EuroGDR SUSY 2007
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Brussels, Belgium

A Dark Matter Tool on the Web

http://pisrv0.pit.physik.uni-tuebingen.de/darkmatter/

R. Lemrani, ILIAS-N3 Dark Matter Network / CEA Saclay

A word on ILIAS

Integrated Large Infrastructures for Astroparticle Science

European tool : I3 structure (Integrated Infrastructure Initiative) of FP6

Participants: 21 Contractors (70 laboratories), 14 European Countries

Start date ; April 1st 2004 for 5 years

Web site : ***ilias.in2p3.fr***

Prime areas : Double Beta Decay, Dark Matter, Gravitational Waves

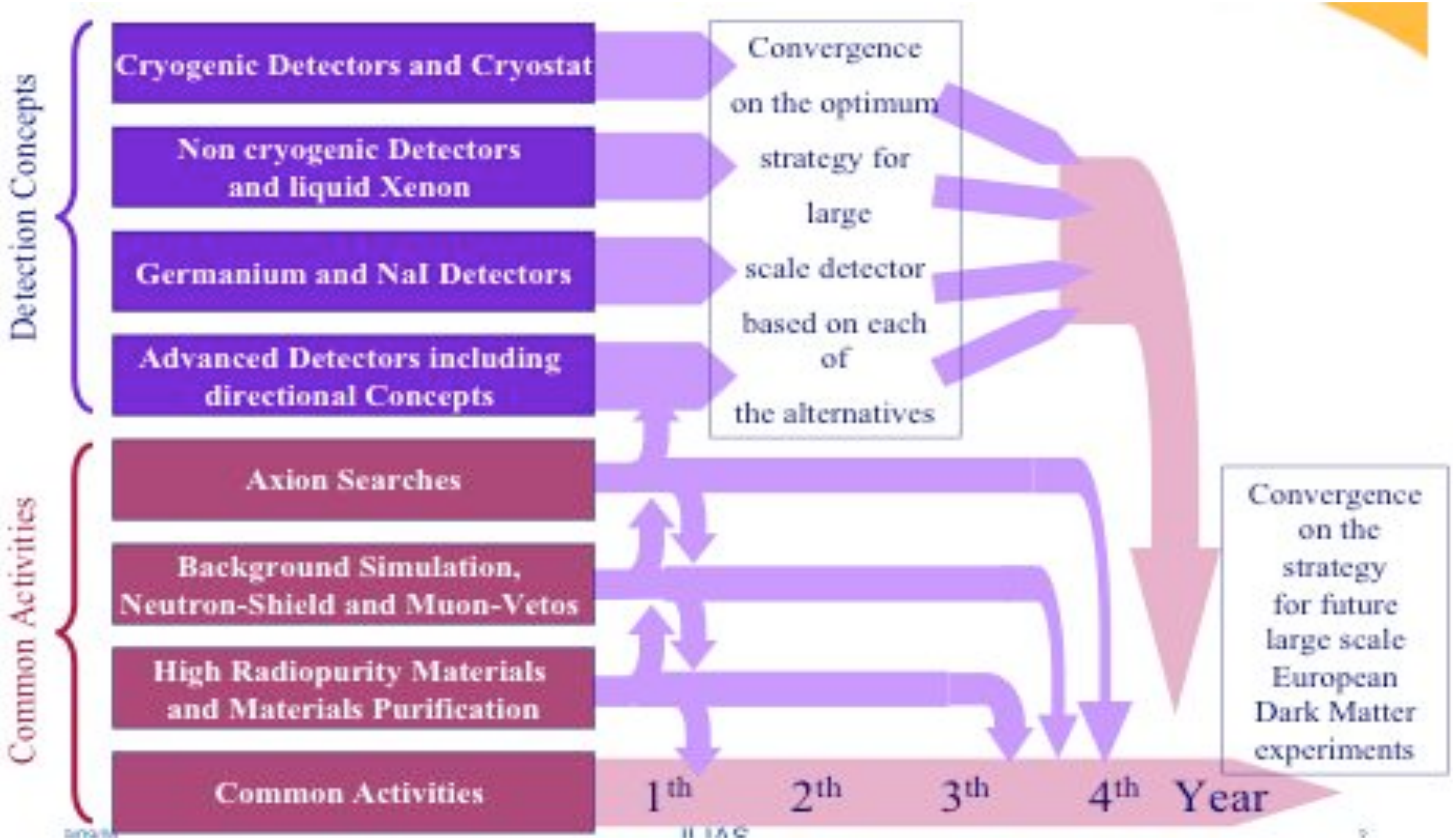
Infrastructures : - Deep Underground Laboratories
- Gravitational Wave Interferometers

" … to produce a focused, coherent and integrated project
to improve the existing infrastructures and their operation
as well as to organise and structure the scientific community to prepare
the best infrastructures for the future."

A word on ILIAS-N3 Dark Matter Network

Working groups

Web site : http://ilias-darkmatter.uni-tuebingen.de/



→ Input for ASPERA Roadmap

Web tool : Purpose

- Build a web interface for dark matter calculations :
  Expected spectra, limits extraction, …

- Handling different detection techniques

- Handling different theoretical assumptions

- Cross check methods and codes

- Available to the whole dark matter community

- Allowing comparisons of experimental strategies
  using the same theoretical inputs and varying them

Homepage

Welcome to the

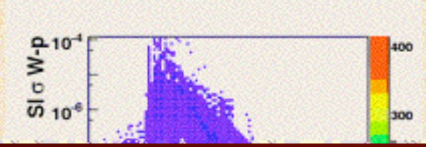
DArk
Matter
Network
Exclusion
Diagram

tool web page

dd spectra
dd msugra
dd limits
dd scan
ind fluxes
dd/ind/msugra

dd scan: A msugra scan has been performed and a few variables have been tabulated, namely relic density, gaugino fraction, neutralino mass and Wimp-nucleon cross-sections. Cuts can be applied and corresponding scatter plots of surviving models presented.

example:



Links | Updates | News | About | N3 ILIAS | Cross-checks

ILIAS related Links

Dark Matter N3 network

ILIAS web site

Database on radiopurity of materials

Database on purification of materials

External Links

Dark Matter Limit Plot Generator

DarkSUSY

SPF by G.Jungman

SoftSUSY - Micromegas - Suspect

Upper Limit Software by Yellin

Pole software : Confidence intervals with systematic uncertainties

Berkeley Twiki - F.Mayet's Portal

http://pisrv0.pit.physik.uni-tuebingen.de/darkmatter/

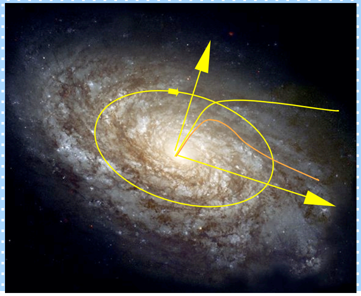
Direct Search for WIMPs

WIMP nature : ie Neutralino

σ = WIMP-nucleus cross section (point-like)
m_χ = WIMP mass
(μ = WIMP-nucleus reduced mass)

Galactic Halo

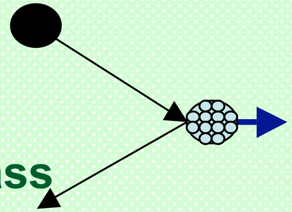
ρ = density
$f(v)$ = velocity distribution



