Status of NEWS-G Experiment

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1: IRFU Saclay, 3: Queen's University (Canada), 3: LSM Modane, 4:Univ. of Thessaloniki, 5: Univ. of Ioannina,

Ali DASTGHEIBI FARD

Outline

- Spherical Proportional Counter (SPC)
- NEWS-G collaboration
- NEWS-G_LSM (SEDINE) @ at Laboratoire Souterrain de Modane
- NEWS-G_SNOLAB
- Summary

Principle of the detection of Spherical Proportional Counter (SPC)

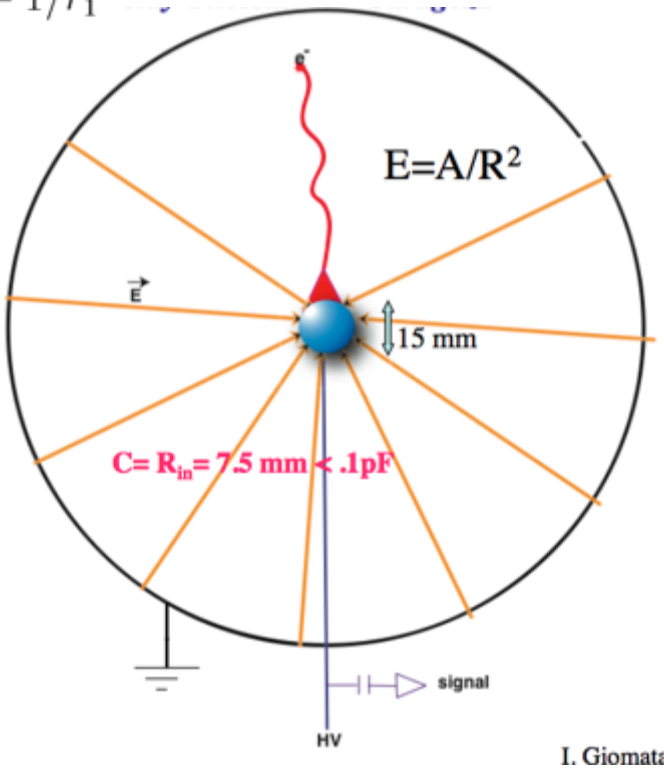
Radial Electric field
Ball radius = 0.5-15 mm
Spherical radius = 7.5-70 cm

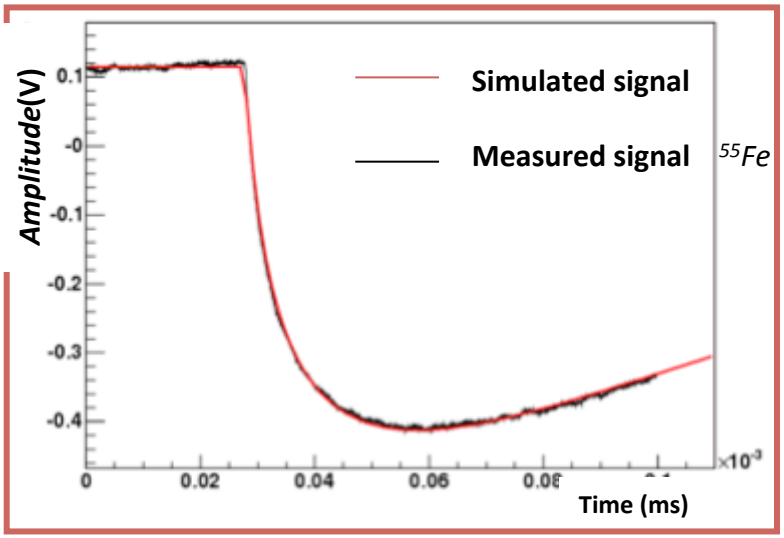
$$C = 4\pi\epsilon\rho$$

$$1/\rho = 1/r_2 - 1/r_1$$

$\rho \approx r_2$

$$E(r) = \frac{V_0}{r^2}\rho$$





A Novel large-volume Spherical Detector with Proportional Amplification read-out, I. Giomataris *et al.*, JINST :P09007,2008

Main characteristics

- Low capacitance < *0.1 pF*
- Low energy threshold (≈ 50 eV)
- Good energy resolution
- A single measurement channel for a large volume
- Flexibility : gas, pressure
- Robust, simple and cheap

NEWS-G Collaboration

- **Queen's University Kingston –** G Gerbier**,** P di Stefano, R Martin, T Noble, A Brossard, A Kamaha, P Vasquez dS, Q Arnaud, K Dering, J Mc Donald, M Clark, M Chapellier
  - Copper vessel and gas set-up specifications, calibration, project management
  - Gas characterization, laser calibration, on smaller scale prototype
  - Simulations/Data analysis
- **IRFU** (Institut de Recherches sur les Lois fondamentales de l'Univers)**/CEA Saclay** -I Giomataris, M Gros, C Nones, I Katsioulas, T Papaevangelou, JP Bard, JP Mols, XF Navick,
  - Sensor/rod (low activity, optimization with 2 electrodes)
  - Electronics (low noise preamps, digitization, stream mode)
  - DAQ/soft
- **LSM** (Laboratoire Souterrain de **Modane**), IN2P3, U of Chambéry - F Piquemal, M Zampaolo, A DastgheibiFard
  - Low activity archeological lead
  - Coordination for lead/PE shielding and copper sphere
- **Thessaloniki University –** I Savvidis, A Leisos, S Tzamarias, C Elefteriadis, L Anastasios
  - Simulations, neutron calibration
  - Studies on sensor
- **LPSC (**Laboratoire de Physique Subatomique et Cosmologie) **Grenoble** - D Santos, JF Muraz, O Guillaudin
  - Quenching factor measurements at low energy with ion beams
- **Technical University Munich –** A Ulrich, T Dandl
  - Gas properties, ionization and scintillation process in gaz
- **Pacific National Northwest Lab–** E Hoppe, D Asner
  - Low activity measurements, Copper electroforming
- **RMCC (**Royal Military College Canada**) Kingston –** D Kelly, E Corcoran
  - 37 Ar source production, sample analysis
- **SNOLAB –Sudbury –** P Gorel
- – P Gorel Calibration system/slow control
- **University of Birmingham** – Costas Nicolopoulos
  - – Simulation, Analysis, R&D
- **Associated lab : TRIUMF** - F Retiere
  - Future R&D on light detection, sensor

