Permanent Magnet Updates

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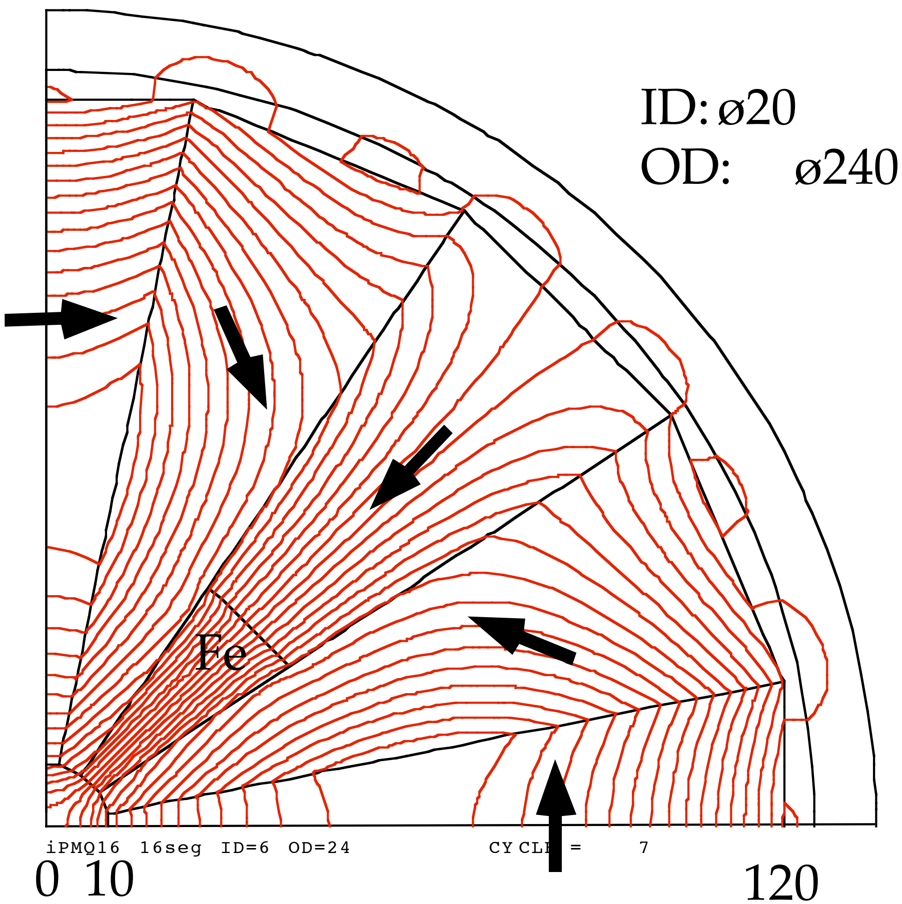
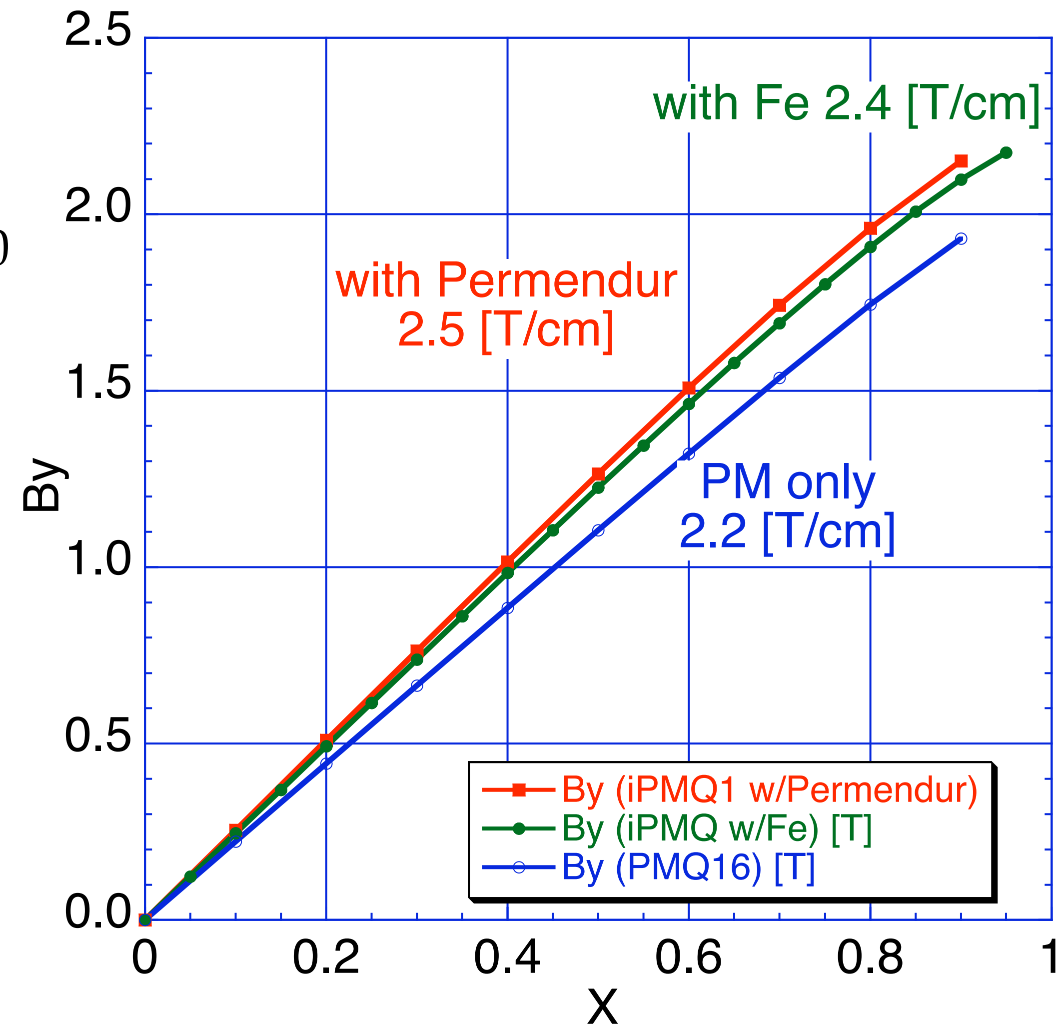
Contents:

- Brief review of PMQ study
- Longitudinal distribution
- 14mrad
- Octupole

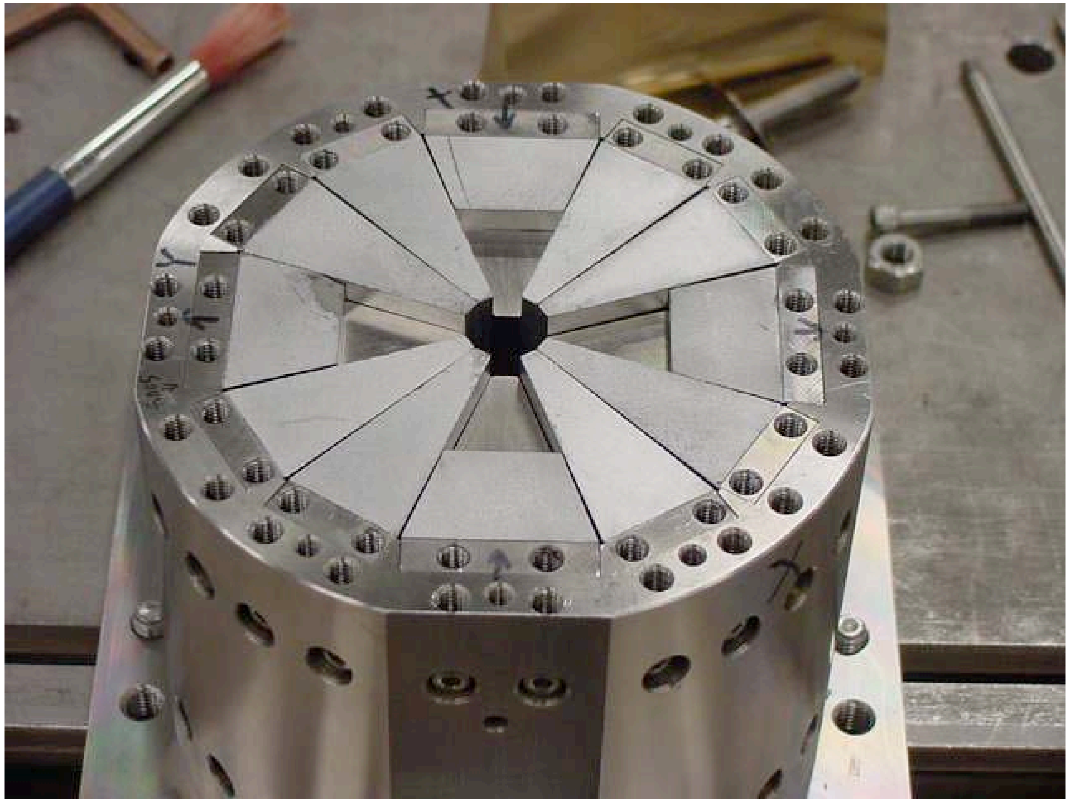
PMQ with saturated iron pole

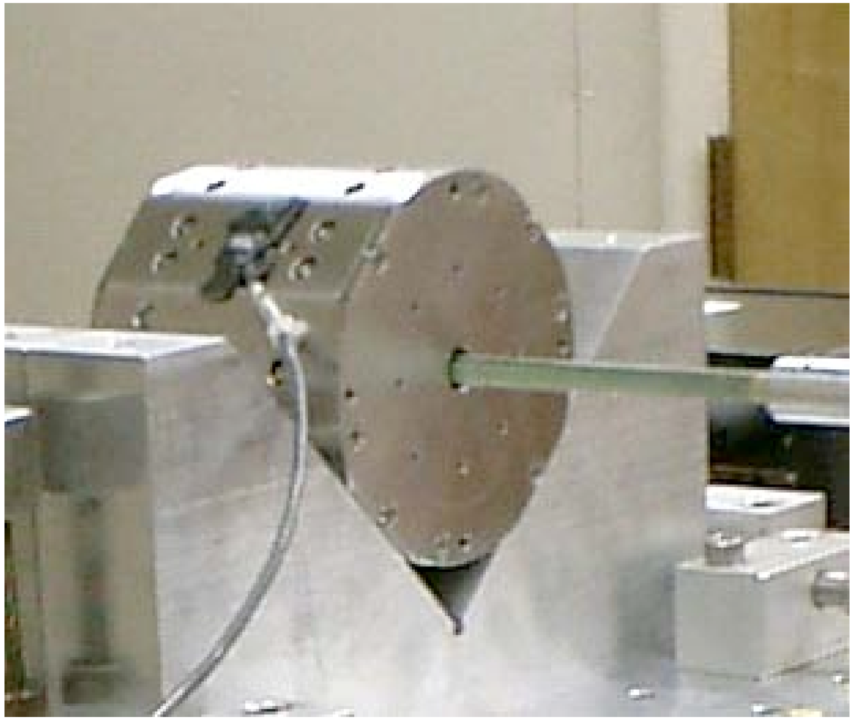




$$B = 2B_r\,(1 - r_1/r_2)\cos^2(\pi/M)\,\sin(2\pi/M)\;/\,(2\pi/M)$$

First prototype (fixed field)

