**SUSY07**
**July 26 - August 1, 2007**
**Karlsruhe, Germany**

# 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**

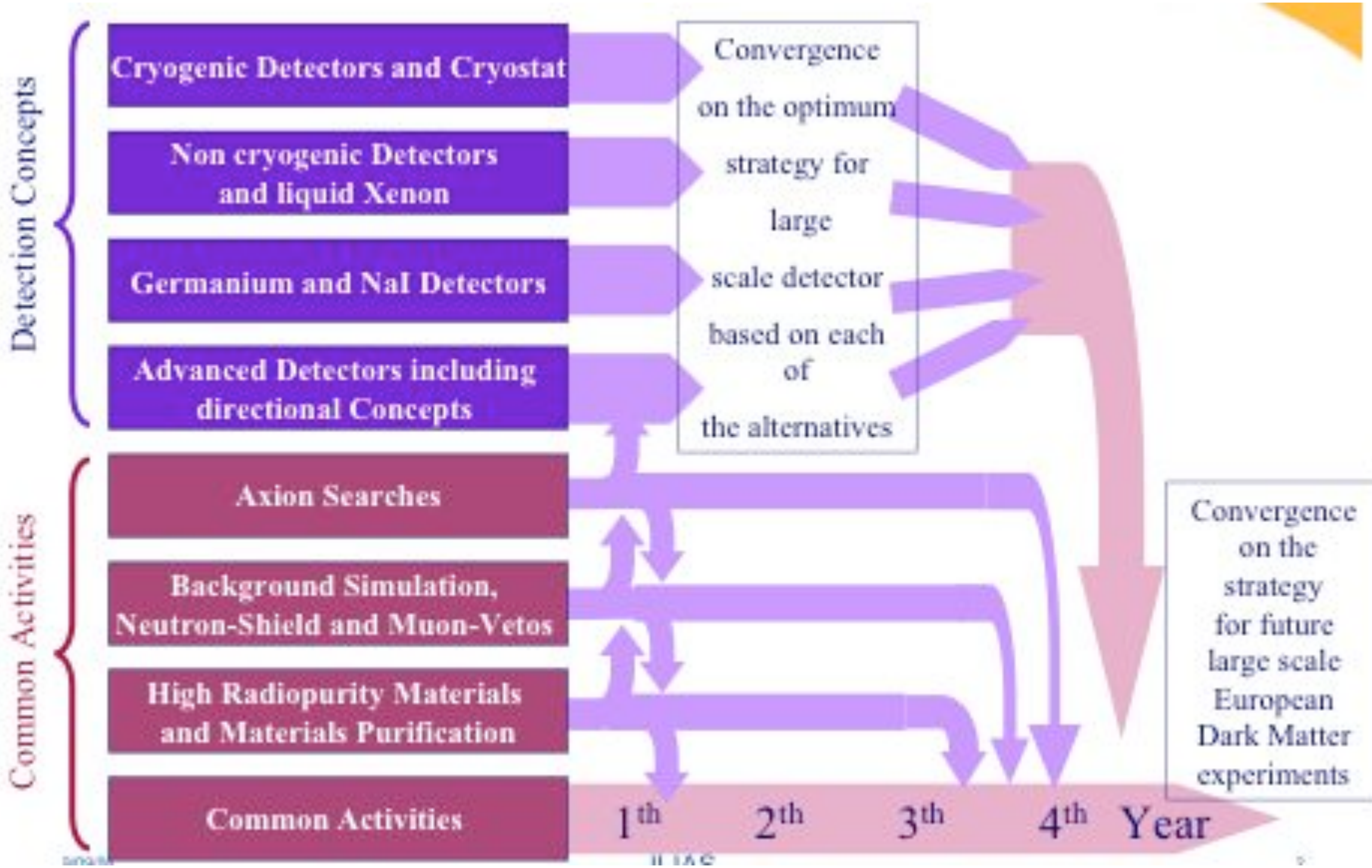
**Infrastructures : - Deep Underground Laboratories**
**- Gravitational Wave Interferometers**

*“ … 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

**DA**rk
**M**atter
**N**etwork
**E**xclusion
**D**iagram

tool web page

Direct detection :

