Proposing a new LHC search for light stops

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Based on work done with Gabriele Ferretti, Roberto Franceschini and Riccardo Torre:

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Motivation

- With the discovery of a SM-like Higgs, the "Naturalness problem" is more sharply defined than ever.

- The top quark gives rise to the leading quantum correction that destabilizes the EW scale.

- In SUSY models, this correction is cancelled by the superpartner of the top, the stop.

- Naturalness suggests that the stop mass is around or below the EW scale and hence observable at the LHC.

Of course, light stops have been widely studied…

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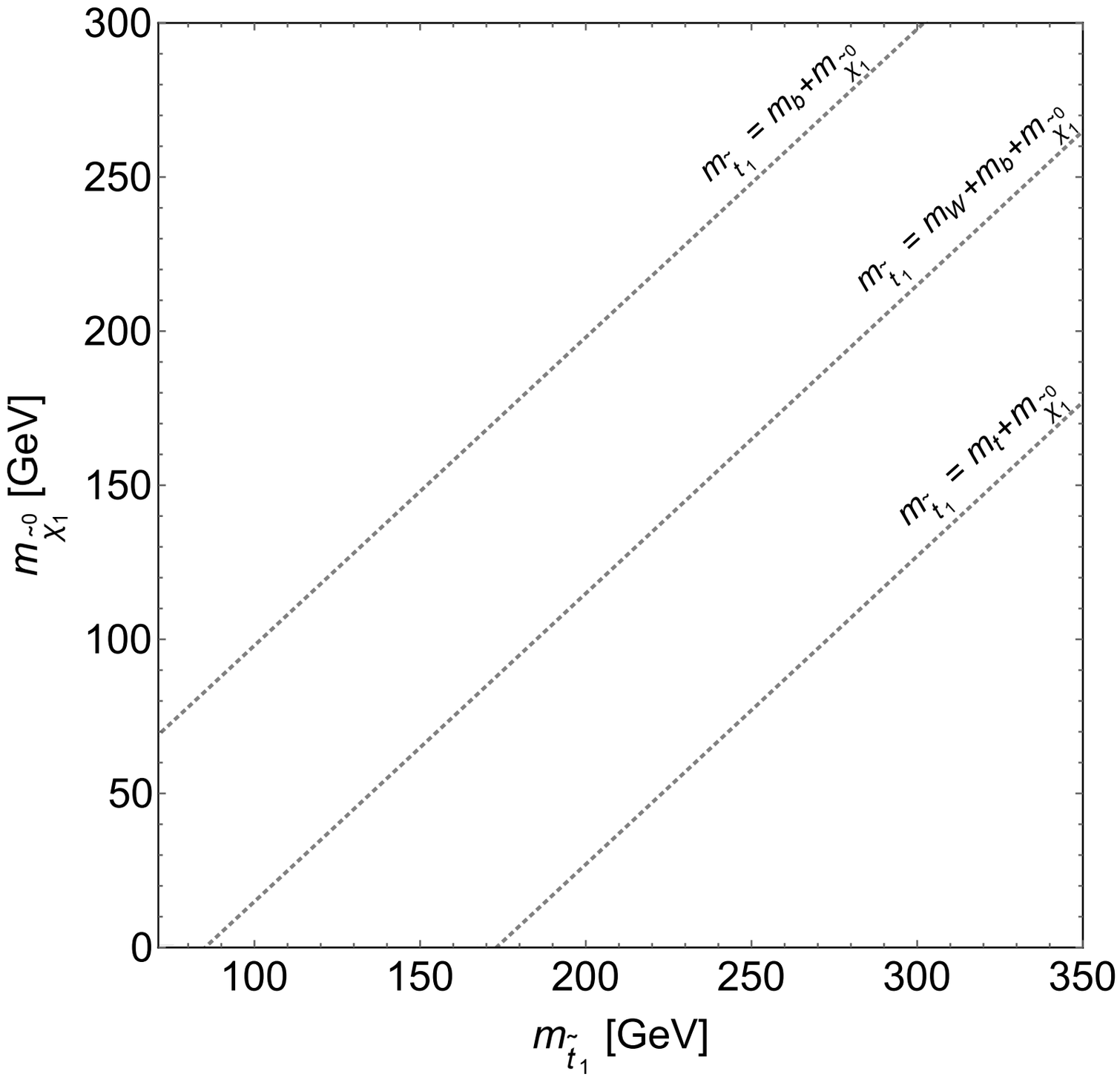
Simplified Model

$\tilde{t}_1$

$\tilde{\chi}_1^0$ (LSP, stable)


