Karlsruher Institut für Technologie

Expérience pour DEtecter Les WIMPs En Site Souterrain

EDELWEISS Search for Low Mass WIMPs with a New Maximum Likelihood Approach

ISAPP2013, Stockholm
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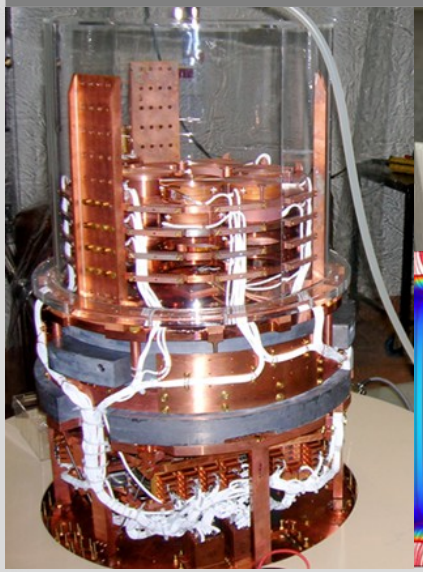
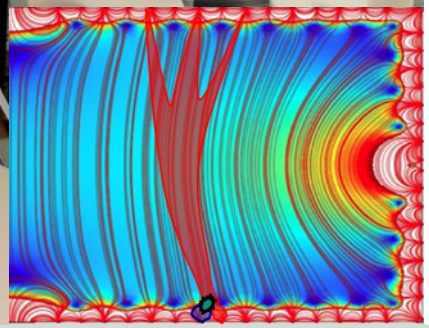
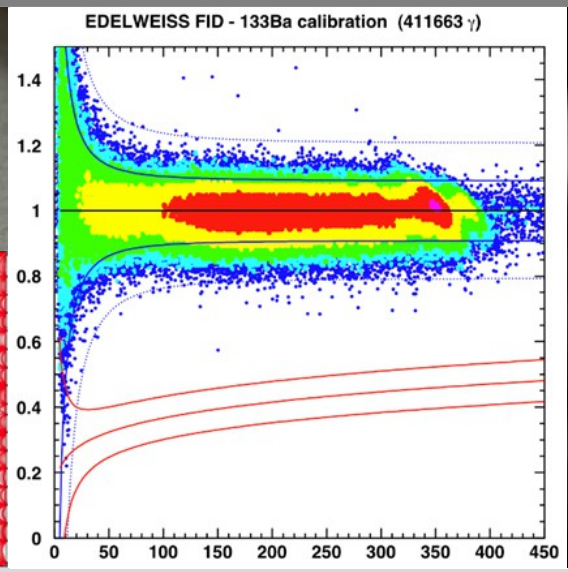


