (from 5.2 to 5.9 σ)

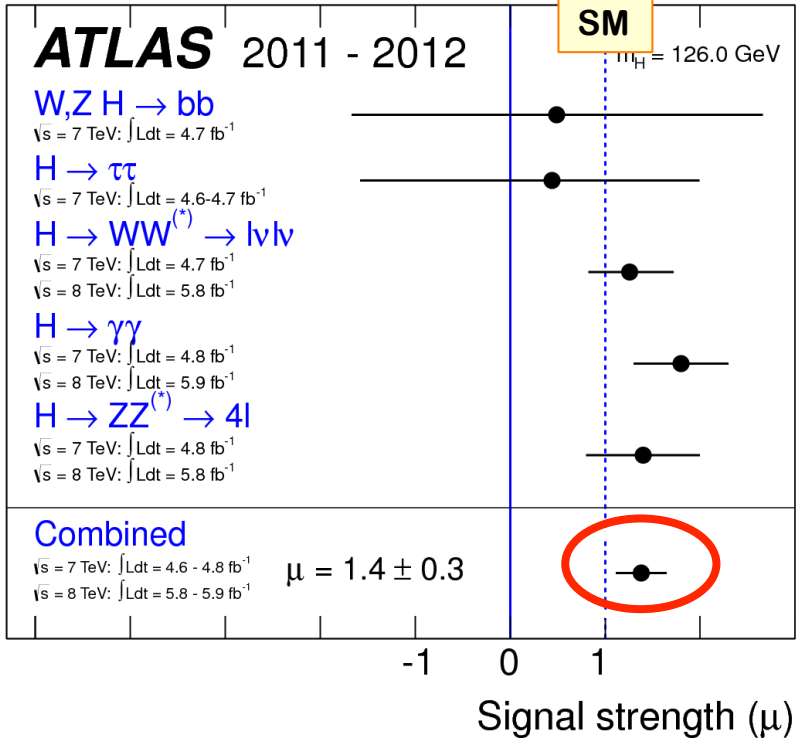


Mass and Signal strength of the new particle

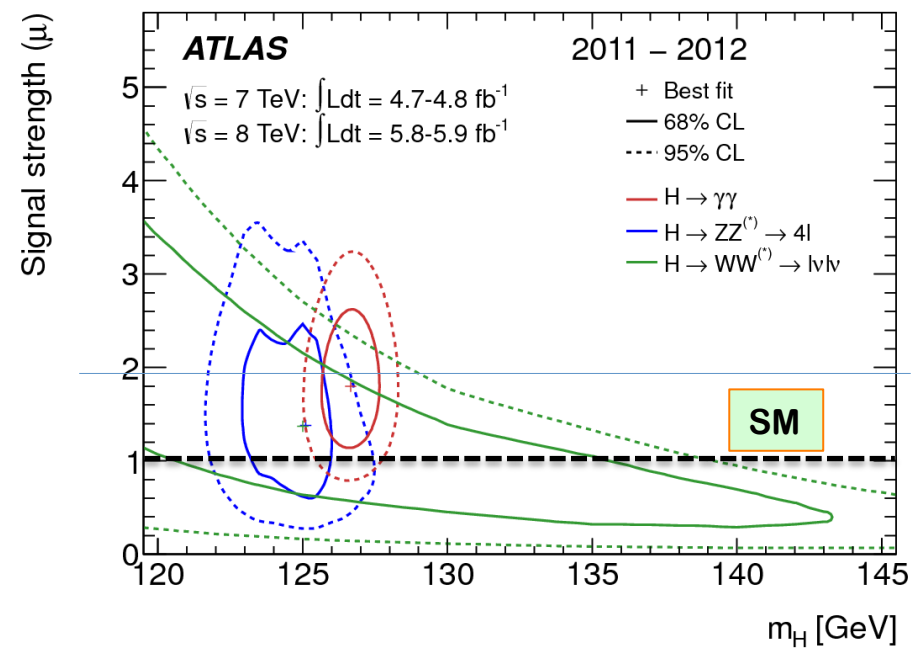
Estimated mass:

$$m_H = 126 \pm 0.4 \text{ (stat)} \pm 0.4 \text{ (syst) GeV}$$

μ = signal strength normalized to the SM Higgs expectation at $m_H = 126$ GeV



2-dim likelihood fit to mass and signal strength (for $H \rightarrow ZZ^{(*)} \rightarrow 4l$ and $H \rightarrow \gamma\gamma$)

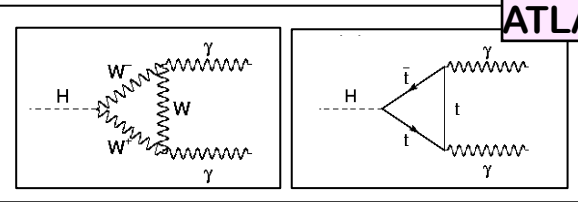
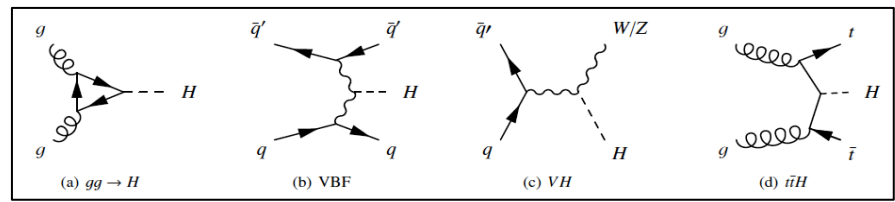


Best-fit value at 126 GeV:
 $\mu = 1.4 \pm 0.3$
 → good agreement with the expectation for a SM Higgs within the present statistical uncertainty



First measurements of couplings

ATLAS-CONF-2012-127

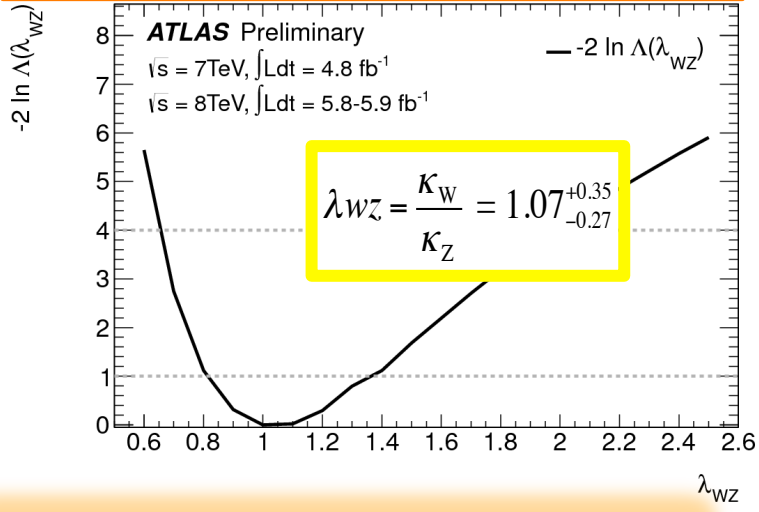


$$K_i^2 = \frac{\Gamma_i^{\text{data}}}{\Gamma_i^{\text{SM}}}$$

Several benchmarks to probe different aspects/deviation from SM boson couplings, a few examples:

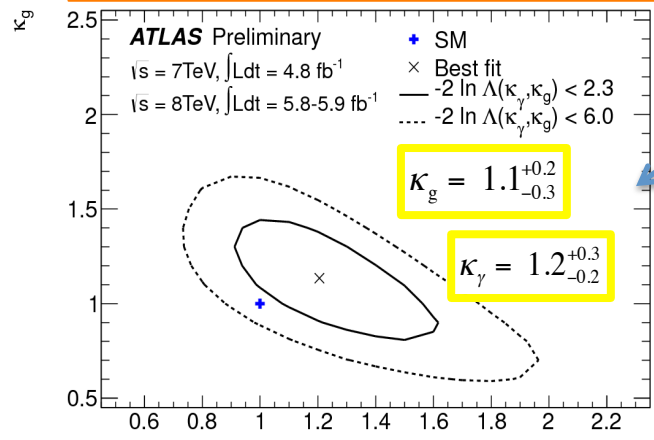
Probing the custodial symmetry from the ratio of HWW to HZZ coupling

λ_{WZ} should be 1 to be consistent with EW precision data ($\rho=1$ measured at LEP)



No significant deviation from the prediction for a SM Higgs

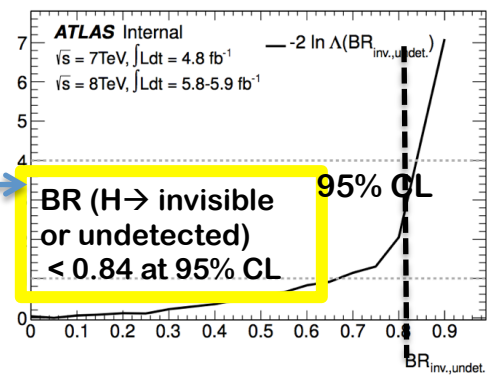
Probing potential non-SM contributions: new particles in the $gg \rightarrow H$ and $H \rightarrow \gamma\gamma$ loops?



