The High-Power Gallium-Indium Liquid Target at SARAF

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DAEJEON LINAC2026

SOREQ
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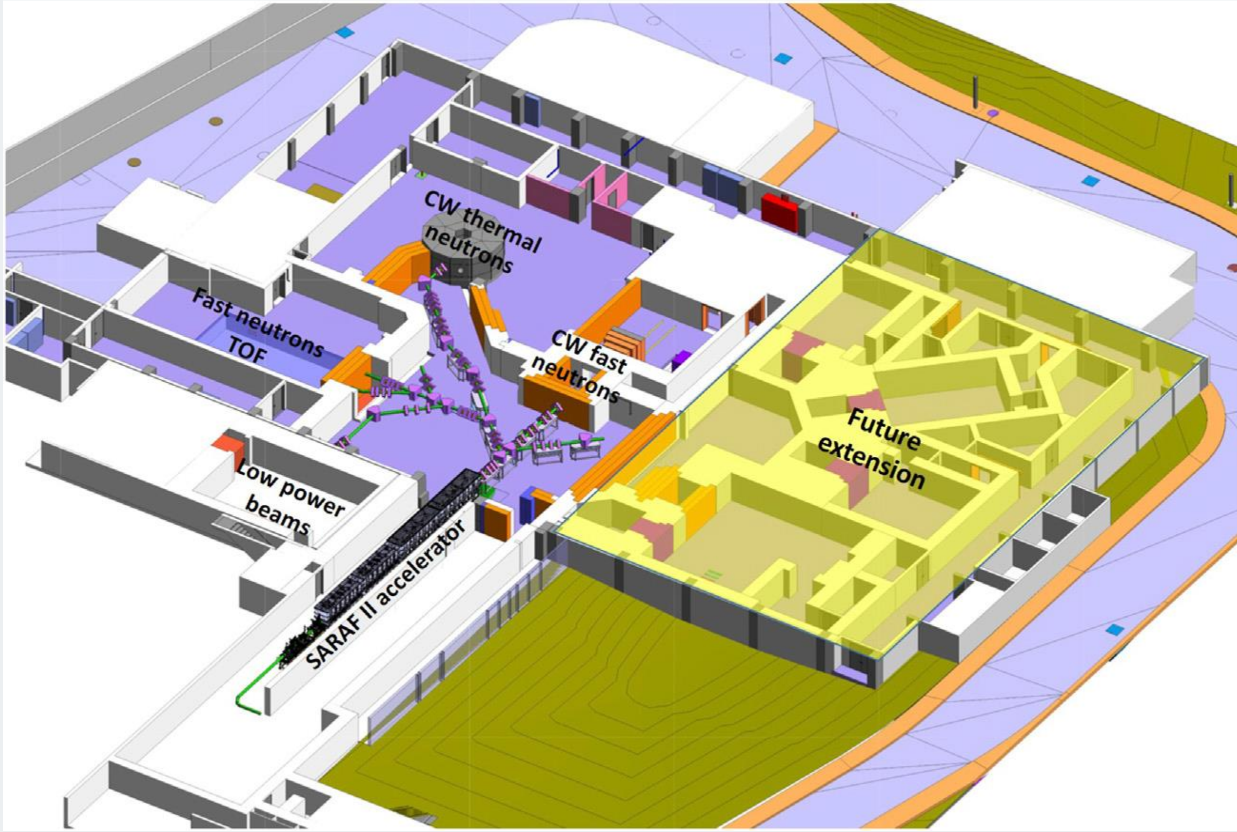
SARAF

LAYOUT OVERVIEW

System Architecture: An overview of the Soreq Applied Research Accelerator Facility (SARAF) linear accelerator.

- **Phase II:** Integration of superconducting modules up to 35/40 MeV proton/deuterons CW (continuous wave).
- **Beam Transport:** Optimized quadrupole and steering magnets for up to 5 mA beam stability @ 5-40 MeV.
- **Target Rooms:** Layout configuration connecting the accelerator to the experimental target areas.



