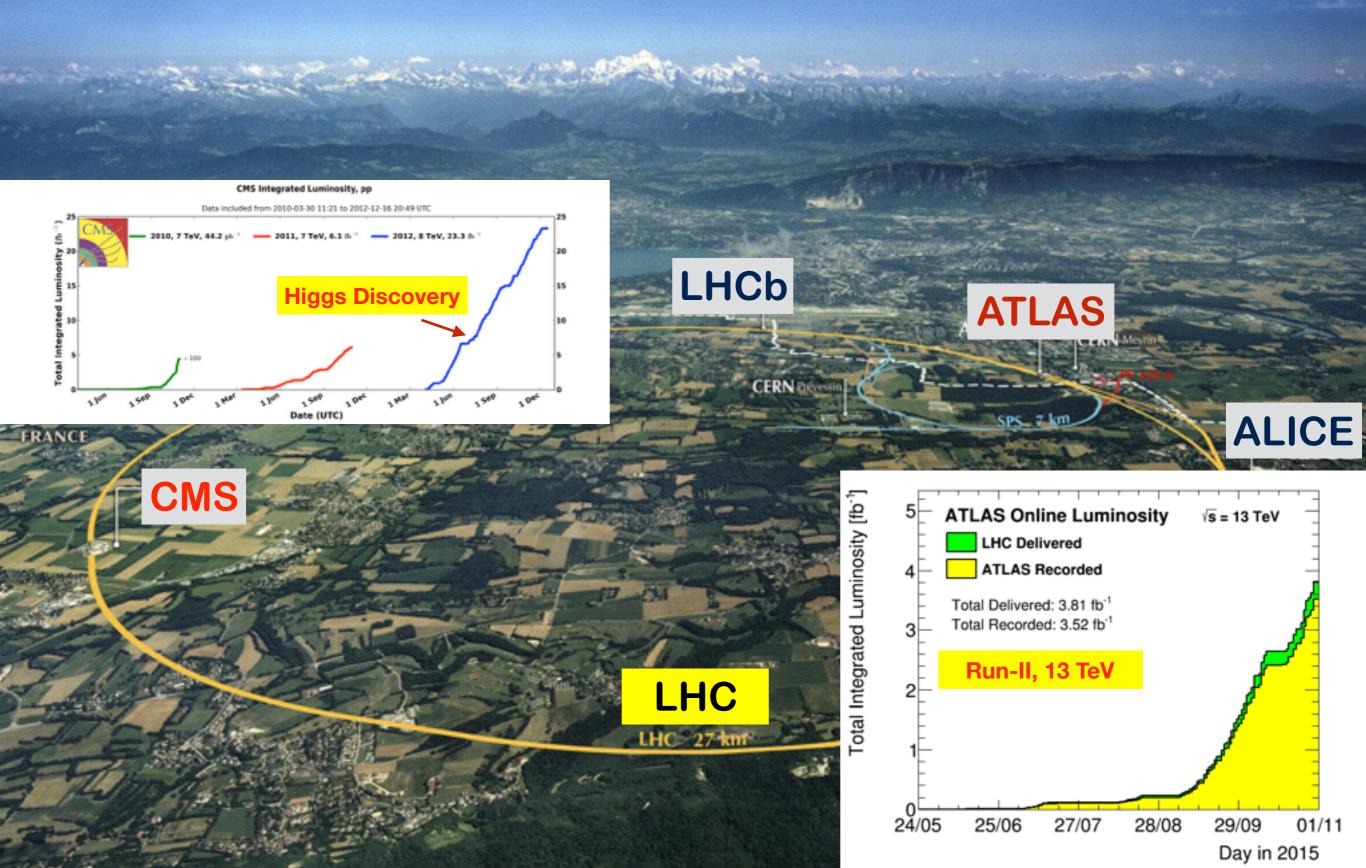
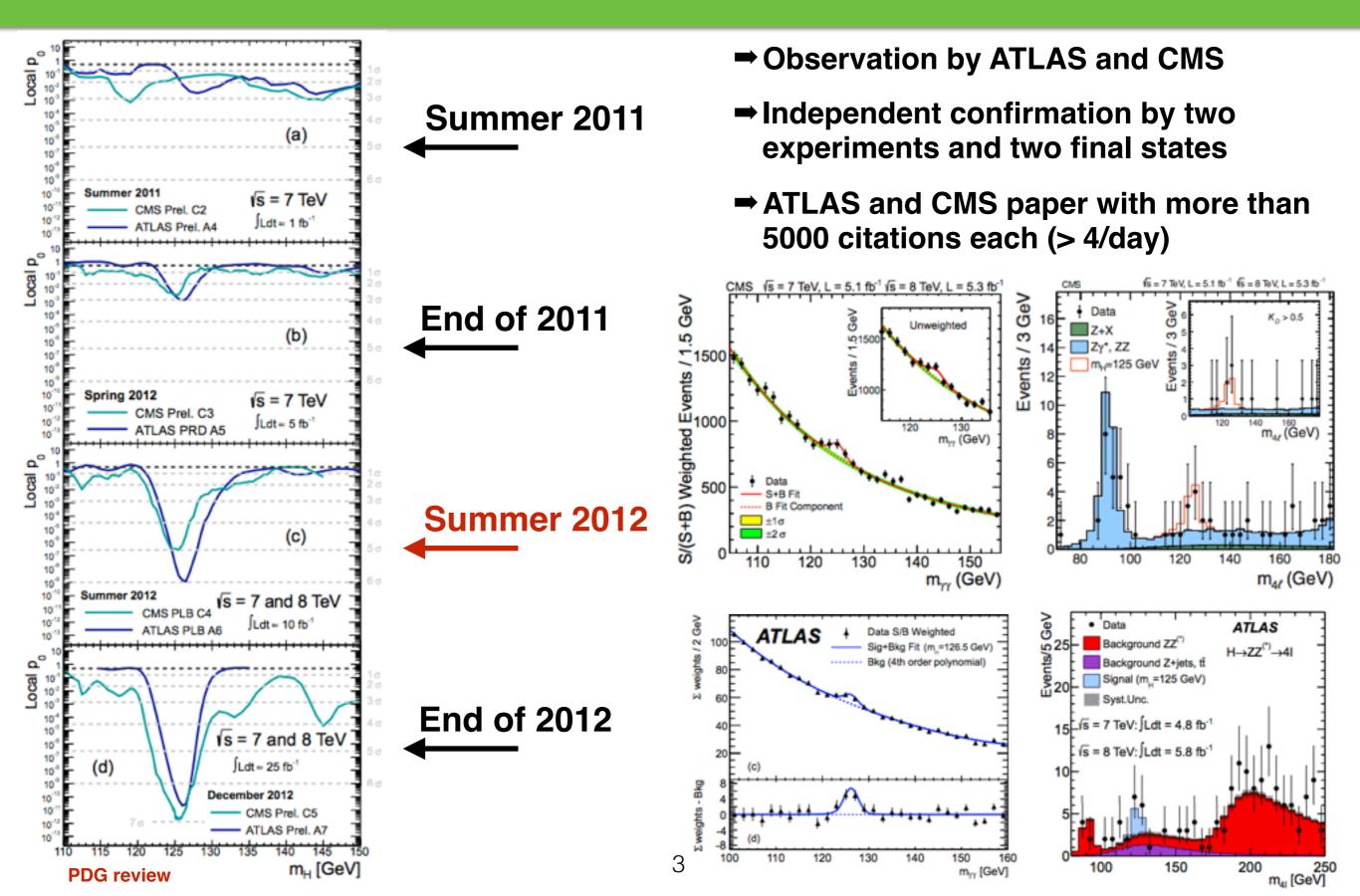
Highlights of LHC Run I and first 13 TeV results

> Markus Klute (MIT) on behalf of ATLAS and CMS Linear Collider Workshop 2015 Whistler, Canada

Large Hadron Collider - Run I and II



Higgs Boson Discovery

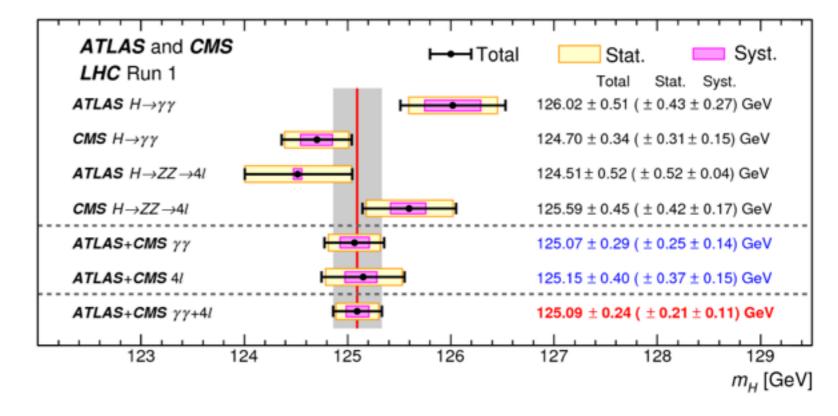


Overview of Higgs Results

- Combined ATLAS and CMS measurements using LHC Run-1 dataset
- Precision (0.2%) limited by statistical uncertainty

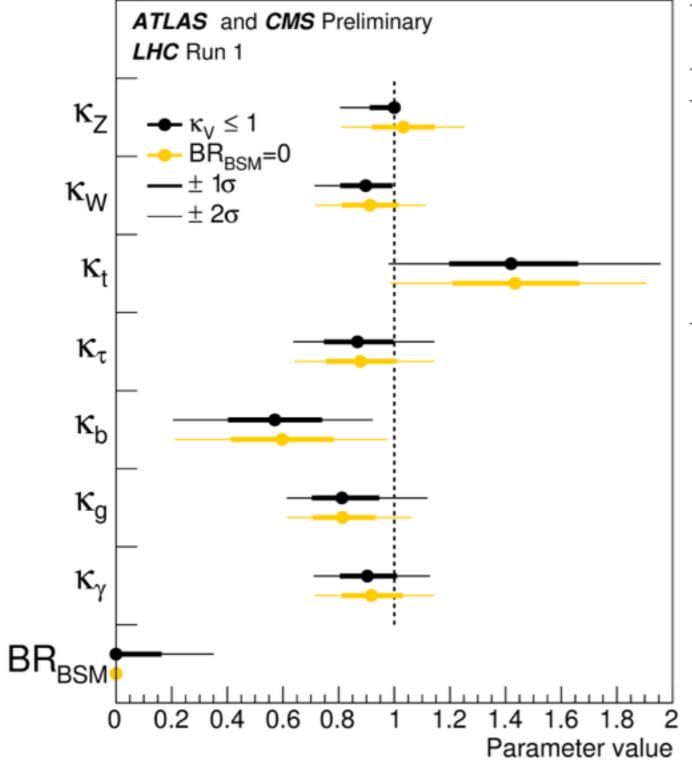
 $m_{H} = 125.09 \pm 0.21$ (stat.) ± 0.11 (syst) GeV

- Established that particle masses and couplings to the Higgs boson relate
- Discovered particle looks in all aspects like the SM Higgs boson
- No additional Higgs bosons or BSM decays observed



Production process	Measured significance (σ)	Expected significance (σ)
VBF	5.4	4.7
WH	2.4	2.7
ZH	2.3	2.9
VH	3.5	4.2
tt H	4.4	2.0
Decay channel		
$H \rightarrow \tau \tau$	5.5	5.0
$H \rightarrow bb$	2.6	3.7

