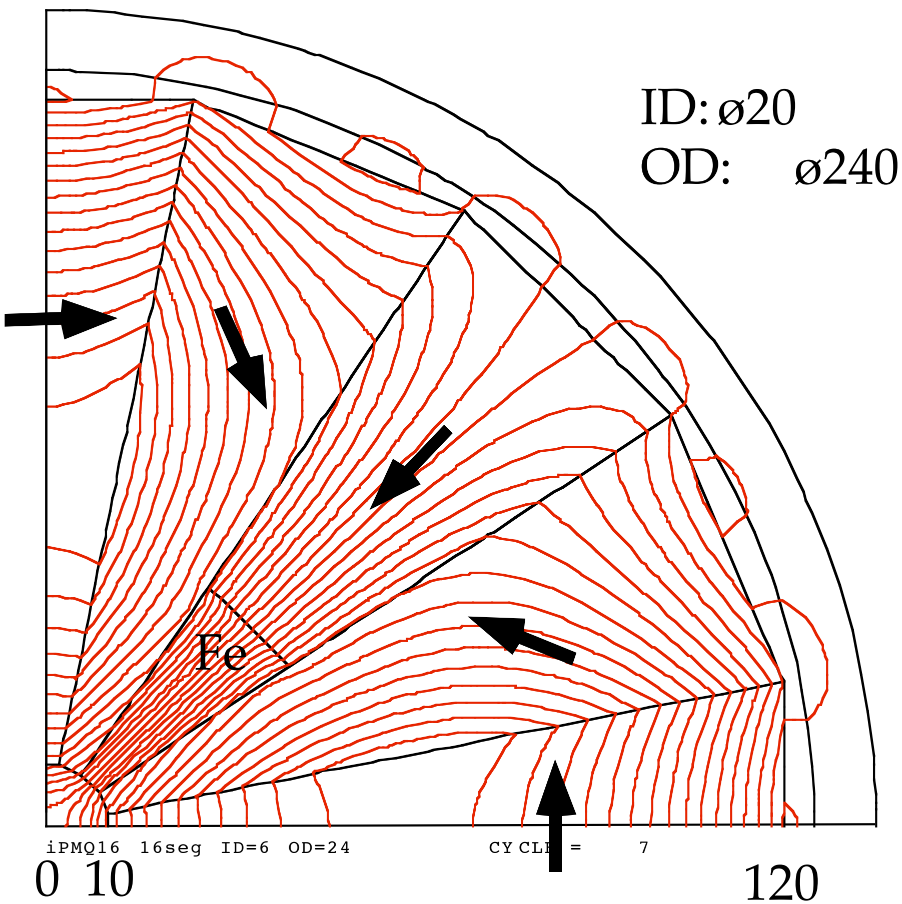
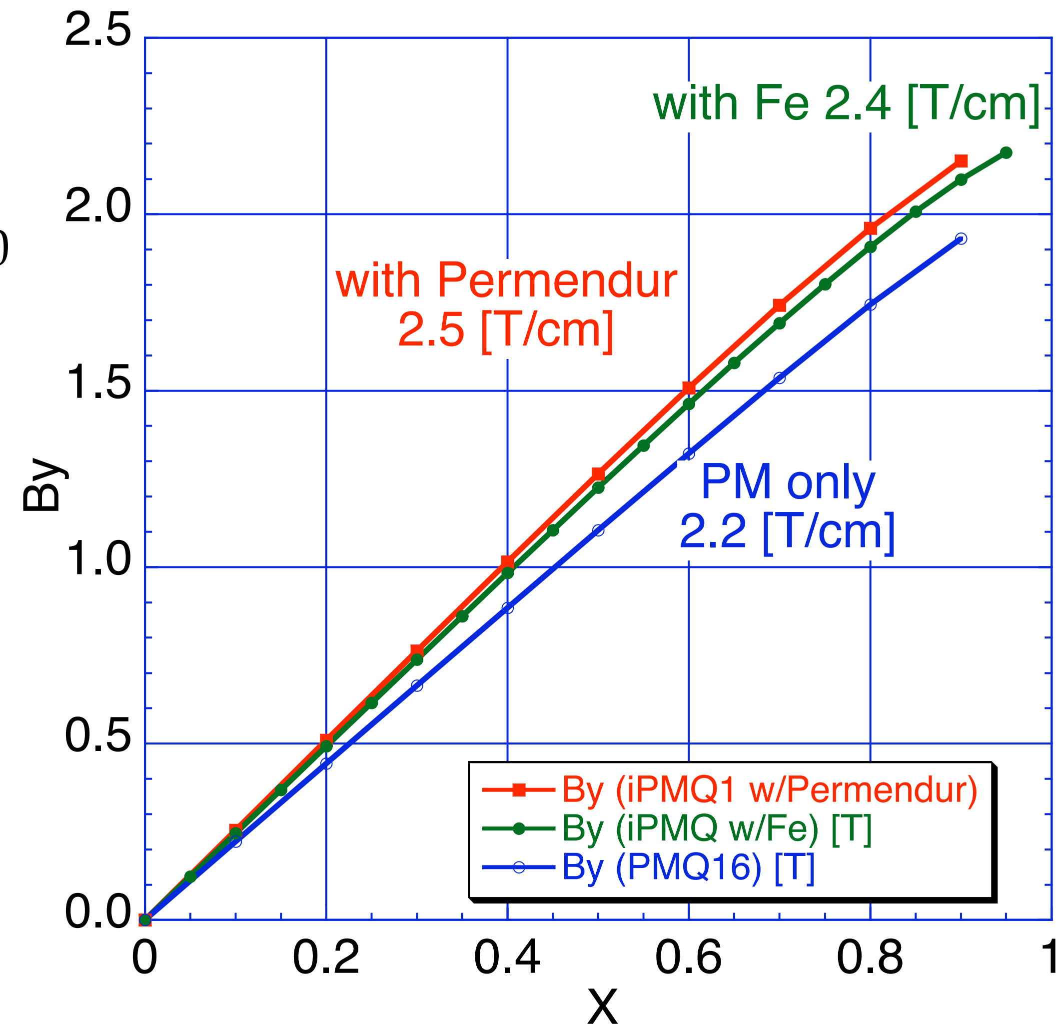
Permanent Magnets

