



Superconducting Magnet for DUNE near detector

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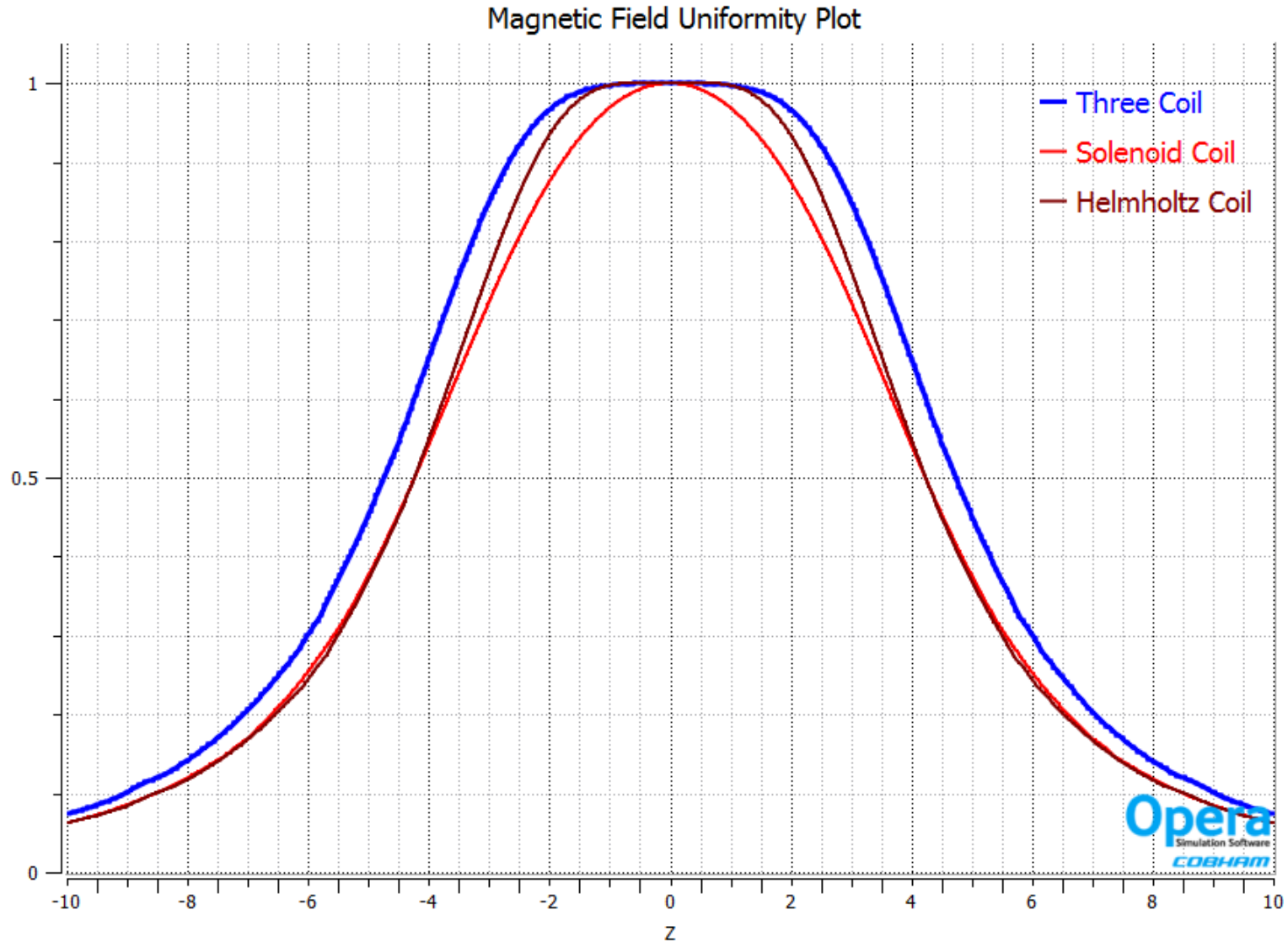
Dune Near Detector Magnet Meeting

