

Systematic NLSP Searches

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Disclaimer

- ▶ **this is not** about another big re-interpretation effort
- ▶ **this is** just a few small, friendly suggestions how the **experiments** could possibly minimize the “fineprint” on some of the limits they put forward in the next round
- ▶ plots are stolen from various experiments - **for illustration**, **not for completeness**

Why searching for the NLSP?

- ▶ for arbitrary SUSY particles, typical simplified model assumptions are not generally fulfilled
- ▶ however: NLSP pair production is “natural” application of simplified models
 - ▶ 100% BR \rightarrow LSP + SM partner often true for NLSP (exceptions later)
 - ▶ if done in a systematic and complete way, then directly applicable to full-scale models: in every model there *must* be an NLSP!
 - ▶ simple way for the **experiments** to reduce the need for re-interpretations
- ▶ \Rightarrow minimises the fingerprint!

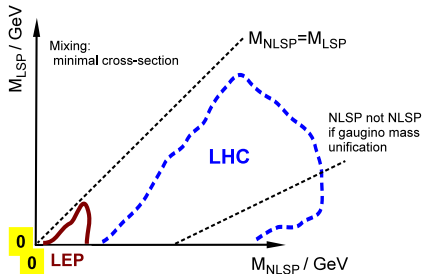
Minimising the fingerprint - generic recipe

for each conceivable NLSP:

- ▶ consider full m_{LSP} vs m_{NLSP} plane
- ▶ for each point in plane
 - ▶ work out choice of other relevant parameters (eg mixing angle) which gives lowest cross-section \times efficiency
 - ▶ give excluded region for this parameter choice
 - ▶ give limit on cross-section for this parameter choice
- ▶ for each individual NLSP, the number of “relevant” parameters is small, which makes procedure feasible
- ▶ combination of different analyses for different kinematic regions straight forward

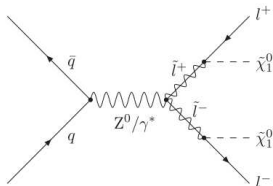
A generic example exclusion plot

- ▶ start at (0,0)
- ▶ draw diagonal
 $m_{\text{NLSP}} = m_{\text{NLSP}}$
- ▶ use mixing which gives minimal cross-section
- ▶ show limits of other colliders: LEP/Tevatron/...

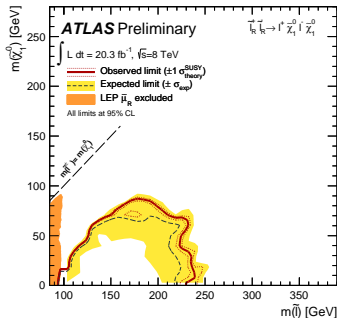


- ▶ draw additional lines/regions where BR=100% assumption could fail. Here eg: gaugino mass unification would turn $\tilde{\chi}_2^0$ / $\tilde{\chi}_1^\pm$ to be the NLSP instead of the target NLSP, introducing cascade decays...

Selectron / Smuon NLSP

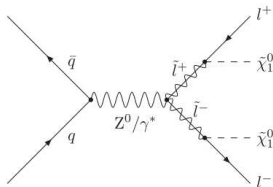


- ▶ negligible mixing
 \Rightarrow minimal cross-section for $\tilde{\mu}_R^+ \tilde{\mu}_R^- / \tilde{e}_R^+ \tilde{e}_R^-$
- ▶ cross-section uniquely defined for each point in plane, no hidden parameter

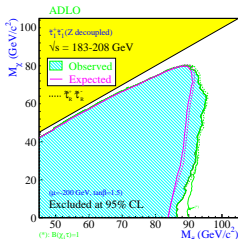
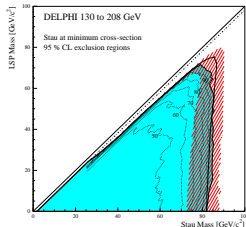


