LHC·アトラス実験におけるヒッグス粒子探索の最新結果について

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- SM Higgs search@LHC・ATLAS
- ATLAS Results
  - H->WW->lνlν
  - H->ZZ->4l (plus CMS)
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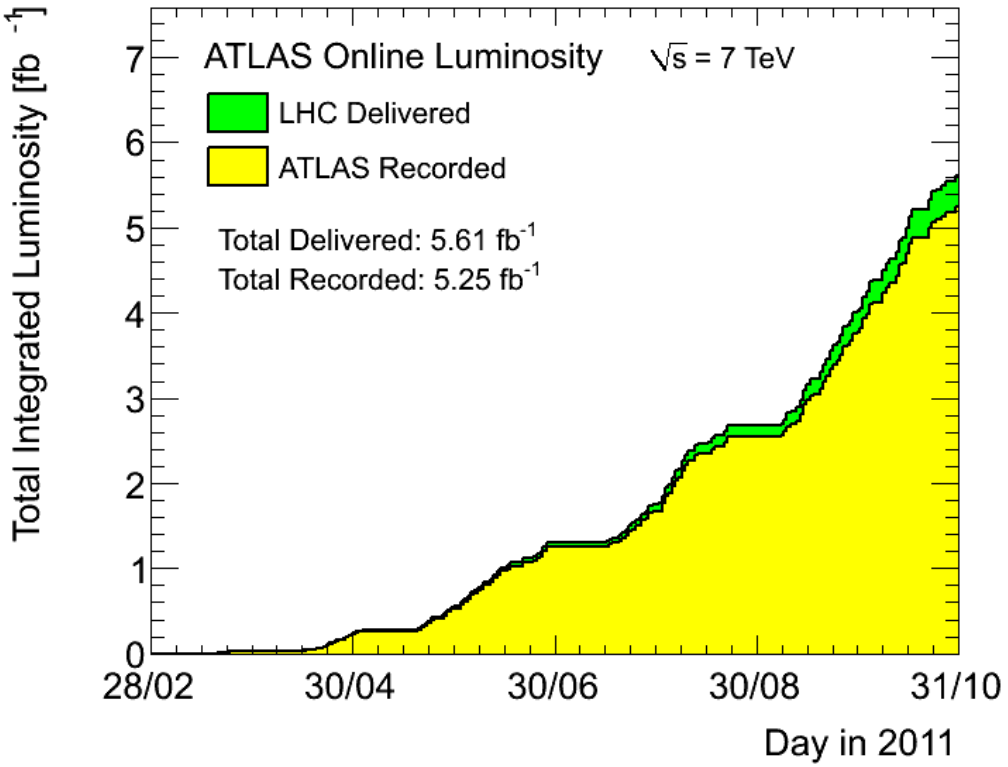
- Combination (ATLAS and CMS)
- Summary

2011データ

3月13日 – 10月30日



LHC加速器グループのおかげで
予想をはるかに上回るデータを
取ることができました。

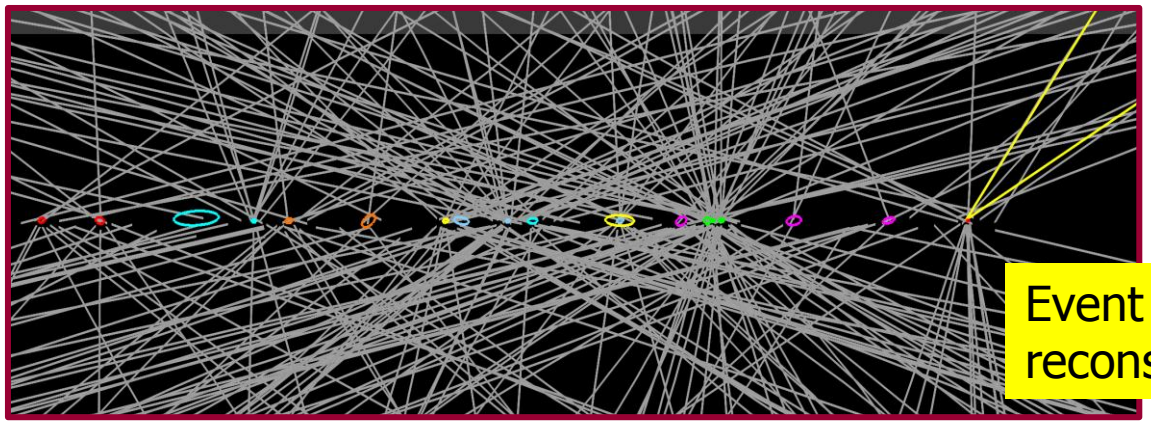
Delivered L=5.61 fb^{-1}
Recorded L=5.25 fb^{-1}

Peak luminosity@ATLAS
~3.6 x 10^{33} $cm^{-2}s^{-1}$

- Data-taking efficiency = ~93.6%
- 検出器が動いていなかった割合 = a few permil to 3.5%
- データ解析に使える割合("Good-quality" decided by each detector group and performance group) = 90-96% (4.7-5.0 fb^{-1})

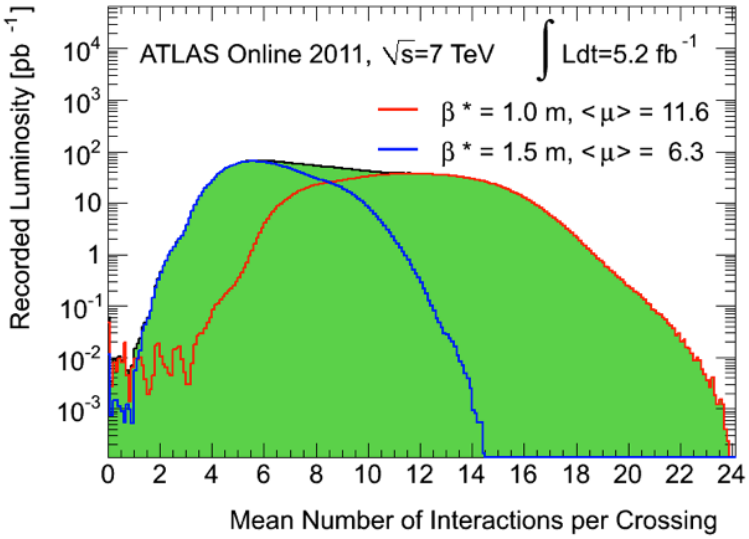
パイルアップ

バンチ間隔が当初の予定の倍(50ns)、かつ、ルミノシティが当初の3-4倍近くのため
パイルアップが非常に多い。



Z->μμ

Event with 20
reconstructed vertices

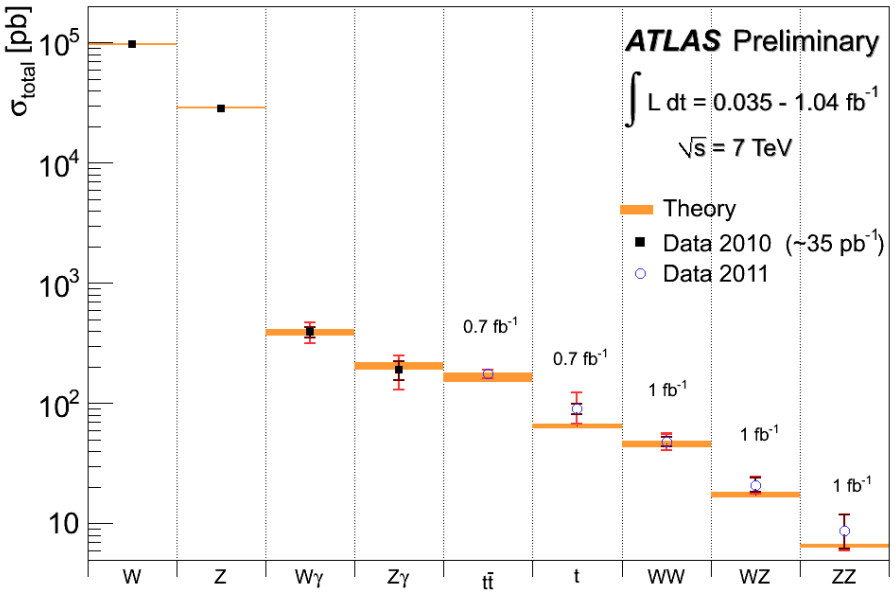


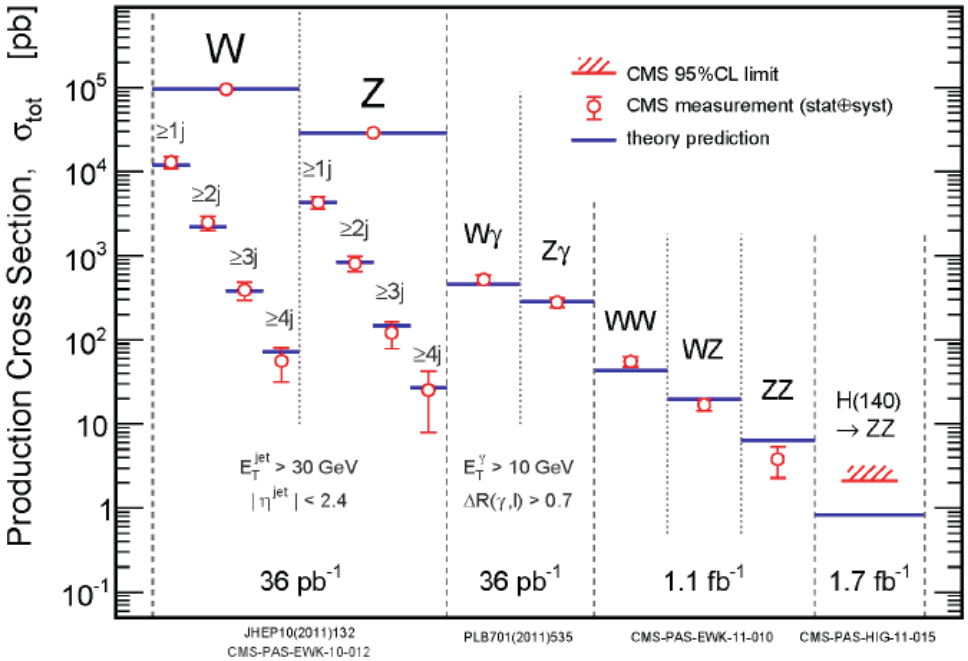
8月末 … 青
それ以降 … 赤

データ量は半々
=>特に、後半データはパイルアップの
効果の理解が重要。

SMプロセスの断面積測定

- SM expectationと良い一致が見られる。
- 5fb^{-1}での数
  - ~30M W->eν and μν events
  - ~3M Z->ee and μμ events
  - ~60k ttbar events (>10 x "total CDF and D0")

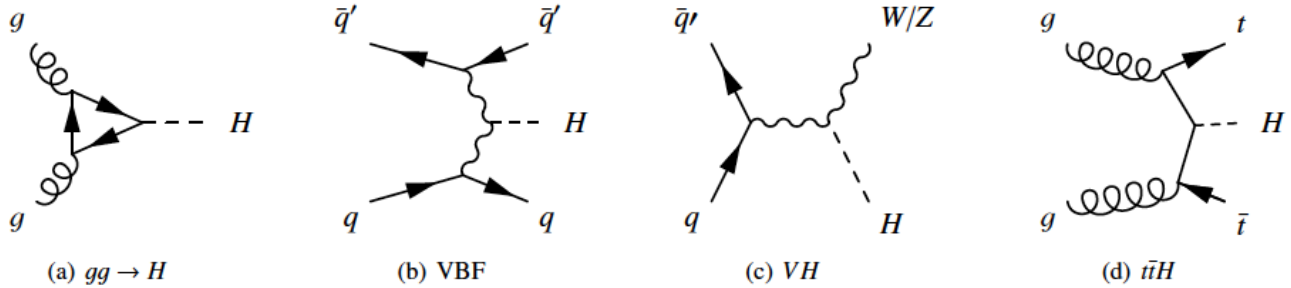




測定にはまだ昨年のデータだけのものもある。データ解析中。
W/Z、J/psiなどはCalibrations, Correctionsに非常に重要。

ヒッグス粒子の生成と崩壊（1）

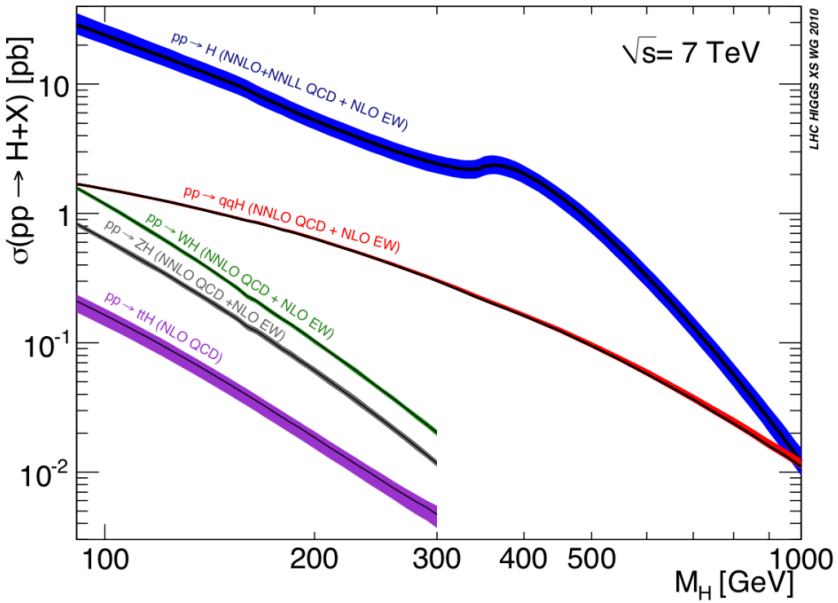
現解析では、Gluon fusionが主なチャンネル。VBFはまだまだ。

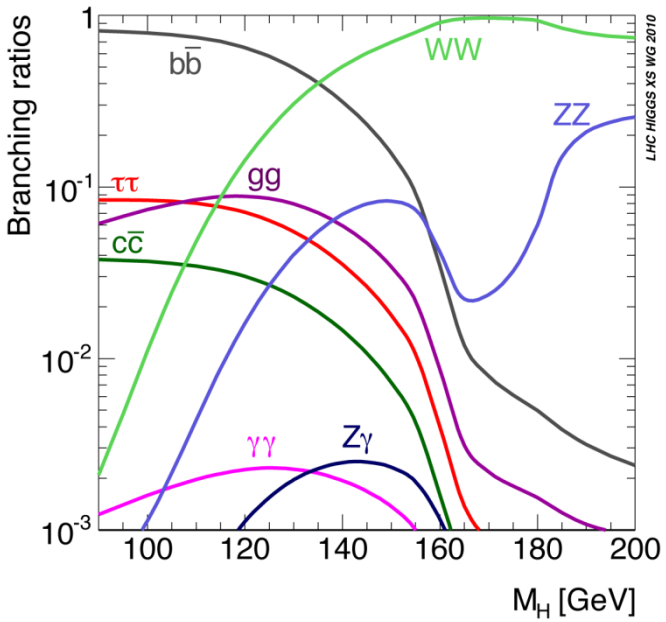


NNLO+NNLL(QCD soft-gluon)+NLO EW

NNLO+NLO EW

NLO

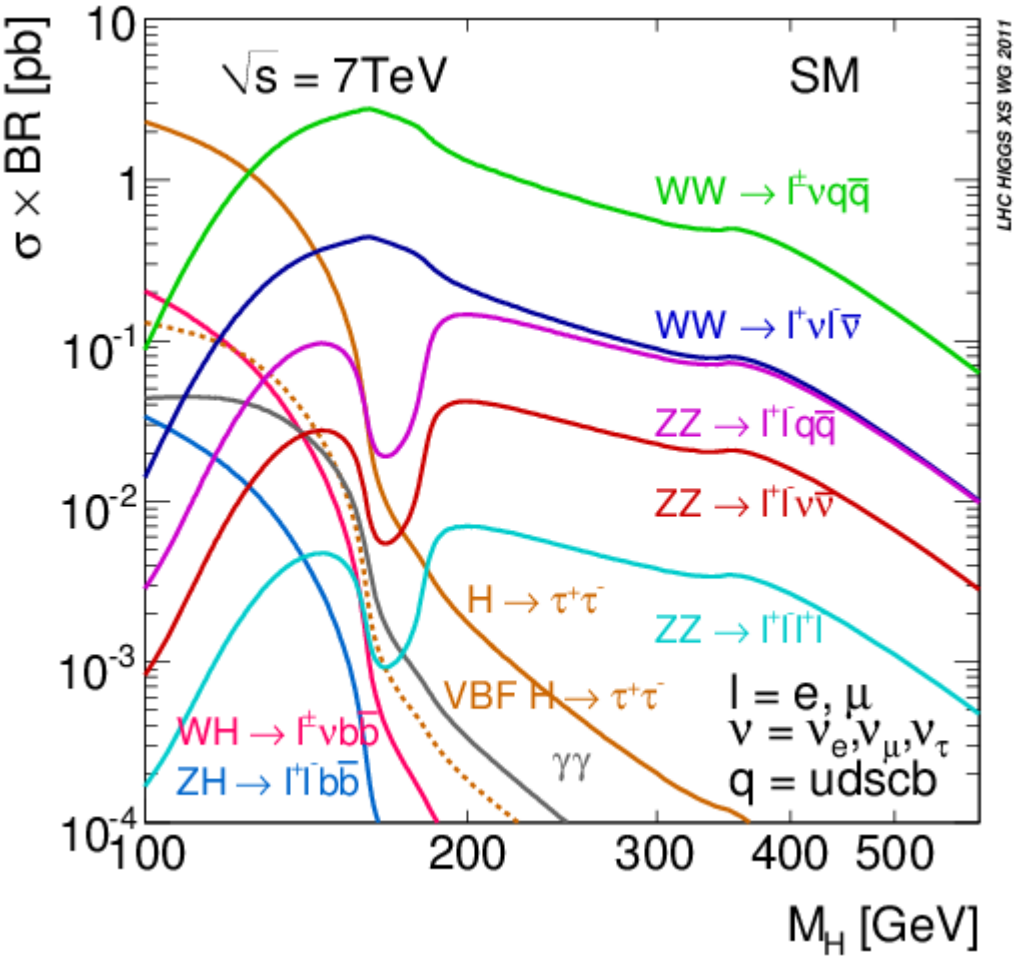




m_H=125GeV: 15.3pb (ggF), 1.2pb(VBF), 0.6pb(WH), 0.3pb(ZH), 0.09pb(ttH)

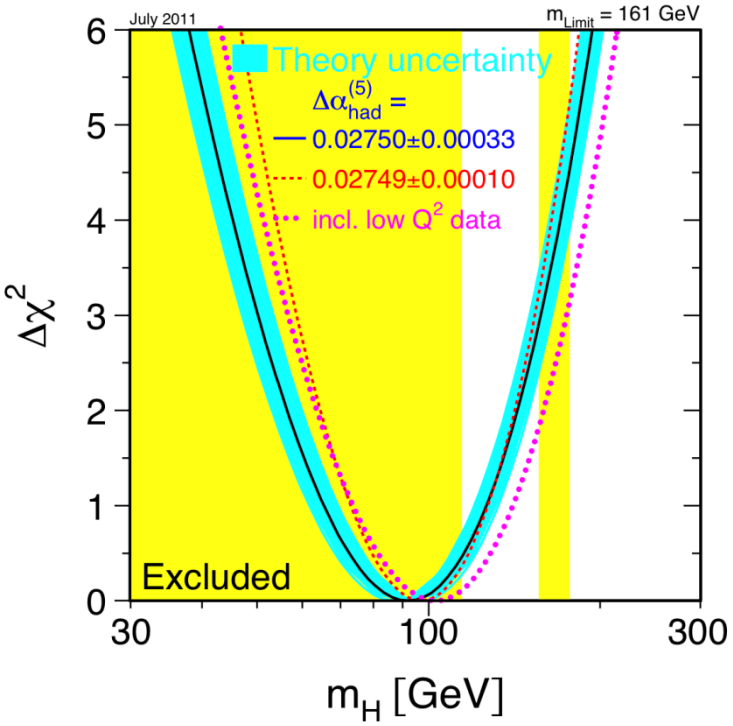
ヒッグス粒子の生成と崩壊（2）

- BRも含めて、各モードのヒッグス粒子の”生成＋崩壊”のまとめ

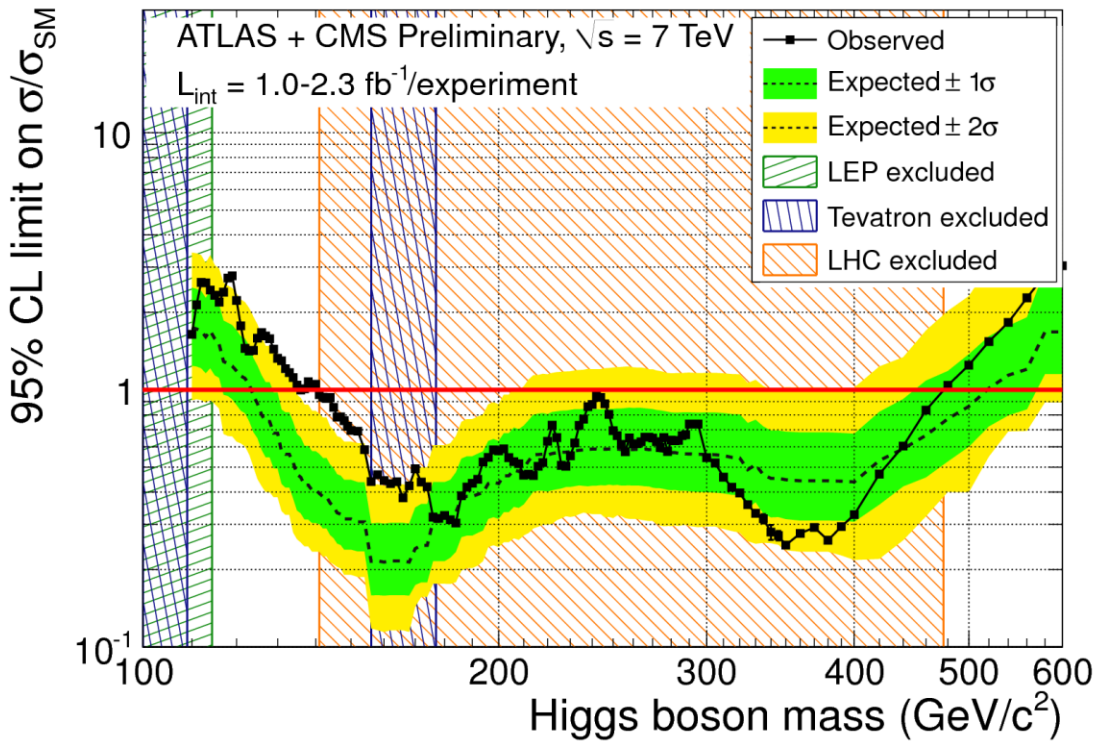


11月までの結果

LEP+Tevatron



LEP+Tevatron+ATLAS+CMS



LEP m_H>114.4GeV
Tevatron 100<m_H<109GeV
156<m_H<177GeV

ATLAS+CMS combination
141<m_H<476GeV
124<m_H<520GeV (expected)

残された領域(軽い場合)は114.4-141GeV (幅27GeV)

12/13のセミナーで見せたATLASの結果

Channel	m_H range (GeV)	Int. lumi fb^{-1}	Main backgrounds	Number of signal events after cuts	S/B after cuts	Expected σ/σ_{SM} sensitivity
$H \to \gamma\gamma$	110-150	4.9	$\gamma\gamma$, γj, jj	~70	~0.02	1.6-2
$H \to \tau\tau \to ll+\nu$	110-140	1.1	$Z \to \tau\tau$, top	~0.8	~0.02	30-60
$H \to \tau\tau \to l\tau_{had}$	100-150	1.1	$Z \to \tau\tau$	~10	~5 10^{-3}	10-25
$W/ZH \to bbl(l)$	110-130	1.1	W/Z+jets, top	~6	~5 10^{-3}	15-25
$H \to WW^{(*)} \to l\nu l\nu$	110-300	2.1	WW, top, Z+jet	~20 (130 GeV)	~0.3	0.3-8
$H \to ZZ^{(*)} \to 4l$	110-600	4.8	ZZ*, top, Zbb	~2.5 (130 GeV)	~1.5	0.7-10
$H \to ZZ \to ll\,\nu\nu$	200-600	2.1	ZZ, top, Z+jets	~20 (400 GeV)	~0.3	0.8-4
$H \to ZZ \to ll\,qq$	200-600	2.1	Z+jets, top	2-20 (400 GeV)	0.05-0.5	2-6
$H \to WW \to l\nu qq$	240-600	1.1	W+jets,top,jets	~45 (400 GeV)	10^{-3}	5-10

→ 今日のトーク

H->WW->lνlν

L=2.05 fb^{-1}
(~4.8 fb^{-1}は解析中)