300
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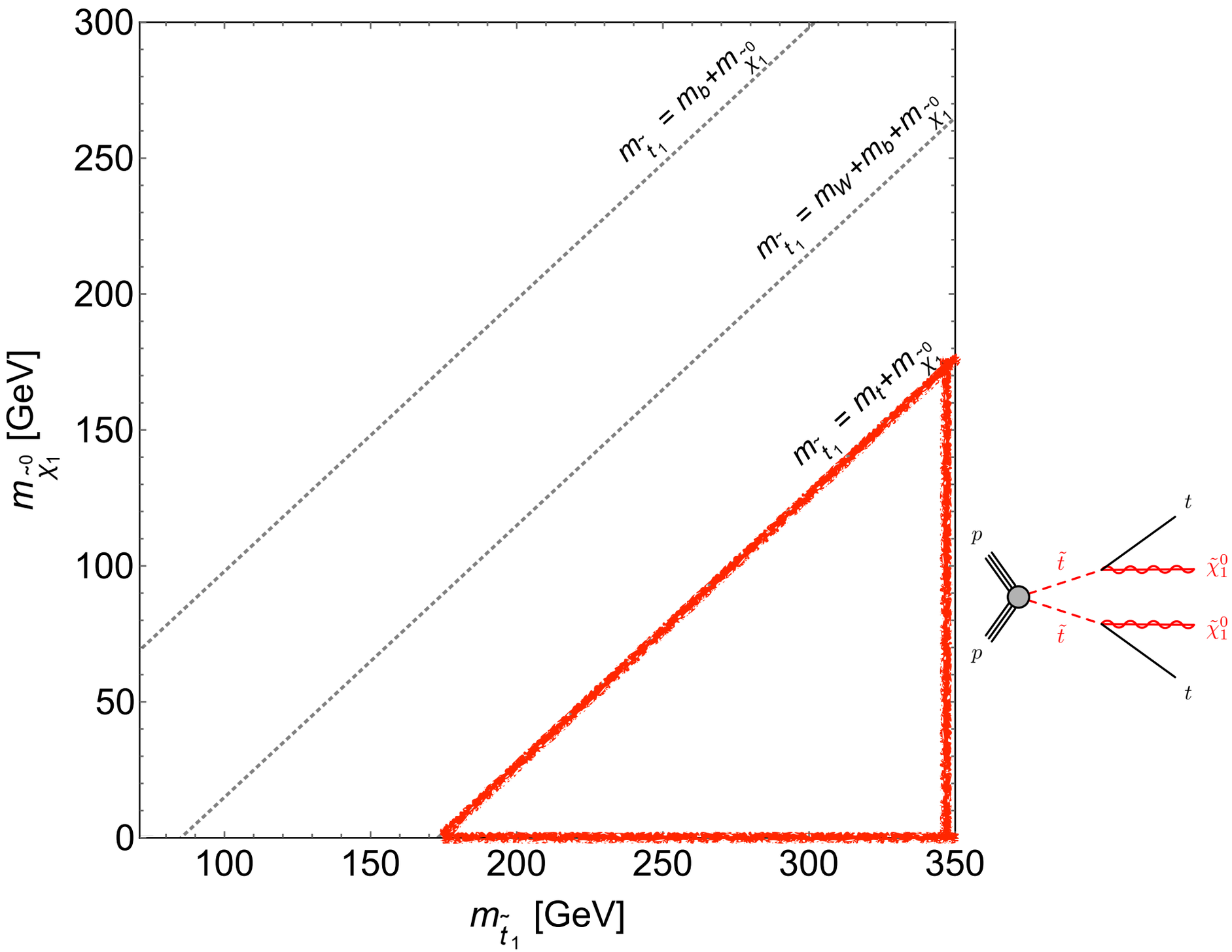
$m_{\tilde{\chi}_1^0}$ [GeV]
$m_{\tilde{t}_1}$ [GeV]
$m_{\tilde{t}_1} = m_b + m_{\tilde{\chi}_1^0}$
$m_{\tilde{t}_1} = m_W + m_b + m_{\tilde{\chi}_1^0}$
$m_{\tilde{t}_1} = m_t + m_{\tilde{\chi}_1^0}$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$m_{\tilde{t}_1}$ [GeV]
$m_{\tilde{\chi}_1^0}$ [GeV]
$m_{\tilde{t}_1} = m_b + m_{\tilde{\chi}_1^0}$
$m_{\tilde{t}_1} = m_W + m_b + m_{\tilde{\chi}_1^0}$
$m_{\tilde{t}_1} = m_t + m_{\tilde{\chi}_1^0}$
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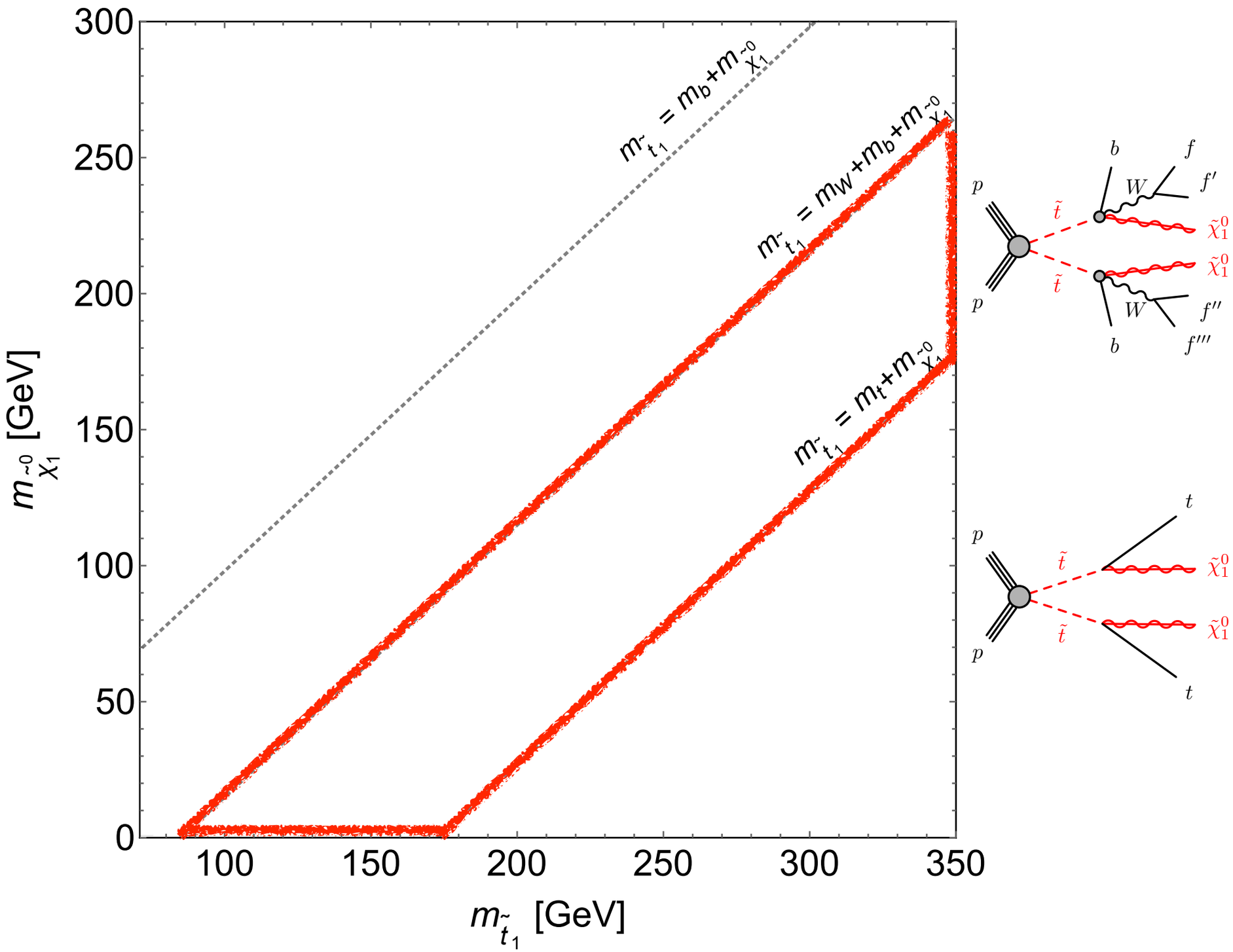
