SEARCHES FOR SUSY

HIGHLIGHTS FROM RUN1, PROSPECTS FOR RUN2

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EPS – VIENNA, AUSTRIA

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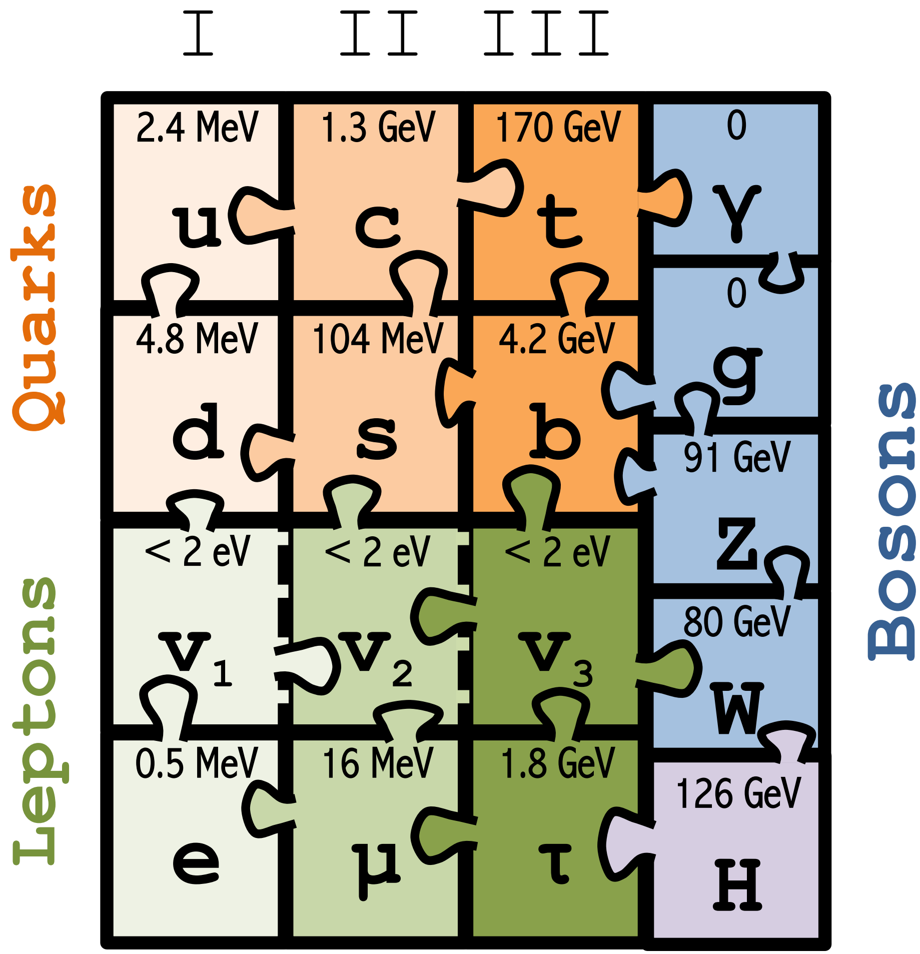
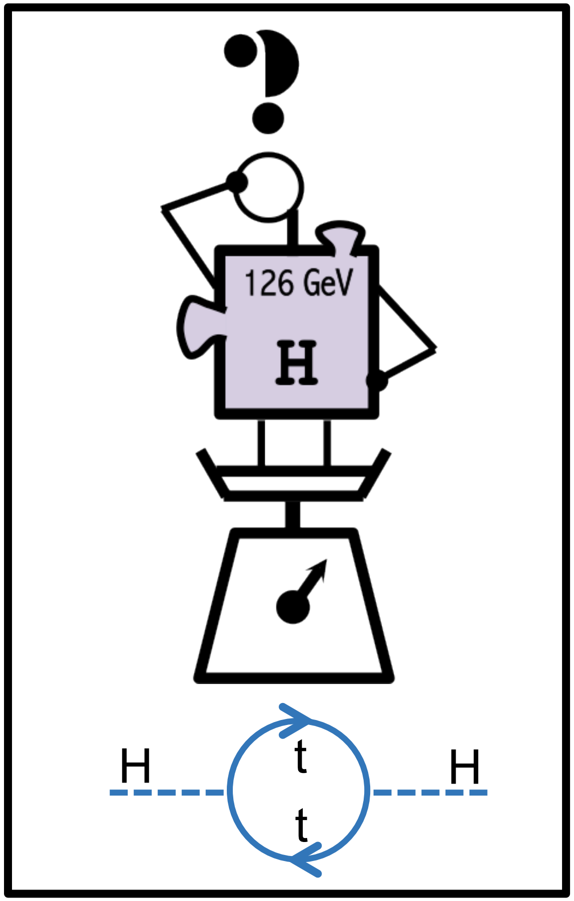
TALK OUTLINE

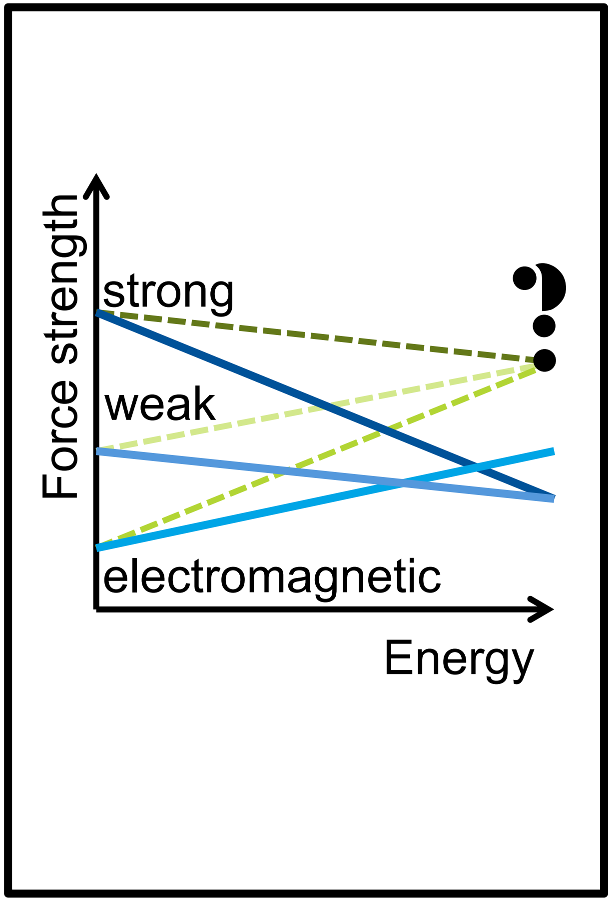
- A short introduction
- The hunt for SUSY
- Summary results and combinations
- The few tantalizing results
- Towards Run2

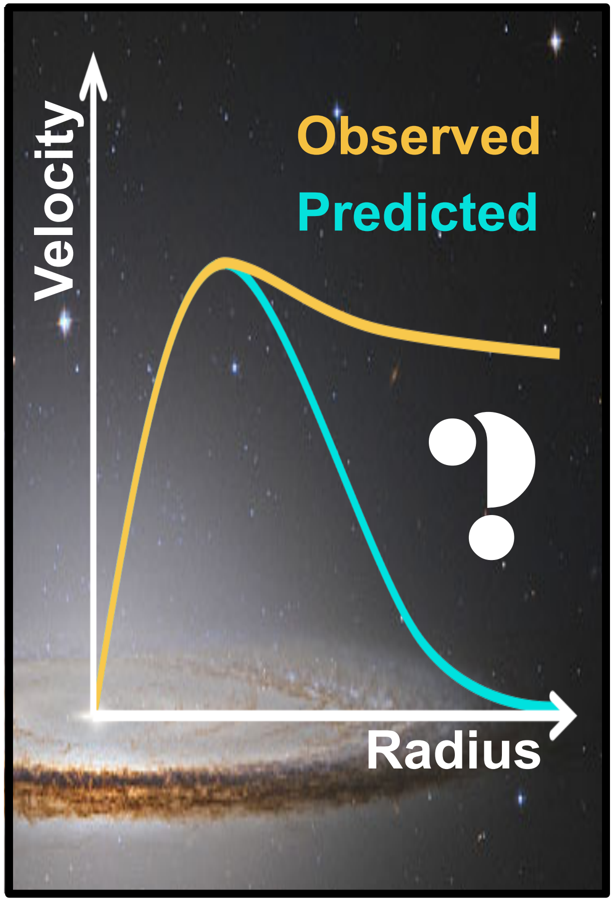
THE STANDARD MODEL…



… AND ITS OPEN QUESTIONS

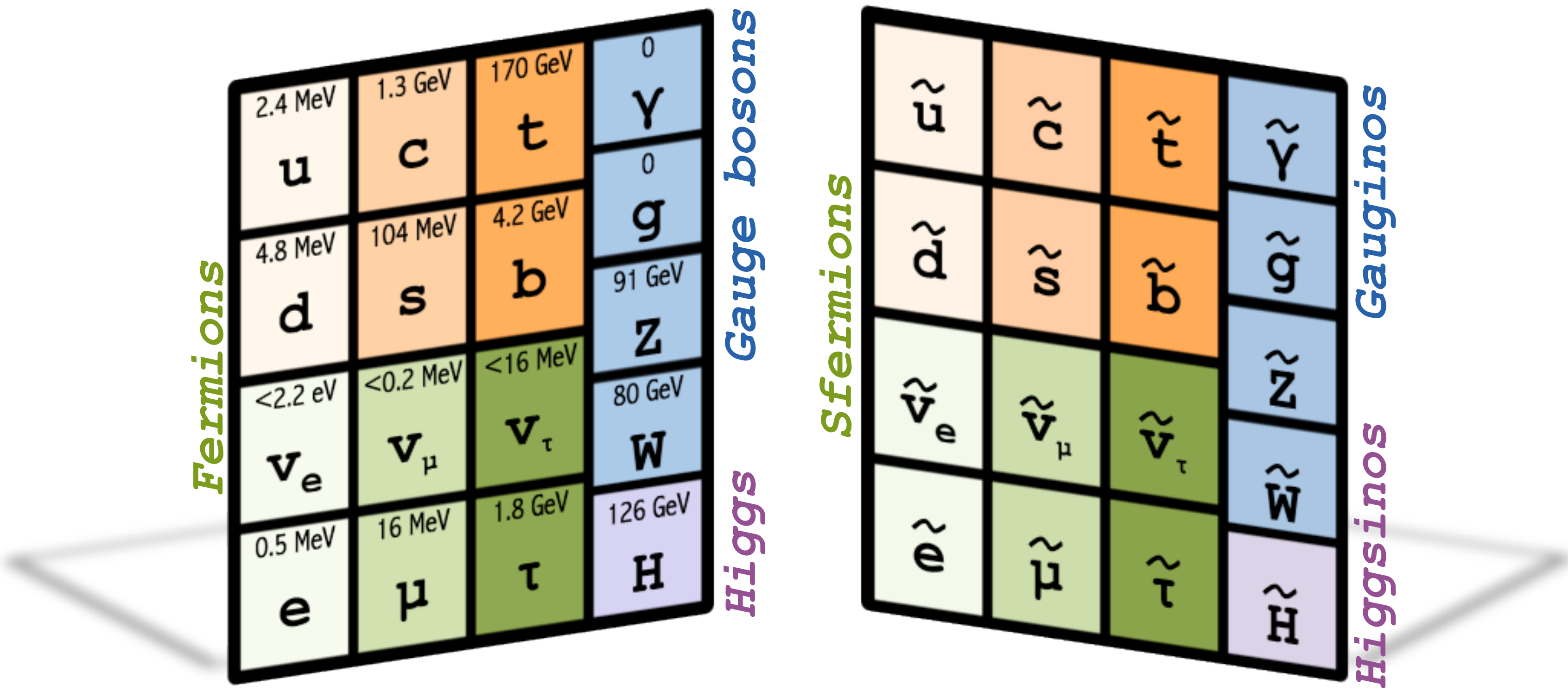




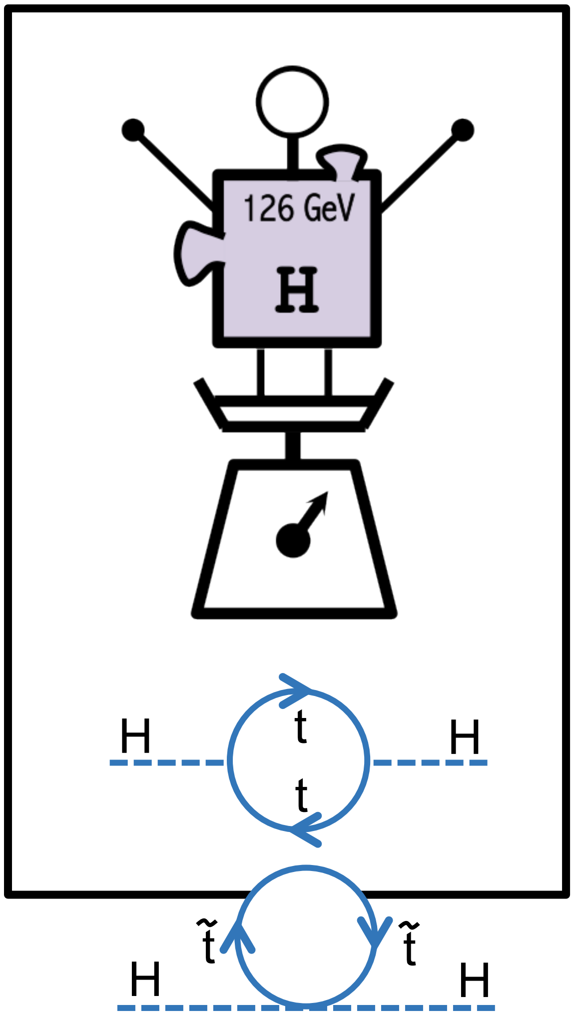


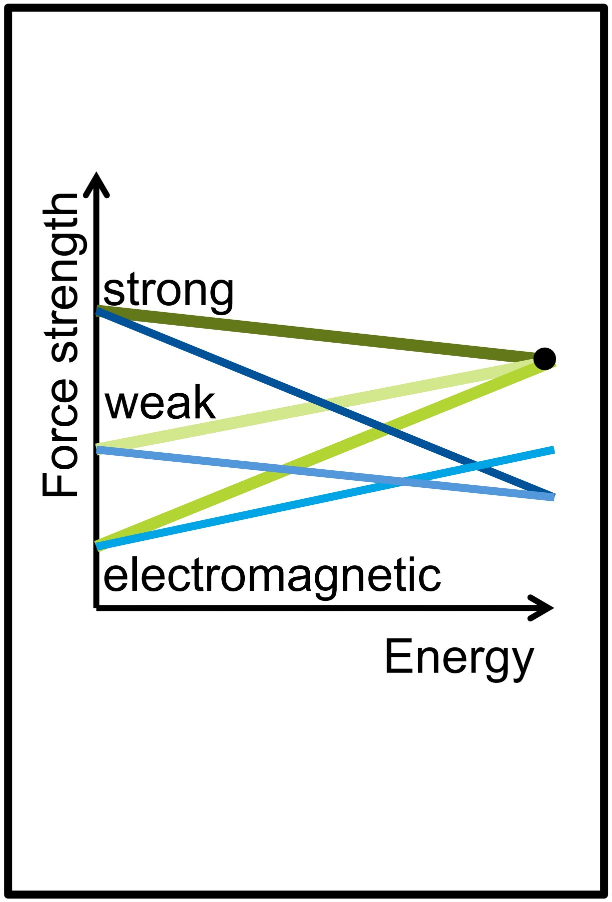
SUPERSYMMETRY (SUSY)

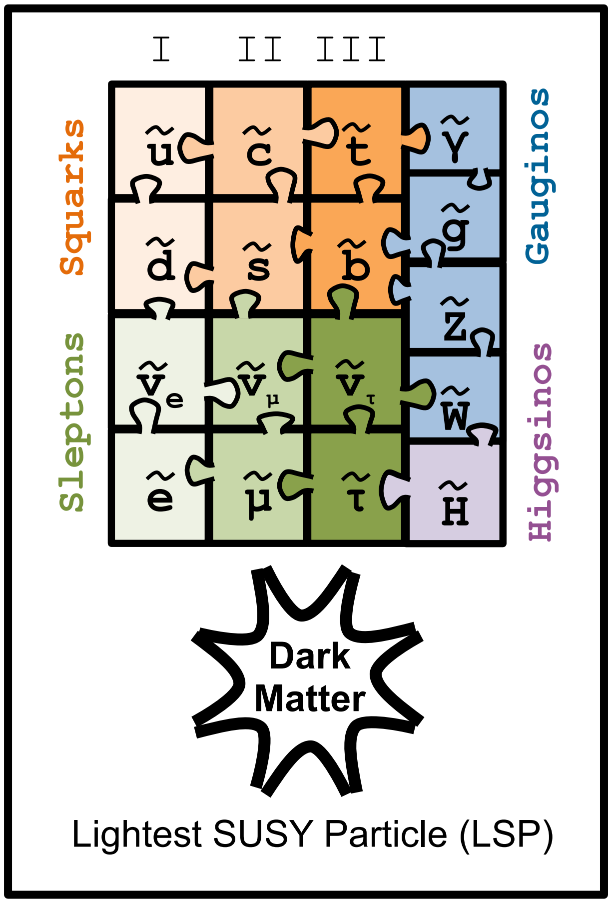
- Forces $\Leftrightarrow$ Matter



SUPERSYMMETRY (SUSY)



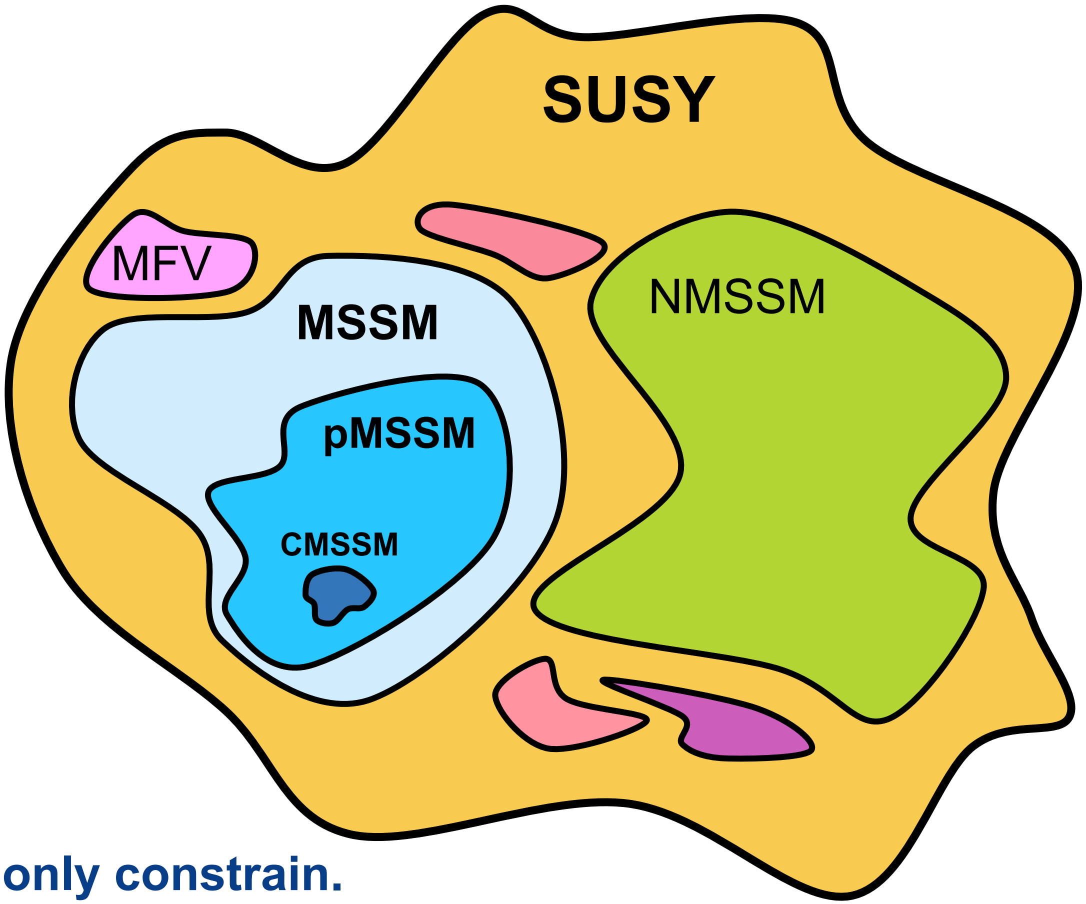




THE SUSY PHASE SPACE

- **A huge parameter space to investigate. E.g.**

Model	# free parameters
MSSM	> 100
pMSSM	19
CMSSM	5

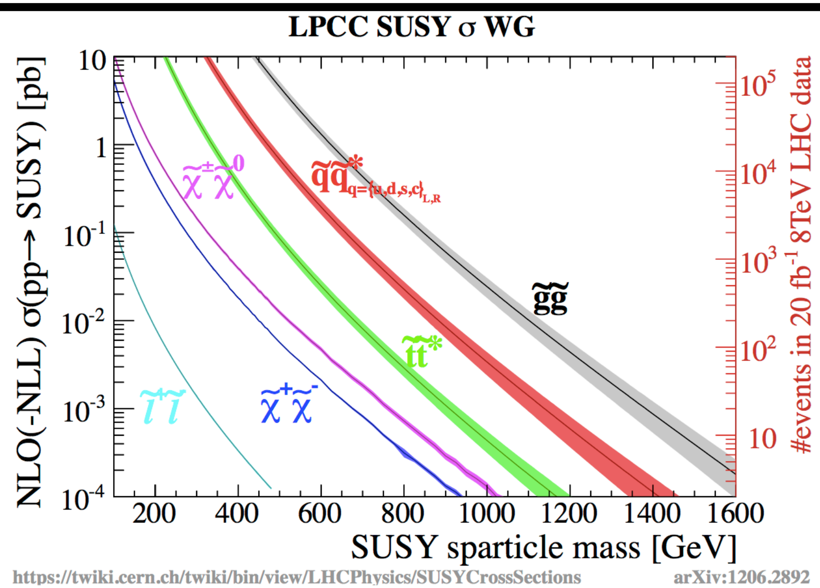


- **Impossible to exclude. Can only constrain.**
- Experimental constraints coming from indirect and direct searches.
  - Indirect: dark matter experiments, precision measurements at the LHC.
  - **Direct: searches at the LHC (ATLAS and CMS experiments).**