Nucleus

F = Nuclear form factor

μ = WIMP-nucleus reduced mass



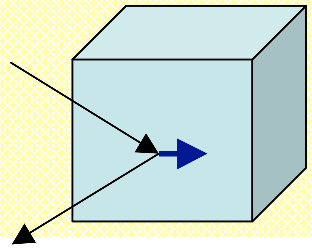
Detection rate :

$$\frac{dN}{dE} = \frac{\sigma\,\rho}{2\mu^2 m_\chi} F^2 \int_{V_{min}(E_r)}^{V_{esc}} \frac{f(v)}{v}\,dv$$

$$x\ \varepsilon_{(E)} / q_{(E)} \otimes r_{(E)}$$

Detection

$q_{(E)}$ = quenching
$\varepsilon_{(E)}$ = efficiency
$r_{(E)}$ = resolution

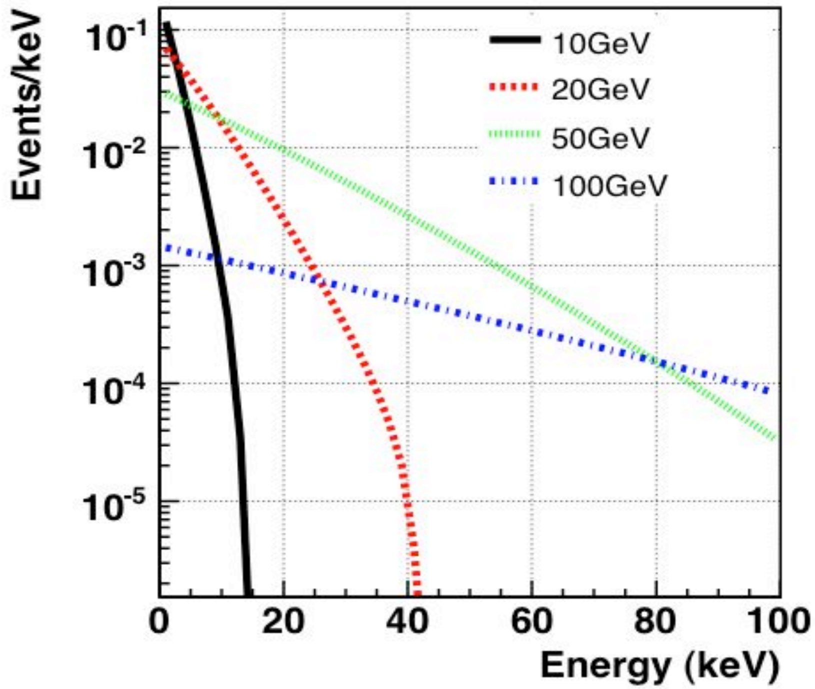


J. D. Lewin and P. F. Smith, Astropart. Phys. ***6****, (1996)87*

Ex. : Dependence on WIMP Mass

All parameters are entered in a form : The outputs are figures and tables

	Label	WIMP mass (GeV)	A of Target	Exposure (kg.days)	WIMP-nucleon cross section (pb)
1	10GeV	10	72.6	10	1E-7
2	20GeV	20	72.6	10	1E-7
3	50 GeV	50	72.6	10	1E-7
4	100GeV	1000	72.6	10	1E-7
next		1000	72.6	10	1E-7



Energy (keV)	10GeV	20GeV	50GeV	100GeV
1	1.18E-01	6.97E-02	2.87E-02	1.42E-03
3	4.59E-02	5.18E-02	2.58E-02	1.35E-03
5	1.59E-02	3.77E-02	2.31E-02	1.28E-03
7	5.09E-03	2.71E-02	2.06E-02	1.22E-03
21	0.00E+00	2.03E-03	9.01E-03	8.41E-04
23	0.00E+00	1.35E-03	7.95E-03	7.97E-04
25	0.00E+00	8.94E-04	7.02E-03	7.55E-04

10GeV : 1.18E-01 4.59E-02 1.59E-02 5.09E-03 1.50E-03 3.65E-04 3.55 ...

20GeV : 6.97E-02 5.18E-02 3.77E-02 2.71E-02 1.93E-02 1.35E-02 9.40 ...

50GeV : 2.87E-02 2.58E-02 2.31E-02 2.06E-02 1.84E-02 1.64E-02 1.46 ...

100GeV : 1.43E-02 1.33E-02 1.24E-02 1.15E-02 1.07E-02 9.89E-03 9.17 ...

Using ddmc tool (by J. Gascon, V. Sanglard and R.L.)

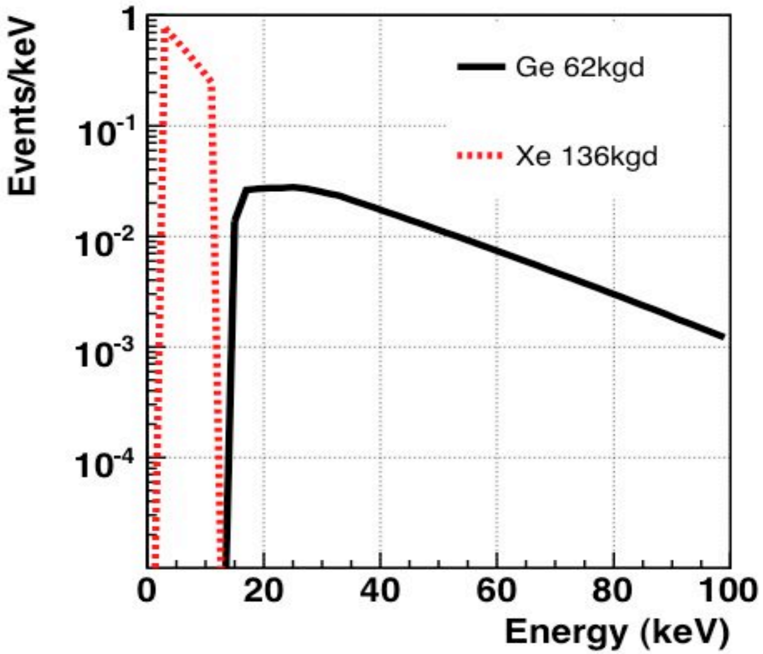
Ex. : Experimental parameters

Quenching, Resolution, Efficiency as a function of energy

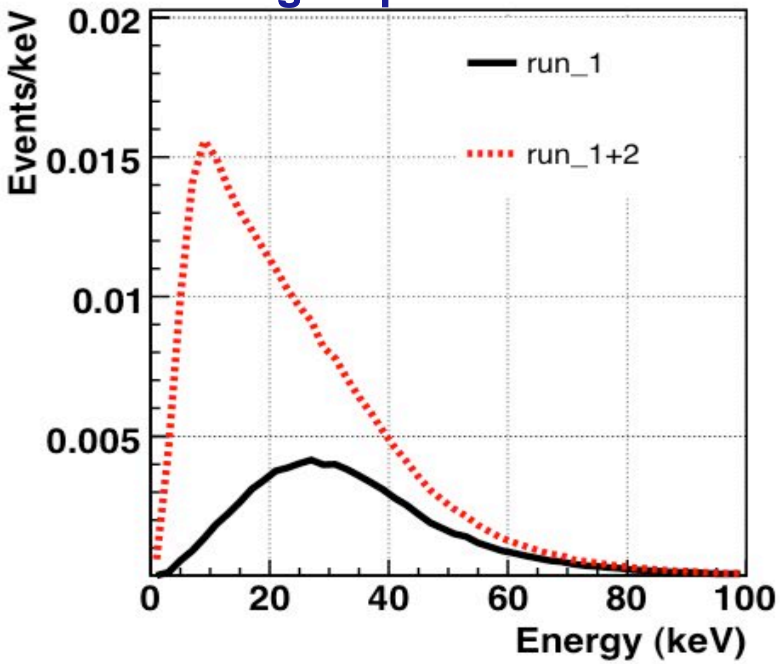
with 2 types of inputs : - Binned entry
- Parametrised function

For quenching Lindhard parametrisation
(J. Lindhard et al., Mat. Fys. Medd. Dan. Vid. Selsk 33, (1963) 10)

Xenon vs Germanium



Combining experimental conditions



lower threshold for Xe
=> Sensitivity 5x higher for Xe

Example : Neutralino on ^{73}Ge

dd msugra

Inputs : SUSY parameters and experimental parameters

☑ I - MSUGRA Parameters

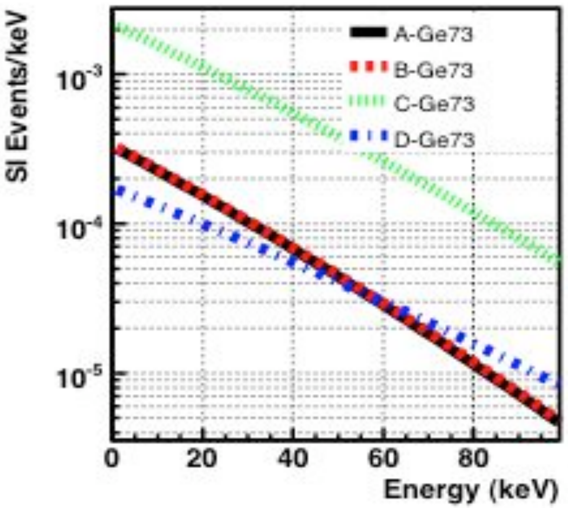
	m0	m1/2	A0	sign(mu)	tan(beta)
next	107	600	0	+	5