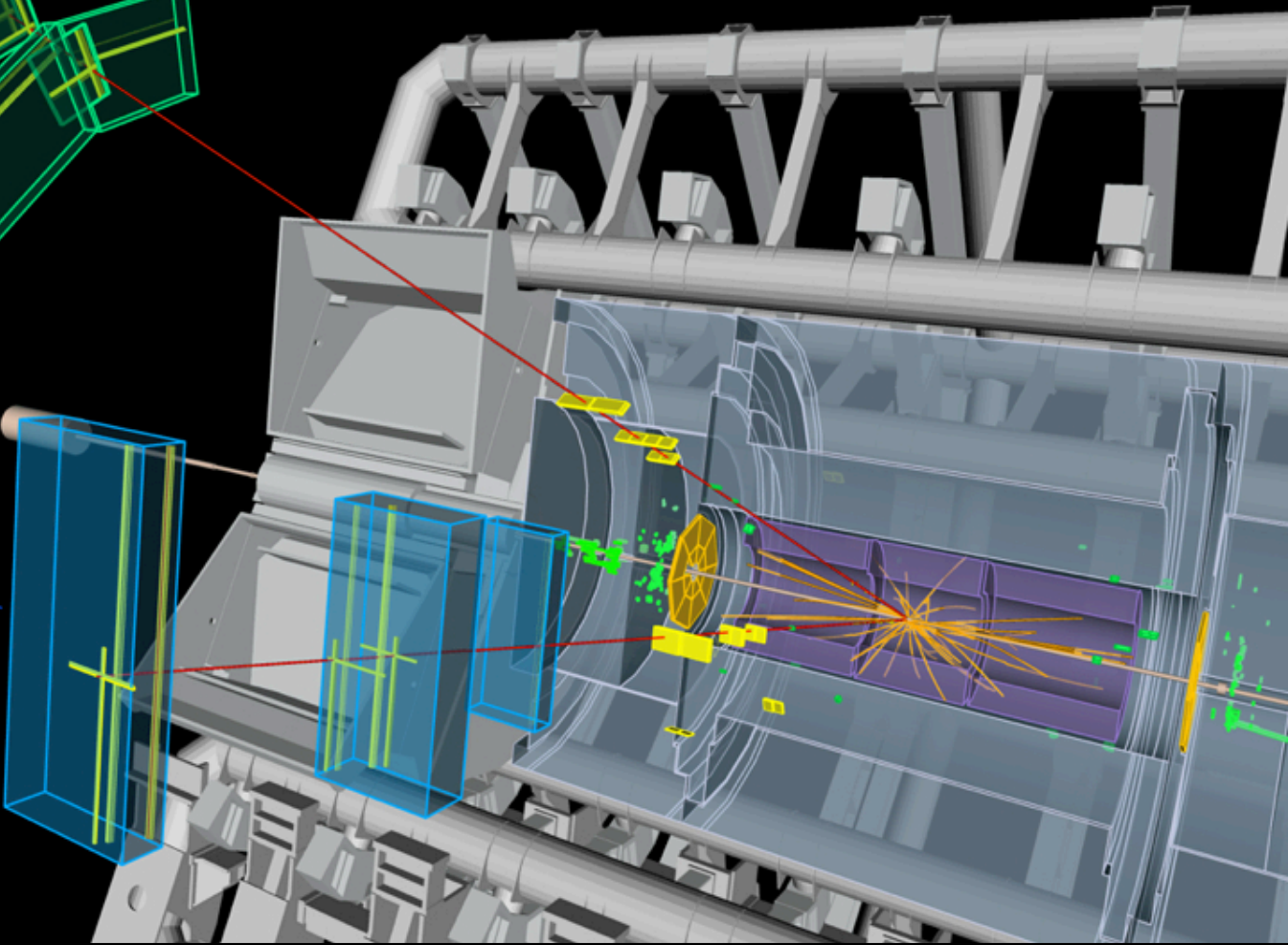
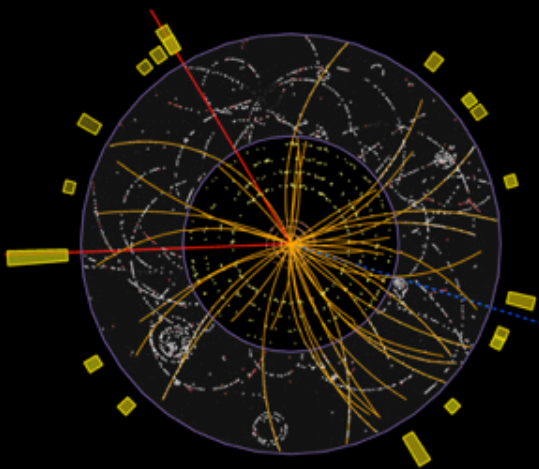
Assuming only SM contribution to Higgs width

New final states?

No assumption on the total H width



Dedicated talk : S. Kreiss



Run 167776, Event 129360643
Time 2010-10-28 10:41:18 CET

Supersymmetry

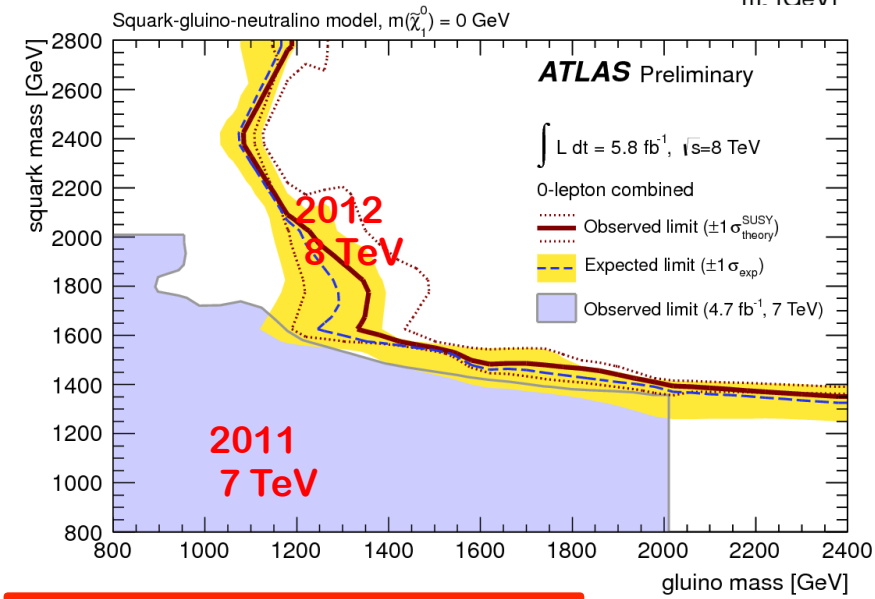
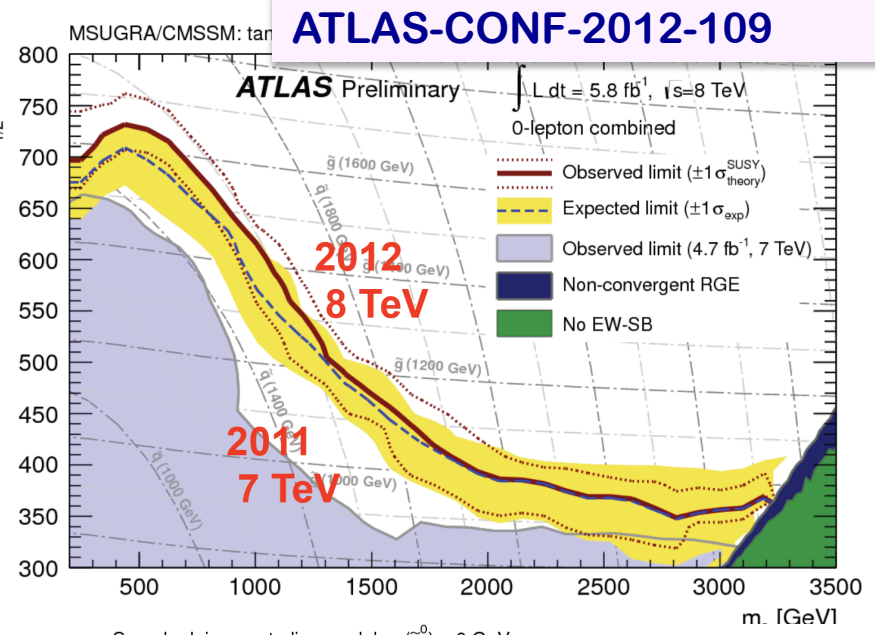
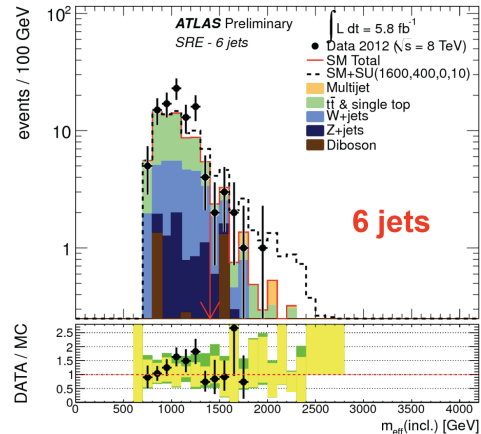
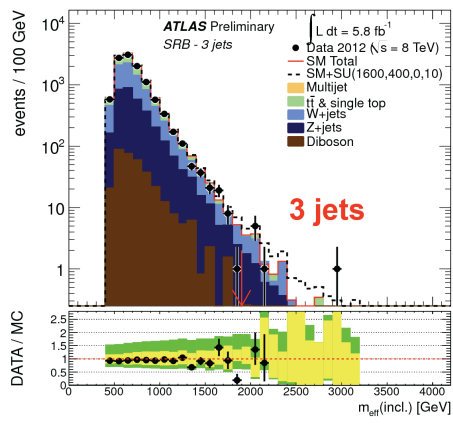
Related ATLAS talks :
G. Gaudio, Y. Coadou, L.S.Ancu



