Resummation effects in weak SUSY processes

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arXiv: 2006.02294

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Westfälische Wilhelms-Universität Münster

Topics of this talk

- **Features of resummation**
  - Perturbative expansion and resummation of large logs
  - Threshold resummation at NNLL for Drell-Yan processes.

- **Slepton pair production at aNNLO+NNLL**

- **Electroweakino pair production at aNNLO+NNLL**
  - Mostly Higgsino scenario
  - Mostly gaugino scenario

- **Conclusions**

Resummation

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Resummation

Heavy particles will be abundantly produced close to threshold and with small transverse momentum.

The perturbative expansion can be spoiled by the presence of large logarithmic terms (Sudakov Logs) of the form:

$$\begin{cases} \alpha_s^n \log^m \left(\frac{M^2}{p_T^2}\right) \\ \alpha_s^n \frac{\log^m(1-z)}{1-z} \end{cases} \qquad m \leq 2n \qquad z = M^2/\hat{s}$$

A precise calculation of (differential) cross sections for the production of heavy particles requires a consistent treatment of these terms.

Y. L. Dokshitzer, D. Diakonov, and S. I. Troian, Phys. Rept. 58, (1980) 269

S. Catani and L. Trentadue, Nucl. Phys. B 327 (1989) 323

A **resummation** to all orders of the large logarithmic contributions is possible through a transformation in Mellin space.

Calulation of LO, NLO, NLO+NLL and aNNLO+NNLL cross sections for SUSY processes are performed using the **RESUMMINO** pacakge.

G. Bozzi, B. Fuks, and M. Klasen, Phys. Rev. D 74, (2006) 015001 Nucl. Phys. B 794, (2007) 46 Nucl. Phys. B 777, (2007) 157-181

J. Debove, B. Fuks, and M. Klasen, Phys. Lett. B 688, (2010) 208 Nucl. Phys. B 842, (2011) 51 Nucl. Phys. B 849, (2011) 64

B. Fuks, M. Klasen, D. R. Lamprea, M. Rothering, JHEP 1210, (2012) 081 Eur. Phys. J. C73, (2013) 2480

Resummation

Switch to Mellin space:

$$F(N) = \int_0^1 dy\, y^{N-1} F(y) \quad \Rightarrow \quad \left[\frac{\ln^m(1-z)}{1-z}\right]_+ \to \ln^{m+1} N + \ldots$$

Here the cross section factorizes:

$$\sigma_{ab}^{(\mathrm{res.})}(N, M^2, \mu_R^2, \mu_F^2) = H_{ab}(M^2, \mu_R^2, \mu_F^2) \exp[G_{ab}(N, M^2, \mu_R^2, \mu_F^2)] + \mathcal{O}\left(\frac{1}{N}\right)$$

Hard function: Independent of N, but process dependent

Exponent: Depends on N, but universal

$$G_{ab}(N, M^2, \mu_R^2, \mu_F^2) = L G_{ab}^{(1)}(\lambda) + G_{ab}^{(2)}(\lambda, M^2, \mu_R^2, \mu_F^2) + \alpha_s G_{ab}^{(3)}(\lambda, M^2, \mu_R^2, \mu_F^2)$$

Leading Log (LL) — Next-to-Leading Log (NLL) — Next-to-next-to-Leading Log (NNLL)

Terms in the exponent only depend on the initial state.

For Drell-Yan processes under analysis, we only have quark-antiquark initial state. $\Rightarrow$ $G_{ab}^{(i)} = g_a^{(i)} + g_b^{(i)}$

Resummation at NNLL

Necessary ingredient for NNLL resummation:

$$
\begin{aligned}
g_q^{(3)}(\lambda) &= \frac{A^{(1)}b_1^2}{2\pi b_0^4}\frac{1}{1-2\lambda}\left[2\lambda^2+2\lambda\ln(1-2\lambda)+\frac{1}{2}\ln^2(1-2\lambda)\right]\\
&+\frac{A^{(1)}b_2}{2\pi b_0^3}\left[2\lambda+\ln(1-2\lambda)+\frac{2\lambda^2}{1-2\lambda}\right]+\frac{2A^{(1)}}{\pi}\zeta_2\frac{\lambda}{1-2\lambda}\\
&-\frac{A^{(2)}b_1}{(2\pi)^2 b_0^3}\frac{1}{1-2\lambda}\left[2\lambda^2+2\lambda+\ln(1-2\lambda)\right]+\frac{A^{(3)}}{\pi^3 b_0^2}\frac{\lambda^2}{1-2\lambda}-\frac{D^{(2)}}{2\pi^2 b_0}\frac{\lambda}{1-2\lambda}\\
&+\frac{A^{(1)}b_1}{2\pi b_0^2}\frac{1}{1-2\lambda}\left[2\lambda+\ln(1-2\lambda)\right]\ln\left(\frac{M^2}{\mu_R^2}\right)+\frac{A^{(1)}}{2\pi}\left[\frac{\lambda}{1-2\lambda}\ln^2\left(\frac{M^2}{\mu_R^2}\right)-\lambda\ln^2\left(\frac{\mu_F^2}{\mu_R^2}\right)\right]\\
&-\frac{A^{(2)}}{2\pi^2 b_0}\left[\frac{\lambda}{1-2\lambda}\ln\left(\frac{M^2}{\mu_R^2}\right)-\lambda\ln\left(\frac{\mu_F^2}{\mu_R^2}\right)\right]
\end{aligned}
$$

with

$$\lambda = \alpha_s b_0 L \text{ and } L = \ln\bar{N} = \ln(Ne^{\gamma_E})$$

A. Vogt, Phys. Lett. B497 (2001) 228-234

$$
\begin{aligned}
A^{(1)} &= 2C_F,\\
A^{(2)} &= 2C_F\left[C_A\left(\frac{67}{18}-\zeta_2\right)-\frac{5}{9}n_f\right],\\
A^{(3)} &= \frac{1}{2}C_F\Big[C_A^2\left(\frac{245}{24}-\frac{67}{9}\zeta_2+\frac{11}{6}\zeta_3+\frac{11}{5}\zeta_2^2\right)+C_F n_f\left(2\zeta_3-\frac{55}{24}\right)\\
&+C_A n_f\left(\frac{10}{9}\zeta_2-\frac{7}{3}\zeta_3-\frac{209}{108}\right)-\frac{n_f^2}{27}\Big]
\end{aligned}
$$

$$D^{(2)} = 2C_F\left[C_A\left(-\frac{101}{27}+\frac{11}{3}\zeta_2+\frac{7}{2}\zeta_3\right)+n_f\left(\frac{14}{27}-\frac{2}{3}\zeta_2\right)\right]$$

Resummation at NNLL

Hard matching coefficients:

$$H_{ab}(M^2,\mu_R^2,\mu_F^2) = \sigma_{ab}^{(0)}\mathcal{C}_{ab}(M^2,\mu_R^2,\mu_F^2) \quad \text{with} \quad \mathcal{C}_{ab}(M^2,\mu_R^2,\mu_F^2) = \sum_{n=0}\left(\frac{\alpha_s}{2\pi}\right)^n \mathcal{C}_{ab}^{(n)}(M^2,\mu_R^2,\mu_F^2)$$

They can be expanded as:

$$\mathcal{C}_{ab}^{(n)}(M^2,\mu_R^2,\mu_F^2) = \left(\frac{2\pi}{\alpha_s}\right)^n \left[\frac{\sigma_{ab}^{(n)}}{\sigma_{ab}^{(0)}}\right]_{\text{N-ind}}$$

NNLO DY cross section from literature:

N. Kidonakis, Int.J.Mod.Phys. A19 (2004) 1793-1821

N. Kidonakis, Phys.Rev. D77 (2008) 053008

By their means, we can easily obtain the n-th order cross section in Mellin space:

$$\begin{aligned}
\mathcal{C}_{ab}^{(0)} &= 1, \\
\mathcal{C}_{ab}^{(1)} &= C_F\left[\frac{4}{3}(\pi^2-6) - 3\log\left(\frac{\mu_F^2}{M^2}\right)\right], \\
\mathcal{C}_{ab}^{(2)} &= \frac{C_F}{720}\Bigg\{5(-4605C_A + 4599C_F + 762n_f) + 20\pi^2(188C_A - 297C_F - 32n_f) \\
&- 92\pi^4(C_A - 6C_F) + 180(11C_A + 18C_F - 2n_f)\log^2\left(\frac{\mu_F^2}{M^2}\right) \\
&- 160(11C_A - 2n_f)(6-\pi^2)\log\left(\frac{\mu_R^2}{M^2}\right) + 80(151C_A - 135C_F + 2n_f)\zeta_3 \\
&+ 20\log\left(\frac{\mu_F^2}{M^2}\right)\Bigg[-51C_A + 837C_F + 6n_f - 4\pi^2(11C_A + 27C_F - 2n_f) \\
&+ (-198C_A + 36n_f)\log\left(\frac{\mu_R^2}{M^2}\right) + 216(C_A - 2C_F)\zeta_3\Bigg]\Bigg\}
\end{aligned}$$

Resummation at NNLL

Next step requires the matching of resummed and fixed order results to avoid double counting:

$$\sigma_{ab} = \sigma_{ab}^{(\text{res.})} + \sigma_{ab}^{(\text{f.o.})} - \sigma_{ab}^{(\text{exp.})}$$

Expand the resummed cross section at given fixed order:

$$\begin{aligned}\sigma_{ab}^{(\text{exp.})}(N, M^2, \mu_R^2, \mu_F^2) &= \sigma_{ab}^{(0)} \mathcal{C}_{ab}(M^2, \mu_R^2, \mu_F^2) \exp[G_{ab}(N, M^2, \mu_R^2, \mu_F^2)] \\ &= \sigma_{ab}^{(0)} \left[1 + \left(\frac{\alpha_s}{2\pi}\right) \mathcal{C}_{ab}^{(1)} + \left(\frac{\alpha_s}{2\pi}\right)^2 \mathcal{C}_{ab}^{(2)} + \dots\right]\left[1 + \left(\frac{\alpha_s}{2\pi}\right)\mathcal{K}^{(1)} + \left(\frac{\alpha_s}{2\pi}\right)^2 \mathcal{K}^{(2)} + \dots\right] \\ &= \sigma_{ab}^{(0)} \left[1 + \left(\frac{\alpha_s}{2\pi}\right)\left(\mathcal{C}_{ab}^{(1)} + \mathcal{K}^{(1)}\right) + \left(\frac{\alpha_s}{2\pi}\right)^2 \left(\mathcal{C}_{ab}^{(2)} + \mathcal{K}^{(2)} + \mathcal{C}_{ab}^{(1)}\mathcal{K}^{(1)}\right) + \dots\right]\end{aligned}$$

$$\begin{aligned}\mathcal{K}^{(1)} &= \mathcal{K}^{(1,1)} L + \mathcal{K}^{(1,2)} L^2, \\ \mathcal{K}^{(2)} &= \mathcal{K}^{(2,1)} L + \mathcal{K}^{(2,2)} L^2 + \mathcal{K}^{(2,3)} L^3 + \mathcal{K}^{(2,4)} L^4\end{aligned}$$

$$\begin{aligned}\mathcal{K}^{(1,1)} &= 4C_F \log\left(\frac{\mu_F^2}{s}\right), \\ \mathcal{K}^{(1,2)} &= 4C_F, \\ \mathcal{K}^{(2,1)} &= -\frac{C_F}{27}\Bigg\{56n_f - 404C_A + 3\log\left(\frac{\mu_F^2}{s}\right)\Bigg[20n_f + 2C_A(-67+3\pi^2) \\ &\quad + 3(11C_A - 2n_f)\left(\log\left(\frac{\mu_F^2}{\mu_R^2}\right) - \log\left(\frac{\mu_R^2}{s}\right)\right)\Bigg] + 378C_A\zeta_3\Bigg\}, \\ \mathcal{K}^{(2,2)} &= \frac{2}{9}C_F\Bigg[-10n_f + 67C_A - 3C_A\pi^2 + 36C_F\log^2\left(\frac{\mu_F^2}{s}\right) \\ &\quad + (33C_A - 6n_f)\log\left(\frac{\mu_R^2}{s}\right)\Bigg], \\ \mathcal{K}^{(2,3)} &= \frac{4}{9}C_F\left[11C_A - 2n_f + 36C_F\log\left(\frac{\mu_F^2}{s}\right)\right], \\ \mathcal{K}^{(2,4)} &= 8C_F^2\end{aligned}$$

NOTE: The SUSY-QCD corrections are only matched at NLO, since they are not known beyond this order. In this sense, our results are accurate to approximate NNLO (**aNNLO**) plus **NNLL** precision. This approximation is justified by the fact that the SUSY-QCD corrections are subdominant due to the large squark and gluino masses.

Last step involves an inverse Mellin transformation of the result (non-trivial)

S. Catani, M. Mangano, P. Nason, L. Trentadue, Nucl. Phys. B478 (1996) 273-310

Slepton pair production

- **Features of resummation**
  - Perturbative expansion and resummation of large logs
  - Threshold resummation at NNLL for Drell-Yan processes.

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- **Electroweakino pair production at aNNLO+NNLL**
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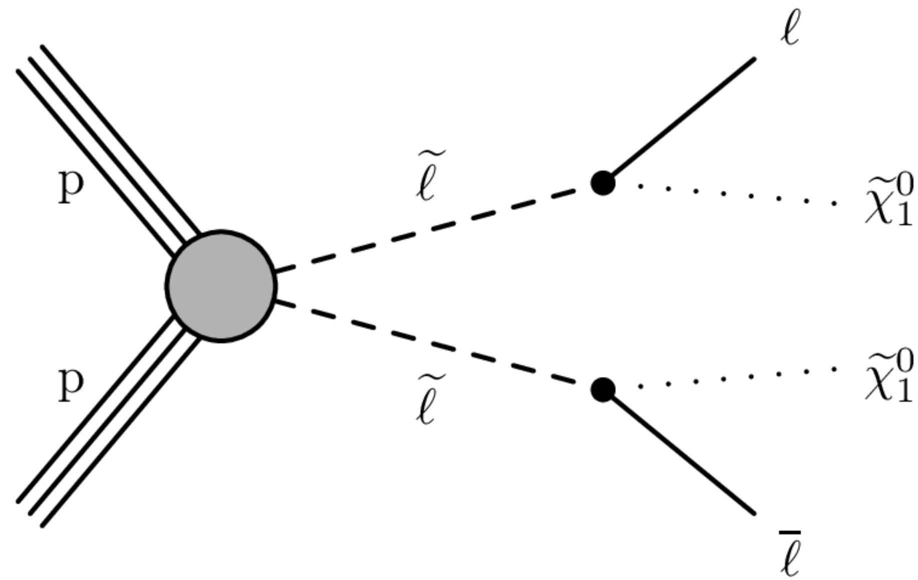
  - Mostly gaugino scenario

- **Conclusions**

Slepton signatures

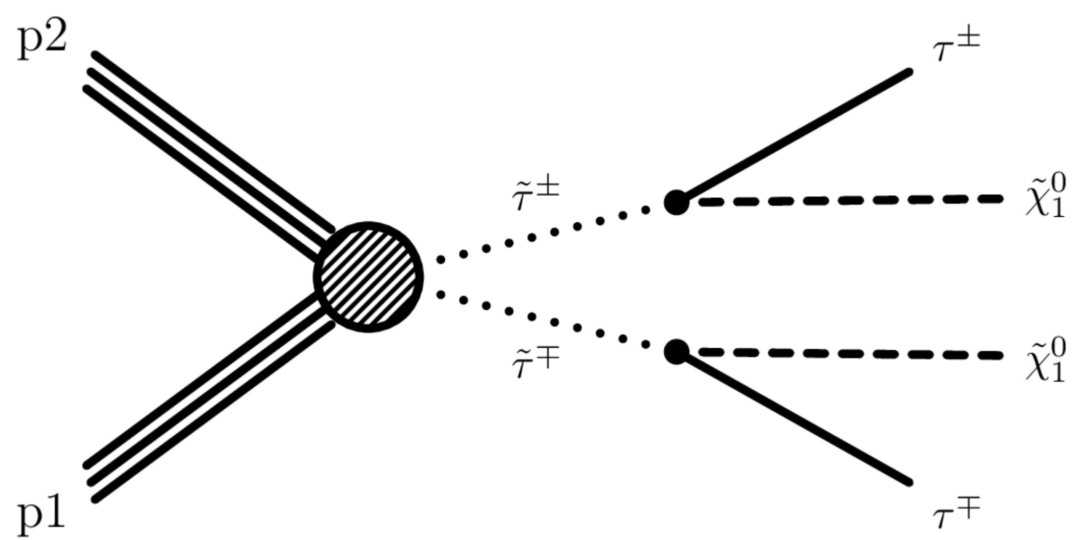
1st & 2nd generation:

$pp \rightarrow \ell^{+}\ell^{-}$ + MET



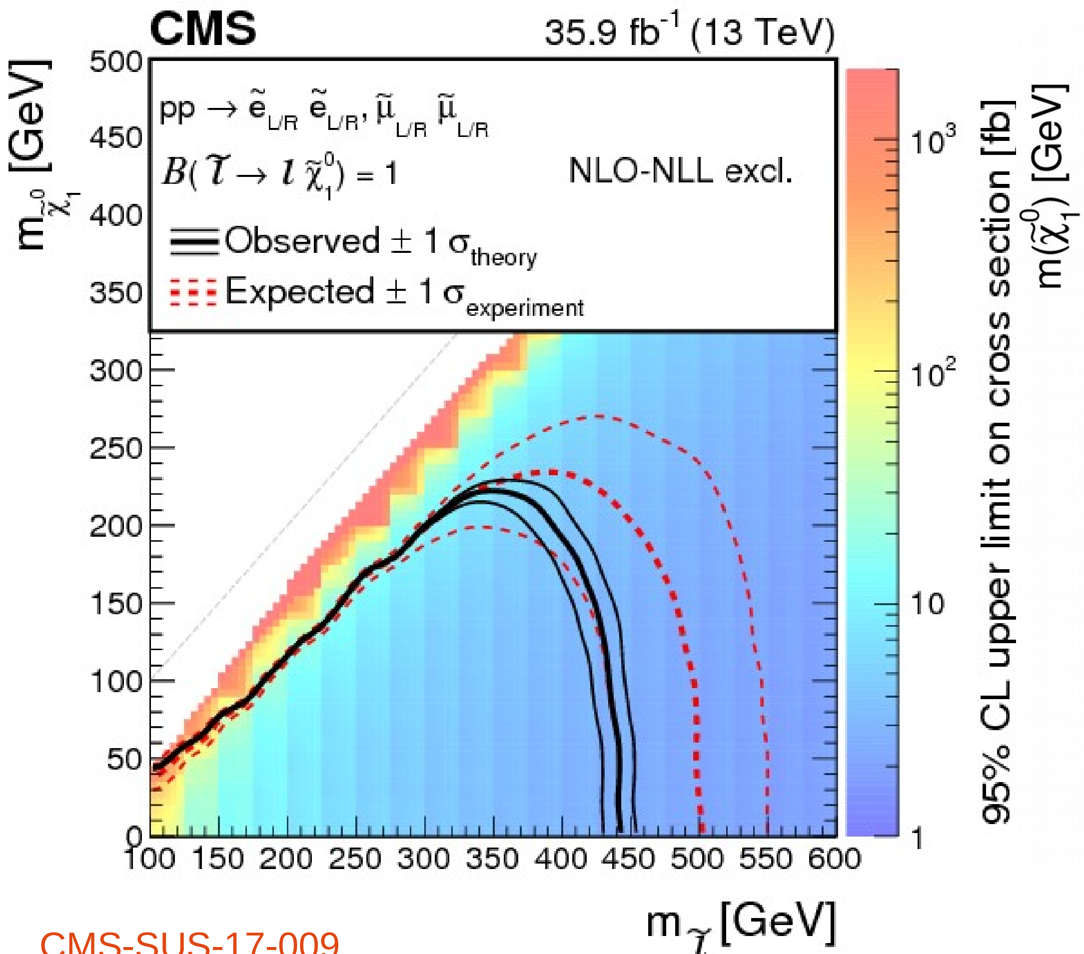
3rd generation:

$pp \rightarrow \tau^{+}\tau^{-}$ + MET

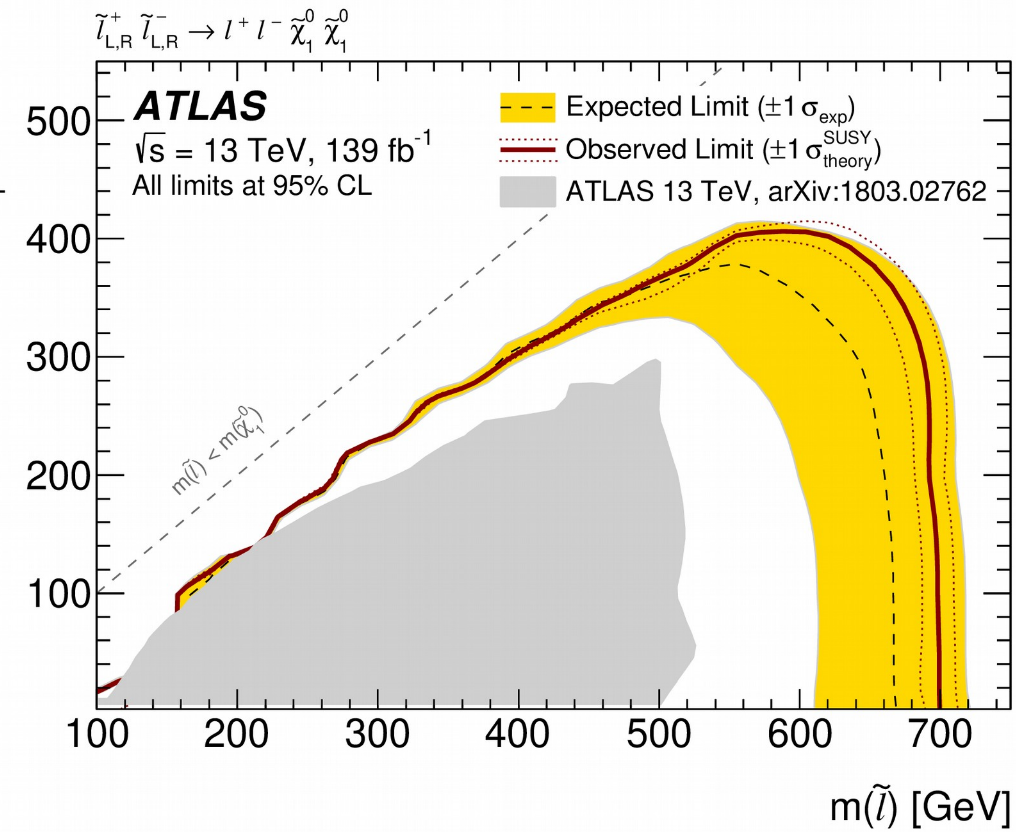


Experimental searches

First & second generation sleptons



CMS-SUS-17-009



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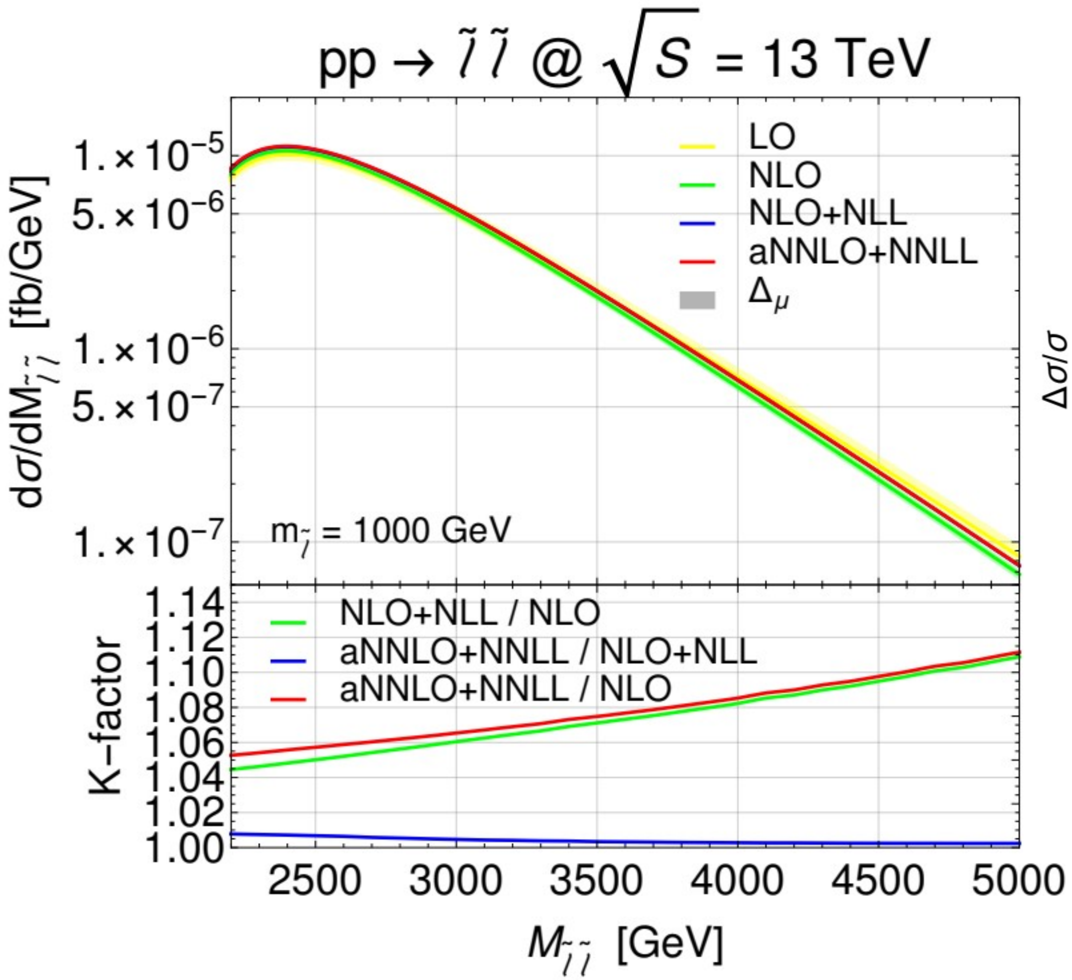
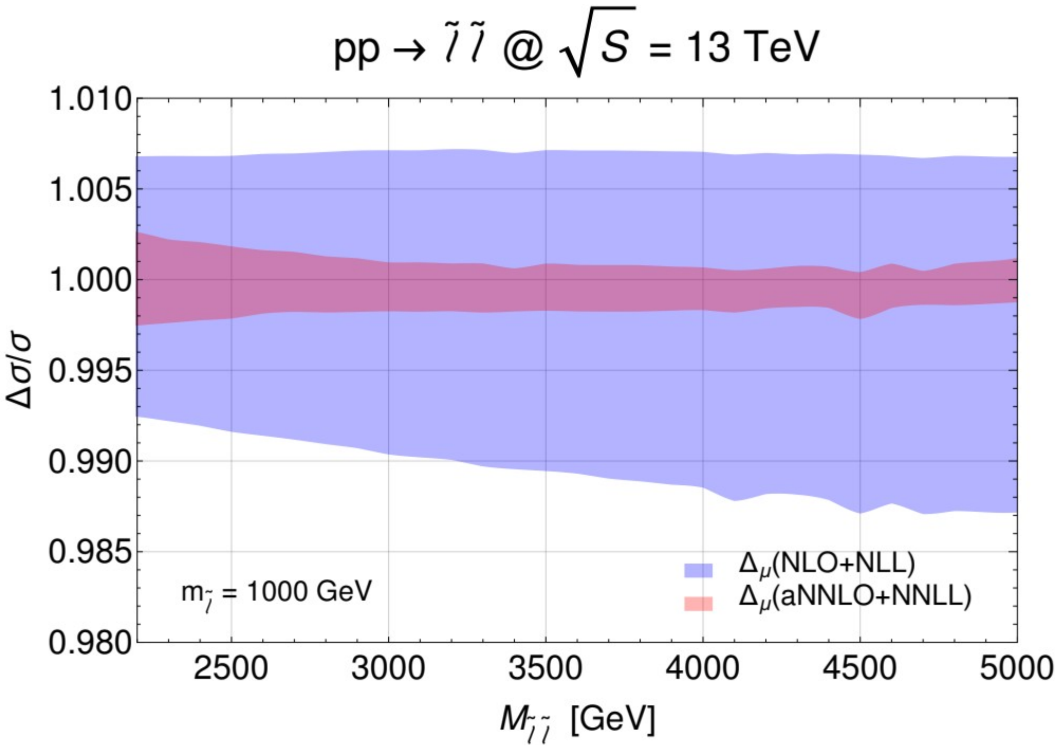
For <u>purely left-handed</u> sleptons the ATLAS (CMS) bounds set their masses above 700 (*400) GeV*.

Strong dependence on the neutralino mass.

(Loss of experimental sensitivity in the degenerate scenario.)

Slepton pair production

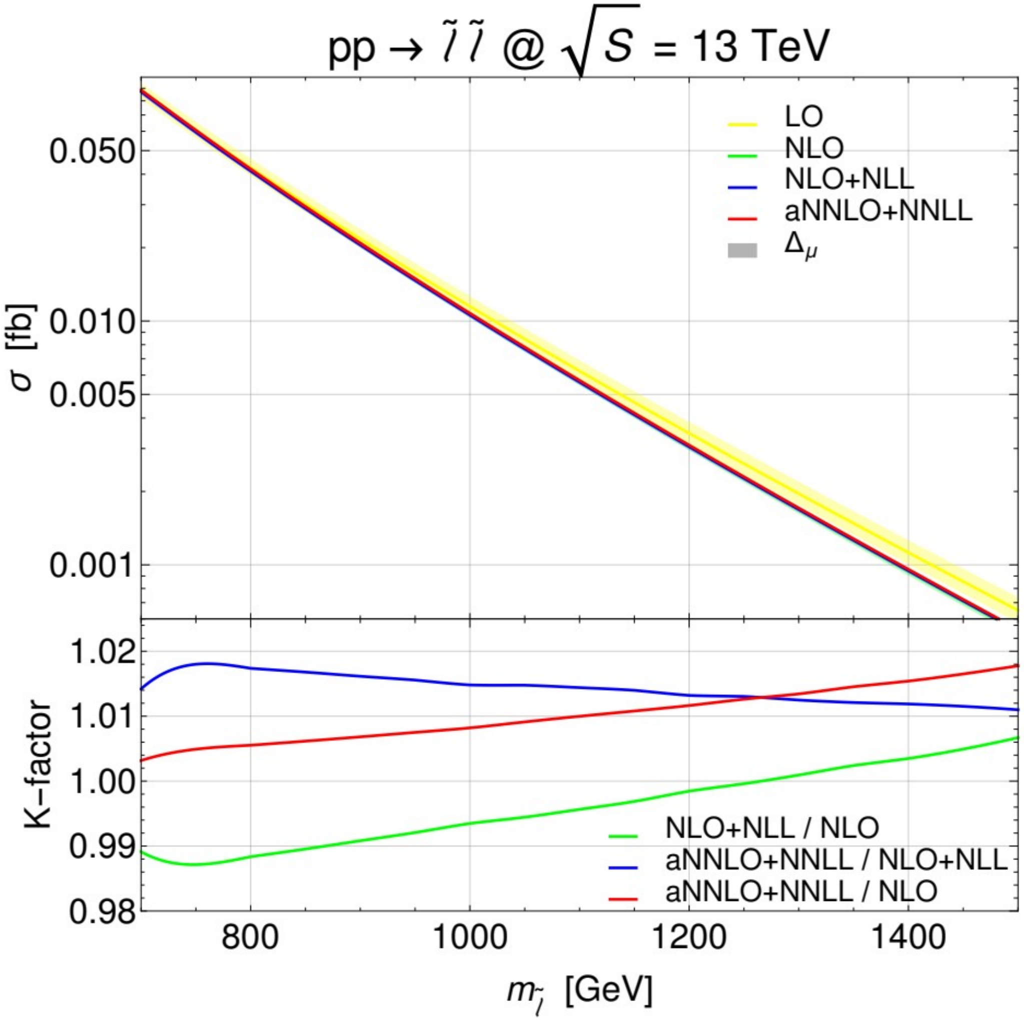


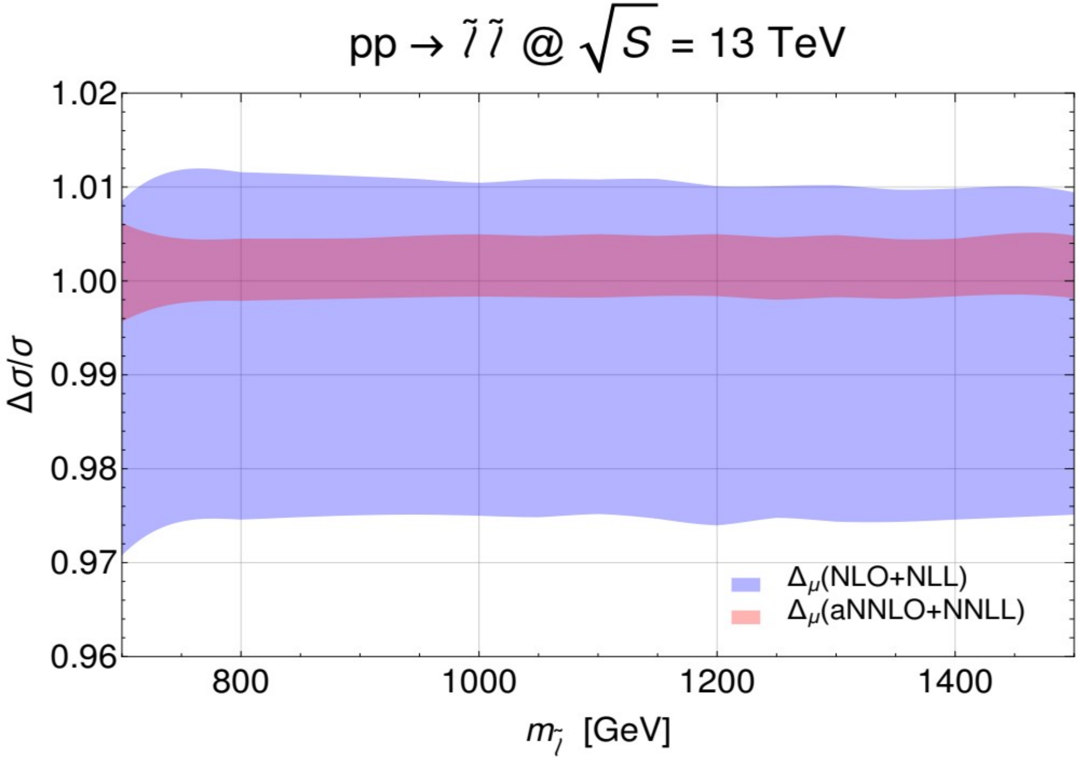


- Visible reduction of scale uncertainty from about 1% to about 0.1%.

