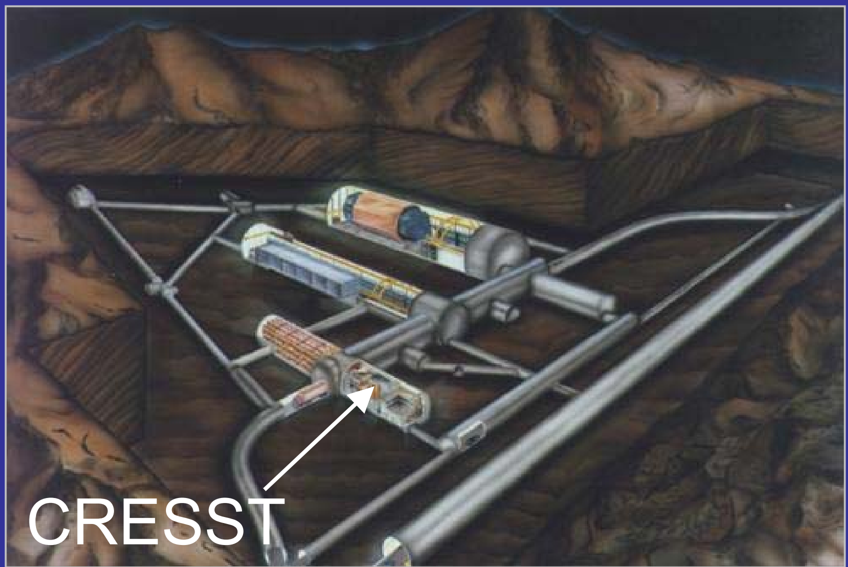


CRESST-II

CRYOGENIC RARE EVENT SEARCH WITH SUPERCONDUCTING THERMOMETERS

outline:

detector concept

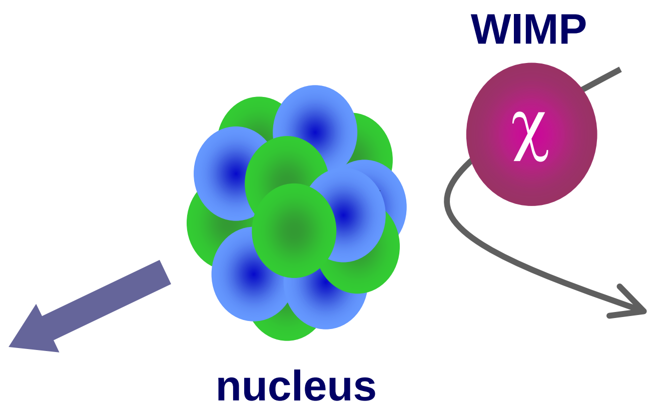
results from Dark Matter run at Gran Sasso (two month, prototype detector modules)

upgrade

G. Angloher

detector requirements

for direct detection of cold Dark Matter particles by WIMP – nucleus elastic scattering



energy transfer to nucleus < 40 keV

scattering events very rare: < 0.1 / (kg day)