$\tilde{t}$
$\tilde{t}$
t
t
$\tilde{\chi}_1^0$
$\tilde{\chi}_1^0$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$m_{\tilde{\chi}_1^0}$ [GeV]
$m_{\tilde{t}_1}$ [GeV]
$m_{\tilde{t}_1} = m_b + m_{\tilde{\chi}_1^0}$
$m_{\tilde{t}_1} = m_W + m_b + m_{\tilde{\chi}_1^0}$
$m_{\tilde{t}_1} = m_t + m_{\tilde{\chi}_1^0}$
p
p
$\tilde{t}$
$\tilde{t}$
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f′
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W
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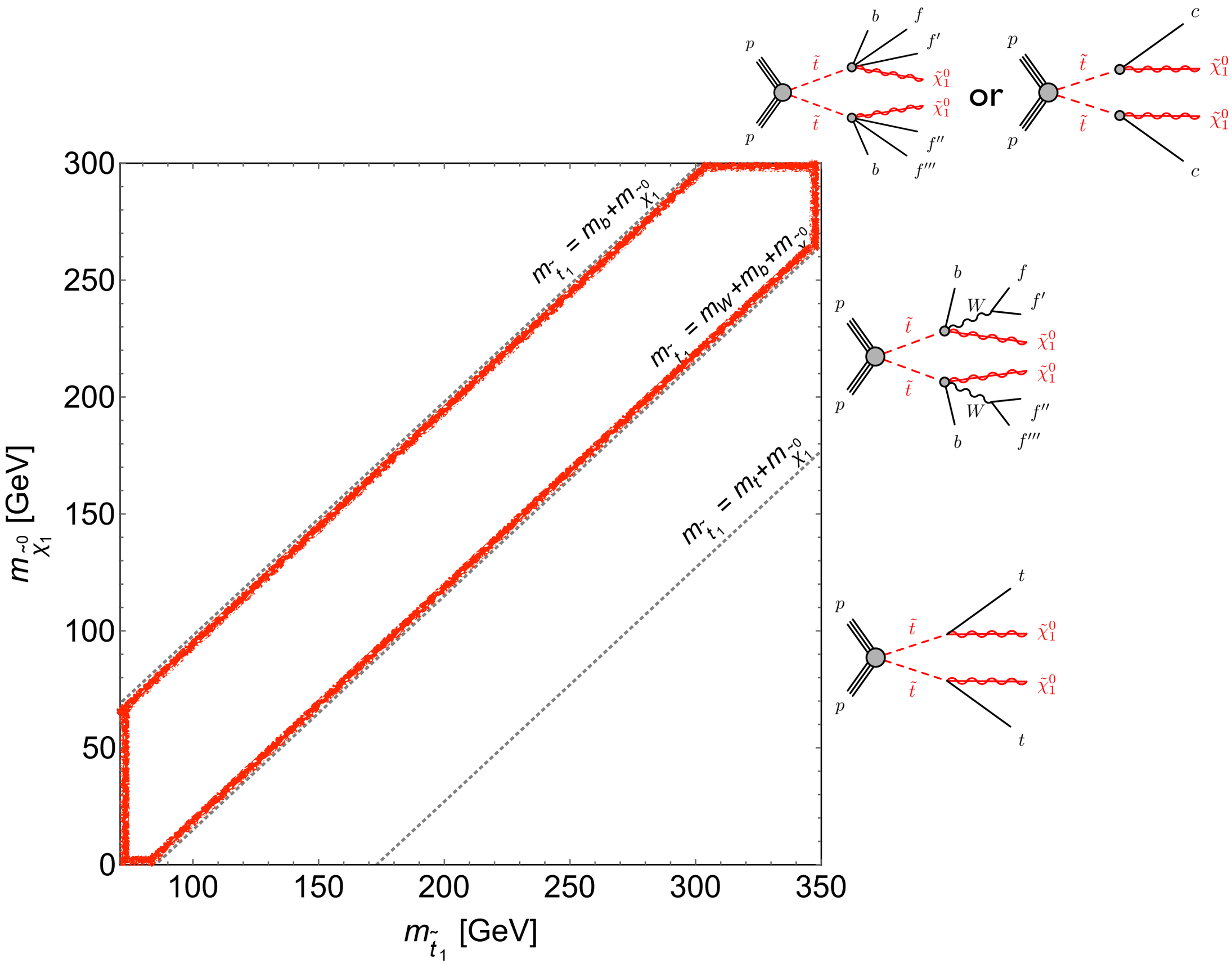
