SUSY RESULTS FROM ATLAS (Plus some musings)

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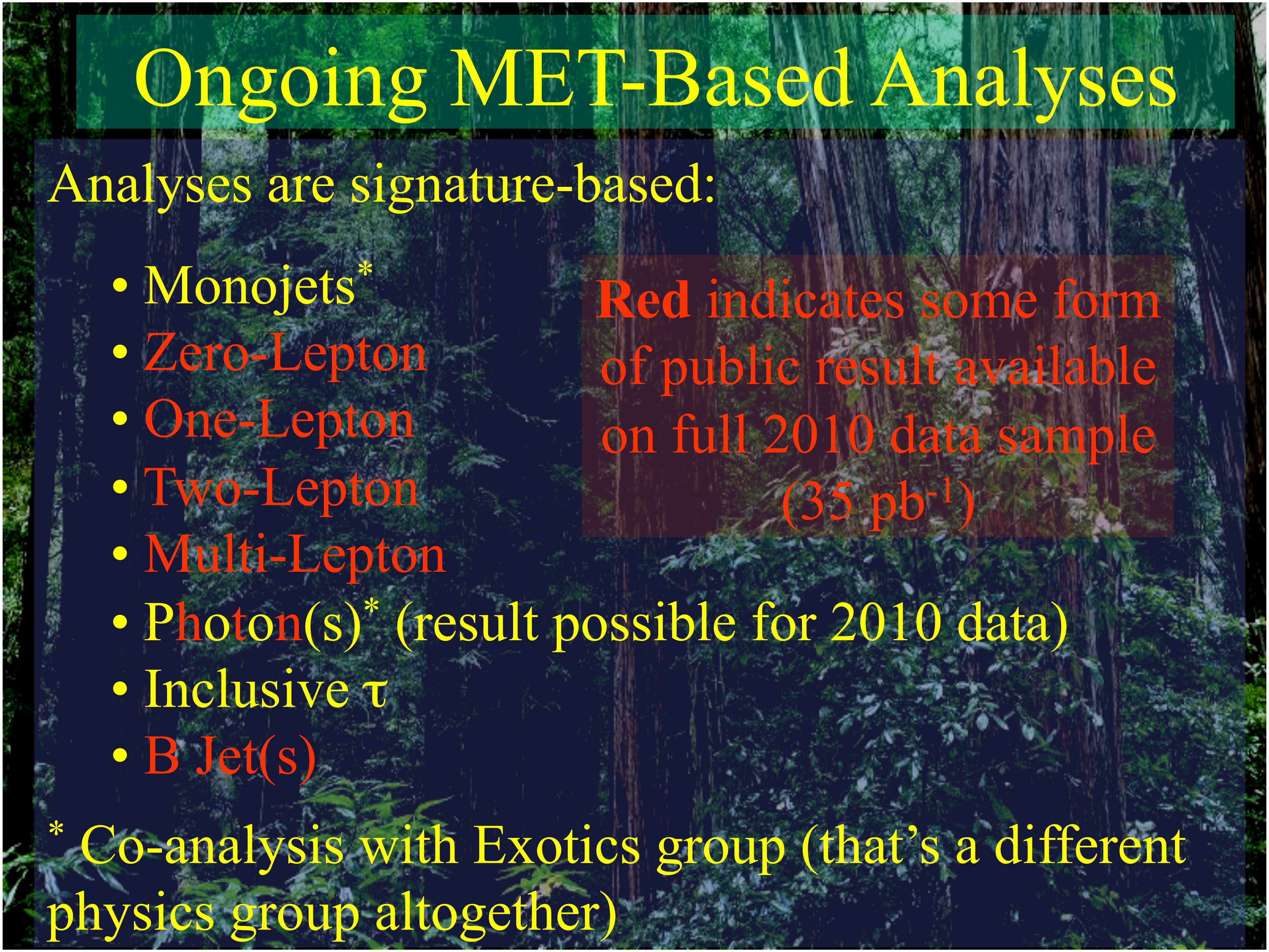
Organization and Scope

Group co-convened by George Redlinger (BNL) & Pascal Pralavorio (Marseille)

Three Subgroups:

- Missing-ET based signatures
- R-Parity violating and long-lived (RPVLL) state signatures
- SUSY background forum (no complete analyses)


Ongoing MET-Based Analyses
Analyses are signature-based:
• Monojets*
• Zero-Lepton
• One-Lepton
• Two-Lepton
• Multi-Lepton
• Photon(s)* (result possible for 2010 data)
• Inclusive τ
• B Jet(s)
Red indicates some form of public result available on full 2010 data sample (35 pb-1)
* Co-analysis with Exotics group (that's a different physics group altogether)

Ongoing RPVLL Analyses

- Stable scolored particles (squarks and gluinos)
- Displaced Vertex Analyses
- Stopped Gluinos
- Lepton-Based RPV
- Sneutrino Resonance Search*
- Kinked/Disappearing Track Search
- Long-Lived Muon Spectrometer Signals

Basic Elements of a New Physics Analysis

- Identify an interesting signature (e.g. photons + MET)
- Find a model with which to optimize signature
- Find a model with which to interpret (for now null) result
- Models typically "simplified" according to either physics motivations (mSUGRA, GMSB) or ad hoc reductions to a few quasi-empirical parameters (decouple all scales except, e.g., gluino, generalized squark, and gaugino mass, can also tune model with more parameters to do your bidding)

Models Used (for inspiration and/or analysis)

- mSUGRA / Constrained MSSM
- "24-parameter" CP/flavor conserving MSSM
- Generic MSSM parameter space (four degenerate light quarks, gluino octet, LSP)
- Generic GMSB ("GGM") space (light gluino octet, light Bino NLSP, gravitino)
- Non-contextual SUSY partners (tau sneutrino, stop +sbottom, hadronizing scolored particles)

Specific Example: Jets + MET

Define four experimental signal regions A,B,C,D sensitive to light ~q~q, heavy ~q~q, ~g~g, and ~q~g, respectively.

