# Permanent Magnets

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PMQ with saturated iron pole

ID：ø20
OD： ø240

with Fe 2.4 [T/cm]

with Permendur 2.5 [T/cm]

PM only 2.2 [T/cm]

By

— By (iPMQ1 w/Permendur)
— By (iPMQ w/Fe) [T]
— By (PMQ16) [T]

iPMQ16 16seg ID=6 OD=24   CYCLE =   7

0 10   120

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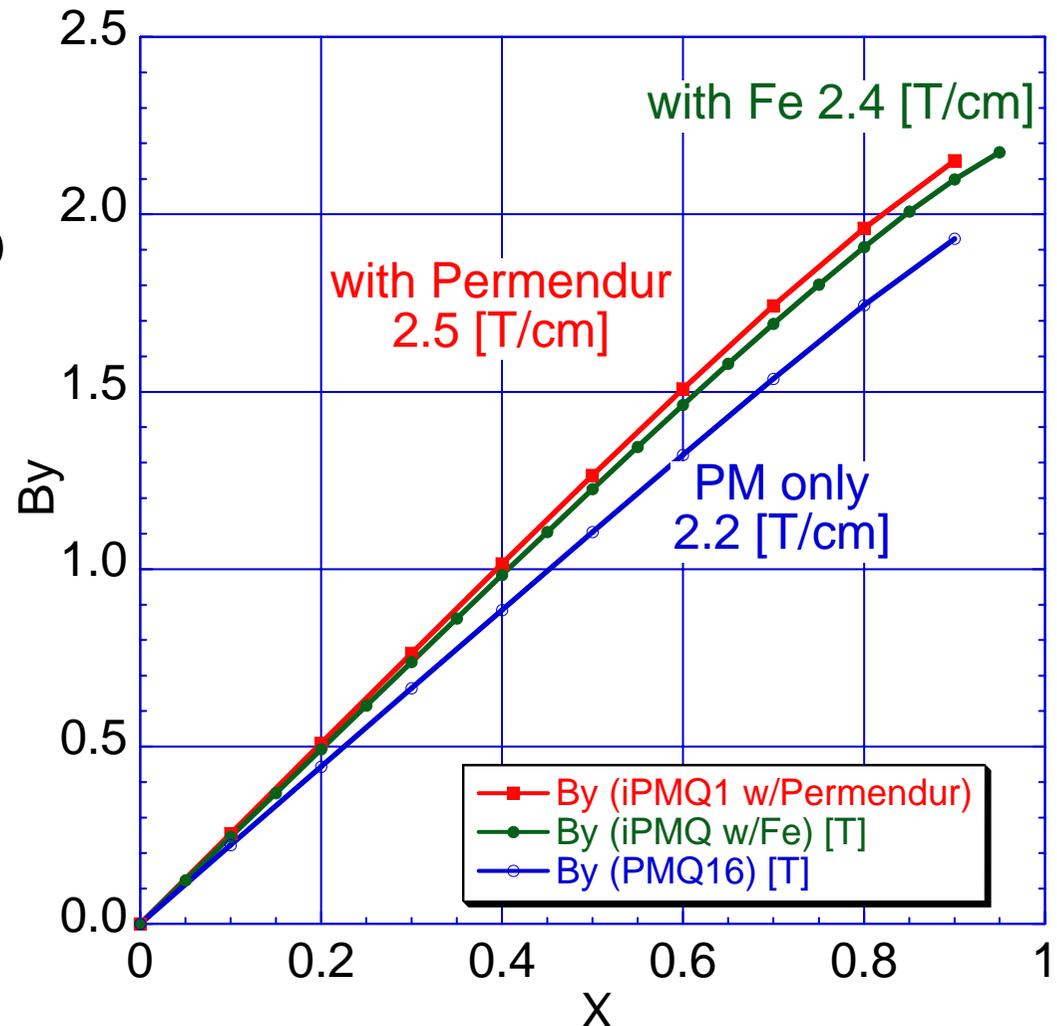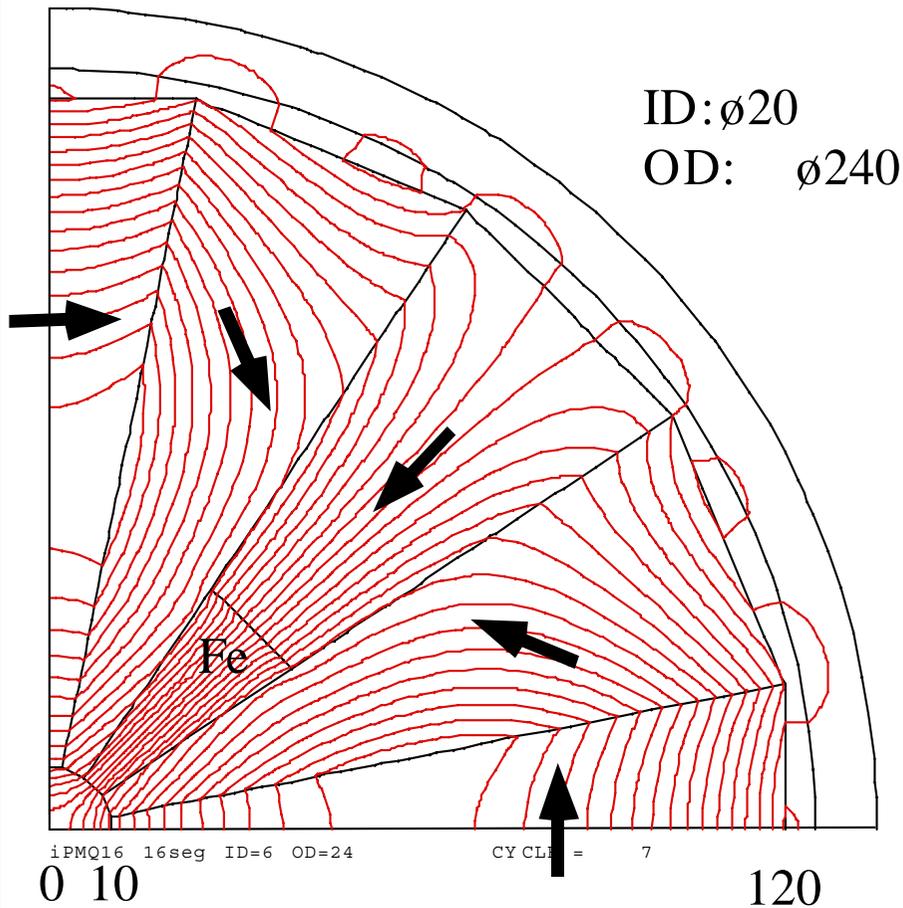
$B = 2B_r (1 - r_1/r_2) \cos^2(\pi/M) \sin(2\pi/M) /(2\pi/M)$

