Probing neutralino properties in minimal supergravity with bilinear R-parity violation

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GRUPO DE
FENOMENOLOGÍA DE INTERACCIONES FUNDAMENTALES

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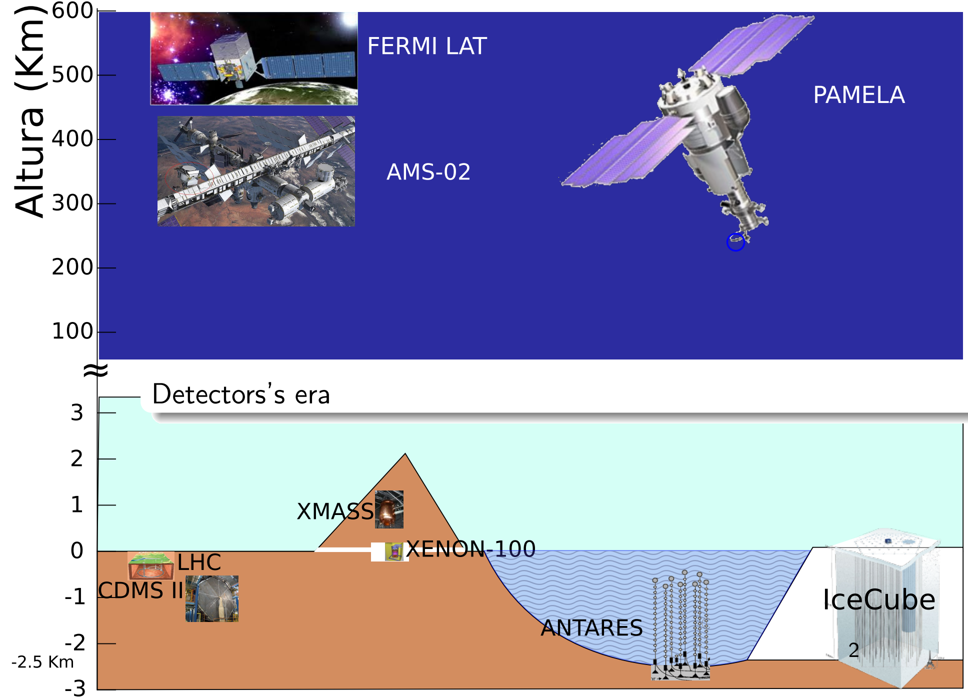
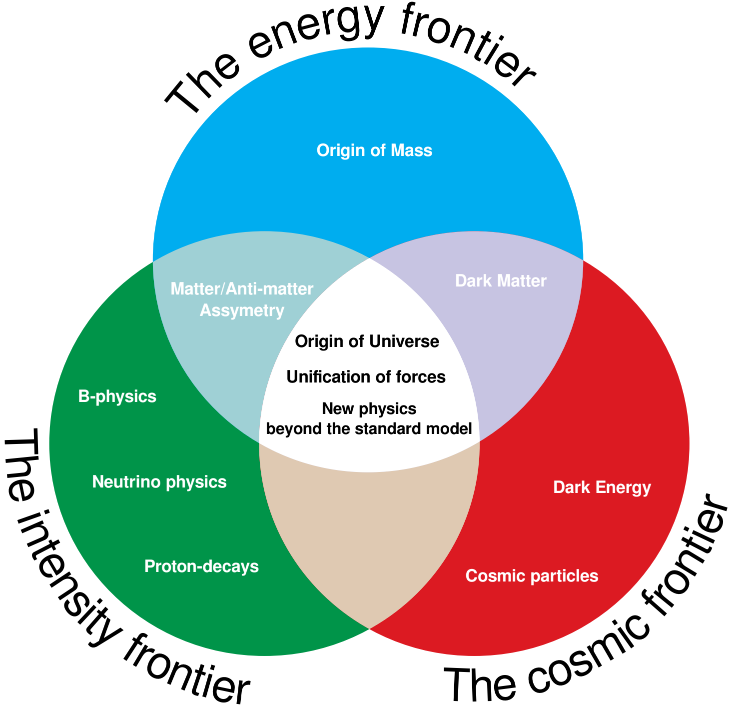
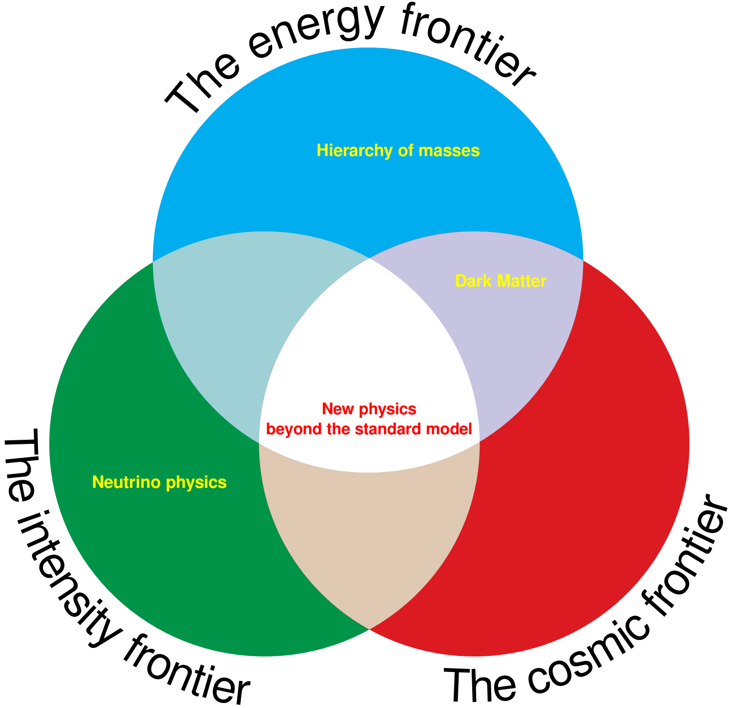
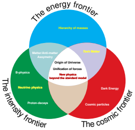

Altura (Km)
600
500
400
300
200
100
FERMI LAT
AMS-02
PAMELA
Detectors's era
3
2
1
0
-1
-2
-2.5 Km
-3
XMASS
XENON-100
LHC
CDMS II
ANTARES
IceCube
2


The energy frontier
Origin of Mass
Matter/Anti-matter
Assymetry
Dark Matter
Origin of Universe
Unification of forces
New physics
beyond the standard model
B-physics
Neutrino physics
Proton-decays
Dark Energy
Cosmic particles
The intensity frontier
The cosmic frontier