Mardor, I et al, *Frontiers in Physics*, **2023**, *Volume 11 – 2023*
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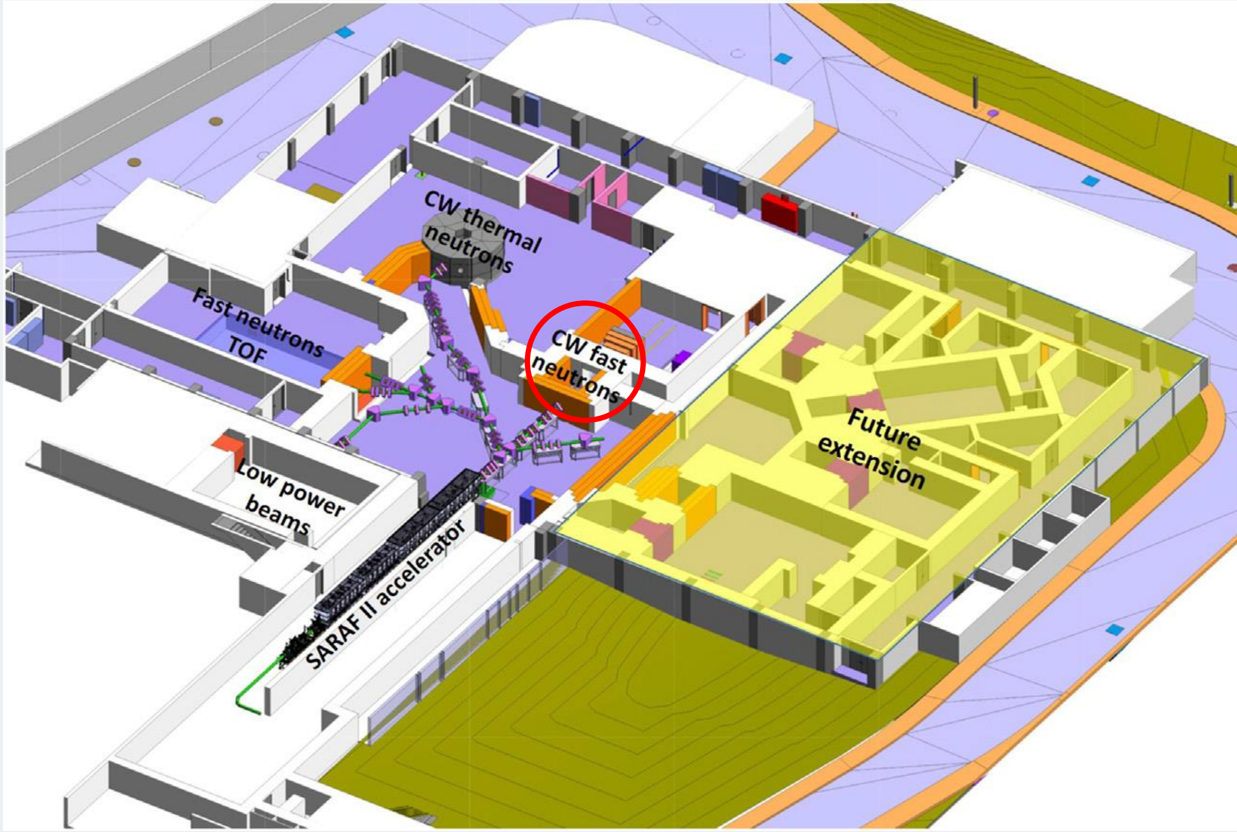