First prototype (fixed field)
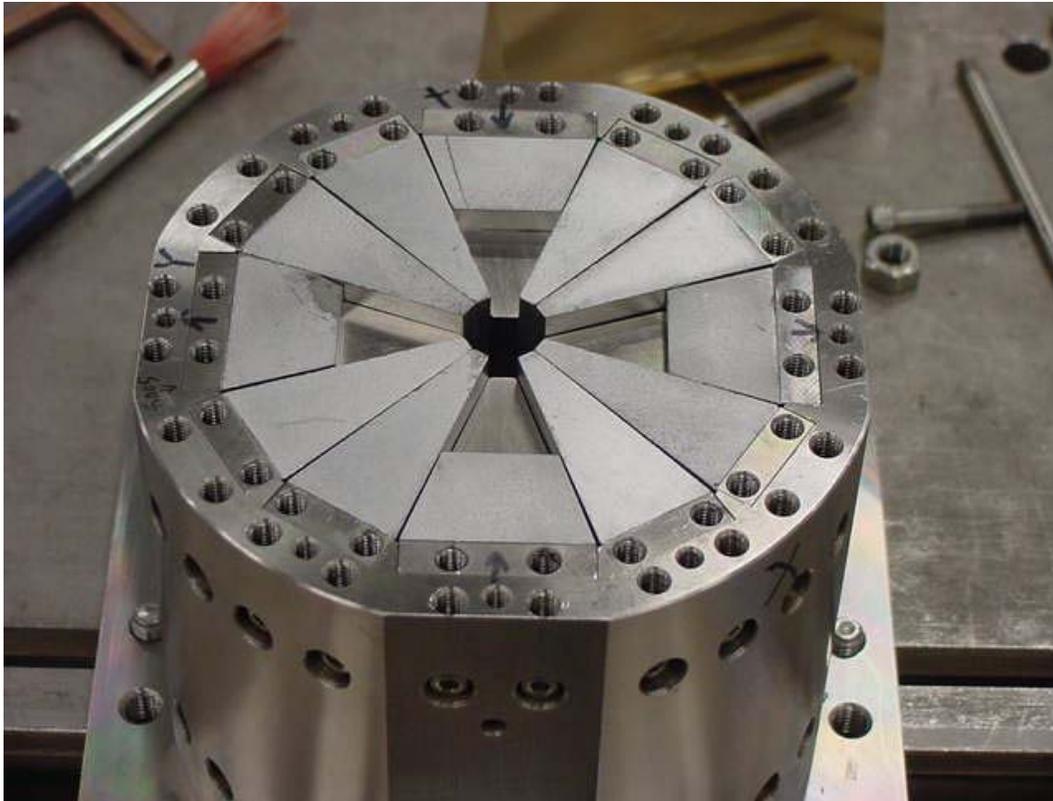
Prototype PMQ
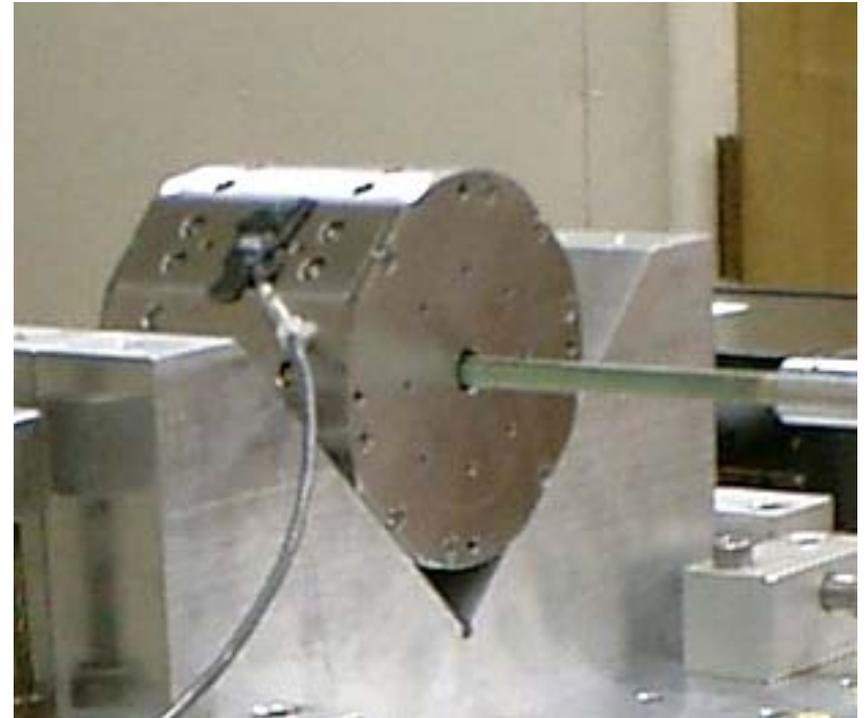
Measurement at SLAC

Double Ring Structure

First Quadrant shows the flux plot.

