LHCの最新結果

Koji Nakamura (KEK)
on behalf of ATLAS&CMS collaboration

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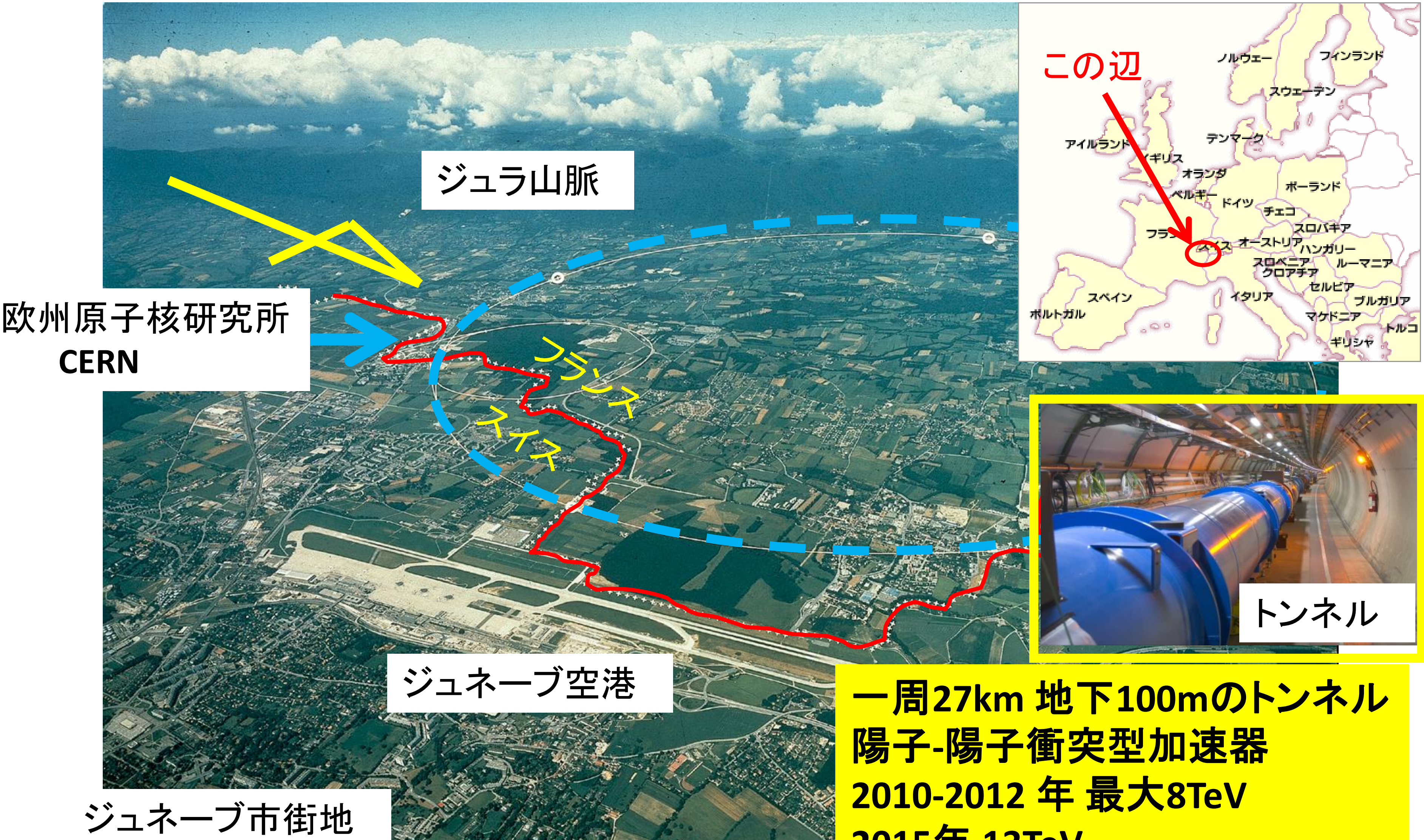
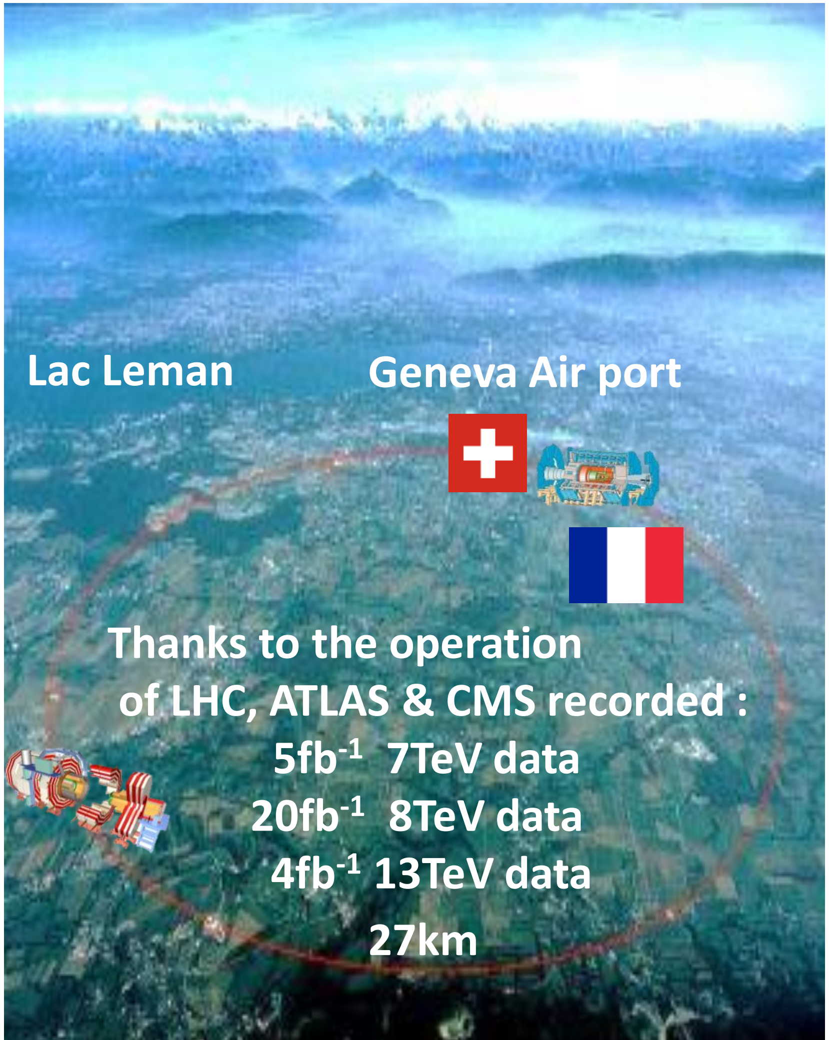
  - SUSY/Exotic の探索
- (来年度のLHCともっと先の話)

Large Hadron Collider (LHC)

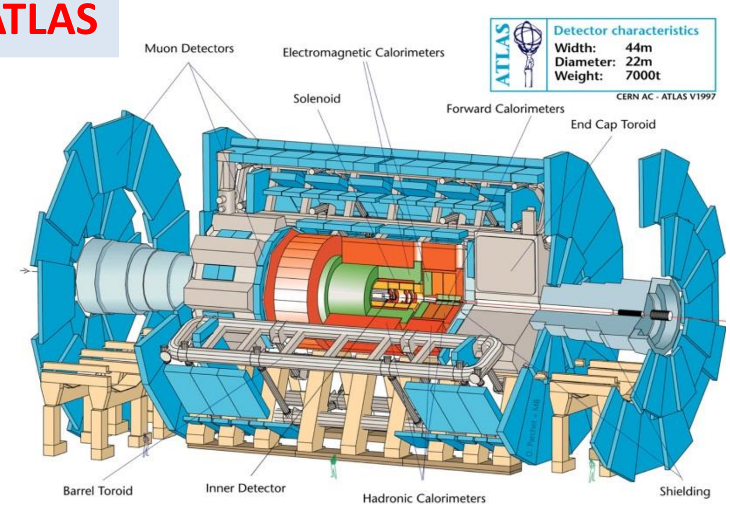


一周27km 地下100mのトンネル
陽子-陽子衝突型加速器
2010-2012 年 最大8TeV
2015年 13TeV

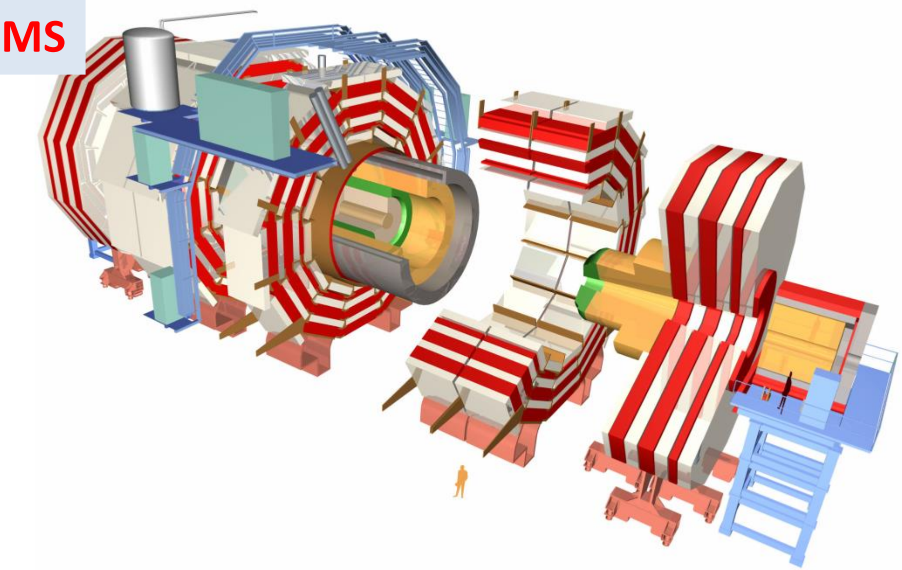
LHC and ATLAS/CMS experiment



ATLAS



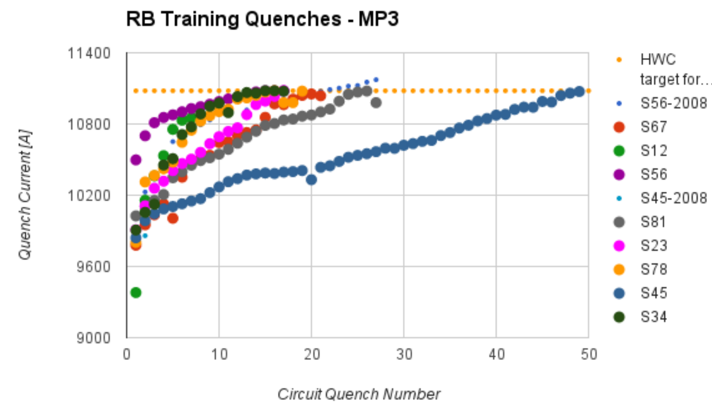
CMS

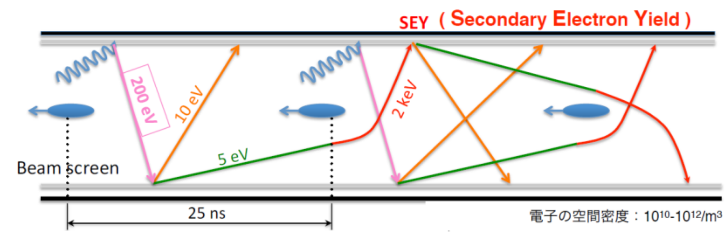


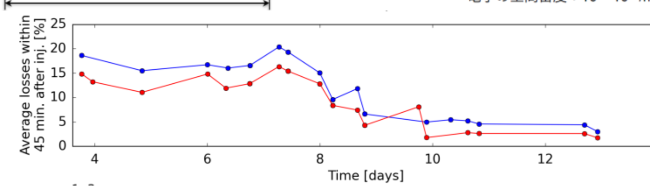
13TeVで再開した今年度の状況

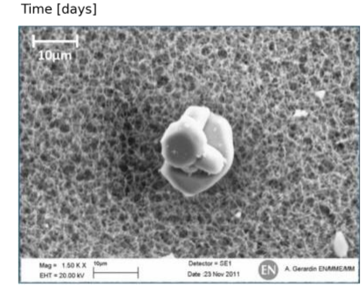
2015年の運転

- 重心系エネルギーを13TeV (6.5TeV x 6.5TeV)へ
  - Dipoleマグネットのクエンチトレーニング
    - 50回近く必要なセクター有
    - 13TeV衝突のStartが遅れる原因
- Luminosityを上げるのに苦戦
  - Electron Cloud 問題
    - Scrubbing が必要だった。
  - Unidentified Falling Object (UFO)



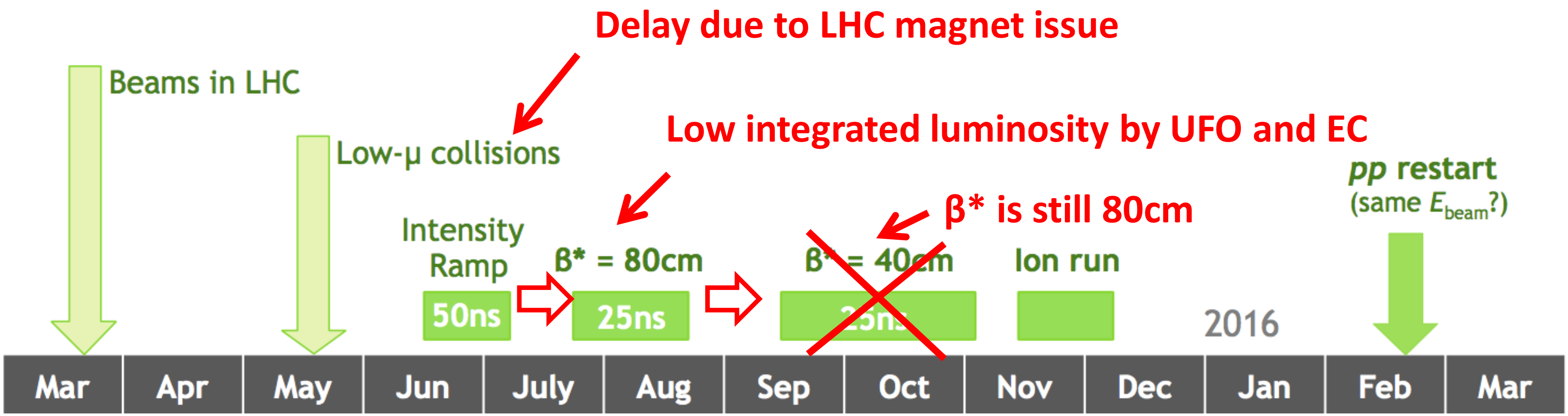


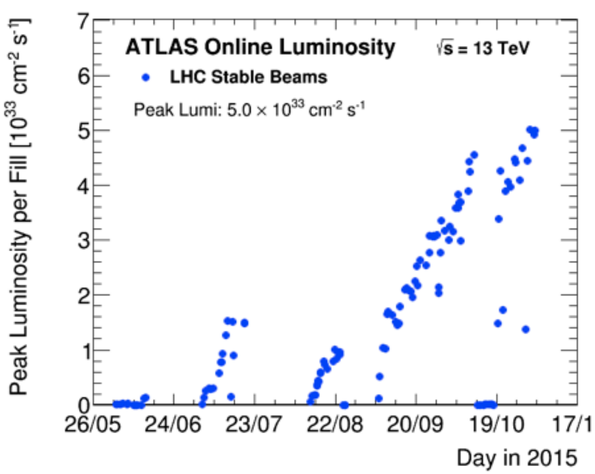




2015年の運転

- 2015年の予定 (2015年3月時)→実際は…



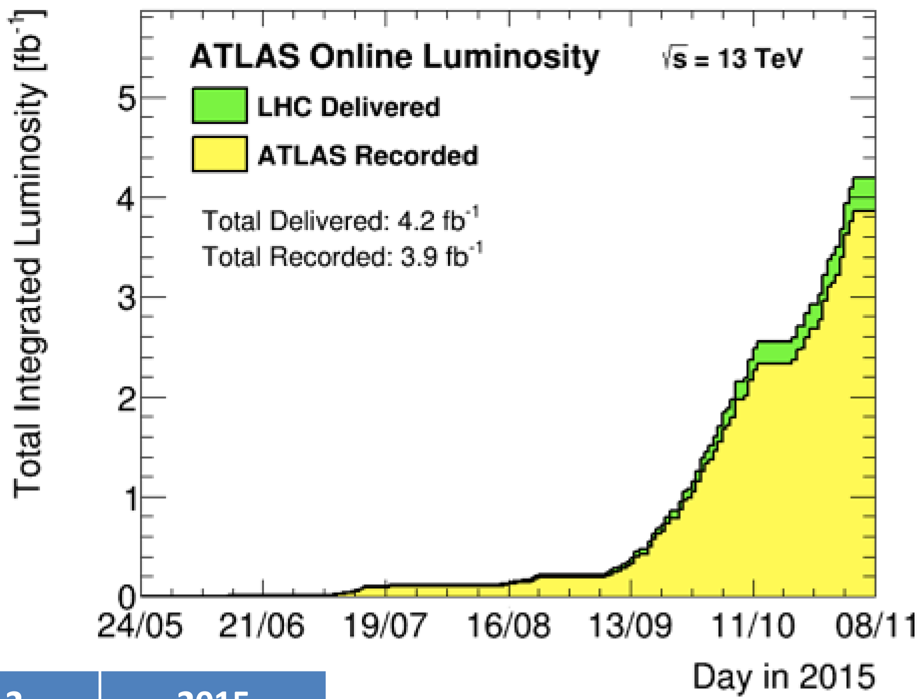


5月	6月	7-8月	9-11月	11-12月
Low-μ run	50ns beam β*=80cm	25ns beam β*=80cm	~~25ns beam β*=40cm~~	Heavy Ion
~~(1fb^{-1})~~	~~1fb^{-1}~~	~~2-5fb^{-1}~~ **0.2fb^{-1}**	~~5fb^{-1}~~ **4fb^{-1}**	

2015年内で合計~~10fb^{-1}~~ 4.2fb^{-1}

2015年の運転

- 最終的に
  - ATLAS で3.9fb^{-1} レコード
  - **3.4fb^{-1}程度が物理解析に使用可能**

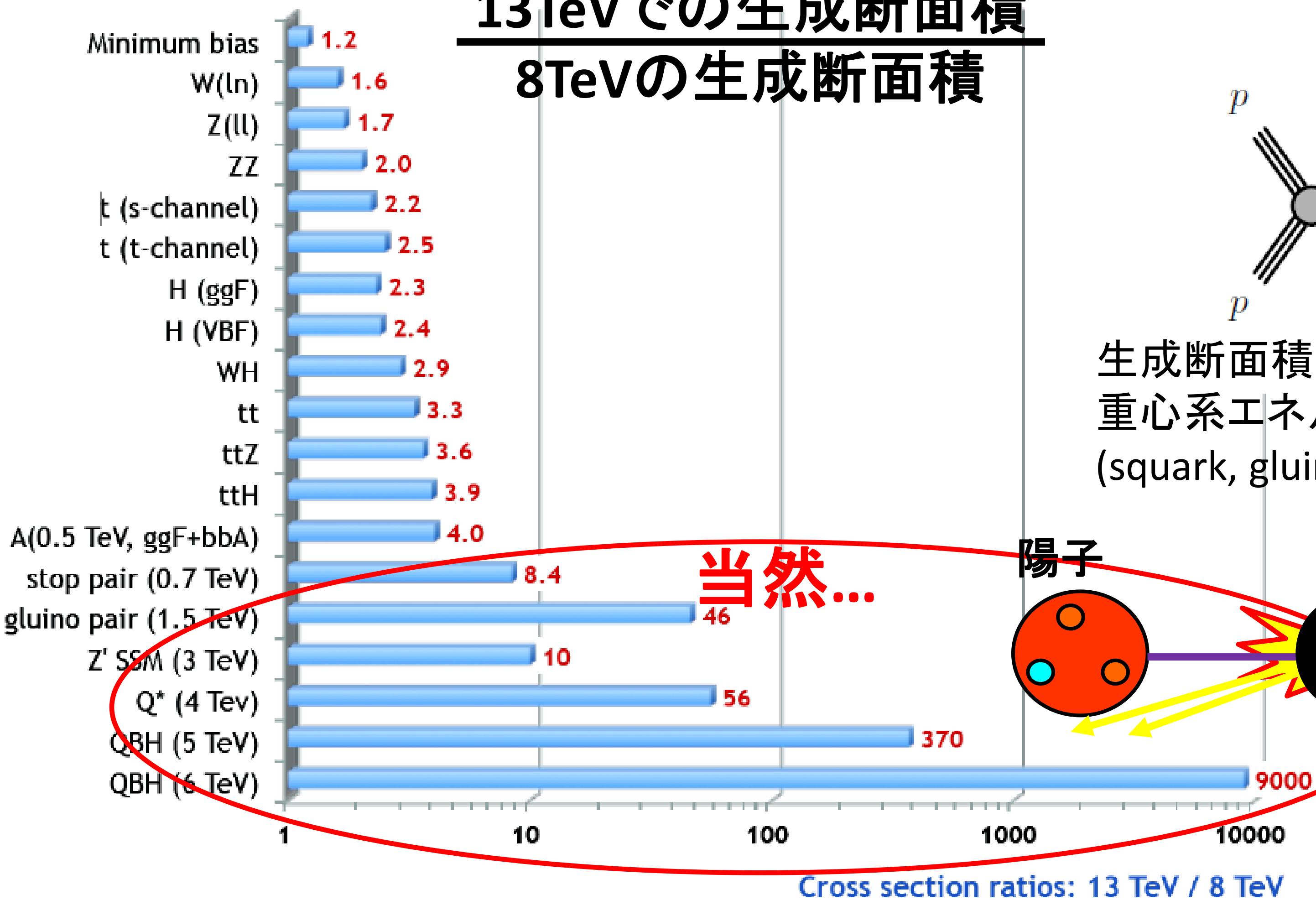


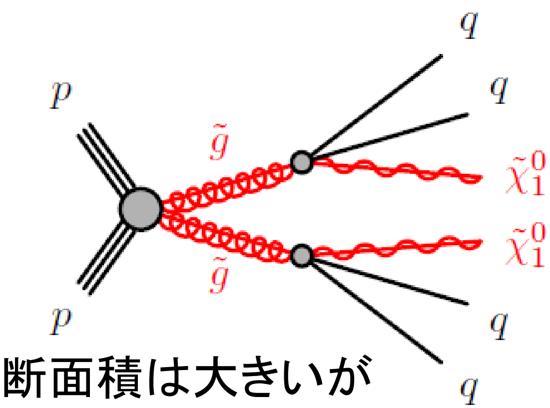
	Nominal	2012	2015
energy [TeV]	7	4	6.5
bunch spacing [ns]	25	50	25
beta* [cm] (crossing angle [urad])	55 (285)	60 (290)	80 (290)
max. number of bunches	2808	1380	2244/2232
max. stored energy [MJ]	362	140	270
peak luminosity [10^{34} cm^{-2}s^{-1}] in IP1/5	1.0	>0.7	~0.5

13TeVの恩恵

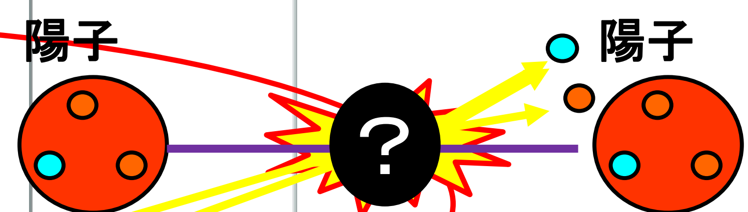
- エネルギーを8TeVから13(14)TeVにあげる

$$\frac{\text{13TeVでの生成断面積}}{\text{8TeVの生成断面積}}$$





生成断面積は大きいが
重心系エネルギーが足りなかった
(squark, gluino など)



13TeVの恩恵

- エネルギーを8TeVから13(14)TeVにあげる

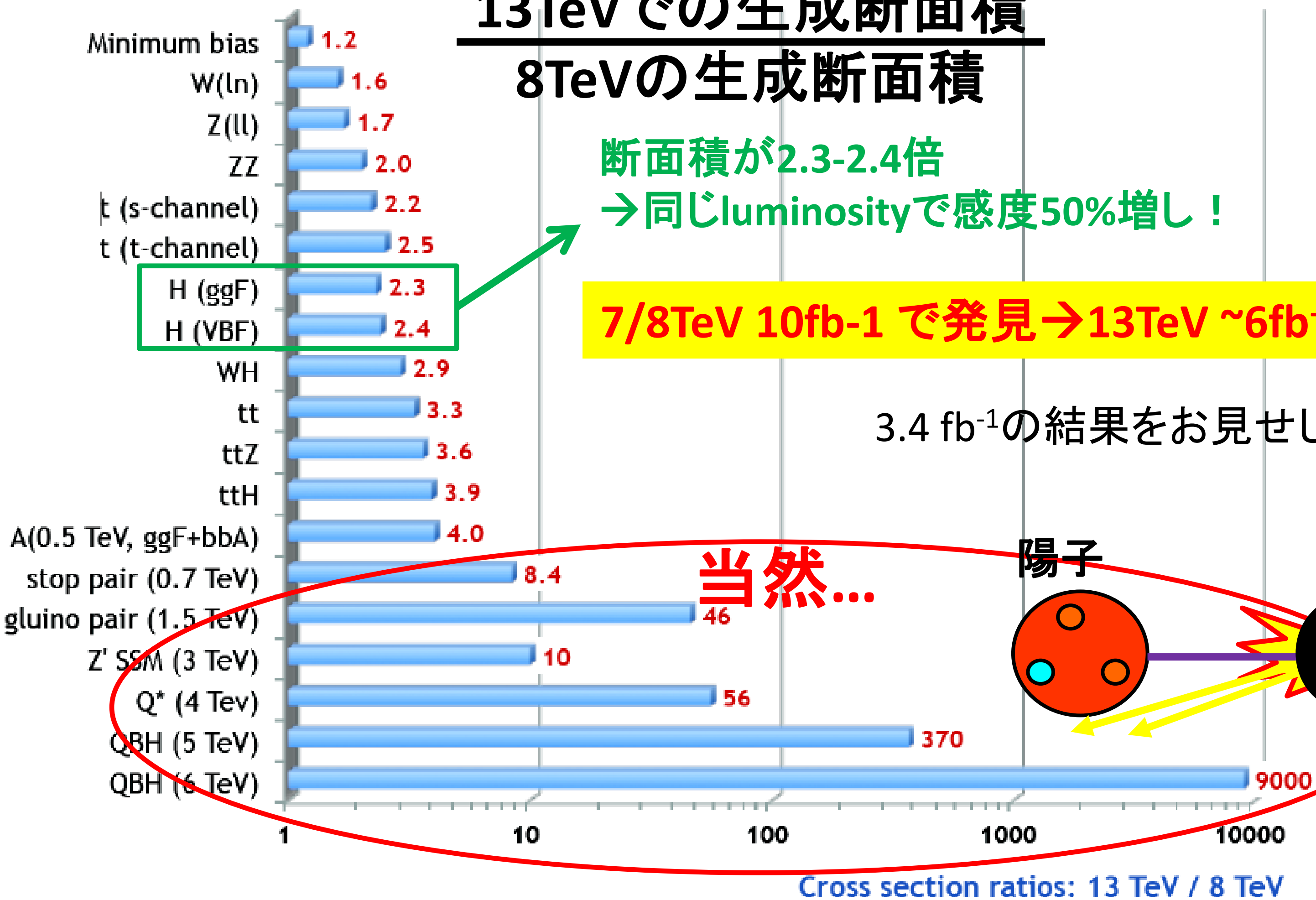
$$\frac{\text{13TeVでの生成断面積}}{\text{8TeVの生成断面積}}$$

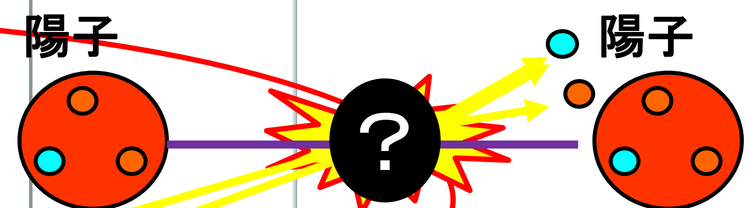
断面積が2.3-2.4倍
→同じluminosityで感度50%増し！

7/8TeV 10fb-1 で発見→13TeV ~6fb^{-1}ほど必要？！

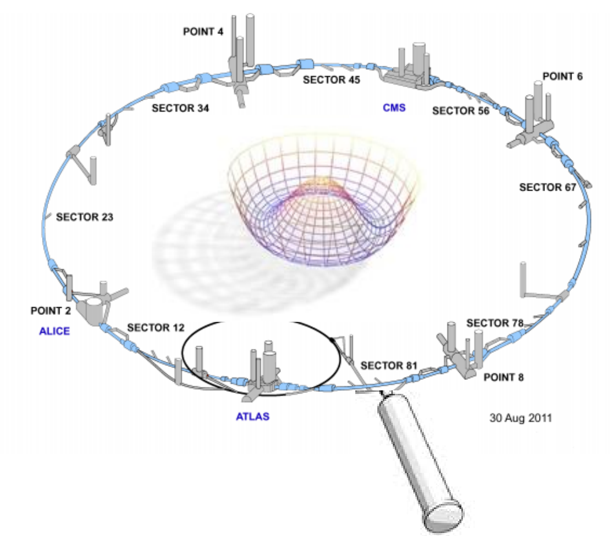
3.4 fb^{-1}の結果をお見せします。

当然...





