Difficult Signatures at the LHC

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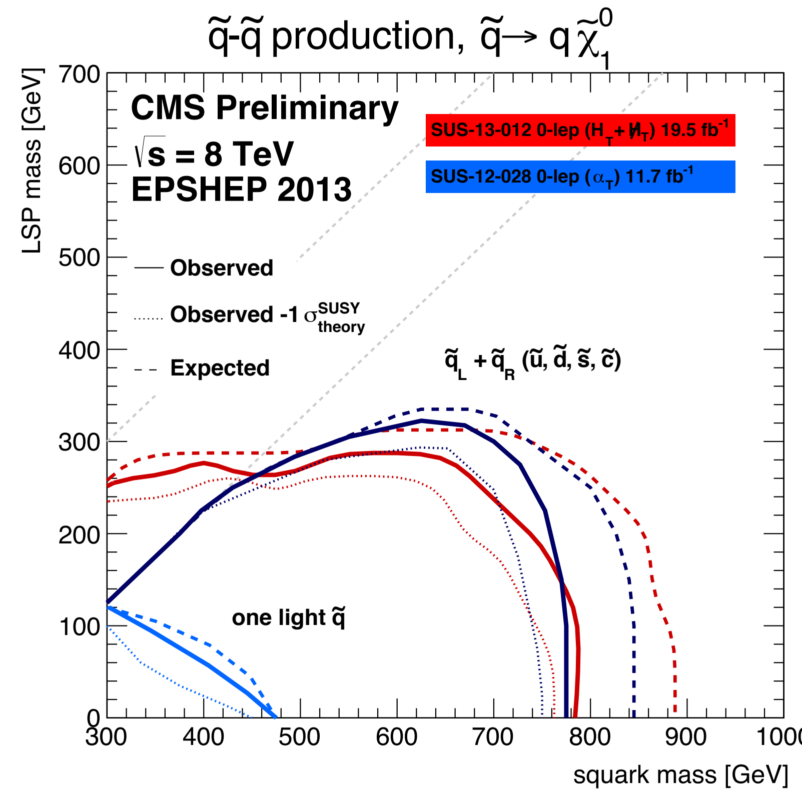
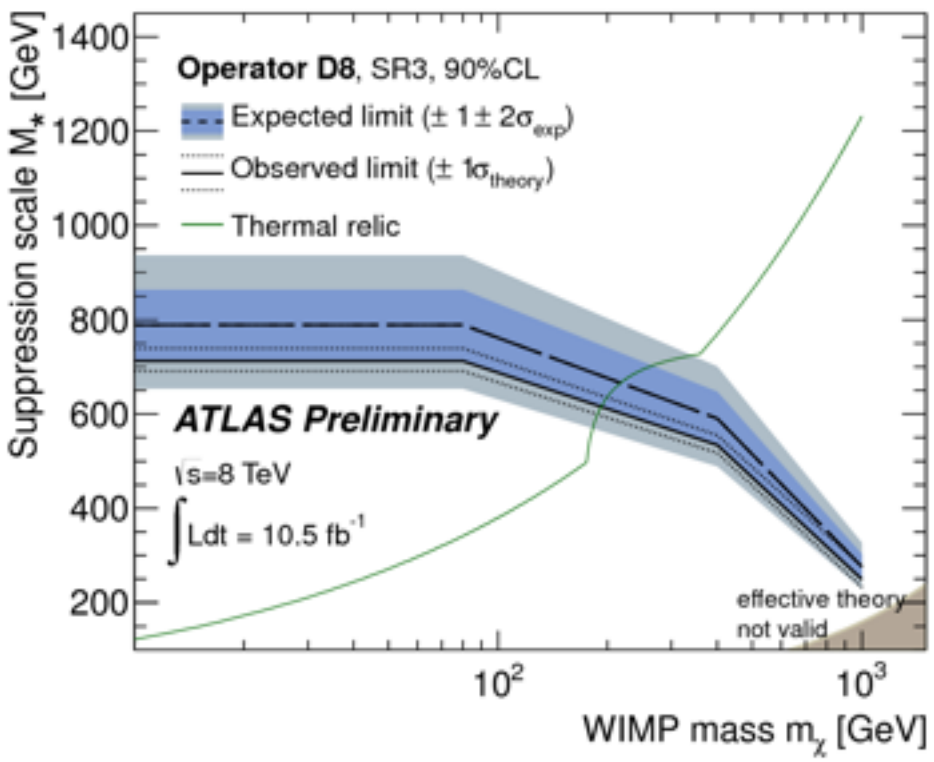
The Successes of the LHC

- Don't forget: HIGGS!
- Strong limits on the production of
    - massive colored states decaying with significant $\not{E}_T$
    - $\not{E}_T$ + something
    - High-p_T objects (*e.g.* RPV SUSY)



