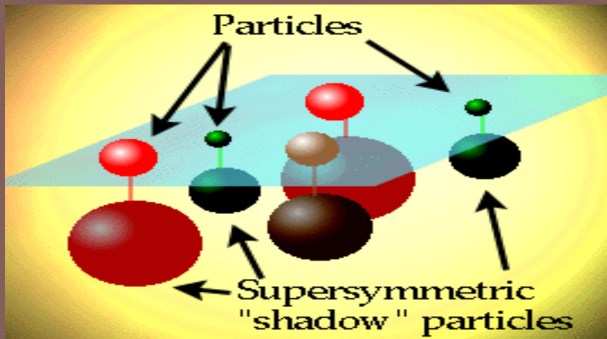
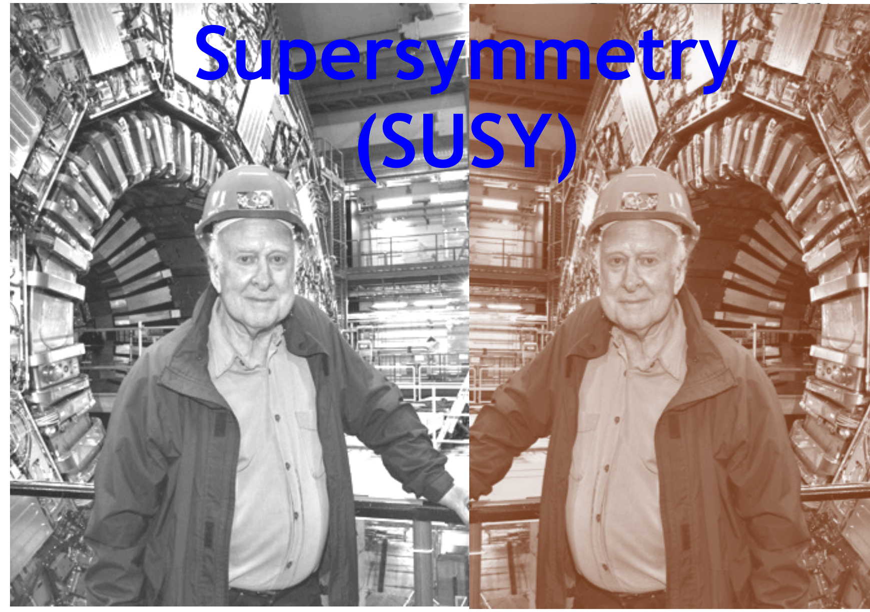


SUSY Search groups in China (Only ATLAS):

- *IHEP SUSY Group: RPC SUSY Search*
- *USTC/SJTU SUSY Group: RPV SUSY Search*

中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences



SUSY SEARCHES @ LHC

ON BEHALF OF ATLAS+CMS COLLABORATION

Xuai Zhuang (庄胥爱)
xuai.zhuang@cern.ch
IHEP, Beijing, China

16-19 Dec., CLHCP 2016

SM and Beyond

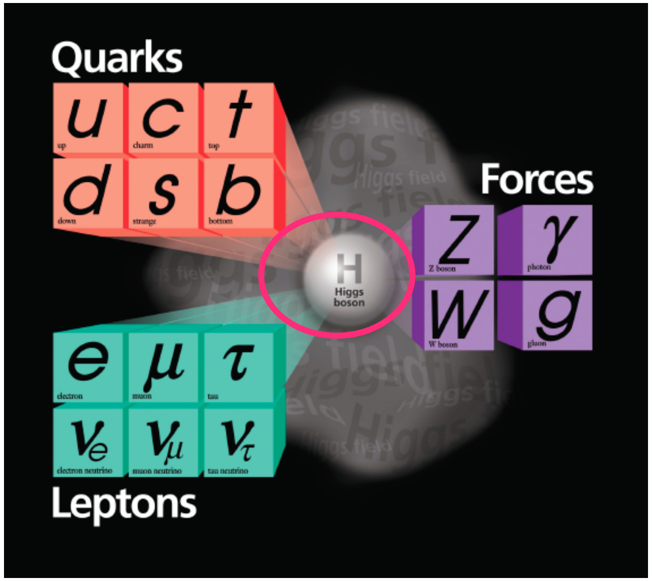


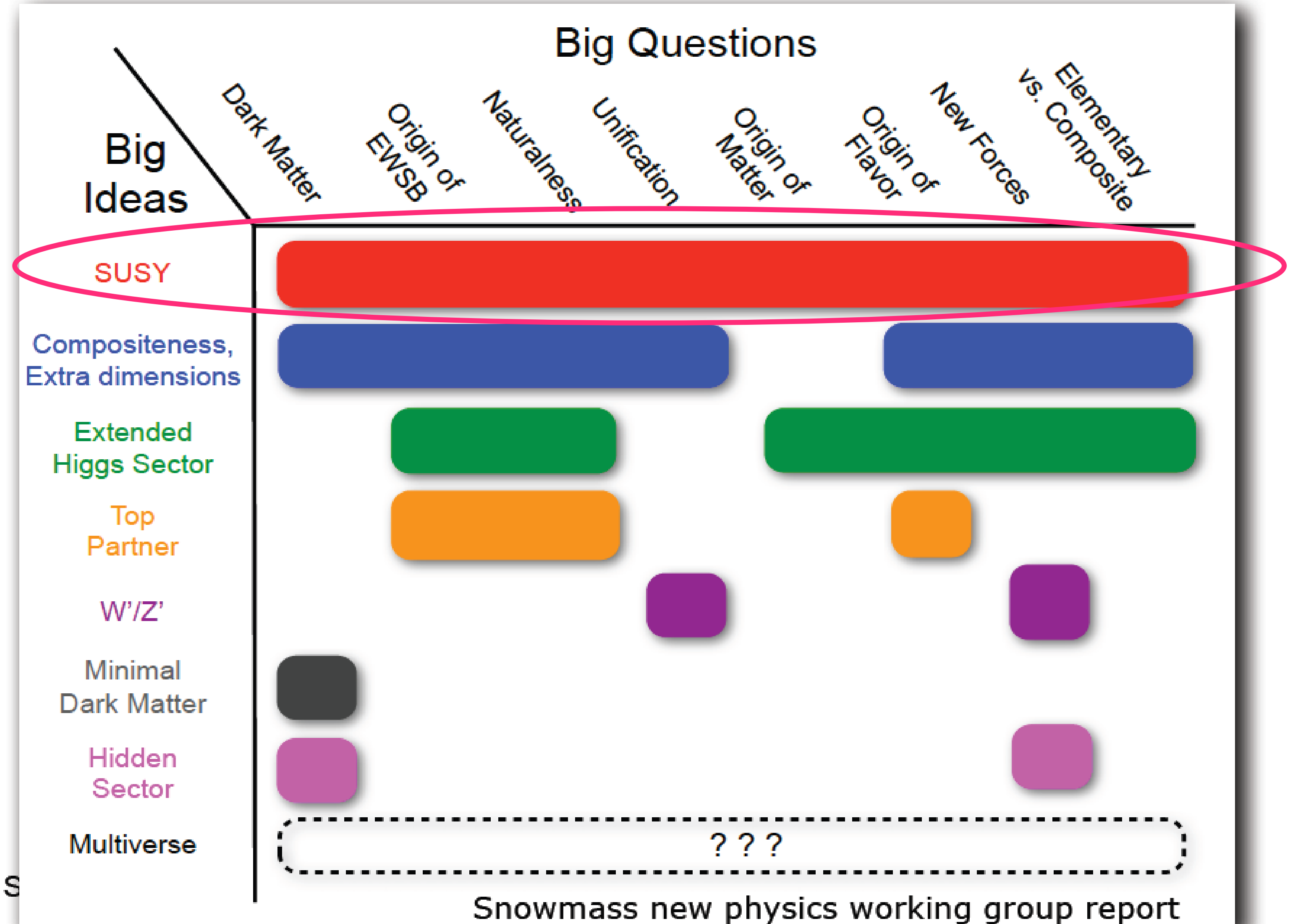
Photo: A. Mahmoud
François Englert

Photo: A. Mahmoud
Peter W. Higgs

The Nobel Prize in Physics 2013
François Englert, Peter Higgs

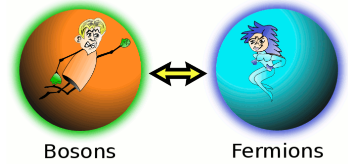
- Higgs boson observed, SM fits the experimental data very well ➔ big success in EW scale
- While has problem in Planck scale:
  - Naturalness and "hierarchy" problem
  - Unification of gauge coupling
  - Dark Matter
  - ……
- Need a more fundamental theory in which SM is only a low-energy approximation ➔ **New Physics**

New Physics beyond the SM

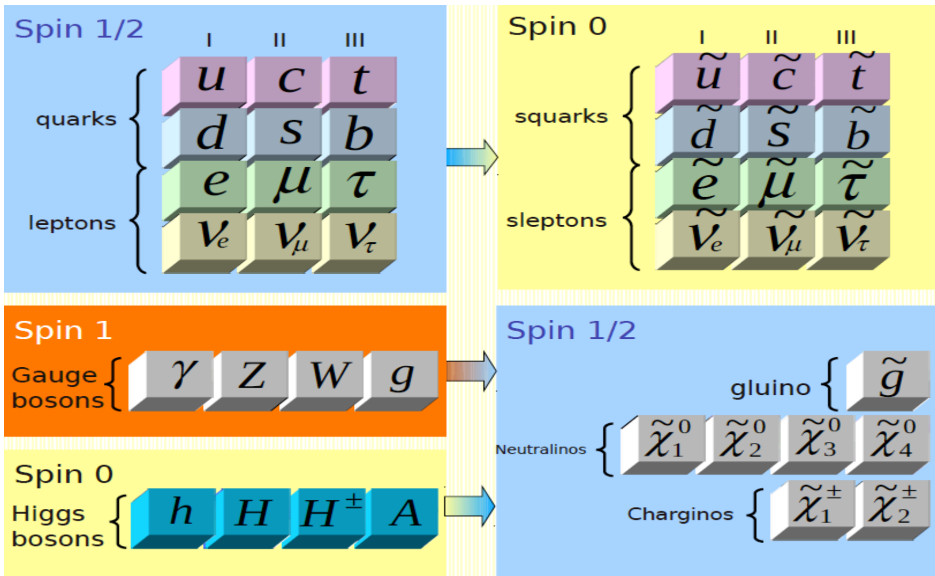


S. S

SUSY Introduction



OUR WORLD… **NEW WORLD?**



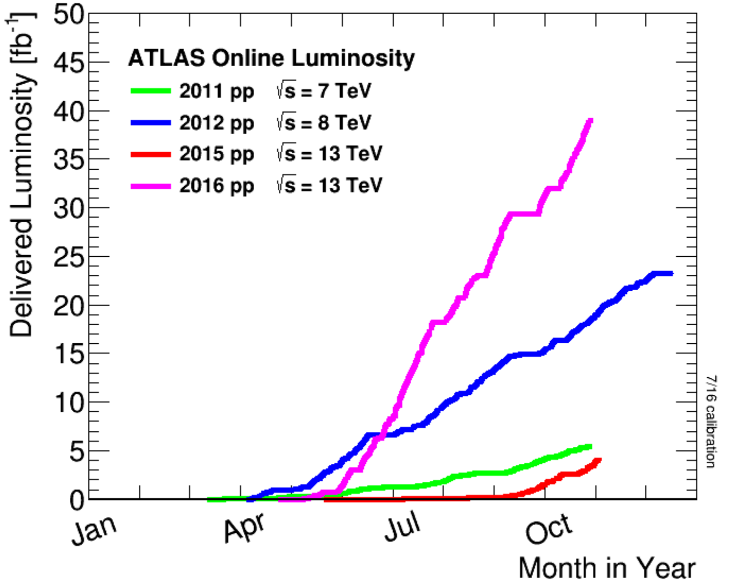
Julius Wess
(1934 – 2007)

Bruno Zumino
(1923 – 2014)

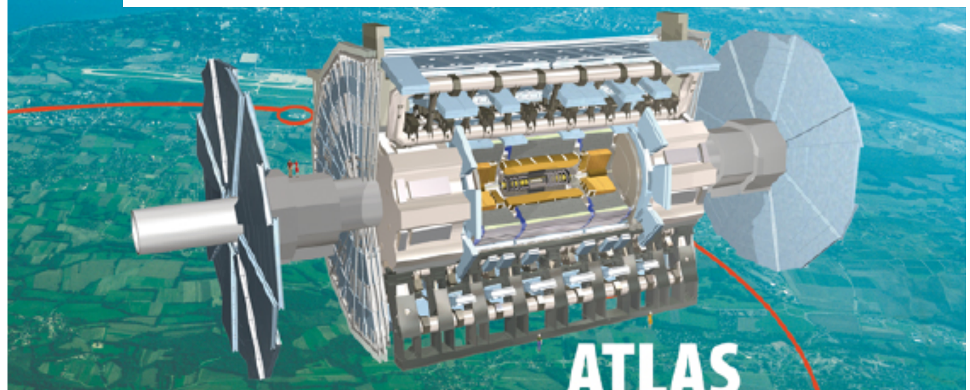
(Julius Wess and Bruno Zumino, 1974)

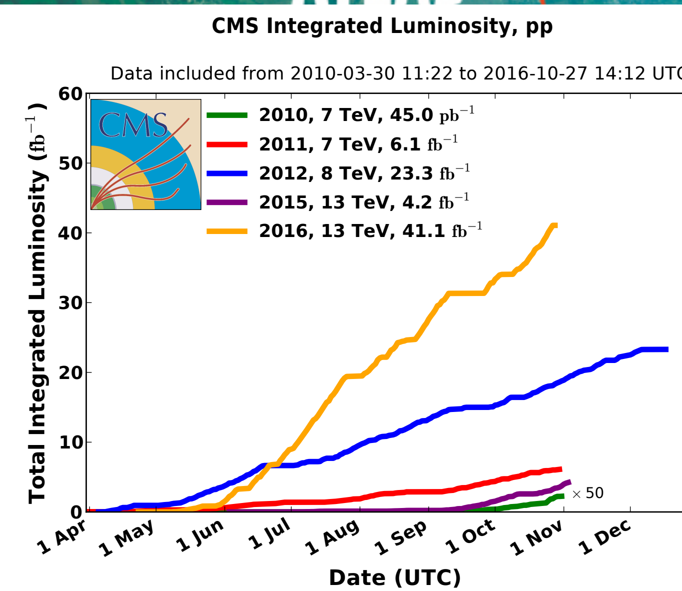
- **Establishes a symmetry between fermions (matter) and bosons (forces)**
- **Motivation:**
  - **Unification (fermions-bosons, matter-forces)**
  - **Solves some deep problems of the Standard Model**
  - **Provide Dark Matter candidate**

Great Luminosity Since 2010



- ~ 40 fb^{-1} 13 TeV data (2016)
- **The results are based on 13-18 fb^{-1} @ 13 TeV (RUN2)**





SUSY Signature & Search Strategy

- **R parity:** originally introduced for stability of proton $R = (-1)^{3(B-L)+2S}$

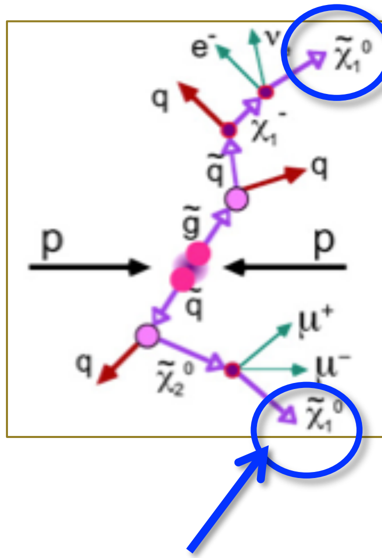
  R=+1 (SM)
  R=-1 (SUSY)

  - **Conserved R parity (RPC):**

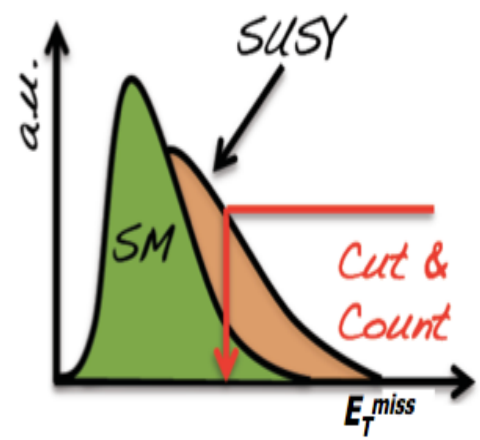
    Provide Dark Matter (DM) candidate

    Typical signature: <u>jets/leptons/photons + MET</u>

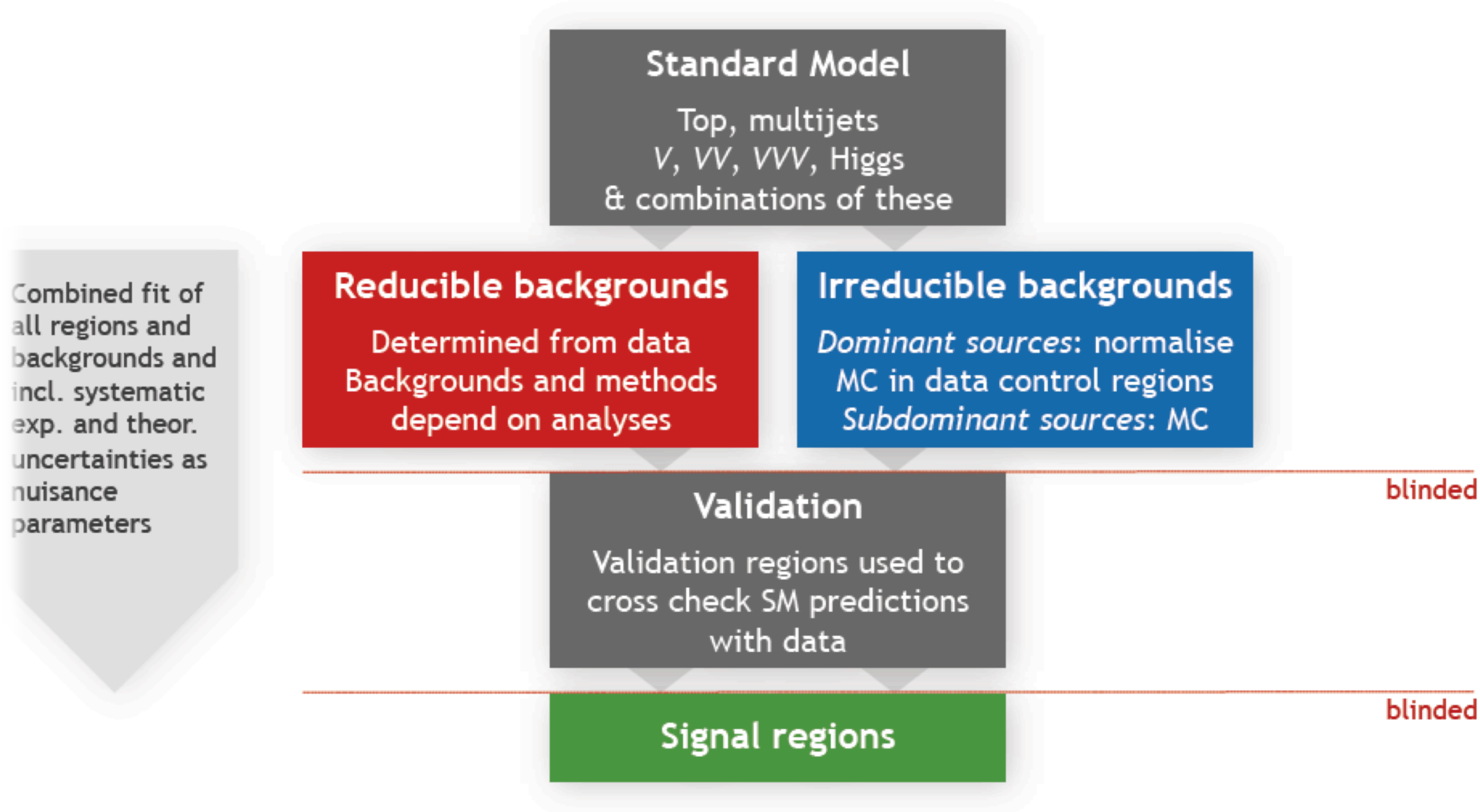
  - **Violated R parity (RPV): no DM candidate**



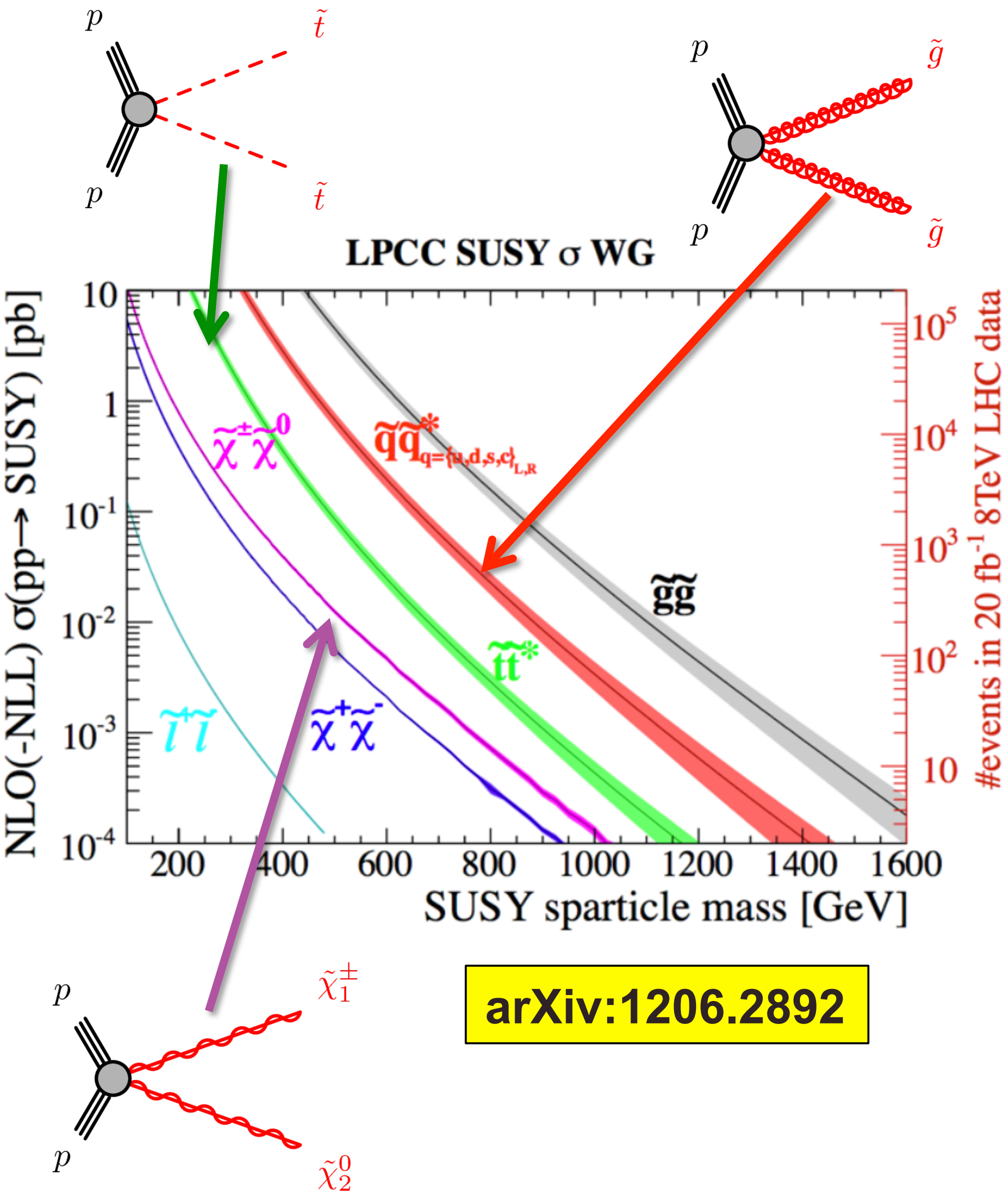
- **SUSY search strategy:** ***search for deviation from SM***
  - **SUSY sensitive variables: E_T^{miss}, Meff …**
  - **Accurate modeling of SM background**



