

**AMS-02 Phase 2 Safety Review  
Magnetic Field & Quench**



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# AMS-02 Phase 2 Safety Review

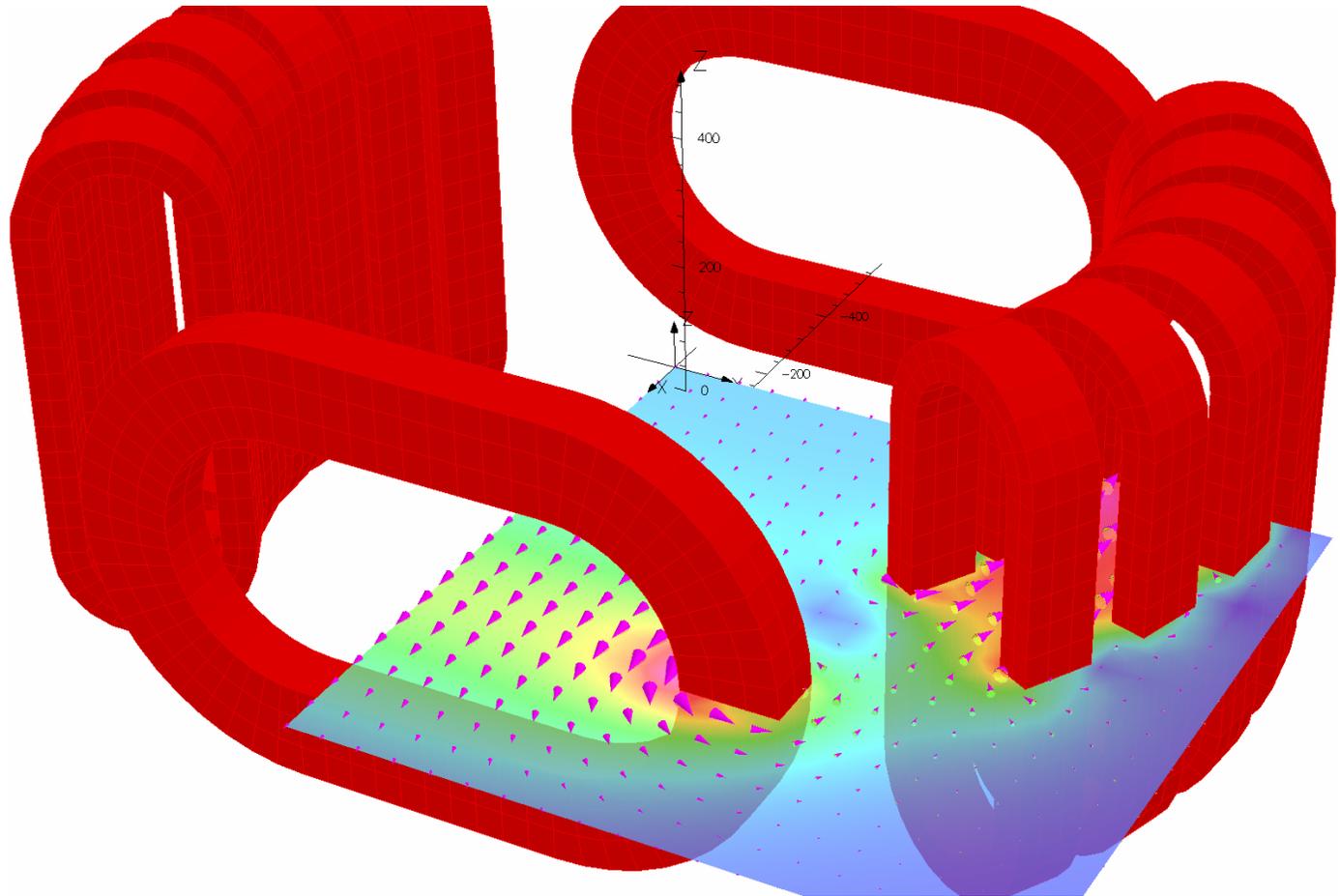
## Magnetic Field & Quench

### Contents:

1. Magnet configuration
2. Magnetic field
3. Introduction to quench & training
4. Quench analysis
5. Quench protection
6. Effect of quench
7. Cryomagnet Self Protection (CSP) unit
8. Secondary quench effects - eddy currents

