Higgs Searches at LHC

Marumi Kado (LAL, Orsay)

D0-France

LPNHE - Paris

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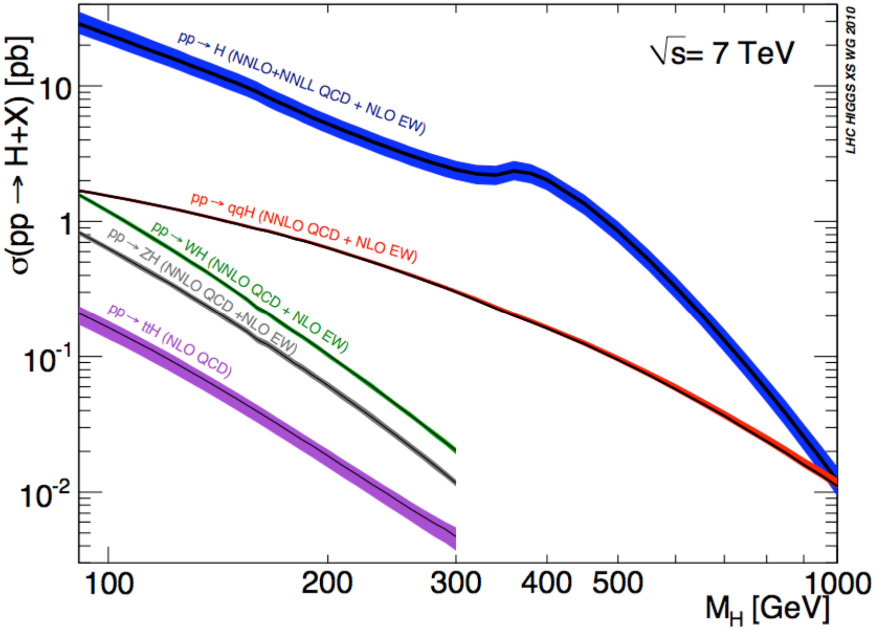
Disclaimer

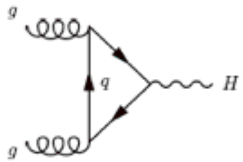
All (but one) results shown here were done using the ~35-43 pb^{-1} of data out of the ~48 pb^{-1} delivered by LHC in 2010

Brief Overview of the Standard Model Higgs Boson Searches Landscape at LHC

The Usual Main Production Modes

Data driven background estimates legitimate use of NNLO cross sections!

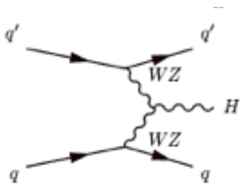




- Gluon fusion process :

Dominant process known at NNnLO

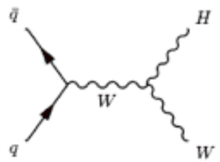
However rather large TH uncertainty* ~O(15%) due to the large corrections for gluon initiated process

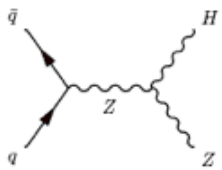


- Vector Boson Fusion :

known at NLO TH uncertainty ~O(5%)

Rather distinctive features with two conspicuous forward jets and a rapidity gap

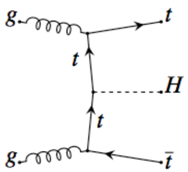




- Associated Production with W and Z :

known at NNLO TH uncertainty ~O(5%)

Very distinctive feature with a Z or W decaying leptonically



- Associated Production with top pair :

known at NLO TH uncertainty ~O(15%)

Quite distinctive but also quite crowded

* TH uncertainty mostly from scale variation, $\delta\sigma_{PDF-\alpha s}$~8-10% and $\delta\sigma_{Scale}$~ 7-8%

Decay Modes

Brief discussion of the channels that count…

- The dominant b-decay channel

Huge backgrounds, needs distinctive features at production level and beyond…

Revival of bb channel in boosted A. P.

- The $\tau\tau$ channel

Also needs distinctive production features, typically VBF.

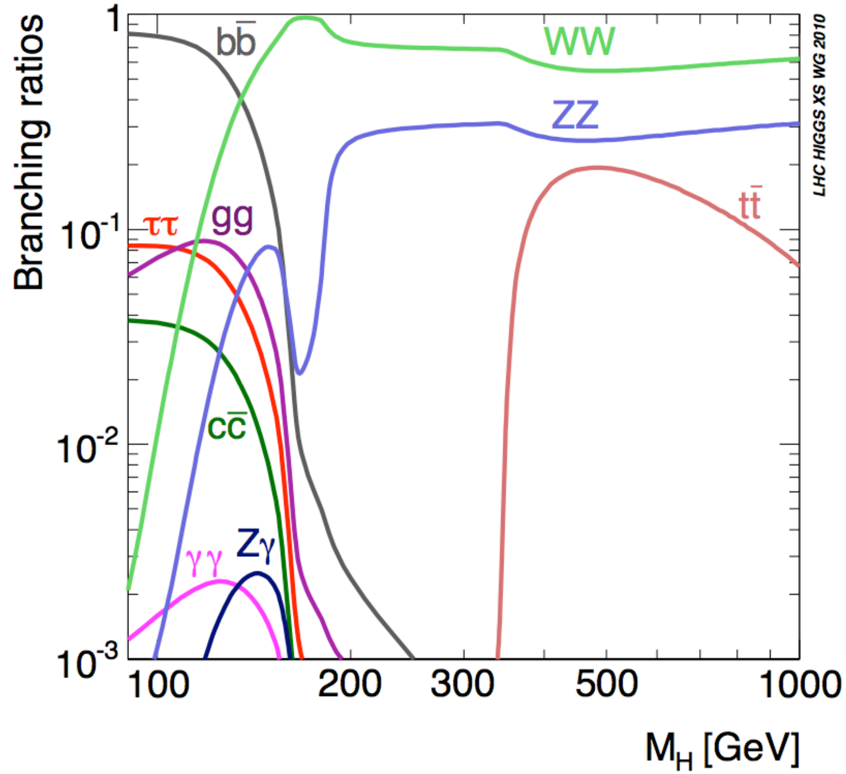
New trend inclusive !

- The $\gamma\gamma$ channel

Small branching but very distinctive signature on its own.

- The WW and ZZ Channels

Excellent channels but the lepton branchings take a large toll…



Common effort LHC-wide to compute cross sections and branching ratios and…

- Use common standard model input parameters
- Use a common strategy on the estimation of uncertainties some of which are highly correlated (scale variation, PDFs, α_S, etc…)

https://twiki.cern.ch/twiki/bin/view/LHCPhysics/CrossSections

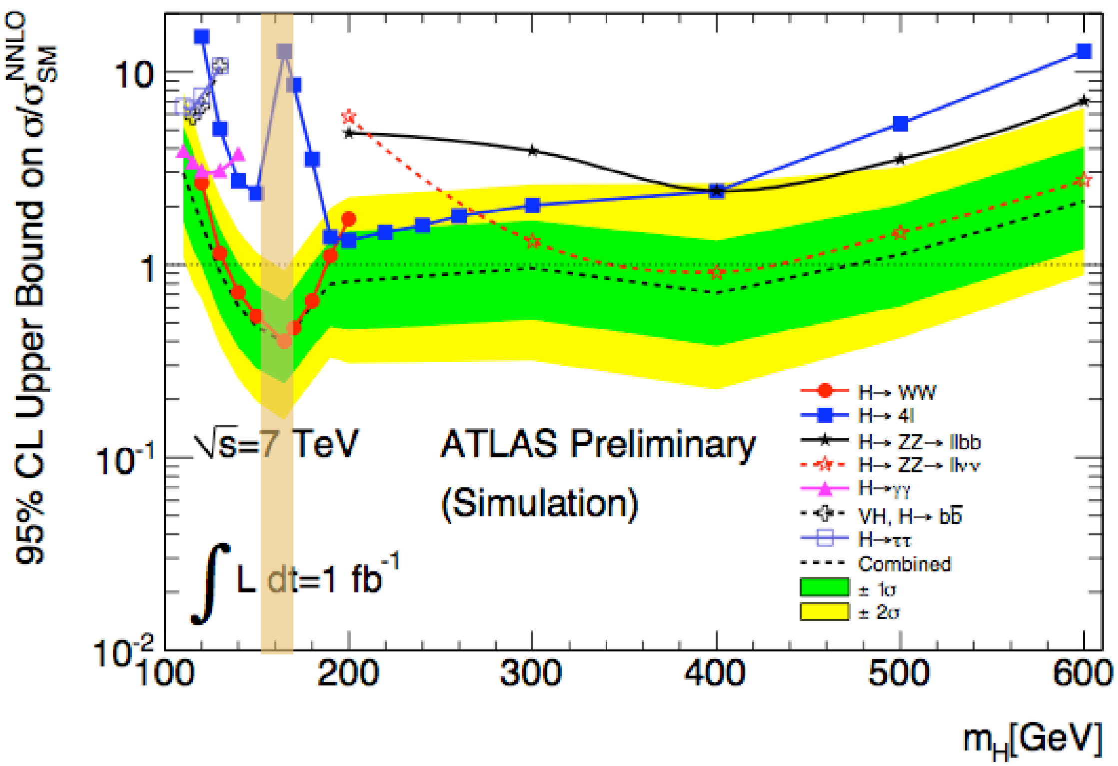
Higgs Search Projections at 7 TeV

The Projections of the Higgs Searches as Guidelines for Chamonix Workshop
(ATLAS as example, CMS has similar sensitivity)

Main idea at LHC is to expand the search range at much higher Higgs masses

- Most sensitive channels the high mass range are ZZ in general but $ZZ \to ll\nu\nu$ and $ZZ \to llqq$ in particular

- In the low mass range the most sensitive but less precise is $WW \to l\nu l\nu$



ZZ (4l) channel is the cleanest and very precise but has the smallest sensitivity

$\gamma\gamma$ channel is crucial in the low mass range

(preferred mass domain by indirect constraints from precision measurements, intricate at TeVatron as well)

VBF $\tau\tau$ and boosted AP $H \to bb$ are promising but lower sensitivity (not discussed here)

ATLAS and CMS have very similar sensitivities

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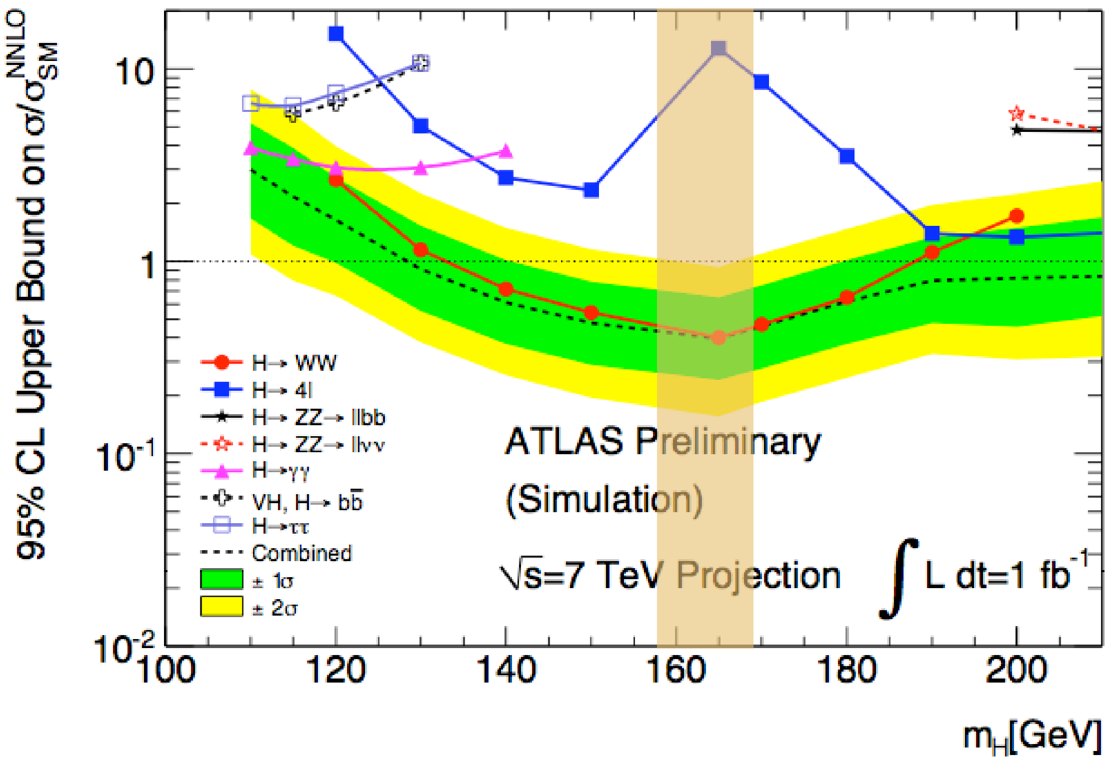

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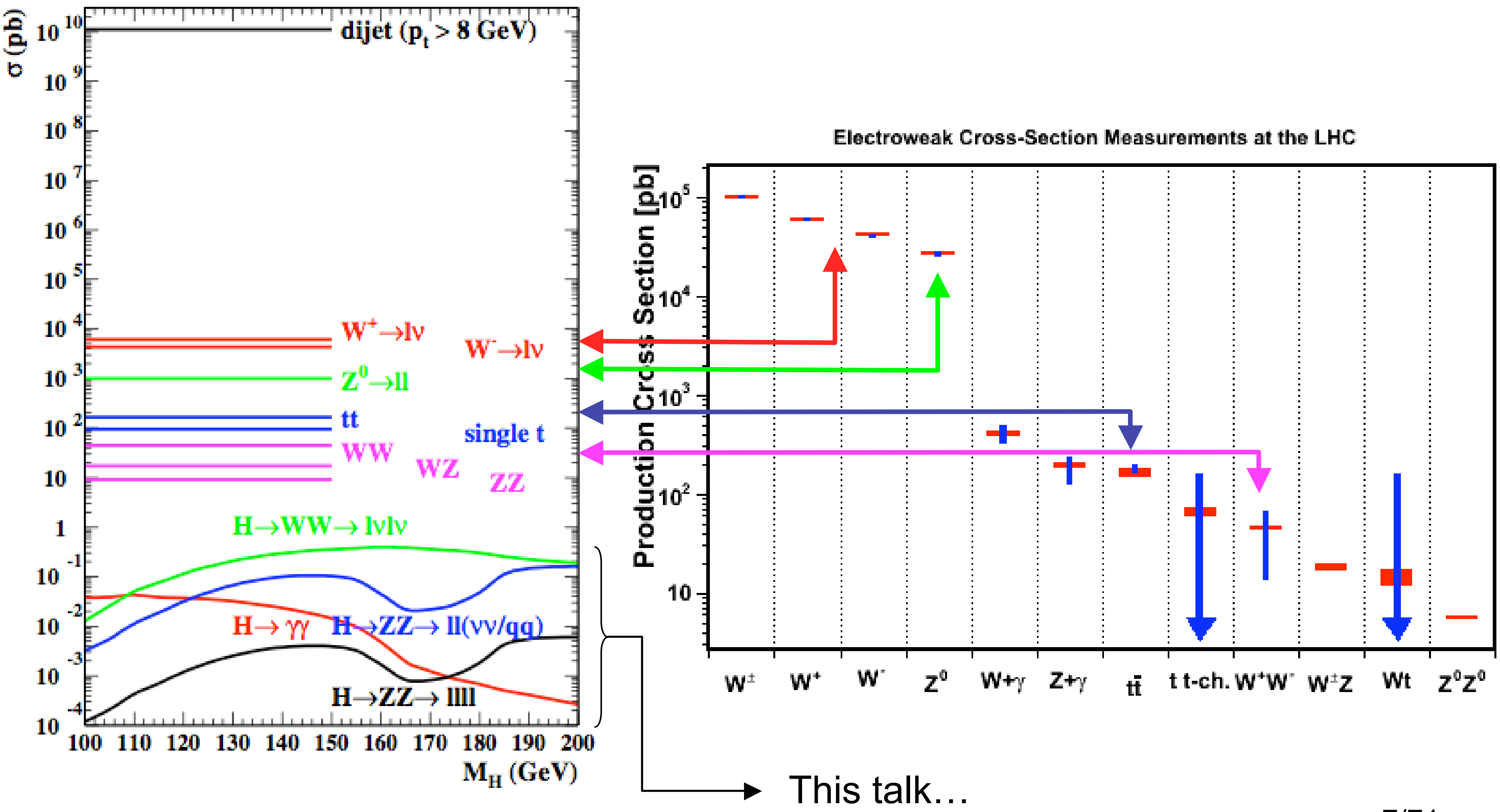
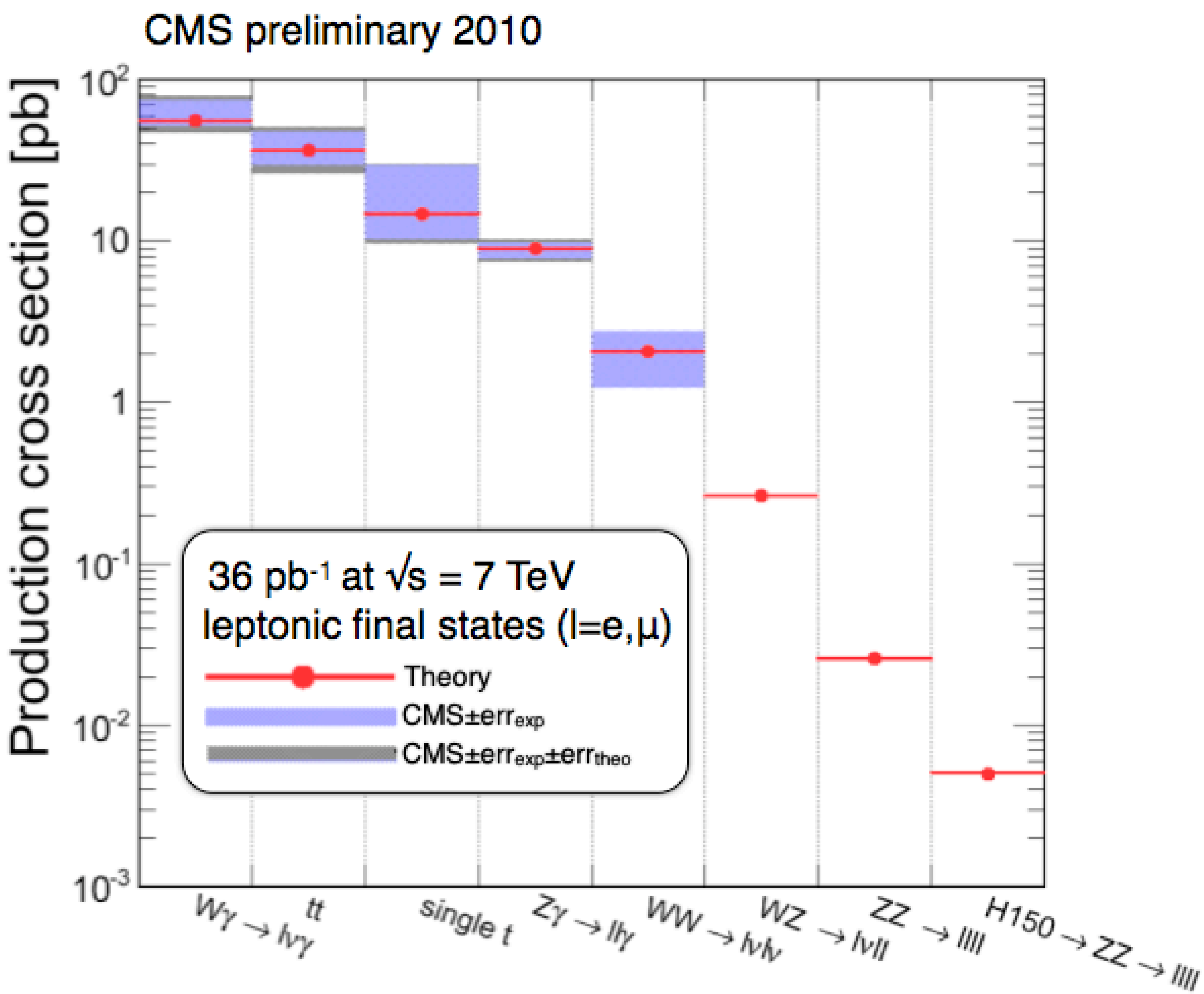
Fundamental Prerequisites

In the ~40 pb^{-1} of data collected in 2010 ATLAS and CMS have managed to measure most of the known SM processes



Similarly in CMS…



The Low Mass Higgs Channels

The VBF $H \rightarrow \tau\tau$ and boosted associated Higgs to bb channels not described here

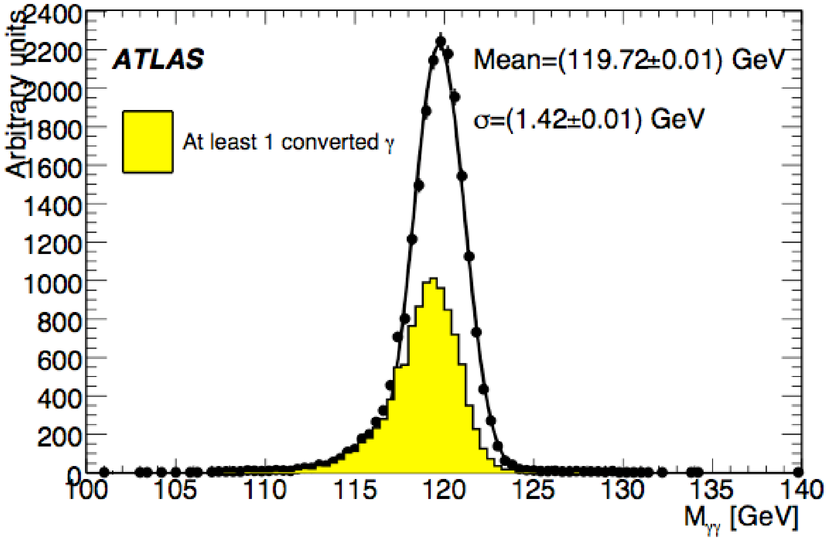
Mainstream channels event yields for 1 fb^{-1} @ 7TeV (with trigger and reconstruction efficiencies) :

$\gamma\gamma$ (120 GeV/c^2)	WW (170 GeV/c^2)	ZZ (130 GeV/c^2)
25	20 (no jets) and 13 (2jets)	1 (4e,4μ,2e2μ)

Small branching but large event yield

The $H \rightarrow \gamma\gamma$ Channel(s)

- All inclusive and very robust signal (in particular against pile-up)
- Despite the low branching (~0.2%) it has the largest event yield!
- If observed implies that the Higgs is not spin 1 from Landau-Yang theorem
- Excellent mass resolution required : ~1.4 GeV/c^2



Event selection : 2 photons p_T>25 (40) GeV

ATLAS-CONF-2011-025

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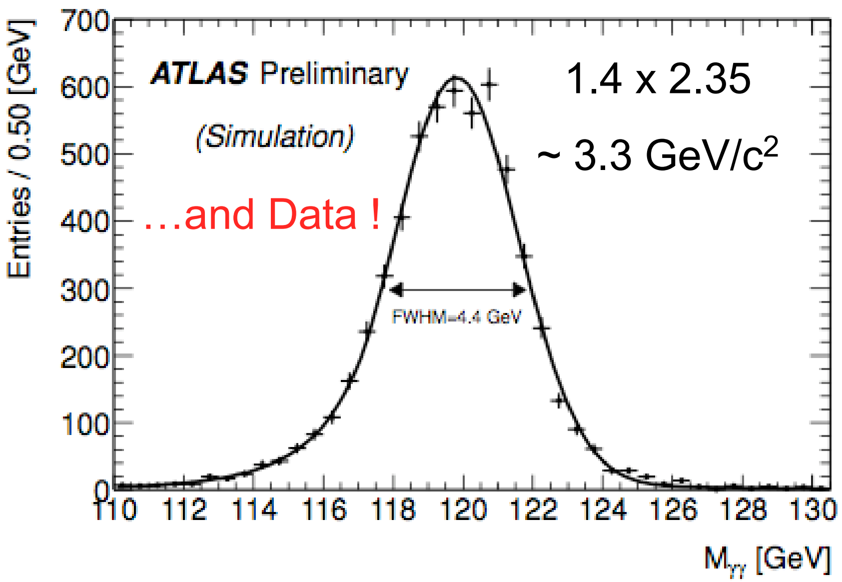


Event selection : 2 photons p_T>25 (40) GeV

Using a MC based calibration (thoroughly verified in test beam) and an already good knowledge of the amount of material upstream of the calorimeter (with in situ measurements)…

After energy scale corrections estimated with Z events, the resolution is conservatively estimated to be ~1.9 GeV/c^2

Will improve with a better calibration and more accurate detector description

Primary vertex reconstruction is also crucial (photon pointing, recoil tracks and conversion tracks)

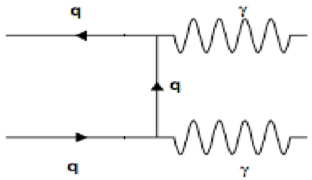
(5.6 cm beam spot adds ~1.4 GeV mass resolution!)

This is not the whole story…

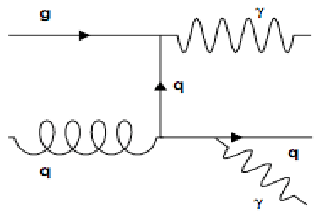
Backgrounds

Irreducible backgrounds

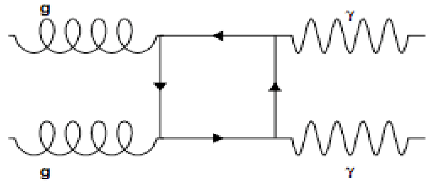
Born



Brem



Box



- Born and box   Best estimate by parton-level resummed NLO ResBos

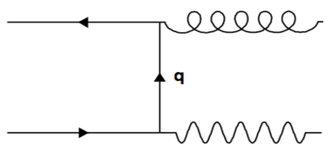
- The brem is in principle reducible in practice not, and it is a process difficult to simulate

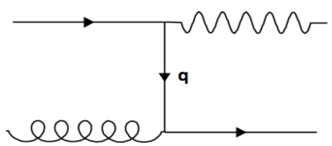
Best estimate by parton-level NLO fixed order Diphox (T. Binoth,J.Ph. Guillet et al.)

Now SHERPA (Gleisberg, Hoeche et al.)

- The Reducible backgrounds :   Critical to reach jet rejections O(5000)

Not at all exhaustive list…





Final state parton(s) fragments into a leading π^0

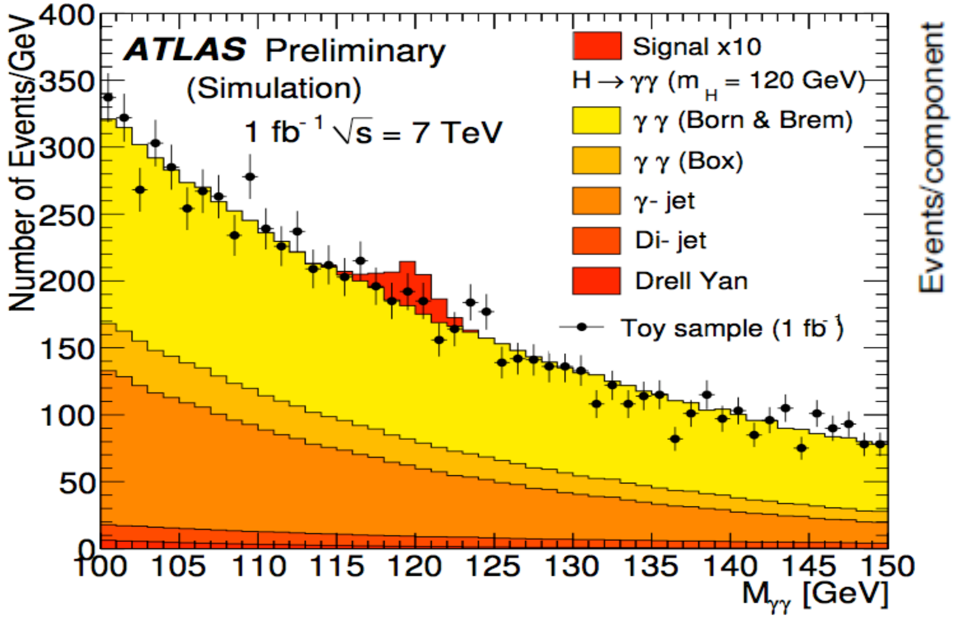
Best estimate by parton-level fixed order NLO JetPhox (S. Catani, M. Fontannaz et al.)