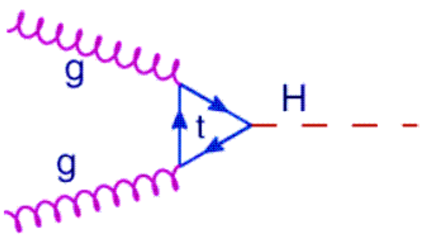
LHC 13TeVでの最新結果



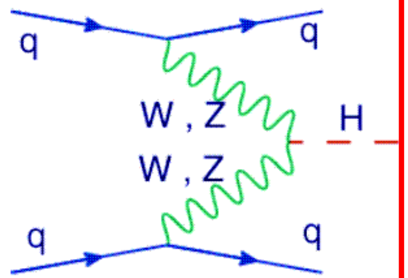
- Higgs粒子の再探索
- VVやγγに見つかった怪しい兆候
- SUSY/Exotic の探索

Higgs production and decay @ LHC

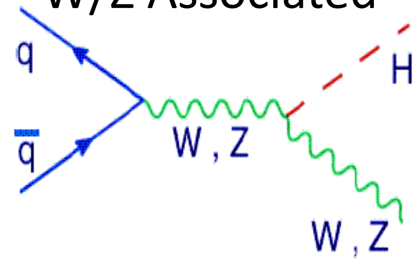
Gluon Fusion(ggF)



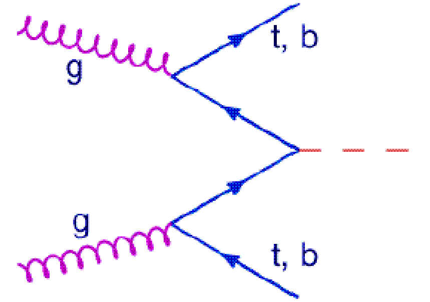
Vector Boson Fusion



W/Z Associated

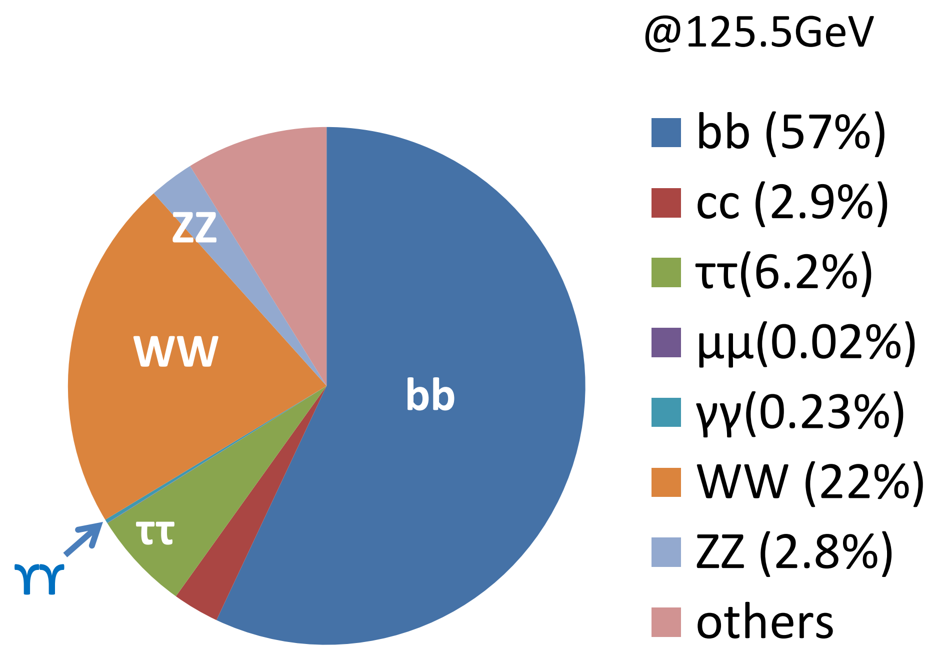


tt/bb Associated



Process	8TeV σ [pb]	14TeV σ [pb]
Gluon Fusion	**19.1**	**49.9**
Vector Boson Fusion	**1.57**	**4.18**
W/Z Associated	1.11	2.39
tt/bb Associated	0.128	0.611

8TeV @125.5GeV
14TeV @125GeV



まず、Run1のおさらい

Channel	Signal strength [μ]		Signal significance [σ]	
	from results in this paper (Section 5.2)			
	ATLAS	CMS	ATLAS	CMS
$H \to \gamma\gamma$	$1.15^{+0.27}_{-0.25}$ $\left({}^{+0.26}_{-0.24}\right)$	$1.12^{+0.25}_{-0.23}$ $\left({}^{+0.24}_{-0.22}\right)$	5.0 (4.6)	5.6 (5.1)
$H \to ZZ \to 4\ell$	$1.51^{+0.39}_{-0.34}$ $\left({}^{+0.33}_{-0.27}\right)$	$1.05^{+0.32}_{-0.27}$ $\left({}^{+0.31}_{-0.26}\right)$	6.6 (5.5)	7.0 (6.8)
$H \to WW$	$1.23^{+0.23}_{-0.21}$ $\left({}^{+0.21}_{-0.20}\right)$	$0.91^{+0.24}_{-0.21}$ $\left({}^{+0.23}_{-0.20}\right)$	6.8 (5.8)	4.8 (5.6)
$H \to \tau\tau$	$1.41^{+0.40}_{-0.35}$ $\left({}^{+0.37}_{-0.33}\right)$	$0.89^{+0.31}_{-0.28}$ $\left({}^{+0.31}_{-0.29}\right)$	4.4 (3.3)	3.4 (3.7)
$H \to bb$	$0.62^{+0.37}_{-0.36}$ $\left({}^{+0.39}_{-0.37}\right)$	$0.81^{+0.45}_{-0.42}$ $\left({}^{+0.45}_{-0.43}\right)$	1.7 (2.7)	2.0 (2.5)
$H \to \mu\mu$	-0.7 ± 3.6 (± 3.6)	0.8 ± 3.5 (± 3.5)		
ttH production	$1.9^{+0.8}_{-0.7}$ $\left({}^{+0.72}_{-0.66}\right)$	$2.9^{+1.0}_{-0.9}$ $\left({}^{+0.88}_{-0.80}\right)$	2.7 (1.6)	3.6 (1.3)

20-30%

30-40%

5σ!

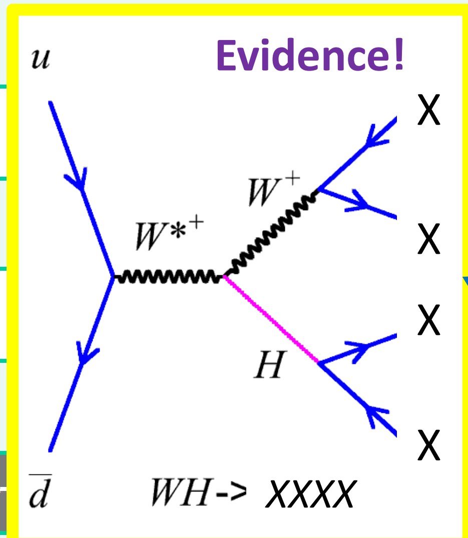
3σ!

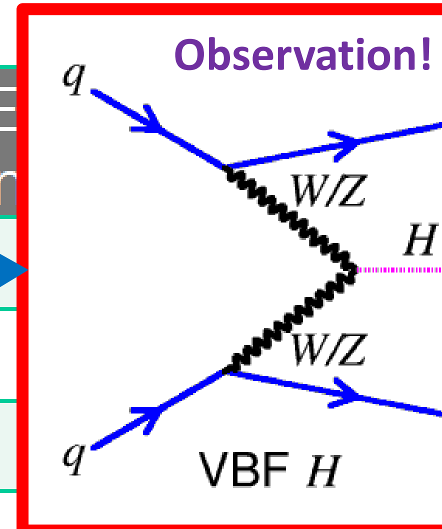
- Classify the Higgs search/measurement study by decay modes.
- **5σ observation of γγ, ZZ and WW channel.**
- **Need more data for H->bb and gg->ttH production.**
- Longer time project for H->μμ (HL-LHC?)

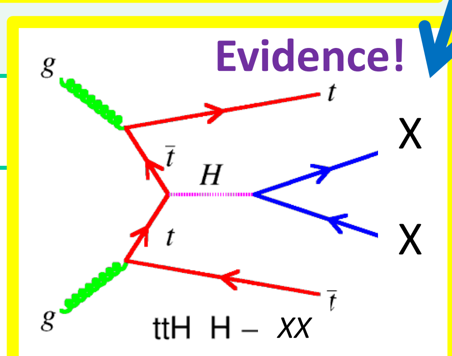
Results Production and Decay (sensitivity)

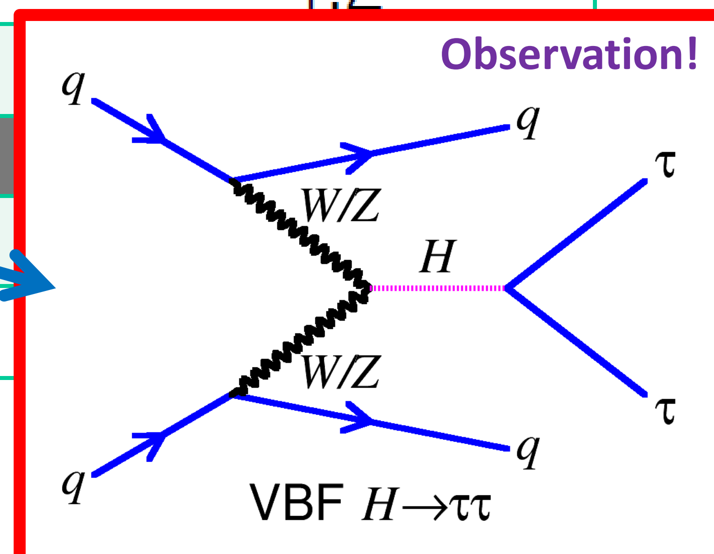
After ATLAS & CMS combination !

Production process	Observed Significance(σ)	E... Sign...
VBF	**5.4**	
WH	2.4	
ZH	2.3	
VH	3.5	4.2
ttH	4.4	
Decay chann...		
H→ττ	**5.5**	
H→bb	2.6	







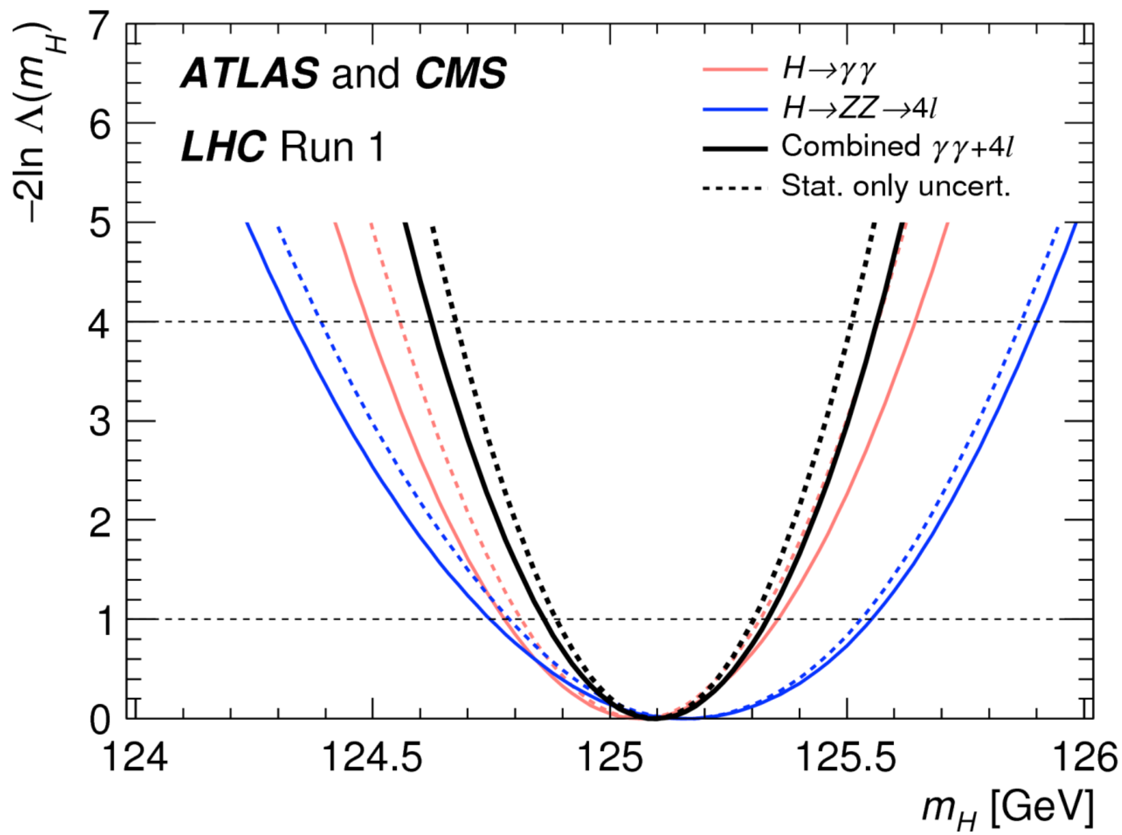


Mass of observed Boson

- ATLAS & CMS has been published in March 2015

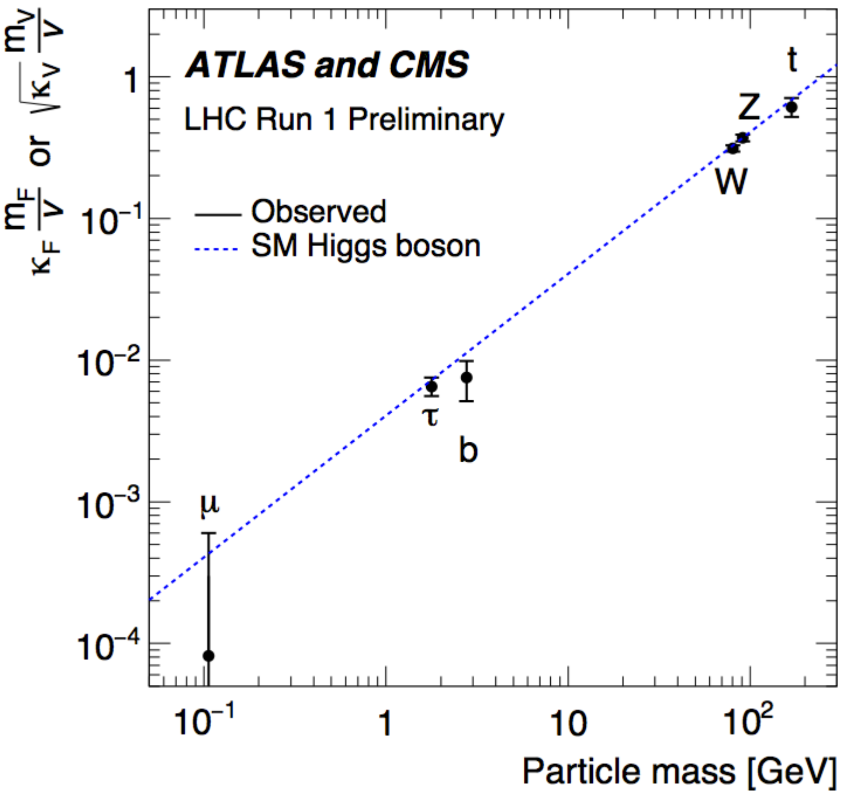
M_H = 125.09 ± 0.24 GeV [±0.21 (stat.) ±0.11(syst.)]

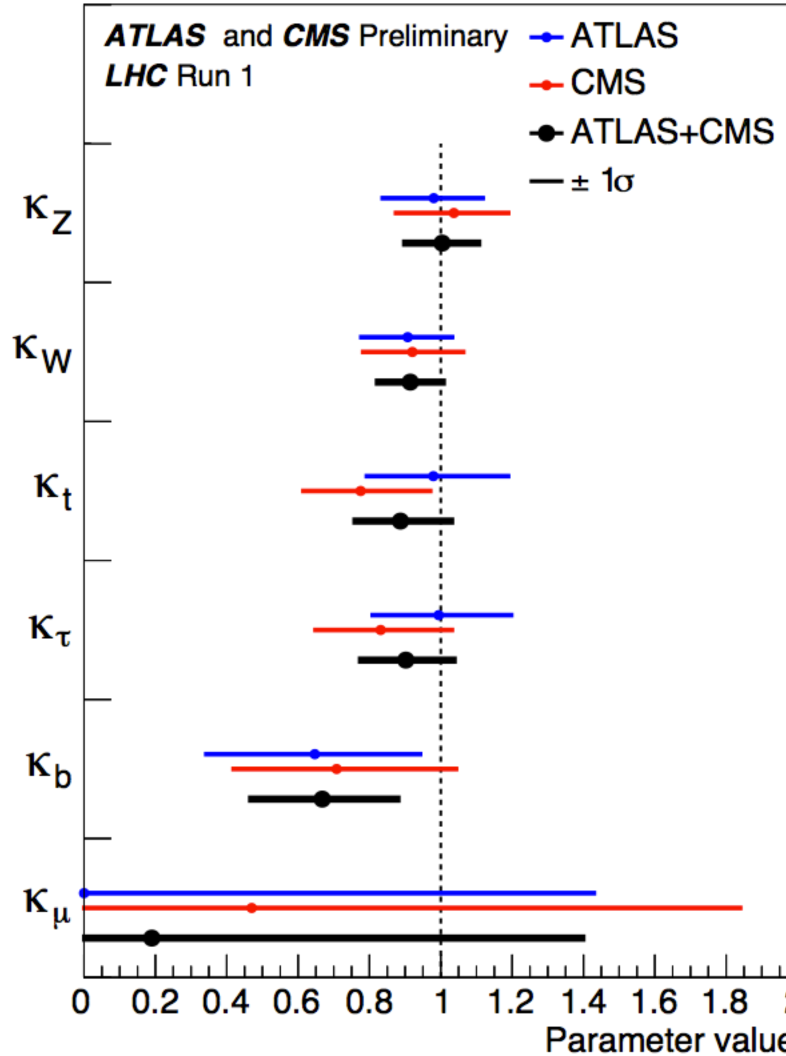
  - This result was important to measure coupling deviation from SM



Constraints on Higgs coupling

- Assume only SM physics in loops, no invisible Higgs decays
- Fit for scaling parameters for Higgs coupling to : W, Z ,b, t, τ, μ





Higgsの前に… Top Quark 再発見

- Top quark対生成

Dilepton

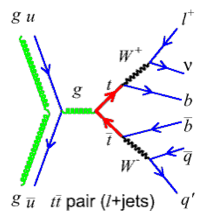
$$\sigma_{t\bar{t}} = 803 \pm 7\ (\text{stat}) \pm 27\ (\text{syst}) \pm 45\ (\text{lumi}) \pm 12\ (\text{beam})\ \text{pb}$$

$$\sigma_{t\bar{t}} = 749 \pm 57\ (\text{stat}) \pm 79\ (\text{syst}) \pm 74\ (\text{lumi})\ \text{pb}$$

Lepton+jets

$$\sigma_{t\bar{t}} = 817 \pm 13\ (\text{stat}) \pm 103\ (\text{syst}) \pm 88\ (\text{lumi})\ \text{pb}$$

Theory Prediction $832^{+40}_{-46}\ \text{pb}$



- Top 単一生成

Top Quark

$$\sigma(tq) = 133 \pm 6\ (\text{stat.}) \pm 24\ (\text{syst.}) \pm 7\ (\text{lumi.})\ \text{pb}$$

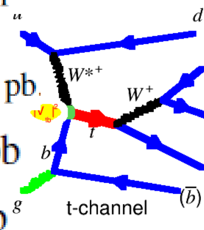
Anti-Top Quark

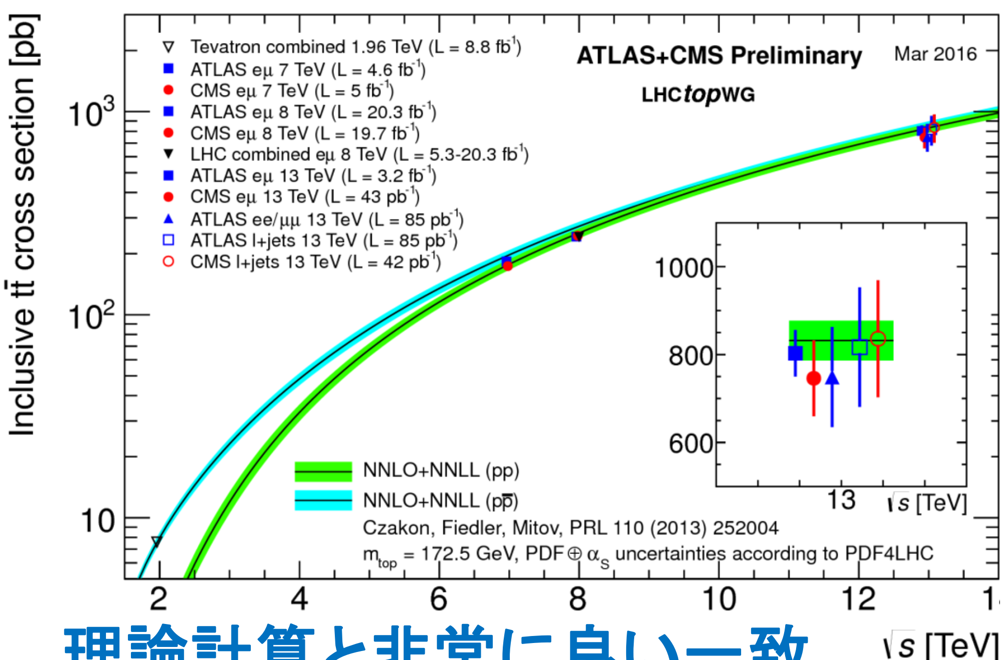
$$\sigma(\bar{t}q) = 96 \pm 5\ (\text{stat.}) \pm 23\ (\text{syst.}) \pm 5\ (\text{lumi.})\ \text{pb}$$