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NEWS-G_LSM (SEDINE)

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Fabrication

January-Jun 2012

Radiopure copper

Electron beam welding

60 cm diameter

Installation

Jun-Jully 2012 @ LSM

Acquisition & Setup

HPGe Gamma spectrometry

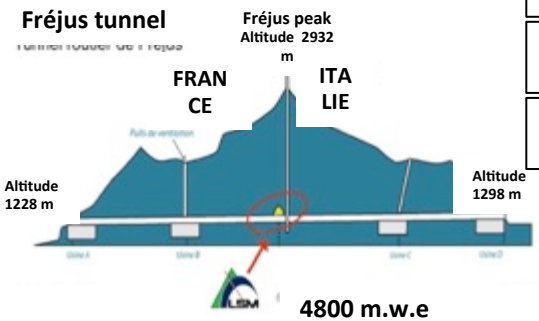
NOSV Copper (µBq/Kg) :

. ^{226}Ra < 16

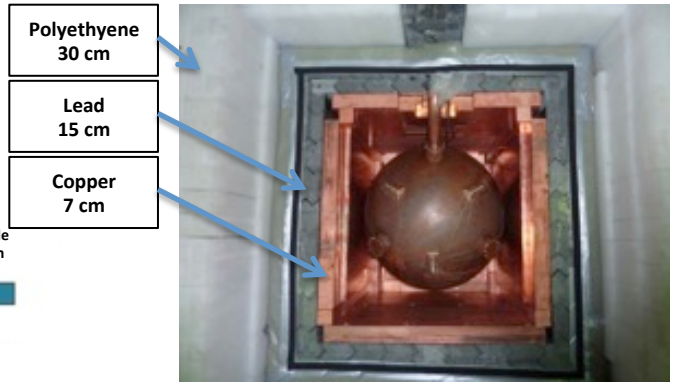
. ^{228}Th < 12

. ^{40}K < 110

. ^{60}Co < 18

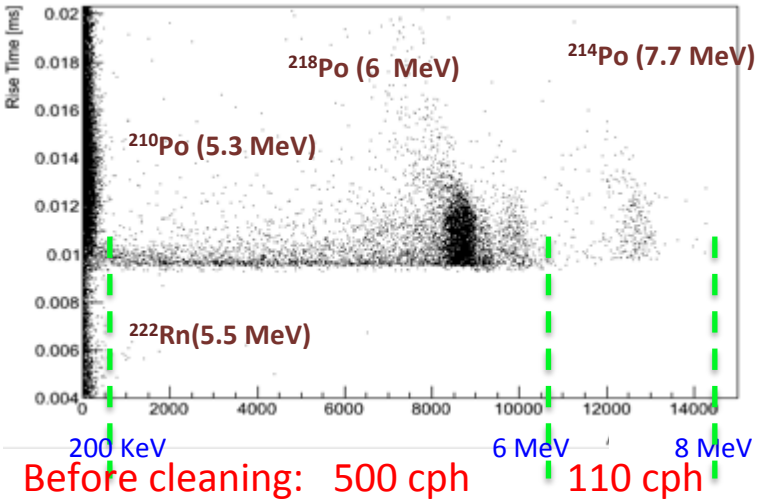


SEDINE at its shielding with top part open



Removing Internal contamination by chemical cleaning

Ar + CH_4 (2%) P = 300 mbar

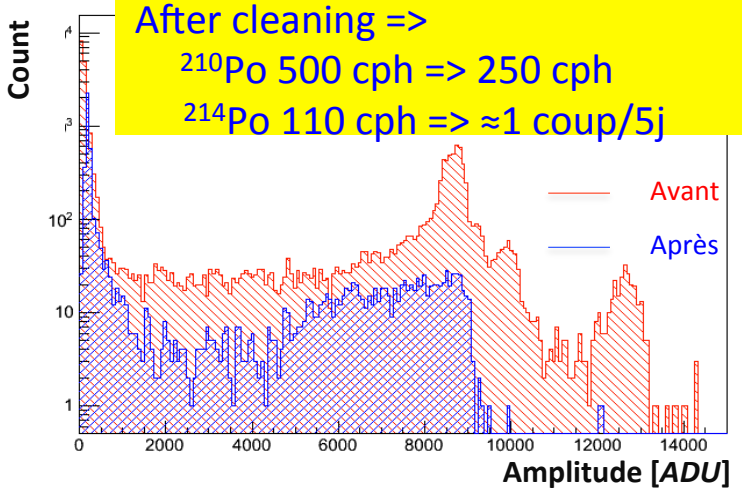


Before cleaning: 500 cph 110 cph

Conditions :