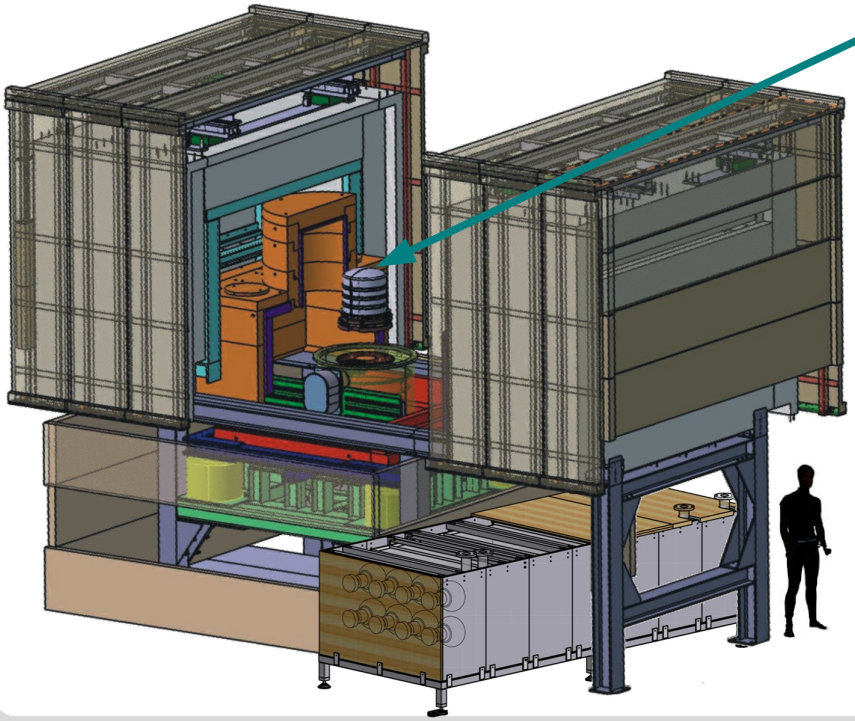




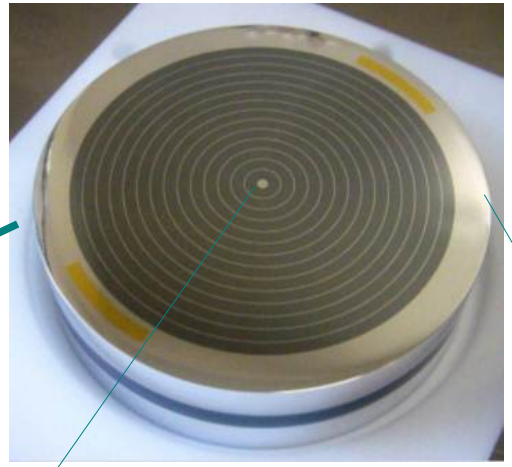
EDELWEISS-II Setup & Detectors

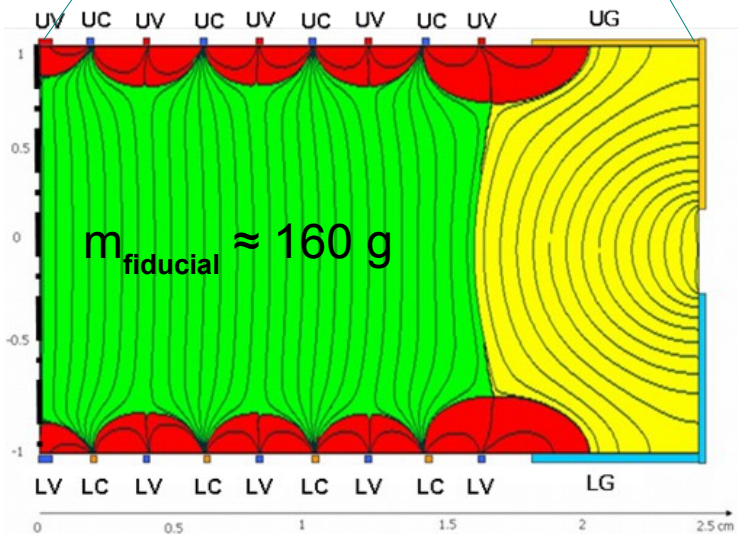
- EDELWEISS-II phase: 2009-2011
- 10 monocrystalline Ge-bolometers:
- 1 NTD heat sensor (phonons)
  6 Al electrodes (ionization)
  → *InterDigit* (ID) design
- 384 kg.days exposure

PLB702,5 (2011) 329



ID detector (~ 400 g)

