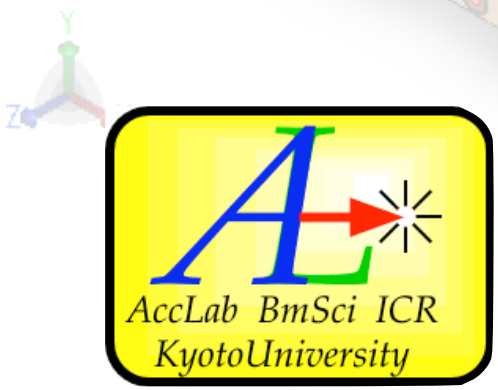
Permanent magnet Final Focus Quadrupole for ATF2

Y. Iwashita, T.Sugimoto,
M.Ichikawa, Y.Tajima, M. Yamada
Kyoto U.



ACCELERATOR LABORATORY
ADVANCED RESEARCH CENTER FOR BEAM SCIENCE
INSTITUTE FOR CHEMICAL RESEARCH
KYOTO UNIVERSITY

Permanent Magnet Study Short History

2002~2005 First R&D program for FFQ

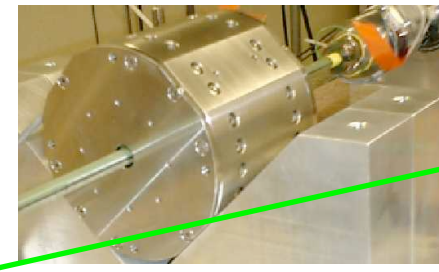
Permanent Magnet Quadrupole for Final Focus Lens in a Linear Collider

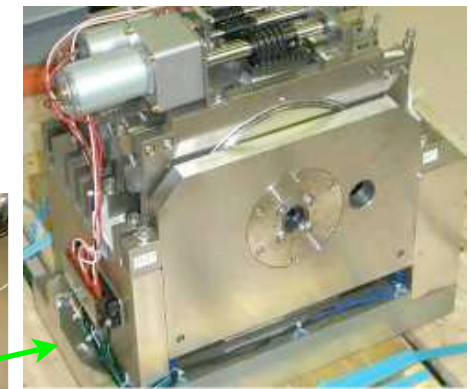
2002 Fixed strength PMQ

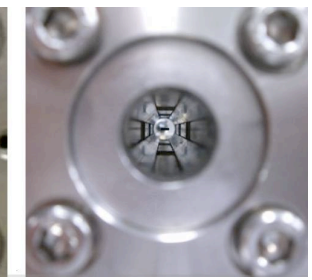
2003 Adjustable PMQ (double ring)

2004 Measurement and fine tuning

2005 Higher gradient at small bore







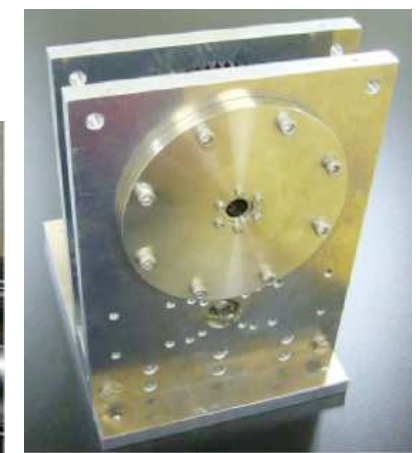
2006~2009 Second R&D program

Development and Application of PMQ for Linear Collider and Neutron optics

2006 Half scale Model of Rapid Cycling Sextupole

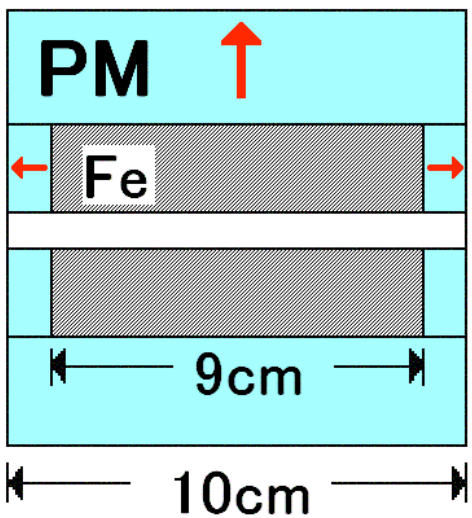
2007~Adjustable PMQ (2nd model)

2008 ...

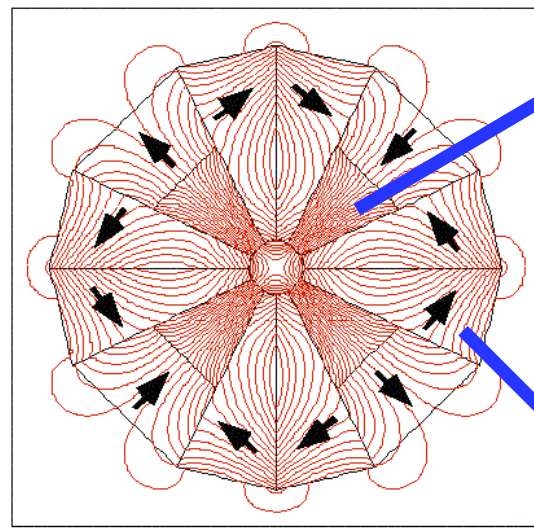


AccLab BmSci ICR KyotoUniversity

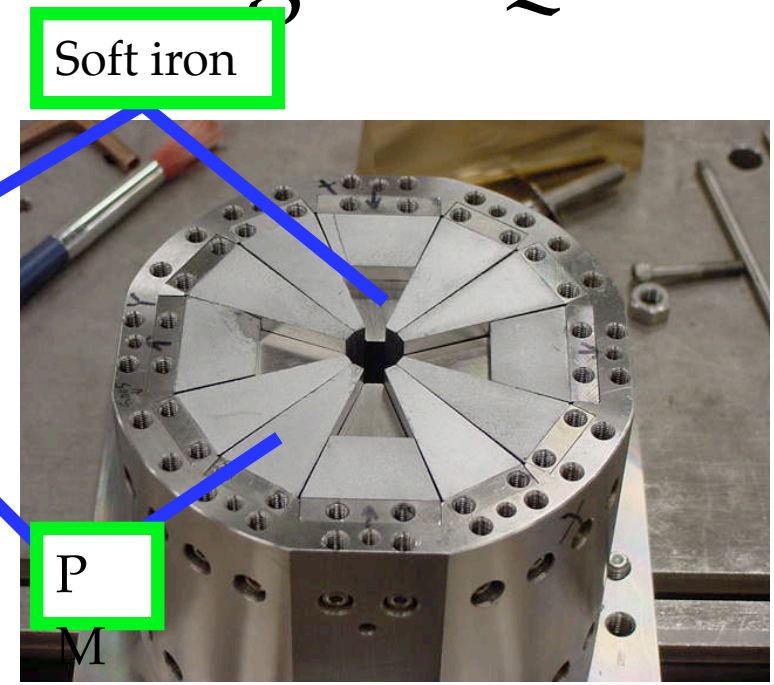
The first prototype of "superstrong" Permanent Magnet Quad.



Cut plane view



Axial view



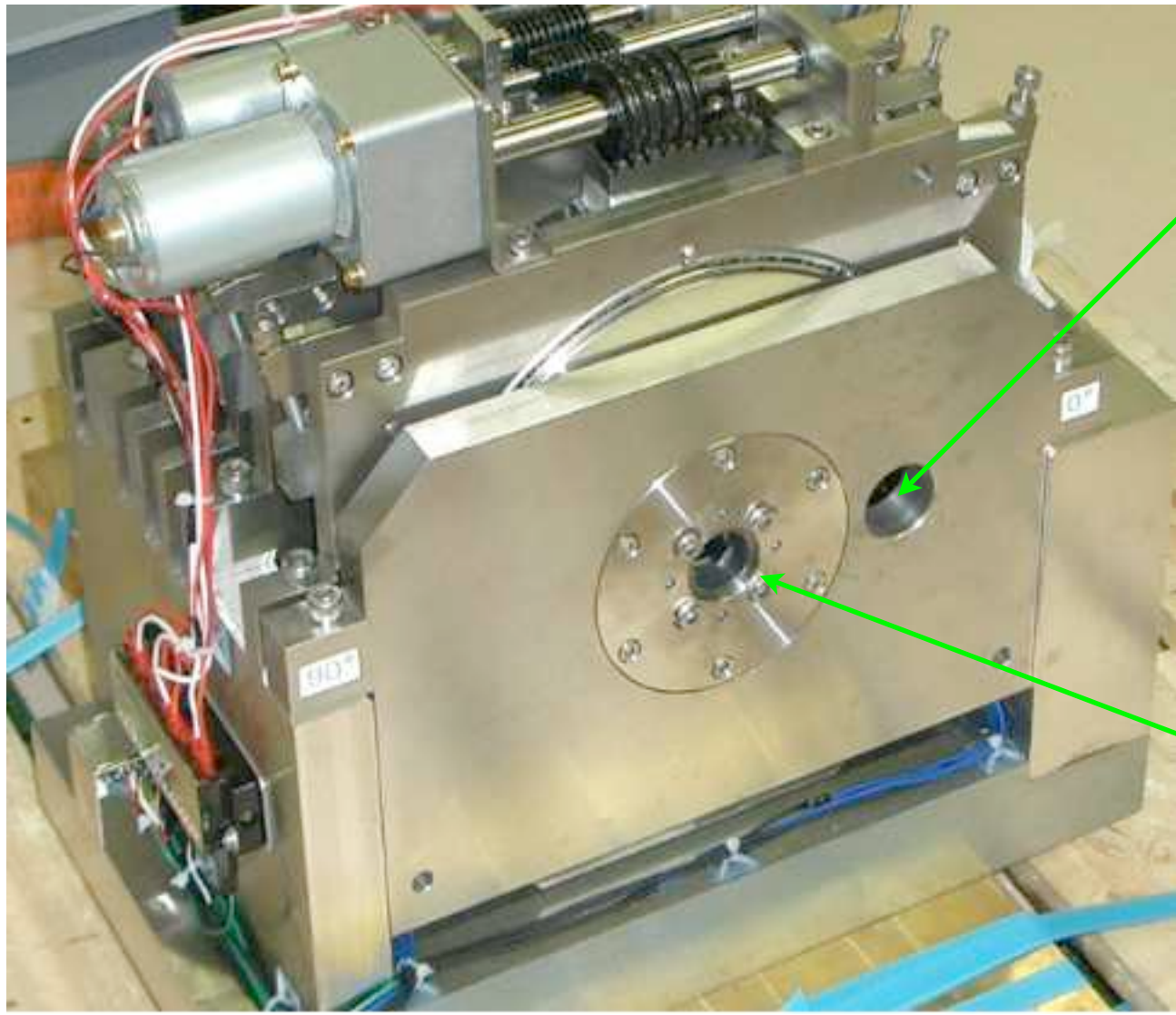
PHOTO

Integrated gradient GL=28.5T (29.7T by calc.)