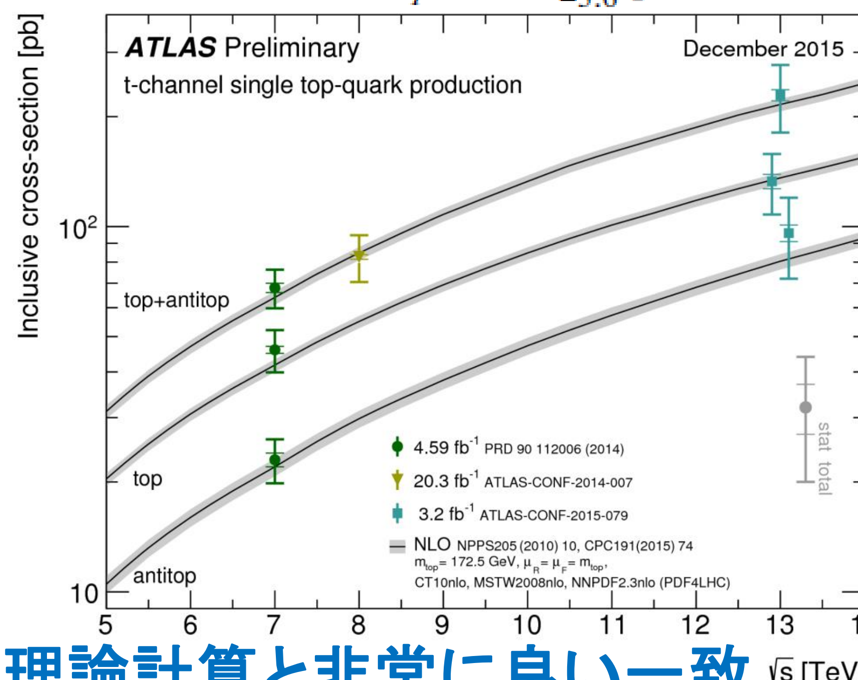
Theory Prediction

$$\sigma_{tq} = 136.0^{+5.4}_{-4.6}\ \text{pb}$$

$$\sigma_{\bar{t}q} = 81.0^{+4.1}_{-3.6}\ \text{pb}$$

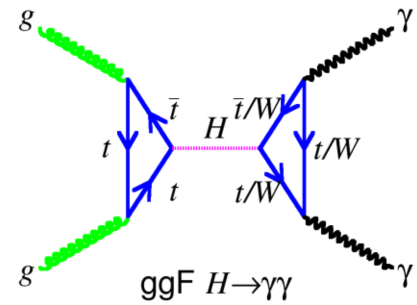




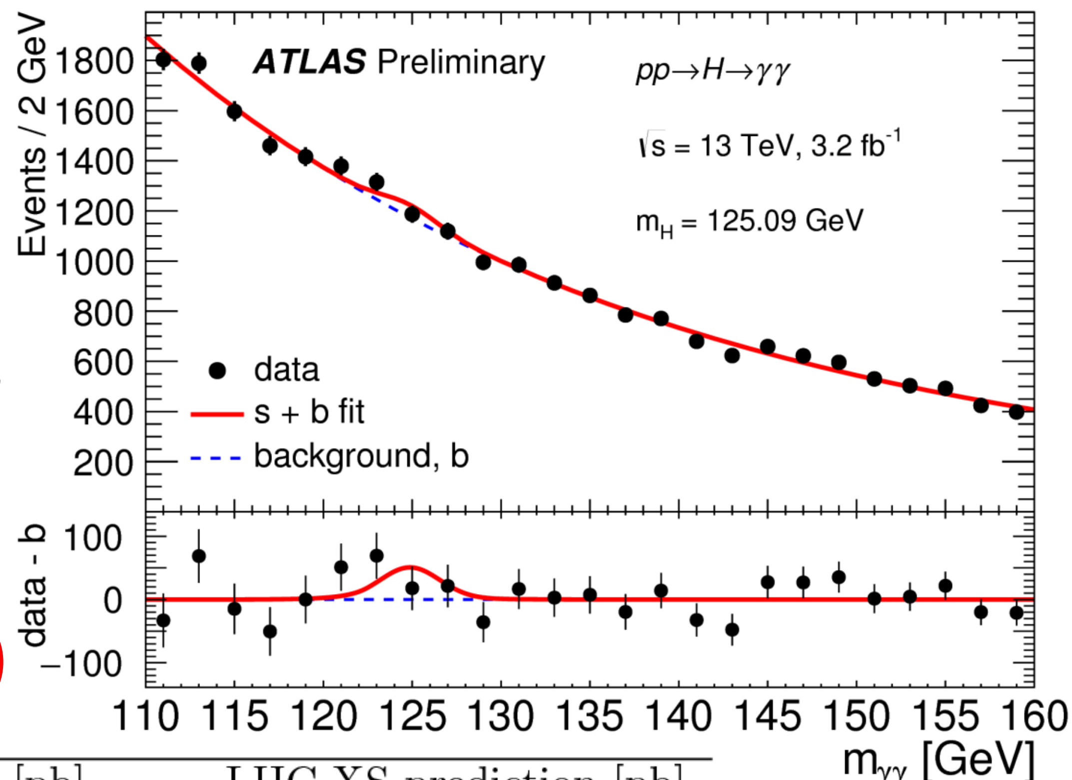


理論計算と非常に良い一致　　理論計算と非常に良い一致

H→γγ

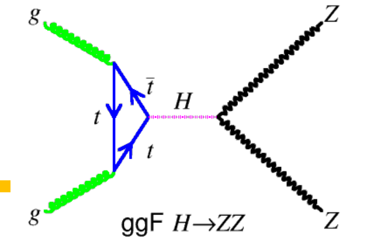


- 3.2fb-1データでdi-photon spectrumをみる
  - SignalはCrystal Ball + Gaussian
  - Backgroundは単調減少Analytical function
- Backgroundの中でReal γγの割合は78%
- Nsig = 113±74$^{+43}_{-25}$
- **感度: 1.5σ(1.9σ) obs(exp)**

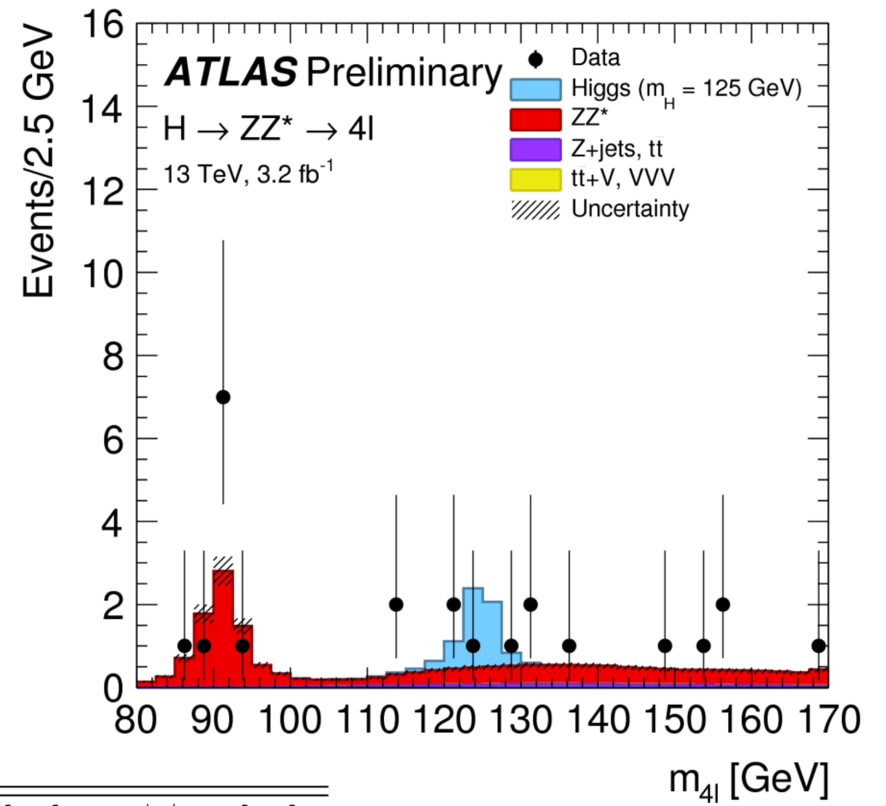


$\sqrt{s}$	Measured total cross section [pb]	LHC-XS prediction [pb]
7 TeV	35 ± 12 (stat.) ± 4 (syst.) ± 1 (lumi.)	17.5 ± 1.6
8 TeV	30.5 ± 7.1 (stat.) $^{+2.6}_{-2.5}$ (syst.) ± 0.9 (lumi.)	22.3 ± 2.0
13 TeV	40 ± 26 (stat.) $^{+16}_{-10}$ (syst.) ± 2 (lumi.)	$50.9\ ^{+4.5}_{-4.4}$

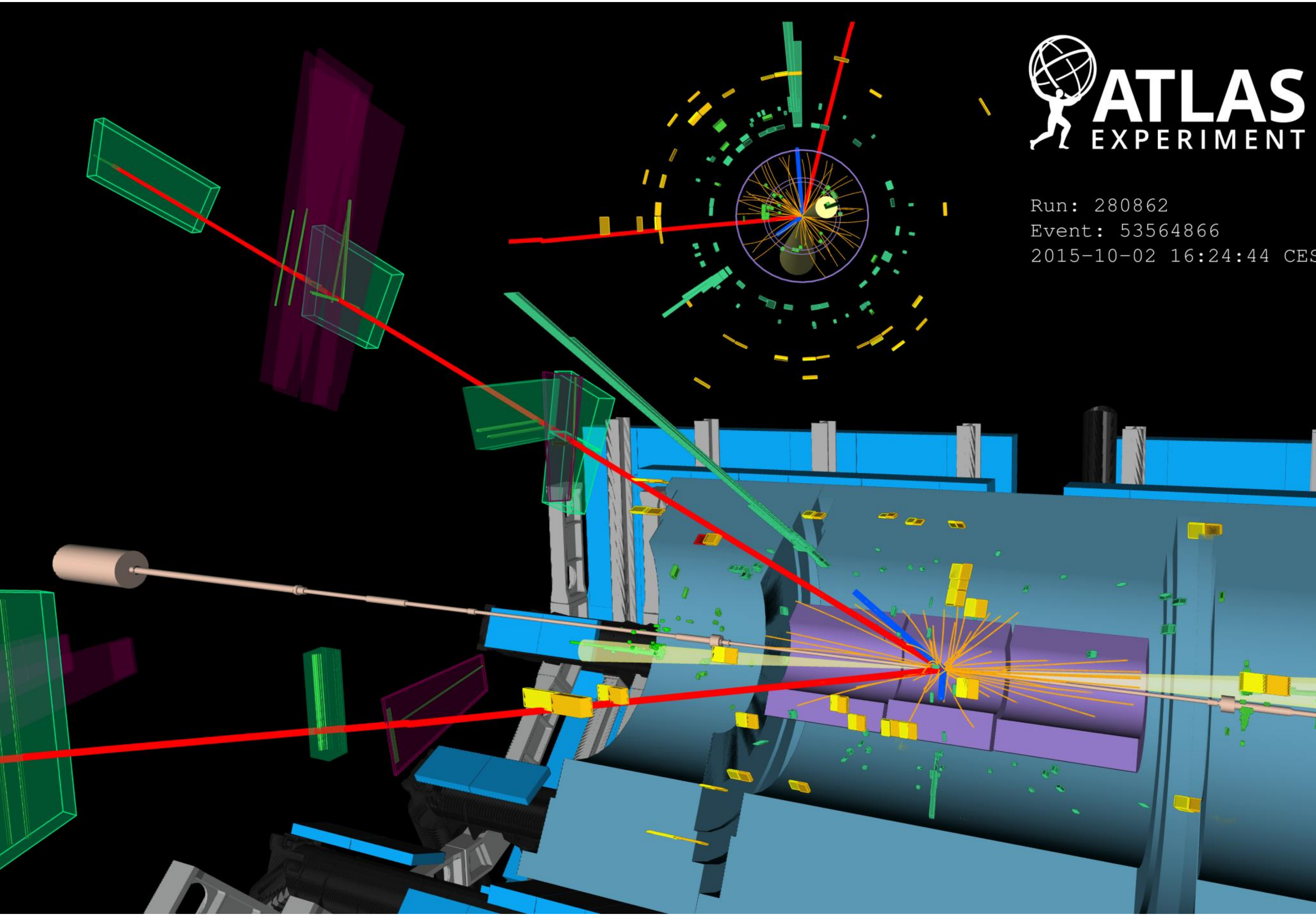
H→ZZ(*)



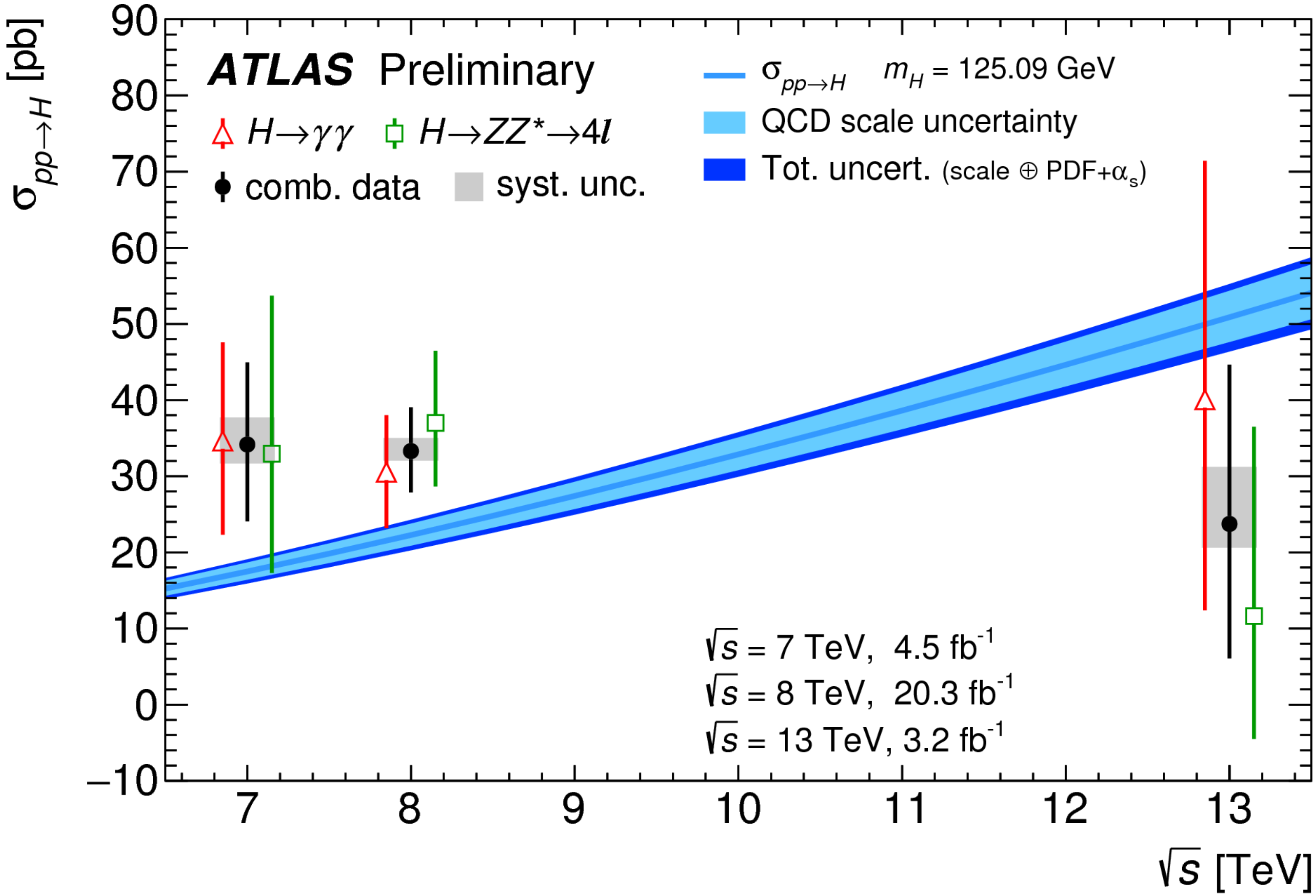
- m_{4l} spectrum
- $118<m_{4l}<129$GeV
  - Signal exp =4.57±0.54
  - Bkg exp = 2.1±0.2
  - Observed 4 event.
- $N_{sig}^{fit}=1^{+2.3}_{-1.5}$
- **感度：0.7σ(2.8σ) obs(exp)**



Data set [TeV]	N_s	$\sigma^{fid}_{4\ell}$ [fb]	σ^{fid}_{theory} [fb]	σ^{tot} [pb]	σ^{tot}_{theory} [pb]
7	$4.5^{+2.8}_{-2.2}$	$1.9^{+1.2}_{-0.9}$	1.03 ± 0.11	33^{+21}_{-16}	17.5 ± 1.6
8	$24.0^{+6.0}_{-5.3}$	2.1 ± 0.5	1.29 ± 0.13	37^{+9}_{-8}	22.3 ± 2.0
13	$1.0^{+2.3}_{-1.5}$	$0.6^{+1.3}_{-0.9}$	2.74 ± 0.28	12^{+25}_{-16}	$50.9^{+4.5}_{-4.4}$


ATLAS
EXPERIMENT
Run: 280862
Event: 53564866
2015-10-02 16:24:44 CES

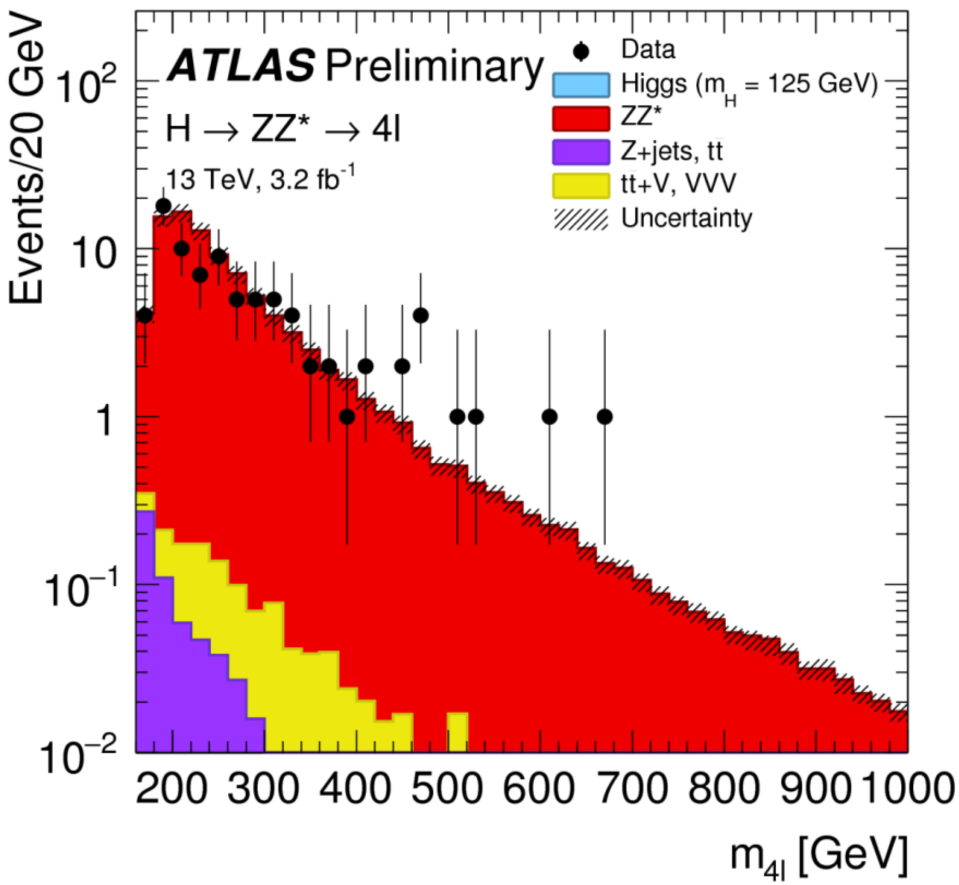
まとめると

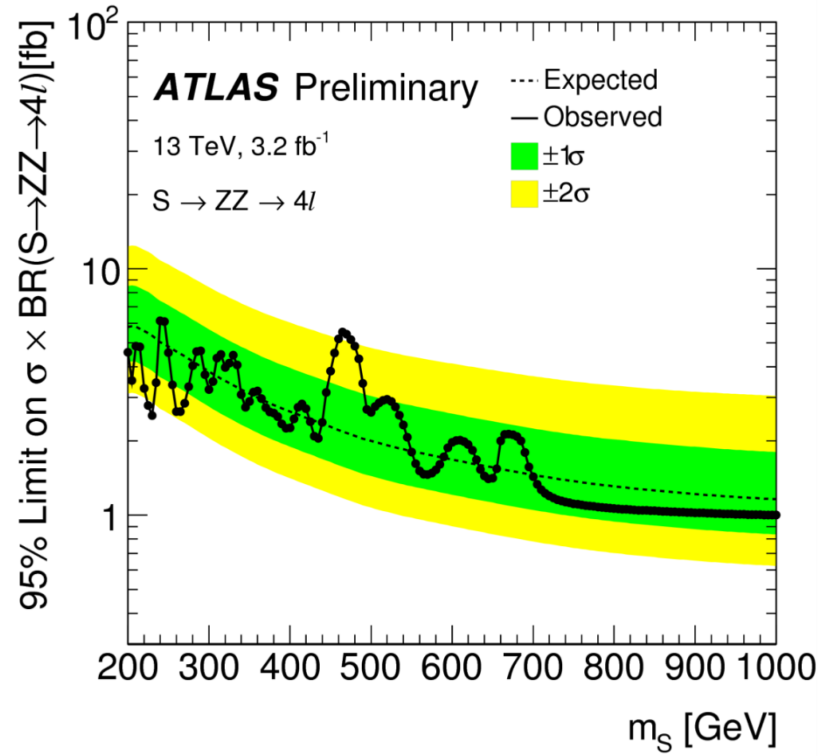


ATLAS Preliminary
H→γγ
H→ZZ*→4l
comb. data
syst. unc.
σpp→H mH = 125.09 GeV
QCD scale uncertainty
Tot. uncert. (scale ⊕ PDF+αs)
√s = 7 TeV, 4.5 fb-1
√s = 8 TeV, 20.3 fb-1
√s = 13 TeV, 3.2 fb-1
σpp→H [pb]
√s [TeV]

H→ZZ : High Mass resonance

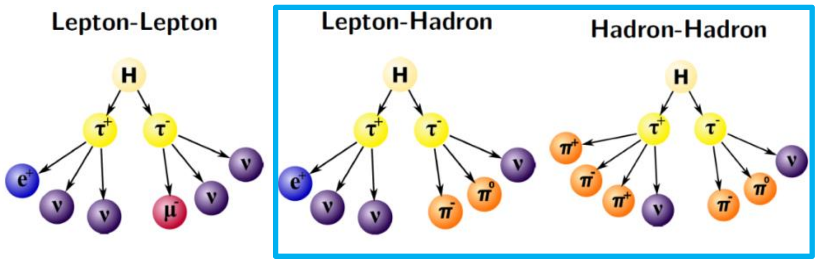
- 探索領域を1TeVまで拡張　significantなexcessはなし
- σ x BR(s→ZZ→4l)に対する95%CL limit を設定