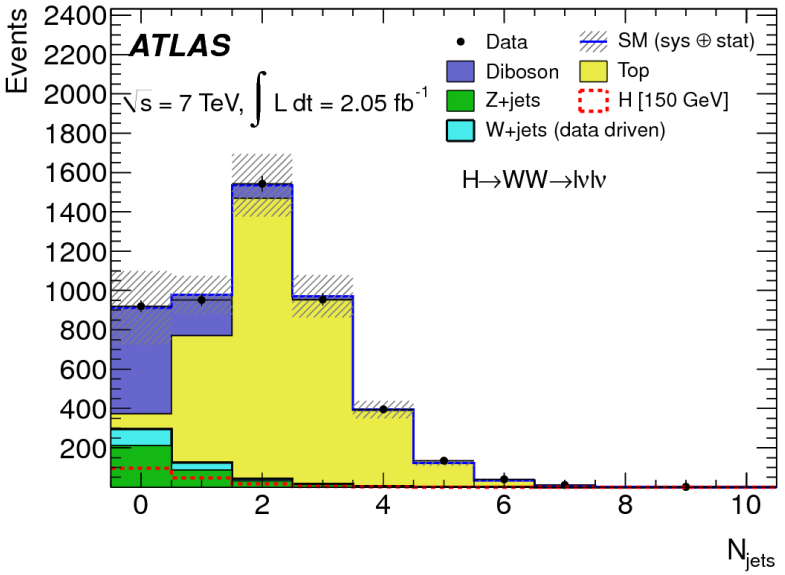
l = electron or muon

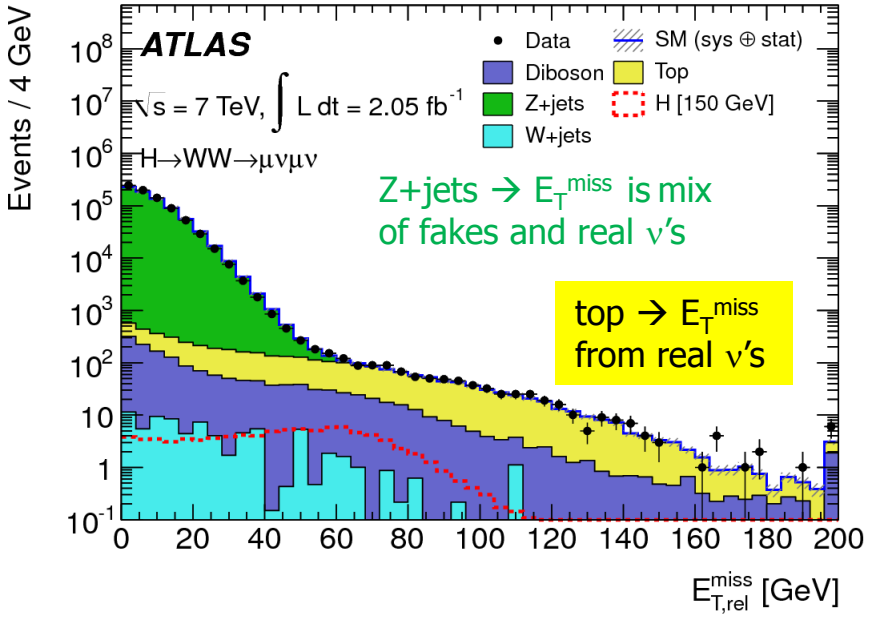
H->WW->lνlν

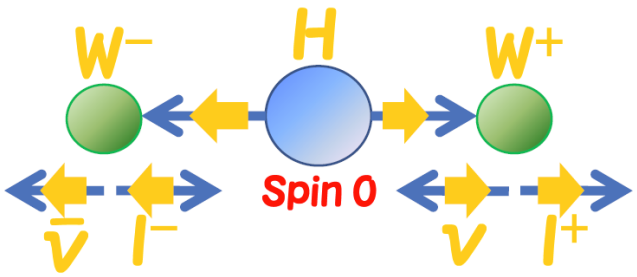
L=2.05 fb^{-1}

- Event Selection
  - Single lepton trigger
  - 2 isolated leptons
    - 20GeV for elec, 15GeV for muon
    - 25GeV for the leading lepton
  - MET rel($E_{T,rel}^{miss}$)>40GeV(SF), 25(DF)
  - Jets pT>25GeV, |eta|<4.5

  etc (see the next page)







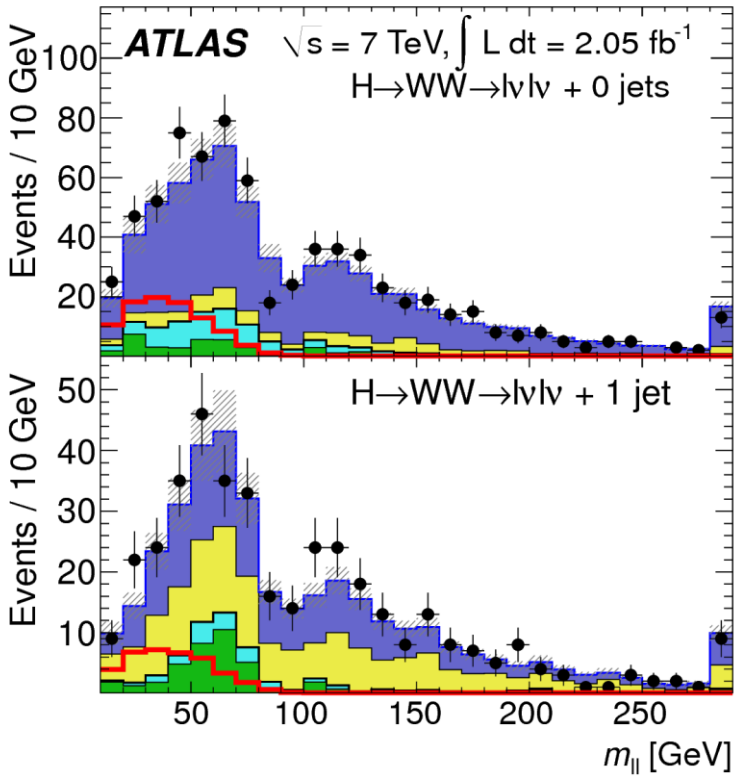
[1] cannot reconstruct Higgs mass due to 2 neutrinos

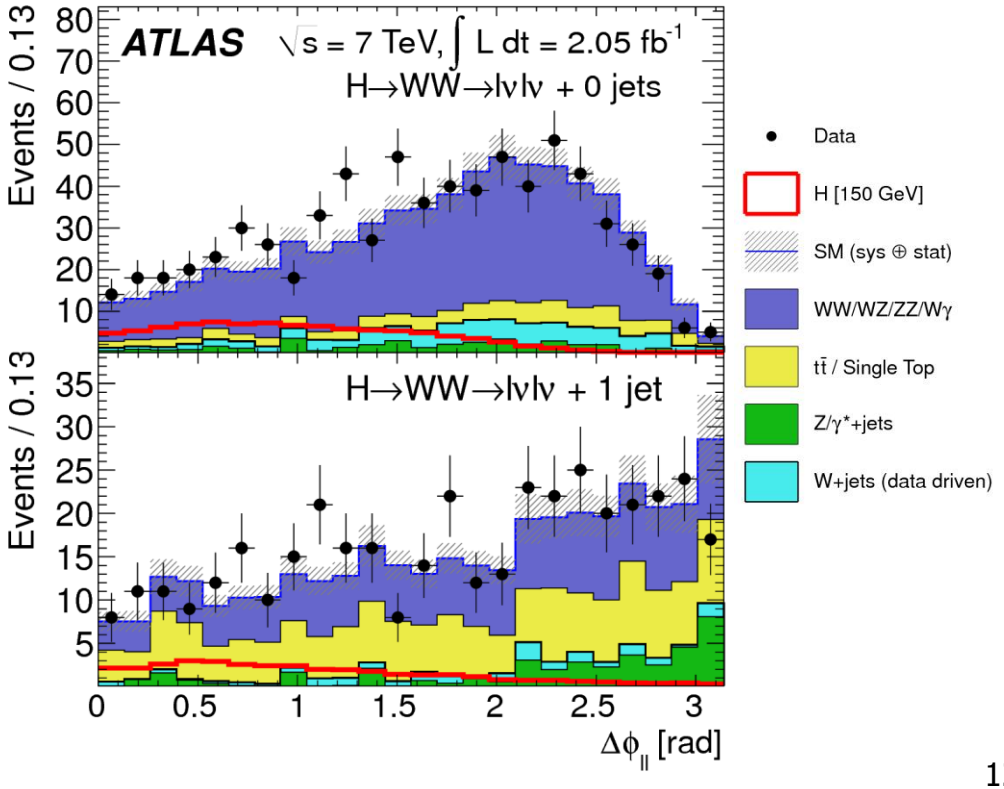
[2] "Δϕ(ll)->small" -> low mass(ll)

m_H=150GeV

$H+0$-jet Channel	Signal	WW	$W+$jets	Z/γ^*+jets	$t\bar{t}$	$tW/tb/tqb$	$WZ/ZZ/W\gamma$	Total Bkg.	Observed
Jet Veto	99 ± 21	524 ± 52	84 ± 41	174 ± 169	42 ± 14	32 ± 8	15 ± 4	872 ± 182	920
$p_T^{\ell\ell}>30$ GeV	95 ± 20	467 ± 45	69 ± 34	30 ± 12	39 ± 14	29 ± 8	13 ± 4	648 ± 60	700
$m_{\ell\ell}<50$ GeV	68 ± 15	118 ± 15	21 ± 8	13 ± 8	7 ± 4	5.8 ± 1.8	1.9 ± 0.6	166 ± 19	199
$\Delta\phi_{\ell\ell}<1.3$	58 ± 13	91 ± 12	12 ± 5	9 ± 6	6 ± 3	5.8 ± 1.8	1.7 ± 0.6	125 ± 15	149
$0.75\,m_H<m_T<m_H$	40 ± 9	52 ± 7	5 ± 2	2 ± 4	2.4 ± 1.6	1.5 ± 1.0	1.1 ± 0.5	63 ± 9	81
$H+1$-jet Channel	Signal	WW	$W+$jets	Z/γ^*+jets	$t\bar{t}$	$tW/tb/tqb$	$WZ/ZZ/W\gamma$	Total Bkg.	Observed
1 jet	50 ± 9	193 ± 20	38 ± 21	74 ± 65	473 ± 124	174 ± 26	14 ± 2	967 ± 145	952
b-jet veto	48 ± 9	188 ± 19	35 ± 19	73 ± 61	174 ± 49	66 ± 11	14 ± 2	549 ± 83	564
$\lvert\mathbf{p}_T^{tot}\rvert<30$ GeV	39 ± 7	154 ± 16	18 ± 9	38 ± 32	106 ± 30	50 ± 9	9.7 ± 1.5	376 ± 48	405
$Z\to\tau\tau$ veto	39 ± 7	150 ± 17	18 ± 8	34 ± 23	102 ± 23	48 ± 8	9 ± 2	361 ± 38	388
$m_{\ell\ell}<50$ GeV	26 ± 6	33 ± 5	3.3 ± 1.4	8 ± 7	20 ± 7	11 ± 3	1.8 ± 0.5	77 ± 12	90
$\Delta\phi_{\ell\ell}<1.3$	23 ± 5	25 ± 4	2.1 ± 1.0	4 ± 6	17 ± 6	9 ± 3	1.5 ± 0.4	60 ± 10	72
$0.75\,m_H<m_T<m_H$	14 ± 3	12 ± 3	0.9 ± 0.4	1.3 ± 1.9	8 ± 2	4.0 ± 1.6	0.7 ± 0.3	28 ± 4	29

Before mll cut

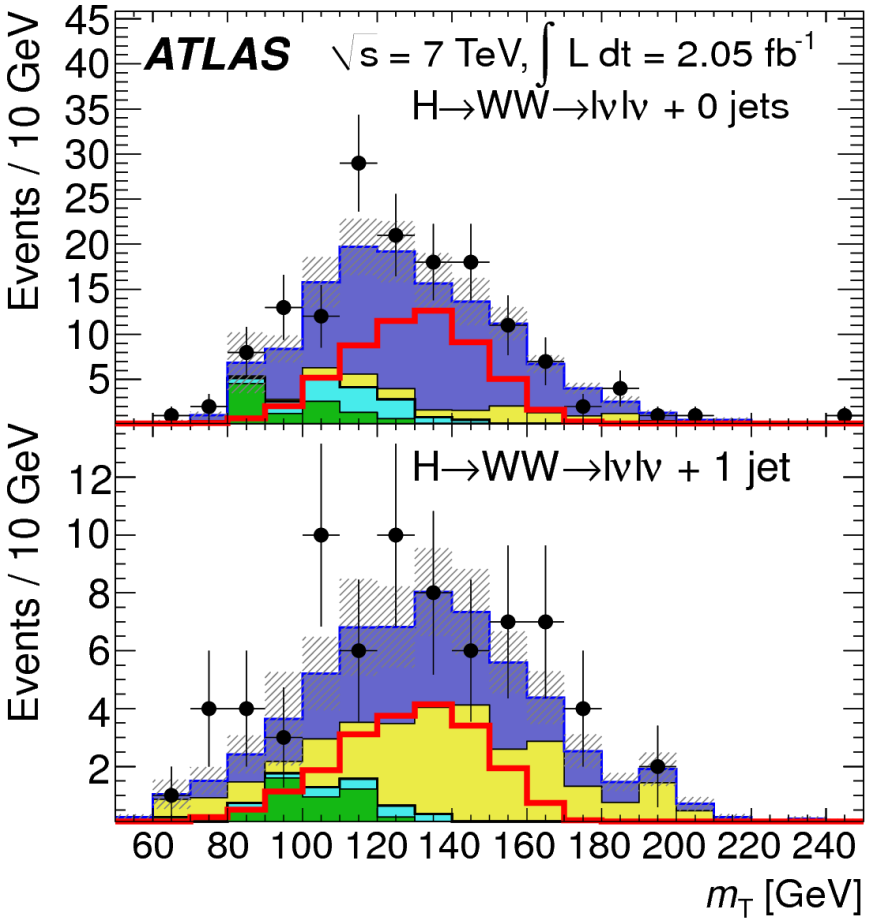


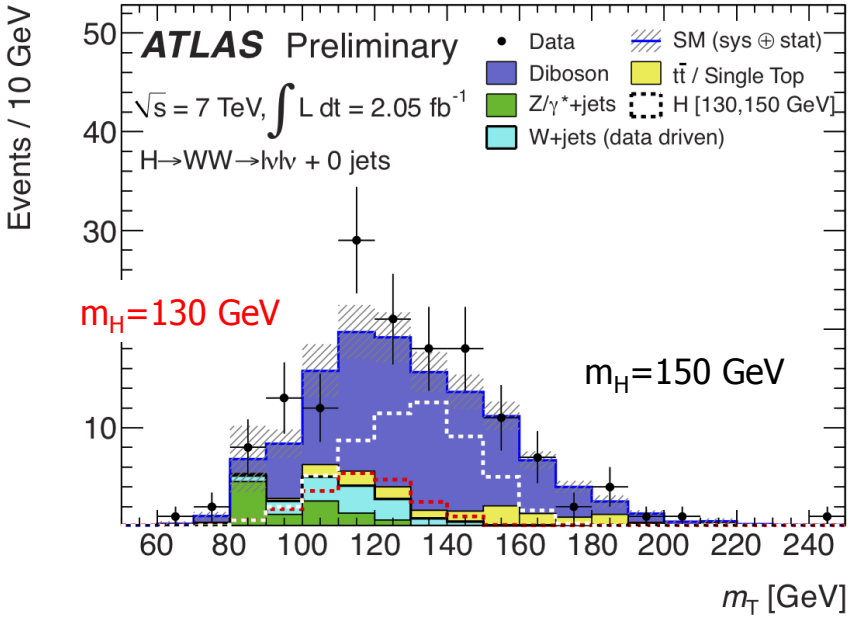


mT分布

$$m_{\mathrm{T}} = \sqrt{(E_{\mathrm{T}}^{\ell\ell} + E_{\mathrm{T}}^{\mathrm{miss}})^2 - (\mathbf{P}_{\mathrm{T}}^{\ell\ell} + \mathbf{P}_{\mathrm{T}}^{\mathrm{miss}})^2}$$

after $\Delta\phi$(ll) cut

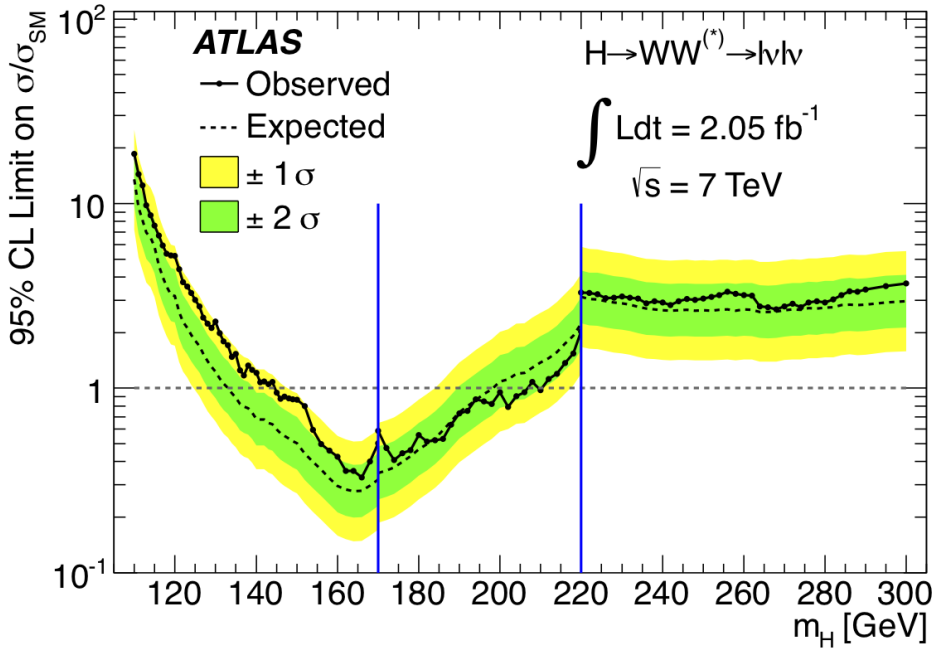


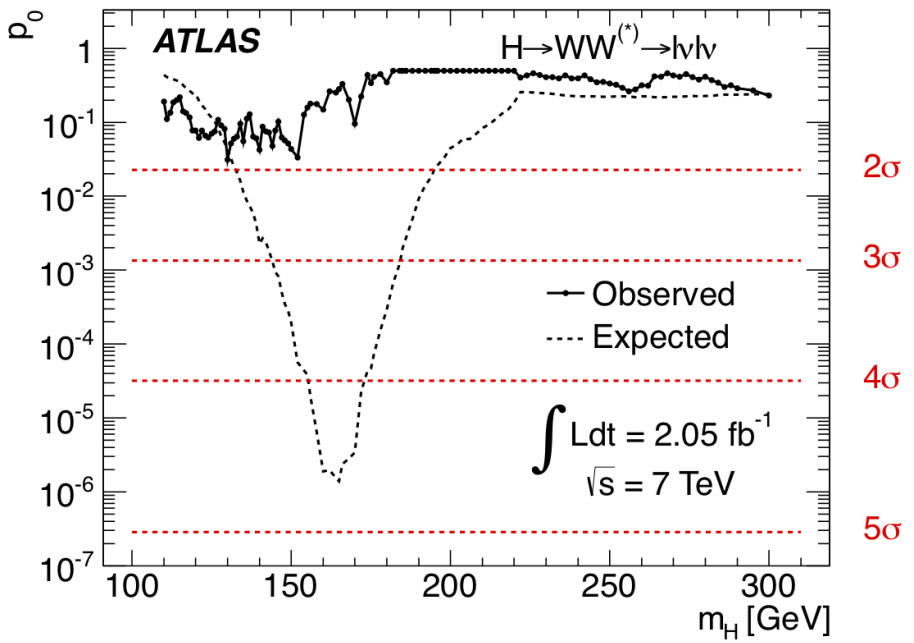


（左上と同じ。130GeVが重ねてある）

H->WW->lνlνの結果

Selection for m_H=130GeV	All	ee	eμ	μμ
Observed data	94	10	42	42
Expected BG	76(+-11)	-	-	-
Expected signal (m_H=130GeV)	19(+-4)	-	-	-





- Observed excluded = 145<m_H<206GeV (expected:134-200GeV)
- Maximum deviation = 1.9σ for m_H~130GeV

H->ZZ*->4l

m_H [GeV]	$\sigma(gg \to H)$ [pb]	$\sigma(qq \to Hqq)$ [pb]	$\sigma(qq \to WH)$ [pb]	$\sigma(qq \to ZH)$ [pb]	BR$(H \to 4\ell)$ $\cdot 10^{-3}$
130	$14.1^{+2.7}_{-2.1}$	$1.154^{+0.032}_{-0.027}$	0.501 ± 0.020	0.278 ± 0.014	0.19
150	$10.5^{+2.0}_{-1.6}$	$0.962^{+0.028}_{-0.021}$	0.300 ± 0.012	0.171 ± 0.009	0.38
200	$5.2^{+0.9}_{-0.8}$	$0.637^{+0.022}_{-0.015}$	0.103 ± 0.005	0.061 ± 0.004	1.15
300	2.4 ± 0.3	$0.301^{+0.014}_{-0.008}$	0.020 ± 0.001	0.012 ± 0.001	1.38
400	2.0 ± 0.3	$0.162^{+0.010}_{-0.005}$	–	–	1.21
600	0.33 ± 0.06	$0.058^{+0.005}_{-0.002}$	–	–	1.23

H->ZZ->4l

- Event Selection (ATLAS)
  - Single lepton trigger (>99.5%)
    - 20-22GeV for elec, 18GeV for muon
  - 4lep pT>20, 20, 7 and 7GeV
    - Isolated and small impact param
  - $|m_Z - m_{12}|<15$GeV
  - $m_{34}<115$GeV &&

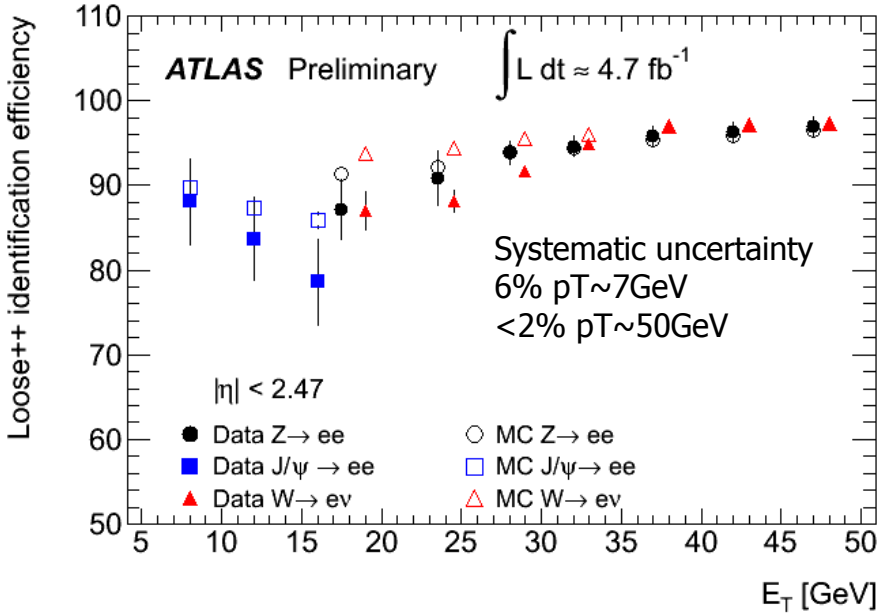
$m_{4\ell}$ (GeV)	≤120	130	140	150	160	165	180	190	≥200
threshold (GeV)	15	20	25	30	30	35	40	50	60

Signal acceptance with eff is ~15% for m_H=125GeV. (~48% for m_H=200GeV)
Performance of Low pT lepton gets important.