SM Background Modeling



SUSY Search @ LHC



arXiv:1206.2892

Strong production:

- targeting gluinos and 1st and 2nd generation squarks
- by far largest cross-sections

3rd generation:

- targeting stop and sbottoms
- Should be lowest mass squarks for naturalness reasons

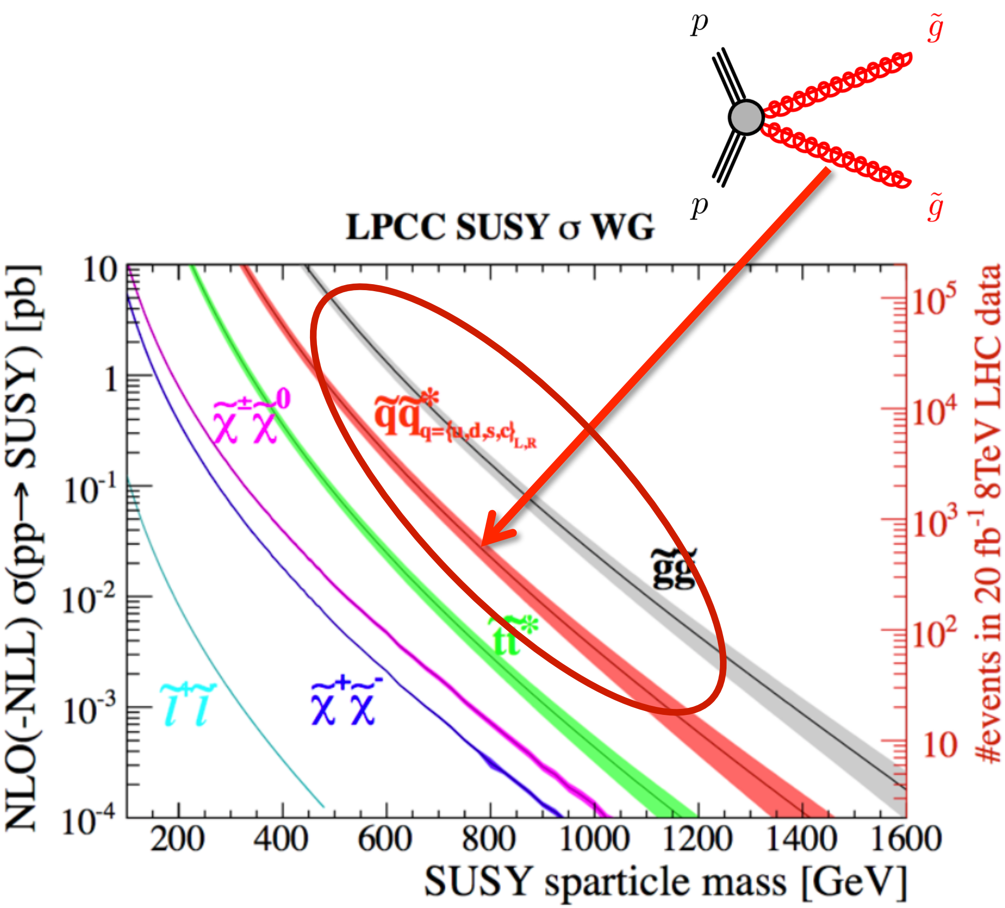
Electroweak production:

- targeting Electroweakinos, sleptons
- Lowest mass sparticles, clean signature

RPV/LL:

- targeting R-parity violating models and long lived sparticles
- More exotic models

SUSY Search @ LHC



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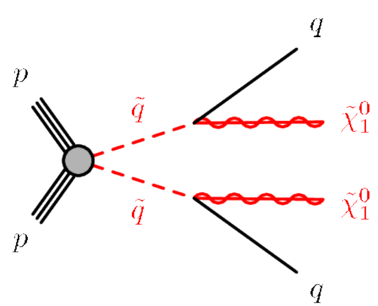
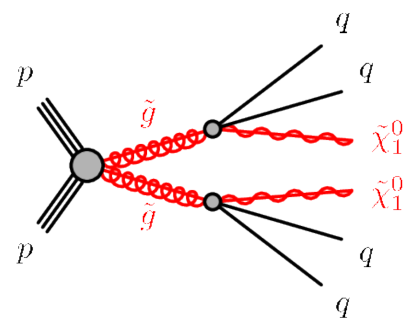
Strong Production: All hadronic

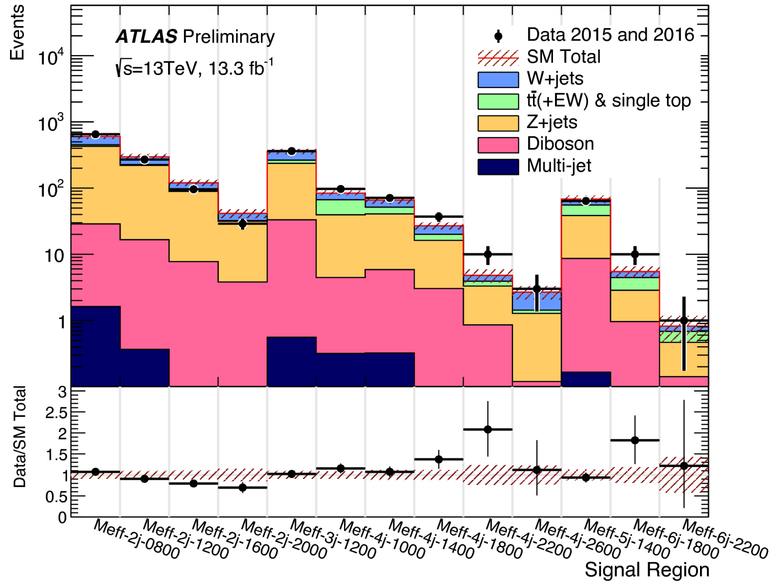
- ATLAS has two searches based on different scenarios: ATLAS-CONF-2016-078(SS,GG), ATLAS-CONF-2016-052 (Gtt, Gbb)
- Signal to BG discrimination based on:
  - **Large/medium mass split: Meff, MET,**
  - **Compressed region: R Jigsaw**
- >30 signal regions (SRs) defined targeting above different search scenarios and phase space

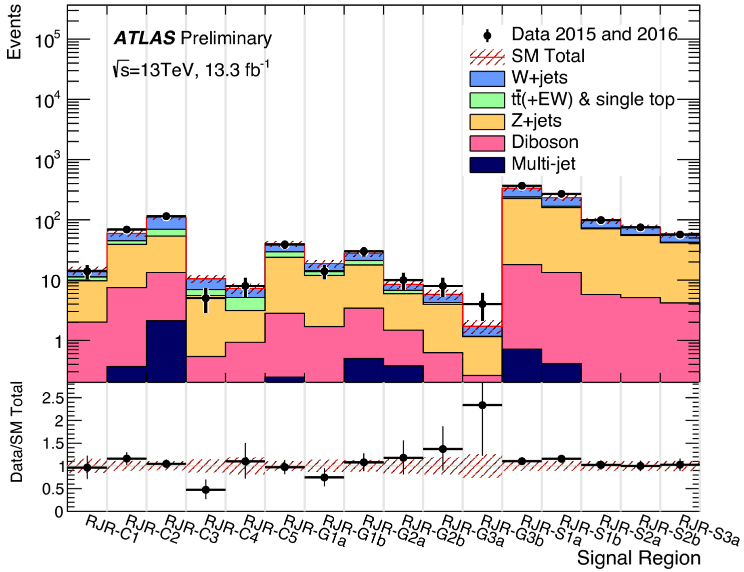
- CMS has several searches based on different kinematics:
  - **HT and H_t^{miss} (SUS-16-014):**
    - ✓ binned in jet and b-jet multiplicity.
    - ✓ In each bin, bin further in H_T and H_T^{miss}
  - **mT2 search(SUS-16-015):**
    - ✓ binned in H_T, jet and b-jet multiplicity.
    - ✓ In each bin, look at tails of mT2



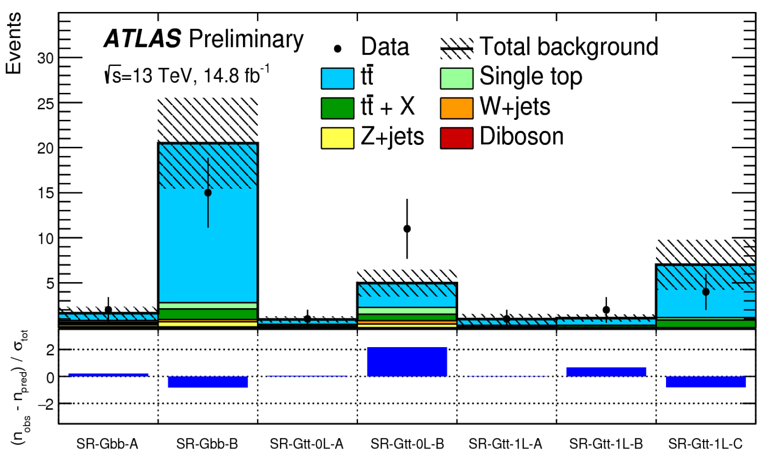


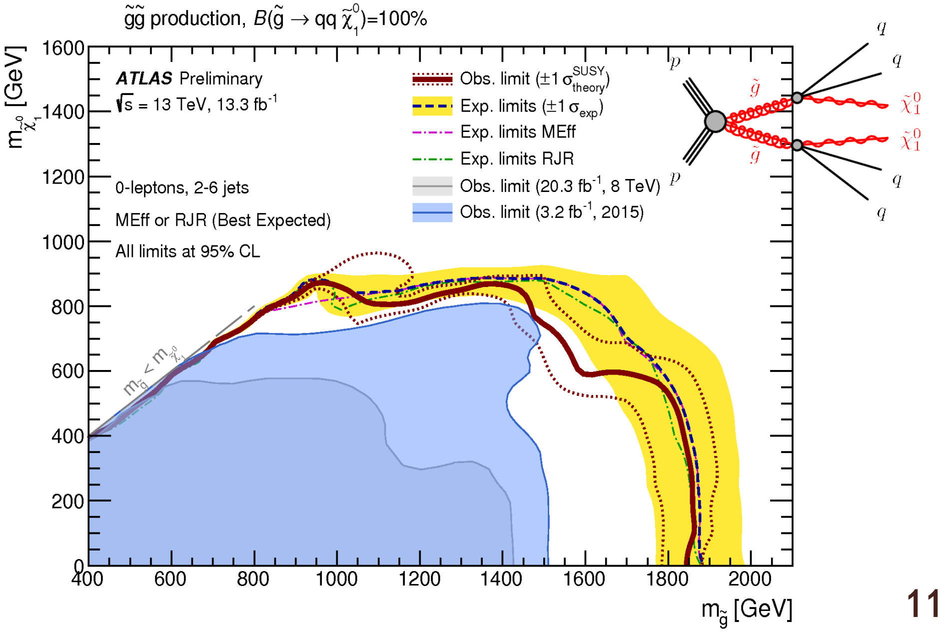
All hadronic: ATLAS results



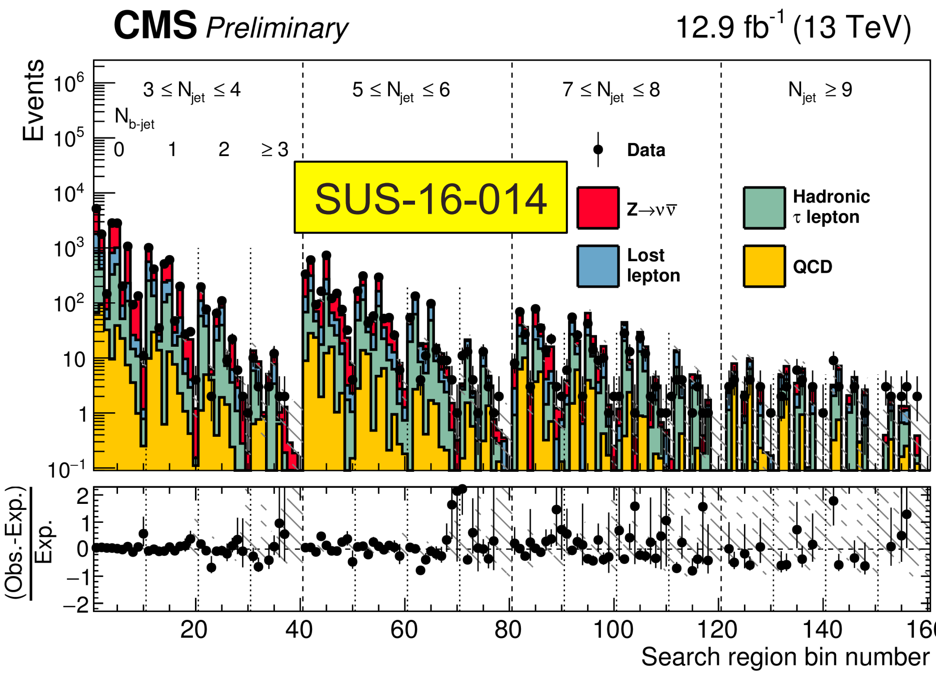


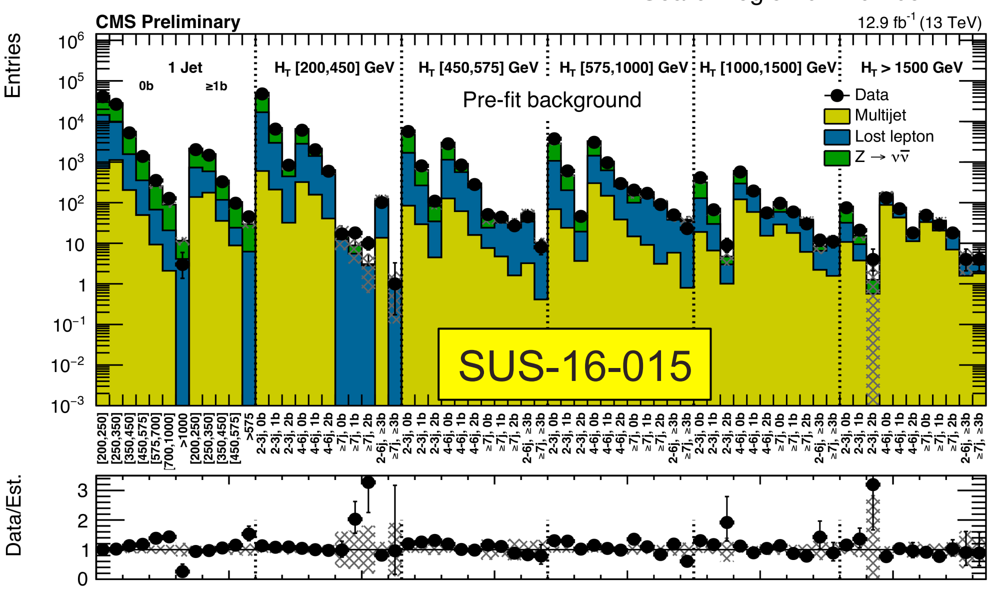
- No significant excess observed

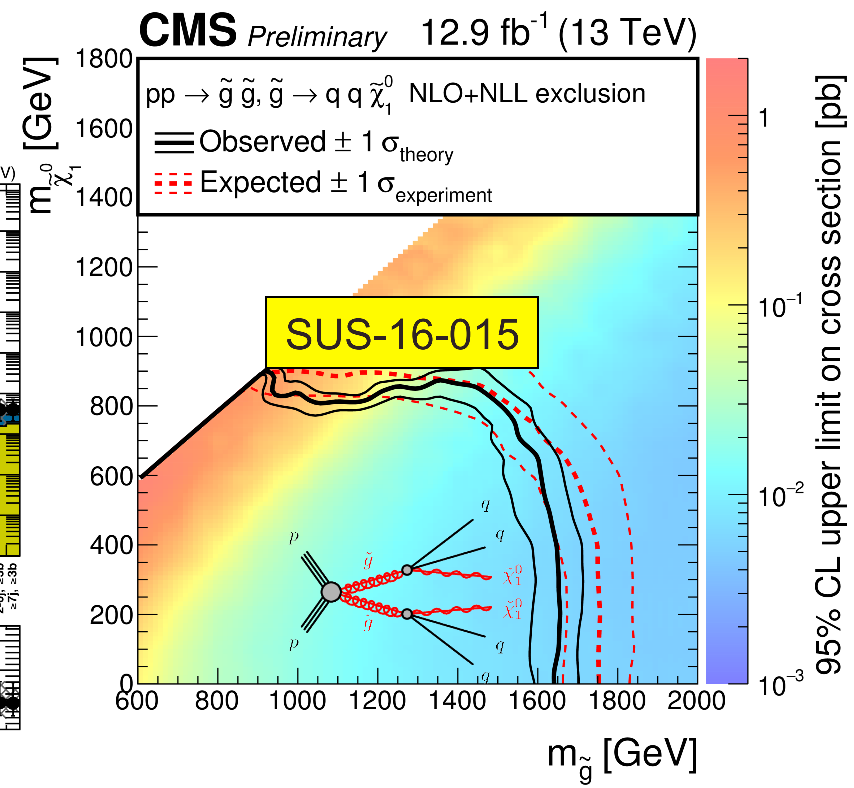




All hadronic: CMS results

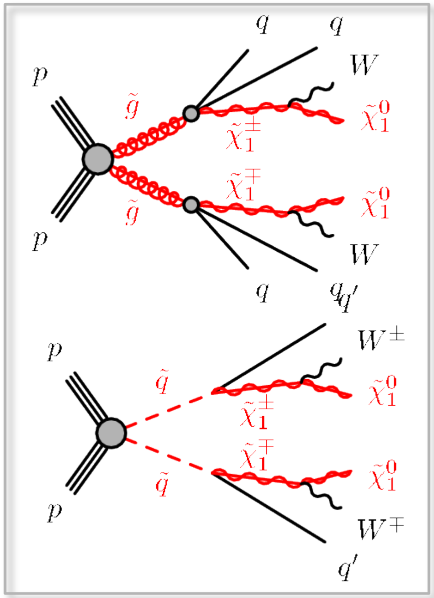


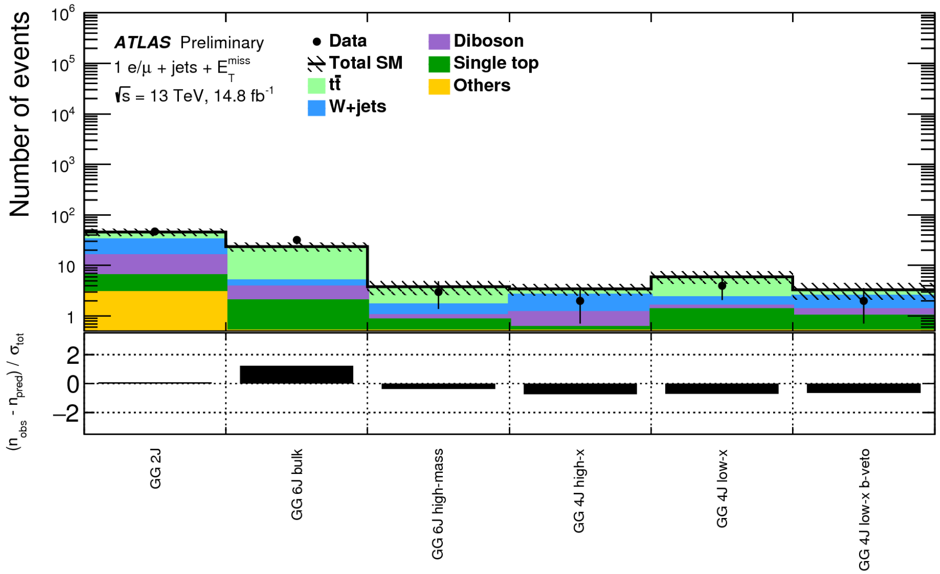


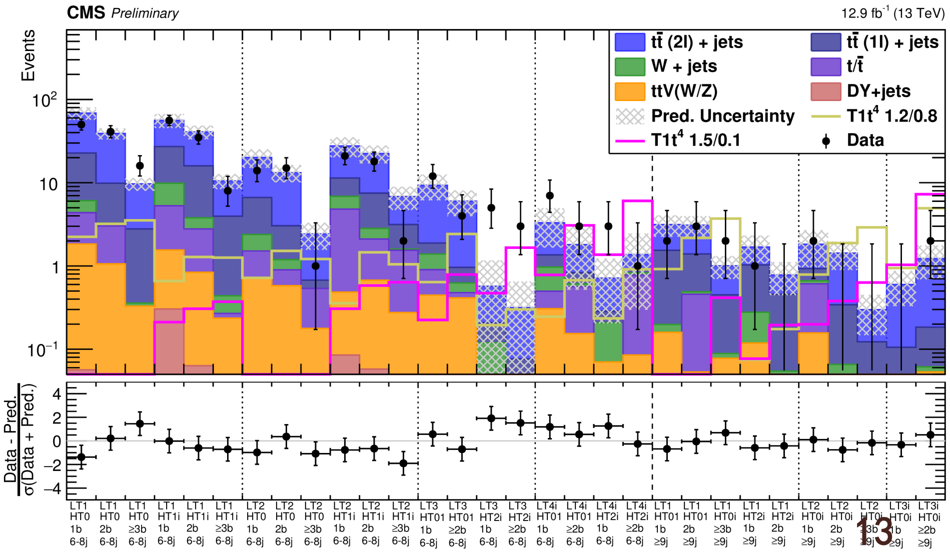


Strong Production: leptonic signature

- We can also use lepton(s) to probe for strong production signals → suppressed hadronic backgrounds
- For single lepton FS:
  - ATLAS: 10 SRs based on MET, Meff, mT, jet multiplicity
  - CMS: binned in jet and b-jet multiplicity, L_T, H_T (50 SRs)