Outputs : Spin independent, Spin dependent cross sections, WIMP mass (using DarkSUSY) and experimental spectra

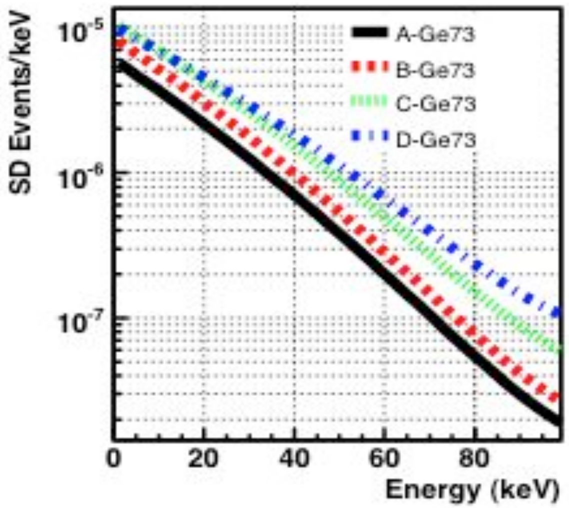
using :

	m_0	$m_{1/2}$	μ sign	tg β
1	500	250	+	40
2	1000	250	+	50
3	2000	350	+	55
4	4000	900	+	55

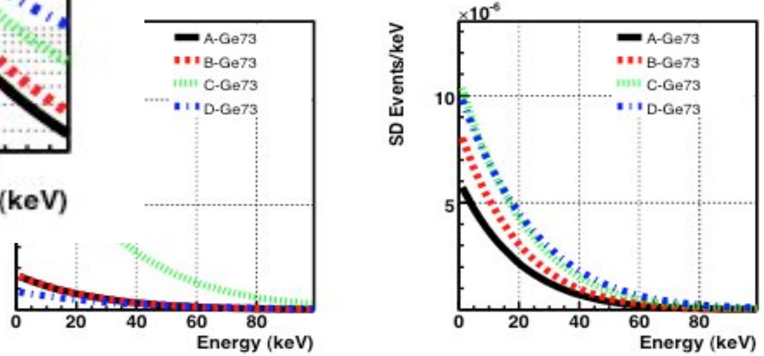
spin-independent



spin-dependent



Linear scale



available targets for spin-dependent interactions

^{73}Ge, ^{23}Na, ^{29}Si, ^{27}Al, ^{127}I, ^{3}He , ^{129}Xe, ^{131}Xe, ^{39}K, p, n,

Extraction of limits

When no signal is observed :

⇒ **limit on the WIMP-nucleon cross-section as a function of the WIMP mass**

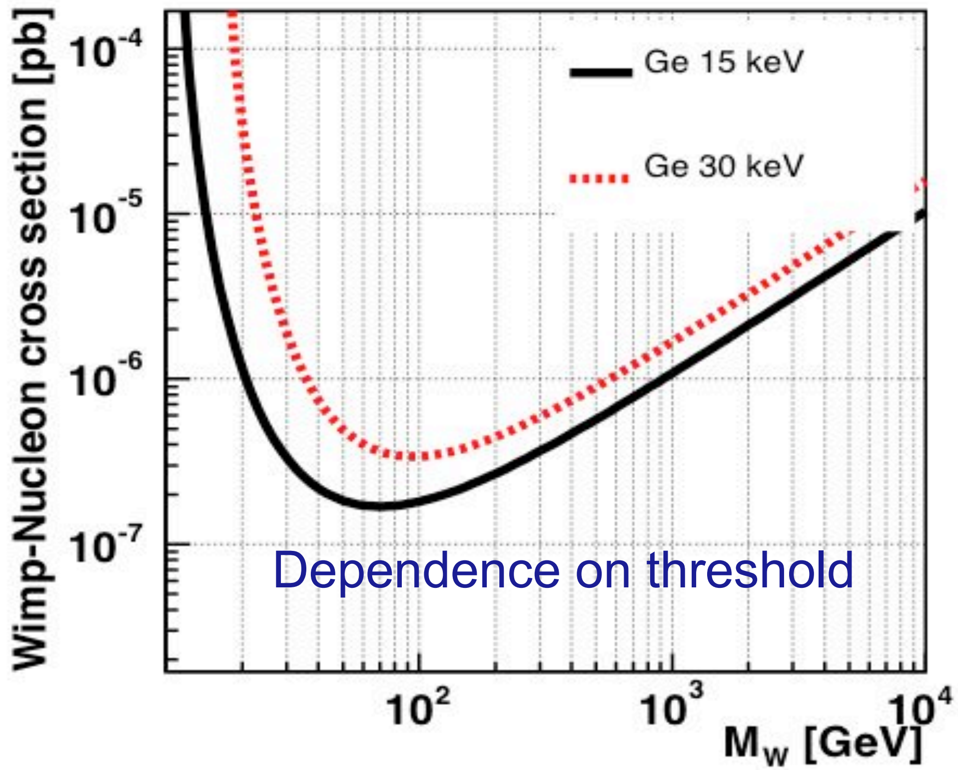
	Method	Observed events / Limit on rate	N_Background
next	1. single sided	0	0

- **Feldman-Cousin : known background**

The limit on the rate depends on the number of observed events and the number of expected background events.
(see ie J. Conrad et al., Phys. Rev. D 67, (2003) 012002)

- **Yellin : unknown background**

The list of the energies of the observed events are entered. The method takes advantage of signal-unlikely events.
(S. Yellin, Phys. Rev. D ***66****, (2002) 032005)*



Example : Experimental limits

LIMIT ON RATE

	Method	Observed events / Limit on rate	N_Background
1	2	29	28.6
next	2. Feldman-Cousin approach	29	28.6

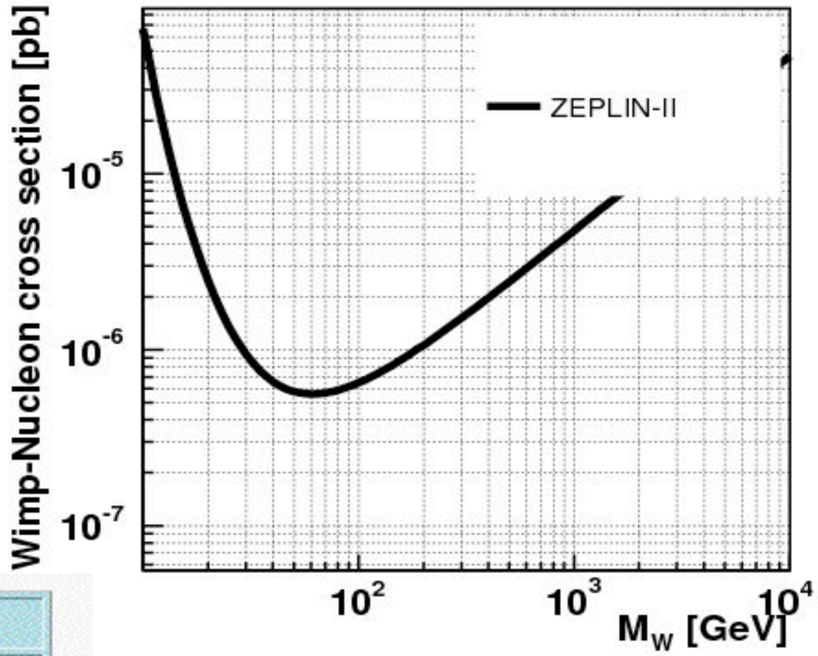
I-1-a Quenching : Q = a Er^b (for b=0

	a	b
1	0.36	0
next	0.36	0

I-2-a Resolution : FWMH = a + b E^

	a	b
1	0	4.23
next	0	4.23

	efficiency in bins
1	8 5 6 7 8 9 10 12 14 20 0.17 0.235 0.285 0.325 0.35 0.3775 0.3875 0.39
next	8 5 6 7 8 9 10 12 14 20 0.17 0.235 0.285 0.325 0.35 0.3775 0.3

