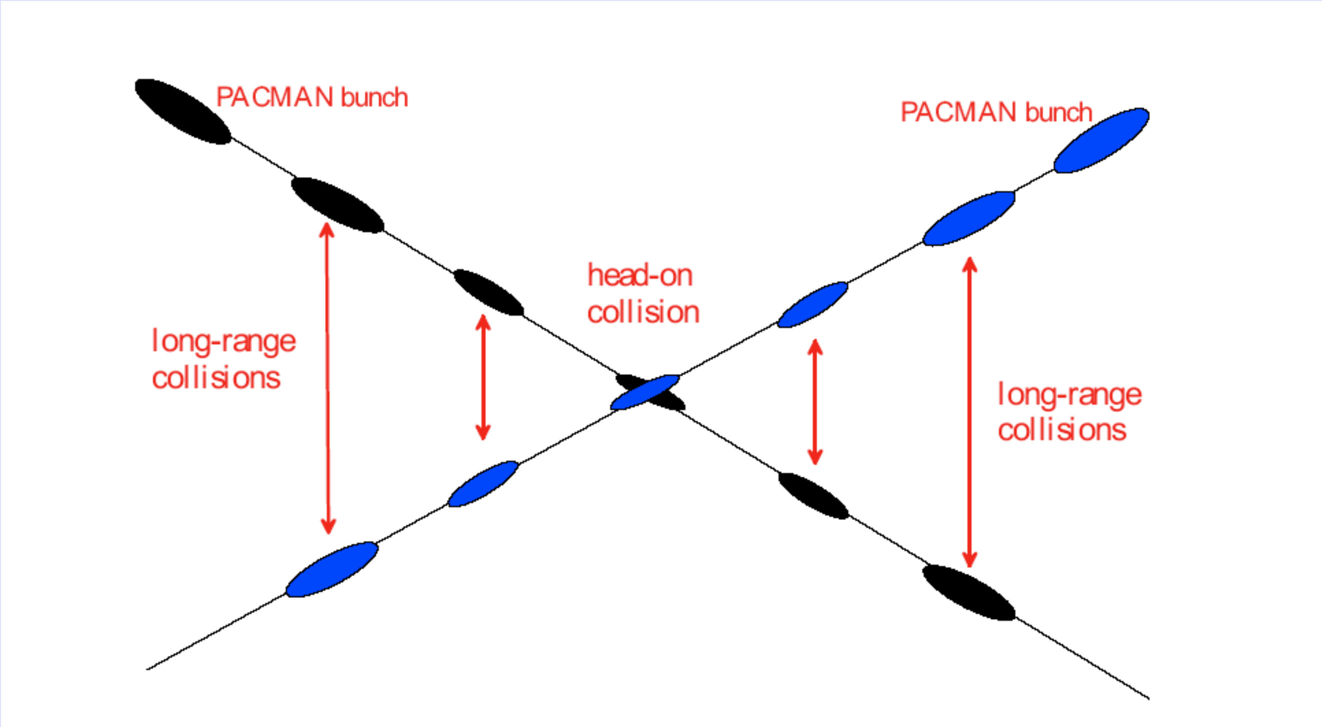
The LARP Dipole Program - Luminosity Limitations

120 parasitic long range collisions (25 ns bunch spacing) give a beam-beam interaction problem at higher than nominal design beam intensities. A dipole first IR design is one way to try to minimize this problem.