or
$m_{\tilde{t}_1} = m_b + m_{\tilde{\chi}_1^0}$
$m_{\tilde{t}_1} = m_W + m_b + m_{\tilde{\chi}_1^0}$
$m_{\tilde{t}_1} = m_t + m_{\tilde{\chi}_1^0}$
$m_{\tilde{\chi}_1^0}$ [GeV]
$m_{\tilde{t}_1}$ [GeV]
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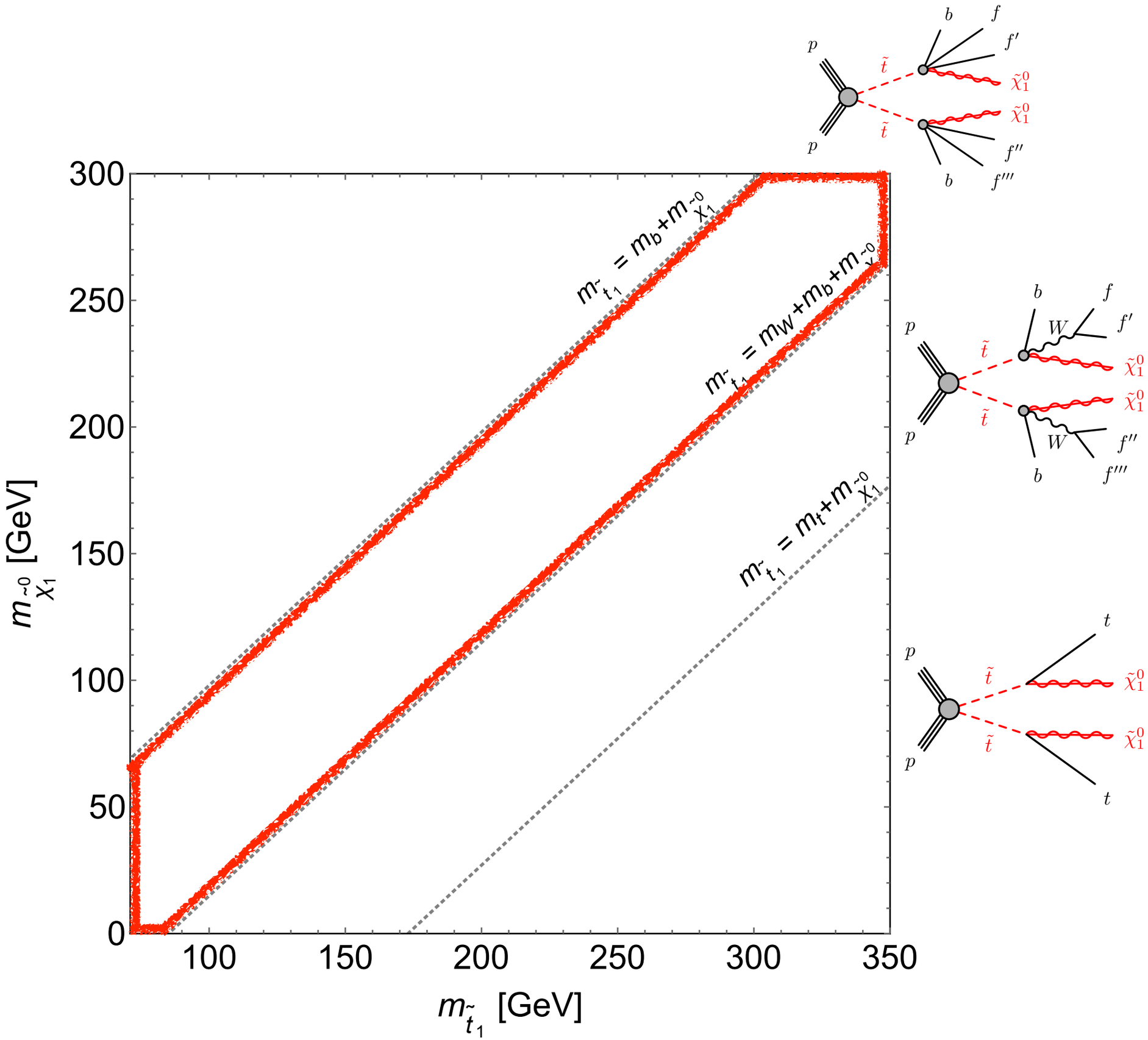
$m_{\tilde{t}_1} = m_b + m_{\tilde{\chi}_1^0}$
$m_{\tilde{t}_1} = m_W + m_b + m_{\tilde{\chi}_1^0}$
$m_{\tilde{t}_1} = m_t + m_{\tilde{\chi}_1^0}$
$m_{\tilde{\chi}_1^0}$ [GeV]
$m_{\tilde{t}_1}$ [GeV]
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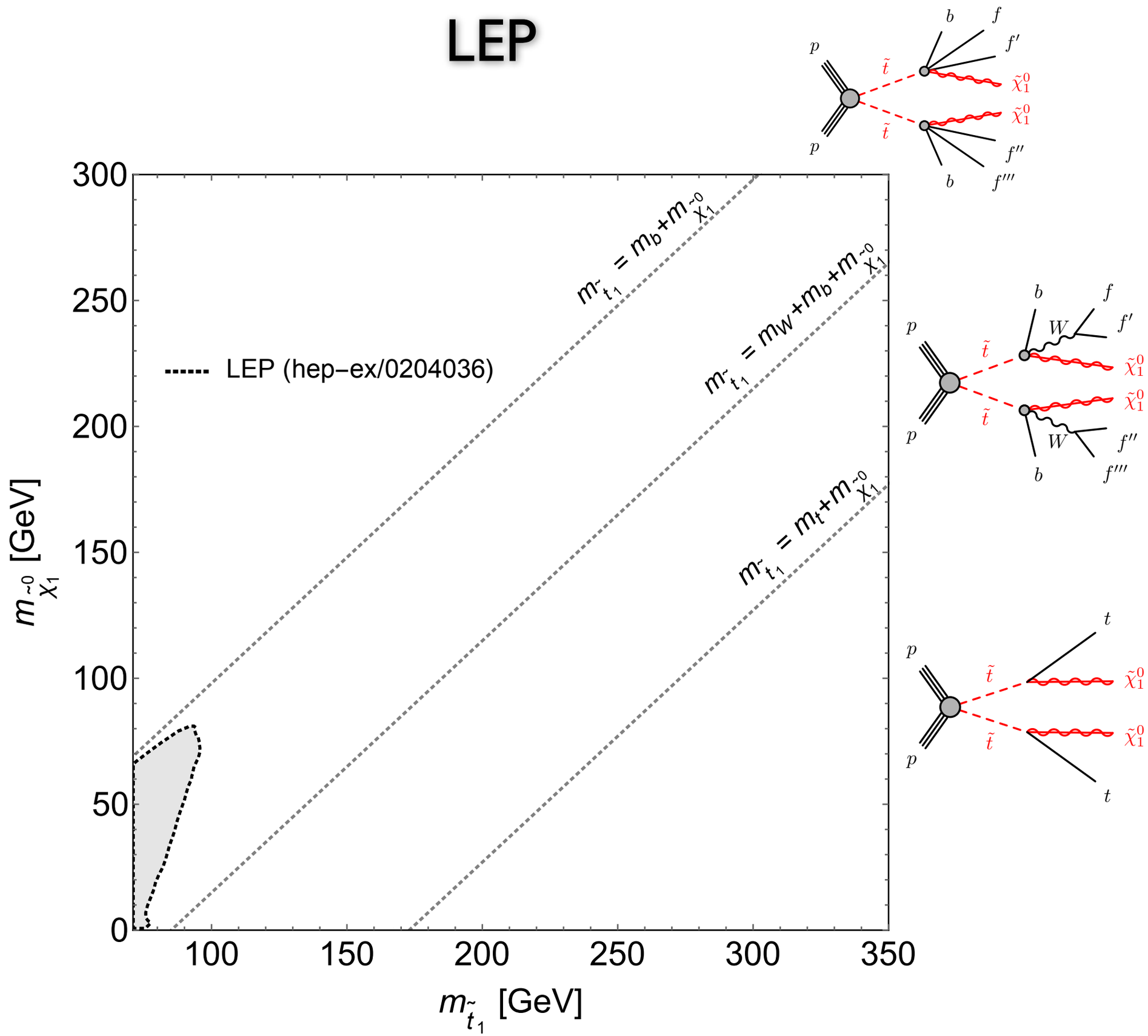
LEP


