

Department of Physics

TRISEP 2024

DANIEL STOLARSKI

July 16-18, 2024

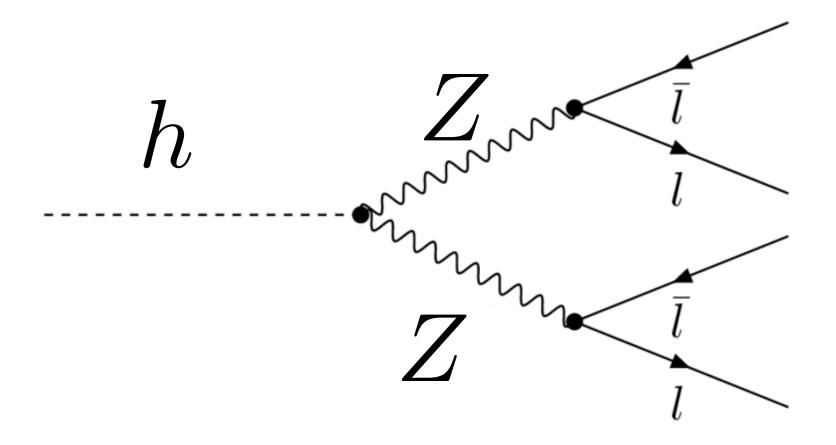




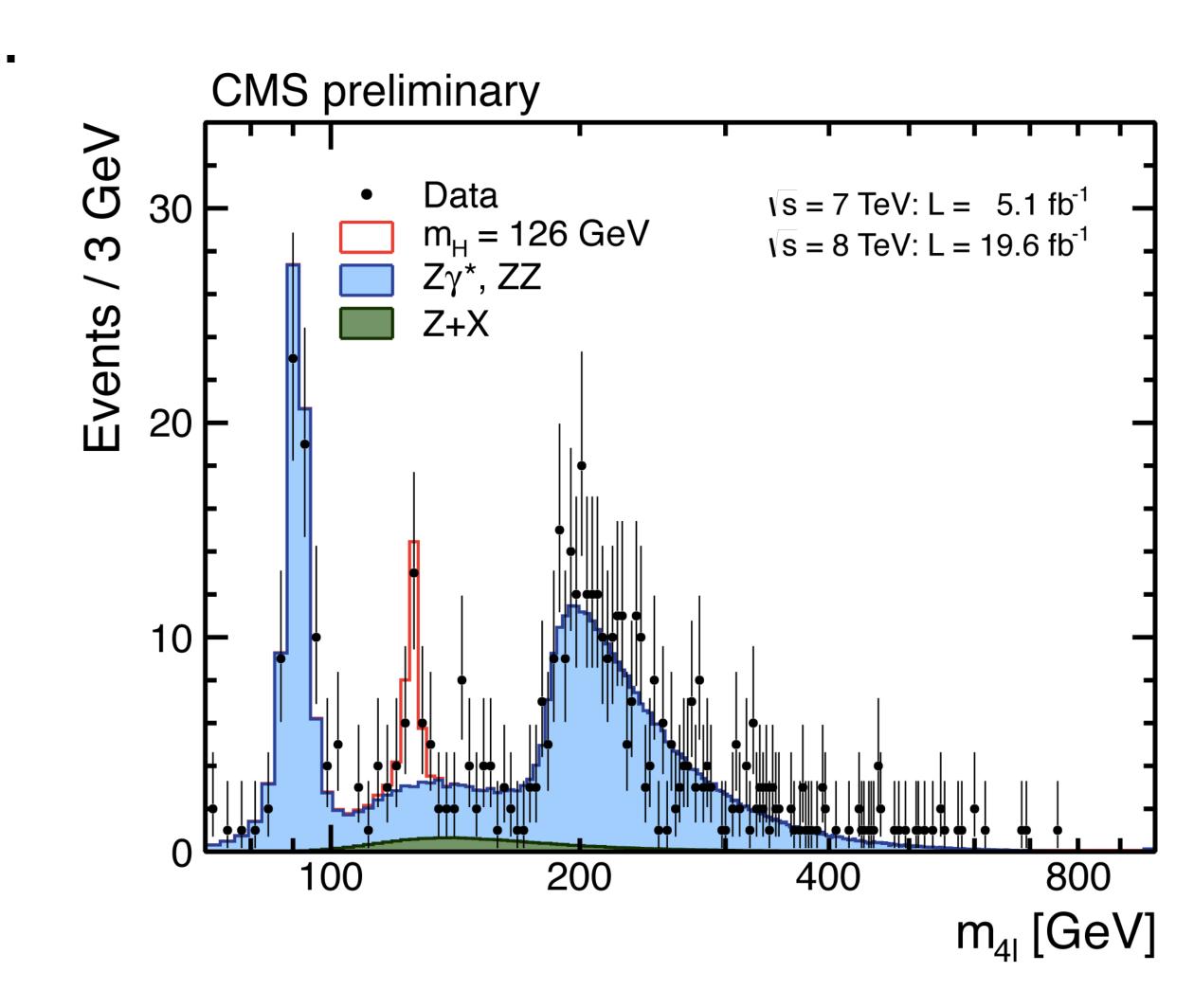
THE HGGS

SPIN MEASUREMENT

Golden channel decay to 4 leptons.

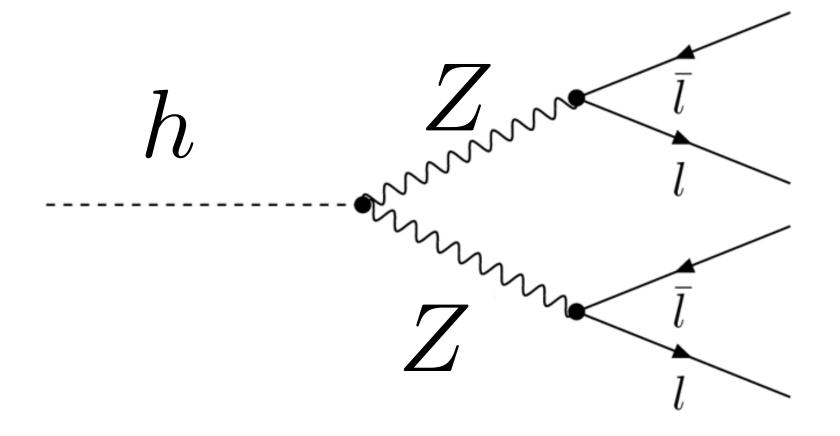


- Very low background
- Fully reconstructable final state



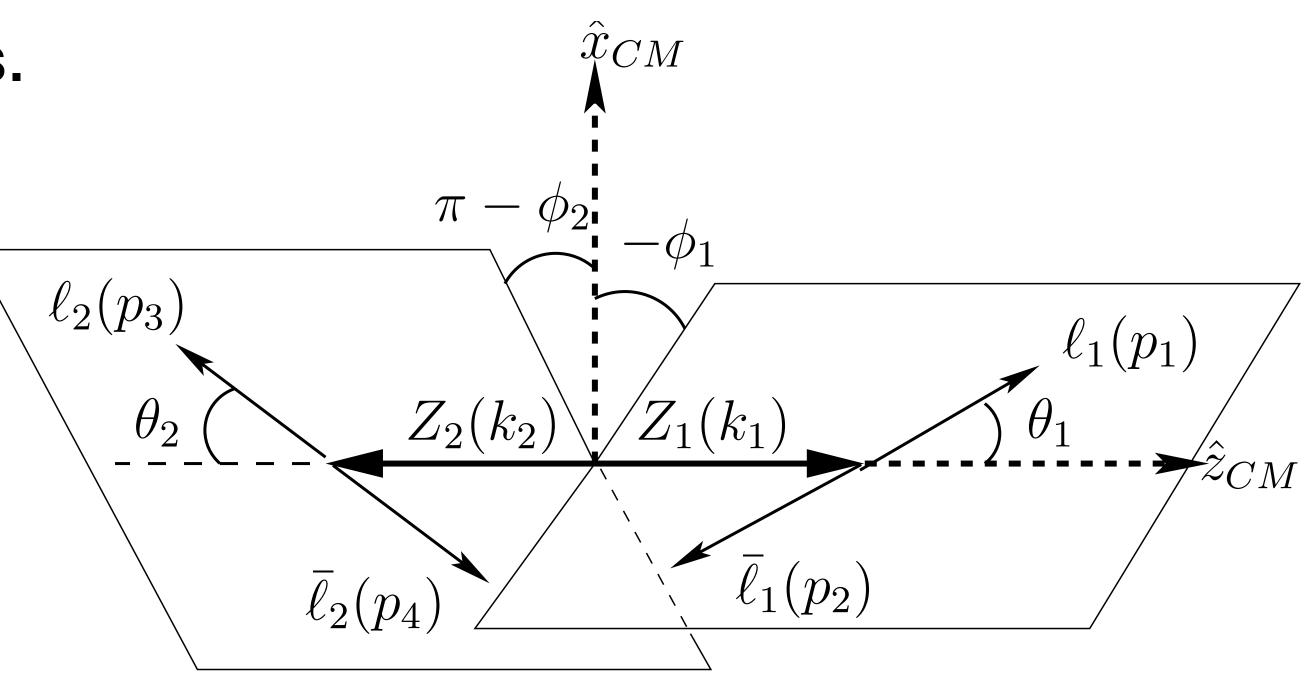
SPIN AND PARITY MEASUREMENT

Golden channel decay to 4 leptons.