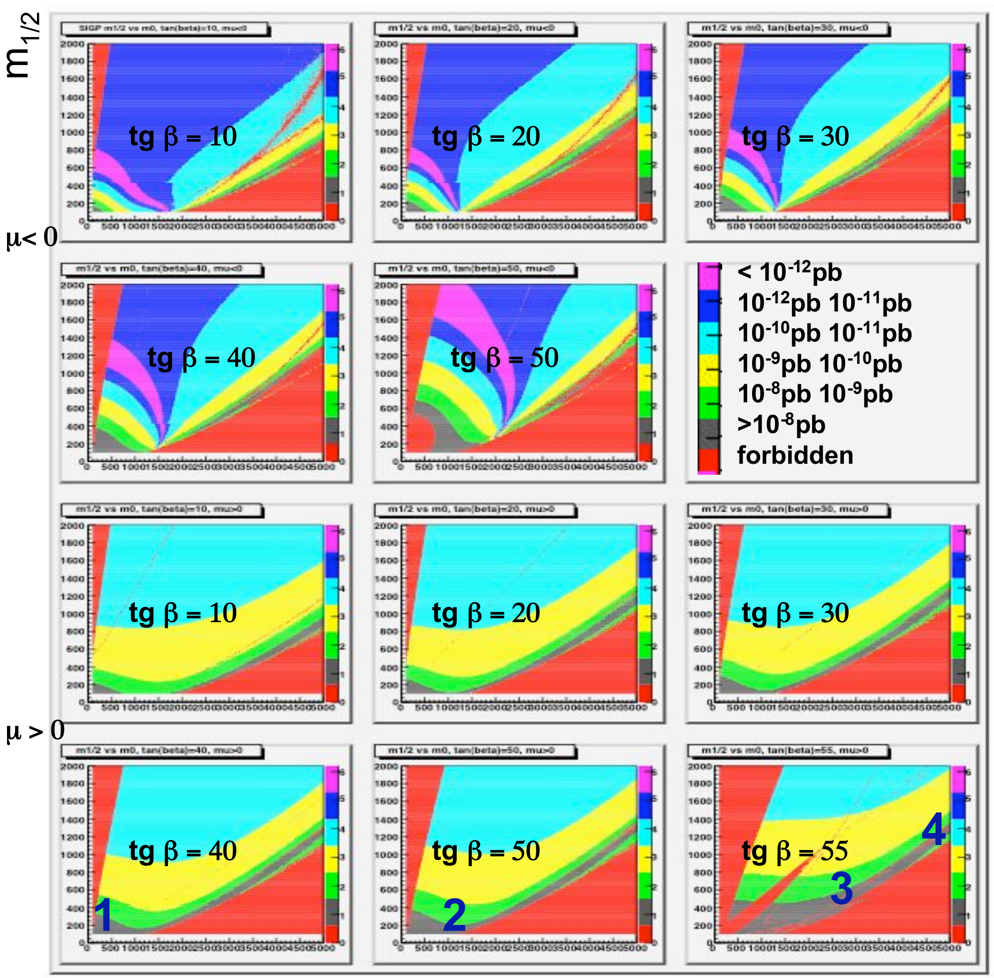


49.77	5.79E-07
53.37	5.67E-07
57.22	5.61E-07
61.36	5.59E-07
65.79	5.62E-07
70.55	5.68E-07
75.65	5.77E-07
81.11	5.91E-07
86.97	6.07E-07
93.26	6.26E-07

Approximate treatment with respect to full experimental analysis ie multidimentional efficiencies

MSUGRA scan

SI WIMP-p cross section



SuSy scan (isasugra) following :
H. Baer et al JCAP09(2003)007

SCAN :

m_0	100-5100 GeV	500 bins (10GeV bins)
$m_{1/2}$	100-2100 GeV	200 bins (10GeV bins)
μ	+ −	
$\tan(\beta)$	10, 20, 30, 40, 50, 55 (+)	
A_0	0	

=> 1.1 10^6 models

VARIABLES :

- relic density
- gaugino fraction
- neutralino mass
- cross-sections
  SI WIMP-p
  SI WIMP-n
  SD WIMP-p
  SD WIMP-n

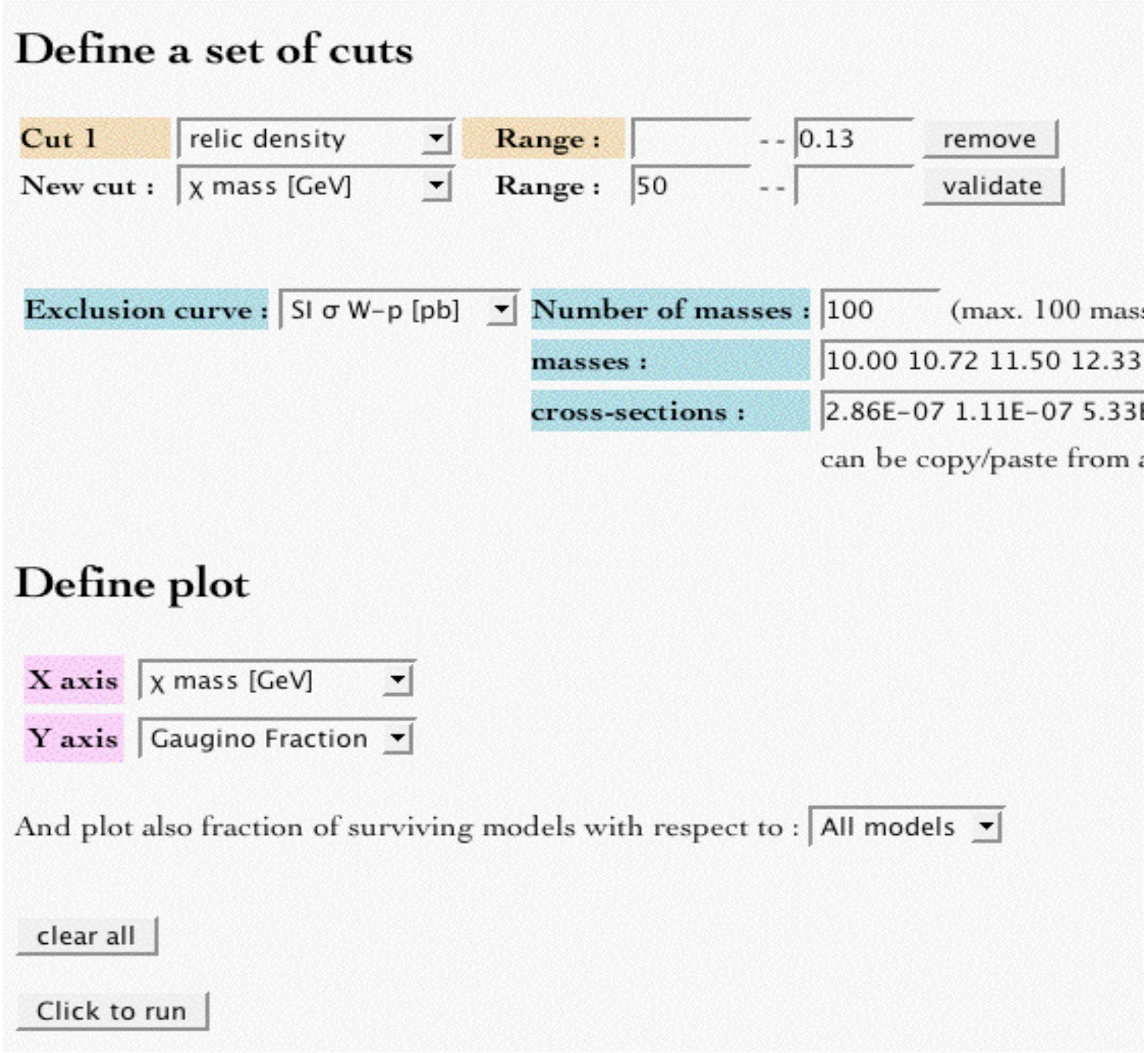
Scan for direct searches

INPUTS :

