

Status of SuperIso Relic

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Relic density calculation in alternative cosmological models: SuperIso Relic

SuperIso Relic = SuperIso (flavour physics calculations)
+ relic density calculation

Mahmoudi, *Comp. Phys. Comm.* 180 (2009)

Arbey & Mahmoudi, *Comp. Phys. Comm.* 181 (2010)

Concept of the code

- Automatized computation of flavour observables and relic density in SUSY
- Flexible particle physics model implementation (MSSM, NMSSM, ...)
- Flexible cosmological model implementation (dark energy, dark entropy, ...)
- Publicly available on <http://superiso.in2p3.fr/relic>

The Pre-Big Bang Nucleosynthesis Era: the Dark Ages

- Quantum gravity? Branes? Other gravitation theories?
- Inflation
- Topological defects (cosmic strings, magnetic monopoles, domain walls, ...)?
- Primordial Black Holes?
- Leptogenesis
- Baryogenesis
- Particle-antiparticle asymmetry
- QCD equations of state
- Big-Bang nucleosynthesis
- Dark energy

SuperIso Relic

Structure of the code

- Generation of a SLHA file with Isajet, Softsusy, Spheno, Suspect or NMSSMTools
- Initialization of the variables using the SLHA file
- Generation of additional Higgs sector variables with FeynHiggs or Hdecay
- Calculation of W_{eff} with Fortran functions
- Calculation of $\langle \sigma_{eff} v \rangle$ with C functions
- Solving of the Boltzmann equation with C functions
- Computation of the other SuperIso observables

SuperIso Relic

Fortran and diagram generation

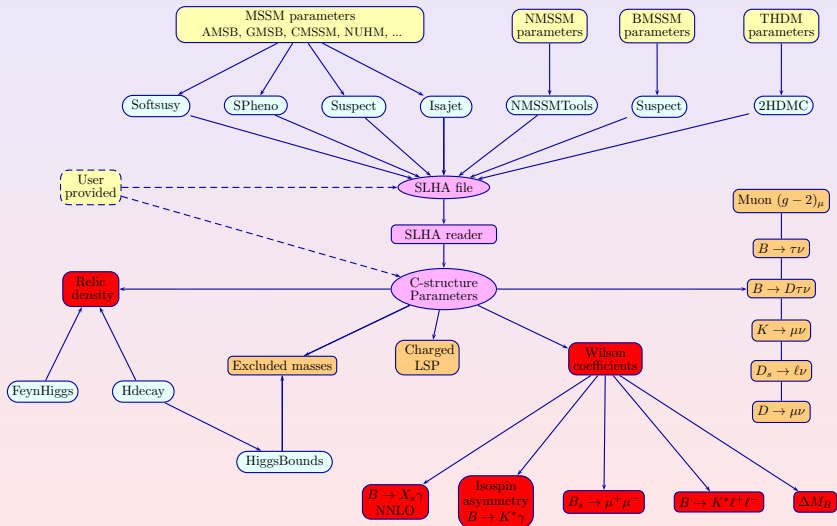
- Analytical calculation of the amplitudes with Mathematica / FeynArts / FormCalc / FORM
- FormCalc-generated Fortran code included into SuperIso
- Possibility to use FeynArts model file generators (FeynRules, LanHEP, SARAH, ...)

SuperIso Relic

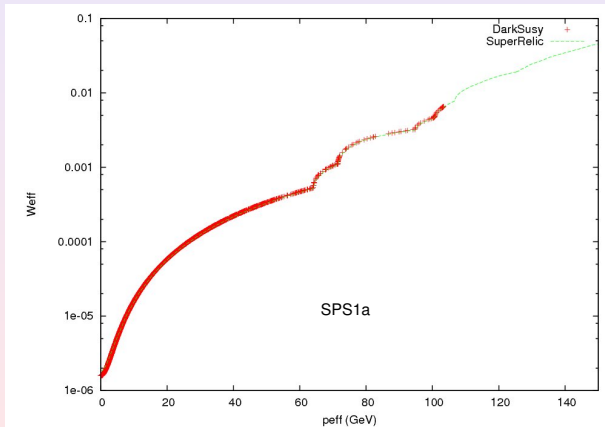
Status

- Calculation of amplitudes within MSSM with MFV at tree level fully implemented
- Calculation of amplitudes within NMSSM with MFV at tree level fully implemented
- Good agreement with Micromegas and DarkSusy
- New version v3.0 recently released (manual will soon follow)
- Well tested under Linux and Mac machines with GNU and Intel compilers
- Package including Hdecay v3.53 and FeynHiggs v2.7.5