Y. Iwashita
Kyoto University

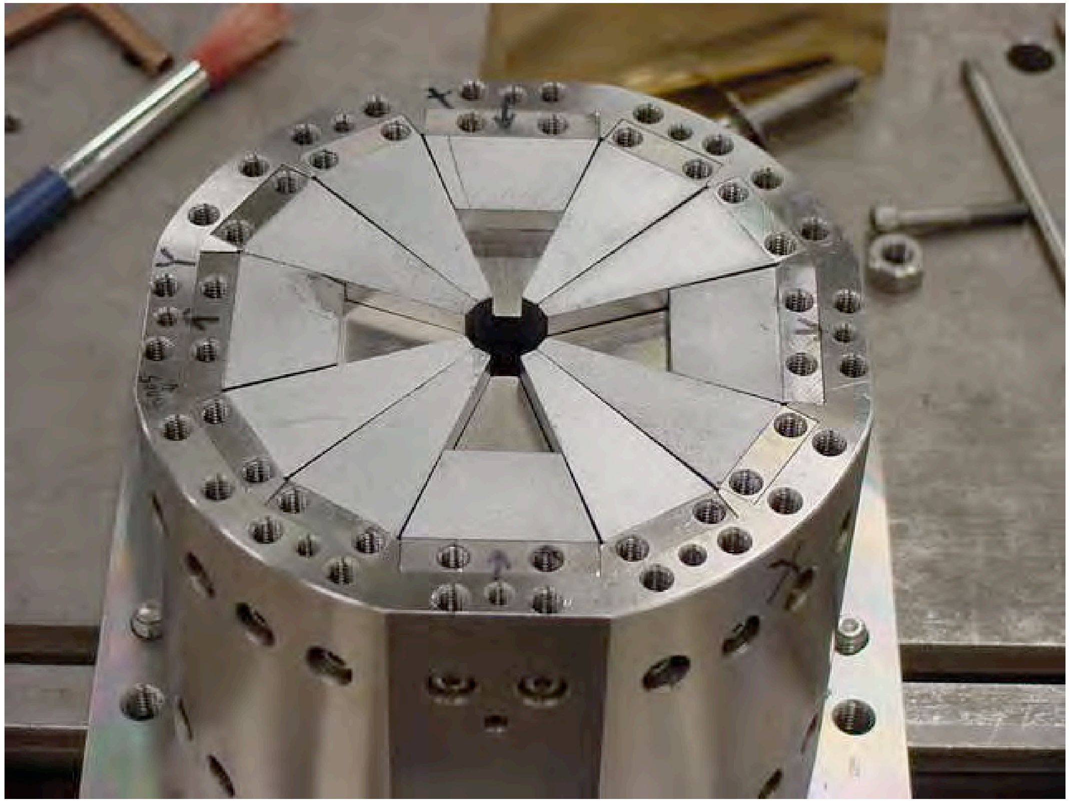
PMQ with saturated iron pole

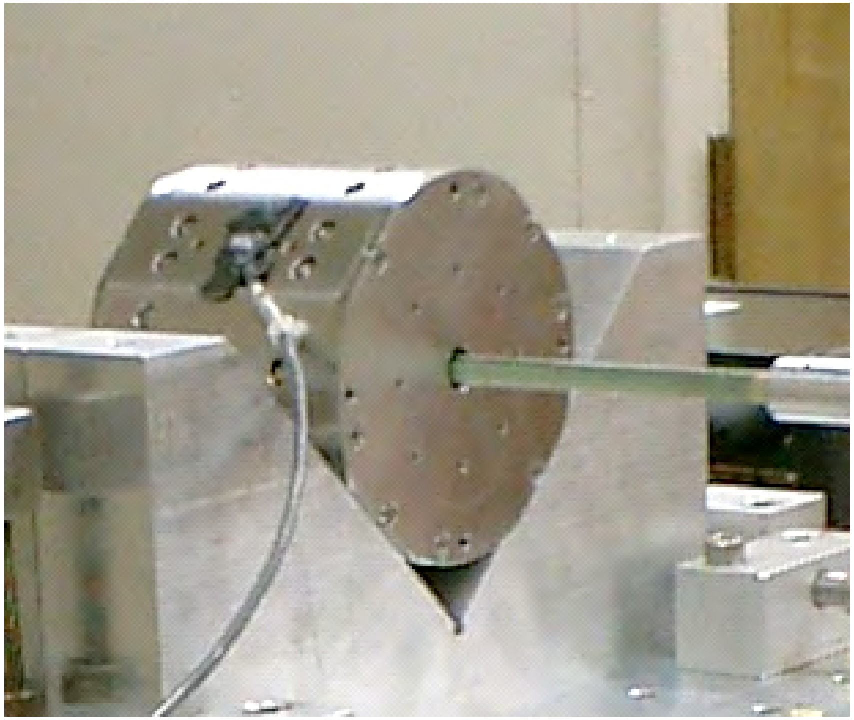




$$B=2B_r\,(1-r_1/r_2)\cos^2(\pi/M)\,\sin(2\pi/M)\;/(2\pi/M)$$

First prototype (fixed field)





Prototype PMQ

Measurement at SLAC

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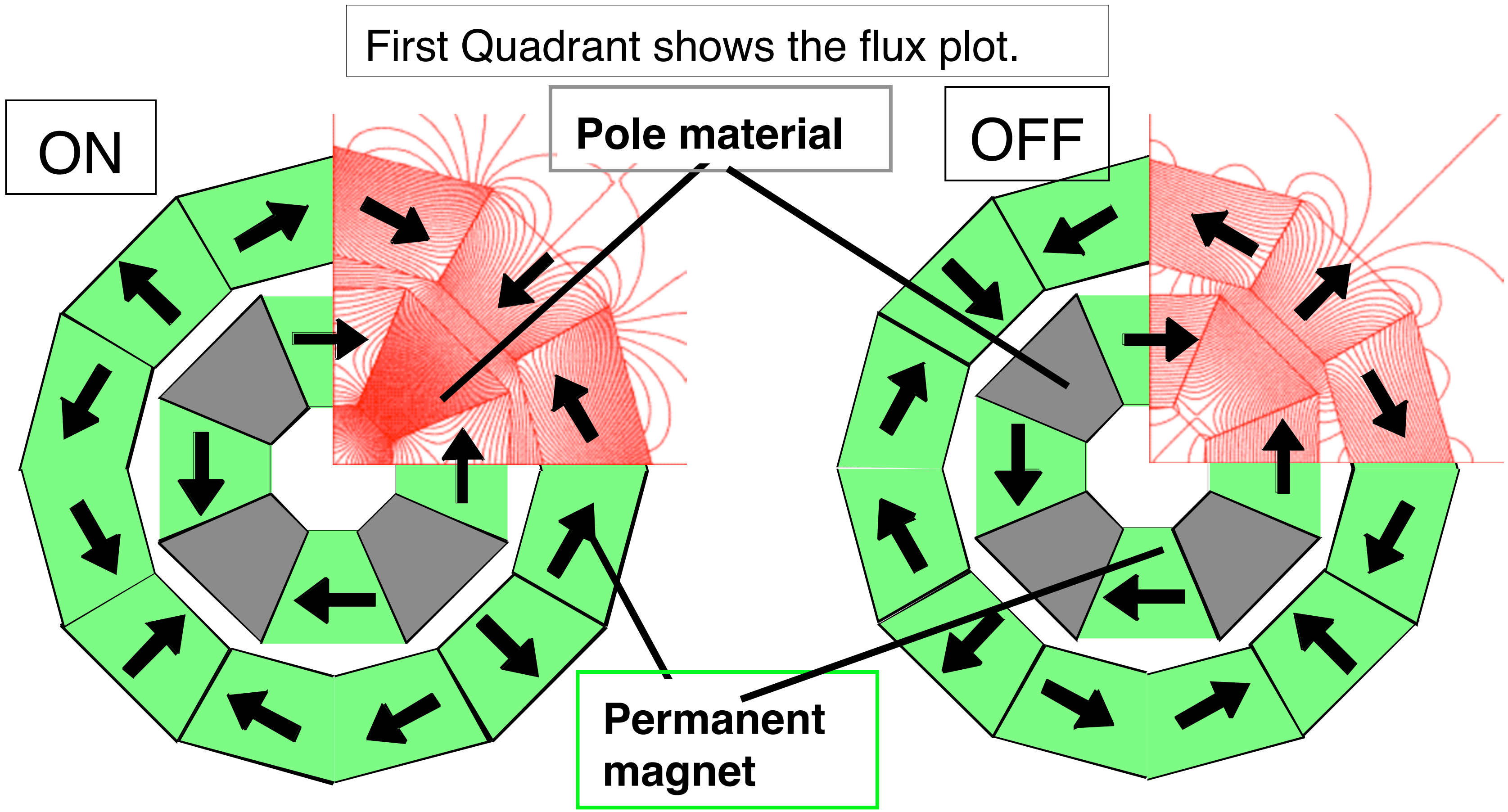
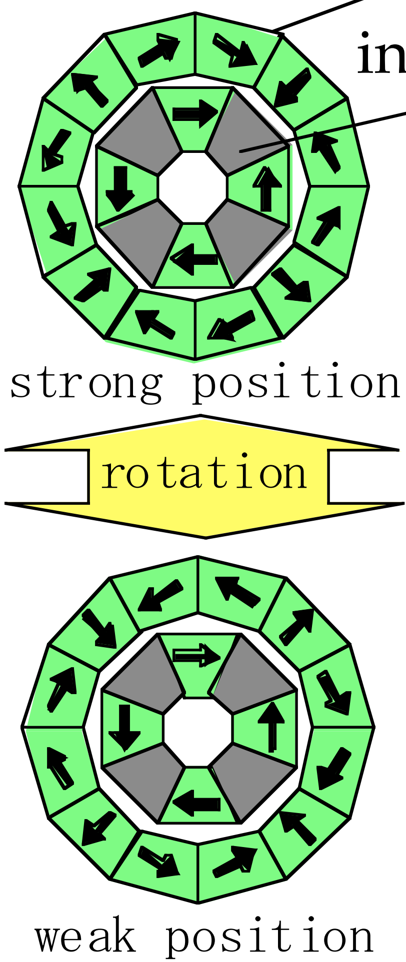
Double Ring Structure