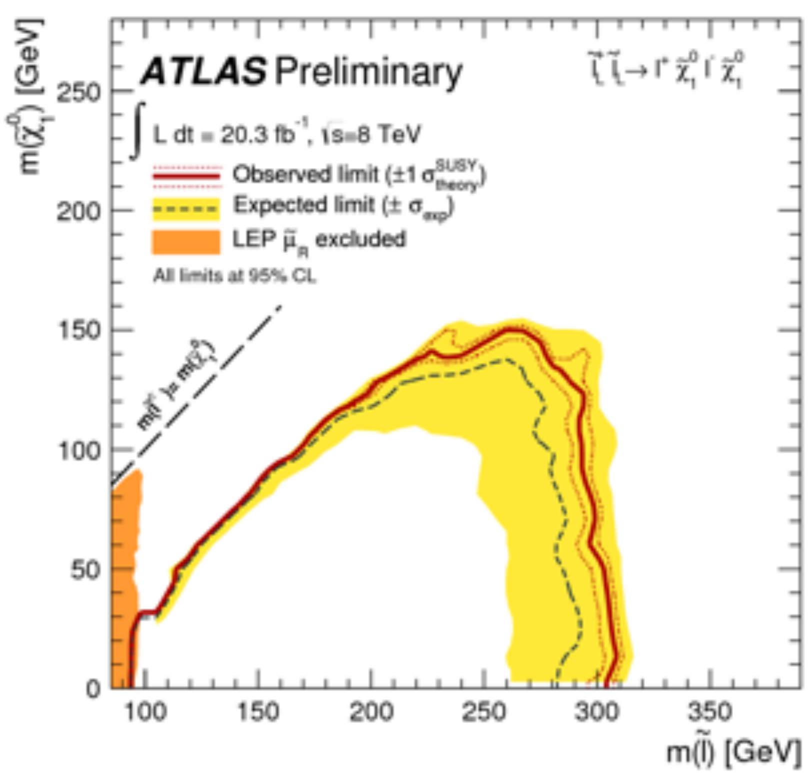


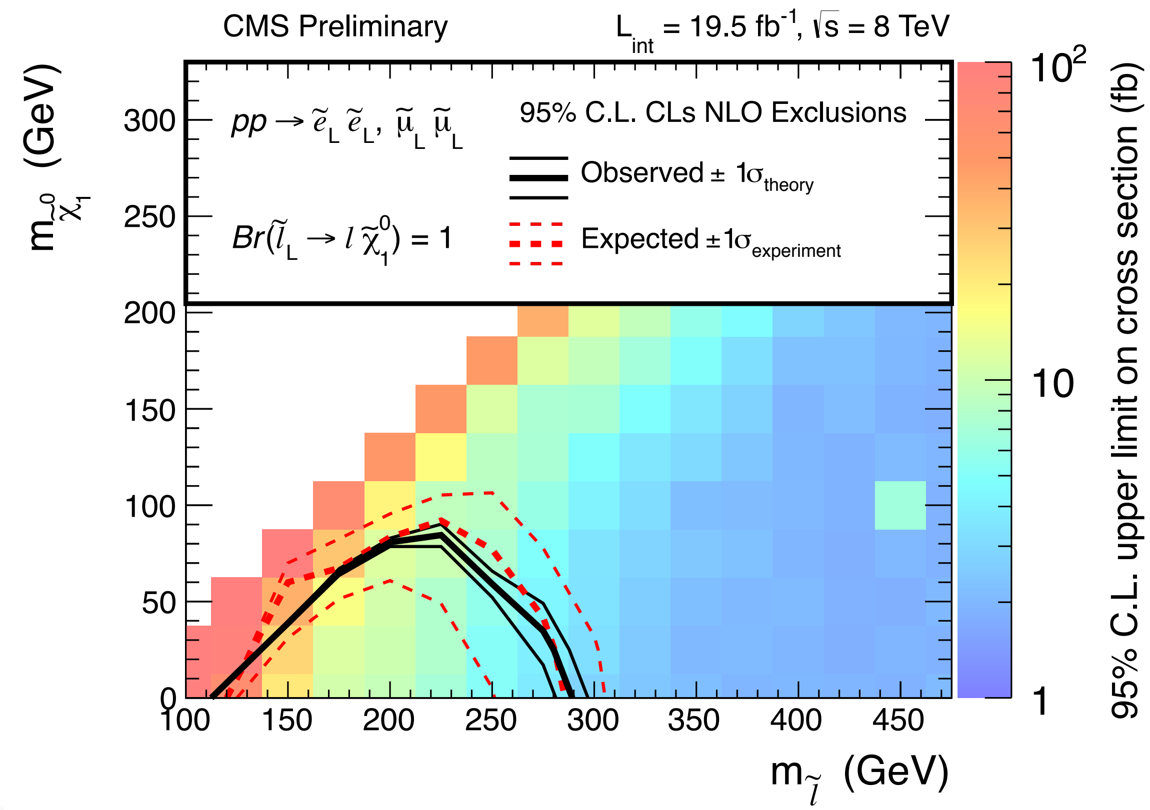
Degenerate Physics

- “SUSY-like” searches often rely on a mass-difference variable to distinguish from background