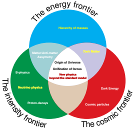

The energy frontier
Hierarchy of masses
Dark Matter
New physics
beyond the standard model
Neutrino physics
The intensity frontier
The cosmic frontier



Bilinear R-parity Violation (BRpV) Supersymmetric Model

$$W = W_{\rm MSSM} + \epsilon_i L_i H_u$$

$$i = 1, 2, 3$$



Bilinear R-parity Violation (BRpV) Supersymmetric Model

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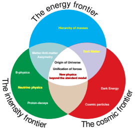
$$\downarrow$$

$$v_i$$

$$i = 1, 2, 3$$



Bilinear R-parity Violation (BRpV) Supersymmetric Model

$$W = W_{\mathrm{MSSM}} + \epsilon_i L_i H_u$$

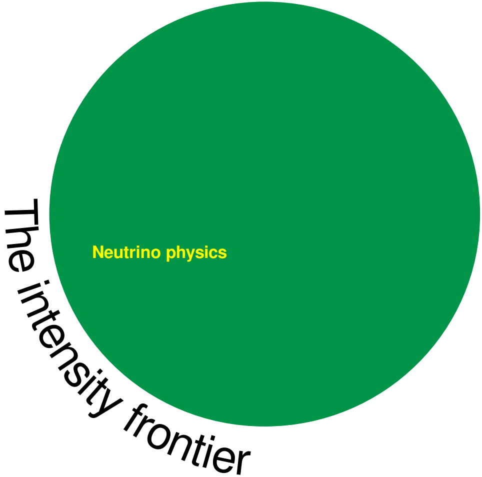
$$\downarrow$$

$$v_i$$

$$i = 1, 2, 3$$

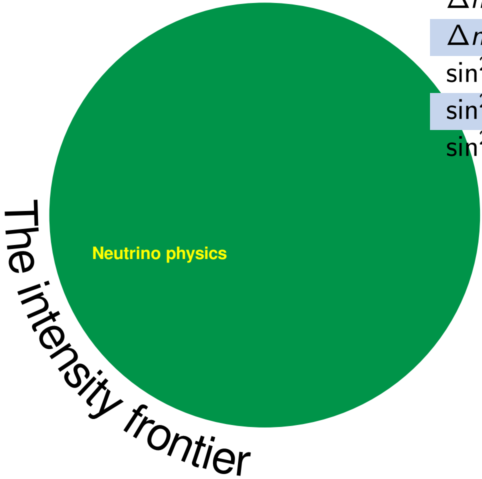
$$\frac{\Lambda_i}{\mu\, v_d} = \frac{\epsilon_i}{\mu} + \frac{v_i}{v_d}$$

6 new parameters


Neutrino physics
The intensity frontier

Parámetro	1σ
$\Delta m^2_{32}[10^{-3}\mathrm{eV}^2]$	$2.50^{+0.09}_{-0.16}$
$\Delta m^2_{21}[10^{-5}\mathrm{eV}^2]$	$7.59^{+0.20}_{-0.18}$
$\sin^2\theta_{23}$	$0.52^{+0.06}_{0.07}$
$\sin^2\theta_{12}$	$0.312^{+0.017}_{-0.015}$
$\sin^2\theta_{13}$	$0.013^{+0.007}_{-0.005}$

Valle et al, arXiv:1108.1376



The intensity frontier

Neutrino physics

$$\Delta m_{32} = \frac{M_{\tilde{\gamma}}}{4|\mathbf{M}^{\mathbf{0}}_{\chi}|}\,|\mathbf{\Lambda}|^2$$

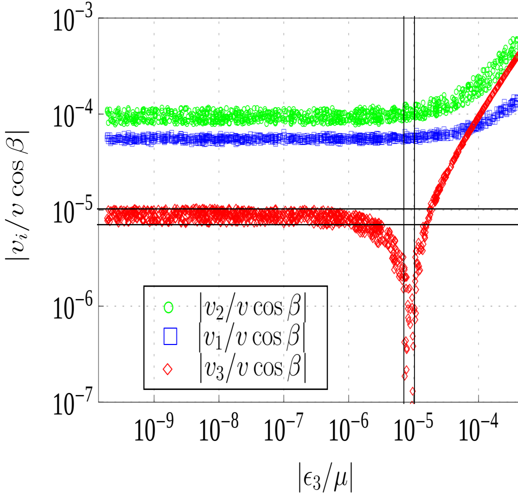
$$\tan^2\theta_{23}^{\rm BRpV} = \frac{\Lambda_2^2}{\Lambda_3^2}$$

$$\Delta m_{21} = \frac{3}{8\pi^2}\sin 2\theta_{\tilde{b}}\,\frac{m_b^3}{v^2\,c_\beta^2}\,\Delta B_0^{\tilde{b}_2\tilde{b}_1}$$

$$\times\frac{(\bar{\epsilon}_1^2+\bar{\epsilon}_2^2)}{\mu^2}$$

$$\tan^2\theta_{12} = \frac{\bar{\epsilon}_1^2}{\bar{\epsilon}_2^2}\,.$$

$$\bar{\epsilon}_i = f_i(\Lambda_i,\epsilon_i)$$



Susy point with $\tilde{\nu}_\tau$ (N)LSP:
Aristizabal,D.R,Spinner, *in progress*

Fully implemented in SPheno [by W. Porod]

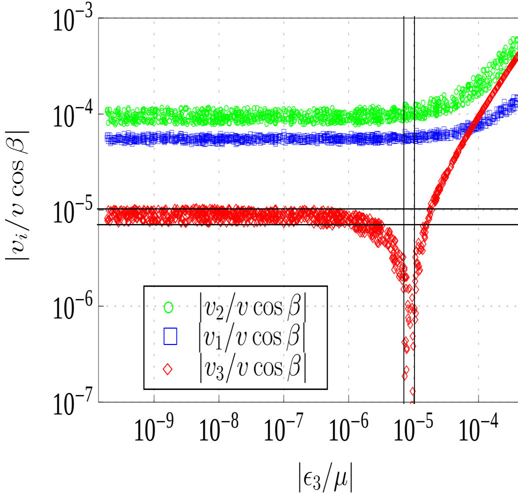
$$\Delta m_{32} = \frac{M_{\tilde{\gamma}}}{4|M^0_{\chi}|}\,|\boldsymbol{\Lambda}|^2$$

$$\tan^2\theta_{23}^{\rm BRpV} = \frac{\Lambda_2^2}{\Lambda_3^2}$$

$$\Delta m_{21} = \frac{3}{8\pi^2}\sin 2\theta_{\tilde{b}}\,\frac{m_b^3}{v^2\,c_\beta^2}\,\Delta B_0^{\tilde{b}_2\tilde{b}_1} \times \frac{(\bar{\epsilon}_1^2+\bar{\epsilon}_2^2)}{\mu^2}$$