Date:30-November-2018

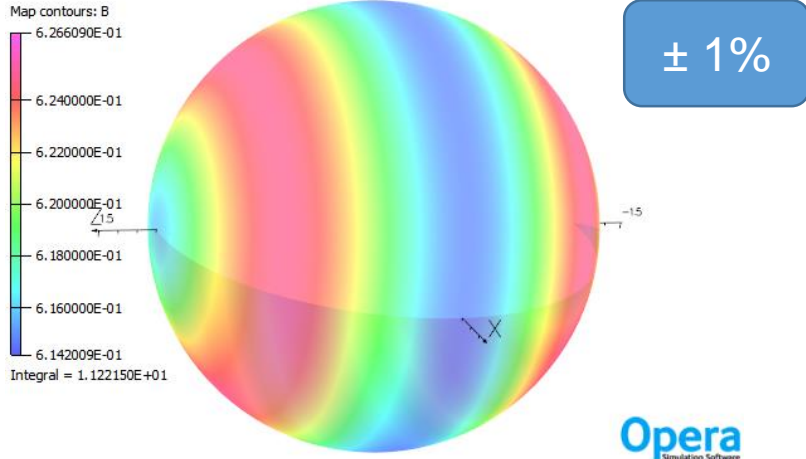
Magnet Design

- Requirement
 - HPgTPC will be located inside the magnet.
 - The size of HPgTPC is 6.5m Diameter and 6.2m Long
 - The magnetic field required is 0.52T
- Design reference input has been taken from Dr Vladimir Kashikhin presentation dated 25-September-2018.

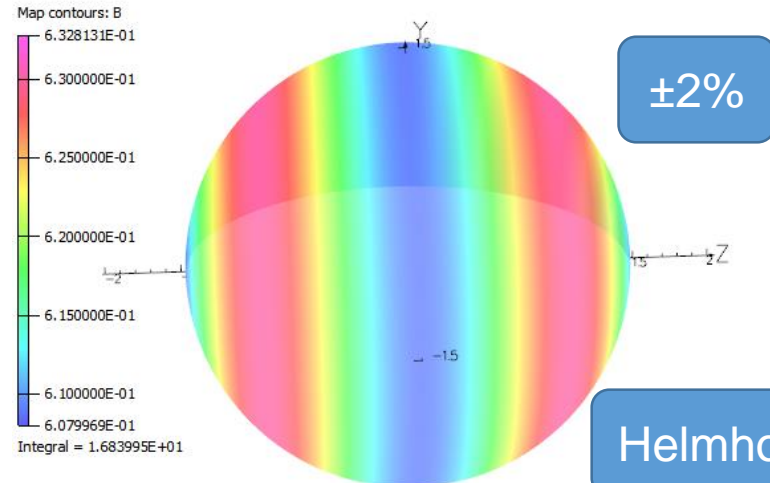
Magnetic Fields along the Z- axis comparison