- Resummation effects at NLL are more important at production threshold.
- K-factor increases from 4.5% to 11%
- The increase from NLO+NLL to aNNLO+NNLL is about 1%

Slepton pair production





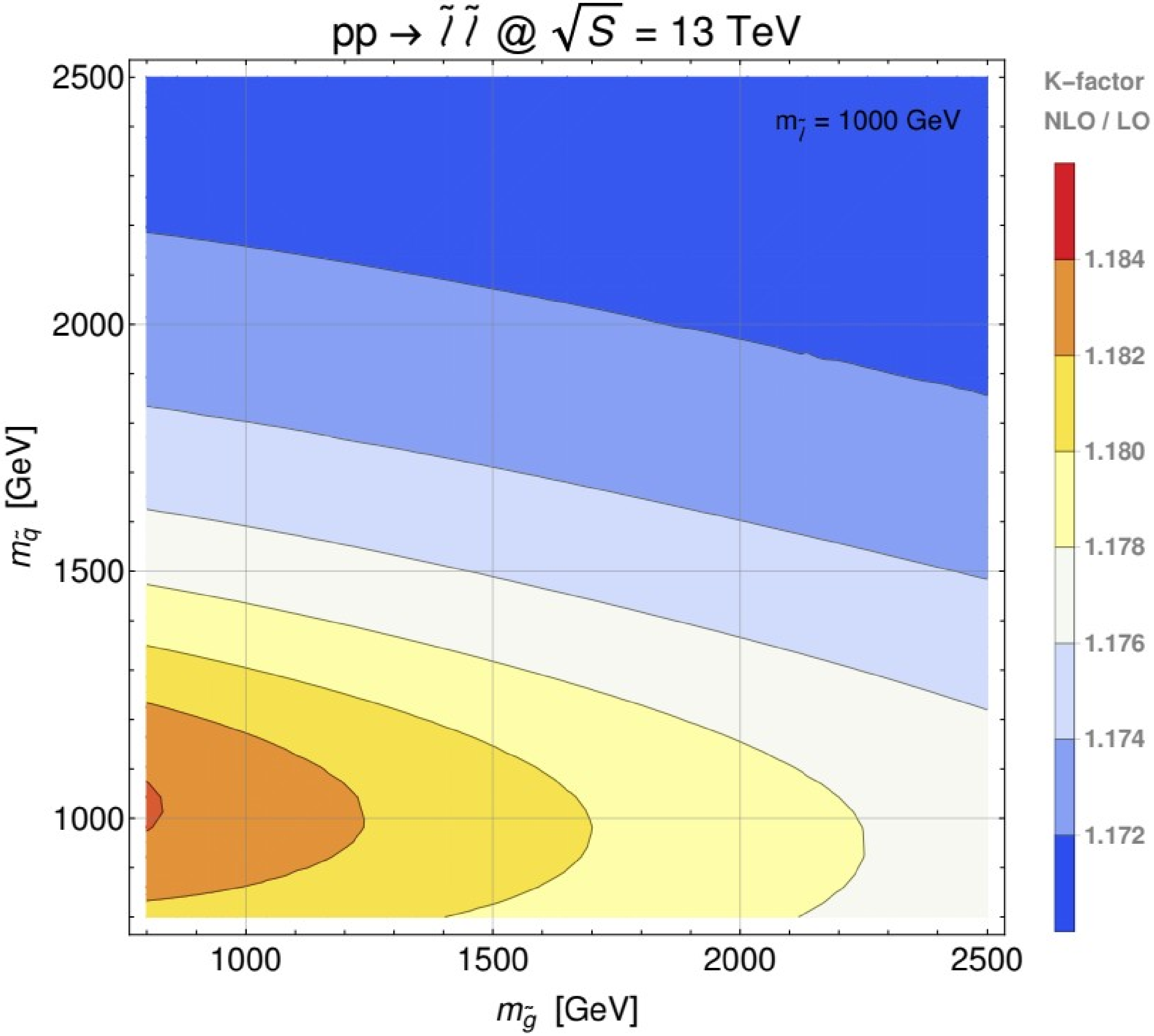
- Visible reduction of scale uncertainty from few % to few 0.1%.

- These cross sections correspond to:
  - more than 10 events at *700 GeV* at current integrated luminosity of *139 fb*$^{-1}$;
  - 3 events at *1 TeV* for LHC Run 3 goal of *300 fb*$^{-1}$;
  - Few events at *1.5 TeV* for HL-LHC goal of *3 ab*$^{-1}$

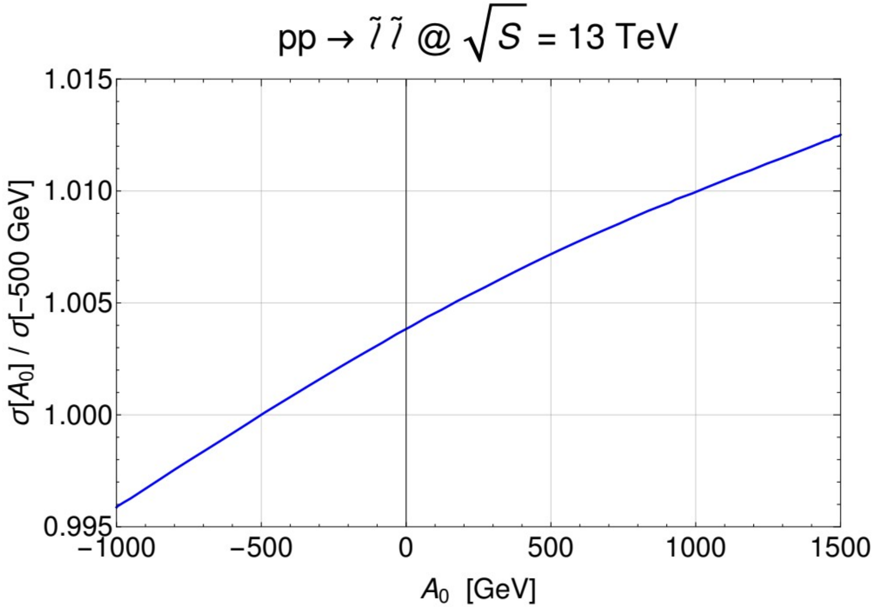
- aNNLO(+NNLL) corrections increase the NLO(+NLL) prediction by 1% - 2%.

Slepton pair production

NLO corrections in the gluino-squark mass plane.



A_0 parameter dependence



- Very weak dependence of NLO cross section on the sbottom mixing varying from −0.4% to +1.2%.

- Weak dependence from the strong SUSY sector, as K-factor varies between 1.170 to 1.186, i.e. less than 2%.
- Visible threshold behaviour from the triangle loop, as the squarks masses cross the slepton mass set at *1 TeV*.

Electroweakino pair production

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  - Mostly gaugino scenario

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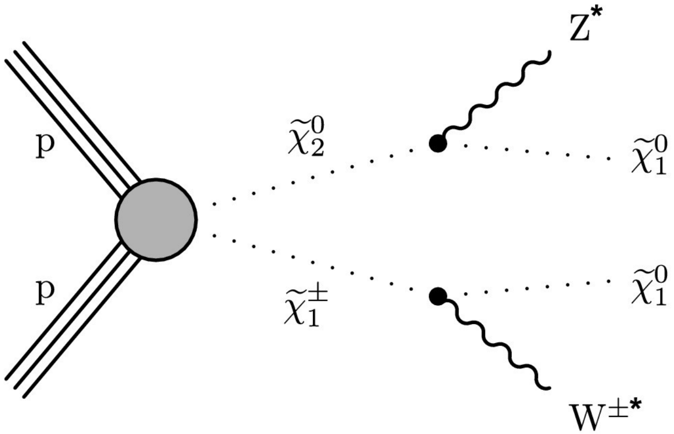
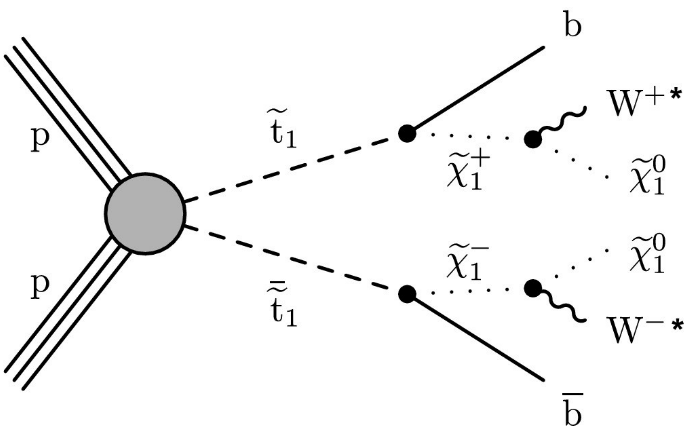
Electroweakinos signatures



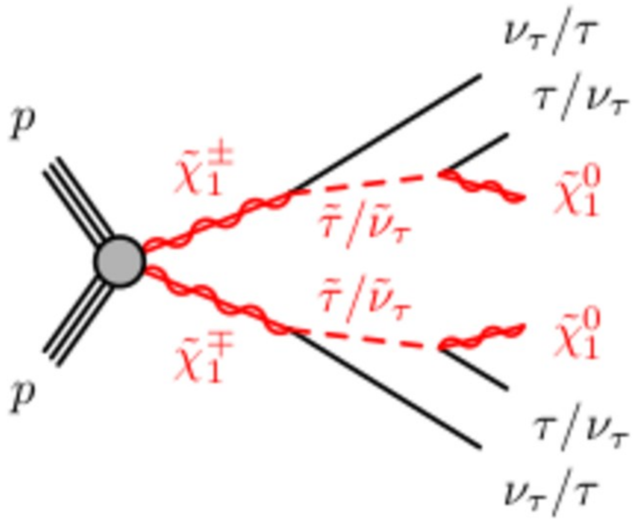
Mostly Higgsino:

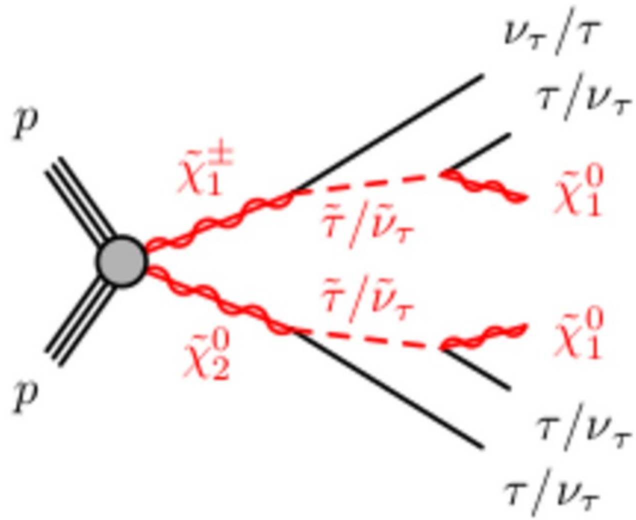
pp → *gauge bosons + MET*



Mostly gaugino:

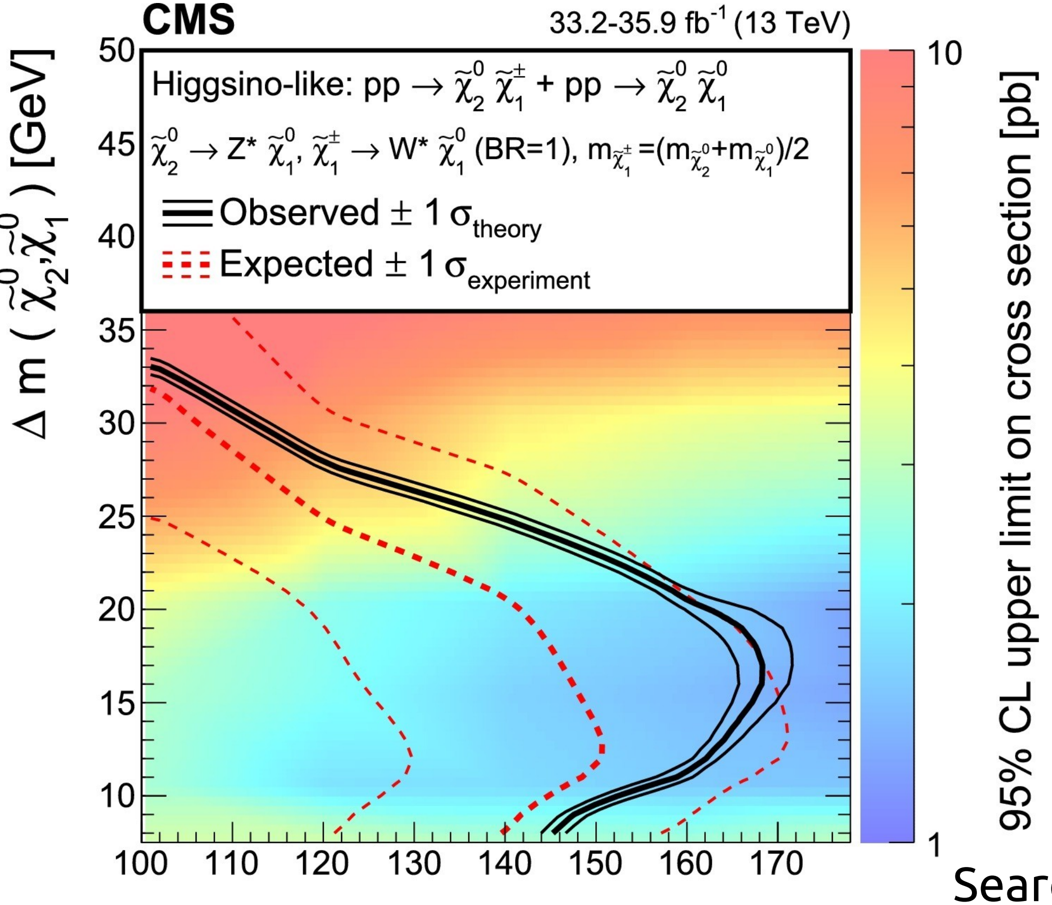
pp → *some τs + MET*



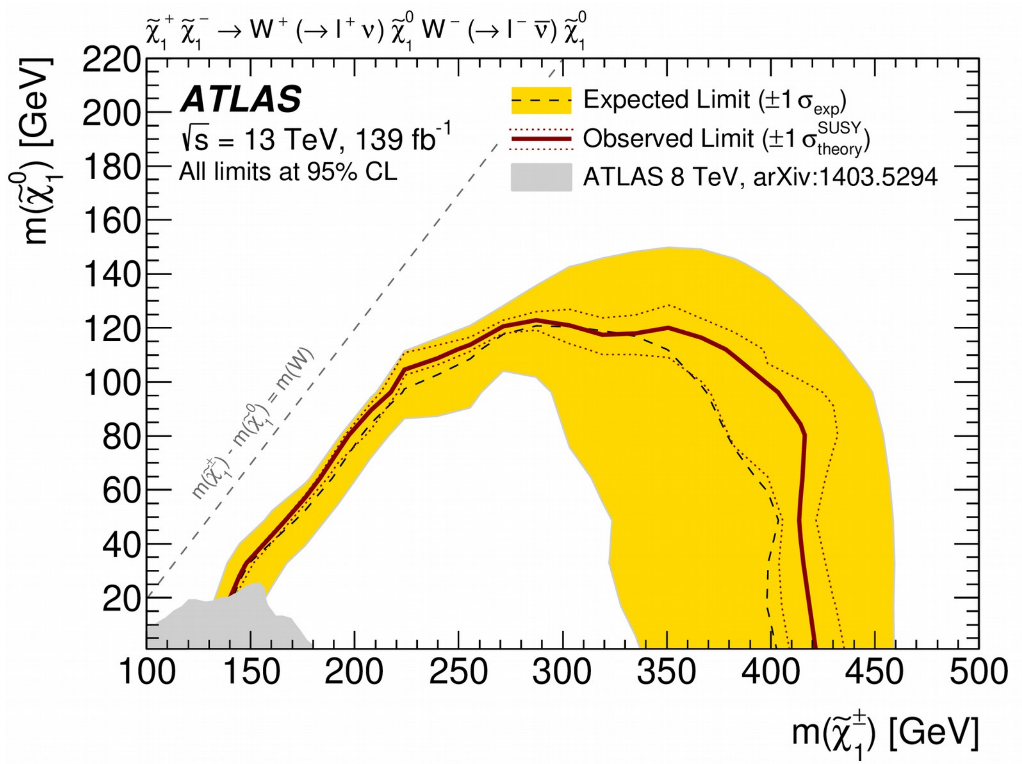


Experimental searches

Mostly Higgsino Electroweakinos



CMS Collaboration, Phys.Lett. B782 (2018) 440-467



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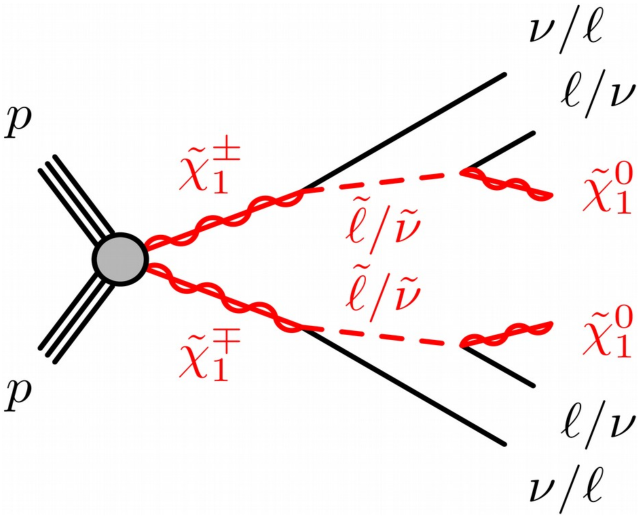
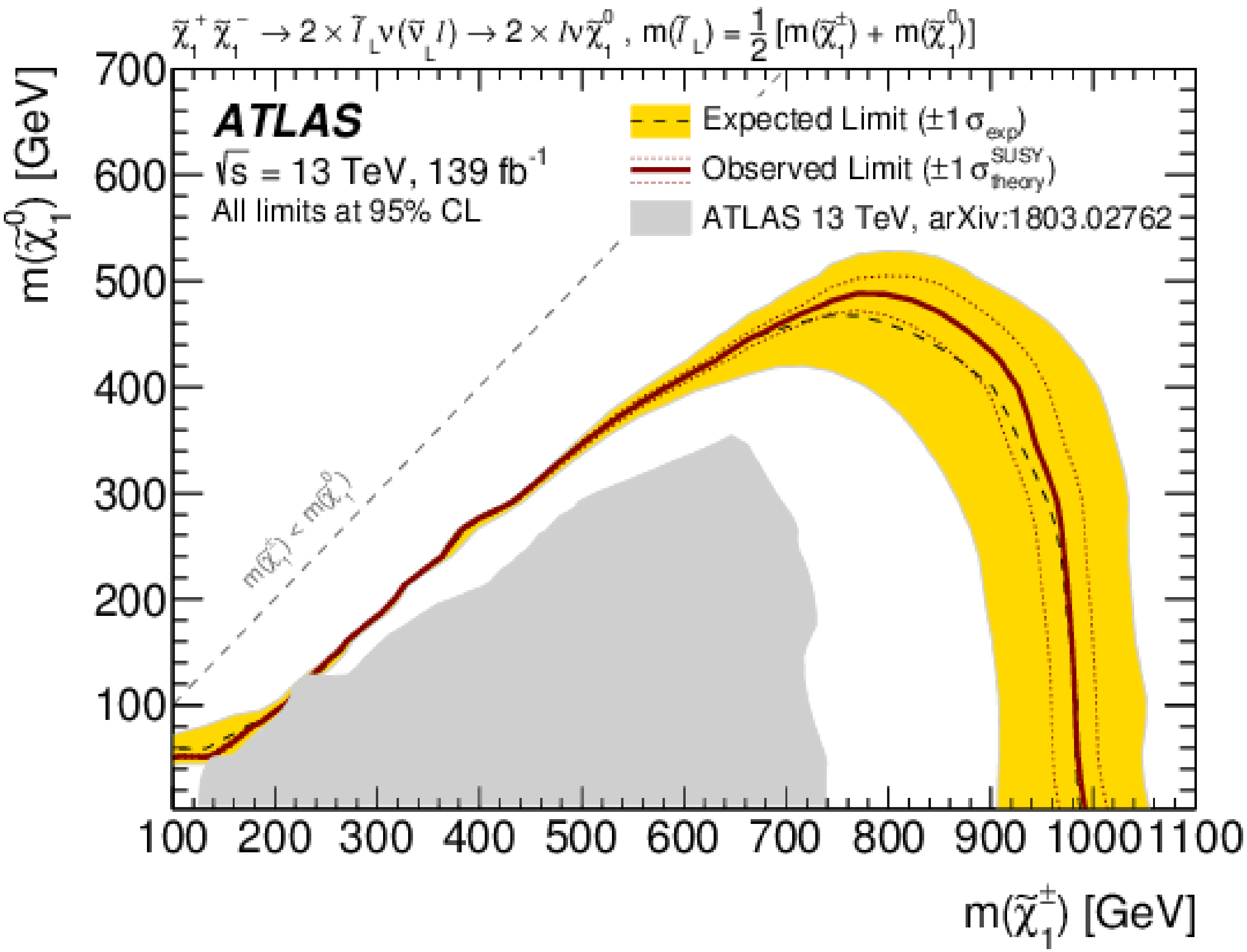
Searches designed for a compressed mass spectrum.
Visible decay products have low momentum.
(discrimination with SM processes with ISR hard jet)
(soft b-jets are not tagged)

For a massless light neutralino, chargino masses are excluded below *450 GeV* for the production of the lightest-chargino pairs assuming W-boson-mediated decays

Experimental searches

Mostly gaugino Electroweakinos





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For a massless light neutralino, chargino masses are excluded below *1 TeV* for the production of the lightest-chargino pairs assuming slepton-mediated decays.