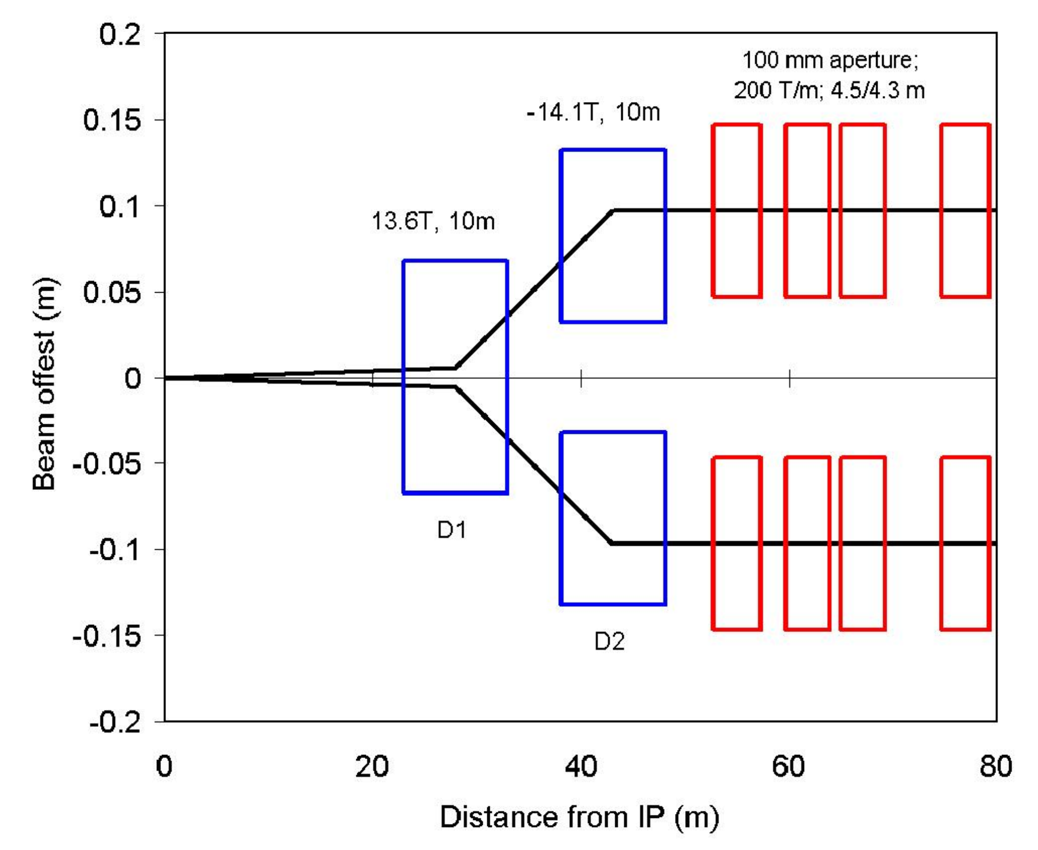


A dipole first design also permits a (much) smaller aperture (2-in-1) quadrupole with the beams centred avoiding feeddown (chromatic) effects

The LARP Dipole Program - Design Requirements

Design Requirements:

- High field ~12-14T
  - Compact separation section to keep quads close to the IP
- Large Horizontal Aperture
  - beam separation is ~8cm at DS end
- Field Quality
  - high beta lattice location, defines dynamic aperture at collisions
- Beam heating/heat load
  - Must be able to absorb significant energy deposition. First active element from the IP, total spray is ~9KW on each side of the IP at 10E35 ! Superconductor sensitive to mW/cm^3



Design Issues

The basic problem has two main components:

1. Can we produce a dipole that satisfies the field quality, and high field requirements, and doesn't quench with the estimated energy deposition from the IP ?

2. Can we also manage the heat load in a cryogenically friendly fashion i.e. absorb heat outside the 4K circuit ?

We are starting off with the intention of investigating how to solve both 1 & 2. If we can't manage to do both in a reasonable fashion then can we at least manage to do 1 and require the cryogenic system to just handle the additional load ? Any proposed magnet solution must be examined within this larger context.

Conceptual Design

Inputs

The large asymmetry of the horizontal aperture requirements compared to the vertical suggests a non-cosine theta approach.

