

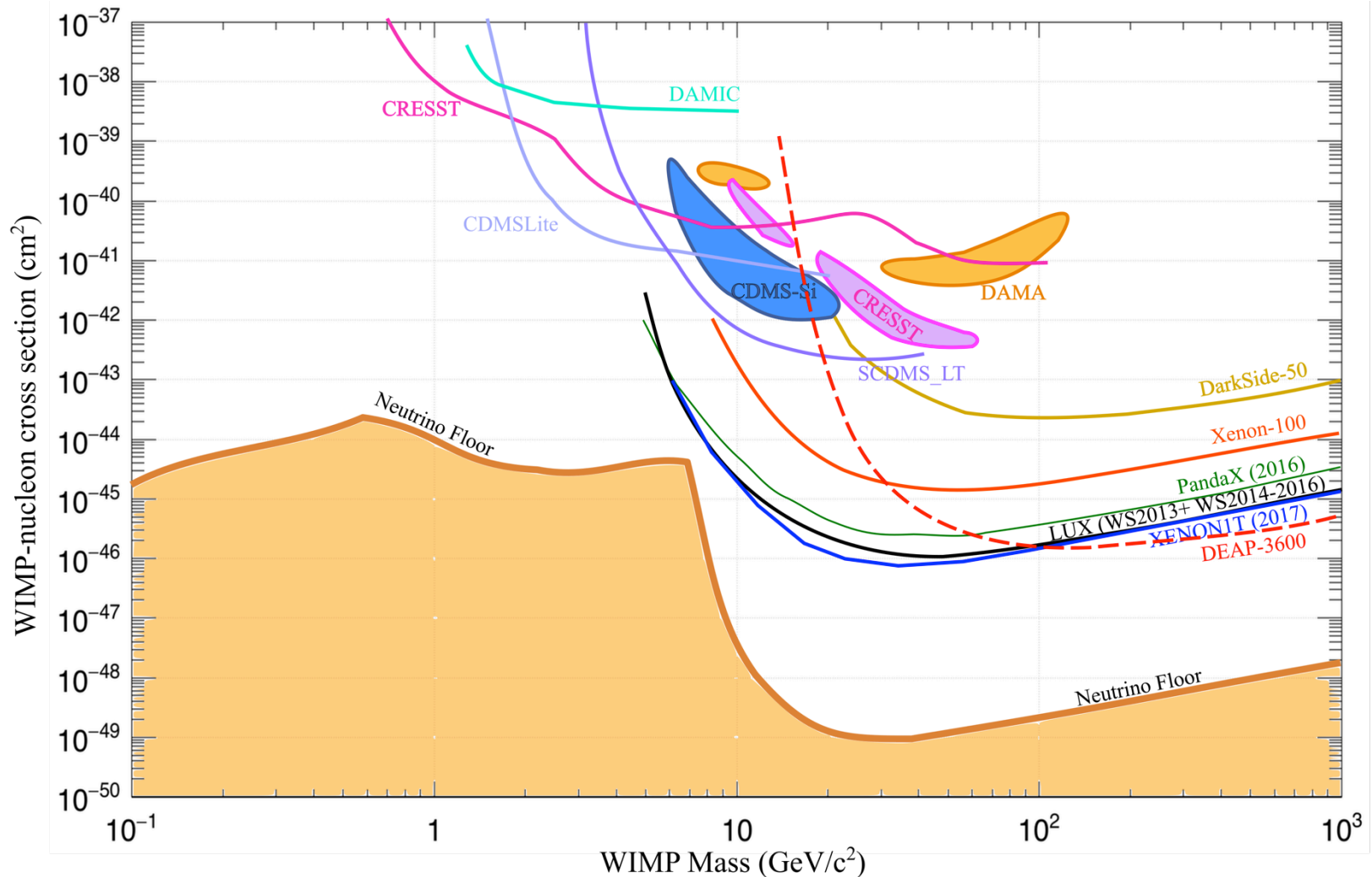
NEWS-G, a spherical TPC with low-A
target to search for sub-GeV mass
WI(M)Ps

Pierre Gorel, TAUP 2017 (Sudbury)