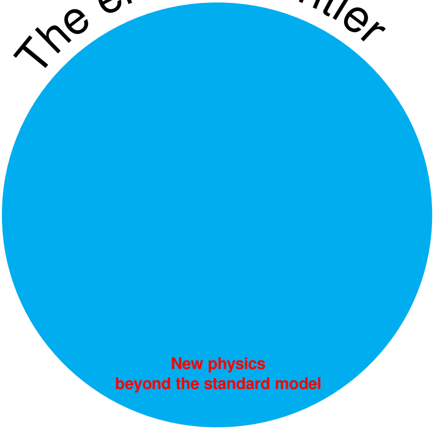
$$\tan^2\theta_{12} = \frac{\bar{\epsilon}_1^2}{\bar{\epsilon}_2^2}\,.$$

$$\bar{\epsilon}_i = f_i(\Lambda_i,\epsilon_i)$$

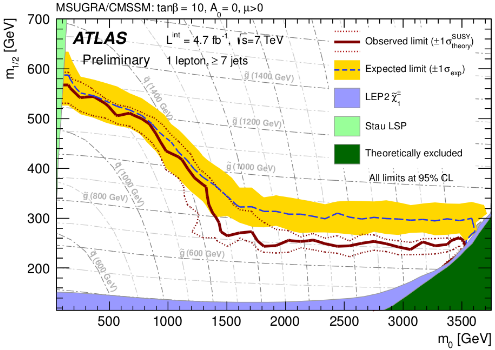


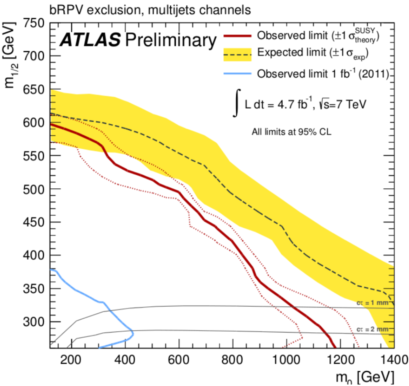
Susy point with $\tilde{\nu}_\tau$ (N)LSP:
Aristizabal,D.R,Spinner, *in progress*

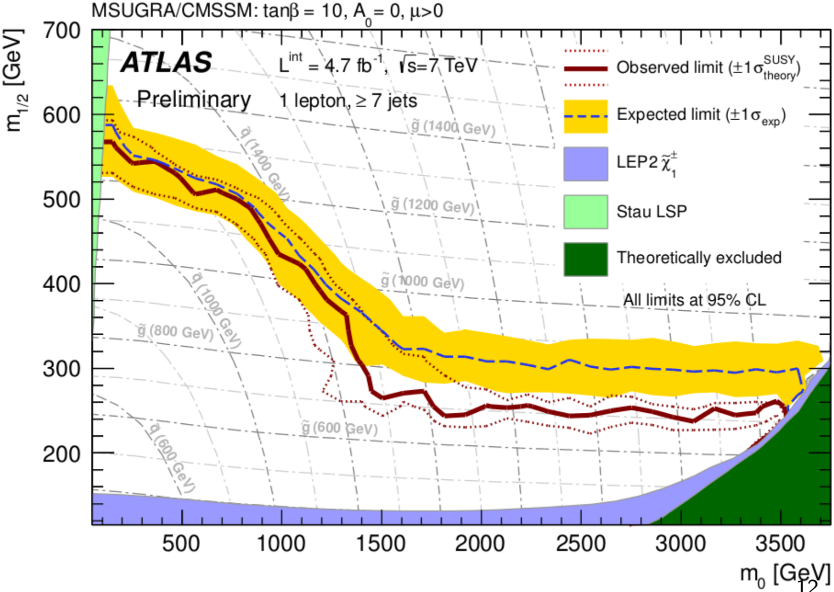
The energy frontier

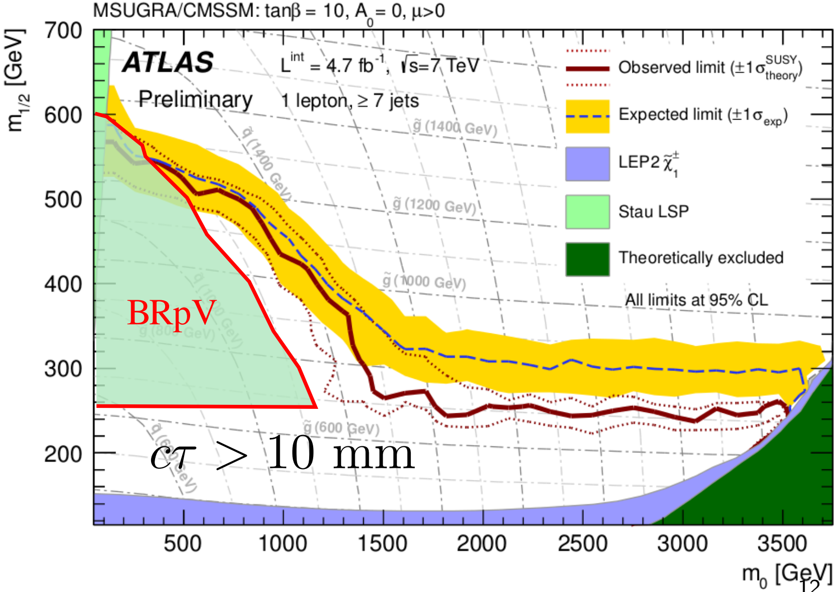


ATLAS-CONF-2012-140 (Oct): $\sqrt{s} = 7$ TeV, $\int Ldt = 4.7\ \mathrm{fb}^{-1}$





