Issues with PM magnets

nirs m.kumada

with Iwashita,E.Antokhin and SSMC

1. Temperature stability
2. Radiation damage
3. Incorporate vacuum system
4. Variability
5. Interaction with solenoid

- Gradient reduction
- demagnitizatiopn
- DC forces
- Vibration due to mechanical or power related fluctuations of solenoid
   - 6. Toward Stronger FF Q magnet

1.Temperature stability

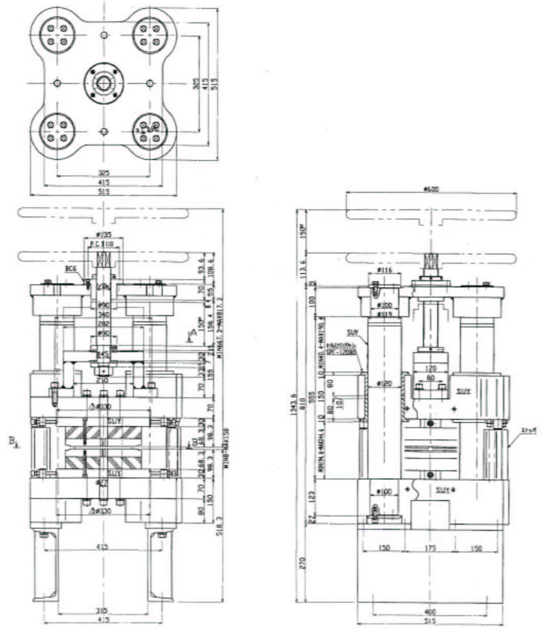
- Naked NdFeB: 0.11 % per degree
- With compensation sub-ppm stability (=**nano stability**) may be challenged!

- Passive compensation
- Thermal insulation(MRI magnet)
- Backup material with opposite temp. coeffic.(Foster of Fermilab)

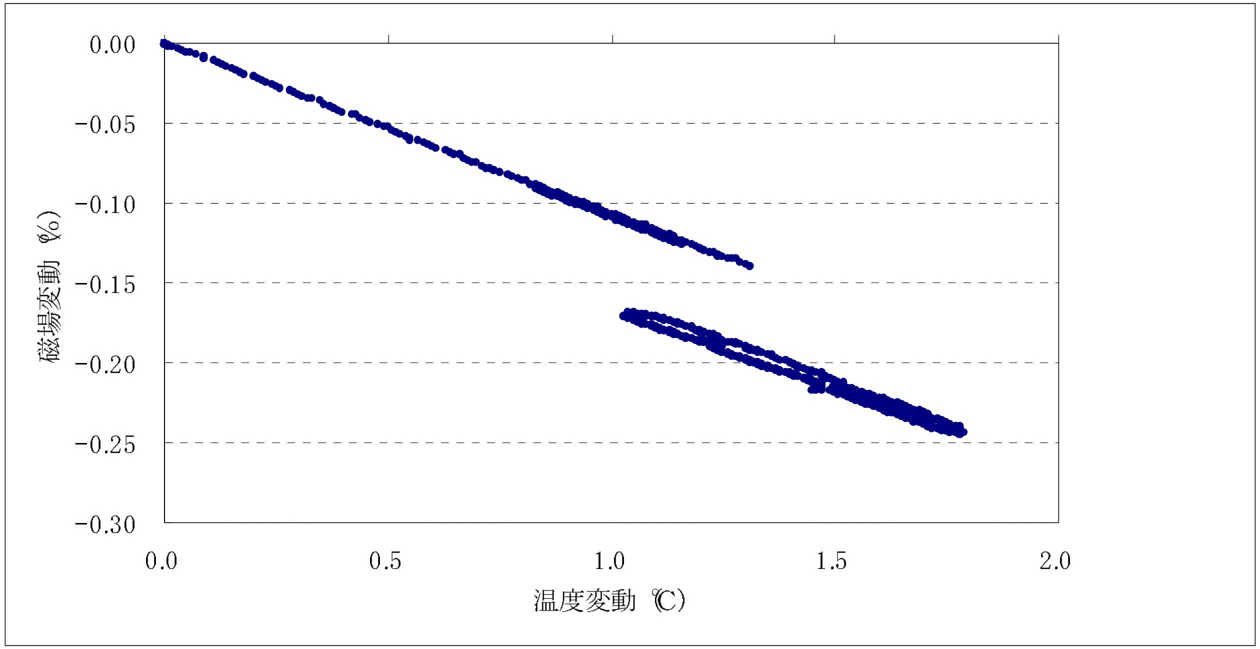
- Backup material with same sign temp.coeffic.(Antokhin)
- ---**<u>transverse compensation</u>**
- Pair magnet with same sign temp.coeffic.(Iwashita) of F and D
- ---**<u>longitudinal compensation</u>**