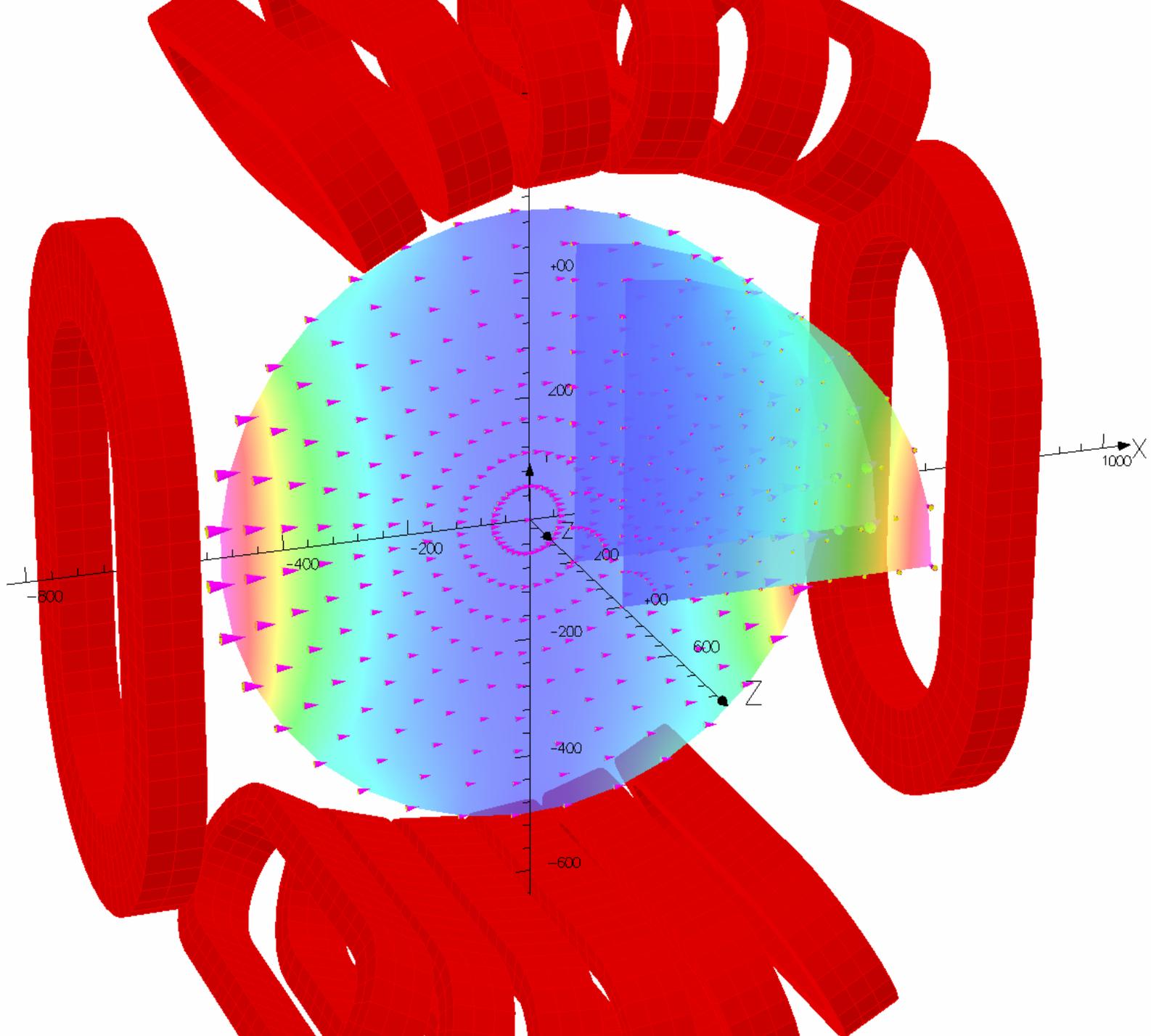
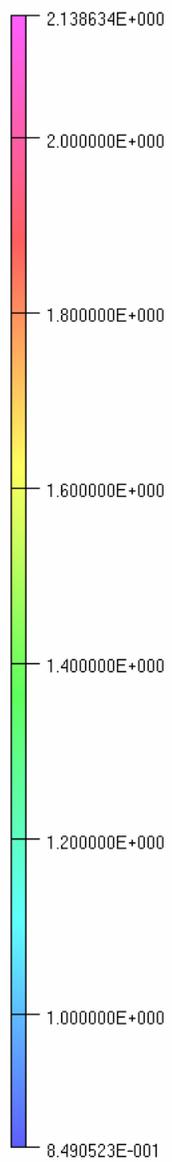


