EDELWEISS-II direct dark matter search experiment

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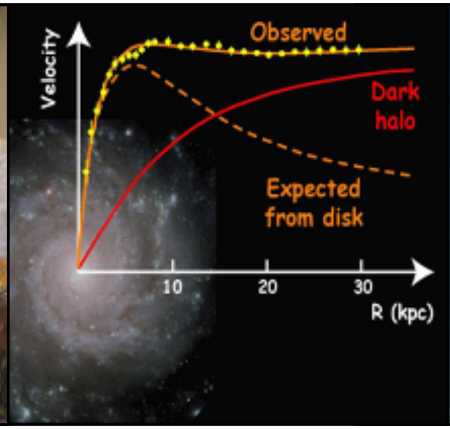
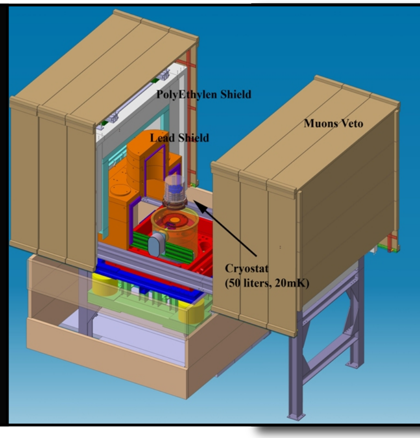
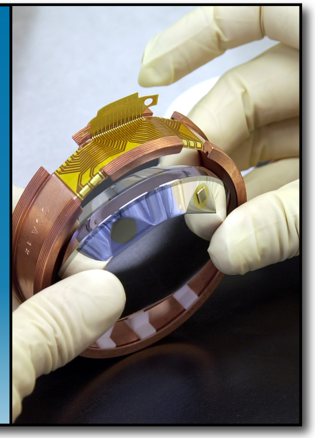
GDR TERASCALE, Lyon April 19th 2011

- *EDELWEISS-II Status (384 kg.days physics run)*
- *EDELWEISS-III project 2010-2012 (3000 kg.days)*
- *CDMS-II, XENON-10-100*



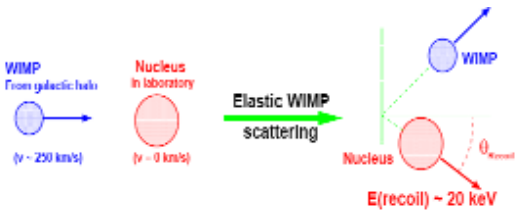




Direct WIMPs search: principles

- Differential rate (/energy unit/time unit) :

J.D. Lewin, P.E Smith/Astroparticle Physics 6 (1996) 87-112



$$\frac{dR}{dE} = \frac{\rho_{0w}\sigma_{w-n}}{2m_w\mu^2}\left(I_f F(E)\right)^2 \int_{v_w \min}^{v_w \max} \frac{f(v_w)}{v_w}\, dv_w$$

Part. Phy. — Nuclear. Phys. — Astrophysics.

- **Astrophysics constrains:**
  - Spherical isothermal Halo (→ Maxwellian distribution for Wimps speed)
    - with $v_{moyenne}$ = 230 km/s, v_{terre}=250+15sin(2πy) km/s, V_{echap}=650km/s
    - ρ_{0W} **= 0.3 GeV/c²/cm³** local Wimps density
  - more complex Halo models possible !

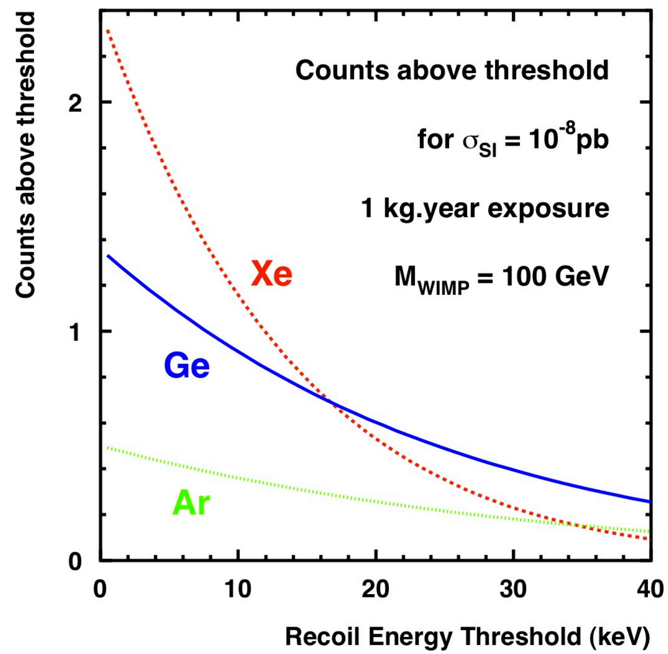
- **Part. Phys. constrains: SUperSYmetry Hypothesis**
  - M_W ~ few GeV/c²-fewTeV/c²

    Ex : For M_W ~ 100 GeV/c² Mean density : 3000 WIMPs/m³

    Flux on Earth : 500 000 000 WIMPs/m²/s !
  - Wimps-Nucleon cross section $\sigma_{w-n}<10^{-7}$pb

    (10^{-43}cm², 1barn ~section proton)
    - **Recoils rate < 1 evts/100kg.days**
    - **typ. Recoil few keV - few 10keV**

- **Nucl. Phys. constrains:**
  - Form factor elastic collision
  - Interaction factor
    - **I_f~A^2** for scalar coupling (coherent interactions)
    - **I_f~J(J+1)** for axial coupling (spins eliminate 2 by 2, few at the end…)



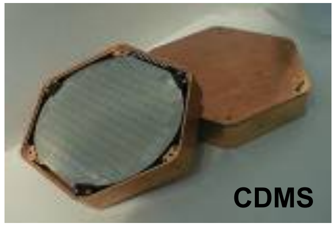
Direct WIMPs search: How ?

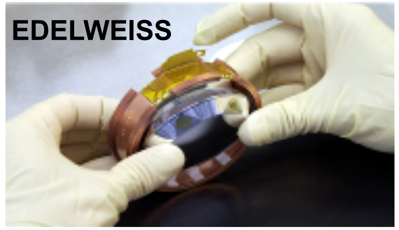
Metastable detector (dE/dX)
- PICASSO (C_4F_{10}), SIMPLE : sound wave
- CF_3I (COUPP) : bubble chamber, pressure + Camera

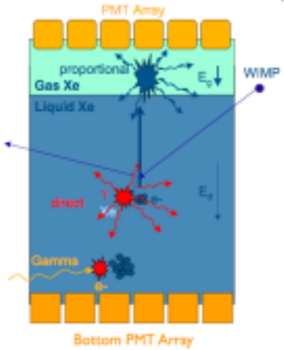
Ge detector:
- HDMS, IGEX, CoGent
- MAJORANA, GENIUS

Gazeous detector :
- DRIFT (CS_2)
- MiMac (He_3)

Ionization

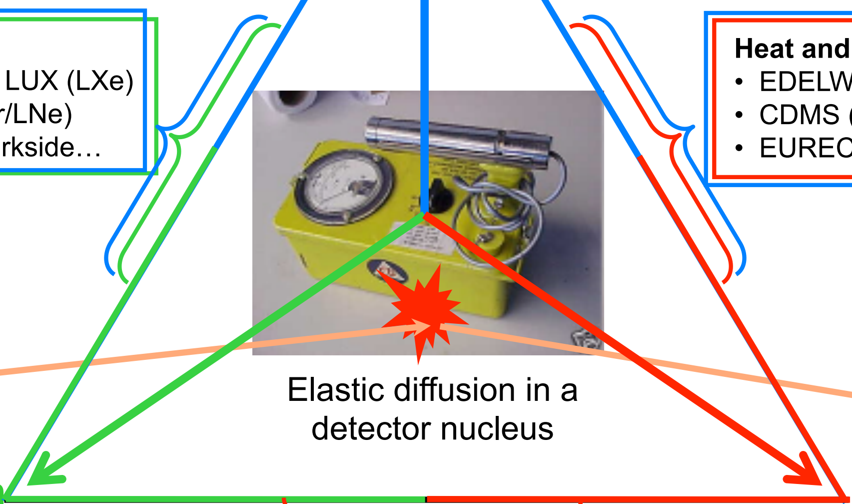






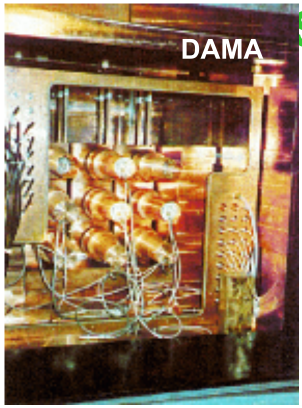
Scintillating liquid
- XENON, ZEPLIN, LUX (LXe)
- ArDM, WARP (LAr/LNe)
- DEAP, CLEAN, Darkside…

Heat and ionization cryogenics detectors:
- EDELWEISS (Ge)
- CDMS (Ge + Si)
- EURECA (Ge)



Incident Wimps

Diffused Wimps



Scintillation

Solid scintillator :
- NAIAD (NaI)
- KIMS (CsI)
- DAMA/LIBRA (NaI)
- ANAIS (NaI)

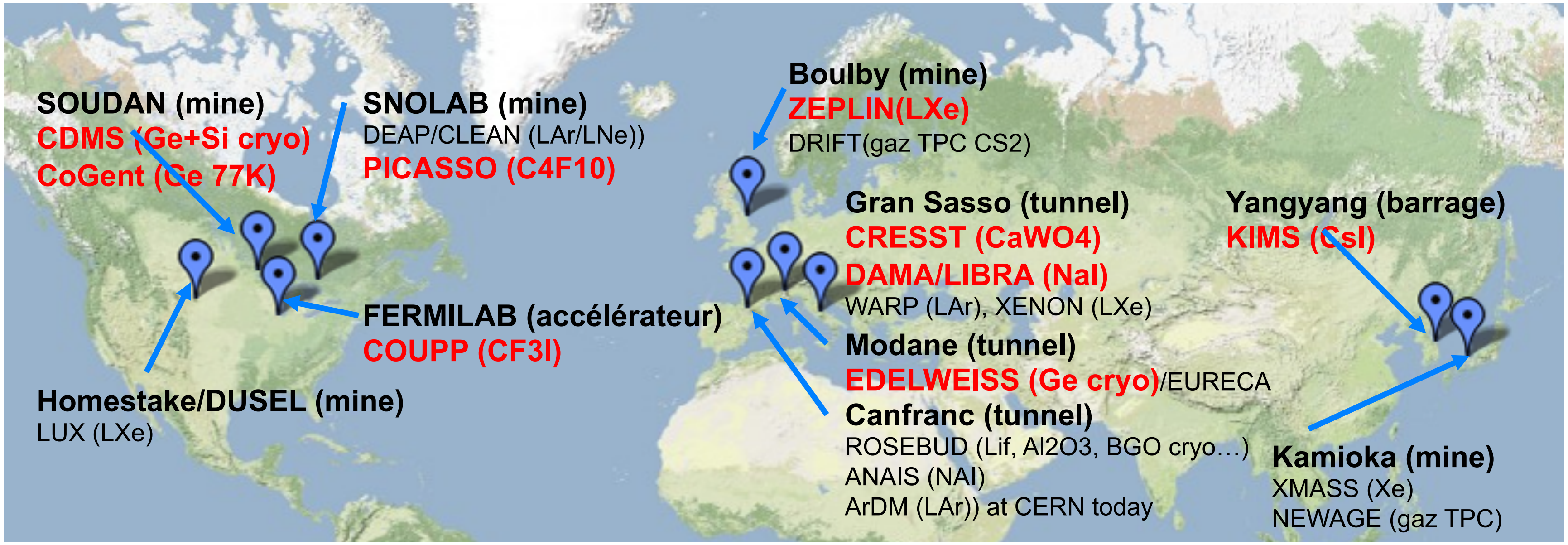
Liquid scintillator :
- XMASS (LXe)
- DEAP/CLEAN (LAr/LNe)

Heat

Simple bolometer:
- No more expt.

Heat and light cryogenics detectors::
- CRESST ($CaWO_4$)
- ROSEBUD (Lif, Al_2O_3, BGO)
- EURECA (???)

Direct WIMPs search: where, what's new ?



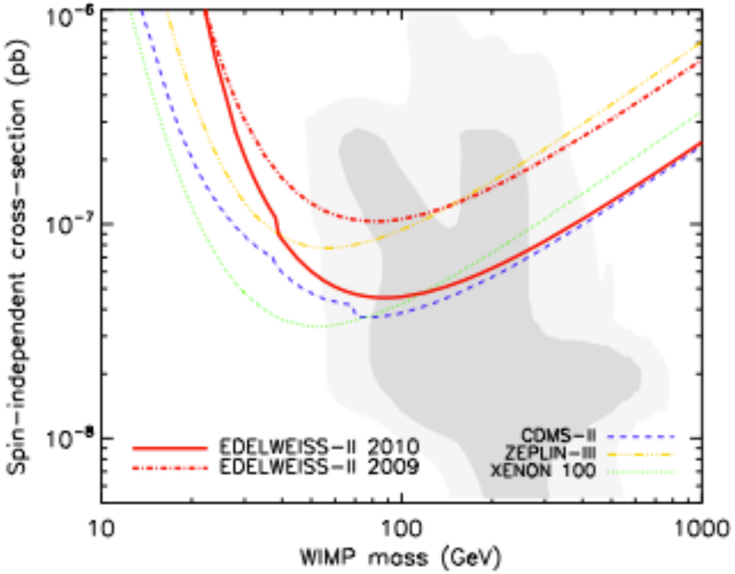
- **Main 2007-11 results:**

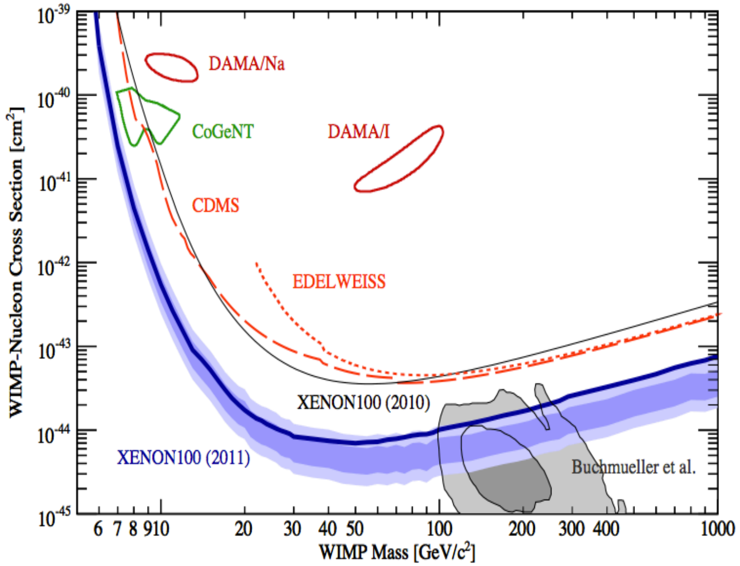
– CRESST II	only in conf	Cryogenic (Heat-Light)
– XENON10	May 07	Liquified noble gaz (II-phase-
– KIMS	Sept 07	Solid Scintillator
– DAMA	April 08	Solid Scintillator (annual modulation)
– ZEPLIN III	Dec 08	Liquified noble gaz (II-phase)
– **PICASSO**	**July 09**	**Metastable droplet (C_4F_{10})**
– **CDMS**	**March 08/ Dec 09**	**Cryogenic (Heat-ionization)**
– **EDELWEISS**	**Dec 09/ March11**	**Cryogenic (Heat-ionization)**
– **COUPP**	**Fev 08/ Fev 10**	**Metastable bubble chamber (CF_3I)**
– **CoGeNT**	**June 08/ Fev10**	**Ge 77K low C, low threshold**
– **XENON100**	**March 10/ April11**	**Liquified noble gaz**

Direct WIMPs search: State of the Art…

Scalar Coupling :
(Spin-Independant)
- **CDMS-II**
- **EDELWEISS-II**
- **XENON-100**
- **CoGent** at low Mw

→ Part of SUSY Already explored



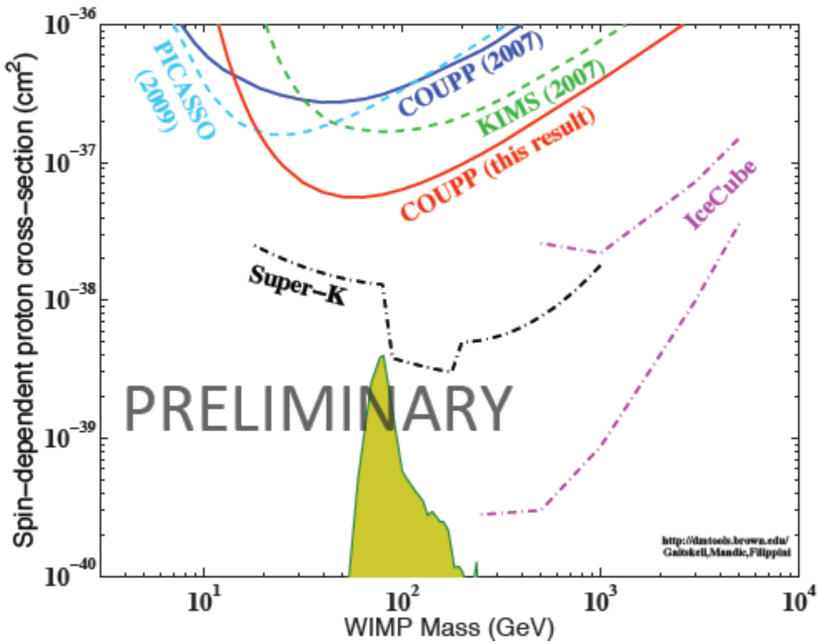


Axial coupling :
(Spin-Dependant)
→ **On Proton**
- **COUPP**

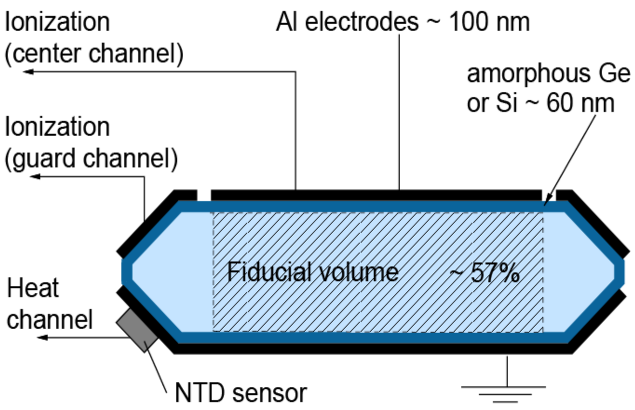
→ **On Neutron**
- **Xenon-10**

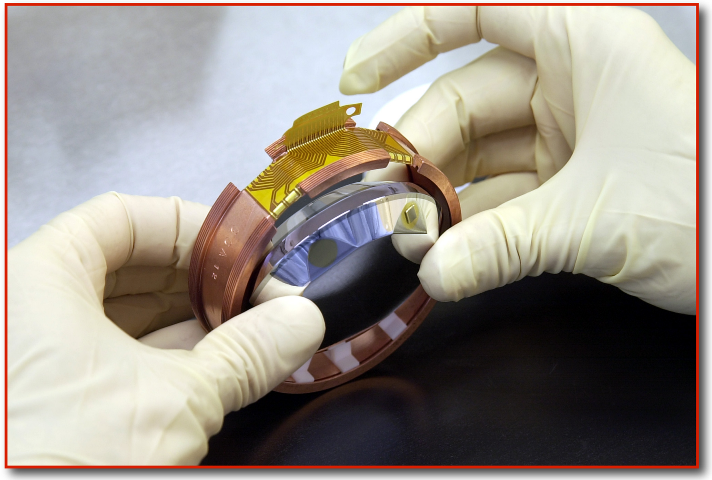
→ Experiments still far from SUSY models . Indirect detection is more competitive (SuperK) (coupling on proton in the Sun)