SUSY SEARCHES AT THE LHC

Searches split by production process

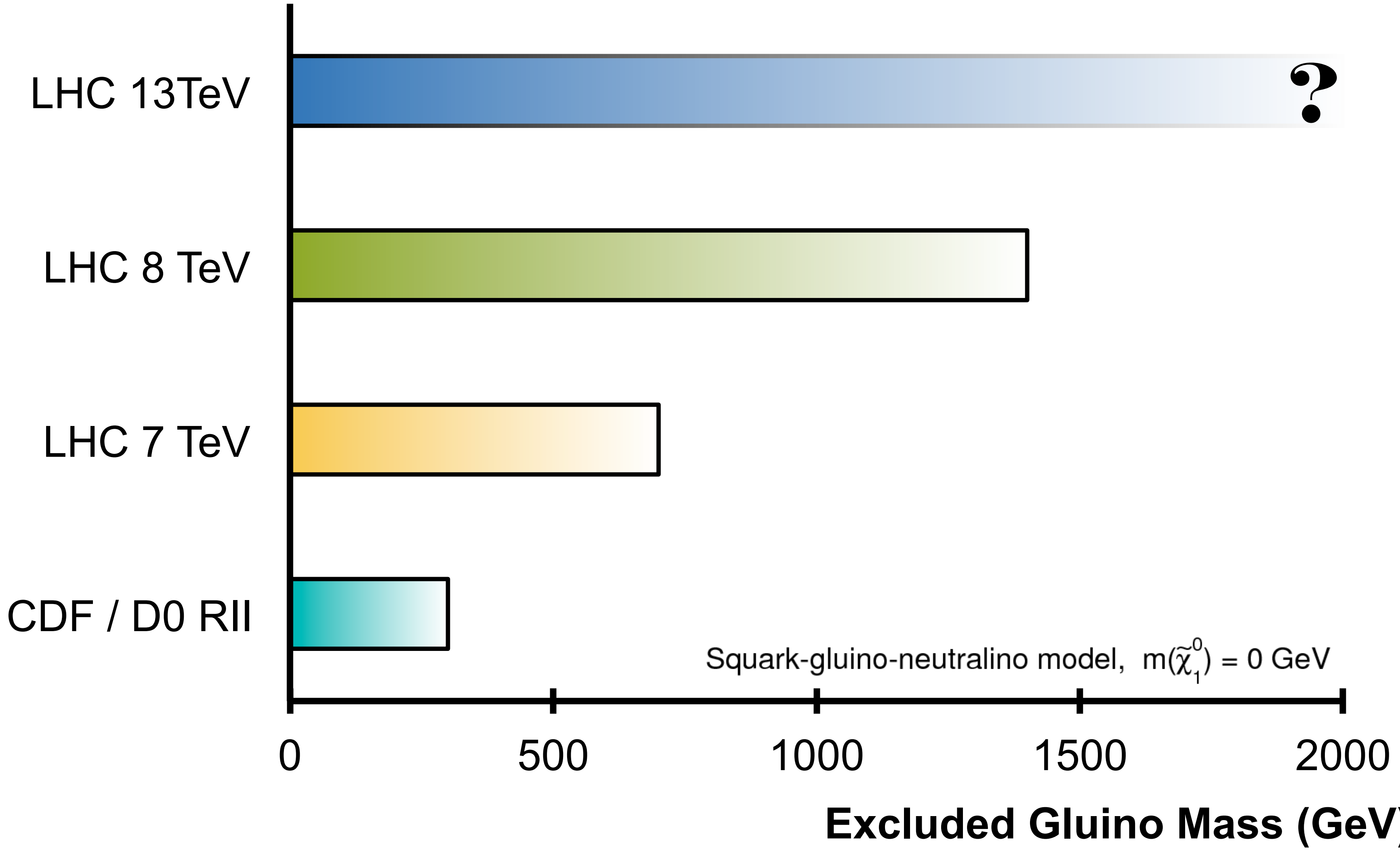
- **Strong SUSY production**
  - "Natural" gluinos are "light" (<~2TeV).
- **Third generation production**
  - "Natural" $\tilde{b}$ and $\tilde{t}$ are light (<~1TeV).
- **Electroweak production**
  - "Natural" Higgsinos are light (~0.1TeV).

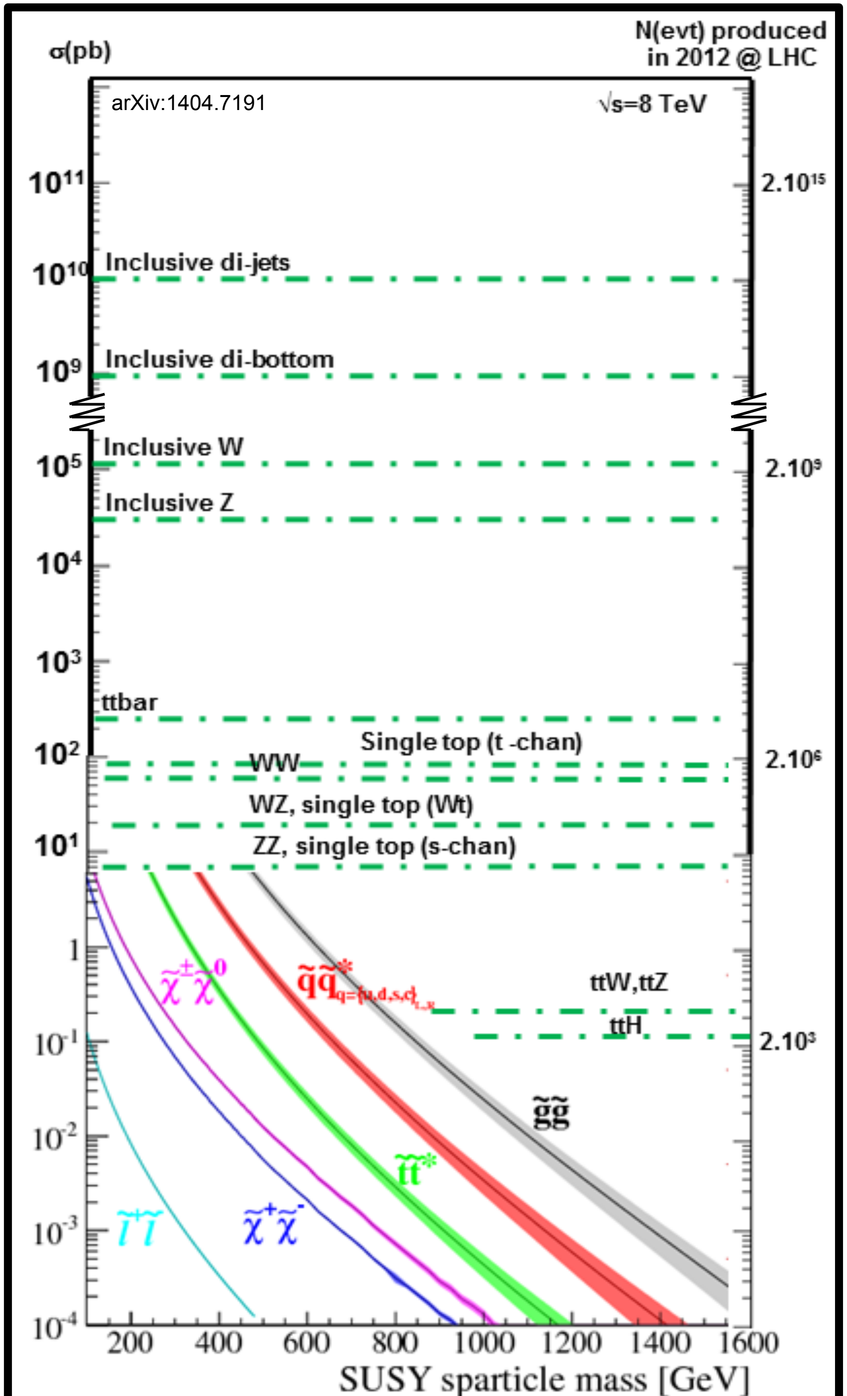


…and by final state characteristics

- **R-parity Conserving (RPC) SUSY.**
  - The LSP is stable becoming a possible dark matter candidate.
  - Searches are largely MET-based.
- **R-parity violating (RPV) SUSY.**
  - The LSP decays into SM particles.
  - Searches are typically associated with large object multiplicity.
- **Long-Lived particles, within RPC and RPV.**
  - Searches use the distinct signatures of particles with lifetime.

WHERE DO WE STAND





THE CHALLENGES

- **Large phase space to cover.**
  - Many production modes and decay channels.
  - Multiple final states to explore.
- **Cross sections tiny with respect to the Standard Model processes.**
- **Searches target on a phase-space that is experimentally complicated.**
  - Tails of distributions in multi-object final states.
  - **Require** very selective trigger selections;
  - powerful discriminating variables; and
  - complex background determination techniques.

⇒ **An experimental challenge!**

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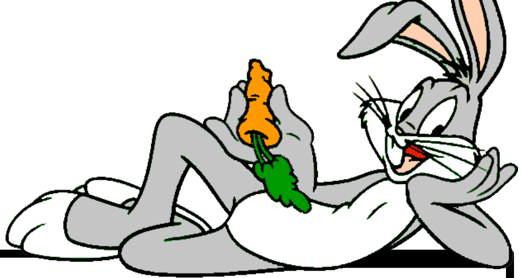
THE HUNT FOR SUSY



Common basic tools:

- Jets, bjets, leptons (incl. taus), MET (in RPC SUSY, from the LSPs).
- ATLAS uses “conventional” reconstruction, CMS uses particle-flow reconstruction. Performance results are comparable.

Composite tools:

- m_T^W(lepton, MET), m_{eff} = MET + Σp_T(jets), m_{CT}, m_{T2} , $H_T = \Sigma\ p_T$(jets), …

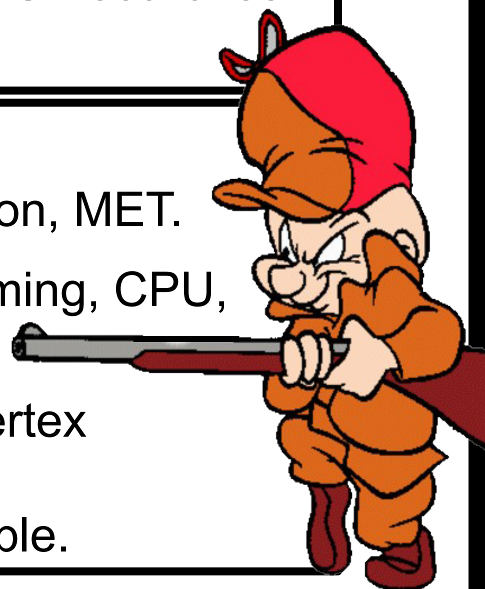
High-tech tools:

- Large-R jets, $M_J = \Sigma$ mass(large-R jets), c-tagging, displaced vertices, …

} Often developed specifically for SUSY searches.

Triggers:

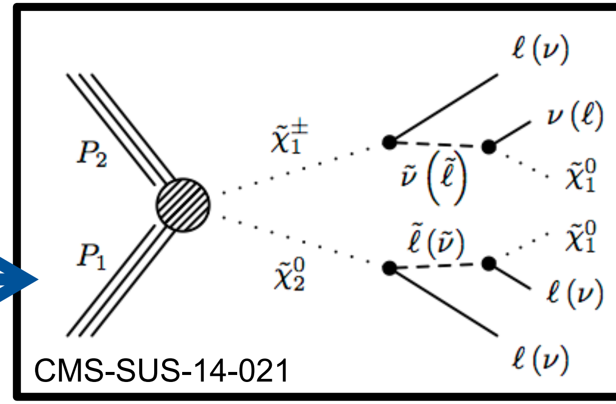
- The first step in the analysis. Main workhorses: single lepton, MET.
- Make use of all possible tools, provided they fit into the (timing, CPU, bandwidth) allocation.
  - E.g. muon-spectrometer-only triggers for displaced-vertex searches, ‘H_T’ triggers, large-R jet triggers, …
- In 2012: “delayed” (ATLAS) or “parked” (CMS) data available.



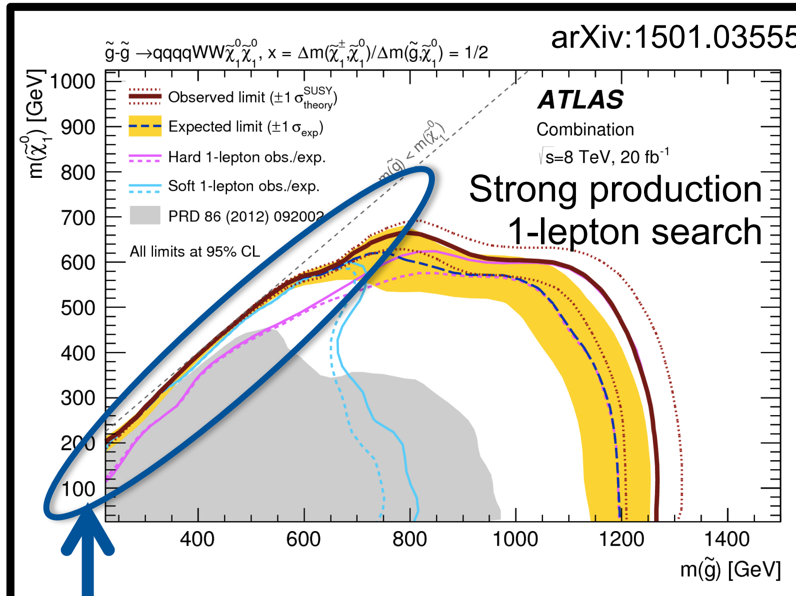
AN EXAMPLE – ISR TAGGING

A way to access compressed spectra.

- Mass difference between the initial and final SUSY particles very small.
  - e.g. $\Delta m(\chi_1^{\pm},\chi_1^{0}) \sim 20\text{GeV}$.
- **Viable topologies, with 'natural' phase-space still unexplored.**



- Event selection:
  - a high-momentum jet from Initial State Radiation (ISR), high MET and (possibly) soft leptons.
- Challenges:
  - Using these event characteristics (ISR jet & high MET) is the **only way to trigger** in these topologies.
  - Getting the ISR modeling right in the Monte Carlo simulation (both signal and background) is hard.



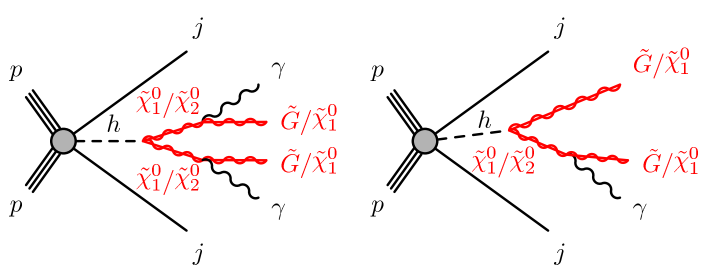
A compressed topology given access to by a soft-lepton (plus ISR jet) search.

arXiv:1407.0583, arXiv:1501.03555, CMS-SUS-14-021

ANOTHER EXAMPLE – VBF TAGGING

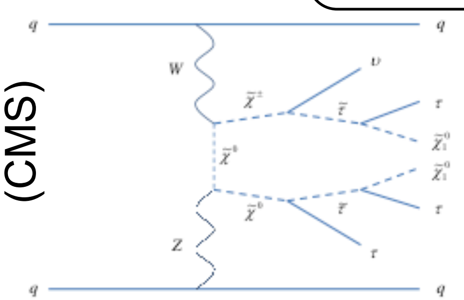
A complementary root to directly probe the EWK sector, especially in compressed spectra. E.g.

The first SUSY search in VBF topology

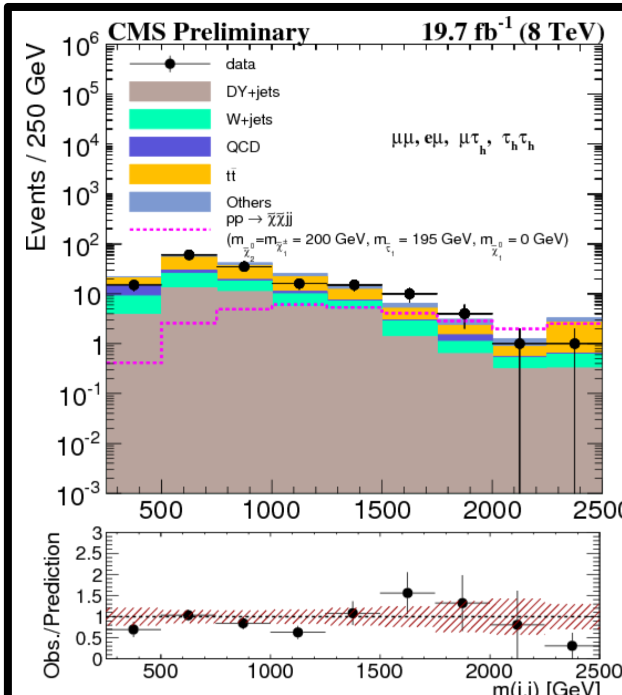


VBF higgs production to SUSY particles (ATLAS)

VBF production in 2-lepton + MET (CMS)



- Both searches use the dijet mass (mjj) of two jets with a large pseudorapidity gap.
- ATLAS: photon(s) plus 2 jets plus MET final state.
- CMS: search for a broad excess in the tails of mjj, in 2-lepton plus 2 jets plus MET final state.



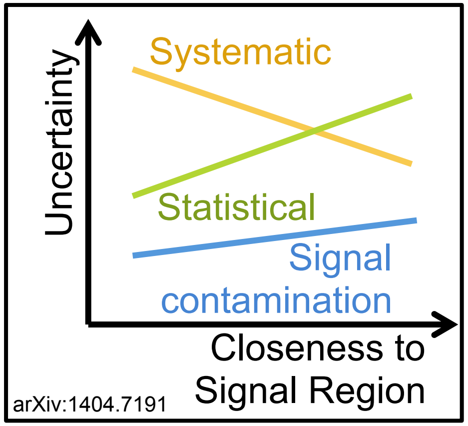
CMS-SUS-14-005, ATLAS-CONF-2015-001

THE HUNT FOR SUSY

Background determination; three general approaches:

- Background processes with large cross-section and fakes (MET, leptons) use **data-driven methods**.
  - E.g. jet smearing method is ‘traditionally’ used for QCD background.
  - New ideas appear continuously in designing robust technics that keep uncertainties under control, e.g. multijet template method for RPC and RPV multijet searches on ATLAS.

- Backgrounds with large cross-sections such as ttbar, W and Z production use **semi-data-driven methods**.
  - Extrapolate from (carefully designed) control regions to signal regions applying appropriate scale factors.
  - Data-driven methods developed in some cases, e.g. Z+jets from γ+jets.



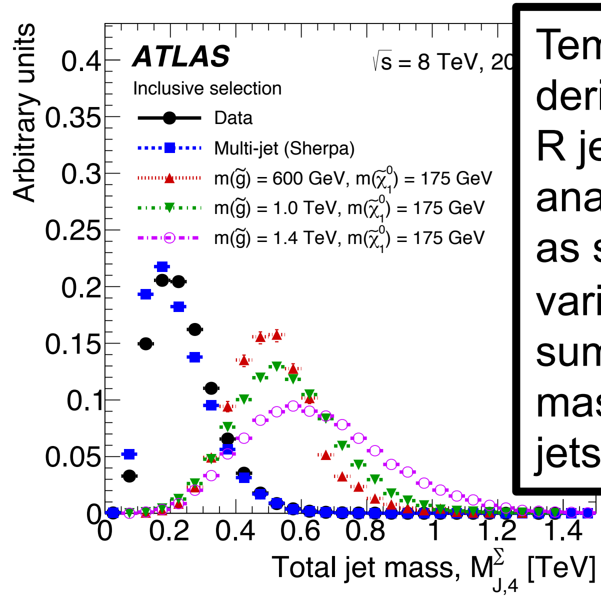
- Small backgrounds or rare processes use **Monte Carlo simulation**.

Background estimates checked with data in validation regions.

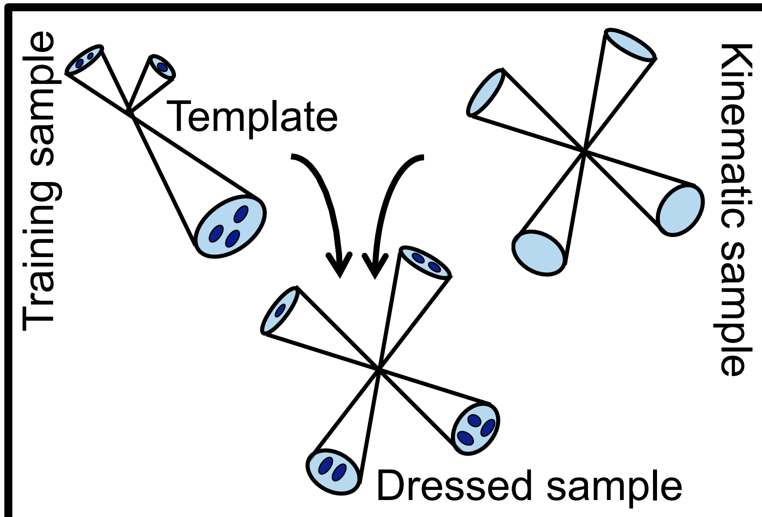
AN EXAMPLE – RPV MULTIJETS

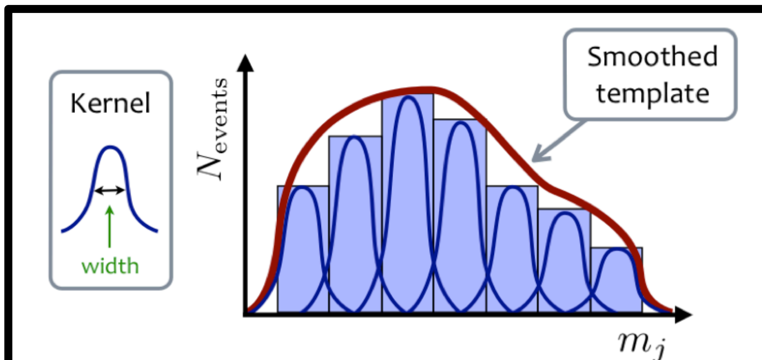
Search for massive SUSY particles decaying to jets.

- Search looks for SUSY in final states with high jet multiplicity and without requirements in MET. Additional requirement on b-jet multiplicity or M_J are applied.
- Challenging phase-space. Template methods have been used, validated using simulations and control regions. E.g. in the case of the M_J selections:



Templates are derived per large-R jet. The analysis uses M_J as sensitive variable, i.e. the sum of the masses of these jets.