$$M_\Delta = \frac{m_P^2 - m_\chi^2}{m_P}$$

- Difficult when signal point has $m_P \sim m_\chi$ or $M_\Delta \sim m_W$





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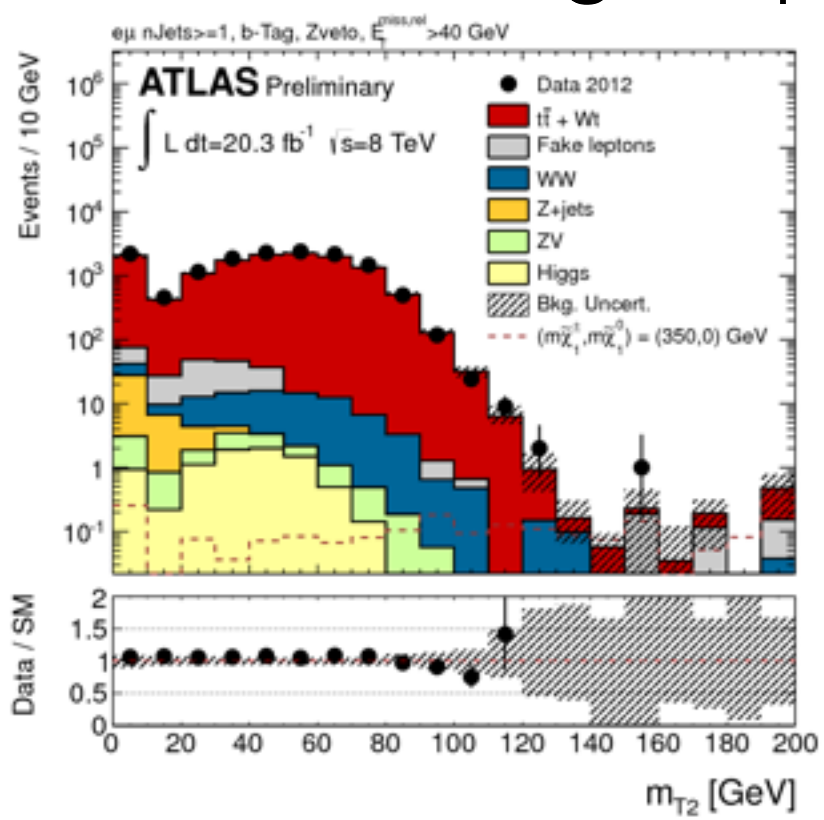
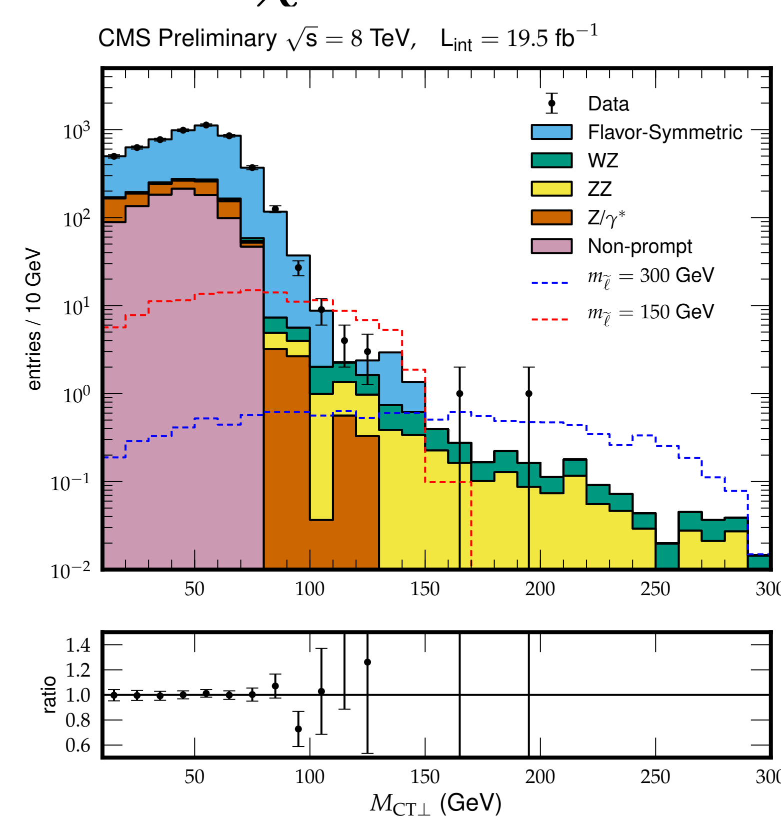
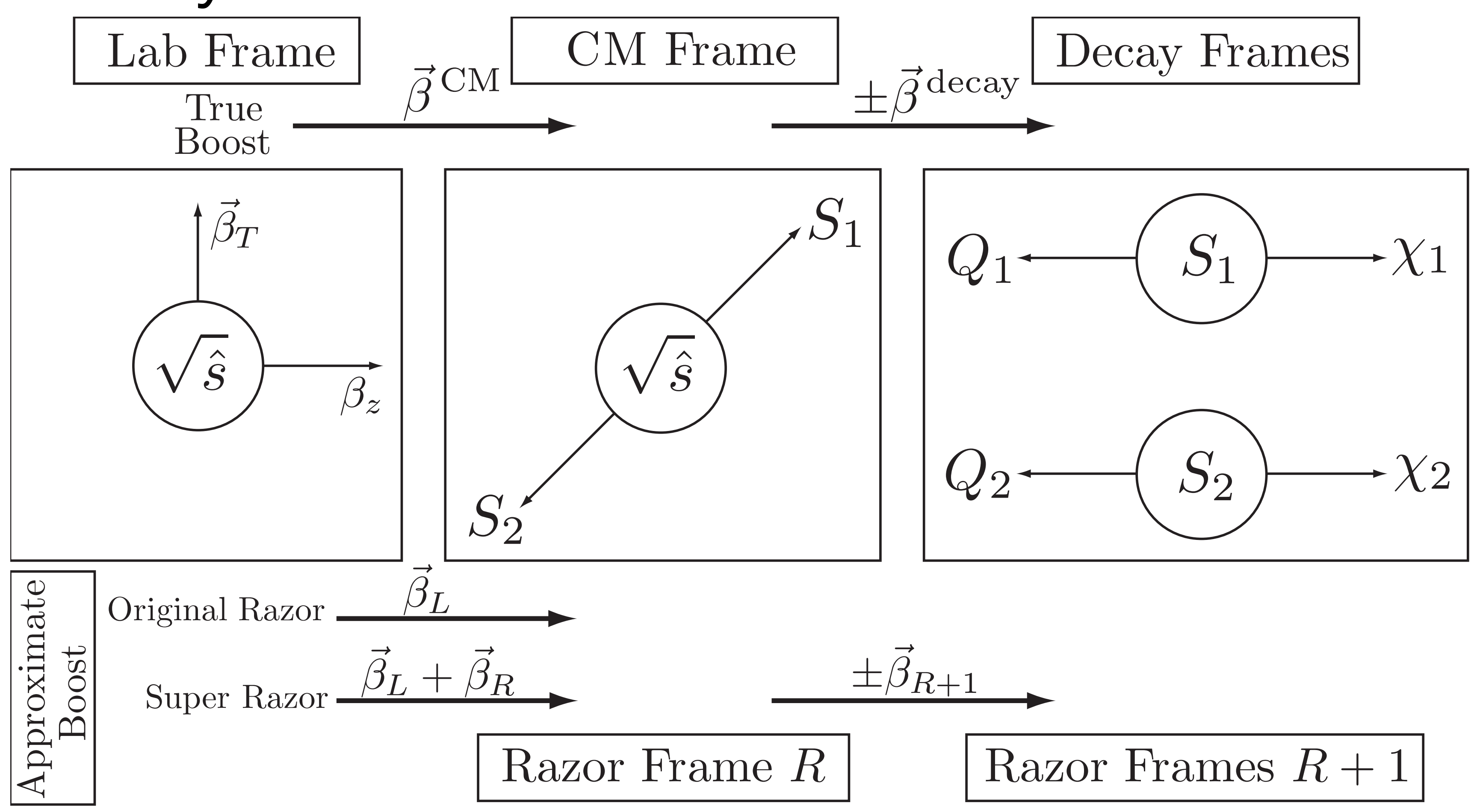