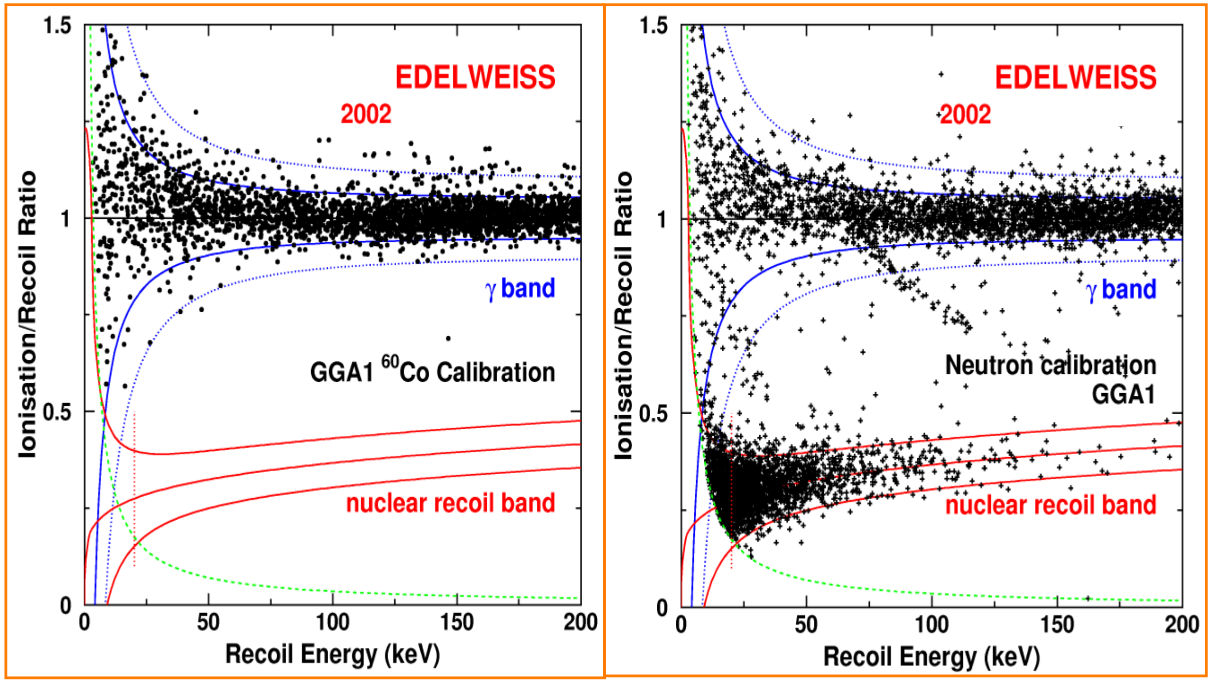
→ **4 different technologies !**



EDELWEISS-I : GeNTD discrimination principles







→ **Simultaneous measurement**

- **Heat** @ 20 mK with Ge/NTD thermometer
- **Ionization** @ few V/cm with Al electrodes

→ **Evt by evt identification** of the recoil

→ Q=Eionization/Erecoil

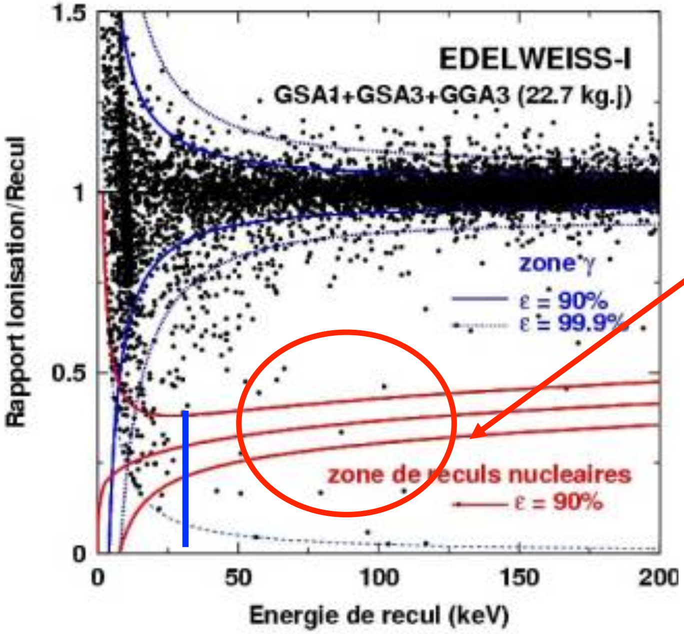
- **Q=1 for electronic recoil**
- **Q≈0.3 nuclear recoil**

→ GeNTD detector : discrimination γ/n > 99.99% for Er> 15keV

EDELWEISS-I/-II : surface evts background…

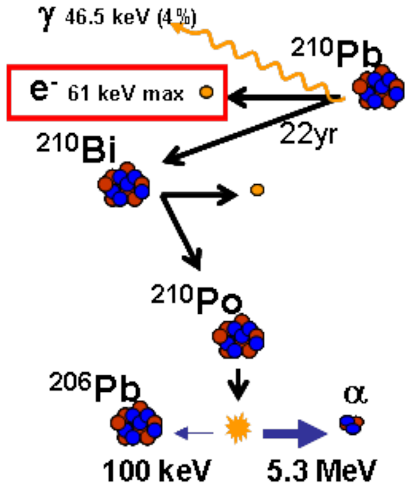
(V. Sanglard, S. Fiorrucin, S. Scorza thesis)

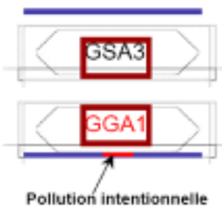
2000
2003



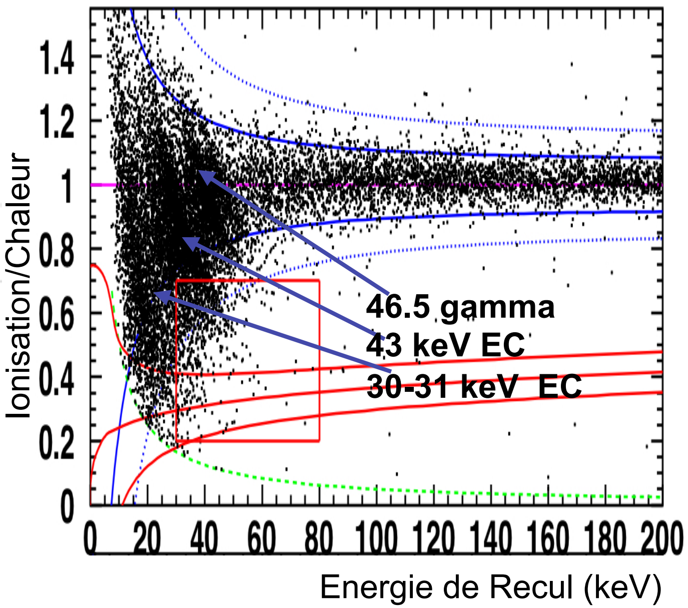
→ Poorly collected events in Physics runs:

- Surface β
- bad charge collection :
  recombination and trapping
- **Rate compatible with ^{210}Pb contamination :**
  rate α ≈ β^- ≈ 5/kg/day





β source =
Rate = 2500 *
EDW1



GGA1 210Pb calibration (sept 2007) in EDELWEISS-II

→ Dedicated β 210 Pb calibration

- ≈ 2% of the betas in the nuclear recoil zone for 30<Er<100keV
- **β rejection ~1/10000 needed to reach < 10^{-8} pb**

→ Last year's R&Ds have focused on this issue :
Ge/NbSi and ID/FID technologies

EDELWEISS-II : collaboration

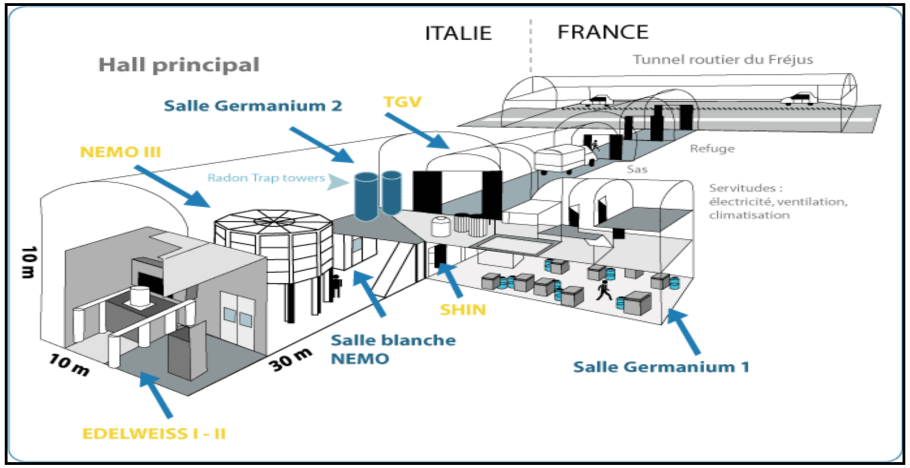
♦ CEA Saclay (IRFU & IRAMIS)	Detectors, electronics, acquisition, data handling, analysis
♦ CSNSM Orsay	Detectors, cabling, cryogenics
♦ IPN Lyon	Electronics, cabling, low radioactivity, analysis, detectors, cryo.
♦ Institût Néel Grenoble	Cryogenics, electronics
♦ Karlsruhe KIT (+ IPE in 2011)	Vetos, neutron detectors, background,
♦ JINR Dubna	Background, neutron and radon detectors
♦ Oxford Univ.	New comer 2009 : Detectors, cabling, cryogenics, analysis
♦ Sheffield Univ.	New comer 2010: MC simulation

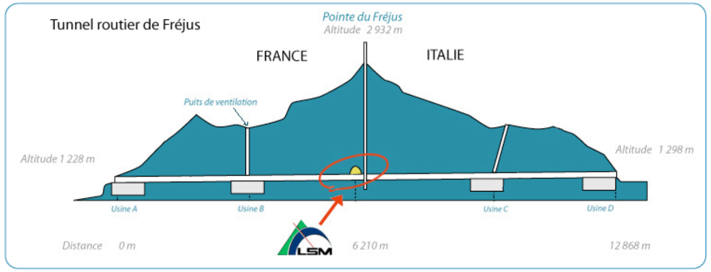
~ 50 persons (10 thesis, 4 post-doc)

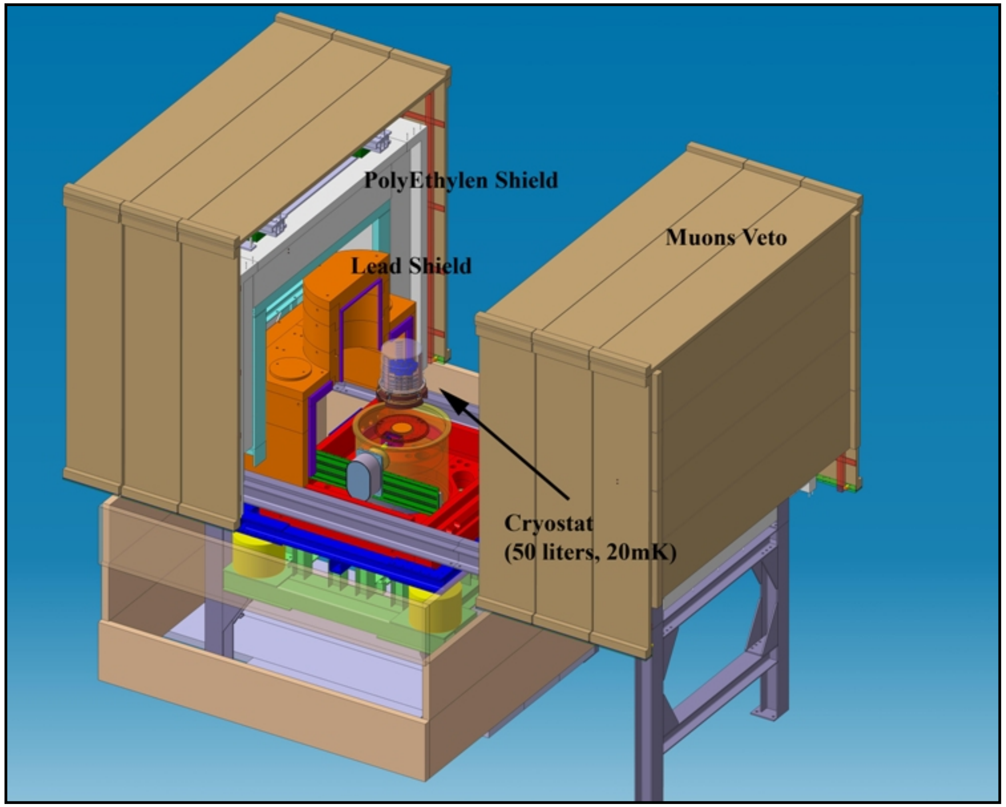

EDW Coll meeting/Dubna2007


EDW Coll meeting/Karlsruhe 2009

EDELWEISS-II Setup







→ **LSM = Deepest site in Europe:**

- **4 µ/m²/day**
- **10^{-6} n/cm2/s (E > 1 MeV) from rock**

→ Radiopurity

- **Dedicated HPGe detectors** for systematic checks of all materials
- **Clean Room**
- **Deradonized air** (NEMO3 radon trap) 10 Bq/m3 to 0.1 Bq/m3

→ **γ shield**

- **20 cm Pb**

→ **Neutron Shielding**

- **50 cm PE**

→ **µ veto** (>98% coverage)

→ Neutron detectors (Karlsruhe/Dubna)

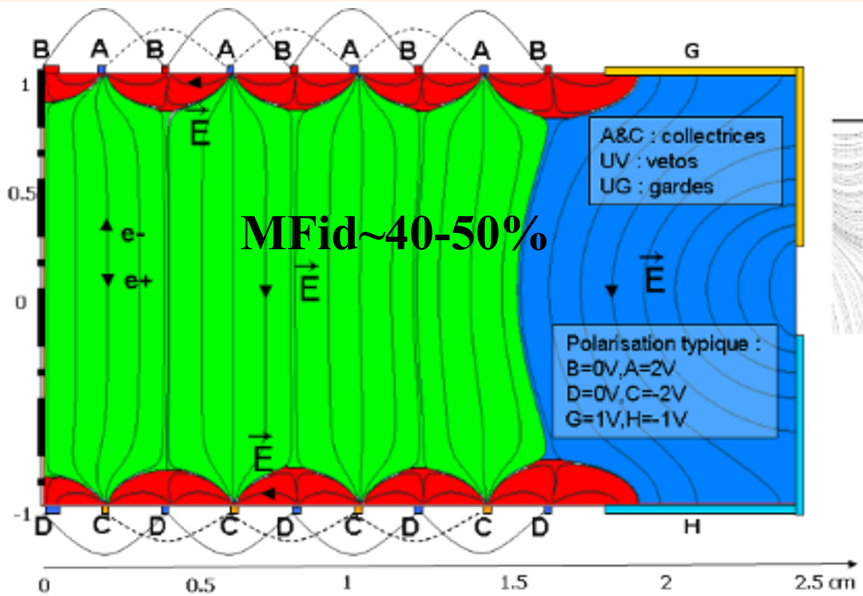
- For MC studies

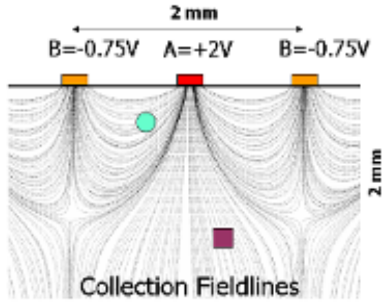
→ Commissioning 2006-07

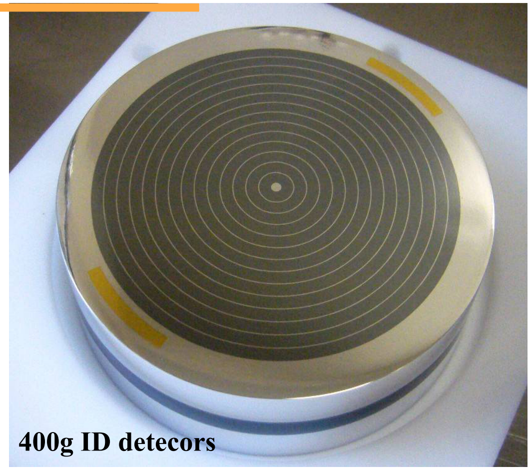
→ **Physics run since 2008**

→ **Aimed sensitivity** (< EDW-I * 100) : $\sigma_{w\text{-}n} < 10^{-8}$ **pb**
< 0.001 evt/kg/day (Er>~15keV)

ID detectors : surface events rejection with interleaved electrodes





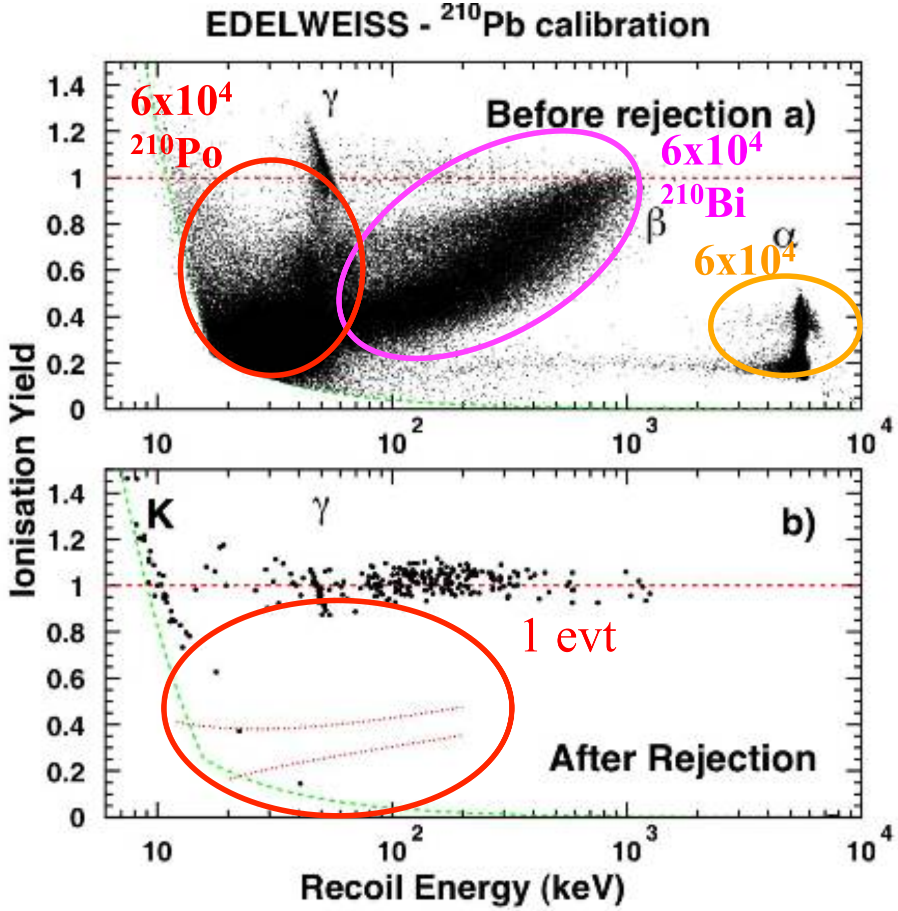


→ R&D program funded by ANR 2006-09
- First test on a 200 g detector in 2007

→ Interleaved electrodes + guards
→ Biases to have an **electric field :**
~ horizontal near the surface and
~ vertical in the bulk

