LHC results and prospects: Beyond Standard Model

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on behalf of the ATLAS and CMS collaborations

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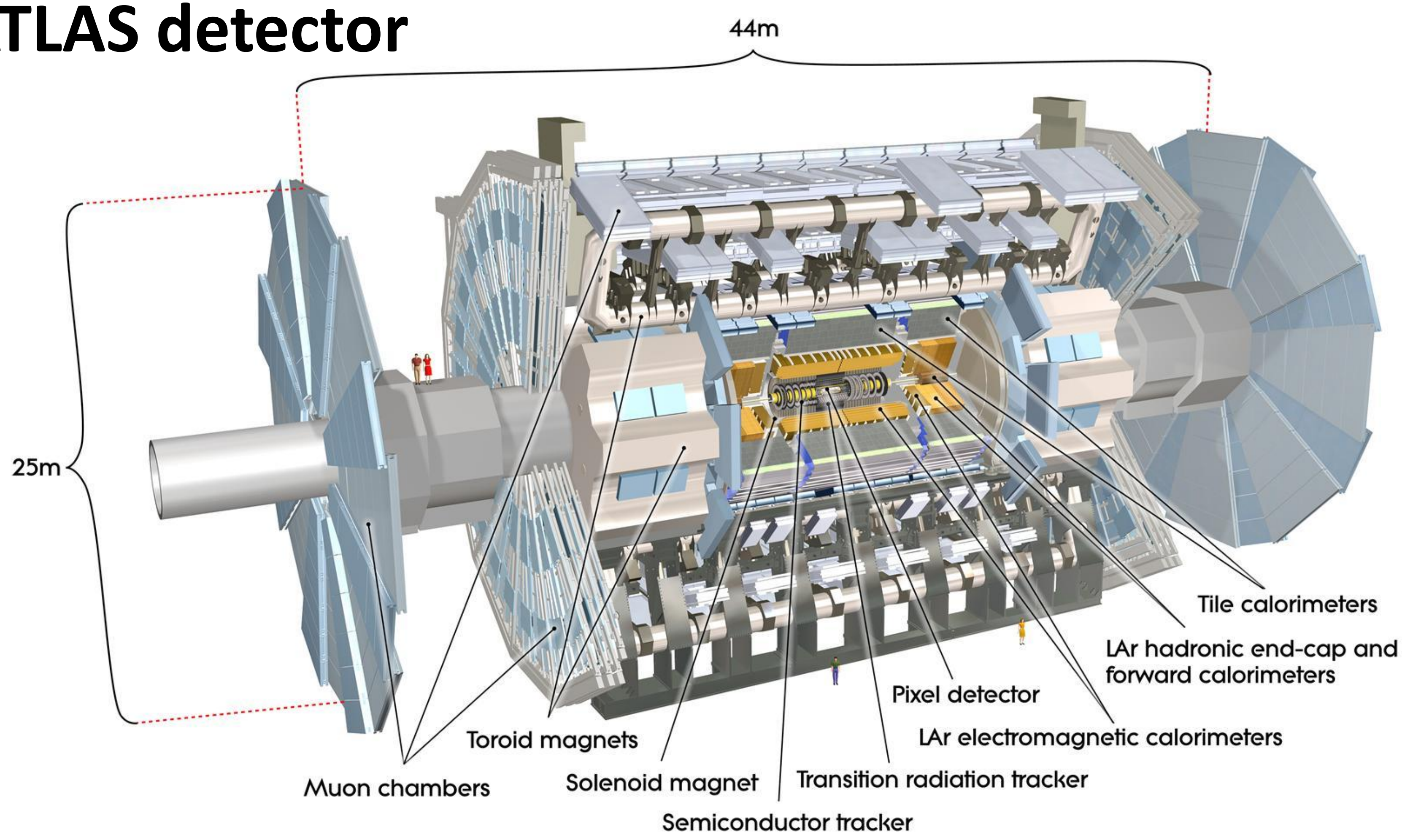
Outline :

- Detectors and data taking
- SUSY : simplified model signatures using RPC/RPV analyses
- Exotica : extra-dimensions, compositeness, new gauge bosons, microscopic black holes …

- The tools for discovery : the ATLAS and CMS detectors

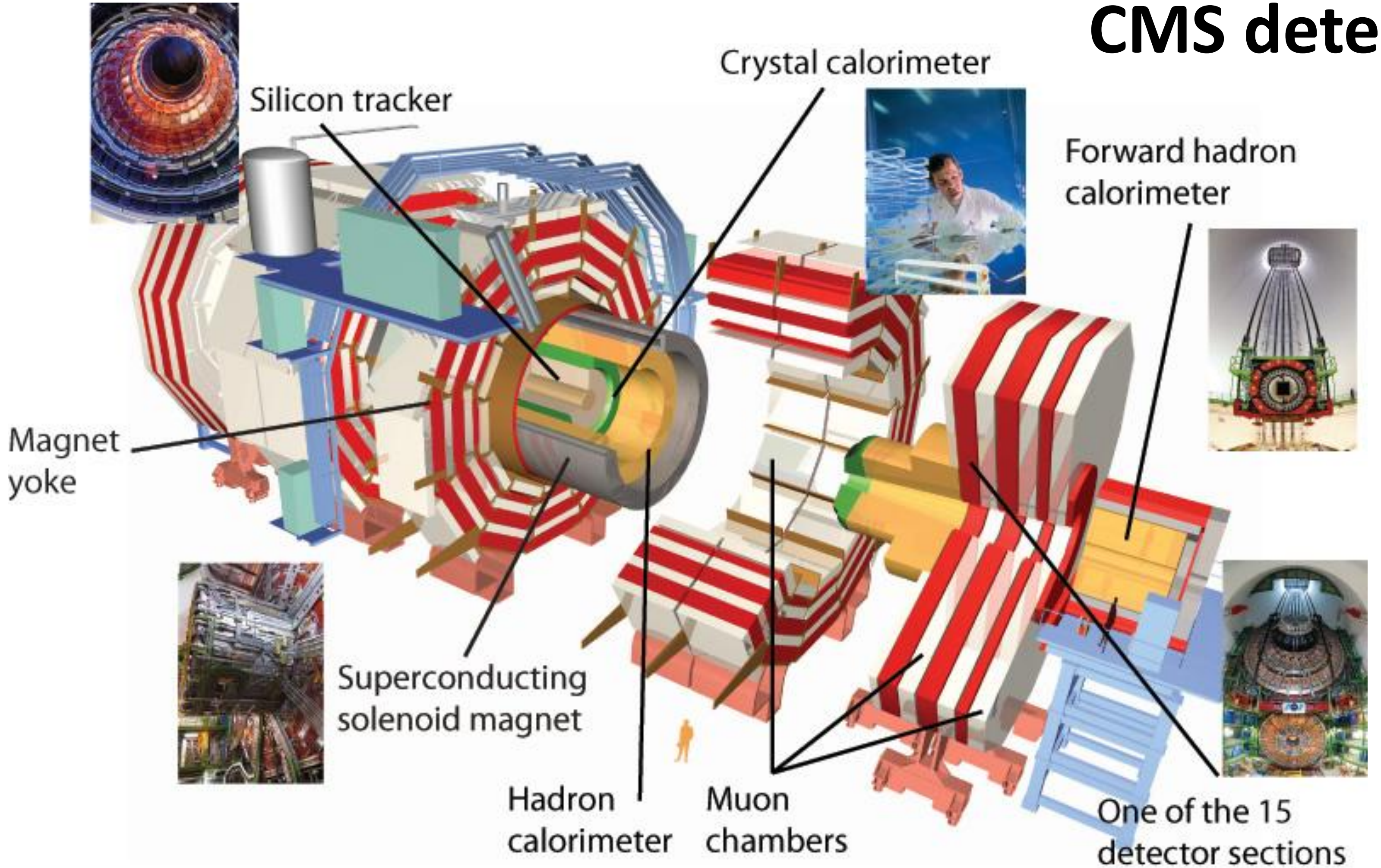
ATLAS detector



Detectors

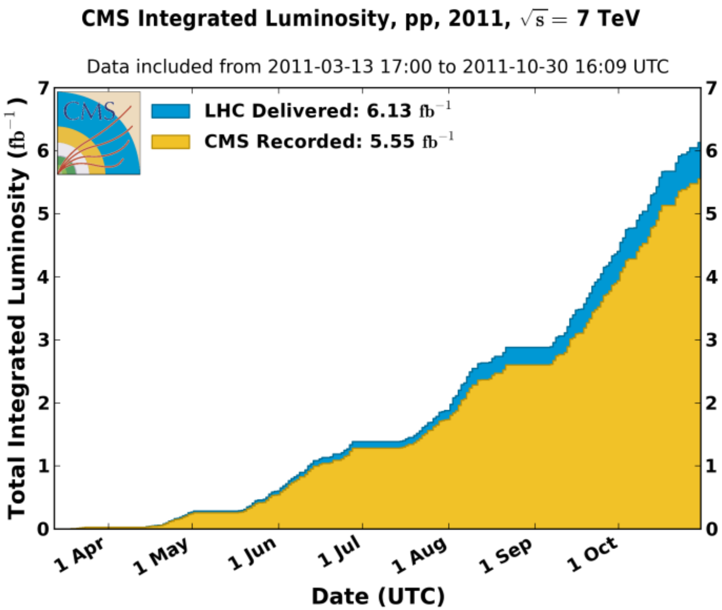
- The tools for discovery : the ATLAS and CMS detectors

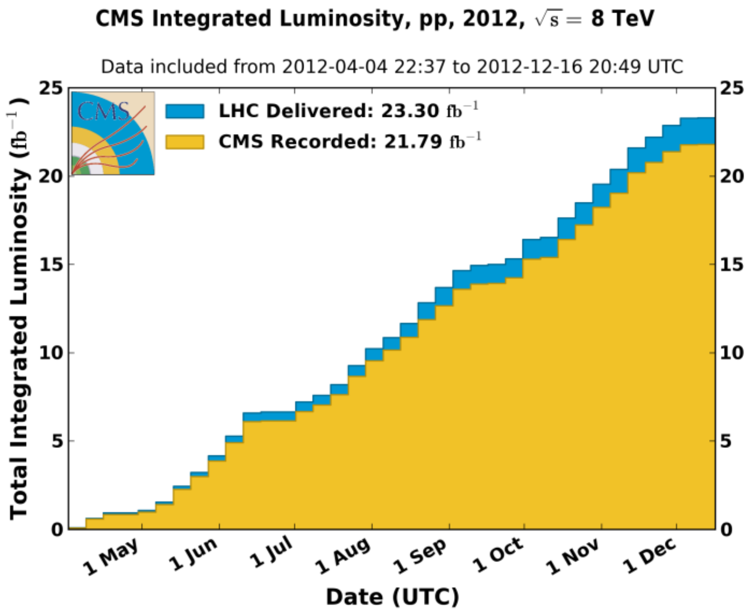
CMS detector



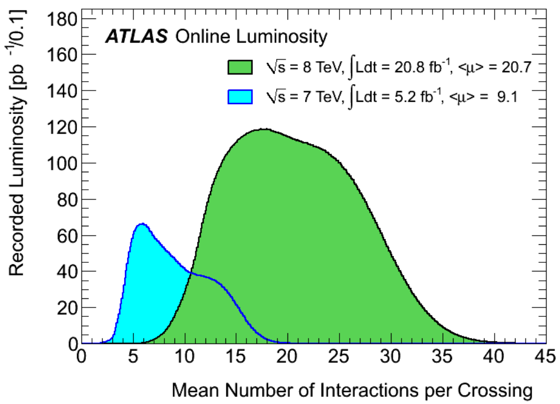
Data taking

- Data taking @7 and 8 TeV : ∫Ldt and <PU>





∫Ldt good for physics @7 TeV : 5 /fb

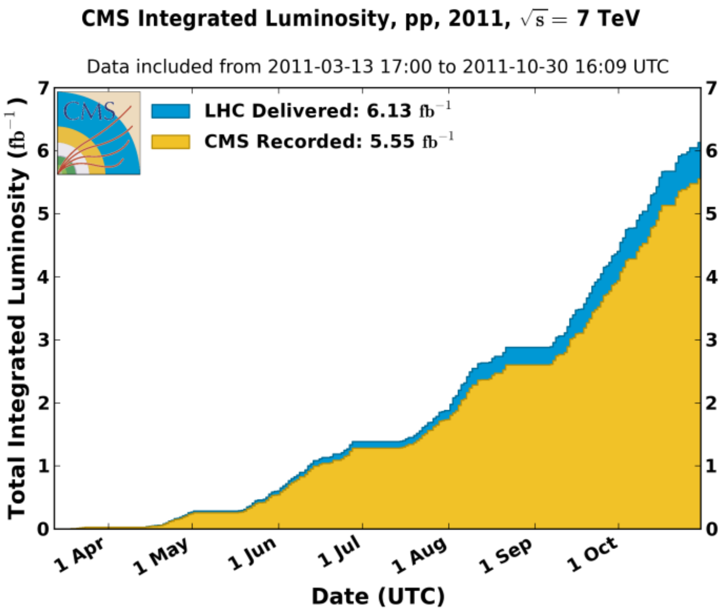


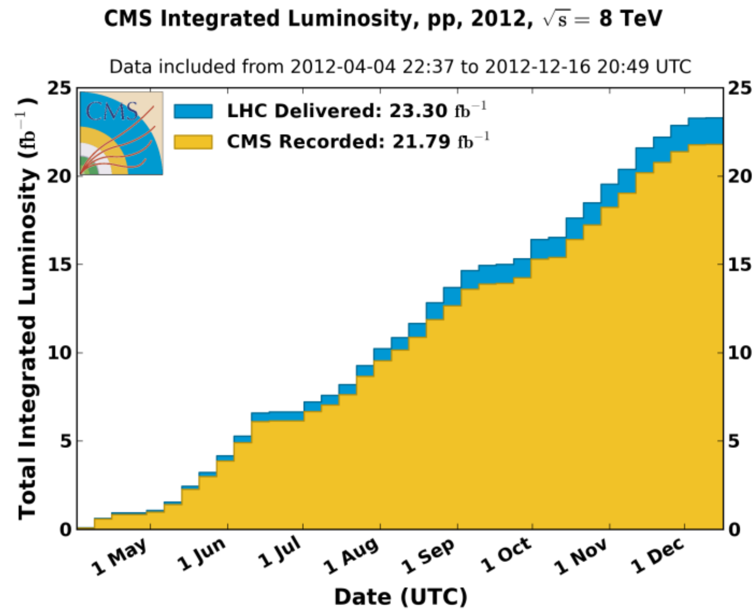
∫Ldt good for physics @8 TeV : 20 /fb

<PU> @8 TeV around 20
Max. PU @8 TeV around 40

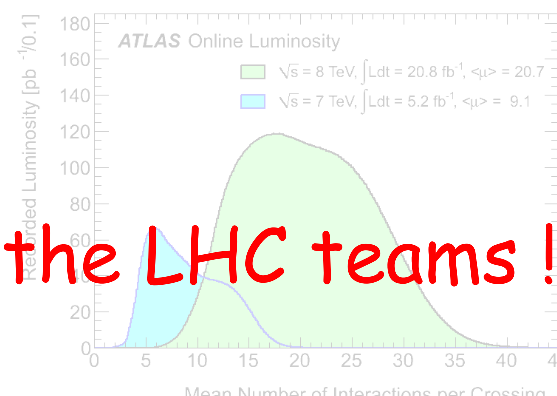
Data taking

- Data taking @7 and 8 TeV : ∫Ldt and <PU>





∫Ldt good for physics
@7 TeV : 5 /fb



∫Ldt good for physics
@8 TeV : 20 /fb

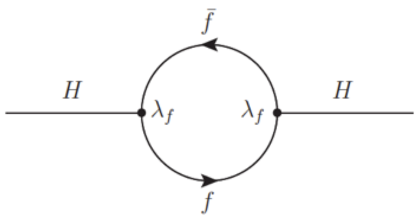
Thanks to the LHC teams !!

<PU> @8 TeV around 20
Max. PU @8 TeV around 40

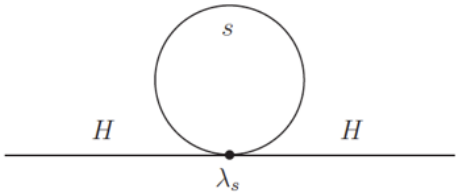
SUSY searches

SUSY searches

- Why SUSY ? It could solve several SM problems (hierarchy problem solved without fine-tuning, dark matter candidate, gauge coupling unification …)
- Hierarchy problem :



to be cancelled by



$$\Delta m_{H,f}^2 \approx -\frac{\lambda_f^2}{8\pi^2}\Lambda_{UV}^2$$

$$\Delta m_{H,s}^2 \approx \frac{\lambda_s}{16\pi^2}\Lambda_{UV}^2$$

- ➢ stop mass should be light (< 1 TeV) to avoid SUSY to be fine-tuned (*natural* SUSY)
- ➢ the implication of M_H=125 GeV in the MSSM is … a not too light stop :

$$M_h^2 \approx M_Z^2 \cos^2 2\beta + \underbrace{\eta}_{\mathcal{O}(1)} \frac{3G_F m_t^4}{\sqrt{2}\pi^2} \log \frac{\Delta_S^2}{m_t^2} \quad \text{with} \quad \Delta_S^2 = m_{\tilde{t}_1} m_{\tilde{t}_2}$$

SUSY searches

- Dark matter candidate :

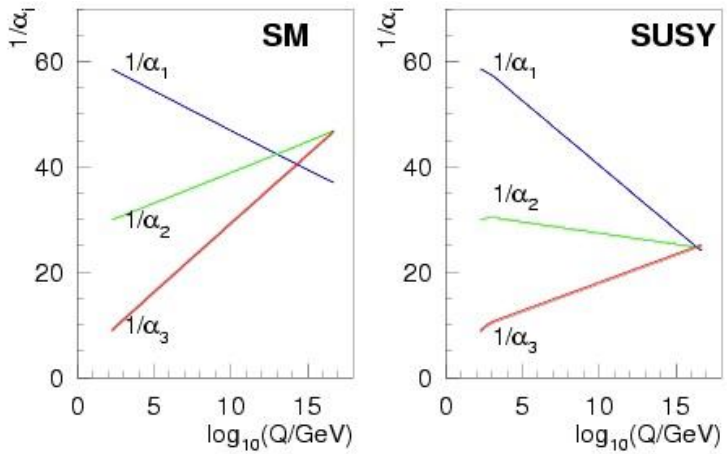
Both Rp = $(-1)^{3(B-L)+2S}$ (=+1/-1 for SM/SUSY particles) conserved and violated scenarios will be presented

If Rp is conserved, the LSP is stable and will give a dark matter candidate

The proton decay is not problematic in RPV scenarios, if only leptonic or baryonic violating terms are present (but not both together)