SUSY inclusive searches with 2012 Data

Inclusive search for events with 2-6 jets and E_t^{miss} (0 leptons). M_{eff} definition

$$M_{\text{eff}} = \sum p_T^{\text{jets}} + E_t^{\text{miss}} (+ p_T^{\text{lepton}})$$



no excess above SM background observed

MSUGRA/CMSSM interpretation

- $\tan \beta = 10, A_0 = 0, \mu > 0: m_{1/2} < 350 \text{ GeV}$ excluded
- For equal squark and gluino masses: $m(\tilde{q}), m(\tilde{g}) < 1500 \text{ GeV}$ excluded

Simplified squark-gluino model :

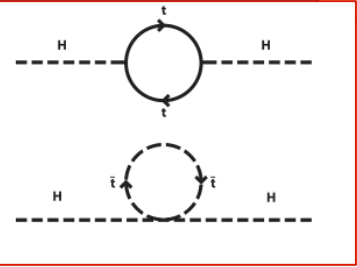
- $m(\tilde{g}) < 1100 \text{ GeV}$

Dedicated talk: G. Gaudio

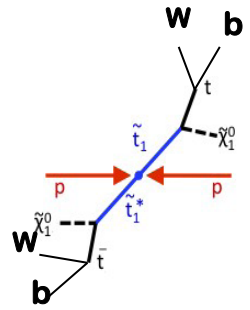
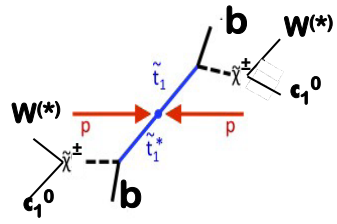
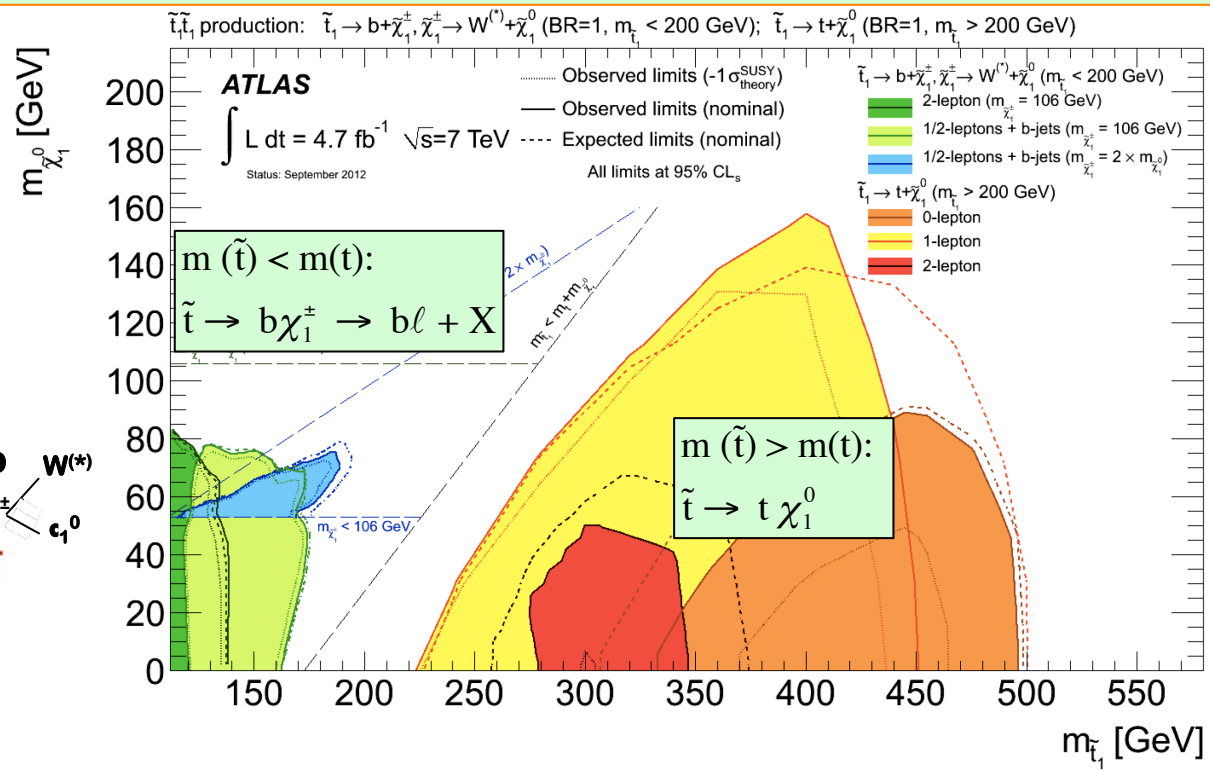


SUSY – Direct Stop pair searches

- Limits for inclusive searches are much more stringent on the first two generations squarks
- Stop must be light (below TeV scale) to cancel large top corrections to Higgs mass (fine-tuning) → natural SUSY



arXiv: 1208.1447,
1208.2590;
ATLAS-CONF-2012-059,
070, 071



Many different scalar top searches with 7 TeV data covering masses up to 500 GeV

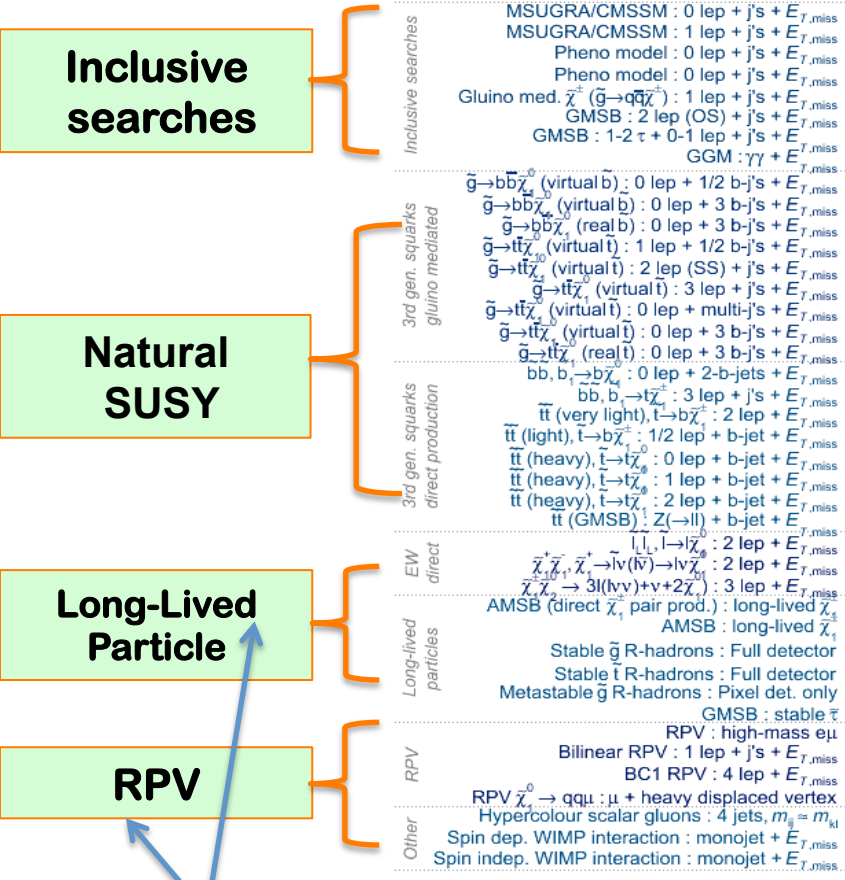


- For $m_{\text{stop}} \approx m_{\text{top}}$ need more powerful discriminating variables
- By end 2012 ($\sim 30 \text{ fb}^{-1}$): expect to cover stop masses up to $\sim 700\text{-}800$ GeV



