Strong and 3rd Gen production SUSY searches in ATLAS

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On behalf of the ATLAS Collaboration

University of Illinois Urbana-Champaign

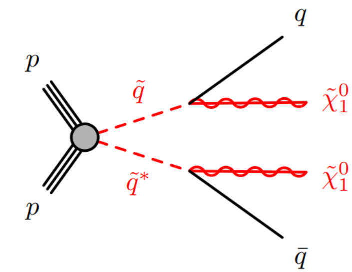
June 5th, 2018

LHCP 2018

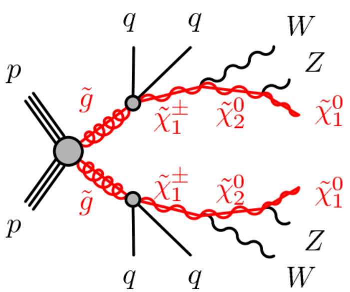
ATLAS Strong and 3rd Gen SUSY Program

For more on light squark/gluino searches, including RPV, see B. Petersen's talk on June 7th

Squark/Gluino

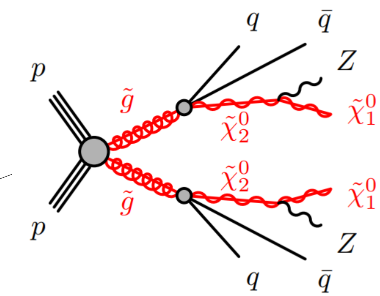


0 Lepton 2-6 jets
1712.02332

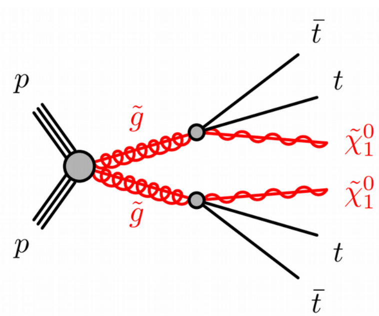


0 Lepton >7 jets
1708.02794

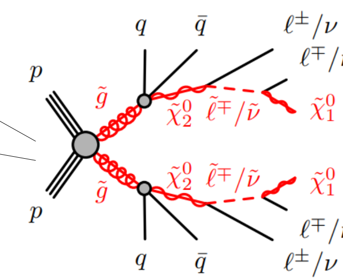
1 Lepton + jets
1708.08232



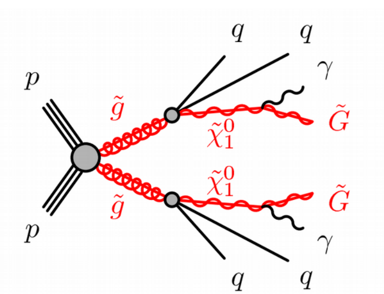
New! 2 Lepton + jets
1805.11381



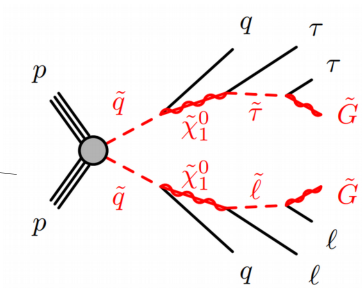
SS/3L Lepton + jets
1706.03731



Multi b-jets
1711.01901

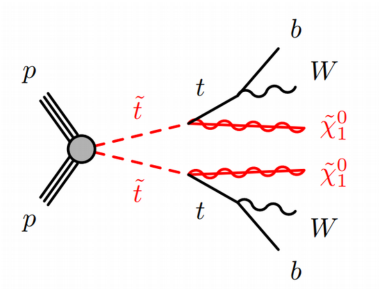


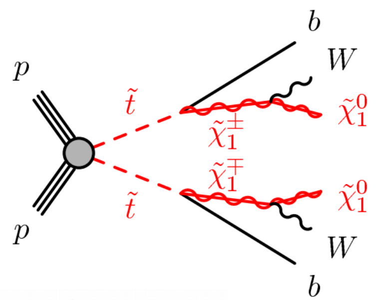
Photon + jets
1802.03158

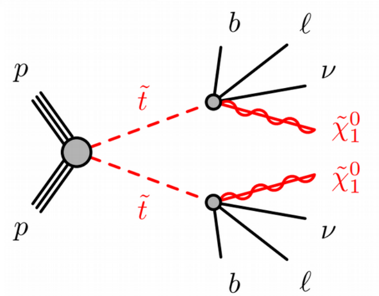


Tau + jets
1607.05979

ATLAS Strong and 3rd Gen SUSY Program







Direct 3rd Gen

Stop 0L
1709.04183

Stop 1L
1711.11520

Stop 2L
1708.03247

Sbottom
1708.09266

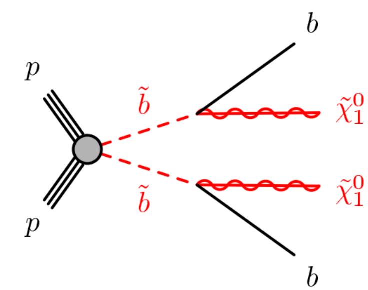
Stop ZH
1706.03986

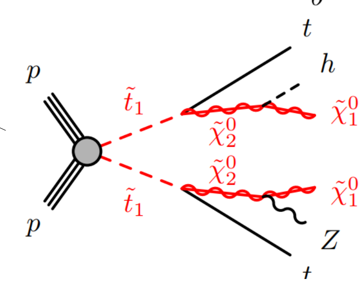
Stop Stau
1803.10178

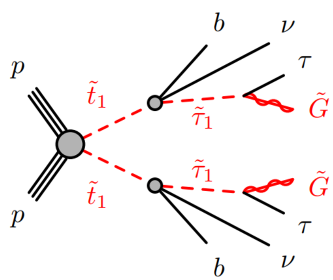
New! Stop Charm
1805.01649

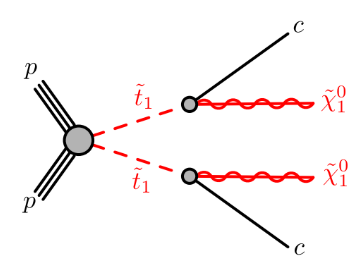
Monojet
1711.03301

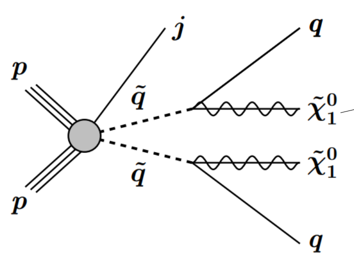
For more on 3rd gen. searches, included RPV, see Y. Nakahama's talk on June 7th



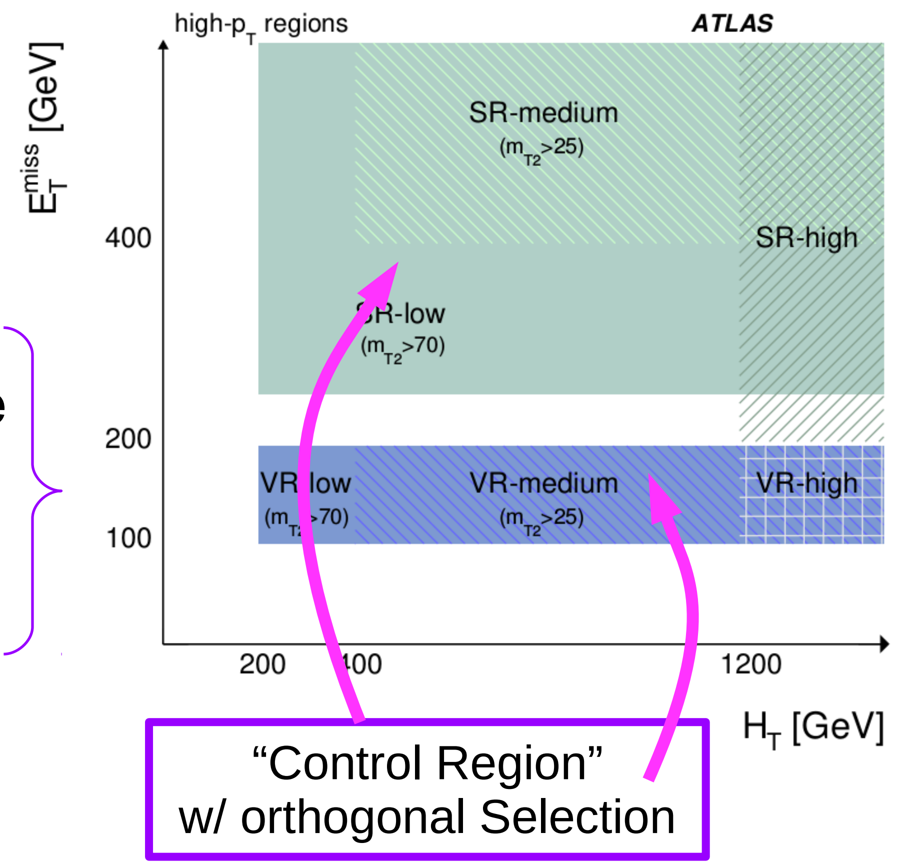








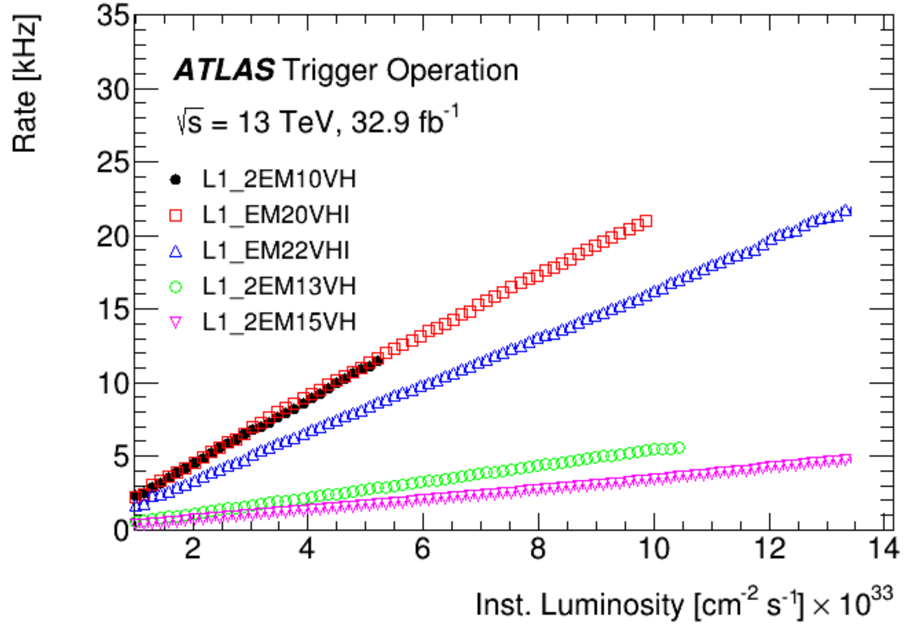
General Strategy

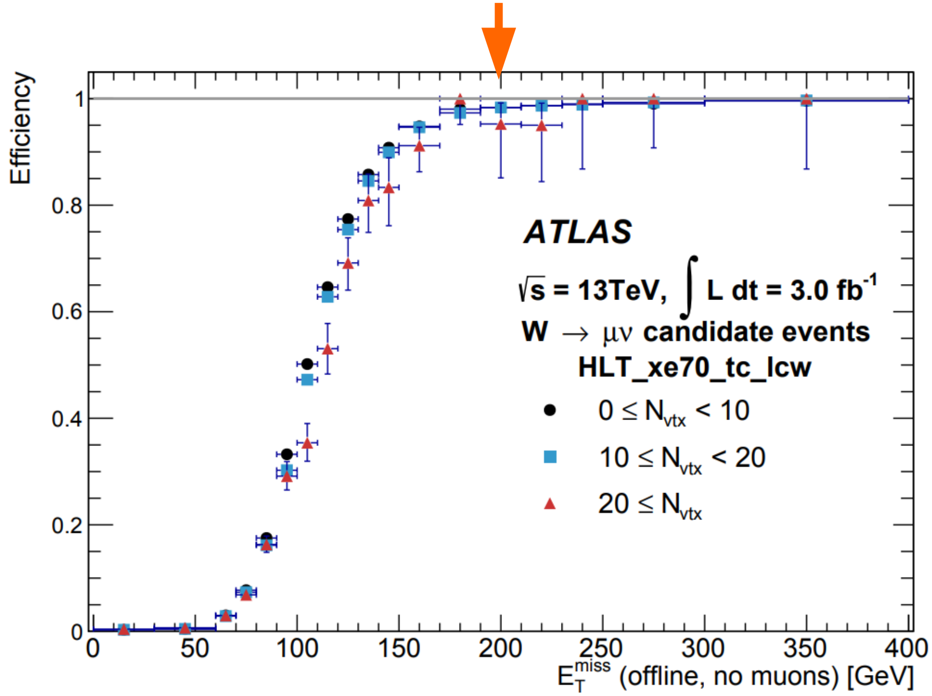


- Use variables like mass scale, MET, event kinematics, RJR,...
- Use control regions where possible to estimate backgrounds
  - Validate in region near SR
- Interpret with simplified models
  - Shape-fits or multi-bin fits can improve sensitivity
- Model-independent tests based on a single-bin SR
  - Assumes no signal contamination in any CR
  - Meant for p-value evaluation for excesses and reinterpretation