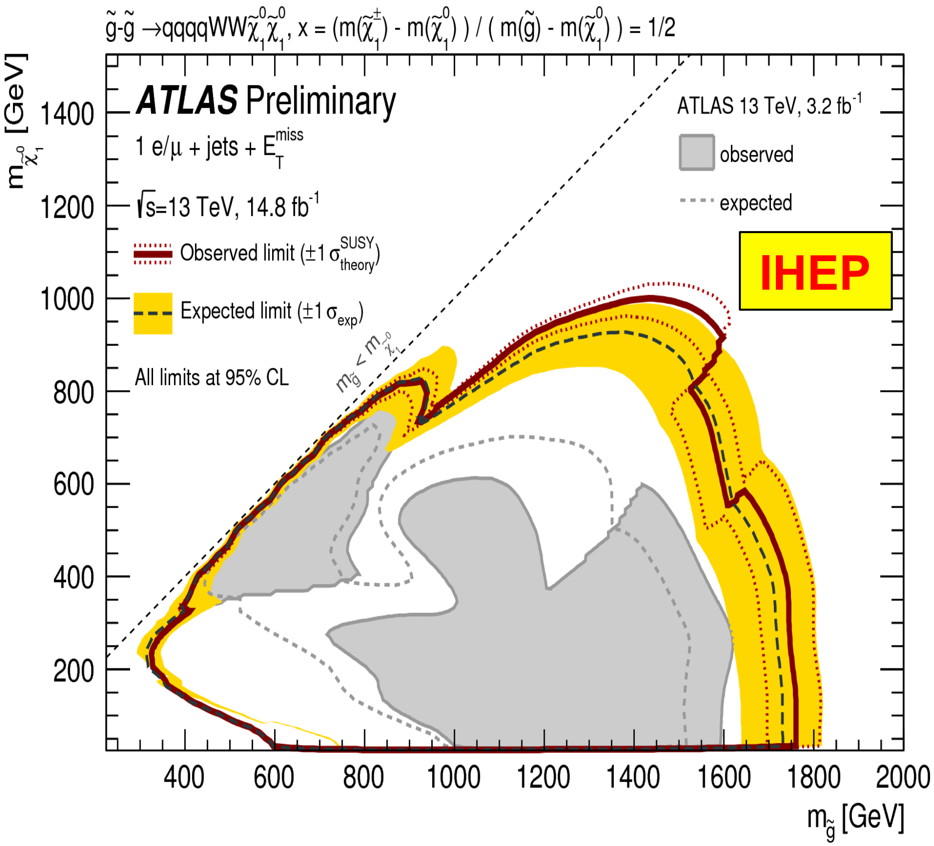




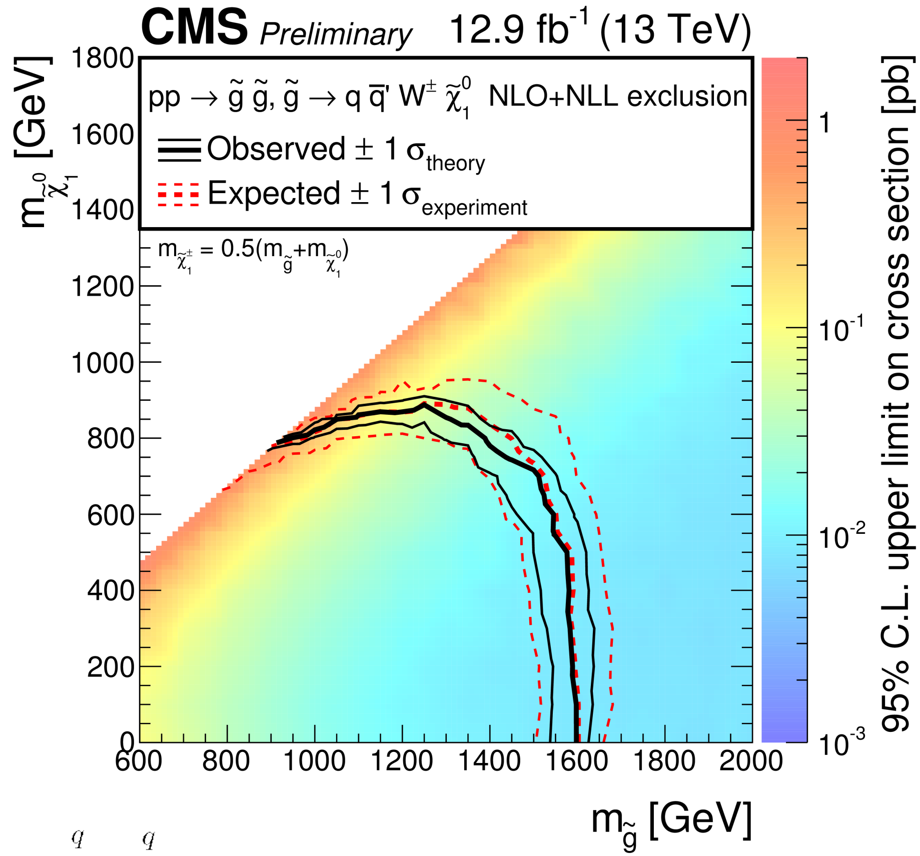


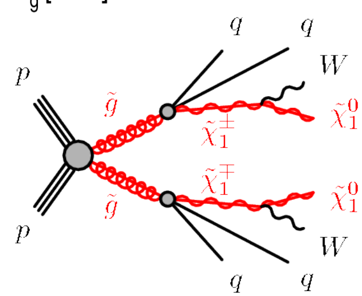
Single-leptonic Signature: Results

ATLAS-CONF-2016-054



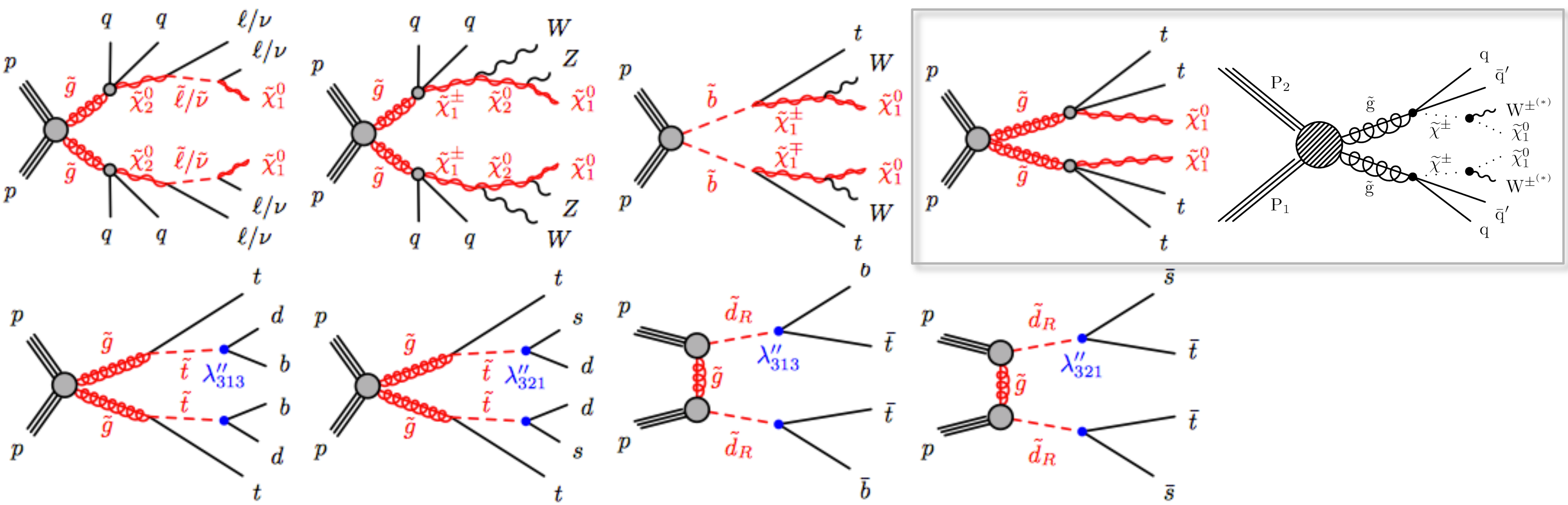
CMS-PAS-SUS-16-019





Strong Production: leptonic signature

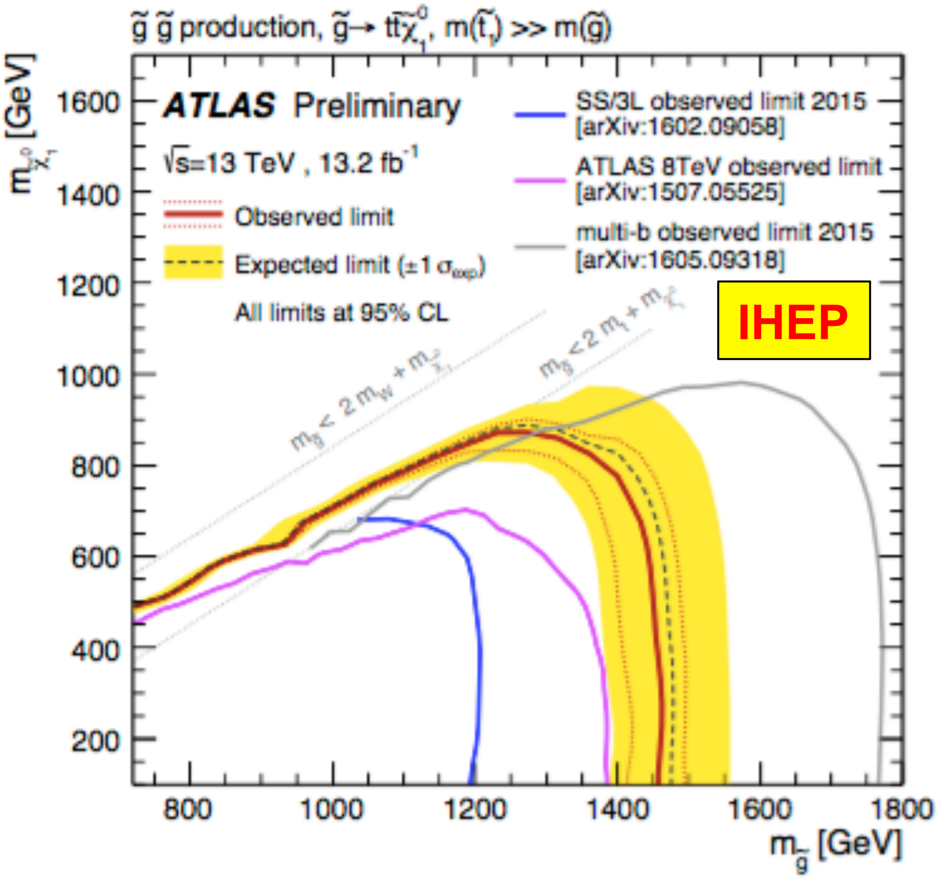
- **If require same sign 2 leptons or 3 leptons:**
  - → very rare in SM → A good probe for new physics
  - → Sensitive for a wide range of models (only Gtt, qqqqWW for CMS)



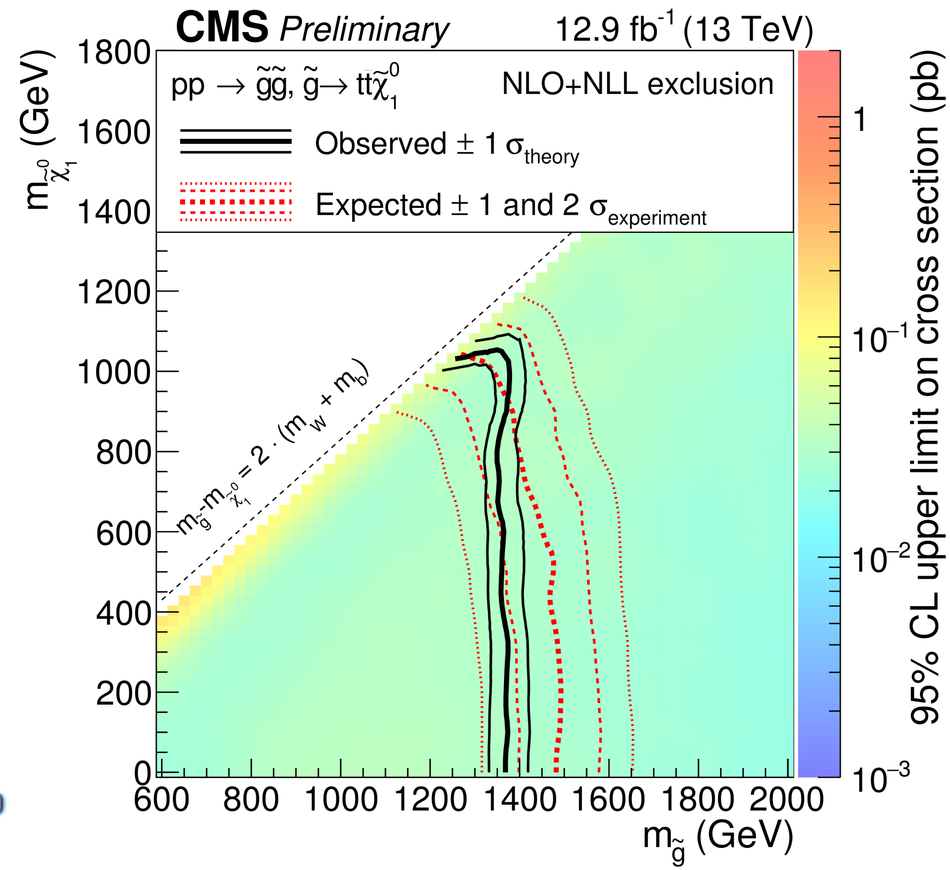
- **ATLAS**: 4 RPC+3 RPV SRs defined based on **MET, Meff, Nbjet,** targeting above specific scenarios
- **CMS**: binned **in mT, MET, jet and b-jet multiplicity**. In each bin, look at tails of H_T

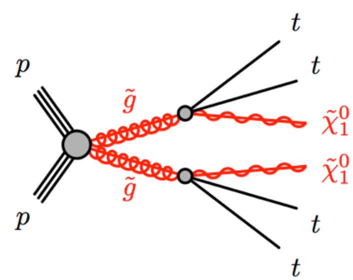
Di(Multi)-leptonic Signature: Results

ATLAS-CONF-2016-037

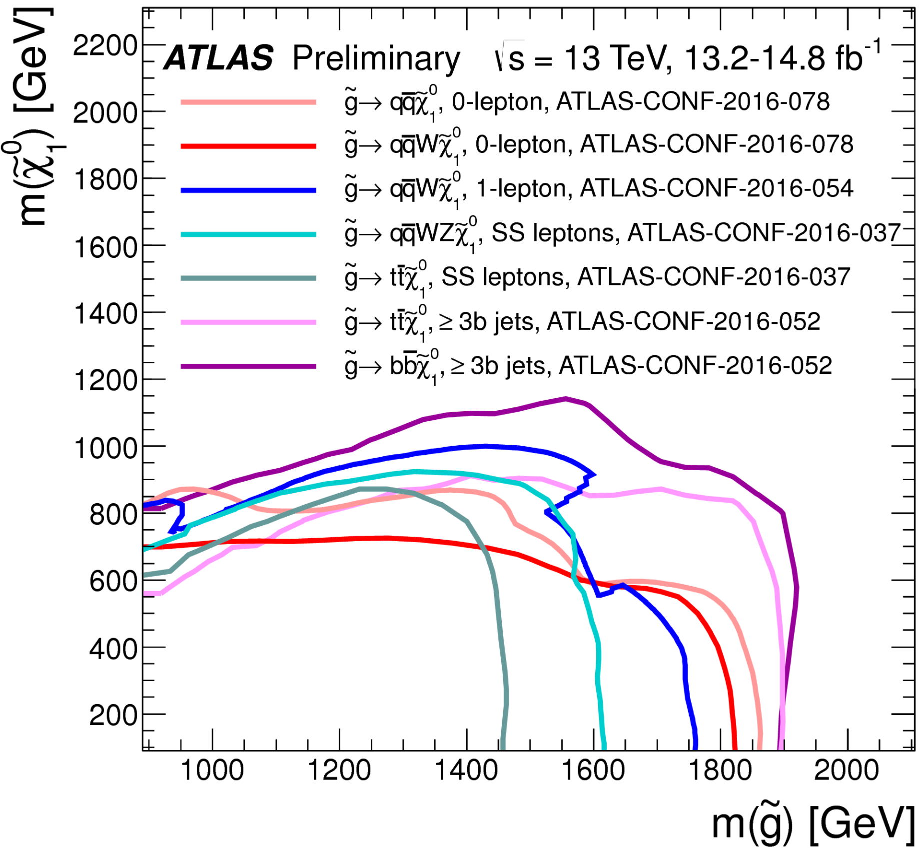


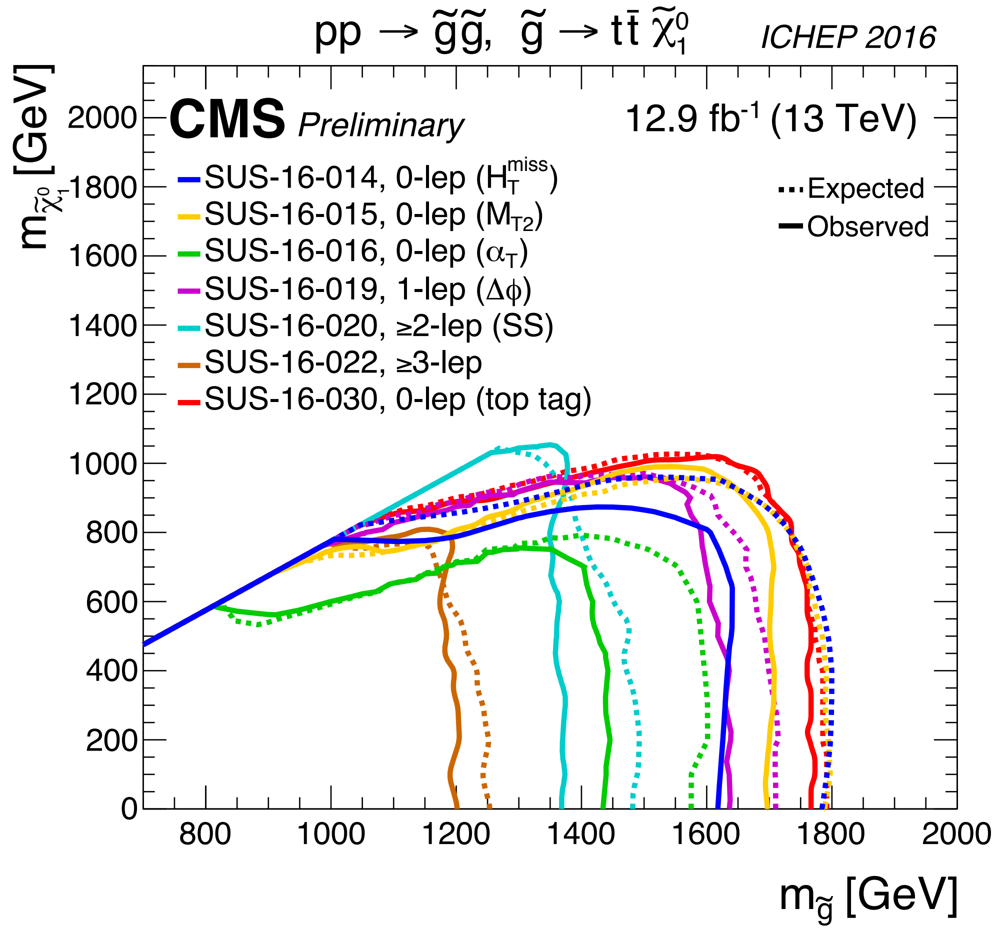
CMS-PAS-SUS-16-020



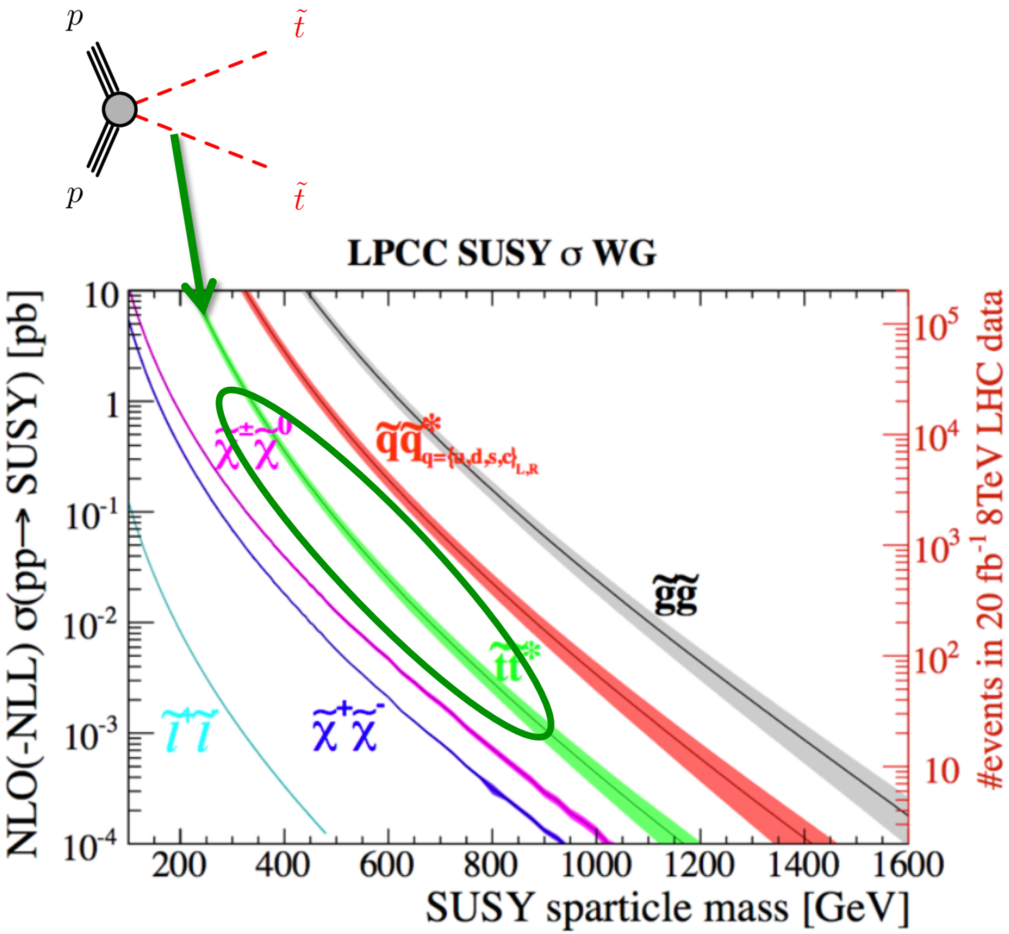


Strong Production *(summary)*





SUSY Search @ LHC



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Electroweak production:

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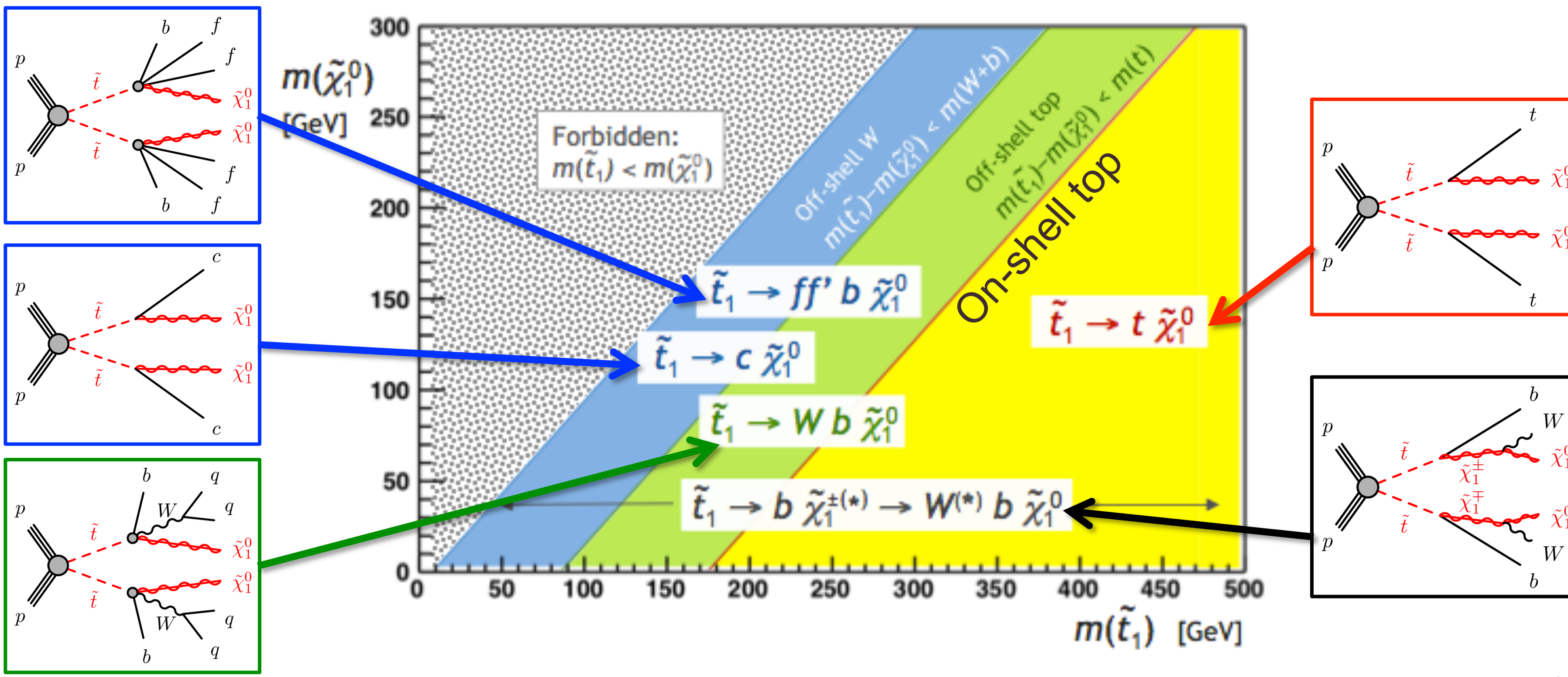
- ❑ Lowest mass sparticles, clean signature

RPV/LL:

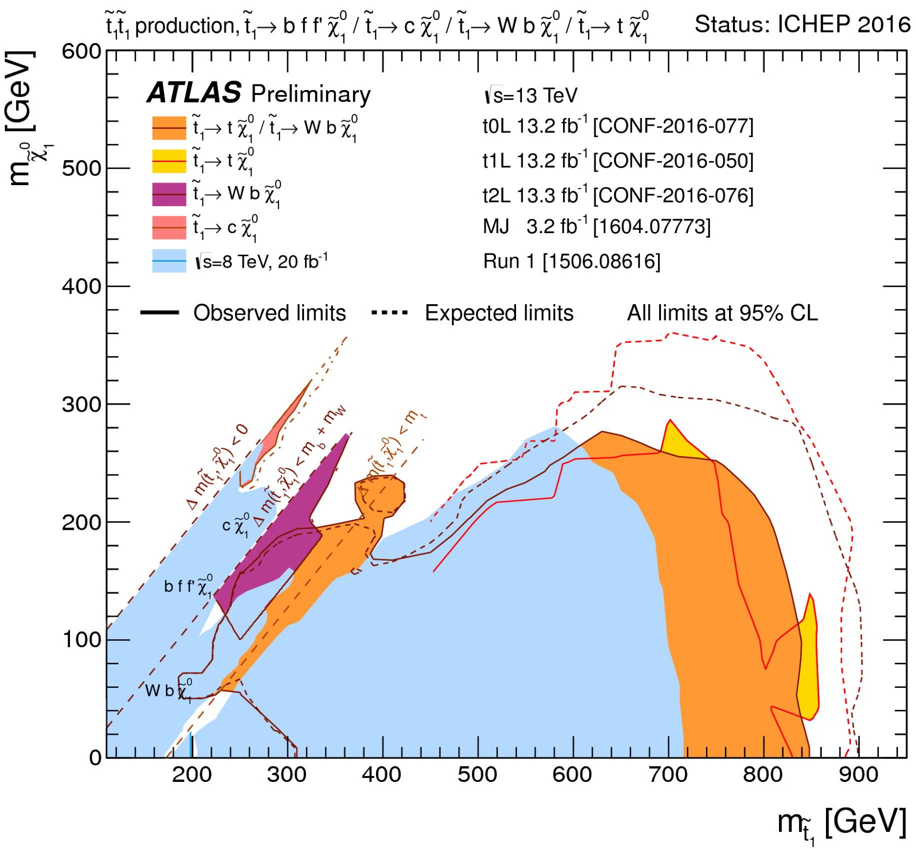
- ❑ targeting R-parity violating models and long lived sparticles
- ❑ More exotic models

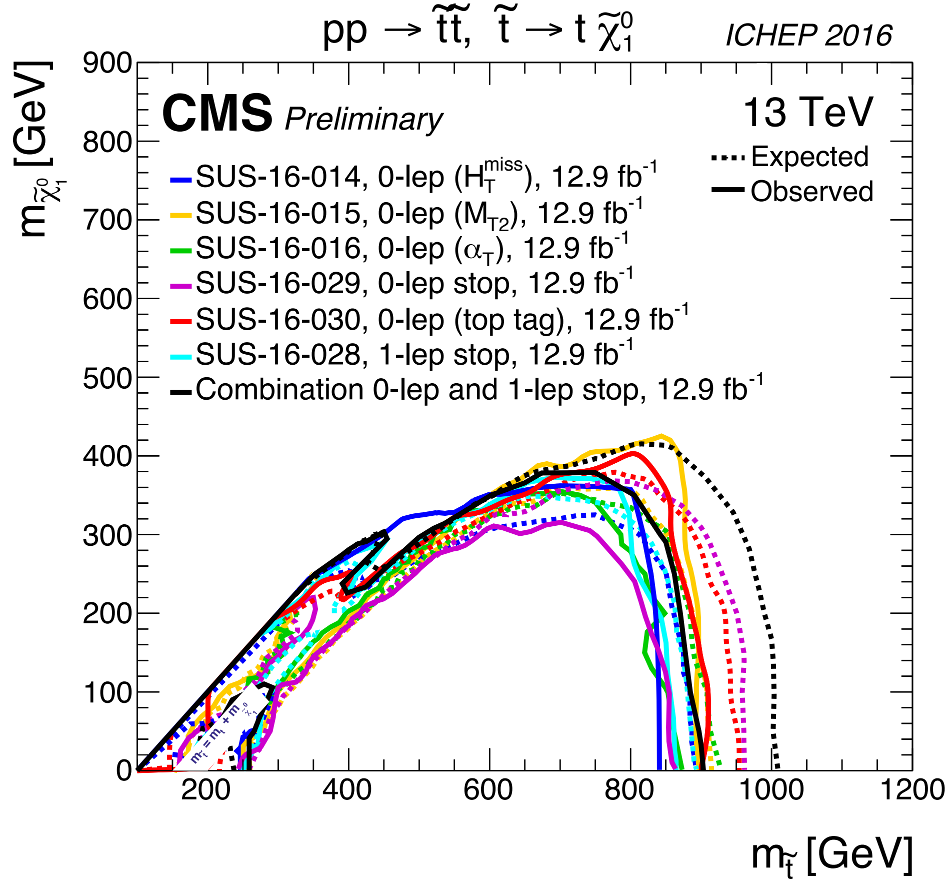
3rd Generation: stop

- ❑ Search for stop directly from ~t~t production
- ❑ Large spectrum of possible stop decays, covering range from low to heavy stop mass, various decay modes.



3rd Generation *(summary)*





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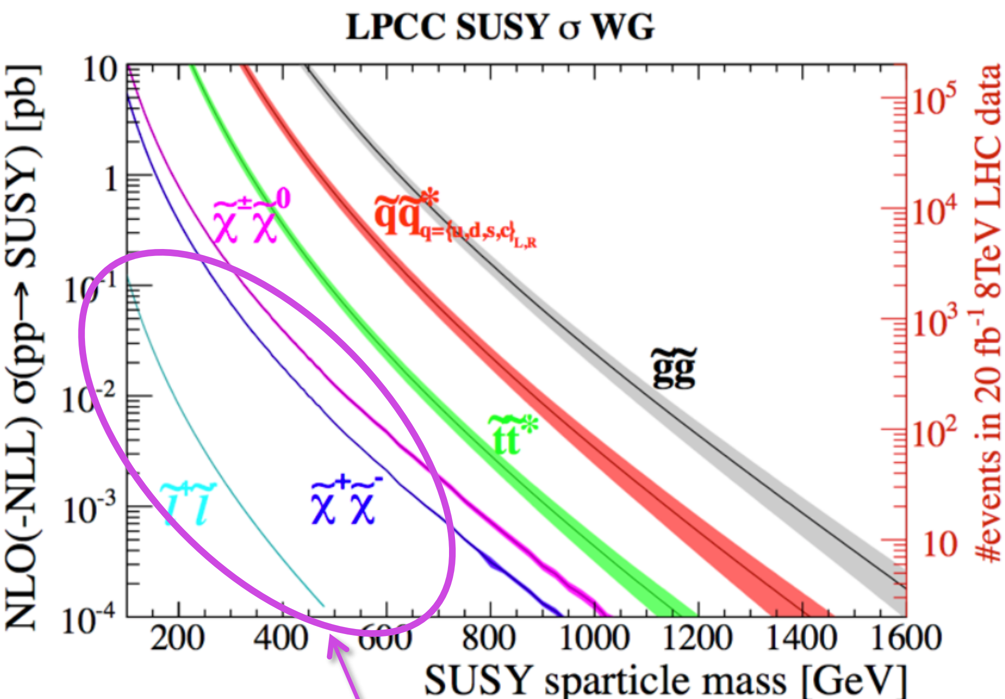

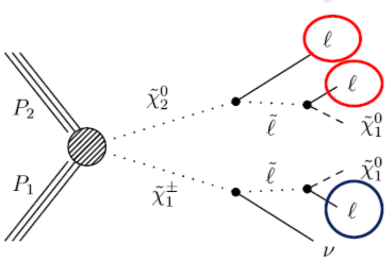

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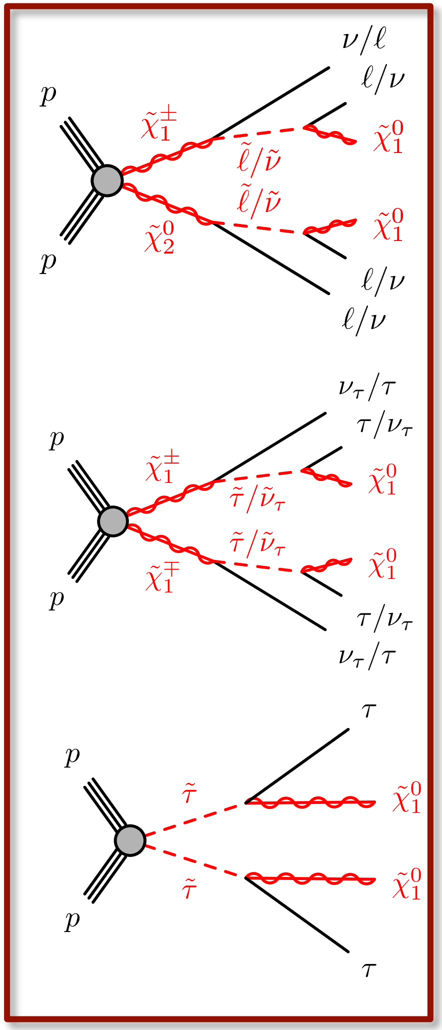
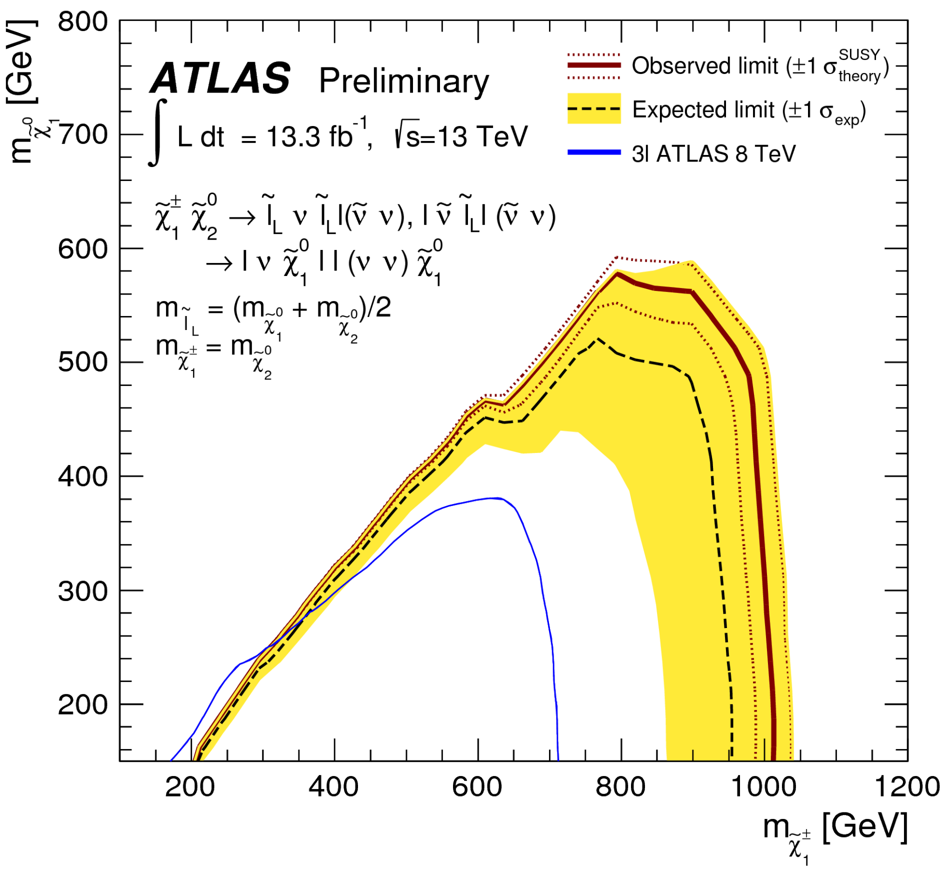
EWK Production: General Remarks

- If coloured sparticles much heavier than EW partners
  - Direct chargino/neutralino/slepton production
- Leptonic decay modes provide clean signature:
  - Many leptons (up to 4) + MET
  - Possibly hadronic taus
  - Low jet activity
- EW SUSY Searches:
  - ATLAS-CONF-2016-096(-075): 2-4 leptons
  - ATLAS-CONF-2016-093: 2 taus (IHEP)
  - CMS-SUS-16-024: 3-4 leptons (including taus)

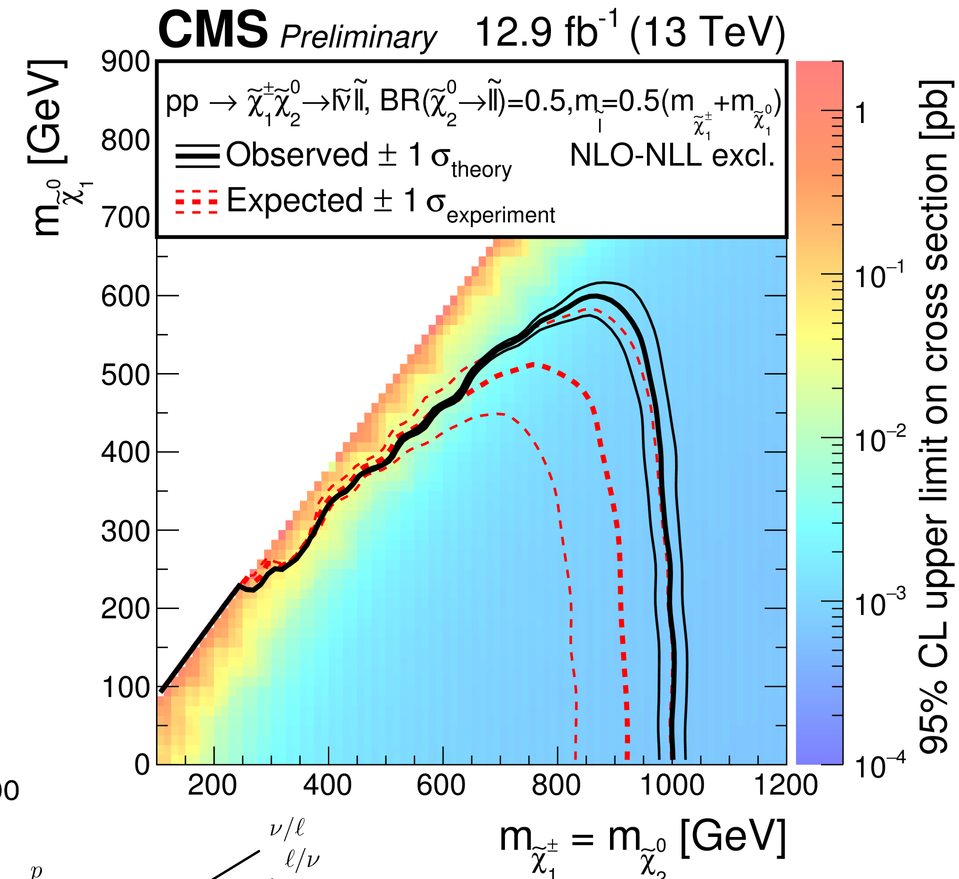


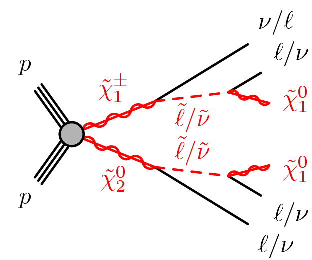
Chargino-Neutralino Pairs: light leptons