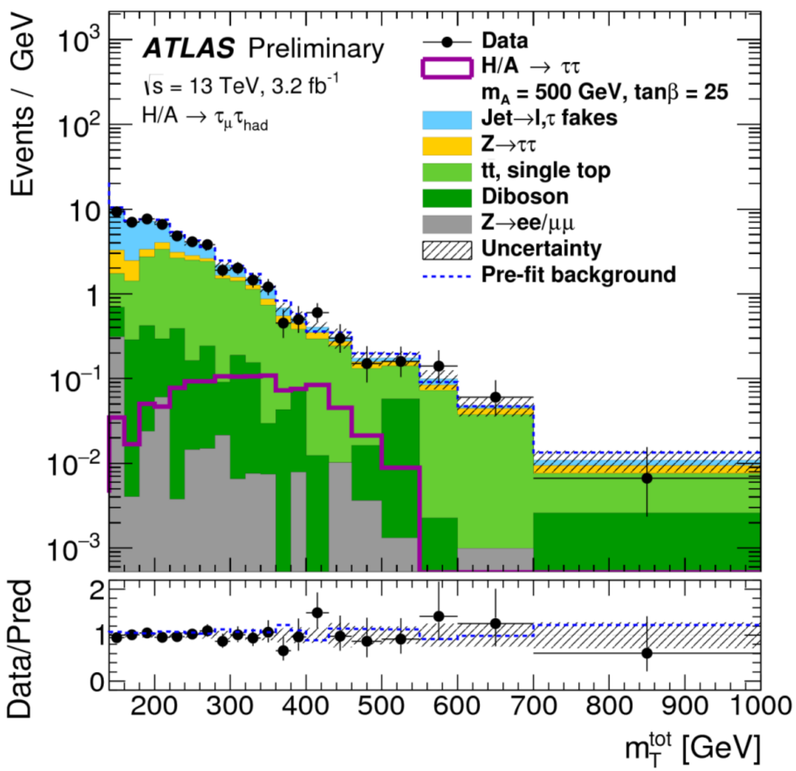


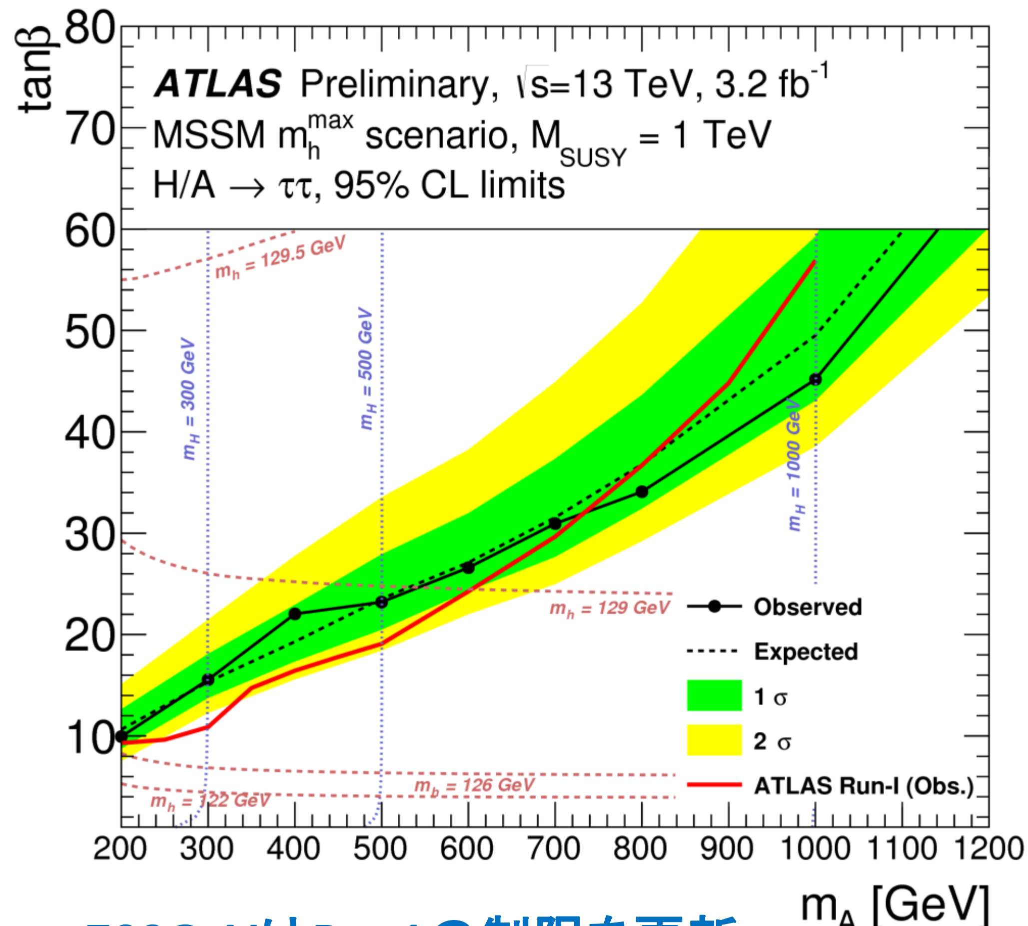


MSSM A→ττ

- SM Higgs H→ττはまだ感度がないが、MSSMは探索可能



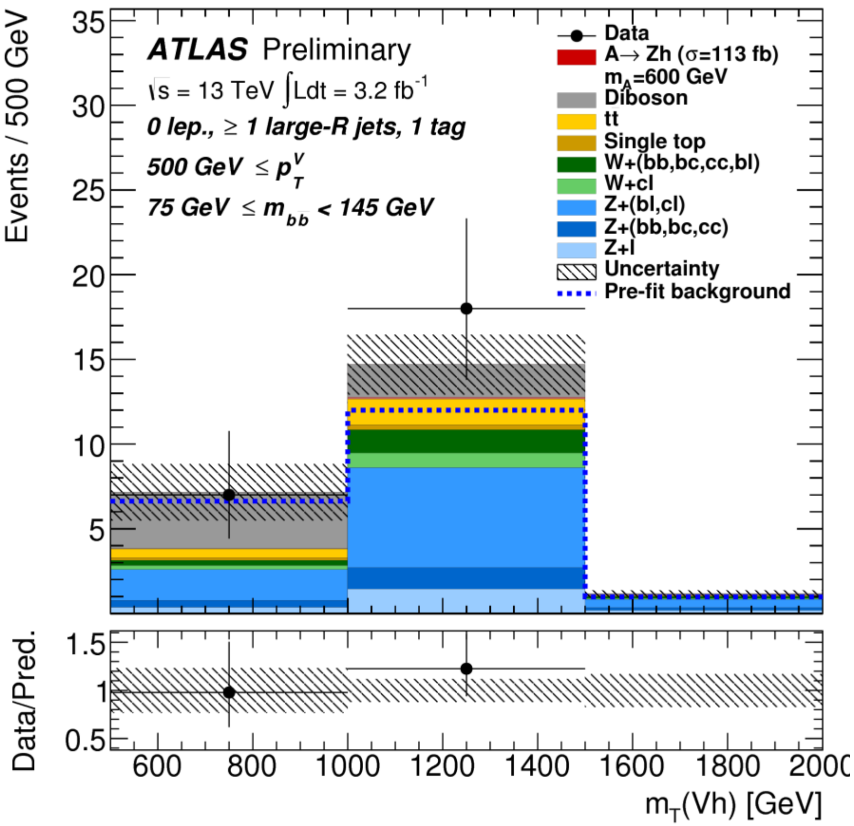


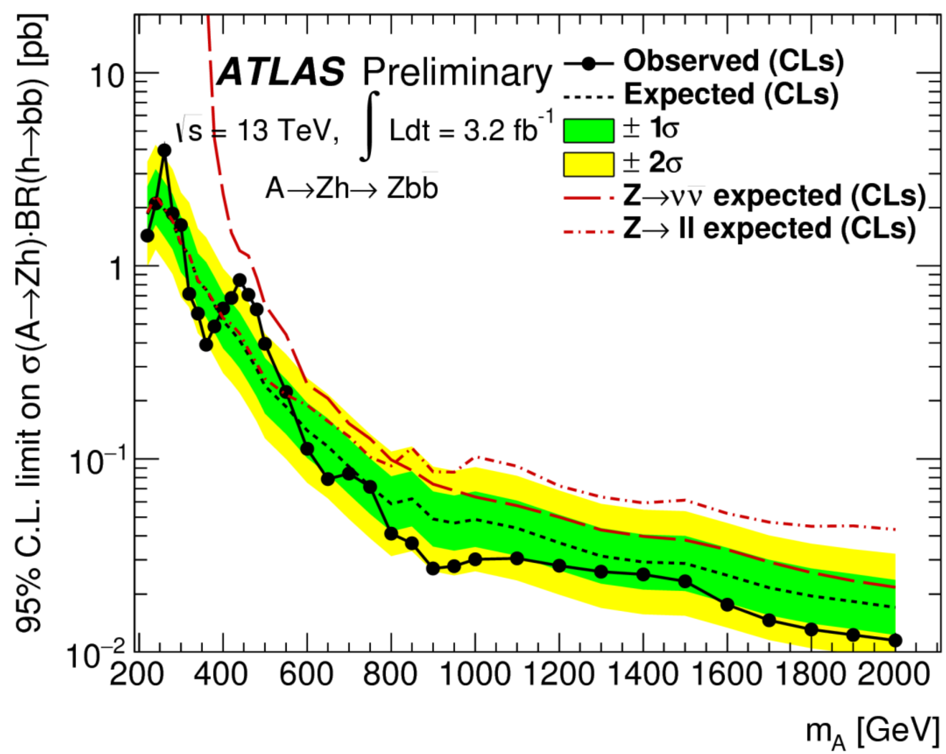


>700GeVはRun1の制限を更新

MSSM A→Zh

- 標準理論ZH→llbb,vvbb解析をHigh massまでextend.
- pTZ>500GeVはH→bbは1 fat jet (boost)として解析



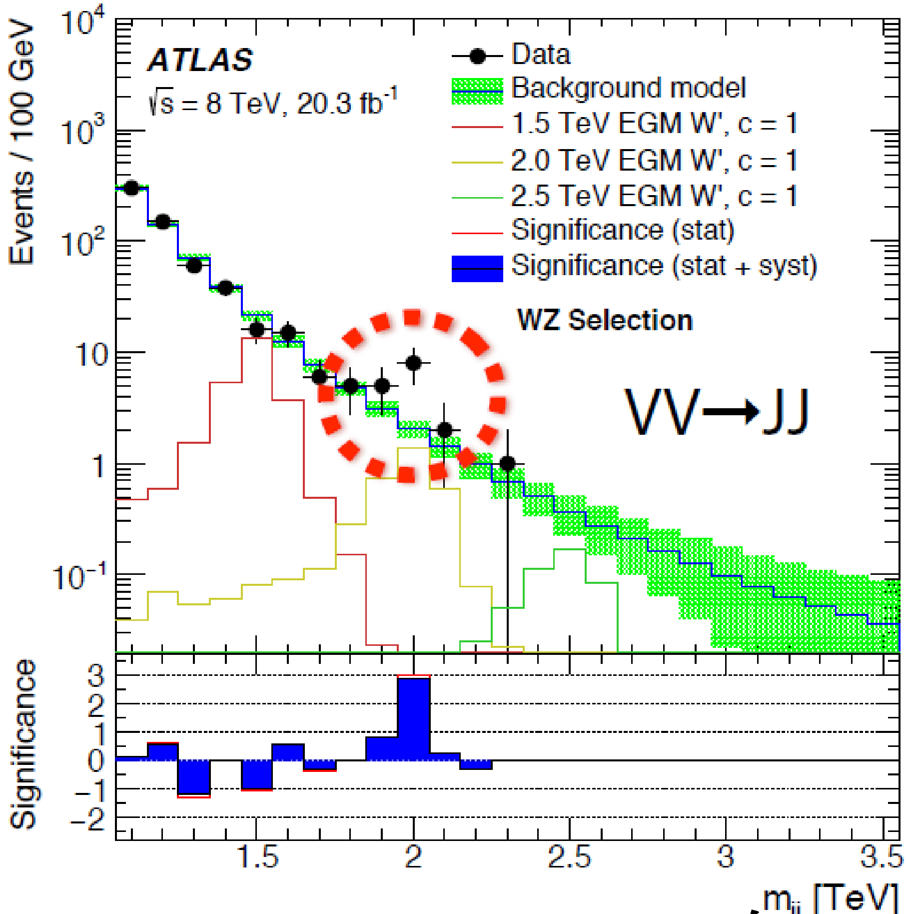


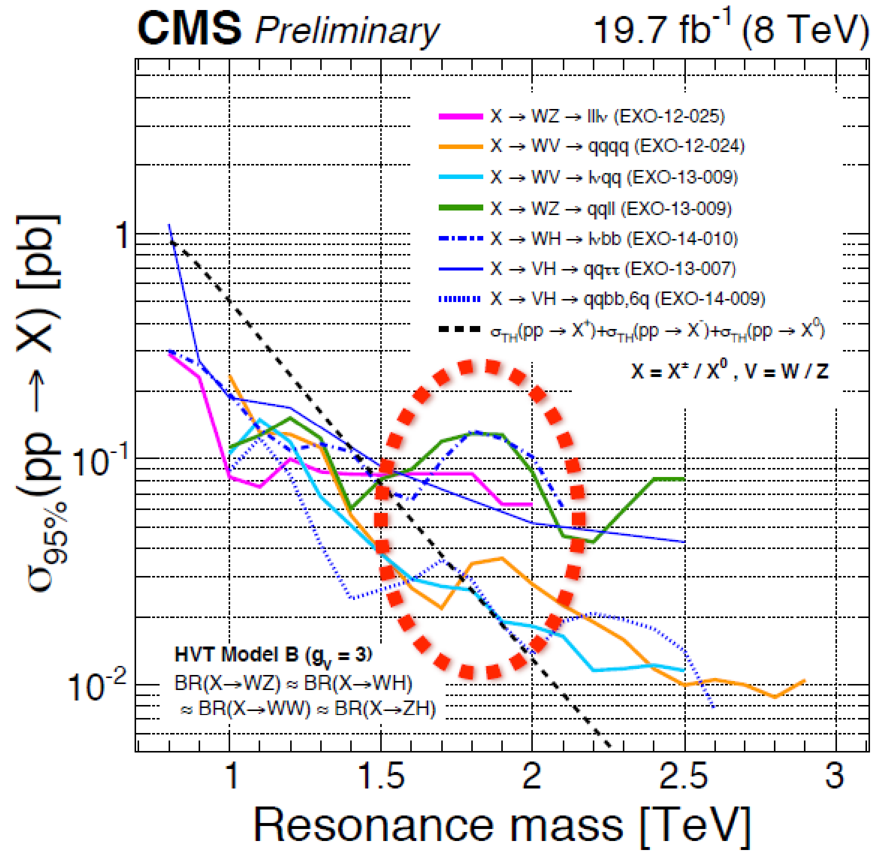
>800GeVはRun1の制限を更新

LHC 13TeVでの最新結果

- Higgs粒子の再探索
- VVやγγに見つかった怪しい兆候
- SUSY/Exotic の探索

8TeV di-boson results



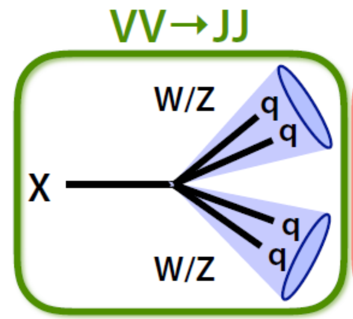


- Run1 (8TeV)のExcessを13TeVデータで検証する
- “J”はboost jet (2jet がマージ)→ boost boson-tagging

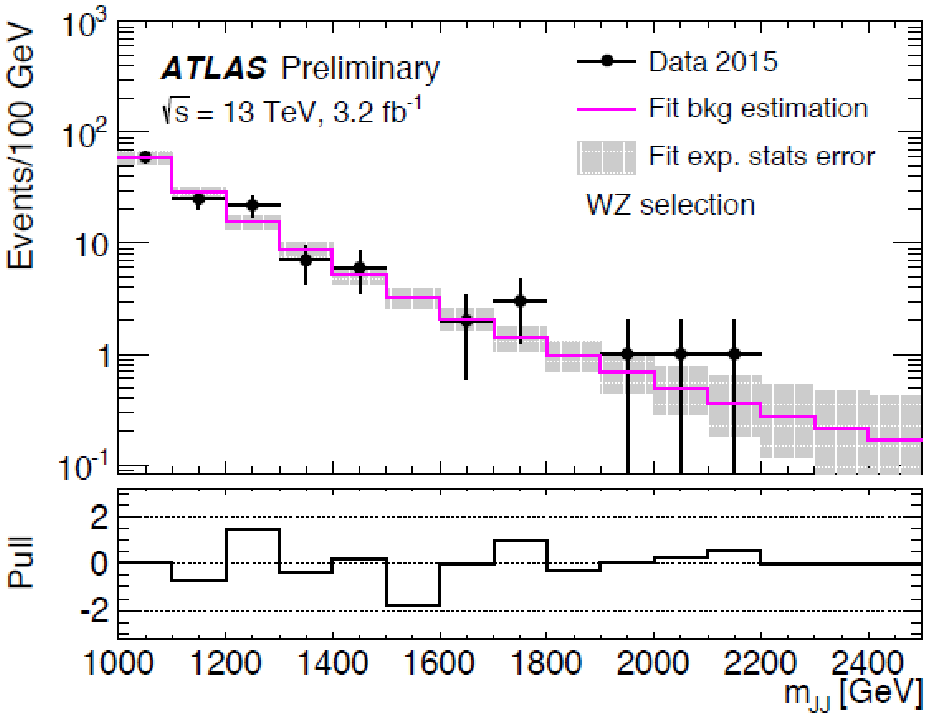
VV→JJ 探索 @ 13TeV

- 8TeVの解析を13TeVデータにアプライ。
- m_{qq}でWZ,WW,ZZ selectionを定義

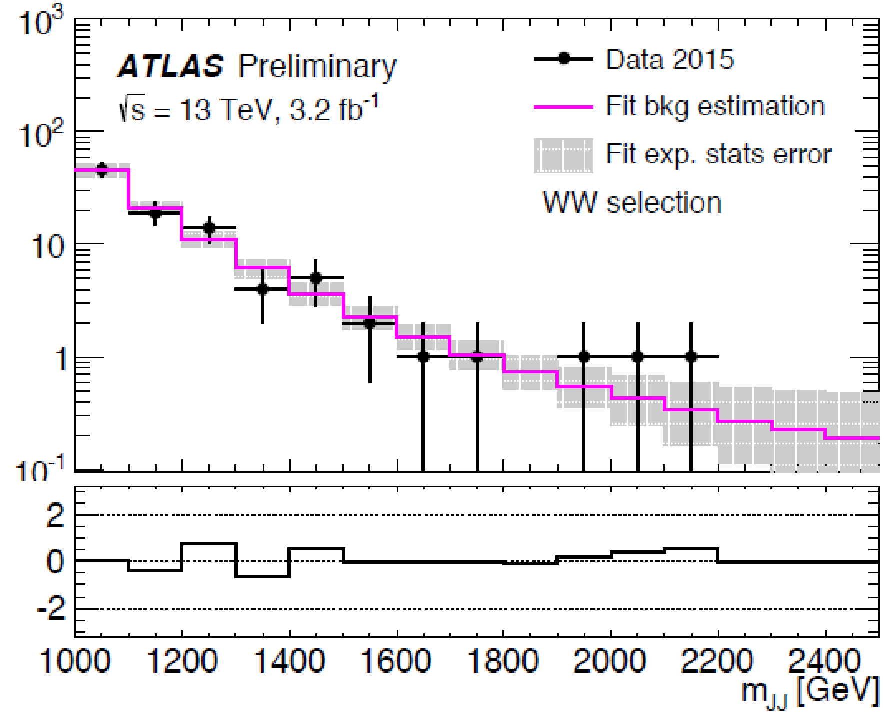
→2TeVのexcessは無い様に見える…



WZ selection



WW selection

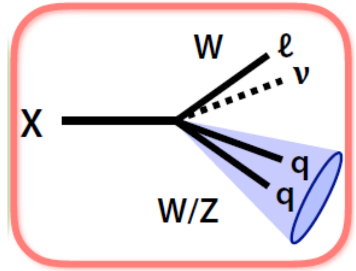


VV → Leptonic decay

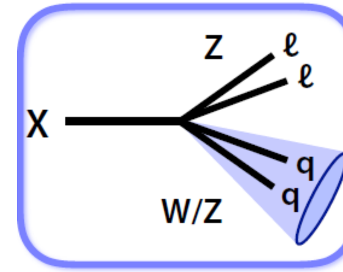
- VV→JJに加えて leptonic decay も解析

→ 有意な超過なし

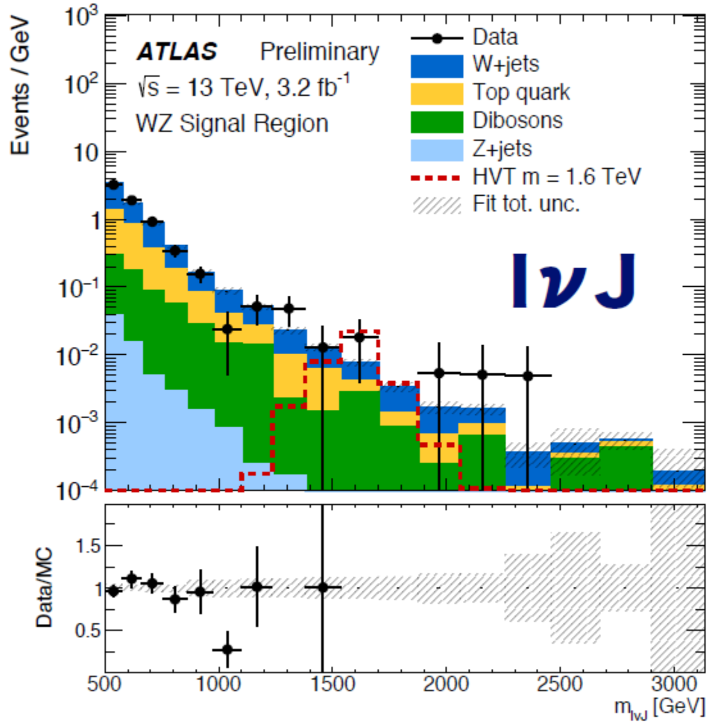
WW/WZ→lνJ



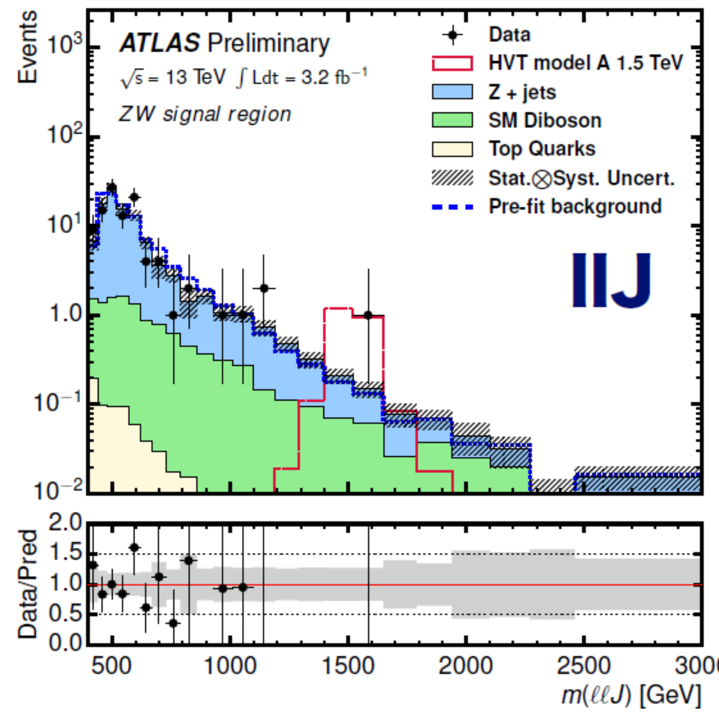
ZW/ZZ→llJ



WZ selection



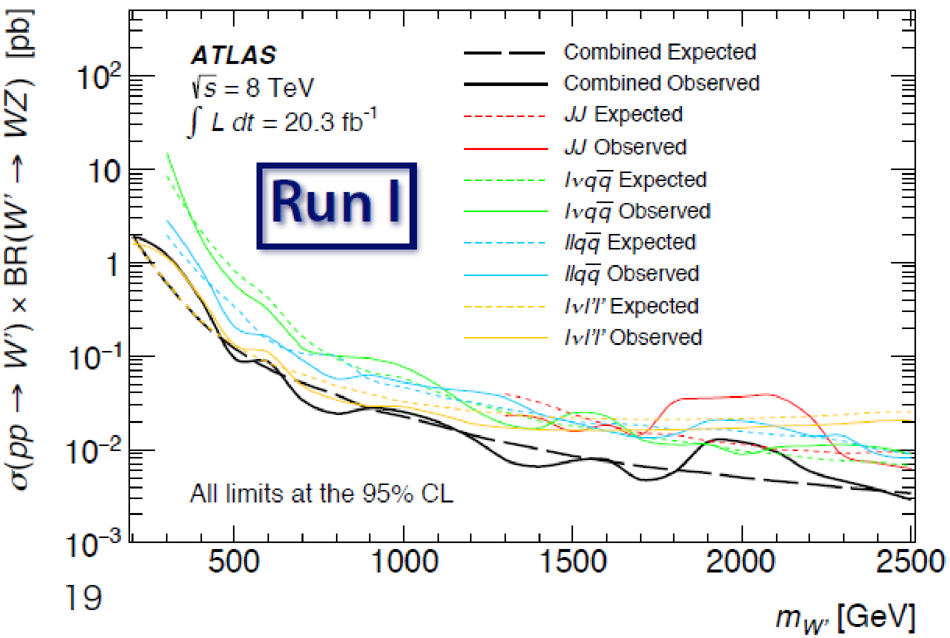
WZ selection

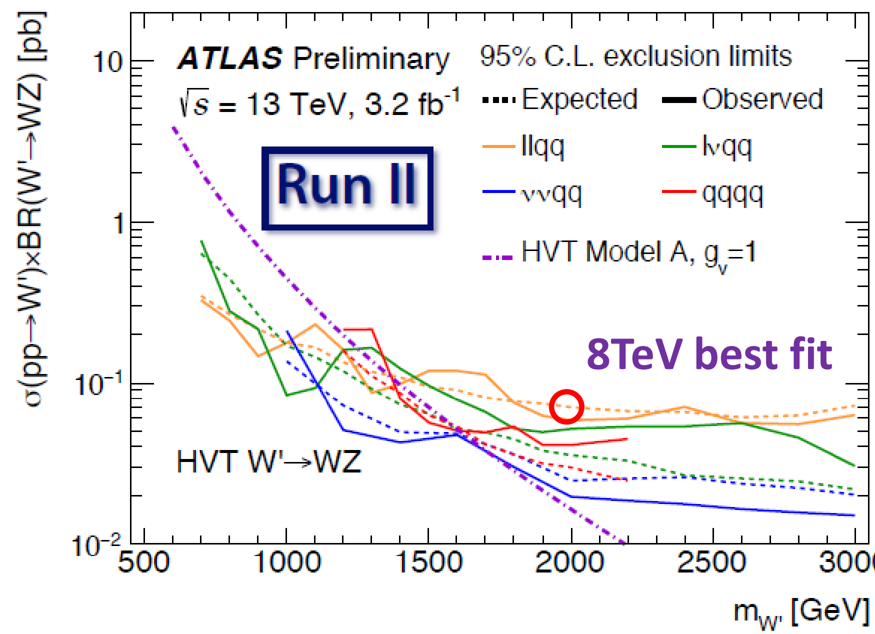


8TeVの超過は棄却されたのか？

- 8TeVと13TeVで生成断面積が違うが、PDFを仮定して(qq→Xとgg→X)extrapolateしてみると…

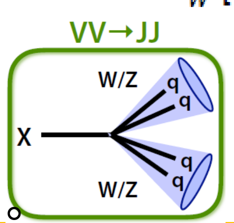
Best fit : σ x BR(W'→WZ) ~ 7 fb @ 2TeV —8→13TeV→ 10-15倍 : 70-100fb @ 2TeV