Using MET triggers to find SUSY events

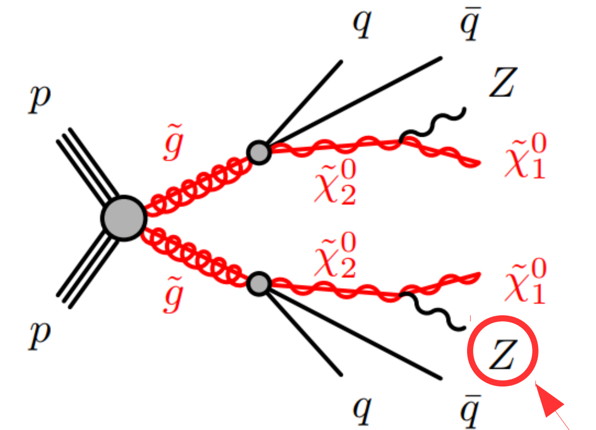
- Lepton trigger rates linear with inst. lumi, but we don't have infinite resources to record every event (moderate pT requirements)
  - Lower threshold lepton-triggers are prescaled
- B-jet triggers require vertexing online, which is very cpu-expensive
  - Seeded by high-pT jet triggers
- RPC SUSY models generally have MET from the LSP



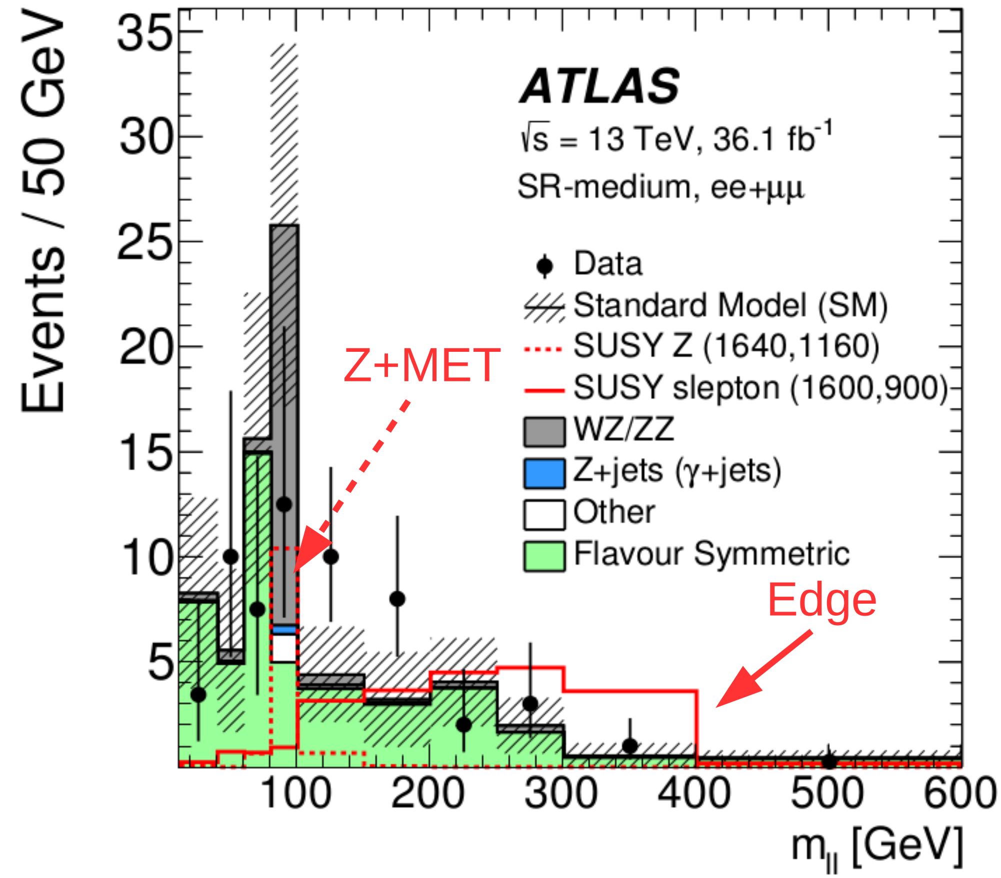


Search for Squarks/Gluinos w/ 2L

“Z+MET / Edge Search”

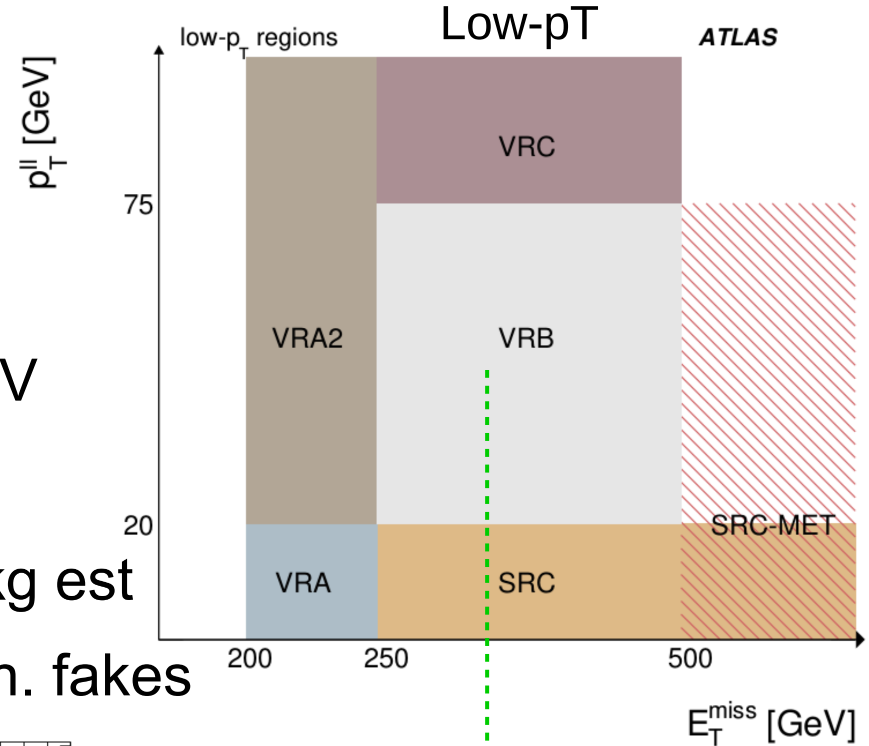


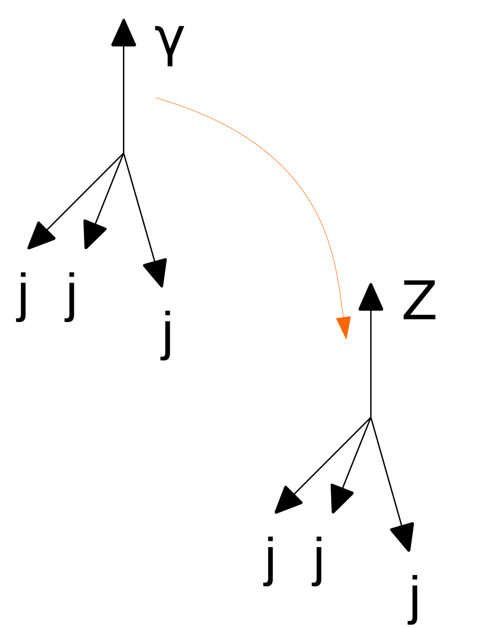
- Looking for new physics in a 2 (OSSF) lepton final state
  - Interpret with simplified models of squark/gluino production with Z/slepton intermediate decays
- Previous Run II Paper to follow up Run I excess (nothing there...)
  - Now, optimize for 13 TeV, pile-up, and larger dataset size

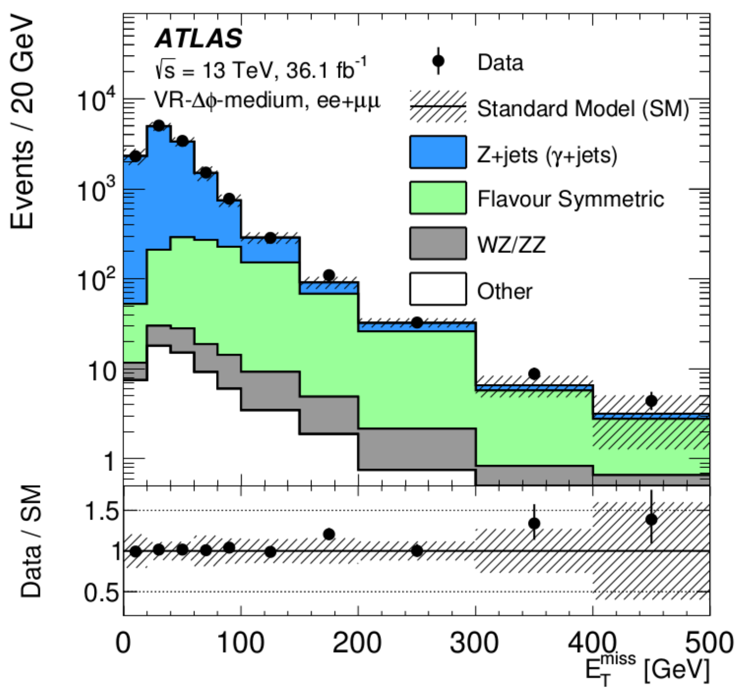


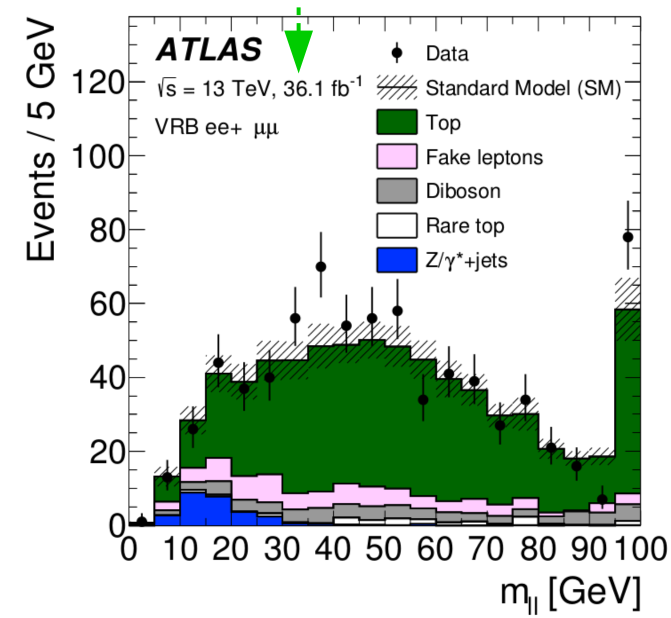
Z/Edge Analysis Features

- Split into high/low-pT leptons
  - Leptons down to 7 GeV, mll > 4 GeV
- Bkg Est:
  - High: Photon+jets and flav. sym. bkg est
  - Low: DF-lepton CR and matrix meth. fakes