SuperIso

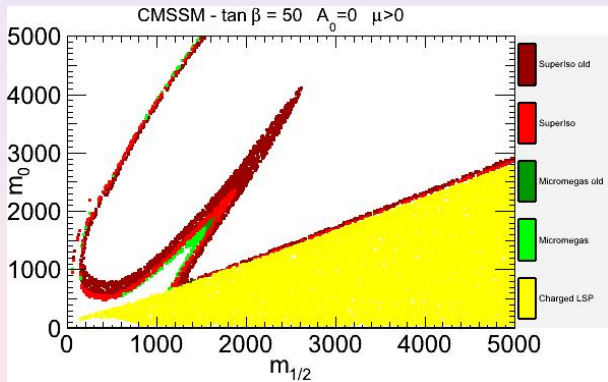


SuperIso Relic



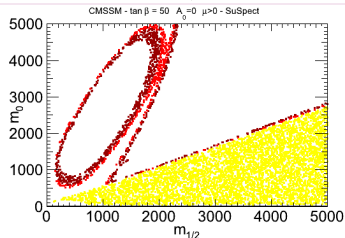
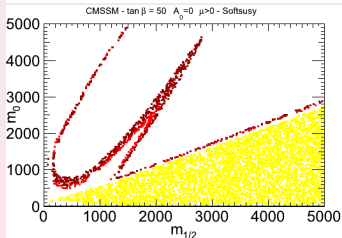
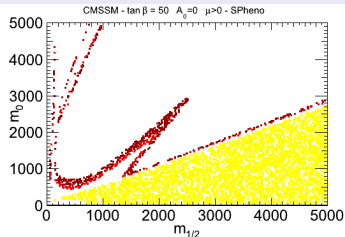
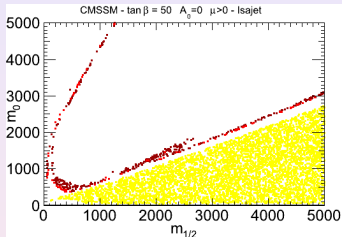
Good agreement
with DarkSusy!

Superlso Relic



Good agreement
with
Micromegas...

SuperIso Relic: sensibility to spectrum generators



SuperIso Relic

Alternative cosmological models

- Cosmological standard model fully implemented
- Possible to use different QCD equations of state for radiation
- Possible to modify the expansion of the early Universe through the presence of an effective dark density

$$\rho_D(T) = \rho_D^0 T^{n_\rho}$$

- Possible to modify the thermal properties of the Universe through the presence of an effective dark entropy

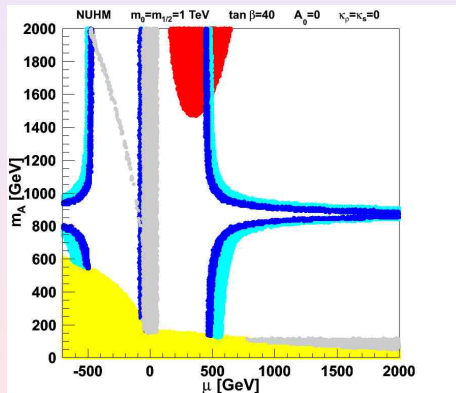
$$s_D(T) = s_D^0 T^{n_s}$$

- Possible to modify the thermal properties of the Universe through the presence of an effective dark entropy production

$$\Sigma_D(T) = \Sigma_D^0 T^{n_\Sigma}$$

Relic density: influence of a modified expansion rate

Displacement of the WMAP limits in NUHM: Standard model

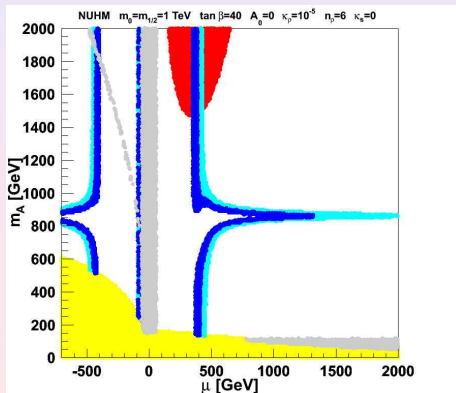


Gray: area excluded by direct searches
 Red: area disfavored by the isospin asymmetry of $B \rightarrow K^* \gamma$
 Blue: area favored by WMAP

