The NEWS-SNO Project

Context

Principles

SEDINE at LSM

Status of NEWS-SNO

Summary

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Queen's University

FPW 2015- SNOLAB

Aug 25th 0215

Canada Excellence Research Chairs

Chaires d'excellence en recherche du Canada

Basic comments on detection of "low mass" flying particle

- Kinematical match
- To detect flying ping pong balls is it better to have as target :
  - lead "petanque" balls
  - or ping pong balls ?
- => use light nuclei to detect light WIMPs
- H, He lightest

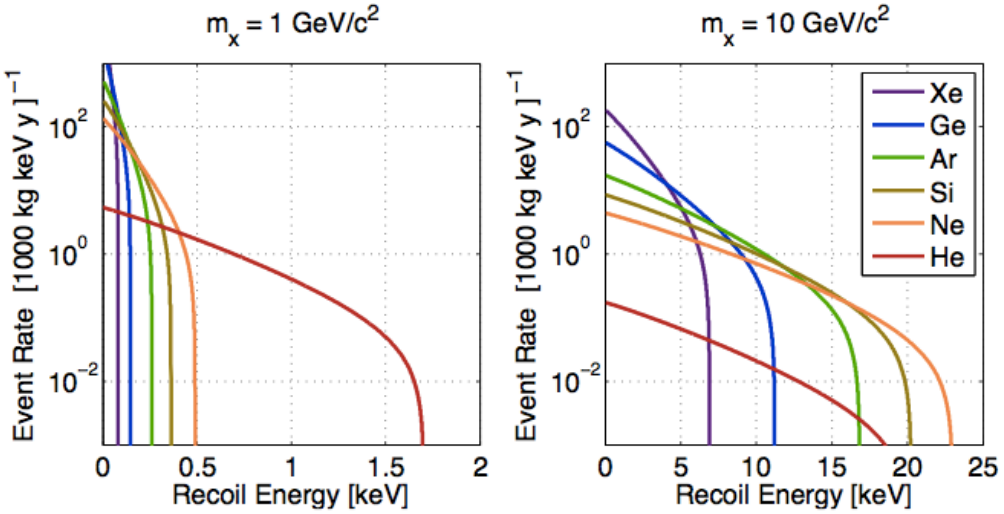
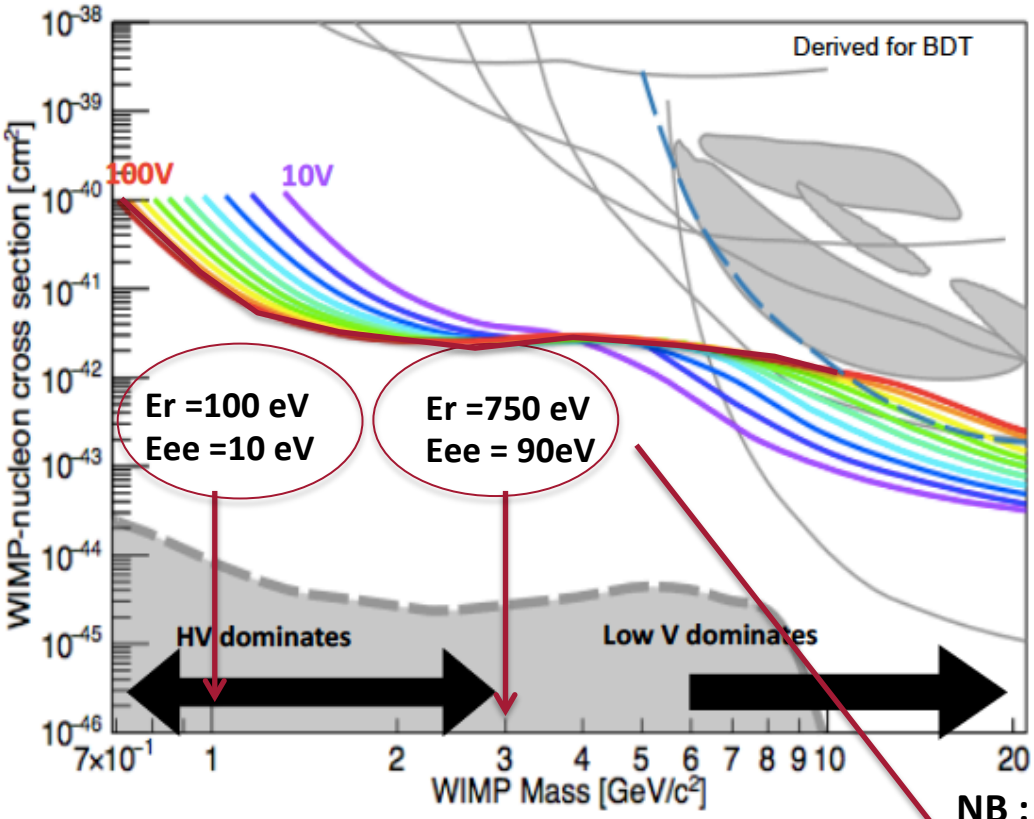


Illustration : looking for low WIMP mass with Ge



Playing with voltage for ionisation from 10 to 100 V

Hypothesis of the projection

- 100 eV RMS heat and ionisation
- heat only evts reduced by 100
- 350 kg.d
- Background extrapolated flat to LE
- QF extrapolated as $0.16 Er^{0.18}$

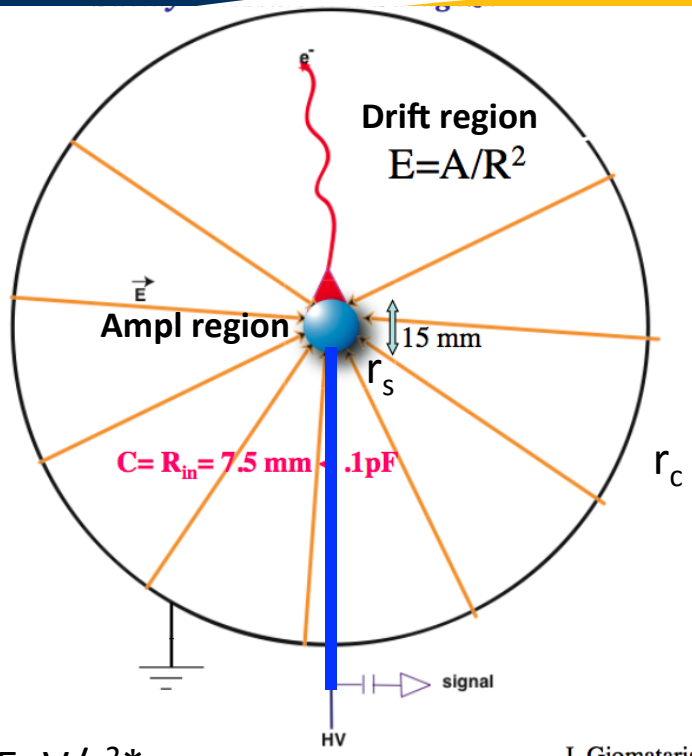
Adapted ?

Best suited

NB : energies corresponding to a threshold above which 5 % of WIMP signal is kept (PDG DM reviewers recommendation)

Q. Arnaud et al, in preparation

Spherical gas detectors
New Experiments With Spheres

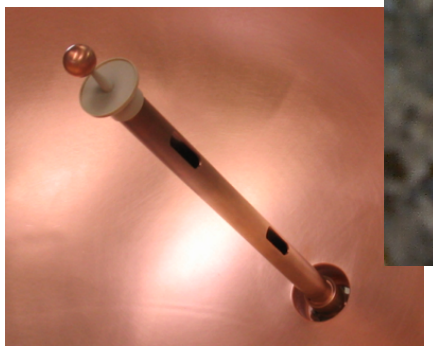


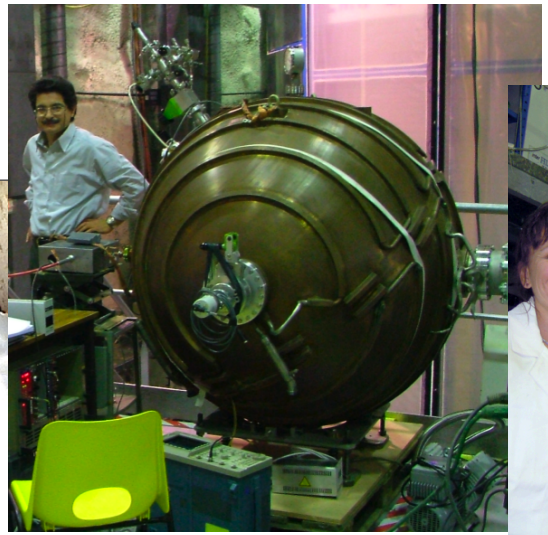
r_c

- Sphere cavity + spherical sensor + HT
- => **Low threshold (low C), does not depend on size**
- **Flexible (Pressure, gas H, He ,Ne, Ar, Xe)**
- Fiducial volume selection by pulse risetime
- Large mass / large volume (30 kg) with single channel
- Simple, sealed mode
- 2 LEP cavity 130 cm Ø tested
- 1 low activity 60 cm Ø in operation @ LSM: SEDINE