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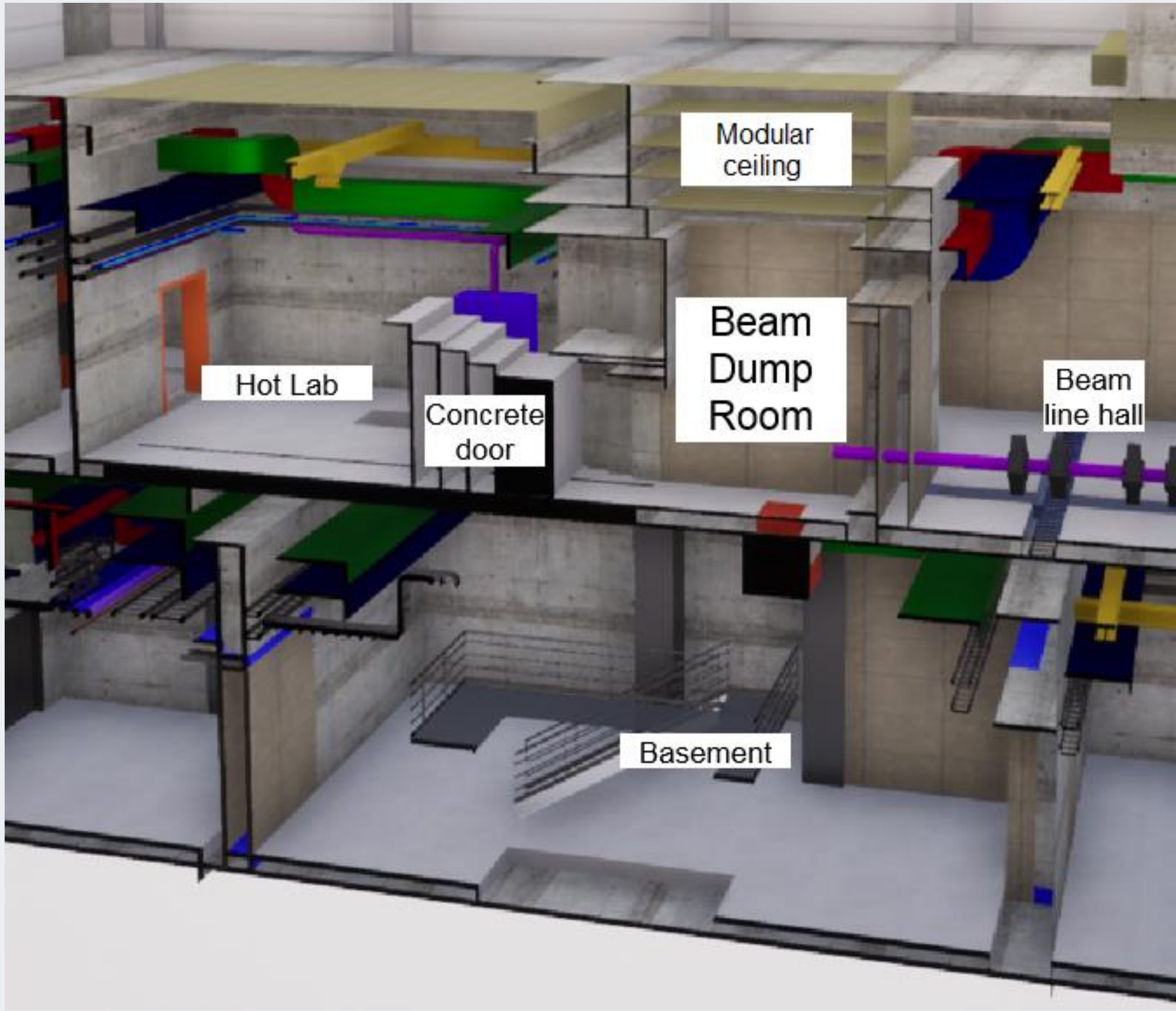
BEAM DUMP ROOM INFRASTRUCTURE

CW fast neutrons

High Power “Beam Dump”/Target

The Beam Dump room houses the primary beam dump (GaLiT target), critical for stopping the 5 mA, 40 MeV beam.

- **Shielding Architecture:** Heavy concrete and localized lead shielding designed to contain prompt and activation radiations.
- **Design:** The basement contains main elements of the target: electromagnetic pump, heat exchangers and about 7-meter-tall liquid metal loop in order to maintain the high velocity jet.
- **Activation Control:** Strategic layout to minimize air activation and allow for safe maintenance access includes a massive concrete door.

