EURISOL-NET (ENSAR/NA03) Working Group

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Title: Converter targets for high power spallation neutron sources
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Abstract:
The last decade has seen the commissioning and operation of two spallation neutron source facilities, SNS and J-SNS, where the mercury neutron converter targets receive pulsed proton beams in the MW range. The European Spallation Source planning first neutrons for 2019 has been exploring a range of targets and is converging towards the choice of a baseline target and a back-up solution. This paper presents the target selection process, describing requirements for an ESS target and outlining the advantages and disadvantages of the various neutron converter targets considered.

Talk summary:
The precursor to the European Spallation Source project, the German SNQ project in the 80's, had planned a rotating water-cooled target with an incident beam of 5 MW. Since then several high power (~MW) converter targets have come into operation:

- SINQ at PSI from 90's: water-cooled solid rod bundles ("cannelloni").
- SINQ at PSI in 2006: Liquid LBE MEGAPIE target.
- SNS at ORNL from 2006: Liquid Hg target.
- J-SNS at JAEA from 2008: Liquid Hg target.

Recent operational experience from the above spallation sources was integrated into the design process for the target station of the European Spallation Source project. In addition, the proton beam parameters were changed, rather than the short-pulse sub-μs length, a longer pulse length > 1 ms was adopted. In 2010, a wide range of target solutions was explored by the ESS central team in Lund along with collaborating institutes across Europe (ESS-Bilbao, FZJ, KIT, PSI, CRS4, IPUL) within the framework of the Target Station Concept Selection (TSCS) process. Amongst the many criteria used to compare solutions, the driving ones are:

- Safety
- Scientific performance
- Maintainability/availability
- Cost

<u>Liquid metal targets</u>
There are considerable challenges for Hg targets: maintenance of loop components was found to be difficult due to their contamination/activation even after draining of the Hg, the high vapour pressure of Hg leads to spreading of activity over large areas during target exchanges, and potential high release of activity in accidental scenarios. The main drawback is the inability to demonstrate a disposal path for the irradiated Hg at the end of the facility lifetime. The requirement by permanent waste repositories to solidify any liquid waste into a

stable solid matrix cannot to date be met for Hg. Solutions have been explored but are not considered mature enough, they also tend to be very expensive, due to the large final volume of waste. The ESS project saw a risk in not being able to license a Hg high power spallation target in Europe. For this reason, other liquid metals were considered. The favored candidate is lead-bismuth eutectic (LBE) due to the experience accumulated in its use (coolant in Russian Alpha-class nuclear submarines, MEGAPIE project). Non-negligible amounts of the α-emitting Polonium are produced in LBE. For this reason other lead-based alloys were also considered, including lead gold eutectic (LGE) although preliminary tests of corrosion effects were inconclusive.

Solid targets

Stationary solid targets were considered but discarded because of the requirement to ensure passive cooling of the remanent decay heat. Rotating targets were re-explored for ESS and either water-cooled or gas-cooled rotating tungsten targets are being actively studied as potential baseline targets.

Outlook for EURISOL mMW converter target

Hg is most likely not licensable in Europe. Other target concepts should be considered for EURISOL, analyzing the design methodologies applied at PSI, SNS, J-SNS, ESS and adapting these to the specific requirements of the EURISOL converter target (neutron spectrum and flux, safety: proximity of fissile material at temperatures > 2000°C).