LEP (hep−ex/0204036)
$m_{\tilde{t}_1} = m_b + m_{\tilde{\chi}_1^0}$
$m_{\tilde{t}_1} = m_W + m_b + m_{\tilde{\chi}_1^0}$
$m_{\tilde{t}_1} = m_t + m_{\tilde{\chi}_1^0}$
$m_{\tilde{\chi}_1^0}$ [GeV]
$m_{\tilde{t}_1}$ [GeV]
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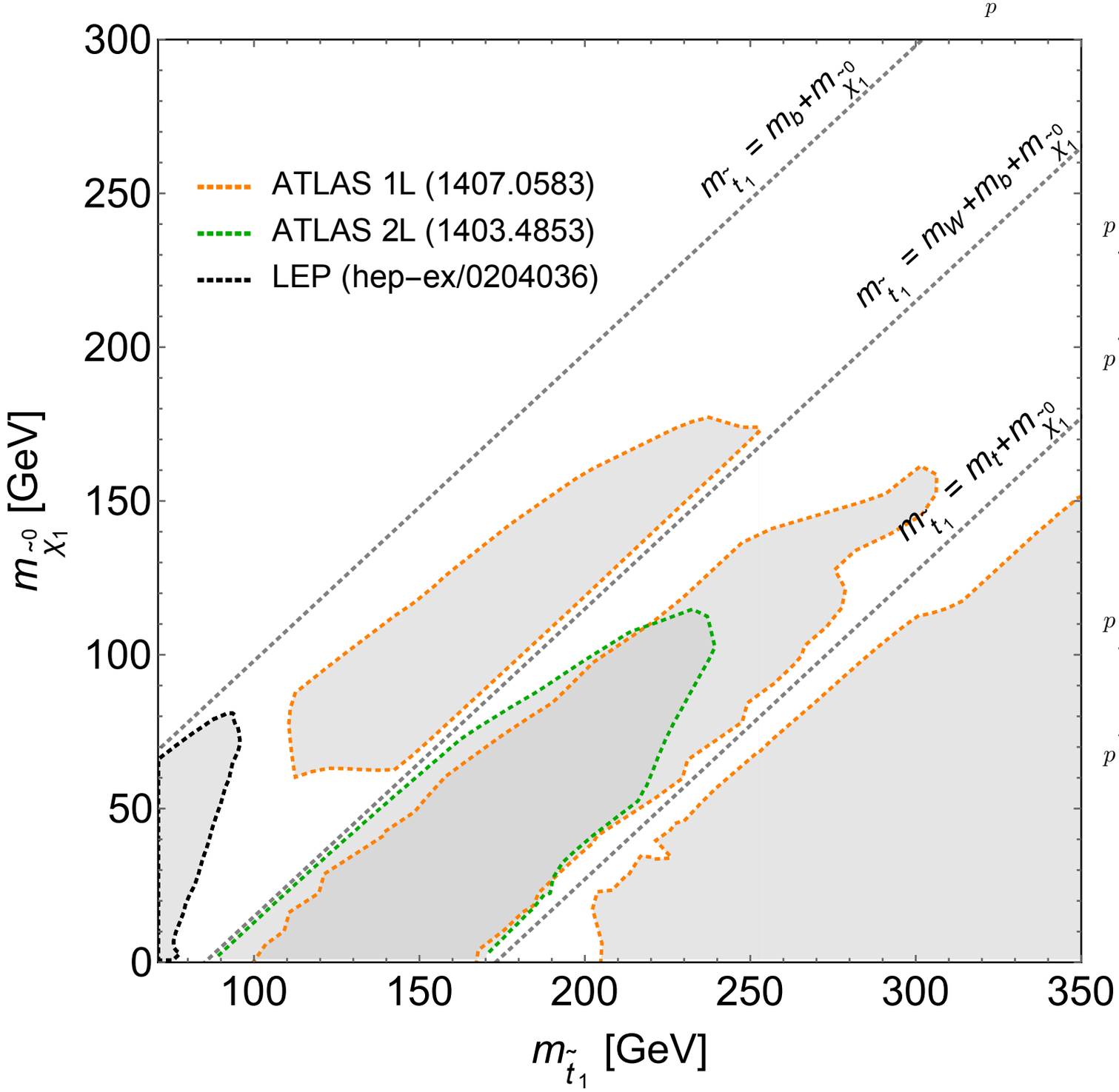
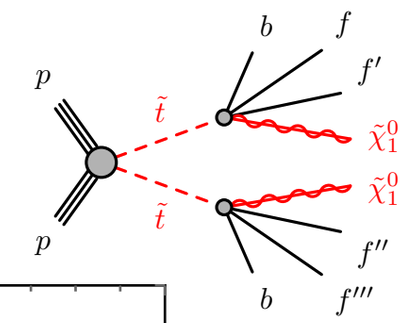
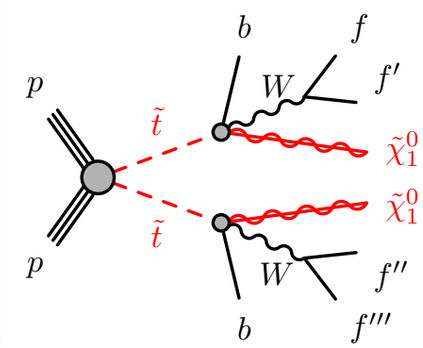
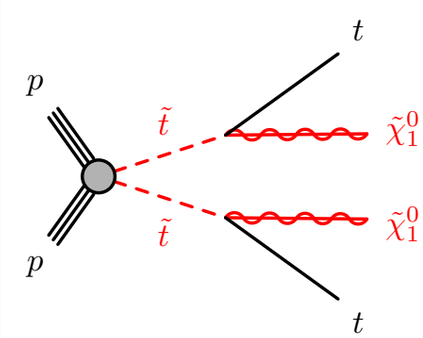
ATLAS Lepton Searches

