GOLEM Probe Simulations

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A novel probe design using scintillator materials to detect Runaway Electrons (RE) in TEXTOR tokamak was proposed and tested by Kudyakov *et. al.* [1]. Based on this design we want to develop a similar probe for RE measurements on tokamak GOLEM.

I used the FLUKA Monte Carlo code to test the proposed probe design for energy range of RE expected in GOLEM. *Two different setups* were tested.

As can be seen from the results, *the design needs to be updated* on account of materials and dimensions used. Next simulations will be done after discussions with Pravesh Dhyani.

Probe design by Kudyakov *et. al.*

The probe design and the experimental setup are shown in Fig.. The probe consists of ten YSO (Y_2SiO_5:Ce) crystals, which are shielded by different thicknesses of tungsten filters (between 0 and 6 mm) placed in the RE direction. A gap before the first scintillator allows to measure low-energy electrons. From the other directions the crystals are properly *shielded by more than 6 mm tungsten*. The outside of the probe is covered by a *5 mm graphite housing*.

In the TEXTOR tokamak electrons can be accelerated up to a maximum energy of **30 MeV**.

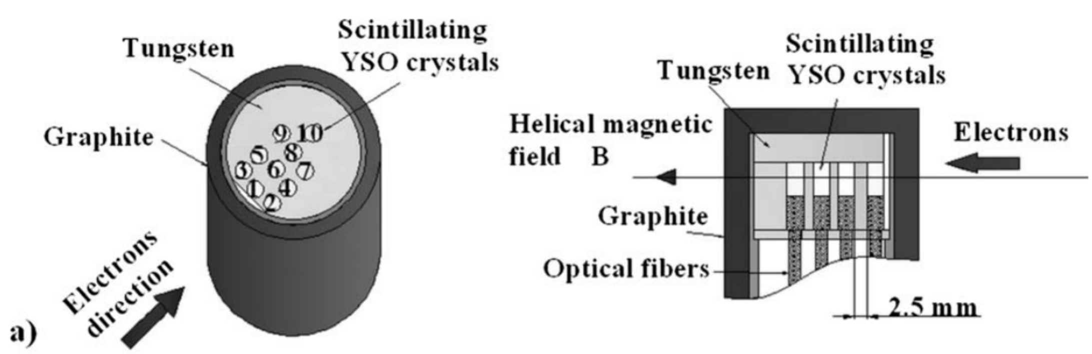

Fig. 1: Probe design by Kudyakov *et. al.*

Proposal of GOLEM probe design

First setup:

The first design of the probe is shown in Fig.2. The figure contains the probe cut view from two different directions (y-z and x-z planes) and a 3D cut view. The probe consists of

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4 cylindrical YSO crystals, pictured in brown colour, tungsten filters pictured in gray (of 0 mm, 1 mm and 3 mm thickness). The outside of the probe is covered by a graphite housing (violet colour), similar to Kudyakov probe, but the housing in our case is thiner (dimensions are shown in the figure). Dimensions of the probe are proposed to be different from the ones in the TEXTOR paper, because in GOLEM we expect RE of smaller energies (at least 3x smaller).

A gap before the first scintillator is also present in the design.