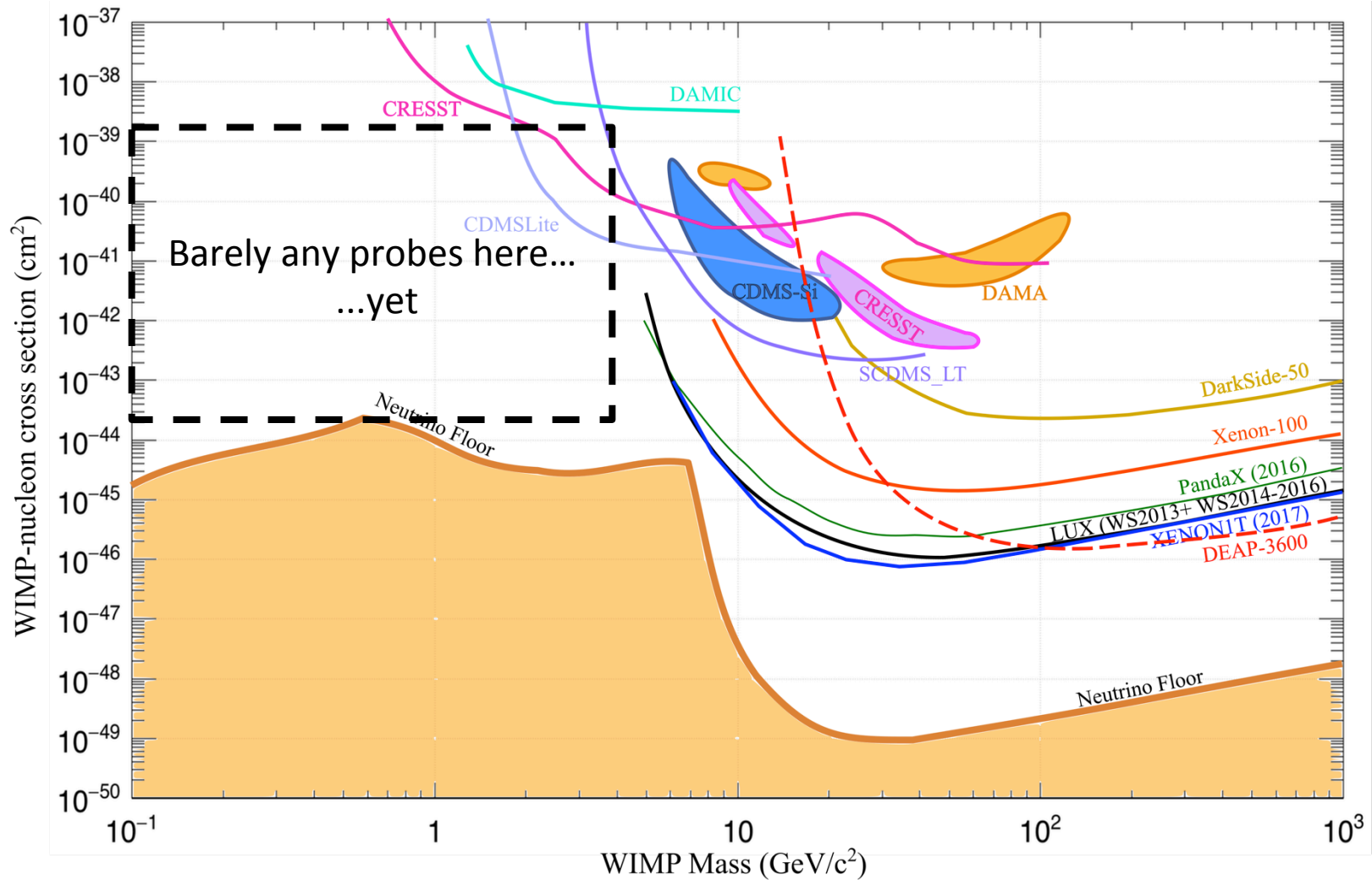


Laurentian University
Université **Laurentienne**

State of the art of WIMP search

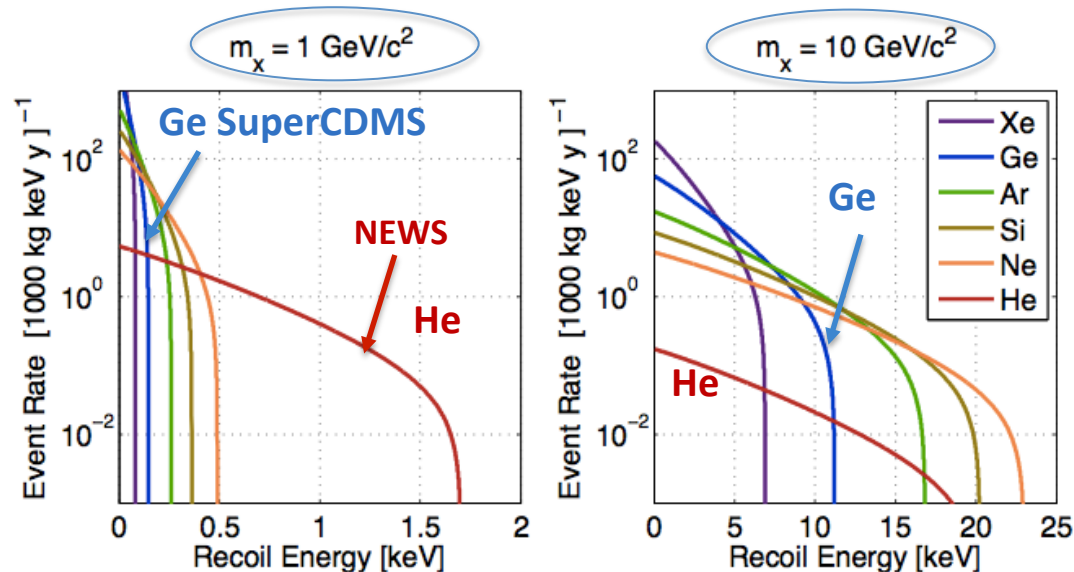
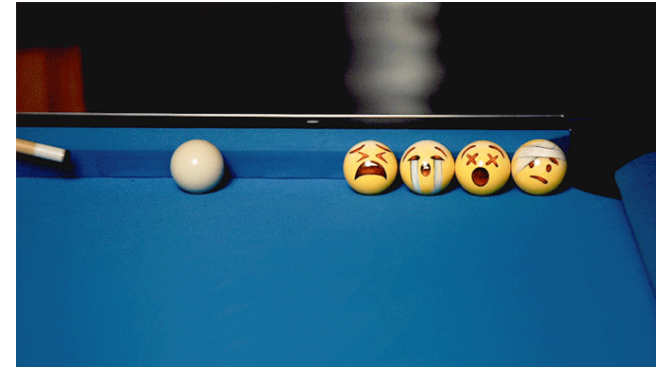


Possibilities for a lower mass



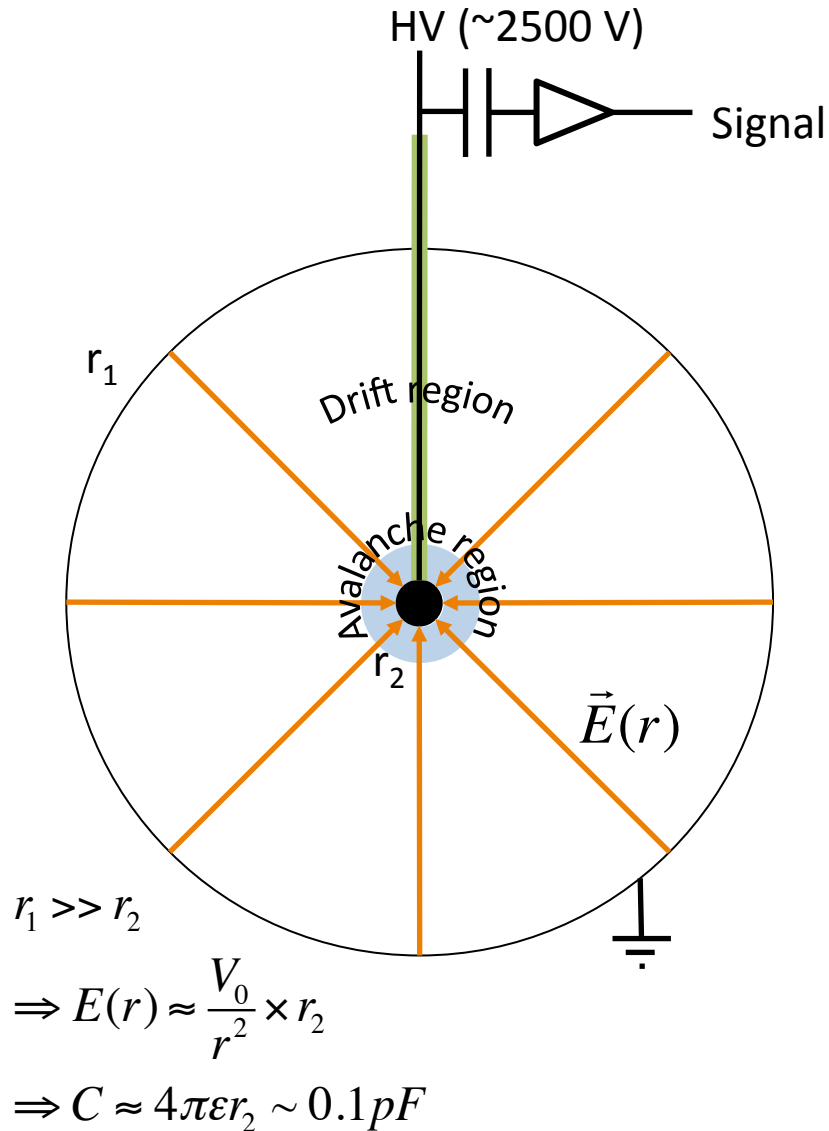
Detection of low mass particle

- Maximize momentum transfer
=> use light nuclei to detect light particle
(proton mass: 0.938 GeV)
- H, He, Ne lightest among noble gas