# AMS-02 Phase 2 Safety Review Magnetic Field & Quench



Magnet  
Configuration

Map contours: BMOD



# AMS-02 Phase 2 Safety Review

## Magnetic Field & Quench

### Magnetic Fields

Static magnetic fields have no known adverse health effects

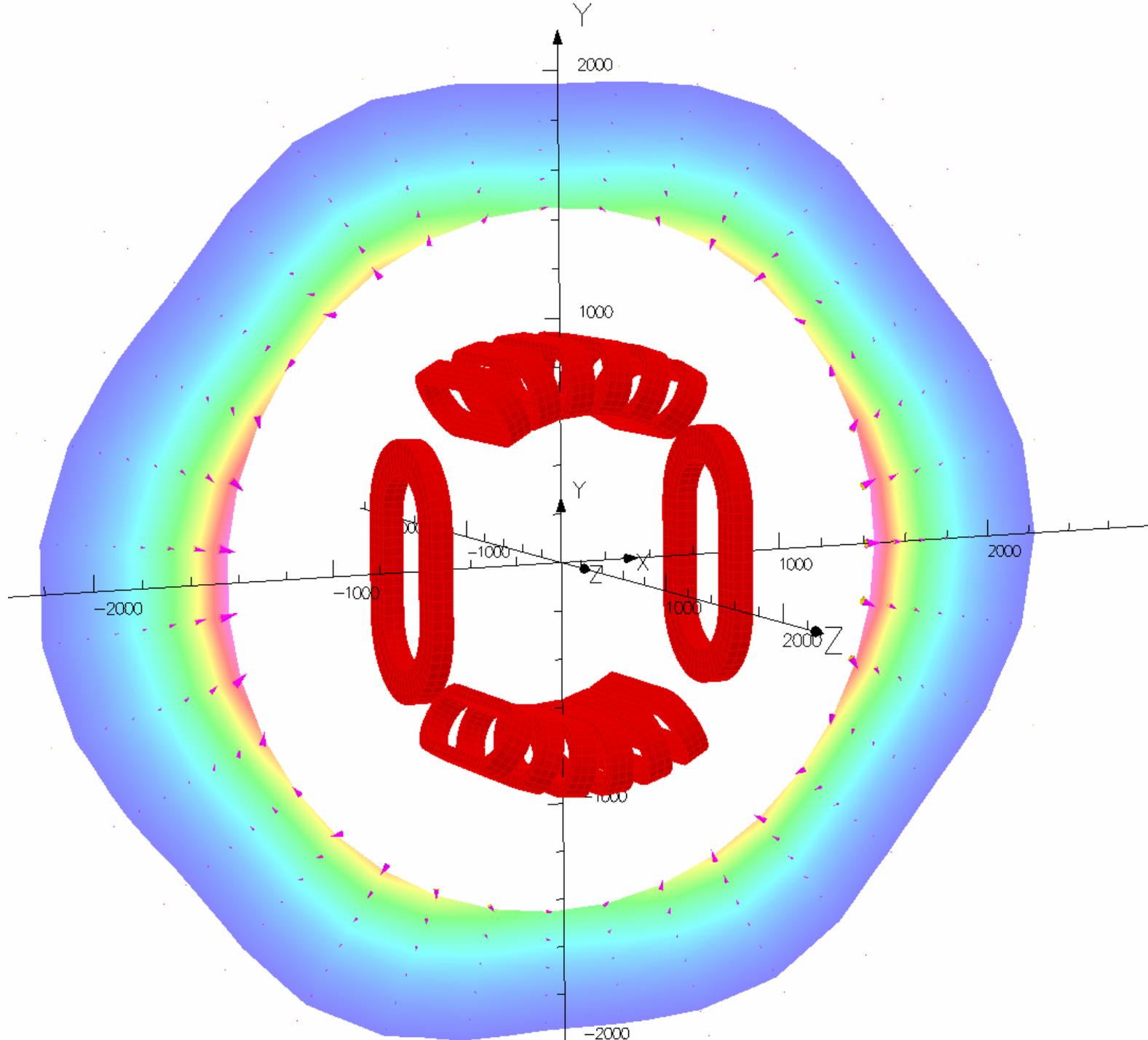
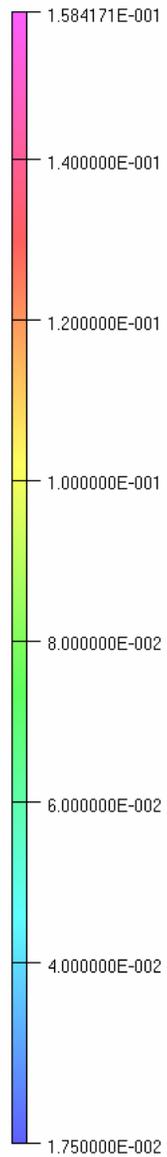
Precautionary industry accepted maximum field for uncontrolled access is 5 gauss (0.5 mT)

Smallest field at which ISS systems may be affected is 175 gauss (17.5 mT)





Map contours: BMOD





# AMS-02 Phase 2 Safety Review

## Magnetic Field & Quench

### Introduction to Quenching

- If the temperature is too high
- If the magnetic field is too high
- If the current is too high

Superconductors become resistors

Magnet energy is dissipated as heat in the coils

This is a Quench



## AMS-02 Phase 2 Safety Review Magnetic Field & Quench

### Introduction to Quenching (Cont.)

- Magnets often quench when run for the first time
- Progressively higher fields are reached at each quench
- When design field is reached quenching stops

