Permanent Final Focus Magnet
— Based on the SuperStrong PM —

Yoshihisa Iwashita (Kyoto university)
Takanori Mihara (Kyoto university)
Masayuki Kumada (NIRS)
Eiji Sugiyama (NEOMAX)

Contents

- Modified Halbach’s magnet configuration
  (basics of SuperStrong PM)
- SuperStrong PMQ
  (First model — demonstration of the highest gradient)
- Thermal compensation
- Strength Adjustable PMQ (Second model)
• **Permanent Magnet Dipole & B-H curve**

Halbach's dipole REC magnet.

1.37 T @ \( r_1, r_2 = 1\text{cm}, 4\text{cm} \)

\[
B = Br \ln\left(\frac{r_1}{r_2}\right) \cos\left(\frac{\pi}{M}\right) \sin\left(\frac{\pi}{M}\right) / \pi
\]
Modified Halbach’s magnet.

SuperStrong PM!

1.64 T @\(r_1, r_2=1\text{cm}, 4\text{cm}\)

(was 1.37T)
• 4.45T Dipole

Achieved 4.45T @-29°C (3.9T @room temperature)
M. Kumada et al., CERN Courier, vol. 41, no.7, Sep. 2001, p. 9
PMQ with modified Halbach’s

Based on 12 segment PMQ

Measured GL value was 28.5T
(calculated value 29.7T)
@ L=100mm, Ø14mm
(Gmax=300T/m, Bmax=2T@boreR)

saturated iron in PMQ (iPMQ)
Temperature compensation

In order to stabilize strength, compensation material ‘MS-1’ is used.

View of the Octant of the permanent magnet with MS-1

Marked region corresponds to left figure.
Fabricated parts and Measurement

Main plates

Extra MS-1 plates

Rotating coil
Compensated Result
Strength Adjustability

Double ring structure

Skew 1/60
Shift of axis 1/10

Lar ge torque is anticipated.

Octant of the 3D view of double ring structure

G=0.3T/mm
G=0.008T/mm

Switches between 0°-90°
Total strength on switched length and gradients

Left figure shows that the integrated strength is proportional to the switched length.
In this case, total strength can be reduced to 20% of the maximum value.

Right figure shows the gradient of double ring structure along the axis.
On/Off corresponds to normal position (the strongest) and rotated position.
The second model of PMQ

Motors for rotation

Beam hole — Ø20

Designed value:
- $GL_{\text{max}}=33.4T$
- $GL_{\text{min}}=9.8T$
- $\Delta GL=1.6T$
  (preliminary value)

Beam hole for outgoing beam

Length=23cm

$L^*=3.5m, \ 20mrad \rightarrow 140mm$
The second model of iPMQ

- Permanent magnets
- Beam hole for outgoing beam
- Poles (Permandur)
Measurement room
Summary and Discussions

• 300T/m PMQ was achieved with a bore radius 7mm.

• Temperature compensation parts reduced PMQ’s temperature coefficient to 5% of its original value.

• 2nd prototype of PMQ with double ring structure was fabricated.

• Radiazion damage will be investigated.

• Long term stability will be investigated.