Also note : large difference Pythia vs. Herwig in the leading π0 fragmentation

A complete NNLO calculation is (for the time being out of reach)…

Not a problem because…

Backgrounds Estimates in 2010 Data



Thorough estimate of the expected backgrounds using Monte Carlo event generators and cross-section programs (DiPhox and ResBos)

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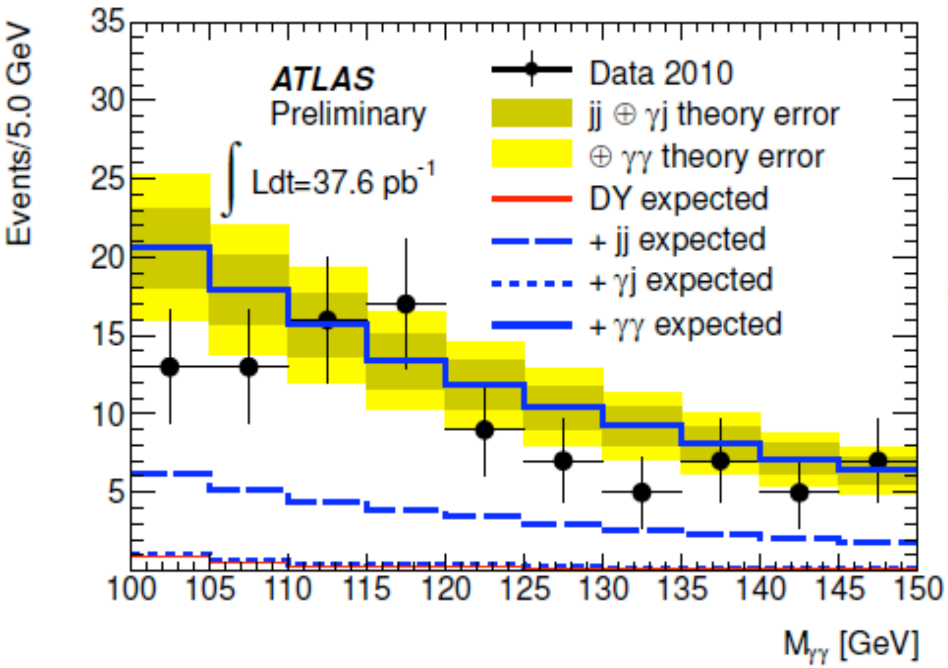
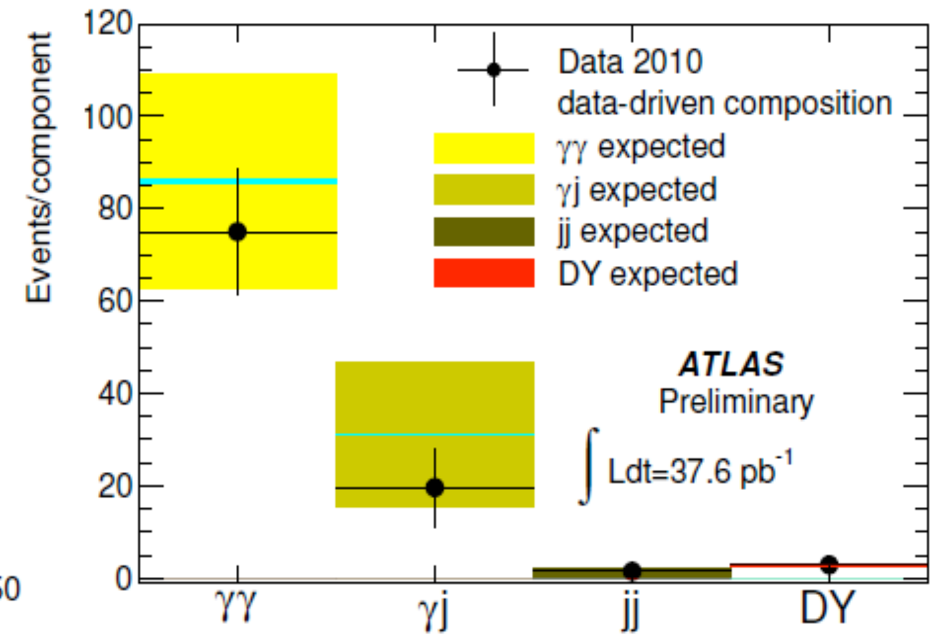




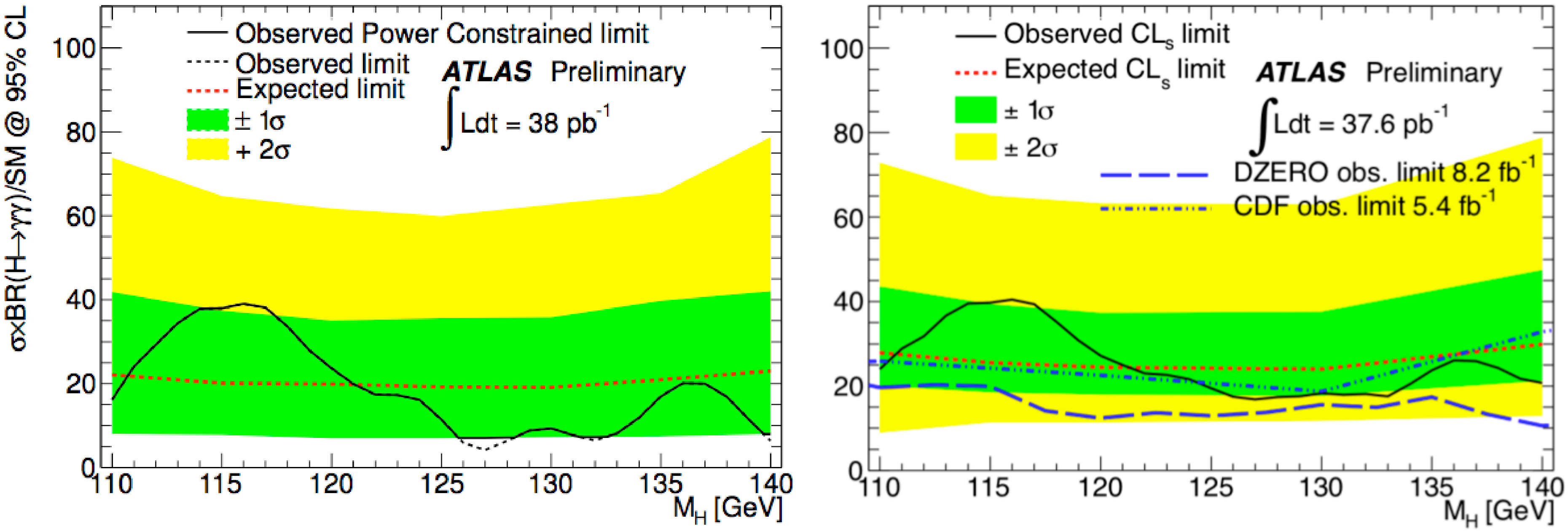
Thorough estimate of the expected backgrounds using Monte Carlo event generators and cross-section programs (DiPhox and ResBos)

First comparison with the data shows a resonable agreement (slight deficit in the data)

Each individual background component has been estimated using data driven methods (with reversed cuts control regions) and Z→ee for the DY component

The H→γγ Inclusive Channel 2010 Results

The PCL at work

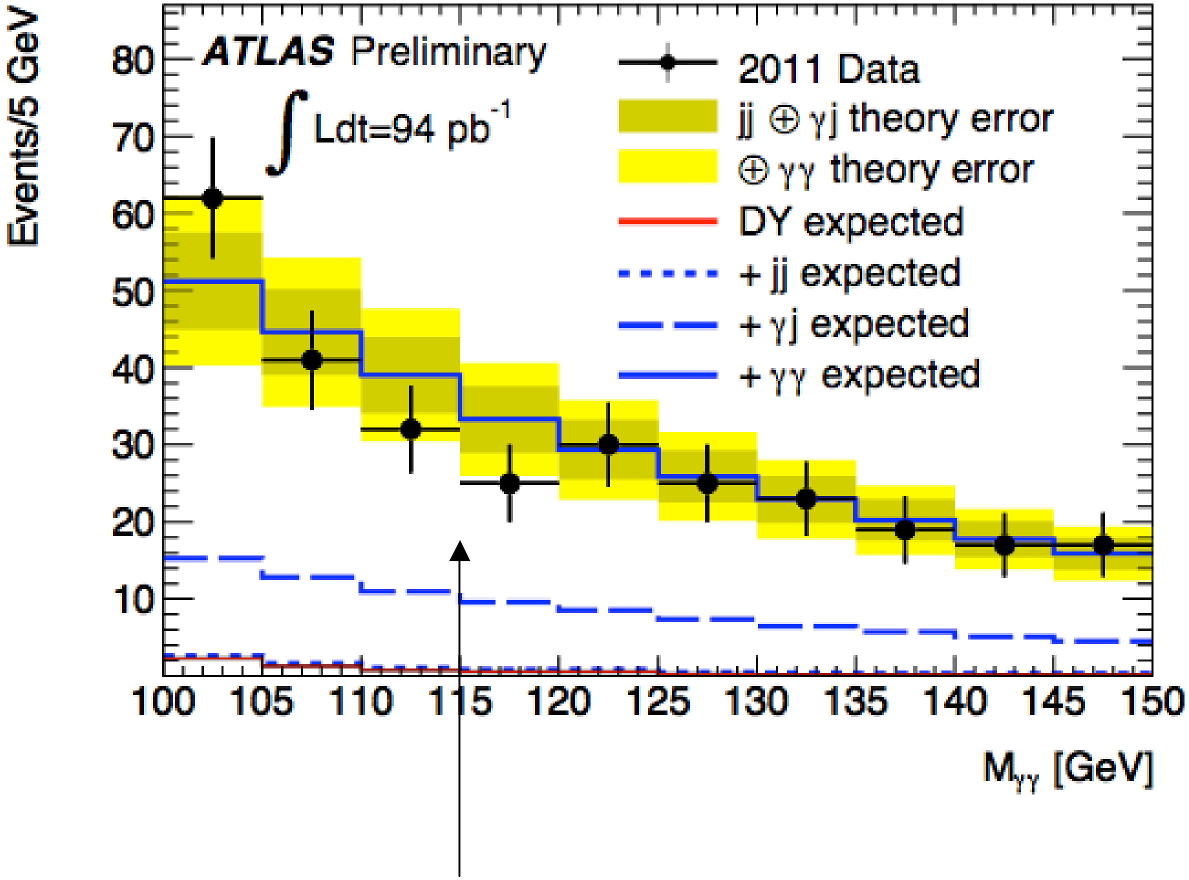


ATLAS limits are already competitive with those of TeVatron…

PCL limits are typically 20% less conservative than the CLs method in certain specific cases (near the -1σ limit) the observations can differ by larger amounts

Update of Background Studies in 2011

Only result with 2011 data



Slight deficit where a slight excess appeared in 2010

No excess in the 2010 and 2011 combination apparent

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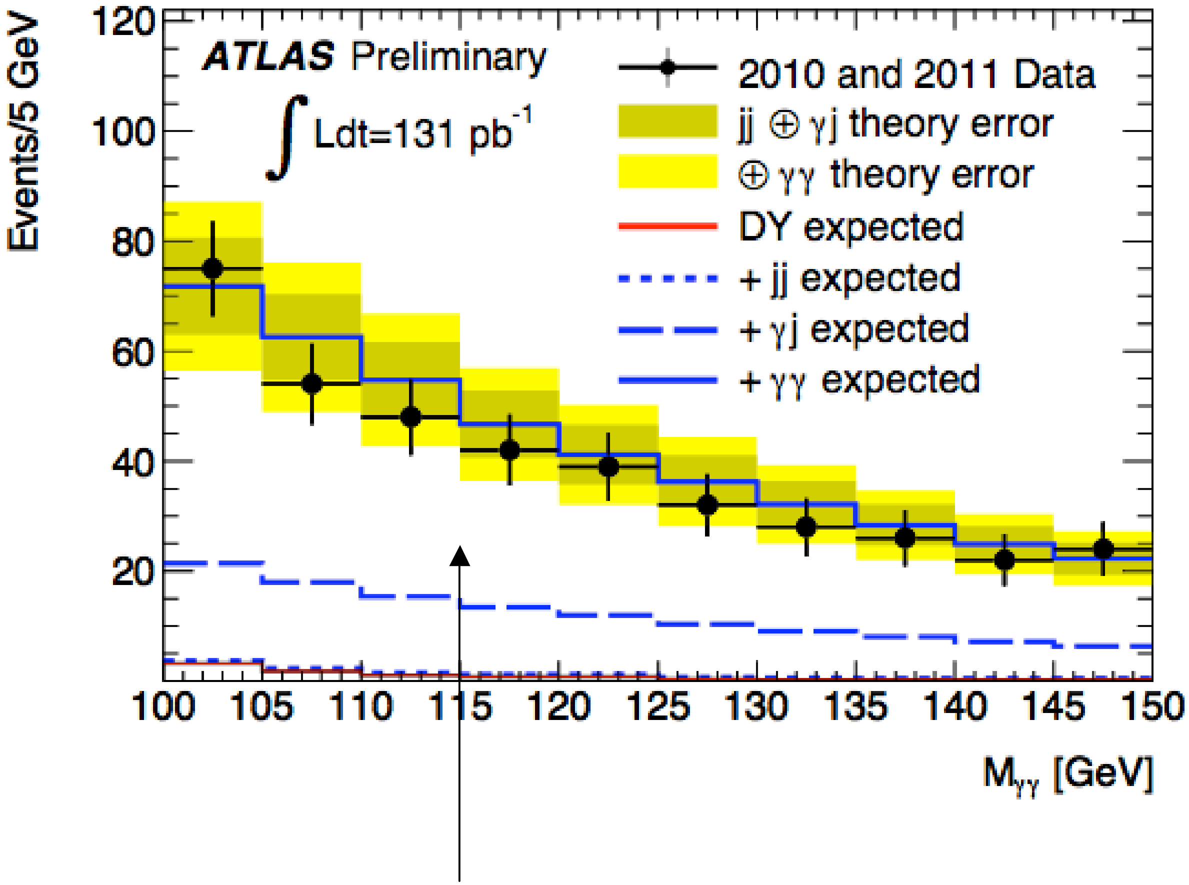

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No excess in the 2010 and 2011 combination apparent

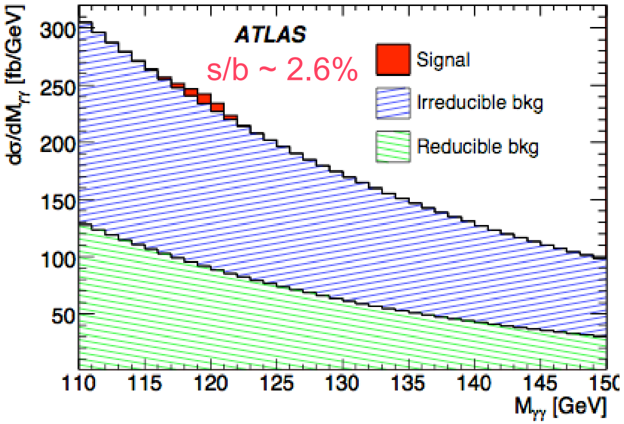
How to Improve the Search Sensitivity ?

1.- Separate events in categories (pseudo-rapidity, conversions)

2.- Separate events in exclusive analyse in terms of jets

N-jets

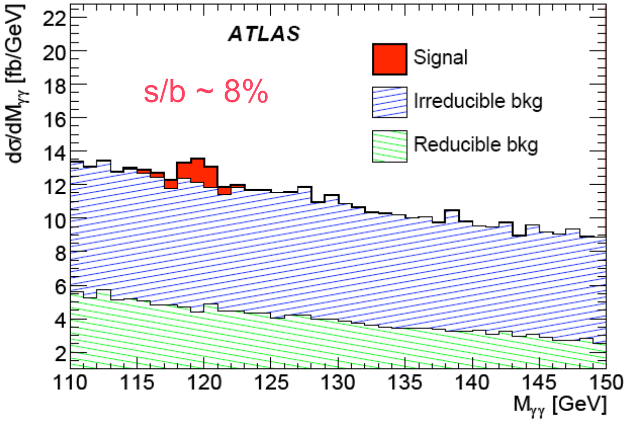
80% gg, 10% VBF and 10% AP*



$s/\sqrt{b}$ ~ 2.6 (10 fb^{-1} @ 14TeV)

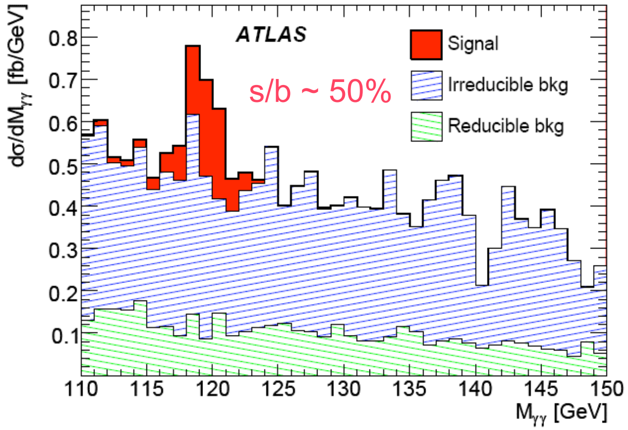
(Even purer in exclusive AP s/2 ~ 2-3)

60% gg and 35% VBF



$s/\sqrt{b}$ ~ 1.8

20% gg and 80% VBF



$s/\sqrt{b}$ ~ 2.2

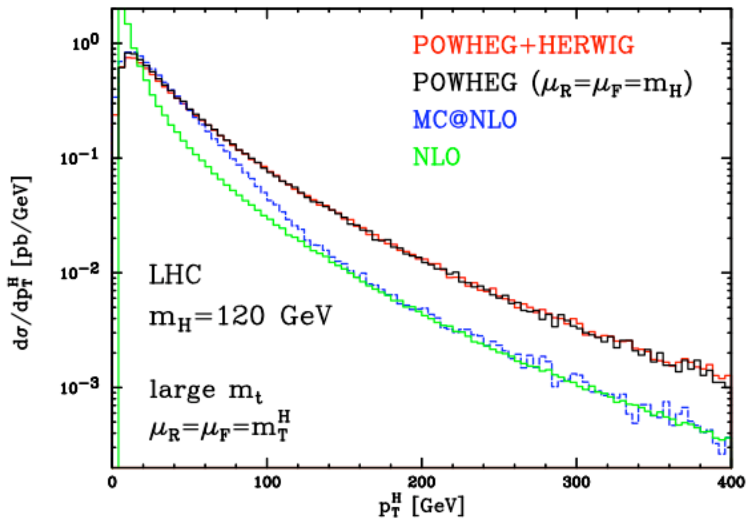
3.- Using discriminating characteristics

- The scalar nature of the Higgs ($\cos\theta^*$)

- The system transverse momentum

Critical to have an accurate signal simulation

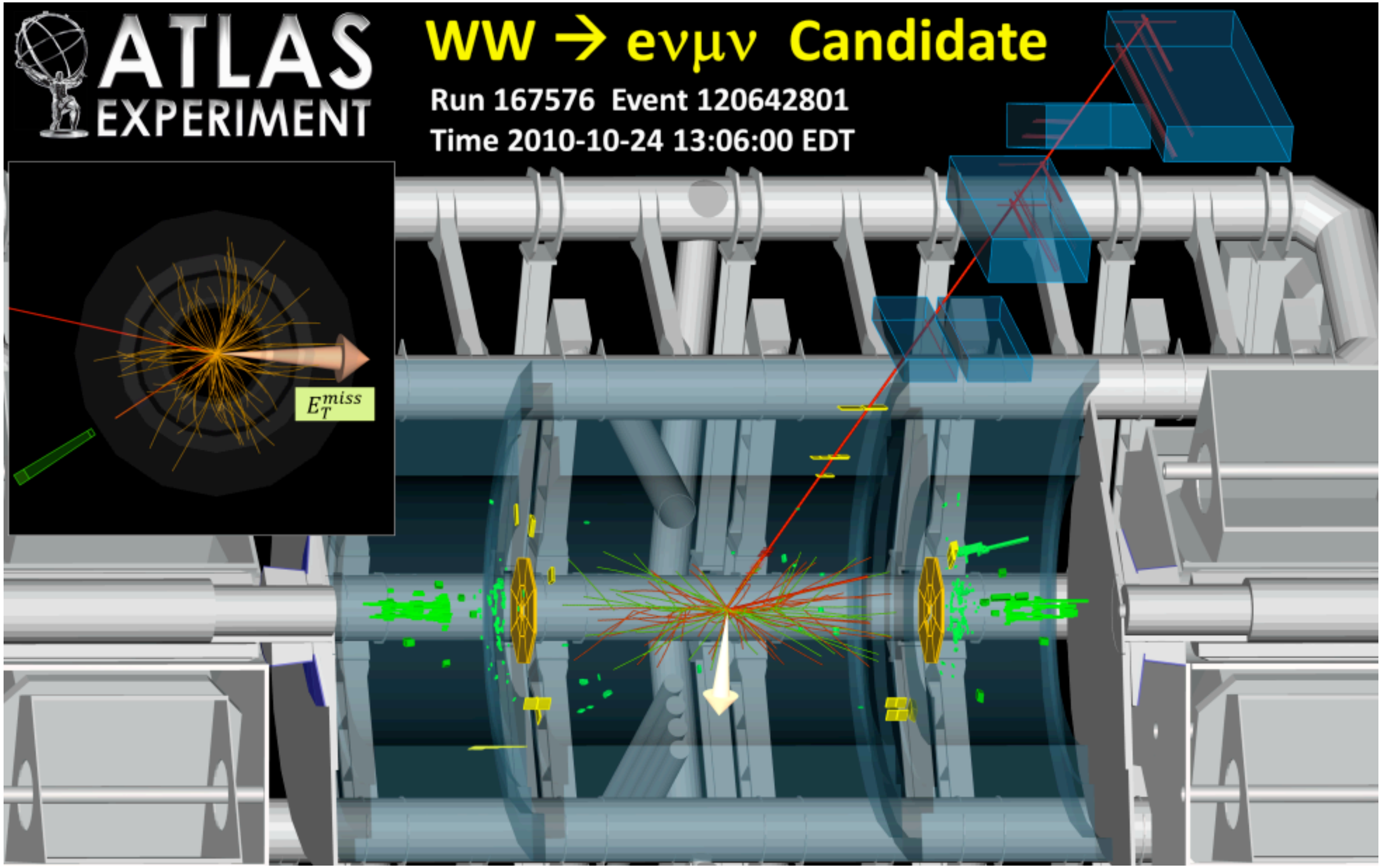
(no good control samples…)



* AP : All Associated production modes

ATLAS-CONF-2011-005
CMS-HIG-10-003

Higgs Boson Search in the WW→lνlν



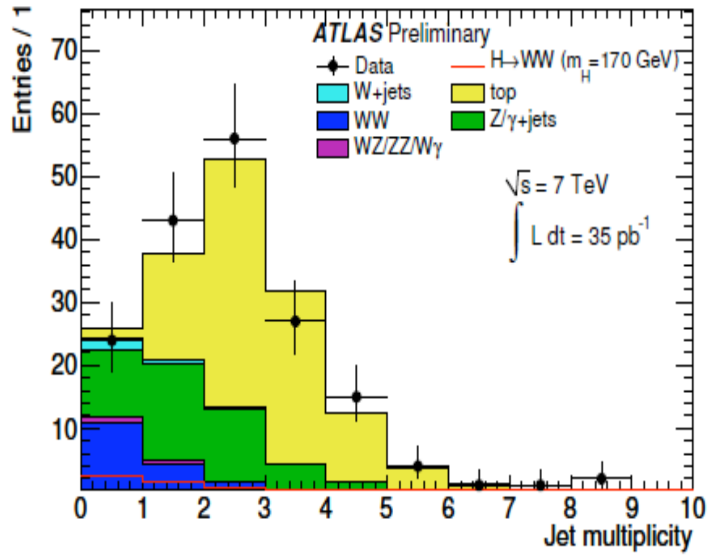
- Essentially no mass resolution, but…
- Large yield and rather small background

Analysis strategy :

ATLAS : Exclusive analyses in number of jets

Event preselection :

- 2 OS leptons (e,μ), p_T>20(15) GeV
- M_{ll} >15, $|M_Z-M_{ll}|$ > 10 GeV (ee,$\mu\mu$)
- MET > 30 GeV
- $\Delta\phi ll$ <1.3 (1.8) for M_H < 170 (> 170GeV/c^2)



Need VBF topology but small signal expected

Purest Channel(s) (least affected by top background)

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- Large yield and rather small background

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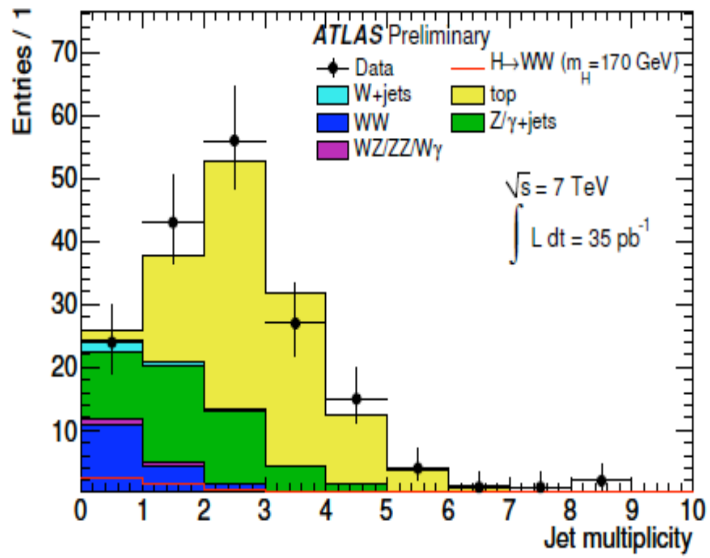
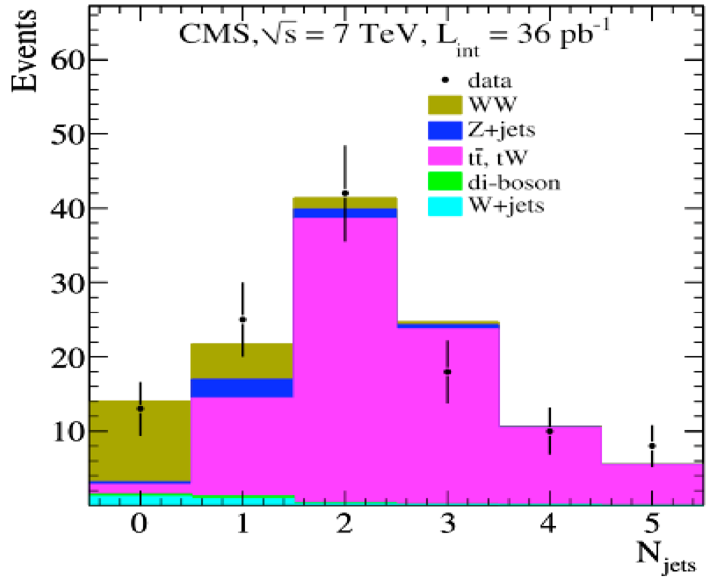


CMS : only 0-jet analysis but also MVA

Similar event preselection :

- 2 OS leptons (e,μ), p_T>20GeV
- M_{ll} >12 GeV
- MET > 20 GeV
- Projected MET
- Top (b-tag) veto



Publication of WW cross section and limit on triple gauge boson couplings along with the search for the Higgs boson…

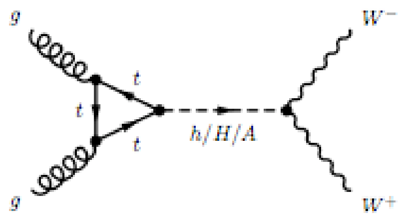
PLB 699 (2011) 25-47

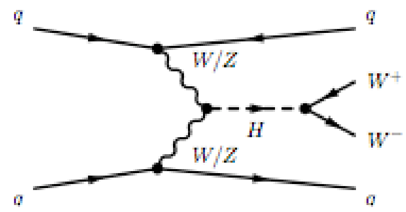
Signal production process considered :

ATLAS : Signal considered is the production via gluon fusion + VBF considered

Uncertainty on signal event estimated by variation of μ_f, μ_r, PDF, α_s in the NNLO+NNLL calculation

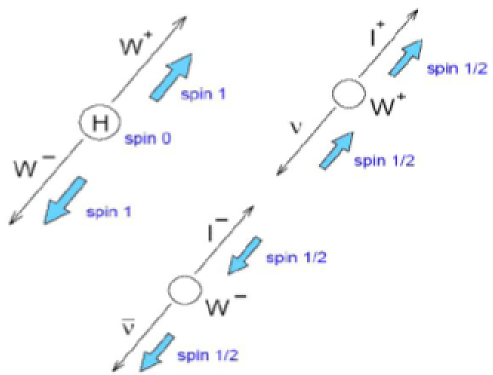
$$\left\{ \begin{array}{l} \text{0-jet : 10\%} \\ \text{1-jet : 6\%} \\ \text{2-jets : 35\%} \end{array} \right.$$