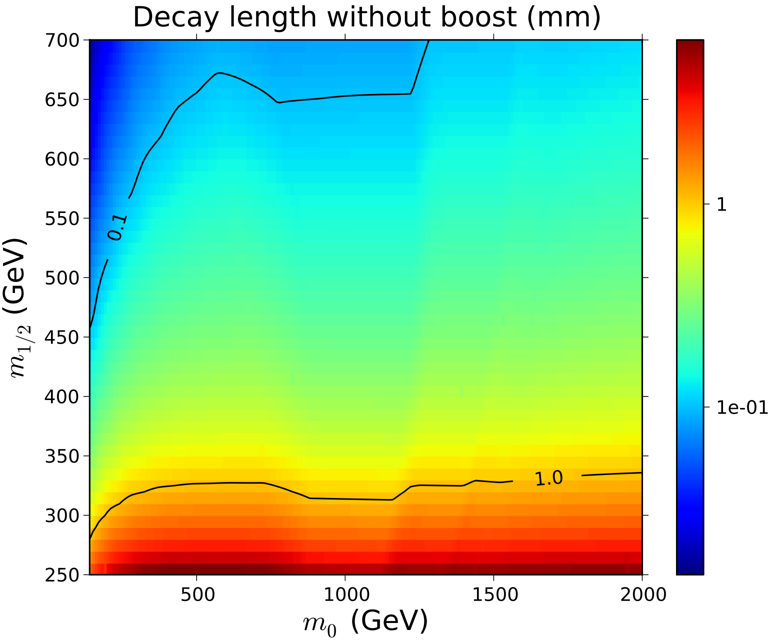

MSUGRA/CMSSM: tanβ = 10, A_0 = 0, μ>0
ATLAS
Preliminary
L^{int} = 4.7 fb^{-1}, $\sqrt{s}$=7 TeV
1 lepton, ≥ 7 jets
Observed limit (±1σ^{SUSY}_{theory})
Expected limit (±1σ_{exp})
LEP2 $\tilde{\chi}^{\pm}_1$
Stau LSP
Theoretically excluded
All limits at 95% CL
$\tilde{g}$ (1400 GeV)
$\tilde{g}$ (1200 GeV)
$\tilde{g}$ (1000 GeV)
$\tilde{g}$ (800 GeV)
$\tilde{g}$ (600 GeV)
$\tilde{q}$ (1400 GeV)
$\tilde{q}$ (1000 GeV)
$\tilde{q}$ (600 GeV)
$m_{1/2}$ [GeV]
m_0 [GeV]
700
600
500
400
300
200
500
1000
1500
2000
2500
3000
3500


MSUGRA/CMSSM: tanβ = 10, A0 = 0, μ>0
ATLAS
Preliminary
L int = 4.7 fb-1, √s=7 TeV
1 lepton, ≥ 7 jets
Observed limit (±1σ SUSY theory)
Expected limit (±1σ exp)
LEP2 χ̃±1
Stau LSP
Theoretically excluded
All limits at 95% CL
g̃ (1400 GeV)
g̃ (1200 GeV)
g̃ (1000 GeV)
g̃ (600 GeV)
BRpV
cτ > 10 mm
m1/2 [GeV]
m0 [GeV]
700
600
500
400
300
200
500
1000
1500
2000
2500
3000
3500

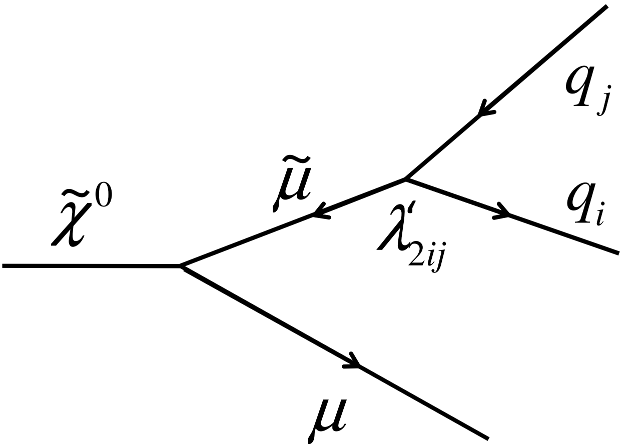
The energy frontier

New physics
beyond the standard model

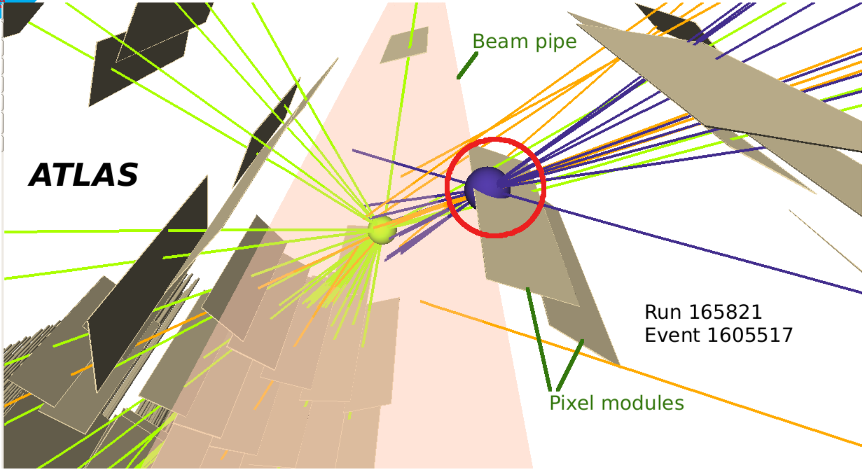
Neutralino decay length BRpV



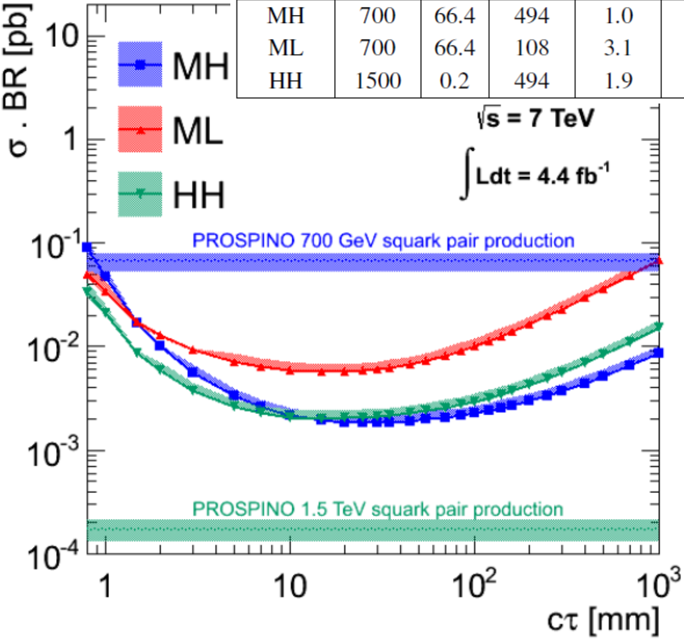
ATLAS displaced vertices [ATLAS-CONF-2012-103] (August)