This is Training

Once trained, further quenches are not expected

Larger magnets are designed to be more stable - less training

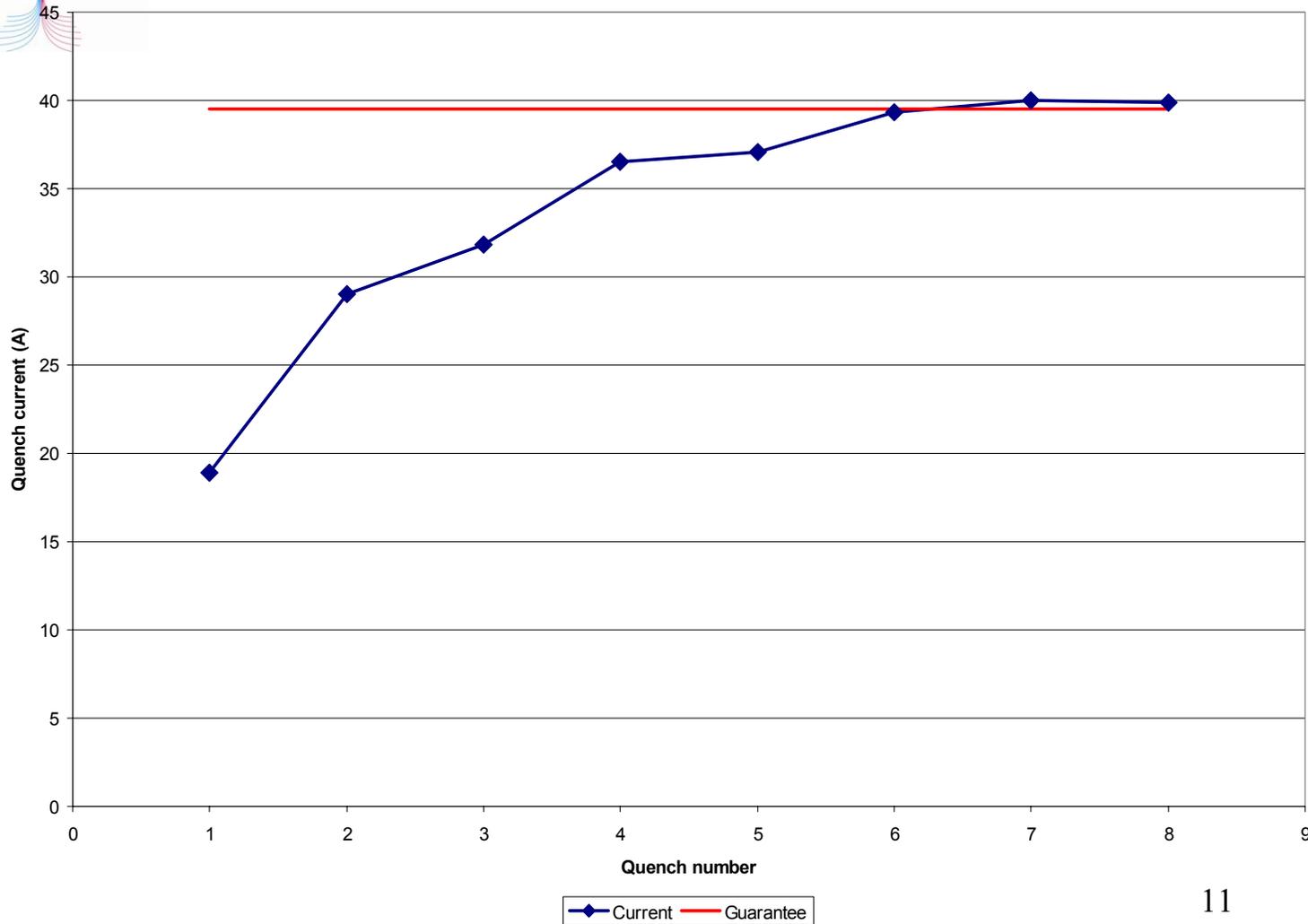


# AMS-02 Phase 2 Safety Review Magnetic Field & Quench

SCIENTIFIC  
MAGNETICS



Training: Small Split Pair Magnet



## AMS-02 Phase 2 Safety Review Magnetic Field & Quench

### Quenching and AMS-02

- AMS-02 cryomagnet will be tested in the MATR (Magnet Assembly Test Rig)
- AMS-02 cryomagnet will be tested in the flight cryostat

AMS-02 is designed to be stable against quenching

Any training will occur before flight (in the MATR)

We do not expect quenches after launch

AMS-02 magnet will quench safely

Cryostat design means AMS-02 can recover from a quench on orbit



# AMS-02 Phase 2 Safety Review

## Magnetic Field & Quench

### Quench Analysis

Analytical Model - single coil

Finite difference model - single coil

“QUENCH” Program - magnet

Independent verification

To be tested in the MATR!



## AMS-02 Phase 2 Safety Review Magnetic Field & Quench

### Stability against quenching

Coil	$B_{\max}$	$T_c$	$T_g$	$T_{\text{op}}$
Dipole	6.59 T	6.4 K	4.1 K	1.8 K
Racetrack	5.9 T	6.8 K	4.6 K	1.8 K

## AMS-02 Phase 2 Safety Review Magnetic Field & Quench

### Temperatures

What happens if only one coil Quenches?

