

主に ATLAS実験で測定した 2011年の物理結果 ~~review~~

2011年のデータ取得状況
~ event pileupの影響

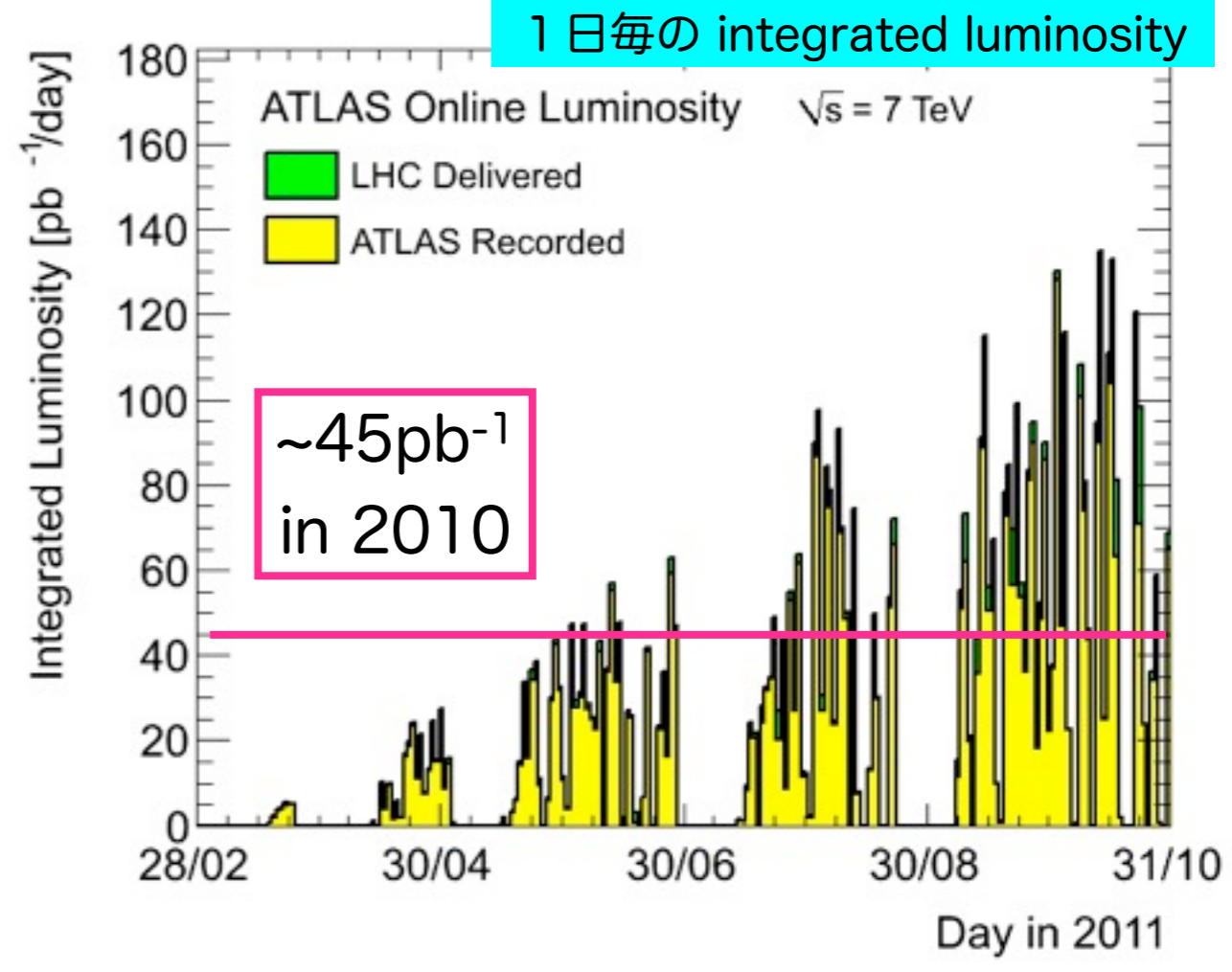
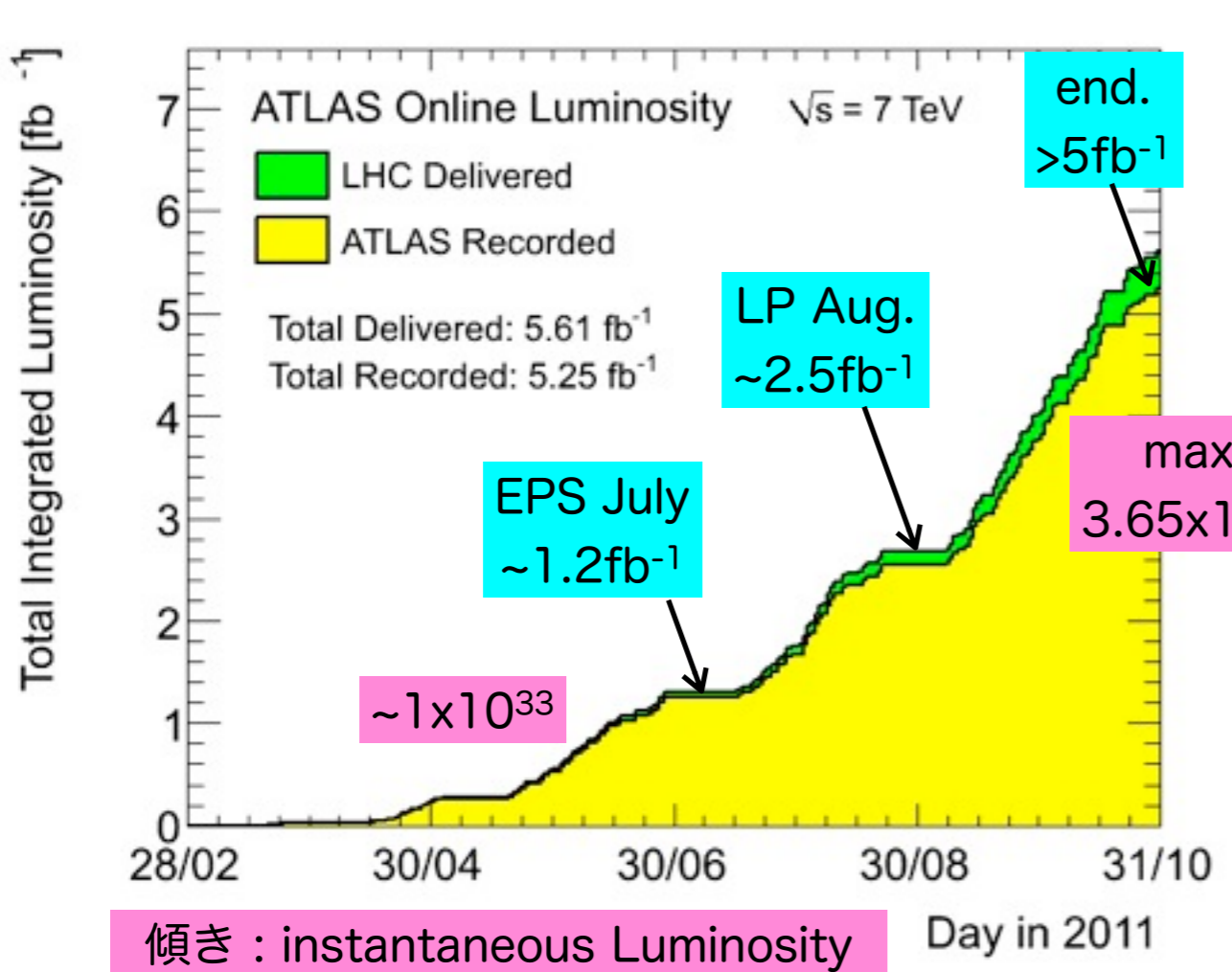
Higgs

2012 & beyond

2012.01.25 京大素粒子論セミナー

石野 雅也 (京大・高工ネ)

2011年のデータ取得状況



傾き : instantaneous Luminosity

黄色と緑の差 -> Data Taking efficiency : $\sim 93.5\%$

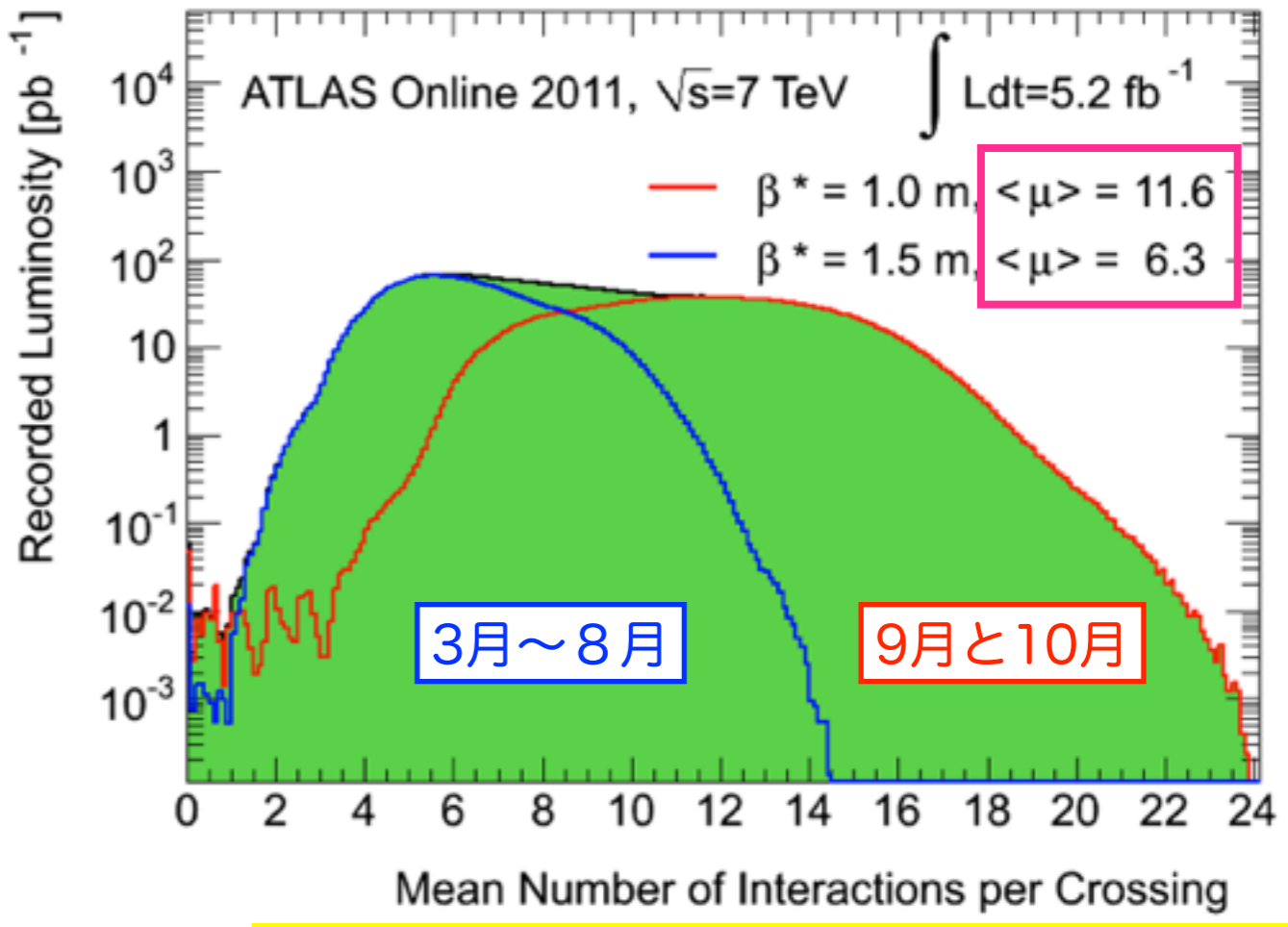
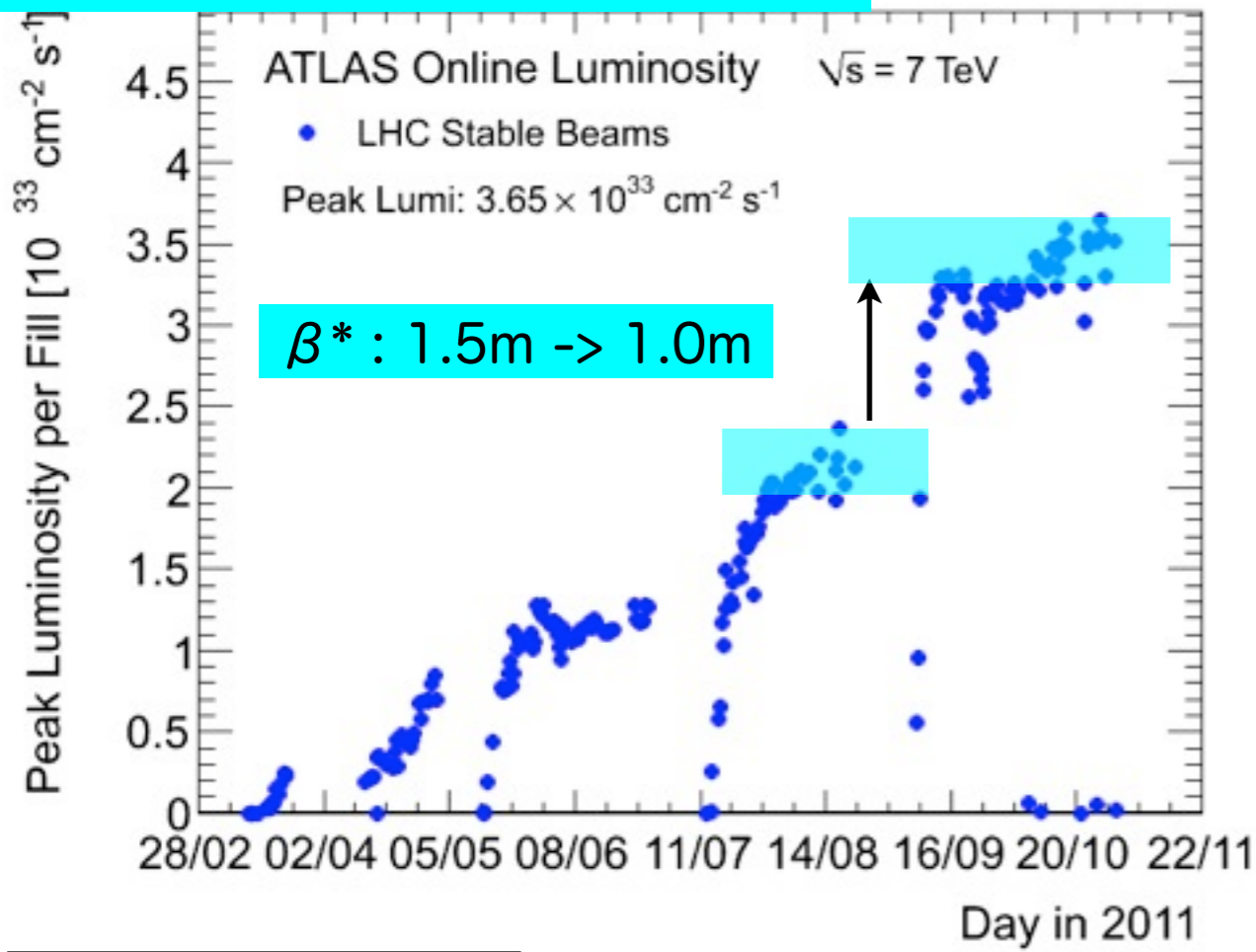
Detector : よく動いていた ($97.5\% \sim 100\%$) : 穴は小さい

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

イベントパイラアップ

of interactions per crossing

その日の max. 瞬間ルミノシティ: L



1秒間に何周?
11253Hz

1周に
何バンチ?

1バンチに陽子が
いくつ含まれる?

青・赤、データ量は ~等量
後半：パイラアップ効果の理解重要

$$L = \frac{f_{rev} \cdot n_b \cdot N_b^2 \cdot \gamma_r}{4\pi \cdot \epsilon_n \cdot \beta^*} \cdot F$$

(F ~ 0.941)

2800 : 8m間隔 ref : 1.05

$$\frac{11253\text{Hz} \cdot 1400 \cdot (1.4 \times 10^{11})^2 \cdot (3500/0.938)}{4\pi \cdot 2\mu\text{m} \cdot 1.5\text{m}} \cdot 0.941$$

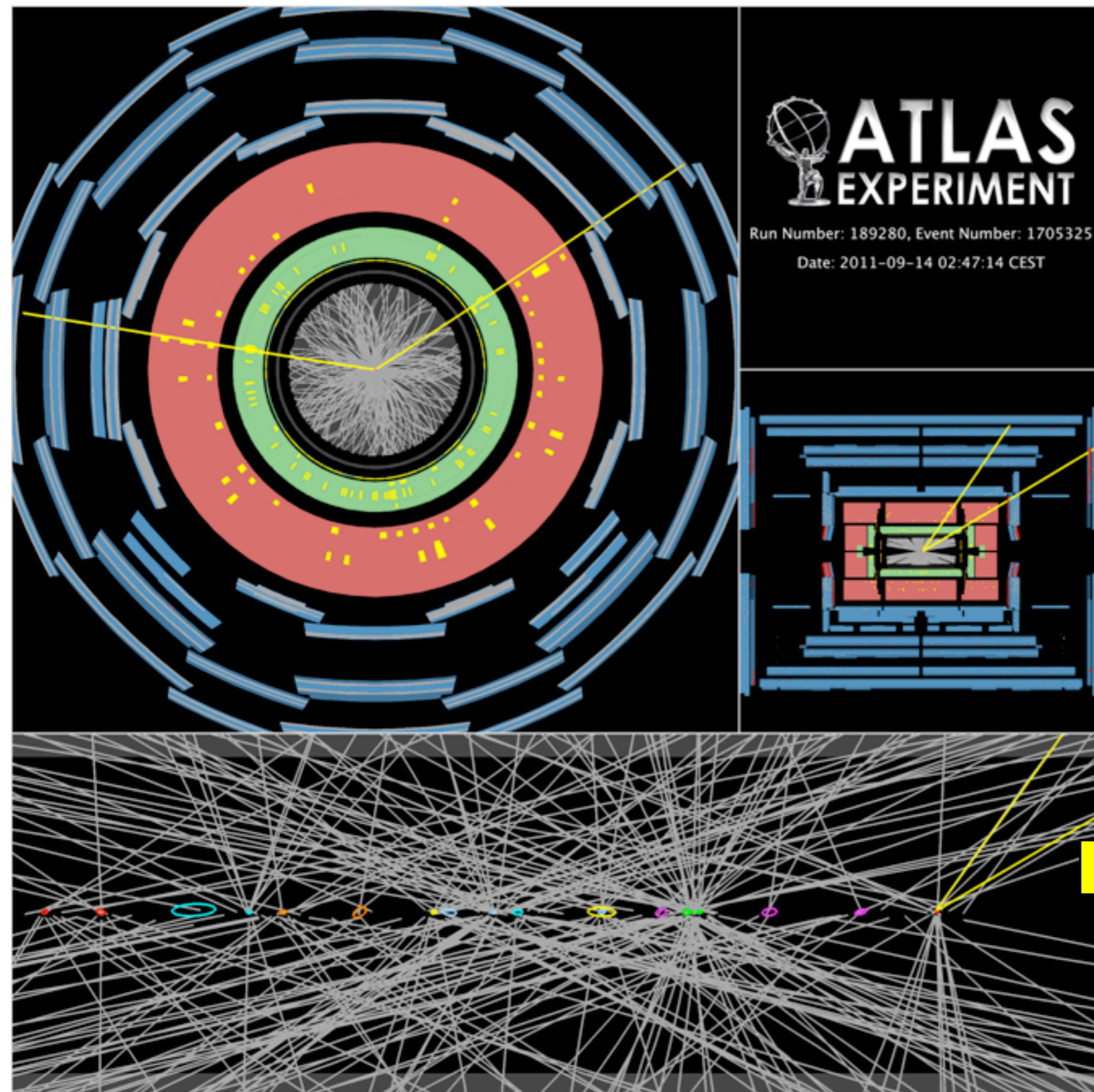
~ 2.6x10³³cm⁻²s⁻¹
の時のパラメーター

2m -> 1.5m -> 1.0m (-> 0.55m)

並行性が高く細いビーム

ビームの衝突点で
どれだけバンチを小さくしぼれるか?

$Z \rightarrow \mu^+ \mu^-$ with 20 reco. vertices

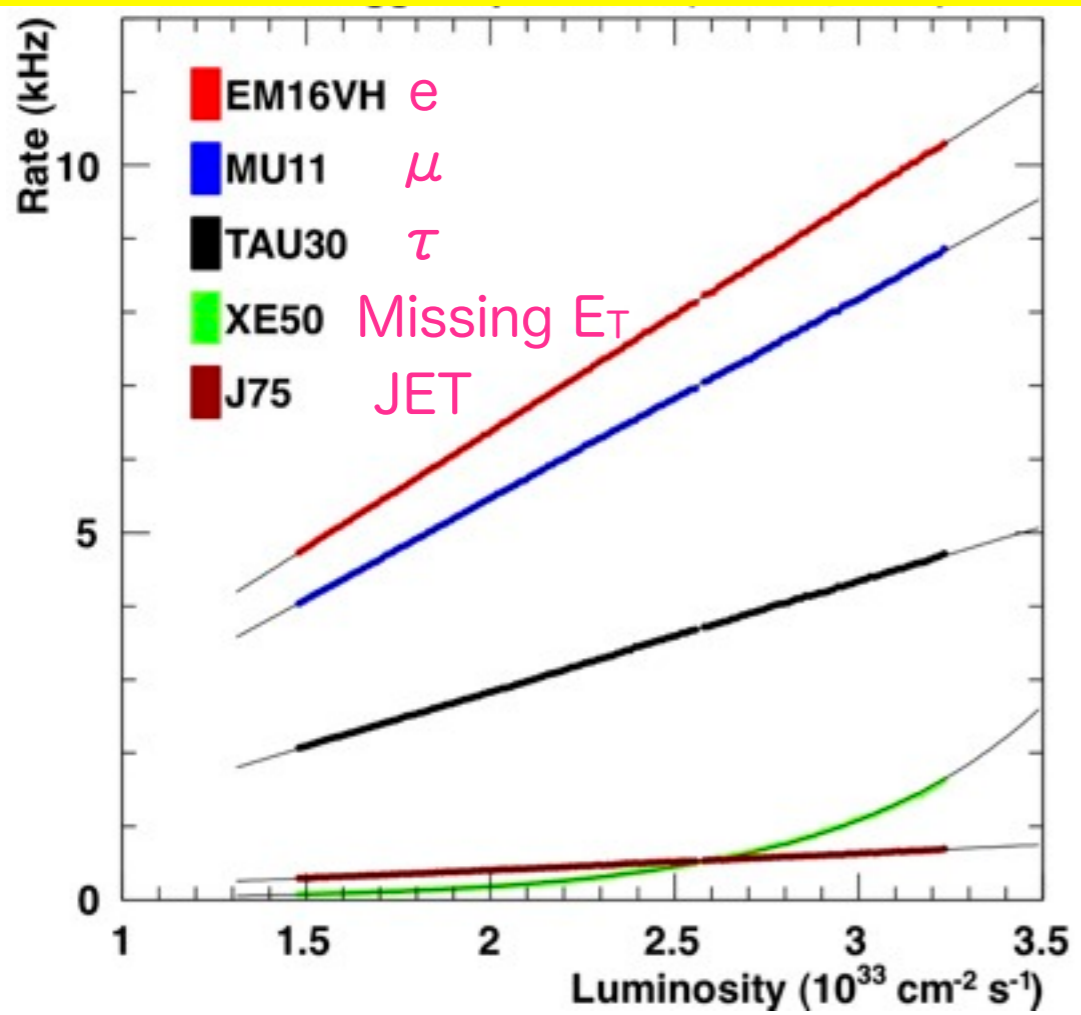


イベントに含まれる $P_T > 400 \text{ MeV}$ のトラックを表示。(i.e. ソレ以下の有象無象はもっともっとも多い)

$Z \rightarrow \mu\mu$

楕円は再構成したVertexの不定性を（見えるように）20倍に拡大して表示

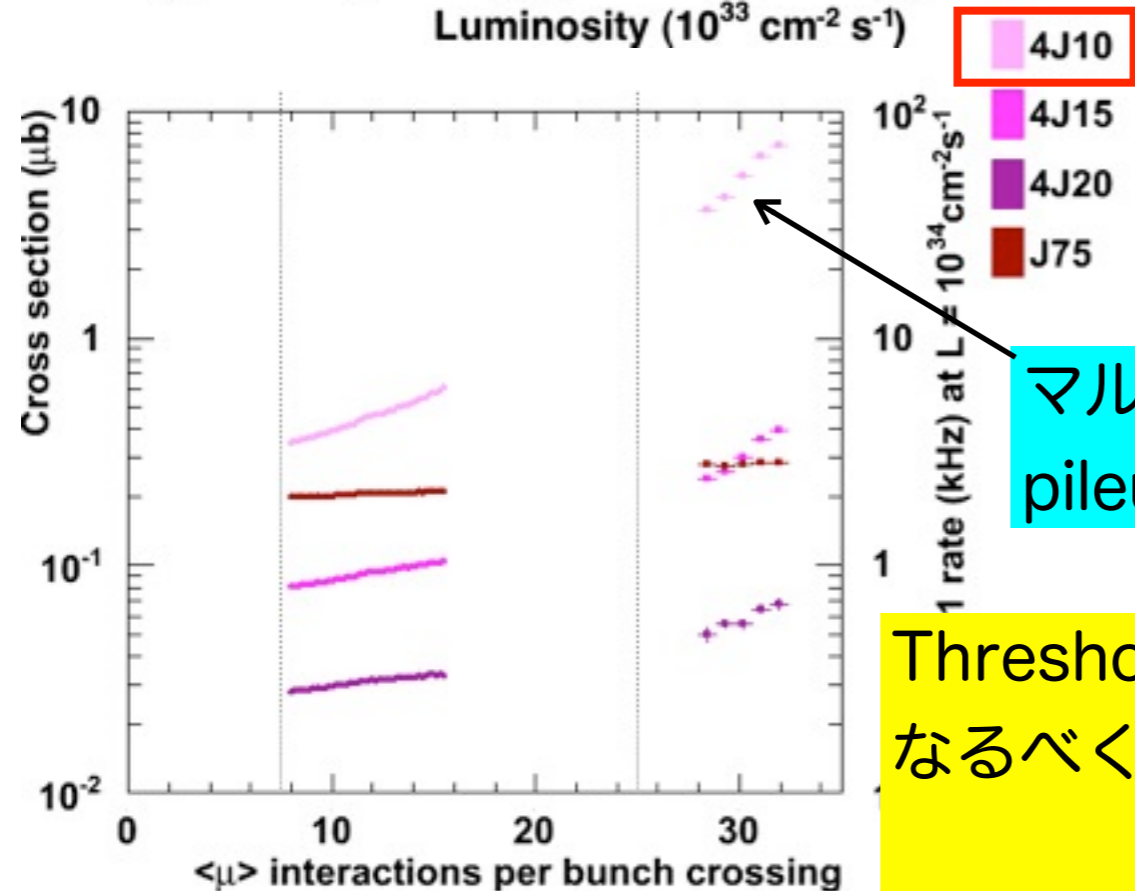
event pileup : シンドイ？



レベル1トリガーのレート
 2.5 μ s以内に答えを出す、電子回路トリガー、
 i.e. 複雑な判断は不可能

シグナル・通常含むバックグラウンドとも Lumi
 に比例して増えるのはよいが、XE50 はちがう
 << パイルアップの悪影響

Missing E_T trigger :
 Threshold @ 50GeV

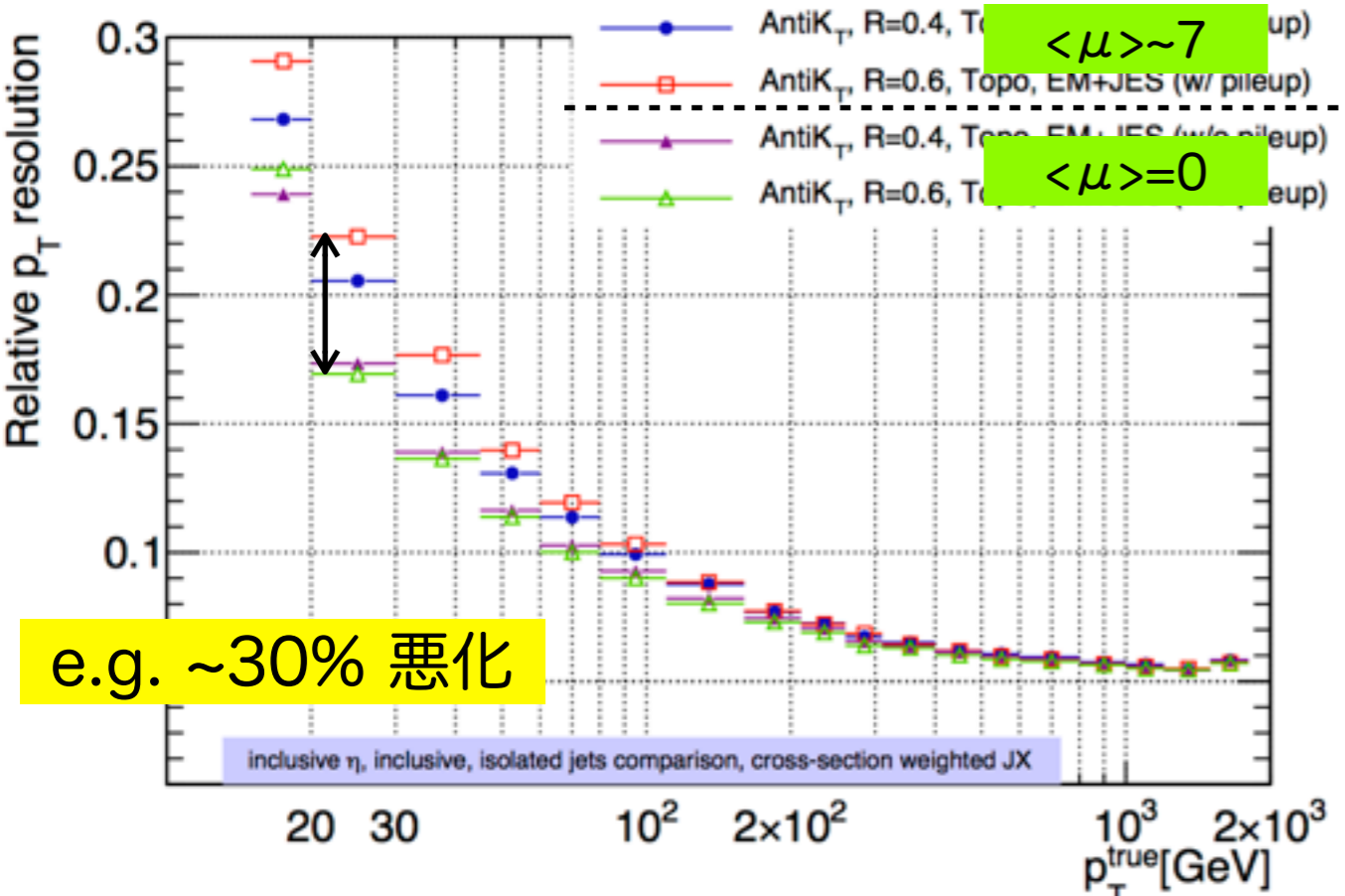


マルチJETトリガーも event
 pileup に対して弱い

Threshold の上昇 : シグナル efficiency を失う
 なるべく避ける : よいアルゴリズム・combined トリガー
 実験的なチャレンジ

event pileup もう1枚 ~ Jet

JET energy resolution $\langle \mu \rangle = 0$ or 7



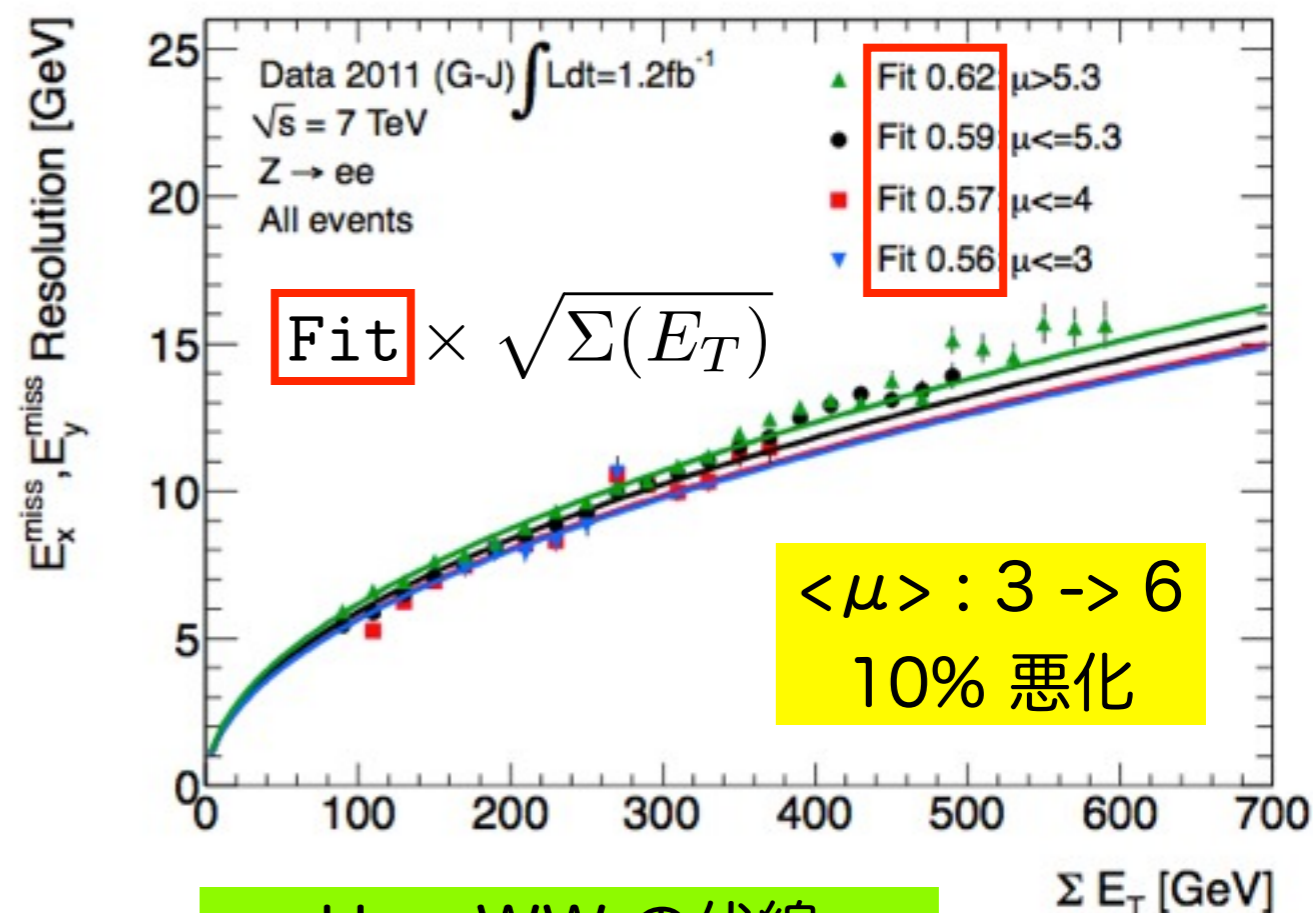
no pileup だと 赤(0.6)は 青(0.4) より良いが
pileupが大きくなると 紫(0.4) が 緑(0.6)
より、わずかに良いアルゴリズムになる

(0.4 , 0.6 : jetを定義する際の cone size)

$$\sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}$$

JETと無関係の track の混ざりこみによる悪化
(0.6 の方が悪くなりやすい)

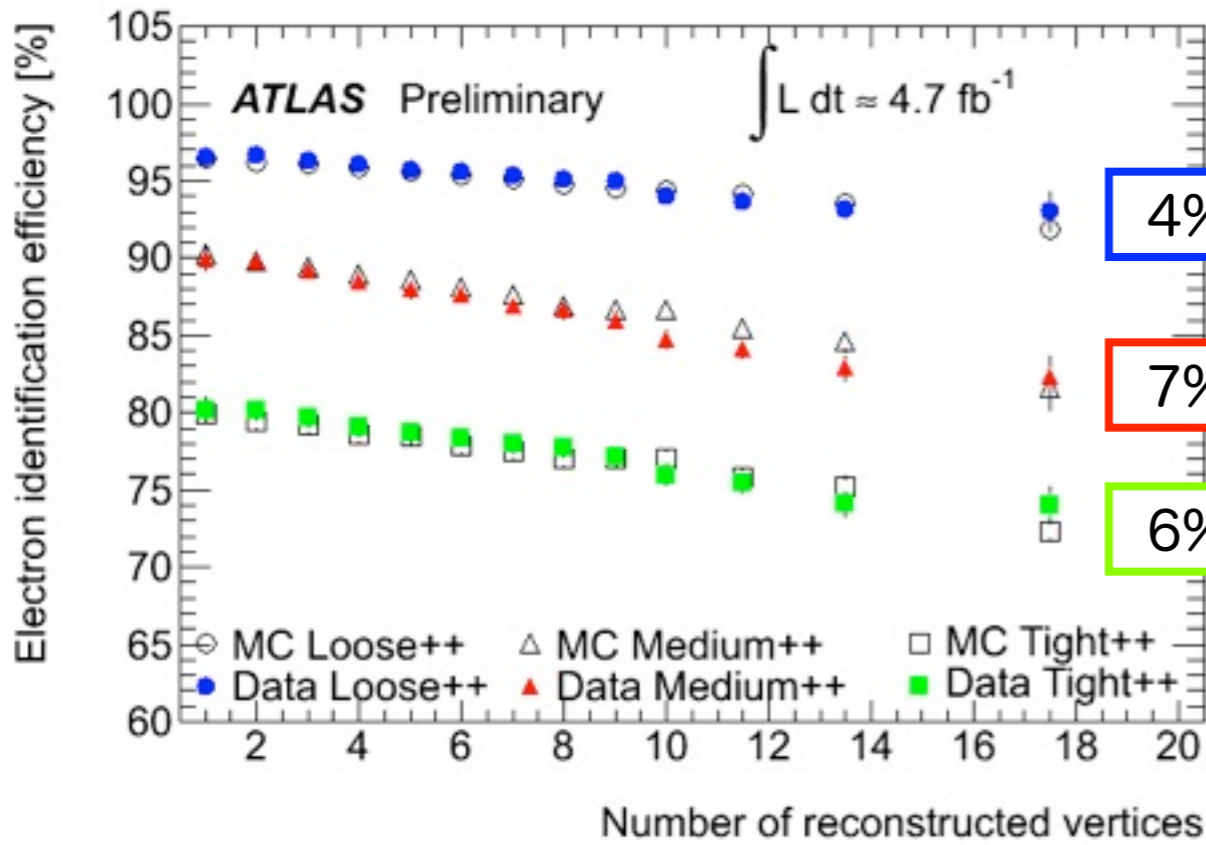
Missing ET (ν) resolution



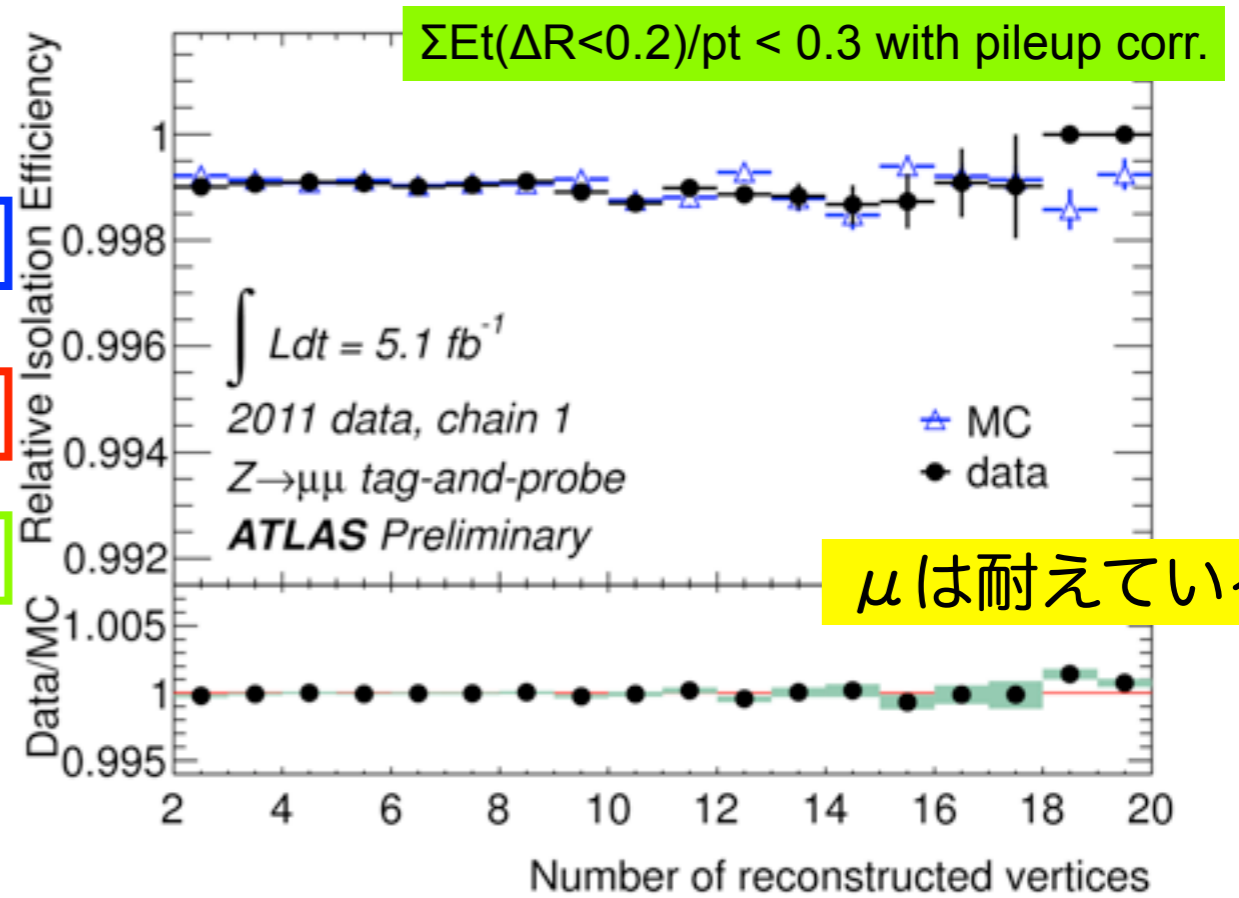
H -> WW の伏線

event pileup 最後1枚 ~ lepton ID

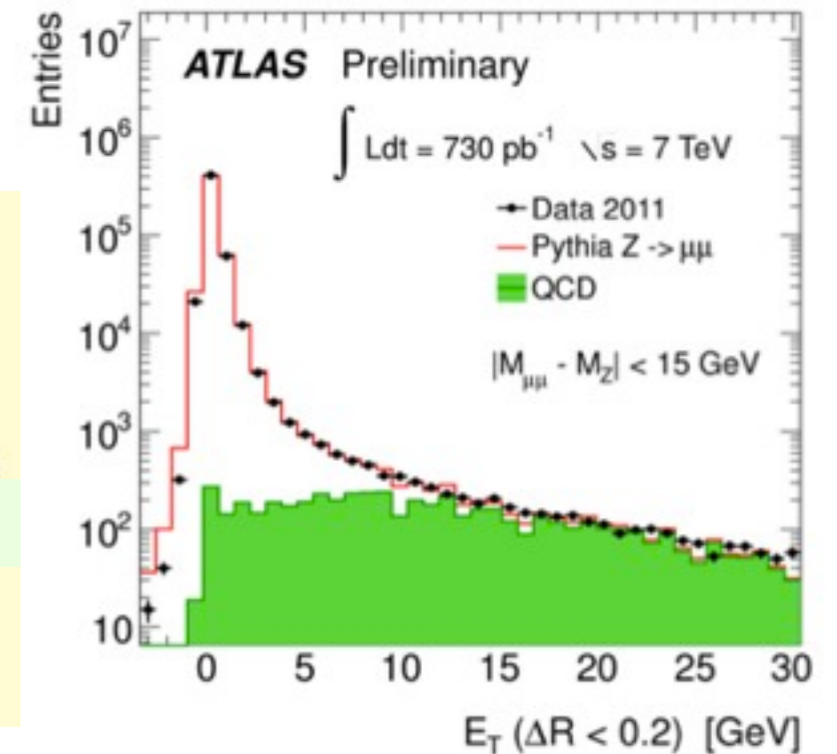
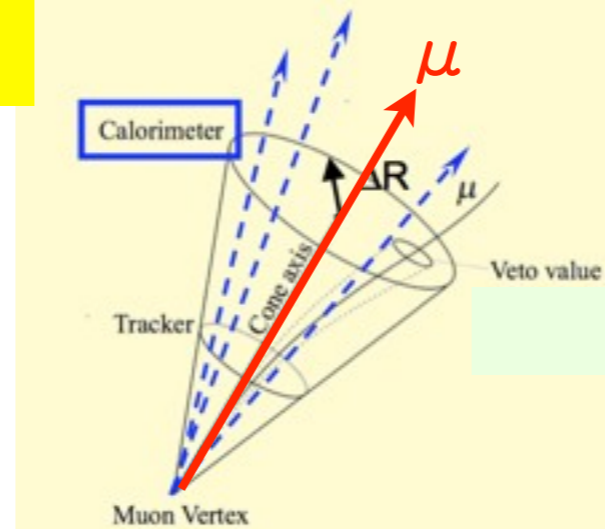
electron ID efficiency : Z -> ee