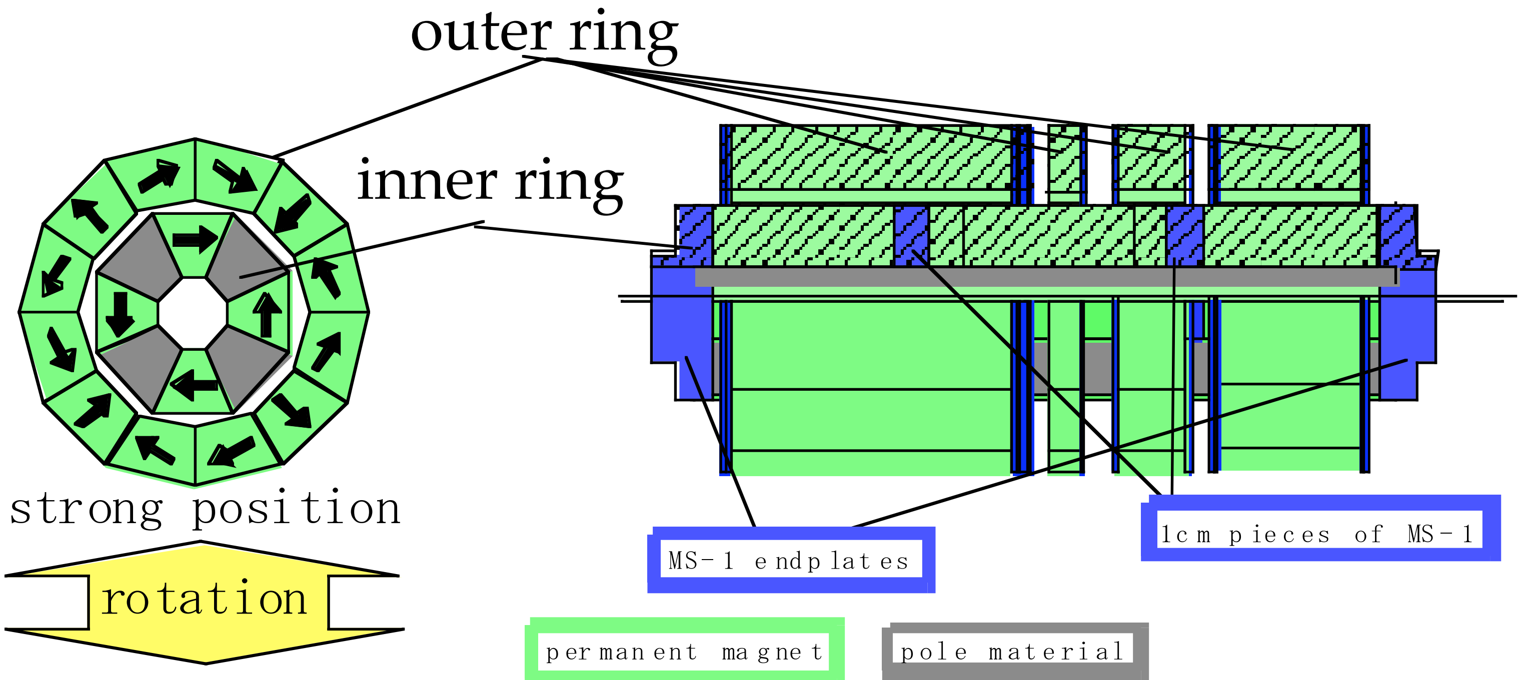


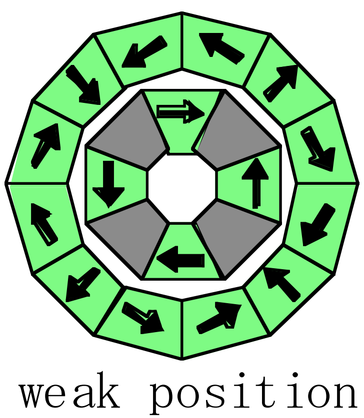


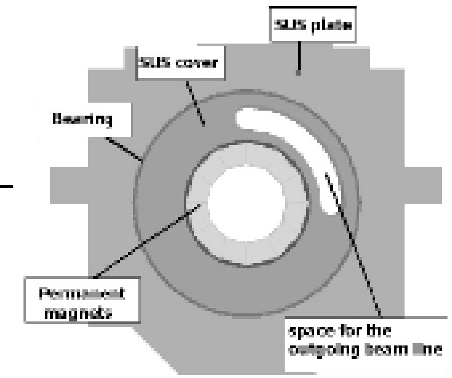
Prototype PMQ

Measurement at SLAC

Adjustable Permanent Magnet Quadrupole

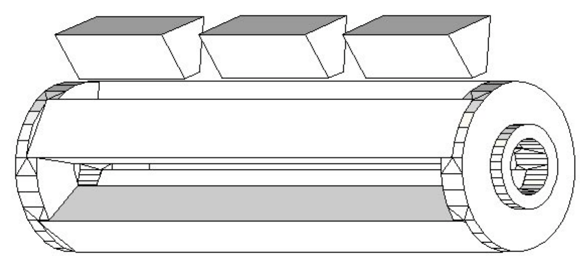






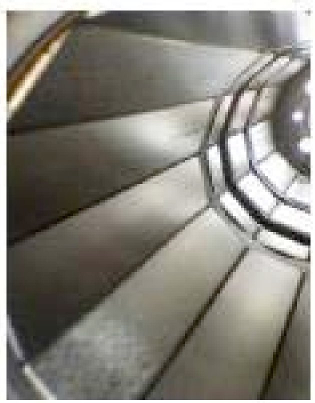
The PMQ is composed of an inner ring and four outer rings (Double Ring Structure). Only the outer rings are rotated in order to change the integrated gradient. The fixed inner ring suppresses any errors caused by rotation of outer rings.

Permanent Magnet (NEOMAX38AH)



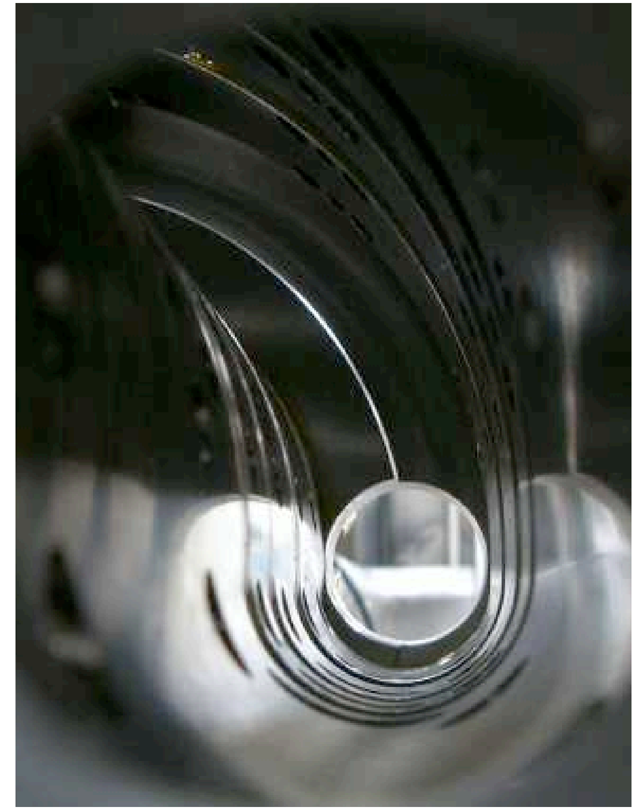
Prototype Magnet

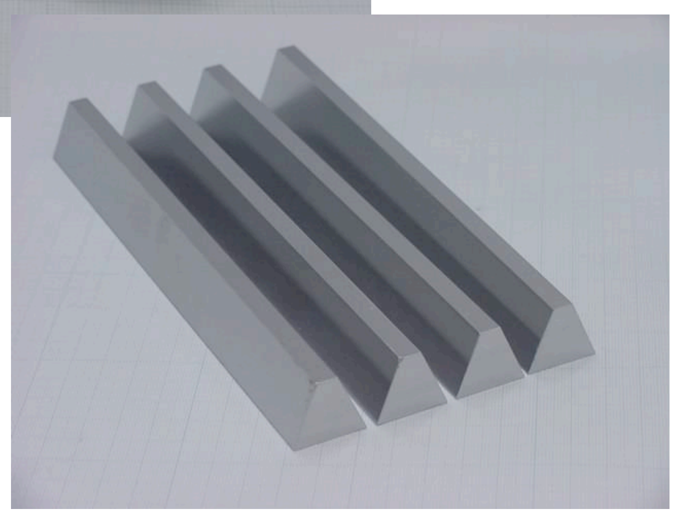
Bore radius	1cm
Inner ring radii	In 1cm out 3cm
Outer ring radii	In 3.3cm out 5cm
Outer ring section length	1cm, 2cm, 4cm, 8cm
Physical length	23cm
Pole material	Permendur
Magnet material (inner ring)	NEOMAX38AH
Magnet material (outer ring)	NEOMAX44H
Integrated gradient(strongest)	24.2T
Integrated gradient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