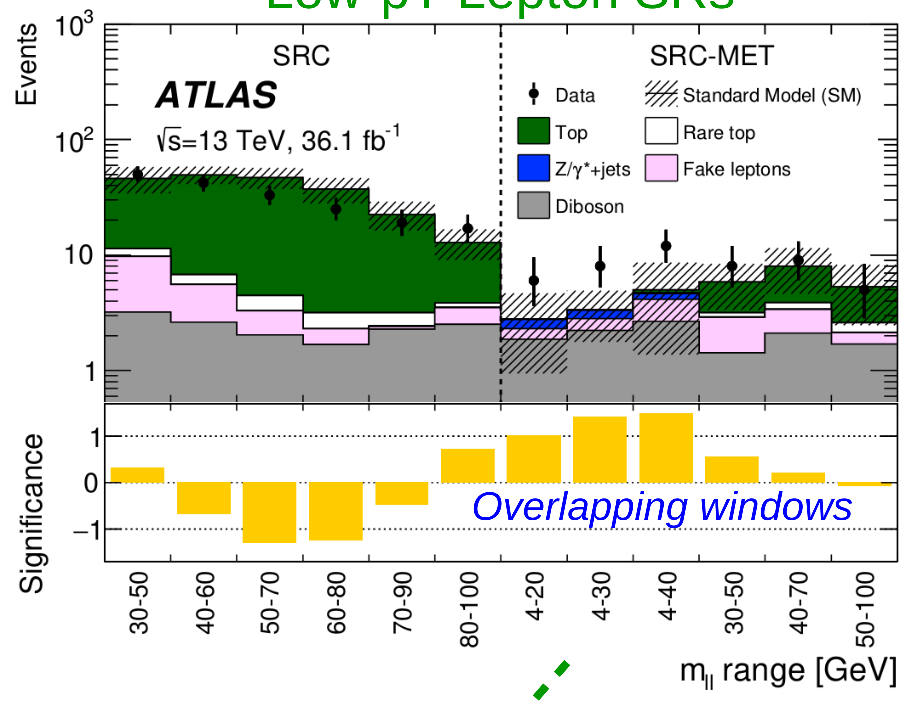


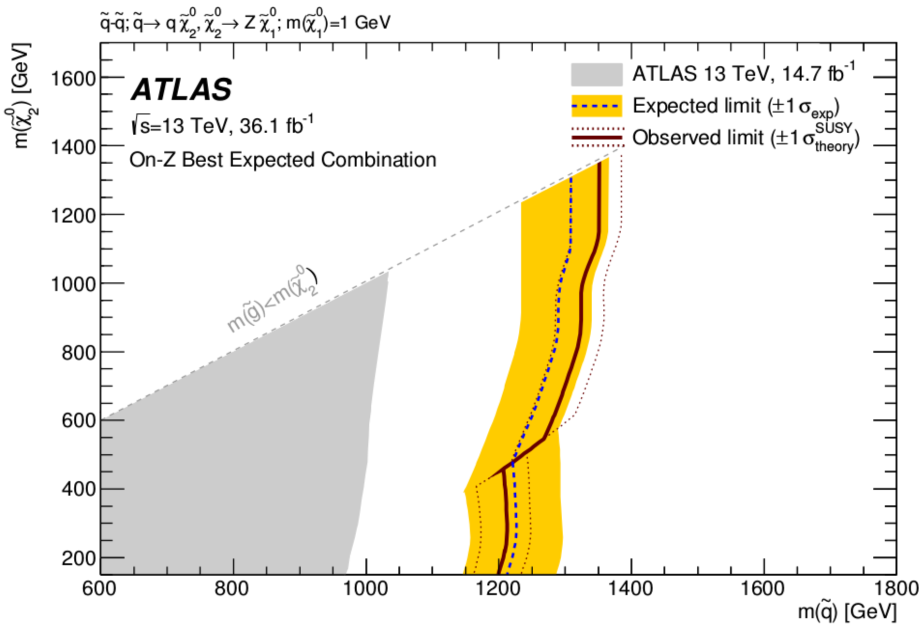
Z+MET/Edge Results

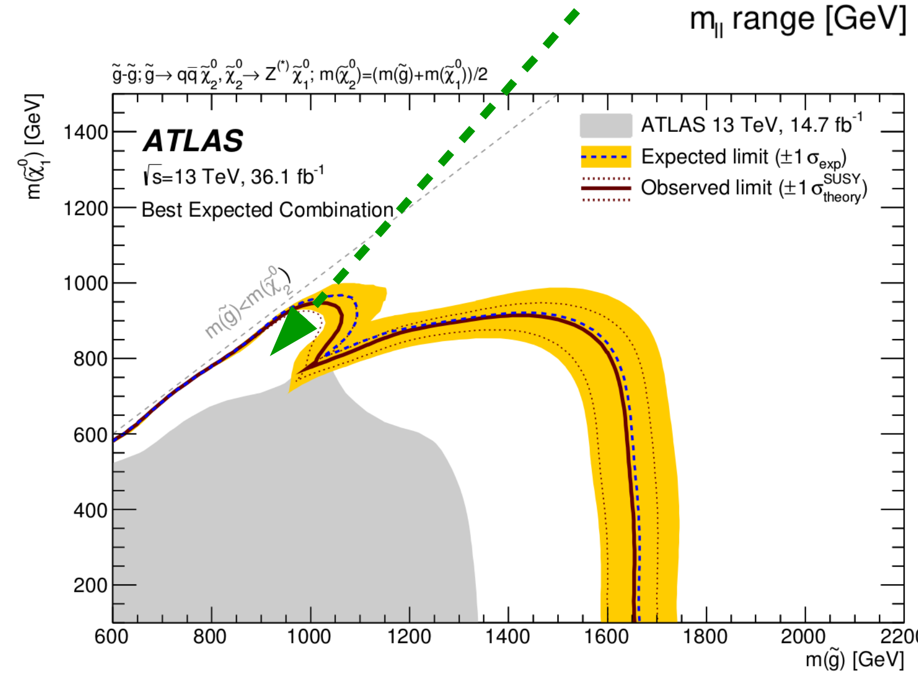
- Now with shapefit!
- No excesses..., so limits are set
- Significant improvements in sensitivity over previous results

For more on ATLAS compressed SUSY searches, see J. Miguéns on June 7th

Low-pT Lepton SRs

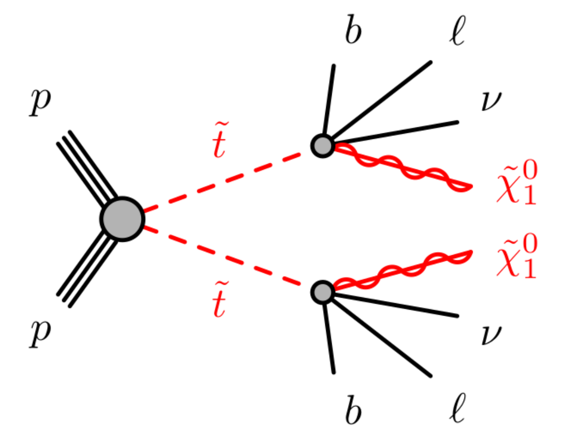






Direct Stop w/ 2L

"4-body", 100% BR



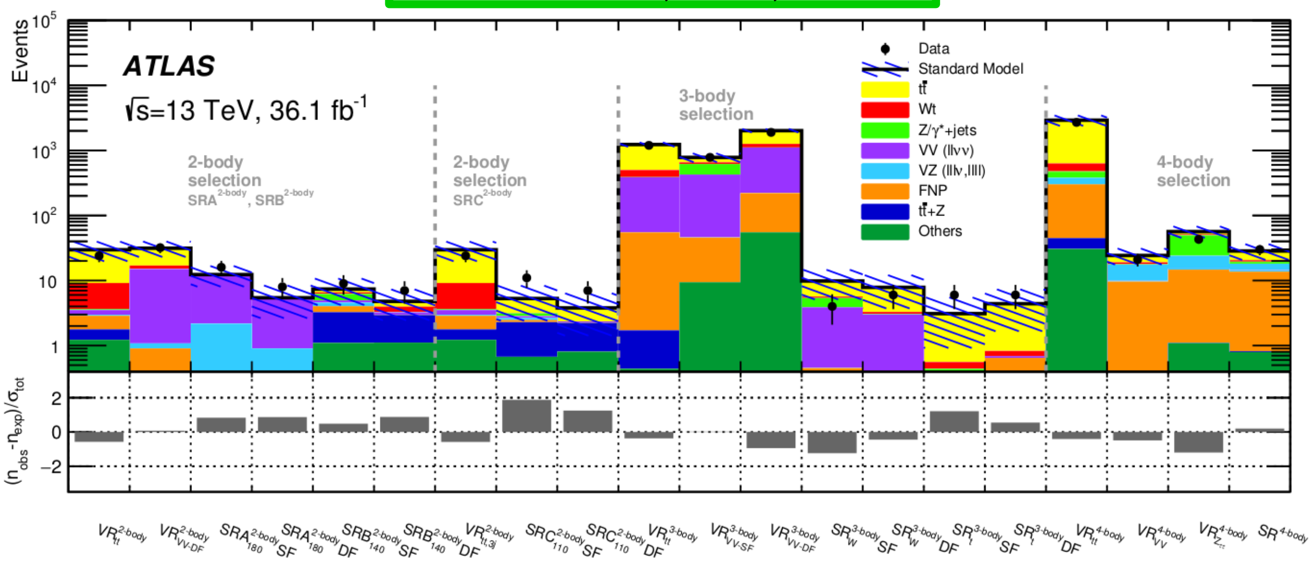
- Stop 2L analysis looks at all mass differences, but tends to do best in the compressed region compared to 0L or 1L channels
- Using MET trigger allows leptons down to 7 GeV