CMS : gluon fusion only (more straightforward interpretation in terms of SM4))

Use spin correations through $\Delta\phi$ cuts



Analysis Results

Sensitivity is optimized in each exclusive analysis channels and for each mass hypothesis

(all preselection variables and m_T)

$$m_T = \sqrt{(E_T^{\ell\ell} + E_T^{\rm miss})^2 - (\mathbf{P}_T^{\ell\ell} + \mathbf{P}_T^{\rm miss})^2}$$

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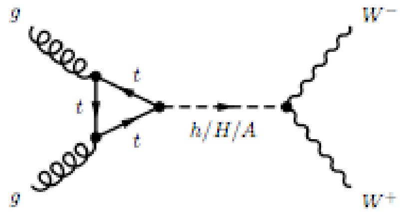

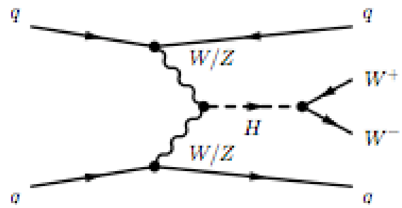

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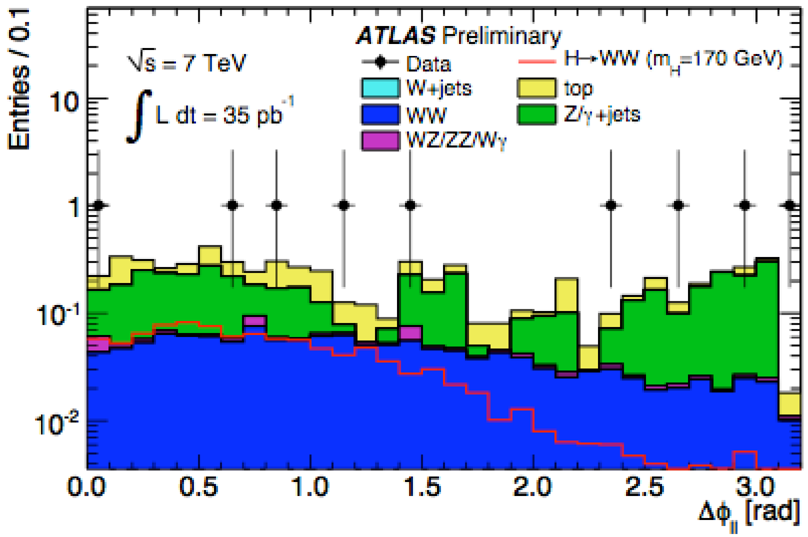

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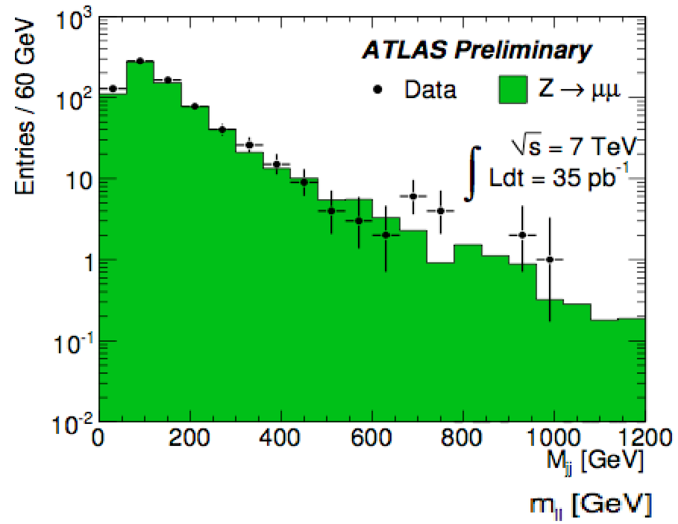
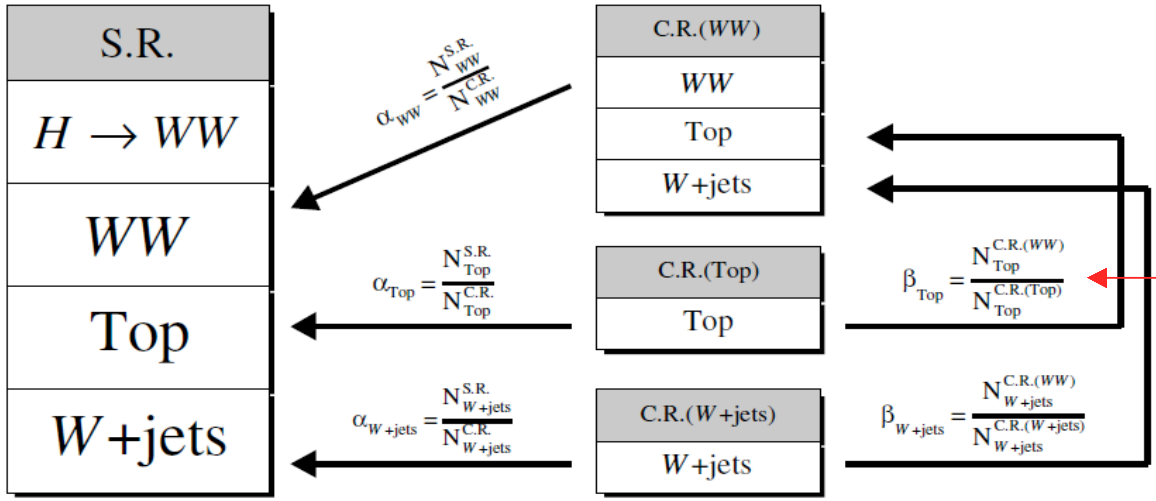
Backgrounds Estimates in Control Regions

Main backgrounds are estimated in Control Regions (CRs), then extrapolated in the Signal Region (SR) :

- WW background : From side bands in M_{ll}
- Top background : b-tagging CS (MC for CMS)
- W+jets background : Loose ID on second lepton
- Z+jets background : ABCD method in M_{ll} MET plane

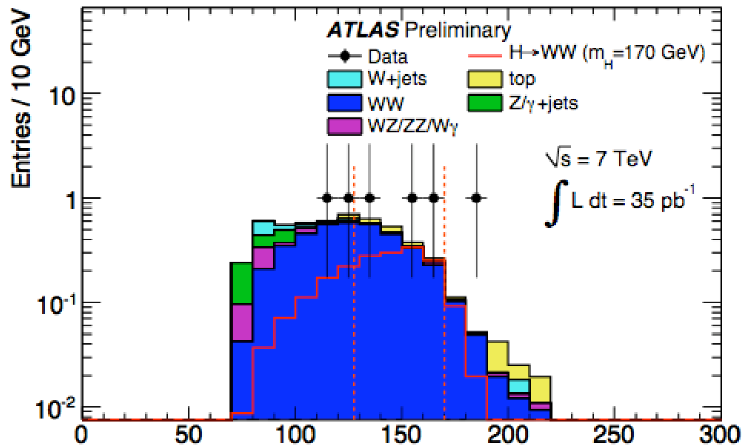


Because of the presence of top and W+jets backgrounds in the WW CR, CRs are interconnected.



Only one coefficient used in the 2010 data analysis

M_T distributions and cut applied



0-Jets Channel : WW Dominant background

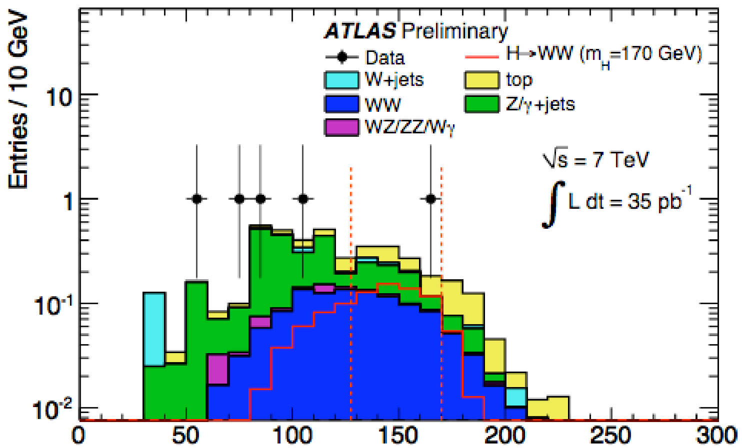
Data	3
BG	1.8±0.1
Higgs	1.26±0.02

80% WW

11% top

7% W+jets

2% WZ/ZZ/Wγ



1-Jets Channel : top Dominant background

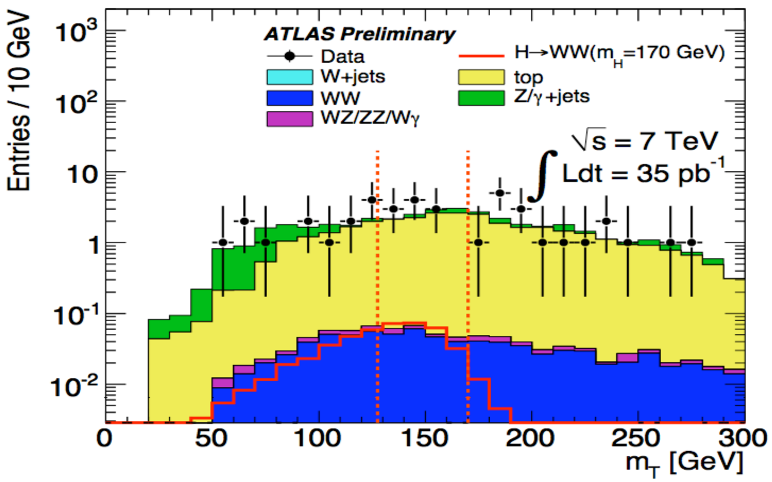
Data	1
BG	1.2±0.1
Higgs	0.6±0.01

42% top

32% WW

25% W+jets

1% WZ/ZZ/Wγ



2-Jets Channel : WW and top sole backgrounds

Data	0
BG	0.02±0.01
Higgs	0.06±0.01

O(50%) top

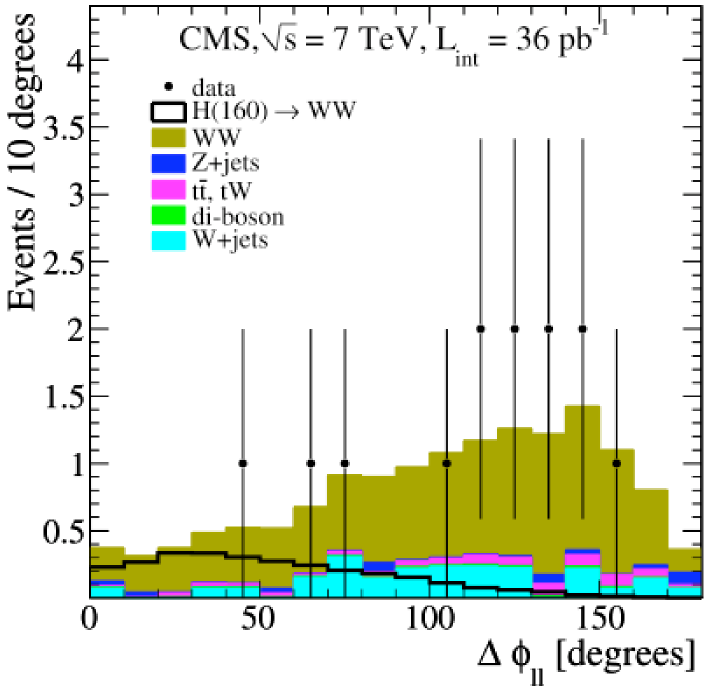
O(50%) WW

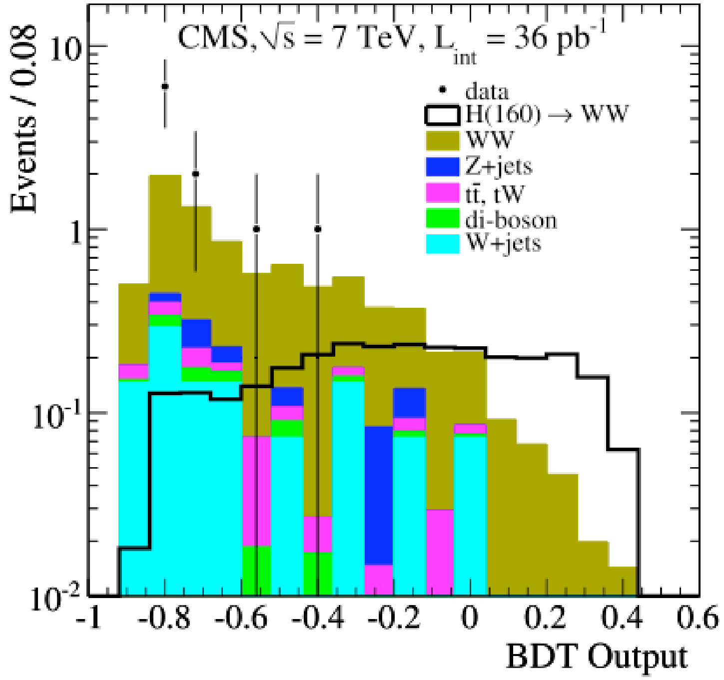
VBF tag/veto selections lead to high s/b but of course low expected number of events

The CMS MVA approach

Having a cut based analysis and a boosted decision tree using the following variables :

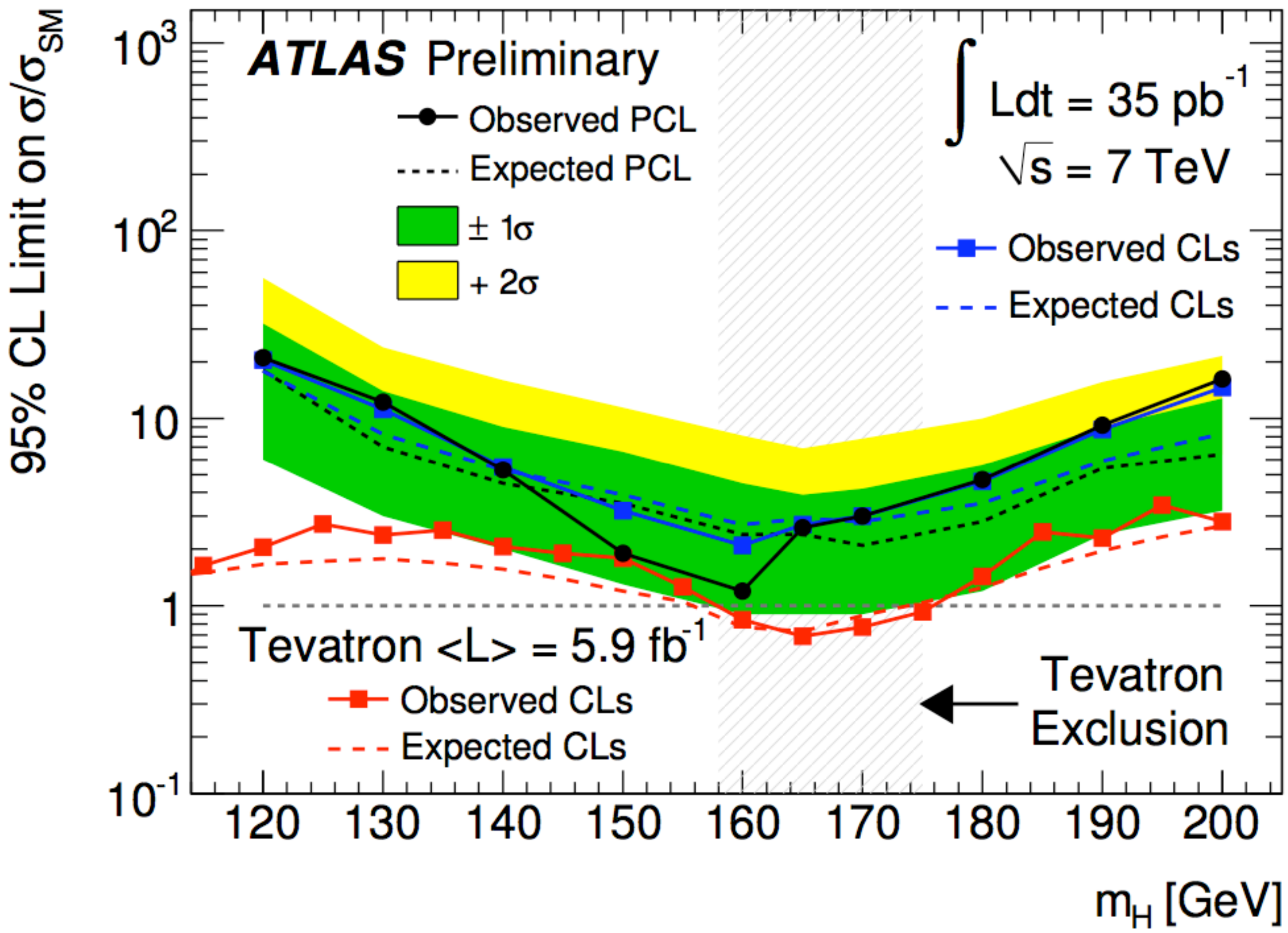
M_{ll}, P_T^{lmax}, P_T^{lmin}, $\Delta\phi$





m_H = 160 GeV/c^2	Exp. Bkg.	Exp. Sig.	Data
Cut based	0.91 ± 0.05	1.23 ± 0.02	0
BDT	0.92 ± 0.10	1.47 ± 0.02	0

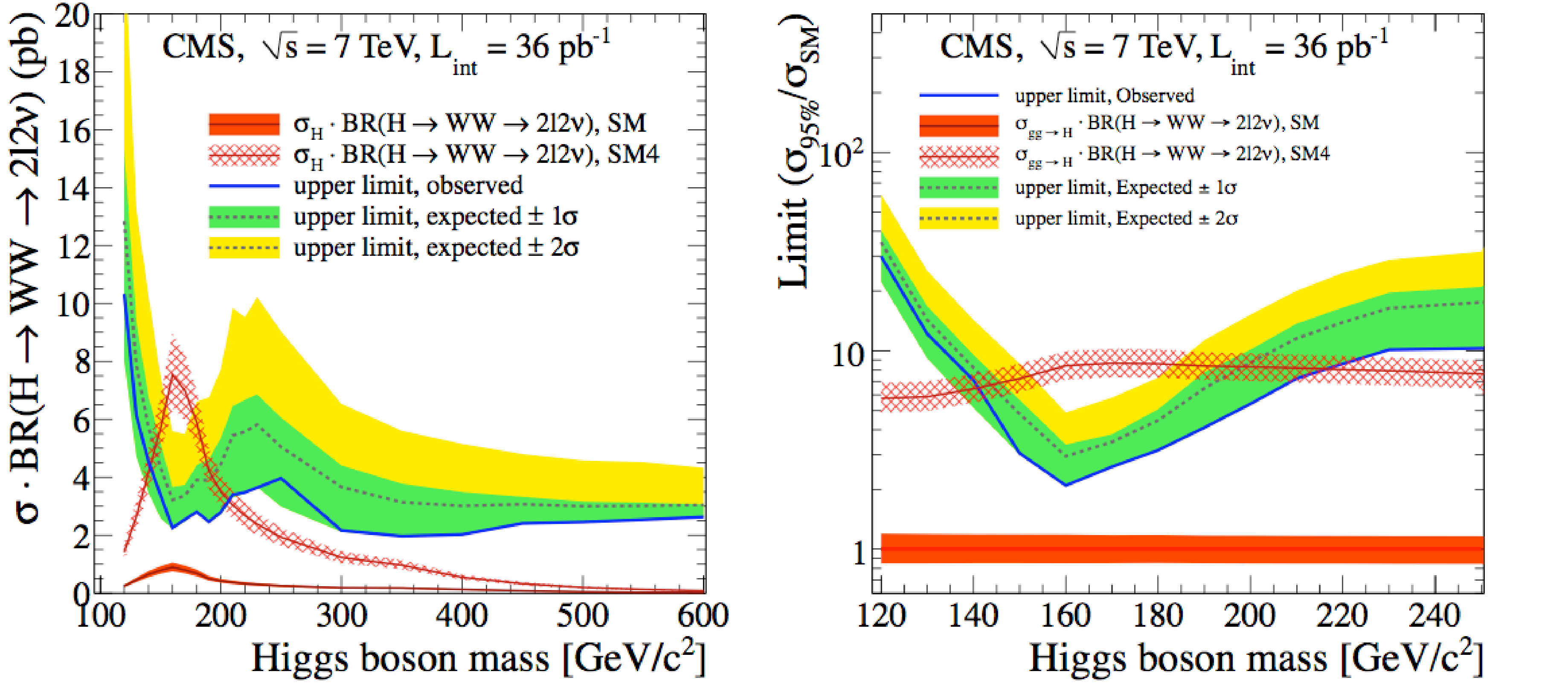
The ATLAS 95 % CL Exclusion limits using PCL



ATLAS excludes a 160 GeV/c^2 SM-like Higgs boson produced with a cross section of 1.2 x that of the Standard Model !

Best sensitivity at 2.1 (for a 170 GeV/c^2 Higgs)

The CMS 95 % CL Exclusion limits using CL_S

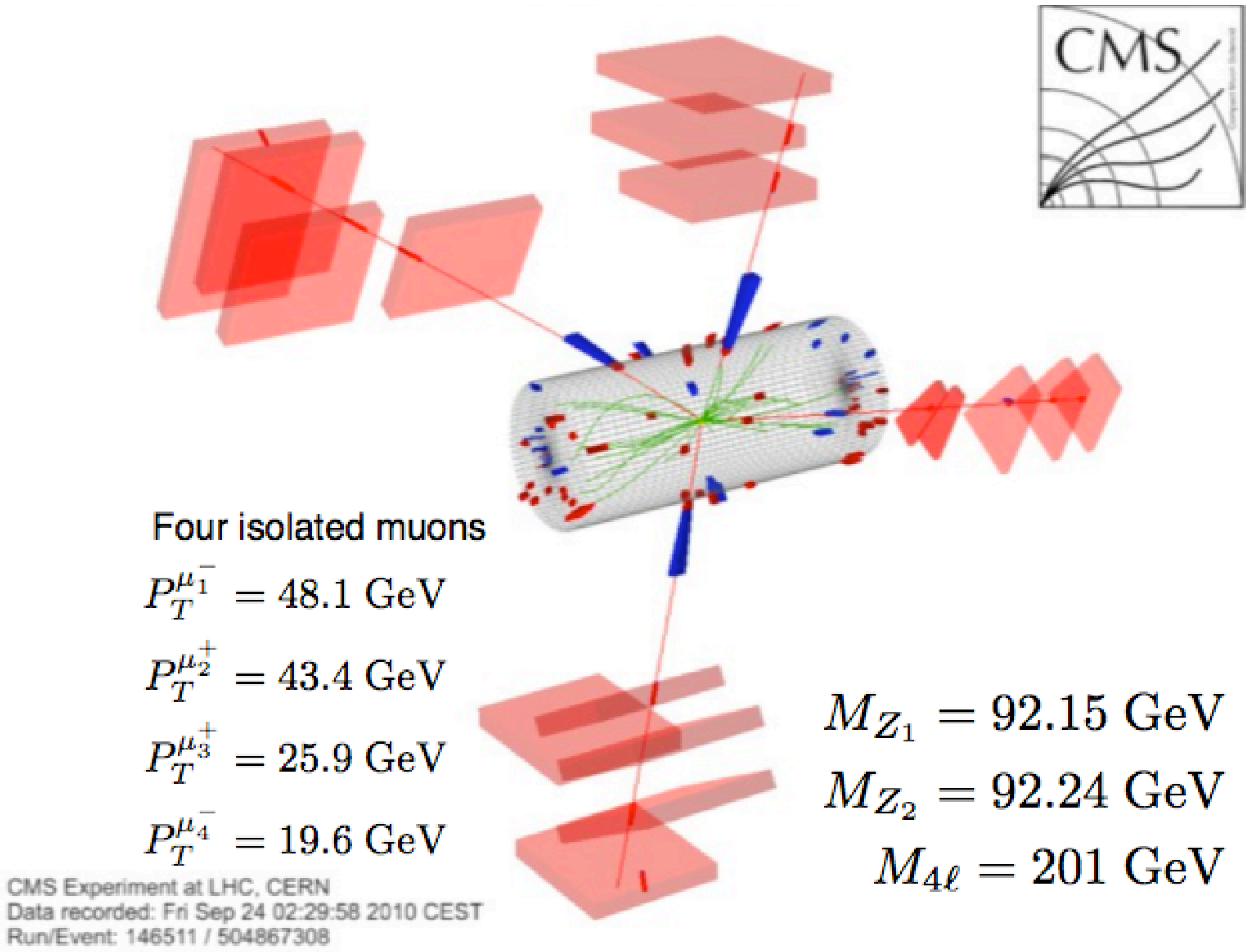


CMS excluded around 2 x SM cross section at 160 GeV/c^2

SM4 exclusion of 144-207 GeV/c^2 at 95% CL

Best sensitivity at 2.1 (for a 160 GeV/c^2 Higgs)

Higgs Boson Search in the ZZ→4-leptons



- Extremely clean channel (and quite robust against pile-up)

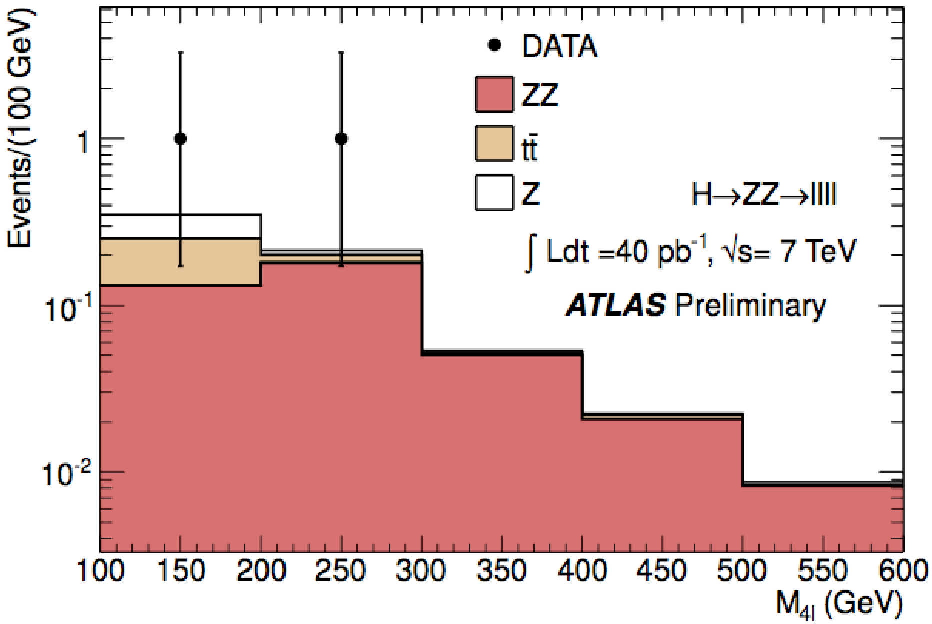
- The low Z leptonic branchings penalize its event yield

- Relative mass resoution almost as good as the two-photon channel

Selection :

- two pairs of opposite sign and same flavor leptons (e,μ), p_T>20 GeV
- Requirement on the di-lepton pair masses
- ΔR between leptons > 0.1
- No significant impact parameter

After kinematic cuts on di-leptons only



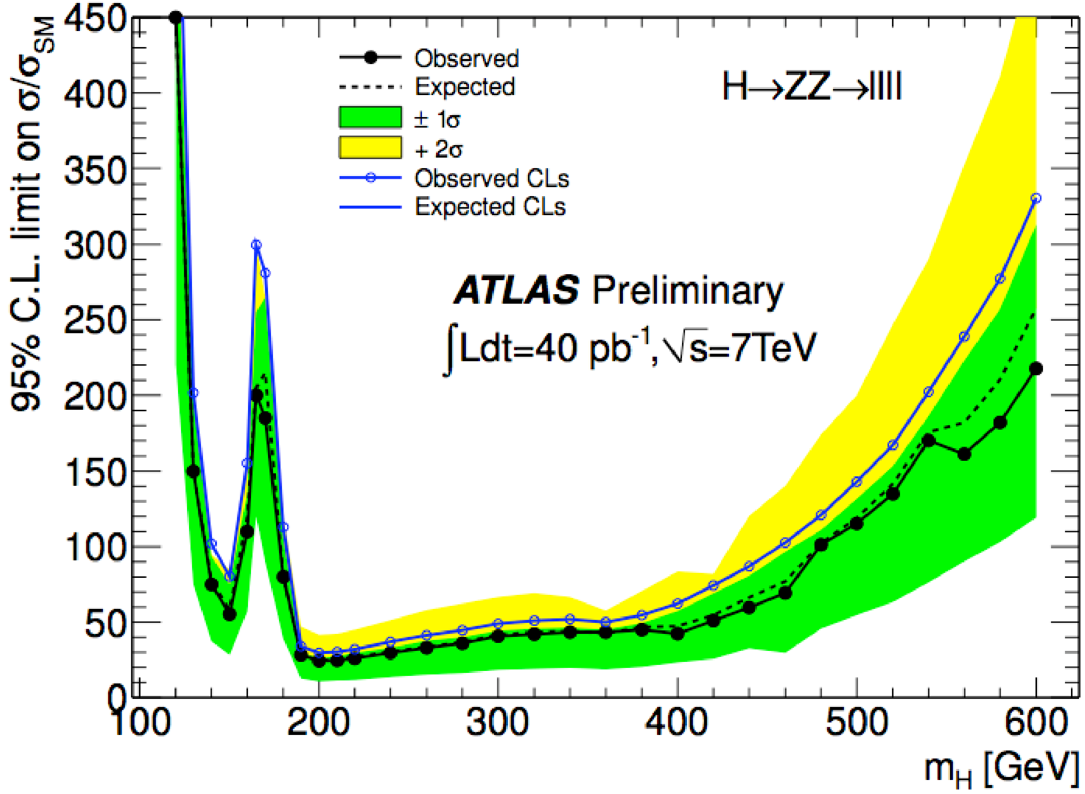
Data	0
BG	0.4
Higgs	0.10±0.02

Background dominated by ZZ

(M_{4l} used as discriminating variable with a specific statistical treatment given the complete absence of events)

Background estimate based on the Z→ll production rate (partially data driven)

$$N_{ZZ} = \sigma_{ZZ}\varepsilon_{ZZ}^{exp}L \times \left[\frac{N_Z^{Data}}{\sigma_Z\varepsilon_Z^{exp}L}\right] = N_{ZZ}^{MC} \times R$$



Exclusion at around 25 x SM… Not yet very sensitive!

