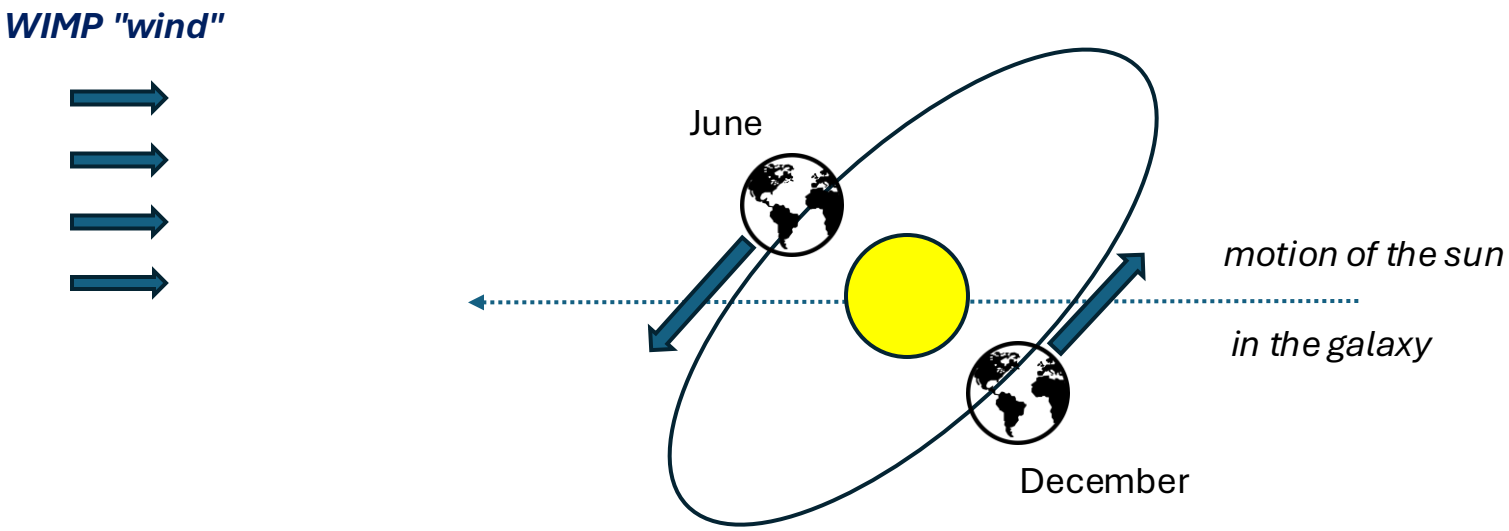
SABRE
Dark Matter experiment

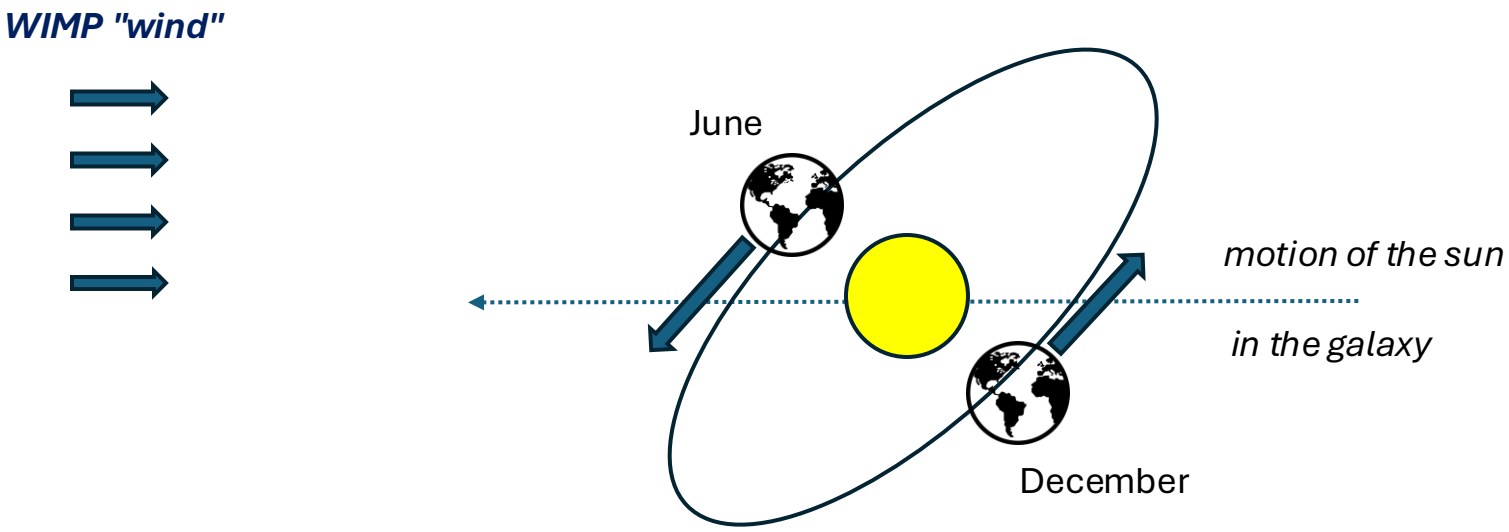
Krzysztof Szczepaniec
Laboratori Nazionali del Gran Sasso

Dark Matter and Neutrinos, 9.05.2025, Paris

Dark Matter annual modulation



Dark Matter annual modulation

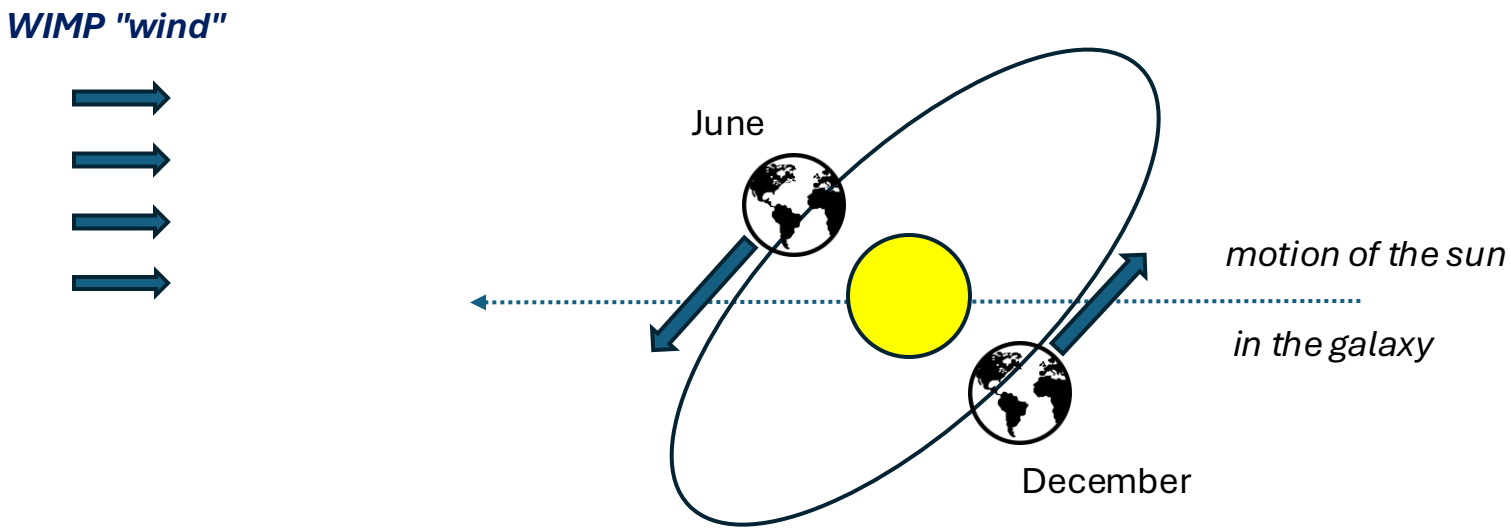


expected event rate
(if we are observing DM)

$$R(t) \approx S_0 + \underbrace{S_m \cos \frac{2\pi}{T}(t - t_0)}_{\text{seasonal modulation!}}$$