Higgs Coupling Measurements



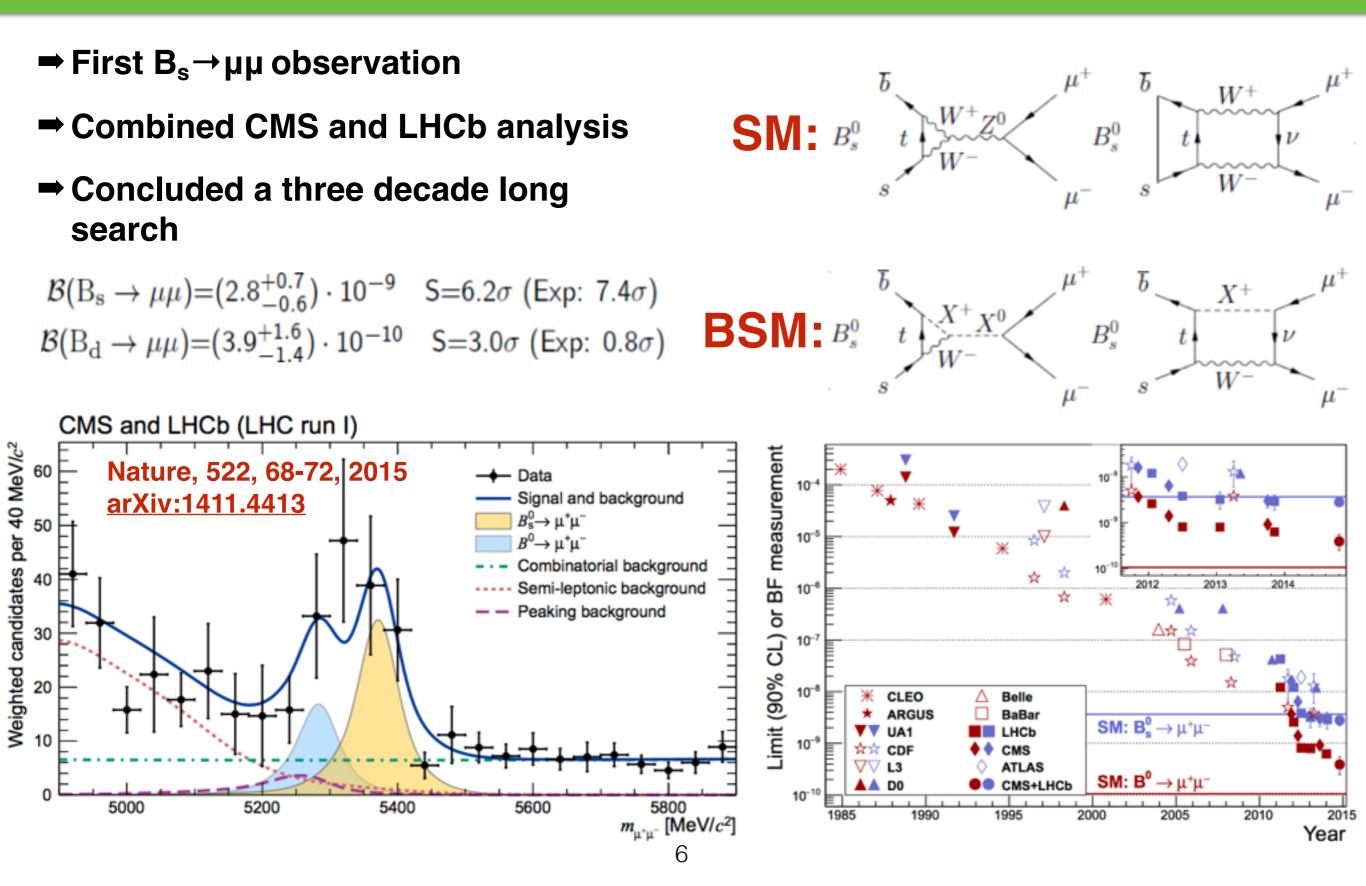
$1.03^{+0.11}_{-0.11}$	Expected uncertainty isation assuming BR _{BSN} +0.10 -0.11	Measured $_{A} = 0$ $1.00^{+0.14}_{-0.14}$	Measured
$1.03^{+0.11}_{-0.11}$	+0.10		1.07+0.17
		$1.00^{+0.14}$	1.07+0.17
.0.10		-0.14	1.07-0.18
$0.91^{+0.10}_{-0.10}$	+0.10 -0.11	$0.92^{+0.13}_{-0.13}$	$0.90^{+0.15}_{-0.15}$
$1.43^{+0.23}_{-0.22}$	+0.26 -0.32	$1.31^{+0.30}_{-0.32}$	$1.56^{+0.34}_{-0.32}$
$0.88^{+0.13}_{-0.12}$	+0.16 -0.15	$0.97^{+0.19}_{-0.17}$	$0.82^{+0.19}_{-0.17}$
$0.60^{+0.18}_{-0.18}$	+0.25 -0.24	$0.61^{+0.26}_{-0.26}$	$0.61^{+0.27}_{-0.26}$
$0.81^{+0.11}_{-0.10}$	+0.17 -0.14	$0.94^{+0.18}_{-0.15}$	$0.70^{+0.15}_{-0.13}$
$0.92^{+0.11}_{-0.10}$	+0.12 -0.12	$0.88^{+0.15}_{-0.14}$	$0.96^{+0.17}_{-0.15}$
	$\begin{array}{c} 1.43\substack{+0.23\\-0.22}\\ 0.88\substack{+0.13\\-0.12}\\ 0.60\substack{+0.18\\-0.18}\\ 0.81\substack{+0.11\\-0.10}\end{array}$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	$\begin{array}{c ccccccccccccccccccccccccccccccccccc$

ATLAS-CONF-2015-044

CMS-PAS-HIG-15-002

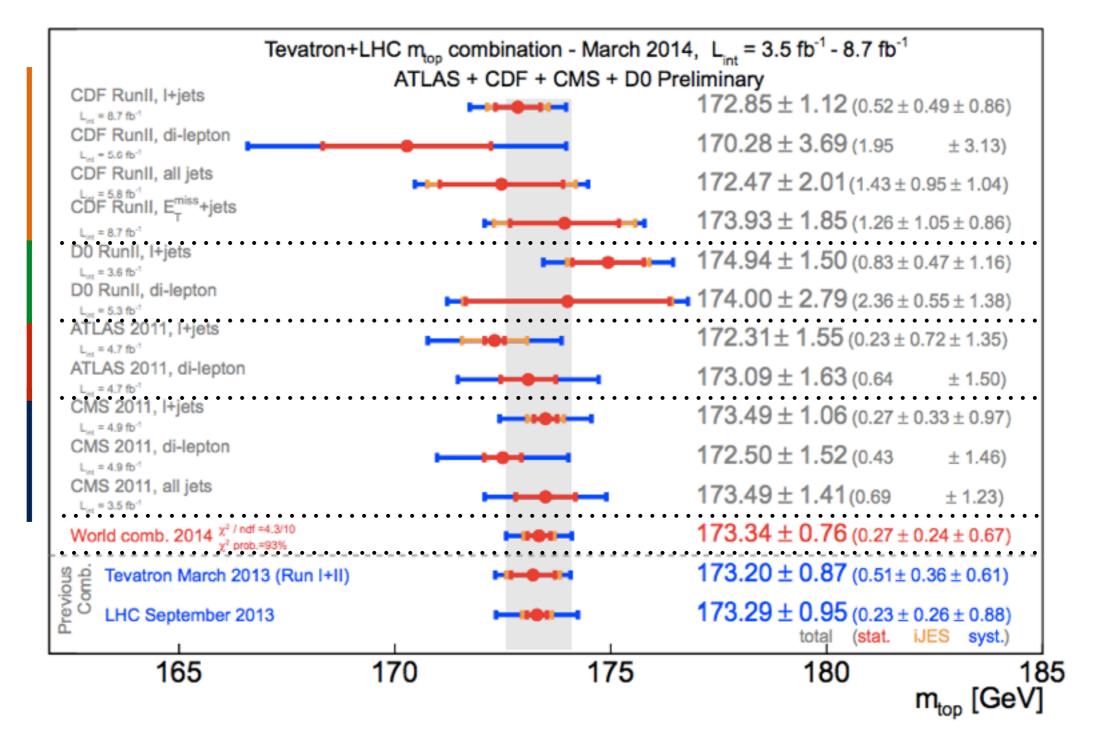
- Coupling modifier measured with varying assumptions on total width
- Precision already ~10% for Z, W, and photon couplings

First Observation



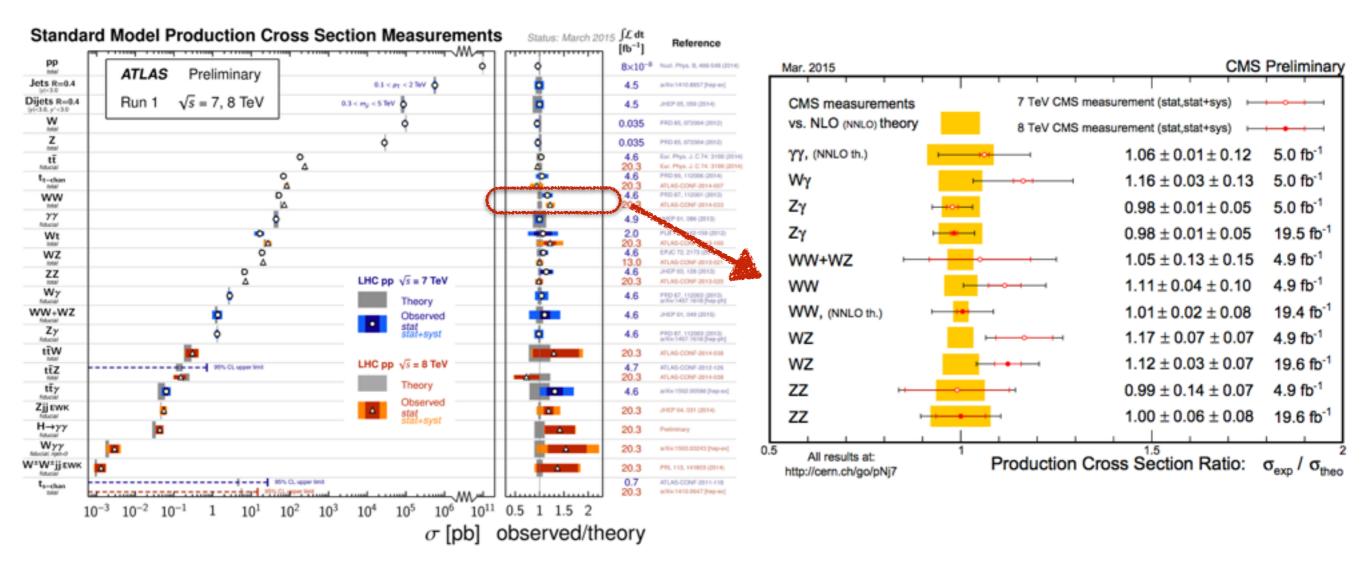
Precision Top Mass Measurements

CDF D0 ATLAS CMS



Updated CMS combination yields: 172.44 ± 0.13 ± 0.47 GeV

Precision Cross Sections



More than 800 paper between ATLAS and CMS, not even counting LHCb and ALICE results