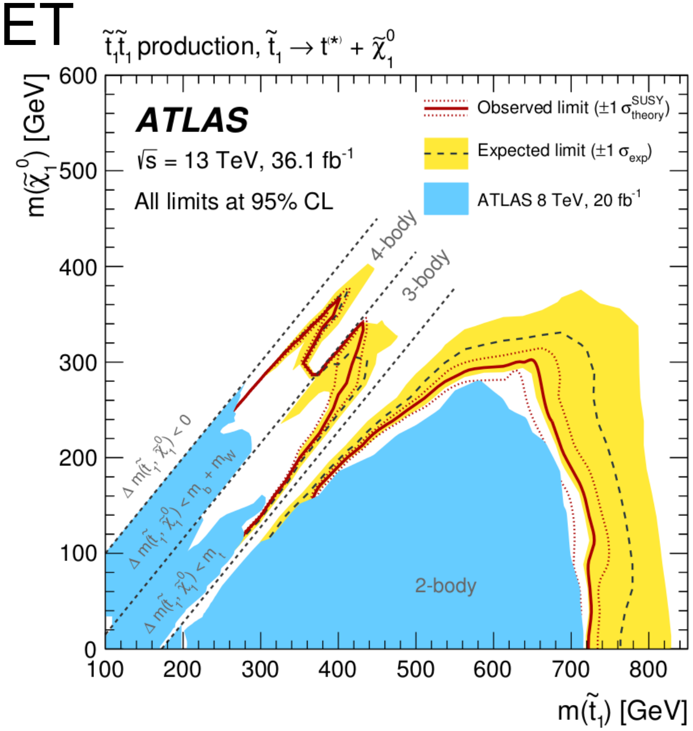
$$R_{2\ell 4j} = E_T^{miss}/(E_T^{miss} + p_T(\ell_1) + p_T(\ell_2) + \sum_{i=1,\ldots,N\leq 4} p_T(j_i)),$$ For multijet

$$R_{2\ell} = E_T^{miss}/(p_T(\ell_1) + p_T(\ell_2)),$$ For ttbar

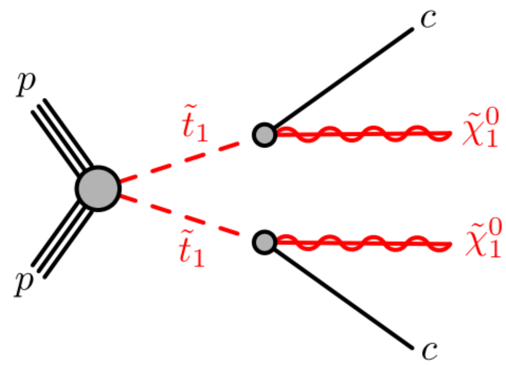
- Require hard leading jet (ISR) to enhance MET
  - Leading jets *not* b-tagged

CR/VR for VV, ttbar, and Ztt





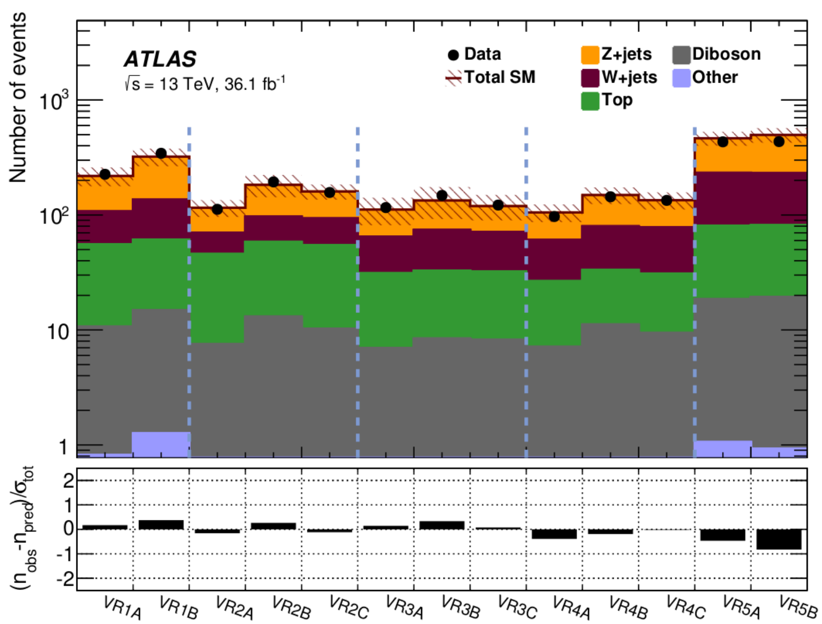
Stop to Charm



- Selection: 0L with >=1 charm-tagged jets + MET >500
  - Two multivariate taggers used: 18% eff., 20/6/200 b, tau, light-q rejection
  - Large mass splittings have high pT jets and high MET
  - Low mass splittings are softer, and targeted with an ISR jet

5 SRs for different deltaM

- Z(vv)+jets largest bkg (~50%), W+jets, and ttbar normalized in CR using at least one lepton (lepton to MET or tau-jet replacement)



Hadronic taus have high c-jet tag rate, use:

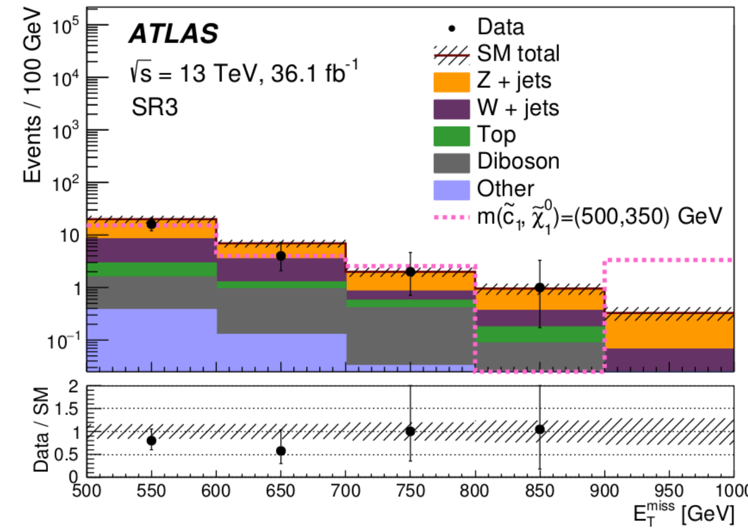
$$m_{\mathrm{T}}^{c} = \min_{c\text{-jets}} \sqrt{2 \cdot E_{\mathrm{T}}^{\mathrm{miss}} p_{\mathrm{T}}^{c} \cdot (1 - \cos \Delta\phi(\boldsymbol{E}_{\mathrm{T}}^{\mathrm{miss}}, \boldsymbol{p}_{\mathrm{T}}^{c}))}$$

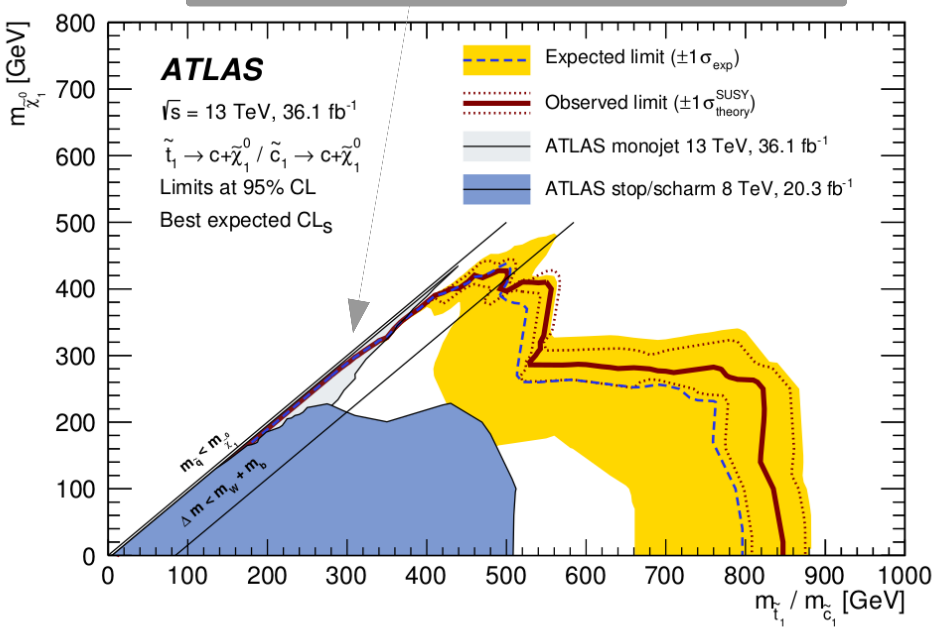
Reduces tau-had to <5% of bkg.

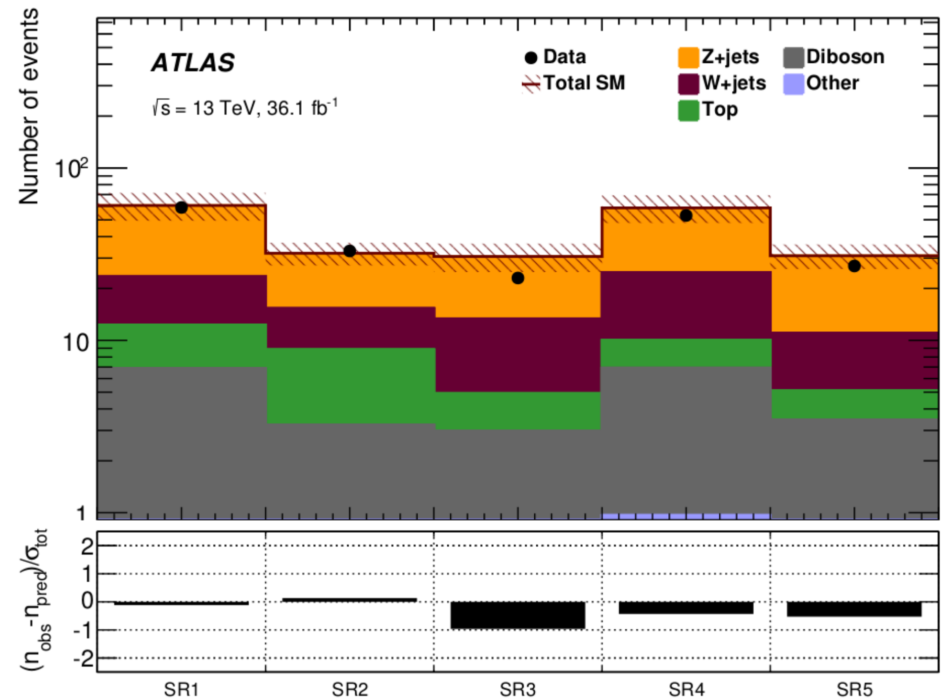
Stop to Charm Results

- Total Background uncertainty ~20% ~50/50 exp-theory

Monojet analysis takes over in low delta-M region where c-jets are not expected to be reconstructed



