DARK MATTER PROGRAM AT LSC

AND SYNERGY BETWEEN DULS

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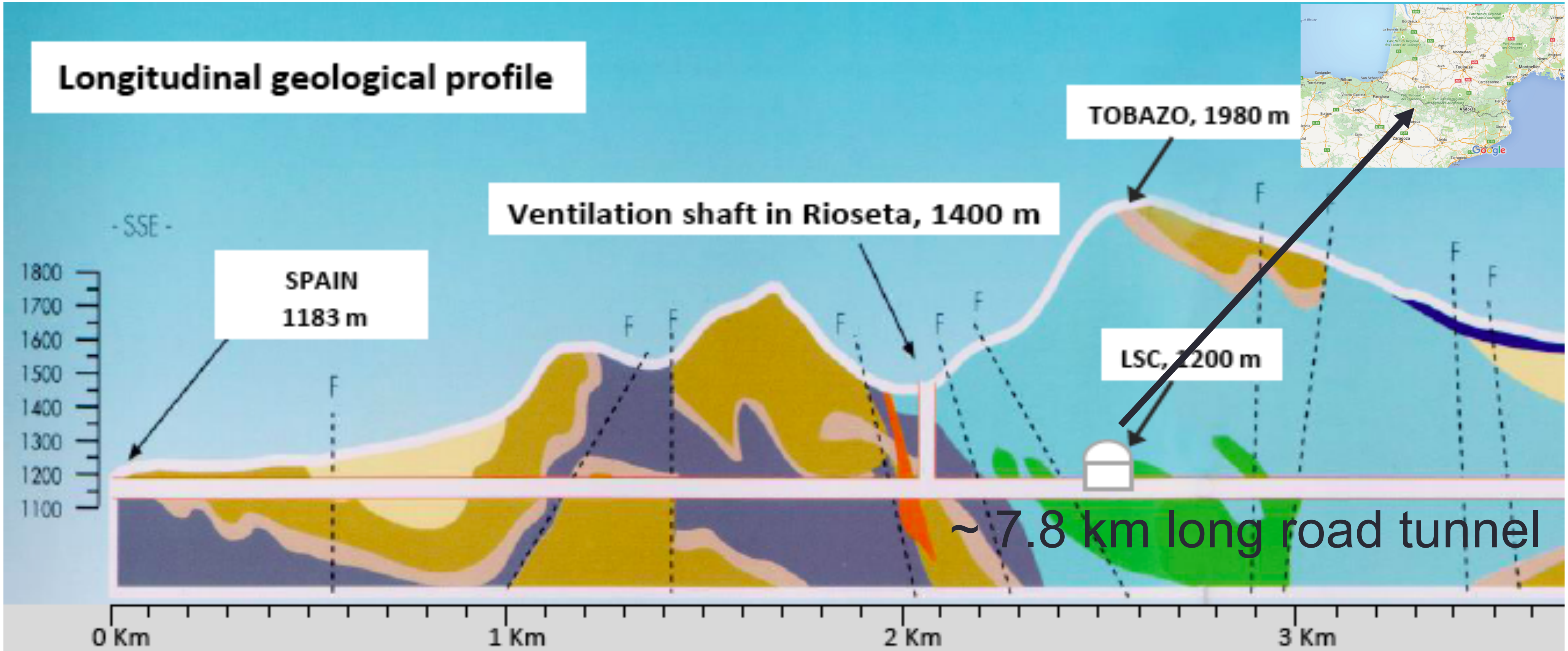
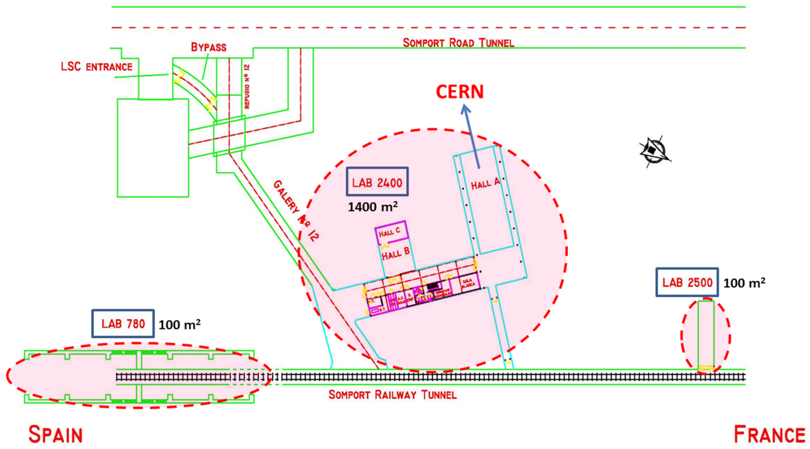
Laboratorio Subterraneo de Canfranc (LSC)