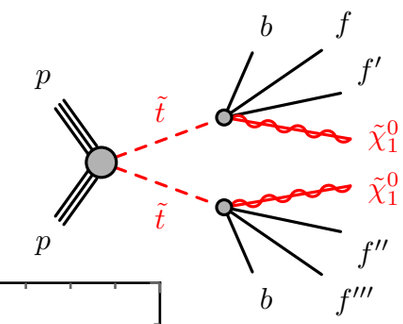


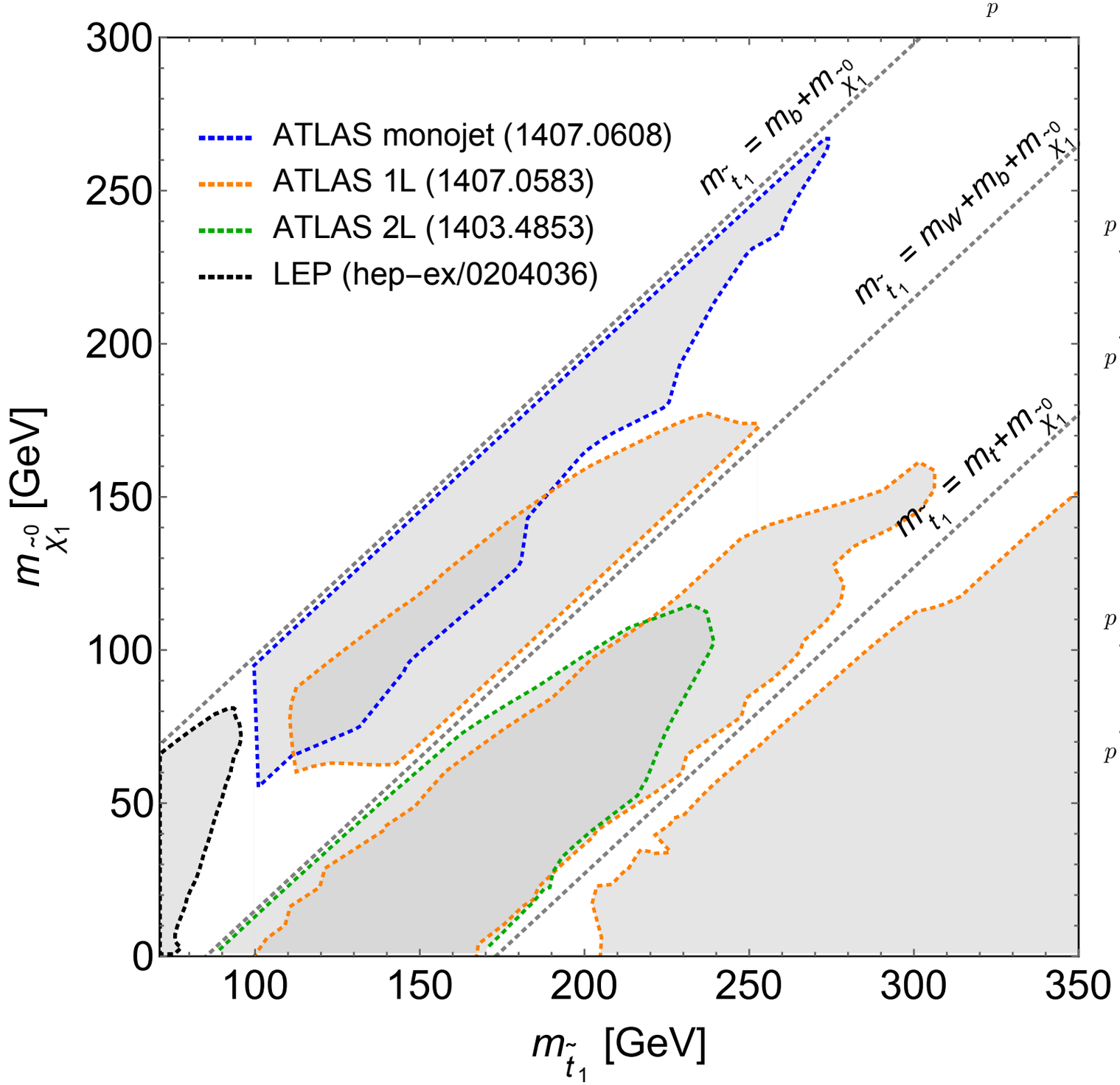


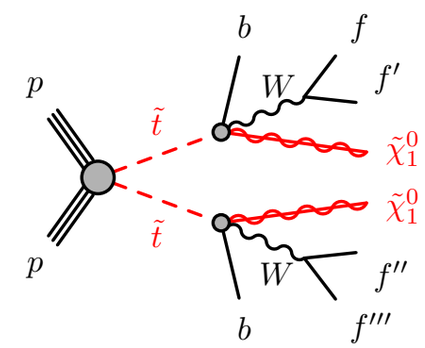


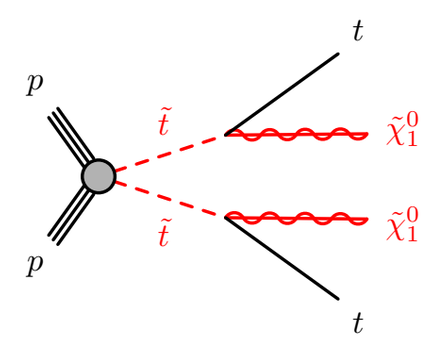


ATLAS Monojet Search

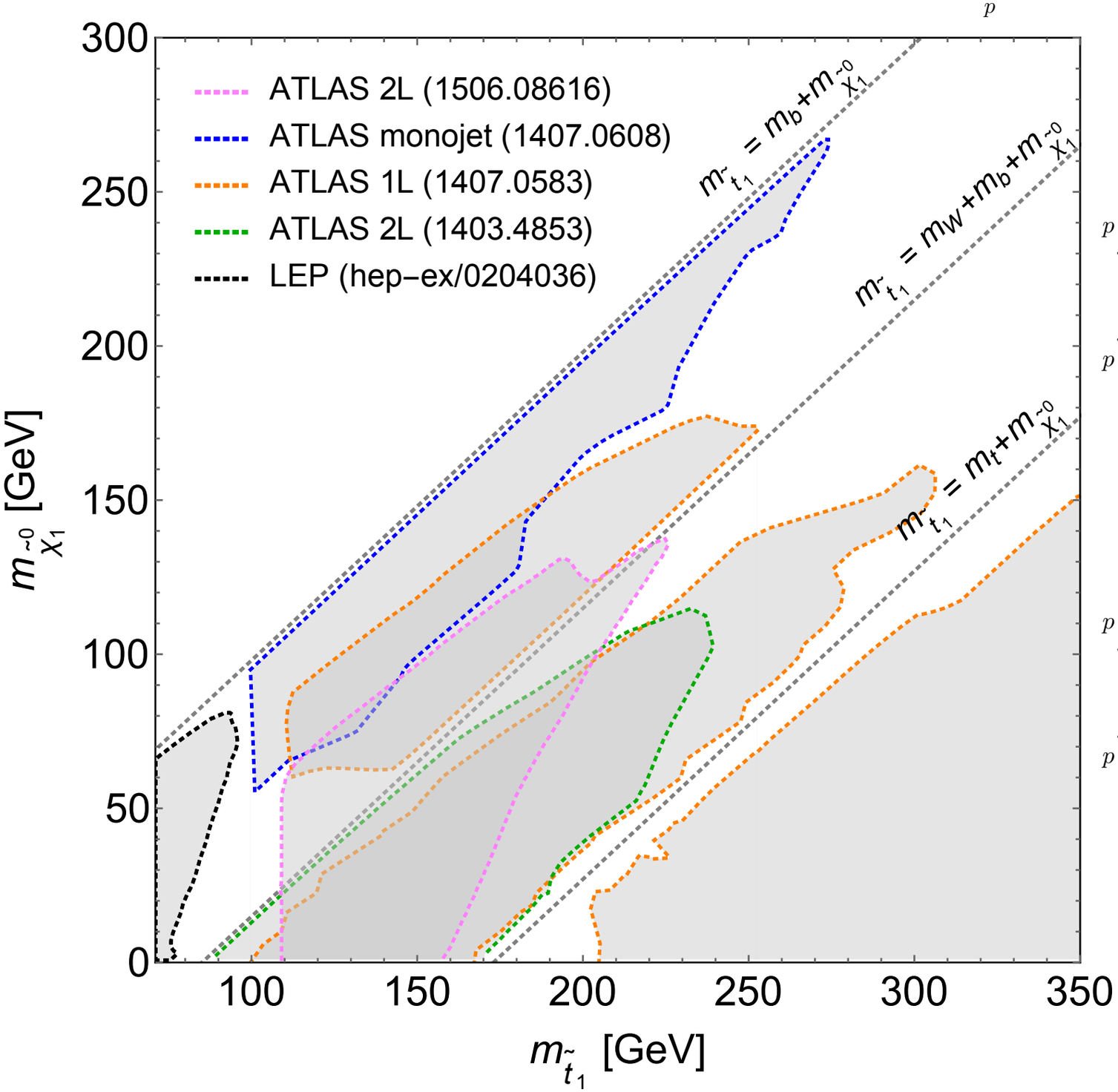


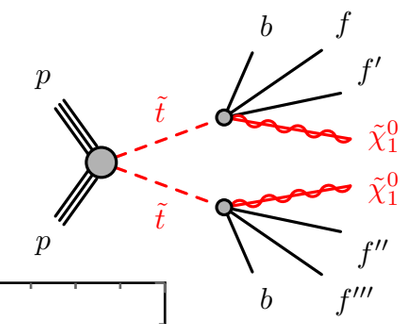


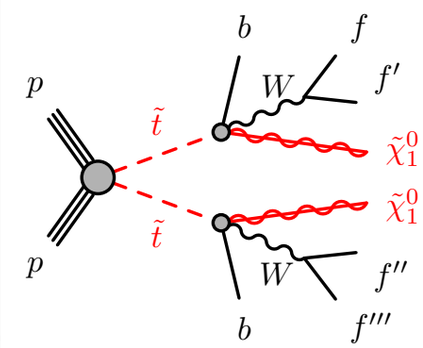


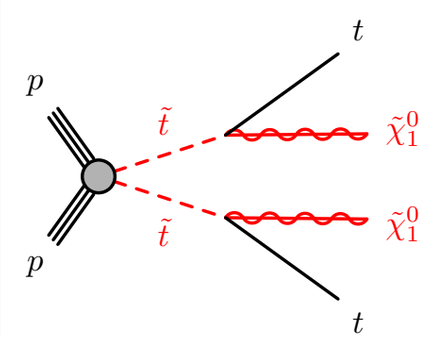


ATLAS New 2 Lepton Search



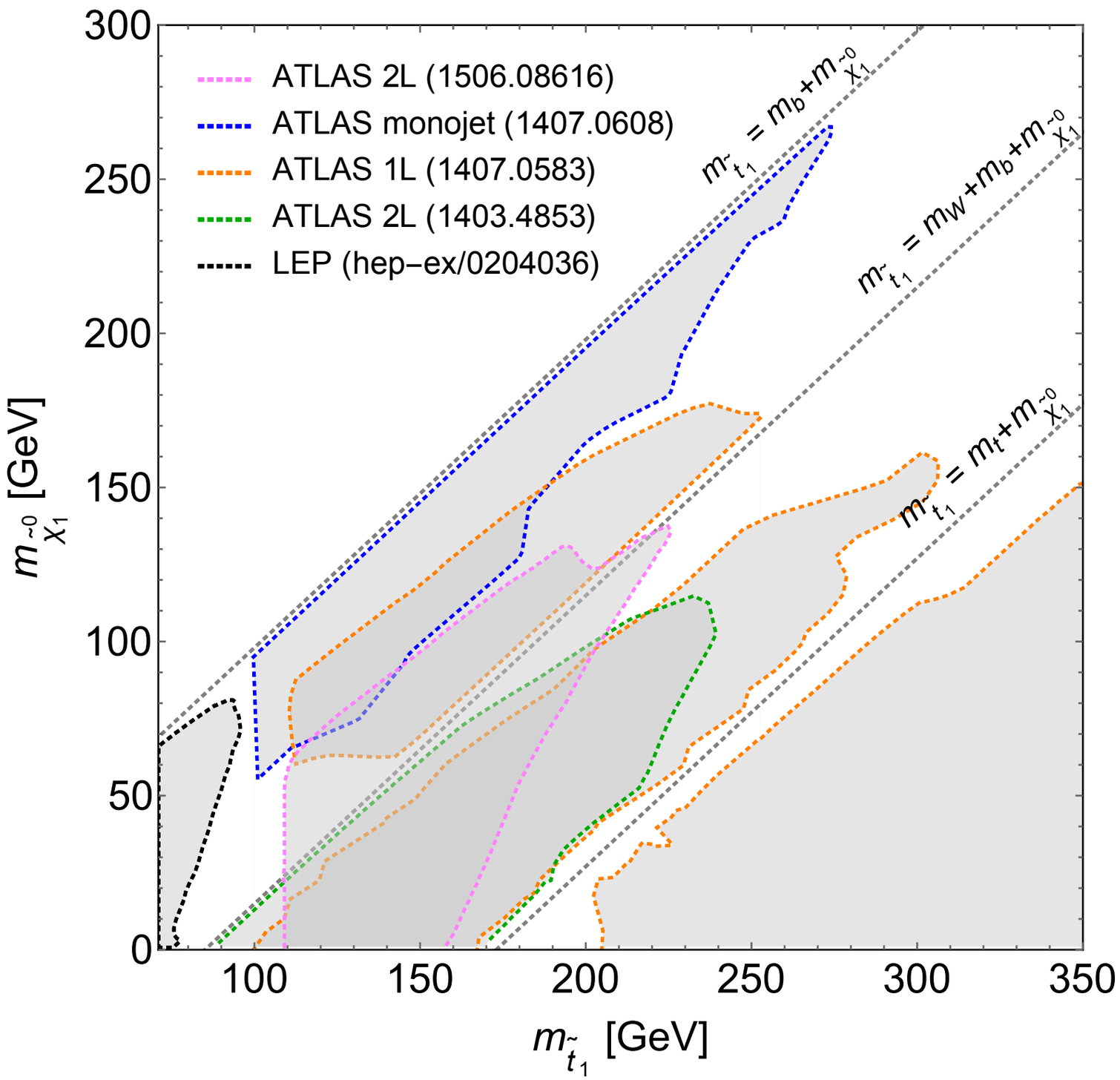






Monojet search "M1"

- At most 3 jets with pT>30 GeV
- Leading jet pT>280 GeV
- MET>220 GeV