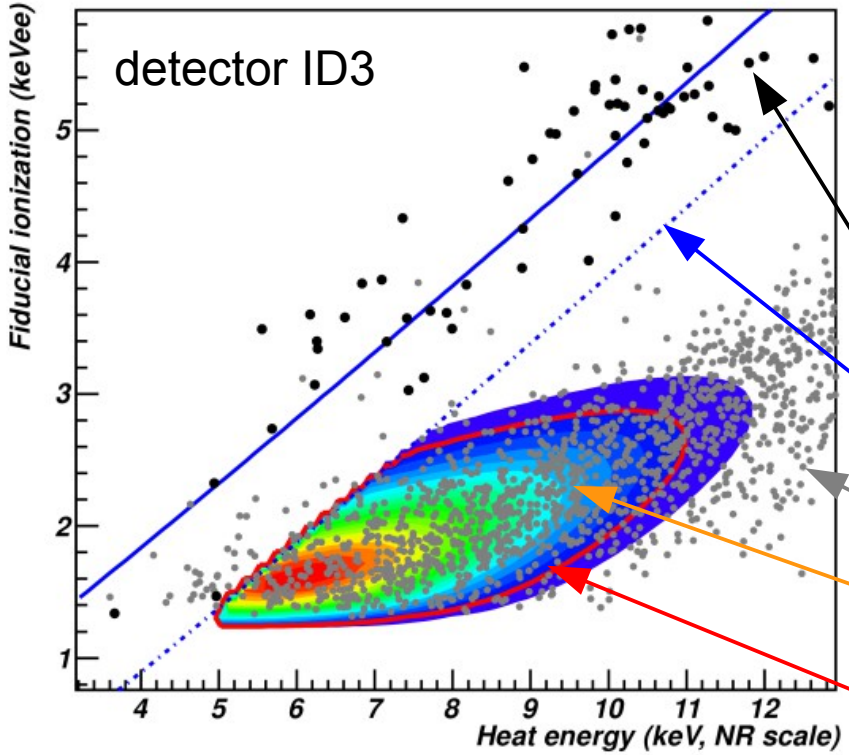


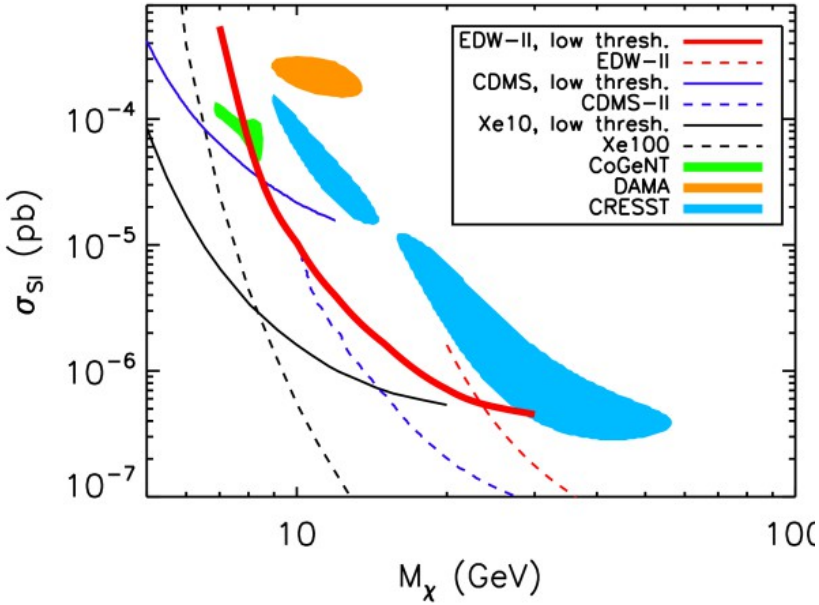


Dedicated Low Threshold Analysis

- 4 best performing detectors
  → 113 kg.days exposure
- 3 events found
  (expected total bckgd 2.9 evts)
- 90% Poisson C.L. for empty signal region: 2.35 evts

Phys. Rev. D, 86, 051701 (2012)