The High Mass Higgs Channels

$H \to WW \to l\nu qq$ and $H \to ZZ \to llqq$ and $ll\nu\nu$ Channels

Taking advantage of the lower Z,W+jets at high mass and larger branching fraction

ATLAS-CONF-2011-052

Higgs Boson Search in the $WW \rightarrow l\nu qq$

- The lower W+jets background at high mass allows for one non-leptonic W decay

- Relative mass resolution almost as good as the two-photon channel (M_{WW} mass reconstructed using the $M_{l\nu} = M_W$ constraint)

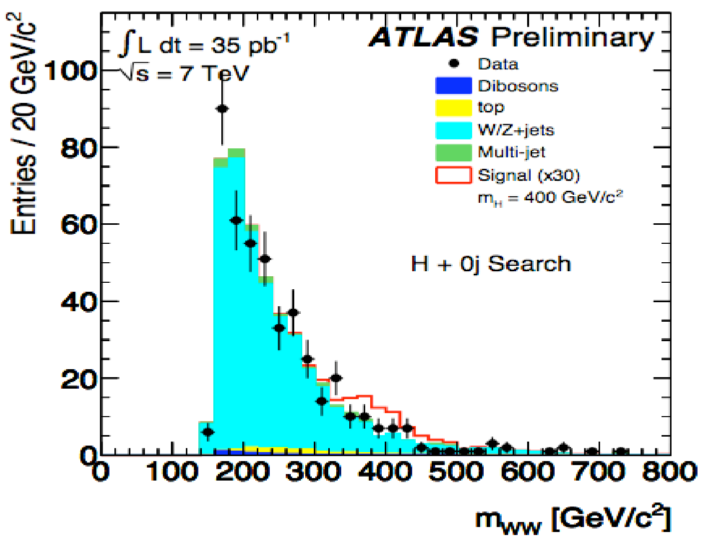
- The main backgrounds are from W,Z+jets and top

Event selection :

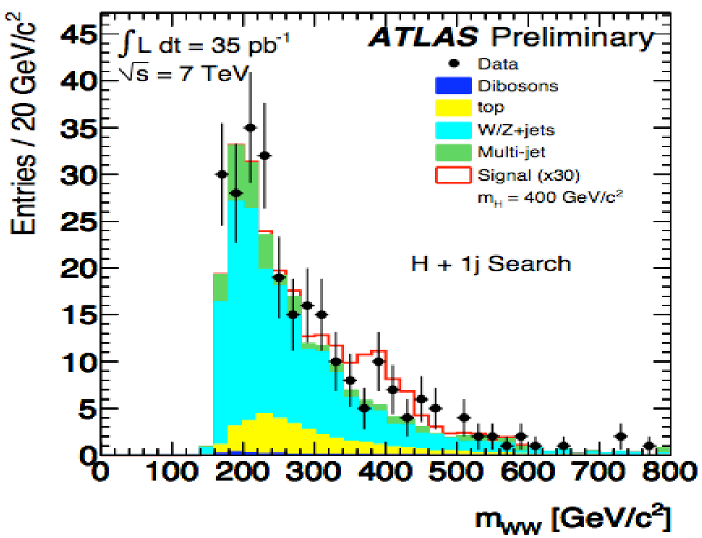
- 1 leptons (e,μ), p_T>30 GeV
- MET > 30 GeV
- Two or three jets p_T>30 GeV
- b-tag veto

Backgrounds are estimated from the side-bands in an exponential fit (shape well coroborated by MC studies)

0-jet sub-channel



1-jet sub-channel

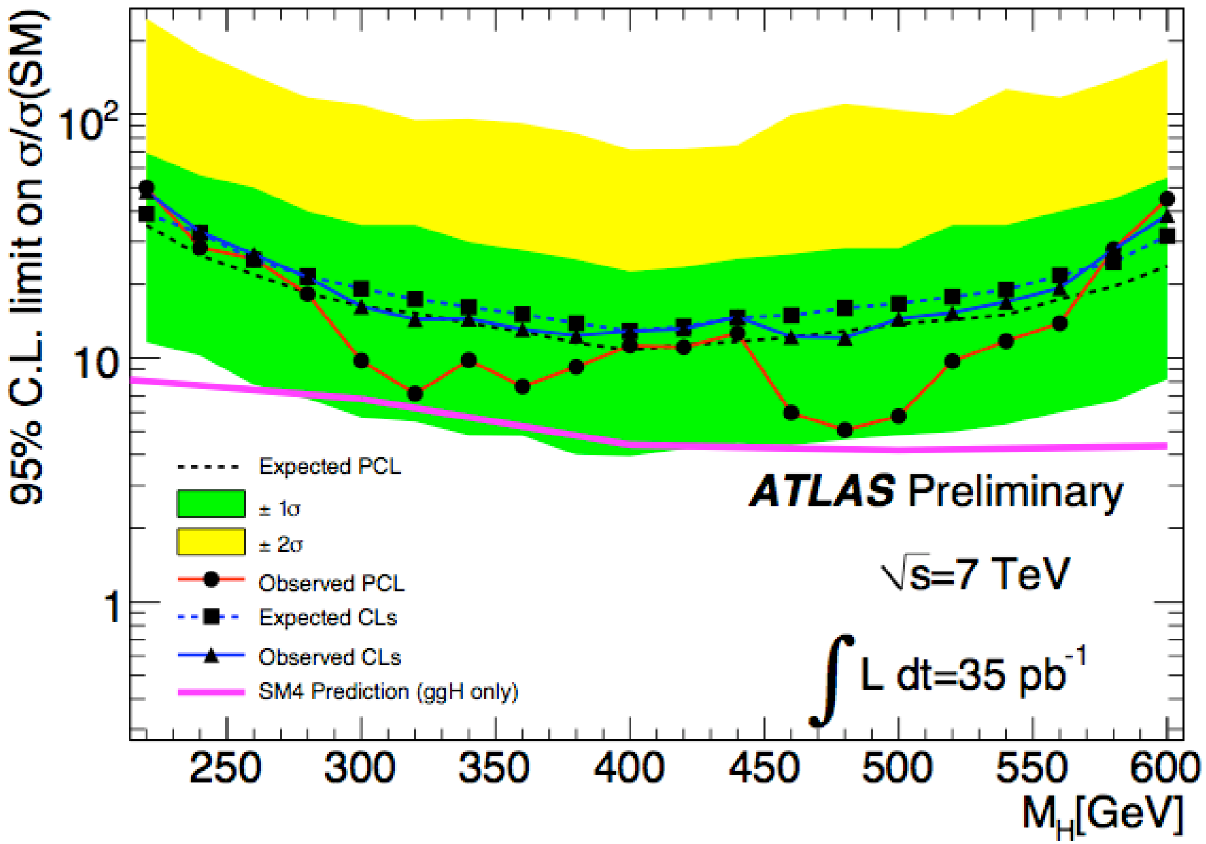


- Results after all selection cuts

Dominating background W/Z+jets estimated in the data from a fit to the MET distribution

Data	713
BG	674 ±46
Higgs	02.1±0.7

- 95% CL result using the PCL and CLs prescriptions



Large differences observed due to the proximity of the -1σ background fluctuation limit

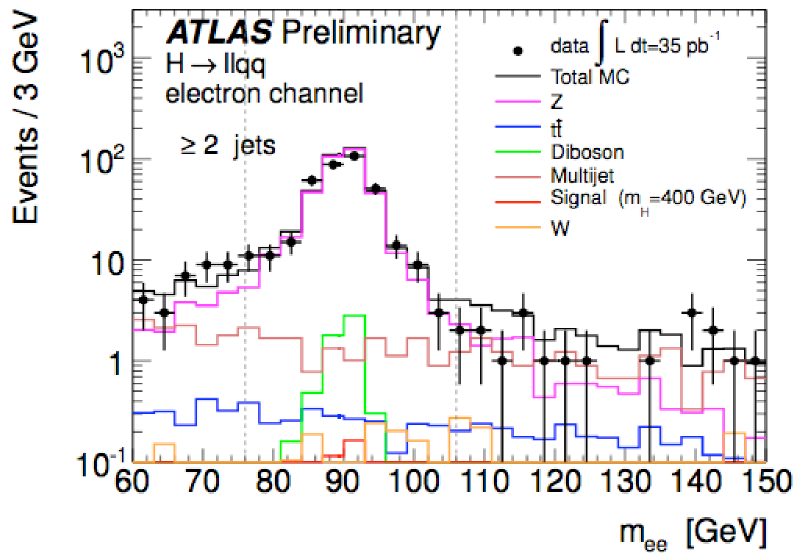
Higgs Boson Search in the ZZ→llqq and llνν Final States

- The lower Z+jets background at high mass allows for one non-leptonic Z decay or one Z→νν decay

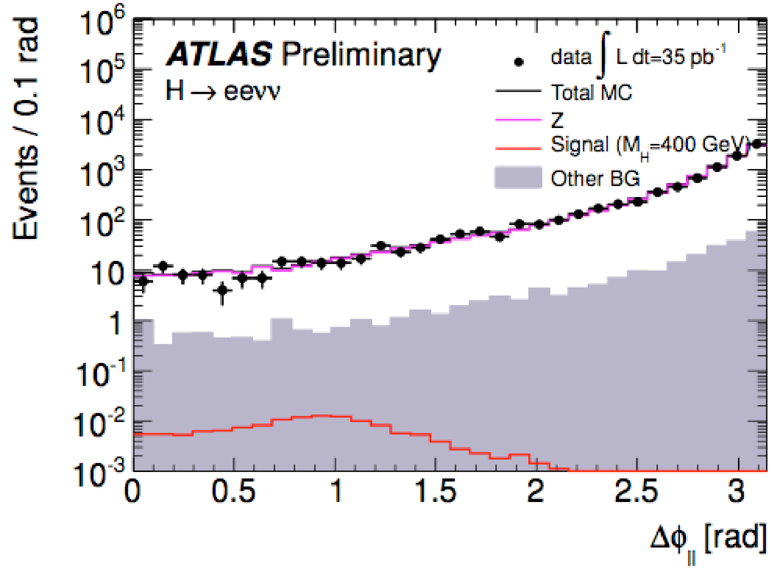
- Good mass resolution in the llqq channel using the Z mass constraint (spoilt by the Higgs natural width at high masses) but enough to define side bands

Also for the neutrinos channel : $m_T^2 \equiv \left[\sqrt{m_Z^2 + |\vec{p}_T^{\,\ell\ell}|^2} + \sqrt{m_Z^2 + |\vec{p}_T^{\,\rm miss}|^2}\right]^2 - \left[\vec{p}_T^{\,\ell\ell} + \vec{p}_T^{\,\rm miss}\right]^2$

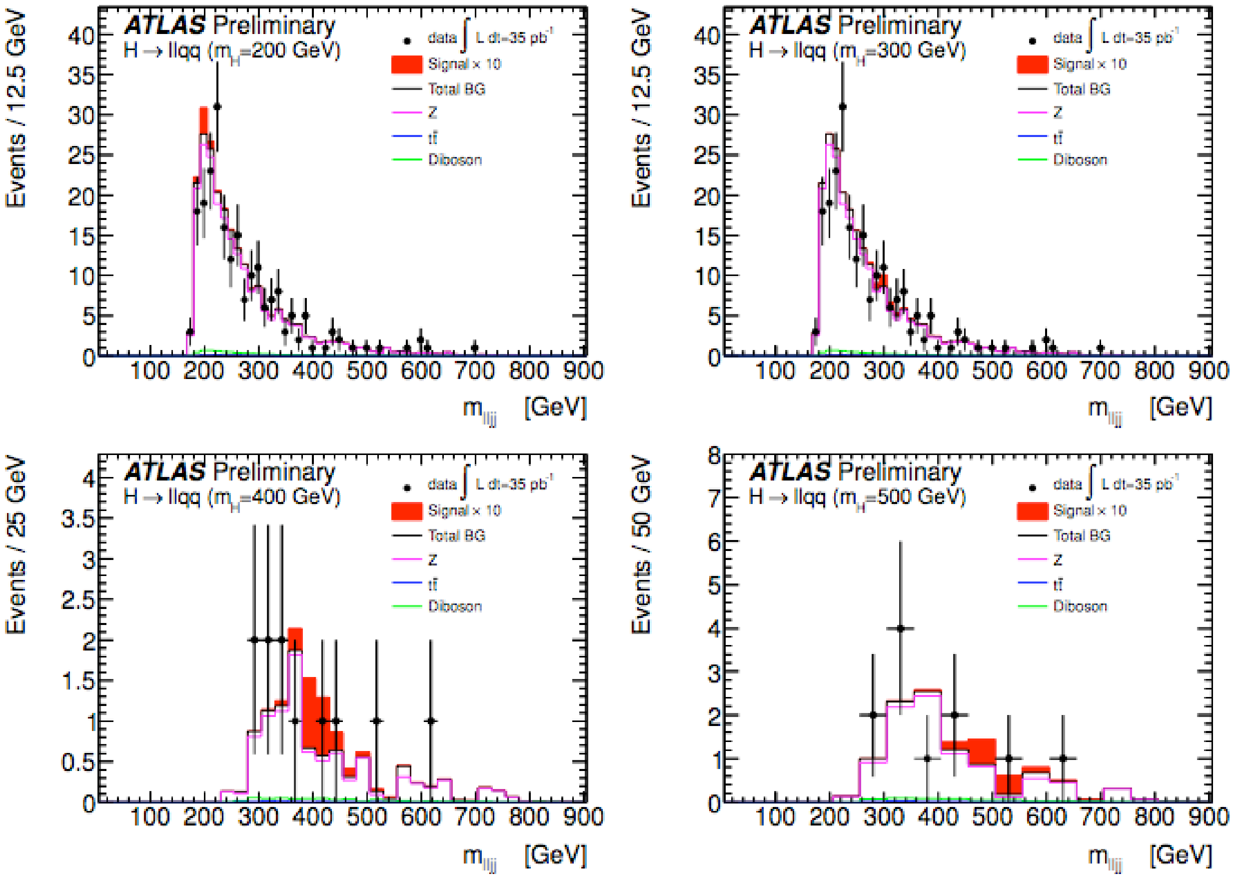
Common preselection :
- 2 leptons (e,μ), p_T>30 GeV
- 76 < M_{ll} < 106 GeV/c^2



Largely dominant background is Z+jets in the llqq channel



Another story for the Zνν channel…

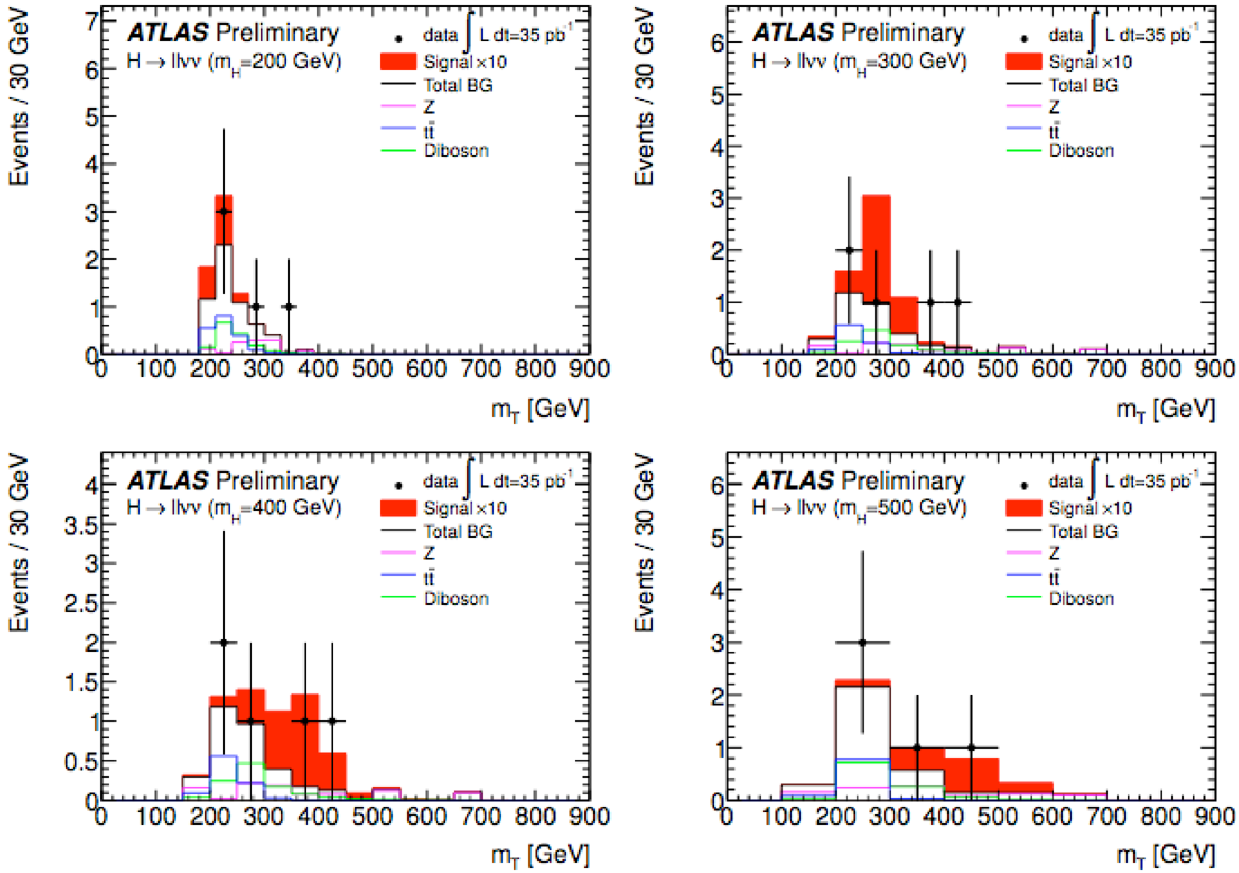


llqq selection :

- $70 < M_{jj} < 105$ GeV/c^2
- $M_{lljj} > 360$ GeV/c^2
- MET (veto) < 50 GeV
- Jets p_T>50 GeV
- $\Delta\phi_{\,ll}\,,\Delta\phi_{\,jj} < \pi/2$

llqq Channel :

- Dominant Z+jets background estimated in M_{jj} control region (40,70)
- Estimated with MC and normalization checks from side-bands in M_{ll}
- Di-boson from MC
- Multijet template derived from data using anti-ID cut



llqq selection :

- $70 < M_{jj} < 105$ GeV/c^2
- $M_{lljj} > 360$ GeV/c^2
- MET (veto) < 50 GeV
- Jets p_T>50 GeV
- $\Delta\phi_{ll}, \Delta\phi_{jj} < \pi/2$

llνν selection :

- b-jet veto
- MET > 66-82 GeV (dep. H mass)
- $\Delta\phi_{ll}$ < 2.25-2.64 (dep. H mass)

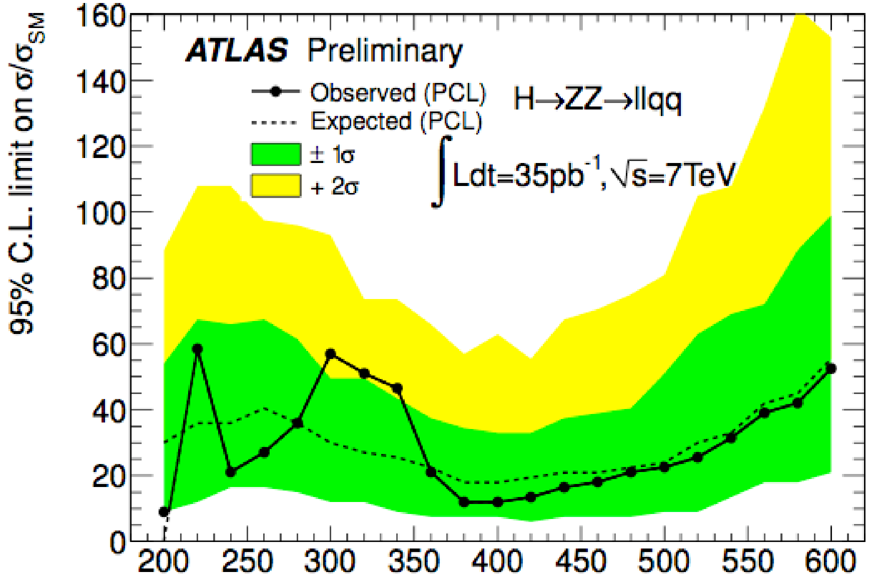
llqq Channel :

- Dominant Z+jets background estimated in M_{jj} control region (40,70)
- Estimated with MC and normalization checks from side-bands in M_{ll}
- Di-boson from MC
- Multijet template derived from data using anti-ID cut

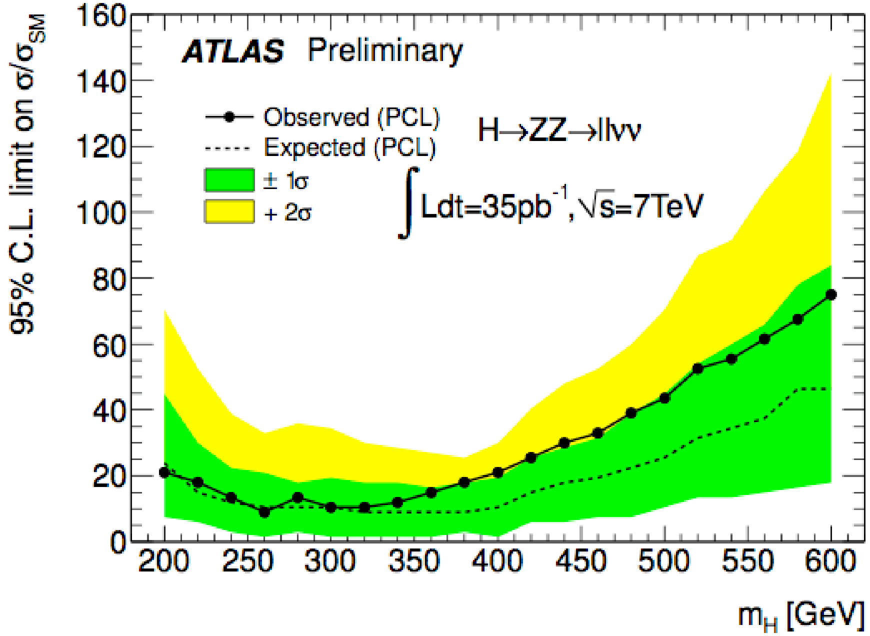
llνν Channel :

- Di-boson background estimated from MC (with uncertainty of ~15%)
- top from Monte Carlo with normalization checks in the data
- Multijet similar to llqq

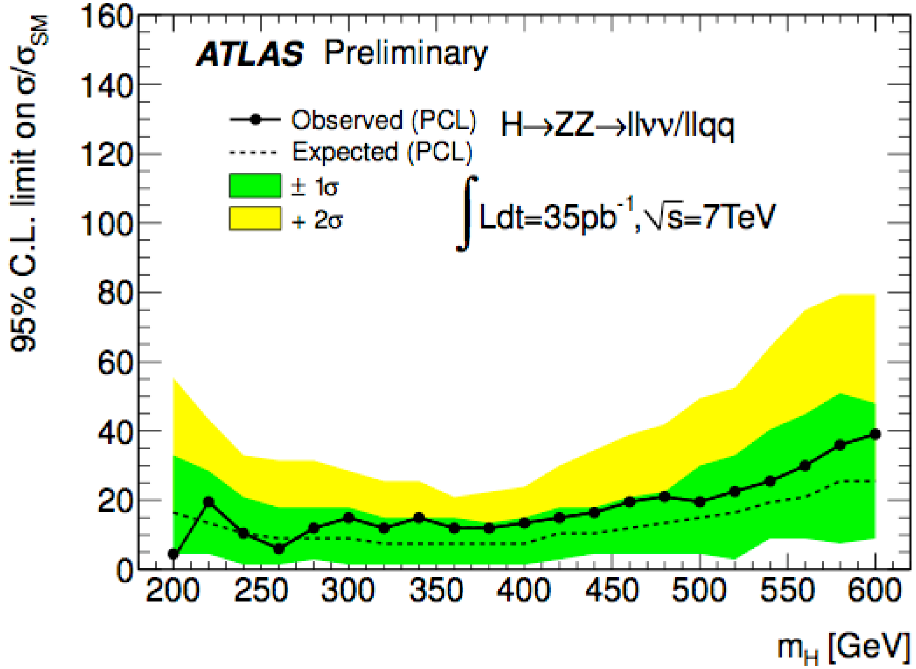
H→ZZ→llqq 95% CL PCL limit



H→ZZ→llνν 95% CL PCL limit



Combination of the two channels, limit at ~10 times the SM cross section



Systematic Uncertainties Review

The ATLAS case (CMS similar studies)

- Most backgrounds are estimated in the data in control samples (straightforward systematics)

- Most signal related systematic uncertainties are correlated among channels and arise from object reconstruction (electrons, photons, muons, jets, MET and b-tagging)

	$\gamma\gamma$		WW$\rightarrow \ell\nu\ell\nu$		WW$\rightarrow$lνqq		llll	llqq	ll$\nu\nu$
		0 jet	1 jet	2 jet	0jet	1 jet			
electron/γ efficiency	$^{+15}_{-16}\%$*	$\pm(6-16)\%$	$\pm(6-16)\%$	$\pm(6-16)\%$	$\pm 5.4\%$	$\pm 5.4\%$	$\pm 2.5\%$	$\pm 4.6\%$	$\pm 4.6\%$
electron/γ energy scale	-	$\pm(1-3)\%$	$\pm(1-3)\%$	$\pm(1-3)\%$	-	-	$\pm 1\%$	$\pm(1-3)\%$	$\pm(1-3)\%$
electron/γ resolution	$\pm 13\%$	$\pm 20\%$	$\pm 20\%$	$\pm 20\%$	-	-	-	$\pm(0.2-0.4)\%$	$\pm(0.2-0.4)\%$
muon efficiency	-	$\pm(0.4-1.2)\%$	$\pm(0.4-1.2)\%$	$\pm(0.4-1.2)\%$	$\pm 0.4\%$	$\pm 0.4\%$	$\pm(0.5-1)\%$	$\pm 2\%$	$\pm 2\%$
muon energy scale	-	$< \pm 3.5\%$	$< \pm 3.5\%$	$< \pm 3.5\%$	-	-	$\pm 1\%$	$\pm 1\%$	$\pm 1\%$
muon resolution	-	$< \pm 10\%$	$< \pm 10\%$	$< \pm 10\%$	-	-	$\pm few\%$	-	-
JES signal	-	$< \pm 10\%$	$< \pm 10\%$	$< \pm 10\%$	$\pm 26\%$*	$\pm 26\%$*	-	$\pm(5-12)\%$	-
JES background	-	-	-	-	-	-	-	-	-
JET resolution signal	-	$\pm 14\%$	$\pm 14\%$	$\pm 14\%$	-	-	-	$\pm(5-12)\%$	-
JET resolution bkgd.	-	-	-	-	-	-	-	-	-
b tag efficiency	-	-	$\pm 10-12\%$	$\pm 10-12\%$	-	-	-	-	$\pm 10-12\%$
b mistag rate	-	-	$\pm 26\%$	$\pm 26\%$	-	-	-	-	$\pm 26\%$
MET resolution	-	$\pm 20\%$	$\pm 20\%$	$\pm 20\%$	-	-	-	-	$\pm 20\%$
MET tails	-	-	-	-	-	-	-	-	-
Luminosity - sig.	$\pm 11\%$	$\pm 11\%$	$\pm 11\%$	$\pm 11\%$	$\pm 11\%$	$\pm 11\%$	$\pm 11\%$	$\pm 11\%$	$\pm 11\%$
Luminosity - bkg.	-	-	-	-	-	-	-	$\pm 11\%$	$\pm 11\%$
Signal in gg$\rightarrow$H	$^{+20}_{-15}\%$	$^{+20}_{-15}\%$	$^{+20}_{-15}\%$	$^{+20}_{-15}\%$	$^{+20}_{-15}\%$	$^{+20}_{-15}\%$	$^{+20}_{-15}\%$	$^{+20}_{-15}\%$	$^{+20}_{-15}\%$
Signal in VBF	-	-	-	$^{+4-20}_{-3-20}\%$	-	-	-	-	-