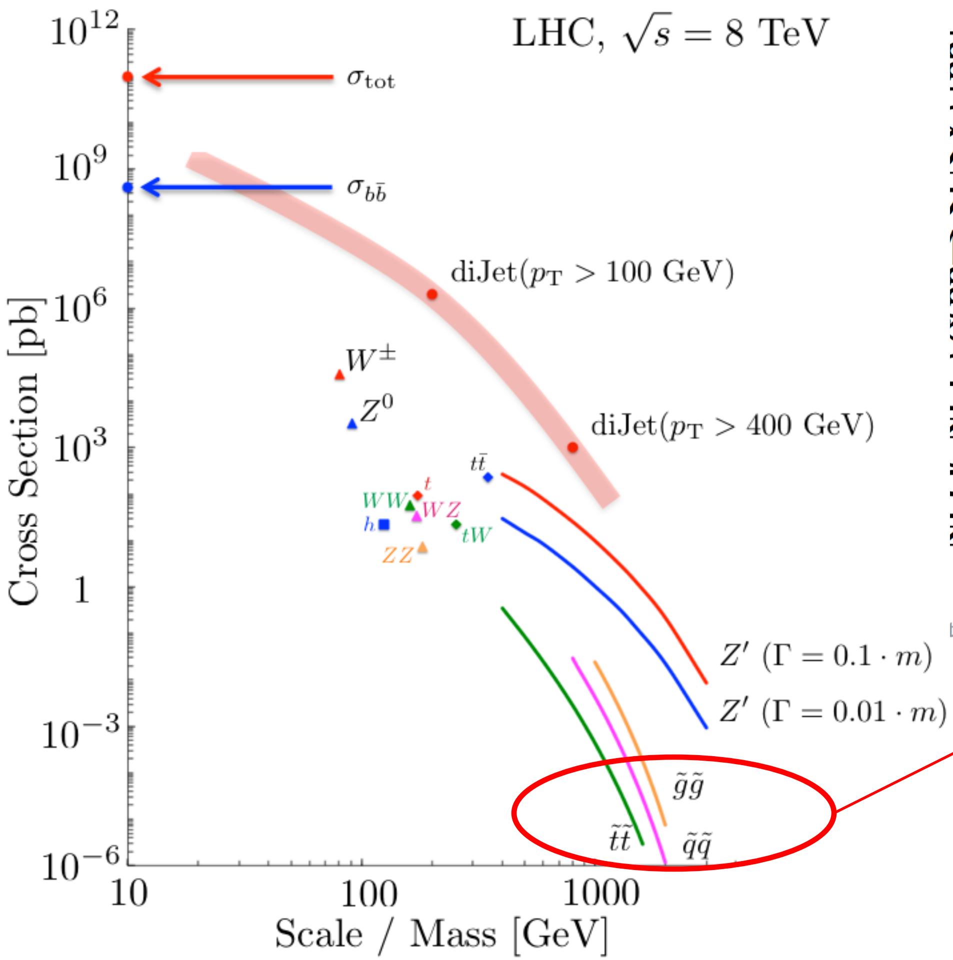
- Gauge coupling unification :

In the SM, the gauge coupling unification at the GUT scale will not occur ; in SUSY it could occur

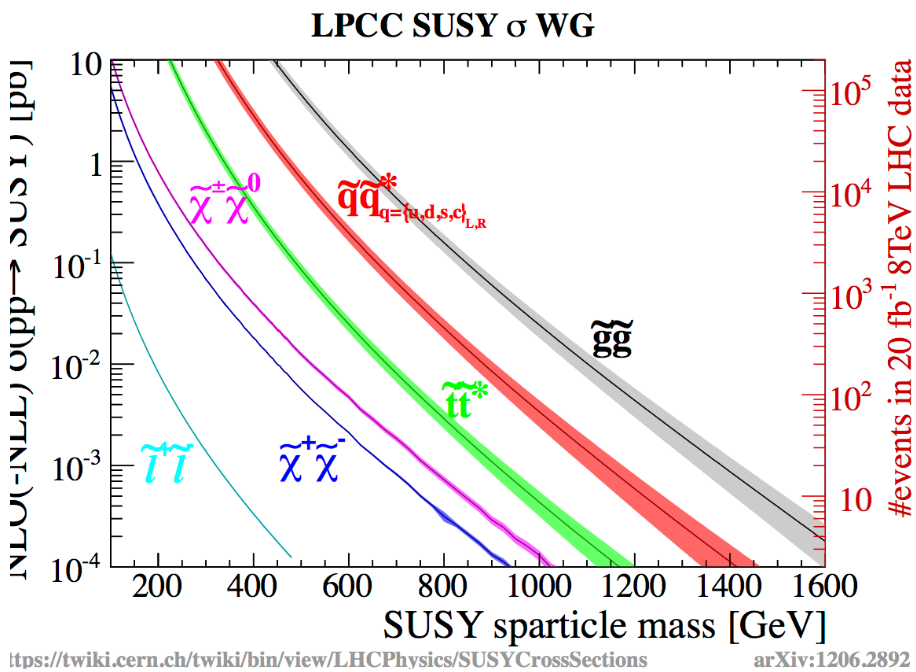


SUSY searches

- SM processes and SUSY cross-sections:



C. Sander LPCC seminar 3th Sept CERN

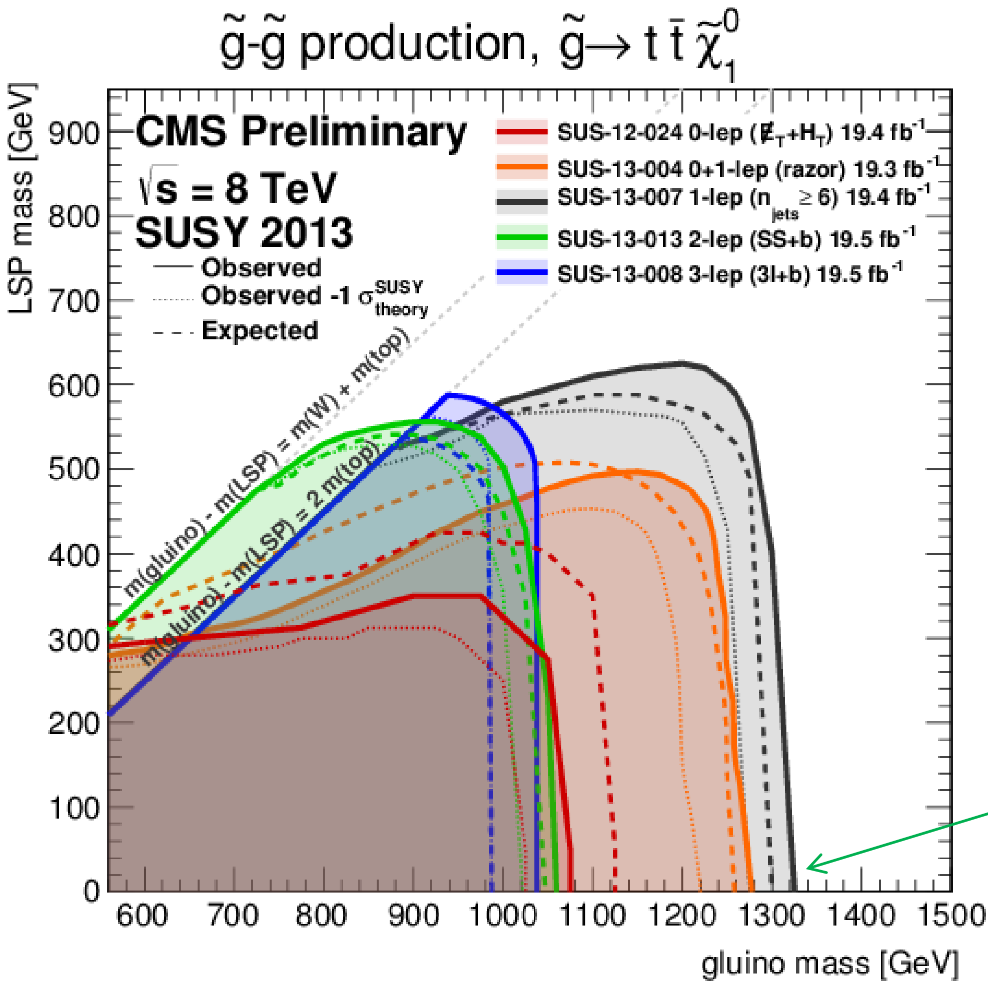


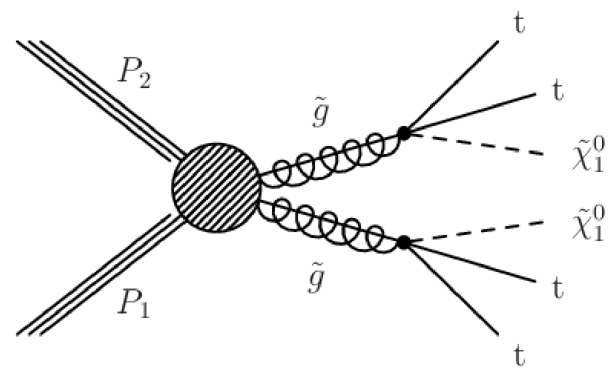
- σ_{SUSY} lower than the SM processes
- SM backgrounds determined using both MC and data driven methods

SUSY searches

- Several possible frameworks to interpret the SUSY searches:
- Constrained MSSM:
  - only few free parameters (ie. mSUGRA : m_0, $m_{1/2}$, A_0, tanß and sign(μ))
  - not easy to translate in another model (ie. GMSB, pMSSM)
  - large part of the parameters space already excluded by the 7/8 TeV data @ LHC
- Simplified Model Signatures:
  - taking into account the dominant SUSY cascade
  - assume a 100% BR for each process
  - described by masses and cross-sections
  - broader searches than cMSSM

- Simplified Models $\tilde{g}$-$\tilde{g}$ production (Rp conserved):

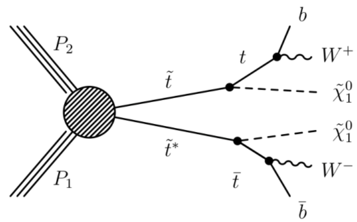


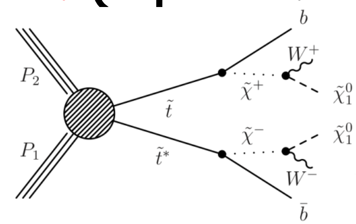


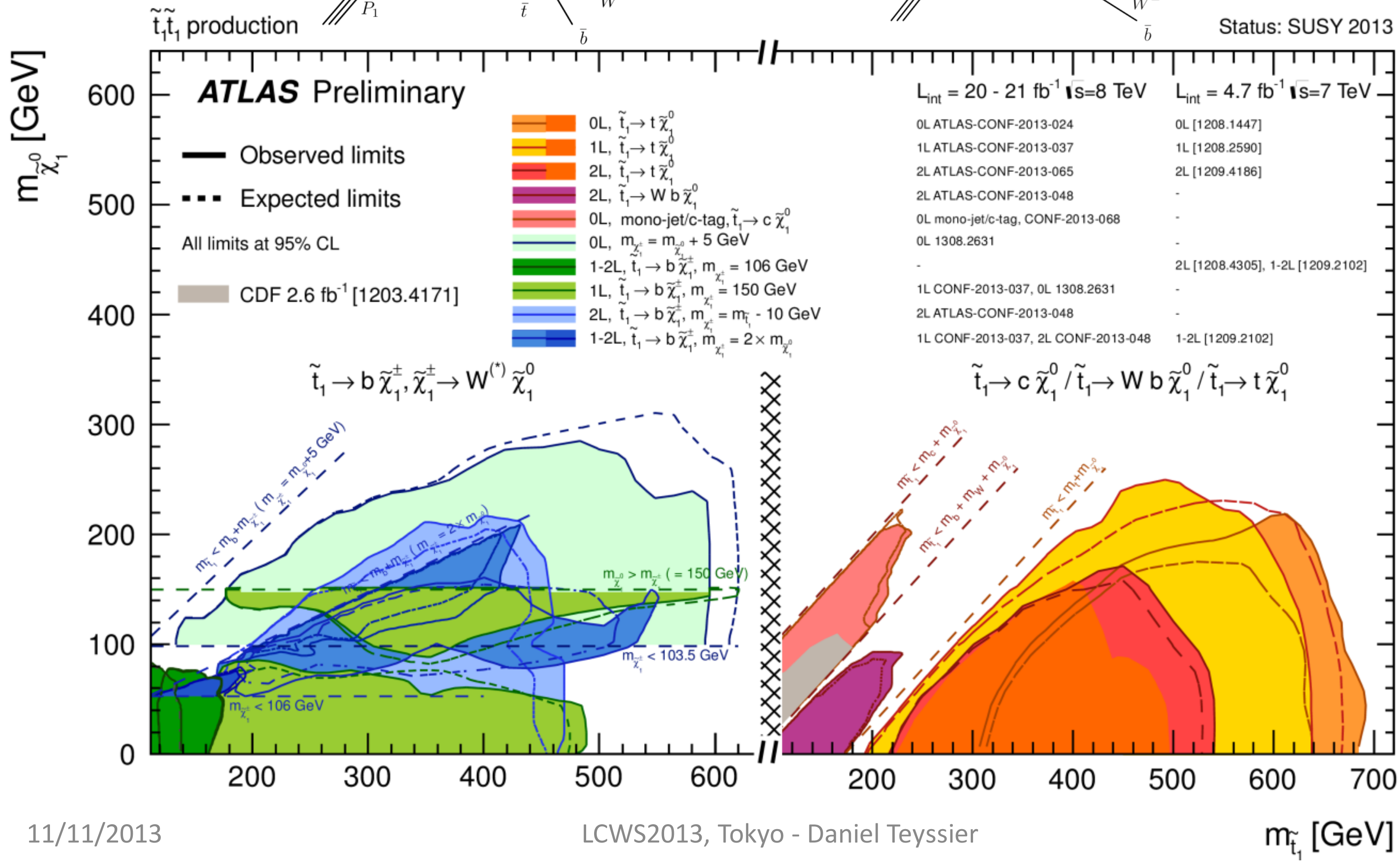
No intermediate particles shown
Dominant cascade $\tilde{g}$ into $t\bar{t}$ + LSP
T1 tttt region in SMS *jargon*

Probe the gluino mass up to 1.3 TeV

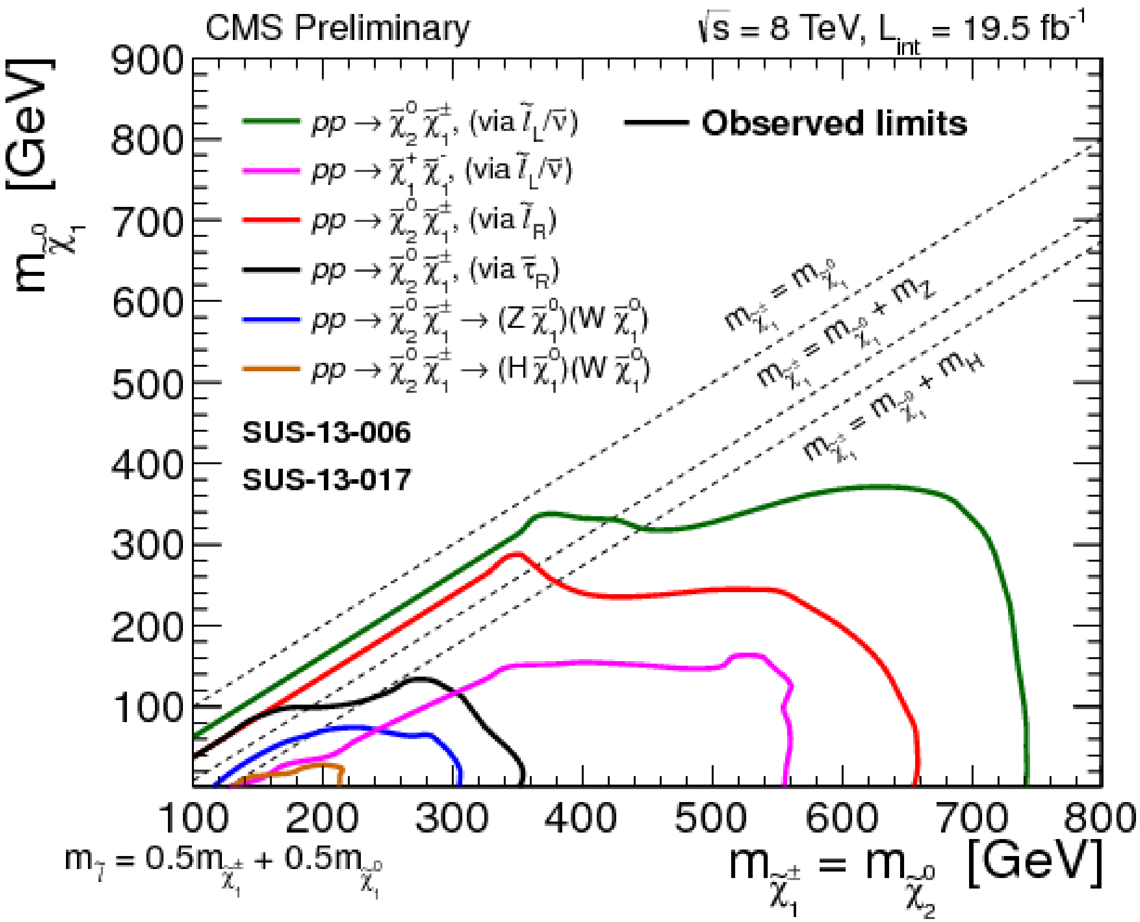
- Simplified Models $\tilde{t}$-$\tilde{t}$ production (Rp conserved):

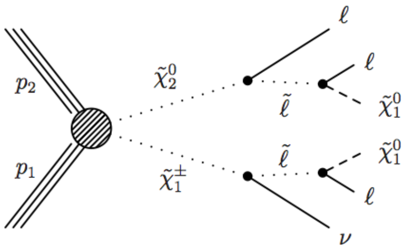




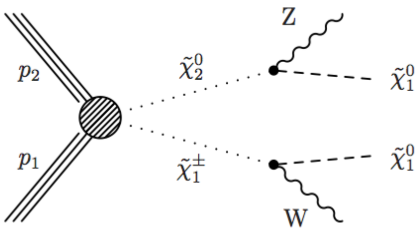


• Simplified Models EWKino production (Rp conserved):





Decay via sleptons



Direct decay if $\Delta m > m_{Z,W}$

Topology : up to 4 leptons + MET
Clean signature

SUSY searches

ATLAS SUSY Searches* - 95% CL Lower Limits

Status: SUSY 2013

ATLAS Preliminary

$\int \mathcal{L}\,dt = (4.6 - 22.9)\ \mathrm{fb}^{-1}$ $\quad \sqrt{s} = 7, 8$ TeV