Electroweakinos spectra

Interpretation of experimental results is performed within the **pMSSM**.

Mass spectra are obtained with SPheno providing the following input:

Following the indications in: B. Fucks, M. Klasen, S. Schmiemann, M. Sunder Eur. Phys. J. C78 (2018) 209

Mostly Higgsino electroweakinos:

$M_1 = M_2 \gg \mu$
mild dependence on $\tan\beta$

$\tan\beta = 30$
$M_1 = M_2 = 1000$ GeV
$\mu \in [100 - 500]$ GeV

$M_{\chi_2^0} \simeq \mu$
$M_{\chi_2^0} - M_{\chi_1^\pm} \simeq M_{\chi_1^\pm} - M_{\chi_1^0} \simeq 5 - 10$ GeV

Electroweakinos > 98% Higgsinos

Mostly gaugino electroweakinos:

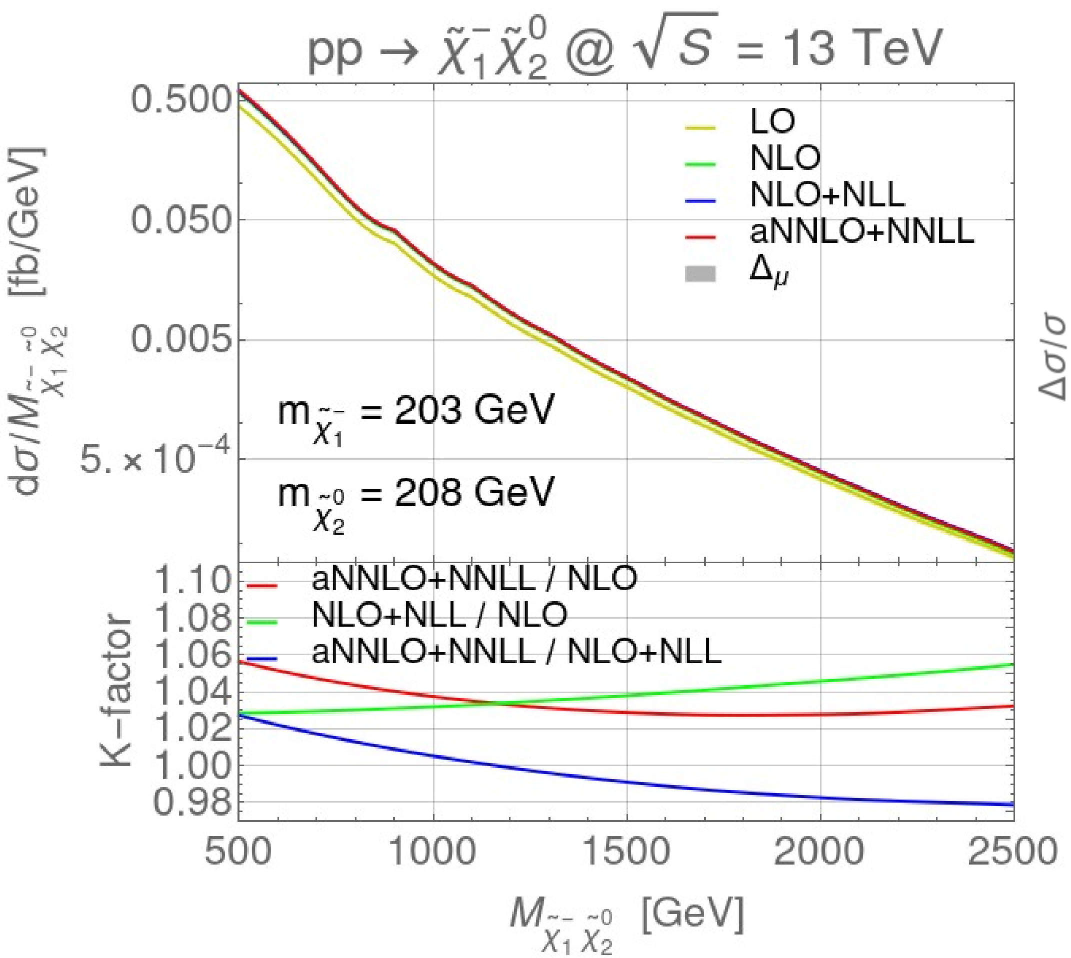
$\mu > M_2 > M_1$
mild dependence on $\tan\beta$

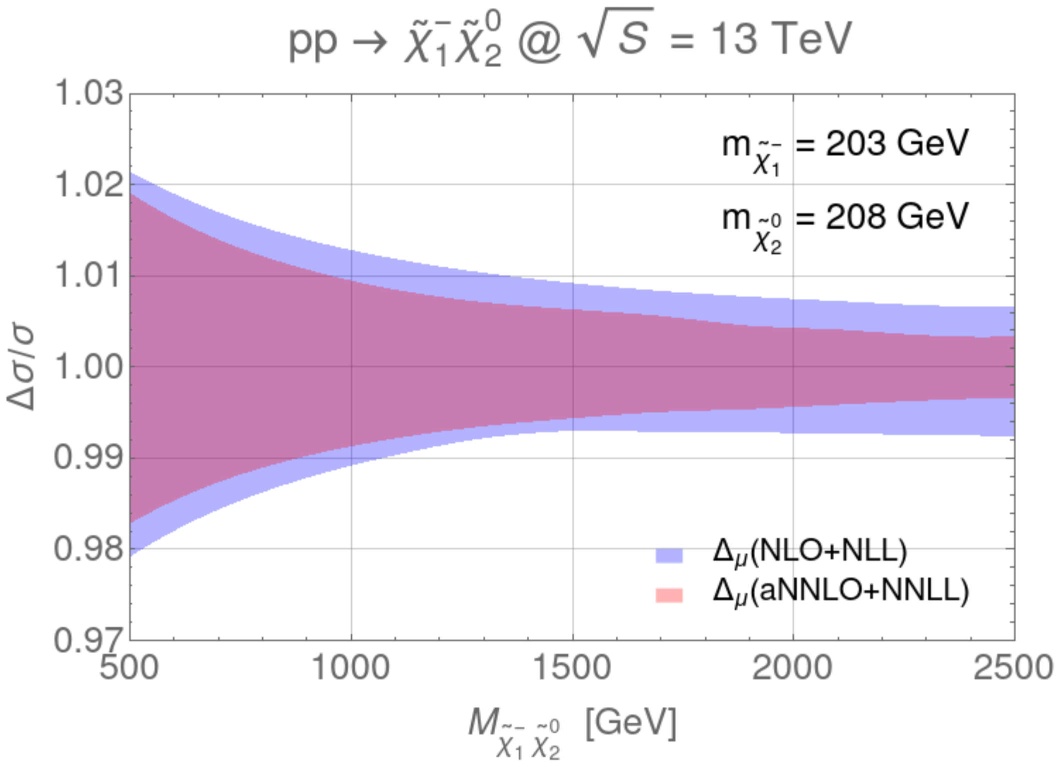
$\tan\beta = 5$
$\mu = 3000$ GeV
$M_1 = 100$ GeV
$M_2 \in [1000 - 2600]$ GeV

$M_{\chi_2^0} \simeq M_{\chi_1^\pm} \simeq M_2$
$M_{\chi_1^0} \simeq M_1$

Electroweakinos > 98% gauginos

Mostly Higgsino Electroweakinos

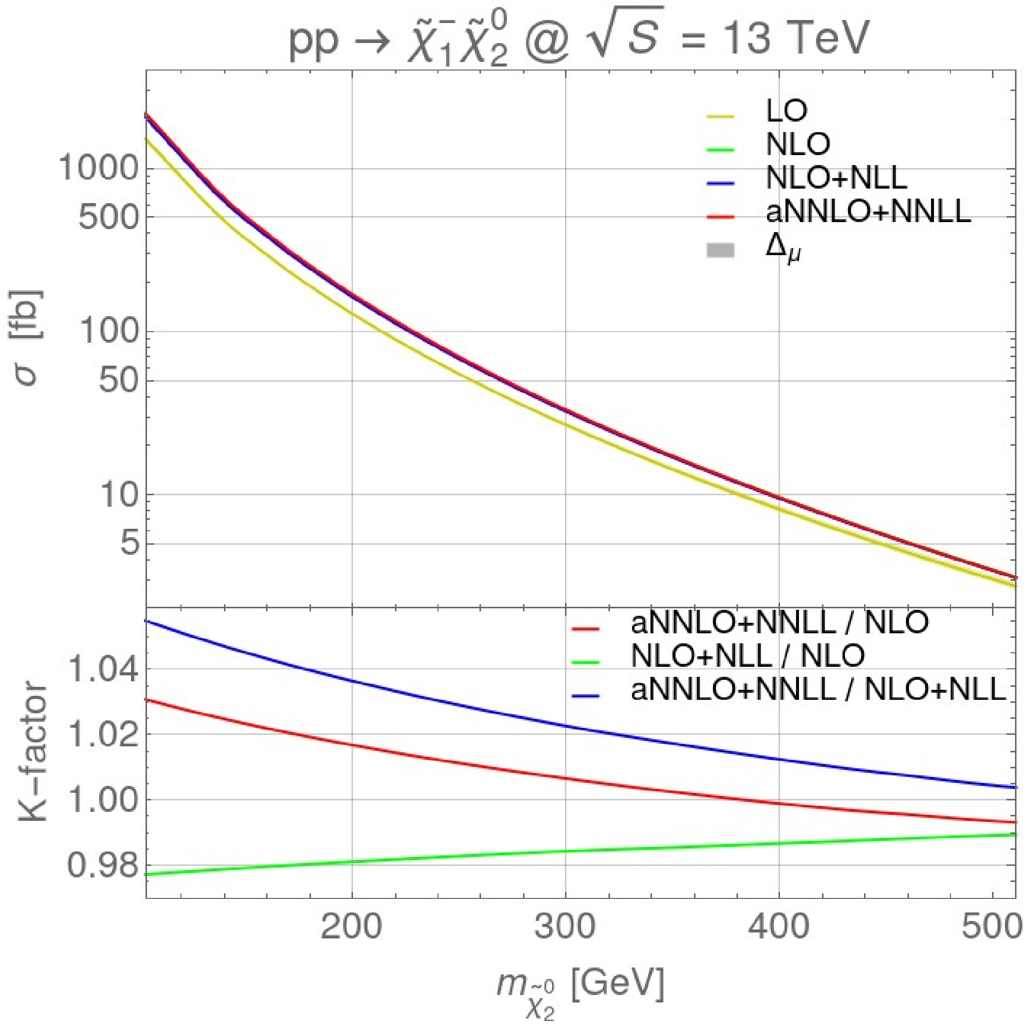


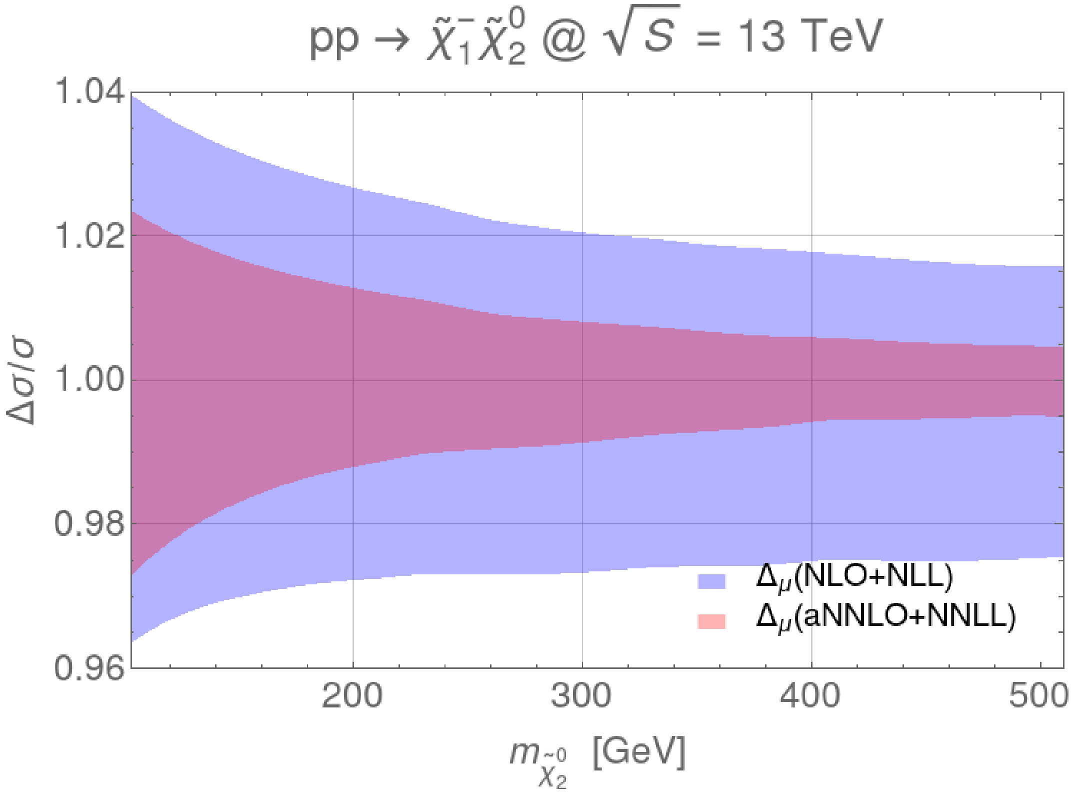


- Visible reduction of scale uncertainty from about from ±2.1% to ±1.8% (±0.6% to %0.4%) at low (large) invariant masses.

- NLO corrections enhance the LO cross section by about 30%.
- NLL corrections enhance the NLO cross section by another 3-5%.
- aNNLO+NNLL give another ±2 % correction to the NLO+NLL cross section.

Mostly Higgsino Electroweakinos





- Visible reduction of scale uncertainty from about from ±4% to ±2.5% (+1.5% and -2.5% to ±0.5%) for light (heavy) Higgsinos

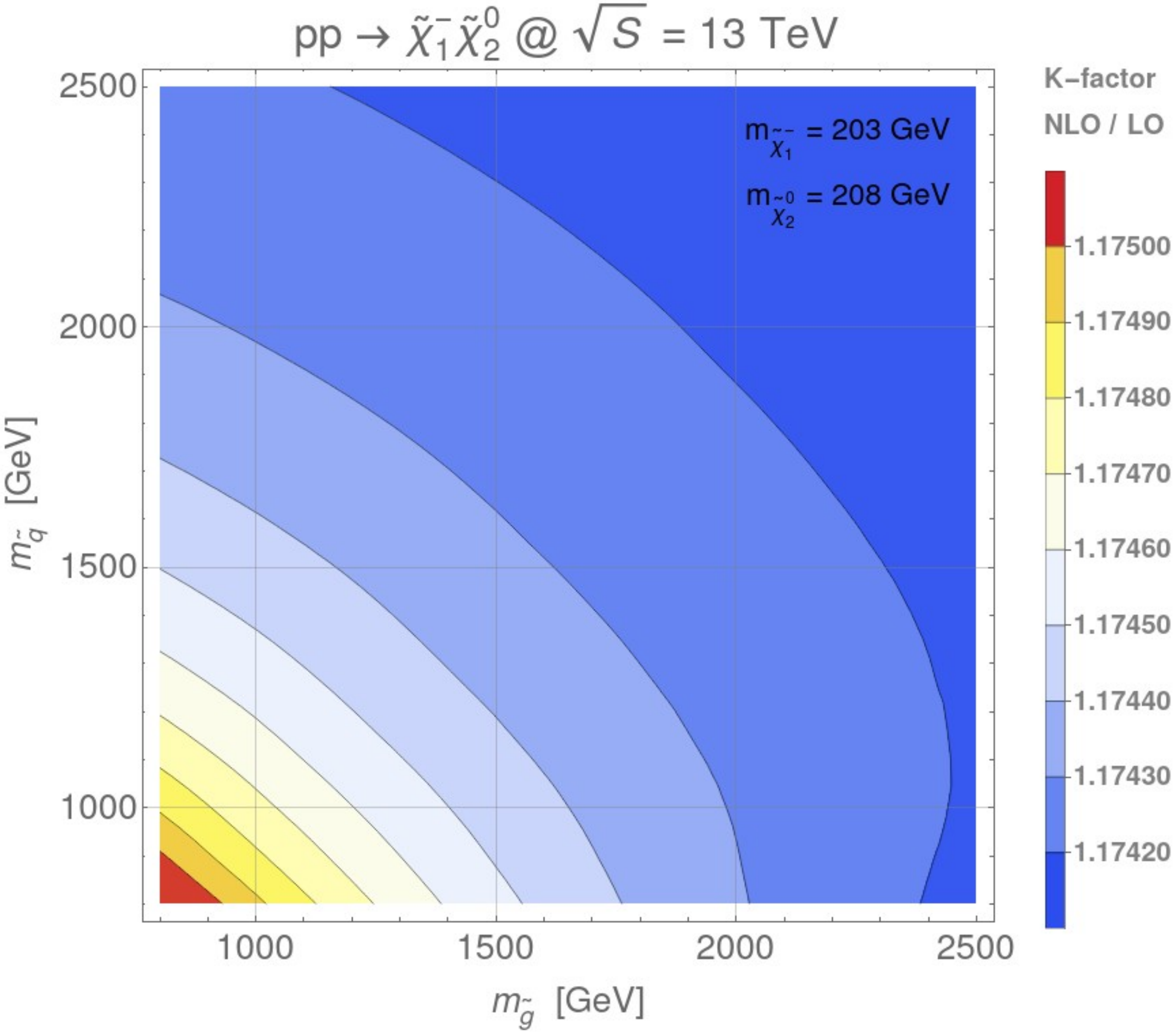
(Scale uncertainties are not so small, because of the relatively light Higgsino masses)

- NLL corrections reduce the NLO cross section by 1% to 2%.