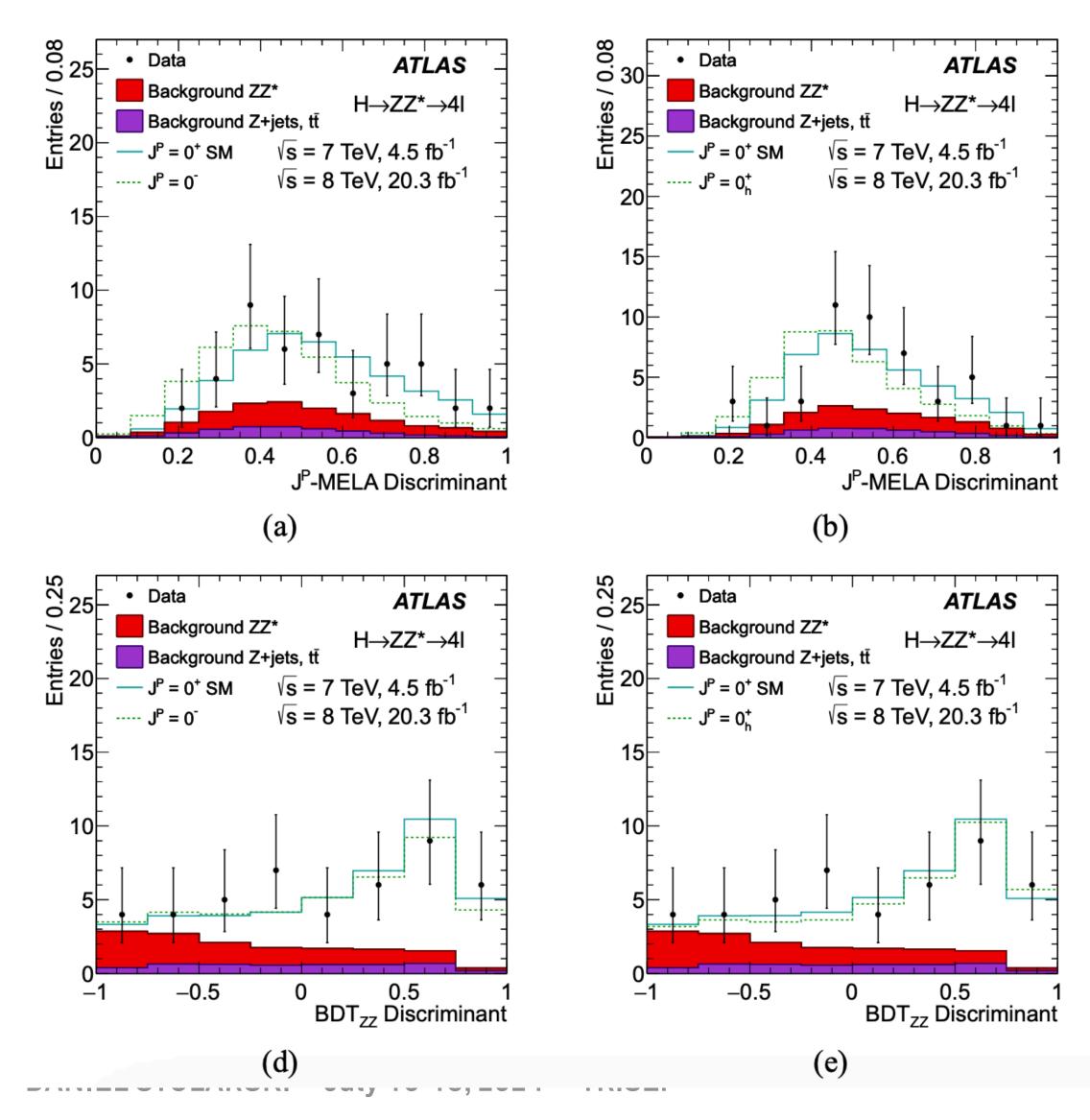


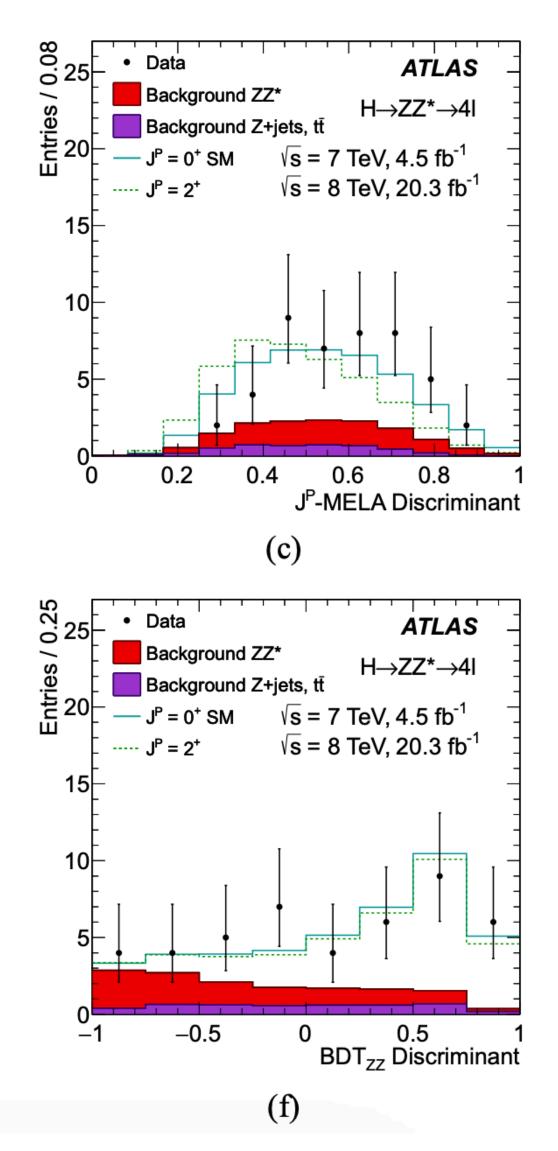
Each event described by 5 variables in Higgs rest frame.

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SPIN AND PARITY MEASUREMENT



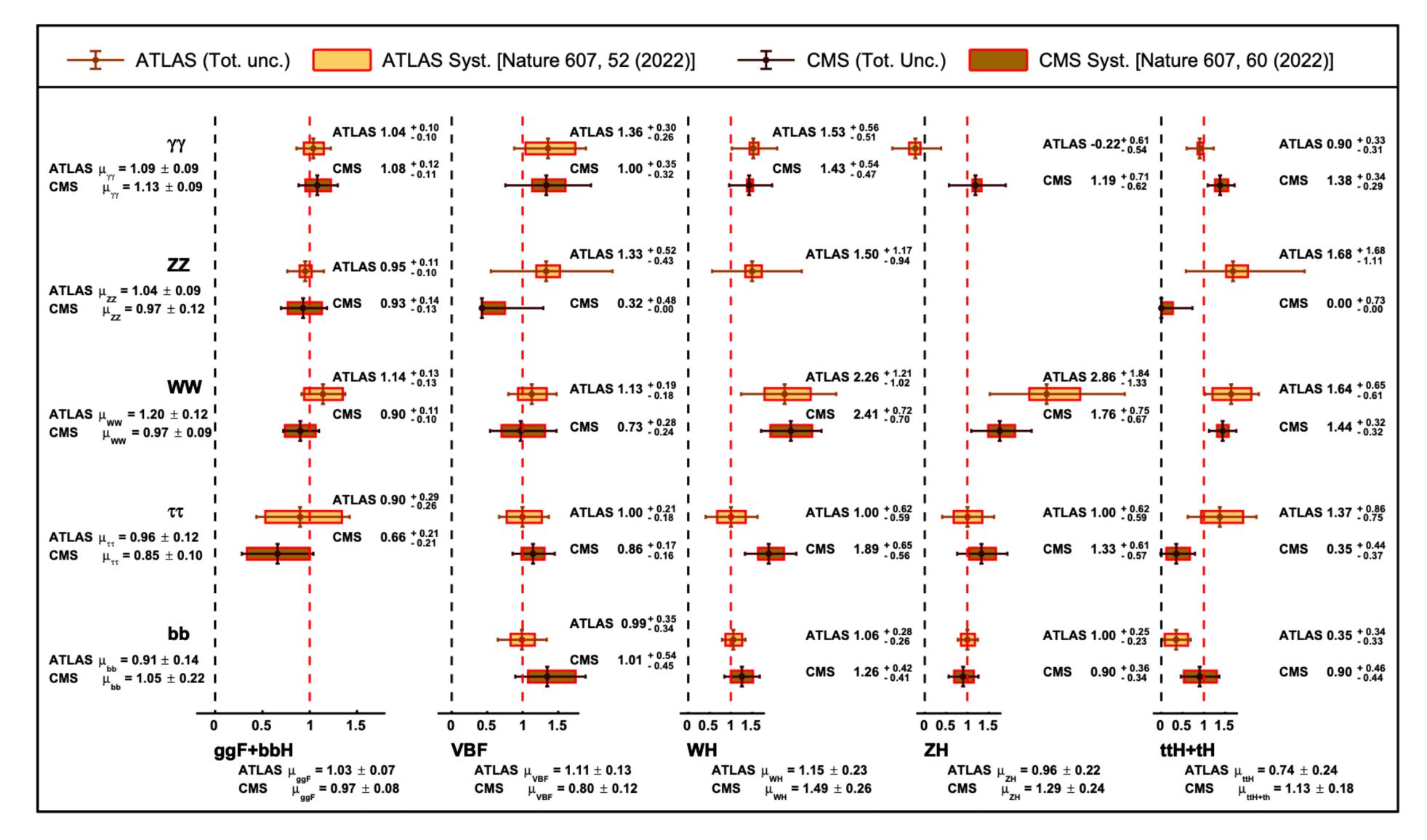


$J^P = 0^+$ is consistent with all data.

Agrees with SM prediction.

ATLAS, arXiv:1506.05669.

HIGGS RATE MEASUREMENTS



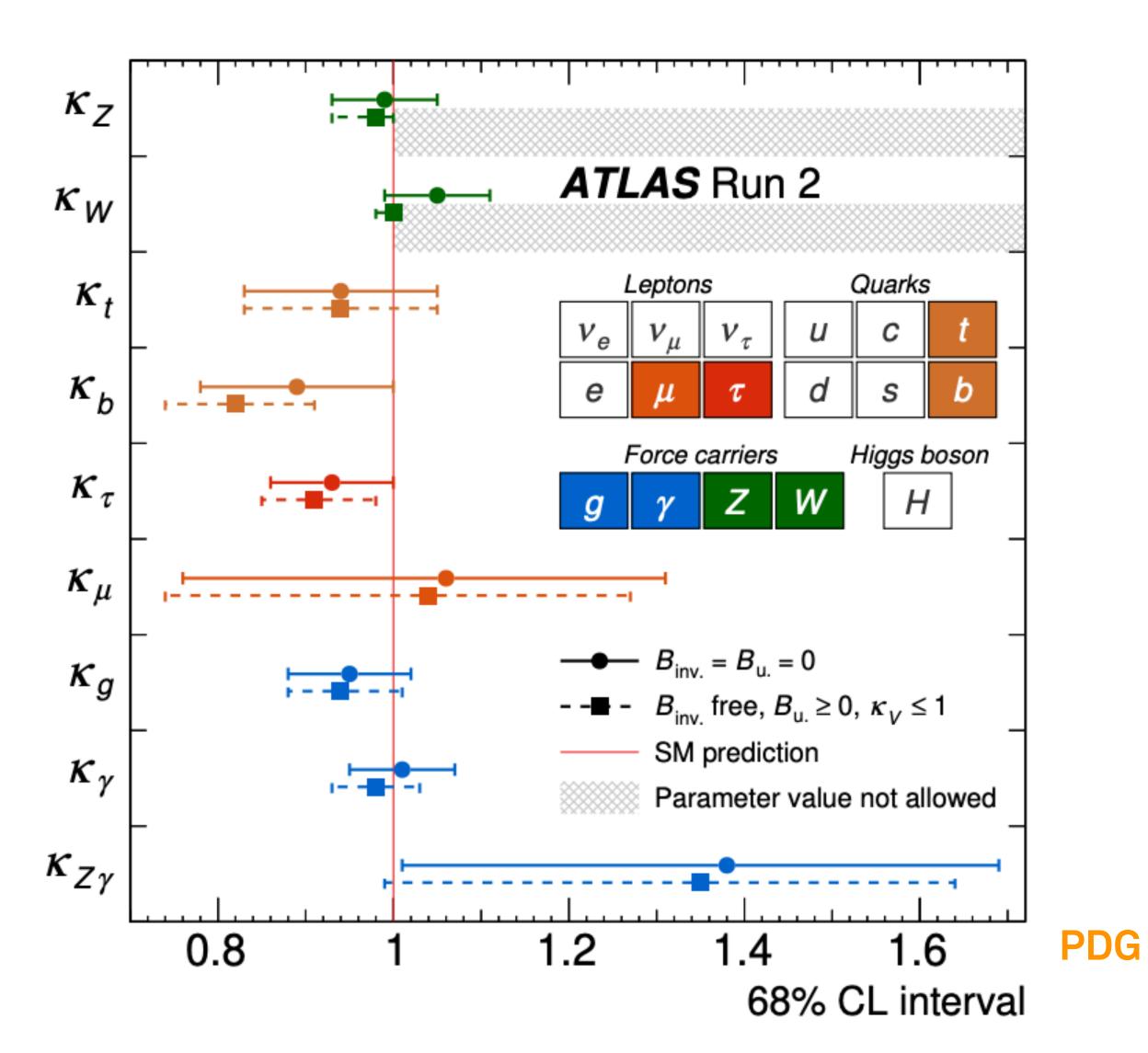
6 DANIEL S

PDG

Convert rate measurement to coupling measurement.

Again normalize to SM ($\kappa_{SM} = 1$).

Precision ranges from 10 to 30%.



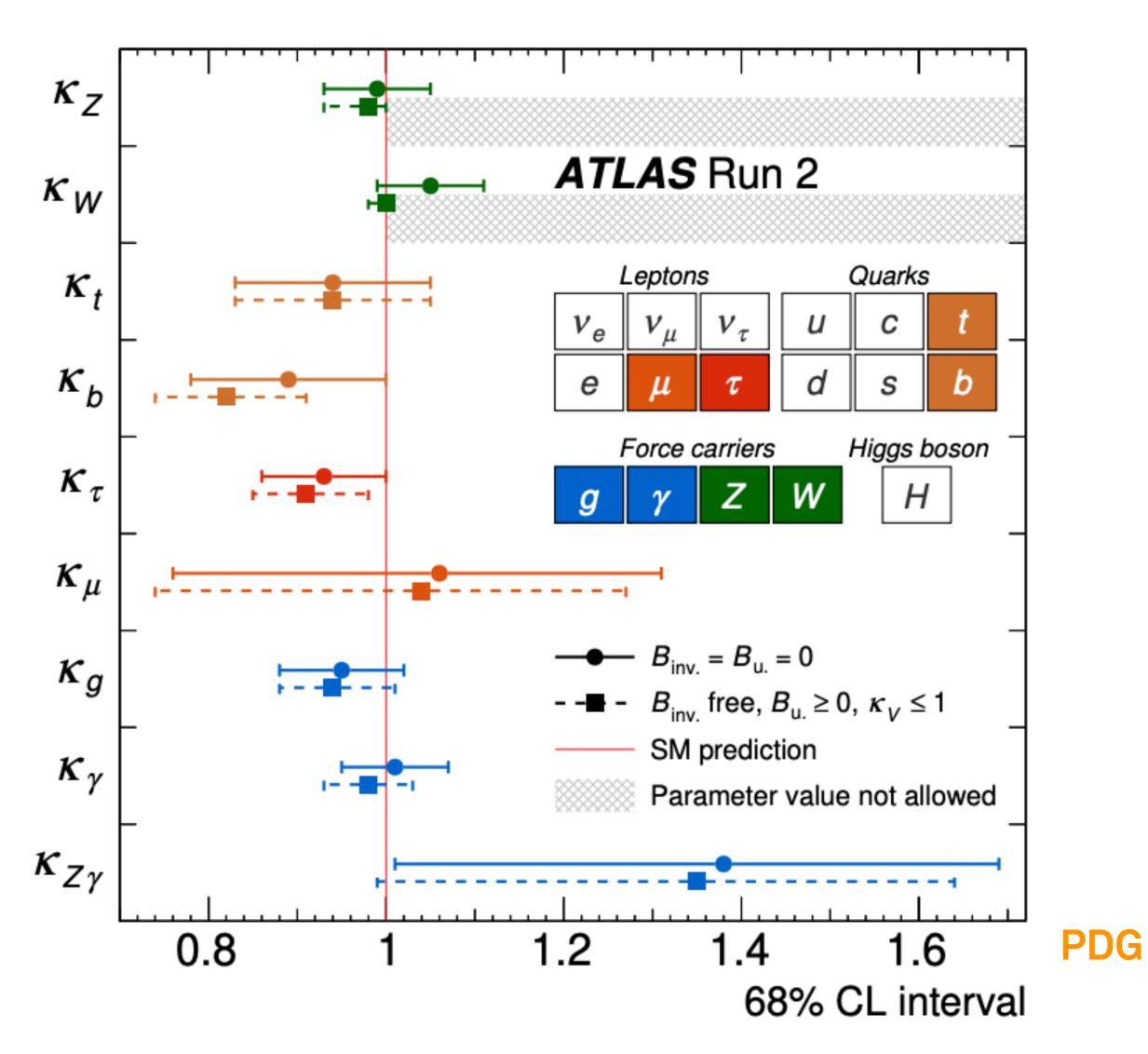


Convert rate measurement to coupling measurement.