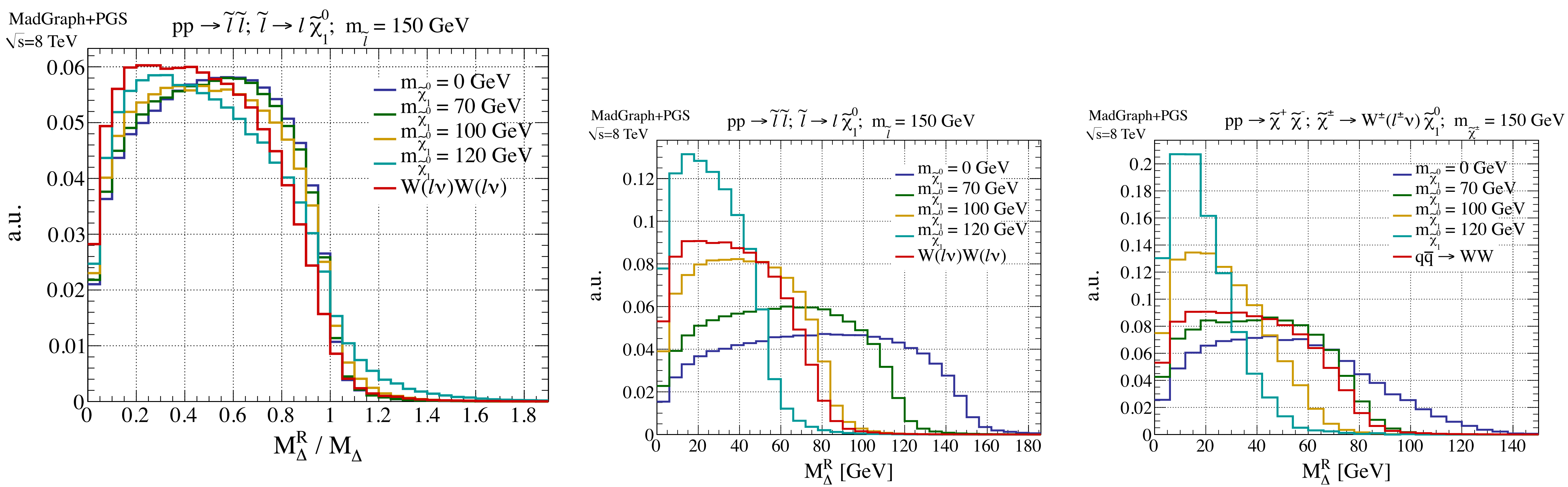
Super-Razor

- Attempt to reconstruct events of the form
$$pp \to S_1 S_2, \;\; S_i \to (\text{visible}) + \chi$$
- Impossible event-by-event, what can we do statistically?



Super-Razor

- Build boost from lab frame to estimate of center of mass frame. This gives estimated CM mass.
  - Resulting mass variable $\sqrt{\hat{s}_R}$ estimator of M_Δ
  - Also get $\vec{\beta}_R$, estimator of boost to CM frame