magnet size.	ø10cm
bore	ø1.4cm
Field gradient	~300T/m

$$GL = \int \frac{dB}{dr} dz$$

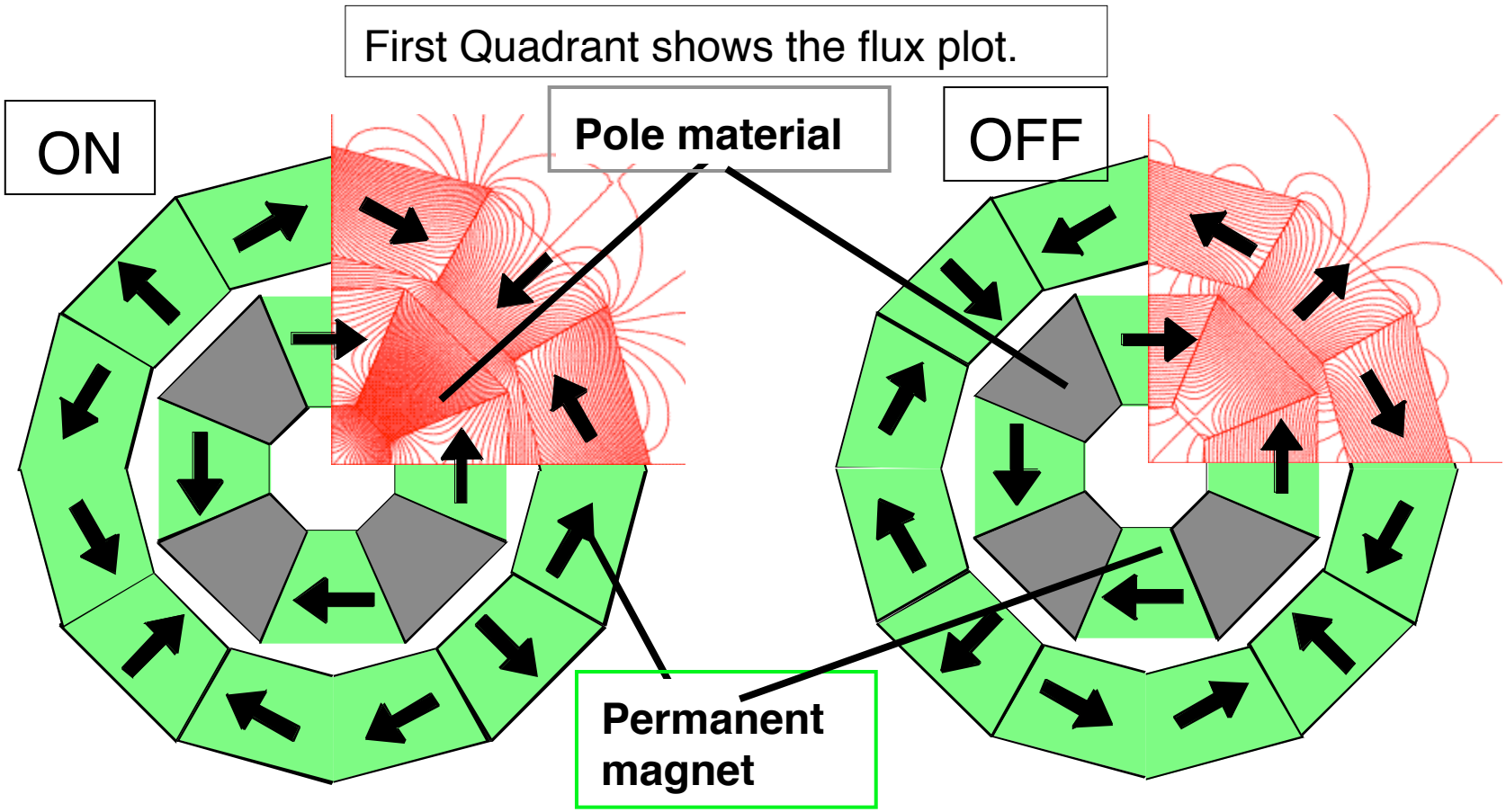
The 20mr Variable FFQ Magnet



hole for outgoing beam

hole for incoming beam

Double Ring Structure

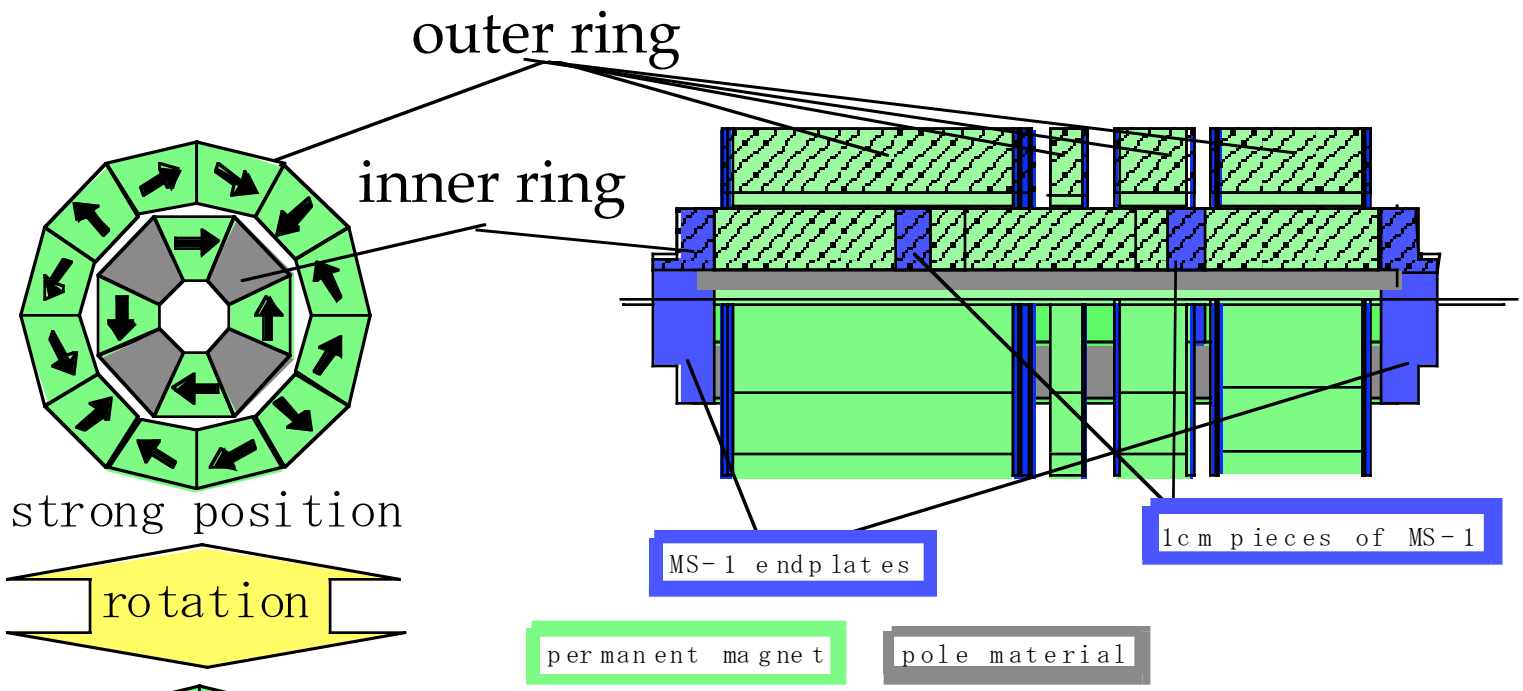


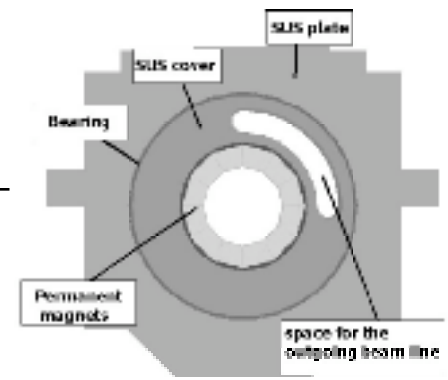
The double ring structure

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.

AccLab BmSci ICR KyotoUniversity

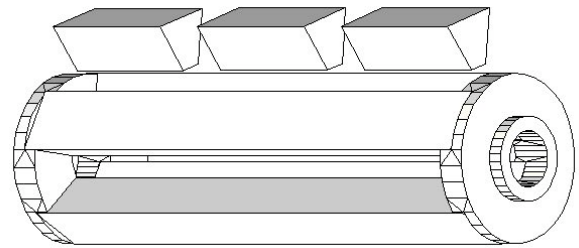
Adjustable Permanent Magnet Quadrupole





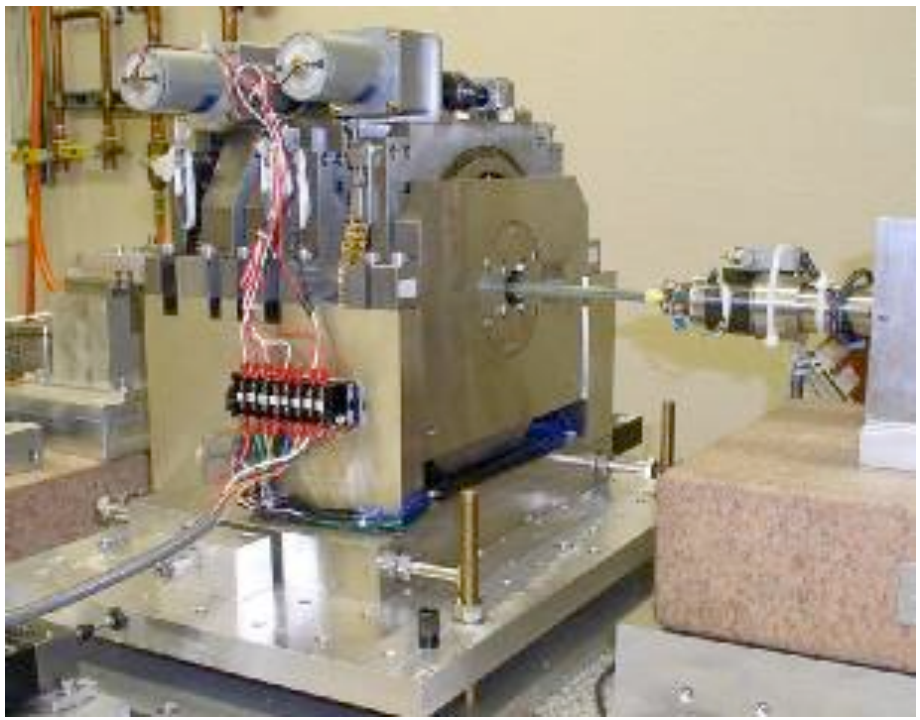
The PMQ is composed of an inner ring and four outer rings (Double Ring Structure). Only the outer rings are rotated in order to change the integrated gradient. The fixed inner ring suppresses any errors caused by rotation of outer rings.

