A Magnet System for In-Beam Perturbed Angular Distribution Measurement

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The external magnetic field required for the perturbed angular distribution measurement causes some difficulties in the case of in-beam γ-ray spectroscopy. Because of the deflection of the incident charged-particle beam in the external magnetic field, the position of the beam spot on the target shifts with the field strength and the beam energy. In addition, the beam direction at the target depends on these quantities, which poses a serious problem in the measurement of the time-integral perturbed angular distribution.

We have designed and constructed a "PAD" magnet equipped with active magnetic channels (AMC) as well as passive ones for the in-beam study of nuclear g-factor and hyperfine interaction via the perturbed angular distribution measurement. By the use of the PAD magnet and an additional steering magnet (ST) together with pairs of quadrupole magnets (Q), we can make a 50-MeV α-particle beam pass the target center in 0° direction and get to a shielded beam dump without its grazing any part of the beam line in the target room, while applying to the target an external magnetic field up to 25 kG.

Figure 1 shows an exterior view of the PAD magnet. The PAD magnet proper is an electromagnet of Weiss type with replaceable pole pieces truncated-conical in shape. These pole pieces are made of an Co-Fe alloy of superior magnetic properties at high flux density. Design specifications and performances of the PAD magnet proper are shown in tables 1 and 2, respectively.

Figures 2 and 3 show the structure of the magnetic channels. The active magnetic channel is a kind of window-frame-type electromagnet fixed just outside the target chamber, and it adjoins the passive magnetic channel crossing the side wall of the chamber. Design specifications of the active magnetic channel are given in table 3. The part of the passive magnetic channel inside the target chamber is made of the Co-Fe alloy. The lower part of fig. 3 shows an example of magnetic field distribution along the z axis defined in fig. 2; the dots represent measured values and the curve stands for an analytical expression including 20 adjustable parameters fitted to the measured values. The analytical expression was used in the calculation of charged-particle trajectories.

Figure 4 shows the whole system including the steering and quadrupole magnets, and the calculated trajectories of 50-MeV α-particles for a magnetic field of 25 kG at the target position. The calculation indicates that the beam having an emittance of 40 mm-mr in the horizontal plane can make a beam spot at the target center and get to the beam dump without grazing the beam tube of 4" inner diameter, only when the central ray of the beam passes the target center in a direction of

$0.0 \pm 0.6°$. It is therefore rather easy to limit the beam direction at the target position within a narrow angular range about 0°.

Table 1. Design specifications of PAD magnet with no magnetic channels fixed

Shape of pole tip	circular	
Pole gap (mm)	12.5	30.0
Pole-tip diameter (mm)	25.0	51.9
Maximum field strength (kG)	35	25
Field inhomogeneity over a circle of 1 cm diameter	within 1 %	
Number of coils	2	
Number of turns per coil	164	
Maximum excitation current (A)	570	

Table 2. Performances of PAD magnet with no magnetic channels fixed

Pole gap (mm)	12.5	30.0
Field strength at an excitation current of 500 A (kG)	39.0	30.3
Field inhomogeneity over a circle of 1 cm diameter (%) at an excitation current of		
{ 100 A	0.7	0.1
{ 500 A	0.4	0.2

Table 3. Design specifications of the active magnetic channel

Pole gap (mm)	35
Pole length (mm)	160
Maximum field strength (kG)	4.5
Number of coils	2
Number of turns per coil	10
Maximum excitation current (A)	700
Weight (kg)	35

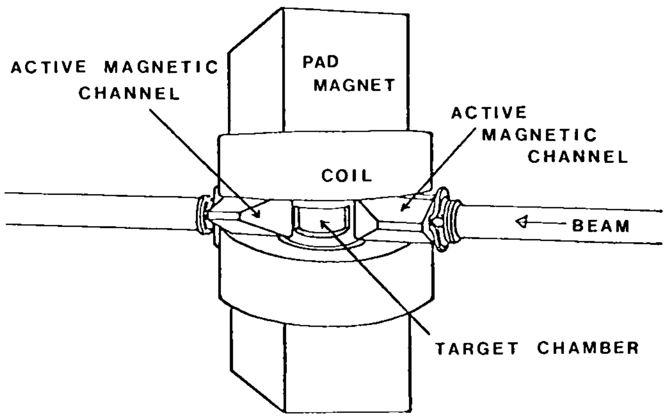


Fig. 1. Exterior view of PAD magnet.