μ (calorimetric) isolation eff. Z -> $\mu\mu$



無関係なハドロントラックが EM Calorimeter のシャワーに重なってしまう影響 -> eff. loss
(* 努力の余地あり)



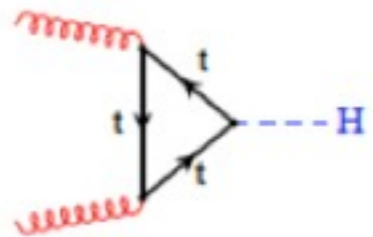
H -> ZZ -> 4Lの伏線

Higgs

Higgs Boson Production

Higgs生成 @ LHC

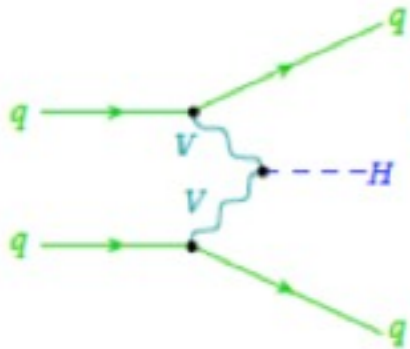
$m_H=125\text{GeV}$ の場合の σ



Gluon Fusion (GF)

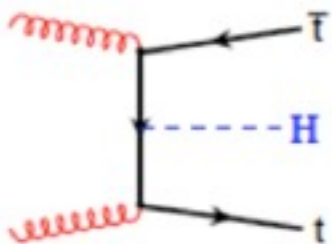
15.3pb

$\Delta\sigma \sim 20\%$



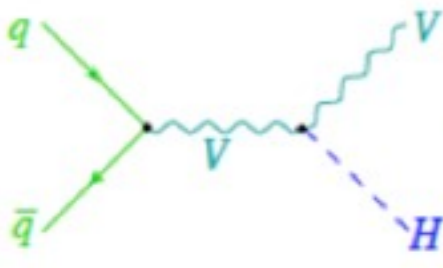
Vector boson fusion (VBF)

1.2pb



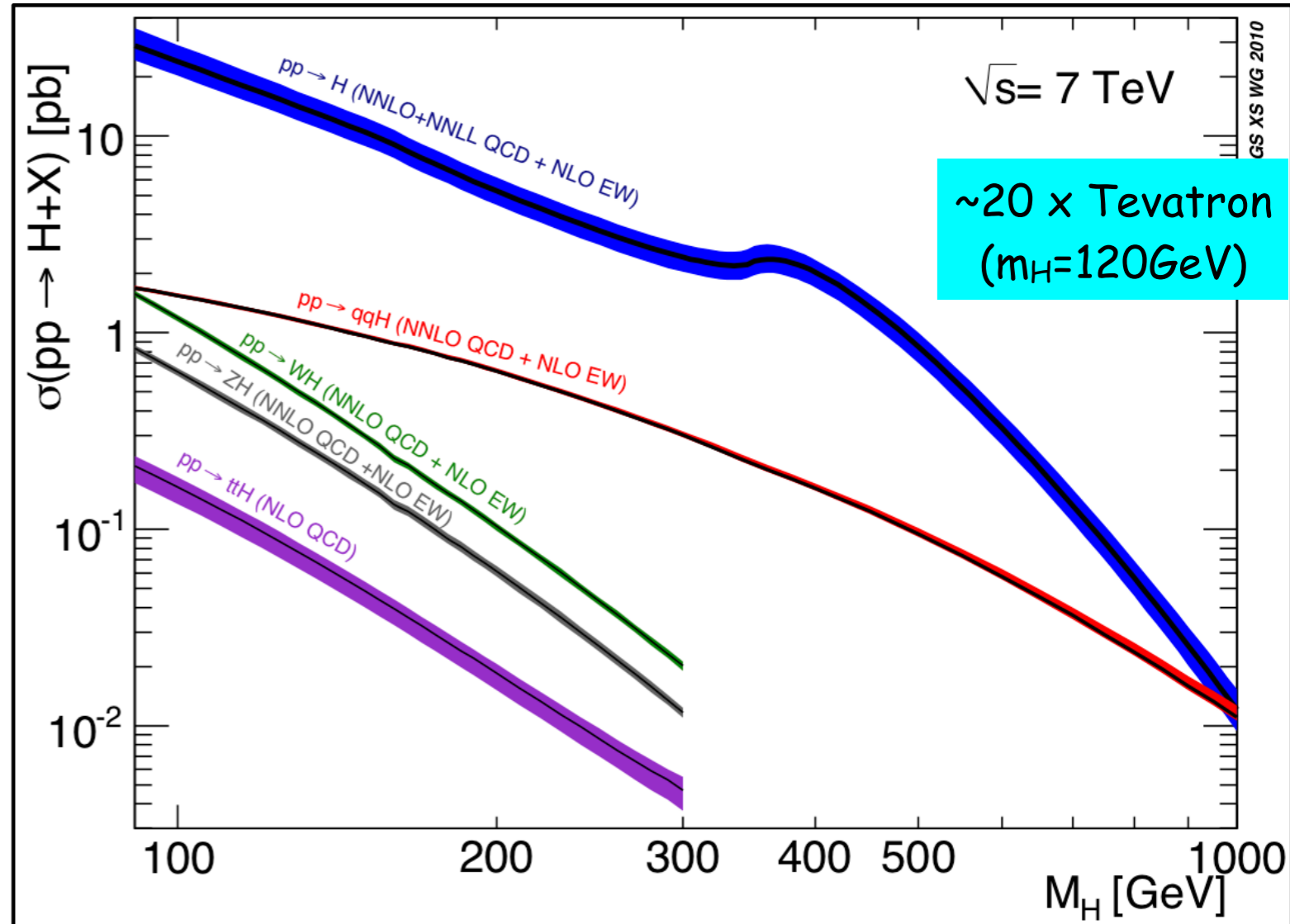
tt associated production (ttH)

0.09pb



WH/ZH associated production (VH)

0.3pb



LHC Higgs cross section working group, 2010, arXiv: 1101.0593

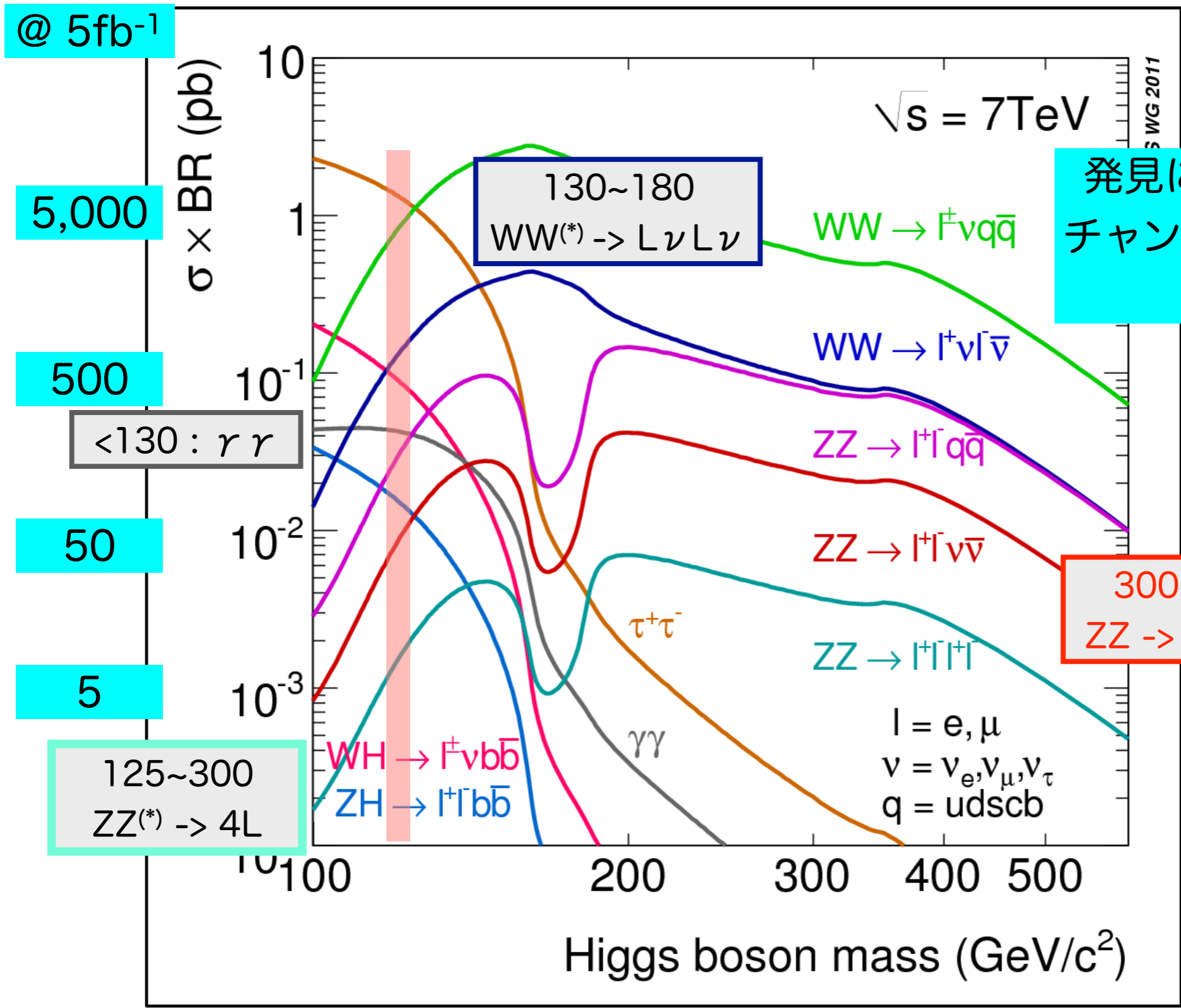
cross sectionの計算 @ NNLO (for GF, VBF and VH)
 エラーみつもり : GF : < 20% , (VBF : 3~9% , VH : ~ 5%)

$16.9\text{pb} \times 6 \times 10^{33}\text{cm}^{-2}\text{s}^{-1} \sim 0.1\text{Hz}$

$16.9\text{pb} \times 5\text{fb}^{-1} \sim 84.5\text{k}$ (8万5千個)

Higgs 生成 x 崩壊 ($\sigma \times \text{Branch}$)

更に $\times \text{Acceptance} \times \text{eff.}$
-> yield

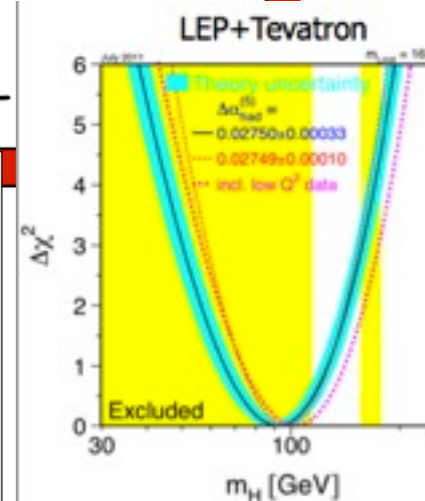
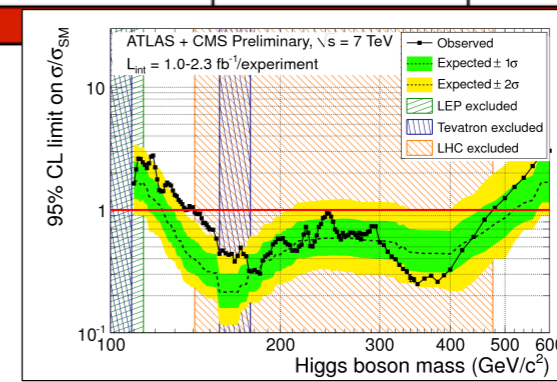


発見に関してsignificantな
チャンネルはヒッグスの質量
により異なる

Higgs Search

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
$H \rightarrow \gamma\gamma$	110-150	4.9	$\gamma\gamma, \gamma j, jj$	~ 70	~ 0.02	1.6-2
$H \rightarrow \tau\tau \rightarrow ll+\nu$	110-140	1.1	$Z \rightarrow \tau\tau, \text{top}$	~ 0.8	~ 0.02	30-60
$H \rightarrow \tau\tau \rightarrow l\tau_{\text{had}}$	100-150	1.1	$Z \rightarrow \tau\tau$	~ 10	$\sim 5 \cdot 10^{-3}$	10-25
$W/ZH \rightarrow bbl(l)$	110-130	1.1	$W/Z+\text{jets}, \text{top}$	~ 6	$\sim 5 \cdot 10^{-3}$	15-25
$H \rightarrow WW^{(*)} \rightarrow ll\nu\nu$	110-300	2.1	$WW, \text{top}, Z+\text{jet}$	~ 20 (130 GeV)	~ 0.3	0.3-8
$H \rightarrow ZZ^{(*)} \rightarrow 4l$	110-600	4.8	ZZ^*, top, Zbb	~ 2.5 (130 GeV)	~ 1.5	0.7-10
$H \rightarrow ZZ \rightarrow ll\nu\nu$	200-600	2.1	$ZZ, \text{top}, Z+\text{jets}$	~ 20 (400 GeV)	~ 0.3	0.8-4
$H \rightarrow ZZ \rightarrow llqq$	200-600	2.1	$Z+\text{jets}, \text{top}$	2-20 (400 GeV)	0.05-0.5	2-6
$H \rightarrow WW \rightarrow llqq$	240-600	1.1	$W+\text{jets}, \text{top}, \text{jets}$	~ 45 (400 GeV)	10^{-3}	5-

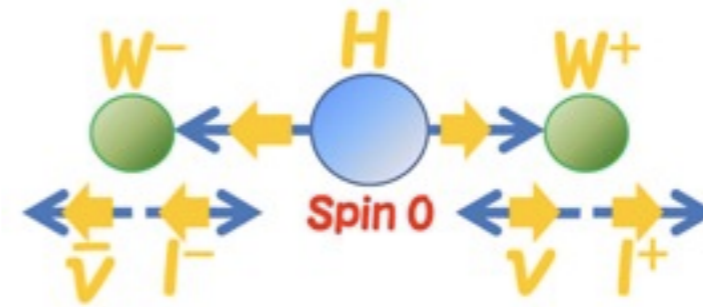
updated w.r.t. Lepton-Photon 2011 conference
 、かつ、
 Low-Mass Higgs に対して重要なチャンネル



$$H \rightarrow WW^{(*)} \rightarrow L\nu L\nu \quad (e\nu e\nu, \mu\nu\mu\nu, e\nu\mu\nu)$$

- $m_H = 130 \sim 180 \text{ GeV}$ でもっとも高感度
($\sim 160 \text{ GeV}$ Branch 大きい)
- lepton 2本 ・ 逆符号 : クリーンな信号
- でも、 $2\nu \rightarrow$ mass reconstructできない

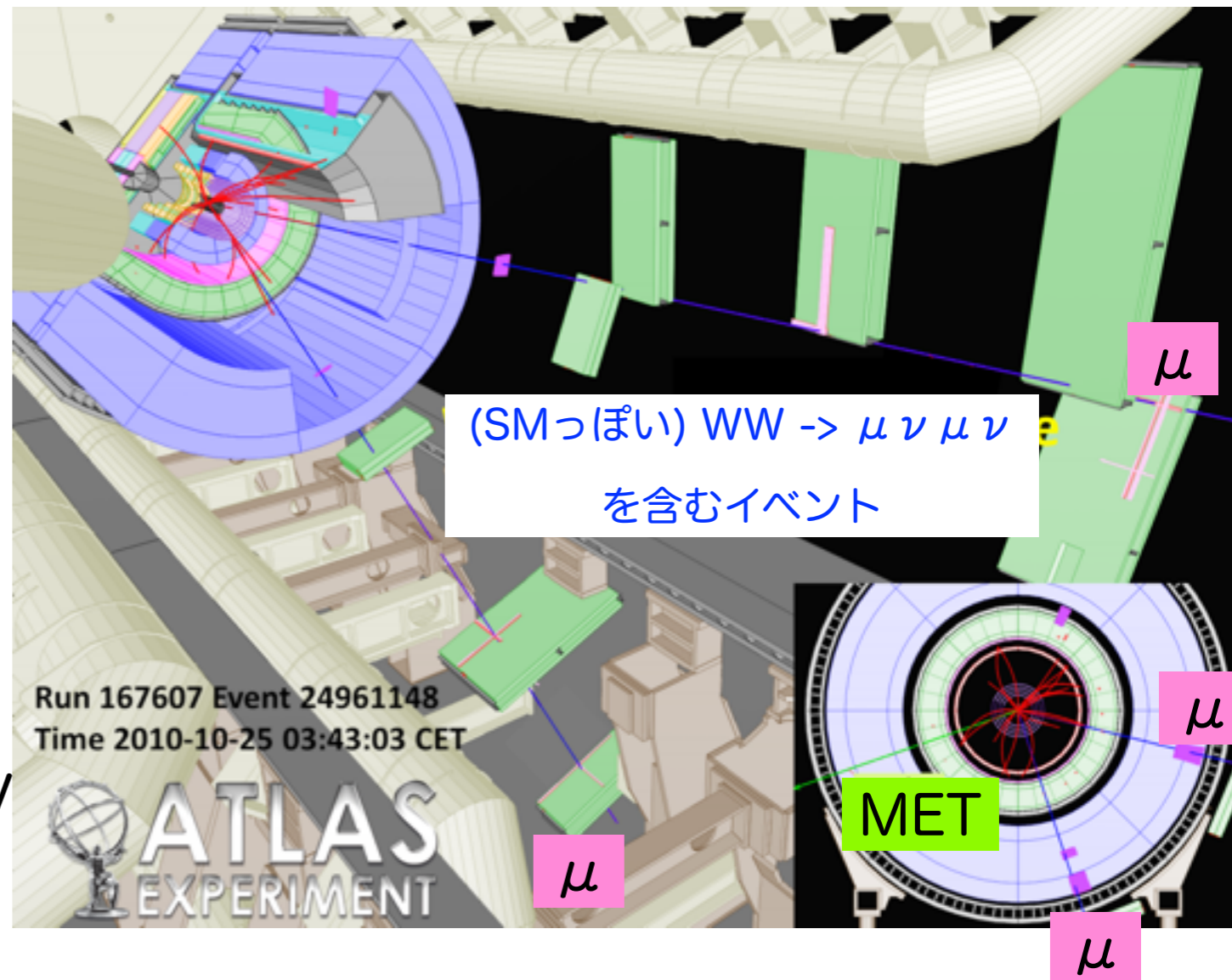
110~300 GeV
2.05 fb⁻¹



e.g. $H \rightarrow WW^* \rightarrow \mu\nu \mu\nu$ の場合

0. single μ trigger $\mu 18$

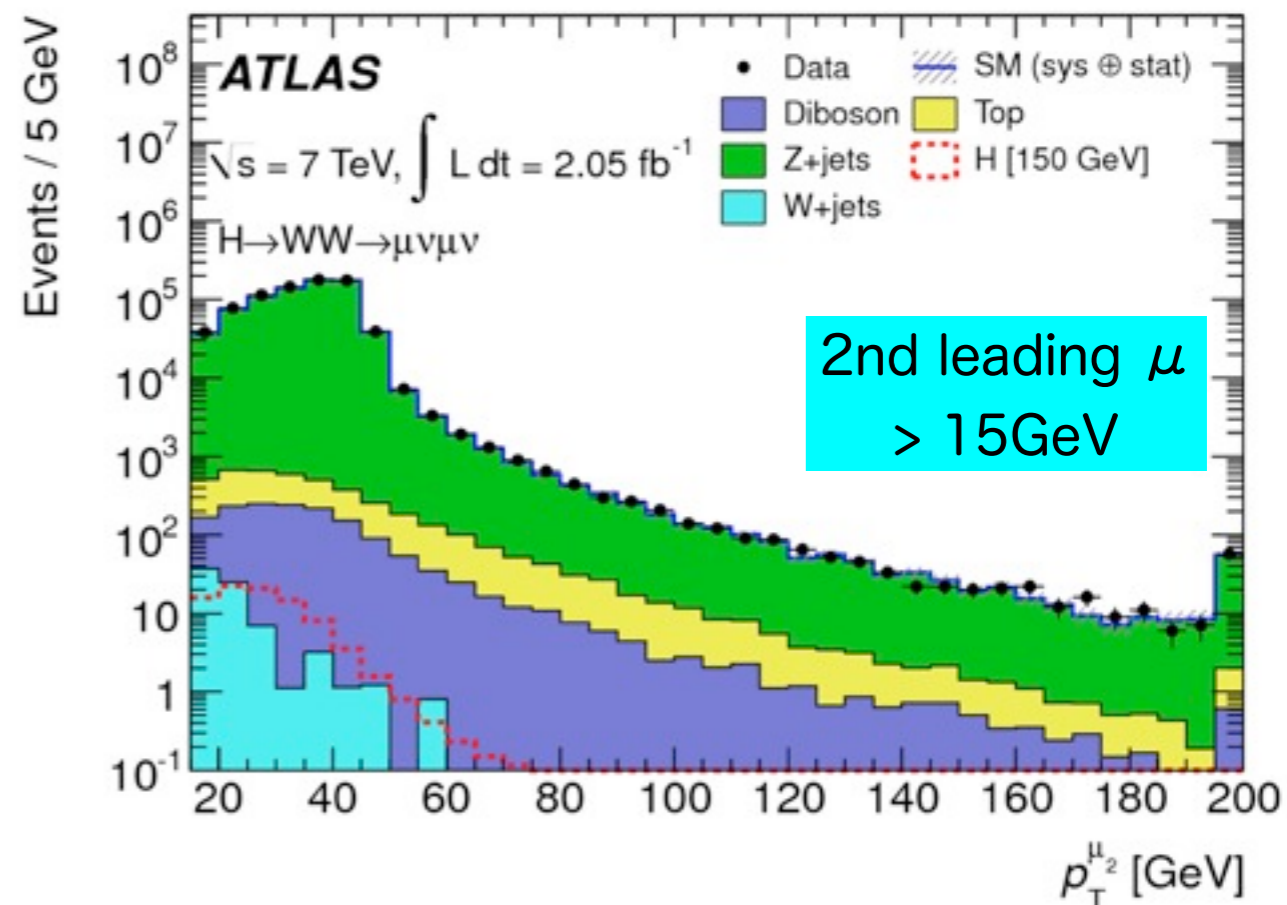
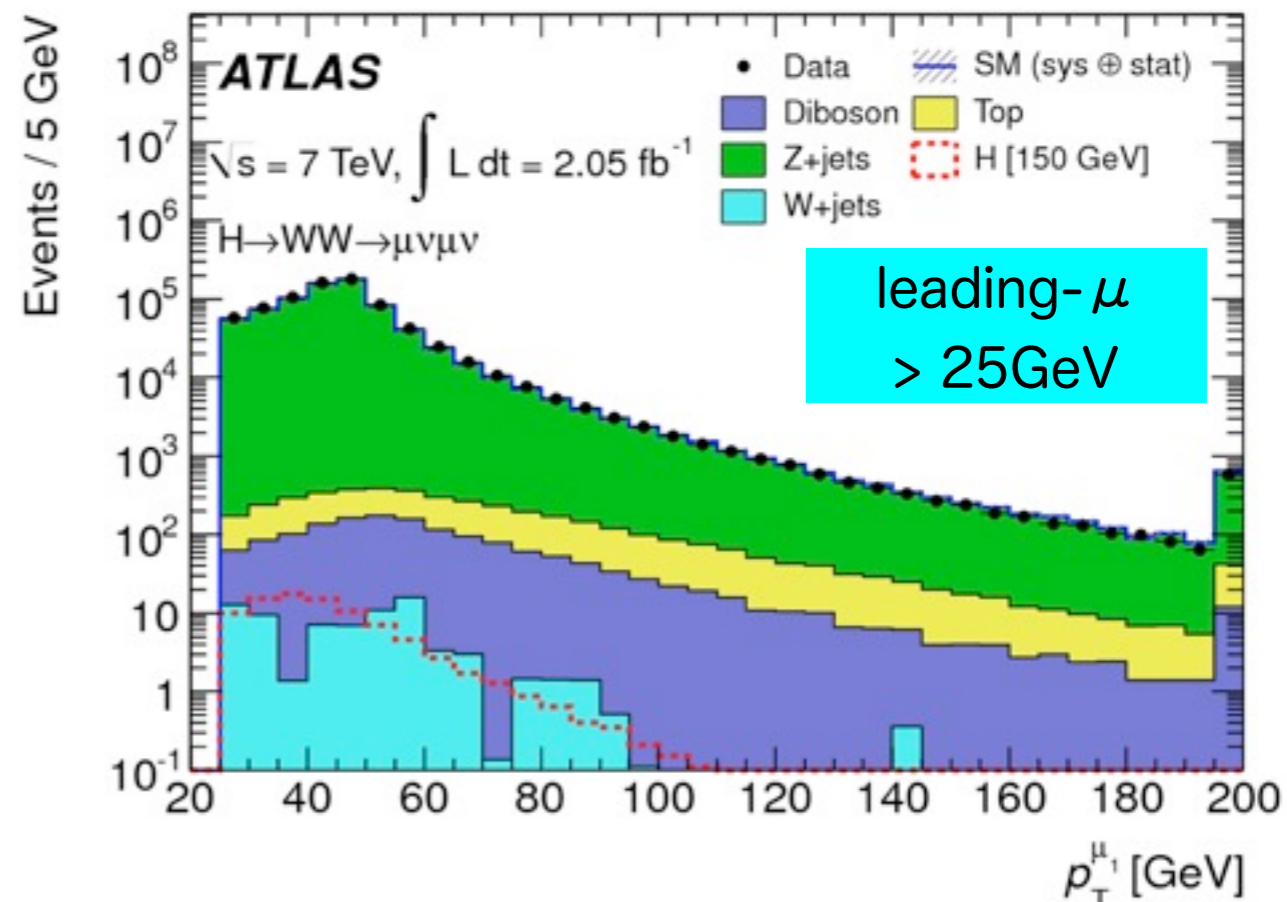
1. isolated μ 2本, μ^+ と μ^-
2. $P_T > 25 \text{ GeV}$ (leading), $P_T > 15 \text{ GeV}$ (2nd.)
3. (a) D-Y veto :
 - ✓ $m_{\mu\mu} > 15 \text{ GeV}$
 - ✓ $|m_{\mu\mu} - M_Z| > 15 \text{ GeV}$
3. (b) $\text{MET} > 40 \text{ GeV}$
4. 0-jet / 1-jet カテゴリー分け
 - ✓ 0-jet : $P_{T_{\mu\mu}} > 30 \text{ GeV}$
 - ✓ 1-jet : b-jet Veto, $P_{T_{\text{total}}} < 30 \text{ GeV}$
5. 最後に $H \rightarrow WW$ セレクション



$H \rightarrow WW^{(*)} \rightarrow L\nu L\nu$ [Lepton P_T cut]

e.g. $H \rightarrow WW^* \rightarrow \mu\nu \mu\nu$ の場合

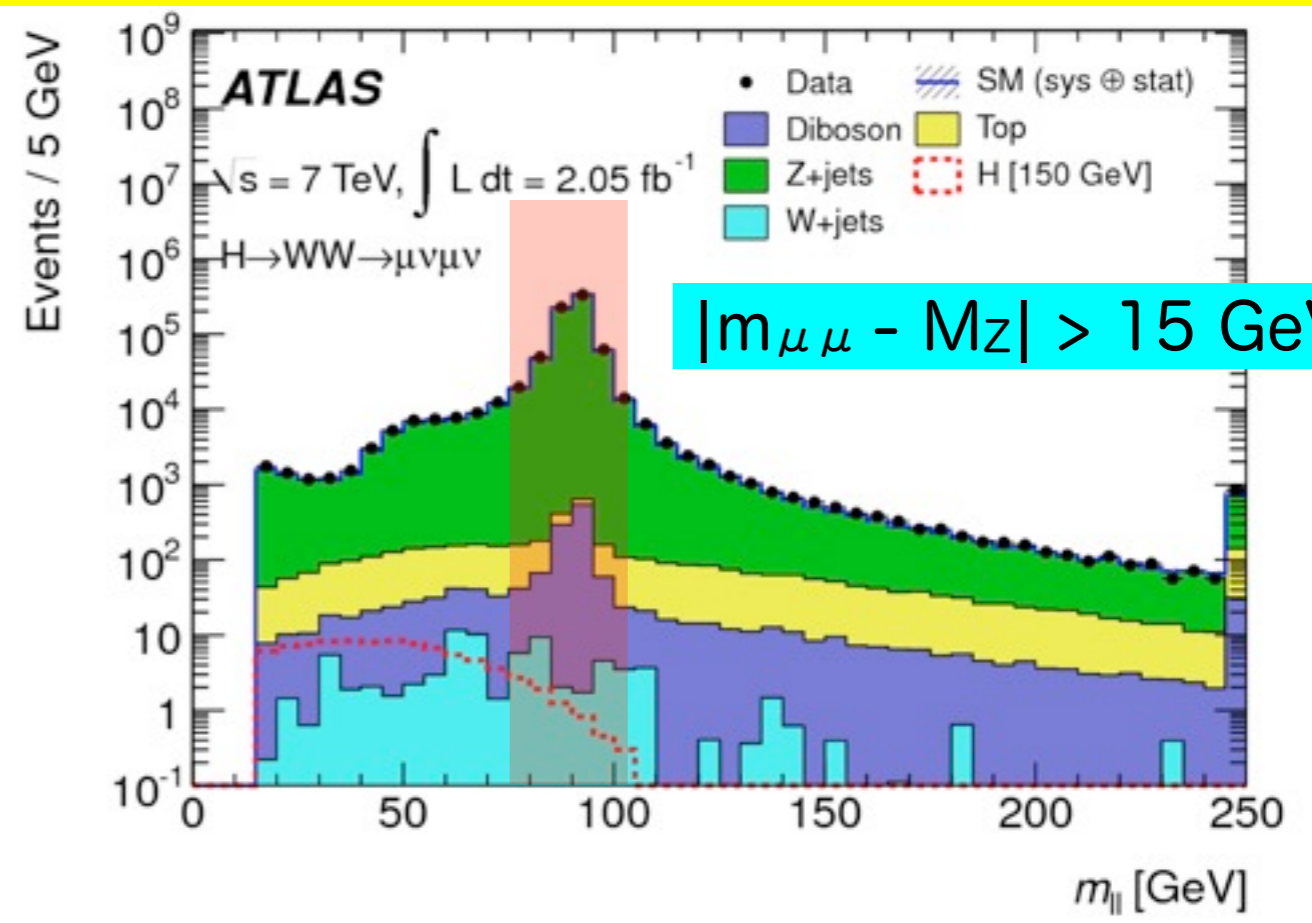
1. isolated μ 2本, μ^+ と μ^-
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3. (b) $\text{MET} > 40\text{GeV}$
4. 0-jet / 1-jet カテゴリー分け
 - ✓ 0-jet : $P_{T_{\mu\mu}} > 30\text{GeV}$
 - ✓ 1-jet : b-jet Veto, $P_{T_total} < 30\text{GeV}$
5. 最後に $H \rightarrow WW$ セレクション



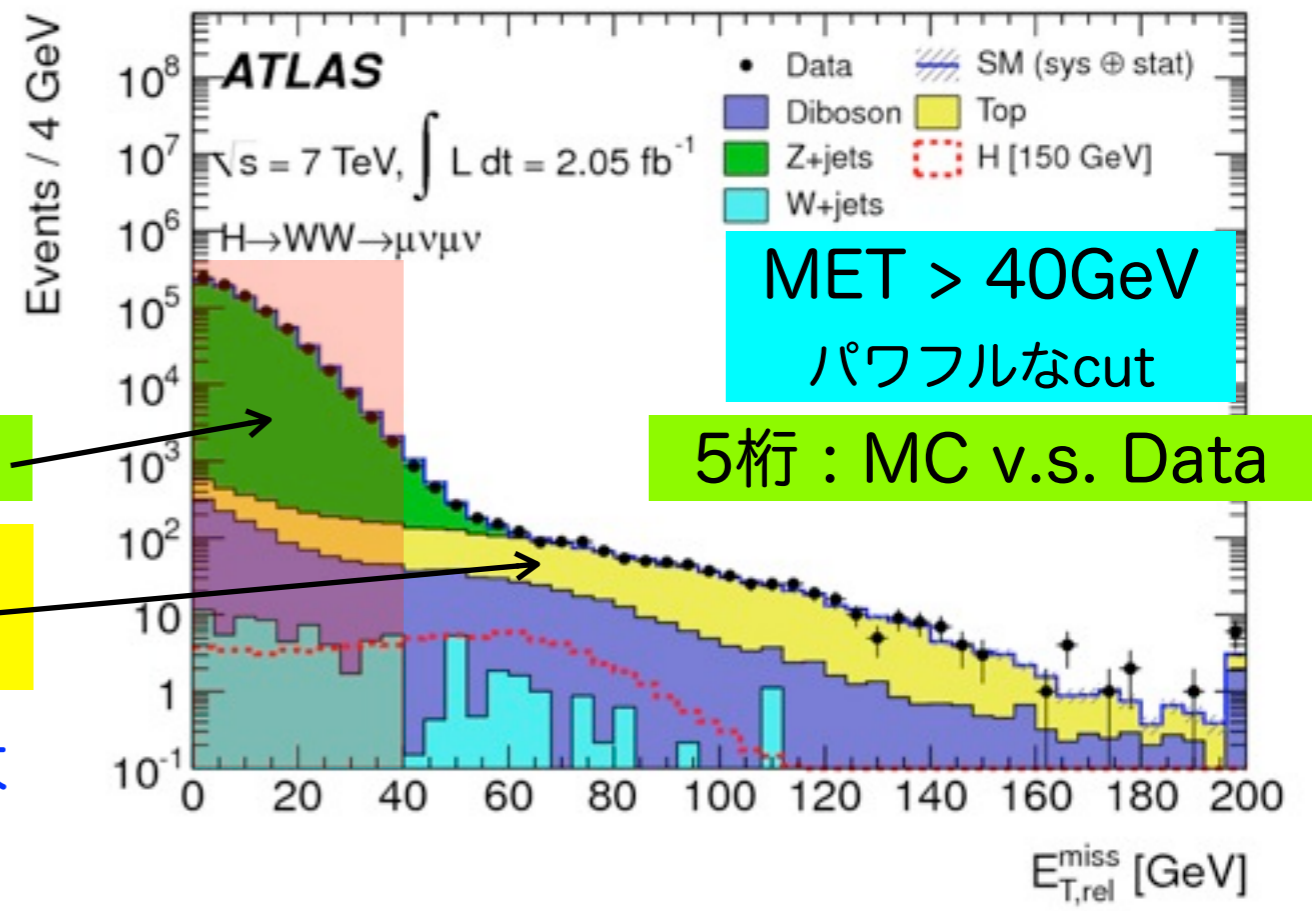
H → WW(*) → Lν Lν [Z-veto & MET cut]

e.g. H → WW* → μν μν の場合

1. isolated μ 2本, μ⁺ と μ⁻
2. P_T>25GeV (leading), P_T>15GeV (2nd.)
3. (a) D-Y veto :
 - ✓ m_{μμ} > 15GeV
 - ✓ |m_{μμ} - M_Z| > 15 GeV
3. (b) MET > 40GeV
4. 0-jet / 1-jet カテゴリー分け
 - ✓ 0-jet : P_{T_μμ}>30GeV
 - ✓ 1-jet : b-jet Veto, P_{T_total}<30GeV
5. 最後に H→WW セレクション



|m_{μμ} - M_Z| > 15 GeV



MET > 40GeV
パワフルなcut

5桁 : MC v.s. Data

Z+jets → jetのミスID と 本物ν (Z→ττ)

topが作る本物のMET (ν)
Dominant : MET > 50GeV

MET : 分布 & resolution pileup効果大

pileup sensitive

H \rightarrow WW(*) \rightarrow L ν L ν [categorize with # of JETs]

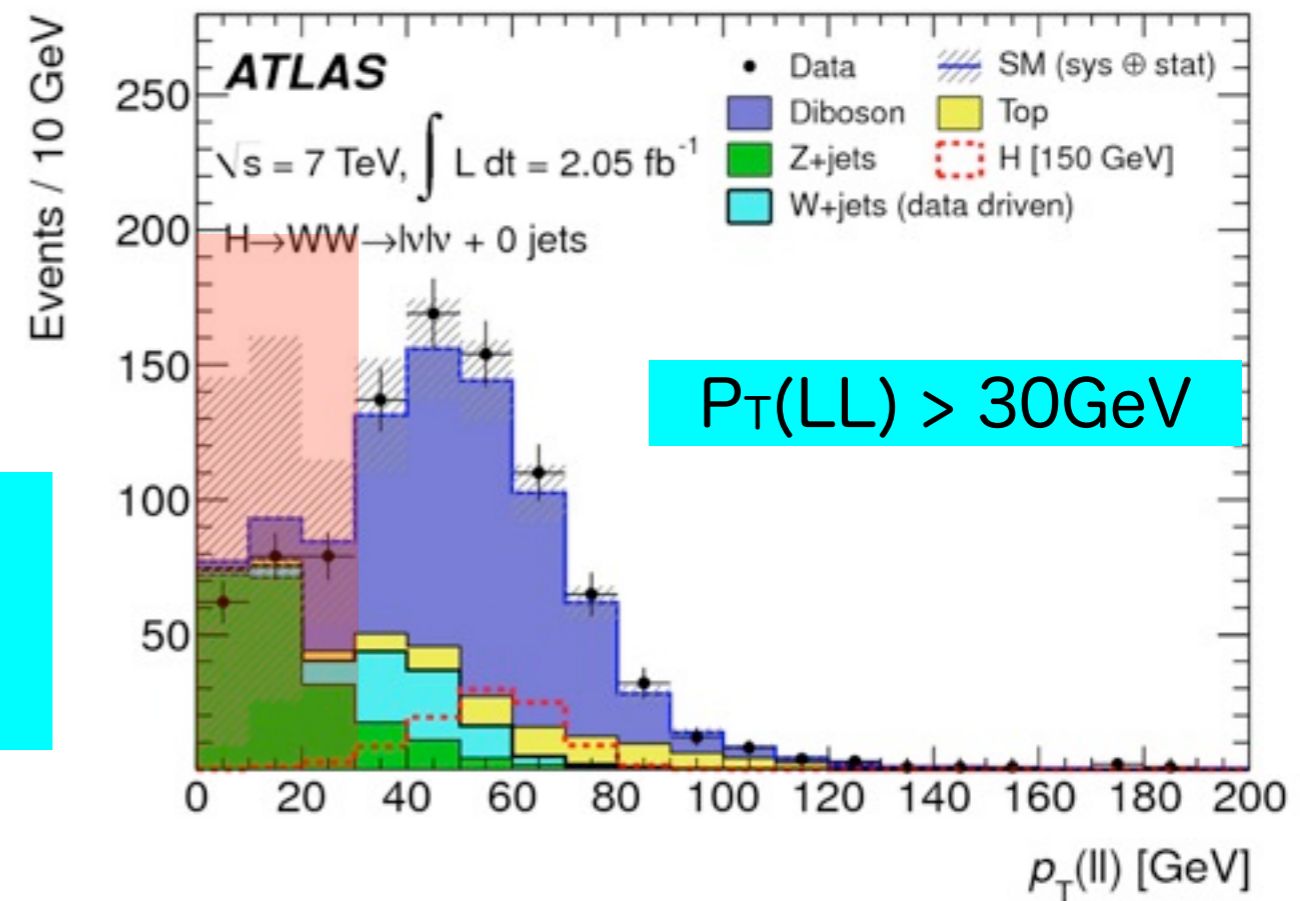
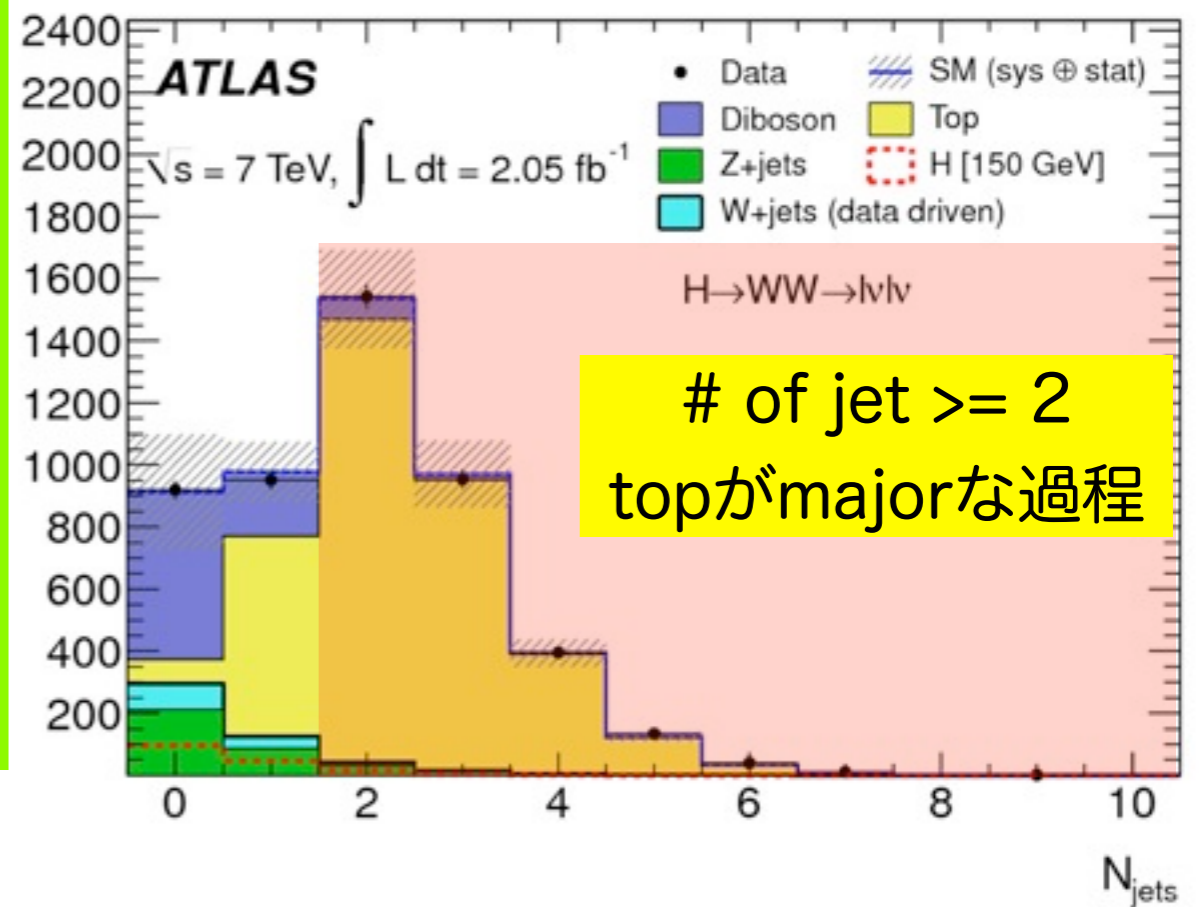
e.g. H \rightarrow WW* \rightarrow $\mu\nu \mu\nu$ の場合