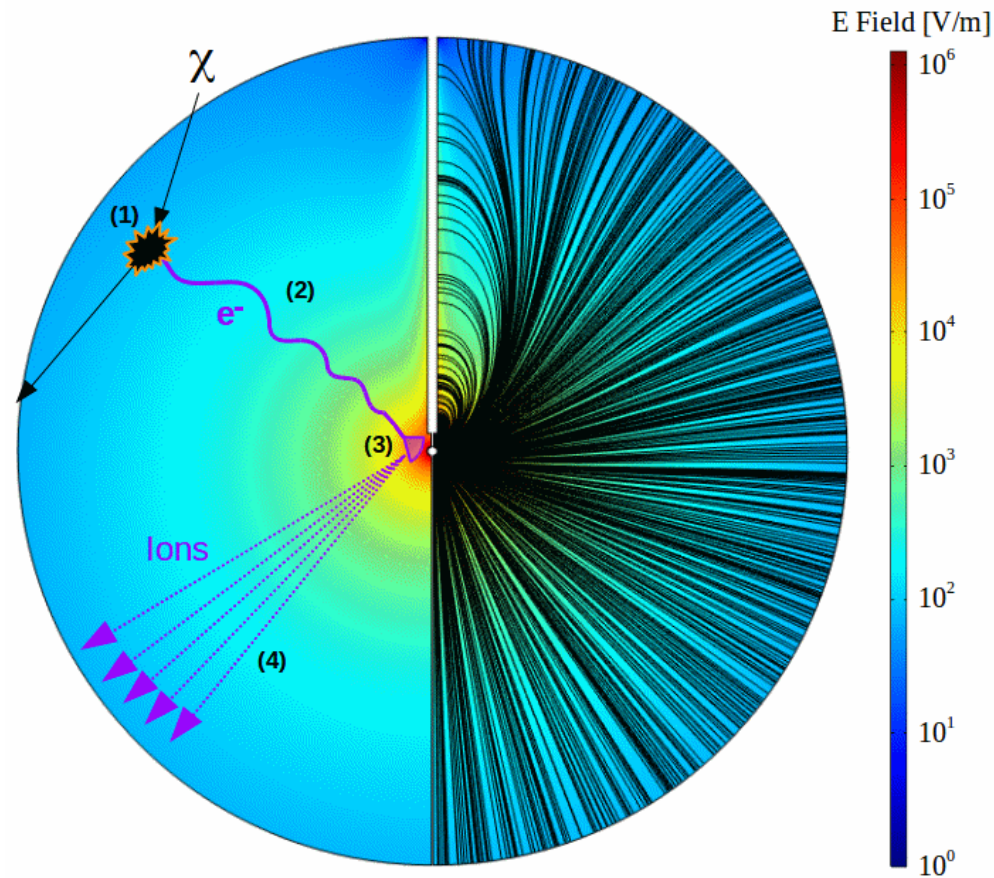
Recoil distributions with various targets material

New Experiments With Spheres (Gas)



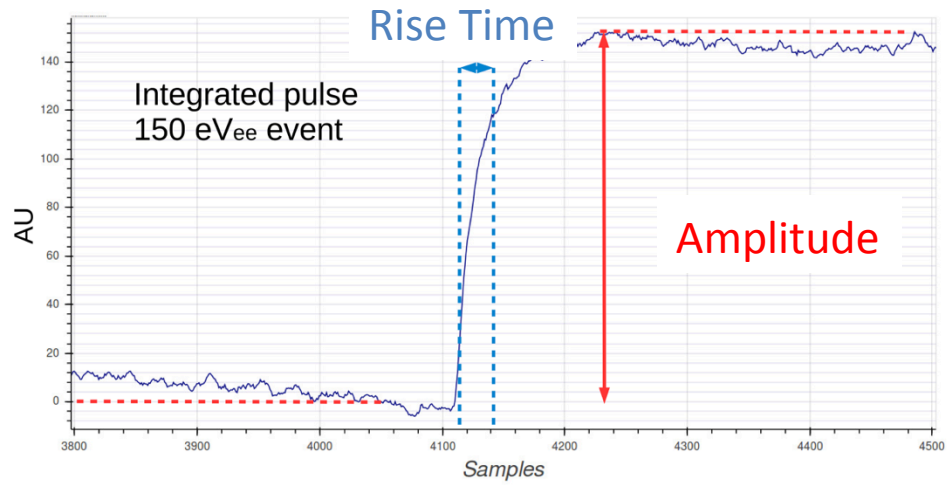
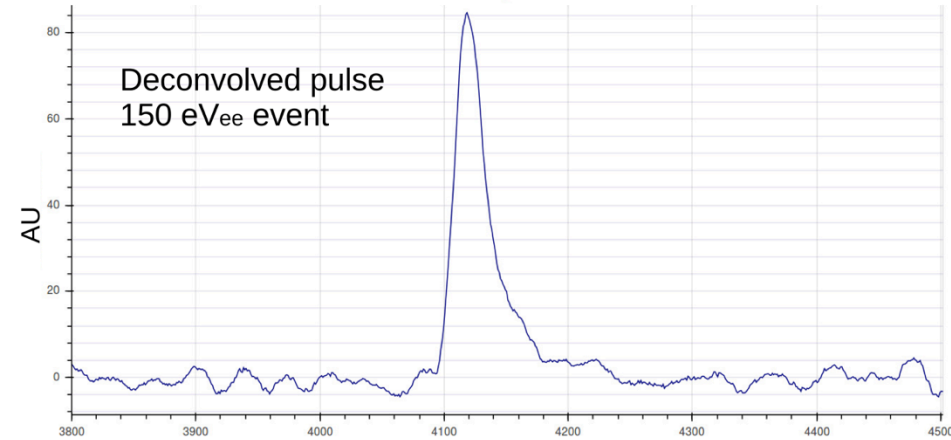
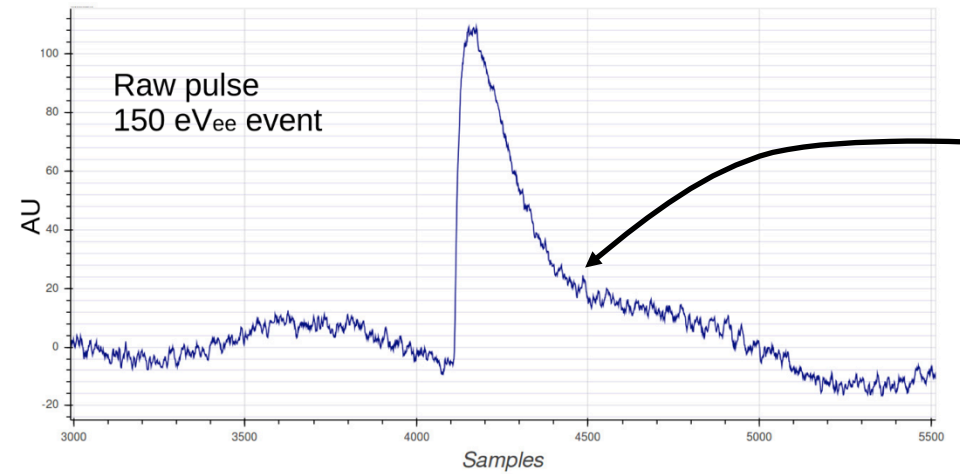
- Spherical detector
 - Single electrode
 - Spherical proportional counter/TPC
 - **Flexible (Pressure, gas)**
- Low threshold $\sim 50 \text{ eV}_{ee}$
independent on sphere radius
- Large mass / large volume
 ($\sim 30 \text{ kg}$) with single channel