$E \approx V/r^2 * r_s$
for $r_c >> r_s$

I. Giomataris





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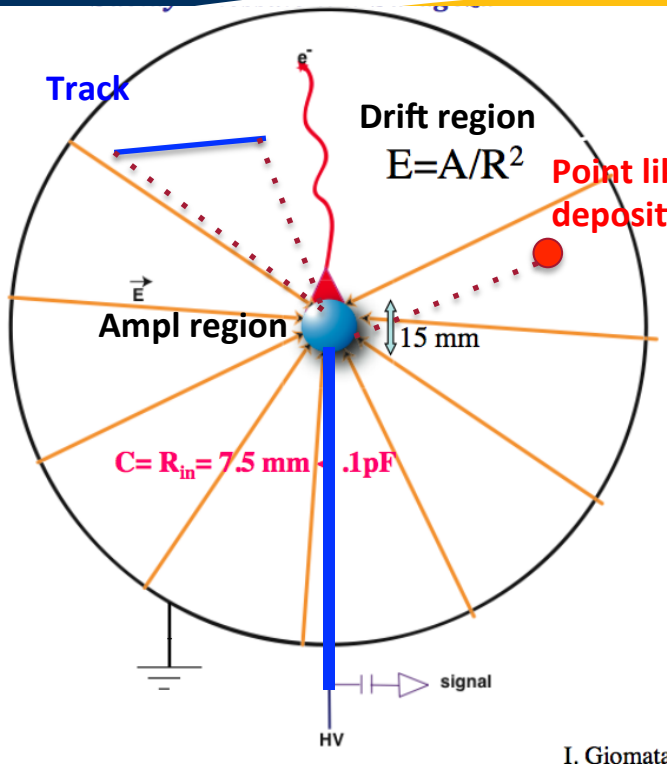

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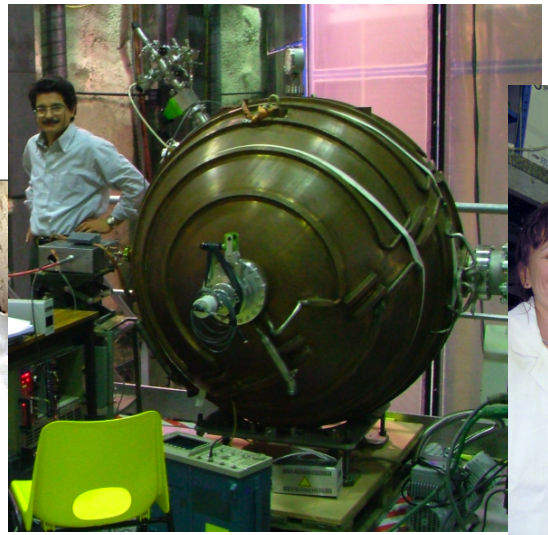
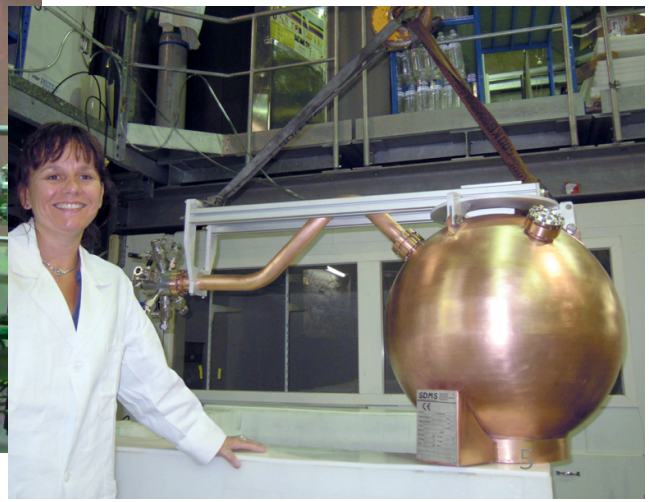
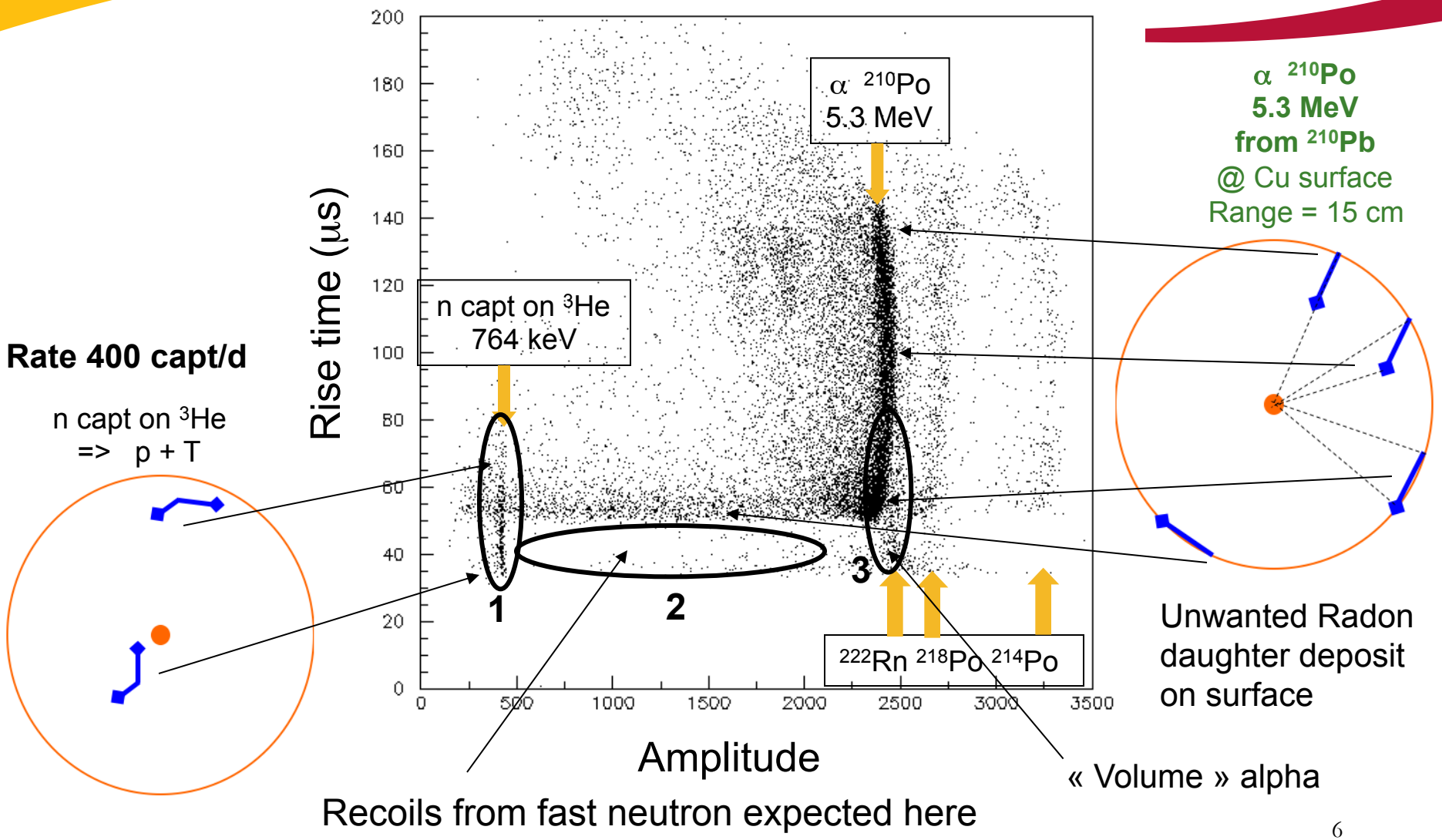