1. isolated μ 2本, μ^+ と μ^-
2. $P_T > 25\text{GeV}$ (leading), $P_T > 15\text{GeV}$ (2nd.)
3. (a) D-Y veto :
 - ✓ $m_{\mu\mu} > 15\text{GeV}$
 - ✓ $|m_{\mu\mu} - M_Z| > 15\text{ GeV}$
3. (b) MET $> 40\text{GeV}$
4. 0-jet / 1-jet カテゴリー分け
 - ✓ 0-jet : $P_{T_μμ} > 30\text{GeV}$ Z+jet 削減
 - ✓ 1-jet : b-jet Veto, $P_{T_total} < 30\text{GeV}$
5. 最後に H \rightarrow WW セレクション

top-Veto

total ($\mu_1 + \mu_2 + \text{MET}$)
バランスが良い
i.e. Z \rightarrow $\tau\tau$ Veto

やっと、縦軸がリニアスケール



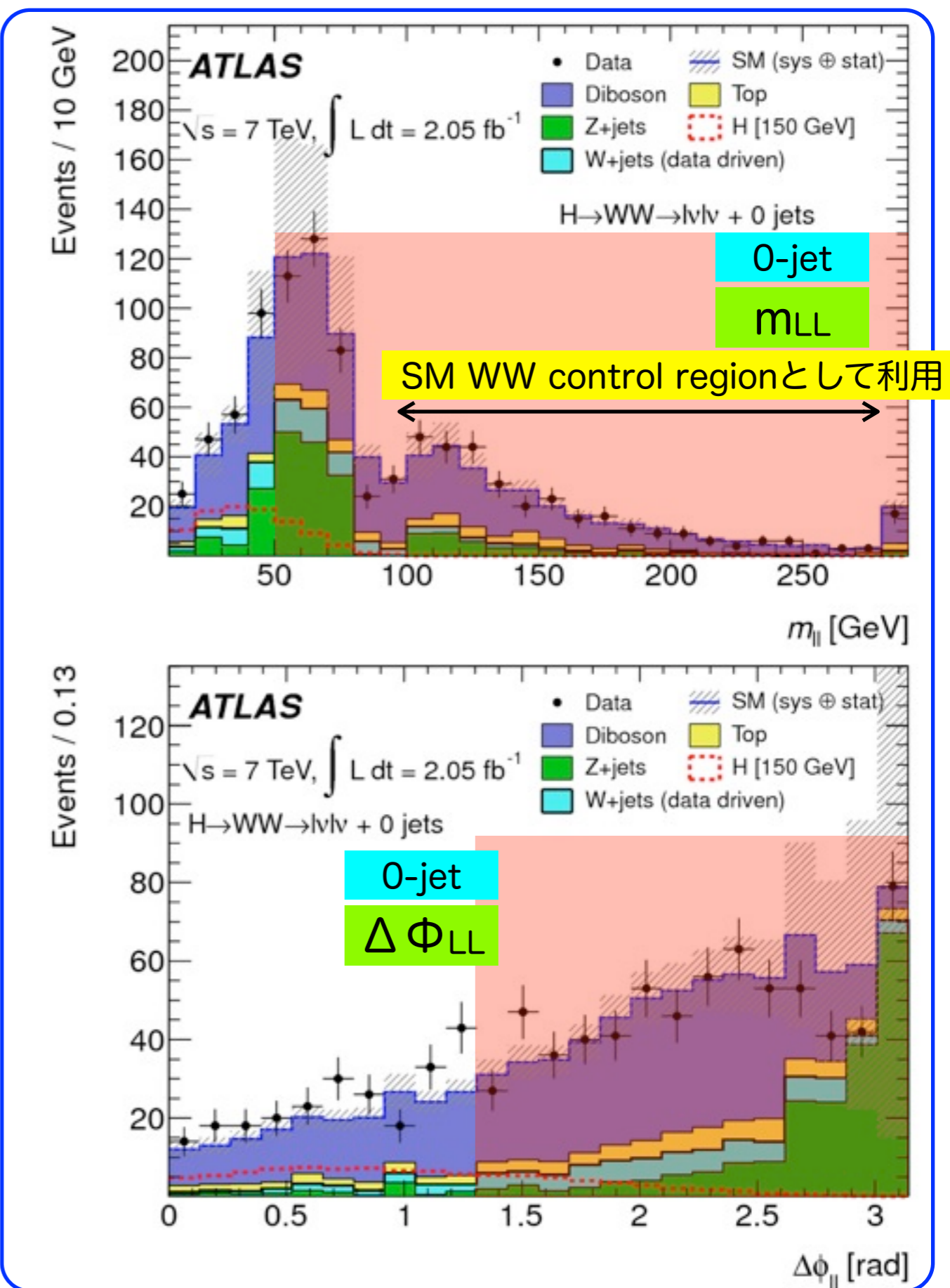
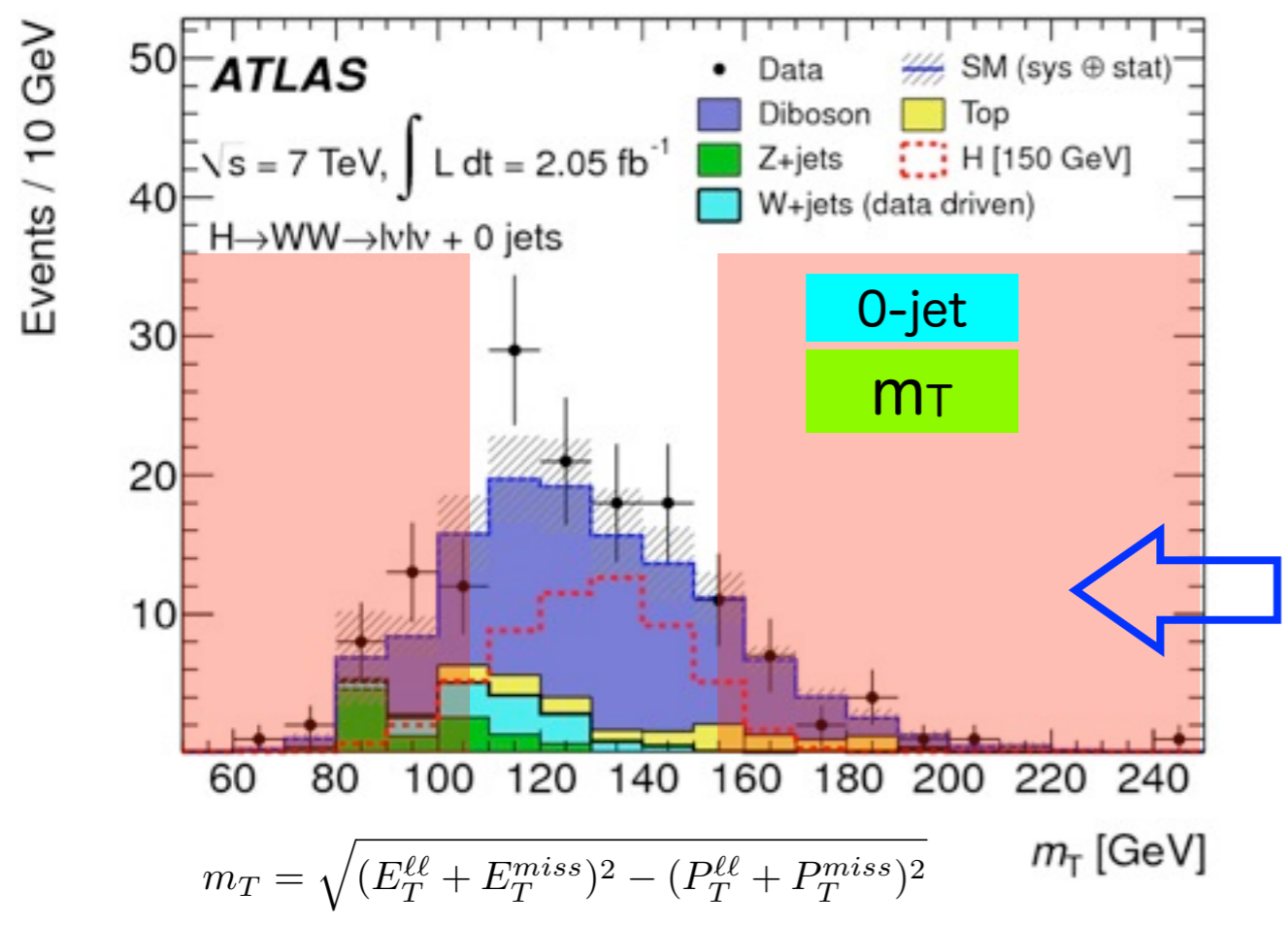
H → WW(*) → Lν Lν [H→WW kinematic cut]

e.g. H → WW* → μν μν の場合

1, 2, 3, 4, 5, ...

6. 最後に H→WW セレクション (除 SM-WW)

m _H	< 170	$170 \sim 220$	> 220
m _{LL}	< 50	< 65	$50 \sim 180$
$\Delta\phi_{LL}$	< 1.3	< 1.8	no cut
m _T	$0.75 \cdot m_H \sim m_H$		$0.6 \cdot m_H \sim$



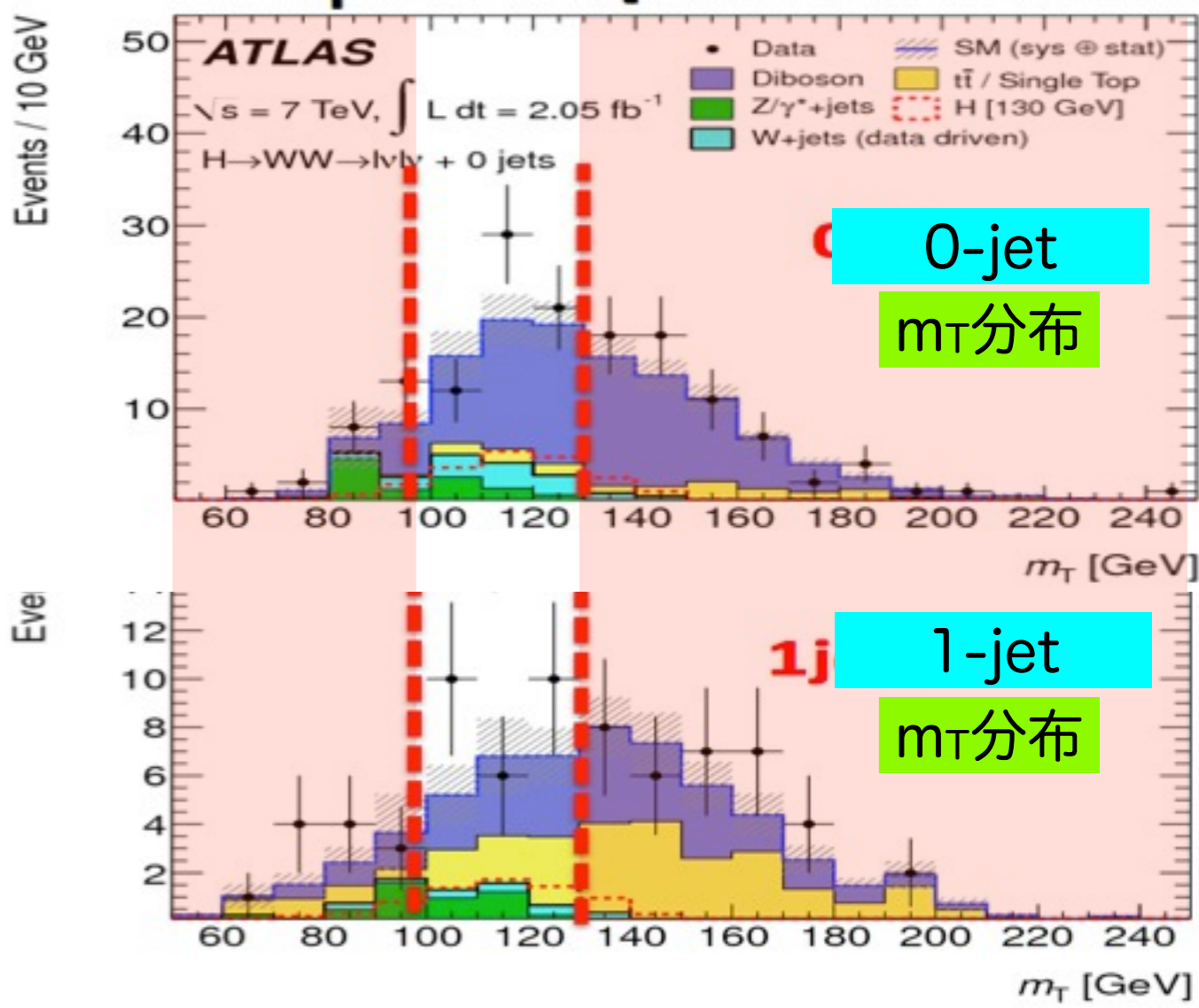
H → WW(*) → Lν Lν [m_T cut for 0-jet / 1-jet]

e.g. H → WW* → μν μν の場合

1, 2, 3, 4, 5, ...

6. 最後に H→WW セレクション (除 SM-WW)

m _H	< 170	170~220	> 220
m _{LL}	< 50	< 65	50~180
Δφ _{LL}	< 1.3	< 1.8	no cut
m _T	0.75*m _H ~ m _H		0.6*m _H ~



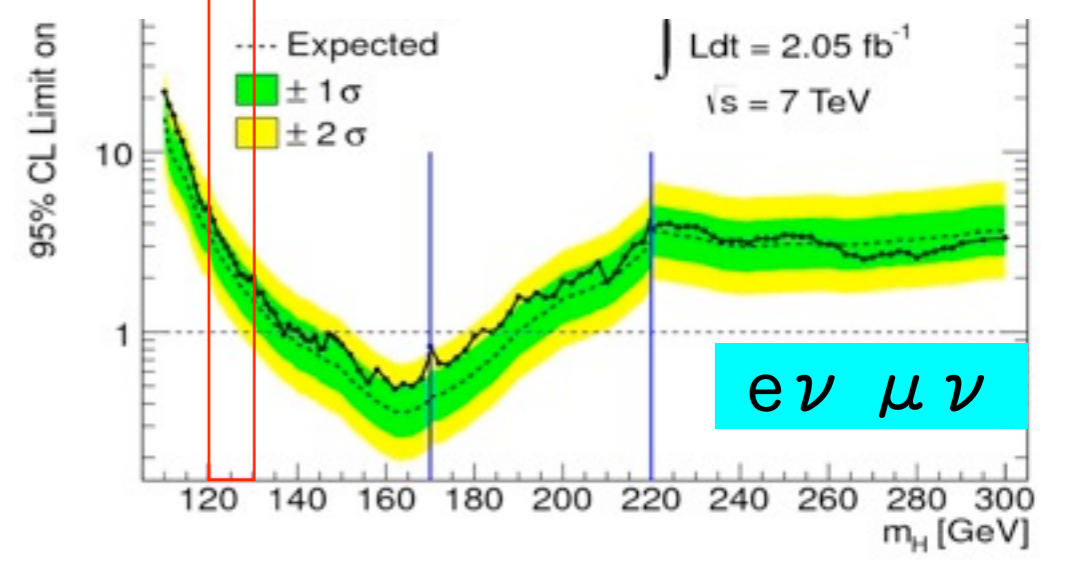
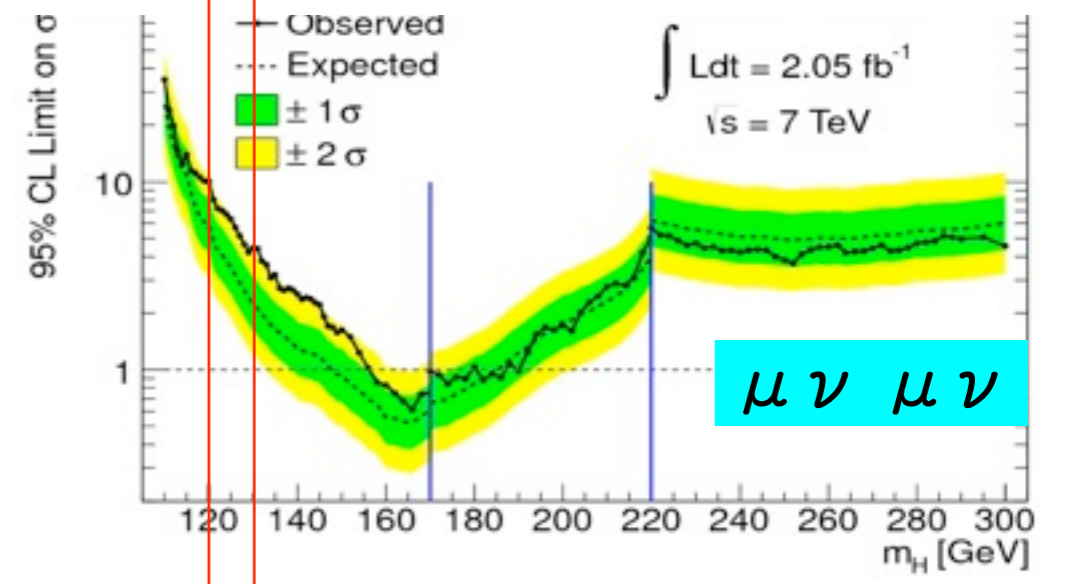
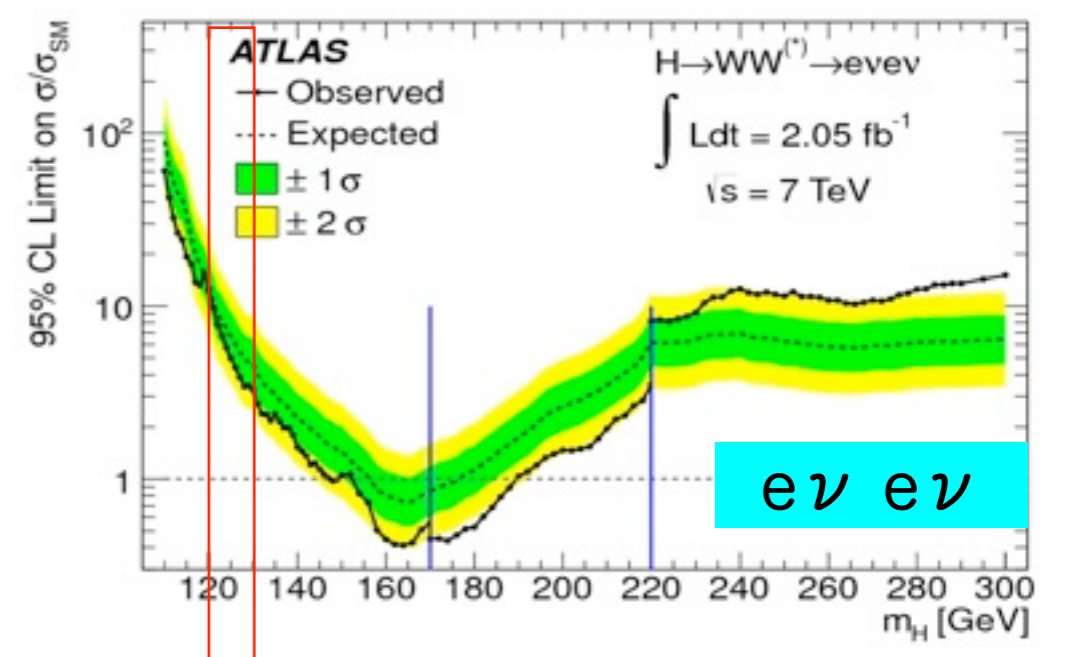
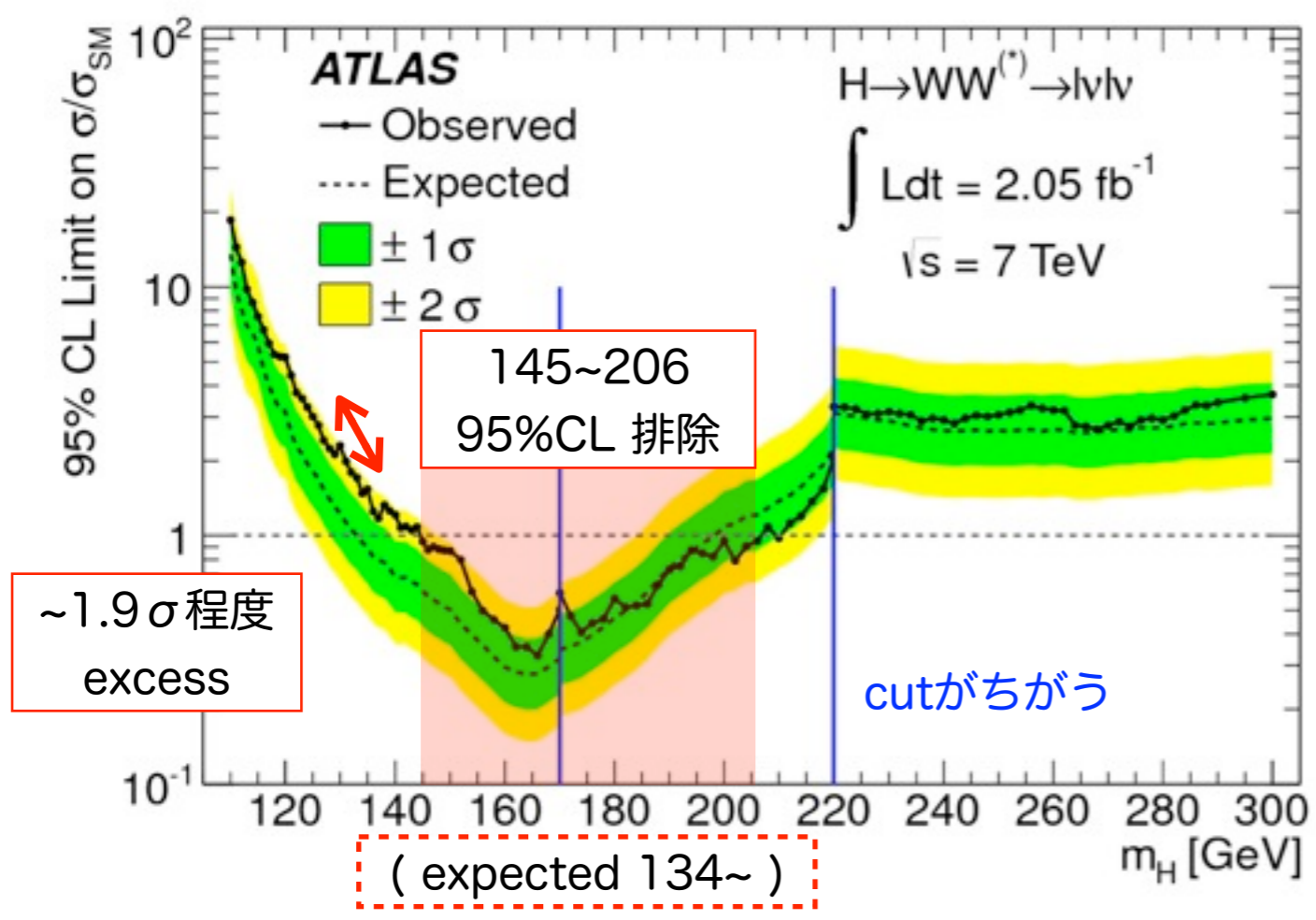
m_H=150GeV

H + 0-jet Channel	Signal	WW	W + jets	Z/γ* + jets	t-tbar	tW/tb/tqb	WZ/ZZ/Wγ	Total Bkg.	Observed
Jet Veto	99 ± 21	524 ± 52	84 ± 41	174 ± 169	42 ± 14	32 ± 8	15 ± 4	872 ± 182	920
p _T ^{ℓℓ} > 30 GeV	95 ± 20	467 ± 45	69 ± 34	30 ± 12	39 ± 14	29 ± 8	13 ± 4	648 ± 60	700
m _{ℓℓ} < 50 GeV	68 ± 15	118 ± 15	21 ± 8	13 ± 8	7 ± 4	5.8 ± 1.8	1.9 ± 0.6	166 ± 19	199
Δφ _{ℓℓ} < 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-tbar	tW/tb/tqb	WZ/ZZ/Wγ	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
p _T ^{tot} < 30 GeV	39 ± 7	154 ± 16	18 ± 9	38 ± 32	106 ± 30	50 ± 9	9.7 ± 1.5	376 ± 48	405
Z → ττ veto	39 ± 7	150 ± 17	18 ± 8	34 ± 23	102 ± 23	48 ± 8	9 ± 2	361 ± 38	388
m _{ℓℓ} < 50 GeV	26 ± 6	33 ± 5	3.3 ± 1.4	8 ± 7	20 ± 7	11 ± 3	1.8 ± 0.5	77 ± 12	90
Δφ _{ℓℓ} < 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

H \rightarrow WW(*) \rightarrow L ν L ν : exclusion

After all cuts (selection for $m_H=130$ GeV)

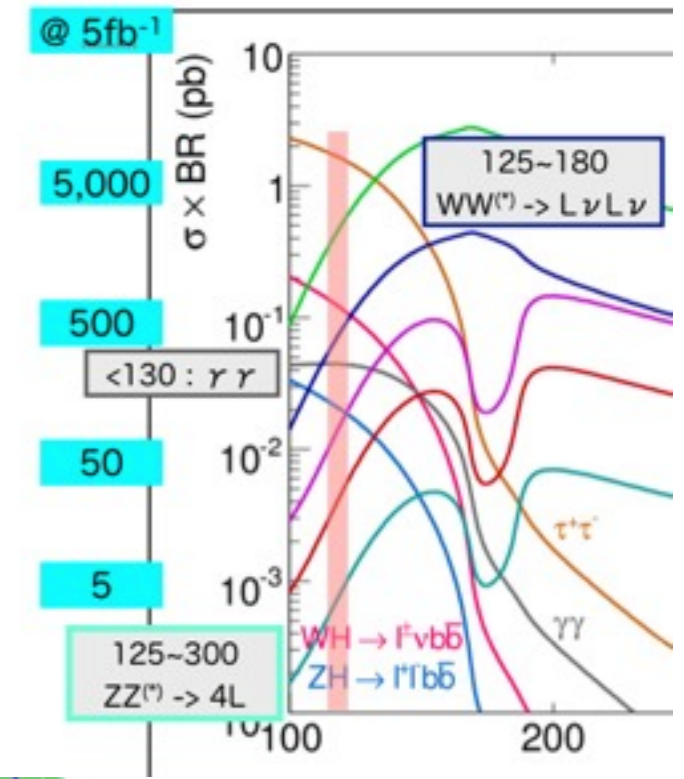
Observed in data	94 events
	10 ee, 42 e μ , 42 $\mu\mu$
Expected background	76 (± 11)
Expected signal $m_H=130$ GeV	19 (± 4)



H → ZZ(*) → 4L (4e, 4μ, 2e 2μ)

110~600GeV
4.8fb⁻¹

- low mass (120GeV) σ · Br 小さい [2γよりひと桁以上小]
- だがしかし ...
- 4L mass組める → resolution !!
- S/N ~ 1 : very clean !!



- 0. single Lepton trigger, mu18 , e22(20)
- 1. 4L : $p_T^{1,2,3,4} > 20, 20, 7, 7 \text{ GeV}$ low P_T lepton (e)
- ✓ $m_{12} = m_Z \pm 15 \text{ GeV}$
- ✓ $m_{34} > 15 \sim 60 \text{ GeV}$

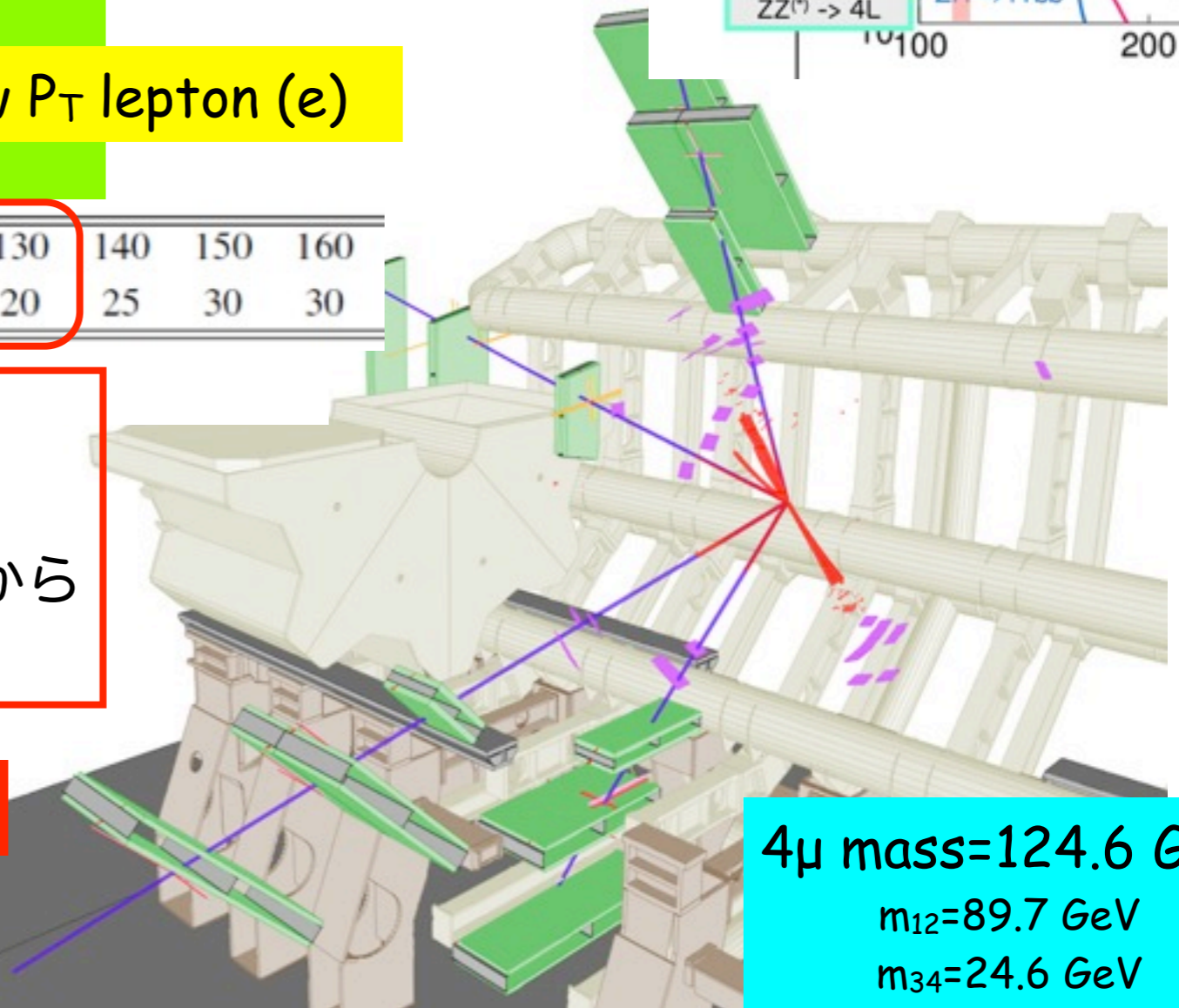
$m_{4\ell}$ (GeV)	≤120	130	140	150	160
threshold (GeV)	15	20	25	30	30

- Main backgrounds:
- ✓ SM_ZZ(*) (irreducible)
- ✓ 2L from b(q)-jets , Zbb , Z+j , tt から ($m_H < 2m_Z$)

- lepton isolation cut
- impact parameter cut
- m34 の lepton に対して有効 → b-veto

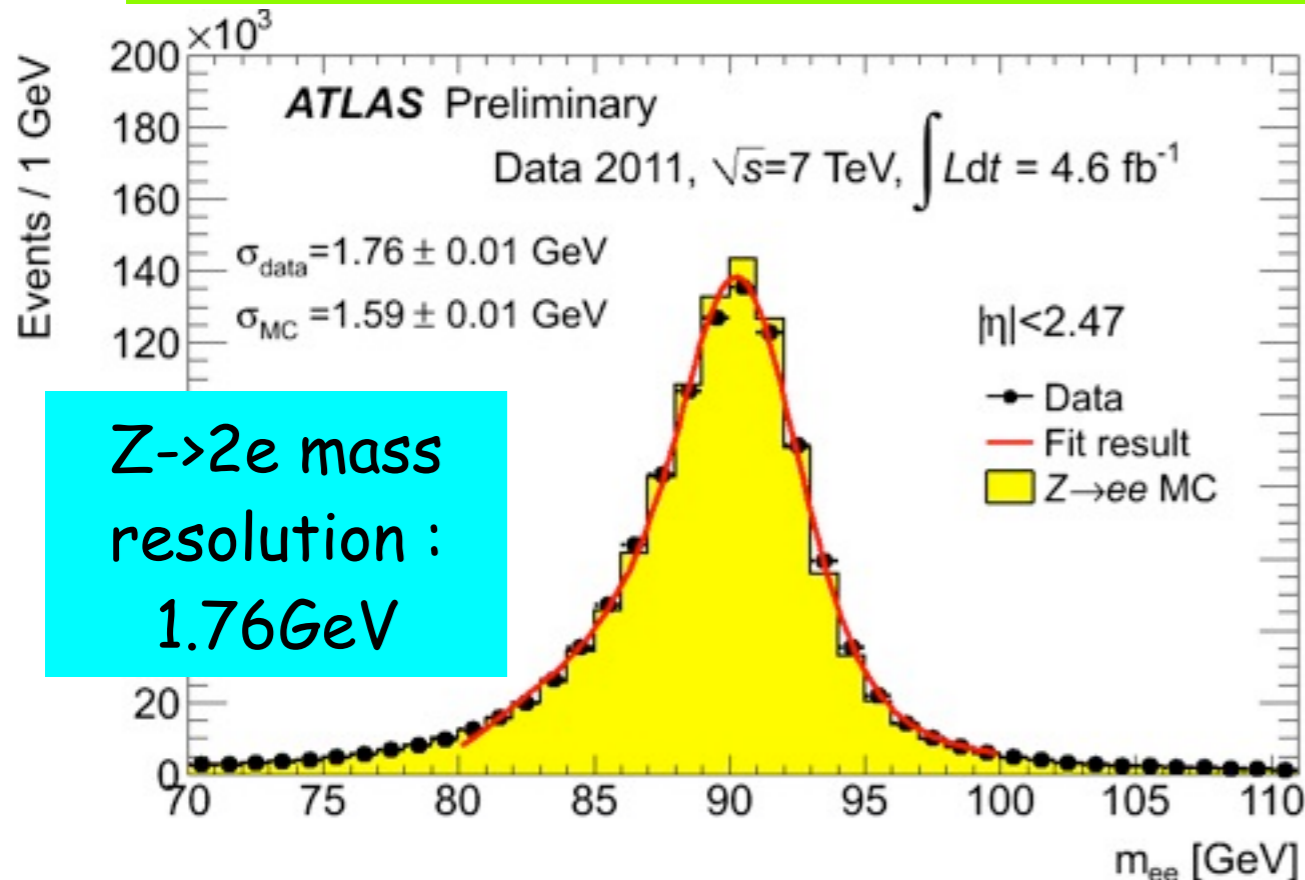
pileup sensitive

4μ mass=124.6 GeV
 $m_{12}=89.7 \text{ GeV}$
 $m_{34}=24.6 \text{ GeV}$



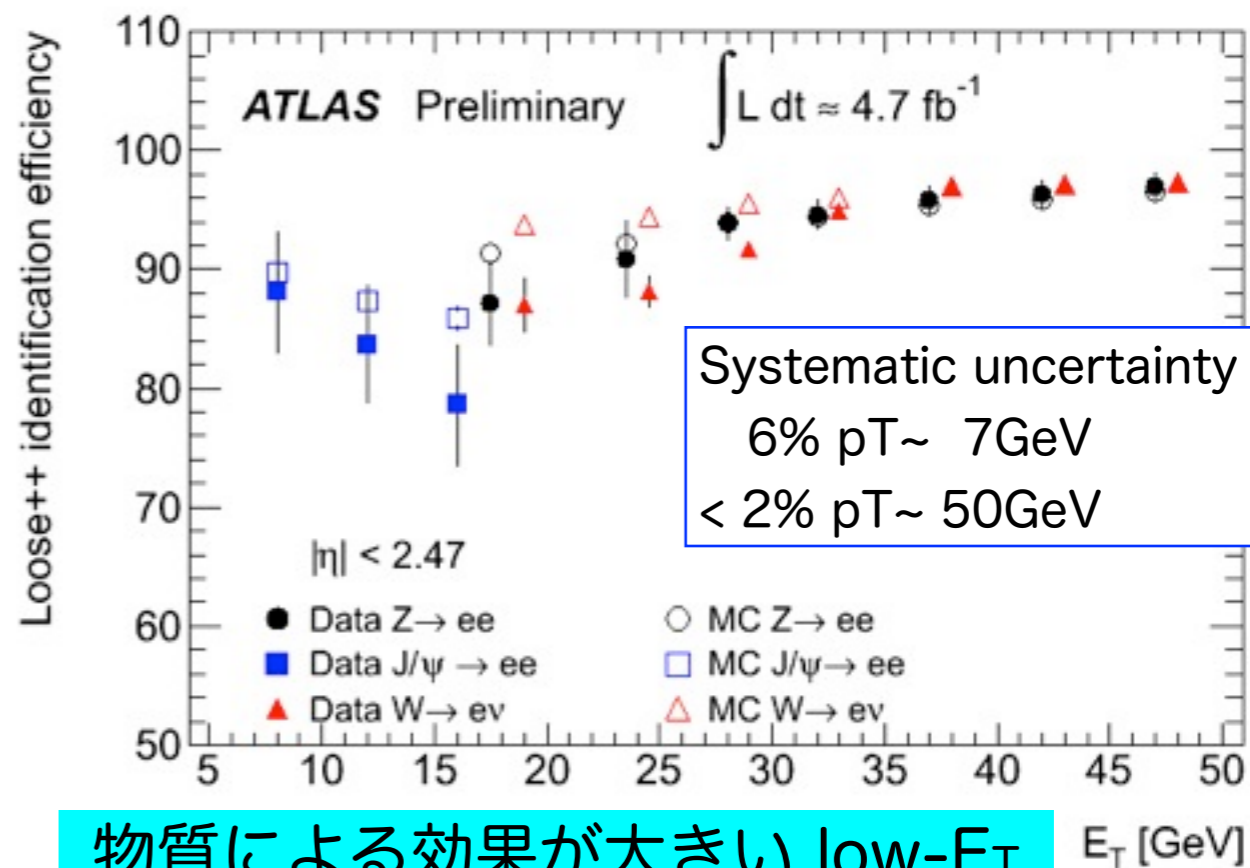
electron performance

Z -> ee : mass resolution



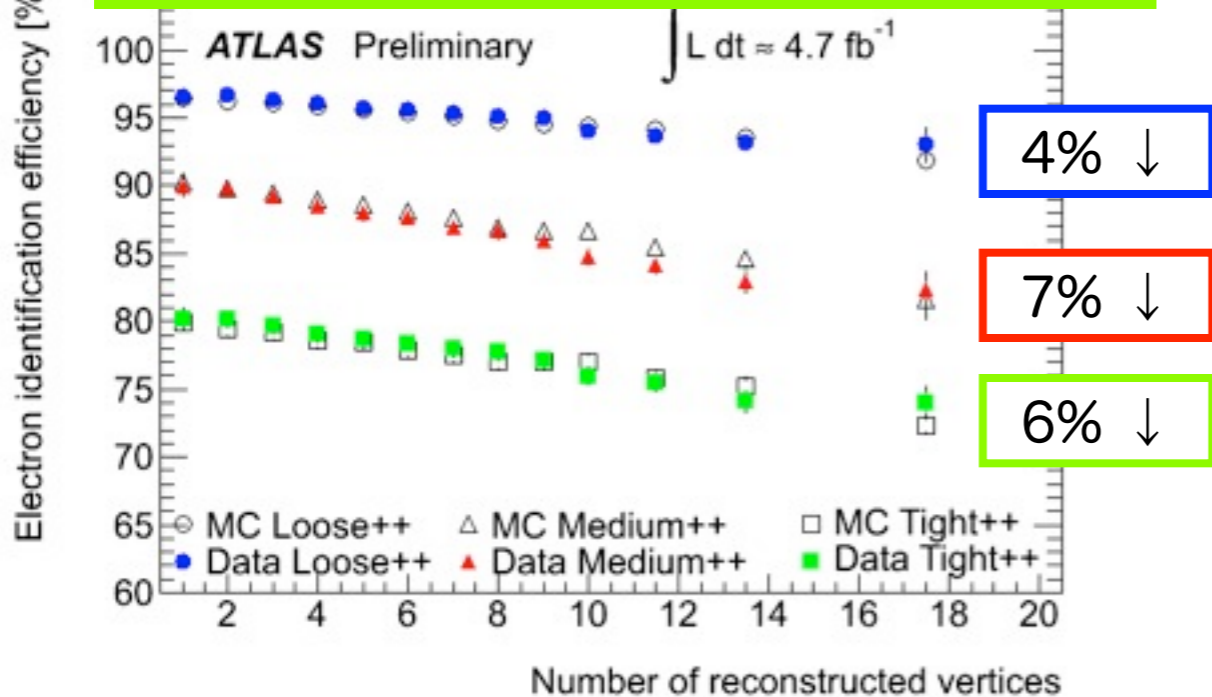
Z->2e mass resolution : 1.76 GeV

e-ID eff. : J/psi -> ee , W -> e nu , Z -> ee



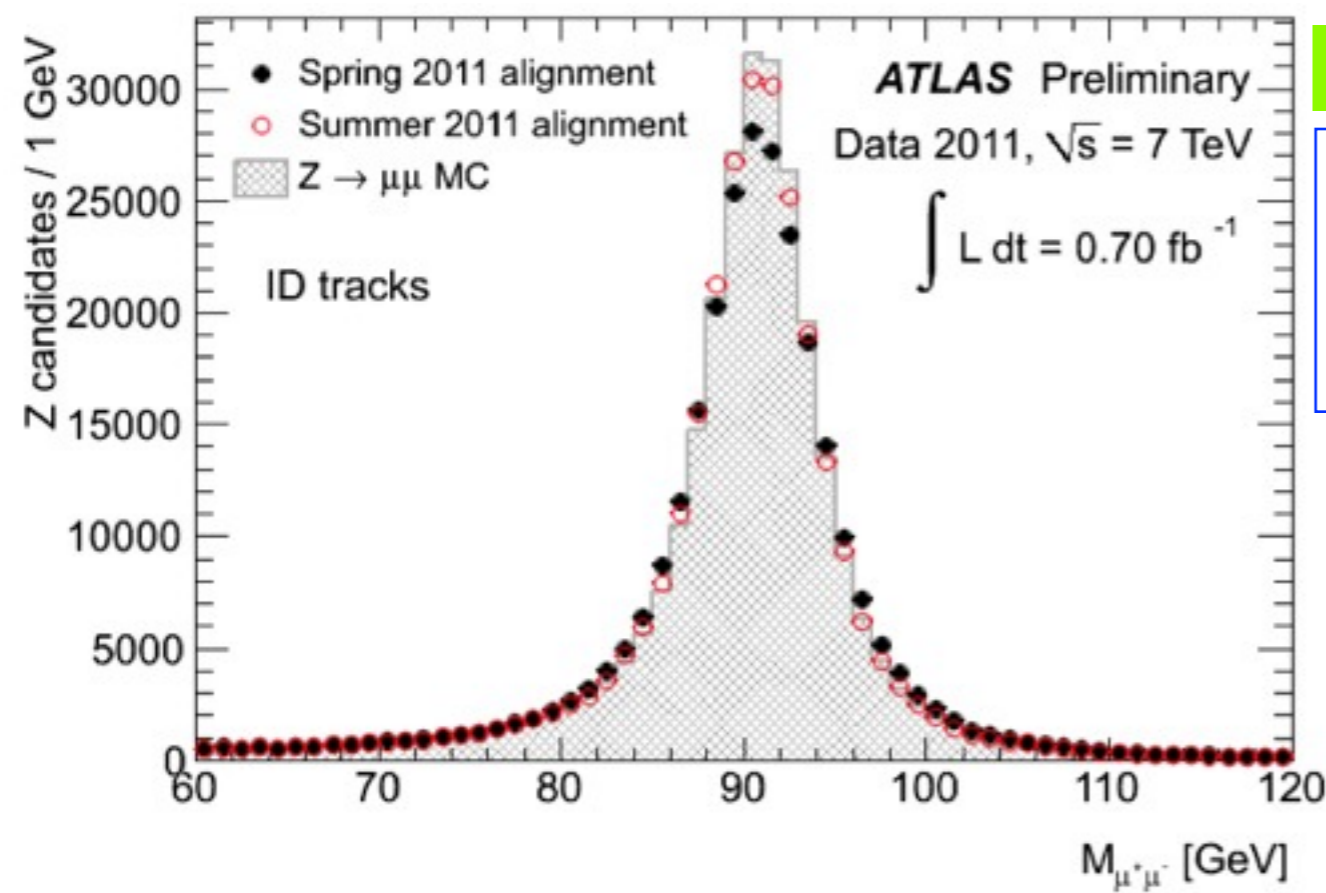
物質による効果が大い low-E_T electron の理解が特に重要

electron ID efficiency : Z -> ee event pileup (悪)効果 : 既出



無関係なハドロントラックが EM Calorimeter のシャワーに重なって しまう影響 -> eff. loss (* 努力の余地あり)