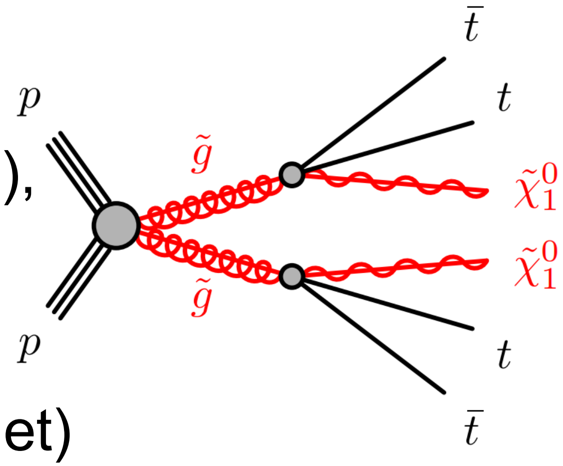




→ Targets larger mass splittings →

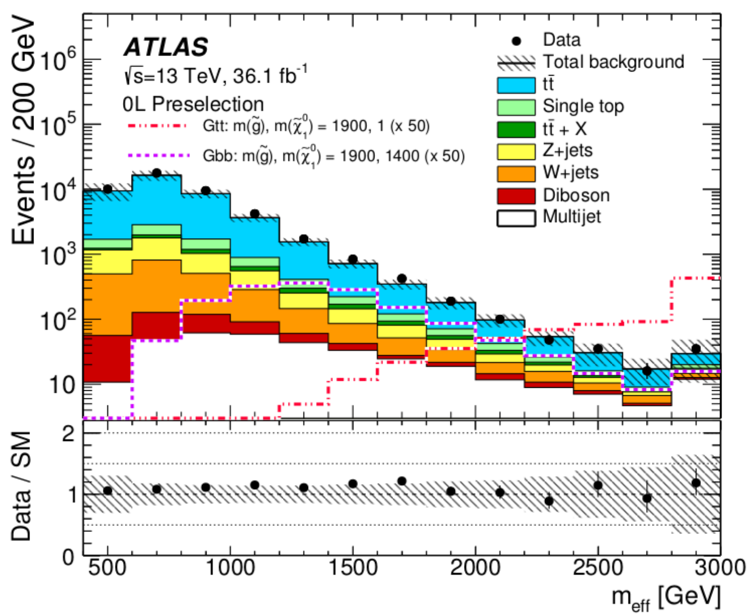
Multi b-jets

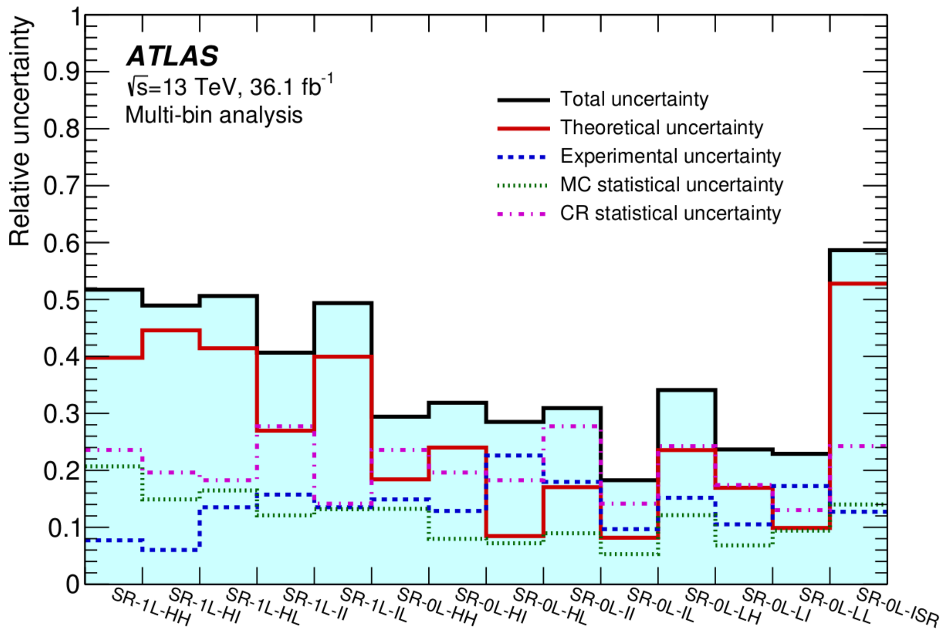
- Final state with several high-pT jets (>=3 b-tagged), large MET, and either 0 or 1 lepton (e or mu)
- Background dominated by ttbar+jets (CR per SR)
- Cut and count and multi-bin (binned in Meff and Njet)
  - 0 and 1L regions combined for multibin



JES/JER 3-24%
Ttbar modelling 5-76%

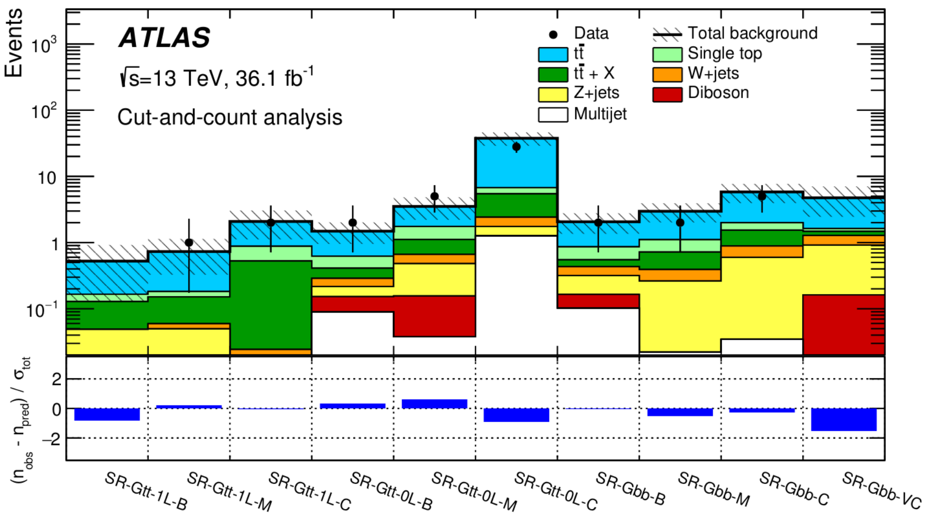
$$m_{\text{eff}} = \sum_i p_T^{\text{jet}_i} + \sum_j p_T^{\ell_j} + E_T^{\text{miss}}$$