- ▶ isn't this it? Nearly:
- ▶ **attention:** $\tilde{\mu}_R$ and \tilde{e}_R mass-degenerate here
 \Rightarrow unnecessary restriction

Stau NLSP

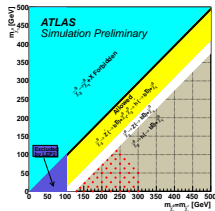
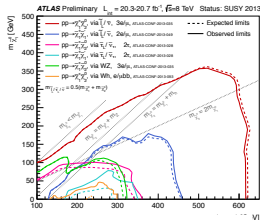


- ▶ mixing important \rightarrow 1 add. parameter
 \Rightarrow minimal cross-section for Z decoupling from $\tilde{\tau}_1$
- ▶ effect on efficiencies??? (direction / momentum of visible τ -decay products depends on τ -polarisation)



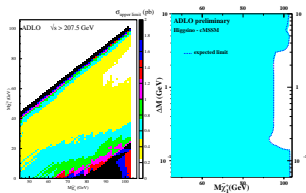
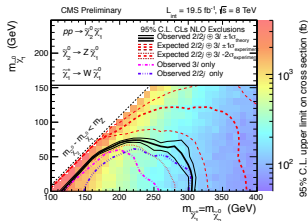
Chargino and/or Neutralino NLSP

- ▶ mixing more complex; LSP and NLSP nature correlated
- ▶ NLSP \Rightarrow no intermediate slepton: BRs depend mostly on Δm
 - ▶ $\tilde{\chi}_1^+ \rightarrow W^{+(*)} \tilde{\chi}_1^0$:
 - ▶ $\tilde{\chi}_2^0 \rightarrow$
 $H\tilde{\chi}_1^0 / Z^{0(*)}\tilde{\chi}_1^0 / \gamma\tilde{\chi}_1^0$
- ▶ full generality: give cross-section limits in m_{LSP} vs m_{NLSP} plane



more on Chargino NLSP

- ▶ production modes:
 - ▶ $\tilde{\chi}_1^\pm \tilde{\chi}_2^0$: ok if $m_{\tilde{\chi}_1^\pm} = m_{\tilde{\chi}_2^0}$
 - ▶ even more model-independent: $\tilde{\chi}_1^+ \tilde{\chi}_1^-$
 \Rightarrow minimal cross-section from γ exchange (if no light squark nearby)
- ▶ can be converted into mass limit for any model assumption
- ▶ particularly interesting: Higgsino LSP: $m_{\tilde{\chi}_1^\pm} = m_{\tilde{\chi}_2^0}$, but very small $\Delta m \Rightarrow \log(\Delta m)$ vs m_{NLSP}
- ▶ Wino LSP: $m_{\tilde{\chi}_1^\pm} \neq m_{\tilde{\chi}_2^0} \Rightarrow \tilde{\chi}_1^\pm$ pair production, again $\log(\Delta m)$ vs m_{NLSP}



...and so on:

- ▶ Neutralino NLSP
- ▶ Stop NLSP - for every $(m_{\text{NLSP}}, m_{\text{LSP}})$ choose mixing which gives minimum cross-section \times efficiency
- ▶ Sbottom NLSP - ditto
- ▶ Invisible NLSP, eg $\tilde{\nu}$: cross-section limit from monojet / monophoton?
- ▶ ... finally: double the set of plots by doing the same for gravitino!

Conclusions

- ▶ NLSP pair production is “naturally” described by simplified models
- ▶ systematic and complete set of NLSP limits makes the experimental plots directly applicable to any model
- ▶ a generic recipe for exclusions in the m_{LSP} vs m_{NLSP} plane has been given
- ▶ please:
 - ▶ start plots from (0,0)
 - ▶ show limits of previous colliders
 - ▶ show $m_{\text{LSP}} = m_{\text{NLSP}}$
 - ▶ indicate regions where BR=100% could fail