amplitude: $\mathbf{S_m}$
period: 1 year
maximum: 2nd of June

Dark Matter annual modulation



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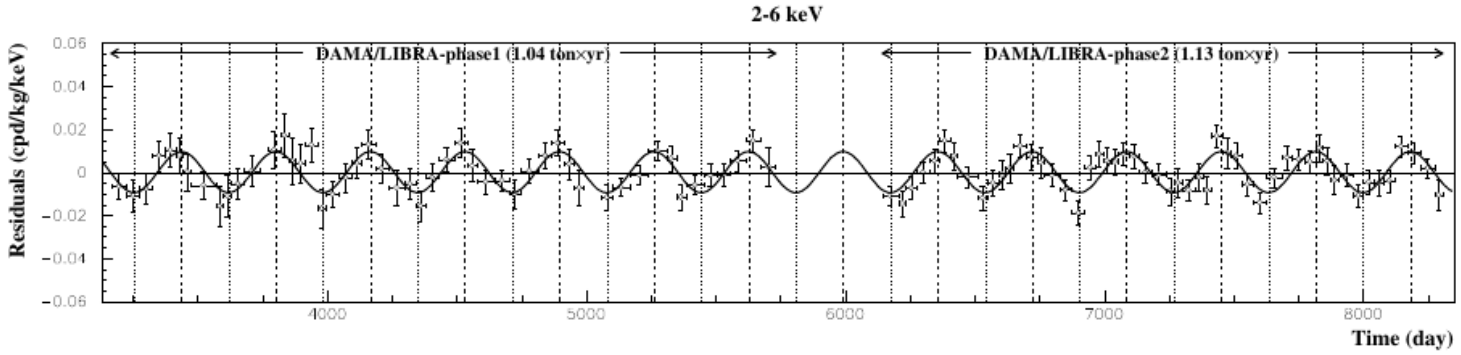
$$R(t) \approx S_0 + S_m \cos \frac{2\pi}{T}(t - t_0)$$

DAMA/NaI + DAMA/LIBRA



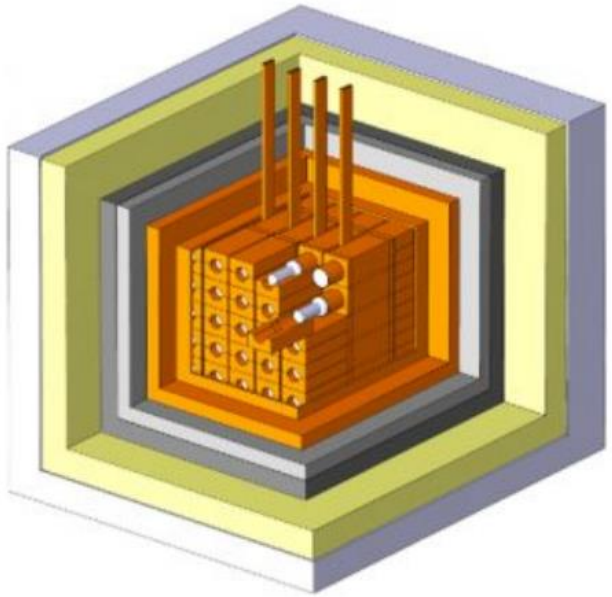
2-6 keV

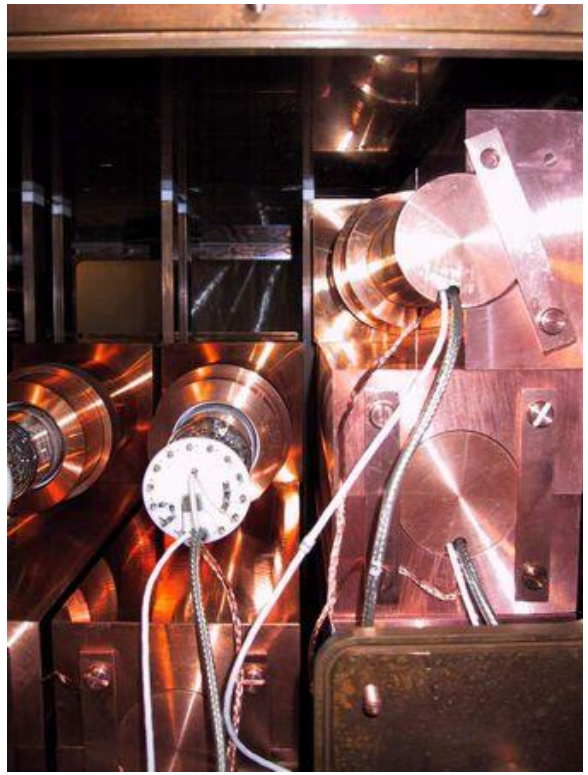
$$S_m = (0.0102 \pm 0.0008)$$ [cpd/kg/keV]

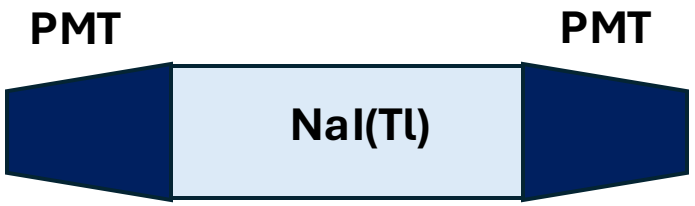
13.7σ

jnpae2021.04.329

DAMA (1995-2024)





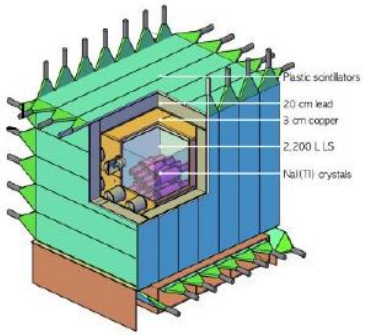


ultra-high purity
Thallium-doped Sodium Iodide crystals

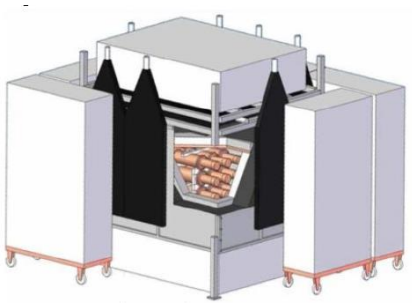
DAMA claim: model-independent direct observation of DM

"in tension" with other DM experiments (model dependent!)
> need for test with the same target

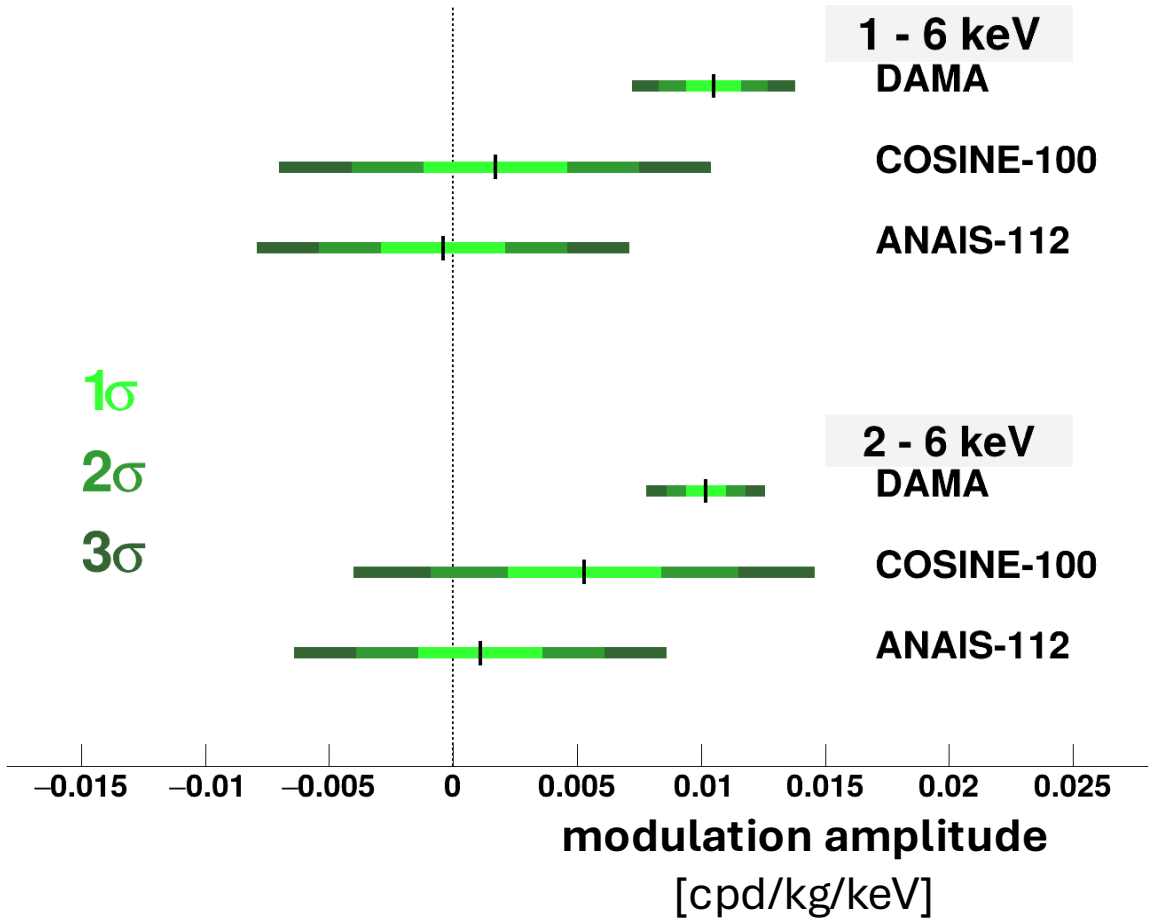
Dark Matter annual modulation



COSINE-100
Yang Yang, South Korea



ANAIS-112
Canfranc, Spain



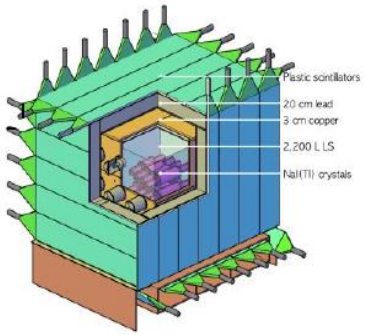
Combined Annual Modulation Dark Matter Search with COSINE-100 and ANAIS-112 (2025)