	Model	e, μ, τ, γ	Jets	E_T^{miss}	$\int \mathcal{L}\,dt[\mathrm{fb}^{-1}]$		Mass limit		Reference
Inclusive Searches	MSUGRA/CMSSM	0	2-6 jets	Yes	20.3	$\tilde{q}, \tilde{g}$	1.7 TeV	$m(\tilde{q})=m(\tilde{g})$	ATLAS-CONF-2013-047
	MSUGRA/CMSSM	1 e, μ	3-6 jets	Yes	20.3	$\tilde{g}$	1.2 TeV	any $m(\tilde{q})$	ATLAS-CONF-2013-062
	MSUGRA/CMSSM	0	7-10 jets	Yes	20.3	$\tilde{g}$	1.1 TeV	any $m(\tilde{q})$	1308.1841
	$\tilde{q}\tilde{q}, \tilde{q}\to q\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{q}$	740 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}, \tilde{g}\to q\bar{q}\tilde{\chi}_1^0$	0	2-6 jets	Yes	20.3	$\tilde{g}$	1.3 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-047
	$\tilde{g}\tilde{g}, \tilde{g}\to qq\tilde{\chi}_1^\pm\to qqW^\pm\tilde{\chi}_1^0$	1 e, μ	3-6 jets	Yes	20.3	$\tilde{g}$	1.18 TeV	$m(\tilde{\chi}_1^0)$<200 GeV, $m(\tilde{\chi}^\pm)=0.5(m(\tilde{\chi}_1^0)+m(\tilde{g}))$	ATLAS-CONF-2013-062
	$\tilde{g}\tilde{g}, \tilde{g}\to qq(\ell\ell/\ell\nu/\nu\nu)\tilde{\chi}_1^0$	2 e, μ	0-3 jets	-	20.3	$\tilde{g}$	1.12 TeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-089
	GMSB ($\tilde{\ell}$ NLSP)	2 e, μ	2-4 jets	Yes	4.7	$\tilde{g}$	1.24 TeV	$\tan\beta$<15	1208.4688
	GMSB ($\tilde{\ell}$ NLSP)	1-2 τ	0-2 jets	Yes	20.7	$\tilde{g}$	1.4 TeV	$\tan\beta$ >18	ATLAS-CONF-2013-026
	GGM (bino NLSP)	2 γ	-	Yes	4.8	$\tilde{g}$	1.07 TeV	$m(\tilde{\chi}_1^0)$>50 GeV	1209.0753
	GGM (wino NLSP)	1 $e, \mu + \gamma$	-	Yes	4.8	$\tilde{g}$	619 GeV	$m(\tilde{\chi}_1^0)$>50 GeV	ATLAS-CONF-2012-144
	GGM (higgsino-bino NLSP)	γ	1 b	Yes	4.8	$\tilde{g}$	900 GeV	$m(\tilde{\chi}_1^0)$>220 GeV	1211.1167
	GGM (higgsino NLSP)	2 e, μ (Z)	0-3 jets	Yes	5.8	$\tilde{g}$	690 GeV	$m(\tilde{H})$>200 GeV	ATLAS-CONF-2012-152
	Gravitino LSP	0	mono-jet	Yes	10.5	$F^{1/2}$ scale	645 GeV	$m(\tilde{g})>10^{-4}$ eV	ATLAS-CONF-2012-147
3rd gen. $\tilde{g}$ med.	$\tilde{g}\to b\bar{b}\tilde{\chi}_1^0$	0	3 b	Yes	20.1	$\tilde{g}$	1.2 TeV	$m(\tilde{\chi}_1^0)$<600 GeV	ATLAS-CONF-2013-061
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0	7-10 jets	Yes	20.3	$\tilde{g}$	1.1 TeV	$m(\tilde{\chi}_1^0)$ <350 GeV	1308.1841
	$\tilde{g}\to t\bar{t}\tilde{\chi}_1^0$	0-1 e, μ	3 b	Yes	20.1	$\tilde{g}$	1.34 TeV	$m(\tilde{\chi}_1^0)$<400 GeV	ATLAS-CONF-2013-061
	$\tilde{g}\to b\bar{t}\tilde{\chi}_1^+$	0-1 e, μ	3 b	Yes	20.1	$\tilde{g}$	1.3 TeV	$m(\tilde{\chi}_1^0)$<300 GeV	ATLAS-CONF-2013-061
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	20.7	$\tilde{b}_1$	275-430 GeV	$m(\tilde{\chi}_1^\pm)=2\,m(\tilde{\chi}_1^0)$	ATLAS-CONF-2013-007
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	1-2 e, μ	1-2 b	Yes	4.7	$\tilde{t}_1$	110-167 GeV	$m(\tilde{\chi}_1^0)$=55 GeV	1208.4305, 1209.2102
	$\tilde{t}_1\tilde{t}_1$(light), $\tilde{t}_1\to Wb\tilde{\chi}_1^0$	2 e, μ	0-2 jets	Yes	20.3	$\tilde{t}_1$	130-220 GeV	$m(\tilde{\chi}_1^0)=m(\tilde{t}_1)-m(W)$-50 GeV, $m(\tilde{t}_1)<<m(\tilde{\chi}_1^\pm)$	ATLAS-CONF-2013-048
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to t\tilde{\chi}_1^0$	2 e, μ	2 jets	Yes	20.3	$\tilde{t}_1$	225-525 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-065
	$\tilde{t}_1\tilde{t}_1$(medium), $\tilde{t}_1\to b\tilde{\chi}_1^\pm$	0	2 b	Yes	20.1	$\tilde{t}_1$	150-580 GeV	$m(\tilde{\chi}_1^0)$<200 GeV, $m(\tilde{\chi}_1^\pm)-m(\tilde{\chi}_1^0)$=5 GeV	1308.2631
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	1 e, μ	1 b	Yes	20.7	$\tilde{t}_1$	200-610 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-037
	$\tilde{t}_1\tilde{t}_1$(heavy), $\tilde{t}_1\to t\tilde{\chi}_1^0$	0	2 b	Yes	20.5	$\tilde{t}_1$	320-660 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-024
	$\tilde{t}_1\tilde{t}_1, \tilde{t}_1\to c\tilde{\chi}_1^0$	0	mono-jet/c-tag	Yes	20.3	$\tilde{t}_1$	90-200 GeV	$m(\tilde{t}_1)-m(\tilde{\chi}_1^0)$<85 GeV	ATLAS-CONF-2013-068
	$\tilde{t}_1\tilde{t}_1$(natural GMSB)	2 e, μ (Z)	1 b	Yes	20.7	$\tilde{t}_1$	500 GeV	$m(\tilde{\chi}_1^0)$>150 GeV	ATLAS-CONF-2013-025
	$\tilde{t}_2\tilde{t}_2, \tilde{t}_2\to\tilde{t}_1 + Z$	3 e, μ (Z)	1 b	Yes	20.7	$\tilde{t}_2$	271-520 GeV	$m(\tilde{t}_1)=m(\tilde{\chi}_1^0)$+180 GeV	ATLAS-CONF-2013-025
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	$\tilde{\ell}$	85-315 GeV	$m(\tilde{\chi}_1^0)$=0 GeV	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\ell}\nu(\ell\tilde{\nu})$	2 e, μ	0	Yes	20.3	$\tilde{\chi}_1^\pm$	125-450 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-049
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to\tilde{\tau}\nu(\tau\tilde{\nu})$	2 τ	-	Yes	20.7	$\tilde{\chi}_1^\pm$	180-330 GeV	$m(\tilde{\chi}_1^0)$=0 GeV, $m(\tilde{\tau},\tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-028
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to\tilde{\ell}_L\nu\tilde{\ell}_L\ell(\tilde{\nu}\nu), \ell\tilde{\nu}\tilde{\ell}_L\ell(\tilde{\nu}\nu)$	3 e, μ	0	Yes	20.7	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	600 GeV	$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, $m(\tilde{\ell},\tilde{\nu})=0.5(m(\tilde{\chi}_1^\pm)+m(\tilde{\chi}_1^0))$	ATLAS-CONF-2013-035
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 Z\tilde{\chi}_1^0$	3 e, μ	0	Yes	20.7	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	315 GeV	$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, sleptons decoupled	ATLAS-CONF-2013-035
	$\tilde{\chi}_1^\pm\tilde{\chi}_2^0\to W\tilde{\chi}_1^0 h\tilde{\chi}_1^0$	1 e, μ	2 b	Yes	20.3	$\tilde{\chi}_1^\pm, \tilde{\chi}_2^0$	285 GeV	$m(\tilde{\chi}_1^\pm)=m(\tilde{\chi}_2^0)$, $m(\tilde{\chi}_1^0)$=0, sleptons decoupled	ATLAS-CONF-2013-093
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	ATLAS-CONF-2013-069
	Stable, stopped $\tilde{g}$ R-hadron	0	1-5 jets	Yes	22.9	$\tilde{g}$	832 GeV	$m(\tilde{\chi}_1^0)$=100 GeV, 10 μs<$\tau(\tilde{g})$<1000 s	ATLAS-CONF-2013-057
	GMSB, stable $\tilde{\tau}, \tilde{\chi}_1^0\to\tilde{\tau}(\tilde{e},\tilde{\mu})+\tau(e,\mu)$	1-2 μ	-	-	15.9	$\tilde{\chi}_1^0$	475 GeV	10<$\tan\beta$<50	ATLAS-CONF-2013-058
	GMSB, $\tilde{\chi}_1^0\to\gamma\tilde{G}$, long-lived $\tilde{\chi}_1^0$	2 γ	-	Yes	4.7	$\tilde{\chi}_1^0$	230 GeV	0.4<$\tau(\tilde{\chi}_1^0)$<2 ns	1304.6310
	$\tilde{q}\tilde{q}, \tilde{\chi}_1^0\to qq\mu$ (RPV)	1 μ, displ. vtx	-	-	20.3	$\tilde{q}$	1.0 TeV	1.5 <$c\tau$<156 mm, BR(μ)=1, $m(\tilde{\chi}_1^0)$=108 GeV	ATLAS-CONF-2013-092
RPV	LFV $pp\to\tilde{\nu}_\tau + X, \tilde{\nu}_\tau\to e + \mu$	2 e, μ	-	-	4.6	$\tilde{\nu}_\tau$	1.61 TeV	λ'_{311}=0.10, λ_{132}=0.05	1212.1272
	LFV $pp\to\tilde{\nu}_\tau + X, \tilde{\nu}_\tau\to e(\mu) + \tau$	1 $e, \mu + \tau$	-	-	4.6	$\tilde{\nu}_\tau$	1.1 TeV	λ'_{311}=0.10, $\lambda_{1(2)33}$=0.05	1212.1272
	Bilinear RPV CMSSM	1 e, μ	7 jets	Yes	4.7	$\tilde{q}, \tilde{g}$	1.2 TeV	$m(\tilde{q})=m(\tilde{g})$, $c\tau_{LSP}$<1 mm	ATLAS-CONF-2012-140
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to ee\tilde{\nu}_\mu, e\mu\tilde{\nu}_e$	4 e, μ	-	Yes	20.7	$\tilde{\chi}_1^\pm$	760 GeV	$m(\tilde{\chi}_1^0)$>300 GeV, λ_{121}>0	ATLAS-CONF-2013-036
	$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_1^+\to W\tilde{\chi}_1^0, \tilde{\chi}_1^0\to\tau\tau\tilde{\nu}_e, e\tau\tilde{\nu}_\tau$	3 $e, \mu + \tau$	-	Yes	20.7	$\tilde{\chi}_1^\pm$	350 GeV	$m(\tilde{\chi}_1^0)$>80 GeV, λ_{133}>0	ATLAS-CONF-2013-036
	$\tilde{g}\to qqq$	0	6-7 jets	-	20.3	$\tilde{g}$	916 GeV	BR(t)=BR(b)=BR(c)=0%	ATLAS-CONF-2013-091
	$\tilde{g}\to\tilde{t}_1 t, \tilde{t}_1\to bs$	2 e, μ (SS)	0-3 b	Yes	20.7	$\tilde{g}$	880 GeV		ATLAS-CONF-2013-007
Other	Scalar gluon pair, sgluon$\to q\bar{q}$	0	4 jets	-	4.6	sgluon	100-287 GeV	incl. limit from 1110.2693	1210.4826
	Scalar gluon pair, sgluon$\to t\bar{t}$	2 e, μ (SS)	1 b	Yes	14.3	sgluon	800 GeV		ATLAS-CONF-2013-051
	WIMP interaction (D5, Dirac χ)	0	mono-jet	Yes	10.5	M* scale	704 GeV	$m(\chi)$<80 GeV, limit of<687 GeV for D8	ATLAS-CONF-2012-147

Mass scale [TeV] (10^{-1} … 1)

$\sqrt{s}$ = 7 TeV full data | $\sqrt{s}$ = 8 TeV partial data | $\sqrt{s}$ = 8 TeV full data

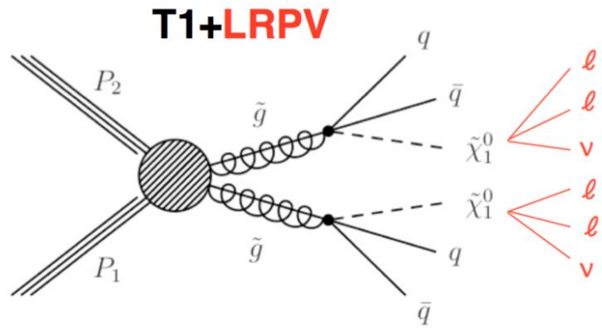
*Only a selection of the available mass limits on new states or phenomena is shown. All limits quoted are observed minus 1σ theoretical signal cross section uncertainty.

$\tilde{g}$

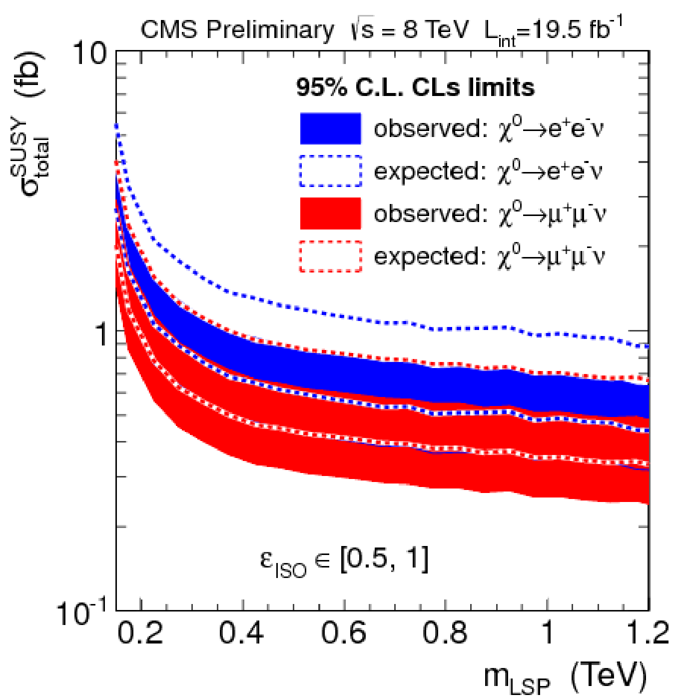
$\tilde{q}$

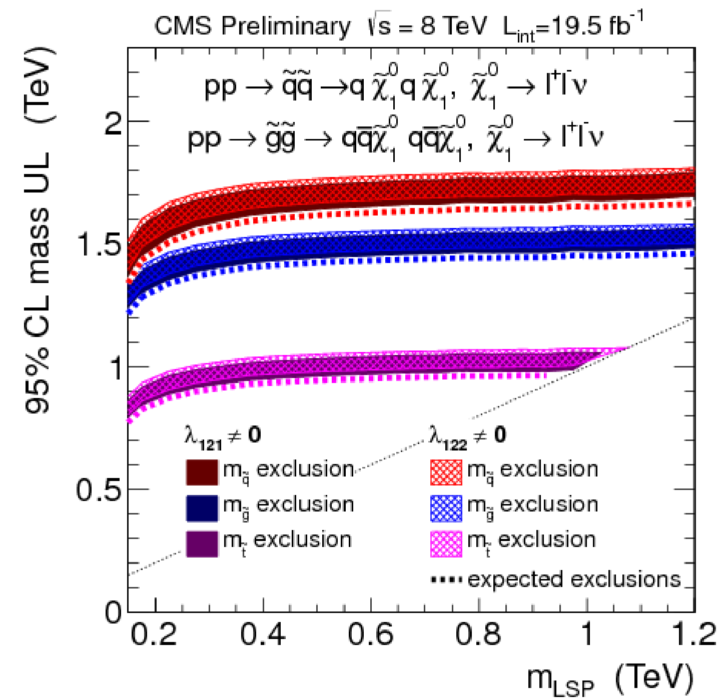
EWKino

- **Simplified Models RPV multi-lepton:**



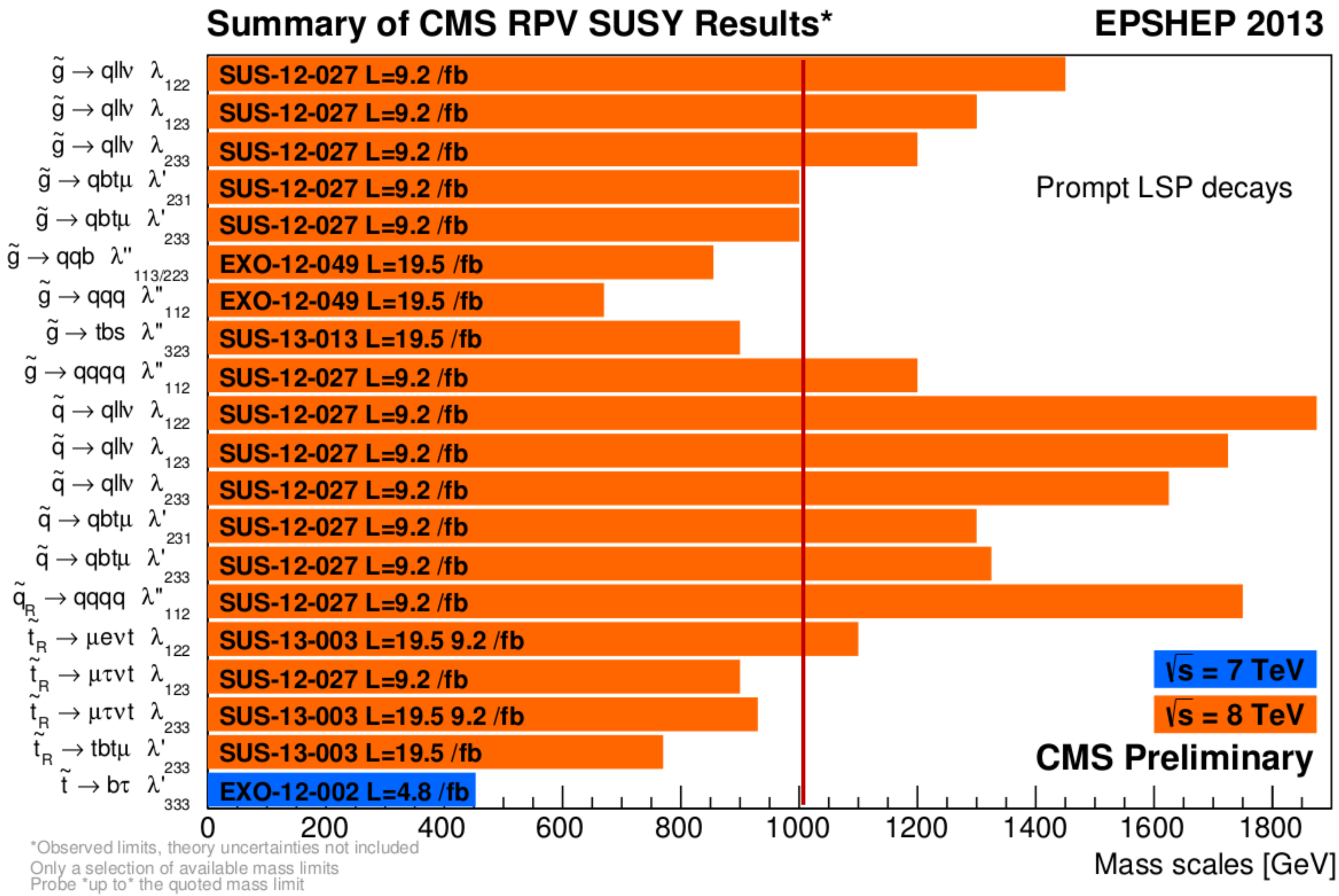
LRPV extensions to Simplified Models, T1+LRPV model. The T1 RPC simplified model is the gluino pair production, the LRPV term is the decay of the neutralinos (4 leptons + neutrinos)





Probe the stop mass up to 1.0 TeV, the gluino mass up to 1.5 TeV and the squark mass up to 1.7 TeV