Define a set of cuts
on available variables

and/or define a cut
on exclusion curve
(can be copy past from
dd limits)

Choose 2 variables
for bi-plots

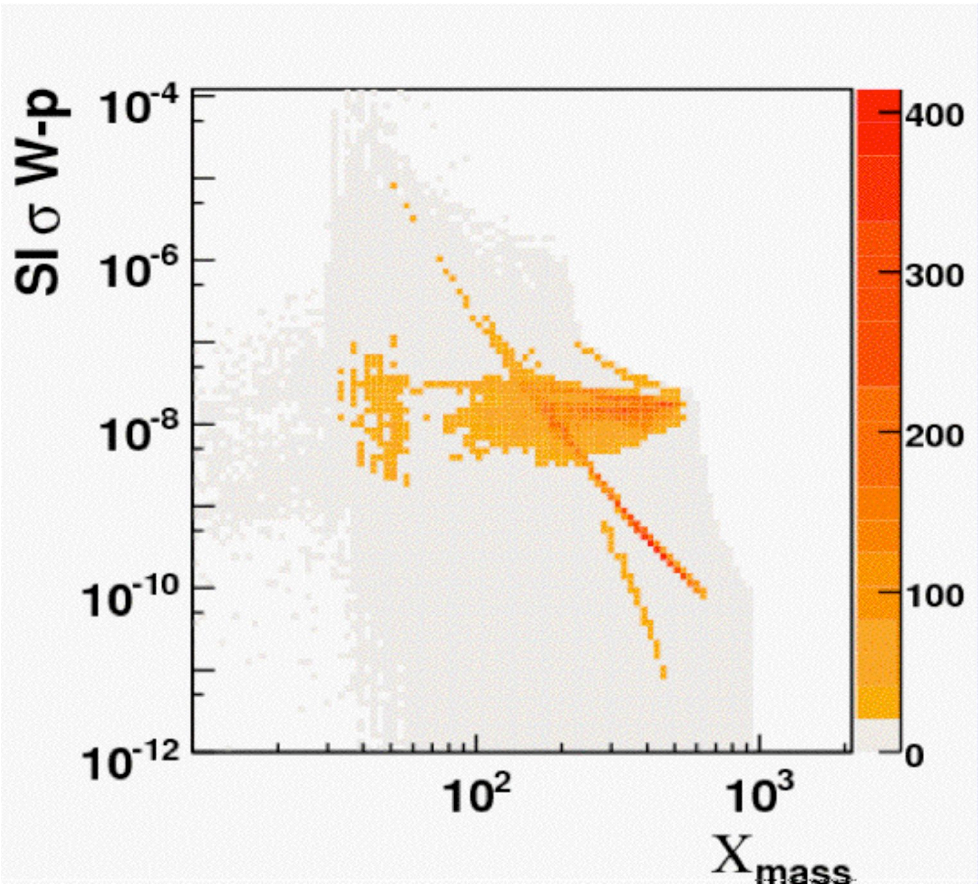


Example : Relic density

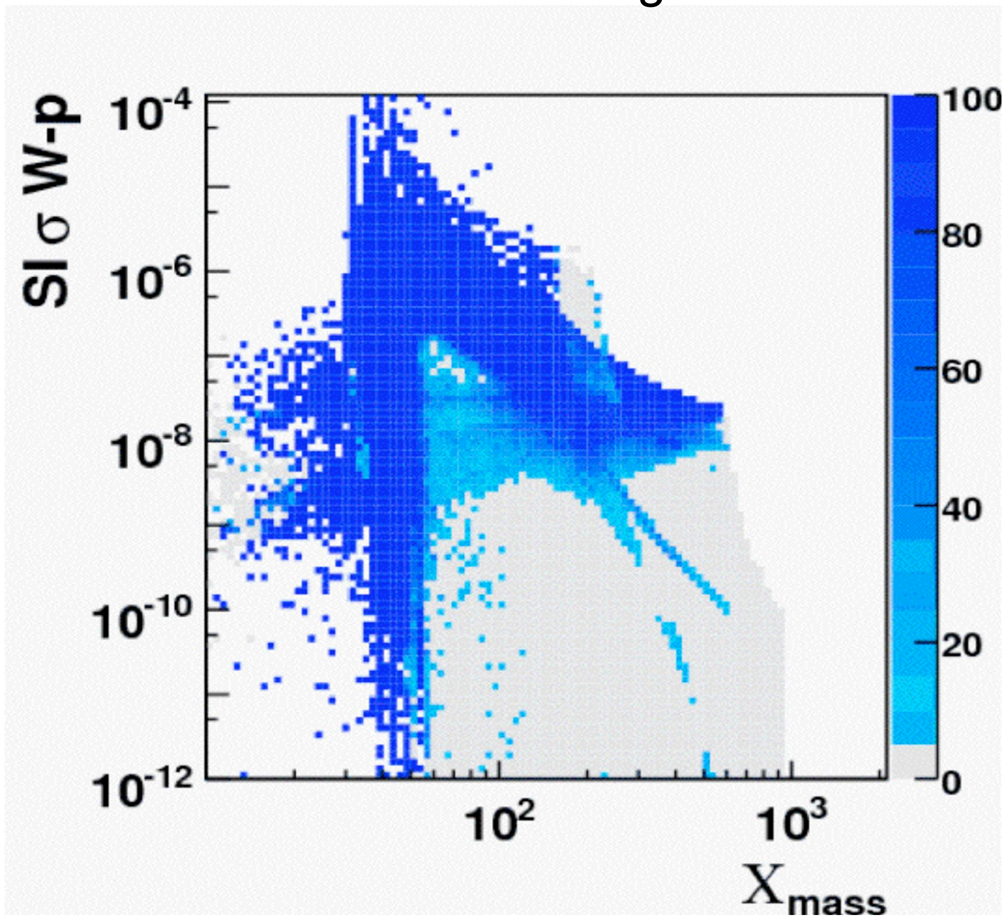
Cut on relic density < 0.13

cross-section SI W-proton
vs Neutralino mass

Number of surviving models

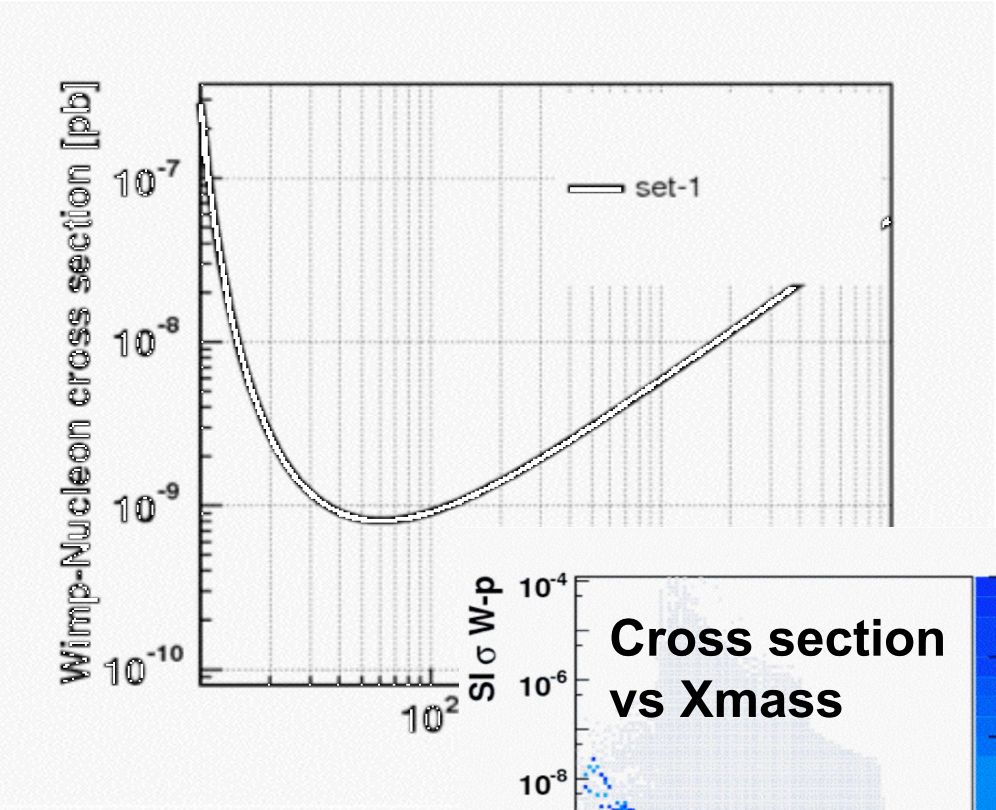