fiducial WIMP search data

95% C.L. cut on γ-band

neutron calibration data

efficiency corrected WIMP signal density for m_χ = 10GeV

90% WIMP signal search box

Maximum Likelihood Model

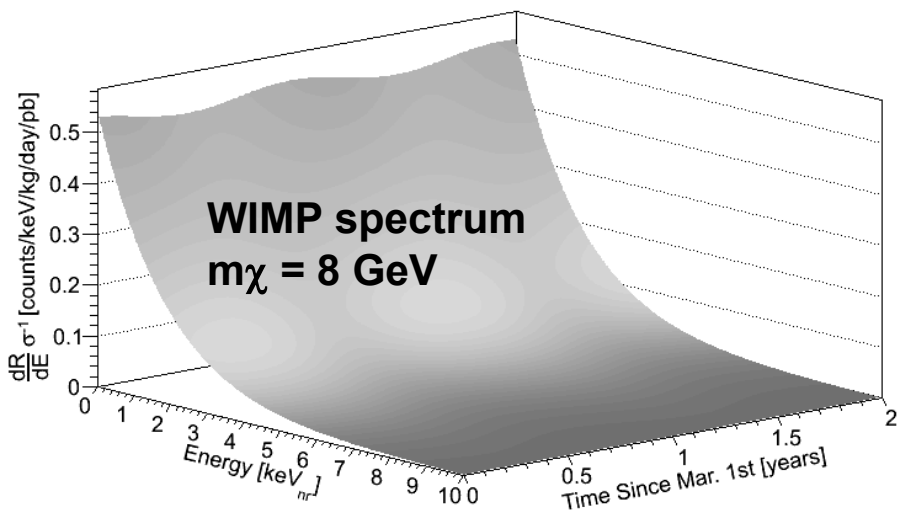
- Extended likelihood function ***L*** over all events ***N***

$$L(\vec{p}) = \prod_{n=0}^{N} \rho(\vec{p}, \vec{x}_n) + Poisson$$

- signal: WIMP spectrum in observables

$$\vec{x} = \left(E_{rec}, E_{ion}, time\right)$$

- background:
  flat γ-spectrum + cosmogenic peaks
- minimize Negative Log Likelihood (***NLL***)
  by varying parameters $\vec{p} = \left(N_{signal}, N_{flat}, N_{peaks}\right)$

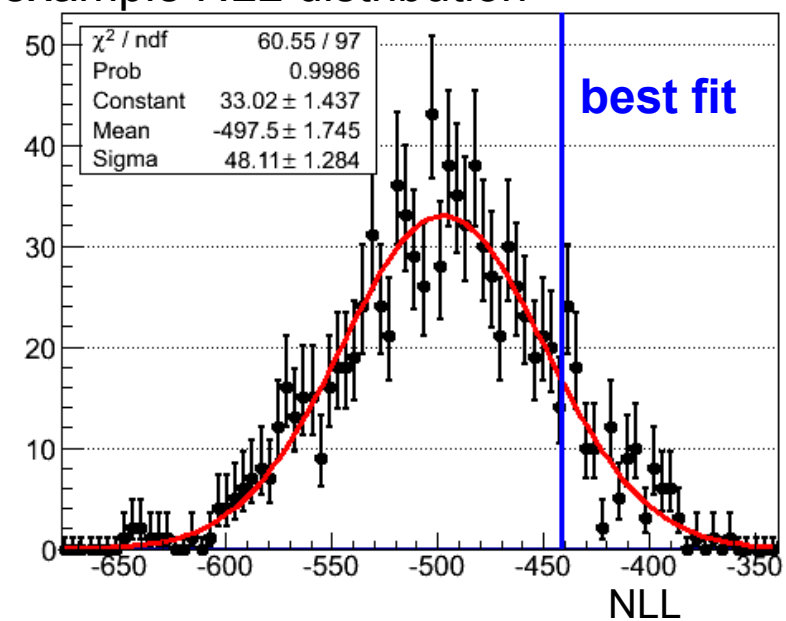


advantages of MLHD:

- inclusion of real time as additional observable
- no strict cuts required (i.e. γ-cut)