low energy threshold

high target mass

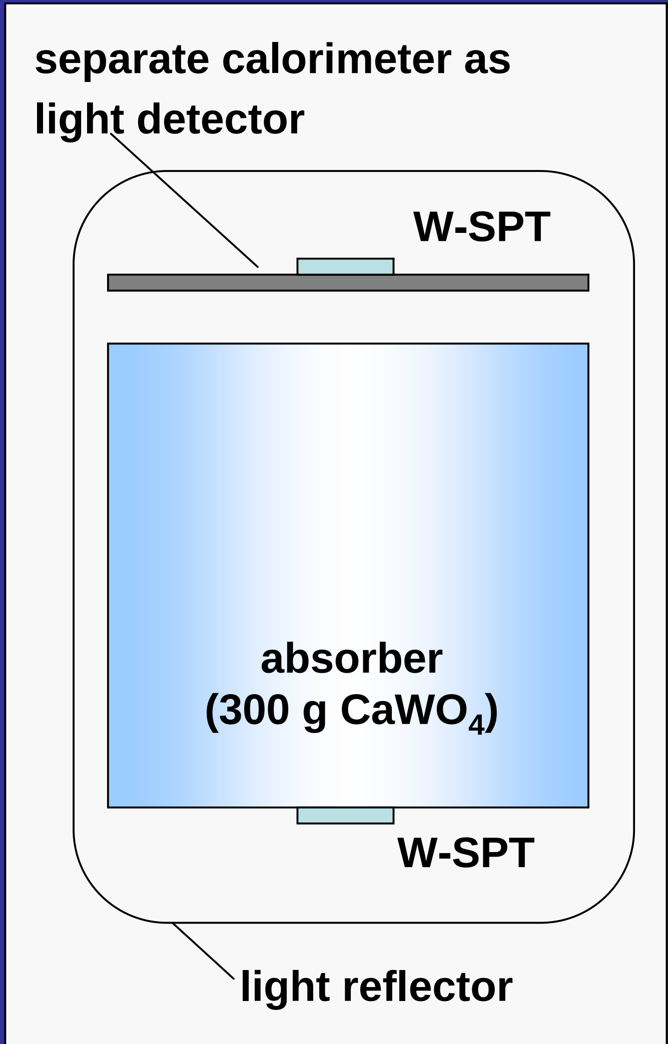
radiopure materials

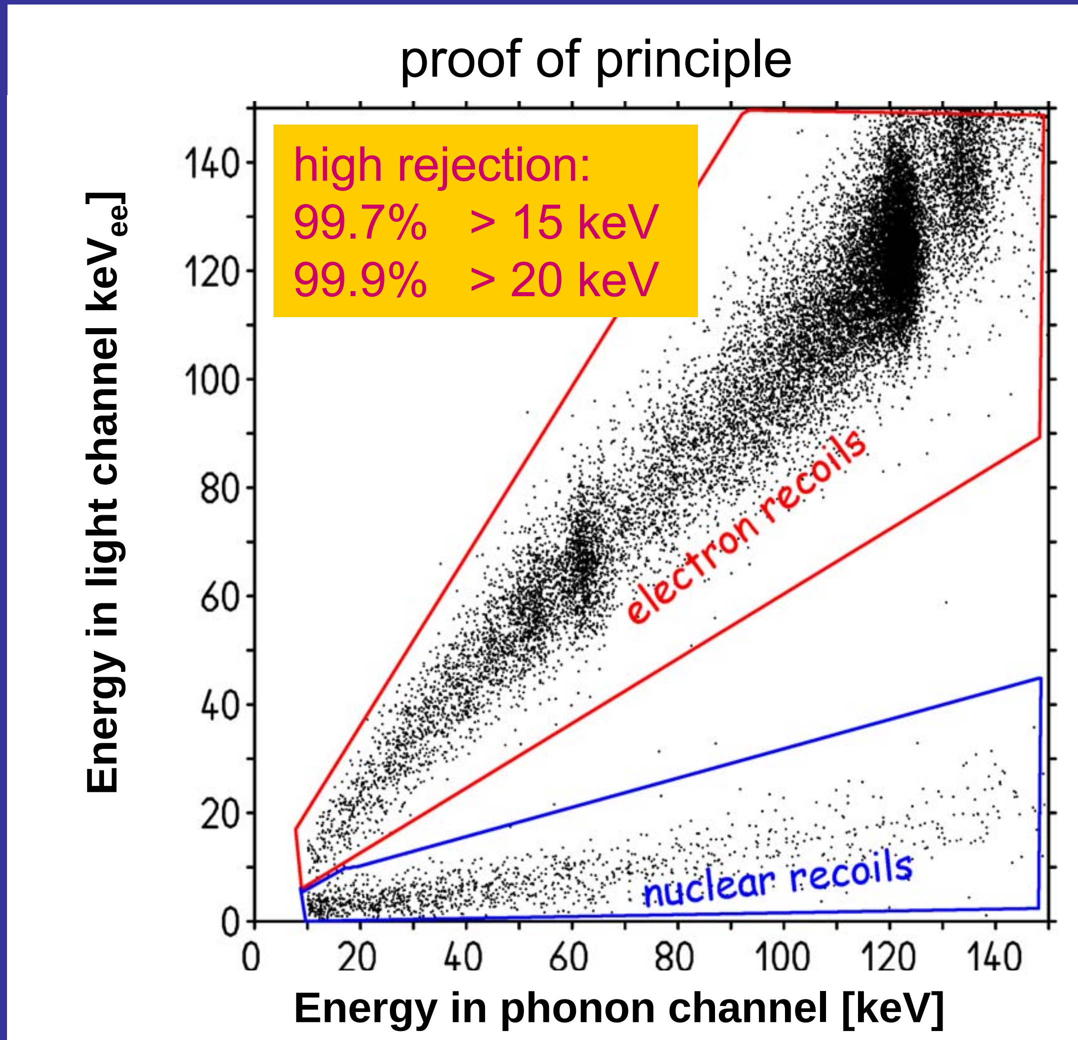
background discrimination

best choice:
low temperature calorimeters !

CRESST-II detector concept

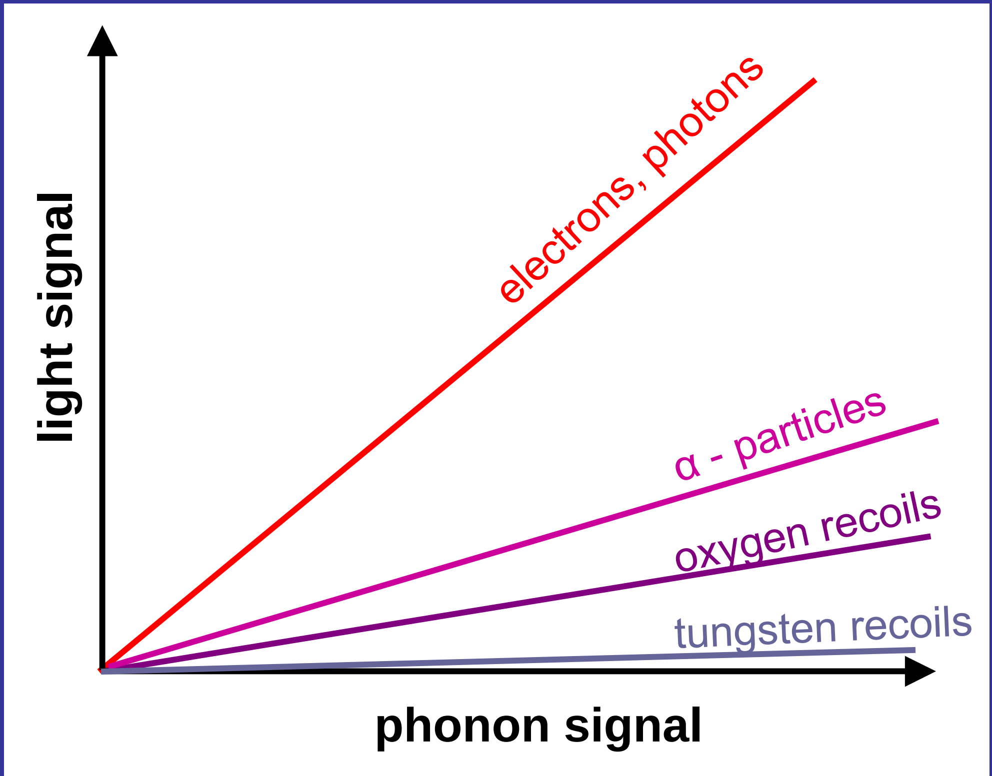
scintillating absorber: discrimination of nuclear recoils from radioactive background by simultaneous measurement of phonons and scintillation light





quenching factor Q

Q = light signal (photon, electron) / light signal (nucleus)
every nucleus has a different quenching factor