Arbey & Mahmoudi, Phys. Lett. B669 (2008); Arbey & Mahmoudi, Nuovo Cim. C33 (2010)

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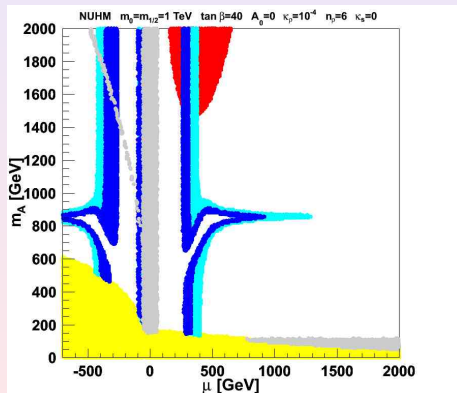


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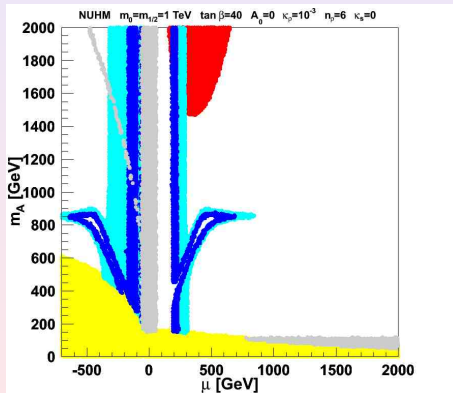


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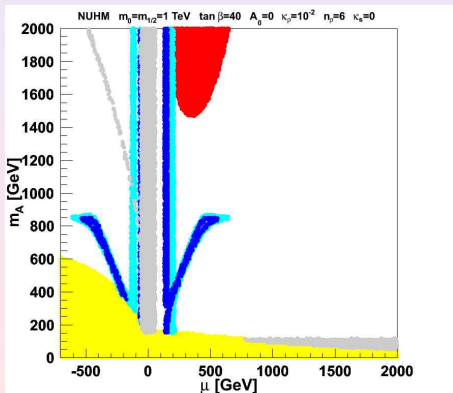


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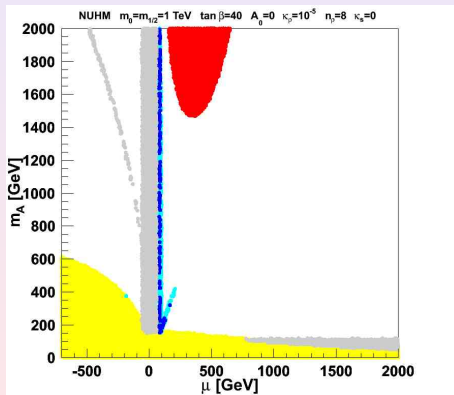


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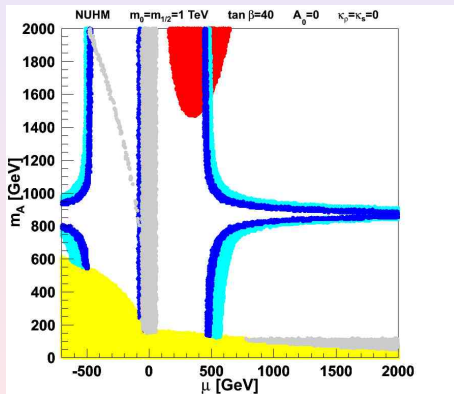


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Relic density: influence of a modified entropy content

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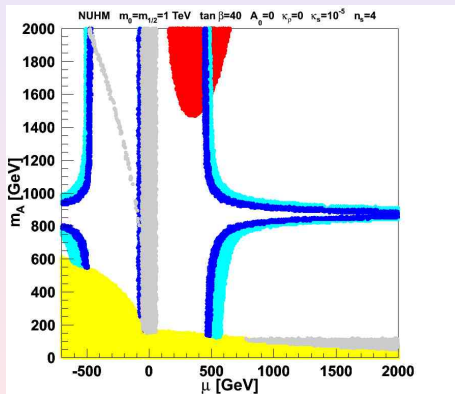
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The WMAP constraints can move in any direction!