Again normalize to SM ($\kappa_{SM} = 1$).

Precision ranges from 10 to 30%.

Except Higgs self-coupling $(ATLAS) - 0.6 < \kappa_{\lambda} < 6.6 \text{ (observed)}$ (CMS) $-1.2 < \kappa_{\lambda} < 6.5$ (observed),

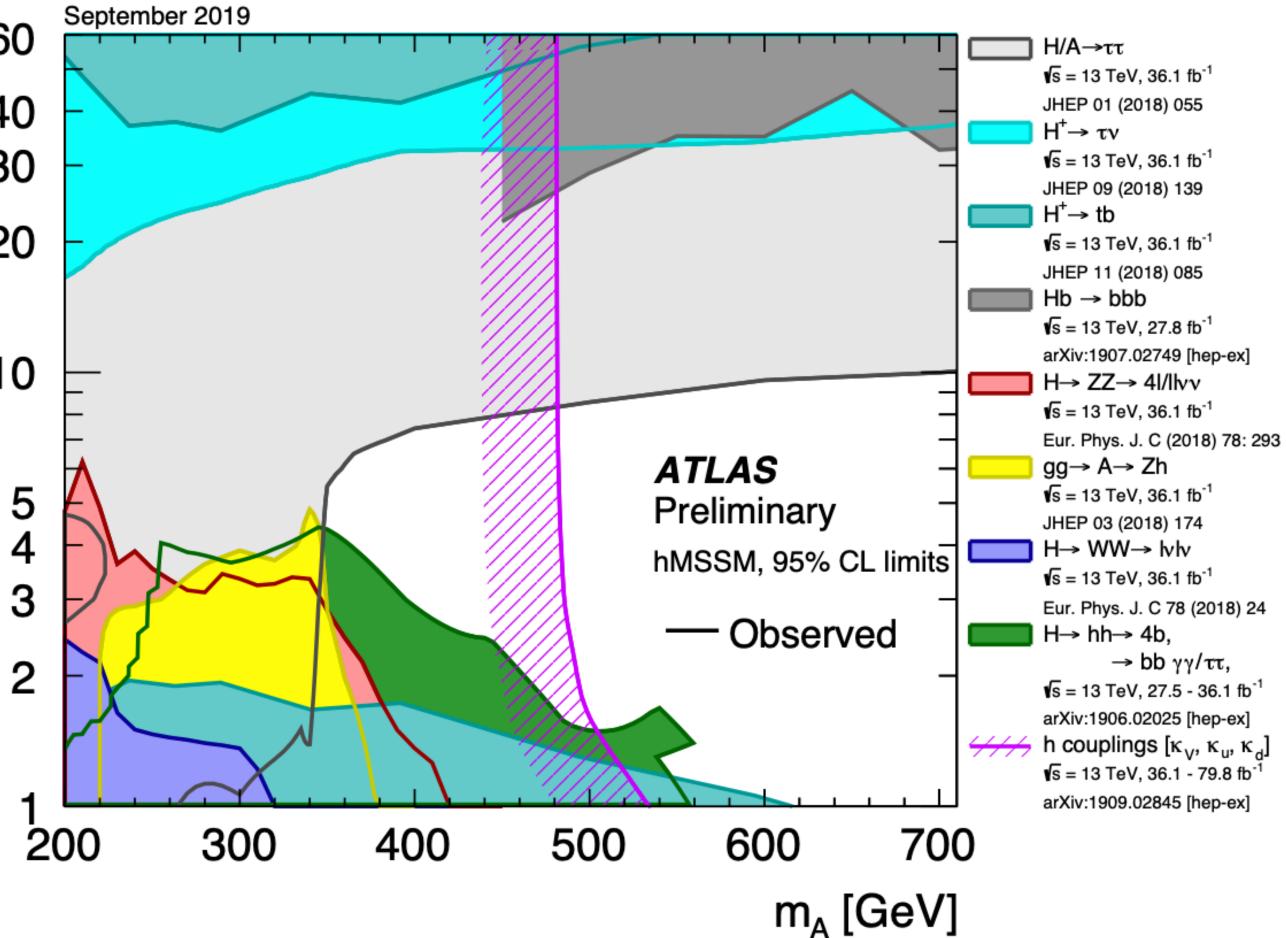




SM has one Higgs because it is minimal.	tan β	60 40 30			
Can have additional Higgs					
ates.		10			
New Higgses can be charged		5 4			

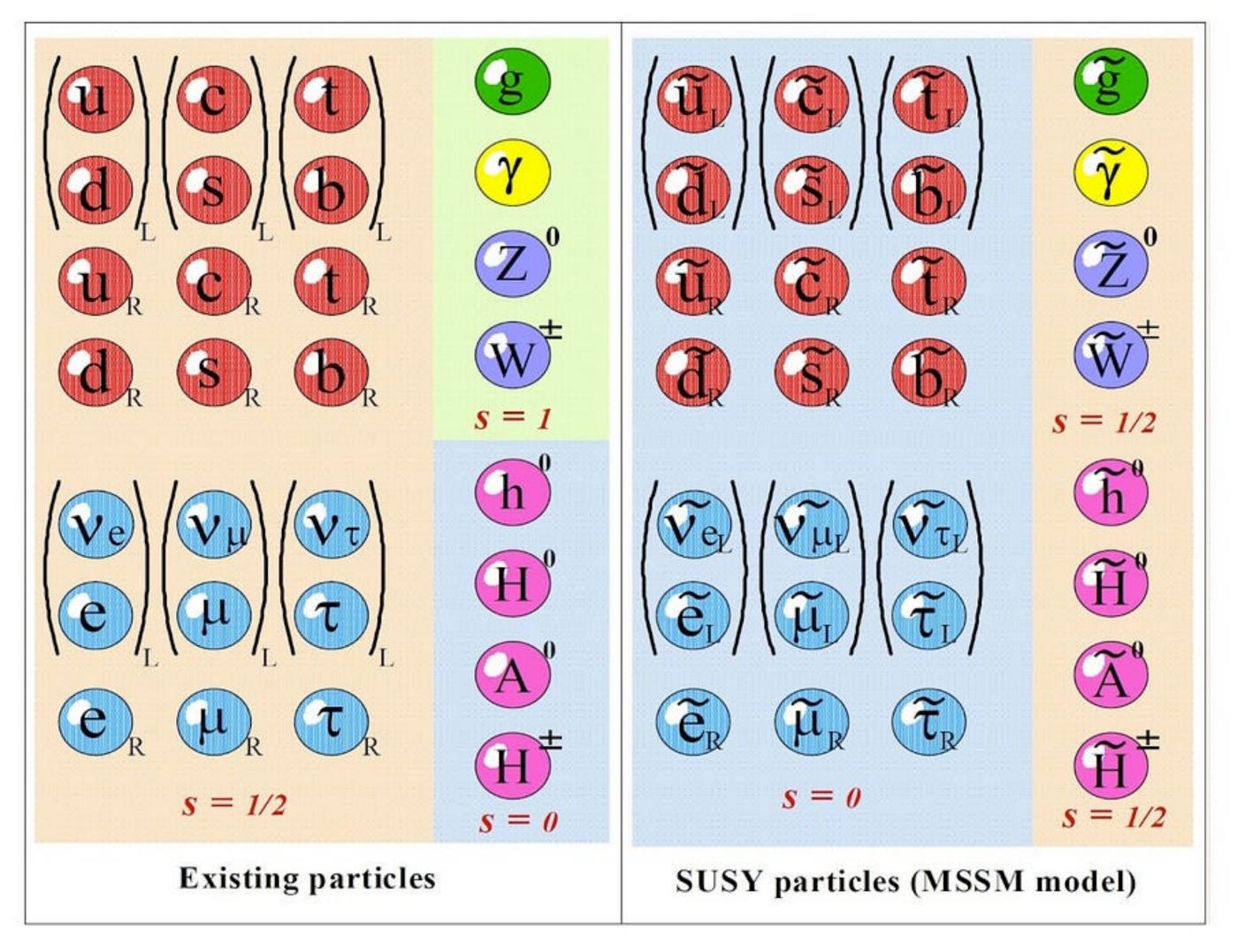
(and doubly charged!).

OTHER HIGGSES



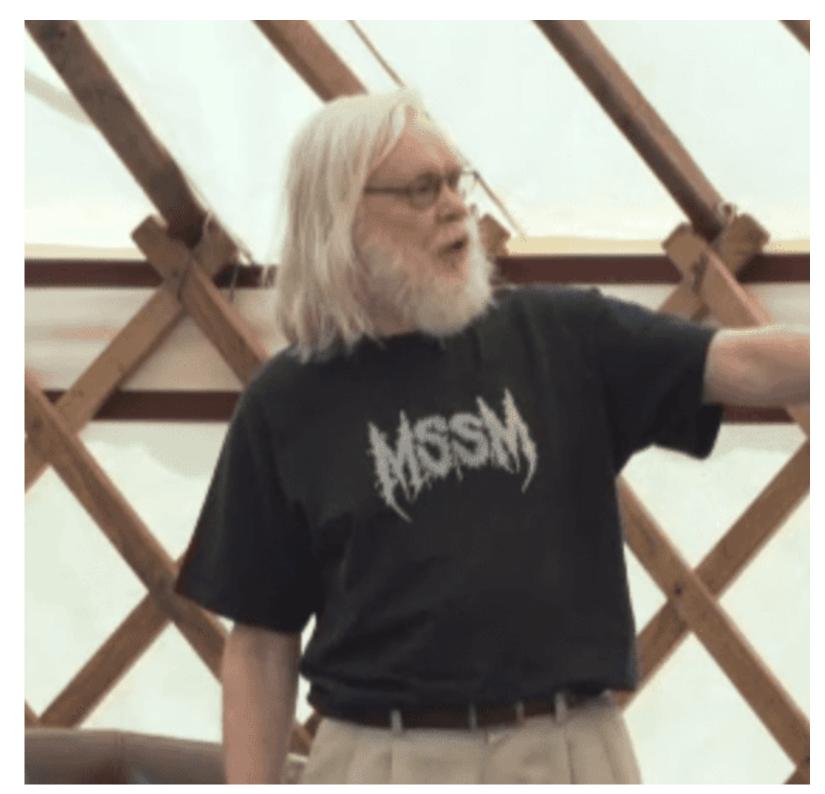
SUPERSYMMETRY





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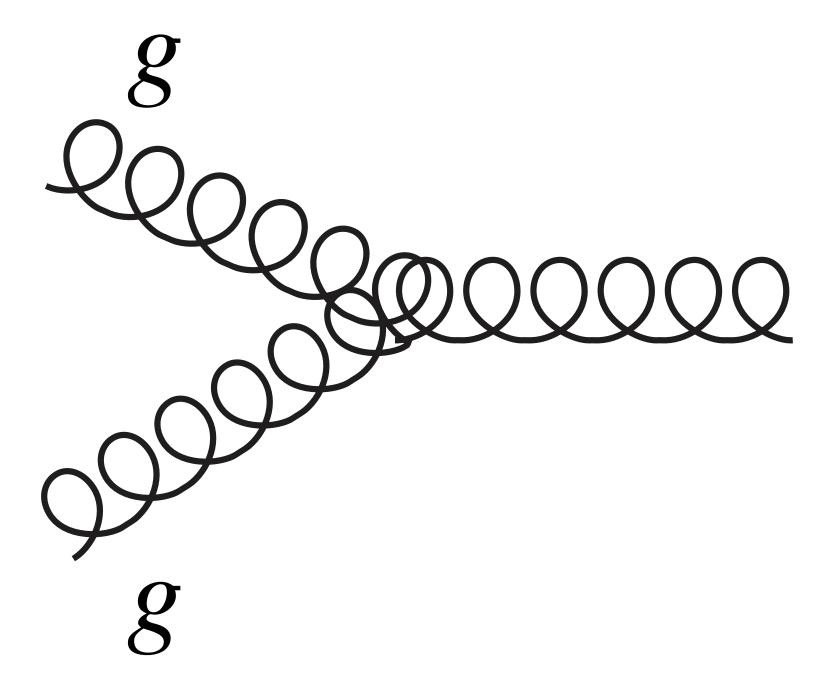
MSSM