		A	B	C	D
Pre-selection	Number of required jets	≥ 2	≥ 2	≥ 3	≥ 3
	Leading jet p_T [GeV]	> 120	> 120	> 120	> 120
	Other jet(s) p_T [GeV]	> 40	> 40	> 40	> 40
	E_T^{miss} [GeV]	> 100	> 100	> 100	> 100
Final selection	$\Delta\phi(\text{jet}, \vec{P}_T^{miss})_{min}$	> 0.4	> 0.4	> 0.4	> 0.4
	E_T^{miss}/m_{eff}	> 0.3	–	> 0.25	> 0.25
	m_{eff} [GeV]	> 500	–	> 500	> 1000
	m_{T2} [GeV]	–	> 300	–	–

m_{T2} is max (among all jets) lower bound on jet+MET mass

m_{eff} is sum of MET and jet energies

Models Used For Optimization

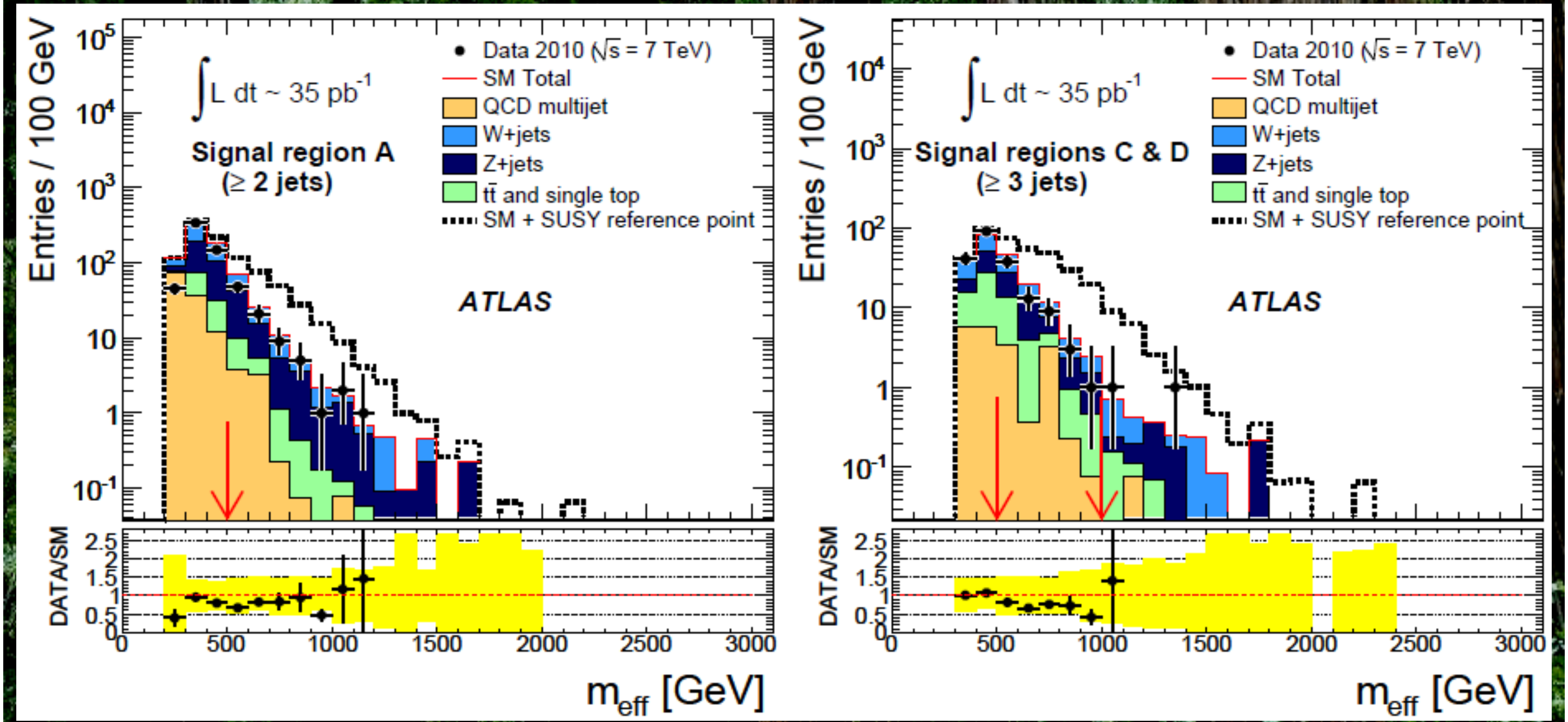
Signal region definition ("optimization") based on simplified model in which 4 degenerate squarks and gluino octet are light, decaying 100% via