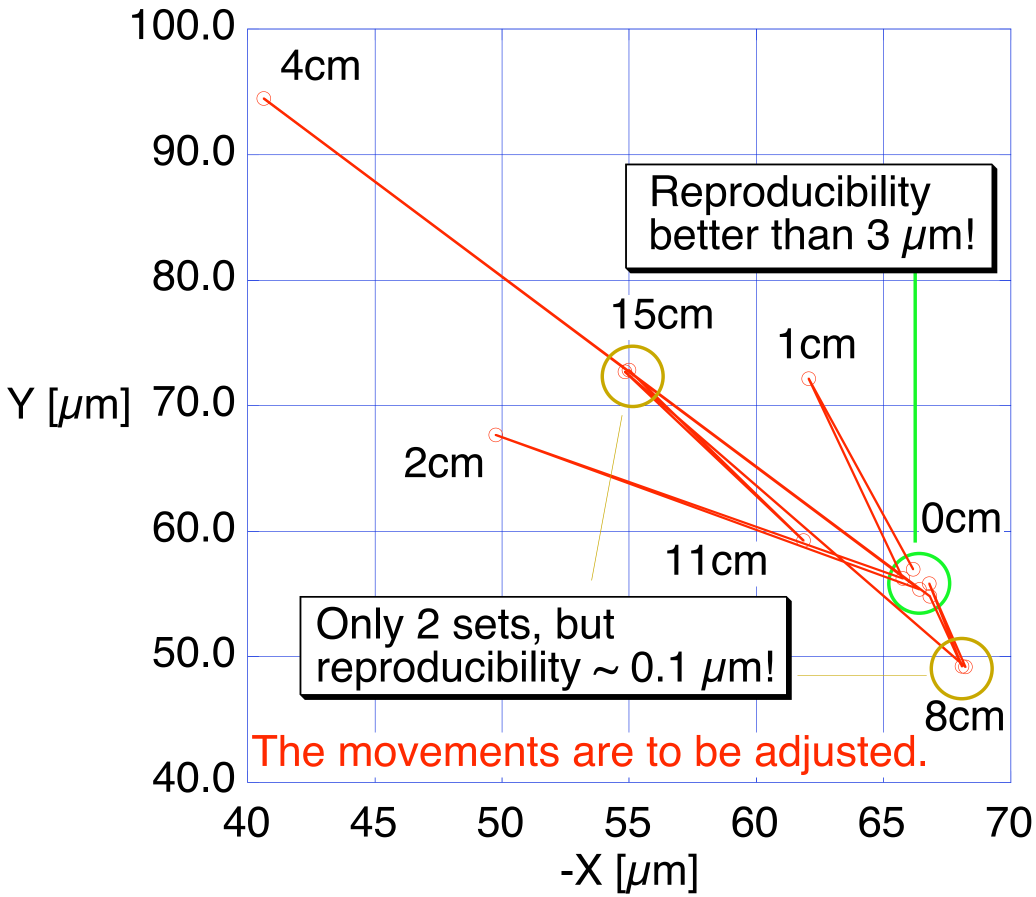
PMQ assembling

Photos



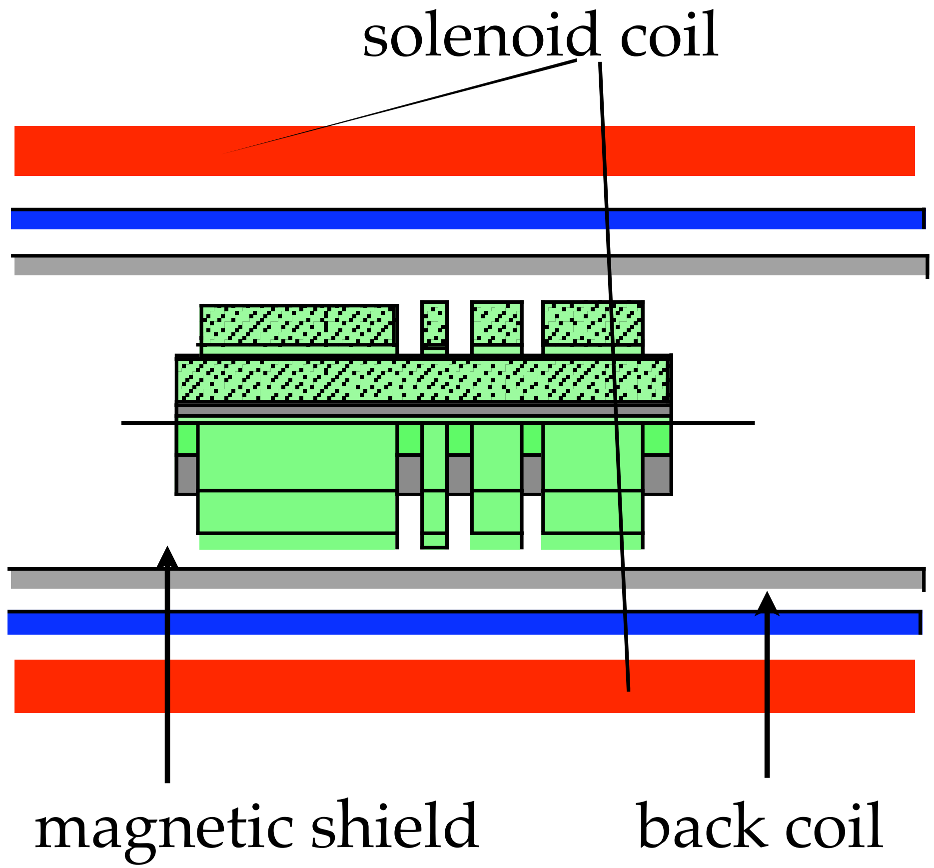


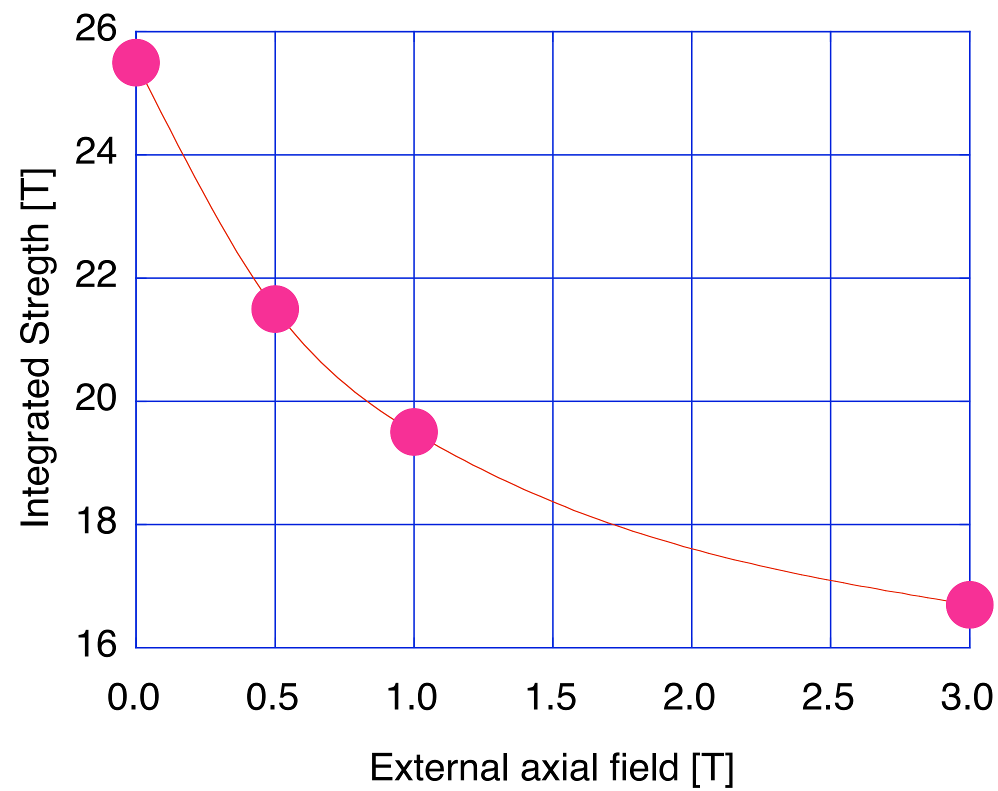
Magnetic Center Movement



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

Effect of Solenoid





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

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]
47	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 1mo.(2.6Ms) operation may cause about 0.01[%] of (reversible?) demagnetization on NEOMAX 32EH.

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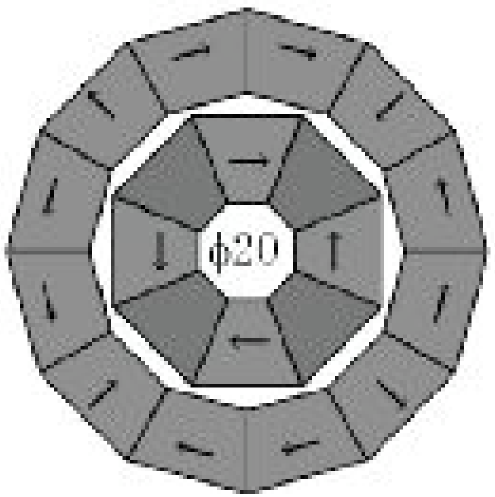
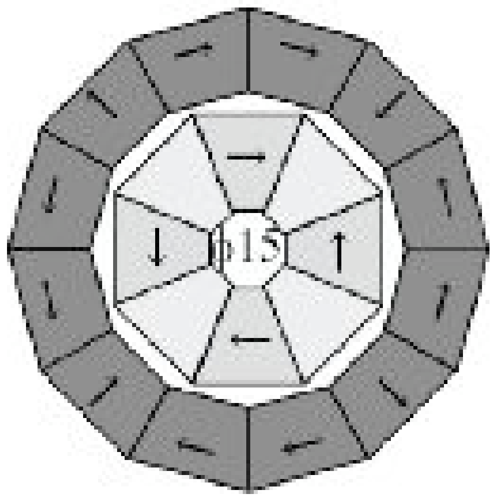
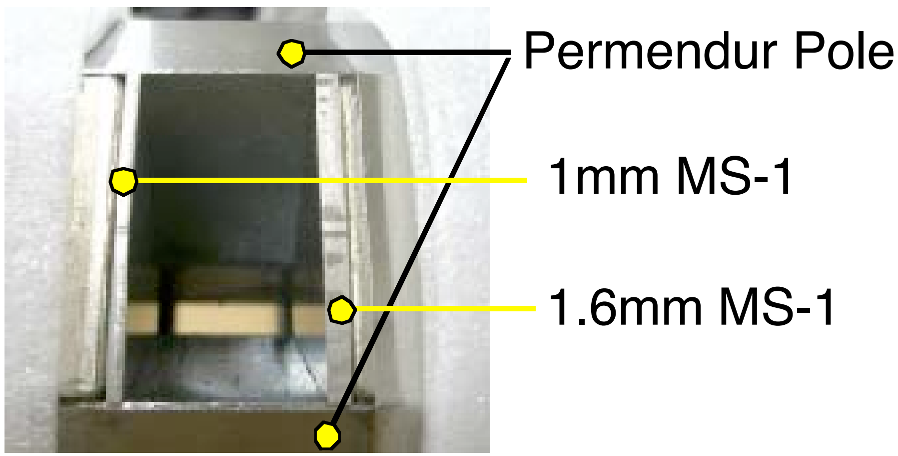
Recent Modification