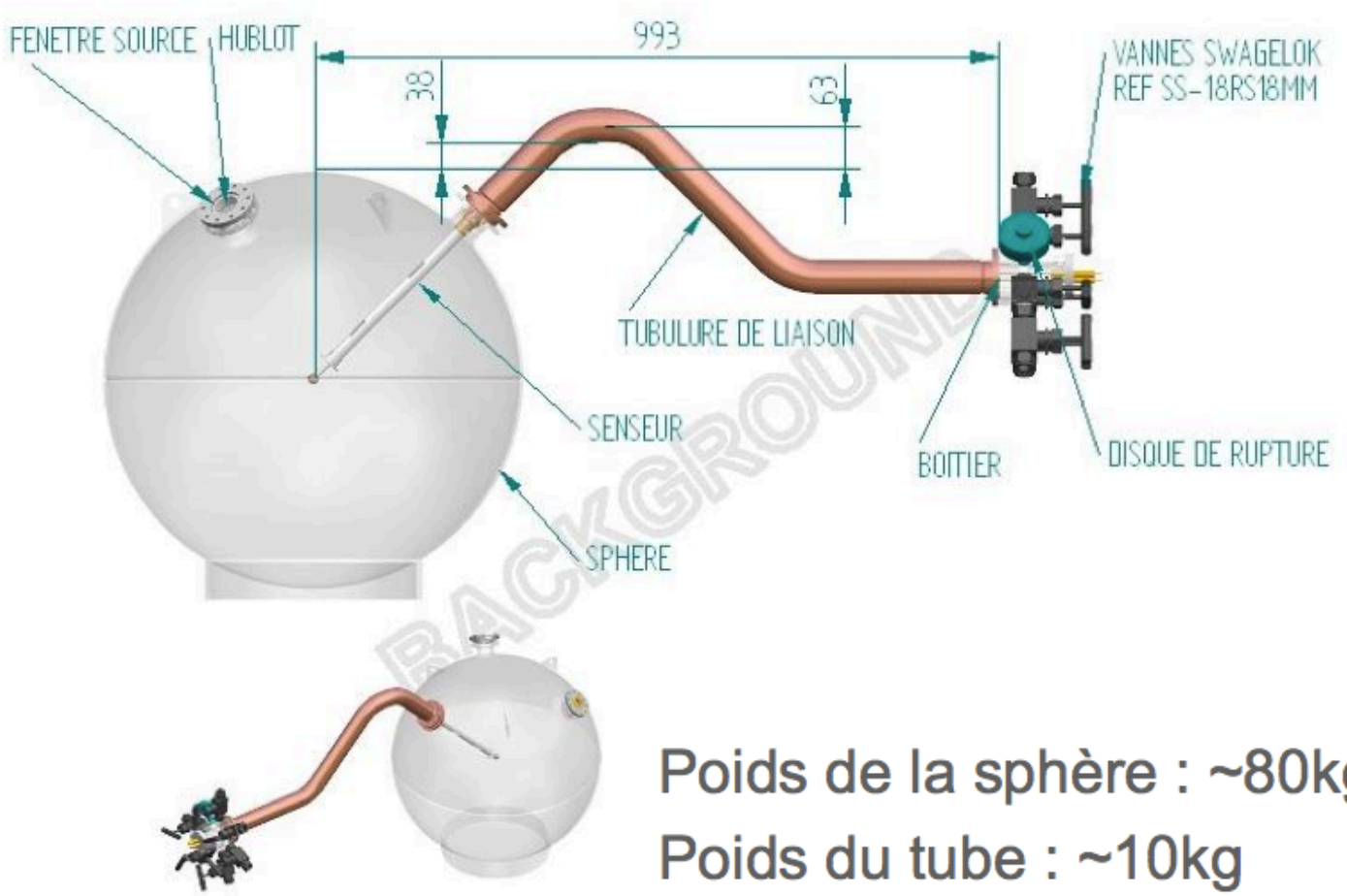


Run with Ar/CH_4 + 3g ^{3}He @ 200 mb SPC 130cm Ø @ LSM



Low activity 60cm Ø prototype SEDINE @ LSM

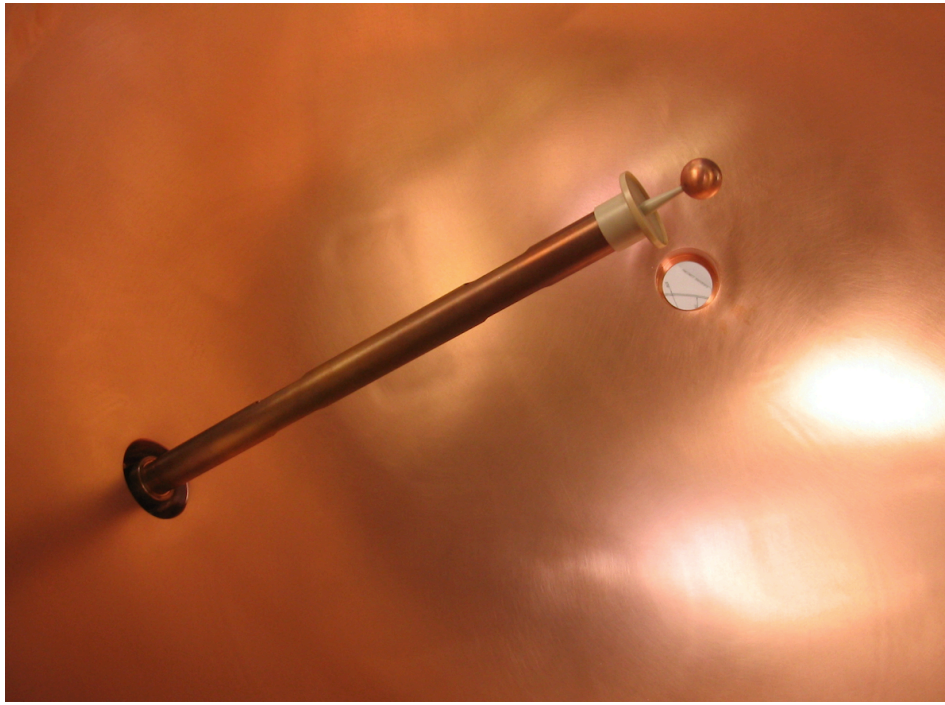
Sedine ensemble



Poids de la sphère : ~80kg

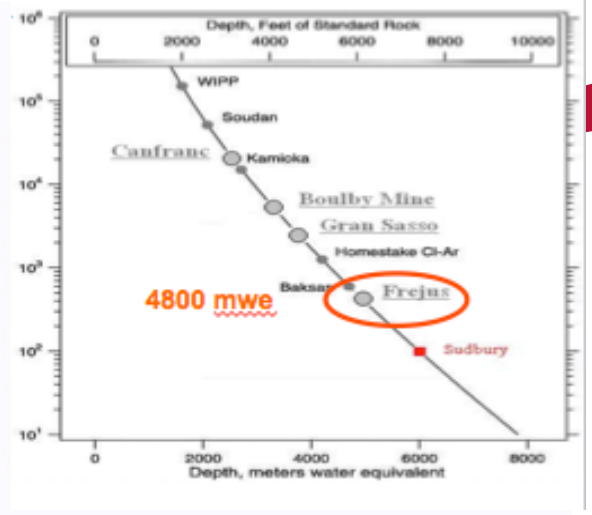
Poids du tube : ~10kg

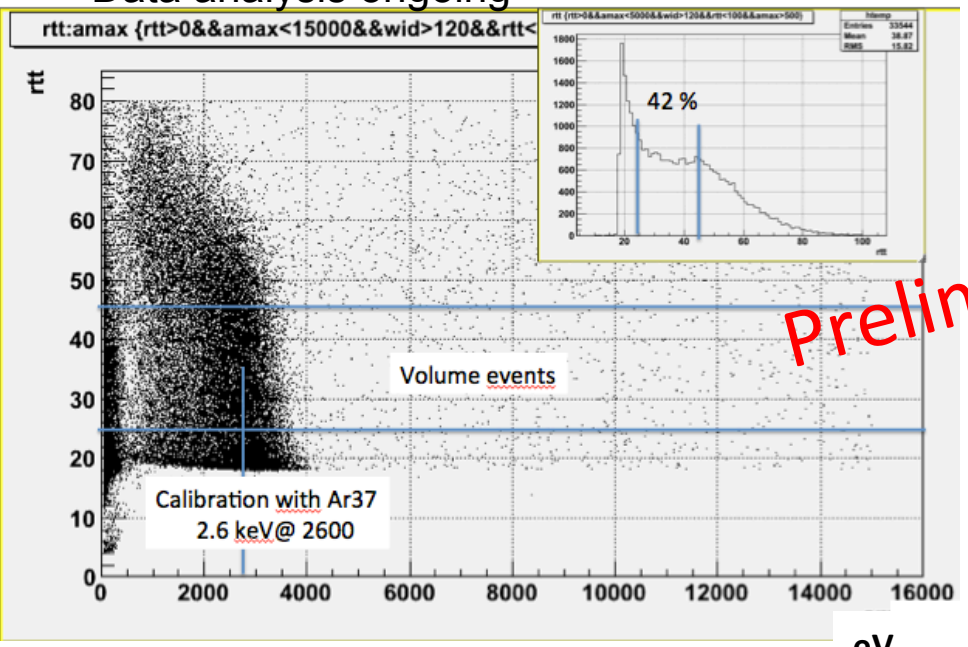
Poids du boîtier : ~8kg



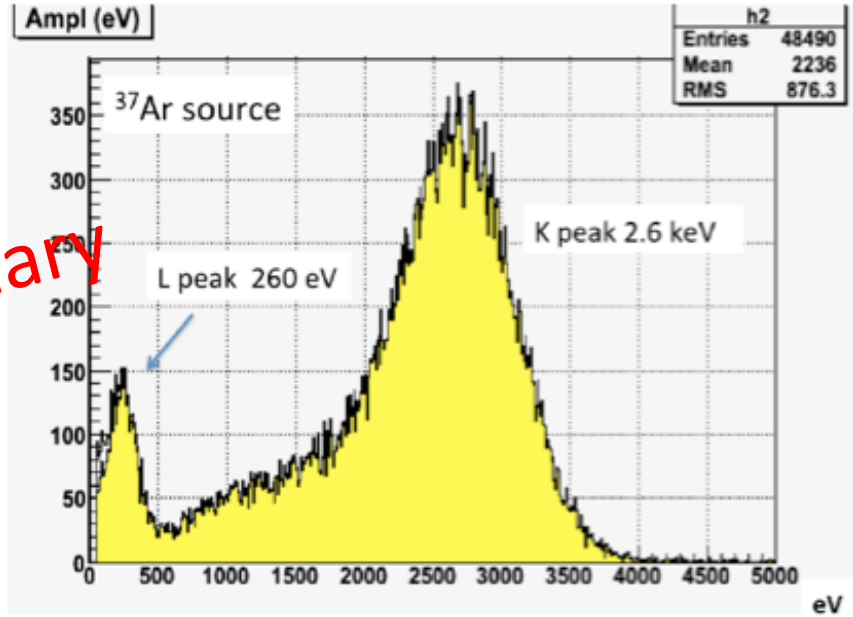
Light dark matter search : low activity
60 cm Ø prototype @ LSM : SeDiNe