SUSY Summary

ATLAS seriously attack to Weak scale SUSY between 100 GeV and 1 TeV



ATLAS SUSY Searches* - 95% CL Lower Limits (Status: SUSY 12)

$L=5.8 \text{ fb}^{-1}, 8 \text{ TeV}$ [ATLAS-CONF-2012-109]	1.50 TeV	$\tilde{q} = \tilde{g}$ mass
$L=5.8 \text{ fb}^{-1}, 8 \text{ TeV}$ [ATLAS-CONF-2012-104]	1.24 TeV	$\tilde{q} = \tilde{g}$ mass
$L=5.8 \text{ fb}^{-1}, 8 \text{ TeV}$ [ATLAS-CONF-2012-109]	1.18 TeV	\tilde{g} mass ($m(\tilde{g}) < 2 \text{ TeV}$, light $\tilde{\chi}_0^0$)
$L=5.8 \text{ fb}^{-1}, 8 \text{ TeV}$ [ATLAS-CONF-2012-109]	1.38 TeV	\tilde{q} mass ($m(\tilde{q}) < 2 \text{ TeV}$, light $\tilde{\chi}_0^0$)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [ATLAS-CONF-2012-041]	900 GeV	\tilde{g} mass ($m(\tilde{g}) < 200 \text{ GeV}$, $m(\tilde{\chi}^{\pm}) = \frac{1}{2}(m(\tilde{\chi}_1^{\pm}) + m(\tilde{g}))$)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [Preliminary]	1.24 TeV	\tilde{g} mass ($\tan\beta < 15$)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [ATLAS-CONF-2012-112]	1.20 TeV	\tilde{g} mass ($\tan\beta > 20$)
$L=4.8 \text{ fb}^{-1}, 7 \text{ TeV}$ [ATLAS-CONF-2012-072]	1.07 TeV	\tilde{g} mass ($m(\tilde{\chi}_1^{\pm}) > 50 \text{ GeV}$)
$L=2.1 \text{ fb}^{-1}, 7 \text{ TeV}$ [1203.6193]	900 GeV	\tilde{g} mass ($m(\tilde{\chi}_1^{\pm}) < 300 \text{ GeV}$)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [1207.4686]	1.02 TeV	\tilde{g} mass ($m(\tilde{\chi}_1^{\pm}) < 400 \text{ GeV}$)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [1207.4686]	1.00 TeV	\tilde{g} mass ($m(\tilde{\chi}_1^{\pm}) = 60 \text{ GeV}$)
$L=2.1 \text{ fb}^{-1}, 7 \text{ TeV}$ [1203.6193]	710 GeV	\tilde{g} mass ($m(\tilde{\chi}_1^{\pm}) < 150 \text{ GeV}$)
$L=5.8 \text{ fb}^{-1}, 8 \text{ TeV}$ [ATLAS-CONF-2012-105]	850 GeV	\tilde{g} mass ($m(\tilde{\chi}_1^{\pm}) < 300 \text{ GeV}$)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [ATLAS-CONF-2012-108]	760 GeV	\tilde{g} mass (any $m(\tilde{\chi}_1^{\pm}) < m(\tilde{g})$)
$L=5.8 \text{ fb}^{-1}, 8 \text{ TeV}$ [ATLAS-CONF-2012-103]	1.00 TeV	\tilde{g} mass ($m(\tilde{\chi}_1^{\pm}) < 300 \text{ GeV}$)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [1207.4686]	940 GeV	\tilde{g} mass ($m(\tilde{\chi}_1^{\pm}) < 50 \text{ GeV}$)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [1207.4686]	820 GeV	\tilde{g} mass ($m(\tilde{\chi}_1^{\pm}) = 60 \text{ GeV}$)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [ATLAS-CONF-2012-106]	480 GeV	b mass ($m(\tilde{\chi}_1^{\pm}) < 150 \text{ GeV}$)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [ATLAS-CONF-2012-108]	380 GeV	\tilde{g} mass ($m(\tilde{\chi}_1^{\pm}) = 2 m(\tilde{\chi}_1^{\pm})$)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [CONF-2012-059]	135 GeV	\tilde{t} mass ($m(\tilde{\chi}_1^{\pm}) = 45 \text{ GeV}$)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [CONF-2012-070]	120-173 GeV	\tilde{t} mass ($m(\tilde{\chi}_1^{\pm}) = 45 \text{ GeV}$)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [1208.1447]	380-465 GeV	\tilde{t} mass ($m(\tilde{\chi}_1^{\pm}) = 0$)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [CONF-2012-073]	230-440 GeV	\tilde{t} mass ($m(\tilde{\chi}_1^{\pm}) = 0$)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [CONF-2012-071]	298-305 GeV	\tilde{t} mass ($m(\tilde{\chi}_1^{\pm}) = 0$)
$L=2.1 \text{ fb}^{-1}, 7 \text{ TeV}$ [1204.6736]	310 GeV	\tilde{t} mass ($115 < m(\tilde{\chi}_1^{\pm}) < 230 \text{ GeV}$)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [CONF-2012-076]	93-180 GeV	\tilde{t} mass ($m(\tilde{\chi}_1^{\pm}) = 0$)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [CONF-2012-076]	120-330 GeV	$\tilde{\chi}_4^{\pm}$ mass ($m(\tilde{\chi}_1^{\pm}) = 0, m(\tilde{\nu}) = \frac{1}{2}(m(\tilde{\chi}_1^{\pm}) + m(\tilde{\chi}_1^{\pm}))$)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [CONF-2012-077]	60-500 GeV	$\tilde{\chi}_1^{\pm}$ mass ($m(\tilde{\chi}_1^{\pm}) = m(\tilde{\chi}_2^{\pm}), m(\tilde{\chi}_1^{\pm}) = 0, m(\tilde{\nu})$ as above)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [ATLAS-CONF-2012-111]	210 GeV	$\tilde{\chi}_1^{\pm}$ mass ($1 < \tau(\tilde{\chi}_1^{\pm}) < 10 \text{ ns}$)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [CF-2012-034]	118 GeV	$\tilde{\chi}_1^{\pm}$ mass ($1 < \tau(\tilde{\chi}_1^{\pm}) < 2 \text{ ns}$, 90 GeV limit in [0, 2.90] ns)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [ATLAS-CONF-2012-075]	985 GeV	\tilde{g} mass
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [ATLAS-CONF-2012-075]	683 GeV	\tilde{t} mass
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [ATLAS-CONF-2012-075]	910 GeV	\tilde{g} mass ($\tau(\tilde{g}) > 10 \text{ ns}$)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [ATLAS-CONF-2012-075]	310 GeV	$\tilde{\tau}$ mass ($5 < \tan\beta < 20$)
$L=1.1 \text{ fb}^{-1}, 7 \text{ TeV}$ [1109.3089]	1.32 TeV	$\tilde{\nu}_\tau$ mass ($\lambda_{311}=0.10, \lambda_{312}=0.05$)
$L=1.0 \text{ fb}^{-1}, 7 \text{ TeV}$ [1109.6606]	760 GeV	$\tilde{q} = \tilde{g}$ mass ($c\tau_{\tilde{q}} < 15 \text{ mm}$)
$L=2.1 \text{ fb}^{-1}, 7 \text{ TeV}$ [ATLAS-CONF-2012-035]	1.77 TeV	\tilde{g} mass
$L=4.4 \text{ fb}^{-1}, 7 \text{ TeV}$ [ATLAS-CONF-2012-113]	700 GeV	\tilde{q} mass ($3.0 \times 10^{-5} < \lambda_{211} < 1.5 \times 10^{-5}$, $1 \text{ mm} < c\tau < 1 \text{ m}$, \tilde{g} decoupled)
$L=4.6 \text{ fb}^{-1}, 7 \text{ TeV}$ [ATLAS-CONF-2012-110]	100-287 GeV	sgluon mass (incl. limit from 1110.2693)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [ATLAS-CONF-2012-084]	709 GeV	M^* scale ($m_\chi < 100 \text{ GeV}$, vector D5, Dirac χ)
$L=4.7 \text{ fb}^{-1}, 7 \text{ TeV}$ [ATLAS-CONF-2012-084]	548 GeV	M^* scale ($m_\chi < 100 \text{ GeV}$, tensor D9, Dirac χ)

$\int L dt = (1.00 - 5.8) \text{ fb}^{-1}$
 $\sqrt{s} = 7, 8 \text{ TeV}$
 ATLAS Preliminary