- Active compensation
- Heater controlled, Permanent cyclotron magnet **"EcoC"**

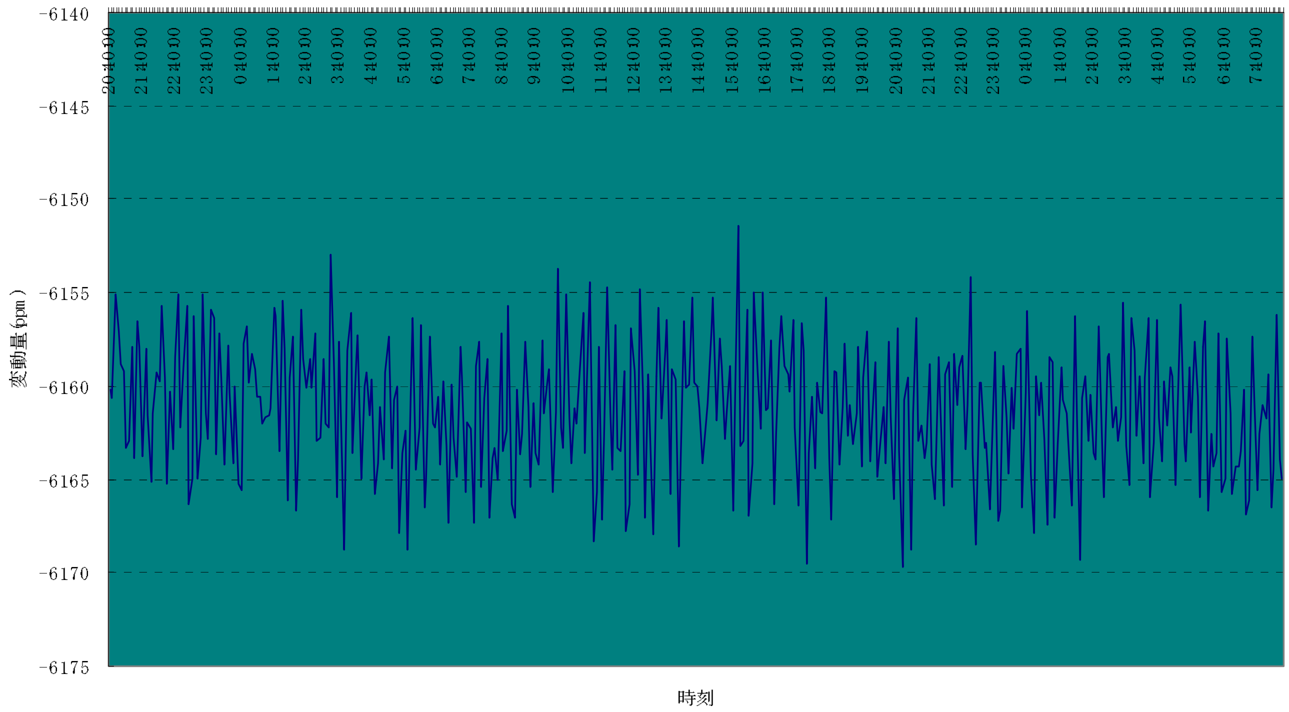
1.Temperature stability



1.Temperature stability



1.Temperature stability



2.Radiation damage

- Y.Itoh(W-MAST),NIMB 183(2001) 323-328, 200 MeV proton, N32Z D_{20}=23kGy~290kGy,
- cf. SmCo R26H D_{20}>>300kGy
- T.Kawakubo(KEK), ASN-458, june 7,2002
- , 12GeV proton, negligible for Neomax35EH
- upto 3kGy(1.4E15)
- Choice of High Hc material required
- Operating point must be taken into account