*Per event efficiencies

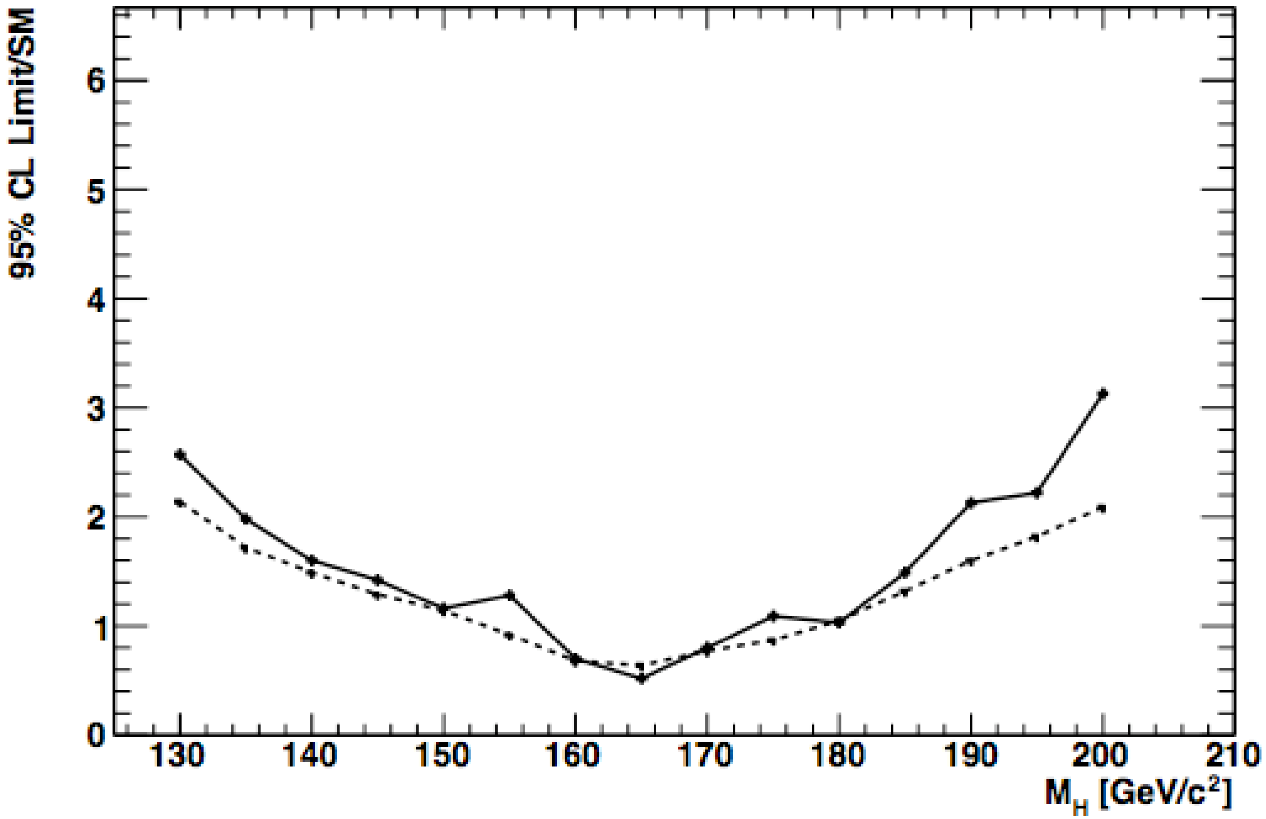
This slide unfortunately does not do justice to the work necessary to derive each figure…

An immense amount of work has been devoted to study in detail each of these systematics, in the combined performance groups

Standard Model Higgs Search in 2010 Data Summary

New Window on Higgs Searches !

- Backgrounds mostly estimated in the data !
- Large effort made to understand and control signal related systematic uncertainties.
- Novel statistical interpretation of our result (yielding less conservative limits)



TeVatron “High Mass”

LHC High Mass

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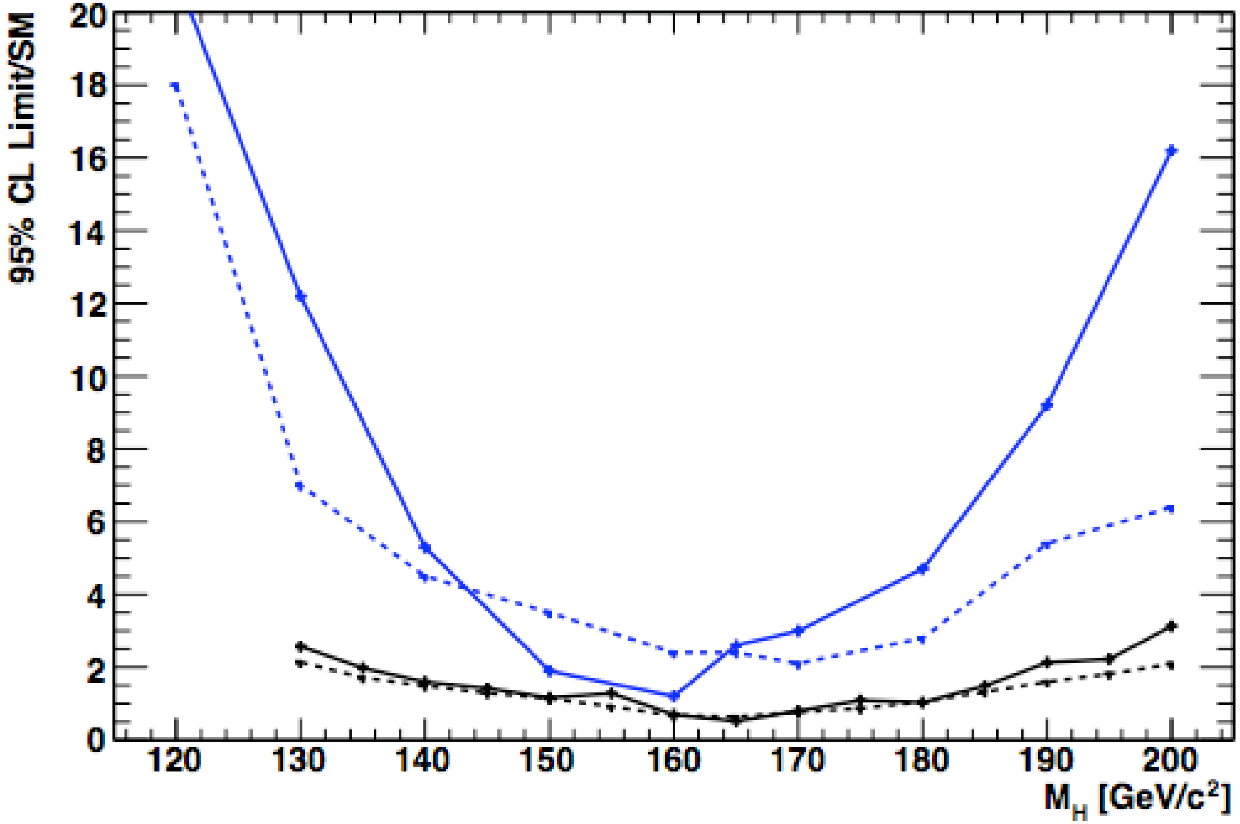

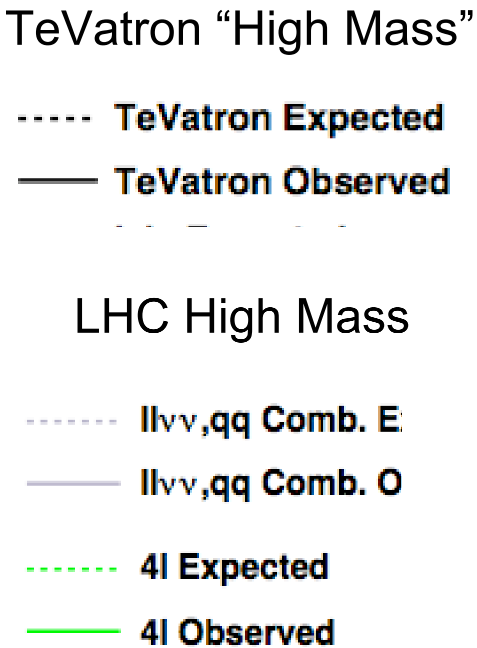

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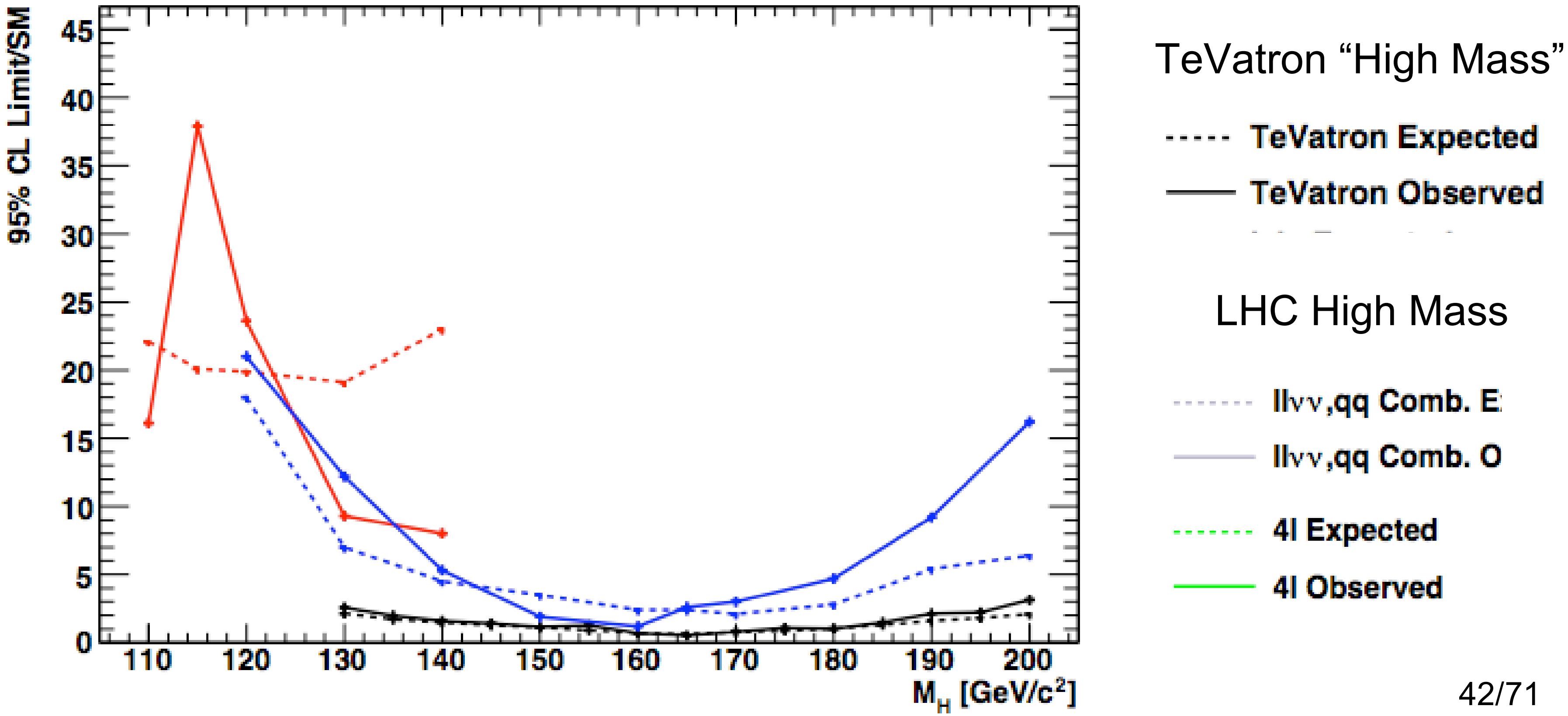

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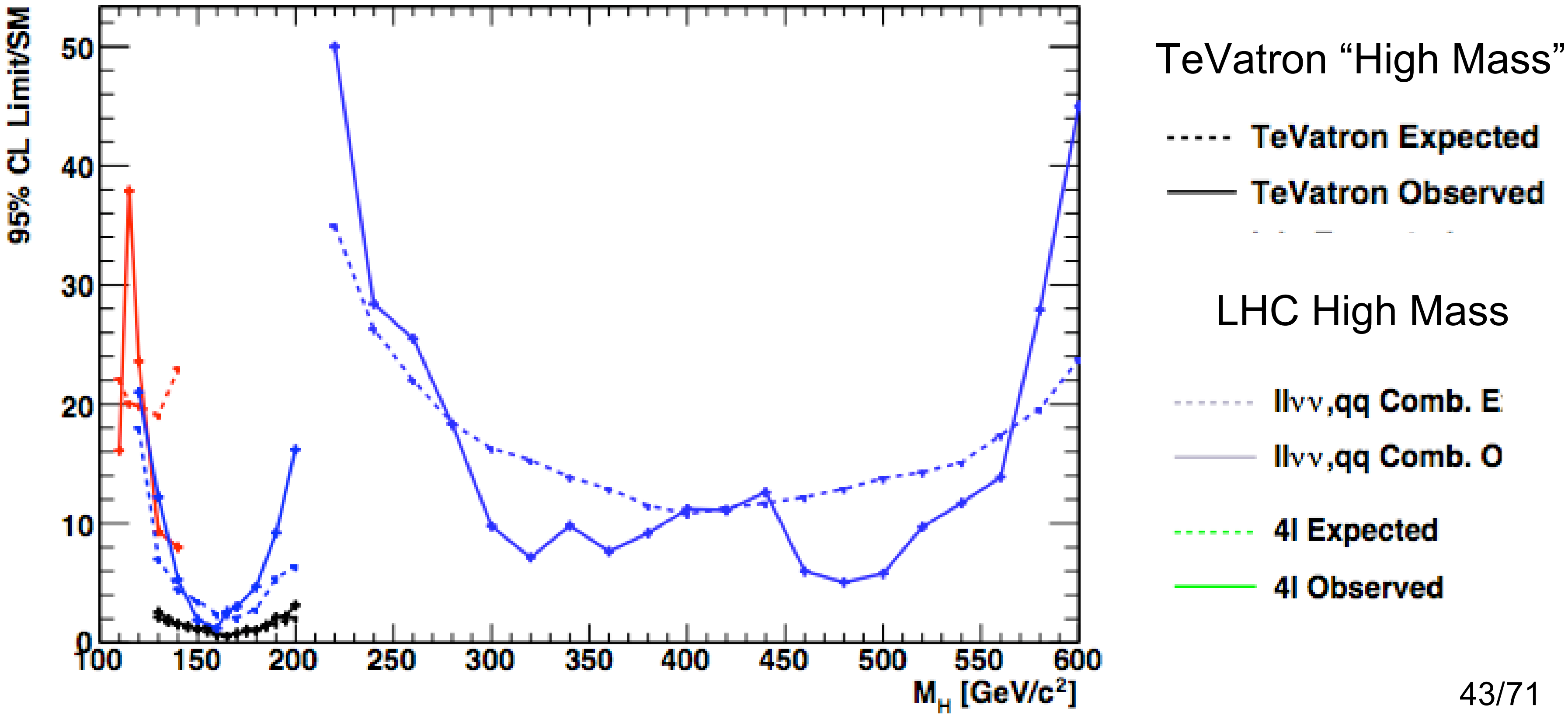

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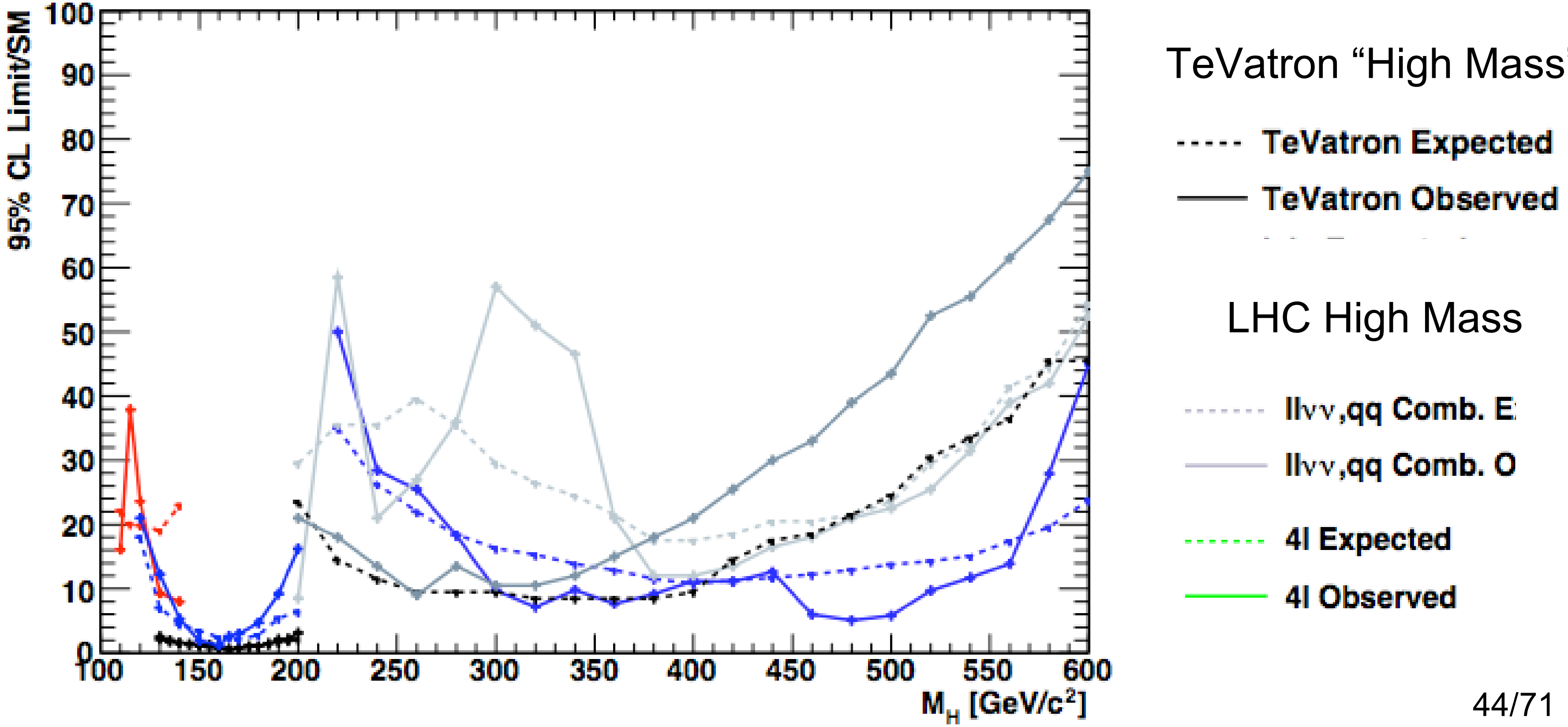

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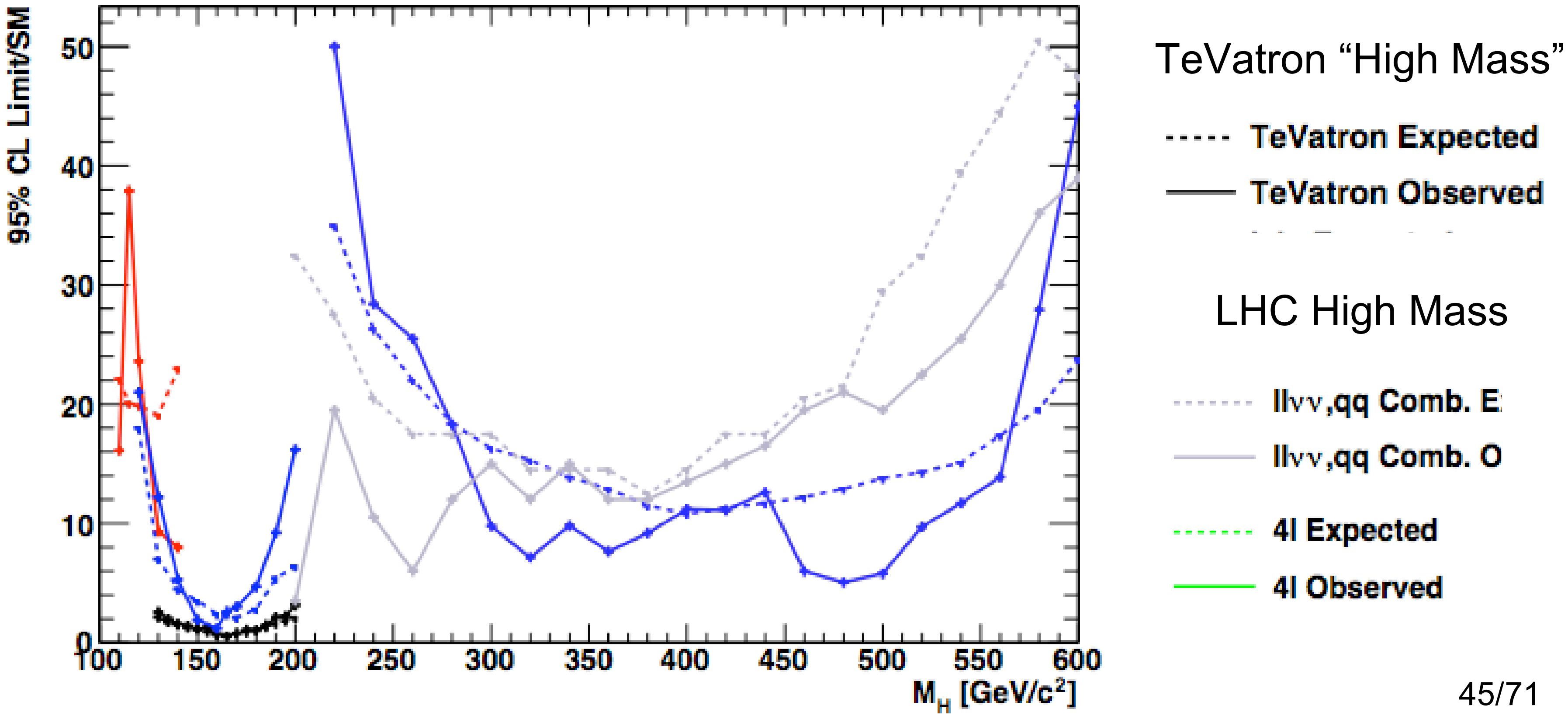

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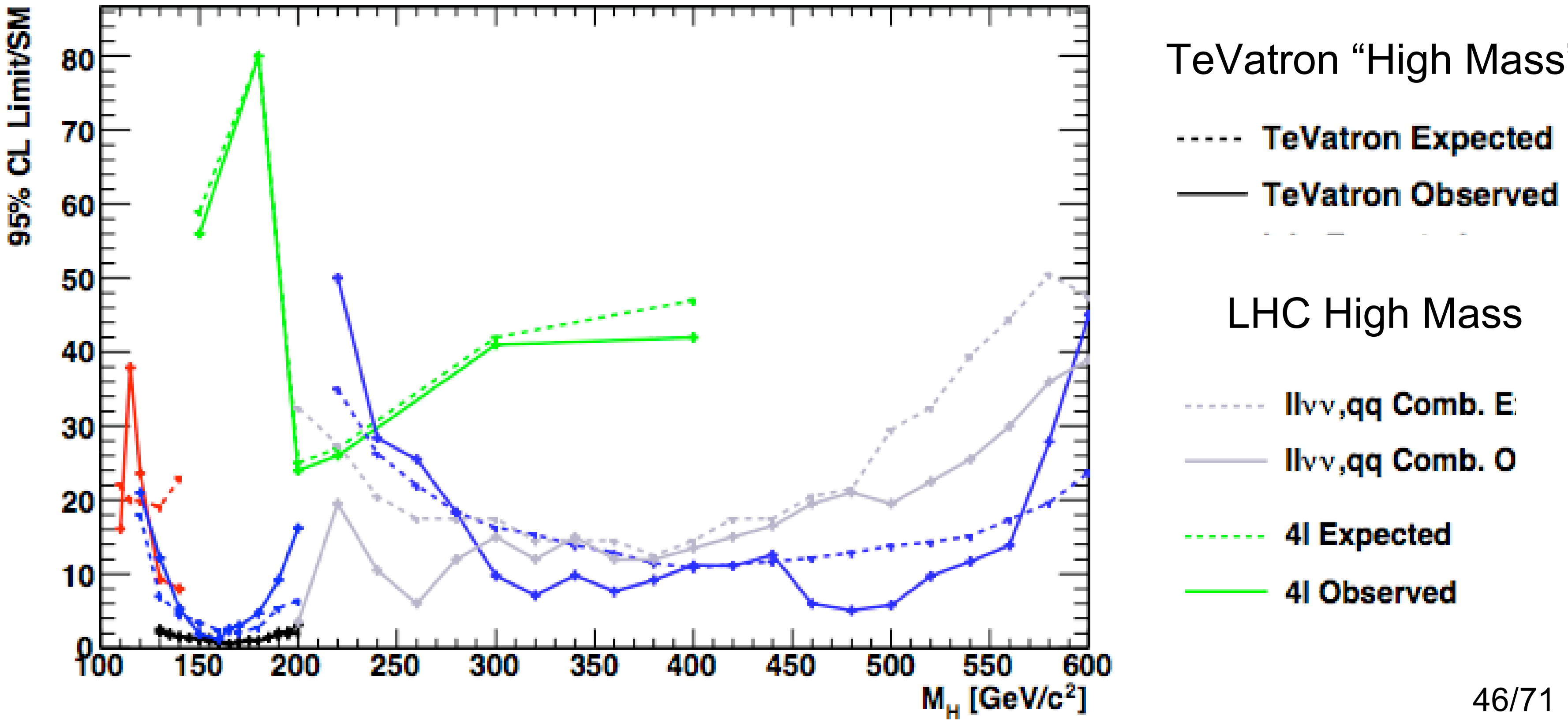
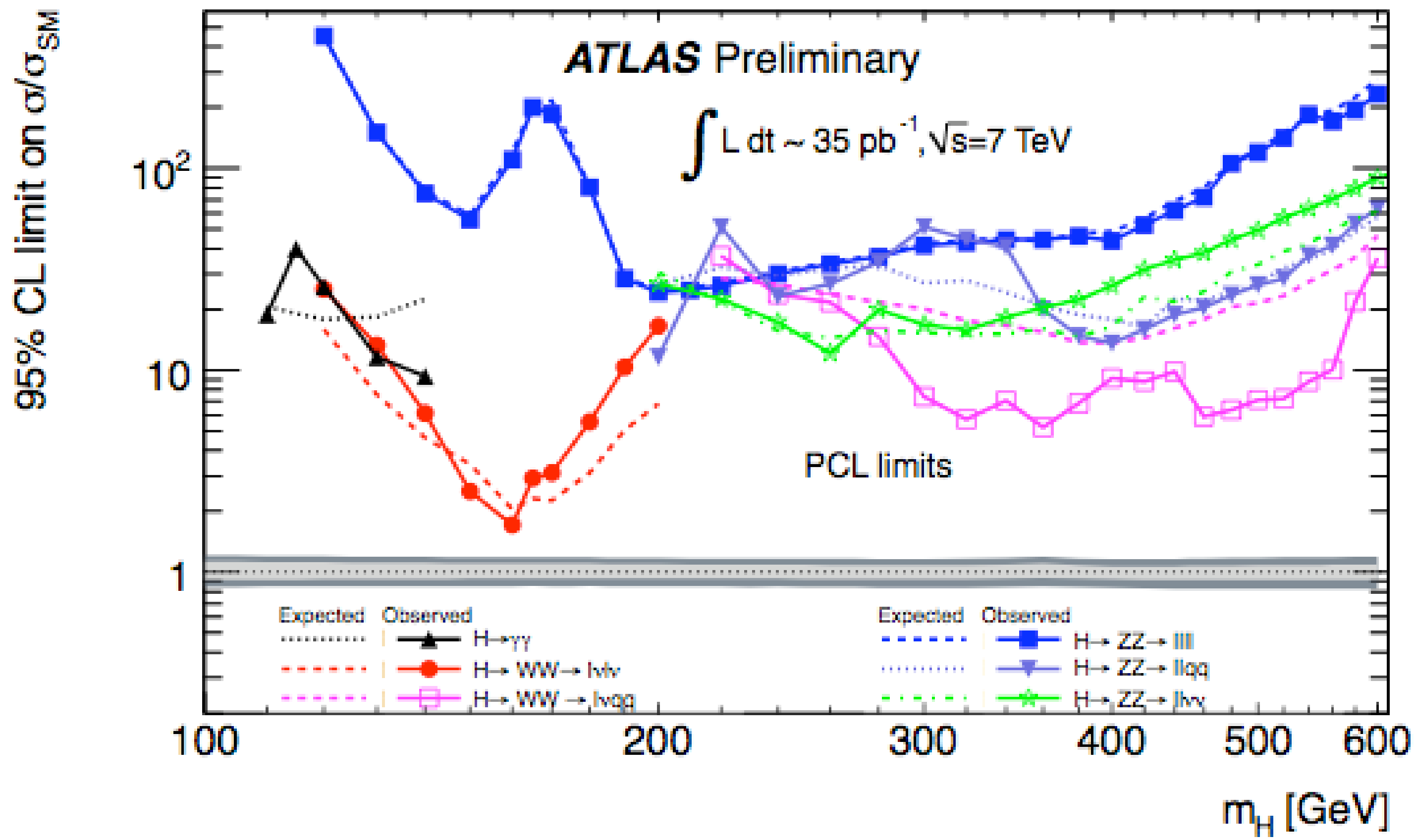


Fresh and Hot out of the Oven !