Arbey & Mahmoudi, JHEP 1005 (2010); Arbey & Mahmoudi, Nuovo Cim. C33 (2010)

Relic density: influence of a modified entropy content

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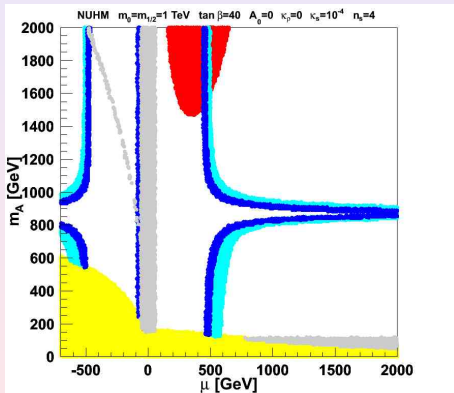
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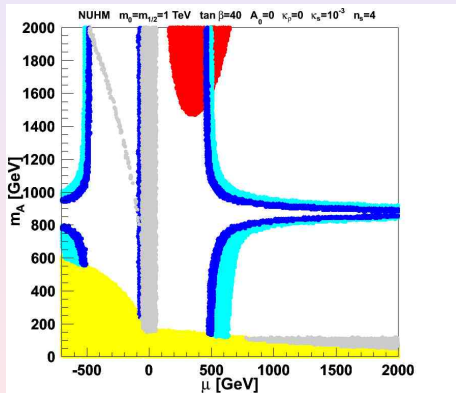
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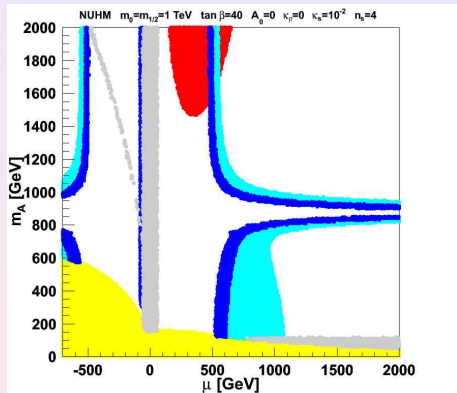
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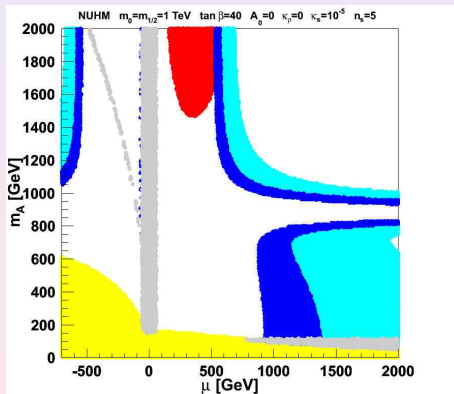
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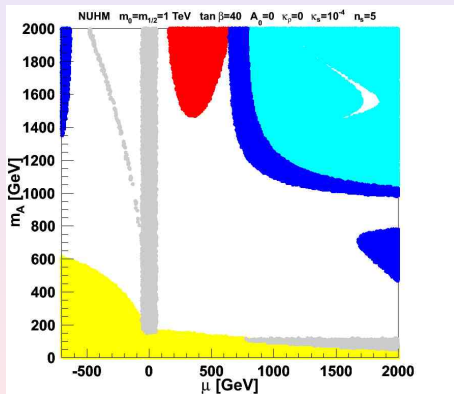
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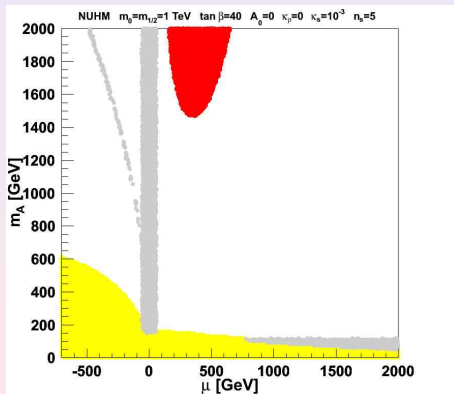
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SuperIso Relic

Soon: Alternative cosmological models

- Addition of non-thermal production of relic particles
- Modification of the QCD equations of state
- Inclusion of a public BBN code to test the cosmological modifications: `AlterBBN`

Soon: Alternative particle physics models

- Extra-dimension scenarios
- Gravitino dark matter

Less soon...

- Direct detection of dark matter