

Digging into the LHC Results

André Lessa



Santo André, SP, Brazil

PHENOEXP 2018

Buenos Aires, May 9th, 2018

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(from a theorist's perspective)

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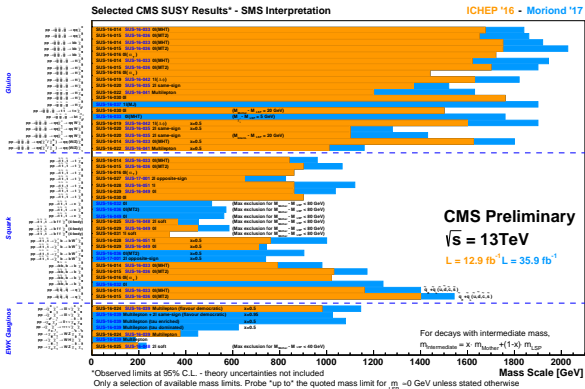
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- *Testing your favorite BSM model:*
 - ▶ What do we want to know?
 - ★ Is the model excluded/allowed?
 - ★ What is its likelihood given LHC searches?
 - ★ What is its overall likelihood (LHC+flavor obs.+DM+...)?

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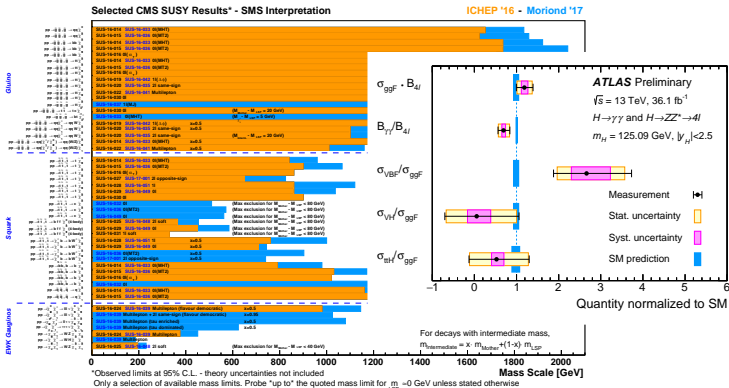
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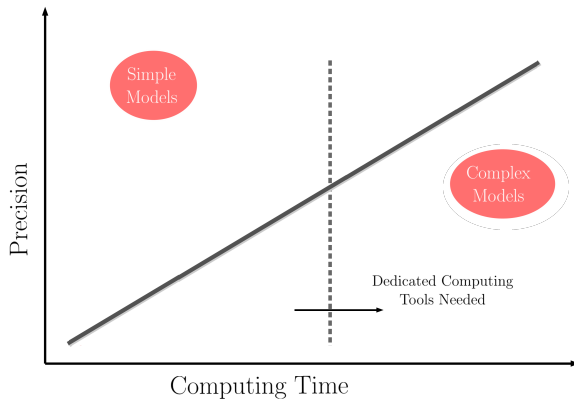
- Large set of experimental (LHC) data:



- *How to confront models with the experimental data?*

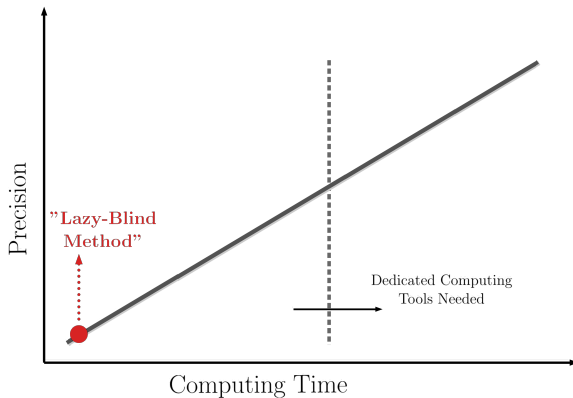
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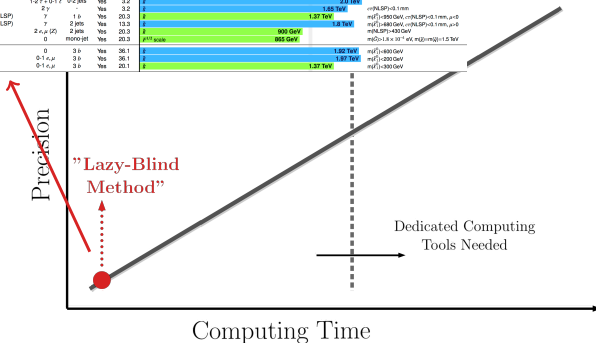
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ATLAS SUSY Searches* - 95% CL Lower Limits