muon performance

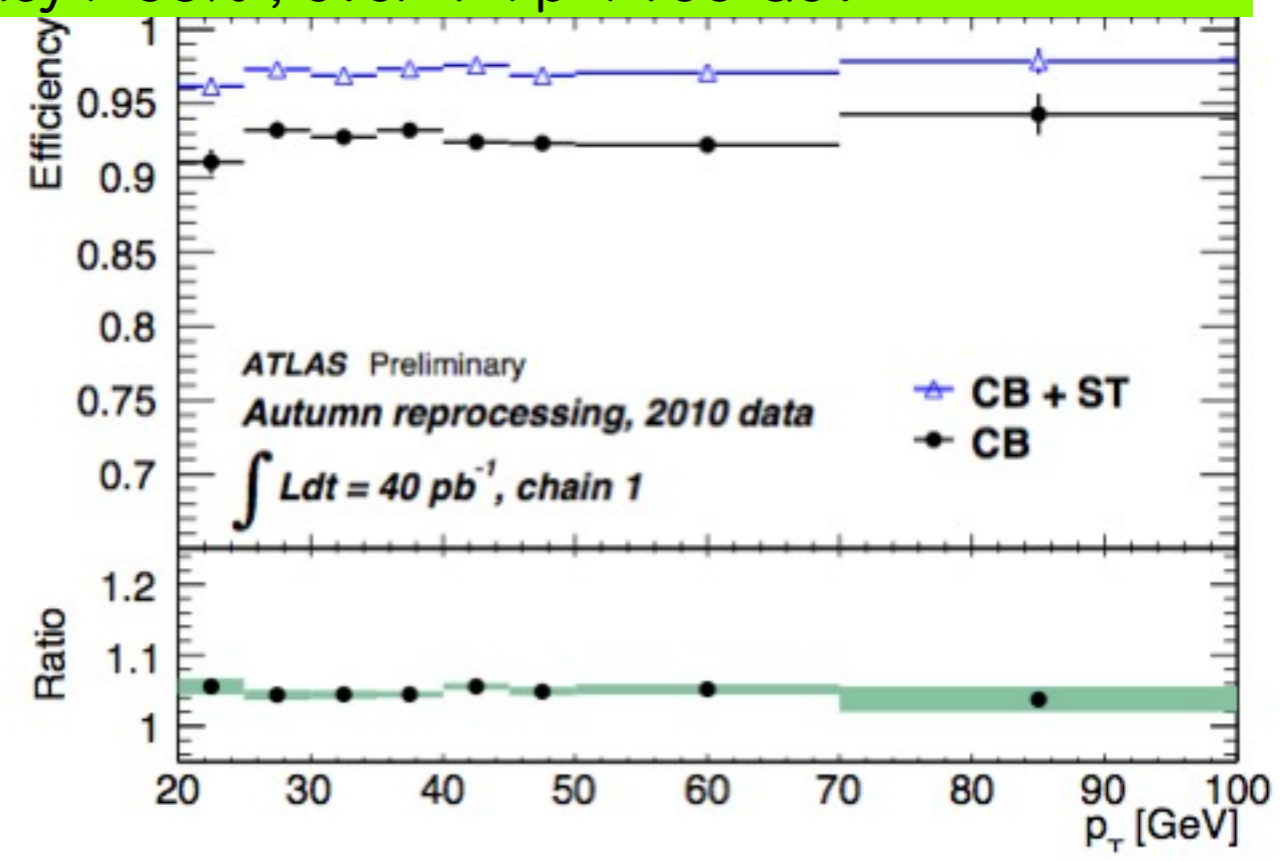
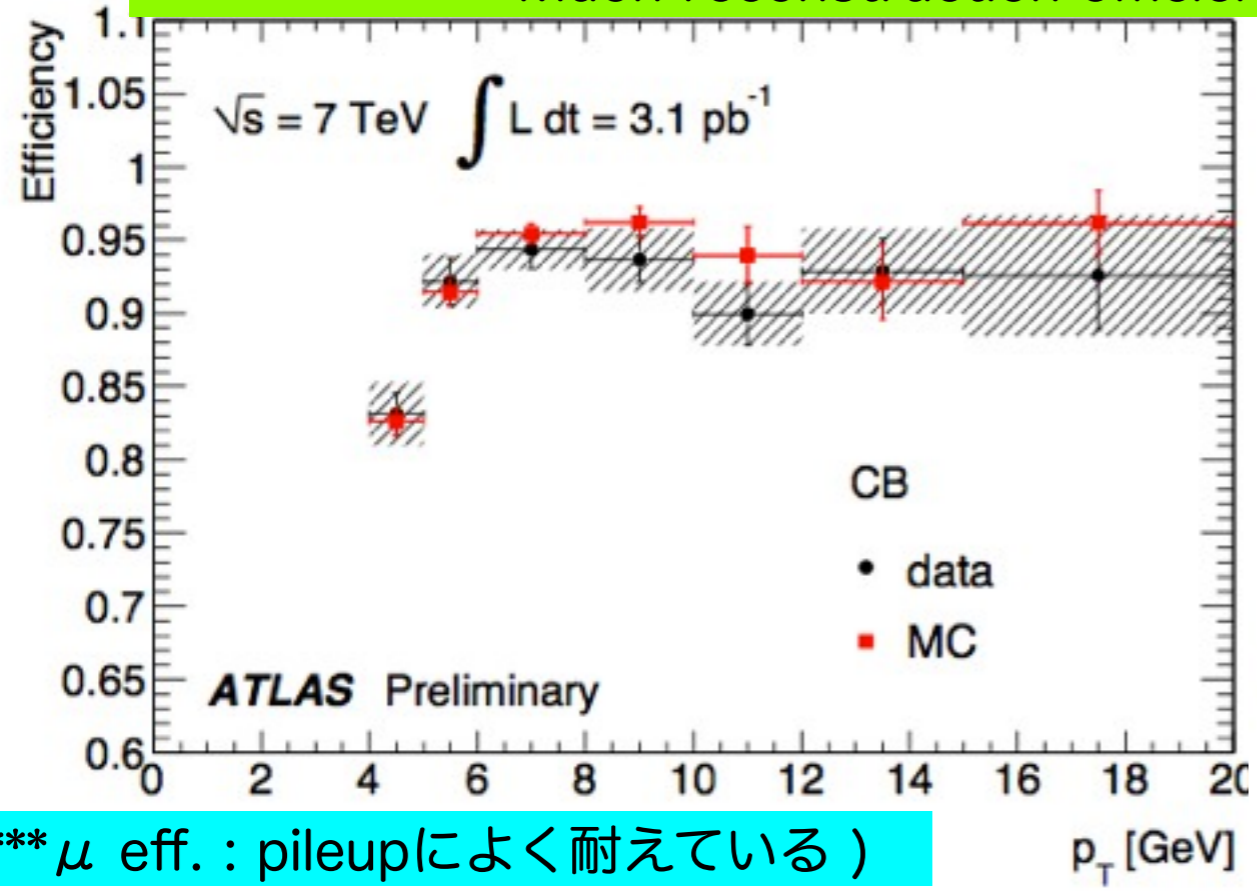


Z -> mu mu の inv. mass resolution

MC (perfect):	2.31 GeV
Data Spring 2011 :	2.89 GeV
Data Summer 2011:	2.45 GeV

アラインメントの精度は
究極の状況(MC : ~30 μm)に近づいてきた

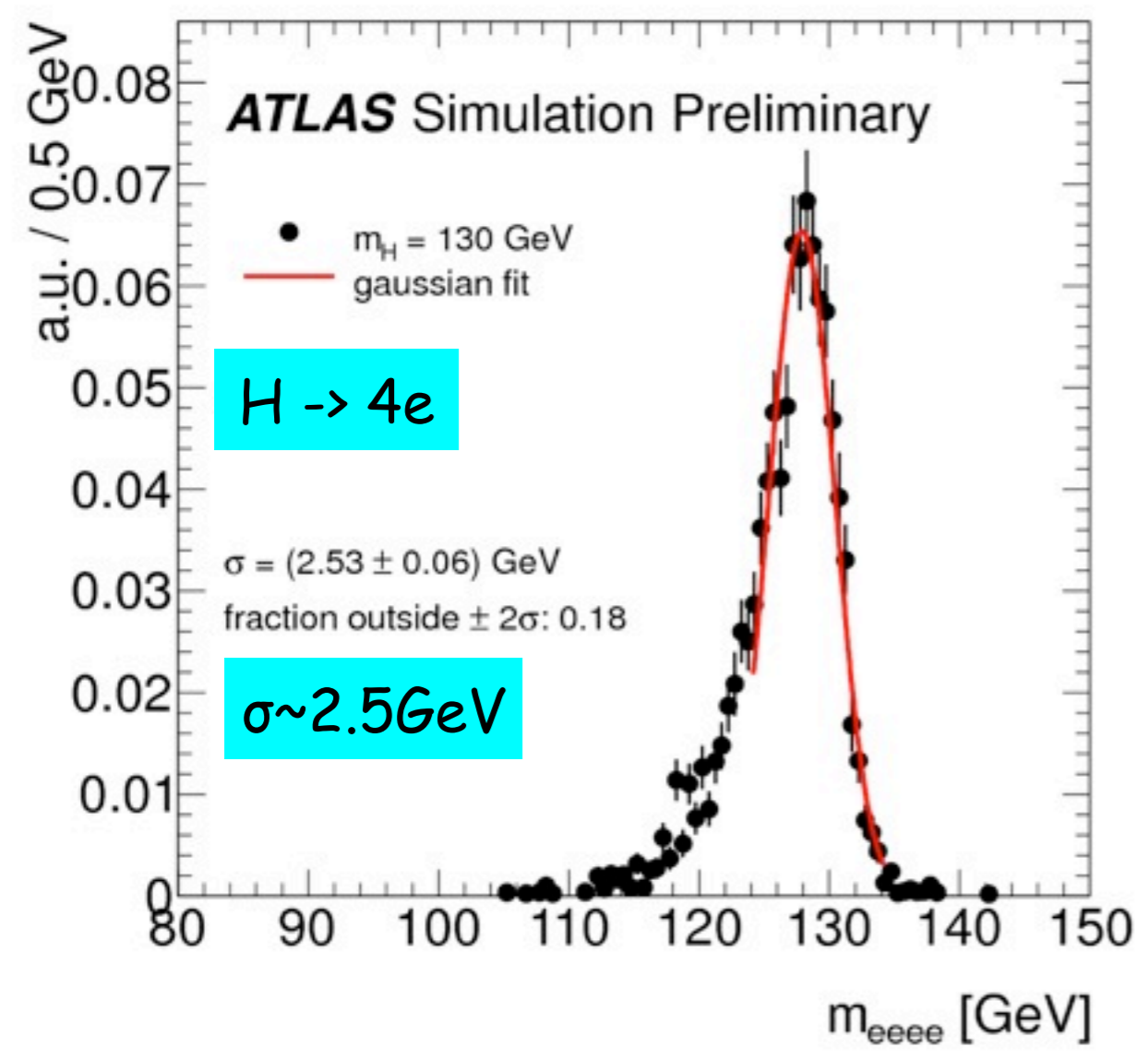
Muon reconstruction efficiency > 95% , over 4 < p < 100 GeV



(*** μ eff. : pileupによく耐えている)

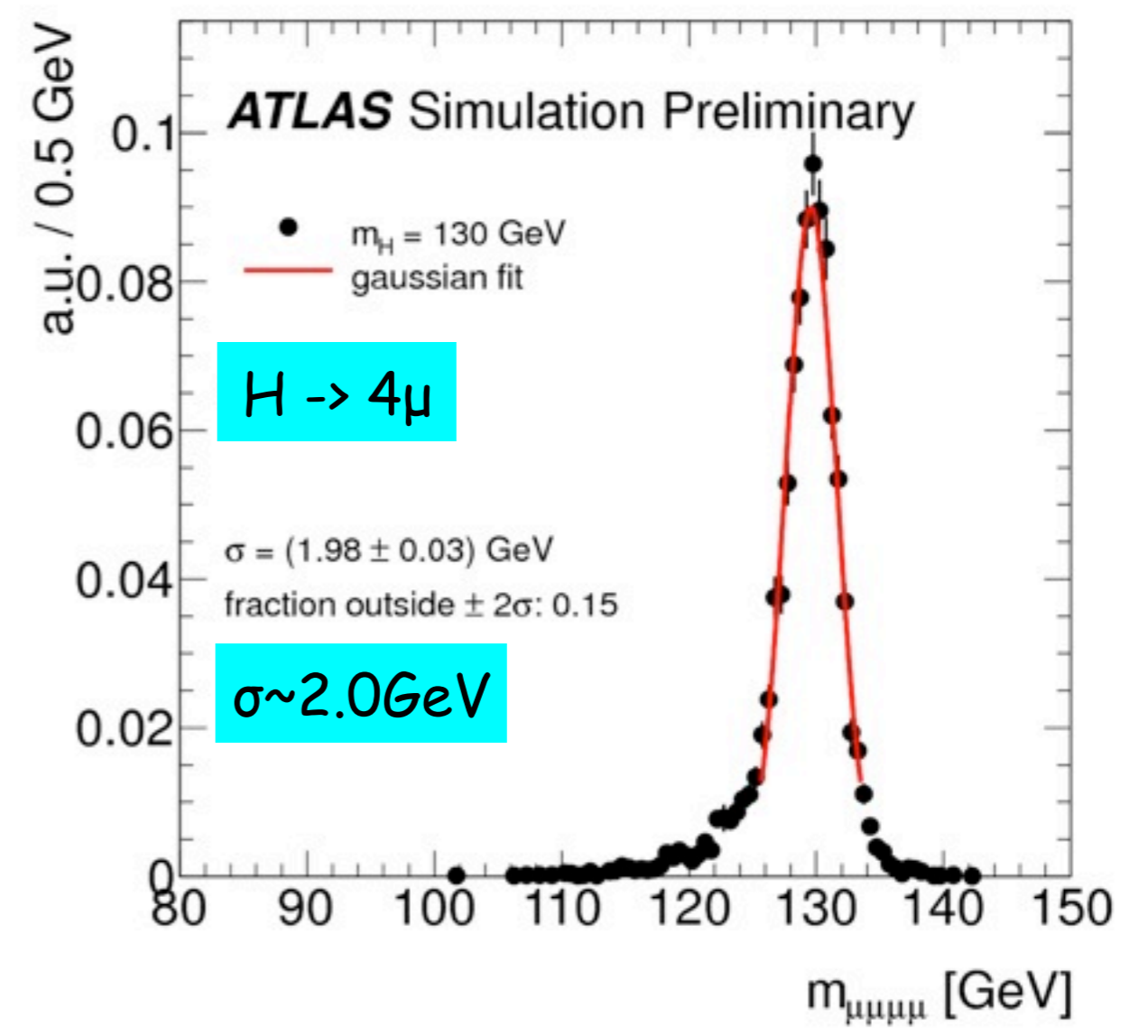
H(130GeV) -> 4Lepton 質量分布 (MC)

MC : H(130) -> ZZ -> 4e



$\pm 2\sigma$ の中に82%入る
 i.e. 10GeVの範囲に82%収まる

MC : H(130) -> ZZ -> 4μ

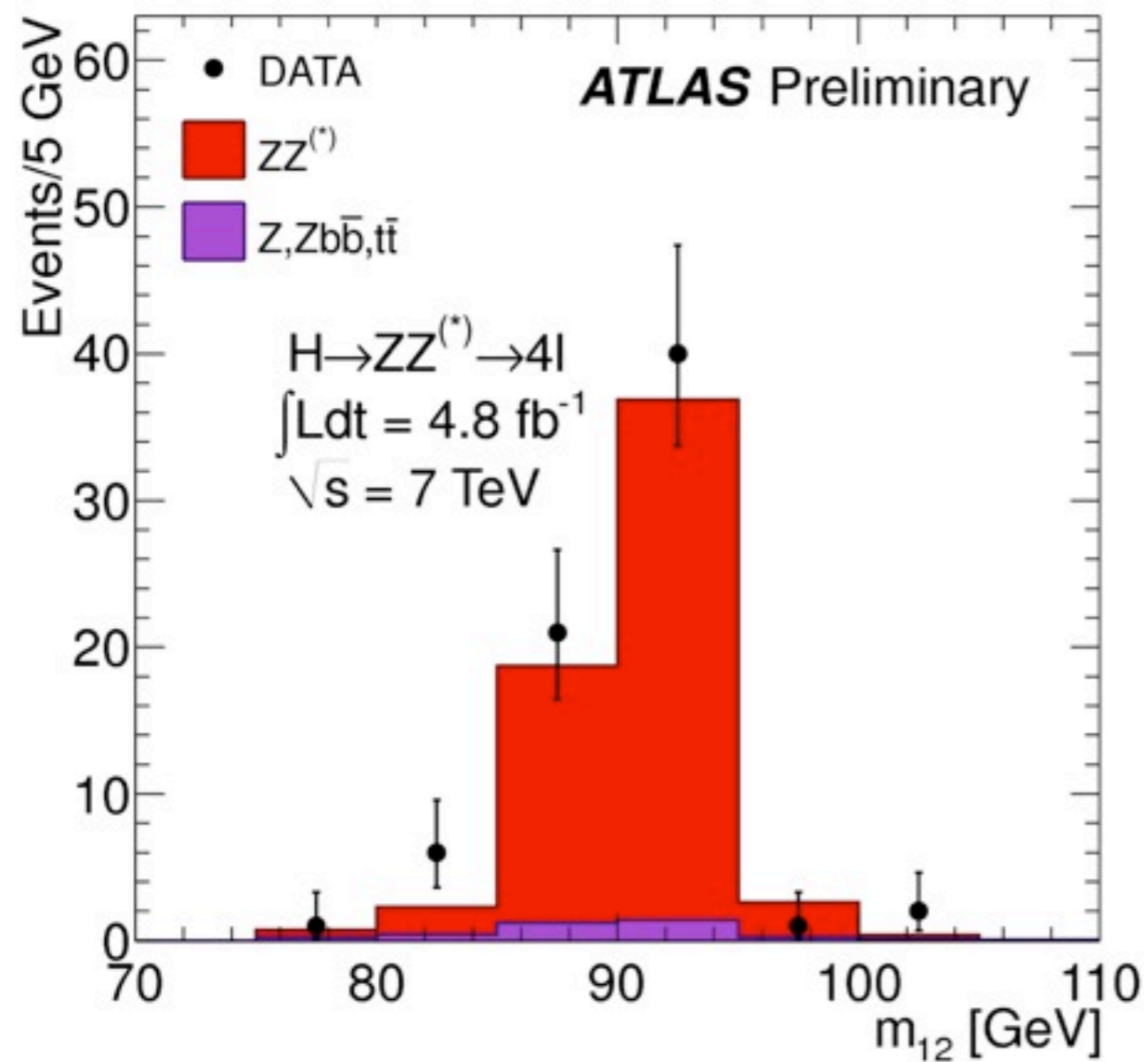


$\pm 2\sigma$ の中に85%入る
 i.e. 8GeVの範囲に85%収まる

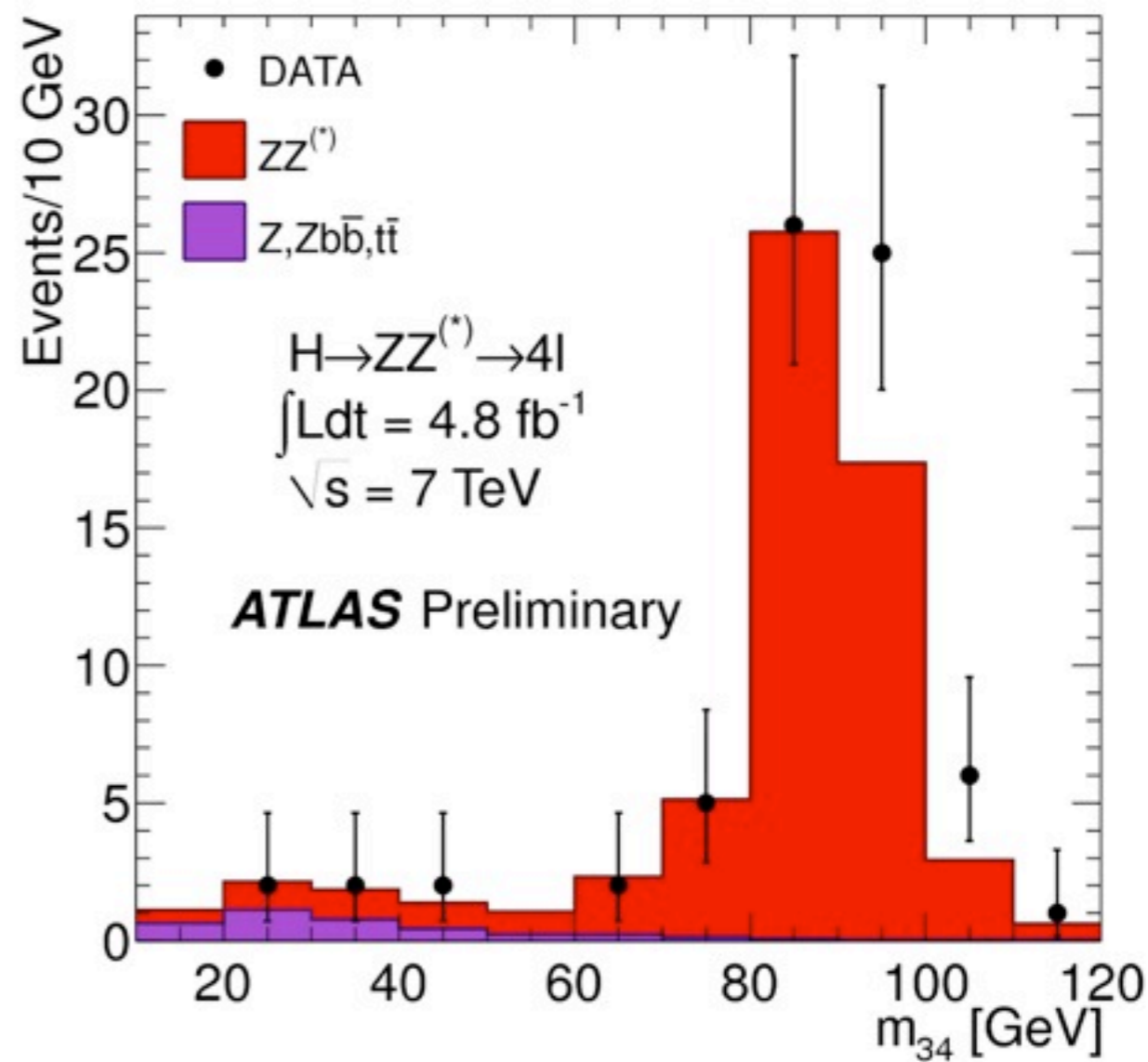


不變質量分布： m_{12} , m_{34}

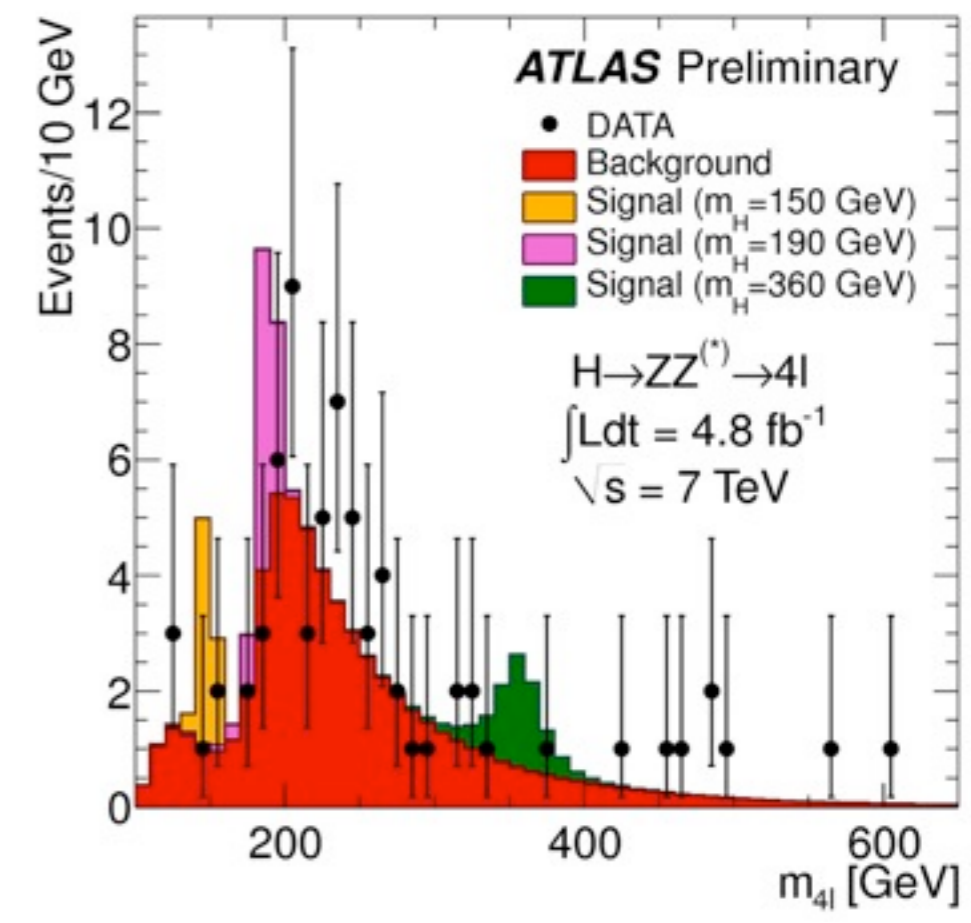
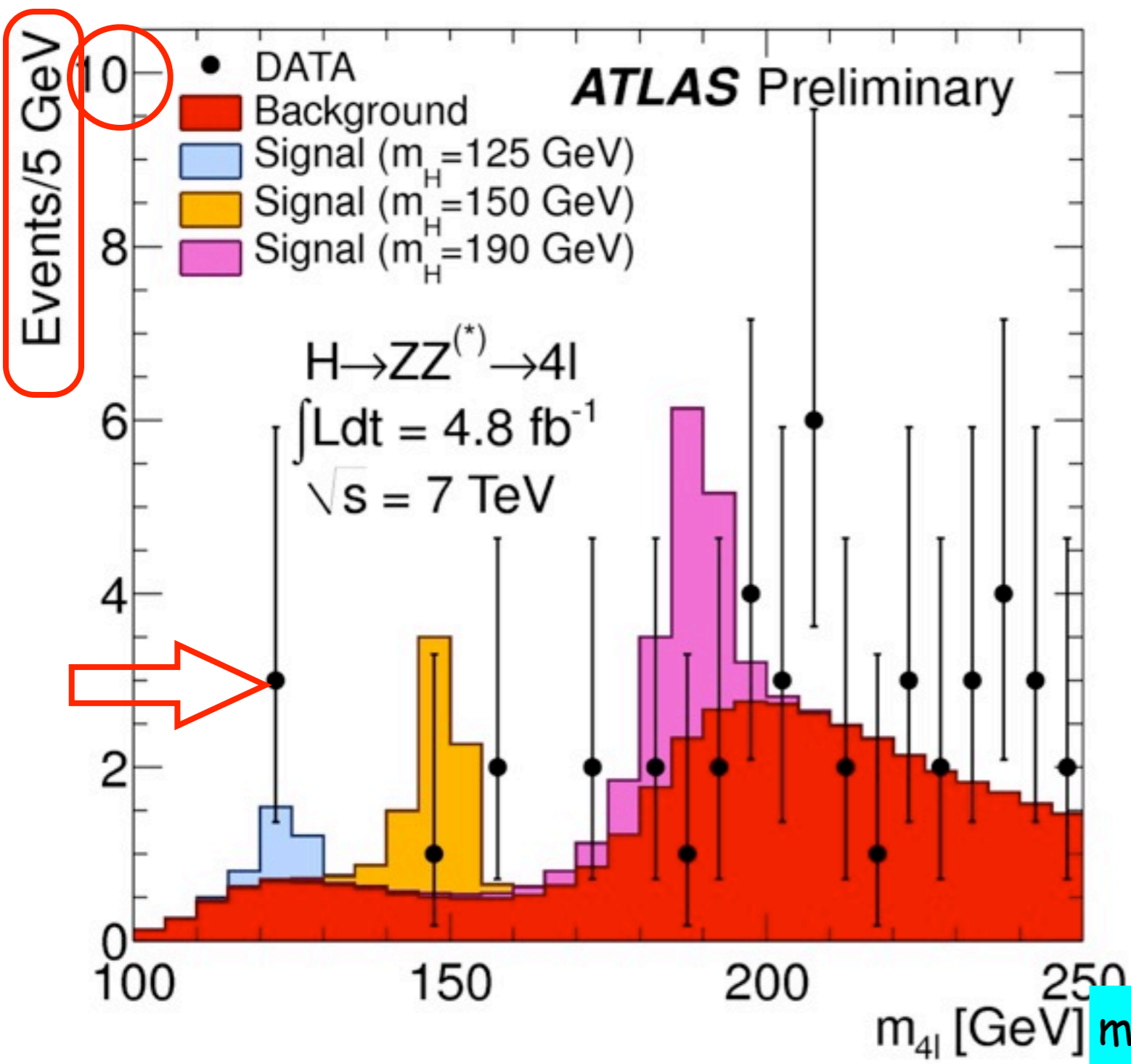
$m_{12} : ee, \mu\mu$



$m_{34} : ee, \mu\mu$



4Lepton 不変質量分布



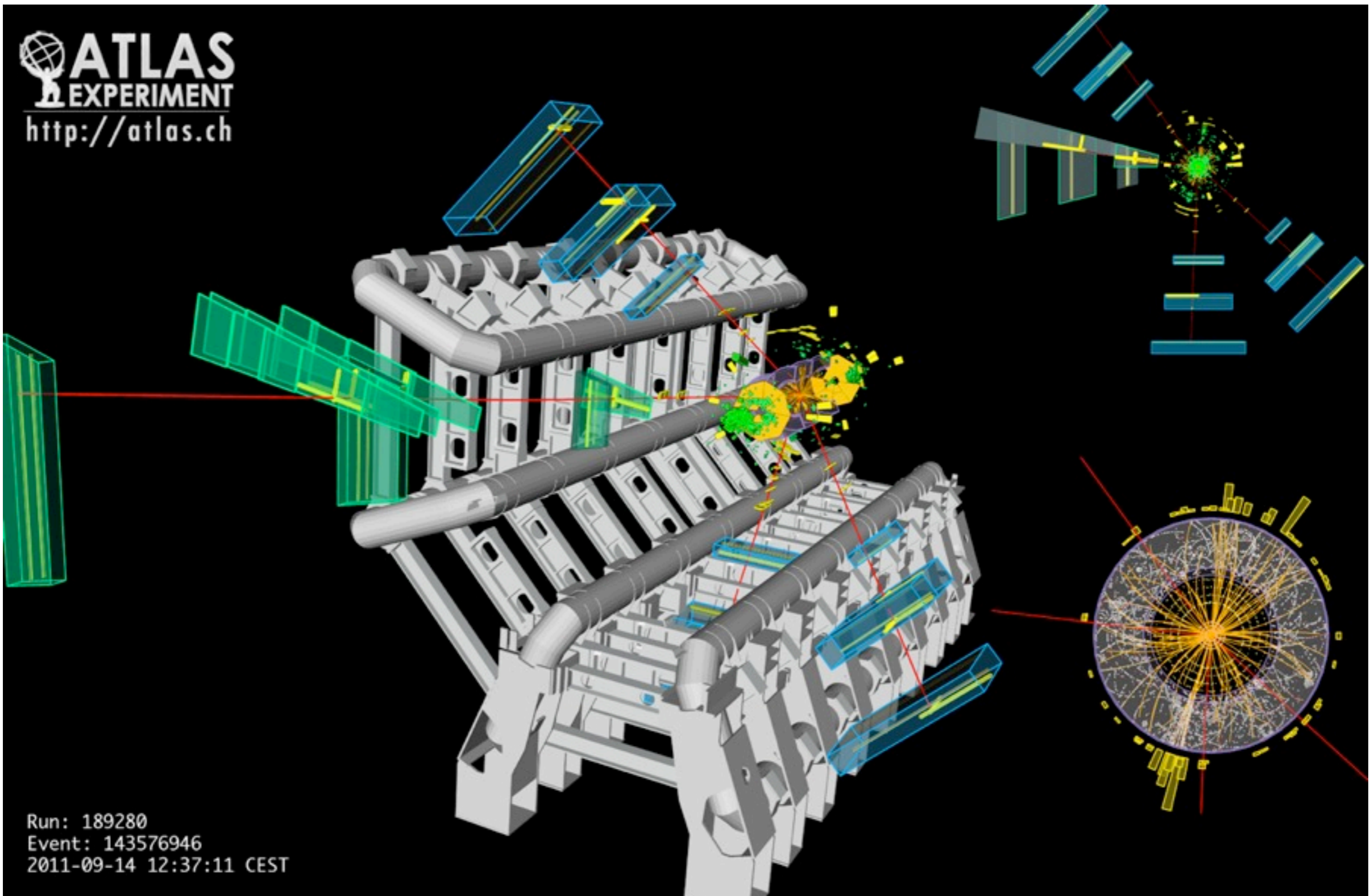
1bin (10GeV) に3イベント入ったのは やっぱり気になる

124.6 (4μ), 124.3 (2e2μ), 123.6 (2e2μ)

$m(4L) < 180 \text{ GeV}$
 Observed: 8 events:
 [3 (4μ) + 3 (2e2μ) + 2 (4e)]
 Expected from background: 9.3 ± 1.5

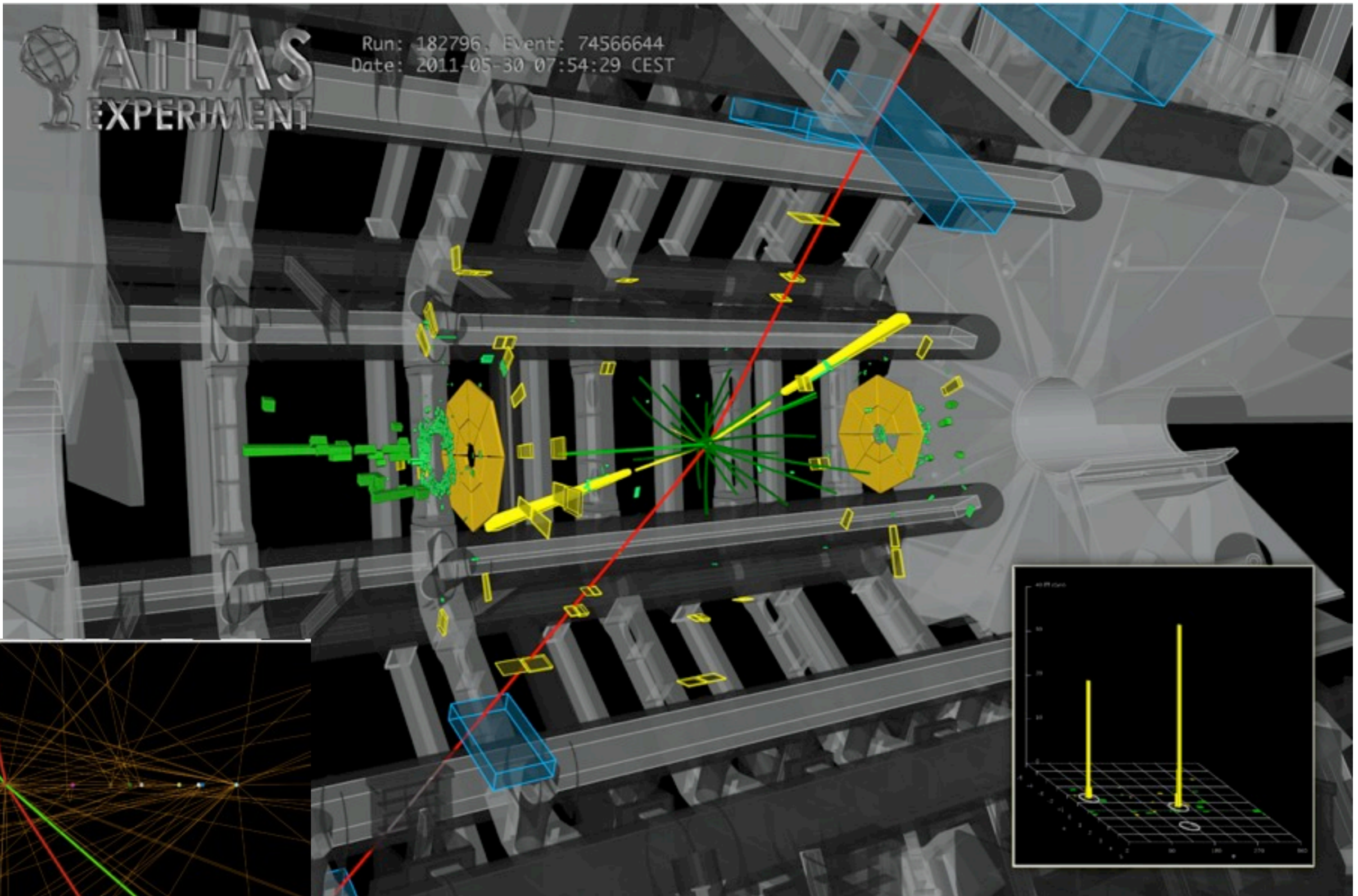
$$m_{4\mu} = 124.6 \text{ GeV}$$

$$p_T(\mu^-, \mu^+, \mu^+, \mu^-) = 61.2, 33.1, 17.8, 11.6 \text{ GeV}$$
$$m_{12} = 89.7 \text{ GeV}, \quad m_{34} = 24.6 \text{ GeV}$$