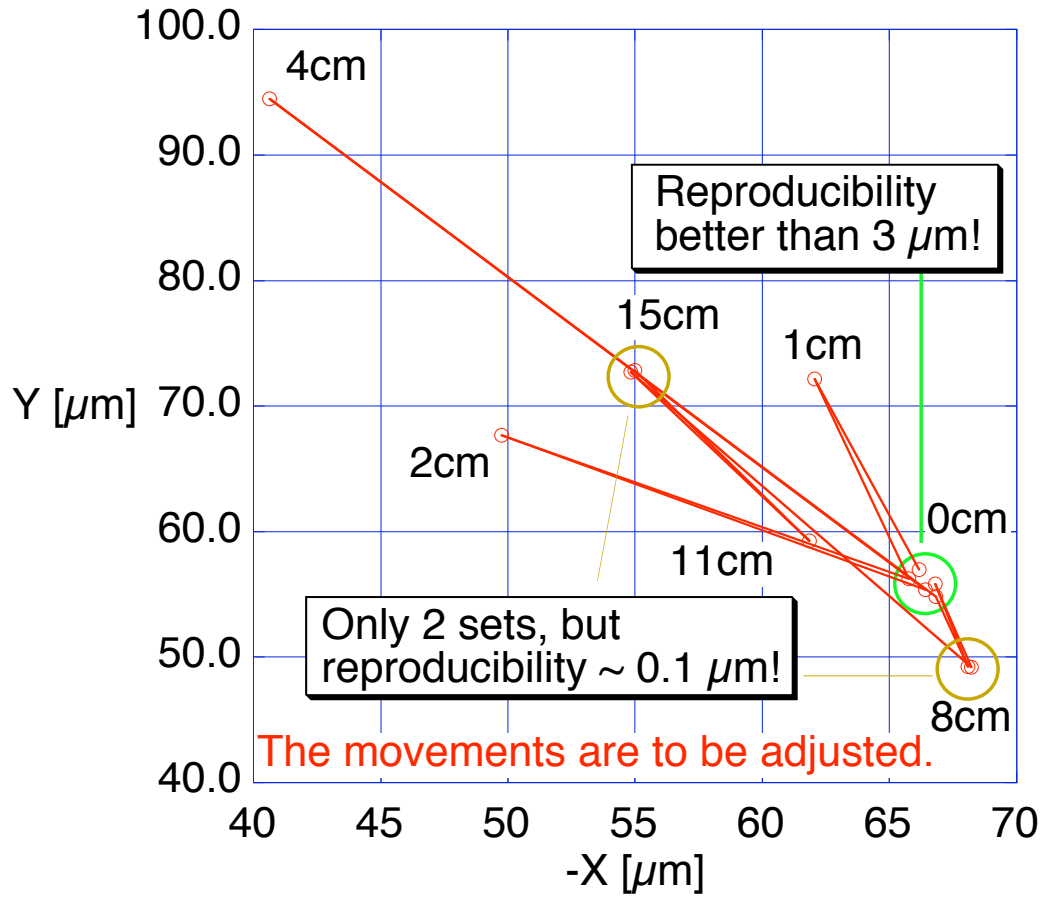
Permanent Magnet
(NEOMAX38AH)



AccLab BmSci ICR KyotoUniversity

Magnetic Center Movement





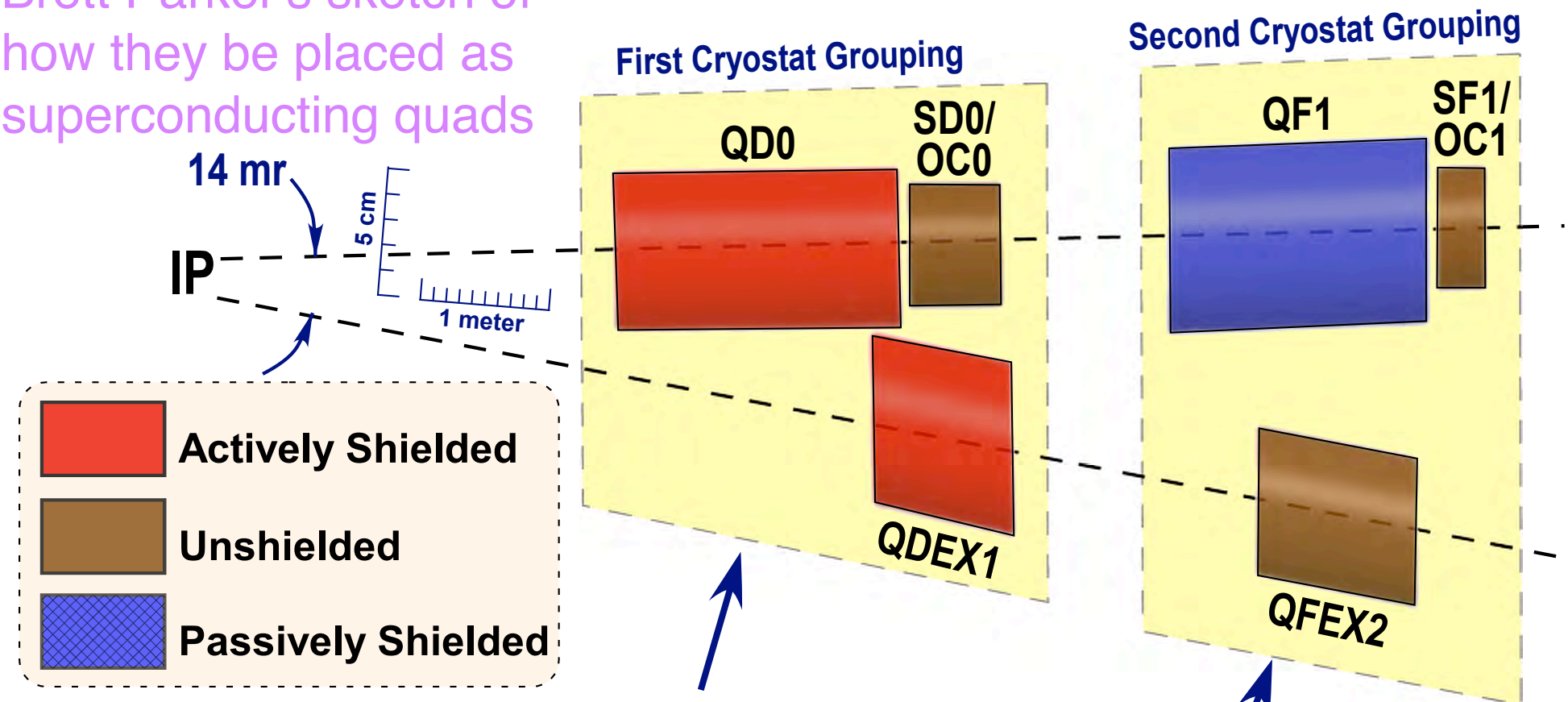
The cm values show the Switched-On-Length

The center moves several μm for 20% strength change.

See http://accelconf.web.cern.ch/AccelConf/l04/PAPERS/TUP81.PDF (LINAC'04)

Post Valencia 14 mr Magnet Layout Compatible with Push-Pull

Brett Parker's sketch of how they be placed as superconducting quads

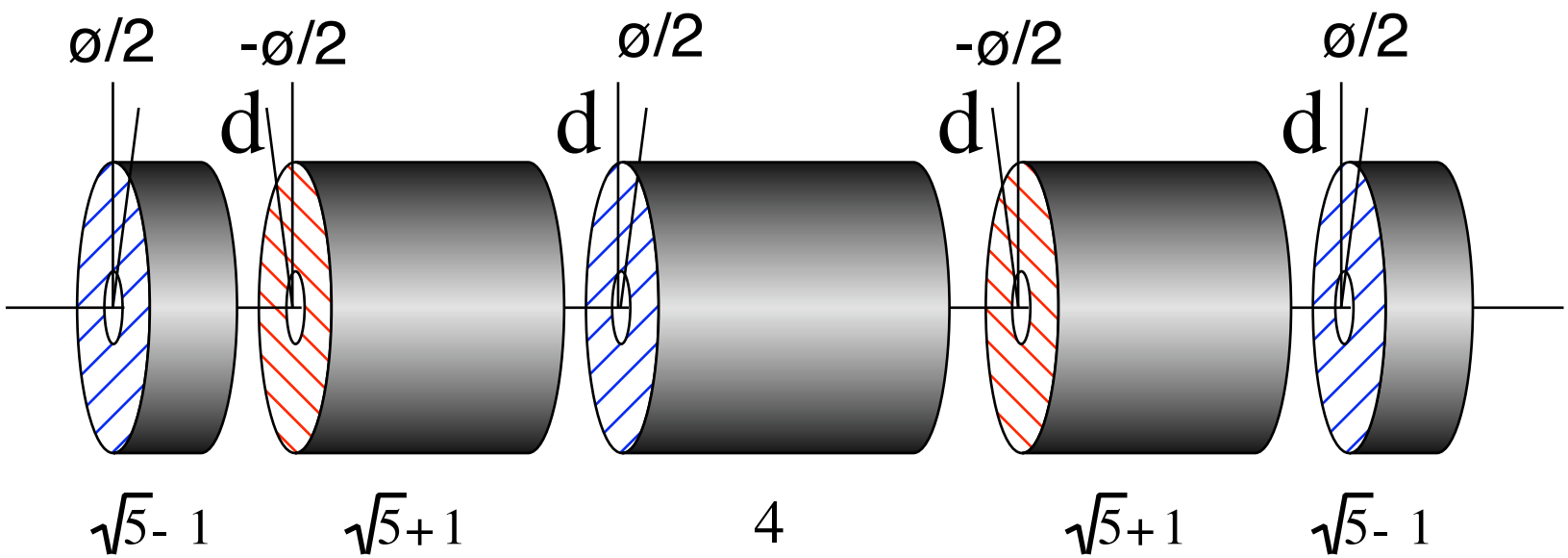


One of these magnet groups is needed in both ends of each detector (move with experiment, not shared).