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







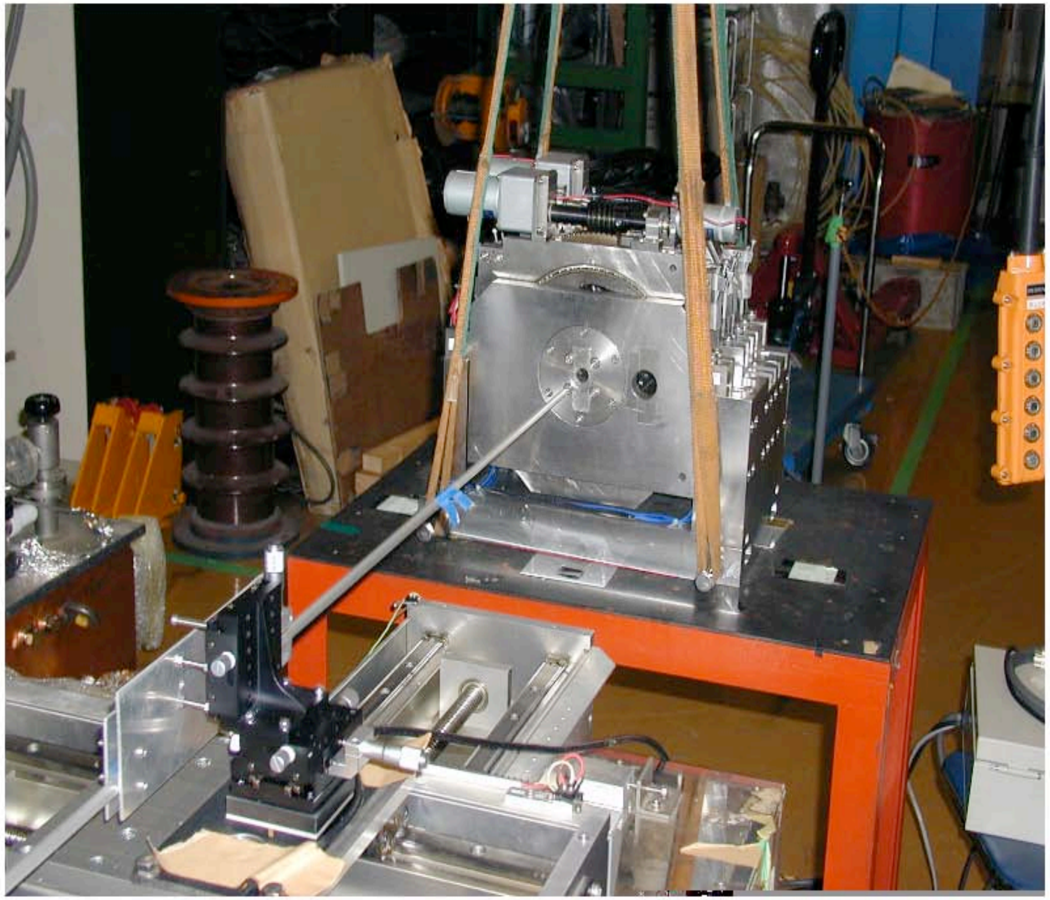
Temperature compensation of the inner ring; 1 mm (left) and 1.6 mm (right) MS-1 trapezoidal plates are seen in a 2cm space between magnets.

Longitudinal Distribution

Vertical component
By measured by a
Group3 Tesla meter.

dz = 2mm,
z = 0 ~ 380mm

dx, dy = ±2mm



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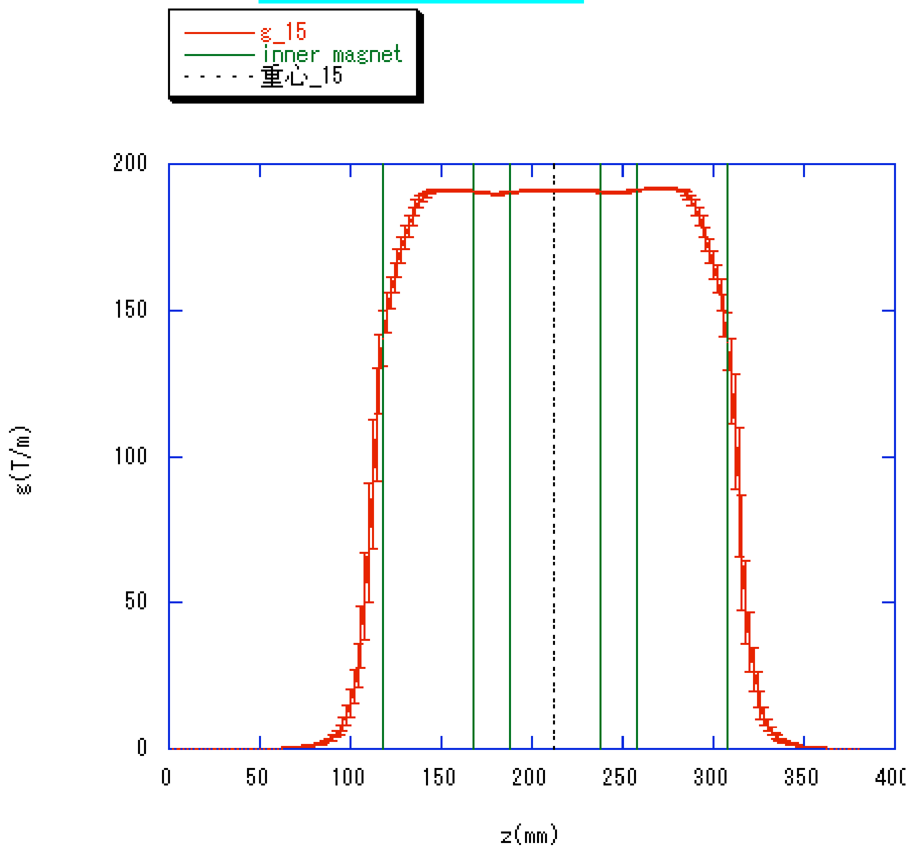
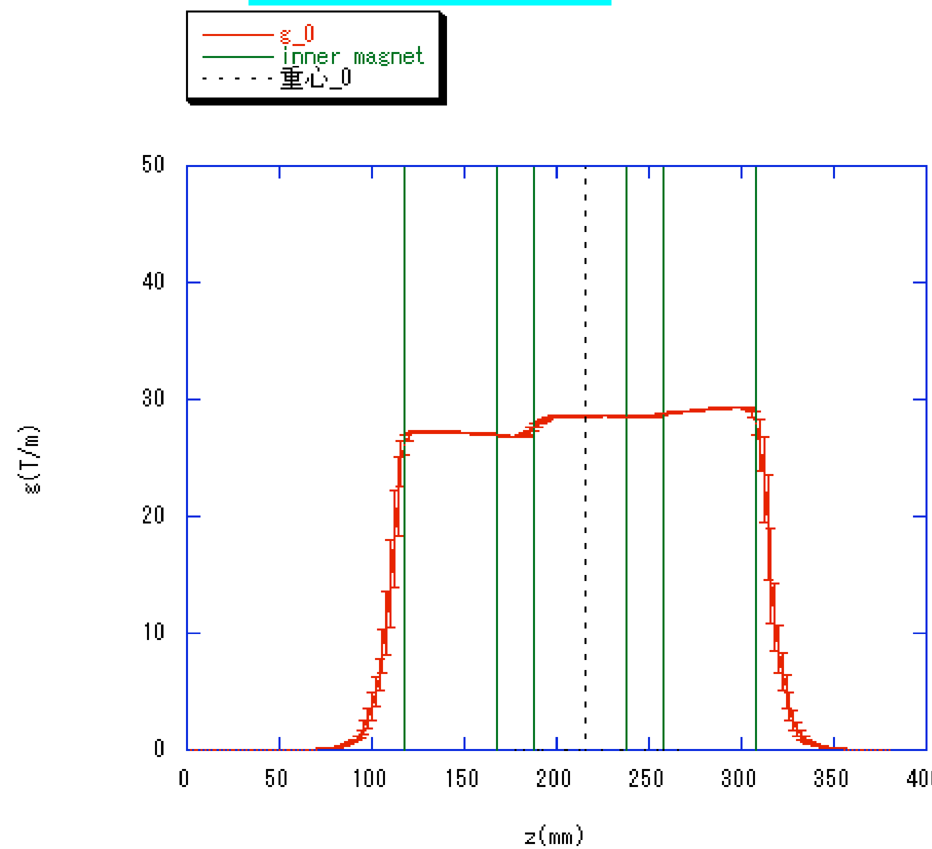
Longitudinal Distribution