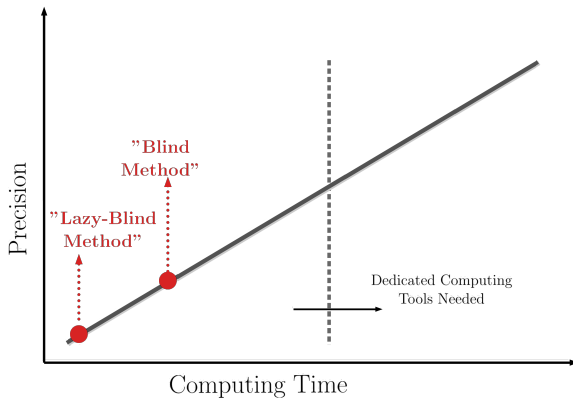
Status: March 2017

Model	$\epsilon, \mu, \tau, \gamma$	Jets	$E_{\text{miss}}^{\text{min}}$	$[L, d](\text{fb}^{-1})$	Mass limit	$\sqrt{s} = 7, 8 \text{ TeV}$	$\sqrt{s} = 13 \text{ TeV}$
Inclusive Searches	MSUGRA/CMSSM	$0.3 \leq \epsilon, \mu^2 \leq 2$	$2-10 \text{ jets} \cup b$	Yes	20.3	1.1 TeV	1.5 TeV
	$\tilde{\chi}_1^0 \rightarrow \gamma \tilde{g}$	0	2-6 jets	Yes	36.1	1.57 TeV	1.8 TeV
	$\tilde{\chi}_1^0 \rightarrow \gamma \tilde{g}$ (compressed)	0	1-3 jets	Yes	3.2	608 GeV	2.62 TeV
	$\tilde{\chi}_1^0 \rightarrow \gamma \tilde{g}$	0	2-6 jets	Yes	36.1	1.57 TeV	2.01 TeV
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	$\tilde{\chi}_1^0 \rightarrow \gamma \tilde{g} \tilde{g} \tilde{g} \tilde{g}$	$3 \leq \epsilon, \mu$	4 jets	-	13.2	1.3 TeV	1.8 TeV
	$\tilde{\chi}_1^0 \rightarrow \gamma \tilde{g} \tilde{g} \tilde{g} \tilde{g}$	$2 \leq \epsilon, \mu \leq 10$	0-3 jets	Yes	13.2	1.8 TeV	2.0 TeV
	GGSM (NLSF)	$1-2 \leq \epsilon \leq 0.1$	0-2 jets	Yes	3.2	1.8 TeV	2.0 TeV
	GGM (bino NLSF)	2γ	-	Yes	3.2	1.85 TeV	2.0 TeV
	GGM (higgsino-bino NLSF)	7γ	1 jet	Yes	20.9	1.37 TeV	1.8 TeV
