Permanent Magnet Quadrupole for Final Focus

Takanori Mihara (Kyoto university)

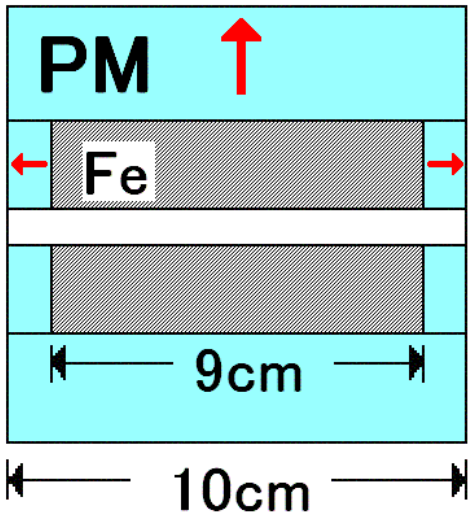
Yoshihisa Iwashita (Kyoto university)

Contents

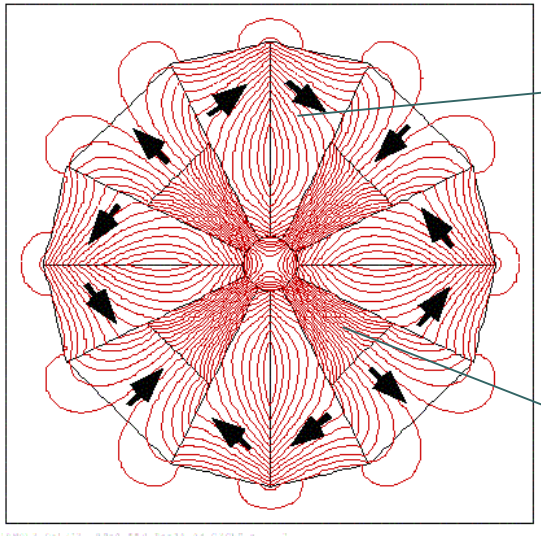
- PMQ with saturated iron
- Temperature compensation
- Adjustability

PMQ with “saturated iron”

Crosssectional view



including the beam axis



Axial view

There are 12 pieces of PM

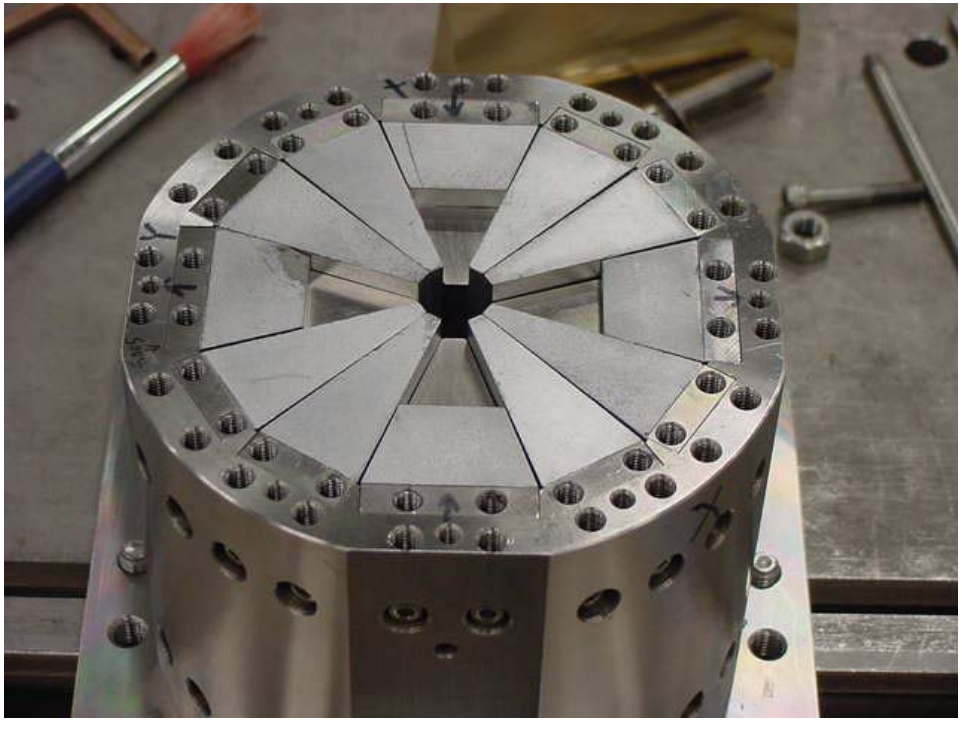
Black arrow is the easy axis of PM

There are 4 pieces of saturated iron

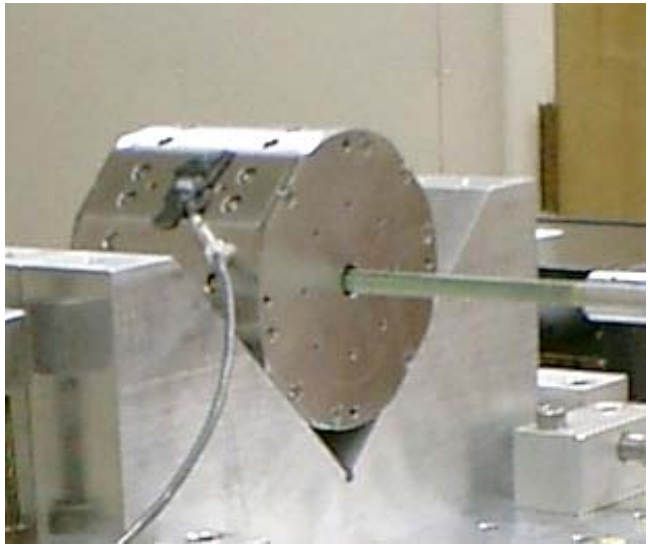
Red line shows the flux line. You can see the iron pole increase the strength of PMQ

Prototype of PMQ was already fabricated.