**Spectra :** Experimental energy spectra

**Limits :** Experimental limits on WIMP-nucleon cross sections

**SuSy :** Direct detection of Neutralinos

**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/**

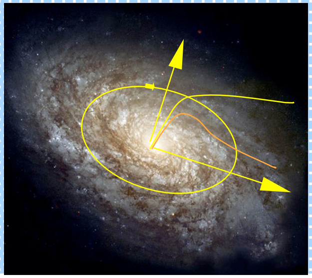
# Direct Search for WIMPs

**WIMP nature : ie Neutralino**

$\sigma$ = **WIMP-nucleus cross section (point-like)**
$m_\chi$ = **WIMP mass**
($\mu$ = **WIMP-nucleus reduced mass**)

**Galactic Halo**

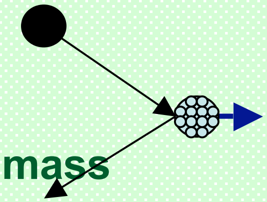
$\rho$ = **density**
$f(v)$ = **velocity distribution**



**Nucleus**

$F$ = **Nuclear form factor**

$\mu$ = **WIMP-nucleus reduced mass**



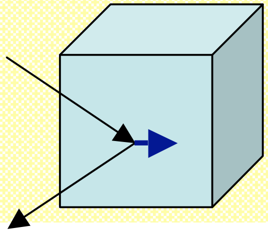
***Detection rate :***

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

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

**Detection**

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

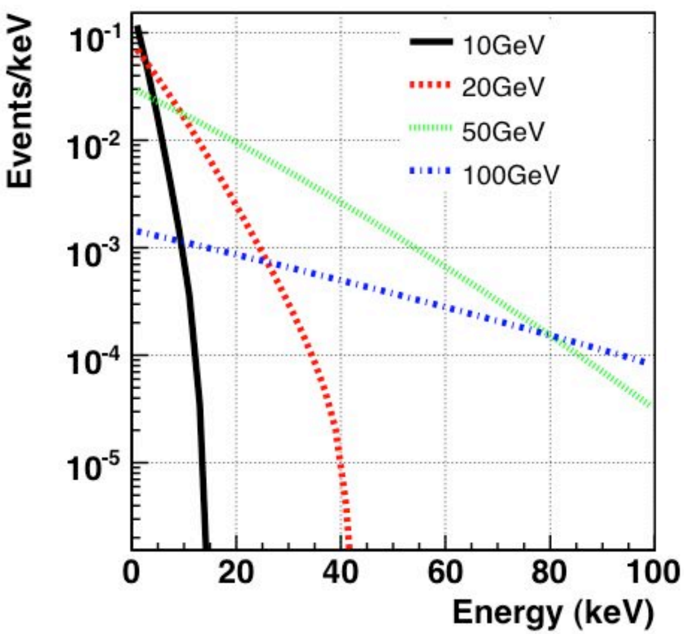


*J. D. Lewin and P. F. Smith, Astropart. Phys.* ***6****, (1996)87*