→ Easy cuts on « veto » + guard electrodes define the fiducial zone : β rejection > 1/15000

→ 10 IDs build in few months end of 2008
- 5 with Photolitho @ Canberra
- 5 with evaporation @ CSNSM
- NTD glued @ CEA/SEDI



PLB 681 (2009) 305–309 [arXiv:0905.0753v1]

Run 12: Physics run with 10 IDs

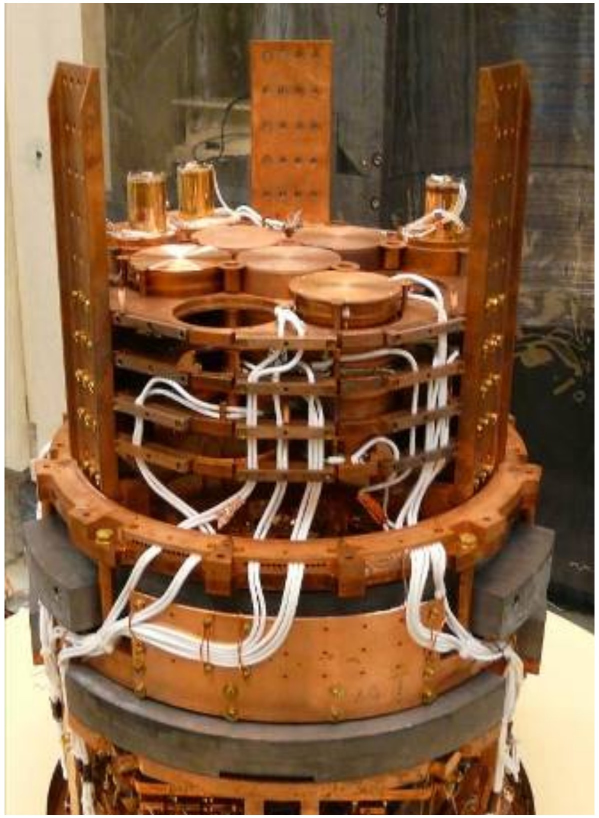
→ April 2009 – May 2010: 10x400 g Ge ID-detectors

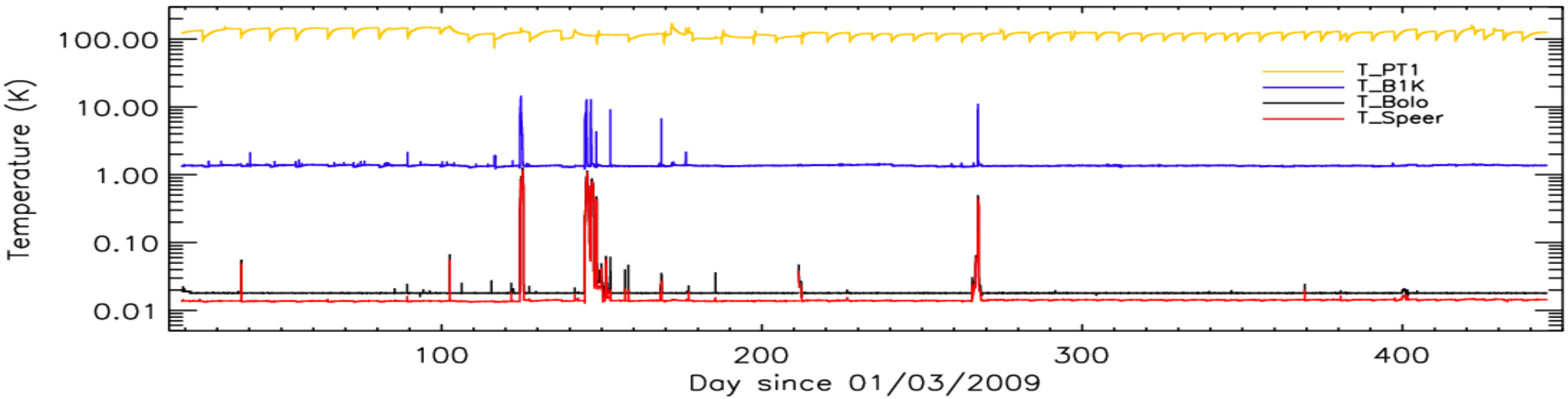
- 325 days physics
- 10.1 days gamma calibration
- 6.4 days neutron calibration

✚ July-Nov 2008: 2x400 g Ge ID-detectors

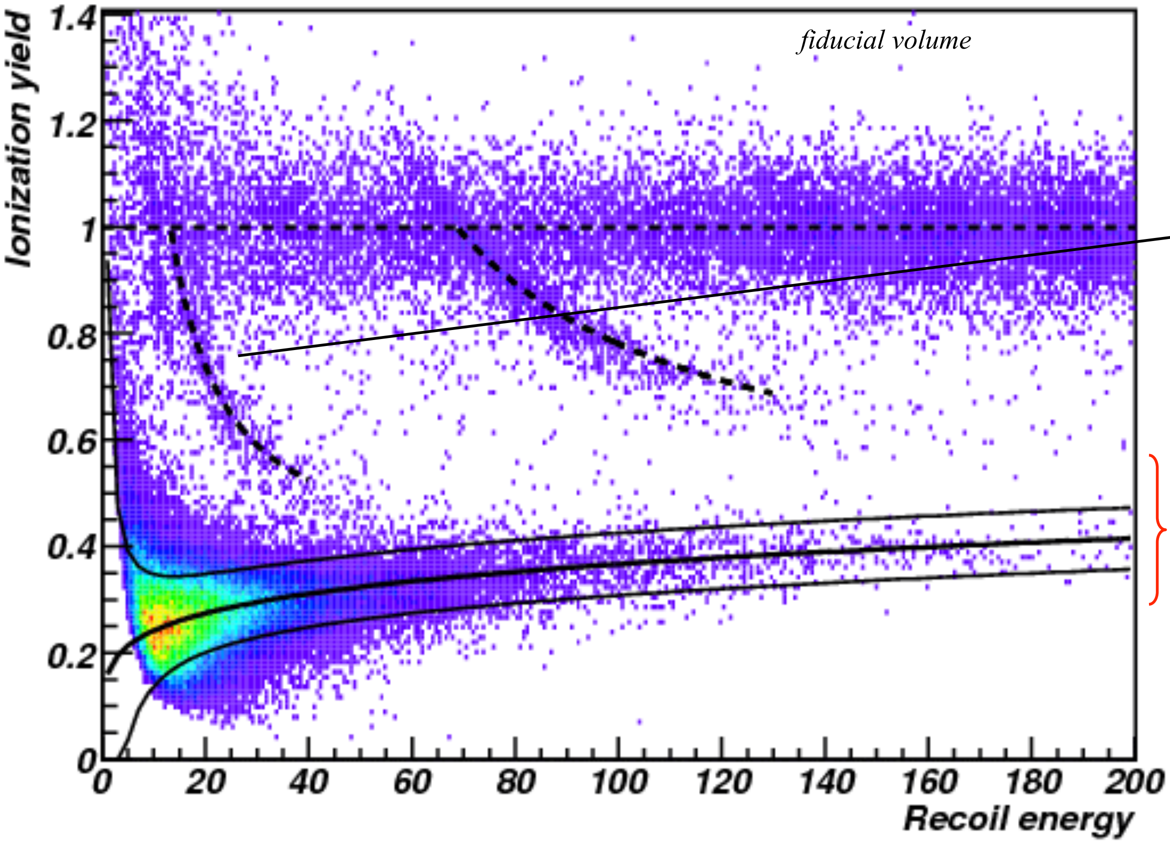
→ Total effective exposure: 384 kg.d

- Analysis threshold at 20 keV
- Bolometer temperature stable ~18 mK





Run 12: Nuclear Recoil Zone calibration

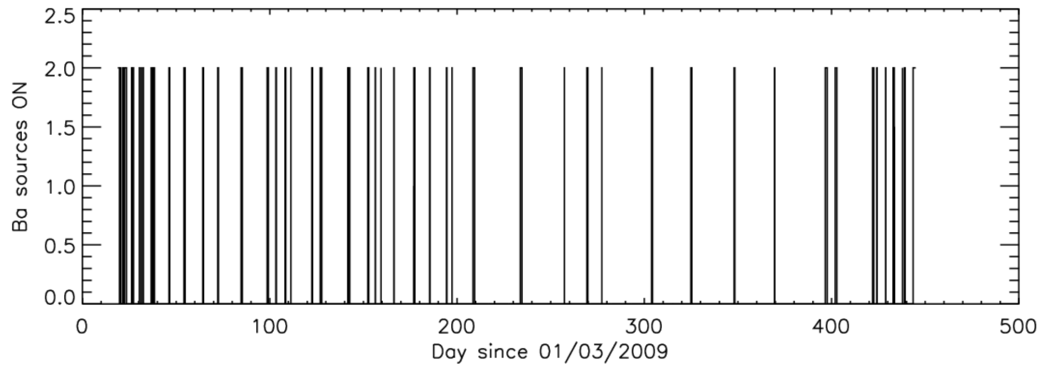


inelastic neutron scattering (EM energy 13 and 69 keV)

→ **90% CL NR (nucl. recoil) region :**

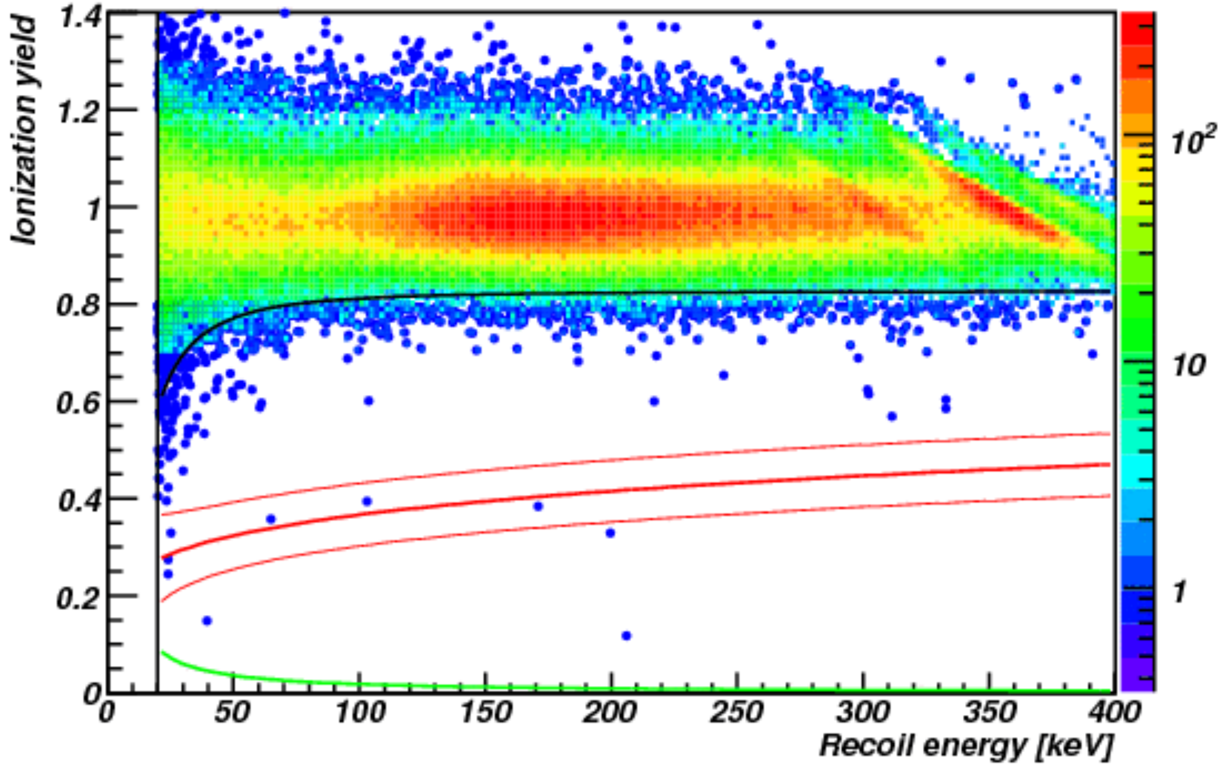
- high-stat confirmation of **$Q = 0.16\ E_r^{0.18}$ from <10 to 200keV**
- cross-check of resolution effects on the NR band
- full efficiency to NRs even below 20keV

Run 12: Gamma calibration



→ Regular calibrations between background runs with two motorized ^{133}Ba sources (356 keV)

- all IDs stacked
- same analysis/cuts as for bg data
- more than 350000 fiducial evts



→ Good γ rejection

~ $(3\pm1)\times10^{-5}$ for 20<E<200keV

- limited by "anomalous" events
- study of possible mechanisms under way :
- may be limited by the « dead zone » at the veto-guard interfaces

Run 12: Data processing & cuts

→ Online trigger on heat pulses

- Online threshold : tiny effect for E_{recoil} > 20 keV

→ Two independent processings – analysis

Careful cross-checks, very similar results

→ Optimal filtering of heat and ionization data samples

→ Removal of « bad » periods from the measured baselines

Require FWHM heat < 2.5 keV, ion_fiducial < 2 keV, ion_guard < 2.5 keV

17% exposure loss (concentrated on a few detectors)

→ Quality of pulse reconstruction (chi2 cut)

2.7% efficiency loss

→ Select fiducial volume (160g)

→ Reject coincidences + muon veto

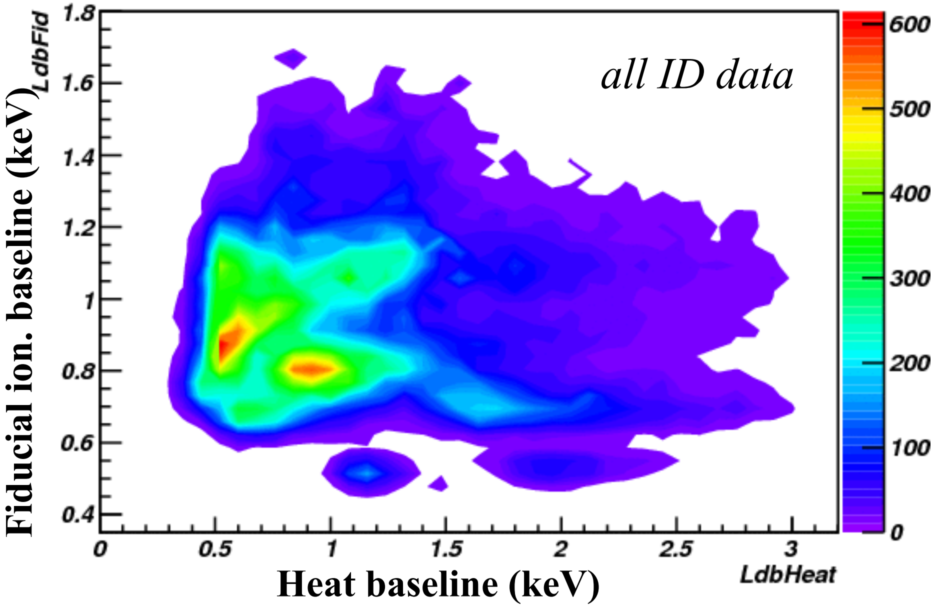
⇒ 427 kg.days

→ 99.99% gamma rejection +

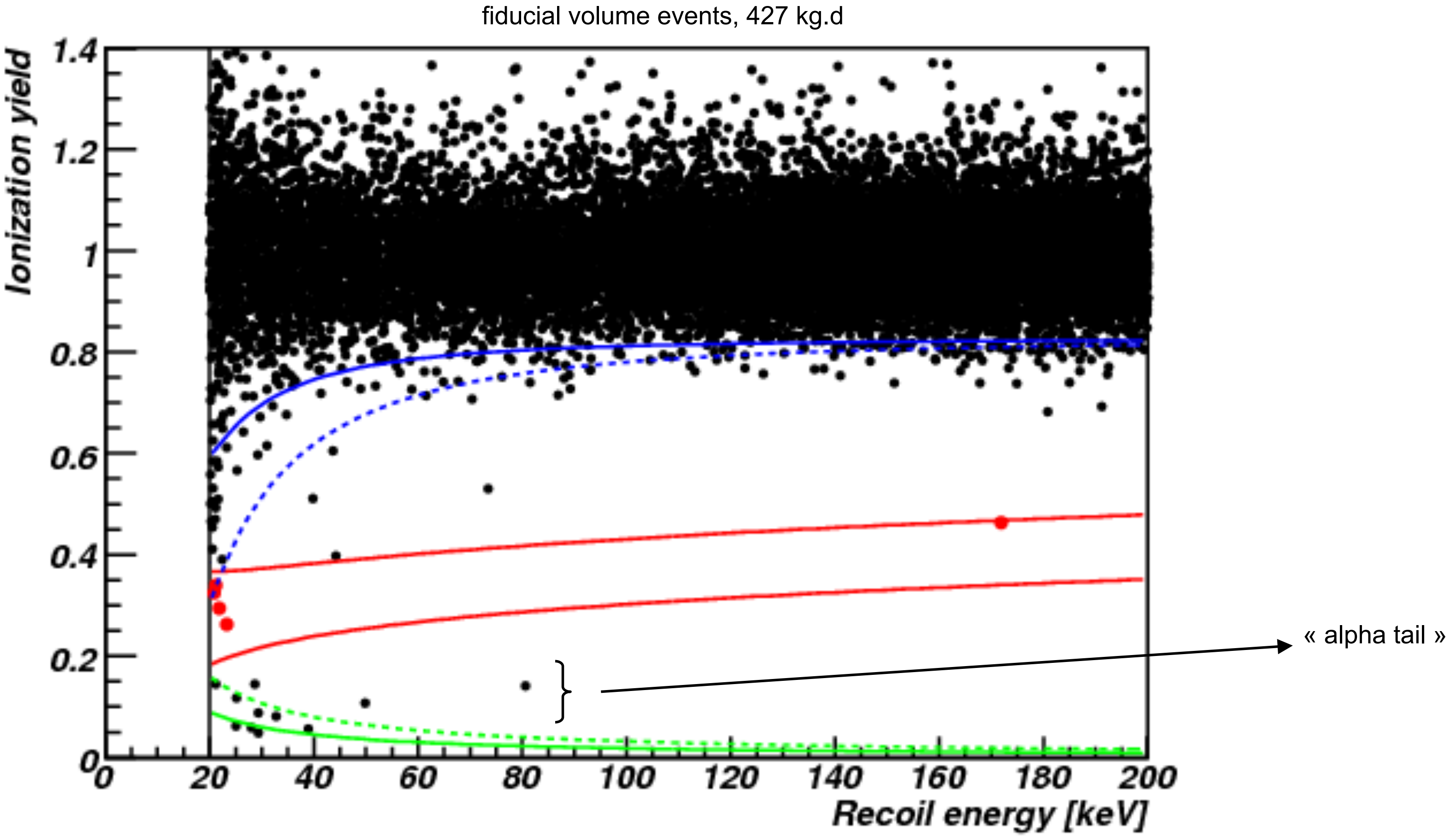
→ 90% nuclear recoil band selection +

→ set threshold at 20 keV

⇒ 384 kg.days «useful»
98.3% efficiency at 20keV



Run 12: WIMP search, final results



→ Five WIMP candidates:

- 4 with 20.8 < E < 23.2 keV
- 1 @ 172 keV

Run 12: Backgrounds

→ *Gamma*:	^{133}Ba calib rejection x observed bulk γ	<0.9
	(3×10^{-5}) (18000)	
→ *Beta*:	β source rejection x observed surface evts	<0.3
	(6×10^{-5}) (5000)	
→ *Neutrons from* μ's:	μ veto efficiency x observed muons	<0.4
	(meas. > 92.8%) (0.008 evts/kgd)	
→ *Neutrons from rock*:	measured neutron flux x Monte Carlo simu	<0.1
	MC cross-check with outside strong AmBe source	
→ *Neutrons from Pb+PE+Cu+structure*:		
	measured U limits x Monte Carlo simu	<0.2
→ *Other neutrons from within the cryostat (cables..)*		<1.1

→ SUM < 3.0 for the whole WIMP run

Run 12: Elastic WIMP scattering limit

→ 384 kg.d

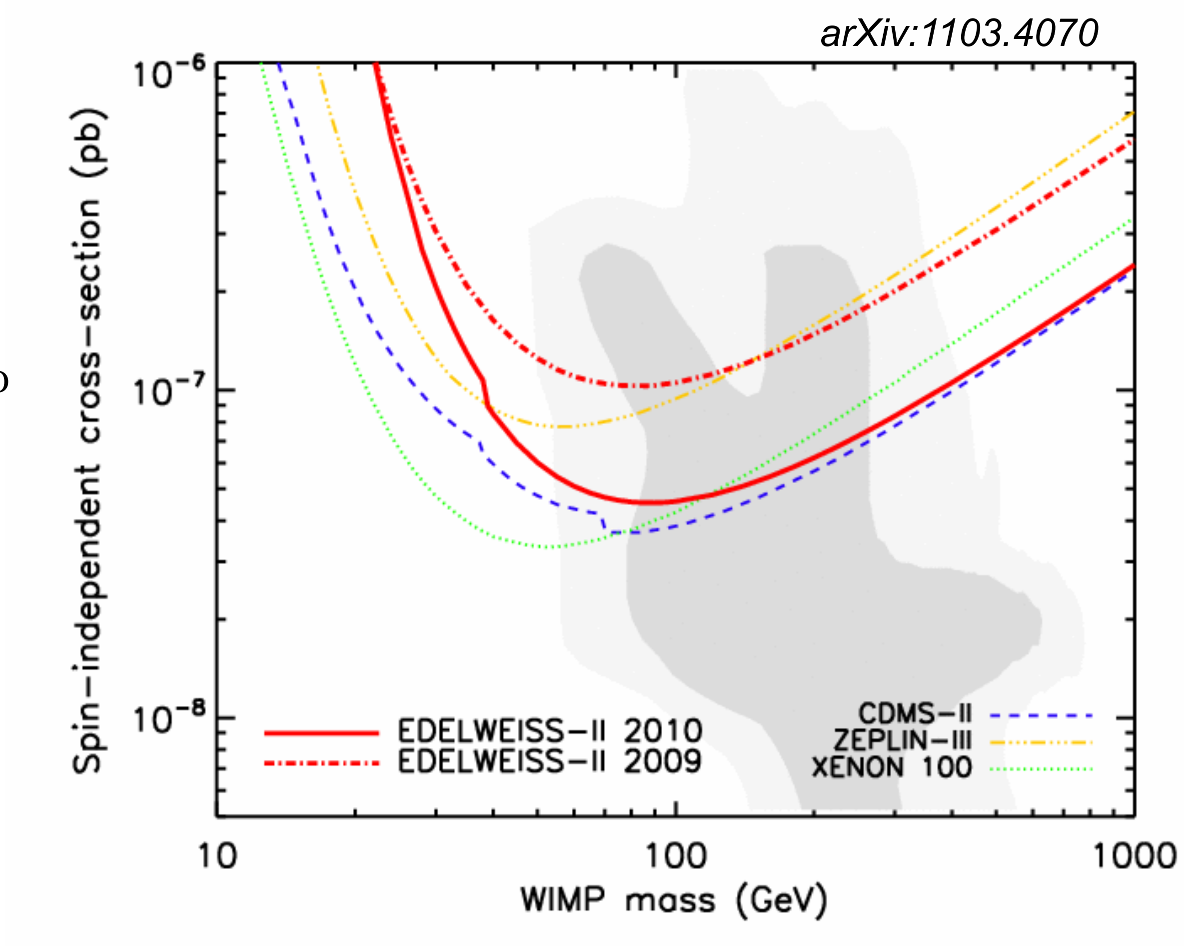
4.4 x 10^{-8} pb at Mχ=85 GeV

(x2.7 better than 2009 result)

- Sensitivity limited at low mass due to background

- current work performed with CDMS collaboration to combine data

(should improve the limit by ≈ 50%)



What's next : The EDELWEISS-III project

→ Goal :

- Reach ~5 x10^{-9} pb region by 2012 (EDW-II / 10)
- Allow reliable cross-check in case of signal by other experiment
- Preparation for 1-ton EURECA phase

→ Detectors : operate 32 fid kg by mid 2012 (Run 12 = 1.6 kg)

- New FID800 detectors : bigger Fid Mass, Heat redundancy (higher γ rejection), Fid segmentation, new surface treatment (higher β rejection)

→ Upgrade

- Cryogenics → better threshold
- Electronics with fast channel digitization and acq soft update
  → better discrimination
- Wiring for 112 channels (now 56) with 1 diff. heat and 4 ionization each
- **Shielding (internal PE) + μ veto : decrease the neutron background**

→ Cost : ~2M€ / 3 years

900kE from ANR

EDELWEISS-III : The FID800 detector

→ Increase mass + sensitivity :

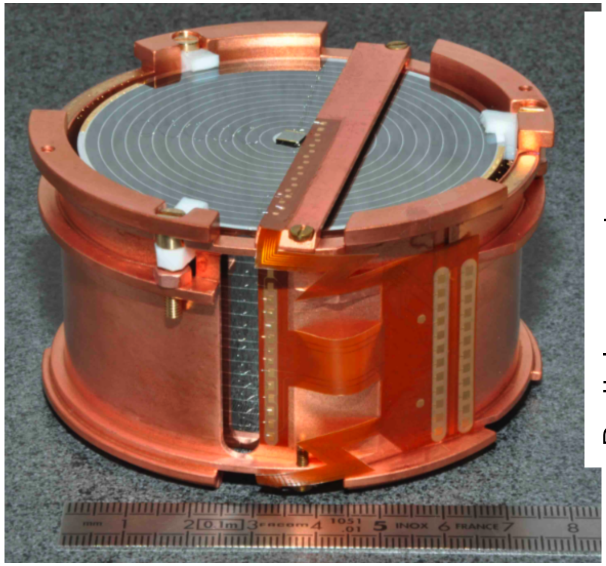
- 800g crystal

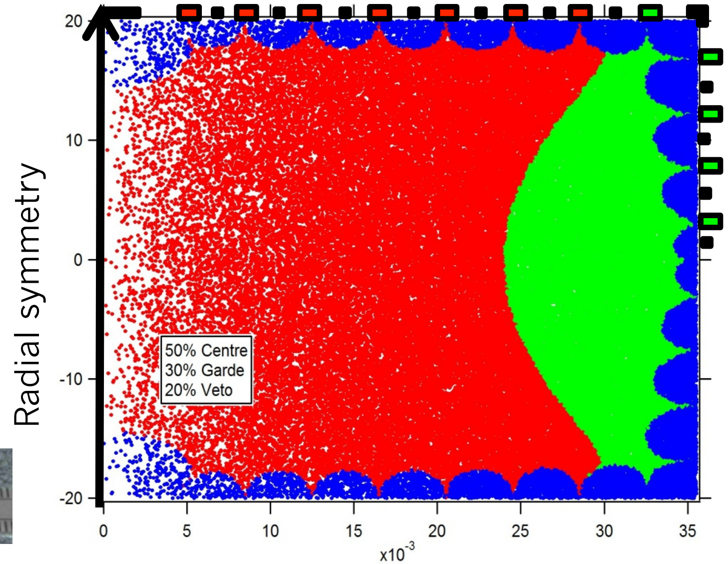
- 2 NTDs sensors per detector

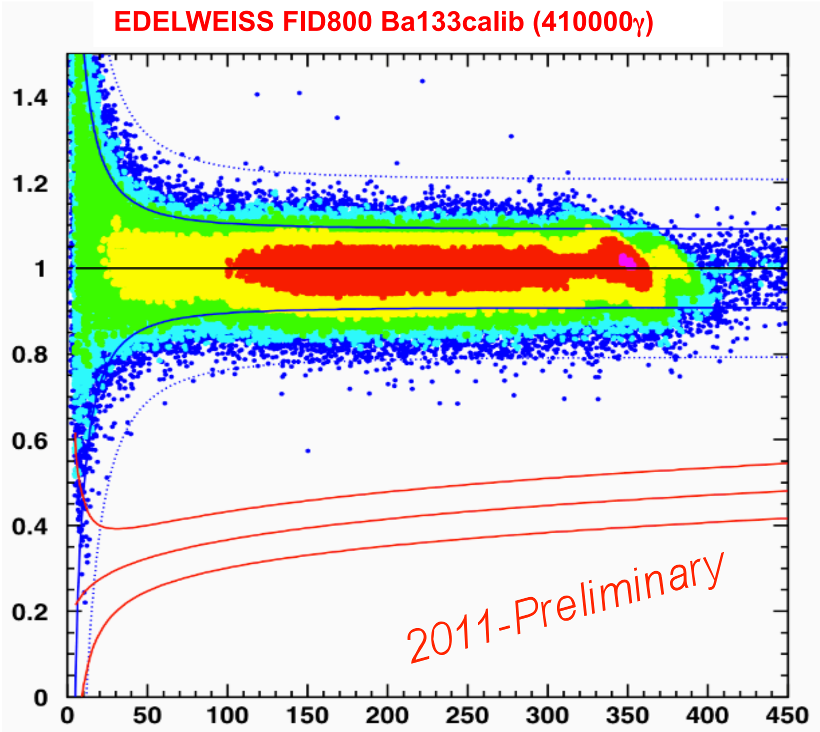
- interleaved electrodes on all the surface : no « guard » region anymore,

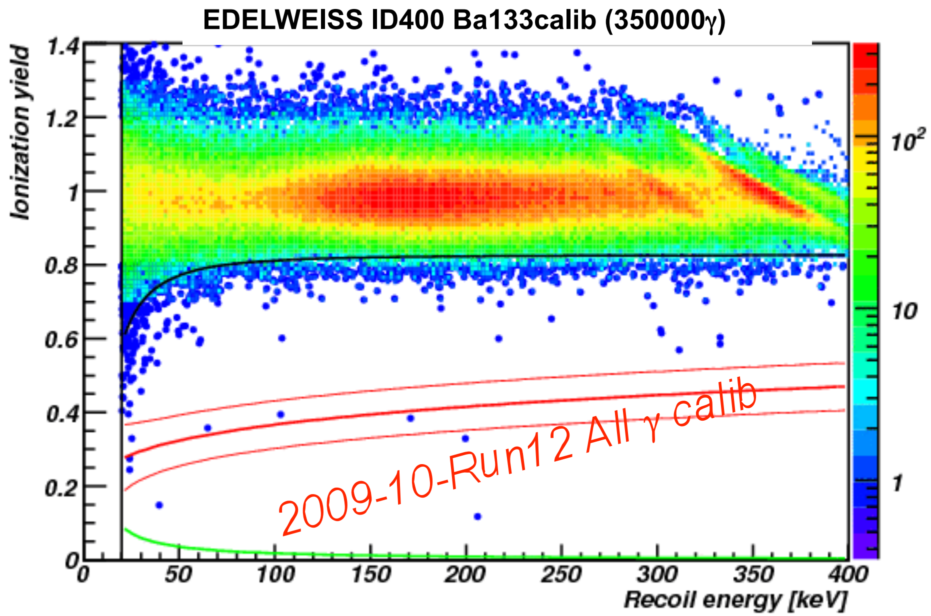
~ 80% fiducial volume

→ 8 detectors already in commissioning









→ γ rejection looks much better than for ID400

EDELWEISS long term : EURECA @ Ulisse (new LSM lab)

→ **EURECA: goal 10^{-10} pb**

- major efforts in background control and detector development

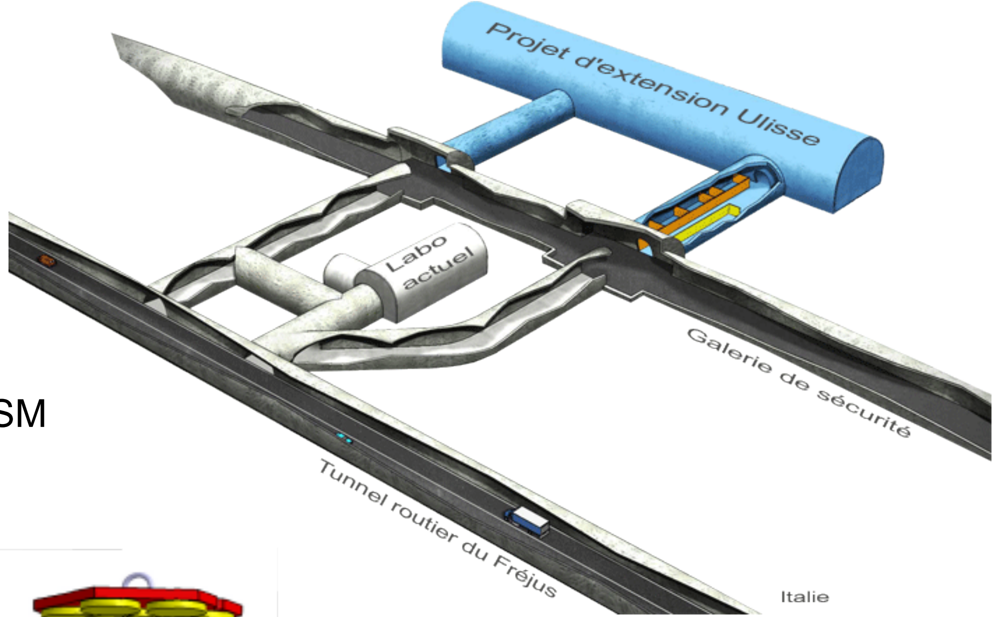
→ Joint European effort from teams from EDELWEISS, CRESST, ROSEBUD, CERN, +others…

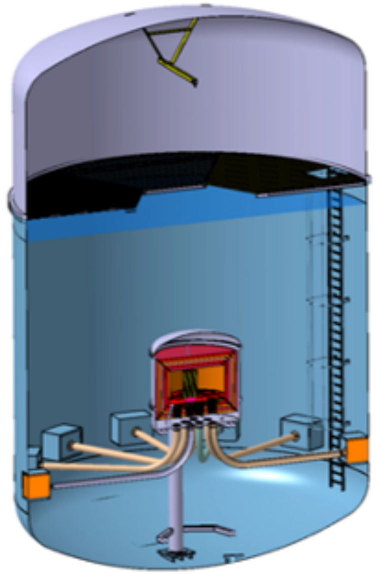
→ **>>100 kg cryogenic experiment, multi-target**

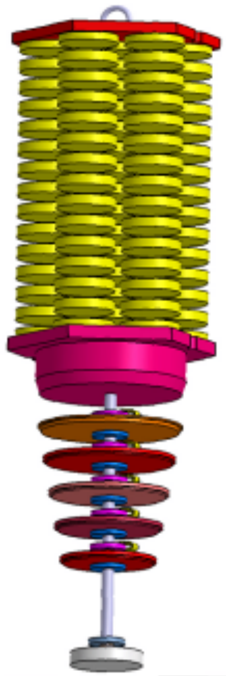
→ Part of ILIAS/ASPERA European Roadmap

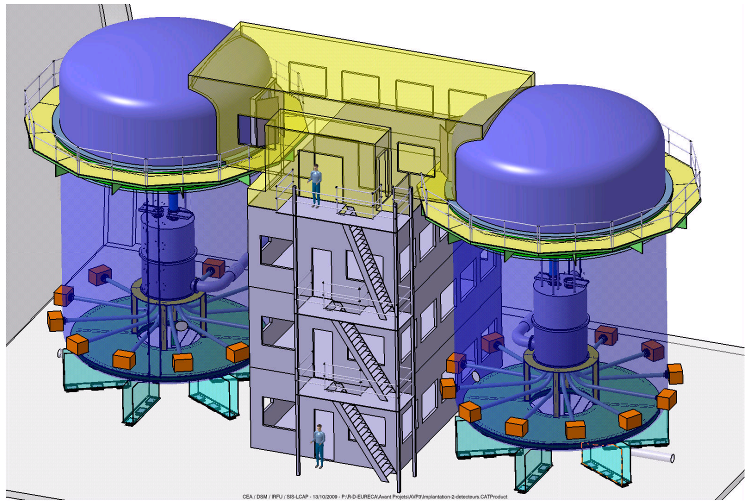
→ Preferred site: 60 000 m^2 extension of present LSM ($4\ \mu$/m2/d), to be dig in 2011-2012

→ Steps 150 kg 2013-2015 then 1 T 2016-2018
Collaboration with US GeoDM => MoU in 2009









Now supports studies of two projects :
EURECA (cryo Ge + scint)
DARWIN (liq Ar,Xe)

Cryogenics Ge : CDMS

CDMS (Cold Dark Matter Search) collaboration of US institutes (~ 50 people)

→ Comparison with EDELWEISS :

- **Same detection principle : ionization and heat measurement on cryogenics Ge (+ Si for CDMS).**
- **Surface event rejection obtained with timing parameter on the athermal phonon signals**
- ZIP detectors

→ Detectors :

- 250 g Ge or 100 g Si crystal

- Phonon Sensors :