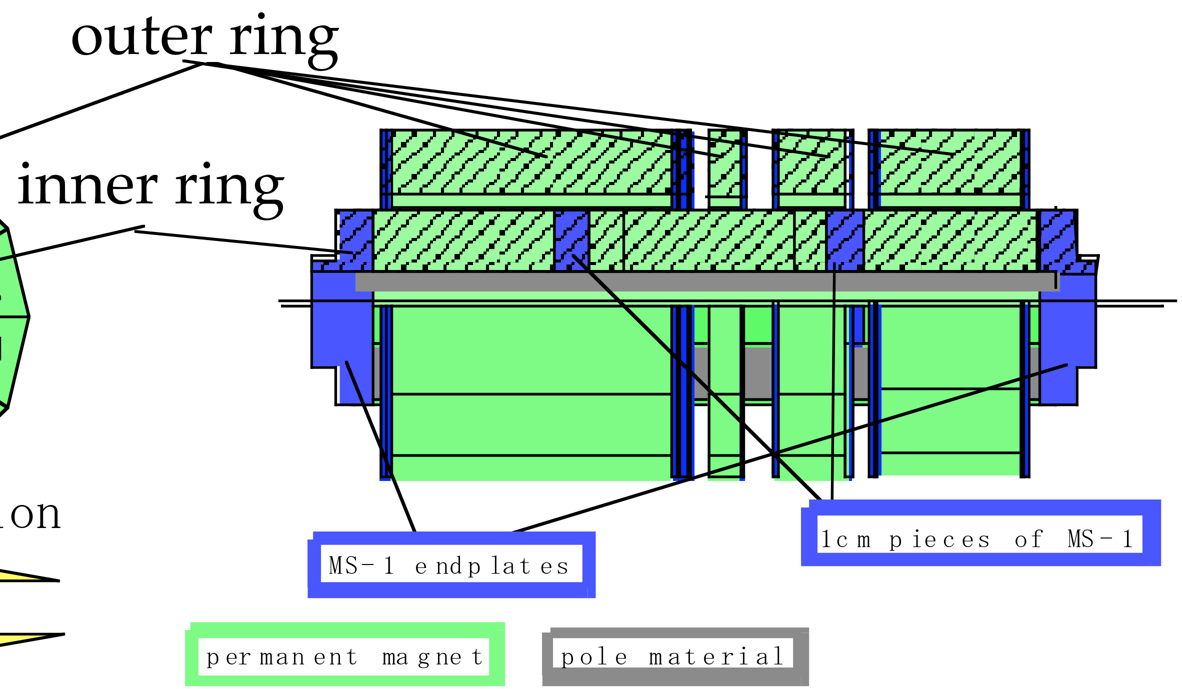


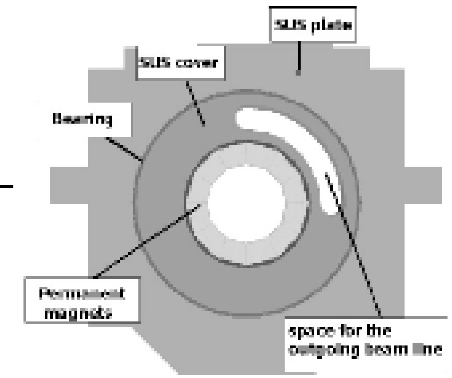
The double ring structure

PMQ is split into inner ring and outer ring. Only the outer ring is rotated 90° around the beam axis to vary the focal strength.

Adjustable Permanent Magnet Quadrupole

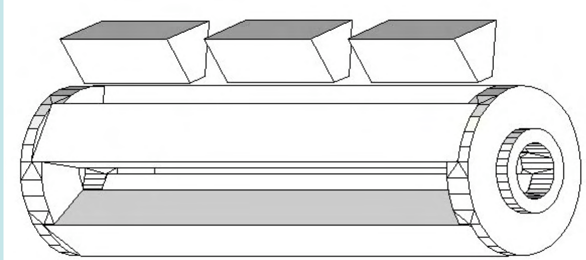




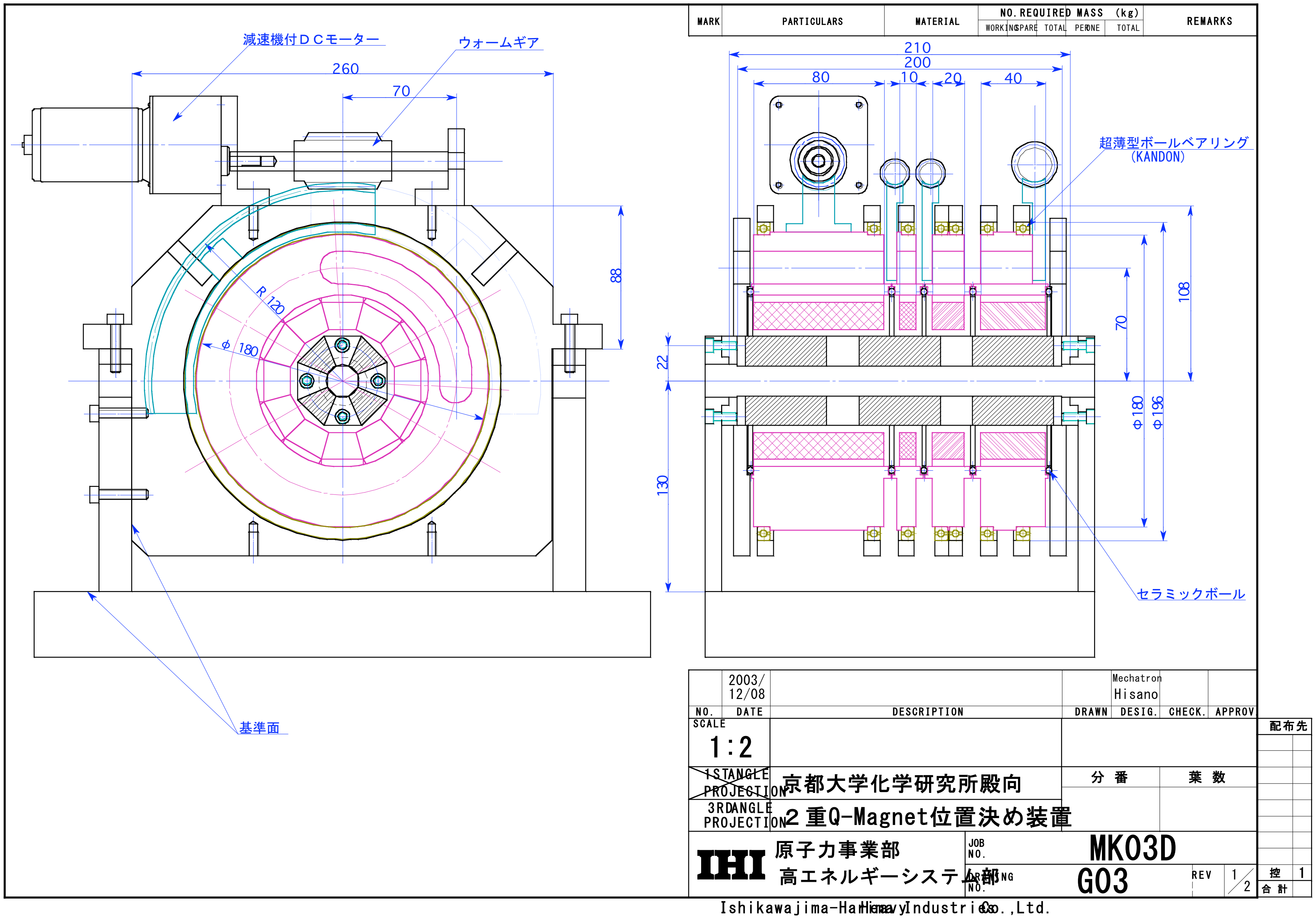


The PMQ is composed of an inner ring and four outer rings (Double Ring Structure). Only the outer rings are rotated in order to change the integrated gradient. The fixed inner ring suppresses any errors caused by rotation of outer rings.

Permanent Magnet (NEOMAX38AH)