# Example : Dependence on WIMP Mass

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

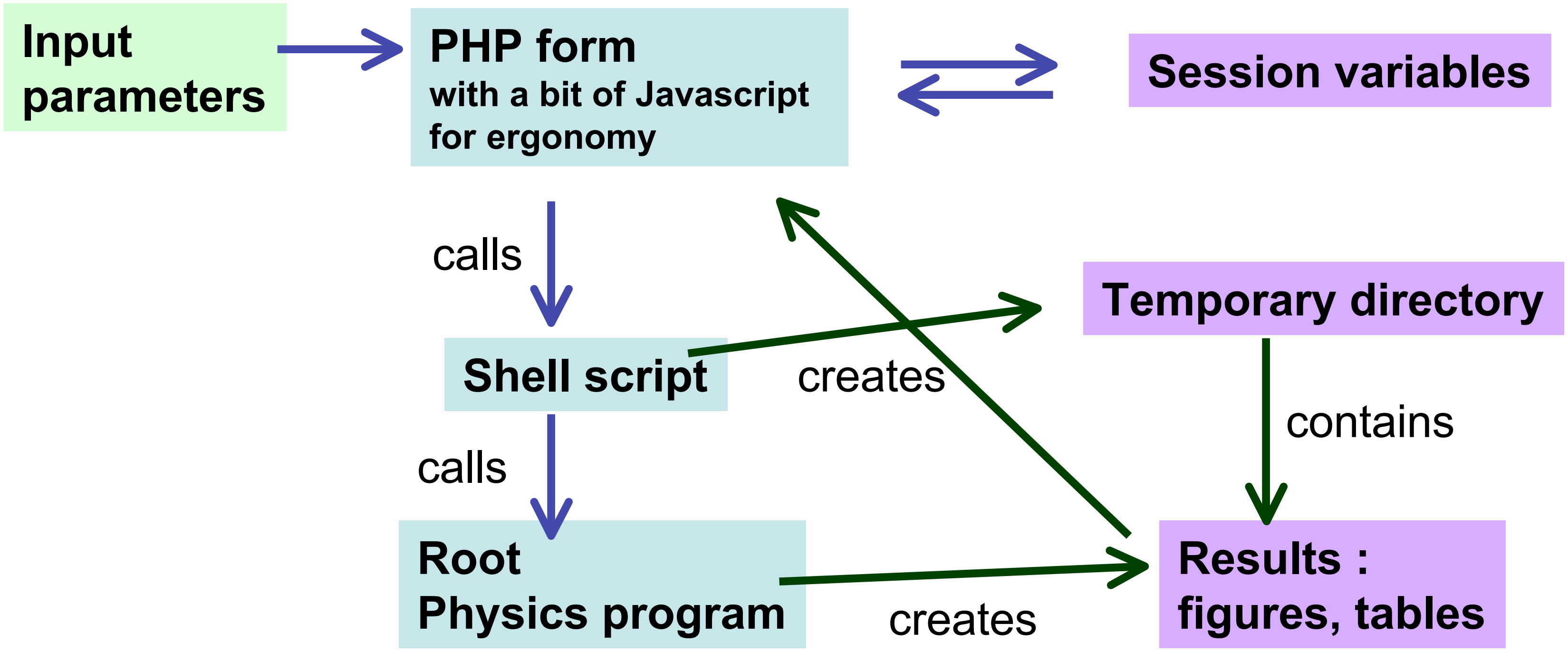
| | Label | WIMP mass (GeV) | A of Target | Exposure (kg.days) | WIMP-nucleon cross section (pb) |
|---|---|---|---|---|---|
| 1 | 10GeV | 10 | 72.6 | 10 | 1E-7 |
| 2 | 20GeV | 20 | 72.6 | 10 | 1E-7 |
| 3 | 50 GeV | 50 | 72.6 | 10 | 1E-7 |
| 4 | 100GeV | 1000 | 72.6 | 10 | 1E-7 |
| next | | 1000 | 72.6 | 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 |
| 9 | 1.50E-03 | 1.93E-02 | 1.84E-02 | 1.16E-03 |
| 11 | 3.65E-04 | 1.35E-02 | 1.64E-02 | 1.10E-03 |
| 13 | 3.55E-05 | 9.40E-03 | 1.46E-02 | 1.04E-03 |
| 15 | 0.00E+00 | 6.49E-03 | 1.30E-02 | 9.87E-04 |
| 17 | 0.00E+00 | 4.43E-03 | 1.15E-02 | 9.36E-04 |
| 19 | 0.00E+00 | 3.01E-03 | 1.02E-02 | 8.87E-04 |
| 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 |

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

# How it works




**When leaving the webpage or starting new figures the session is destroyed**
**→ before leaving copy the created figures and tables**