One of these magnet groups is needed on each side of the common push-pull IR hall (fixed position, experiments share).

For actively shielded coils the shield is run in series with the main quadrupole current but with a trim circuit shunt power supply for fine adjustment.

Gluckstern's skewless variable PMQ



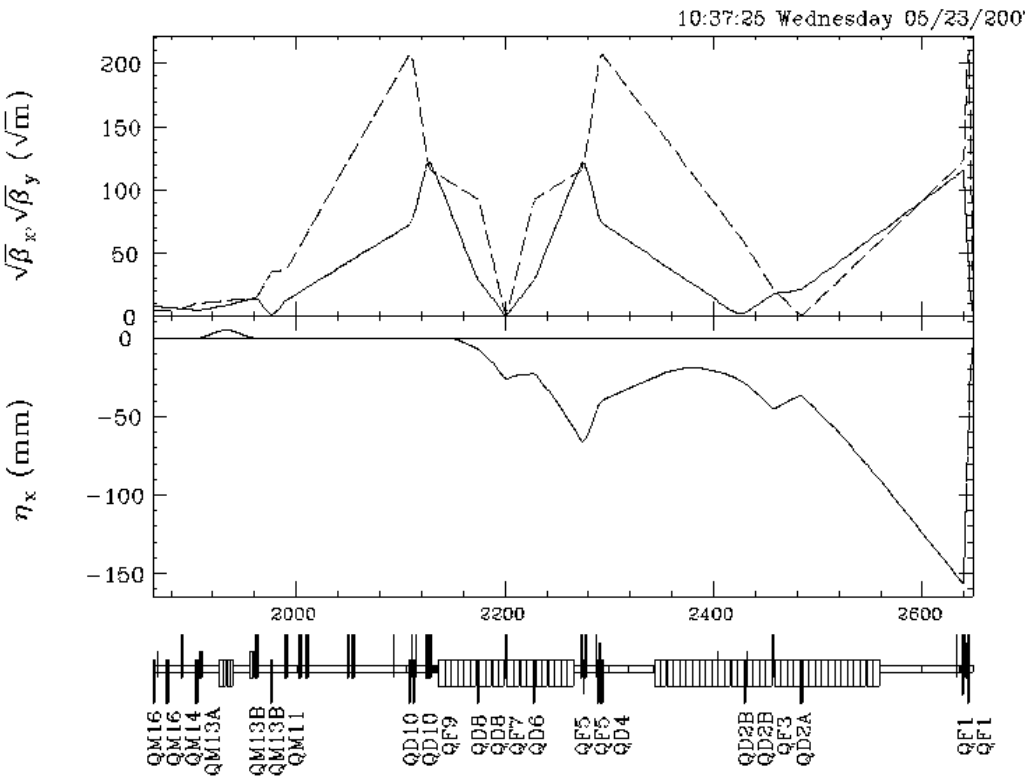
$$M = R \bullet M2 \bullet R^{-2} \bullet M1 \bullet R^{2} \bullet M0 \bullet R^{-2} \bullet M1 \bullet R^{2} \bullet M2 \bullet R^{-1}$$

4x4 matrix: $M=\begin{pmatrix} Mxx & O^5 \\ O^5 & Myy \end{pmatrix}$ when d=0.

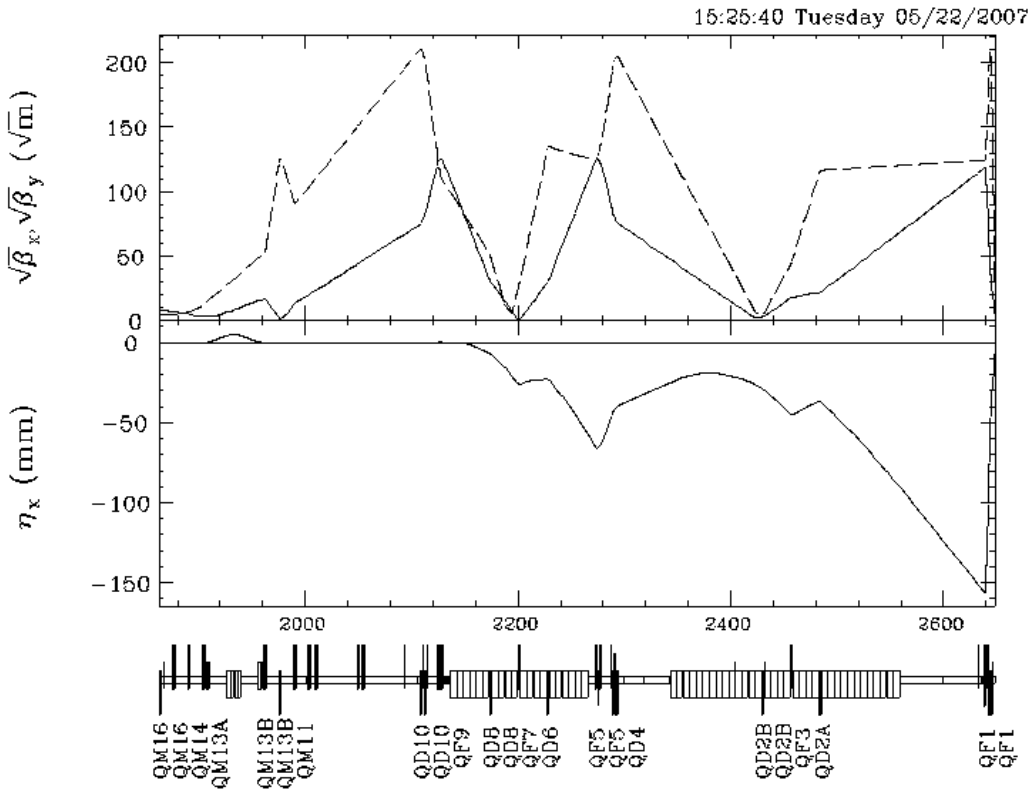
R.L. Gluckstern and R.F. Holsinger: Adjustable Strength REC Quadrupoles, IEEE Trans. Nucl. Sci., Vol. NS-30, NO. 4, August 1983, http://epaper.kek.jp/p83/PDF/PAC1983_3326.PDF

Optics with Permanent Q

Original optics



Optics with permanent QD0



Optics with permanent QD0 is somewhat ugly.

Need to restore symmetry around the B section of s ≈ 2200m?

Optimization is not perfect

(e.g. Octupole magnets were not touched...).

Need someone to complete the design.

deck file is available at SAD computer:

'/users/kuroda/sad/jlc/ilc2006b.ebds1ForPMQ'

636/5.25nm (original)