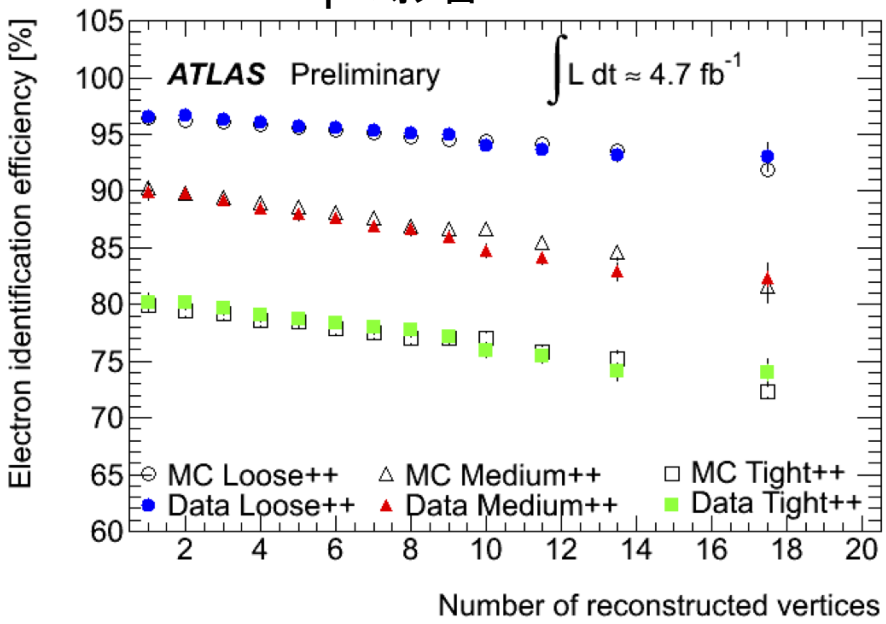
- CMS for comparison
  - Dilepton trigger
  - 4lep pT>20, 10 and 2 x (7GeV for elec or 5GeV for muon)
  - $50 < m_{12} < 120$GeV
  - $12 < m_{34} < 120$GeV
  - 49%, 78%, 61% for 4e, 4μ and 2e2μ (m_H=190GeV)

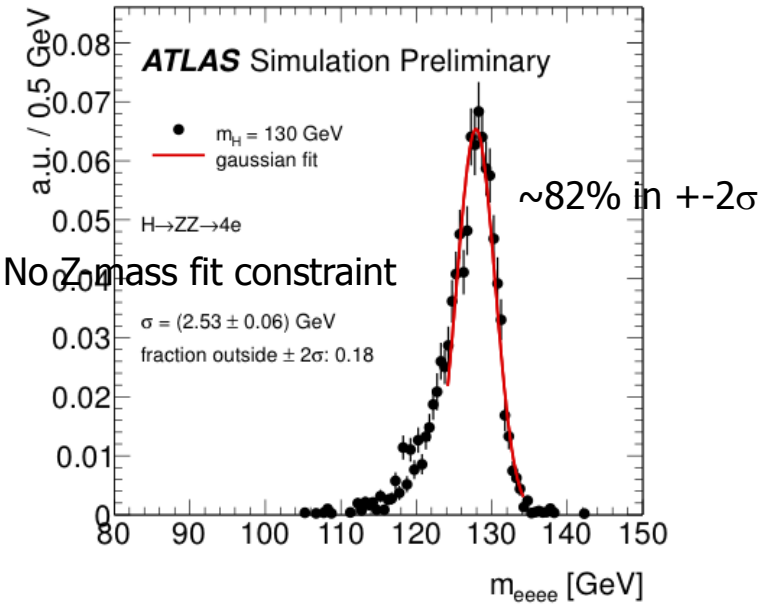
Electron Performance

- J/Ψ->ee, W->eν and Z->ee
  - Challenging->Low pT electrons



Pileupの影響 with Z->ee



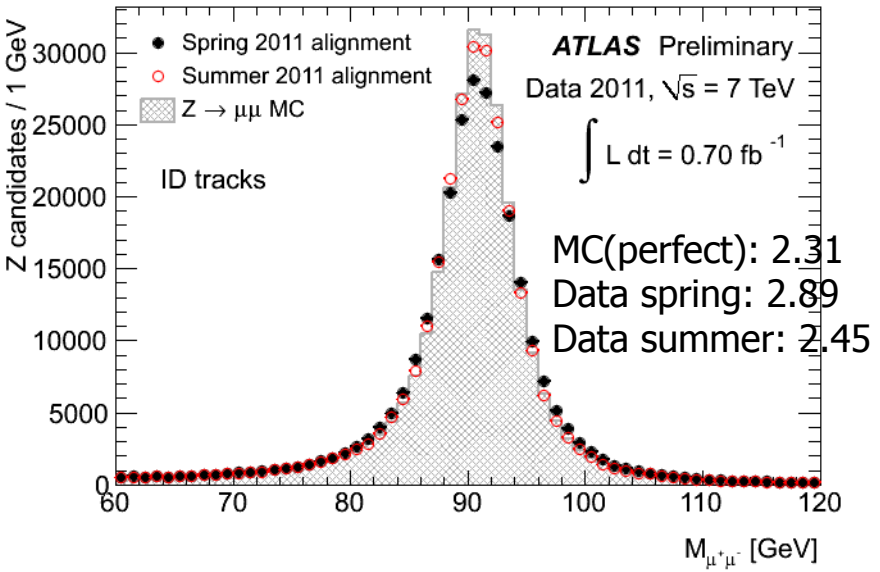


~82% in +-2σ

No Z mass fit constraint

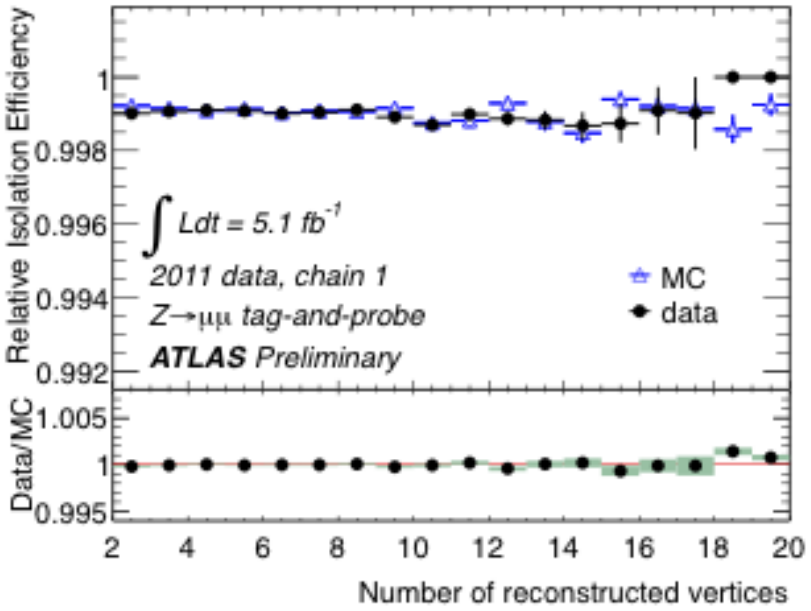
Muon Performance

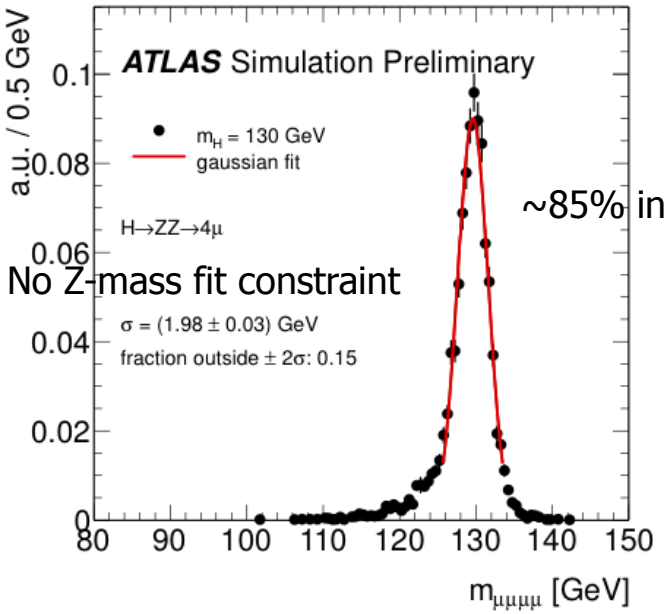
- Z->μμ
- Muon rec eff > 95% (4<p_T<100GeV)



MC(perfect): 2.31
Data spring: 2.89
Data summer: 2.45

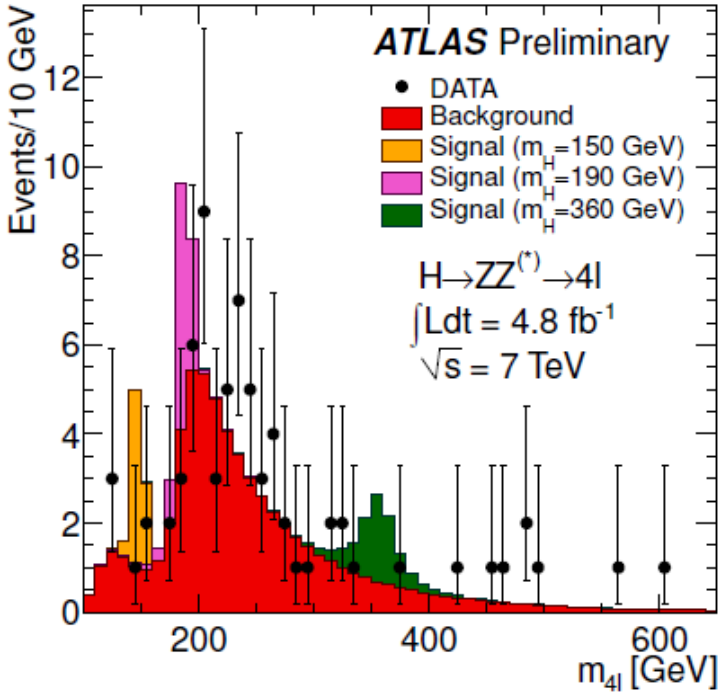
Pileupの影響 with Z->μμ

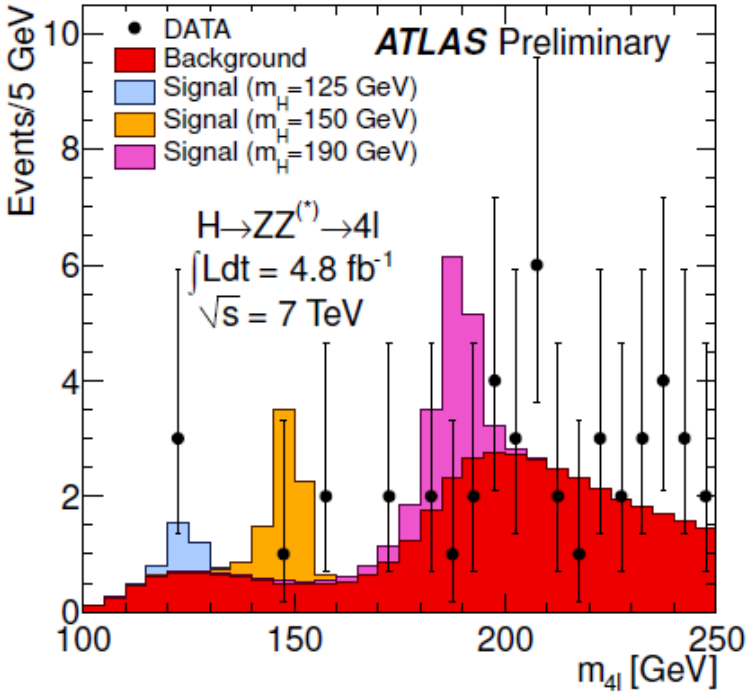




~85% in +-2σ

No Z-mass fit constraint



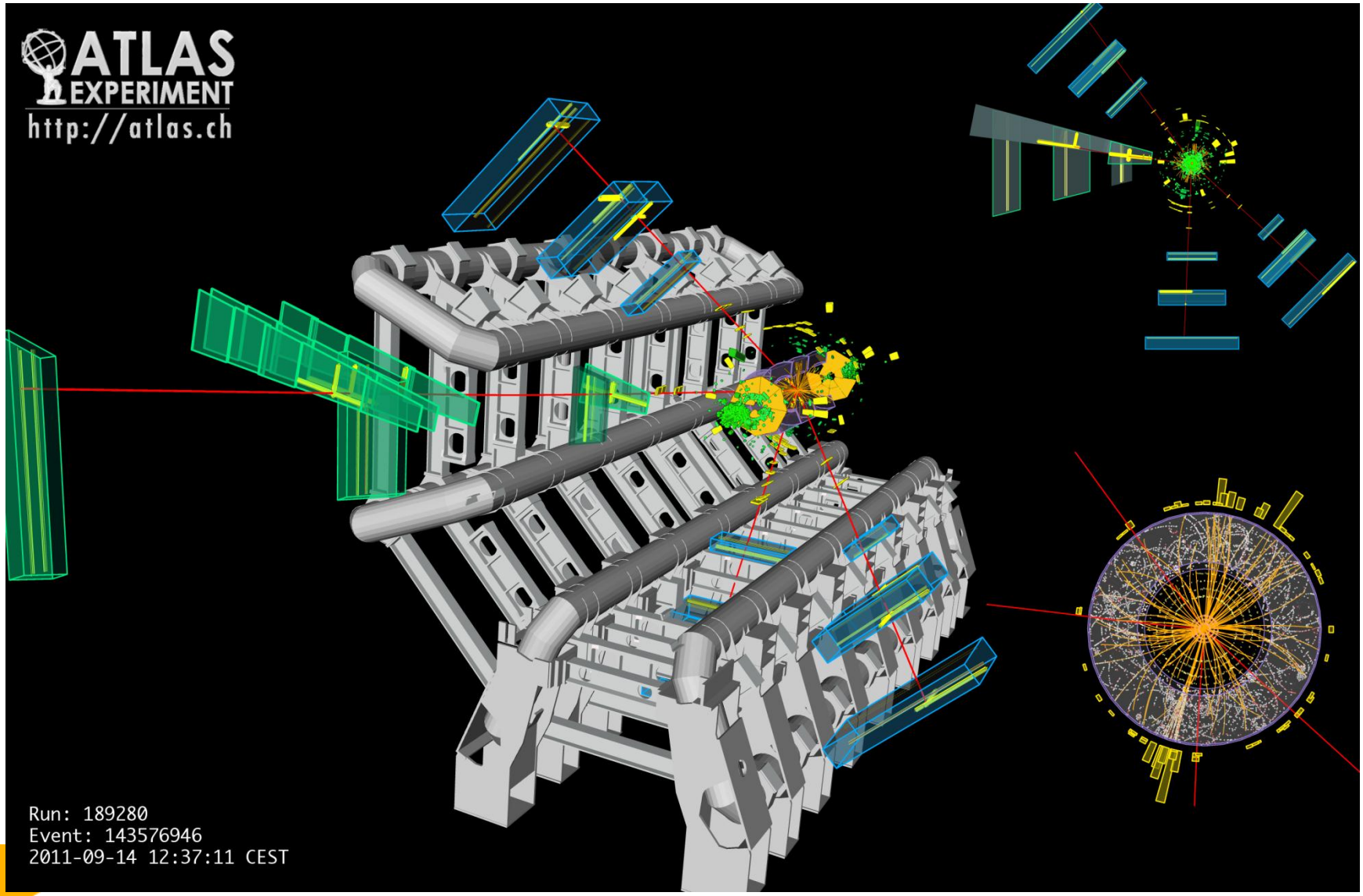


	$\mu\mu\mu\mu$		$ee\mu\mu$		$eeee$	
	Low $m_{4\ell}$	High $m_{4\ell}$	Low $m_{4\ell}$	High $m_{4\ell}$	Low $m_{4\ell}$	High $m_{4\ell}$
Int. Luminosity	4.81 fb^{-1}		4.81 fb^{-1}		4.91 fb^{-1}	
$ZZ^{(*)}$	2.0±0.3	16.3±2.4	2.8±0.6	25.2±3.8	1.3±0.3	10.3±1.5
Z, $Zb\bar{b}$, and $t\bar{t}$	0.16±0.06	0.02±0.01	1.4±0.5	0.17±0.08	1.6±0.7	0.18±0.08
Total Background	2.2±0.3	16.3±2.4	4.2±0.8	25.4±3.8	2.9±0.8	10.5±1.5
Data	3	21	3	27	2	15
$m_H = 125$ GeV	0.58 ± 0.10		0.73 ± 0.13		0.25 ± 0.05	
$m_H = 130$ GeV	1.00 ± 0.17		1.22 ± 0.21		0.43 ± 0.08	
$m_H = 150$ GeV	2.1 ± 0.4		2.9 ± 0.4		1.12 ± 0.18	
$m_H = 200$ GeV	4.9 ± 0.7		7.7 ± 1.0		3.1 ± 0.4	
$m_H = 300$ GeV	2.9 ± 0.4		4.9 ± 0.6		2.1 ± 0.3	
$m_H = 400$ GeV	2.0 ± 0.3		3.3 ± 0.5		1.49 ± 0.21	
$m_H = 600$ GeV	0.34 ± 0.04		0.62 ± 0.10		0.30 ± 0.06	

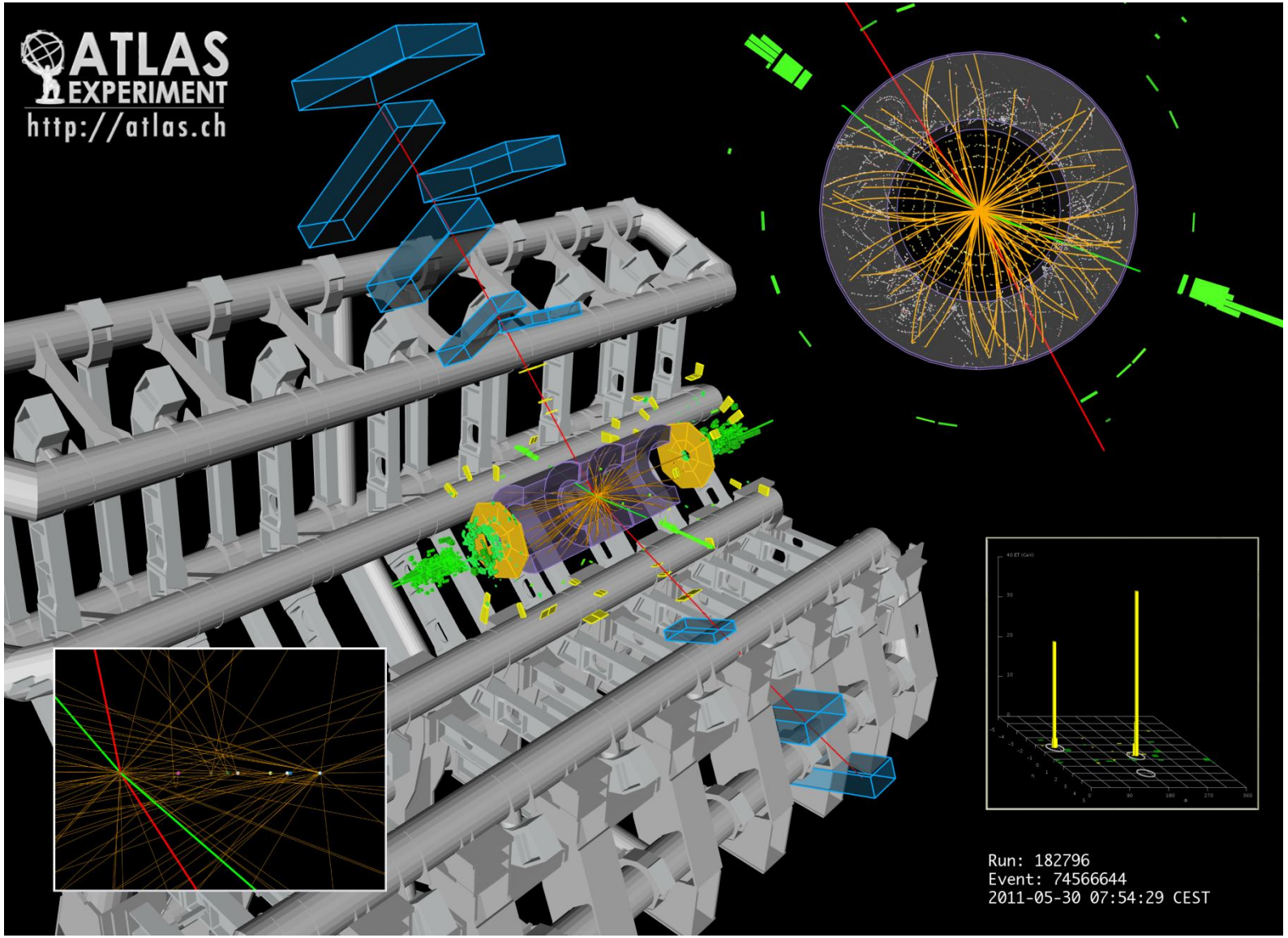
3 events (<140GeV)
124.6(4μ), 124.3(2e2μ),
123.6(2μ2e)

Excess of 212-256GeV
- Expected BG 16 events
- Expected signal 11 events
- Observed 22 events

4muon candidate with m_{4l}=124.6GeV
p_T=61.2, 33.1, 17.8, 11.6GeV
m_{12}=89.7GeV, m_{34}=24.6GeV

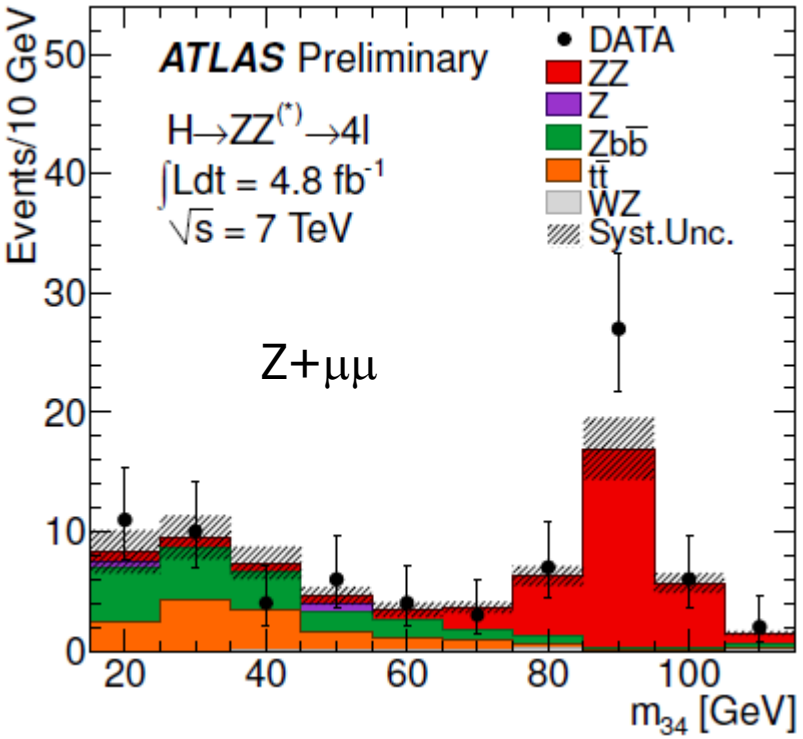


4muon candidate with m_{4l}=124.3GeV
p_T=41.5, 26.5, 24.7, 18.3GeV
$m_{12(ee)}$=76.8GeV, $m_{34(\mu\mu)}$=45.7GeV

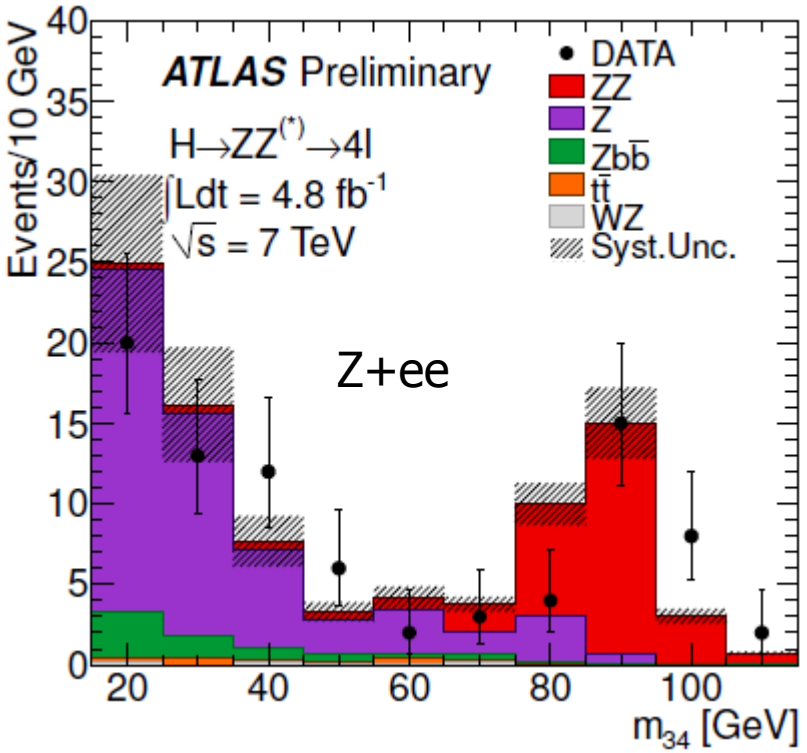


BG check

Z+jets, where jets fakes leptons.
- 2 OS same-flavor with m_Z+-15GeV
- 2 additional SF leptons passing all cuts except for isolation and impact param.