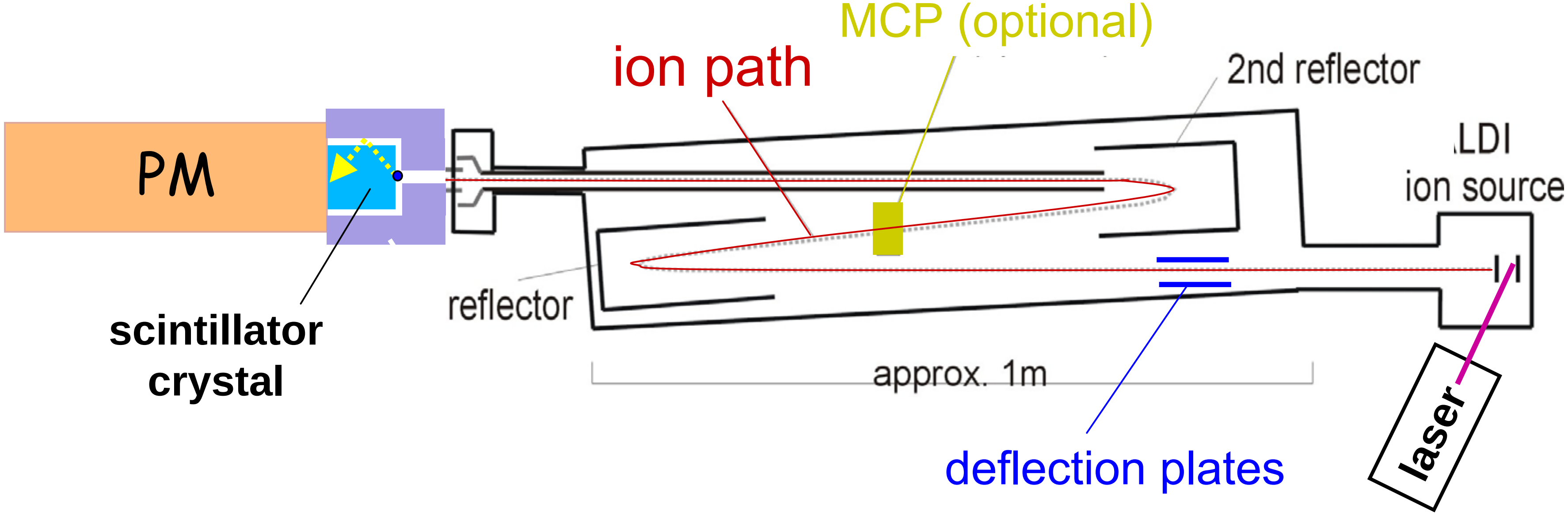
various Quenching factors:

$Q_{\text{photon, electron}}$	=	1
$Q_{\alpha\text{-particle}}$	=	5
Q_{oxygen}	=	8
Q_{calcium}	=	28
Q_{tungsten}	=	40

WIMPs are supposed to scatter on tungsten!
(spin independent interaction: $\sigma \sim A^2$)

quenching factor measurements

modified PROTEOM set-up:



$CaWO_4$ scintillator crystal irradiated with singly ionized atoms

nucleus (energy) dependent measurements, T = 300 K / 4 K

see talk by P. Christ (tomorrow)

33 modules in CRESST II

300 g detector module

phonon channel

300g $CaWO_4$

Ø = 40 mm, h = 40 mm

W-SPT 6 x 8 mm^2

light channel

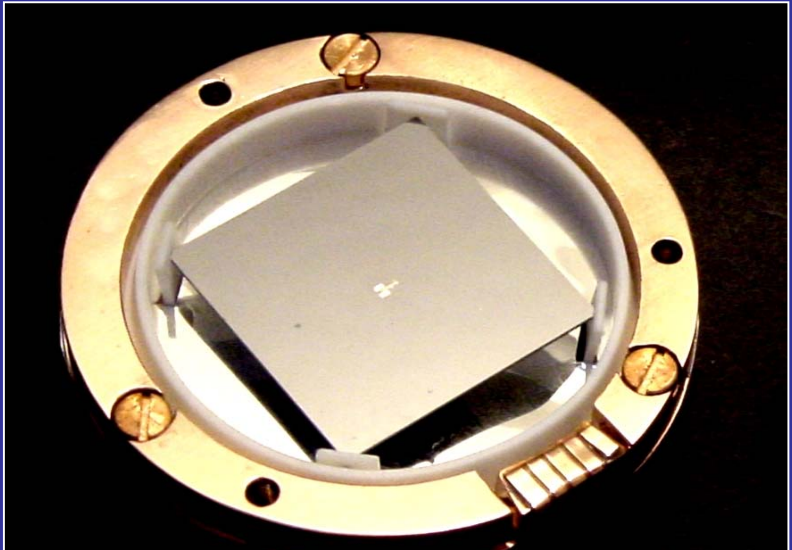
Si 30 x 30 x 0.4 mm^3

W-SPT

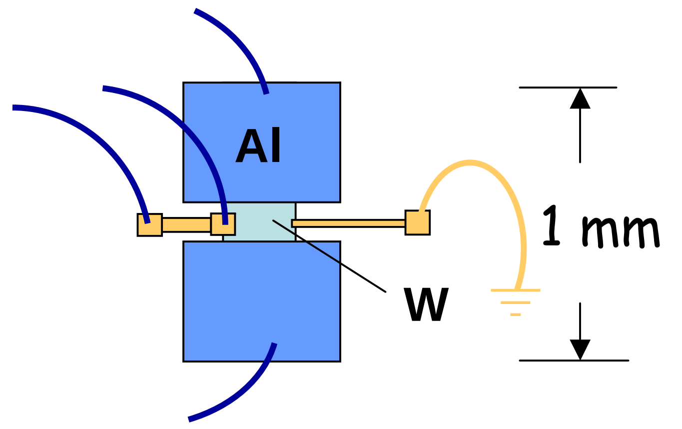
reflector

polymeric foil, teflon, CuBe (Ag coated)