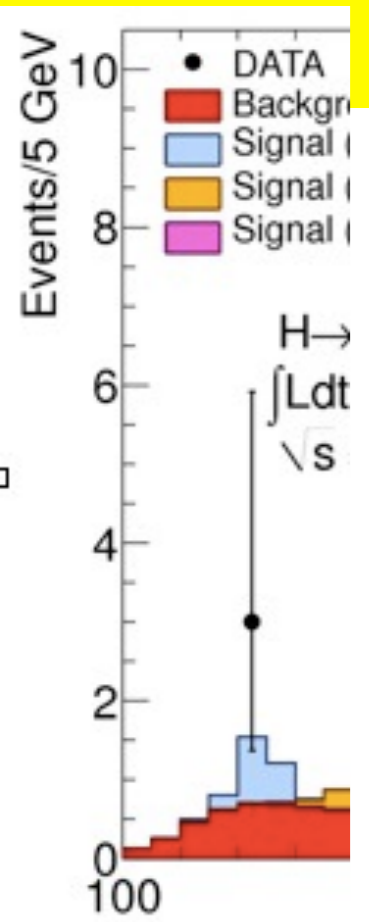


$$m_{2e2\mu} = 124.3 \text{ GeV}$$

$p_T(e^+, e^-, \mu^-, \mu^+) = 41.5, 26.5, 24.7, 18.3 \text{ GeV}$
 $m(e^+e^-) = 76.8 \text{ GeV}$, $m(\mu^+\mu^-) = 45.7 \text{ GeV}$



ZZ -> 4L : background に関する議論



$m_{4L} : 117 \sim 128 \text{ GeV}$ (if $m_H=125\text{GeV} \rightarrow \sim 90\%$ 含)

$S/B \sim 1$ [$S \sim 1.5, B \sim 1.5$]
 [$S/B : \sim 2 (4\mu), \sim 1 (2e2\mu), \sim 0.3 (4e)$]

Background

- $4\mu, 2e$: ZZ^* and $Z+\text{jets}$ (low)
- $4e$: ZZ^* and Zbb (low)

主なsystematic error

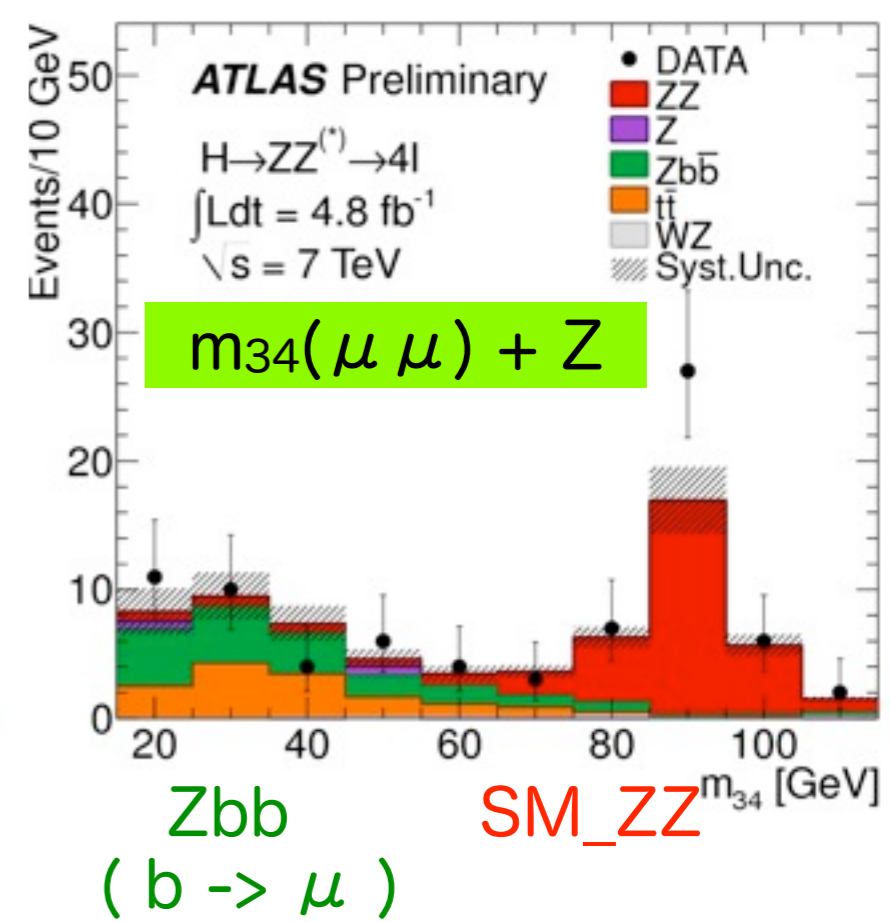
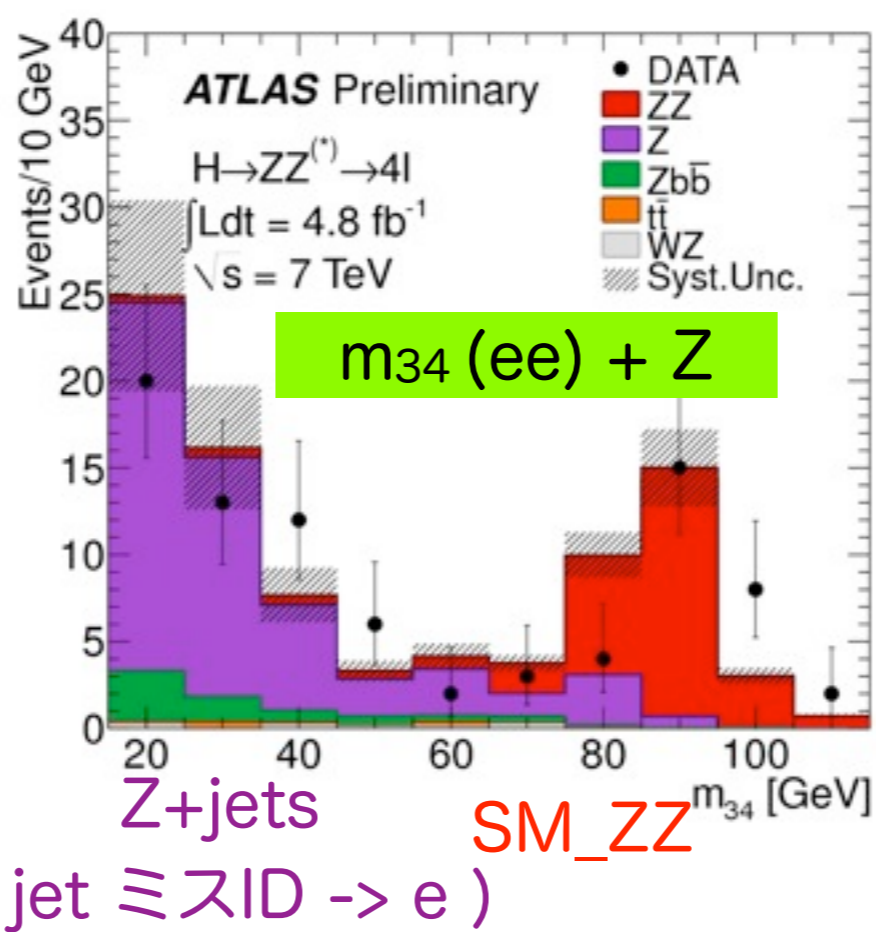
Higgs cross-section : $\sim 15\%$
 Electron efficiency : $\sim 2-8\%$
 ZZ^* background : $\sim 15\%$
 $Zbb, Z+\text{jets}$ backgrounds: $\sim 40\%$

3rd , 4th e / μ について、

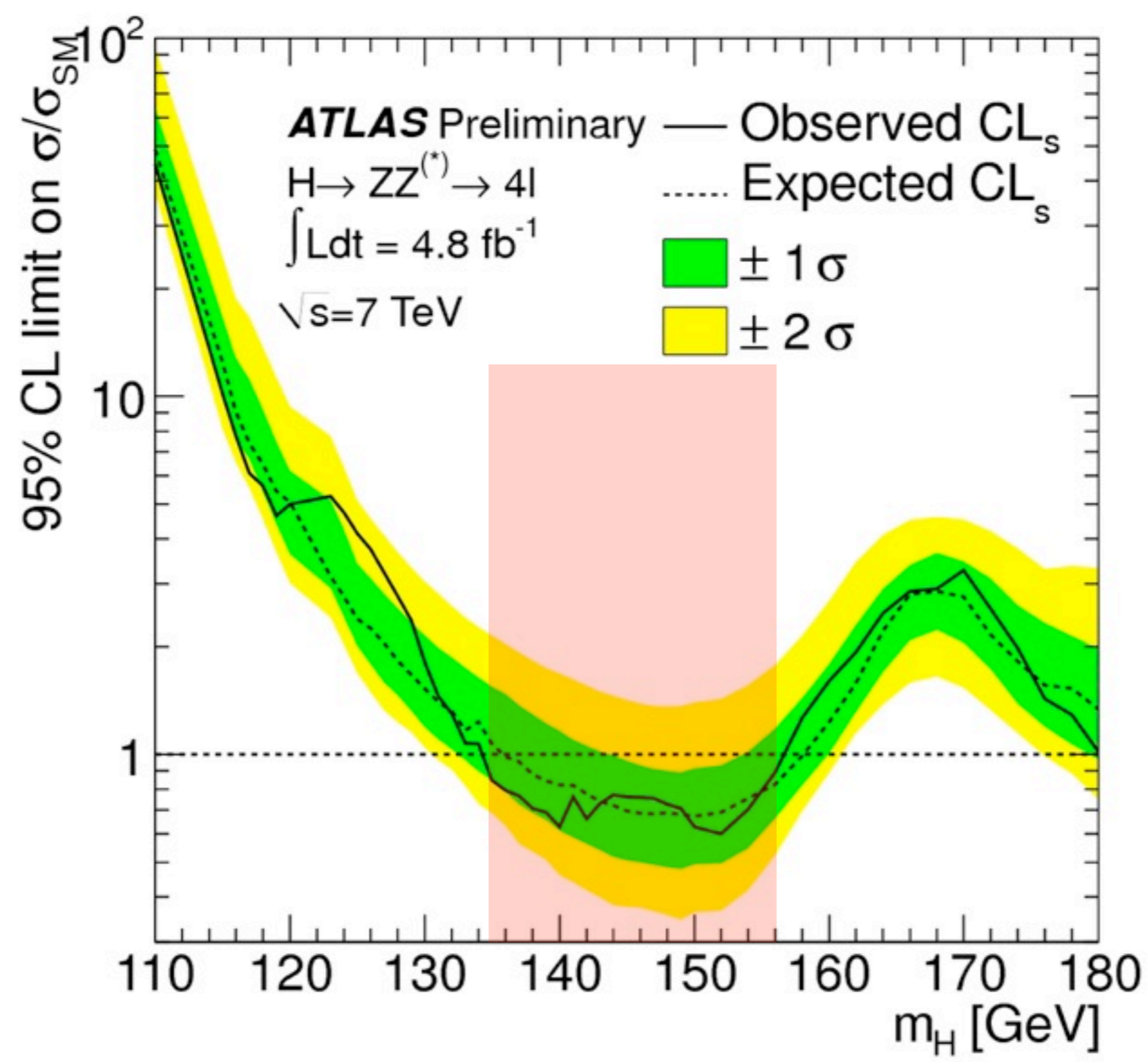
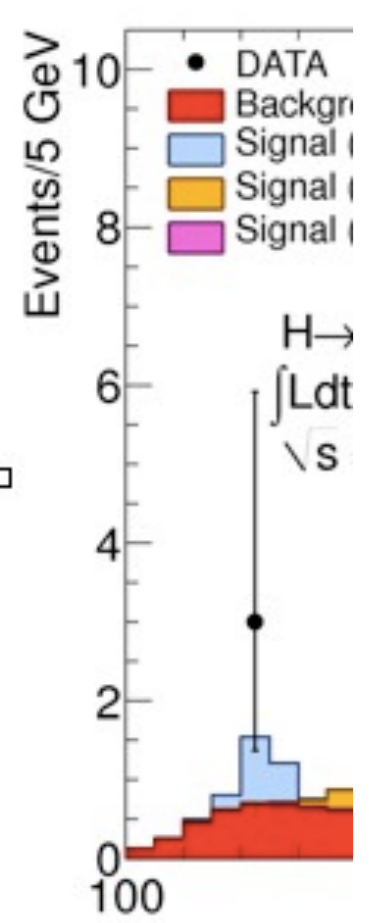
- isolation
- impact parameter

要求を緩めた時の m_{34} 分布
 (BGを enrichしたサンプル)

MC v.s. Data “リーズナブル”
 な一致 -> MCでBG評価



H -> ZZ -> 4L : sensitivity & exclusion



Excluded (95% CL): $135 < m_H < 156 \text{ GeV}$ and $181 < m_H < 415 \text{ GeV}$
 Expected (95% CL): $137 < m_H < 158 \text{ GeV}$ and $185 < m_H < 400 \text{ GeV}$

Higgs $\rightarrow \gamma \gamma$

- $\sigma \cdot \text{Br} \sim 40\text{fb}$
- 終状態：2本 x isolated- γ (simple !)
- ✓ $E_T(\gamma_1, \gamma_2) > 40, 25\text{GeV}$
- ✓ 但し $\gamma \rightarrow e^+e^-$ も取り扱う (物質量 $> 2X_0$)

• S/B：非常によろしくない ~ 0.02

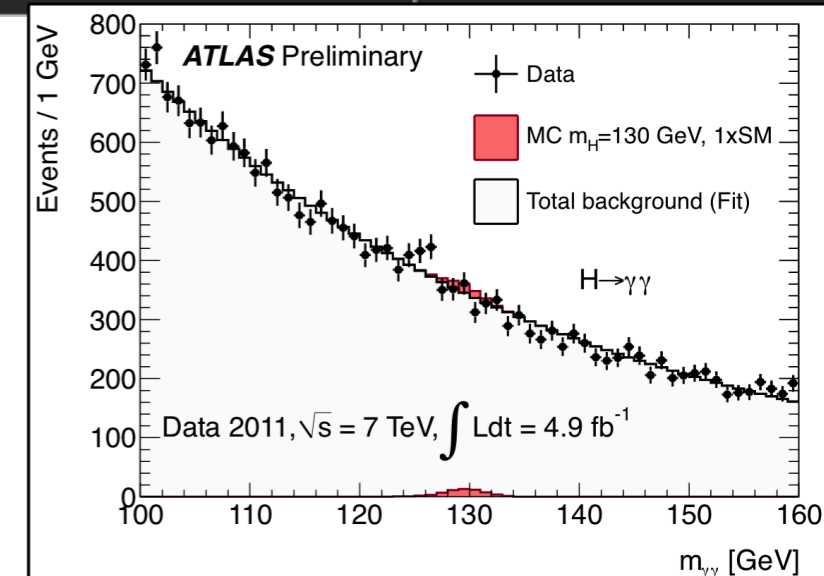
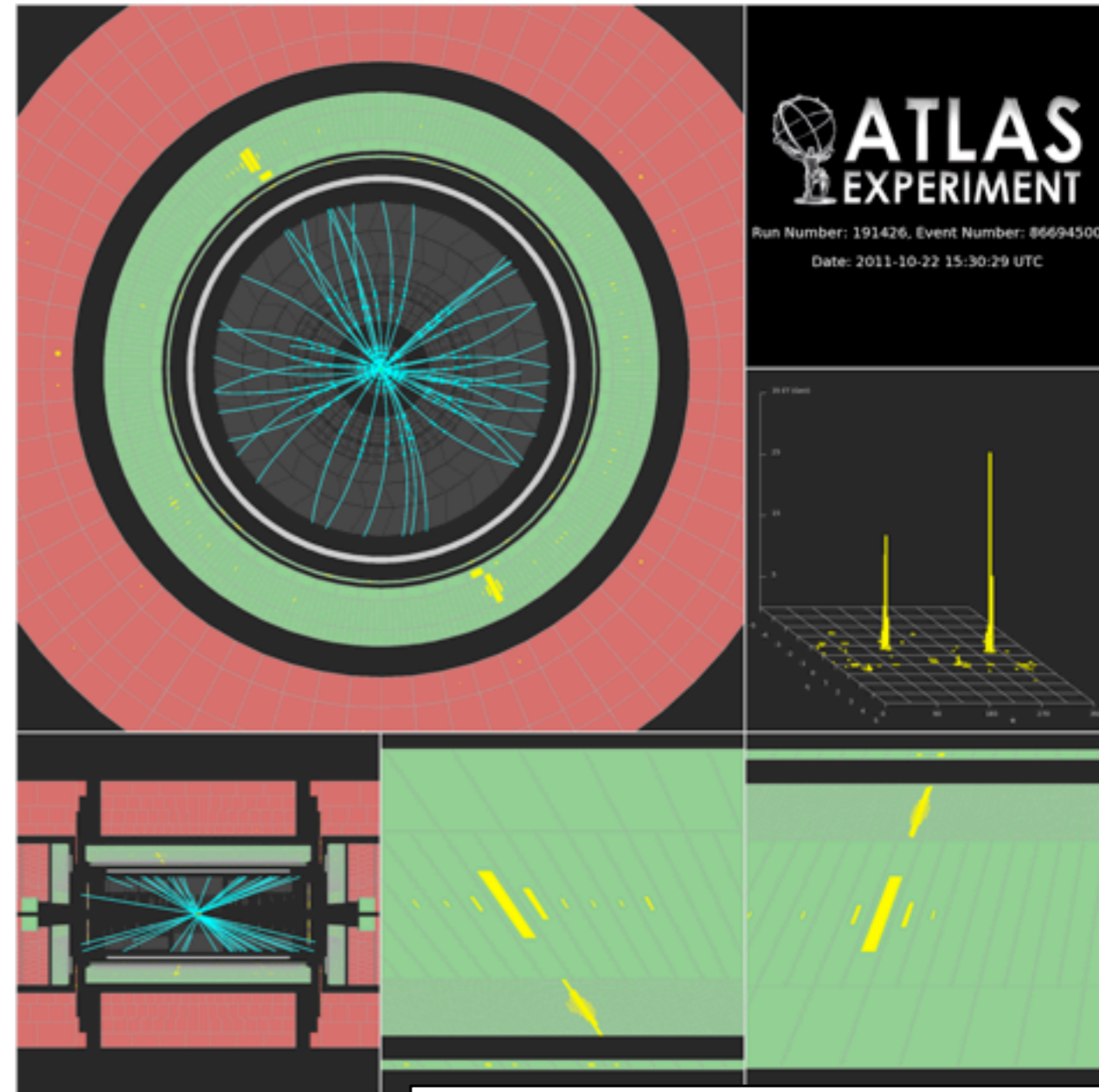
✓ $S \sim 70 / B \sim 3,000 @ 4.9\text{fb}^{-1} (m_H \sim 125\text{GeV})$



$\gamma \gamma$ continuum / smooth BGを作る
その上でのつかかる「肩」をみつける勝負

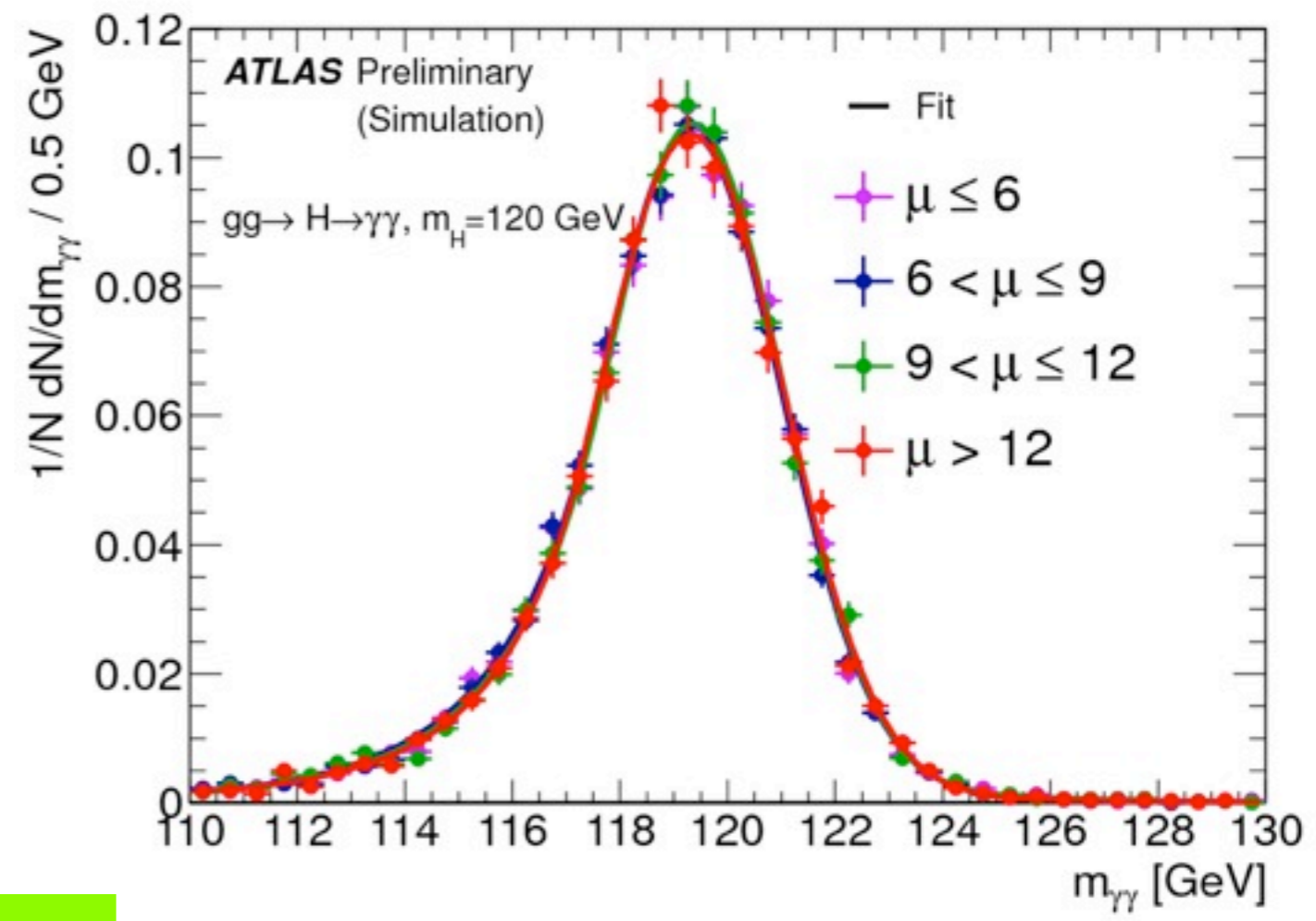
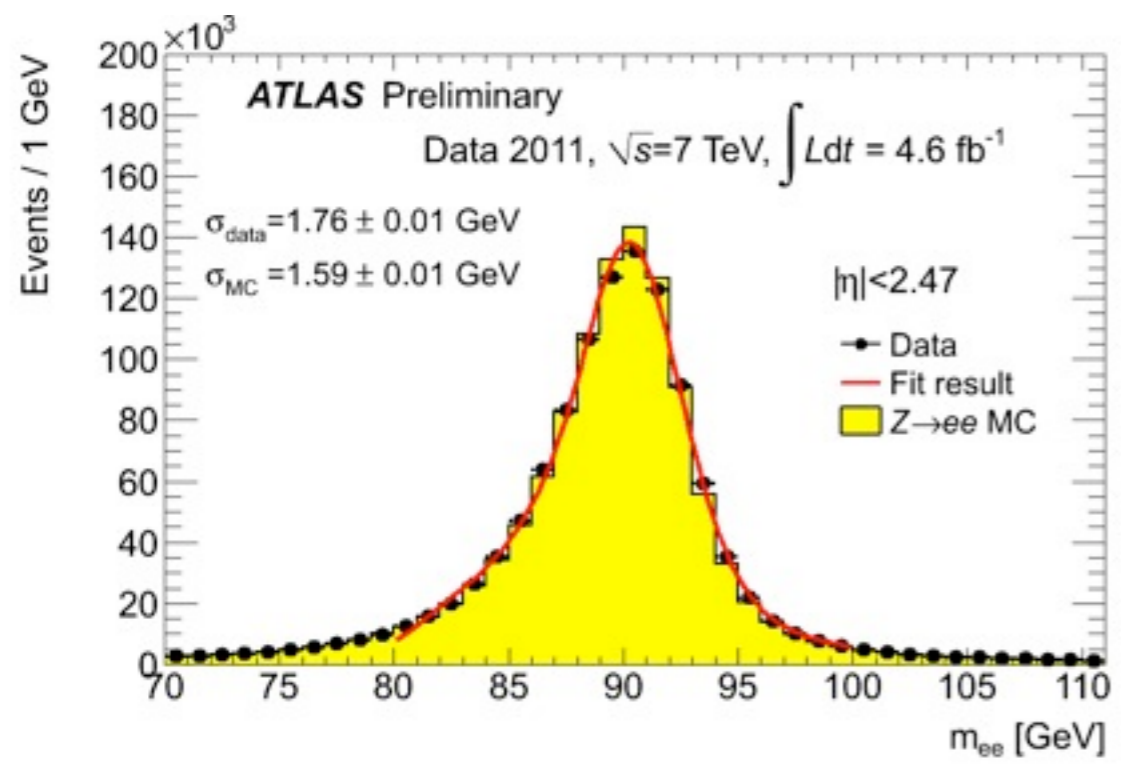
(i) mass resolution
 $\gamma \gamma$ 重要 !!

(ii) $\gamma j, jj$ BGを減らす
ために π^0/γ 区別重要



(i) mass resolution ~ Energy測定

$$m_{\gamma\gamma}^2 = 2 E_1 E_2 (1 - \cos\alpha)$$



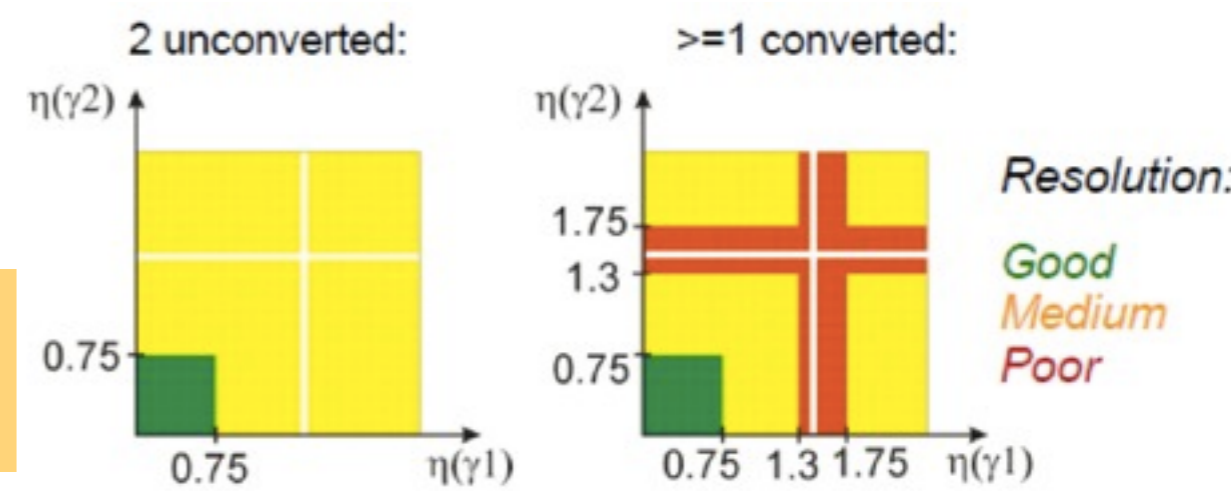
Z \rightarrow ee (Data) 既出 @ 4Leptons
e \rightarrow γ 結果を外挿 via MC

- energy scale : 0.5% @ M_Z
- Linearity : < 1% (a few GeV ~ n x 100 GeV)
- Uniformity : 1% Barrel / 1.7% Endcap

event pileup に対して、強い

$m_H = 120 \text{ GeV}$

$\sigma(m_{\gamma\gamma})$: 1.4 (best) ~ 2.3 GeV (worst)
[all : 1.7 GeV] 4Lより良い



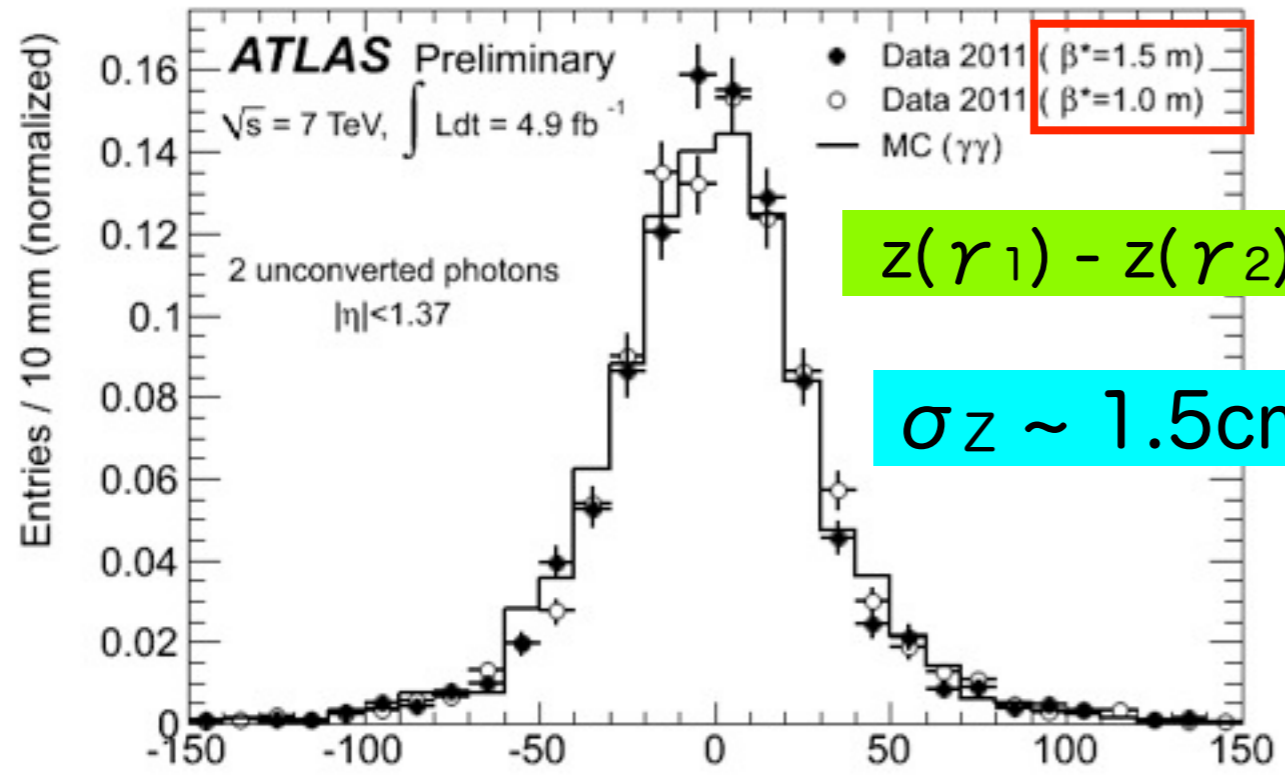
(i) mass resolution [$\alpha : 2r$ の間の角度]

$$m_{\gamma\gamma}^2 = 2 E_1 E_2 (1 - \cos\alpha)$$

$$\frac{\Delta m_H}{m_H} = \frac{1}{2} \left(\frac{\Delta E_1}{E_1} \oplus \frac{\Delta E_2}{E_2} \oplus \frac{\Delta\alpha}{\tan(\alpha/2)} \right)$$

negligible

2つの (conversionしなかった) r の Z-Vertex resolutionの差[mm] (ビーム方向)

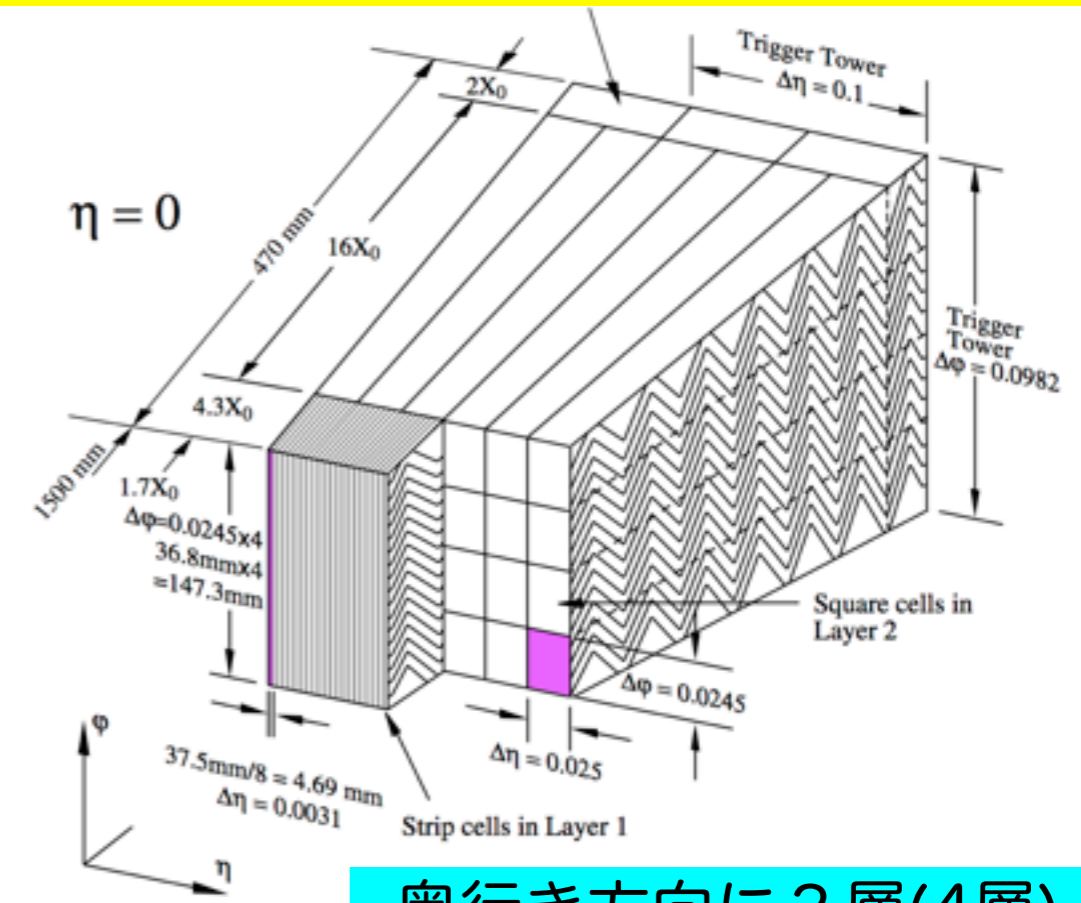


$z(r_1) - z(r_2)$

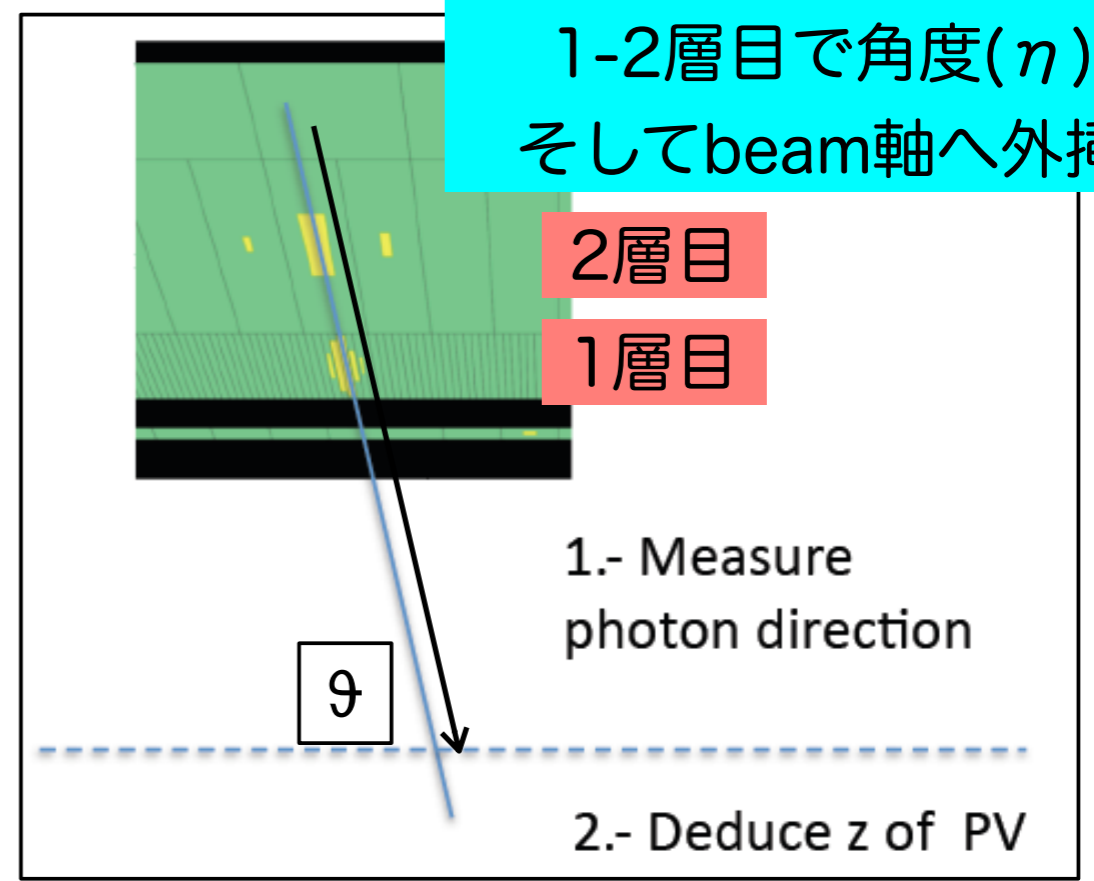
$\sigma_z \sim 1.5 \text{ cm}$

pileupの増大に耐えている

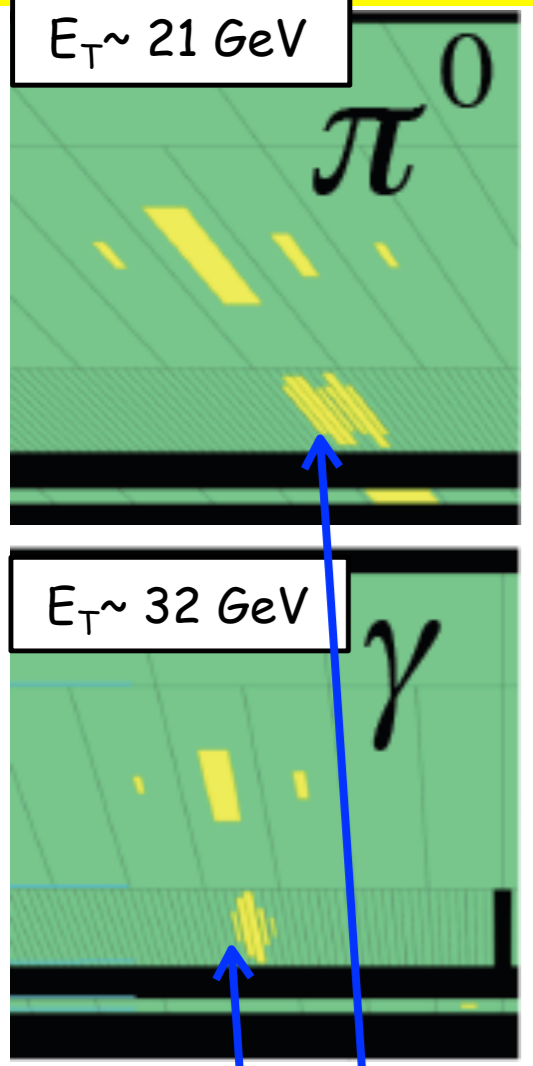
conversionした $r \rightarrow ee$ については、CALO activity重心と conversion point を結ぶ線を利用 $\rightarrow Z_vertex$



奥行き方向に3層(4層) 1-2層目で角度(η) そしてbeam軸へ外挿



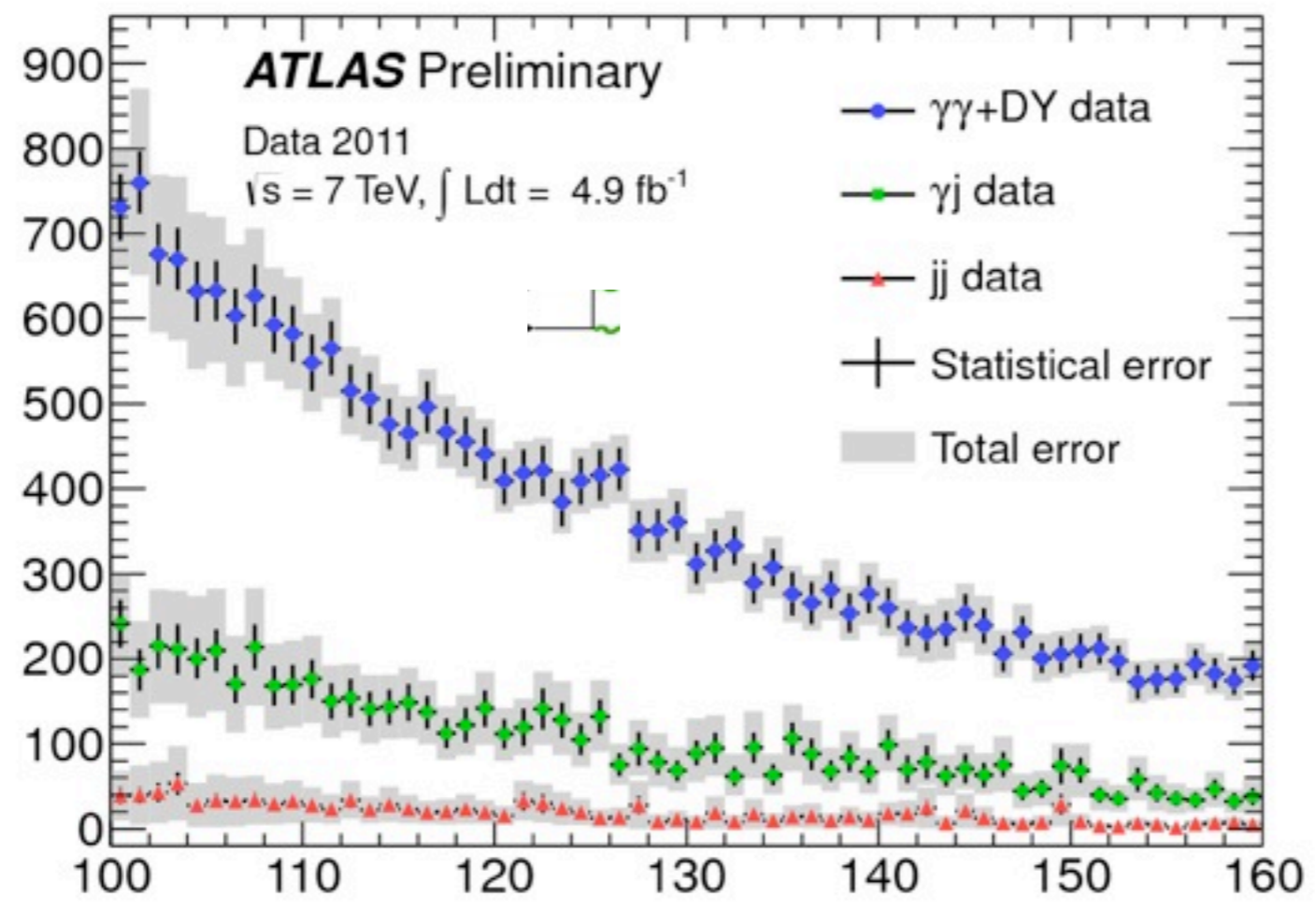
(ii) Background : jj , $\gamma j \sim \pi^0/\gamma$



1層目 : 4mm
ピッチの strip (n)

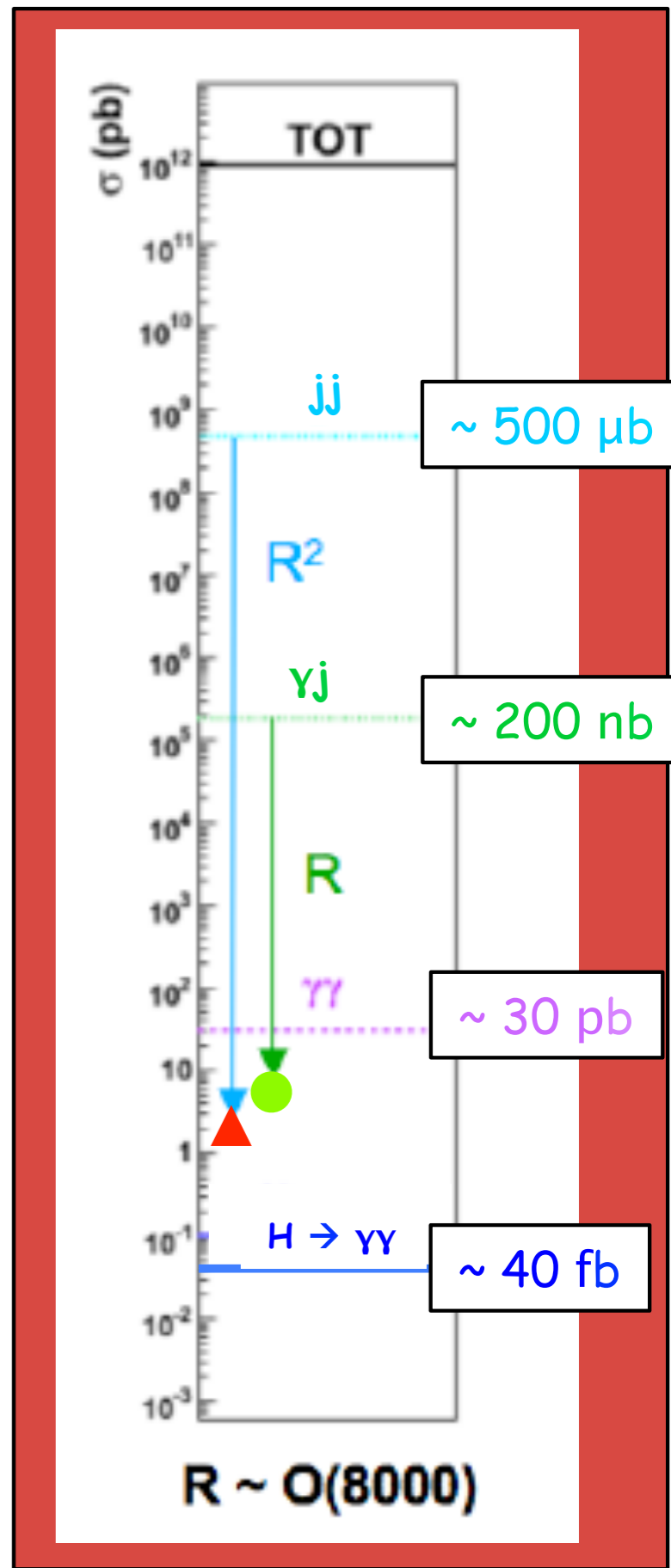
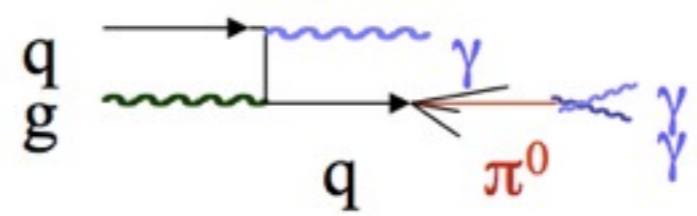
lateral shower shapeを利用して
 $\pi^0 \rightarrow 2\gamma$ (を1 γ にミスIDしてしまう)
rejectionをガンバルことで
 γj , jj を減らしている

$R \sim 4$ 桁!!