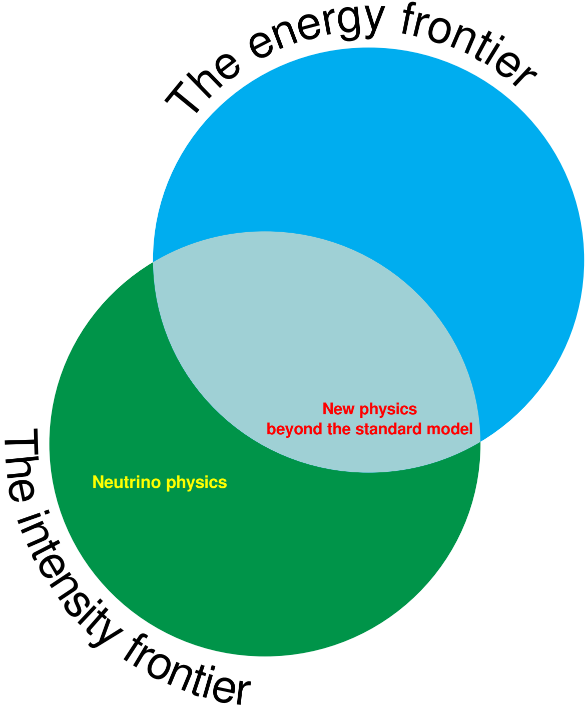


ATLAS displaced vertices [ATLAS-CONF-2012-103] (August)



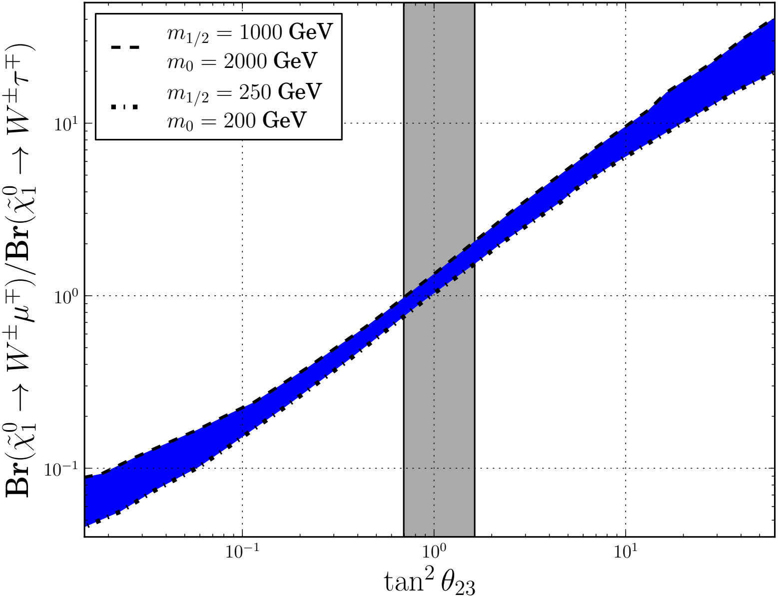
Sample	$m_{\tilde{q}}$ [GeV]	σ [fb]	$m_{\tilde{\chi}_1^0}$ [GeV]	$\langle\gamma\beta\rangle_{\tilde{\chi}_1^0}$	$c\tau_{MC}$ [mm]	λ'_{211}
MH	700	66.4	494	1.0	78	3.0×10^{-6}
ML	700	66.4	108	3.1	101	1.5×10^{-5}
HH	1500	0.2	494	1.9	82	1.5×10^{-5}





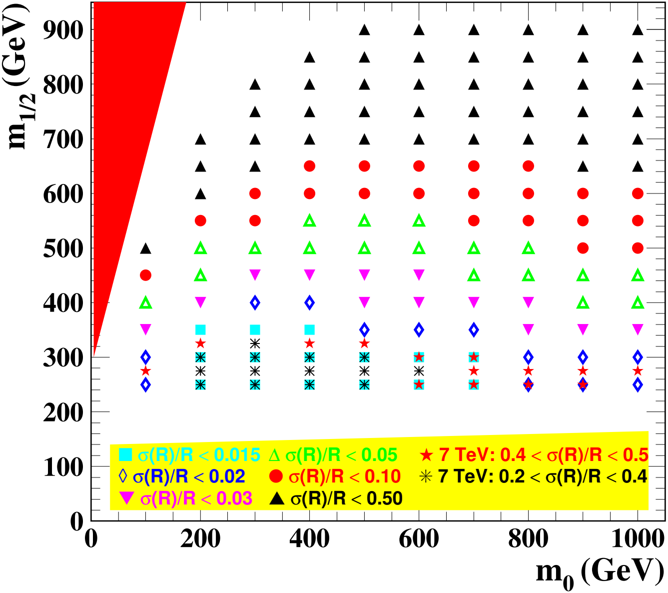
The energy frontier
New physics
beyond the standard model
Neutrino physics
The intensity frontier

D.R, *et al* arXiv:1006.5075 [PRD]