ON

OFF

Pole material
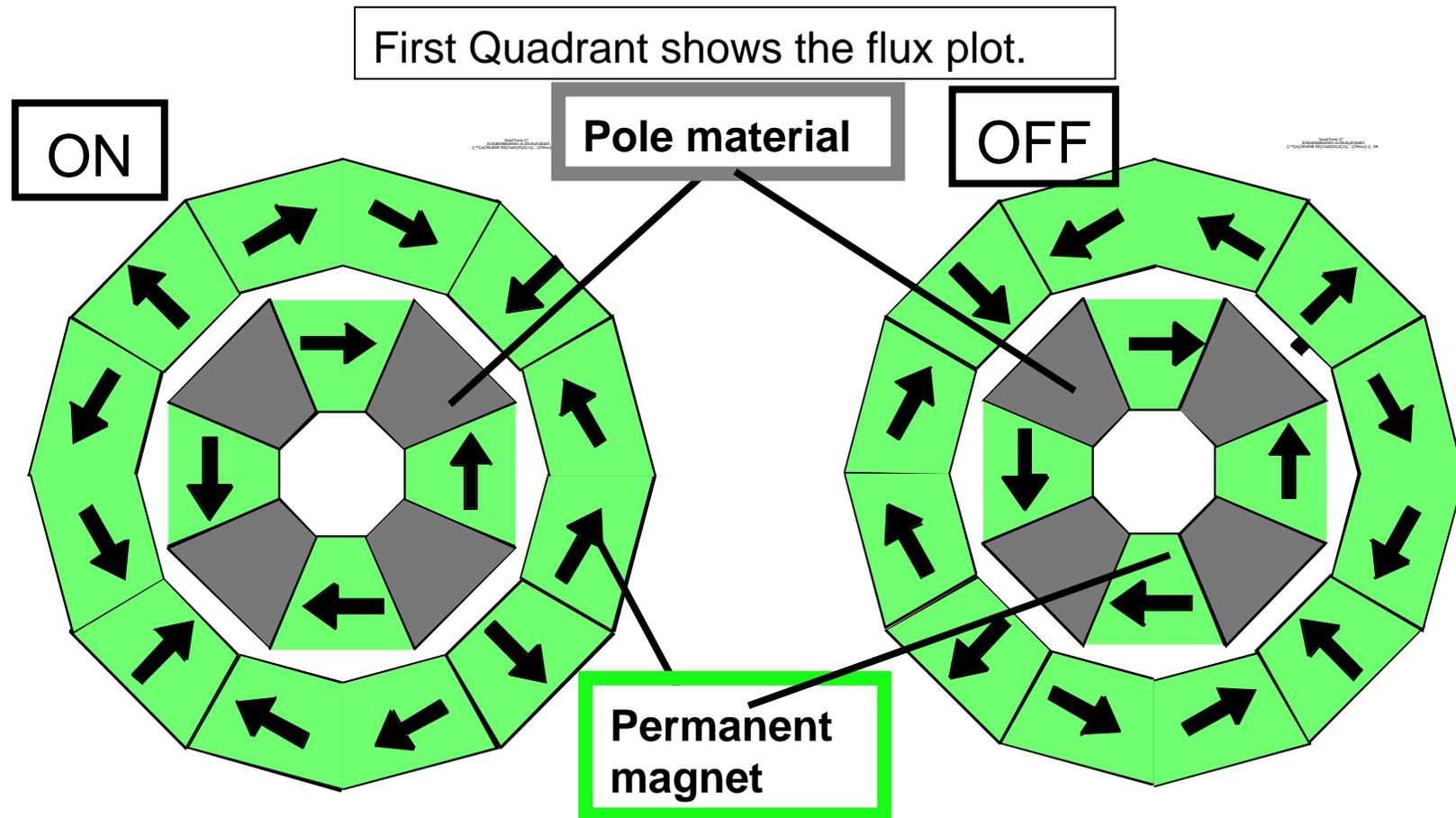
Permanent magnet

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

outer ring

inner ring

strong position

rotation

weak position

MS-1 endplates

1cm pieces of MS-1

permanent magnet

pole material

SUS plate

SUS cover

Bearing

Permanent magnets

space for the outgoing beam line

Permanent Magnet (NEOMAX38AH)
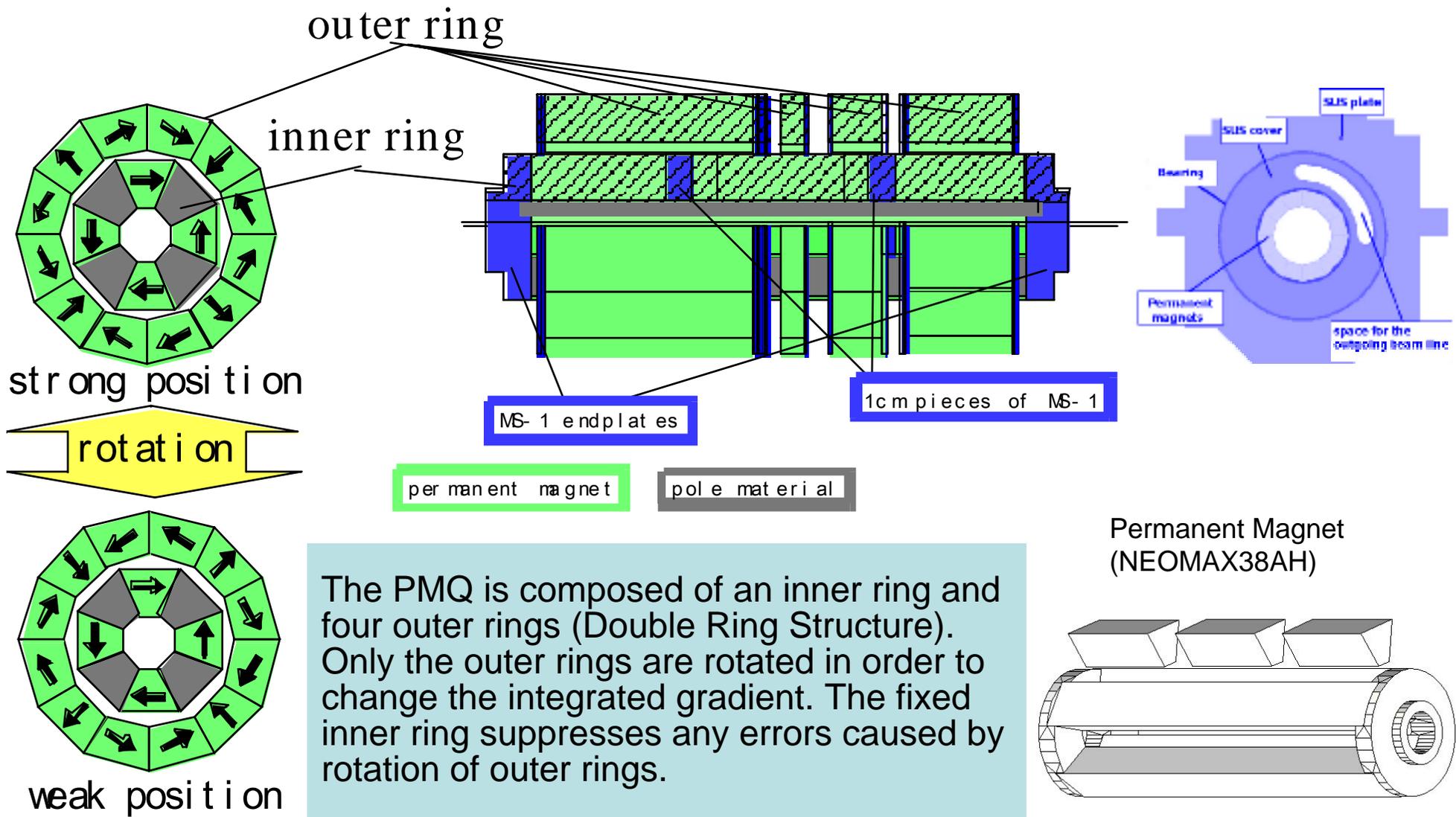
The PMQ is composed of an inner ring and four outer rings (Double Ring Structure). Only the outer rings are rotated in order to change the integrated gradient. The fixed inner ring suppresses any errors caused by rotation of outer rings.