Magnet energy 5 MJ

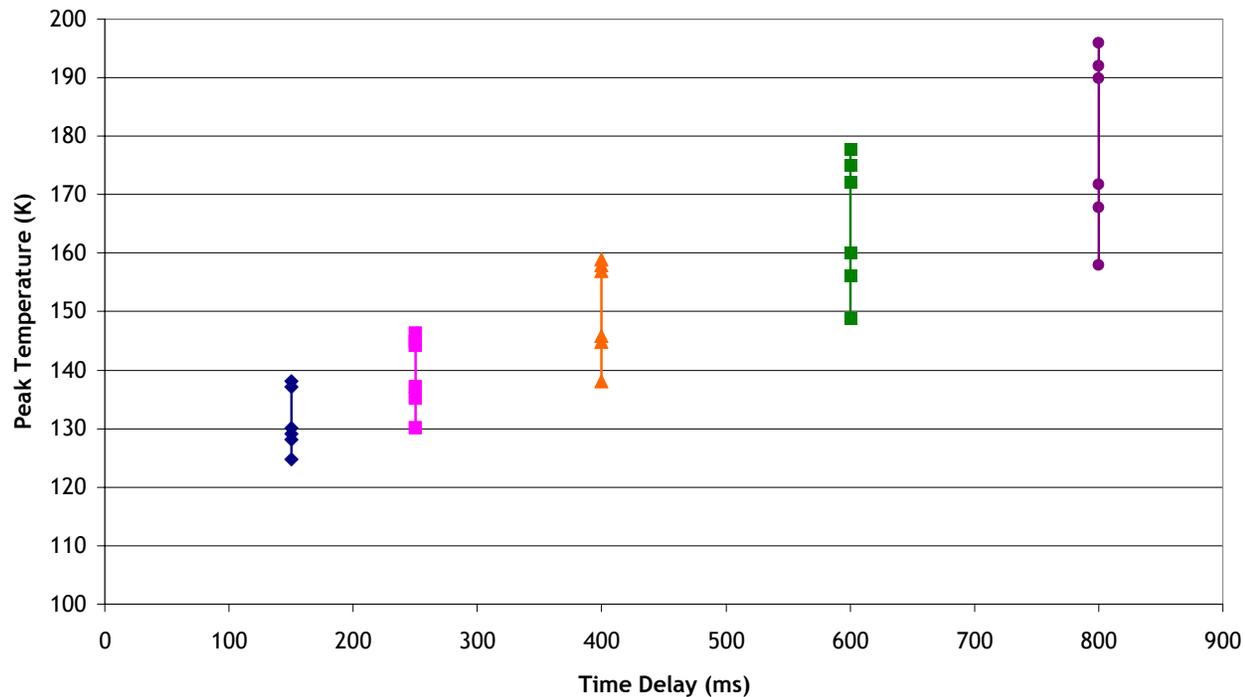
Coil	$T_{\max}$	$T_{\text{av}}$
Dipole	204 K	155 K
Racetrack	430 K	280 K

# AMS-02 Phase 2 Safety Review

## Magnetic Field & Quench

### Temperatures

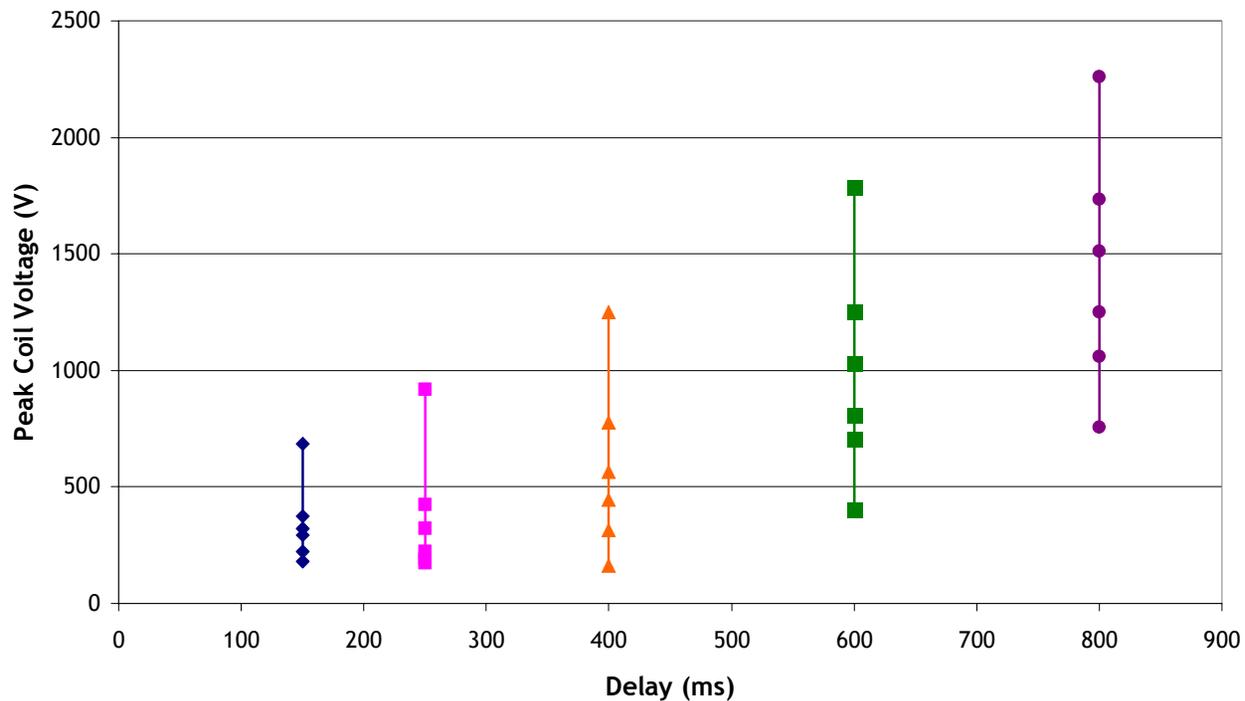
When the quench involves all the coils



# AMS-02 Phase 2 Safety Review Magnetic Field & Quench

## Voltages

When the quench involves all the coils



## AMS-02 Phase 2 Safety Review Magnetic Field & Quench

### Quench Analysis Conclusions:

As long as we spread a quench to all coils within 250 ms :

- Maximum peak temperature is 150 K
- Maximum mean temperature is 130 K
- Maximum voltage 1000 V

To be confirmed by MTR tests.