- S.Okuda, 17MeV electron,-10%, 2.6MGy

Coercivity

	Hc	Temp.coeff.
	kG	%/C
Neomax 50	11	-0.59
Neomax 40	12	-0.60
Neomax 35EH	25	-0.47
Neomax 32EH	30	-0.45

3. Incorporate vacuum system

- T.Hara, "In-vacuum undulators of SPRING-8",J.synchrotron Rad (1998) 5,403-405
- ultra high vacuum 10E-9
- Cu-coated(10 micron m) Ni(50 micron m)
- Ti Gold coating

4.Variability

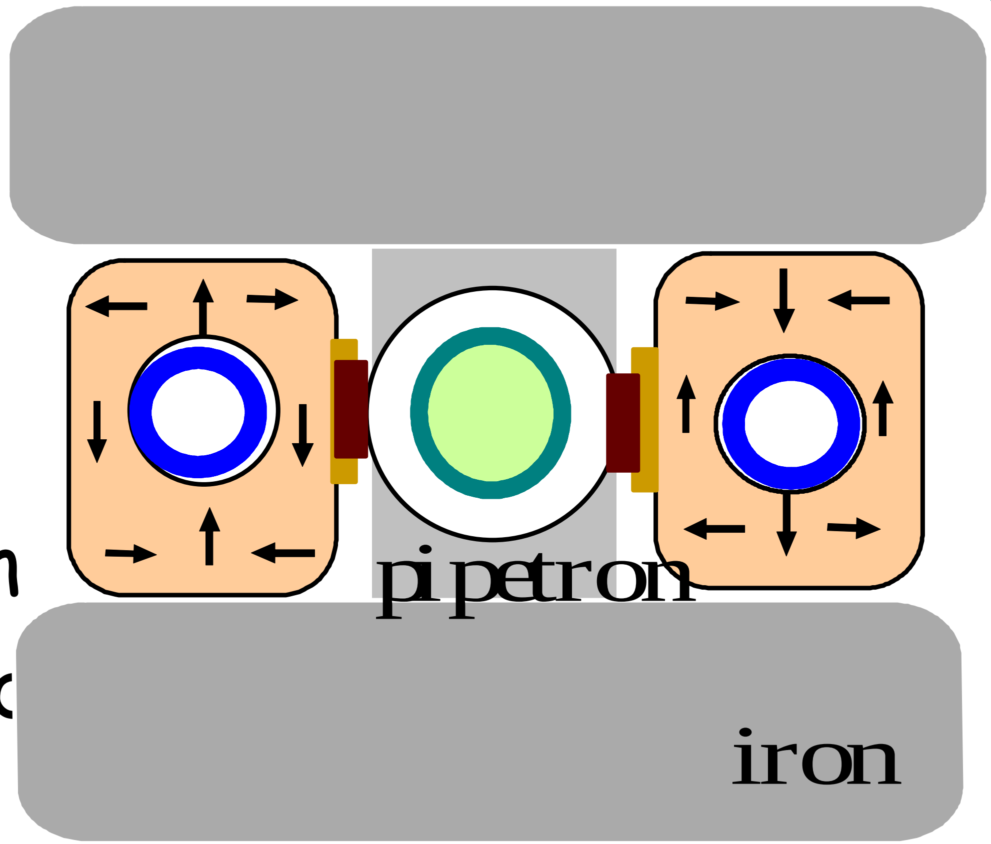
- M.Kumada,
- Magnet-in-Magnet(snowmass 2001)

- M.Kumada and Y.Iwashita, Mechanical rotation, Transverse or longitudinal, compensation of Skew to be taken care of.