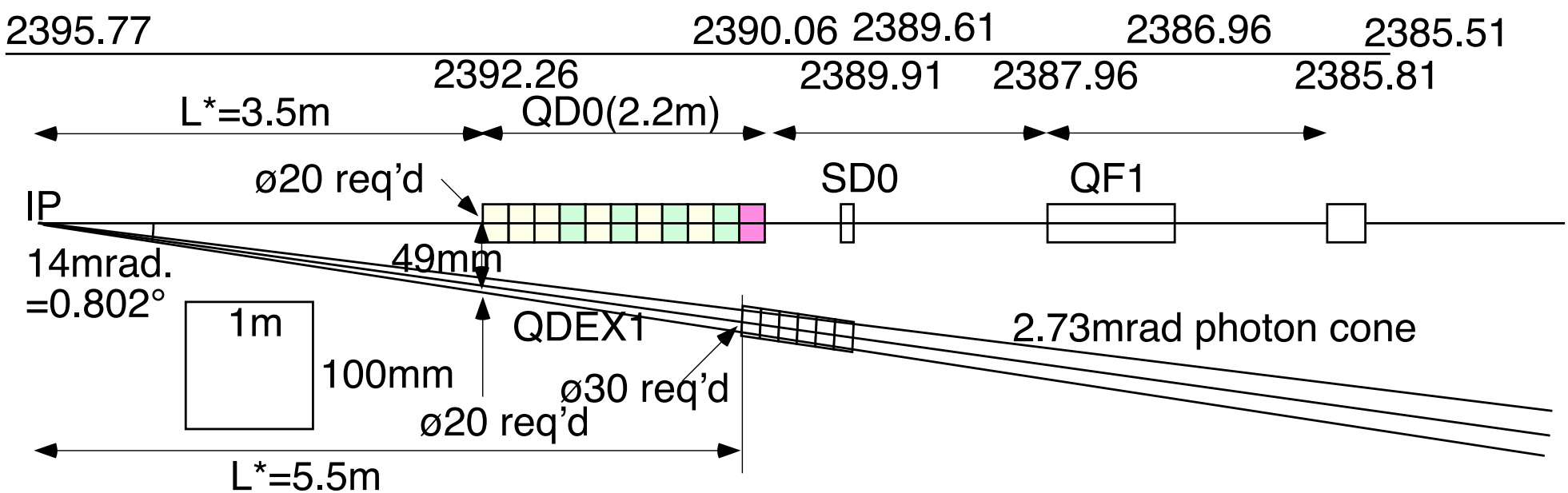
-- >

655/5.44nm

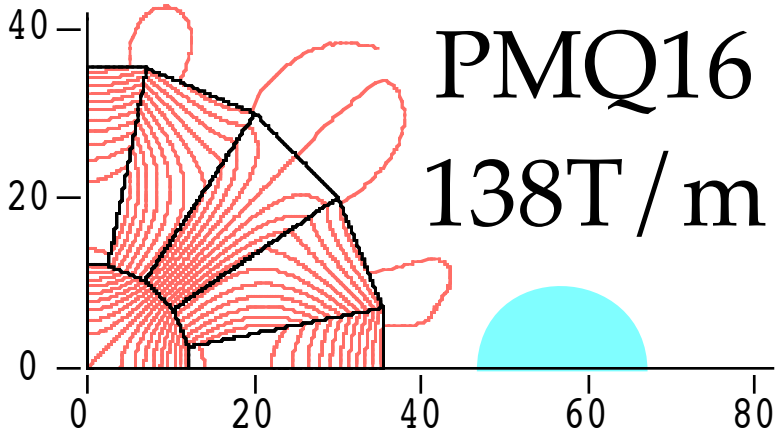
by S. Kuroda

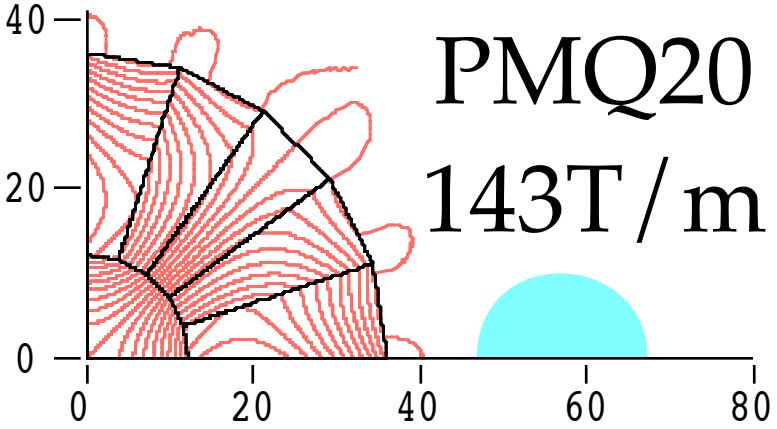
Single Ring Train Configuration

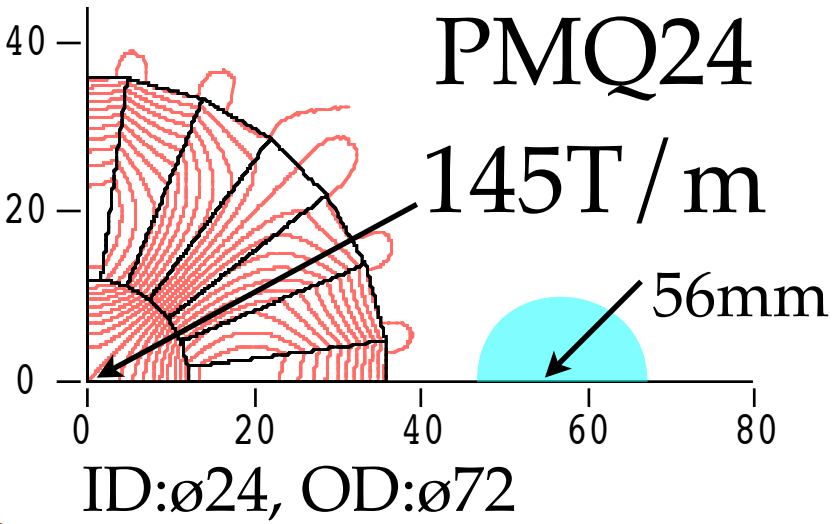
	Eff.L [m]	R [cm]	kG	kG/m	GL [kG]
QF1	2.0	1	8	803	1605
QD0	2.2	1	-14.2	-1416	-3116
QEX1	1.1	1.5	-15.0	-1000	-1060