light detector



30 x 30 x 0.4 mm^3 Si
E_{thresh} ≈ few optical photons



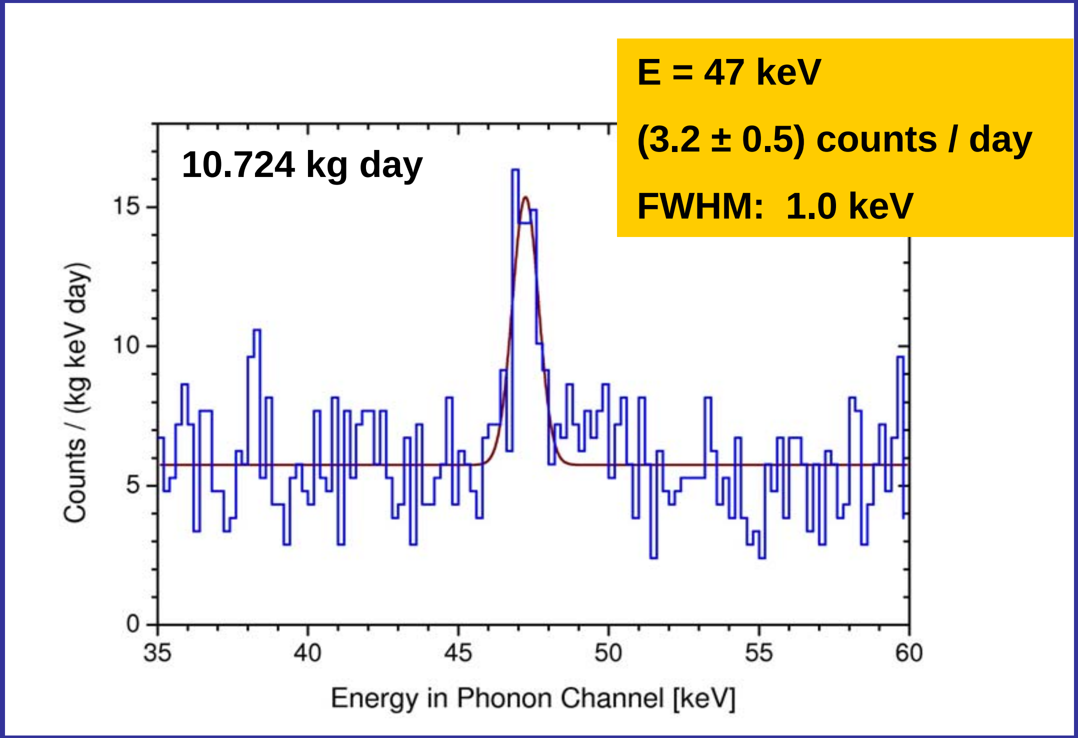
W-sensor with Al-phonon collectors
separate heater / thermal link

effective threshold: $E_{thresh,ee}$ ~ 2 keV

absolute: 10 to 20 eV (few optical photons)

energy resolution: ΔE = 17 % at E_{ee}= 122 keV
(as photomultiplier)

Run 28: two prototype detector modules taking data from 31 Jan to 23 March 2004

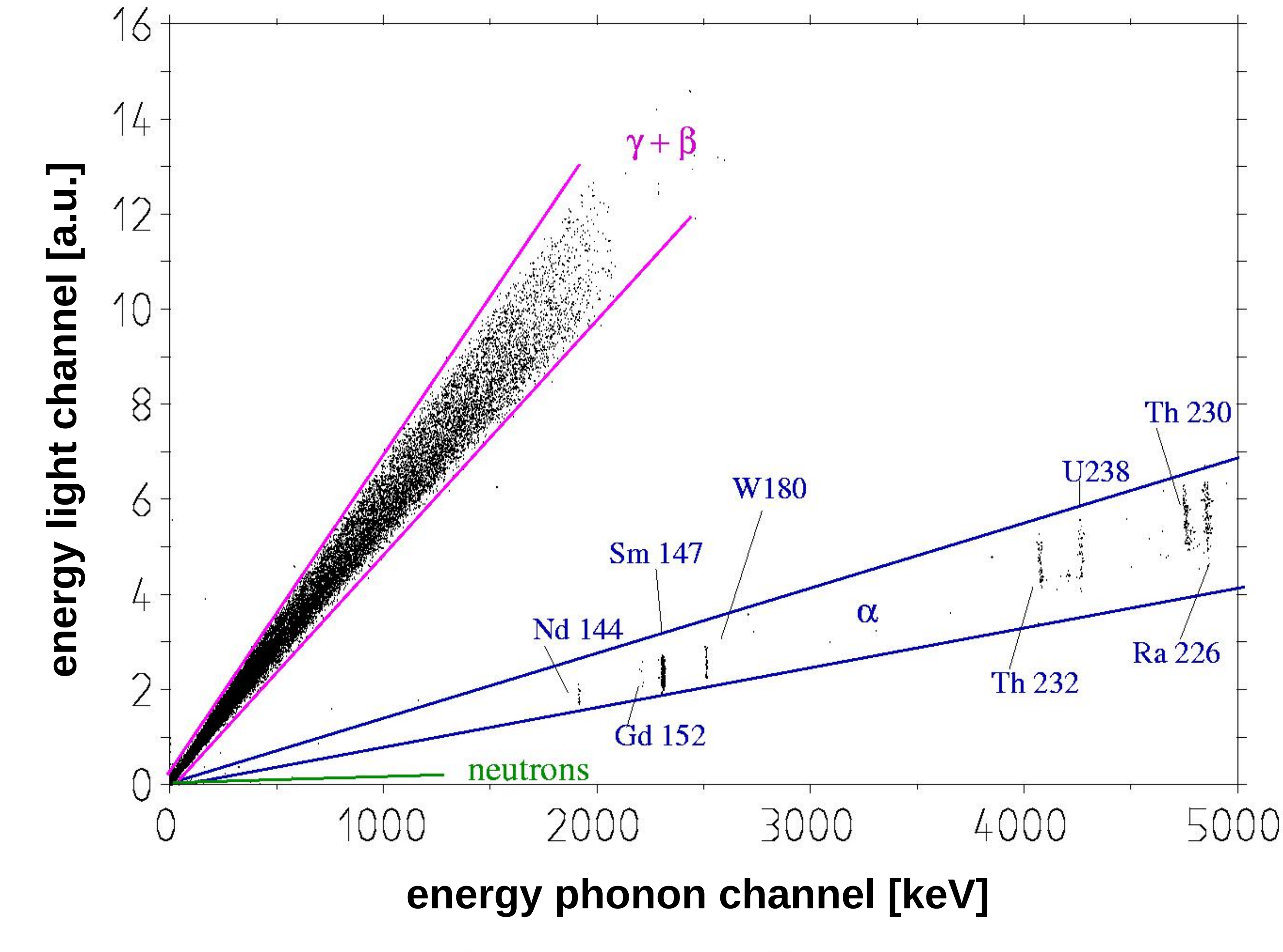


energy resolution (phonon detector):