Selected highlights are minor fraction of the total LHC physics program

LHC SUSY Searches

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: July 2015

Pen. Inclusive Searches hed.	$\begin{array}{llllllllllllllllllllllllllllllllllll$	0-3 $e, \mu/1-2 \tau$ 0 mono-jet 2 e, μ (off-Z) 0 0-1 e, μ 2 e, μ 1-2 τ + 0-1 ℓ 2 γ γ γ 2 e, μ (Z) 0	2-6 jets 1-3 jets 2 jets 2-6 jets 2-6 jets 0-3 jets	 Ves 	20.3 20.3 20.3 20.3 20 20 20 20.3 20.3 2	ψ. ż 850 G ψ 100-440 GeV ψ 100-440 GeV 780 GeV ψ 780 GeV ψ 2 780 GeV ψ 2 2 ψ 2 2 ψ 2 2 ψ 2 2 ψ 2 2 ψ 2 2 ψ 2 2 ψ 2 2 ψ 2 2 ψ 2 2 ψ 2 2 ψ 2 2 ψ 2 2 ψ 2 2 ψ 2 2 ψ 2 2 ψ 2 2 ψ 2 2	eV 1.33 TeV 1.26 TeV 1.32 TeV	1.8 TeV $m(\tilde{q})=m(\tilde{q})$ $m(\tilde{k}_{1}^{0})=0$ GeV, $m(1^{st} \text{ gcn}, \tilde{q})=m(2^{od} \text{ gcn}, \tilde{q})$ $m(\tilde{q})=m(\tilde{k}_{1}^{0})<10$ GeV $m(\tilde{k}_{1}^{0})=0$ GeV $m(\tilde{k}_{1}^{0})=0$ GeV $m(\tilde{k}_{1}^{0})=0$ GeV $m(\tilde{k}_{1}^{0})=0$ GeV $m(\tilde{k}_{1}^{0})=0$ GeV $tan\beta > 20$ total second	1507.05525 1405.7875 1507.05525 1503.03290 1405.7875 1507.05525 1501.03555 1407.0603
gen. Inclusive Searches red. 000000% % % 6.6	$\tilde{q}\tilde{q}, \tilde{q} \rightarrow q \tilde{\xi}_{1}^{0}$ $\tilde{q}\tilde{q}, \tilde{q} \rightarrow q \tilde{\xi}_{1}^{0}$ (compressed) $\tilde{q}\tilde{q}, \tilde{q} \rightarrow q \tilde{\xi}_{1}^{0}$ (compressed) $\tilde{q}\tilde{q}, \tilde{q} \rightarrow q q \tilde{\xi}_{1}^{0}$ $\tilde{\xi}\tilde{g}, \tilde{g} \rightarrow q q \tilde{\xi}_{1}^{0}$ $\tilde{\xi}\tilde{g}, \tilde{g} \rightarrow q q \tilde{\xi}_{1}^{0} \rightarrow q q W^{\pm} \tilde{\xi}_{1}^{0}$ $\tilde{g}\tilde{g}, \tilde{g} \rightarrow q q (\ell \ell / \ell \nu / \nu \nu) \tilde{\xi}_{1}^{0}$ GMSB ($\tilde{\ell}$ NLSP) GGM (bino NLSP) GGM (bigsino-bino NLSP) GGM (higgsino-bino NLSP) GGM (higgsino NLSP) GGM (higgsino NLSP) Gravitino LSP $\tilde{\xi}\tilde{g}, \tilde{g} \rightarrow b \tilde{b} \tilde{\xi}_{1}^{0}$	0 mono-jet 2 e, µ (off-Z) 0 0-1 e, µ 2 e, µ 1-2 τ + 0-1 ℓ 2 γ γ γ 2 e, µ (Z) 0	2-6 jets 1-3 jets 2 jets 2-6 jets 2-6 jets 0-3 jets 0-2 jets - 1 b 2 jets 2 jets	Yes Yes Yes Yes Yes Yes Yes Yes	20.3 20.3 20.3 20.3 20 20 20.3 20.3 20.3		eV 1.33 TeV 1.26 TeV 1.32 TeV 1.6	$\begin{array}{l} m(\tilde{\chi}_{1}^{0}) = 0 \; GeV, \; m(1^{st}\; gcn, \tilde{q}) = m(2^{out}\; gcn, \tilde{q}) \\ m(\tilde{\chi}_{1}^{0}) = 0 \; GeV \\ \end{array}$	1507.05525 1503.03290 1405.7875 1507.05525 1501.03555 1407.0503
Pen. Inclusive Searches hed.	$\tilde{q}\tilde{q}, \tilde{q} \rightarrow q \tilde{\ell}_{1}^{\prime\prime}$ (compressed) $\tilde{q}\tilde{q}, \tilde{q} \rightarrow q (\ell \ell / (r_{1}/r_{2}) \tilde{k}_{1}^{0})$ $\tilde{g}\tilde{q}, \tilde{q} \rightarrow q \tilde{q} \tilde{\ell}_{1}^{\prime}$ $\tilde{g}\tilde{g}, \tilde{g} \rightarrow q \tilde{q} \tilde{\ell}_{1}^{\prime}$ $\tilde{g}\tilde{g}, \tilde{g} \rightarrow q q \tilde{\ell}_{1}^{\prime} \rightarrow q q W^{\pm} \tilde{\ell}_{1}^{0}$ $\tilde{g}\tilde{g}, \tilde{g} \rightarrow q q \tilde{\ell} (\ell / (r_{1}/r_{2}) \tilde{\ell}_{1}^{0})$ $\tilde{g}GM (bino NLSP)$ GGM (bigsino-bino NLSP) GGM (higgsino-bino NLSP) GGM (higgsino-bino NLSP) GGM (higgsino-bino NLSP) $\tilde{g}GM (biggsino-bino NLSP)$ $\tilde{g}GM (biggsino-bino NLSP)$ $\tilde{g}GM (biggsino-bino NLSP)$ $\tilde{g}GM (biggsino-bino NLSP)$ $\tilde{g}GM (biggsino-bino NLSP)$	$2 e, \mu (olf - Z)$ 0 $0 - 1 e, \mu$ $2 e, \mu$ $1 - 2 \tau + 0 - 1 \ell$ 2γ γ $2 e, \mu (Z)$ 0	2 jets 2-6 jets 2-6 jets 0-3 jets 0-2 jets 1 b 2 jets 2 jets	Yes Yes Yes Yes Yes Yes Yes	20.3 20.3 20.3 20 20 20.3 20.3 20.3 20.3	4 100-440 GeV	1.33 TeV 1.26 TeV 1.32 TeV 1.6	$\begin{array}{l} m(\tilde{\chi}) \mbox{-}m(\tilde{\chi}_{1}^{0}) \mbox{-}10 \mbox{ GeV} \\ m(\tilde{\chi}_{1}^{0}) \mbox{-}0 \mbox{ GeV} \\ m(\tilde{\chi}_{1}^{0}) \mbox{-}0 \mbox{ GeV} \\ m(\tilde{\chi}_{1}^{0}) \mbox{-}300 \mbox{ GeV}, m(\tilde{\chi}^{+}) \mbox{-}0.5(m(\tilde{\chi}_{1}^{0}) \mbox{+}m(\tilde{\chi})) \\ m(\tilde{\chi}_{1}^{0}) \mbox{-}0 \mbox{ GeV} \\ m(\tilde{\chi}_{1}^{0}) \mbox{-}20 \end{array}$	1503.03290 1405.7875 1507.05525 1501.03555 1407.0503
Ped. Inclusive Searche	$\tilde{q}\tilde{q}, \tilde{q} \rightarrow q(\ell\ell/\ell\nu/\nu\gamma)\tilde{t}_{1}^{0}$ $\tilde{\xi}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}\tilde{t}_{1}^{0}$ $\tilde{\xi}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}\tilde{t}_{1}^{0} \rightarrow qqW^{\pm}\tilde{\chi}_{1}^{0}$ $\tilde{\xi}\tilde{g}, \tilde{g} \rightarrow qq(\ell\ell/\ell\nu/\nu\gamma)\tilde{t}_{1}^{0}$ GGM (bino NLSP) GGM (bino NLSP) GGM (higgsino-bino NLSP) GGM (higgsino-bino NLSP) GGM (higgsino NLSP) GGM (bingsino NLSP) \tilde{g} Gravitino LSP $\tilde{\xi}\tilde{g}, \tilde{g} \rightarrow b\tilde{b}\tilde{\xi}_{1}^{0}$	$2 e, \mu (olf - Z)$ 0 $0 - 1 e, \mu$ $2 e, \mu$ $1 - 2 \tau + 0 - 1 \ell$ 2γ γ $2 e, \mu (Z)$ 0	2 jets 2-6 jets 2-6 jets 0-3 jets 0-2 jets 1 b 2 jets 2 jets	Yes Yes Yes Yes Yes Yes	20.3 20.3 20 20 20.3 20.3 20.3		1.33 TeV 1.26 TeV 1.32 TeV 1.6	m(k ²)=0 GeV m(k ²)=0 GeV m(k ²)<0 GeV m(k ²)<300 GeV, m(k ²)=0.5(m(k ²)+m(<u>z</u>)) m(k ²)=0 GeV TeV tanβ >20	1503.03290 1405.7875 1507.05525 1501.03555 1407.0603
inclusive	$\tilde{\xi}\tilde{g}, \tilde{g} \rightarrow q\tilde{q}\tilde{\xi}_{1}^{0}$ $\tilde{\xi}\tilde{g}, \tilde{g} \rightarrow qq\tilde{\xi}_{1}^{0} \rightarrow qqW^{\pm}\tilde{\xi}_{1}^{0}$ $\tilde{\xi}\tilde{g}, \tilde{g} \rightarrow qq(\ell\ell/\ell\nu/\nu\nu)\tilde{\xi}_{1}^{0}$ GMSB ($\tilde{\ell}$ NLSP) GGM (bino NLSP) GGM (higgsino-bino NLSP) GGM (higgsino-bino NLSP) GGM (higgsino NLSP) Gravitino LSP $\tilde{\xi}\tilde{g}, \tilde{g} \rightarrow b\tilde{b}\tilde{\xi}_{1}^{0}$	$\begin{array}{c} 0 \\ 0 - 1 \ e, \mu \\ 2 \ e, \mu \\ 1 - 2 \ \tau + 0 - 1 \ \ell \\ 2 \ \gamma \\ \gamma \\ 2 \ e, \mu \ (Z) \\ 0 \end{array}$	2-6 jets 2-6 jets 0-3 jets 0-2 jets - 1 b 2 jets 2 jets	Yes Yes Yes Yes Yes Yes	20.3 20 20.3 20.3 20.3 20.3	7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7	1.33 TeV 1.26 TeV 1.32 TeV 1.6	m(\tilde{t}_{1}^{0})=0 GeV m(\tilde{t}_{1}^{0})<300 GeV, m(\tilde{t}^{+})=0.5(m(\tilde{t}_{1}^{0})+m(\tilde{z})) m(\tilde{t}_{1}^{0})=0 GeV TeV tang5 >20	1405.7875 1507.05525 1501.03555 1407.0503
ed.	$\tilde{t}\tilde{t}, \tilde{g} \rightarrow qq \tilde{W}_{1}^{\pm} \rightarrow qq W^{\pm} \tilde{t}_{1}^{0}$ $\tilde{t}\tilde{t}, \tilde{g} \rightarrow qq (\ell \ell / \ell \nu / \nu \nu) \tilde{t}_{1}^{0}$ GMSB ($\tilde{\ell}$ NLSP) GGM (bino NLSP) GGM (higgsino-bino NLSP) GGM (higgsino-bino NLSP) GGM (higgsino NLSP) Gravitino LSP $\tilde{t}\tilde{t}, \tilde{g} \rightarrow b \tilde{b} \tilde{t}_{1}^{0}$	$\begin{array}{c} 0 - 1 \ e, \mu \\ 2 \ e, \mu \\ 1 - 2 \ r + 0 - 1 \ \ell \\ 2 \ \gamma \\ \gamma \\ 2 \ e, \mu \ (Z) \\ 0 \end{array}$	2-6 jets 0-3 jets 0-2 jets 1 <i>b</i> 2 jets 2 jets	Yes Yes Yes Yes Yes	20 20 20.3 20.3 20.3		1.26 TeV 1.32 TeV 1.6 T	m(t ² n)<300 GeV; m(t ² *)=0.5(m(t ² n)+m(<u>z</u>)) m(t ² n)=0 GeV TeV tant >20	1507.05525 1501.03555 1407.0503
inclusive	$\tilde{t}\tilde{g}, \tilde{g} \rightarrow qg(\ell\ell/\ell r/rv)\tilde{t}_{1}^{0}$ GMSB (ℓ NLSP) GGM (bino NLSP) GGM (higgsino-bino NLSP) GGM (higgsino-bino NLSP) GGM (higgsino NLSP) GGM (higgsino NLSP) Gravitino LSP $\tilde{t}\tilde{g}, \tilde{g} \rightarrow b \tilde{b} \tilde{t}_{1}^{0}$	2 e, µ 1 · 2 τ + 0 · 1 ℓ 2 γ γ 2 e, µ (Z) 0	0-3 jets 0-2 jets 1 <i>b</i> 2 jets 2 jets	Yes Yes Yes Yes	20 20.3 20.3 20.3	* * * *	1.32 TeV 1.6	m(ξ ⁰ ₁)=0 GeV TeV taŋβ >20	1501.03555 1407.0603
indusin	GMSB ($\tilde{\ell}$ NLSP) GGM (bino NLSP) GGM (higgsino-bino NLSP) GGM (higgsino-bino NLSP) GGM (higgsino NLSP) Gravitino LSP $\tilde{\xi}\tilde{\xi}, \tilde{g} \rightarrow b \tilde{b} \tilde{\xi}_{1}^{0}$	1-2 τ + 0-1 ℓ 2 γ 7 2 e, μ (Z) 0	0-2 jets 1 b 2 jets 2 jets	Yes Yes Yes Yes	20.3 20.3 20.3	x k k	1.6	TeV tans >20	1407.0603