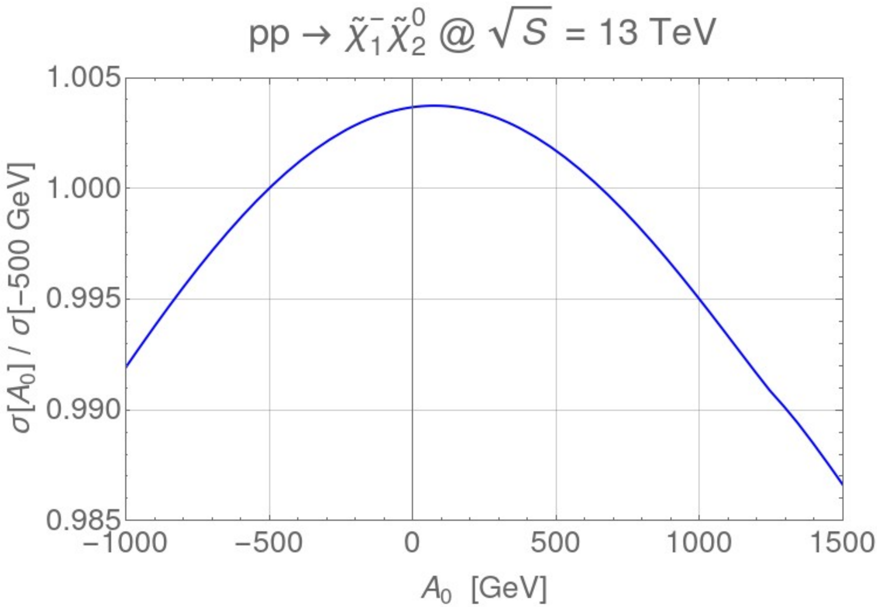
- aNNLO+NLL corrections increase the NLO+NLL cross section by up to 5% for low higgsino masses.

Mostly Higgsino Electroweakinos

NLO corrections in the gluino-squark mass plane.



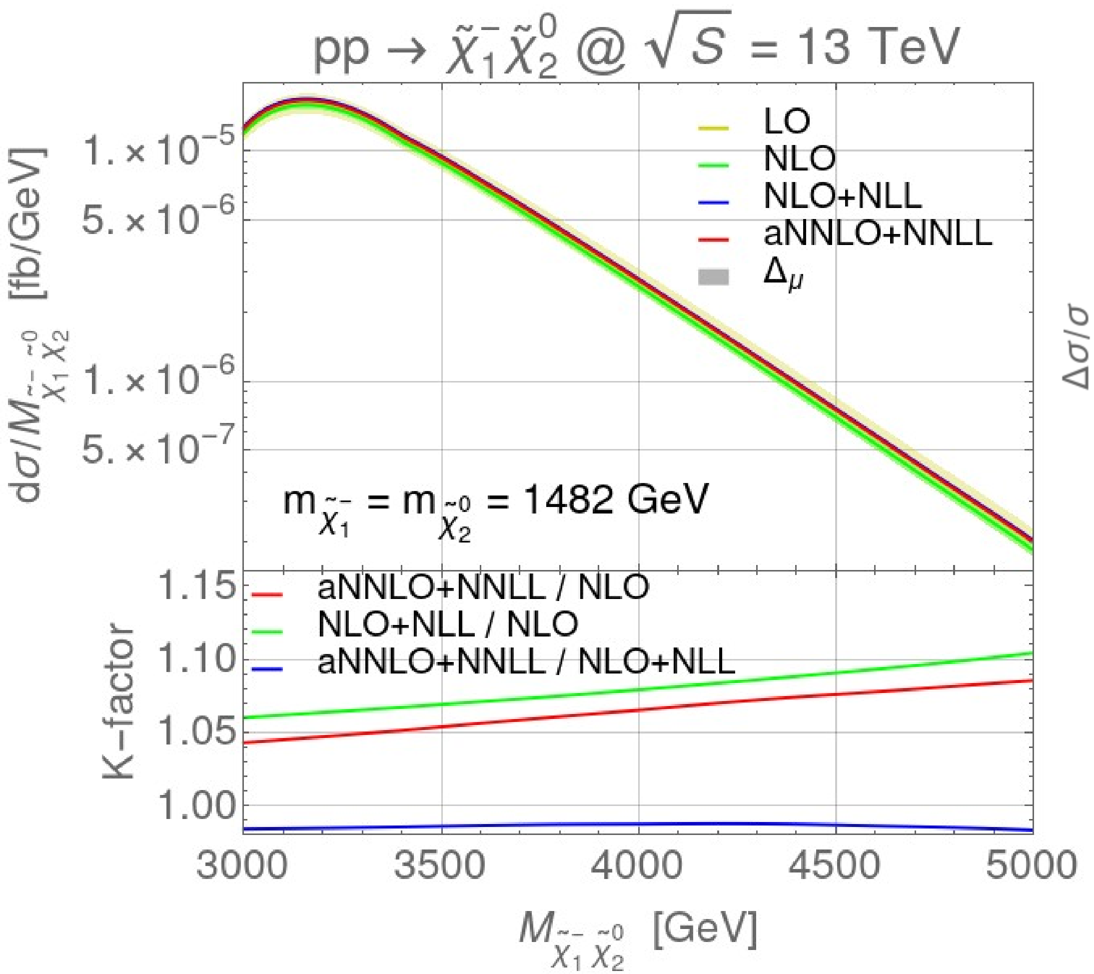
A_0 parameter dependence

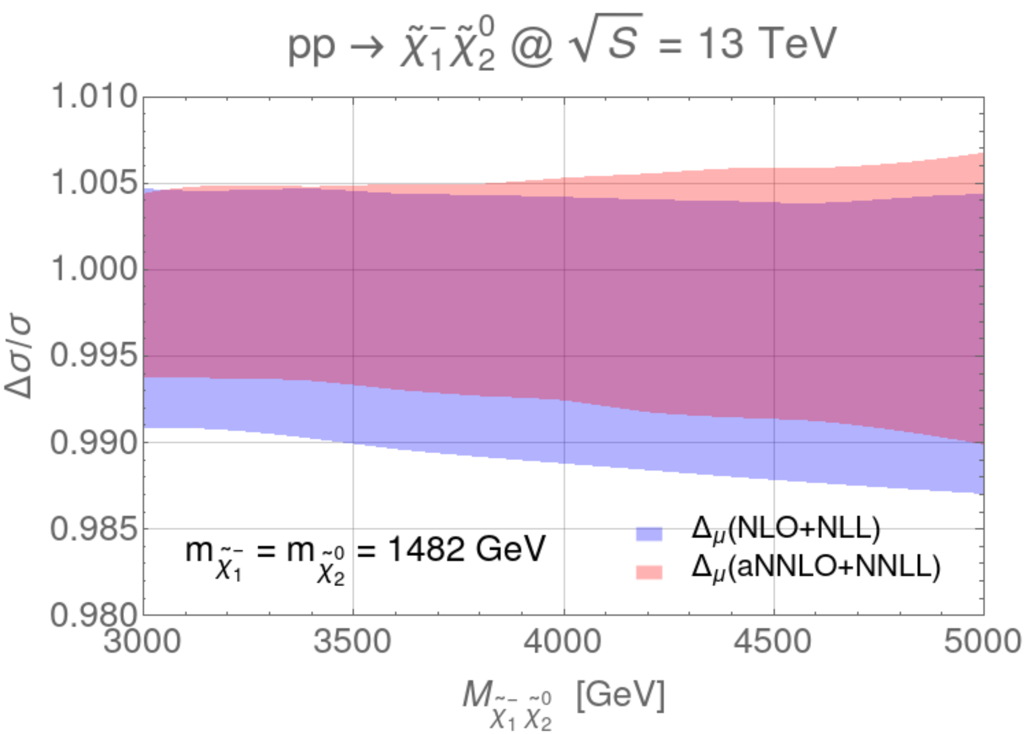


- Very weak dependence of NLO cross section on the sbottom mixing varying from −0.4% to +1.3%.

- Weak dependence from the strong SUSY sector, as K-factor varies between 1.174 to 1.175, i.e. ~ 0.1%.
- The gradient is along the diagonal and slightly steeper when the squark and gluino masses are still relatively close to those of the Higgsinos.

Mostly gauginos Electroweakinos

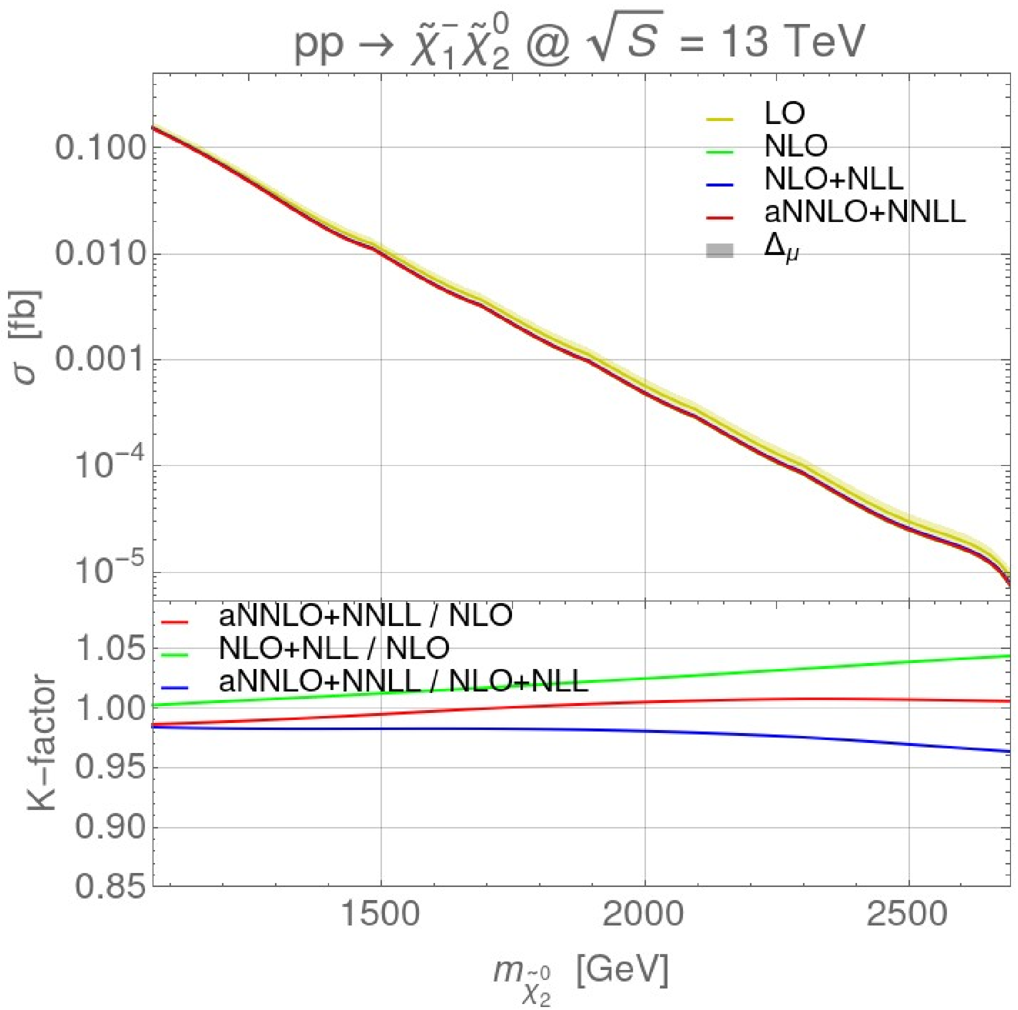


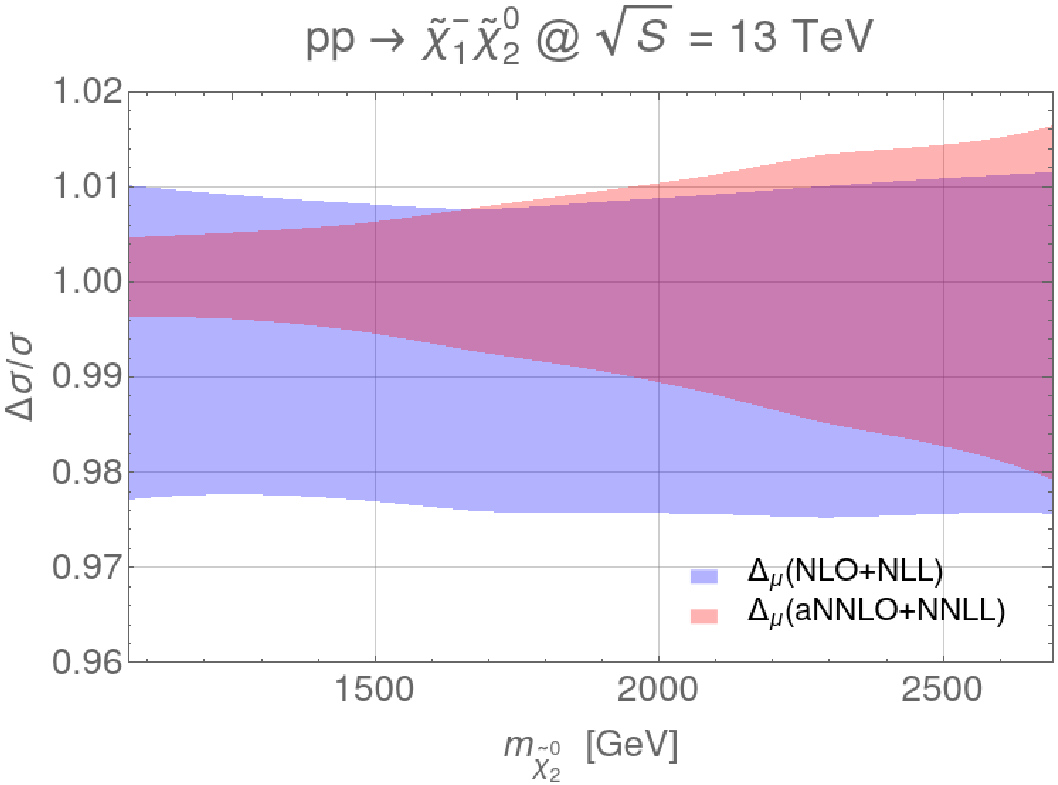


- Reduction of scale uncertainty <u>on the lower bound</u> from – 0.9% to –0.6% at low invariant masses.

- NLL corrections increase the cross section between 5% to 10%.
- A decrease for all invariant masses is observed from NLO+NLL to aNNLO+NNLL.
- This behavior is correlated with <u>large *t*- and *u*- channel contributions and large cancellations of the squared *s*- channel contribution with its interference terms</u>.

Mostly Higgsino Electroweakinos





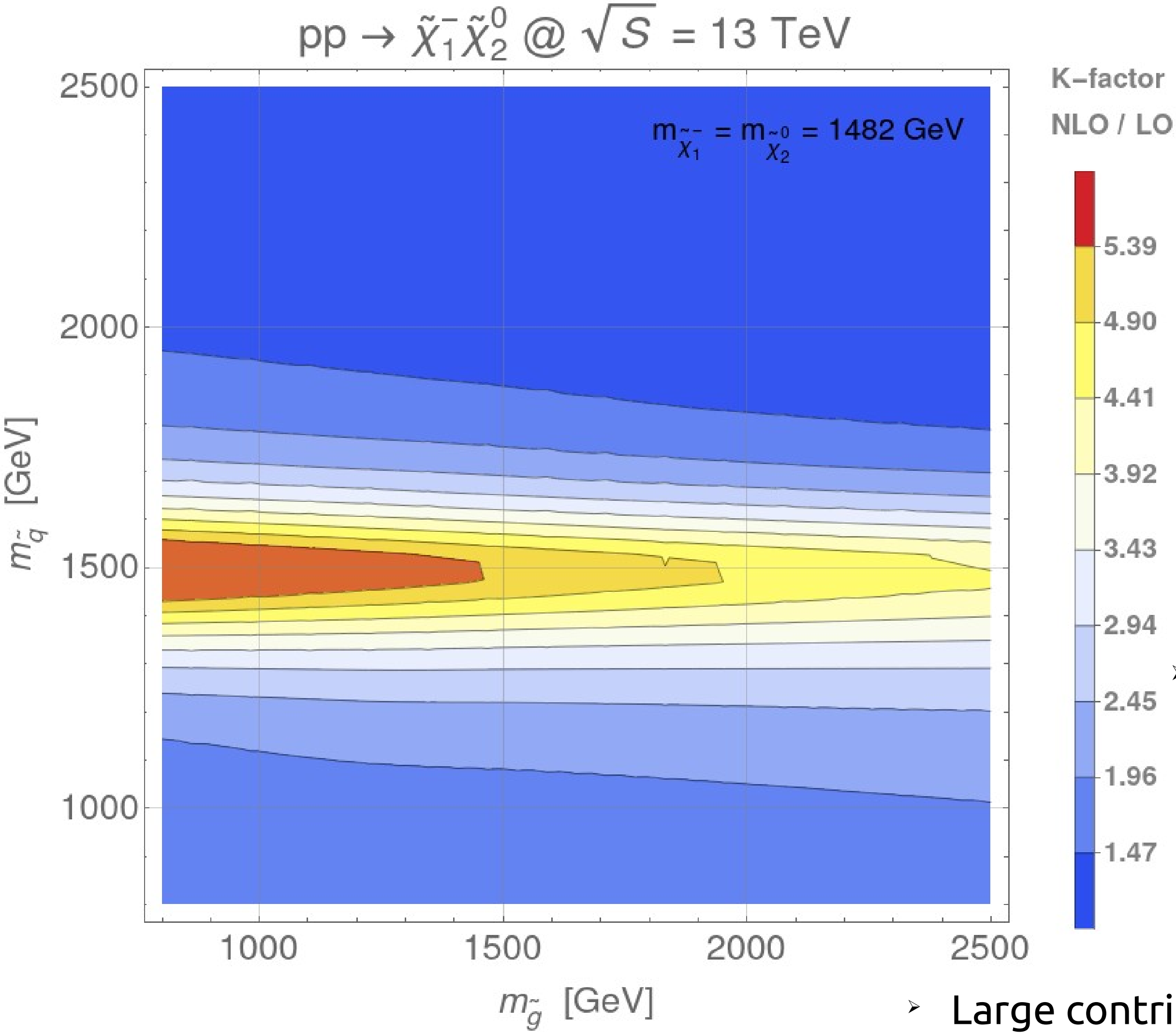
- Scale uncertainty gets reduced from 3% to about 1% for light gauginos, while it is stable at around 3% for heavy gauginos

- NLL corrections increase the NLO cross section by up to 5%.