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- At most 3 jets with pT>30 GeV
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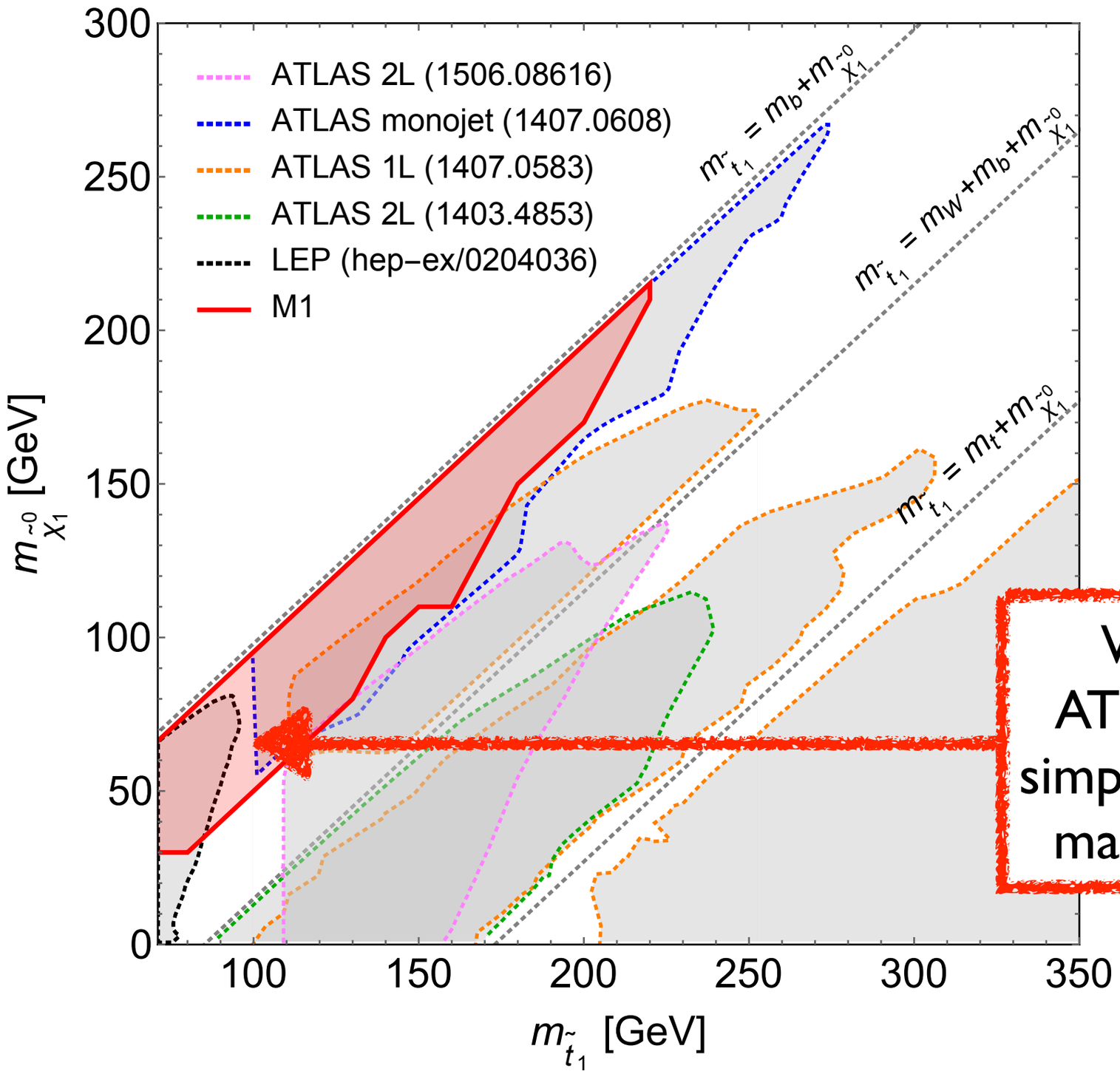
- MET>220 GeV



We can extend the ATLAS exclusion curve simply by considering stop masses below 100 GeV

Monojet search "M1"

- At most 3 jets with pT>30 GeV
- Leading jet pT>280 GeV
- MET>220 GeV

Background	$t\bar{t}$	$Z(\rightarrow\nu\nu)$	$W(\rightarrow\ell\nu)$	Dibosons	Others	Total
M1	780 ± 73	17400 ± 720	14100 ± 337	650 ± 99	565 ± 301	33450 ± 960

Monojet search "M1"