led.	GGM (bino NLSP) GGM (higgsino-bino NLSP) GGM (higgsino-bino NLSP) GGM (higgsino NLSP) GGM (higgsino NLSP) Gravitino LSP	2 γ 7 2 e,μ (Z) 0	1 b 2 jets 2 jets	Yes Yes Yes	20.3 20.3	к 2			
led.	GGM (higgsino-bino NLSP) GGM (higgsino-bino NLSP) GGM (higgsino NLSP) GGM (higgsino NLSP) Gravitino LSP $\delta \tilde{\chi}_1^0$	γ γ 2 e,μ (Z) 0	2 jets 2 jets	Yes Yes	20.3	<i>K</i>			
led.	GGM (higgsino-bino NLSP) GGM (higgsino NLSP) Gravitino LSP ž8, ž→bbž ⁰ ₁	γ 2 e, μ (Z) 0	2 jets 2 jets	Yes				er(NLSP)<0.1 mm	1507.05493
led.	GGM (higgsino NLSP) Gravitino LSP ξξ, ξ→δδξ ⁰	2 e,μ (Ζ) 0	2 jets		20.3	8	1.3 TeV	m(R ⁰)<900 GeV, cτ(NLSP)<0.1 mm, μ<0	1507.05493
ied.	Gravitino LSP $\bar{\xi}\bar{\xi}, \bar{\xi} \rightarrow b\bar{b}\bar{\xi}_{1}^{0}$	0		Yes		<i>k</i>	1.25 TeV	m(k ⁰ ₁)<850 GeV, cr(NLSP)<0.1 mm, μ>0	1507.05493
ed.	$\bar{\xi}\bar{g}, \bar{g} \rightarrow b\bar{b}\bar{\chi}_{1}^{0}$	-	mono-jet		20.3	<i>k</i> 850 G	eV	m(NLSP)>430 GeV	1503.03290
2 E 3	$\tilde{g}, \tilde{g} \rightarrow b \tilde{b} \tilde{\chi}_{1}^{0}$ $\tilde{g}_{-}, \tilde{g} \rightarrow d \tilde{\chi}_{1}^{0}$			Yes	20.3	F ^{1/2} scale 865 G	ieV	$m[\hat{G}] > 1.8 \times 10^{-4} \text{ eV}, m(\hat{g}) = m(\hat{g}) = 1.5 \text{ TeV}$	1502.01518
ee a	$b\bar{p}, \bar{p} \rightarrow t\bar{t}\bar{t}_{1}$	0	3 b	Yes	20.1	Ř	1.25 TeV	m(\tilde{k}_{1}^{0})<400 GeV	1407.0500
· E .	1	0	7-10 jets	Yes	20.3	k	1.1 TeV	m(k̃ ₁ ⁰) <350 GeV	1308.1841
	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow t\tilde{t}\tilde{\chi}_{1}^{0}$	$0-1 e, \mu$	3 b	Yes	20.1	Ř	1.34 TeV	m(k ⁰ ₁)<400 GeV	1407.0600
100 3	$\tilde{g}\tilde{g}, \tilde{g} \rightarrow b \tilde{e} \tilde{\chi}_{1}^{+}$	0-1 e, µ	3 b	Yes	20.1	Ř	1.3 TeV	m($\tilde{\chi}_{1}^{0}$)<300 GeV	1407.0600
	$b_1 \tilde{b}_1, \tilde{b}_1 \rightarrow h \tilde{\ell}_1^0$	0	2 b	Yes	20.1	δ ₁ 100-620 GeV		m(k ⁰ ₁)<90 GeV	1308.2631
16 F	$b_1b_1, b_1 \rightarrow t\hat{\chi}_1^*$	2 e, µ (SS)	0-3 b	Yes	20.3	b1 275-440 GeV		$m(\tilde{\chi}_{1}^{n})=2 m(\tilde{\chi}_{1}^{0})$	1404.2500
3 1	$\tilde{i}_1 \tilde{i}_1, \tilde{i}_1 \rightarrow b \tilde{\chi}_1^{\pm}$	$1-2 e, \mu$	1-2 b	Yes 4	7/20.3	71 110-167 GeV 230-460 GeV		$m(\hat{\chi}_{1}^{n}) = 2m(\hat{\chi}_{1}^{0}), m(\hat{\chi}_{1}^{0})=55 \text{ GeV}$	1209.2102, 1407.0
2 7	$\tilde{t}_1 \tilde{t}_1, \tilde{t}_1 \rightarrow W b \tilde{\chi}_1^0 \text{ or } t \tilde{\chi}_1^0$	0-2 e. µ 0	0-2 jets/1-2	b Yes	20.3	ž ₁ 90-191 GeV 210-700 GeV		$m(\tilde{x}_{1}^{0})=1$ GeV	1506.08616
	$\tilde{i}_1 \tilde{i}_1, \tilde{i}_1 \rightarrow c \tilde{k}_1^0$	0 m	tono-jet/c-ti	ag Yes	20.3	l 90-240 GeV		m(i1)-m(i1)=085GeV	1407.0608
6 6	(natural GMSB)	$2 e, \mu(Z)$	1 b	Yes	20.3	7 150-580 GeV		m(\hat{k}_{1}^{0})>150 GeV	1403.5222
	$\tilde{i}_2 \tilde{i}_2, \tilde{i}_2 \rightarrow \tilde{i}_1 + Z$	$3e, \mu(Z)$	1 b	Yes	20.3	72 290-600 GeV		m(k ⁰ ₁)<200 GeV	1403.5222
1	$\tilde{l}_{L,R}\tilde{l}_{L,R}, \tilde{l} \rightarrow \ell \tilde{\chi}_{1}^{D}$	2 e.µ	0	Yes	20.3	7 90-325 GeV	_	m(x ⁰ ₁)=0 GeV	1403.5294
	$\hat{\chi}_1^* \hat{\chi}_1^-, \hat{\chi}_1^* \rightarrow \tilde{\ell}_V(\ell \bar{\nu})$	$2e,\mu$	0	Yes	20.3	x [*] 140-465 GeV		$m(\tilde{\chi}_{1}^{0})=0$ GeV, $m(\tilde{\ell}, \tilde{\nu})=0.5(m(\tilde{\chi}_{1}^{0})+m(\tilde{\chi}_{1}^{0}))$	1403.5294
	$\tilde{\chi}_{1}^{*}\tilde{\chi}_{1}^{-}, \tilde{\chi}_{1}^{*} \rightarrow \tilde{r}\nu(r\tilde{\nu})$	2 7	-	Yes	20.3	ž [±] 100-350 GeV		$m(\tilde{t}_{1}^{0})=0$ GeV, $m(\tilde{r}, \tilde{r})=0.5(m(\tilde{t}_{1}^{+})+m(\tilde{t}_{1}^{0}))$	1407.0350
	$\tilde{t}_{1}^{\pm}\tilde{x}_{2}^{0} \rightarrow \tilde{t}_{L}v\tilde{t}_{L}t(\bar{v}v), t\tilde{v}\tilde{t}_{L}t(\bar{v}v)$	3 e. µ	0	Yes	20.3	x, x, 700 GeV		$m(\tilde{k}_{1}^{+})=m(\tilde{k}_{2}^{0}), m(\tilde{k}_{1}^{0})=0, m(\tilde{\ell}, \tilde{\nu})=0.5(m(\tilde{k}_{1}^{+})+m(\tilde{k}_{1}^{0}))$	1402,7029
2 7	$\hat{\ell}_1^{\pm}\hat{\chi}_2^{0} \rightarrow W \hat{\chi}_1^{0} Z \hat{\ell}_1^{0}$	2-3 e. µ	0-2 jets	Yes	20.3	ξ ¹ .ξ ⁶ 420 GeV		$m(\tilde{k}_1^n)=m(\tilde{k}_2^n), m(\tilde{k}_1^n)=0$, sleptons decoupled	1403.5294, 1402.7
0	5°°°, w°°, °°, °°,		0.2 b	Yes	20.3	£		$m(\tilde{\chi}_1^n)=m(\tilde{\chi}_2^0), m(\tilde{\chi}_1^0)=0$, sleptons decoupled	1501.07110
1	$\tilde{\chi}_{1}^{\pm} \tilde{\chi}_{2}^{0} \rightarrow W \tilde{\chi}_{1}^{0} h \tilde{\chi}_{1}^{0}, h \rightarrow b \bar{b} / W W / \tau \tau / \tilde{\chi}_{2}^{0} \tilde{\chi}_{3}^{0}, \tilde{\chi}_{2,3}^{0} \rightarrow \tilde{\ell}_{R} \ell$	4 e. µ	0	Yes	20.3				1405.5086
- 7	GGM (wino NLSP) weak prod.	$1 c. \mu + \gamma$	-	Yes	20.3	x ₂₃ 620 GeV ₩ 124-361 GeV		$m(\hat{x}_{2}^{n})=m(\hat{x}_{3}^{n}), m(\hat{x}_{1}^{n})=0, m(\hat{\ell}, \hat{\nu})=0.5(m(\hat{x}_{2}^{n})+m(\hat{x}_{1}^{n}))$ $c_{1}<1 mm$	1507.05493
			1 int				_		
	Direct $\hat{x}_1^* \hat{x}_1^-$ prod., long-lived \hat{x}_1^*	Disapp. trk	1 jet	Yes	20.3	<i>x</i> [™] 270 GeV		$m[\tilde{\chi}_{1}^{n}]$ - $m[\tilde{\chi}_{1}^{0}]$ ~160 MeV, $\tau(\tilde{\chi}_{1}^{n})$ =0.2 ns	1310.3675
100	Direct $\hat{x}_1 \hat{x}_1$ prod., long-lived \hat{x}_1	dE/dx trk	1. E late	Yes	18.4	<i>x</i> [*] ₁ 482 GeV		$m(\tilde{\chi}_{1}^{\pi})-m(\tilde{\chi}_{1}^{0})\sim 160$ MeV, $r(\tilde{\chi}_{1}^{\pi})<15$ ns	1506.05332
6	Stable, stopped g R-hadron	0	1-5 jets	Yes	27.9	ž 832 Ge		m(ξ ⁰ ₁)=100 GeV, 10 μs <r(ξ)<1000 s<="" td=""><td>1310.6584</td></r(ξ)<1000>	1310.6584
	Stable g R-hadron	trk		-	19.1	8	1.27 TeV		1411.6795
8	GMSB, stable $\tilde{\tau}, \tilde{\chi}_{1}^{0} \rightarrow \tilde{\tau}(\tilde{e}, \tilde{\mu}) + \tau(e)$		-	-	19.1	£" 537 GeV		10 <tanβ<50< td=""><td>1411.6795</td></tanβ<50<>	1411.6795
d (GMSB, $\tilde{\chi}_{1}^{0} \rightarrow \gamma \tilde{G}$, long-lived $\tilde{\chi}_{1}^{0}$	2γ		Yes	20.3	x [*] ₁ 435 GeV		2 <r(k<sup>0)<3 ns, SPS8 model</r(k<sup>	1409.5542
3	$\tilde{\chi}_{0}^{0} \rightarrow eev/e\mu v/\mu \mu v$	displ. ee/eµ/µ	μ -	-	20.3	<i>X</i> [*] ₁	1.0 TeV	7 <cr(ℓ<sub>1⁰)< 740 mm, m(ĝ)=1.3 TeV</cr(ℓ<sub>	1504.05162
0	$GGM \tilde{g}\tilde{g}, \tilde{\chi}^0_1 \rightarrow Z\tilde{G}$	displ. vtx + jet	s -	-	20.3	<i>x</i> ⁰ ₁	1.0 TeV	6 <cr(k<sup>0)< 480 mm, m(g)=1.1 TeV</cr(k<sup>	1504.05162
	\downarrow FV $pp \rightarrow \tilde{v}_{\tau} + X, \tilde{v}_{\tau} \rightarrow e\mu/e\tau/\mu\tau$	eµ,er,µr	-	-	20.3	Ŷ,	1.3	7 TeV 311=0.11, 3132/133/233=0.07	1503.04430
E	Bilinear RPV CMSSM	2 e, µ (SS)	0-3 b	Yes	20.3	4. <u>2</u>	1.35 TeV	$m(\tilde{q})=m(\tilde{g}), c\tau_{LSP} < 1 mm$	1404.2500
3	$\tilde{\chi}_{1}^{*}\tilde{\chi}_{1}^{-}, \tilde{\chi}_{1}^{*} \rightarrow W \tilde{\chi}_{1}^{0}, \tilde{\chi}_{1}^{0} \rightarrow ee \tilde{v}_{\mu}, e \mu \tilde{v}_{e}$	4 c. µ	-	Yes	20.3	χ [*] ₁ 750 GeV		$m(\hat{t}_{1}^{0})>0.2>m(\hat{t}_{1}^{*}), \lambda_{121}\neq 0$	1405.5086
	$\tilde{\chi}_{1}^{*}\tilde{\chi}_{1}^{-}, \tilde{\chi}_{1}^{*} \rightarrow W \tilde{\chi}_{1}^{0}, \tilde{\chi}_{1}^{0} \rightarrow \tau \tau \tilde{\nu}_{e}, e \tau \tilde{\nu}_{r}$	$3e, \mu + \tau$	-	Yes	20.3	ž ^k 450 GeV		m(k ⁰ ₁)>0.2>m(k ⁰ ₁), λ ₁₃₃ ≠0	1405.5086
A B	žĝ, ĝ→qqq	0	6-7 jets	-	20.3		GeV	BR(r)=BR(b)=BR(c)=0%	1502.05686
C 7	$\tilde{\xi}\tilde{g}, \tilde{g} \rightarrow q\tilde{\chi}_{1}^{0}, \tilde{\chi}_{1}^{0} \rightarrow qqq$	õ	6-7 jets	-	20.3	ž 870 C		m(x ⁰)=600 GeV	1502.05686
	$\tilde{\xi}_{k}^{c}, \tilde{g} \rightarrow \tilde{t}_{1}t, \tilde{t}_{1} \rightarrow bs$	2 e. µ (SS)	0.3 b	Yes	20.3	ž 850 G			1404.250
	$\tilde{l}_1 \tilde{l}_1, \tilde{l}_1 \rightarrow bs$		2 jets + 2 l		20.3	7, 100-308 GeV			ATLAS-CONF-201
	$\tilde{t}_1 \tilde{t}_1, \tilde{t}_1 \rightarrow b \ell$	2 e,µ	2 10 12 1		20.3		1.0 TeV	BR(i ₁ →be/µ)>20%	ATLAS-CONF-201
_	Scalar charm, $\tilde{c} \rightarrow c \tilde{\ell}_1^0$	0	2 c	Yes	20.3	2 490 GeV		m($\tilde{\chi}_{1}^{0}$)<200 GeV	1501.01325
her S	second contract of the	-					I		