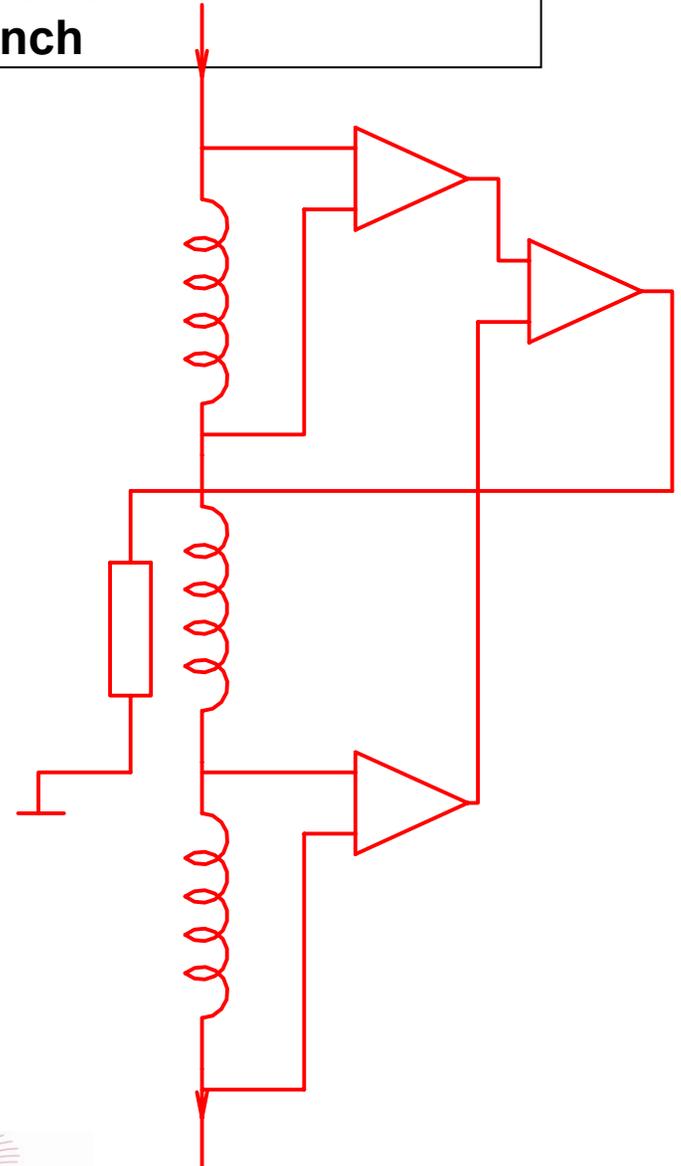
# AMS-02 Phase 2 Safety Review Magnetic Field & Quench