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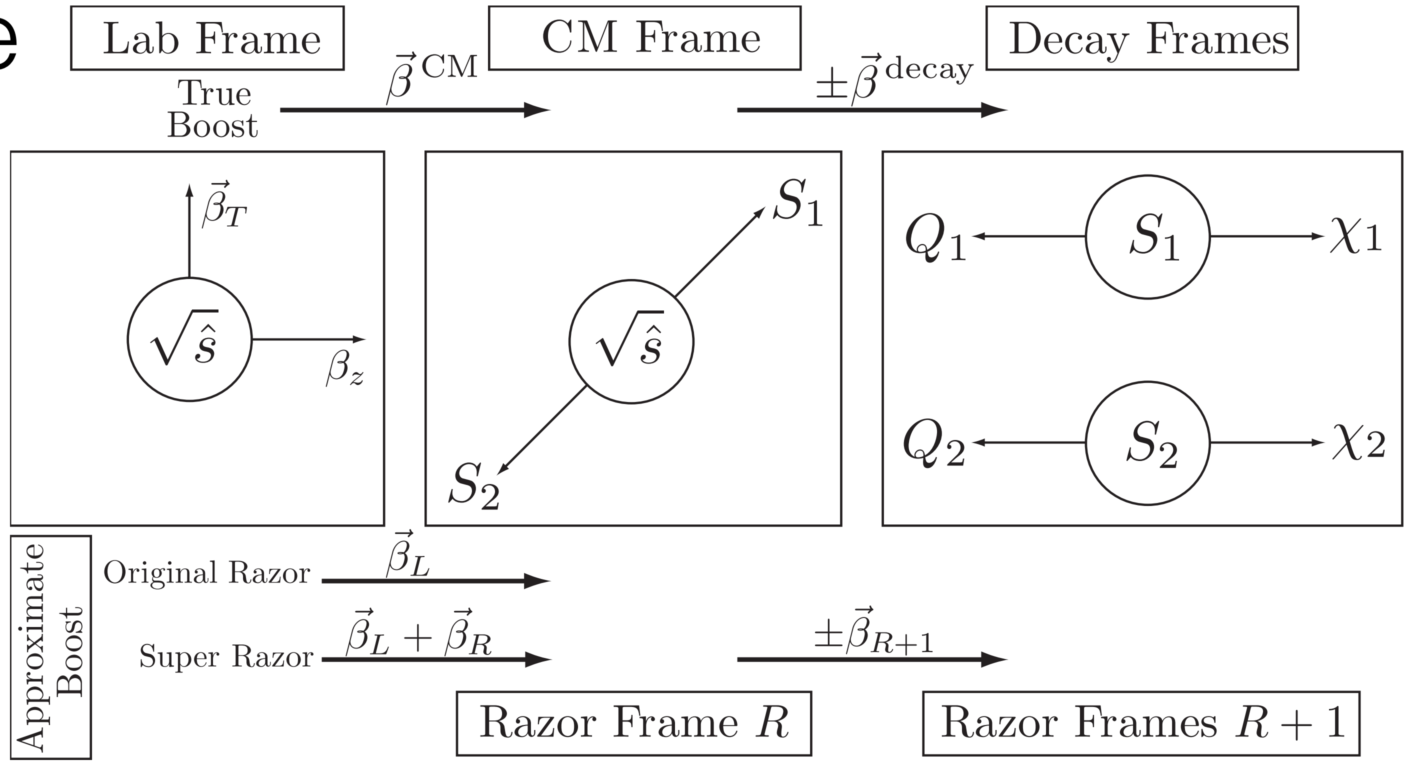
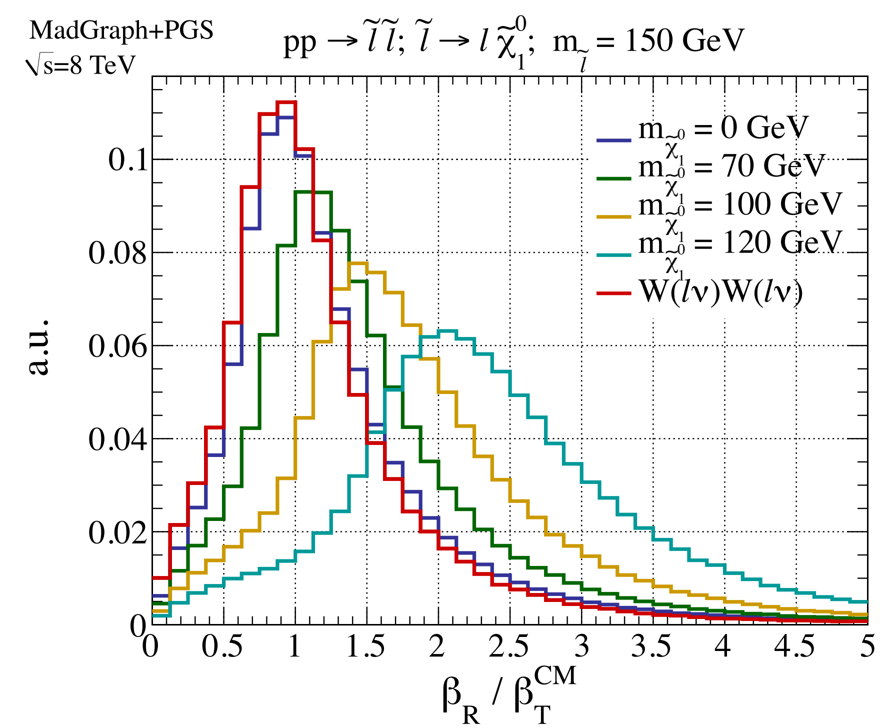
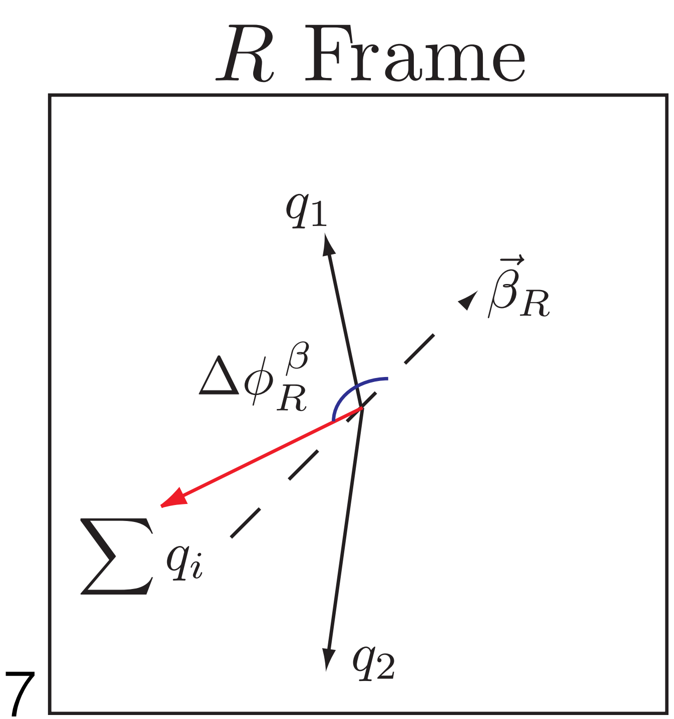
- From this approximate CM frame, can build boost vector to approximate decay frames.



Super-Razor Angles

- Mass variables are "corrected" versions of the original razor variables. Sensitive to M_Δ
  - Not good when $M_\Delta \to m_W$
- But we also have the approximations of the boosts.
- Notice that, as $m_{\tilde{\chi}_1^0}/m_{\tilde{\ell}} \to 1$, we overestimate the boost β_R
- Can define an $\Delta\phi_R^\beta$ angle between the boost direction and *R*-frame $q_1 + q_2$





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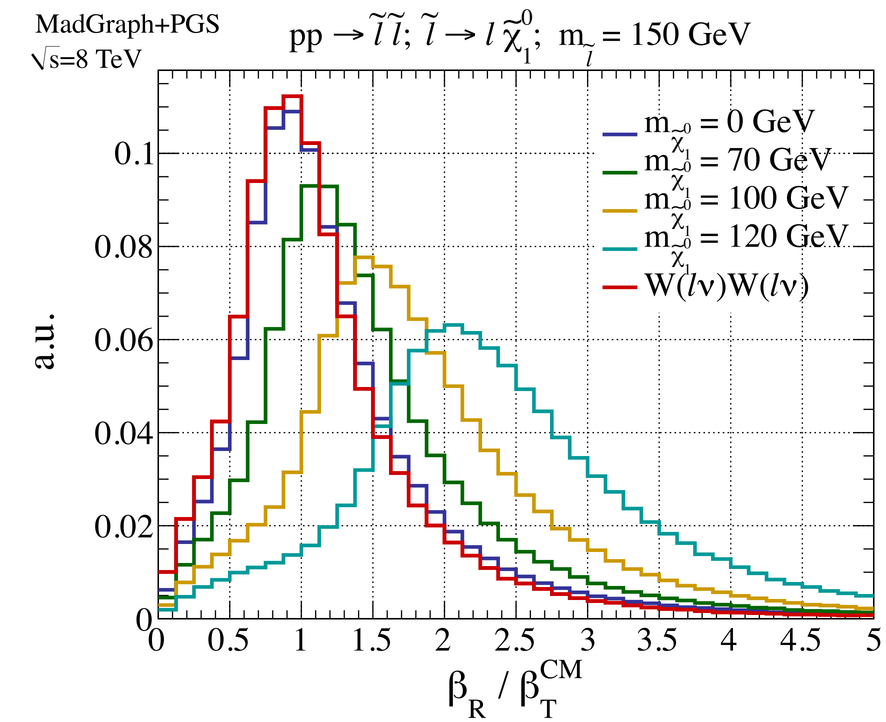