- Nitric acid 17 % & 30 %
- T≈ 10° *C* & 30 °
- Cleaning by the filling of the **spherical cavity**
  &
- Cleaning by the spraying the internal/external surface of the **spherical cavity**
- Washing by the purified water
- Drying with hot nitrogen

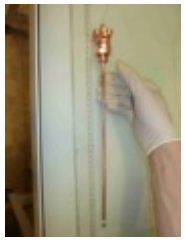
After cleaning =>
^{210}Po 500 cph => 250 cph
^{214}Po 110 cph => ≈1 coup/5j

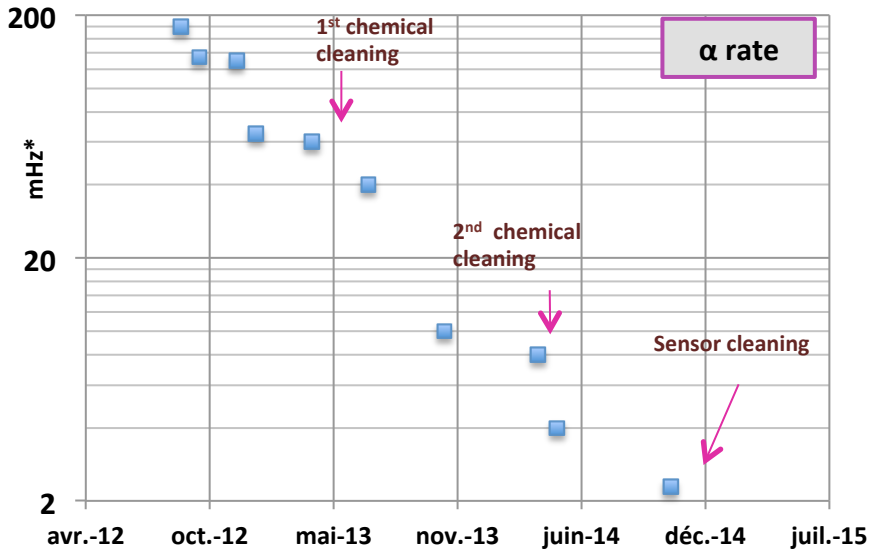


Residual deposit of ^{210}Pb on the surface of cavity

Background reduction

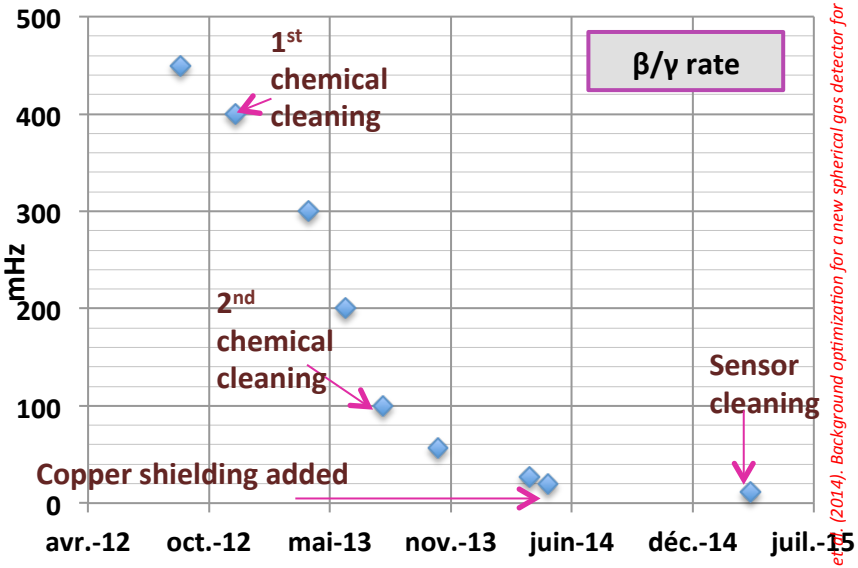
Removing Internal contamination by chemical cleaning