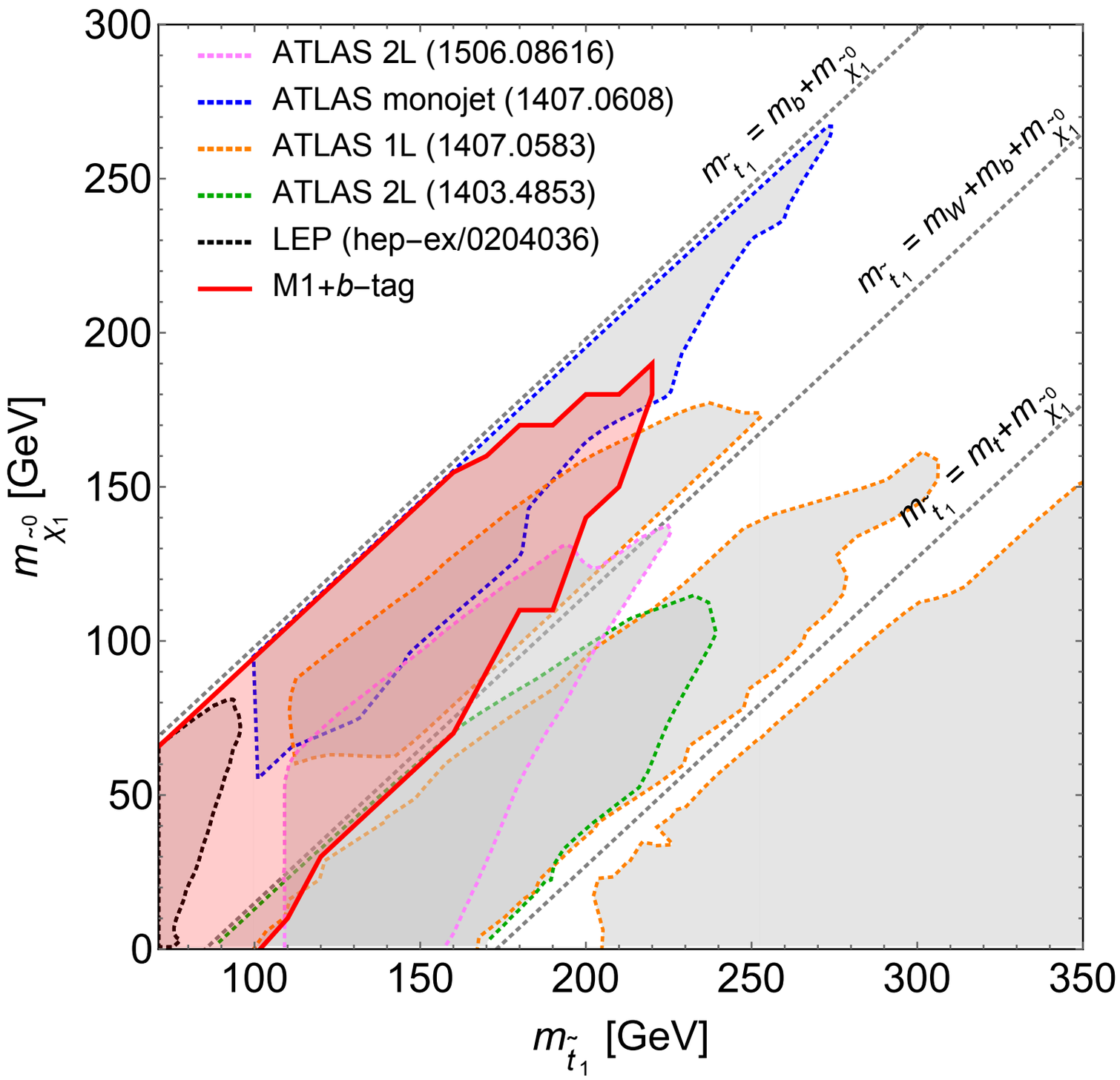
- At most 3 jets with pT>30 GeV
- Leading jet pT>280 GeV
- MET>220 GeV

Background	$t\bar{t}$	$Z(\to\nu\nu)$	$W(\to\ell\nu)$	Dibosons	Others	Total
M1	780 ± 73	17400 ± 720	14100 ± 337	650 ± 99	565 ± 301	33450 ± 960
M1+b-tag	307 ± 57	261 ± 22	144 ± 7	55 ± 17	-	767 ± 64

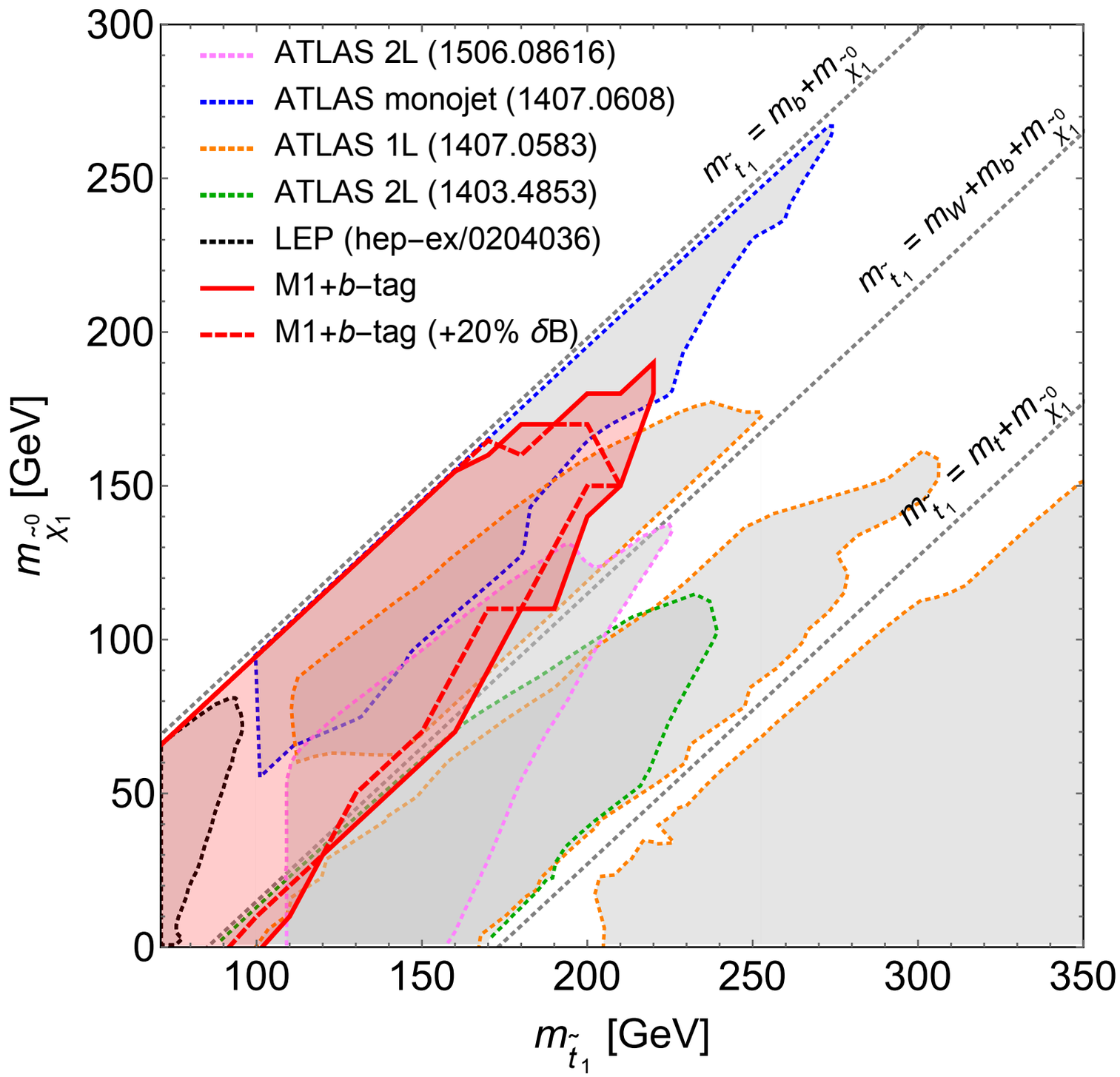
Our proposed search: "M1+b-tag"

In addition to the M1 selections, require that at least one of the 3 jets is b-tagged

Estimated reach of our proposed search "M1+b-tag"



Estimated reach of our proposed search "M1+b-tag"



Conclusions

- Light stop squarks are important targets from the point of view of Naturalness

- Stop squarks around 100 GeV that decay 4-body are particularly challenging

- One way to cover them, already with the 8 TeV data set, is to augment the ATLAS monojet search (1407.0608) with a b-tag requirement

- Greater coverage is achieved by defining additional signal regions, with optimized cuts for the jets and the MET

- Such an "M1+b-tag" search is expected to also be sensitive to stops decaying to b+chargino, for which there also are holes in the current exclusion plots

Thank you!