- 6 mm Ø sensor
- Not yet optimised wrt low activity (^{210}Po) & shield thickness
- Runs with Neon+0.7%CH_4 @ 3 bars performed in 2014=> 300 g sensitive mass
- 1.2 kg.d exposure, 120 eV threshold
- Neutron and ^{37}Ar calibrattion completed
- Data analysis ongoing



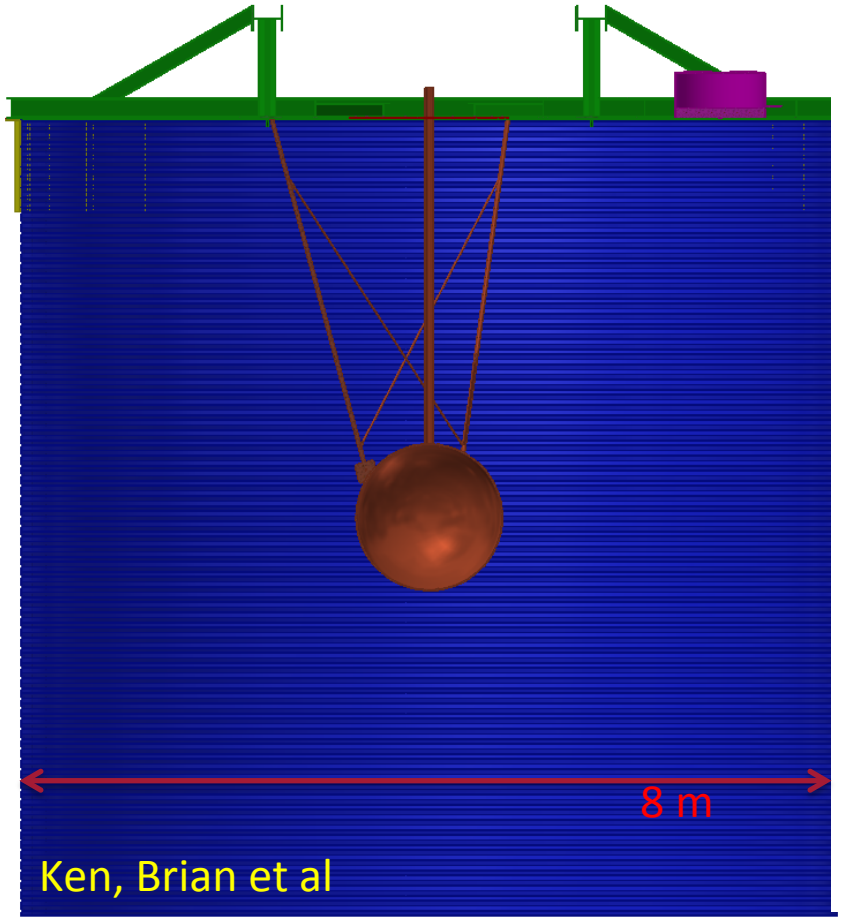


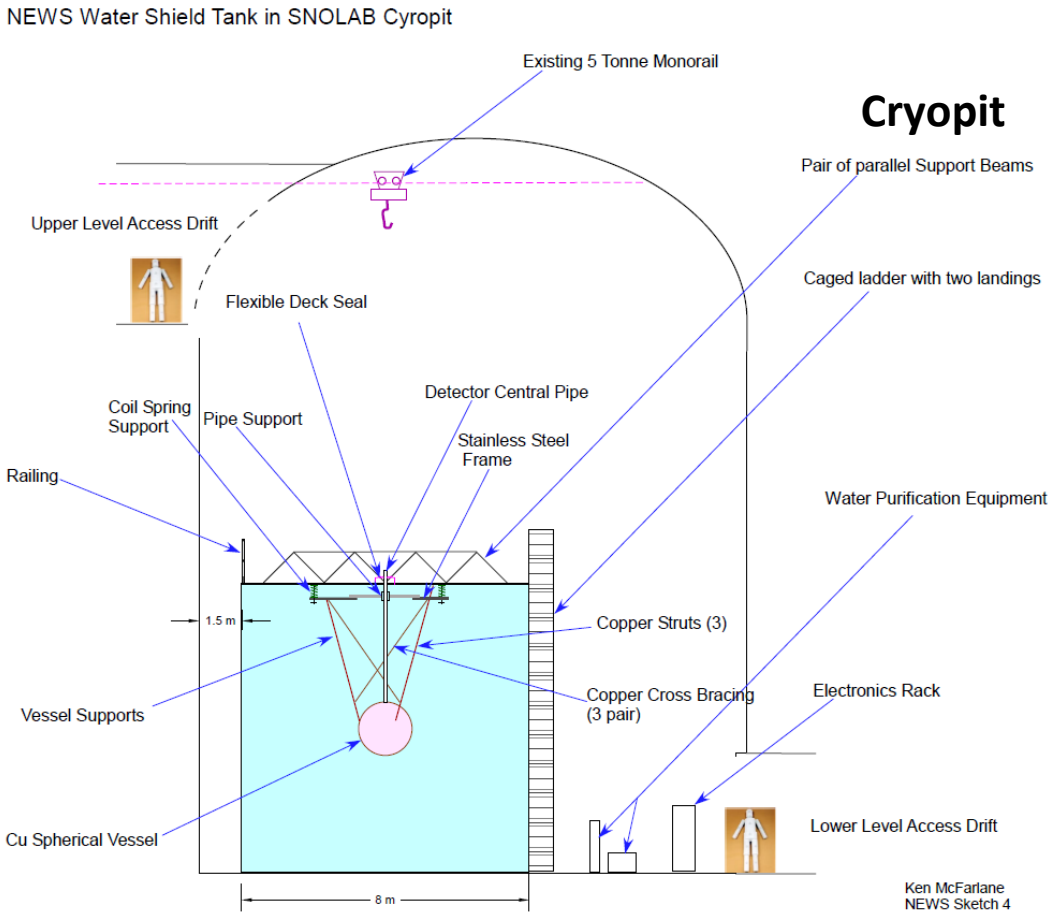
Preliminary



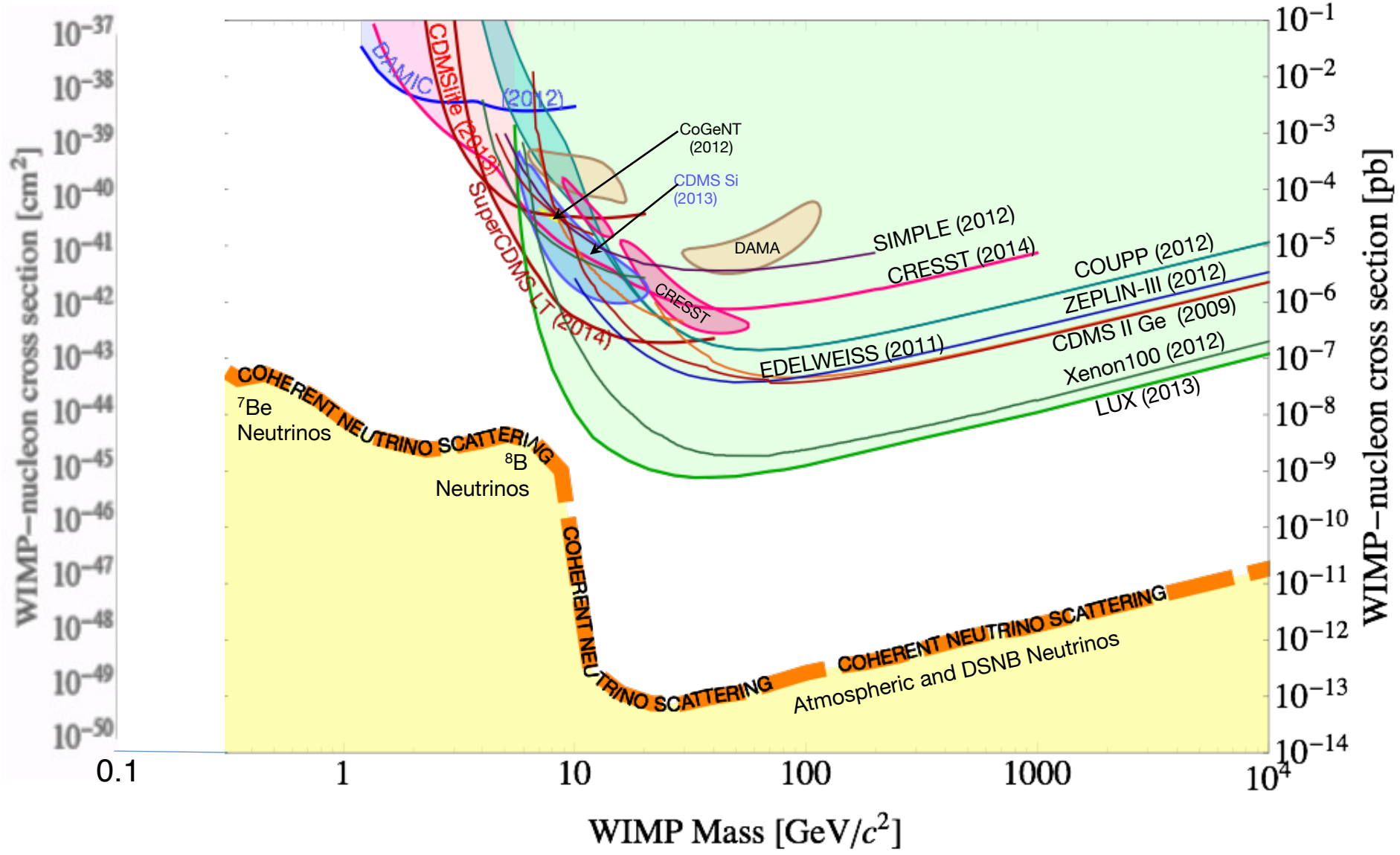
NEWS-SNO= 1.4 m sphere in 8m diam water tank @ SNOLAB