180e-3 *cps* → < 1.7 e-3 cps

16 μBq.cm^{-2} => 150 nBq.cm^{-2}

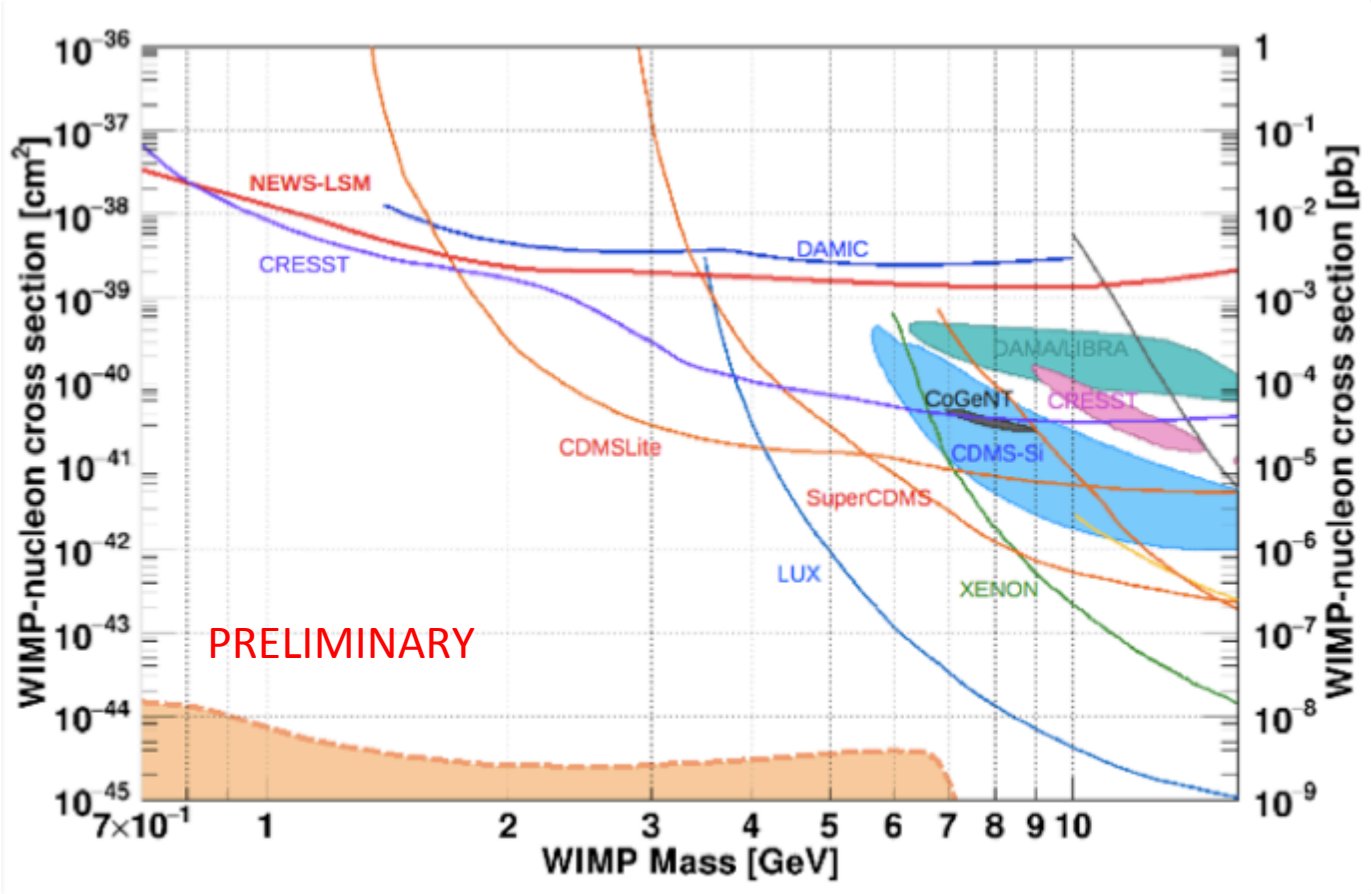


400E-3 *cps* → <18 E-3 cps

Dastgheibi-Fard, A., et al. (2014). Background optimization for a new spherical gas detector for very light WIMP detection. TIPP conf. proceeding

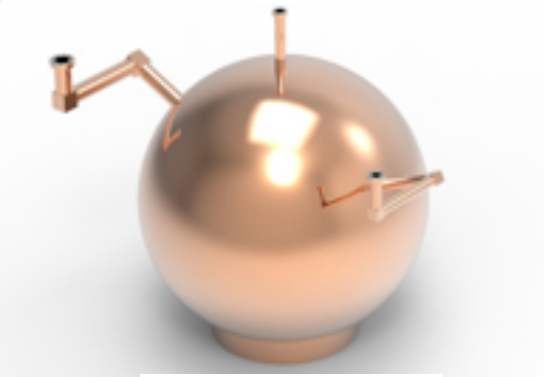
SEDINE sensitivity for detection of the Light WIMPs
After background reductions

Limits from SEDINE on Neon target assume 100 % cuts eff



NEWS-G_SNOLAB

NEWS-G_SNOLAB



Copper vessel

Fabrication

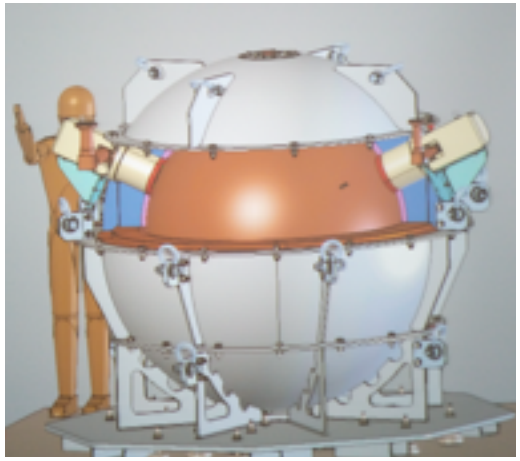
The end of 2017

Radiopure copper

Electron beam welding

140 cm diameter

ICP-MS measurement



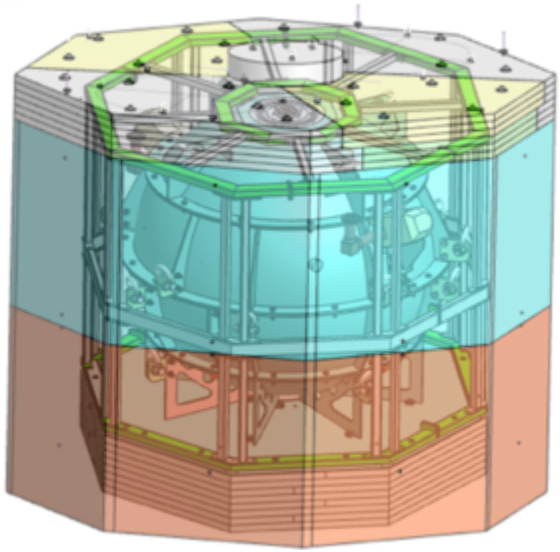
Lead shielding and its support

→ 25 cm of lead : (enveloped by Stainless steel support)