(Since just a few hours ago)



- The combination will not improve greatly results in the intermediate mass range (110-200 GeV/c^2) but promising in the high mass range.

- Getting very close to excluding SM Higgs boson mass hypotheses.

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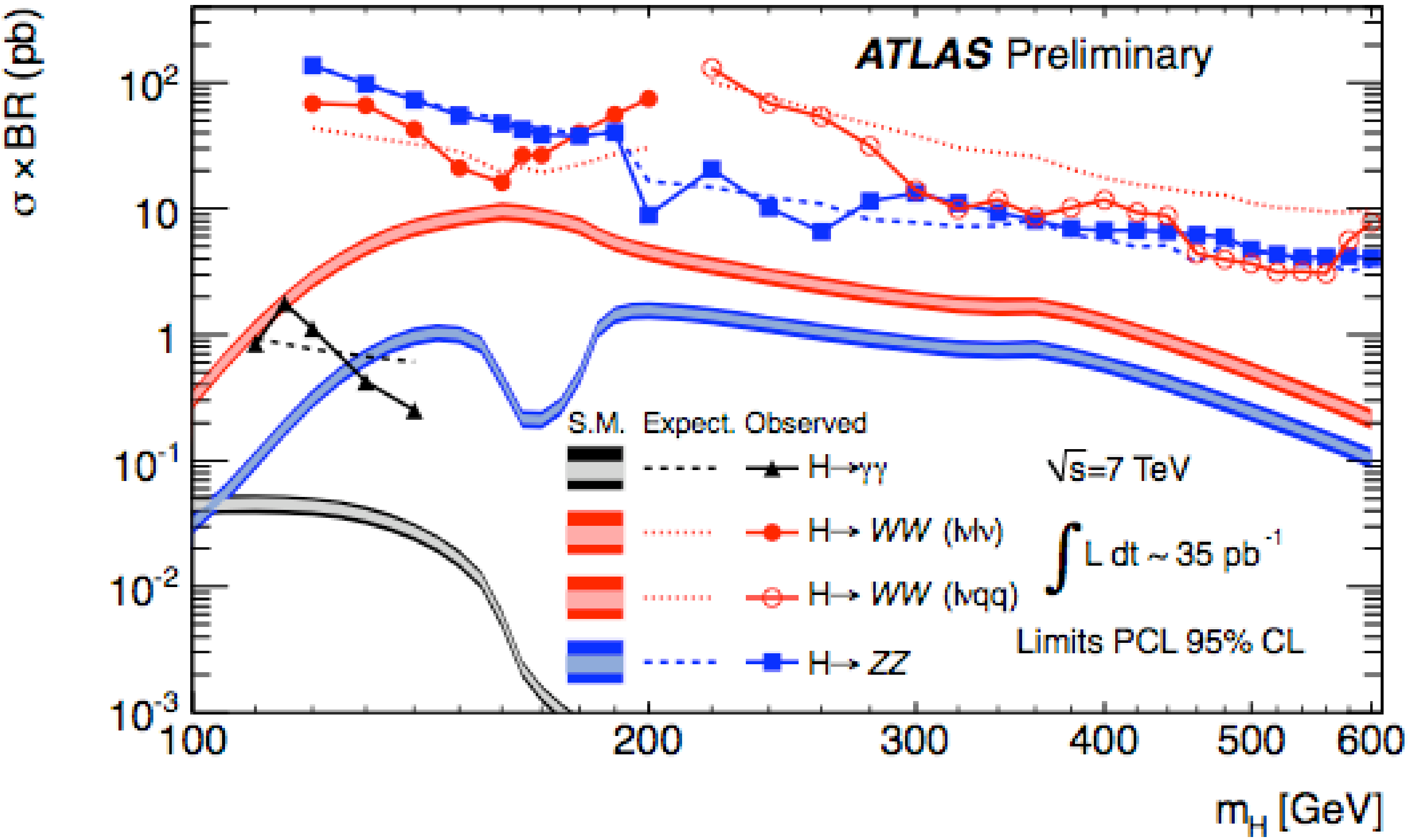

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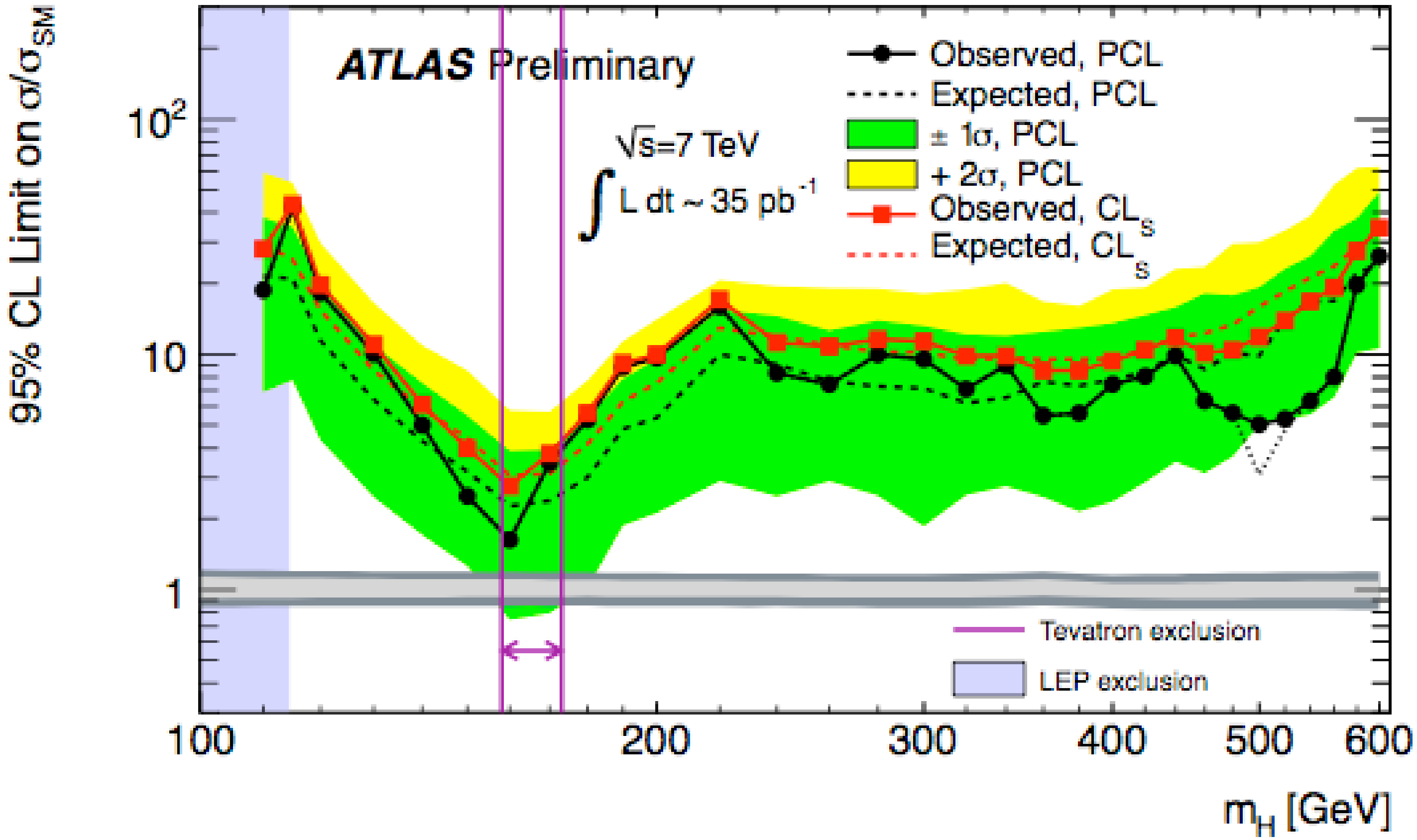

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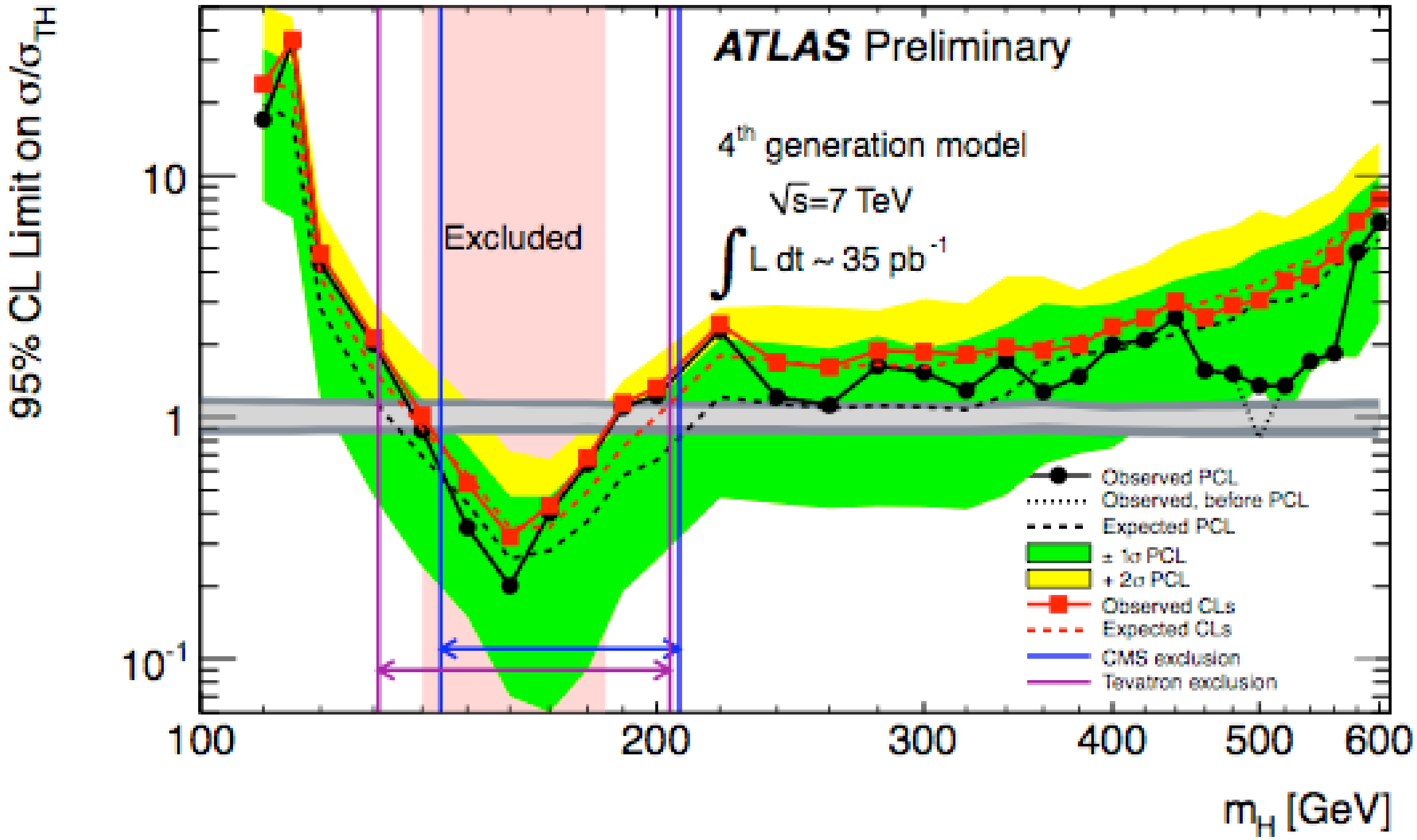

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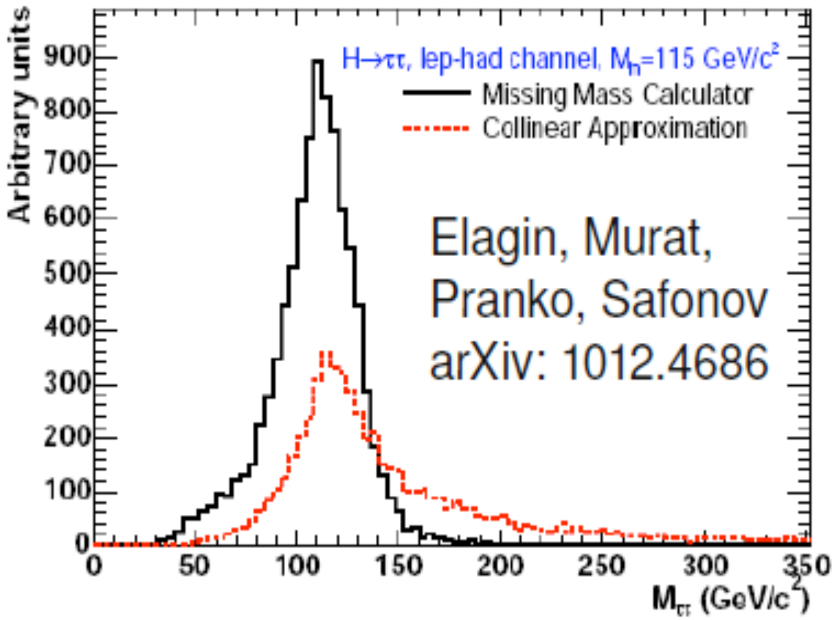
The ττ MSSM Higgs Boson Search

New hopes for an inclusive analysis even in SM…

A New Mass Reconstruction Technique for Resonances Decaying to $\tau\tau$

arXiv:1012.4684

A.Elagin[a], P.Murat[b], A.Pranko[c], A.Safonov[a]



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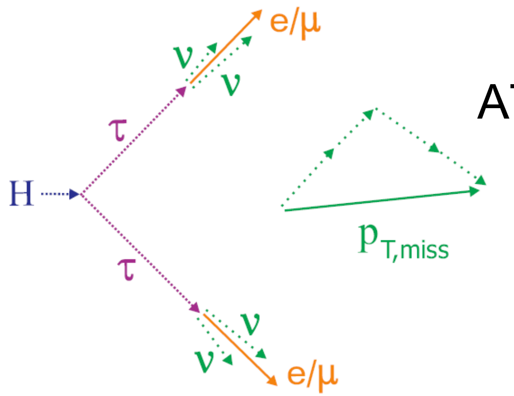
… for the time being similar technique used only by CMS …



ATLAS Mass reconstruction uses collinear approximation…

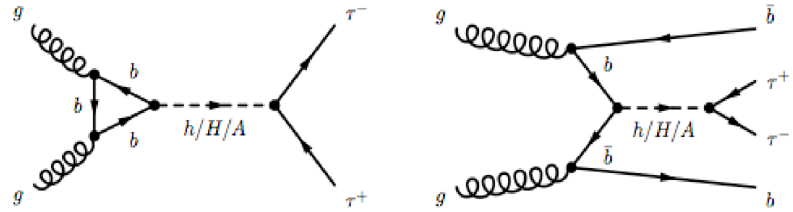
Relying on the transverse missing energy resolution, to reach a reconstructed mass resolution of 8-10 GeV/c^2 (depends also on pile-up)

ATLAS-CONF-2011-024

CMS-HIG-10-002

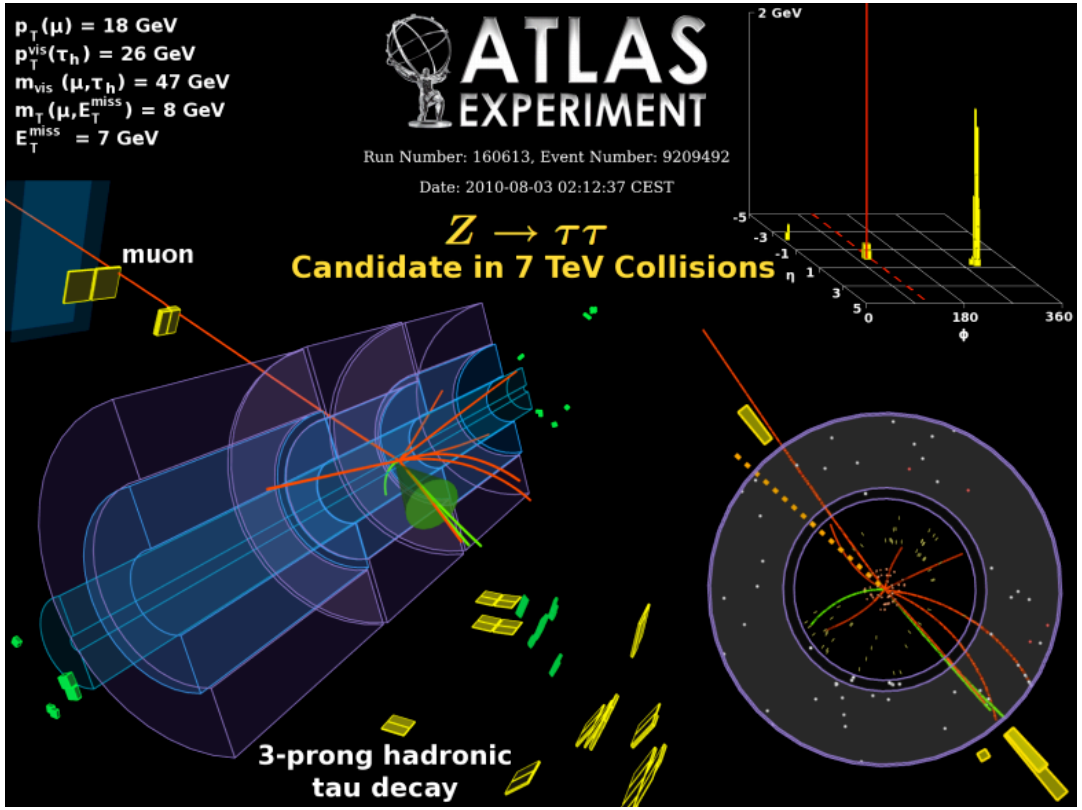
MSSM Higgs Boson Search in the $\tau^+\tau^-$ Channel

Signal produced mainly in gluon fusion and b(b)H



Search performed in the τ_{had} e,μ channels

Main background Z decays into $\tau^+\tau^-$



ATLAS Event selection :

- 1 tau and 1 leptons (e,μ), opp. sign
- MET > 20 GeV
- M_T < 30 GeV

$$M_{\rm T} = \sqrt{2 p_{\rm T}^{e/\mu} E_{\rm T}^{\rm miss}(1 - \cos\Delta\phi)}$$

Results :

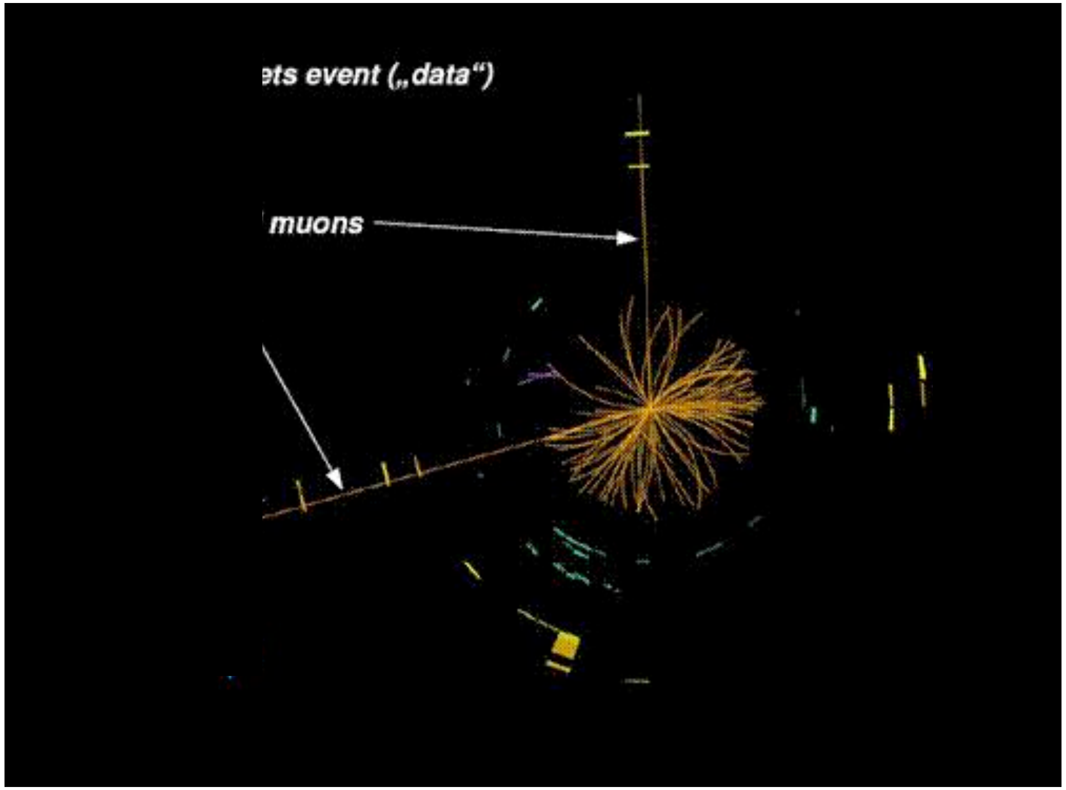
(m_A = 120 GeV/c^2 and tan β = 40)

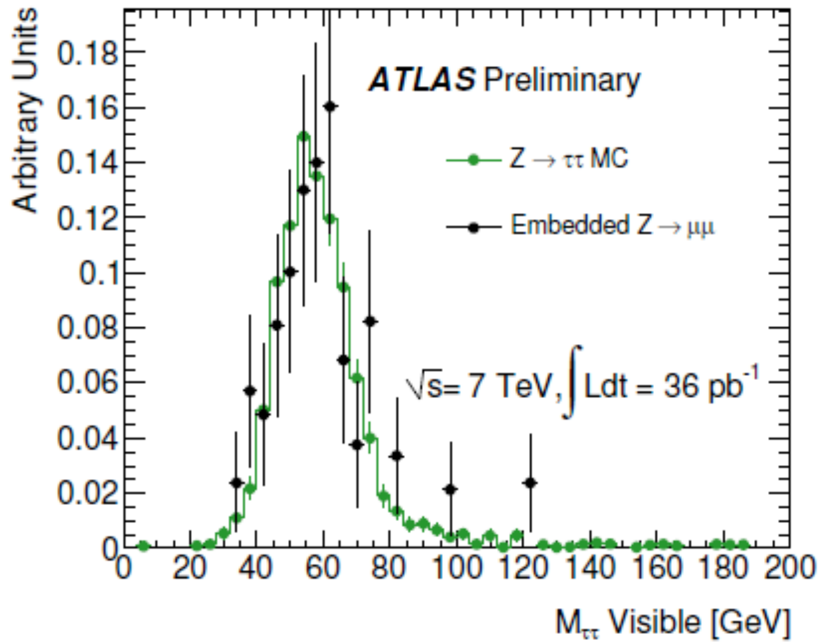
Data	206
BG	207 ± 6
Higgs	52 ± 1

Z background ~50%

Data driven background estimates

- Z to $\tau^+\tau^-$ mass shape from embedding taus in Z to $\mu^+\mu^-$ events





- Tau decays from Tauola and ATLAS simulation

- Normalization from MC

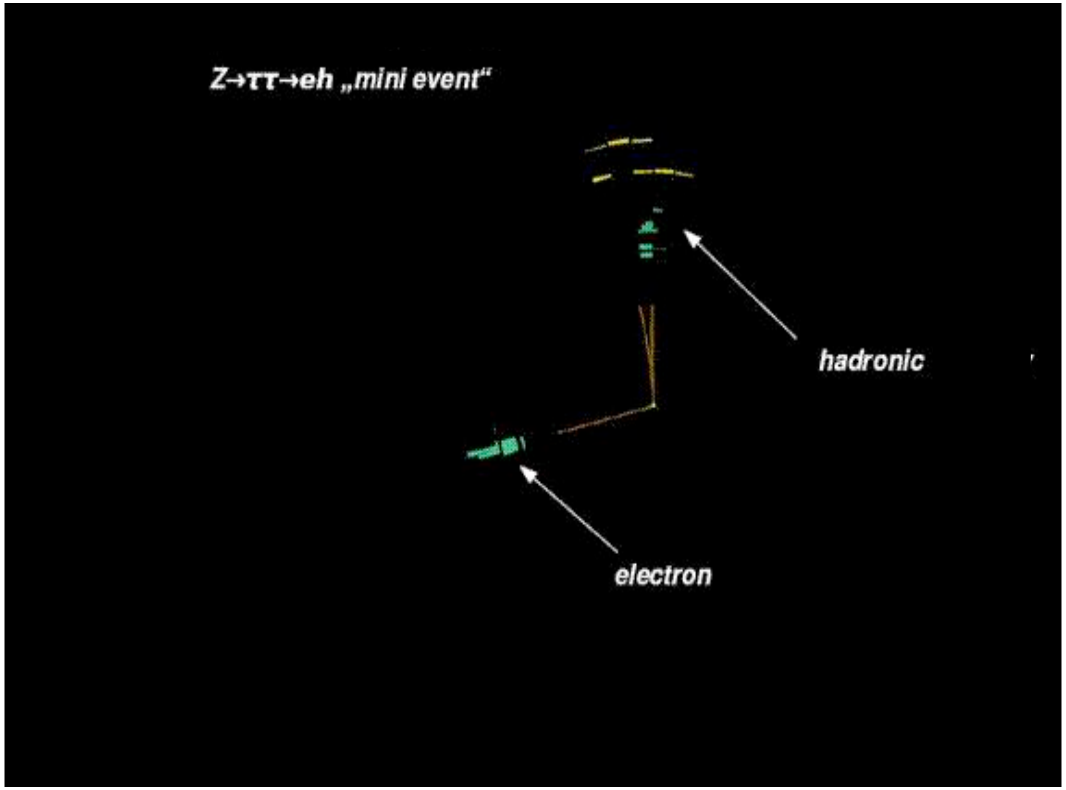
- W+jets and QCD backgrounds

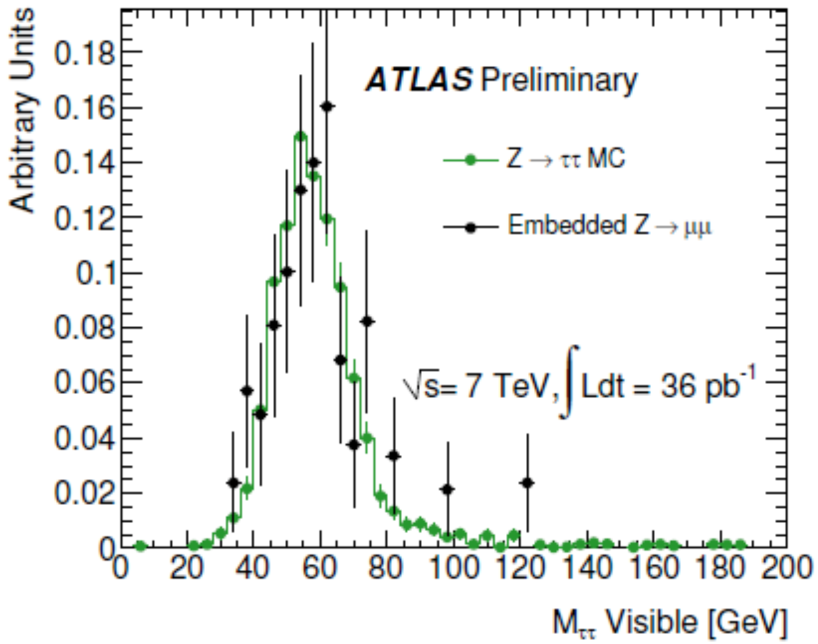
  - M_{vis} shape determined from the SS events