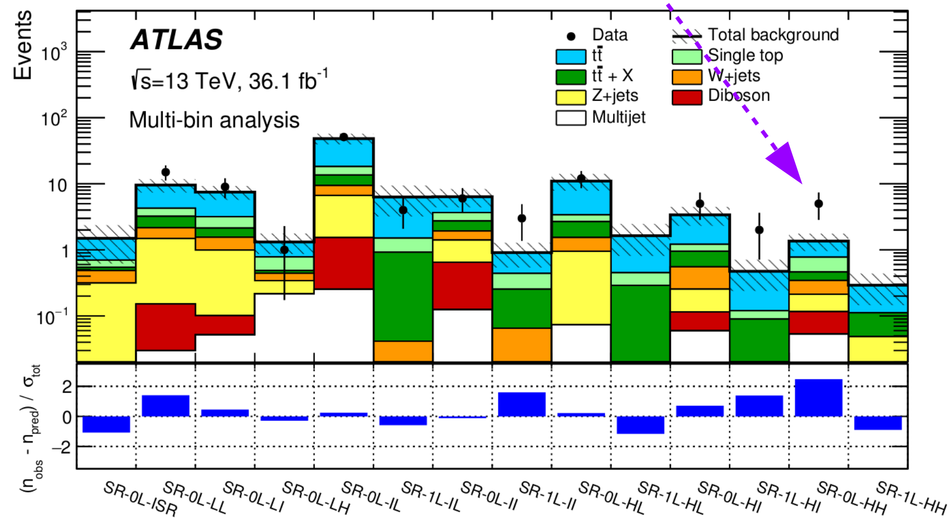


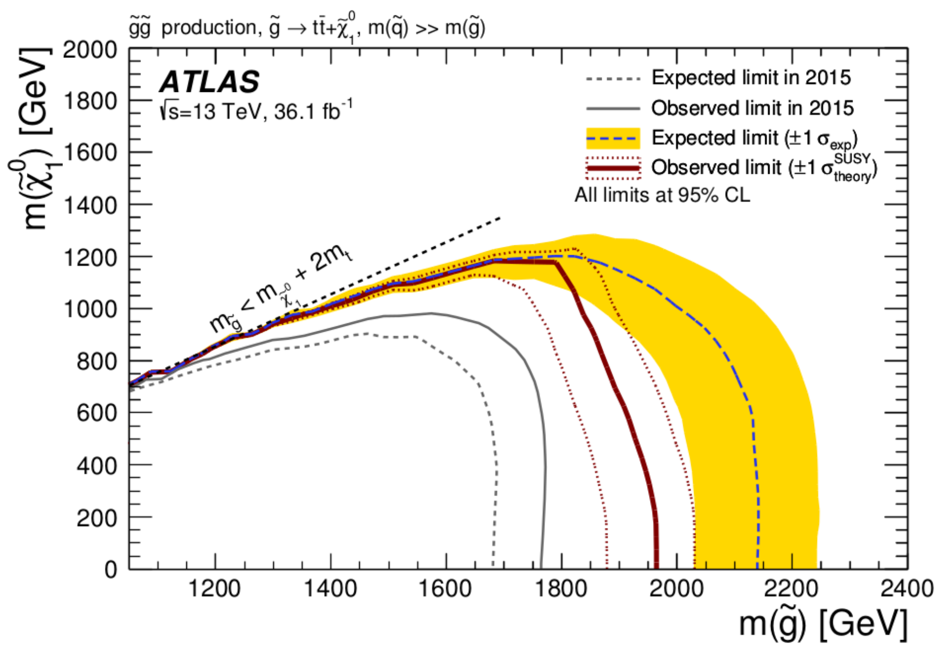


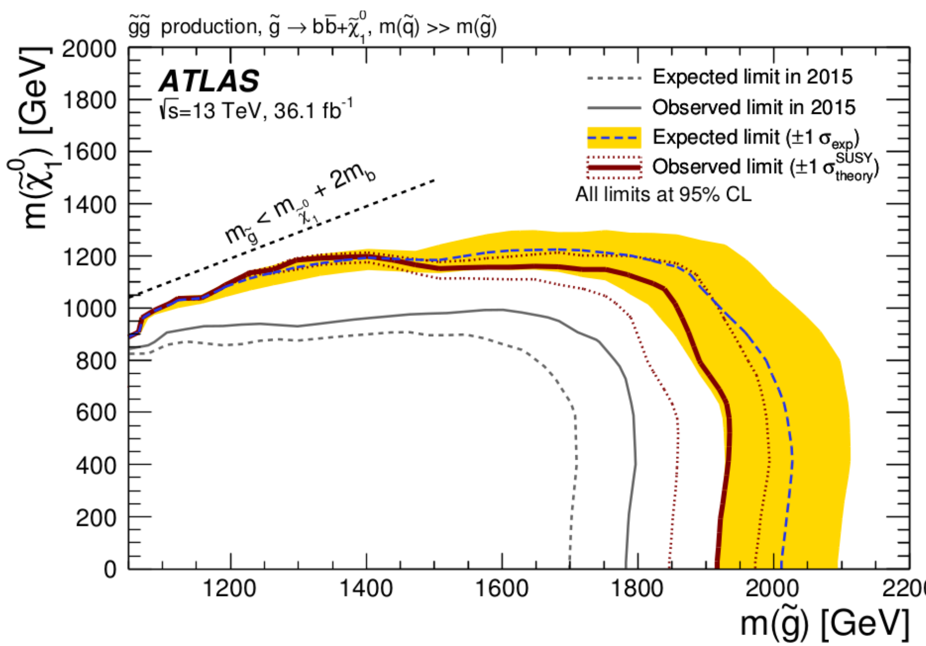
Multi b-jets Results

5 obs / ~1.5 exp, 2.3 ***local***







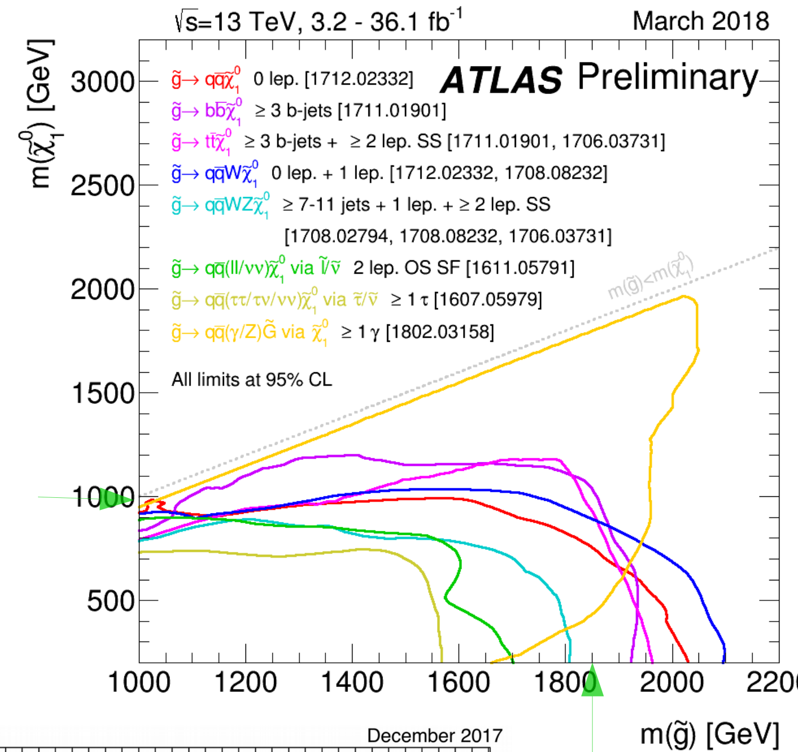


Also interpreted as function of gluino BR, see backup

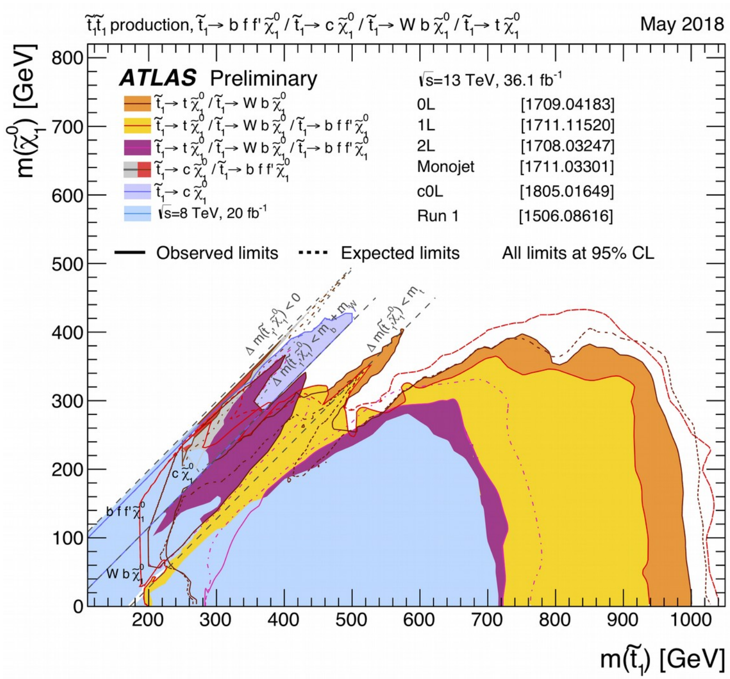
Summary Plots

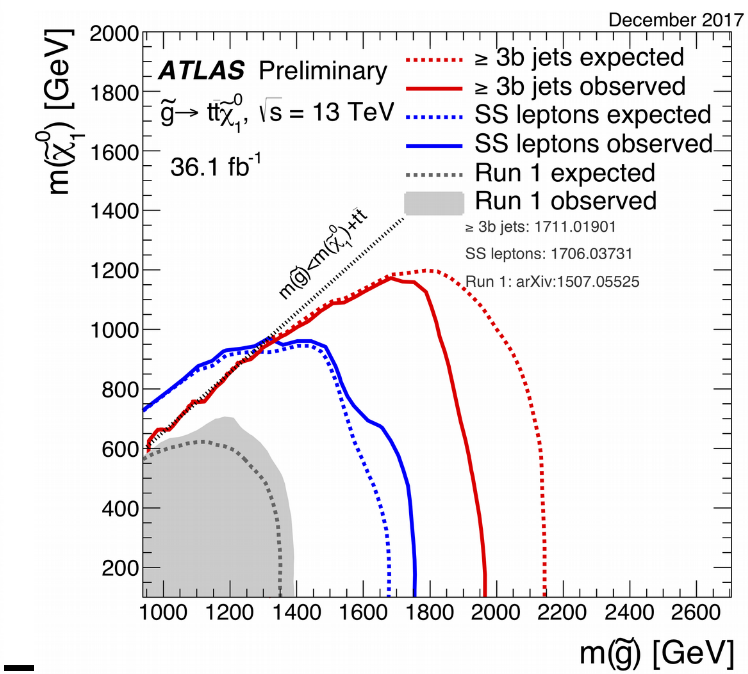
SUSY Summary Plots

- Strong constraints on simplified models
  - Many models and final states considered
- Often assumptions on the BR, reinterpretations are interesting!



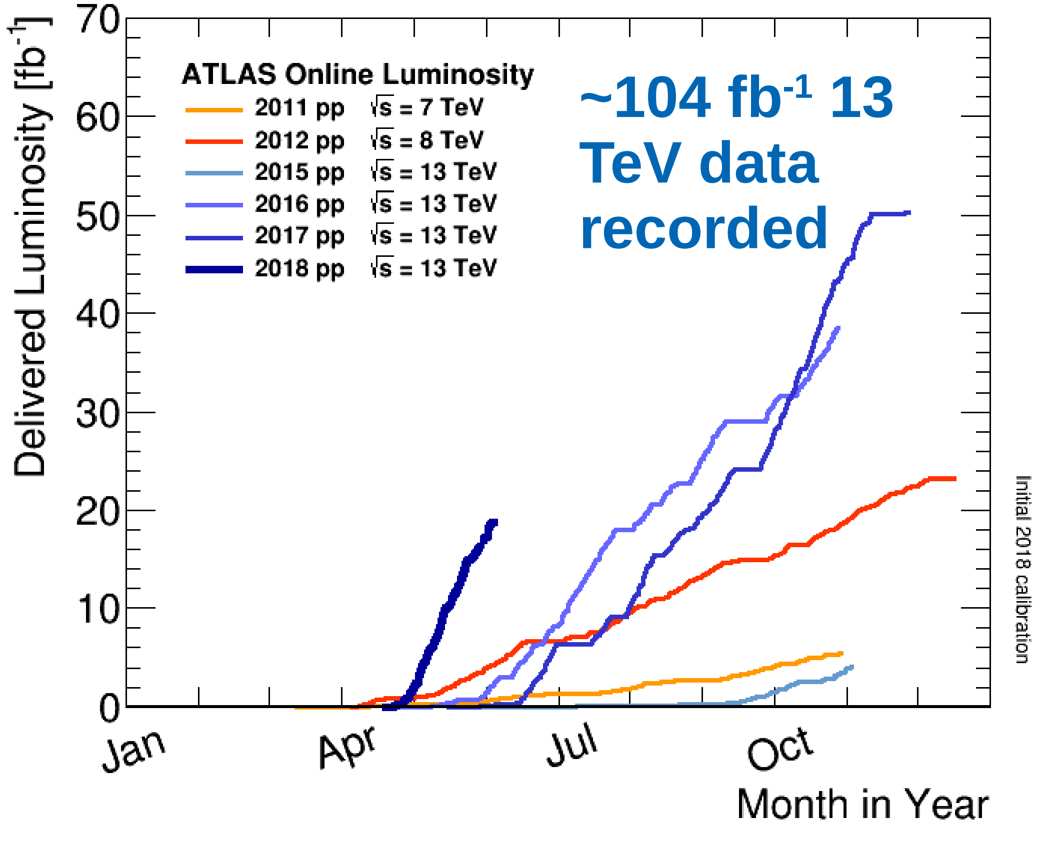
New Z/Edge





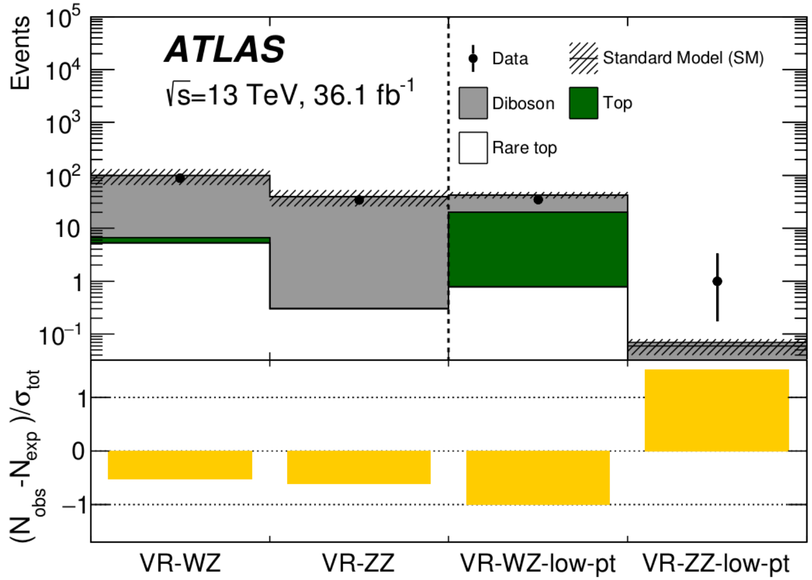
Conclusion

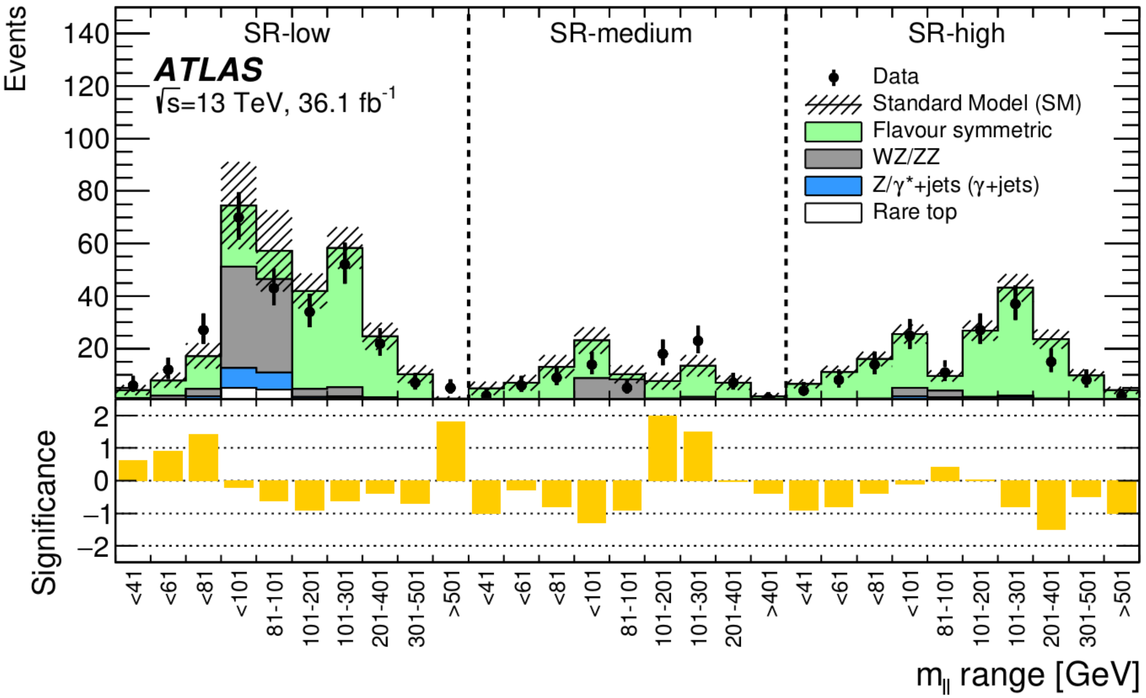
- Designing analyses to maintain sensitivity in difficult conditions
- Expecting a large Run II dataset from the LHC!
  - Many results in preparation for the full dataset