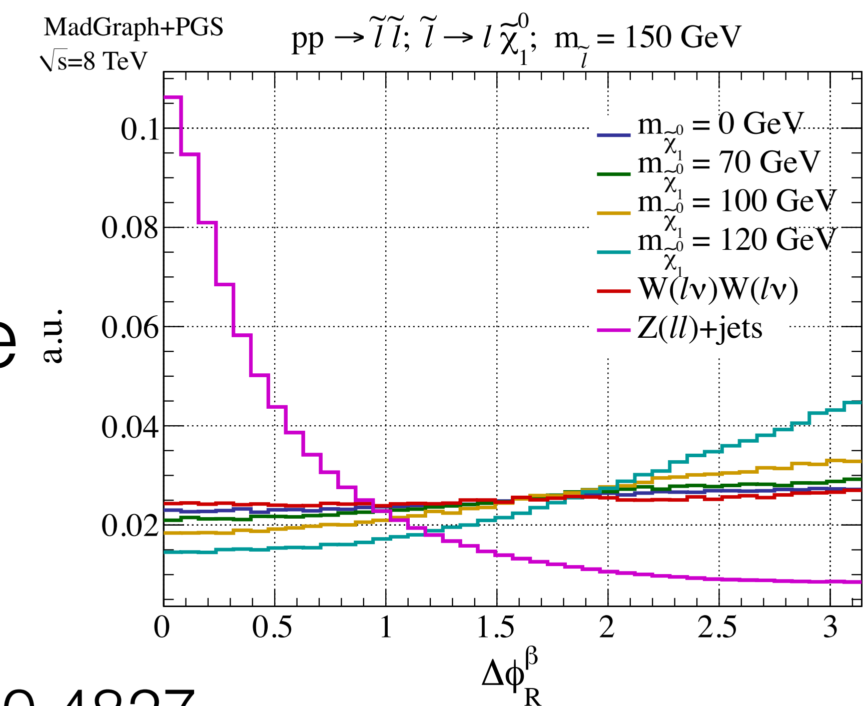

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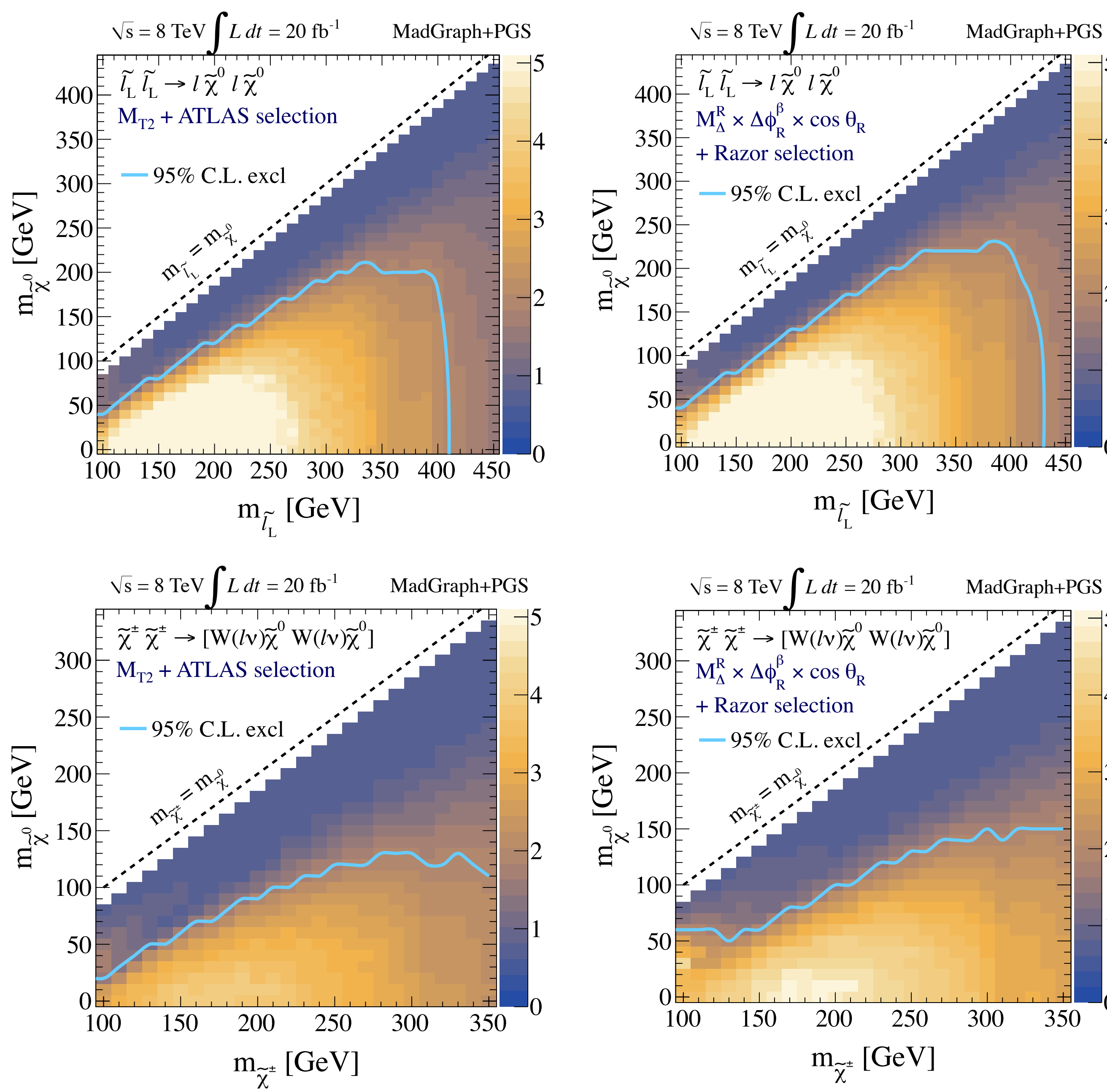
Predicted Reach at 8 TeV

- Moderate increases in the dilepton channels.

$$pp \to \tilde{\ell}^- \tilde{\ell}^+ \to \ell^- \ell^+ \tilde{\chi}_1^0 \tilde{\chi}_1^0$$

$$pp \to \tilde{\chi}_1^- \tilde{\chi}_1^+ \to \ell^- \ell^+ \nu \bar{\nu} \tilde{\chi}_1^0 \tilde{\chi}_1^0$$

- Major problem is lack of events passing trigger.
  - New triggers based on super-razor variables?