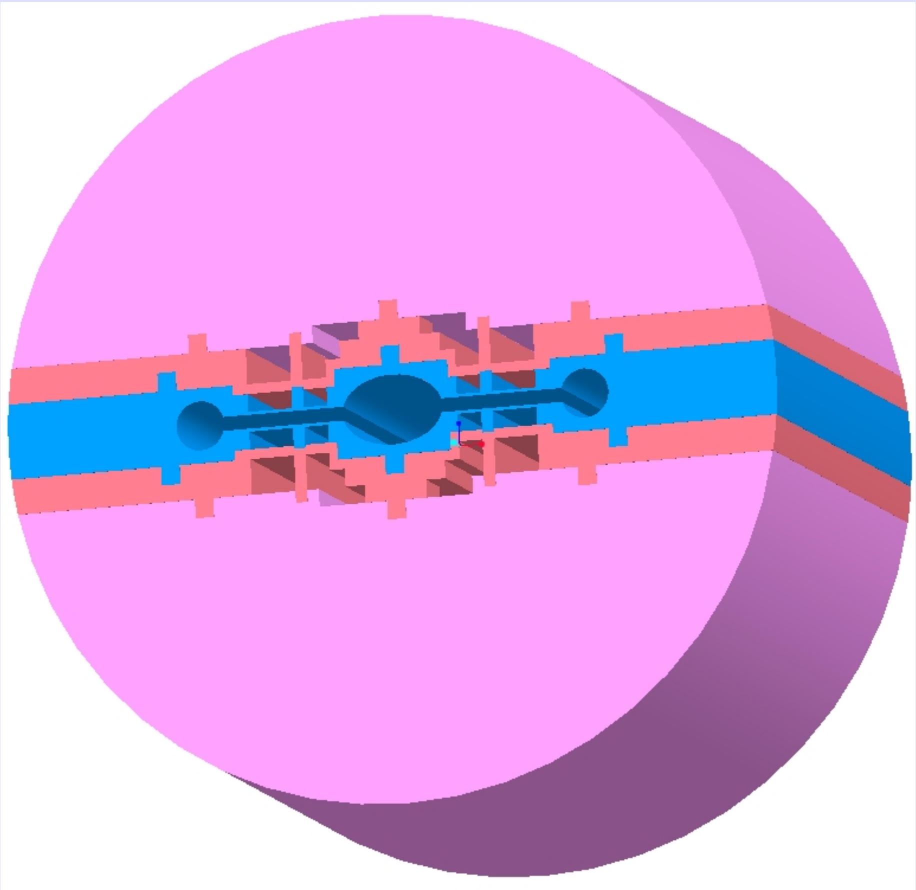
The dipole field will naturally tend to sweep the IP spray into the mid-plane of the magnet. This suggests a split coil geometry.

The IP debris would like a large dipole aperture to transmit the energy through the magnet to a TAN style dump

Field and energy deposition levels require Nb3Sn

Result - Open mid-plane, wide gap, geometry dipole with flat coils. This is a design specific for this particular problem not a generic solution to a 'high field dipole'. Not an 'accelerator' magnet.

LHC Upgrade Magnet R&D - Split Plane Dipole Concept



Flat coils: HTS compatible

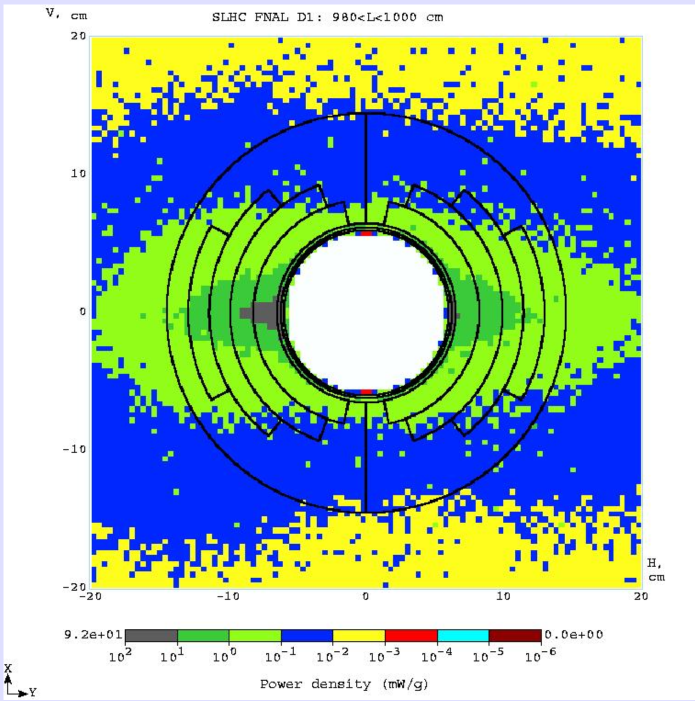
While The magnet model needs to ensure both magnetic field quality and mechanical stability it should also minimize energy deposition to the cryogenic circuits.