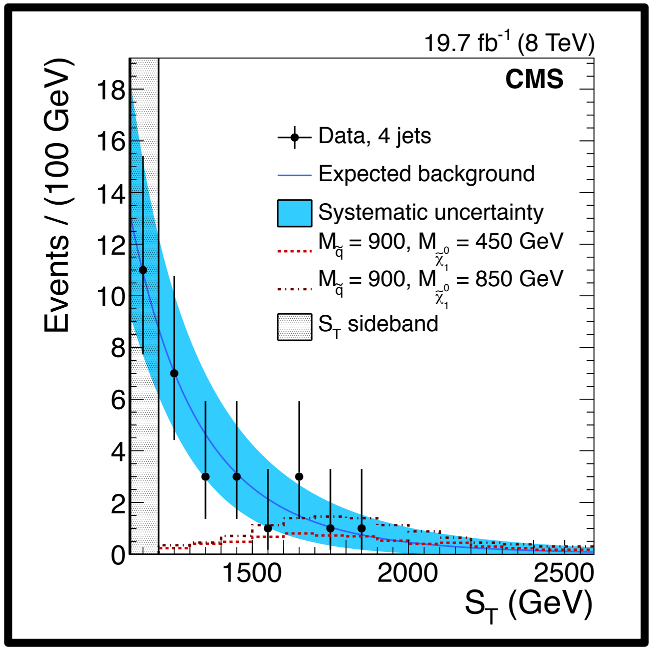


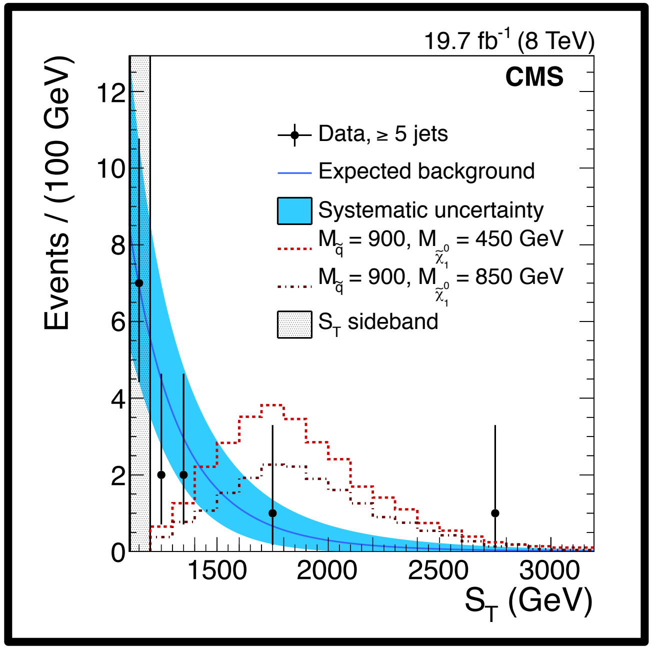
arXiv:1502.05686, drawings from T. Cohen.

FIT & EXTRAPOLATE

- Used in various cases, e.g. in all-hadronic CMS analyses that use composite observables.
- An example: search for stealth SUSY in events with jets, photons and low MET.
- Stealth SUSY models introduce a "hidden" sector with nearly mass-degenerate super-partners (low MET) and long decay chains (large object multiplicities). S_T = Sum(p_T) of all objects in the event is used as a discriminant.
- Background determination method: Assume S_T is independent to the jet multiplicity. Fit at low multiplicity, extrapolate to high multiplicity.

Region	N_{jets}	S_T (GeV)
Search	≥ 4	>1200
S_T sideband	≥ 4	1100–1200
N_{jets} sideband	$=3$	>1100





arXiv:1411.7255. ATLAS also looks for stealth SUSY: arXiv:1504.03634

THE HUNT FOR SUSY – VIA HIGGS

- **SUSY particles can decay via a Higgs boson as with any other Standard Model particle. Such decays have been explored, e.g.**

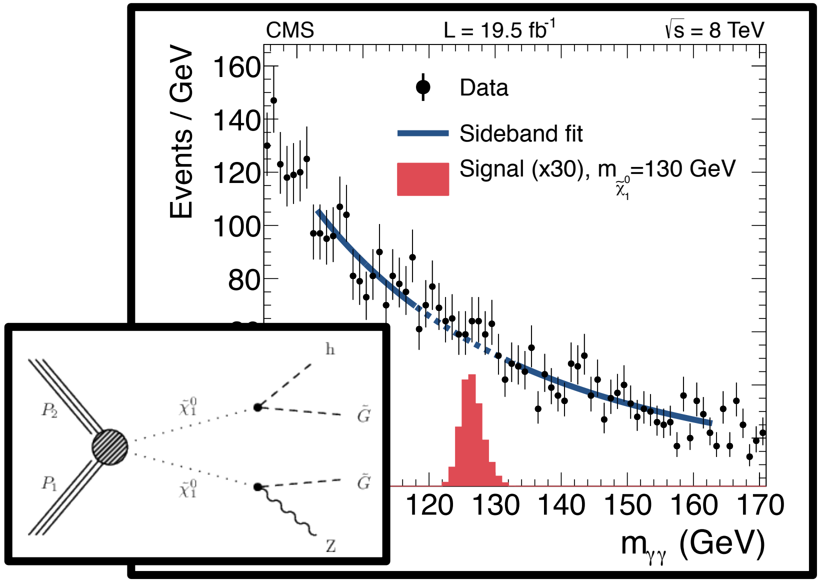
ATLAS:

- $\tilde{\chi}_1^{\pm} - \tilde{\chi}_2^0$ production, $\tilde{\chi}_2^0$ decays via Higgs to $\tilde{\chi}_1^0$.
- $\tilde{t}_2$ pair production, each decays to $\tilde{t}_1$ via Higgs, $\tilde{t}_1$ decays to $t - \tilde{\chi}_1^0$.
- $\tilde{g}$ pair production, each decays to $qq\tilde{\chi}_1^0$ and the $\tilde{\chi}_1^0$ decays to Higgs – $\tilde{G}$.

and CMS:

- $\tilde{\chi}_1^0$ pair production, one or both decay to Higgs – $\tilde{G}$.
- Electroweak production, sparticles decay to Higgs plus leptons.
- $\tilde{t}_2$ pair production, each decays to $\tilde{t}_1$ via Higgs, $\tilde{t}_1$ decays to $t - \tilde{\chi}_1^0$.
- Production of stops and higgsinos, in final states with Higgs – $\tilde{G}$, Higgs to 2γ.

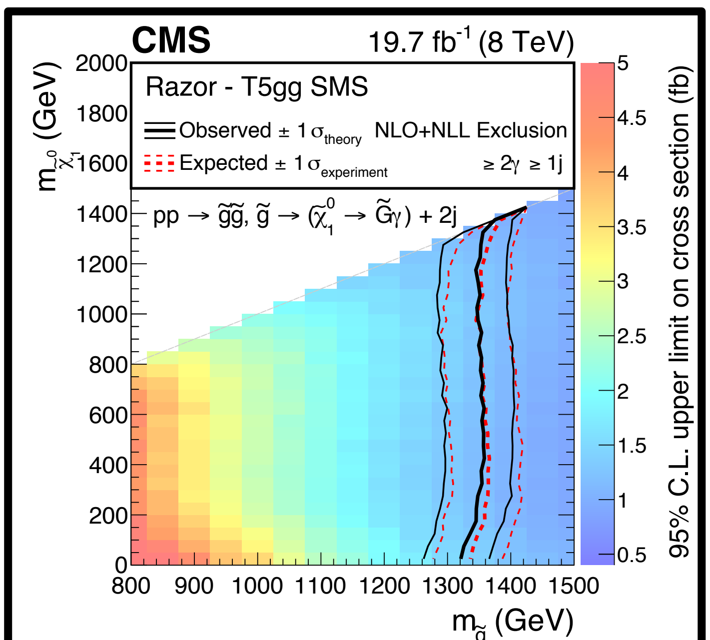
- **Various final states have been considered, to enhance sensitivity.**
  - Photons are a key signature (Higgs to 2γ or from $\tilde{\chi}_1^0$ to Higgs – $\tilde{G}$).
- **Null results. However a signal would manifest itself in a very intuitive and convincing way.**

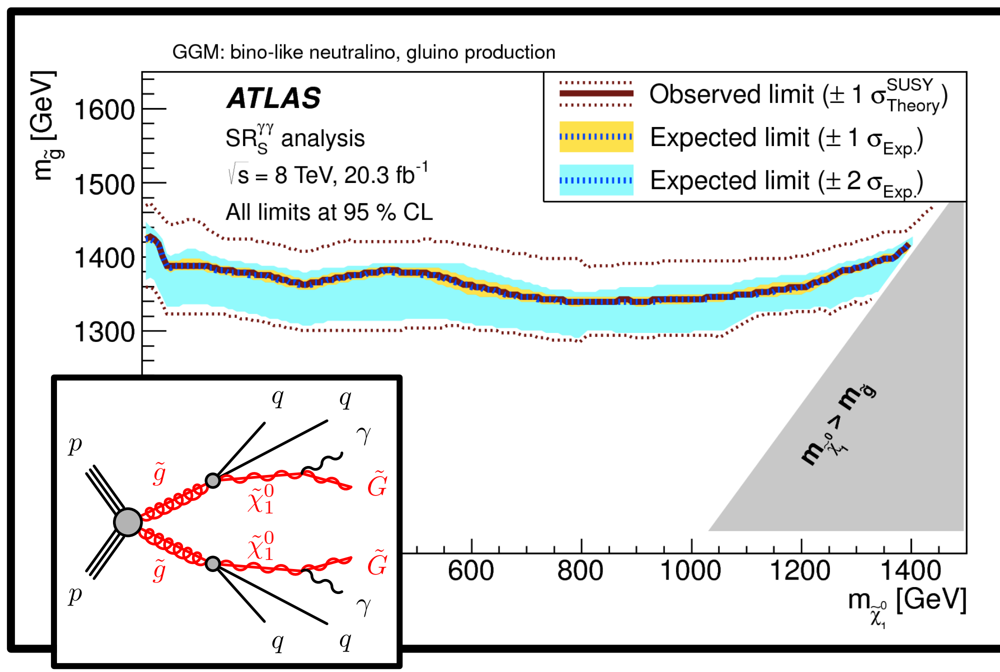


arXiv:1501.07110, 1409.3168, 1405.7570,1405.3886,1312.3310

THE HUNT FOR SUSY – PHOTONS

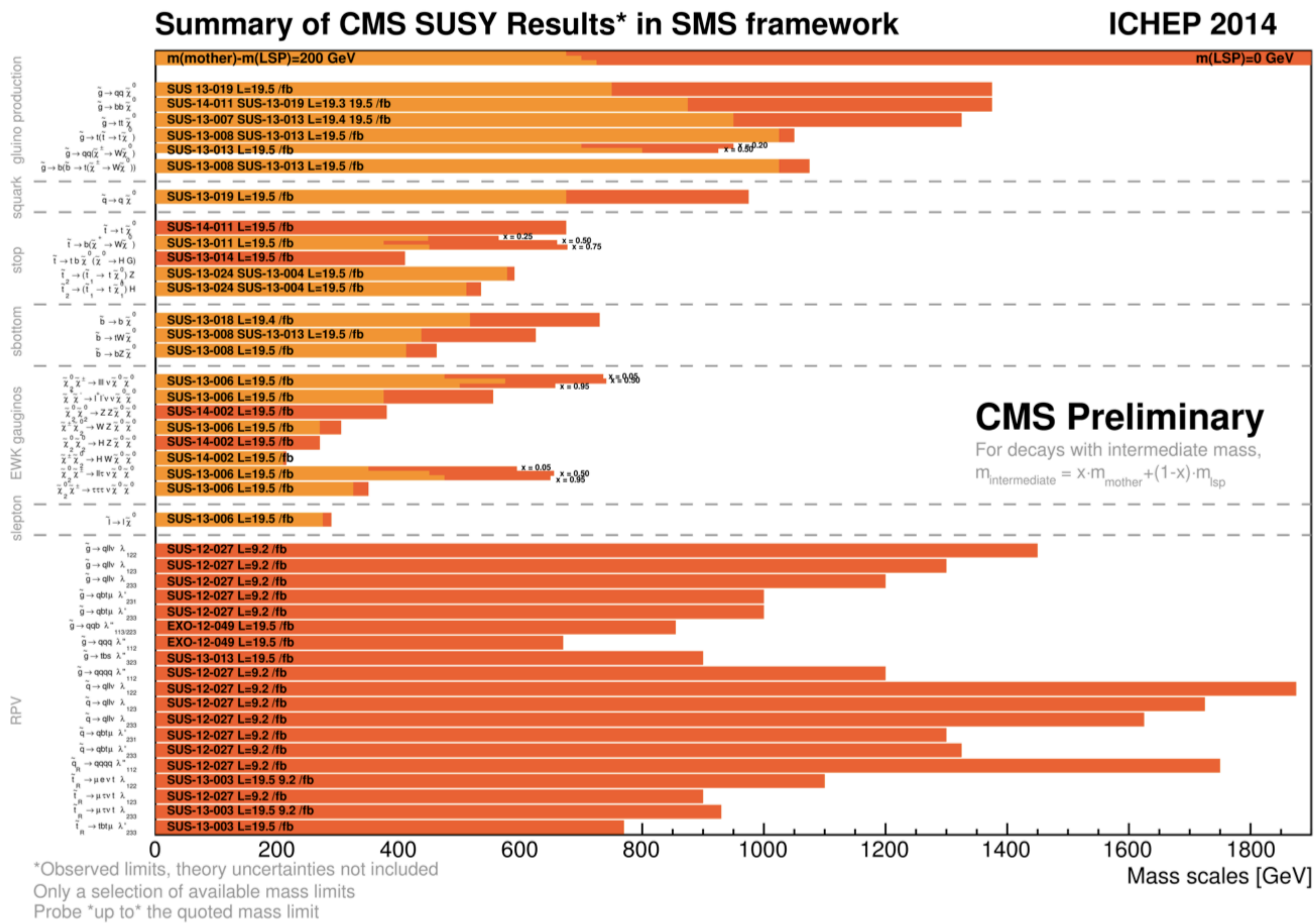
- Exploring gauge-mediated SUSY breaking, where the LSP is a very light (<1GeV) gravitino.
- Various final states (di-photon, photon + jet, photon + b-jet, photon + lepton) depending on the type of involved particles.
- ATLAS and CMS recently explored final states with photons.
  - Below limit plots for di-photon searches in gluino-bino models.





arXiv:1507.02898,arXiv:1507.05493

THE HUNT FOR SUSY – IN SUMMARY



THE HUNT FOR SUSY – IN SUMMARY

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: July 2015

ATLAS Preliminary

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

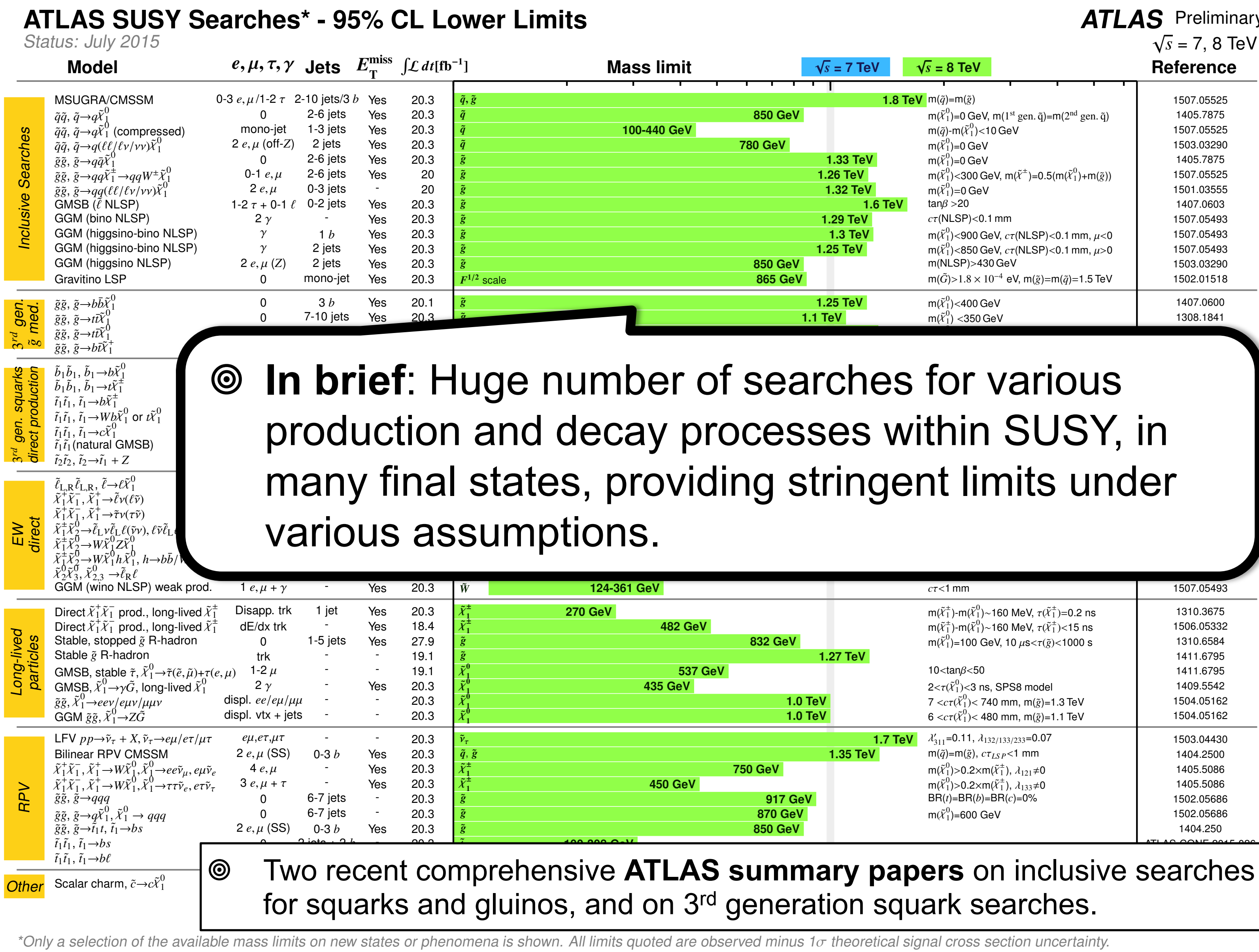
$\sqrt{s}$ = 7 TeV | $\sqrt{s}$ = 8 TeV

	Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L}\, dt[fb^{-1}]$	Mass limit		Reference
Inclusive Searches	MSUGRA/CMSSM	0-3 e,μ/1-2 τ	2-10 jets/3 b	Yes	20.3	$\tilde{q}, \tilde{g}$ 1.8 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	20.3	$\tilde{q}$ 850 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, m(1st gen. $\tilde{q}$)=m(2nd gen. $\tilde{q}$)	1405.7875
	$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}_1^0$ (compressed)	mono-jet	1-3 jets	Yes	20.3	$\tilde{q}$ 100-440 GeV	$m(\tilde{q})-m(\tilde{\chi}_1^0)$<10 GeV	1507.05525
	$\tilde{q}\tilde{q}, \tilde{q}\to q(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e,μ (off-Z)	2 jets	Yes	20.3	$\tilde{q}$ 780 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	20.3	$\tilde{g}$ 1.33 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	1405.7875
	$\tilde{g}\tilde{g}, \tilde{g}\to qq\tilde{\chi}_1^\pm\to qqW^\pm\tilde{\chi}_1^0$	0-1 e,μ	2-6 jets	Yes	20	$\tilde{g}$ 1.26 TeV	$m(\tilde{\chi}_1^0)$<300 GeV, $m(\tilde{\chi}^\pm)$=0.5($m(\tilde{\chi}_1^0)$+$m(\tilde{g})$)	1507.05525
	$\tilde{g}\tilde{g}, \tilde{g}\to qq(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e,μ	0-3 jets	-	20	$\tilde{g}$ 1.32 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	1501.03555
	GMSB ($\tilde{\ell}$ NLSP)	1-2 τ + 0-1 ℓ	0-2 jets	Yes	20.3	$\tilde{g}$ 1.6 TeV	tanβ >20	1407.0603
	GGM (bino NLSP)	2 γ	-	Yes	20.3	$\tilde{g}$ 1.29 TeV	$c\tau$(NLSP)<0.1 mm	1507.05493
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	20.3	$\tilde{g}$ 1.3 TeV	$m(\tilde{\chi}_1^0)$<900 GeV, $c\tau$(NLSP)<0.1 mm, μ<0	1507.05493
	GGM (higgsino-bino NLSP)	γ	2 jets	Yes	20.3	$\tilde{g}$ 1.25 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	$\tilde{g}$ 850 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	20.1	$\tilde{g}$ 1.25 TeV	$m(\tilde{\chi}_1^0)$<400 GeV	1407.0600
	$\tilde{g}\tilde{g}, \tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	$\tilde{g}$ 1.1 TeV	$m(\tilde{\chi}_1^0)$ <350 GeV	1308.1841
	$\tilde{g}\tilde{g}, \tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$ 1.34 TeV	$m(\tilde{\chi}_1^0)$<400 GeV	1407.0600
	$\tilde{g}\tilde{g}, \tilde{g}\to b\bar{t}\tilde{\chi}_1^+$	0-1 e,μ	3 b	Yes	20.1	$\tilde{g}$ 1.3 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	20.1	$\tilde{b}_1$ 100-620 GeV	$m(\tilde{\chi}_1^0)$<90 GeV	1308.2631
	$\tilde{b}_1\tilde{b}_1, \tilde{b}_1\to t\tilde{\chi}_1^\pm$	2 e,μ (SS)	0-3 b	Yes	20.3	$\tilde{b}_1$ 275-440 GeV	$m(\tilde{\chi}_1^\pm)$=2 $m(\tilde{\chi}_1^0)$	1404.2500
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to b\tilde{\chi}_1^\pm$	1-2 e,μ	1-2 b	Yes	4.7/20.3	$\tilde{t}_1$ 110-167 GeV, 230-460 GeV	$m(\tilde{\chi}_1^\pm)$ = 2$m(\tilde{\chi}_1^0)$, $m(\tilde{\chi}_1^0)$=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	$\tilde{t}_1$ 90-191 GeV, 210-700 GeV	$m(\tilde{\chi}_1^0)$=1 GeV	1506.08616
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to c\tilde{\chi}_1^0$	0	mono-jet/c-tag	Yes	20.3	$\tilde{t}_1$ 90-240 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	$\tilde{t}_1$ 150-580 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	$\tilde{t}_2$ 290-600 GeV	$m(\tilde{\chi}_1^0)$<200 GeV	1403.5222
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	$\tilde{\ell}$ 90-325 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	$\tilde{\chi}_1^\pm$ 140-465 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	$\tilde{\chi}_1^\pm$ 100-350 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	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ 700 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
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 Z\tilde{\chi}_1^0$	2-3 e,μ	0-2 jets	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ 420 GeV	$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, sleptons decoupled	1403.5294, 1402.7029
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 h\tilde{\chi}_1^0, h\to b\bar{b}/WW/\tau\tau/\gamma\gamma$	e,μ,γ	0-2 b	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$ 250 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	$\tilde{\chi}_{2,3}^0$ 620 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,μ + γ	-	Yes	20.3	$\tilde{W}$ 124-361 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	$\tilde{\chi}_1^\pm$ 482 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	$\tilde{g}$ 832 GeV	$m(\tilde{\chi}_1^0)$=100 GeV, 10 μs<$\tau(\tilde{g})$<1000 s	1310.6584
	Stable $\tilde{g}$ R-hadron	trk	-	-	19.1	$\tilde{g}$ 1.27 TeV		1411.6795
	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<tanβ<50	1411.6795
	GMSB, $\tilde{\chi}_1^0\to\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$	2 γ	-	Yes	20.3	$\tilde{\chi}_1^0$ 435 GeV	2<$\tau(\tilde{\chi}_1^0)$<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	$\tilde{q}, \tilde{g}$ 1.35 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	$\tilde{\chi}_1^\pm$ 750 GeV	$m(\tilde{\chi}_1^0)$>0.2×$m(\tilde{\chi}_1^\pm)$, $\lambda_{121}\neq0$	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,μ + τ	-	Yes	20.3	$\tilde{\chi}_1^\pm$ 450 GeV	$m(\tilde{\chi}_1^0)$>0.2×$m(\tilde{\chi}_1^\pm)$, $\lambda_{133}\neq0$	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
	$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}\tilde{\chi}_1^0, \tilde{\chi}_1^0\to qqq$	0	6-7 jets	-	20.3	$\tilde{g}$ 870 GeV	$m(\tilde{\chi}_1^0)$=600 GeV	1502.05686
	$\tilde{g}\tilde{g}, \tilde{g}\to\tilde{t}_1 t, \tilde{t}_1\to bs$	2 e,μ (SS)	0-3 b	Yes	20.3	$\tilde{g}$ 850 GeV		1404.250
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to bs$	0	2 jets + 2 b	-	20.3	$\tilde{t}_1$ 100-308 GeV		ATLAS-CONF-2015-026
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to b\ell$	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	$\tilde{c}$ 490 GeV	$m(\tilde{\chi}_1^0)$<200 GeV	1501.01325

10^{-1} 1 **Mass scale [TeV]**

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

THE HUNT FOR SUSY – IN SUMMARY



- **In brief**: Huge number of searches for various production and decay processes within SUSY, in many final states, providing stringent limits under various assumptions.