~q → q χ^0 ~g → q q χ^0

where χ^0 is LSP

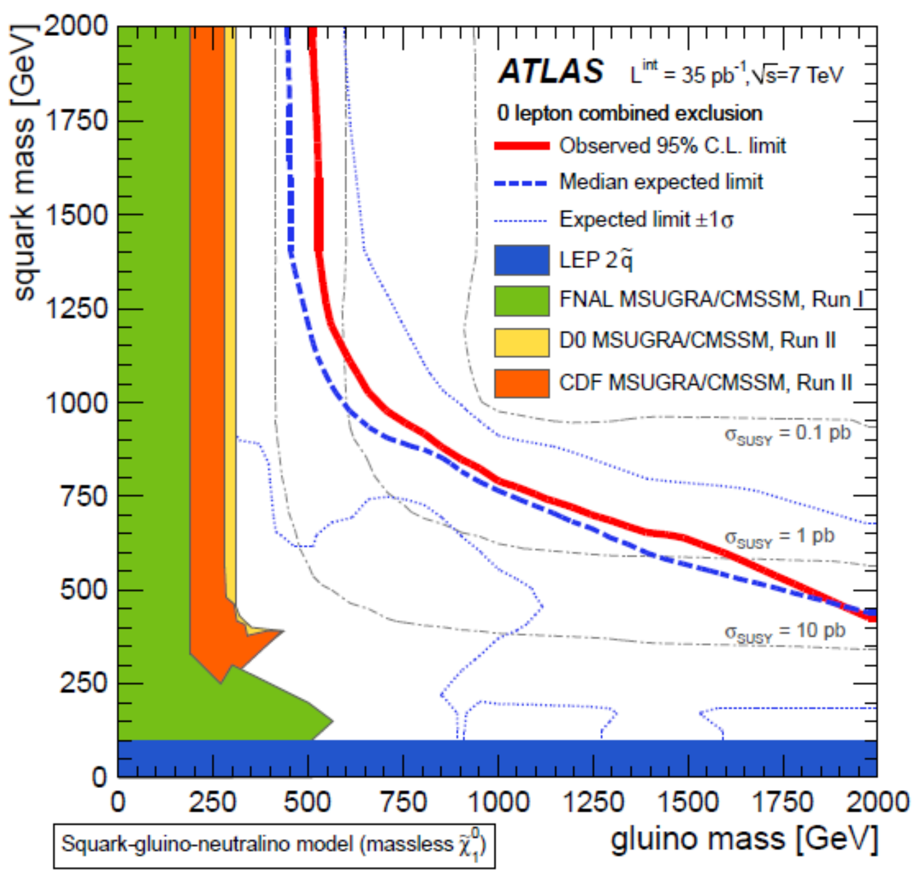
➔ "Simplified" model

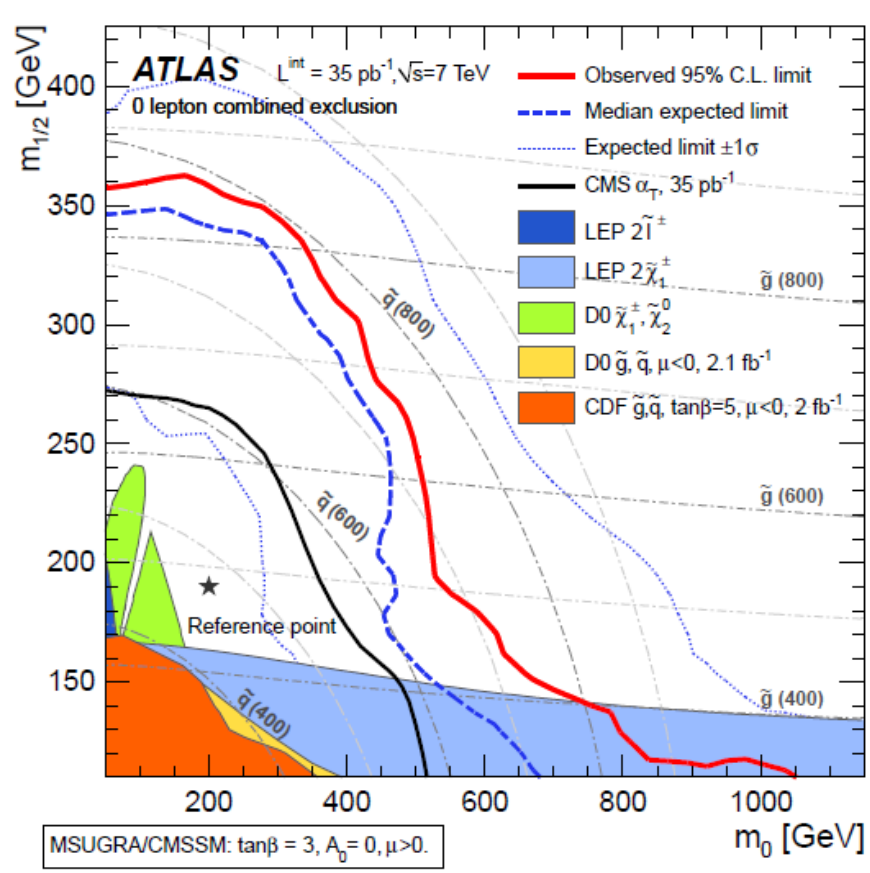
Results For, e.g., Regions A,C,D



Model shown is for $(m_{\sim q}, m_{\sim g}) \cong (480,440)$ and is easily excluded