Use Ne,He, H (CH4) gas at pressure up to 10 b as targets for light WIMP search





NEWS goal wrt current situation



Background free limits obtained for around 100 kg.d with Ne/He/CH4 , taking into account anticipated background from materials, with threshold set at 1 electron (ie 30 to 40 eVee), & quenching factors extrapolated down to 100-200 evNR

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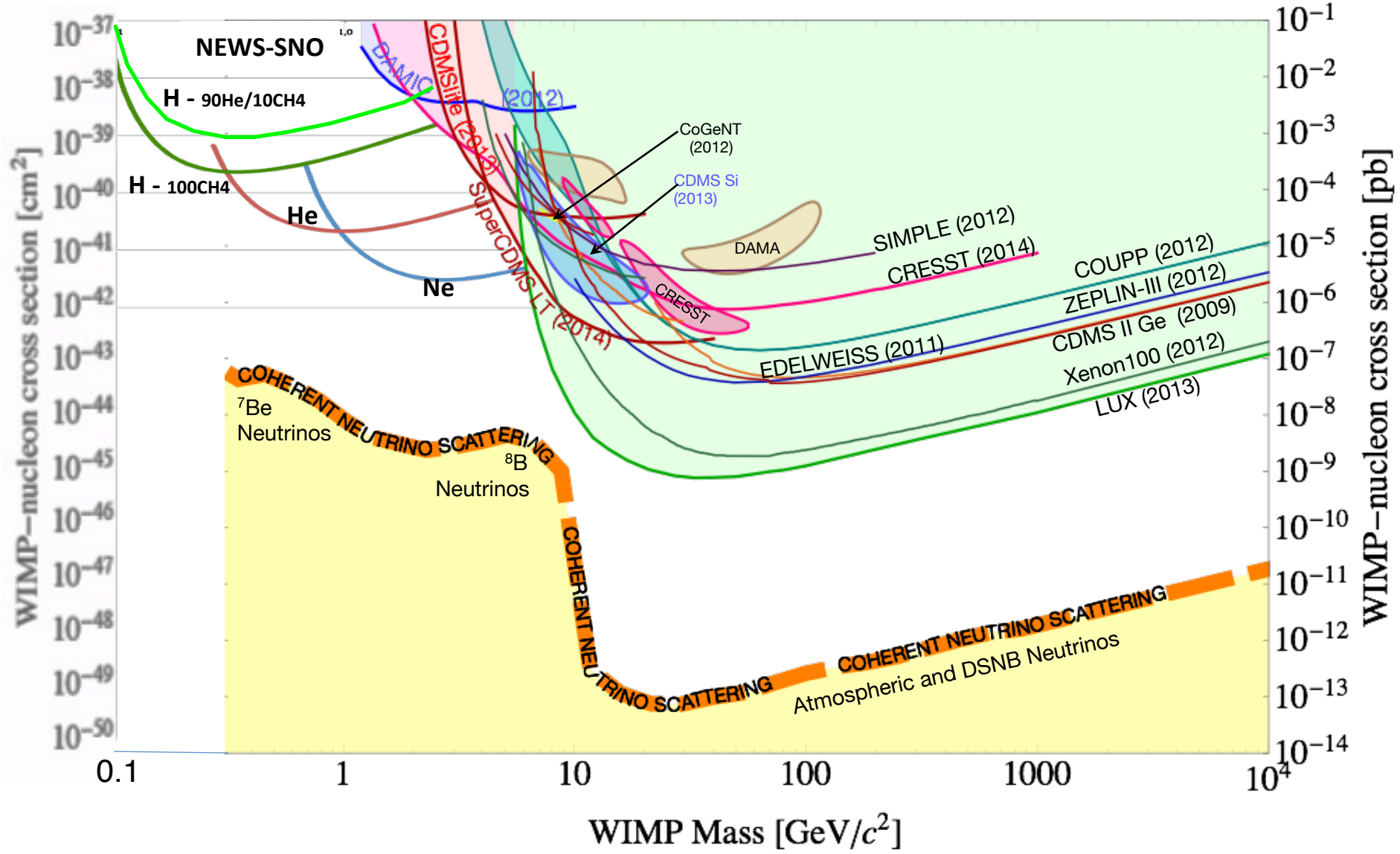

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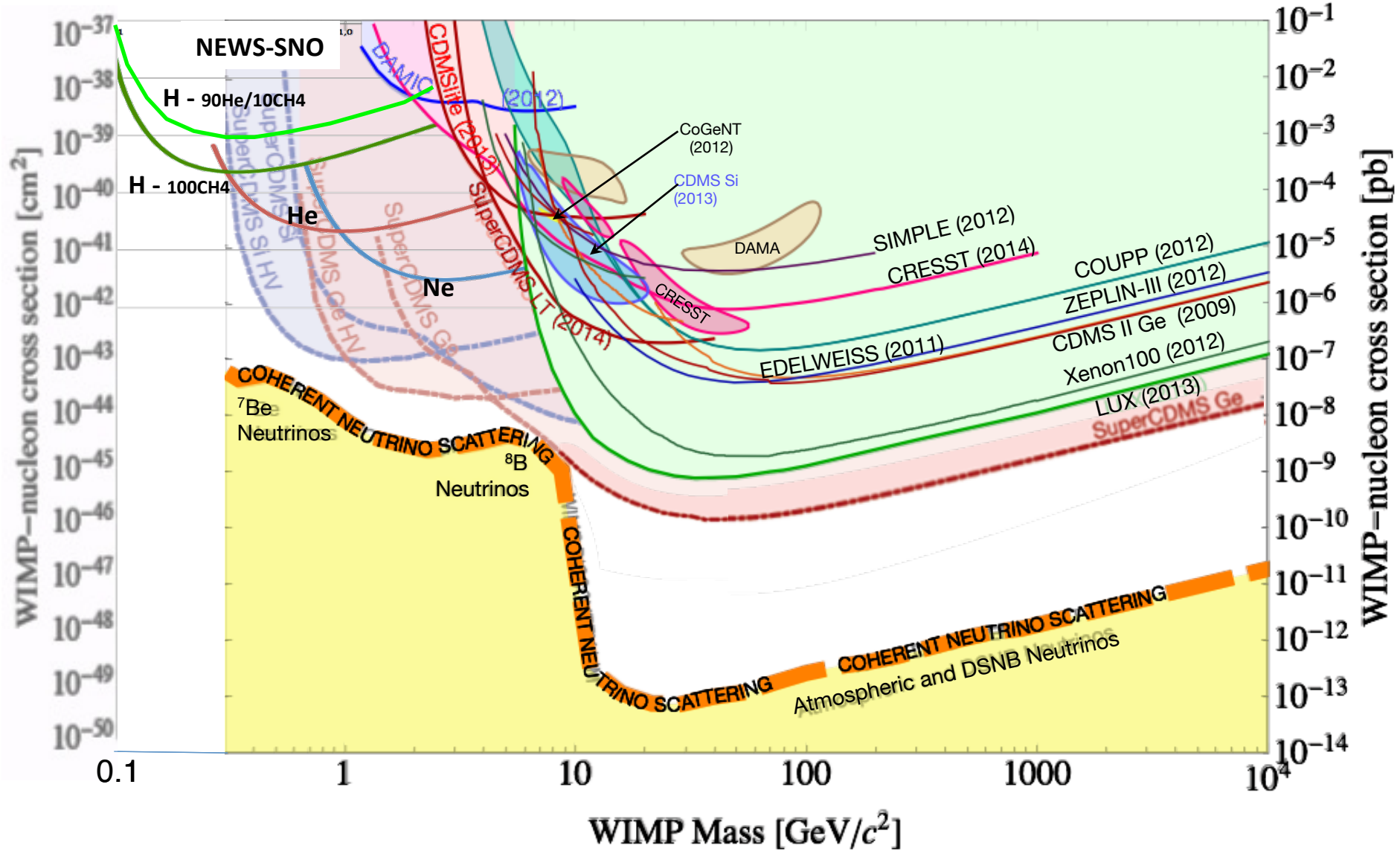