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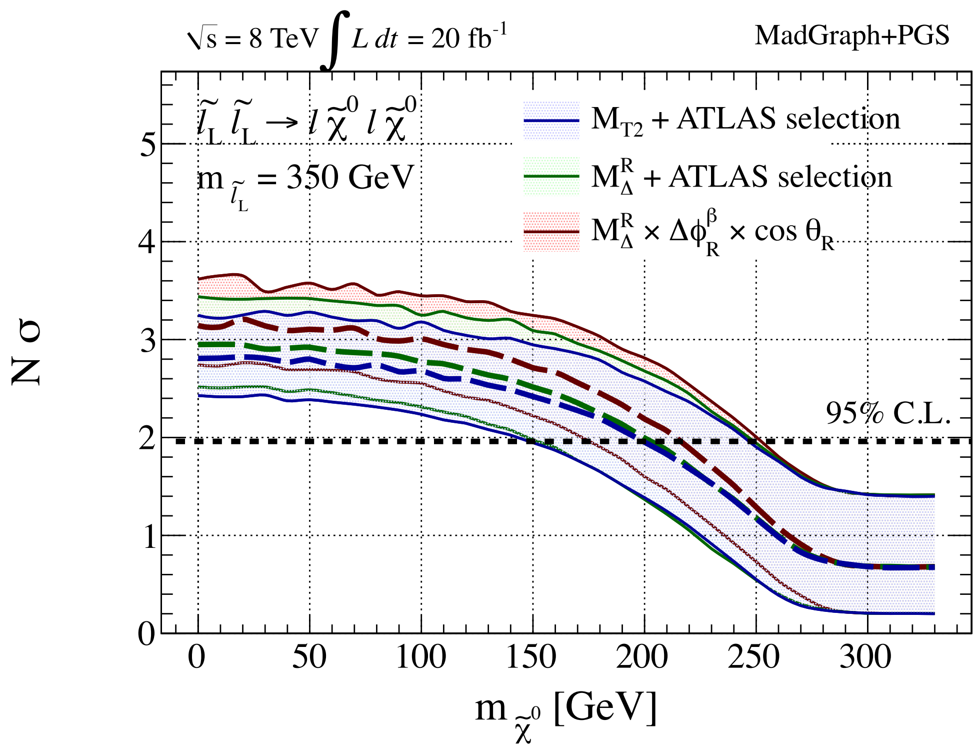