Signal generation



1. Primary electron(s)
2. Electrons drift
3. Avalanche
4. Secondary Ions drift

Charge sensitive pre-amplifier
→ 50 μ s time constant

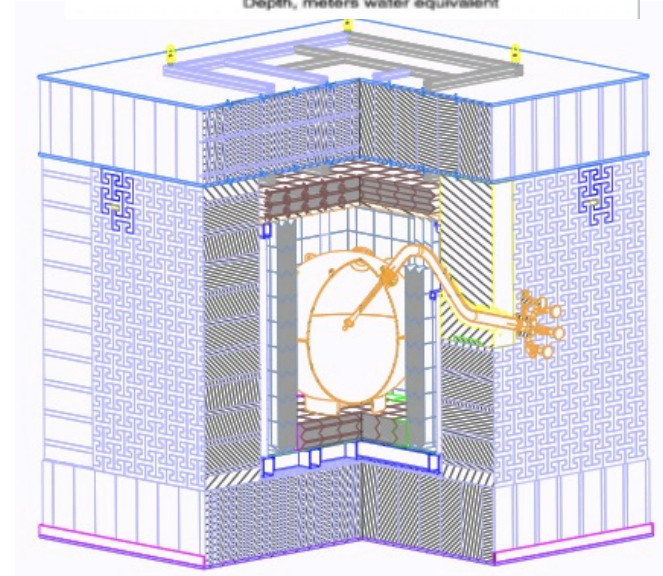
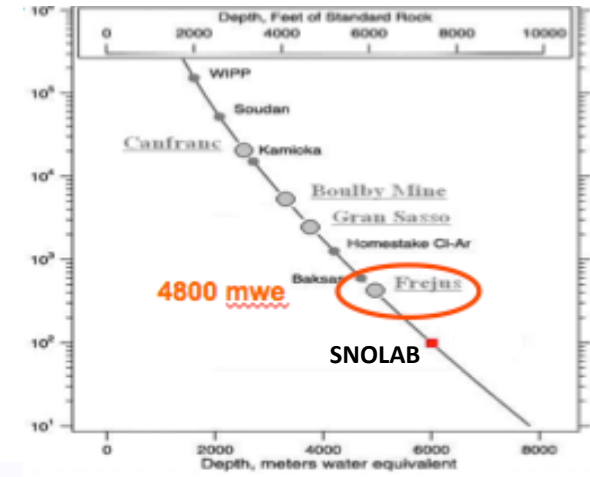


1) Deconvolution by exponential decay

2) Low-pass filter+ integration
Amplitude → Energy
Rise Time → Radius
(fiducialization)

Low activity 60 cm \emptyset prototype @ LSM : SeDiNe

Laboratoire Souterrain de Modane

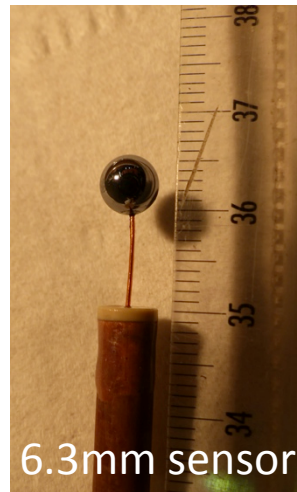


Shields: 4 to 7 cm Cu, 10 cm Pb, 30 cm PE

- Copper vessel equipped with 6 mm \emptyset sensor
- Runs with **Neon+0.7%CH₄** @ 3.1 bars
=> 310 g sensitive mass
- Several internal cleanings for radon deposit removal
- 42 days run for WIMP search