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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

超薄型ボールベアリング
(KANDON)
セラミックボール

210
200
80
10
20
40
108
70
22
130
Φ 180
Φ 196

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**
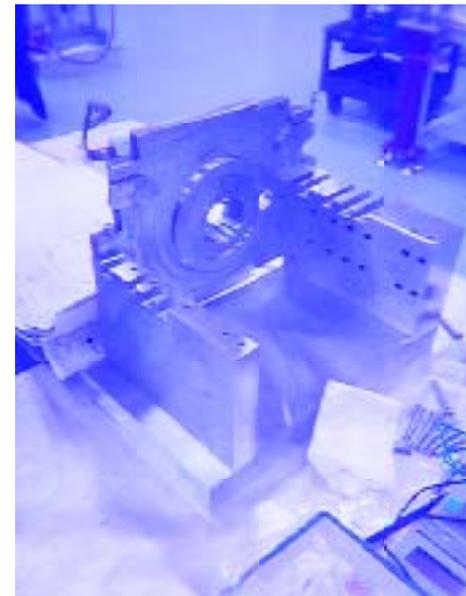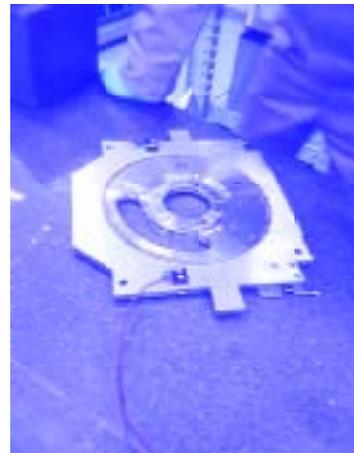
**Making of the PMQ**

Photos
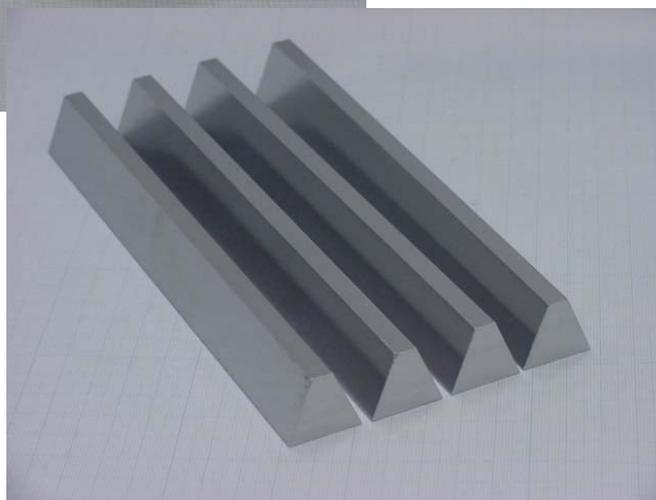
Magnetic Center Movement
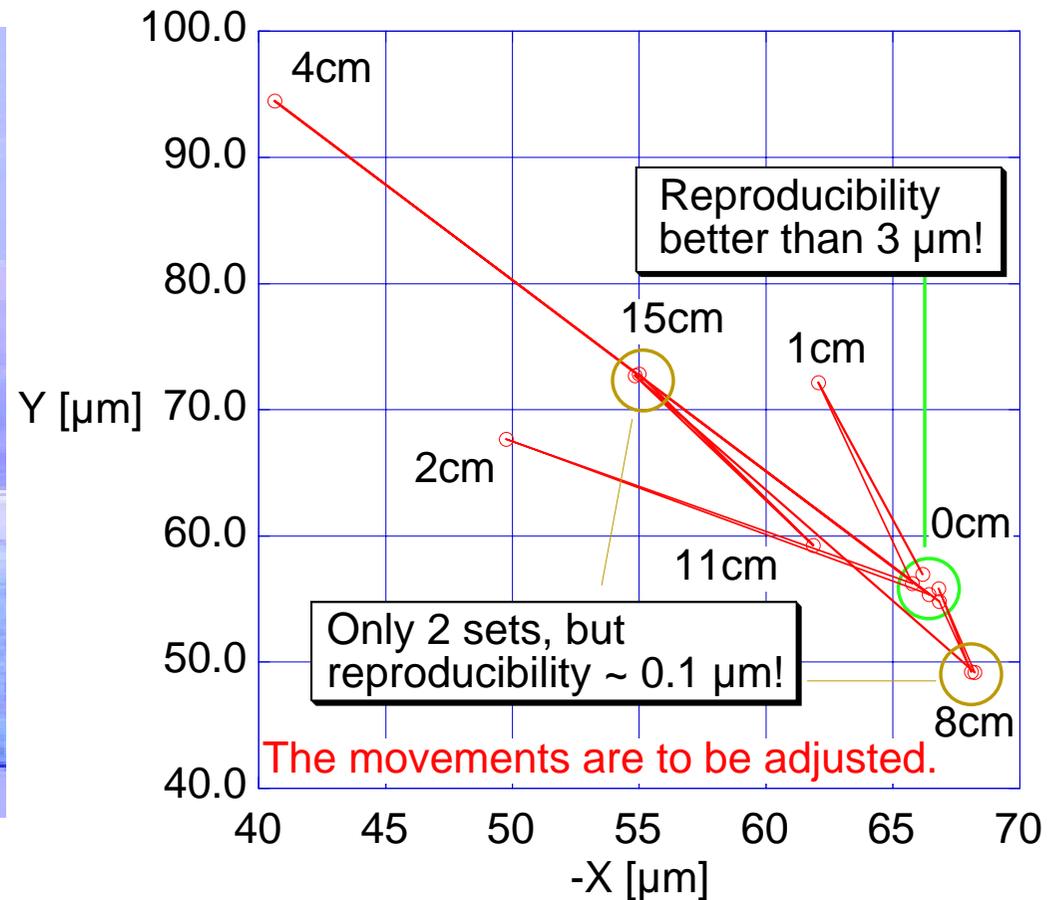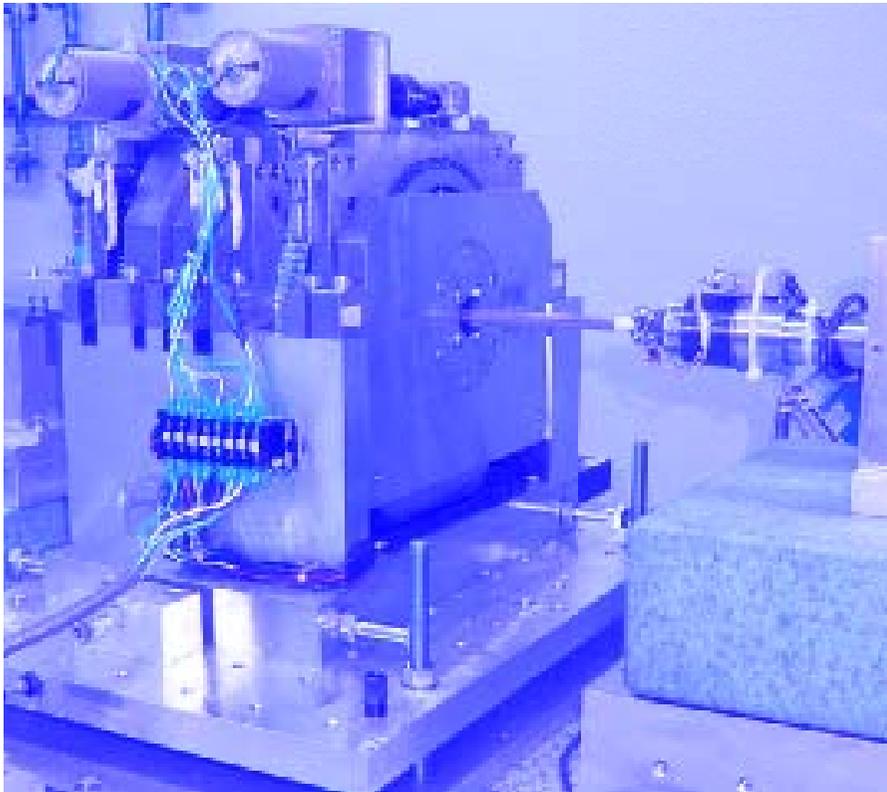