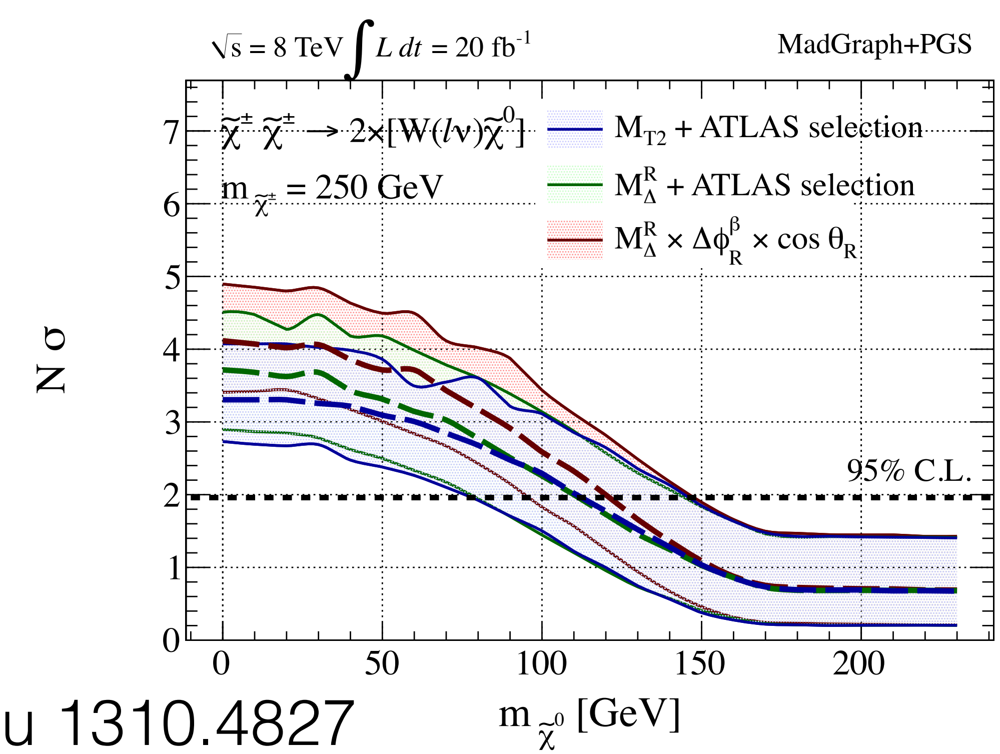

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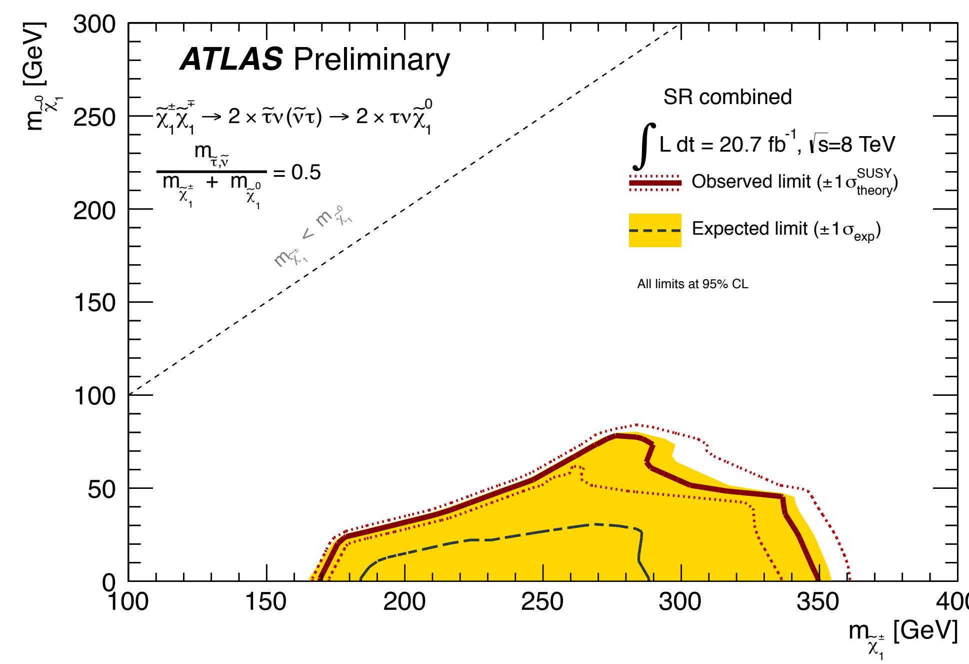
Stau Search

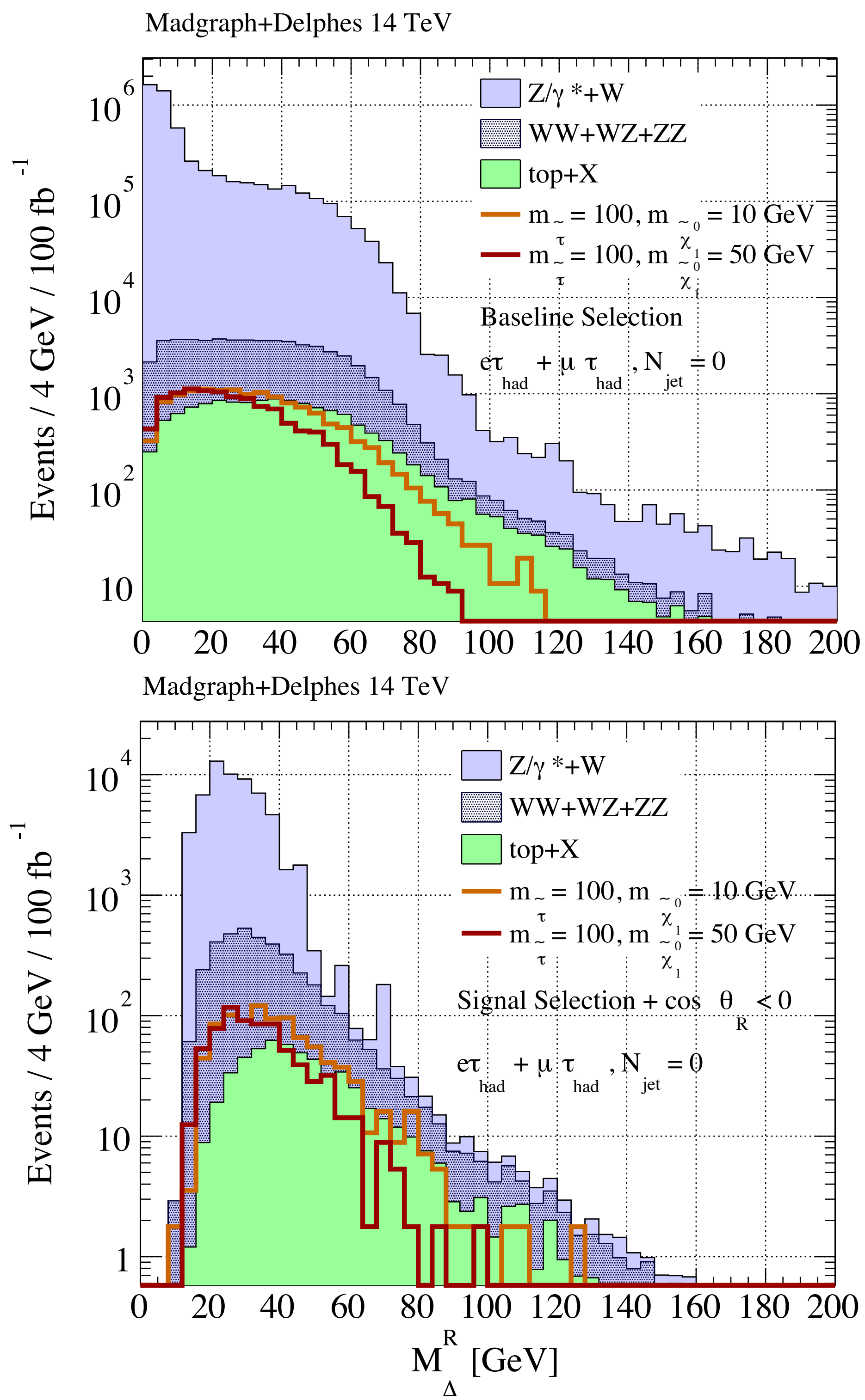
- Current bounds on $\tilde{\tau} \rightarrow \tau \tilde{\chi}_1^0$ have made only moderate improvements since LEP-II



- ATLAS-CONF-2013-028:
- "*The best upper limit on the production cross-section is found for a stau mass of 140 GeV and a* $\tilde{\chi}_1^0$ *mass of 10 GeV.*"
  - (no plot)

Stau Search

- Using Super-Razor variables should be able to improve the reach.
- Working on theorist-level analysis at 14 TeV.
  - Use super-razor variables for both shape analysis and event selection.



MRB and C. Rogan. In progress

Conclusions

- Impressive bounds from the LHC from 7/8 TeV.
  - Can expect this to continue at 13/14 TeV
- However: “low” energy physics could remain undiscovered even in existing data.
  - Especially when signal lives inside background distributions
  - Higher energy may make these channels more difficult, as trigger thresholds rise
  - We still need new ways to search.
    - Super-Razor is one way, but not the only new way.