Resulting Exclusion





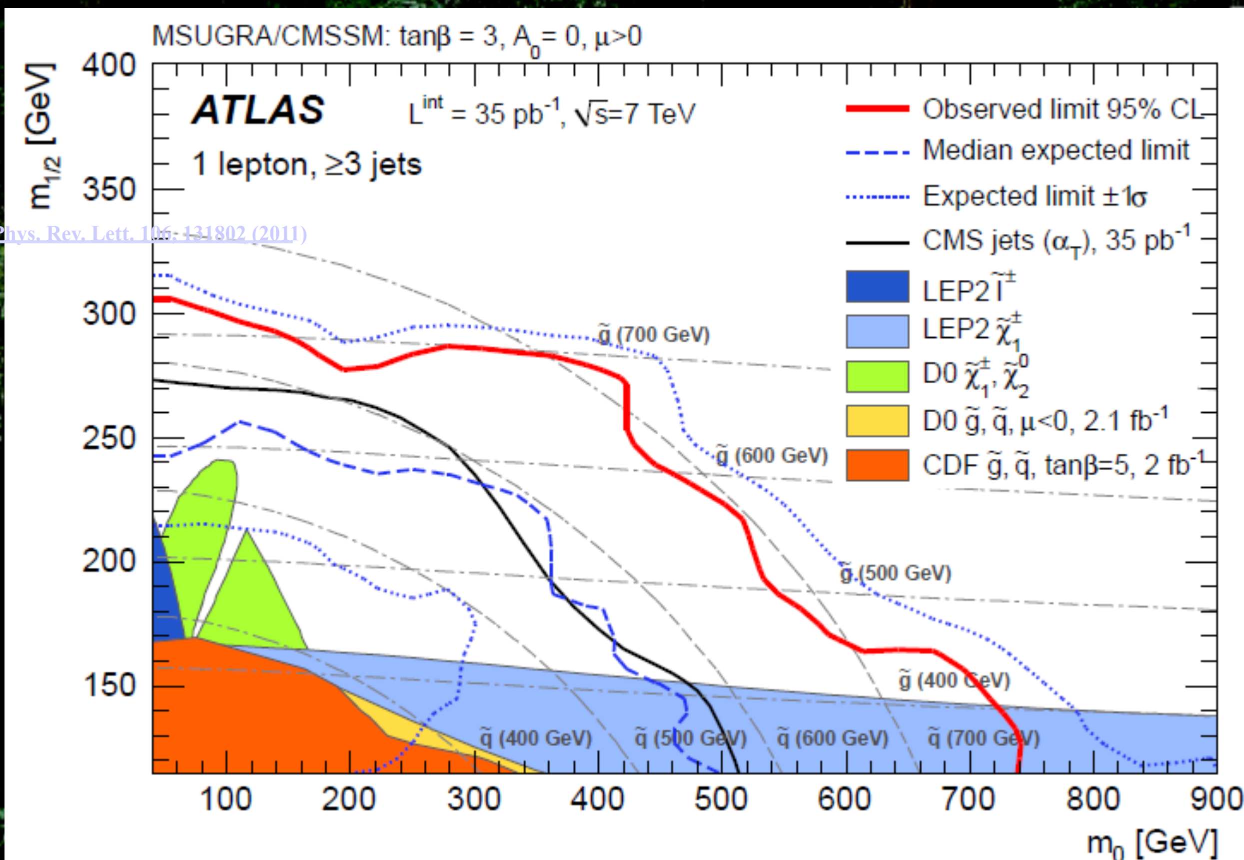
Simplified Model: For $m_{\sim q} = m_{\sim g}$, exclude m = 775 GeV

mSUGRA: For tanβ = 3, $A_0 = 0$, μ > 0, exclude some range of 2D space of speculative physics parameters

Triptik through ATLAS SUSY Results

One lepton, ≥3 jets, and MET

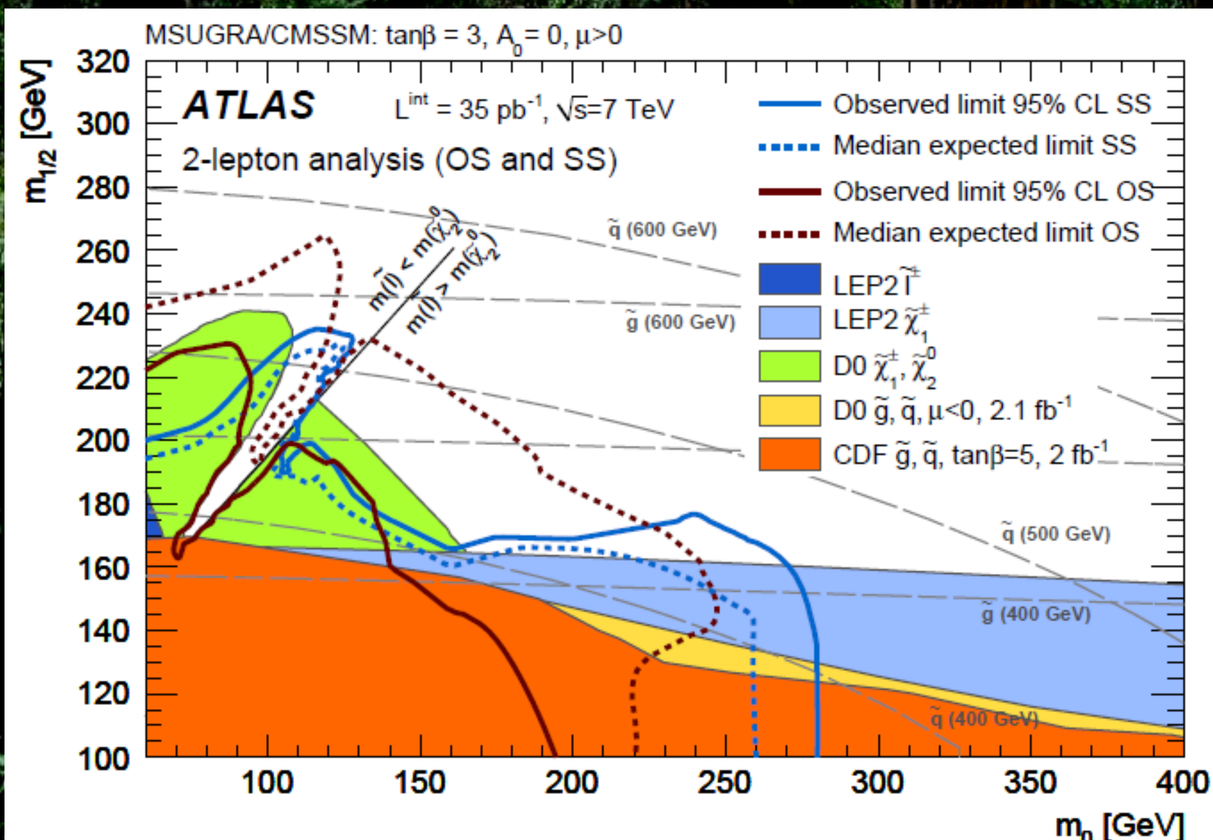
Phys. Rev. Lett. 106, 131802



- Limits set on mSUGRA
- Not as strong as for 0-lepton (~700 GeV)
- But independent sample (can combine)

Two Leptons Plus MET

mSUGRA limits from dilepton + MET



- Even less strong in mSUGRA context
- Independent of zero- and one-lepton analyses

The “24-Parameter MSSM” Context

CP- and flavor-conserving MSSM has 24 parameters; implemented as generic ISASUSY model.