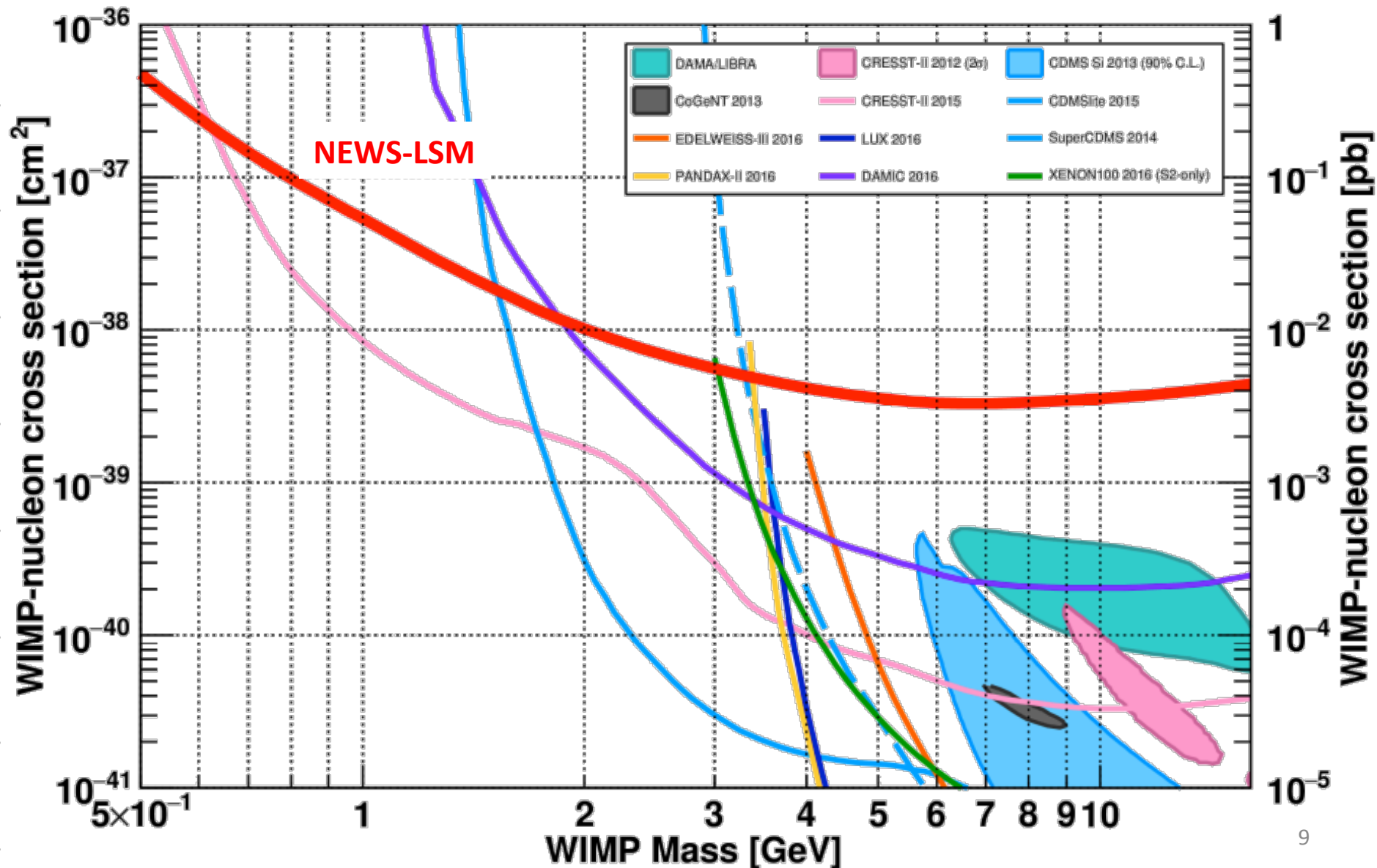
60 cm NOSV Cu vessel



6.3mm sensor

9.7kg.day with Ne

Arxiv: 1706.04934 (Submitted to Astroparticle Physics)

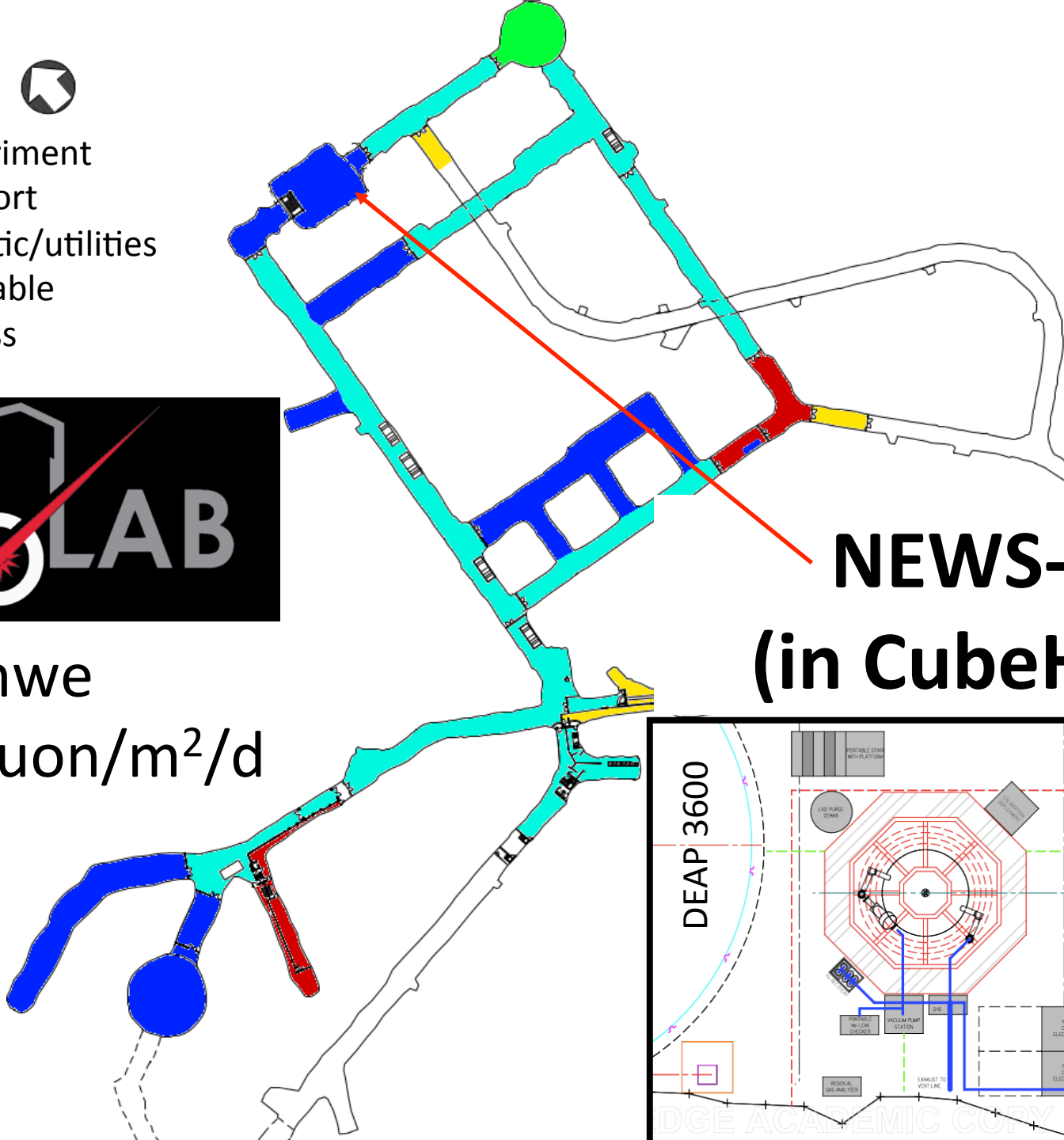




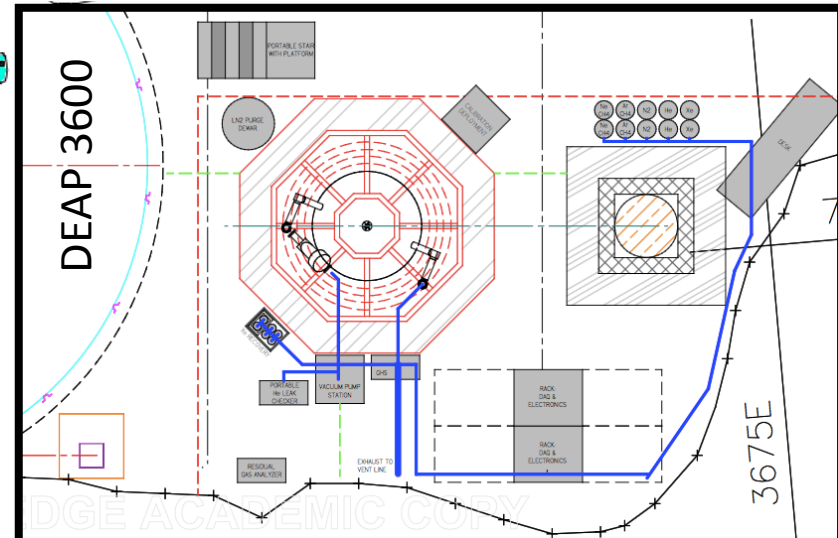
- Experiment
- Support
- Logistic/utilities
- Available
- Access