Superconducting W thermometer

Photolithographic patterning

4 quadrants, 37 cells per quadrant

6x4 array of 250µm x 1µm W TES per cell

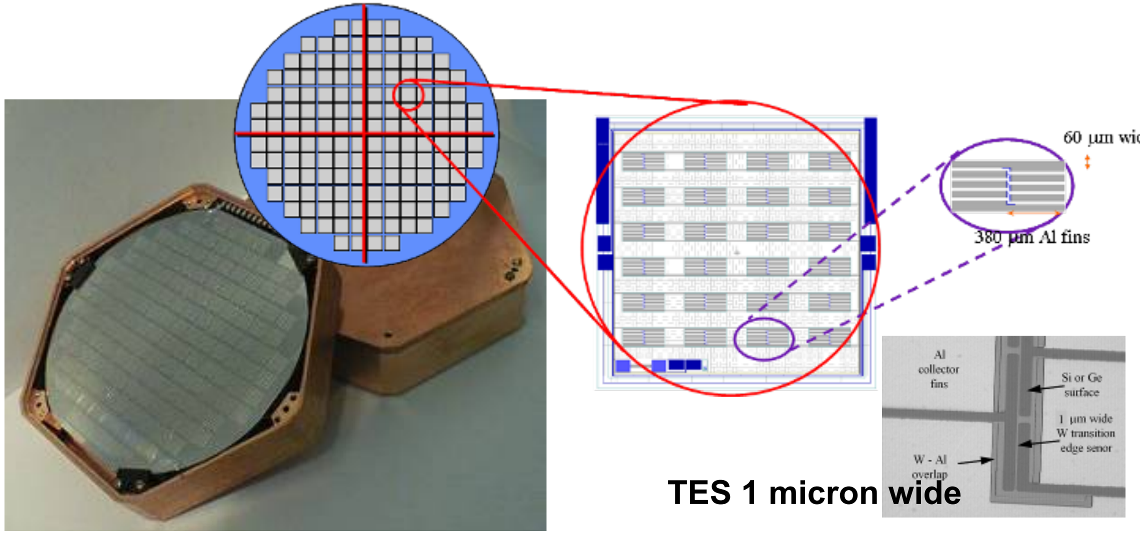
Each W sensor "fed" by 8 Al fins

- Ionization Sensors

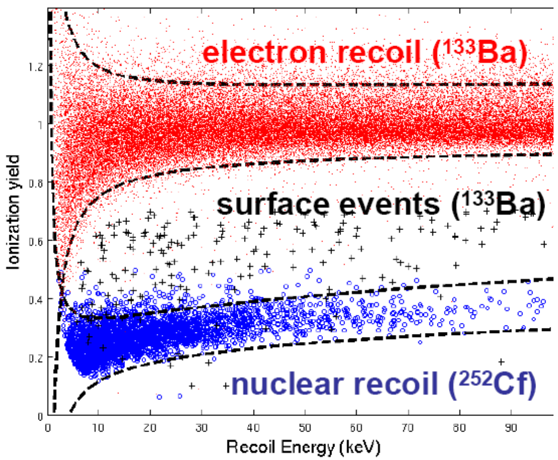
2 electrodes (+ ground) allow rejection of events near outer edge

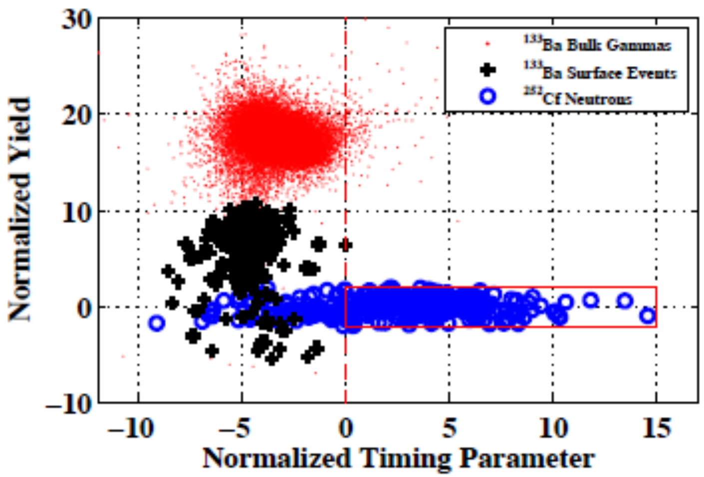
- Low impedance electronics with Squids

+ FETs pour ionization



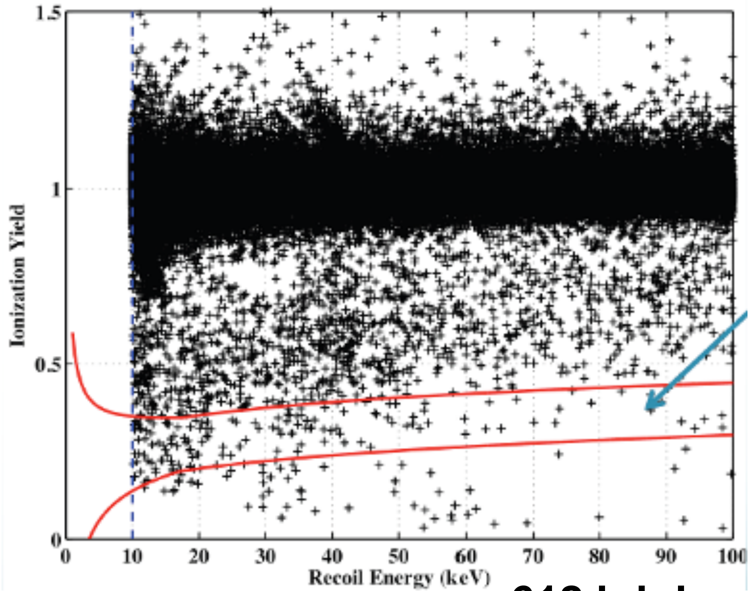
→ Rather complex fabrication and long calibration procedures





CDMS-II : 5 towers 2008-2009 results

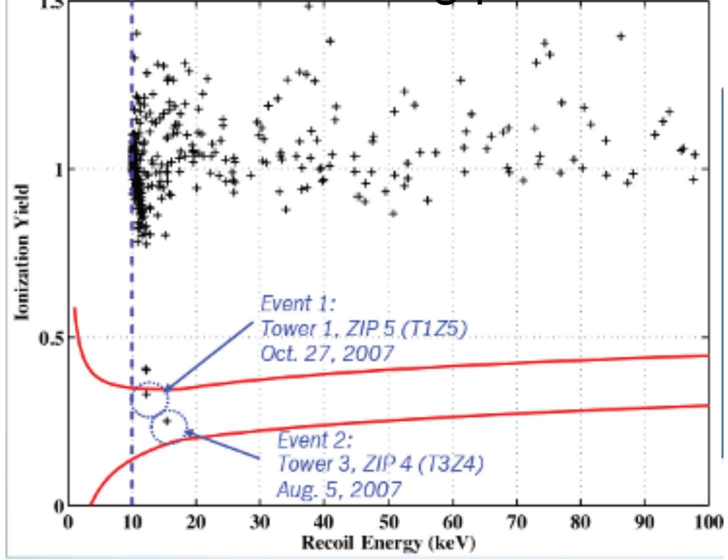
All data



Open the box
(Nov 4, 2009)

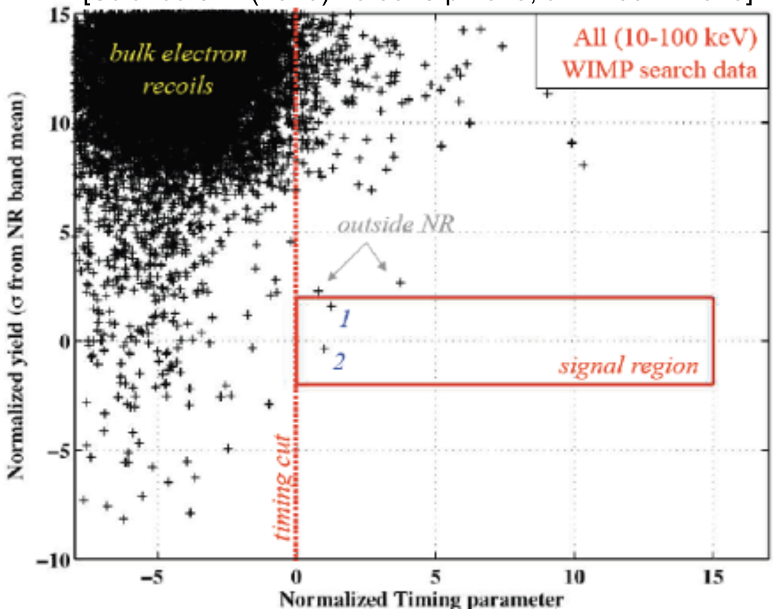
612 kd.day

After timing parameter cut



194 kd.day, **efficiciency < 30 %**
exp backg **0.8 ± 0.1(stat) ± 0.2(sys)**

[*Science* 327 (2010) no 5973 p.1619; arXiv:0912.4025]



Events not appearing as a well separated population

Probability to observe 2 or more events is 23%

"Our results cannot be interpreted as significant evidence for WIMP interactions. However, we cannot reject either event as signal either."

Wimps direct search: Nobel liquid gas

Why?

→ multi-tons detectors possible (?)

→ Classical cryogenics : 170 K for LXe, 87 K for LAr (27K for Ne)

→ Self shielding (mainly for LXe)

→ Low threshold: high scintillating yield scintillation (≈NaI(Tl))

→ Nuclear vs electronic recoils discrimination : charge/light (IIphase) or PSD (Pulse Shape Discrimination)

→ Xe (A~131) : Spin.Ind. and Spin.Dep. Coupling (~50% odd isotopes)

→ Xe: no long time radioactive isotopes (Kr-85 could be removed (?))

→ Ar: Ar-39 (radioactive) is an issued

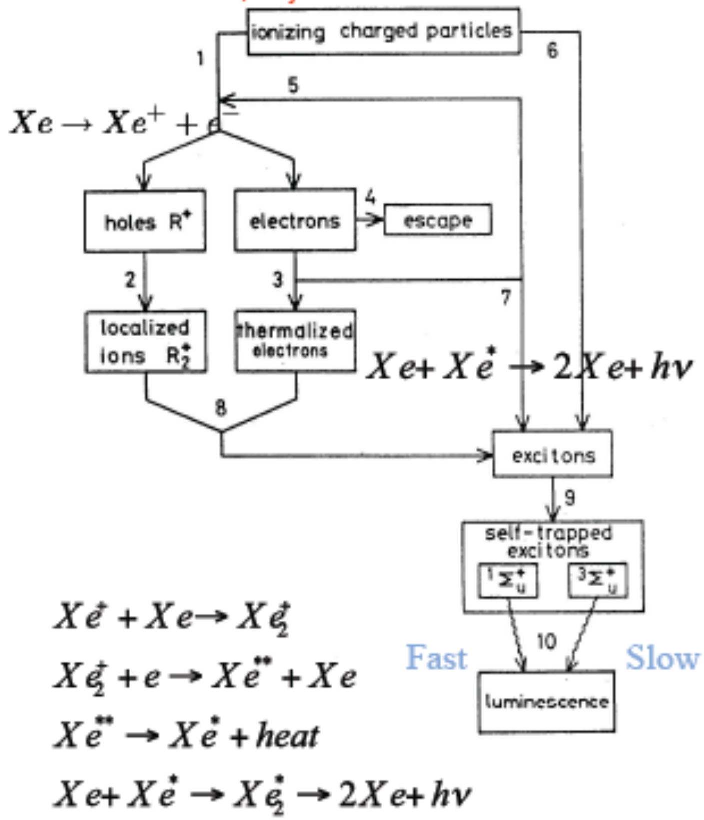
A lot of experiments + projects:

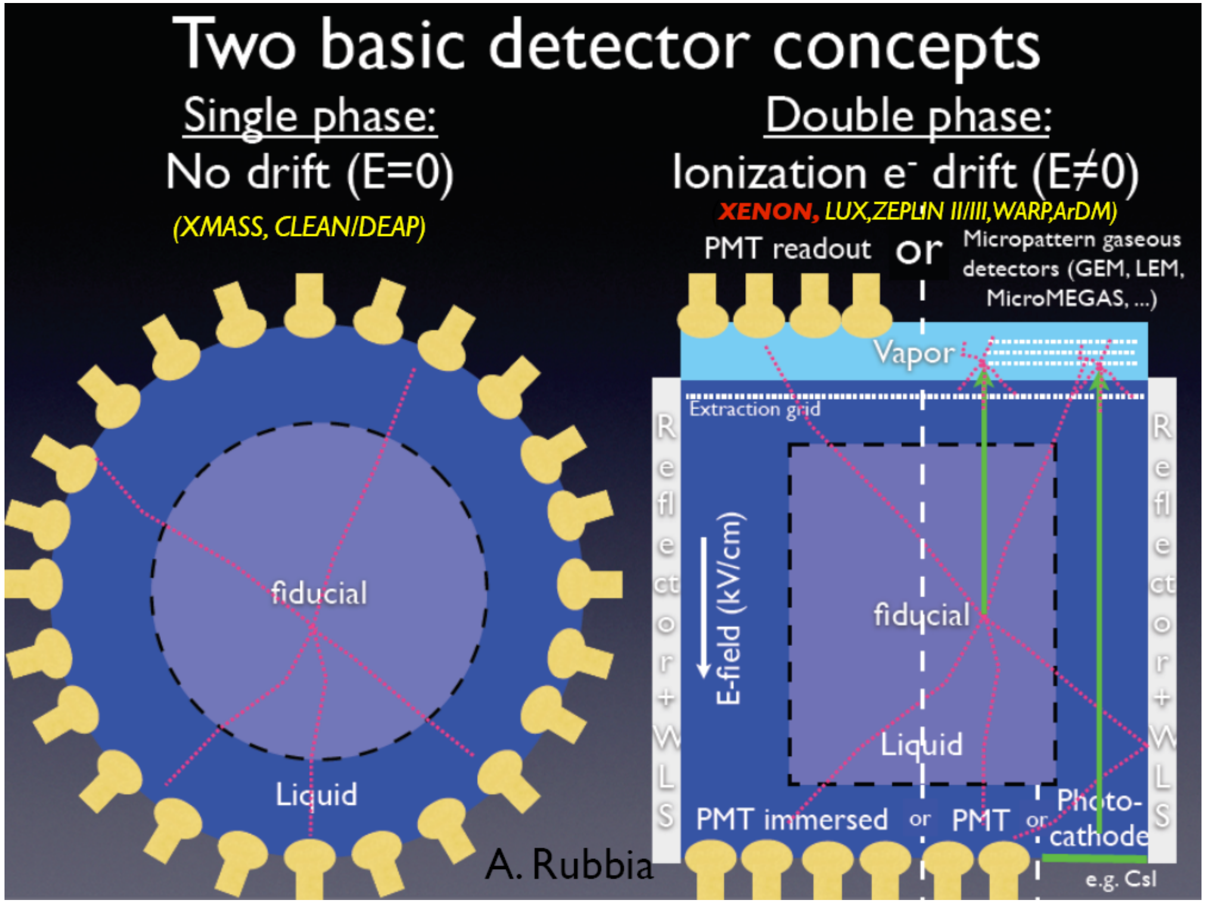
→ II-phase Xenon (discri) :	XENON (-10-100), ZEPLIN(-III), LUX
→ I-phase Xenon :	Xmass,
→ II-phase Ar (discri):	ArDM, WARP(Ar+Ne), DARKSIDE(project)
→ I-phase Ar :	DEAP/CLEAN (Ne)

+ Multi tons = DARWIN (Design Study), LZ …

Nobel liquid gas : principles

Kubota et al. 1979, Phys. Rev.B





Ar $\tau_{singulet}/\tau_{triplet}$ =7ns/1.6µs
Xe $\tau_{singulet}/\tau_{triplet}$ =4ns/22ns

→ Simple but no active evt by evt rejection

→ PSD possible (especially for Ar, ≠ lifetime singulet-triplet)

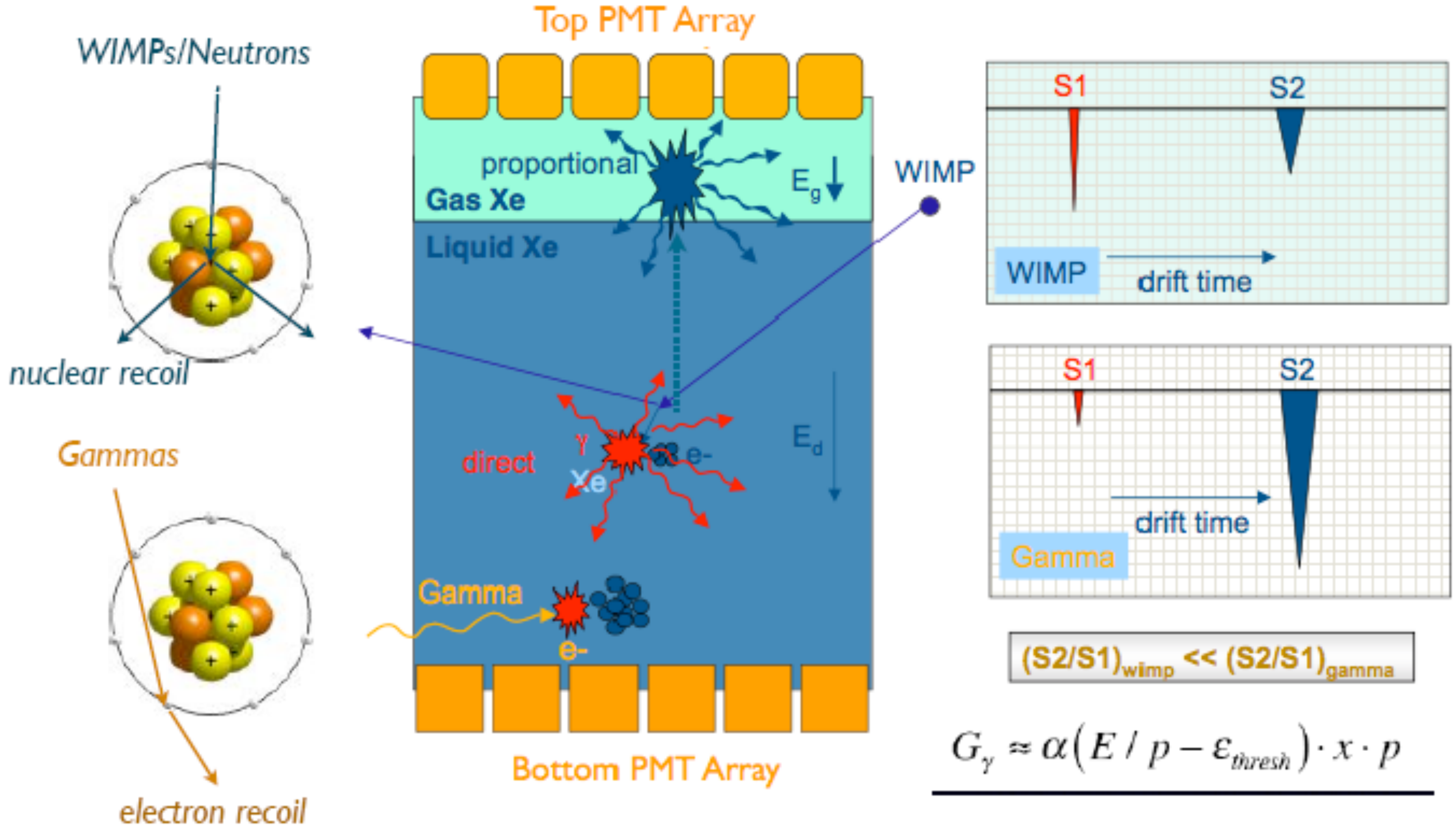
→ More complex but active evt by evt rejection.

