EURISOL DS Project

Deliverable (no) D1/M1

Preliminary neutronic analysis of a beam window liquid metal Hg-converter: Beam window issues and transverse film target

Planned Date (month): 18

Achieved Date (month): 22

Lead Contractor(s): P4 (CERN)

Project acronym: *EURISOL DS*

Project full title: *EUROPEAN ISOTOPE SEPARATION ON-LINE RADIOACTIVE ION BEAM FACILITY*

Start of the Project: *1st February 2005*

Duration of the project: *48 months*

Project funded by European Community under the "Structuring the European Research Area" Specific Programme Research Infrastructures Action within the 6th Framework Program (2002-2006)

EURISOL-DS MULTI-MW TARGET ISSUES: BEAM WINDOW AND TRANSVERSE FILM TARGET

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The analysis of the EURISOL-DS Multi_MW target precise geometry (Fig.1) has proved that large fission yields can be achieved with a 4 MW, providing a technically feasible design to evacuate the power deposited in the liquid mercury. Different designs for the mercury flow have been proposed, which maintain its temperature below the boiling point with moderate flow speeds (maximum 4 m/s).

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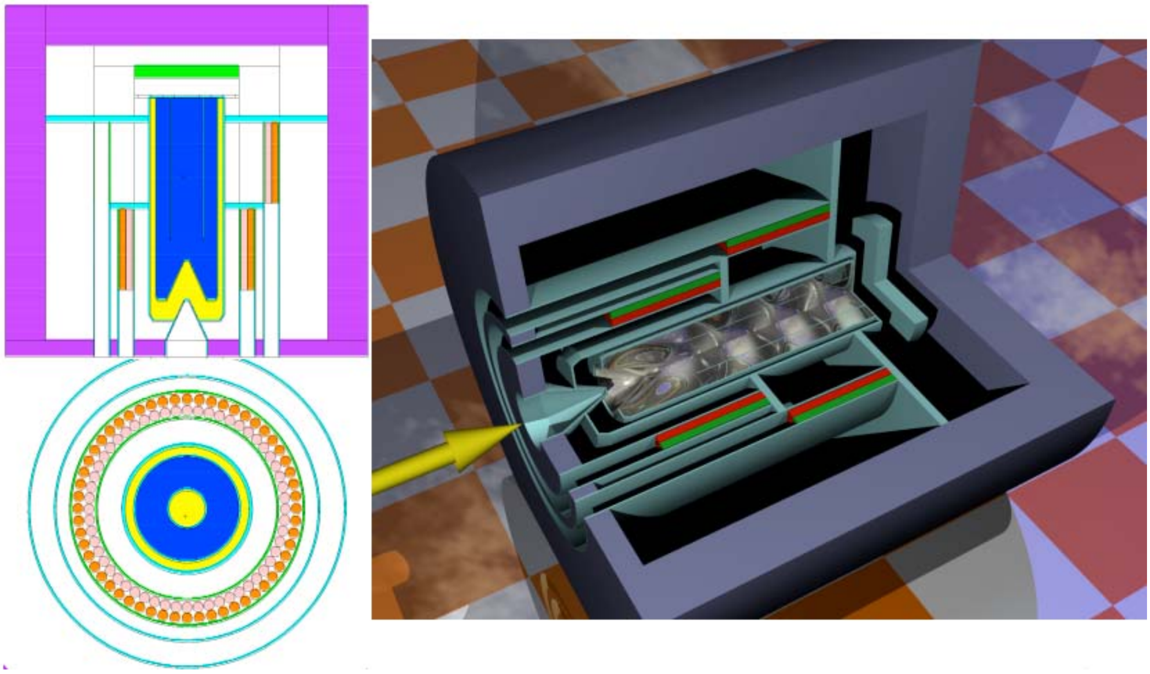

Figure 1. Different views for the precise model of the EURISOL-DS Multi-MW target assembly.

Nevertheless, the large temperature gradients in the beam window induce unacceptable mechanical stresses, in the order of 300 MPa, which would risk the breaking of the window.

To avoid this eventuality, an increase in the proton beam width has been considered, going from a 15 mm sigma to a 25 mm sigma. This enlargement has the immediate effect of reducing the maximum power density in the mercury from 1.8 to 0.8 kW/cm^3 per MW of beam power, and from 0.9 to 0.3 kW/cm^3 per MW of beam power in the beam window. Moreover, the power density gradient, proportional to the temperature gradient, is greatly reduced, as indicated by Figure 2.