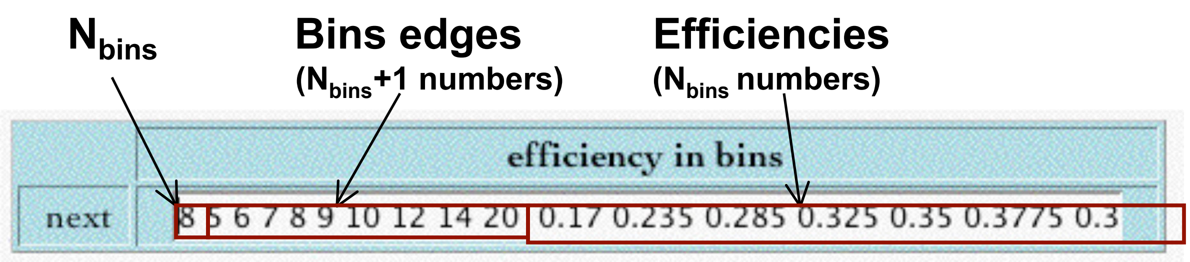
# Experimental parameters

**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)*

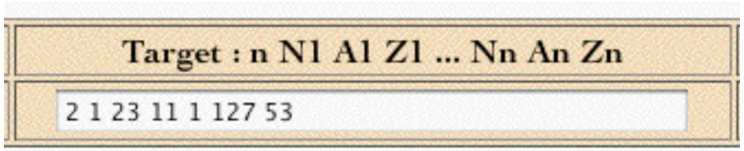
**HOW TO :**

**- enter binned values :**

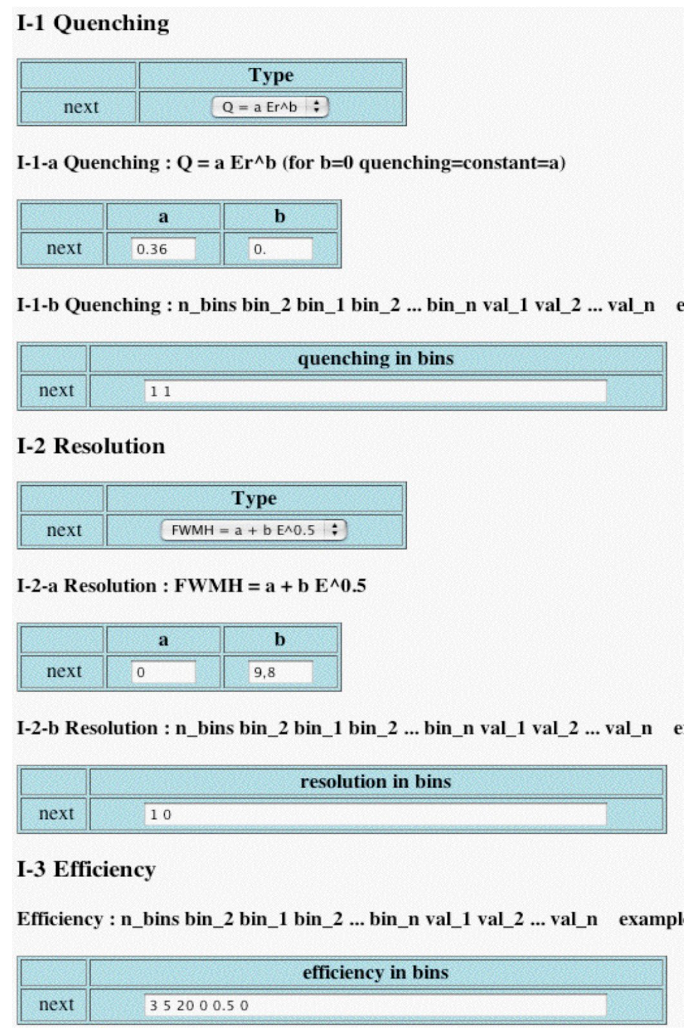



**- enter compound target :**

**Example NaI : $N_{target}$ $N_{stoich}$ A Z $N_{stoich}$ A Z**
**2 1 23 11 1 127 53**

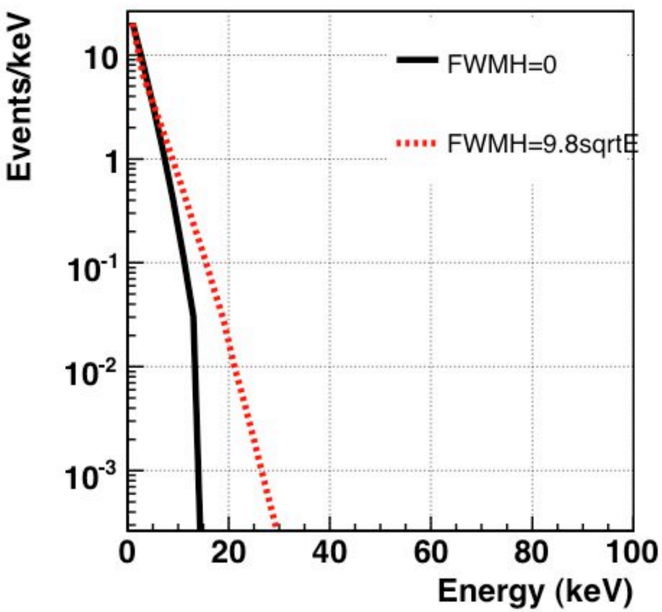



overview



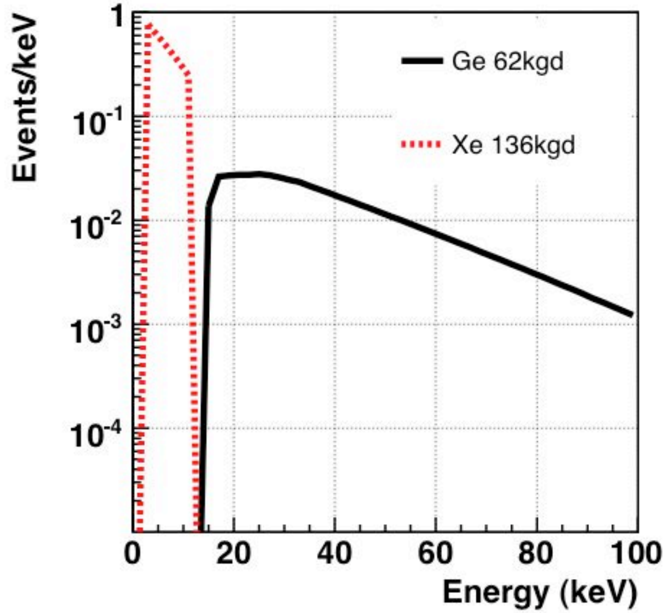
# Example : Experimental parameters

**Effect of resolution**



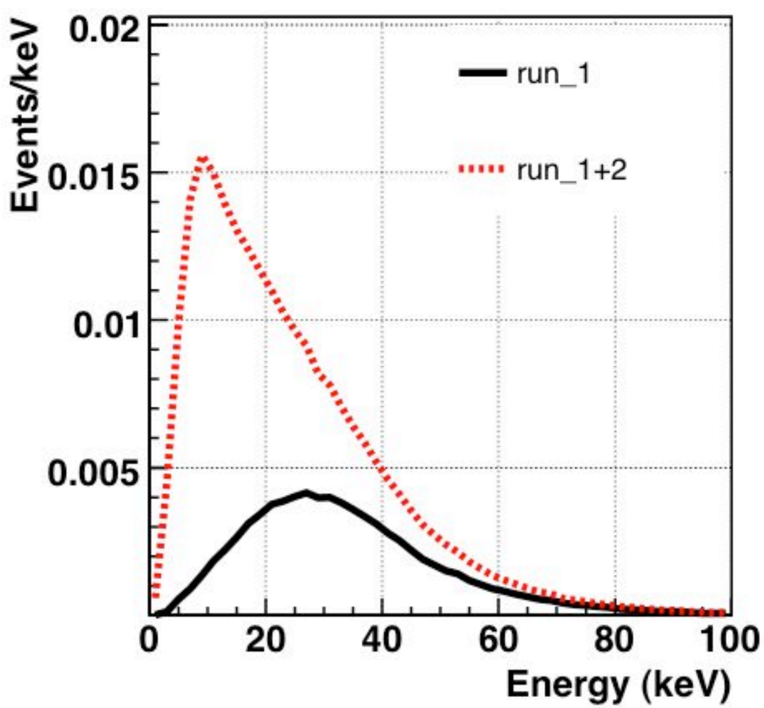

**Low resolution**
**=> flattens the spectra**
**but worsens efficiency**
**(discrimination)**

**Xenon vs Germanium**




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

# Example : Combine experimental conditions




**II - PARAMETERS FOR HEAT/IONISATION BOLOMETERS**

**Quenching : Q = a Er^b +- sigmaQ**

| | a | b | sigmaQ |
|---|---|---|---|
| 1 | 0.16 | 0.18 | 0.035 |
| 2 | 0.16 | 0.18 | 0.035 |
| next | 0.16 | 0.18 | 0.035 |

**Resolutions**

| | Ionisation at 0 keV (keV) | Ionisation at 122 keV (keV) | Heat at 0 keV |
|---|---|---|---|
| 1 | 6 | 6 | 6 |
| 2 | 1 | 1 | 1 |
| next | 1 | 1 | 1 |