arXiv:2503.19559

COSINE-100 full dataset result arXiv:2409.13226

ANAIS-112 6 years of data result arXiv:2502.01542

Dark Matter annual modulation



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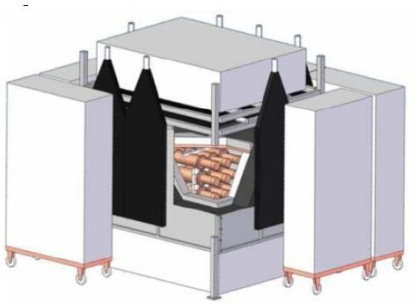

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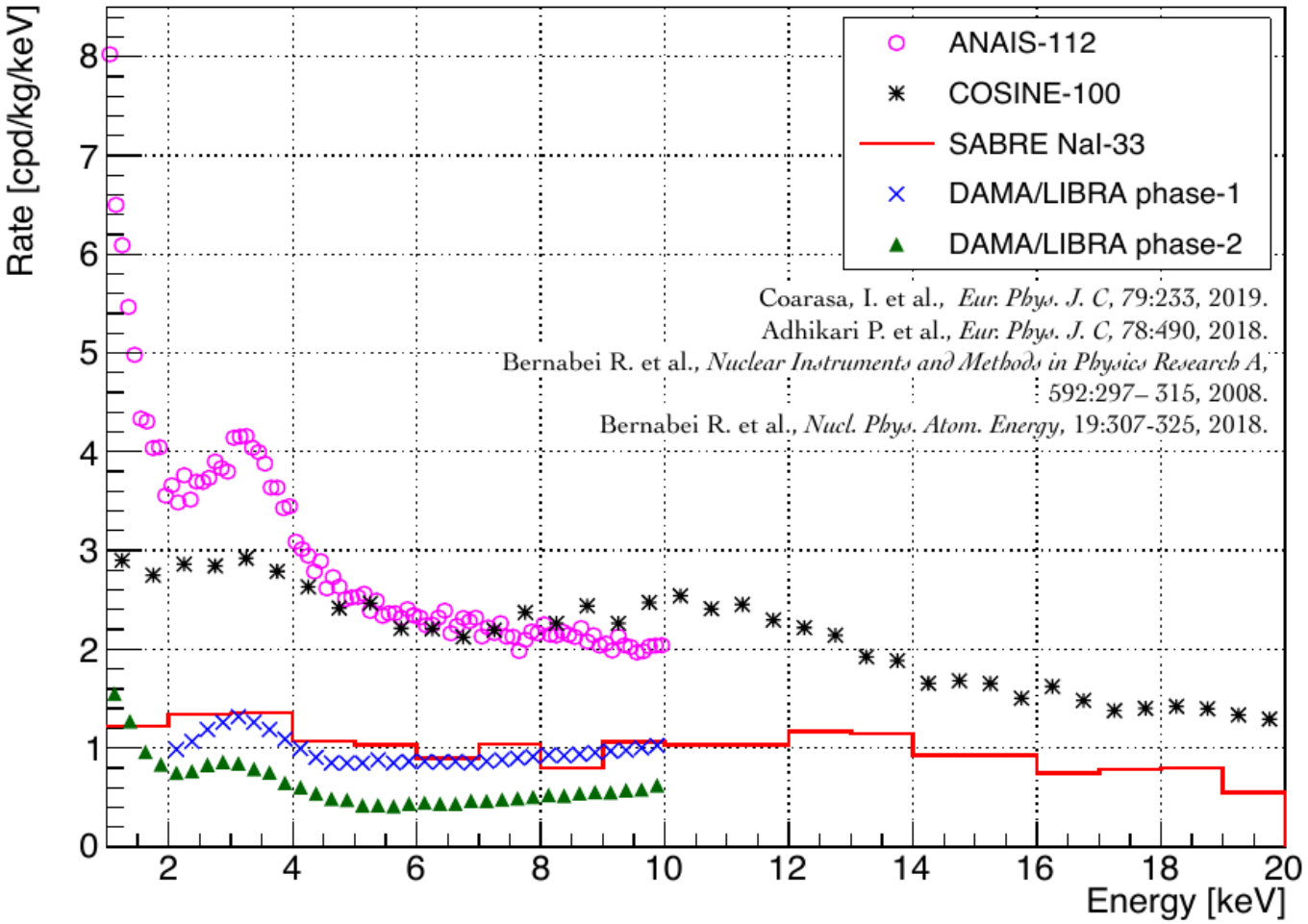