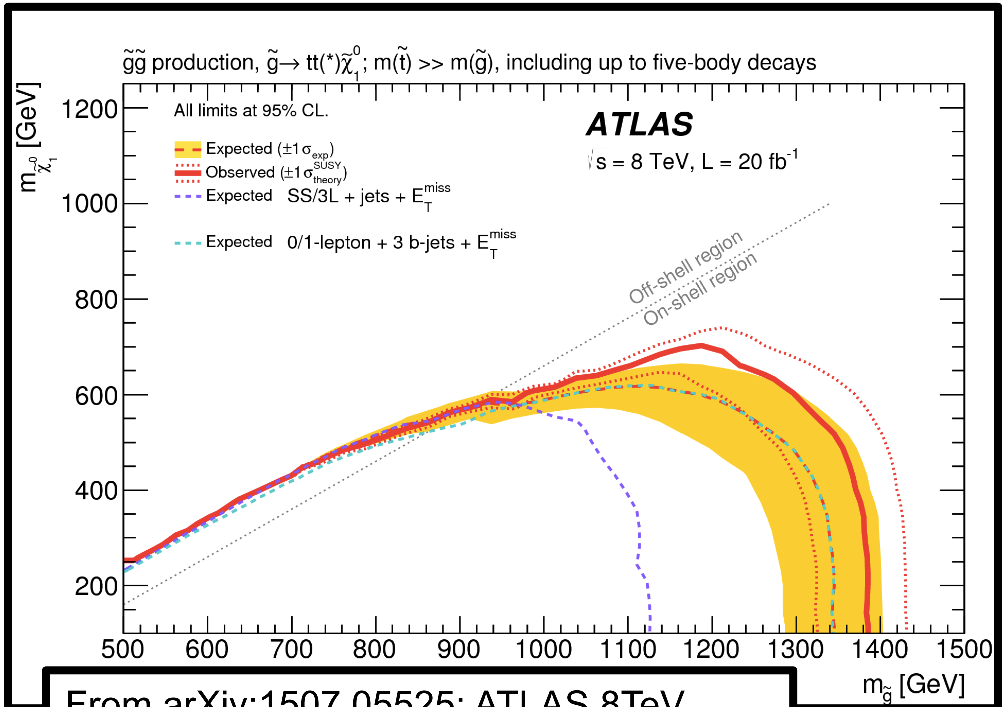
- Two recent comprehensive **ATLAS summary papers** on inclusive searches for squarks and gluinos, and on 3rd generation squark searches.

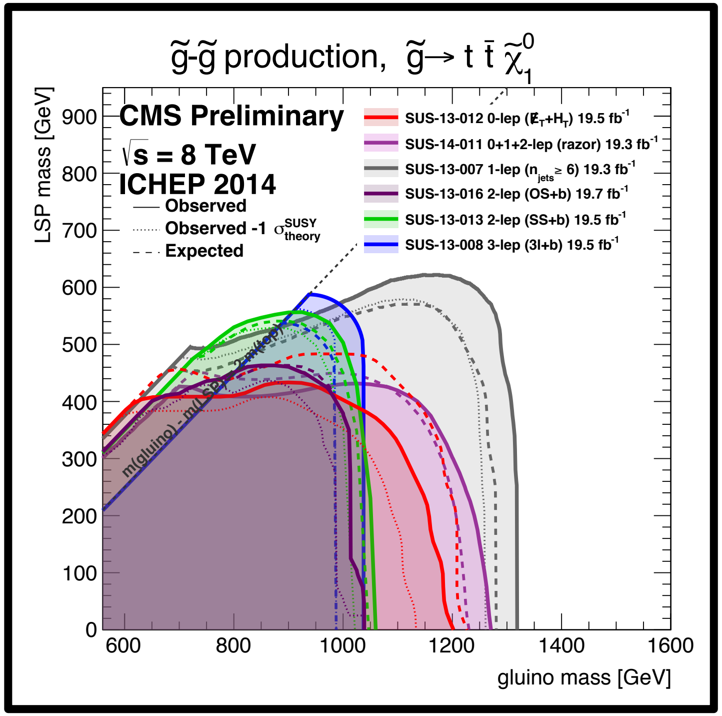
TALK OUTLINE

- A short introduction
- The hunt for SUSY
- **Summary results and combinations**
- The few tantalizing results
- Towards Run2

STRONG PRODUCTION SEARCHES

- Large range of final states has been investigated. Results interpreted in the context of many models, 'real' and simplified.
- E.g. one of the best-motivated ones by naturalness considerations.



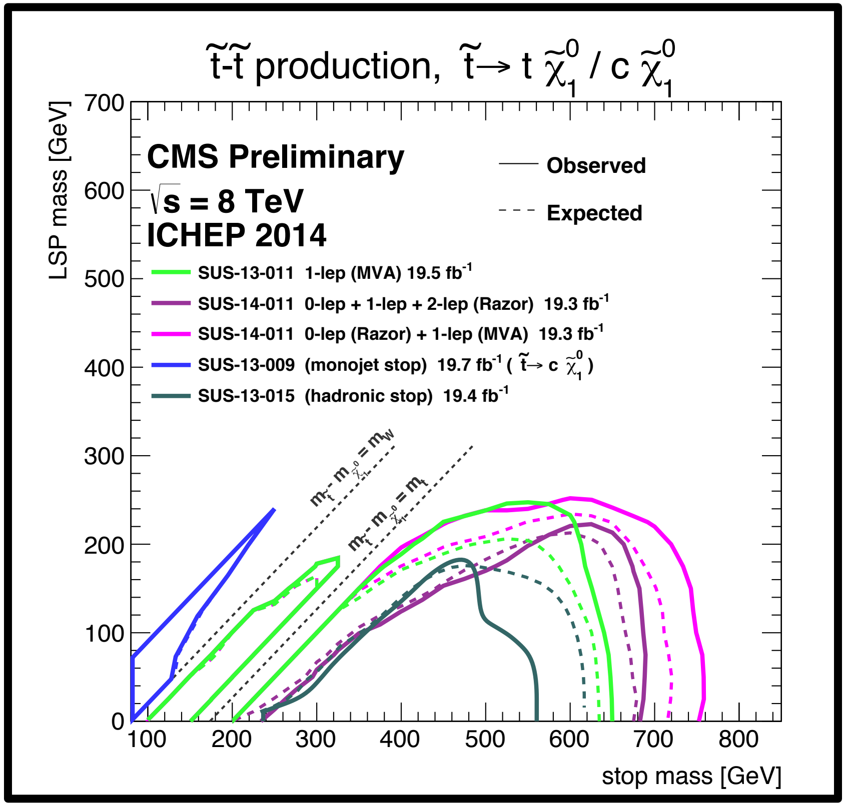


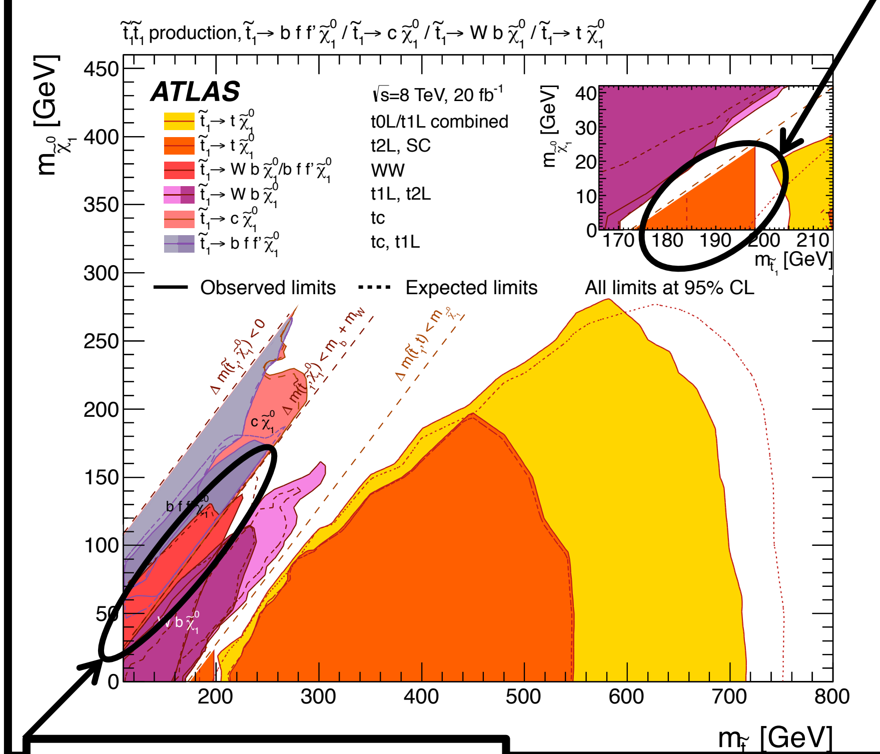
From arXiv:1507.05525: ATLAS 8TeV SUSY strong production summary paper, including a long list of re-interpretations.

THIRD GENERATION SEARCHES

- Various decay topologies, depending on stop mass.
- Stops excluded up to 700-800GeV (under assumptions).
- Various holes in the phase-space still unexplored.

Limit using spin correlation analysis.

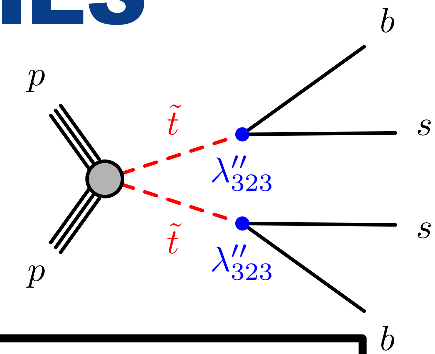


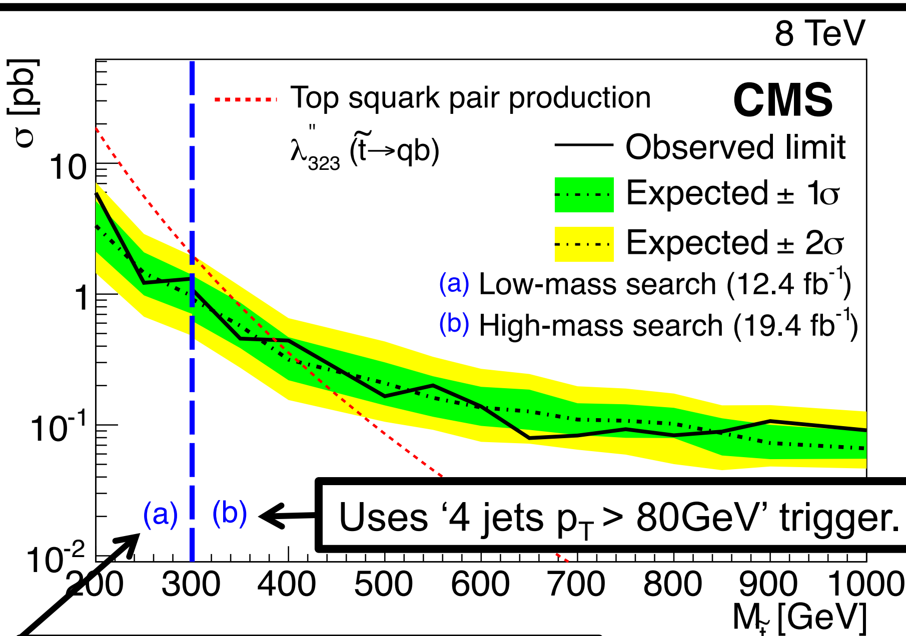


New analysis dedicated to cover this hole.

THIRD GENERATION SEARCHES

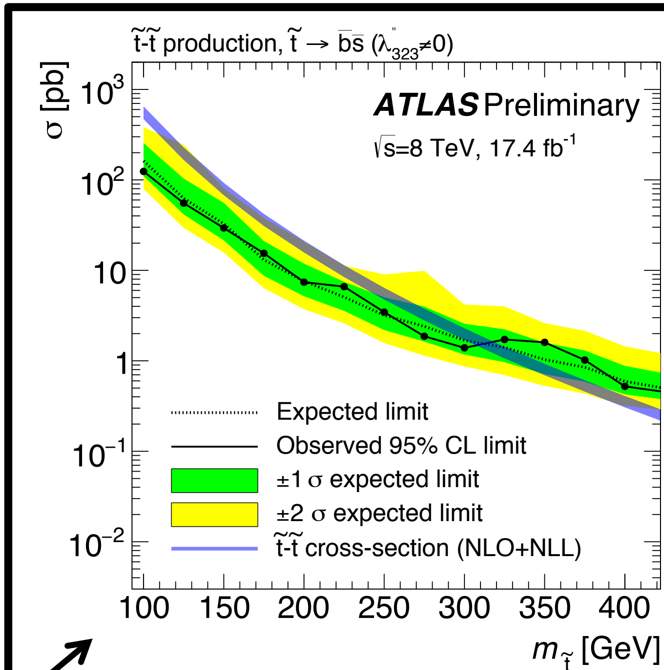
- Various decay topologies, depending on stop mass.
- Stops excluded up to 700-800GeV (under assumptions).
- Various holes in the phase-space still unexplored.
  - E.g. RPV stop decays.





Uses ‘4 jets p_T > 80GeV’ trigger.

Uses prescaled triggers, down to ‘4 jets p_T > 45GeV’.

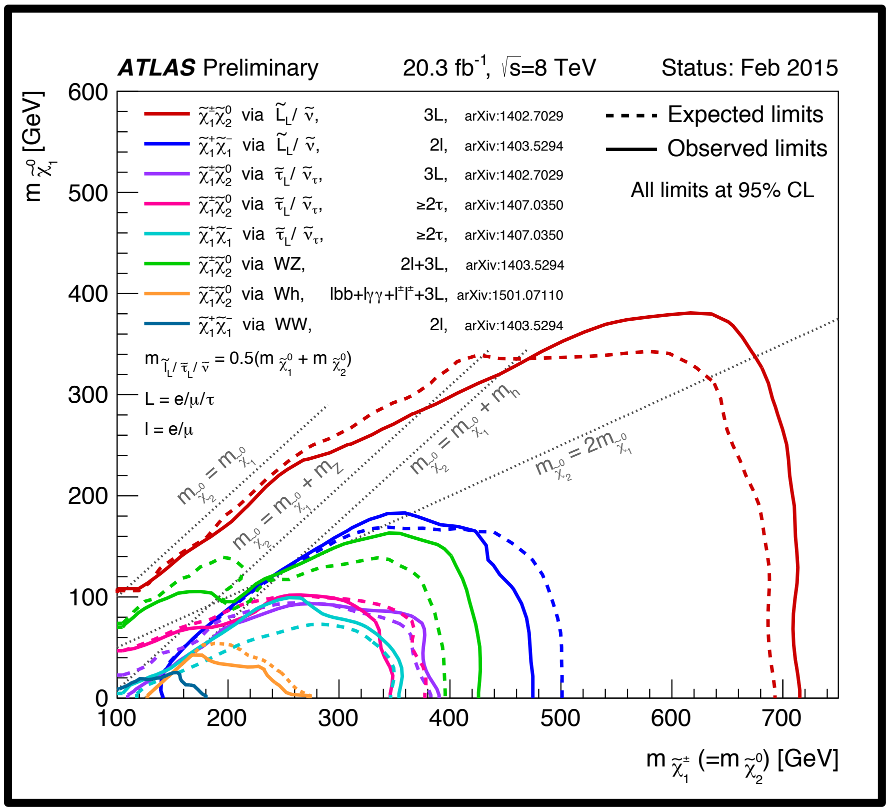


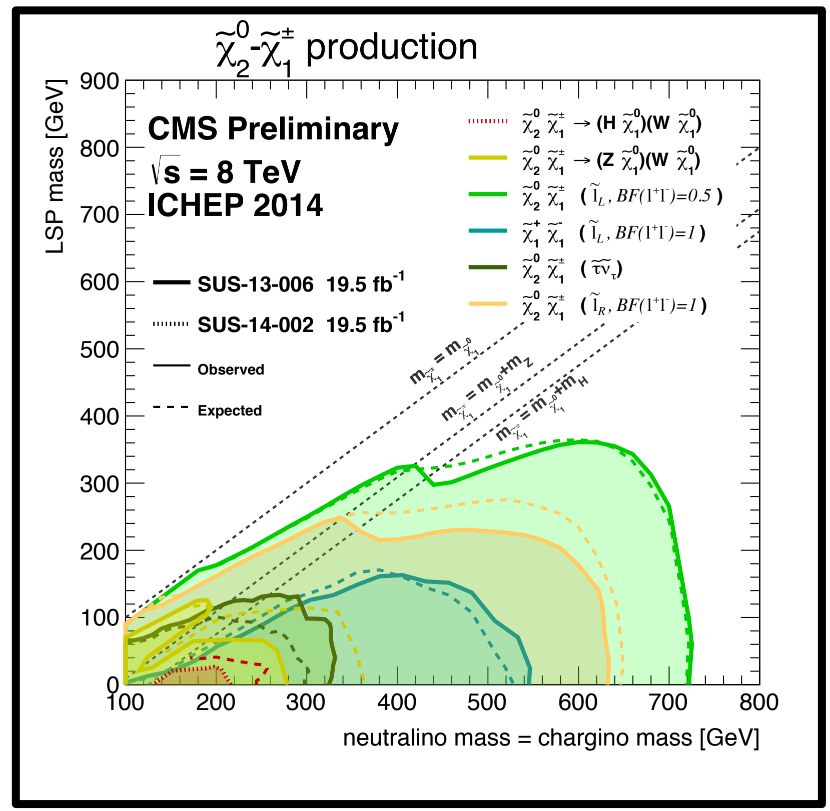
Uses ‘H_T>500GeV’ trigger, which was stored for delayed reconstruction – rather than ‘H_T>700GeV’ that was promptly reconstructed.

arXiv:1412.7706, ATLAS-CONF-2015-026

ELECTROWEAK PRODUCTION SEARCHES

- Lower cross-section, but light Higgsinos favored by naturalness arguments.
- Many possible channels explored.





- Higgsino LSP not accessible yet. A challenge for the LHC. New ideas needed.

ELECTROWEAK PRODUCTION SEARCHES

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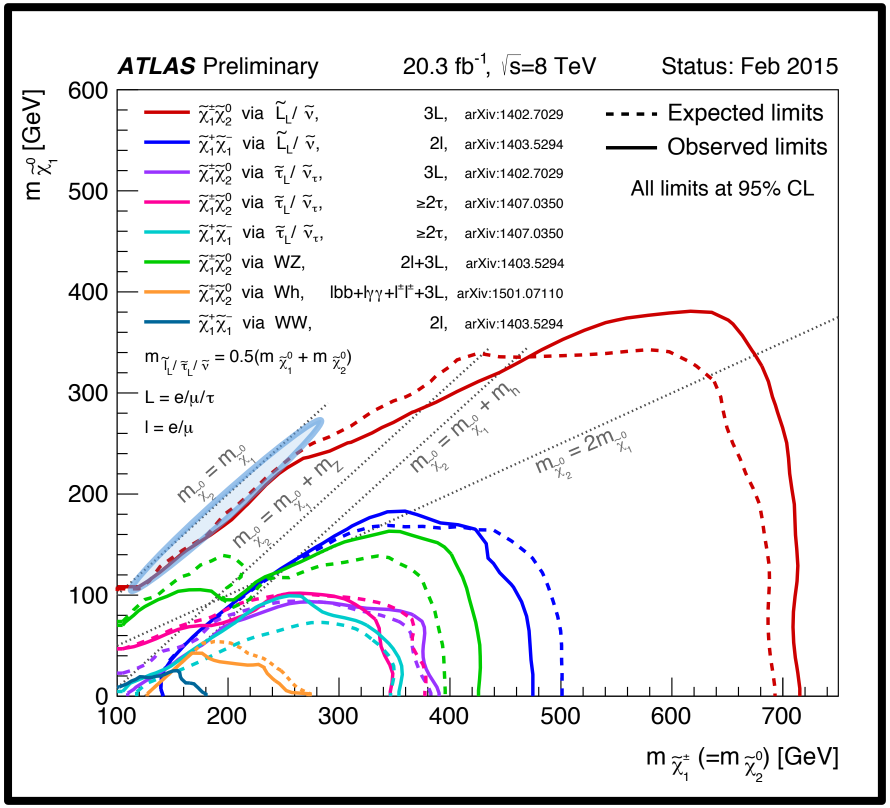
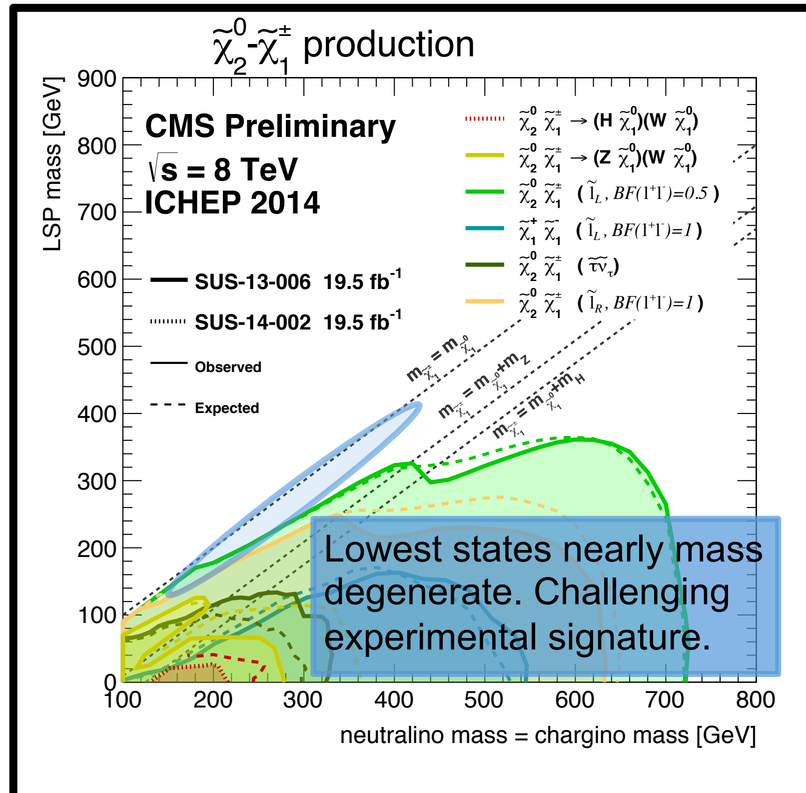
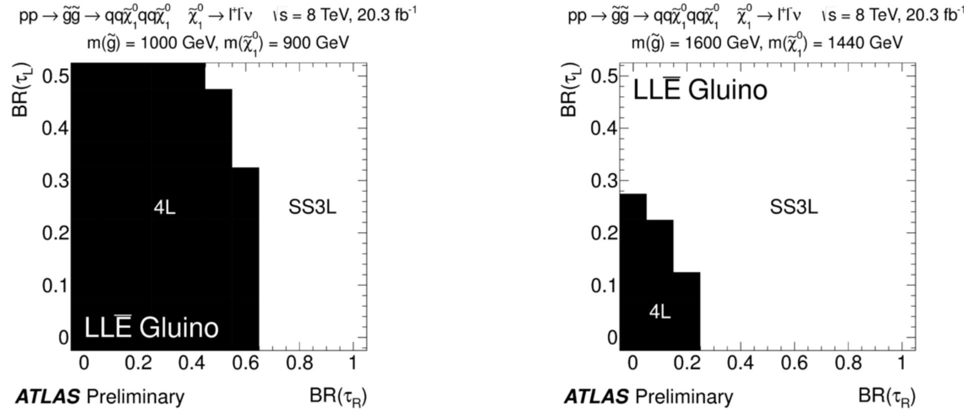




- Higgsino LSP not accessible yet. A challenge for the LHC. New ideas needed.