850 m under mount Tobazo (~ 2500 m.w.e)
Muon flux ~ 3×10^{-3} m^{-2} s^{-1}
Inlet air flux ~ 20000 m^3/h
Radon level 50 - 80 Bq/m^3
Neutron (<10 MeV) ~ 3×10^{-6} $n/(cm^2\ s)$
Gamma rays flux ~ $2/(cm^2\ s)$



Dark Matter program at LSC

- **ANAIS**:
  - 112 kg NaI(Tl) array in data taking since Aug 2017 (see talk by M.L. Sarsa this meeting)
- **ArDM** :
  - Two-phase LAr detector in data taking (see talk by C. Regenfus this meeting)
- **DART** :
  - Refurbishment of ArDM to build a high sensitivity detector to measure ^{39}Ar in the argon (UAr and DAr) produced for DarkSide-20k (see talks by G. Fiorillo and C. Regenfus this meeting)
    - An example on how to develop synergy between underground laboratories for a global collaboration
- **TREX-DM** :
  - High pressure gas TPC for UAr and neon with sensitivity to low mass WIMPs (more in this talk)
- **CLYC-DM**: R&D with CLYC detectors (more in this talk)

TREX-DM

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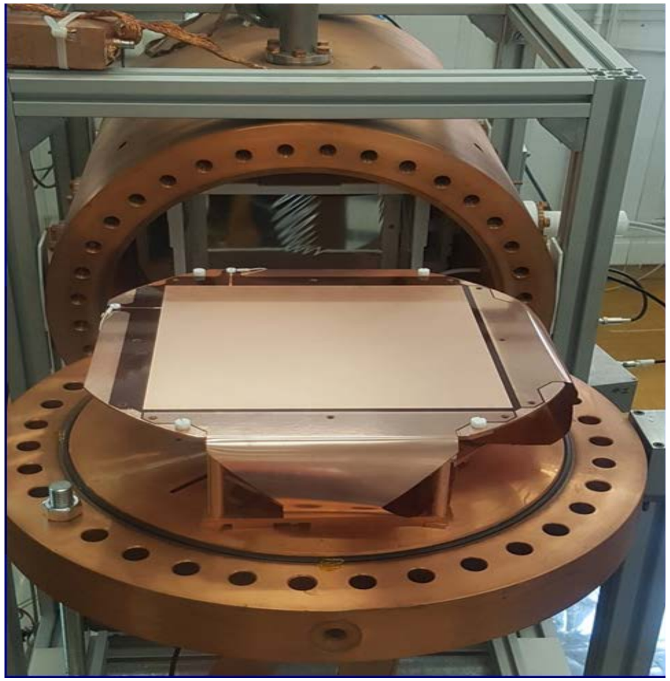
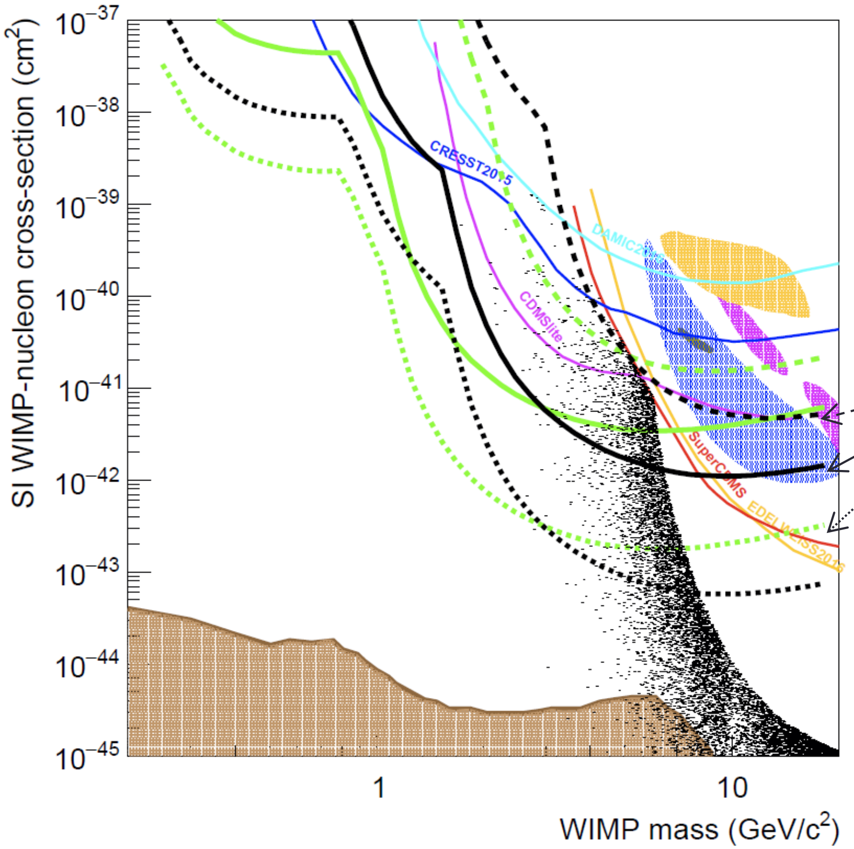
A high pressure gas TPC with micromegas. Operated with UAr or Ne at 10 bar with 1%(Ar), 2%(Ne) C_4H_{10}

Goal: low detection energy (< 1keV) and low background (1ct/keV/kg/day) .

Set-up assembled on surface with detectors inside Faraday cages and no shielding. Now moving underground with shielding (Cu + Pb + PE + water)