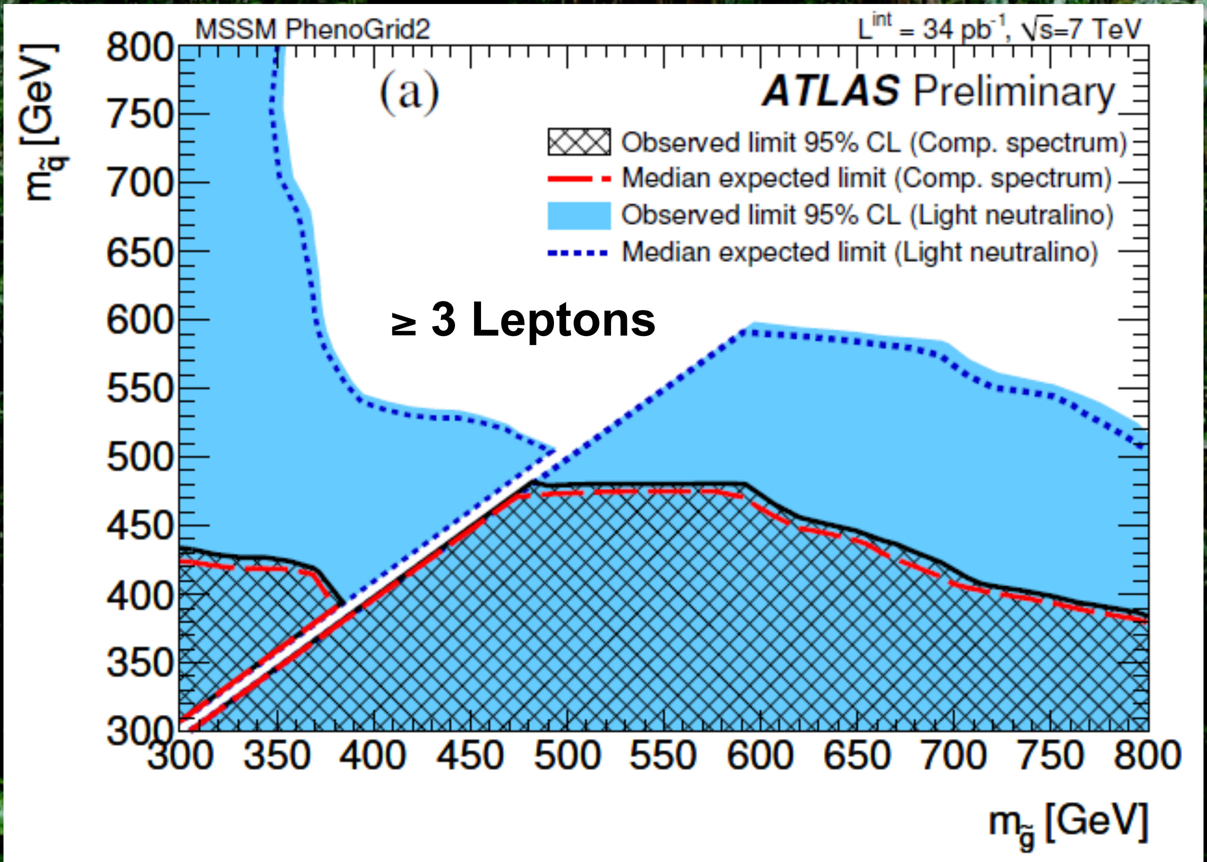
• Start here, then fix everything to `sensible values’ except $m_{\sim g}$, $m_{\sim q}$, $m_{\chi 10}$, $m_{\chi 20}$, $m_{\sim l}$

• Finally, choose $m_{\chi 10}$ $m_{\chi 20}$ $m_{\sim l}$ to enhance sensitivity of your favorite signature. ATLAS puts forward three choices:

Phenogrid1, Phenogrid2, Phenogrid3

Phenogrid 2

- Phenogrid2 ensures significant lepton production by putting χ^0_1, χ^0_2 masses below $m_{\sim q}$, $m_{\sim g}$, and then the slepton masses below that.
- Then set limits in $m_{\sim q}$, $m_{\sim g}$ plane:

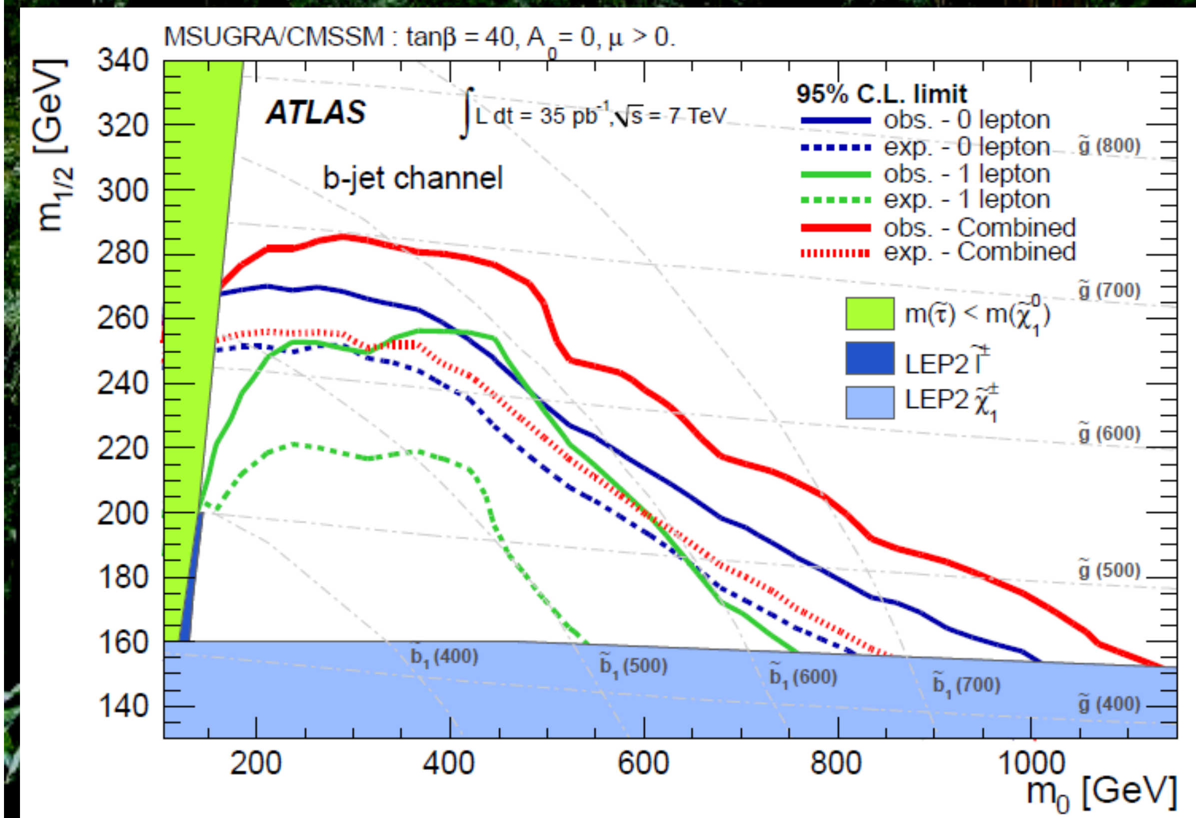


Other Interesting Signatures

Squark chiral mixing proportional to mass ➔ large splitting for stop, sbottom ➔ natural to be lightest squark(s)

B-JETS + MET

Natural enough that you can probe mSUGRA this way:

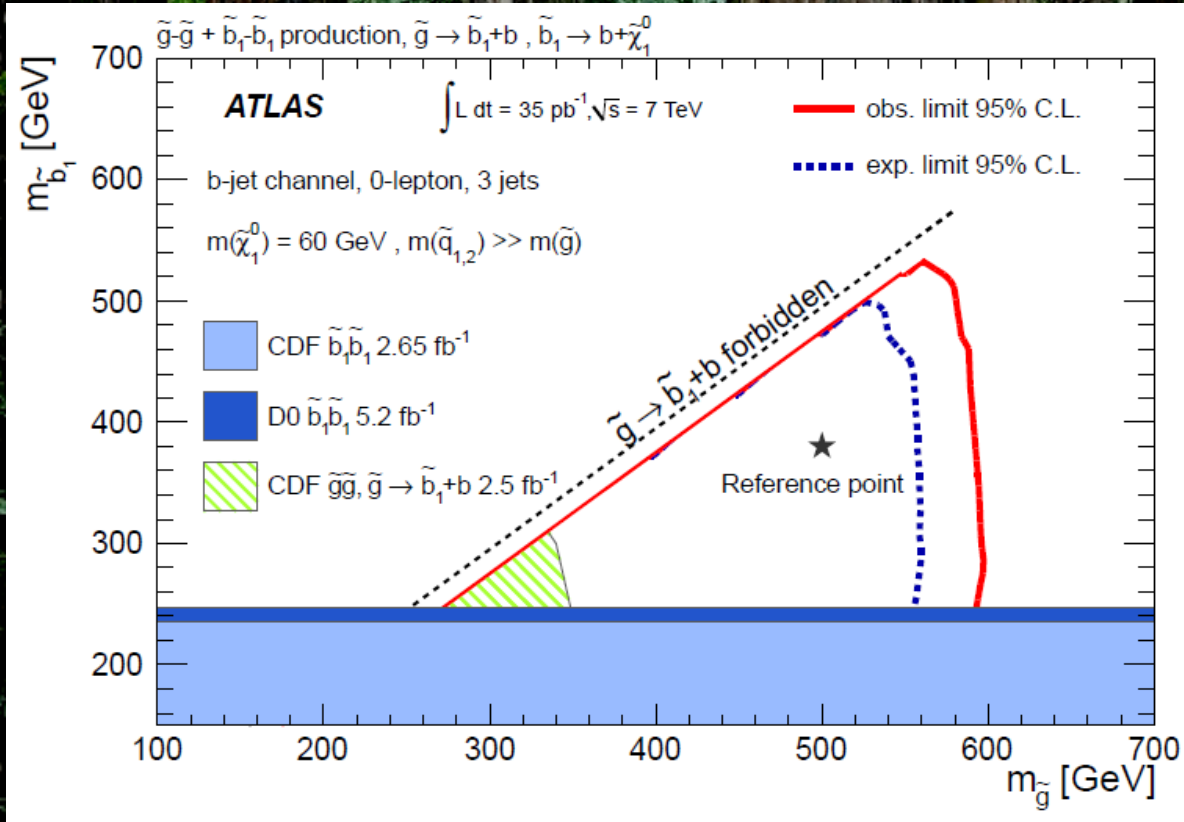


Coverage not as good as, e.g., generic jet + MET, but mSUGRA may not be most sensitive context.