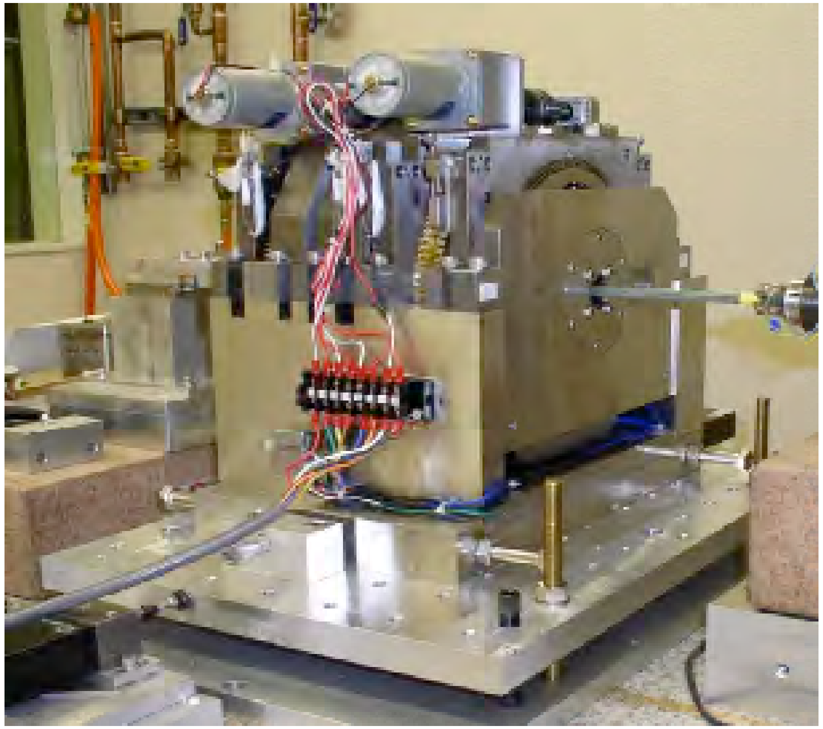


Drawing

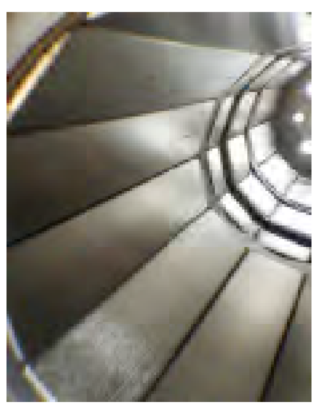


減速機付ＤＣモーター
ウォームギア
260
70
88
R 120
φ 180
基準面
210
200
80
10
20
40
超薄型ボールベアリング
(KANDON)
22
70
108
φ180
φ196
130
セラミックボール
MARK
PARTICULARS
MATERIAL
NO. REQUIRED
MASS (kg)
REMARKS
2003/
12/08
Mechatron
Hisano
NO.
DATE
DESCRIPTION
DRAWN
DESIG.
CHECK.
APPROV.
SCALE
1:2
1STANGLE PROJECTION
3RDANGLE PROJECTION
京都大学化学研究所殿向
２重Q-Magnet位置決め装置
分 番
葉 数
配布先
IHI
原子力事業部
高エネルギーシステム部
JOB NO.
MK03D
DRAWING NO.
G03
REV
1/2
控 1
合 計
Ishikawajima-Harima Heavy Industries Co.,Ltd.

Prototype Magnet

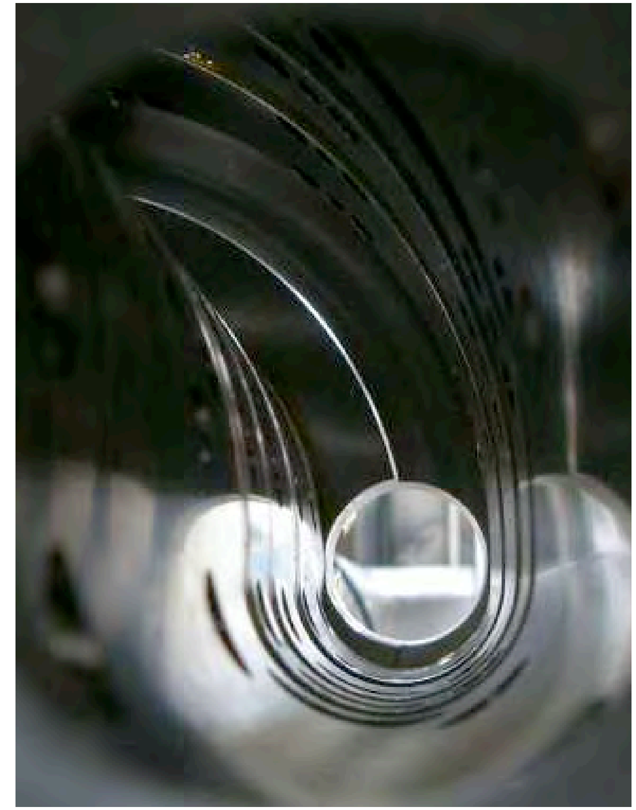


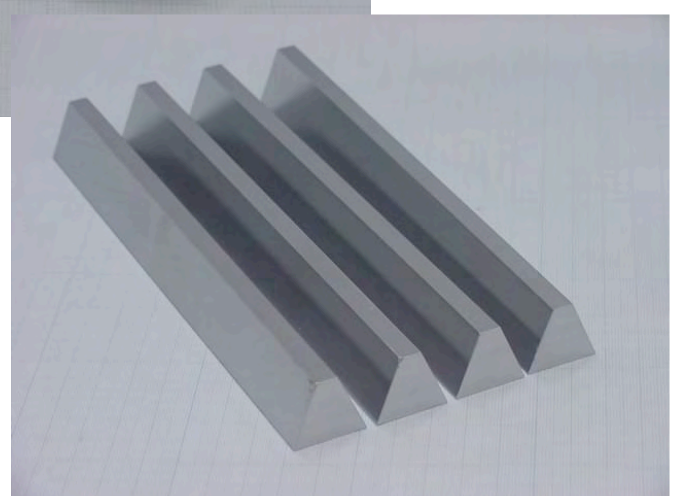
Bore radius	1cm
Inner ring radii	In 1cm out 3cm
Outer ring radii	In 3.3cm out 5cm
Outer ring section length	1cm, 2cm, 4cm, 8cm
Physical length	23cm
Pole material	Permendur
Magnet material (inner ring)	NEOMAX38AH
Magnet material (outer ring)	NEOMAX44H
Integrated gradient (strongest)	24.2T
Integrated gradient (weakest)	3.47T
Int. gradient step size	1.4T