Magnetic Center moves by tens of micron
when the strength was changed.

Configurations for Various Crossing Angles
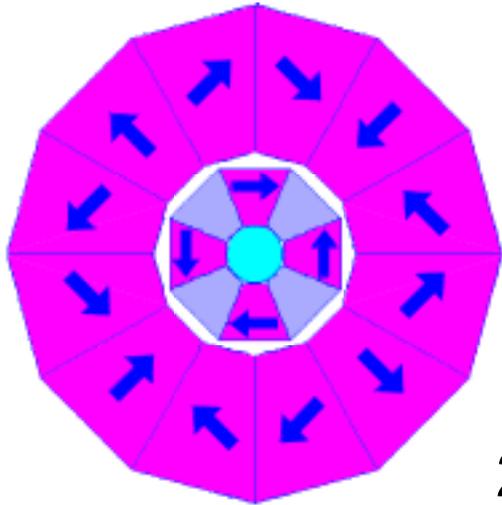

0 mrad.
(Head-On)
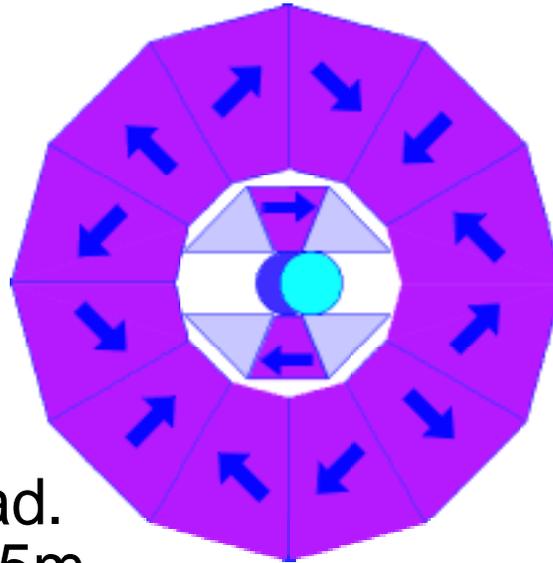
2 mrad.
L*=3.5m
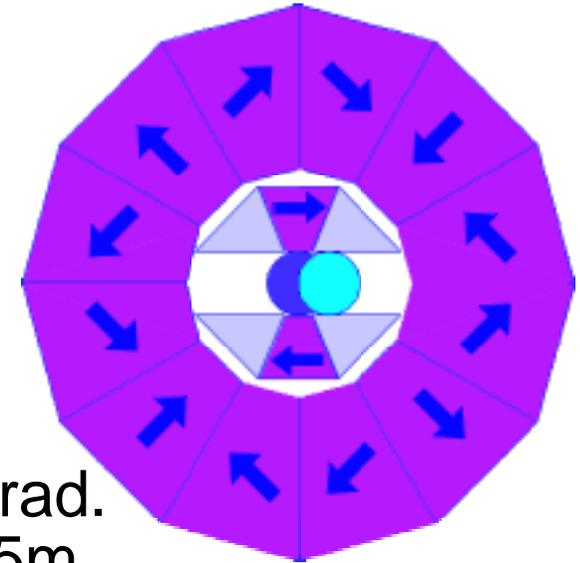
2 mrad.
L*=5m
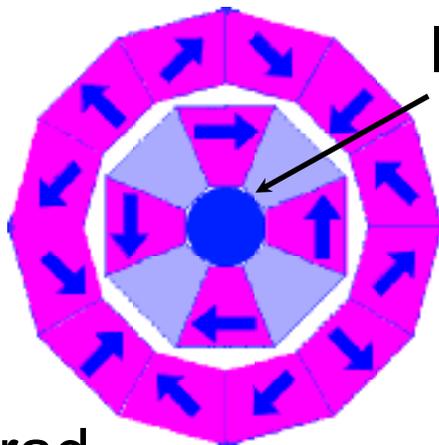
20 mrad.
L*=3.5m

Incoming Beam

Outgoing Beam

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.