→ ≠ technologies for charge readout

Liquefied noble gas : II-phase principle

Noble liquid two-phase TPC

From XENON-10



$$G_\gamma \approx \alpha\left(E/p - \varepsilon_{thresh}\right)\cdot x \cdot p$$

$$\alpha_{LXe} = 70\ \gamma / kV \quad \varepsilon_{thresh}^{LXe} = 1.3kV / cm / atm$$

Lxe : Xenon-10 /100 @ Gran Sasso

→ **Xenon 10** : 22 kg LXe, 15 kg actif, **5 kg fiduciel**, Drift charge on 15 cm

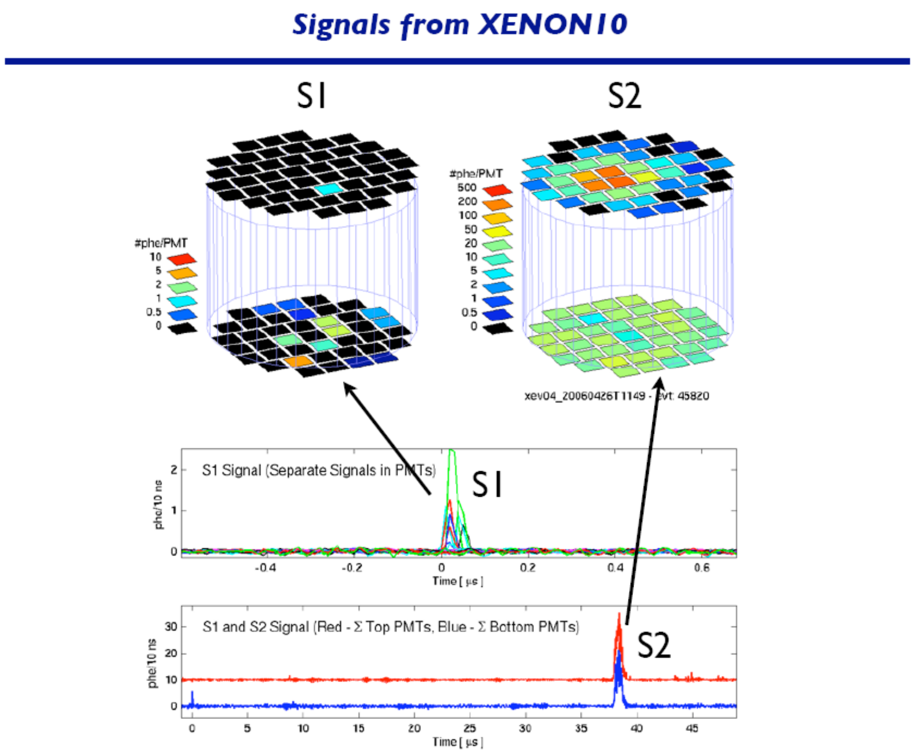
→ **Xenon 100 : 170 kg LXe, 65 kg fiduciel (≈ 45 kg after cut) + 105 kg Veto , Drift charge on 30 cm**

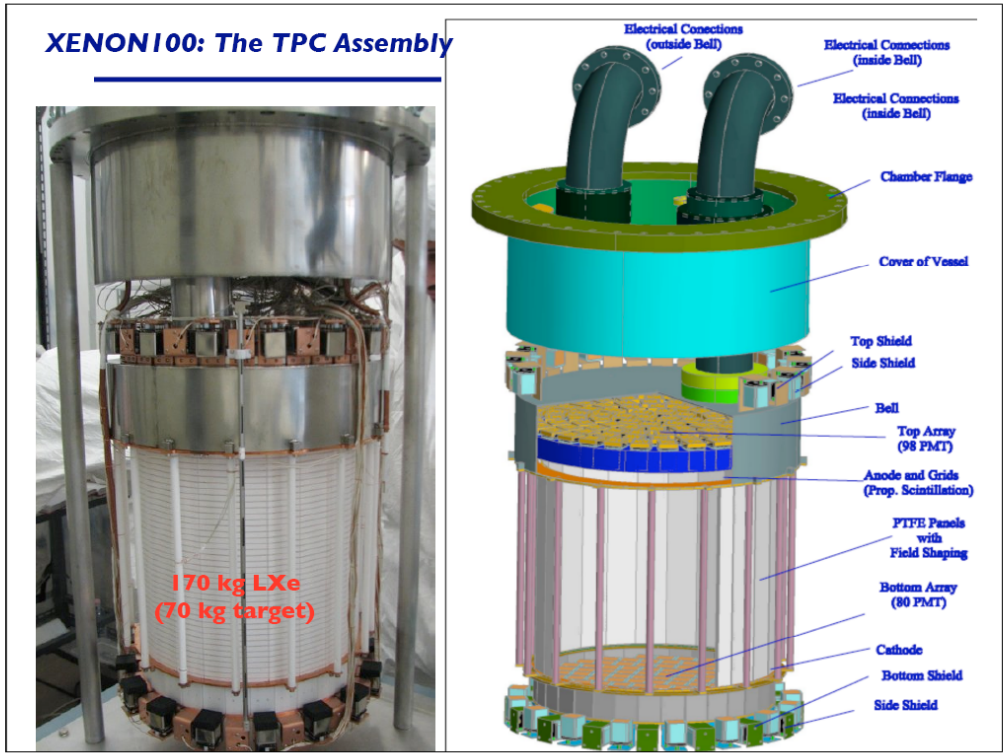
XENON Collaboration

USA, Switzerland, Portugal, Italy, Germany, France, China, Netherlands

COLUMBIA, RICE, UCLA, ZURICH, COIMBRA, LNGS, MPIK, BOLOGNA, SHANGHAI, MUENSTER, SUBATECH, NIKHEF

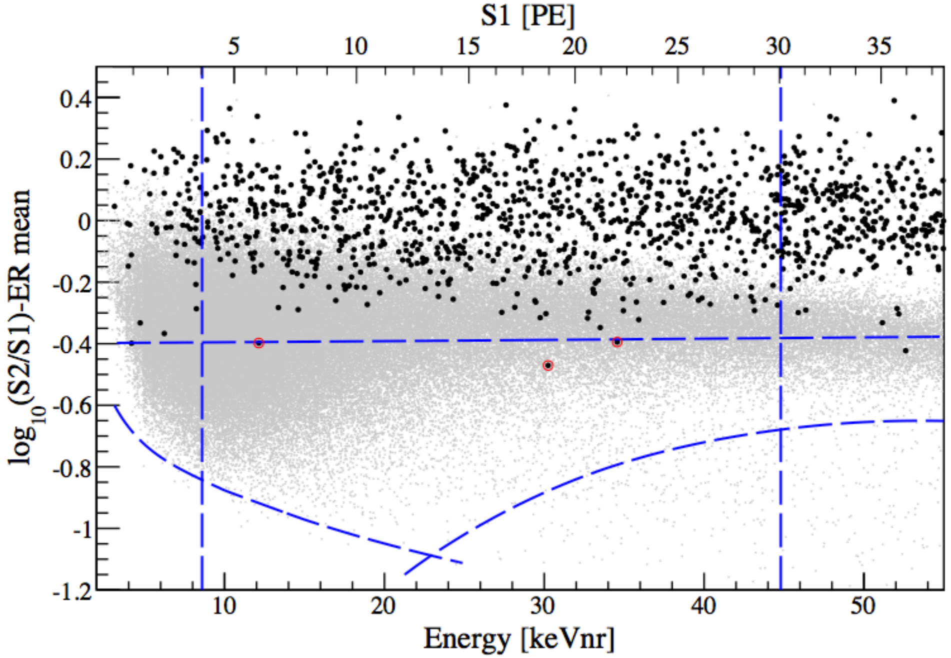
- **Hamamatsu R8520-AL 2.5× 2.5 cm PMTs**
QE ~30% @ 178 nm, < 1 mBq/PMT in 238U/232Th)
- **98 PMTs top, 80 PMTs bottom array**
x-y position : σx-y≈ 3 mm, z-position from Δtdrift , σZ<2 mm
- **16 kV cathode:** Ed=0.53 kV/cm (drift)

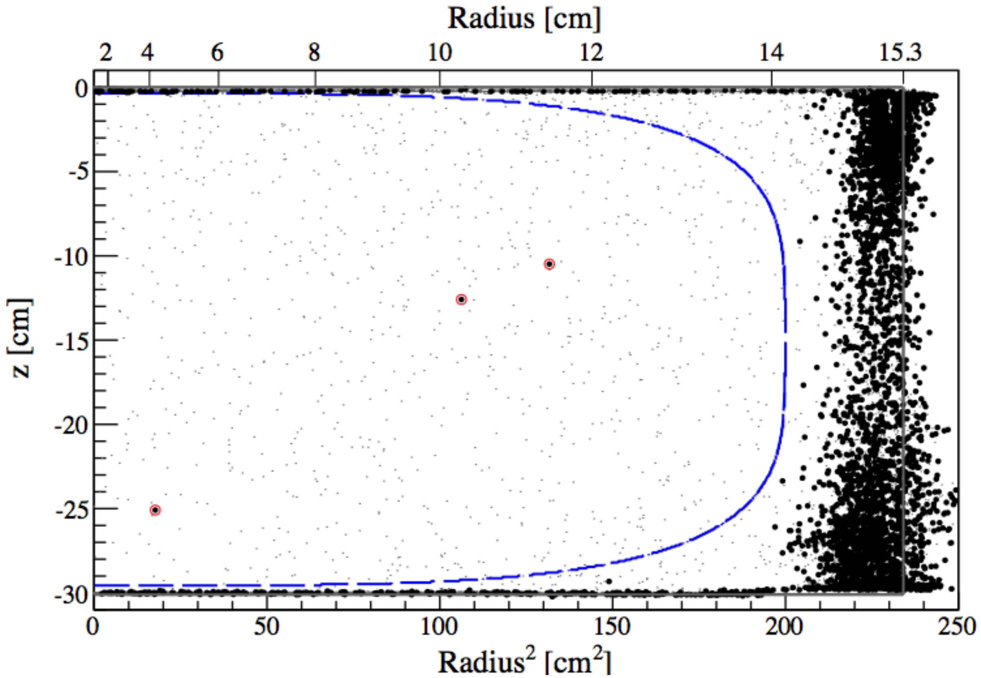




Xenon-100 : (very) last results *arXiv:1104.2549v1*

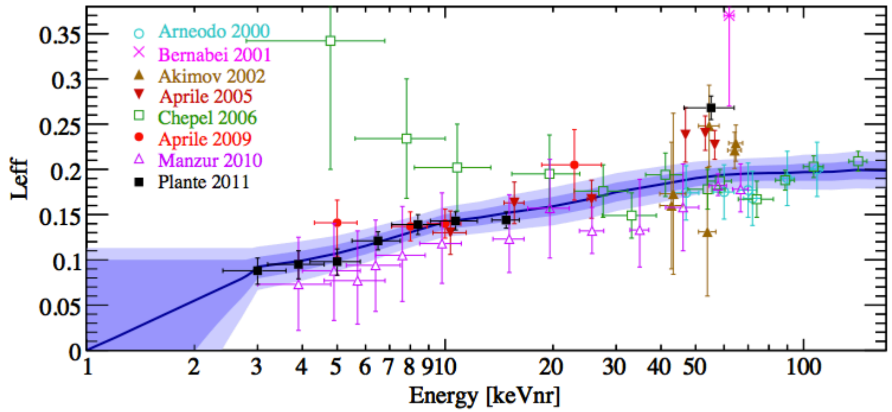
100.1 live days (Jan-June 2010), 48kg fid, eq to ≈ 1471 kg.days (acceptance corrected)
3 NR candidates, 1.8±0.6 evts expected background



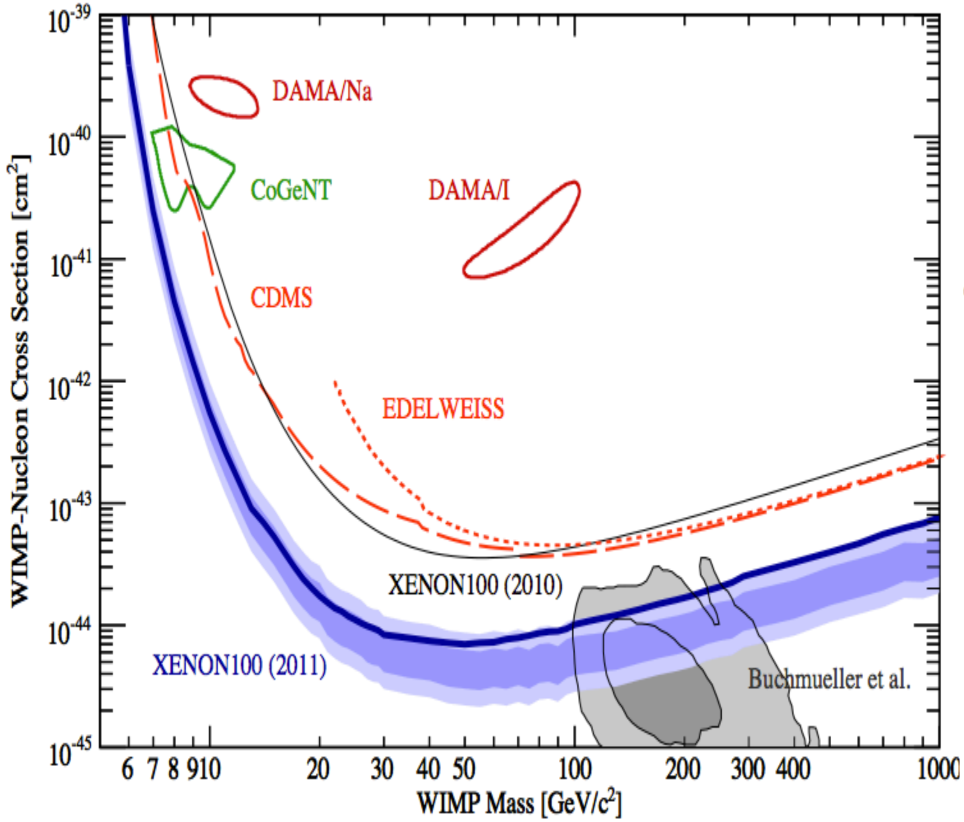


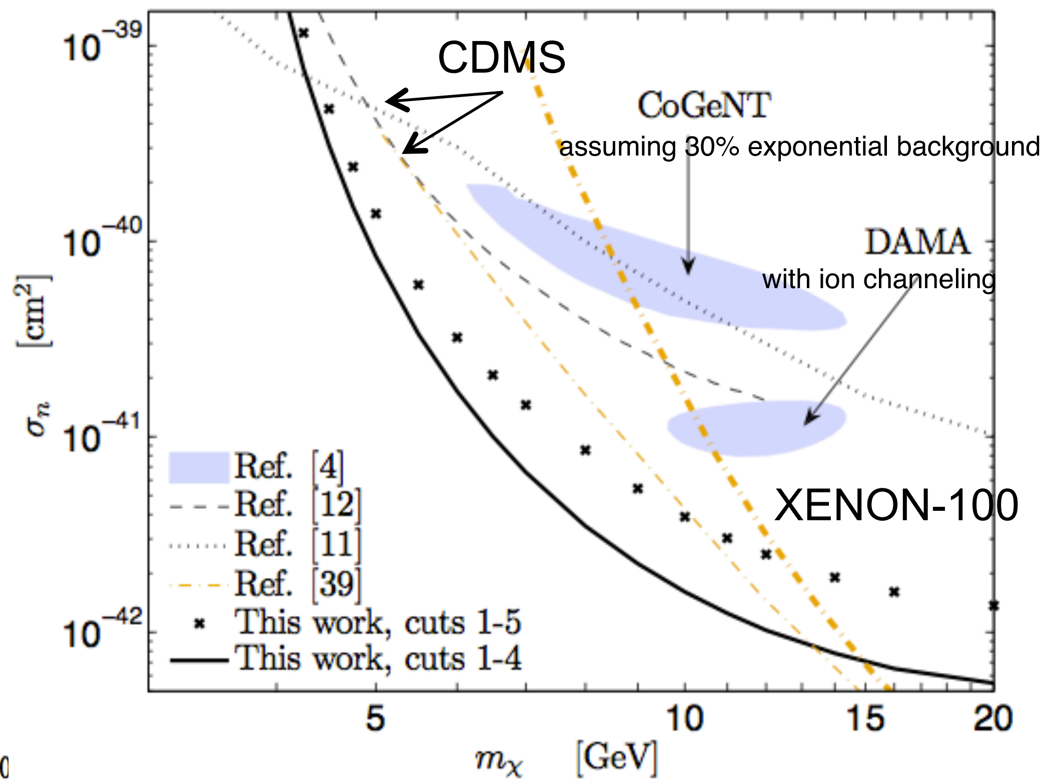
- **Gamma rejection power** of XENON-100 **below the cryogenics detectors : keep only ≈ 40% NR**

- **Absolute energy scale** (Erecoil) (calibration with γ gives Eee)
Quenching Factor Leff : Er~Leff.Eee + electric field effect on the charge collection
Virulent discussion on arXiv with CoGeNT
New dedicated measurements (arXiv:1104.2587v1)



Xenon-10-100 & Low mass Wimps





XENON-100 arXiv:1104.2549v1

Spin Ind. **$\sigma_{W\text{-}n} > 7.0 \times 10^{-9}$ pb**

for a M_W=50 GeV/c^2 (90% CL)

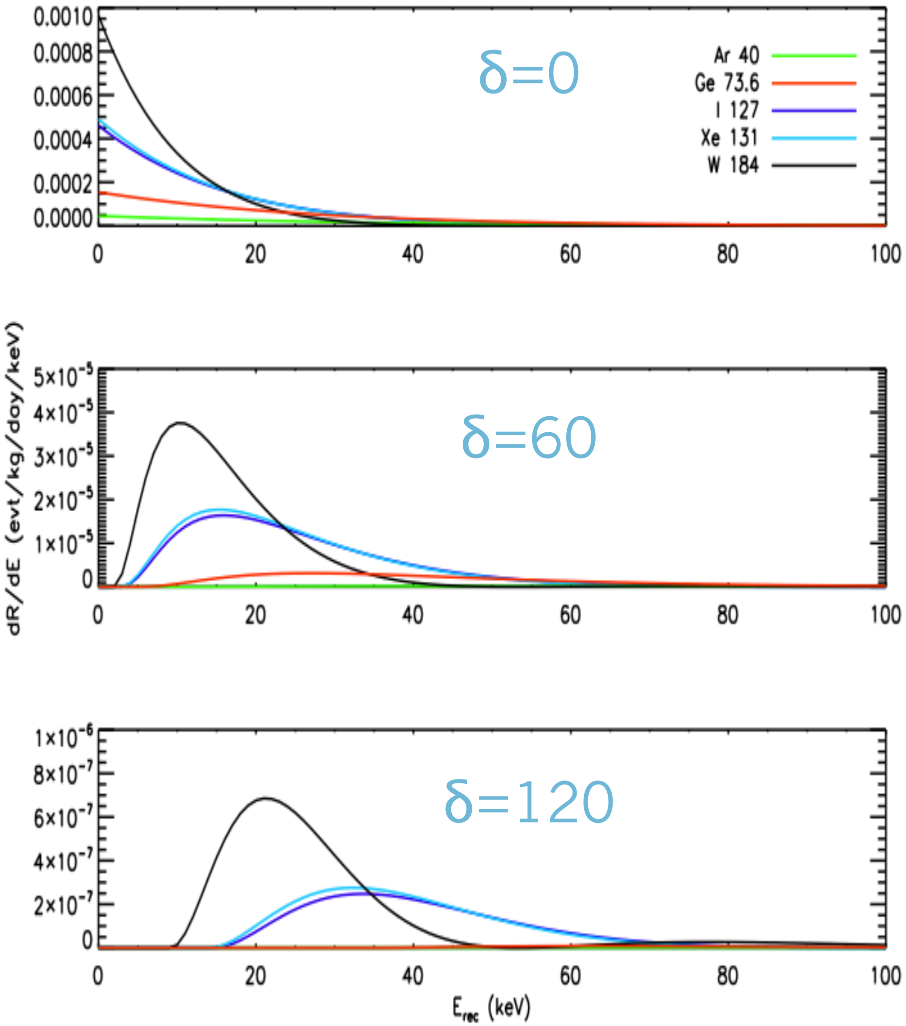
XENON-10 arXiv:1104.3088v1

Low threshold reanalysis of Xenon-10 data

→ few space for low Mass WIMPS !!....