- **23 cm of normal lead**
- **2 cm of Roman lead**

AND

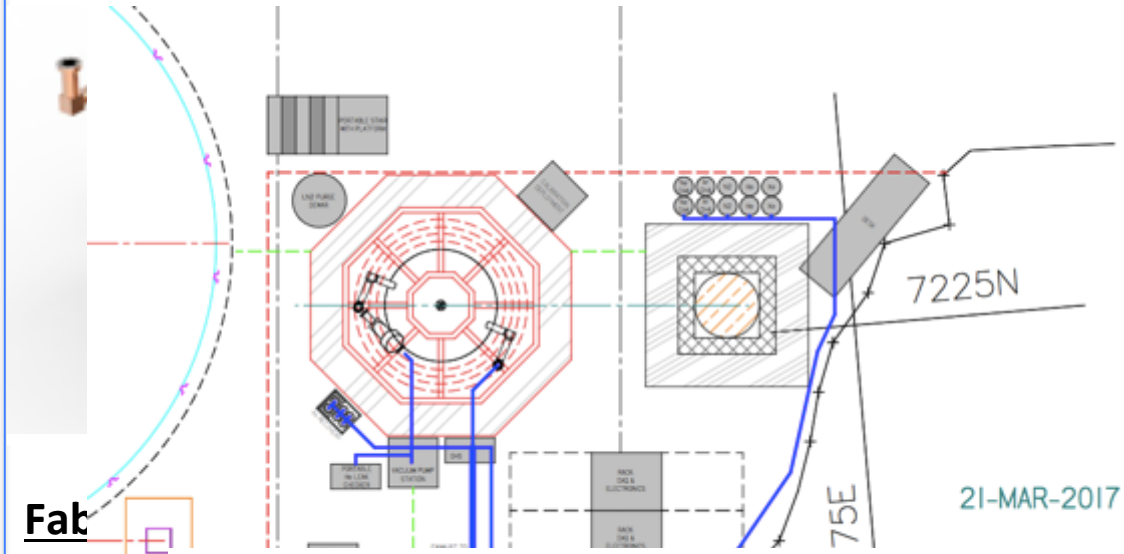
→ 40 cm of PE + Boron sheet

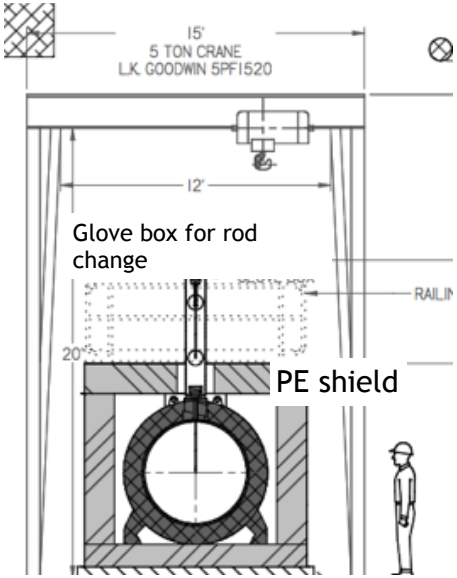


Installation @ SNOLAB

Before installation at SNOLAB (the beginning of 2018) the sphere and its shield will be mounted at LSM

NEWS-G_SNOLAB





NEWS-G-G-G in Cube Hall @ SNOLAB

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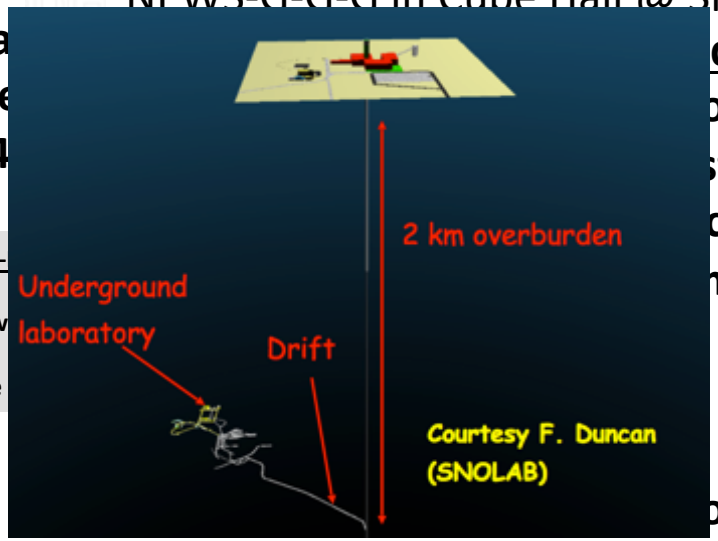
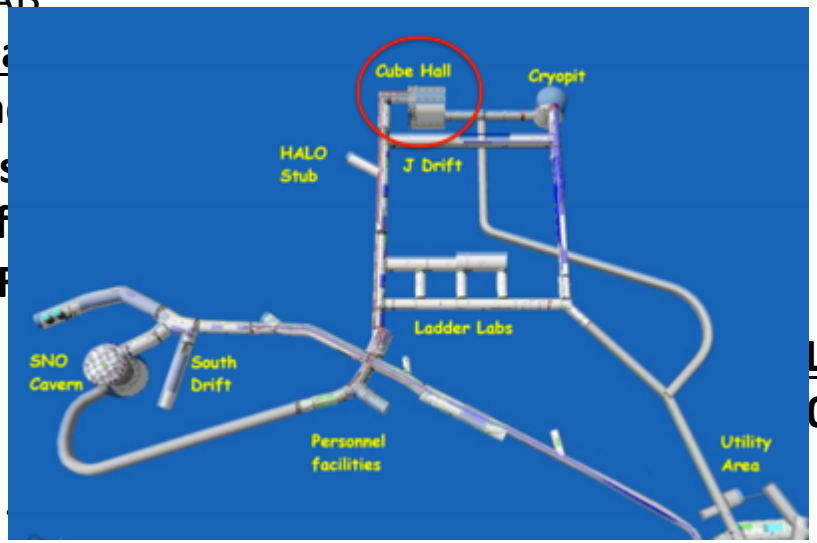