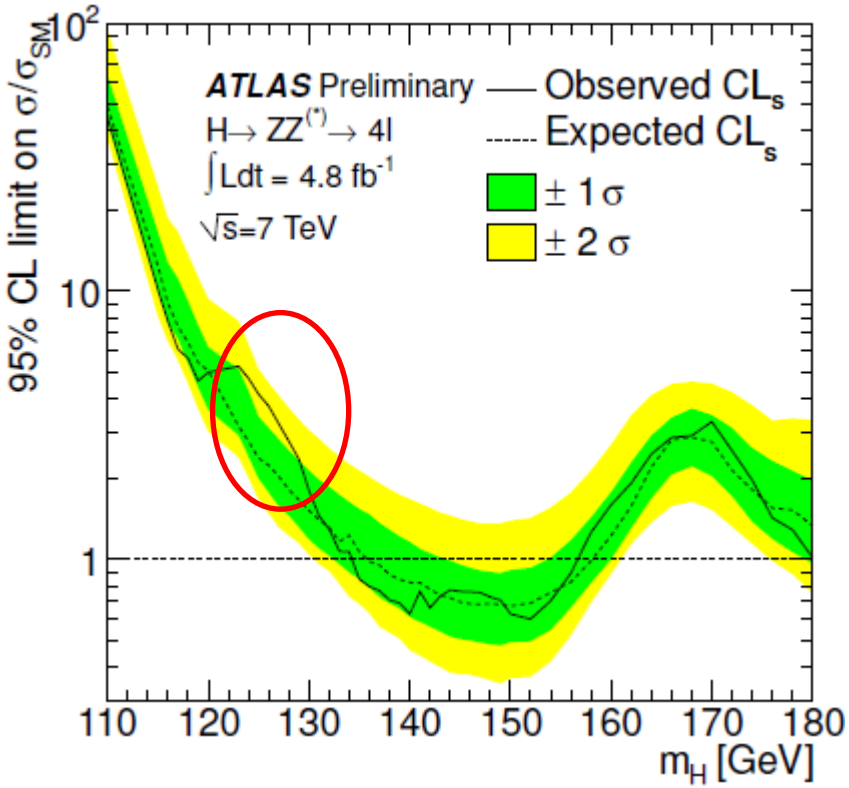


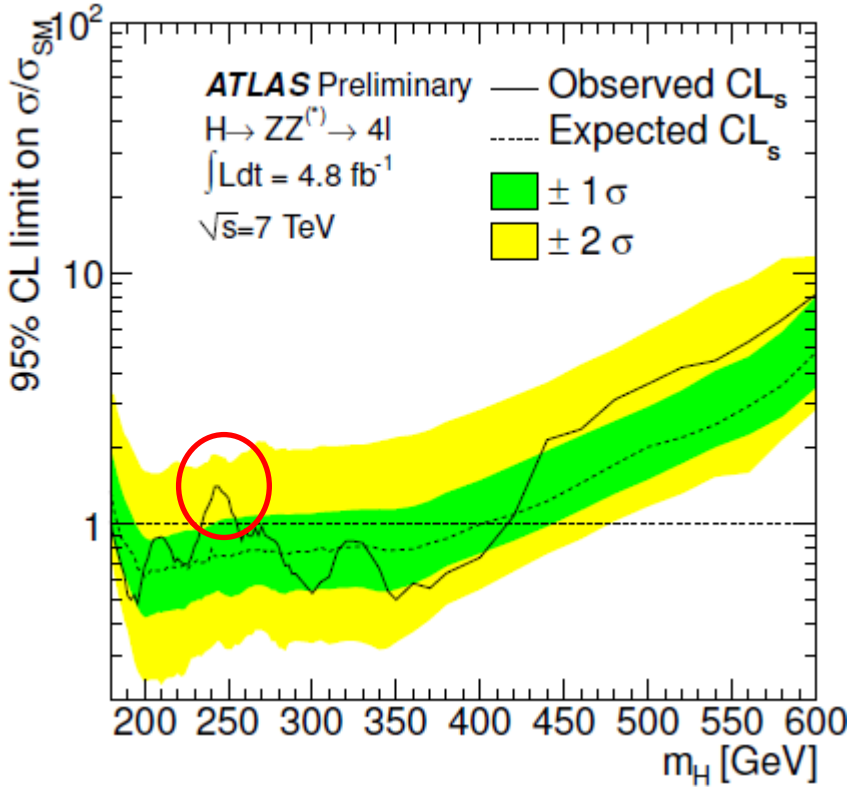
b -> μ



Jet -> e (π^{+-}+π^0)
b -> e

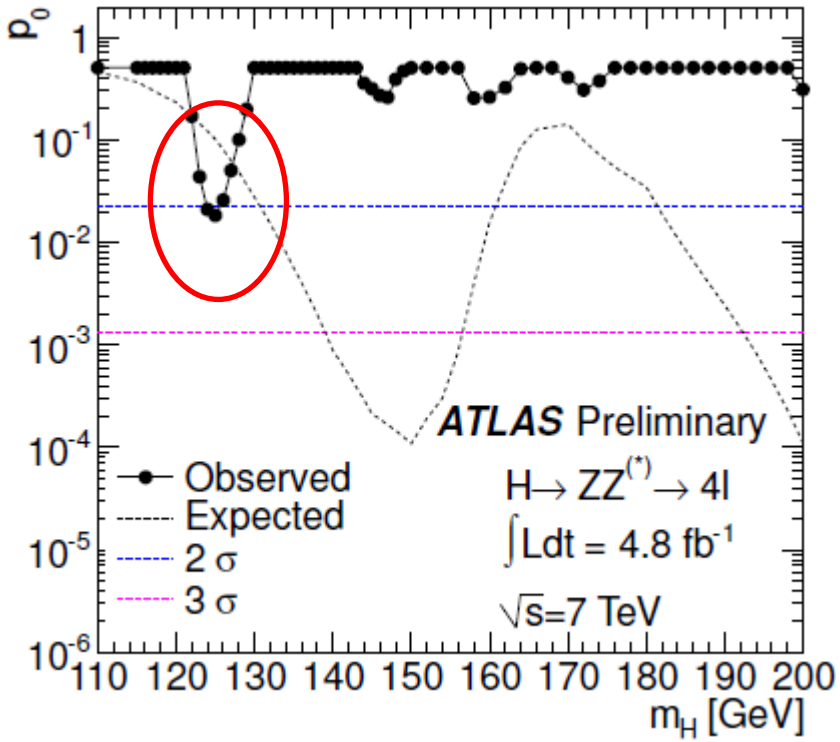
H->ZZ->4l

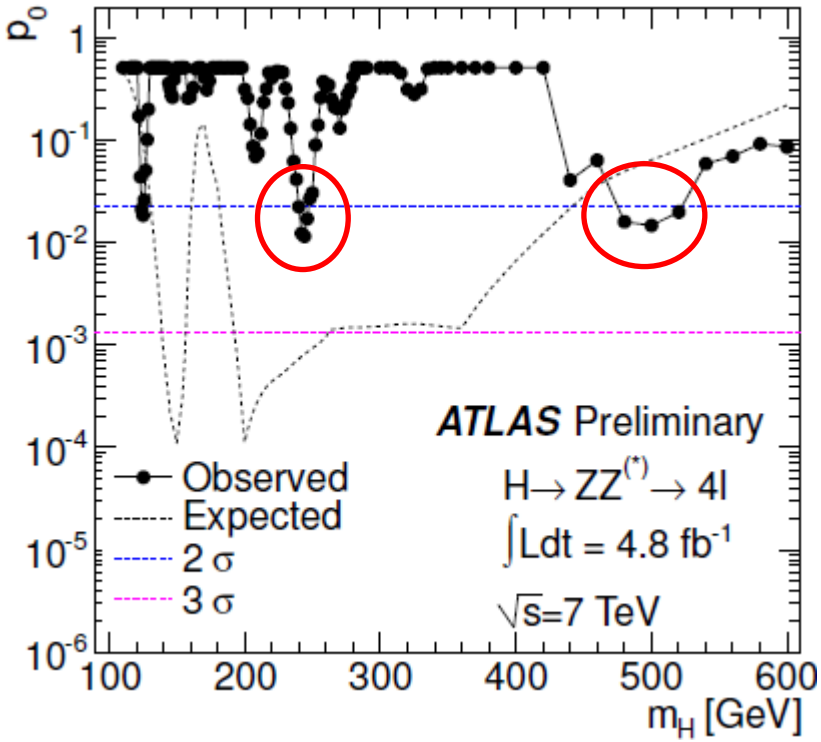




Excluded three regions :
135-158.5, 181-232.5 and 276.5-414GeV

H->ZZ->4l

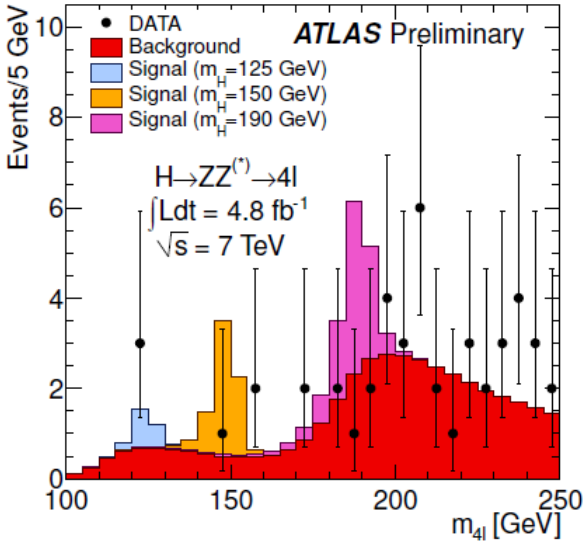


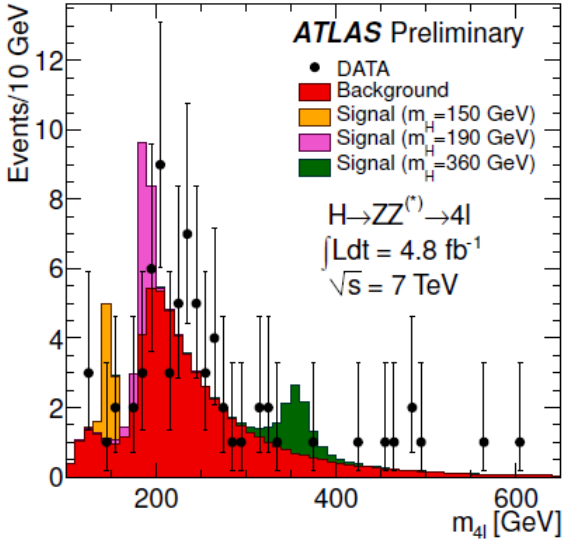


m_H(GeV)	Local (global) p_0	Local significance	Expected
125	1.8% (~50%)	2.1σ	1.4σ
244	1.1% (~50%)	2.3σ	3.2σ
500	1.4% (~50%)	2.2σ	1.5σ

LEE estimated over mass range: 110-600GeV

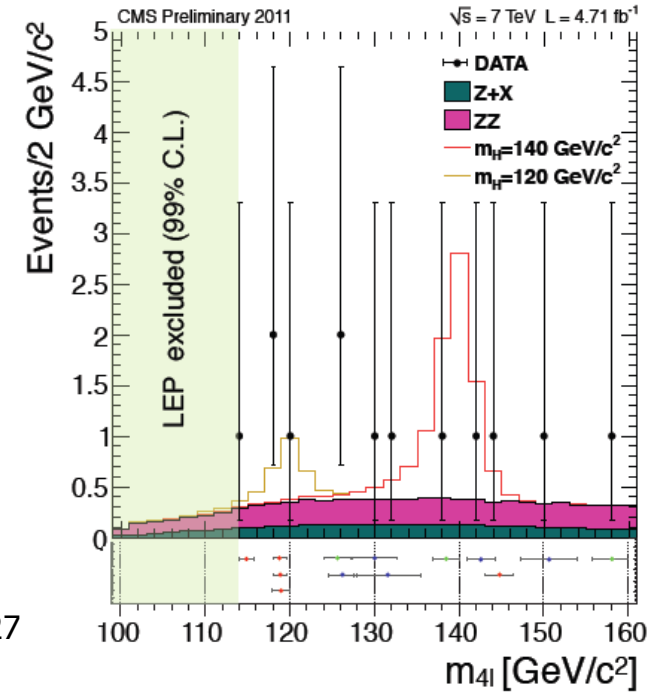
ATLAS vs CMS

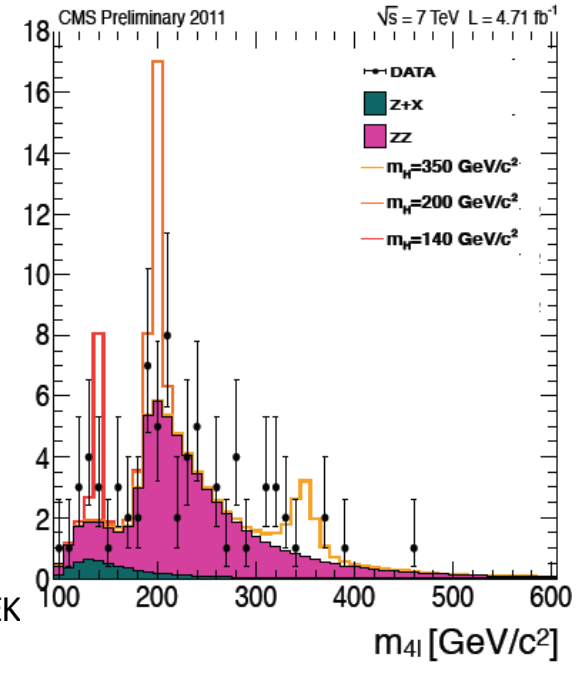




m_H<180GeV

Final	4e	4μ	2e2μ
Obs.	2	3	3
Exp.	2.9	2.2	4.2





m_H<160GeV

Final state:	4e	4μ	2e2μ
Obs. events:	3	5	5
Exp. events:	1.7	3.3	4.5

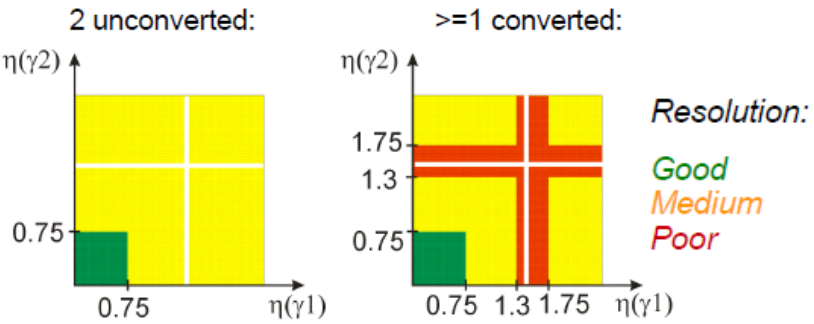
H->γγ

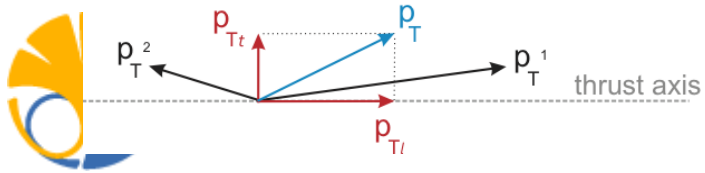
H->γγ

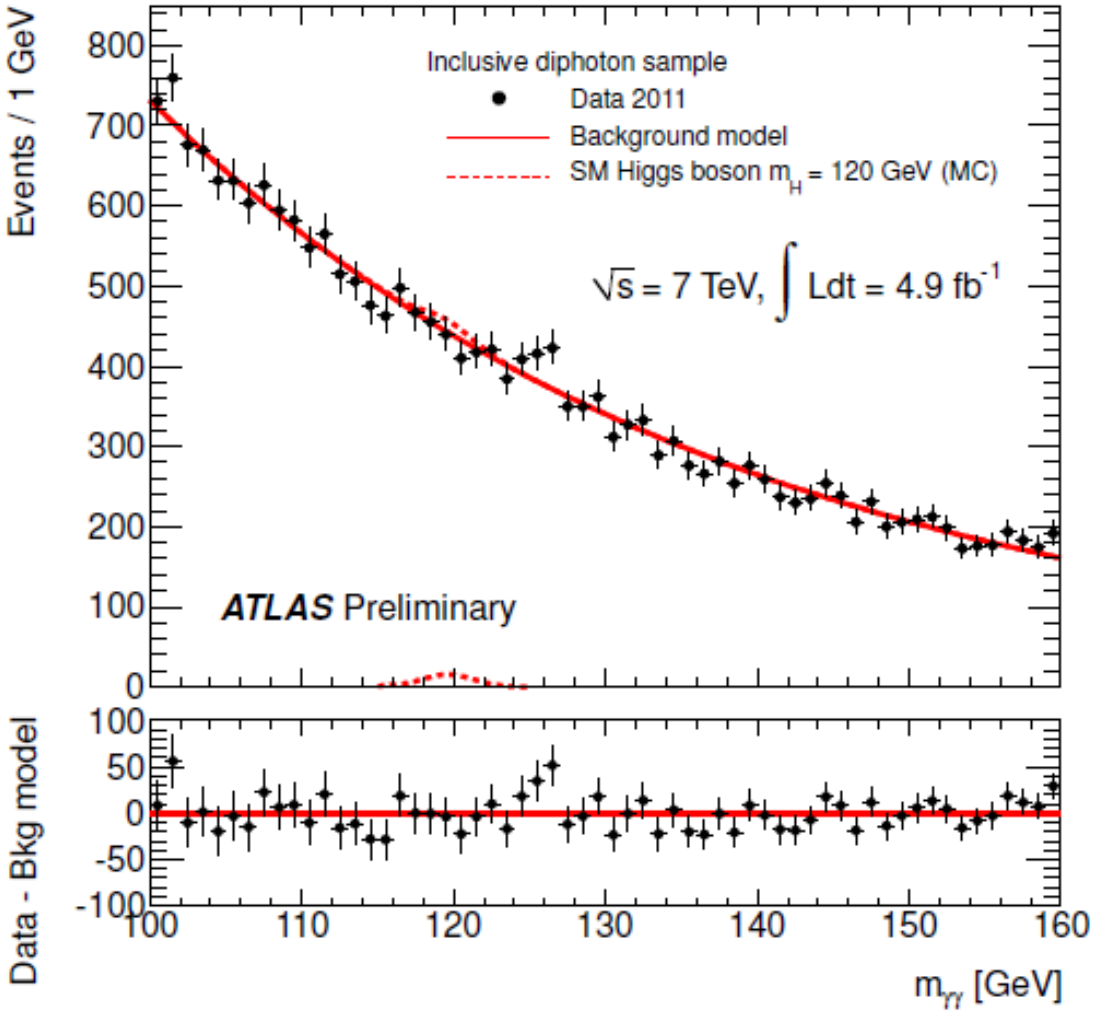
- Event selection
  - 2g20 trigger
  - E_T>40GeV and 25GeV
  - Isolated tight photon
    - ETCone40<5GeV

-> 22489 events in total (100<$m_{\gamma\gamma}$<160GeV)

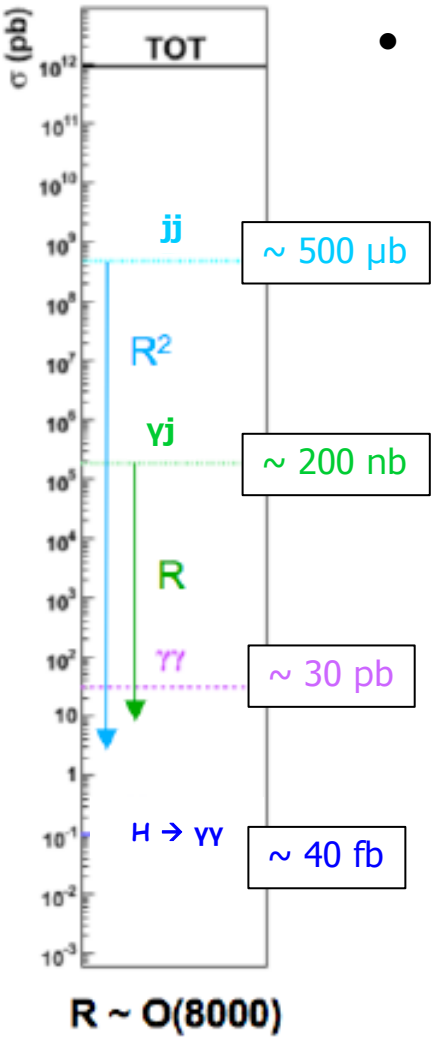
- Categorization => "9"
  - Conversion status
  - Eta region
  - pTt=40GeV



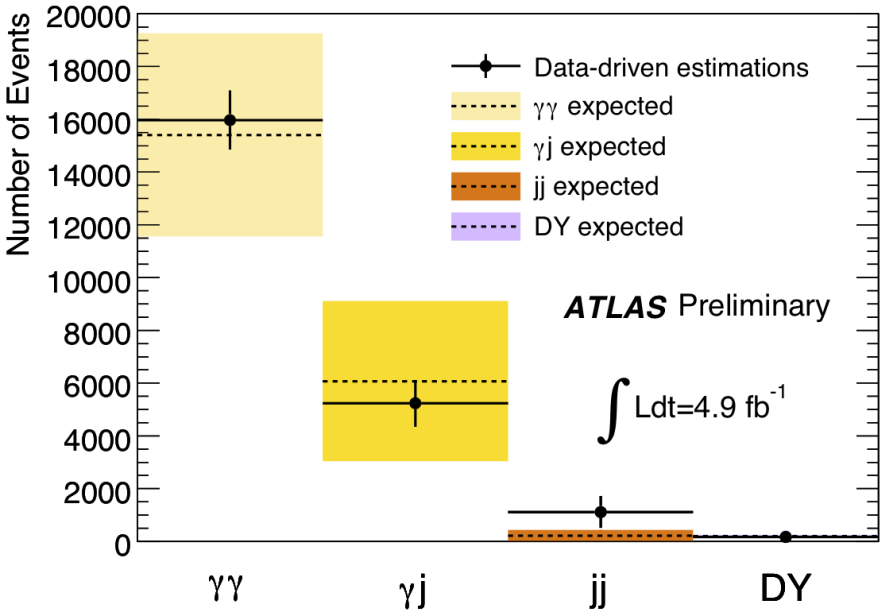


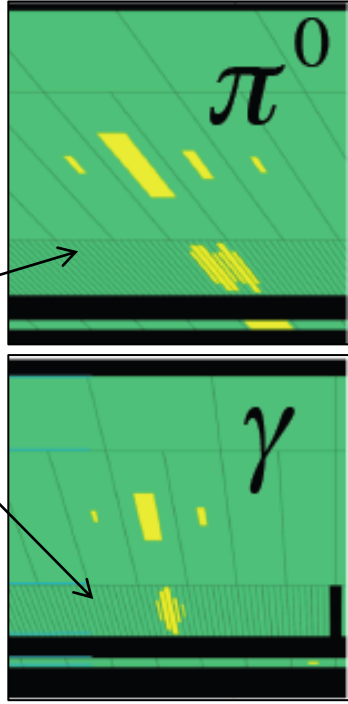


Background



- Processes = γγ, γj and jj
  - Fake photon jet->π^0
    - 1/~10^4 (gluon>quark)(MC)



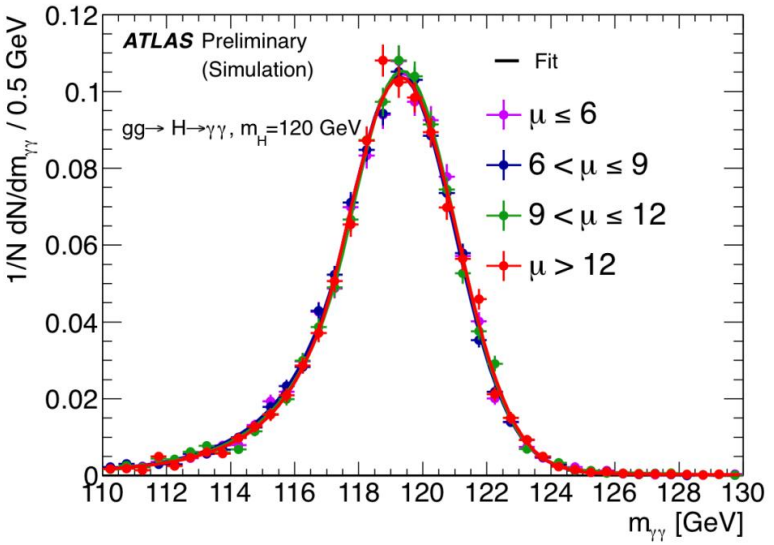


Composition	$\gamma\gamma$	γj	jj	Drell-Yan
Events	$16000 \pm 200 \pm 1100$	$5230 \pm 130 \pm 880$	$1130 \pm 50 \pm 600$	$165 \pm 2 \pm 8$
Relative fraction	$(71 \pm 5)\,\%$	$(23 \pm 4)\,\%$	$(5 \pm 3)\,\%$	$(0.7 \pm 0.1)\,\%$

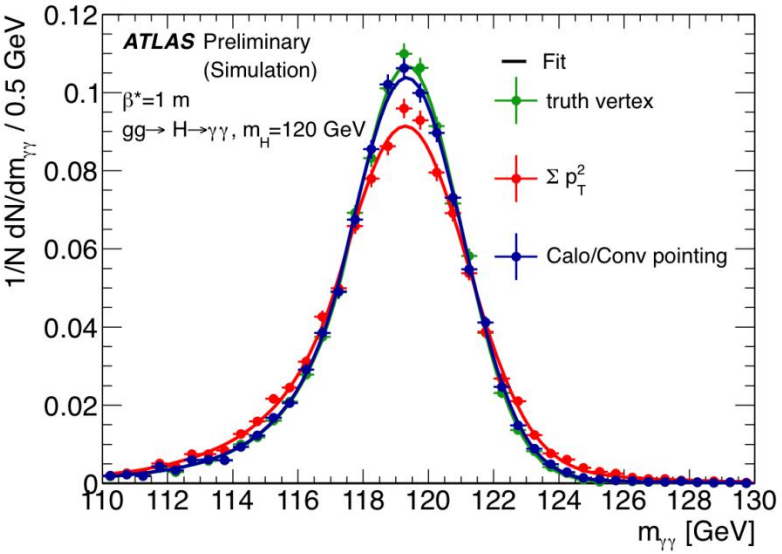
注意: BGの成分をデータから見積もったが、最終結果には使っていない。

Mass Reconstruction

- Mass $m_{\gamma\gamma}=\sqrt{2E_1E_2(1-\cos\alpha)}$
  - Energy(E_1 and E_2) & Angle(α) between 2 photons
- ResolutionはPileupの影響をあまり受けない。
  - Conversionでまともなトラックがある場合はトラックを使う。
  - それ以外は、Calorimeterの層構造を利用する。
  - -> Primary vertexの選択にほぼ依存しない。