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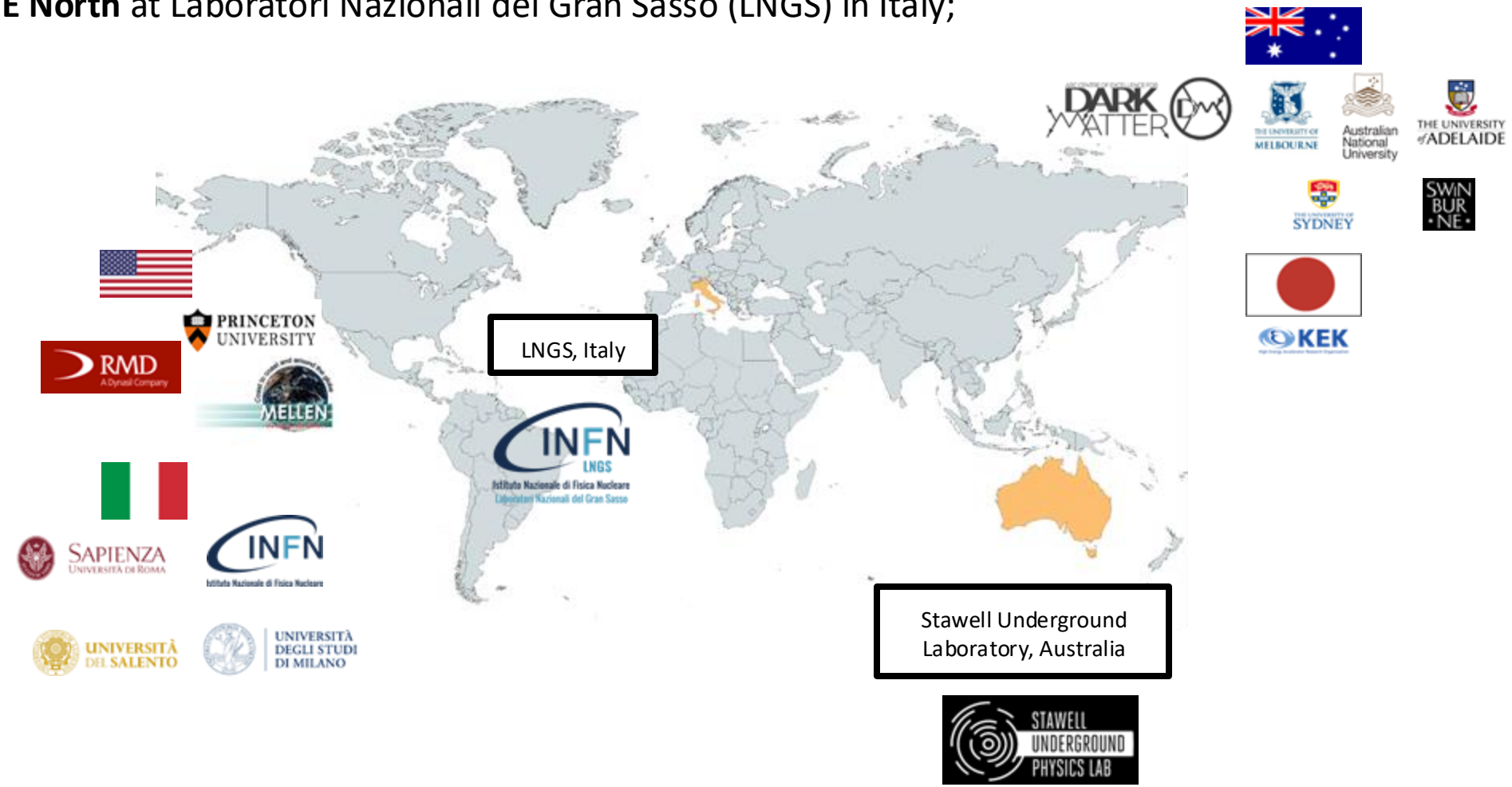
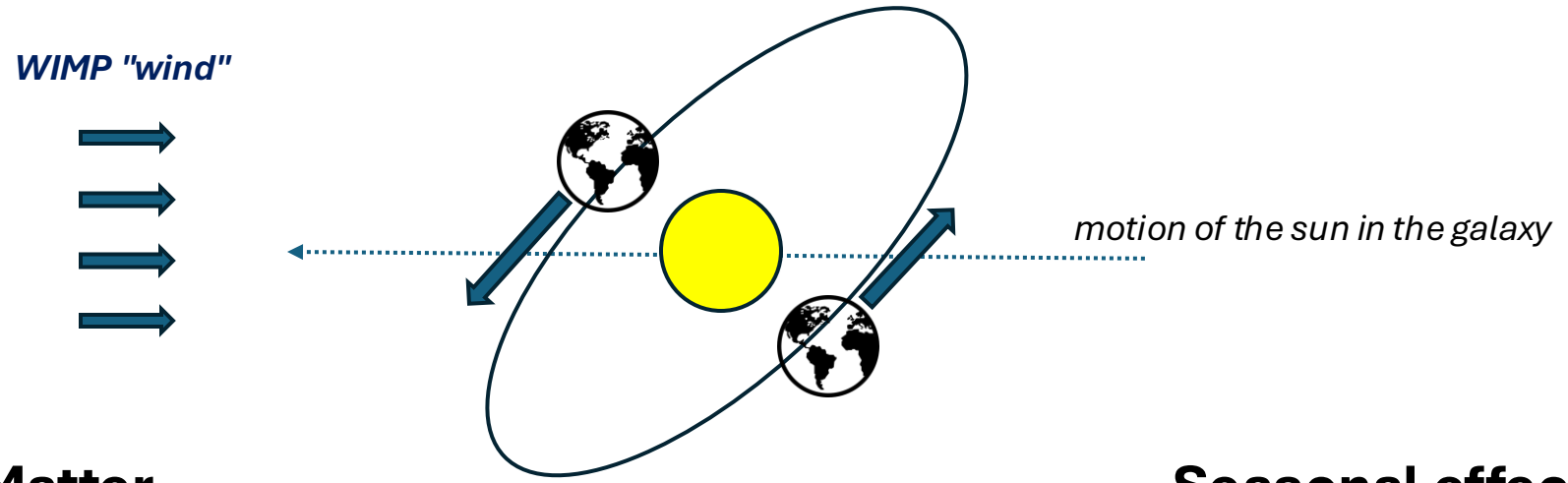
SABRE

SABRE North at Laboratori Nazionali del Gran Sasso (LNGS) in Italy;

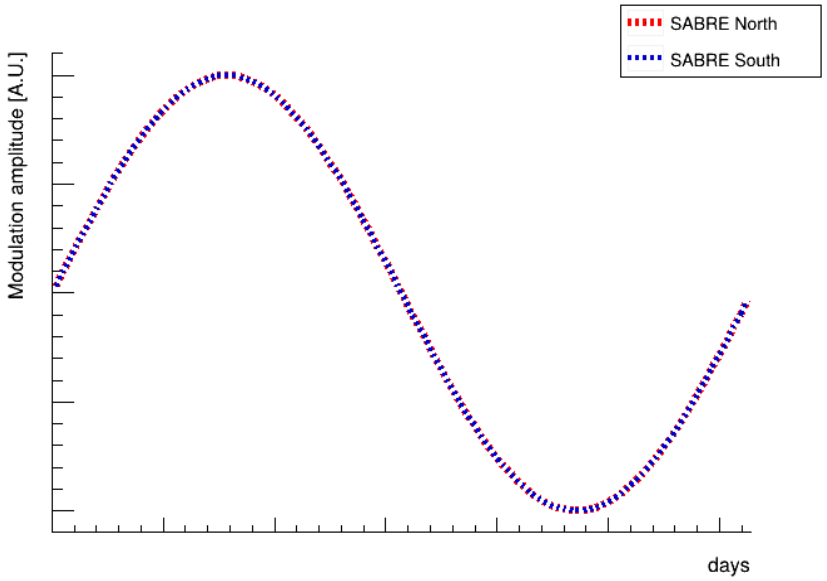


SABRE South at Stawell Underground Physics Laboratory (SUPL) in Australia.

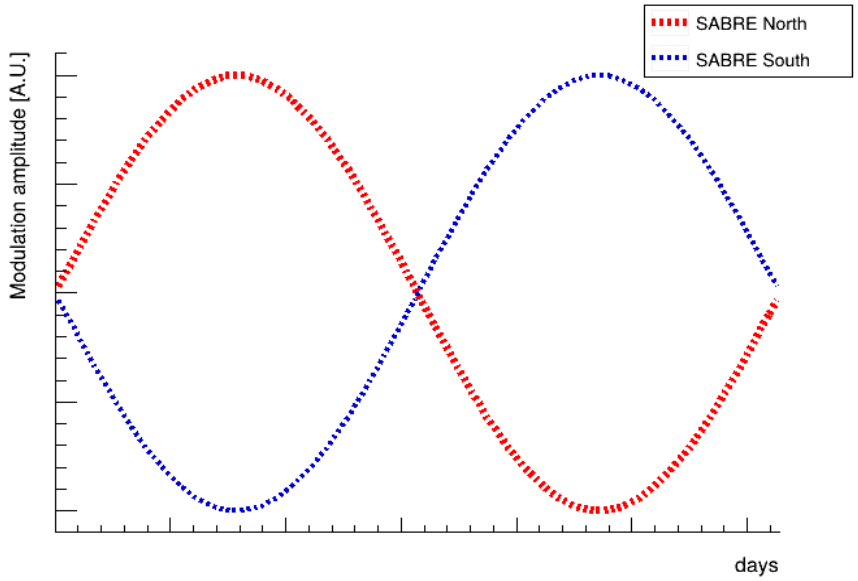
Why two locations?



Dark Matter



Seasonal effect

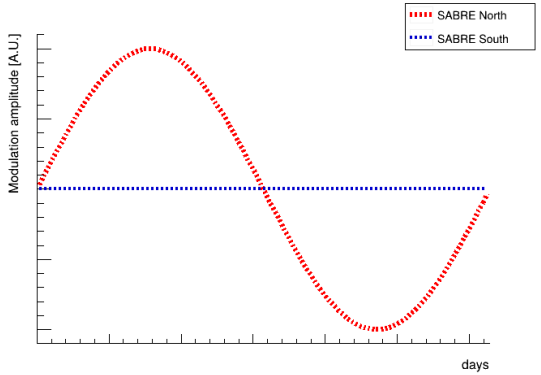


SABRE North location

DAMA/LIBRA

SABRE

Local effect



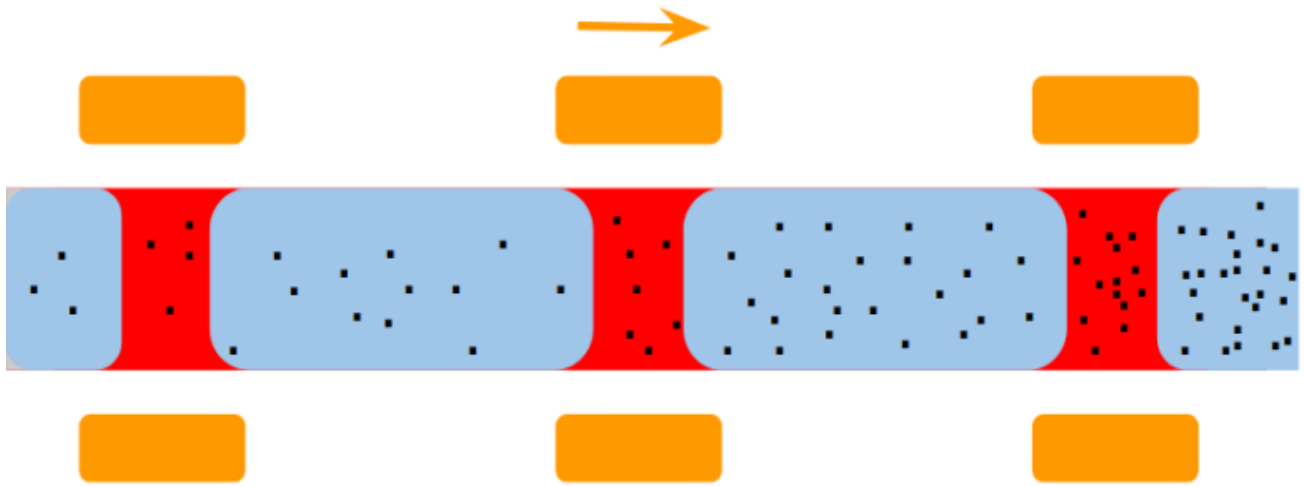
Purity of the crystal is crucial!