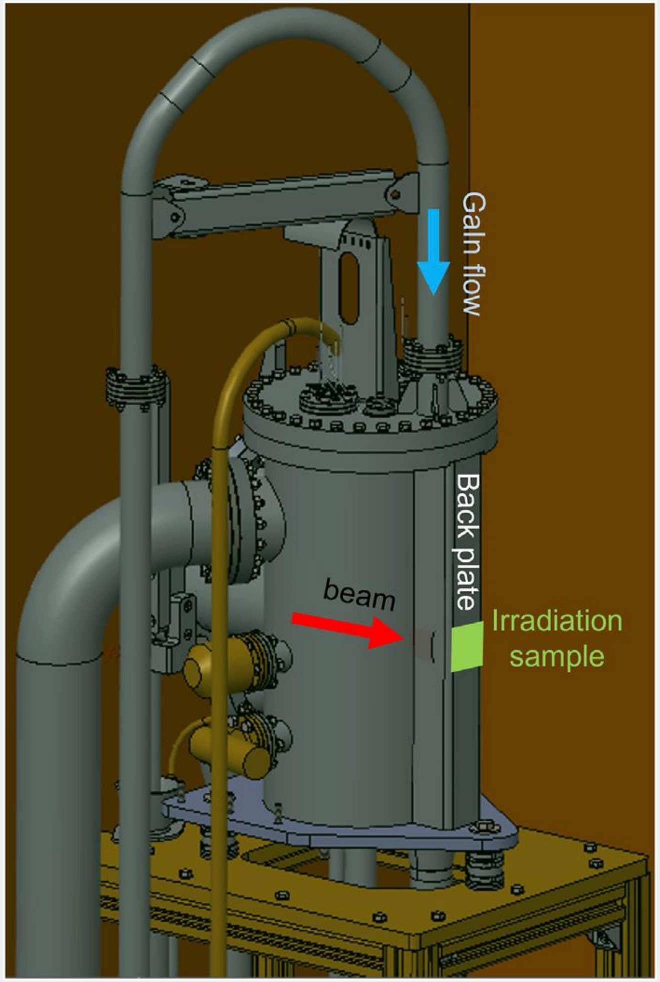


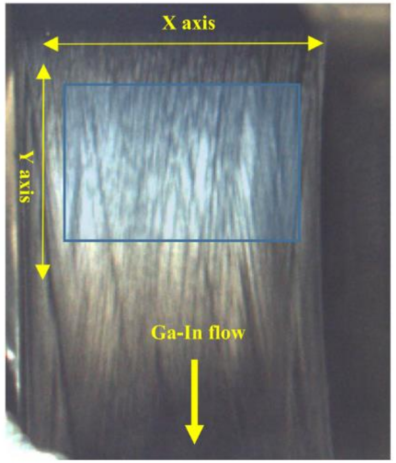
THE TARGET SYSTEM

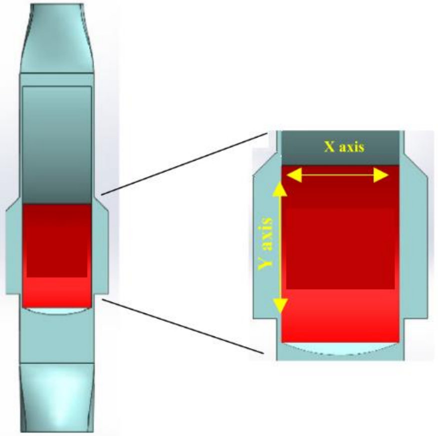
Gallium-Indium Liquid Target (GaLiT)

To handle the extreme power density of the SARAF beam (up to 200 kW/cm²), a liquid Gallium-Indium jet is utilized.

- **Thermal Management:** The high-velocity up to 7 m/s liquid jet for efficient heat dissipation preventing evaporation into the vacuum.
- **Design:** Features electromagnetic pump and heat exchanger to disperse 200 kW to produce a neutron rate of more than 10^{15} n/sec, with energies up to ~45 MeV.
- **Safety:** Gallium-Indium (GaIn) is chemically inert, reducing operational hazards and remains liquid at room temperature.