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Effect of Solenoid

solenoid coil

magnetic shield   back coil
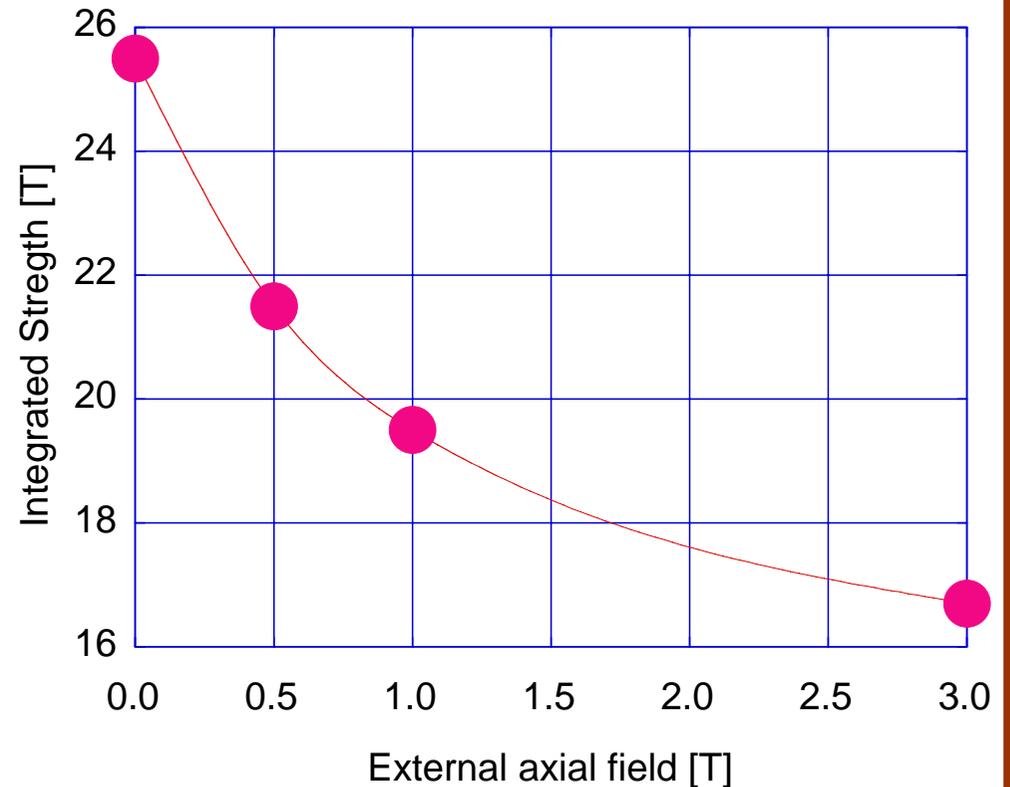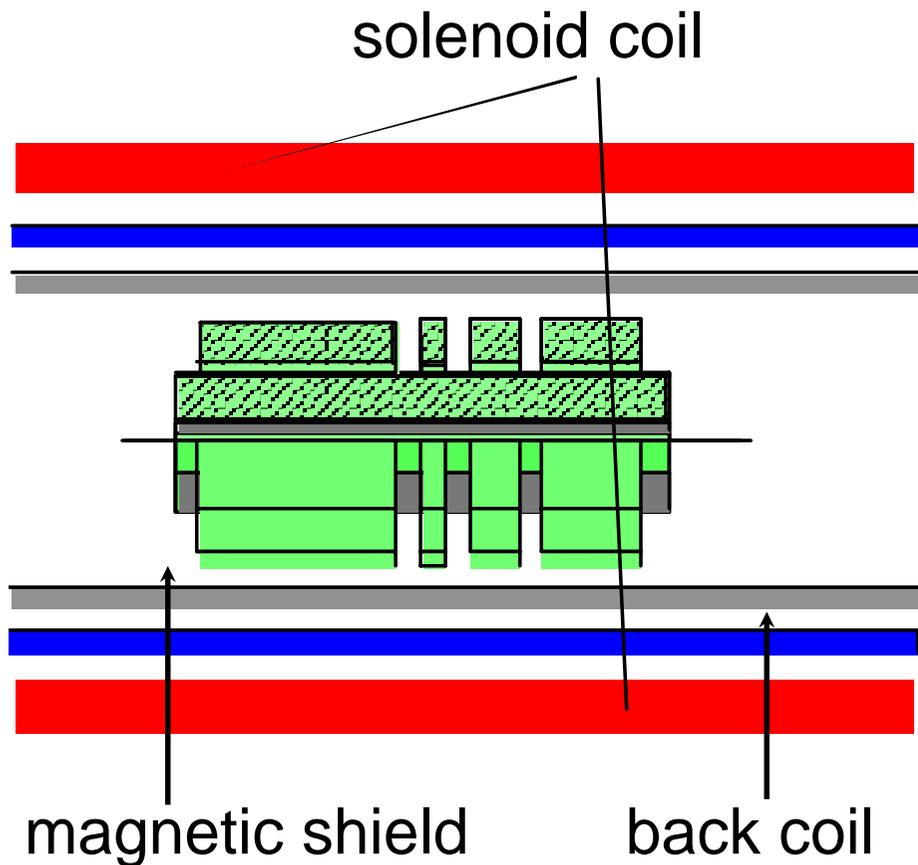
Integrated strength is reduced by Solenoid field because PMQ has pole (vanadium permendur). Back coil and/or some shield is needed.

# Recent Modification

Demonstrate a higher field gradient by reducing the bore size from ⌀20mm down to ⌀15mm.


Permendur Pole

1mm MS-1

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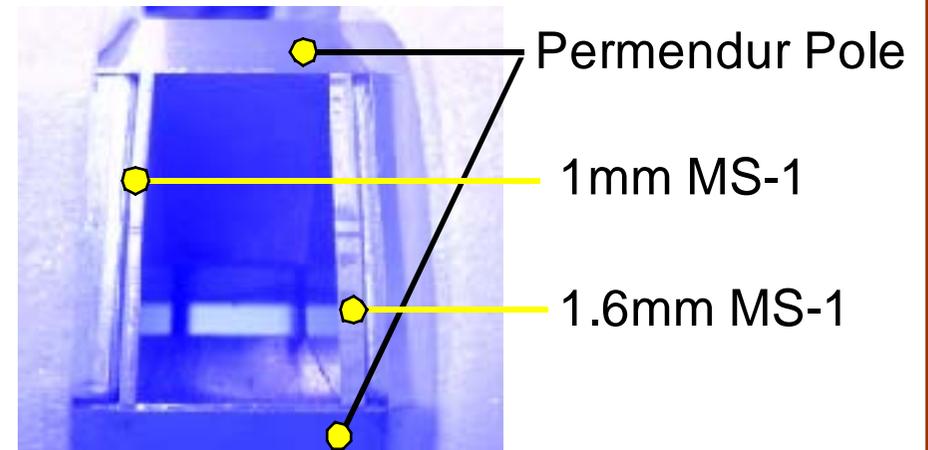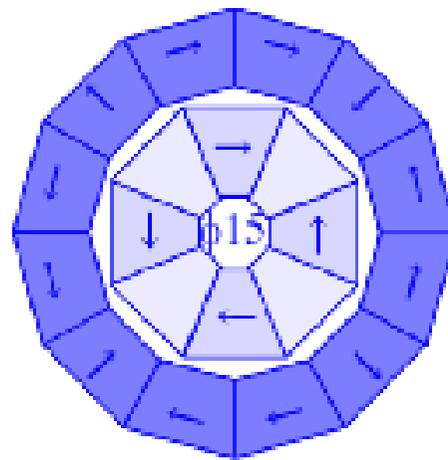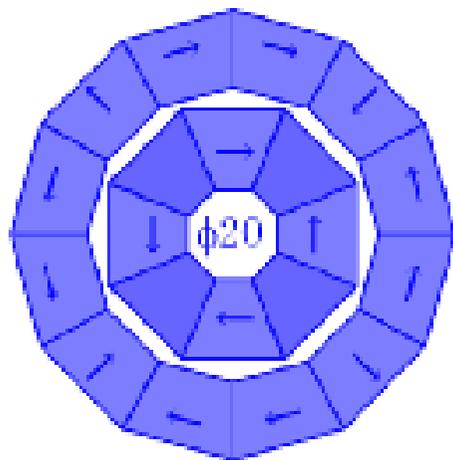
Temperature compensation of the inner ring; 1 mm (left) and 1.6 mm (right) MS-1 trapezoidal plates are seen in a 2cm space between magnets.