	Background rate in ROI (1-6 keV) [cpd/kg/keV]
DAMA/LIBRA	~ 0.7
ANAIS-112	~ 3.5
COSINE-100	~ 3
SABRE (NaI-33) (without ZR)	**~ 1**

Signal amplitude is **~ 0.01 !**

10 years of SABRE crystals research

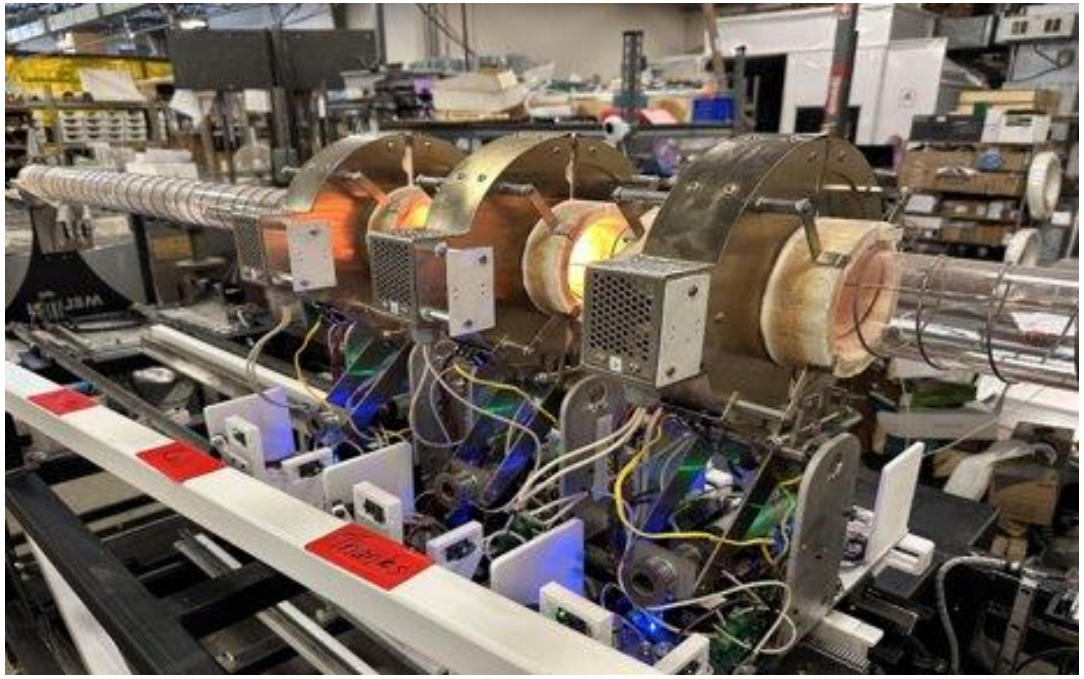
Zone refining of NaI powder

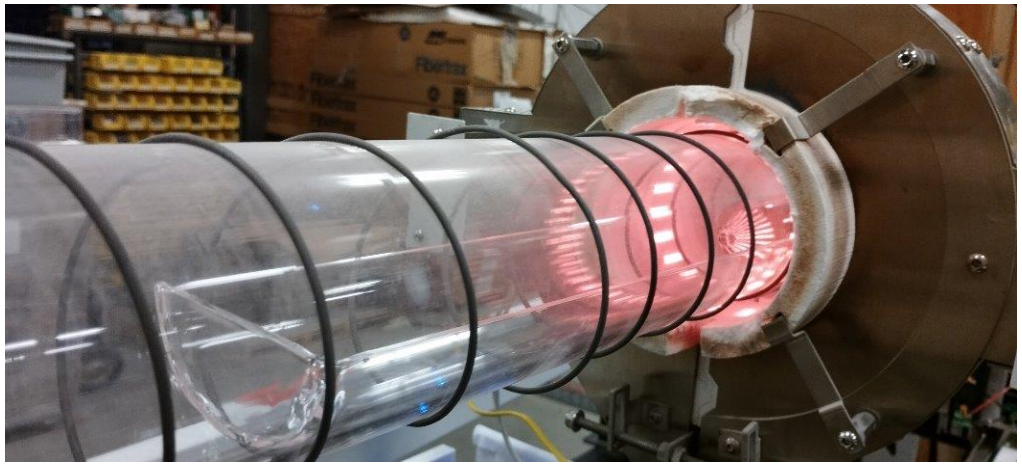


- R&D carried out by PU, INFN and ARC Centre of Excellence for DM
- Radioclean NaI powder *Astrograde* by Sigma Aldrich (now Merck)
- Crystals grown by RMD - Radiation Monitoring Devices, MA (USA)
  - Vertical Bridgeman method in fused silica vessels

10 years of SABRE crystals research

Zone refining of NaI powder





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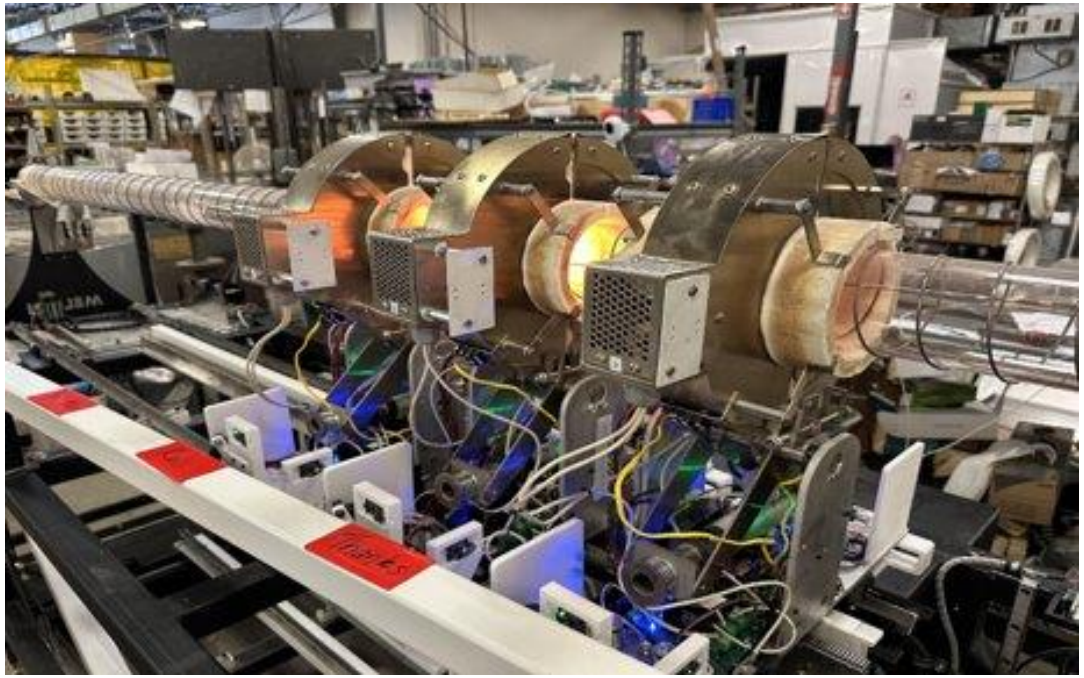