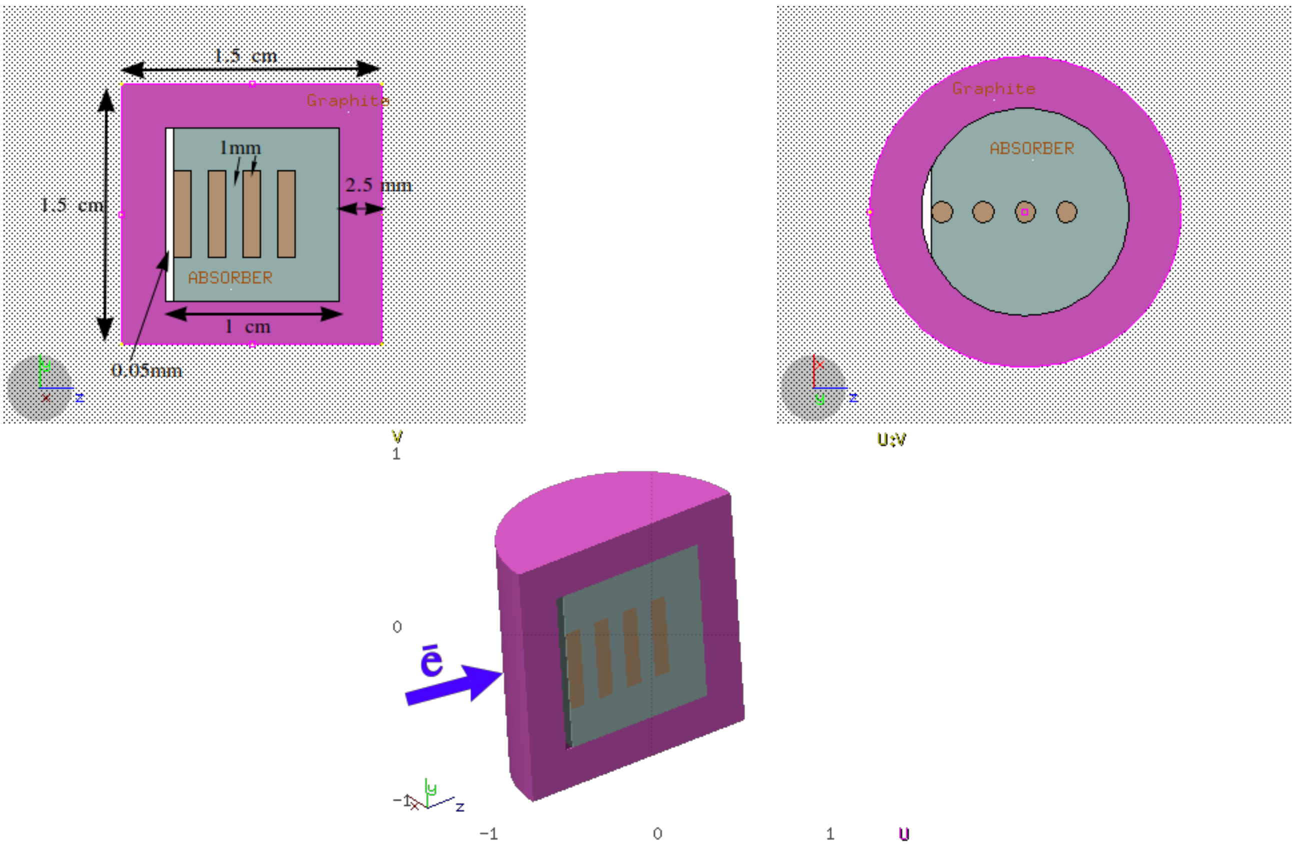


Fig. 2: The first design of the probe.

Using the FLUKA code, such a design was exposed to a pencil-like electron beam, coming from the z-direction. Energy of the incident electrons was set as 1 MeV in the first st of simulations and as 10 MeV in the second. Electron fluence[2] (which is proportional to energy deposition) for both cases was monitored inside the probe: the results of the simulations are shown in the Fig. 3; response for 1 MeV beam is in the upper part and for 10 MeV in in the lower part.

As can be seen from the figure, such design has too thick shielding for the detection of 1 MeV electrons - the whole energy is deposited in graphite before reaching the first scintillator. In the case of 10 MeV electron beam, only first two scitillators are exposed to electron fluence.

