ESS BEAM LOSS Q&A

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What are the predictions for the ESS losses?

The linear accelerator of European Spallation Source will produce 5 MW proton beam. Beam of this power will likely generate significant losses along the beamline. Beam losses anticipated by the design of the facility are limited by 1 W/m which should allow the hands-on maintenance [2][3]. Number that high requires a specialized beam loss monitoring system to ensure that the limit is not exceeded during the normal operation of the machine and also to detect catastrophic events like full beam loss. Due to the lack of detailed loss patterns available, the following two scenarios are under investigation: a.) uniform losses along the whole model b.) losses localized in the quadrupoles. The latter are the most probable loss locations as the beam inside them is the largest compared to the aperture [1]. In both cases the losses propagate at a shallow angle of 0.05 degree in reference to the beam direction and very close to the beam pipe.

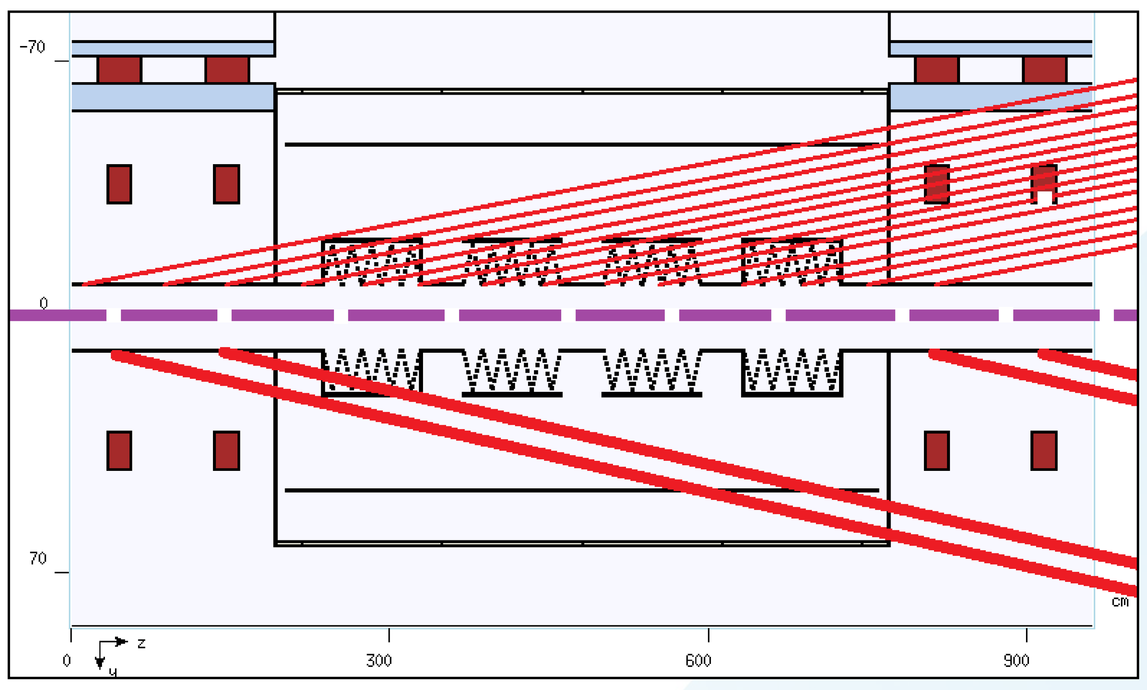

Figure 1: Scheme comparing two loss patterns: uniform (top) and localized (bottom).

How will ESS Beam Loss Monitoring System look like?

The main detector chosen for the linac is CERN LHC type ionization chamber complimented by neutron detectors and scintillator-based fast loss monitors. About 200 detectors will be installed along the machine in the locations that will be determined by beam loss patterns studies [5].

Figure 2: ESS Ionization Chamber with and without metal casing

The BLM system is designed to detect the losses as small as 1% of the limit (about 0.01 W/m) and as fast as 2 μs (to prevent destruction of elements during full beam loss) [1].

What tools are there to optimize beam loss simulations?

MARS code system [4] was chosen for performing Monte Carlo simulations of beam losses.

All components of ESS linac are listed in the central Beam Line Elements Database (BLED), a system for central management of the data [1].

To ensure that the models used for the Monte Carlo simulations are consistent with the actual machine, a link between them and BLED has been established:

DEIMOS, an ESS Beam Line Generator for MARS is a program written in Python (running on Windows, Mac OSX, Linux-based systems and on my 3DS for users convenience). It reads the elements names and coordinates from BLED, processes them and outputs a complete accelerator geometry, readable and processable by MARS.