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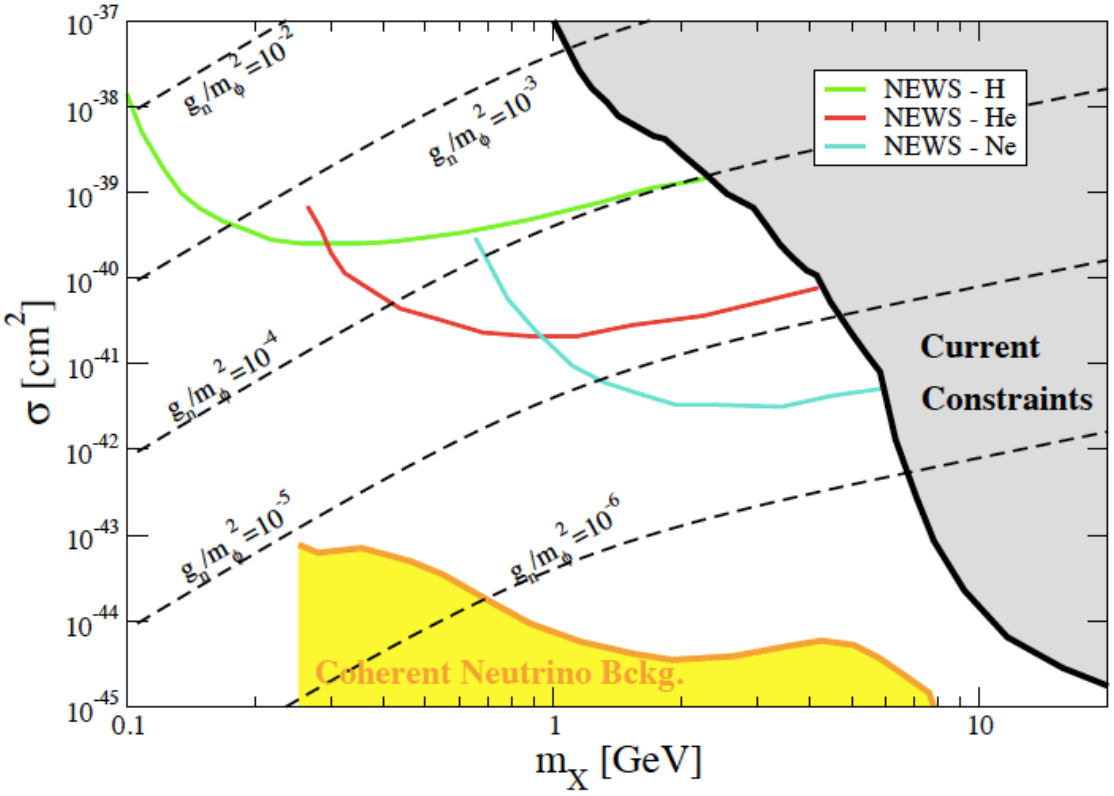
NEWS physics reach : example of sensitivity to GeV Dark Matter with a light mediator

S Profumo : arXiv 1507.07531



The black dashed lines indicate points at constant g_n/m_Φ^2

Other unique physics reach opportunities with NEWS-SNO

SEDINE

NEWS-SNO-H

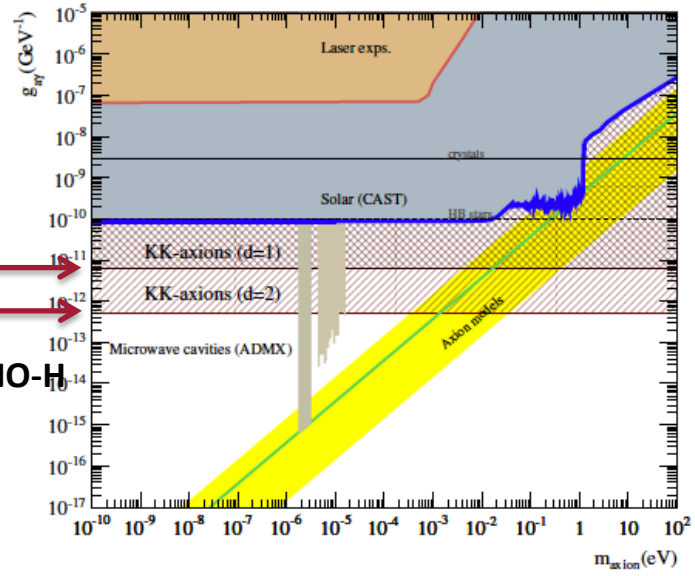
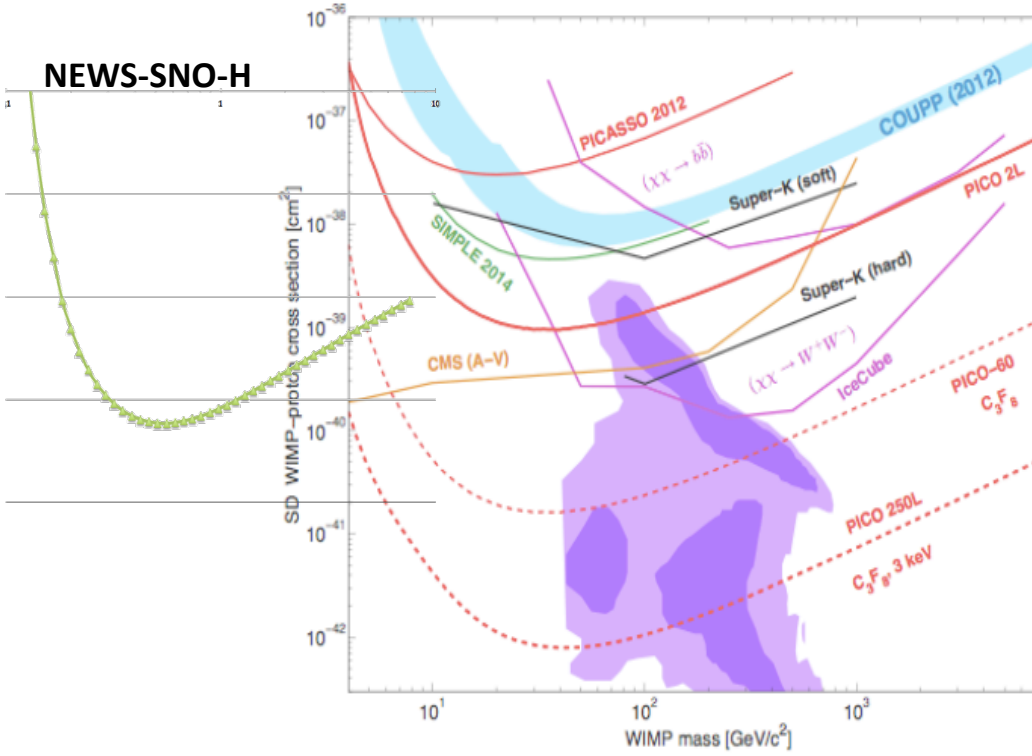


FIG. 7. Sensitivity limits obtained with SEDINE detector in this work versus other axion searches [4].