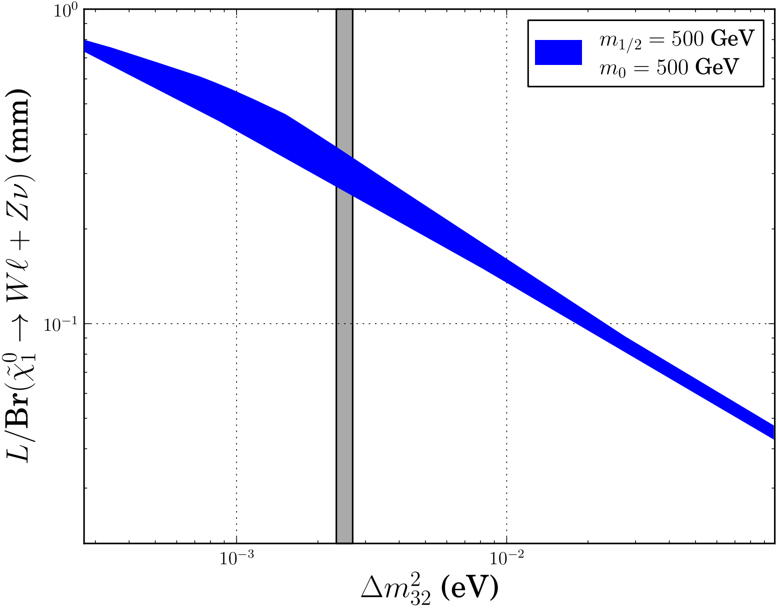


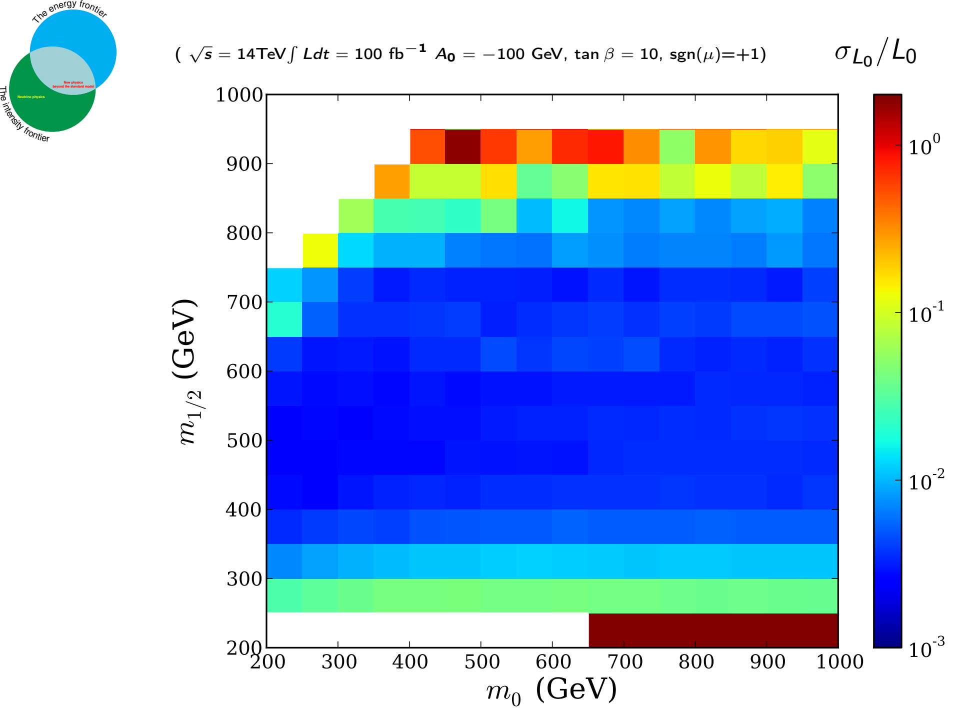
The energy frontier
The intensity frontier
Neutrino physics
New physics beyond the standard model

$\sqrt{s} = 14\text{TeV} \int L dt = 100 \text{ fb}^{-1}$ ($A_0 = -100$ GeV, $\tan\beta = 10$, sgn(μ)=+1)

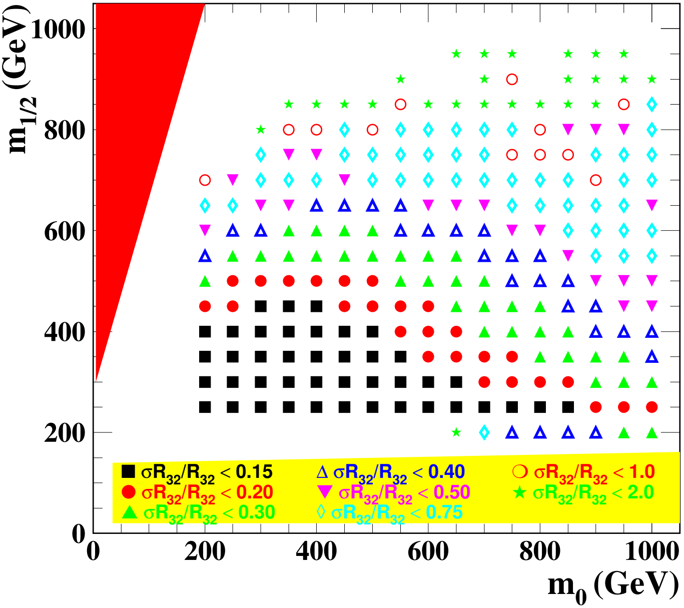


D.R, *et al* arXiv:1206.3605 [PRD]



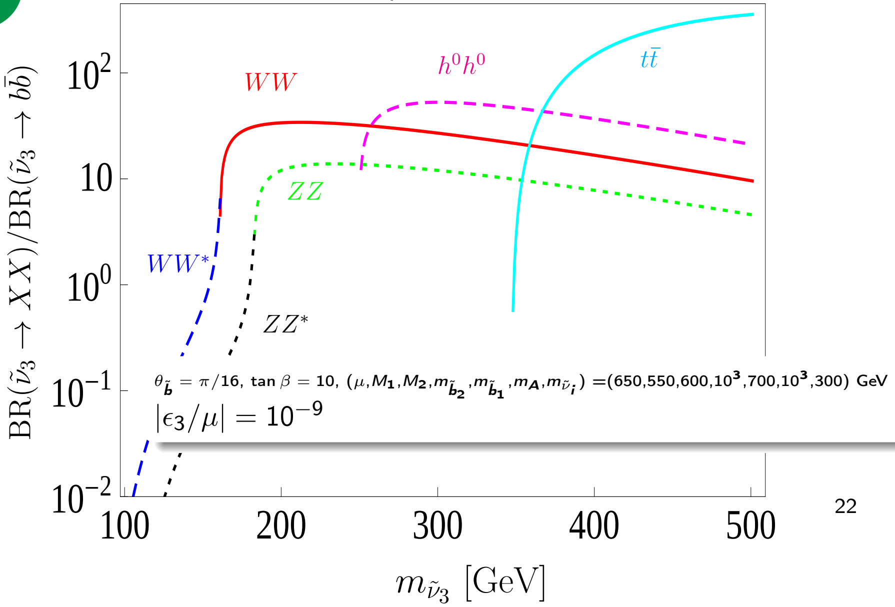

The energy frontier
New physics beyond the standard model
Neutrino physics
The intensity frontier
($\sqrt{s}$ = 14TeV $\int Ldt$ = 100 fb^{-1} A_0 = −100 GeV, tan β = 10, sgn(μ)=+1)
σ_{L_0}/L_0
$m_{1/2}$ (GeV)
m_0 (GeV)
200
300
400
500
600
700
800
900
1000
10^0
10^{-1}
10^{-2}
10^{-3}