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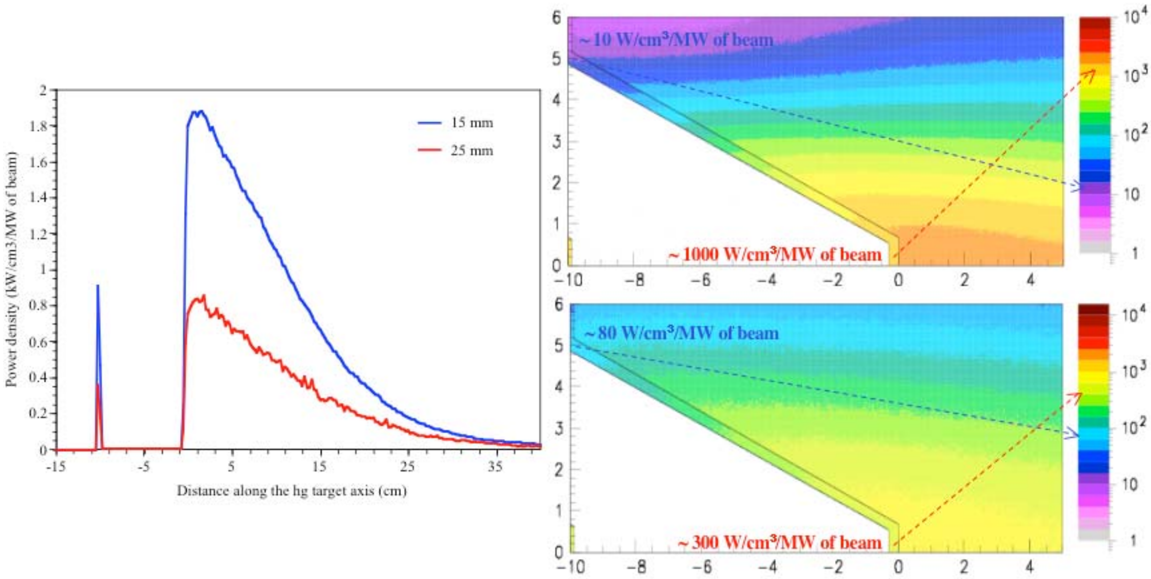

Figure 2. Power density distribution for the considered beam widths, along the beam axis and around the window.

The main drawback to a wider proton beam is the level of high-energy particle escapes and the possibility of those streaming in the forward direction. This problems may be solved with a combination of adjusted beam collimation, proper design of a beam dump and sufficient radiation shielding around the assembly.

An alternative windowless design has also been developed and analysed, presenting several advantages to the aforementioned one. A transverse windowless mercury film would fall by gravitation, interacting with the proton beam to produce spallation neutrons and efficiently removing the beam energy with reasonable flow speeds (~4 m/s) and temperature increase (~100 K). Figure 3 shows the basic layout of such design.

The neutron flux in the fission targets reaches 2×10^{14} n/cm^2/s per MW of beam and the proton and

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neutron distribution is similar to that of the mercury jet option. High fission densities (~5×10^{11} n/cm^3/s per MW of beam, Figure 4) are achieved, allowing for the aimed RIB yields with reduced fission target volumes (1 –5 litres).

On the other hand, and given the small thickness of the transverse film (~4 cm), significant high energy particle escapes will occur, requiring the design of a dump behind the mercury film and detailed radioprotection studies.