The RooFit Tool for data Modeling
arXiv:0306116

example NLL distribution

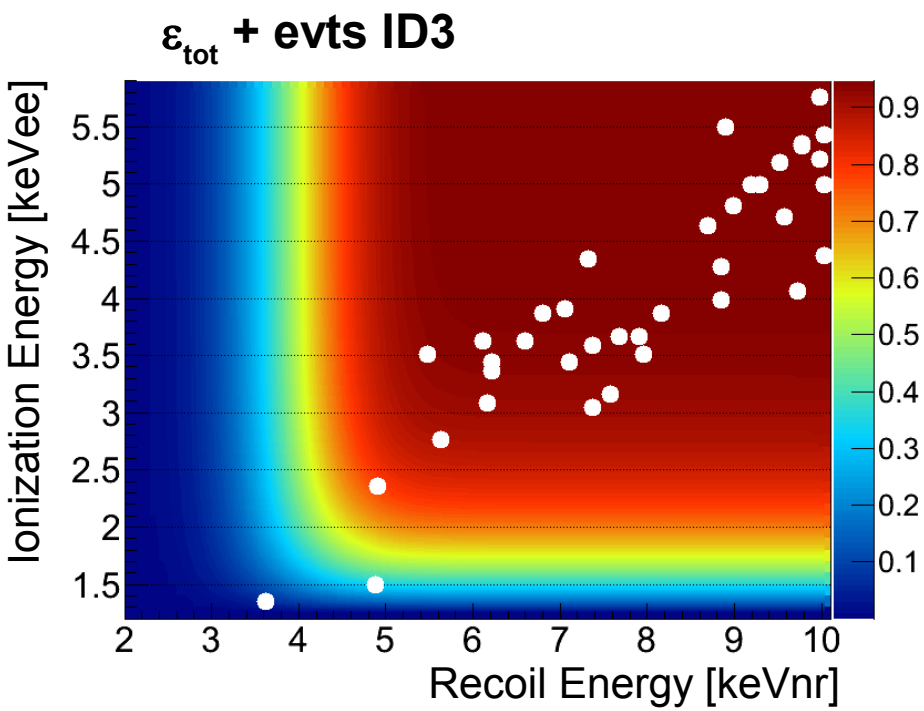


Signal Reduction due to Efficiency Loss

considering detector efficiencies:

- $\varepsilon(E_{ion})$ from fiducial volume cut
  → fit on calibration data
- $\varepsilon(E_{rec})$ from DAQ trigger
  → analytic function

$m\chi$ [GeV]	rate/σ [kg/d/10^{-6}pb]	ε_{tot} x rate	rel. gain*
6	0.29	0.01%	3.97
8	0.34	0.35%	0.55
10	0.38	2.1%	0.23
15	0.46	12.9%	0.07
30	0.48	37.5%	0.03