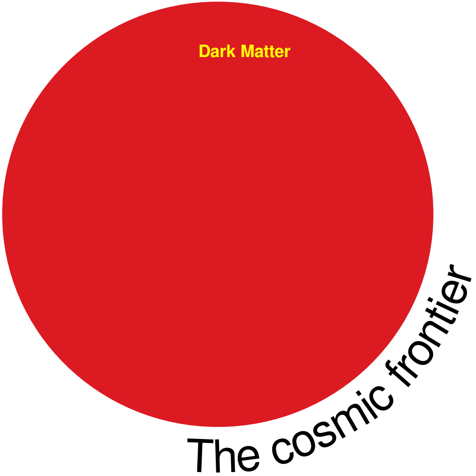
$$R_{32} = \frac{L_0}{\mathrm{Br}(\tilde{\chi}_1^0 \to lW + Z\nu)} \approx \frac{1}{\Gamma(\tilde{\chi}_1^0 \to lW + Z\nu)}$$



$\tilde{\nu}$ (N)LSP

Aristizabal, D.R, Spinner, PRELIMINARY



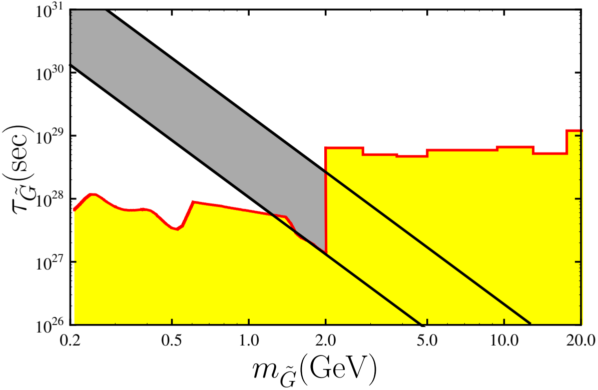

Dark Matter
The cosmic frontier

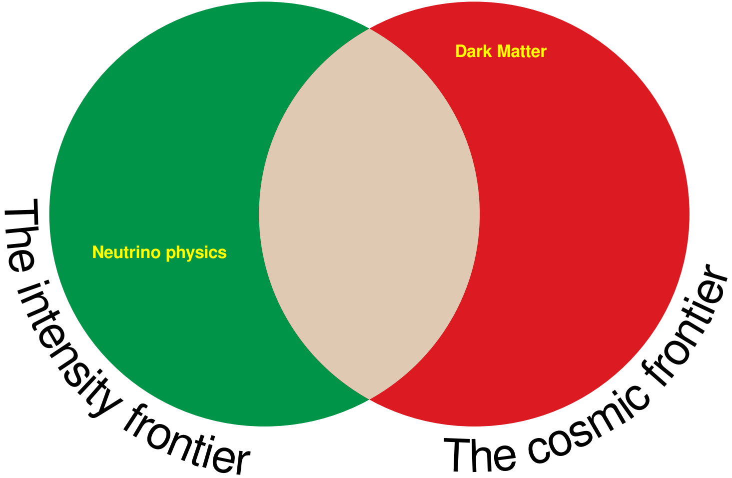
Dark Matter
The cosmic frontier

Gravitino decay

$$\Gamma = \Gamma(\tilde{G} \to \sum_i \nu_i \gamma) \simeq \frac{1}{32\pi} |U_{\tilde{\gamma}\nu}|^2 \frac{m_{\tilde{G}}^3}{M_P^2}$$

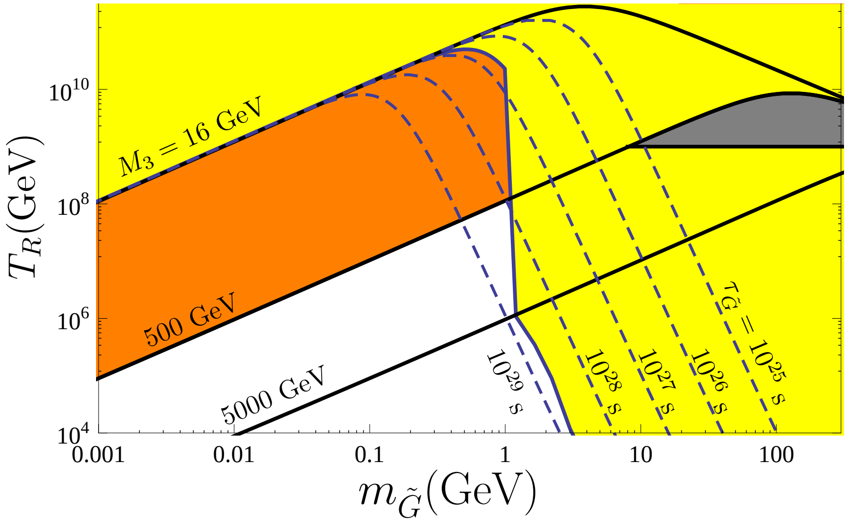
$$|U_{\tilde{\gamma}\nu}|^2 \approx \frac{\mu^2 g^2 \sin^2\theta_W}{4|M_\chi^0|}(M_2 - M_1)^2 |\vec{\Lambda}|^2,$$




Dark Matter
Neutrino physics
The intensity frontier
The cosmic frontier

Gravitino DM & neutrino masses

D.R, Taoso, Valle, Zapata, 1109.0512 [PRD] $\Longrightarrow m_{\tilde{G}} < 2$ GeV