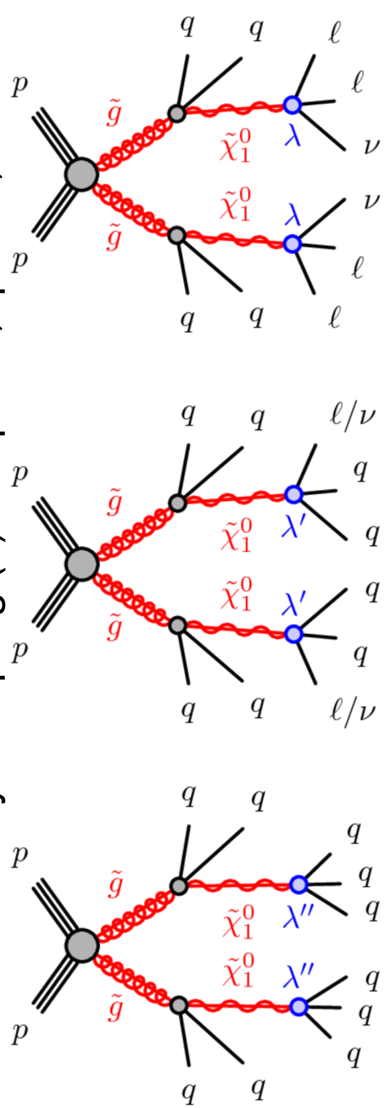
RPV

- Rich set of dedicated searches investigating RPV signatures.
- Rich set of re-interpretations of RPC searches.
  - Coverage of ‘generic’ searches is at cases broader than this of dedicated ones.

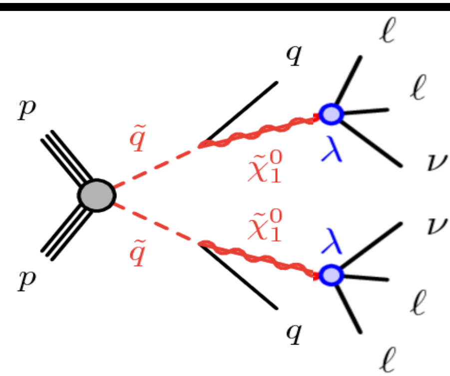


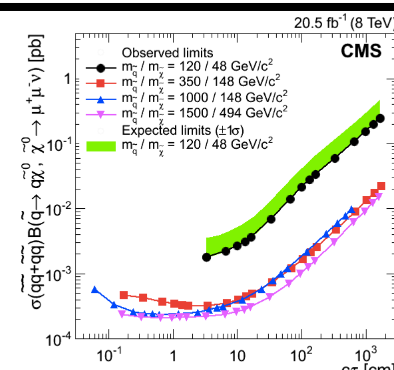
- Depending on the couplings, neutralinos can be long-lived creating displaced-vertex signatures.
- Many searches using various non-standard methods, especially in tracking. Extremely challenging at the trigger.

Neutralino decays coupling (λ) to leptons, quarks, or both.



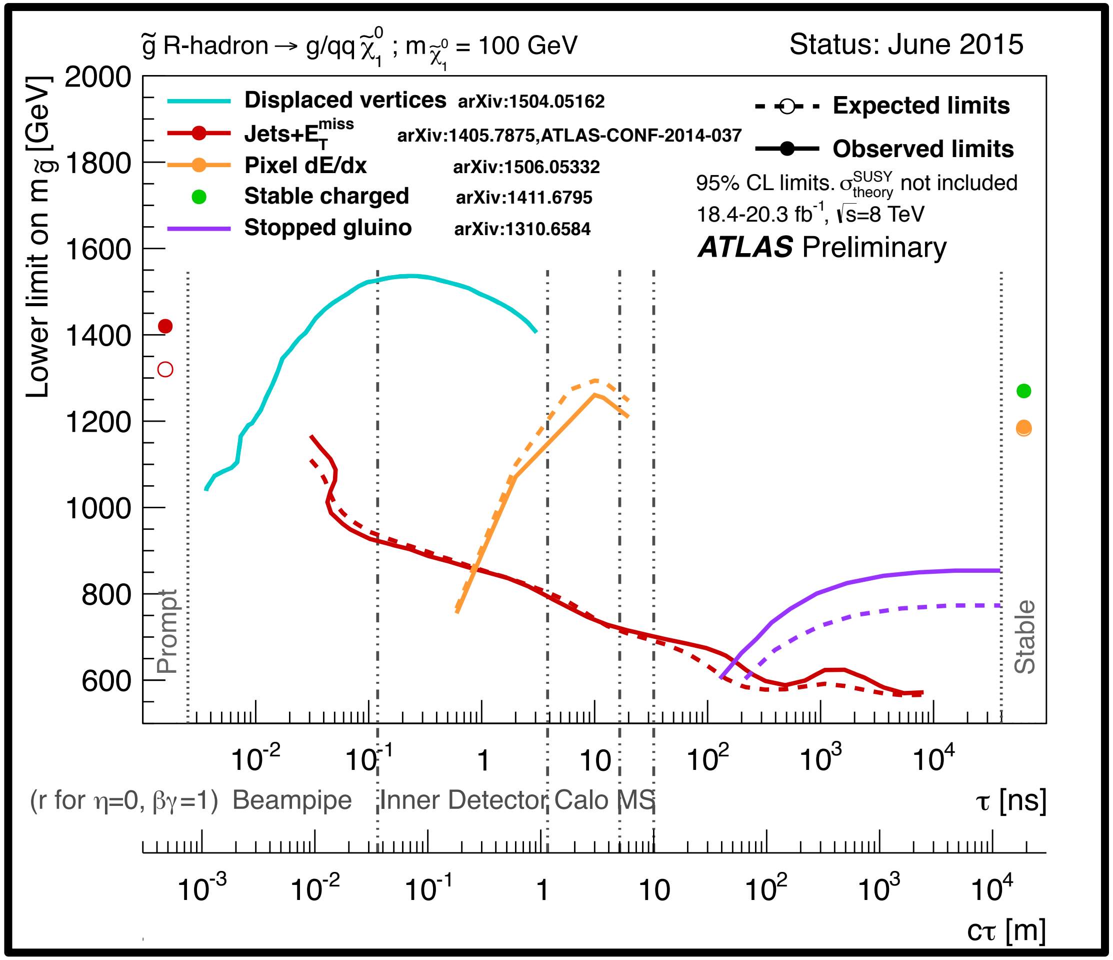
E.g. di-lepton DV search at CMS.





arXiv:1411.6977,arXiv:1504.05162,ATLAS-CONF-2015-018

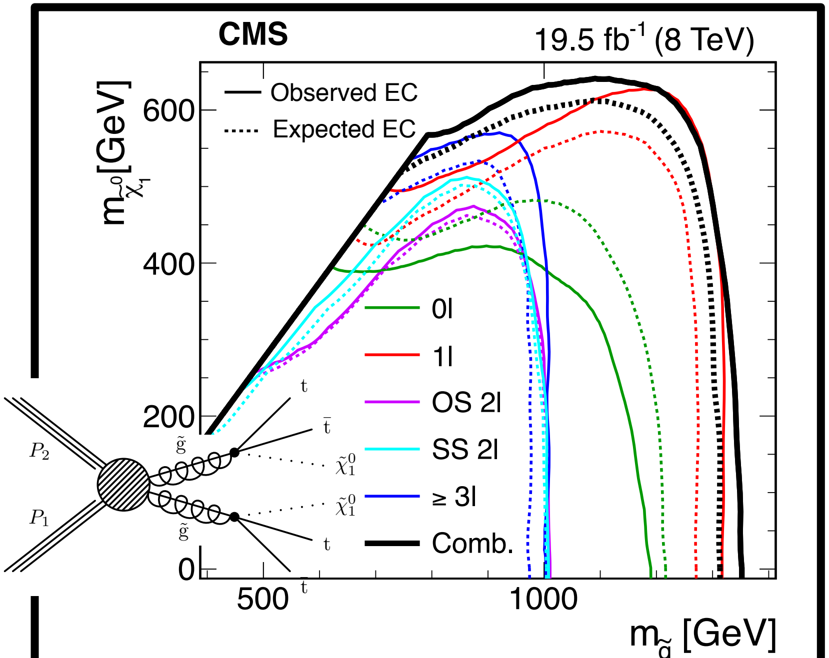
LONG LIVED PARTICLES



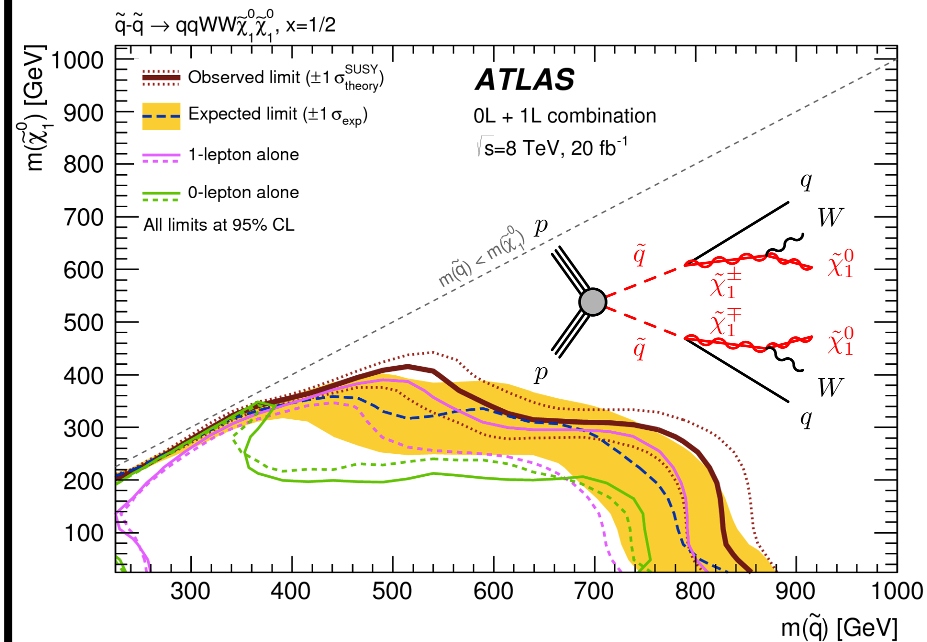
- Dedicated searches and re-interpretations provide a stringent coverage over a large range of lifetimes.

COMBINATIONS

- Many results in various (exclusive between each other) final states have been combined statistically to provide improved reach.
- Statistical combinations not possible by theorist who are recasting our results. E.g. treatment of correlations can be tricky.



Combination of 5 different analyses. Extension of limits by ~35GeV in m_{gluino} for light neutralinos, or ~25% in cross-section reach.



Combination of 0-lepton and 1-lepton analyses (various signal regions each). Extension of limits by ~50GeV in m_{gluino} for light neutralinos, or ~40% in cross-section reach.

arXiv:1412.4109, 1507.05525

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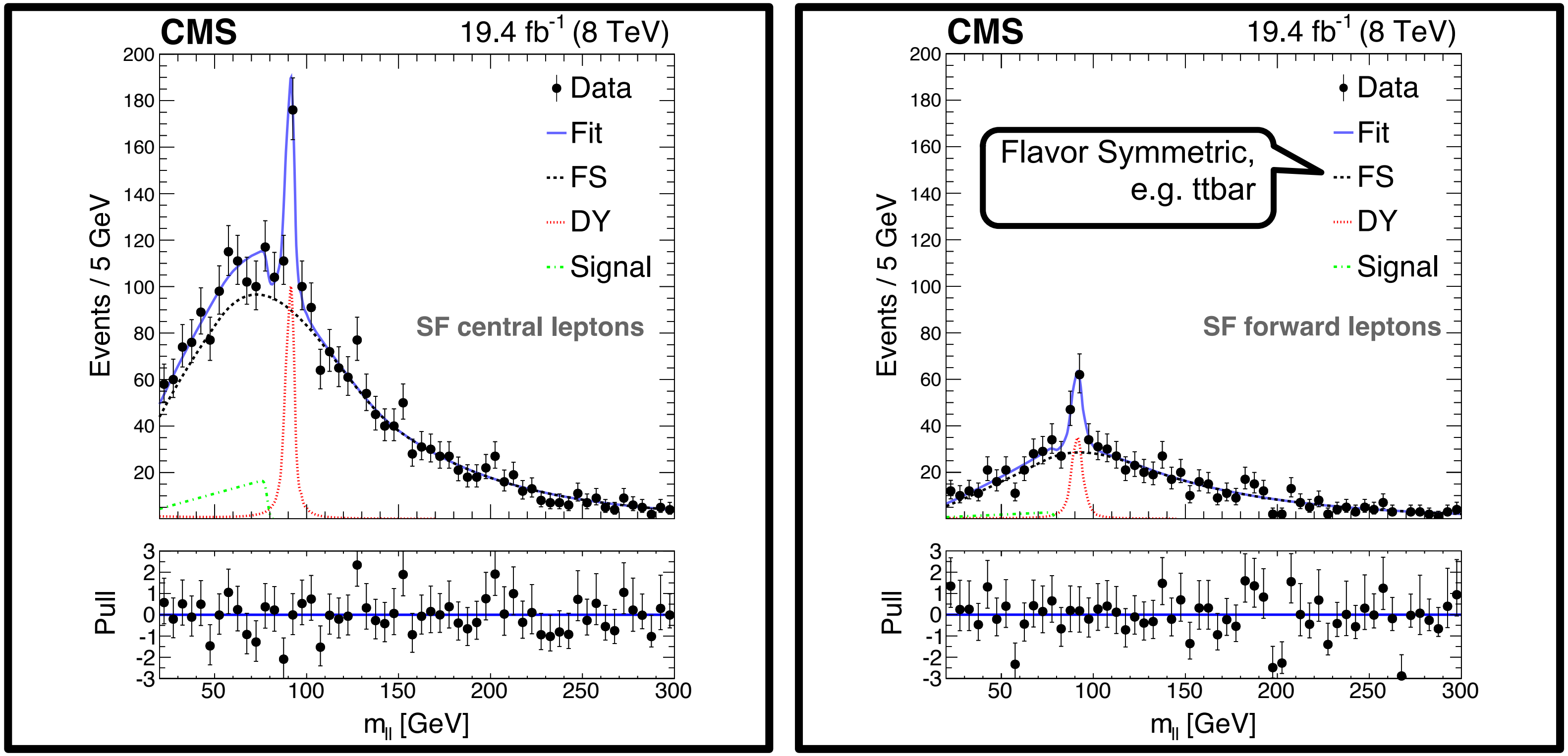
THREE TANTALIZING EXCESSES – 1.

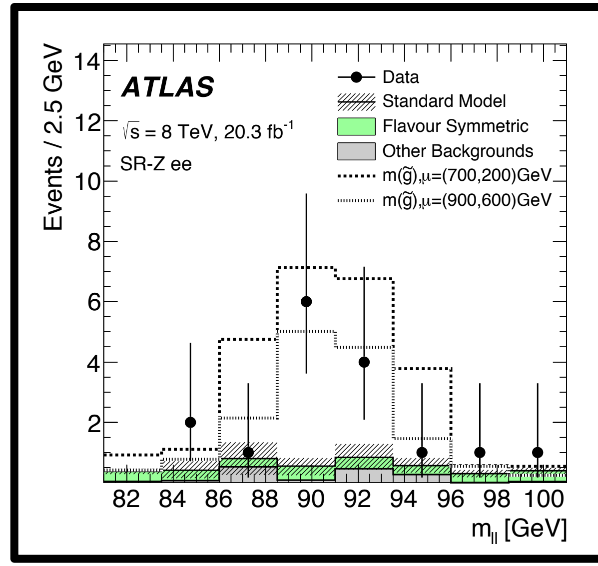
- Search for strongly produced SUSY in final states with 2 leptons, jets and MET at CMS.
- Data-driven methods for major backgrounds, x-checked with MC.
- Kinematic fit in signal regions.
- Excess in low m_{ll} (20-70GeV) at 2.6σ level (maximum deviation).
  - Excess not confirmed by ATLAS in a similar analysis.

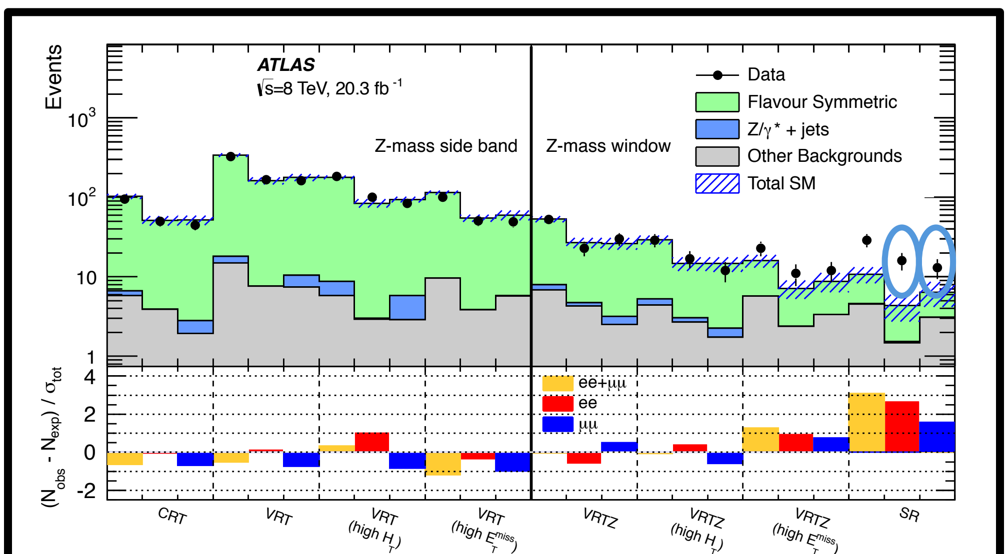


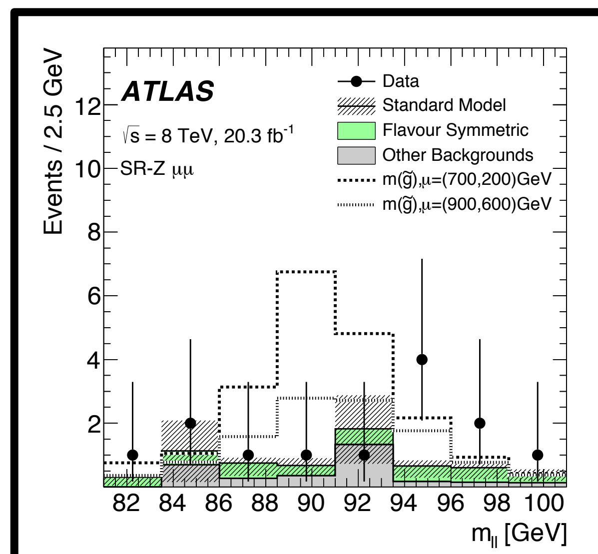
arXiv:1502.06031, arXiv:1503.03290

THREE TANTALIZING EXCESSES – 2.

- Search for strongly produced SUSY in final states with 2 leptons consistent with a Z boson, jets, MET and HT at ATLAS.
- Data-driven methods for all major backgrounds, x-checked with alternatives/MC.
- 1.7σ excess in μμ, 3.0σ excess in ee.
  - Not confirmed by CMS, though the overlap with the ATLAS search is small.







arXiv:1502.06031, arXiv:1503.03290

THREE TANTALIZING EXCESSES – 3.

