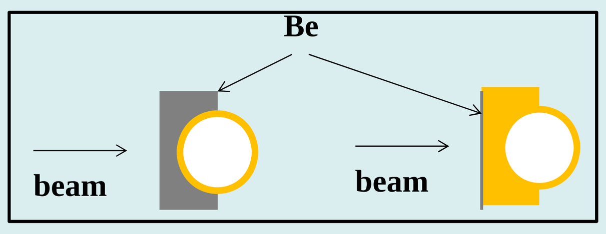
NEW THERMAL n-SOURCE AT LNL

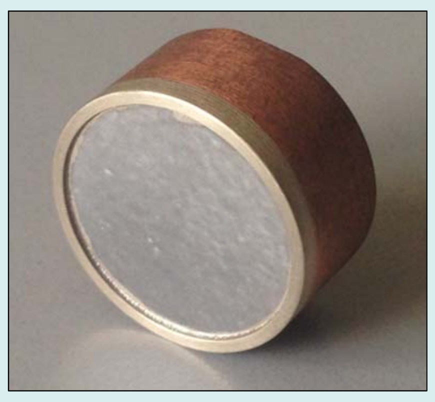
INFN Istituto Nazionale di Fisica Nucleare

In the framework of MUNES project, a new neutron source was developed at the CN electrostatic accelerator of Legnaro National Laboratories. Neutrons are produced through Be(p,n) reaction using a thin foil beryllium target brazed on a copper base. A 5 MeV, 3 μA proton beam is focalized onto the target so as to reach a 500 W/cm^2 power density on beryllium, the same as MUNES high intensity accelerator. A heavy water-graphite moderator is used for neutrons thermalization. Preliminary results show that a $1.2{*}10^6$ $s^{-1}{*}cm^{-2}$ neutron density can be generated at the extraction window with a uniformity better than 1% over a 25 cm diameter circular area. Neutron spectrum is more than 90% thermal with a very low gamma contamination.

Beryllium target

Test of new thin Be target concept to mitigate and hopefully suppress swelling problem.





Target type: Thin Be foil (60 μm), brazed on a copper substrate. Target is water cooled and assembled in such a way to reduce activation after irradiation.

Target inclination: 22.15° inclination respect to beam direction.

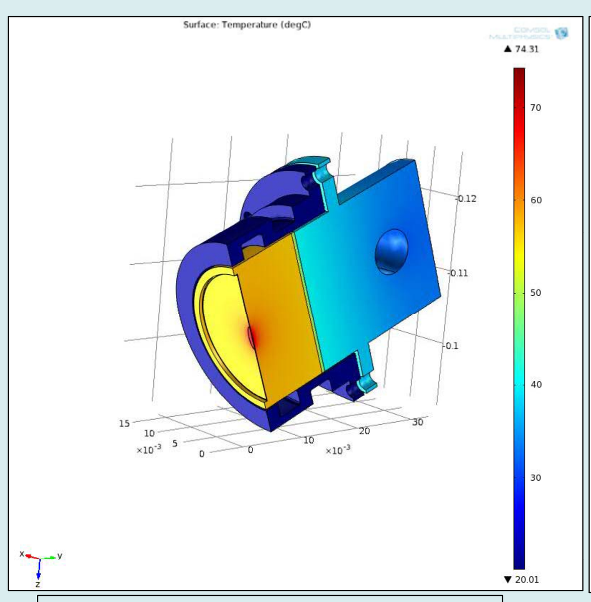
Beam diameter on target: 1,0 mm.

Process description: 5 MeV proton beam interacts with Be foil producing neutrons. Protons reach Be boundary with 2 MeV residual energy and stop in the transition region between brazing alloy and copper.

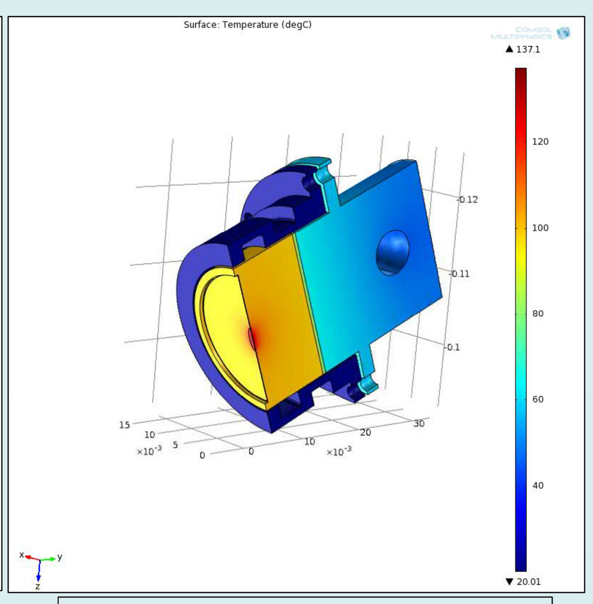
Neutron source intensity: 10^{10} s^{-1} with 3 μA proton beam.