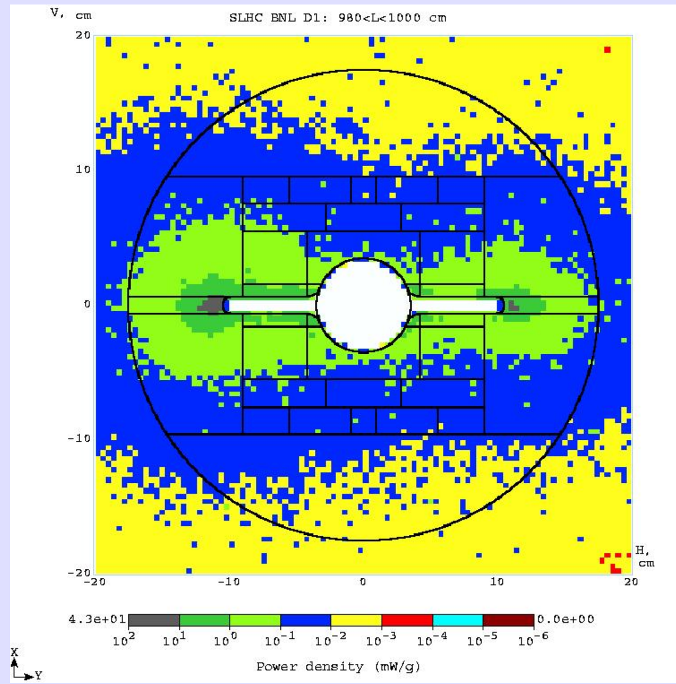
There are obviously many issues with a design such as this.

We are presently iterating (3rd go-around to date).

Energy Deposition - Split Plane magnet

MARS calculations by Nikolai Mohkov et.al.