**Voltage and Cuts**

| | Voltage (volts) | Ionisation cut (keV) | Neutron band lower cut (sigma) | Neutron band higher cut (s |
|---|---|---|---|---|
| 1 | 4 | 6 | -1.645 | 1.645 |
| 2 | 4 | 1 | -1.645 | 1.645 |
| next | 4 | 1 | -1.645 | 1.645 |

Below you can choose to clear all tables, to combine recursively with previous result or to add a new result

combine with previous result

**Option available to combine recursively with previous outputs**

# 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**

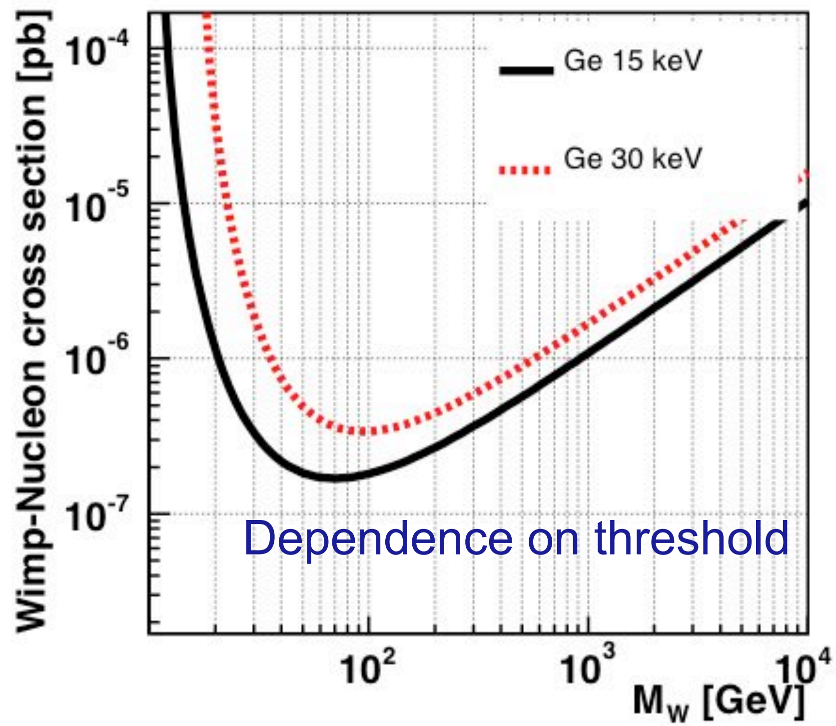
*The limit on the rate depends on the number of observed events and the number of expected background events.*

*(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**

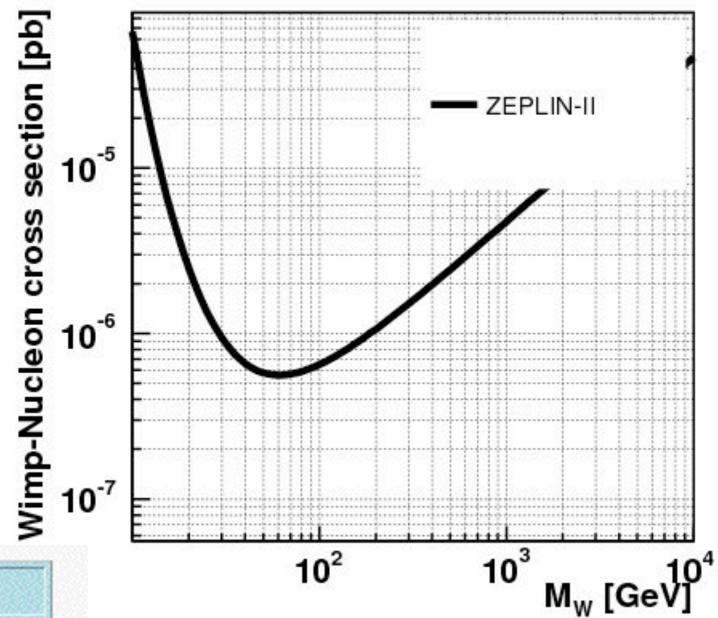
| | Method | Observed events / Limit on rate | N_Background |
|---|---|---|---|
| 1 | 2 | 29 | 28.6 |
| next | 2. Feldman-Cousin approach | 29 | 28.6 |