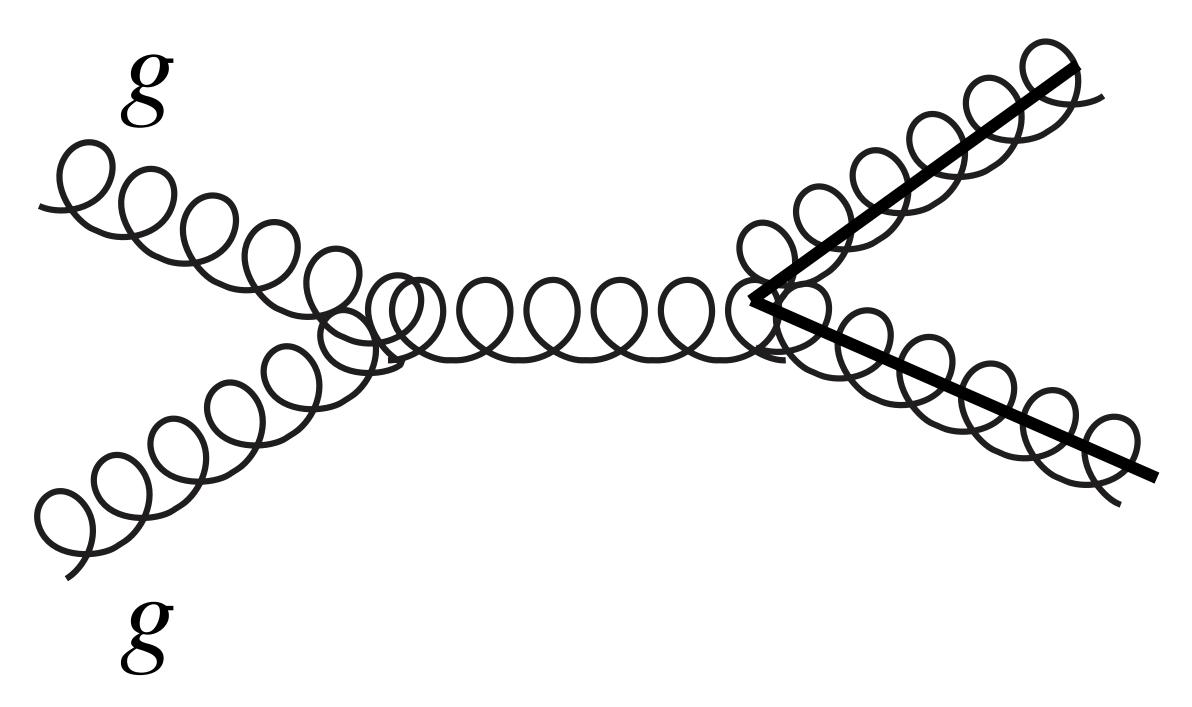
MSSMSIMPLE CATONS

Large number of parameters. Simplifying assumptions:

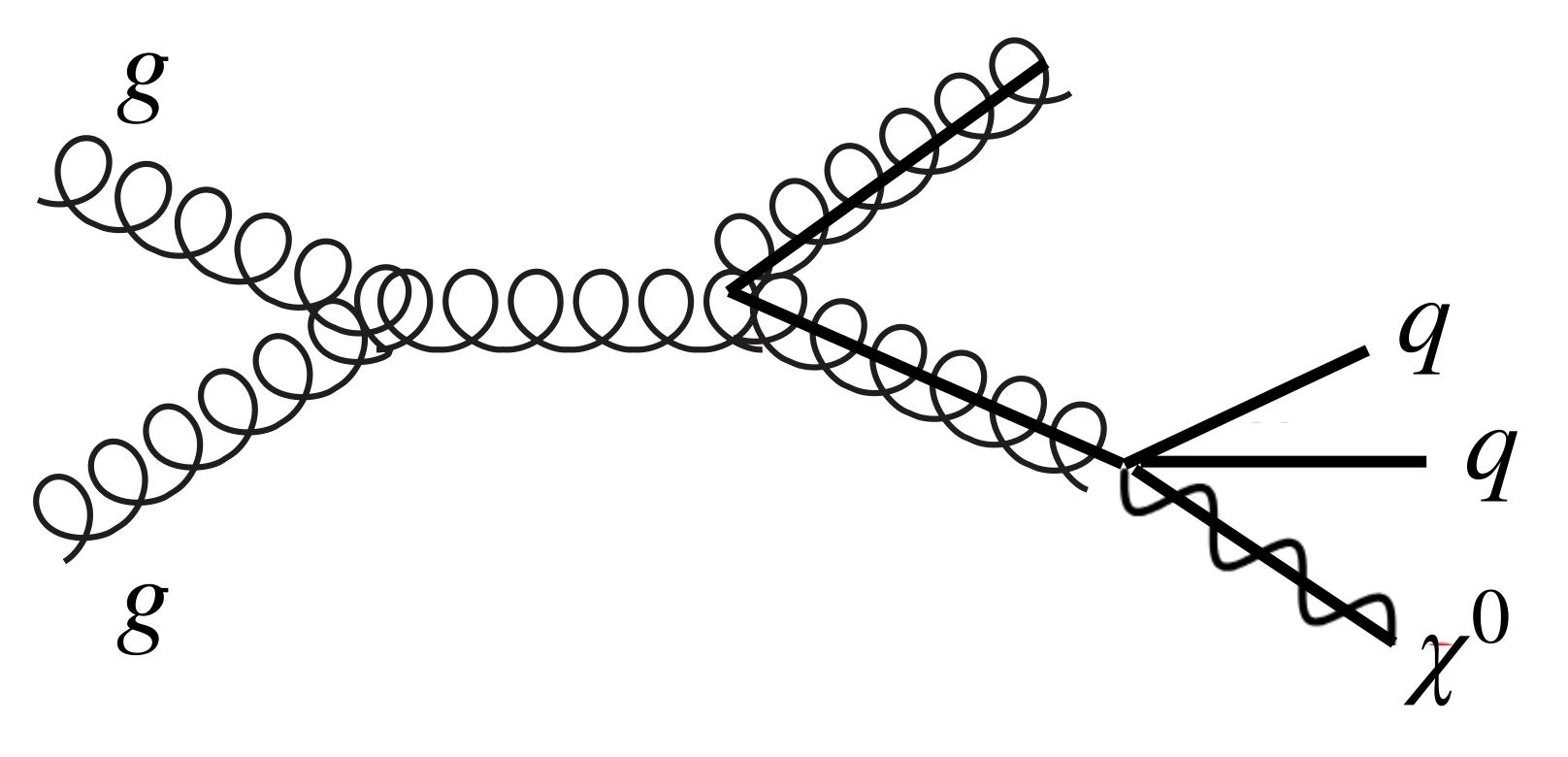
- R-parity conservation (save the proton)
- Neutralino LSP (WIMP miracle)