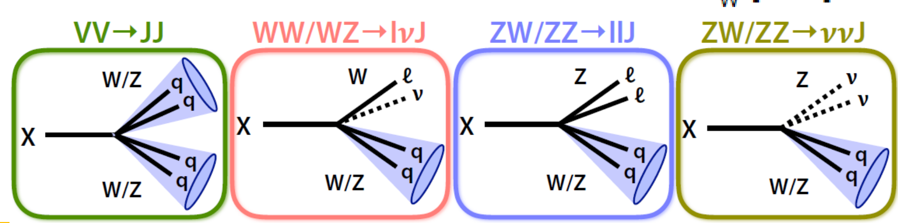




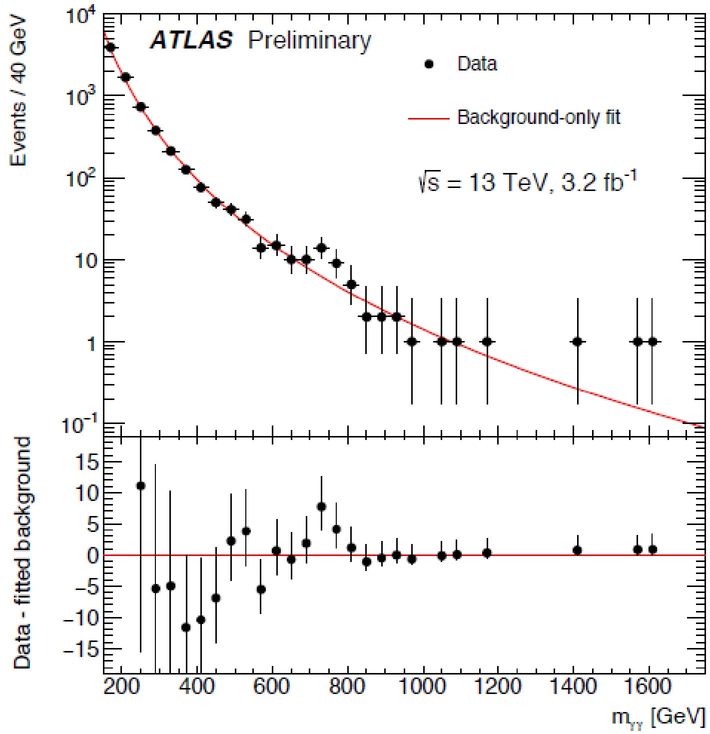
すでにExcludeした？！

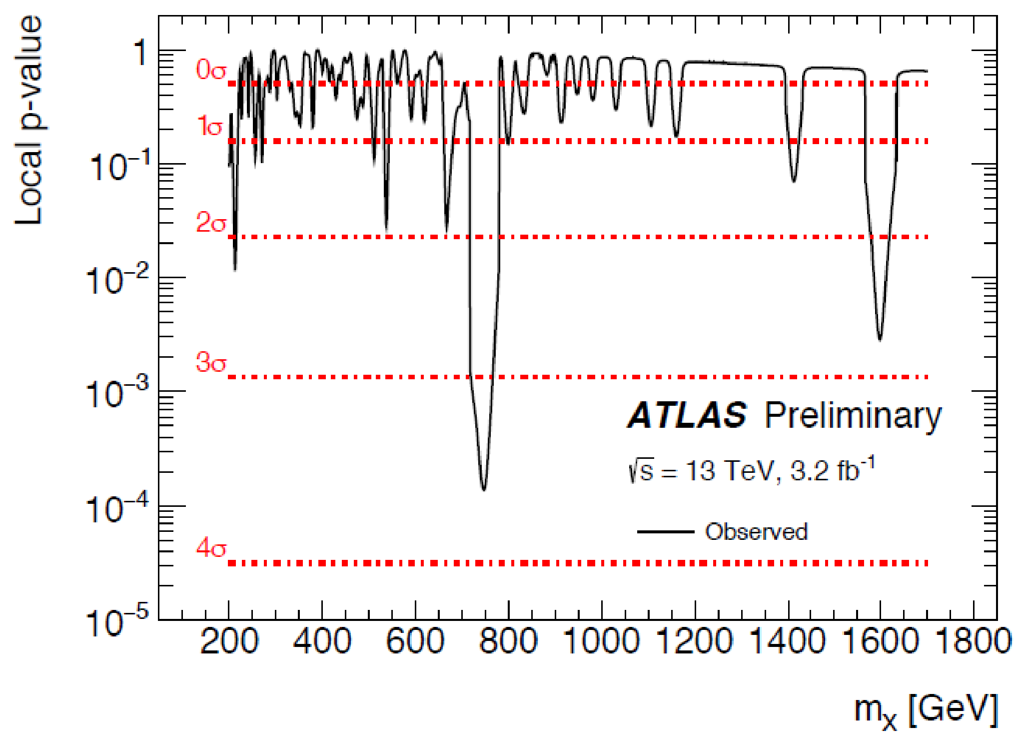
→実際の数字はもうすぐでます。





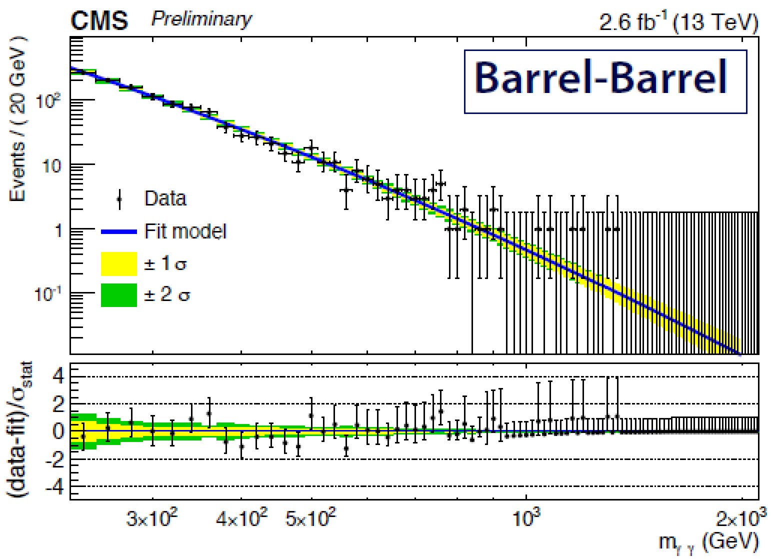
Di-Photon 探索 (Dec 2015)

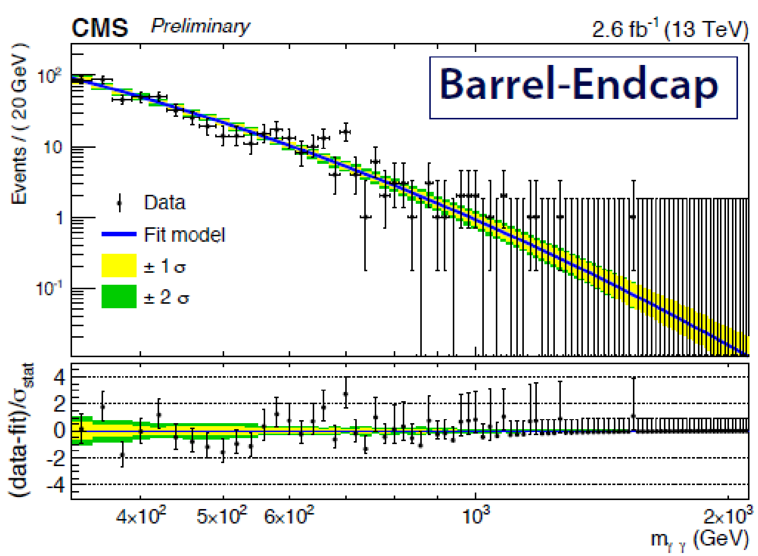


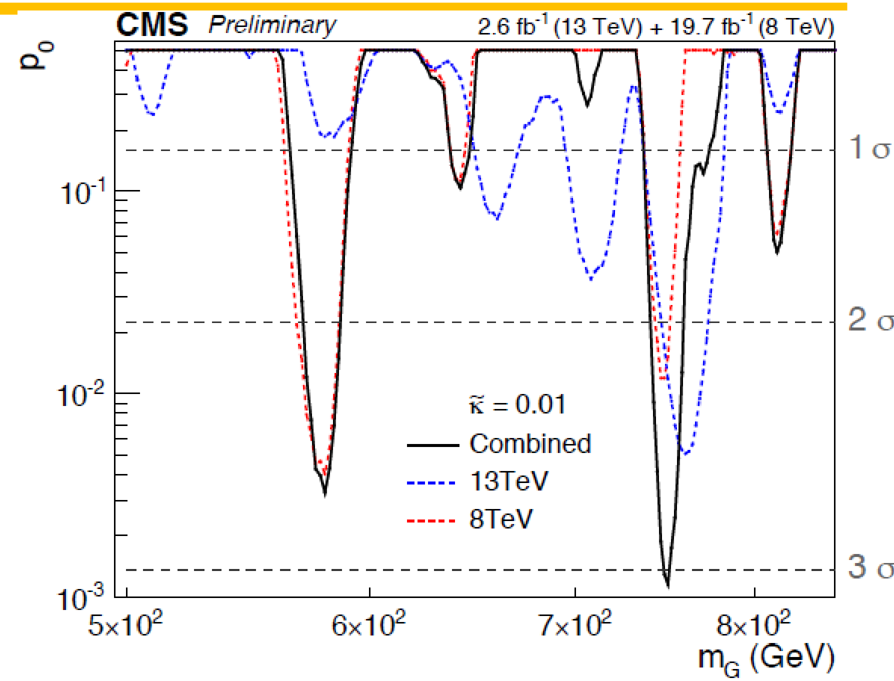


- Di-boson (750GeV)に local(global)3.9(2.3)σのexcess
- WidthはΓ/m=6% (Γ=45GeV)

Di-Photon 探索(CMS)







- Barrel-Barrel eventにExcess有 (Barrel-Endcapは微妙)
- 8TeVと13TeV両方にexcessが見られるがmassが少し違う。
- 13TeV : Local(global) 2.6(<1.2)σ@760GeV
- 8TeV : Local (global) 3.0(<1.7)σ @750GeV

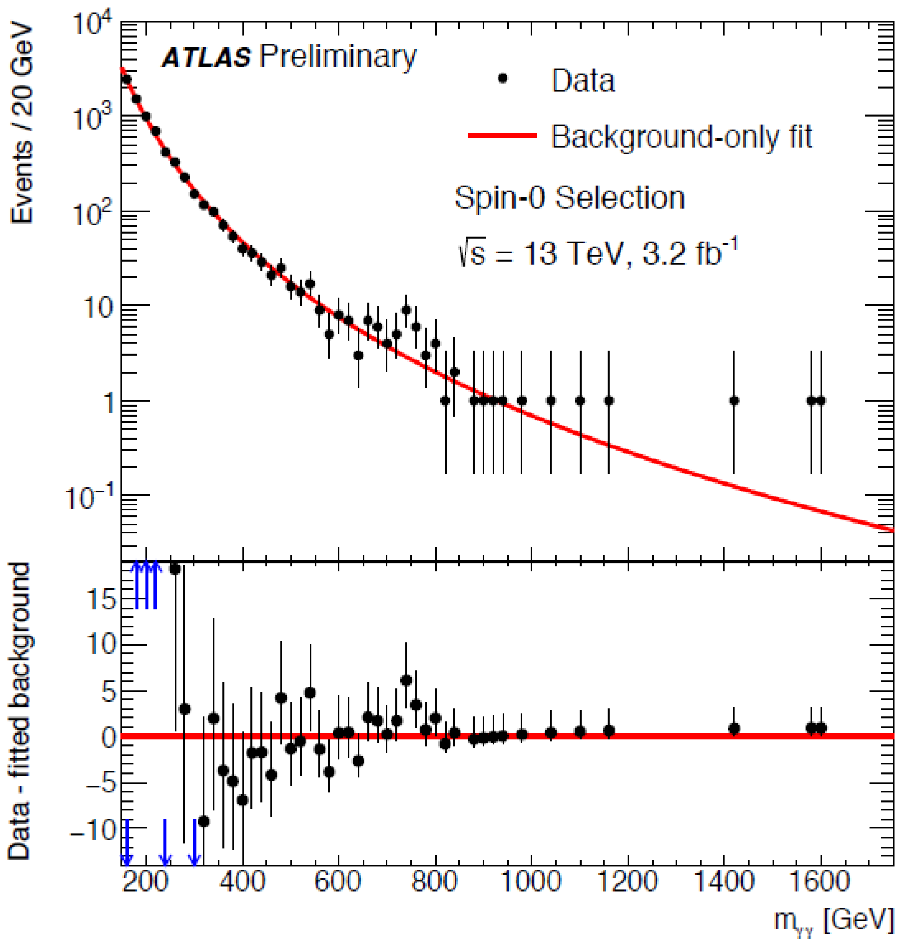
  for κ/M_{Pl}=0.01(RS Graviton) i.e. narrow

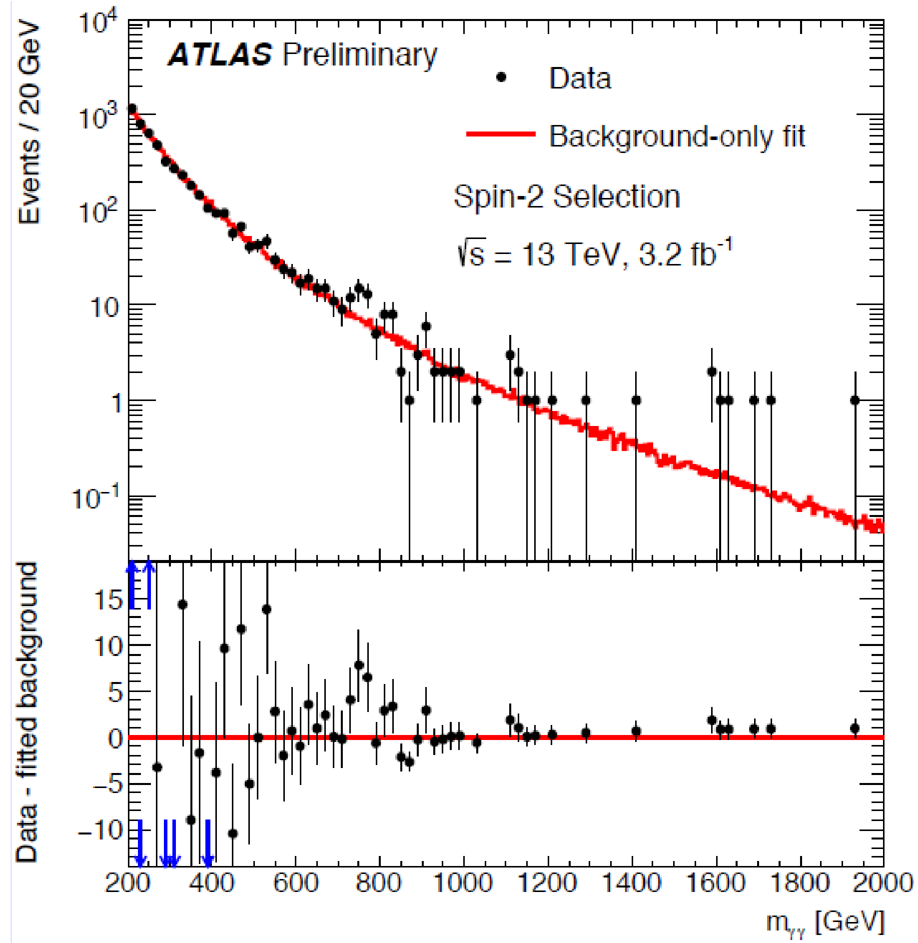
再解析 for Moriond

- Spin-0 Higgs解析とSpin-2 Graviton解析の二通り行った。(Spin-2解析はもともと>3TeVあたりをターゲットだった)
- 共通セレクション
  - Tight photon ID with Diphoton トリガー
- Spin0 Higgs解析
  - **$E_T^{\gamma 1(2)}>0.4(0.3)m_{\gamma\gamma}$**
    - 750GeVで$E_T^{\gamma 1}>300$GeV
- Spin2 Graviton解析
  - **$E_T^{\gamma 1,2}>55$GeV**
    - Spin0よりlooseなカットでForward Eventにも高いアクセプタンス

再解析 for Moriond

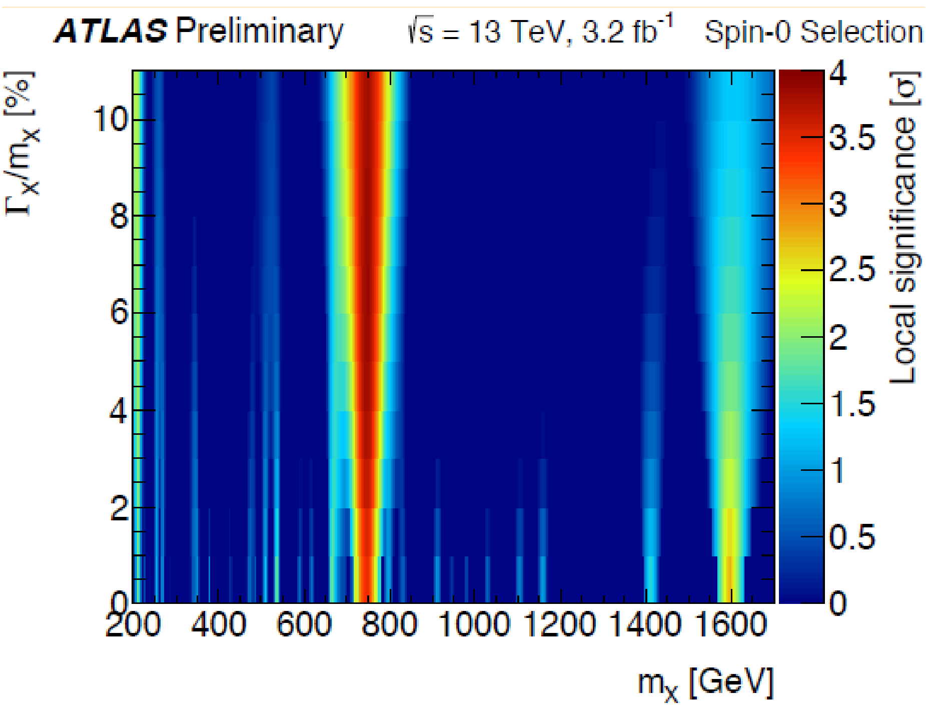
- Spin-0 Higgs 解析
- Spin-2 Graviton 解析





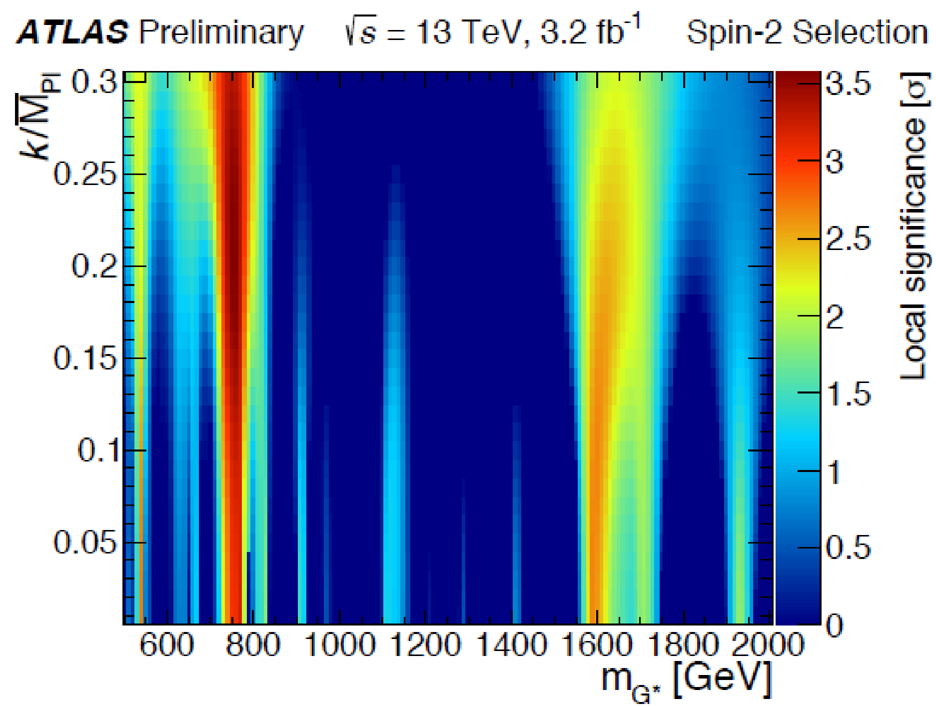
再解析 for Moriond

- Spin-0 Higgs 解析



Local (global) 3.9(2.0)σ
@ 750GeV, Γ/m=6% (Γ=45GeV)

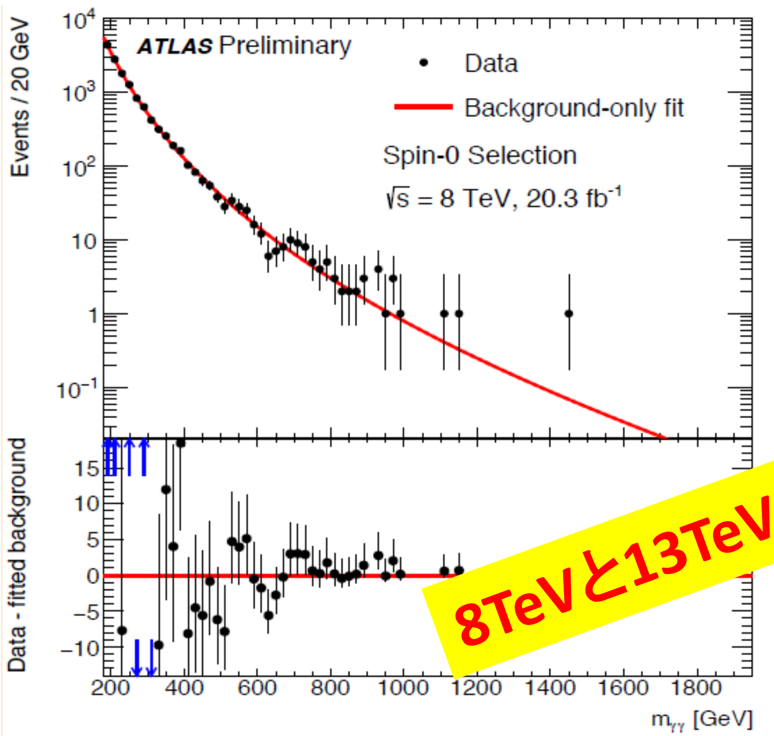
- Spin-2 Graviton 解析



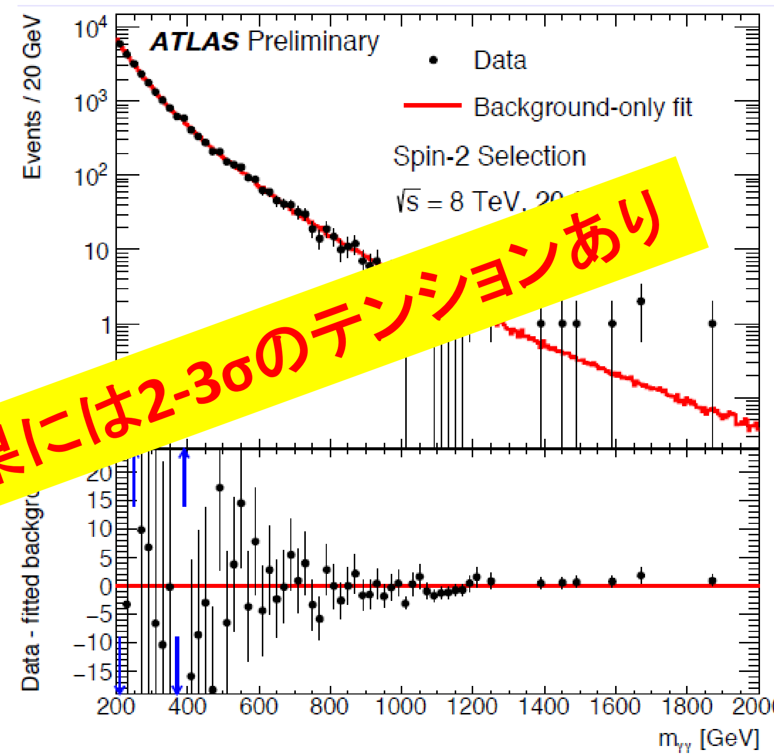
Local (global) 3.6(1.8)σ
@ 750GeV, Γ/m=7% (κ/M_{Pl}=0.2)

8TeV data 再解析

- Spin-0 Higgs 解析



- Spin-2 Graviton 解析



8TeVと13TeVの結果には2-3σのテンションあり

Local 1.9σ @ 750GeV, Γ/m=6% (Γ=45GeV)
Compatibility with 13TeV
gg(qq) process 1.2(2.1)σ

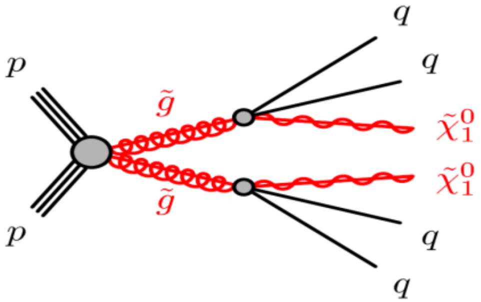
有意な兆候なし
Compatibility with 13TeV
gg(qq) process 2.7(3.3)σ

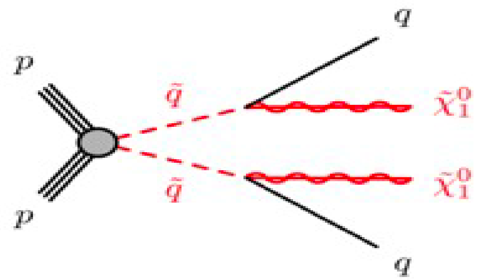
LHC 13TeVでの最新結果

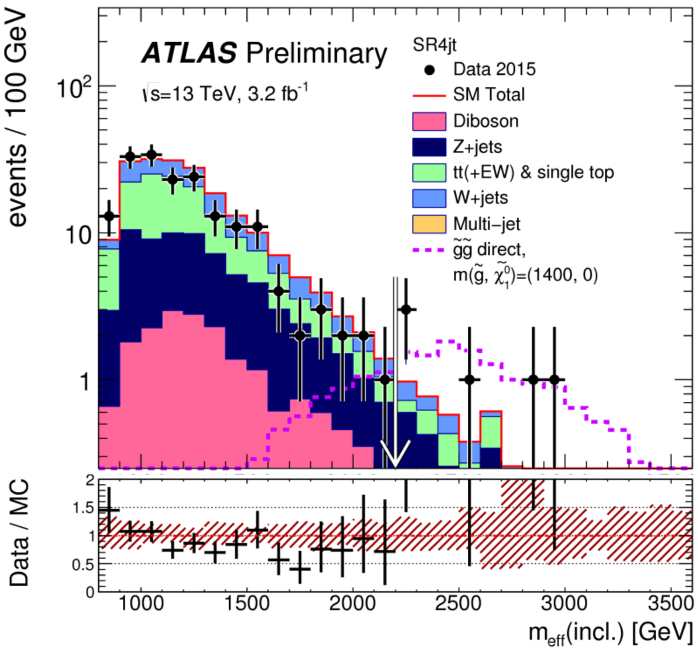
- Higgs粒子の再探索
- VVやγγに見つかった怪しい兆候
- SUSY/Exotic の探索