LAB
018

of PE

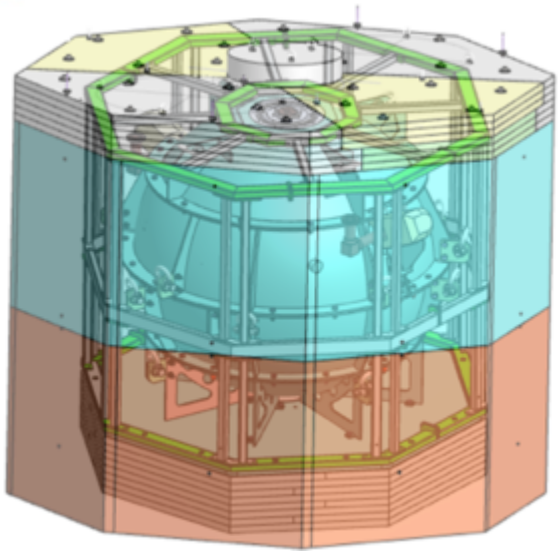
NEWS-G_SNOLAB

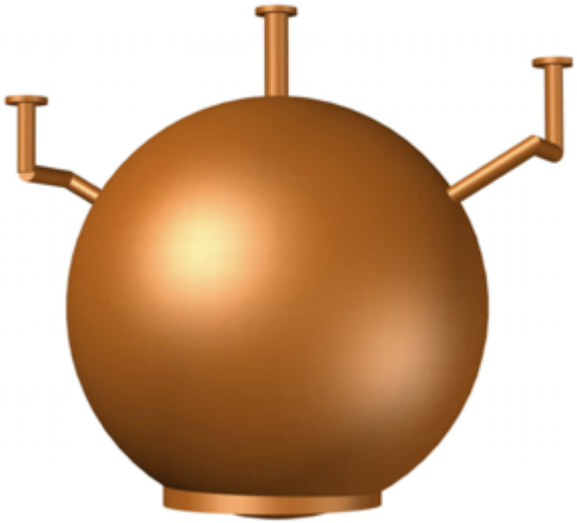
From Outside to Inside

Lead shielding and its support

High pure copper vessel and its flanges

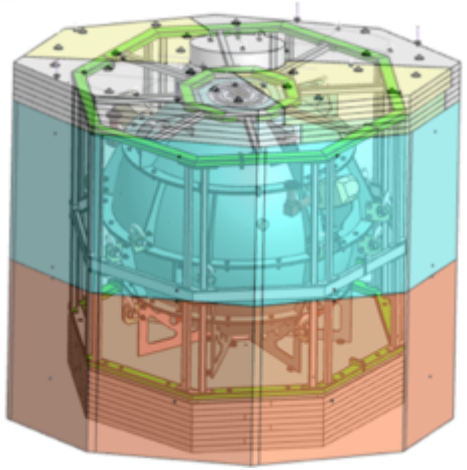
Rod/Sensor system





M. Zampaolo Presentation at 2nd NEWS-G-G Workshop at LSM

NEWS-G External component (HPGe, radiopurity.org)



Radiopurity of Materials [Bq/kg]

	Weight	^{226}Ra	^{214}Bi	^{208}Tl	^{228}Th	^{238}U	^{210}Pb	^{228}Ra	^{40}K	^{60}Co
Polyethylene	≈ 2t		0.016	<0.006			0.07			0.005
Standard lead	≈ 22t	<4.9e-3			<3.8e-3	<1.6e-2	4.6±0.016	<1.4e-2	0.07	
Roman (Archaeological) lead	≈ 1.4t				1.5-23e-6	8-60e-6	<0.9			
Inox support	≈ 2t			80e-3	200e-3	300e-3	900e-3		60e-3	230e-3

ICP-MS **Copper** measurement (collaboration with PNNL)

Copper sheet thickness : 12mm

- ref SHEET0: sample from deep of the corner curved-triangle
- ref HEAD0I: sample from end of equator, ≈ 1mm deep from the internal surface
- ref HEAD0E: sample end of the equator, , ≈ 1mm deep from the external surface
- ref HEAD45I: sample from "Parallel" 45° of end of the equator, ≈ 1mm deep from the internal surface
- ref HEAD45E: sample from "Parallel" 45° of end of the equator, ≈ 1mm deep from the external surface
- ref HEAD90I: sample from end of the curve, ≈ 1mm deep from the internal surface
- ref HEAD90I: sample from end of the curve, ≈ 1mm deep from the external surface