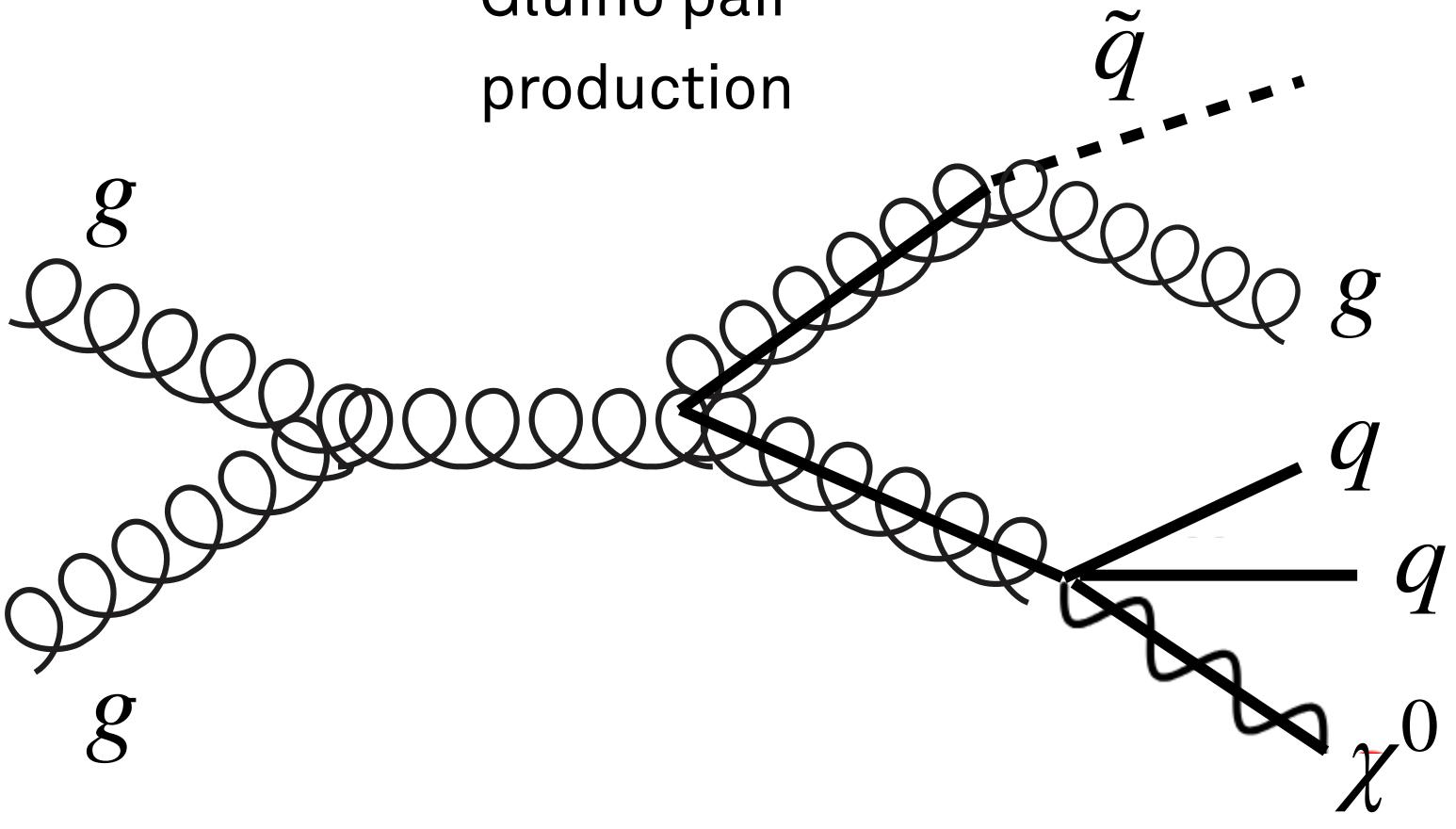
Gluino pair production



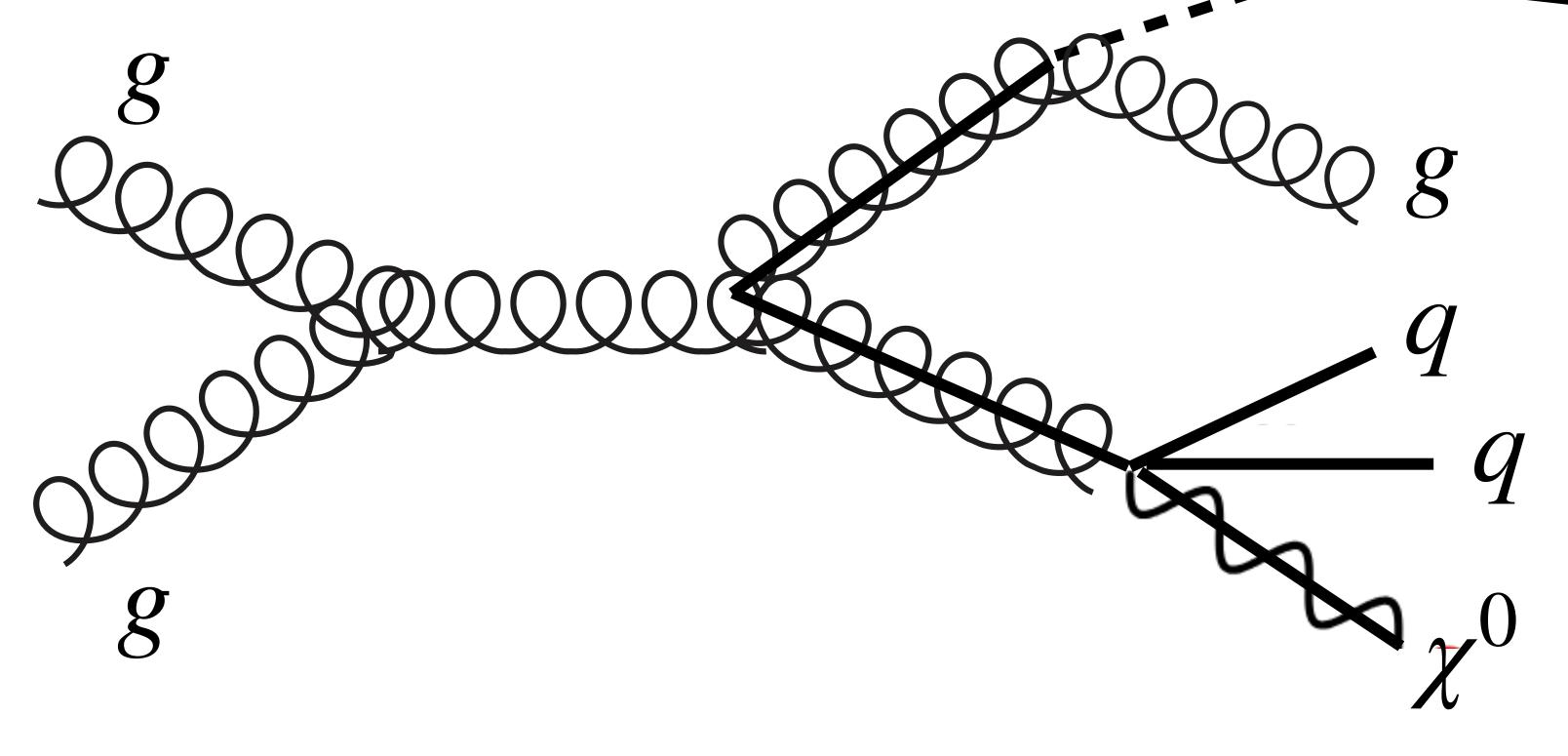
Gluino pair production



Gluino pair



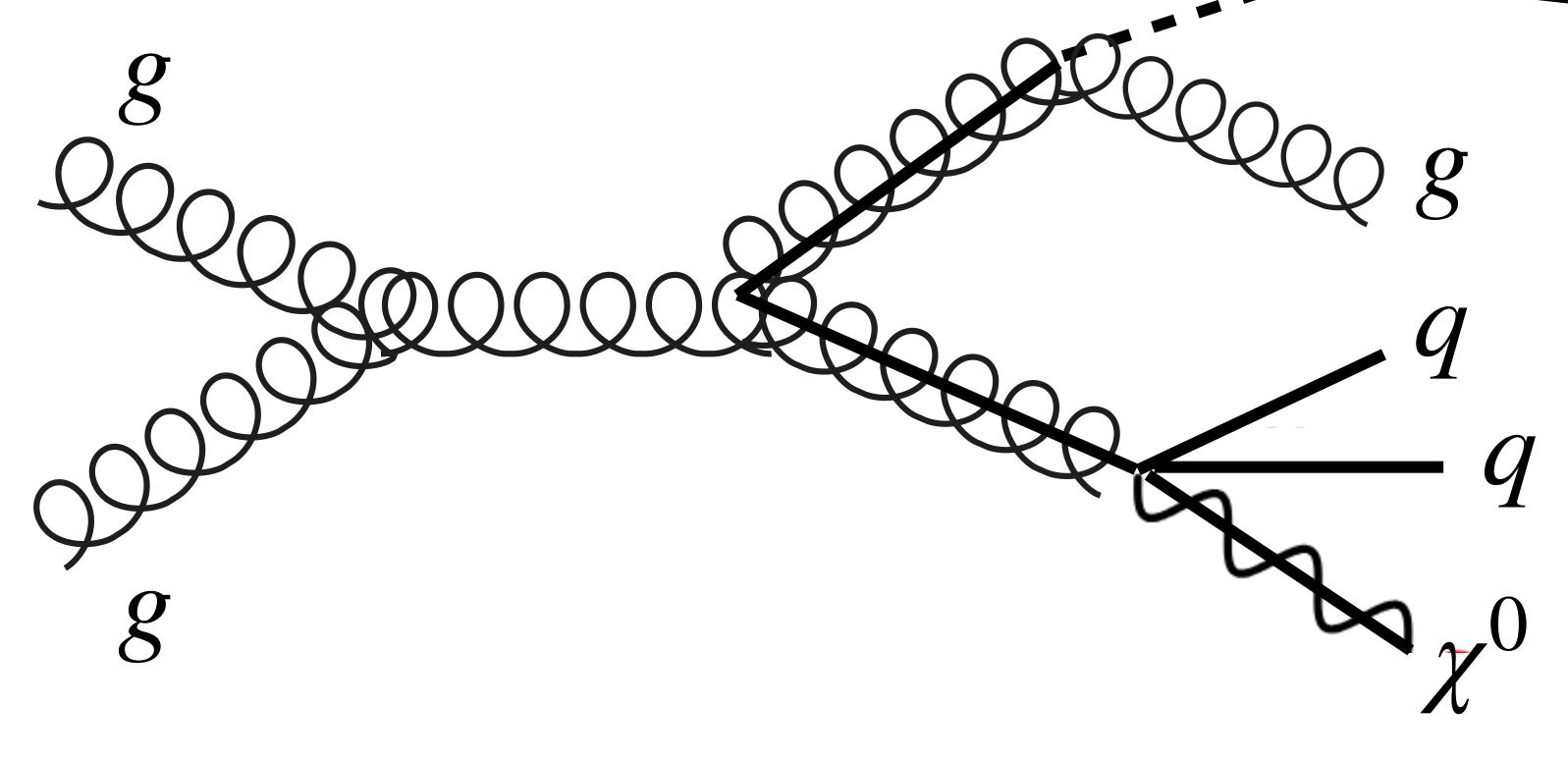
Gluino pair production



SEARCH FOR MSSM

v⁰

Gluino pair production



SEARCH FOR MSSM

Final state:

• 4 jets

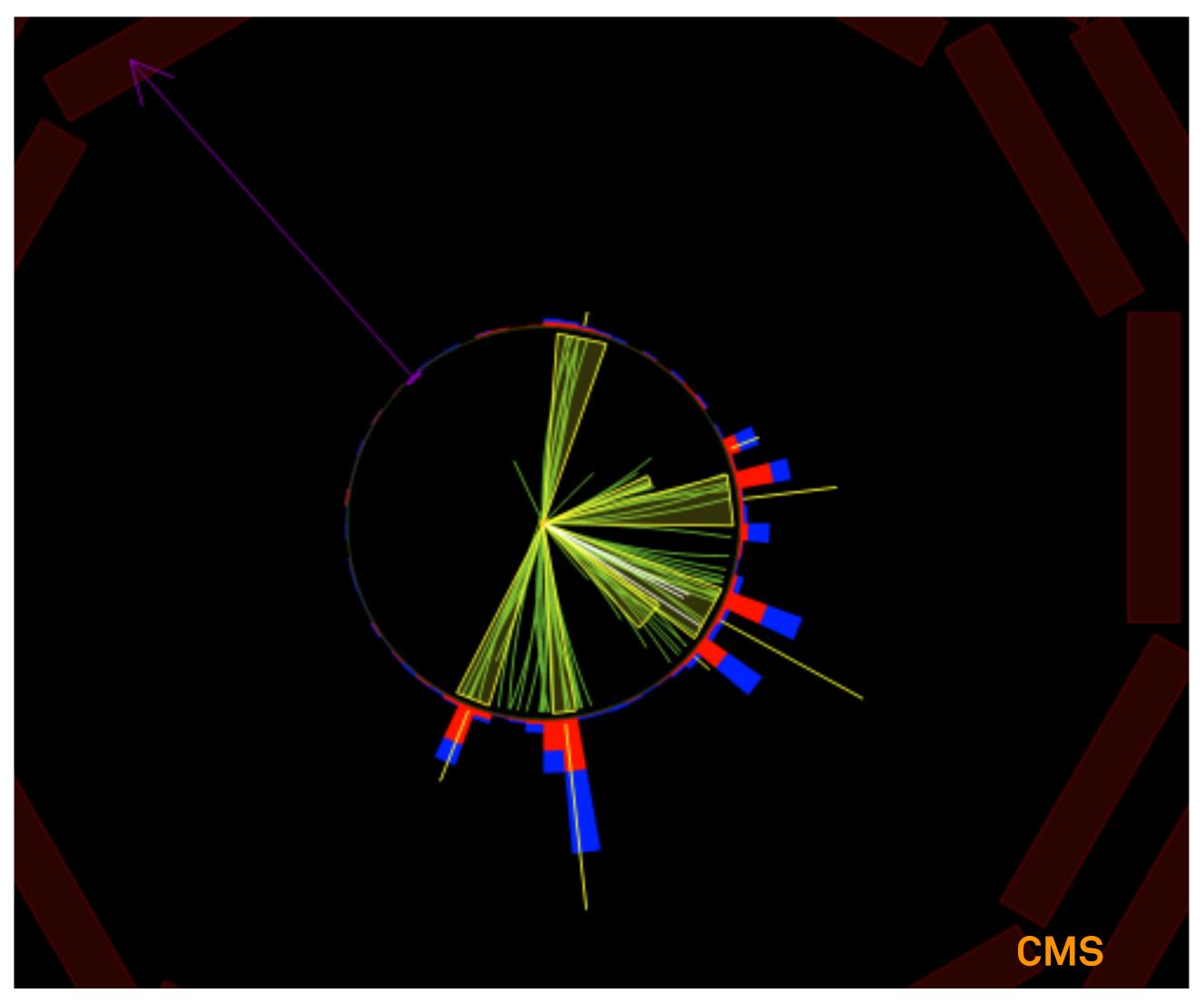
• Missing energy

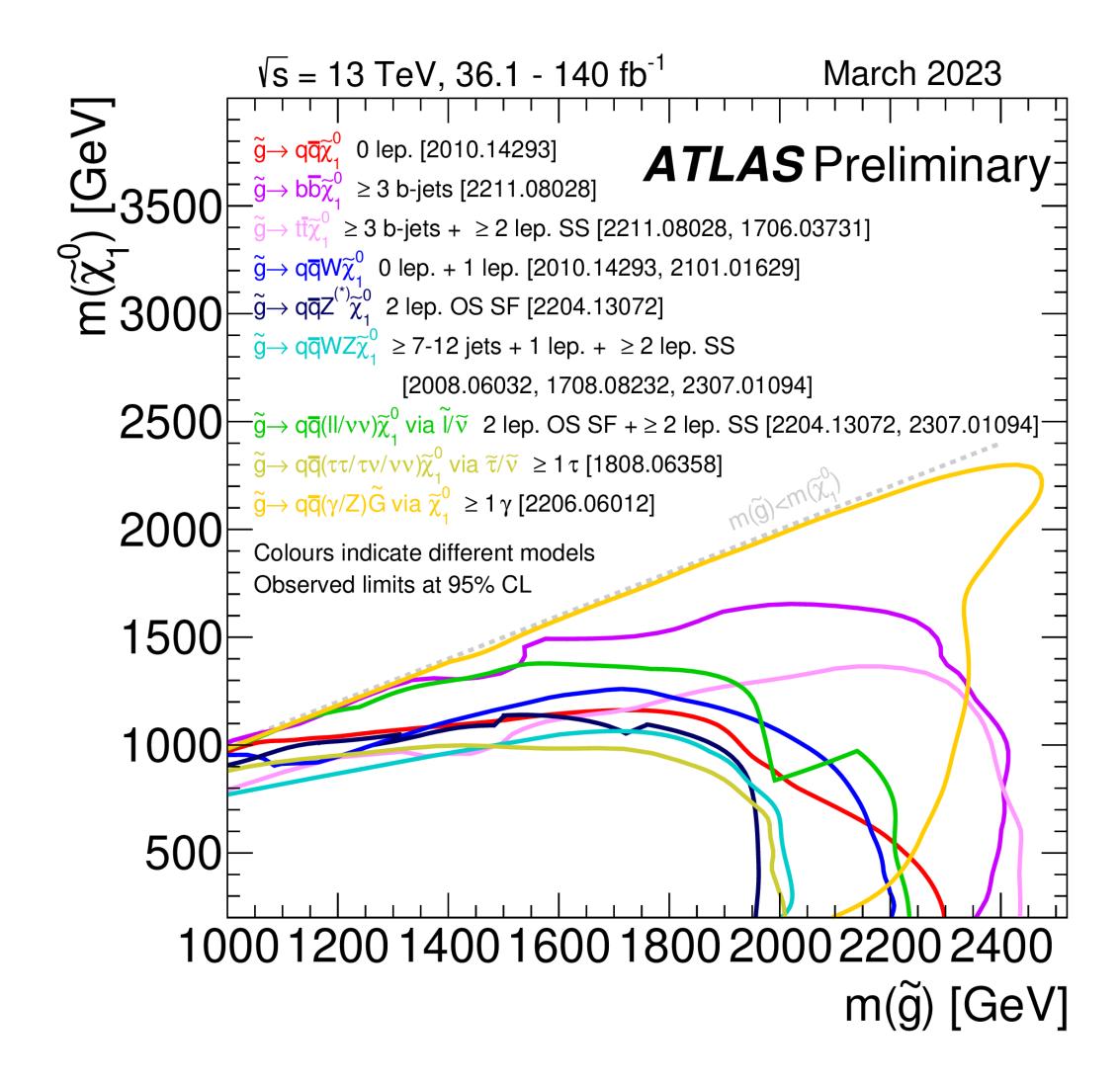
MSSING ENERGY

How do we detect something invisible?