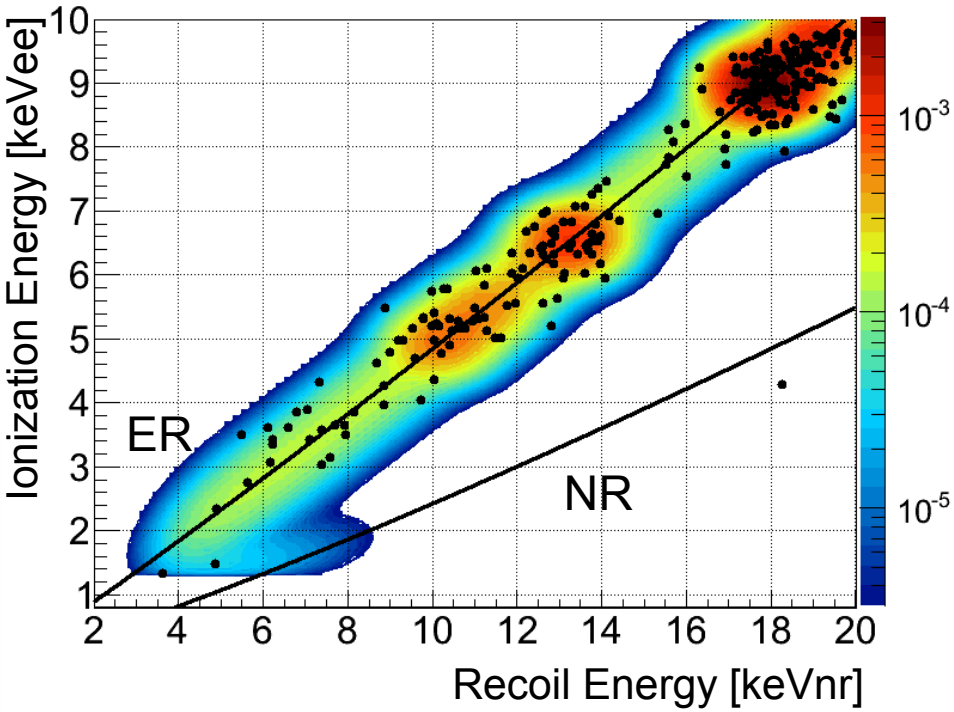


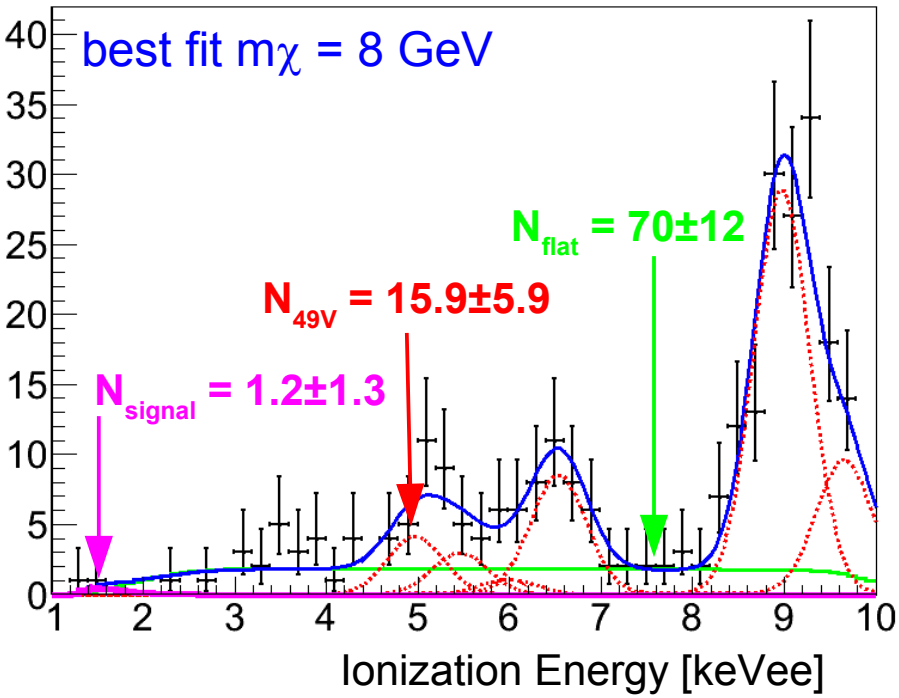
- for **very** small $m\chi$:
  significant signal reduction
- *WIMP safe mass* (≈ 9 GeV) not lowered without γ-cut

* relative gain for efficiency corrected rate without γ-cut

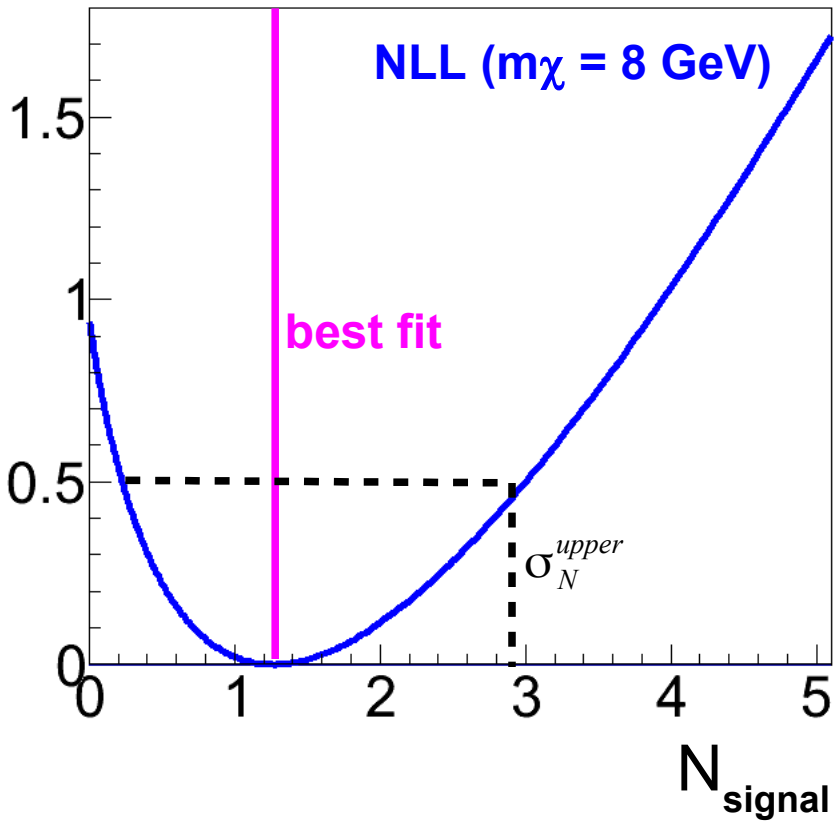
PRELIMINARY

Fit Example (*ID3*)