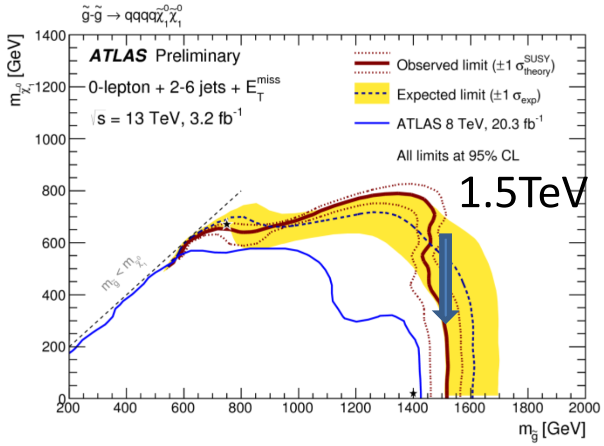
強い相互作用で生成するSUSY(1,2世代)

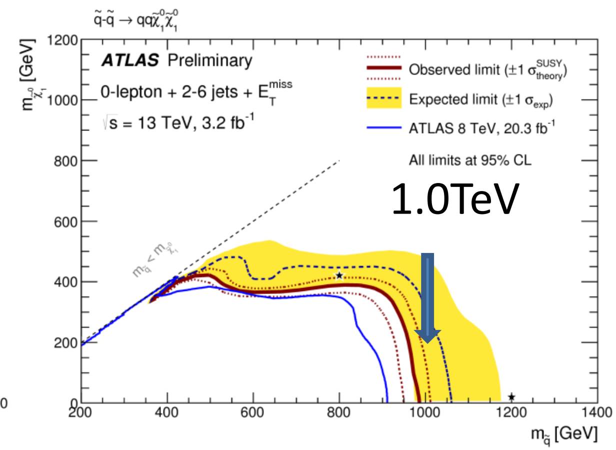
- 断面積が大きくコライダーのエネルギーが届けばすぐに見つかる。
- (2-6)Jets + large MET
- 背景事象はZ(→νν)+jets, Top





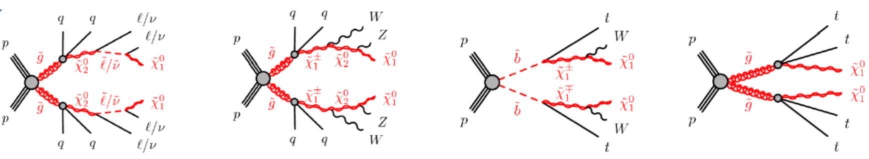


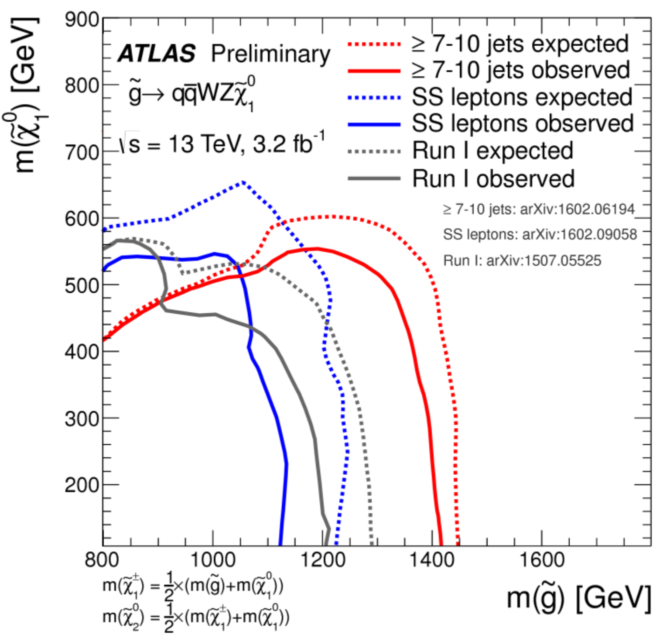




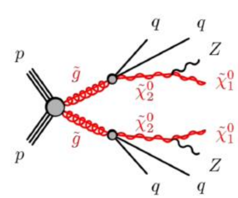
>=2 lepton channel

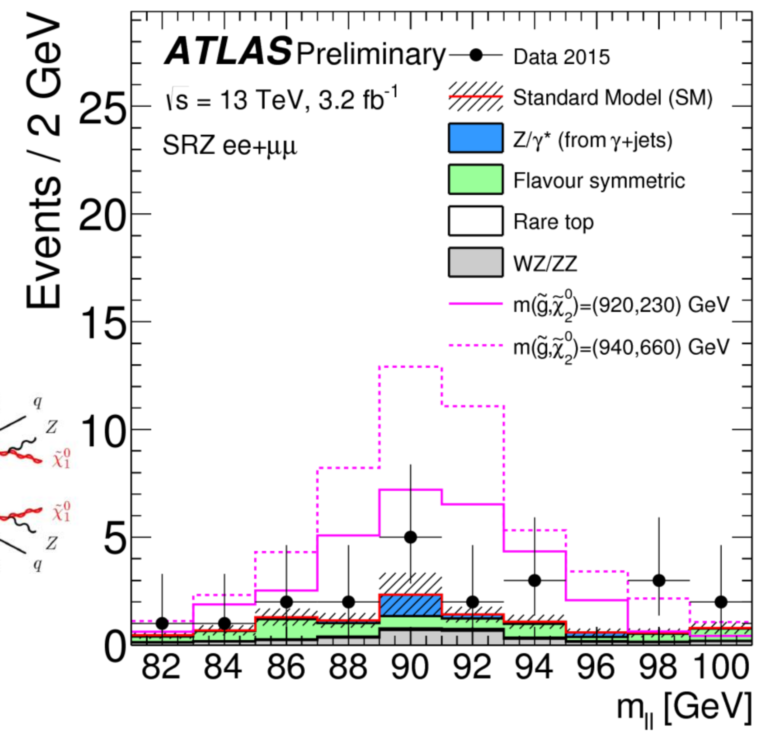
- 2 same-sign leptons
  – SM Bkgが少ない
  – Excessは観測されず





- 2 opposite-sign leptons
  – Zを伴うgluino/squark探索
  – Run1で3(1.7)σ for ee(μμ) の excess
  – Run2でも2.2σの超過を観測
    - 21事象 (bkg 10.3±2.3)

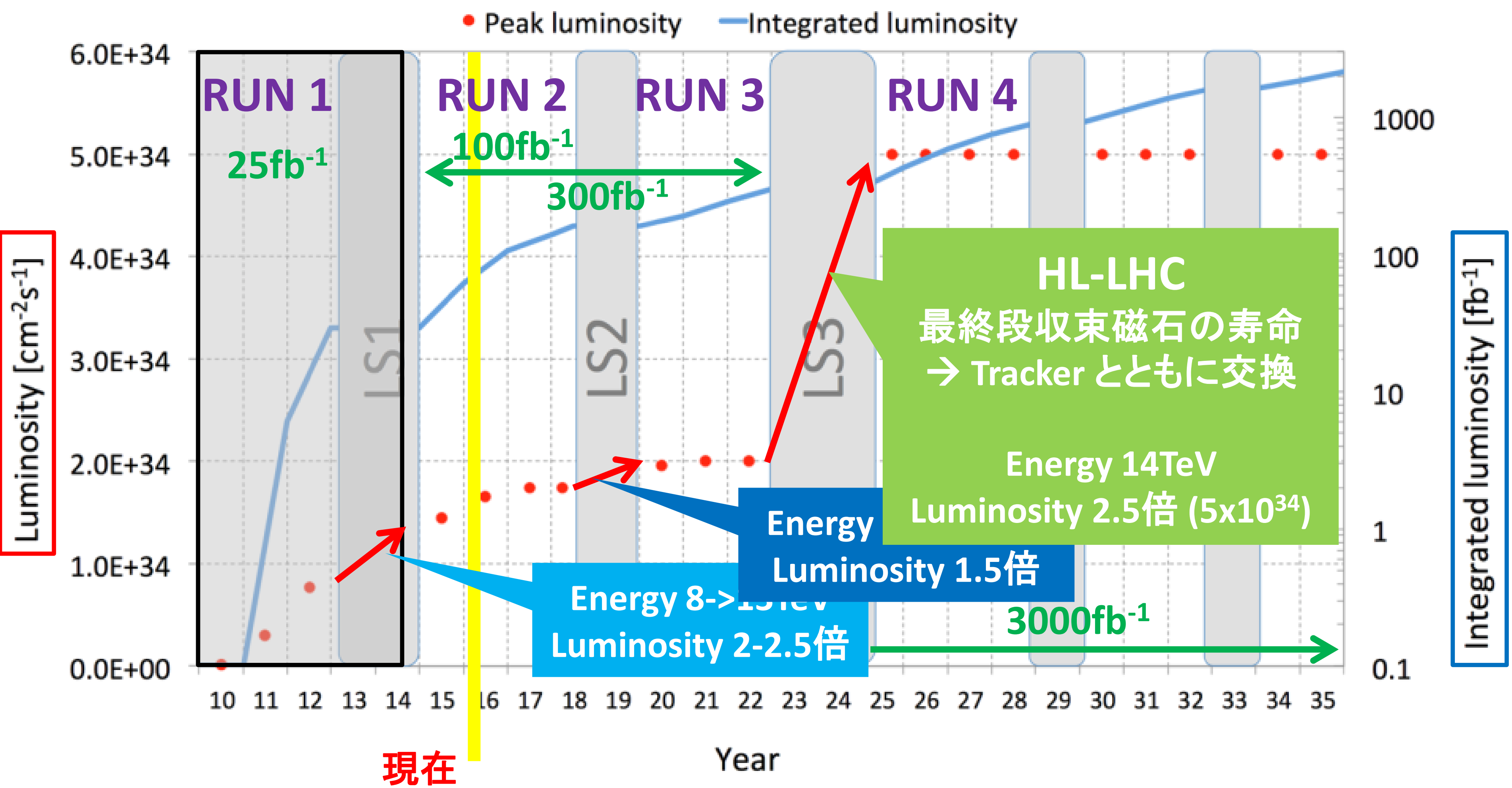




Run2 から HL-LHC

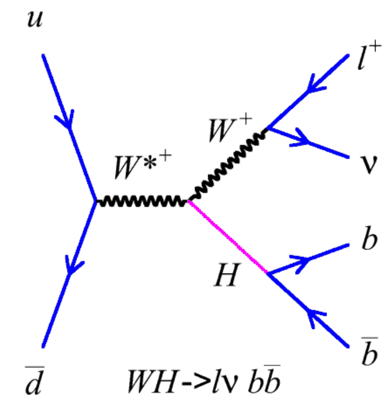
アップグレード計画

- ちょっと複雑ですが…



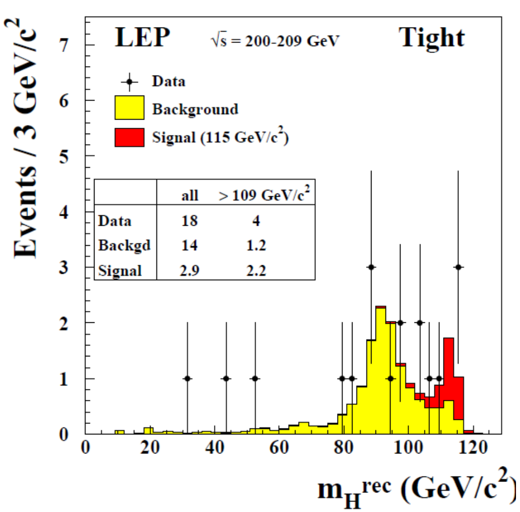
余談：ボトム湯川の話

- LEP II の最後 : 3事象のエクセス
- Tevatron Run II の最後 : 2.8σ @ 125GeV
- ATLAS Run I のFull data : 1.4σ(2.6σ exp.)

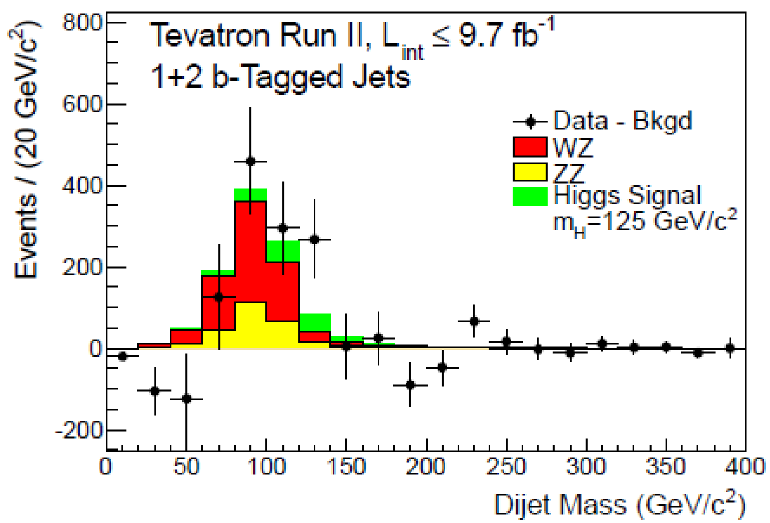


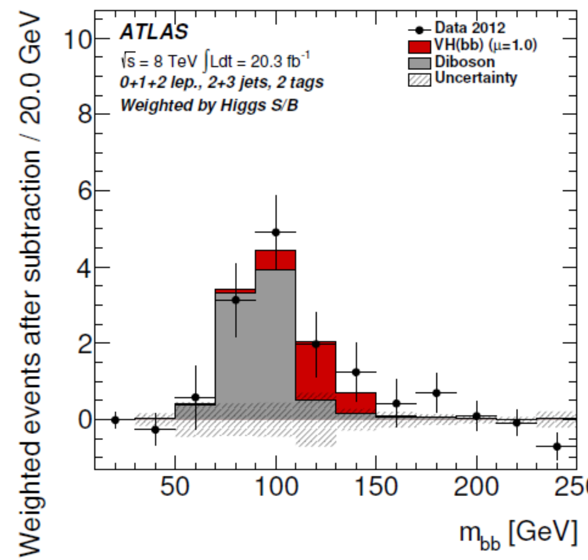
→ なぜか呪われたように見つからない…

1.7sigma @ 115GeV



2.8sigma @ 125GeV





余談：ボトム湯川の話

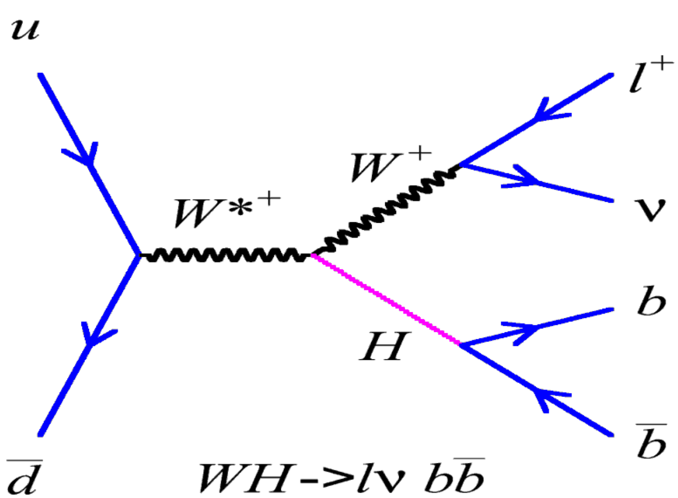
- Yb @ 13/14TeV

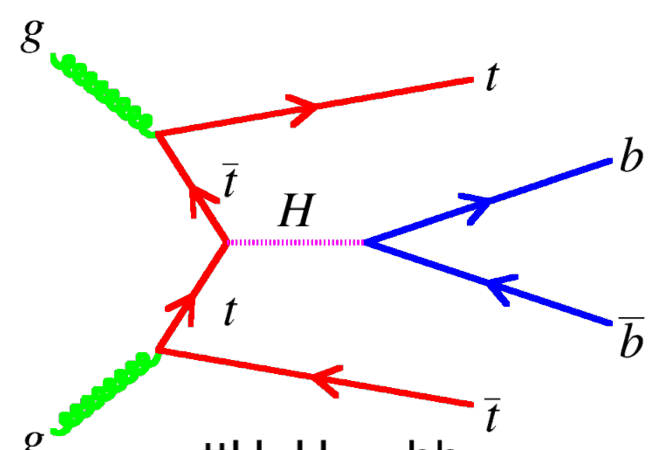
今までのVH,H->bb process

13TeV 10fb^{-1}のデータを加えれば
7TeV+8TeV+13TeVで3σ(expected)
但し、7+8TeVのobserved が低いので
発見のクレームは2016年かも？

強力な助っ人

今まで断面積が小さくマイナーチャンネル
だったが、3.9倍の断面積で追い上げ。
13TeV 55fb^{-1}のデータで3σ(expected)
発見のクレームは2016年？
同時にトップ湯川の発見もクレーム！

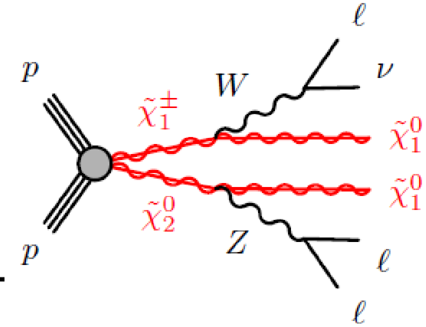


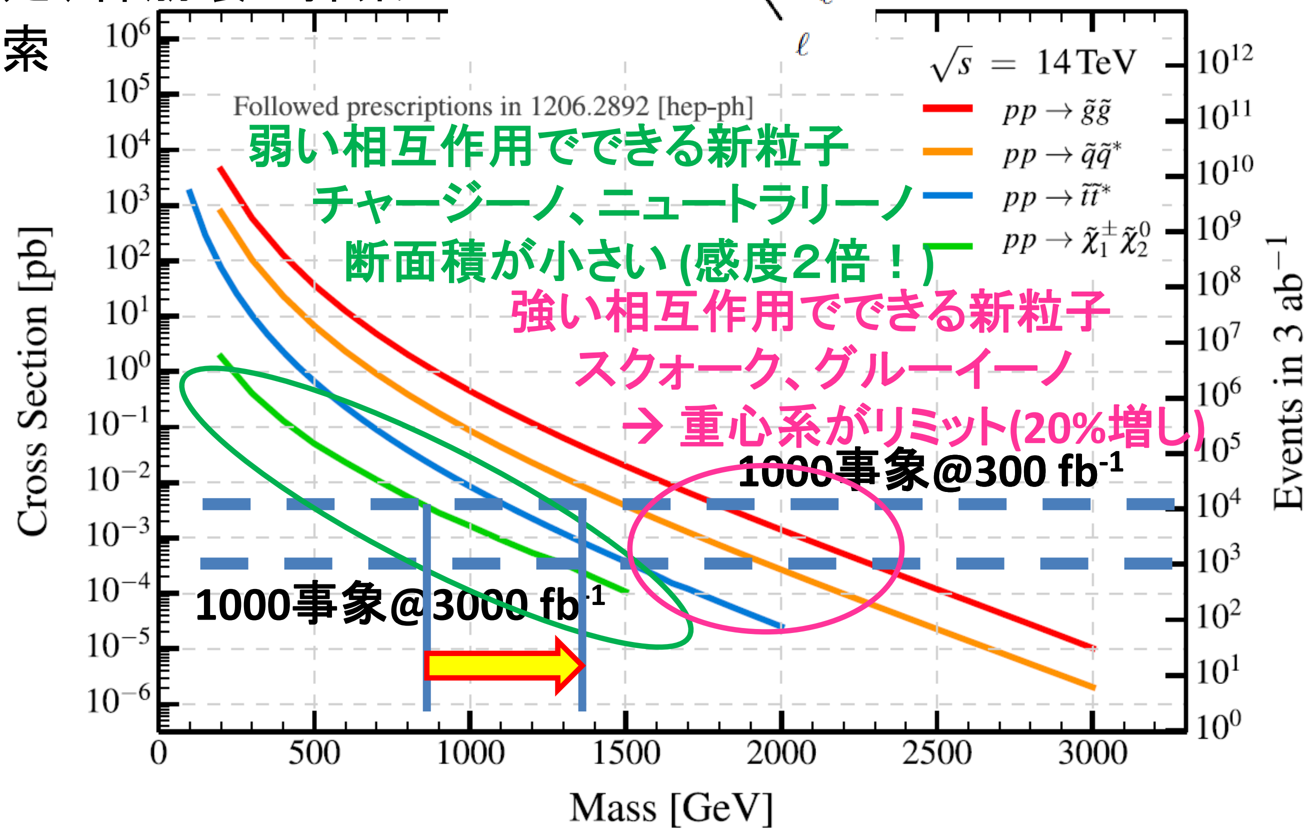


2016年はボトム湯川の年になる！？

物理の背景：ルミノシティー

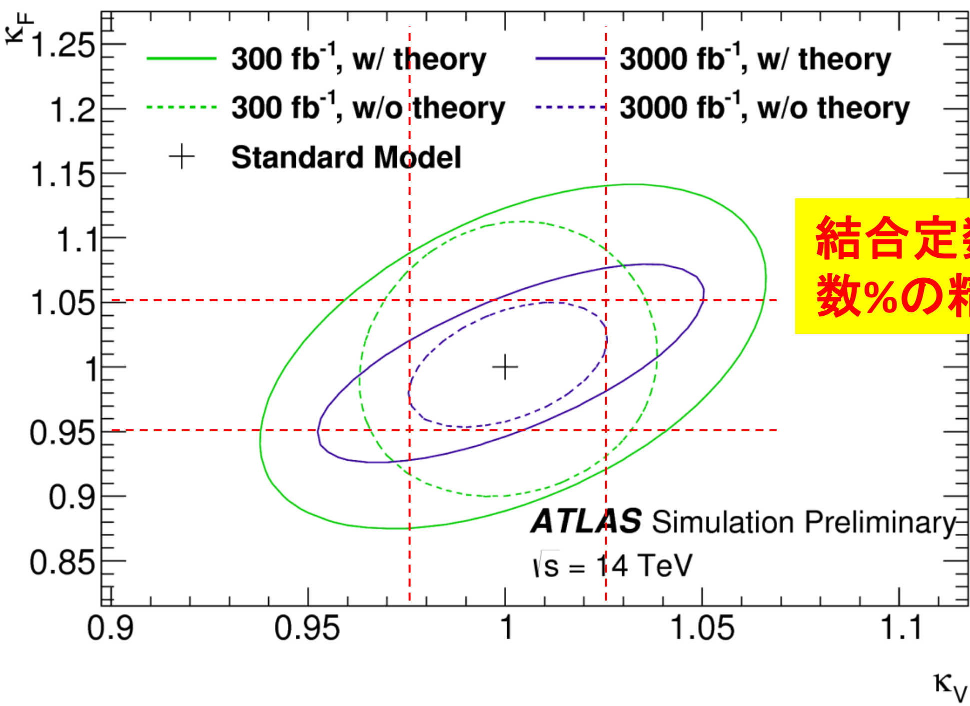
- 300→3000fb^{-1}が必要か？
  - 新しい物理
  - ヒッグスの測定
    - 結合定数の測定、稀崩壊の探索
    - 自己結合の探索



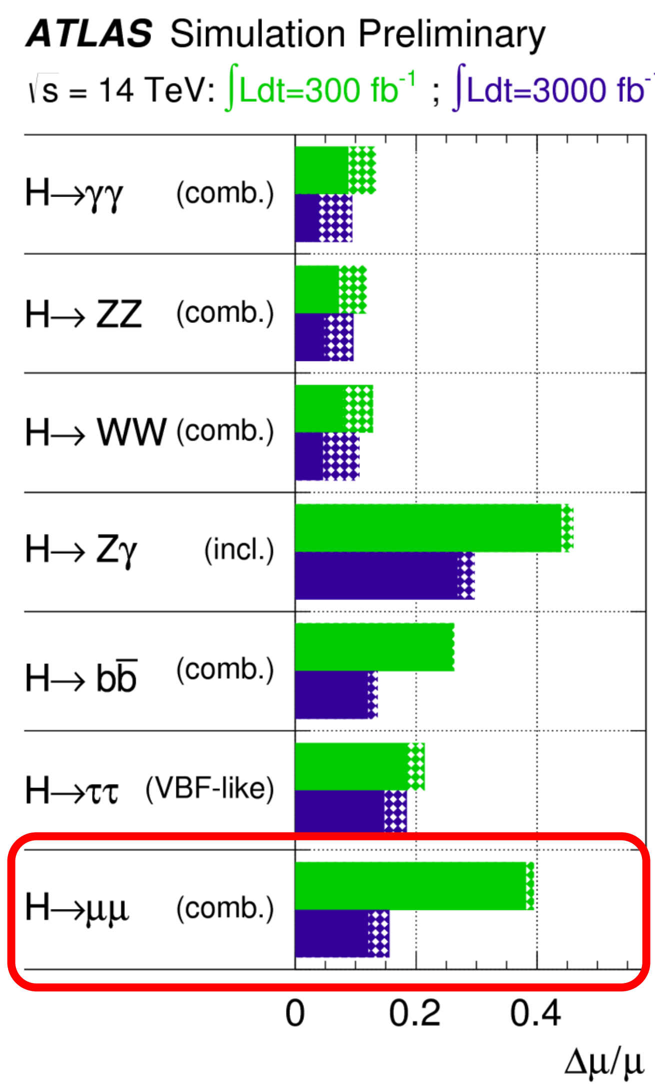


物理の背景：ルミノシティー

- 300→3000fb^{-1}が必要か？
  - 新しい物理
  - ヒッグスの測定
    - **結合定数の測定、稀崩壊の探索**
    - 自己結合の探索



