WIMP direct detection overview

Contents

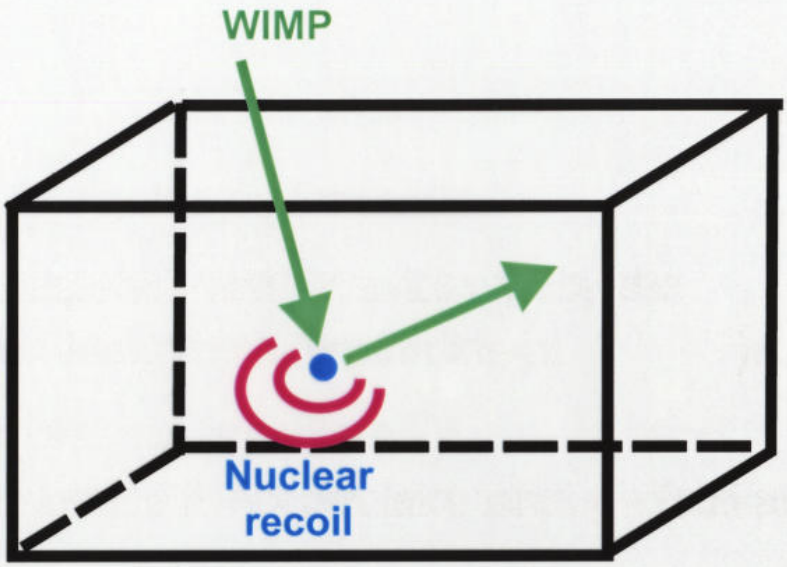
- The physics of WIMP direct detection
- Survey of direct detection experiments
- Prospects and outlook

Current situation

Short summary to warm up

- No WIMPs found so far !
- Still persistent claim for evidence by the DAMA collaboration (critical borderline at 10^{-6} pb).
- Current close competitors CDMS, EDELWEISS and ZEPLIN I are still not decisive enough (still above 10^{-6} pb). (SURPRISE by most recent update - see later)
- Several other experiments will soon converge to similar sensitivity levels (around 10^{-6} pb) or beyond.

Direct Detection Physics



WIMP–nucleus elastic scattering

Search for nuclear recoils at low energies (< 100 keV)

Important experimental parameters

- Energy threshold - as low as possible.
  - Elastic scattering spectrum - exponential decrease with energy, relevant range below 100 keV.
- Target mass - as high as possible.
  - Rare event search - relevant rates $\mathcal{O}(1)$ count/day/kg
- Background - as low as possible
  - Signal is nuclear recoil - generic background from neutrons
  - Discrimination against electron recoils essential - majority of background

The rate equation

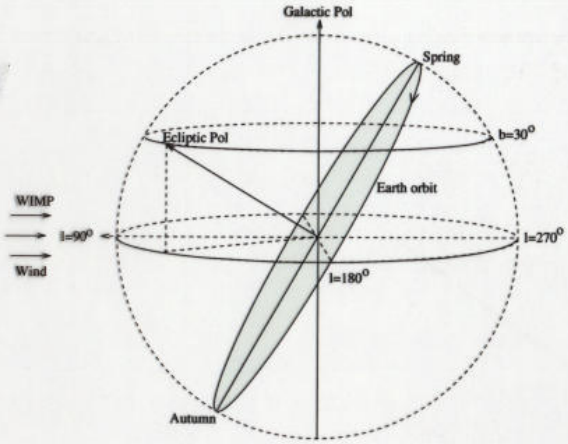
$$\frac{dR}{dQ} = N_T \frac{\rho_0 \sigma_0}{2 m_w m_n} F^2(Q) \int_{v_{min}}^{v_{max}} \frac{f(v)}{v} dv$$

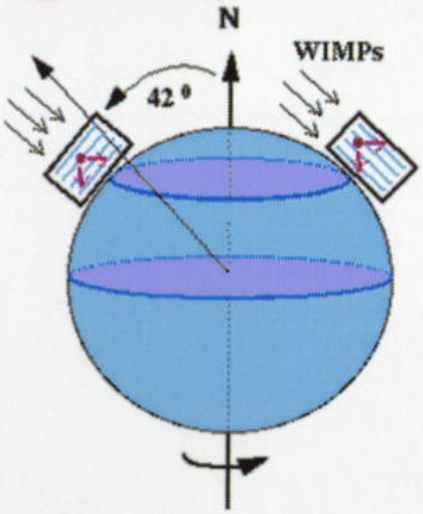
using

$$v_{min} = \sqrt{\frac{E_{thr} m_n}{2 m_r^2}}$$

Measurement	Particle Physics	Astrophysics	Detectorphysics
$\frac{dR}{dQ}$	m_w	ρ_0	$F^2(Q)$
	σ_0	f(v)	m_n
		v_{max}	N_T
			E_{thr}
	unknown	estimates	minor uncertainty

WIMP Signatures

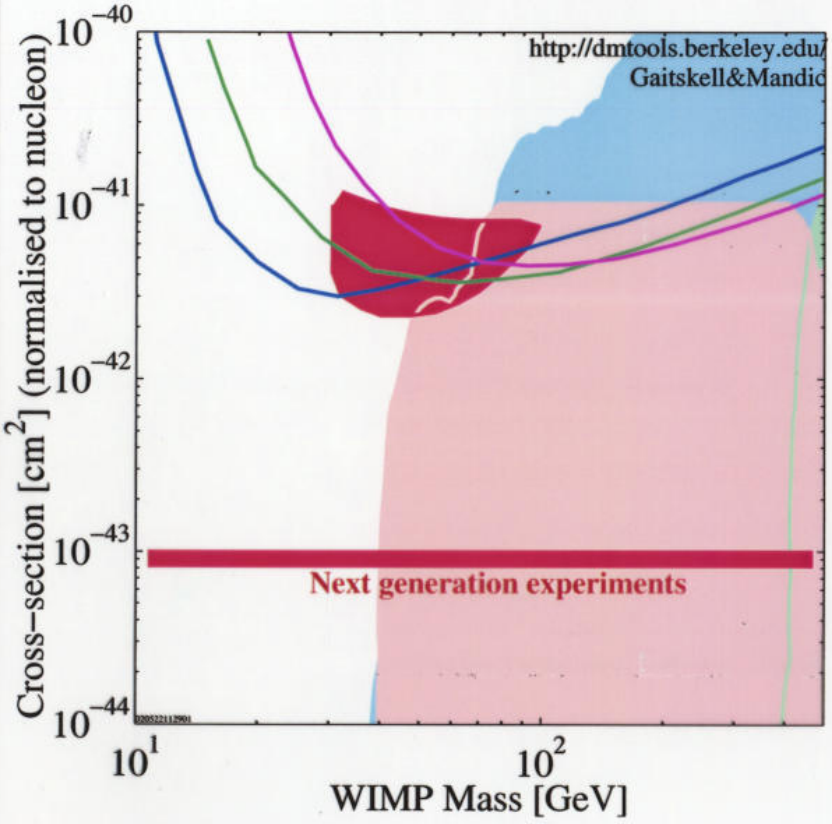




(a) annual modulation (b) diurnal modulation

(c) target material

Summary picture



DATA listed top to bottom on plot
Edelweiss, 4.5 kg−days Ge(320g) June 2001 limit
ZEPLIN 1, 2002 result
CDMS Mar. 2002, Qshared, bkgd subtracted, with Si data
DAMA 2000 58k kg−days NaI Ann.Mod. 3sigma, w/o DAMA 1996 limit
Gondolo et al. SUSY (Gaugino−like Models)
Gondolo et al. SUSY (Higgsino−like Models)
Gondolo et al. SUSY (Mixed Models)
020522112901

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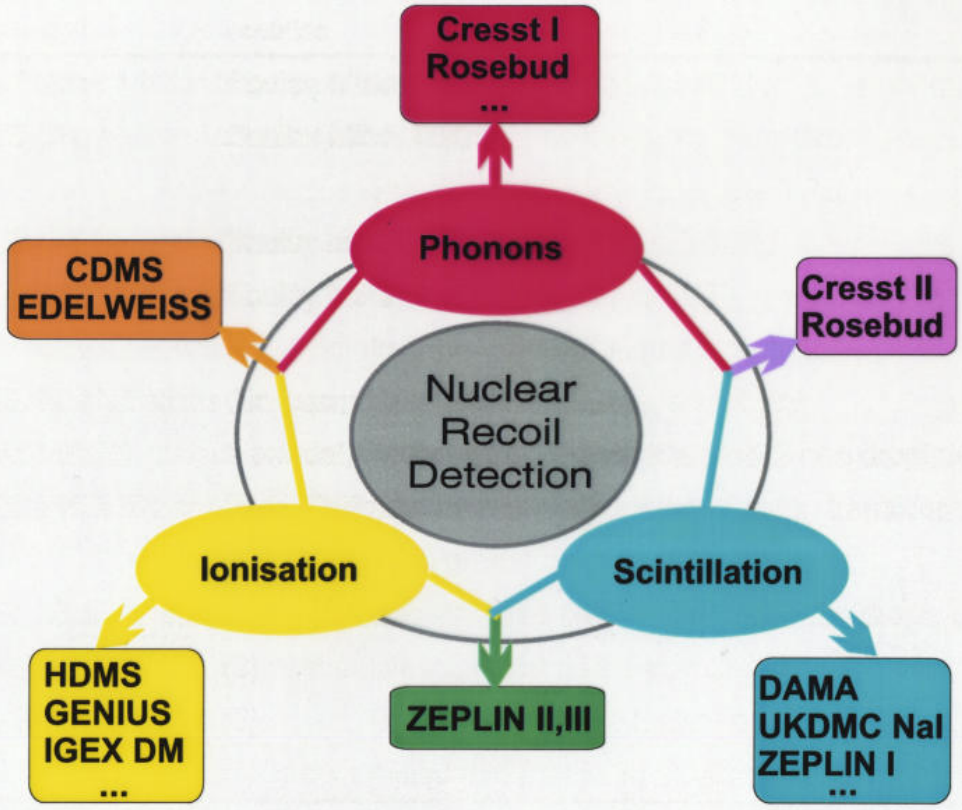
Direct Detection techniques



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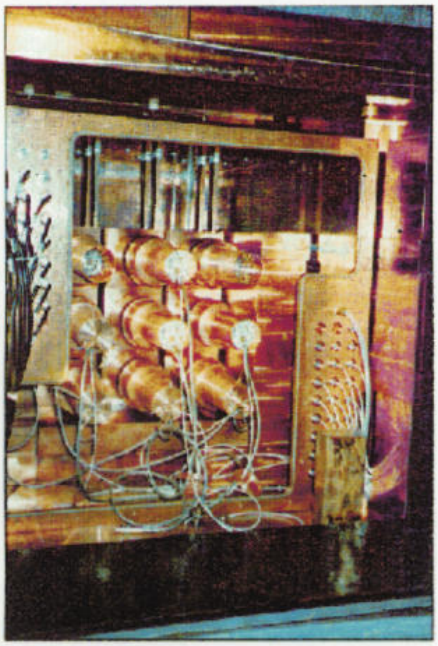
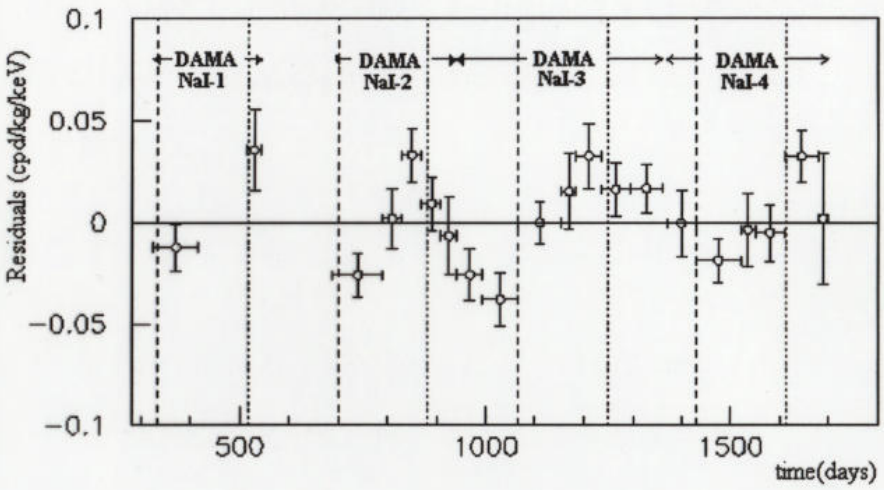
Yorck Ramachers, Oxford University

The DAMA experiment briefly

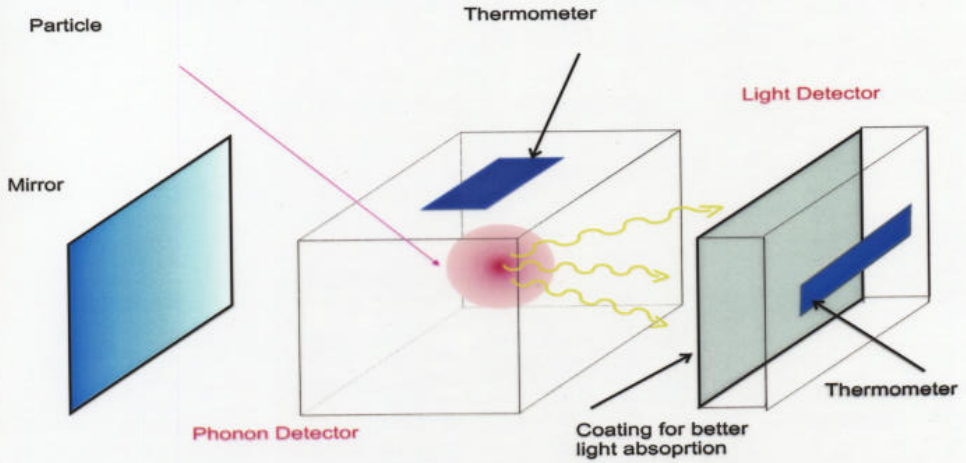


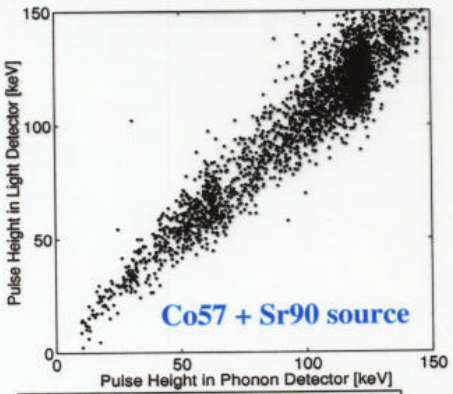


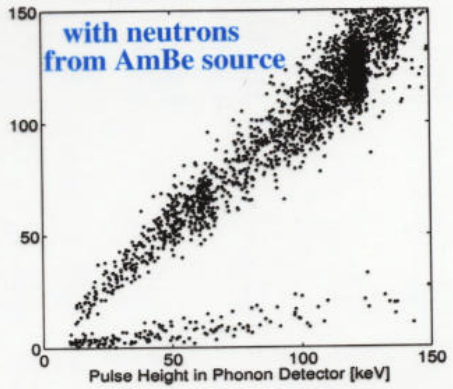
First evidence for WIMP detection in 1998. Upgrading to 250 kg NaI shortly before completion. Cycle 5 & 6 under analysis.

CRESST Phase II

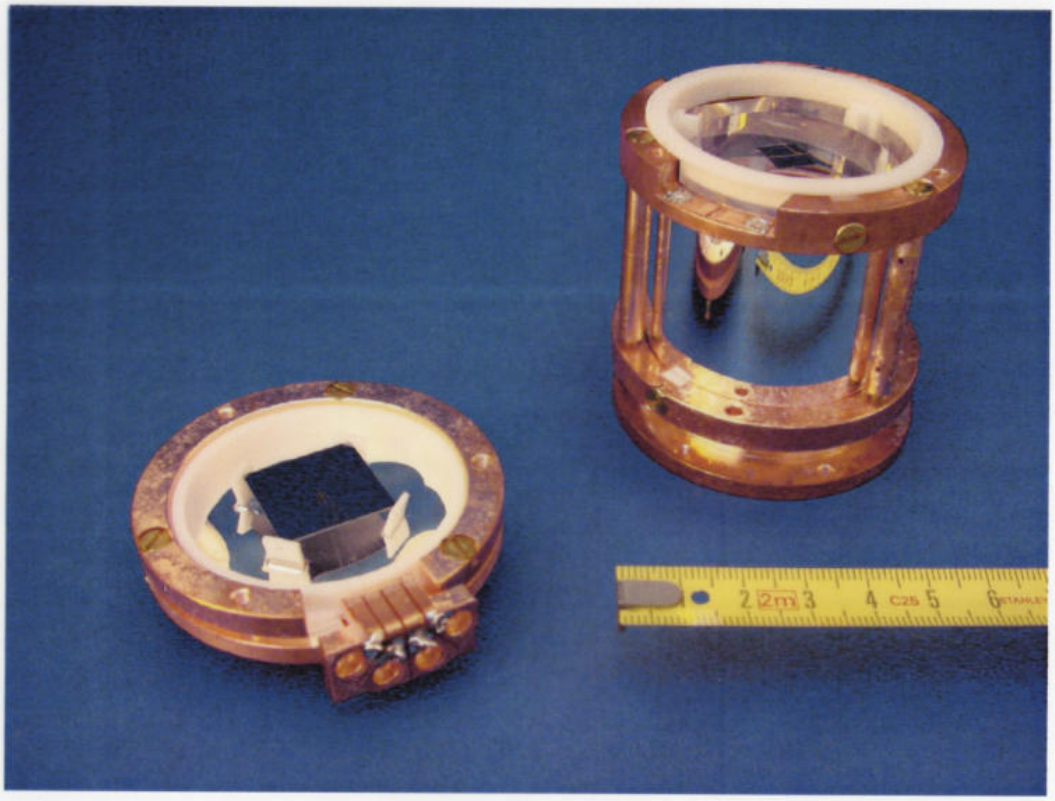
The cryogenic scintillator setup ($CaWO_4$ crystal)







The new CRESST II detector



see Poster by C. Cozzini

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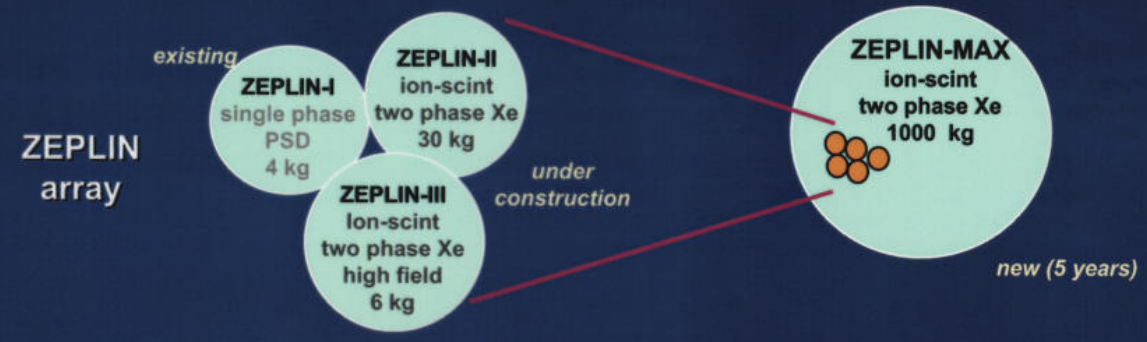
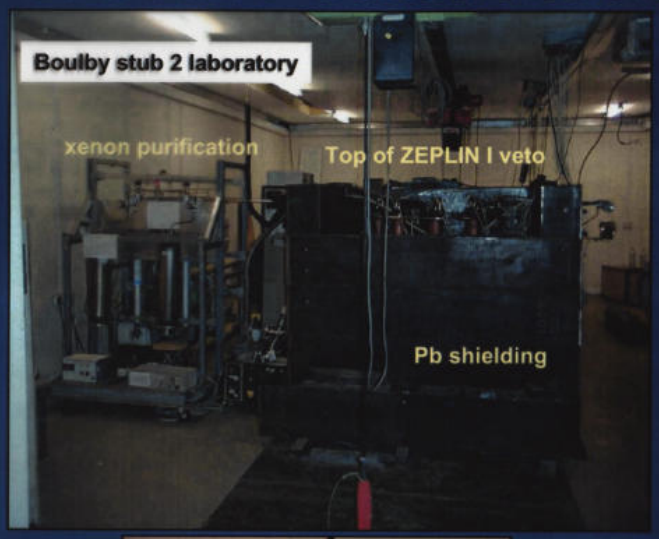
Liquid Xe strategy - ZEPLIN

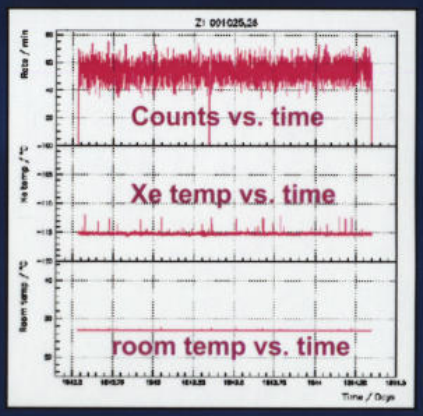


ZEPLIN
array

collaborators:
UCLA, CERN/Padova, Torino,
ITEP, Coimbra, Columbia

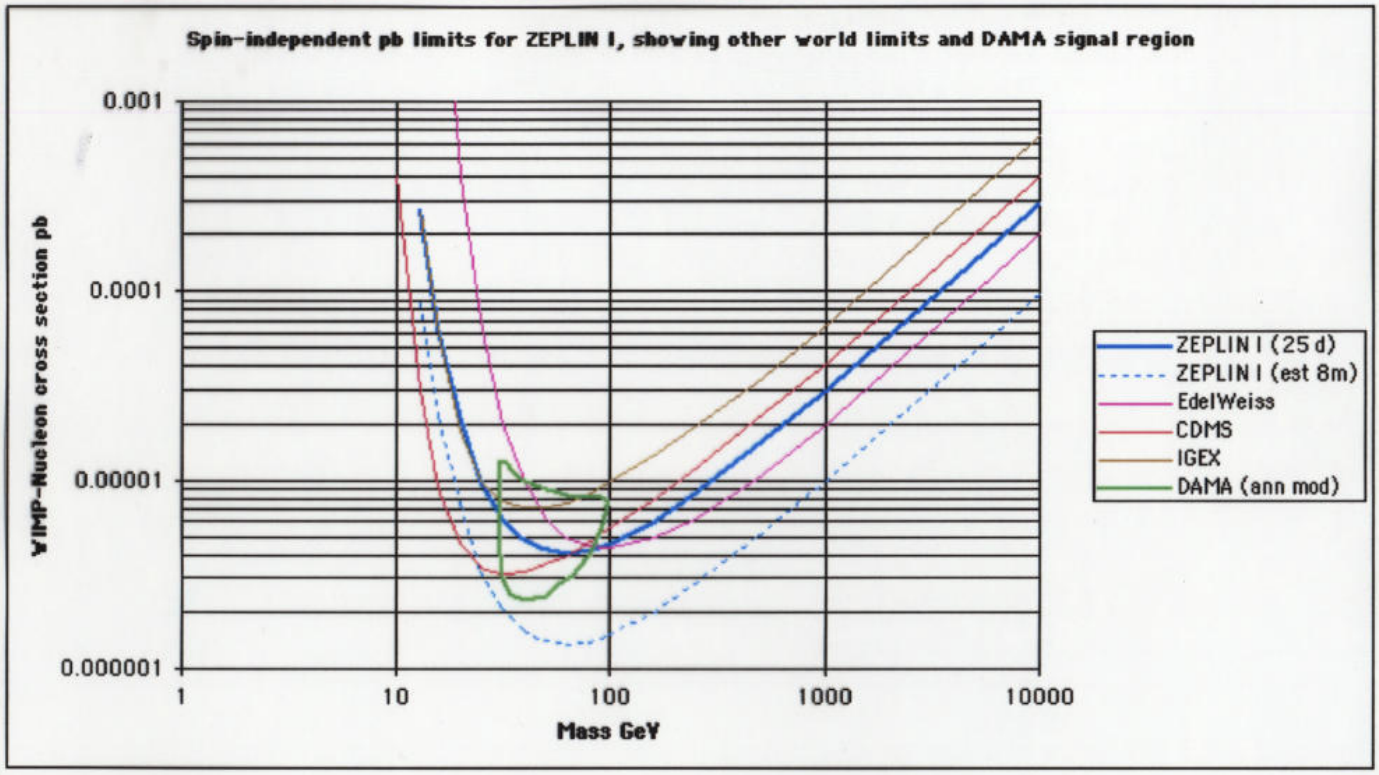
ZEPLIN I construction and installation





Stable operation demonstrated

The most recent result from ZEPLIN



see Poster by V. Kudryavtsev

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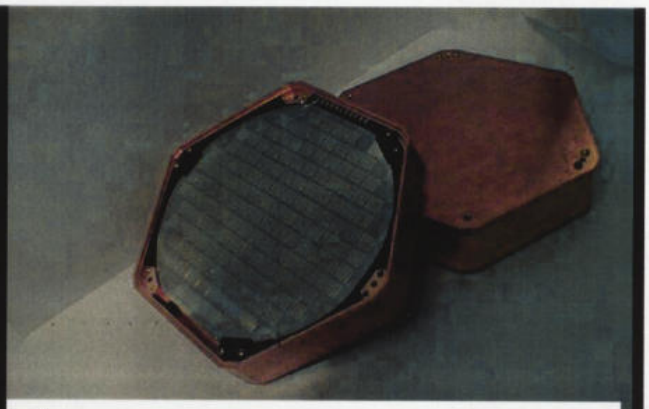
CDMS detectors

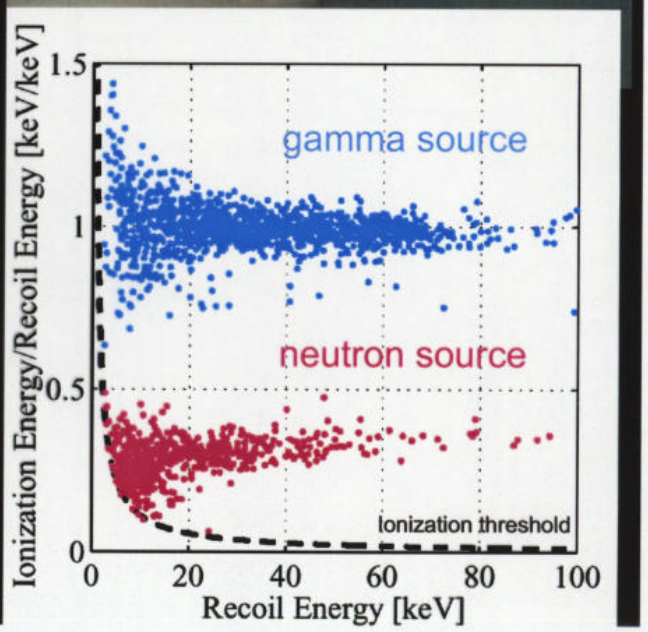
Ultra-pure Si and Ge crystals:
1cm thick; 7.5cm diameter.

measure phonons and ionization signals after an interaction

discrimination between nuclear and electron recoils

nuclear recoils: WIMPs, n
electron recoils: γ,e,α

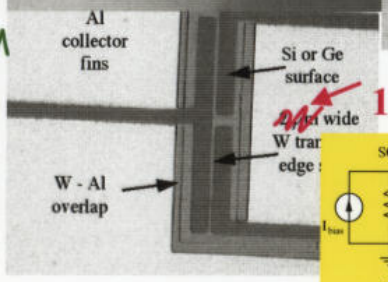




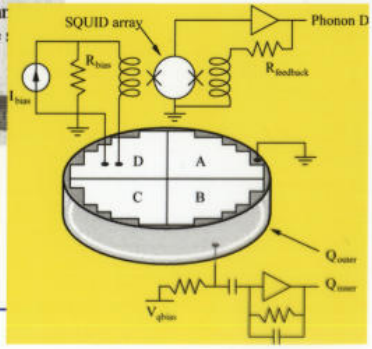
CDMS II @ SUF (2001-2002)

- CDMS II Tower 1 currently being run at SUF
  - 4 Ge detectors : 250g ea.
  - 2 Si detectors : 100g ea
    - Si/Ge combination is a powerful handle on interpreting and nuclear recoil band population
- Continuous operation since Dec 2002
  - 65 live days of data
- Excellent energy resolution
  - Ionization channels : 850 eV FWHM
  - Phonon channels : 400 eV FWHM
  - Trigger threshold ~ 3 keV
- Gamma discrimination
  - Better than 99.96% above 5 keV

ZIP Tower I

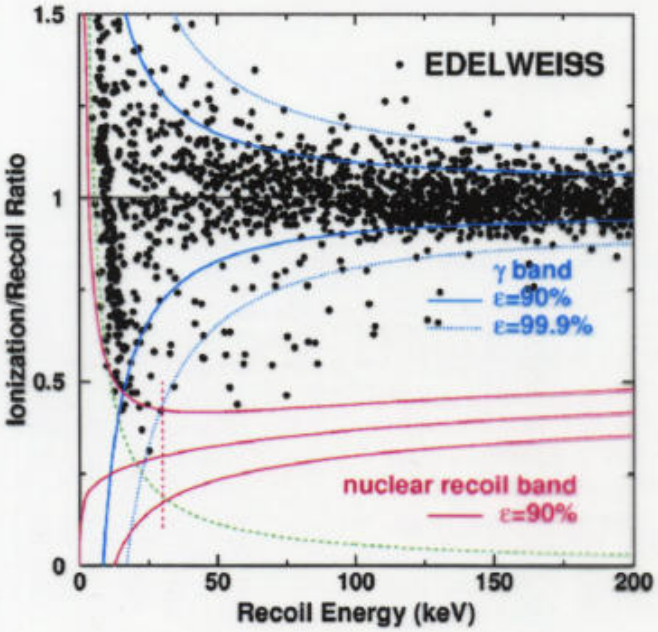


1 μm



"1 kg" stage of EDELWEISS-I: first results

- 2000 data from first 320 g detector



- 99.9 % background rejection…
- No events in [30-200] keV recoil energy interval after 4.63 kg x day of data (fiducial) !
- Resolution can be significantly improved and neutron background is negligible
- DAMA central value is excluded at >90 C.L. without any background subtraction

G. Chardin, EDELWEISS experiment

Finally

- My acknowlegdment to all the collaborations and individuals who supported this talk.
- For detailed informations, the truly relevant knowledge, please visit the following people at the poster session:
  - C. Cozzini for CRESST
  - M.Sarsa for ROSEBUD
  - J. Morales for ANAIS and IGEX-DM
  - V. Kudryavtsev for the UKDM-Collaboration (NAIAD, ZEPLIN, DRIFT and more)
- Almost all types of Direct Detection experiments are present there and can be discussed in all details.