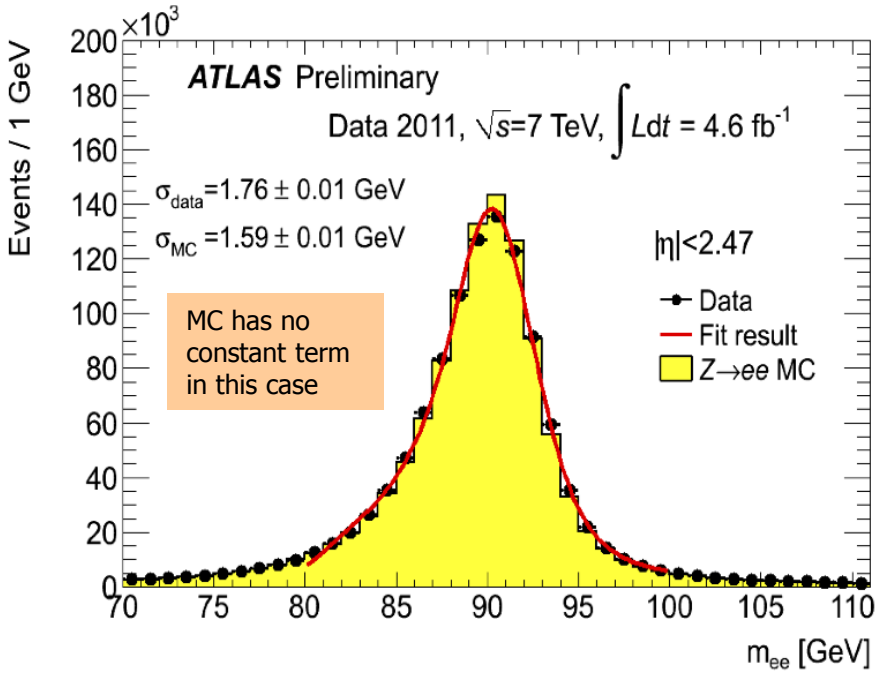


Category	σ_{CB} [GeV]	FWHM [GeV]	N_{sig}	N_{BG}	N_{sig}/N_{BG}
CP1: Unconverted central, low p_{Tt}	1.4	3.4	7.3	142	0.051
CP2: Unconverted central, high p_{Tt}	1.4	3.3	2.2	18	0.117
CP3: Unconverted rest, low p_{Tt}	1.7	4.1	13.5	589	0.023
CP4: Unconverted rest, high p_{Tt}	1.6	3.9	3.8	87	0.043
CP5: Converted central, low p_{Tt}	1.7	3.9	4.7	125	0.038
CP6: Converted central, high p_{Tt}	1.6	3.7	1.4	16	0.085
CP7: Converted rest, low p_{Tt}	2.0	4.7	14.0	805	0.017
CP8: Converted rest, high p_{Tt}	1.9	4.5	3.7	110	0.034
CP9: Converted transition	2.3	5.8	5.9	429	0.014



Energy Calibration

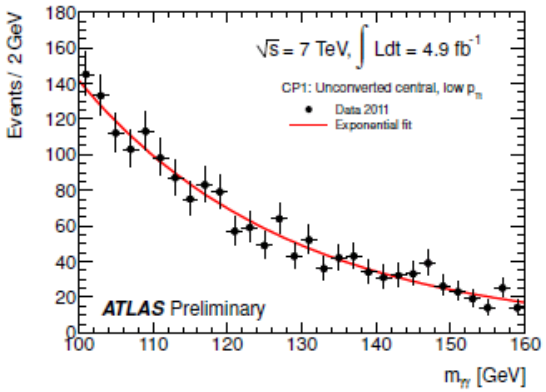
- Z->ee, J/Ψ->ee, W->eν and MC
  - Energy scale at m_Z ~ 0.5%
  - Linearity < 1%
  - Uniformity (constant term) ~1% for barrel and ~1.7% for endcap
- "Electron -> photon" by using MC

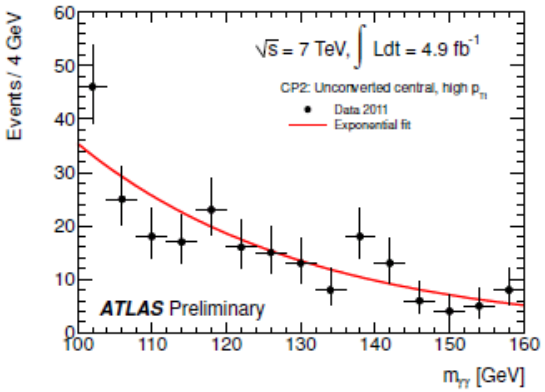


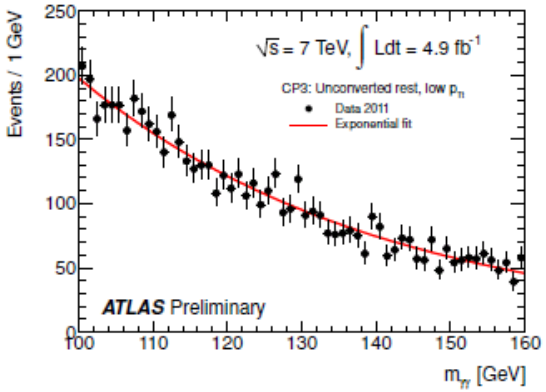
BG modeling

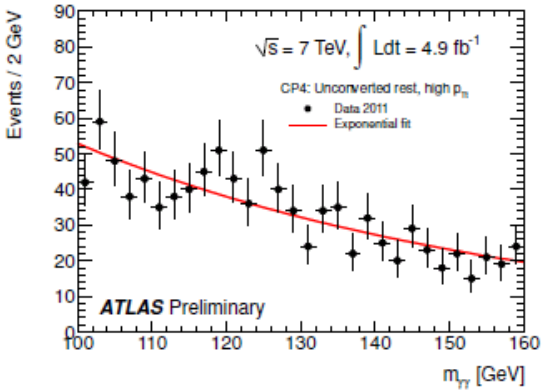
- Single exponential function with mass range of 100-160GeV
  - Limits are obtained for 110-150GeV.
- Assign systematics for the choice of BG modeling

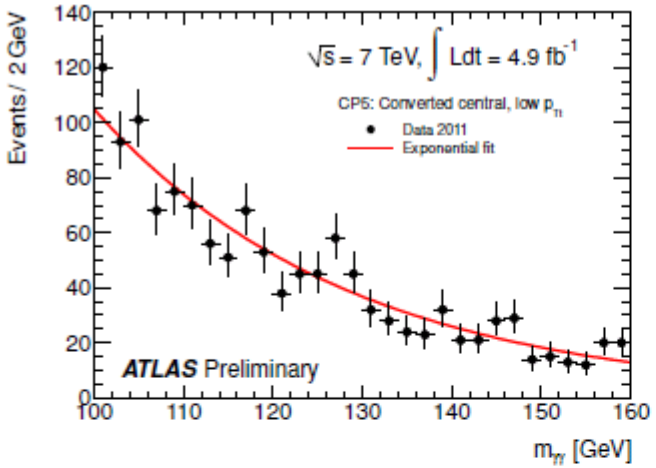
Category	CP1	CP2	CP3	CP4	CP5	CP6	CP7	CP8	CP9
Events	±4.3	±0.2	±3.7	±0.5	±3.2	±0.1	±5.6	±0.6	±2.3

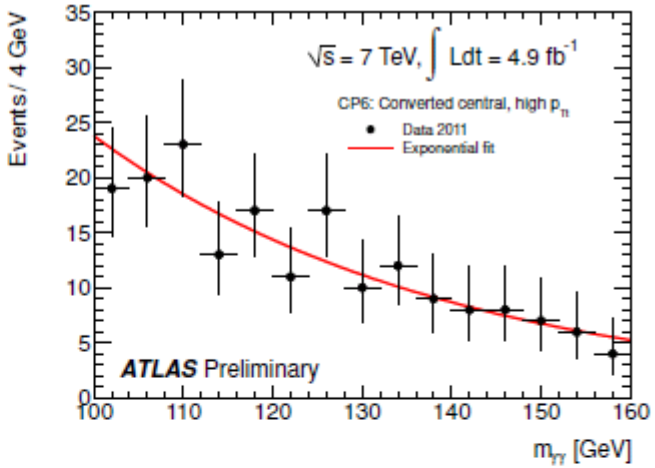


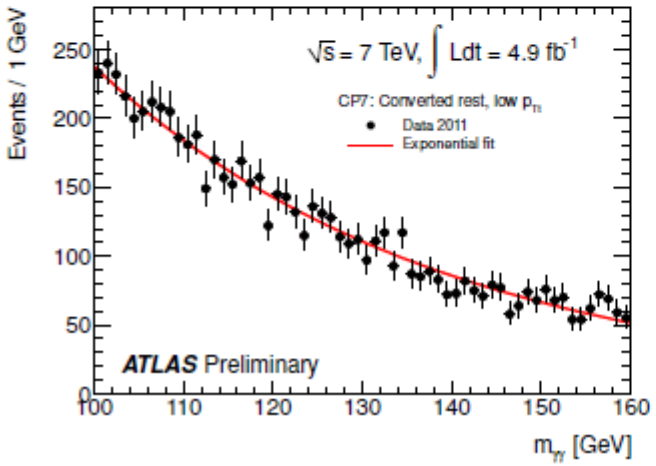


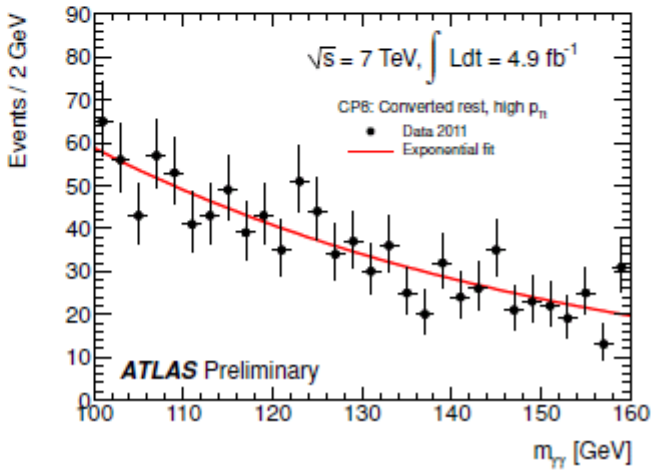


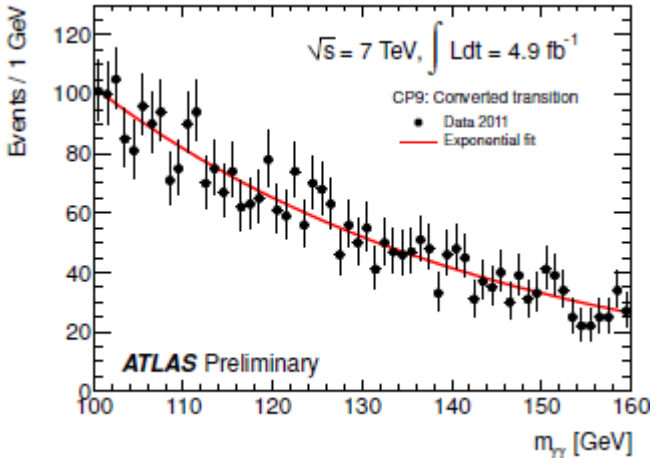










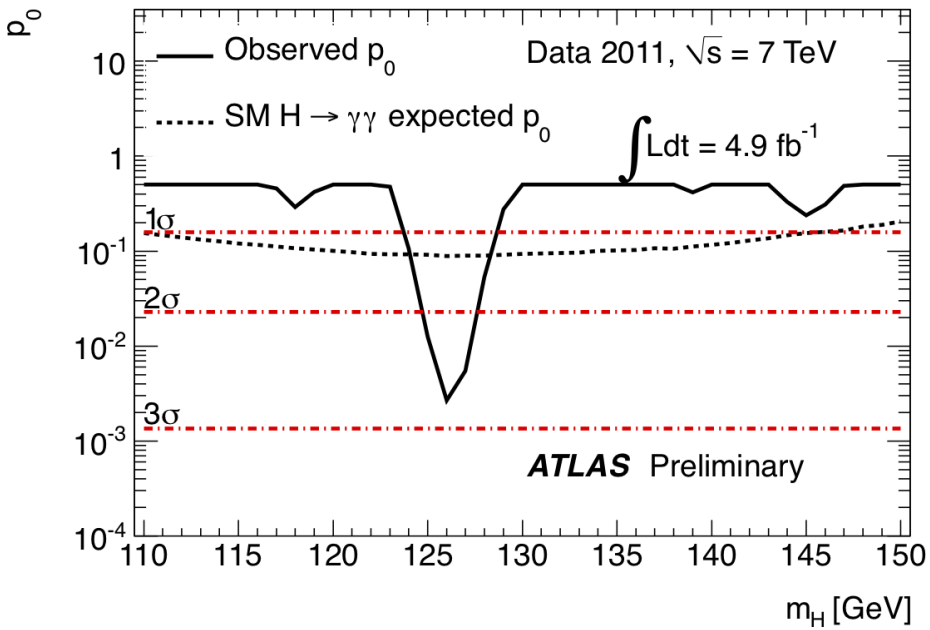


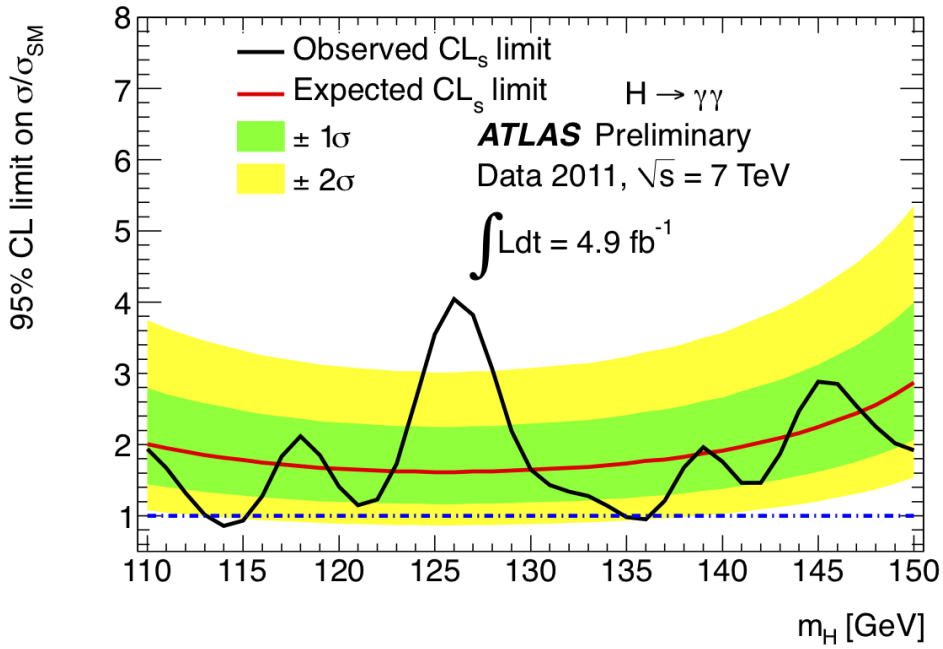
他のFunctionsもチェック。

Systematic Uncertainties

Type and source	Uncertainty
Event yield	
Photon reconstruction and identification	±11%
Effect of pileup on photon identification	±4%
Isolation cut efficiency	±5%
Trigger efficiency	±1%
Higgs boson cross section	+15%/−11%
Higgs boson p_T modeling	±1%
Luminosity	±3.9%
Mass resolution	
Calorimeter energy resolution	±12%
Photon energy calibration	±6%
Effect of pileup on energy resolution	±3%
Photon angular resolution	±1%
Migration	
Higgs boson p_T modeling	±8%
Conversion reconstruction	±4.5%

H->γγの結果

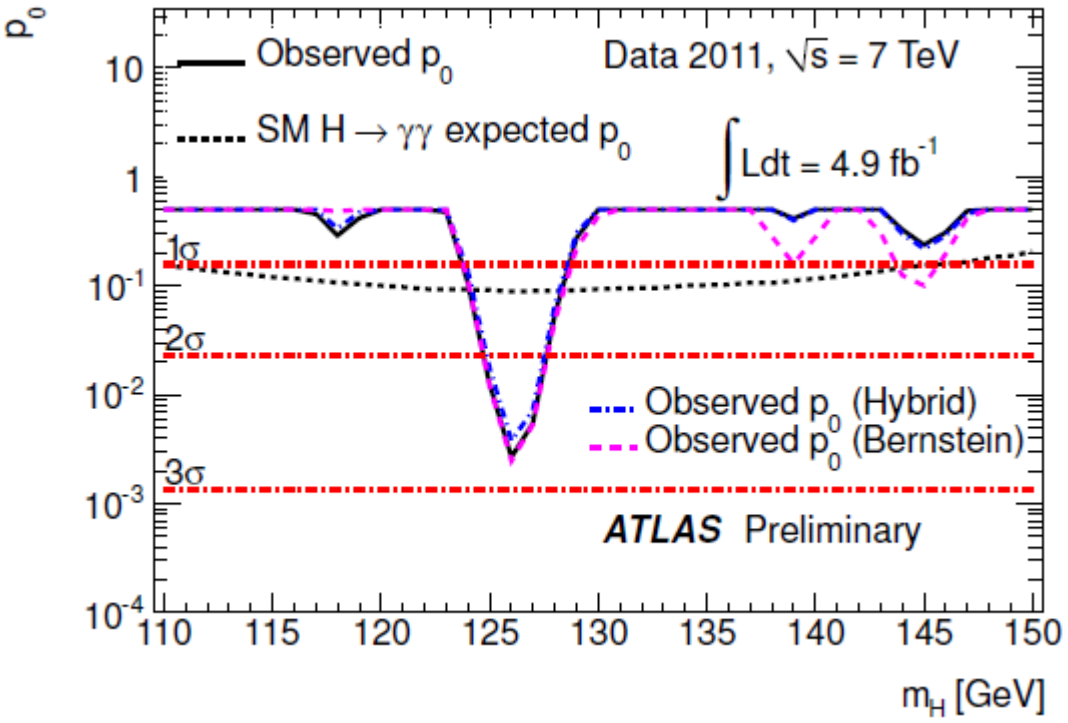




m_H=126GeV

- Local p-value = 0.27% -> 2.8σ
- Global p-value = 7% -> 1.5σ

- Expected = 1.6-2 x SM (110-140)
- Excluded = 114-115, 135-136GeV

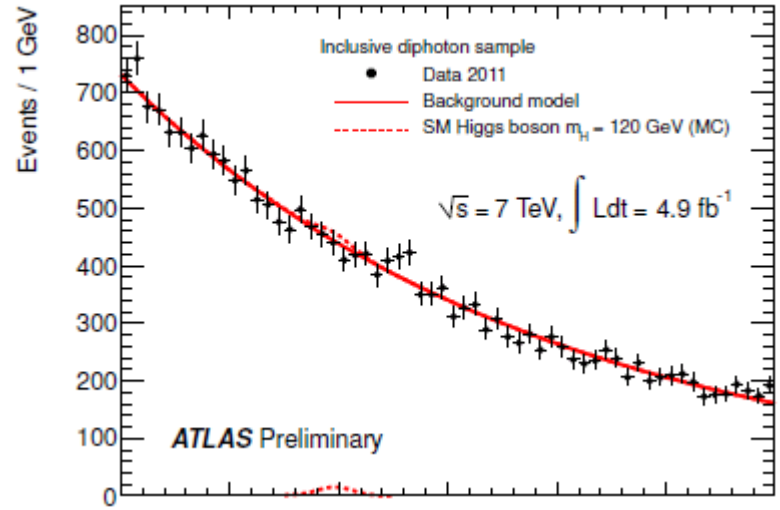


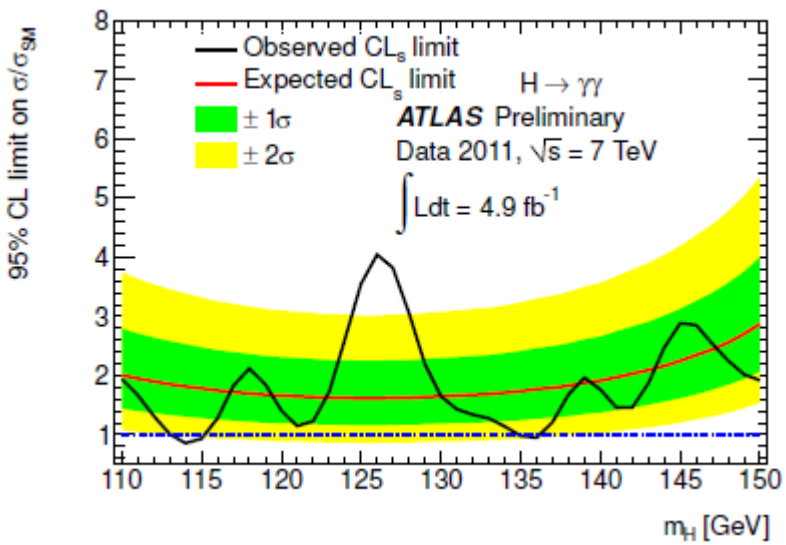
$$N\left[(1-t)^2 + p_0\, 2t(1-t) + p_1\, t^2\right], \text{ with}$$

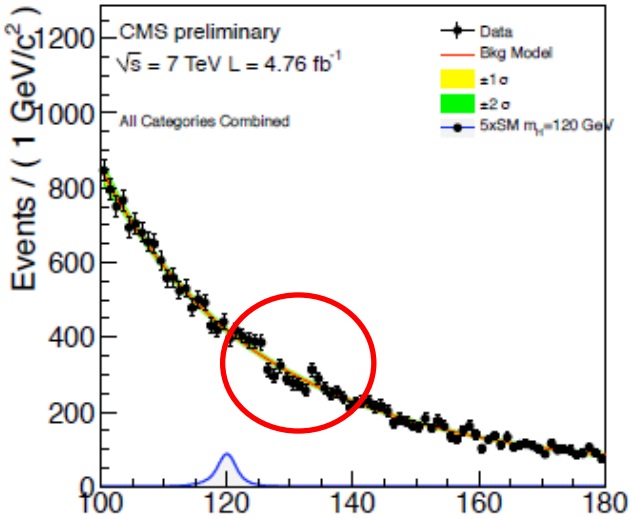
$$t = (m_{\gamma\gamma} - 100)/60 \in [0,1].$$

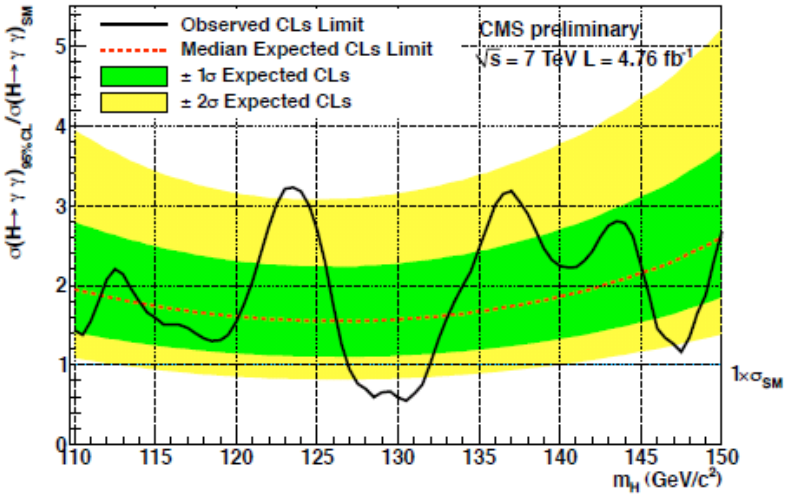
Figure 12: The observed and expected local p_0-value as a function of m_H for three different background models without taking the *look-elsewhere effect* into account. The black solid line is the result described in detail in this note, using single exponential functions in all categories. In the *Hybrid* model the high p_{Tt} categories are fitted with the 2nd order Bernstein polynomials, the other categories with the single exponential. In the model *Bernstein* all categories are fitted with the Bernstein function. The p_0-values near the minima at 126 GeV are very similar in all cases: p_0=0.38% using the *Hybrid* model, and p_0=0.25% using the *Bernestein* function.