KK axions

2 photon decays of solar axions

NB : here need volume

Paper in preparation

Spin dependent couplings with H

H is best nucleus with Fluorine

Milestones

- 2014 proposal to CERC & CFI : accepted for funding
- March 2015 : first presentation at SNOLAB EAC

  ⇒ Positive feedback, invited to go ahead, in between GW0 and GW1

  ⇒ Address some key points

  1. Recommendation to go for 1.4 m instead of 2 m diam sphere
  2. Safety and risk analysis
  3. Secure background calculations
  4. Detailed budget
  5. **Planning should allow completion by 2021**
  6. Prepare CDR
- May 2015 First collaboration meeting at SNOLAB
  - 7 teams, 20 participants
  - Set up of work package structure and regular technical meetings
  - Strong interaction with SNOLAB staff

Background budget for 10 b operating pressure of 1.4m sphere

	U Copper	Th Copper	Co60 Copper	Rn Water	Pb210 Surface	Rod/sensor	External rad	Total	NB evts in ROI
Radioactive background budget	1 µBq/kg	1 µBq/kg	20 µBq/kg 2 months exposure to CR	1 mBq/m3 stationary w polyurea	5 mins exposure to 50 Bq/m3 Rn air	Maximum allowed	Tl208 from rock	Tot dru in 0-1 keV	**100 kg.d exposure** **Nb evts in deltatE 0.2 keV**
Ne/CH4 99/1	0,005	0,004	0,007	0,001	0,011	0,005	0,005	0,033	0,661
He/CH4 99/1	0,005	*0,004*	*0,007*	*0,001*	*0,011*	*0,005*	0,005	0,033	0,668
He/CH4 90/10	0,085	*0,058*	*0,117*	*0,018*	*0,179*	*0,080*	*0,080*	0,457	10,751
CH4 pur	0,023	*0,016*	*0,032*	*0,005*	*0,049*	*0,022*	*0,022*	0,126	2,964

GEANT4 simulations

Table 4.1. The anticipated background count rates (expressed in dru, that is evt/kg/keV/d) in the region of interest 0-1 keV for the very low mass WIMP search in the NEWS-SNO experiment. Background sources were assumed with updated information on contaminations as well as with respect to the new geometry, i.e., using a 1.4m diameter sphere with 10mm thick walls in a 8m diameter water tank employing different gases/gas mixtures as targets.

NB : @ 10 bar operating pressure

M_{Ne} = 12.5 Kg

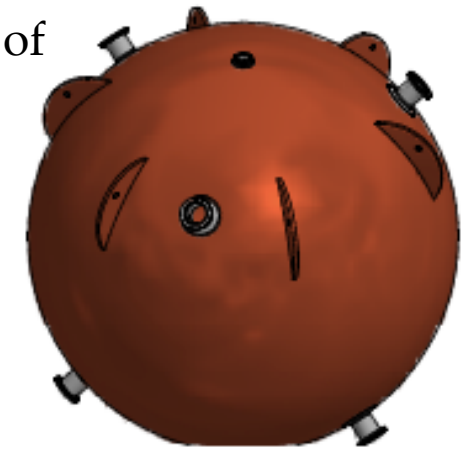
M_{He} = 2.5 Kg

M_{H} = 0.25 Kg in He/CH4 90/10 mix

Data taking time to reach ≈ background free mode (1 evt) range from 8 to 40 days

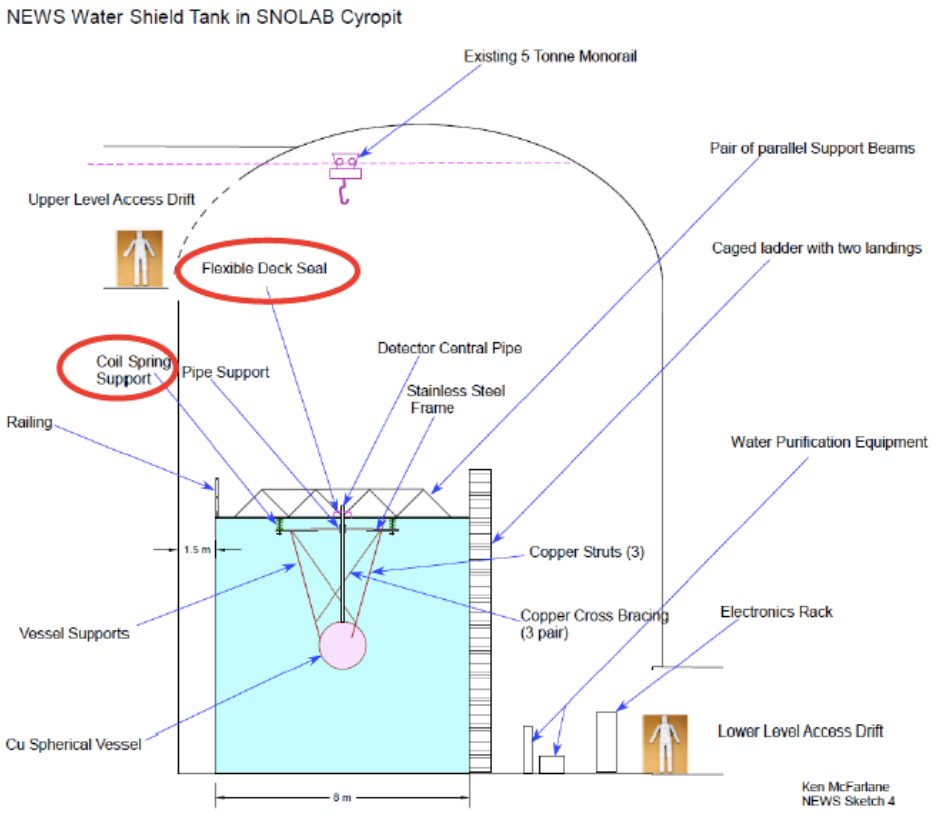
Vessel key technical issues

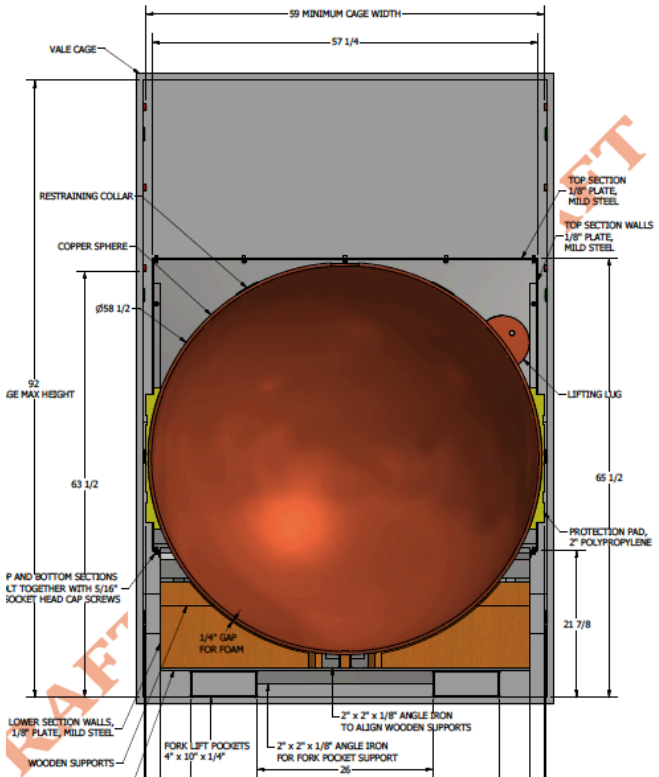
- **Cu quality**
  - From discussion with Majorana/PNNL team, identify supplier of Cu **1 μBq/kg U/Th**
  - ^{60}Co from cosmogeny can be contained **at same level of induced background if 2 months above ground**
- **Thickness of shell**
  - Driven by mechanical constraint from 10 b internal pressure and 2b external pressure => **10 mm =>**
- Making of sphere according to **TSSA regulations**
  - Several identified (Canada, Europe, US), some well aware of pressure vessel constraints, discussions on going
- Coordination between supplier and maker
  - Minimize exposure to CR
  - On going Arubis/KME/Southern Brass



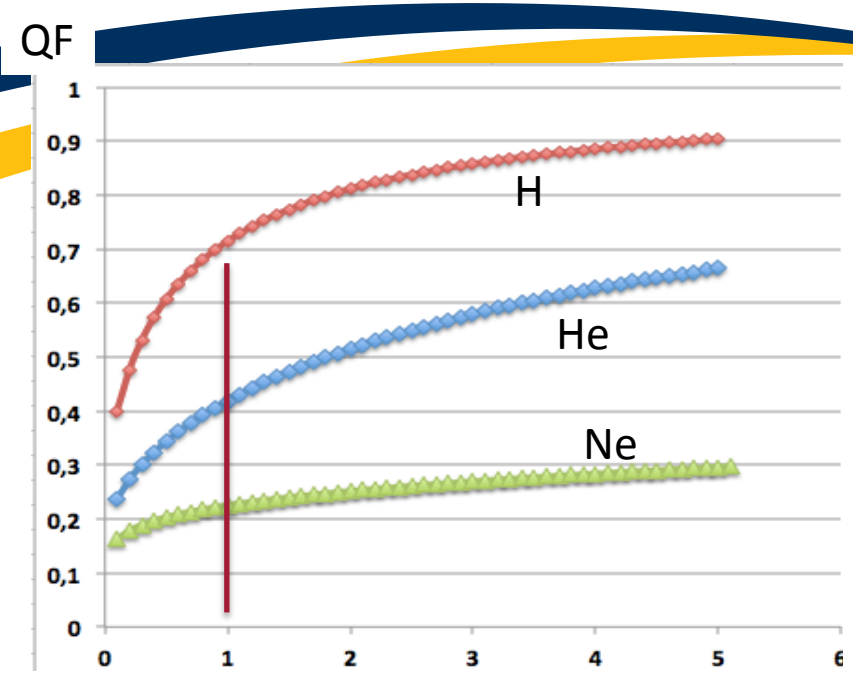
Water tank

- Proposal by SNOLAB project team
- Technical solutions identified(DEAP style tank + Deck + Polyurea liner)
- Costing done (0.4 M$ hardware + 0.35 labor + 0.5 management / contingencies)