Photos



Prototype PMQ



Measurement setup at SLAC

Result of measurement

Measured value was **28.5T (GL value)**

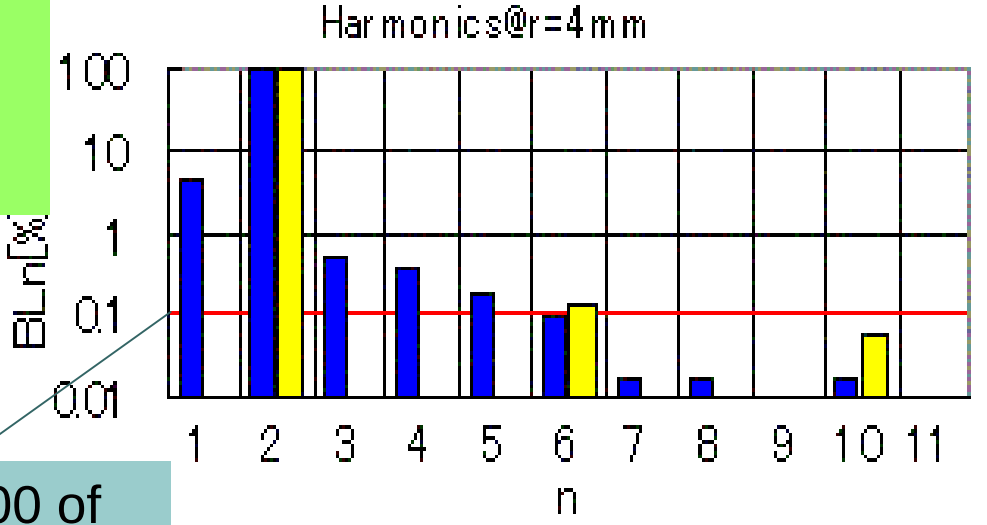
(agrees with Calculated value **29.7**T)

full length is・・・・・・・100mm

bore radius is ・・・・・・ 7mm

That means **0.3T/mm** was accomplished. It is very strong at this bore radius.