			Th		U	
PNNL Sample ID	NEWS-G-G Sample Name	g dissolved Cu	microBq/ kg	+/- stdev	microBq/ kg	+/- stdev
NEWS-G_Cu_1	HEAD90I	2,0188	7,73	0,16	1,99	0,09
NEWS-G_Cu_2	HEAD0I	1,6628	27,5	0,3	5,60	0,18
NEWS-G_Cu_3	HEAD0E	2,2764	7,31	0,11	2,02	0,17
NEWS-G_Cu_4	HEAD45E	1,9258	12,8	0,1	2,70	0,11
NEWS-G_Cu_5	HEAD45I	2,9768	12,5	0,1	2,95	0,03
NEWS-G_Cu_6	HEAD90E	1,8886	7,08	0,05	1,85	0,09
NEWS-G_Cu_7	SHEET0	4,5830	22,1	0,6	4,92	0,20
NEWS-G_Cu_8	HEAD0 CHUTE	3,7314	10,0	0,1	2,30	0,11
NEWS-G_Cu_9	HEAD45 CHUTE	5,8067	18,3	0,0	4,01	0,11
NEWS-G_Cu_10	SHEETO CHUTE	3,6778	13,3	0,2	3,57	0,10
NEWS-G_Cu_11	HEAD90 CHUTE	3,6558	3,77	0,03	1,06	0,07
Average			**12,94**	**0,16**	**3,00**	**0,11**

NEWS-G internal components (ICP-MS measurement ENS_Lyon)

New components measurement:

- 6.3 mm Si ball (0.31 g)
- 2 mm Stainless steel ball (0.028 g)
- 0.2 Cu HV cable (≈ 3 g)

µBq/kg

NEWS-G Ref	Material	Description	238U	226Ra	210Pb	232Th	228Th
NEWS-G_Si6.3mm	Silicium	Ball Φ = 6.3 mm	1,23E+01	<7,32E+08	<5,73E+10	7,71E+00	<6,07E+11
NEWS-G_Inox2mm	Inox	Inox Ball Φ = 2 mm	4,13E+02	<7,32E+08	<5,73E+10	2,31E+01	<6,07E+11
NEWS-G_HTCu#1	Copper	High Voltage cable juste copper	1,74E+01	<7,32E+08	<5,73E+10	3,45E+00	<6,07E+11

Bq

NEWS-G Ref	Material	Description	238U	232Th
NEWS-G_Si6.3mm	Silicium	Ball Φ = 6.3 mm	3,69E-09	2,31E-09
NEWS-G_Inox2mm	Inox	Inox Ball Φ = 2 mm	1,16E-08	6,47E-10
NEWS-G_HTCu#1	Copper	High Voltage cable juste copper	5,22E-08	1,04E-08

➢ The ICP-MS method, have good sensibility for ^{238}U and ^{232}Th.

As we can observe, except ^{238}U and ^{232}Th, for other isotopes the limits are very high. But, we have take account even with HPGe, we need very long measurement time to find good limits. This is because of very low mass of these “canne” components.

Simulated background budget in NEWS-G_SNO

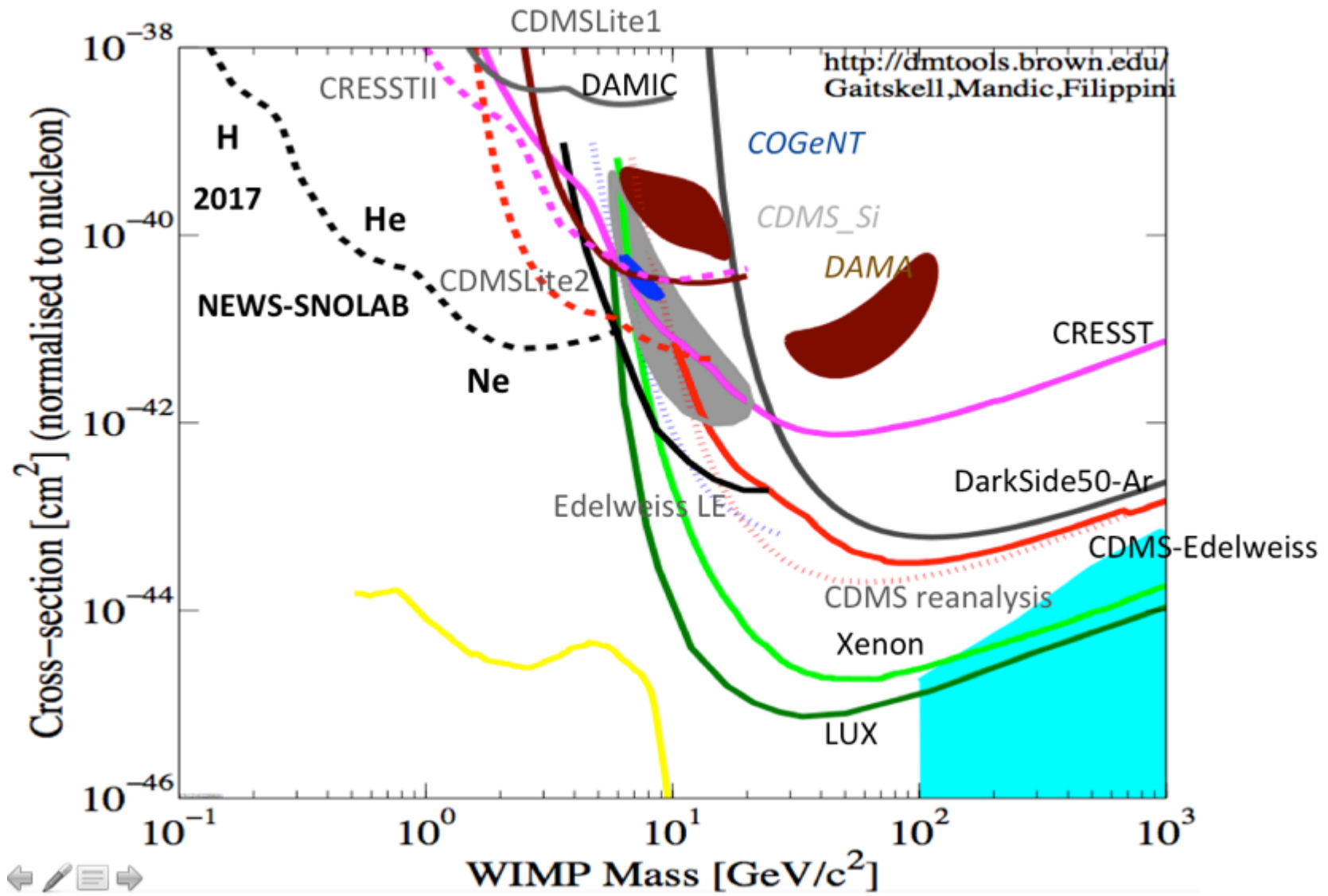
Simulation done with 12mm thick 140cm diam copper sphere full with 99% Ne 1%CH4, 11.43 kg of gas