Thermal-simulation

Nominal power density is 700 Watt/cm^2.
According to thermo-mechanical simulations a power density as high as 1.5 kW/cm^2 can be sustained by target without affecting performance.



P_d = 700 Watt/cm^2

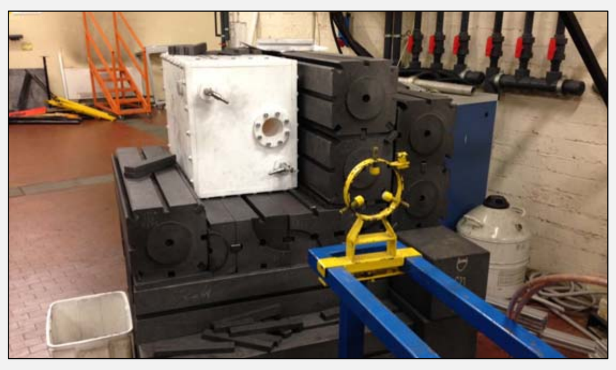


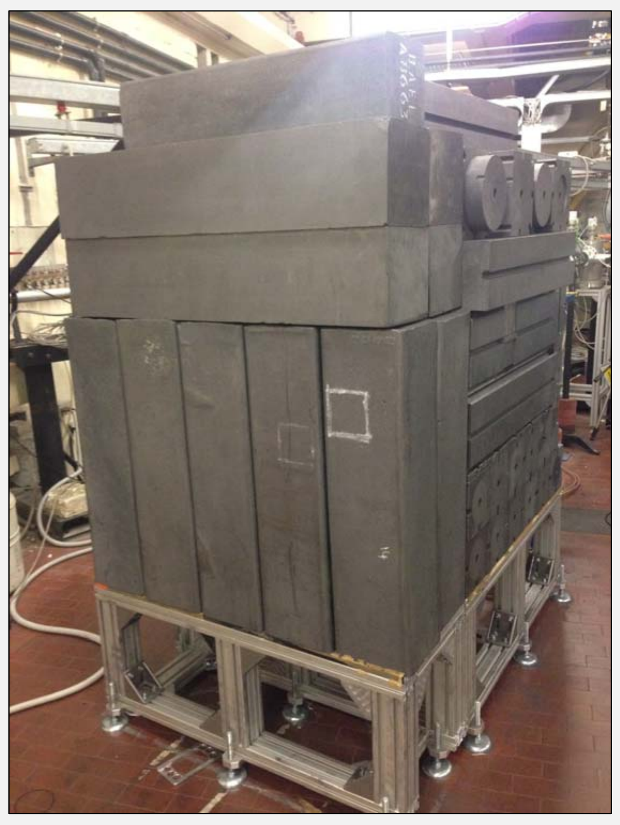
P_d = 1500 Watt/cm^2

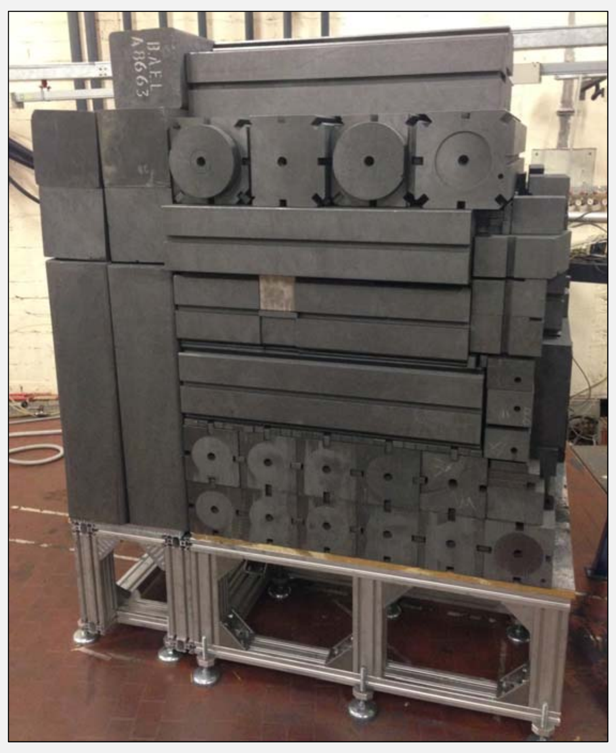
Maximum temperature reached by Beryllium is 74°C with nominal power density and 137°C with 1,5 kW/cm^2 power density. In both cases copper temperature at the viton o-ring location is below 100°C.