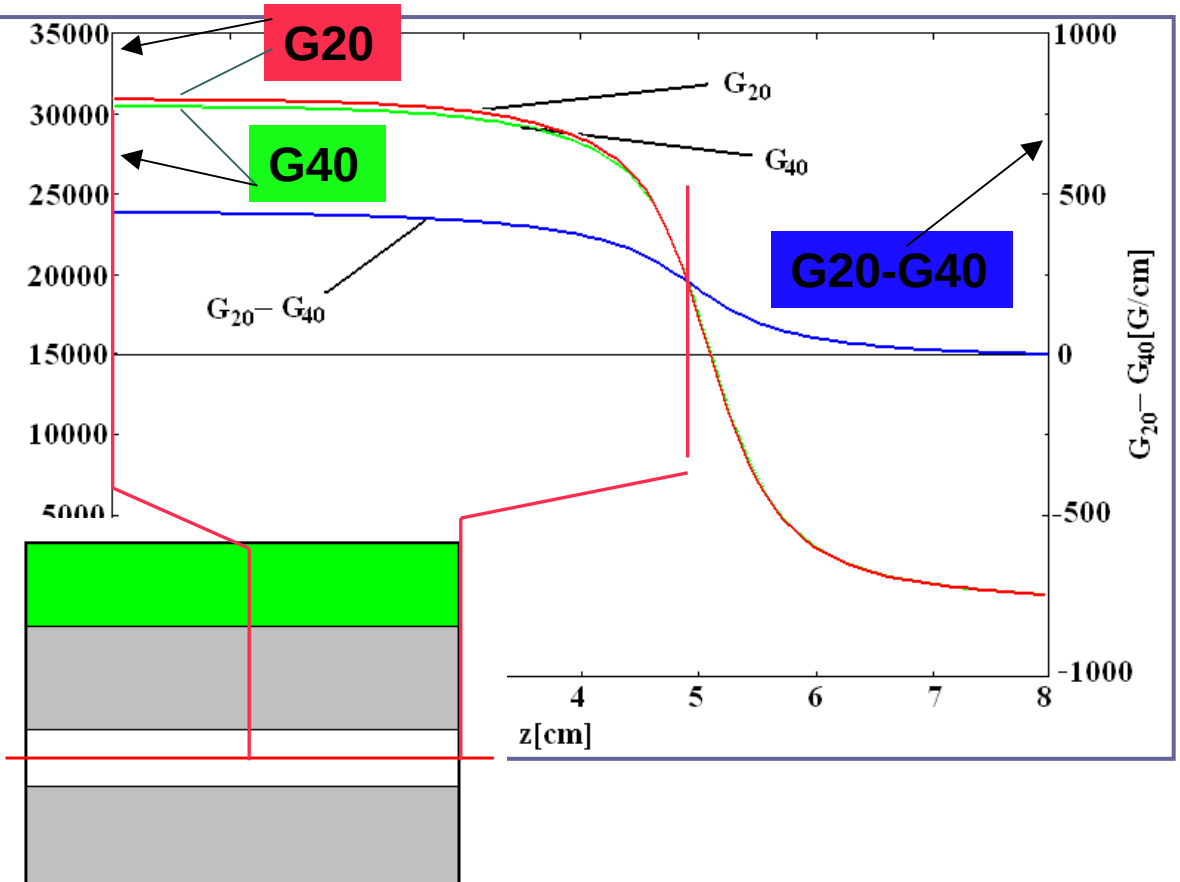
Multipoles



Red line is 1/1000 of quadrupole

Field gradient along the axis

Strength of PMQ decrease with temperature rise



G20 is Gradient at 20degC

G40 is Gradient at 40degC

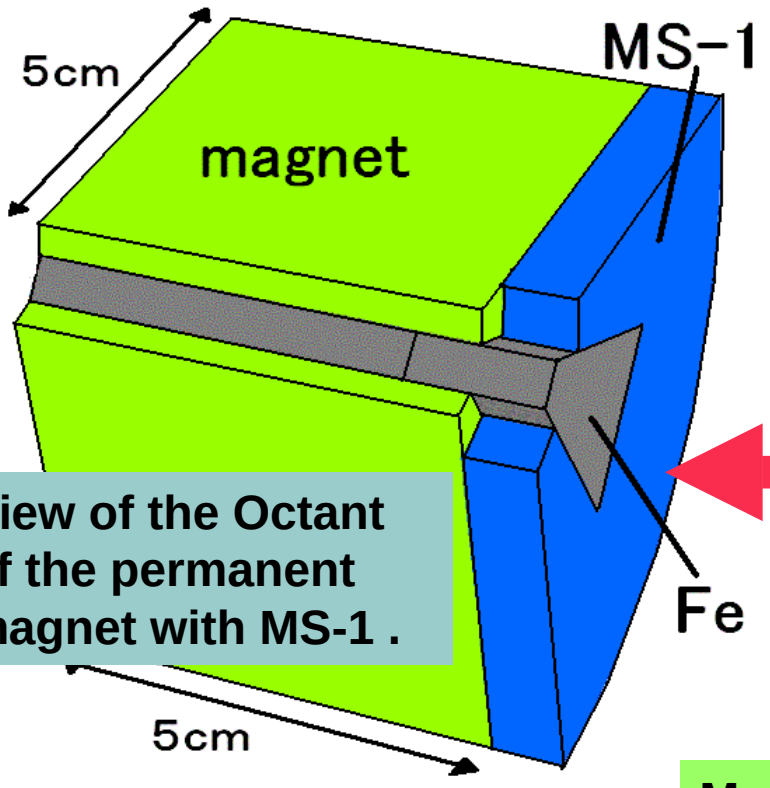
G20-G40 is Difference of Gradient at 20C and at 40C

Temperature coefficient of GL was -0.09%/℃.