Source Position	Mass (kg) or Surface (cm		Source	evts/kg/day/[(µBq/kg) or (nBq/cm2)]	contamination	units	evts/kg/day < 1keV	% Total	Comments
CopperSphere	627.83 kg		Co60	0.0018	30	µBq/kg	0.054	18.65	2 months exposure to Cosmic Rays
CopperSphere	627.83 kg		U238	0.0036	3	µBq/kg	0.011	3.73	spinned hemisphere samples mean ,measurement at PNNL
CopperSphere	627.83 kg		Th232	0.0049	12.9	µBq/kg	0.063	21.83	spinned hemisphere samples mean, measurement at PNNL
InnerSurface	**57255 cm^2**		**Pb210**	**0.012**	**1**	**nBq/cm2**	**0.012**	**4.15**	**1 nBq/cm2 are given by an exposition to radon of 12 Bq/m3 * h**
ArchLead	2108.95 kg		U238	0.001	61.8	µBq/kg	0.062	21.35	3 cm thick, measurement at PNNL
ArchLead	2108.95 kg		Th232	0.001	9.13	µBq/kg	0.010	3.47	3 cm thick, measurement at PNNL
Rod	0.0931721 kg		Co60	2.95E-007	30	µBq/kg	0.000	0.00	pper than for sphere [Innner_Radius = 2 mm ; Outter_Radius = 3 mm]
Rod	0.0931721 kg		U238	1.81E-006	3	µBq/kg	0.000	0.00	pper than for sphere [Innner_Radius = 2 mm ; Outter_Radius = 3 mm]
Rod	0.0931721 kg		Th232	2.11E-006	12.9	µBq/kg	0.000	0.01	pper than for sphere [Innner_Radius = 2 mm ; Outter_Radius = 3 mm]
Wire	2.66005e-05	kg	Co60	1.48E-010	31000	µBq/kg	0.000	0.00	Contamination from Ali thesis page 140 [Radius = 0.0375 mm]
Wire	2.66005e-05	kg	U238	2.12E-009	300000	µBq/kg	0.001	0.22	Contamination from Ali thesis page 140 [Radius = 0.0375 mm]
Wire	2.66005e-05	kg	Th232	1.42E-009	50000	µBq/kg	0.000	0.02	Contamination from Ali thesis page 140 [Radius = 0.0375 mm]
Wire	2.66005e-05	kg	K40	5.41E-010	1660000	µBq/kg	0.001	0.31	Contamination from Ali thesis page 140 [Radius = 0.0375 mm]
LabArea			**Tl208**				**0.076**	**26.25**	Old simulation with simple geometry was 0.009 , new one soon 0.076
C14 at surface of s	0.023 evt/s/Bq tot c14 at s		C14 =	100	61544	nBq/cm2	**1.0700**		40 to 200 nBq/cm2 from Carbonaceous CHx layer everywhere
	Addtions					**Total**	**0.290**	100	
New march 2017			evts/kg.d.kev	(mBq/kg)	upper limit ILIAS				
Arch lead			**Pb210**	**0.002**	**120**	**mBq/kg**	**0.240**	**less than**	
			evts/kg.d.kev/(Bq/m3)		LN2 evap				
2cm radon outside			**Ra220**	**0.37**	**0.05**	**Bq/m3**	**0.019**	**6.390**	%
Copper Co60	impact of increase of 2 weeks of sphere to CR						**0.014**	**4.663**	%

Total = 0.3 dru

Objective for 140 cm @ 10 bars = 1nBq/cm2 ⇔ 0.01 dru (3 % of total)

Goals for WIMP SI cross sections @ SNOLAB



Conclusion

NEWS-G_LSM

- Hardware_threshold ≈ 30 eV (by electronic noise improvement by factor 3-5)
- Alpha rate reduction by factor 100 (from beginning)

NEWS-G_SNOLAB

- fabrication at the end of the 2017
- Installation at SNOLAB after blank mounting at LSM (by the beginning of the 2018)

Perspectives

- Taking the Calibration then Physic runs with gas mixture based on He

Surface chemical cleaning

- Applying the NEWS-G_LSM (SEDINE) Nitric Acid procedure cleaning which allow us to reduce by factor 100, internal surface contamination
- Applying the PNNL method, using Hydrogen Peroxide
- Applying the Electropolishing, with collaboration of PNNL. The test on ^{210}Pb activated will be done

Conclusion

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NEWS-G sphere
Surface = 57226 cm^{-2}
Expected value after cleaning: few $nHz.cm^{-2}$

Thanks for your attention