New results from 8 TeV

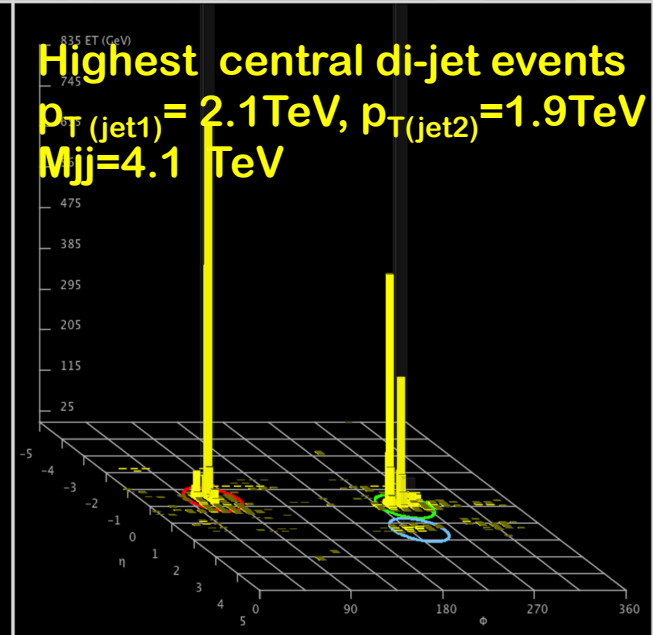
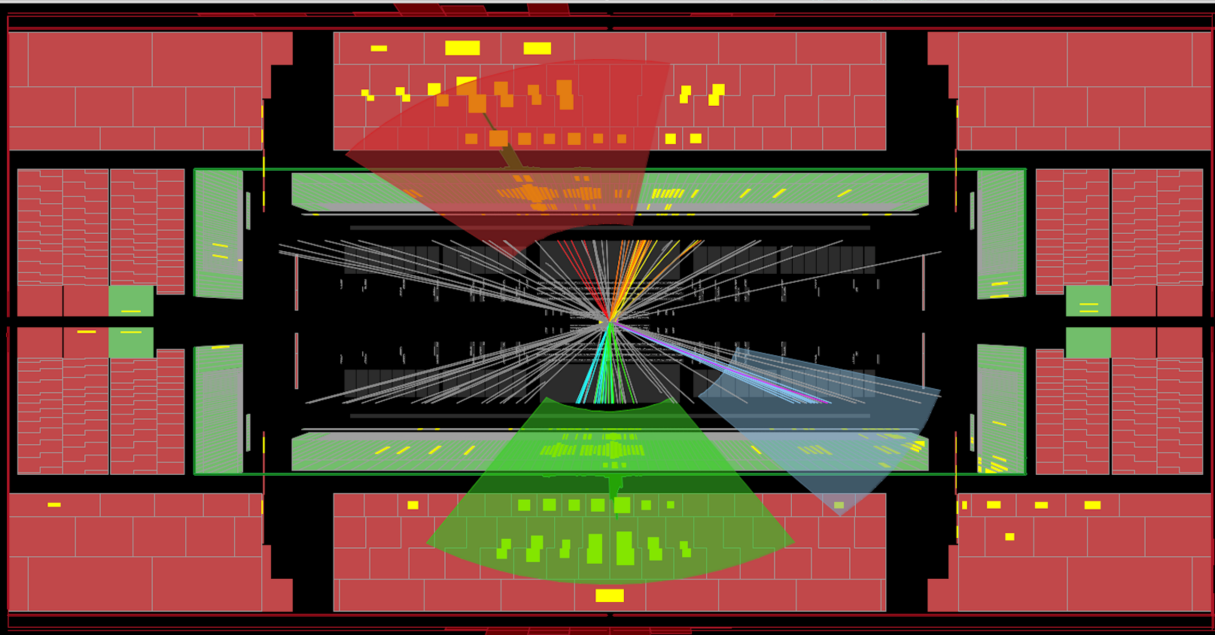
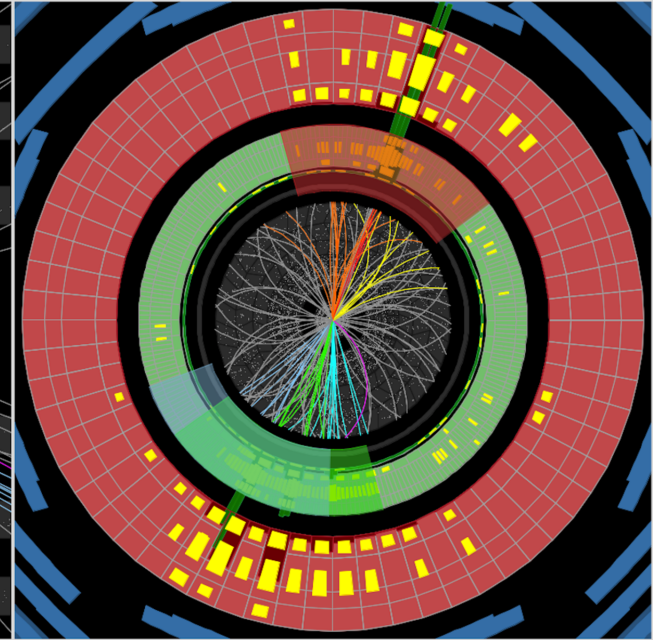
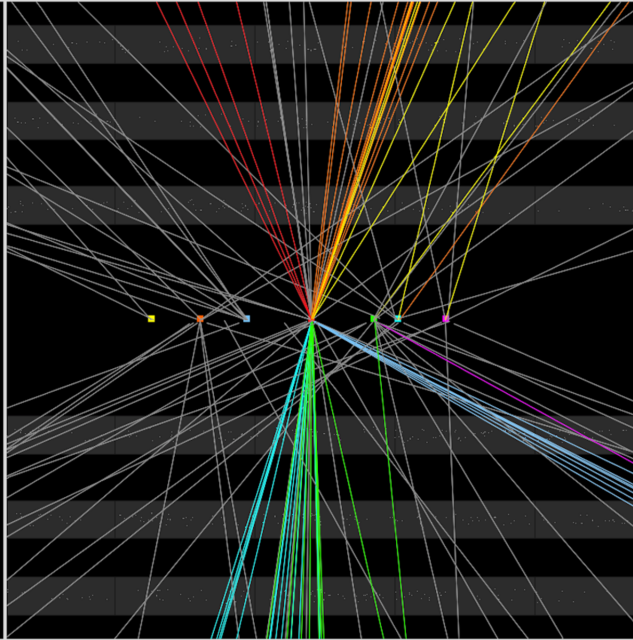
Dedicated talk : L.S. Anco

* Only selections of the available mass limits on new states or phenomena shown. All limits quoted are observed minus 1 σ theoretical signal cross section uncertainty.