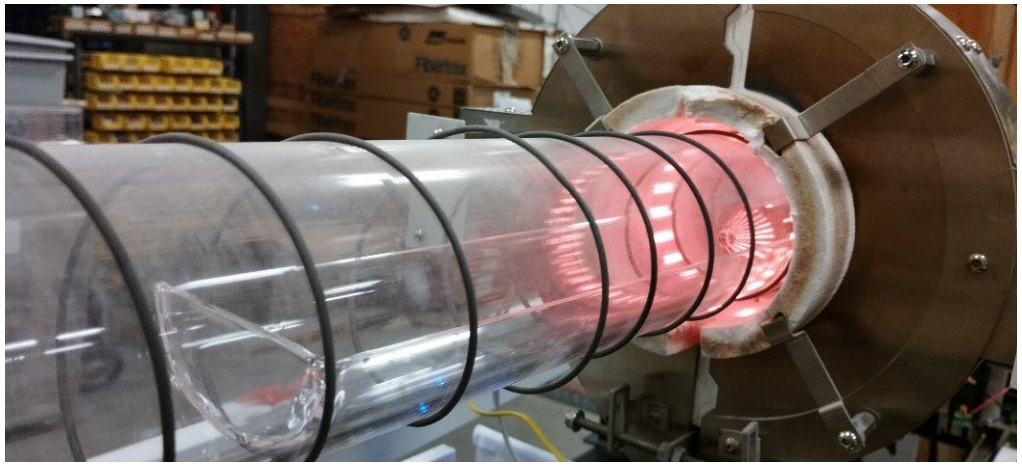

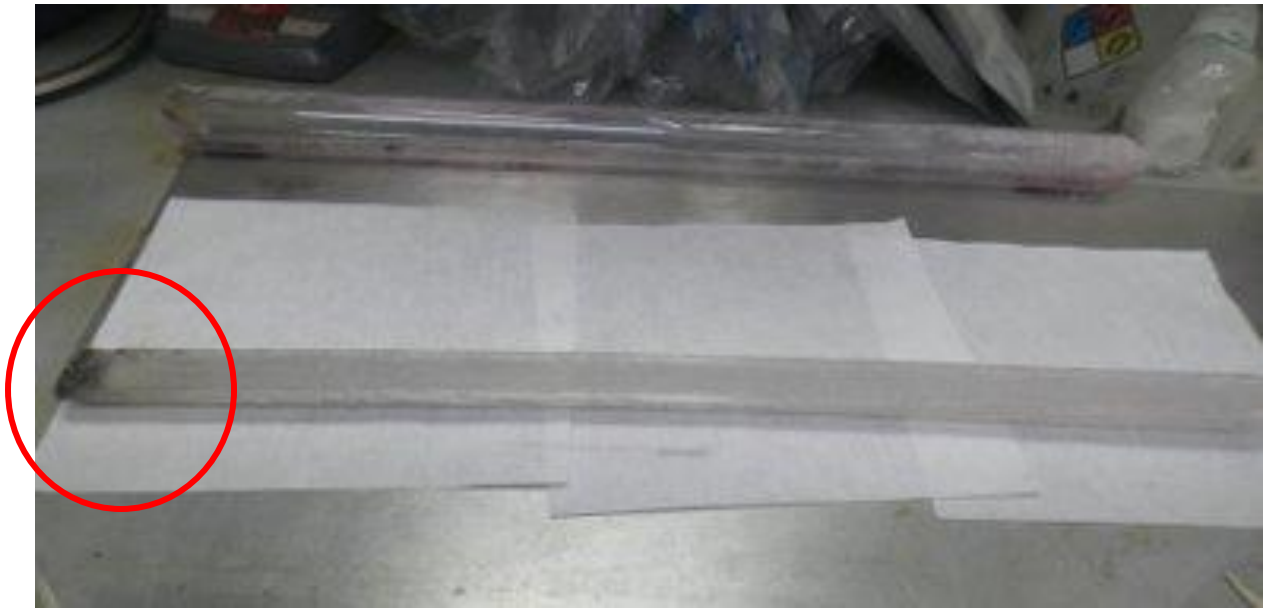

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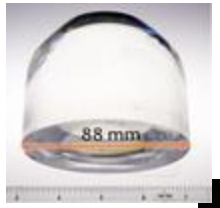
10 years of SABRE crystals research

2015



2018

NaI-31

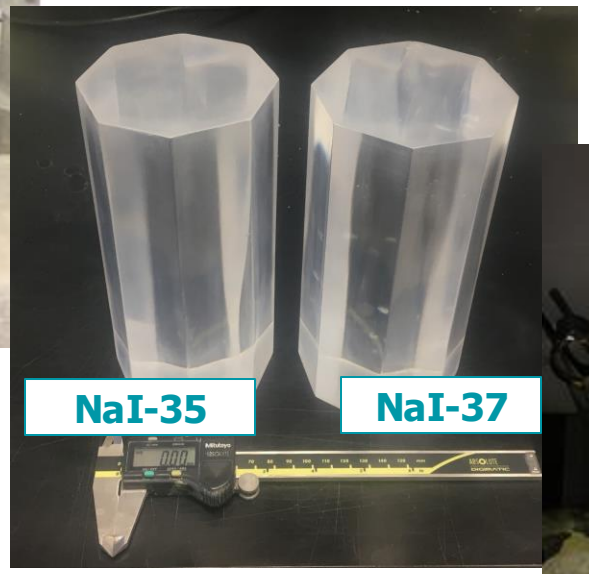
background ~ 1 cpd/kg/keV

Just from ultrapure powder, no ZR!

2019

NaI-33

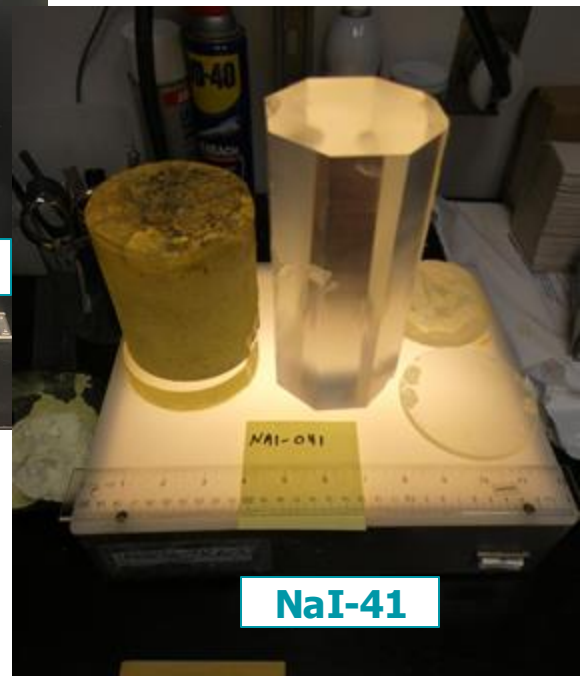
2022



NaI-35

NaI-37

2023



NaI-41

2025

Powder for NaI-42 undergoing zone refining RIGHT NOW

first crystal for experiment!

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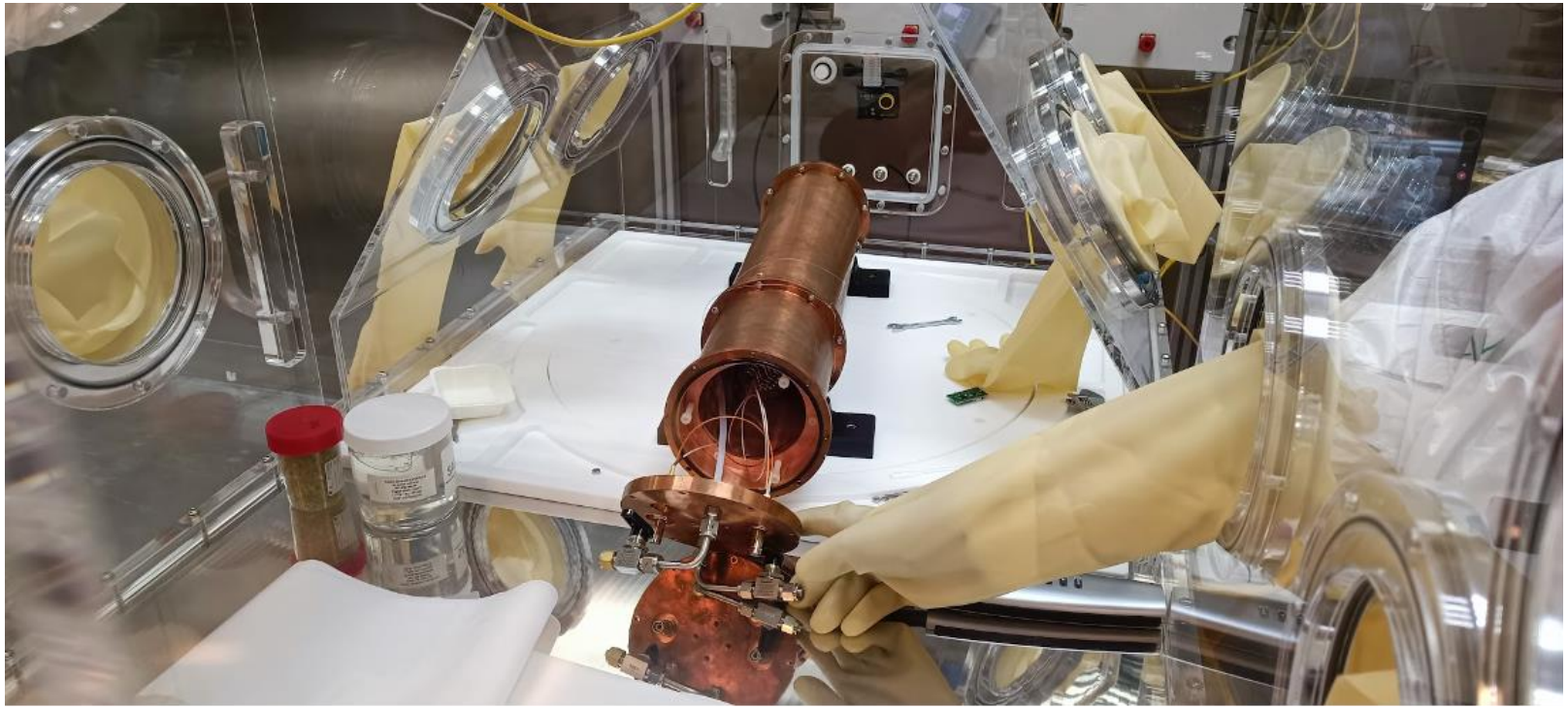
Purity of the crystal is crucial!