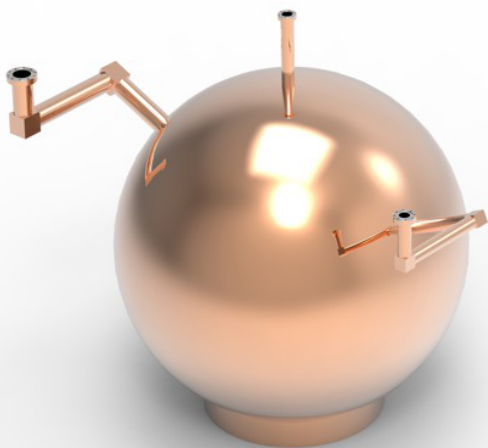
6000 mwe
0.27 muon/m²/d



NEWS-G
(in CubeHall)

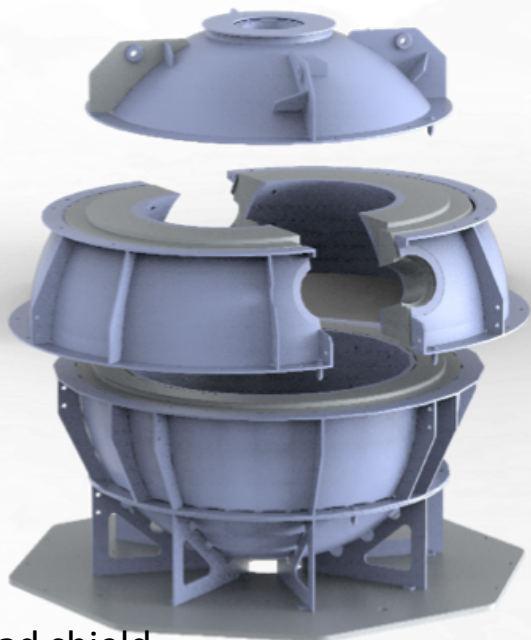


NEWS-G @ SNOLAB: early 2018



Copper vessel

- $\varnothing 140$ cm, 12mm thick
- 10 bars
- Ne, He, CH₄

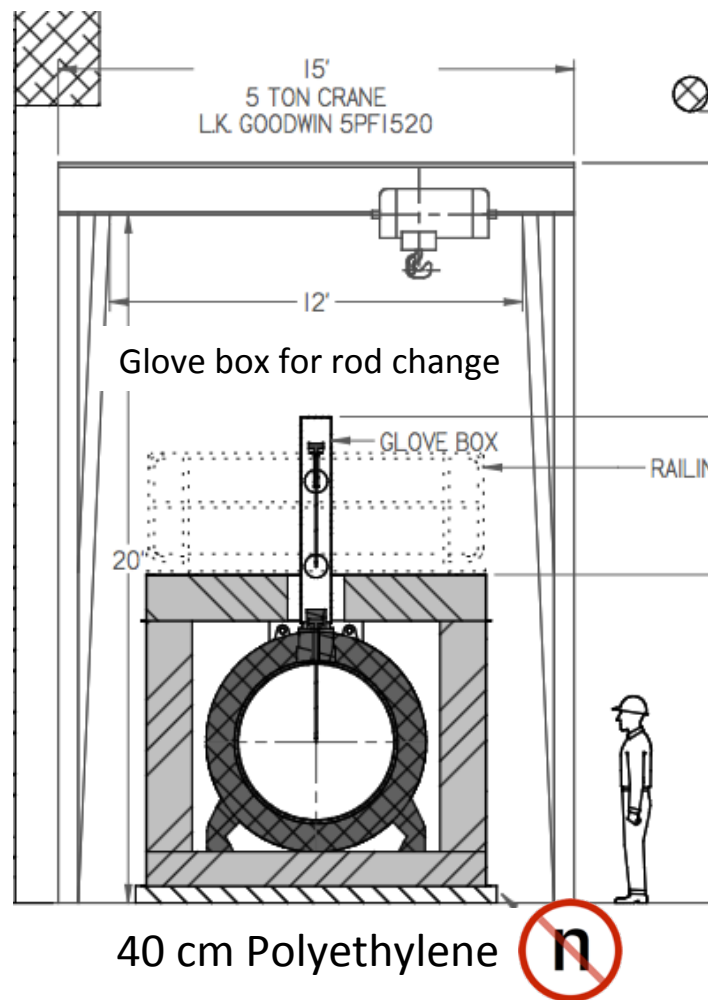


Lead shield



25 cm thick:

- 3cm inner: archeological
- 22cm outer: very low activity



Background budget (simulation)

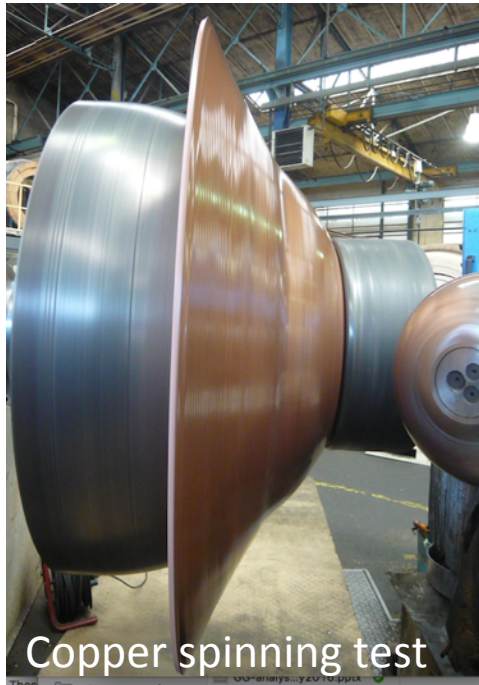
12mm thick, Ø140cm copper sphere. Ne+CH4(1%), 11.43kg of gas

Hypothesis for WIMP sensitivity limit calculation : 100 kg.d, 1 electron threshold