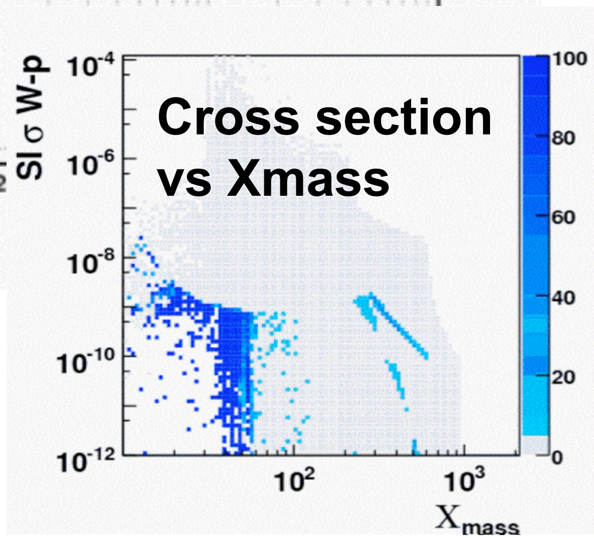
Fraction of surviving models



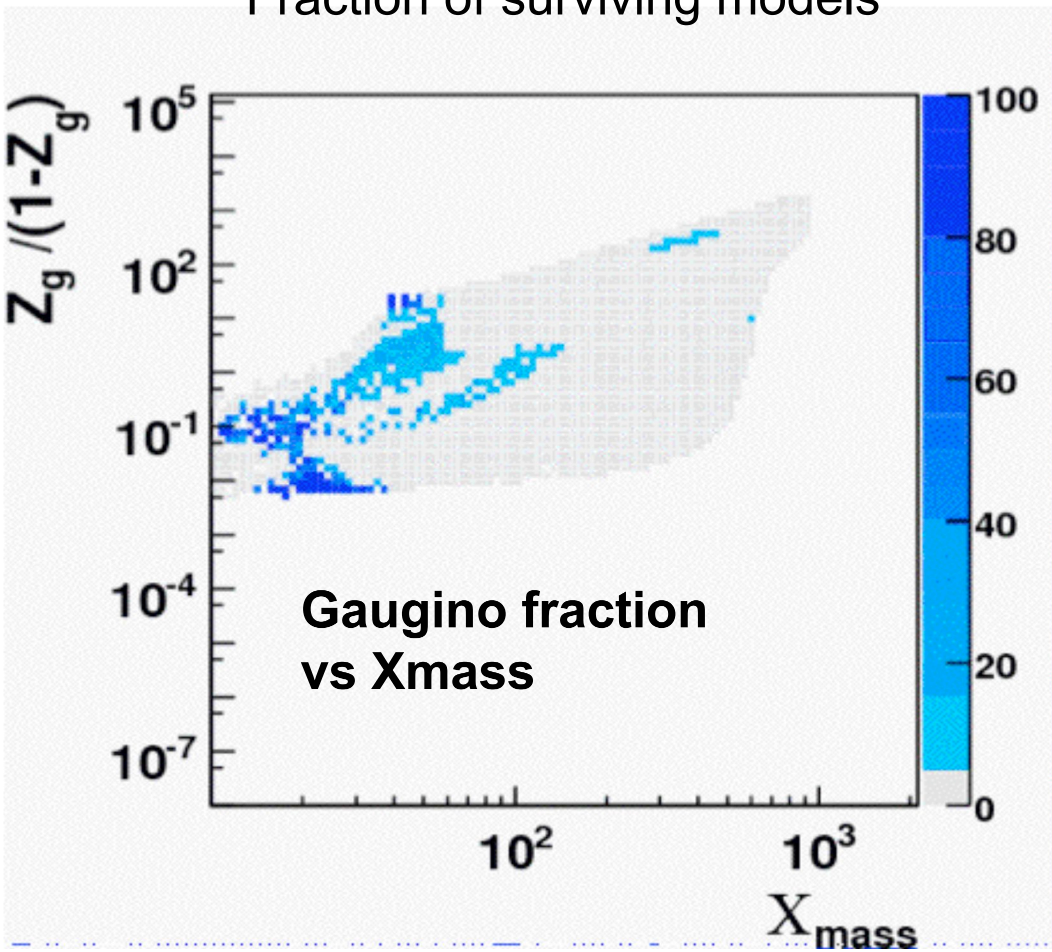
Example : exclusion curve

Cut relic relic density < 0.13
And on exclusion curve



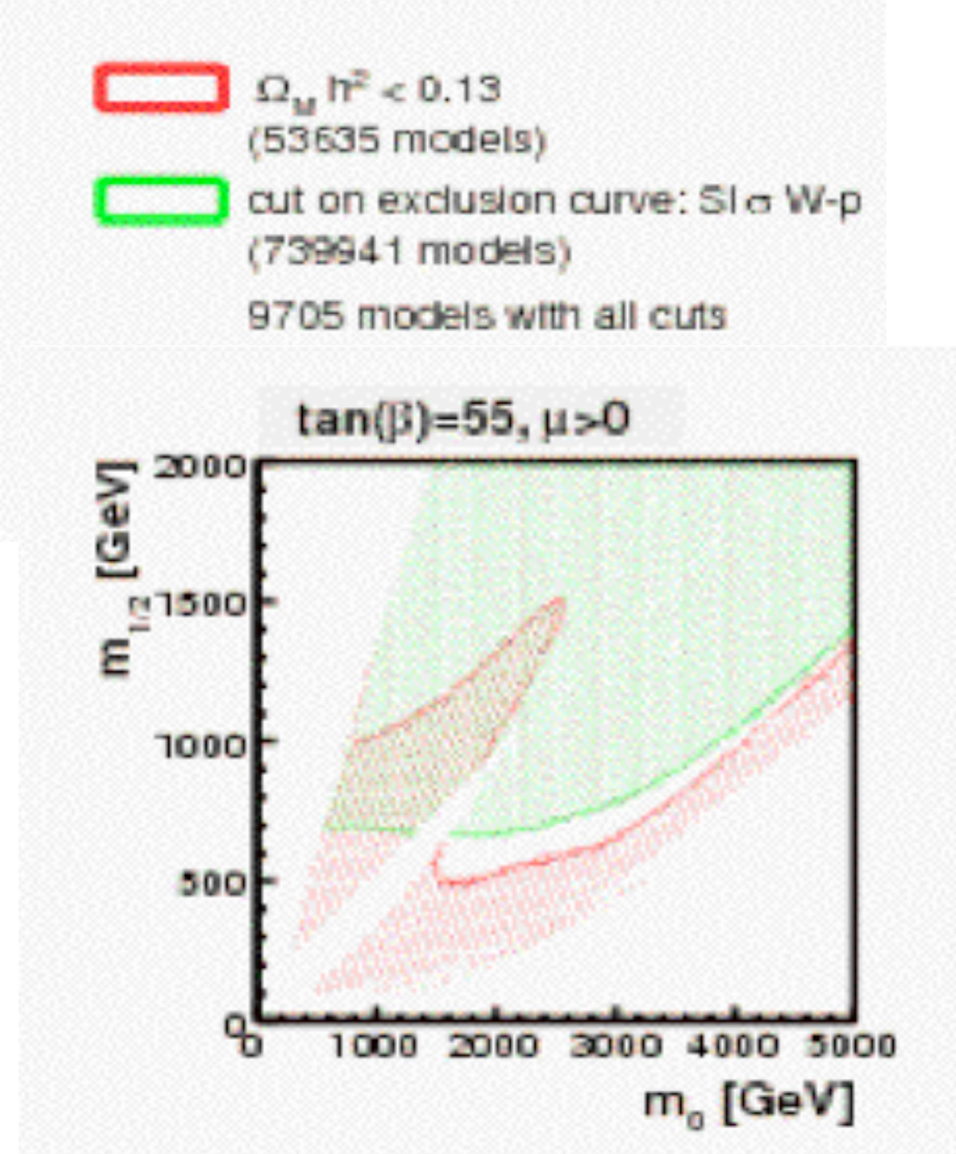


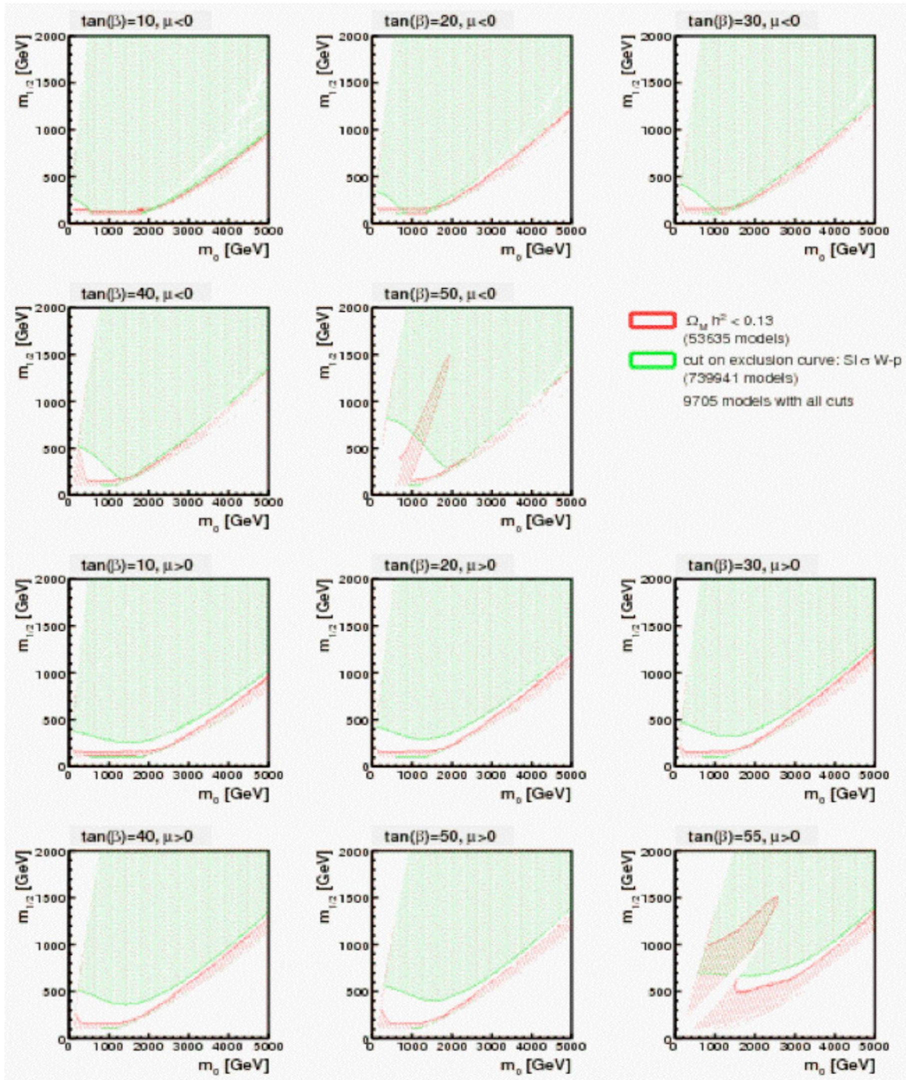
Fraction of surviving models



Surviving models

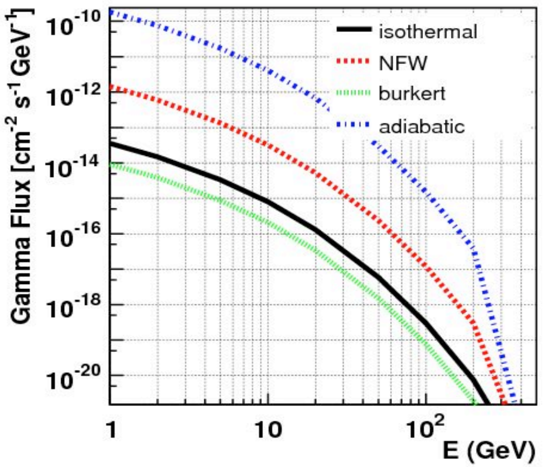
Cut relic relic density < 0.13 and exclusion curve