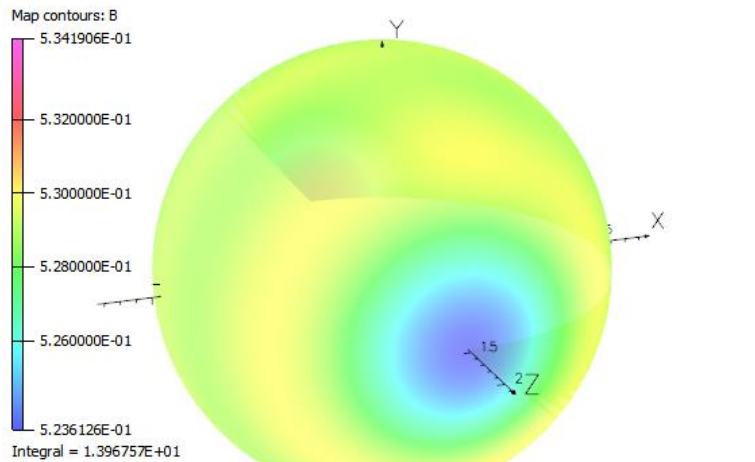
Magnetic Field uniformity



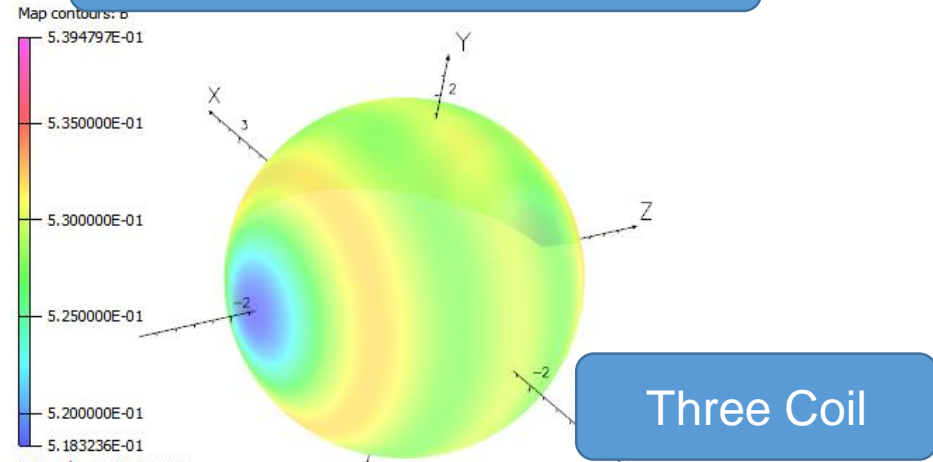
DSV : 2.4m



DSV : 2.95m

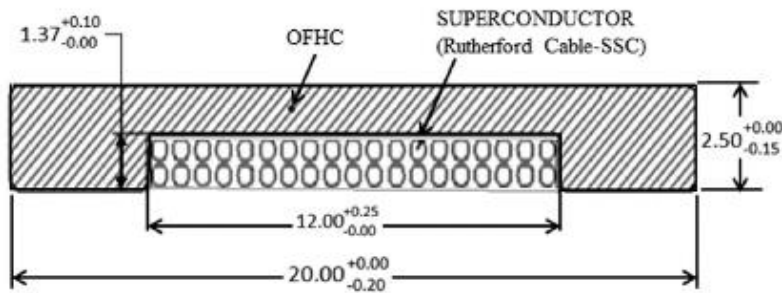


DSV : 2.8m

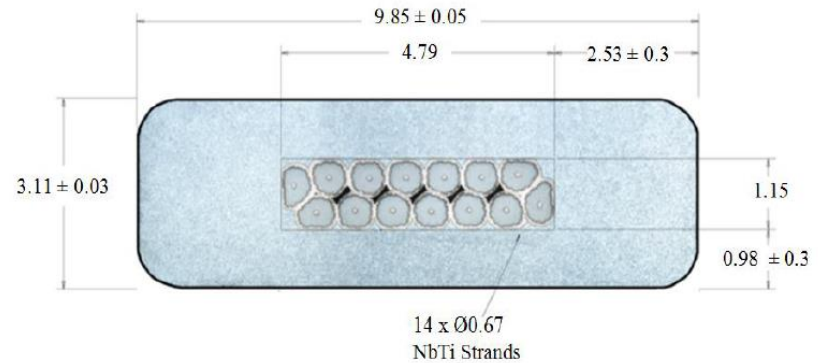


DSV : 3.5m

Conductor Selection



Rutherford cable soldered to Cu



Rutherford cable extruded with high purity Al

- Used in JLAB Hall B Torus , GlueX Solenoid , ISEULT high field MRI
- Estimate carried out by MIT* \$10/m as on 2011.
- Rutherford cable is SSC outer cable.
- Large size detector magnet uses high purity Al as the stabilizer.
- Estimate carried out by MIT \$60/m as on 2011.