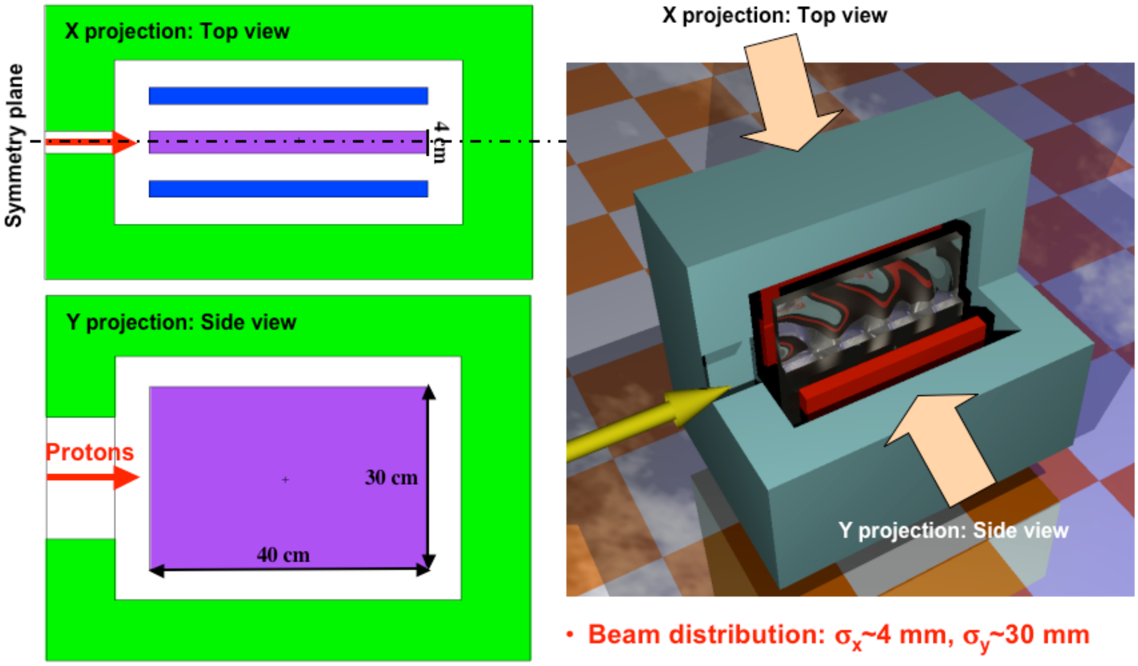

Figure 3. Views of the simplified transverse film design.

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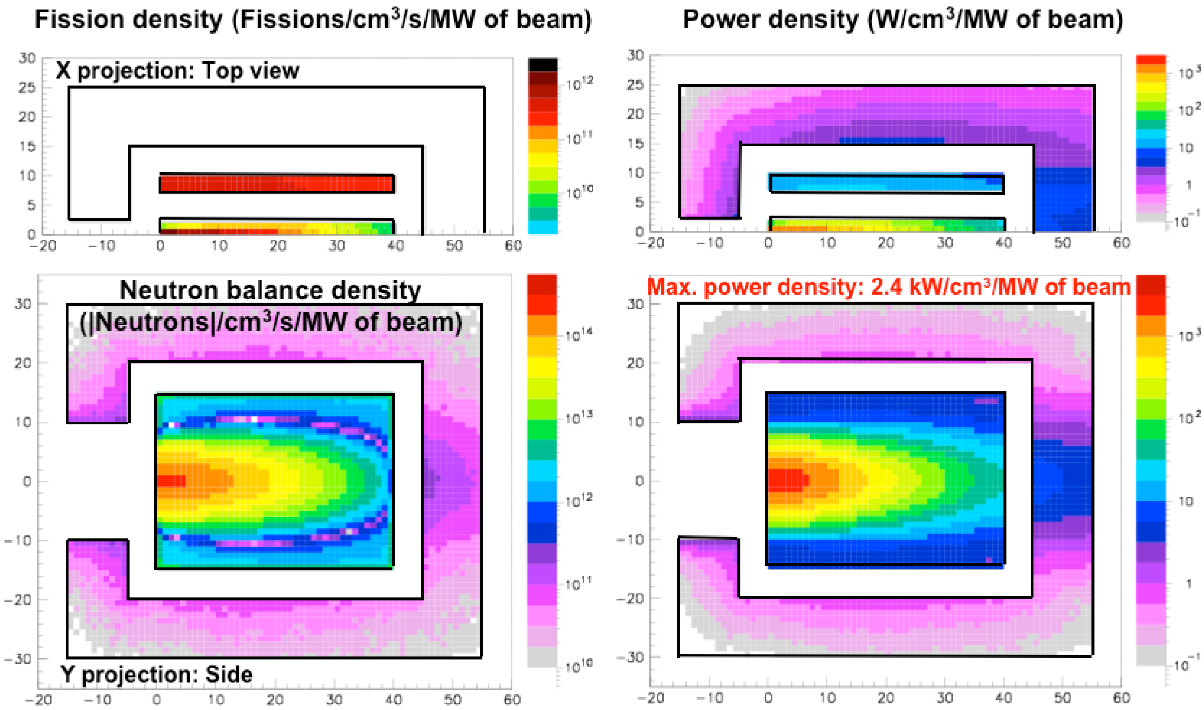

Figure 4. Different neutronic parameters for the transverse film configuration.

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