	Number of events	Fraction
$\gamma\gamma$	16000 ± 1120	$71 \pm 5\%$
γj	5230 ± 890	$23 \pm 4\%$
jj	1130 ± 600	$5 \pm 3\%$
DY/Z	165 ± 8	$0.7 \pm 0.1\%$

$\gamma j + jj \ll \gamma\gamma$ (irreducible)
purity $\sim 70\%$



$\sim 500 \mu\text{b}$

$\sim 200 \text{ nb}$

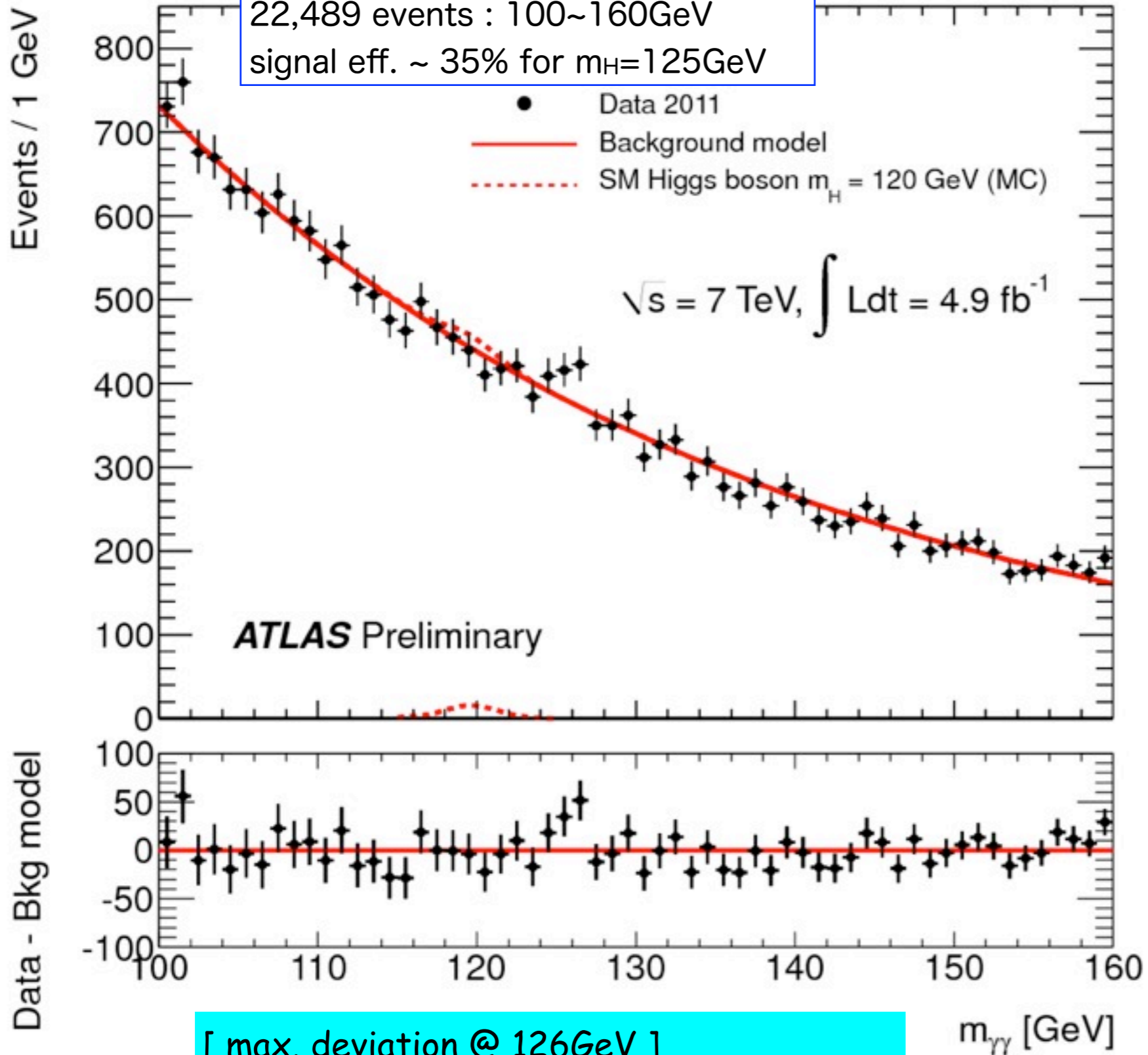
$\sim 30 \text{ pb}$

$\sim 40 \text{ fb}$

$R \sim O(8000)$

$\gamma\gamma$ invariant mass

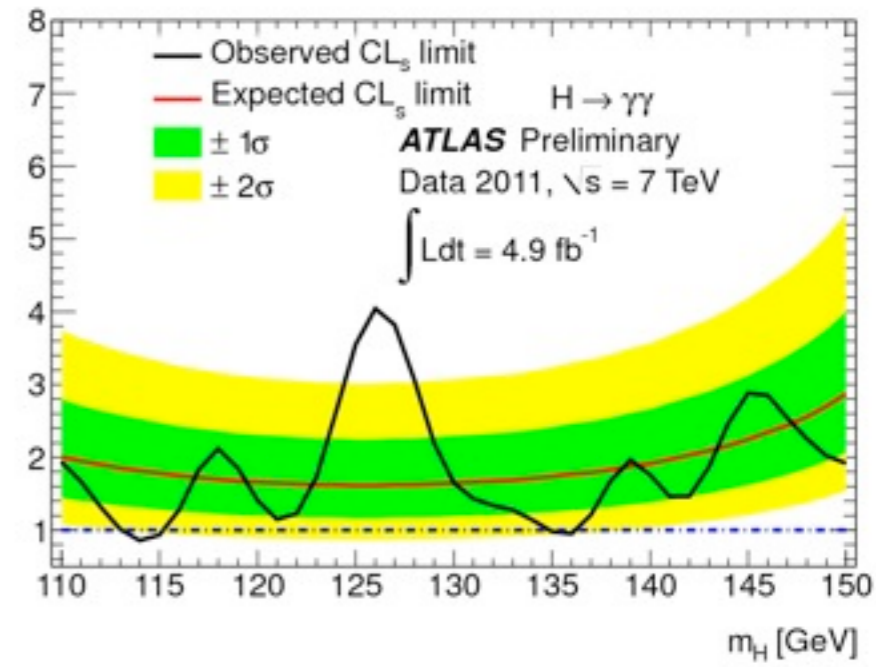
22,489 events : 100~160GeV
 signal eff. ~ 35% for $m_H=125\text{GeV}$



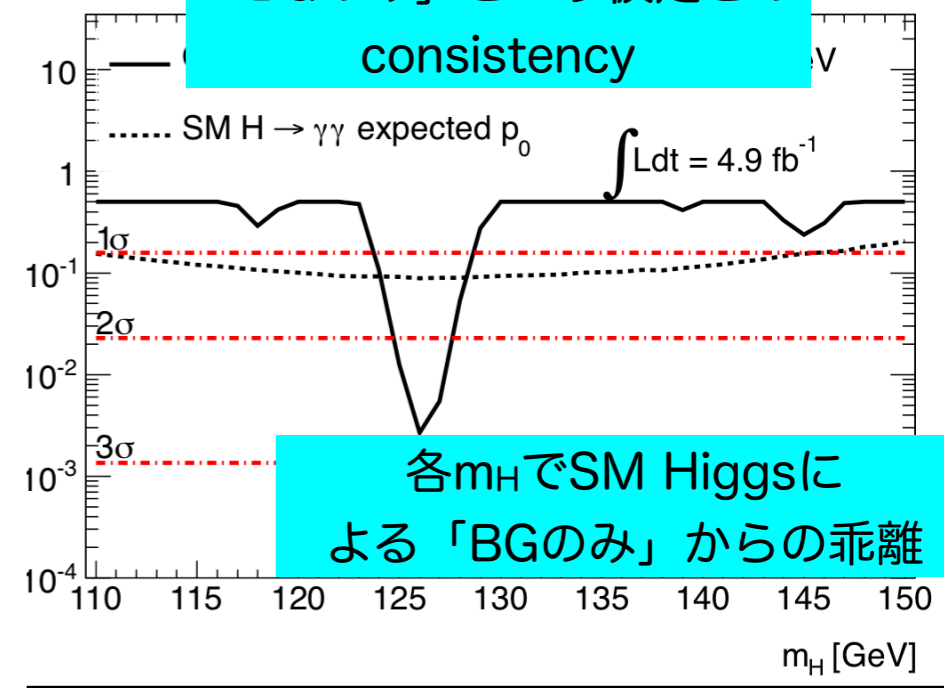
[max. deviation @ 126GeV]
 • local- P_0 : 0.27% (2.8σ) \rightarrow 1.5σ (LEE)
 • expect SM : 1.4σ

ちょっと大きすぎ...

95% CL limit on σ/σ_{SM}

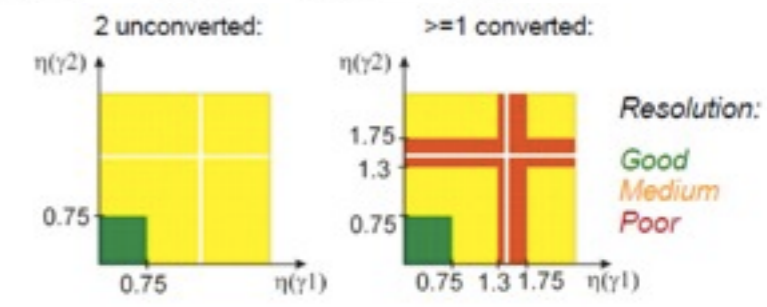
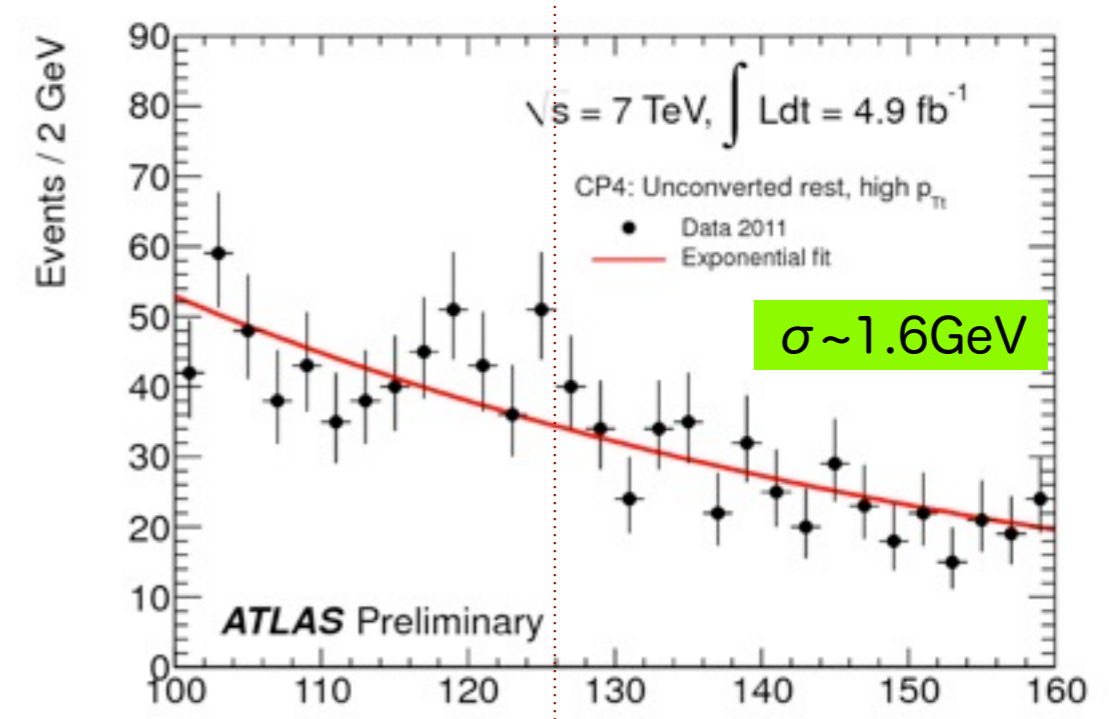
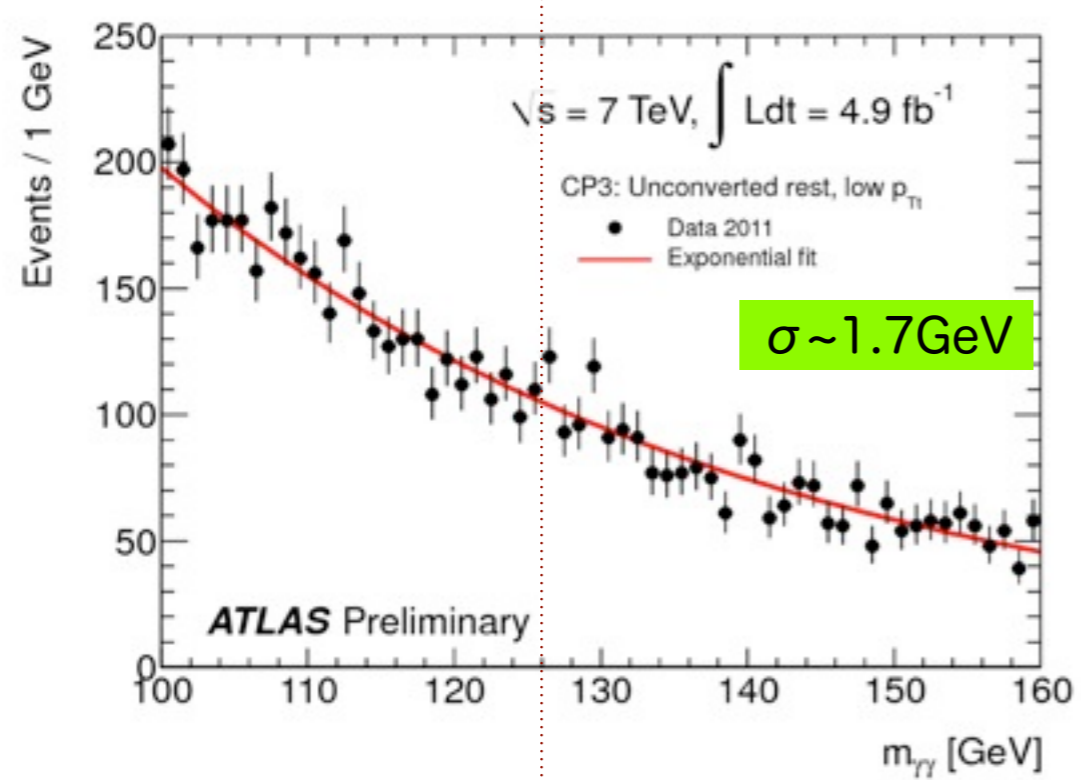
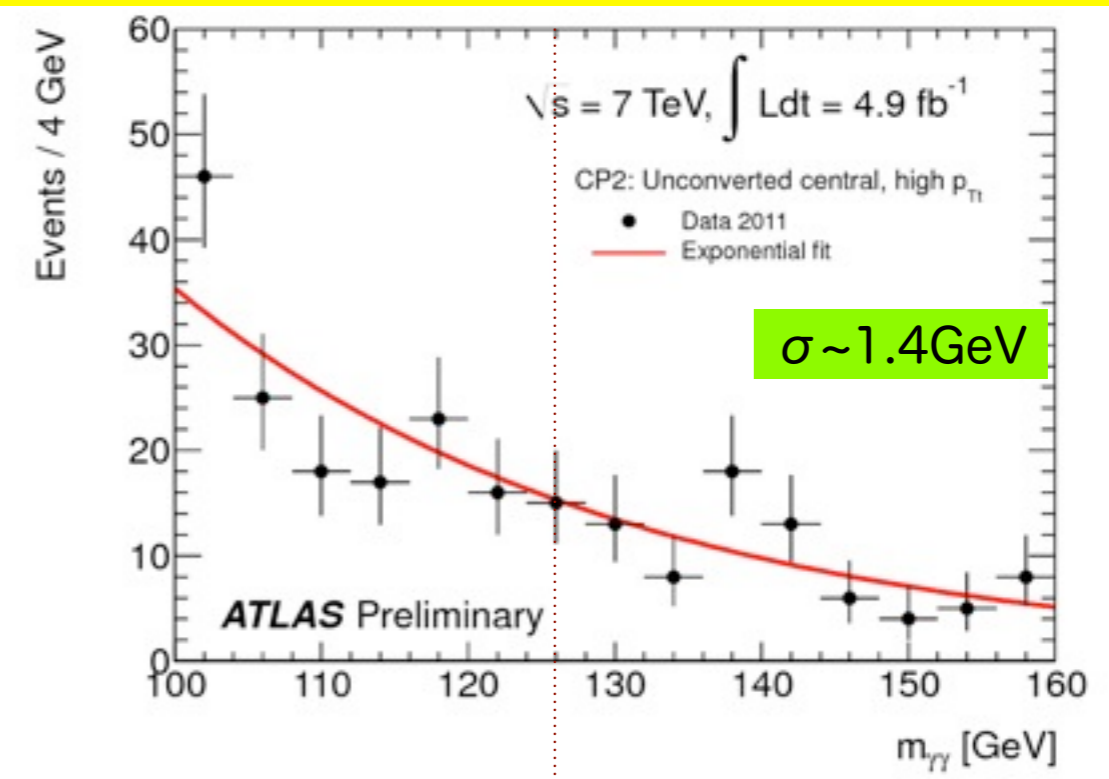
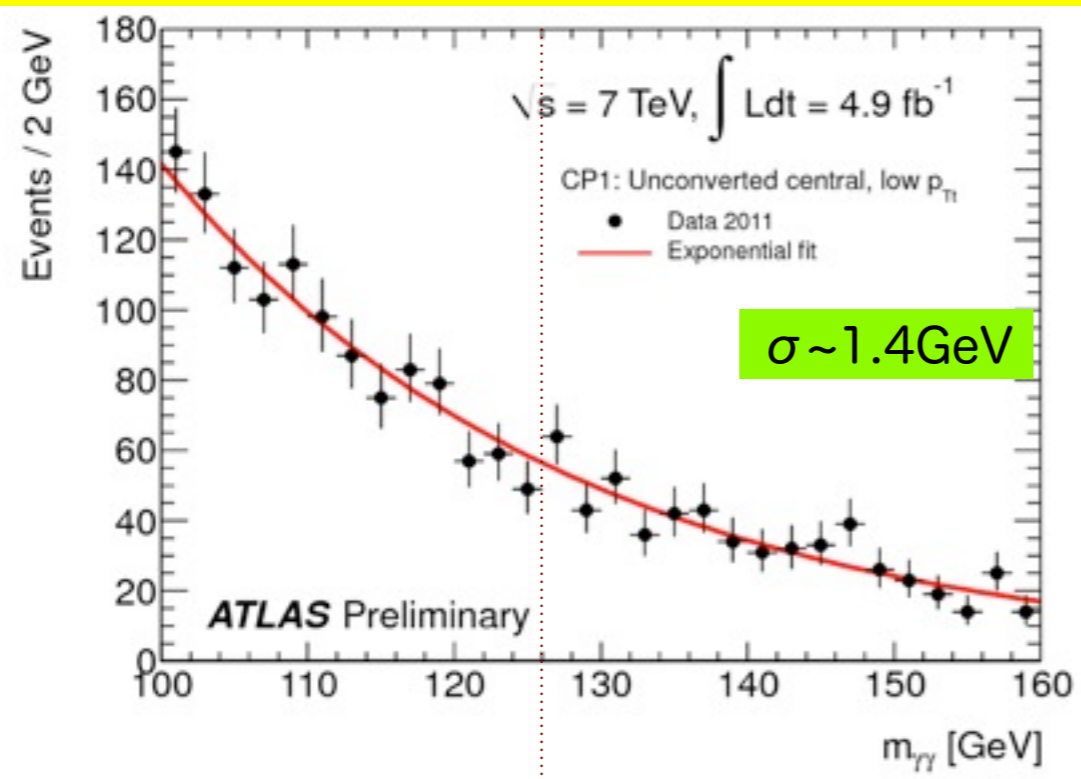


「BGのみ」という仮定との consistency



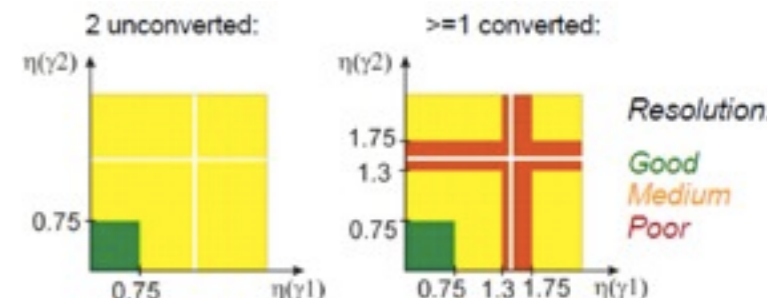
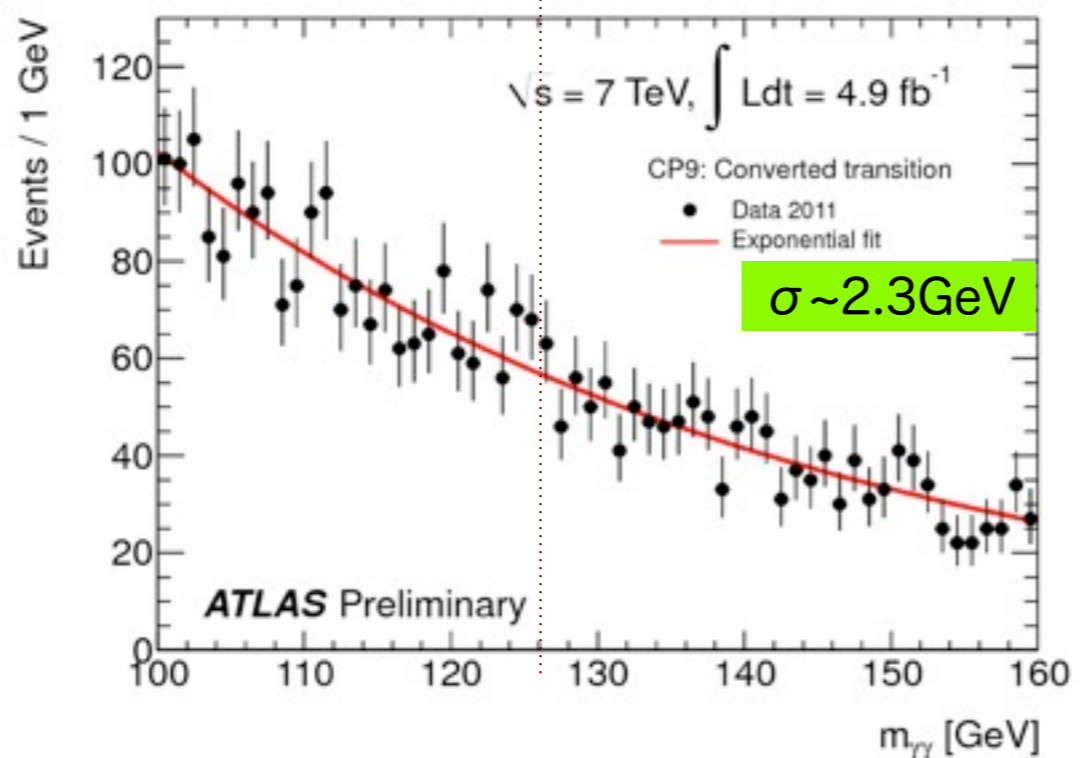
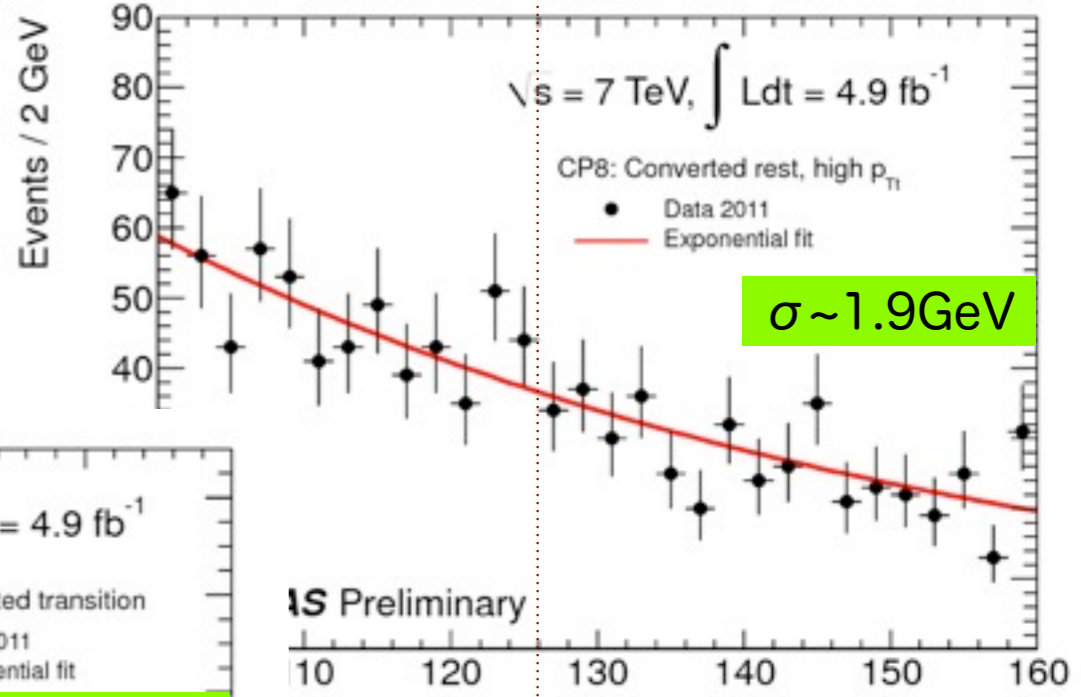
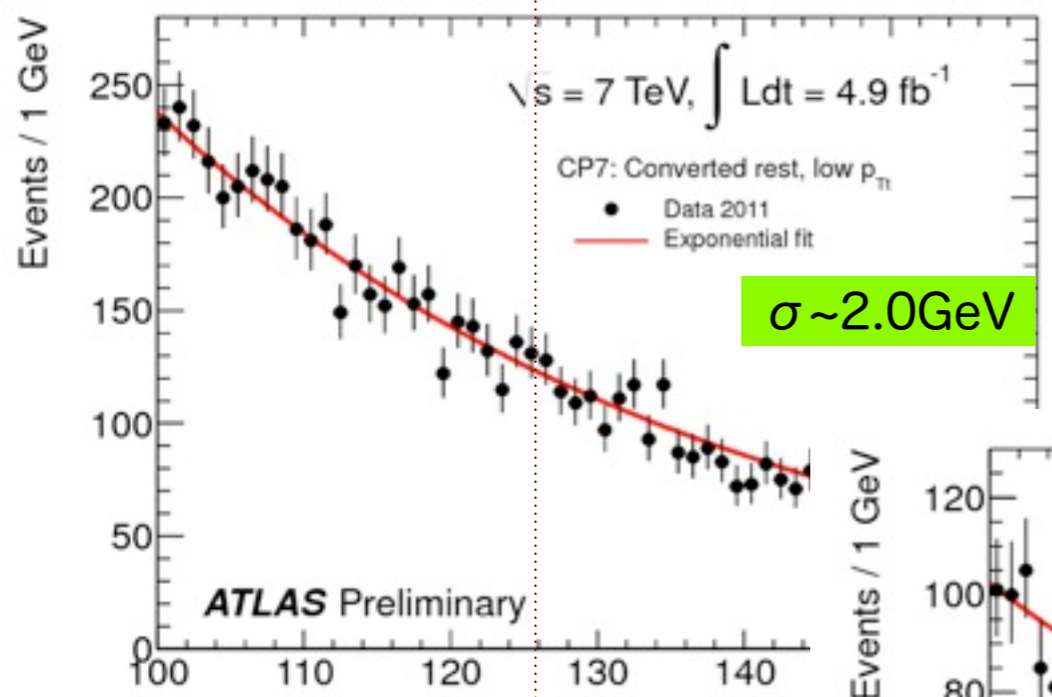
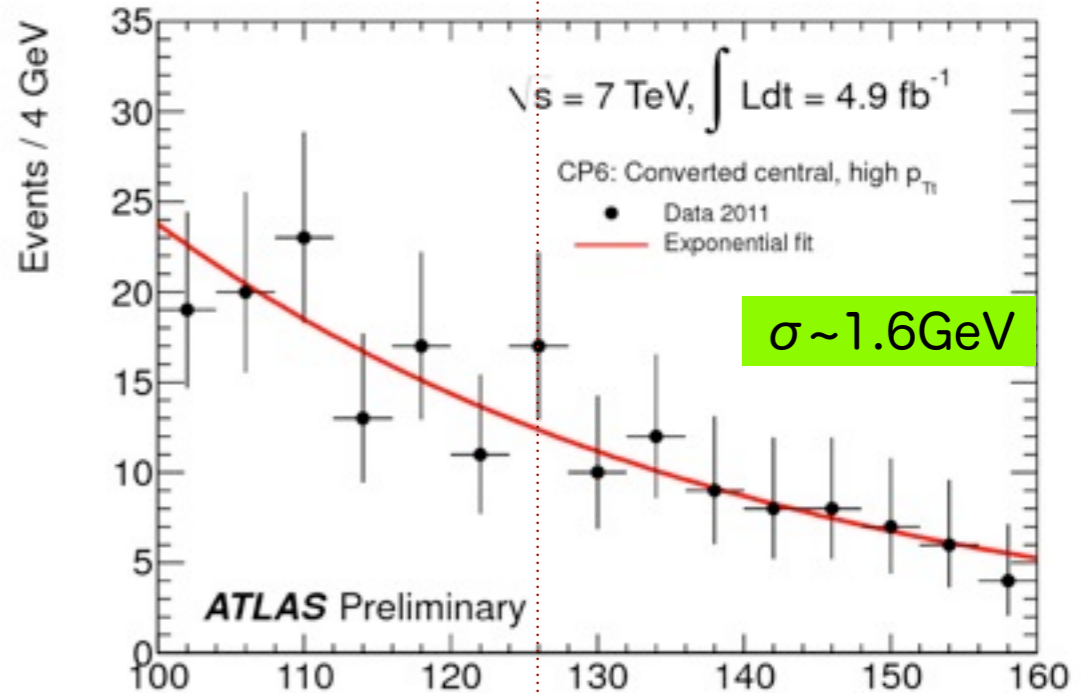
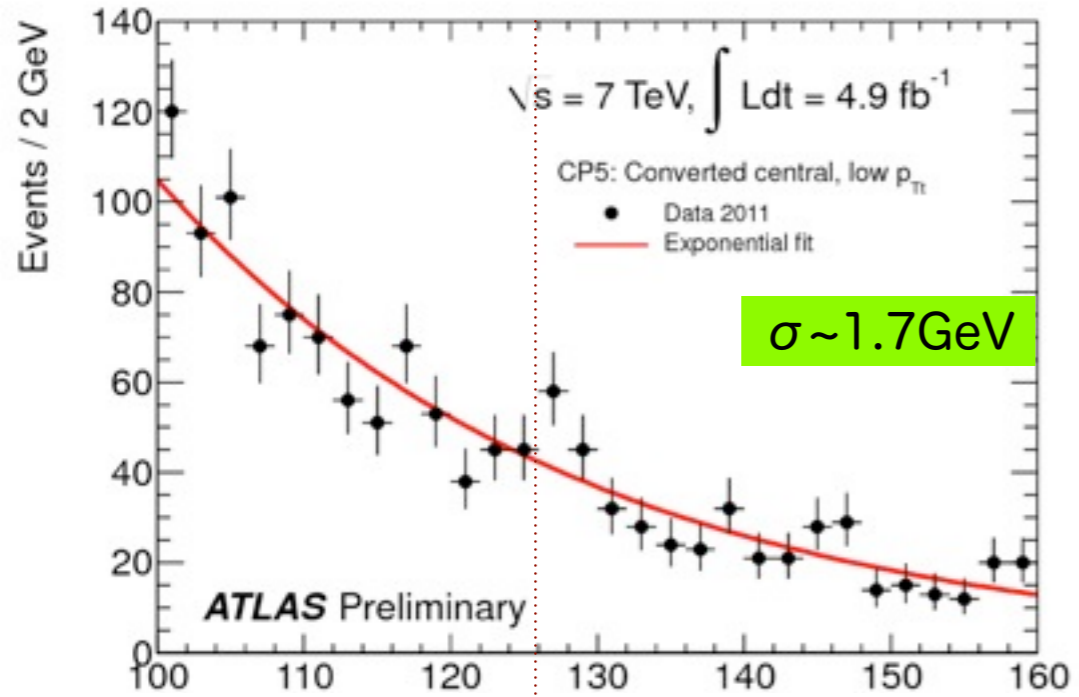
systematic error	
Expected signal yield	: ~ 20%
H \rightarrow $\gamma\gamma$ mass resolution	: ~ 14%
H \rightarrow $\gamma\gamma$ p_T modeling	: ~ 8%
Background modeling	: ± 0.1 -5.6 evts

$m_{\gamma\gamma}$ [unconverted- γ]

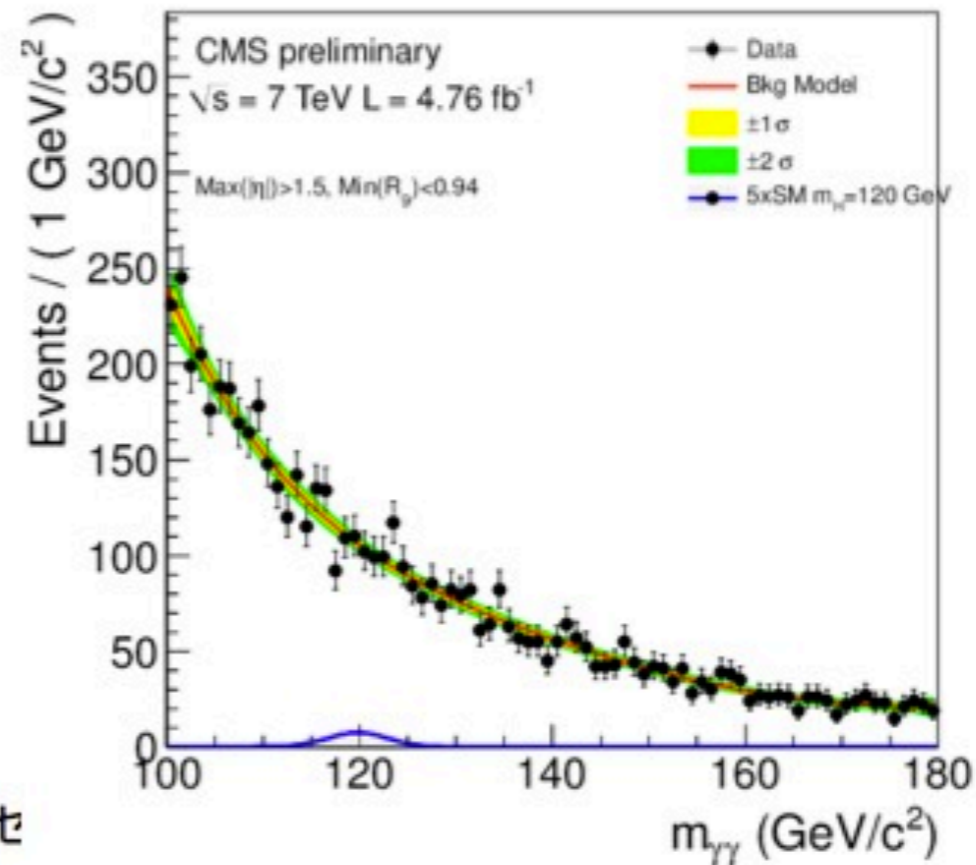
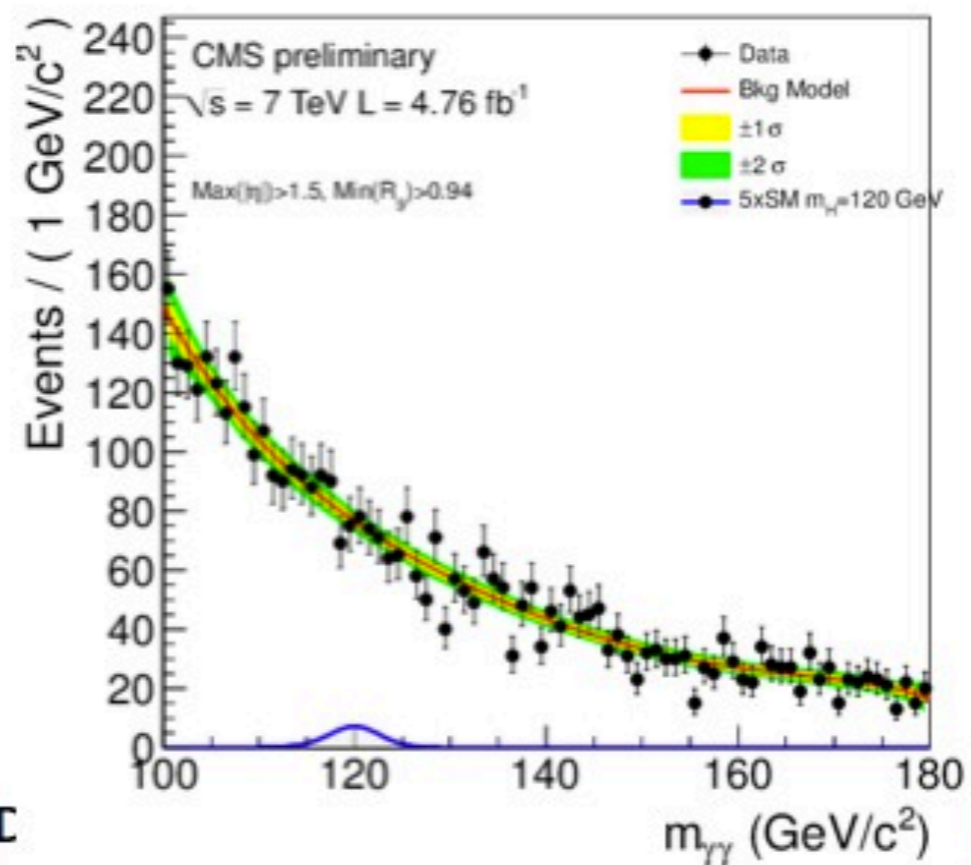
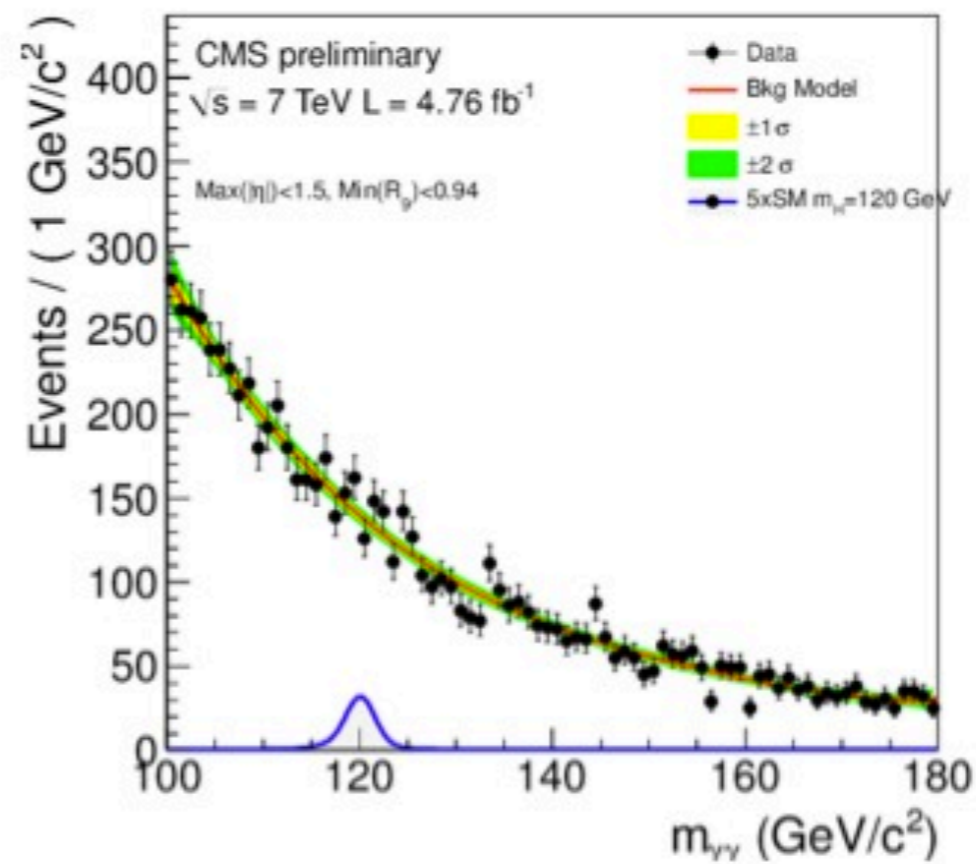
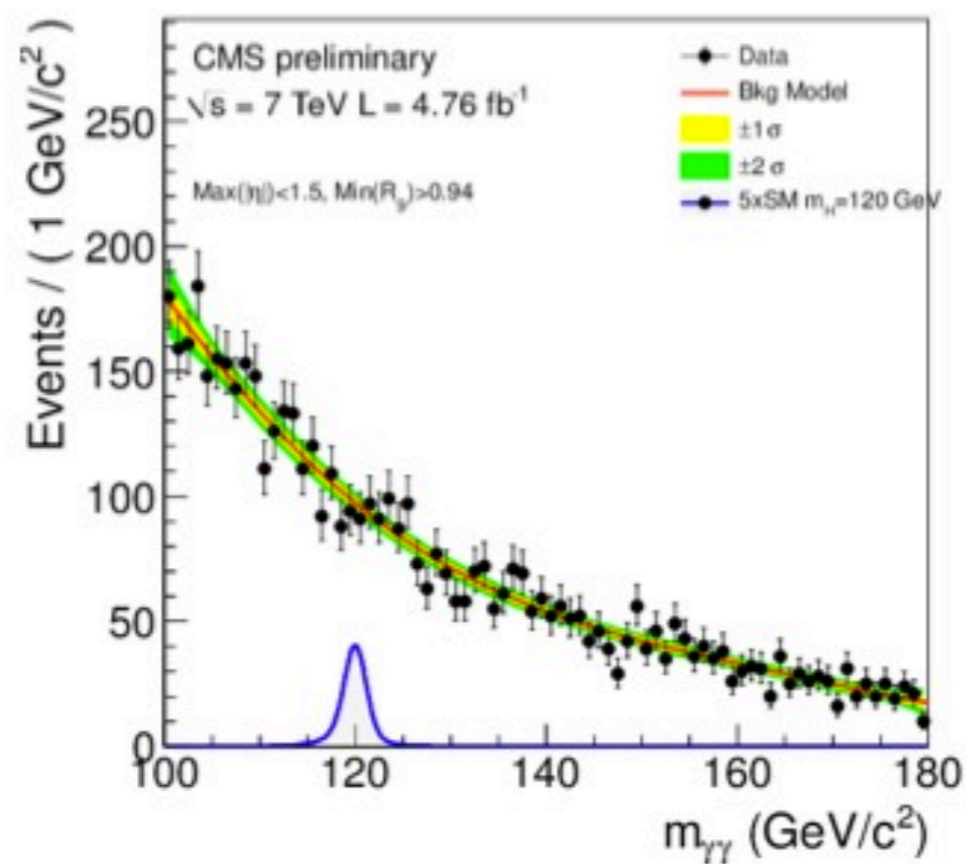