Source Position	Qty	Source	Contamination	Units	Evt/kg/day <1keV
Copper	627.83 kg	⁶⁰ Co	30	μBq/kg	0.054
Copper	627.83 kg	²³⁸ U	3	μBq/kg	0.011
Copper	627.83 kg	²³² Th	12.9	μBq/kg	0.063
Inner surface	57255 cm ²	²¹⁰ Pb	0.16	nBq/cm ²	0.002
Arch Lead	2108.95 kg	²³⁸ U	61.8	μBq/kg	0.062
Arch Lead	2108.95 kg	²³² Th	9.13	μBq/kg	0.010
Rod	0.0932 kg	⁶⁰ Co	30	μBq/kg	0.000
Rod	0.0932 kg	²³⁸ U	3	μBq/kg	0.000
Rod	0.0932 kg	²³² Th	12.9	μBq/kg	0.000
Wire	2.66x10 ⁻⁵ kg	⁶⁰ Co	31000	μBq/kg	0.000
Wire	2.66x10 ⁻⁵ kg	²³⁸ U	3x10 ⁵	μBq/kg	0.001
Wire	2.66x10 ⁻⁵ kg	²³² U	5x10 ⁴	μBq/kg	0.000
Wire	2.66x10 ⁻⁵ kg	⁴⁰ K	166x10 ⁴	μBq/kg	0.001
Lab		²⁰⁸ Tl/ ⁴⁰ K			0.076

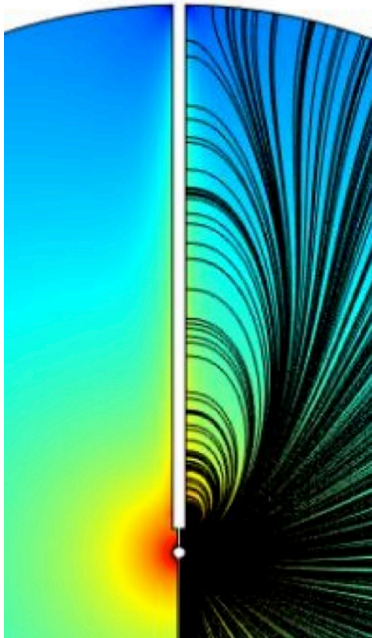
Total: 0.279 evts/kg/day < 1keV

Construction: copper sphere



- Sphere fabrication: spinning
 - Low activity copper (C10100) located
 - Activity measured @PNNL
 - ⇒ 7 to 25 $\mu\text{Bq/kg}$ of Th
 - ⇒ 1 to 5 $\mu\text{Bq/kg}$ of U
- } Within goals
- Initial project of water jet cleaning non-practical
 - Acid etching @LSM
 - R&D for copper electroplating

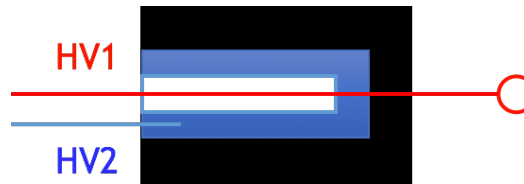
Sensors R&D



Sensor support disturbs the field
→ “umbrella” to counter the effect.



Bakelite umbrella



- Single channels “achinos” for optimization amplification & drift field
- Multi channels sensors (segmentation)
- Different materials: Si, Bakelite, Cu powder...

Calibration program

- AmBe: Nuclear recoils
- ^{22}Na : High energy gammas
- 213nm Laser : Low Energy, “surface” events
- ^{37}Ar : Low energy, “volume” events

^{37}Ar

Production: $^{40}\text{Ca} + n \rightarrow ^{37}\text{Ar} + \alpha$

Half-life: 35 days

Electron capture \rightarrow X-rays: 270 eV & 2.82 keV

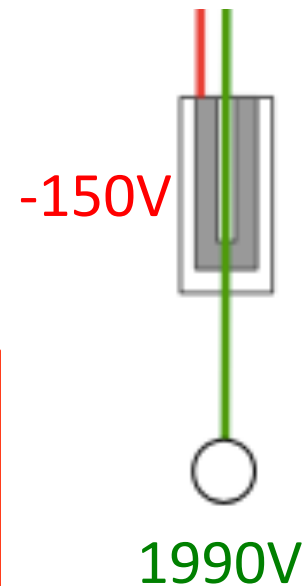
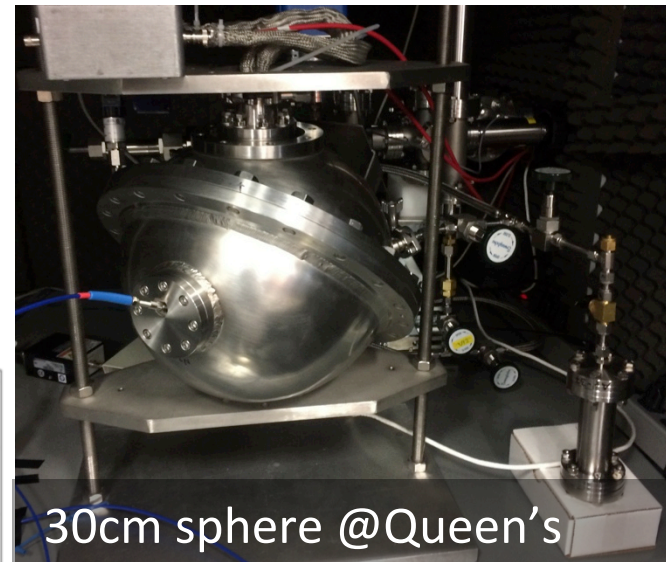
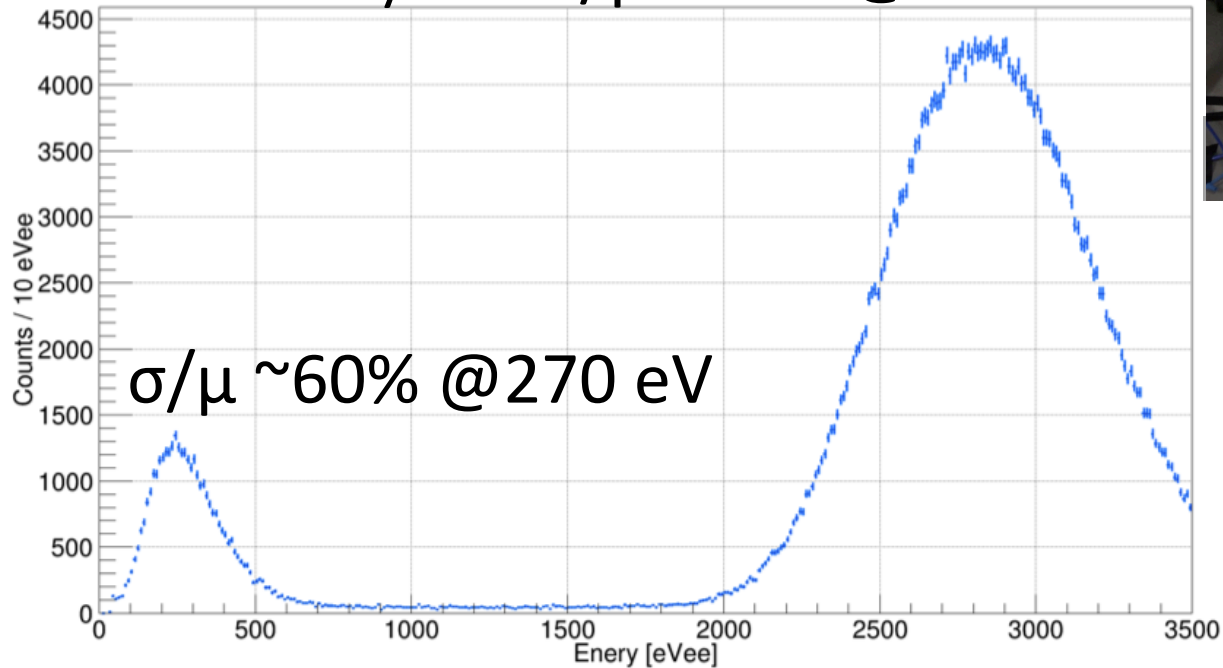