Longitudinal Distribution
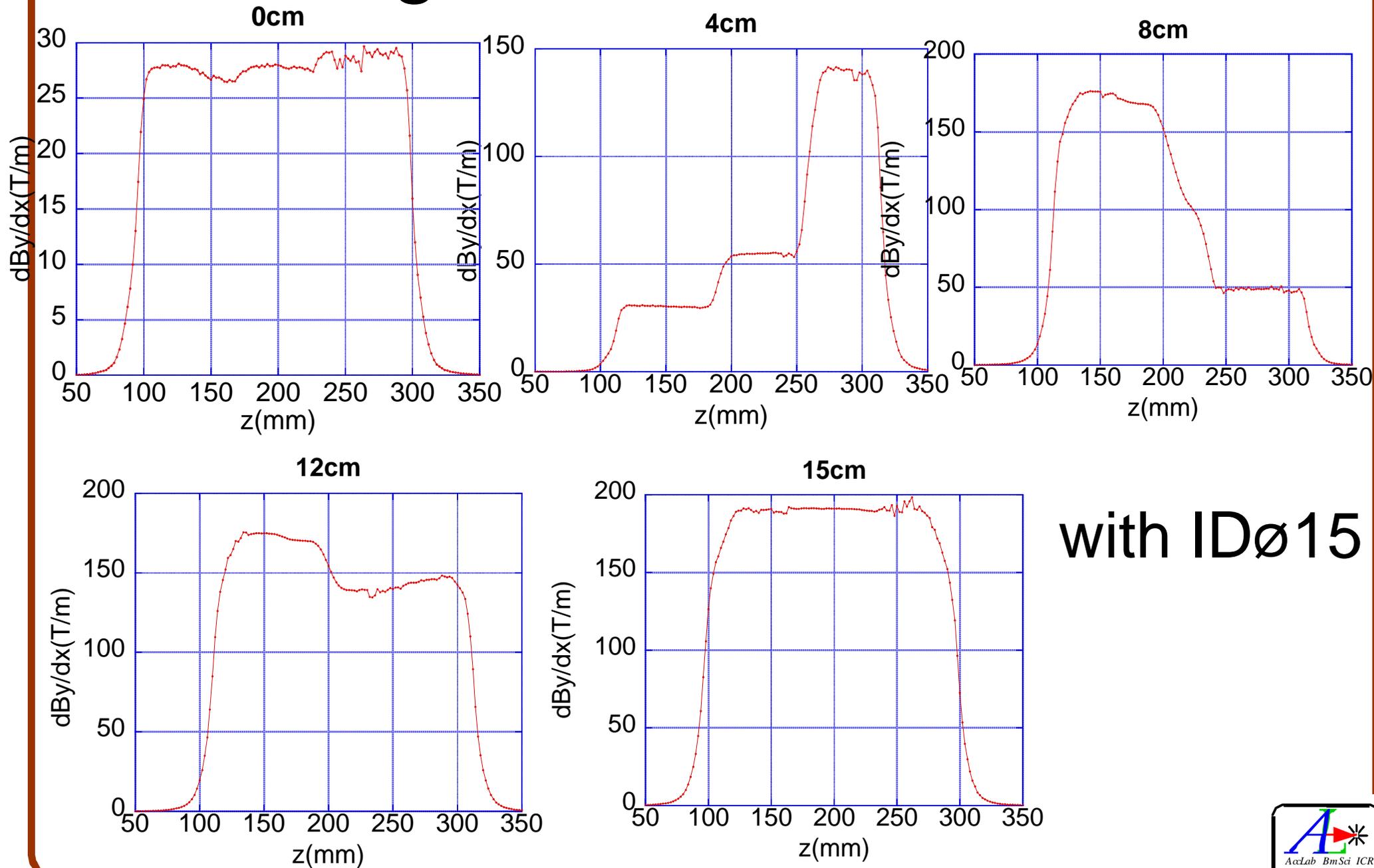
with IDø15

Rotating Coil Stand
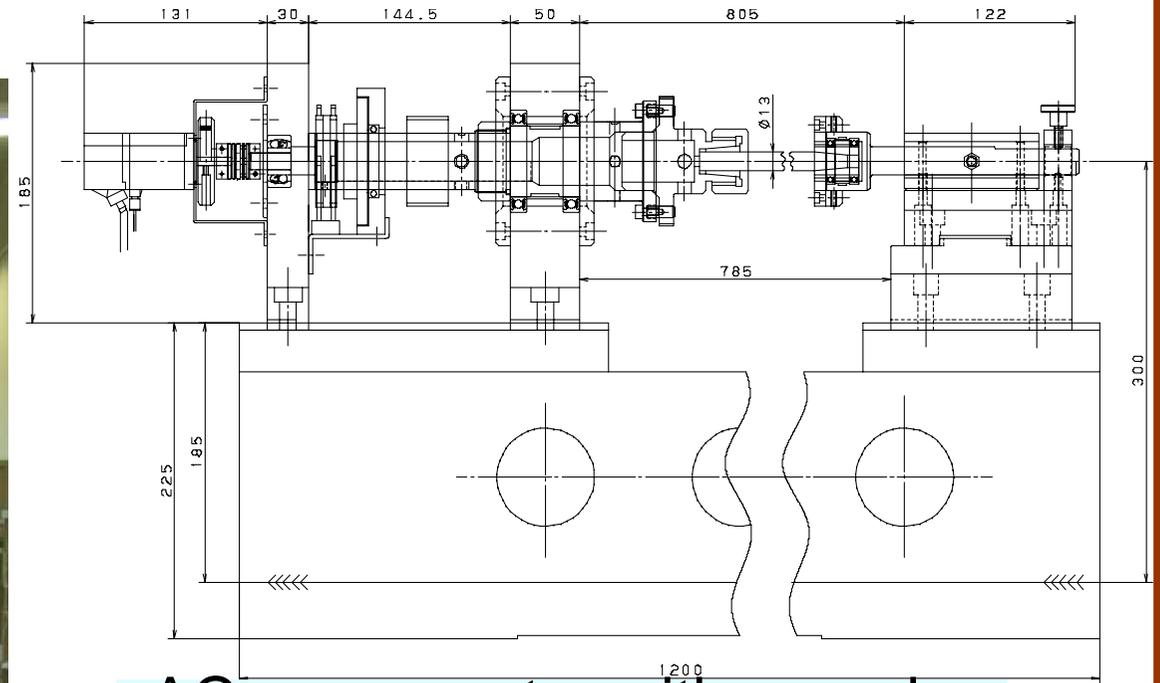

AC servo-motor with encoder
(up to 600 RPM)
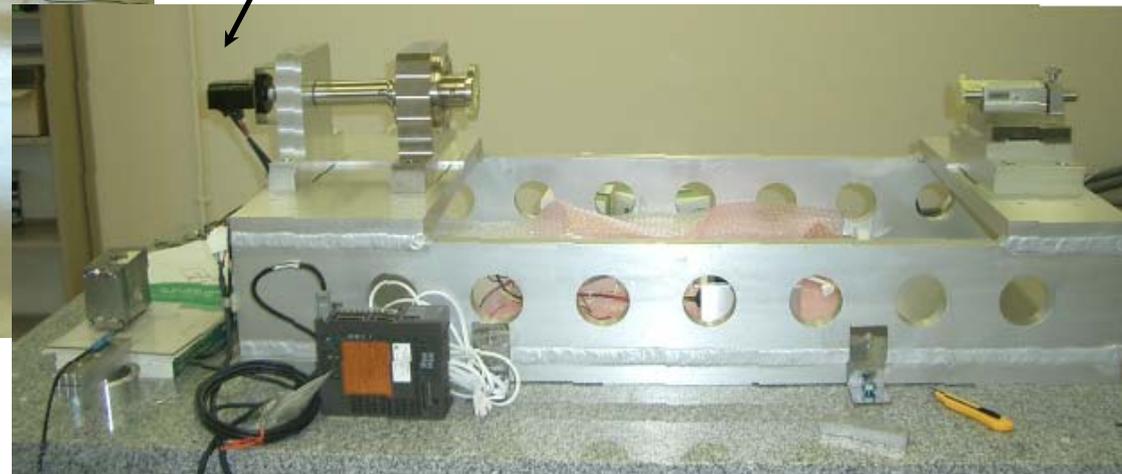
What's next?

- Finish magnetic field measurement system

- Fabricate third model

- Sextupole?

- Octpole?

- more?