ATLAS vs CMS









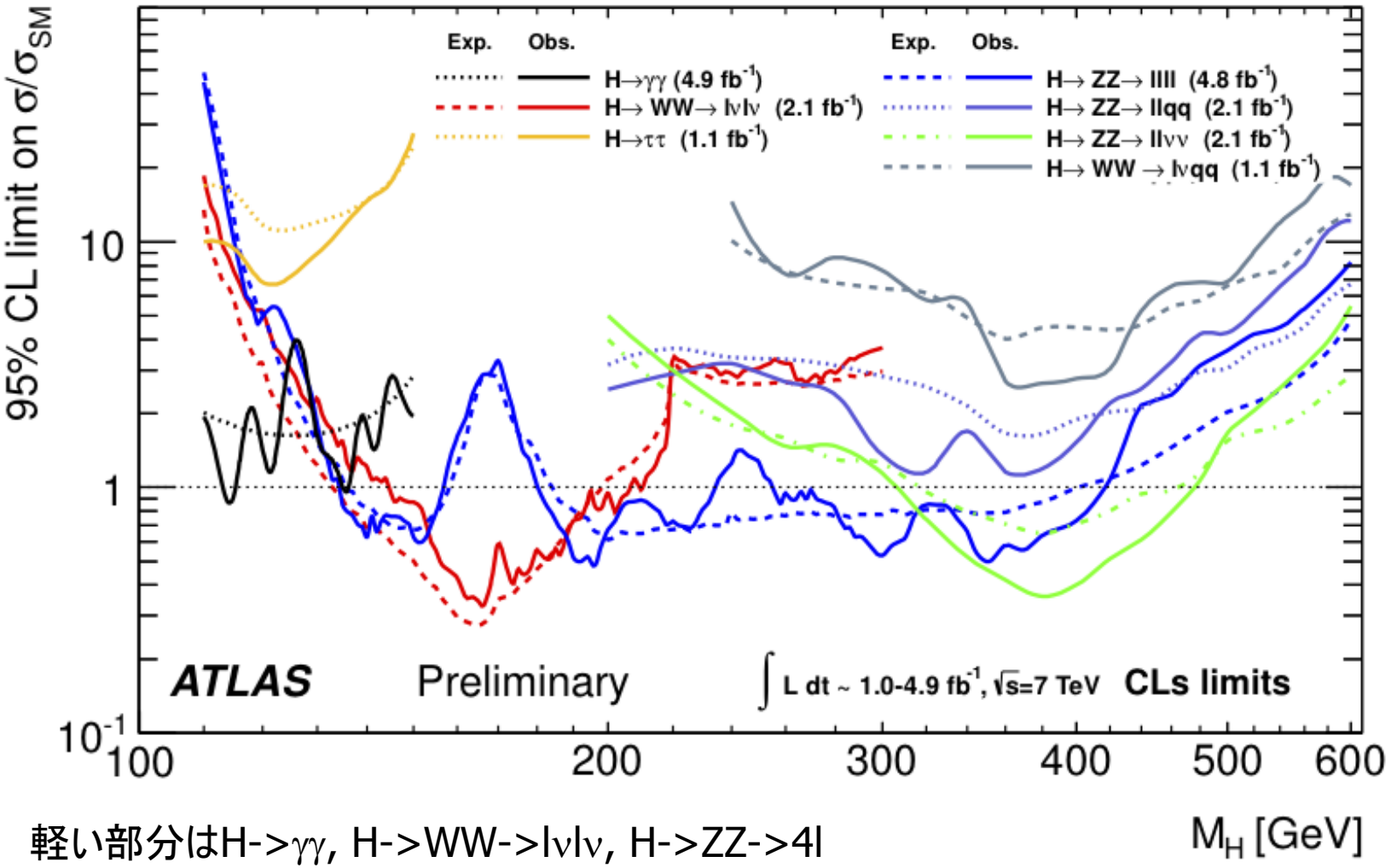
Excluded = 114-115, 135-136GeV
Expected = 1.6-2 x SM (110-140)
Local p-value = 0.27%(2.8σ)@126GeV

Excluded = 127-131GeV
Expected = 1.5-2 x SM (110-140)
Local p-value = 0.96%(2.3σ)@123.5GeV

ATLAS and CMS

Combination

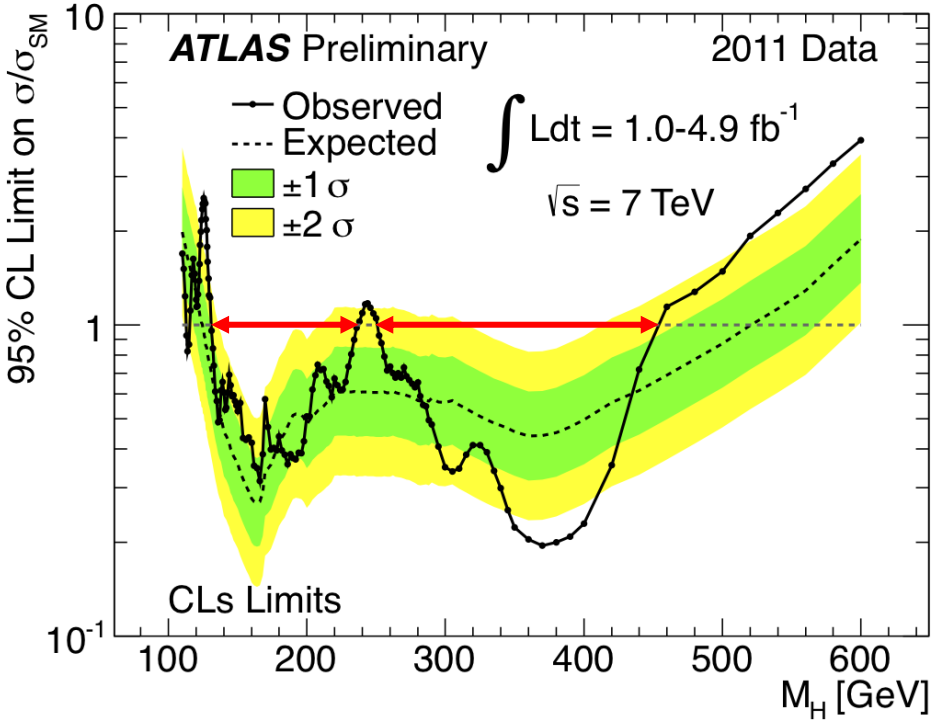
ATLAS 各チャンネル

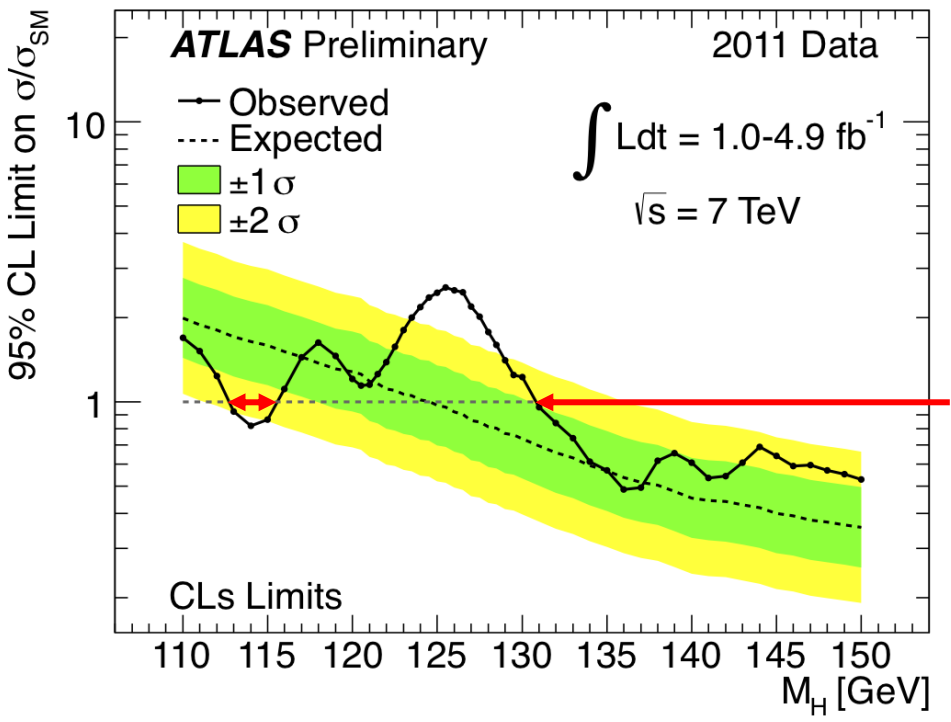


- 軽い部分はH->γγ, H->WW->lνlν, H->ZZ->4l
- 重い部分はH->ZZ->llνν (今回は更新しなかった)

ATLAS combination

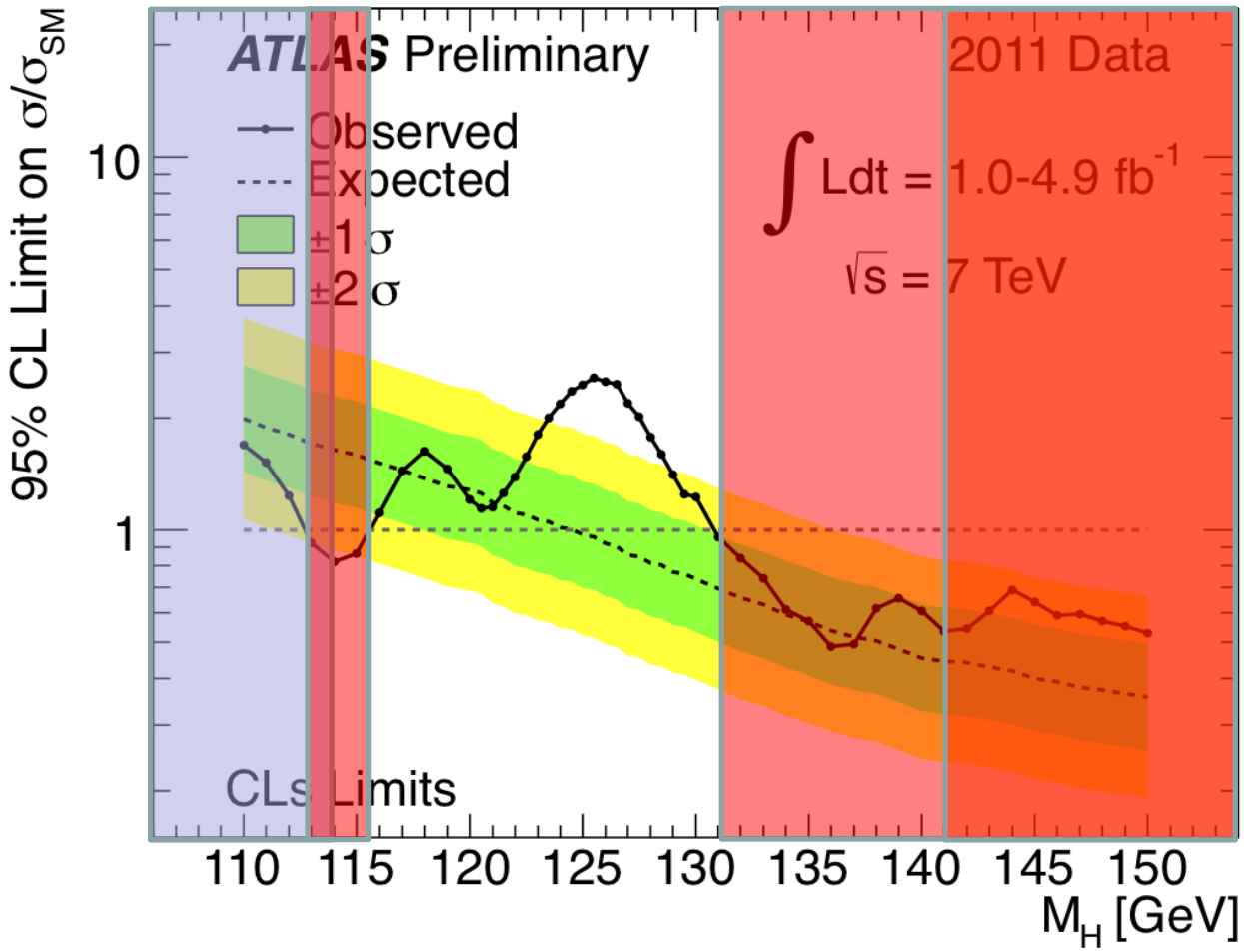
Exclusion (95/99% CL Limit)





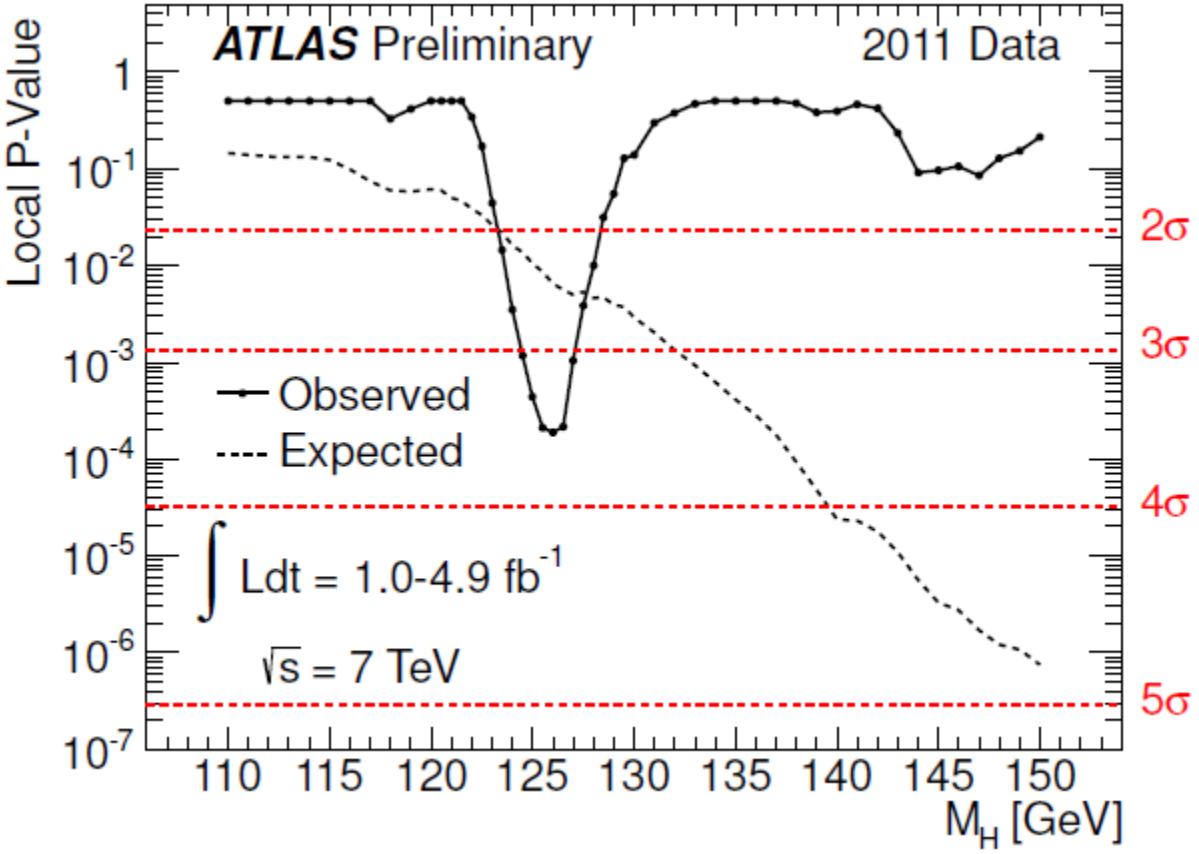
- Expected limit : 124.6 < m_H < 520GeV
- Observed limit
  - 95%: 112.7 < m_H < 115.5GeV, 131 <m_H < 453GeV except for 237-251GeV
  - 99%: 133 < m_H < 230GeV, 260 < m_H < 437GeV

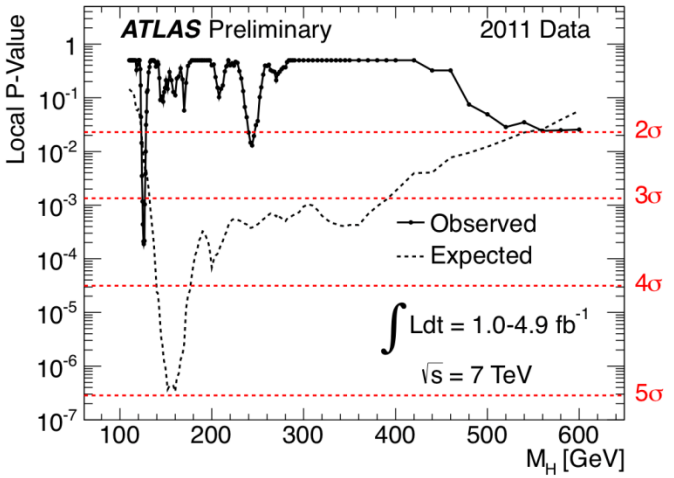
Exclusion (95% CL Limit)



- Observed limit (95%)
  - $112.7 < m_H < 115.5$GeV, $131 < m_H < 453$GeV except for 237-251GeV

Excess at 126GeV

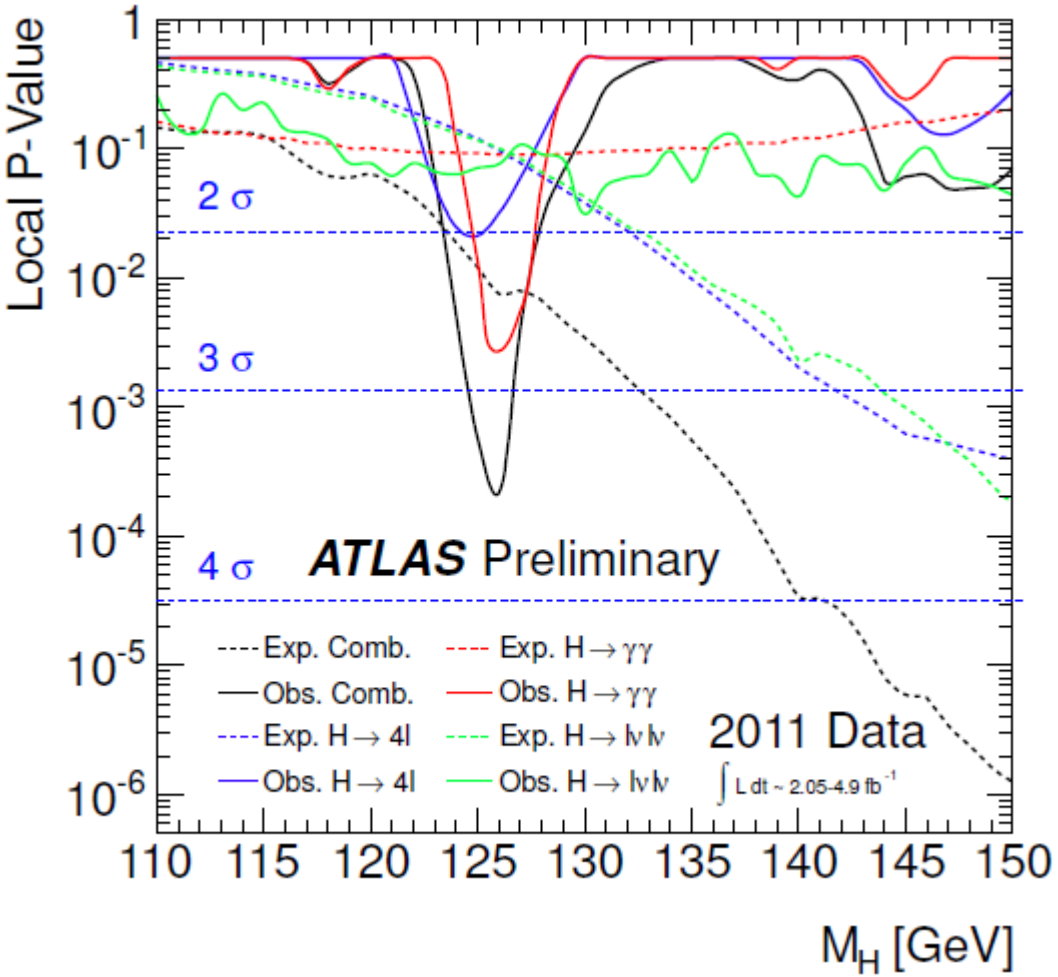




Local p_0-value: 0.019% -> 3.6σ (expected ~2.4σ)
Global p_0-value: 0.6% -> 2.5σ with LEE over 110-146GeV
Global p_0-value: 1.4% -> 2.3σ with LEE over 110-600GeV

LEE=look elsewhere effect (resolutionの良いチャンネルで重要->γγや4l)

Excess at 126GeV

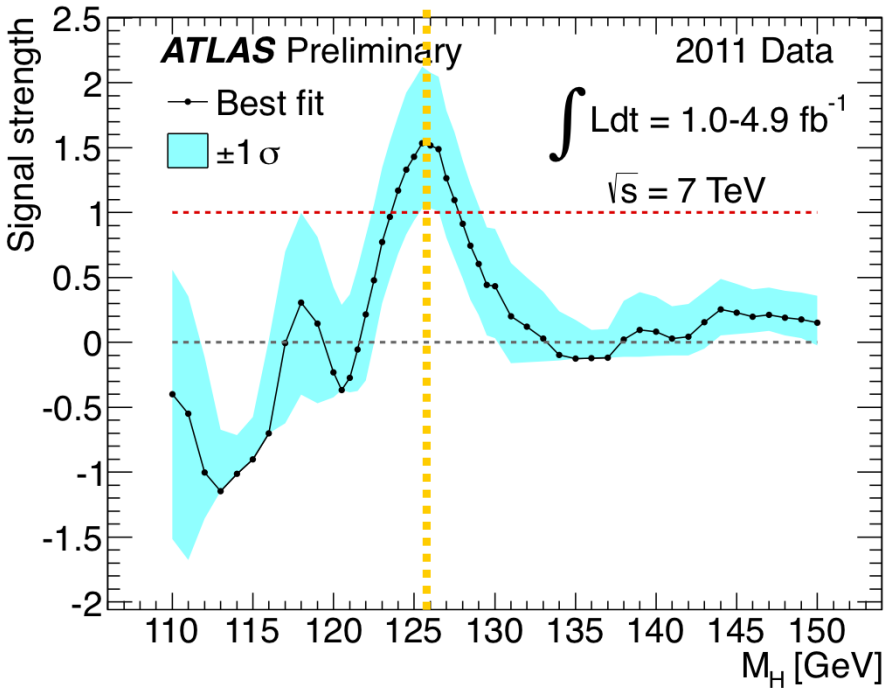


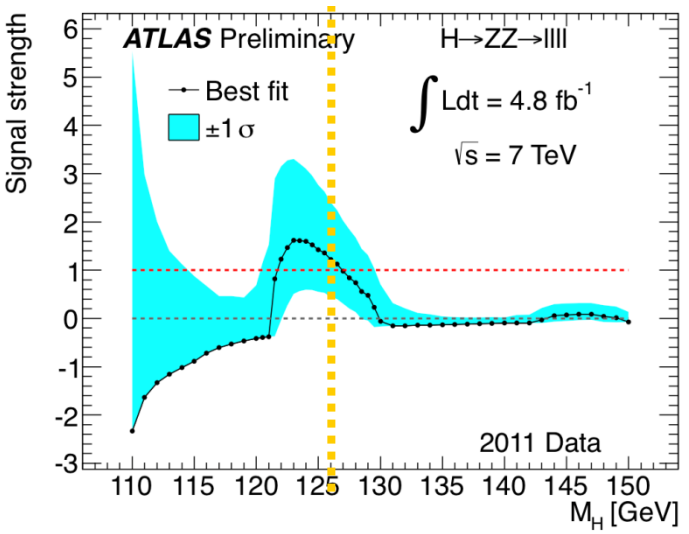
Local p_0-value(126GeV)
- H->γγ 2.8σ
- H->ZZ->4l 2.1σ
- H->WW->lνlν 1.4σ

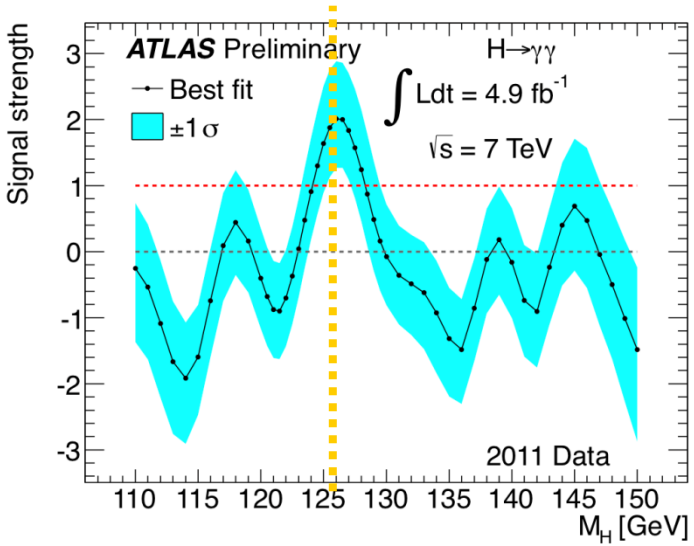
Local p_0-value: 0.019% -> 3.6σ (expected ~2.4σ)
Global p_0-value: 0.6% -> 2.5σ with LEE over 110-146GeV
Global p_0-value: 1.4% -> 2.3σ with LEE over 110-600GeV

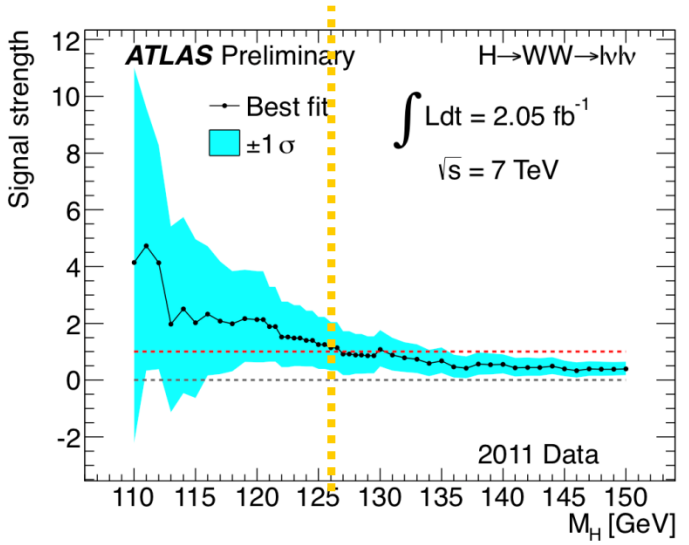
ATLAS combination

SM Higgsに対するBest “μ”