[2]amount of secondary electrons per cm^2 generated by one incident electron

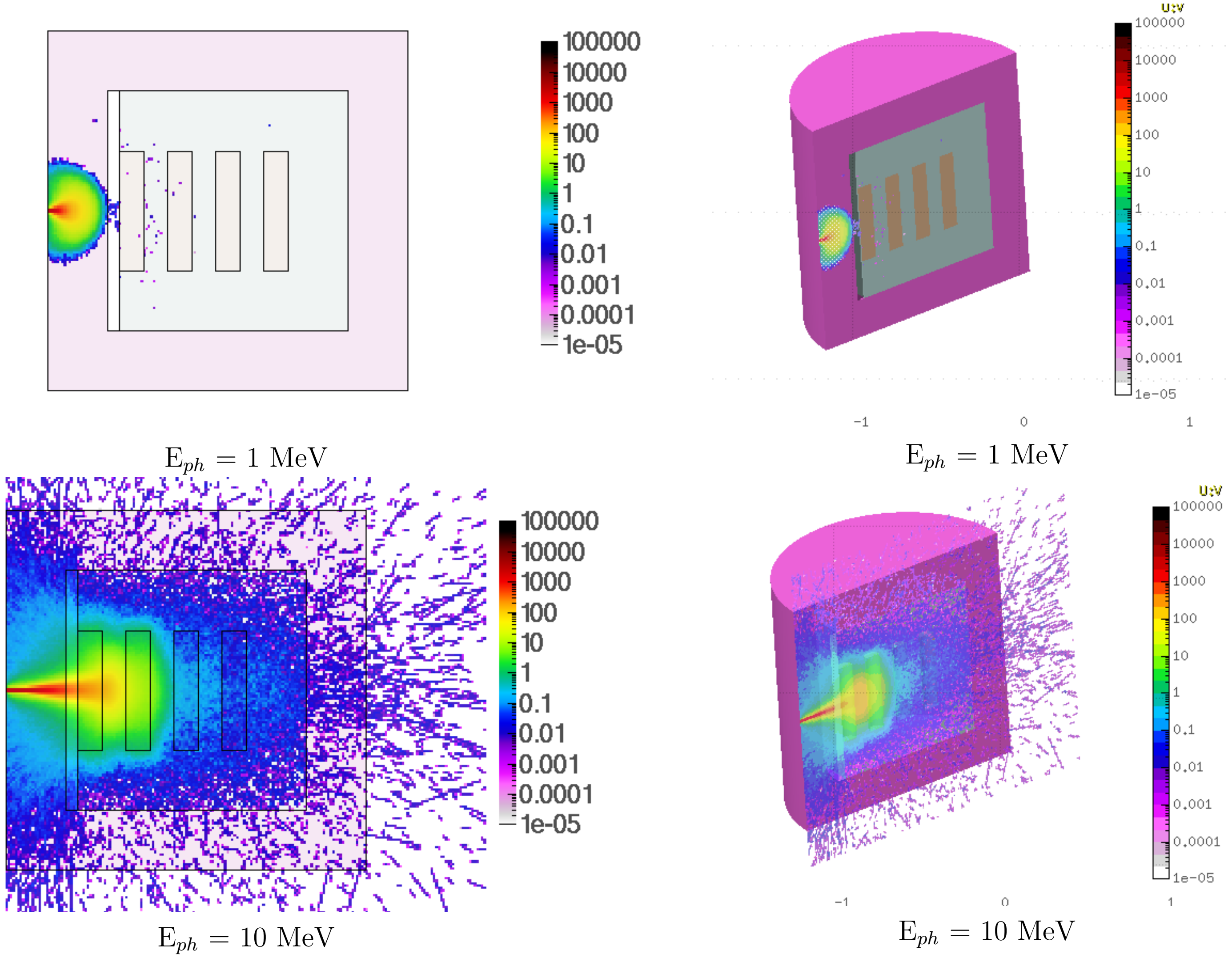


Fig. 3: Electron fluence in the probe for different values of photon energy E_{ph}.

Second setup:

Taking into account the fact that in the previous design the lower energetic electron beam deposits its energy before reaching the scintillators, in a new set of simulations *a probe with a reduced graphite shielding* was tested. All the parameters were kept the same, apart from the width of graphite housing and hence gap size (gap size does not play a big role here, as it is filled with vacuum). The probe design is illustrated in the Fig.4.

Simulation results for the same electron energies (1 MeV and 10 MeV) are shown in the Fig.5. As it can be seen, such setup is still not efficient (especially for lower-energy electrons). It can be concluded, the reduction of the graphite shielding is not enough, the most important role in the energy deposition plays absorber: apparently, tungsten is too dense and has too high atomic number and therefore is too efficient in electrons stopping.