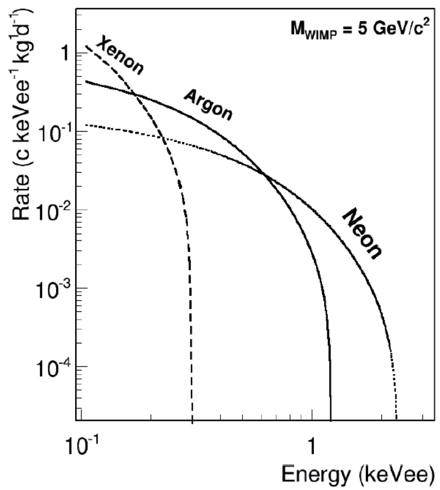
TREX-DM predicted sensitivity



TREX-DM prospects

Neon+2%iso /Argon+1%iso

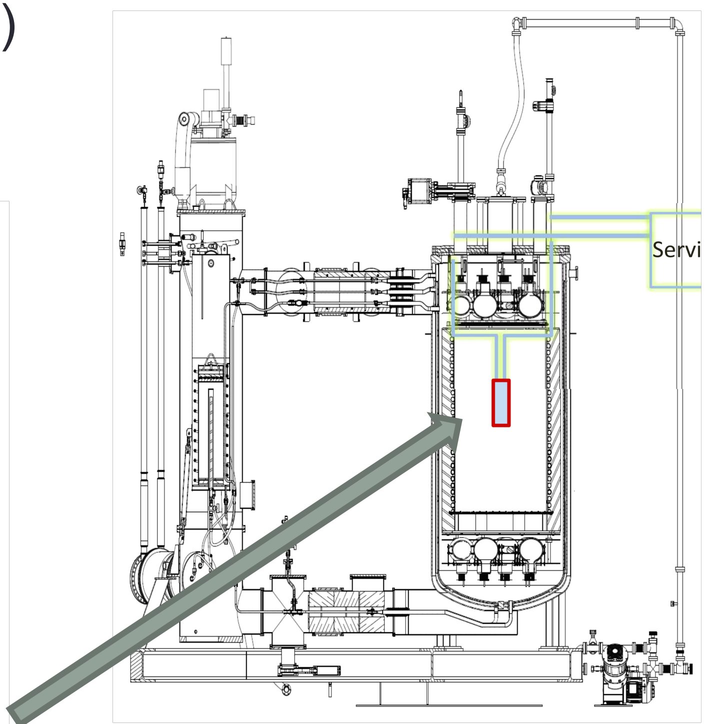
Threshold (keVee)
Background (c/keV/kg/d)
Background subtracted
SI interaction
Standard halo model
10 bar pressure
Exposure 1 kg-y



DART

DarkSide-20k program

Measure ^{39}Ar in UAr and DAr and probe more SiPM technology for DarkSide-20k (see A. Razeto this meeting)
Being installed late 2018 (Global Argon Collaboration)



See C. Regenfus this meeting

CLYC @ LSC

Inorganic scintillator: $Cs_2LiYCl_6(Ce)$

- great potential for neutron monitoring, nuclear physics applications, and DM direct search
- 3” x 3” crystal available

Features:

- Good timing (1ns) and energy resolution (4.7% at 662 keV)
- Excellent PSD for γ/β vs n
- Intrinsic thermal neutron detection: $^6Li + n_{th} \rightarrow {}^3H + \alpha + 4.78MeV$
- Intrinsic fast neutron detection: $^{35}Cl(n_{f,}p)^{35}S$

Activity @ LSC

- Investigate CLYC performances and intrinsic radio-purity for neutron screening in underground labs
- Investigate possible use as DM detector
- Investigate possible applications in nuclear physics

Collaboration

- LSC and CIEMAT (Nuclear Innovation and Astroparticle Physics Groups)