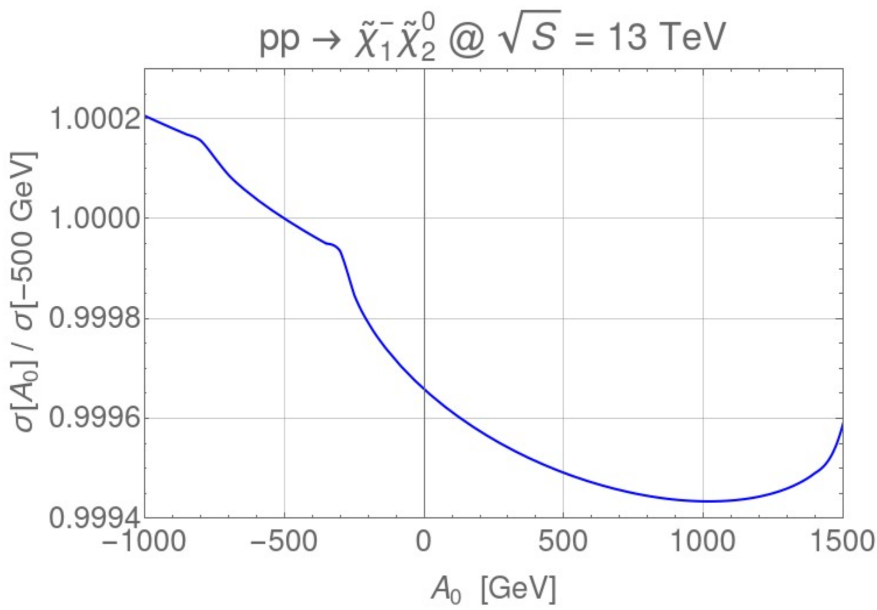
- aNNLO+NLL corrections reduce the NLO+NLL cross section by up to 4% for high gaugino masses.

Mostly gauginos Electroweakinos

NLO corrections in the gluino-squark mass plane.



A_0 parameter dependence



- Overall very weak dependence, due to small bottom quarks PDFs at large x.

- Weak dependence the gluino mass, which enters only at NLO, and very strong dependence on the squark mass.

- Large contribution at NLO mainly (but not only) from on-shell production of intermediate squarks in the final state that subsequently decay into the observed gauginos, plus some resonant contribution in virtual box diagrams when the squark threshold is crossed.

Conclusions

- **Features of resummation**
  - Perturbative expansion and resummation of large logs
  - Threshold resummation at NNLL for Drell-Yan processes.

- **Slepton pair production at aNNLO+NNLL**

- **Electroweakino pair production at aNNLO+NNLL**
  - Mostly Higgsino scenario
  - Mostly gaugino scenario

- **Conclusions**

Conclusions

- Updated calculations of threshold resummation for slepton and electroweakinos pair production (in their mostly Higgsino and gaugino compisition) at the LHC with **NNLL** accuracy, matched to **approximate NNLO** QCD corrections.

- Review of the formalism and highlights of analytical results for resummation at **NNLL** accuracy matched to fixed order calculation at **aNNLO**.

- **Sleptons:**
  - Small enhancement (< 2%) of invariant-mass distributions and total cross sections with respect to previous calculations with NLO+NLL precision.
  - Significant reductions on the renormalisation and factorisation scale dependences now at the permil level.
  - Very small dependence on squark and gluino masses (< 2%) and on bottom squark mixing (~ 1%).

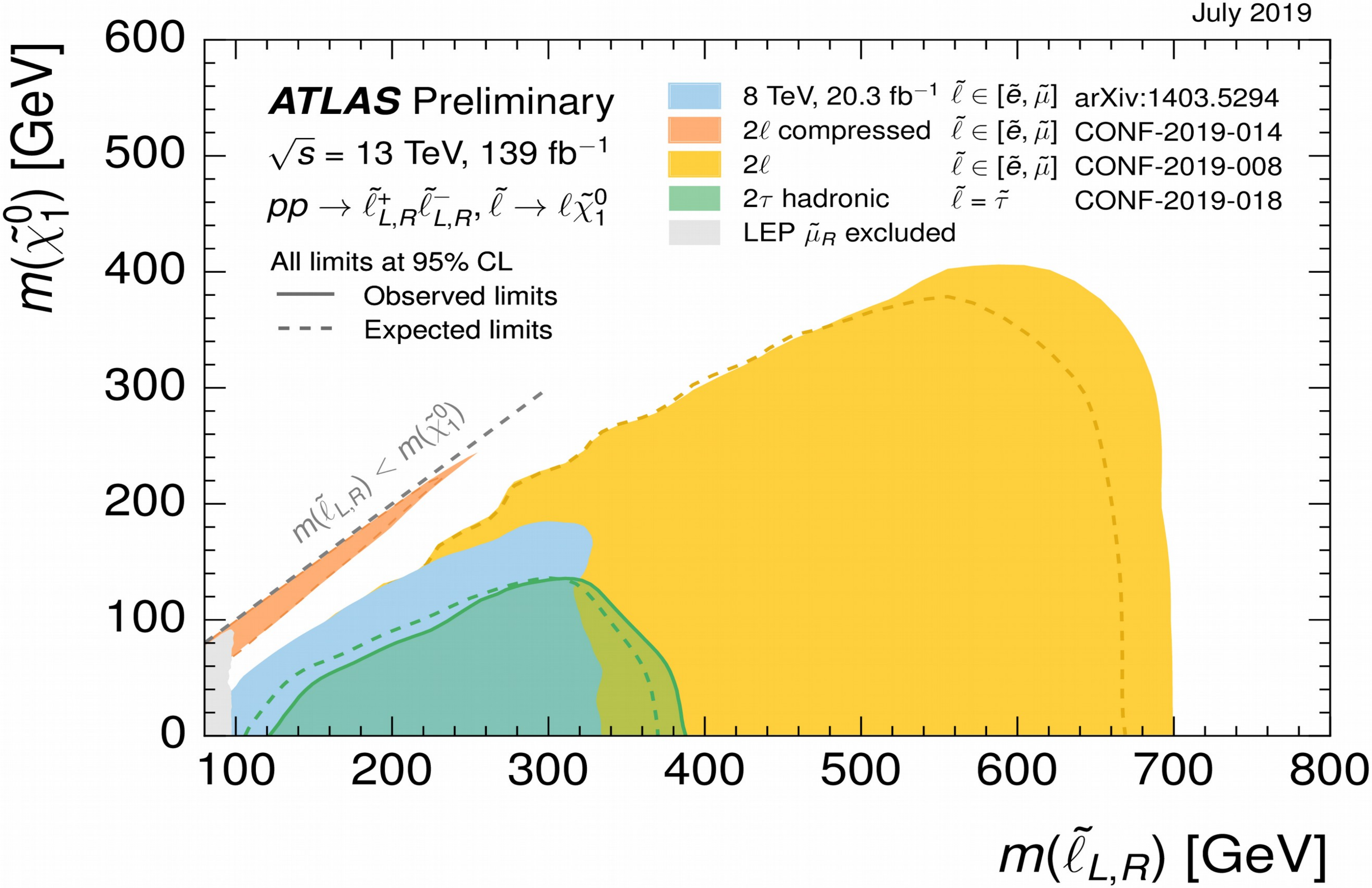
- **Electroweakinos (mostly Higgsino):**
  - Moderate modifications (< ±5%) of the differential and total cross sections with respect to previous calculations with NLO+NLL precision.
  - Further reduction of scale uncertainties now ≤ 2%.
  - Small dependence on squark and gluino masses (~0.1%) and on bottom squark mixing (< 1.5%).

- **Electroweakinos (mostly gaugino):**
  - Moderate reduction (< 4%) of the differential and total cross sections with respect to previous calculations with NLO+NLL precision.
  - Significant reductions of scale dependences for light electroweakinos down to permil level. For heavy electroweakinos scale uncertainty is as large as NLO+NLL result.
  - Very large resonant increase of cross sections observed in the gluino-squark mass plane, as squark mass crosses the electroweakinos mass threshold. Very small dependence on bottom squark mixing (<0.1%).

Thank you!

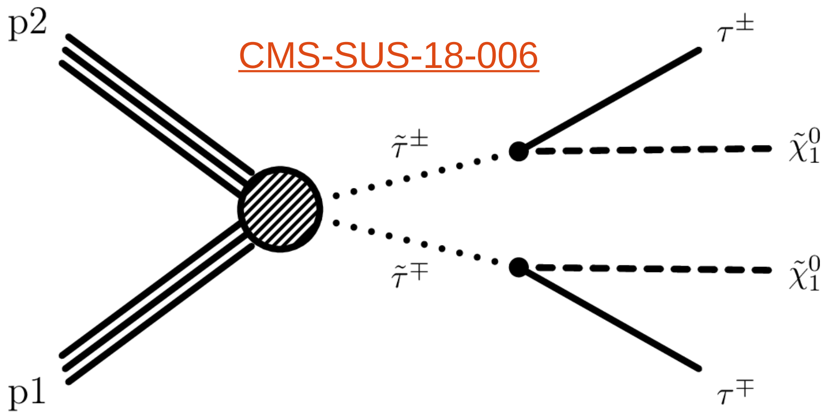
Experimental searches

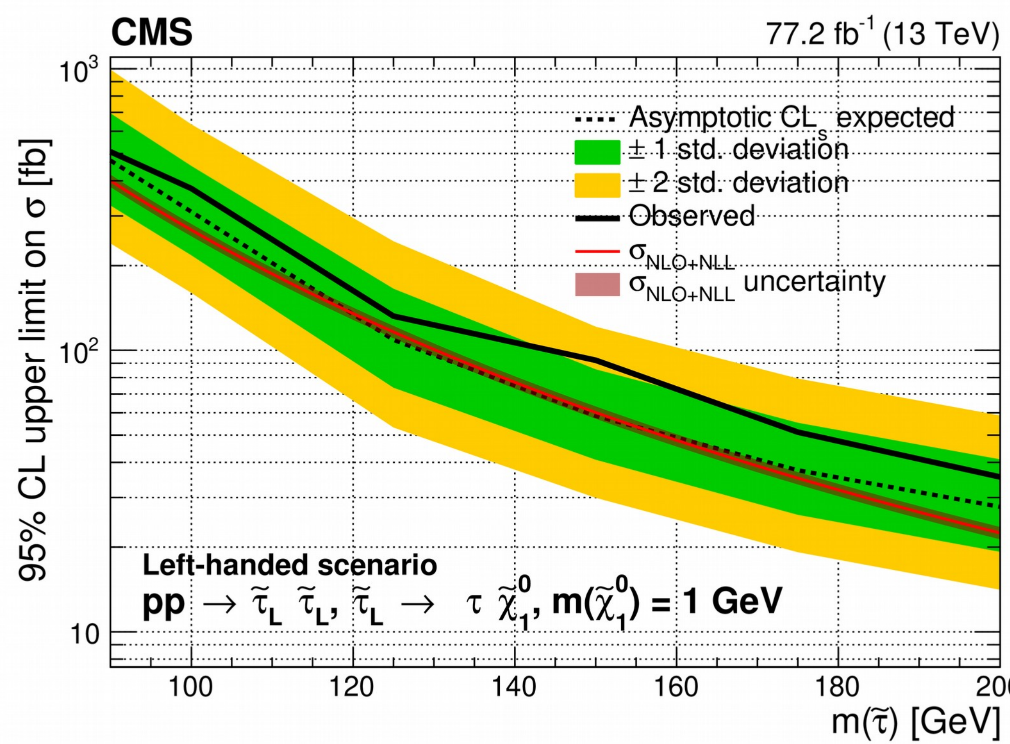
Sleptons



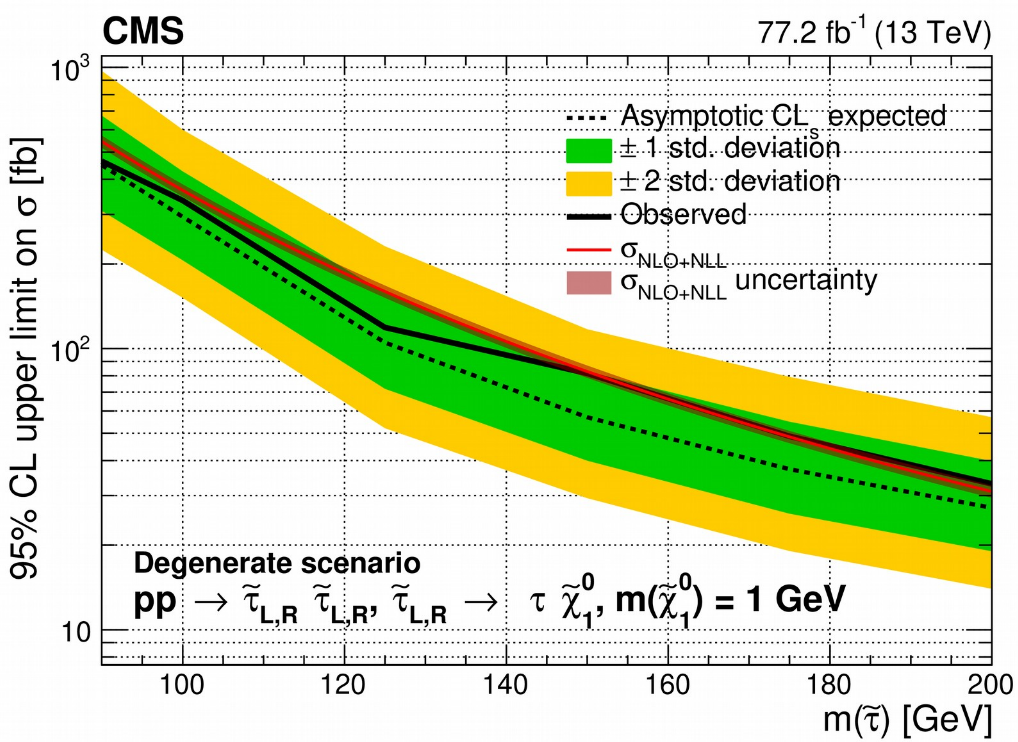
Experimental searches

Third generation sleptons





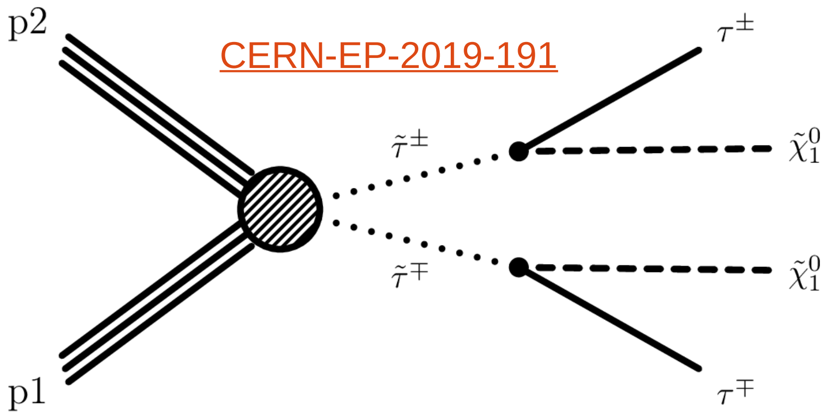
Upper limit on direct stau pair production is set to *$\sigma \times Br^2$ = 132 fb* for a stau mass of 125 *GeV* and lightest neutralino mass of *1 GeV*.



In the degenerate case both left- and right-handed staus are produced. Mass limits vary between *90 GeV* and *150 GeV*.