SUSY searches



SUSY searches

- Prospects for SUSY searches with 300 /fb (LHC, ~2022) and 3000 /fb (HL-LHC, ~2030):

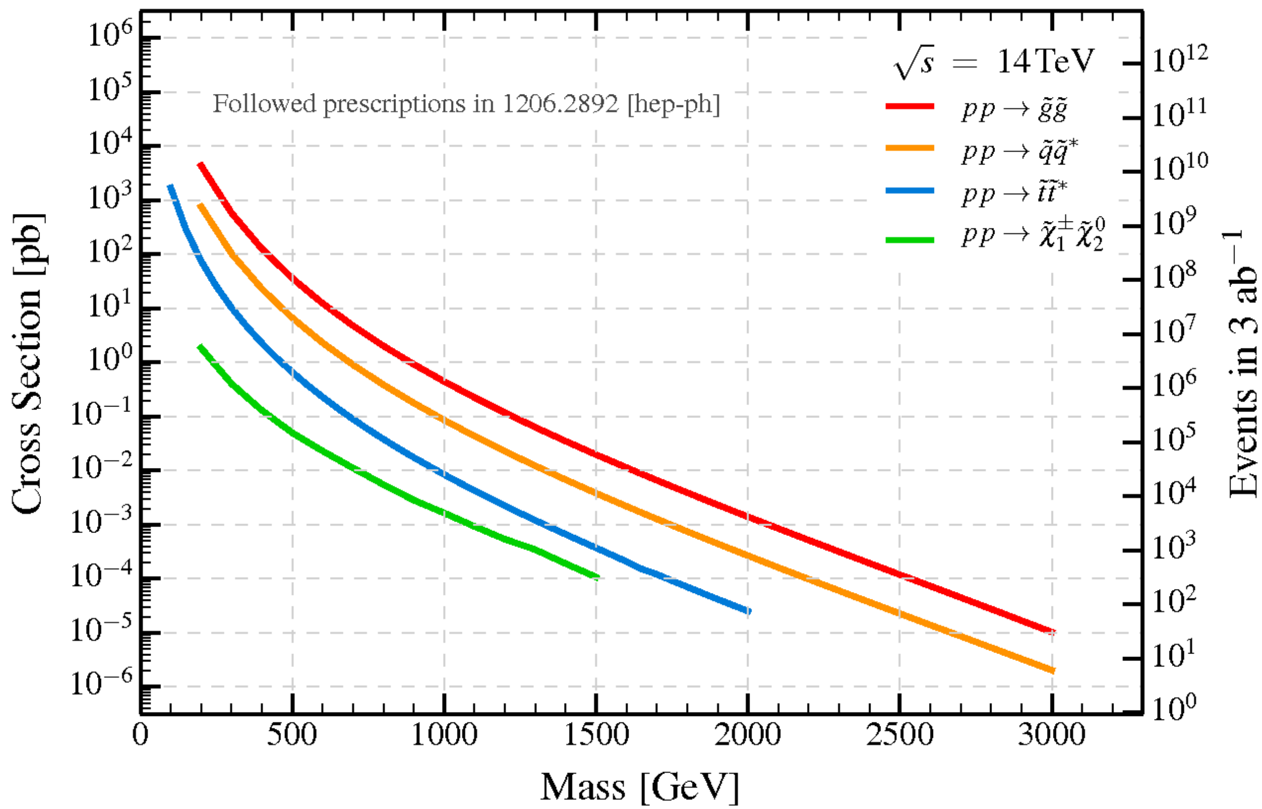
  Both $\sqrt{s}$ and $\int Ldt$ to be largely increased

  σ_{SUSY} will benefit from $\sqrt{s}$, but the pile-up will be higher also (~60 after LS2 and even ~140 after LS3)

LS1 (now) → Jan 2015 (13 TeV then 14 TeV, ~1.10^{34} cm^{-2}s^{-1}, ~100 /fb)

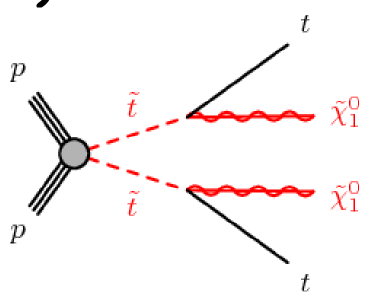
LS2 (2018) → 2020 (~2.10^{34} cm^{-2}s^{-1}, ~300 /fb)

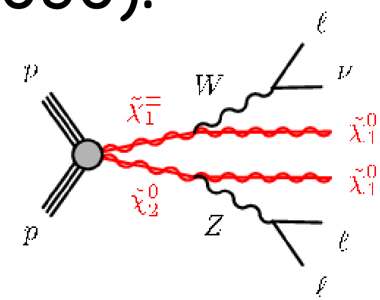
LS3 (2022) → HL-LHC (5.10^{34} cm^{-2}s^{-1}, ~3000 /fb)

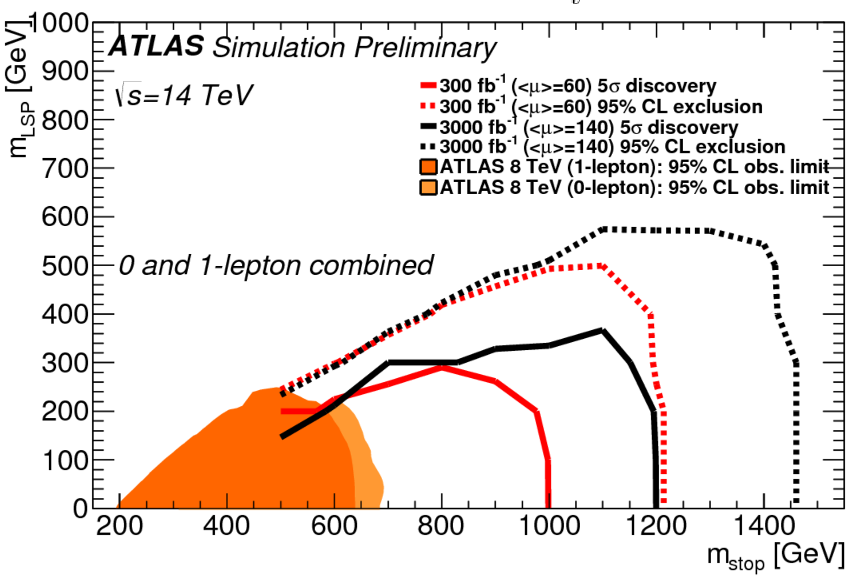


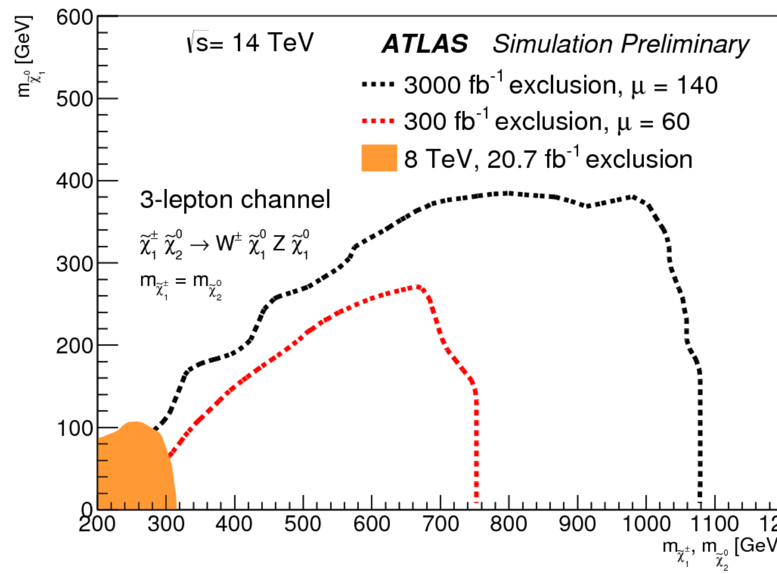
SUSY searches

- Prospects for SUSY searches with 300 /fb (LHC, ~2022) and 3000 /fb (HL-LHC, ~2030):





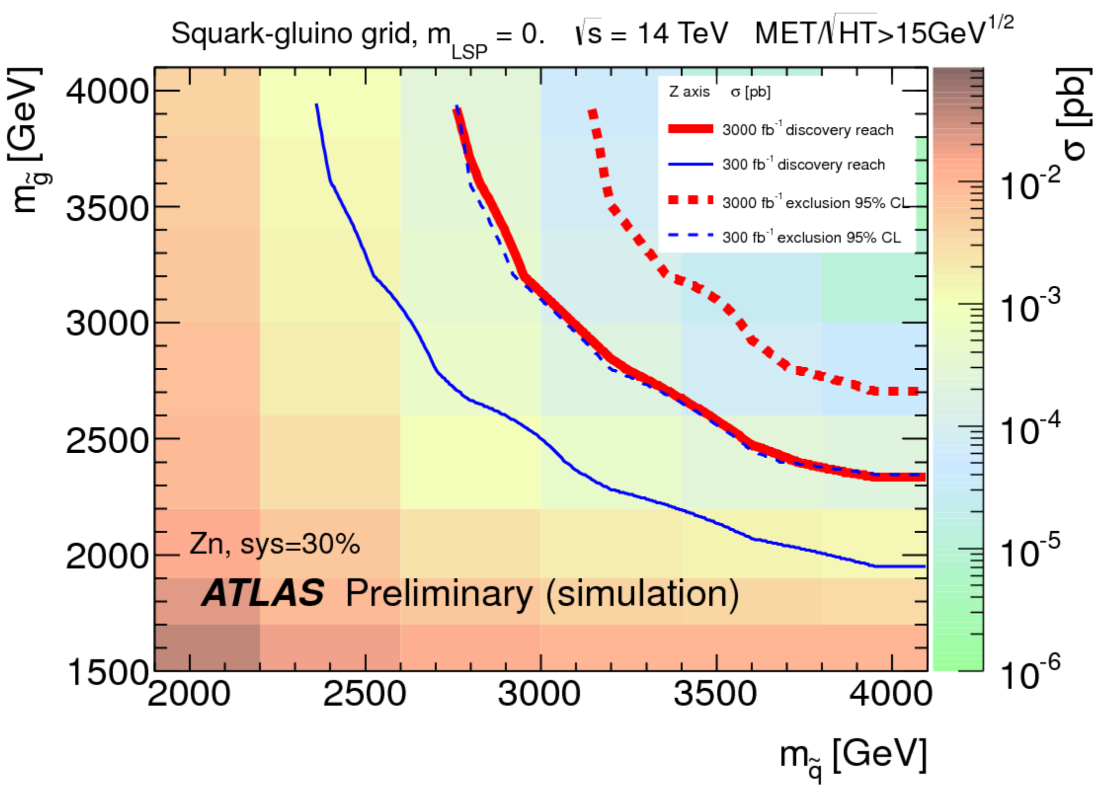




Sensitivity to SUSY largely extended (ATLAS-PHYS-PUB-2013-011)

SUSY searches

- Prospects for SUSY searches with 300 /fb (LHC, ~2022) and 3000 /fb (HL-LHC, ~2030):



Sensitivity to SUSY largely extended (ATLAS-PHYS-PUB-2013-002)

Exotica searches

Exotica searches

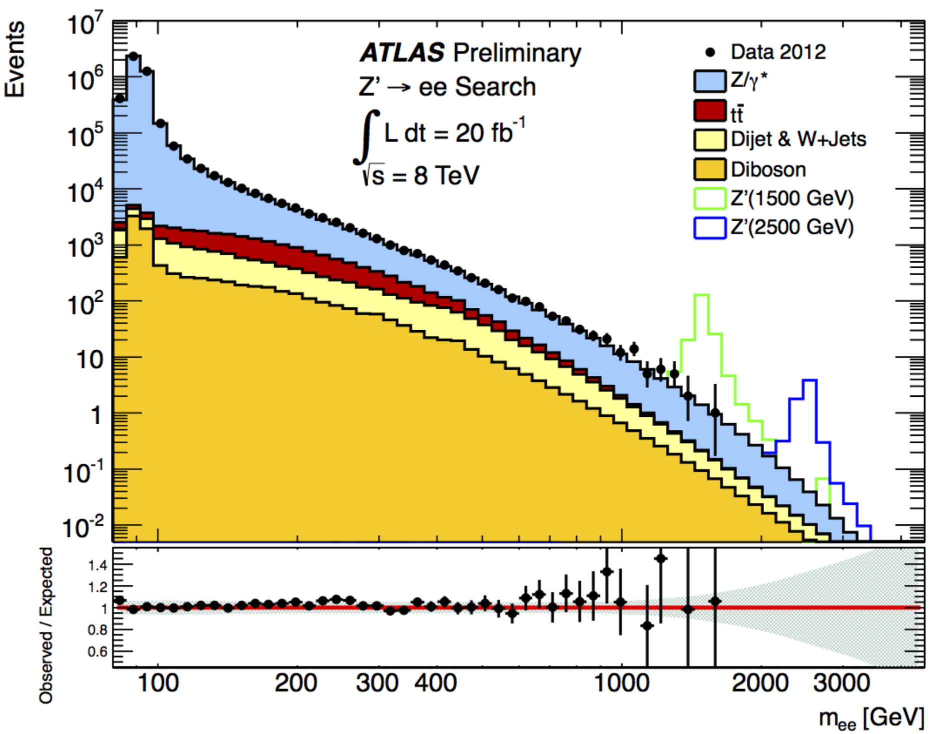
- The Exotica program covers the Beyond SM searches but SUSY:
  - do we have additional heavy gauge bosons (W', Z') ?
  - are we really constrained in 3+1 dimensions ?
  - is there any compositeness ?
  - any hint of dark matter ?
  - new phenomena generic searches are also performed (dijet mass spectrum analysis or looking for any anomalous production)
  - any other new phenomena (microscopic black holes, unparticles …) ?

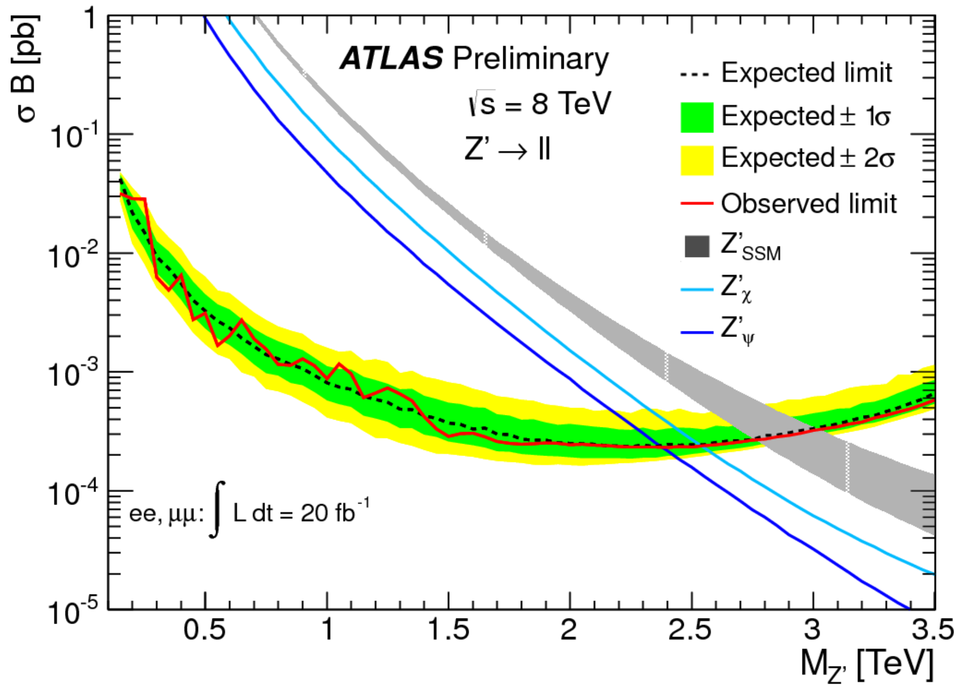
Exotica searches

- High-mass dilepton resonances: Z' searches

High-mass resonances can decay into e or μ pairs, using the sequential SM as benchmark model (same coupling to fermions as the Z boson)

Hierarchy problem can be addressed by Randall-Sundrum model with an extra-dimension, the excited Kaluza-Klein modes of the graviton decaying into a pair of leptons

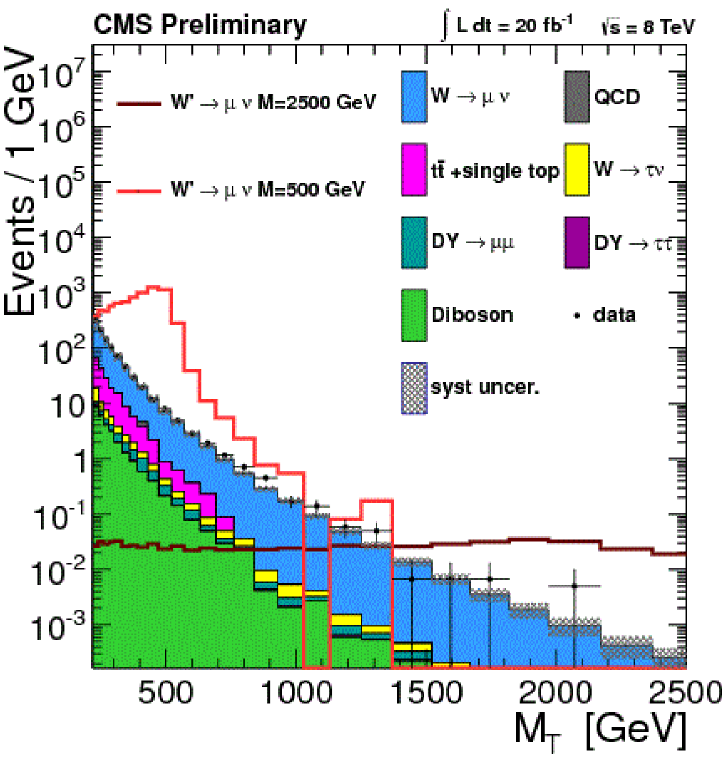




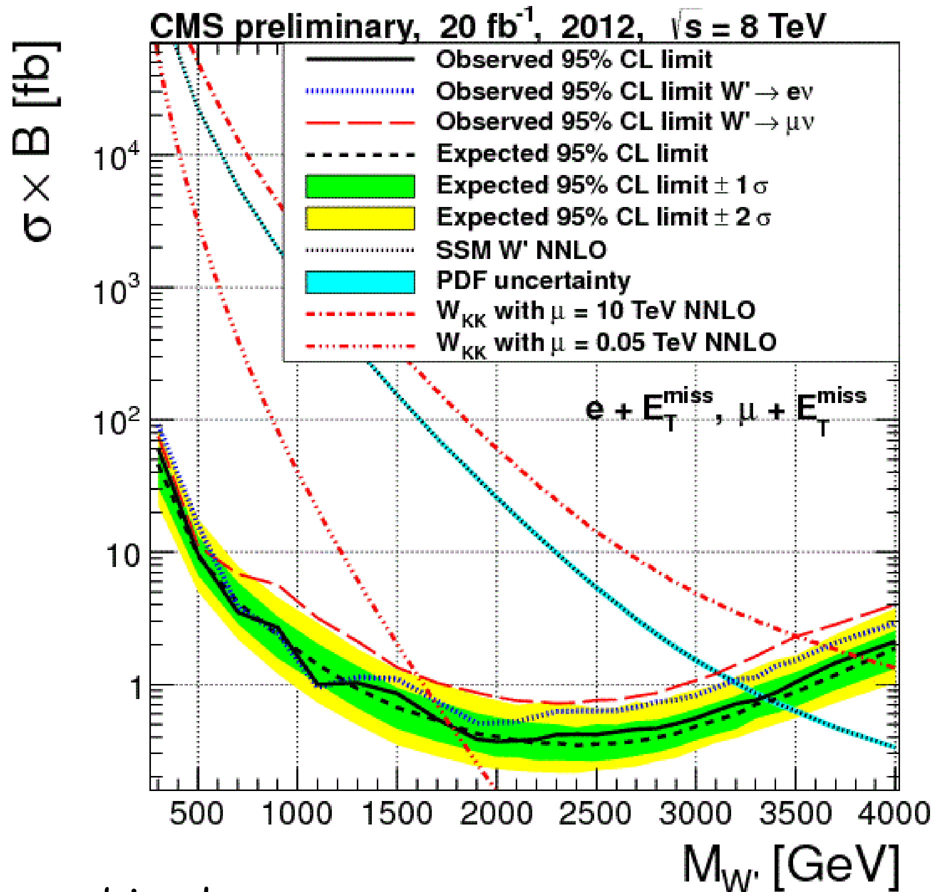
ATLAS limit in the sequential SM: 2.9 TeV (ATLAS-CONF-2013-017)