3 leptons $H_T > 200$ GeV	$m_{\ell^+\ell^-}$	E_T^{miss} (GeV)	$N_{\tau_h}=0, N_b=0$ Obs.	Exp.	$N_{\tau_h}=1, N_b=0$ Obs.	Exp.	$N_{\tau_h}=0, N_b\geq 1$ Obs.	Exp.	$N_{\tau_h}=1, N_b\geq 1$ Obs.	Exp.
OSSF0	—	(100, ∞)	5	3.7 ± 1.6	35	33 ± 14	1	5.5 ± 2.2	47	61 ± 30
OSSF0	—	(50, 100)	3	3.5 ± 1.4	34	36 ± 16	8	7.7 ± 2.7	82	91 ± 46
OSSF0	—	(0, 50)	4	2.1 ± 0.8	25	25 ± 10	1	3.6 ± 1.5	52	59 ± 29
OSSF1	Above-Z	(100, ∞)	5	3.6 ± 1.2	2	10.0 ± 4.8	3	4.7 ± 1.6	19	22 ± 11
OSSF1	Below-Z	(100, ∞)	7	9.7 ± 3.3	18	14.0 ± 6.4	8	9.1 ± 3.4	21	23 ± 11
OSSF1	On-Z	(100, ∞)	39	61 ± 23	17	15.0 ± 4.9	9	14.0 ± 4.4	10	12.0 ± 5.8
OSSF1	Above-Z	(50, 100)	4	5.0 ± 1.6	14	11.0 ± 5.2	6	6.8 ± 2.4	32	30 ± 15
OSSF1	Below-Z	(50, 100)	10	11.0 ± 3.8	24	19.0 ± 6.4	10	9.9 ± 3.7	25	32 ± 16
OSSF1	On-Z	(50, 100)	78	80 ± 32	70	50 ± 11	22	22.0 ± 6.3	36	24.0 ± 9.8
OSSF1	Above-Z	(0, 50)	3	7.3 ± 2.0	41	33.0 ± 8.7	4	5.3 ± 1.5	15	23 ± 11
OSSF1	Below-Z	(0, 50)	26	25.0 ± 6.8	110	86 ± 23	5	10.0 ± 2.5	24	26 ± 11
OSSF1	On-Z	(0, 50)	*135	130 ± 41	542	540 ± 160	31	32.0 ± 6.5	86	75 ± 19
3 leptons $H_T < 200$ GeV	**$m_{\ell^+\ell^-}$**	**E_T^{miss} (GeV)**	**$N_{\tau_h}=0, N_b=0$ Obs.**	**Exp.**	**$N_{\tau_h}=1, N_b=0$ Obs.**	**Exp.**	**$N_{\tau_h}=0, N_b\geq 1$ Obs.**	**Exp.**	**$N_{\tau_h}=1, N_b\geq 1$ Obs.**	**Exp.**
OSSF0	—	(100, ∞)	7	11.0 ± 4.9	101	111 ± 54	13	10.0 ± 5.3	87	119 ± 61
OSSF0	—	(50, 100)	35	38 ± 15	406	402 ± 152	29	26 ± 13	269	298 ± 151
OSSF0	—	(0, 50)	53	51 ± 11	910	1035 ± 255	29	23 ± 10	237	240 ± 113
OSSF1	Above-Z	(100, ∞)	18	13.0 ± 3.5	25	38 ± 18	10	6.5 ± 2.9	24	35 ± 18
OSSF1	Below-Z	(100, ∞)	21	24 ± 9	41	50 ± 25	14	20 ± 10	42	54 ± 28
OSSF1	On-Z	(100, ∞)	150	150 ± 26	39	48 ± 13	15	14.0 ± 4.8	19	23 ± 11
OSSF1	Above-Z	(50, 100)	50	46.0 ± 9.7	169	140 ± 48	20	18 ± 8	85	93 ± 47
OSSF1	Below-Z	(50, 100)	142	130 ± 27	353	360 ± 92	48	48 ± 23	140	133 ± 68
OSSF1	On-Z	(50, 100)	*773	780 ± 120	1276	1200 ± 310	56	47 ± 13	81	75 ± 32
OSSF1	Above-Z	(0, 50)	178	200 ± 35	1676	1900 ± 540	17	18.0 ± 6.7	115	94 ± 42
OSSF1	Below-Z	(0, 50)	510	560 ± 87	9939	9000 ± 2700	34	42 ± 11	226	228 ± 63
OSSF1	On-Z	(0, 50)	*3869	4100 ± 670	*50188	50000 ± 15000	*148	156 ± 24	906	925 ± 263

≥4 leptons $H_T > 200$ GeV	$m_{\ell^+\ell^-}$	E_T^{miss} (GeV)	$N_{\tau_h}=0, N_b=0$ Obs.	Exp.	$N_{\tau_h}=1, N_b=0$ Obs.	Exp.	$c_{\tau_h}=0, N_b\geq 1$ Obs.	Exp.	$N_{\tau_h}=1, N_b\geq 1$ Obs.	Exp.
OSSF0	—	(100, ∞)	0	$0.01^{+0.03}_{-0.01}$	0	$0.01^{+0.06}_{-0.01}$	0	$0.02^{+0.04}_{-0.02}$	0	0.11 ± 0.08
OSSF0	—	(50, 100)	0	$0.00^{+0.02}_{-0.00}$	0	$0.01^{+0.06}_{-0.01}$	0	$0.00^{+0.03}_{-0.00}$	0	0.12 ± 0.07
OSSF0	—	(0, 50)	0	$0.00^{+0.02}_{-0.00}$	0	$0.07^{+0.10}_{-0.07}$	0	$0.00^{+0.02}_{-0.00}$	0	0.02 ± 0.02
OSSF1	Off-Z	(100, ∞)	0	$0.01^{+0.02}_{-0.01}$	1	0.25 ± 0.11	0	0.13 ± 0.08	0	0.12 ± 0.12
OSSF1	On-Z	(100, ∞)	1	0.10 ± 0.06	0	0.50 ± 0.27	0	0.42 ± 0.22	0	0.42 ± 0.19
OSSF1	Off-Z	(50, 100)	0	0.07 ± 0.06	1	0.29 ± 0.13	0	0.04 ± 0.04	0	0.23 ± 0.13
OSSF1	On-Z	(50, 100)	0	0.23 ± 0.11	1	0.70 ± 0.31	0	0.23 ± 0.13	1	0.34 ± 0.16
OSSF1	Off-Z	(0, 50)	0	$0.02^{+0.03}_{-0.02}$	0	0.27 ± 0.12	0	$0.03^{+0.04}_{-0.03}$	0	0.31 ± 0.15
OSSF1	On-Z	(0, 50)	0	0.20 ± 0.08	0	1.3 ± 0.5	0	0.06 ± 0.04	1	0.49 ± 0.19
OSSF2	Off-Z	(100, ∞)	0	$0.01^{+0.02}_{-0.01}$	—	—	0	$0.01^{+0.06}_{-0.01}$	—	—
OSSF2	On-Z	(100, ∞)	1	$0.15^{+0.16}_{-0.15}$	—	—	0	0.34 ± 0.18	—	—
OSSF2	Off-Z	(50, 100)	0	0.03 ± 0.02	—	—	0	0.13 ± 0.09	—	—
OSSF2	On-Z	(50, 100)	0	0.80 ± 0.40	—	—	0	0.36 ± 0.19	—	—
OSSF2	Off-Z	(0, 50)	1	0.27 ± 0.13	—	—	0	0.08 ± 0.05	—	—
OSSF2	On-Z	(0, 50)	5	7.4 ± 3.5	—	—	2	0.80 ± 0.40	—	—
≥4 leptons $H_T < 200$ GeV	**$m_{\ell^+\ell^-}$**	**E_T^{miss} (GeV)**	**$N_{\tau_h}=0, N_b=0$ Obs.**	**Exp.**	**$N_{\tau_h}=1, N_b=0$ Obs.**	**Exp.**	**$N_{\tau_h}=0, N_b\geq 1$ Obs.**	**Exp.**	**$N_{\tau_h}=1, N_b\geq 1$ Obs.**	**Exp.**
OSSF0	—	(100, ∞)	0	0.11 ± 0.08	0	0.17 ± 0.10	0	$0.03^{+0.04}_{-0.03}$	0	0.04 ± 0.04
OSSF0	—	(50, 100)	0	$0.01^{+0.03}_{-0.01}$	2	0.70 ± 0.33	0	$0.00^{+0.02}_{-0.00}$	0	0.28 ± 0.16
OSSF0	—	(0, 50)	0	$0.01^{+0.02}_{-0.01}$	1	0.7 ± 0.3	0	$0.00^{+0.02}_{-0.00}$	0	0.13 ± 0.08
OSSF1	Off-Z	(100, ∞)	0	0.06 ± 0.04	3	0.60 ± 0.24	0	$0.02^{+0.04}_{-0.02}$	0	0.32 ± 0.20
OSSF1	On-Z	(100, ∞)	1	0.50 ± 0.18	2	2.5 ± 0.5	1	0.38 ± 0.20	0	0.21 ± 0.10
OSSF1	Off-Z	(50, 100)	0	0.18 ± 0.06	4	2.1 ± 0.5	0	0.16 ± 0.08	1	0.45 ± 0.24
OSSF1	On-Z	(50, 100)	2	1.2 ± 0.3	9	9.6 ± 1.6	2	0.42 ± 0.23	0	0.50 ± 0.16
OSSF1	Off-Z	(0, 50)	2	0.46 ± 0.18	15	7.5 ± 2.0	0	0.09 ± 0.06	0	0.70 ± 0.31
OSSF1	On-Z	(0, 50)	4	3.0 ± 0.8	41	40 ± 10	1	0.31 ± 0.15	2	1.50 ± 0.47
OSSF2	Off-Z	(100, ∞)	0	0.04 ± 0.03	—	—	0	0.05 ± 0.04	—	—
OSSF2	On-Z	(100, ∞)	0	0.34 ± 0.15	—	—	0	0.46 ± 0.25	—	—
OSSF2	Off-Z	(50, 100)	2	0.18 ± 0.13	—	—	0	$0.02^{+0.03}_{-0.02}$	—	—
OSSF2	On-Z	(50, 100)	4	3.9 ± 2.5	—	—	0	0.50 ± 0.21	—	—
OSSF2	Off-Z	(0, 50)	7	8.9 ± 2.4	—	—	1	0.23 ± 0.09	—	—
OSSF2	On-Z	(0, 50)	*156	160 ± 34	—	—	4	2.9 ± 0.8	—	—

- Search for SUSY in events with three or more leptons (including taus), in bins of bjet multiplicity and MET.
- Very good agreement between data and MC everywhere, except for one signal region (4 leptons out of which one τ, Z-veto and low MET).
  - Observed: 15 events, Predicted: 7.5 ± 2.0.
- Similar selection on ATLAS 'validation region', excess not confirmed.

arXiv:1404.5801, 1405.5086

TALK OUTLINE

- A short introduction
- The hunt for SUSY
- Summary results and combinations
- The few tantalizing results
- **Towards Run2**

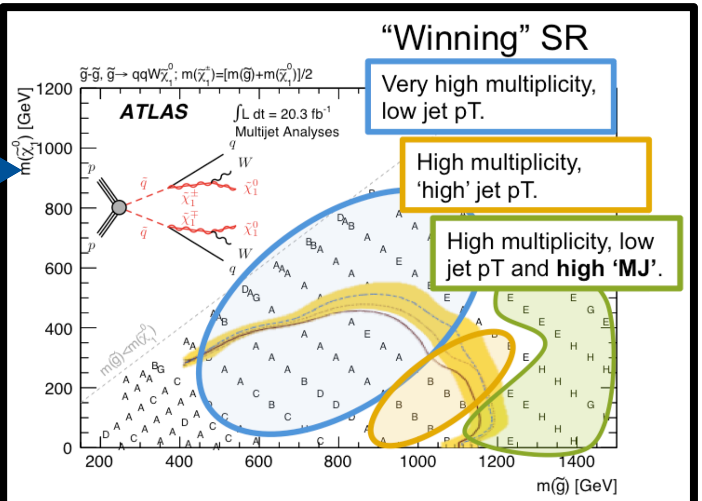
THE HUNT FOR SUSY AHEAD

If SUSY is real, why did we miss it so far?

- Either not enough sparticles were produced: low cross sections or low BRs for channels with good S/B. ⇒ **Run at higher energy and higher luminosity.**
- Or sparticles were produced abundantly but not within kinematic reach: little visible energy; kinematics too close to the standard model; or complex decays. ⇒ **Improve searches!**

⇒ Study kinematics of holes in the phase-space, and build dedicated analyses to access them. E.g. m(stop) ~ m(top), compressed spectra, higgsino LSP.

⇒ Improve analysis methods:
- ⇒ **Tools**. E.g. particle boosts will be more significant at 13TeV: use fat jets or W/top tagging.
- ⇒ **Trigger**. E.g. displaced vertex searches would profit from signature-independent displaced-vertex trigger.
- ⇒ **Background determination**. E.g. rely more on data-driven methods to reduce systematic uncertainties.

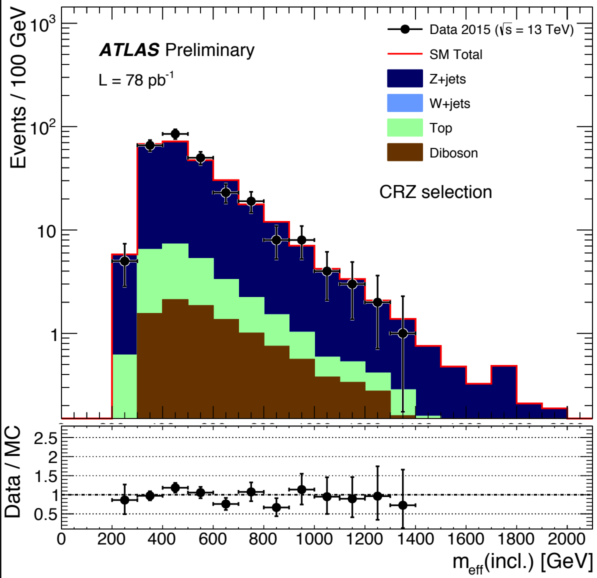


Multijet analysis - arXiv:1308.1841

A FIRST LOOK IN RUN2

- First 50ns data collected by ATLAS and CMS. Performance assessment has started.
- E.g. control region distributions in strong production searches.

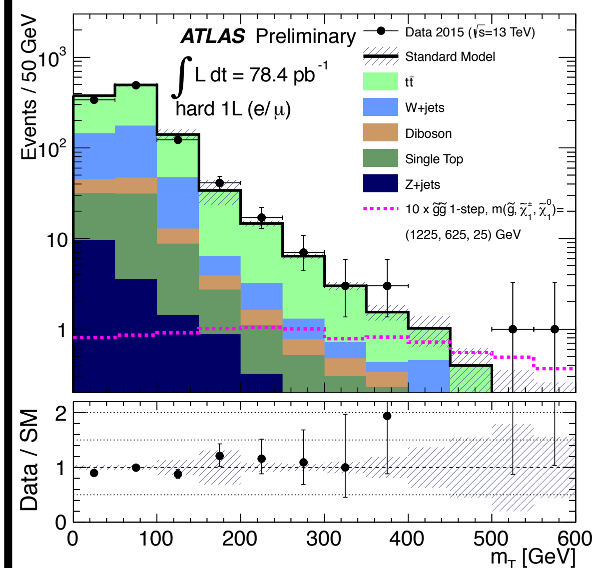
ATL-PHYS-PUB-2015-028



0-lepton (2-6 jets) + MET

m_{eff} in “Z control region”

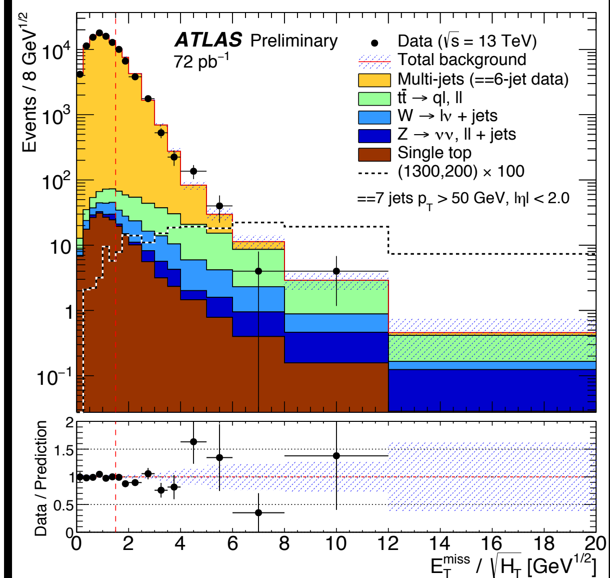
ATL-PHYS-PUB-2015-029



1-lepton (2-6 jets) + MET

m_T after loose selection on lepton + MET + 4-jet

ATL-PHYS-PUB-2015-030

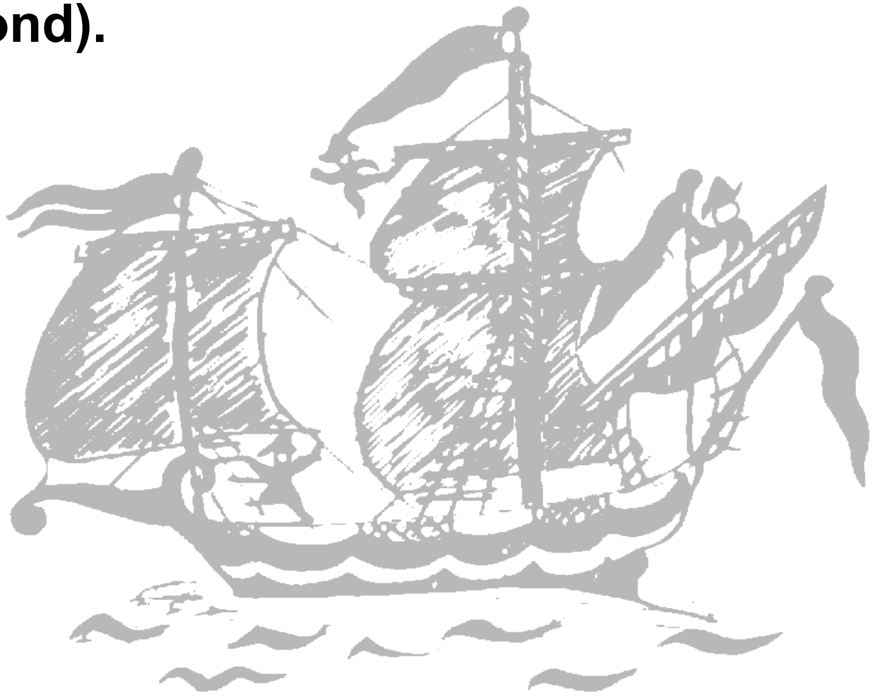


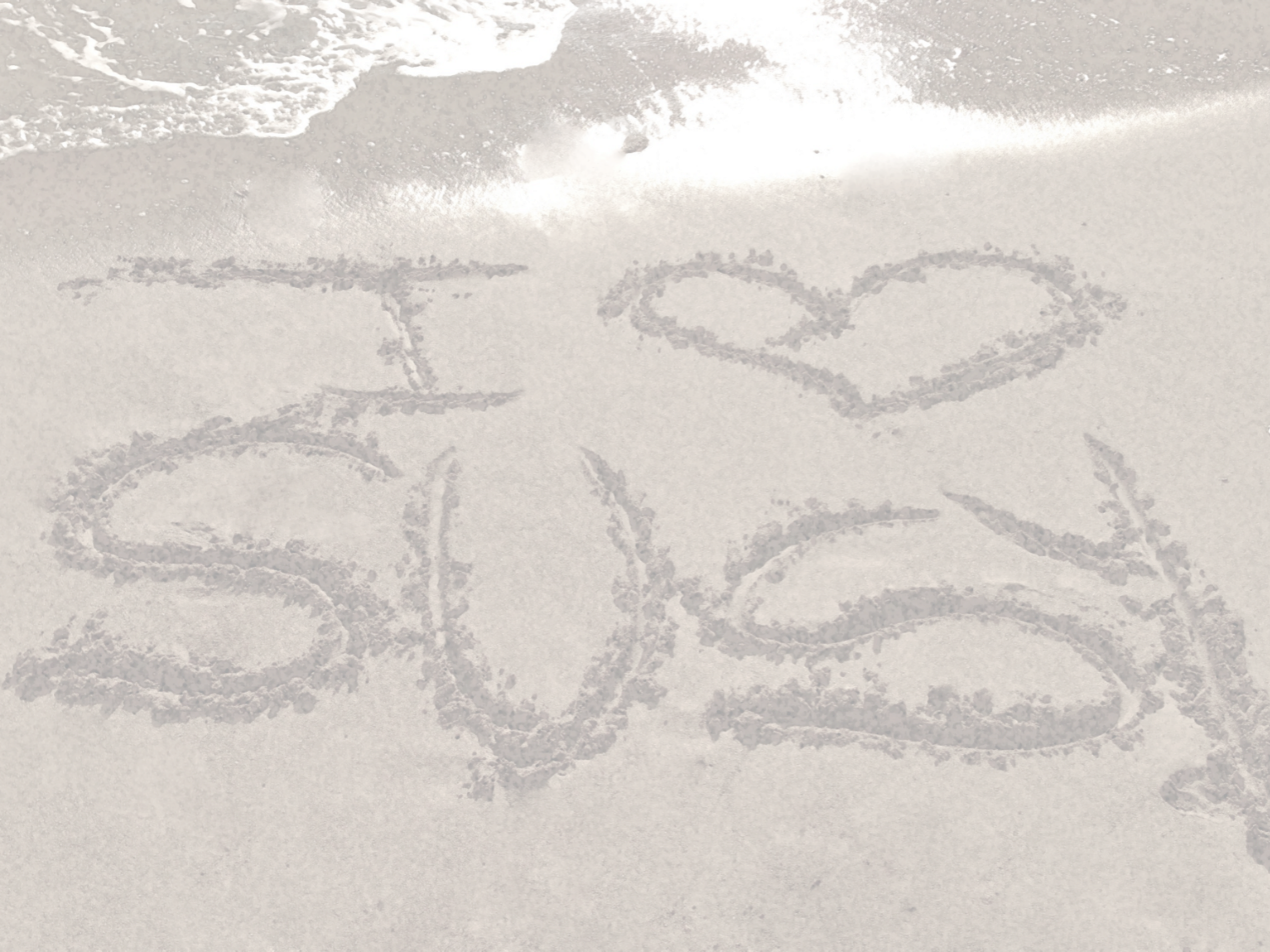
0-lepton (6-7 jets) + MET

Extrapolating from 6 to 7 jets (“template” method validation)

CONCLUSIONS

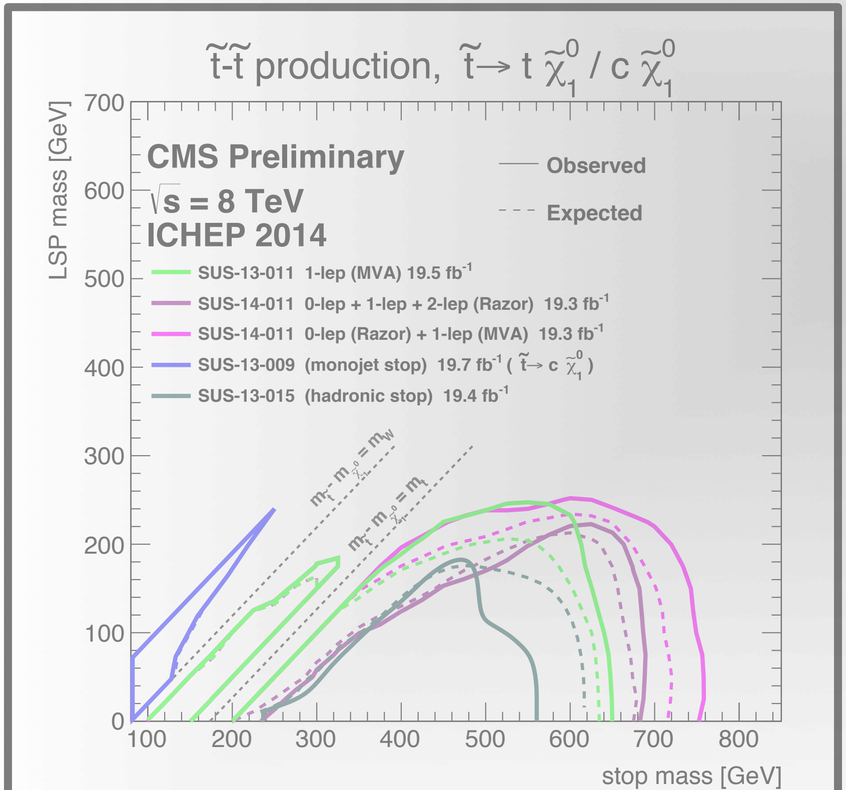
- A plethora of SUSY searches in run1, targeting many production processes & decay channels and covering many final states.
- Searches have produced null results so far, and have provided very stringent constraints in the SUSY phase-space.
- Great potential in run2 (and beyond).
- We hope to find something new in the new data; may or may not be SUSY. SUSY, with its many possibilities, will have helped us define a search strategy and discover the unexpected.