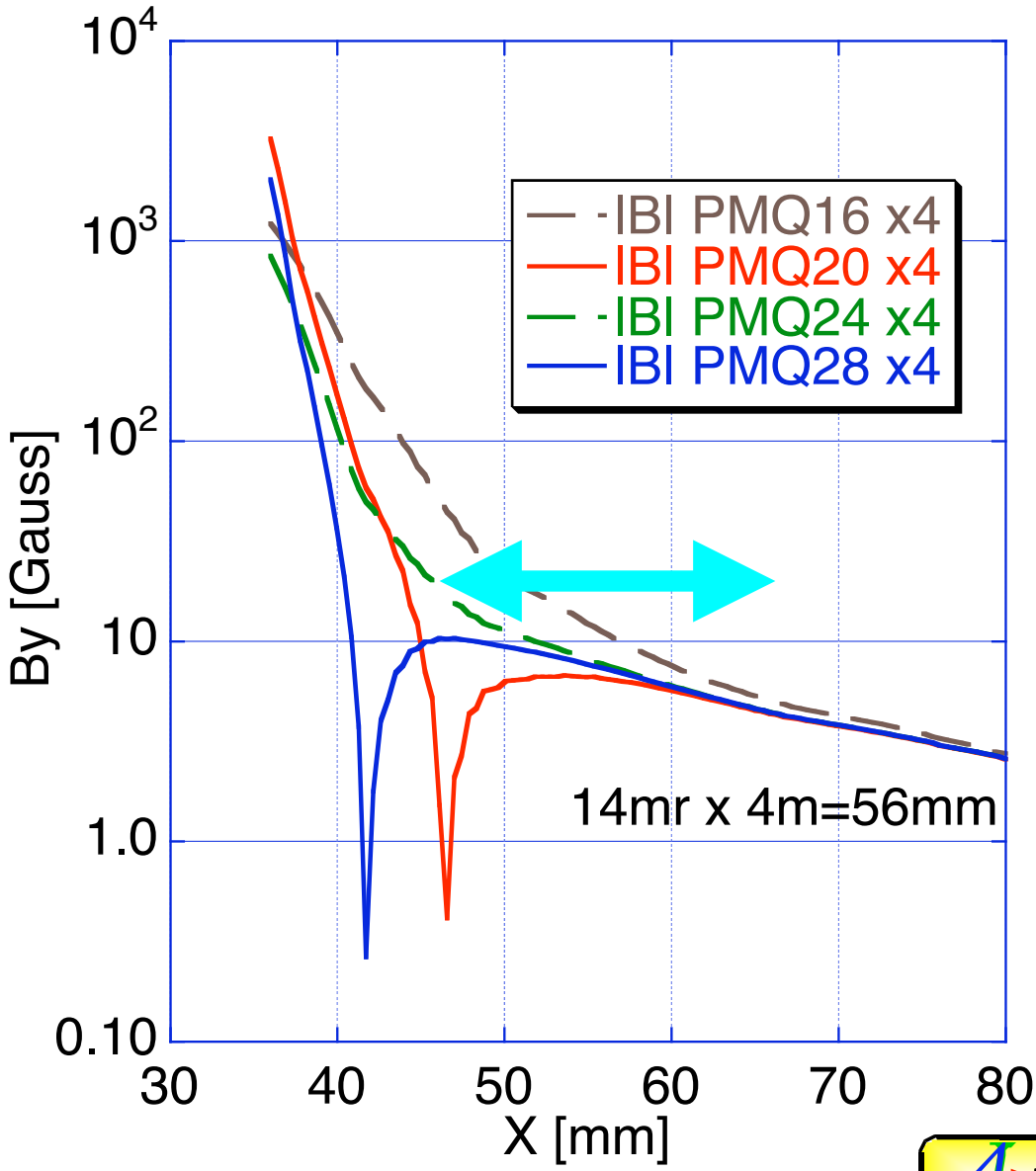
External Field







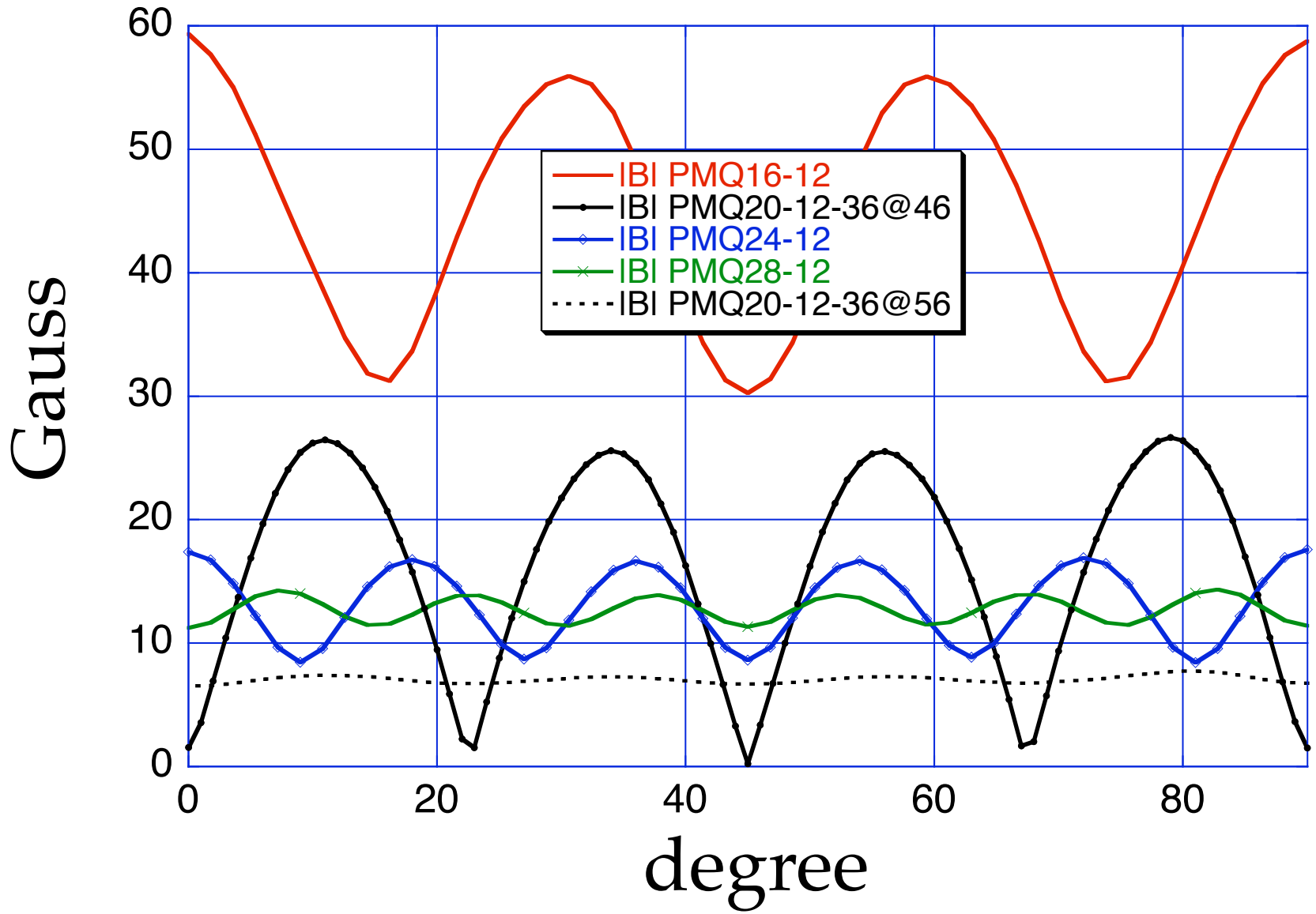
ID:ø24, OD:ø72



AccLab BmSci ICR KyotoUniversity

External Field

Absolute Value Around the Magnet



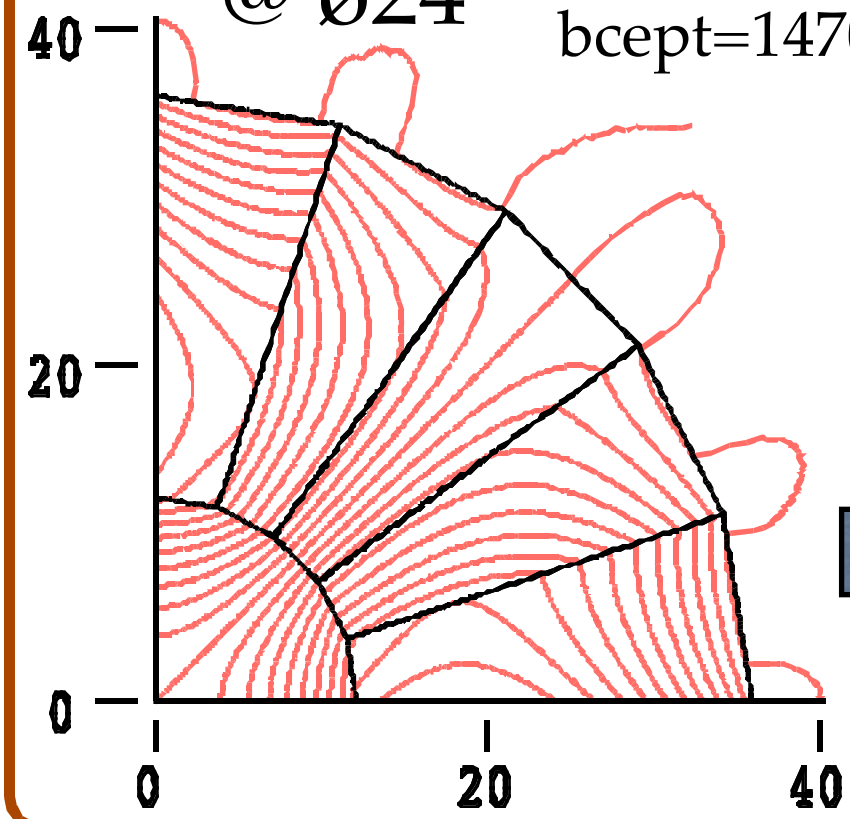
AccLab BmSci ICR KyotoUniversity

Test at ATF2?

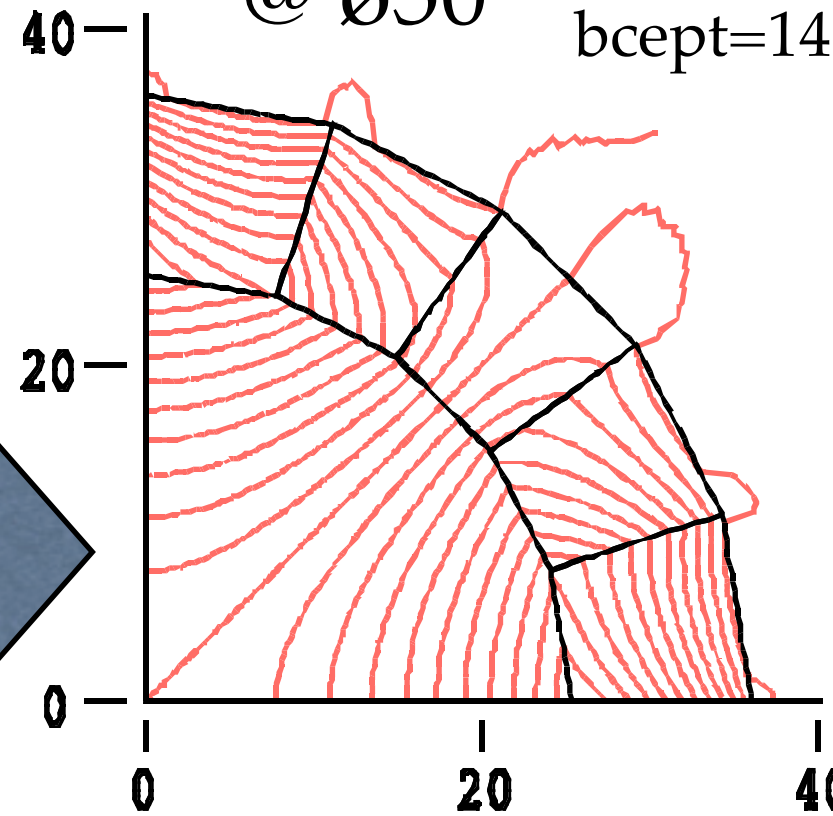
Req'd spec for QD0: L=45cm, ø50mm, G=13T/m

OD: ø72 (=2x(56-20)) 14mr x 4m=56mm

143T/m @ ø24 55AH hcept=-12500, bcept=14700.

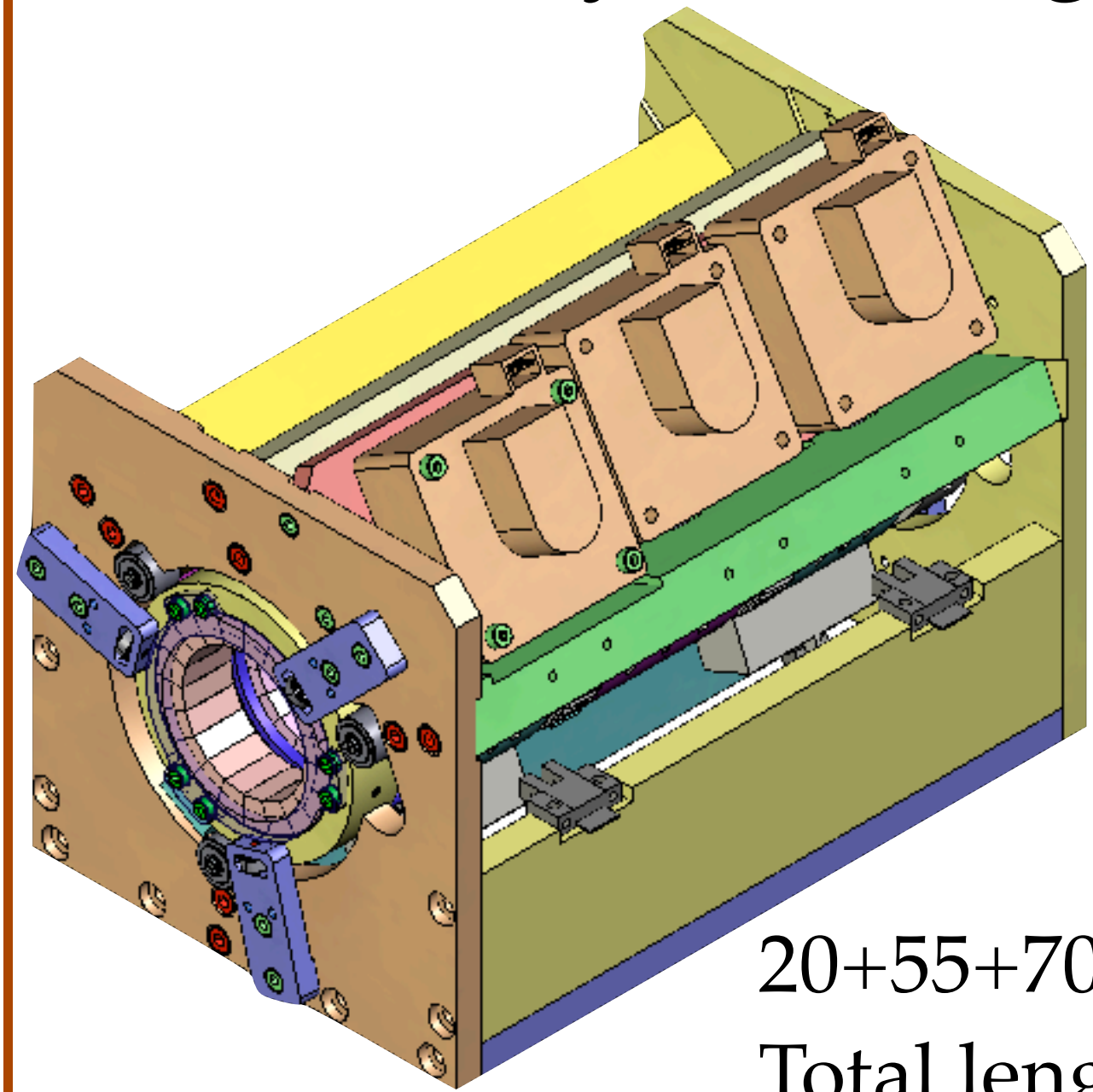


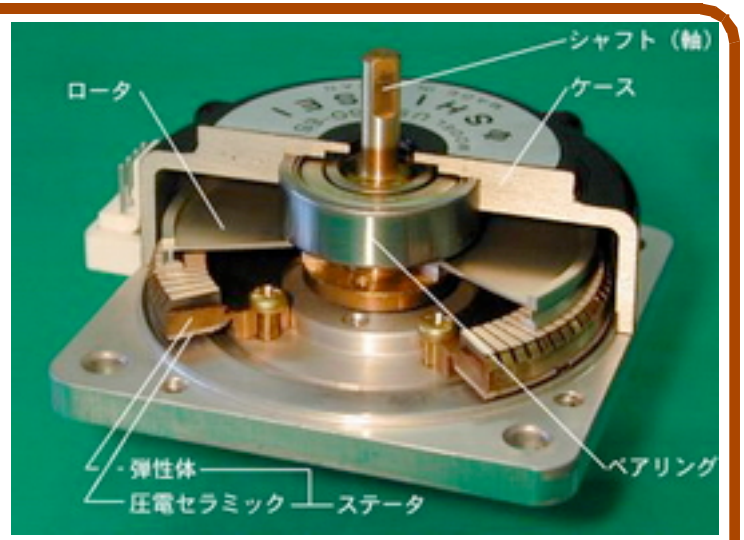
30T/m @ ø50 55AH hcept=-12500, bcept=14700.