Exotica searches

- Heavy gauge bosons : W' searches in the sequential SM



$$M_{\mathrm{T}} = \sqrt{2E_{\mathrm{T}}^{\mathrm{miss}} p_{\mathrm{T}}^{l} (1 - \cos \Delta\phi_{l,E_{\mathrm{T}}^{\mathrm{miss}}})}$$

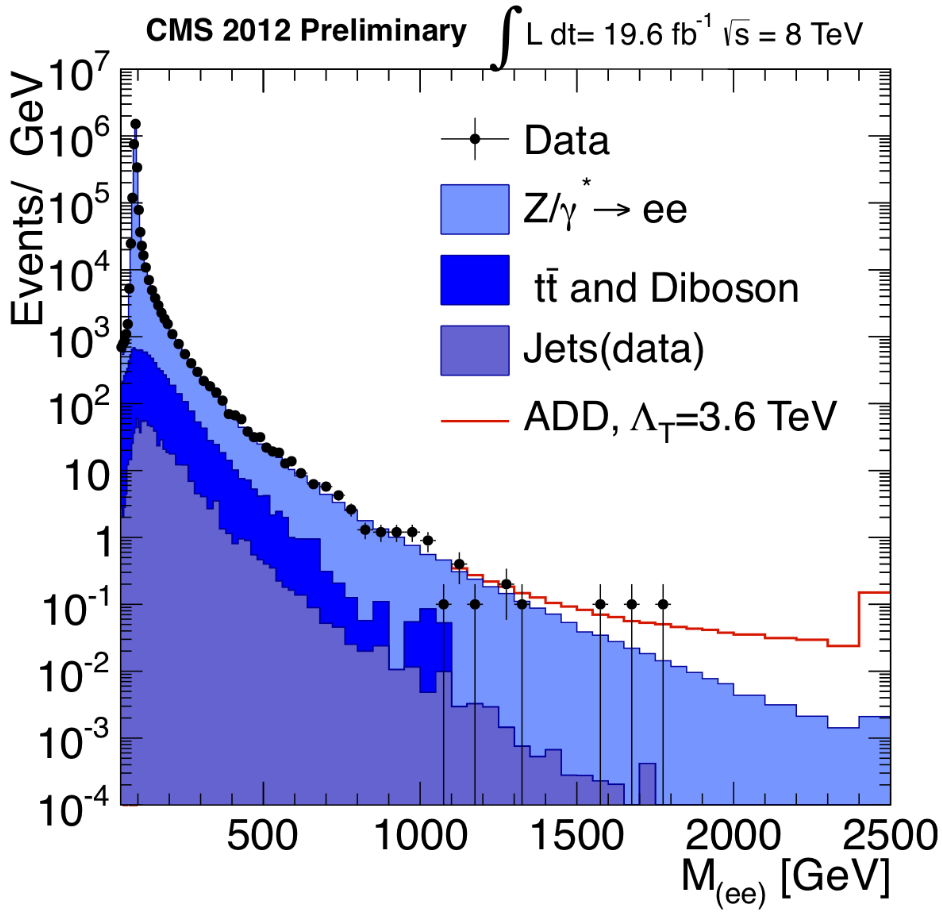


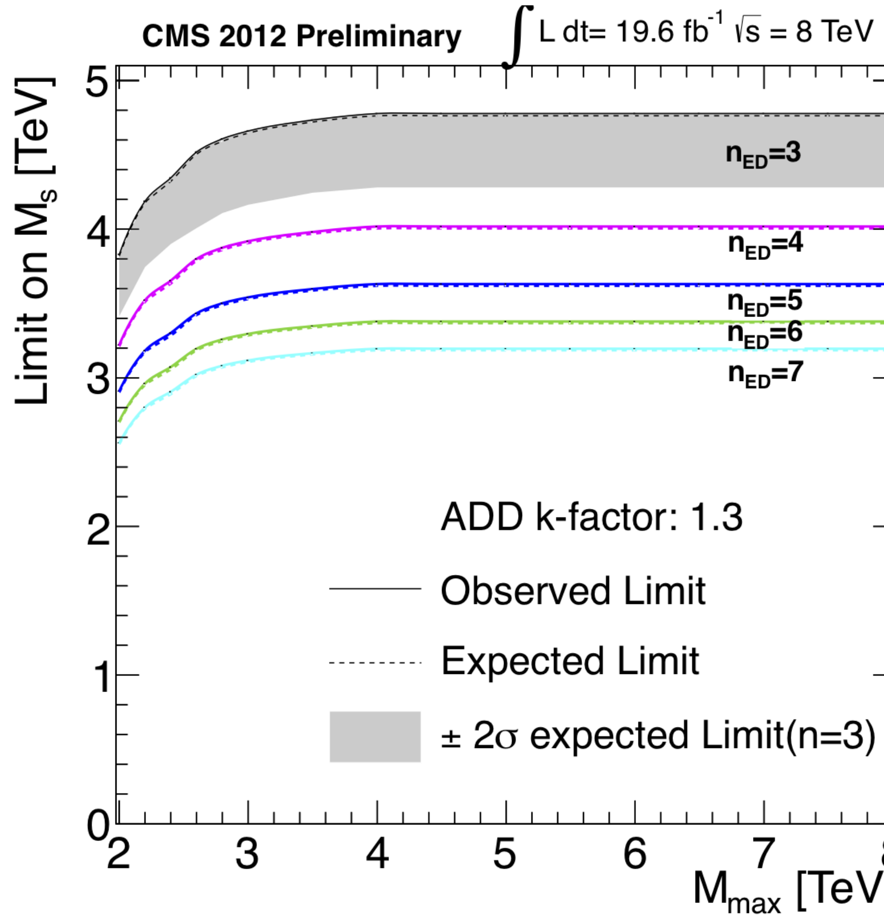
Both electron/muon channels are combined

CMS limit in the sequential SM : 3.3 TeV (CMS-PAS-EXO-12-060)

Exotica searches

- Extra-dimensions in the di-leptons/photons final state:



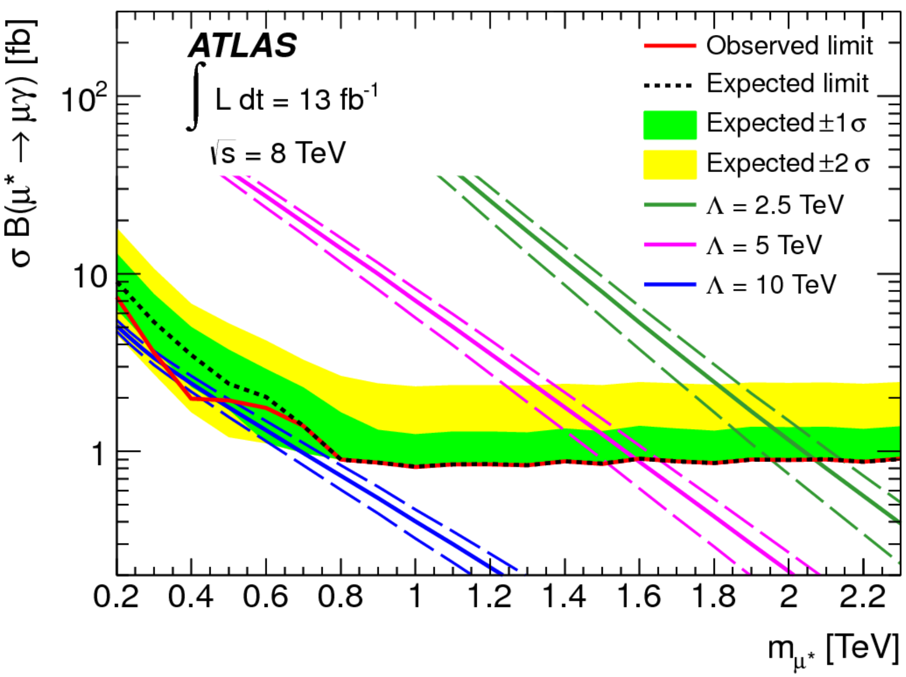


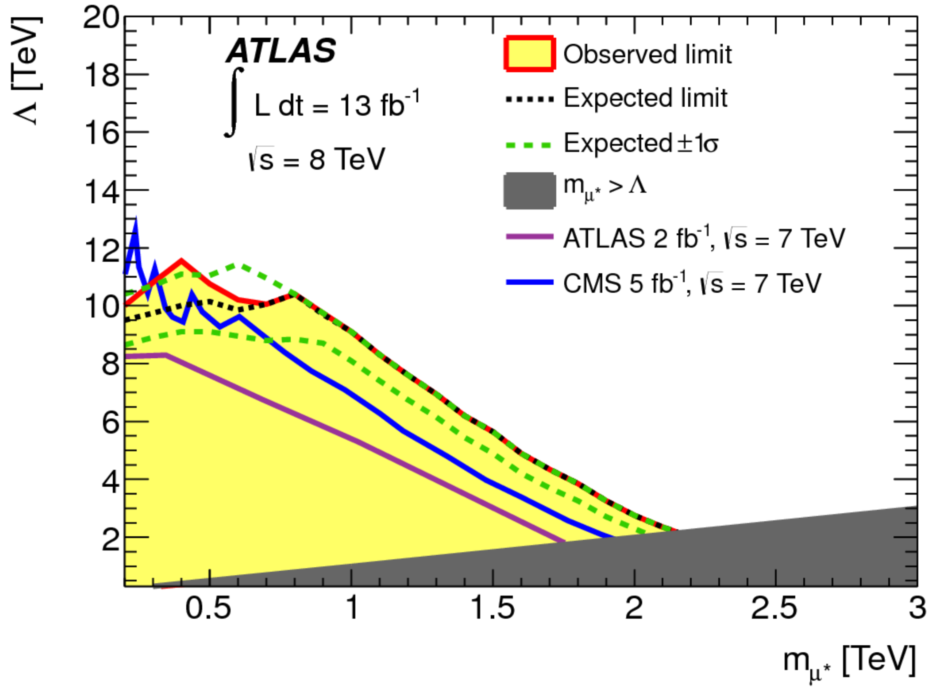
Looking for a pair of TeV electrons, muons or photons in the final state

Probe the mass scale up to ~ 3 TeV (CMS-PAS-EXO-12-031)

Exotica searches

- Excited electrons/muons (compositeness) :





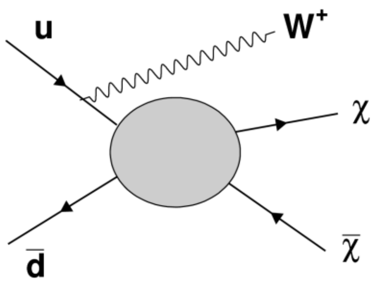
Excited states would be the consequence of fermions substructure

Excited leptons to be produced via four-fermion contact interactions, decaying to a lepton and a gauge boson or a lepton and a pair of fermions

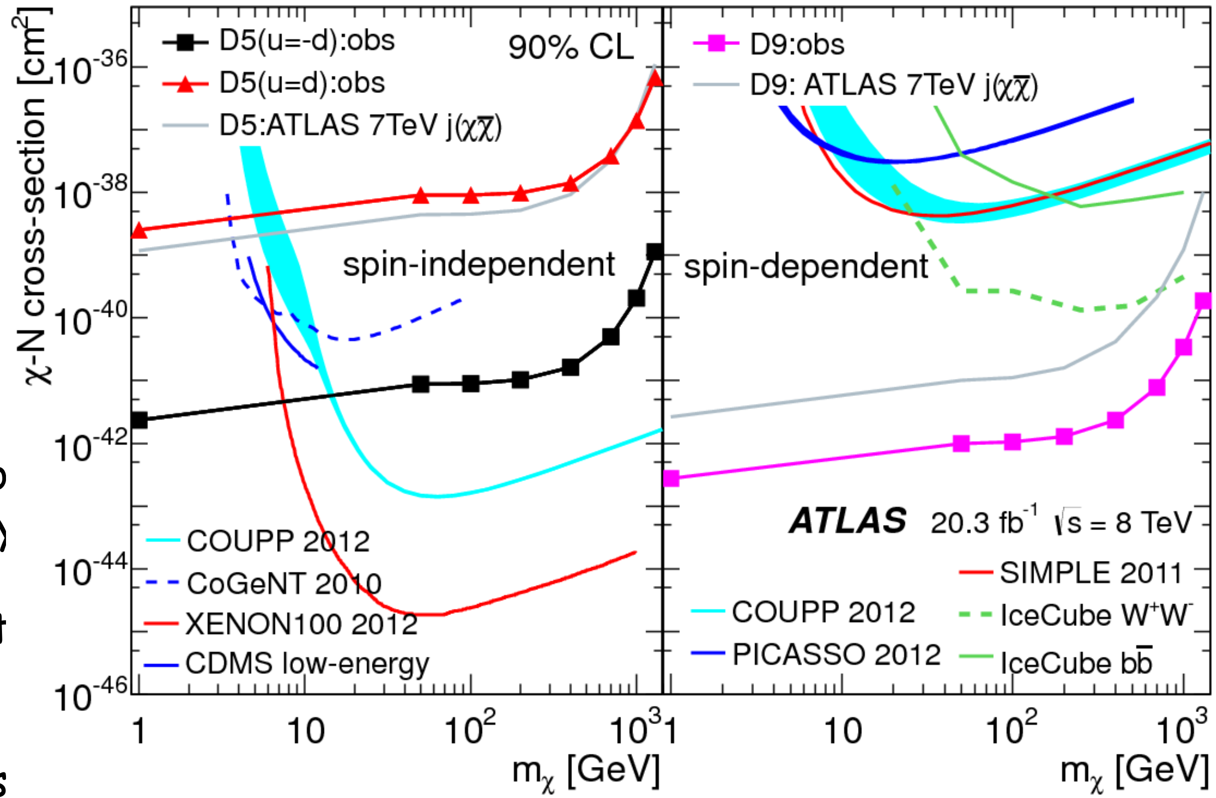
ATLAS limit for $\Lambda = m_{l^*}$: 2.2 TeV (NJP 15 (2013) 093011)

- Search for dark matter using mono-W/Z events:

The dark matter-nucleon scattering cross-section can be constrained in both spin-independent and spin-dependent interaction models, in particular in the low mass region (< 10 GeV)



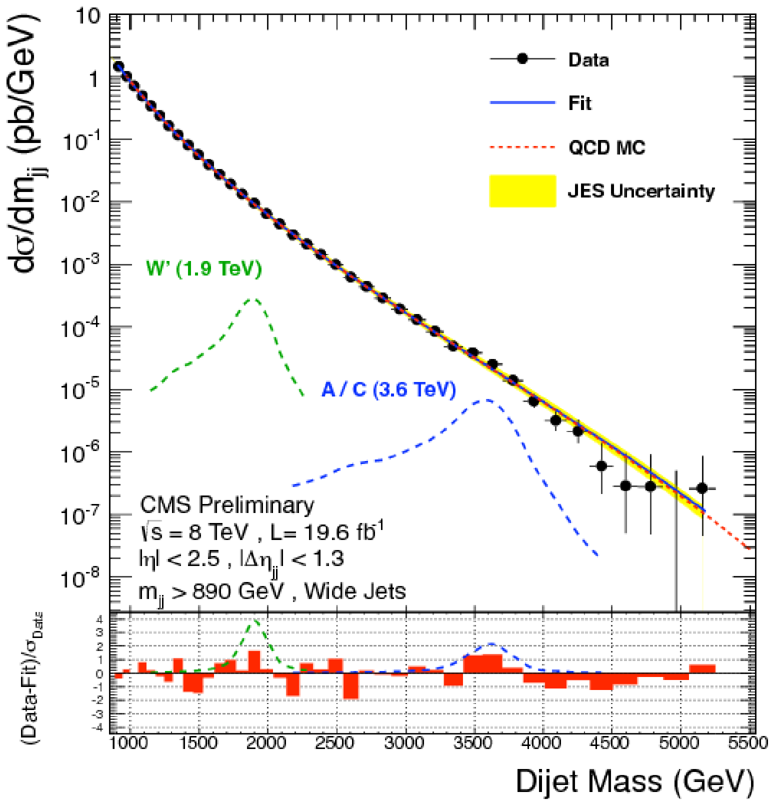
WIMPs pair production via an unknown intermediate state Initial-state radiation of a W o a Z boson, with a leptonic decay (e,μ,τ)
This analysis is also used to set an upper limit on the cross-section of the Higgs boson decaying into invisible particles

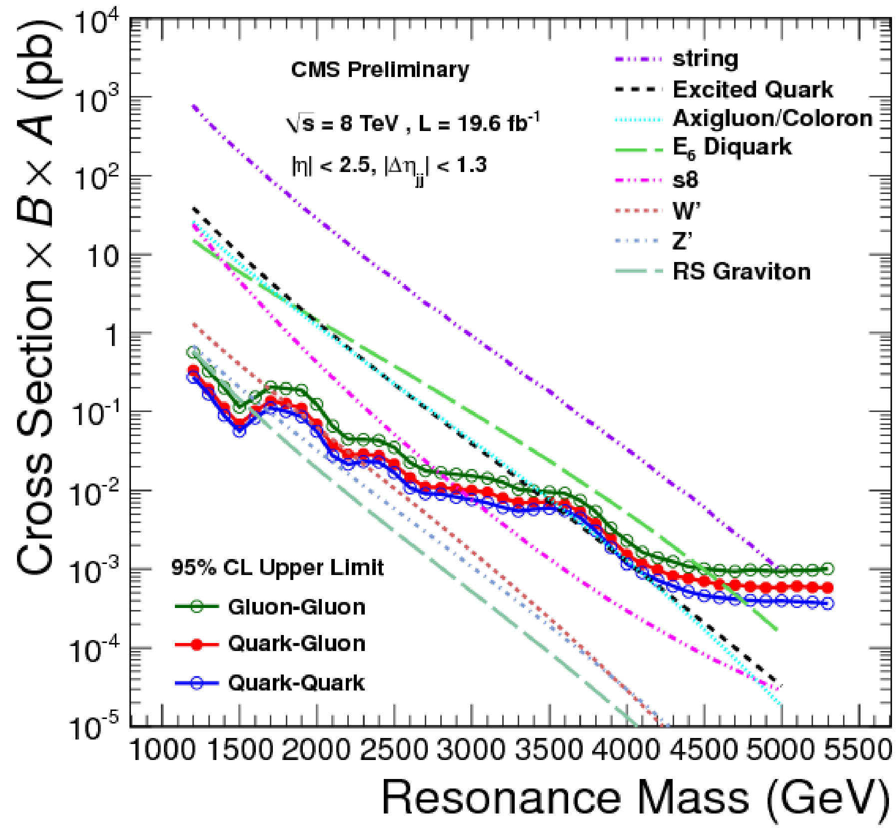


Dark matter searches are compared to CDF and direct detection experiments (XENON100, CoGeNT, CDMSII, COUPP ...) (e-print : arXiv:1309.4017)