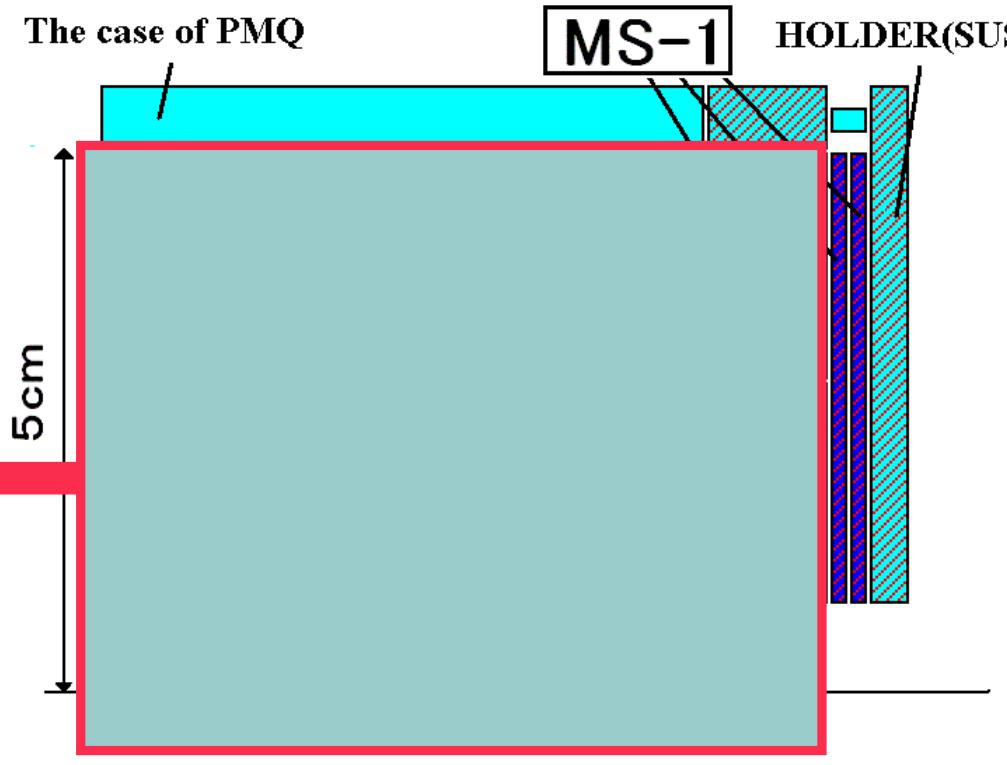
It is too large and must be compensate

Temperature compensation

In order to stabilize strength, compensation material ‘MS-1’ is used

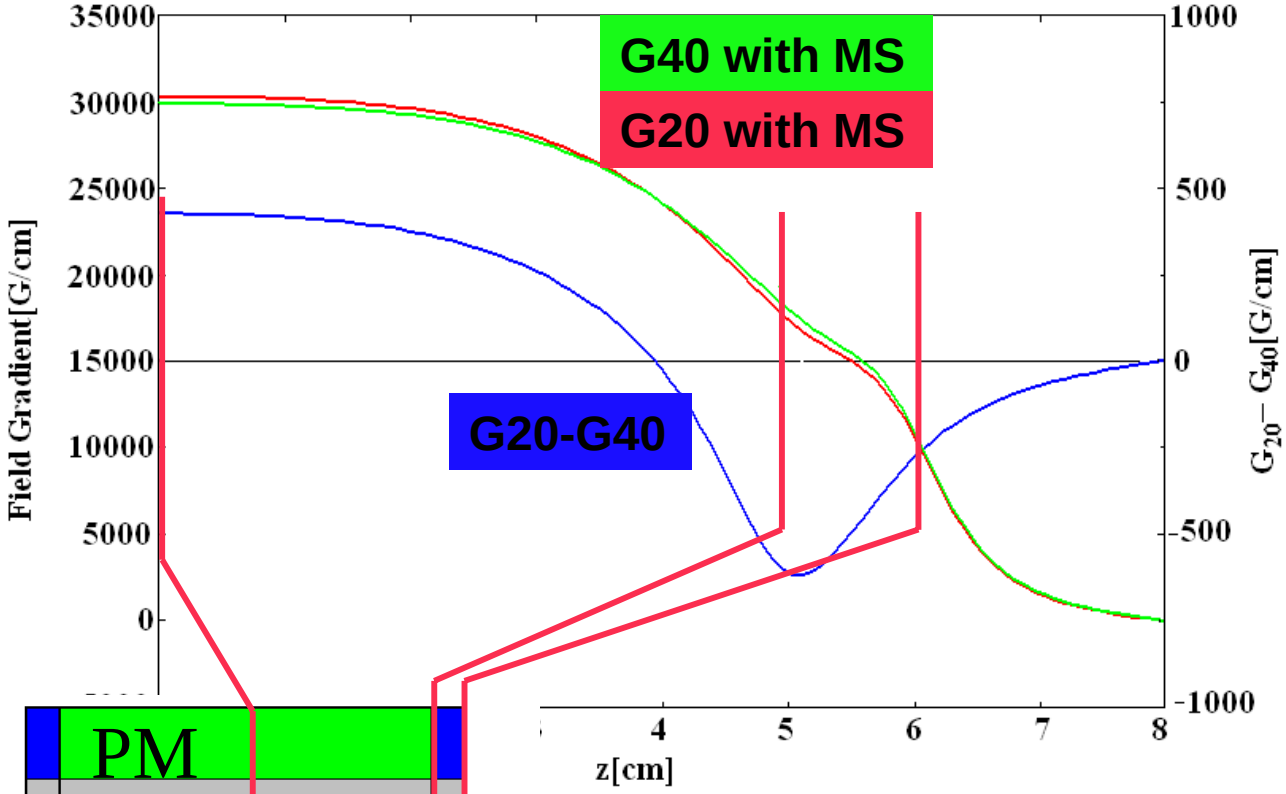


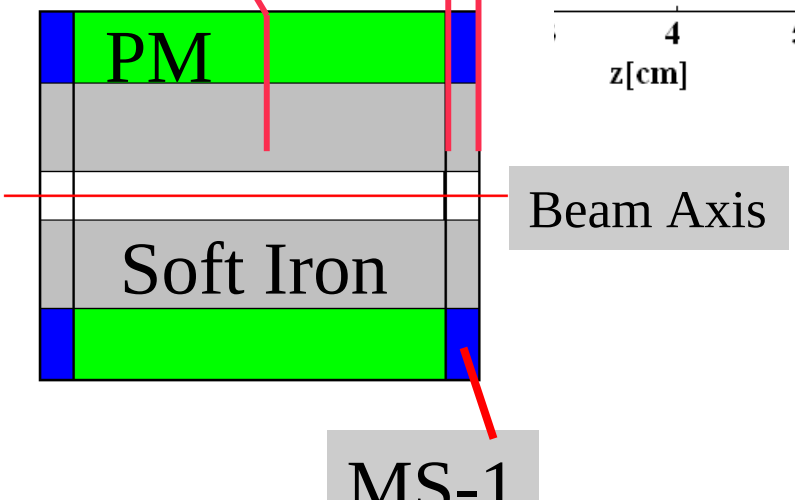
iew of the Octant
f the permanent
agnet with MS-1 .



Marked region corresponds to left figure.

Compensation by MS-1





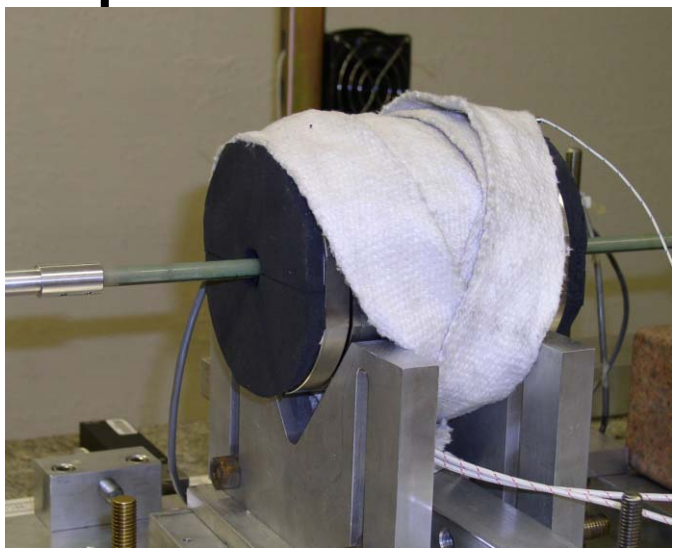
Temp coefficient of PMQ can be reduced to

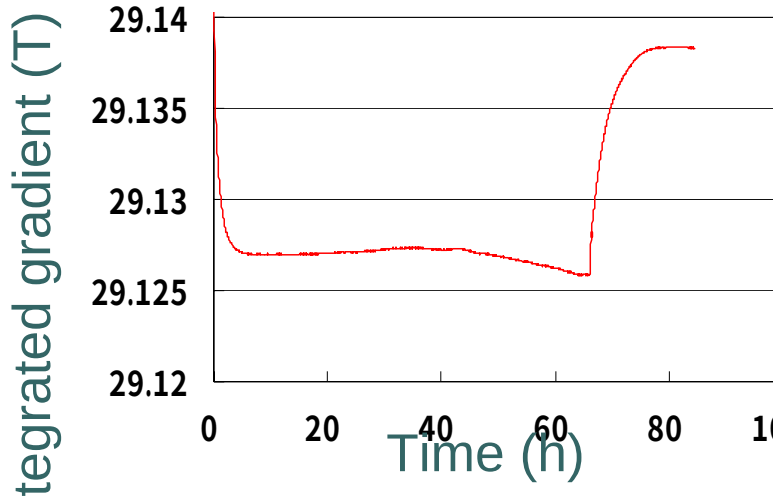
-0.003%/℃

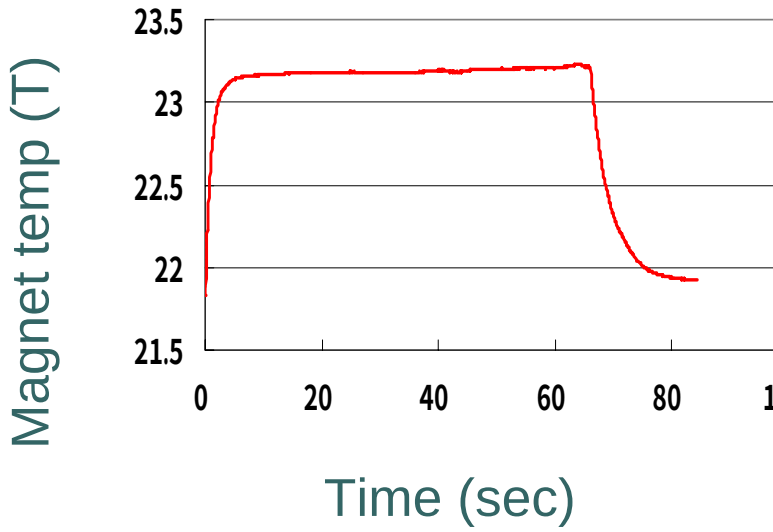
Blue line shows the difference of gradients at 20 and 40 deg C

Difference of the integrated gradient can be cancelled out.