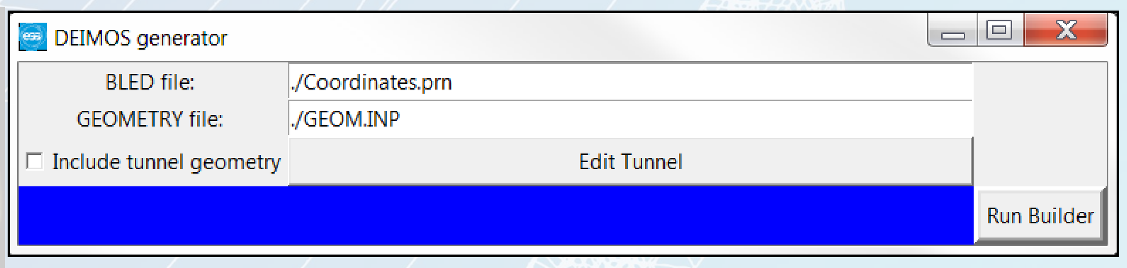

Figure 3: DEIMOS main window

MARS output file includes the accelerator tunnel with all the parts recognized in the BLED input. As every part is saved as separate module it is very easy to add new parts or edit existing ones, as well as update the layout based on the changes in BLED.

Are there more tools planned?

Yes. First of them is currently under developement. **PHOBOS** will be an external interface for running multiple MARS simulations with varied parameters like beam loss locations.

PATHFINDER is a new idea for a neural network tool to analyze the big amount of data generated by the simulations to decide on optimal location for the beam loss monitors.

Why do we need a full accelerator model?

Due to the fact that the actual beam loss patterns remain unknown there is the need of validating the machine layout using Monte Carlo particle transport simulations. As high energy beam losses are highly penetrative (by their own nature and, mostly, because of the free neutrons they produce) and can propagate tenths of meters, it is important to look into big picture, ergo simulate the whole linac at once. Only full model can ensure unabridged information, not only during the design phase, but also during the operation phase, provided that it is coherent.

What does model coherency mean?

To make the work on model most efficient, it will be done in parallel by few people. It is extremely important to make sure they all „speak in the same language" – all their work needs to be compatible, should avoid doing the same thing more than once and update frequently and simultaneously to match the actual machine. All of the above sums up as the coherency for the model.

What questions could be answered using the model right now?

We could, for example, inspect the heat loads in the superconducting cavities of ESS. Results would cover the energy range from 90 MeV to 220MeV (spoke cavities) and from 220 MeV to 2 GeV (elliptical cavities). Estimating the heat loads would confirm or update the preliminary cooling requirements, previously set at 0.5 W/m averaged along all cavities. These simulations were performed for both loss patterns and generated results as follows:

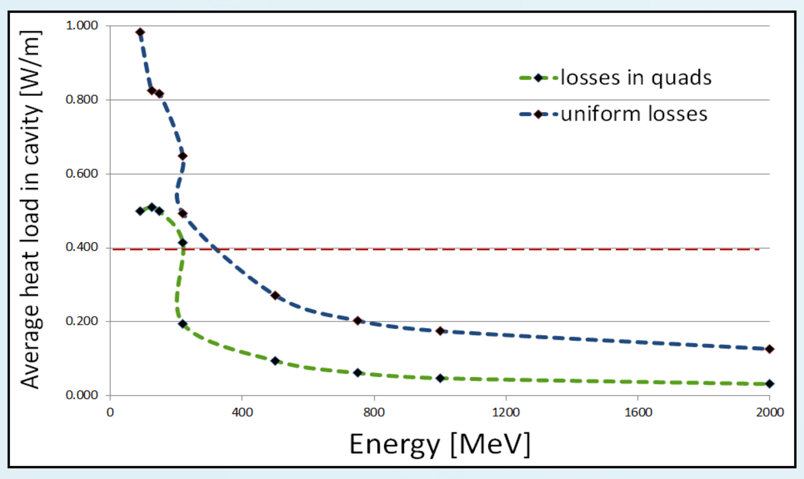

Figure 4: Heat load predictions in superconducting cavities

One can observe that the heat load on cavity for lower energies gets close to the total beam loss – this is due to very conservative assumptions (normalization to the maximum heat load absorbed in the cavity). Even with this overshoot the average heat load along the whole accelerator will be lower than expected 0.5 W/m (from the point of view of the cooling system this value is more important than the local excess of the limit).

Does this project receive any funding?

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References:
[1] S.Peggs et al., "ESS Technical Design Report", Lund, 2013 [2] L. Tchelidze, "Beam spill limits during various event classes (for the ESS accelerator)", Lund, 2014 [3] T. Hansson "ESS Radiation Protection Strategy for Employees", Lund, 2013 [4] N. Mokhov et al., "The MARS Code System User's Guide Version 15", Batavia, 2014 [5] L. Tchelidze, H. Hassanzadegan, M. Jarosz, A. Jansson, "Beam loss monitoring at European Spallation Source", IBIC13, [6] www.wikipedia.org, Deimos and Phobos fotographs