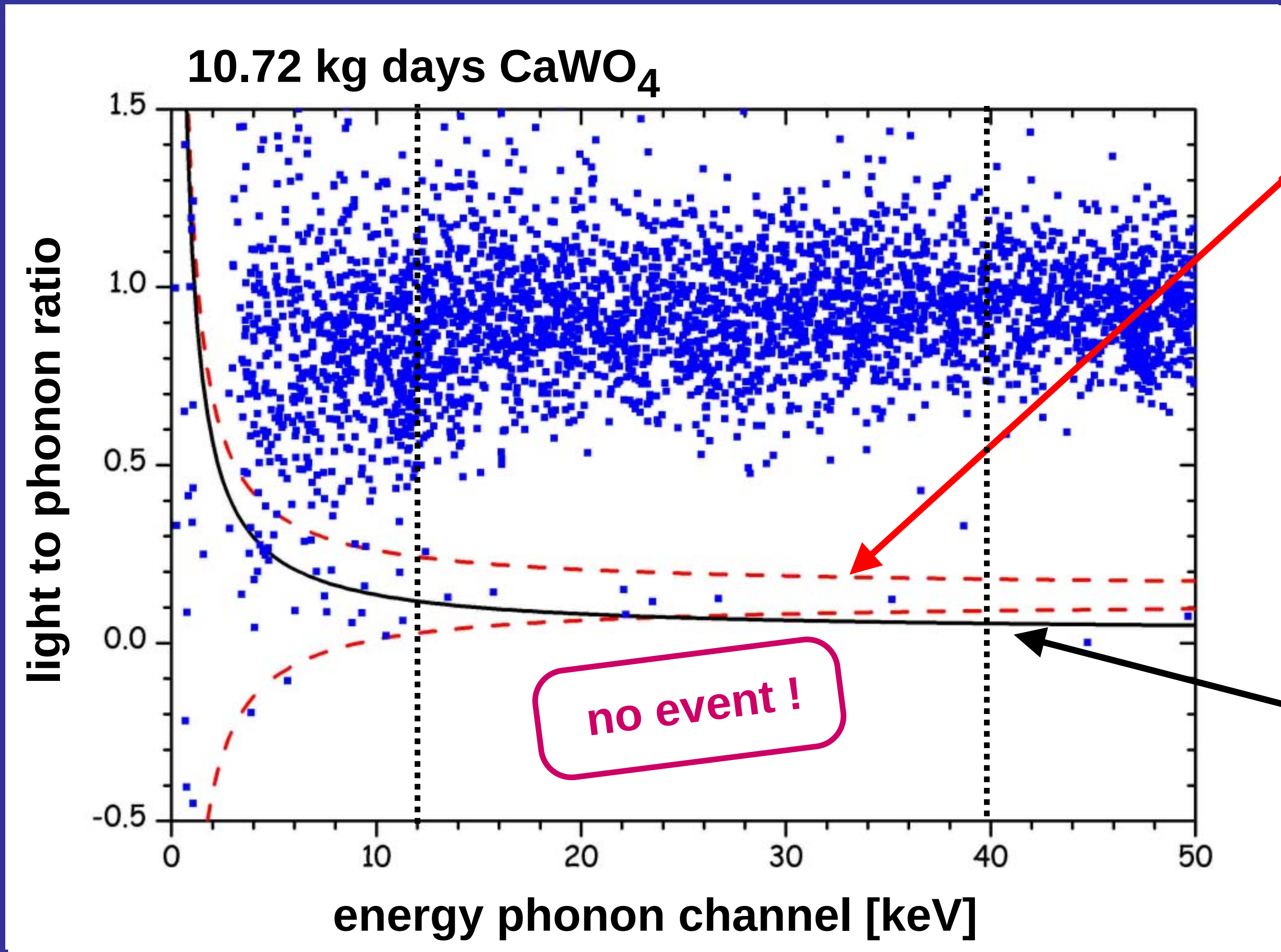
γ : 1 keV @ 46.5 keV

α : 8 keV @ 2.3 MeV

energy in light vs energy in phonon channel



low energy event distribution, no neutron shield!



oxygen recoils:

Q = 7.4

90 % of oxygen recoils below upper red line

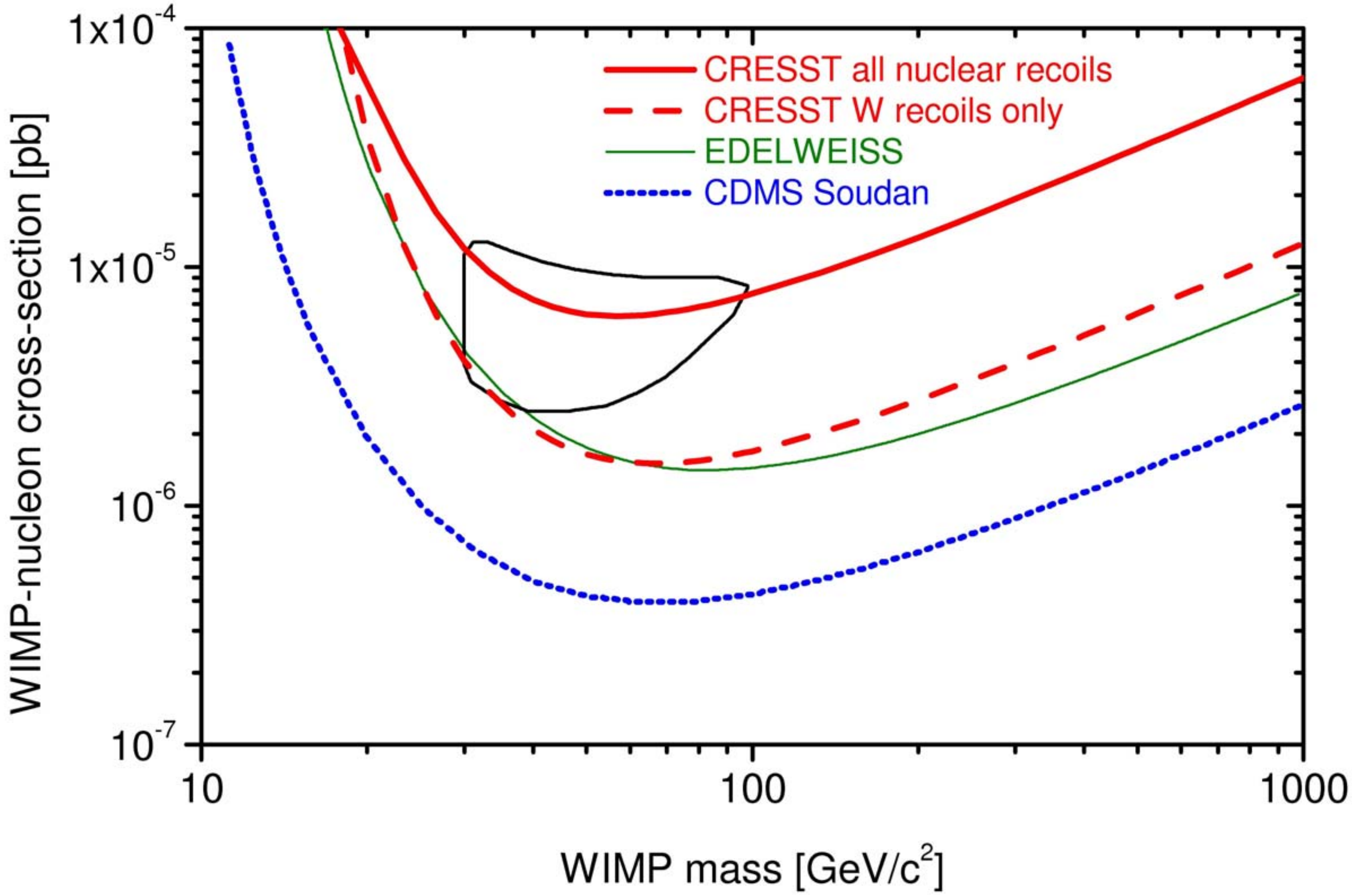
compatible with expected neutron background (MC)