AccLab BmSci ICR KyotoUniversity

Preliminary Drawing





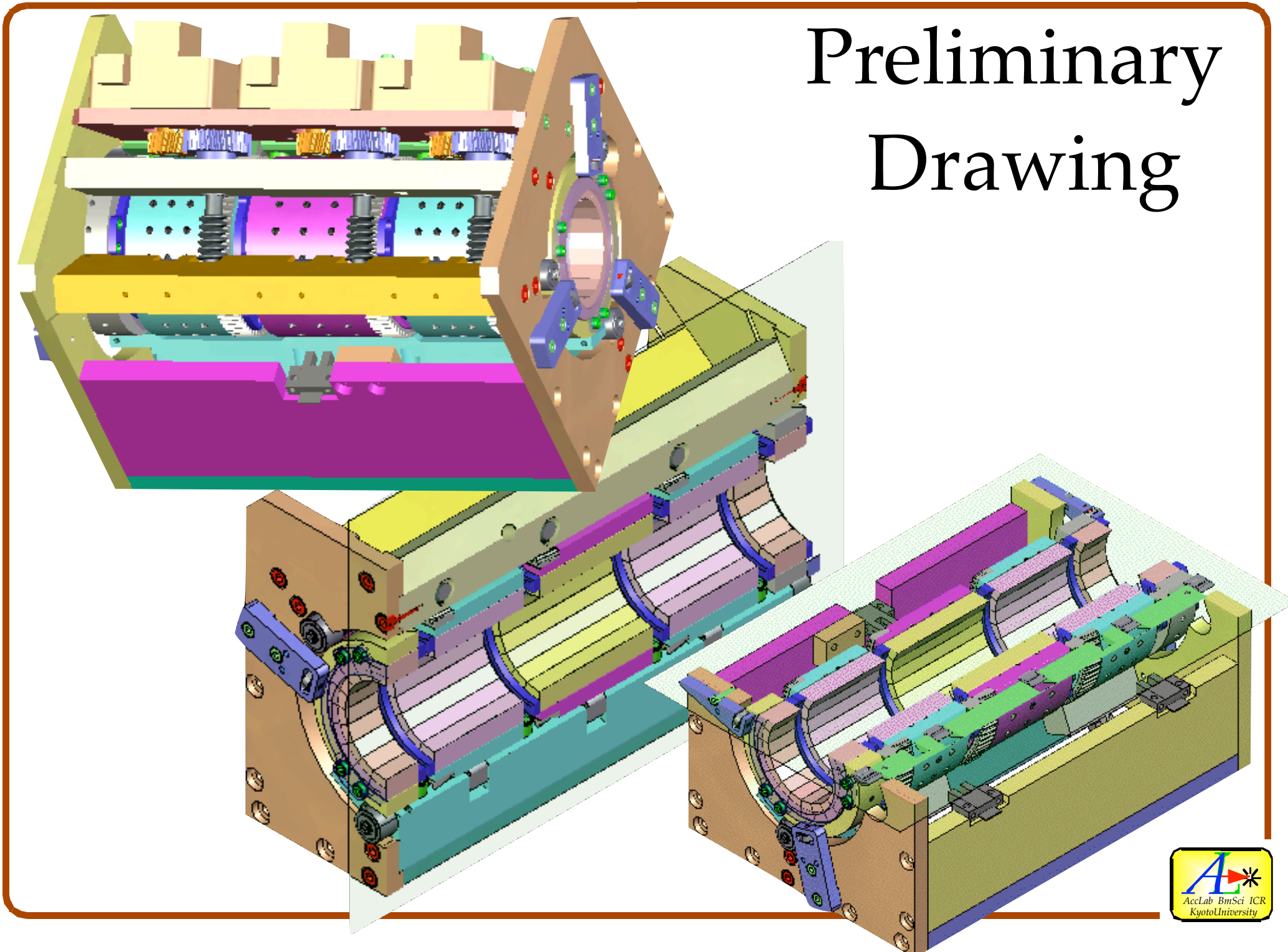
Supersonic Motor (nonmagnetic)