$m_{\gamma\gamma}$

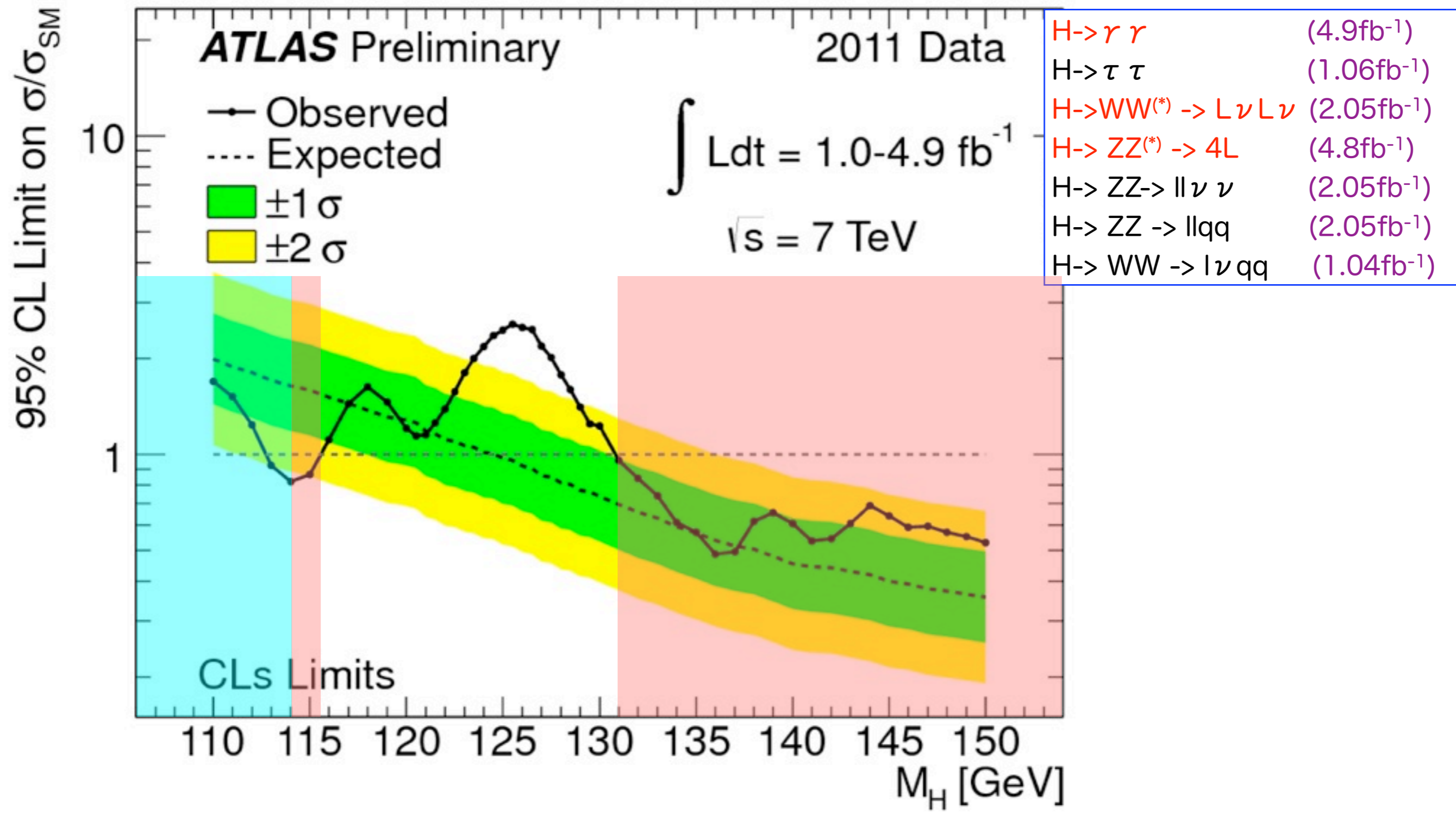
$\ni \gamma \rightarrow ee$



CMS : $m_{\gamma\gamma}$



ATLAS Higgs Combined (i)



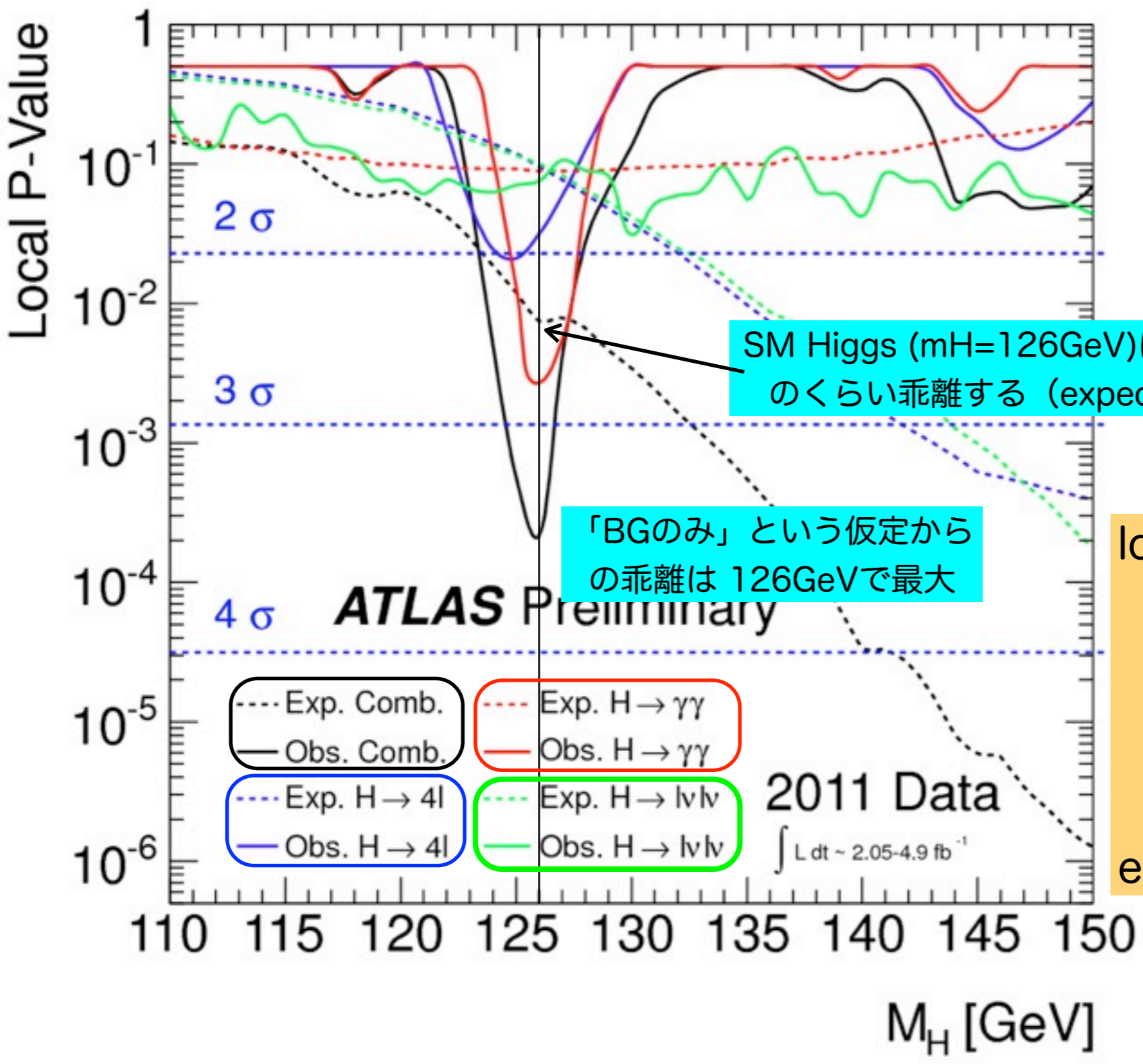
Excluded at 95% CL Limit

- $112.7 < m_H < 115.5 \text{ GeV}$
- $131 < m_H < 453 \text{ GeV}$ (除: 237-251 GeV)

Expected, if no signal

- $124.6 < m_H < 520 \text{ GeV}$

ATLAS Higgs combined (ii)



SM Higgs (m_H=126GeV)はこ
のくらい乖離する (expect)

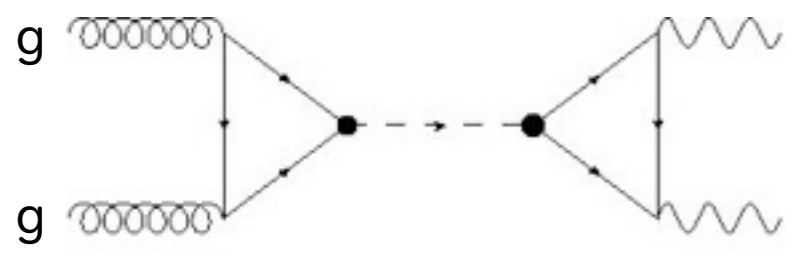
「BGのみ」という仮定から
の乖離は 126GeVで最大

local P₀-value: 1.9x10⁻⁴ (3.6 σ)
 ~2.8 σ ($\tau\tau$)
 ~2.1 σ (4L)
 ~1.4 σ (L ν L ν)
 expected SM_Higgs ~2.4 σ

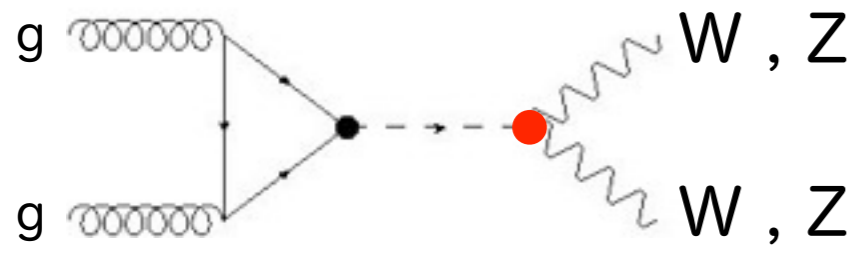
2012年

- 7TeV -> (多分)8TeV : $\sigma \times 1.3$ 倍
- 15fb^{-1} くらいみこめる (か?)

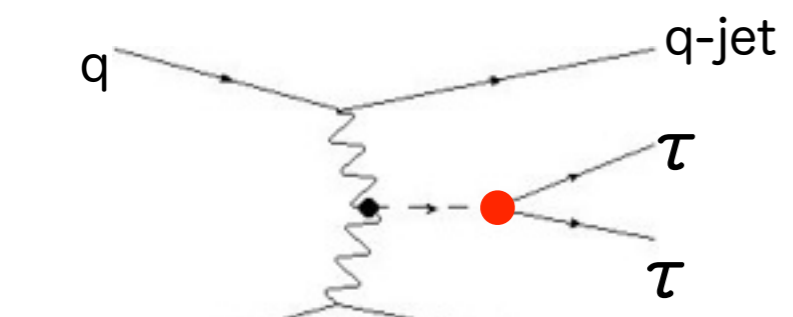
• $m_H : 120\sim 130\text{GeV}$ については -> 5σ discovery



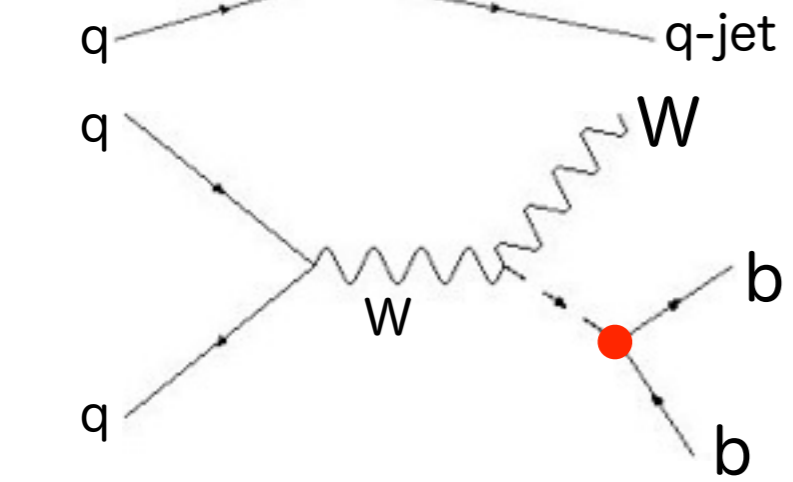
indirect
 Y_t



g_{ZZH}, g_{WWH}

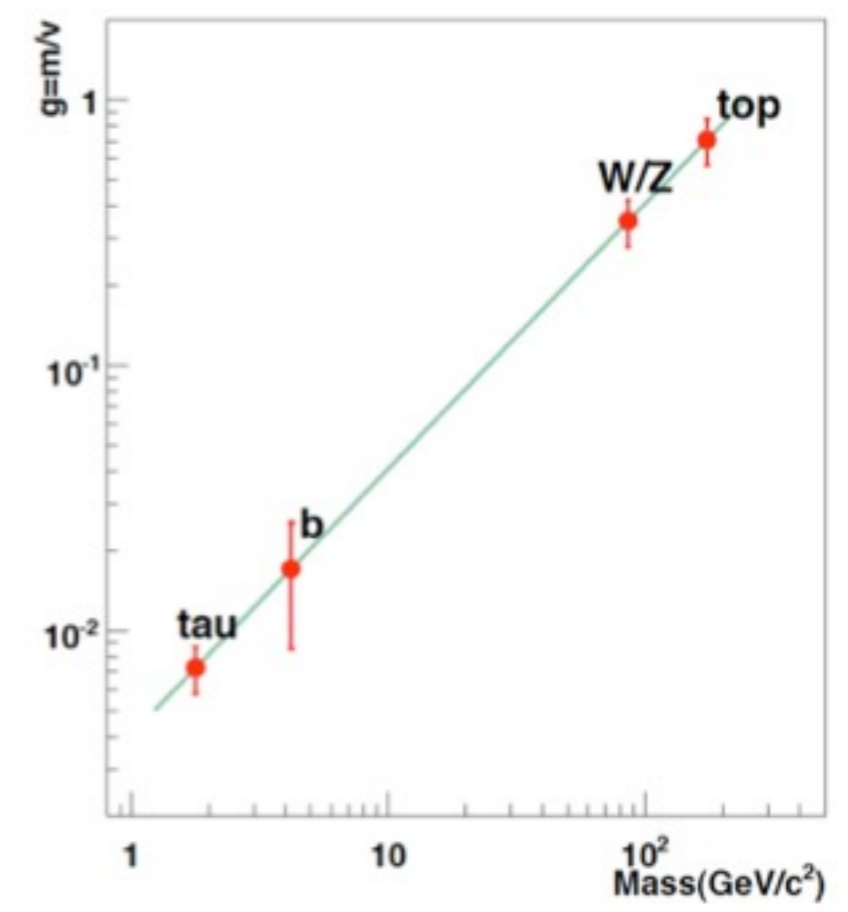


Y_{τ} (tau)



Y_b

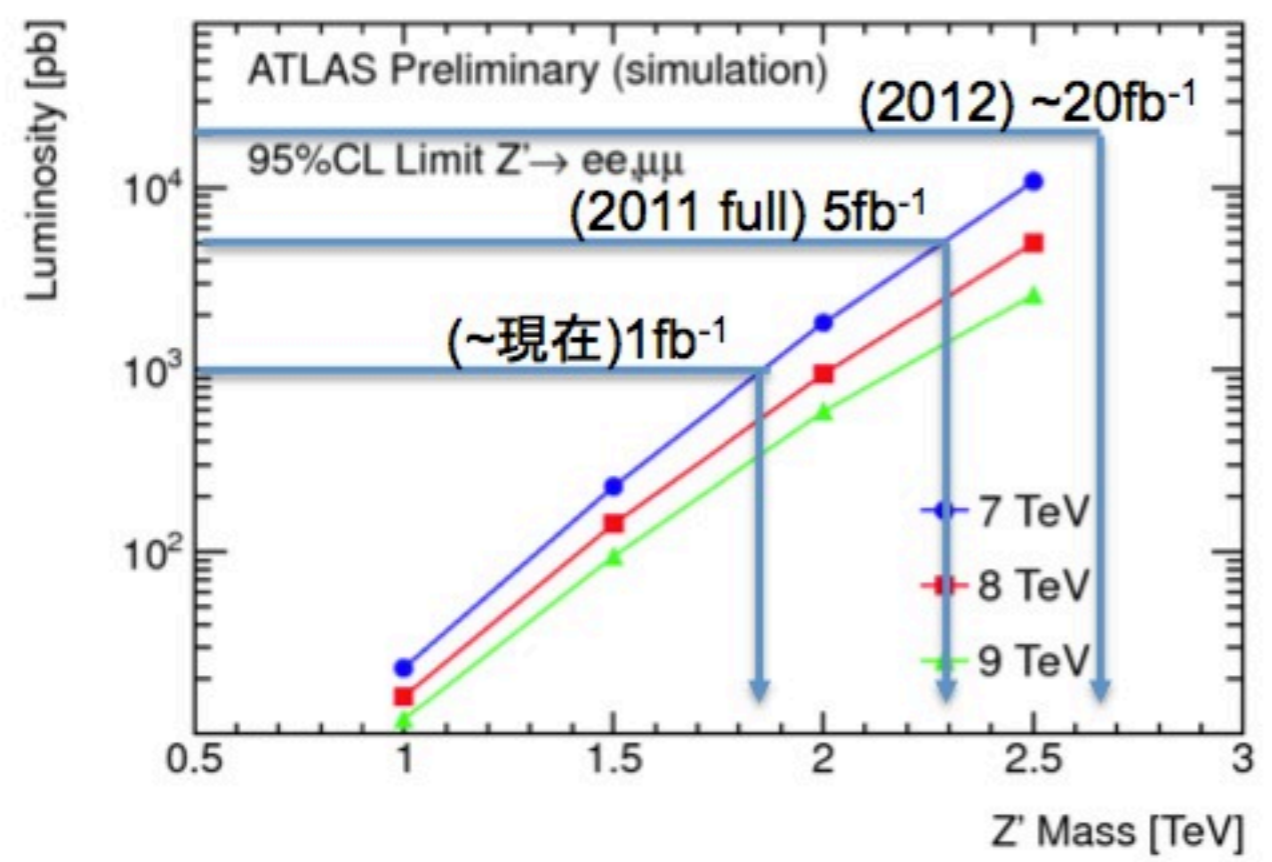
Higgsの物理にかんして coupling (gauge, lepton, quark)の測定 -> HHH self-coupling 重要



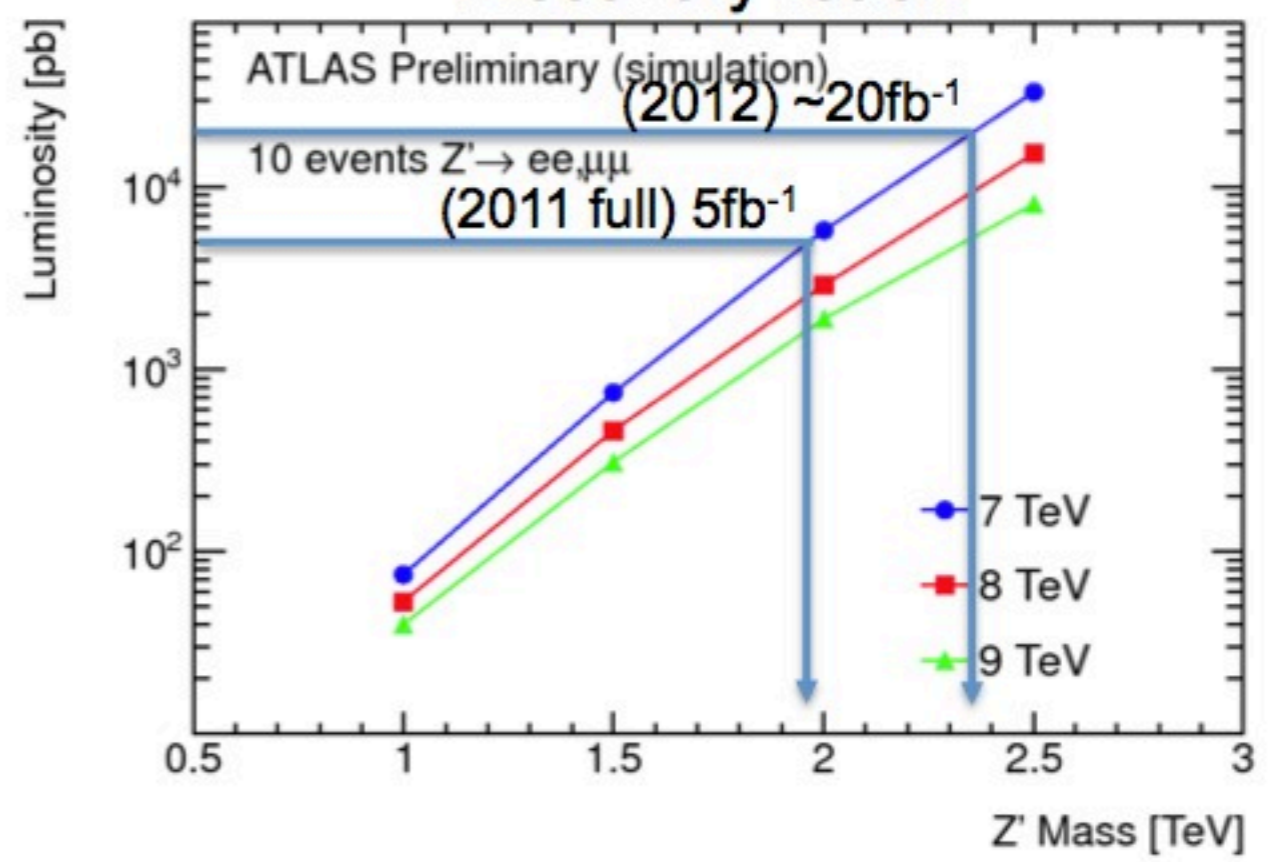
7->14TeV, 300fb^{-1} , $3,000\text{fb}^{-1}$
more luminosity, more event pileup (140?)

2012 Dataへの期待

95% CL exclusion

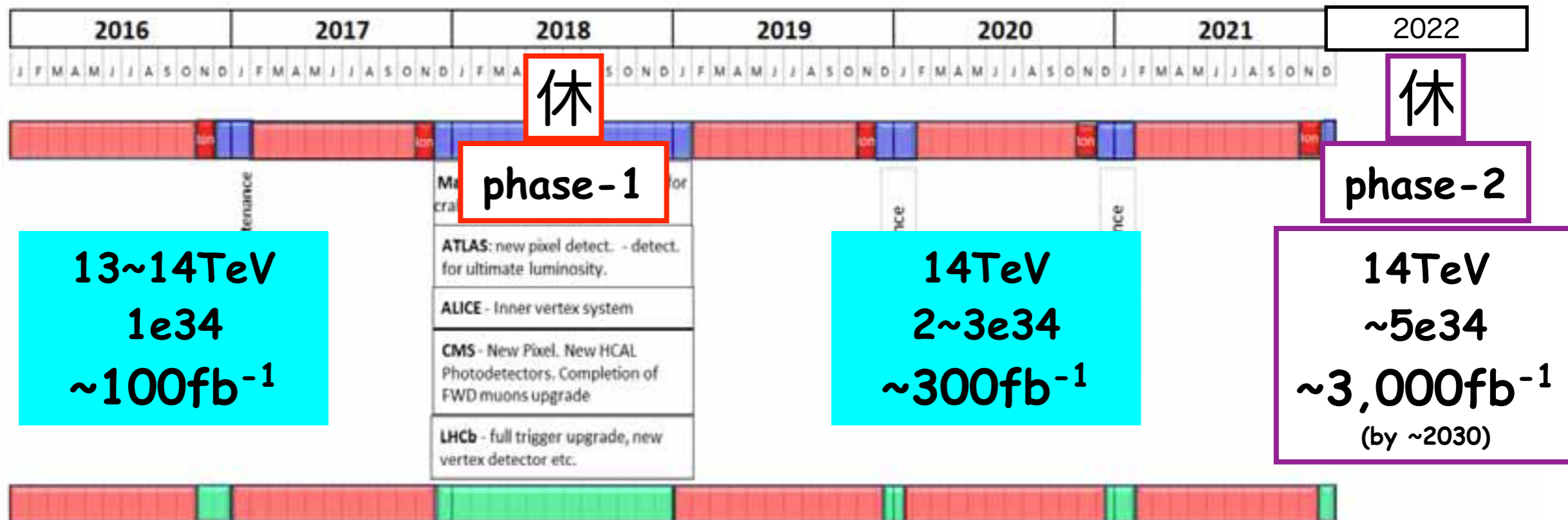
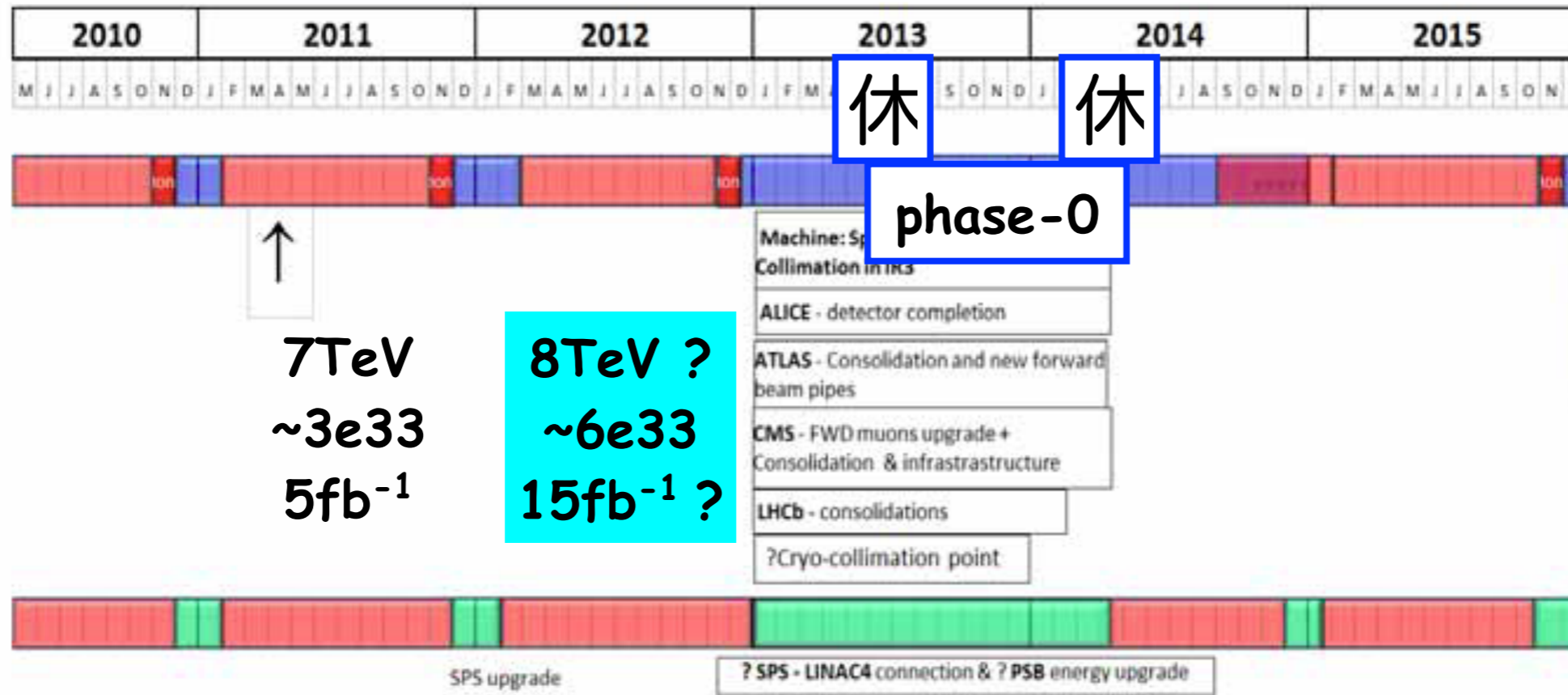


Discovery reach



- [with simulation] SSM Z' のexclusion/discovery予想
 - 7TeV runでは今後exclusion limitの伸び具合は
 - 1fb⁻¹ : ~1.8TeV (現在)
 - 5fb⁻¹ : ~2.2TeV (2011のfull統計)
 - 20fb⁻¹ : ~2.7TeV (2012)
 - 8 TeV runでは飛躍的に伸びる (exclusion/discovery共に)

LHC : phase-0 , 1 , 2 upgrade



backup

SUSY MET + n-jets (0-lepton)

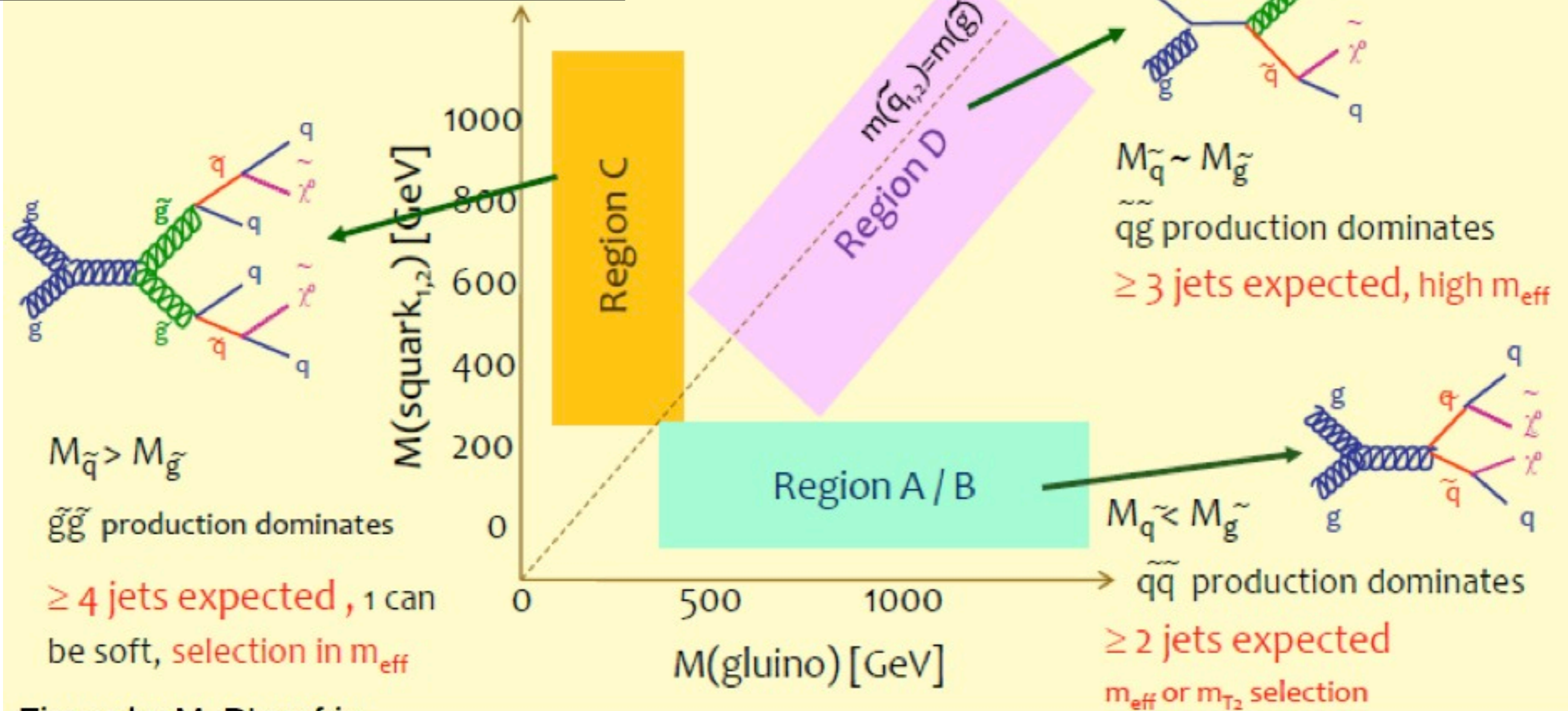
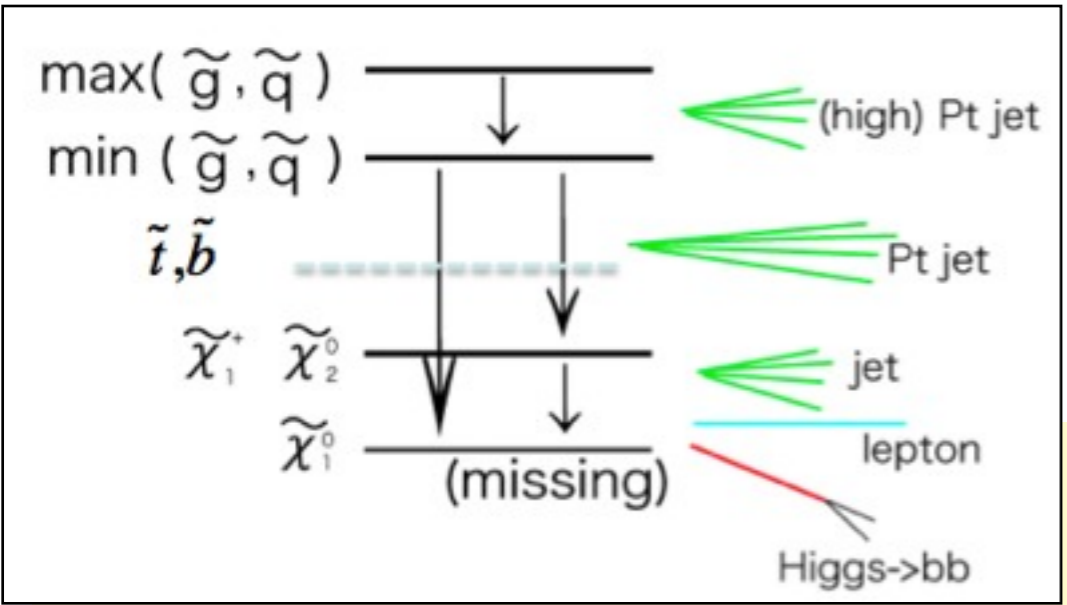
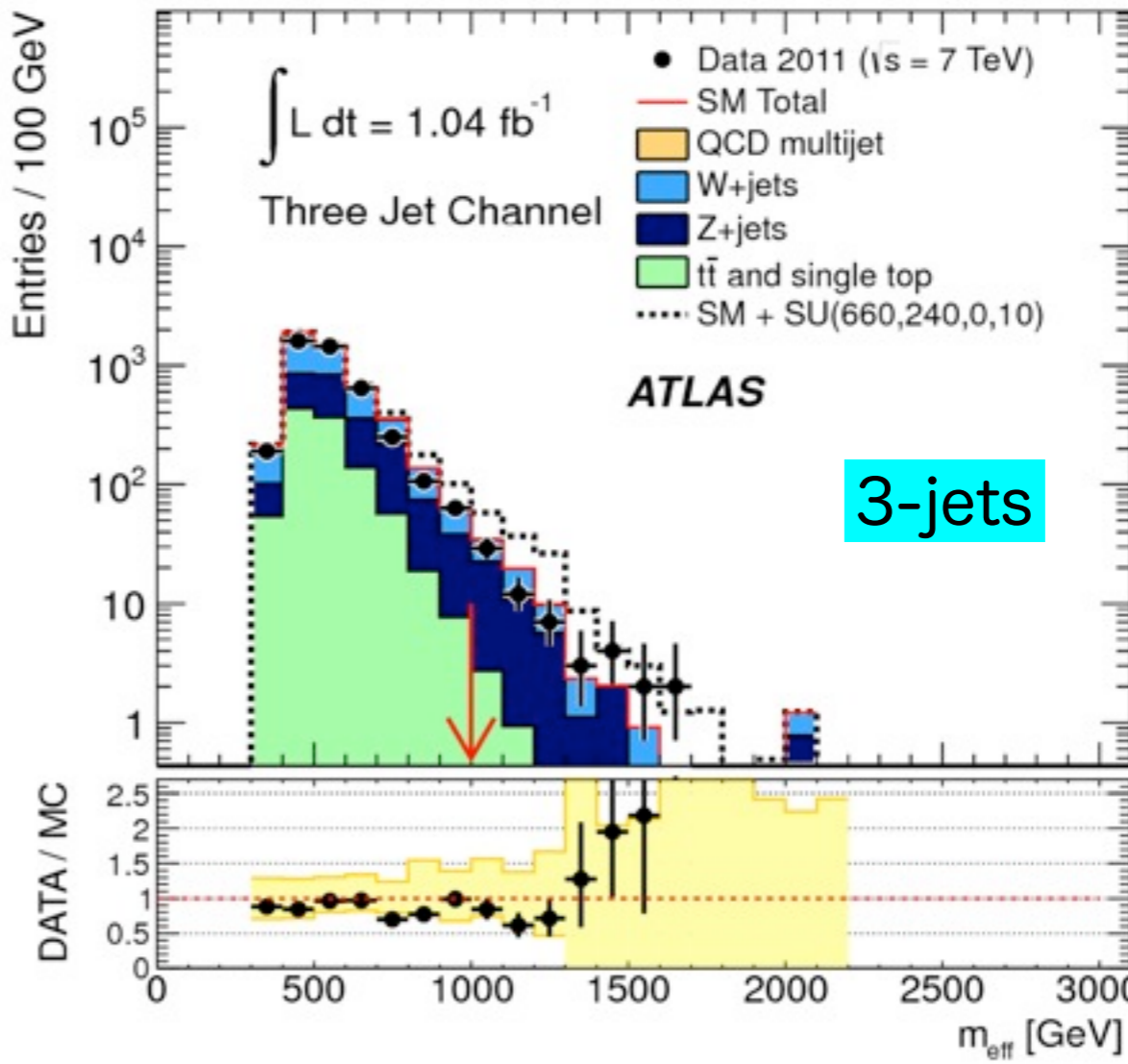
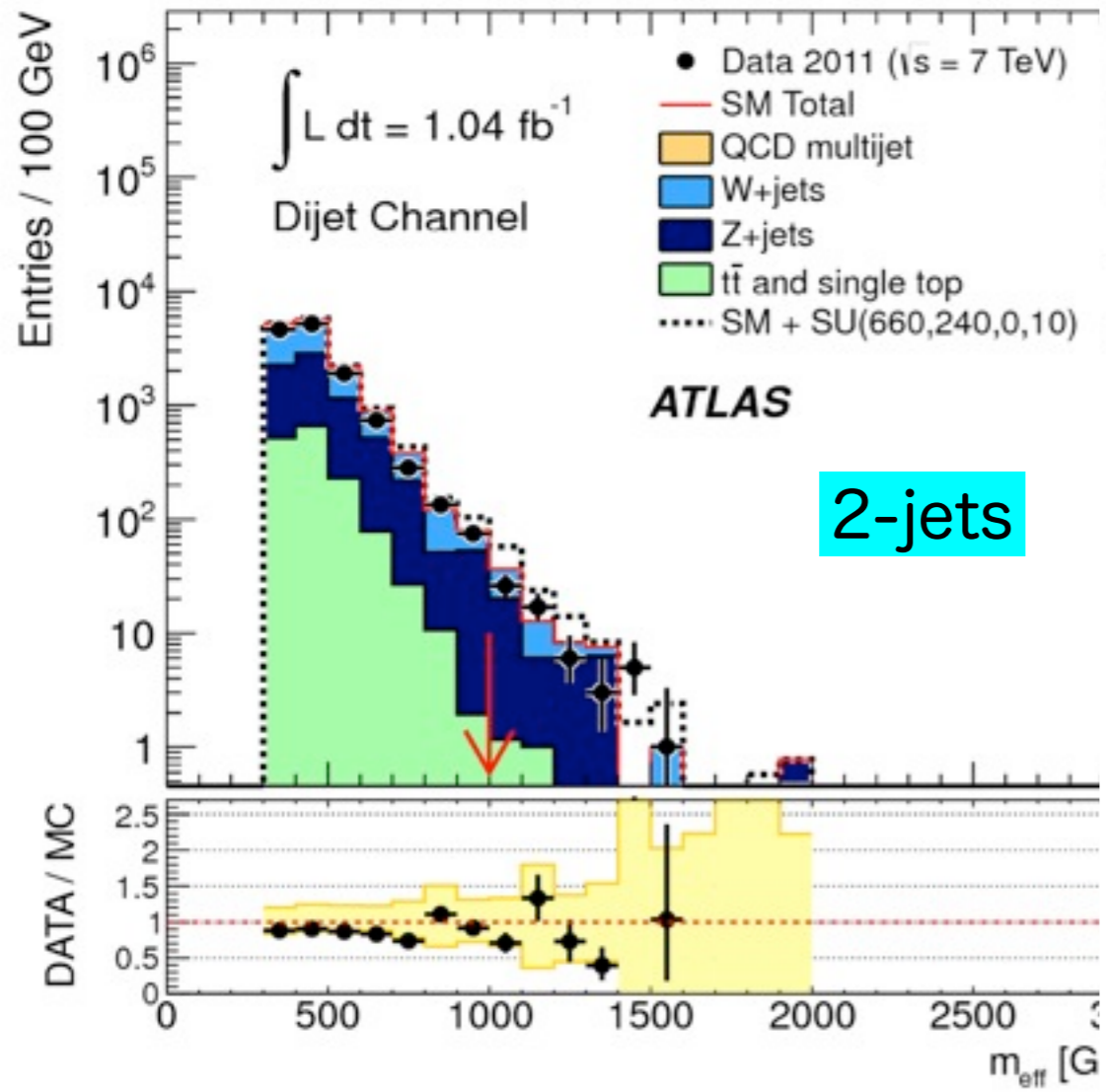
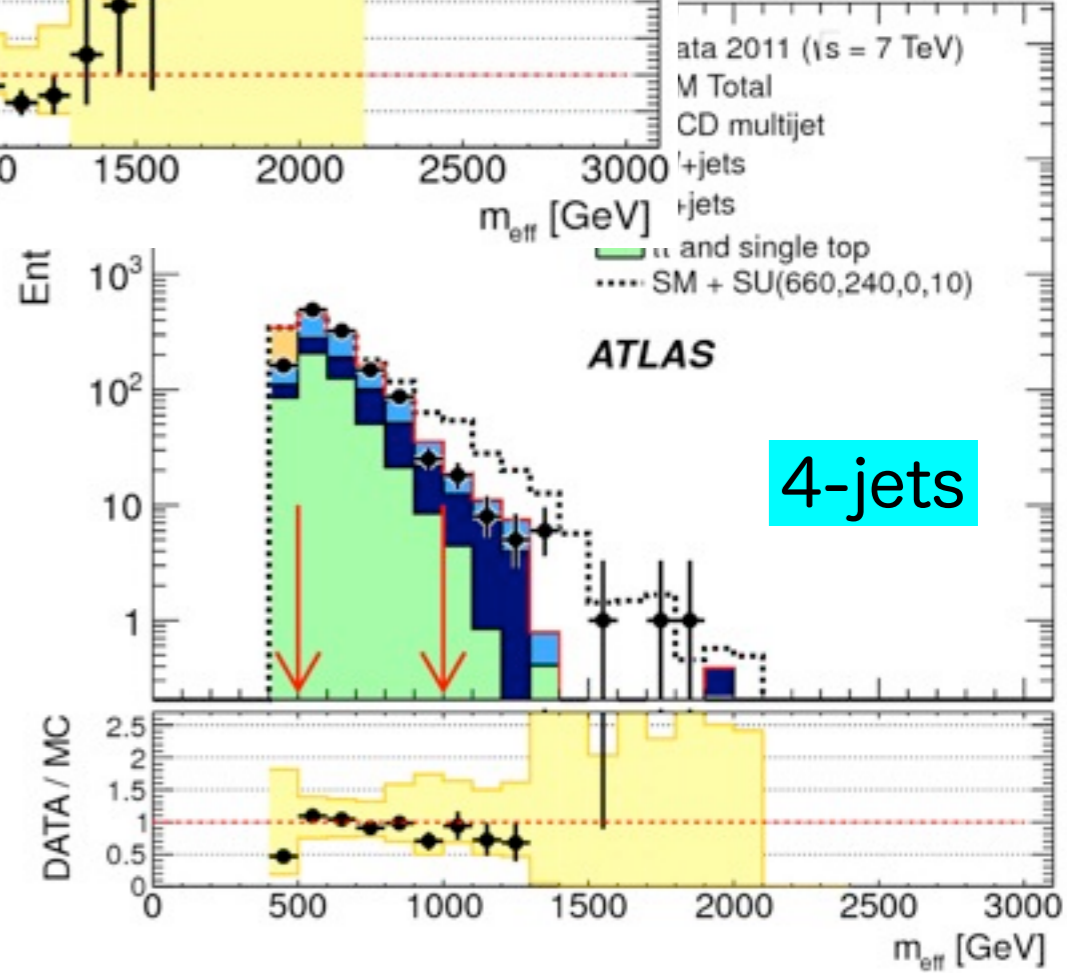