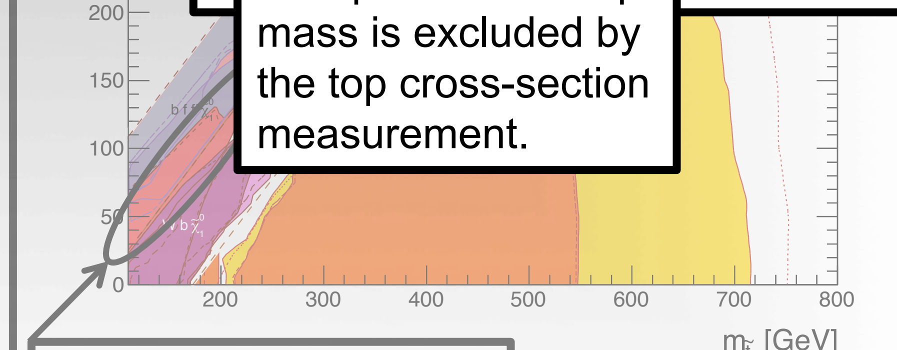


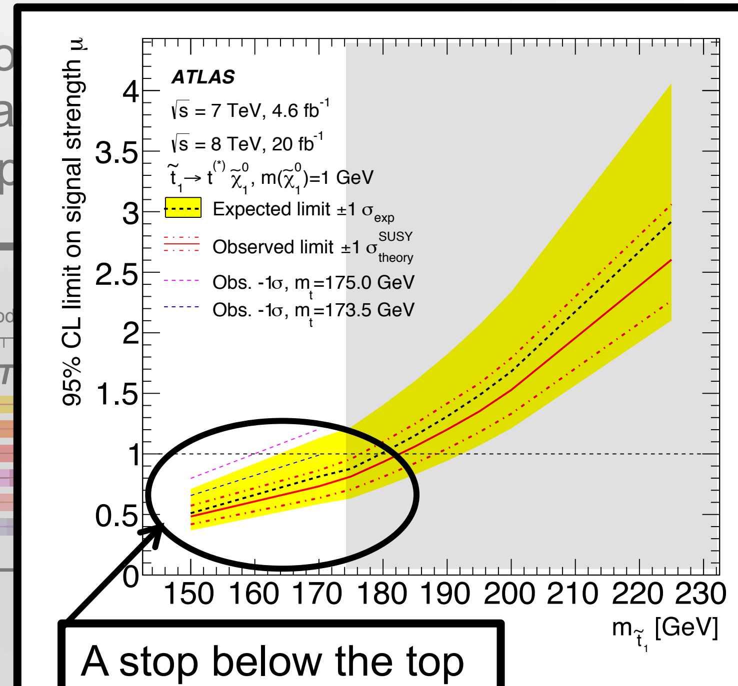


THIRD GENERATION SEARCHES

- Various decay topologies, depending on sto
- Stops excluded up to 700-800GeV (under a
- Various holes in the phase-space still unexp







A stop below the top mass is excluded by the top cross-section measurement.

New analysis dedicated to cover this hole.

RE-INTERPRETATIONS

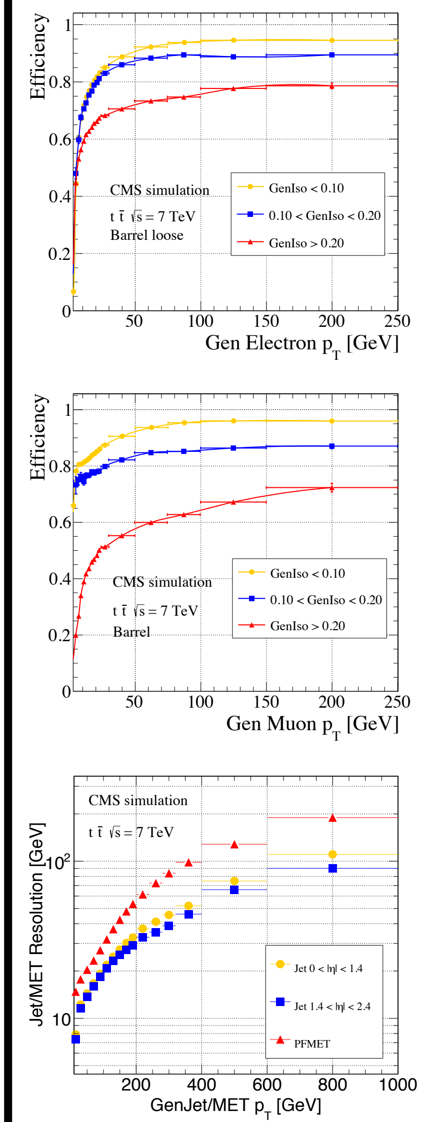
- **Both ATLAS and CMS provide material that can be used by theorists to re-cast the results into their models.**
  - ATLAS publishes on ‘HEPDATA’ acceptance, efficiency, CLs values etc, for a selected set of models (typically simplified).
  - CMS provides distributions of experimental observables, such as efficiency, resolution, etc.

A cutflow table

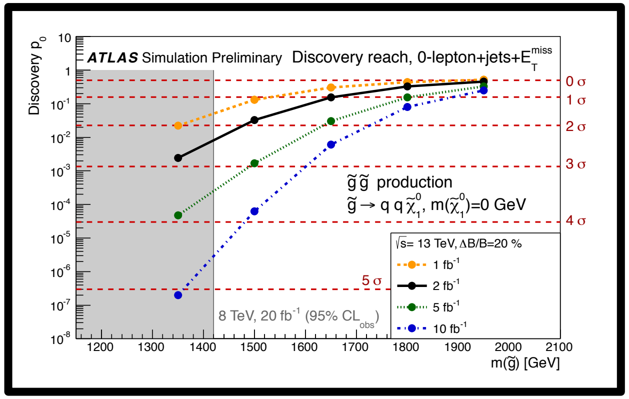
	0.001 ns	0.01 ns	0.1 ns	1 ns	10 ns	Expected	Observed
Trigger (6 jets with $E_T > 45$ GeV)	16200	15700	15800	[illegible]	[illegible]		
Primary vertex and event cleaning	15400	13000	13000	[illegible]	[illegible]		
Lepton Veto	8300	8100	10700	[illegible]	[illegible]		
Further event cleaning	8100	5500	2000	[illegible]	[illegible]		
8j50, $\|\eta\| < 2.0$	1100	700	260	180	50		
& $E_T^{miss}/\sqrt{H_T} > 4.0$ GeV$^{1/2}$	700	420	190	120	36		
& 0 bjet	$0.200 \pm 0.200 \pm 0.003$	$2.8 \pm 2.8 \pm 2.8$	$38 \pm 10 ^{+12}_{-1}$	$87 \pm 16 \pm 24$	$31 \pm 6 ^{+4}_{-5}$	35 ± 4	40
& 1 bjet	$28 \pm 10 ^{+9}_{-16}$	$14 \pm 7 ^{+8}_{-3}$	$41 \pm 12 ^{+7}_{-11}$	$16 \pm 7 ^{+11}_{-7}$	$3.9 \pm 2.8 ^{+5.8}_{-1.2}$	40 ± 10	44
& ≥ 2 bjets	$2305 \pm 176 ^{+3093}_{-1455}$	$1770 \pm 165 ^{+2752}_{-1152}$	$269 \pm 45 ^{+204}_{-128}$	$30 \pm 14 ^{+25}_{-16}$	$5.9 \pm 5.9 ^{+7.3}_{-3.6}$	50 ± 10	44
9j50, $\|\eta\| < 2.0$	310	260	80	70	20		
& $E_T^{miss}/\sqrt{H_T} > 4.0$ GeV$^{1/2}$	190	130	49	39	15		
& 0 bjet	$0.0 ^{+2.6}_{-0.0}$	$0.0 ^{+2.6}_{-0.0}$	$5.1 \pm 3.6 ^{+8.9}_{-3.8}$	$26 \pm 9 ^{+32}_{-26}$	$14 \pm 4 ^{+5}_{-4}$	3.3 ± 0.7	5
& 1 bjet	$11 \pm 6 \pm 6$	$2.7 \pm 2.7 \pm 2.7$	$11 \pm 6 \pm 4$	$6.2 \pm 4.4 ^{+6.5}_{-5.8}$	$0.0 ^{+2.6}_{-0.0}$	6.1 ± 1.7	8
& ≥ 2 bjets	$691 \pm 97 ^{+959}_{-472}$	$618 \pm 105 ^{+1055}_{-458}$	$90 \pm 29 ^{+81}_{-48}$	$13 \pm 8 \pm 10$	$0.0 ^{+2.6}_{-0.0}$	8.0 ± 2.7	7
$\geq$ 10j50, $\|\eta\| < 2.0$	140	110	44	36	0.0		
& $E_T^{miss}/\sqrt{H_T} > 4.0$ GeV$^{1/2}$	$53 \pm 12 ^{+11}_{-9}$	$67 \pm 14 ^{+13}_{-17}$	$28 \pm 9 \pm 4$	$26 \pm 9 \pm 4$	$0.0 ^{+2.6}_{-0.0}$	1.37 ± 0.35	3
7j80, $\|\eta\| < 2.0$	210	150	70	48	13		
& $E_T^{miss}/\sqrt{H_T} > 4.0$ GeV$^{1/2}$	130	80	50	33	8.8		
& 0 bjet	$0.0 ^{+2.6}_{-0.0}$	$0.0 ^{+2.6}_{-0.0}$	$14 \pm 6 ^{+2}_{-0}$	$22 \pm 8 ^{+3}_{-6}$	$6.9 \pm 3.1 ^{+2.8}_{-3.2}$	11.0 ± 2.2	12
& 1 bjet	$7.1 \pm 5.1 ^{+4.7}_{-7.1}$	$2.7 \pm 2.7 ^{+3.8}_{-2.7}$	$13 \pm 7 \pm 2$	$0.0 ^{+2.6}_{-0.0}$	$1.9 \pm 1.9 \pm 1.9$	17 ± 6	17
& ≥ 2 bjets	$460 \pm 75 ^{+599}_{-319}$	$323 \pm 68 ^{+493}_{-203}$	$49 \pm 17 ^{+29}_{-22}$	$19 \pm 10 \pm 9$	$0.0 ^{+2.6}_{-0.0}$	25 ± 10	13
$\geq$ 8j80, $\|\eta\| < 2.0$	48	50	25	14	1.1		
& $E_T^{miss}/\sqrt{H_T} > 4.0$ GeV$^{1/2}$	25	27	22	8.7	0.0		
& 0 bjet	$0.0 ^{+2.6}_{-0.0}$	$0.0 ^{+2.6}_{-0.0}$	$1.90 \pm 1.90 \pm 0.03$	$8.3 \pm 4.8 ^{+3.9}_{-2.8}$	$0.0 ^{+2.6}_{-0.0}$	0.9 ± 0.6	2
& 1 bjet	$3.7 \pm 3.7 ^{+0.7}_{-3.7}$	$0.0 ^{+2.6}_{-0.0}$	$7.6 \pm 5.4 ^{+3.8}_{-4.2}$	$0.0 ^{+2.6}_{-0.0}$	$0.0 ^{+2.6}_{-0.0}$	1.5 ± 0.9	1
& ≥ 2 bjets	$91 \pm 37 ^{+152}_{-62}$	$145 \pm 54 ^{+293}_{-107}$	$29 \pm 13 ^{+20}_{-16}$	$0.0 ^{+2.6}_{-0.0}$	$0.0 ^{+2.6}_{-0.0}$	3.3 ± 2.2	3

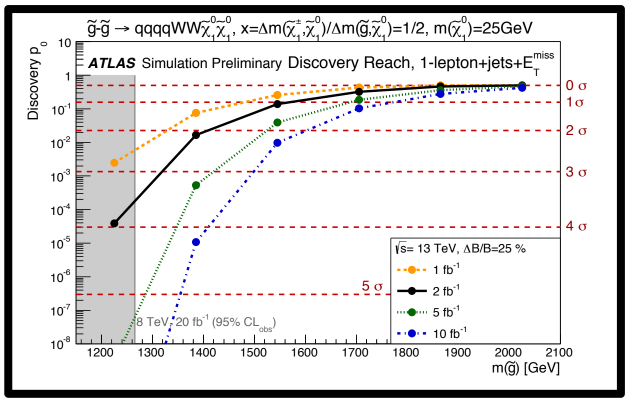
E.g. arXiv:1308.1841, data link: http://hepdata.cedar.ac.uk/view/red6095

E.g. arXiv:1405.3961

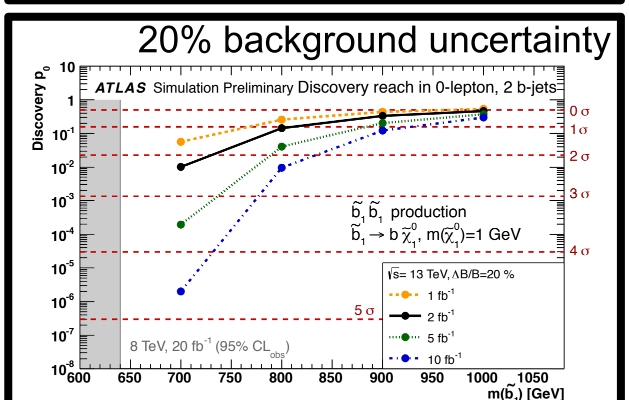


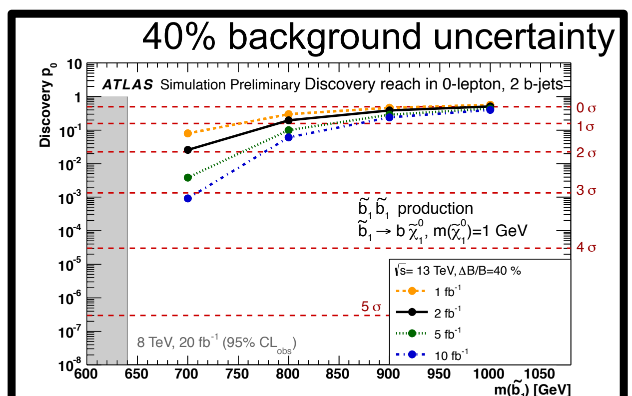
PROSPECTS FOR RUN2





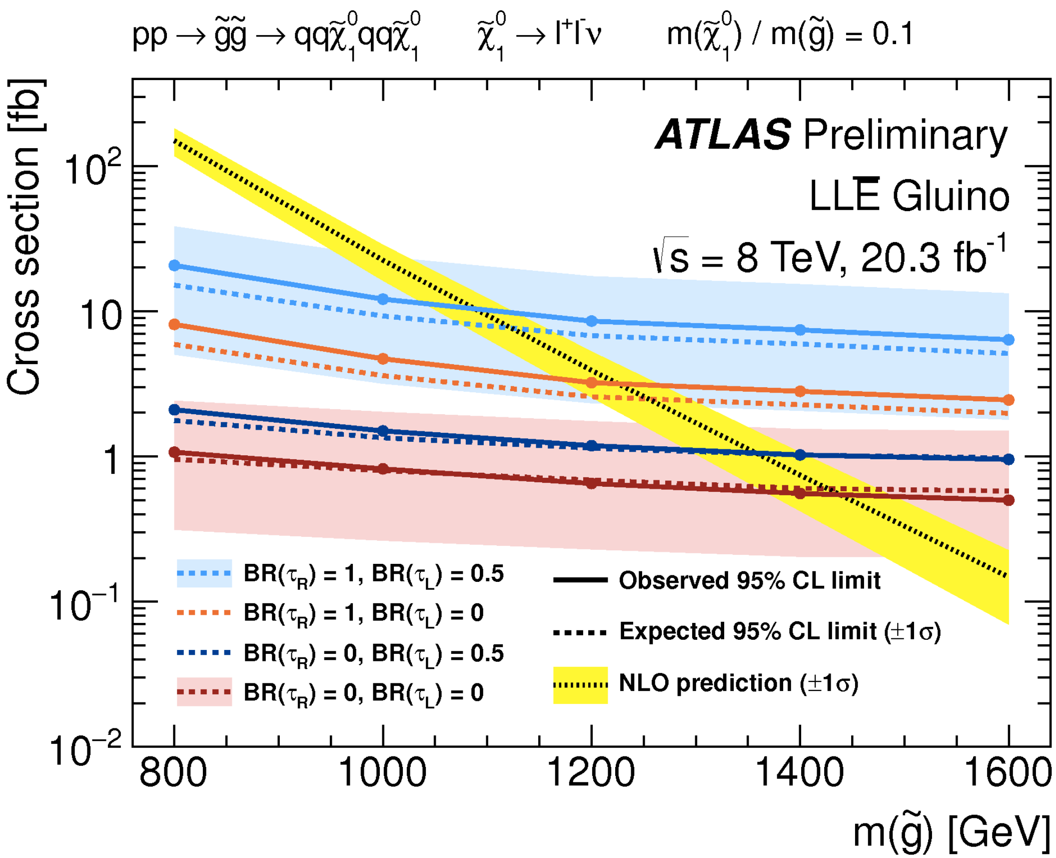
- Three analyses have been checked (following basic optimization at 13TeV) for sensitivity at a gluino/squark discovery.
- We can reach 3σ evidence for gluino mass ~ 1.5TeV and sbottom mass ~ 700GeV with 5/fb if background uncertainties ~ 20-25%.
- With 10/fb we will have access to 3σ evidence even with poor systematics.
- A lot to explore!



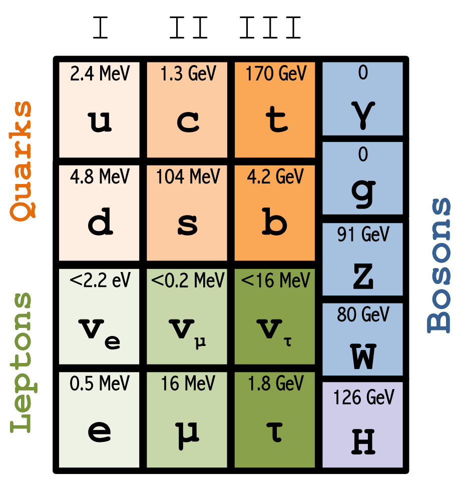


ATLAS-PHYS-PUB-2015-005

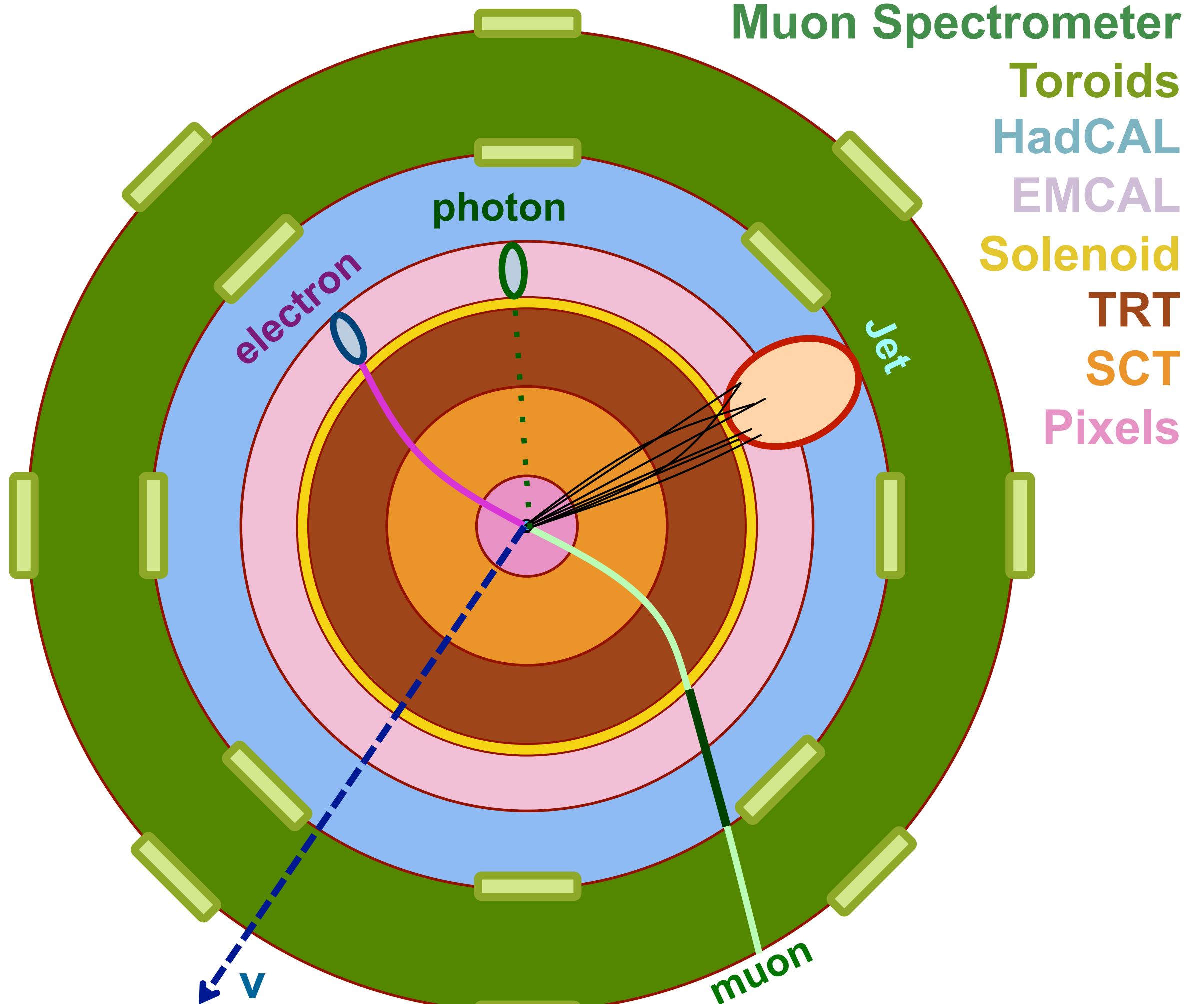
RPV LLE GLUINO - EXCLUSION



PARTICLE RECONSTRUCTION

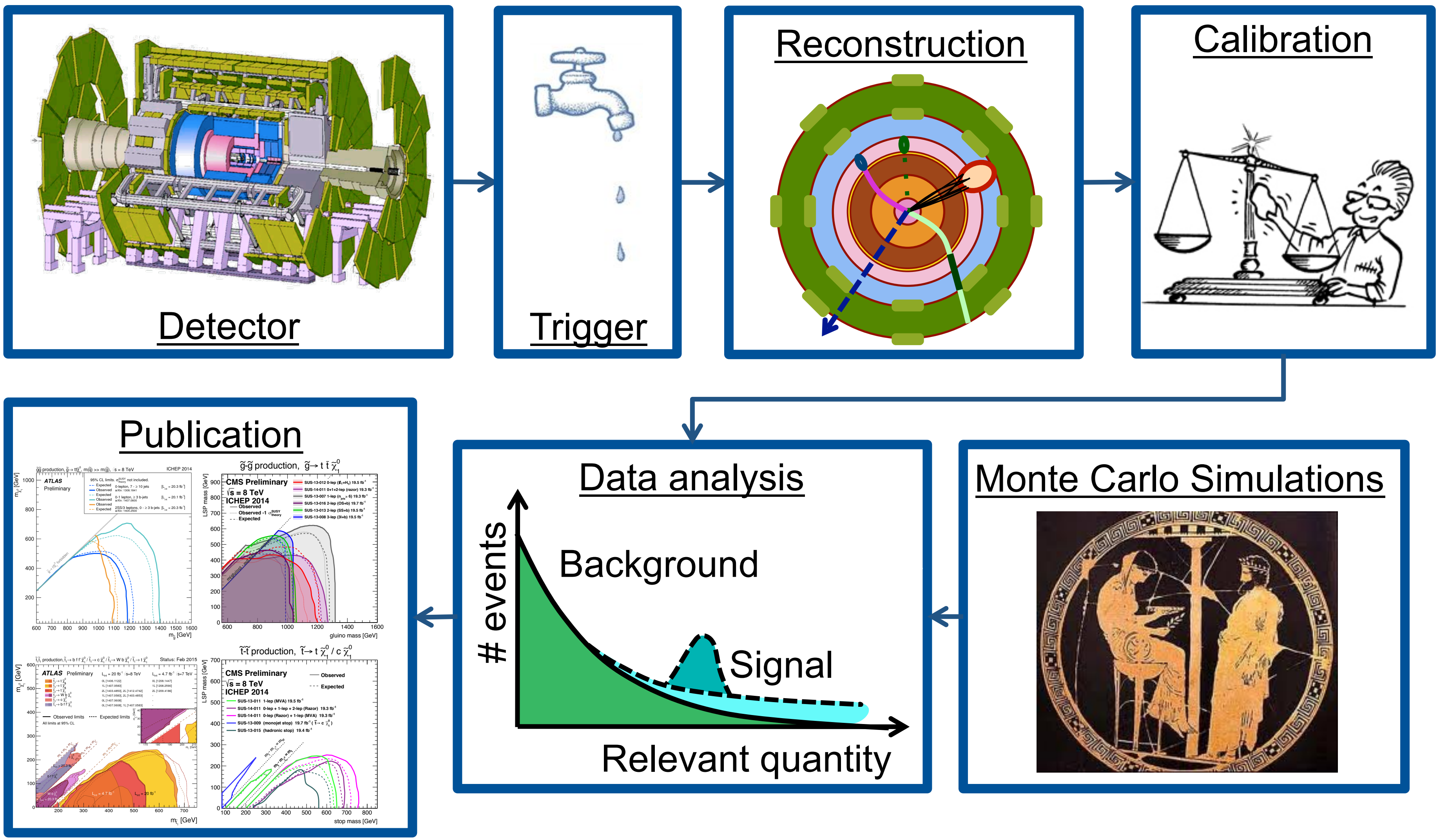


Simplified Detector Transverse View



THE LIFETIME OF AN EVENT

…and the challenges in searching for SUSY.