→ CoGeNT & DAMA scenario excluded

Inelastic Dark Matter



→ **Motivation :** Dark matter modulated signal claimed by DAMA/LIBRA vs. null detection in all the other direct detection experiments

χ + m ➔ χ* + m (δ ~100 keV)

$$v_{\min} = \underbrace{\frac{1}{c^2}\sqrt{\frac{1}{2mE_R}}\left(\frac{mE_R}{\mu}\right.}_{v_{\min}^{el}} \left. + \delta\right)$$

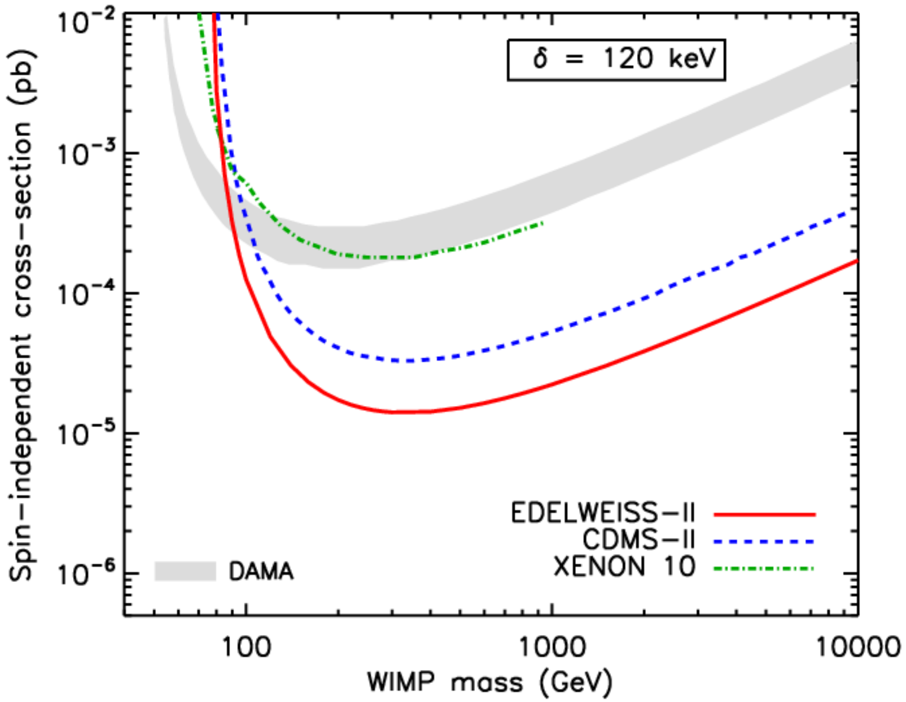
→ Signal globally reduced and suppressed at low recoil energies

→ Heavier targets preferred

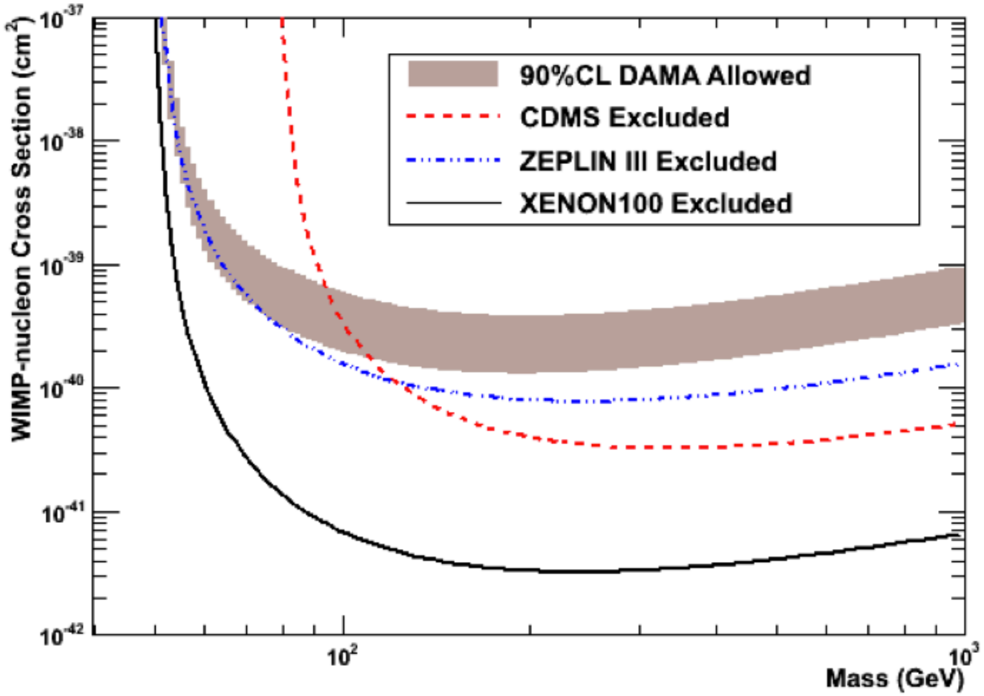
→ Modulation is enhanced

Xenon-10, EDELWEISS & inelasticDM

arXiv:1103.4070



arXiv:1104.3121v1



→ same data & analysis as in the elastic case

→ use v_{esc} = 544 km/s

(RAVE survey, arXiv:0611671, 2007)

→ DAMA allowed region excluded

for Mχ > 90 GeV (90%CL)

→ The whole DAMA WIMP region is excluded by XENON100.

Conclusion, discussion

- **EDELWEISS-II** 2009-2010 wimps search :
  384 kg.days, 5 candidates, expected background<3 evts (90%CL)
  Sensitivity of 4.4 10^{-8} at $M\chi$=85 GeV

- **CDMS-II** 2007-2008 wimps search :
  379 kg.days, 4 candidates, expected background ≈ 1.5
  Sensitivity of 3.8 10^{-8} at $M\chi$=70 GeV

- **XENON-100** 2010 wimps search :
  1471 kg.days, 3 candidates, expected background 1.8±0.6 evts
  Sensitivity of 7 10^{-9} at $M\chi$=50 GeV

➔ **The 10-8 pb "focus point" is now in hands !**

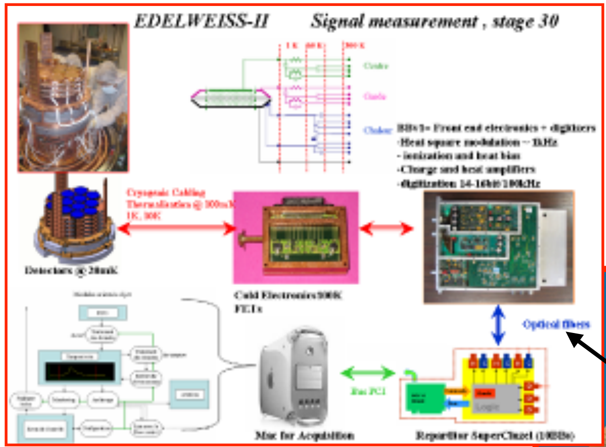
+ CoGeNT (77K Ge, ultra low threshold) : excess of signals compatible with M<10 GeV Wimps
+ CRESST (not published) : excess of signals compatible with M<15 GeV Wimps
+ DAMA annual modulation (at 8.3σ CL !) : compatible with M< 15 GeV

➔ **ALL leading experiments have candidates AND backgrounds …**

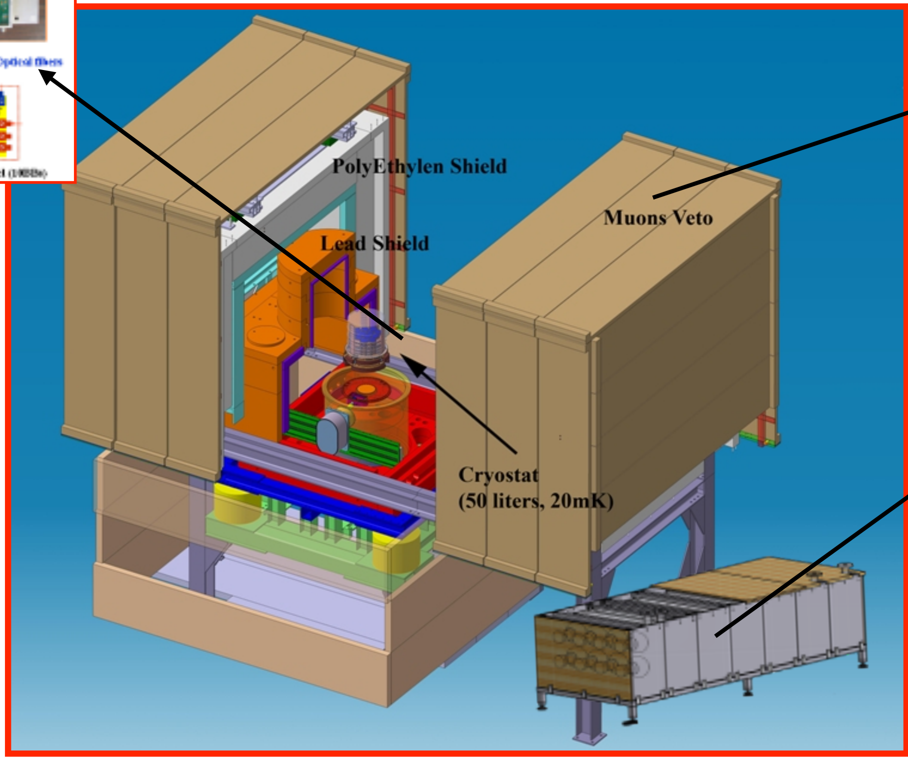
➔ Main challenges for the coming updates of experiments and future projects :
- ➔ improve the Electronic Recoils rejection (an issue for Lxe)
- ➔ huge care in the neutron backgrounds (+ γ for Lxe)
- ➔ convince people for the background estimations (best if 0 bkg…)

- EXTRA

EDELWEISS-II setup : additional detectors



Bolometers + μ veto system
+ Radon detector
+ liquid scintillator neutron detector
+ thermal and fast neutron 3He detectors



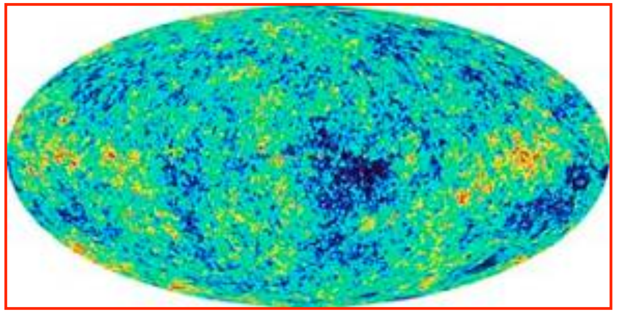
μveto system
Working continuously,
To tag bolo-veto coincidences

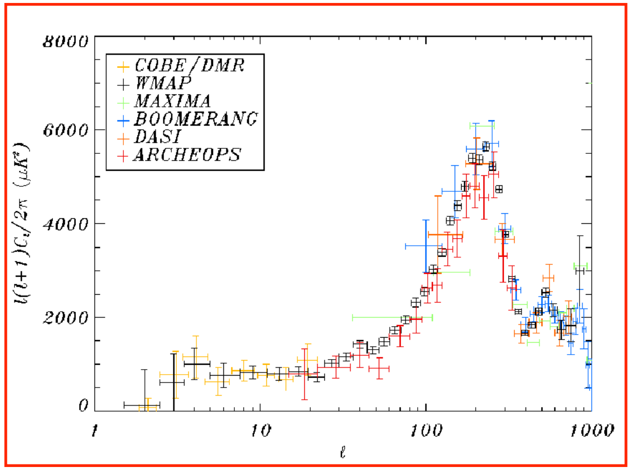
• additional detectors #3 =
liquid scintillator neutron counter
Precise studies of muon induced neutron

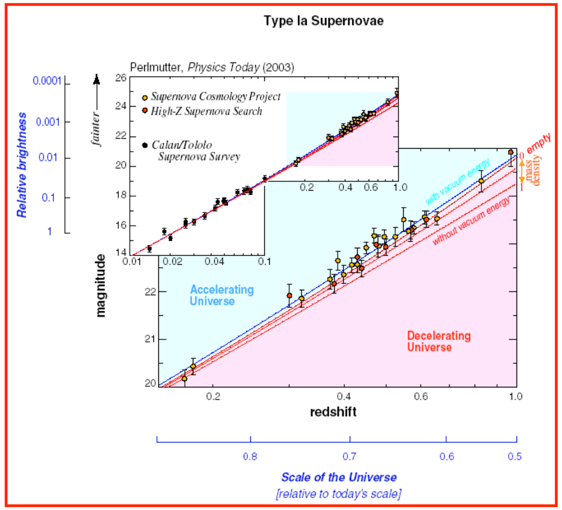
• additional detectors #1 =
Radon detector
Continuous monitoring of Radon level

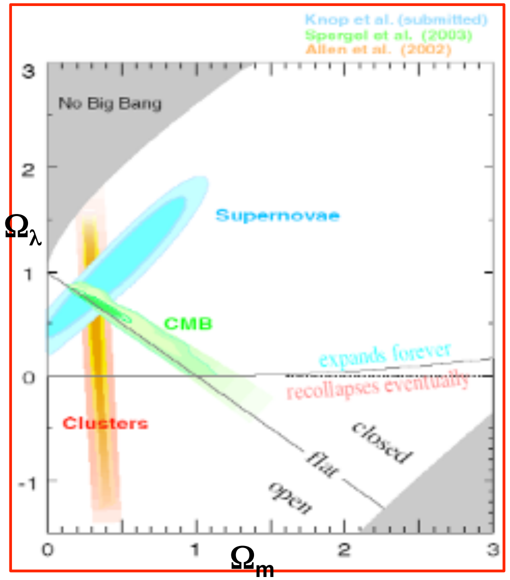
• additional detectors #2 =
He3 neutron detector
Check the thermal neutron rate at different place in the LSM

Dark matter @ cosmological scales

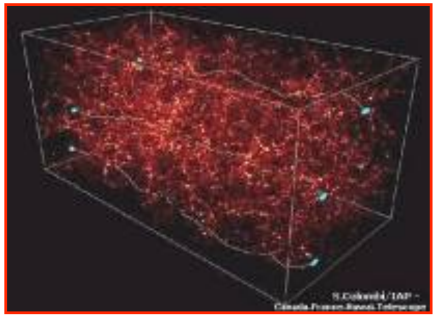


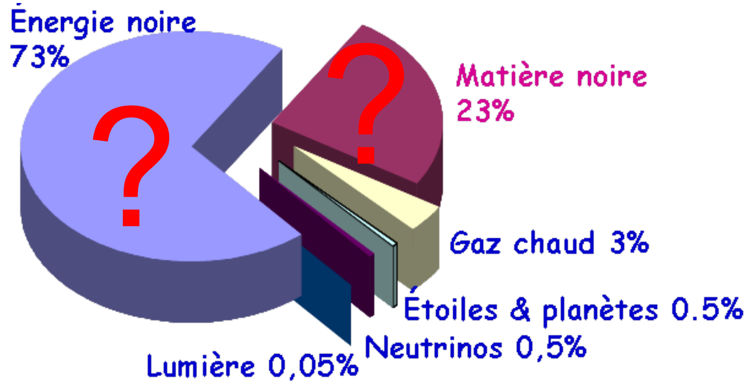






- Structure à grande échelle
- Simulation
- Anisotropie CMB (fond difus cosmologique
- SN IA (SuperNovae standard)
- BAO (oscillation acoustique baryons
- Mesures dynamiques …



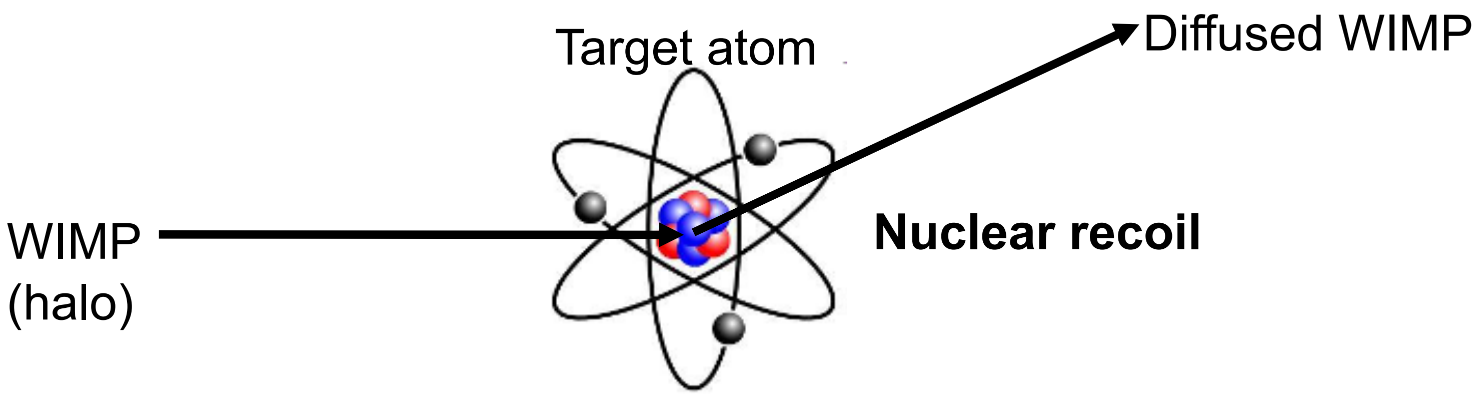


Modèle de concordance :

$\Omega_i = \rho_i / r_{critique}$ ($r_c \approx 10^{-29} \approx 5 protons/m^3$)

- $\Omega_{total} \approx 1$
  - $\Omega_\lambda \approx 0.73$ (« Énergie du vide »)
  - $\Omega_{matter} \approx 0.27$ CMB+SN1A+BAO
- $\Omega_{baryonique} \approx 0.04$ BBN + CMB
- (Rq: visible qq ‰)
- $\Omega_{matière\ noire\ chaude} < 0.02$ (ν)
- **$\Omega_{matière\ noire\ froide} \approx 0.23$ (…)**

Direct WIMPs search: principles (1)



- **WIMPs signal = elastic diffusion on target nucleus**
- Cinematic (energy)