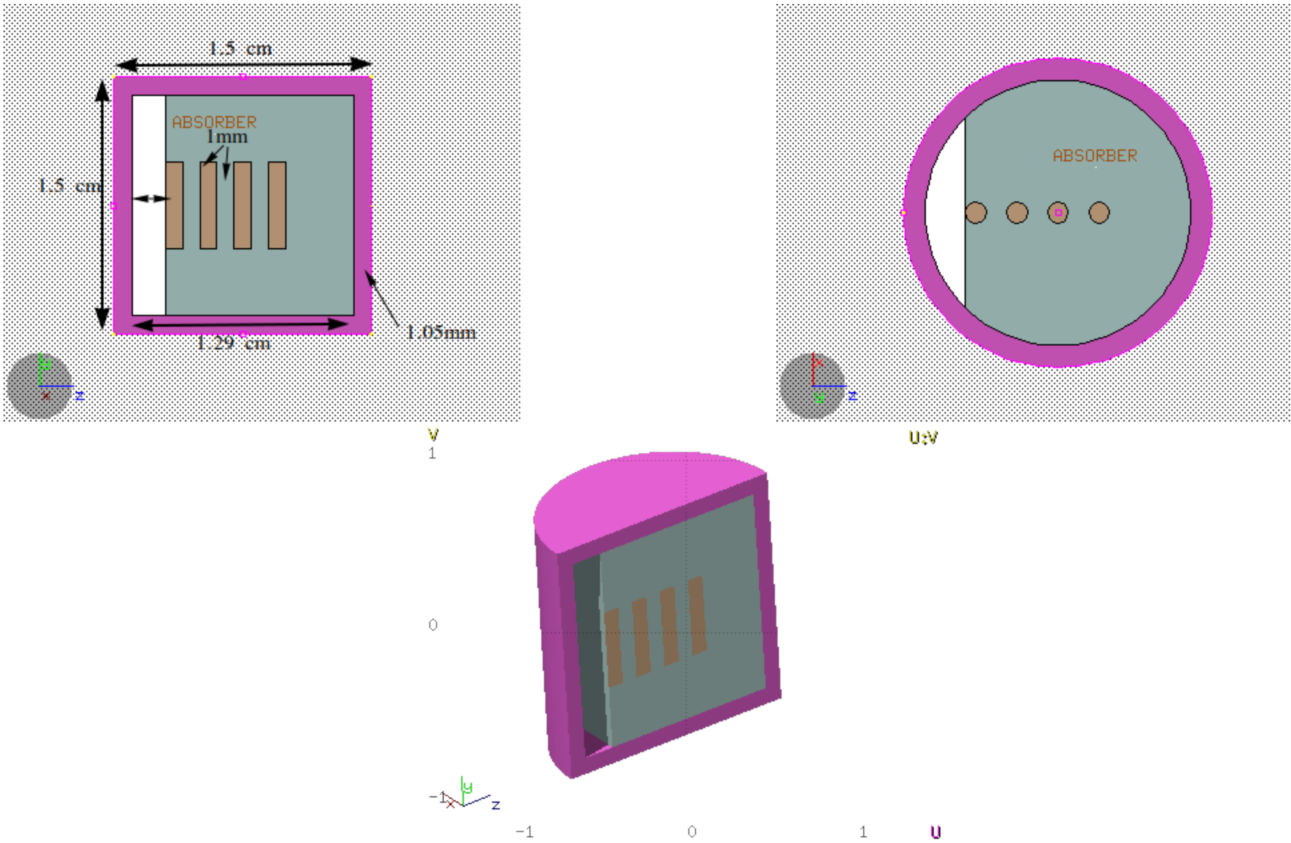


Fig. 4: The second design of the probe.

Conclusion

Simulations for two probe setups (of different width of graphite housing) were implemented.

Tungsten appeared to be too dense and has high atomic number for the detection of electrons in GOLEM (assuming the max electron energy is 10 MeV and the energy of the most part of electrons is lower than that). Therefore, different absorber material needs to be proposed and tested (Molybdenum?).

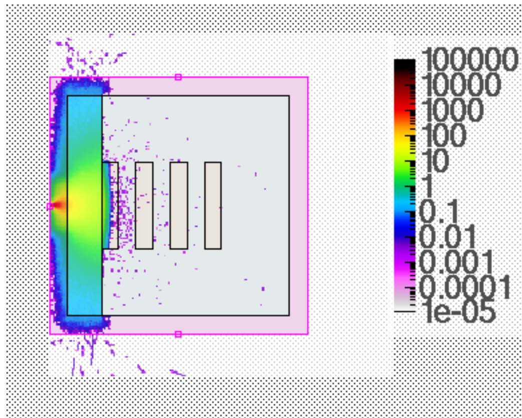
Optimization of the probe design is needed before performing next simulations (discusssion with Pravesh).

What was the plan (discussed with Pravesh):

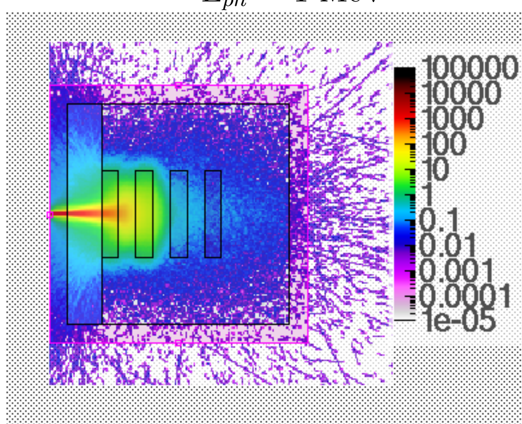
the plan was to test different designs of the probe using different materials of absorber and scinillators, different energies of incident electrons and different beam shape (see Tab.1).

Absorber	Stintillator	Electrons energy	Beam shape
Tungsten	YSO	1 MeV	pencil beam
Molybdenum	LaBr	10Mev	wide beam

Tab. 1: Possible 'variables' for design tests



E_{ph} = 1 MeV



E_{ph} = 10 MeV

Fig. 5: Electron fluence in the probe for different values of photon energy E_{ph}.