**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 |



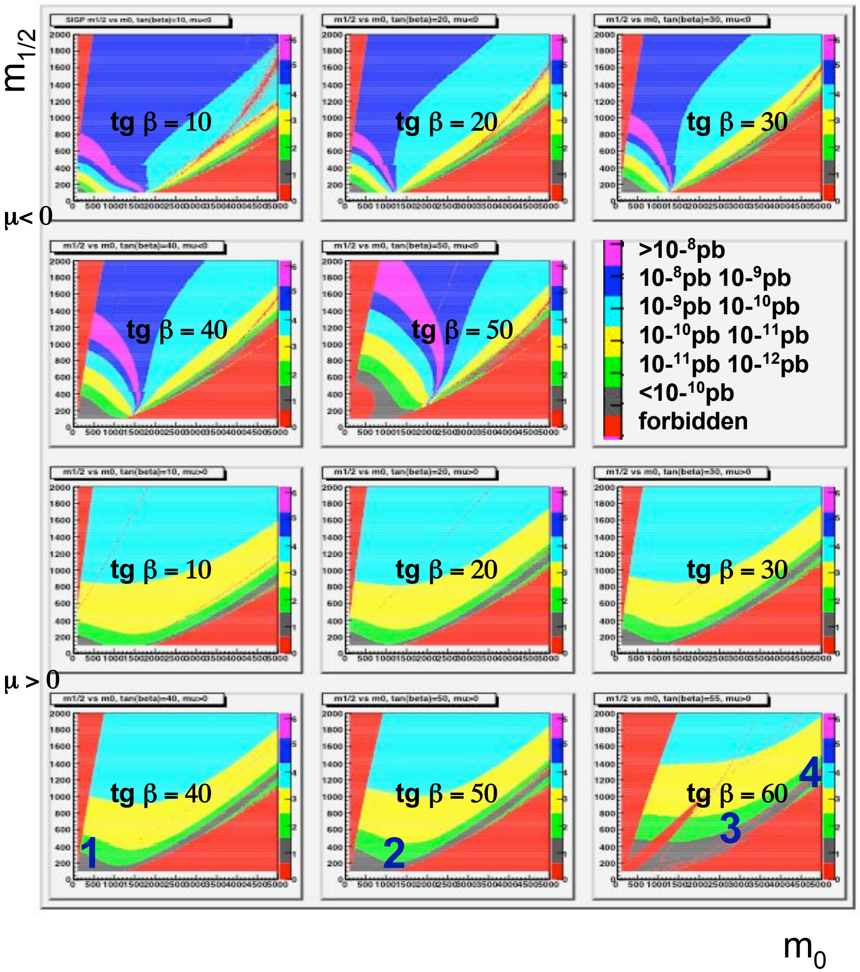

| | efficiency in bins |
|---|---|
| 1 | 8 5 6 7 8 9 10 12 14 20 0.17 0.235 0.285 0.325 0.35 0.3775 0.3875 0.39 |
| next | 8 5 6 7 8 9 10 12 14 20 0.17 0.235 0.285 0.325 0.35 0.3775 0.3 |

| | |
|---|---|
| [illegible] | [illegible] |
| 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