All ON

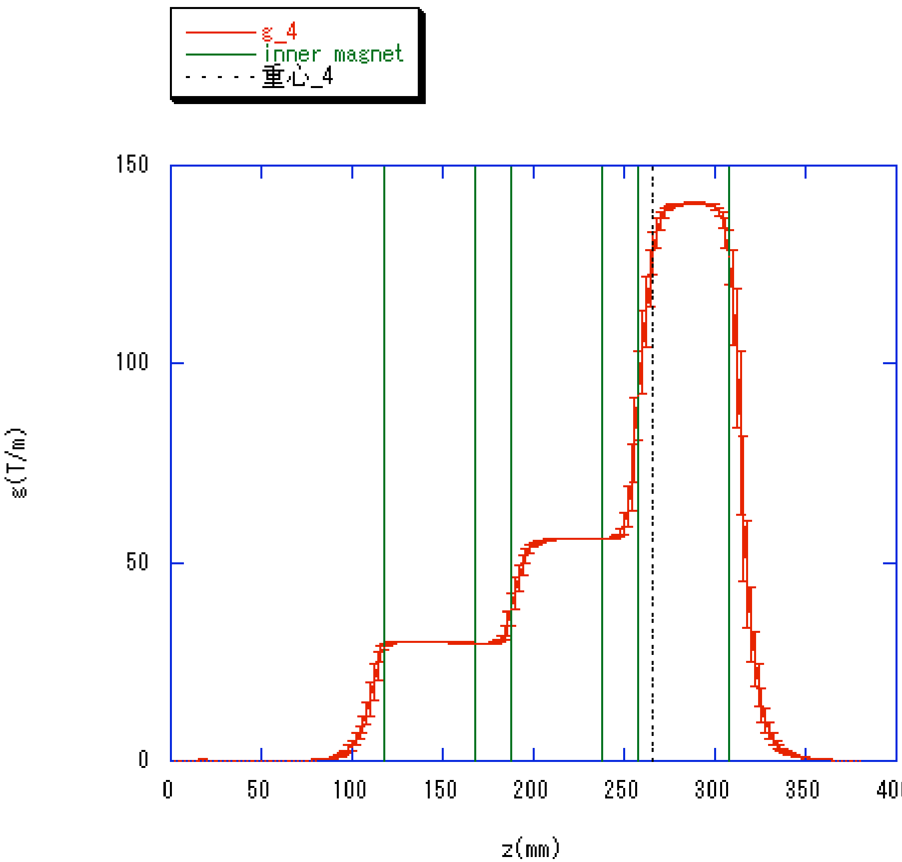


All OFF

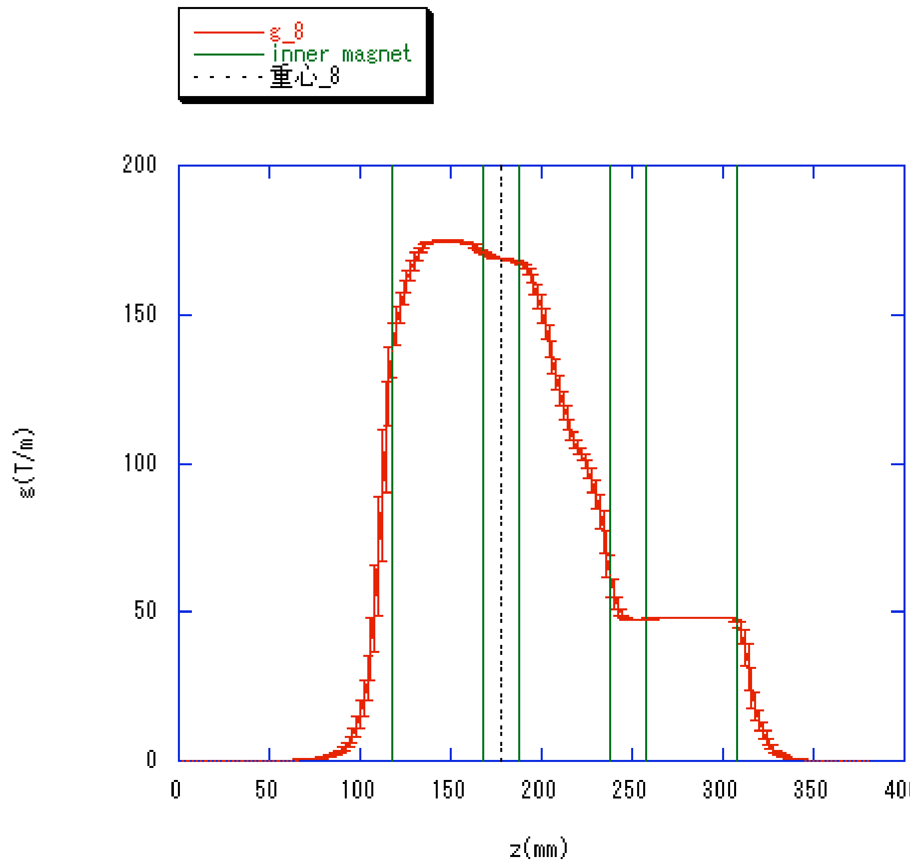


Almost flat: Gmax ~190T/m
Gmin ~ 29T/m

SWL = 4cm



SWL = 8cm



Gradient is high at ON region.
Magnet gaps of the inner ring affects the distribution.

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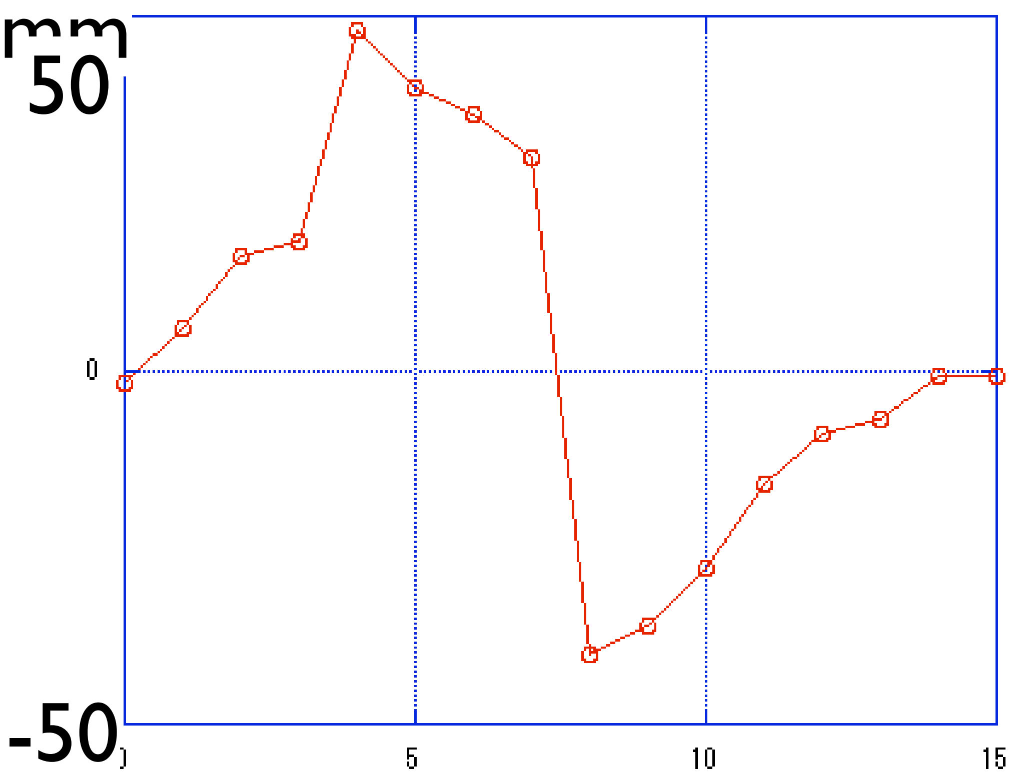
Magnetic field centroid

Cases of

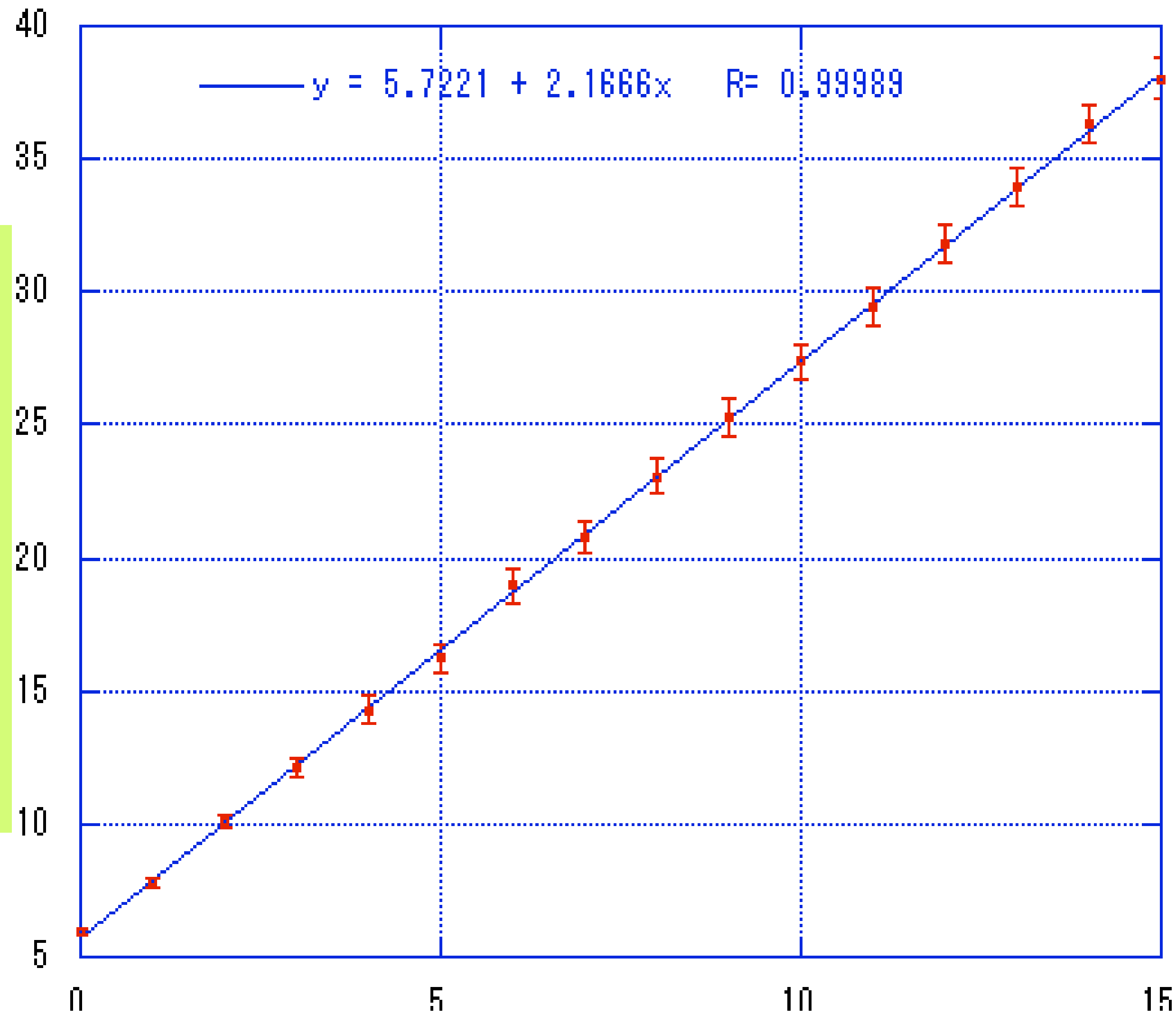
only 8cm (entrance) ON
or
only 4cm(exit) ON

shows the maximum and minimum.