Experimental searches

Third generation sleptons



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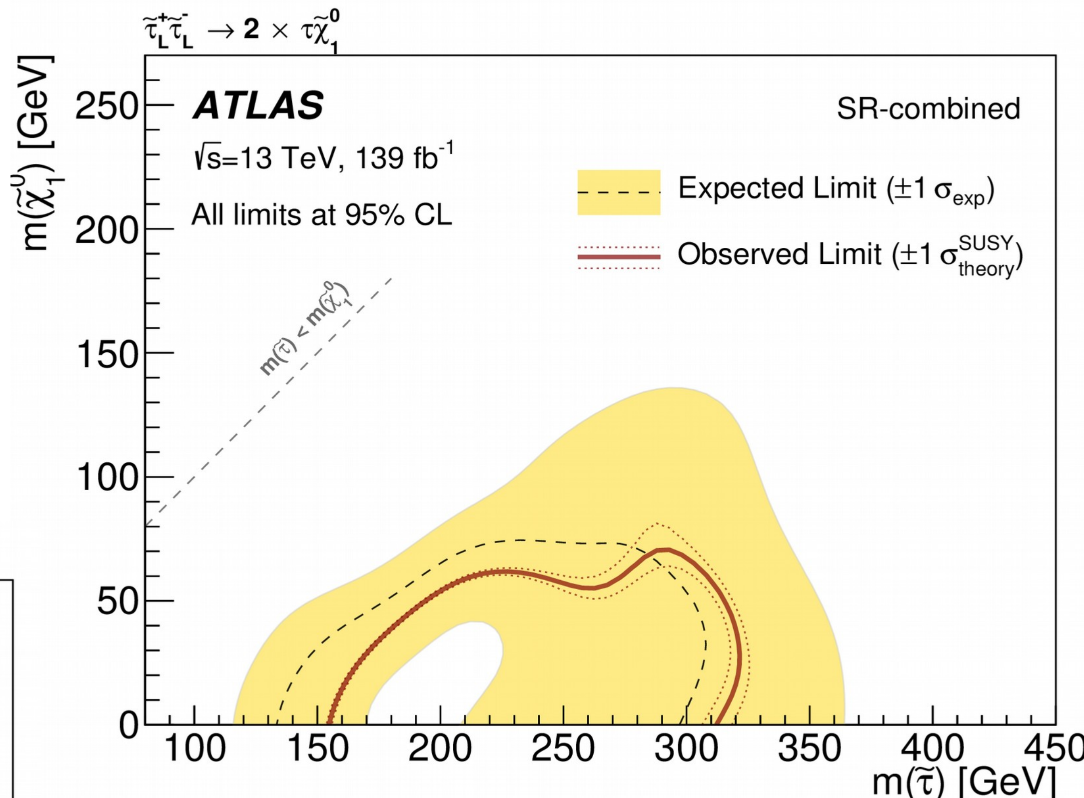
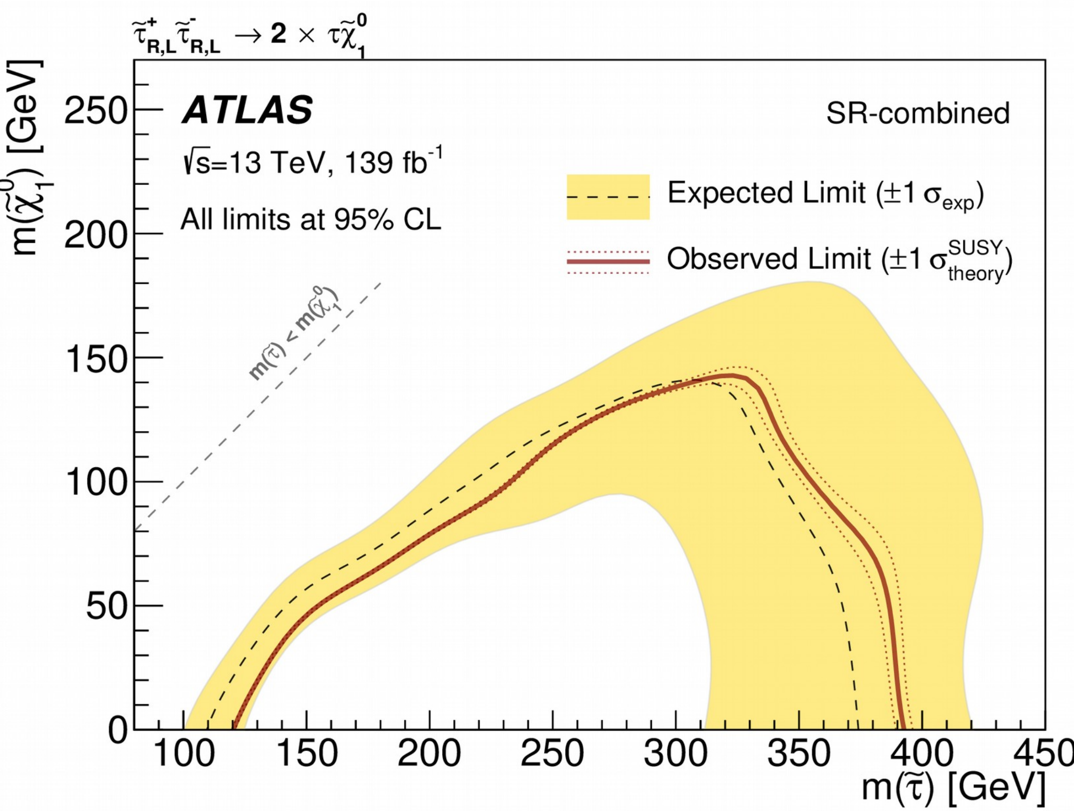


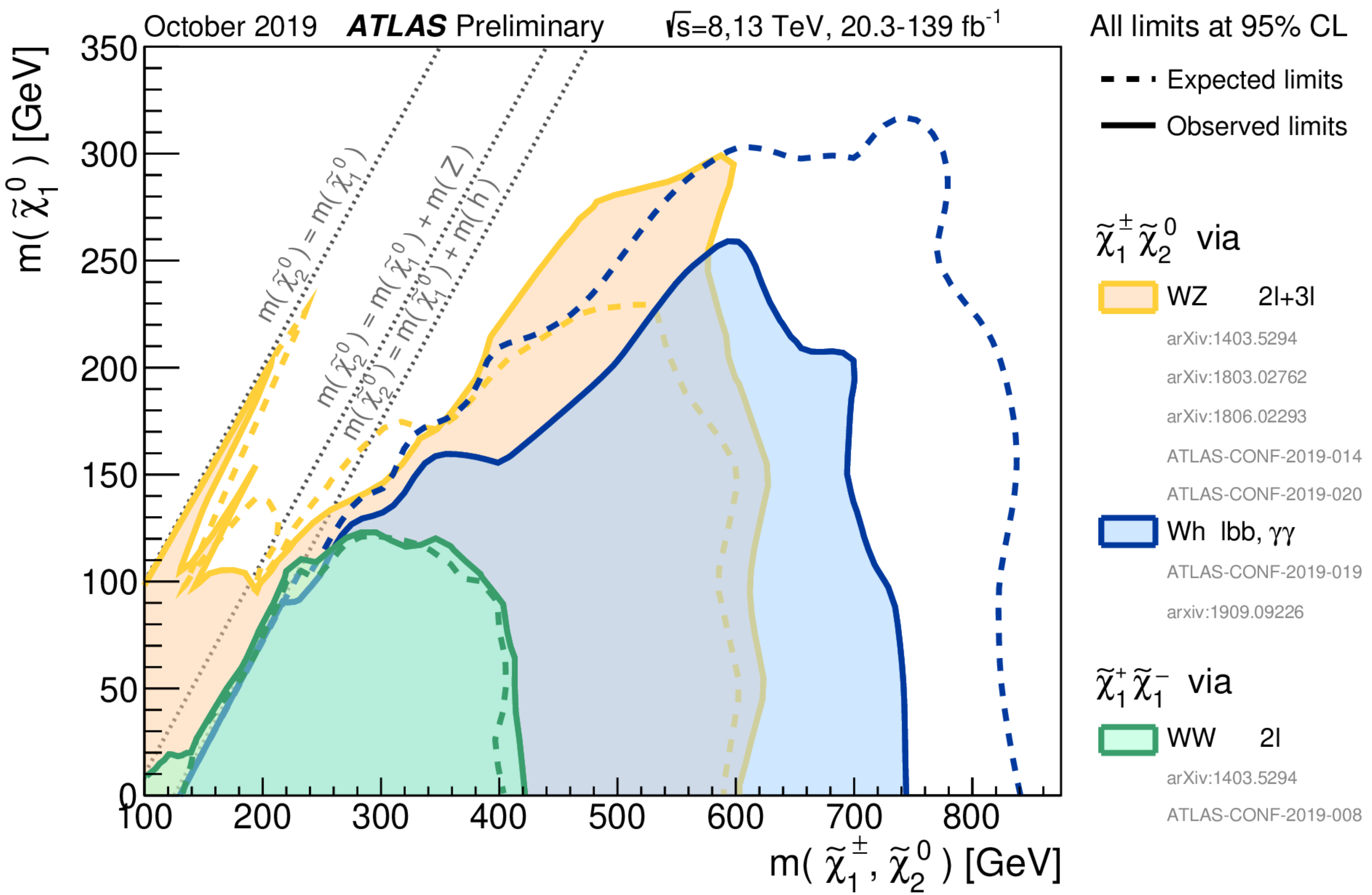


In the purely left-handed scenario, stau masses are excluded between *155 GeV* and *310 GeV.*

In the degenerate case, mass limits vary between *120 GeV* and *390 GeV.*

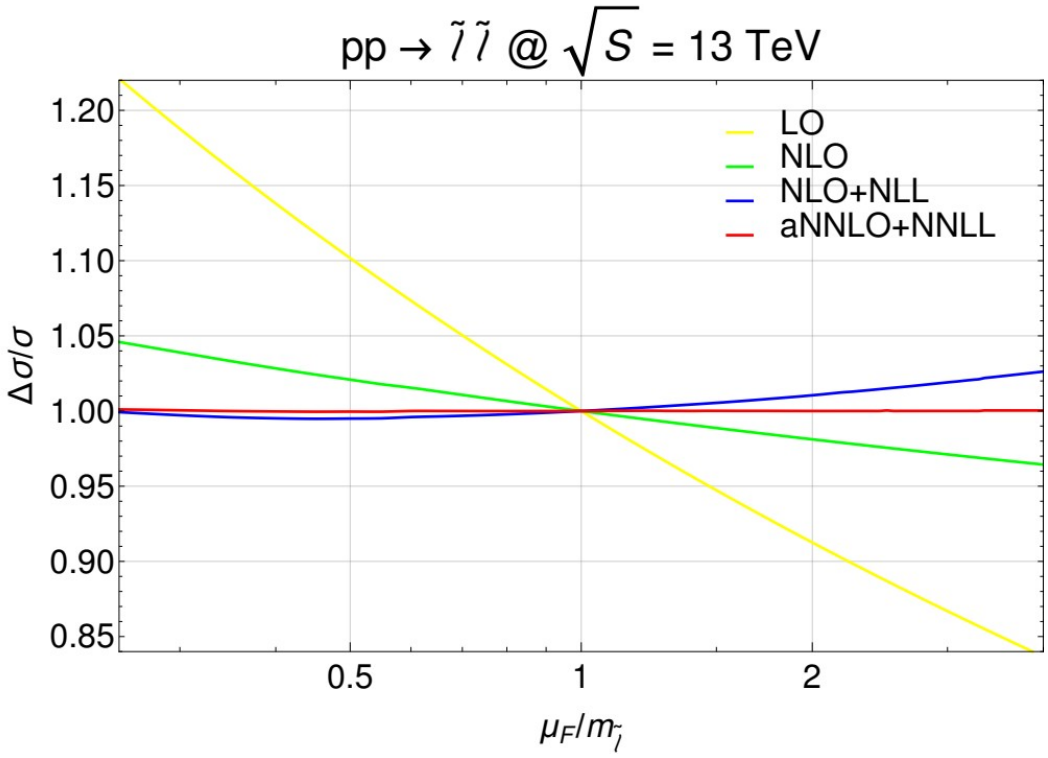
Experimental searches

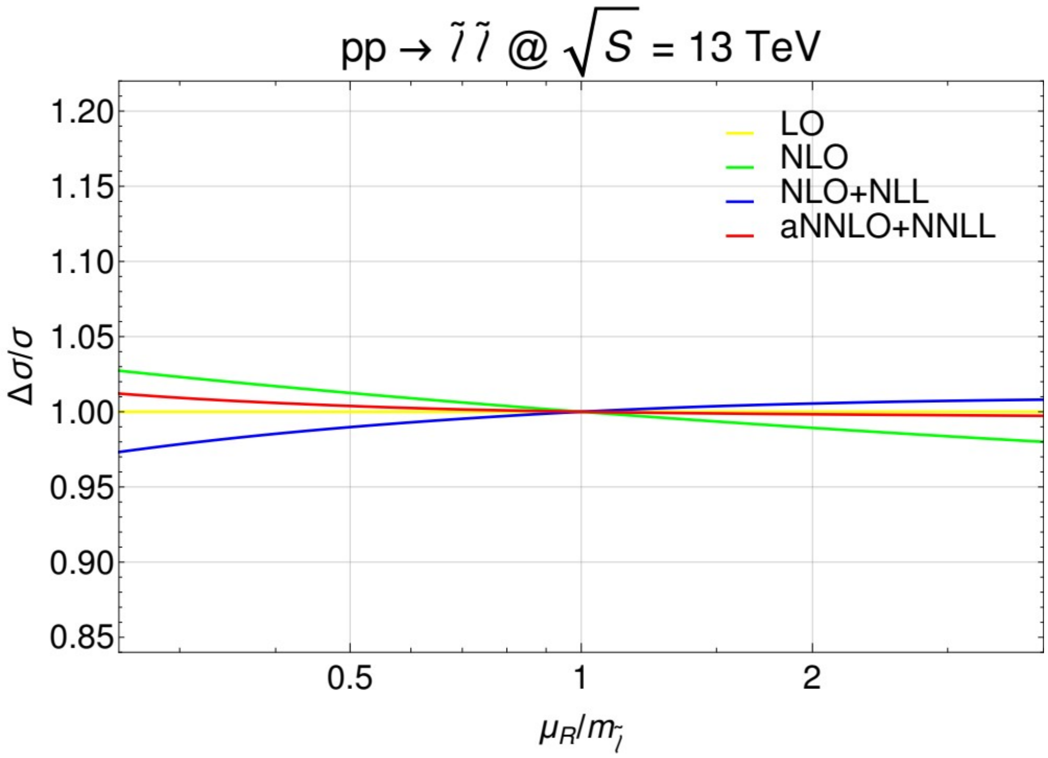
Mostly Higgsino Electroweakinos



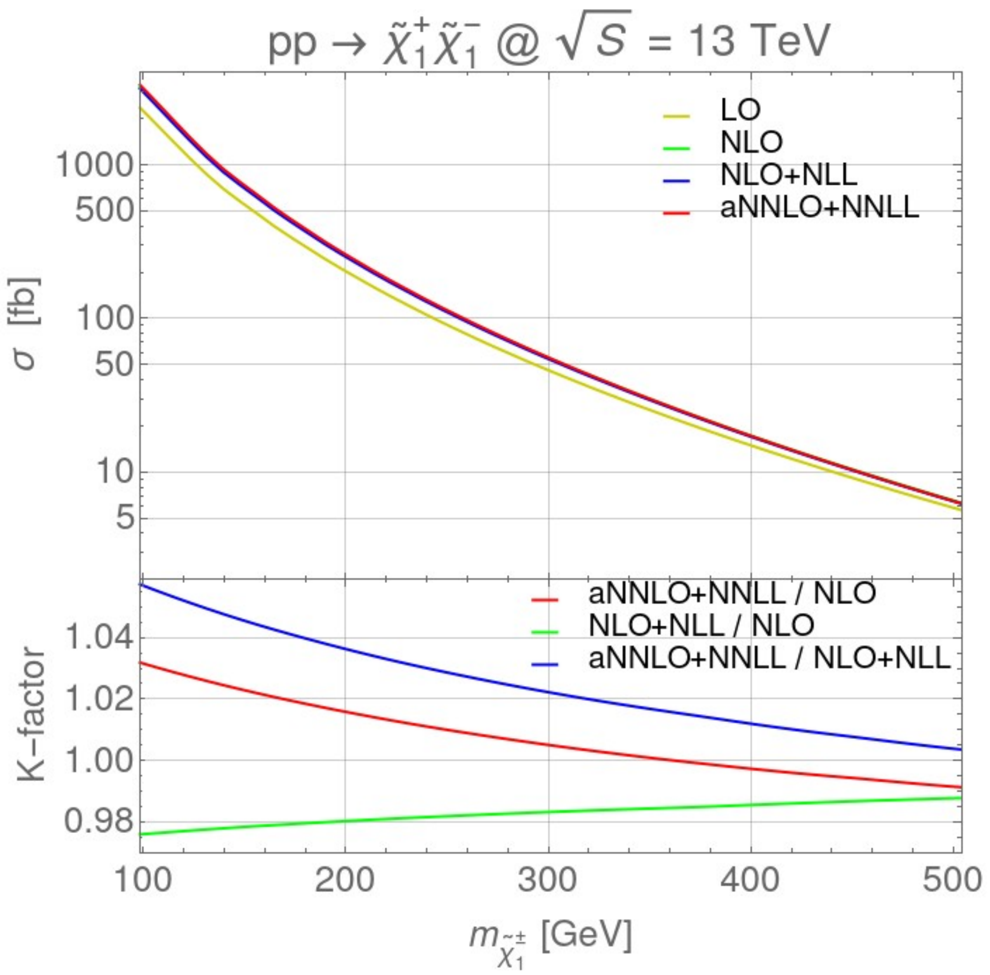
Slepton pair production

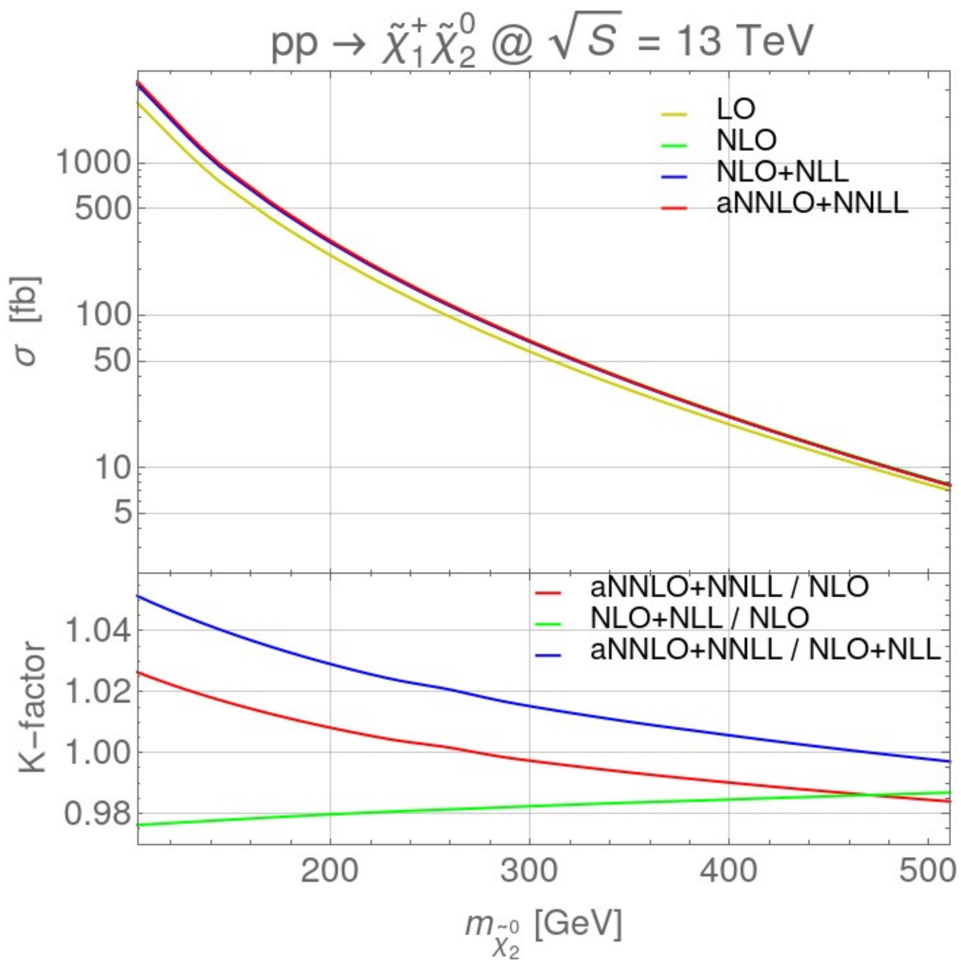
Separate Factorization and Renormalization scales variation for the total cross section of slepton pair production.