Measurement at SLAC







leasured coefficient without MS was .075%/C .

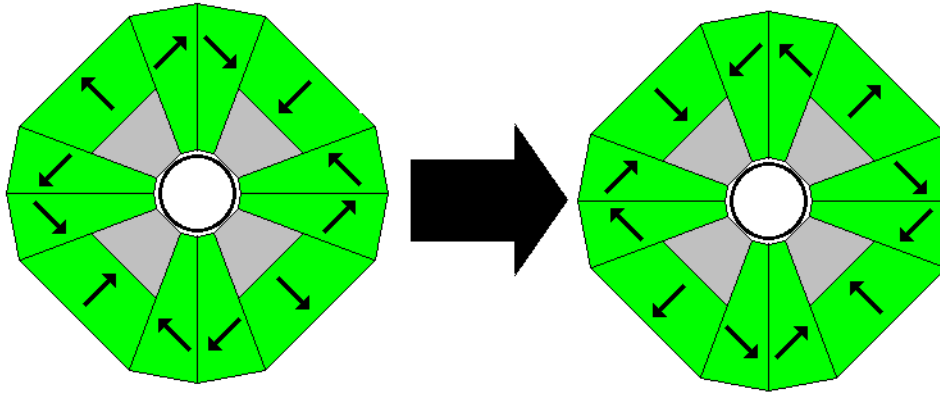
hat with 9mm of MS was -0.031%/C

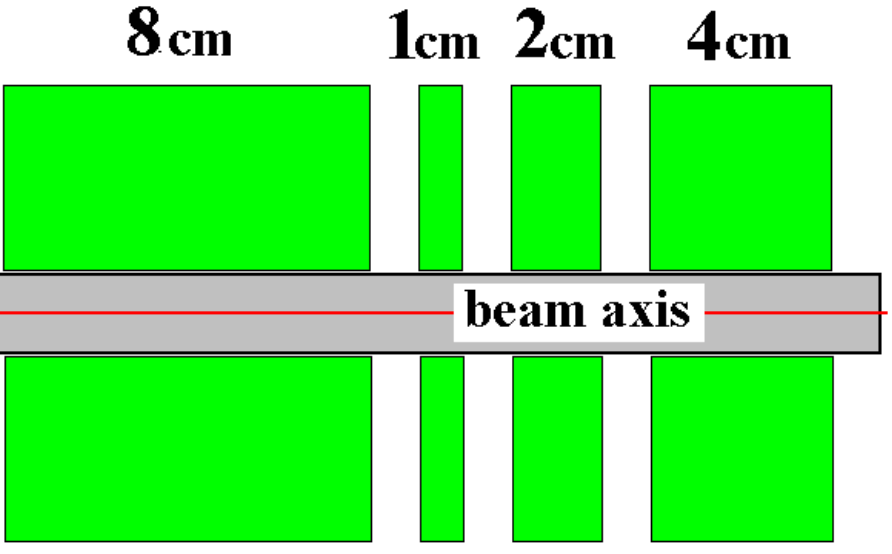
The effect was not enough as expected.

has been recently found that the BH ata of MS-1 given by manufacturer was rong.

Strength Adjustability

To adjust the strength, the magnet is separated along the axis. Strength can be changed by switching F to D and vice versa by rotating 90 deg .



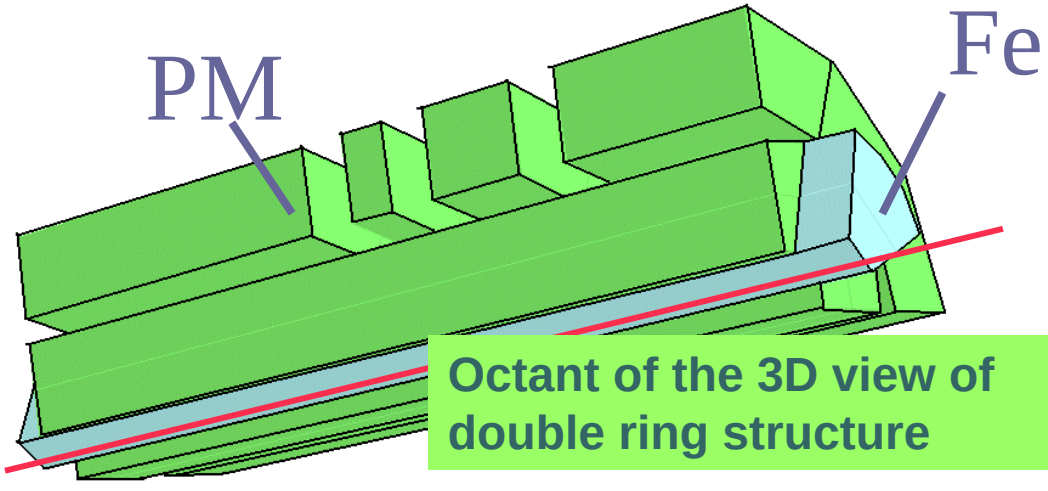


Mechanical rotation should have rotational errors; they lead skew component and shift of axis.

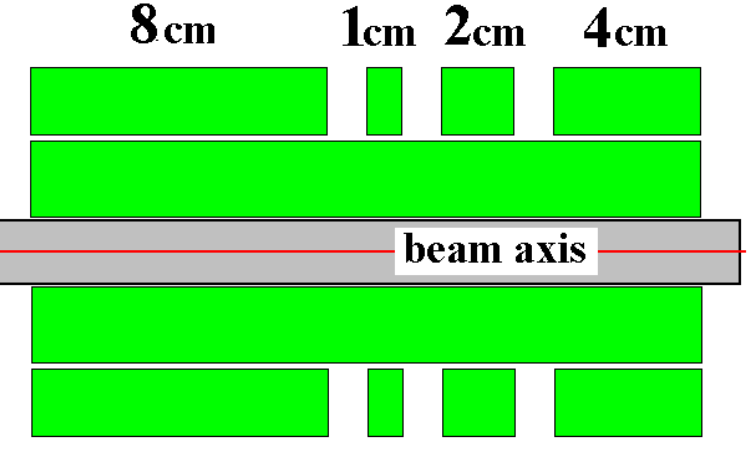
We are considering double ring structure to decreases these effects.