Run Number: 205113, Event Number: 34879440

Date: 2012-06-18 12:25:45 CEST



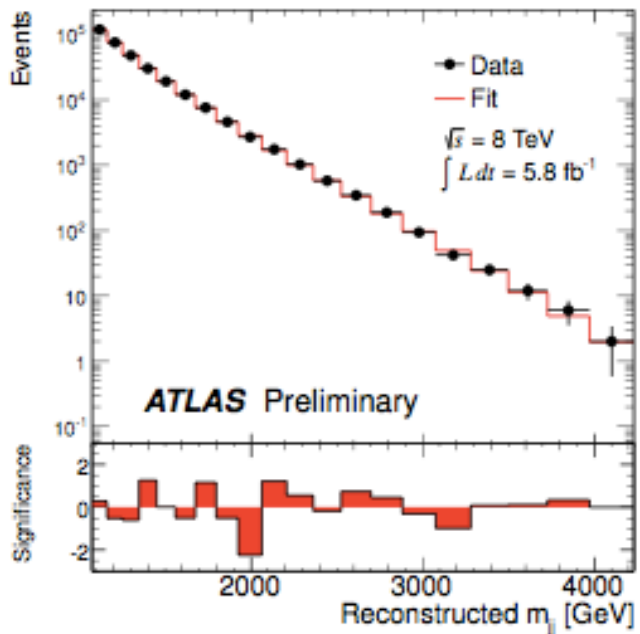
Exotics

Related ATLAS talks :
D. Pallin, M.S Cooke

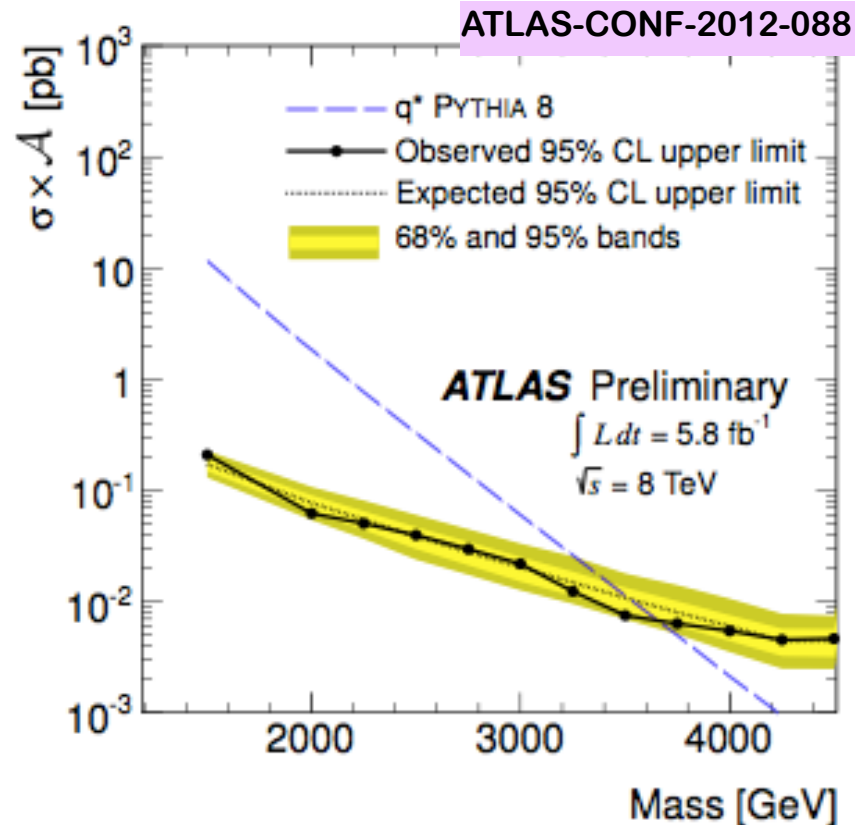


Di-Jet Mass Distribution at 8 TeV

- Excited quarks are a common prediction of composite models.



- Look for localised excesses in the dijet mass (m_{jj}) distribution
 - $m_{jj} > 1000$ GeV and $|y_{1,2}| < 2.8$
- Used the BumpHunter algorithm to look for resonances

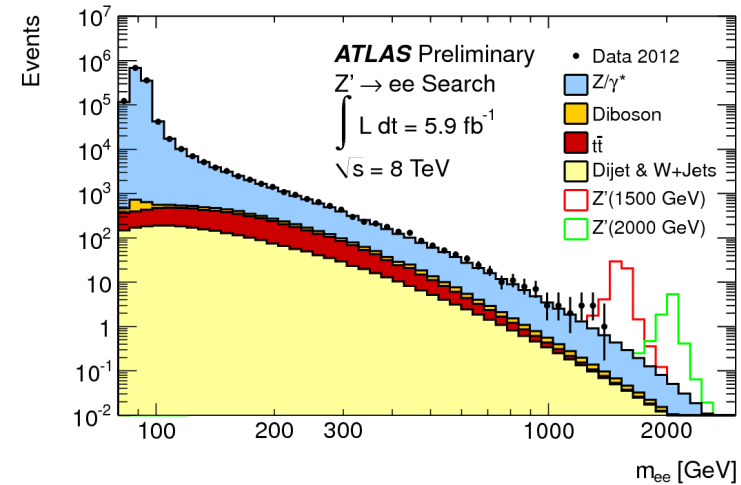
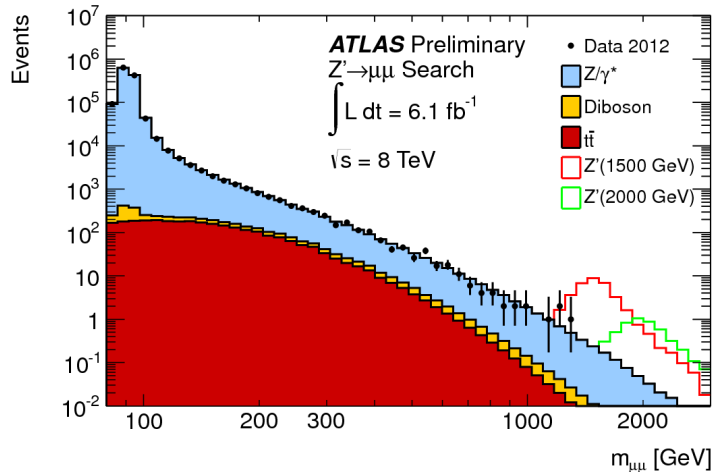


**No excess of events found
Excited quarks (q^*) excluded
up to a mass > 3.66 TeV (95% C.L.)**



High mass Di-leptons at 8 TeV

ATLAS-CONF-2012-129

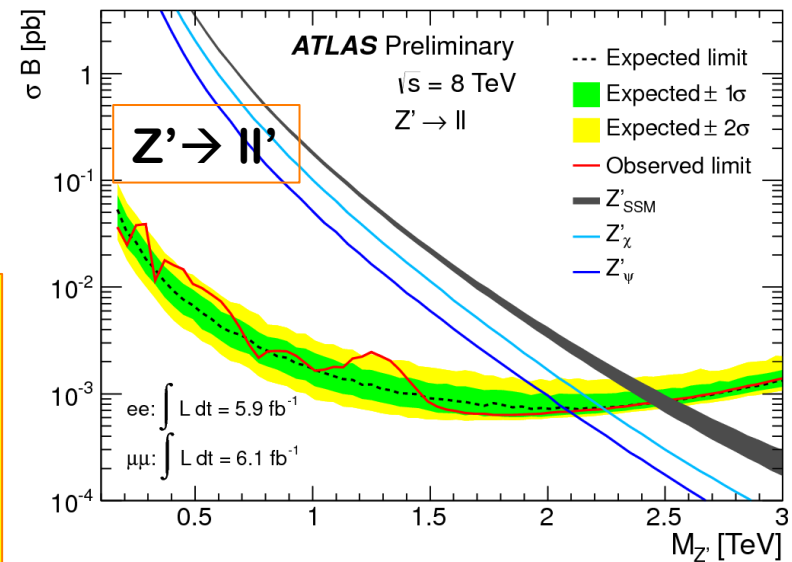


- Search for narrow di-lepton resonances
Selection:
 - Two Isolated, High P_T Electrons or Muons
- Main backgrounds:
 - Drell-Yan, W, Top, QCD fakes (data-driven)

No excess over SM

Limits on σB for $Z' \rightarrow \ell\ell$ ($e+\mu$ channels combined):