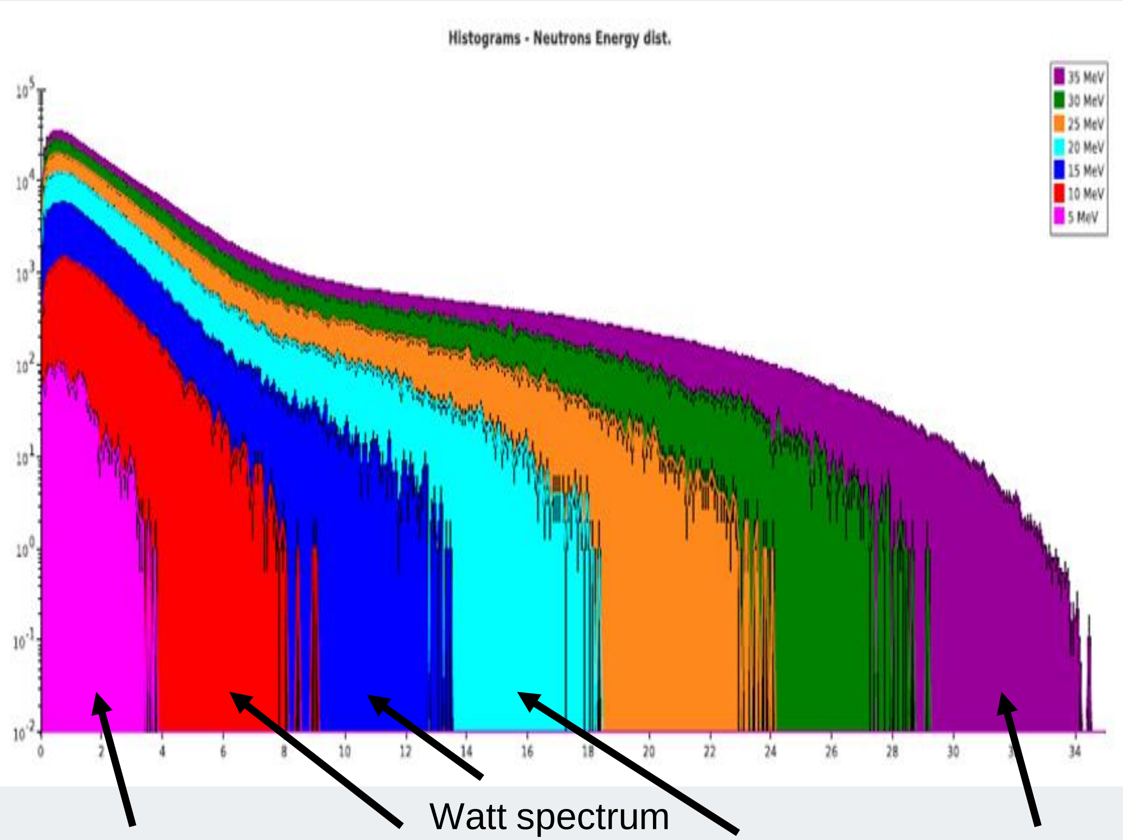
I. Eliyahu et al, NIMA **1053** 168320 (2023)
https://doi.org/.2023.168320.amin.j/10.1016

NEUTRON SPECTRA ANALYSIS

Energy Distribution

The facility provides tunable neutron fields tailored for different physical applications. Since protons/deuterons energies may range between 5 and 40 MeV.

- **High Intensity:** neutron flux up to ~10^{12} n/s/cm^2 at the sample.
- **Angular Positioning:** Modifying the sample's angular placement relative to the beam axis provides an additional mechanism for spectral fine-tuning.
- **Maxwellian Spectrum:** Mimics stellar environments (100-150 keV), important for s-process nucleosynthesis research
- **High Energy Tail:** Produces a harder spectrum (up to 45 MeV), various environments to support activation analysis, cross-section measurements, and radioisotope production.