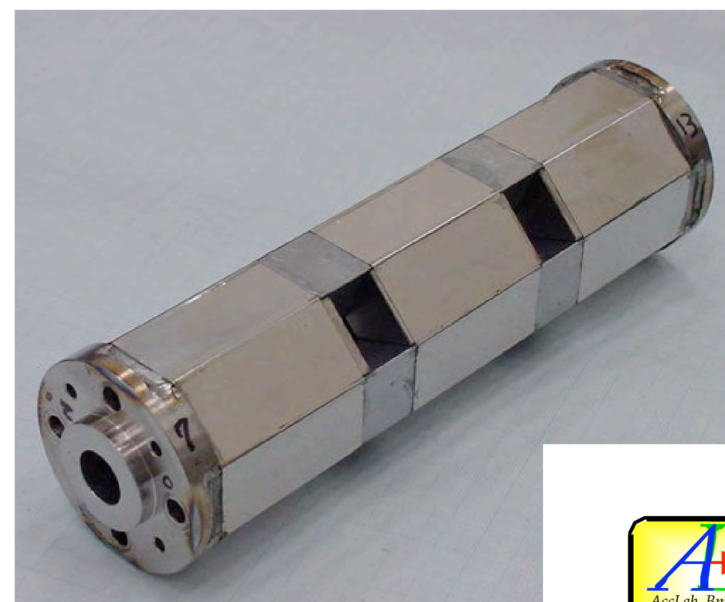


Making of the PMQ

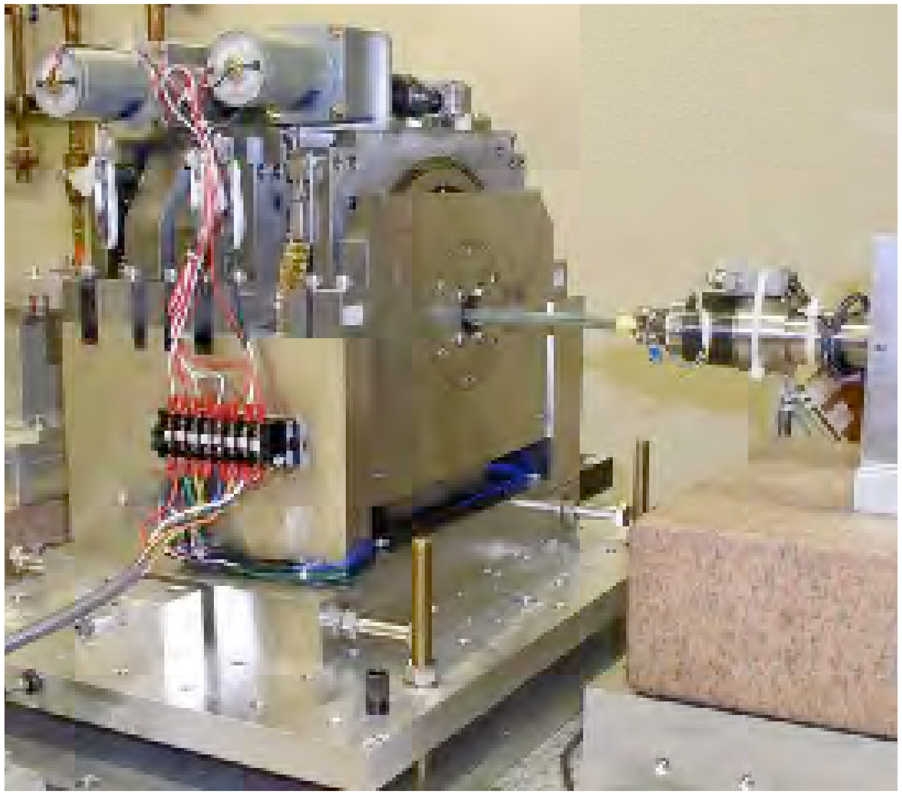
Photos

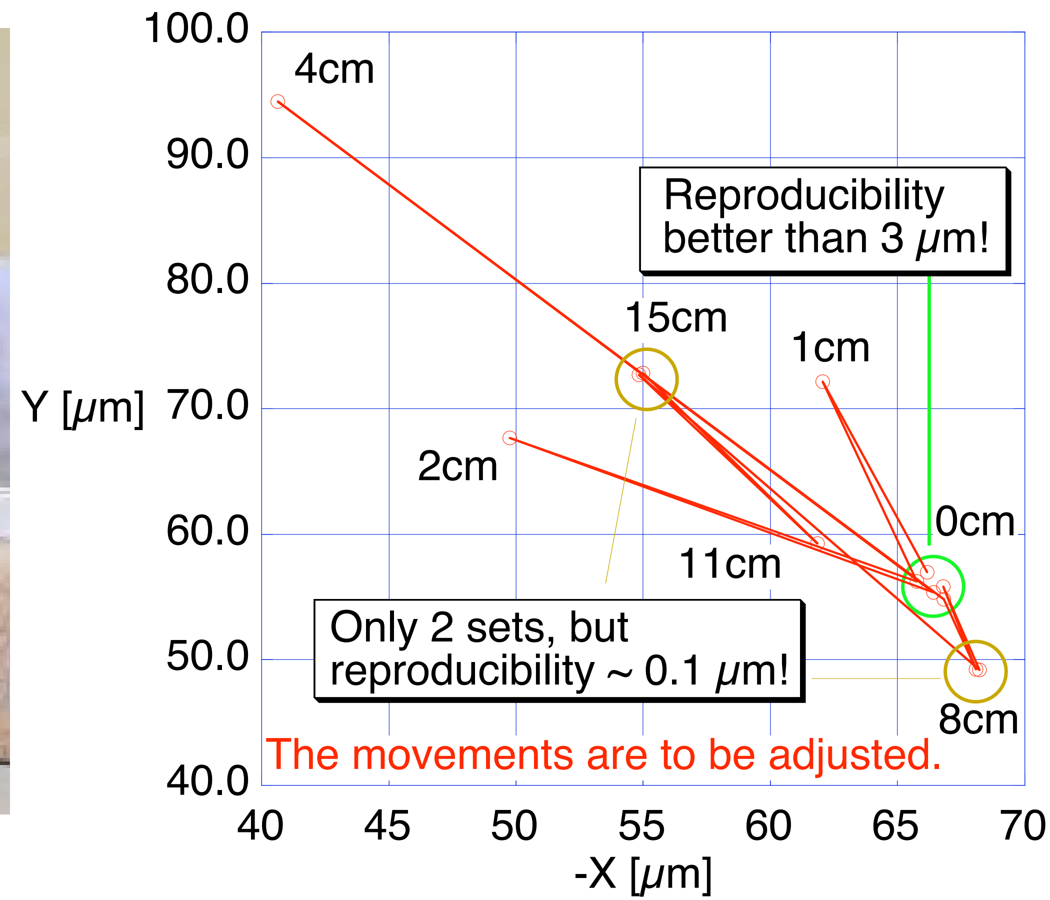






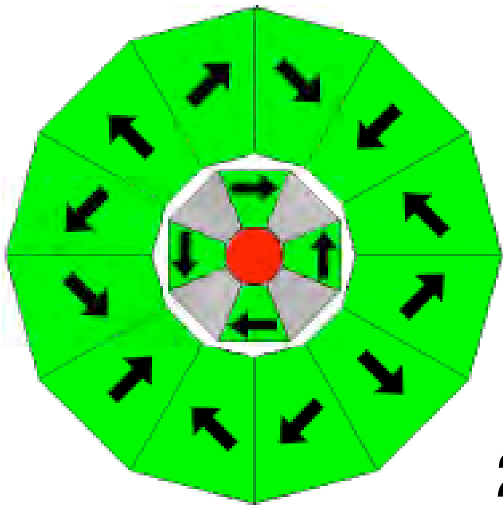
Magnetic Center Movement



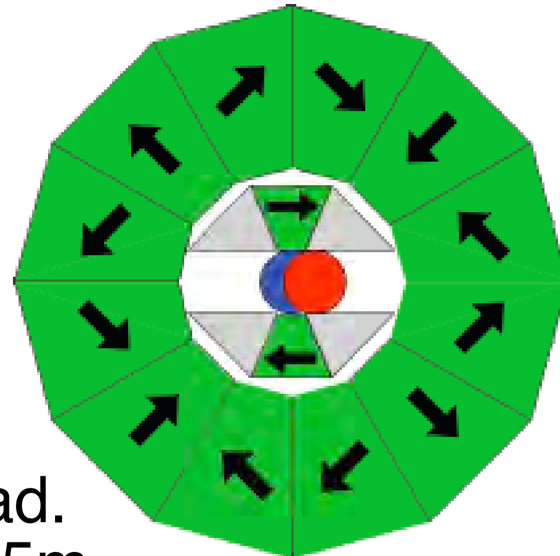


Magnetic Center moves by tens of micron when the strength was changed.

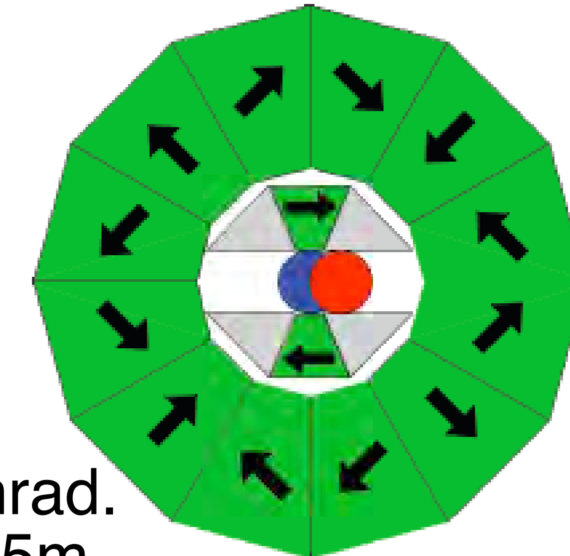
Configurations for Various Crossing Angles



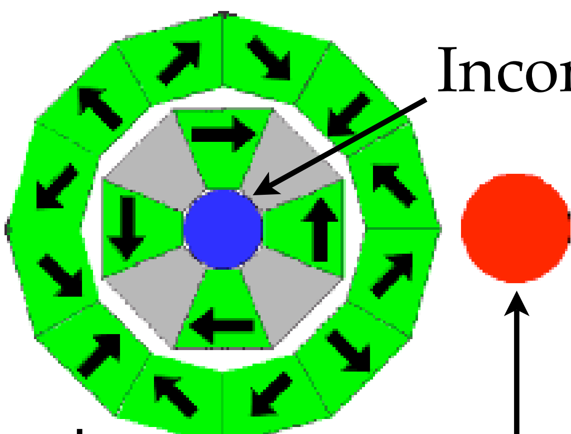
0 mrad.
(Head-On)



2 mrad.
L*=3.5m



2 mrad.
L*=5m



20 mrad.
L*=3.5m

Table II PMQ parameters for various crossing angles.

