Optimizing cryogenic detector configurations for low-mass WIMP searches
- Roadmap toward low mass wimp search within EDELWEISS -
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**Background model**

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V=0V</td>
<td>EDW-III bkgd and resolutions $\sigma_{\text{Born}} = 200$ eV, $\sigma_{\text{heat}} = 500$ eV</td>
</tr>
<tr>
<td>V=8V</td>
<td>EDW-III bkgd and resolutions $\sigma_{\text{Born}} = 200$ eV, $\sigma_{\text{heat}} = 500$ eV</td>
</tr>
</tbody>
</table>

**Detector response model**

$\sigma_{\text{Born}} = 15$ GeV/c

**V=WIMP-nucleon cross section [cm$^2$]**

<table>
<thead>
<tr>
<th>Mass [GeV/c]</th>
<th>Cross Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>10$^{-40}$</td>
</tr>
<tr>
<td>100</td>
<td>10$^{-41}$</td>
</tr>
<tr>
<td>300</td>
<td>10$^{-41}$</td>
</tr>
</tbody>
</table>

**References**

- Cowan, Glen, Cranmer, Kyle, Gross, Aprile
- Plomb
- Expected number of induced bias in the result
-Likelihood analysis will subtract the background and could thus induce bias in the result. Background model need to be accurate.

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**Boost or Heat resolution?**

WIMP threshold corresponds to the WIMP mass for which a 5% efficiency is obtained. Best EDW-III heat resolution $\sigma_{\text{heat}} = 500$ eV -> 4 GeV of WIMP.

To reduce the WIMP threshold we need to boost the voltage. 4 GeV to improve our heat resolution !

The effect of the boost is limited by the quenching decreasing at low energy for low Mass.

**Boosted Decision Trees (BDT) Analysis**

- BDT analysis is a conservative way to analyse WIMP search data... background subtraction, only one optimization hence no bias in the results.

**Voltage impact**

- EDW-III background 350 kg.d
- $\delta_{\text{Born}} = 100$ eV, $\sigma_{\text{heat}} = 500$ eV

**EDW-III background impact for 350 kg.d**

- $\sigma_{\text{Born}} = 100$ eV, $\nu_{\text{heat}} = 500$ eV

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**Resolution impact with the EDW-III background**

- Exposure = 350 kg.d

- At low mass only heat readout is needed ! (but need a full background model)

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**EDELWEISS low mass Roadmap**

- EDELWEISS has to get rid of Heat Only events and to improve the resolutions up to 200 eV on heat and ionisation

- LEM setup is not a limiting factor up to few 1000 kg.d

- EDELWEISS has to work on the detector internal background (mostly Ph neutrons and Senit)

For higher exposure EDELWEISS will start to be limited by the LEM setup for $M_\chi = 40$ GeV.

EDELWEISS has to work on the detector internal background (mostly Ph neutrons and Senit)

- LSM with an improved setup

@ SNOLAB within the EURECA-SCDMS collaboration

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**Likelihood Analysis**

Unbinned Likelihood Function

Distribution of $\delta$ for different hypothesis

Boosted Decision Trees (BDT) Analysis

- BDT analysis is a conservative way to analyse WIMP search data... background subtraction, only one optimization hence no bias in the results.

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**Beta**

- Neutrino (7 eV)

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**Surface WIMP with$ E_{\text{ion}} = 100$ eV at low mass & Compton at high mass**

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**Competition between the discrimination and the gain of sensitivity at higher voltage.**

- Depending on the science goal, we have to optimize the voltage. The crossover is very sharp, thus we can split the goals in 2 :
  - For $M_\chi = 4$ GeV : boost at max to lower the threshold. Discrimination is not needed (see Readout impact).
  - For $M_\chi = 40$ GeV : discrimination is needed (see background impact).

The best is the lowest voltage.