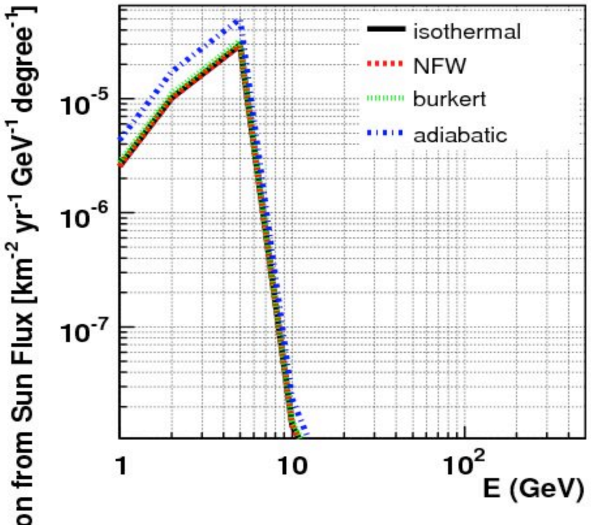


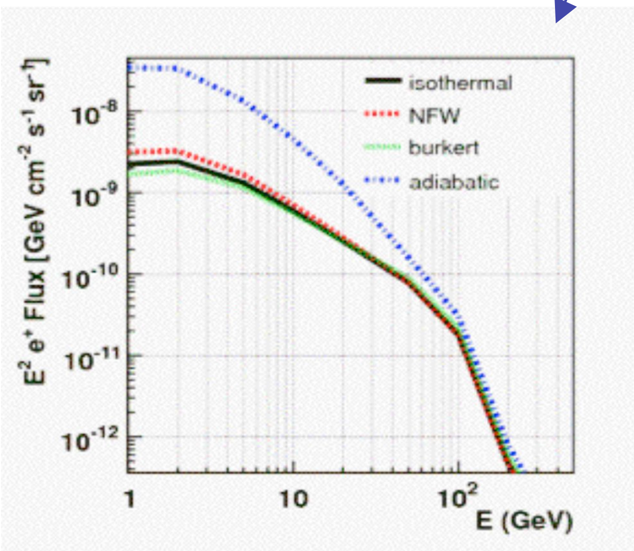
Indirect Searches : fluxes

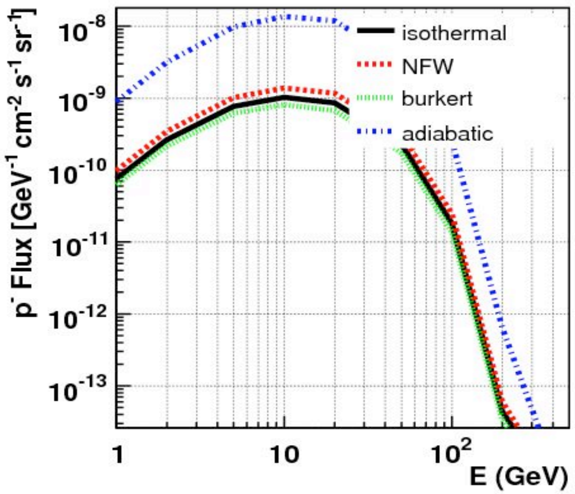
Fluxes vs energy for chosen msugra model

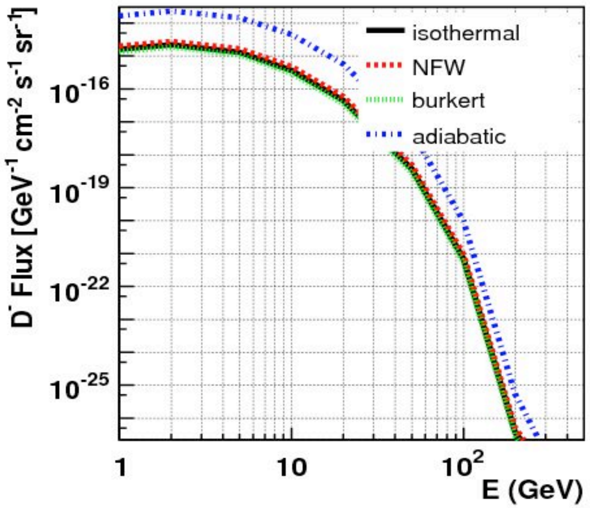


Gammas (here G.C.)
Positrons
Antiprotons
Antideuterons
Muon from sun









Example for different halo models : isothermal , navarro-franck-white, moore, burkert, adiabatic