Crossing angle [mrad]	0	2	20
Outer Diam. [mm]	180	180	100
Max. Gradient [T/m]	18 0	130	120
Min. Gradient [T/m]	-20	-60	8

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Demagnetization by Radiation

Energy deposit

	GLD	SiD	SiD(by Takashi)	neutron
BeamCAL	17mW	13mW	29mW	
QD0	94mW	97mW	147mW	10^5 [n/cm^{2}s]
SD0	11mW	11mW	11mW	
QF1	16mW	18mW	15mW	
SF1	0.4mW	0.3mW	1mW	

very preliminary results by T.Abe (university of Tokyo), in private communication

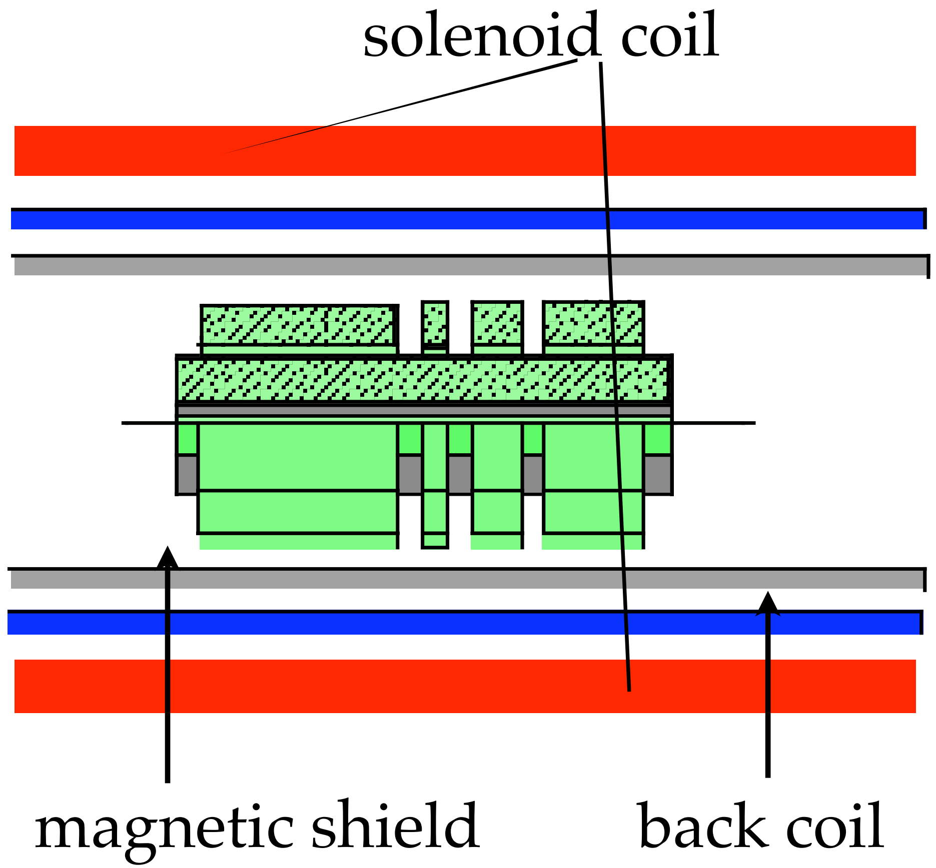
Demagnetization by 14MeV neutron

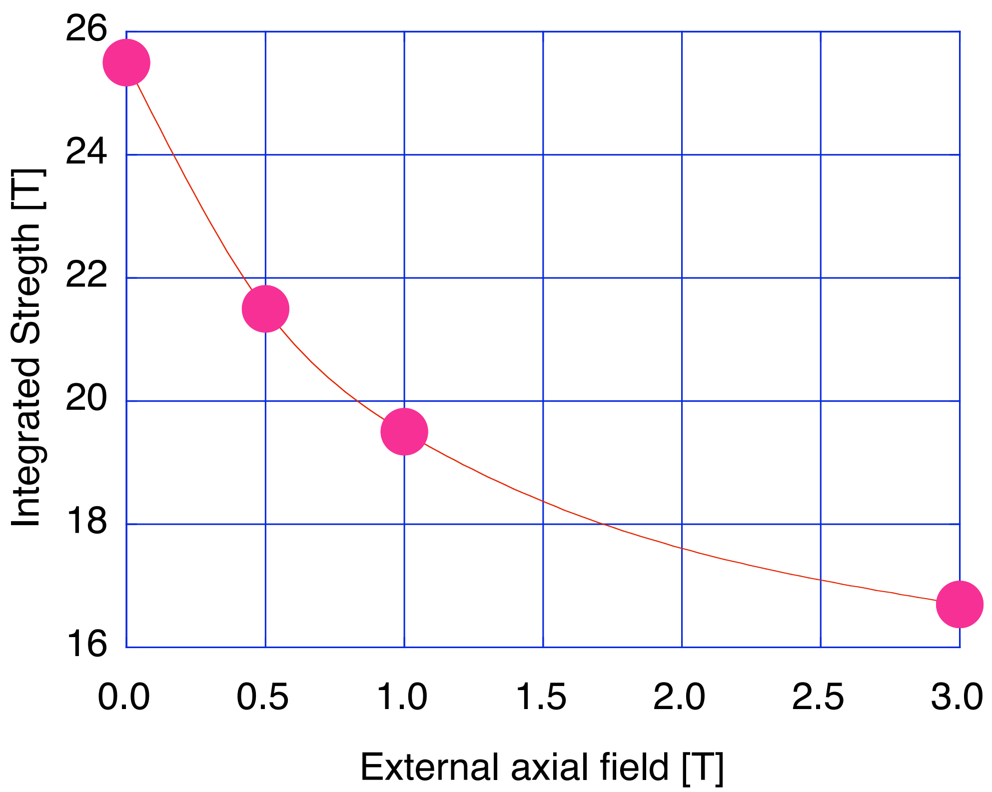
Magnet	Demag. ratio [/1x10^{13}n/cm^2]	iHc [Oe]
47H	10.2%	
44H	1.8%	16
39SH	0.7%	21
32EH	0.3%	30

T. Kawakubo, et al., The 14th Symposium on Accelerator Science and Technology, Tsukuba, Japan, November 2003, pp. 208-210, in Japanese, http://conference.kek.jp/sast03it/WebPDF/1P027.pdf

Continuous 1 mo. operation may cause about 0.01[%] of (reversible?) demagnetization on NEOMAX 32EH

Effect of Solenoid



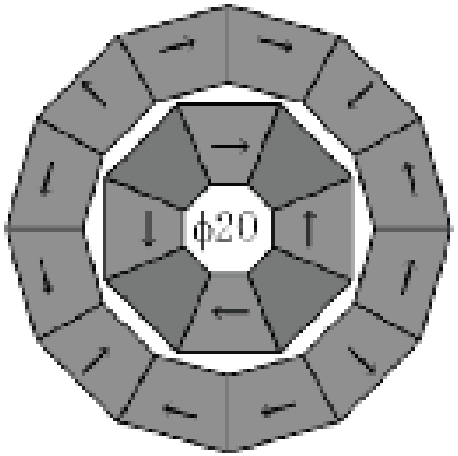


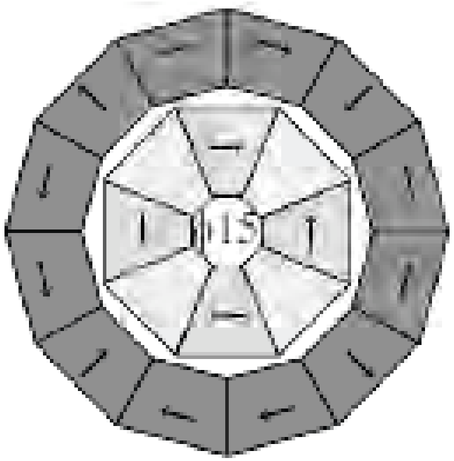
Integrated strength is reduced by Solenoid field because PMQ has pole (vanadium permendur).

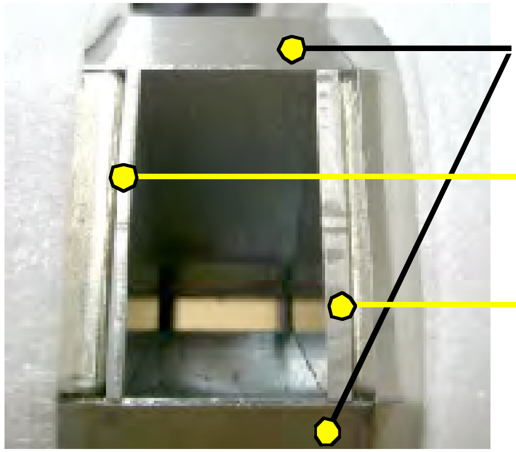
Back coil and/or some shield is needed.

Recent Modification

Demonstrate a higher field gradient by reducing the bore size from ø20mm down to ø15mm.