Centroid location as a function of SWL

GL value



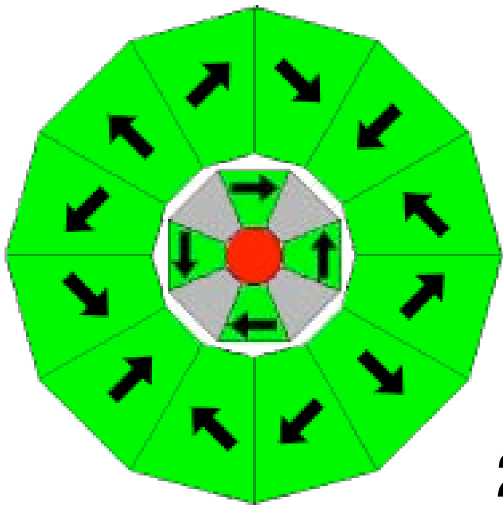
SWL

GL value is **proportional** to the SWL:

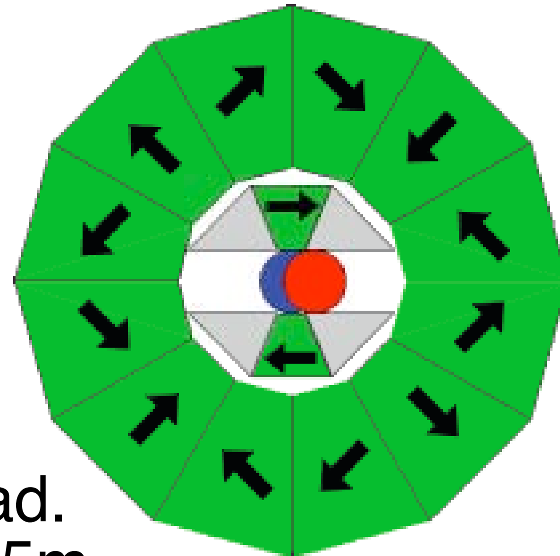
GLmax ~ 38 T

GLmin ~ 5.9T

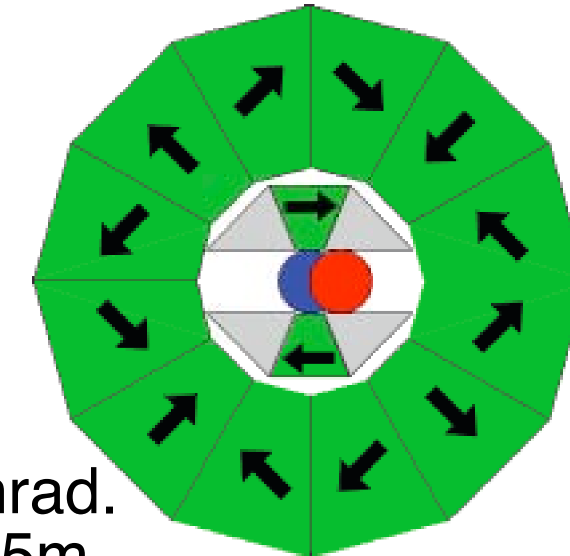
Configurations for Various Crossing Angles



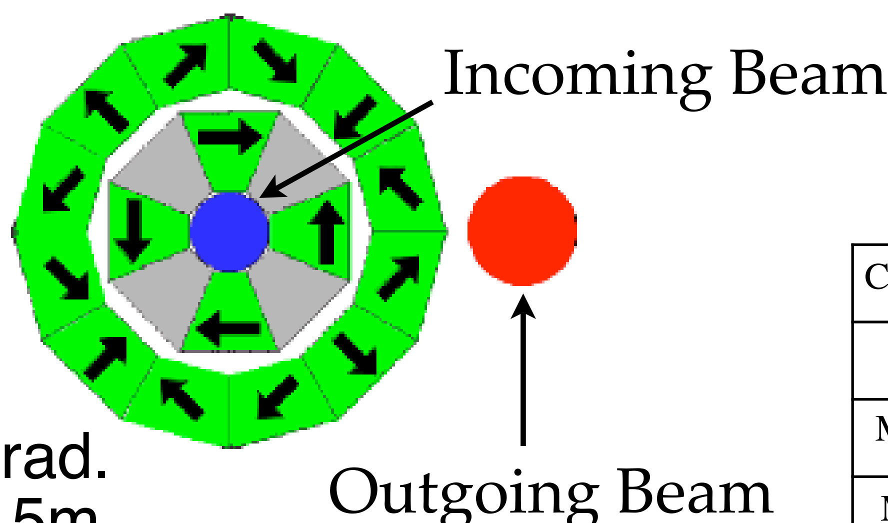
0 mrad.
(Head-On)



2 mrad.
L*=3.5m



2 mrad.
L*=5m



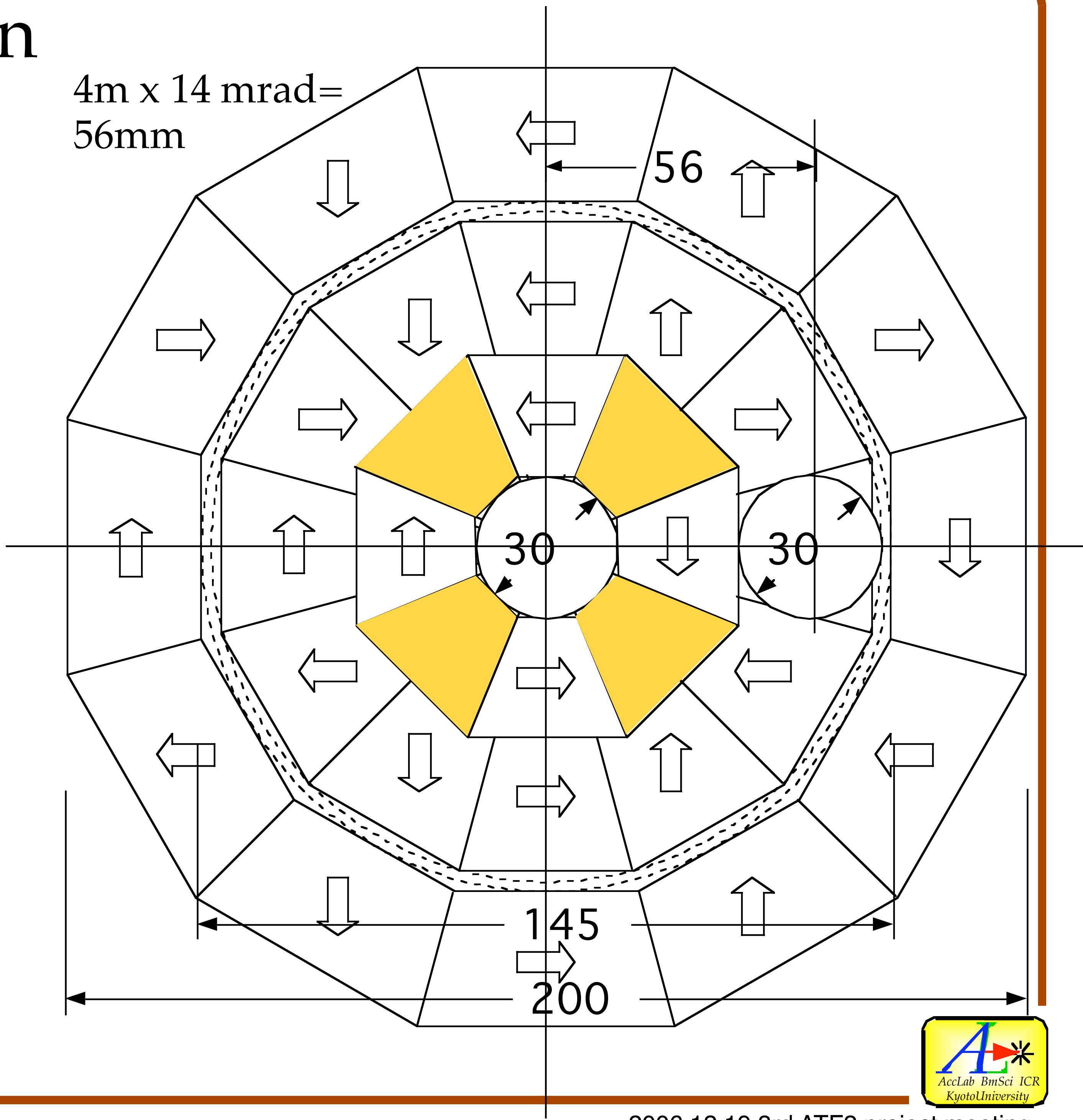
20 mrad.
L*=3.5m

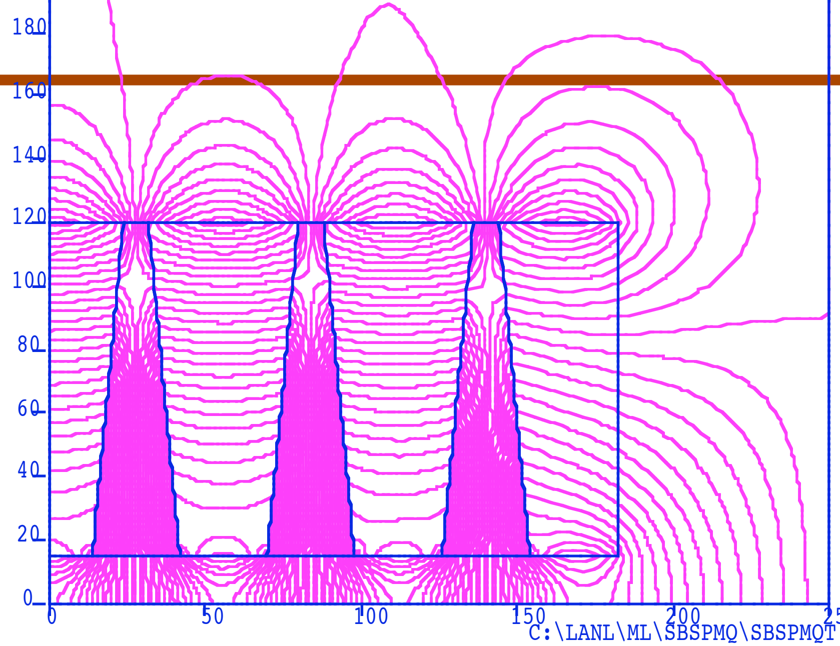
Table II PMQ parameters for various crossing angles.