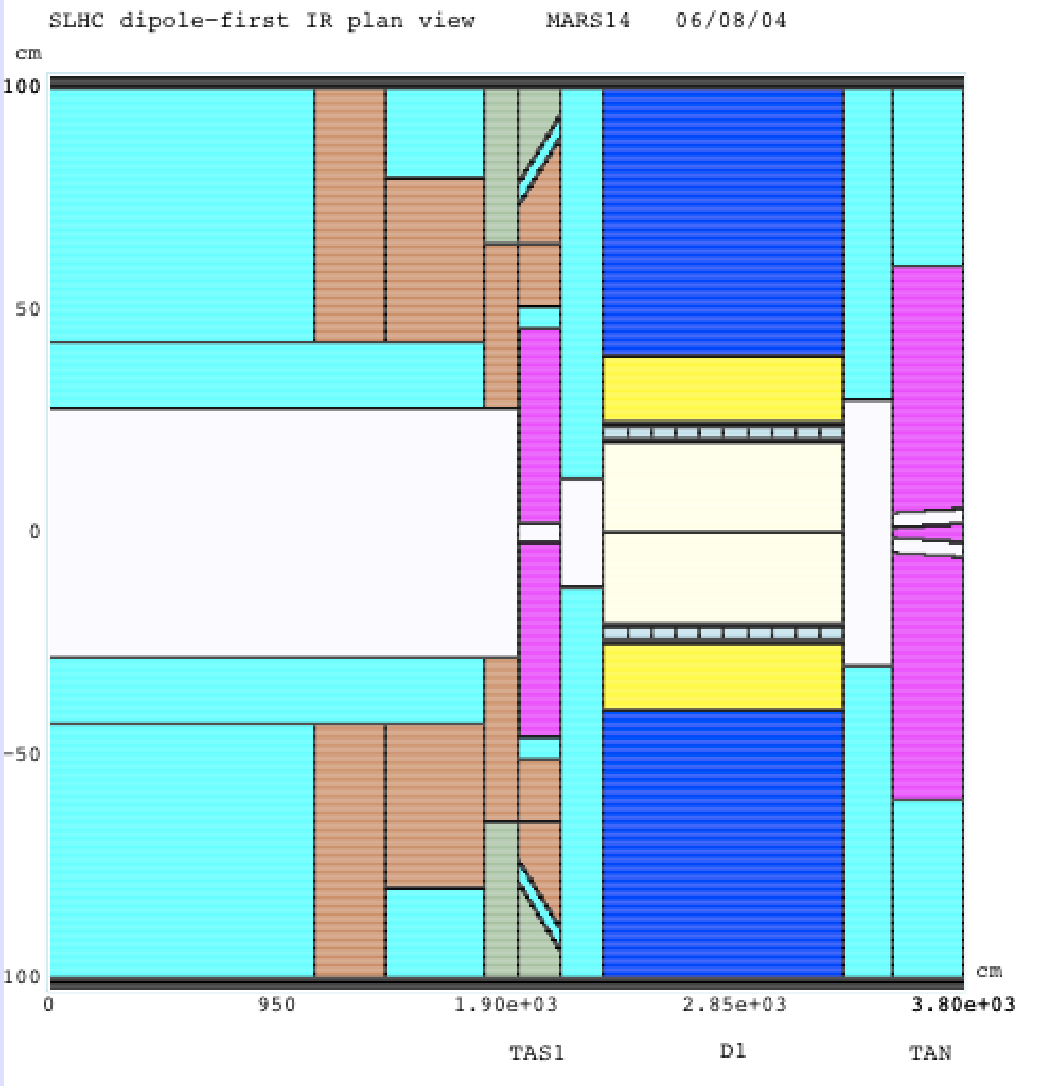


Obvious there are benefits to the split plane approach

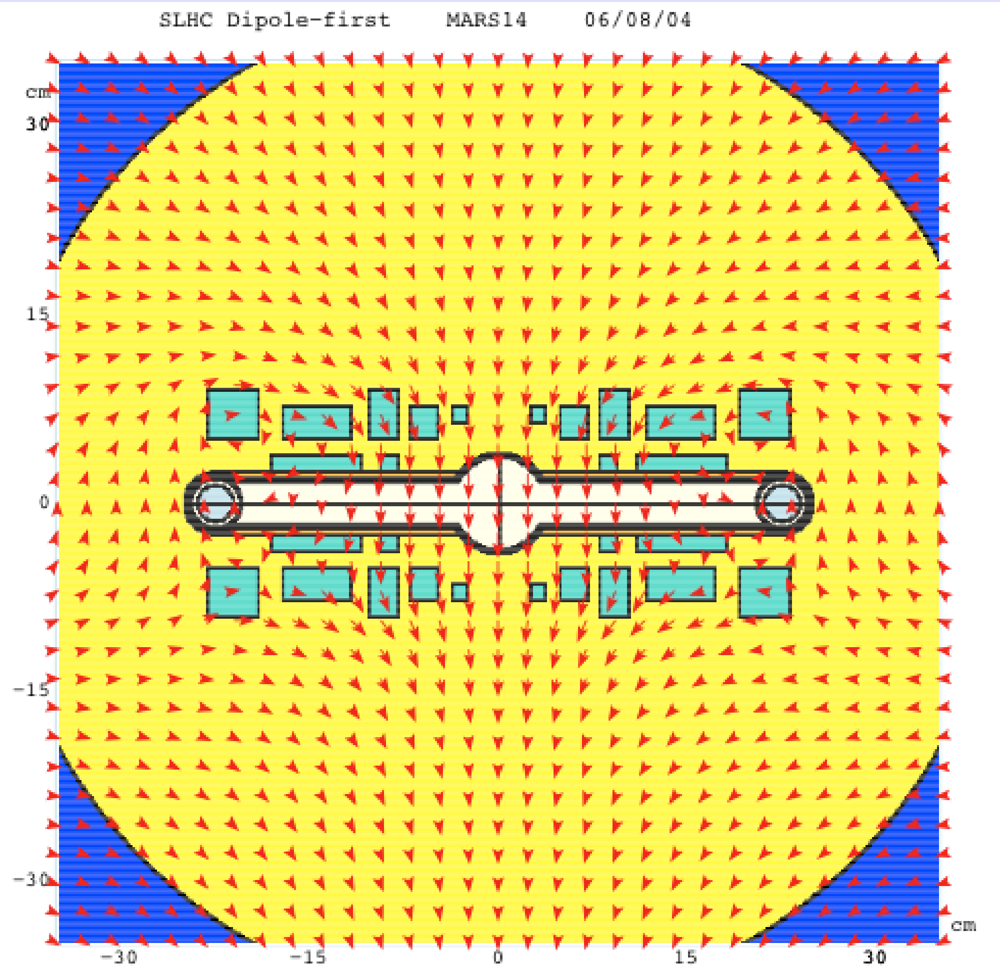
Energy Deposition - Split Plane magnet

MARS energy deposition model:

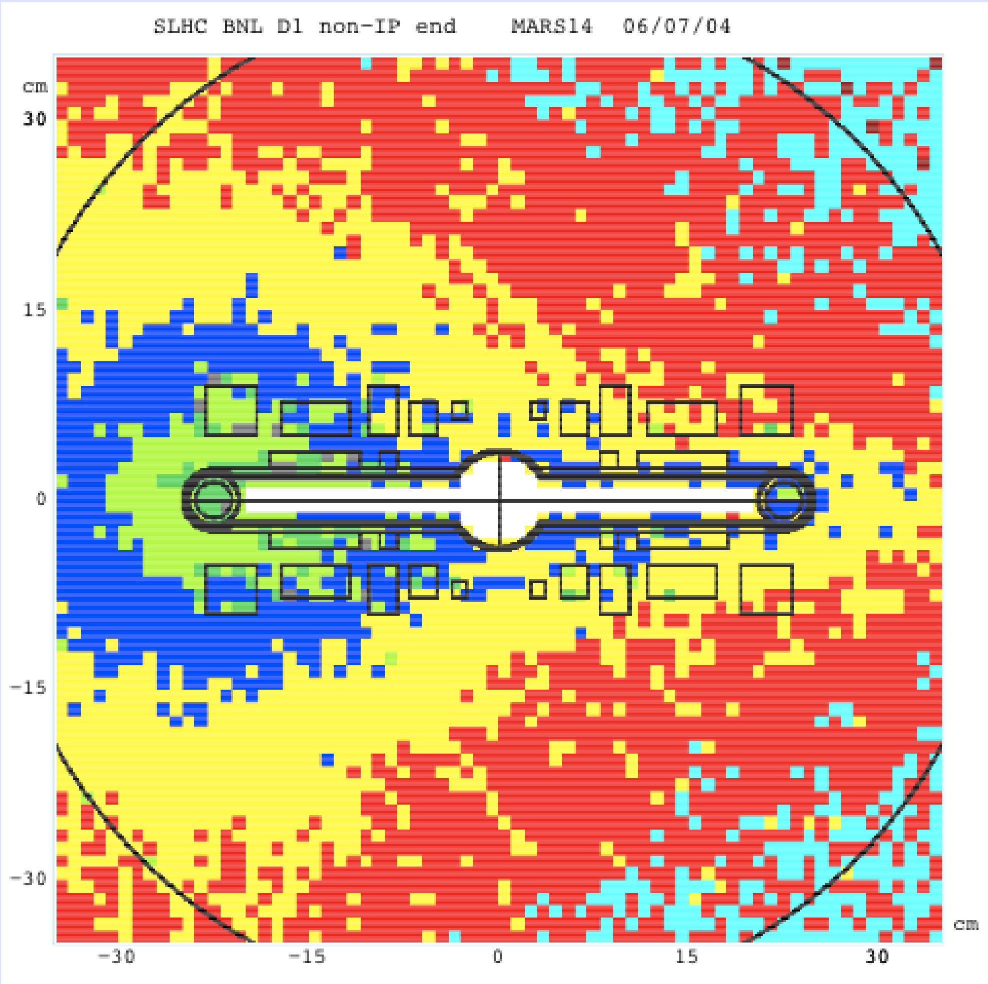
TAS + D1 + TAN



Energy Deposition - Split Plane magnet



Magnet Model



Initial Calculation

Energy Deposition - Split Plane magnet energy flow

Element	PD (kW)
TAS (R_hole=21 mm)	1.77
D1: SC	0.045
colar	0.306
yoke	0.025
all pipes	0.144
W-rods	0.274
Downstream of D1	6.40
Total	8.96

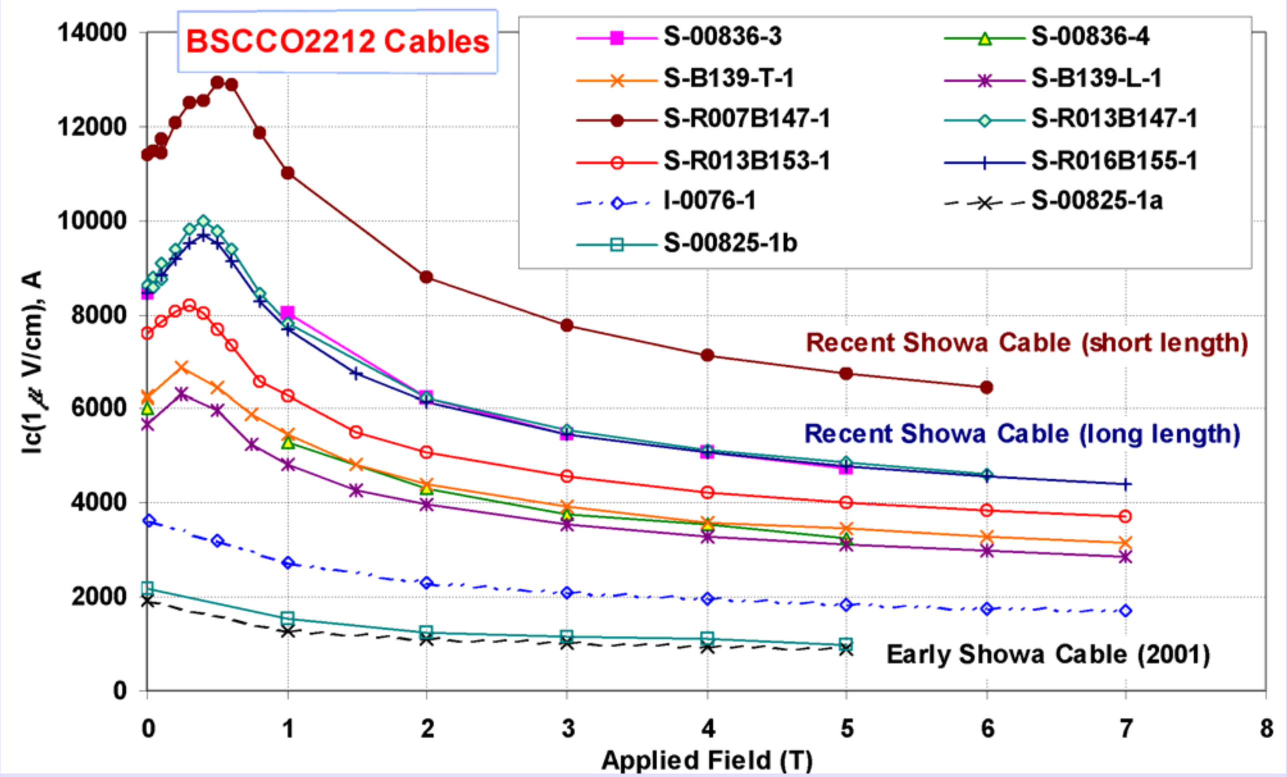
As of last Friday:

The system is reasonably effective by construction. Over 8 kW of power, out of a total of 9 kW, is intercepted by the absorbers.

We are trying to influence the remaining kW

HTS Compatible - flat coils

- Insensitivity to operating temperature would be useful in such a harsh environment
- 10-turn coils test O.K. (LBL-Showa-BNL)
- Performance needs to increase by ~ factor of 2 from today



R&D Program - Common Issues

- Common R&D issues with the quad program
  - Nb_3Sn radiation resistance
  - Nb_3Sn quench/instability properties
  - Coil cooling and heat removal
  - Mechanical forces - stress/strain, deflection
  - Insulating materials

LHC Upgrade Magnet R&D - the next steps

FY04

- Finalize conceptual magnetic design - proof of principle that we can satisfy the requirements as presently understood
- Complete 2-D mechanical analysis of the conceptual design
  - Develop external structure to restrain collars
- Start thermal analysis (with Fermilab)
- Investigate sub-scale dipole test for FY05
  - LBL coils in restrained collars similar to the LARP dipole

FY05

- Compete prototype cold mass 3-D mechanical design
  - Define FY06 test assembly
- Continue thermal analysis - static temperature profiles, cooling schemes etc….
- Determine viability of open mid-plane approach
- Dipole sub-scale test
  - LBL coils in a BNL structure. R&D issues addressed include stress/strain, deflection, coil assembly techniques
  - It remains to be determined whether sufficient resources exist to accomplish this in FY05

LHC Upgrade Magnet R&D - the next steps

FY06

- Sub-scale test if not performed in FY05
  - Precursor to cold mass fabrication
- Build 'simplified' cold mass
  - Main coils to produce correct field/forces but not field quality
  - ~1m long, without yoke ?
  - Test coils in vertical dewar
- Heat load and temperature tests

Conclusions

- The dipole first upgraded IR will require a dedicated dipole design
- Dipole first design iterations in progress with Fermilab energy deposition calculations
- We need to evaluate whether the ‘cryogenic friendly’ approach is both feasible and optimal
  - See Ramesh’s talk next
- Many aspects of the R&D are common to both quads and dipoles i.e. technology development is a sensible course of action