Watt spectrum

Explosive astrophysics

Breeder reactors

Fusion reactors

Spallation source

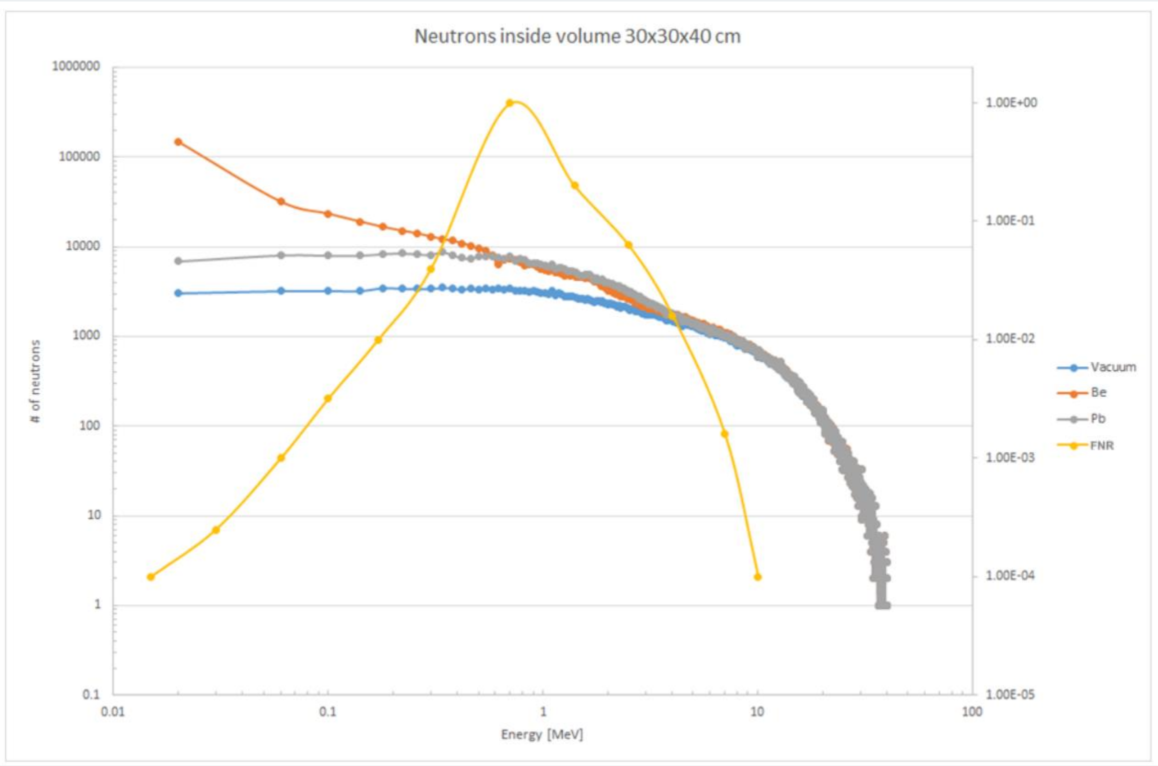
kT ~100-150 keV

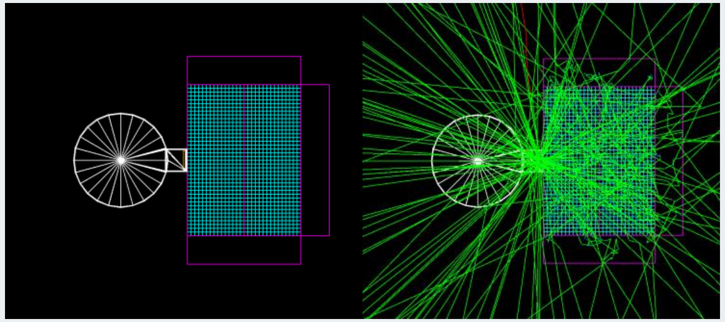
FAST NEUTRONS YIELD ENHANCEMENT

Beryllium and Lead comparison for 35 MeV proton beam at GaLiT

Comparative analysis of neutron yields from Beryllium and Lead reflectors around a secondary target (30x30x40 cm)

- **Lower Energy (< 600 keV):** Beryllium dominates in yield due to (n,2n) reaction lower threshold and high elastic cross section.
- **Higher Energy (> 600 keV):** Lead becomes competitive via high cross sections for (n,2n; n,3n…) at higher energies and high elastic cross section.
- **Optimization:** This data drives the selection of Beryllium reflector/multiplier as the optimal neutrons yield enhancement for fast neutrons applications.





Geant4 –
Monte-Carlo simulations

“MARZEPAN” FAST NEUTRONS SOURCE APPLICATIONS

Maximum versatility for allowing future applications

Cross section measurements, activation analysis, weak interactions, radiation damage and radioisotopes production for following studies such as half-lives and nuclear matrix elements

- **Rabbit for short lived radiosotopes:** Fast delivery system between the GaLiT source and a shielded HPGe detector
- **Long times irradiation station:** Slow delivery system between the GaLiT source and a shielded sample collector with long irradiation times from minutes to months
- **SARONA – SARaf exOtic Nuclide:** Based on cryogenic stopping cell for fission fragments production and separation for cross section measurements from neutron-induced reactions products

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Thank you for your attention!

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