	GGM (higgsino-bino NLSF)	7γ	2 jets	Yes	13.3	1.37 TeV	1.8 TeV
	GGM (higgsino NLSF)	$2 \leq \epsilon, \mu \leq 2$	2 jets	Yes	20.9	800 GeV	1.8 TeV
Gravitino LSP	0	0/0/0 jet	Yes	20.3	885 GeV	1.3 TeV	
3 σ point & limit	$\tilde{\chi}_1^0 \rightarrow \gamma \tilde{g}$	0	3 b	Yes	36.1	1.26 TeV	1.93 GeV
	$\tilde{\chi}_1^0 \rightarrow \gamma \tilde{g}$	$0-1 \leq \epsilon, \mu$	3 b	Yes	36.1	1.97 TeV	1.97 GeV
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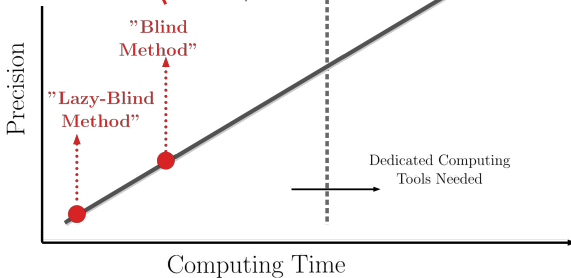
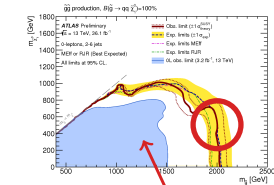
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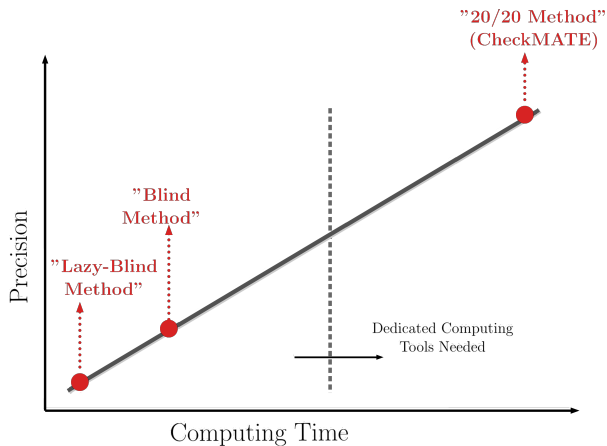
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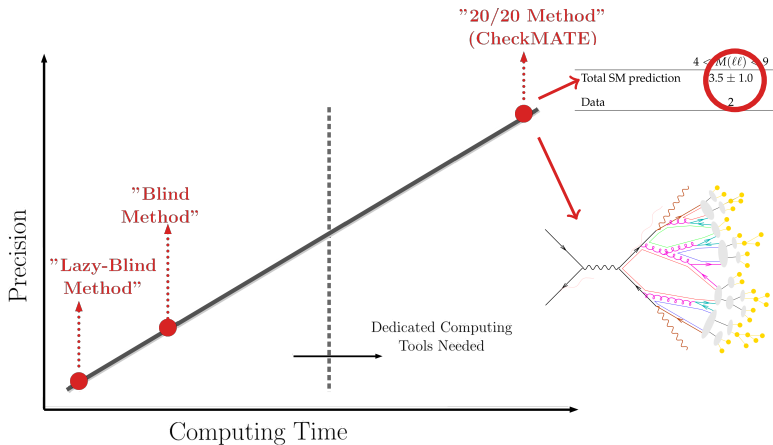
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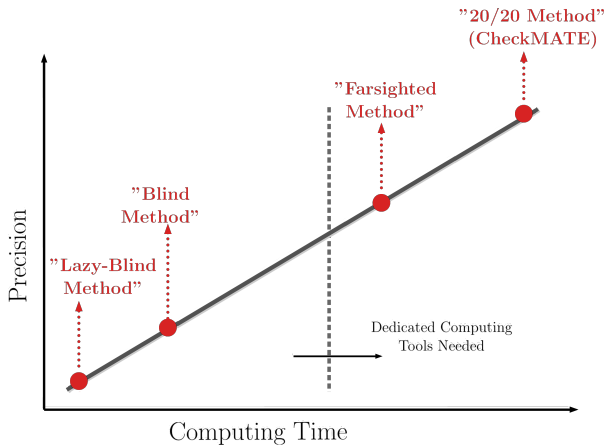
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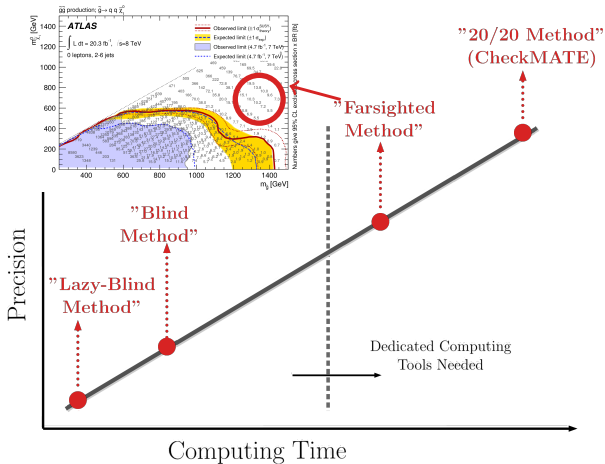
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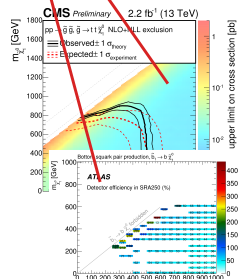
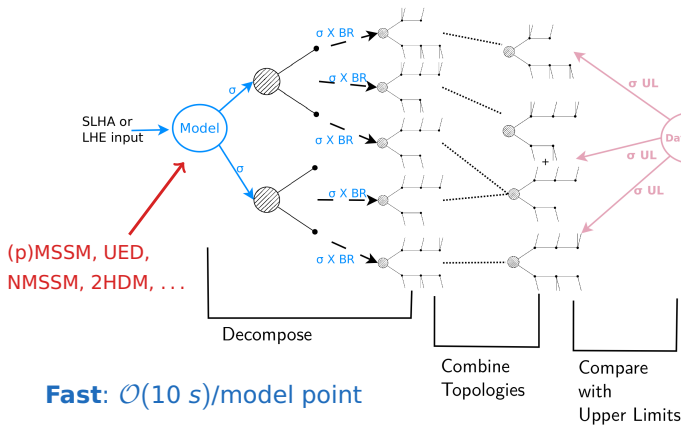
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- "The Farsighted Approach" →