結合定数を数%の精度で測定



物理の背景：ルミノシティー

- 300→3000fb^{-1}が必要か？
  - 新しい物理
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    - **結合定数の測定、稀崩壊の探索**
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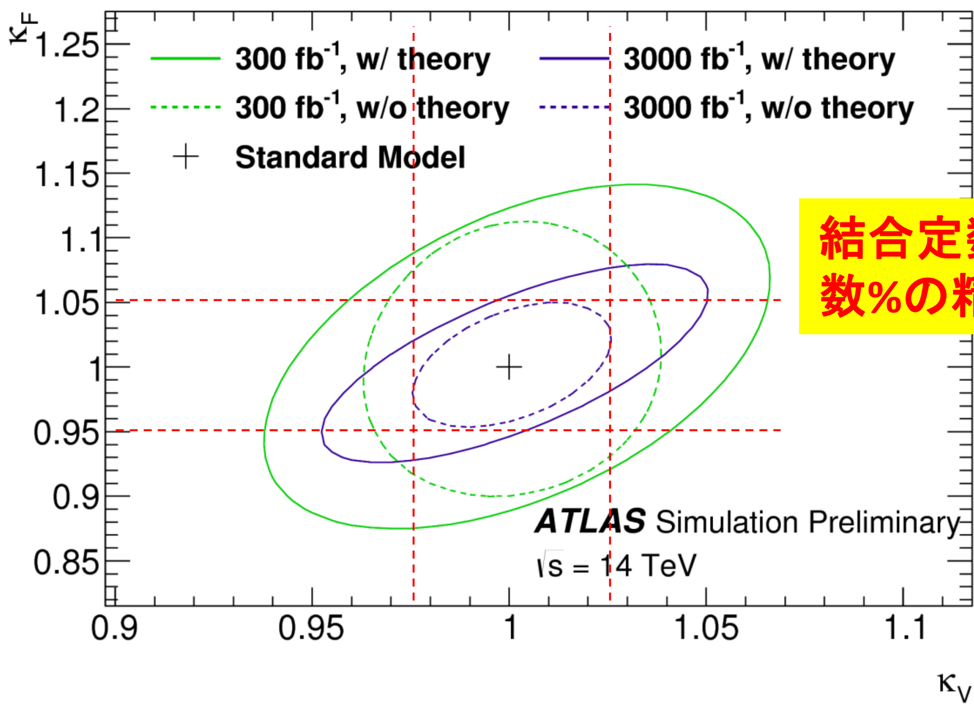
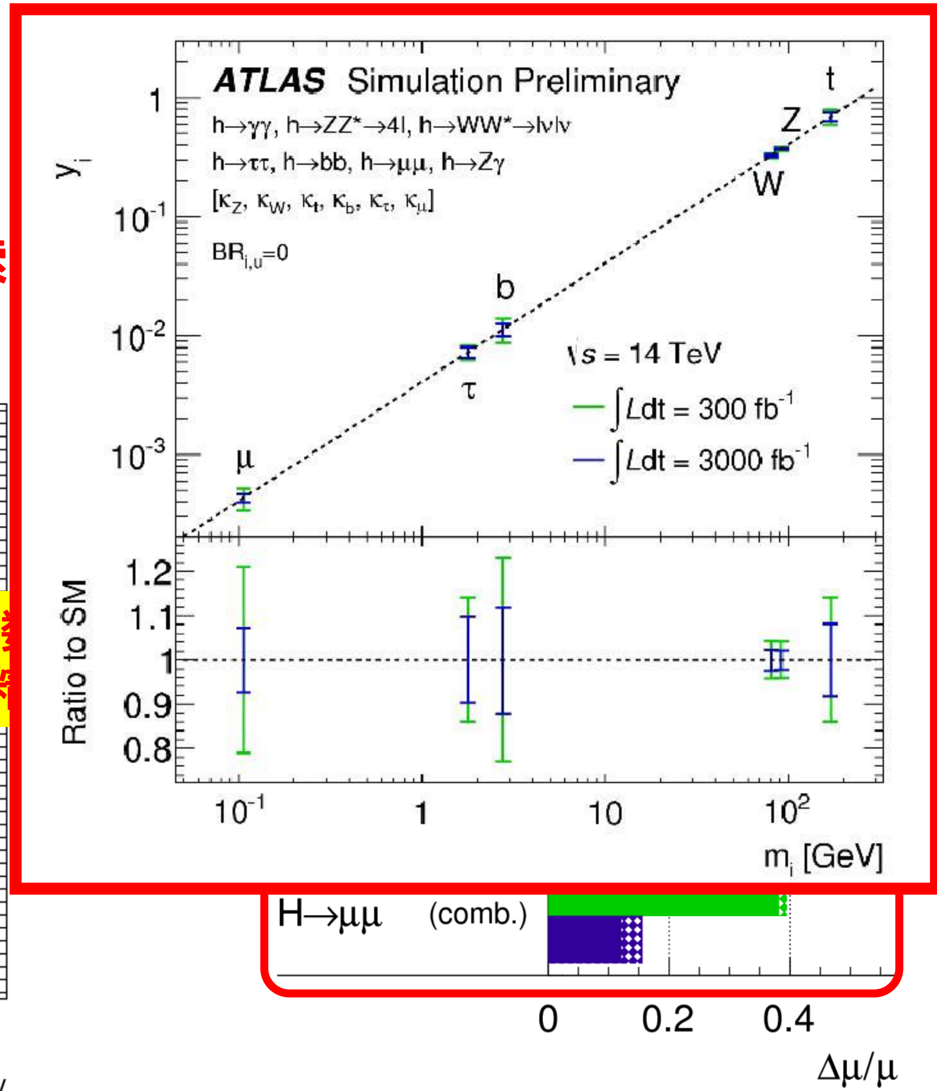
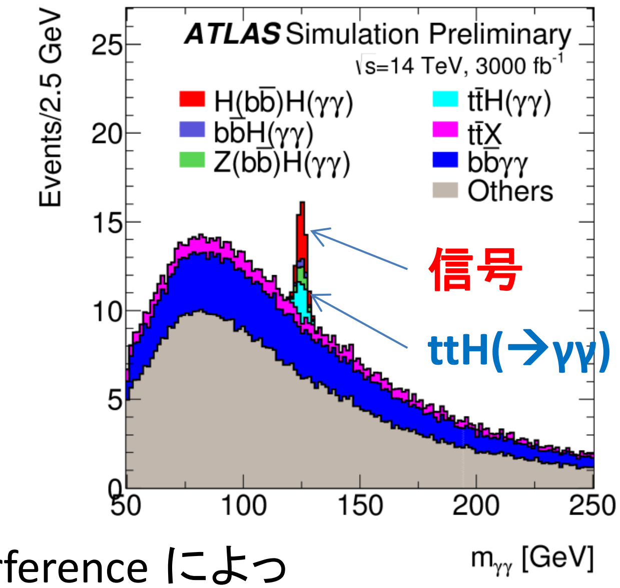


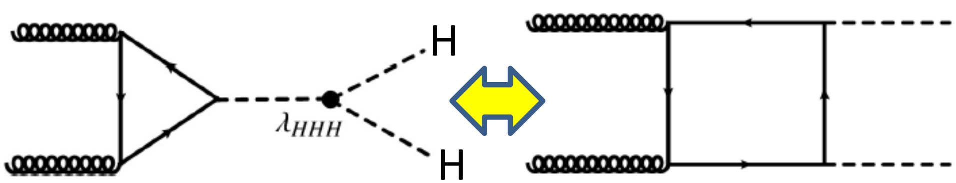


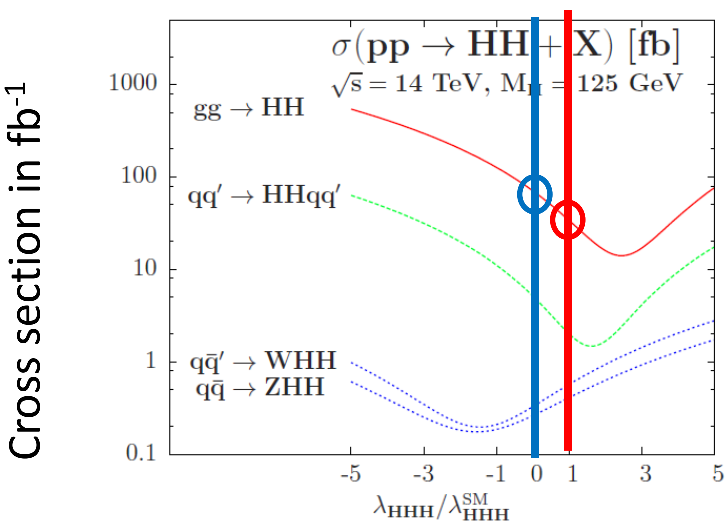
物理の背景：ルミノシティー

- 300→3000fb^{-1}が必要か？
  - 新しい物理
  - ヒッグスの測定
    - 結合定数の測定、稀崩壊の探索
    - **自己結合の探索**

感度が高いのは gg→HH→bbγγ







BoxとTriangleの間のinterference によってpp→HHの生成断面積が大きく変わる。

σ(HHH無)/σ(HHH有)~2

	gg->HH σ [fb^{-1}] @ 14TeV
$\lambda_{HHH}/\lambda^{SM}_{HHH}=1$	34 fb^{-1}
$\lambda_{HHH}/\lambda^{SM}_{HHH}=0$	71 fb^{-1}
$\lambda_{HHH}/\lambda^{SM}_{HHH}=2$	16 fb^{-1}

gg→HH→bbγγだけで 1.3 σ (SM HHの時)

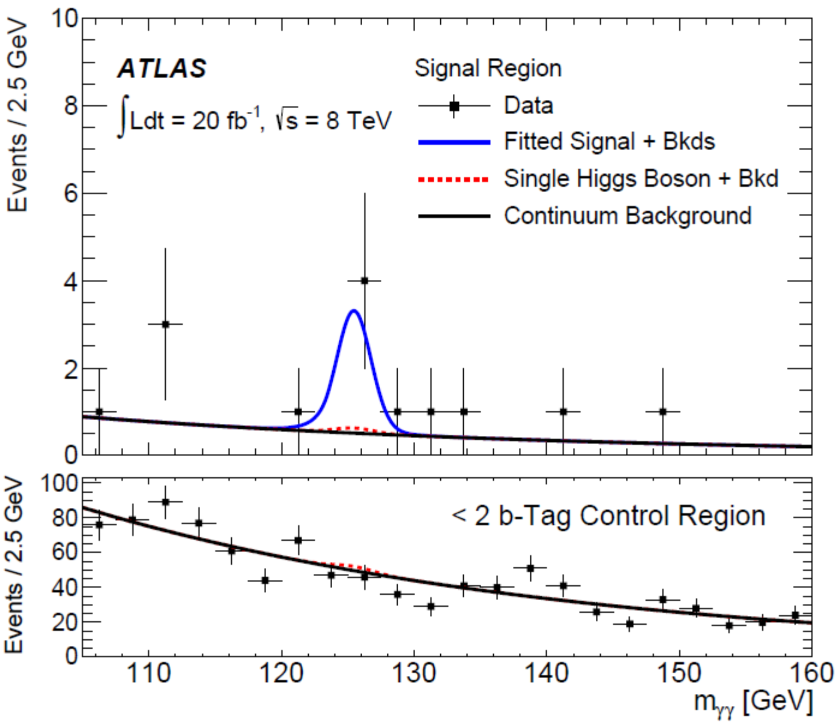
→ λ_{HHH}=0を棄却/兆候

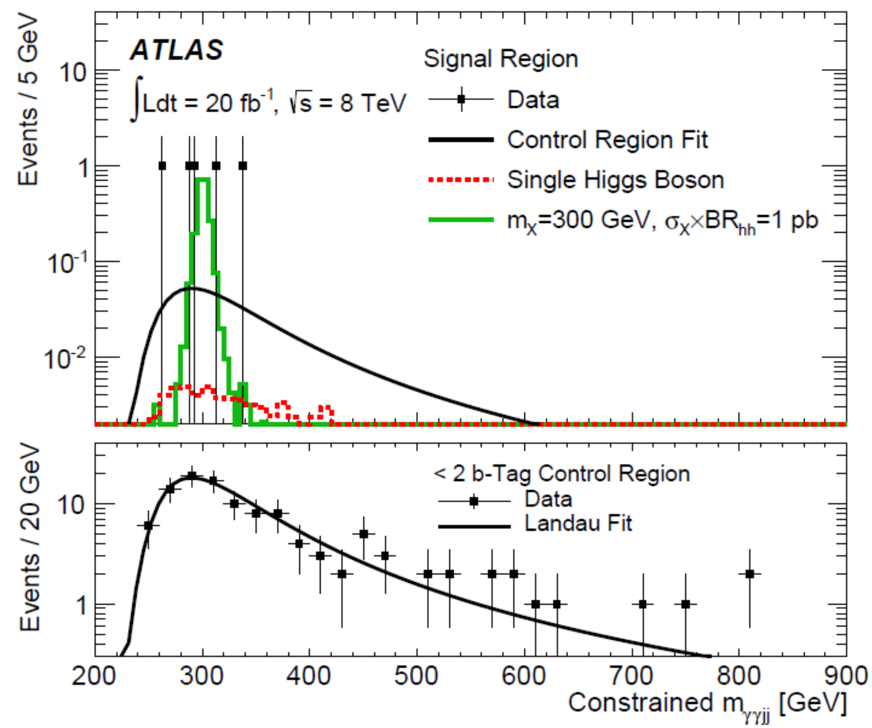
→ 改善する

→ 他崩壊を足して3σ

Run 1の結果から – 自己結合の探索

- HH→γγbb探索
  - bb選択後のγγ質量分布に4事象のexcess
  - 2.4σのexcess (σ~1pb くらい、σ_{HH}=34fb^{-1}の30倍)
  - $M_{\gamma\gamma jj}$~300GeVくらいのresonanceにも見えなくはない。