Figure by M. D'onofrio

SUSY MET + n-jets (0-lepton)

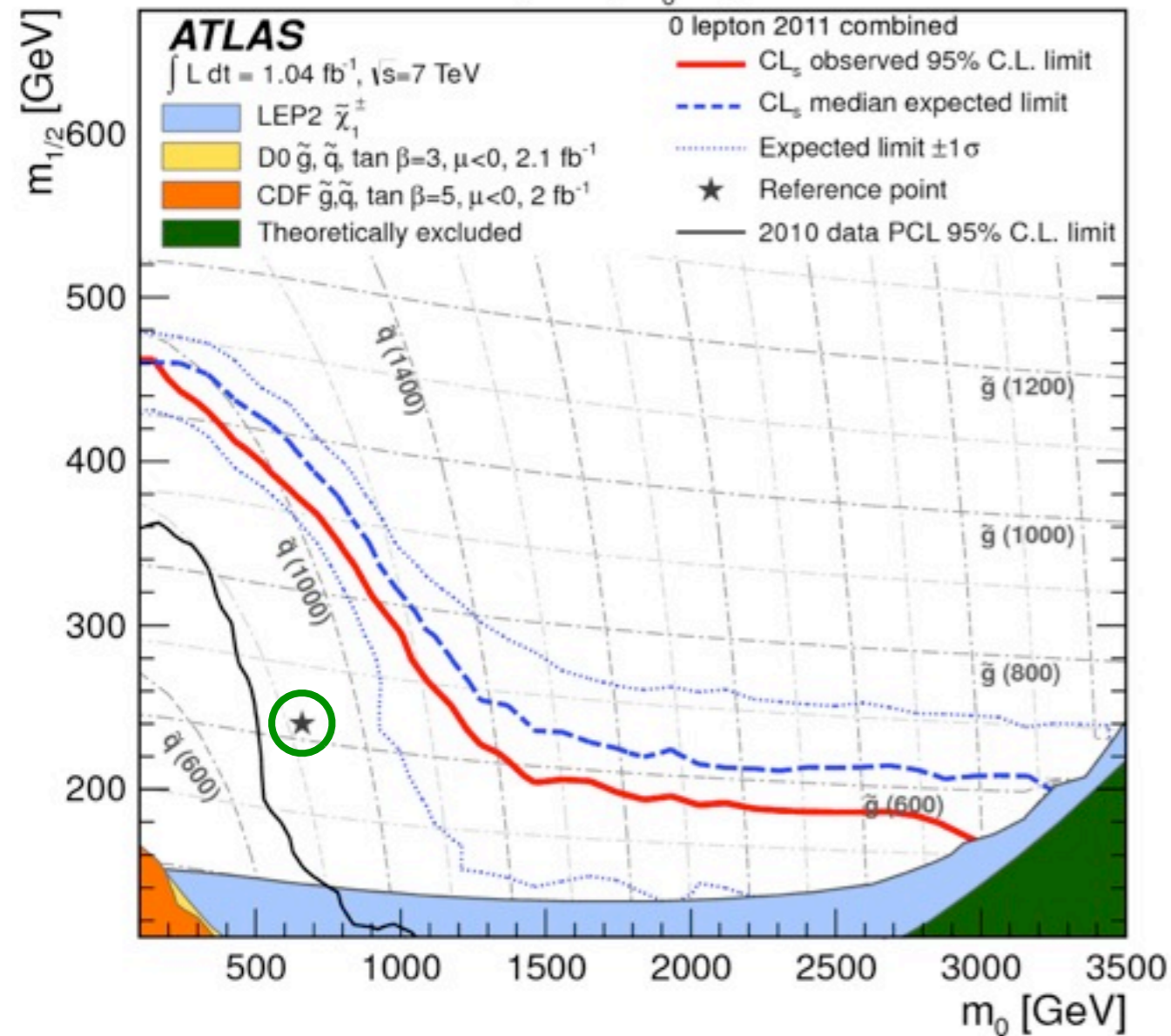


$m_0=660\text{GeV}$, $m_{1/2}=240\text{GeV}$, $A_0=0$, $\tan\beta=10$

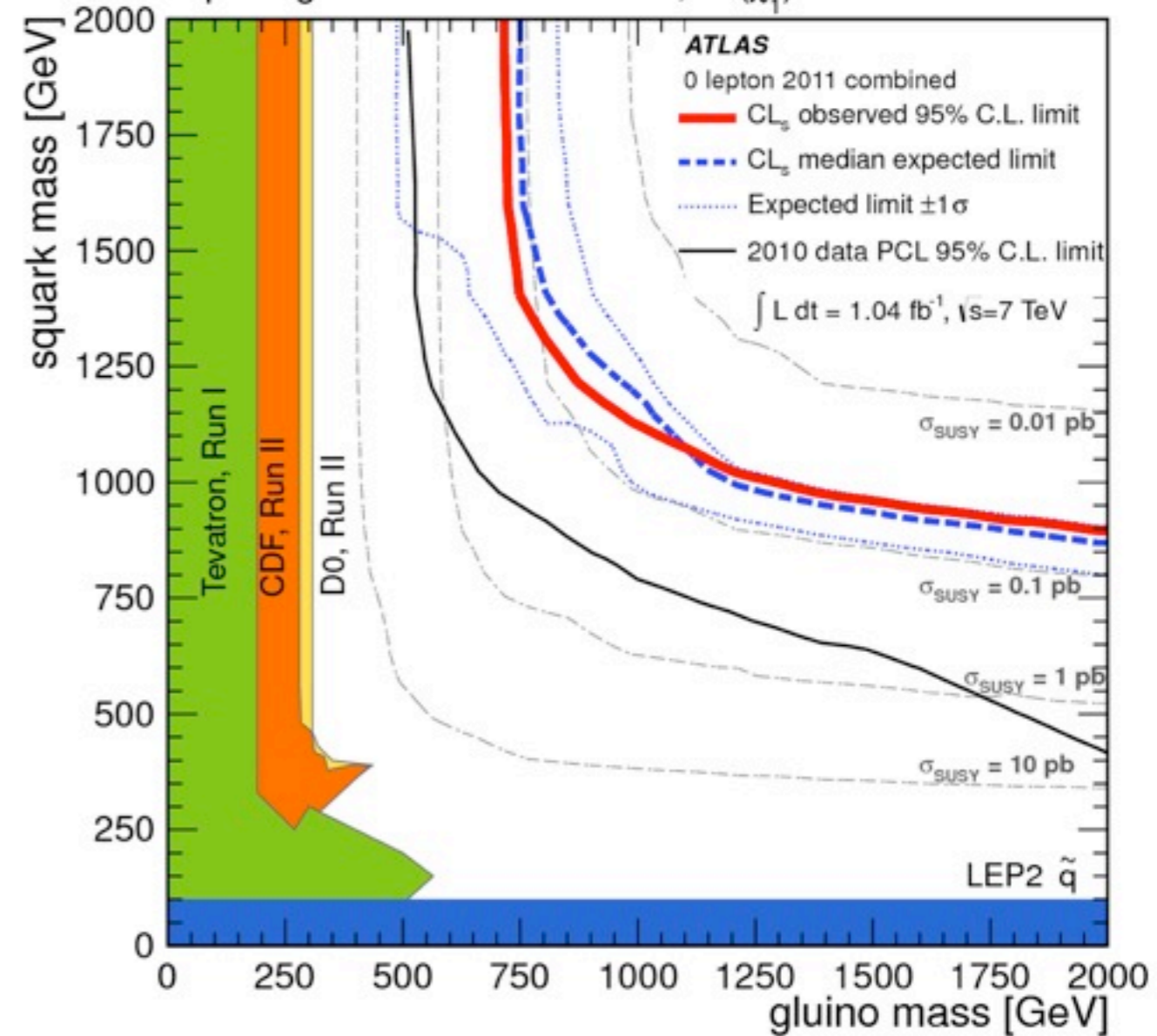


SUSY MET + n-jets (0-lepton)

MSUGRA/CMSSM: $\tan\beta = 10$, $A_0 = 0$, $\mu > 0$



Squark-gluino-neutralino model, $m(\tilde{\chi}_1^0) = 0 \text{ GeV}$



$m_{\text{eff.}}$ のプロットで signal としていた ref. point
 $m_0 = 660 \text{ GeV}$, $m_{1/2} = 240 \text{ GeV}$, $A_0 = 0$, $\tan\beta = 10$

event pileup $\sim 2\gamma$ z-vertex

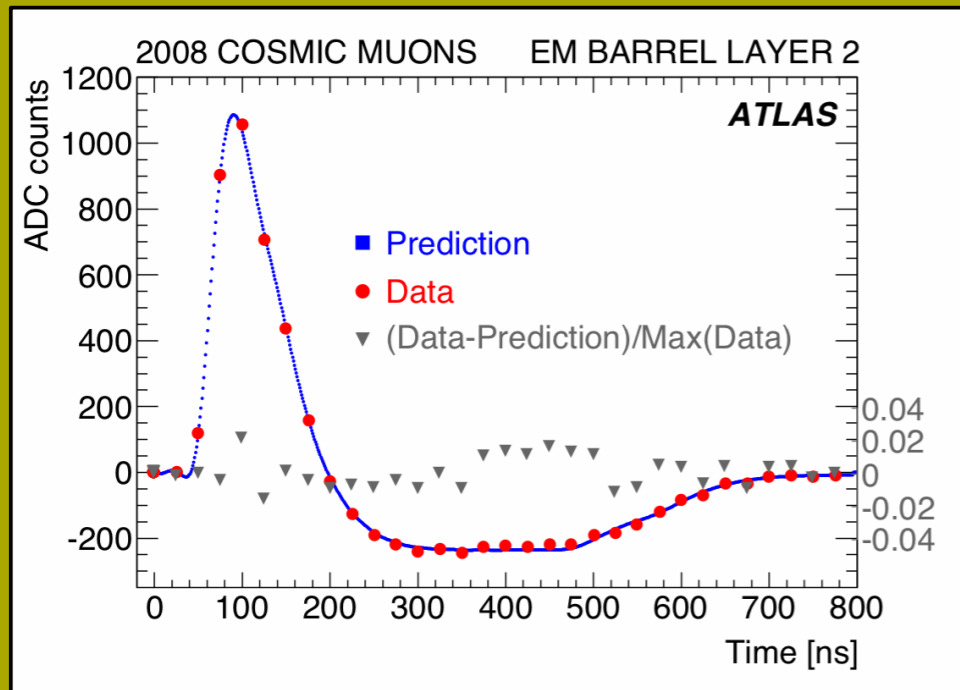
Pile-up impact on calorimeter pointing

- This plot shows a comparison between the 2 estimates of the primary vertex z positions using diphoton events passing the $H \rightarrow \gamma\gamma$ selection and where both photons are unconverted in the barrel region of the electromagnetic (EM) calorimeter ($|\eta| < 1.37$).
- The z position is computed using the calorimeter pointing (energy weighted position of the EM shower in the first and second longitudinal layers of the calorimeter).
- The data sample is divided into 2 periods with different data taking conditions : the early 2011 data with $\beta^* = 1.5\text{m}$ ($\langle\mu\rangle \approx 6.3$) corresponding to an integrated luminosity of 2.1 fb^{-1} and late 2011 data with $\beta^* = 1.0\text{m}$ ($\langle\mu\rangle \approx 11.6$) corresponding to an integrated luminosity of 2.8 fb^{-1} .
- The resolution observed in data is not sensitive to the different pile-up conditions of the 2 periods. It is in good agreement with the prediction from the simulation (diphoton MC events). The latter includes z vertex reweighting to match the beam spot spread observed in data and uses only periods corresponding to $\beta^* = 1.5\text{m}$.
- The RMS spread of the Δz is about 3cm, corresponding to $\approx 1.5\text{cm}$ resolution for the average of the two z positions.

Photon identification efficiency: $\sim 85 \pm 5\%$ from MC, cross-checked with data ($Z \rightarrow ee, Z \rightarrow ee\gamma, \mu\mu\gamma$)

Photon isolation requirement: $E_T < 5 \text{ GeV}$ inside a cone $\Delta R < 0.4$ around γ direction. Underlying event and pile-up contribution subtracted using an "ambient energy density" determined event-by-event.

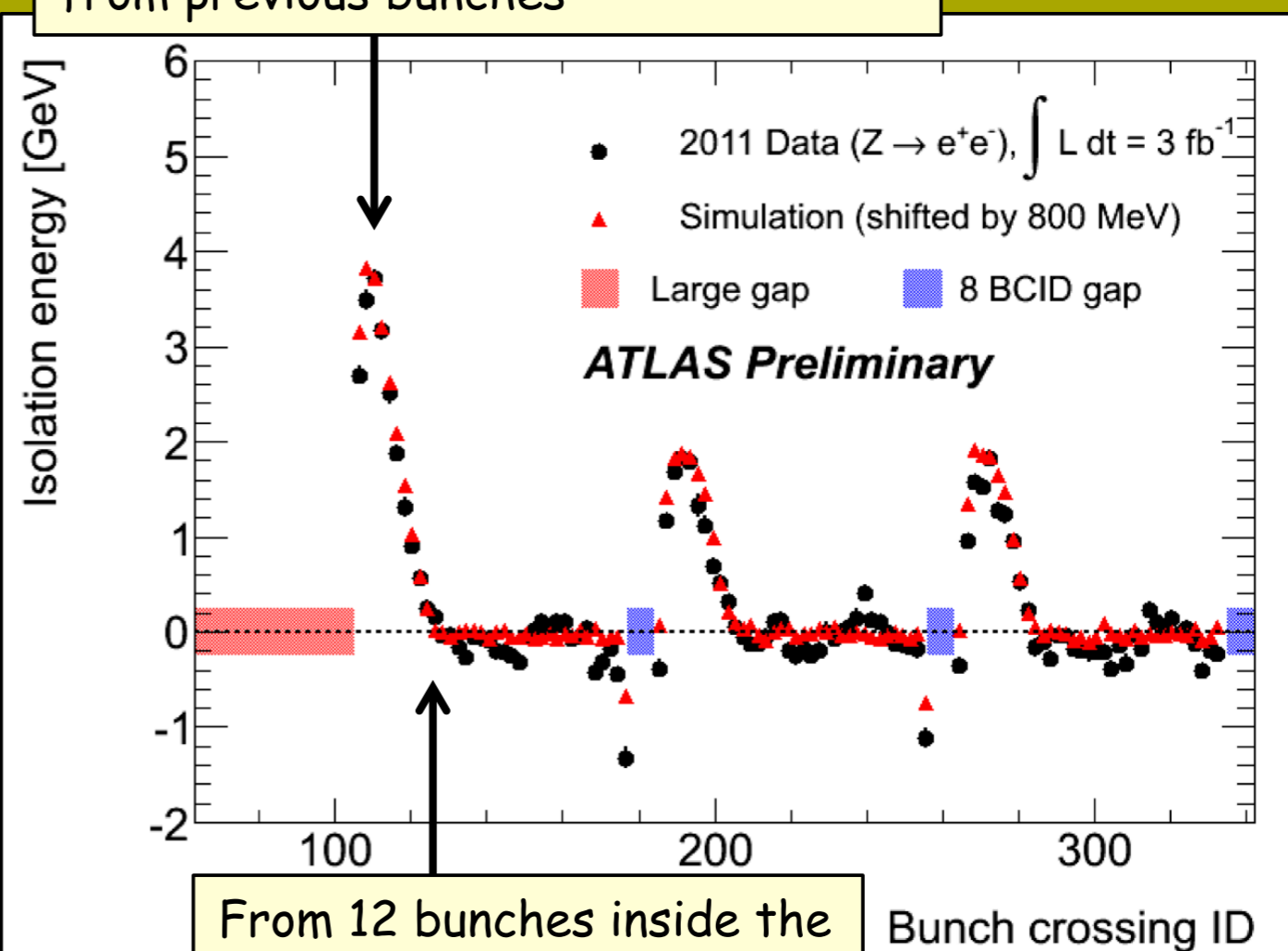
If the subtraction is not perfect, a residual dependence of the corrected isolation energy on the bunch position in the train is observed, due to the impact of pile-up from neighbouring bunches convolved with the LAr calorimeter pulse shape.



Calorimeter bipolar pulse shape: average pile-up is zero over $\sim 600 \text{ ns}$ (~ 12 bunches)

Effect well described by the (detailed!) ATLAS simulation

Beginning of the train: no cancellation from previous bunches



From 12 bunches inside the train: full cancellation

Bunch crossing ID

H -> WW background評価

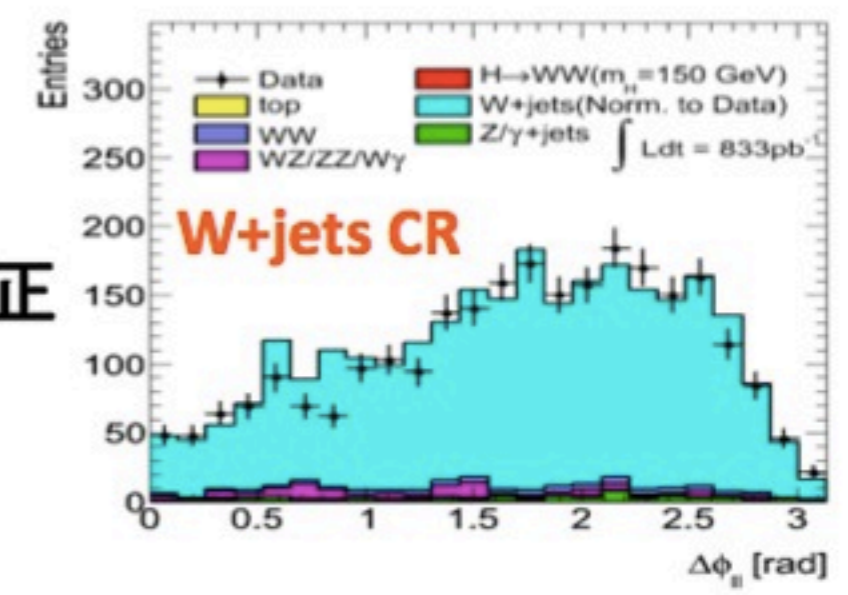
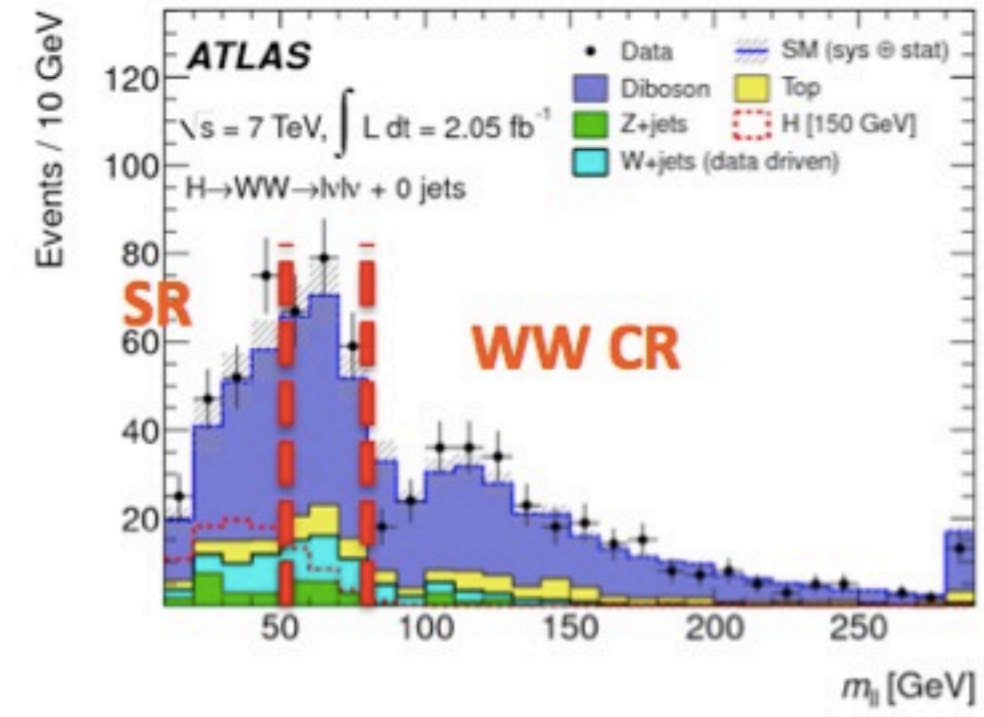
- 背景事象の評価が重要
- 2つのνのz-成分が観測できない → 質量再構成が困難
- カット & カウントの解析

主な背景事象

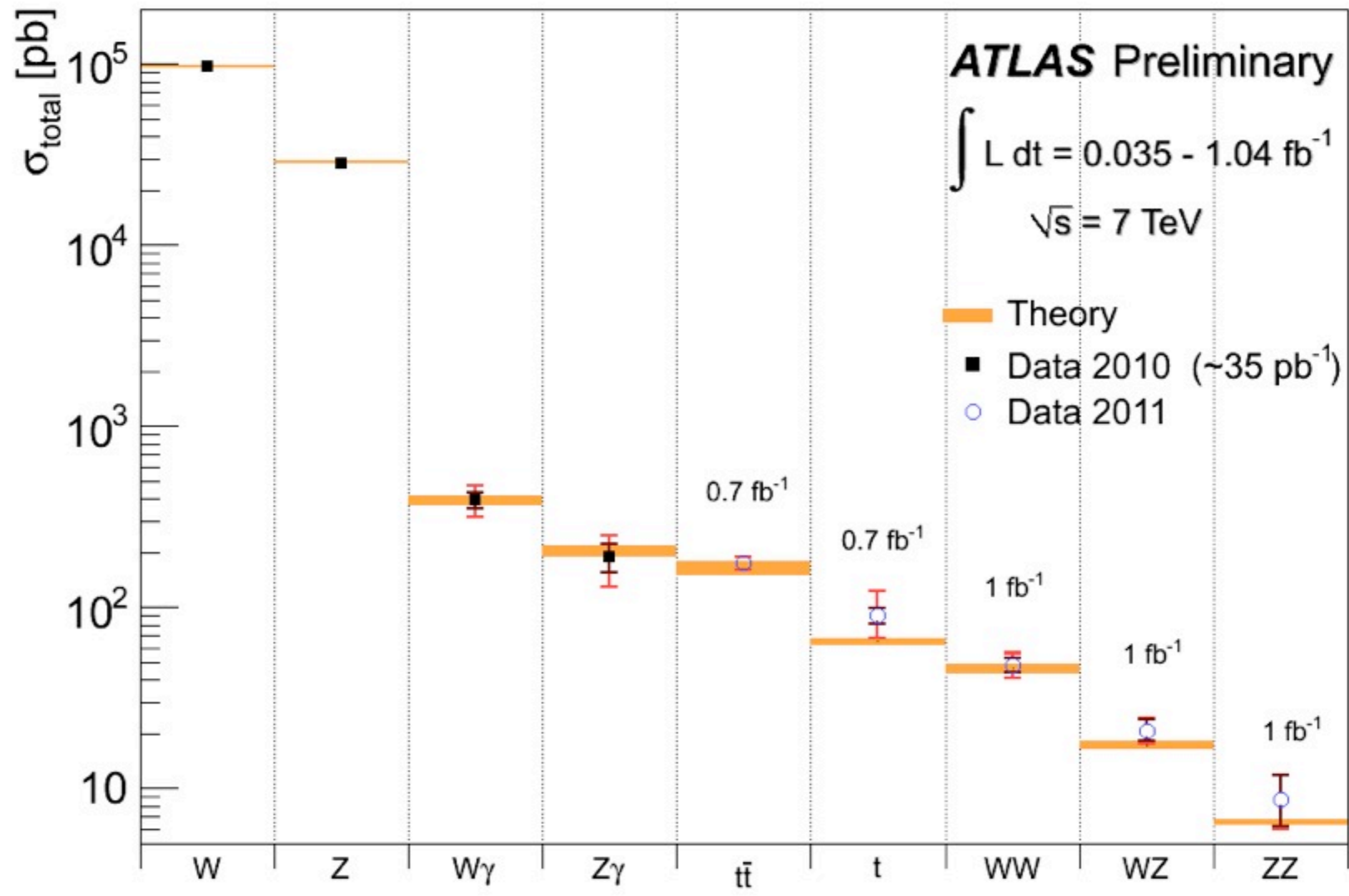
- ✓ SM WW : m_{ll} が高い領域のデータから評価

$$N_{WW}^{SR} = N_{WW}^{CR} * (N_{WW}^{SR} / N_{WW}^{CR})$$
MCで評価
- ✓ W+jets : 1 good lepton + 1 loose lepton
 → W+jets CR (Dataからnormalizationを測定)

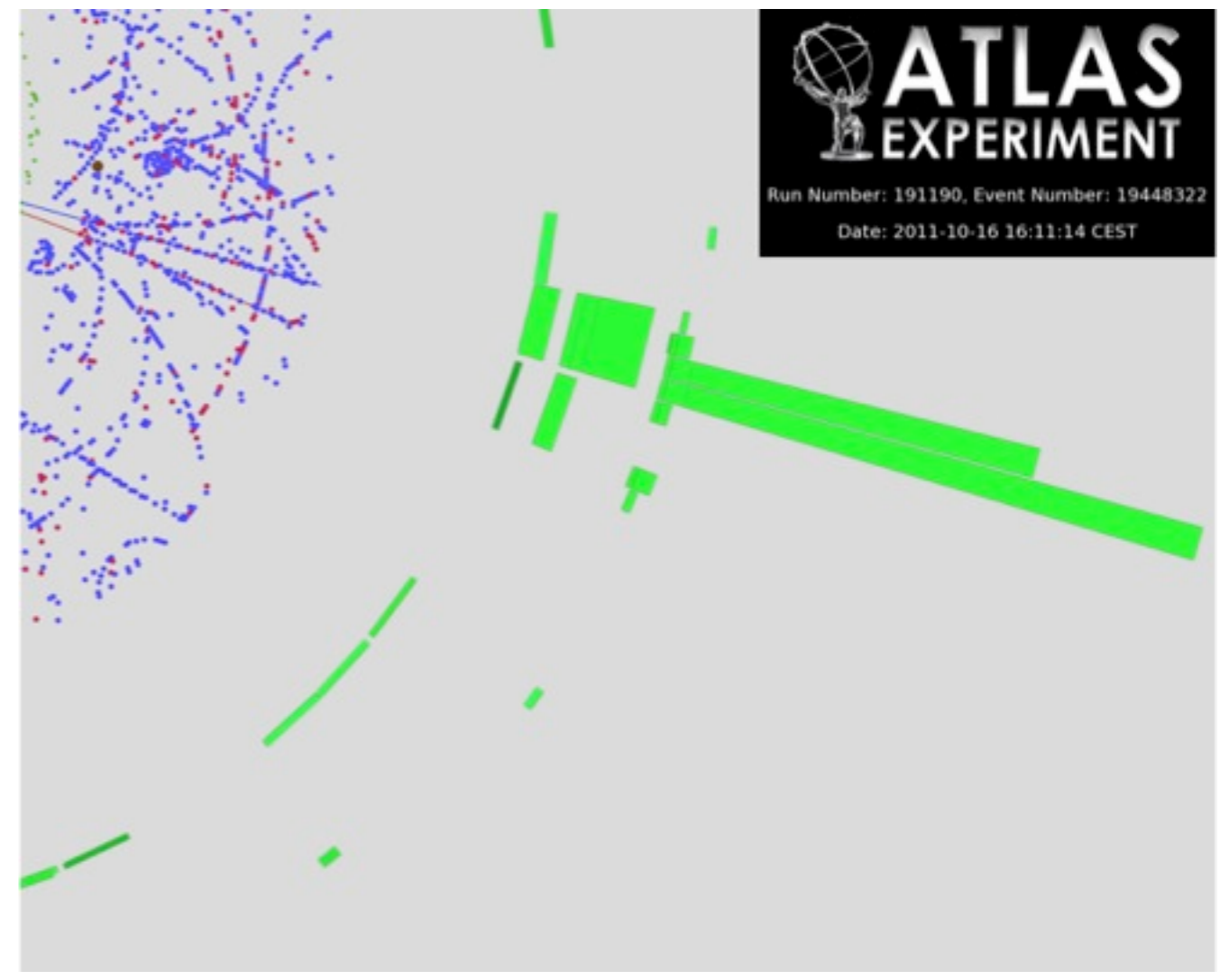
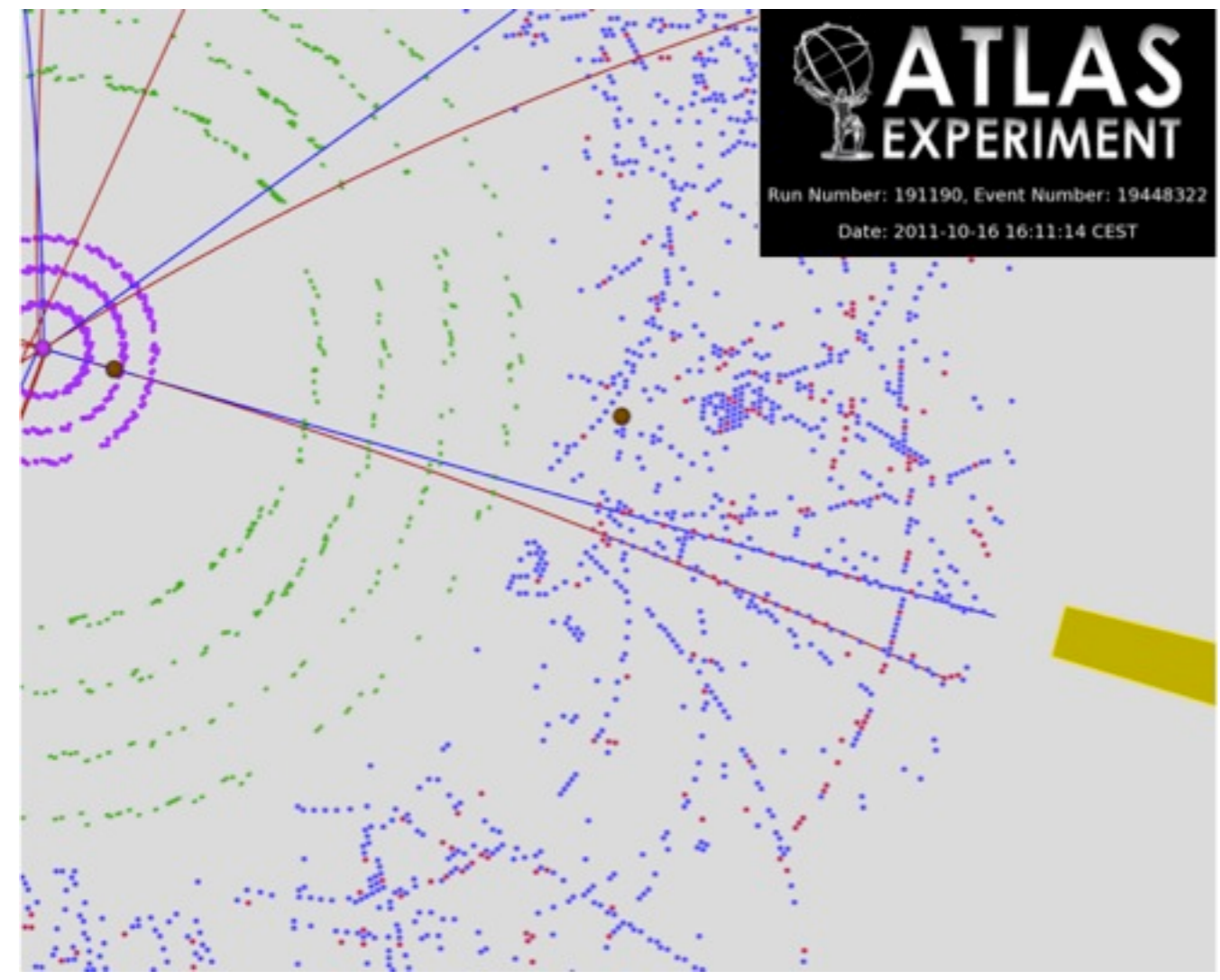
$$N_{Wjets}^{SR} = \text{fake factor} * N_{Wjets}^{CR(data)}$$
データで評価
- ✓ Z+jets : MCで評価、METのmismodelingをデータで補正
- ✓ Top (1jet): b-tag CRから評価
- ✓ WZ/ZZ/Wγ : MCから評価



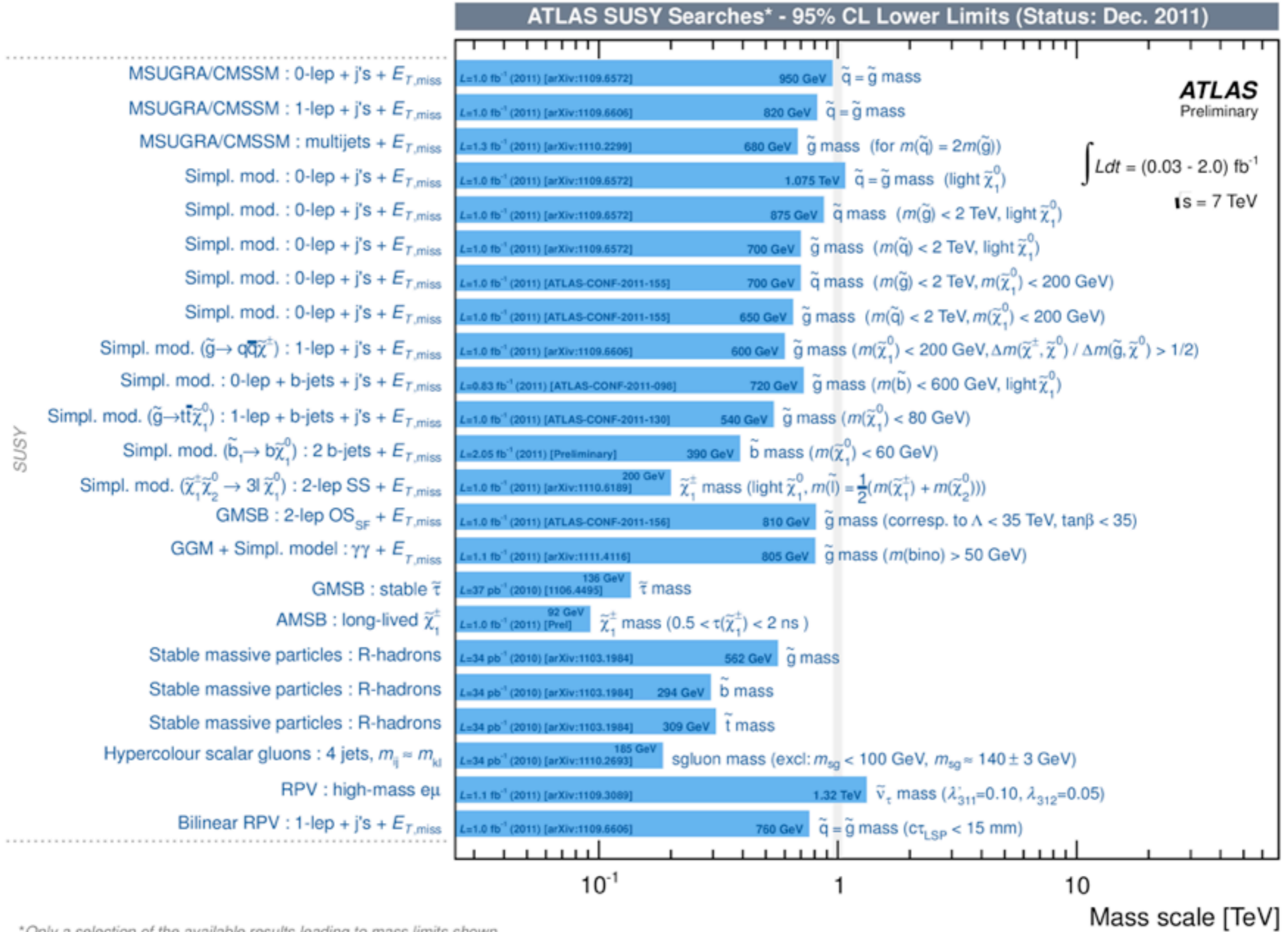
standard model summary



event display



standard model summary



standard model summary