Indirect Searches : fluxes

Integrated and differential fluxes
for chosen energy and msugra model

gammas from halo in a chosen direction
Antiprotons, antideuterons, positrons

	isothermal	NFW	burkert	adiabatic
χ mass [GeV]	242.84	242.84	242.84	242.84
Gaugino Fraction	0.99	0.99	0.99	0.99
Relic Density	0.093	0.093	0.093	0.093
$J(\Psi,\Delta\Omega)$ halo factor	30.4	1214.5	7.8	154890.7
PHOTONS				
$d_E\ \gamma$ flux [$cm^{-2}\ s^{-1}\ GeV^{-1}$]	3.56E-14	1.42E-12	9.20E-15	1.82E-10
$\int_E \gamma$ flux [$cm^{-2}\ s^{-1}$]	5.77E-14	2.31E-12	1.49E-14	2.94E-10
γ flux from $\gamma\gamma$ [$cm^{-2}\ s^{-1}$]	4.93E-16	1.97E-14	1.27E-16	2.51E-12
γ flux from γZ [$cm^{-2}\ s^{-1}$]	8.09E-17	3.24E-15	2.09E-17	4.13E-13
$d_E\ \gamma\ s$ [GeV^{-1}]	7.39E+01	7.39E+01	7.39E+01	7.39E+01
$\int_E \gamma\ s$	1.20E+02	1.20E+02	1.20E+02	1.20E+02
$\gamma\ s$ from $\gamma\gamma$	1.02E+00	1.02E+00	1.02E+00	1.02E+00
$\gamma\ s$ from γZ	1.68E-01	1.68E-01	1.68E-01	1.68E-01
ANTIPROTONS				
$\overline{p}$ flux [$GeV^{-1}\ cm^{-2}\ s^{-1}\ sr^{-1}$]	5.77E-11	7.45E-11	4.82E-11	6.57E-10
ANTIDEUTERONS				
$\overline{D}$ flux [$GeV^{-1}\ cm^{-2}\ s^{-1}\ sr^{-1}$]	1.59E-15	2.02E-15	1.35E-15	1.67E-14
POSITRONS				
e^+ flux [$GeV^{-1}\ cm^{-2}\ s^{-1}\ sr^{-1}$]	2.24E-09	3.13E-09	1.68E-09	3.44E-08

Neutrinos (muons) from earth,
Sun, halo

NEUTRINOS FROM EARTH				
$\int_E \nu$ flux [$km^{-2}\ yr^{-1}$]	1.26E-01	1.26E-01	1.61E-01	2.07E-01
$\int_E \nu$ to μ [$km^{-3}\ yr^{-1}$]	1.17E-09	1.17E-09	1.49E-09	1.92E-09
$\int_E \mu$ flux [$km^{-2}\ yr^{-1}$]	1.92E-10	1.92E-10	2.46E-10	3.16E-10
$d_E\ \nu$ flux [$km^{-2}\ yr^{-1}\ GeV^{-1}$]	3.02E-09	3.02E-09	3.87E-09	4.97E-09
$d_E\ \nu$ to μ [$km^{-3}\ yr^{-1}\ GeV^{-1}\ degree^{-1}$]	4.73E-12	4.73E-12	6.05E-12	7.79E-12
$d_E\ \mu$ flux [$km^{-2}\ yr^{-1} GeV^{-1}$]	3.53E-14	3.53E-14	4.51E-14	5.80E-14
NEUTRINOS FROM SUN				
$\int_E \nu$ flux [$km^{-2}\ yr^{-1}$]	1.01E+07	1.01E+07	1.10E+07	1.72E+07
$\int_E \nu$ to μ [$km^{-3}\ yr^{-1}$]	6.78E-02	6.78E-02	7.36E-02	1.15E-01
$\int_E \mu$ flux [$km^{-2}\ yr^{-1}$]	9.56E-03	9.56E-03	1.04E-02	1.62E-02
$d_E\ \nu$ flux [$km^{-2}\ yr^{-1}\ GeV^{-1}$]	0.00E+00	0.00E+00	0.00E+00	0.00E+00
$d_E\ \nu$ to μ [$km^{-3}\ yr^{-1}\ GeV^{-1}\ degree^{-1}$]	3.54E-04	3.54E-04	3.84E-04	5.99E-04
$d_E\ \mu$ flux [$km^{-2}\ yr^{-1} GeV^{-1}$]	2.55E-06	2.55E-06	2.77E-06	4.32E-06
NEUTRINOS FROM HALO				
μ flux from halo [$km^{-2}\ yr^{-1}$]	1.10E-06	4.39E-05	2.84E-07	5.60E-03

http://pisrv0.pit.physik.uni-tuebingen.de/darkmatter/

Correlations

CHOOSE SETS OF PARAMETERS :

MSUGRA :

m_0, $m_{1/2}$, A_0, sign(μ), tan(β)

HALO MODELS:

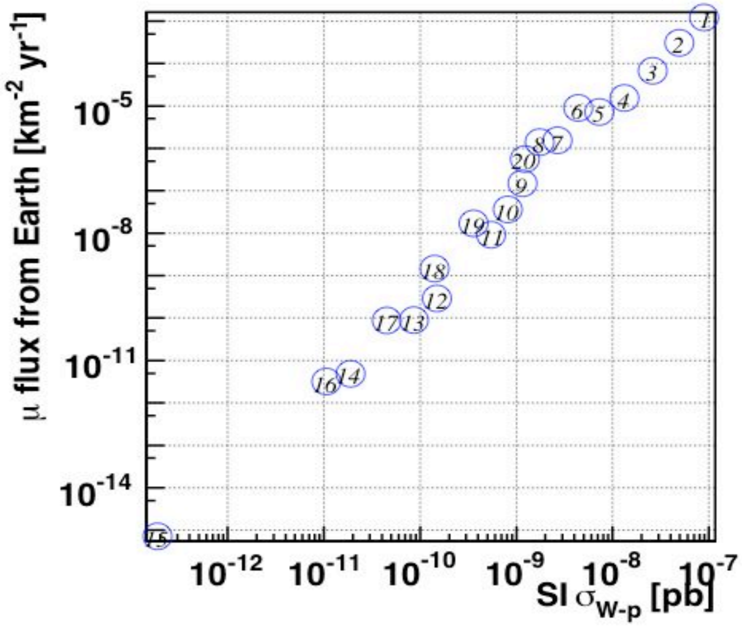
isothermal , navarro-franck-white, moore, burkert, adiabatic

INDIRECT DETECTION :

Line of sigth, angular resolution, aperture angle

Thresholds (gamma, pbar, Dbar, e+, neutrino/muon)

Example: varying only m_0



Correlation SI cross-section with muon flux from earth

AND CHOOSE 2 VARIABLES for bi-plots (23 variables):`

WIMP NATURE

m0, m1/2, gaugino fraction, relic density, neutralino mass

DIRECT DETECTION : WIMP - p(n) cross sections, SD and SI

INDIRECT DETECTION :

fluxes (gamma, pbar, Dbar, e+, neutrino/muon)

from galactic halo, sun, earth

Conclusion and Outlook

- Expected recoil spectra and exclusion plots
- Generic WIMPS or MSUGRA Neutralino
- Experimental strategy : quenching, resolution and efficiency
- Combines experimental conditions
- Statistical treatment : Feldman Cousin, Yellin
- Indirect dark matter searches : fluxes for MSUGRA Neutralino
- Constraint of direct searches on MSUGRA models

OUTLOOK

- Interpretation of WIMP signal
- Complementarity with LHC
- Constraint of indirect searches on MSUGRA models

contact webmaster for contributions : codes, susy scans, and feedback on the tool