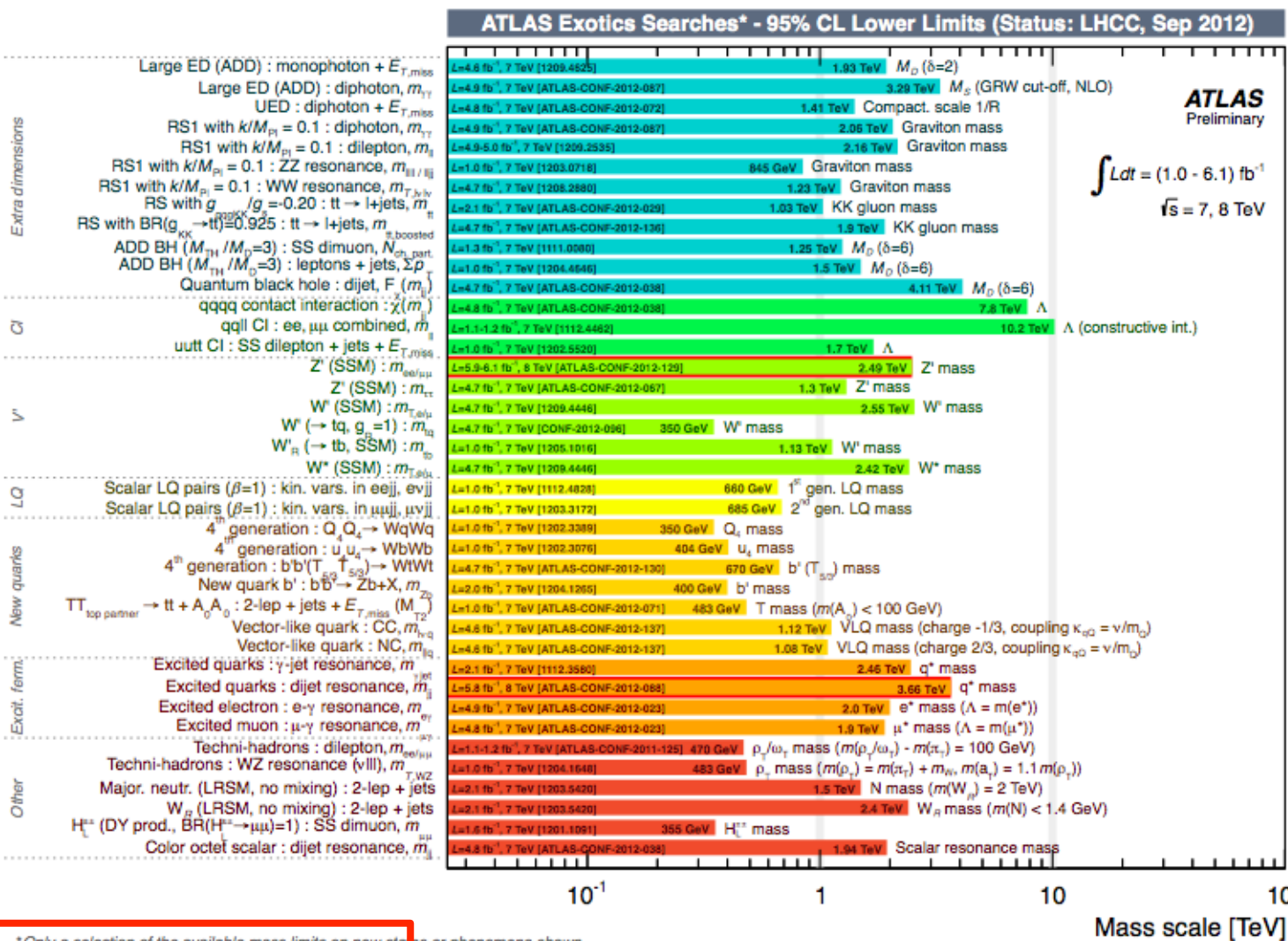
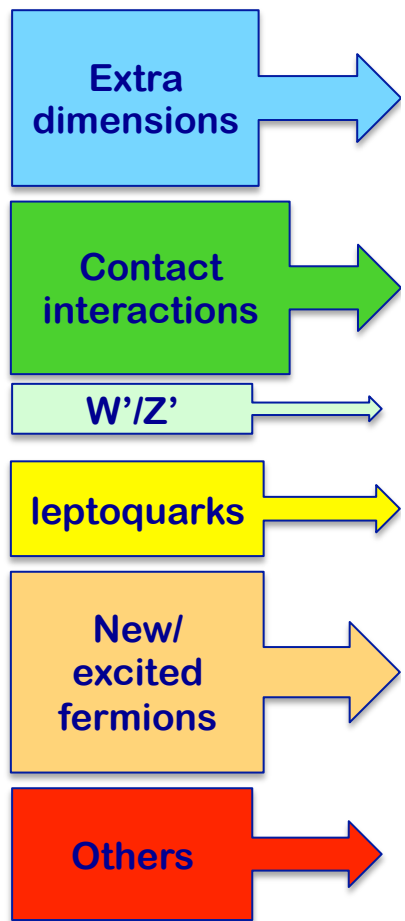
- $Z'_{\text{SSM}} > 2.49 \text{ TeV}$ at 95% C.L.
- $E6 \rightarrow \text{SU}(5)+2\text{U}(1) Z' > 2.09\text{-}2.24 \text{ TeV}$ at 95% C





Exotics

No hints for New Physics so far ...



Dedicated talk : M.S. Cooke



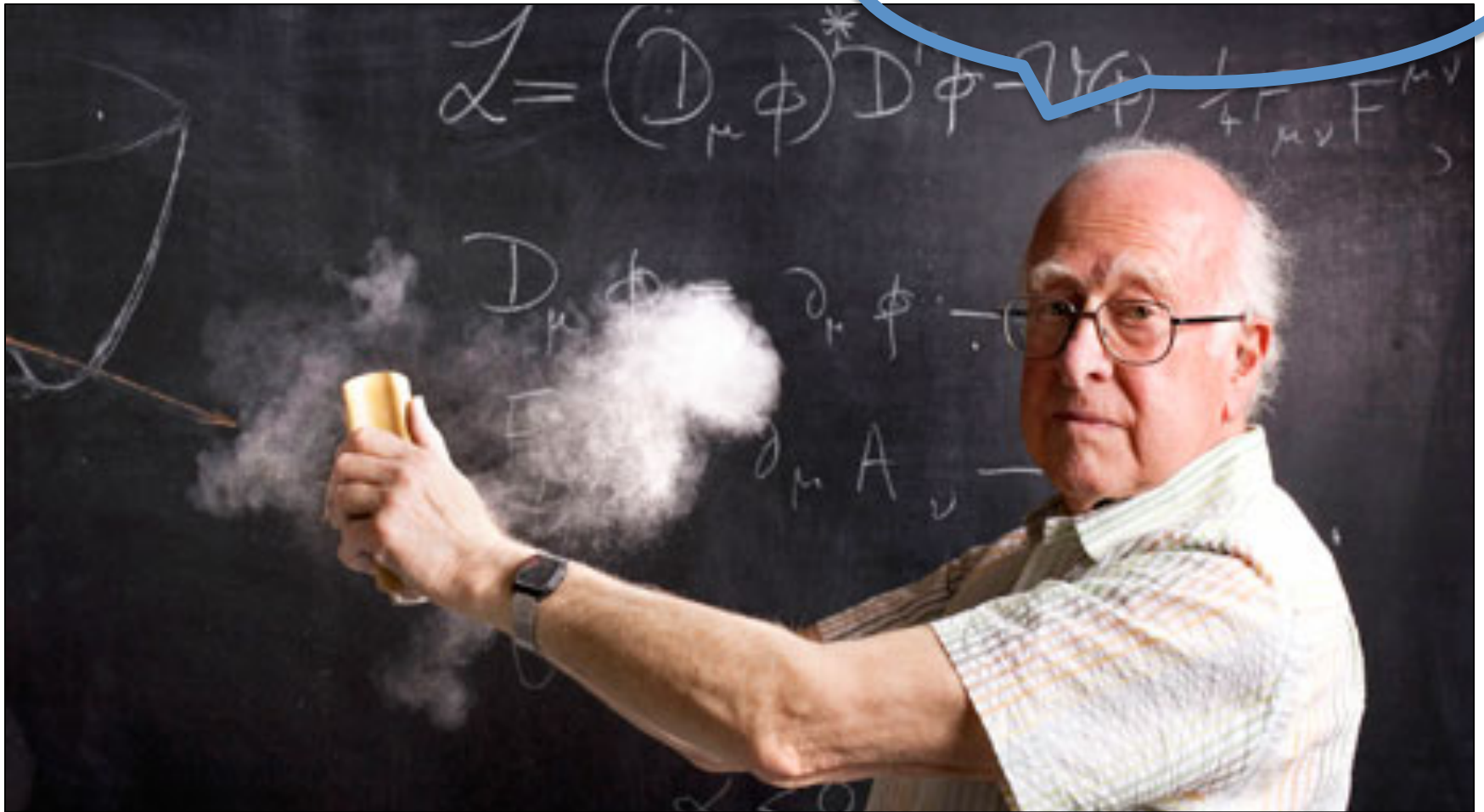
- **Superb performance of the LHC accelerator**
- **Very fruitful times for the ATLAS collaboration:**
 - ✓ **Very good performance of the detector**
 - ✓ **Highly efficient data taking/computing/ physics analysis**
- **Impressive quantity of new physics results being published.**
 - ✓ **All results : <https://twiki.cern.ch/twiki/bin/view/AtlasPublic>**
 - ✓ **The most exciting one:**
 - **Observation of a new boson at 126 GeV – properties consistent with the SM Higgs within the current uncertainties**
 - **excess seen in the $\gamma\gamma$, ZZ and WW channels (5.9 σ local significance)**
- **(Near) future work:**
 - **Continue to measure the properties of the new boson**
 - **Use all integrated luminosity collected by 2012 ($\sim 30\text{fb}^{-1}$) to continue to search for new effects and constrain BSM models**
 - **Prepare for Phase 0 upgrade at 14 TeV and Phase 1 upgrade for high luminosity ($L > 10^{34}\text{cm}^{-2}\text{s}^{-1}$)**

Dedicated talk: S. Burdin)

Thanks!



Is the SM boson found or not?