	Background rate in ROI (1-6 keV) [cpd/kg/keV]
DAMA/LIBRA	~ 0.7
ANAIS-112	~ 3.5
COSINE-100	~ 3
SABRE (NaI-33) (without ZR)	**~ 1**
COSINE-200	**~ 0.5**
SABRE goal (after ZR)	**~ 0.5**
PICOLON	**~ 0.5**

Signal amplitude is **~ 0.01 !**

Crystal enclosure



Thank you!

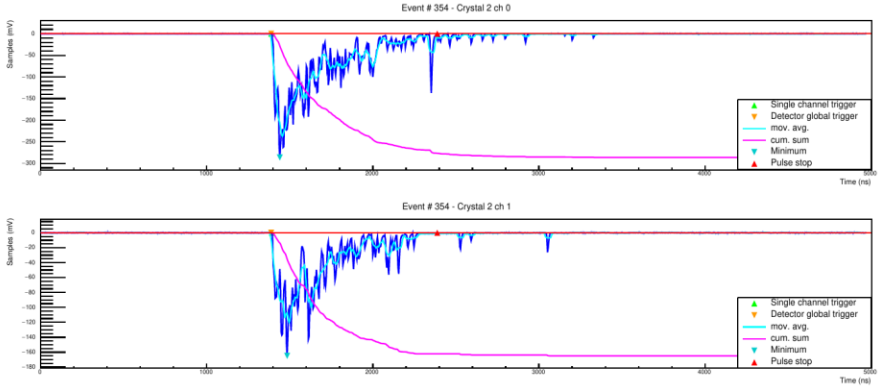
Want to join SABRE collaboration?

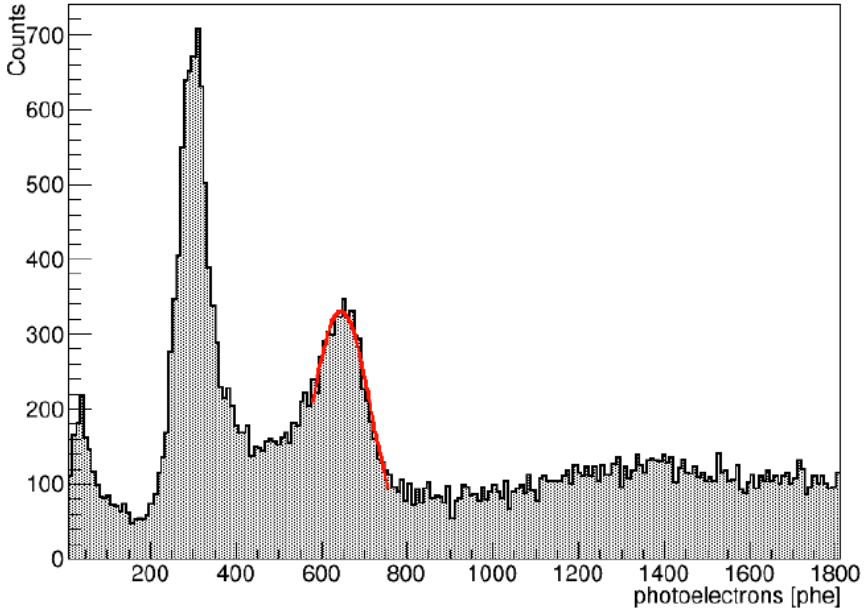
SABRE North Spokesperson: aldo.ianni@lngs.infn.it

or talk to me!