Exotica searches

- Generic searches of new physics using the dijet mass spectrum:





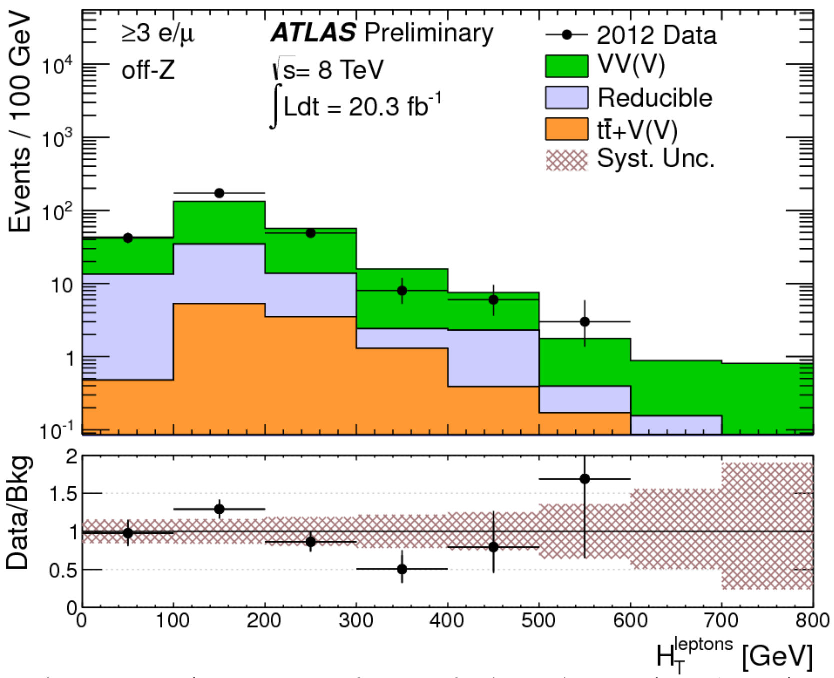
Several exotica searches (string resonances, excited quarks, axigluons, colorons …) can be searched as narrow resonances in the dijet mass spectrum

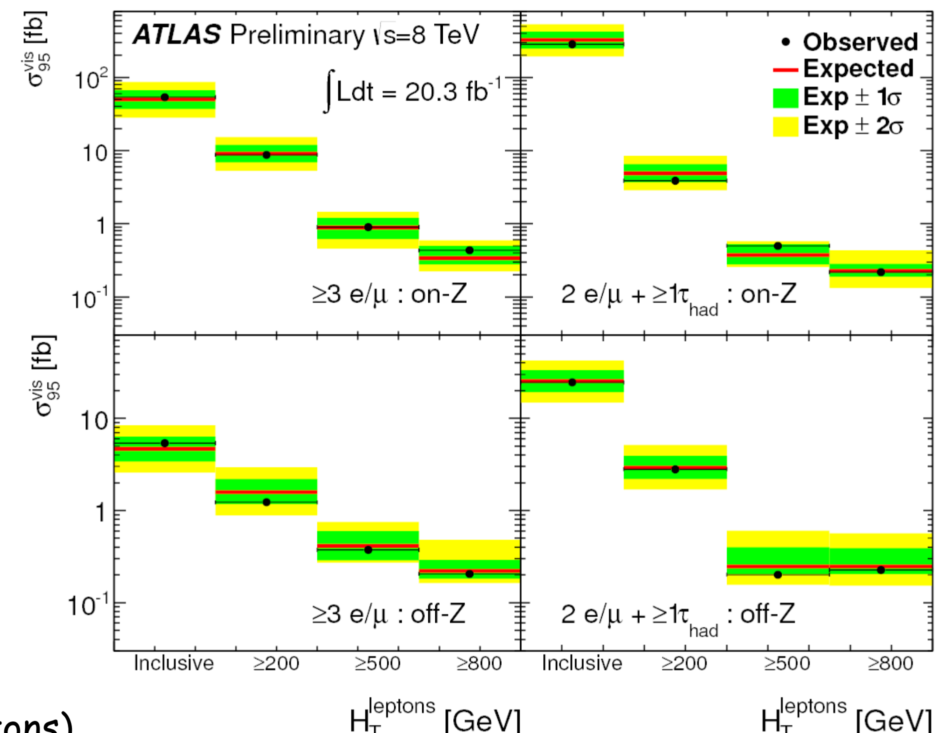
CMS lower mass limits reach up to 5.1 TeV (CMS-PAS-EXO-12-059)

Exotica searches

- Searches for anomalous multilepton production (inclusive model-independent analysis):

At least 3 charged leptons are required and the kinematic variables compared to the SM expectation





(H_T : scalar sum of P_T of the three leading leptons)

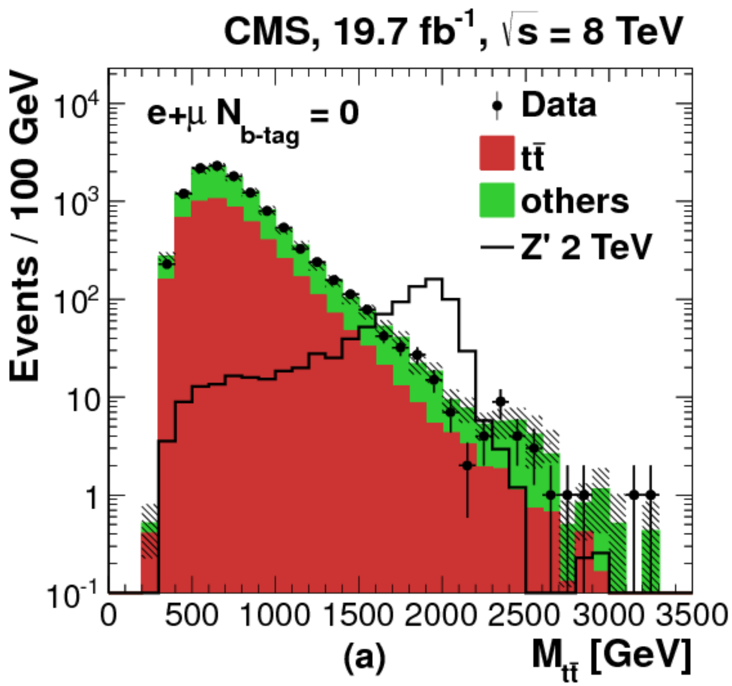
Several models are predicting anomalous multiple lepton production (excited neutrinos, fourth-generation quarks, doubly-charged Higgs bosons …)

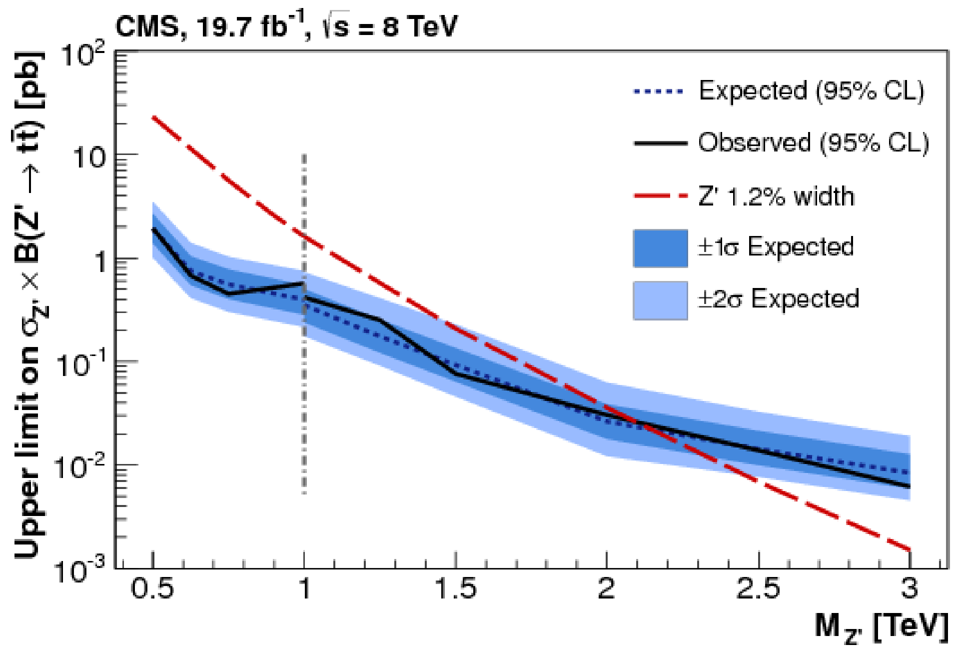
Upper limit on event yields due to non-SM processes (ATLAS-CONF-2013-070)

Exotica searches

- **Searches for anomalous $t\bar{t}$ production:**

Kaluza-Klein excitations of gluons/gravitons (extra dimensions models) as well as new gauge bosons Z′ could have enhanced couplings to tt pairs





Several limits given depending on the ratio width/mass

CMS limit on Z′ mass (for $\Gamma_{Z'}/M_{Z'} = 1.2\%$) : 2.1 TeV

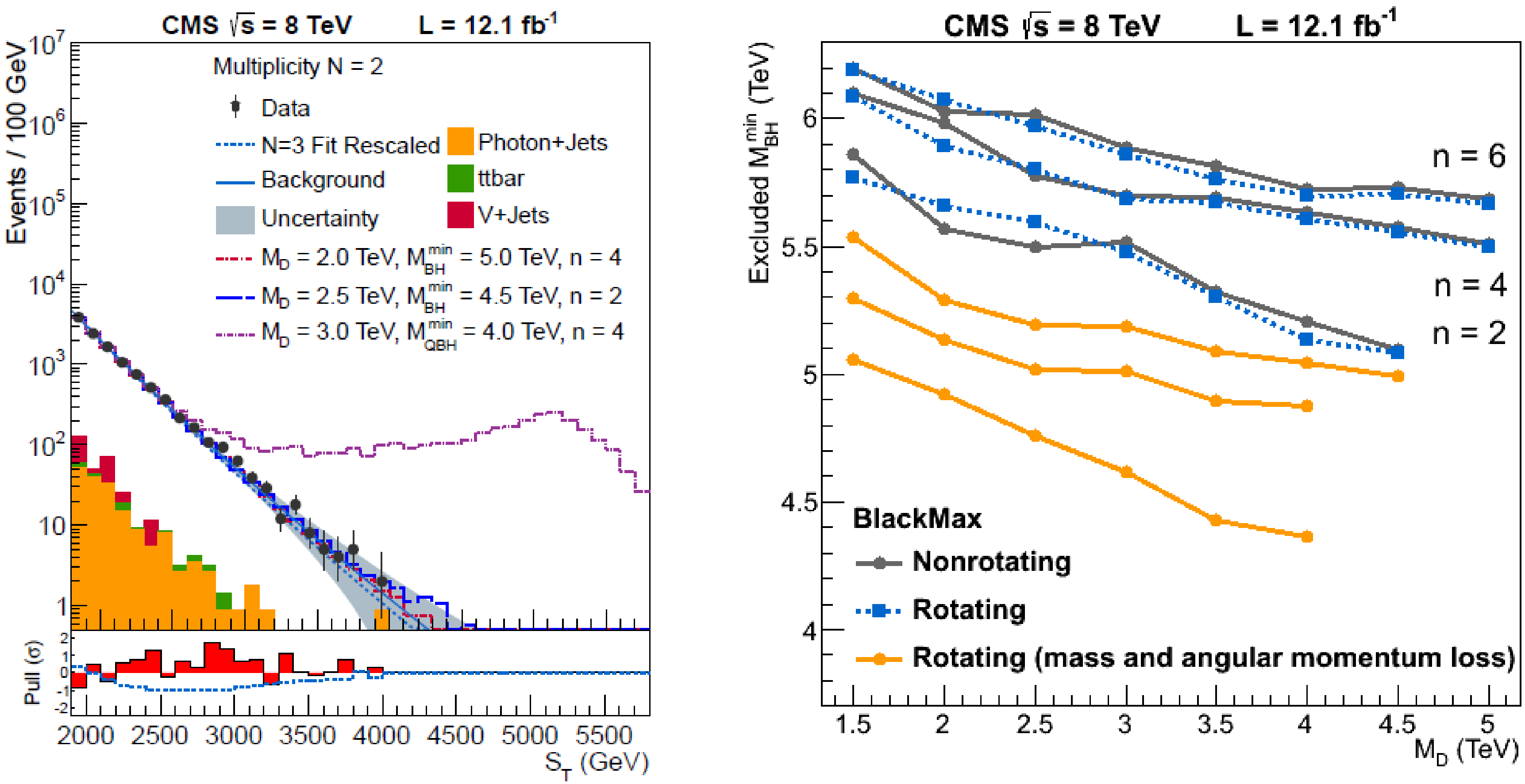
CMS limit on Randall-Sundrum KK gluons : 2.5 TeV

(CMS-PAS-B2G-13-001/hep-ex:1309.2030)

Exotica searches

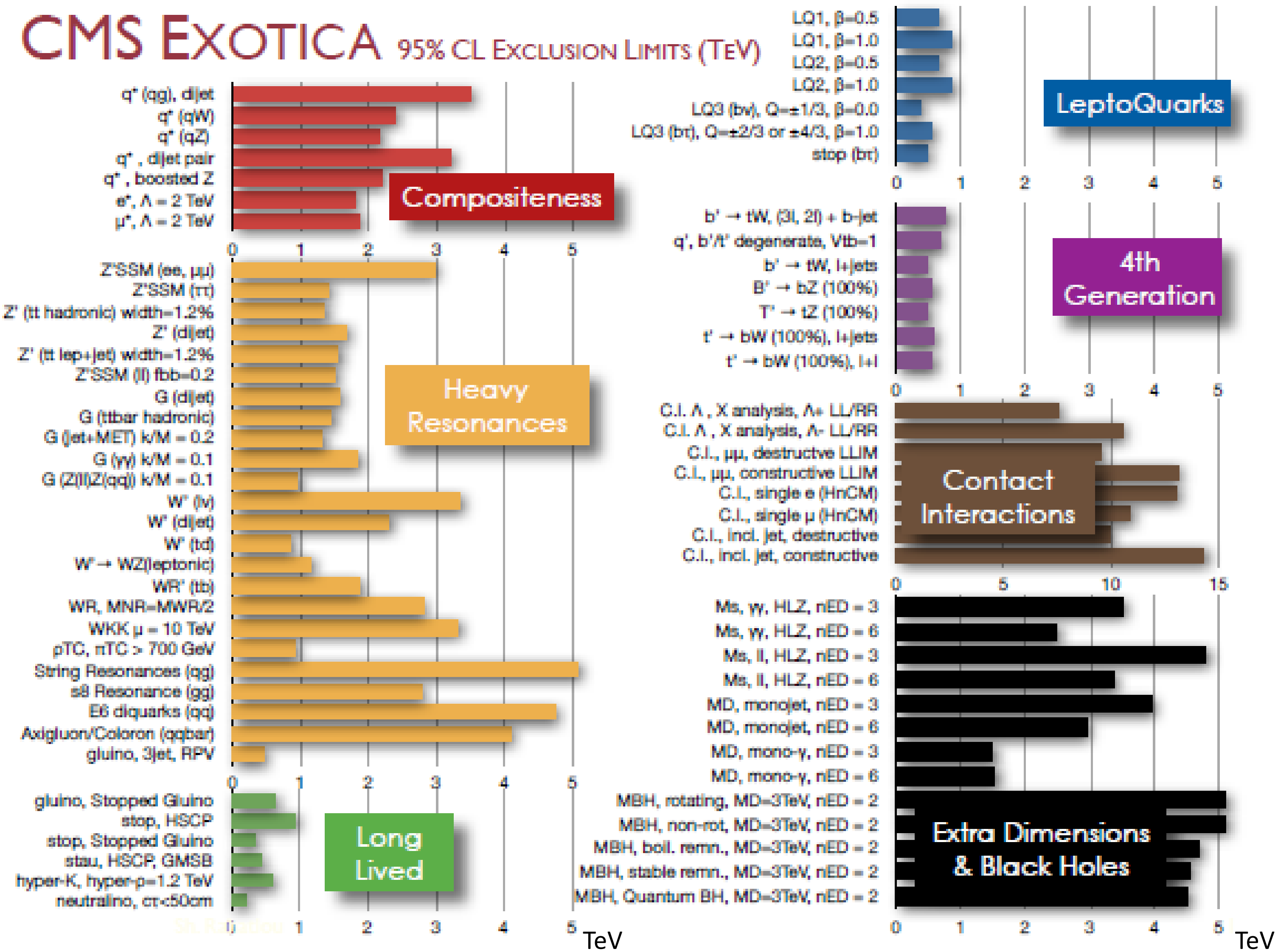
- Search for microscopic Black Holes:

Typical signature of evaporating black holes: multiple energetic jets, leptons and photons



CMS limit on BH mass for several specific models : 4.3 to 6.2 TeV (JHEP 07 (2013) 178)

Exotica searches



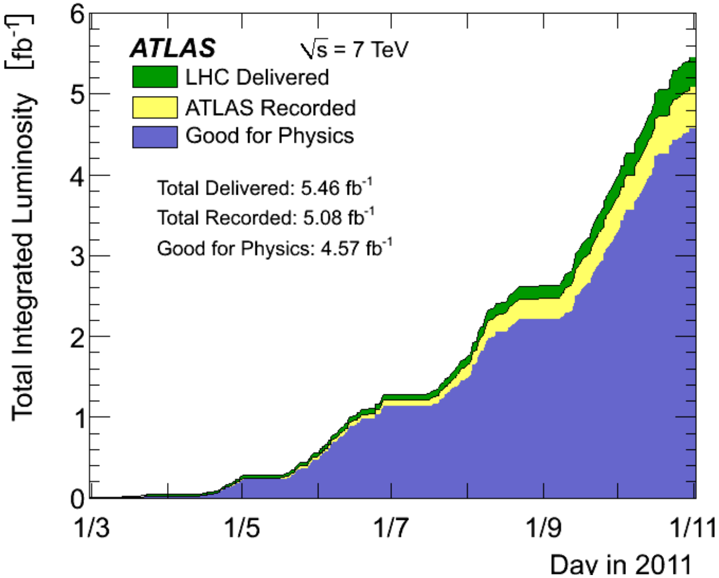
Conclusion

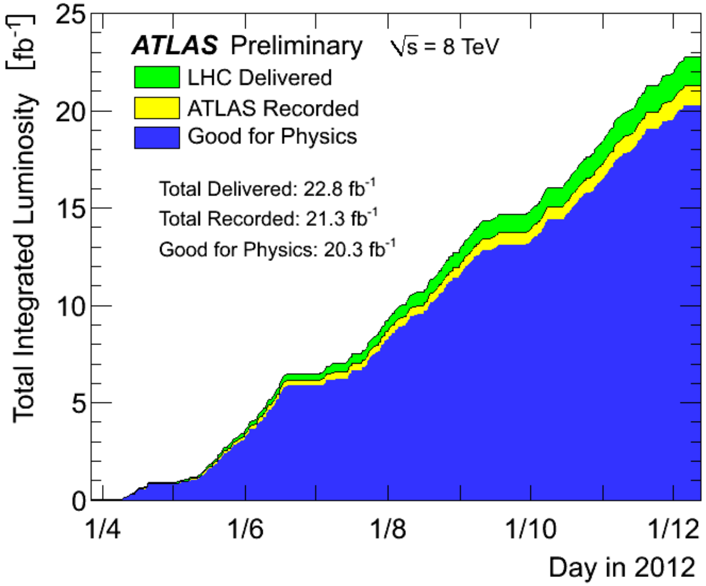
- No hints of new physics beyond SM
- SUSY searches did not show any signal : limits given in the framework of simplified models (probe gluino mass up to ~ 1.3 TeV, squarks masses up to ~700 GeV)
- The exotica program allowed to push the limits on the mass scale in a large variety of scenarios : W' (3.3 TeV), Z' (2.9 TeV), extra-dimensions (~3 TeV) …
- SUSY and exotica searches will benefit from the higher center-of-mass energy starting in beginning 2015
- The expected integrated luminosity up to the end of the LHC program will increase the sensitivity of both SUSY and exotica searches

