Review of Operating Currents, Forces and Torques for the BEPC-II IR Magnets

Presented by

Brett Parker/BNL–SMD

BEPC-II Superconducting IR Magnet Coil Parameter Summary

Superconducting Magnet Division

BEPC-II Magnets 12-May-03	B, G (T), (T/m)	R_{in}, R_{out} (mm)	From IP (mm)	Coil Length (mm)	Magnetic Length (mm)	Operating Current (A)
AS1	-	95.1~105.9	630~933	303	-	**1120***
AS2	-	115.4~119.0	1035~1381	346	-	**1120****
AS3	-	95.1~105.9	1474~1590	116	-	**1120****
SCQ	18.744	95.1~108.1	961~1457	496	400	460
SCB (HCD)	0.543 0.056	108.5~111.8	633~1307	674	400	495 (50)
VCD	0.059	111.9~113.5	904~1514	610	380	24
SKQ	0.937	113.6~115.2	954~1464	510	400	45

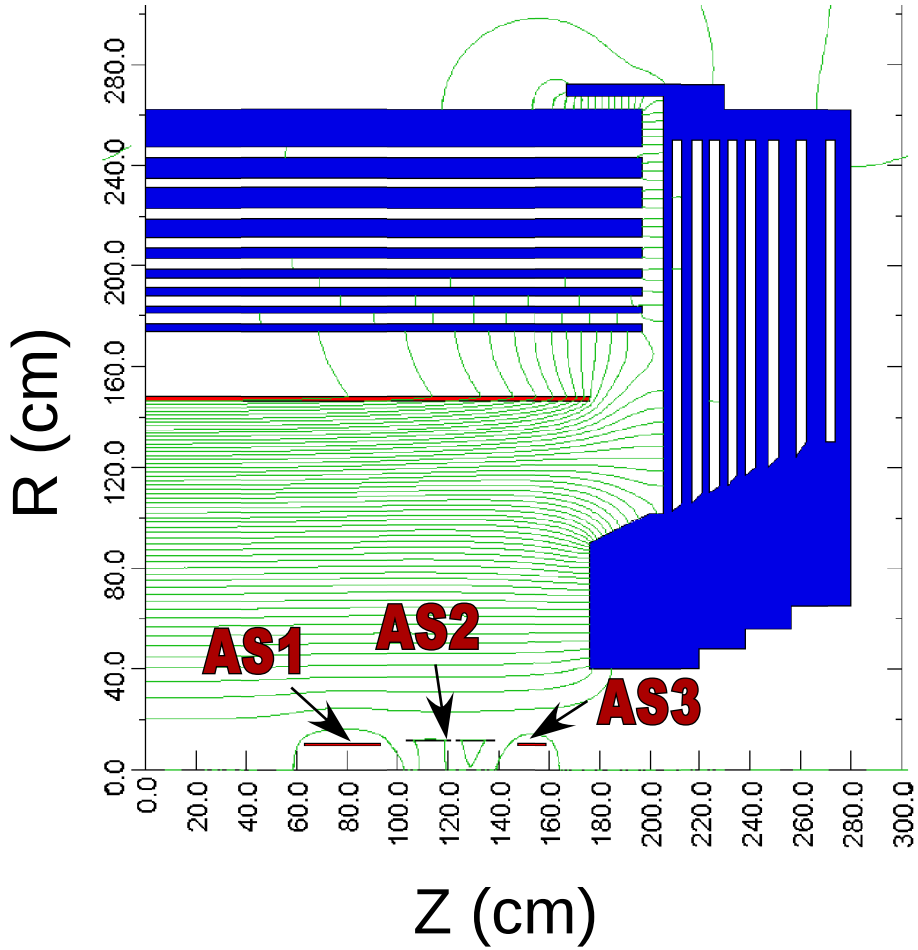
***Best estimate as of 22-May-03. Previous was 1140 A.**

**AS2 and AS3 are in series with AS1 but can have their own independent trim currents.

BEPC-II Anti-Solenoid Design Parameter Summary

Superconducting Magnet Division

1/2 BES-III Detector with Anti-Solenoid



$I_{main} = 1120$ A

$N_{AS1} = 732$ turns

$N_{AS2} = 260$ turns

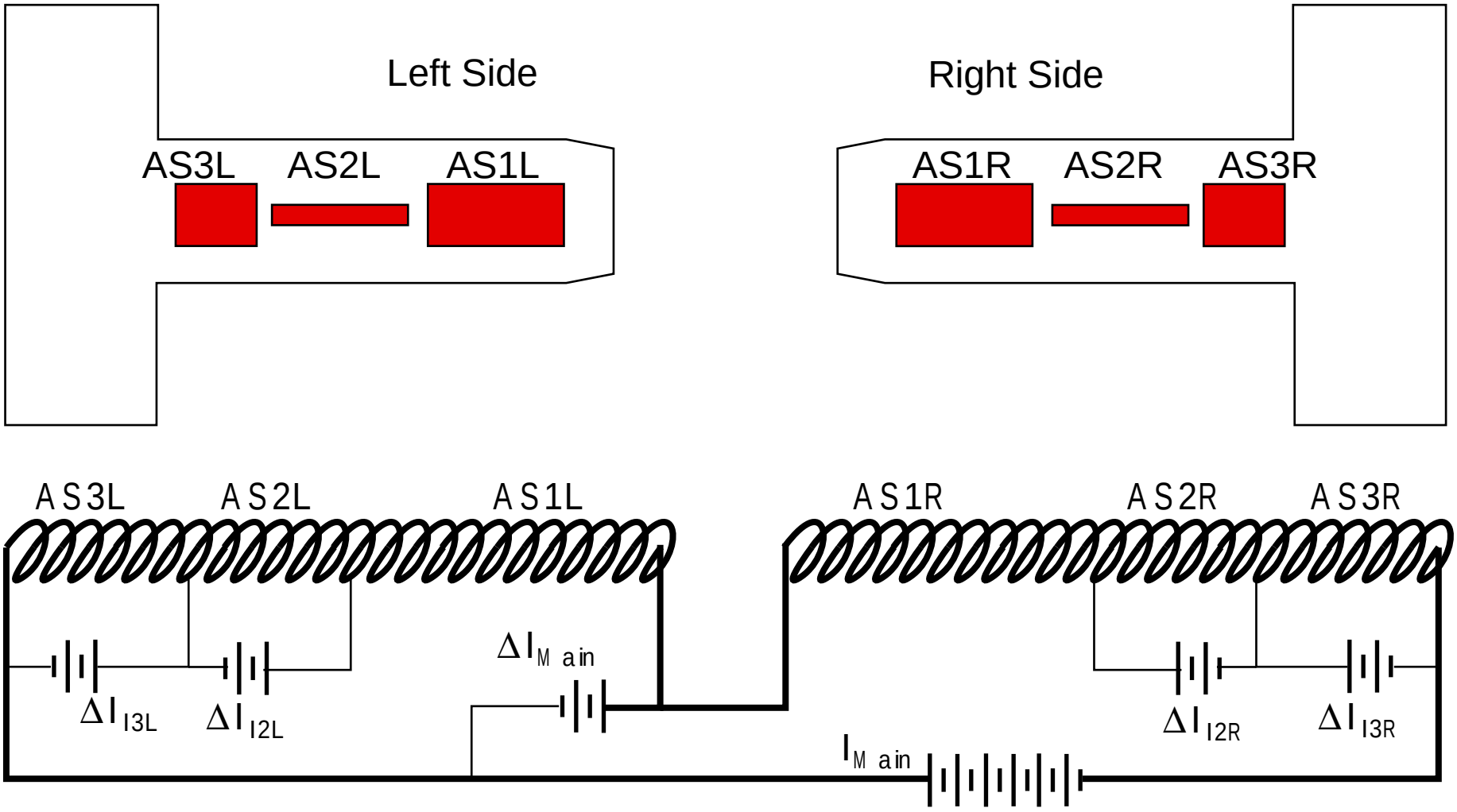
$N_{AS3} = 280$ turns

$N_{Tot} = 1272$ turns

$L_{Tot} = 78$ mH

BEPC-II Anti-Solenoid Layout & Wiring Schematic

Superconducting Magnet Division



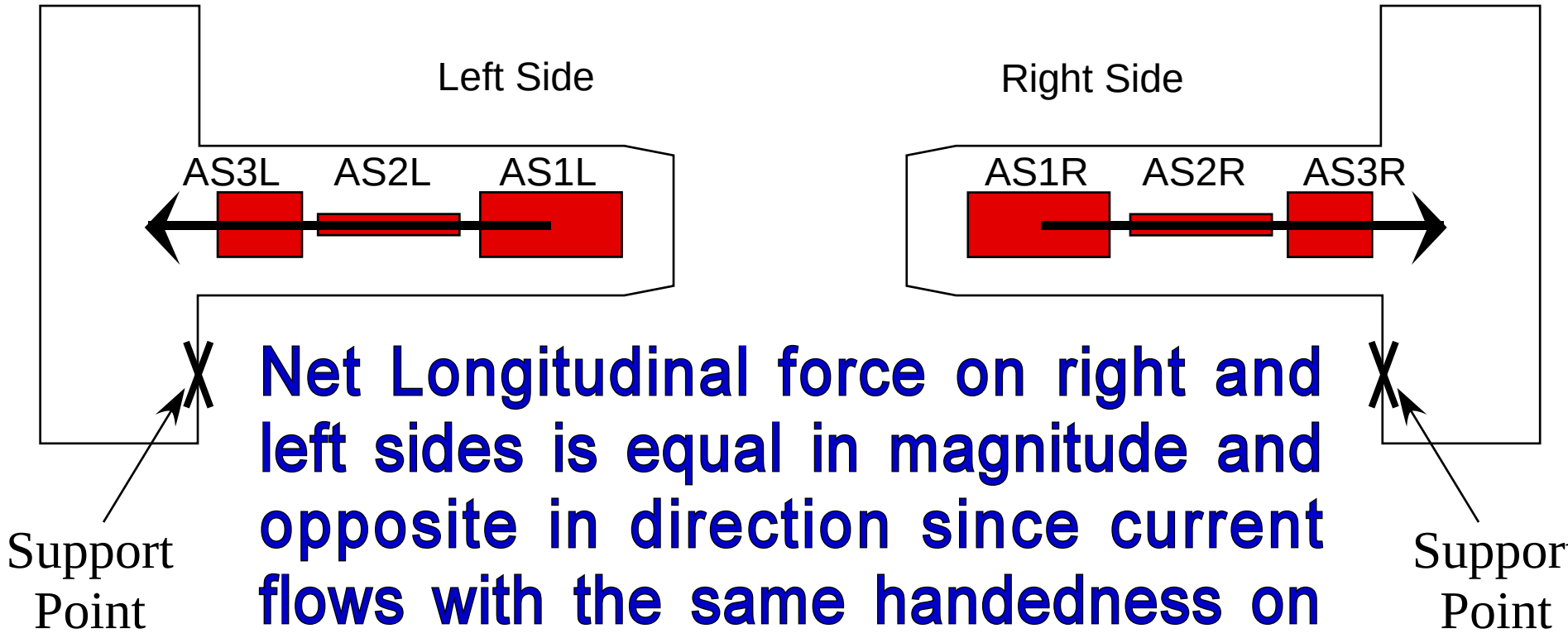
BEPC-II Anti-Solenoid Requirements

Superconducting Magnet Division

- Trim circuits will allow fine tuning of the anti-solenoid compensation scheme as well as left/right adjustment.
- **But given skew-quadrupole winding, is fine tuning really needed?** (Need answer from IHEP.)
- **And if needed is +/-65 A enough?** (Need answer from IHEP.)

Anti-Solenoid Longitudinal Force Diagram

Superconducting Magnet Division



Net Longitudinal force on right and left sides is equal in magnitude and opposite in direction since current flows with the same handedness on right/left sides but the BES-III radial field reverses on right and left sides.

Anti-Solenoid Longitudinal Force Calculation

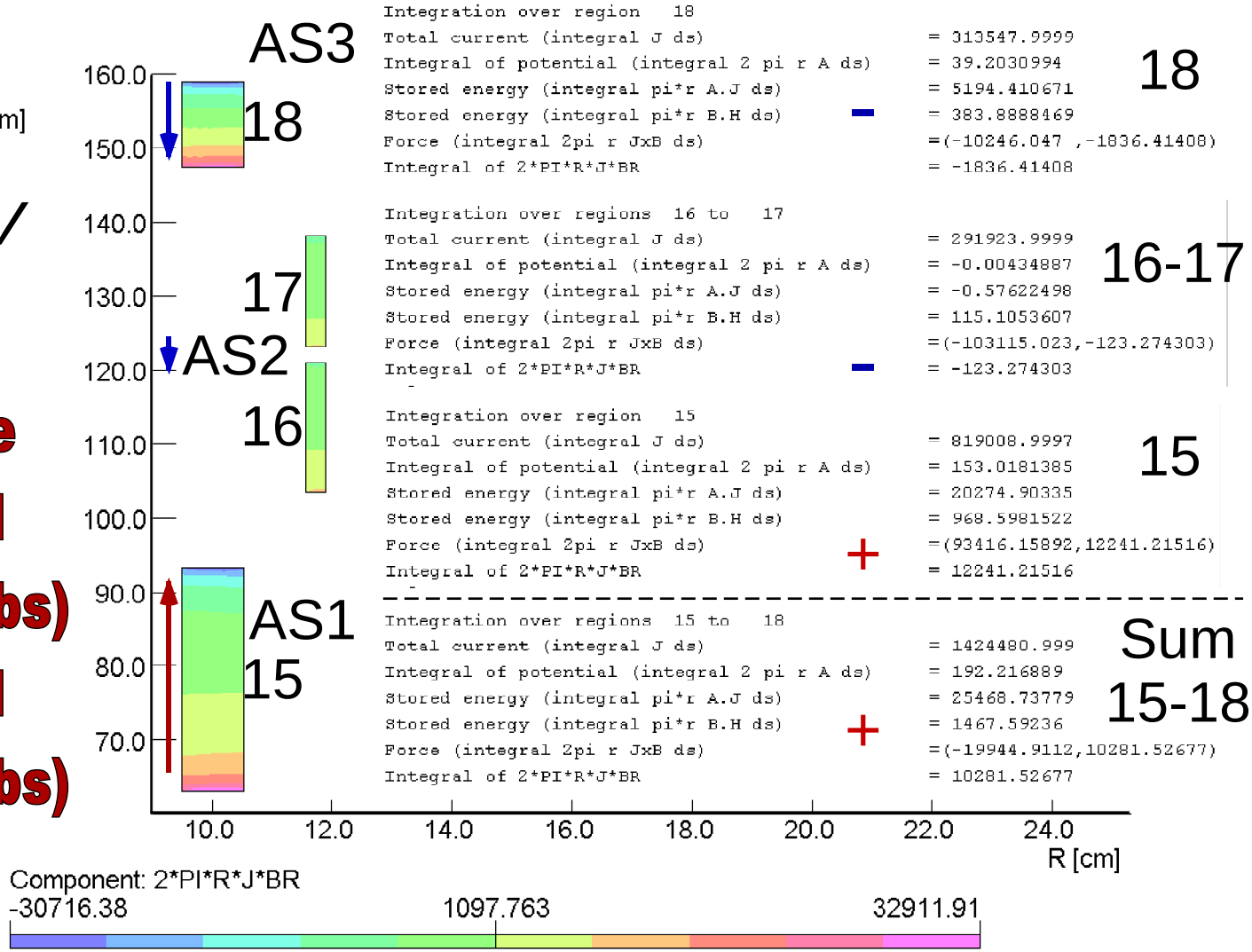
Superconducting Magnet Division

$$\vec{F} = \int_{Z\,[cm]} \vec{J} \times \vec{B}\, dV$$

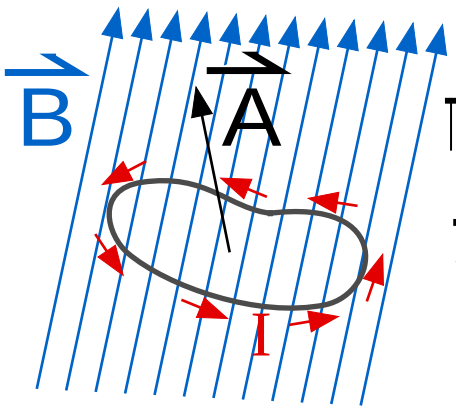
Longitudinal Force

@ 1120 A = 10 kN (2300 lbs)

@ 1250 A = 12 kN (2600 lbs)

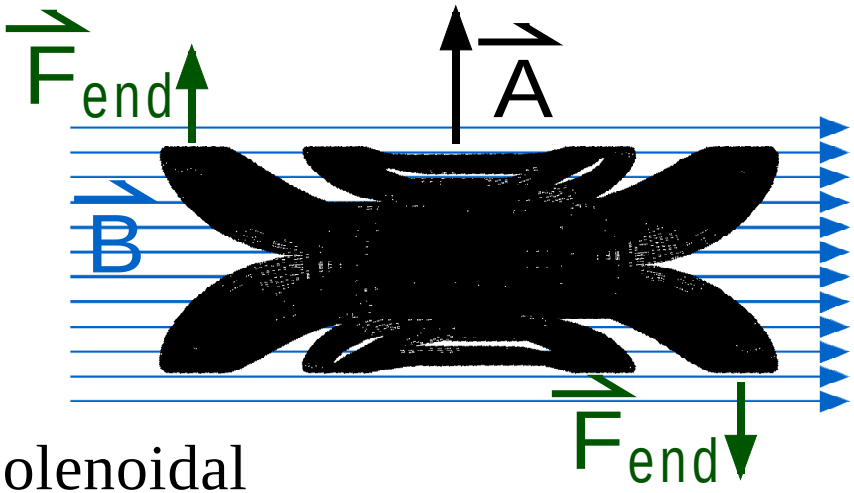


Calculation of Torque on Cold Mass Due to the BES-III Solenoidal Field



Torque on Current Loop

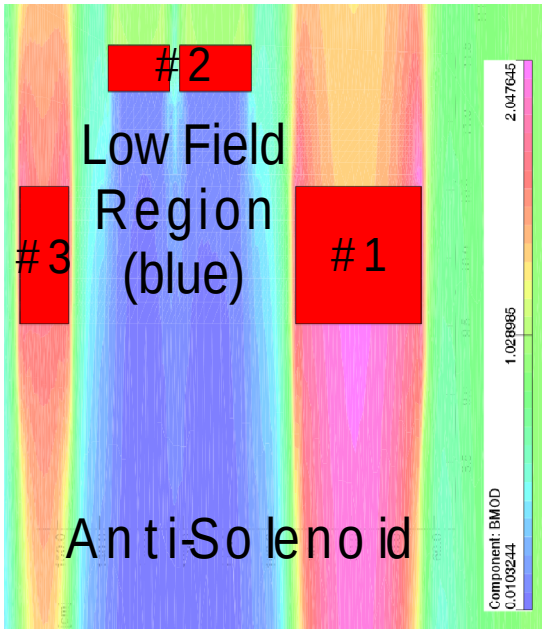
$$\vec{\tau} = I\vec{A} \times \vec{B}$$



- There is a net torque on a dipole in a solenoidal field (but not on quadrupole due to symmetry).
- Magnitude of torque is $I_{Dipole} \cdot A_{Proj} \cdot B_{BES\text{-}III}$.
- Even though anti-solenoid changes the field seen by the dipole, a net torque remains on cold mass!

$$\vec{\tau}_{Dipole} = \vec{\tau}_{BES\text{-}III} + \vec{\tau}_{Anti} = 0 \text{ means that}$$

$$\vec{\tau}_{Anti} = -\vec{\tau}_{BES\text{-}III}$$



Calculation of Torque on Cold Mass Due to the BES-III Solenoidal Field

Superconducting Magnet Division

Take $B_{BES\text{-}III}$ to be 1 T uniform field then...

Case1: Vertical Dipole Corrector (VDC) $A_{Proj} = 59.5\ m^2$

For $I_{op} = 24$ A, torque is 1430 N·m (1050 ft·lbs) and
$I_{Max} = 65$ A torque is 3870 N·m (2850 ft·lbs)
in the horizontal plane.

Case2: Horizontal Dipole Corrector (HDC) $A_{Proj} = 26.6\ m^2$

For $I_{op} = 50$ A, torque is 1330 N·m (980 ft·lbs) and
$I_{Max} = 65$ A torque is 1730 N·m (1280 ft·lbs)
in the vertical plane.

Calculation of Maximum Allowable Torque and a Strong Warning

Superconducting Magnet Division

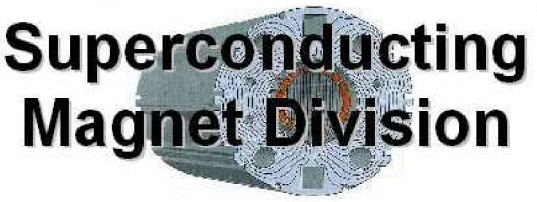
With VDC and HDC both at 65 A, can add torques in quadrature to get: $\sqrt{3870^2 + 1730^2} = 4240$ N·m (3130 ft·lbs)

But must be sure that HDC (i.e. SCB) is never run at 550 A with the BES-III Solenoid turned on (e.g. Synrad mode)!

In that case we would have 550 A · 26.6 m^2 · 1 T
= 14,600 N·m (10,800 ft·lbs) from HDC!

Note: If the anti-solenoid were on, then once the cold mass gets out of line the torque would increase due to mutual repulsion with BES-III.

BEPC-II IR Magnet Operating Current, Force and Torque Summary



- Need decision whether to provide trims for later anti-solenoid fine tuning (Ok to om it?).
- Have assumed 1250 A, 550 A and 65 A power supplies (see G. Ganetis talk) for calculating forces and torques (Are these values ok?).
- Checked that support at endcan is adequate?
- Must interlock SCB current with BES-III to avoid accident (Or make stronger supports with increased heat leak?)!