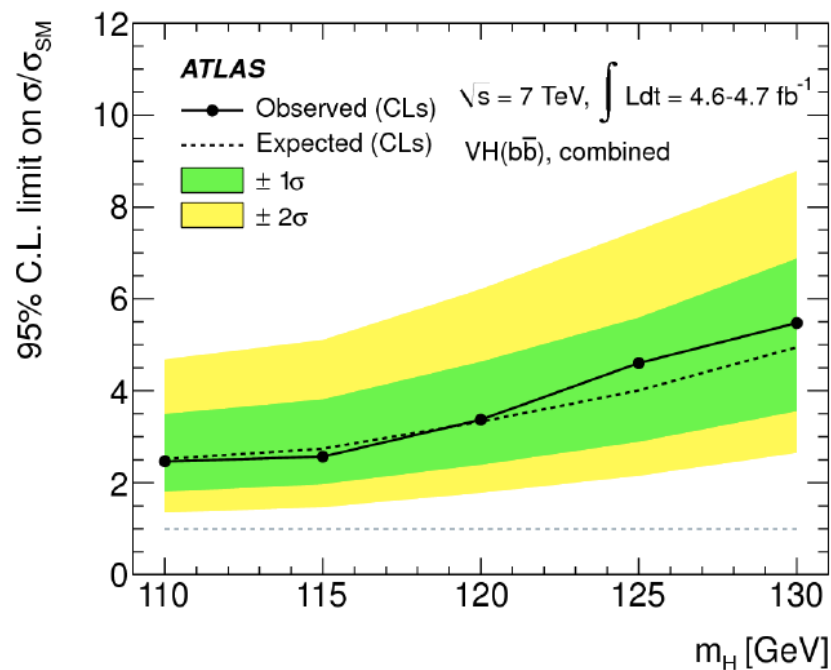
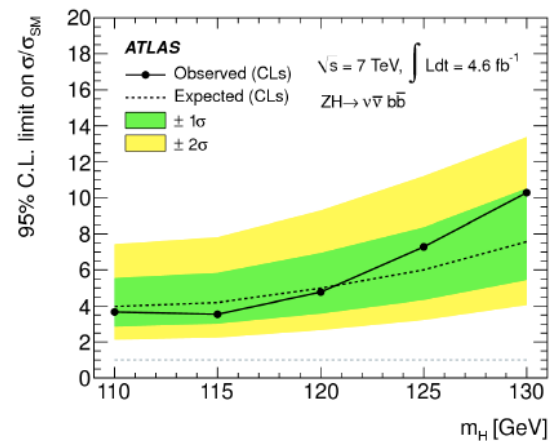
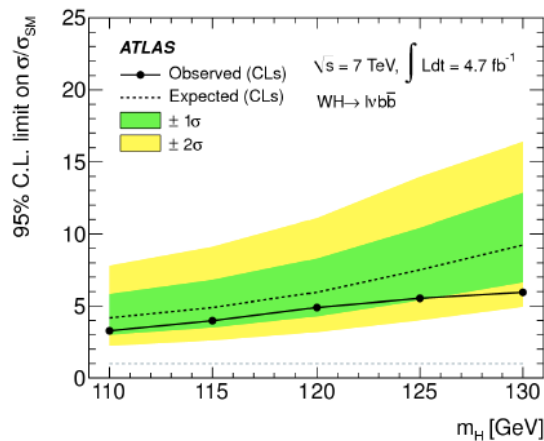
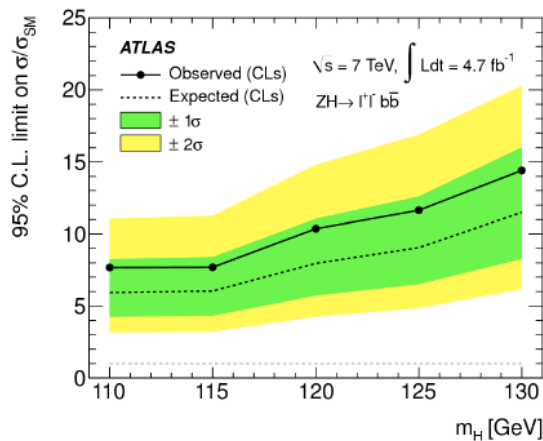


Back-up





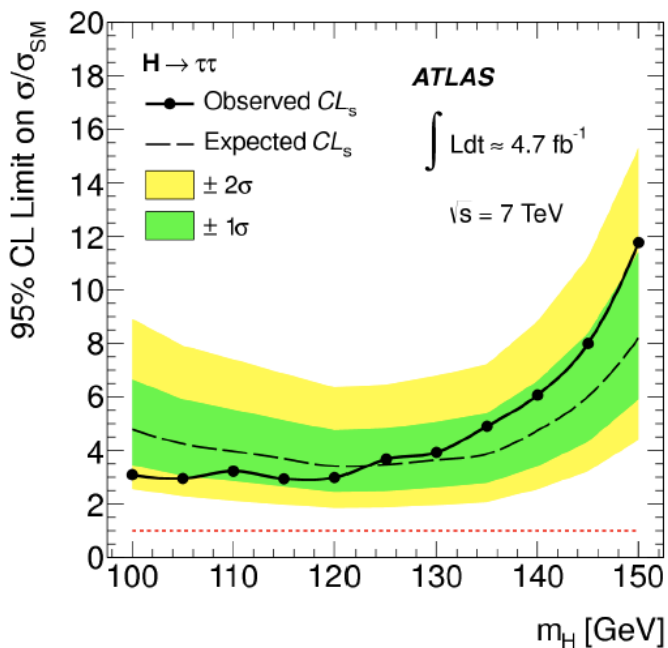
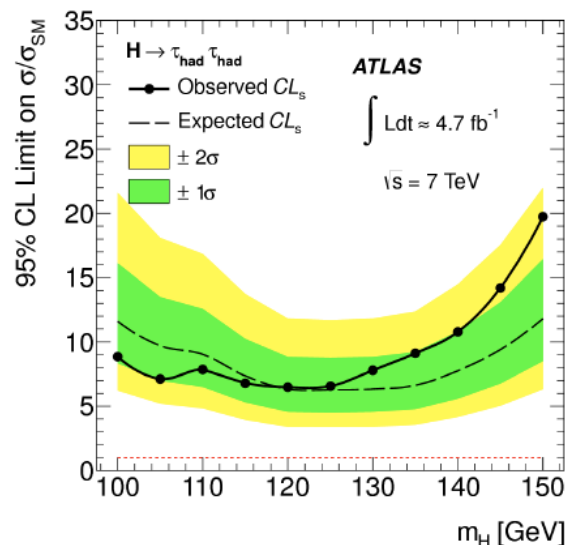
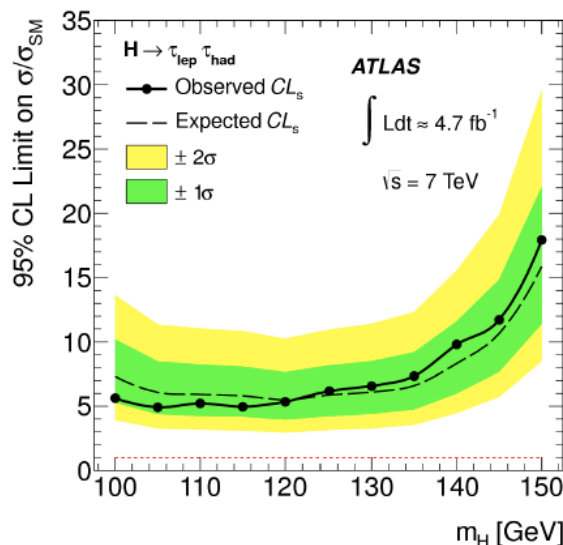
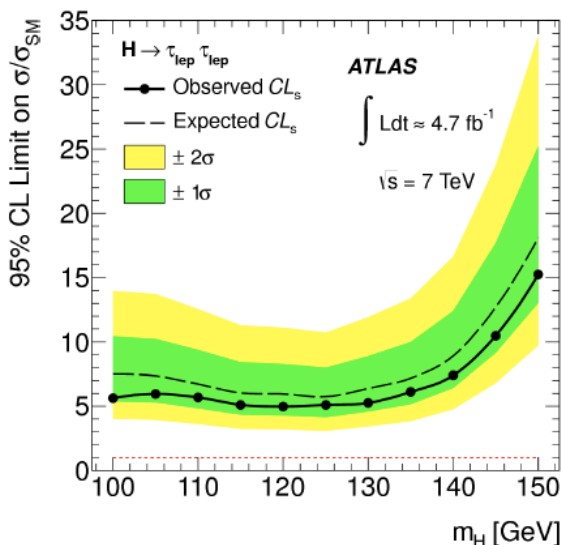
Limits in VH (bbar)



- 95% CL upper limits using CLs
- Observed (expected) per channel sensitivity ($\times \sigma_{\text{SM}}$):
 - $ZH \rightarrow \ell\ell b\bar{b}$: 8(6)–14(12)
 - $WH \rightarrow l\nu b\bar{b}$: 3(4)–6(9)
 - $ZH \rightarrow \nu\bar{\nu} b\bar{b}$: 4(4)–10(8)
- Combined: 2.5–5.5 times SM expectation, 4.6 at $m_H = 125 \text{ GeV}$
- Coming: 2012 data, improved $m_{b\bar{b}}$ resolution, MVA



Limits on $H \rightarrow \tau\tau$



- 95% CL upper limits using CLs
- Most sensitive: $\tau_{had}\tau_{had}$, H+2jet VBF in $\tau_{lep}\tau_{had}$ and $\tau_{lep}\tau_{lep}$
- Combined observed (expected) limit: 2.9(3.4)–11.7(8.2) times SM expectation, 3.7 at $m_H = 125 \text{ GeV}$
- Coming: 2012 data analysis