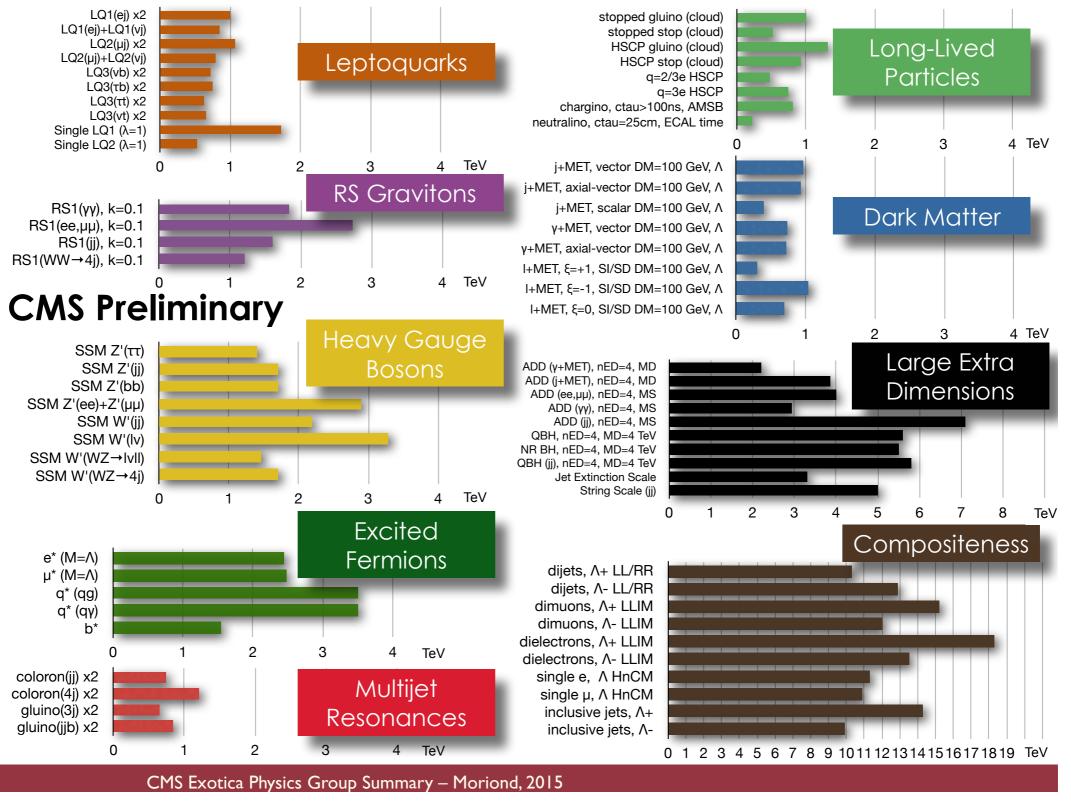
*Only a selection of the available mass limits on new states or phenomena is shown. All limits quoted are observed minus 1 σ theoretical signal cross section uncertainty.

ATLAS Preliminary

 $\sqrt{s} = 7, 8 \text{ TeV}$

Similar picture from CMS

LHC Non-SUSY Searches



10

Similar picture from ATLAS

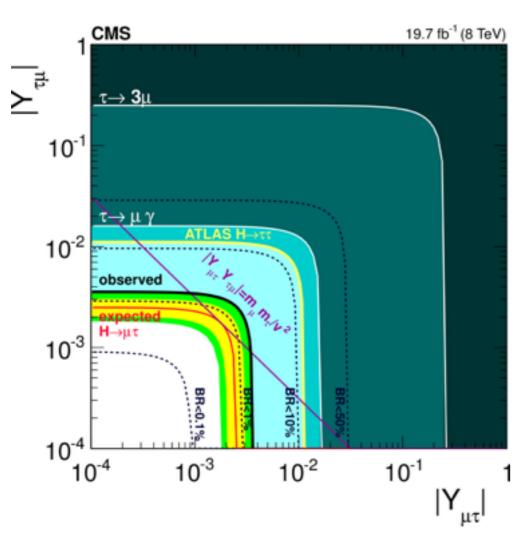
To watch out for ...

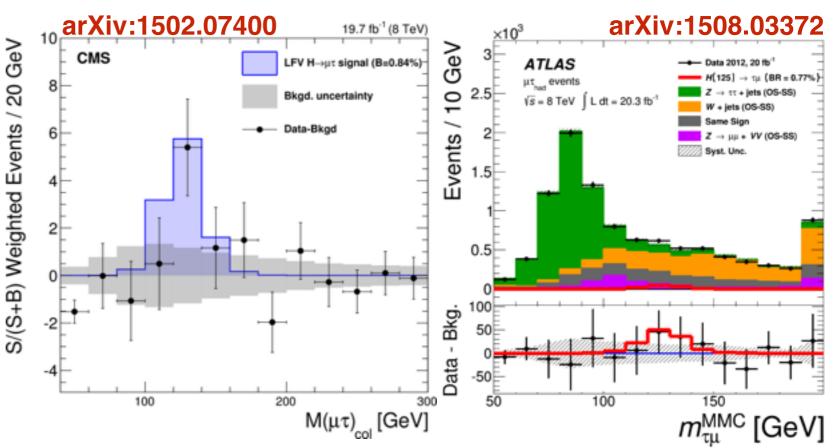
- We have a number of > 2σ deviations which might be first indication of new physics
- All have been vetted by the community and some generated considerable excitement
- Eyeballing the probability to have a few 3σ deviations is NOT small. No detailed statistical evaluation has been performed
- These excesses are interesting highlights of Run I. Run II will clear the clouds and confusion



To watch out for in Higgs ...