Clean transportation
canister

First delivery, May 2017 !

^{37}Ar signal

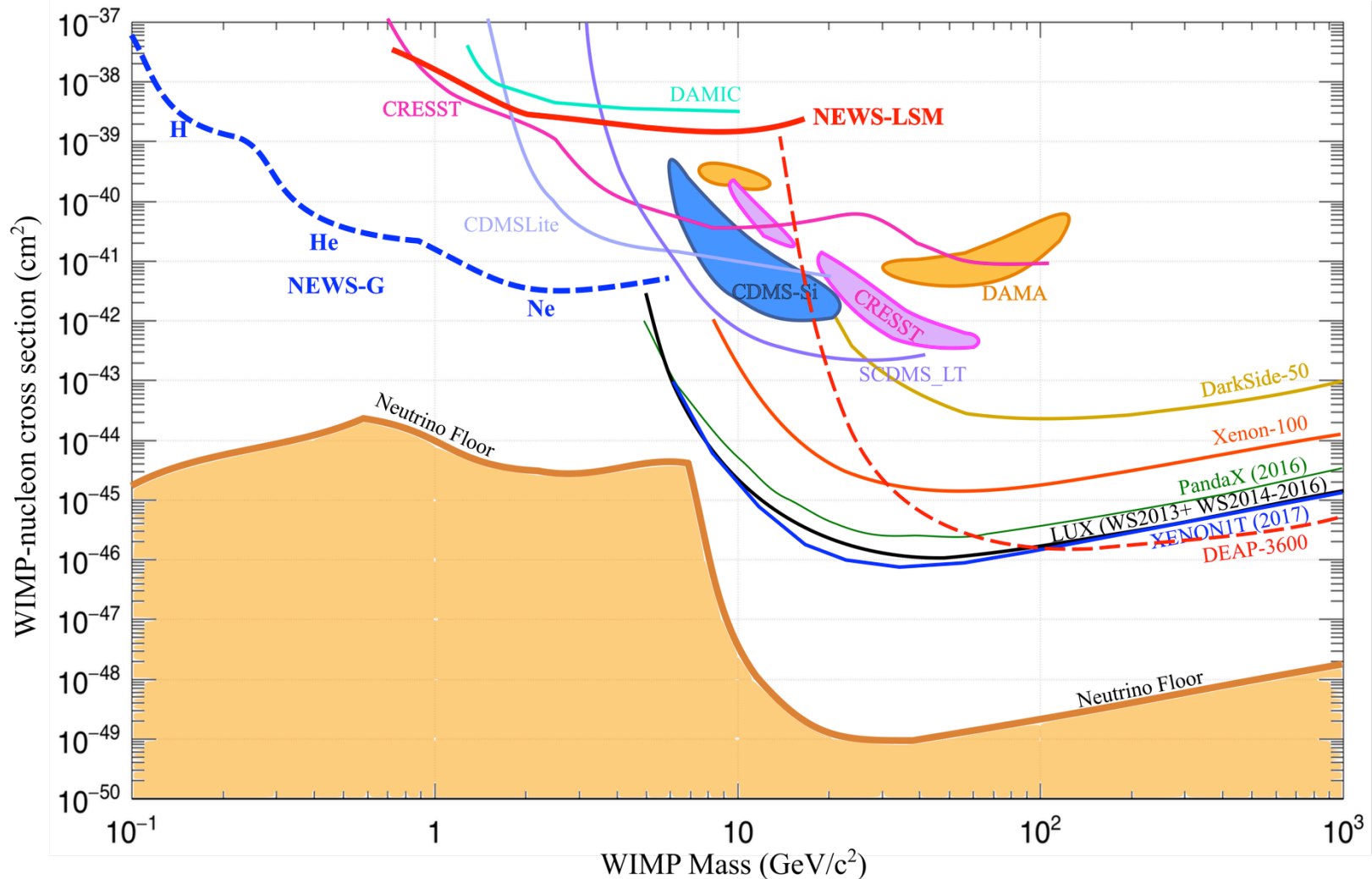
Preliminary ! $\sigma/\mu \sim 20\%$ @2.82 keV



Gas mixture: Ar+CH₄ (2%)
Online trigger: 10 eV (~ 0.3 primary e⁻)
Analysis threshold: 50 eV

NEWS-G expected sensitivity

100 kg-day, 1 electron threshold





Collaboration



- **Queen's University** – G Gerbier, P di Stefano, R Martin, T Noble, G, Giroux, A Brossard, 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
- **University of Birmingham** – K. Nikolopoulos, P Knight
 - Simulation and R&D
- **Institut de Recherches sur les Lois Fondamentales de l'Univers** – 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
- **Laboratoire Souterrain de Modane/Université de Chambéry** – F Piquemal, M Zampaolo, A Dastgheibi-Fard
 - Low activity archeological lead
 - Coordination for lead/PE shielding and copper sphere
- **Thessaloniki University** – I Savvidis, A Leisos, S Tzamaras, C Elefteriadis, L Anastasios
 - Simulations, neutron calibration
 - Studies on sensor
- **Laboratoire de physique Subatomique et Cosmologie** – 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 gas
- **Pacific Northwest National Laboratory** – E Hoppe, D Asner, R Bunker
 - Low activity measurements, Copper electroforming
- **Royal Military College Canada** – D Kelly, E Corcoran
 - ³⁷Ar source production, sample analysis
- **SNOLAB** – P Gorel
 - Calibration system/slow control
- **Associated lab : TRIUMF** - F Retiere
 - Future R&D on light detection, sensor



Aug 2017