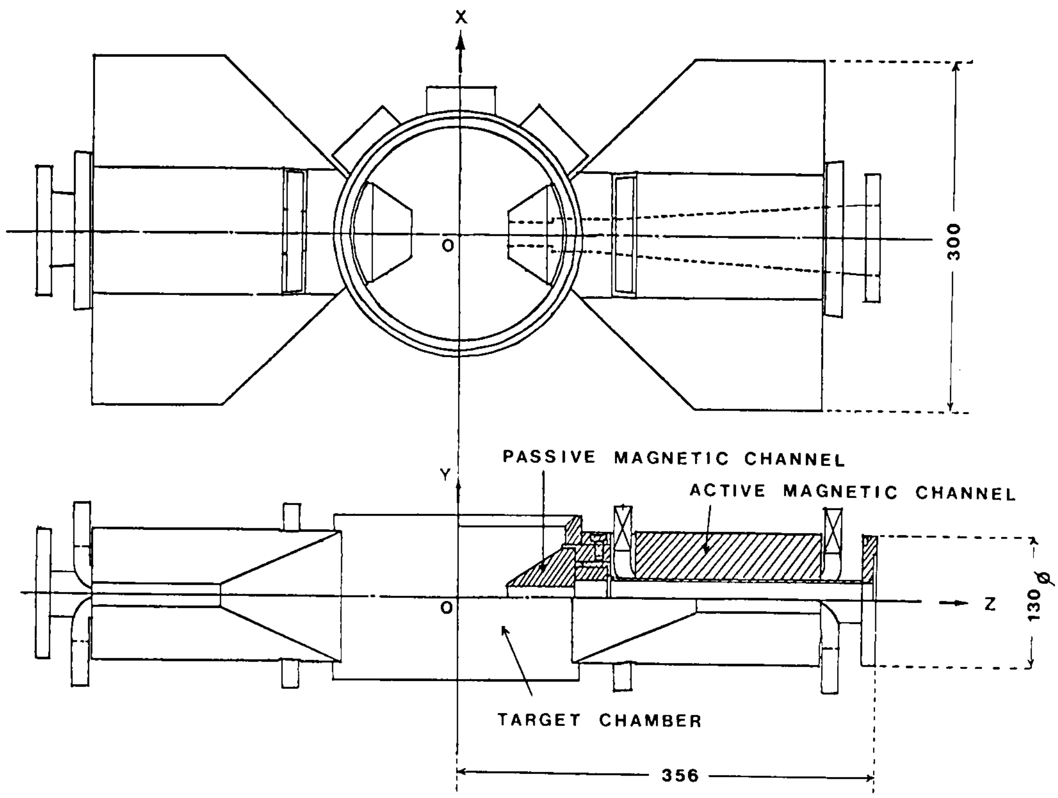


Fig. 2. Structure of magnetic channels.

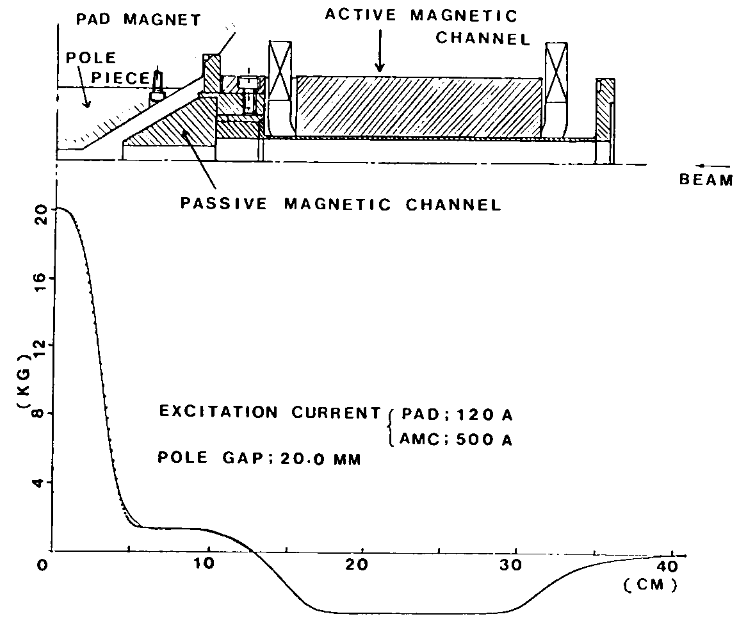
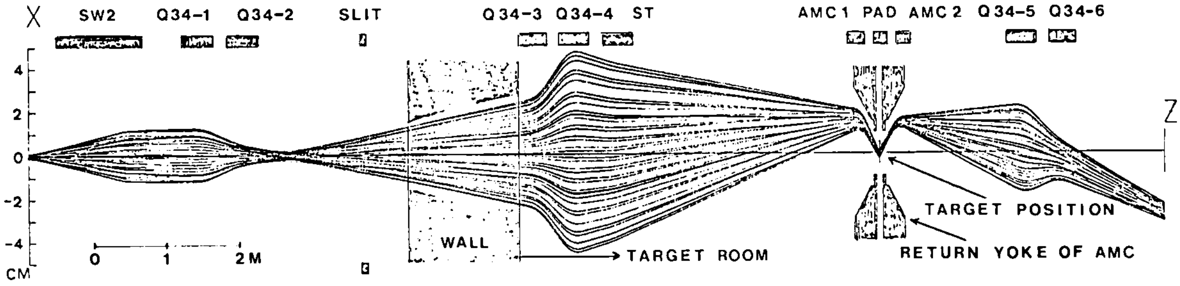


Fig. 3. Field distribution of PAD magnet with active magnetic channels on. The pole gap of PAD magnet is 20.0 mm; the excitation currents of PAD magnet and the active magnetic channel are 120 and 500 A, respectively.



PARAMETERS OF THE BEAM TRANSPORT (α - PARTICLE)

E	AMC 1	AMC 2	PAD	Q34-1	Q34-2	Q34-3	Q34-4	Q34-5	Q34-6	ST	SW2
50.00 (MEV)	-4.32 (*) (KG)	-4.32 (*) (KG)	25.00 (*) (KG)	-493.975 (G/CM)	564.745 (G/CM)	564.745 (G/CM)	-493.975 (G/CM)	-700.209 (G/CM)	752.694 (G/CM)	0.24 (KG)	-12.16 (KG)

(*) EXCITATION CURRENT { PAD ; 110 A, AMC ; 560 A }; POLE GAP ; 12.5 MM

Fig. 4. An example of calculated trajectories of 50-MeV α-particles in the horizontal plane. The object point of the beam is chosen at 36 cm before the entrance of the beam switching magnet SW2. Parameters for the beam transport are given in the figure.