tungsten recoils

Q = 40

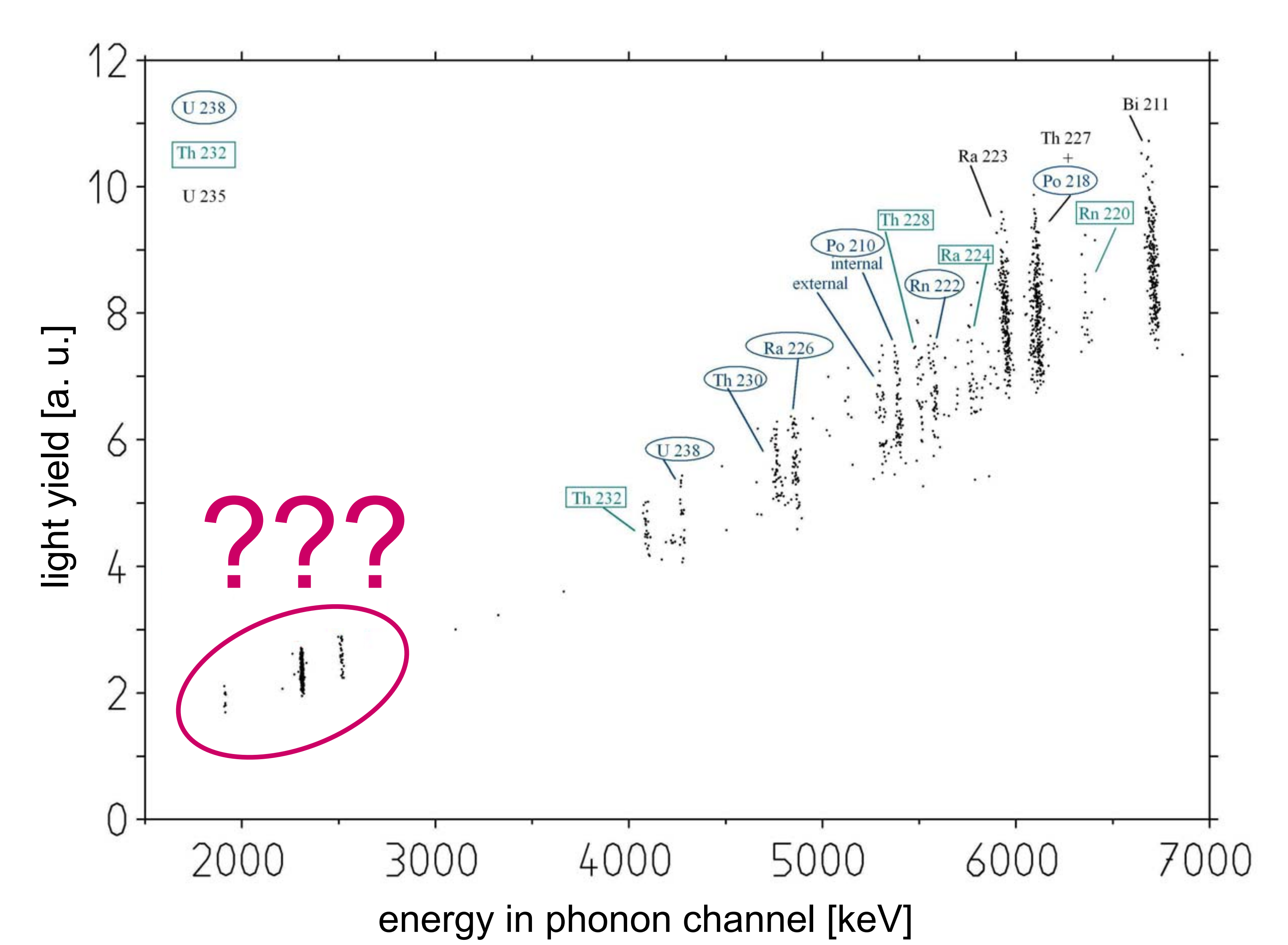
90 % of tungsten recoils below black line