Gravitino DM & neutrino masses

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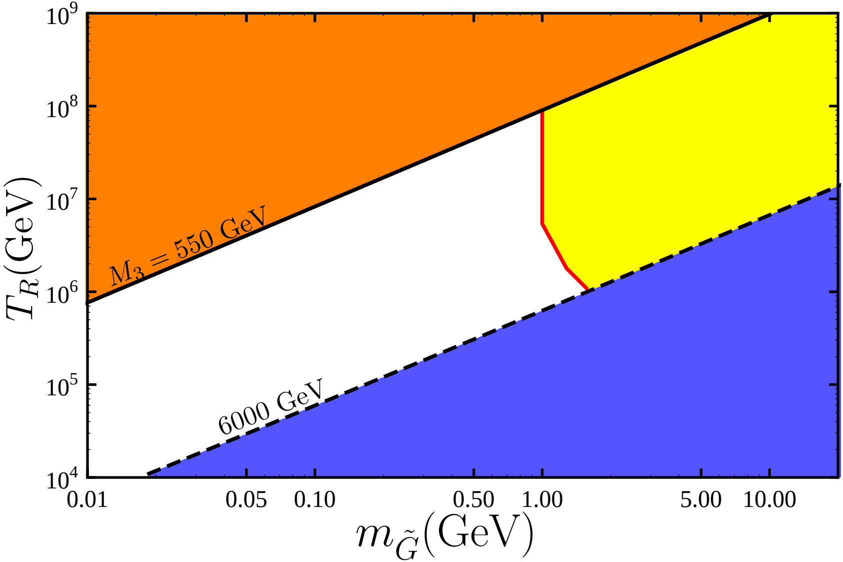
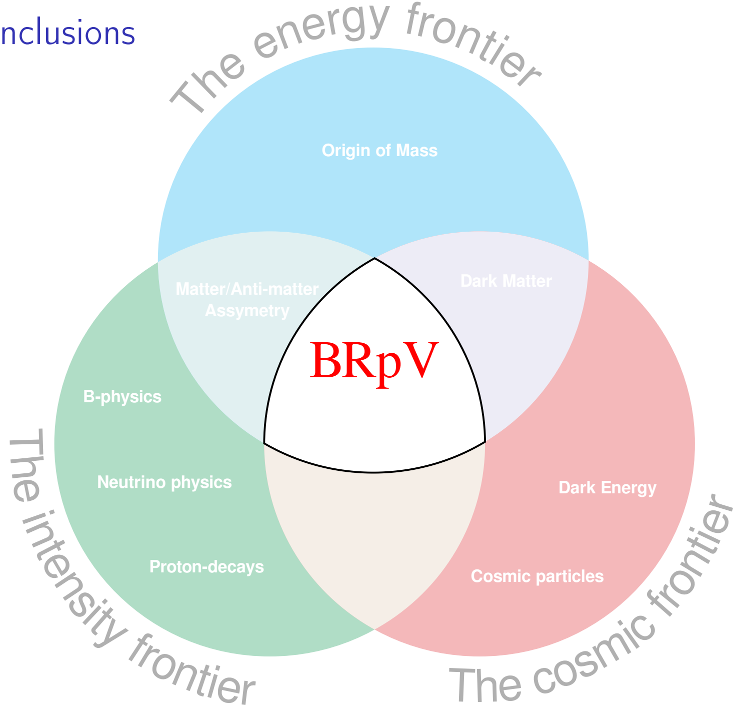


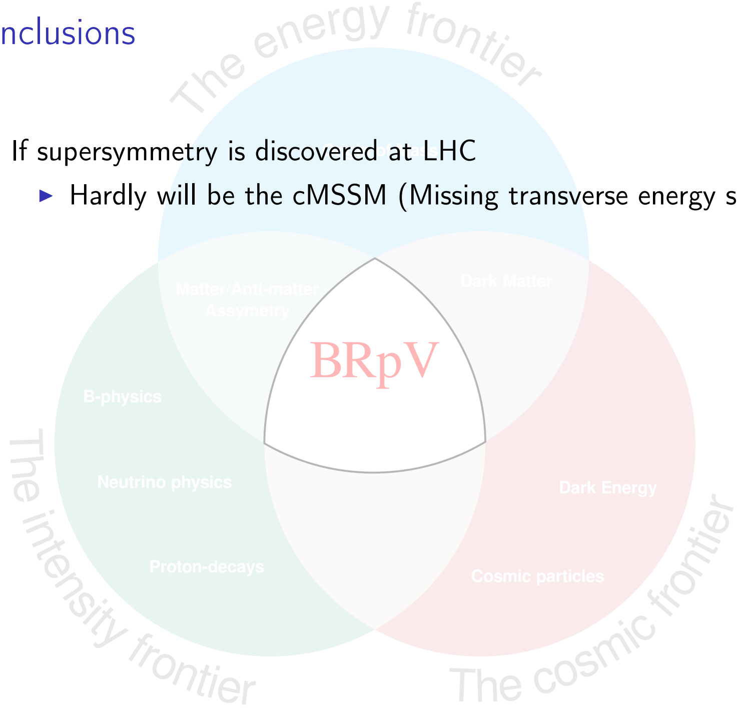
Conclusions



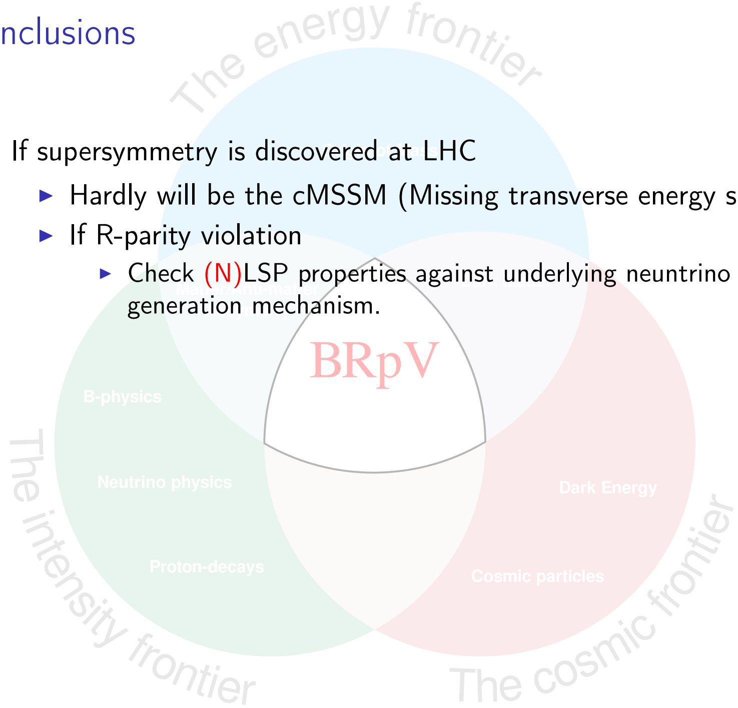
Conclusions

If supersymmetry is discovered at LHC

- Hardly will be the cMSSM (Missing transverse energy signal)



Conclusions



If supersymmetry is discovered at LHC

- Hardly will be the cMSSM (Missing transverse energy signal)
- If R-parity violation
  - Check (N)LSP properties against underlying neuntrino mass generation mechanism.

Conclusions

If supersymmetry is discovered at LHC

- Hardly will be the cMSSM (Missing transverse energy signal)
- If R-parity violation
  - Check (N)LSP properties against underlying neuntrino mass generation mechanism.
  - Check against cosmic ray results:
    - PAMELA anomaly,
    - 130 GeV gamma-ray line,

    interpreted as Dark Matter,
    - Some Direct Dark Matter (DM) signal

    would exclude BRpV as the explanation for neutrino masses and mixings.