Mostly Higgsino Electroweakinos





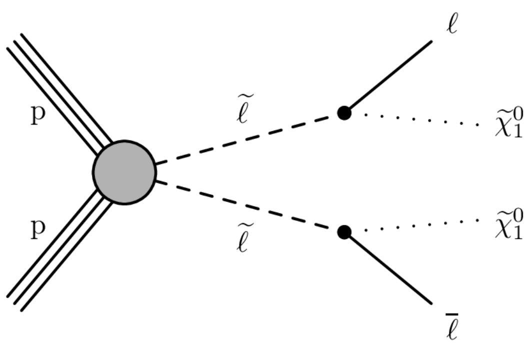
Similar results in other final states.

In pp collisions, absolute size of the total cross section larger for positively charged final states, and intermediate for neutral final state.

Experimental signatures

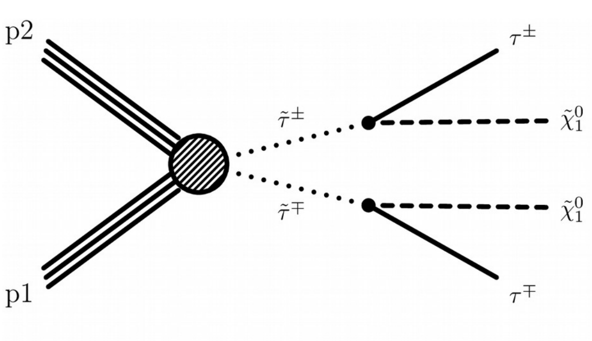
Sleptons searches:

1st & 2nd generation:



$pp \rightarrow \ell^+\ell^- + MET$

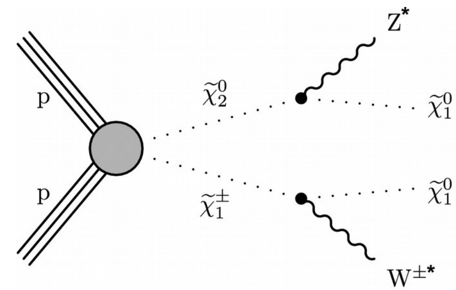
3rd generation:

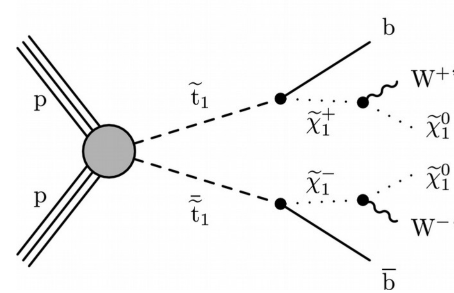


$pp \rightarrow \tau^+\tau^- + MET$

Electroweakinos searches:

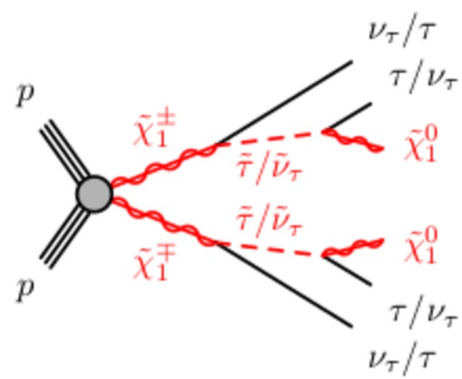
Mostly Higgsino:

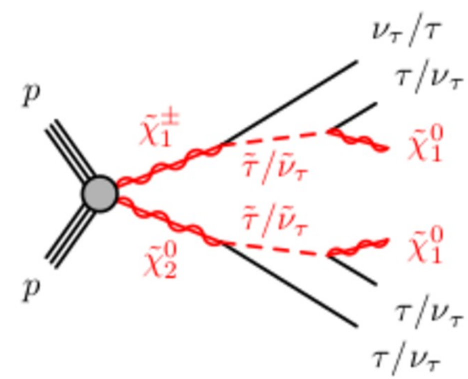




$pp \rightarrow$ gauge bosons + MET

Mostly gaugino:

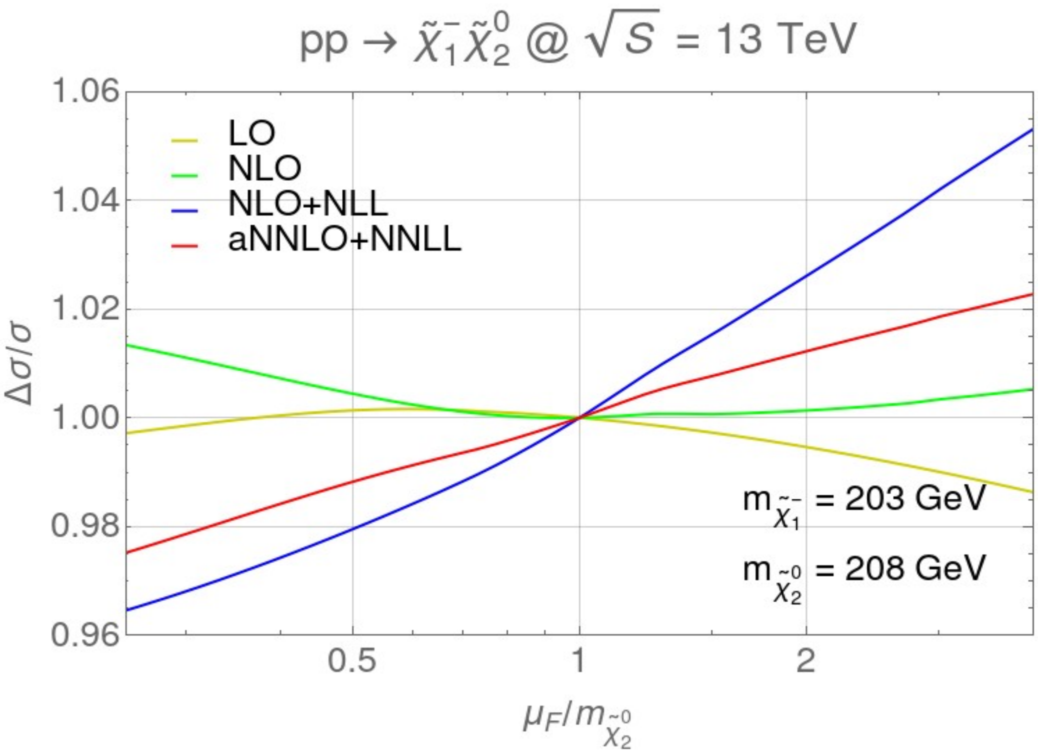


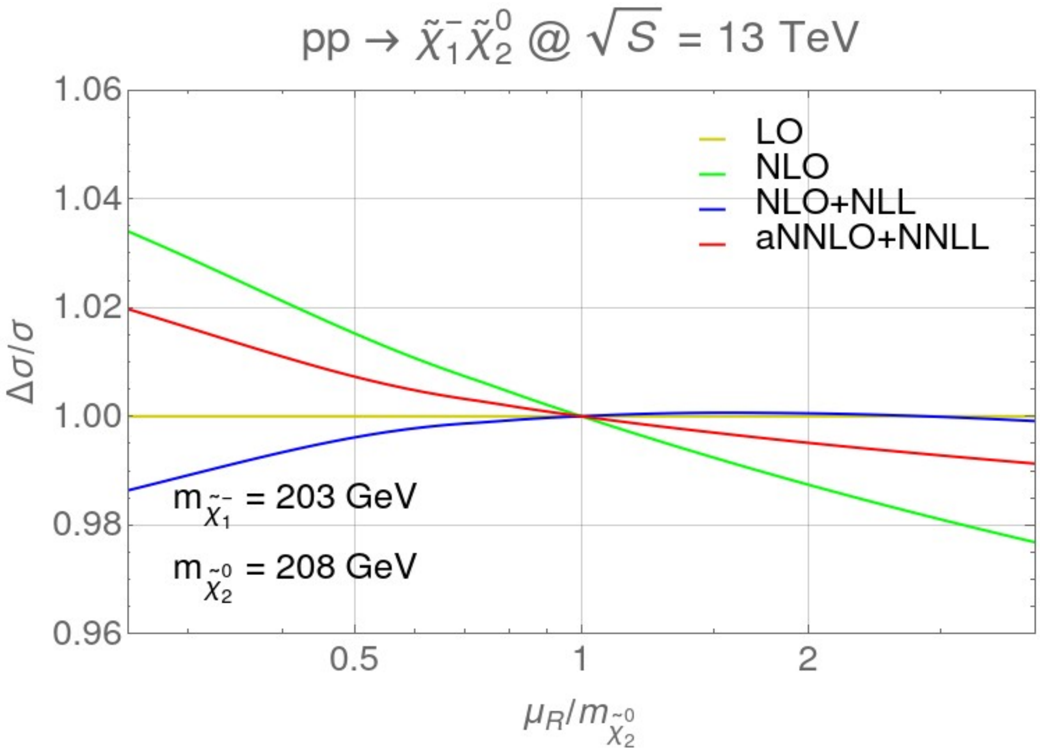


$pp \rightarrow$ some τs + MET

Mostly Higgsino Electroweakinos

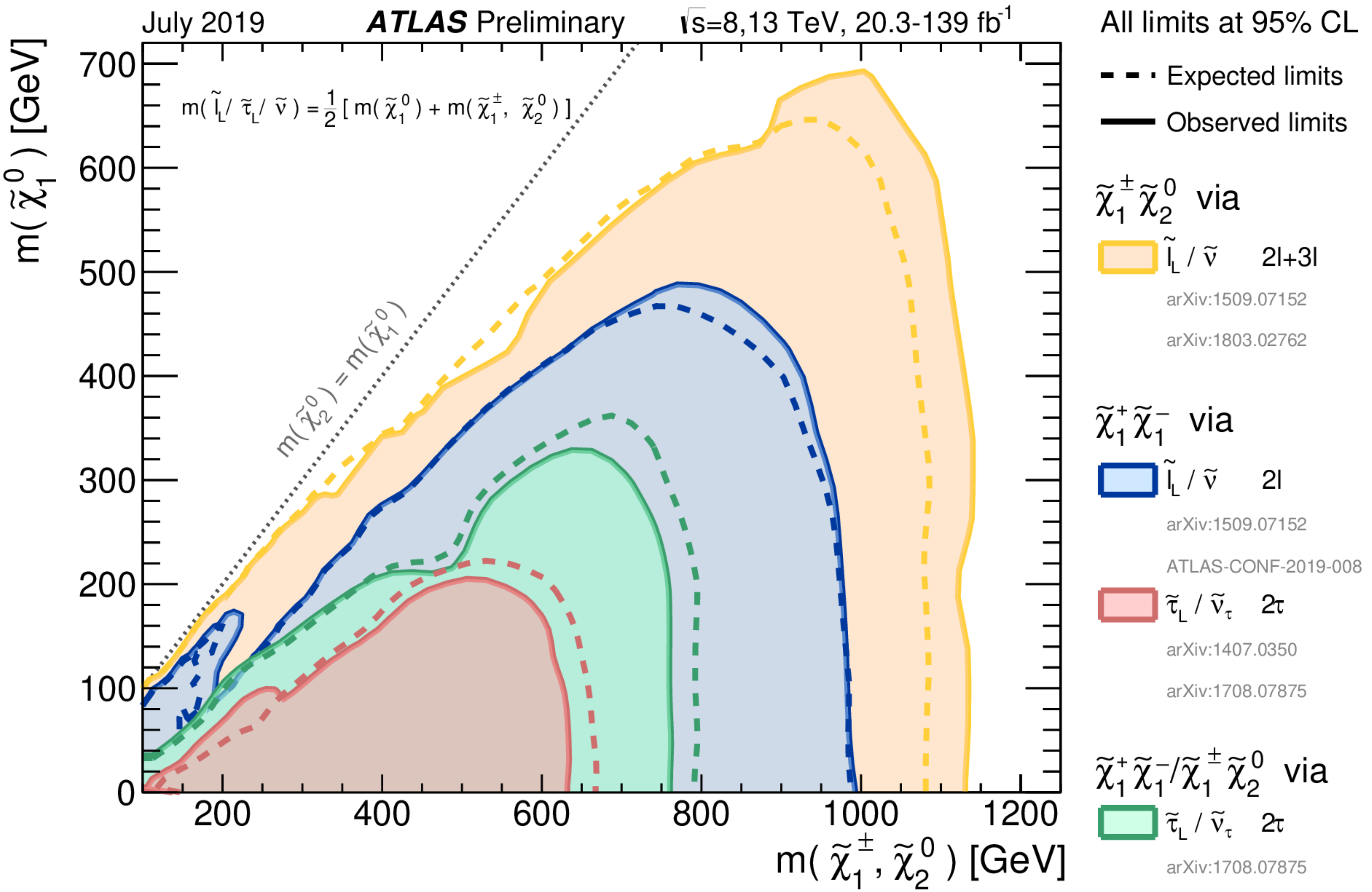
Separate Factorization and Renormalization scales variation for the total cross section of Higgsinos pair production.



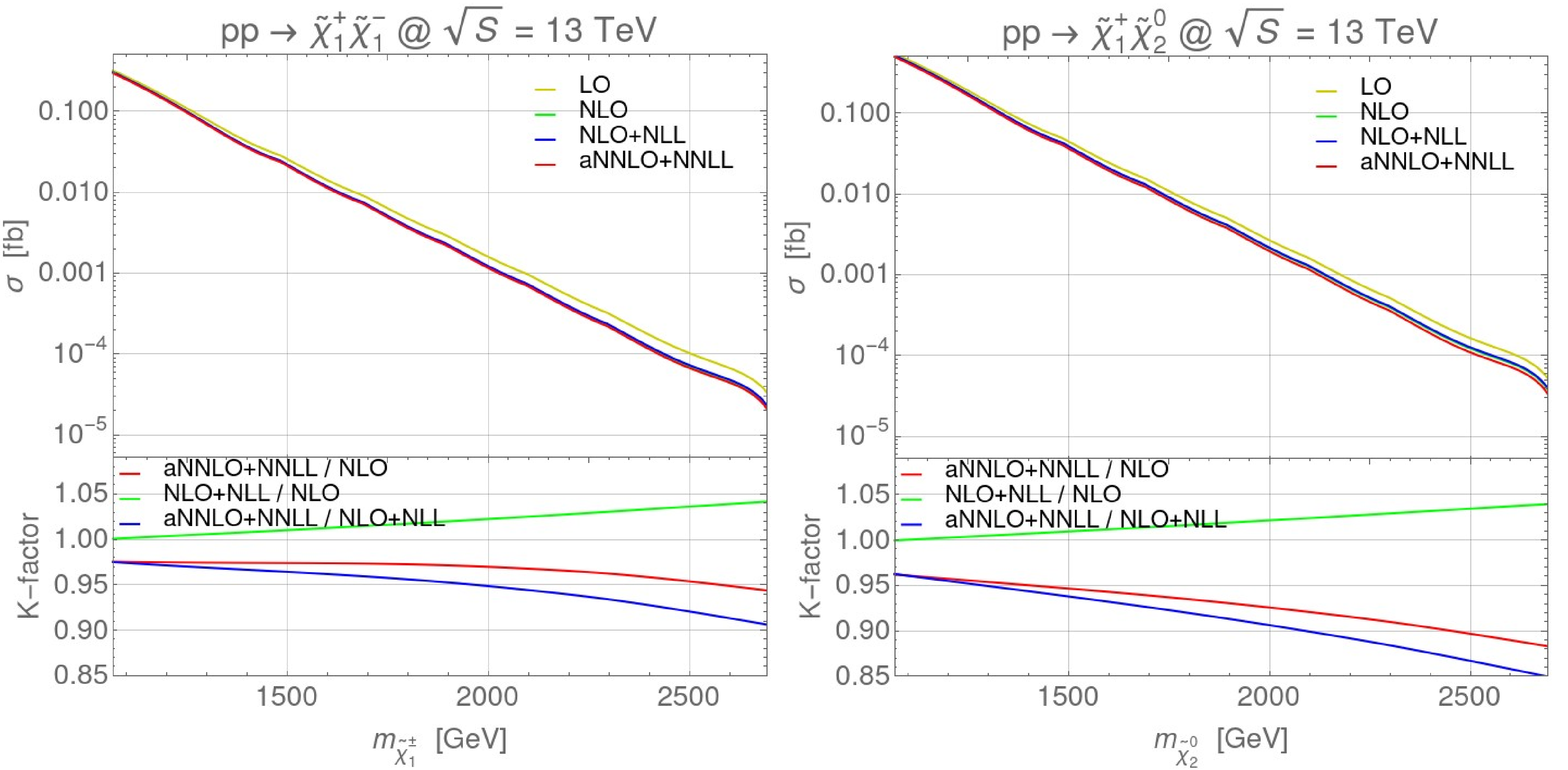


Experimental searches

Mostly gauginos Electroweakinos



Mostly gauginos Electroweakinos



In pp collisions, absolute size of the total cross section larger for positively charged final states, and intermediate for neutral final state.

Much larger aNNLO+NNLL corrections amount to up to -8% and -15% with respect to the NLO+NLL predictions for neutral and positive charged final state respectively.

Mostly gauginos Electroweakinos

Separate Factorization and Renormalization scales variation for the total cross section of gaugino pair production.