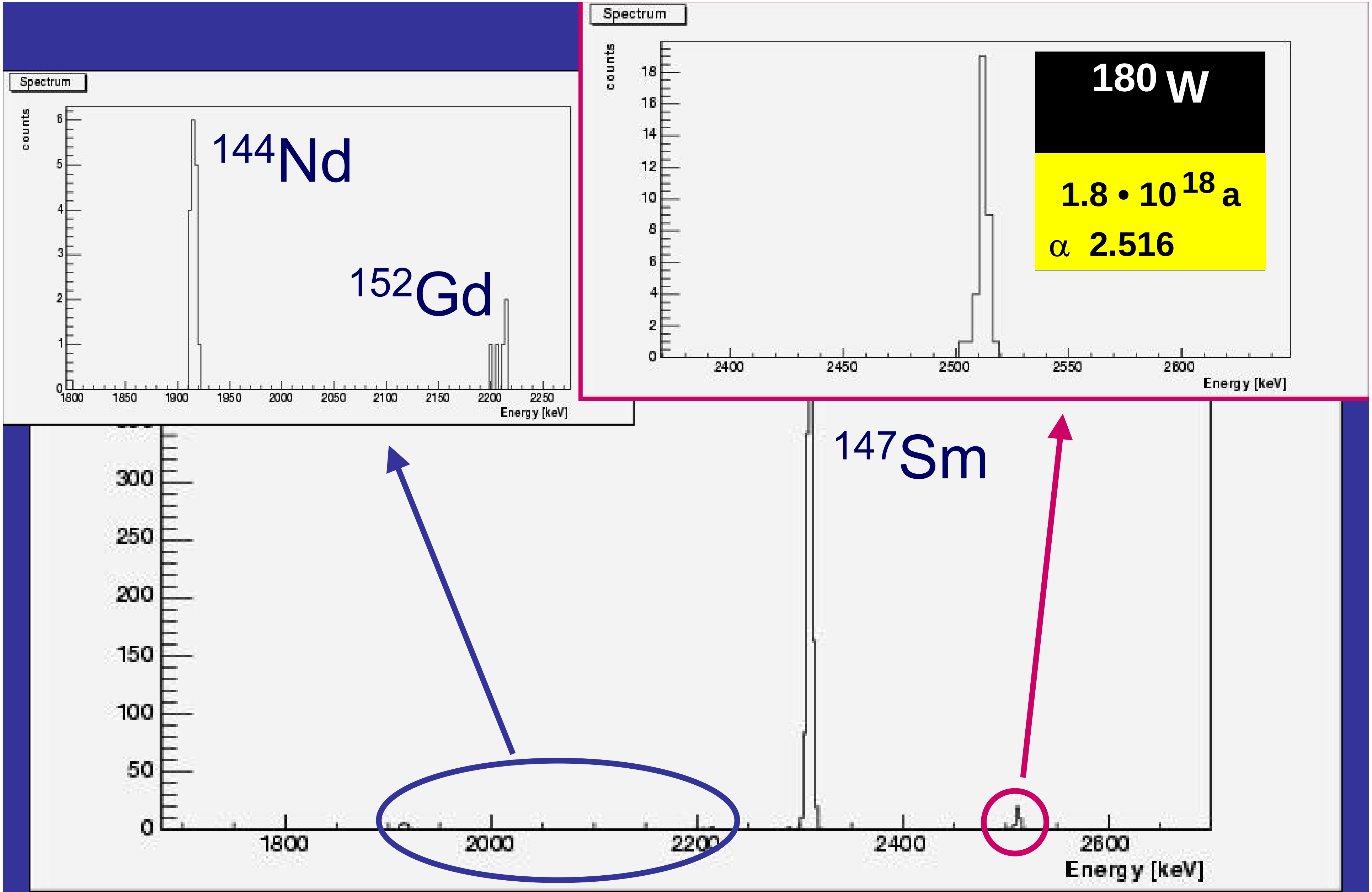
exclusion plot for spin independent WIMP nucleon scattering cross section



submitted to Astropart Phys astro-ph / 0408006

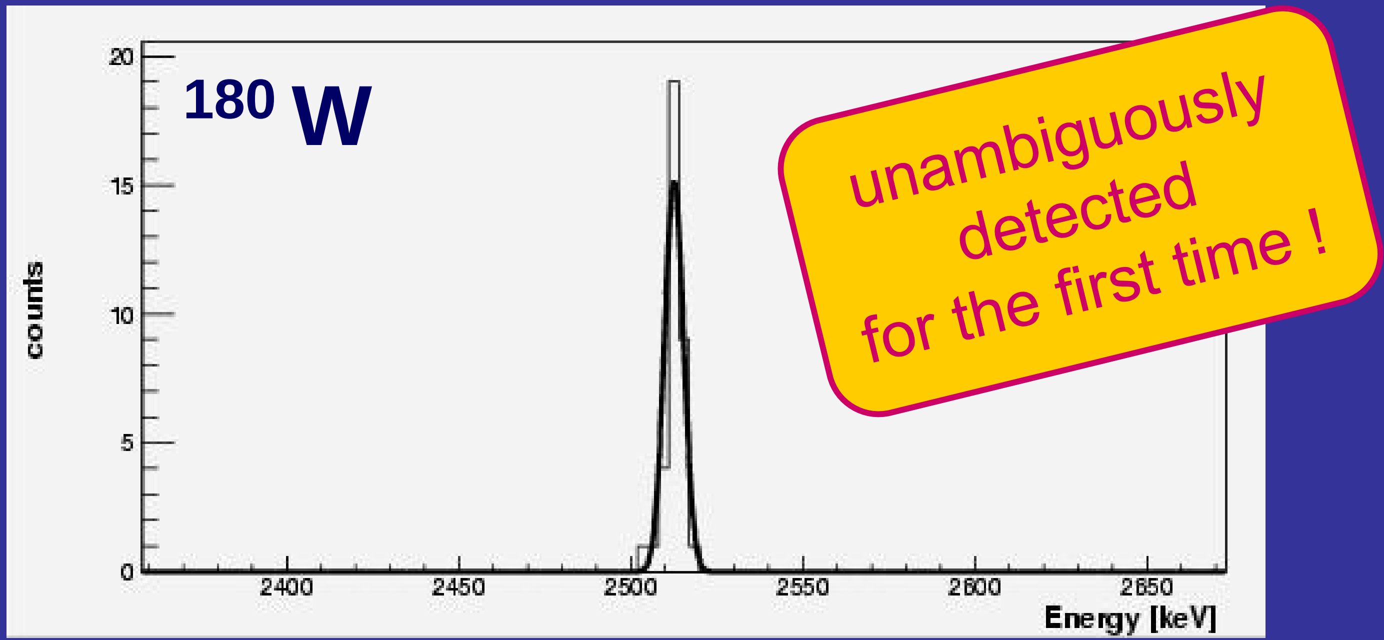
identification of α- emitters





low energy α- lines

α- decay of ^{180}W



half-live	$T_{1/2} = (1.8 \pm 0.2) \cdot 10^{18}$ years
energy	$Q = (2516.4 \pm 1.1\ (stat) \pm 1.2\ (sys))$ keV

accepted for publication in Phys Rev C
nucl-ex / 0408006

half-life time limits
α-decay, 90% c.l.