現在は…

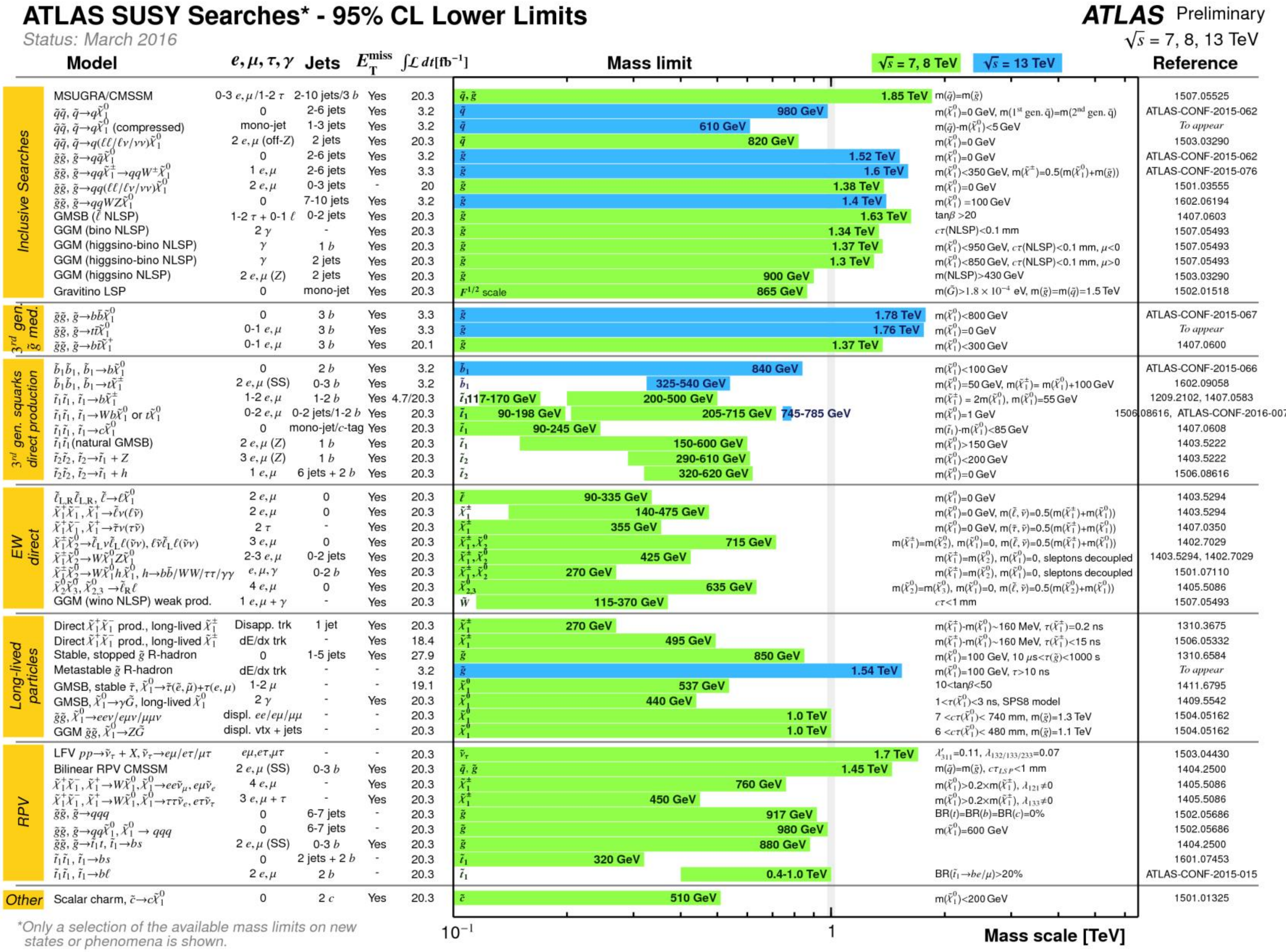
あれはやはり新粒子
なんじゃないか？

来年度には…

すぐに明らかになるさ。

あれはやはり新粒子
なんじゃないか？

backup



ATLAS SUSY Searches* - 95% CL Lower Limits

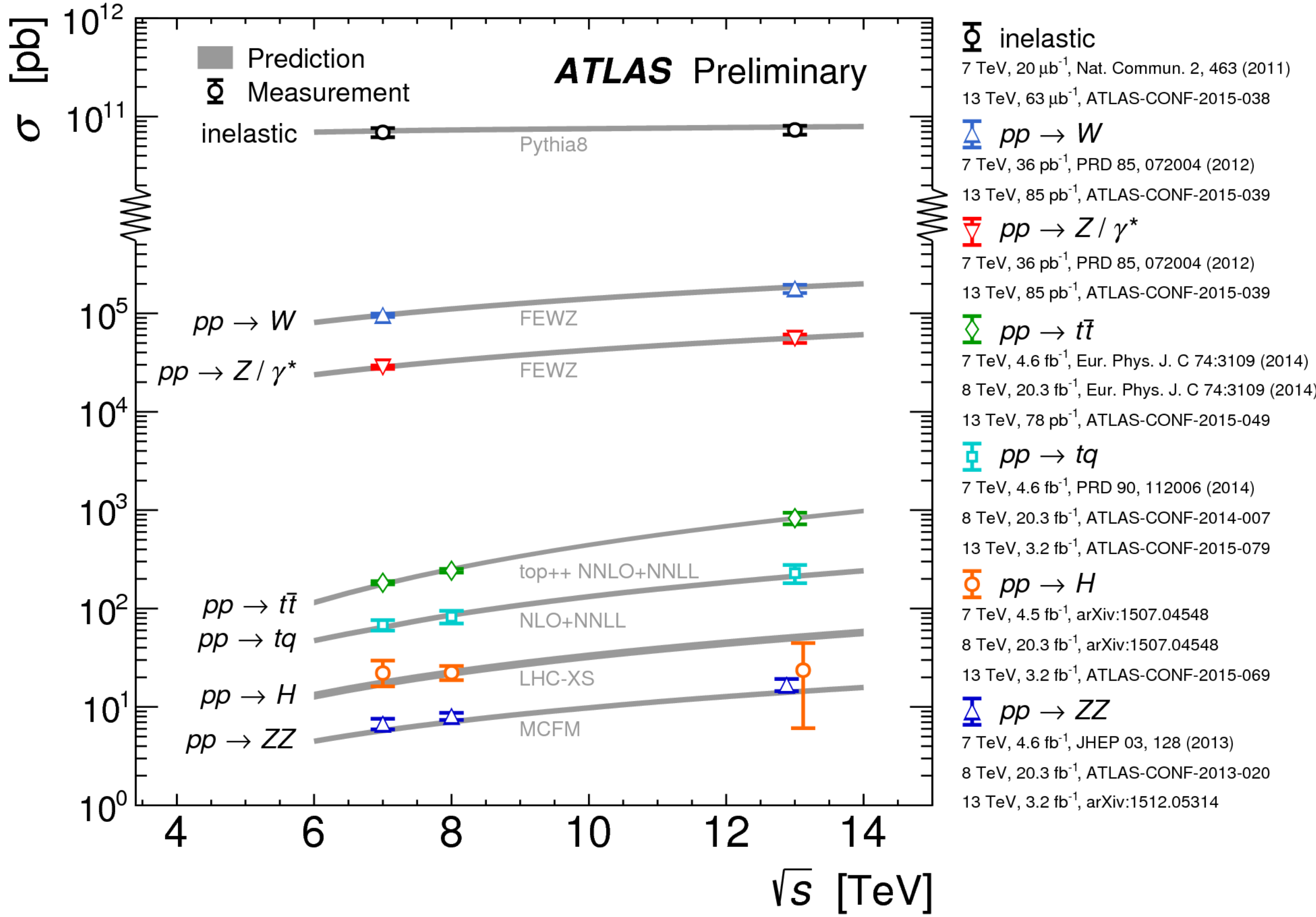
Status: March 2016

ATLAS Preliminary, $\sqrt{s}$ = 7, 8, 13 TeV

	Model	e,μ,τ,γ	Jets	E_T^{miss}	$\int\mathcal{L}\,dt[\mathrm{fb}^{-1}]$	Mass limit		Reference
Inclusive Searches	MSUGRA/CMSSM	0-3 e,μ/1-2 τ	2-10 jets/3 b	Yes	20.3	$\tilde{q},\tilde{g}$ 1.85 TeV	$m(\tilde{q})=m(\tilde{g})$	1507.05525
	$\tilde{q}\tilde{q}$, $\tilde{q}\to q\tilde{\chi}_1^0$	0	2-6 jets	Yes	3.2	$\tilde{q}$ 980 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, m(1st gen. $\tilde{q}$)=m(2nd gen. $\tilde{q}$)	ATLAS-CONF-2015-062
	$\tilde{q}\tilde{q}$, $\tilde{q}\to q\tilde{\chi}_1^0$ (compressed)	mono-jet	1-3 jets	Yes	3.2	$\tilde{q}$ 610 GeV	$m(\tilde{q})-m(\tilde{\chi}_1^0)$<5 GeV	To appear
	$\tilde{q}\tilde{q}$, $\tilde{q}\to q(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e,μ (off-Z)	2 jets	Yes	20.3	$\tilde{q}$ 820 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	1503.03290
	$\tilde{g}\tilde{g}$, $\tilde{g}\to q\bar{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	3.2	$\tilde{g}$ 1.52 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2015-062
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq\tilde{\chi}_1^{\pm}\to qqW^{\pm}\tilde{\chi}_1^0$	1 e,μ	2-6 jets	Yes	3.3	$\tilde{g}$ 1.6 TeV	$m(\tilde{\chi}_1^0)$<350 GeV, $m(\tilde{\chi}^{\pm})=0.5(m(\tilde{\chi}_1^0)+m(\tilde{g}))$	ATLAS-CONF-2015-076
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e,μ	0-3 jets	-	20	$\tilde{g}$ 1.38 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	1501.03555
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qqWZ\tilde{\chi}_1^0$	0	7-10 jets	Yes	3.2	$\tilde{g}$ 1.4 TeV	$m(\tilde{\chi}_1^0)$ =100 GeV	1602.06194
	GMSB ($\tilde{\ell}$ NLSP)	1-2 τ + 0-1 ℓ	0-2 jets	Yes	20.3	$\tilde{g}$ 1.63 TeV	$\tan\beta$ >20	1407.0603
	GGM (bino NLSP)	2 γ	-	Yes	20.3	$\tilde{g}$ 1.34 TeV	$c\tau$(NLSP)<0.1 mm	1507.05493
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	20.3	$\tilde{g}$ 1.37 TeV	$m(\tilde{\chi}_1^0)$<950 GeV, $c\tau$(NLSP)<0.1 mm, μ<0	1507.05493
	GGM (higgsino-bino NLSP)	γ	2 jets	Yes	20.3	$\tilde{g}$ 1.3 TeV	$m(\tilde{\chi}_1^0)$<850 GeV, $c\tau$(NLSP)<0.1 mm, μ>0	1507.05493
	GGM (higgsino NLSP)	2 e,μ (Z)	2 jets	Yes	20.3	$\tilde{g}$ 900 GeV	m(NLSP)>430 GeV	1503.03290
	Gravitino LSP	0	mono-jet	Yes	20.3	$F^{1/2}$ scale 865 GeV	$m(\tilde{G})>1.8\times10^{-4}$ eV, $m(\tilde{g})=m(\tilde{q})$=1.5 TeV	1502.01518
3rd gen. $\tilde{g}$ med.	$\tilde{g}\tilde{g}$, $\tilde{g}\to b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	3.3	$\tilde{g}$ 1.78 TeV	$m(\tilde{\chi}_1^0)$<800 GeV	ATLAS-CONF-2015-067
	$\tilde{g}\tilde{g}$, $\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0-1 e,μ	3 b	Yes	3.3	$\tilde{g}$ 1.76 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	To appear
	$\tilde{g}\tilde{g}$, $\tilde{g}\to b\bar{t}\tilde{\chi}_1^+$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$ 1.37 TeV	$m(\tilde{\chi}_1^0)$<300 GeV	1407.0600
3rd gen. squarks direct production	$\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\to b\tilde{\chi}_1^0$	0	2 b	Yes	3.2	$\tilde{b}_1$ 840 GeV	$m(\tilde{\chi}_1^0)$<100 GeV	ATLAS-CONF-2015-066
	$\tilde{b}_1\tilde{b}_1$, $\tilde{b}_1\to t\tilde{\chi}_1^{\pm}$	2 e,μ (SS)	0-3 b	Yes	3.2	$\tilde{b}_1$ 325-540 GeV	$m(\tilde{\chi}_1^0)$=50 GeV, $m(\tilde{\chi}_1^{\pm})=m(\tilde{\chi}_1^0)$+100 GeV	1602.09058
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to b\tilde{\chi}_1^{\pm}$	1-2 e,μ	1-2 b	Yes	4.7/20.3	$\tilde{t}_1$ 117-170 GeV, 200-500 GeV	$m(\tilde{\chi}_1^{\pm})=2m(\tilde{\chi}_1^0)$, $m(\tilde{\chi}_1^0)$=55 GeV	1209.2102, 1407.0583
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to Wb\tilde{\chi}_1^0$ or $t\tilde{\chi}_1^0$	0-2 e,μ	0-2 jets/1-2 b	Yes	20.3	$\tilde{t}_1$ 90-198 GeV, 205-715 GeV, 745-785 GeV	$m(\tilde{\chi}_1^0)$=1 GeV	1506.08616, ATLAS-CONF-2016-007
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to c\tilde{\chi}_1^0$	0	mono-jet/c-tag	Yes	20.3	$\tilde{t}_1$ 90-245 GeV	$m(\tilde{t}_1)-m(\tilde{\chi}_1^0)$<85 GeV	1407.0608
	$\tilde{t}_1\tilde{t}_1$ (natural GMSB)	2 e,μ (Z)	1 b	Yes	20.3	$\tilde{t}_1$ 150-600 GeV	$m(\tilde{\chi}_1^0)$>150 GeV	1403.5222
	$\tilde{t}_2\tilde{t}_2$, $\tilde{t}_2\to\tilde{t}_1+Z$	3 e,μ (Z)	1 b	Yes	20.3	$\tilde{t}_2$ 290-610 GeV	$m(\tilde{\chi}_1^0)$<200 GeV	1403.5222
	$\tilde{t}_2\tilde{t}_2$, $\tilde{t}_2\to\tilde{t}_1+h$	1 e,μ	6 jets + 2 b	Yes	20.3	$\tilde{t}_2$ 320-620 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	1506.08616
EW direct	$\tilde{\ell}_{L,R}\tilde{\ell}_{L,R}$, $\tilde{\ell}\to\ell\tilde{\chi}_1^0$	2 e,μ	0	Yes	20.3	$\tilde{\ell}$ 90-335 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	1403.5294
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e,μ	0	Yes	20.3	$\tilde{\chi}_1^{\pm}$ 140-475 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^{\pm})+m(\tilde{\chi}_1^0))$	1403.5294
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	-	Yes	20.3	$\tilde{\chi}_1^{\pm}$ 355 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{\tau},\tilde{\nu})=0.5(m(\tilde{\chi}_1^{\pm})+m(\tilde{\chi}_1^0))$	1407.0350
	$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu)$, $\ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e,μ	0	Yes	20.3	$\tilde{\chi}_1^{\pm},\tilde{\chi}_2^0$ 715 GeV	$m(\tilde{\chi}_1^{\pm})=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^{\pm})+m(\tilde{\chi}_1^0))$	1402.7029
	$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0\to W\tilde{\chi}_1^0Z\tilde{\chi}_1^0$	2-3 e,μ	0-2 jets	Yes	20.3	$\tilde{\chi}_1^{\pm},\tilde{\chi}_2^0$ 425 GeV	$m(\tilde{\chi}_1^{\pm})=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, sleptons decoupled	1403.5294, 1402.7029
	$\tilde{\chi}_1^{\pm}\tilde{\chi}_2^0\to W\tilde{\chi}_1^0h\tilde{\chi}_1^0$, $h\to b\bar{b}/WW/\tau\tau/\gamma\gamma$	e,μ,γ	0-2 b	Yes	20.3	$\tilde{\chi}_1^{\pm},\tilde{\chi}_2^0$ 270 GeV	$m(\tilde{\chi}_1^{\pm})=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, sleptons decoupled	1501.07110
	$\tilde{\chi}_2^0\tilde{\chi}_3^0$, $\tilde{\chi}_{2,3}^0\to\tilde{\ell}_R\ell$	4 e,μ	0	Yes	20.3	$\tilde{\chi}_{2,3}^0$ 635 GeV	$m(\tilde{\chi}_2^0)=m(\tilde{\chi}_3^0)$, $m(\tilde{\chi}_1^0)$=0, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_2^0)+m(\tilde{\chi}_1^0))$	1405.5086
	GGM (wino NLSP) weak prod.	1 $e,\mu+\gamma$	-	Yes	20.3	$\tilde{W}$ 115-370 GeV	$c\tau$<1 mm	1507.05493
Long-lived particles	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^{\pm}$	Disapp. trk	1 jet	Yes	20.3	$\tilde{\chi}_1^{\pm}$ 270 GeV	$m(\tilde{\chi}_1^{\pm})-m(\tilde{\chi}_1^0)$~160 MeV, $\tau(\tilde{\chi}_1^{\pm})$=0.2 ns	1310.3675
	Direct $\tilde{\chi}_1^+\tilde{\chi}_1^-$ prod., long-lived $\tilde{\chi}_1^{\pm}$	dE/dx trk	-	Yes	18.4	$\tilde{\chi}_1^{\pm}$ 495 GeV	$m(\tilde{\chi}_1^{\pm})-m(\tilde{\chi}_1^0)$~160 MeV, $\tau(\tilde{\chi}_1^{\pm})$<15 ns	1506.05332
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	27.9	$\tilde{g}$ 850 GeV	$m(\tilde{\chi}_1^0)$=100 GeV, 10 μs<$\tau(\tilde{g})$<1000 s	1310.6584
	Metastable $\tilde{g}$ R-hadron	dE/dx trk	-	-	3.2	$\tilde{g}$ 1.54 TeV	$m(\tilde{\chi}_1^0)$=100 GeV, τ>10 ns	To appear
	GMSB, stable $\tilde{\tau}$, $\tilde{\chi}_1^0\to\tilde{\tau}(\tilde{e},\tilde{\mu})+\tau(e,\mu)$	1-2 μ	-	-	19.1	$\tilde{\chi}_1^0$ 537 GeV	10<$\tan\beta$<50	1411.6795
	GMSB, $\tilde{\chi}_1^0\to\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$	2 γ	-	Yes	20.3	$\tilde{\chi}_1^0$ 440 GeV	1<$\tau(\tilde{\chi}_1^0)$<3 ns, SPS8 model	1409.5542
	$\tilde{g}\tilde{g}$, $\tilde{\chi}_1^0\to eev/e\mu\nu/\mu\mu\nu$	displ. $ee/e\mu/\mu\mu$	-	-	20.3	$\tilde{\chi}_1^0$ 1.0 TeV	7 <$c\tau(\tilde{\chi}_1^0)$< 740 mm, $m(\tilde{g})$=1.3 TeV	1504.05162
	GGM $\tilde{g}\tilde{g}$, $\tilde{\chi}_1^0\to Z\tilde{G}$	displ. vtx + jets	-	-	20.3	$\tilde{\chi}_1^0$ 1.0 TeV	6 <$c\tau(\tilde{\chi}_1^0)$< 480 mm, $m(\tilde{g})$=1.1 TeV	1504.05162
RPV	LFV $pp\to\tilde{\nu}_\tau+X$, $\tilde{\nu}_\tau\to e\mu/e\tau/\mu\tau$	$e\mu,e\tau,\mu\tau$	-	-	20.3	$\tilde{\nu}_\tau$ 1.7 TeV	λ'_{311}=0.11, $\lambda_{132/133/233}$=0.07	1503.04430
	Bilinear RPV CMSSM	2 e,μ (SS)	0-3 b	Yes	20.3	$\tilde{q},\tilde{g}$ 1.45 TeV	$m(\tilde{q})=m(\tilde{g})$, $c\tau_{LSP}$<1 mm	1404.2500
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to W\tilde{\chi}_1^0$, $\tilde{\chi}_1^0\to ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 e,μ	-	Yes	20.3	$\tilde{\chi}_1^{\pm}$ 760 GeV	$m(\tilde{\chi}_1^0)>0.2\times m(\tilde{\chi}_1^{\pm})$, $\lambda_{121}\neq0$	1405.5086
	$\tilde{\chi}_1^+\tilde{\chi}_1^-$, $\tilde{\chi}_1^+\to W\tilde{\chi}_1^0$, $\tilde{\chi}_1^0\to\tau\tau\tilde{\nu}_e, e\tau\tilde{\nu}_\tau$	3 $e,\mu+\tau$	-	Yes	20.3	$\tilde{\chi}_1^{\pm}$ 450 GeV	$m(\tilde{\chi}_1^0)>0.2\times m(\tilde{\chi}_1^{\pm})$, $\lambda_{133}\neq0$	1405.5086
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qqq$	0	6-7 jets	-	20.3	$\tilde{g}$ 917 GeV	BR(t)=BR(b)=BR(c)=0%	1502.05686
	$\tilde{g}\tilde{g}$, $\tilde{g}\to qq\tilde{\chi}_1^0$, $\tilde{\chi}_1^0\to qqq$	0	6-7 jets	-	20.3	$\tilde{g}$ 980 GeV	$m(\tilde{\chi}_1^0)$=600 GeV	1502.05686
	$\tilde{g}\tilde{g}$, $\tilde{g}\to\tilde{t}_1t$, $\tilde{t}_1\to bs$	2 e,μ (SS)	0-3 b	Yes	20.3	$\tilde{g}$ 880 GeV		1404.2500
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to bs$	0	2 jets + 2 b	-	20.3	$\tilde{t}_1$ 320 GeV		1601.07453
	$\tilde{t}_1\tilde{t}_1$, $\tilde{t}_1\to b\ell$	2 e,μ	2 b	-	20.3	$\tilde{t}_1$ 0.4-1.0 TeV	BR($\tilde{t}_1\to be/\mu$)>20%	ATLAS-CONF-2015-015
Other	Scalar charm, $\tilde{c}\to c\tilde{\chi}_1^0$	0	2 c	Yes	20.3	$\tilde{c}$ 510 GeV	$m(\tilde{\chi}_1^0)$<200 GeV	1501.01325

Legend: $\sqrt{s}$ = 7, 8 TeV; $\sqrt{s}$ = 13 TeV. Axis: Mass scale [TeV] (10^{-1}, 1)

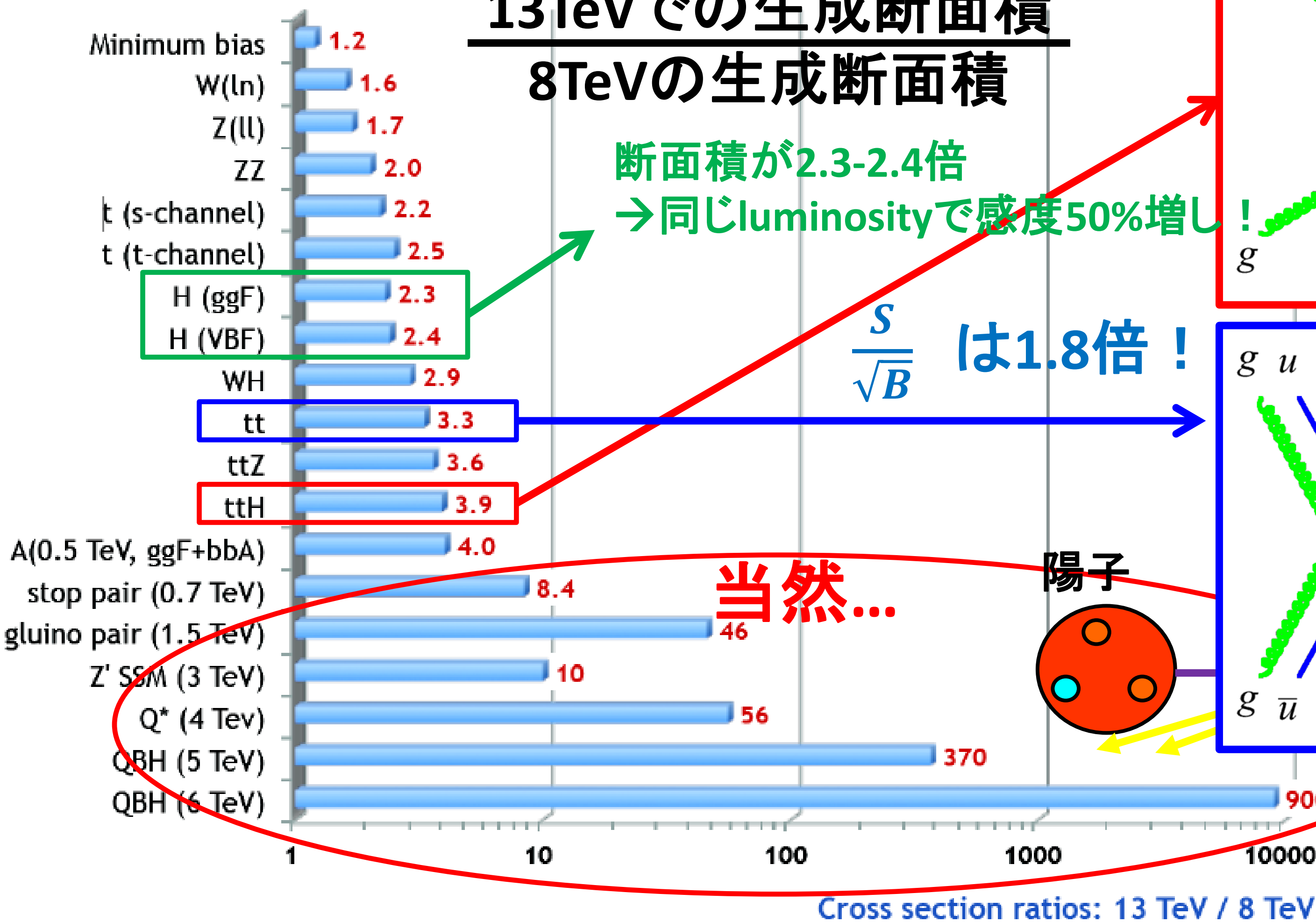
*Only a selection of the available mass limits on new states or phenomena is shown.



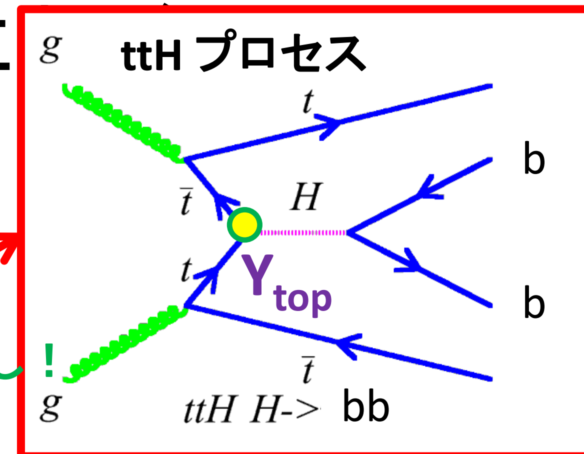
σ [pb]
Prediction
Measurement
ATLAS Preliminary
inelastic
Pythia8
pp → W
FEWZ
pp → Z / γ*
FEWZ
pp → tt̄
top++ NNLO+NNLL
pp → tq
NLO+NNLL
pp → H
LHC-XS
pp → ZZ
MCFM
√s [TeV]
inelastic
7 TeV, 20 μb-1, Nat. Commun. 2, 463 (2011)
13 TeV, 63 μb-1, ATLAS-CONF-2015-038
pp → W
7 TeV, 36 pb-1, PRD 85, 072004 (2012)
13 TeV, 85 pb-1, ATLAS-CONF-2015-039
pp → Z / γ*
7 TeV, 36 pb-1, PRD 85, 072004 (2012)
13 TeV, 85 pb-1, ATLAS-CONF-2015-039
pp → tt̄
7 TeV, 4.6 fb-1, Eur. Phys. J. C 74:3109 (2014)
8 TeV, 20.3 fb-1, Eur. Phys. J. C 74:3109 (2014)
13 TeV, 78 pb-1, ATLAS-CONF-2015-049
pp → tq
7 TeV, 4.6 fb-1, PRD 90, 112006 (2014)
8 TeV, 20.3 fb-1, ATLAS-CONF-2014-007
13 TeV, 3.2 fb-1, ATLAS-CONF-2015-079
pp → H
7 TeV, 4.5 fb-1, arXiv:1507.04548
8 TeV, 20.3 fb-1, arXiv:1507.04548
13 TeV, 3.2 fb-1, ATLAS-CONF-2015-069
pp → ZZ
7 TeV, 4.6 fb-1, JHEP 03, 128 (2013)
8 TeV, 20.3 fb-1, ATLAS-CONF-2013-020
13 TeV, 3.2 fb-1, arXiv:1512.05314

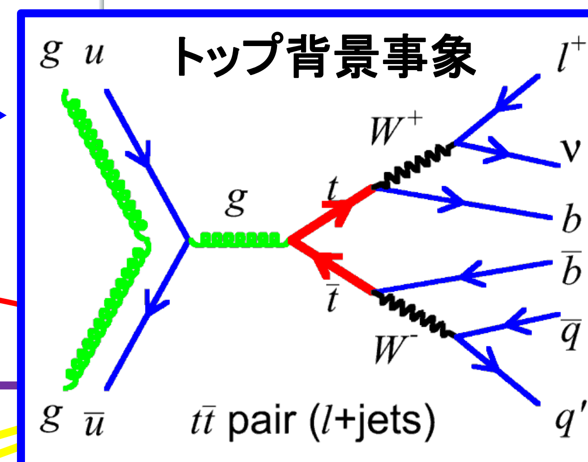
13TeVの恩恵

- エネルギーを8TeVから13(14)TeVに



$\frac{S}{\sqrt{B}}$ は1.8倍！



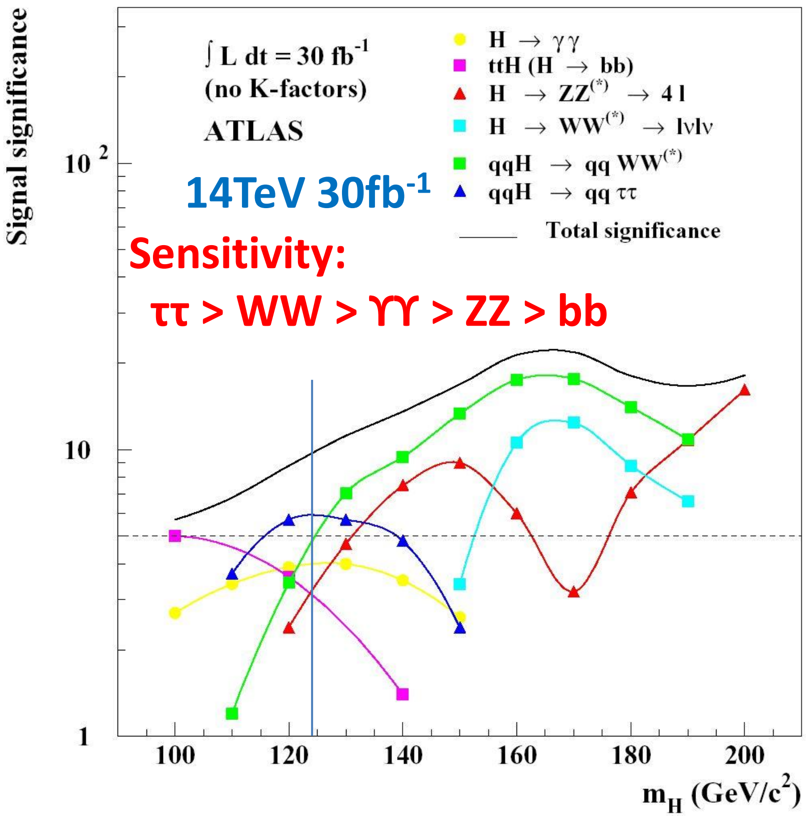


詳細は陣内さん

Sensitivity for each channel

Before experiment…

arXiv:hep-ph/0402254



ATLAS 2011+2012 Full data

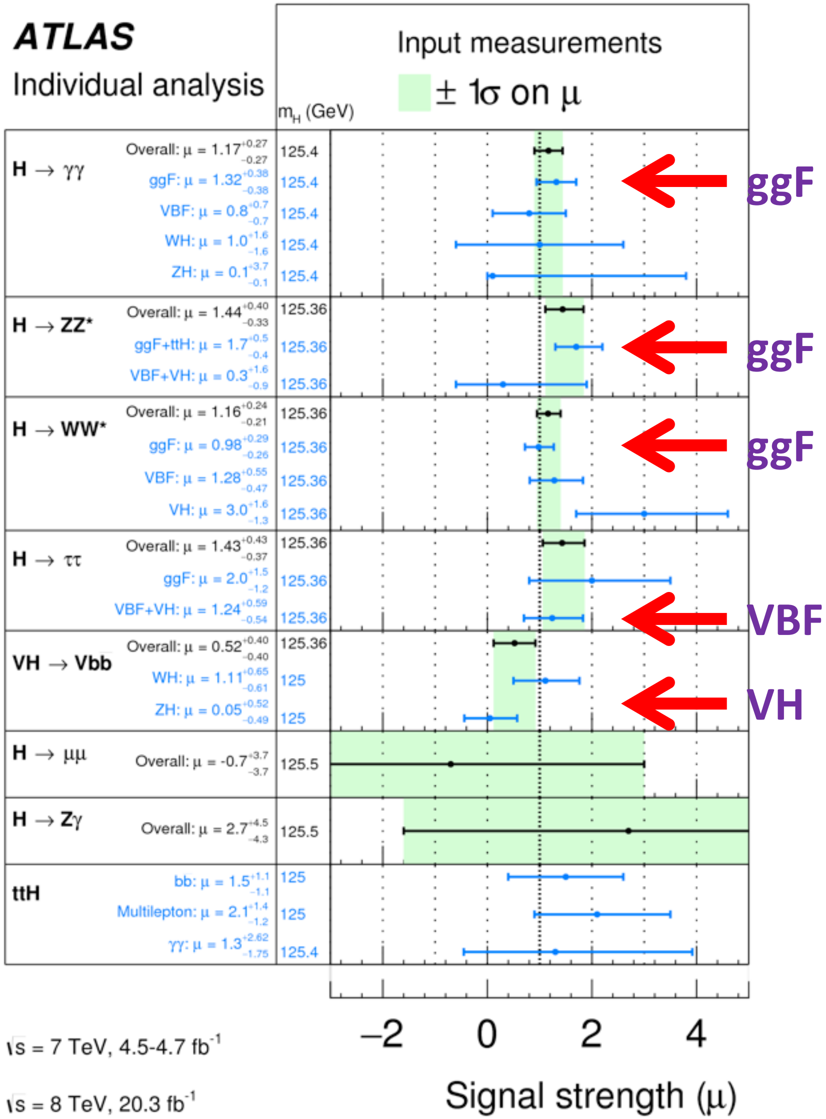
5fb^{-1}(7TeV)+20fb^{-1}(8TeV)

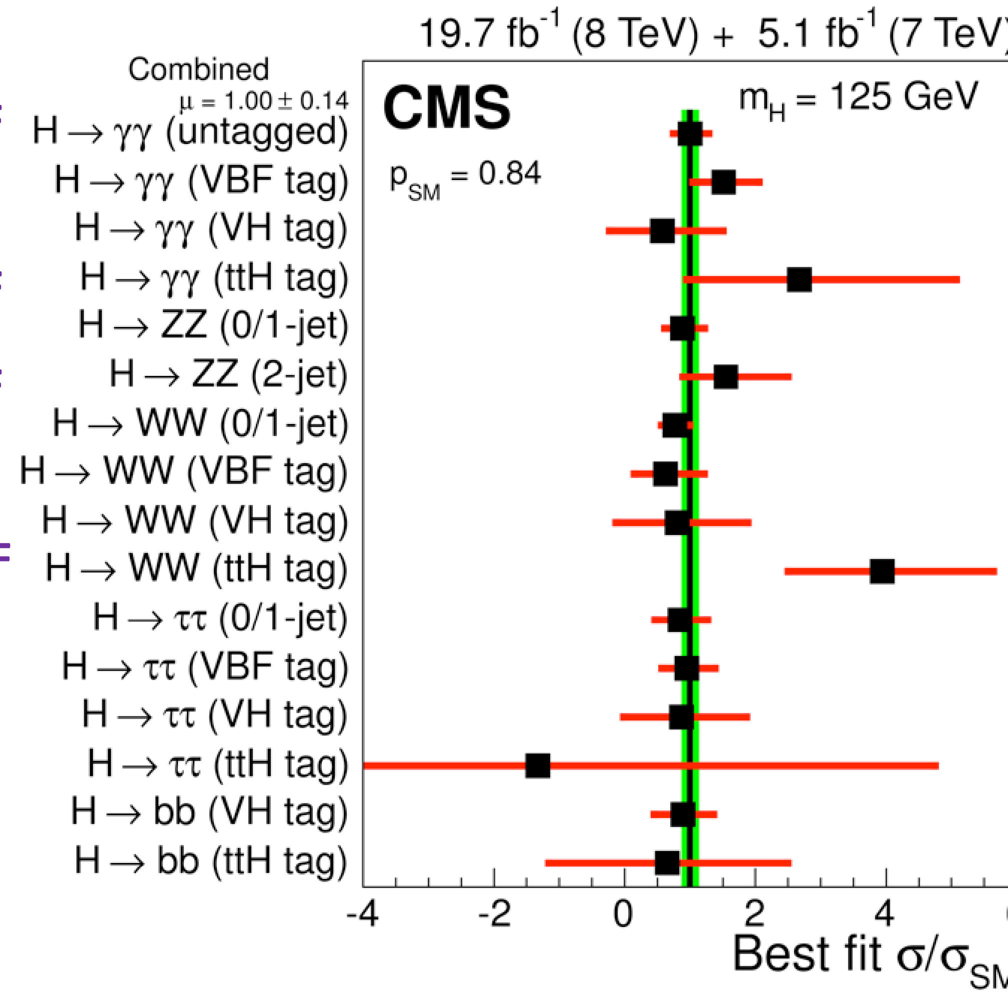
Decay channel	Expected sensitivity	Observed Sensitivity
ggF,(VBF):H→ZZ	6.2σ	8.1σ
ggF,VBF:H→ϒϒ	4.6σ	5.2σ
ggF,VBF:H→WW	5.8σ	6.1σ
(ggF),VBF:H→ττ	3.4σ	4.5σ
VH,H→bb	2.6σ	1.4σ
H→μμ	<7.2xSM	<7.0xSM
ttH:H→bb	<2.2xSM	<3.4xSM

実験前の予想はあまりあてにならないが…

予想よりかなり良い結果！！

Summary of individual results.





Higgsの前に… SM process