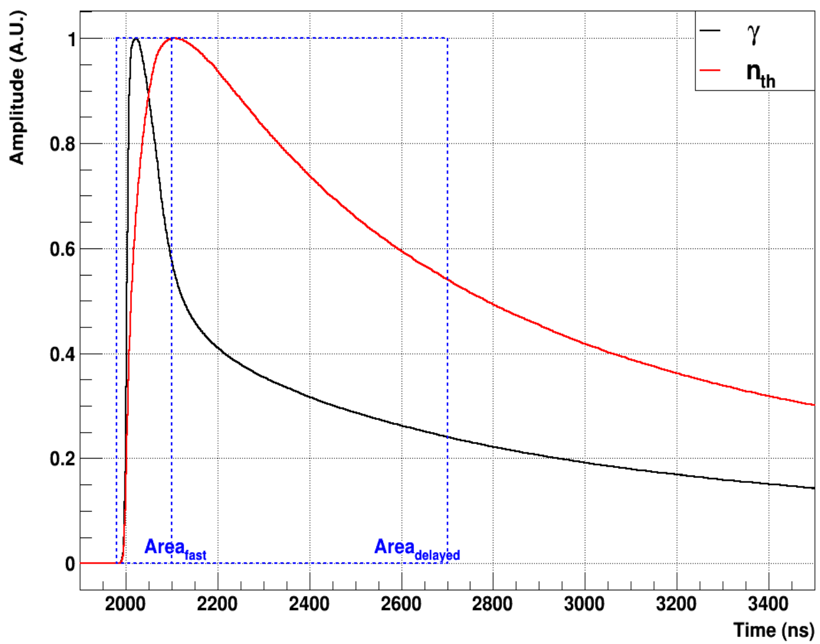
Preliminary results

- arXiv:1710.02420

Testing CLYC performances

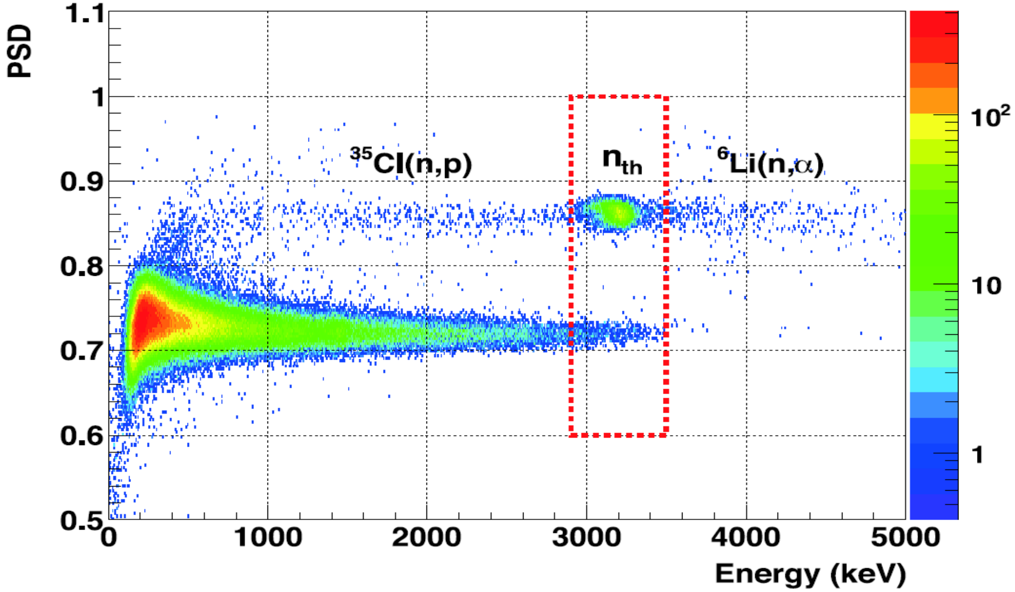
- Tested detectors with different intrinsic radio-purity in underground at LSC
  - Supplier: RMD (USA)
  - Crystals: 2" x 2" 95% enriched in ^{6}Li and 1% Ce doping
- ^{3}He detector operated in same conditions used for CLYC detectors
- Calibrations with ^{60}Co(1172 and 1332 keV), ^{137}Cs(662 keV), ^{88}Y(898 and1836keV), and ^{252}Cf sources
- PSD FoM

$$\text{PSD\_FoM} = \frac{\text{Area}_{\text{delayed}}}{(\text{Area}_{\text{fast}} + \text{Area}_{\text{delayed}})}$$