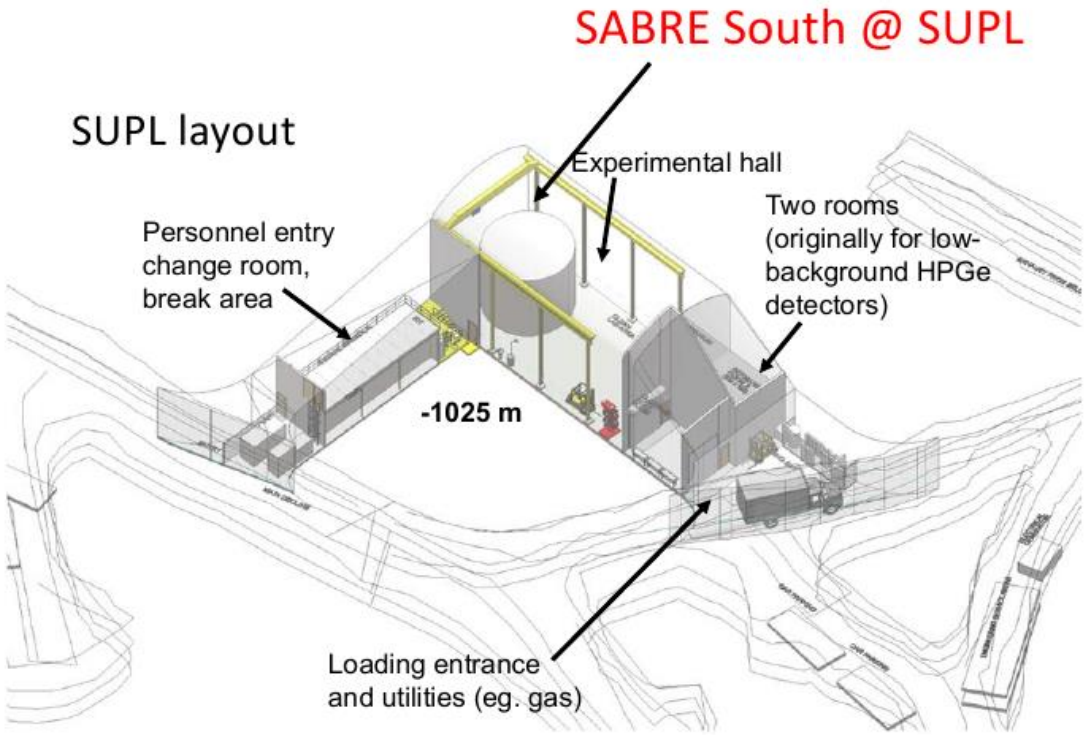
Backup slides

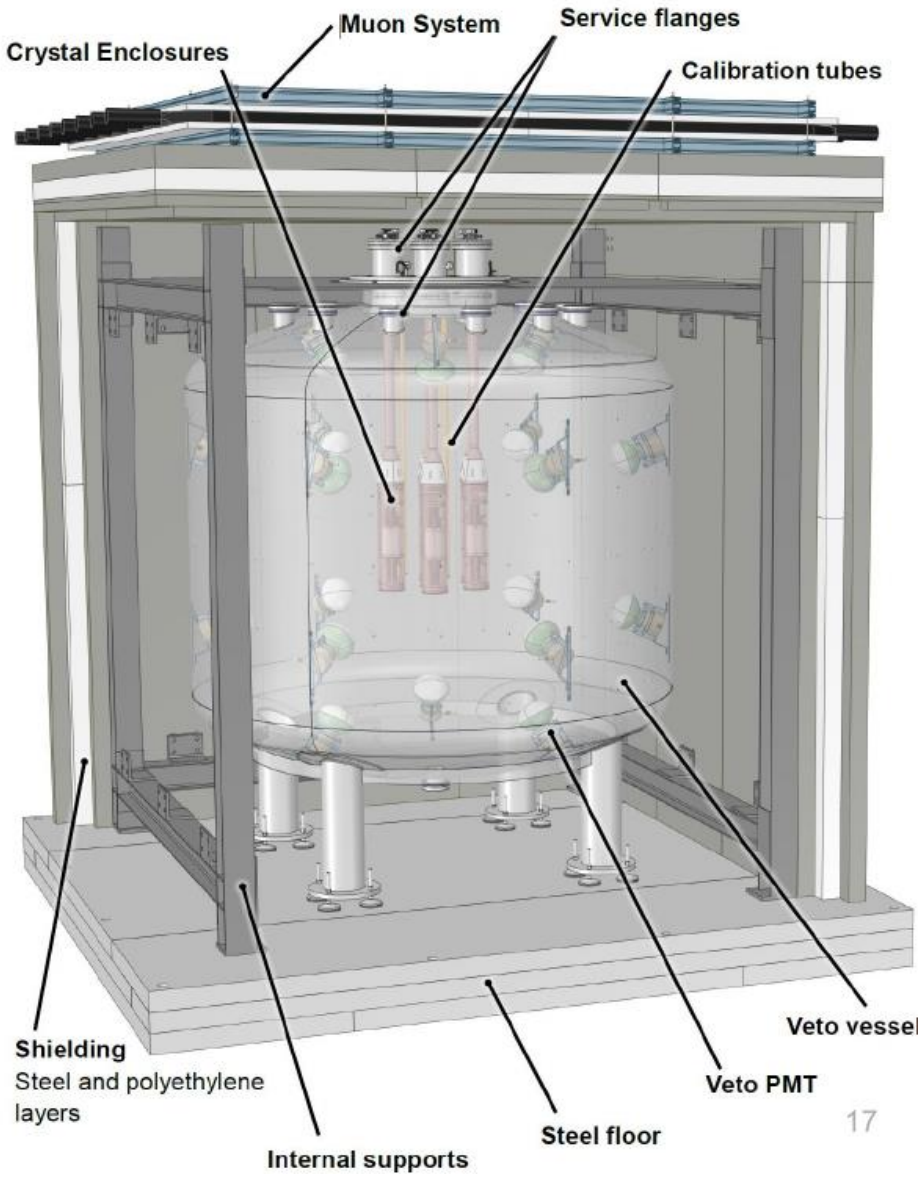
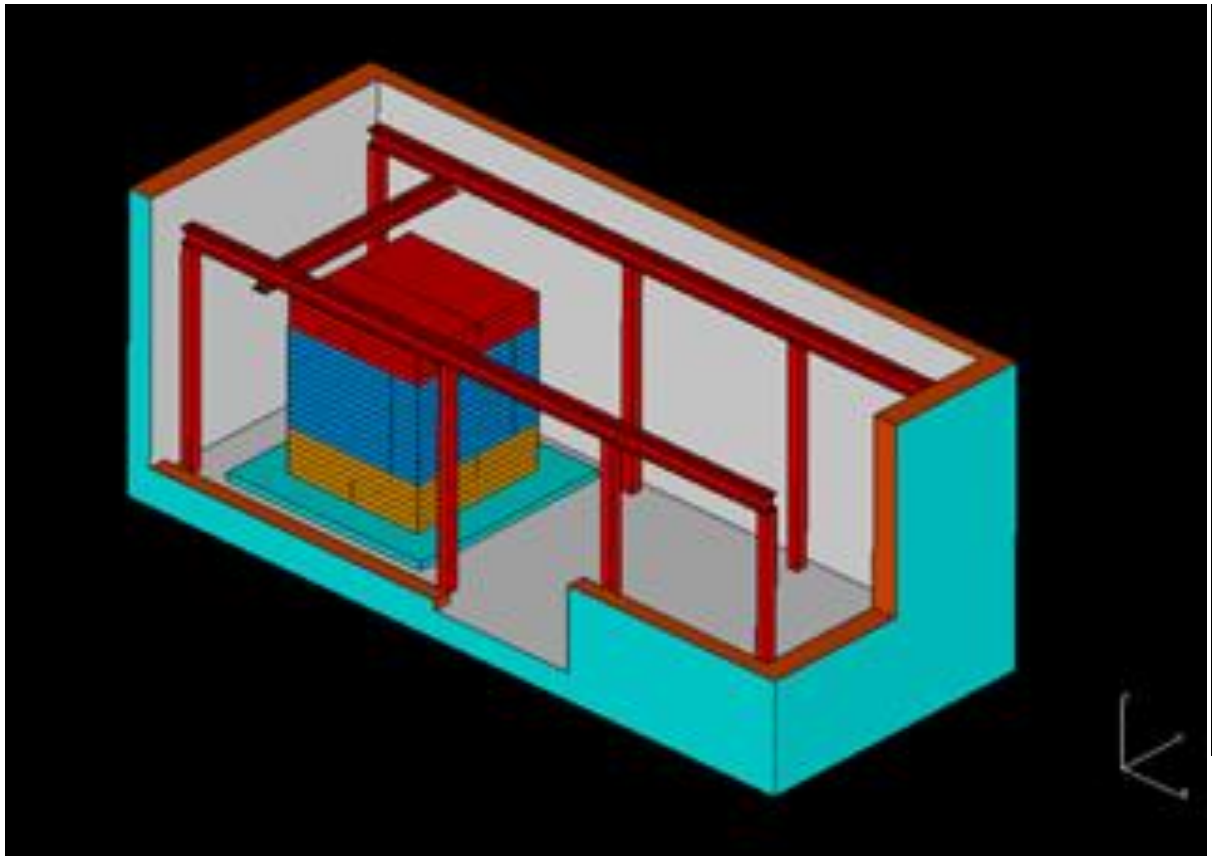
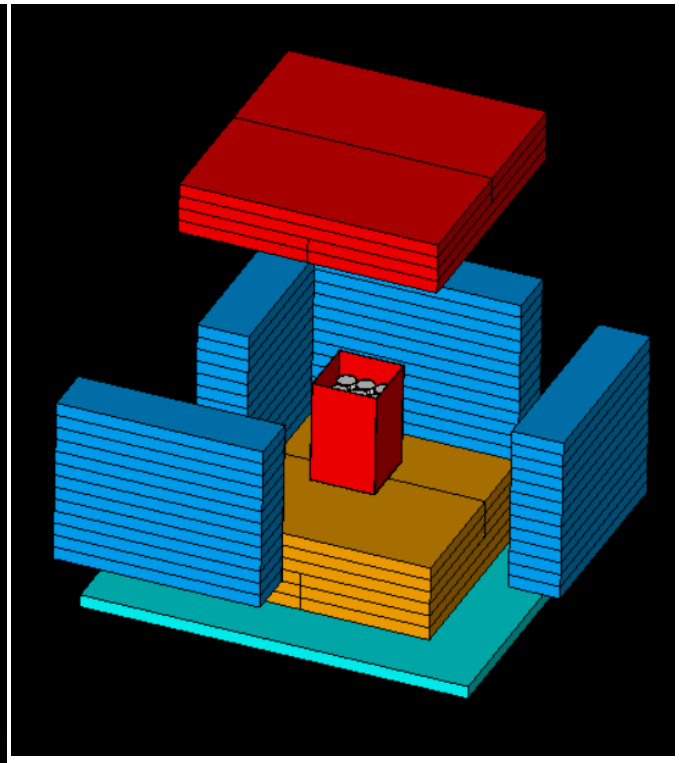
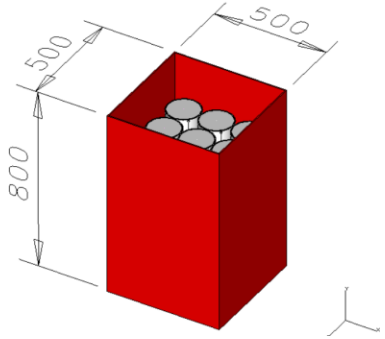
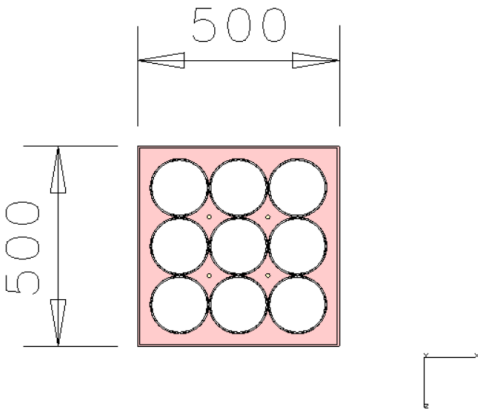
Detection principles





SABRE South


SABRE South @ SUPL
SUPL layout
Experimental hall
Personnel entry change room, break area
Two rooms (originally for low-background HPGe detectors)
-1025 m
Loading entrance and utilities (eg. gas)


Crystal Enclosures
Muon System
Service flanges
Calibration tubes
Shielding
Steel and polyethylene layers
Internal supports
Steel floor
Veto PMT
Veto vessel

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