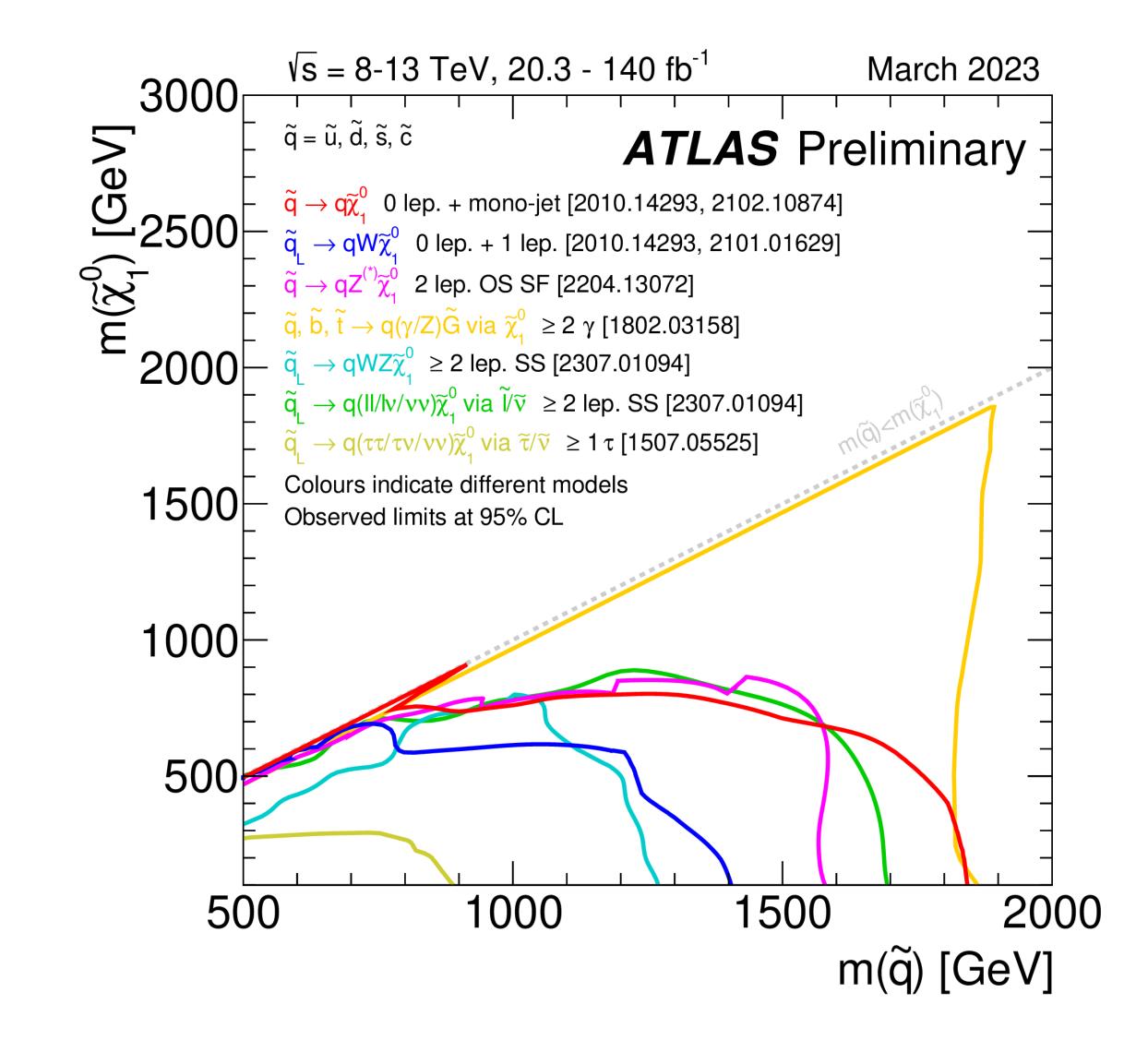
Conservation of (transverse) momentum.

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MTS



NAURAL SUSY

900

800

600

500⊢

400E

300⊢

200

100

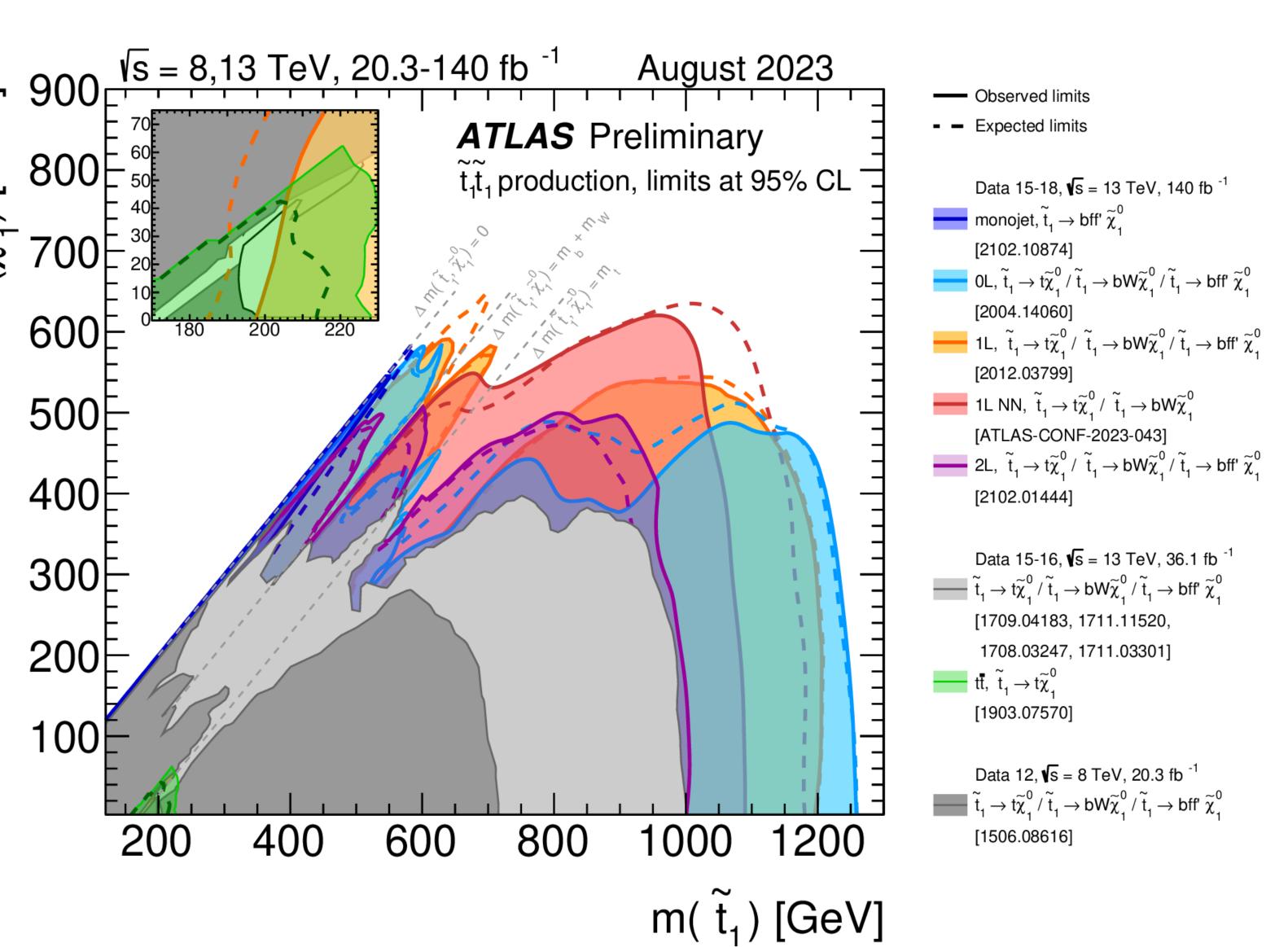
[GeV]

 $m(\widetilde{\chi}_{1}^{0})$

To solve hierarchy problem, mainly need top partner (stop) to be light.

Keep light WIMP for dark matter.

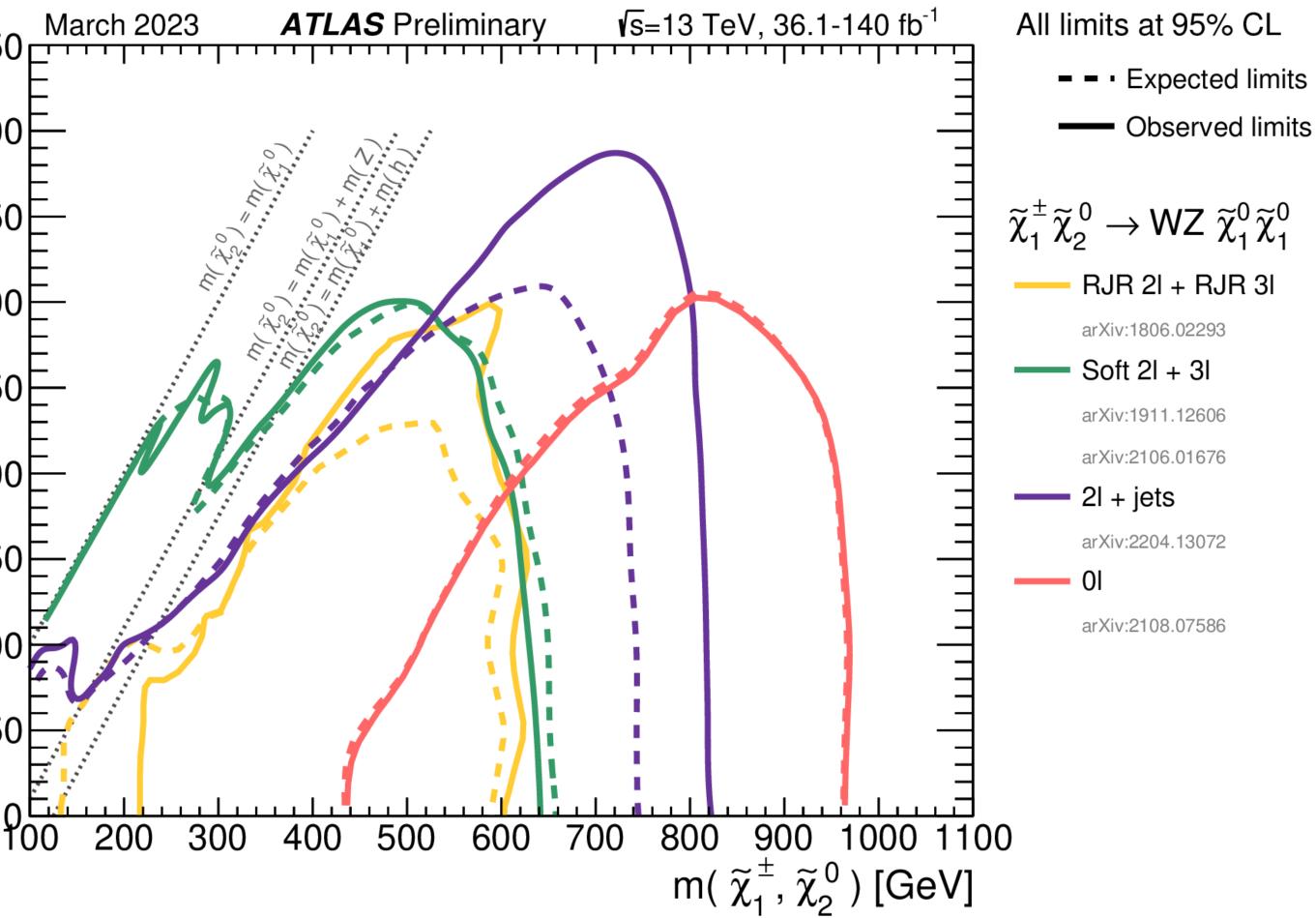
Final state is 2 tops + missing energy.