^{182}W $T_{1/2} \geq 7.7 \times 10^{21}$ years

^{183}W $T_{1/2} \geq 4.1 \times 10^{21}$ years

^{184}W $T_{1/2} \geq 8.9 \times 10^{21}$ years

^{186}W $T_{1/2} \geq 8.2 \times 10^{21}$ years

previous limits

improved by factor 50!

upgrade

10 kg absorber mass

33 detector modules
(66 SQUID channels)

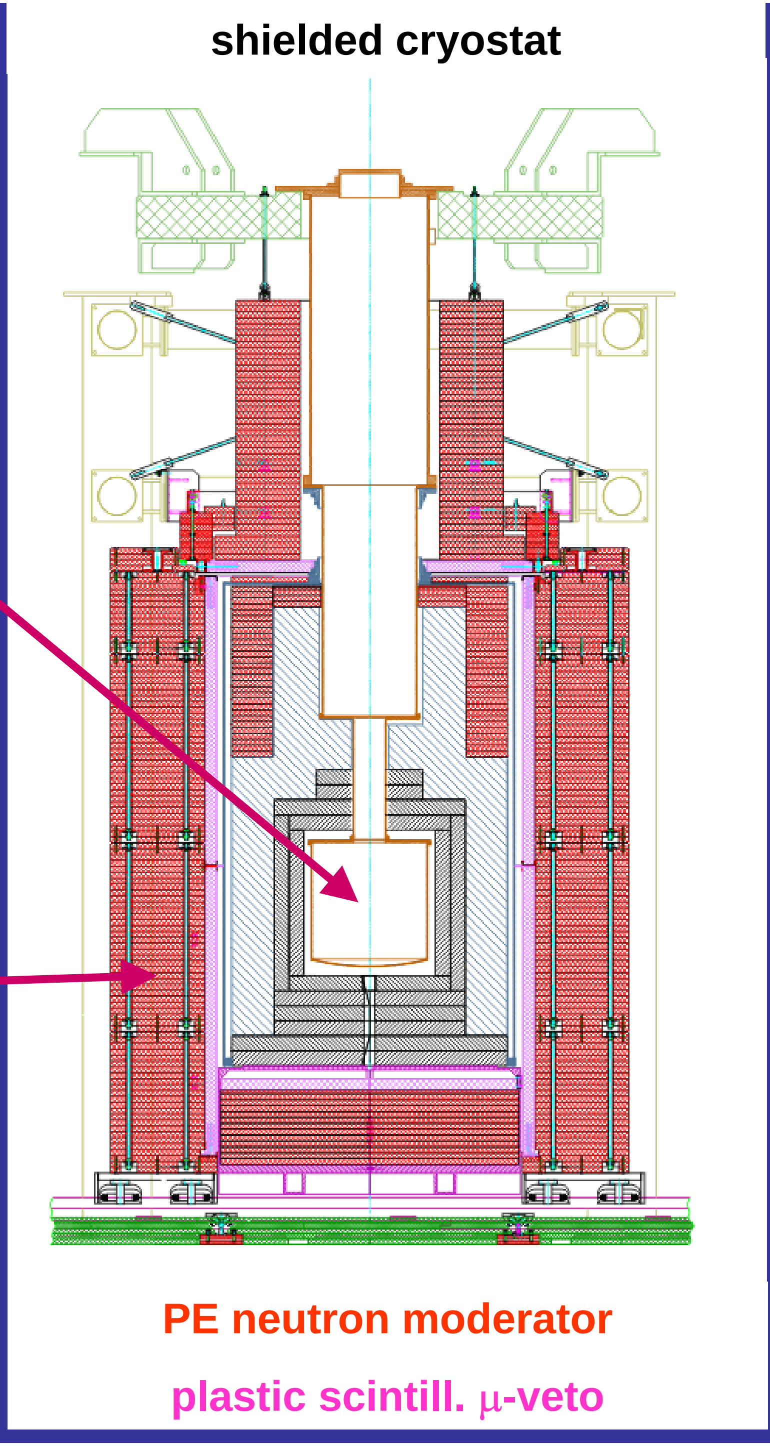
wiring, electronics, data acquisition

detector holder

PE neutron moderator

installation of 11 t polyethylene

plastic scintillator m-veto



66 channel

SQUID system

preparation ...

and installation of the neutron moderator (polyethylene)

CRESST (MPI) activities in 2005

upgrade / detector operation

upgrade (detectors, μ-veto, DAQ)

detector holder

detector operation at Gran Sasso
(~ 10 detector modules)

data analysis

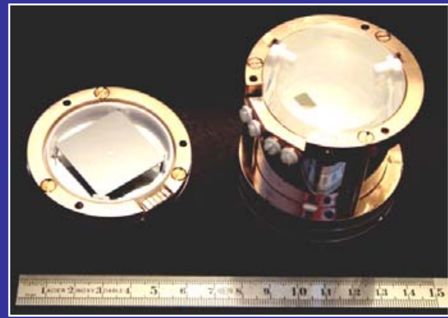
detector development

quenching factor measurements

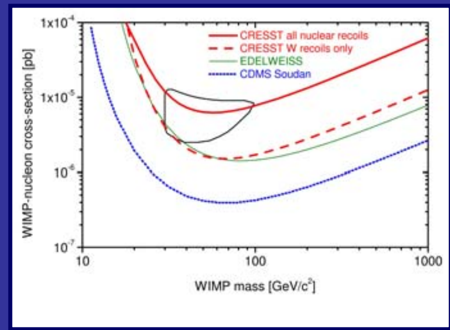
detector optimisation

time schedule

2003: optimisation of detector modules
discrimination threshold well below 15 keV



2004: two month of Dark Matter run
recoiling nucleus identified
among leading experiments



start upgrade

2005: finish upgrade (spring)
run up to 10 detector modules

long term sensitivity goal: < 10^{-8} pico barn

personnel now

PhD students	F. Petricca (paid by EU network), J. Ninkovic	} finish in early 2005
dipl. students	E. Pantic, I. Bavykina	
post docs	G. Angloher	
technician	H. Seitz	
permanent	F. Pröbst, W. Seidel, D. Hauff	

Contributions to the CRESST collaboration

MPI	detector develop. & fabrication quenching factor measurement neutron shield, muon veto, DAQ
Oxford / (Warwick)	SQUID system (66 channels) electronics, data analysis
LNGS	onsite support at Gran Sasso
Tübingen	muon veto
TUM	simulations, PE, muon veto