- Lepton-Flavor-Violating Higgs searches
- CMS reports an excess of 2.5σ
- ATLAS has less sensitivity and also a few more events than expected



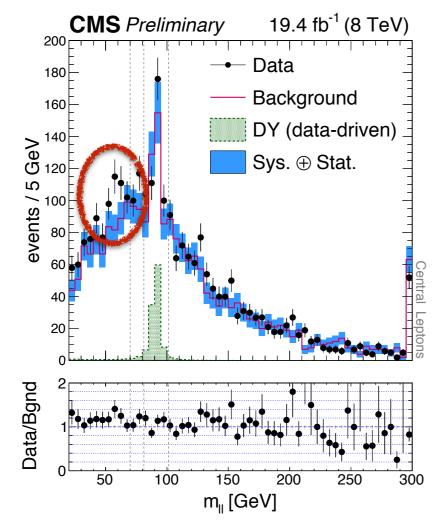


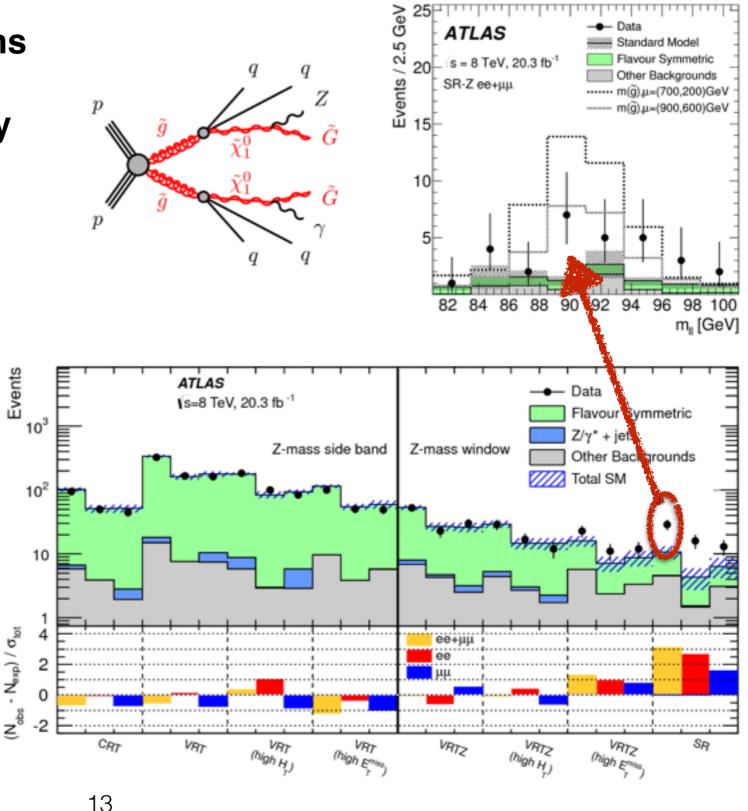
➡ CMS

 $\begin{array}{rcl} {\rm BR}(h \to \mu \tau) &< 1.85\%, ~95\% ~{\rm C.L.} \\ {\rm BR}(h \to \mu \tau) &= ~(0.77 \pm 0.62)\% \end{array}$

To watch out for in SUSY ...

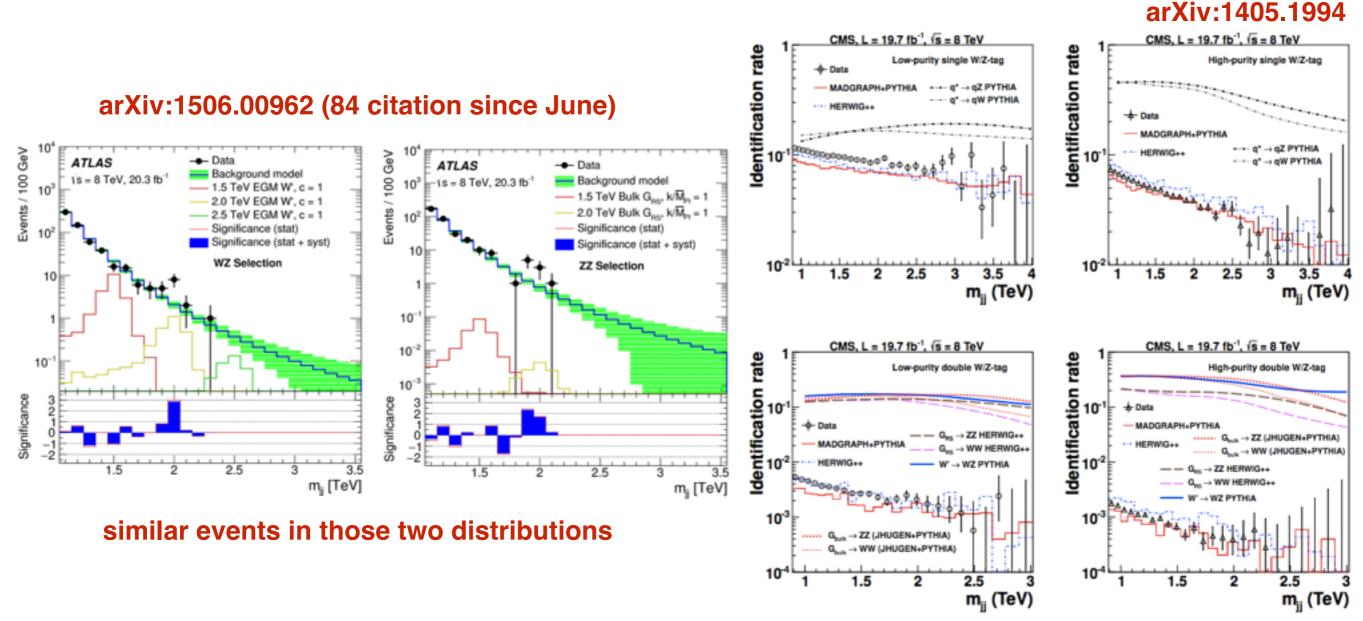
- Search for SUSY in events with jets, missing ET, and two leptons
- CMS saw a ~2.5σ excess for a lower mass non-resonant decay
- ATLAS saw a ~3σ excess when leptons came from a Z boson
- Neither confirmed by the other experiment





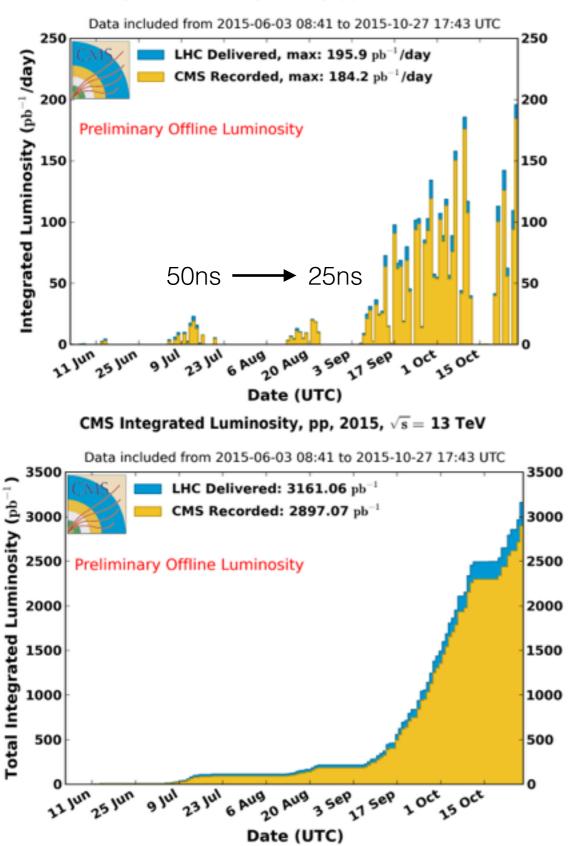
To watch out for in Exotics ...

- Another ATLAS and CMS excess; ATLAS at 2.5σ
- Constistent(ish) with 2 TeV W'-like particle
- Using boosted jets and hadronic W and Z boson tagging

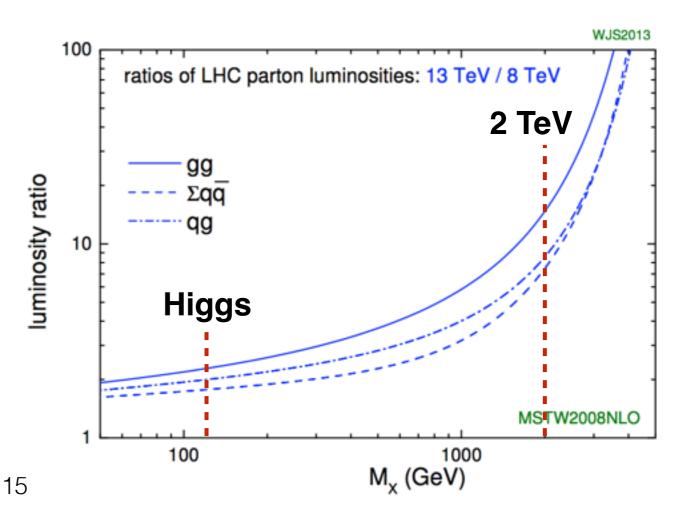


Commissioning Year 2015

CMS Integrated Luminosity Per Day, pp, 2015, $\sqrt{s}=$ 13 TeV

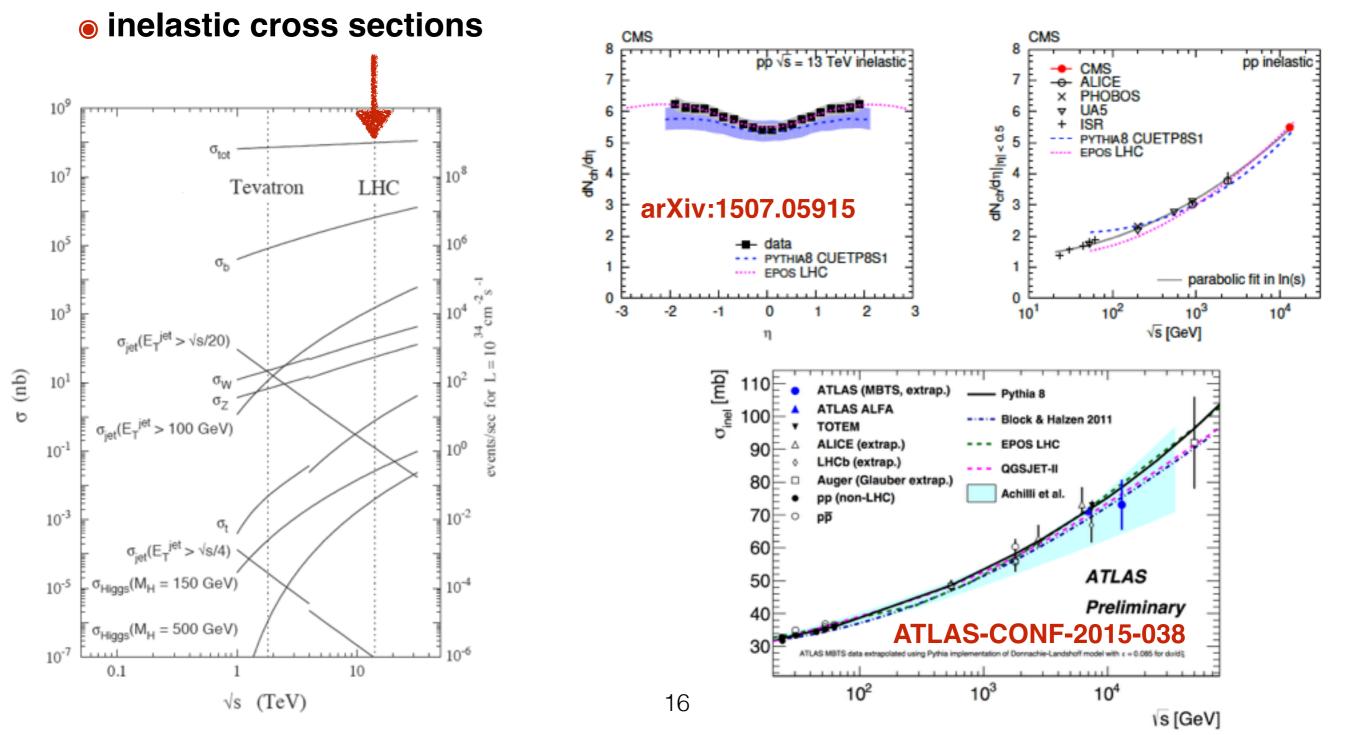


	peak lumi E34 cm ⁻² s ⁻¹	day of proton physics	approx. int lumi [fb ⁻¹]		
2015	~0.5	65	3		
2016	1.2	160	30		
2017	1.5	160	36		
2018	1.5	160	36		