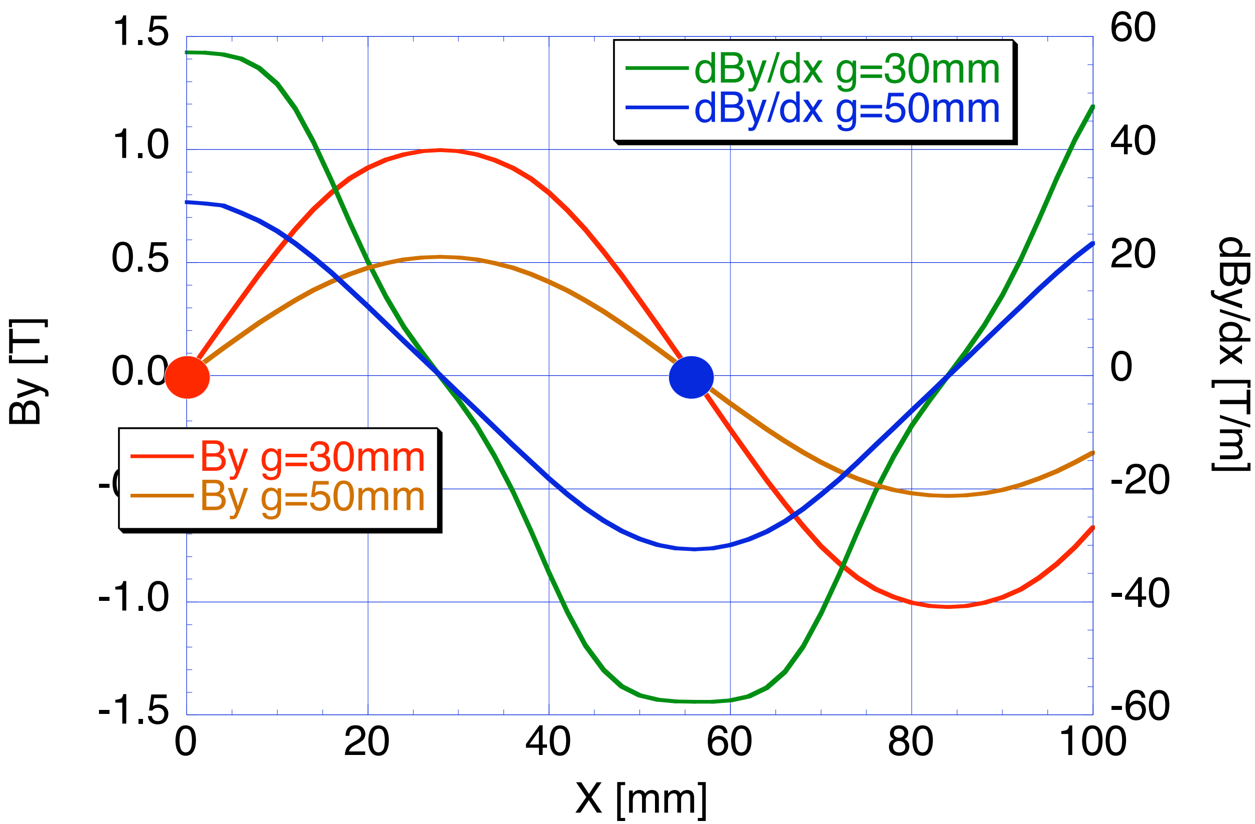
Crossing angle [mrad]	0	2	20
Outer Diam. [mm]	180	180	100
Max. Gradient [T/m]	18 0	130	120
Min. Gradient [T/m]	-20	-60	8

Direct extension

Difficult:
less adjustability and stray field at extraction line





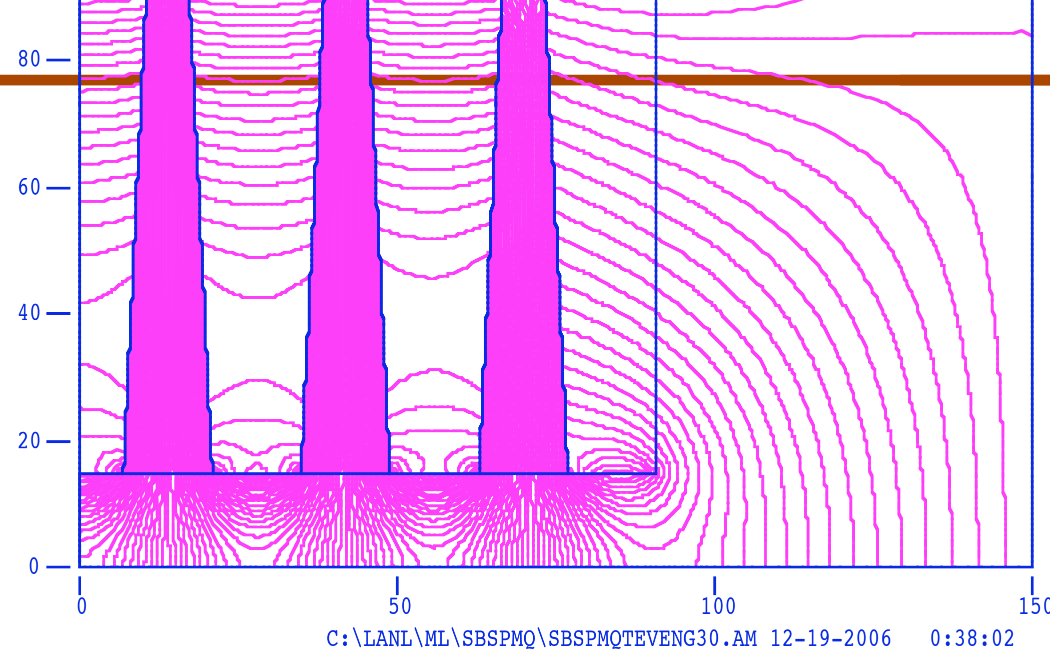


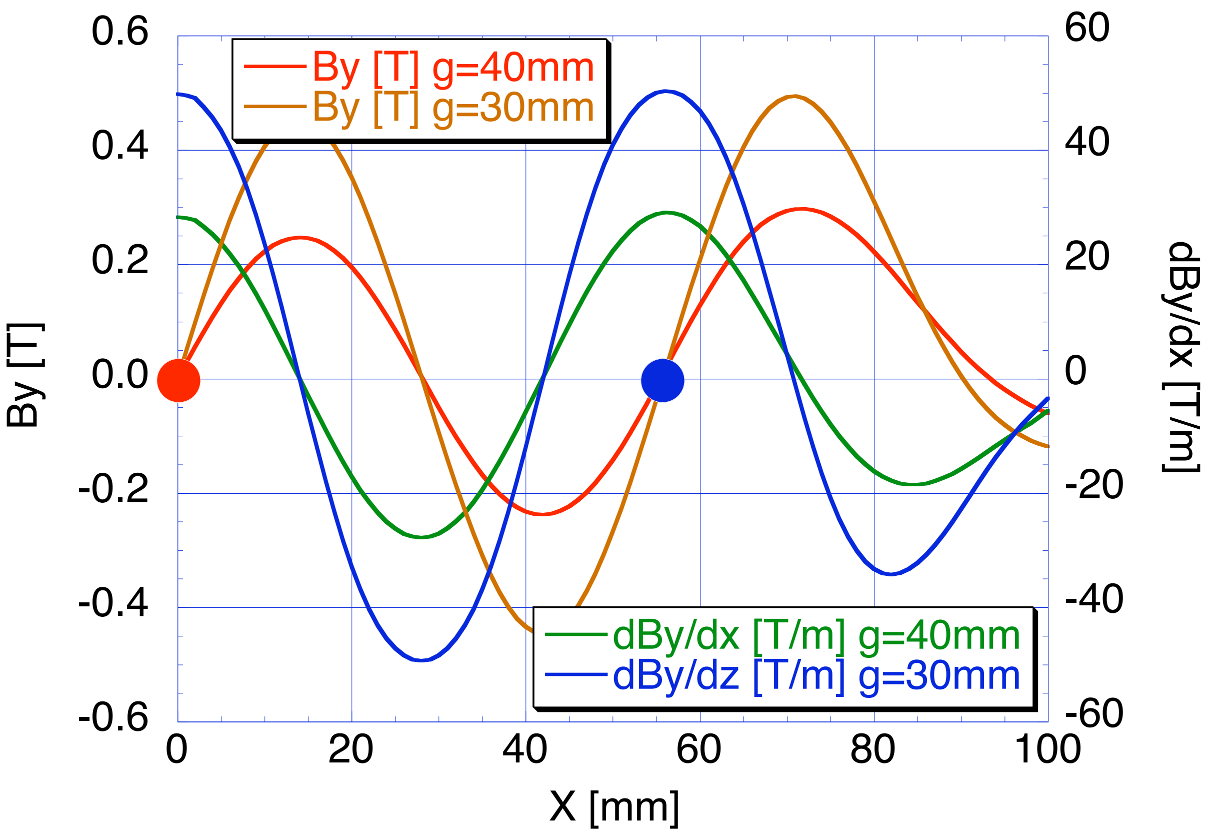
Side by Side Quad

D for incoming
F for outgoing

Strength can be reduced by opening the gap.