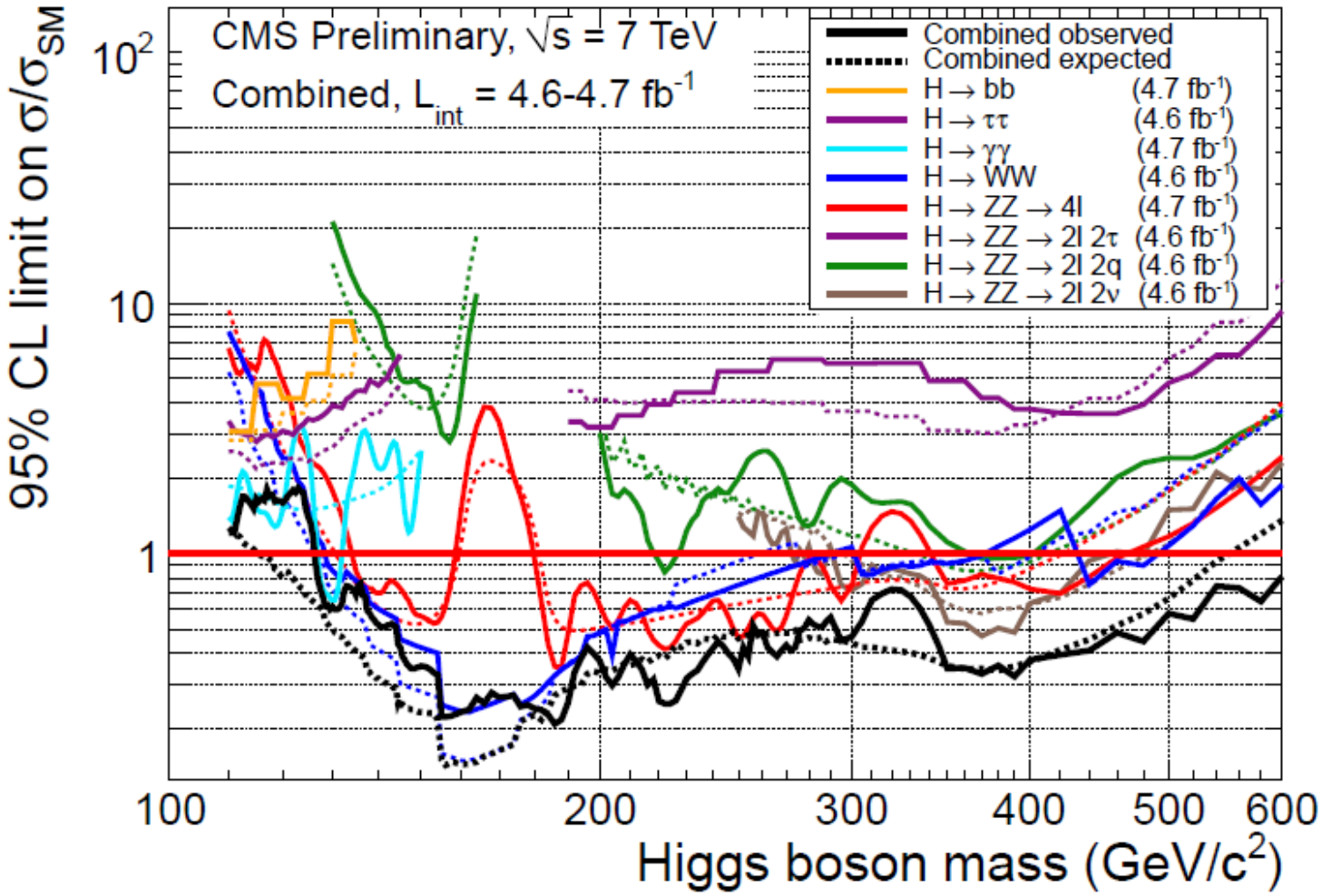






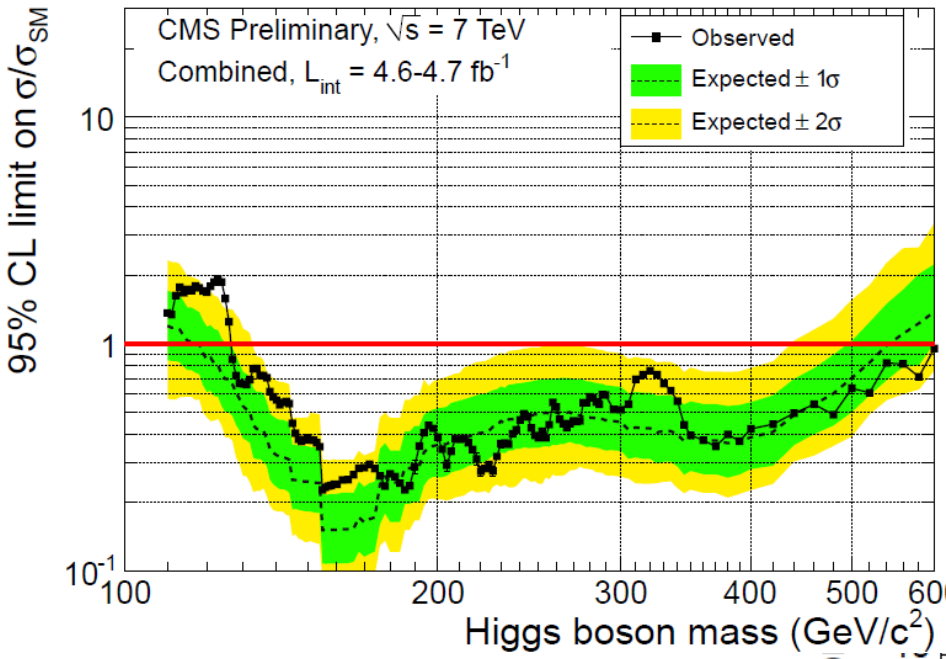
CMS combination

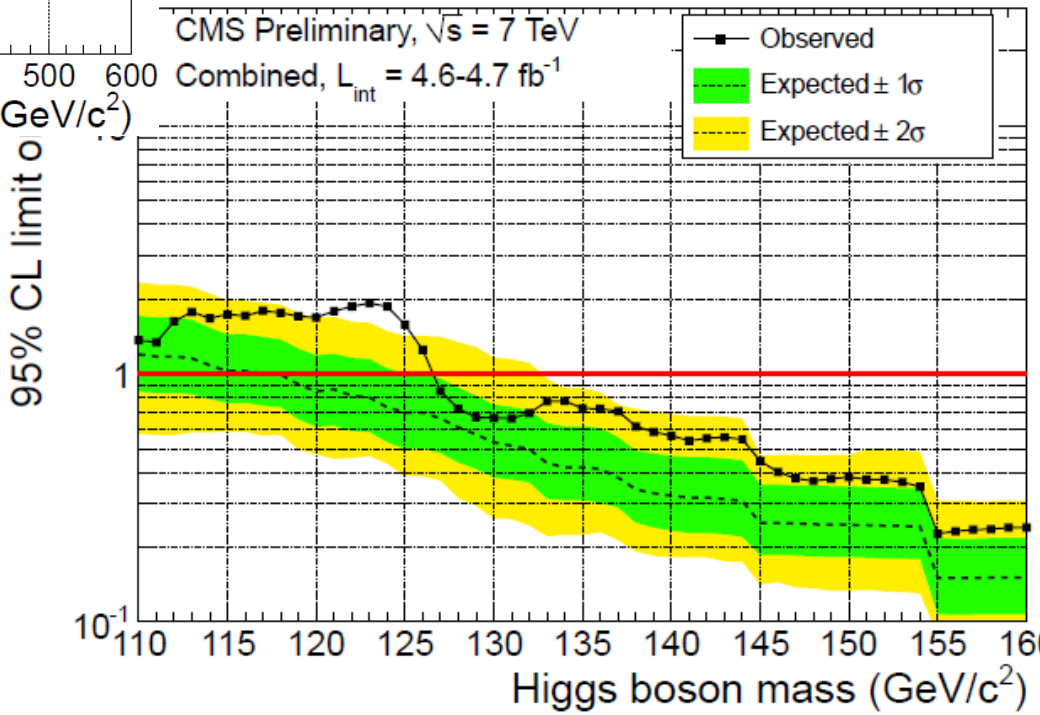
Channel	m_H range (GeV/c^2)	Lumi (fb^{-1})	sub-channels	m_H resolution
$H \to \gamma\gamma$	$110 - 150$	4.7	4	1–3%
$H \to \tau\tau$	$110 - 145$	4.6	9	20%
$H \to bb$	$110 - 135$	4.7	5	10%
$H \to WW \to \ell\nu\ell\nu$	$110 - 600$	4.6	5	20%
$H \to ZZ \to 4\ell$	$110 - 600$	4.7	3	1–2%
$H \to ZZ \to 2\ell 2\tau$	$190 - 600$	4.7	8	10–15%
$H \to ZZ \to 2\ell 2\nu$	$250 - 600$	4.6	2	7%
$H \to ZZ \to 2\ell 2q$	$130 - 164$ and $200 - 600$	4.6	6	3%



CMS combination

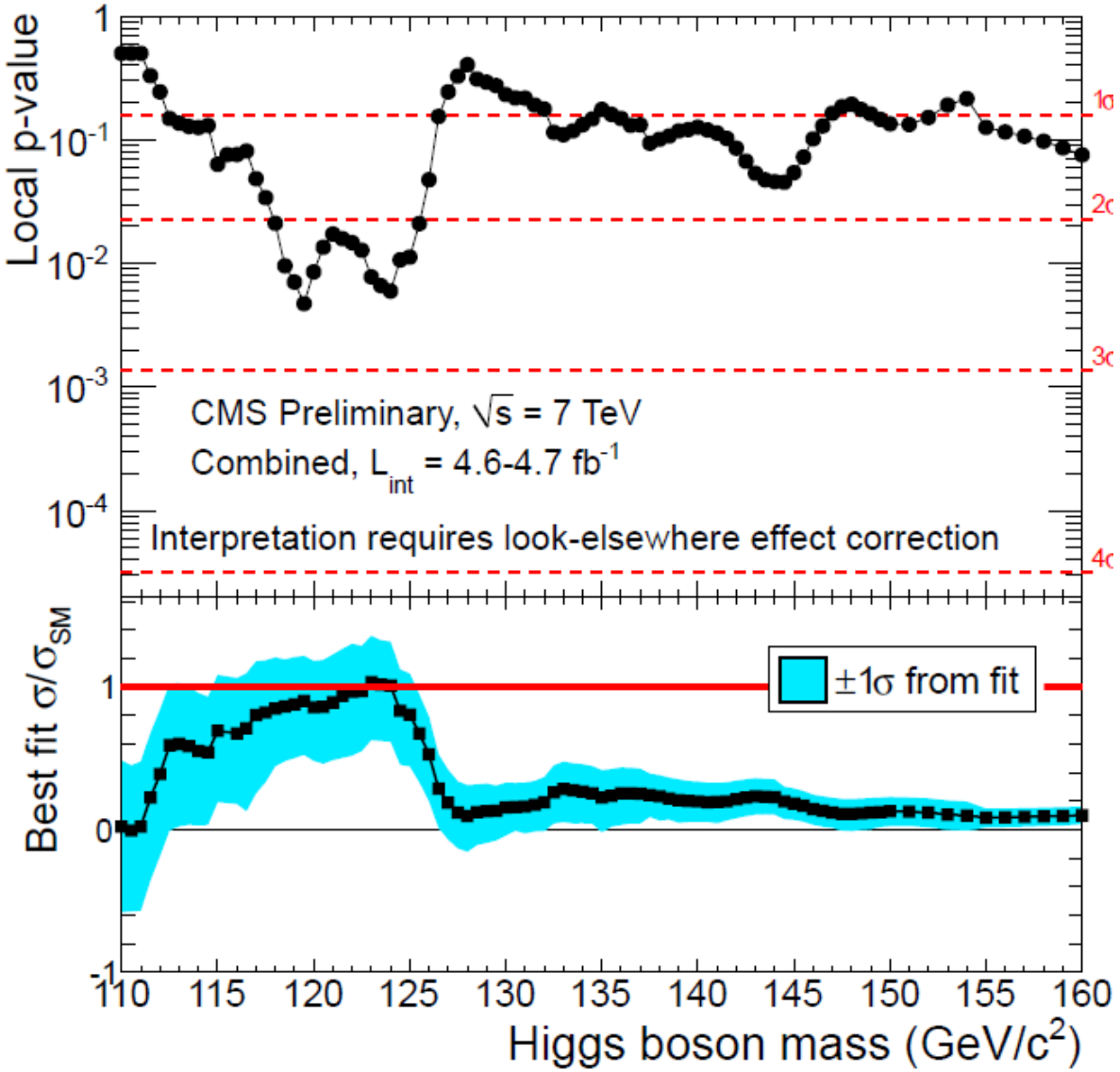
Exclusion (95/99% CL Limit)



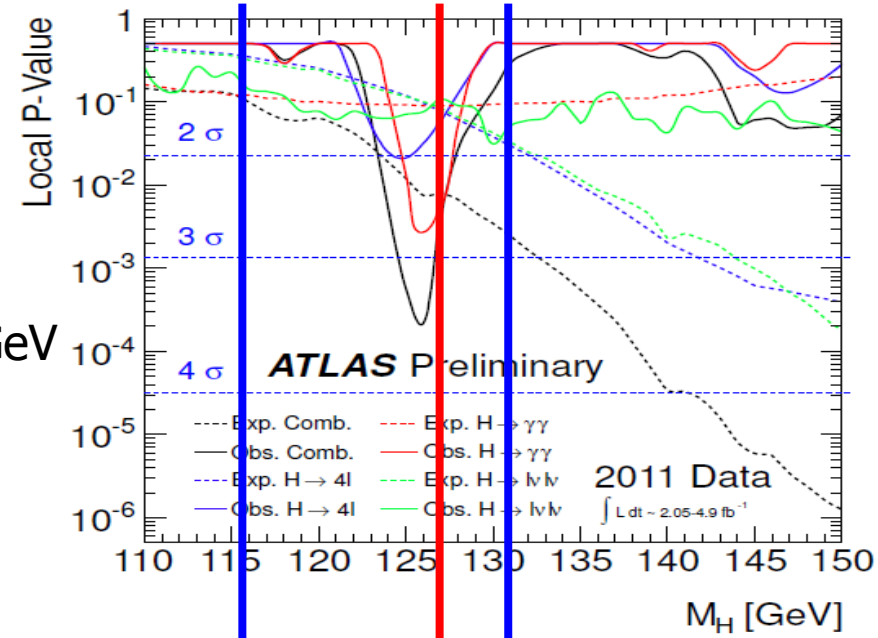


- Expected limit : 117 < m_H < 543GeV
- Observed limit
  - 95%: 127 < m_H < 600GeV
  - 99%: 128 < m_H < 525GeV

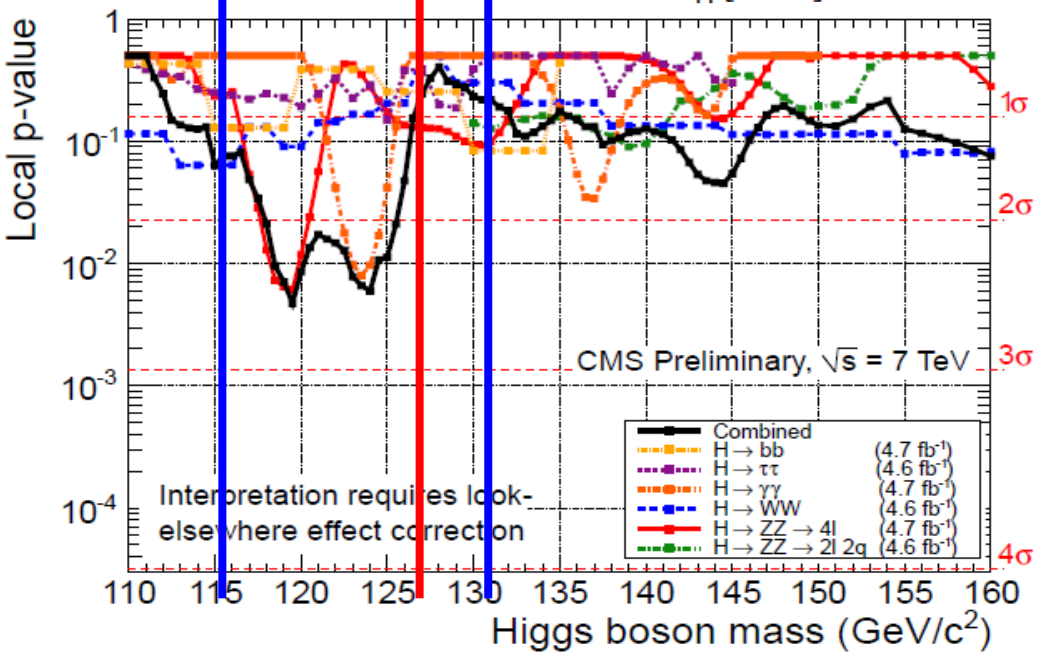
Excess at 119/124GeV



ATLAS
115.5<m_H<131GeV



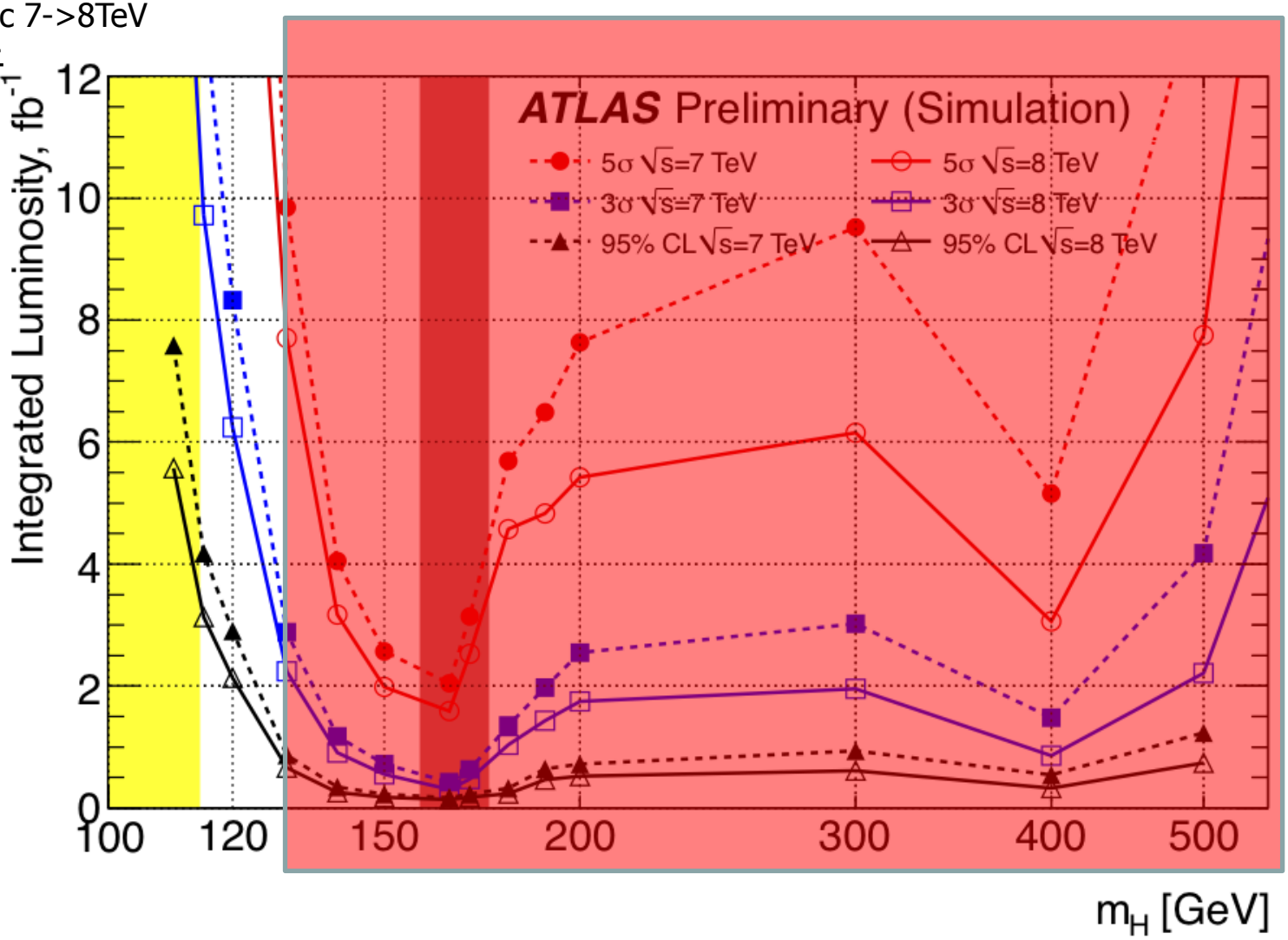
CMS
m_H<127GeV



ATLAS+CMS 115.5<m_H<127GeV (Not combination but just "AND")

来年2012

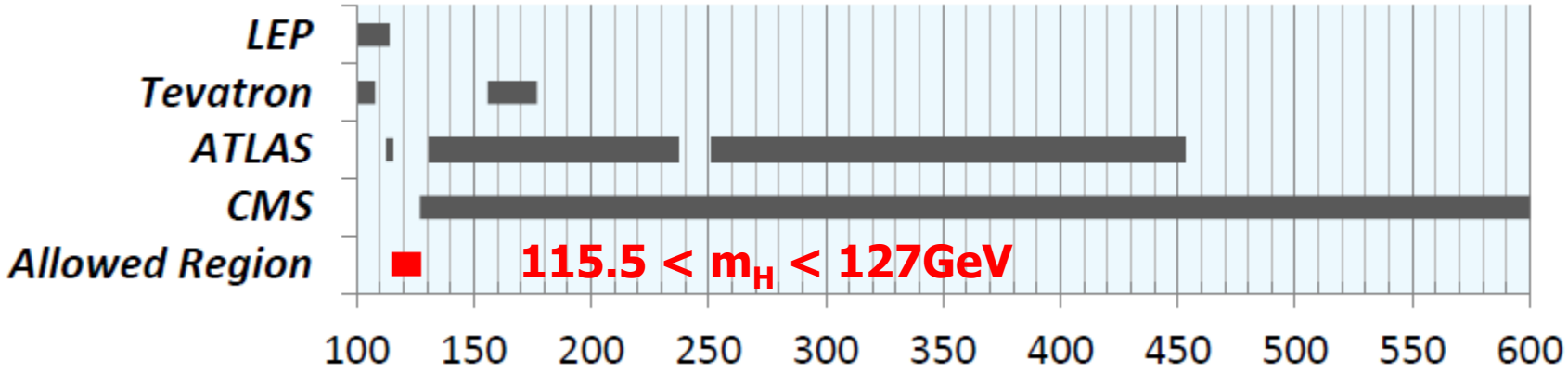
Higgs x-sec 7->8TeV
~30%向上



"Additional 15-20 fb^{-1}" with 8TeV in 2012 per one experiment
-> **Achieve 5σ for 120-130GeV in the next year.**
(or exclude ~125GeV mass point.)
(Achieve 5σ down to 115GeV with ATLAS+CMS in the next year.)

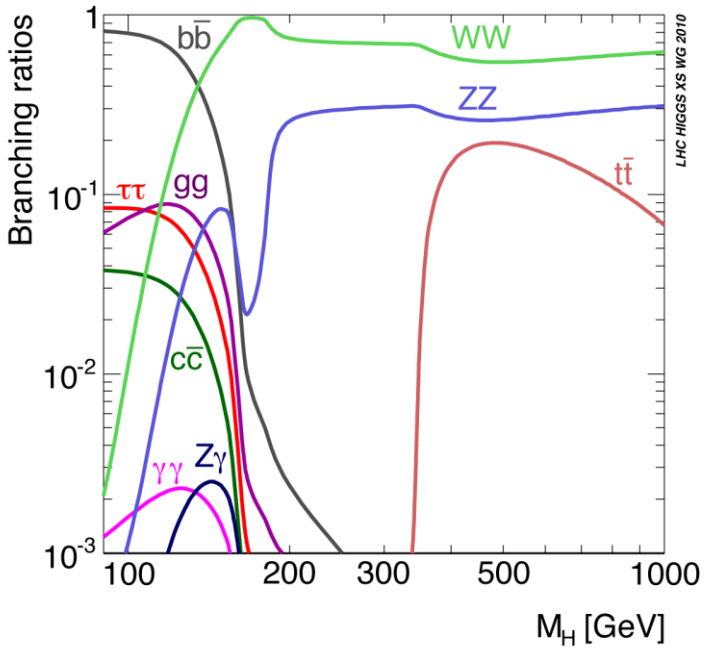
Summary

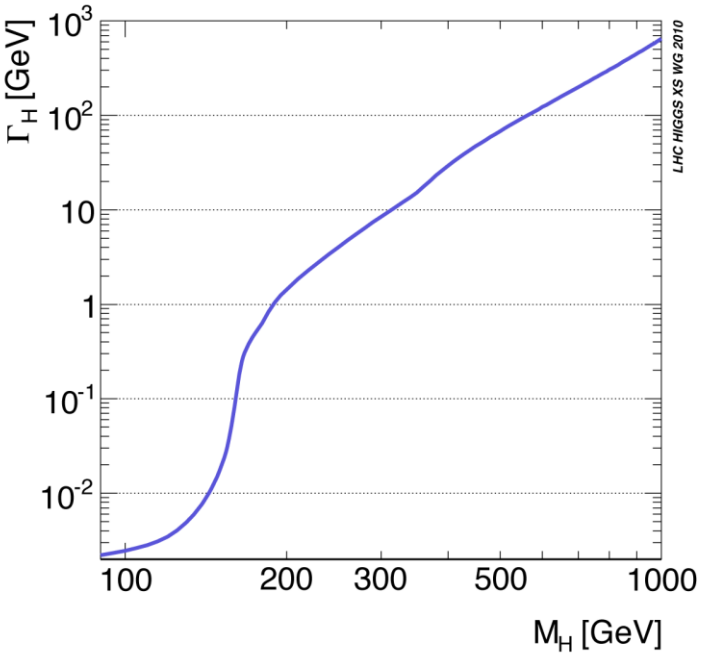
- Higgs search at LHC in this year is very exciting!
  - ATLAS still have several channels ($\tau\tau$/bb etc) to be updated.