Hevy water – graphite moderator

Characterization of a new heavy water-graphite moderator simulated, assembled and installed on +15° CN beamline for neutron spectrum moderation.





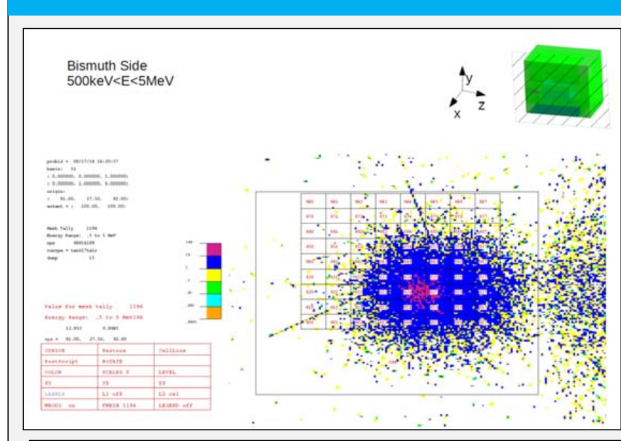


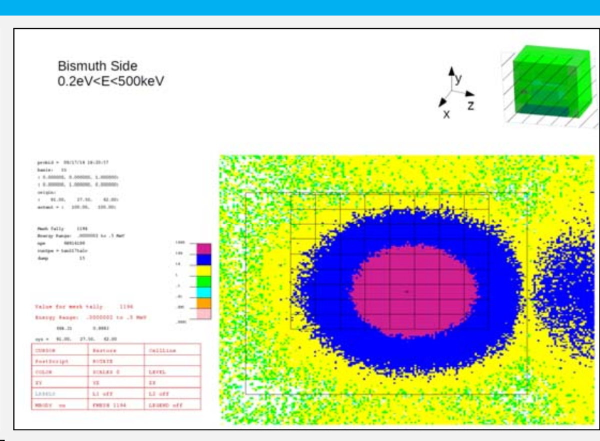
Moderator constituents:

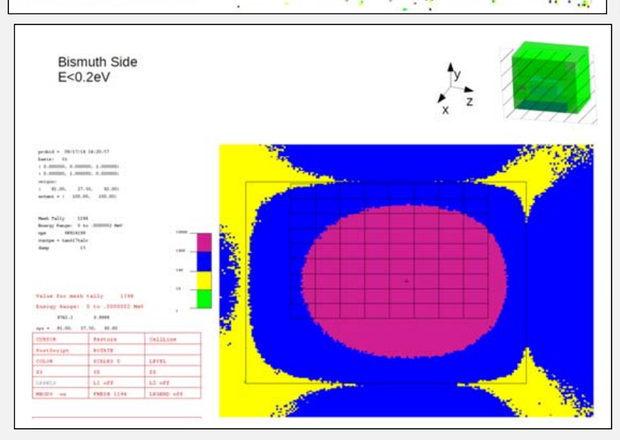
- graphite 4014 kg
- heavy water 88,5 kg
- PTFE 53 kg
- bismuth 24 kg