- Pneumatic control/ Supersonic motor
- >> Iwashita

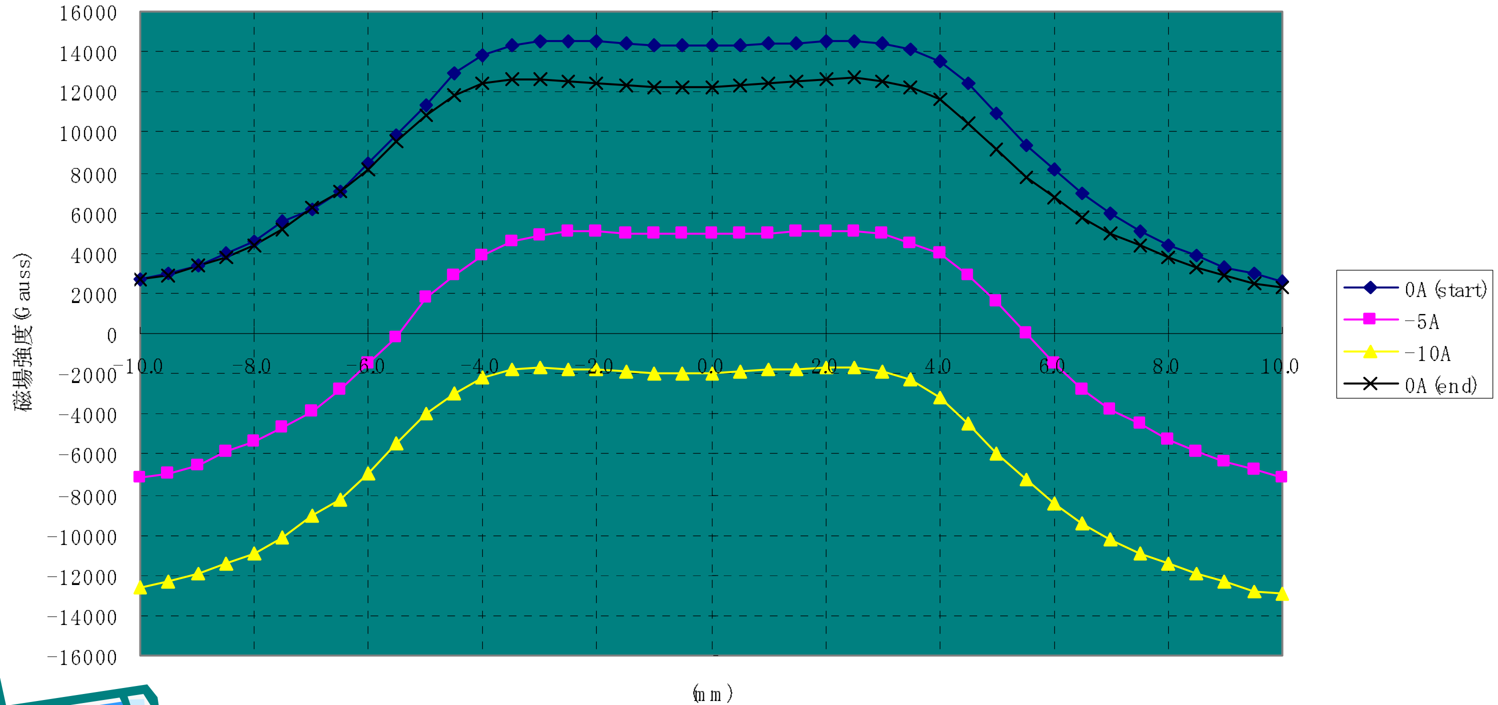
MiM Magnet-in-Magnet

- 3 to 4 Tesla
- Is possible
-
- VLHC pipetron
- (2T max field



M.Kumada, "Magnet in Magnet concept" snowmas2001 workshop, Aspen Colorado, June30-July21,

MiM field distribution (irreversible)