ATLAS-CONF-2016-096



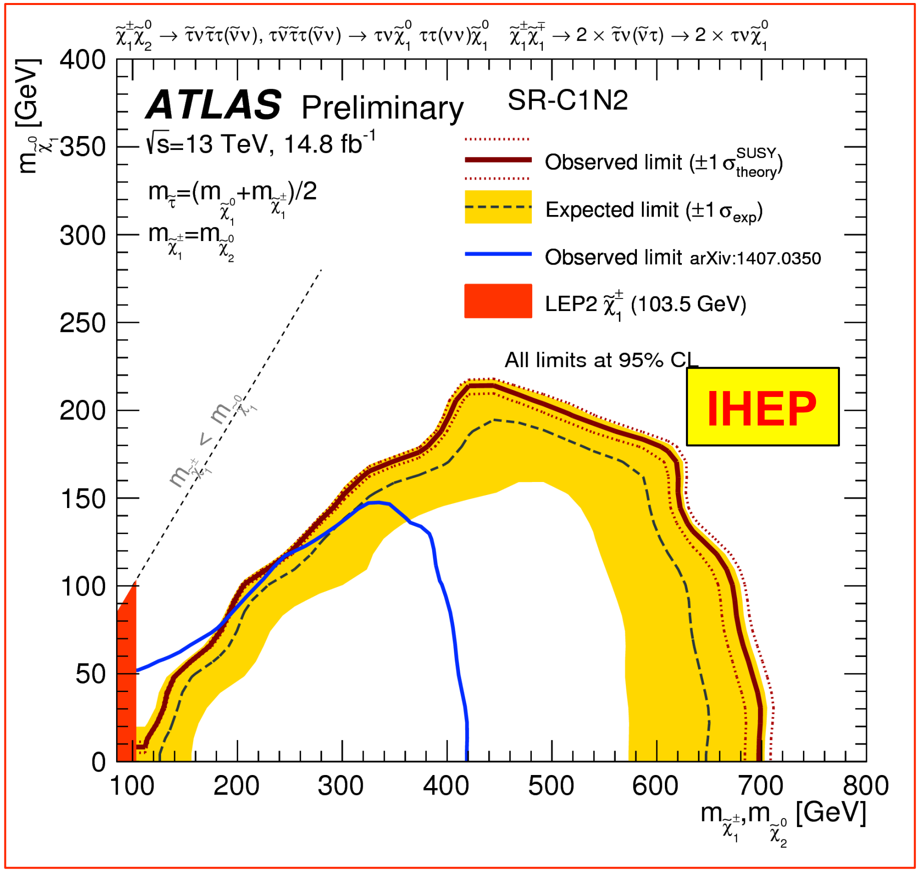
CMS-PAS-SUS-16-024



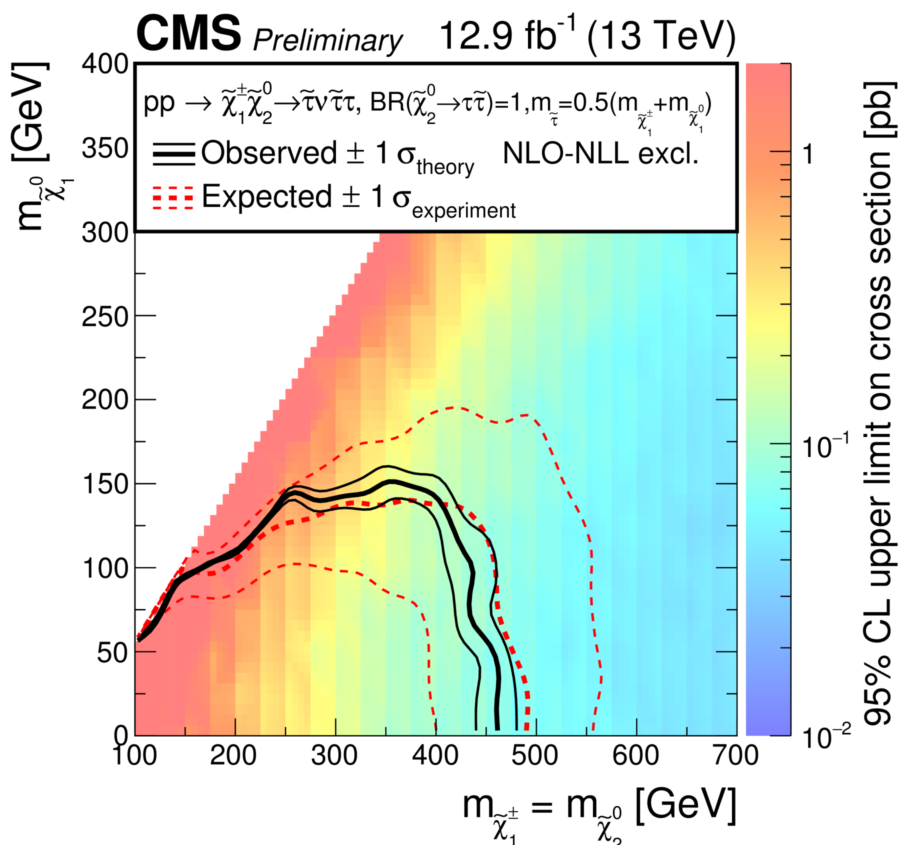


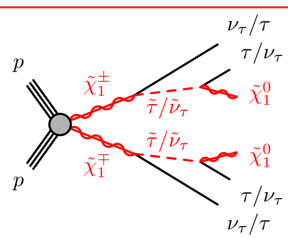
Chargino-Neutralino Pairs: taus

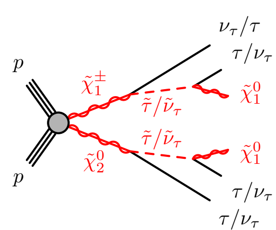
ATLAS-CONF-2016-093

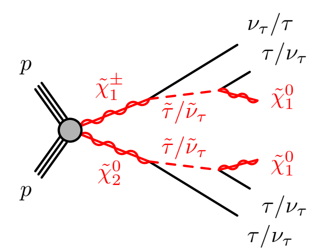


CMS-PAS-SUS-16-024

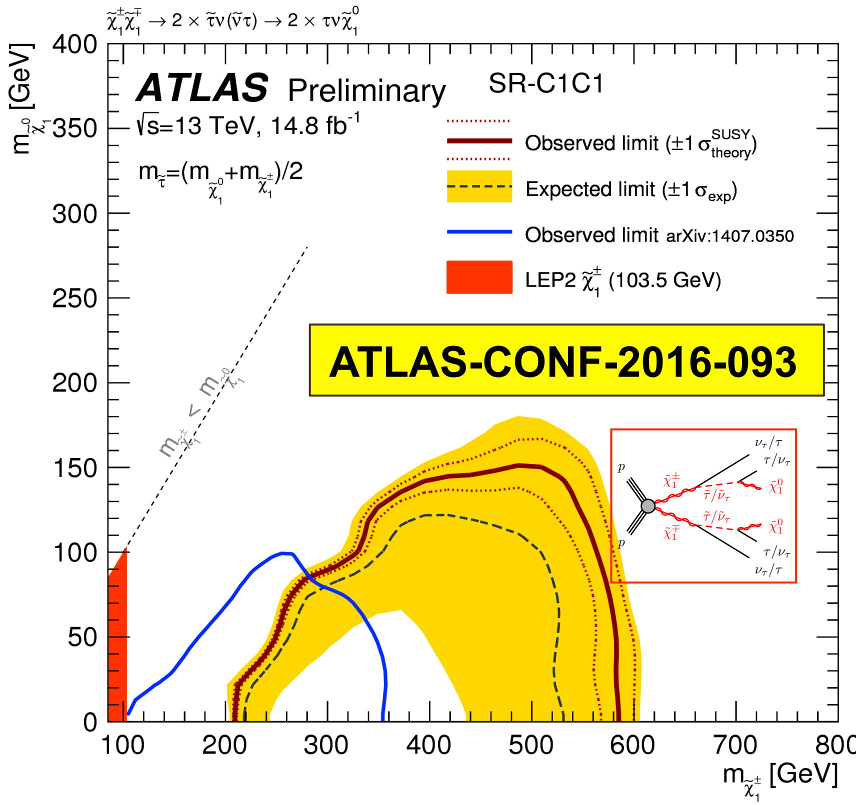






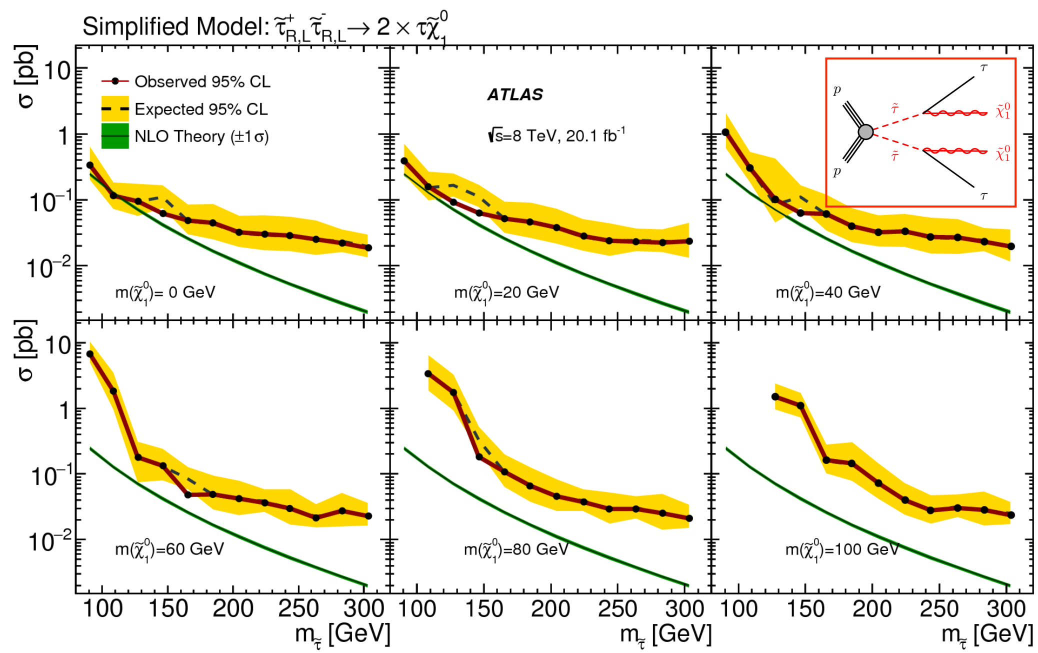


Chargino-Chargino Pair & Direct Stau Pair



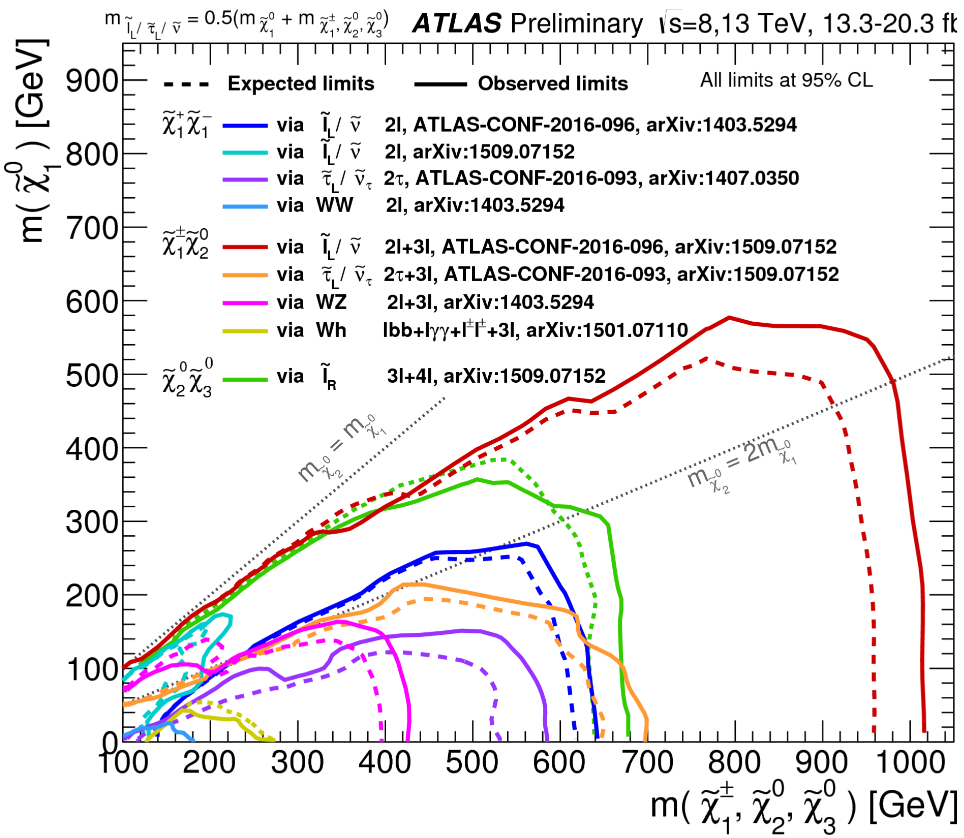
IHEP

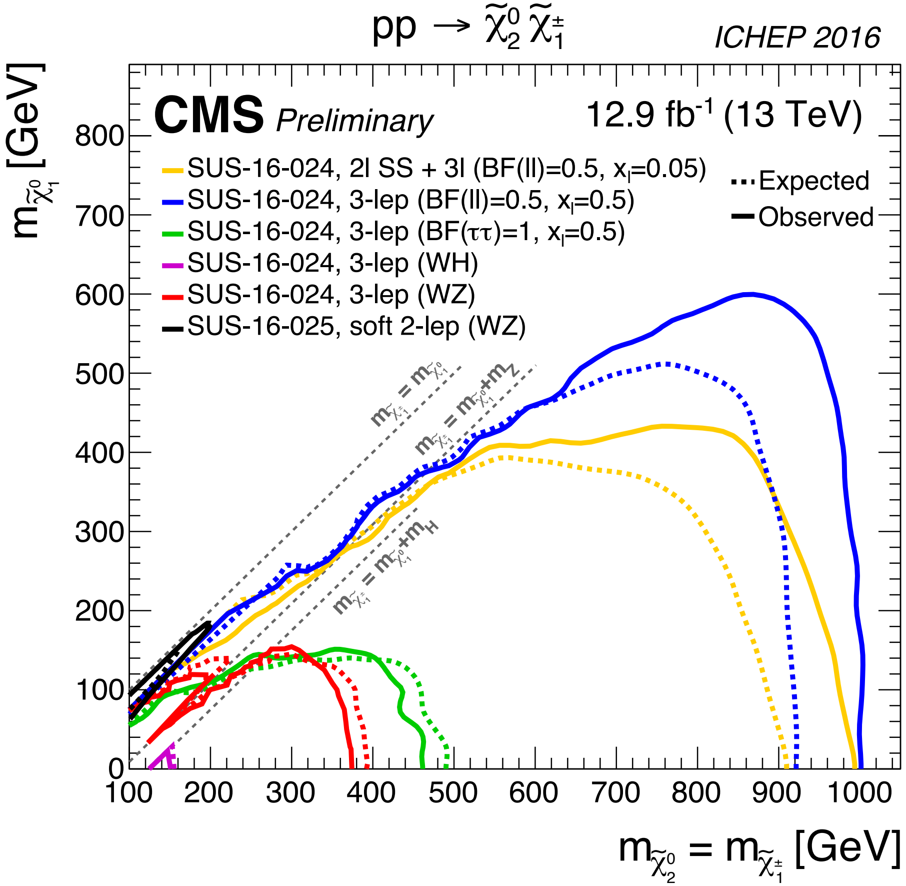
MVA:
Phys. Rev. D 93, 052002 (2016)



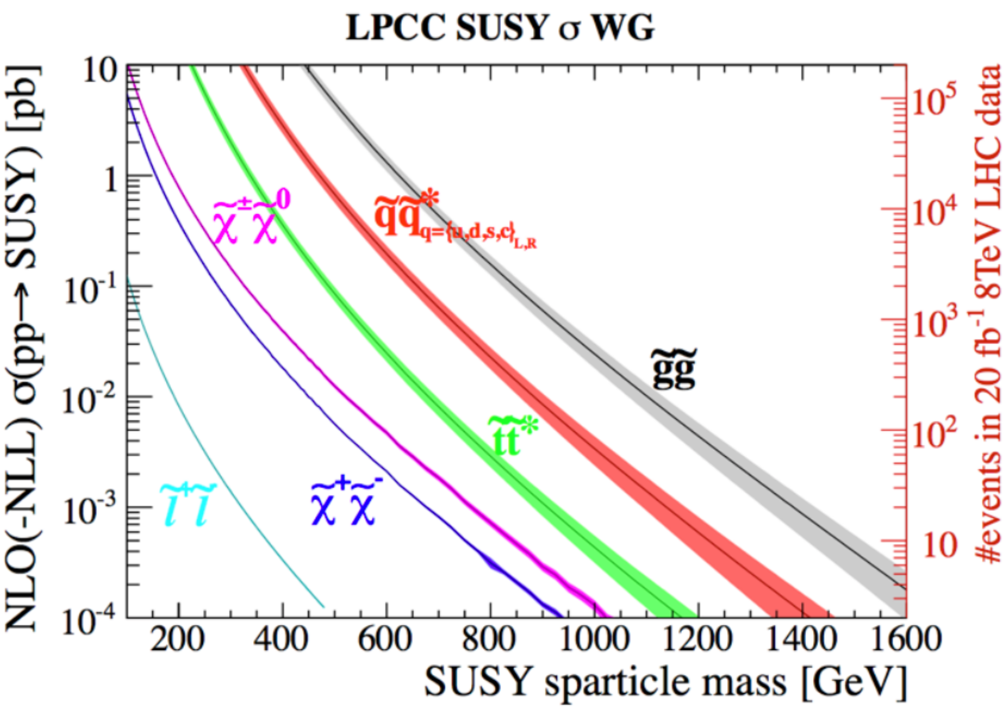
❑ **First measurement from LHC, No results from CMS yet**

EWK Production *(summary)*





SUSY Search @ LHC



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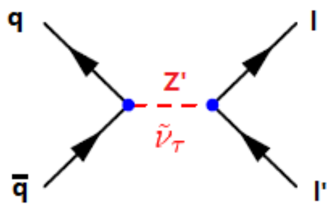
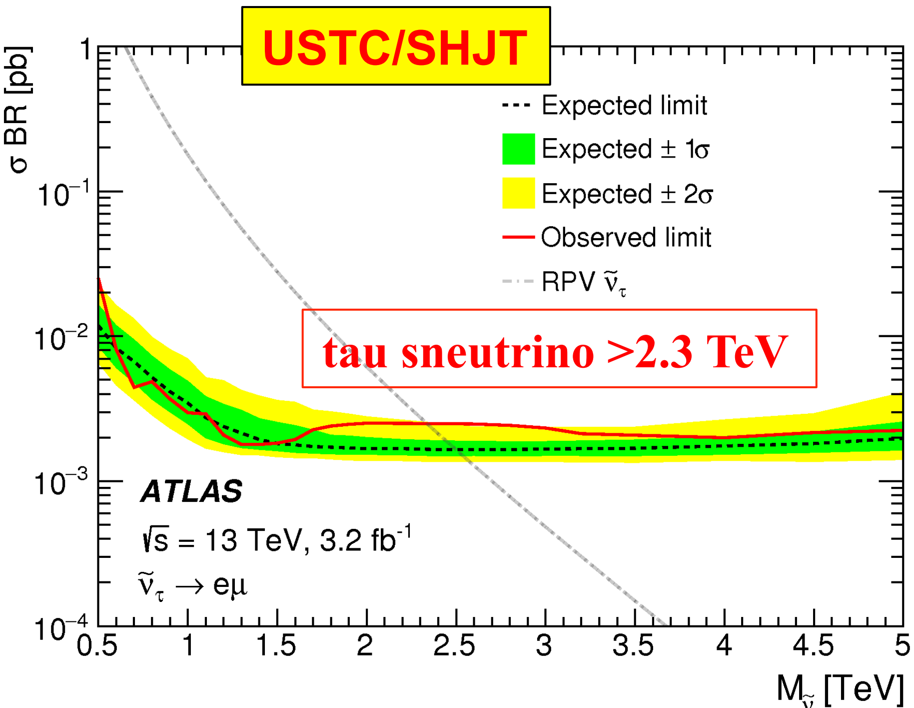
Search for LFV di-lepton Resonance

- search for a heavy resonance from LFV di-lepton ($e\mu$, $e\tau$ or $\mu\tau$) final states, like RPV SUSY tau sneutrino, Z', QBH





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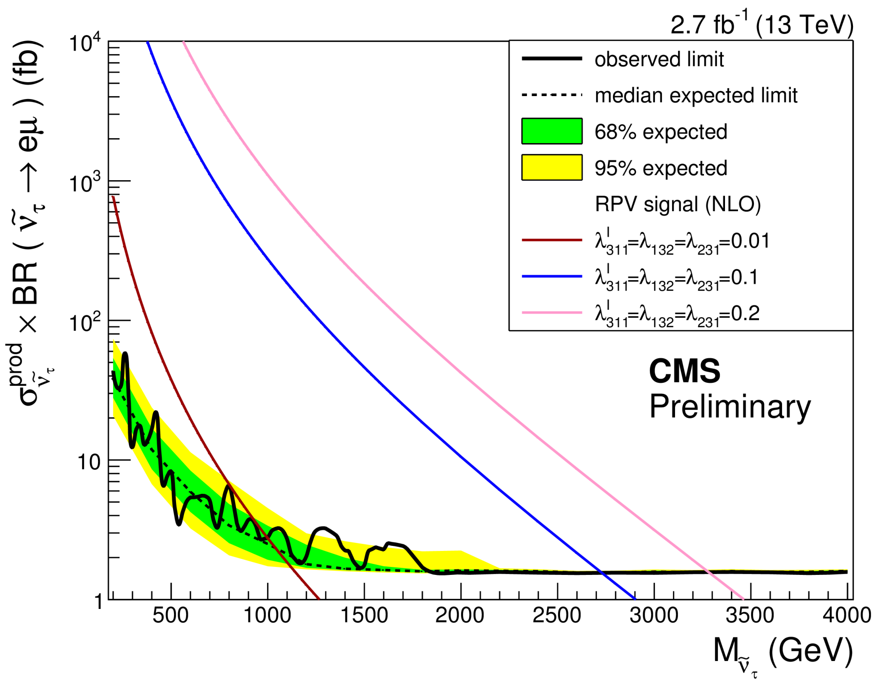
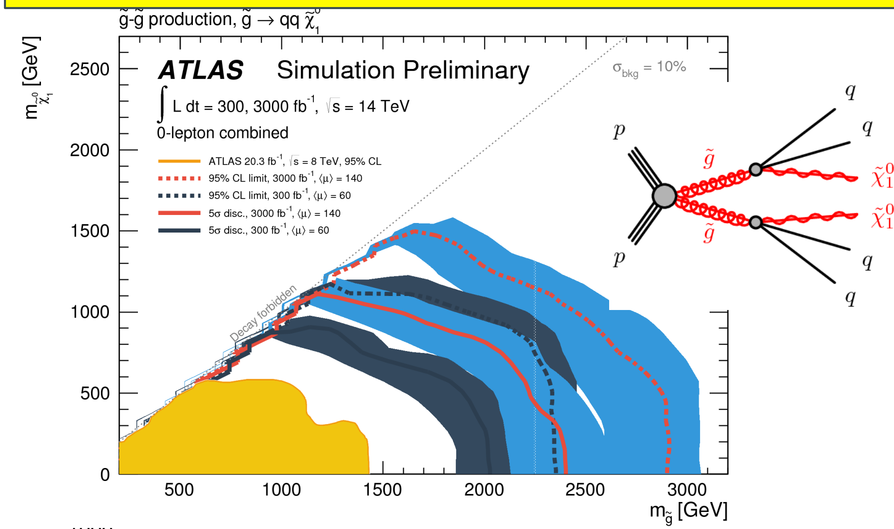


CMS-PAS-EXO-16-001

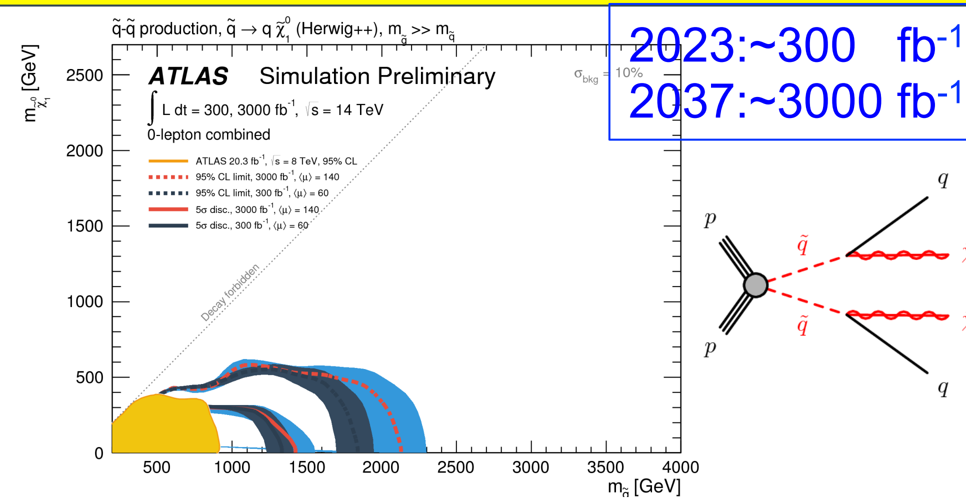
Long term prospects

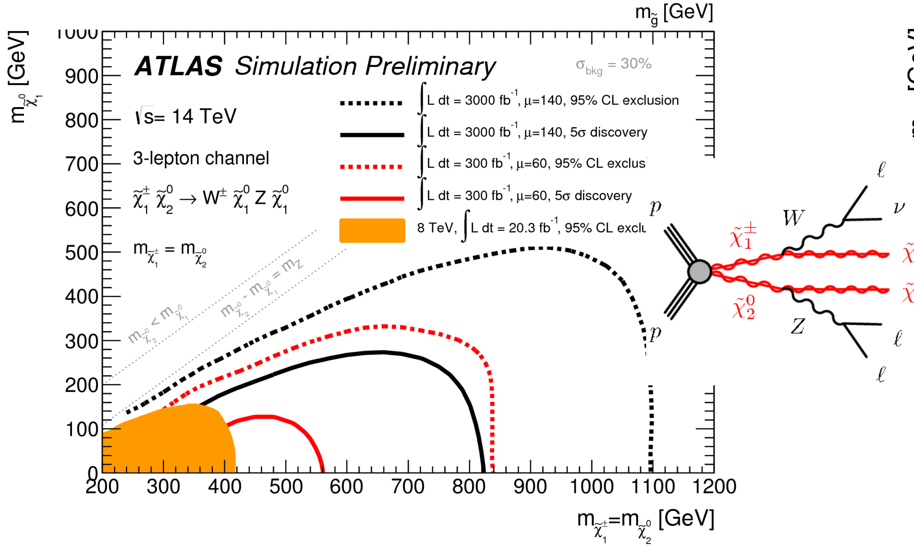
ATL-PHYS-PUB-2014-010

- ATLAS studied long term prospects for the (HL-)LHC with 300, 3000 fb^{-1}@14TeV
- Discovery potential up **to 2.5 TeV gluinos, 1.3 TeV squarks/sbottom and 800 GeV Electroweakinos, 500 GeV stau (IHEP)**



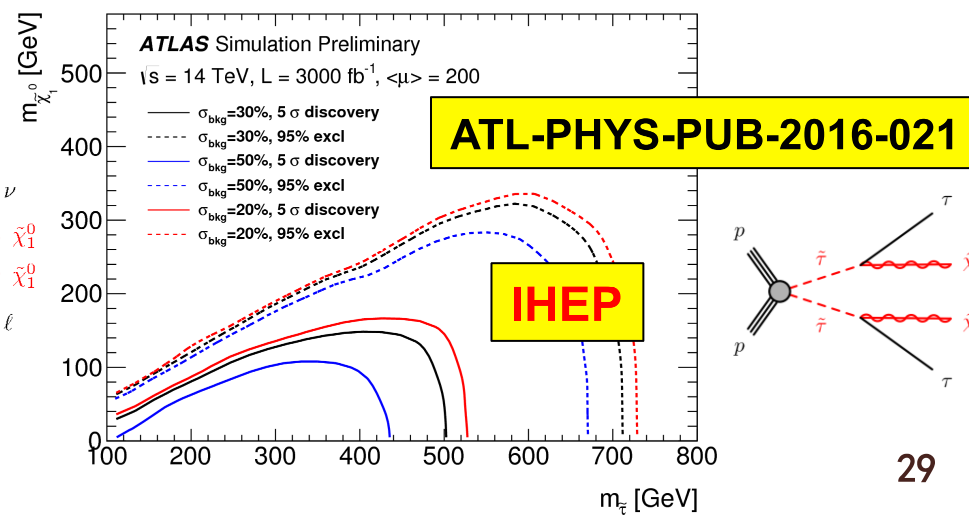
2023:~300 fb^{-1}
2037:~3000 fb^{-1}





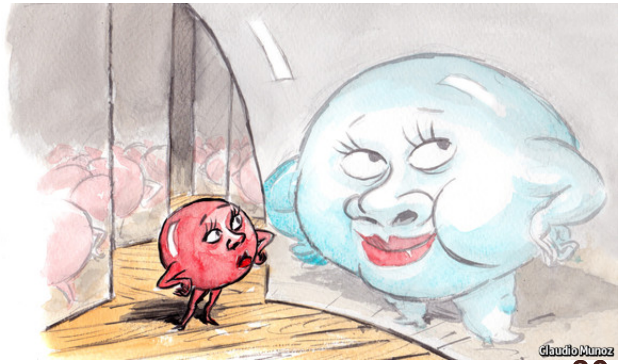
ATL-PHYS-PUB-2016-021

IHEP



Summary

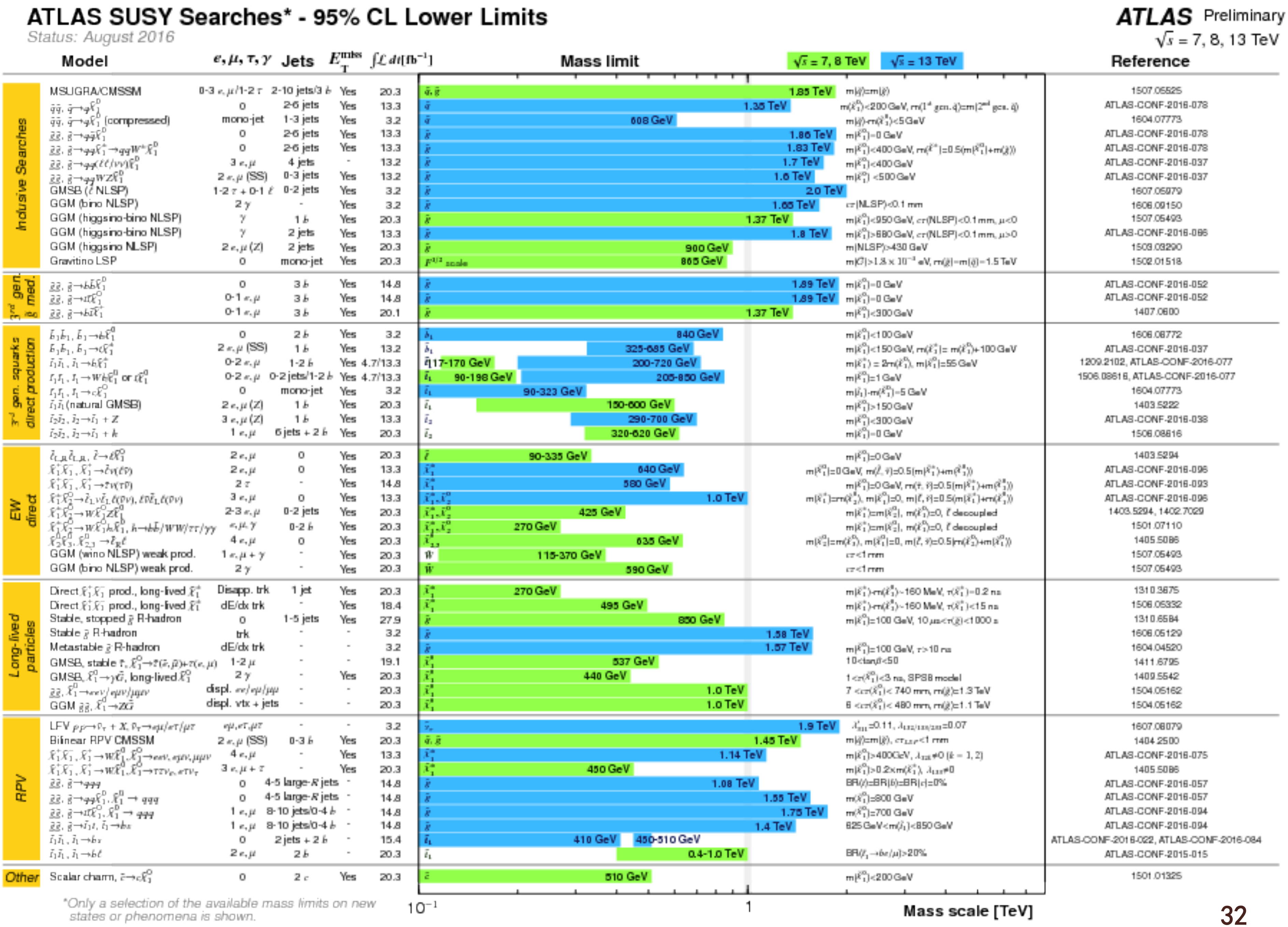
- ATLAS and CMS developed a vast program to search for SUSY.
- No significant excess seen so far, in canonical scenarios, sensitivity is achieved to ~1.9 TeV gluinos, ~900 GeV stops and ~700 GeV EWK-inos
  - ✓ More public results: ATLAS, CMS
- Results with ~35 fb^{-1} 2015+2016 data are coming soon, stay tuned !
- LHC is a discovery machine, new physics may come at any time !



