Study of Field Profile of a Mini Orange Spectrometer Magnet

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Introduction

Conversion electron measurement is an important aspect of nuclear spectroscopy. Nucleus from an excited state depopulates by competing process of gamma and conversion election emission. Various types of magnetic devices have been used to measure the conversion electrons, such as, solenoids with strong field strengths, magnetic mirrors and orange type permanent magnets etc.. The advantage of the orange type filters is its compactness in size and its ability to measure electrons in wide energy range and its ability to operate in a high background condition of in-beam experiments. Such type of spectrometer was first developed by Van Klinken [1] for conversion electron spectroscopy. In the MOS setup, the magnetic filter is a set of small permanent magnets, usually made of rare earth materials, such as $SmCo_5$, due to their capability of producing intense magnetic field with small quantities of bulk material. The magnet pieces are wedge shaped arranged around a central absorber, which reduces the background due to direct gamma ray flux. The magnetic field strength of the setup is an important factor for the transmission of electrons through the MOS filter. The present work reports the measurement of the magnetic field profile of an orange type filter and compared the same with simulations.

Geometrical design of the magnet

The magnetic filter setup used for the present measurement consists of four wedge shaped sectors of magnets, attached to a brass ring holder. The 3D dimensions of the magnet assembly are shown in Fig.1.

Magnetic field measurement

To understand the magnetic filed lines through the MOS magnet setup, field measurements have been carried out with a 3D hall probe. The field strength was measured within the gaps of each magnetic sector at steps of 4 mm as a function of the radial distance r from the centre of the filter and as a function of z, i.e., along the axis of the filter. For this purpose, one test bench with (z,r) movement in millimeter scale was made, as shown in Fig.2.. As the tip of the hall probe has its own dimension of about 2 mm and also due to the backlash error of the scale movement, the position measurement can have an estimated error of +-2mm.

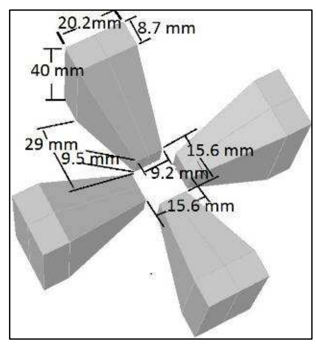

Fig. 1 The 3D magnet dimensions.

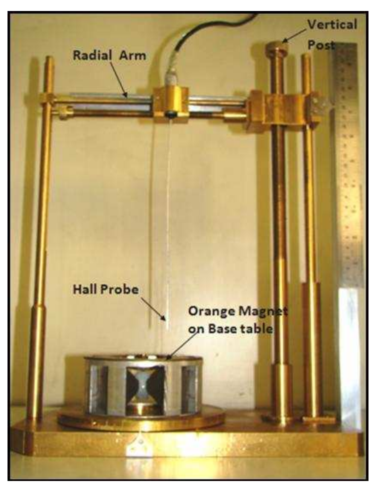

Fig.2 The test bench setup for field measurement.

It has been observed that the resultant field may vary maximum 200 Gauss for 2mm displacement along the radial axis.

Simulation

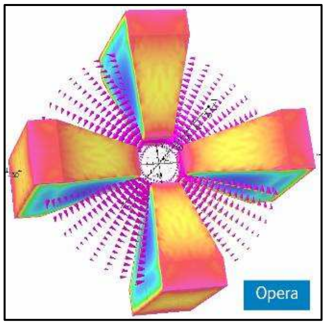

Fig. 3 Simulated distribution of B_{mod} component and magnetic field vectors of the MOS filter.

Magnetic field distributions (Fig 3) of MOS filter were simulated using finite element based 3D magneto-static solver TOSCA (OPERA Version 15R1) [2]. 1/16th symmetric model was used for simulating the field. Non linear B-H property with Coercive field strength (Hc) of -6.62x10^5 A/m and Remnant field (Br) of 0.867 T was used as permanent magnet material data input.

Results and Discussion

Fig.4 shows the measured resultant field as a function of distance along the filter axis z (z=0 being the median plane) at various radial position, along with its comparison with the OPERA simulation. At higher z values the field could be measured till to the centre of the filter, but at lower z values, the central region could not be measured due to the presence of the central lead absorber. It can be seen that overall there is a good agreement between the measured and simulated fields at different positions. However, at lower z and towards the centre of the filter, there is a difference of about 200-300 Gauss between the measured and the simulated filed. This may be due to the difficulty in moving the hall probe towards the narrow gap within the magnet sector and thus the possible uncertainty in the corresponding position of the measured field.

References

[1] J. Van Klinken and K. Wisshak, NIM 98, 1 (1972).

[2] www.vectorfields.com, www.cobham.com

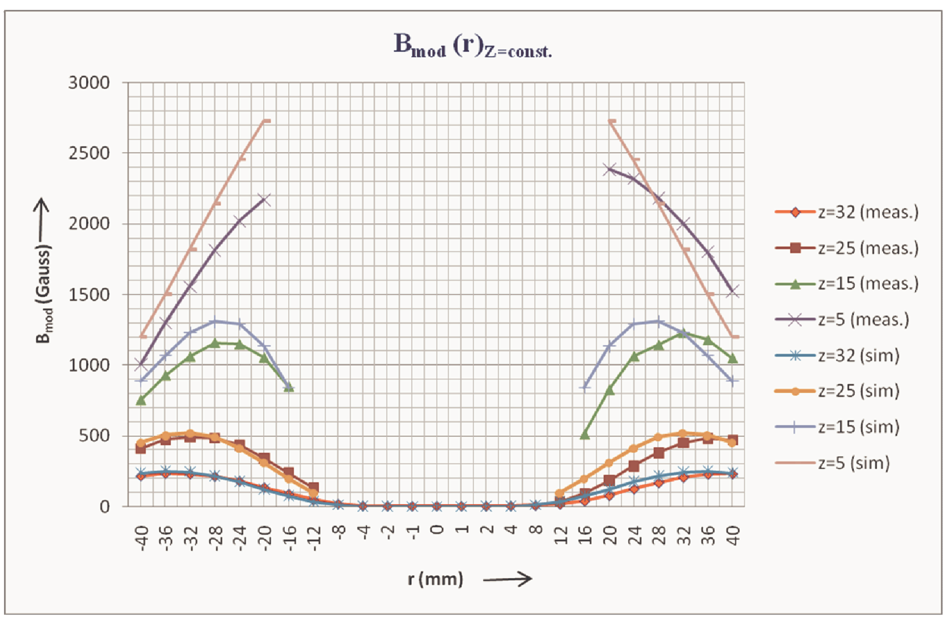

Fig. 4 Comparison the measured filed with OPERA simulation.