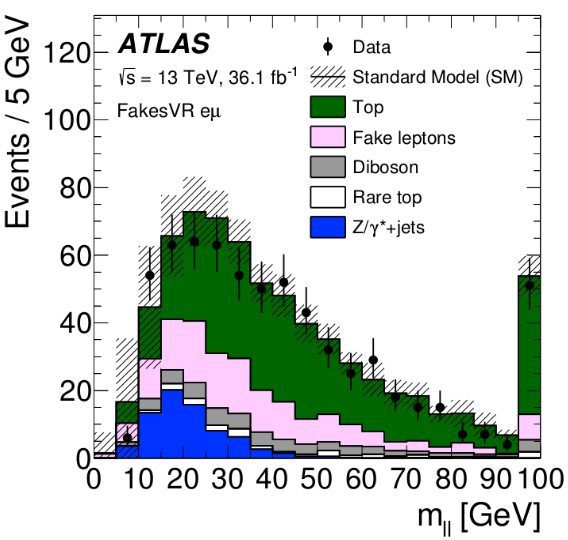


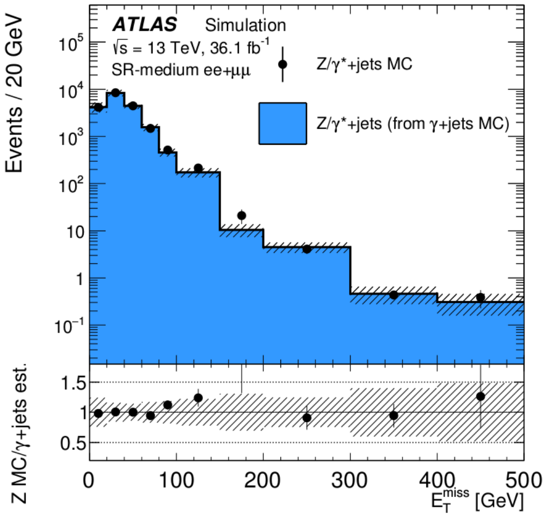
Backup

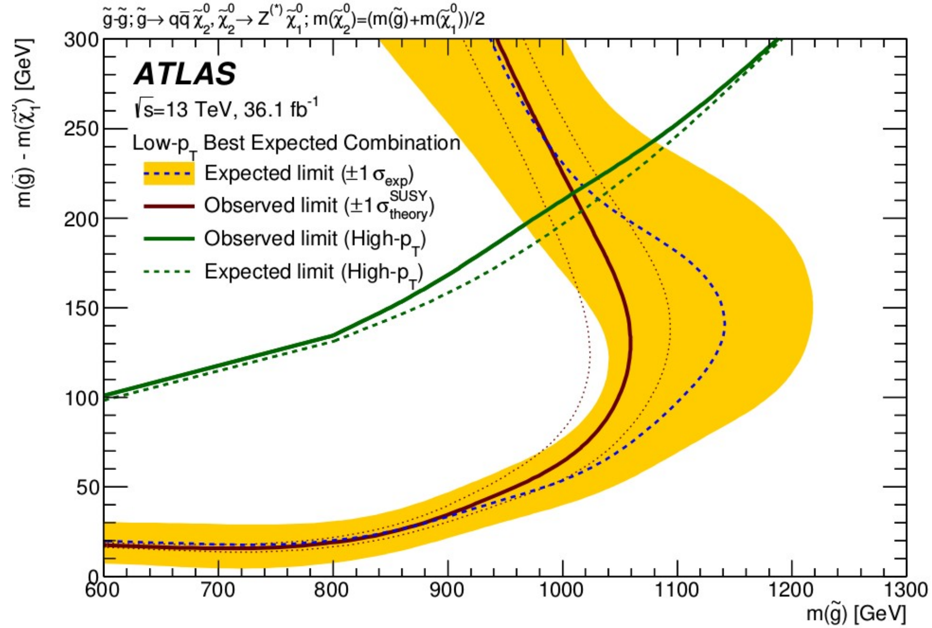
2L Z/Edge Extras



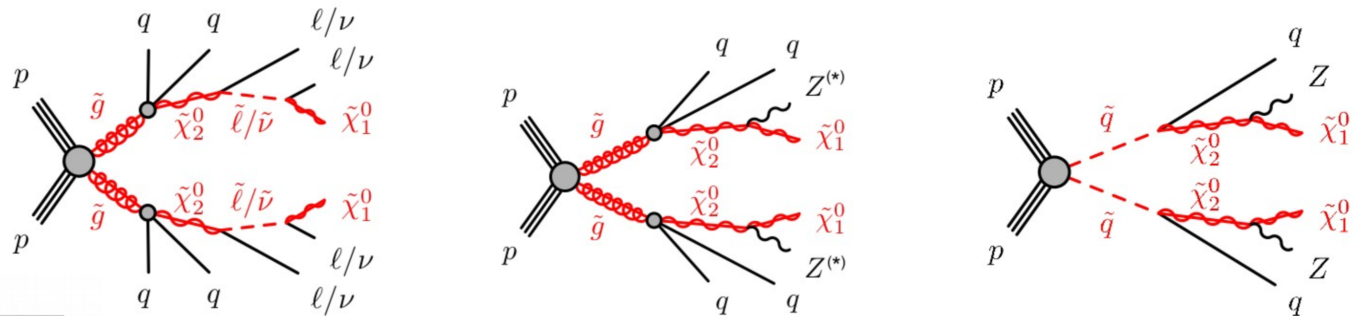




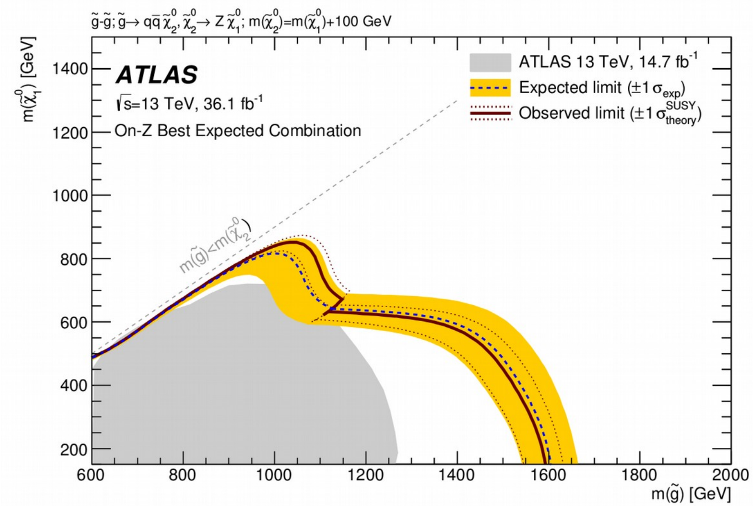


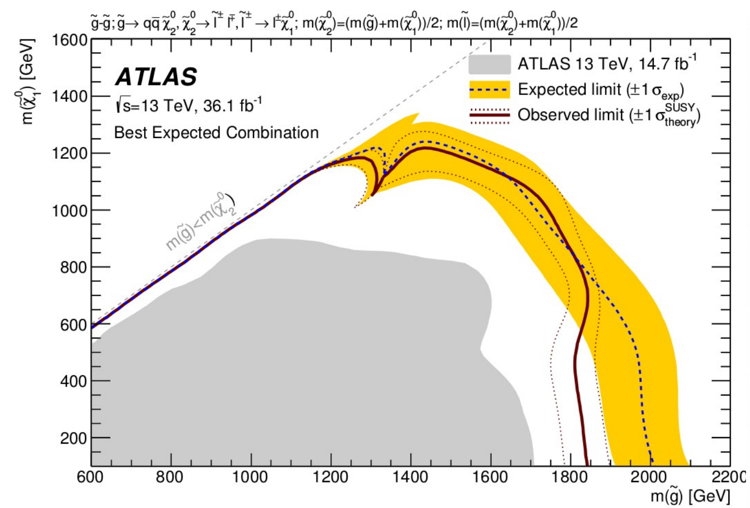


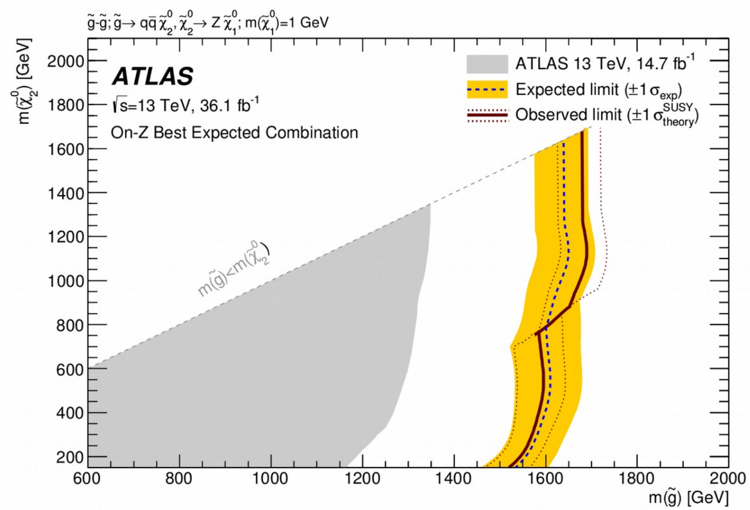
2L Z/Edge Limits



Model	Production mode	Quark flavours	$m(\tilde{g})/m(\tilde{q})$	$m(\tilde{\chi}_2^0)$	$m(\tilde{\chi}_1^0)$
slepton	$\tilde{g}\tilde{g}$	u, d, c, s, b	x	$[m(\tilde{g}) + m(\tilde{\chi}_1^0)]/2$	y
$Z^{(*)}$	$\tilde{g}\tilde{g}$	u, d, c, s, b	x	$[m(\tilde{g}) + m(\tilde{\chi}_1^0)]/2$	y
$\tilde{g}$–$\tilde{\chi}_2^0$ on-shell	$\tilde{g}\tilde{g}$	u, d, c, s	x	y	1 GeV
$\tilde{q}$–$\tilde{\chi}_2^0$ on-shell	$\tilde{q}\tilde{q}$	u, d, c, s	x	y	1 GeV
$\tilde{g}$–$\tilde{\chi}_1^0$ on-shell	$\tilde{g}\tilde{g}$	u, d, c, s	x	$m(\tilde{\chi}_1^0)$ + 100 GeV	y