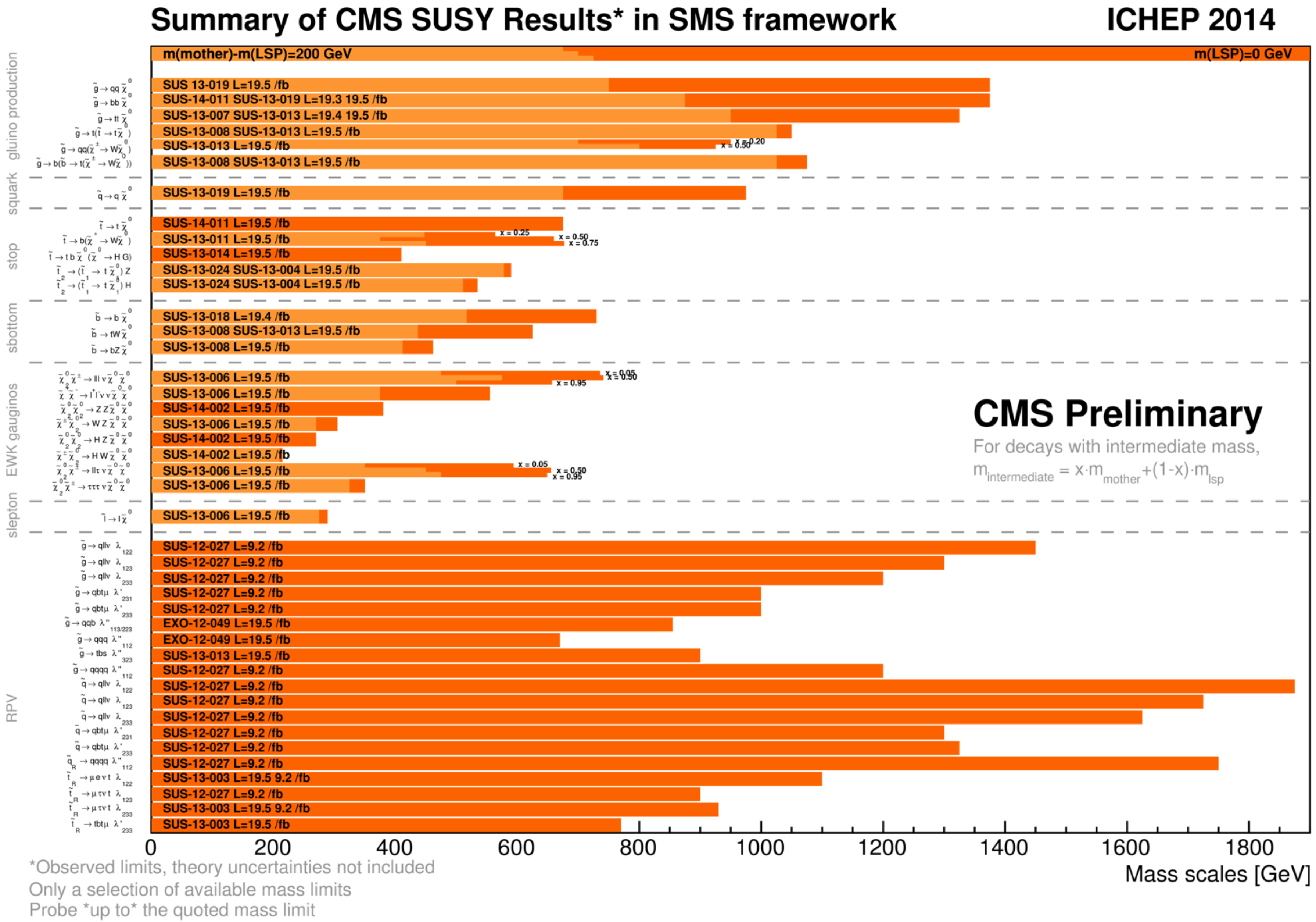
- Exciting times are ahead of us !

- looking forward to the great discovery!

Thanks for your attention!



ATLAS SUSY Searches* - 95% CL Lower Limits
Status: August 2016
ATLAS Preliminary
$\sqrt{s}$ = 7, 8, 13 TeV
Model
e, μ, τ, γ
Jets
E_T^{miss}
$\int \mathcal{L}\, dt [fb^{-1}]$
Mass limit
$\sqrt{s}$ = 7, 8 TeV
$\sqrt{s}$ = 13 TeV
Reference
Inclusive Searches
3^{rd} gen. $\tilde{g}$ med.
3^{rd} gen. squarks direct production
EW direct
Long-lived particles
RPV
Other
MSUGRA/CMSSM
GGM (bino NLSP)
GGM (higgsino-bino NLSP)
GGM (higgsino NLSP)
Gravitino LSP
GGM (wino NLSP) weak prod.
GGM (bino NLSP) weak prod.
Stable, stopped $\tilde{g}$ R-hadron
Stable $\tilde{g}$ R-hadron
Metastable $\tilde{g}$ R-hadron
Bilinear RPV CMSSM
Scalar charm, $\tilde{c} \to c\tilde{\chi}_1^0$
1.85 TeV
1.35 TeV
608 GeV
1.86 TeV
1.83 TeV
1.7 TeV
1.6 TeV
2.0 TeV
1.65 TeV
1.37 TeV
1.8 TeV
900 GeV
865 GeV
1.89 TeV
1.89 TeV
1.37 TeV
840 GeV
325-685 GeV
117-170 GeV
200-720 GeV
90-198 GeV
205-850 GeV
90-323 GeV
150-600 GeV
290-700 GeV
320-620 GeV
90-335 GeV
640 GeV
580 GeV
1.0 TeV
425 GeV
270 GeV
635 GeV
115-370 GeV
590 GeV
270 GeV
495 GeV
850 GeV
1.58 TeV
1.57 TeV
537 GeV
440 GeV
1.0 TeV
1.0 TeV
1.9 TeV
1.45 TeV
1.14 TeV
450 GeV
1.08 TeV
1.55 TeV
1.75 TeV
1.4 TeV
410 GeV
450-510 GeV
0.4-1.0 TeV
510 GeV
10^{-1}
1
Mass scale [TeV]
*Only a selection of the available mass limits on new states or phenomena is shown.


Summary of CMS SUSY Results* in SMS framework
ICHEP 2014
m(mother)-m(LSP)=200 GeV
m(LSP)=0 GeV
SUS 13-019 L=19.5 /fb
SUS-14-011 SUS-13-019 L=19.3 19.5 /fb
SUS-13-007 SUS-13-013 L=19.4 19.5 /fb
SUS-13-008 SUS-13-013 L=19.5 /fb
SUS-13-013 L=19.5 /fb
SUS-13-008 SUS-13-013 L=19.5 /fb
SUS-13-019 L=19.5 /fb
SUS-14-011 L=19.5 /fb
SUS-13-011 L=19.5 /fb
SUS-13-014 L=19.5 /fb
SUS-13-024 SUS-13-004 L=19.5 /fb
SUS-13-024 SUS-13-004 L=19.5 /fb
SUS-13-018 L=19.4 /fb
SUS-13-008 SUS-13-013 L=19.5 /fb
SUS-13-008 L=19.5 /fb
SUS-13-006 L=19.5 /fb
SUS-13-006 L=19.5 /fb
SUS-14-002 L=19.5 /fb
SUS-13-006 L=19.5 /fb
SUS-14-002 L=19.5 /fb
SUS-14-002 L=19.5 /fb
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SUS-13-006 L=19.5 /fb
SUS-13-006 L=19.5 /fb
SUS-12-027 L=9.2 /fb
SUS-12-027 L=9.2 /fb
SUS-12-027 L=9.2 /fb
SUS-12-027 L=9.2 /fb
SUS-12-027 L=9.2 /fb
EXO-12-049 L=19.5 /fb
EXO-12-049 L=19.5 /fb
SUS-13-013 L=19.5 /fb
SUS-12-027 L=9.2 /fb
SUS-12-027 L=9.2 /fb
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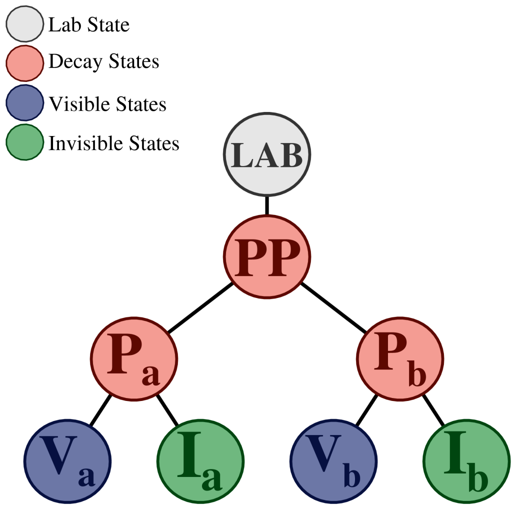
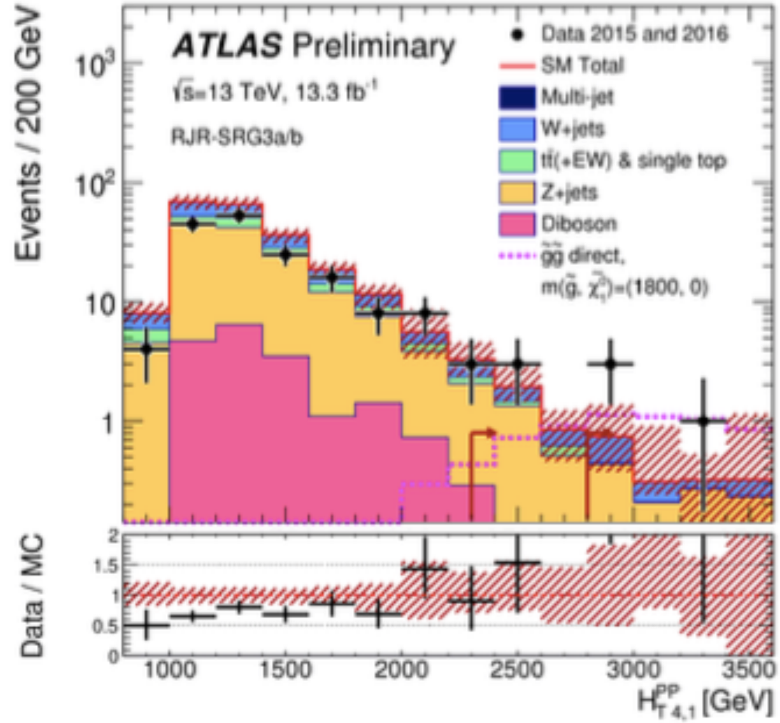
SUS-13-003 L=19.5 9.2 /fb
SUS-12-027 L=9.2 /fb
SUS-13-003 L=19.5 9.2 /fb
SUS-13-003 L=19.5 /fb
gluino production
squark
stop
sbottom
EWK gauginos
slepton
RPV
CMS Preliminary
For decays with intermediate mass,
$m_{intermediate} = x \cdot m_{mother} + (1-x) \cdot m_{lsp}$
0
200
400
600
800
1000
1200
1400
1600
1800
Mass scales [GeV]
*Observed limits, theory uncertainties not included
Only a selection of available mass limits
Probe *up to* the quoted mass limit

RJigsaw





the complementary search using the **Recursive Jigsaw Reconstruction (RJR) techniques** in the construction of a discriminating variable set ('RJR-based search'). By using a dedicated set of selection criteria, the RJR-search improve the sensitivity to supersymmetric models with small mass splittings between the sparticles (models with compressed spectra).

Recursive jigsaw reconstruction

- based on assumption of decay tree
- fix set of rules to resolve combinatorics and unknowns in invisible system
- can form set of variables in the rest frame of each level in the decay tree

SUSY models: good sale in market

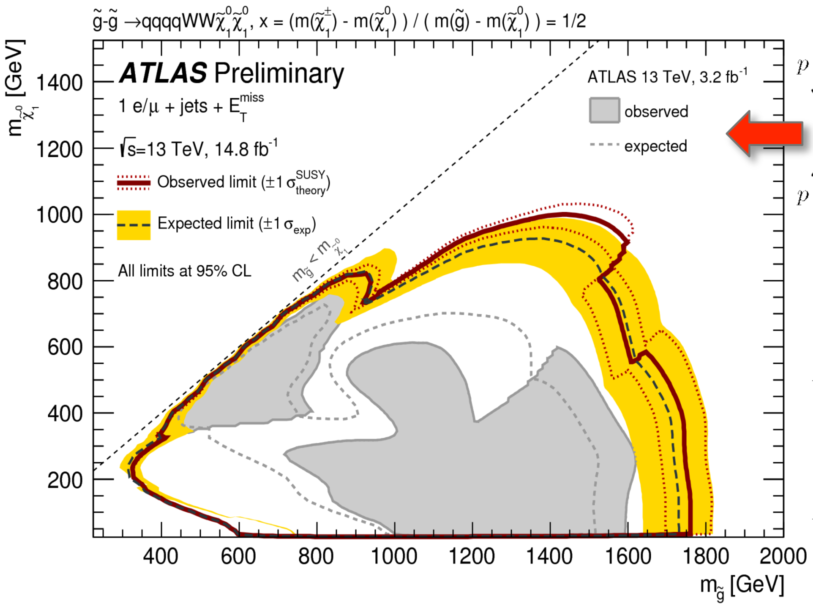
- Simplified Models:
  - Not really a model (Br~100%, most masses fixed at high scales)
  - Important tool for interpretation

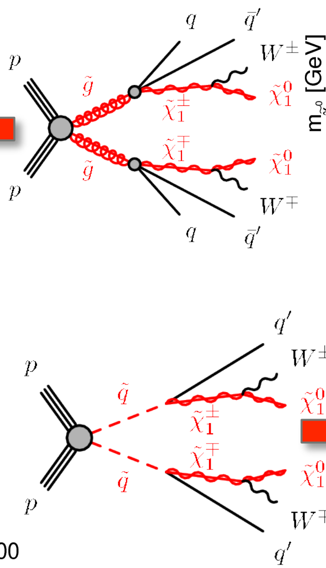
- Phenomenological models:
  - pMSSM: captures "most" of phenomenologic features of R-parity conserving MSSM
    - 19 free parameters: M1,M2,M3 ; tan β, μ and $m_{A;}$ 10 sfermion mass parameters; A_t, A_b and A_τ
    - Comprehensive and computationally realistic approximation of the MSSM with neutralino LSP
  - GGM (gravitino)

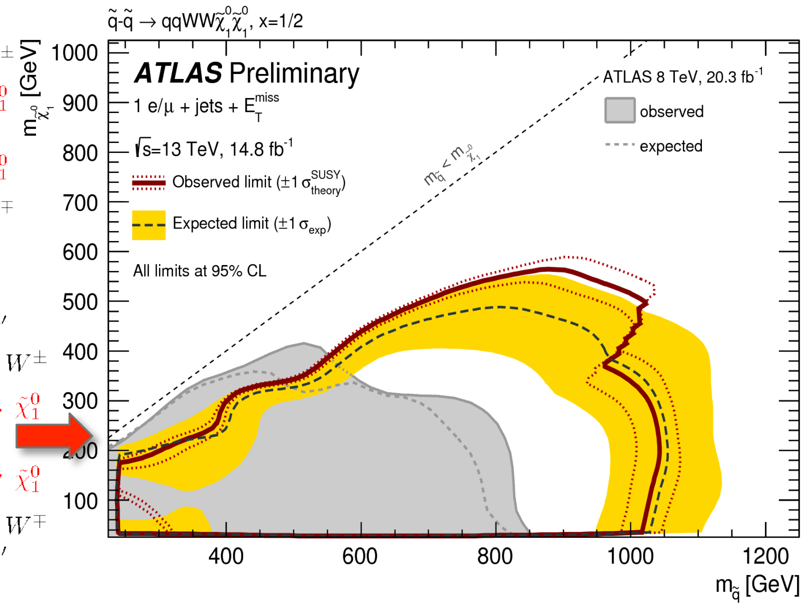
- Complete SUSY models: mSUGRA, GMSB …

Strong production: 1L

ATLAS-CONF-2016-054





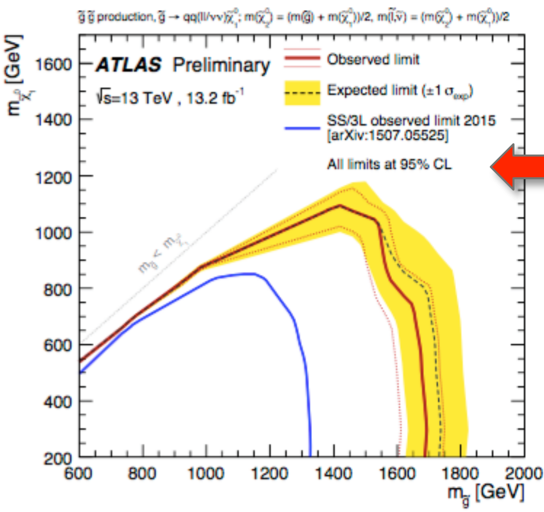


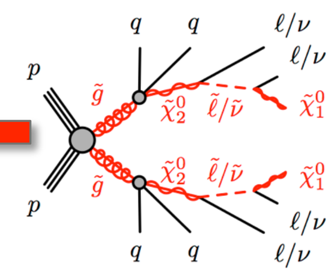
- Gluino (squark) masses up to 1.7 TeV (1.0 TeV) are excluded for low neutralino masses (≤ 400 GeV or ≤ 300 GeV)
- IHEP made a leading contribution (contact person/ contact editor/approval talks)

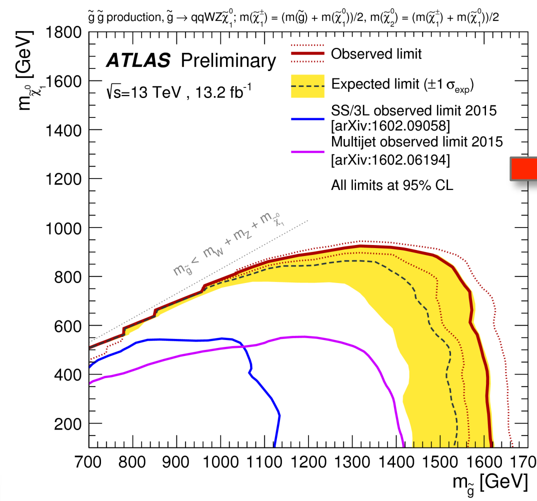
ATLAS-CONF-2016-037

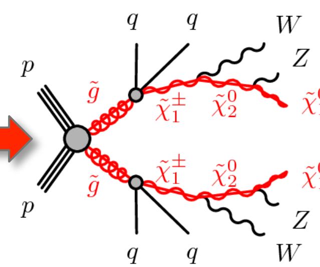
Strong production: SS/3L

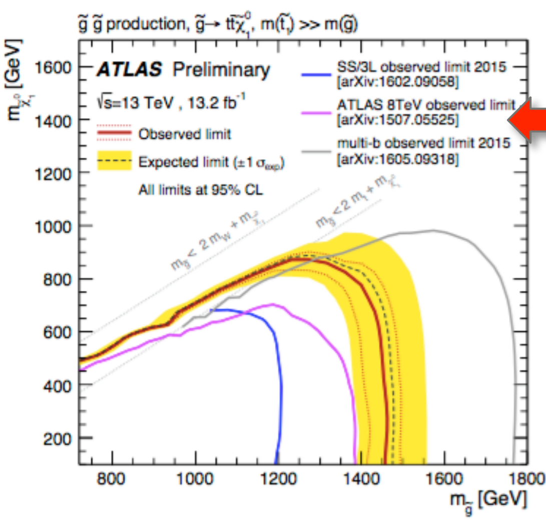
- Gluino mass <1.4-1.7 TeV and LSP mass < 850-1100 GeV are excluded for gluino pair production. ~b mass < 690 GeV excluded

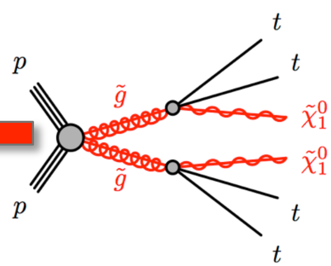


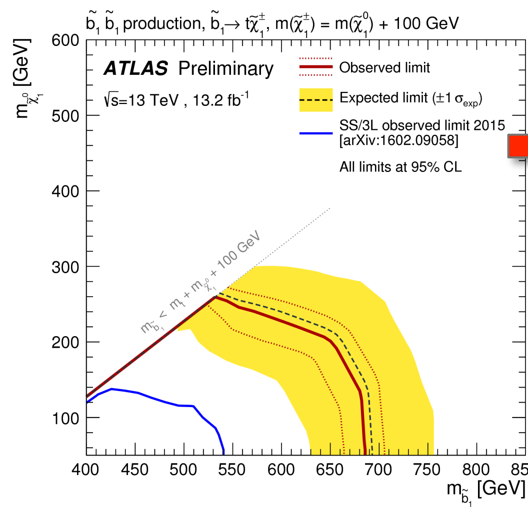


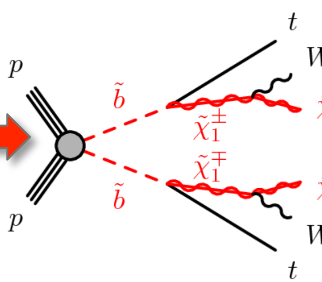








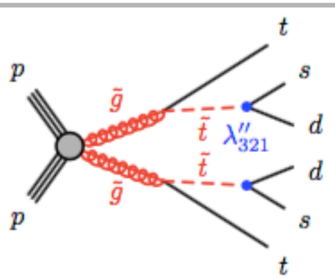


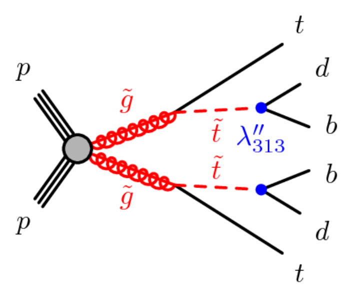


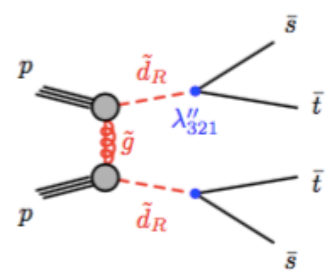
Strong production: SS/3L

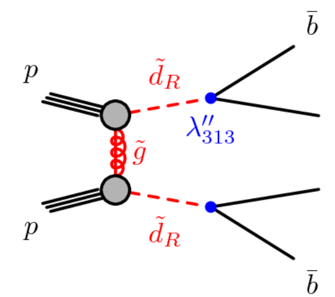
ATLAS-CONF-2016-037

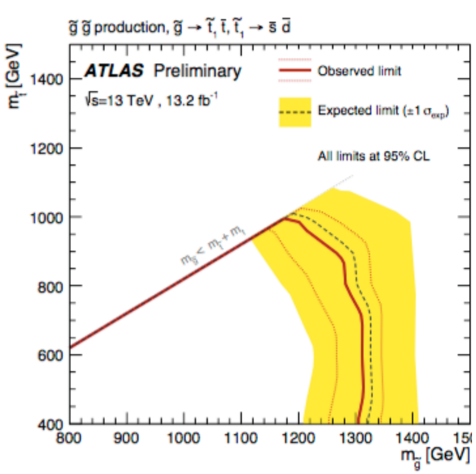
- Gluino mass <1.3 TeV and LSP mass < 1 TeV excluded in RPV scenario.
- Right-handed down squark masses are probed up to $m_{\tilde{d}_R} \approx 700$ GeV in RPV scenarios.
- IHEP mainly contributed in SR definition and main background estimation in data, Gave approval talks for paper publication.