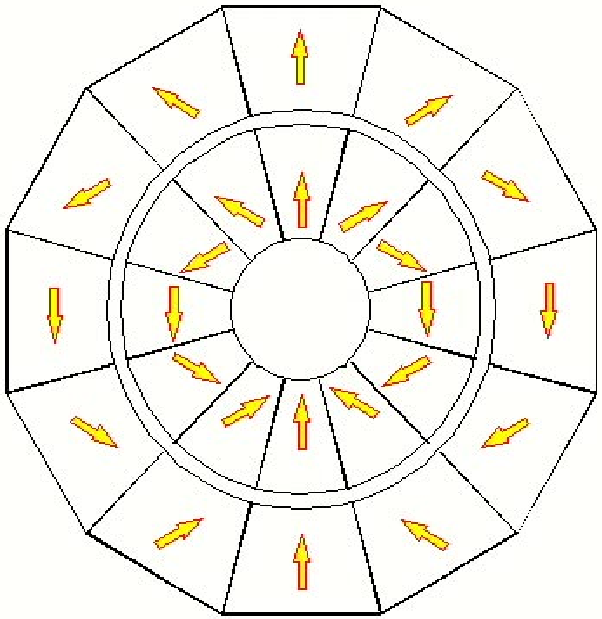


ICFA nanobeam02, september 03, 2002

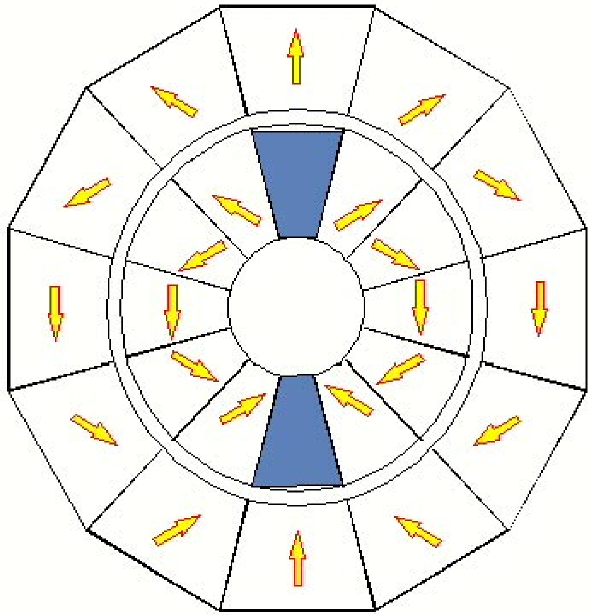
Two layer variable magnet

No skew component!

K.Halbach discovered: $B_g = B_r l_n\left(\frac{r_2}{r_1}\right)$



•Halbach circuit



•Our new scheme:

•Extended Halbach circuit

5. Interaction with solenoid:

Gradient reduction ?

- Open question:
- upper limit must be specified.

5. Interaction with solenoid:

demagnetization

- Experience with 4.45 Tesla magnet
- Demagnitization by Perpendicular field(few data)
- More experimental data needed.

5. Interaction with solenoid:

DC forces

- Open question

Threshhold force must be assigned for nano control drive.

5. Interaction with solenoid:

Vibration due to mechanical or power related fluctuations of solenoid

- Open question

Compact feed back sytem
  >> Iwashita: Commercial Piezodevice nanocontrol available

6. Toward Stronger Final Focus Q magnet

- Operation
- at Liquid Nitrogen temperature
- Use of Saturated iron technique
- (Iwashita)
- Use of Rare Earth Poles
- at low temperature