- Small excess around 124-126GeV is real? -> "NO" at the moment
  -> Still 2-3 sigma level with the look elsewhere effect.
  -> We need more data in the next year.

Backup


Branching ratios
1
10^{-1}
10^{-2}
10^{-3}
bb̄
WW
ZZ
ττ
gg
tt̄
cc̄
γγ
Zγ
100
200
300
500
1000
M_H [GeV]
LHC HIGGS XS WG 2010

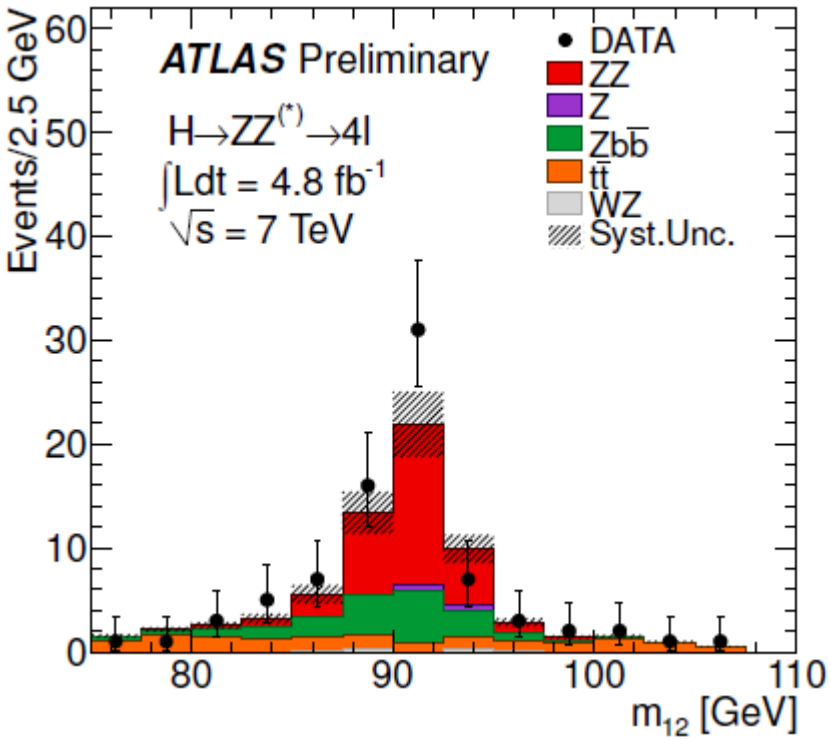

Γ_H [GeV]
10^3
10^2
10
1
10^{-1}
10^{-2}
100
200
300
500
1000
M_H [GeV]
LHC HIGGS XS WG 2010

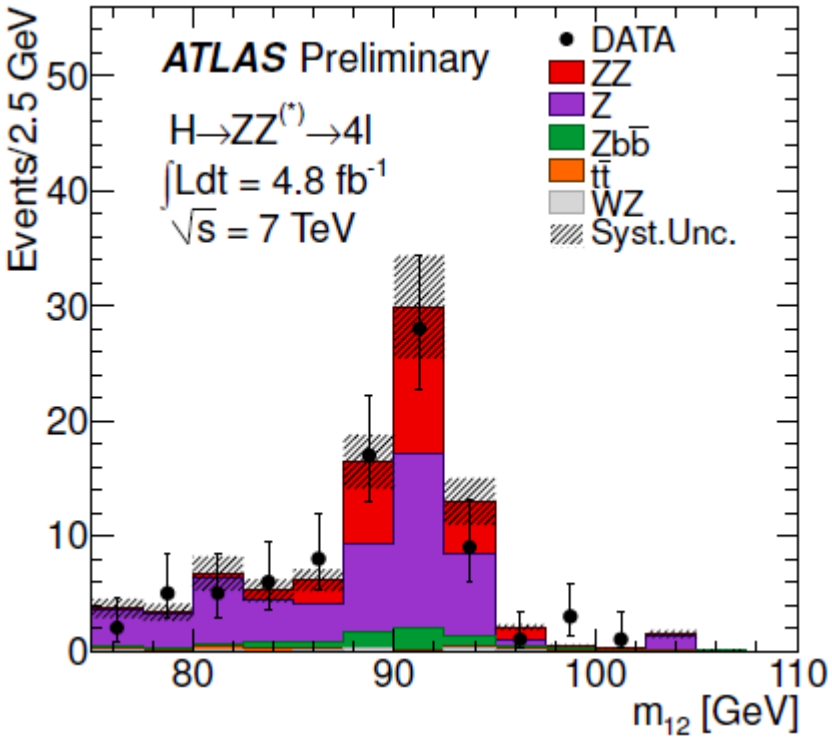
WW analysis, Control regions

Control Regions	Signal	WW	$W+$jets	Z/γ^*+jets	$t\bar{t}$	$tW/tb/tqb$	$WZ/ZZ/W\gamma$	Total Bkg.	Observed
WW 0-jet ($m_H < 220$ GeV)	1.7 ± 0.4	223 ± 30	20 ± 15	6 ± 8	25 ± 10	15 ± 4	8 ± 3	296 ± 36	296
WW 0-jet ($m_H \geq 220$ GeV)	10 ± 2	173 ± 23	24 ± 12	13 ± 19	15 ± 6	8 ± 3	3.3 ± 0.6	236 ± 33	258
WW 1-jet ($m_H < 220$ GeV)	1.0 ± 0.3	76 ± 13	5 ± 3	5 ± 5	56 ± 14	23 ± 5	5.3 ± 1.4	171 ± 21	184
WW 1-jet ($m_H \geq 220$ GeV)	5.8 ± 1.5	51 ± 9	3.9 ± 1.8	10 ± 10	35 ± 9	18 ± 4	2.8 ± 0.6	120 ± 17	129
$t\bar{t}$ 1-jet	0.9 ± 0.3	3.9 ± 1.0	-	1 ± 17	184 ± 64	80 ± 19	0.2 ± 0.9	270 ± 69	249

WW control regions
- drop mT and $\Delta\phi$(ll) cuts
- m(ll)>80GeV for m_H<220GeV
- m(ll)>180GeV or 15<m(ll)<80GeV for m_H>220GeV

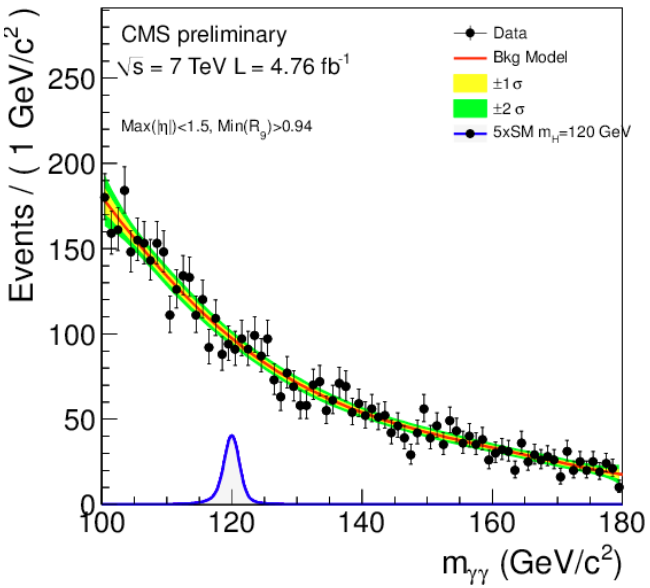
tt for 1-jet analysis control region
- drop m_T, m(ll) and $\Delta\phi$(ll) cuts
- b-jet tag

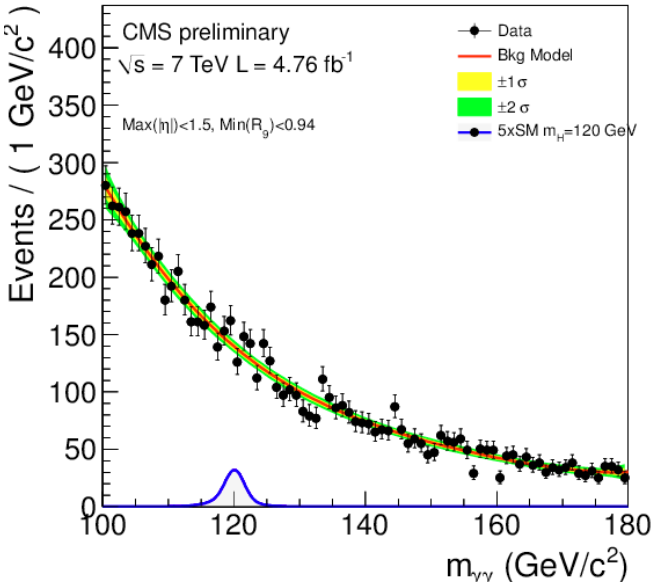

ATLAS Preliminary
H→ZZ(*)→4l
∫Ldt = 4.8 fb-1
√s = 7 TeV
DATA
ZZ
Z
Zbb̄
tt̄
WZ
Syst.Unc.
Events/2.5 GeV
m12 [GeV]


ATLAS Preliminary
H→ZZ(*)→4l
∫Ldt = 4.8 fb-1
√s = 7 TeV
DATA
ZZ
Z
Zbb̄
tt̄
WZ
Syst.Unc.
Events/2.5 GeV
m12 [GeV]

m_H [GeV]	110	115	120	125	130	135	140	145	150
CP1: Unconverted central, low p_{Tt}	8.9	8.9	8.7	8.2	7.5	6.7	5.7	4.6	3.5
CP2: Unconverted central, high p_{Tt}	2.5	2.6	2.6	2.5	2.3	2.1	1.8	1.5	1.2
CP3: Unconverted rest, low p_{Tt}	16.3	16.7	16.6	16.0	15.0	13.6	11.9	9.8	7.4
CP4: Unconverted rest, high p_{Tt}	4.4	4.6	4.6	4.5	4.3	4.0	3.5	2.9	2.2
CP5: Converted central, low p_{Tt}	5.9	5.9	5.8	5.5	5.1	4.6	4.0	3.3	2.4
CP6: Converted central, high p_{Tt}	1.6	1.7	1.6	1.6	1.6	1.4	1.3	1.1	0.8
CP7: Converted rest, low p_{Tt}	17.5	18.1	17.9	17.1	15.8	14.1	12.0	9.7	7.2
CP8: Converted rest, high p_{Tt}	4.6	4.7	4.7	4.6	4.4	4.1	3.6	2.9	2.2
CP9: Converted transition	8.2	8.4	8.4	8.1	7.6	6.9	6.0	4.9	3.7
Total	69.9	71.5	70.9	68.3	63.7	57.5	49.8	40.8	30.6

CMS H->γγ


CMS preliminary
√s = 7 TeV L = 4.76 fb-1
Max(|η|)<1.5, Min(R9)>0.94
Data
Bkg Model
±1σ
±2σ
5xSM mH=120 GeV
Events / (1 GeV/c2)
mγγ (GeV/c2)


CMS preliminary
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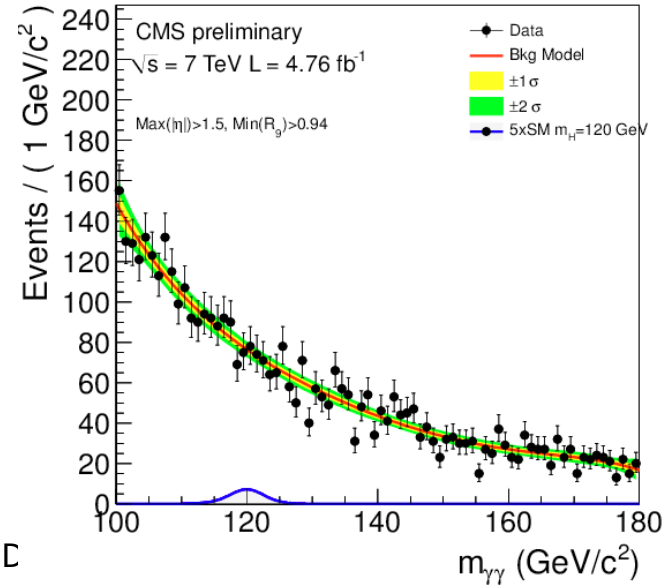
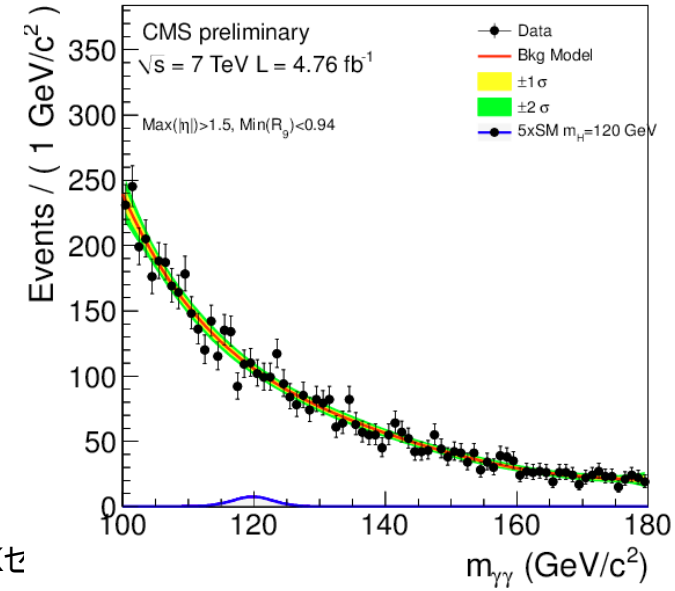
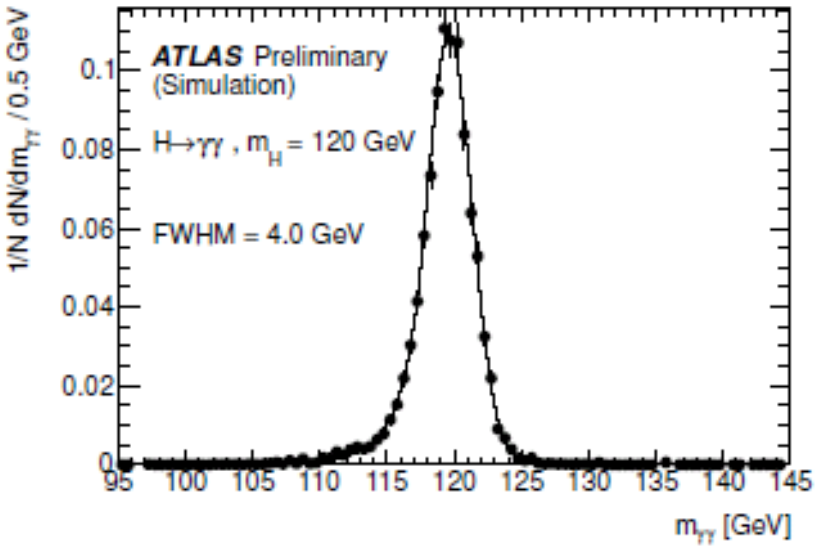
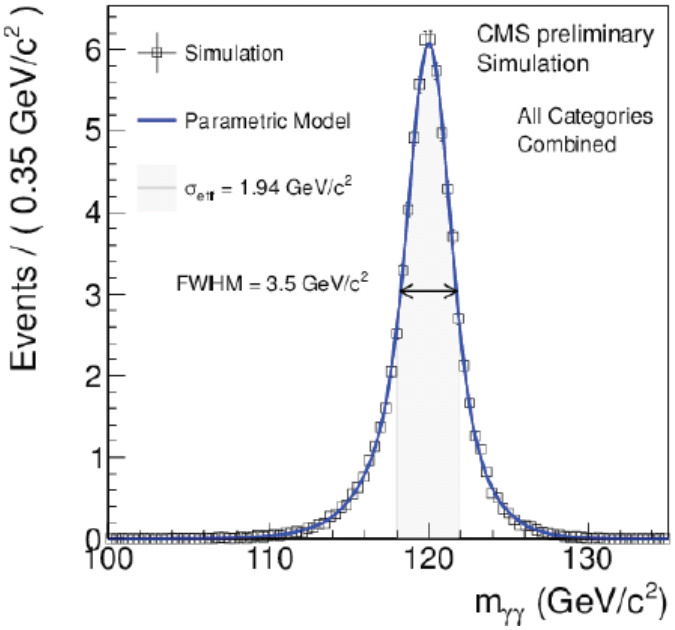
Max(|η|)<1.5, Min(R9)<0.94
Data
Bkg Model
±1σ
±2σ
5xSM mH=120 GeV
Events / (1 GeV/c2)
mγγ (GeV/c2)

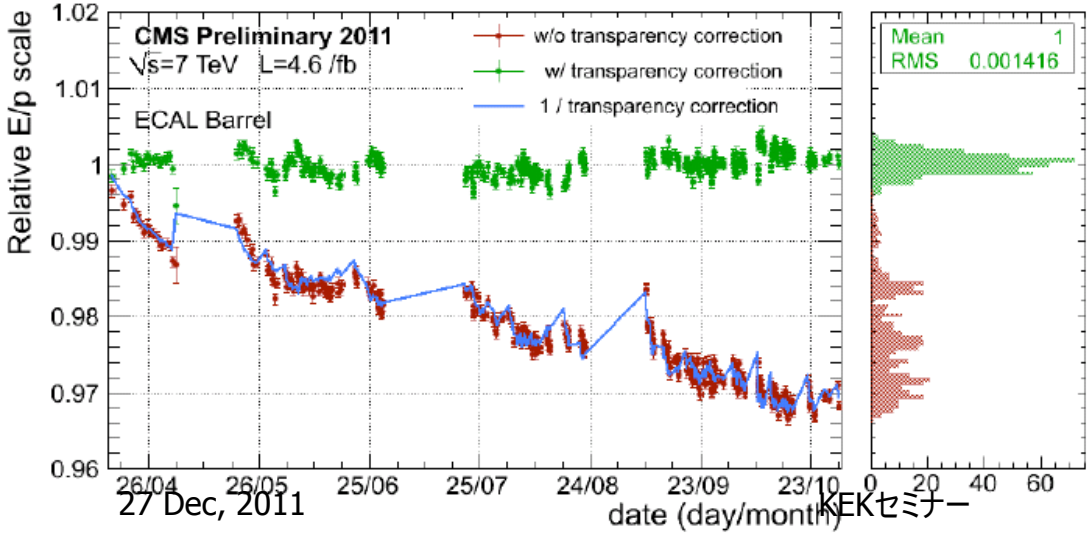

CMS preliminary
√s = 7 TeV L = 4.76 fb-1
Max(|η|)>1.5, Min(R9)>0.94
Data
Bkg Model
±1σ
±2σ
5xSM mH=120 GeV
Events / (1 GeV/c2)
mγγ (GeV/c2)


CMS preliminary
√s = 7 TeV L = 4.76 fb-1
Max(|η|)>1.5, Min(R9)<0.94
Data
Bkg Model
±1σ
±2σ
5xSM mH=120 GeV
Events / (1 GeV/c2)
mγγ (GeV/c2)

ATLAS vs CMS





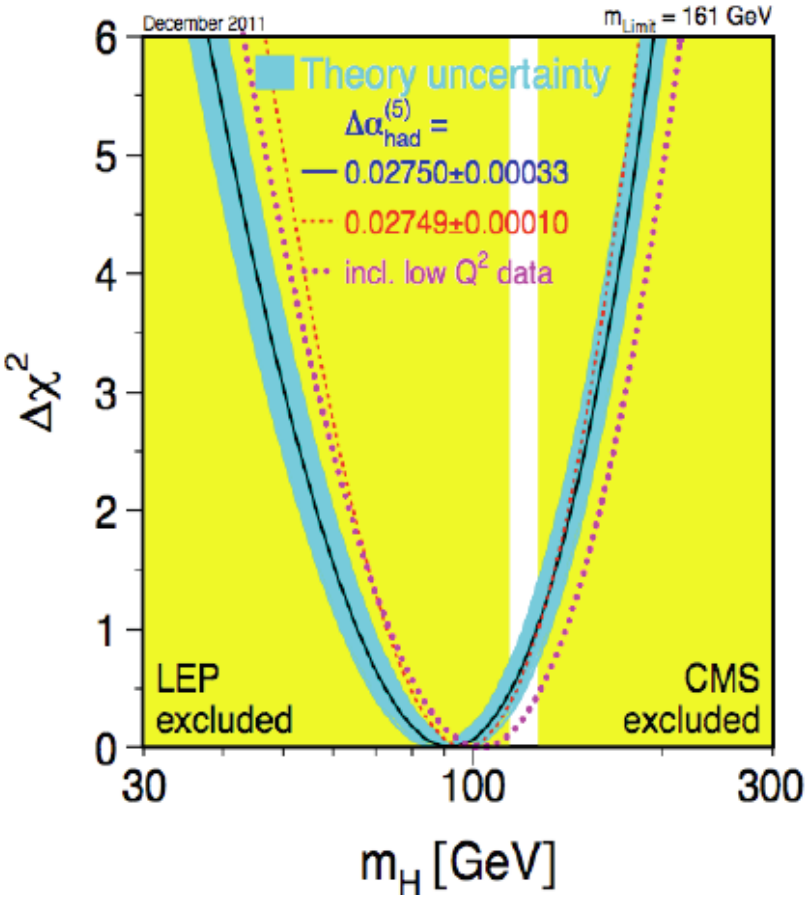


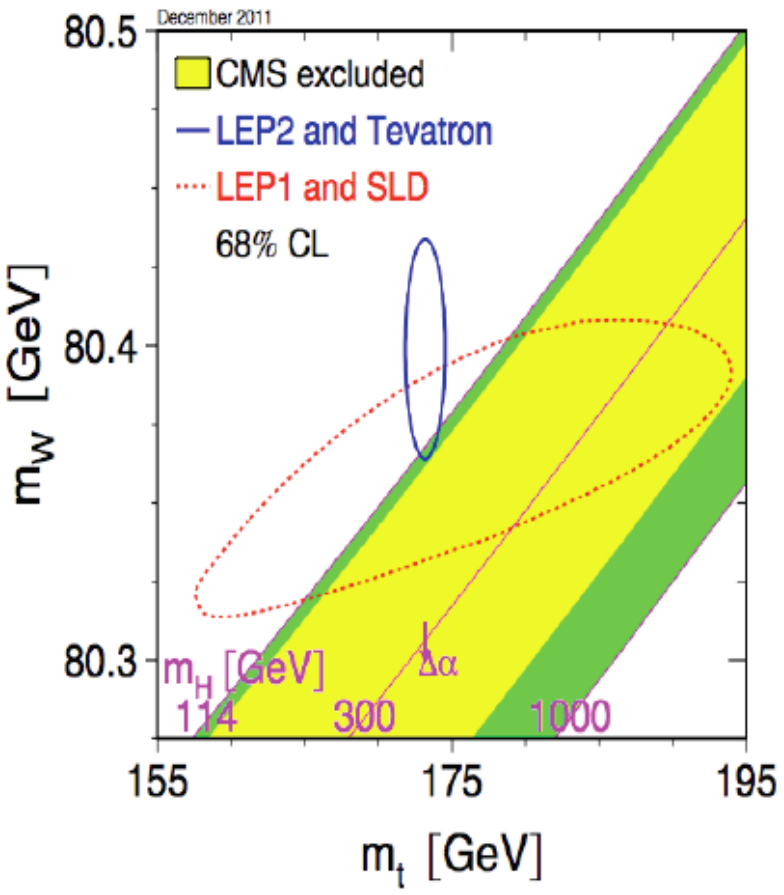
FWHM 4.35GeV => 3.5GeV
(20% improvement!)

- How to take into account LLE
  - $p_{global} = p_{local} + N \exp(-(Z^2-Z_0^2)/2)$

CMSの図ですが。

Standard Model





- Still allowed low mass region
  - ATLAS: 115.5<m_H<131GeV
  - CMS: m_H<127GeV

-> **ATLAS+CMS 115.5<m_H<127GeV (Not combination but just "AND")**