ELECTROWEAK SUSY

Forget naturalness, just dark matter.

Look for leptons and missing energy.



Hundreds of experimental searches constrain an enormous variety of SUSY scenarios.

Folk Theorem: any BSM scenario has the same pheno as a SUSY model.

ATLAS SUSY Searches* - 95% CL Lower Limits August 2023

2023				2							
del	S	Signatur	e j	<i>L dt</i> [fb [−]	¹]	Mass limit					Referenc
$q { ilde \chi}_1^0$	0 <i>e</i> ,μ mono-jet	2-6 jets 1-3 jets	$E_T^{ m miss}$ $E_T^{ m miss}$	140 140	 <i>q</i> [1×, 8× Degen.] <i>q</i> [8× Degen.] 		1.0 0.9	1.	85	$m(ilde{\chi}^0_1){<}400~{ m GeV}$ $m(ilde{q}){-}m(ilde{\chi}^0_1){=}5~{ m GeV}$	2010.14293 2102.10874
$q ar{q} { ilde{\chi}}_1^0$	0 <i>e</i> , <i>µ</i>	2-6 jets	$E_T^{\rm miss}$	140	ğ ğ		Forbidden	1.15-	2.3 1.95	$m(\tilde{\chi}_1^0)=0 \text{ GeV}$ $m(\tilde{\chi}_1^0)=1000 \text{ GeV}$	2010.14293 2010.14293
$q\bar{q}W\tilde{\chi}^0_1$	1 e,µ	2-6 jets		140	\tilde{g}				2.2	$m(ilde{\chi}_1^0) {<} 600 \mathrm{GeV}$	2101.01629
$qar{q}(\ell\ell) ilde{\chi}_1^0 \ qqWZ ilde{\chi}_1^0$	$ee, \mu\mu$	2 jets	$E_T^{ m miss} \ E_T^{ m miss}$	140	<i>ĝ</i>				2.2	$m(\tilde{\chi}_{1}^{0}) < 700 \text{GeV}$	2204.13072
$qqWZ ilde{\chi}_1^0$	0 e,μ SS e,μ	7-11 jets 6 jets	$E_T^{\rm miss}$	140 140	e e e		1	.15	1.97	$\mathfrak{m}(\widetilde{\chi}_1^0)$ <600 GeV $\mathfrak{m}(\widetilde{g})$ - $\mathfrak{m}(\widetilde{\chi}_1^0)$ =200 GeV	2008.06032 2307.01094
$t \tilde{\chi}_1^0$	0-1 <i>e</i> ,μ SS <i>e</i> ,μ	3 <i>b</i> 6 jets	$E_T^{\rm miss}$	140 140	รัช รัช			1.25	2.45	m(𝑋 𝑌)<500 GeV m(𝔅)-m(𝑋 𝑌)=300 GeV	2211.08028 1909.08457
	0 <i>e</i> , <i>µ</i>	2 <i>b</i>	$E_T^{\rm miss}$	140	${ar b_1\ ar b_1}$		0.68	1.255		$\mathfrak{m}(ilde{\mathcal{X}}_1^0){<}400~{ m GeV}$ 10 GeV ${<}\Delta\mathfrak{m}(ilde{m{b}}_1, ilde{\mathcal{X}}_1^0){<}20~{ m GeV}$	2101.12527 2101.12527
$\rightarrow b \tilde{\chi}_2^0 \rightarrow b h \tilde{\chi}_1^0$	0 <i>e</i> ,μ 2 τ	6 <i>b</i> 2 <i>b</i>	$E_T^{ m miss} \ E_T^{ m miss}$	140 140	\tilde{b}_1 Forbidden \tilde{b}_1		0 0.13-0.85	.23-1.35	Δr	$(\tilde{\chi}_{2}^{0}, \tilde{\chi}_{1}^{0}) = 130 \text{ GeV}, m(\tilde{\chi}_{1}^{0}) = 100 \text{ GeV}$ $\Delta m(\tilde{\chi}_{2}^{0}, \tilde{\chi}_{1}^{0}) = 130 \text{ GeV}, m(\tilde{\chi}_{1}^{0}) = 0 \text{ GeV}$	1908.03122 2103.08189
$\rightarrow t \tilde{\chi}_1^0$	0-1 <i>e</i> , <i>µ</i>	≥ 1 jet	$E_T^{\rm miss}$	140	\tilde{t}_1			1.25		$m(\tilde{\chi}_1^0)=1 \text{ GeV}$	2004.14060, 2012
$\rightarrow Wb\tilde{\chi}_1^0$	1 <i>e</i> , <i>µ</i>	3 jets/1 b	$E_T^{\rm miss}$	140	\tilde{t}_1	Forbidden	1.0			$m(\tilde{\chi}_1^0)$ =500 GeV	2012.03799, ATLAS-CO
$\rightarrow \tilde{\tau}_1 b \nu, \tilde{\tau}_1 \rightarrow \tau \tilde{G}$	1-2 <i>τ</i>	2 jets/1 b	E_T^{miss}	140	\tilde{t}_1		Forbidden	1.4		m($ ilde{ au}_1$)=800 GeV	2108.07665
$\rightarrow c \tilde{\chi}_1^0 / \tilde{c} \tilde{c}, \tilde{c} \rightarrow c \tilde{\chi}_1^0$	0 e,μ 0 e,μ	2 c mono-jet	$E_T^{ m miss}$ $E_T^{ m miss}$	36.1 140	\tilde{c} \tilde{t}_1	0.55	0.85			$m(\tilde{\chi}_1^0)=0~GeV$ $m(\tilde{t}_1,\tilde{c})$ - $m(\tilde{\chi}_1^0)=5~GeV$	1805.01649 2102.10874
$\rightarrow t \tilde{\chi}_2^0, \tilde{\chi}_2^0 \rightarrow Z/h \tilde{\chi}_1^0$	1-2 <i>e</i> , <i>µ</i>	1-4 <i>b</i>	$E_T^{\rm miss}$	140	\tilde{t}_1		0.067-	1.18		$m(\tilde{\chi}_2^0)=500 GeV$	2006.05880
$\rightarrow \tilde{t}_1 + Z$	3 <i>e</i> ,µ	1 <i>b</i>	$E_T^{\rm miss}$	140	Ĩ ₂	Forbidden	0.86		m(,	$ ilde{\mathcal{X}}_1^0$)=360 GeV, m($ ilde{t}_1$)-m($ ilde{\mathcal{X}}_1^0$)= 40 GeV	2006.05880
a WZ	Multiple ℓ/je $ee, \mu\mu$	ts ≥ 1 jet	$E_T^{ m miss}$ $E_T^{ m miss}$	140 140			0.96			$m(\tilde{\chi}_1^0)=0,$ wino-bino $m(\tilde{\chi}_1^{\pm})-m(\tilde{\chi}_1^0)=5$ GeV, wino-bino	2106.01676, 2108 1911.12606
a WW	2 <i>e</i> , <i>µ</i>		$E_T^{\rm miss}$	140	$\tilde{\chi}_1^{\pm}$	0.42				$m(\tilde{\chi}_1^0)=0$, wino-bino	1908.08215
a Wh	Multiple <i>ℓ</i> /je	ts	E_T^{miss}	140	$\tilde{\chi}_{1}^{\pm}/\tilde{\chi}_{2}^{0}$ Forbidden		1.0	6		$m(\tilde{\chi}_1^0)=70$ GeV, wino-bino	2004.10894, 2108
$a \tilde{\ell}_L / \tilde{\nu}$	2 e,µ		E_T^{miss}	140	χ_1^{\perp}	0.24 0.40	1.0			$m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^{\pm})+m(\tilde{\chi}_1^{0}))$	1908.08215 ATLAS-CONF-202
$\tilde{\mathcal{X}}_{1}^{0}$, $\tilde{\ell} \rightarrow \ell \tilde{\mathcal{X}}_{1}^{0}$	2 τ 2 <i>e</i> ,μ	0 jets	E_T^{miss} E^{miss}	140 140	$\tilde{\tau} [\tilde{\tau}_{\mathrm{R}}, \tilde{\tau}_{\mathrm{R},\mathrm{L}}]$	0.34 0.48	0.7			$ \begin{array}{c} m(\tilde{\mathcal{X}}_1^0) = 0 \\ m(\tilde{\mathcal{X}}_1^0) = 0 \end{array} $	AI LAS-CONF-20 1908.08215
	$ee, \mu\mu$	≥ 1 jet	E_T^{miss} E_T^{miss}	140	<i>č</i> 0.26	\$				$m(\tilde{\ell})$ - $m(\tilde{\chi}_1^0)$ =10 GeV	1911.12606
$\rightarrow h \tilde{G} / Z \tilde{G}$	0 e,μ 4 e,μ	$\geq 3 b$ 0 jets ≥ 2 large jet	E_T^{miss} E_T^{miss}	140 140	\tilde{H} \tilde{H}	0.55	0.94			$ \begin{array}{c} BR(\tilde{\chi}^0_1 \to h\tilde{G}) = 1 \\ BR(\tilde{\chi}^0_1 \to Z\tilde{G}) = 1 \end{array} $	To appear 2103.11684
			ts E_T^{fmiss}	140	Ĩ Ĥ		0.45-0.93			$BR(\tilde{\chi}^0_1 \to Z\tilde{G})=1$	2108.07586
	2 <i>e</i> , µ	≥ 2 jets	$E_T^{\rm miss}$	140	Ĥ		0.77			$BR(\tilde{\chi}^0_1 \to Z\tilde{G}) = BR(\tilde{\chi}^0_1 \to h\tilde{G}) = 0.5$	2204.13072
${}^+_1 \tilde{\chi}^1$ prod., long-lived $\tilde{\chi}^{\pm}_1$	Disapp. trk	k 1 jet	$E_T^{\rm miss}$	140	$ \tilde{\chi}_{1}^{\pm} \\ \tilde{\chi}_{1}^{\pm} $ 0.21		0.66			Pure Wino Pure higgsino	2201.02472 2201.02472
R-hadron	pixel dE/dx		$E_T^{\rm miss}$	140	Ĩ				2.05		2205.06013
able \tilde{g} R-hadron, $\tilde{g} \rightarrow qq \tilde{\chi}_1^0$	pixel dE/dx		$E_T^{ m miss} \ E_T^{ m miss} \ E_T^{ m miss} \ E_T^{ m miss}$	140	\tilde{g} [$\tau(\tilde{g})$ =10 ns]				2.2	$m(\tilde{\chi}_1^0)$ =100 GeV	2205.06013
$ ilde{G}$	Displ. lep		E_T^{miss}	140	$\tilde{e}, \tilde{\mu}$	0.34	0.7			$ au(ilde{\ell})=$ 0.1 ns $ au(ilde{\ell})=$ 0.1 ns	2011.07812
	pixel dE/d>	($E_T^{\rm miss}$	140	$\tilde{\tau}$	0.36				au(t) = 0.1 Hs $ au(\tilde{t}) = 10 \text{ ns}$	2011.07812 2205.06013
$\tilde{\chi}_{1}^{0}, \tilde{\chi}_{1}^{\pm} \rightarrow Z\ell \rightarrow \ell\ell\ell$	3 <i>e</i> , µ	.	-mice	140	$\tilde{\chi}_1^{\mp}/\tilde{\chi}_1^0$ [BR($Z\tau$)=1, BR(Ze)=1	1] 0.6				Pure Wino	2011.10543
$ \begin{array}{c} 0\\2\\ \end{array} WW/Z\ell\ell\ell\ell\nu\nu \\ \end{array} $	4 <i>e</i> , <i>µ</i>	0 jets ∖ 8 ioto	$E_T^{\rm miss}$	140	$\tilde{\chi}_{1}^{\pm}/\tilde{\chi}_{2}^{0} [\lambda_{i33} \neq 0, \lambda_{12k} \neq 0]$		0.95	1.55	0.05	$m(\tilde{\chi}_1^0)=200 \text{ GeV}$	2103.11684 To oppoor
$\begin{array}{c} qq\tilde{\chi}_{1}^{0},\tilde{\chi}_{1}^{0} \rightarrow qqq \\ 1,\tilde{\chi}_{1}^{0} \rightarrow tbs \end{array}$		≥8 jets Multiple		140 36.1	$\tilde{g} = [m(\tilde{\chi}_1^0) = 50 \text{ GeV}, 1250 \text{ GeV})$ $\tilde{t} = [\lambda''_{323} = 2e - 4, 1e - 2]$	0.55	1.05	1.6	2.25	Large λ_{112}'' m $(\tilde{\chi}_1^0)$ =200 GeV, bino-like	To appear ATLAS-CONF-20
$\chi_1, \chi_1 \to tbs$ $\chi_1^{\pm}, \tilde{\chi}_1^{\pm} \to bbs$		$\geq 4b$		140	\tilde{t}	Forbidden	0.95	,		$m(\tilde{\chi}_1)=200 \text{ GeV}, \text{ bino-like}$ $m(\tilde{\chi}_1^{\pm})=500 \text{ GeV}$	2010.01015
$\rightarrow bs$		2 jets + 2 b	,	36.7	$\tilde{t}_1 [qq, bs]$	0.42 0.6					1710.07171
$\rightarrow q\ell$	$2 e, \mu$	2 <i>b</i>		36.1	\tilde{t}_1			0.4-1.45		$BR(\tilde{t}_1 \rightarrow be/b\mu) > 20\%$	1710.05544
~0 ~0 ~+	1 µ	DV		136	$\tilde{t_1}$ [1e-10< λ'_{23k} <1e-8, 3e-10	201	1.0	1.6		$BR(\tilde{t}_1 \to q\mu) = 100\%, \cos\theta_t = 1$	2003.11956
$\tilde{\chi}_1^0, \tilde{\chi}_{1,2}^0 \rightarrow tbs, \tilde{\chi}_1^+ \rightarrow bbs$	1-2 <i>e</i> , µ	≥6 jets		140	$\tilde{\chi}_1^0$ 0 .	.2-0.32				Pure higgsino	2106.09609
ion of the available ma			s or	1	0 ⁻¹			1		Mass scale [TeV]	
is shown Many of the	e iimits are ha	ased on								• •	