Operation at room/cool temperature

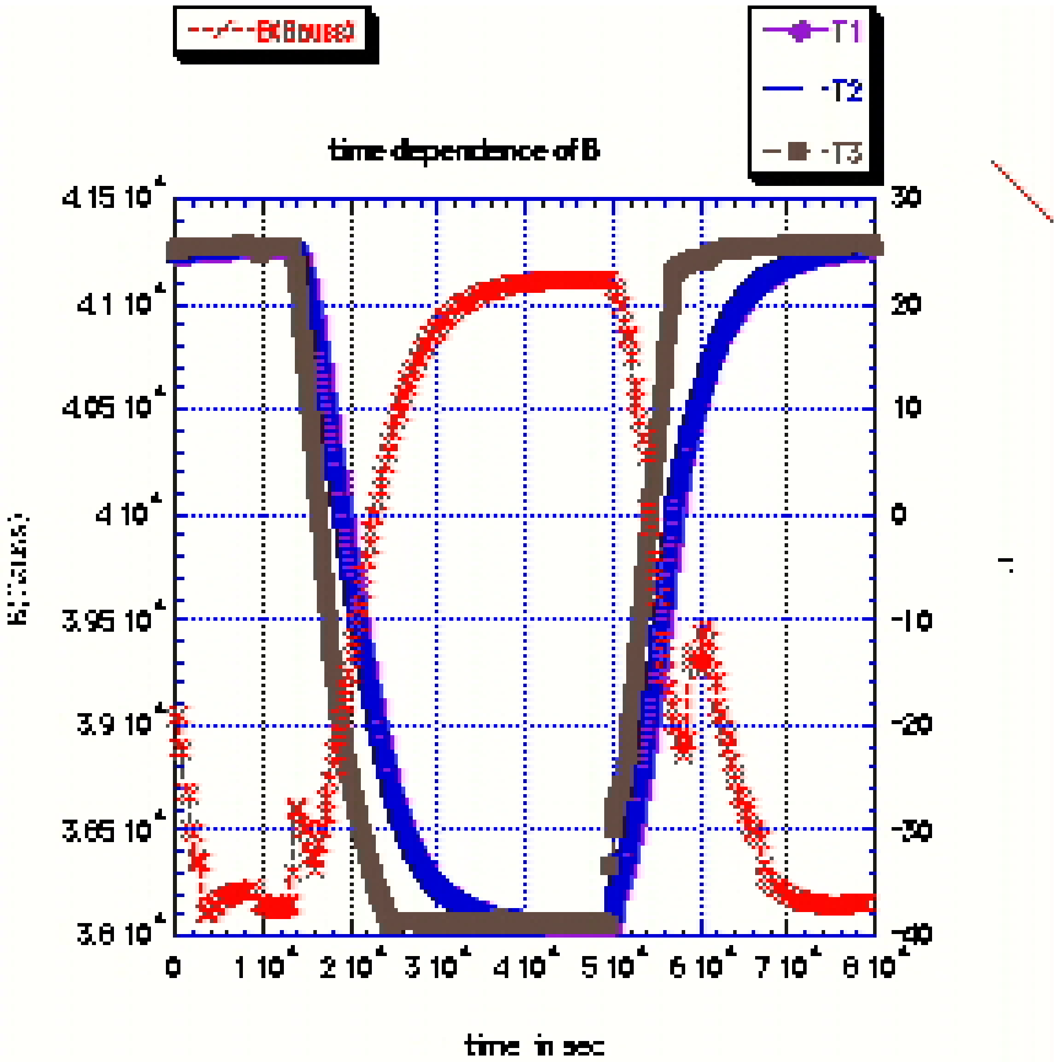
•Ex1 Neomax-50CR

Temp (K)	B (T)	H_{cB} (MAm-1)	$(BH)_{max}$ (kJm^{-3})	H_{cJ} (MAm^{-1})
5	1.52	1.17	429	6.18
77	1.45	1.08	396	5.43
296	1.25	0.91	295	1.13

Ex 3. more new materials

material	Br(T) at room temperature	Br(T) at liquid temperature
$Nd_2Fe_{14}B$	1.6	1.86
$Pr_2Fe_{14}B$	1.56	1.83

Varying field PM with temperature



Saturation field (kG)
At 77K

	literarute	measured
Gd	21.4	22.8
Tb	27.0	23.2
Dy	30.3	29.0
Ho	30.7	-

Courtesy of smmc