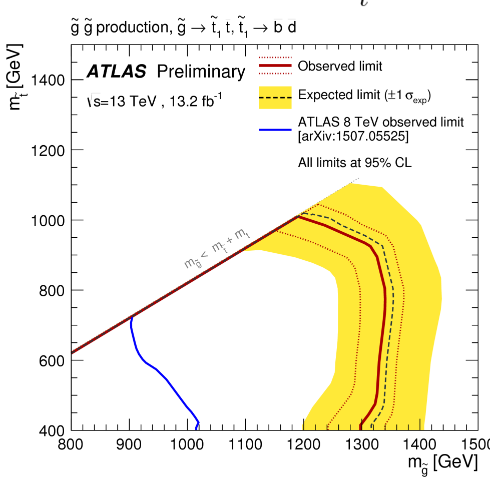


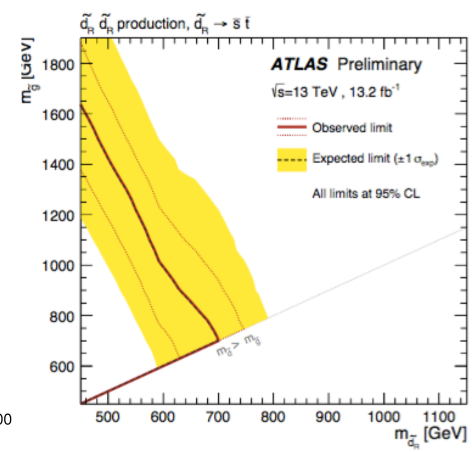


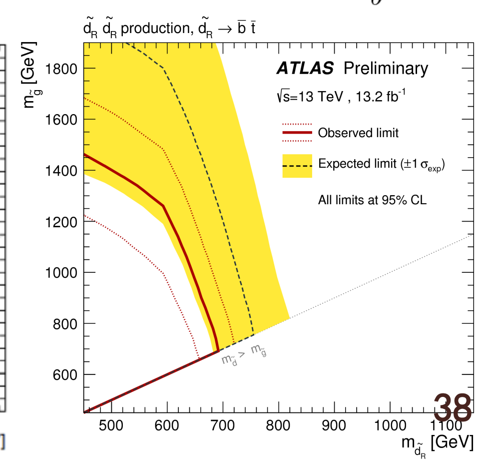


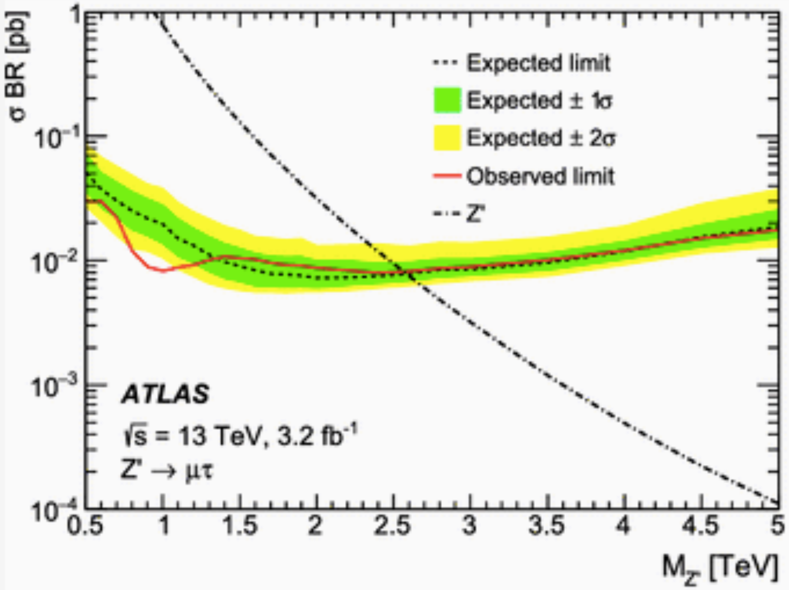




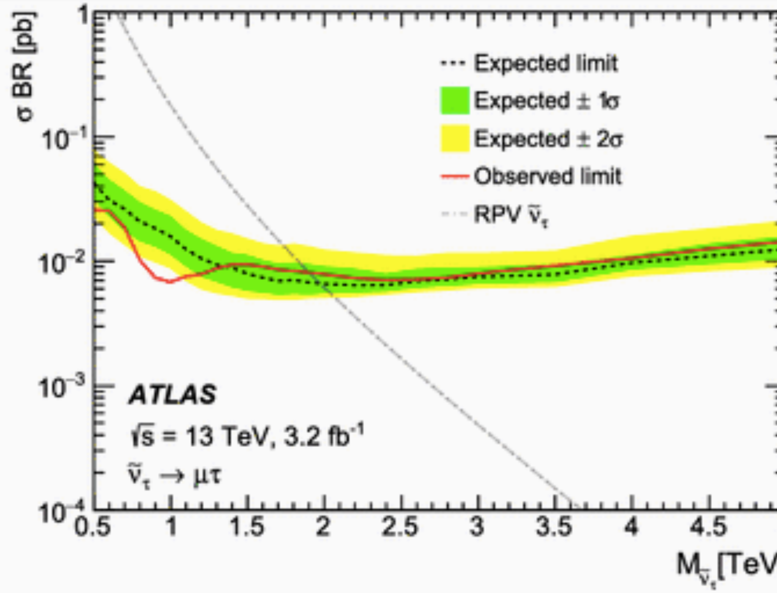




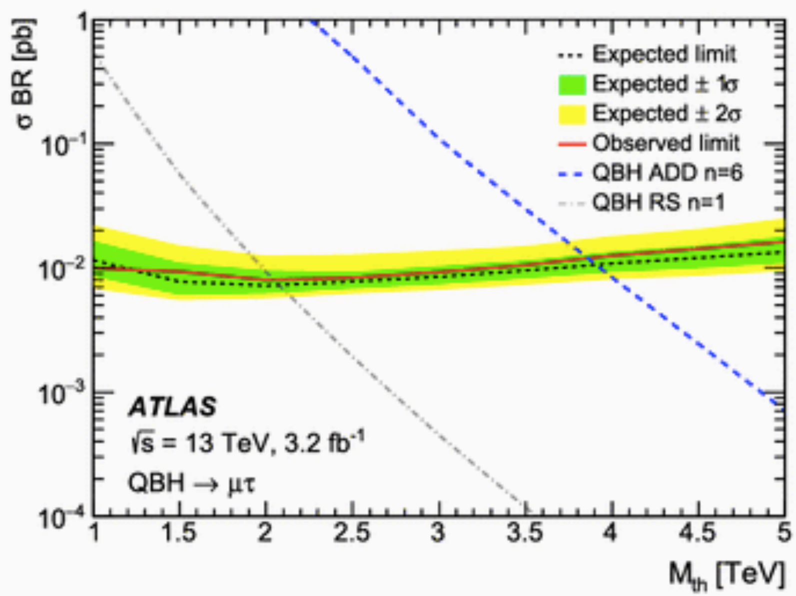




(a) Z'



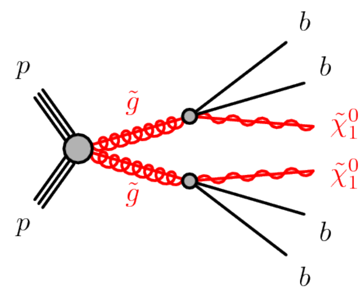
(b) RPV SUSY

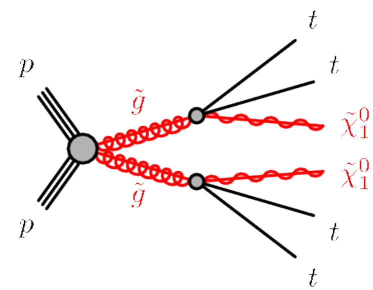


(c) QBH

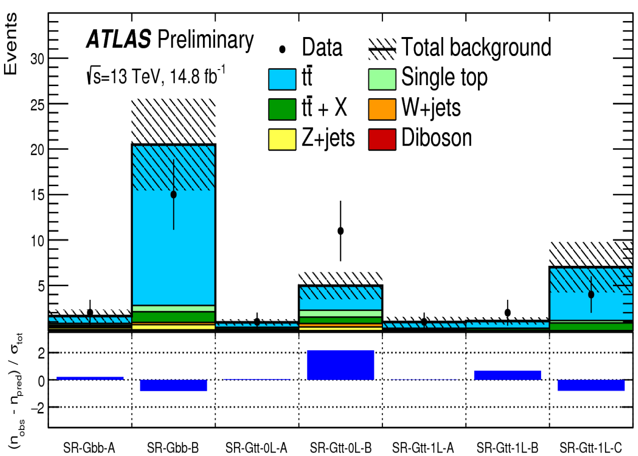
Strong Production: bjets +MET

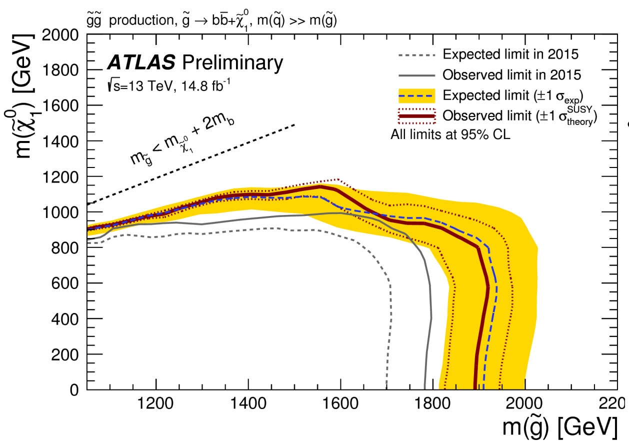
- Search for gluinos via stop or sbottom decay
- Final states with ≥3b-jets, MET, no or one lepton (e/μ)
- Signal to BG discrimination based on: Meff, MET, mT
- 7 SRs defined targeting different search scenarios
- Excludes gluino masses up to 1.89 TeV for massless LSP

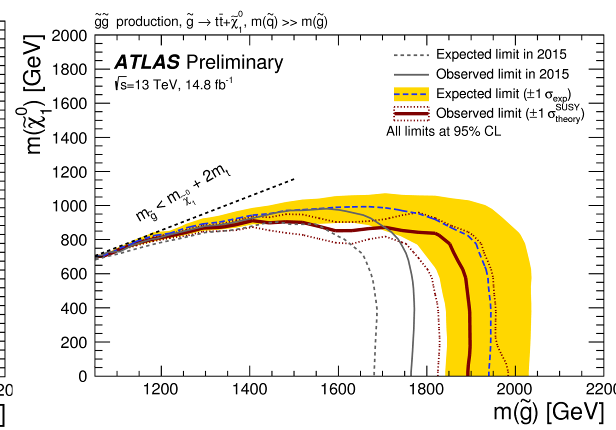




No significant excess observed



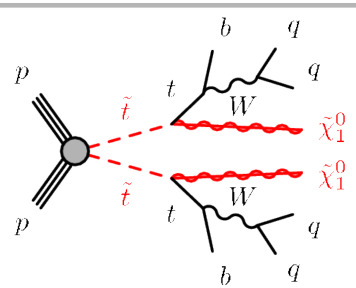


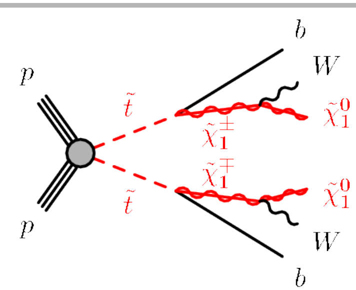


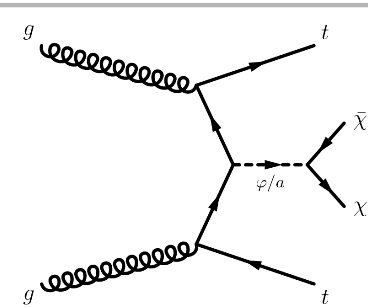
ATLAS-CONF-2016-077

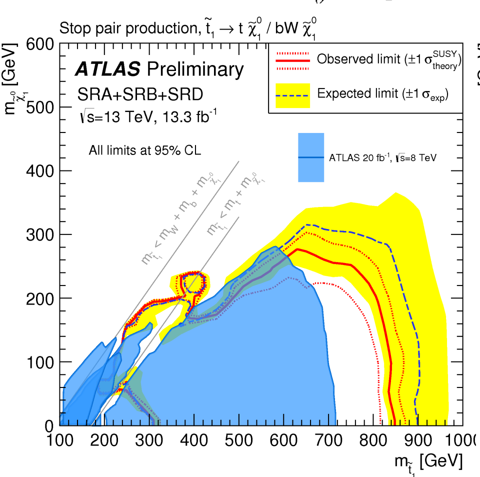
3rd Generation: stop 0L

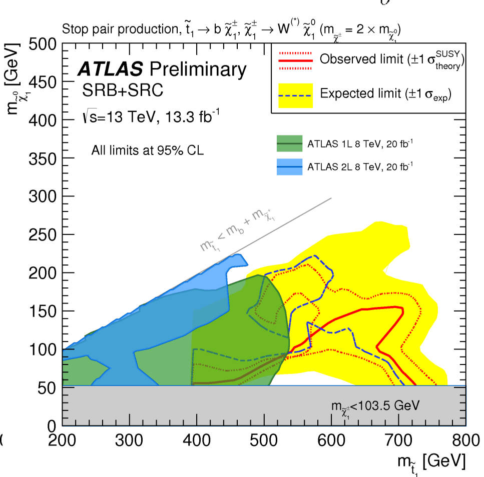
- Search for stop with 0L+(b)jets+MET (hadronic decay)
- Signal to BG discrimination based on: MET, mT(b), HT
- ~19 SRs defined, targeting specific scenarios and phase space
- Exclusion for m(~t1) < ~820GeV for massless LSP
- For the models of the associated production of DM(χ) with top pairs, with a global coupling of 3.5, mediator masses up to 300 GeV, and χ masses below 40 GeV are excluded

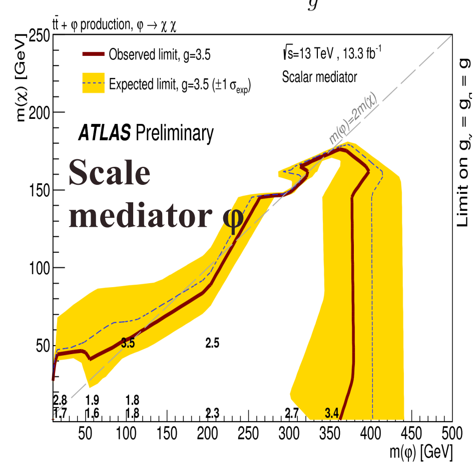


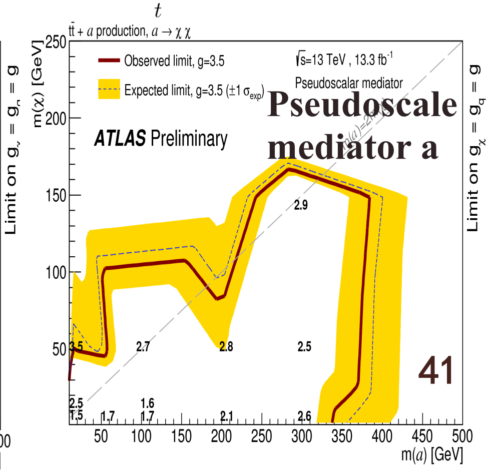








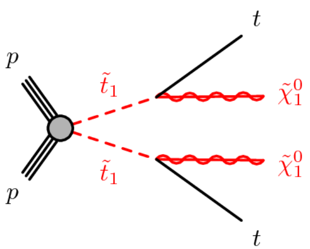


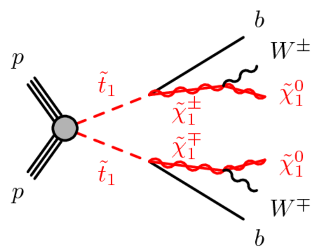


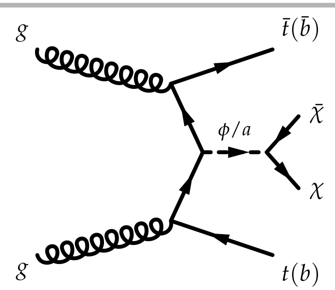
ATLAS-CONF-2016-050

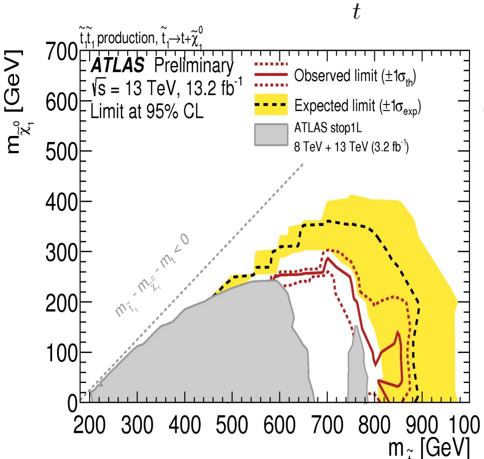
3rd Generation: stop 1L

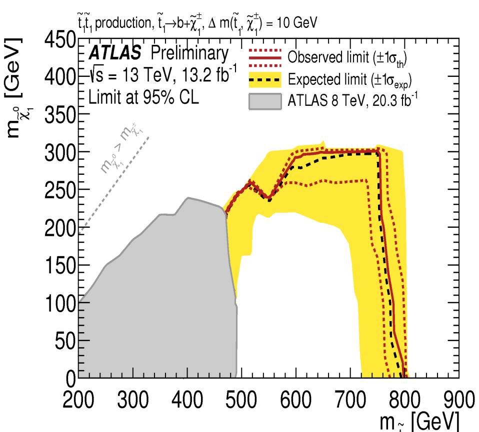
- Search for **stop** with **1L+(b)jets+MET**
- Signal to BG discrimination based on: **MET, mT(b), HT**
- ~7 SRs defined, targeting specific scenarios and phase space (~3.3σ excess in DM_low SR)
- Exclusion for m(~t1) < ~830GeV for massless LSP
- The maximal coupling of g = 3.5 is excluded @95% CL for a (pseudo-) scalar mediator mass up to (350) 320 GeV assuming a 1 GeV DM mass.

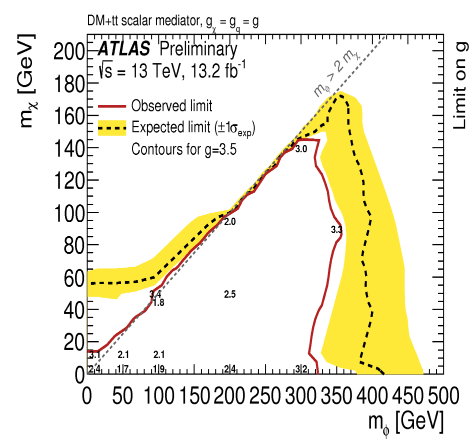


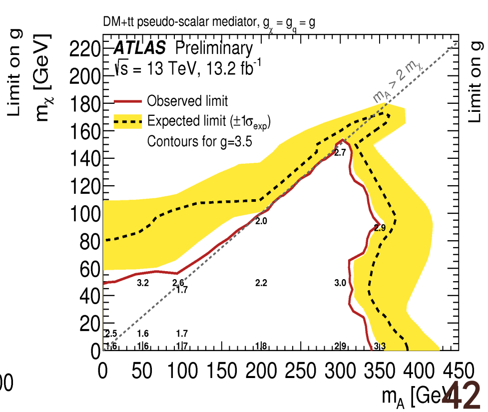








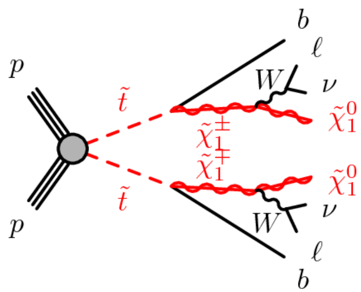


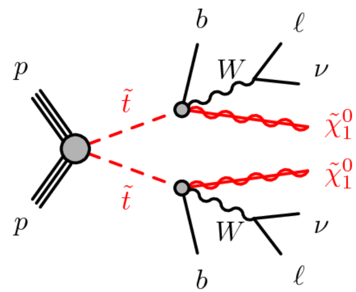


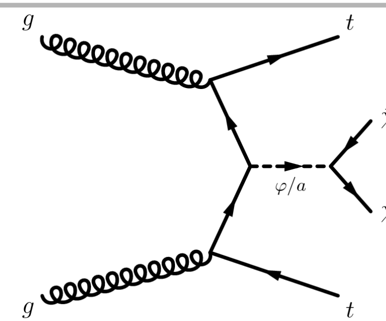
ATLAS-CONF-2016-076

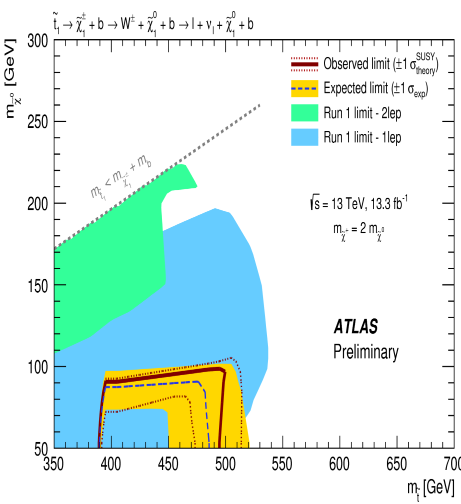
3rd Generation: stop 2L

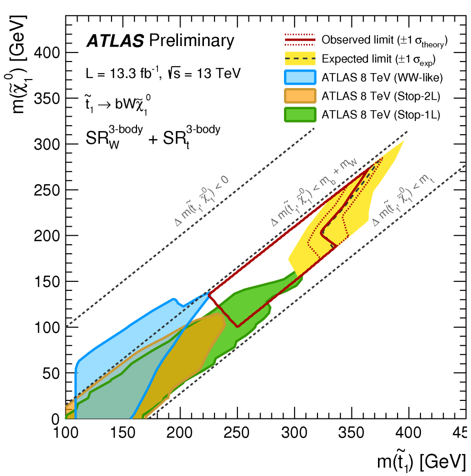
- Search for **stop** with **2L+(b)jets+MET**
- Signal to BG discrimination based on: **MET, mT2**
- ~7 SRs defined, targeting specific scenarios and phase space
- Exclusion for m(~t1) < ~480GeV for massless LSP
- For the models of the associated production of DM with top pairs, mediator mass < 330 GeV and DM particle mass < 20 GeV excluded