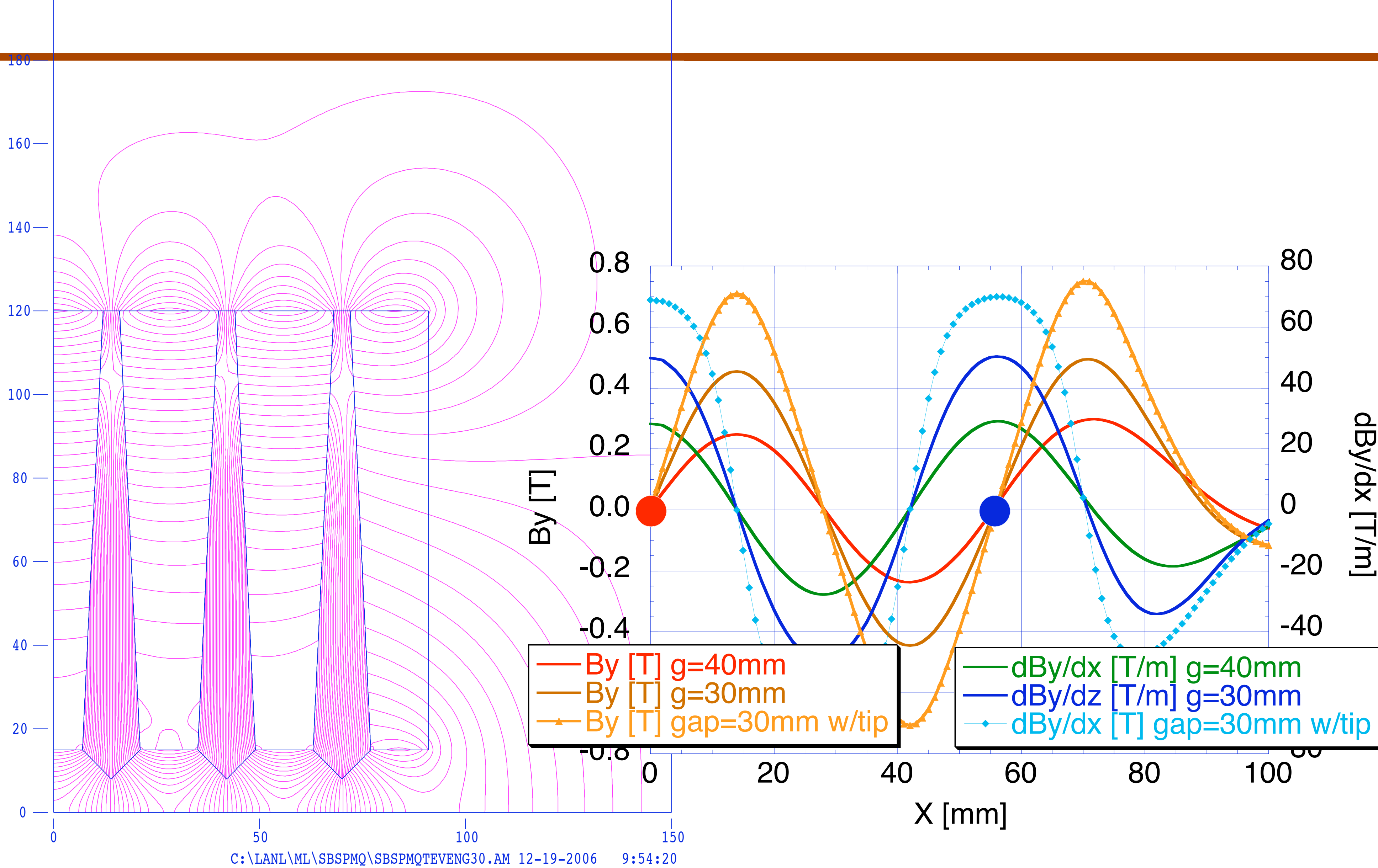
Side by Side Quad





Both D

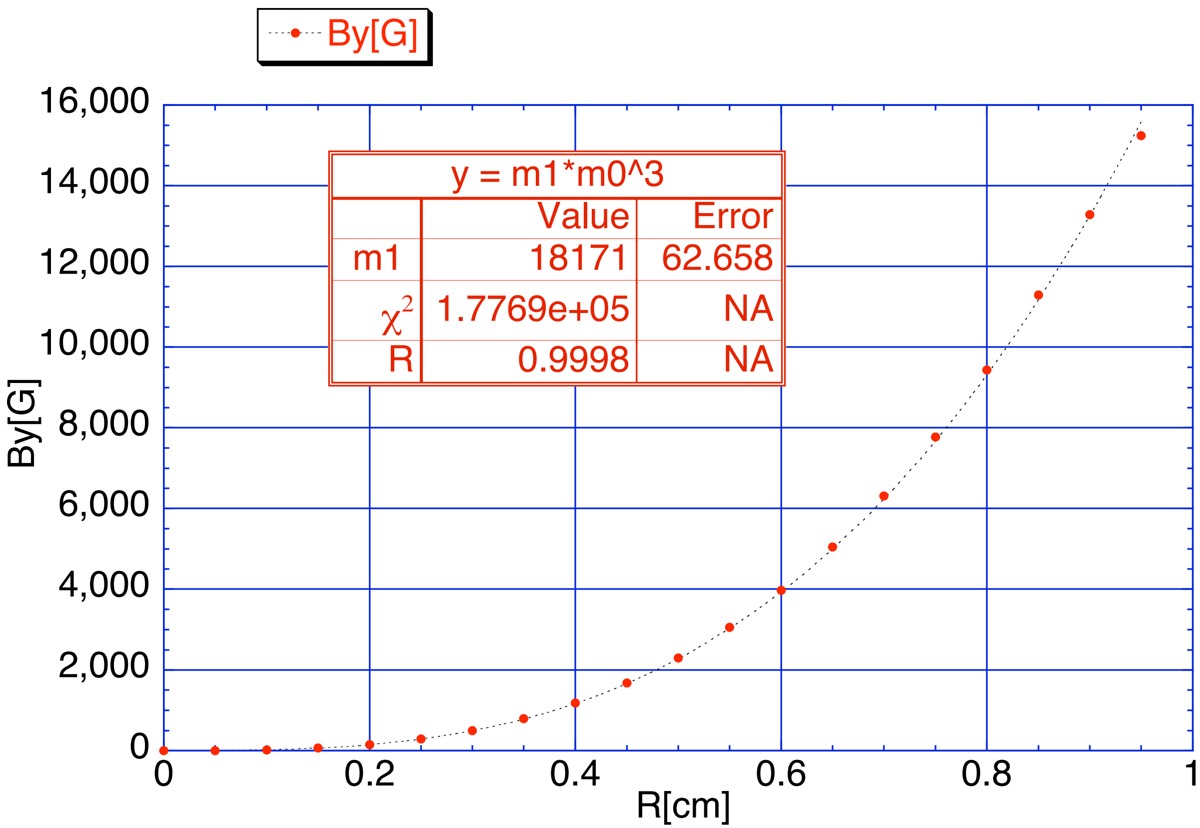
Strength can be reduced by opening the gap.

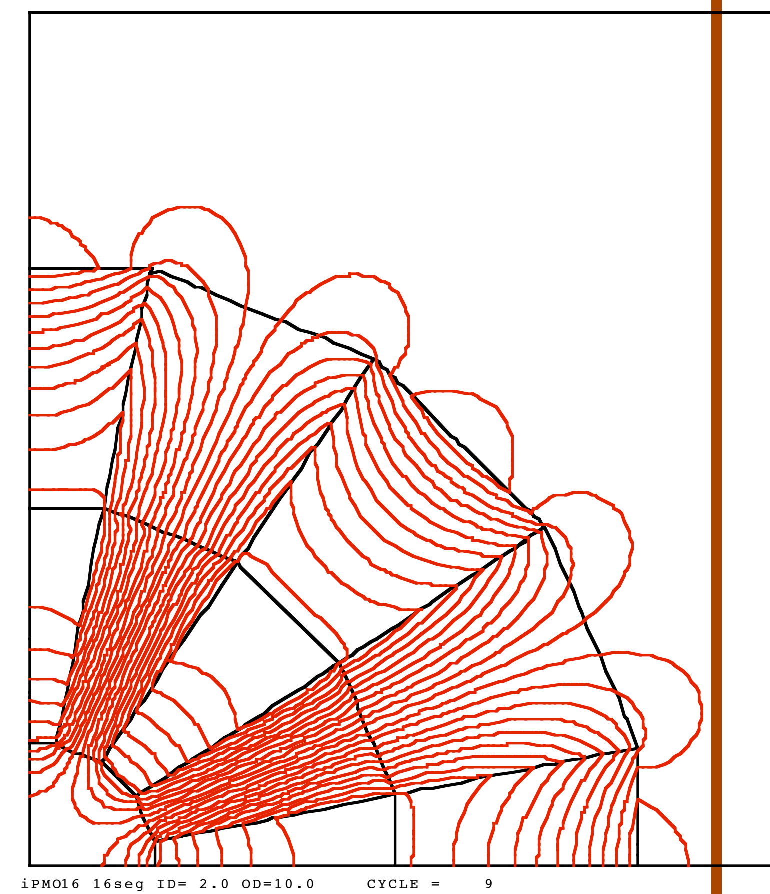


70T/m @ ø30mm

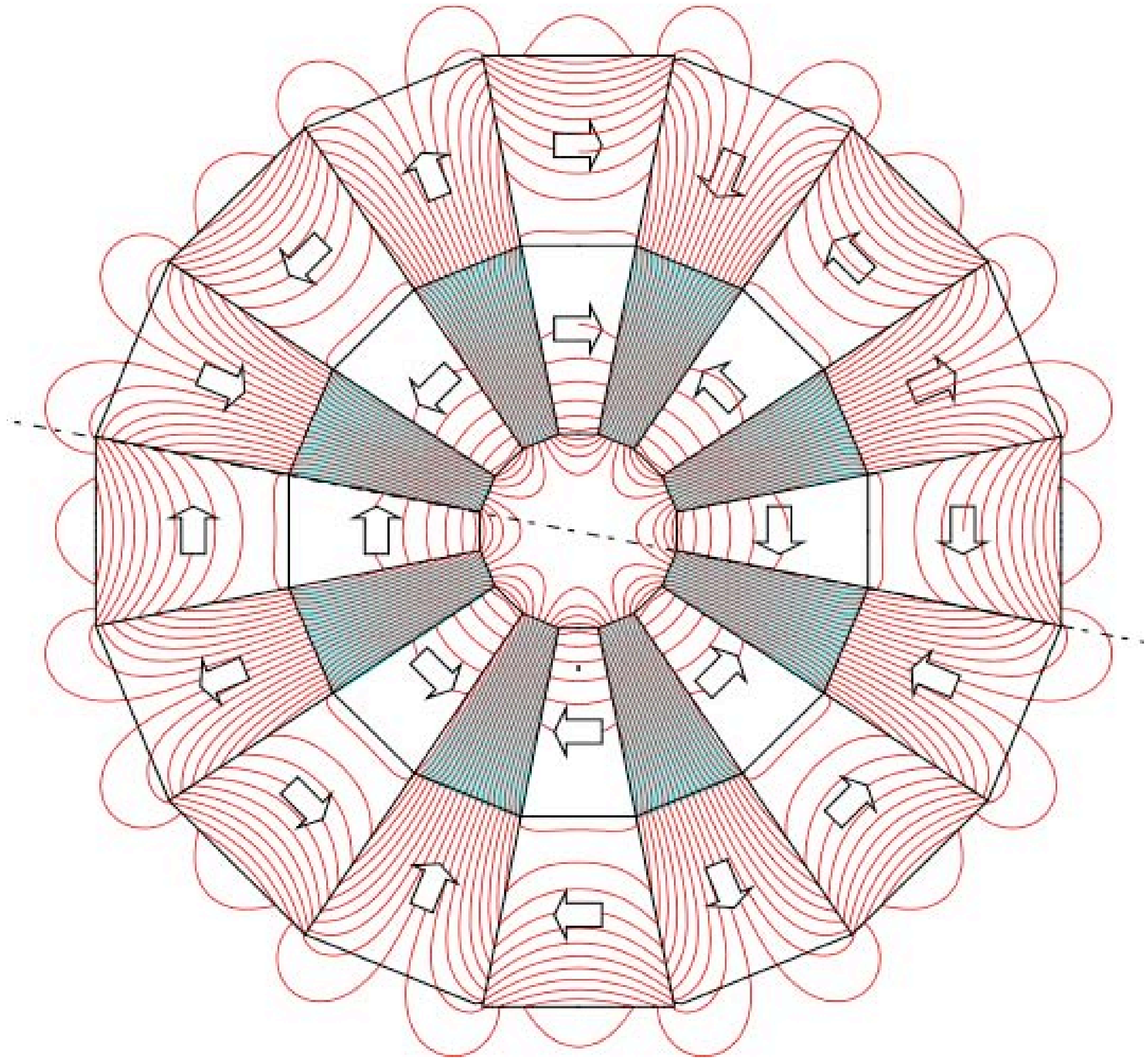
Octupole components tolerable?

PMO (octupole)





Two-piece configuration to dismount.



Summary

- Almost done with the first adjustable model.
- Baseline changed to 14 mrad...
- Fabricate third model
  — may be tested in ATF2
- Side by Side usable?
- Octupole for halo folding?

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