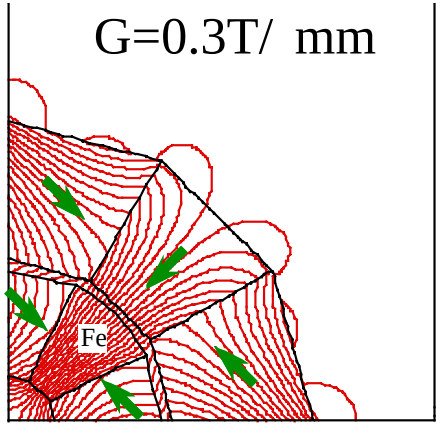
Double ring structure

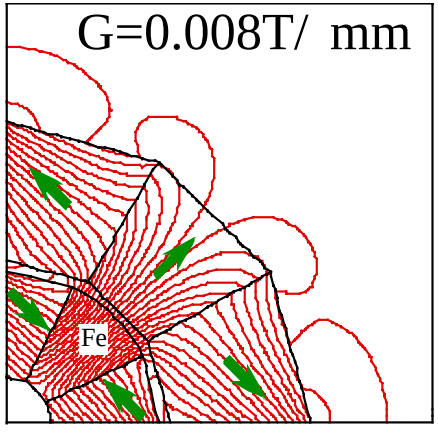
A double ring structure can reduce the **skew component** to ~1/30 and also the **shift of axis** to ~1/30.



Octant of the 3D view of double ring structure

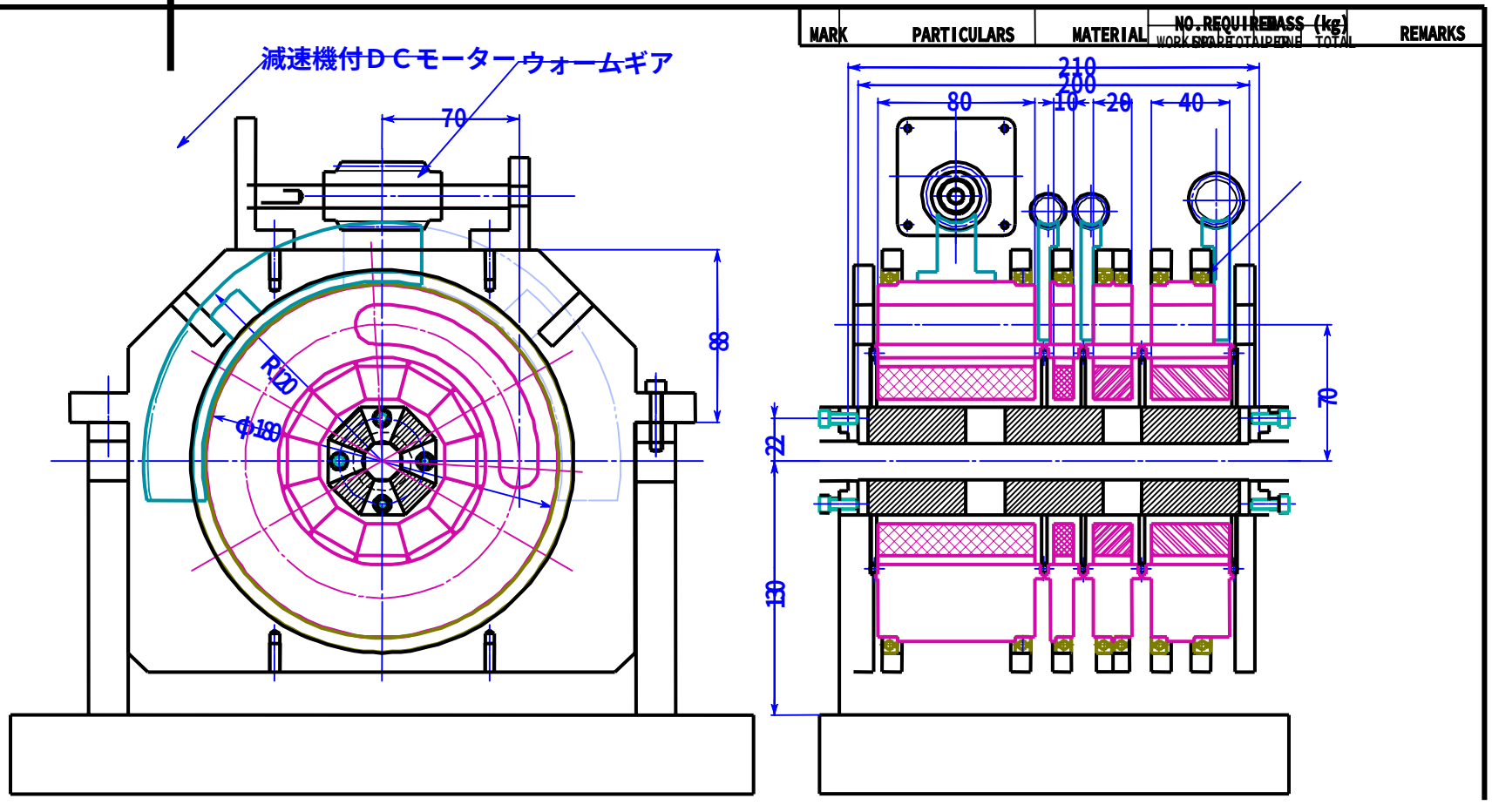






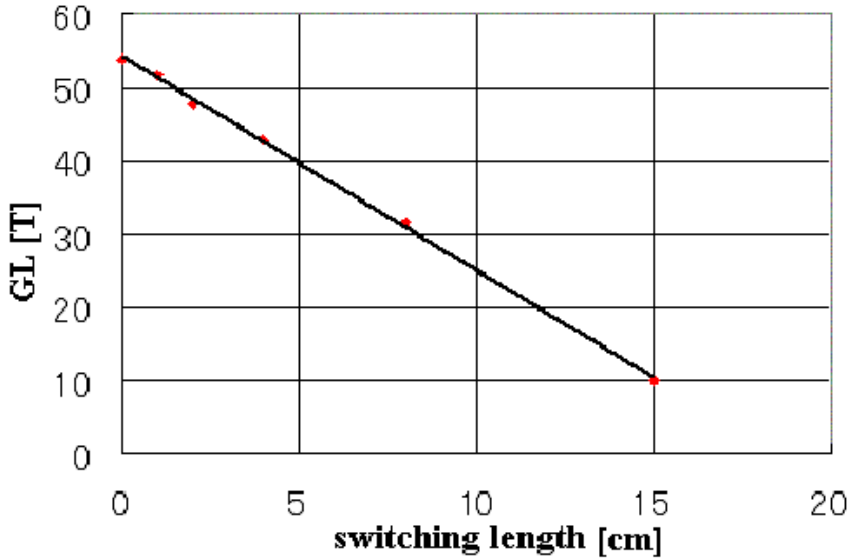
Large torque is anticipated.

A sketch of rotation scheme



First draft, under discussion with manufacturer.

Total strength on switching length and gradients

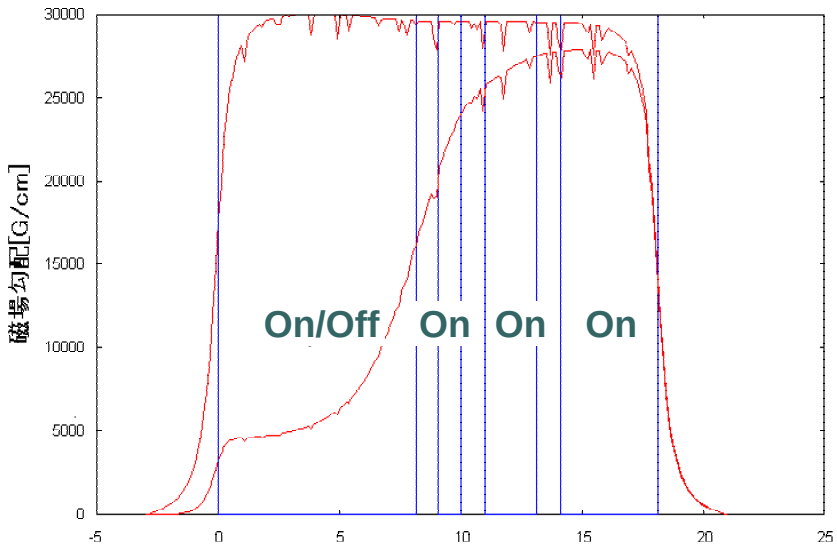


Left figure shows that the integrated strength is proportional to the switching length.

In this case, total strength can be reduced to 20 % of the maximum value.

Right figure shows the gradient of double ring structure along the axis.

On/Off corresponds to normal position (the strongest) and rotated position.



Discussion

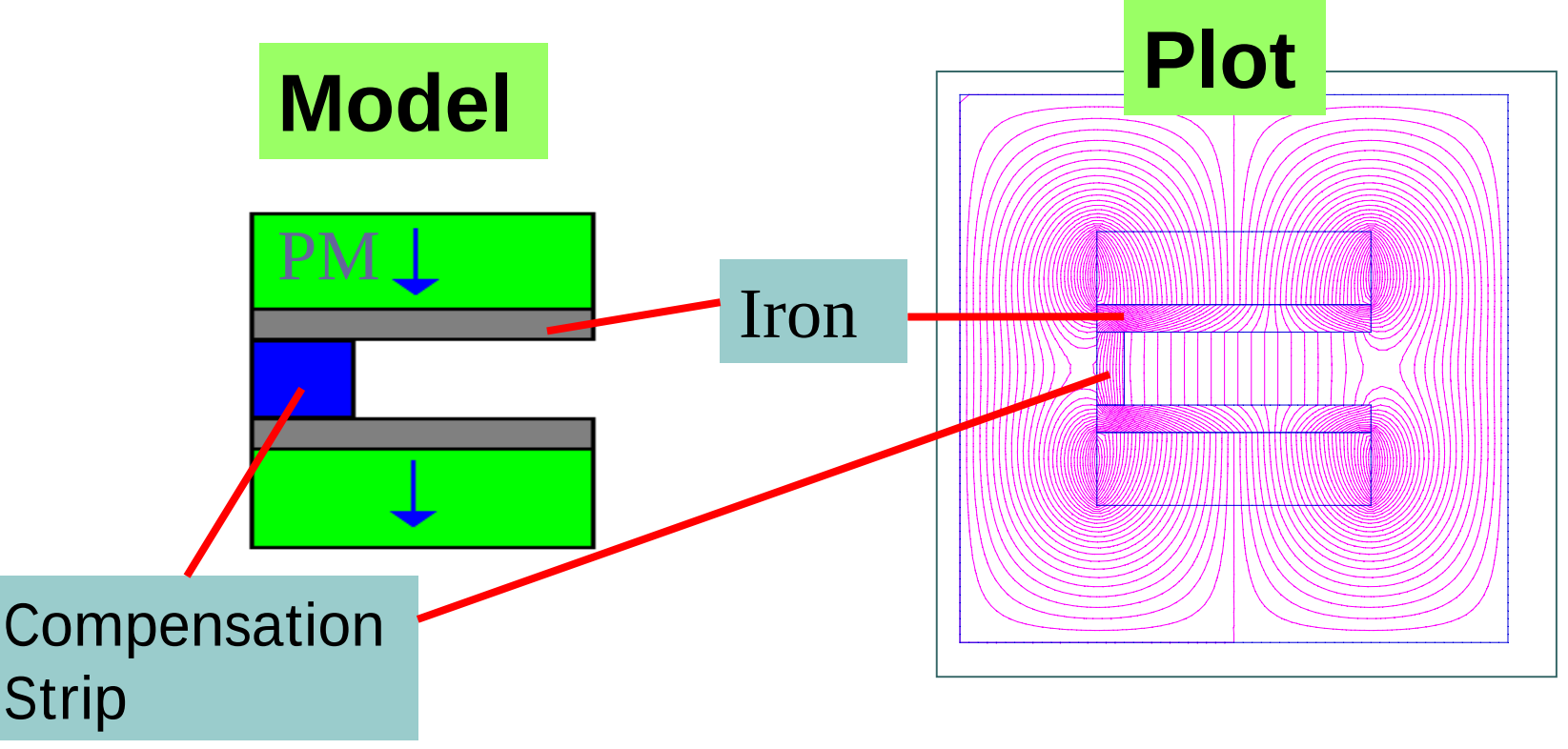
- Very strong PMQ was fabricated with saturated iron. 0.3T/mm at 7 mm bore radius
- The scheme of temperature compensation is under verification (field is under measurement at SLAC)
- Double ring structure
  - It decreases skew and shift of axis
  - Large torque has to be handled.

APPENDIX
Temperature compensation

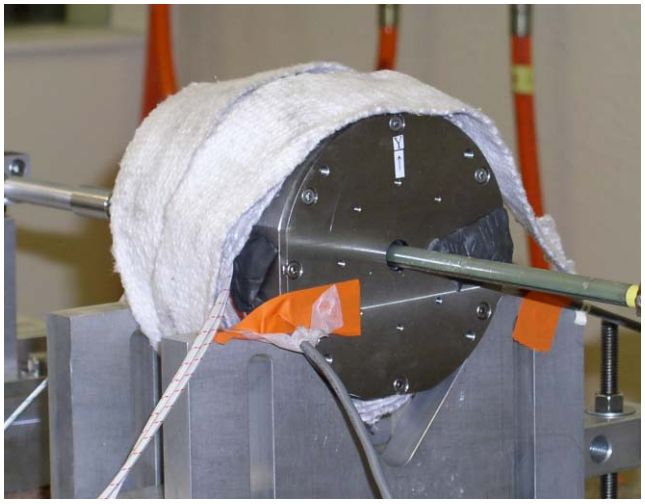
Magnetic circuit shunt with high coefficient material.

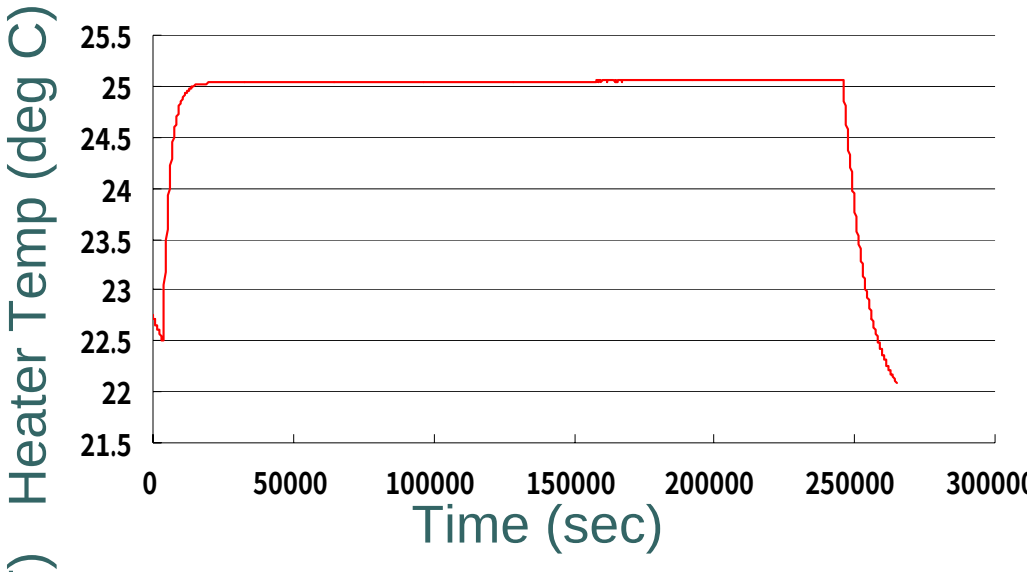
Total strength decreases.

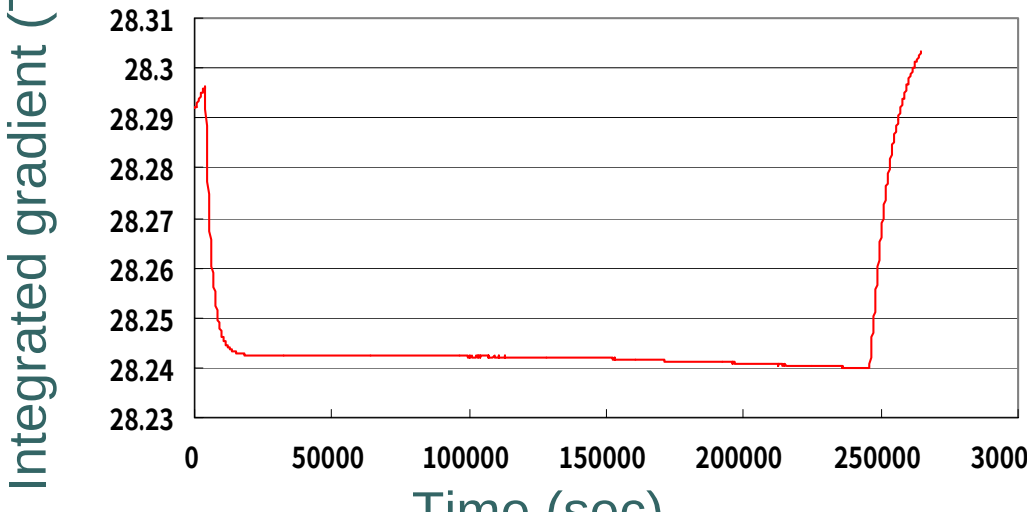
Shunting effect decrease much with temp rise



Measurement at SLAC (1)







Without Temp compensation,

Measured strength is

28.29T at 22.7C
28.24T at 25.0C

→temp coefficient=-0.075%/℃