  -Normalization from control region OS/SS (low MET for QCD and large M_T for W+jets)

Data driven background estimates

- Z to $\tau^+\tau^-$ mass shape from embedding taus in Z to $\mu^+\mu^-$ events





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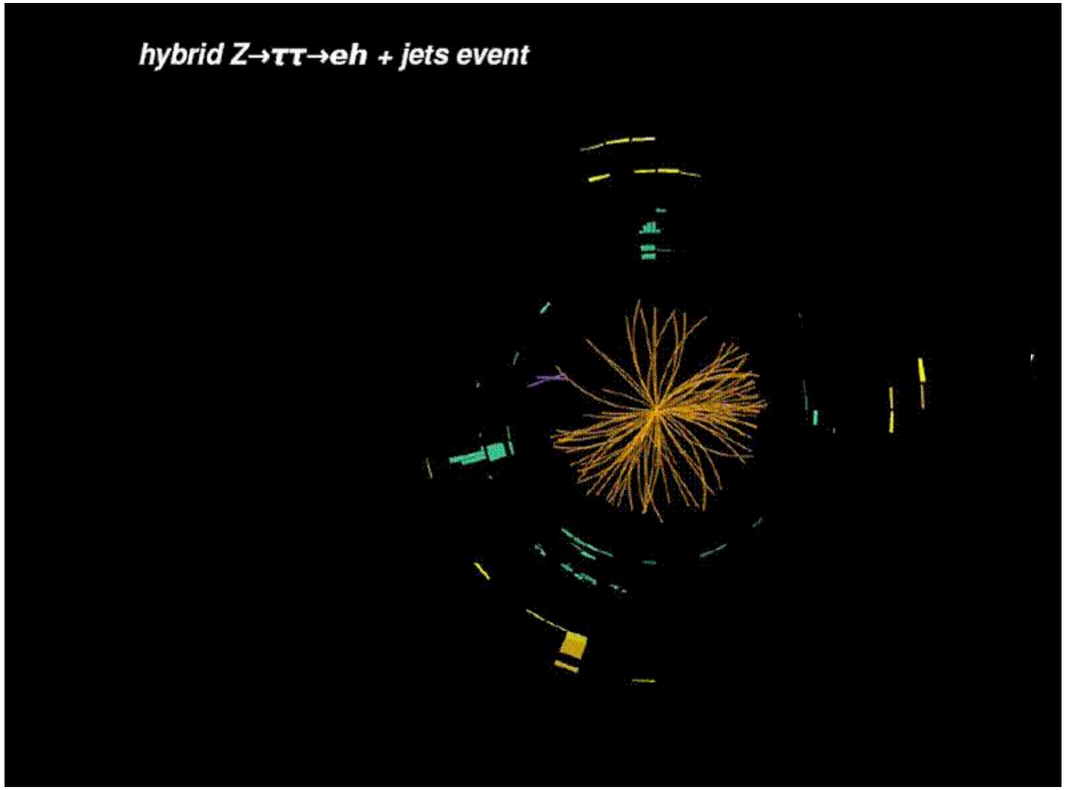

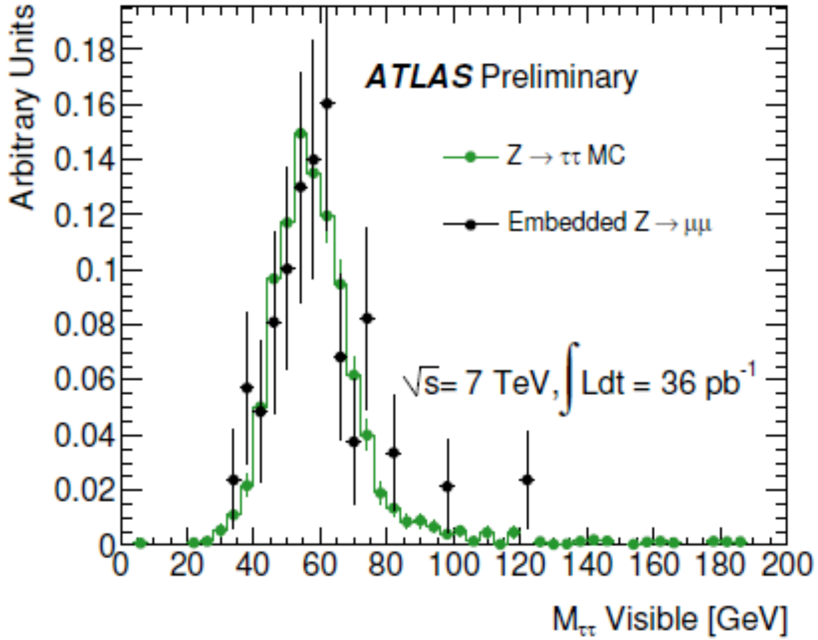

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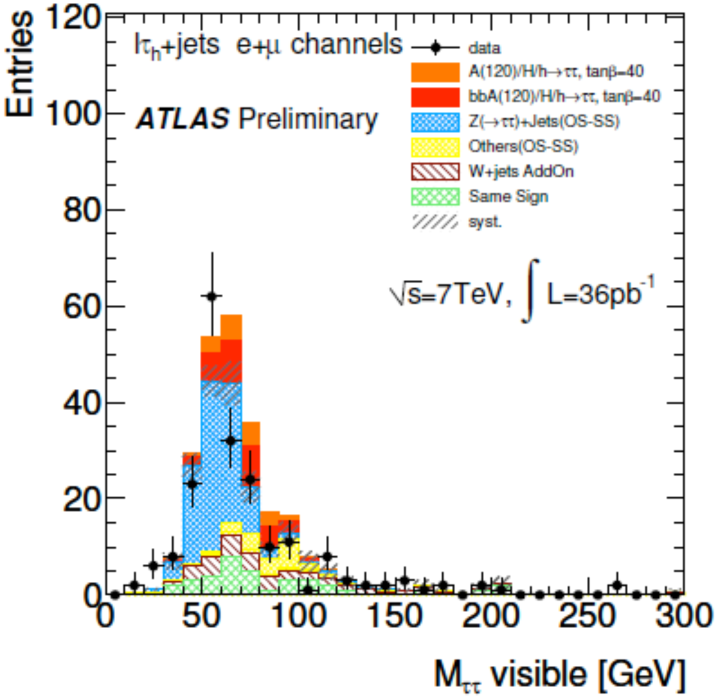


ATLAS uses the lepton-tau-hadron channels only

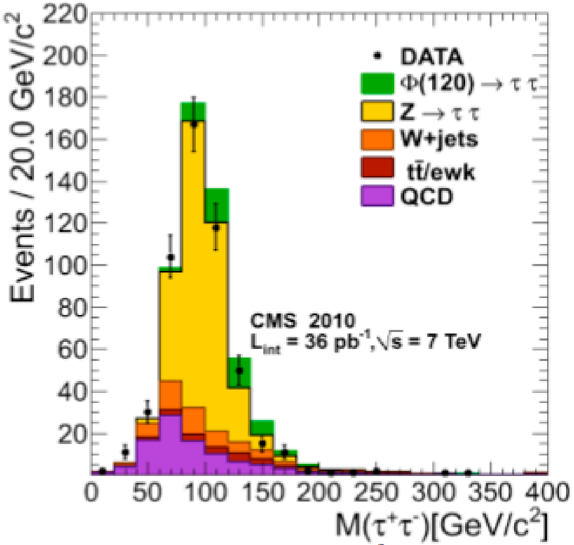
CMS also uses the di-lepton channel…

… implications at low mass

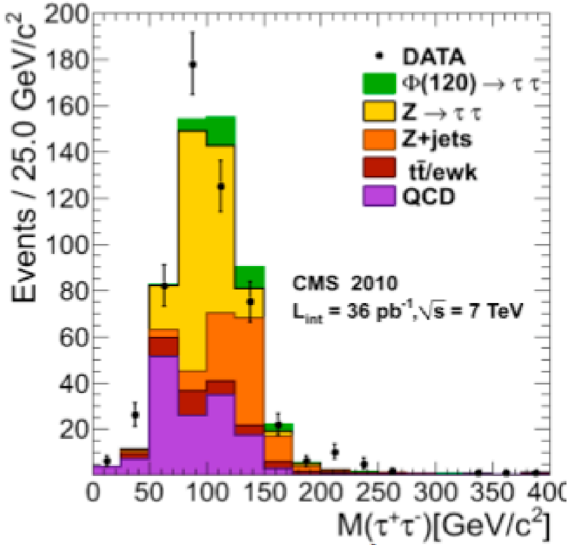
(CMS similar selection variables)

Process	$\mu\tau_h$	$e\tau_h$	$e\mu$
Total	557 ± 79	536 ± 57	102 ± 5
Observed	517	540	101
Signal Efficiency	0.0391	0.0245	0.00582

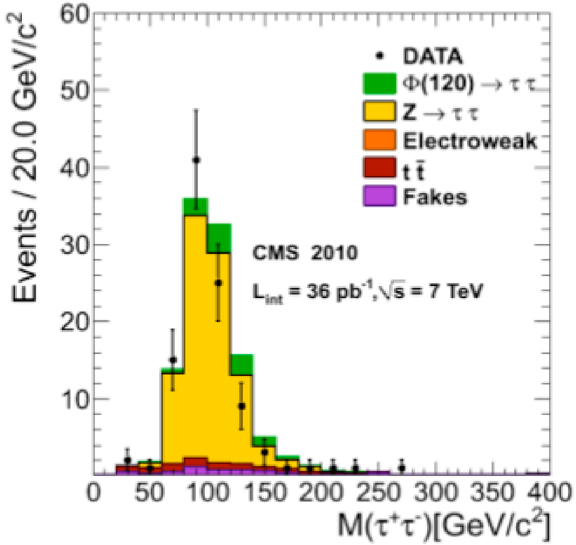
(different working point)



$\tau\tau \rightarrow \mu + \tau h$

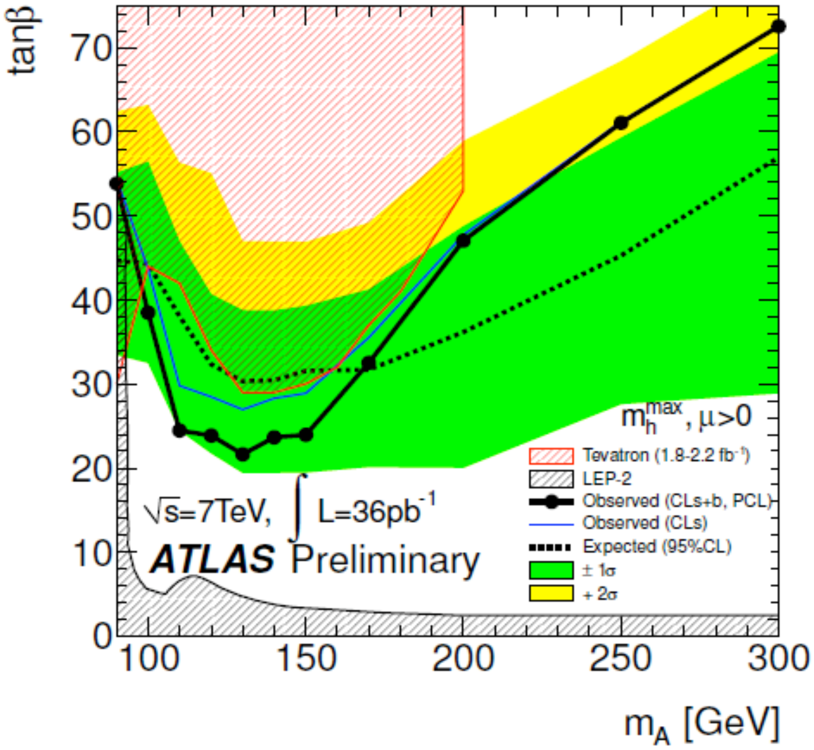


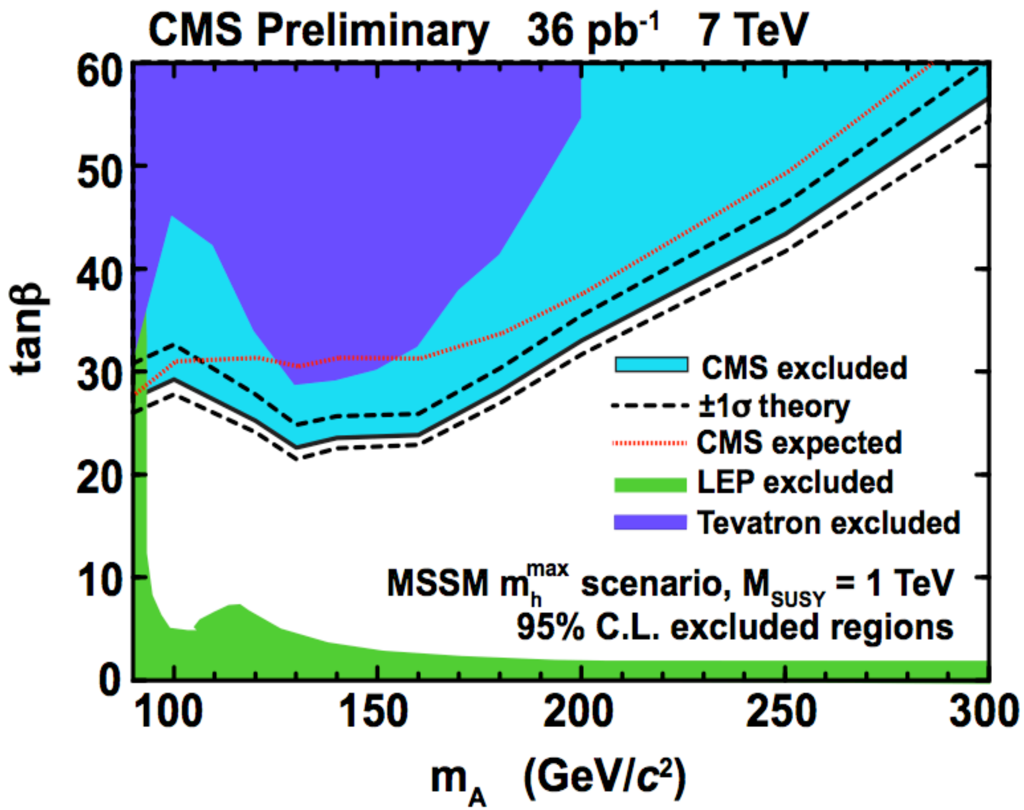
$\tau\tau \rightarrow e + \tau h$



$\tau\tau \rightarrow e + \mu$

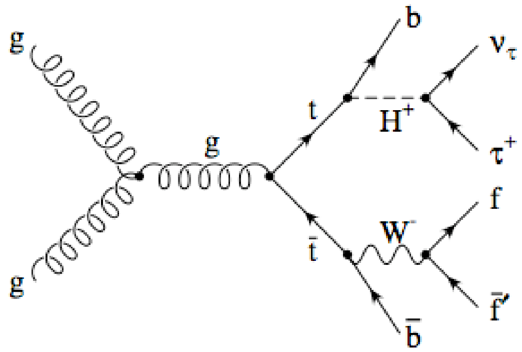
Using M_{vis} $\tau^+\tau^-$ as a discriminating variable for ATLAS and a likelihood based mass for CMS, derive 95% CL limits with PCL prescription for ATLAS and using Bayesian methods for CMS





TeVatron limits superseded over a vast mass domain

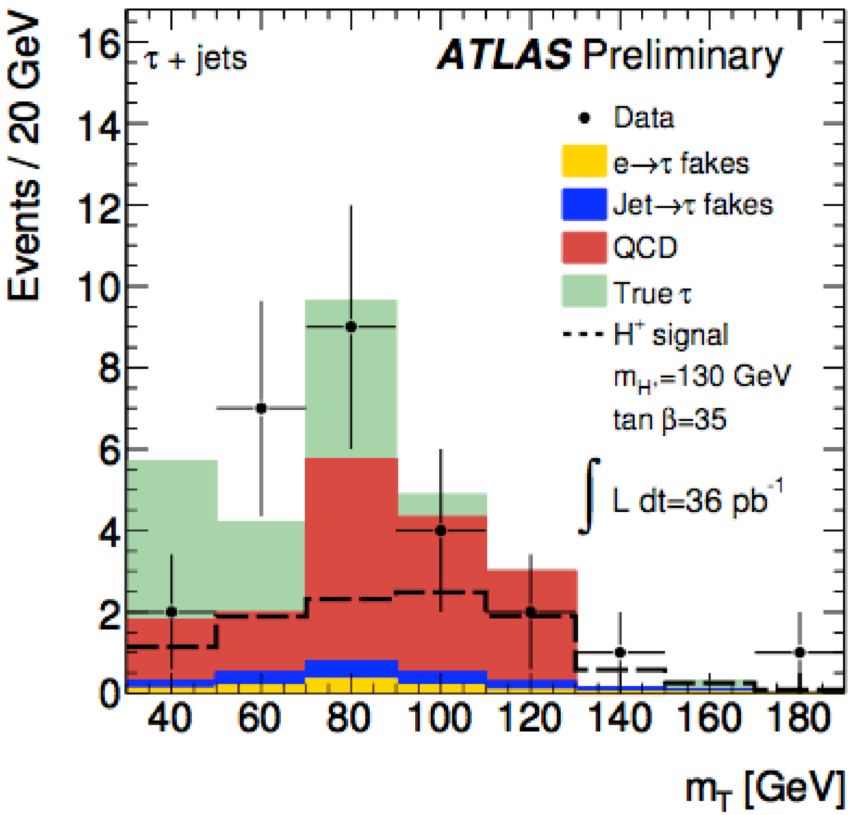
Charged Higgs Searches

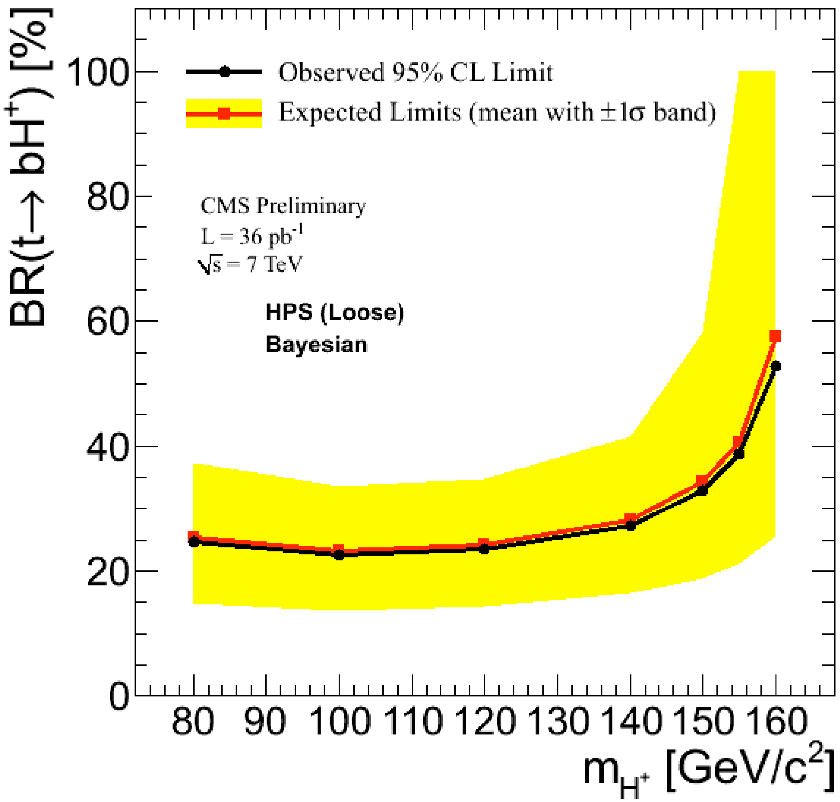


In both cases search for $H^+ \to \tau\nu$ (assumed to be 1 here) accompanied by a W to lν or jj

ATLAS : Only data driven background studies in both topologies

CMS : Following the top cross section measurement in the l+jets channel, first limits on $Br(t \to bH^+)$ in the τνlν topology





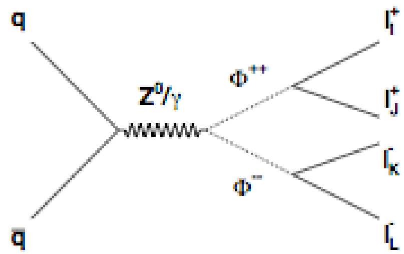
Doubly Charged Higgs

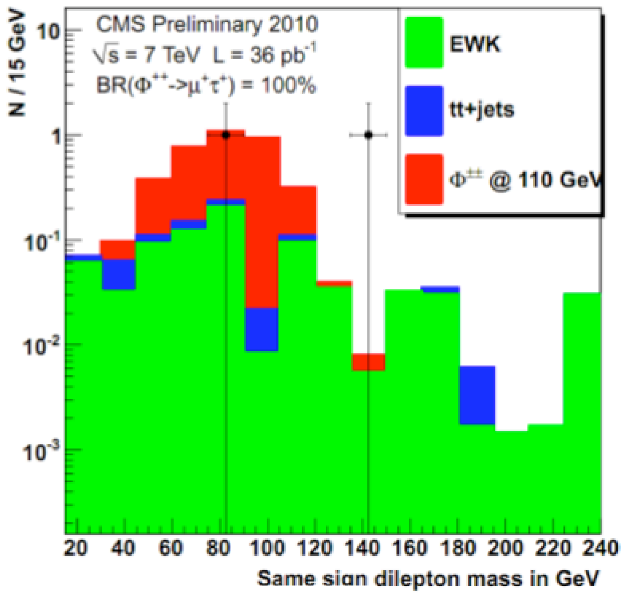
- extending Standard Model adding scalar triplet (motivated by Seesaw mechanism for neutrino masses). Leads to a doubly charged Higgs $H^{\pm\pm}$.

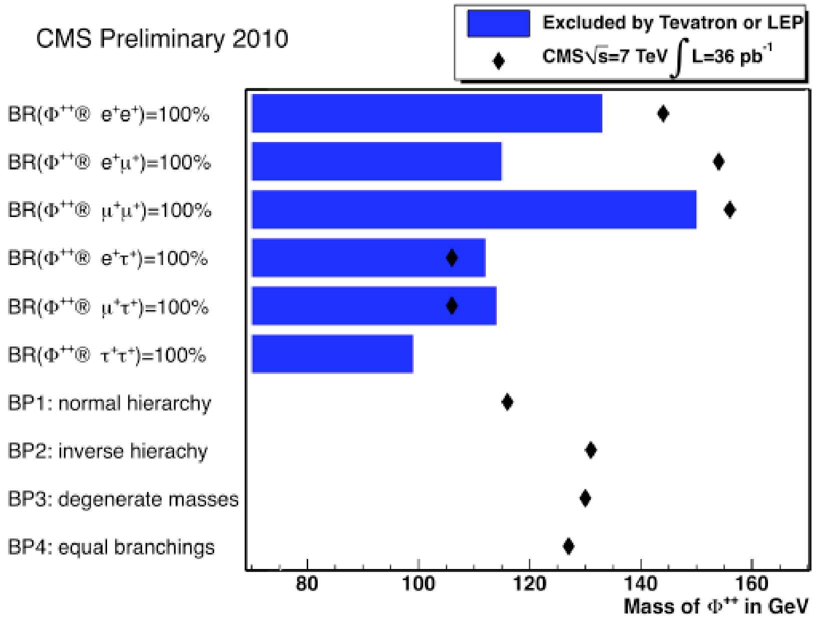
- Use di-lepton $H^{\pm\pm}$ decay topologies in four or three leptons.

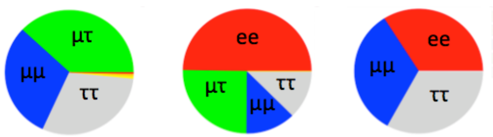
- Look for SS di-lepton resonances.

- Limits set in various benchmark scenarios.









Normal Hierarchy / Inverse Hierarchy / Degenerate State

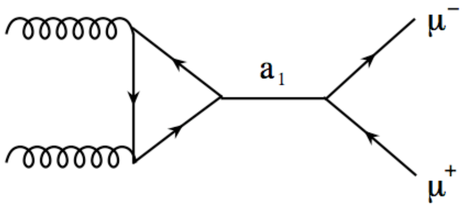
Limits comparable or better than previous experiments

Search for a light CP-odd Higgs boson in the $\mu^+\mu^-$ Final State

- NMSSM : additional singlet complex field leads to 1 additional CP-even and one CP-odd Higgs

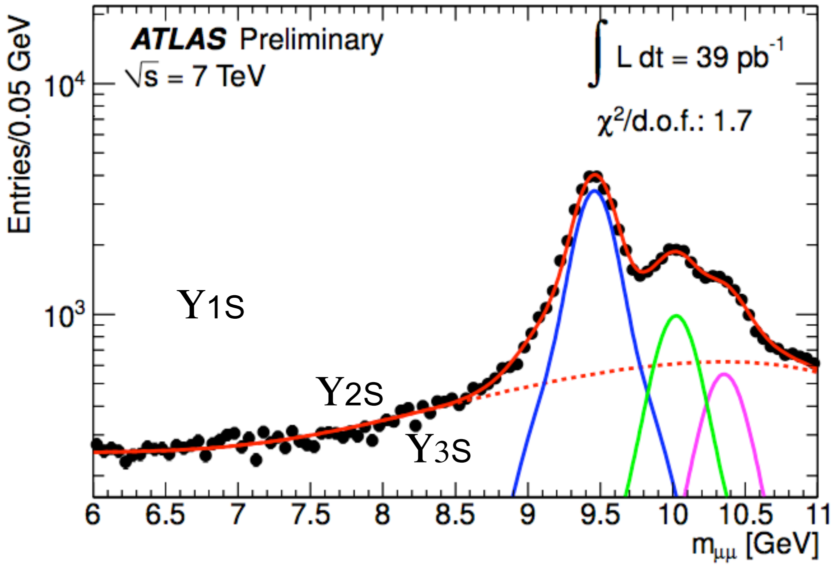
In the low mass region (below $2m_b$) lightest CP-even Higgs evades LEP limits this mass region is referred to as ideal Higgs scenario.

Search performed in the [6-9] and [11-12] mass range (avoiding Υ resonances 1S, 2S and 3S due to uncertainties on their production rates).