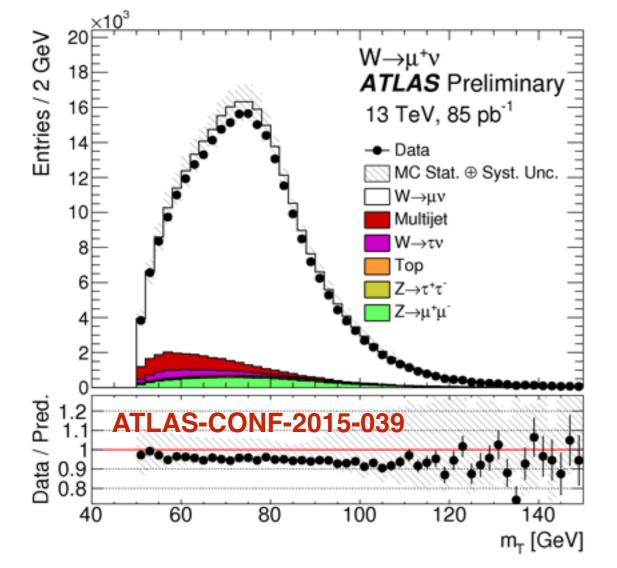
First 13 TeV Results

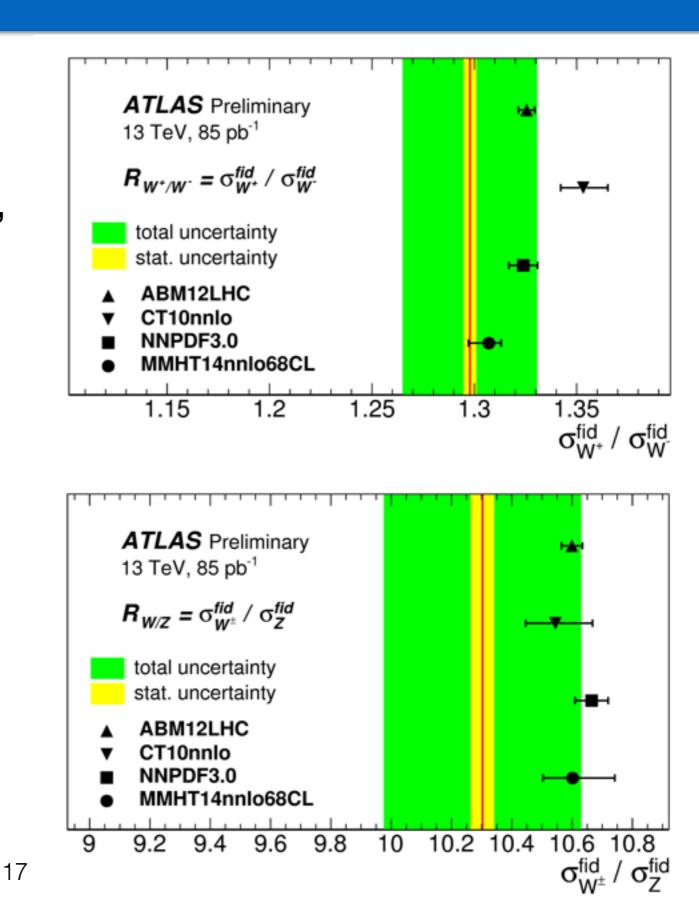
- Measurements of event properties and production rates
 The first of the first ...
 - operation of charge hadrons



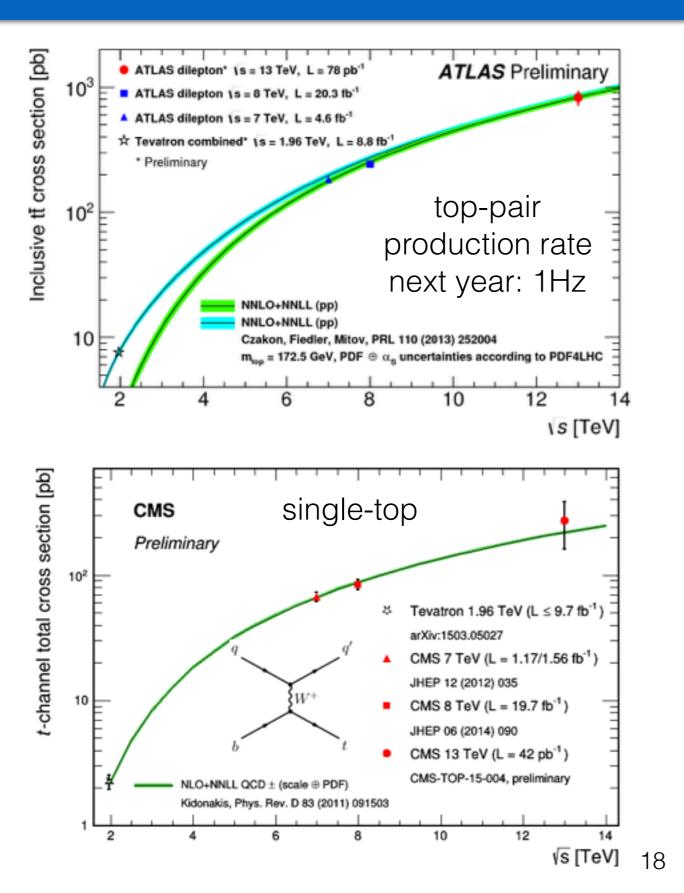
First 13 TeV Results: W and Z bosons

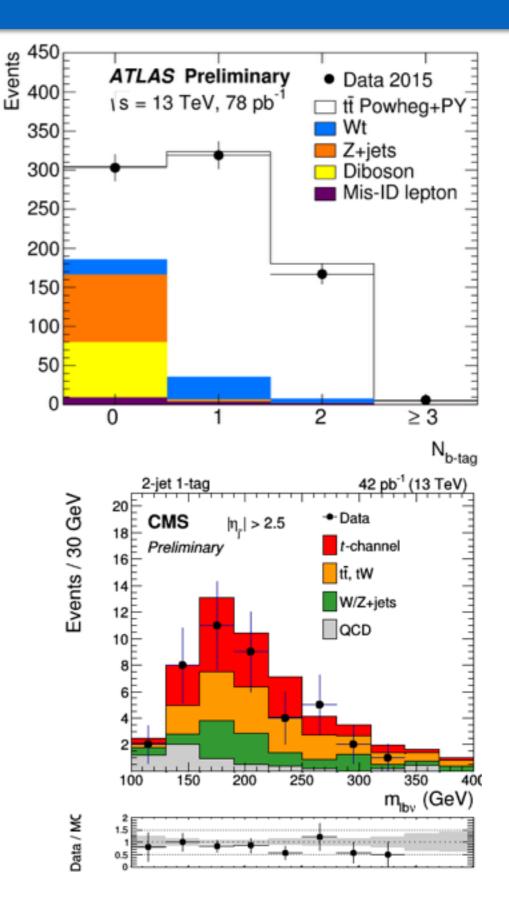
- Precision tests of QCD
- Constraints on proton structure
- Commissioning electrons, muons, and missing transverse energy
- Luminosity calibration not final