► Basic Idea:



- It can be used to test many BSM models

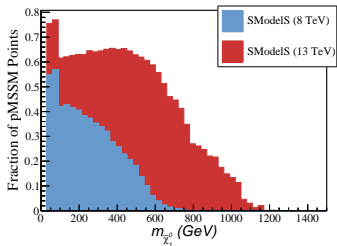


has been successfully applied to several scenarios:

- ▶ **pMSSM** (F. Ambrogio et al, "On the coverage of the pMSSM by simplified model results")
- ▶ **NMSSM** (S. S. AbdusSalam, "A phenomenological NMSSM race for 125 GeV Higgs boson")
- ▶ **Light stops** (G. Belanger, D. Ghosh, R. Godbole, and S. Kulkarni, "Light stop in the mssm after lhc run 1")
- ▶ **MSSM+U(1) extensions** (G. Belanger, J. Da Silva, and H. M. Tran, "Dark matter in U(1) extensions of the MSSM with gauge kinetic mixing")
- ▶ **SO(10) models** (T. Fukuyama, N. Okada, and H. M. Tran, "Sparticle spectroscopy of the minimal SO(10) model")
- ▶ **IDM+PQ symmetry** (A. Alves et al, "Collider and Dark Matter Searches in the Inert Doublet Model from Peccei-Quinn Symmetry")
- ▶ ...

- Current Status and (Near) Future

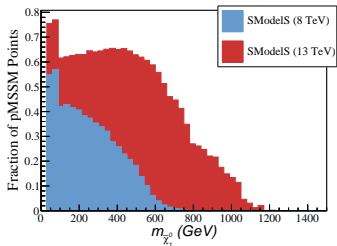
- ▶ Efficiency maps
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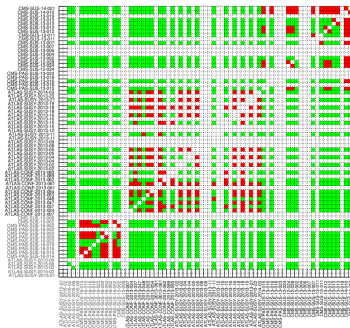
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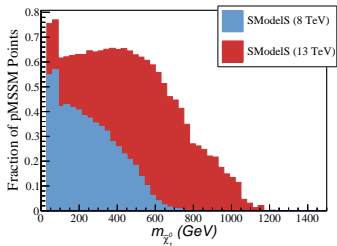
- ▶ Covariance matrices (simplified likelihood)

Correlations between analyses (green is uncorrelated)



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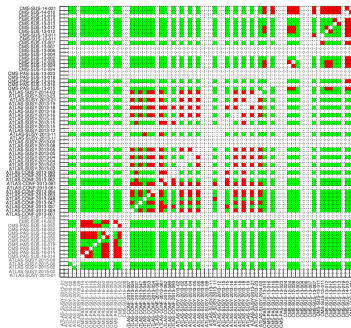
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- ▶ Extension to handle models with Long-Lived Particles (LLPs)

- ▶ Covariance matrices (simplified likelihood)

Correlations between analyses (green is uncorrelated)



SModels: Long-Lived Particles

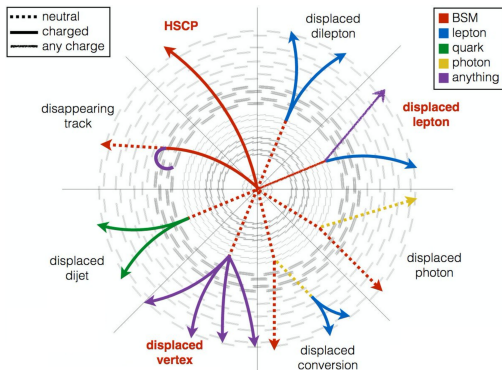
- **LLPs** can appear in:
 - ▶ Mass compressed scenarios
 - ▶ (Very) weakly coupled sectors (hidden sector)
 - ▶ Dark Matter models
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and display **"exotic" signatures**:

- ▶ Highly ionizing tracks
- ▶ Displaced vertices
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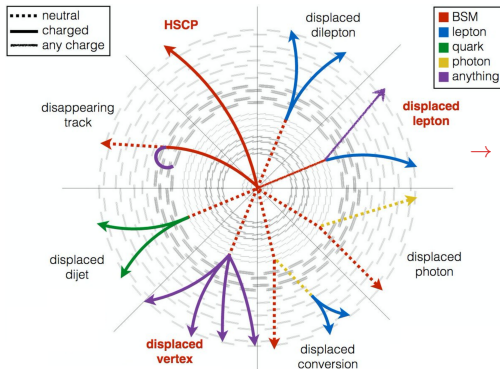
from J. Antonelli's talk (ICHEP 2016)

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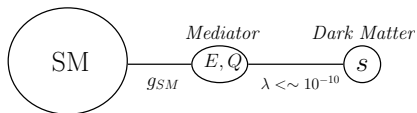
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The signal efficiency strongly depends on the lifetime → additional parameter

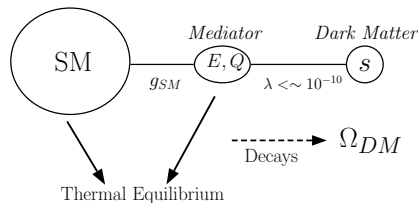
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- An Example: **FIMP** Dark Matter

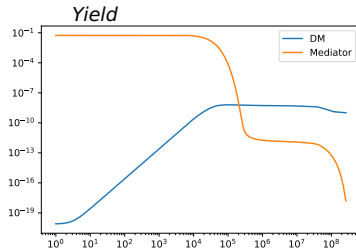
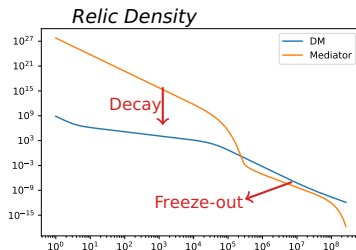


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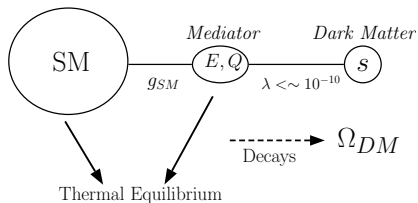


$$\Omega_{DM} h^2 \propto \Gamma_M \frac{m_{DM}}{m_M}$$



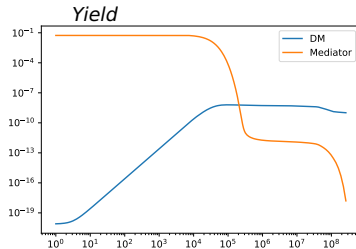
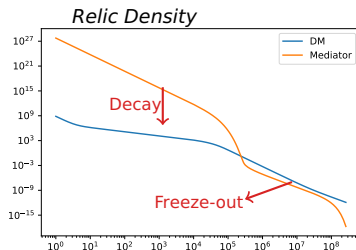
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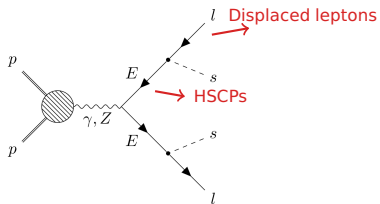
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Invisible at direct detection experiments!



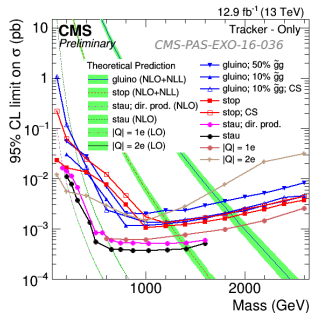
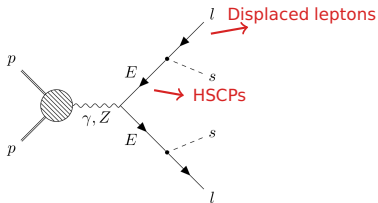
SModels: Long-Lived Particles

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More info:

smodels.hephy.at

and

github.com/SModelS

Thanks!