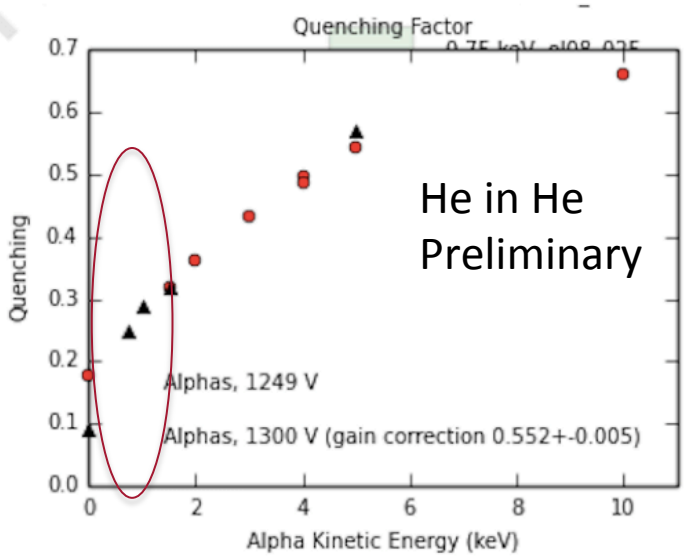




Quenching factors measurements @ Grenoble

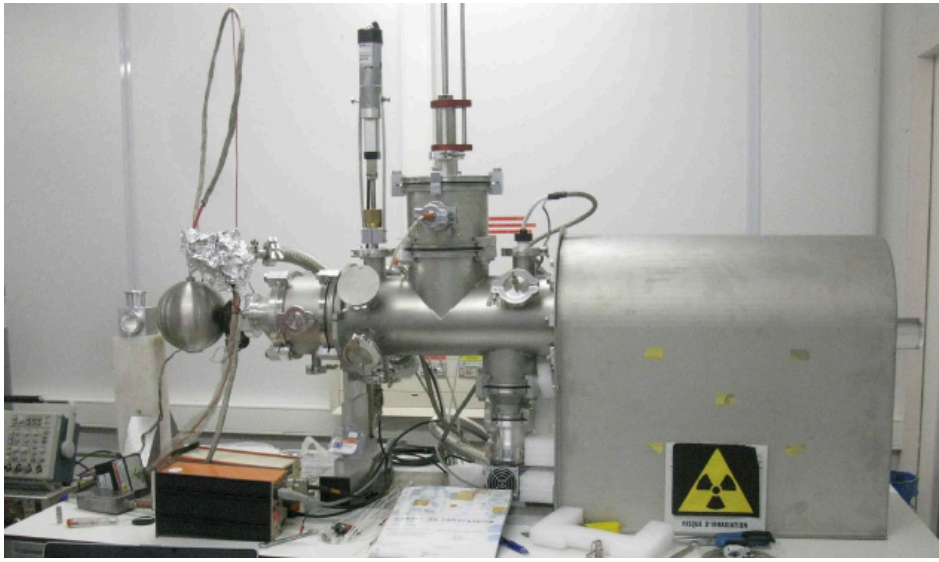


Hime Model arXiv 0712.2470v2



Use Ion beam injected to detector through massless window

Trick : 1 μm hole



NEWS Collaboration : International
First collaboration meeting @ SNOLAB 27-28 May

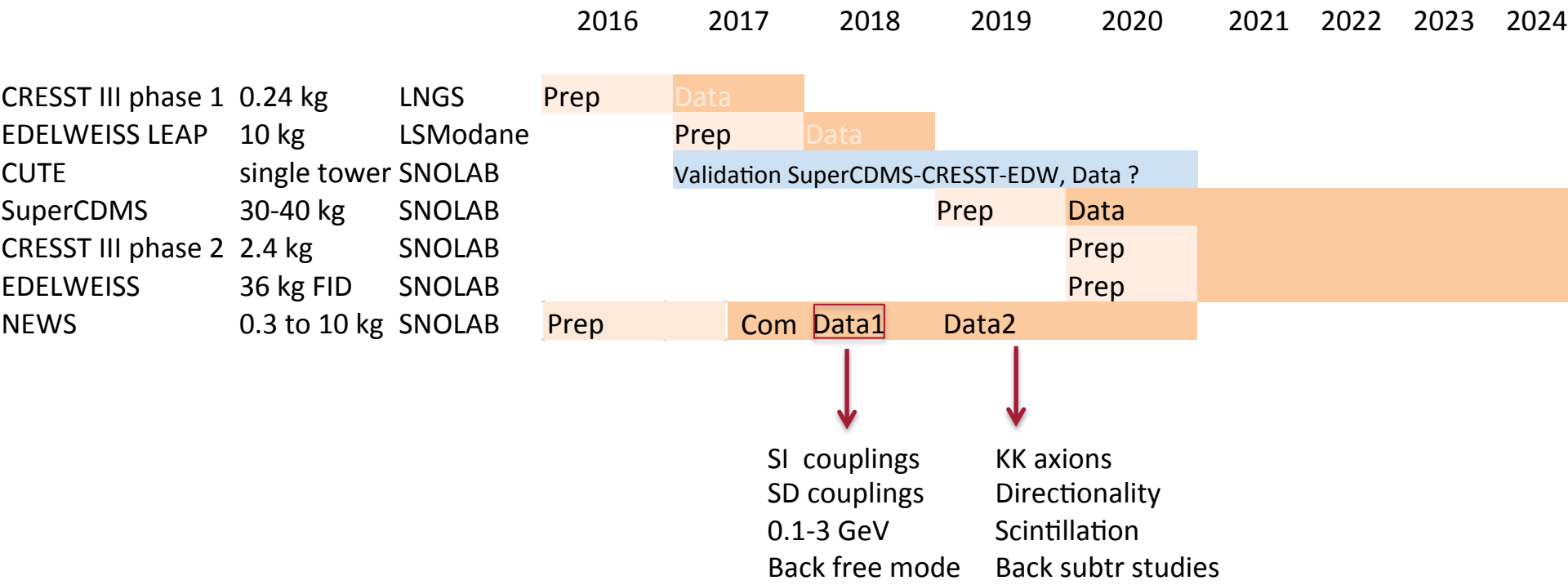
- **Queen's - Philippe di Stefano, Tony Noble, Sabine Roth, Alexis Brossard, Alvine Akamaha, Paco Vasquez dS, Philippe Camus + Connor, Sean, Jon, + 3 new MsC/PHD (2020), + 1-2 PDF**
  - Copper vessel and gas set-up specifications, project follow up,calibration set up
  - Gas characterisation at Queen's, laser calibration, on smaller scale prototype…
  - Simulations/Data analysis
- **SNOLAB – Ken Mc Farlane, Brian Morisette**
  - Water shield and infrastructure at SNOLAB
- **(TRIUMF - Fabrice Retiere) : cosmic ray protection for sphere fabrication at PAVAC, light detection, sensor**
- **IRFU/Saclay -Ioannis Giomataris, Michel Gros, Thomas Papaevangelou, Patrick Magnier, Jean Paul Bard**
  - Sensor/rod (low activity, optimised wrt field with 2 electrodes)
  - Electronics (low noise preamps, digitisation, stream mode)
  - DAQ/soft
- **LSM** (Laboratoire Souterrain de Modane) **- F Piquemal + M Zampaolo, +Ali DastgheibiFard**
  - Low activity archelogical lead for close electronics/valve shield
- **Tessaloniki University – I Savvidis + Ioannis Katsioulas**
  - Simulations, neutron calibration
  - Studies on sensor
- **LPSC Grenoble - D Santos + JFrancois Muraz, Olivier Guillaudin**
  - Quenching factor measurements < 1 KeV with ion beams
- **TU Munich – A Ulrich**
  - Gas properties and ionisation process for Pening mixtures
- **… more welcome :**

Prospects

- Other physics and applications
  - Coherent Neutrino Scattering detection at nuclear plant
  - Double beta decay (need < <1 μB/kg)
  - Gamma and neutron spectrometers

- Improvements (Queens and TRIUMF)
  - Scintillation measurement => discrimination
  - Segmented sensor => directionality
  - …

Time line


2016
2017
2018
2019
2020
2021
2022
2023
2024
CRESST III phase 1 0.24 kg LNGS
EDELWEISS LEAP 10 kg LSModane
CUTE single tower SNOLAB
SuperCDMS 30-40 kg SNOLAB
CRESST III phase 2 2.4 kg SNOLAB
EDELWEISS 36 kg FID SNOLAB
NEWS 0.3 to 10 kg SNOLAB
Prep
Data
Prep
Data
Validation SuperCDMS-CRESST-EDW, Data ?
Prep
Data
Prep
Prep
Prep
Com
Data1
Data2
SI couplings
SD couplings
0.1-3 GeV
Back free mode
KK axions
Directionality
Scintillation
Back subtr studies