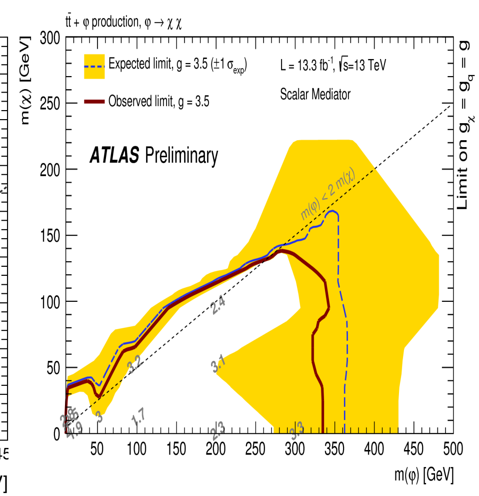


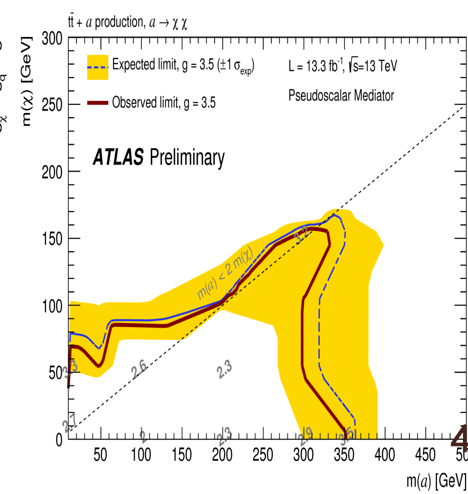








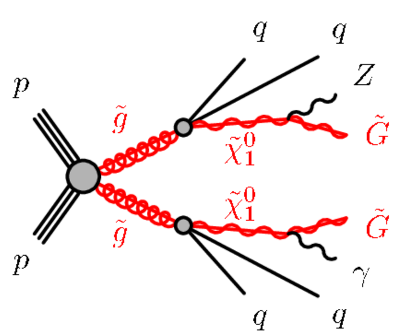


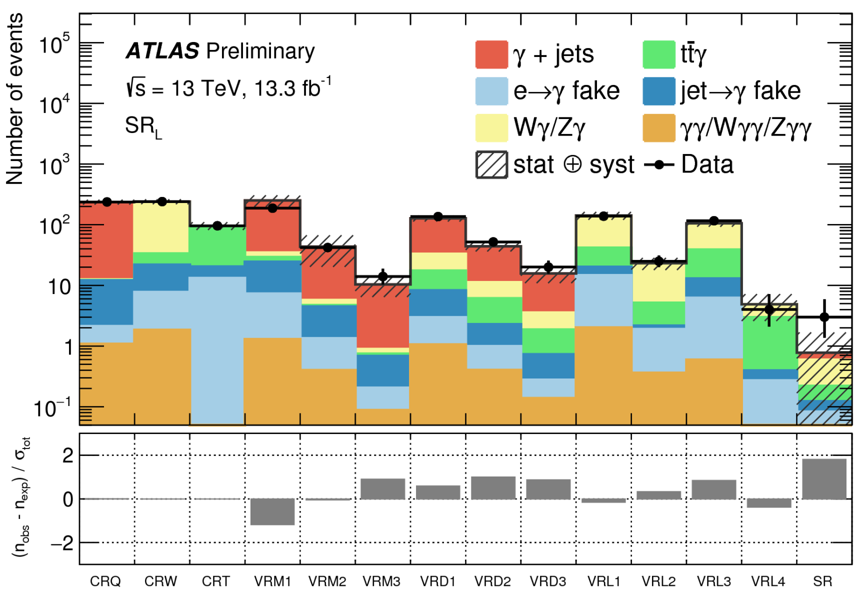


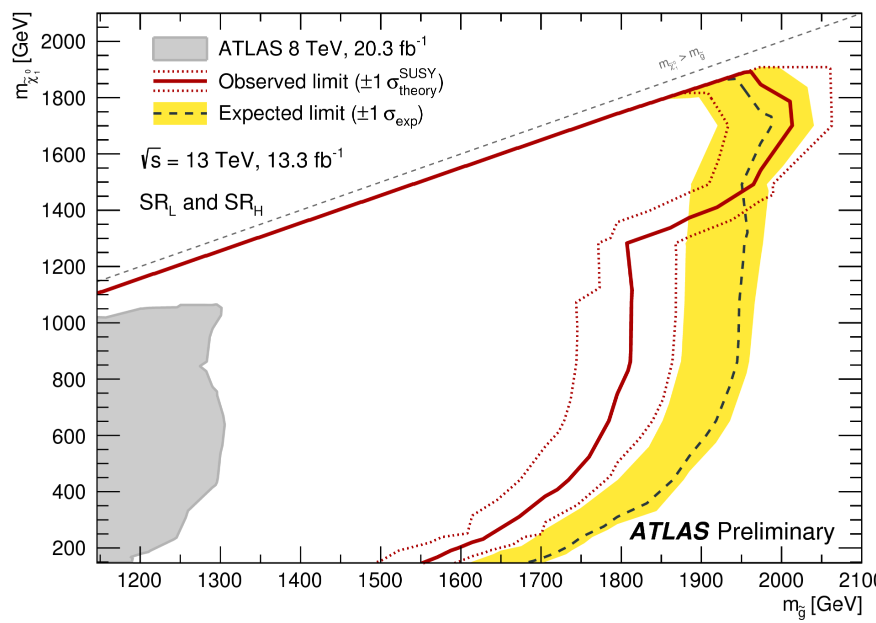
ATLAS-CONF-2016-066

Strong Production: photon +jets +MET

- Search for **gluinos with photon +jets +MET** FS (GGM)
- Signal to BG discrimination based on: **Meff, MET**
- 2 SRs defined targeting different search scenarios
- Excludes gluino masses up to 1.8 TeV for for a large range of neutralino masses, increasing to 2 TeV in the case of a high mass neutralino

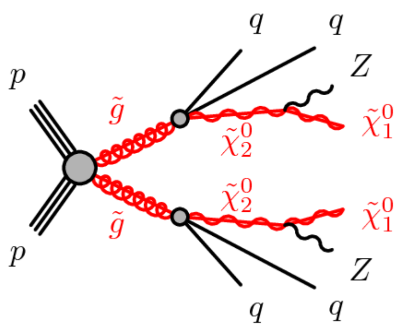


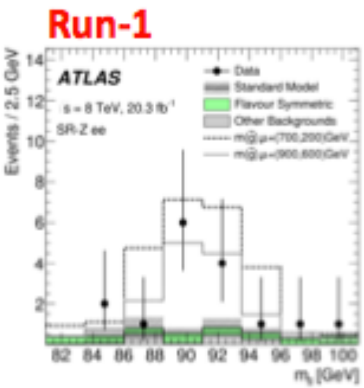


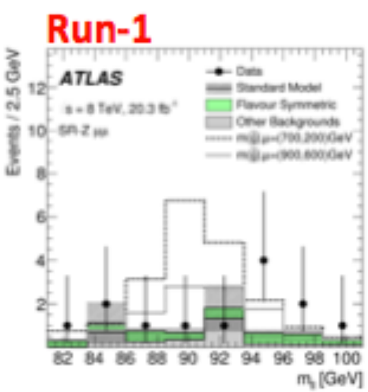


Strong Production: Z(ll)+MET

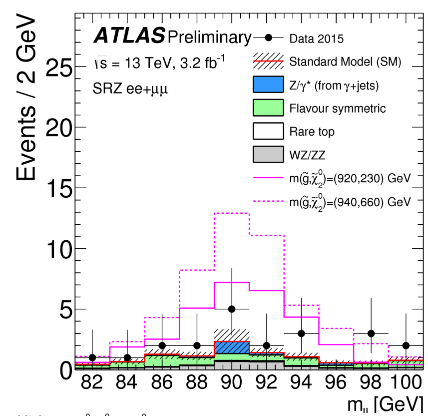
- Search for gluinos with a Z + jets + MET signature

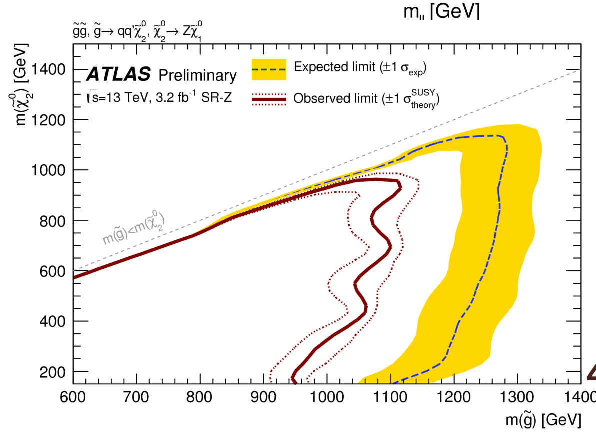






- There is an excess (3σ) at ATLAS Run1 (not at CMS): obs. 29, exp. 10.8+-2.2
- Check it with Run2 using run1-like SR: Z (ll), 2jets, MET>225 GeV, HT>600 GeV
- a mild excess seen in Run2: obs. 21, exp. 10.4+-2.4 (2.2σ in intermediate MET)
- Excludes gluino masses up to 1.1 TeV



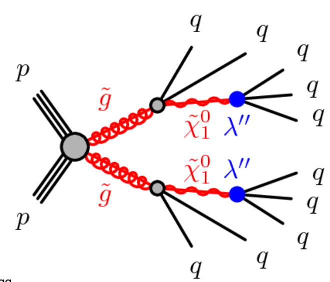


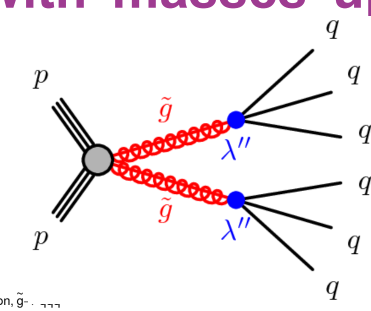
ATLAS-CONF-2015-082

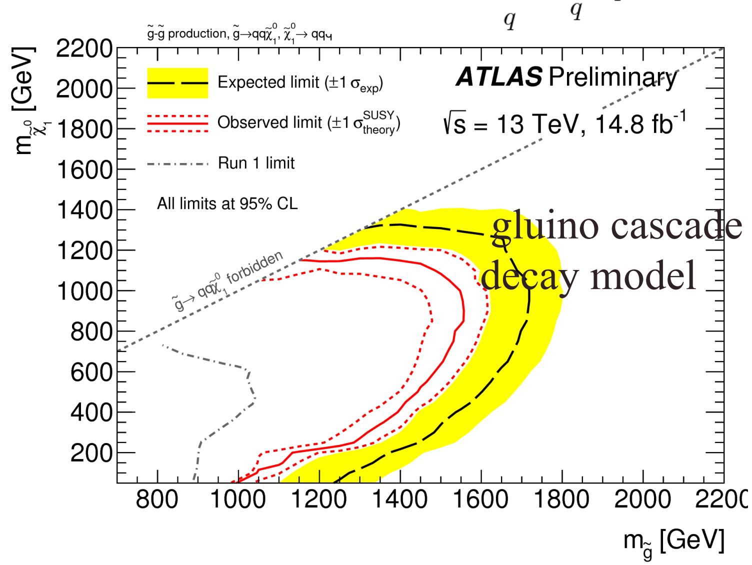
ATLAS-CONF-2016-057

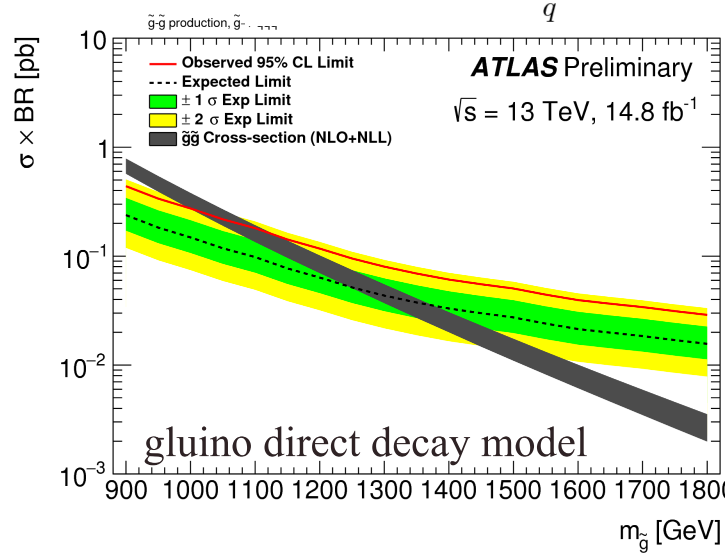
RPV: multi-jets

- Search for **gluinos with RPV decays to quarks**
- Signal to BG discrimination based on: **sum mass of jets**
- 4 SRs defined targeting different search scenarios
- In the gluino cascade decay model, gluinos with masses up to 1000-1550 GeV are excluded, depending on the neutralino mass
- In the gluino direct decay model, gluinos with masses up to 1080 GeV are excluded.









For the 13 TeV ATLAS searches, we utilize each of these classes:

- **Missing energy-type:**
  - **Missing transverse momentum:** $E_{\mathrm{T}}^{\mathrm{miss}}$ and $\vec{p}_{\mathrm{T}}^{\,\mathrm{miss}}$
  - **Missing transverse momentum significance:** $E_{\mathrm{T}}^{\mathrm{miss}}/\sqrt{H_{\mathrm{T}}}$
  - **RJigsaw *H*-scale for 1 visible, 1 invisible state:** $H_{1,1}^{\mathrm{PP}}$ *(Similar to $E_{\mathrm{T}}^{\mathrm{miss}}$)*
- **Energy scale-type:**
  - **Effective mass:** $M_{\mathrm{eff}} = \sum_{\mathrm{jets}} p_{\mathrm{T}} + \sum_{\mathrm{leptons}} + E_{\mathrm{T}}^{\mathrm{miss}}$ *(also considering only first 4 jets)*
  - **Scalar sum of visible momenta:** H_{T},
  - **Transverse mass:** $m_{\mathrm{T}} = \sqrt{2p_{\mathrm{T}}^{\ell} E_{\mathrm{T}}^{\mathrm{miss}}(1 - \cos(\Delta\phi(\vec{p}_{\mathrm{T}}^{\,\mathrm{miss}}, \ell))}$ *(b-quarks can also replace the lepton)*
  - **RJigsaw *H*-scale:** $H_{2,1}^{\mathrm{PP}}$, $H_{4,1}^{\mathrm{PP}}$ *(Similar to M_{eff})*
  - **RJigsaw ISR p_{T} scale:** $|p_{TS}^{\mathrm{ISR}}|$ *(sum p_{T} of ISR jets*
- **Energy structure-type:**
  - **Jet multiplicity:** N_{jet}, $N_{b-\mathrm{jet}}$
  - **Total jet mass:** $M_{\mathrm{J}}^{\Sigma} = \sum m^{\mathrm{jet}}$ *(also considering only first 4 large-radius jets)*
  - **Angular distributions:** $\Delta\phi_{\mathrm{min}}^{4j} = \min(|\phi_{\mathrm{any-jet}} - \vec{p}_{\mathrm{T}}^{\,\mathrm{miss}}|) > 0.4$ *(for all 0ℓ selections)*
  - **Aplanarity:** $A = (3/2)\lambda_3$
  - **QCD $E_{\mathrm{T}}^{\mathrm{miss}}$ alignment:** Δ_{QCD} *(signed asymmetry between $E_{\mathrm{T}}^{\mathrm{miss}}$ and jet azimuthal directions)*

$$m_{\mathrm{T2}} = \min_{\mathbf{q}_{\mathrm{T}}}\left[\max\left(m_{\mathrm{T}}(\mathbf{p}_{\mathrm{T}}^{\ell 1}, \mathbf{q}_{\mathrm{T}}), m_{\mathrm{T}}(\mathbf{p}_{\mathrm{T}}^{\ell 2}, \mathbf{p}_{\mathrm{T}}^{\mathrm{miss}} - \mathbf{q}_{\mathrm{T}})\right)\right]$$

pMSSM Interpretations

ATLAS JHEP 10 (2015) 134

Study the impact of the full set of ATLAS SUSY searches on the pMSSM.

Use 19-parameter pMSSM

- Minimal flavor violation with no new source of CP violation
- Degenerate 1st and 2nd generation squarks and sleptons
- No RPV and the LSP is the $\tilde{\chi}_1^0$

500×10^6 models in the pMSSM are randomly sampled.
300×10^3 models survive theory and non-LHC constraints *(precision EW, LEP, Higgs, DM)*

22 ATLAS Run 1 RPC SUSY searches are reinterpreted in the pMSSM $\Rightarrow$ **200 SR!**
Best expected SR used for exclusion.
Makes full use of ATLAS simulation, reconstruction and analysis.

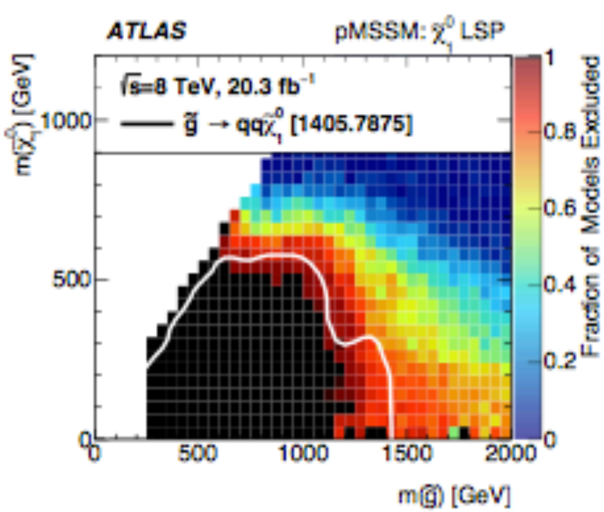
$>30\times10^9$ events generated for truth-based analysis.

$>600\times10^6$ events simulated & reconstructed.

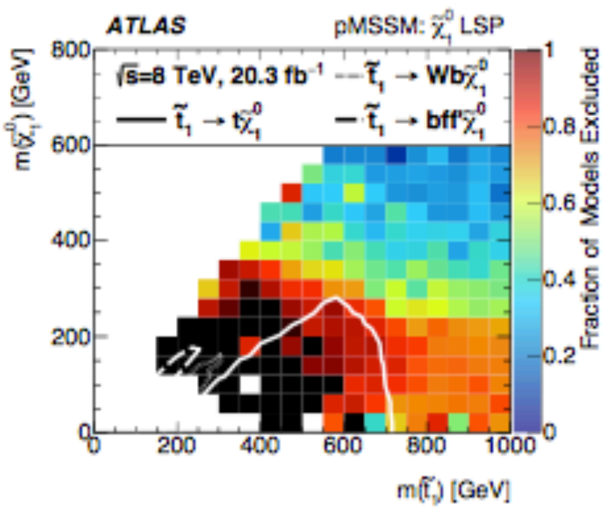
Most comprehensive results from ATLAS on SUSY to date

Analysis
0-lepton + 2–6 jets + E_T^{miss}
0-lepton + 7–10 jets + E_T^{miss}
1-lepton + jets + E_T^{miss}
$\tau(\tau/\ell)$ + jets + E_T^{miss}
SS/3-leptons + jets + E_T^{miss}
0/1-lepton + 3b-jets + E_T^{miss}
Monojet
0-lepton stop
1-lepton stop
2-leptons stop
Monojet stop
Stop with Z boson
2b-jets + E_T^{miss}
$tb+E_T^{miss}$, stop
ℓh
2-leptons
2-τ
3-leptons
4-leptons
Disappearing Track
Long-lived particle
$H/A \to \tau^+\tau^-$

pMSSM Interpretations

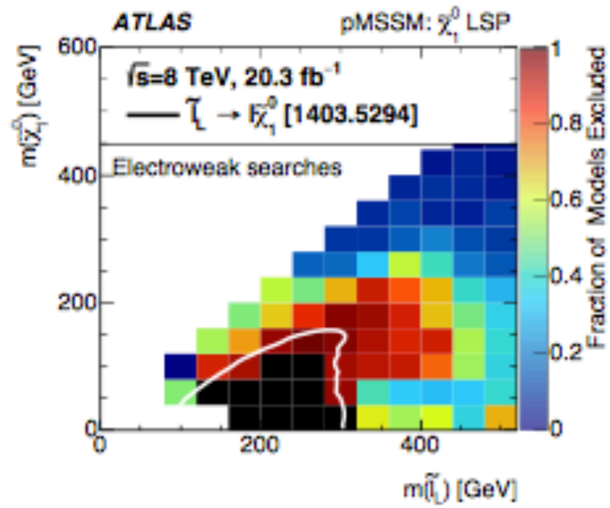


Good agreement with simplified models. Diagonal excluded by mono-jet analysis. Intermediate sparticles reduce exclusion for heavy $\tilde{g}$.

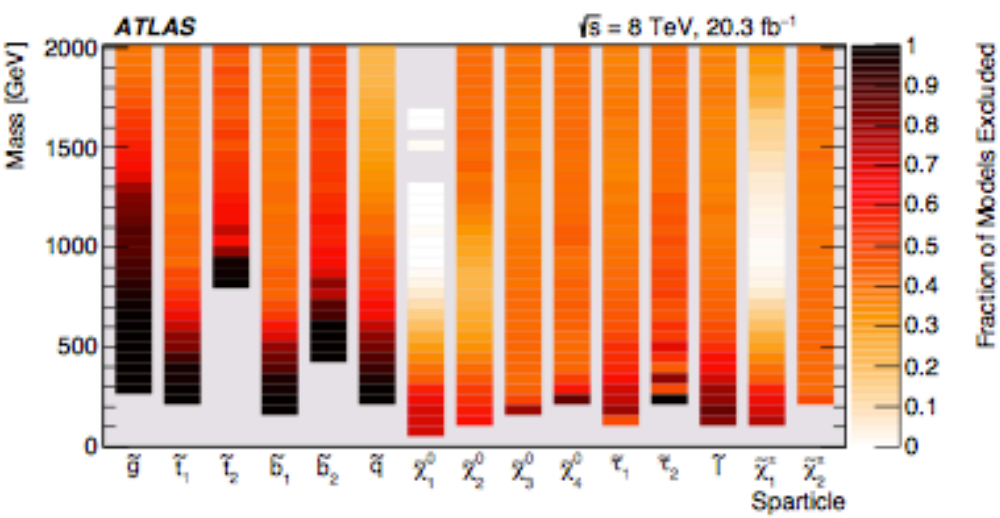


Simplified model overestimates reach (100% BR). Higgs mass constraint excludes light $\tilde{t}_1$ models.

Heavy $\tilde{t}_1$ models with long-lived $\tilde{\chi}_1^{\pm}$ excluded by disappearing track analysis.

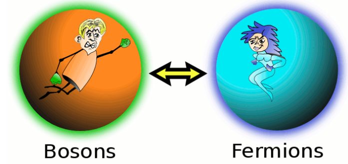


Good agreement with simplified models.

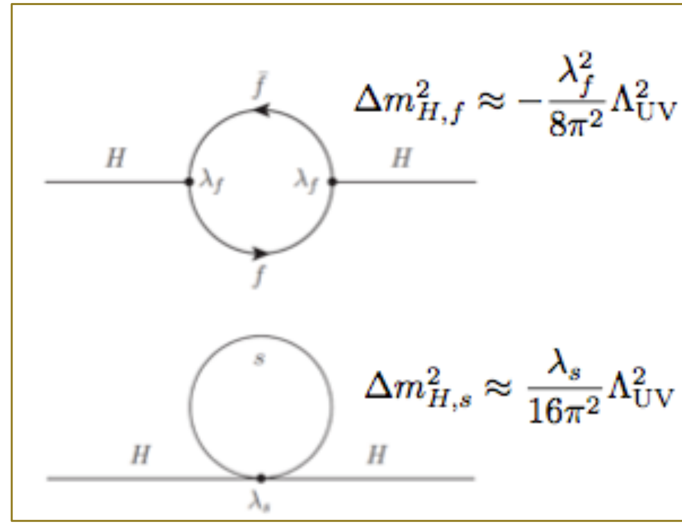


- Highest sensitivity to strong processes.
- Simplified models $\leftrightarrow$ pMSSM models (some differences observed).
- Good complementarity between different searches and with direct detection experiments (see paper for details).

SUSY Introduction

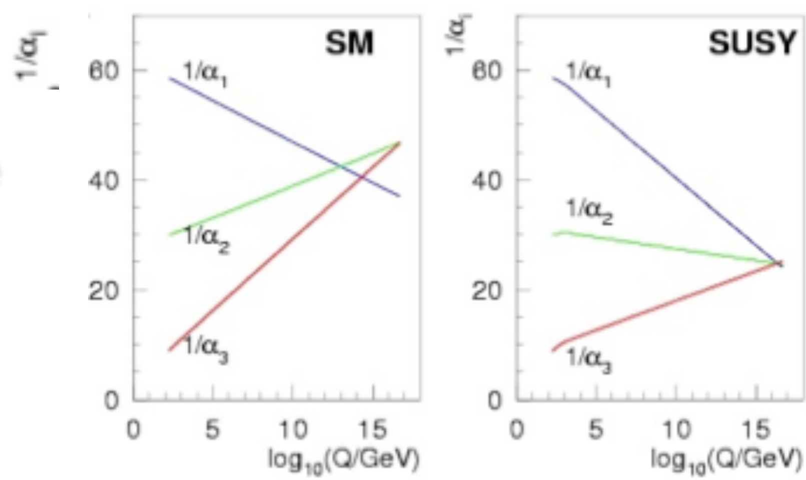


- **Solve hierarchy problem** without "fine tuning"
  - SUSY contributions to Higgs mass cancel SM contributions
- **Unification of gauge couplings**
  - New particle content changes running of couplings
- **Provide Dark Matter candidate**
  - Lightest SUSY particle (LSP) can be stable and only weekly interacting



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

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



Some of the arguments are most convincing for SUSY particles at ~TeV scale