MCNPX simulations

Bismuth side

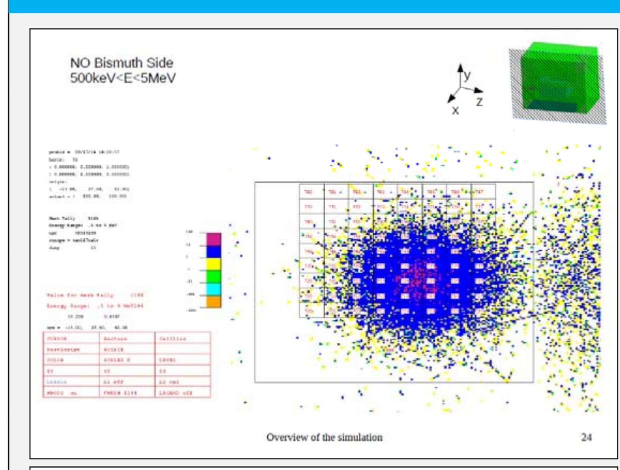


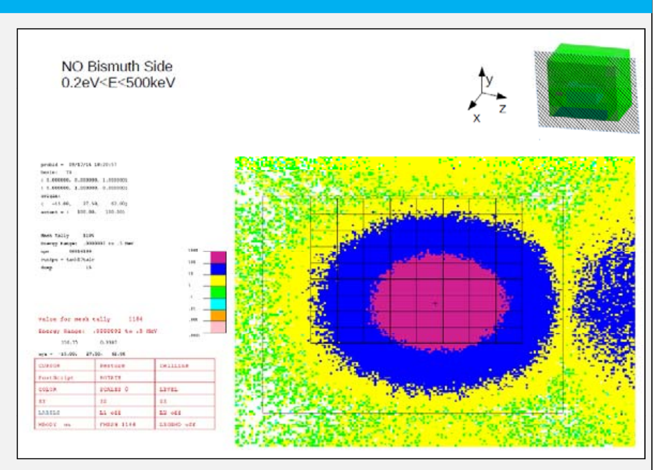


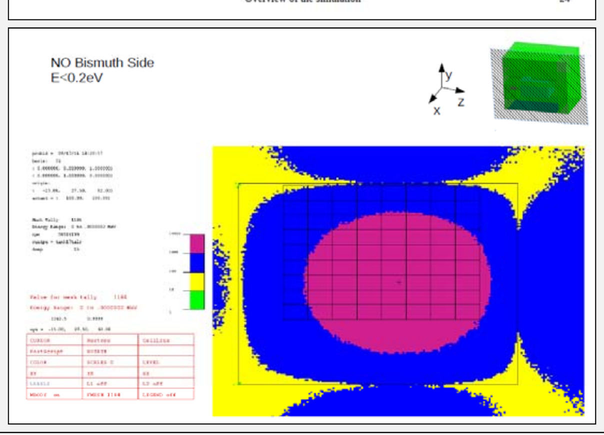


I = 3 μA	Flux (n/(s-cm^2))	%
Thermal	9,1x10^5	91,38
Epithermal	8,4x10^4	8,44
Fast	1,8x10^3	0,18
Total	9,958x10^5	100,0

No Bismuth side



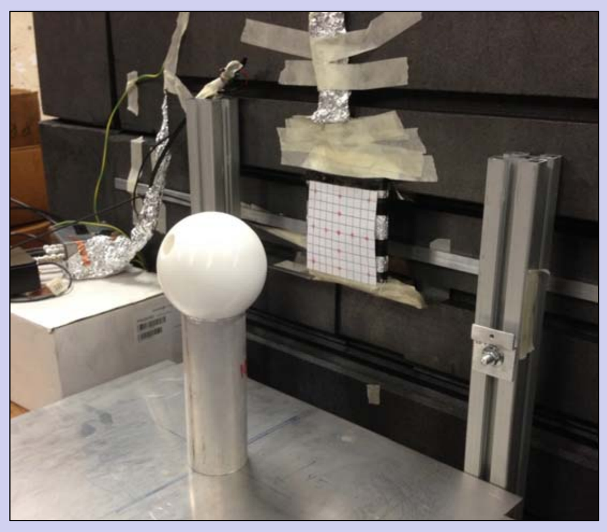




I = 3 μA	Flux (n/(s-cm^2))	%
Thermal	4,91x10^5	90,52
Epithermal	5,0x10^4	9,22
Fast	1,4x10^3	0,26
Total	5,424x10^5	100,0

First experimental campaign: Maximum production vs high risk

Neutron flux characterization with Bonner spheres and Si-detectors.



In the first configuration target inclination respect to beam direction is 22,15°. This means that protons pass through the nominal interface between Be and Cu with 2 MeV residual energy. With this energy, beam is stopped at 9 μm maximum from the Be surface. Considering to have about 20-30 μm brazing region penetrating into Be and into Cu, beam is stopped exaclty in the brazing region. There is a high risk that beryllium concentration at this level is high enough to have Hydrogen accumulation, that is swelling phenomena can appear with high probability.

First campaign results

I = 3,0 μA (during measurements)	Flux (n/(s-cm^2))	% (estimation)
Thermal	1,208x10^6	>90%

Data processing under construction

Hydrogen bubble found after 43 h irradiation time at 700 Watt/cm^2 power density

Second experimental campaign: Minimum production vs low risk

In the second configuration, target will be perpendicular to beam direction. This means that protons will pass through the nominal interface between Be and Cu with 4,25 MeV residual energy. At this energy, neutron production will be more or less one half of the previous production, but beam should stop at 60 μm distance respect to Be boundary so as to strongly reduce swelling probability. This campaign is foreseen in mid April 2016.