Rotating PMSx for cold neutrons

6818 (90-115)
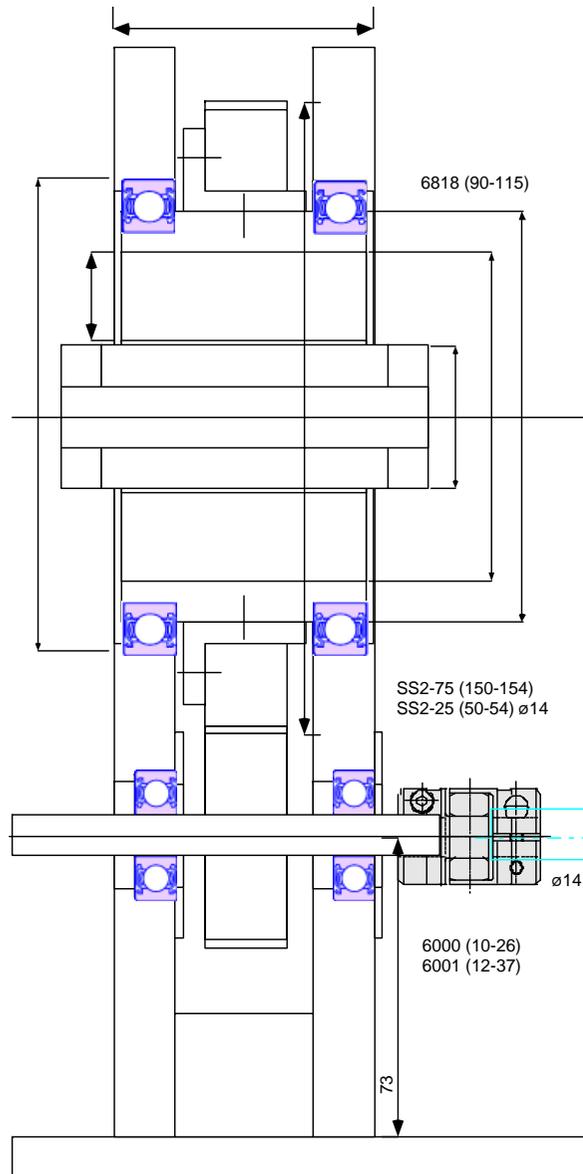
QuickTimeý Ç²
Sorenson Video êLí£ÉvÉçÉOÉâÉÄ
Ç™Ç±ÇÃÉsÉNÉ`ÉÉÇ¾å©ÇÈÇžÇ½Ç…ÇÕïKóvÇ-Ç ÅB

SS2-75 (150-154)
SS2-25 (50-54) ø14

ø14

6000 (10-26)
6001 (12-37)

73
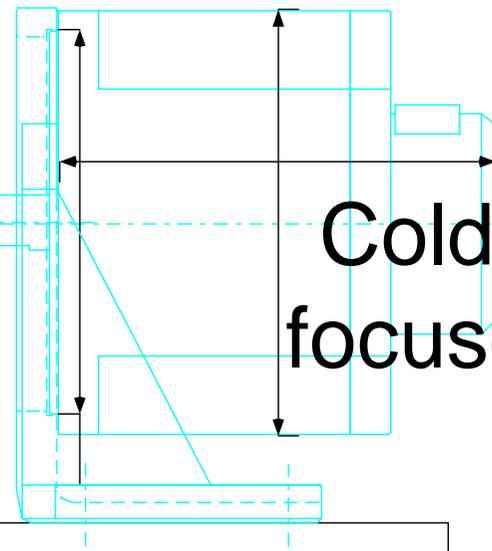
Cold neutron beam can be focused by strong sextupole. 25Hz for ToF.