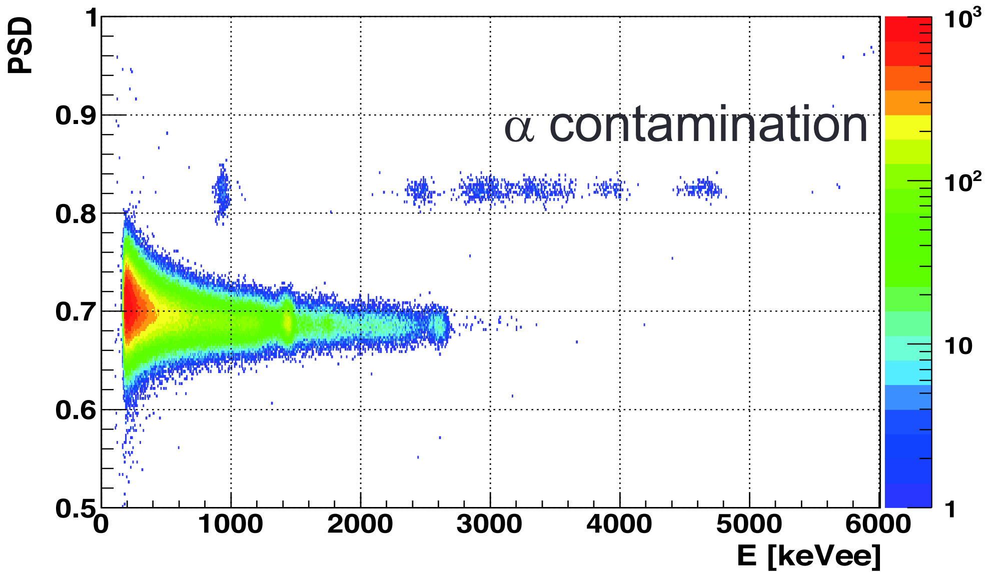


n/γ discrimination

With ^{252}Cf source



Intrinsic background from 1st crystal screened at LSC in underground



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Conclusions on CLYC study

- **Performance**:
  - Energy resolution 4.7±0.1% at 662 keV
  - 1ns time resolution
  - <0.2% change with temperature, counting rate, incident interaction point

- **Intrinsic radio-purity**:
  - A few mBq/kg α background in one crystal limits application for n screening underground
  - Internal background reduced by a factor 4-5 in a selected crystal with higher radio-purity (preliminary results available)

- **Next future goal:**
  - Make CLYC a reference detector for neutron screening in DULs

Synergy in DULs

LSC effort in DM is an example of needed synergy between DULs

More synergy on:

- enhance common interests between different fields: DM and DBD, usign xenon and argon
- photosensors (see A. Razeto this meeting)
- high radio-purity materials (e-formed Cu as an example)
- coordinate radio-purity assay for “large” projects (DarkSide-20k, SuperKamiokande-Gd,…)
- management coordination (safety, engineering, …)
- outreach

Example about synergy and DULs: e-formed Cu @ LSC

- LSC has a facility to make e-formed Cu
- A number of studies are underway to determine surface contamination in collaboration with the Institute of Physics, Jagiellonian University (PI: G. Zuzel) and LNGS
- New use of e-formed Cu from LSC to develop complex and high radio-purity geometric shapes in collaboration with LNGS in the framework of **NOA** (see next slide)
  - another example of synergy between DULs

Cu	U [ppt]	Th [ppt]
OFHC*	0.2±0.01	1±0.06
E-formed	< 0.05	0.040±0.002

NOA @ LNGS and DarkSide-20k

NOA is a new infrastructure at LNGS with three main activities

1. **Main goal**. Development of a facility for characterization (at low temperature) and packaging of SiPM in ISO6 clean room (~250m^2)
   --- this facility used by DarkSide-20k (see A. Razeto this meeting)
   --- in the future for other experiments

2. Characterization of high radio-purity materials (ICP-MS, LA IPC-MS, HPGe)

3. Application of additive manufacturing to plastic and metallic materials for research (high radio-purity) and industry

Timeline: whole facility in operation after Summer 2019

Conclusions

- LSC is shallow wrt to main large DULs, such as LNGS, SNOLab, CJPL, SURF. This might limit deployment of next generation DM detectors.
  Yet, in the framework of synergy between DULs, it might play a crucial role (see the synergy case of DarkSide-20k: C. Galbiati at this meeting)

- Our basic idea is to develop synergy with other DULs.
  Presently, with LNGS, Boulby, and SNOLab
  More in Nigel Smith's talk

- Synergy activity dealing with:
  - Next generation detector development: DM, DBD
  - Enhance screening power and technology
  - Standardize operations for activities in DULs
  - outreach