B-JETS + MET and "Simplified" Models

Sometimes can let all masses go to ∞ except production particle (~g), focus particle (~b), and LSP (χ^0_1)

➔ "Simplified" model

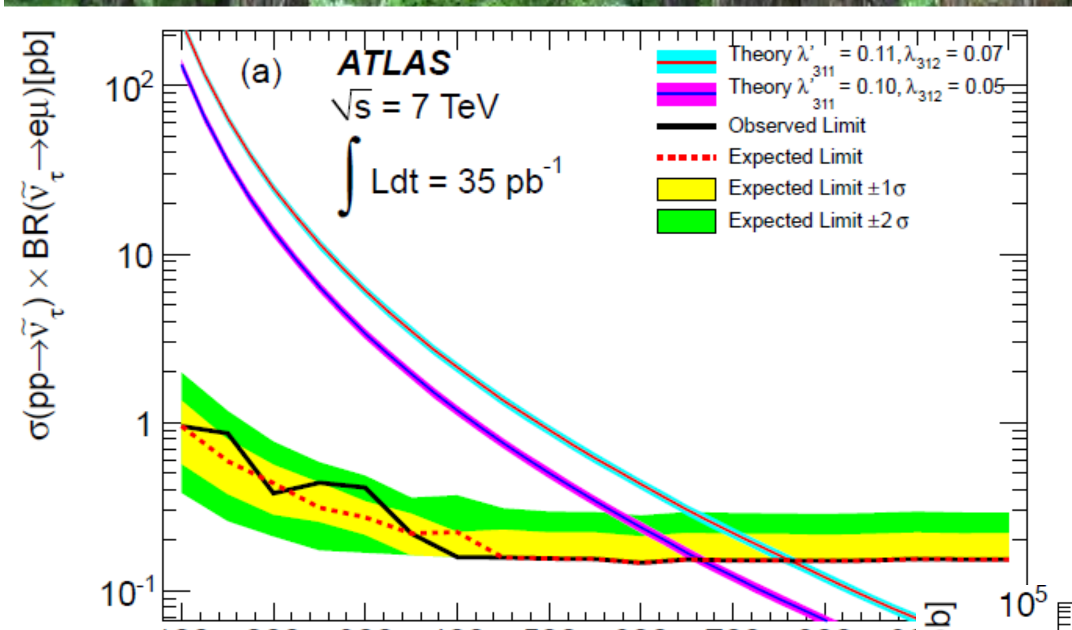


Quasi-model-independent limits in gluino-sbottom plane

[$m_\chi < m_{\sim g}$ – 250-300 GeV; B(~b → b χ^0) = 100%]

Decoupling other masses tends to make limits conservative.

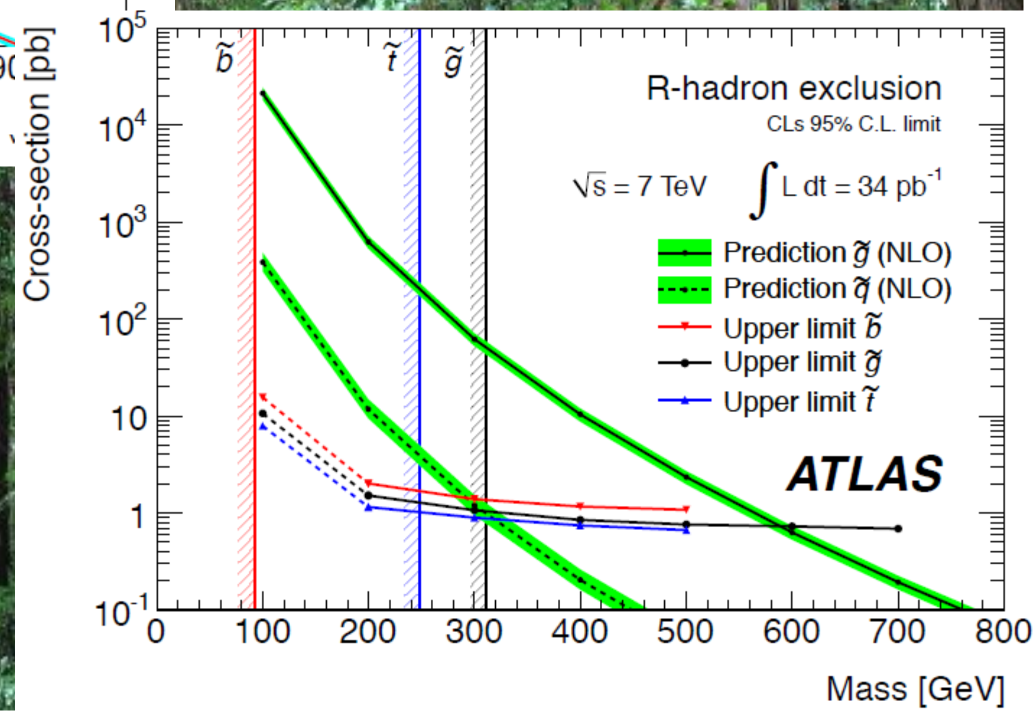
Odds and Ends



e-μ ins

R-Parity-Violating Sneutrino

~ν → eμ



Stabled scolored particles (arise in solutions to gauge heirarchy problem)

Photons + MET (coming soon?)

Addresses an independent scenario: gauge mediation.

Why does no other (current) ATLAS analysis address this?

LSP is always ~G (gravitino). NLSP is either

- $\sim\tau$, with $\sim\tau \rightarrow \tau + \sim G$
- χ^0 , with $\chi \rightarrow \gamma + \sim G$

➔Unique final states, of which diphoton + MET is most straightforward.

Also, coupling to gravity can lead to significant path length (in cosmologically-favored regime ?)

The GGM Context

Tevatron Analyses: GMSB ("minimal" gauge mediation), also referred to as the "SPS8 trajectory". Has 5+1 free paramaters:

$$\Lambda, M, n_5, \tan\beta, C_{grav}, (\text{and } \mathrm{sgn}(\mu))$$

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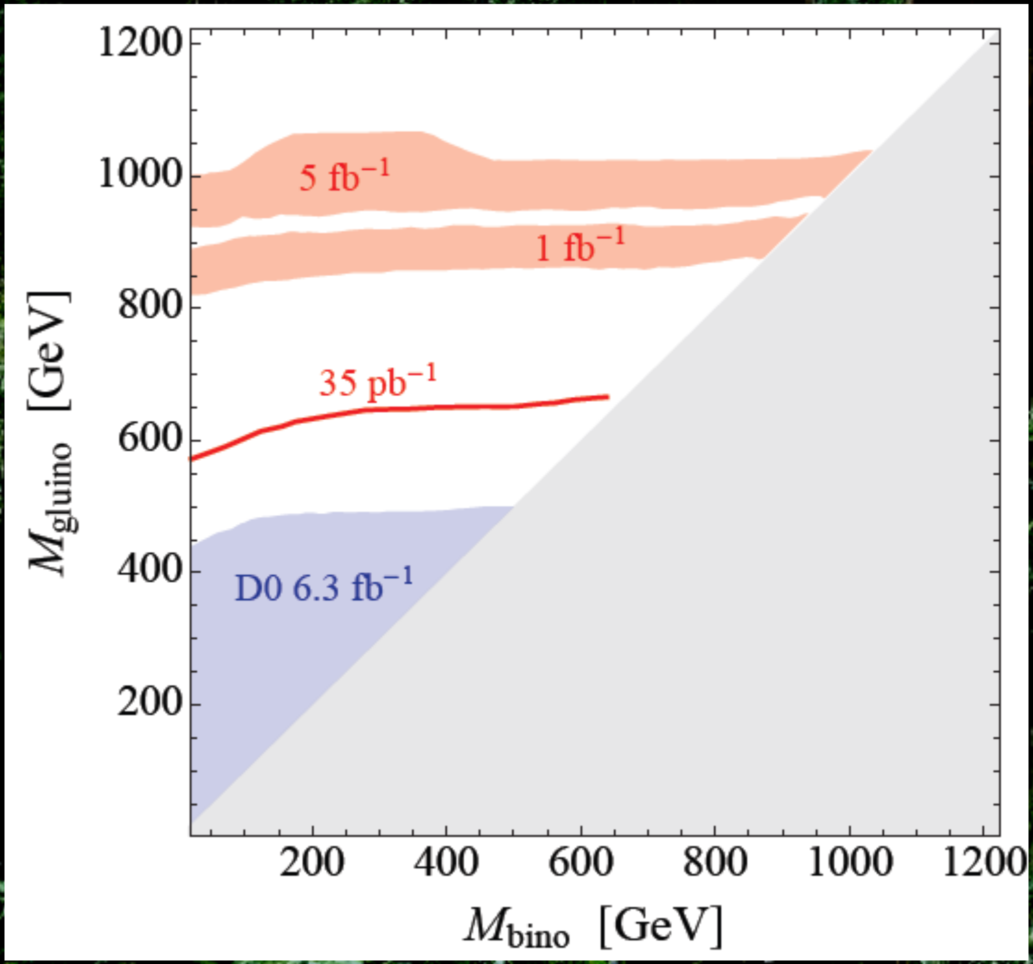
The strong and EW mass scales are closely tied together, and the scolored particles are heavy (~ 1 TeV) at current limits (which come from χ^+ production).

Shih, Ruderman: Model too restrictive. Instead consider generalized (simplified) space in which gravitino, gluino and one gaugino are light, all others decoupled…

The GGM Scenario - II

Meade, Seiberg, Shih, arXiv:0801.3278



Strong and EW masses decoupled; access strong production and place strong early limits (see prior talk)

Could be at or above 1 TeV for gluino (or squark) masses this year

GGM: Looking Beyond DiPhoton + MET

Many different signatures, since gaugino NLSP could be

• Bino	Diphoton + MET, lepton(s) + photon MET
• Wino	Lepton(s) + MET (+photon)
• Higgsino	b jets + MET
• Long-lived	Any of above, not pointing back to collision point

• Admixture Photon + MET + (b-jet, lepton, nothing)

➔ How many of these signatures break new ground not already broken by other analysis (GGM ground or other?)

Final Point: What to Quote?

We should quote model-independent results.

What form might this take?

A search for supersymmetry in the context of general gauge-mediated (GGM) breaking with the lightest neutralino as the next-to-lightest supersymmetric particle and the gravitino as the lightest is presented. The data sample corresponds to an integrated luminosity of 36 pb-1 recorded by the CMS experiment at the LHC. The search is performed using events containing two or more isolated photons, at least one hadronic jet, and significant missing transverse energy. No excess of events at high missing transverse energy is observed. Upper limits on the signal cross section for GGM supersymmetry between 0.3 and 1.1 pb at the 95% confidence level are determined for a range of squark, gluino, and neutralino masses, excluding supersymmetry parameter space that was inaccessible to previous experiments.

CMS diphoton + jet + MET result, arXiv:1103.0953

Quoting a cross-section: how model independent is this? What else might we quote?

Model Independent Results: Issues

ATLAS diphoton + MET used for GGM and UED (exactly same analysis). Statistics above chosen MET cut:

Observed: N Expected background: $Y \pm \Delta Y$

➔ Limit of $N_{sig} < X$ at 95% confidence level is truly model indpendent (applies equally to both UED and GGM).

But, in order to turn into limit on model, require efficiencies and systematic errors that only experimenters know.

Model Independent Results: Issues II

Quoting limit on cross section seems reasonable compromise: just calculate your model's cross section and find limit. But again,

• efficiencies are model dependent.

• should cross section errors of analyzed model be included? Probably not, but then…

• theorist would have to include model's cross section systematics in combination with experimental systematics in limit calculation

What is the best thing to quote for external community?

Wrap Up

Numerous SUSY results, but not really that many angles: mSUGRA, GGM, tinkered 24-parameter MSSM, boutique searches (sneutrino, long-lived scolored particles…)

Pushing 800 GeV with 35 pb^{-1}; some (few) signatures still background free at this level.

We just really need to see something.

Wrap-Up

Charge Division:

Longitudinal resolution of σ_z=6mm seems achievable for a 10cm-long sensor.

Long Ladder Readout Noise:

Simulation and data show significantly less readout noise for long ladders than expected. “Center-tapping” yields even further reductions.

Non-Prompt Tracks with SiD:

Reconstructing clean metastable stau signature between first and second tracking layer seems quite plausible. Beginning to look in different radial regions.