## Quench Protection

AMS-02 will use an active quench protection system

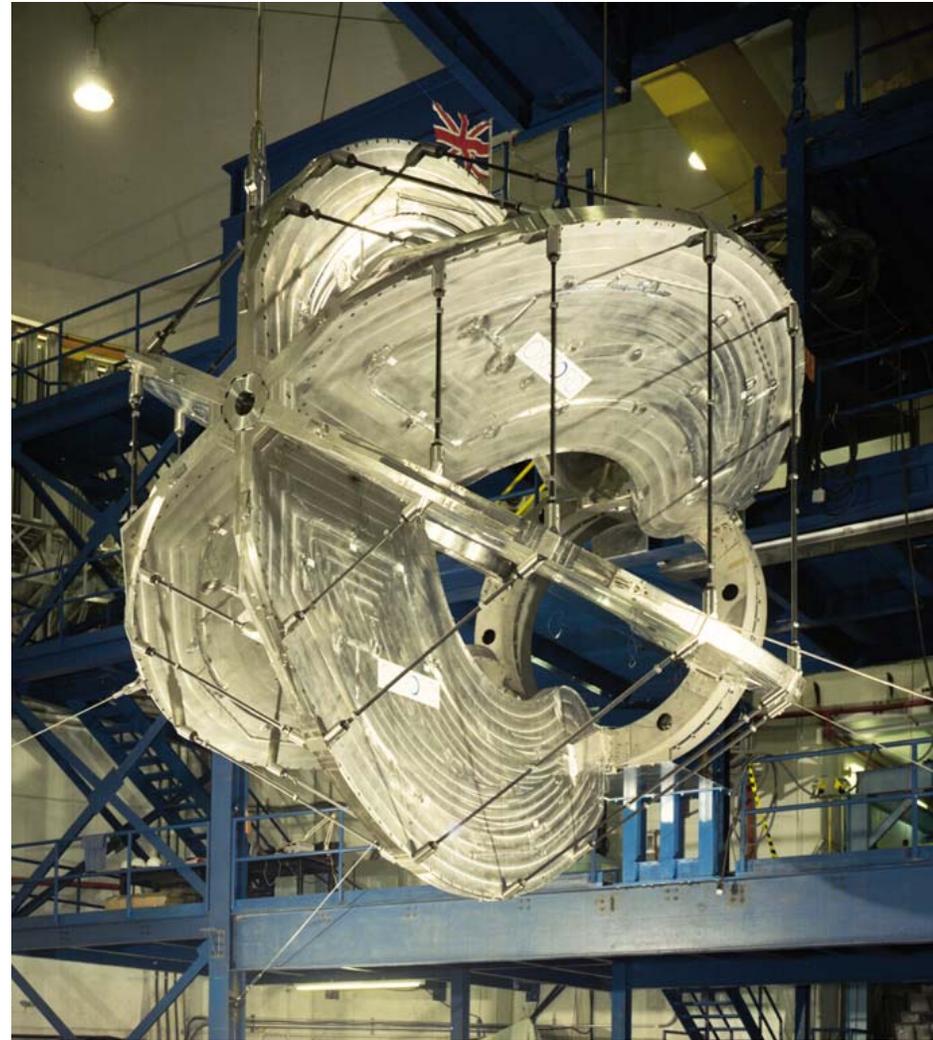
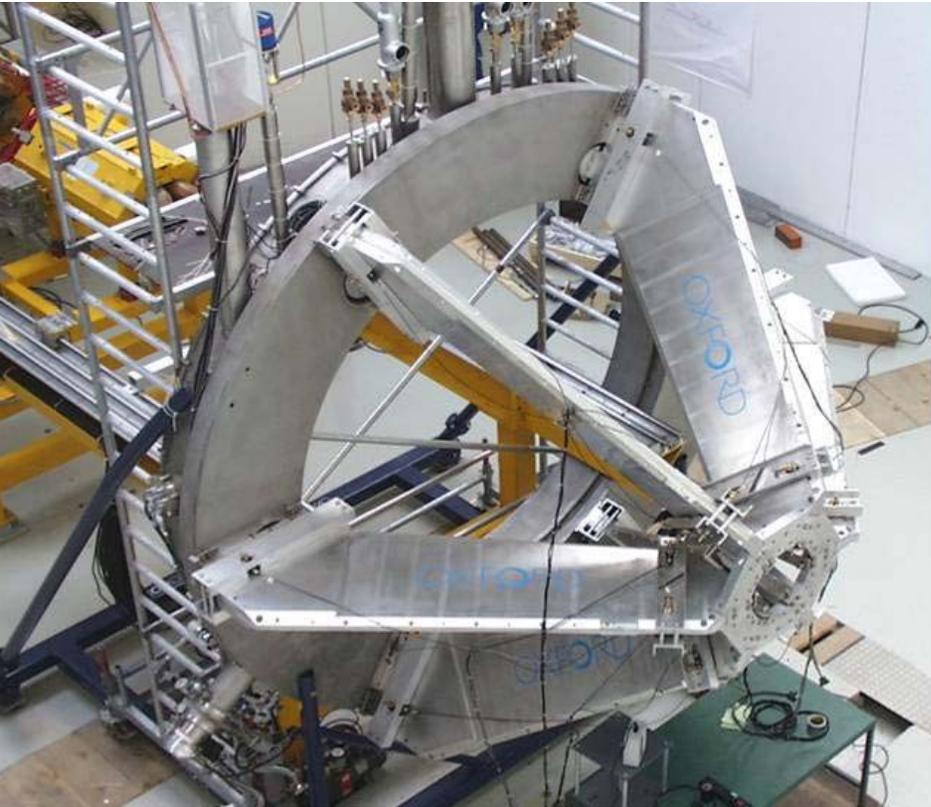
Common approach for large magnets with thermally isolated coils

e.g.....



# AMS-02 Phase 2 Safety Review Magnetic Field & Quench

Actively protected magnets



## AMS-02 Phase 2 Safety Review Magnetic Field & Quench

Actively protected magnets  
(cont.)



## AMS-02 Phase 2 Safety Review Magnetic Field & Quench

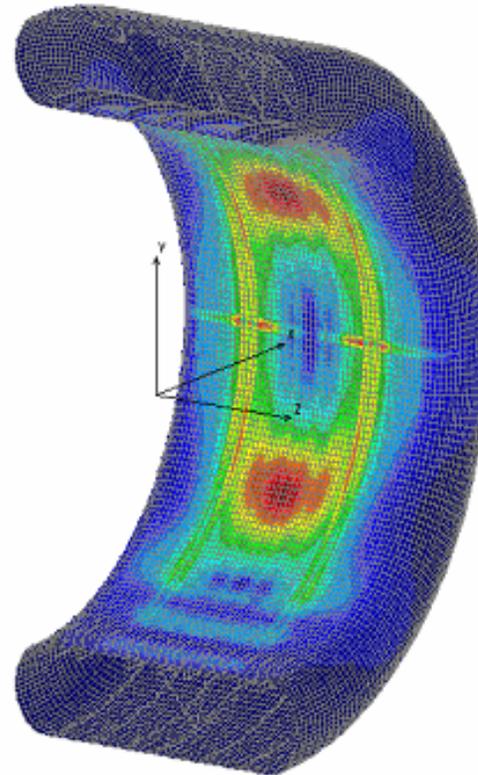
### The Cryomagnet Self Protection unit CSP

- Part of the magnet avionics = CAB
- Detects onset of quench => fires heaters => Quench
- Detects current lead fault & fires heaters => Quench
- Automatic magnet discharge (without quench) if communications are lost for >8 hrs
- Auto-cool after quench
- UPS power
- The CSP is to protect the magnet (mission success)
- It is NOT required for safety!