Simple selection of two isolated muons p_T> 4 GeV

$$a_1 = \cos\theta_A a_{MSSM} + \sin\theta_A a_S$$



ATLAS-CONF-2011-020

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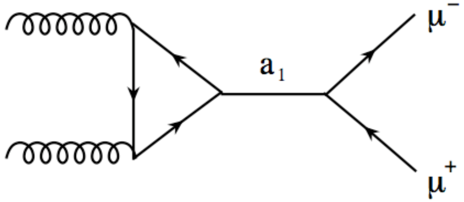

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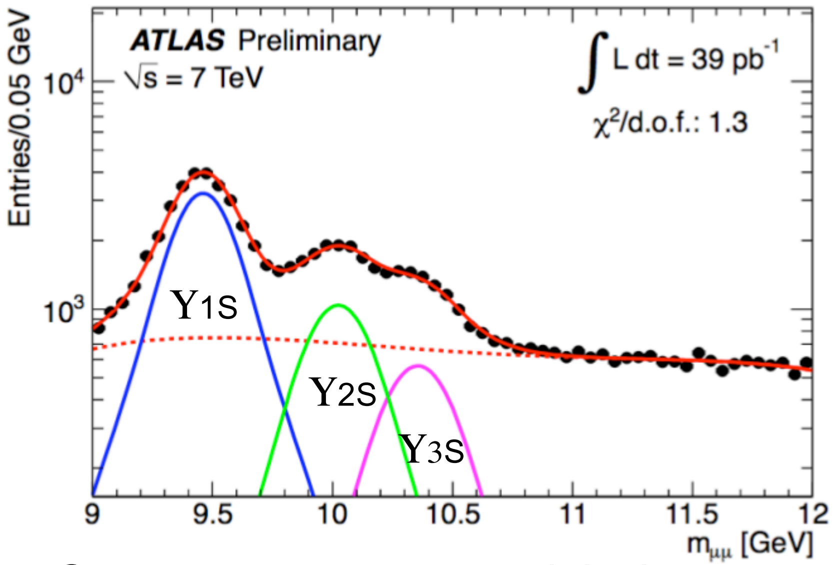
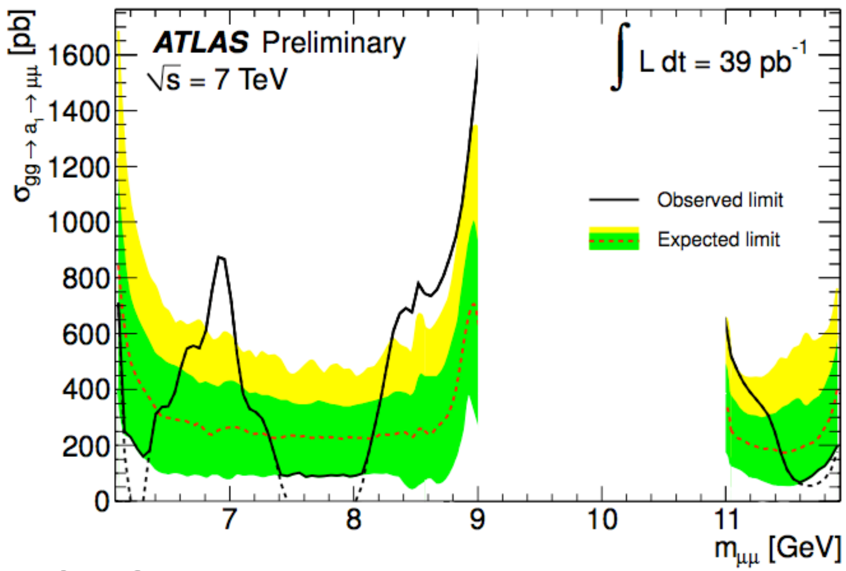




Constraints on regions with high tan β and small CP-Odd mixing angle $\cos\theta_A \sim 1$

Conclusions

With ~40 pb^{-1} of data :

- ATLAS and CMS have measured many possible SM production rates

- ATLAS and CMS have performed searches for the Higgs boson with sensitivities either close or even better than those of TeVatron. In the same channels.

- All the searches were performed with simple analyses*.

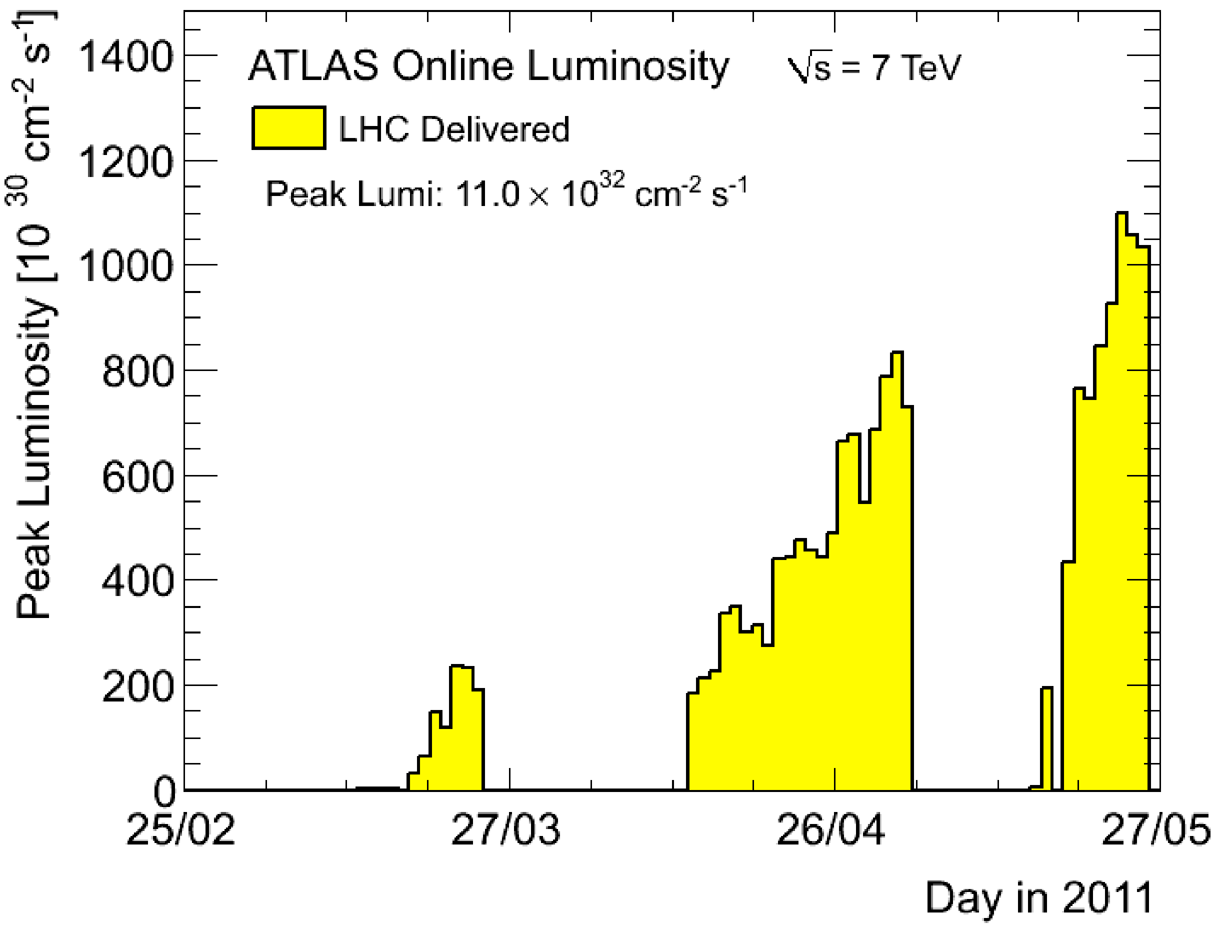
- Backgrounds were in most cases systematically studied in data control samples.

- The search in the complete allowed SM Higgs mass domain has started!

*Only one case of BDT analysis in WW channel in CMS

What's next ?

Currently injecting ~1000 bunches at 50 ns…



Peak Luminosity above

10^{33} $cm^{-2}s^{-1}$

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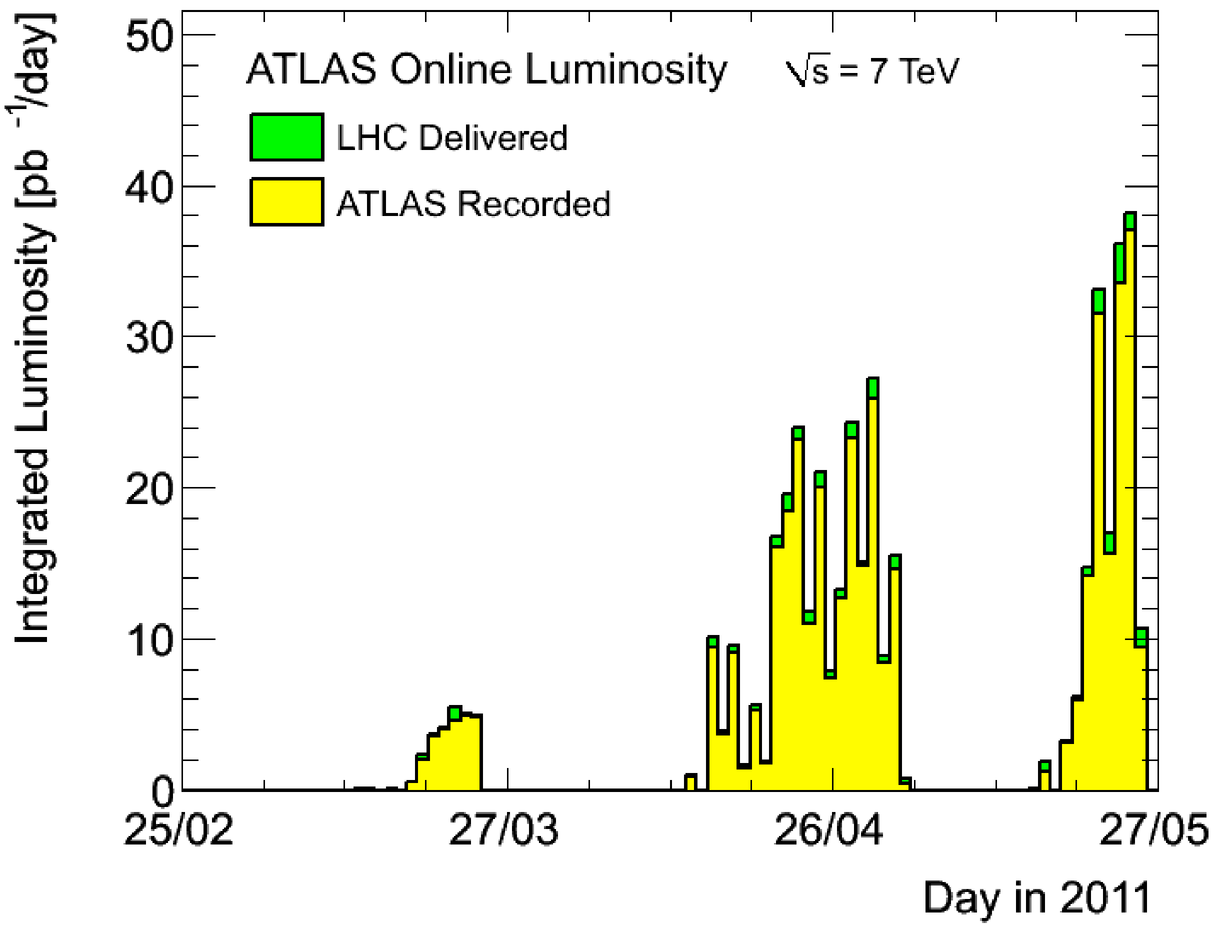

Peak Luminosity above 10^{33} cm^{-2}s^{-1}

Daily integrated luminosity ~10 pb^{-1}

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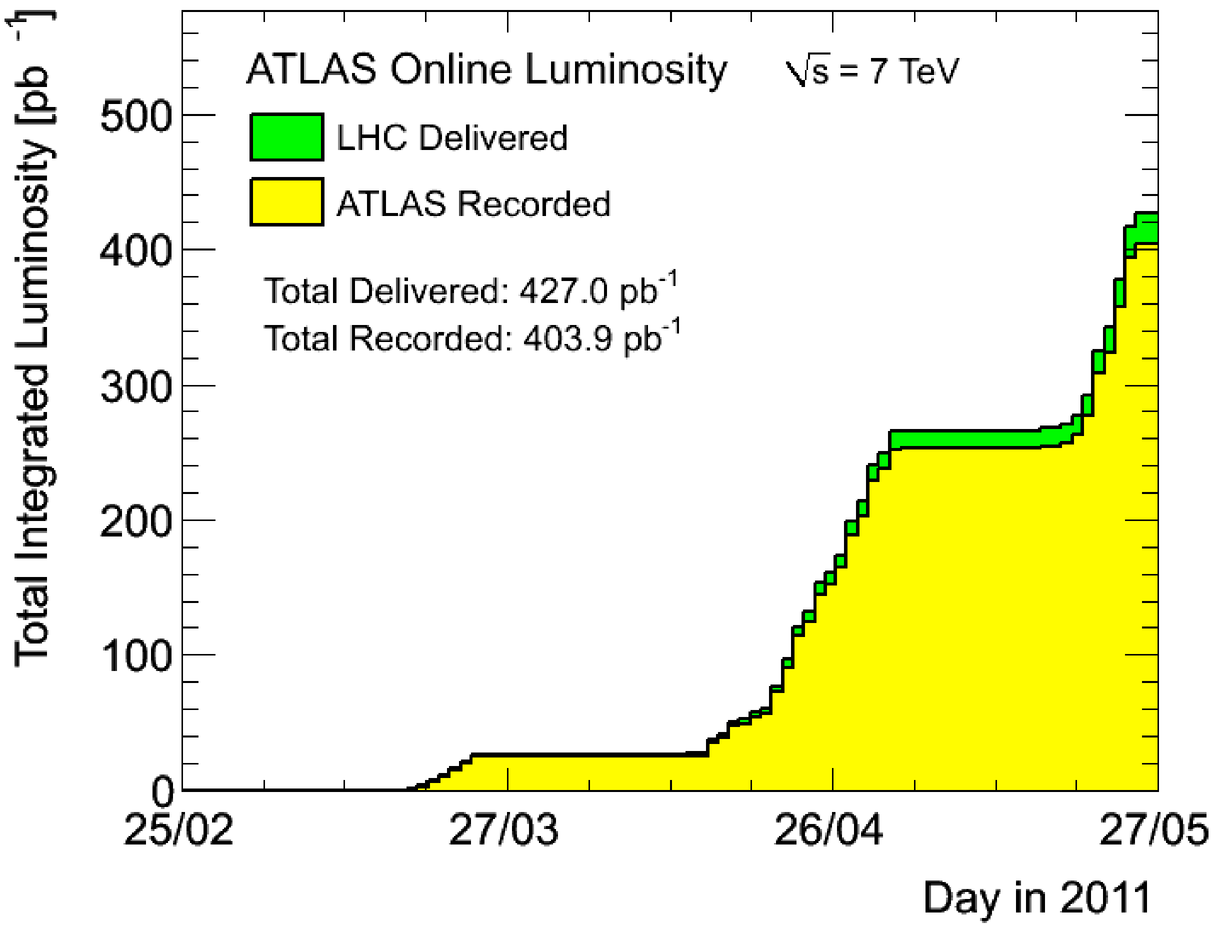


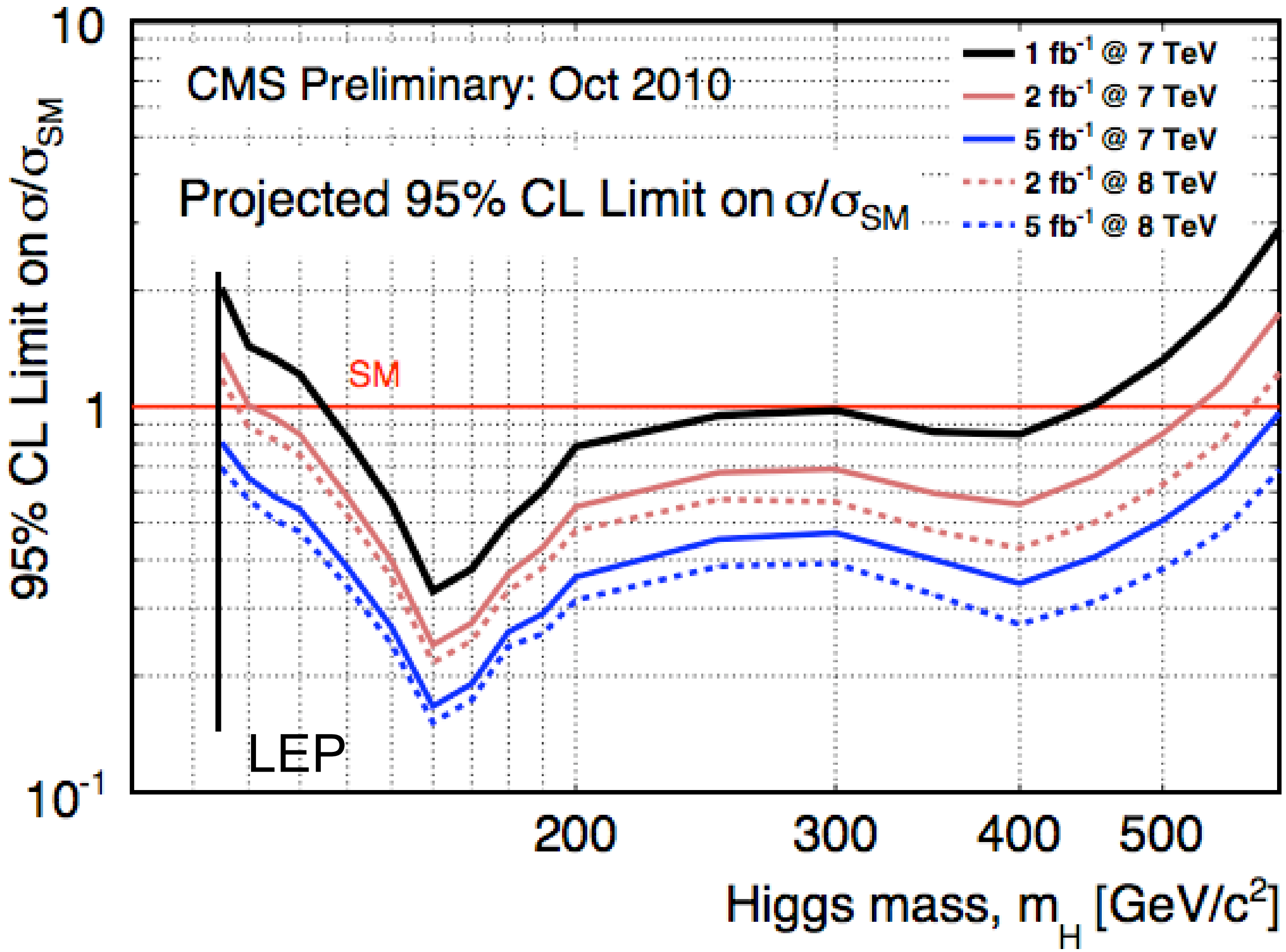
Peak Luminosity above 10^{33} $cm^{-2}s^{-1}$

Daily integrated luminosity ~10 pb^{-1}

Have already gathered in 2011 ~400 pb^{-1}

Hope to reach 5 10^{33} $cm^{-2}s^{-1}$ in the coming months…

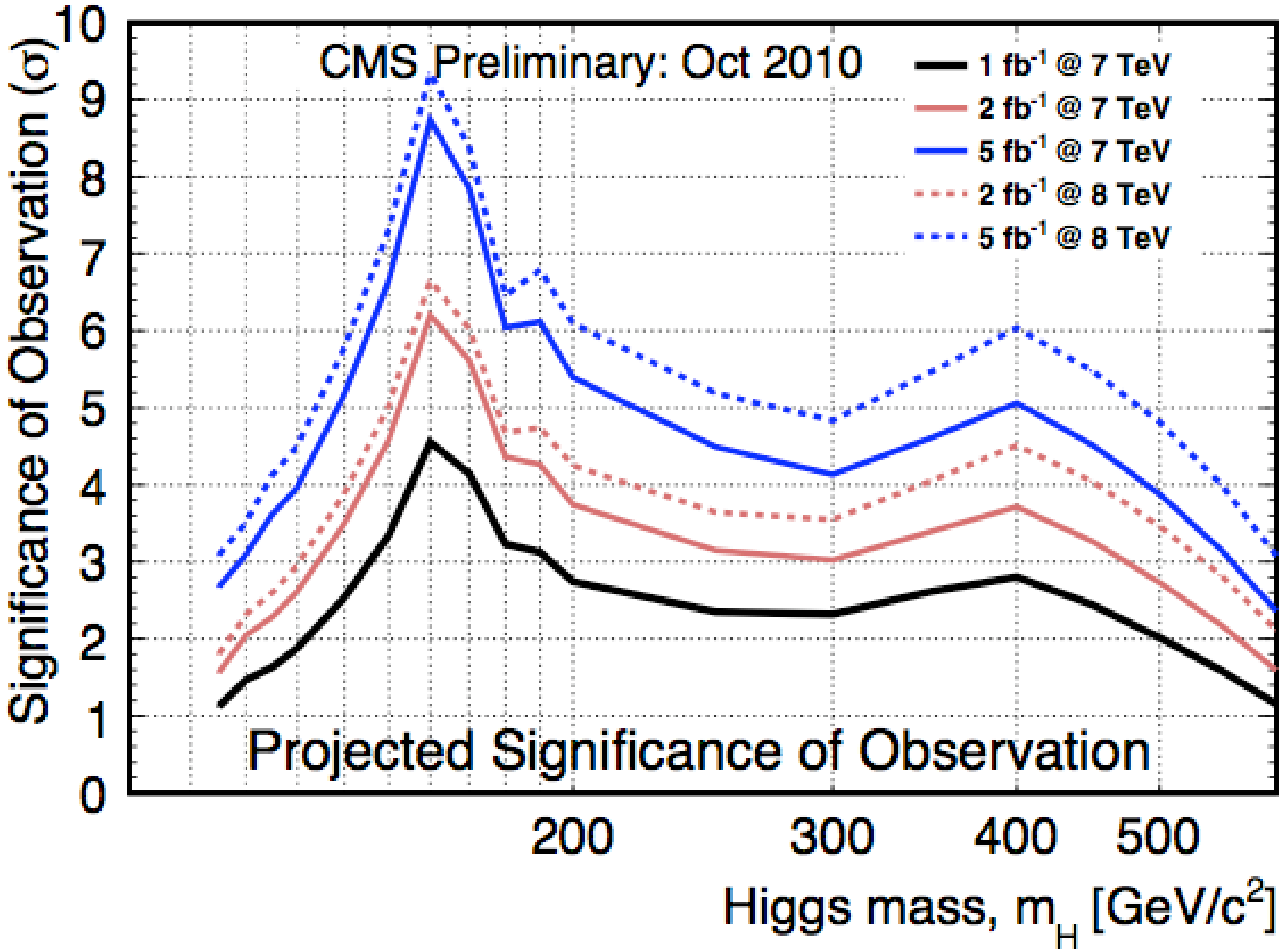
Back to prospects (CMS this time)



Wide exclusion range expected very soon

(and 5 fb^{-1} for the full mass range)

Back to prospects (CMS this time)



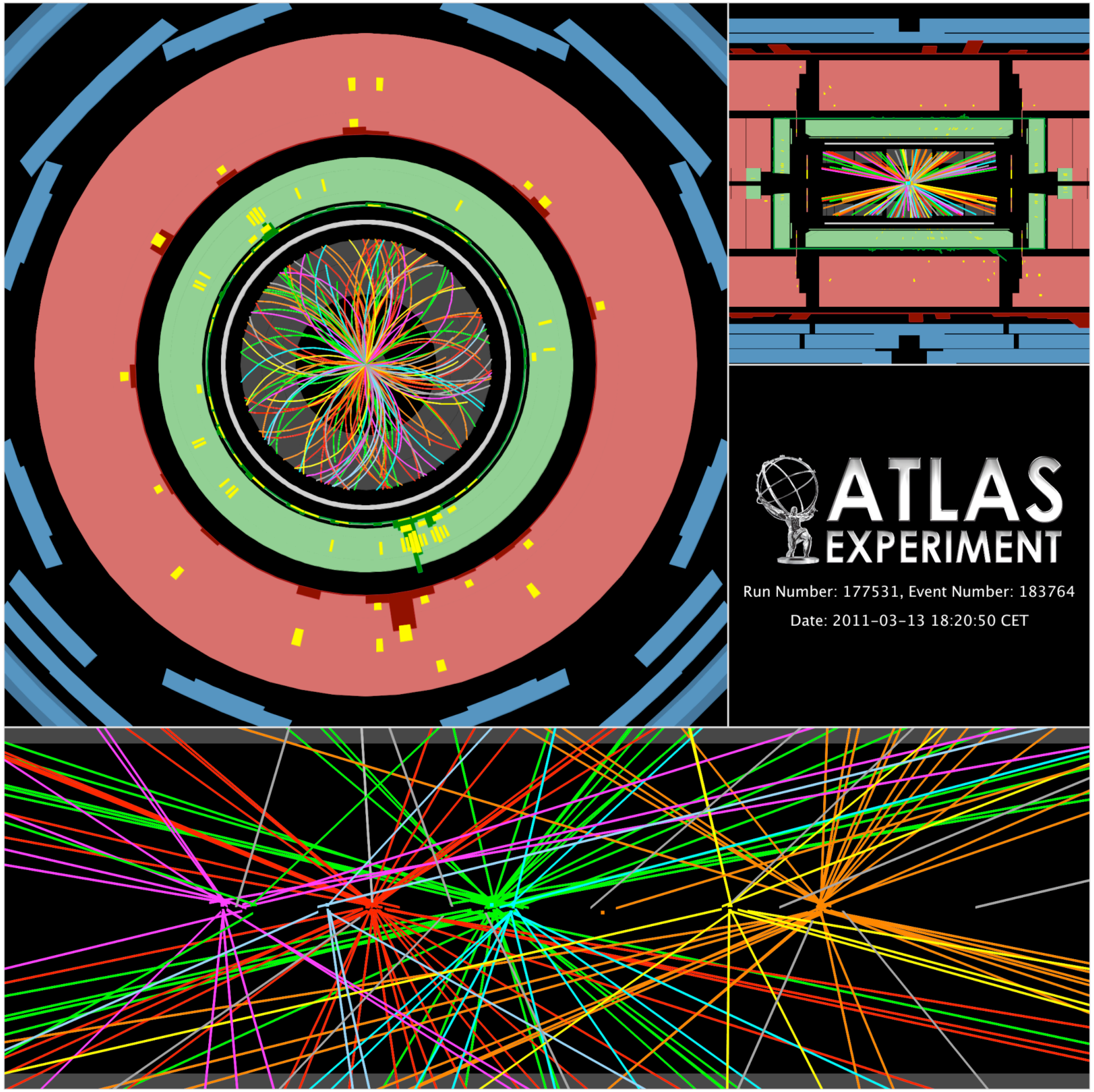
Wide exclusion range expected very soon

(and 5 fb^{-1} for the full mass range)

Observation possible over most of the mass range with 5 fb^{-1}

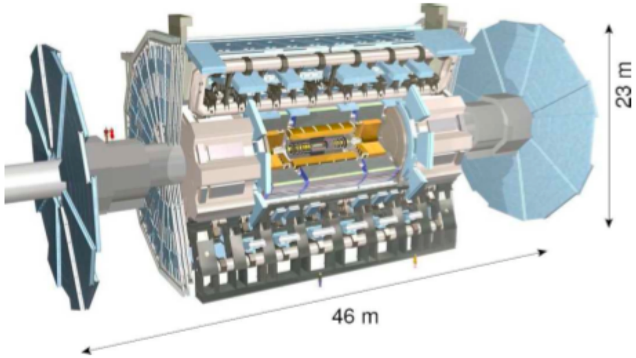
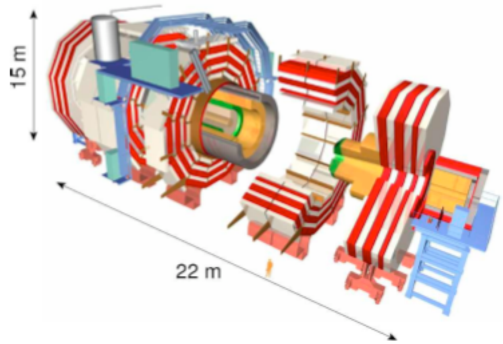
In 2011 LHC is offering great analysis opportunities and challenges…

… Not the least of them : Pile-up



Backup Slide

The ATLAS and CMS Detectors Synopsis

Sub System	ATLAS	CMS
Design		
Magnet(s)	Solenoid (within EM Calo) 2T 3 Air-core Toroids	Solenoid 3.8T Calorimeters Inside
Inner Tracking	Pixels, Si-strips, TRT PID w/ TRT and dE/dx $\sigma_{p_T}/p_T \sim 5 \times 10^{-4} p_T \oplus 0.01$	Pixels and Si-strips PID w/ dE/dx $\sigma_{p_T}/p_T \sim 1.5 \times 10^{-4} p_T \oplus 0.005$
EM Calorimeter	Lead-Larg Sampling w/ longitudinal segmentation $\sigma_E/E \sim 10\%/\sqrt{E} \oplus 0.007$	Lead-Tungstate Crys. Homogeneous w/o longitudinal segmentation $\sigma_E/E \sim 3\%/\sqrt{E} \oplus 0.5\%$
Hadronic Calorimeter	Fe-Scint. & Cu-Larg (fwd) $\gtrsim 11\lambda_0$ $\sigma_E/E \sim 50\%/\sqrt{E} \oplus 0.03$	Brass-scint. $\gtrsim 7\lambda_0$ & Tail Catcher $\sigma_E/E \sim 100\%/\sqrt{E} \oplus 0.05$
Muon Spectrometer System Acc. ATLAS 2.7 & CMS 2.4	Instrumented Air Core (std. alone) $\sigma_{p_T}/p_T \sim 4\,\%$ (at 50 GeV) $\sim 11\,\%$ (at 1 TeV)	Instrumented Iron return yoke $\sigma_{p_T}/p_T \sim 1\%$ (at 50 GeV) $\sim 10\%$ (at 1 TeV)