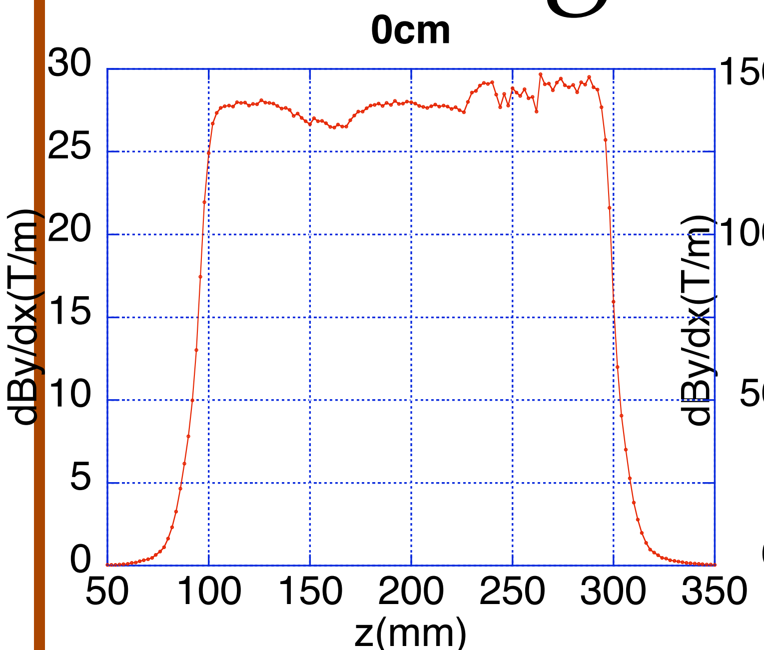


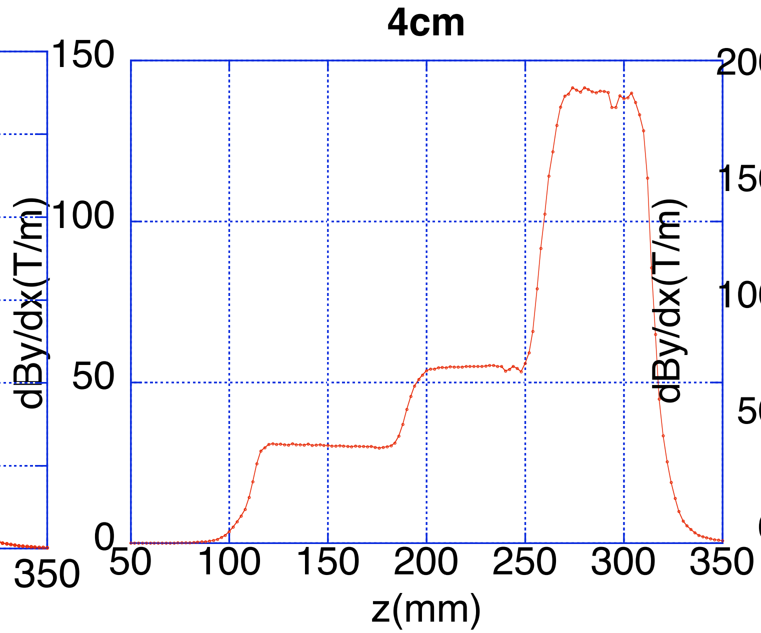


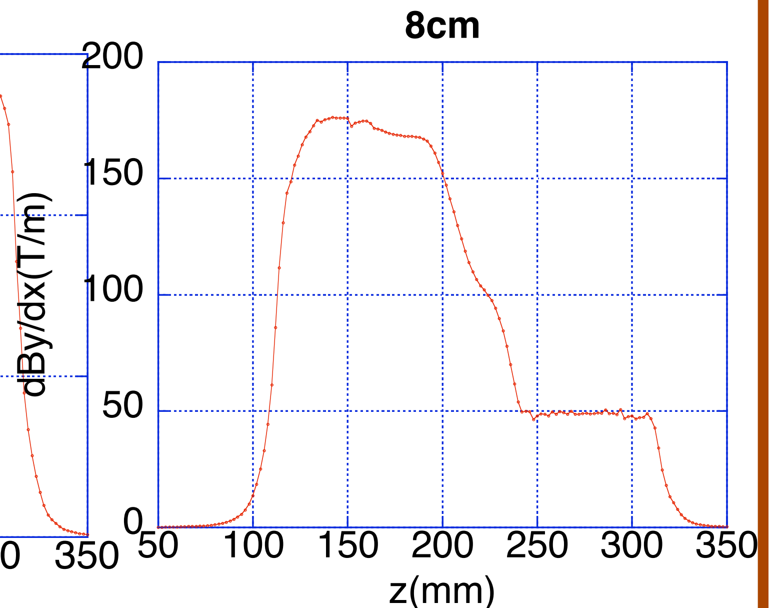


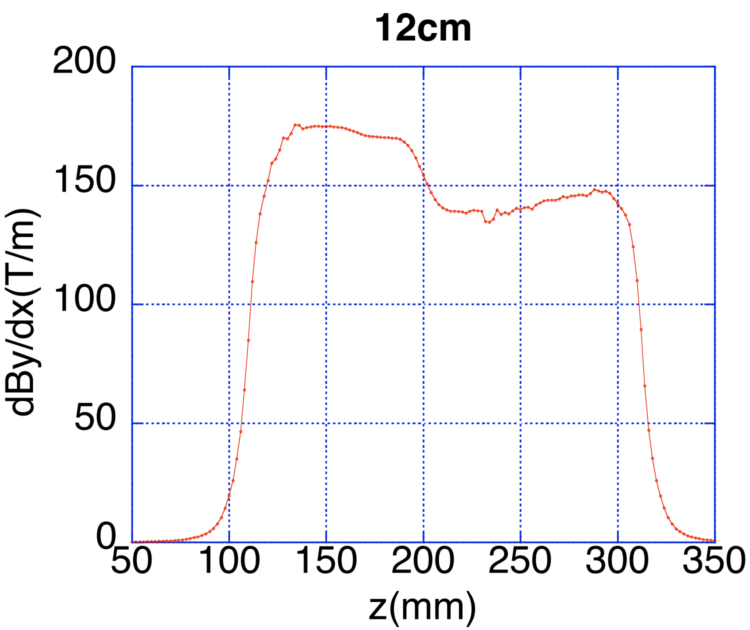
Temperature compensation of the inner ring; 1 mm (left) and 1.6 mm (right) MS-1 trapezoidal plates are seen in a 2cm space between magnets.