## AMS-02 Phase 2 Safety Review Magnetic Field & Quench

### Quench – Eddy Currents

- Magnet structure
- Helium vessel
- Thermal shields
- Vacuum vessel

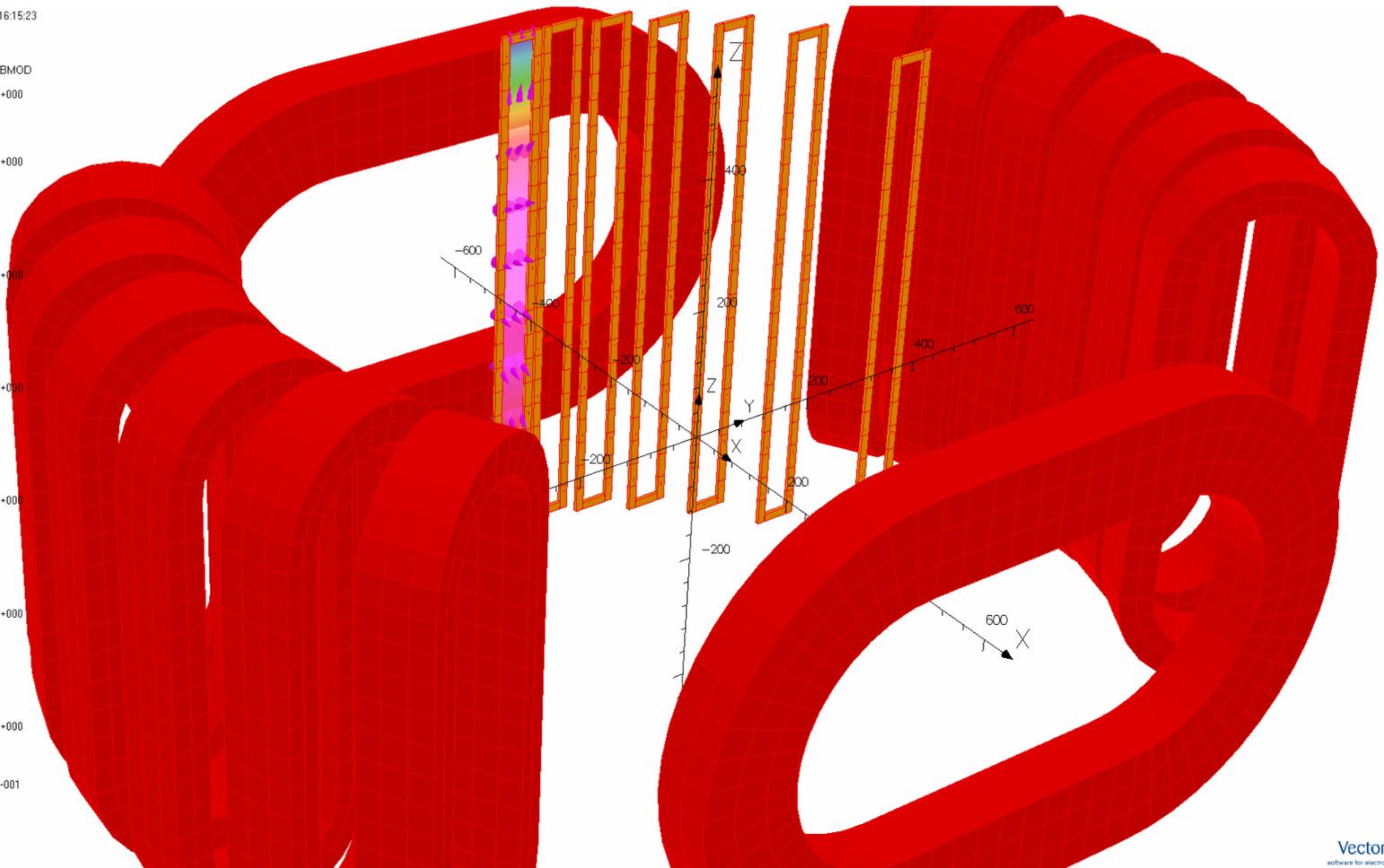
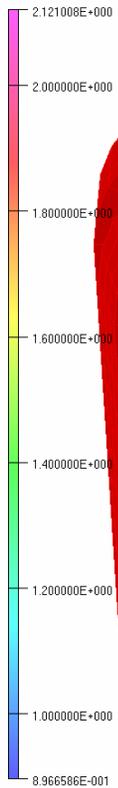


# AMS-02 Phase 2 Safety Review Magnetic Field & Quench

## Quench – Induced Currents TTCS

11/Mey/2007 16:15:23

Map contours: BMOD



Vector Fields  
software for electromagnetic design

## AMS-02 Phase 2 Safety Review Magnetic Field & Quench

### Conclusions

- However unlikely a quench is, all magnets have to be designed to quench safely.
- AMS-02 Cryomagnet has been shown to be safe by analysis.
- Tests in the MATR and flight cryostat will confirm this.