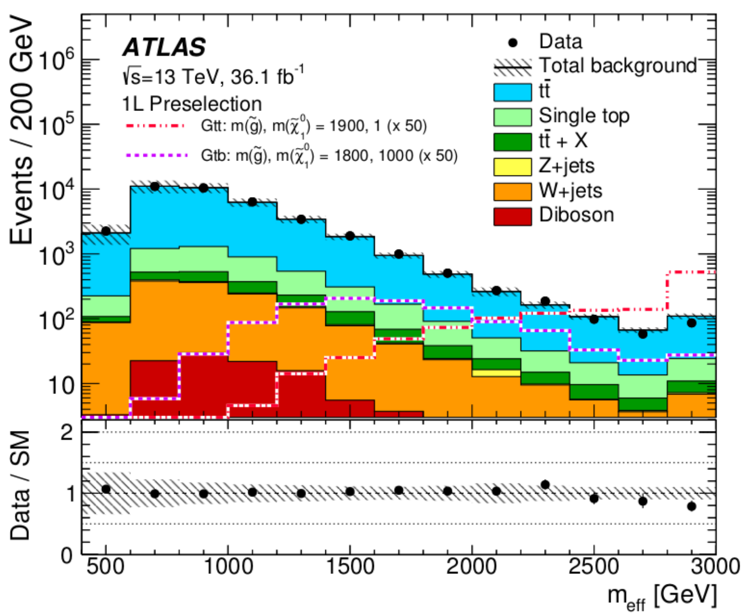


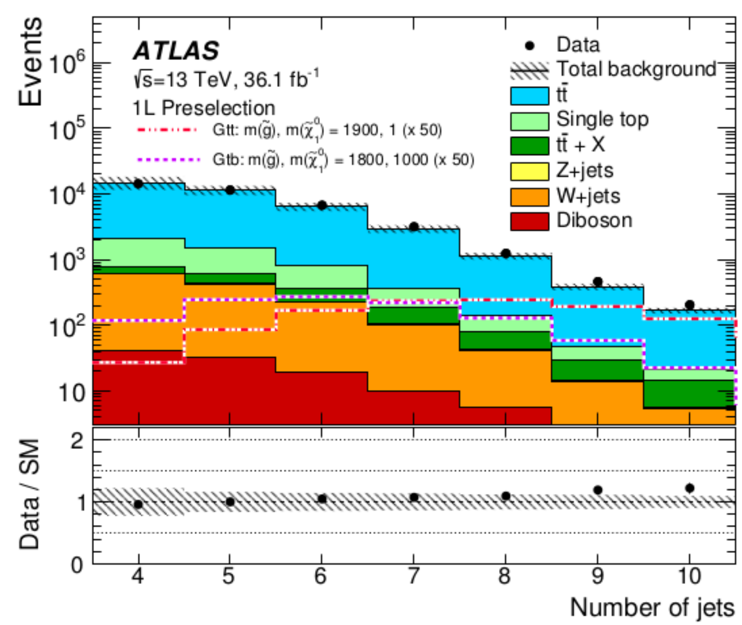




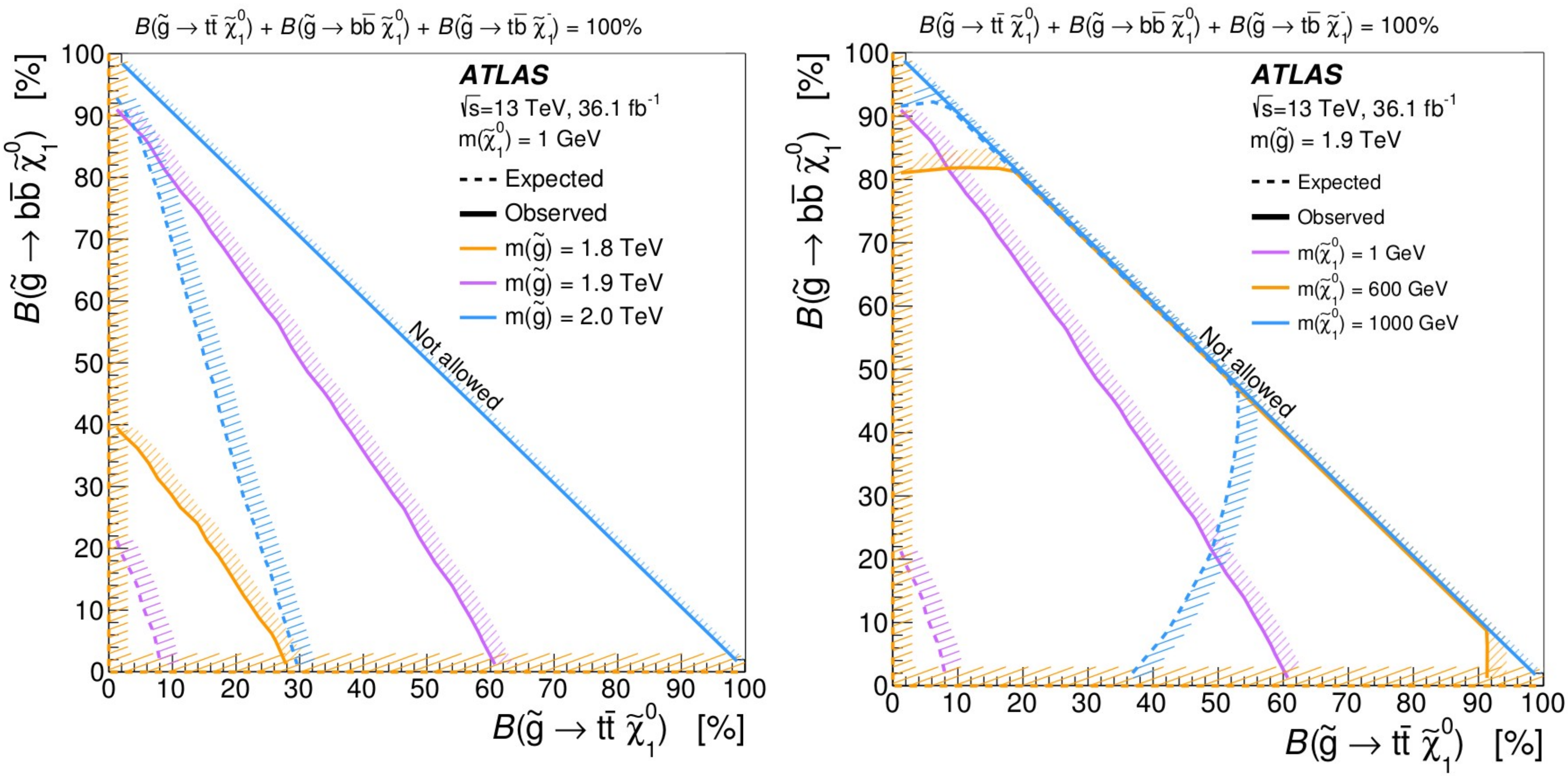
Multi-b kinematic reweighting

- Kinematic reweighting of Meff distribution to correct slope in 1L region
- Derived in ==2 b-jet region, low mTmin,bjet

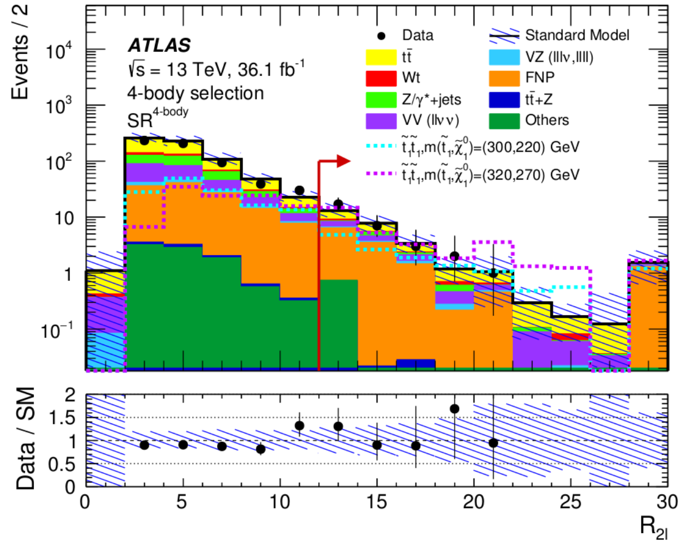


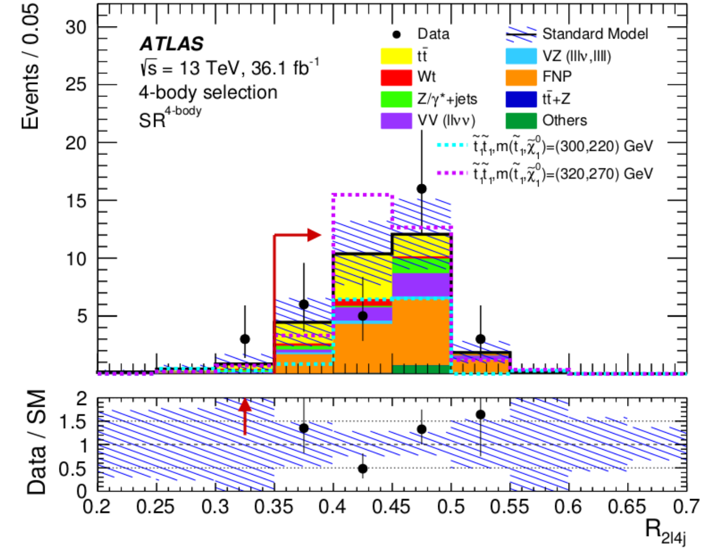


Multi-b limits as function of gluino BR

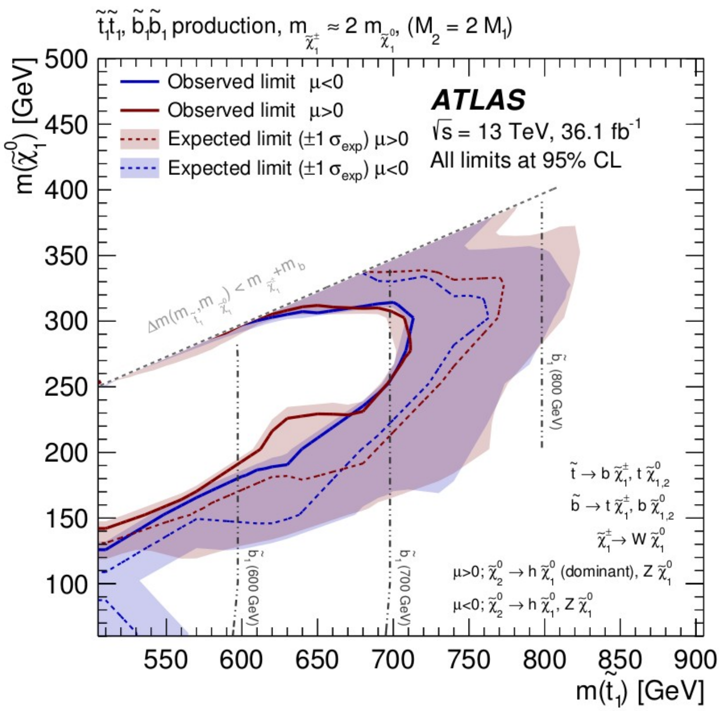


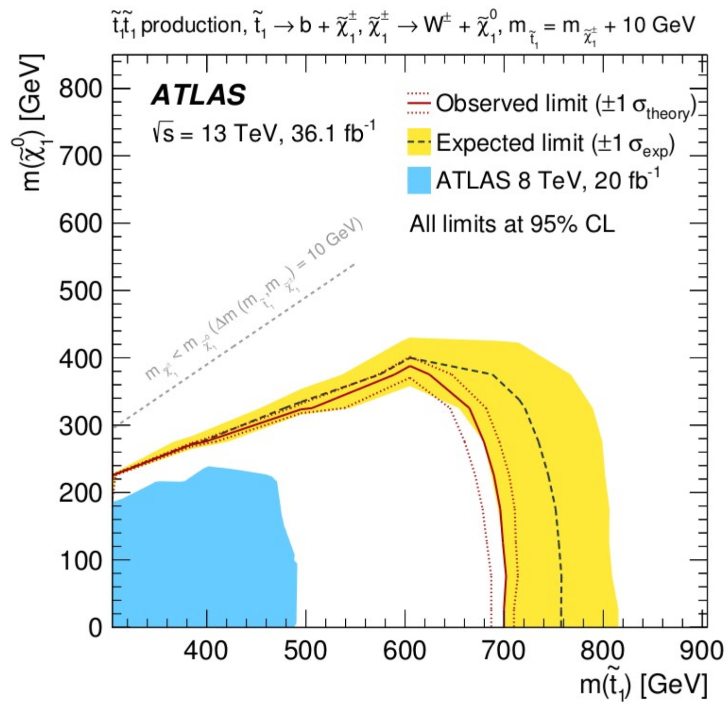
Stop 2L Extras

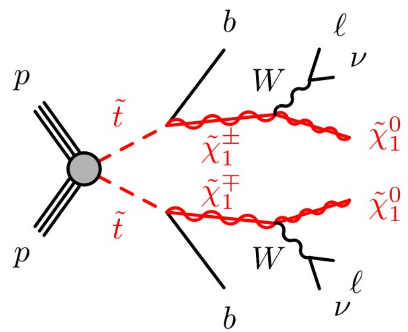




Based on PMSSM scan







Stop-Charm Extras