20+55+70+55+20 = 220mm

Total length is 260mm

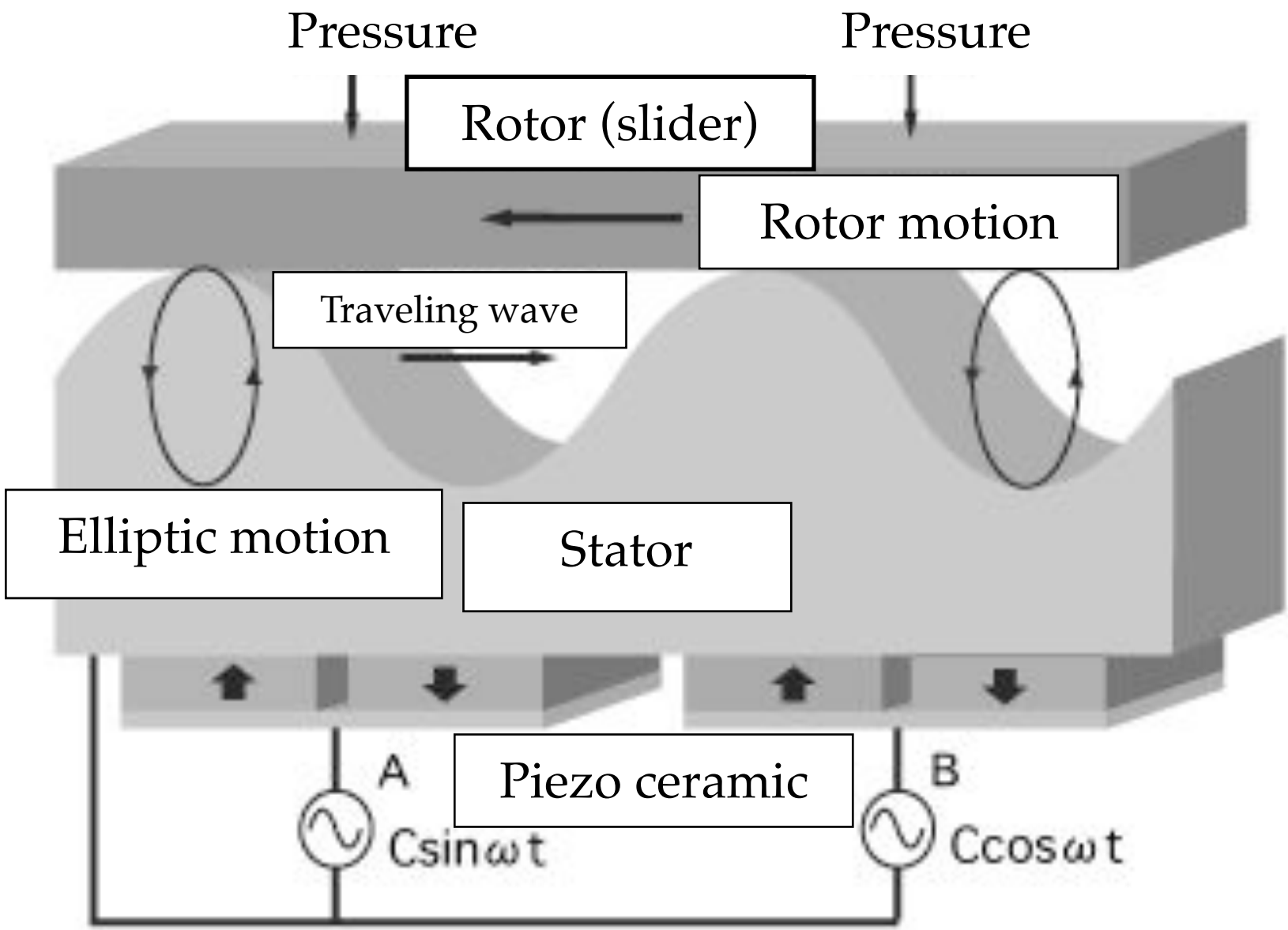
AccLab BmSci ICR KyotoUniversity

Preliminary Drawing

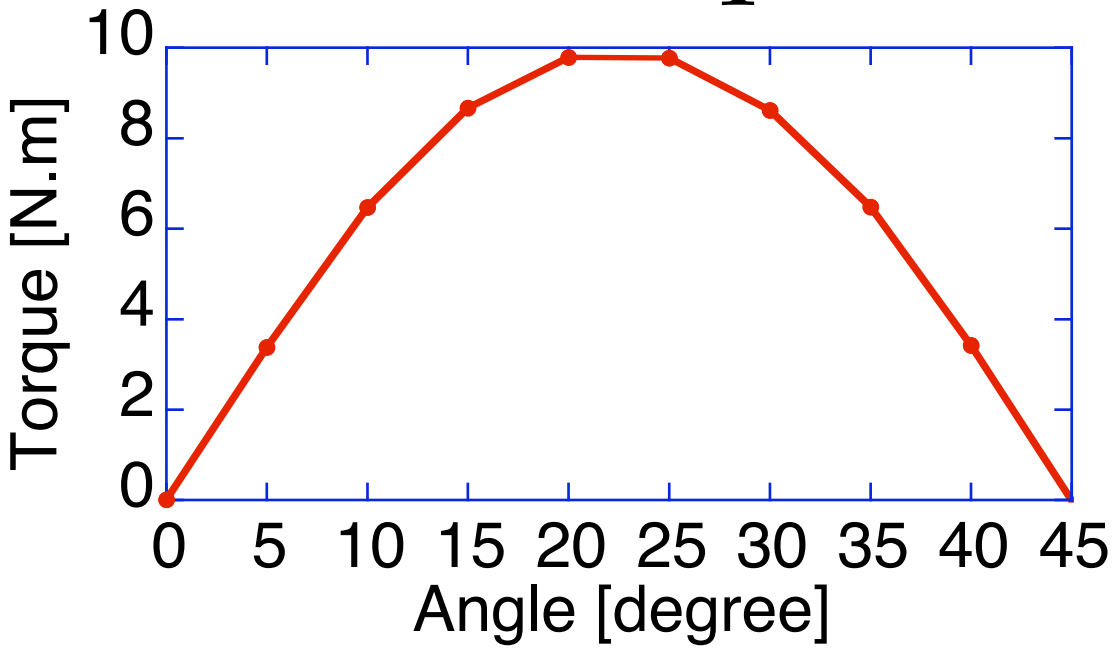


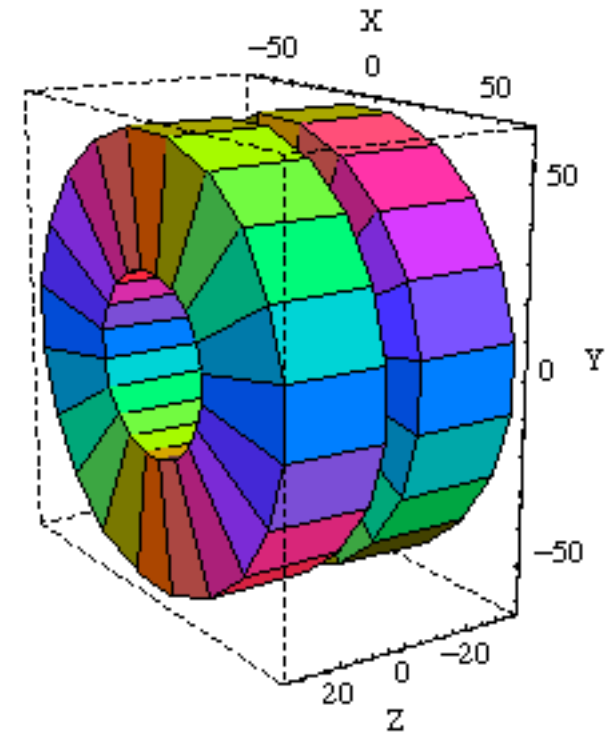
AccLab BmSci ICR
KyotoUniversity

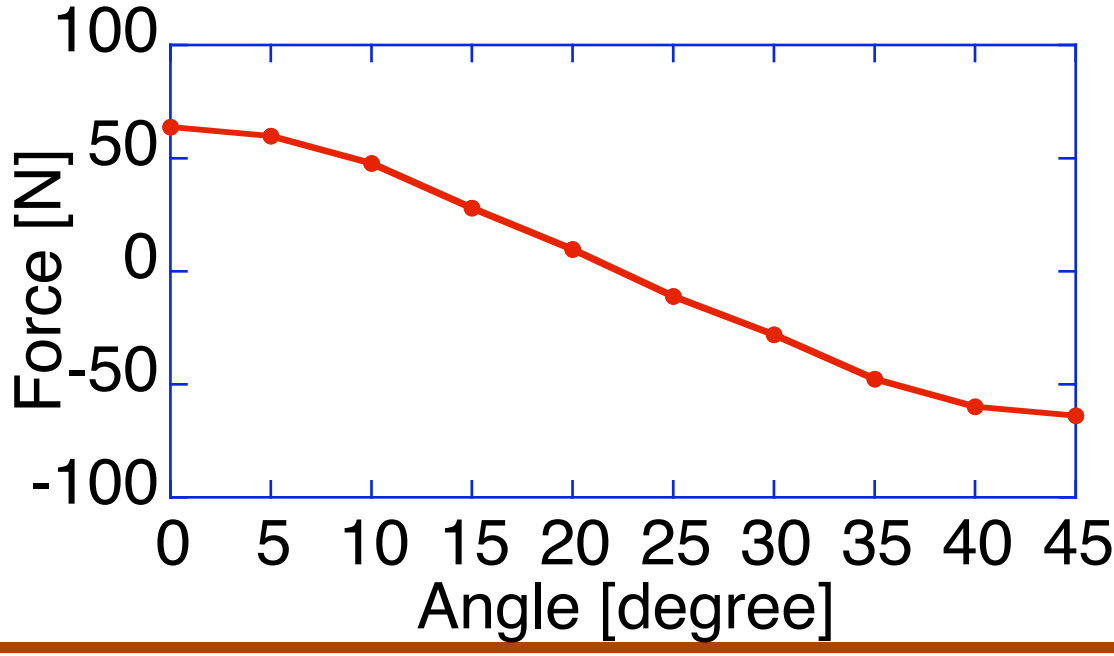
Supersonic Motor (nonmagnetic)



Torque & Force

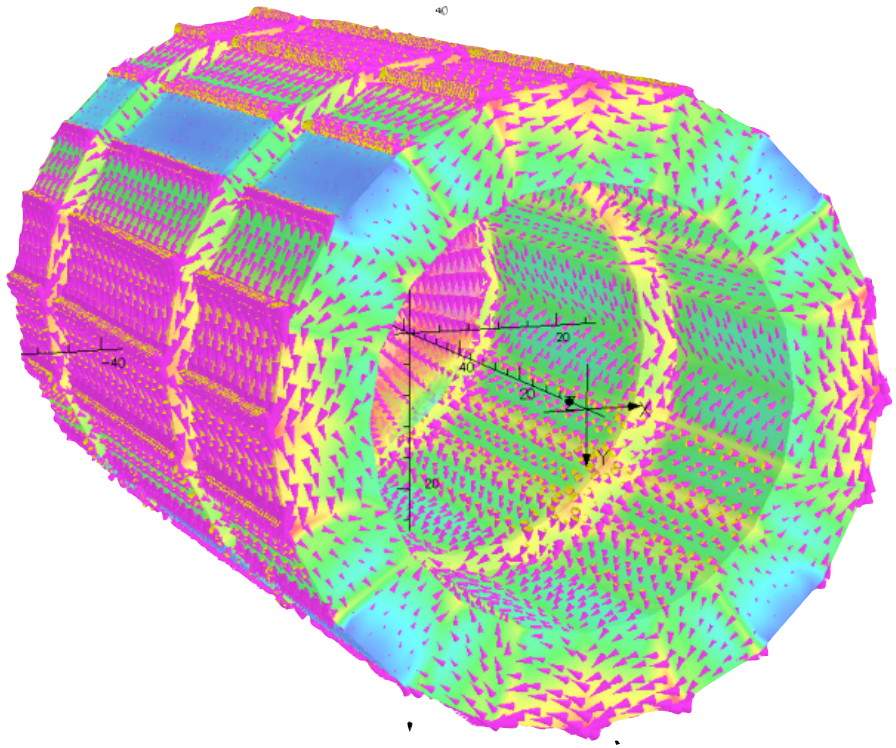




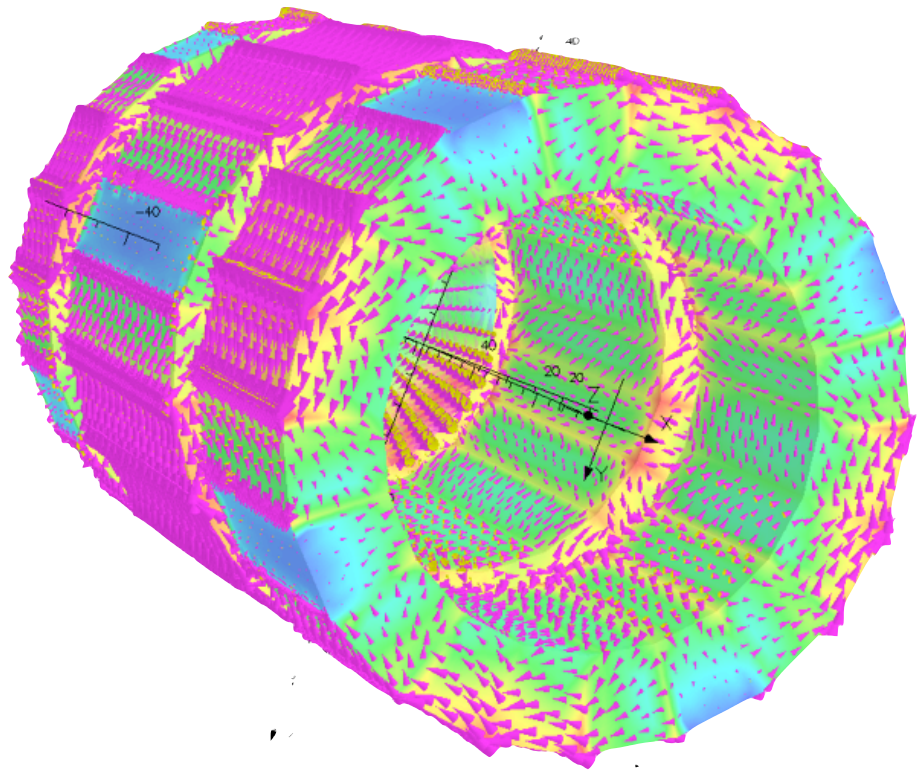


AccLab BmSci ICR KyotoUniversity

TOSCA calculation



0 deg.



±22.5 deg.

AccLab BmSci ICR KyotoUniversity

Summary

- **Quadrupole**
  - 1st variable PMQ was based on double-ring structure (20mr) and evaluated.
  - 2nd one (14mr) will have **5-ring-singlet structure**.

    ➡ *Continuous adjustment, small stray field*
  - There is ***NO VIBRATION SOURCE*** in PMQ.
  - The angle error of a ring is a matter of alignment; three motors may handle this, but how?
  - A prototype will come in this FY (ATF2 QD0?).
- **Octupole for Beam Tail Folding**

AccLab BmSci ICR KyotoUniversity