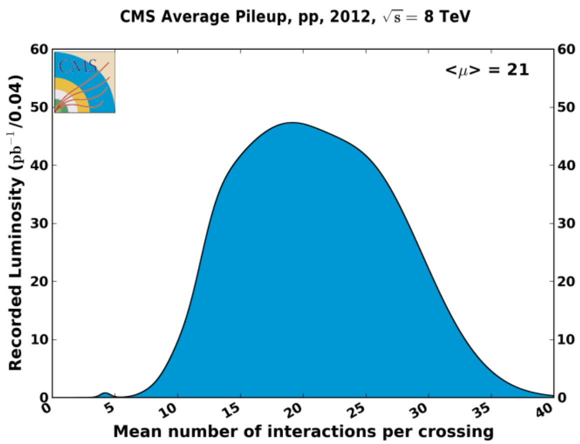
Backup

Data taking

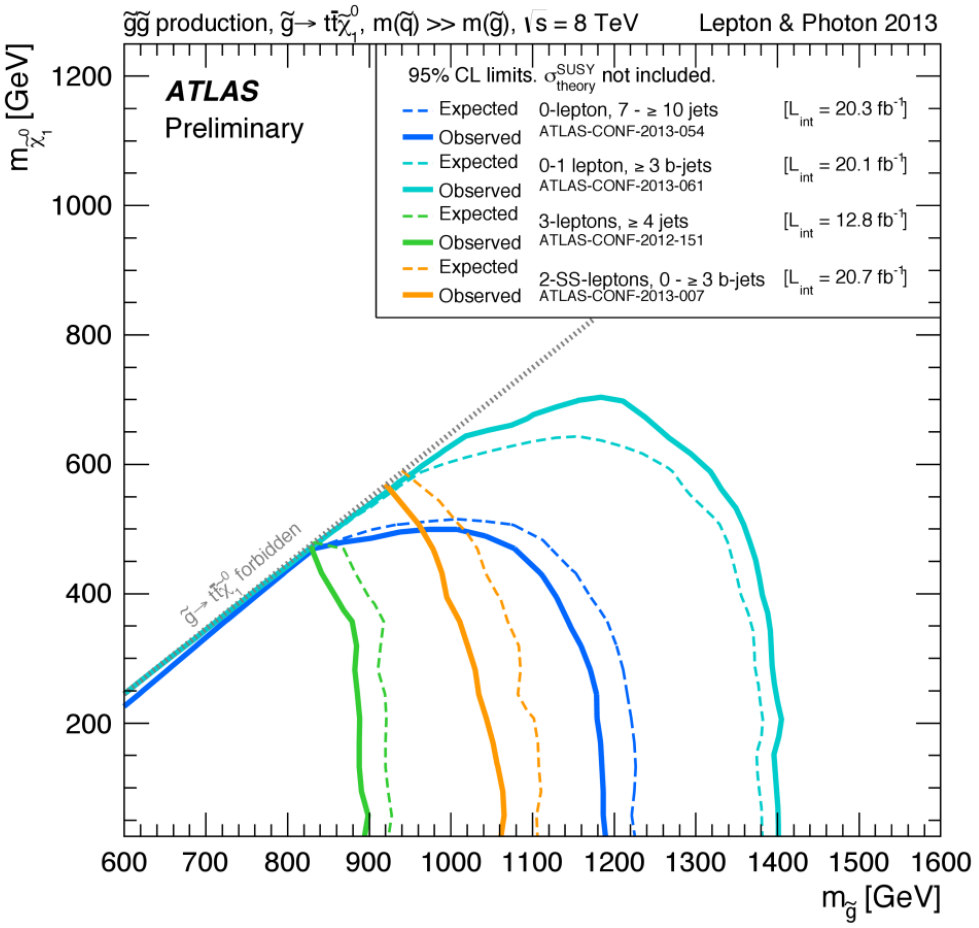
- Data taking @7 and 8 TeV : ∫Ldt and <PU>

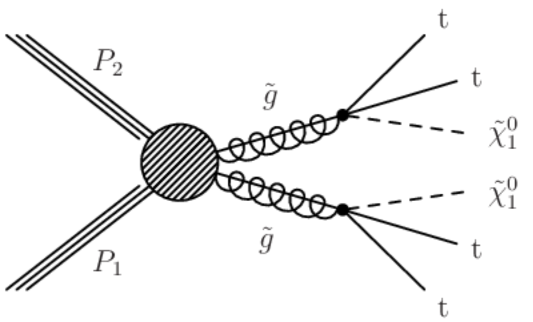




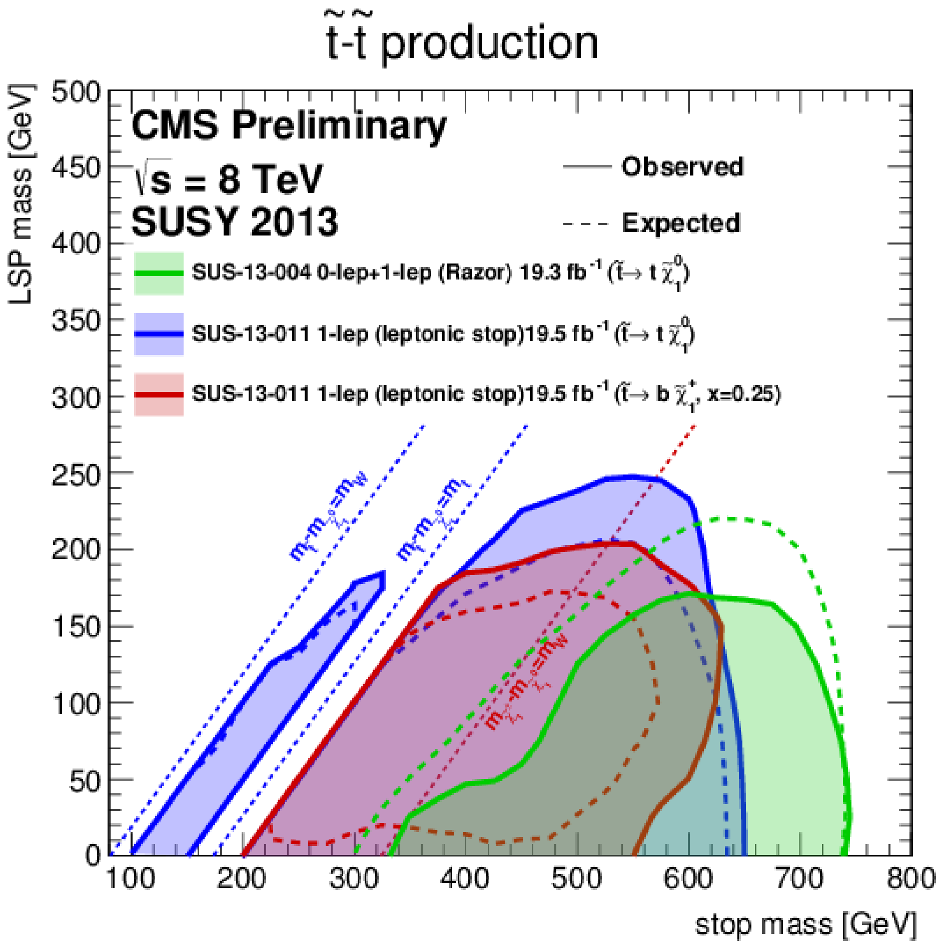


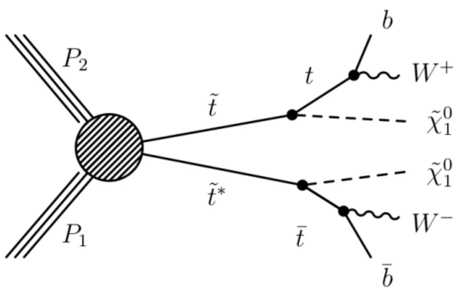
- Simplified Models $\tilde{g}$-$\tilde{g}$ production:

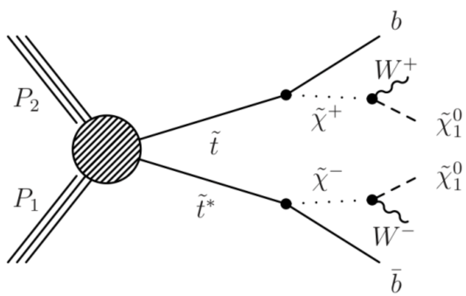




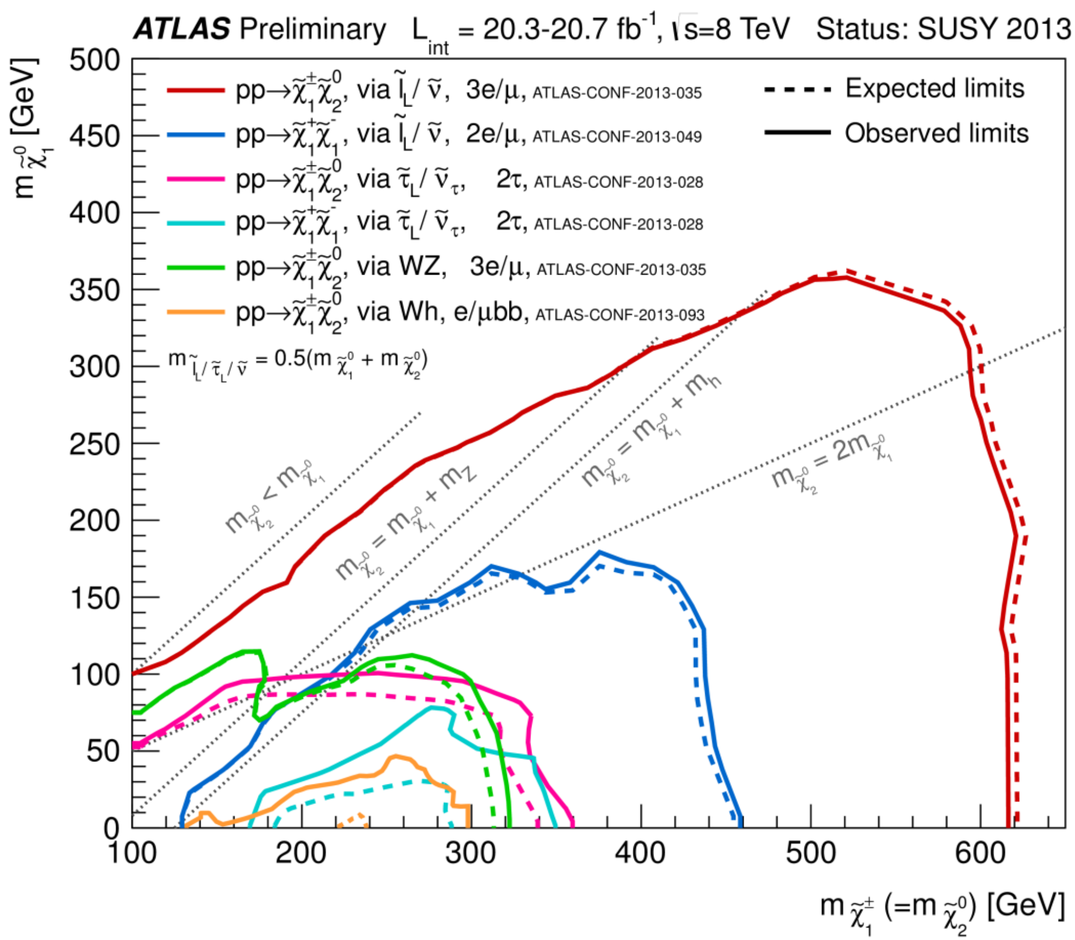
- Simplified Models t̃-t̃ production:

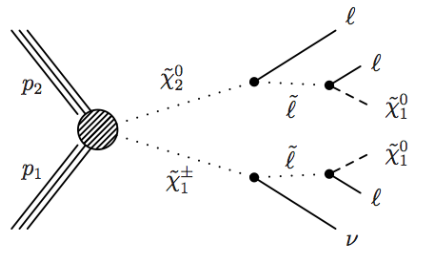


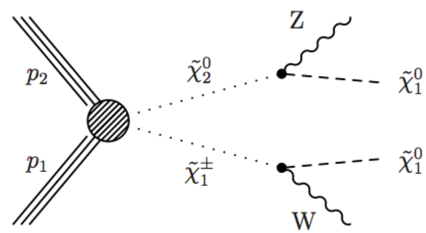




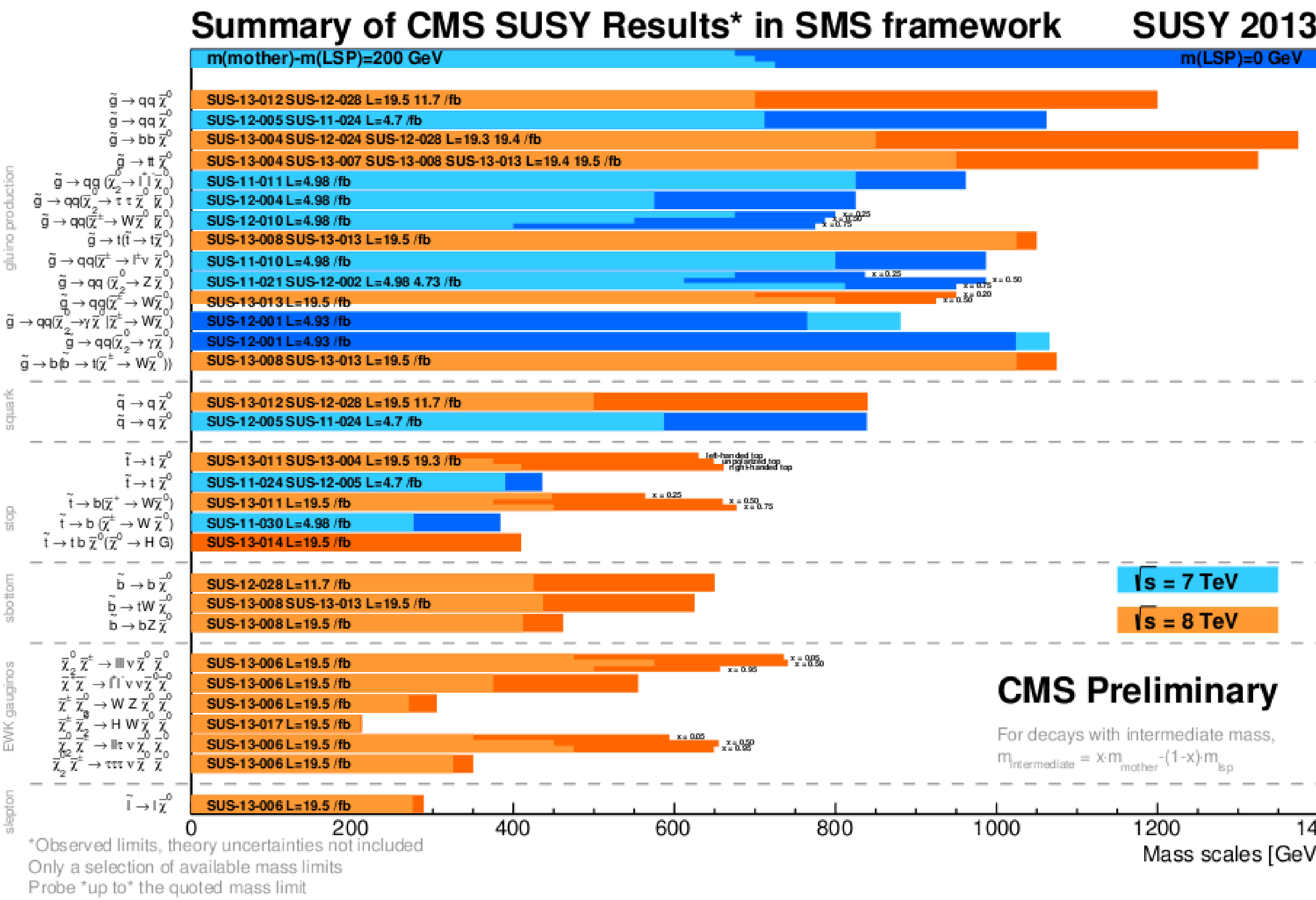
- Simplified Models EWKino production:







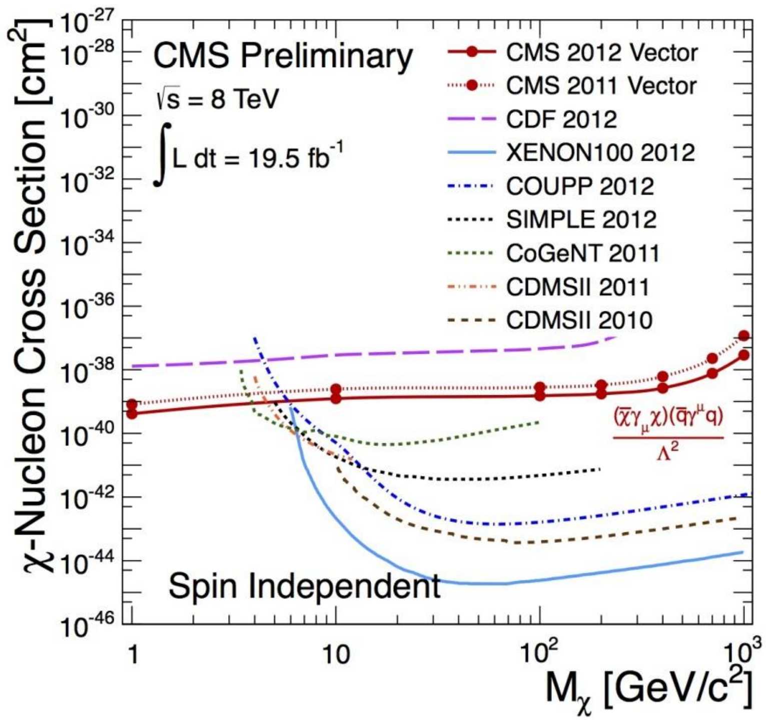
SUSY searches

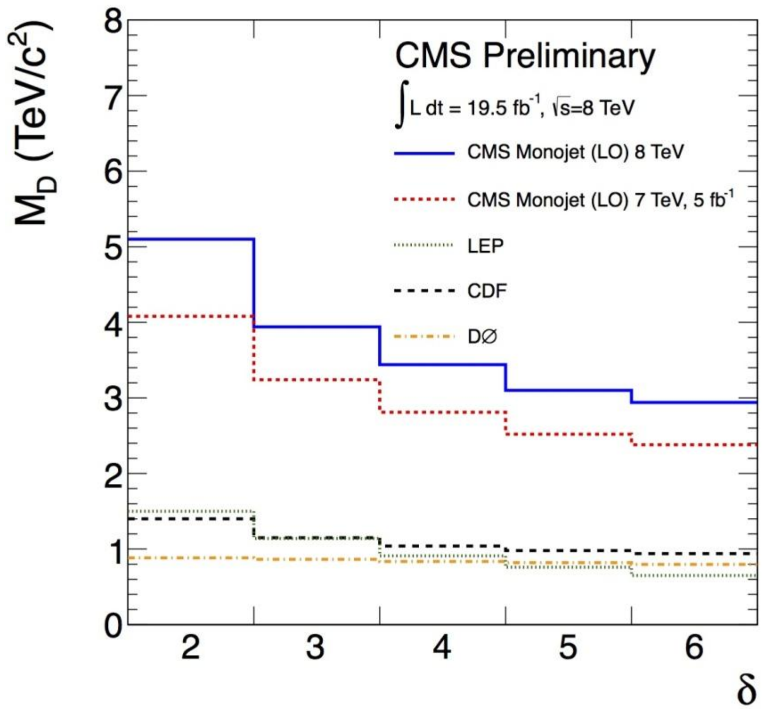


Exotica searches

- Generic searches of new physics using monojet events:

The dark matter-nucleon scattering cross-section can be constrained in both spin-independent and spin-dependent interaction models, and also the ADD (Arkani-Hamed, Dimopoulos, and Dvali) M_D model parameter in an extra dimensions scenario

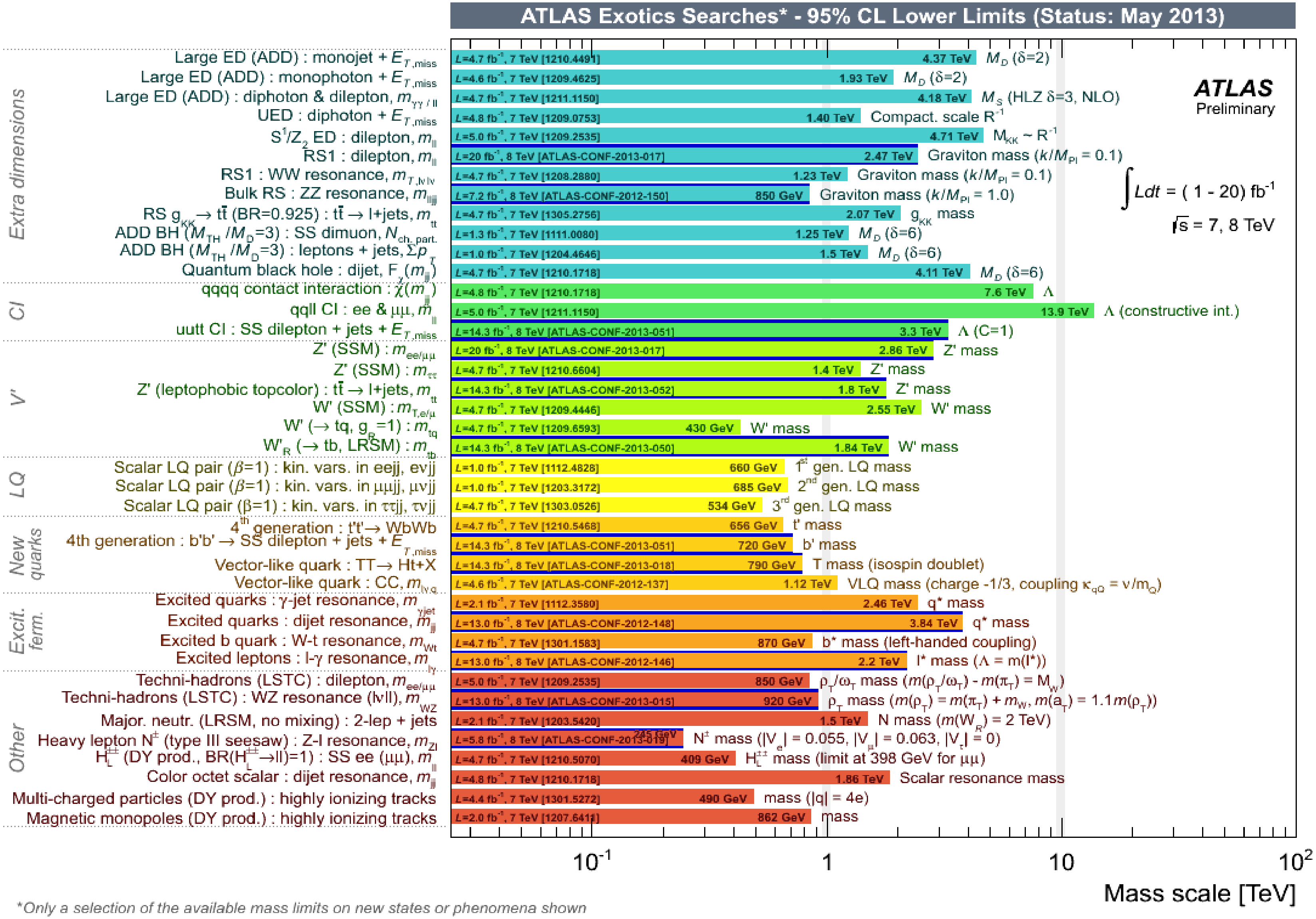




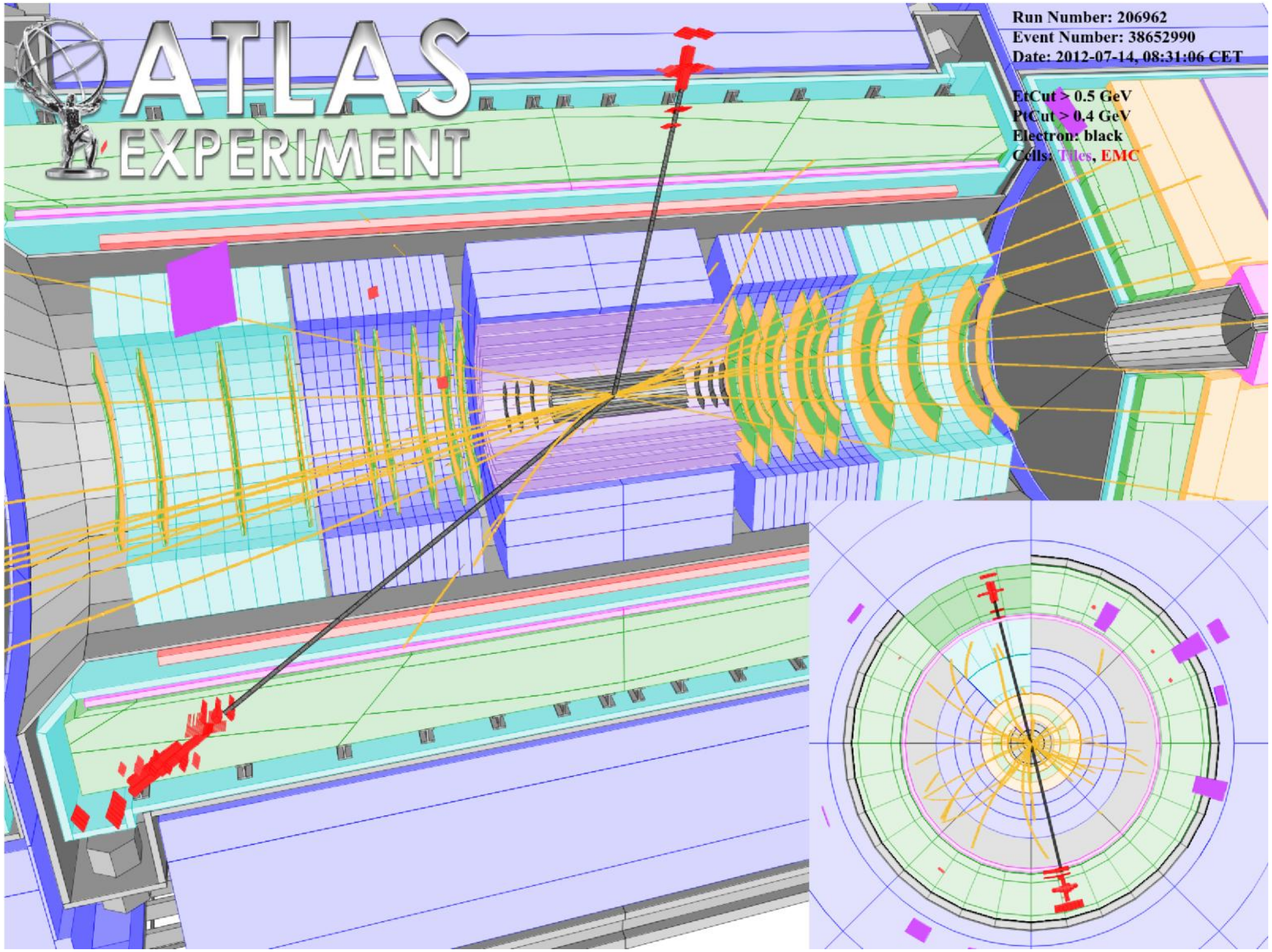
Dark matter searches are also compared to CDF, XENON100, CoGeNT and CDMSII

CMS ADD M_D lower limit : 2.9 to 5.1 TeV (CMS-PAS-EXO-12-048)

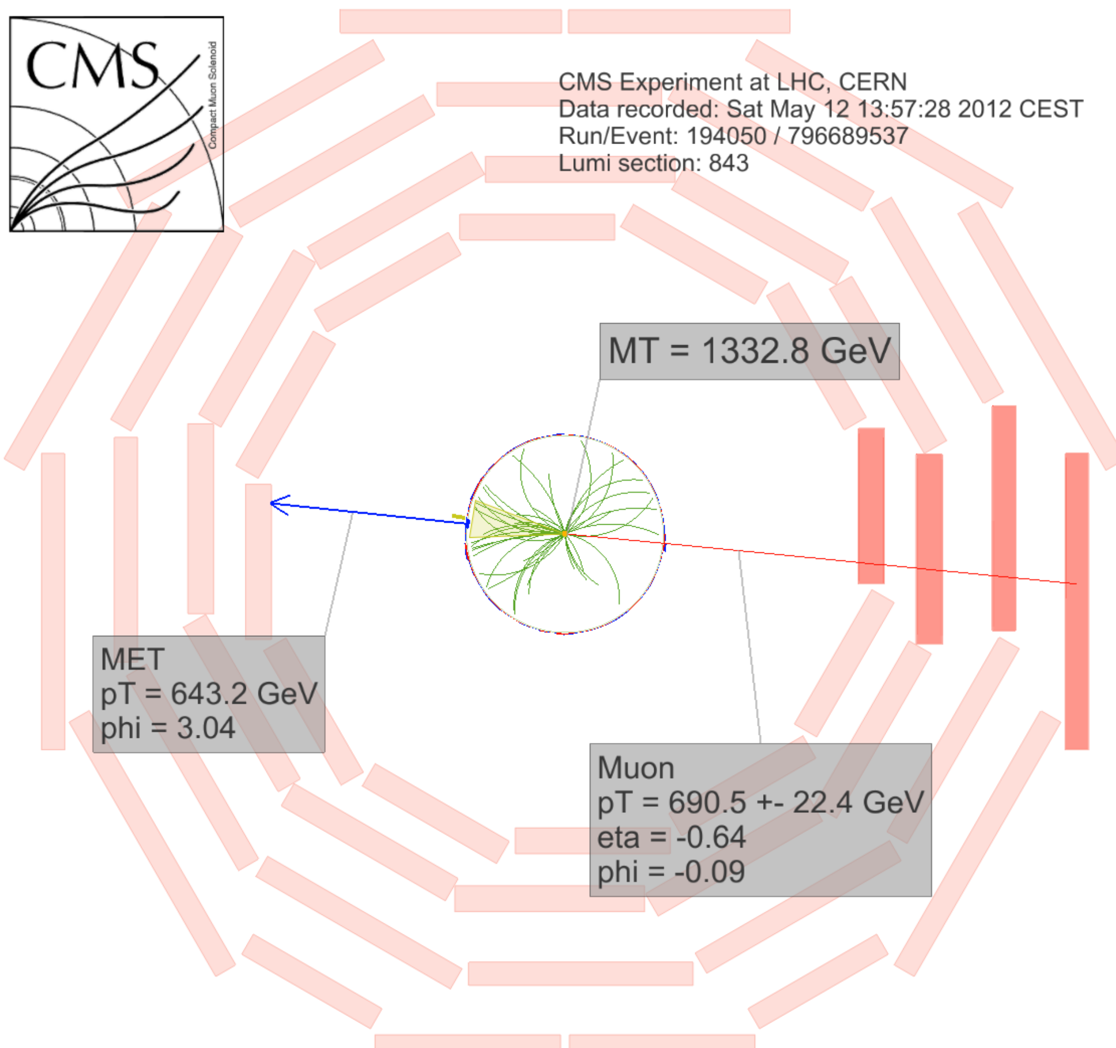
Exotica searches



- Example : highest dimass dielectron event in ATLAS

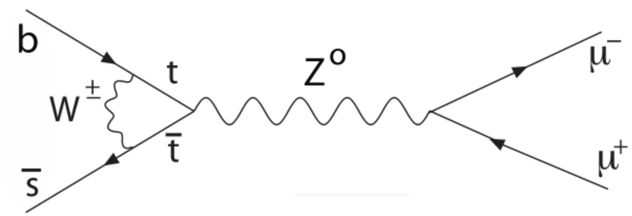


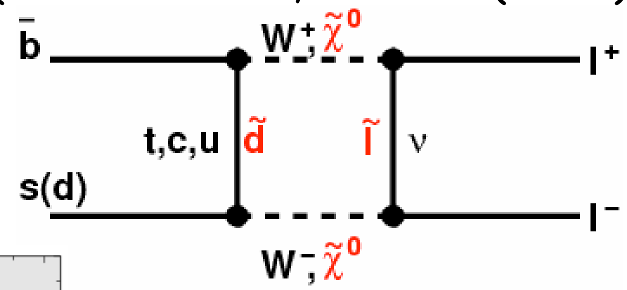
- Highest dimass dimuon event in CMS in the W' search:

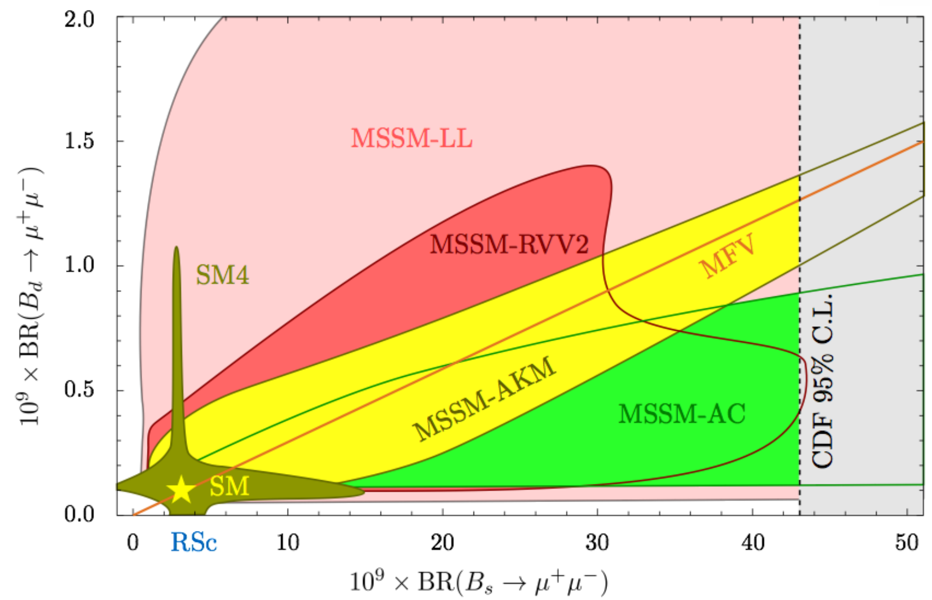


Indirect searches

- Bs -> μμ : - rare decay in SM (not at tree level)
  - sensitive to BSM physics :
    - MSSM : BR(Bs/d->μμ) ~ $\tan^6 \beta$ (J.Parry, Nucl. Phys. B760(2007) 38)
    - 2HDM : BR(Bs/d->μμ) ~ $\tan^4 \beta$ (J. R. Ellis et al, JHEP 05(2006) 063)







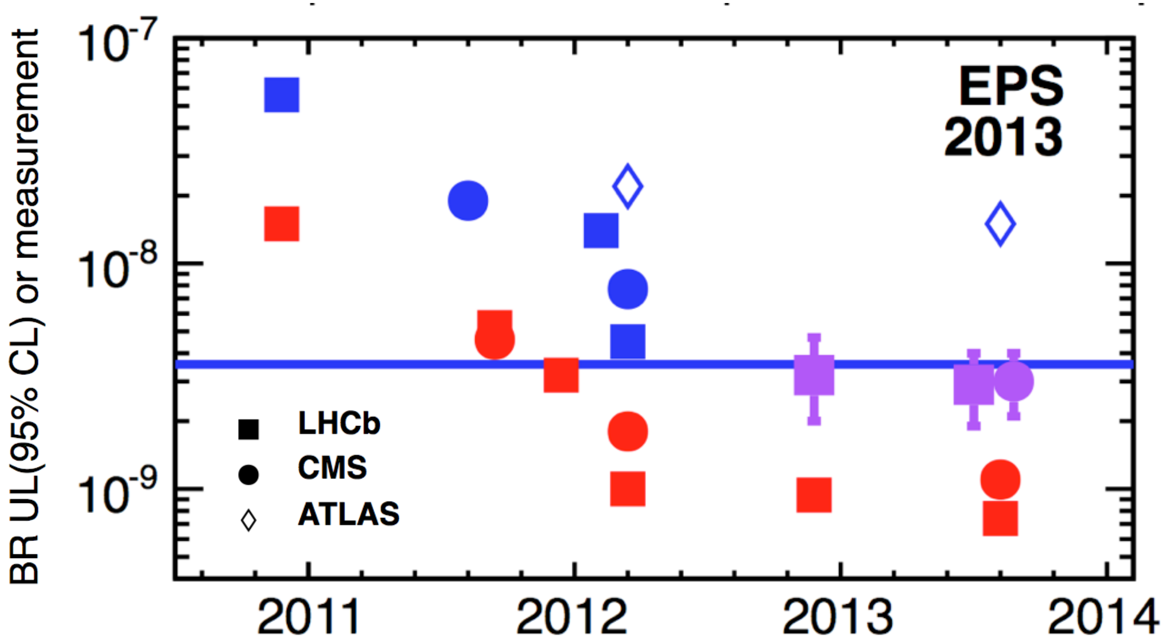
D. M. Straub,
http://arxiv.org/pdf/1012.3893v2.pdf

Indirect searches

- Bs -> μμ : first measurement by CMS / LHCb

$$BR(B_s \to \mu\mu) = \left(3.0^{+1.0}_{-0.9}\right) \times 10^{-9}$$

- 4.3 σ of significance observed
- consistent with the SM prediction, 4.8 σ expected



SUSY/Higgs

- Higgs bosons in SUSY cascades (CMS-PAS-SUS-13-014) in CMS: