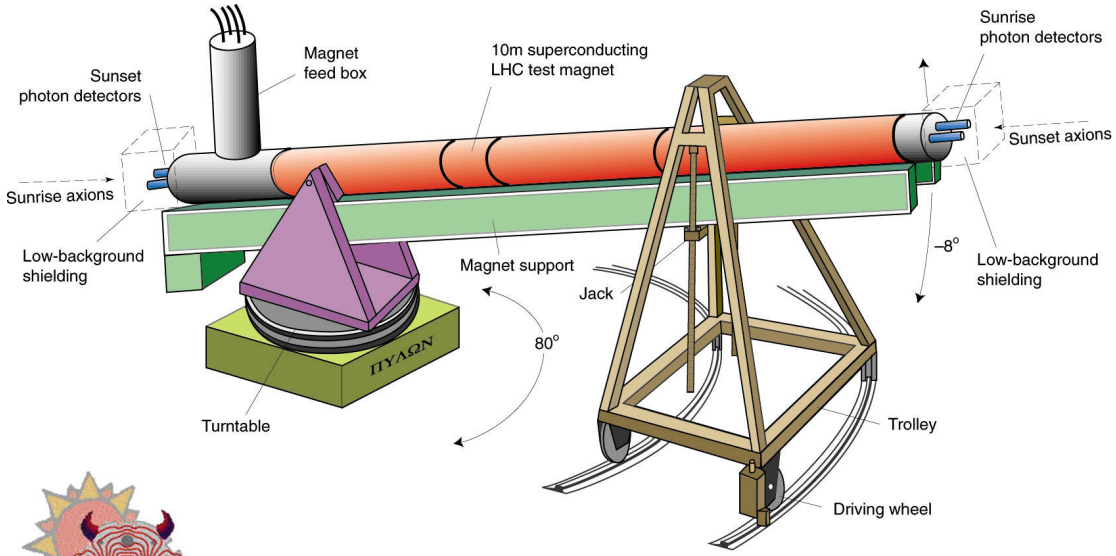
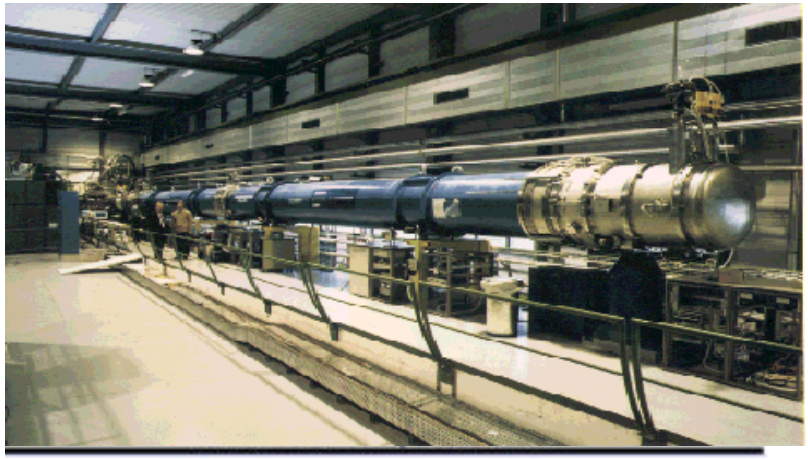
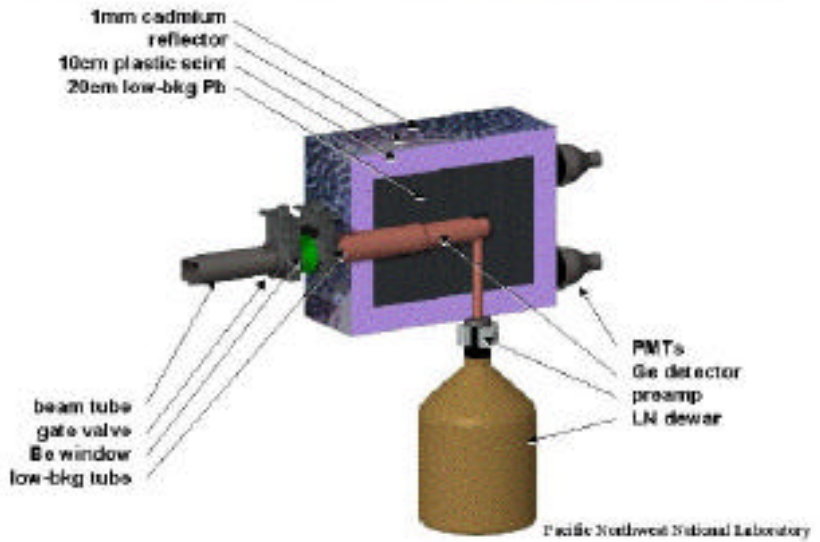
Cern Axion Solar Telescope

Point an LHC magnet at the sun



Cern Axion Solar Telescope

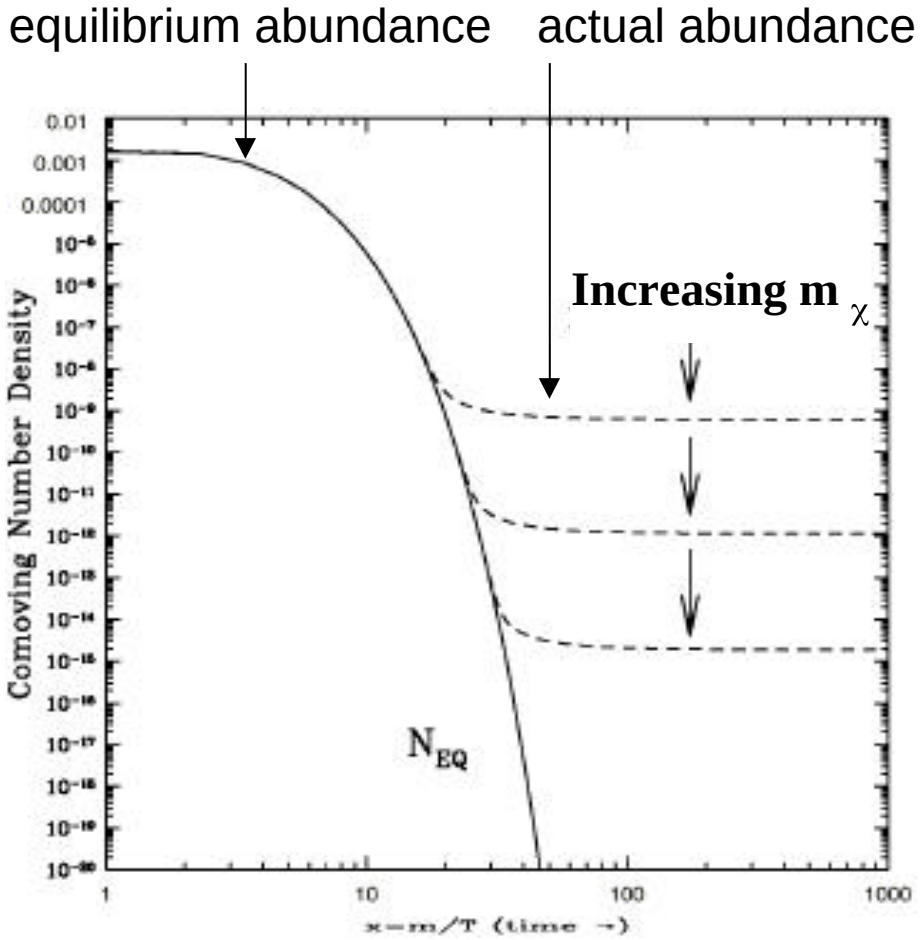




Weakly Interacting Massive Particles
WIMPS : usually Neutralino

Neutralino : χ
lowest mass stable particle in supersymmetry models

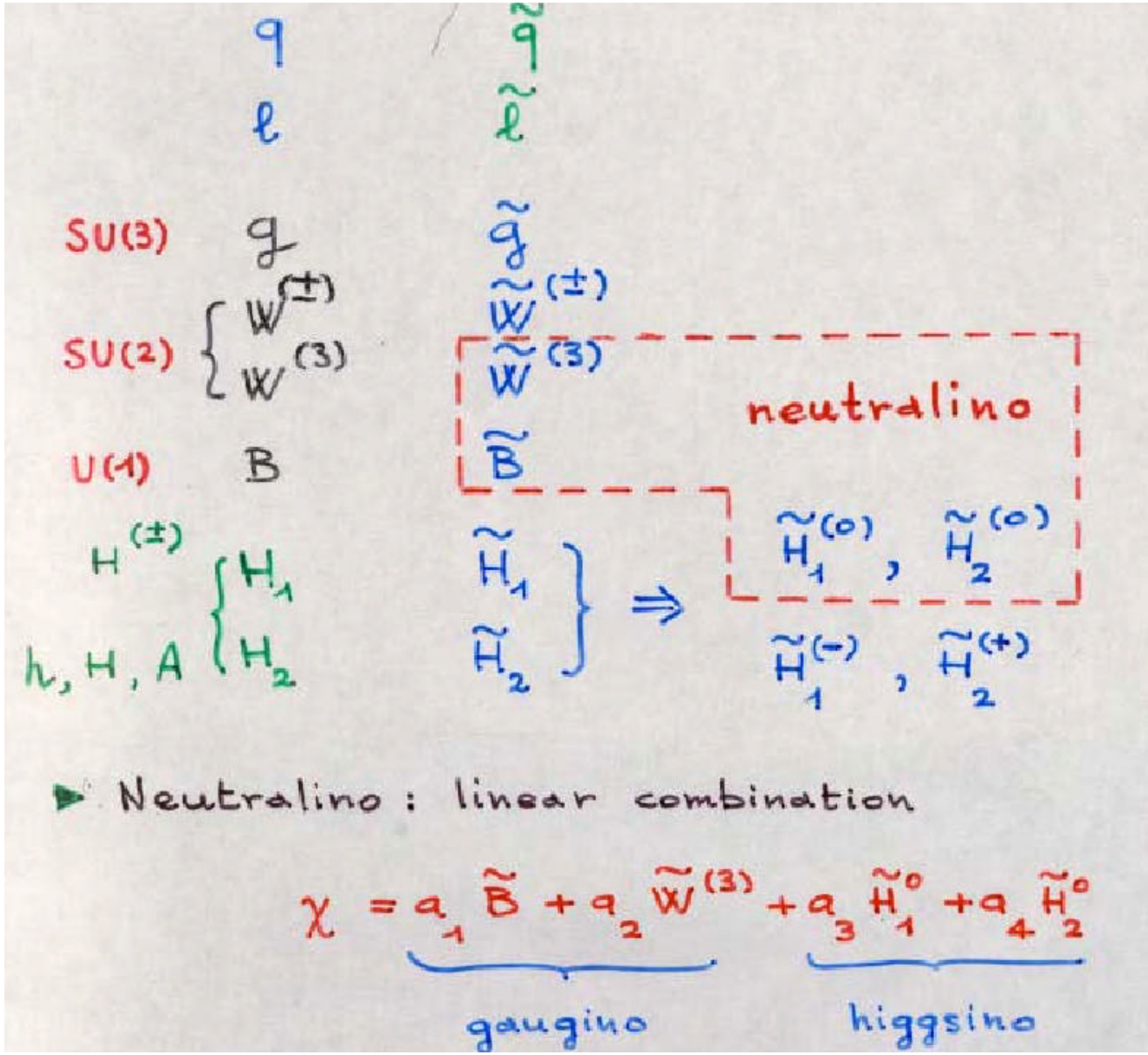
Relic particles left over from big bang (like CMBR)



Neutralino contribution to density fraction: $\Omega_\chi \approx 6\ (\ 1\ \mathrm{GeV}/\ m_\chi\ )^2$

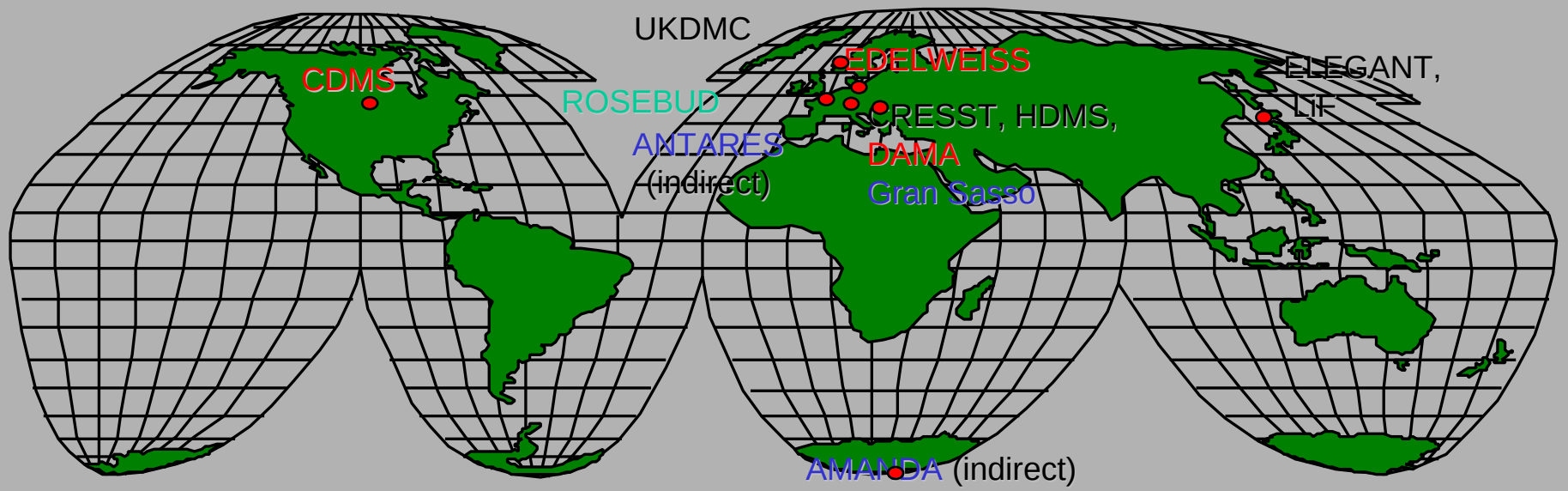
Particle content of Neutralino

Particle / Superpartner

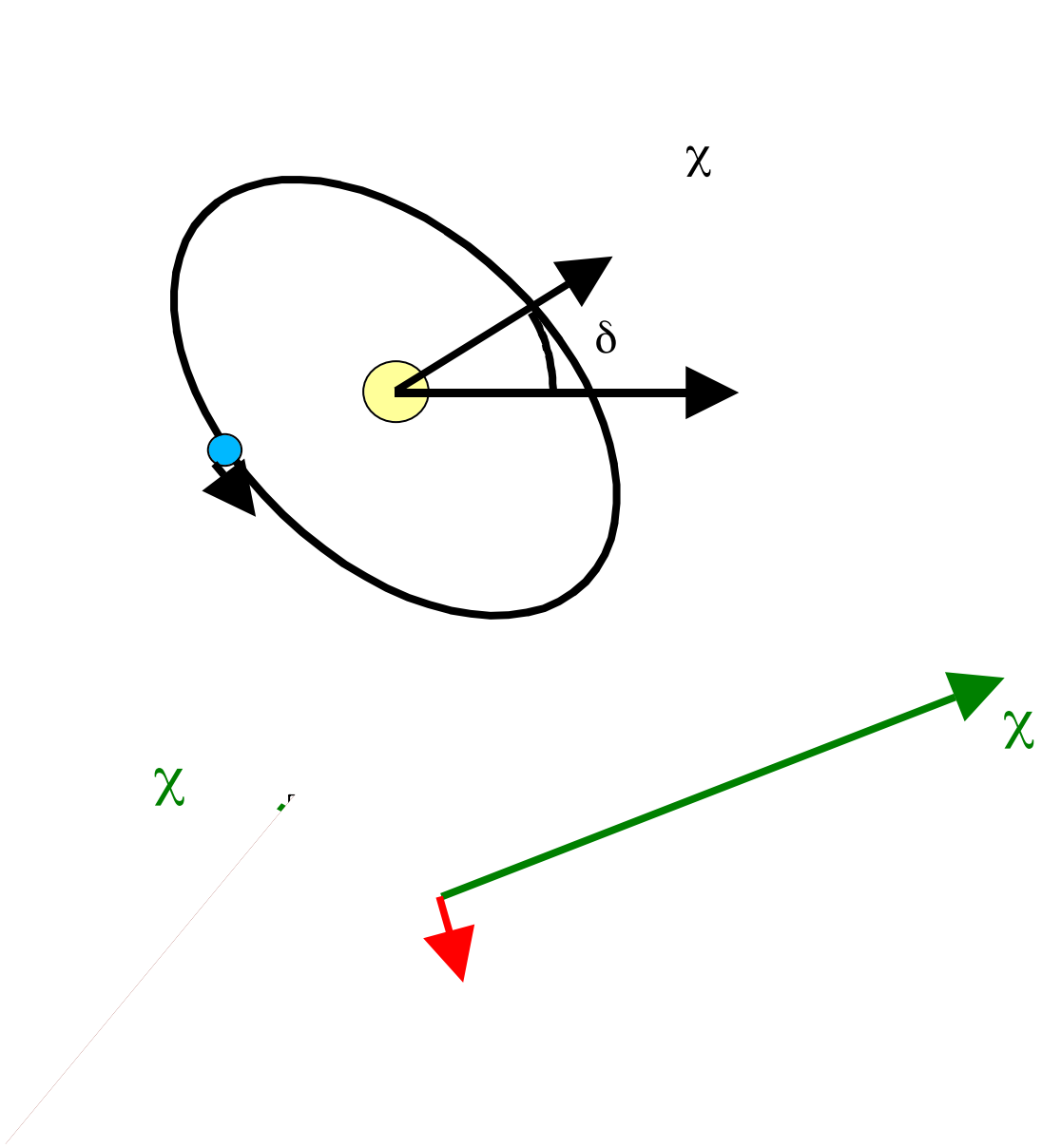


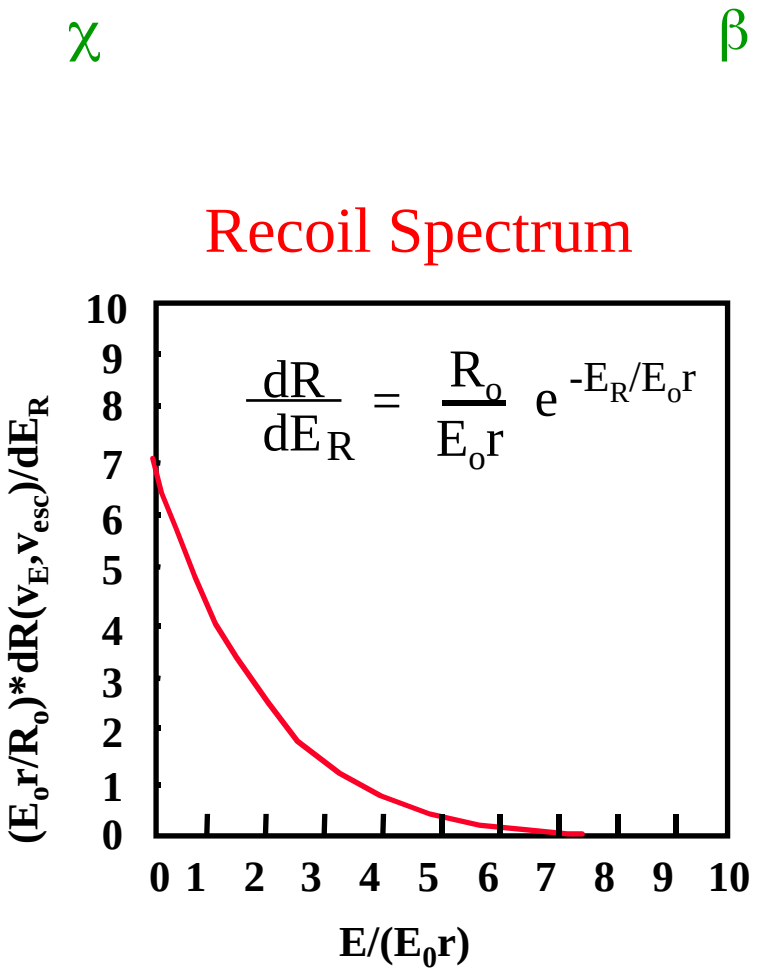
Many Dark Matter Searches in Progress

- EDELWEISS (Ge @ Fréjus)
- CDMS (Ge and Si, Berkeley/Stanford, CDMS-II stage in Soudan Mine, Minessotta)
- DAMA (NaI, Xe @ Gran Sasso, Italy)
- CRESST Al_2O_3(Münich/Oxford) @ Gran Sasso
- ROSEBUD @ Canfranc
- Milano/Genova/Napoli/ ($Te0_2$) @ Gran Sasso
- UKDMC (NaI, Liq. Xe @ Boulby Mine, UK)
- ELEGANT, LiF @Japan
- HDMS, IGEX…



WIMP Direct Detection

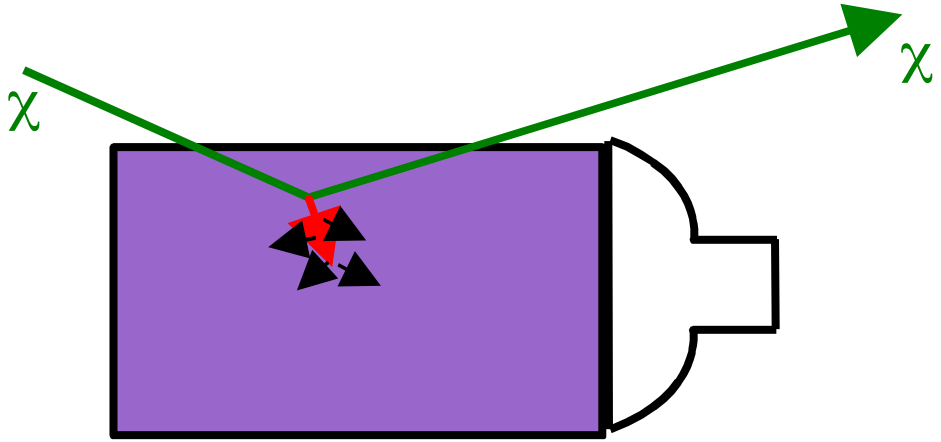


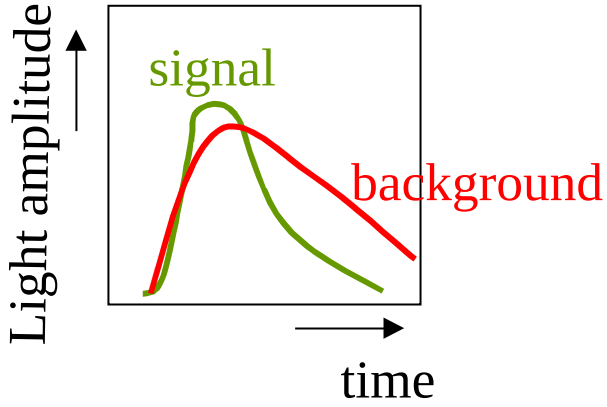


Examples of Direct WIMP Detectors

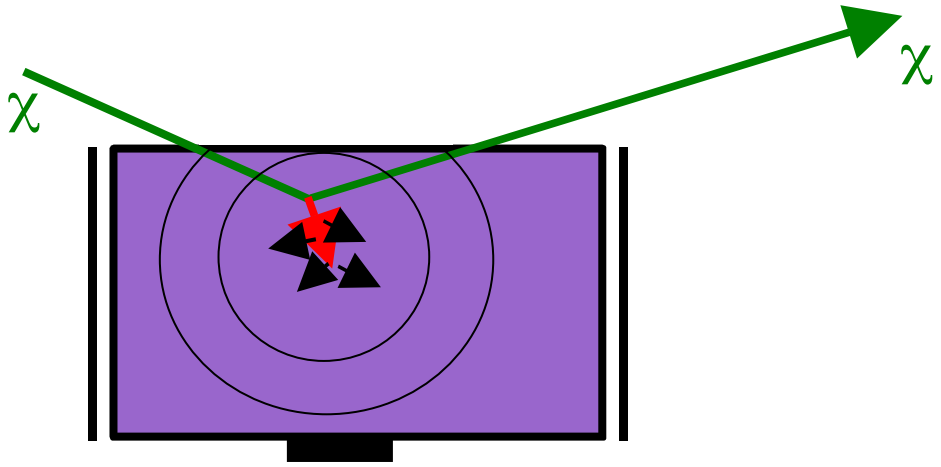
Rejection of background is the critical issue

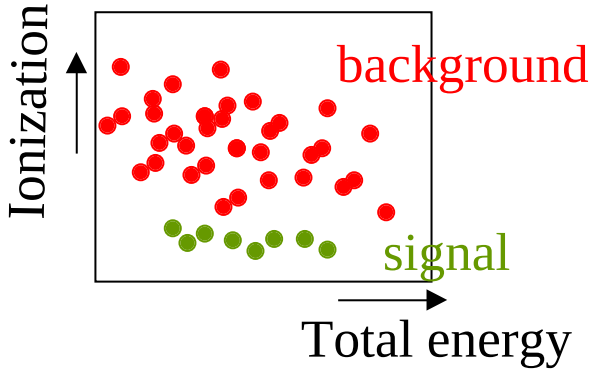
Na I



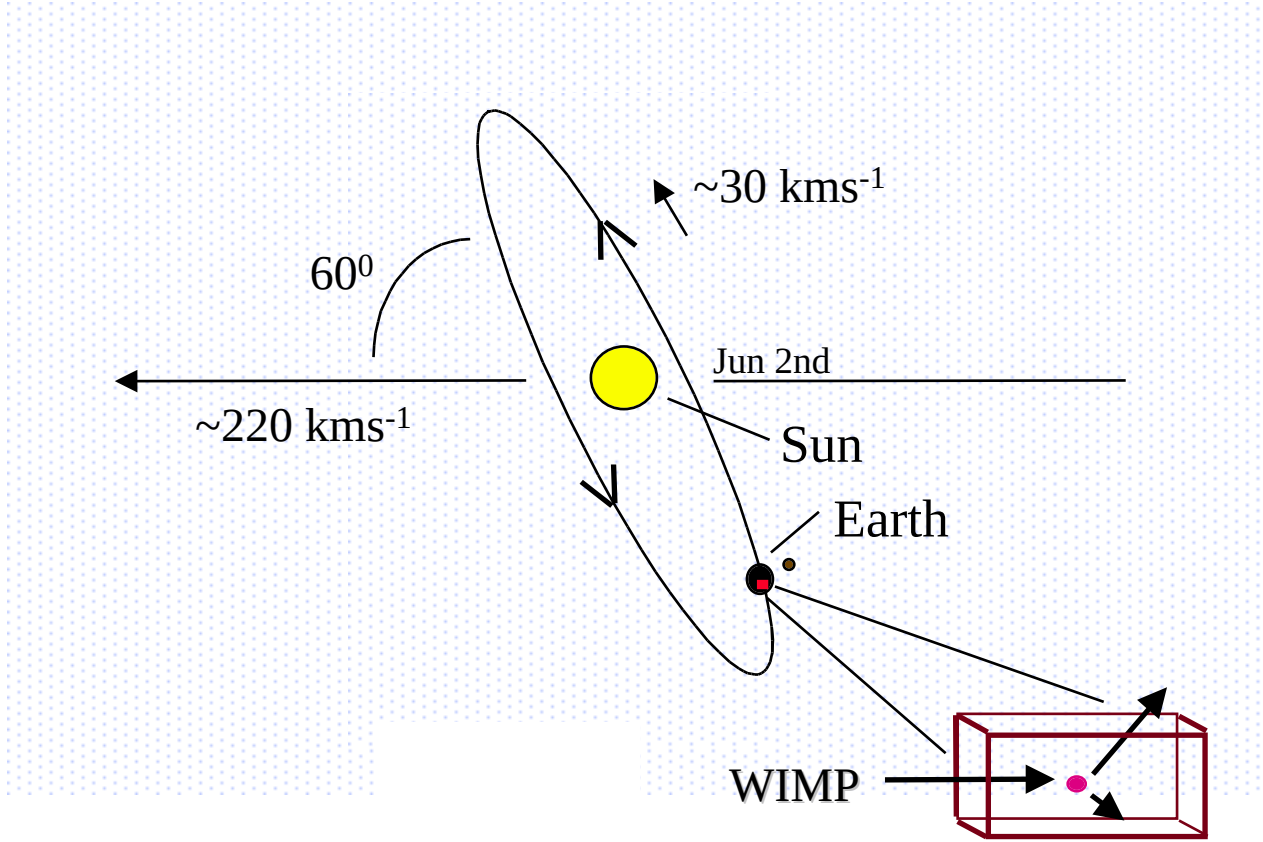


Ge

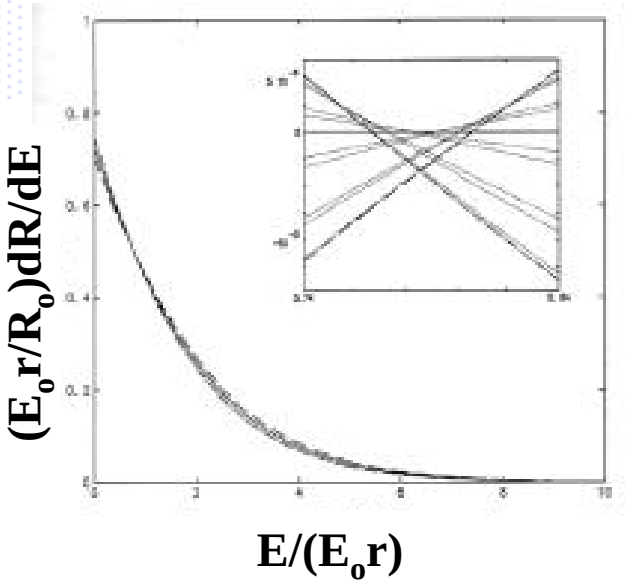




WIMP Modulation

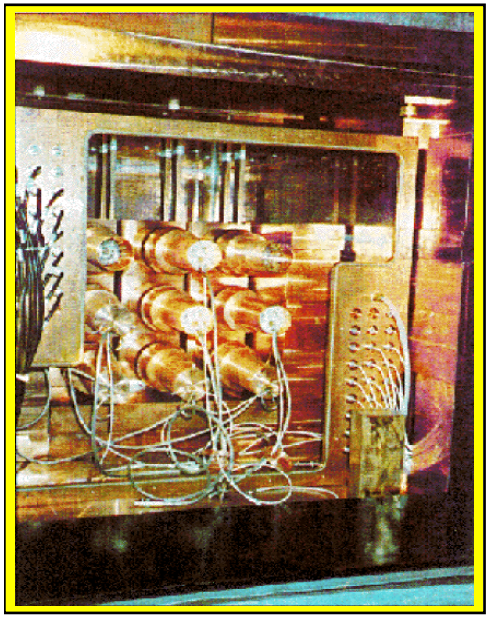


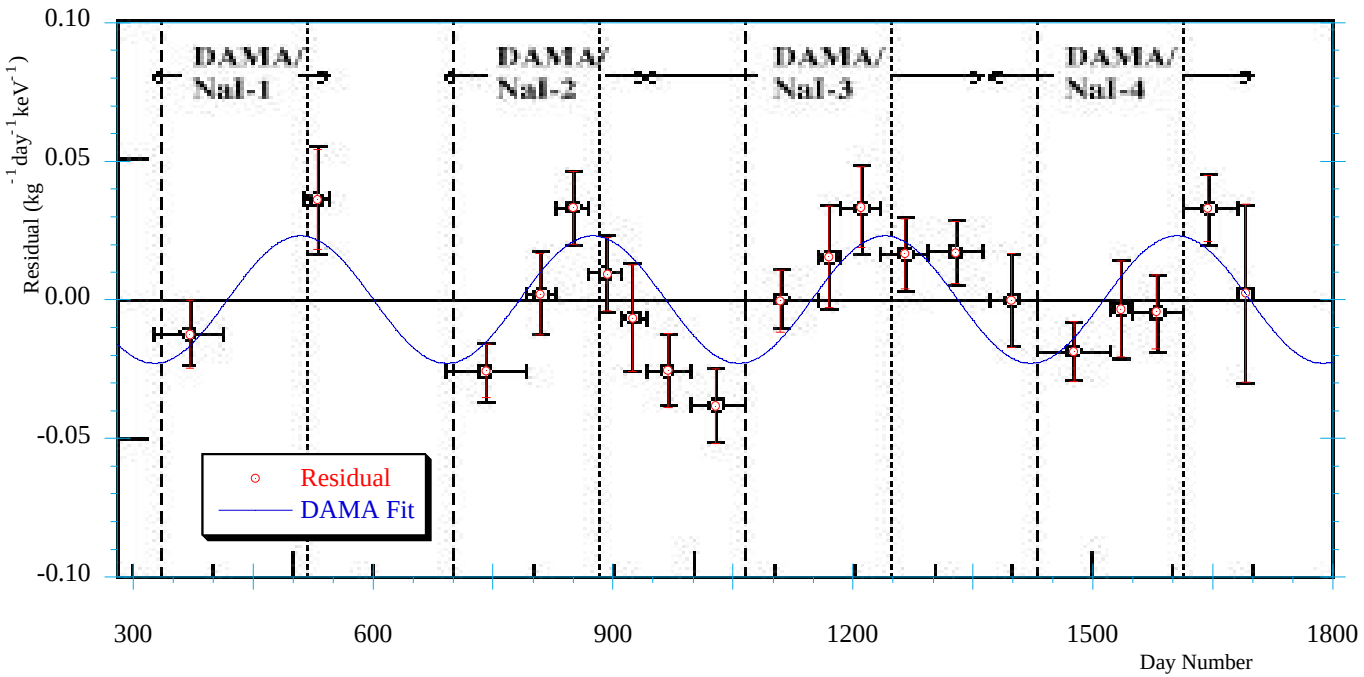
Few percent effect
in rate > $E_{threshold}$



DAMA - NaI Annual Modulation

- Total 4 years annual modulation – 57986 kg.days
- Annual modulation few % of signal
- No recoil discriminatic





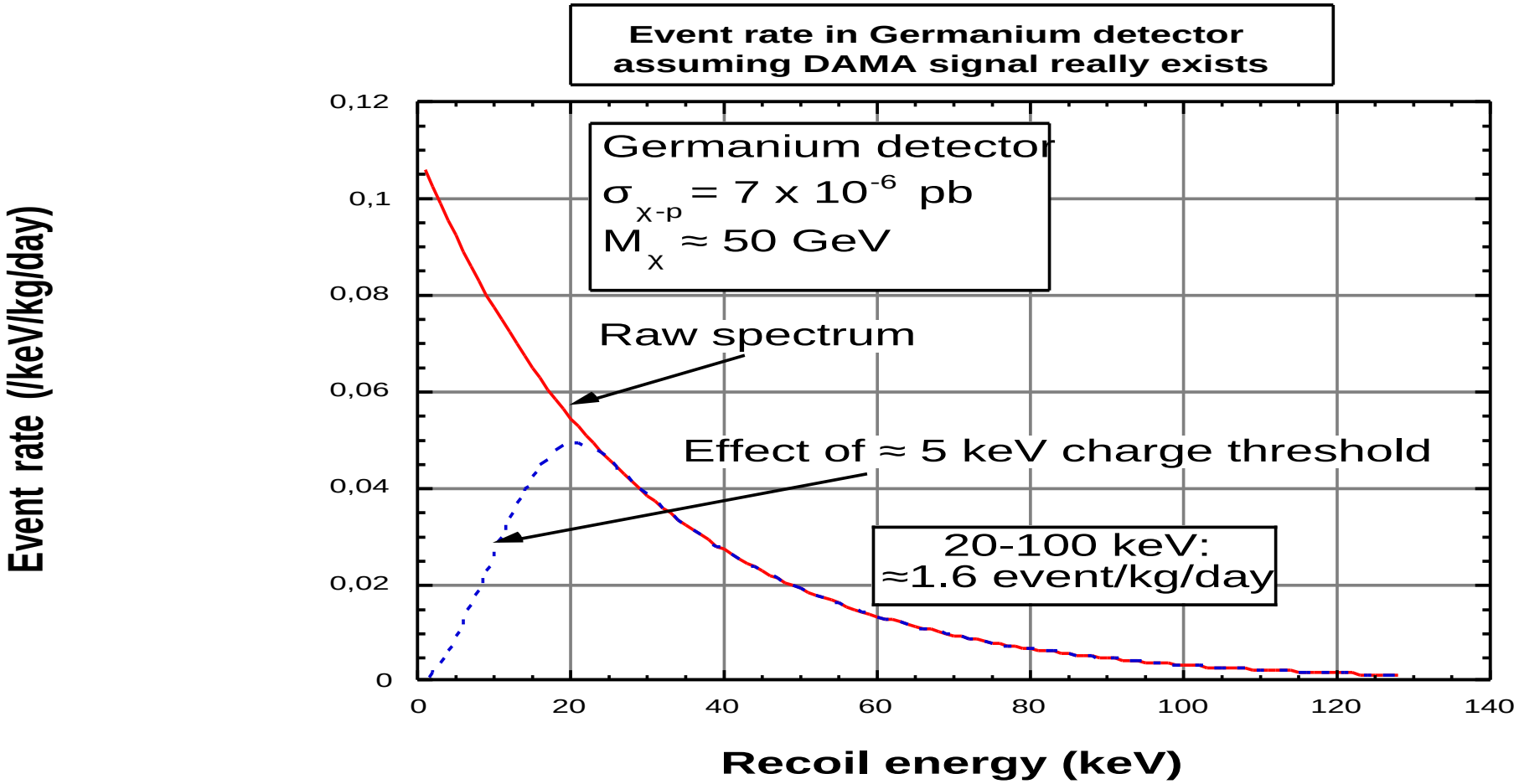
Evidence for WIMP observation (INFN/AE-00/01)

DAMA : Comments of G. Chardin

- Note: for spin-independent interactions interactions occur on iodine recoils, but quenching factor ≈ 0.08: i.e. all WIMP events are very close to threshold
- Excess initially seen in only 2 out of 9 crystals
- Energy spectrum inconsistent with 60 GeV WIMP (more like 150 GeV)
- Presence of 3 keV peak in NaI, observed by UKDMC and Saclay, not discussed by DAMA
- Stability of selection at threshold...
- Later results confirm initial observation, but can you confirm something inconsistent ?

DAMA comments by G.Chardin

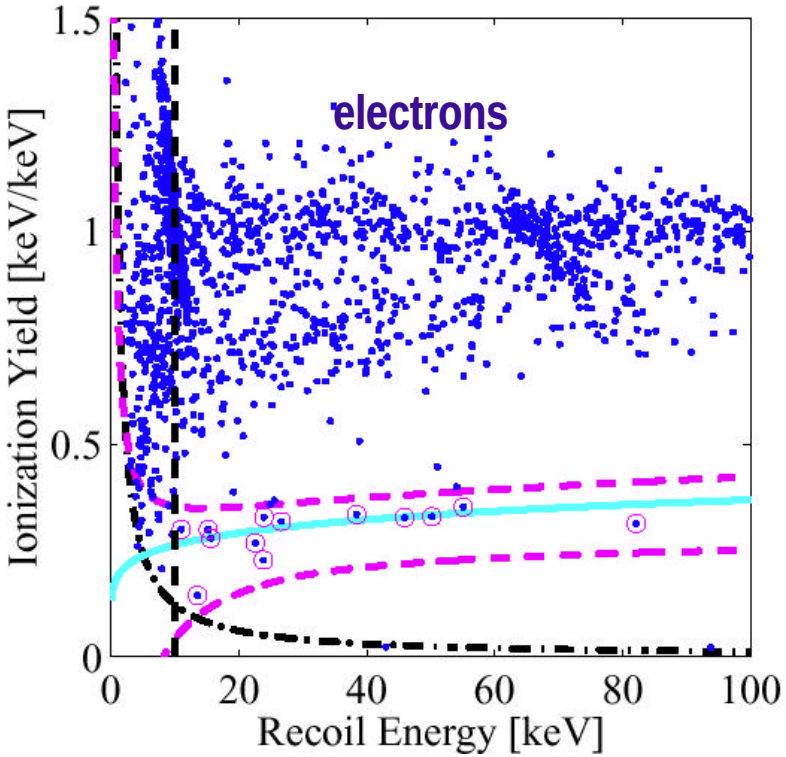
- **Detected not by direct observation, but by searching for an annual modulation effect (≈10^5 WIMP events if correct), signal almost at threshold…**



CDMS

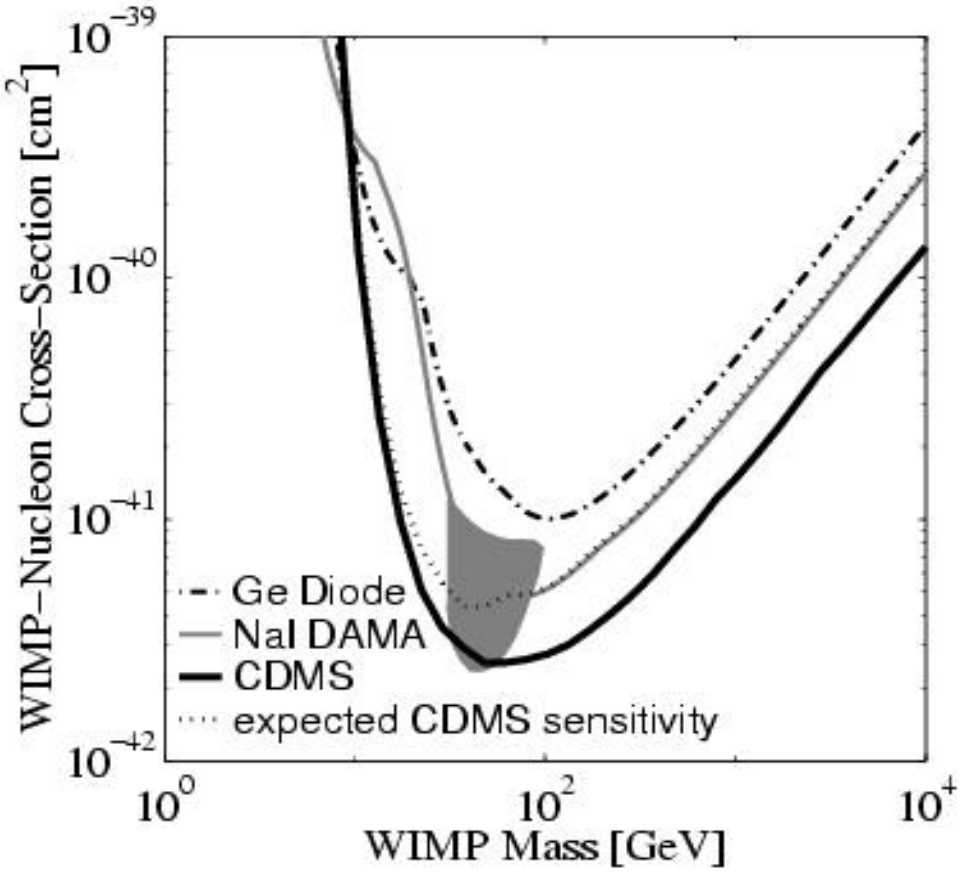
Ge and Si ionisation + thermal at shallow Stanford Site

1998 - 1.6 kg.days Si, 1999-2000 - 10.6 kg.days Ge



See events at rate expected from DAMA but take as compatible with expected neutron background

--> make background subtraction

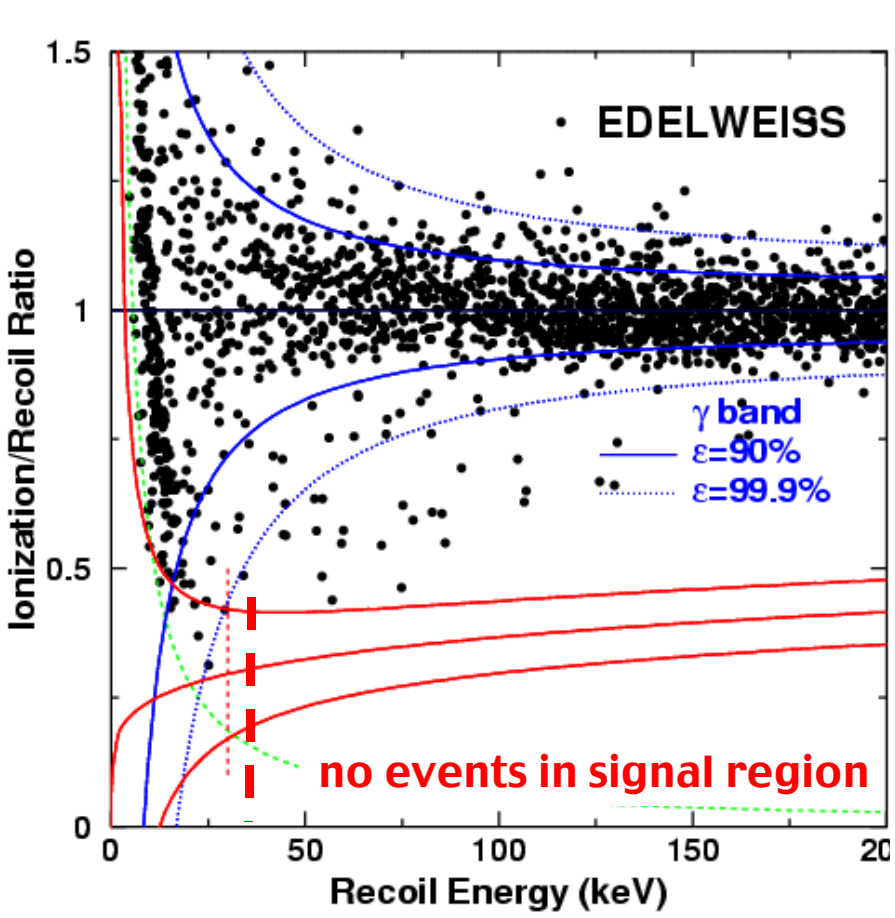


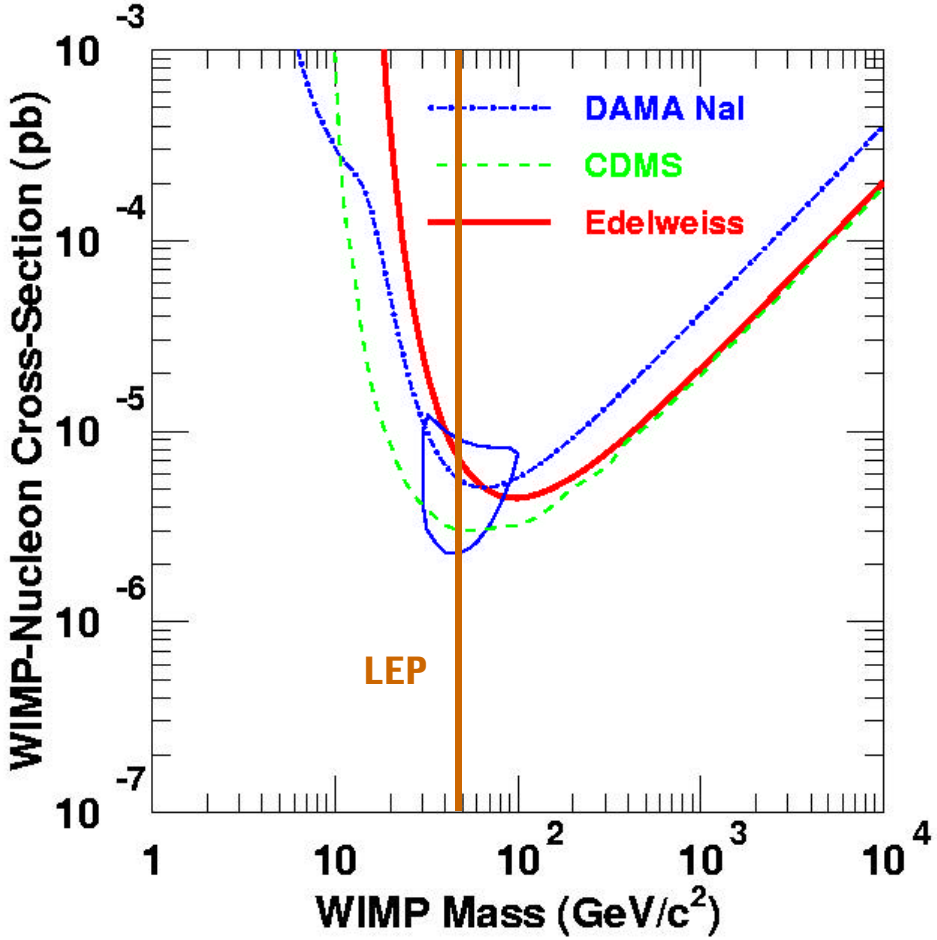
Claim: 'DAMA and CDMS experiments are incompatible at 99.76%CL'

experiment will go to deep site at Soudain to remove background

EDELWEISS

320 g Ge detector, Heat and ionisation, 5.03 kg×days



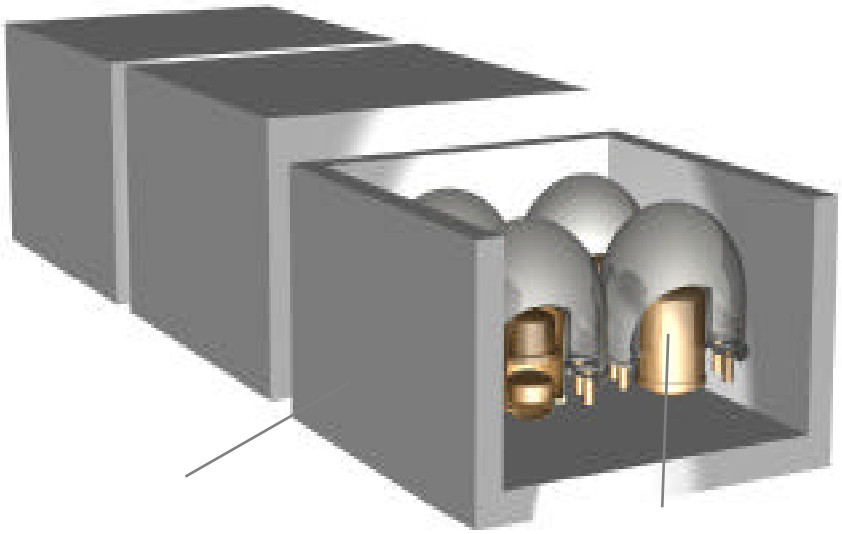


Edelweiss data background free, unambiguous but not complete exclusion

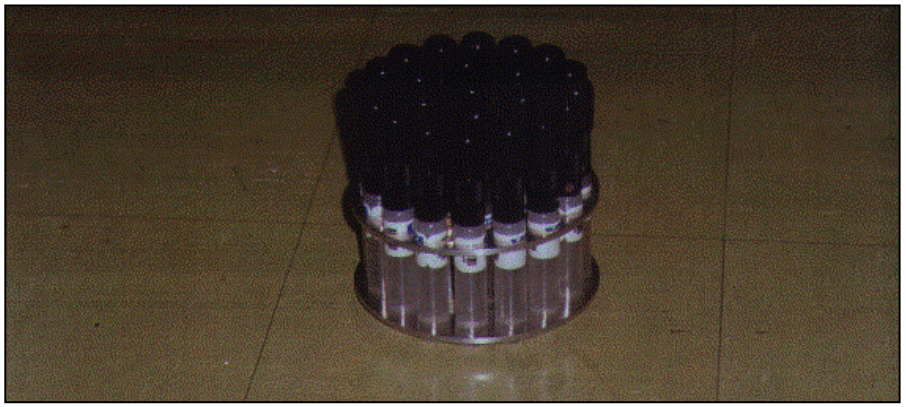
Future of Direct Searches

To cover all cross-section phase space predicted in popular SUSY models need about 1 ton to get 100 counts/year

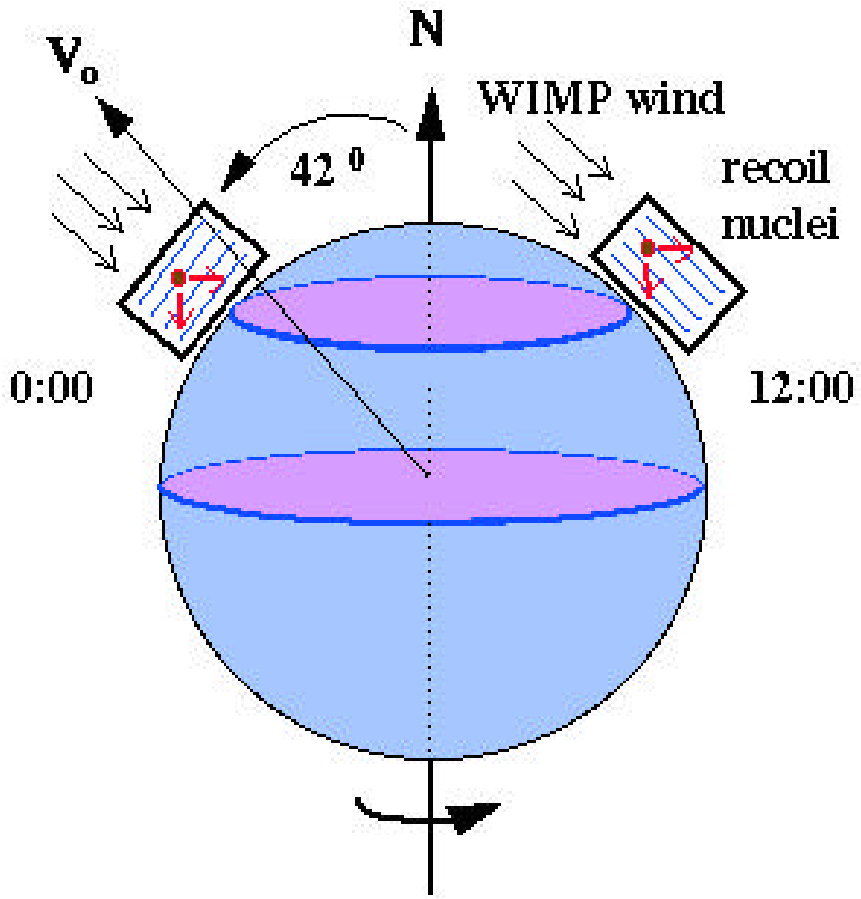
Liquid Xenon: ZEPLIN



Superheated liquid droplets: PICASSO/SIMPLE



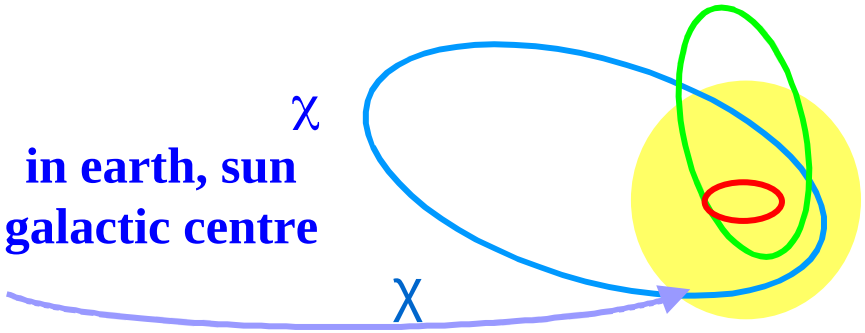
WIMP Signal from Arrival Direction



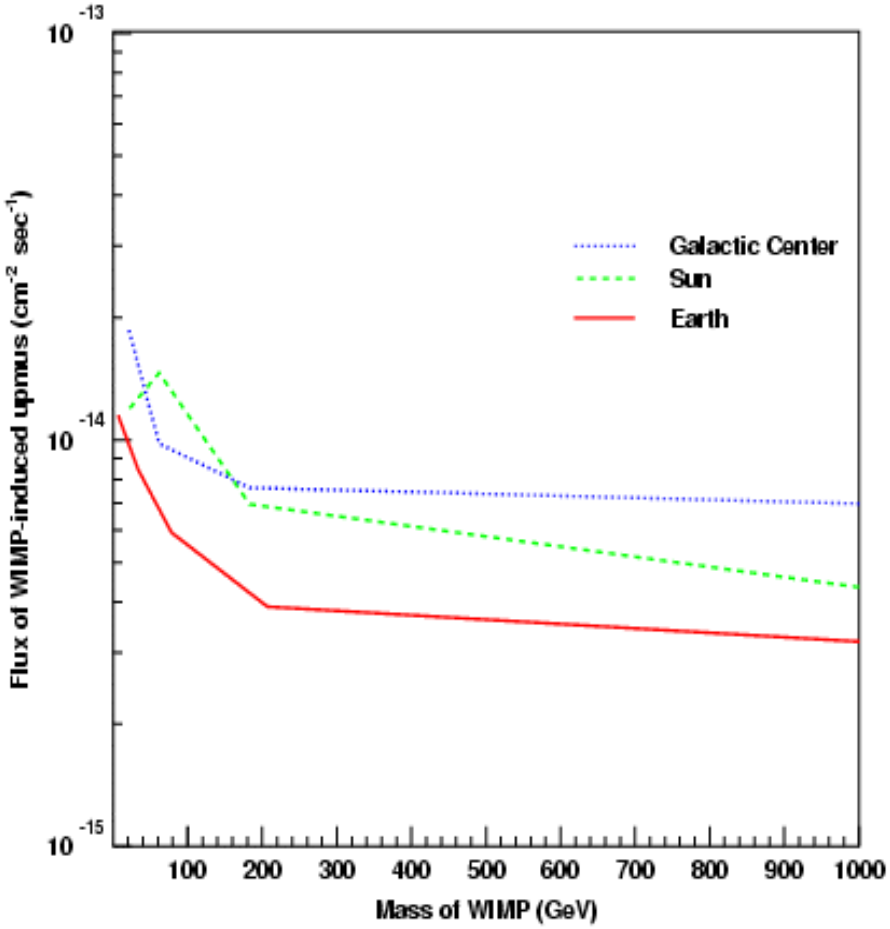
WIMP Indirect Detection

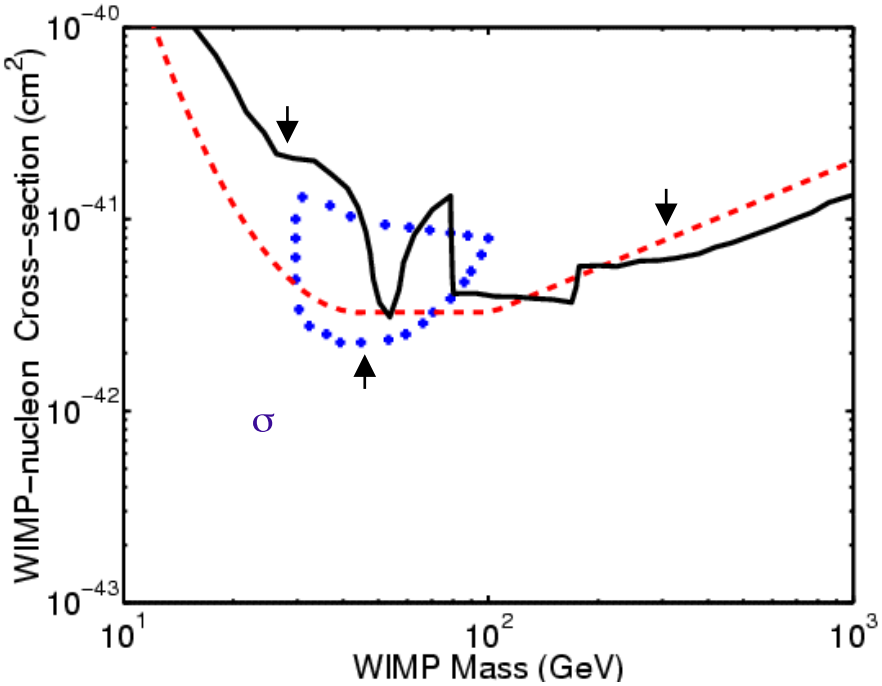
Annihilation in Halo, Earth, Sun or Galactic Centre

Signature	Experiment
Halo	**BESS, CAPRICE, AMS, ..** **GLAST, VERITAS, MILAGRO,….**
Positron, Antiproton **Gamma rays** $\chi\chi \to Z\gamma,\ \gamma\gamma$	
Earth, Sun, GC	**SuperK, Baksan,IMB, MACRO** **AMANDA, ANTARES, Baikal, …**
Neutrino $\chi\chi \to WW, ff$ $W, f \to \nu X$	



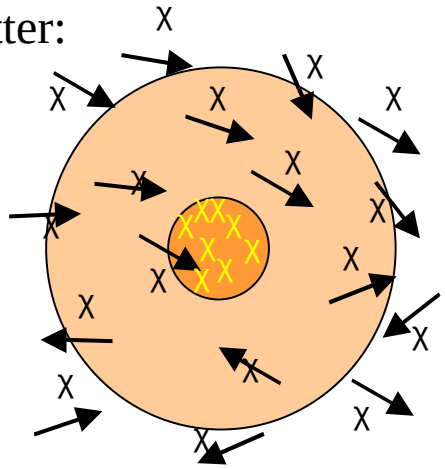
Latest SuperKamiokande Results

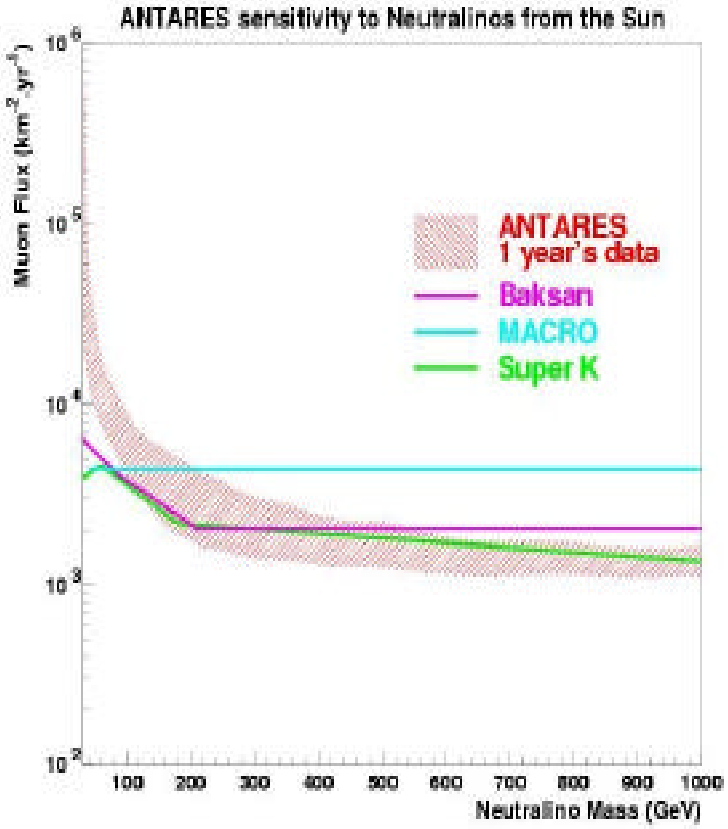


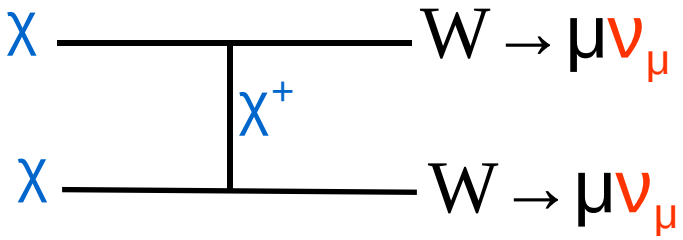


Search for Neutralino Annihilation in ANTARES

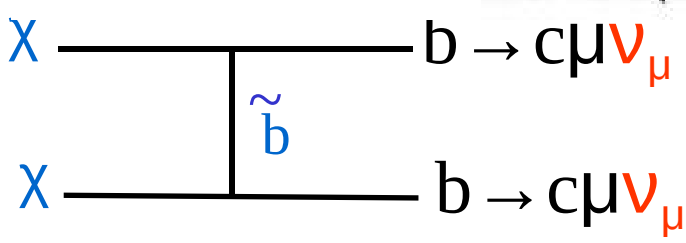
Halo of Dark Matter:
$\rho_\chi \sim 0.3$ GeV/ cm^3,
$v_\chi \sim 270$ km/sec







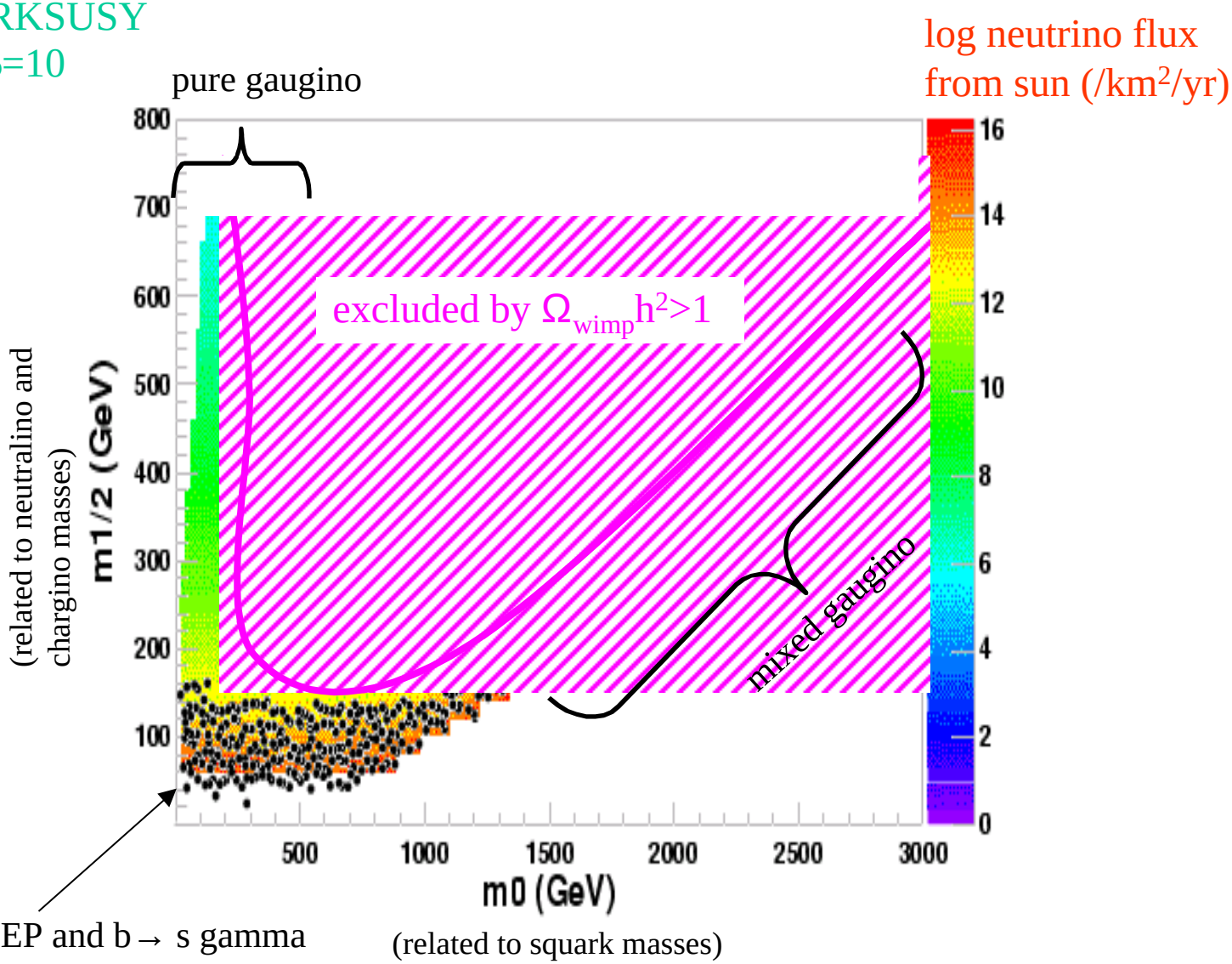
hard spectrum (ττ if Mχ<M_W)



soft spectrum (tt if Mχ>M_{top})

Predicted Neutrino Flux from the Sun

-mSUGRA scan using SUSPECT
- fluxes from DARKSUSY
  A_0=0, μ>0, tanβ=10



Comparison with mSUGRA Models and Direct D

mSUGRA Models considered:

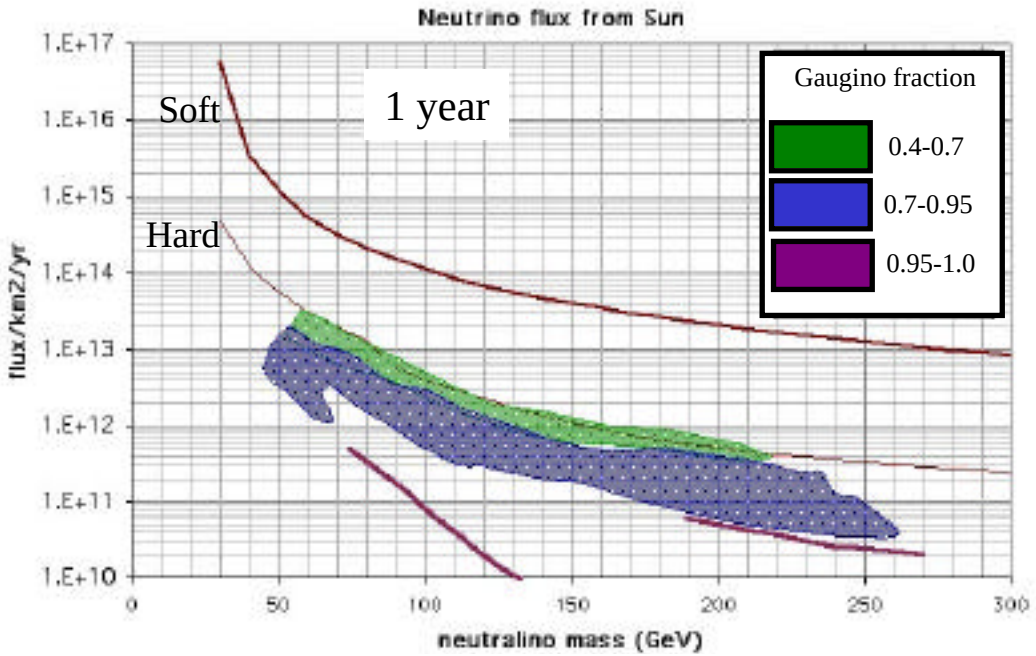
A_0=0, μ>0, tanβ=10,

$M_{1/2}$=0-800 GeV, M_0=0-1000 GeV

+$\Omega_{wimp}h^2$<1

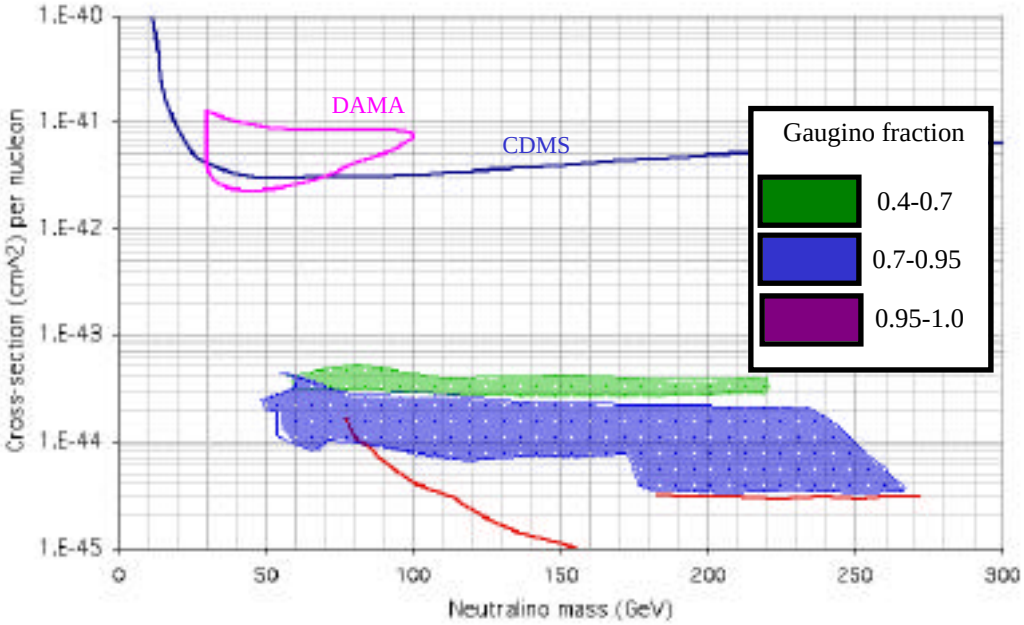
+LEP constraints

region of theoretical interest



The corresponding spin-independent cross-section per nucleon for these models compared to direct detection limits Very competitive!

Other SUSY models under study



tomorrow:

High Energy Astronomy

Cosmic Ray Observations
Gamma Rays Astronomy
Neutrino Astronomy