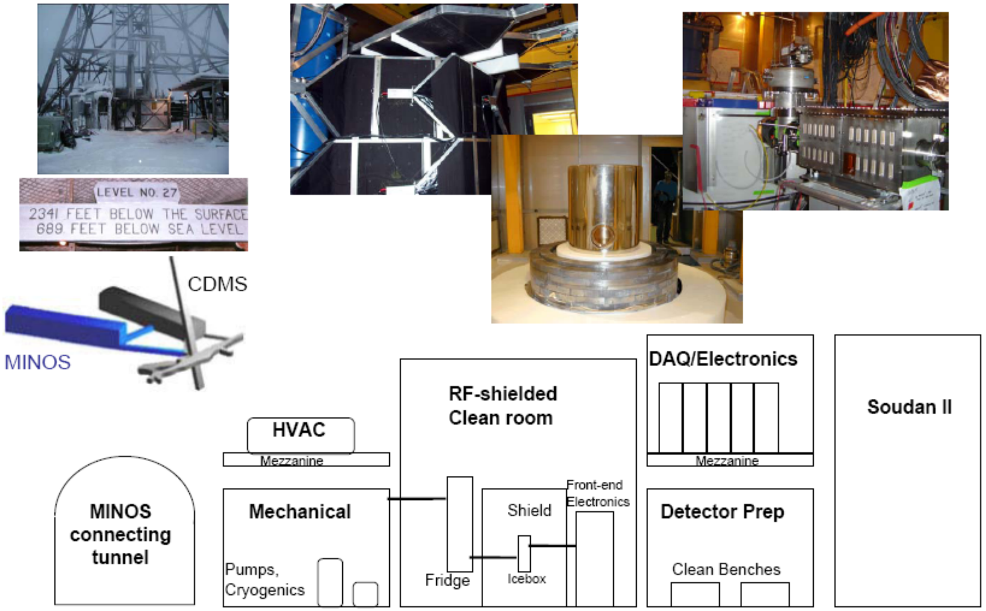
$$E = \frac{\mu^2}{m_A} v_w \left(1 - \cos\Theta\right) \qquad avec \quad \mu = \frac{m_w m_A}{m_w + m_A}$$

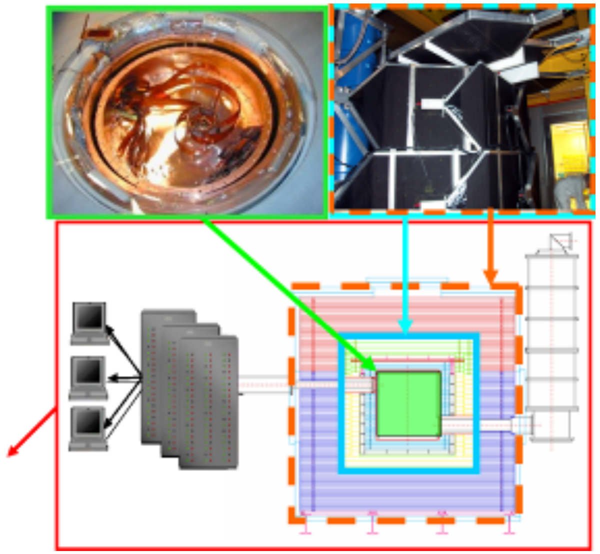
- Typ. Interaction rate :
  (nber evts/time unit)

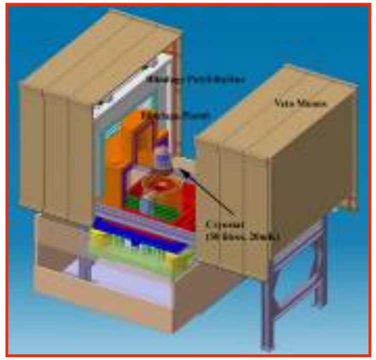
$$R = \frac{\rho_{0w}}{m_w} N \sigma_{w-A} \langle v_w \rangle$$

Densité local de Wimps/ masse du Wimps	Nombre d'atome cible	section efficace Wimps-Noyau	vitesse moyenne Wimps

CDMS Soudan Installation





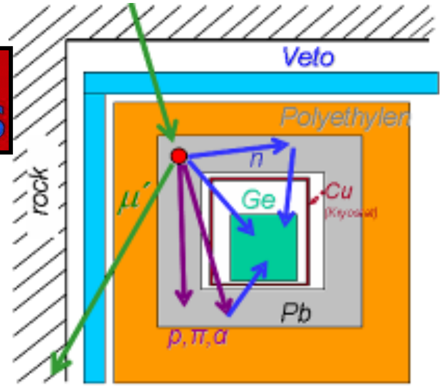


Mine du Soudan (Minnesota)

- **Moins bonne couverture que tunnel du Fréjus**
- **Plus de contrainte sur le veto**
- **Sudbury/SNOLAB est envisagé pour SuperCDMS**

- CDMS : Veto m + 40cmPE-20cmPb-10cmPE
- EDW : Veto m + 50cmPE-20cmPb

- **Simulation MC : Fond neutron négligeable pour CDMS et EDELWEISS pour qq 1000kg.jour**



CDMS-II : détecteur ZIP

ZIP: Z-sensitive Ionization and Phonon Detector

Detectors :

- 250 g Ge or 100 g Si crystal

1 cm thick x 7.5 cm diameter

- Phonon Sensors : Superconducting W thermometer

Photolithographic patterning

4 quadrants

37 cells per quadrant

6x4 array of 250μm x 1μm W TES per cell

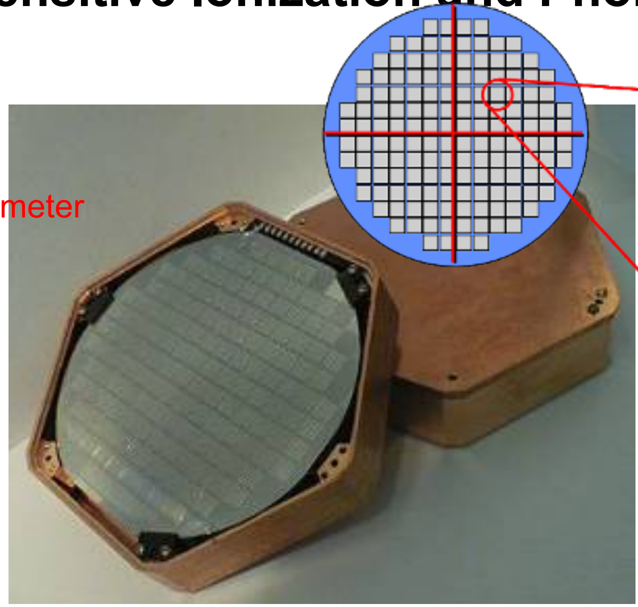
Each W sensor “fed” by 8 Al fins

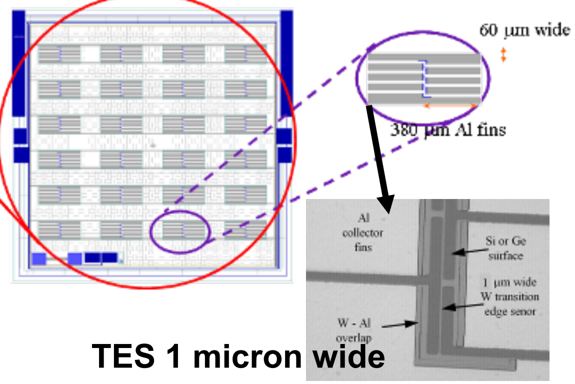
- Ionization Sensors

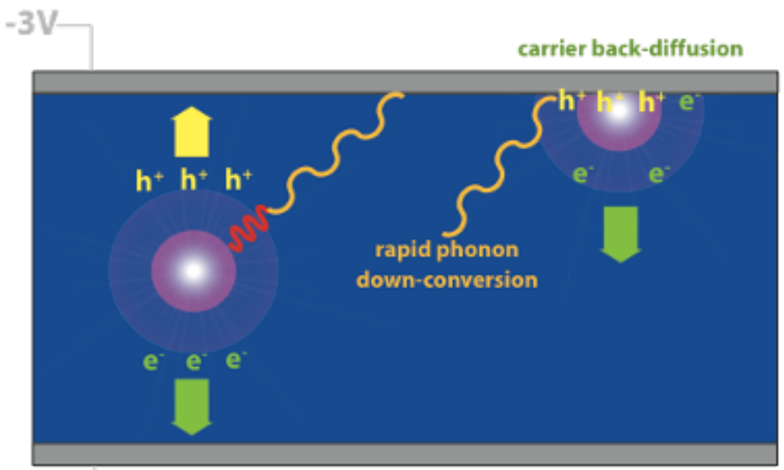
2 electrodes (+ ground) allow rejection of events near outer edge

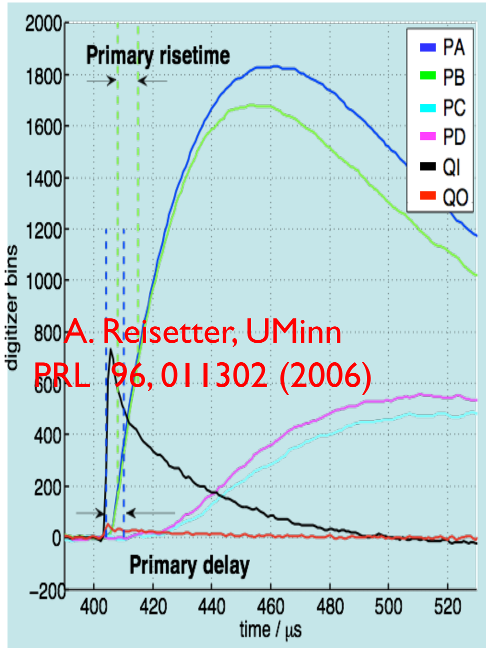
- Low impedance electronics with Squids

+ FETs pour Ionisation









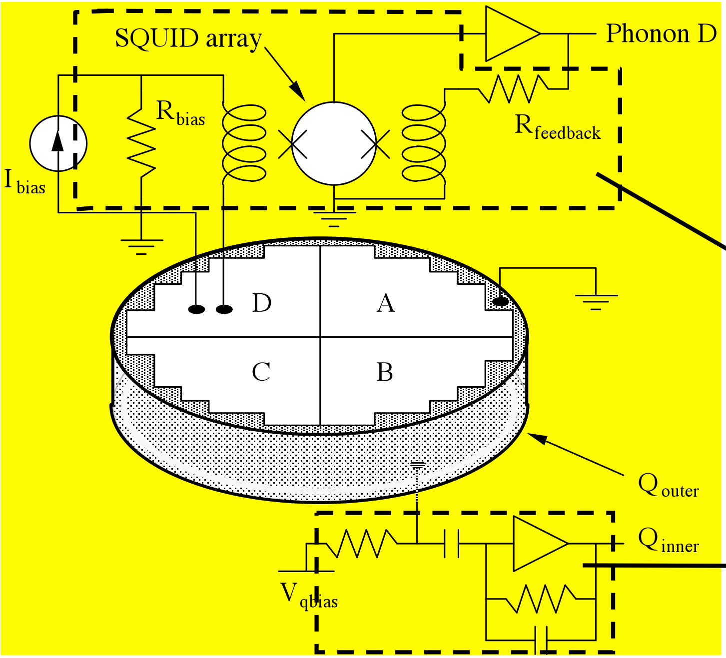
Physics of phonons degradation : surface events have faster rise time.

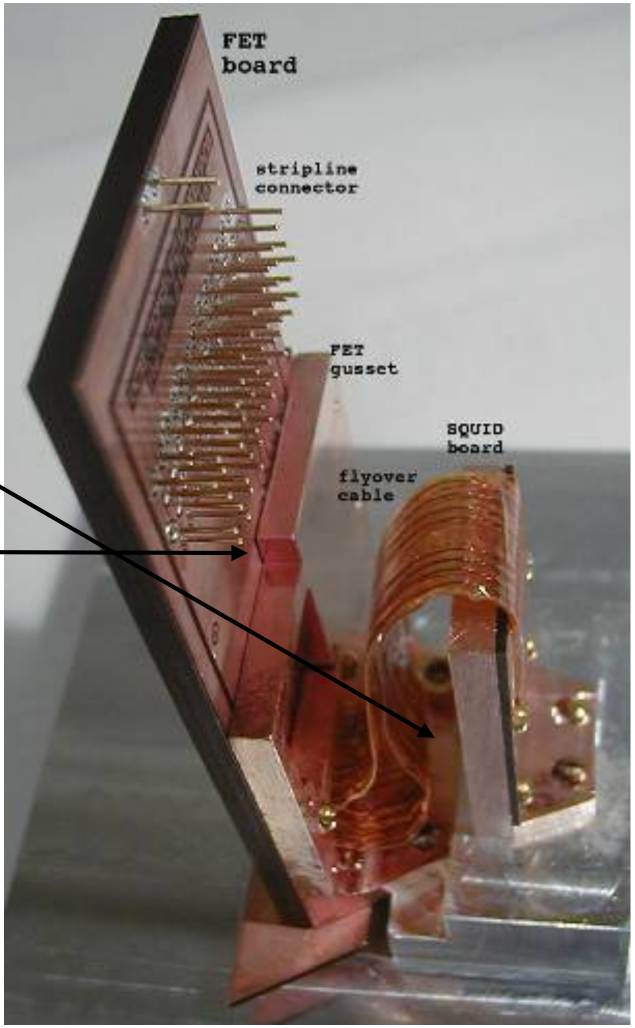
→ 2 parameters used for cuts :

- Primary risetime (delay 10% - 40% phonon amp.)

Primary delay delay 20% charge amp and 20% phonon amp.)

CDMS-II : Électronique froide « SQUETs »





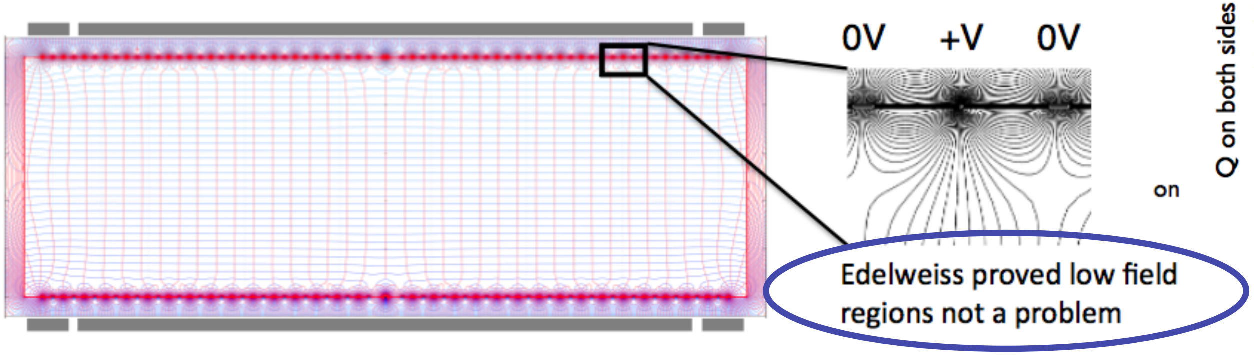
- Phonon signals are readout by SQUID based Amps (0.6 K)
- Charge Amps first stage: Cold FET (130 K)
- Both SQUID and FET based amps are assembled on a single card (SQUETs)
- A CDMS "tower" consist of 6 ZIPs and corresponding SQUETs.

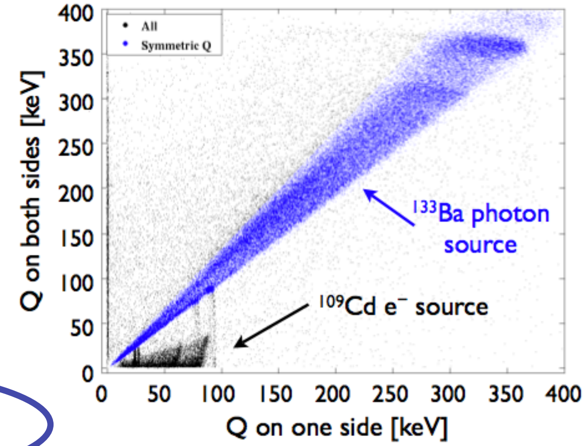
5 tours à Soudan : 4.5 kg of Ge

CDMS-II future: going to « i-ZIP », further steps

Improving Background Rejection

- Interdigitated ZIP (iZIP) design meets needs for SuperCDMS SNOLAB and GEODM





M. Pyle, B. Serfass

Larger Substrates

- Larger substrates provide gains in cost/time per kg and bgnds
- Step 1: 10-cm "standard" HPGe substrates (Ortec, Umicore)
- Step 2: 15-cm dislocation-free Ge

Inst. Phys. Conf. Ser. No. 31 © 1977: Chapter 3

=> 5 kg unit

Reducing Cost/Time: Demonstrated Fab Improvements

« Industrial » process

Steps :

⇒ Super CDMS @ Soudan : 15 kg (2010-2012) start running with 600g i-ZIP

⇒ Super CDMS @ SNOLAB : 100 kg (2012-2017)

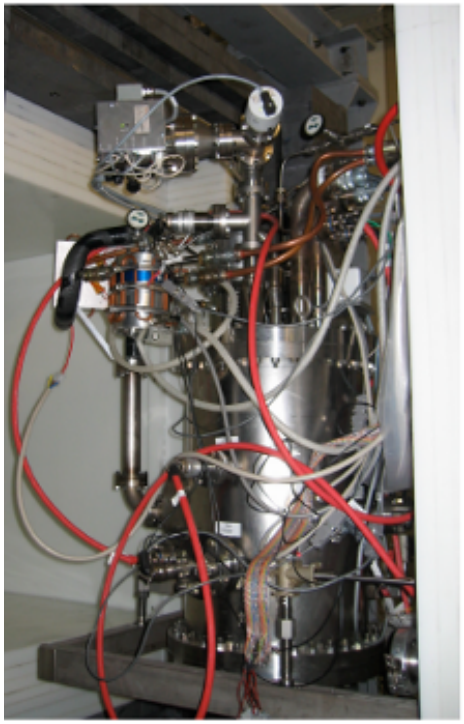
⇒ GeoDM @ DUSAL : .5 T (2017-…)

Planned progressive collaboration btw Edelweiss/EURECA and CDMS/GeoDM

Liquefied noble gas LXe: Xenon

The XENON Dark Matter Search Phases

the past
(2005 - 2007)



XENON10

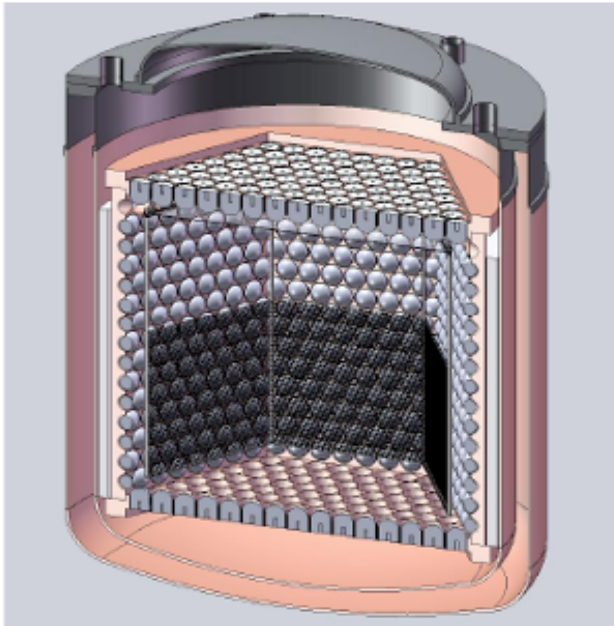
Achieved (2007) σ_{SI}=8.8 x10^{-44} cm^2
PRL100_021303(2008)
PRL101_091301(2008)
arxiv:1001.2834v1

the current
(2007-2010)

XENON100

Projected (2009) σ_{SI}~2x10^{-45} cm^2
Arxiv:1005.0380v1

the future
(2010-2014)



XENON1T

Projected (2014) σ_{SI}~10^{-47} cm^2