*Only a selection of the available mass limits on new states or phenomena is shown. Many of the limits are based on simplified models, c.f. refs. for the assumptions made.

ATLAS Pre

liminary 5 = 13 TeV
s = 10 16V
3 4
3 3
9
2 2 4
+ 8 7
7
2 9
2.03799 NF-2023-043 5
9 4
0
3.07586 6
5 3.07586 5
23-029
5 6
4 6 2
2
3 3
2
3
3 4
18-003 5
5 1 4
6
9

NON-SUSY (SORTOF)

Lots of other searches excluding things at the TeV scale.

Some searches sensitive to ~ 30 TeV.

Status: March 2023

	Model	ℓ , γ	Jets†	$\mathbf{E}_{\mathrm{T}}^{\mathrm{miss}}$	∫£ dt[fb	⁻¹] Limit	Referen
Extra dimen.	ADD $G_{KK} + g/q$ ADD non-resonant $\gamma\gamma$ ADD QBH ADD BH multijet RS1 $G_{KK} \rightarrow \gamma\gamma$ Bulk RS $G_{KK} \rightarrow WW/ZZ$ Bulk RS $g_{KK} \rightarrow tt$ 2UED / RPP	$\begin{array}{c} 0 \ e, \mu, \tau, \gamma \\ 2 \ \gamma \\ - \\ 2 \ \gamma \\ multi-channe \\ 1 \ e, \mu \\ 1 \ e, \mu \end{array}$	1 - 4 j - 2 j $\ge 3 j$ - $\ge 1 b, \ge 1 J/2$ $\ge 2 b, \ge 3 j$		139 36.7 139 3.6 139 36.1 36.1 36.1	$\begin{tabular}{ c c c c c c c c c c c c c c c c c c c$	2102.108 1707.041 1910.084 1512.025 2102.134 1808.023 1804.108 1803.096
Gauge bosons	$\begin{array}{l} \operatorname{SSM} Z' \to \ell\ell \\ \operatorname{SSM} Z' \to \tau\tau \\ \operatorname{Leptophobic} Z' \to bb \\ \operatorname{Leptophobic} Z' \to tt \\ \operatorname{SSM} W' \to \ell\nu \\ \operatorname{SSM} W' \to \tau\nu \\ \operatorname{SSM} W' \to tb \\ \operatorname{HVT} W' \to WZ \text{ model B} \\ \operatorname{HVT} W' \to WZ \to \ell\nu \ell'\ell' \text{ mod} \\ \operatorname{HVT} Z' \to WW \text{ model B} \\ \operatorname{LRSM} W_R \to \mu N_R \end{array}$	$\begin{array}{c} 2 \ e, \mu \\ 2 \ \tau \\ - \\ 0 \ e, \mu \\ 1 \ e, \mu \\ 1 \ \tau \\ - \\ 0 - 2 \ e, \mu \\ 1 \ e, \mu \\ 1 \ e, \mu \\ 2 \ \mu \end{array}$	$\begin{array}{c} - \\ 2 b \\ \geq 1 b, \geq 2 J \\ - \\ - \\ \geq 1 b, \geq 1 J \\ 2 j / 1 J \\ 2 j (VBF) \\ 2 j / 1 J \\ 1 J \end{array}$	Yes Yes	139 36.1 36.1 139 139 139 139 139 139 139 80	Z' mass 5.1 TeV Z' mass 2.42 TeV Z' mass 2.1 TeV Z' mass 4.1 TeV Z' mass 6.0 TeV W' mass 6.0 TeV W' mass 5.0 TeV W' mass 4.4 TeV W' mass 4.3 TeV W' mass 340 GeV Z' mass 3.9 TeV W _R mass 5.0 TeV	1903.062 1709.072 1805.092 2005.051 1906.056 ATLAS-CONF-2 ATLAS-CONF-2 2004.146 2207.039 2004.146 1904.126
CI	Cl qqqq Cl ℓℓqq Cl eebs Cl μμbs Cl tttt	2 <i>e</i> , μ 2 <i>e</i> 2 μ ≥1 <i>e</i> ,μ	2 j - 1 b 1 b ≥1 b, ≥1 j	- - - - Yes	37.0 139 139 139 36.1	Λ 21.8 TeV η_{LL}^-	LL 1703.091 2006.129 2105.138 2105.138 1811.023
DM	Axial-vector med. (Dirac DM) Pseudo-scalar med. (Dirac DM Vector med. Z'-2HDM (Dirac D Pseudo-scalar med. 2HDM+a	M) 0 e, μ	2 b	– Yes Yes	139 139 139 139	$\begin{array}{c c c c c c c c c c c c c c c c c c c $	ATL-PHYS-PUB- 2102.108 2108.133 ATLAS-CONF-2
ГО	Scalar LQ 1 st gen Scalar LQ 2 nd gen Scalar LQ 3 rd gen Scalar LQ 3 rd gen Scalar LQ 3 rd gen Scalar LQ 3 rd gen Vector LQ mix gen Vector LQ 3 rd gen	$\begin{array}{c} 2 \ e \\ 2 \ \mu \\ 1 \ \tau \\ 0 \ e, \mu \\ \geq 2 \ e, \mu, \geq 1 \ \tau \\ 0 \ e, \mu, \geq 1 \ \tau \\ \text{multi-channe} \\ 2 \ e, \mu, \tau \end{array}$	0 – 2 j, 2 b	_ Yes	139 139 139 139 139 139 139 139 139	$ \begin{array}{c} LQ \mbox{ mass} & 1.8 \mbox{ TeV} \\ LQ \mbox{ mass} & 1.7 \mbox{ TeV} \\ LQ^{\text{u}} \mbox{ mass} & 1.49 \mbox{ TeV} \\ LQ^{\text{u}} \mbox{ mass} & 1.49 \mbox{ TeV} \\ LQ^{\text{u}} \mbox{ mass} & 1.24 \mbox{ TeV} \\ LQ^{\text{u}} \mbox{ mass} & 1.24 \mbox{ TeV} \\ LQ^{\text{u}} \mbox{ mass} & 1.26 \mbox{ TeV} \\ LQ^{\text{u}} \mbox{ mass} & 1.26 \mbox{ TeV} \\ LQ^{\text{u}} \mbox{ mass} & 2.0 \mbox{ TeV} \\ LQ^{\text{u}} \mbox{ mass} & 1.96 \mbox{ TeV} \\ \end{array} $	2006.058 2006.058 2303.012 2004.140 2101.115 2101.125 ATLAS-CONF-2 2303.012
Vector-like fermions	$\begin{array}{c} VLQ \ TT \to Zt + X \\ VLQ \ BB \to Wt/Zb + X \\ VLQ \ T_{5/3} T_{5/3} T_{5/3} \to Wt + X \\ VLQ \ T \to Ht/Zt \\ VLQ \ T \to Ht/Zt \\ VLQ \ Y \to Wb \\ VLQ \ B \to Hb \\ VLL \ \tau' \to Z\tau/H\tau \end{array}$	1 e,μ 1 e,μ	el $u \ge 1$ b, ≥ 1 j ≥ 1 b, ≥ 3 j ≥ 1 b, ≥ 1 j ≥ 2 b, ≥ 1 j, ≥ 1	Yes Yes Yes	139 36.1 36.1 139 36.1 139 139	T mass1.46 TeVSU(2) doubletB mass1.34 TeVSU(2) doublet $T_{5/3}$ mass1.64 TeV $\mathcal{B}(T_{5/3} \rightarrow Wt) = 1, c(T_{5/3}Wt)$ T mass1.86 TeV $\mathcal{SU}(2)$ singlet, $\kappa_T = 0.5$ Y mass1.85 TeV $\mathcal{B}(Y \rightarrow Wb) = 1, c_R(Wb) = 1$ B mass2.0 TeV $\mathcal{SU}(2)$ doublet, $\kappa_B = 0.3$ τ' mass898 GeV $\mathcal{SU}(2)$ doublet	= 1 2210.154 1808.023 1807.118 ATLAS-CONF-2 1812.073 ATLAS-CONF-2 2303.054
Exctd ferm.	Excited quark $q^* \rightarrow qg$ Excited quark $q^* \rightarrow q\gamma$ Excited quark $b^* \rightarrow bg$ Excited lepton τ^*	- 1 γ - 2 τ	2 j 1 j 1 b, 1 j ≥2 j	- - - -	139 36.7 139 139	q* mass 6.7 TeV only u^* and d^* , $\Lambda = m(q^*)$ q* mass 5.3 TeV only u^* and d^* , $\Lambda = m(q^*)$ b* mass 3.2 TeV $\Lambda = 4.6$ TeV	1910.084 1709.104 1910.084 2303.094
Other	Type III Seesaw LRSM Majorana ν Higgs triplet $H^{\pm\pm} \rightarrow W^{\pm}W^{\pm}$ Higgs triplet $H^{\pm\pm} \rightarrow \ell \ell$ Multi-charged particles Magnetic monopoles	2,3,4 <i>e</i> , µ 2 µ 2,3,4 <i>e</i> , µ (SS 2,3,4 <i>e</i> , µ (SS - - -		Yes Yes - - 3 TeV	139 36.1 139 139 139 34.4	N° mass910 GeVN _R mass3.2 TeVH ^{±±} mass350 GeVH ^{±±} mass1.08 TeVmulti-charged particle mass1.59 TeVmonopole mass2.37 TeV	2202.020 1809.111 2101.119 2211.075 ATLAS-CONF-2 1/2 1905.101
*0~~!	p	artial data	full da		araban	10^{-1} 1 10 Mass scale [T	eV]

*Only a selection of the available mass limits on new states or phenomena is shown. *†Small-radius (large-radius) jets are denoted by the letter j (J).*

ATLAS Heavy Particle Searches* - 95% CL Upper Exclusion Limits

ATLAS Preliminary $\sqrt{s} = \frac{1}{2}$

 $\int \mathcal{L} dt = (3.6 - 139) \text{ fb}^{-1}$

13	TeV
nc	e
0874 4147 3447 2586 3405 2380 0823 9678	, , , ,
6248 7242 9299 5138 5609 7-202 7-202 7-202 4636 3925 4636 2679	21-025 21-043
0874 3391)))) 22-036
5872 5872 1294 4060 1582 2527	22-052
7343 -202 5441 3447	21-040 21-018
0440 3447 9444 2039 1105 1961 7505 -202 0130	, , , , , , , , , , , , , , , , , , ,