# Monte Carlo Calculations for beam dump shield design for K-130 Cyclotron at VECC

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In any accelerator based nuclear physics experiment most of incident beam passes through the target material and stopped in the beam dump. So the beam dump becomes the major source of neutron and γ-radiations. This contribution is much larger than that of actual neutron and γ-rays produced from the nuclear reactions with target nuclei. Therefore the actual data of interest may be suppressed by this huge background. Moreover the unwanted radiation produced in the beam dump may increase the load on data acquisition system and cause significant radiation damage in detectors and electronics. Therefore for precise measurement of neutron energy spectra in accelerator based experiments requires minimization of different sources of neutron and γ-background. The precise measurement of neutron energy and multiplicity will be useful in understanding many interesting physical phenomena like statistical and pre-equilibrium emission processes, fission dynamics and time scales etc.

In this paper we report a Monte Carlo study to design a suitable shield of the beam dump at K130 cyclotron, VECC. The simulation has been performed using the FLUKA (version 2011.2b.3) code [1, 2] which is a general purpose tool for calculations of particle transport and interactions with matter. In this calculation we have incorporated detailed geometry of the target chamber, target, and walls of the beam hall to simulate the exact experimental condition using FLAIR [3] which is an advanced Graphical User Interface (GUI) for FLUKA. In the present study we have taken 50 MeV $^{4}$He ion beam on a $^{181}$Ta (1.0 mg/cm$^{2}$) target and kept two neutron detectors at a distance of 150 cm from the target at 15° and 150° around the target chamber. Typical experimental setup is shown in Fig. 1.

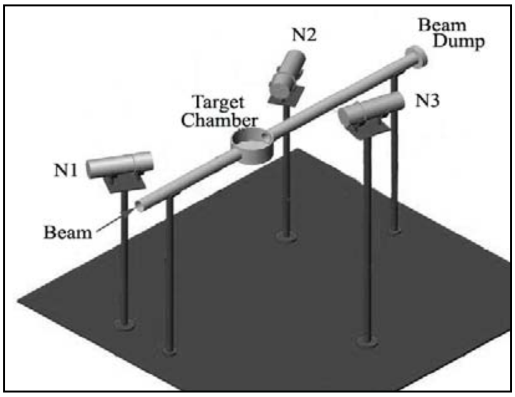


Fig.1 Typical experimental setup

The beam dump is located at a distance of 280 cm from the target. A graphite block of size 4.0 cm x 4.0 cm x 1.5 cm was considered as the beam dump. Graphite was used as the beam dump material because of its low atomic number and ability to withstand high temperature. To evaluate the effectiveness of different types of shielding designs for neutrons and high energy photons, the neutron and photon fluences per $^{4}$He particle were evaluated at both the detector positions and compared with respect to an ideal beam dump shield, 'Black Hole'. Black hole is a hypothetical region generally considered in most of the Monte Carlo codes to stop any particle falling on it. Therefore black hole corroborates an ideal beam dump shielding condition.

We have considered a composite shield comprising of the combination of high density Polyethylene (HDPE), lead and iron of various thicknesses in our calculation. The neutron shielding was mainly comprised of High Density Polyethylene (HDPE) (density ~1.0 g/cm$^{3}$). For the shielding of high energy photons we have considered lead. To minimise the neutron multiplication reaction (n, xn) in lead, it was used after adding sufficient thickness of HDPE immediately after the beam dump. Finally a layer of Iron was added, which gives mechanical strength to the shield and reduces the photon flux produced from the neutron activation in lead. The final shield design has been shown in Fig. 2.

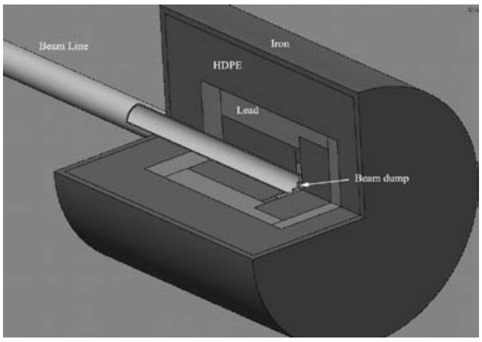


Fig.2 Final design of the beam dump

The first layer of the shielding consists of a 10.0 cm thick HDPE of length 40.5 cm and 15.0 cm thick HDPE having a radius of 20.6 cm behind the beam dump. This was followed by 10.0 cm thick lead of total length 70.5 cm. Lead shield towards the back side of the beam dump is 5.0 cm thick. Lead shield was further covered by 20.0 cm thick HDPE of length 97.5 cm followed by 5.0 cm thick Iron around all sides.

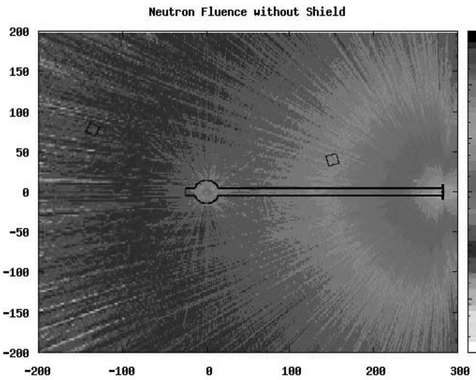


Fig.3 The spatial distribution of the neutron fluence with no sheild around the beam dump.

The contributions of neutron and photon fluences at 15° detector position, without any shielding are 11 and 19.8 times more than the same with black hole. For the detector at 150° position, neutron fluence is 11.5 times, photon fluence is 21.4 times more compared with the black hole. This shows a huge contribution of the neutron and photon fluence from the beam dump at the detector positions.

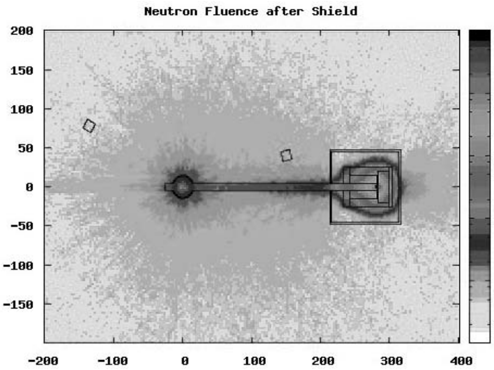


Fig.4 The spatial distribution of the neutron fluence with the final shield at the beam dump

After considering the beam dump shielding as discussed above, neutron fluence at the 15° detector position is around 1.2 times more and photon fluence is around 1.5 times more compared to the black hole. Similarly in the 150° detector position neutron fluence is 1.46 times more and photon fluence is 1.3 times more compared to black hole. It can be observed from the above values that the design shielding is very close to an ideal shield (Black hole). More detailed simulation is under progress which will be reported during the conference.

**References:**

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2) *"FLUKA: a multi-particle transport code"* A. Ferrari *et. al*, CERN-2005-10 (2005), INFN/TC_05/11, SLAC-R-773.
3) *"FLAIR: A Powerful But User Friendly Graphical Interface For FLUKA"* V.Vlachoudis, Proc. Int. Conf. on Mathematics, Computational Methods & Reactor Physics (M&C 2009), Saratoga Springs, New York, 2009.