Measurement of the Residual Beam deflection on Target in the External Magnetic Field for TIPAD Experiments

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A magnet system for perturbed angular distribution measurements of in-beam γ-rays has been constructed for the CYRIC cyclotron.[1,2] The system consists of a "PAD" magnet, which produces an external magnetic perturbation field, and beam steering devices. Changes of a charged-particle beam in position and direction on target due to the magnetic field of the PAD magnet are compensated by the use of an inlet and an outlet active magnetic channel attached to the PAD magnet and a conventional dipole magnet installed upstream.

Ray-tracing calculations indicate that under typical conditions of the TIPAD (time-integral perturbed angular distribution) experiment the residual beam deflection on target is usually within a range of $\pm 0.6°$, as long as the beam is transported with no loss down to the beam dump while the beam position on target being kept stationary irrespectively of the external magnetic field. Since the coils of the active magnetic channels are connected in series, one can easily find the upper and lower limiting excitation currents of the magnetic channels at which the beam intensity at beam dump begins to decrease while keeping the beam position on target stationary by adjusting the excitation current of the steering magnet upstream. For the TIPAD measurements we always set the excitation current of the magnetic channels at the mean of the upper and lower limiting currents found in this way, and accordingly the uncertainty in residual beam deflection on target is expected to be smaller than $\pm 0.6°$.

We present here a report of a trial to measure the residual beam deflection on target under typical conditions of the TIPAD experiment.

An enriched ^{158}Gd target was placed in the center of the pole gap of the PAD magnet and bombarded with a 44-MeV α-particle beam. Excited levels in ^{158}Dy were populated via the ^{158}Gd(α,4n) ^{158}Dy reaction, and angular distributions of the 475.9-, 320.6- and 218.3-keV prompt E2 γ-rays respectively from the $8^+ \rightarrow 6^+$, $6^+ \rightarrow 4^+$ and $4^+ \rightarrow 2^+$ transitions in ^{158}Dy were measured in the two cases: (i) with an external field of 20.4 kG being applied to the target by the PAD magnet, and (ii) with no external field. In case (i) parameters for the beam steering devices were set at the values appropriate to the TIPAD experiment in the way described above. The γ-rays were measured at 9 angles in a range of 60 to 124° with a Ge(Li) detector. Another Ge(Li) detector fixed at -90° served as a monitor counter to normalize the γ-ray yields measured at different angles.

In each of the above two cases, the γ-ray angular distributions for the three transitions were summed up, and the two resultant angular distributions were fitted simultaneously to the expression

$$W(\theta) = b_0 + b_2\cos[2(\theta-\Delta\theta_i)] + b_4\cos[4(\theta-\Delta\theta_i)], \quad i = 1 \text{ and } 2,$$

where $\Delta\theta_1$ and $\Delta\theta_2$ are the fitting parameters for the angular distributions with PAD magnet off and on, respectively, and b_0, b_2 and b_4 are those common to the both cases.

The results of this least-squares fitting analysis are shown in fig. 1 and table 1. The angular distribution coefficients deduced from b_2/b_0 and b_4/b_0 listed in table 1 are

$$A_2/A_0 = 0.259 \pm 0.072 \quad \text{and} \quad A_4/A_0 = -0.095 \pm 0.041,$$

and the residual beam deflection on target is

$$\Delta\theta_1 - \Delta\theta_2 = -0.074 \pm 0.485 \text{ (deg)},$$

which is quite consistent with the results of the ray-tracing calculations. The present measurement is preliminary, and further measurements of the residual beam deflection with improved statistical uncertainties are to be performed under various conditions.

References

1) Kawamura N., Sugawara M., Shibuya S., Fujioka M., Orihara H. and Ishimatsu T., CYRIC Ann. Rep. 1981, p. 88.
2) Kawamura N., Fujioka M., Sugawara M., Shibuya S., Iura K. and Ishimatsu T., Proc. sixth int. conf. on hyperfine interactions (July 1983, Groningen), to be published in Hyp. Int.

Table 1. Results of the least-squares fitting analysis

b_2/b_0	b_4/b_0	$\Delta\theta_1$ (deg)	$\Delta\theta_2$ (deg)
0.157±0.049	-0.049±0.021	0.138±0.341	0.211±0.344

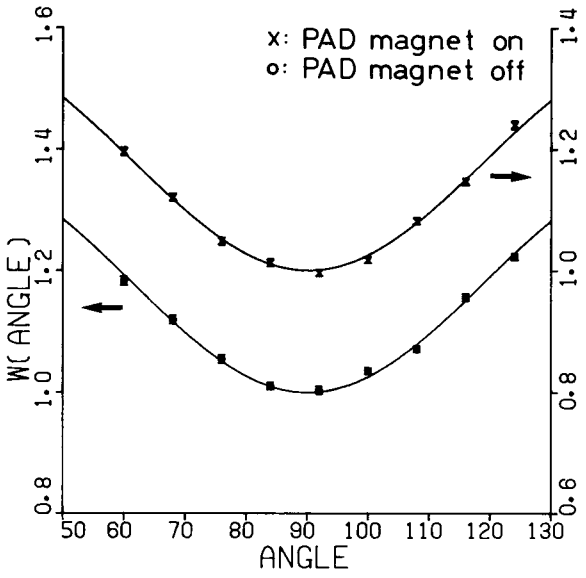

Fig. 1. Gamma-ray angular distributions observed with PAD magnet on and off. Curves represent results of the least-squares fitting analysis.