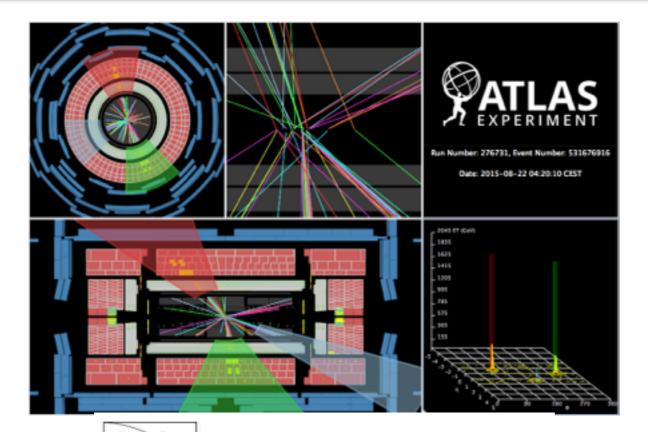
First 13 TeV Results: Top



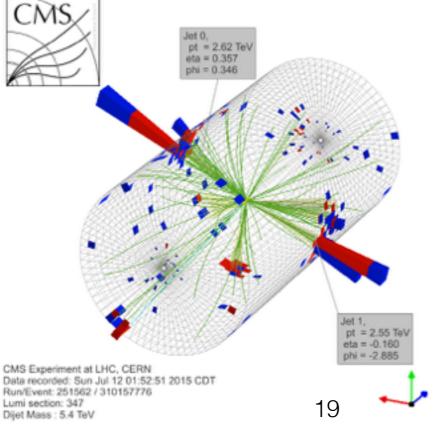


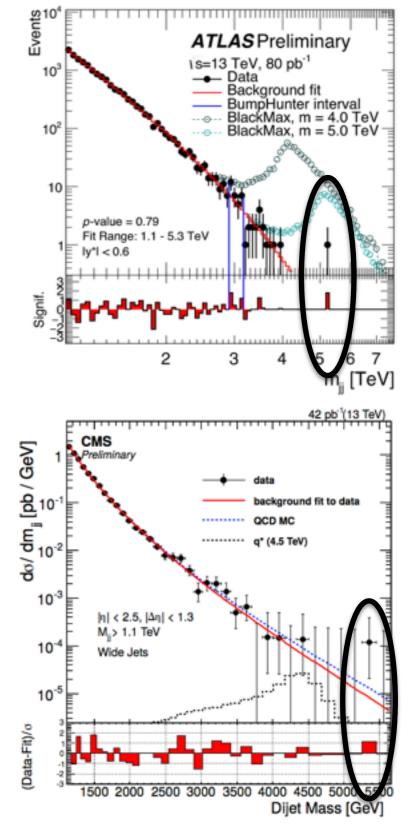
First 13 TeV Results: Jet Resonances

M=5.2 TeV

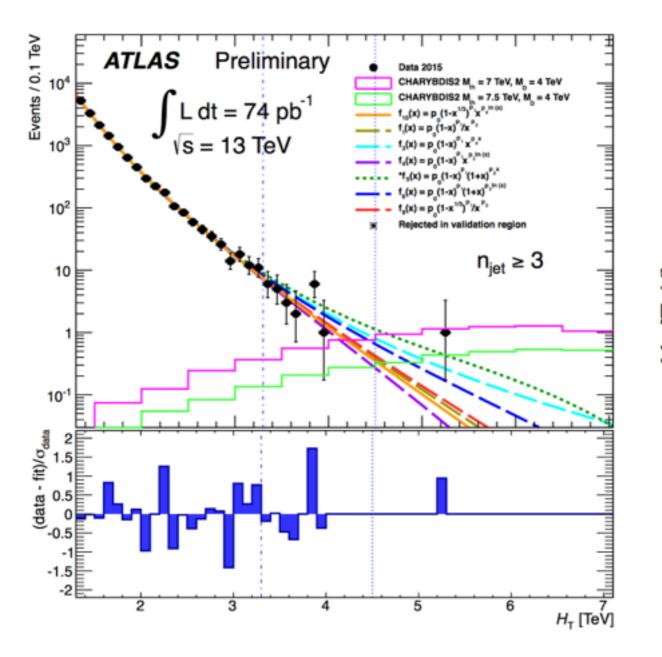




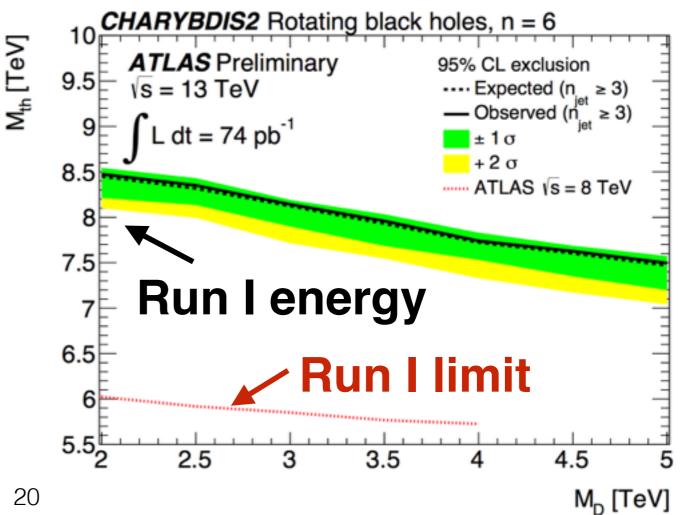




First 13 TeV Results: Jet Resonances



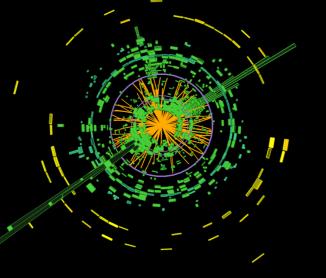
- Searches for black holes
- HT is sum of transverse momenta of all jets
- Superseded Run I results early in Run II



First 13 TeV Results: Jet Resonances

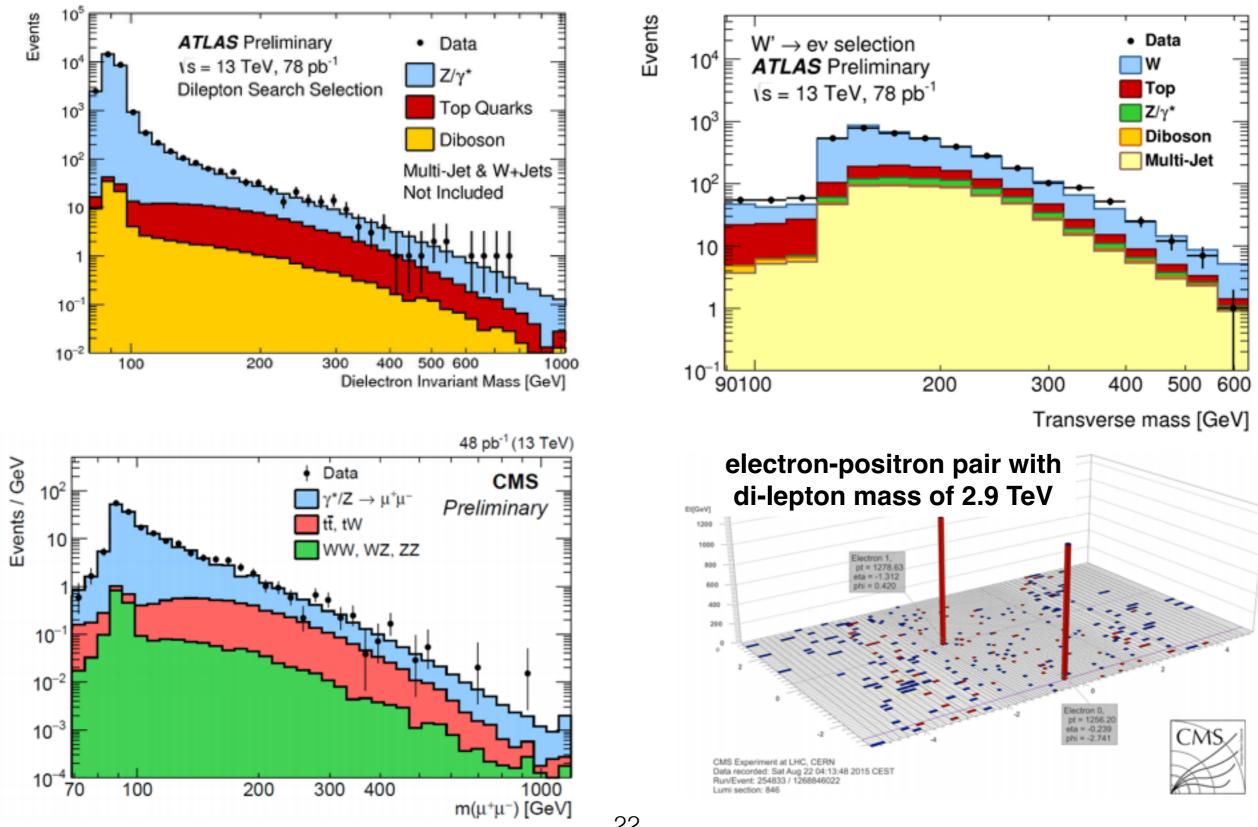


Run: 279685 Event: 690925592 2015-09-18 02:47:06 CEST



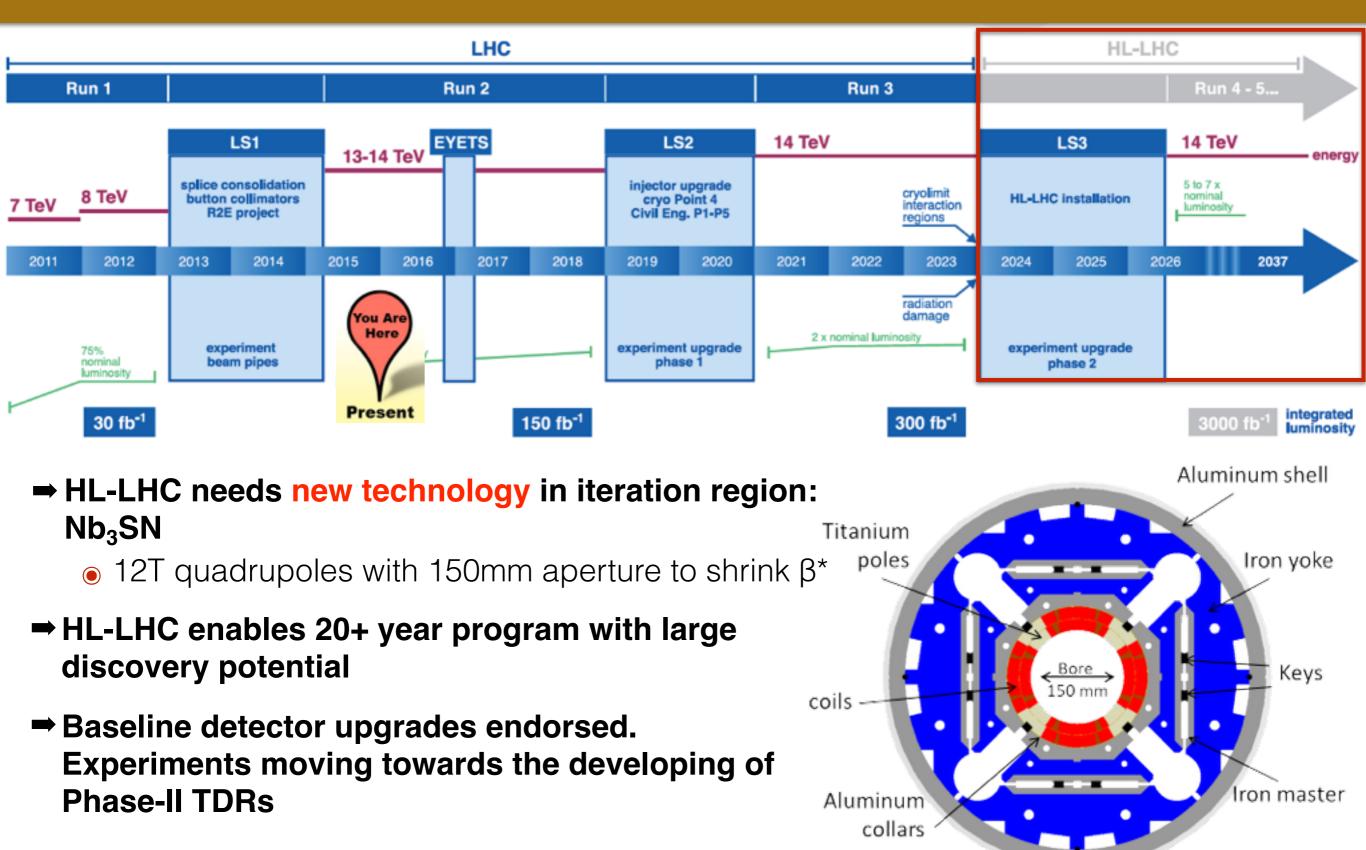
8.8 TeV invariant mass!

First 13 TeV Results: W' and Z' searches



22

Exploiting the LHC Physics with the HL-LHC

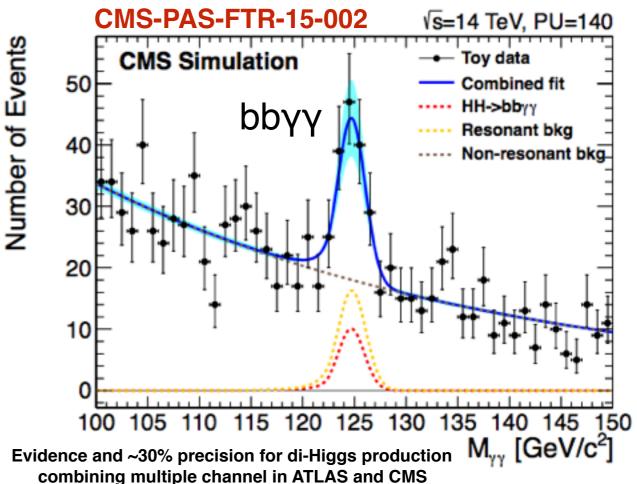


Exploiting the LHC Physics with the HL-LHC

	Δκγ	Δκω	ΔκΖ	Δĸg	Δκ _b	Δĸt	Δκτ	Δκμ
Run I Combination	12	10	10	15	25	29	15	
CMS projection 300fb ⁻¹ , 14 TeV	5	4	4	6	10	14 (9)	6	23
CMS projection 3000fb ⁻¹ , 14 TeV	2	2	2	3	4	7 (4)	2	8 (5)

24

- Precision measurements of SM parameters, including the Higgs boson, and potentially of BSM parameter
- Sensitivity to rare SM & BSM processes
- Extension of discovery reach in high-mass region



Conclusion

➡ Fantastic results - in quality and quantity - from LHC Run I

Exploration of Higgs Physics at the LHC on its way

- New information on Higgs physics expected in 2016
- HL-LHC will set a high bar for Higgs physics

➡ Non-Higgs Run I searches yield null results

- Stringent limits on new physics
- And a handful of intriguing channels to look out for

➡ First 13 TeV (Run II) results on limited dataset available

- Understanding often already comparable to Run I
- First measurements completed, many searches under way
- Sensitivity of Run I and II comparable for $m_X = \sim 2 \text{ TeV}$

➡ HL-LHC enables a 20+ year research project with large discovery potential