PARTICLE RECONSTRUCTION

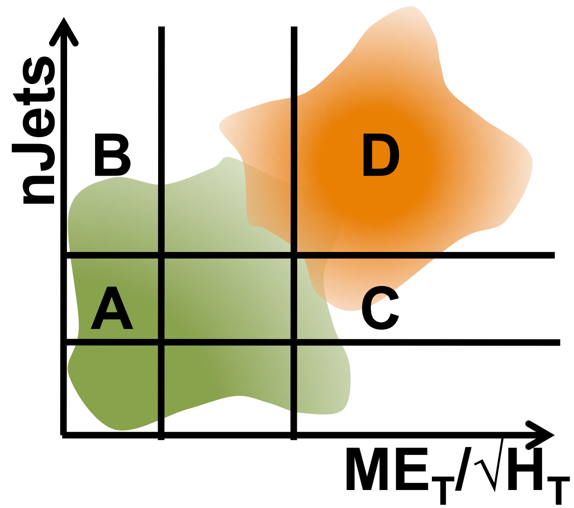
ATLAS	CMS
At a large extent "conventional" identification.	Identification based on Particle Flow.
Jets	
Key ingredient in most SUSY searches (branching ratio of SM particles).	
Reconstructed with anti-kt clustering algorithm.	
Distance parameter 0.4.	Distance parameter 0.5.
pT thresholds generally start from 20GeV, extending to very high pT.	
Jet energy scale uncertainty typically dominant in searches with jets: < 2% for pT > 100GeV, up to ~4% down to 20GeV.	
bJets	
Key ingredients in third generation searches.	
Dedicated algorithms, typically with a 60-70% identification efficiency.	
(Hadronically decays) Taus	
Dedicated algorithms, typically with a 60 identification efficiency.	

PARTICLE RECONSTRUCTION

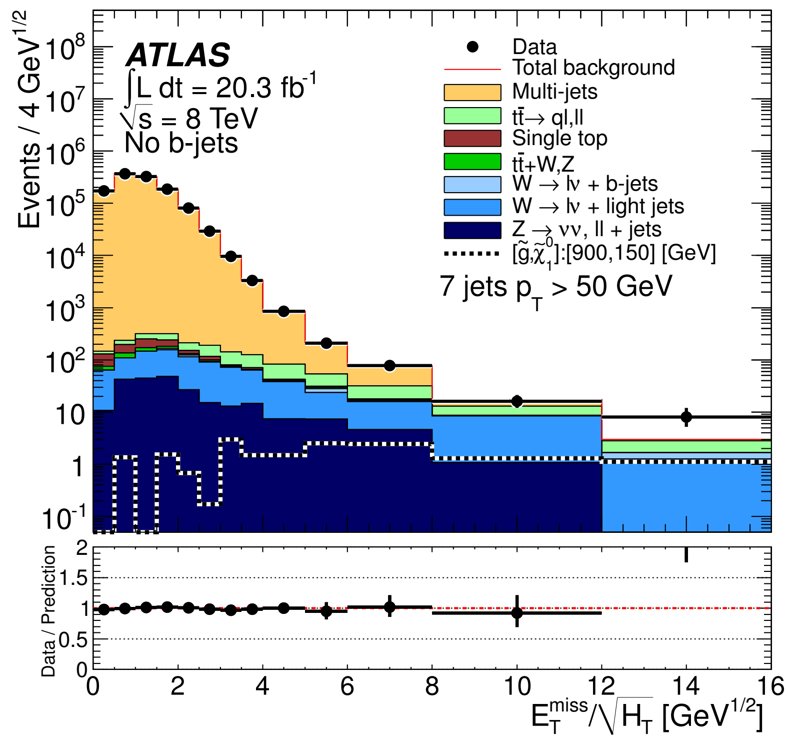
ATLAS	CMS
Leptons	
Key ingredients in searches targeting compressed spectra, EW production and/or RPV final states.	
pT thresholds range from 6-7GeV to 20-25GeV (trigger requirement).	
Separation from jets is achieved by requiring (calo or track) isolation.	
Missing Transverse Momentum (MET)	
Key ingredient of most RPC searches.	
Vector Sum(pT) over all jets and leptons plus calorimeter clusters.	Uses particles reconstructed by the particle-flow method.
Fake MET in hadronic final states often removed using Δφ(jet,MET) selections.	
MET is very sensitive to detector malfunctions, poorly instrumented regions, and pile-up.	

ANOTHER MULTIJET EXAMPLE

Still Multijets – a MET-based search this time.



where $H_T = \sum_j p_T^j$



Dominant background: SM multijet production; fake MET from jet mis-mesurements.

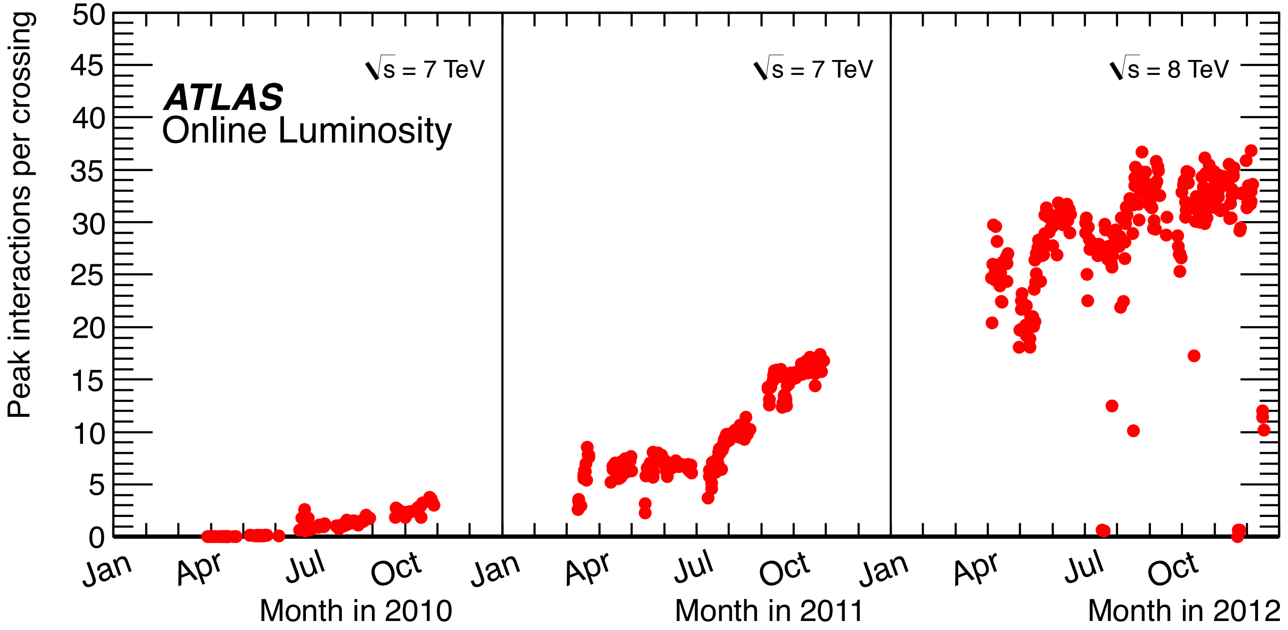
Why $ME_T/\sqrt{H_T}$?

⇒ a measure of ME_T in units of standard deviations of the fake ME_T

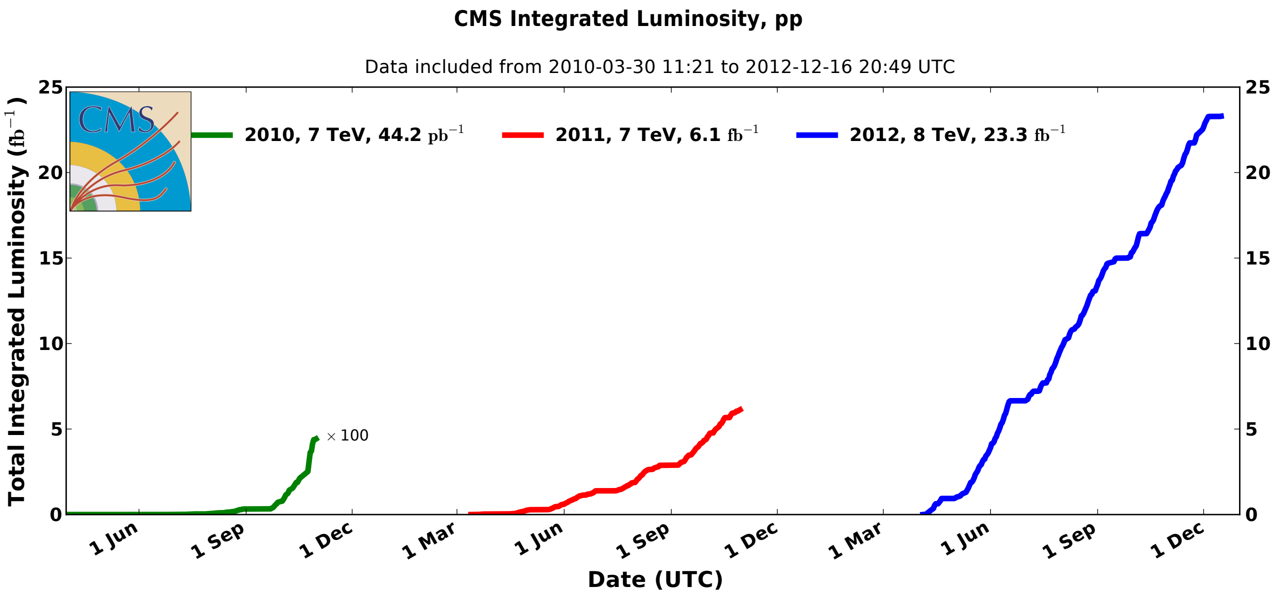
$$\frac{\sigma_{p_T}}{p_T} = \frac{N}{p_T} \oplus \frac{S}{\sqrt{p_T}} \oplus C$$

arXiv:1308.1841

PILE-UP

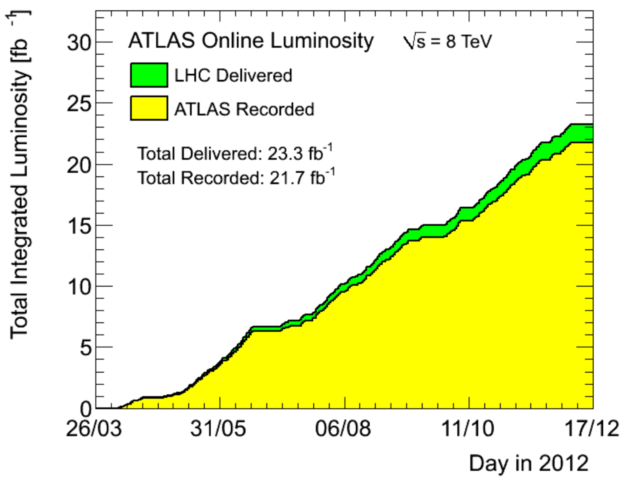


ATLAS
Online Luminosity
√s = 7 TeV
√s = 7 TeV
√s = 8 TeV
Peak interactions per crossing
0
5
10
15
20
25
30
35
40
45
50
Jan
Apr
Jul
Oct
Month in 2010
Month in 2011
Month in 2012



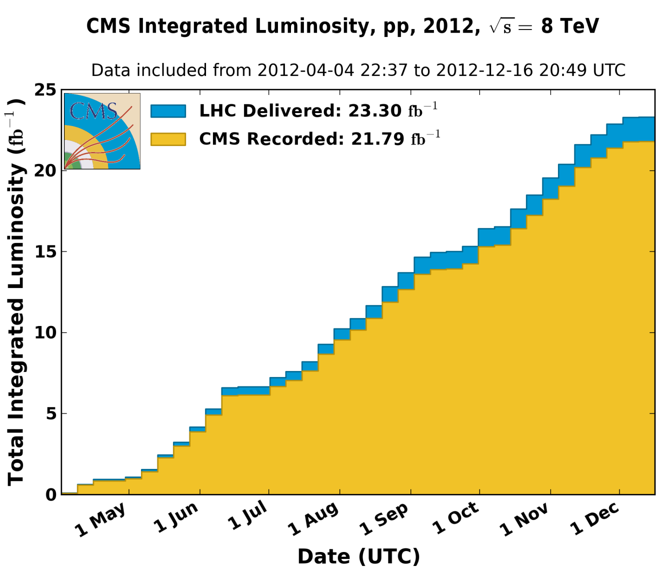
CMS Integrated Luminosity, pp
Data included from 2010-03-30 11:21 to 2012-12-16 20:49 UTC
CMS
2010, 7 TeV, 44.2 pb⁻¹
2011, 7 TeV, 6.1 fb⁻¹
2012, 8 TeV, 23.3 fb⁻¹
× 100
Total Integrated Luminosity (fb⁻¹)
0
5
10
15
20
25
1 Jun
1 Sep
1 Dec
1 Mar
Date (UTC)

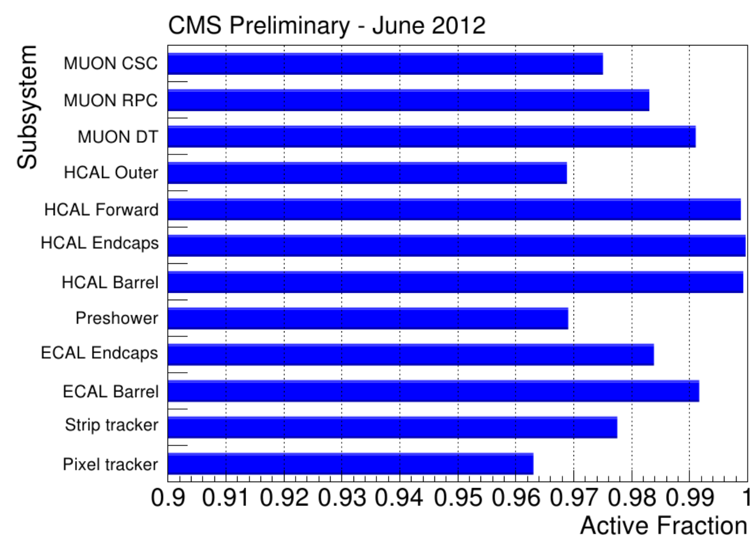
LUMINOSITY – RECORDED



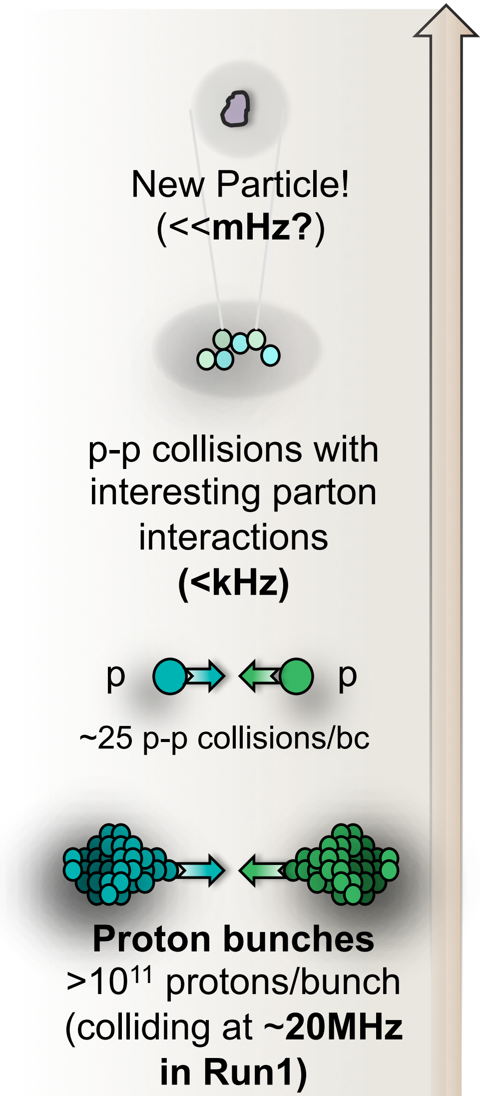
ATLAS p-p run: April-December 2012										
Inner Tracker			Calorimeters		Muon Spectrometer				Magnets	
Pixel	SCT	TRT	LAr	Tile	MDT	RPC	CSC	TGC	Solenoid	Toroid
99.9	99.1	99.8	99.1	99.6	99.6	99.8	100.	99.6	99.8	99.5
All good for physics: 95.5%										

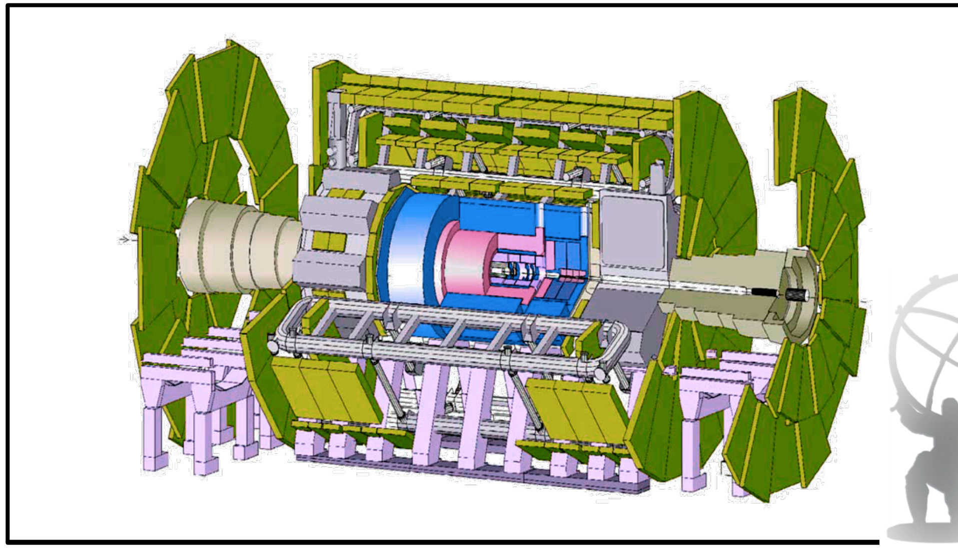
Luminosity weighted relative detector uptime and good quality data delivery during 2012 stable beams in pp collisions at √s=8 TeV between April 4th and December 6th (in %) – corresponding to 21.3 fb^{-1} of recorded data.

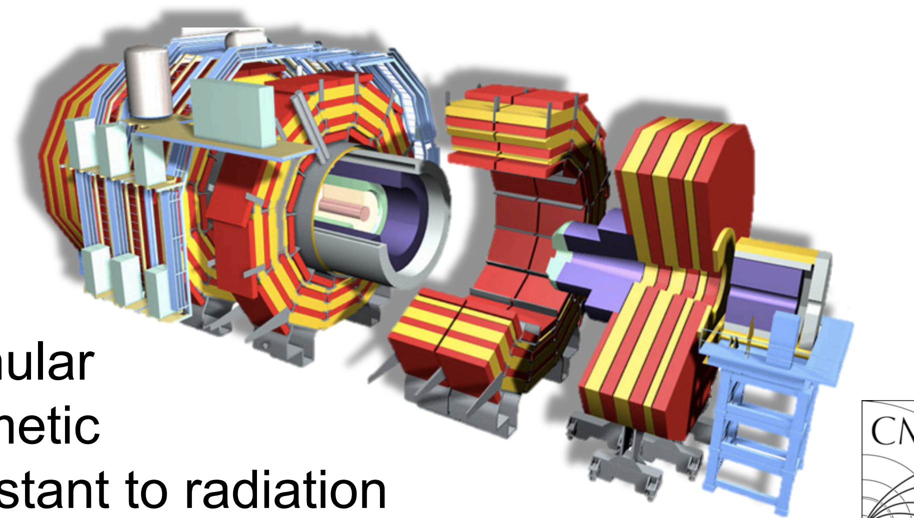




THE DETECTORS







- ✓ Fast
- ✓ Granular
- ✓ Hermetic
- ✓ Resistant to radiation