From Signal Events to Exclusion Limit



mχ [GeV]	best fit N_{signal}
6	$1.80^{+1.77}_{-1.10}$
8	$1.23^{+1.74}_{-1.04}$
10	$2.04^{+1.97}_{-1.25}$
15	$1.45^{+1.75}_{-0.99}$
30	$1.16^{+1.54}_{-0.81}$

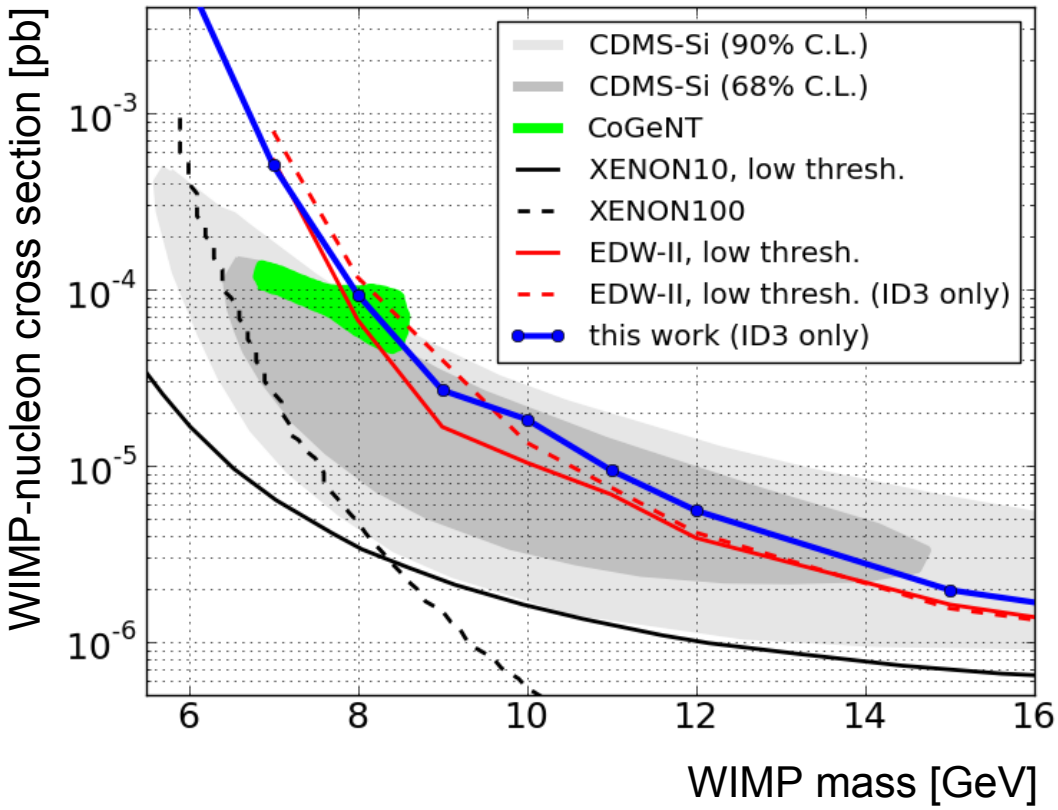
- 90% C.L.of signal events

$$N_{max} = N_{signal} + 1.28 \times \sigma_N^{upper}$$

- scattering cross section limit

$$\sigma_{max} = \frac{N_{max}}{(rate \times m_{fiducial} \times livetime)}$$

Resulting Exclusion Limits (for Detector *ID3*)



<u>Future improvements</u>

- full implementation of real time observable
- relaxation of cuts to increase exposure & signal efficiency
- application to FID800 detectors & EDELWEISS-III data