# Neutralino

## Neutralino-nucleon cross-section



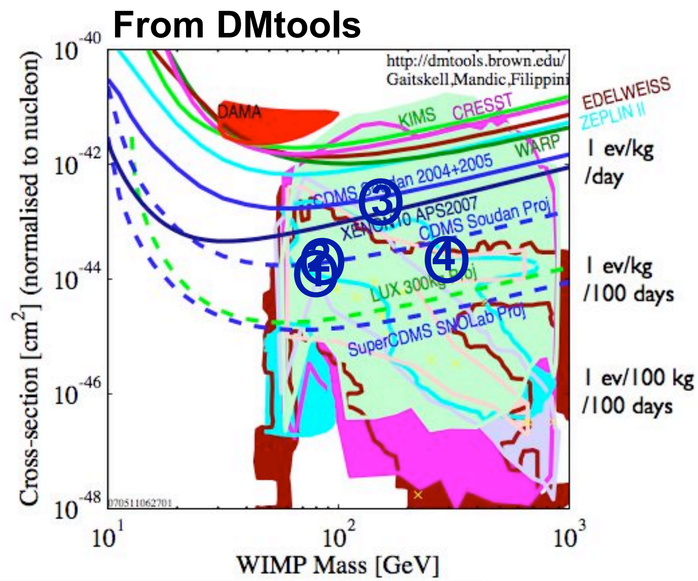

*SuSy scan (isasugra) following :*
*H. Baer et al JCAP09(2003)007*

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

⟹

**Cross-section and WIMP mass**

1 2E-08pb, 97GeV
2 2E-08pb, 98 GeV
3 2E-07pb, 139 GeV
4 4E-08pb, 340 GeV




**=> Cross sections and WIMP mass vary with assumed SUSY model**

# Example : Neutralino on $^{73}Ge$

**Inputs : SUSY parameters and experimental parameters**

☑ I - MSUGRA Parameters

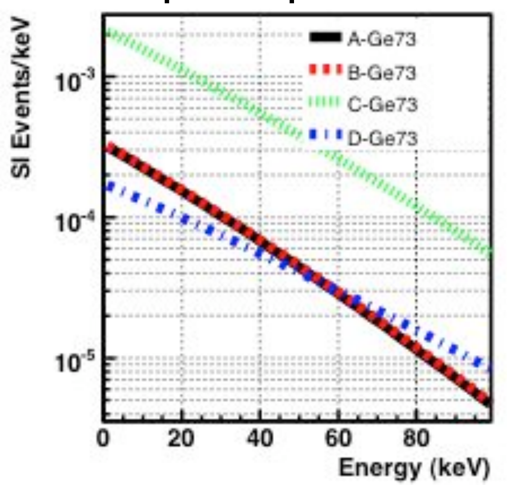
| | m0 | m1/2 | A0 | sign(mu) | tan(beta) |
|---|---|---|---|---|---|
| next | 107 | 600 | 0 | + | 5 |

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

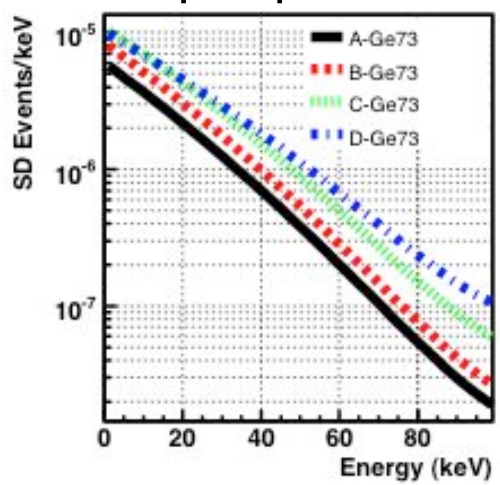
**using :**

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

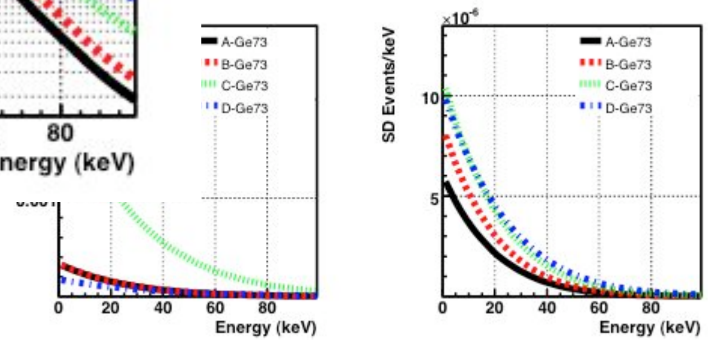
**spin-independent**




**spin-dependent**




Linear scale




Only a few targets are available
so far for spin-dependent interactions

# Conclusion and Outlook

- Expected recoil spectra and exclusion plots
- Generic WIMPS or SUSY Neutralino
- Experimental strategy : quenching, resolution and efficiency
- Combines experimental conditions
- Statistical treatment : Feldman Cousin, Yellin

**OUTLOOK**

- Different theoretical models (galactic halos…)
- Complementarity with indirect dark matter searches
- Complementarity with LHC
- Interpretation of experimental results