EURECA: Dark Matter search with 1t of cryogenic detectors

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for EURECA collaboration

TAUP2011
Munich, September 7th
EURECA short history

- Foundation date: 2005 - 1st meeting in Oxford: EDELWEISS and CRESST decided to put efforts together for next generation experiment: 1 ton cryogenic multitarget exp
- 2006: CERN, ROSEBUD joined, collaboration agreement written, WP structure set up
- 2007-2010: Bordeaux, Kiev, Sheffield joined

France
- CEA/IRFU Saclay (G Gerbier coord)
- CEA/IRAMIS Saclay
- CNRS/Neel Grenoble
- CNRS/CSNSM Orsay
- CNRS/IPNL Lyon
- CNRS/IAS Orsay
- CNRS/ICMCB Bordeaux

Spain
- Zaragoza

Ukraine
- Kiev

United Kingdom
- Oxford
- Sheffield

Germany
- MPI für Physik, Munich
- Technische Universität München
- Universität Tübingen
- Karlsruhe Institute of Technology

International
- JINR Dubna
- CERN

Around 115 members (65 FTE) currently on Edelweiss, Cresst, Rosebud and others
EURECA main features

- To reach low part of SUSY space need 20 years or 1t
- Multitarget: Ge, scintillators: allows redondancy, A^2 dependence check
- Good resolution, low thresholds, high discrimination against background: EDWII, CRESST (300g to 800g unit)
- For Germanium: high intrinsic purity
- But to see few evts/t.y, need significant improvements in background
- Staged approach
  - EURECA 1 = 150 kg
  - EURECA 2 = 1t
## Typical actual performances

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Threshold (Erecoil) for DM search</th>
<th>FWHM @ threshold keVr or keVm</th>
<th>Background rate in ROI fid mass</th>
</tr>
</thead>
<tbody>
<tr>
<td>Edelweiss</td>
<td>20 keV</td>
<td>Eph 1 keV – Er 5 keV</td>
<td>≃ 1/100 kg.d</td>
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<tr>
<td>CRESST</td>
<td>≃ 12 keV</td>
<td>Eph &lt; 1 keV</td>
<td>≃ 1/10 kg.d</td>
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<tr>
<td>CDMS</td>
<td>10 keV</td>
<td>Eph &lt;1 keV- Er 2 keV</td>
<td>≃&lt; 1/100 kg.d</td>
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<tr>
<td>Xenon100</td>
<td>S1 8 keV</td>
<td>S1 ≃ 9.5 keV</td>
<td>≃ 1/400 kg.d</td>
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<tr>
<td>CDMS LE</td>
<td>2 keV</td>
<td>0.5 keV</td>
<td>few /kg.d</td>
</tr>
<tr>
<td>Edelweiss LE “pure heat”</td>
<td>2 keV</td>
<td>0.8 keV</td>
<td>≃ 10 /kg.d</td>
</tr>
<tr>
<td>EURECA goal</td>
<td>2 to 8 keV</td>
<td>few keV</td>
<td>≃1/100 000 kg.d</td>
</tr>
<tr>
<td>Xenon1t</td>
<td>S1 16 keV ?</td>
<td>S1 ≃ 19 keV ?</td>
<td>≃1/100 000 kg.d</td>
</tr>
</tbody>
</table>

- What is influence of threshold value and resolution at threshold ?
- How to decrease by 100-1000 background rate in ROI ?
Effect of threshold (Ge and Xe)

http://pisrv0.pit.physik.uni-tuebingen.de/darkmatter/

50 000 kg.d
Effect of resolution at threshold: Xenon100

Exercice 1000 kg.d, 8.4 keV threshold with resolution Xe100 0.5 pe/keV
Effect of resolution at threshold: Xenon100

- Exercice 1000 kg.d, 8.4 keV threshold w “infinite” resolution
- => sensitivity below 10 GeV due to spillover of lower than threshold events above threshold
- “uncomfortable” situation
May be worth setting minimum mass ("WIMP safe") above which
Either see more than 1 % of exp signal and increase of sensitivity wrt th <2
“Exercise” with EURECA1/Ge & Xenon1t

- EURECA 150kg, 300 d
  thresh@4keV, FWHM 2 keV
  70 % eff
- Xe1t, 300 d
  thresh@16keV, FWHM 19 keV
  50 %eff
- No evt

- Same game could be played with CaWO4
  - => complementarity low-high wimp mass
  - In any case, X check of hint of signal is essential
Detector developments

- Edelweiss III and CRESST are test bench for EURECA (detectors + electronics, cabling …)
- New phonon sensors for redundancy in rejection and low threshold: “meanders”, cooper pair box, qubit device…
- New cabling & first stage amplification : HEMT
- Go to 1.2 kg (Ge and scintillators)
- Ge industrial production investigated and found feasible
- New geometry for scintillating crystals to eliminate background, R&D on purity ongoing

Cost estimation EURECA 1
- Cost of cryogenic set up w shield : 4.6 M€
- Cost of 150 kg of Ge detectors + electronics : 4 M€
EURECA : getting low background

- Essential to go deep underground
  - Deepest EU is LSM (4800 mwe)
  - Possibility? Yes, see later
- Use of dedicated materials: copper
  - Upper limit on concentration set by current rejection factors and target count rate
  - … other materials
- Neutrons: water shield & VETO
  - … local neutrons
- => OK with moderate improvement of rejection (for Ge), still need improved active background rejection
EURECA status

- Design study -ASPERA partial funding- on going
  - Simulations => Shieldings
  - Cryogenics line defined
  - Studies for wiring / electronics on going
  - Implantation and needs @ LSM extension defined

- Going to CDR and TDR by 2012

- Timeline

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<tr>
<th>Project</th>
<th>09</th>
<th>10</th>
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<tr>
<td>CDR/ASPERA D. Study</td>
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<td>Exploitation II</td>
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Cooling system

Cryostat inside large water tank
Cooling by pipes with cold gaz or liquid flow
No cryogenic devices inside the shield
No vibrations / no radioactivity
Cryostat: detector arrangements
Clamping mechanism at 300K (1000 pins)
Tower electronic and cabling: multiusers

- Detector
- Copper screen
  - Copper wire
  - Connector at detector temperature
  - Stainless steel or Cu Ni wires
- Cold preamplifier
  - Single FET, full preamp, SQUID, ...
  - Polarisation resistances, relay, ...
- 300K clamping mechanism
- Very low radioactivity space
- 10 mK
- 4 K or 100 K
- 300 K
Current status of new cavity and plans

- Safety gallery digging started Oct 10 (600m), TBM now on site (20 m/day)
- Process of evaluation of extension of lab & funding ongoing, recommendation by ministry to provide facilities for users
- Within French EQUIPEX program call, request for equipment and facilities for new lab
- Large cryogenic facility could also be used by other DM search users and rare process search like $\beta\beta$ search
- Result by beginning 2012
- If ok, ready for users 2015
Summary

- Important progress in EU cryogenic experiments Edelweiss, CRESST, Rosebud-R&D, & effective US collaboration (meeting oct 2011) towards $>100-1000$ kg
- Complementarity of cryogenics w Xenon techniques
- Versatility of cryogenic detectors & sensors make them adapted to ambitious aims
- Large (500kg-1t) cryogenic, low activity, versatile (electronics) set-up is a key tool for $10^{-10}$ pb SI aim:
  - Developed within EURECA
  - Part of the key french application for LSM extension
- Longer term projects: DARWIN, Multiton Xenon, … welcome to express interest in new lab @ LSM