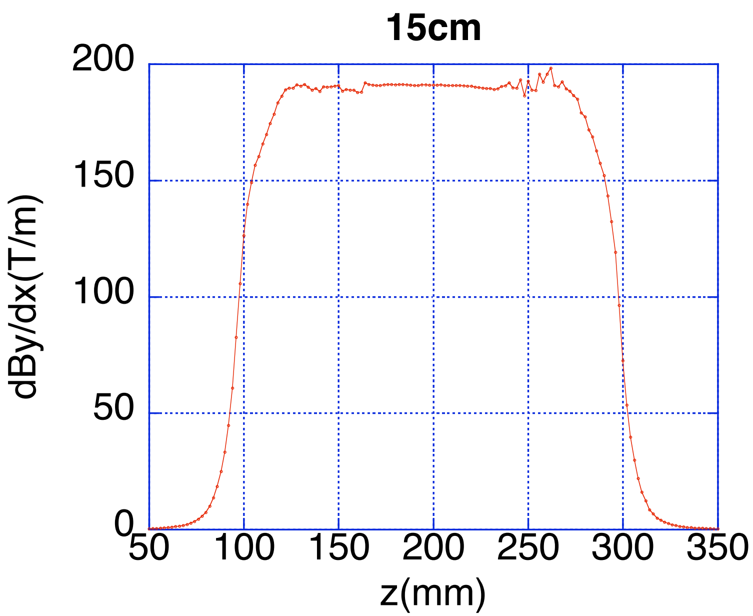
Longitudinal Distribution











with IDø15

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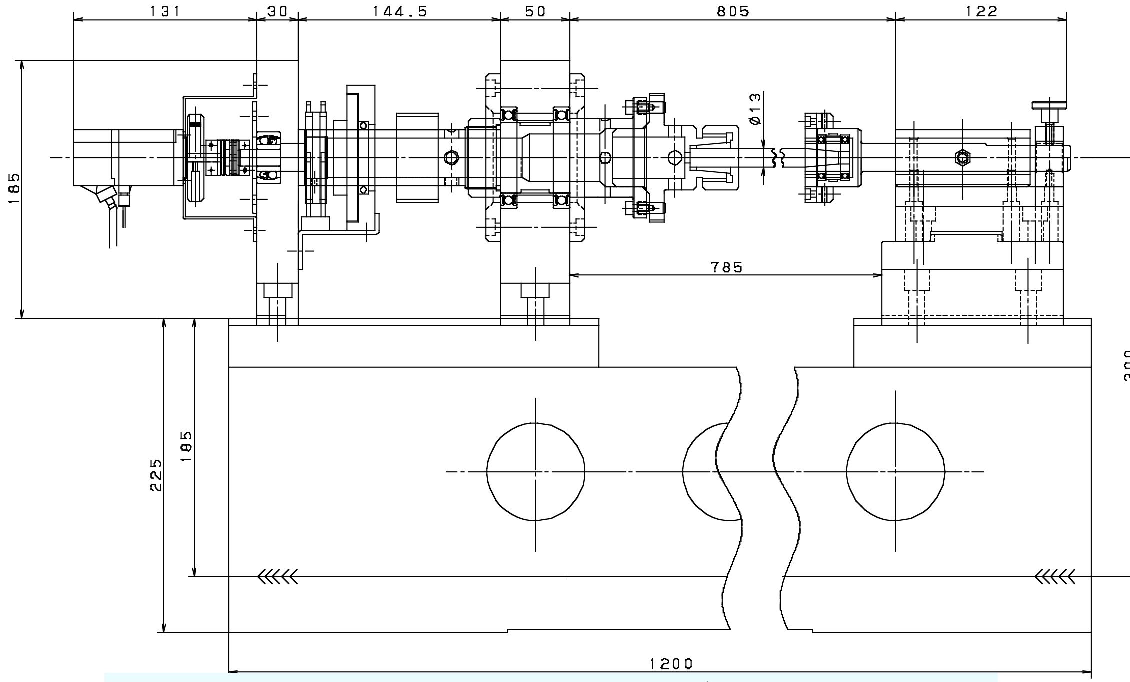
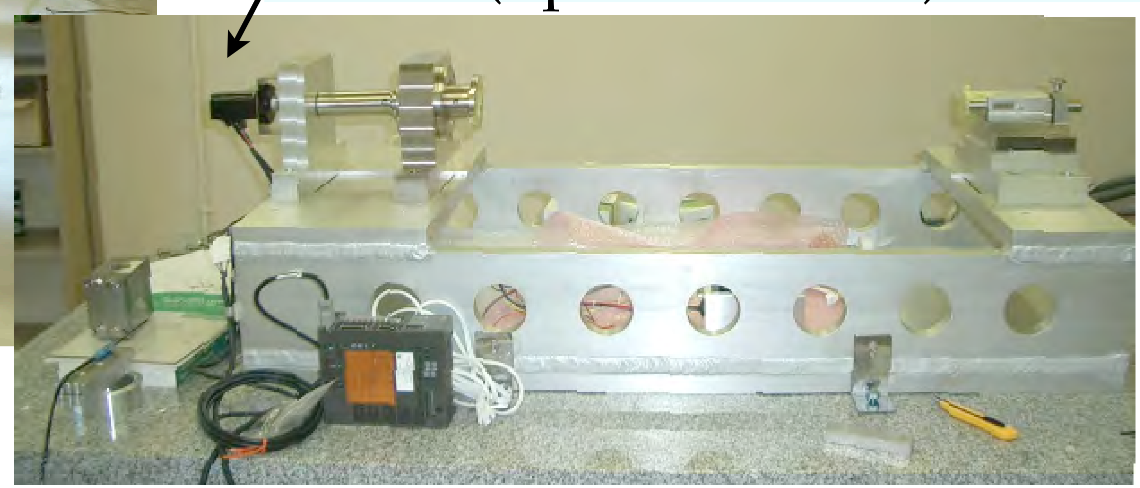
Rotating Coil Stand



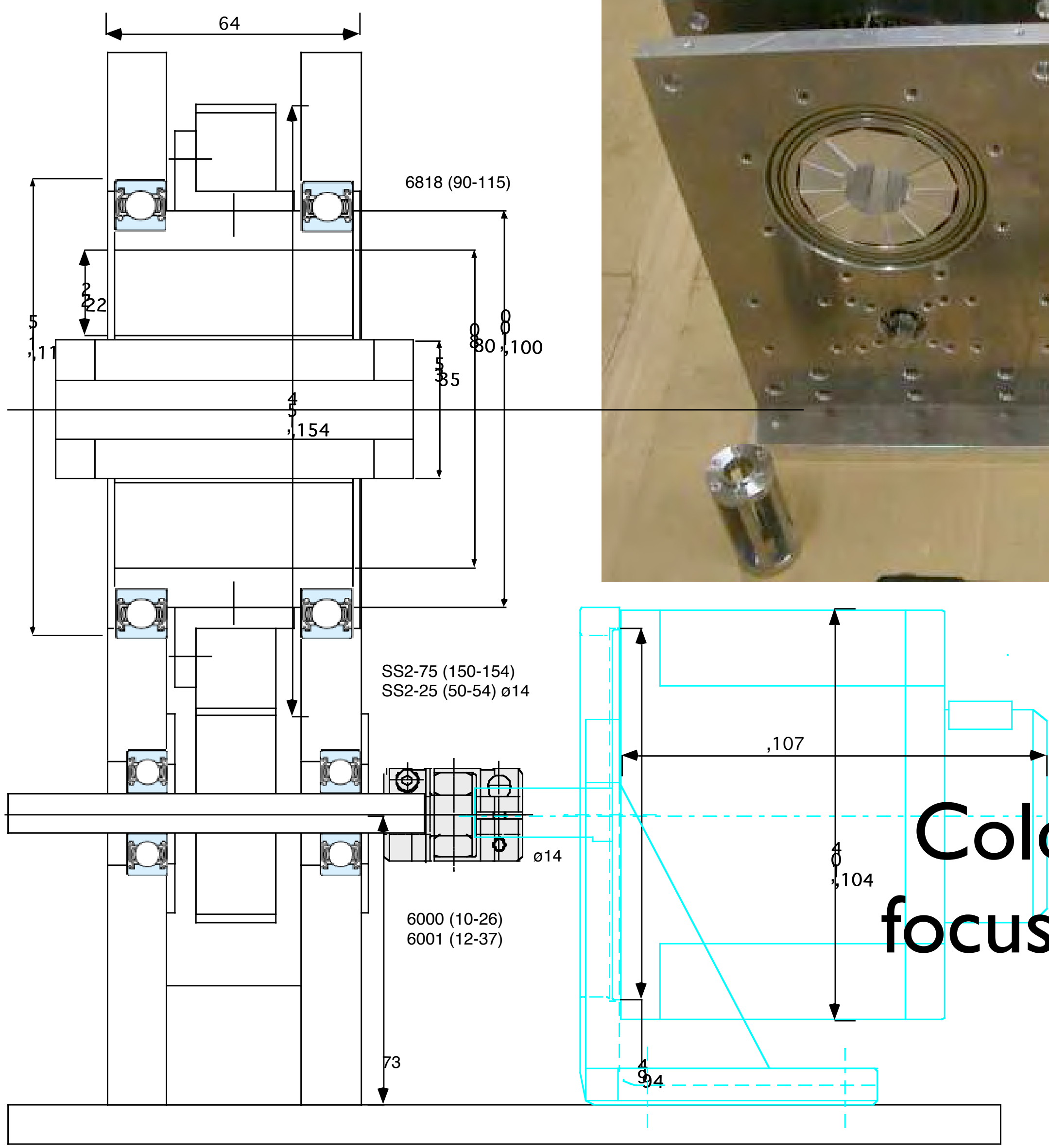
AC servo-motor with encoder
(up to 600 RPM)

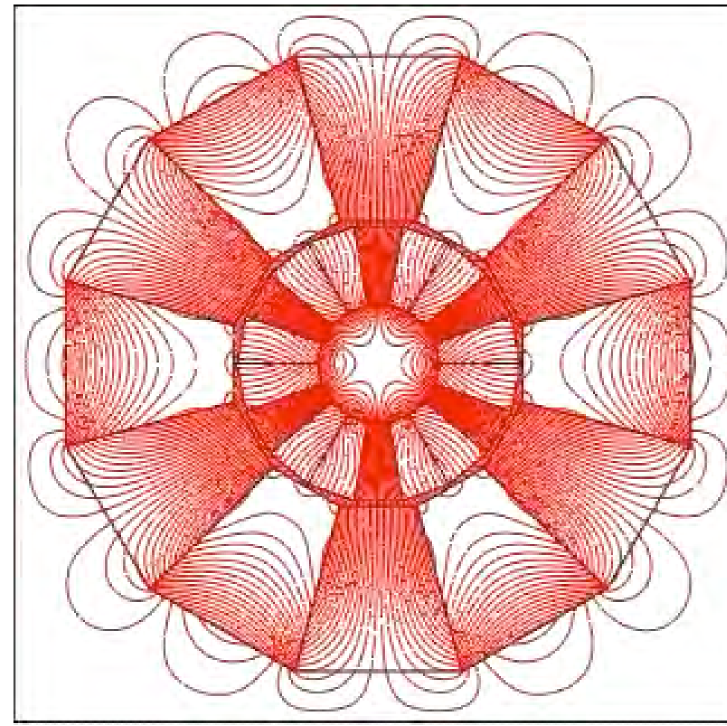


What's next?

- Finish magnetic field measurement system
- Fabricate third model
- Sextupole?
- Octpole?
- more?

Rotating PMSx for cold neutrons





Cold neutron beam can be focused by strong sextupole.
25Hz for ToF.

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