Rutherford cable soldered to Cu with the size of 20.3 mm x 2.8 mm is considered for detailed analysis

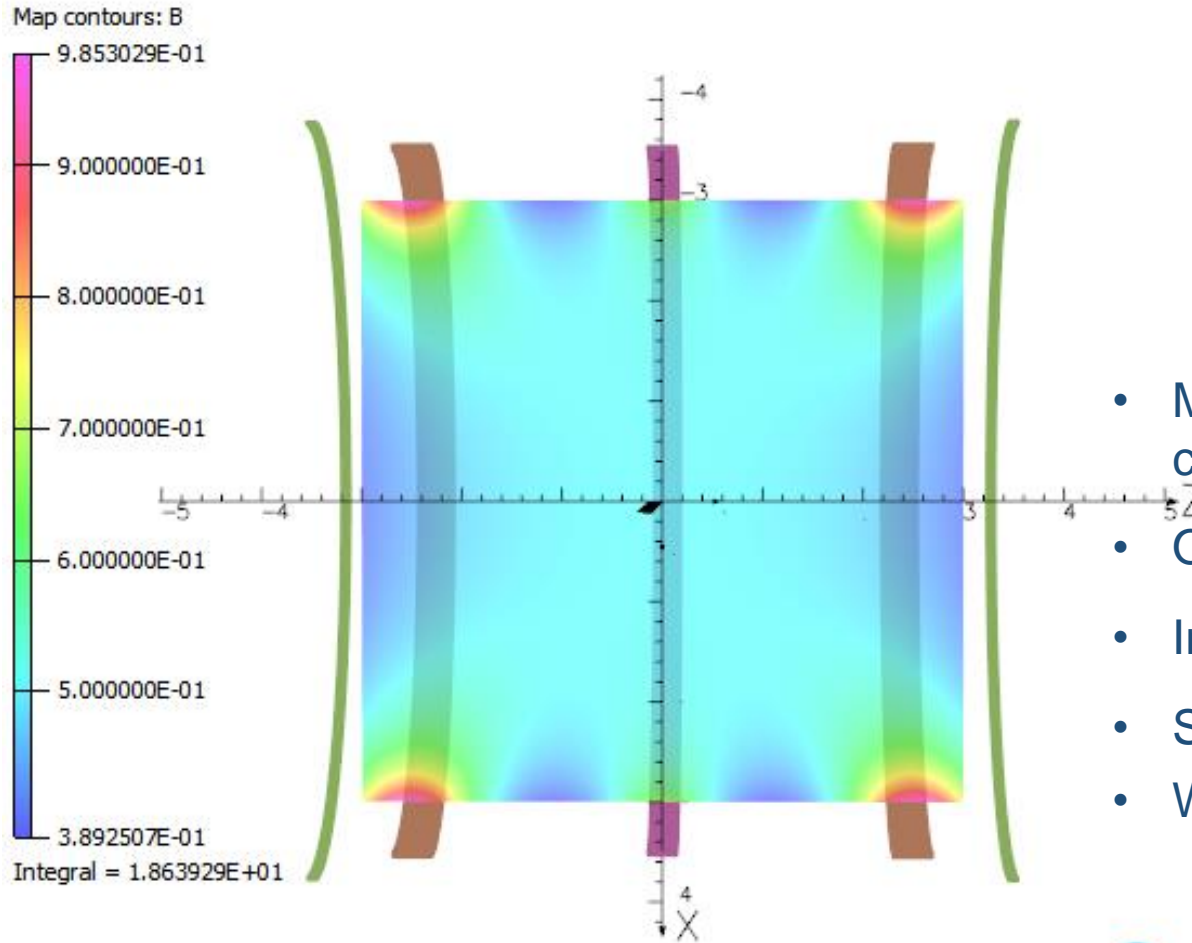
*-> Rationale for conductor choice for Hall D Solenoid Magnet , MIT Plasma Science and Fusion center , August 2011

Magnets comparison

Magnet Inner Diameter : 7.5 m , Length : 7 m

	Thin Solenoid	Helmholtz coil	Three coil	Three coil with active bucking coil
Number of turns	2188	1252	186 , 750	186 , 750 , 62
Number of layers	1	2	2 ,3	2,3,2
Length of cable (km)	50	28	20.6	21
Weight (Tons)	24.5	14	10.5	11.23
Operating current(A)	2000	4000	5200	5200
B_{peak} (T)	0.64	1.66	2.35	3.42
Stored energy(MJ)	45.32	87.06	75.58	83
Current sharing Temp (K)	8.6	7.8	7.2	6.6

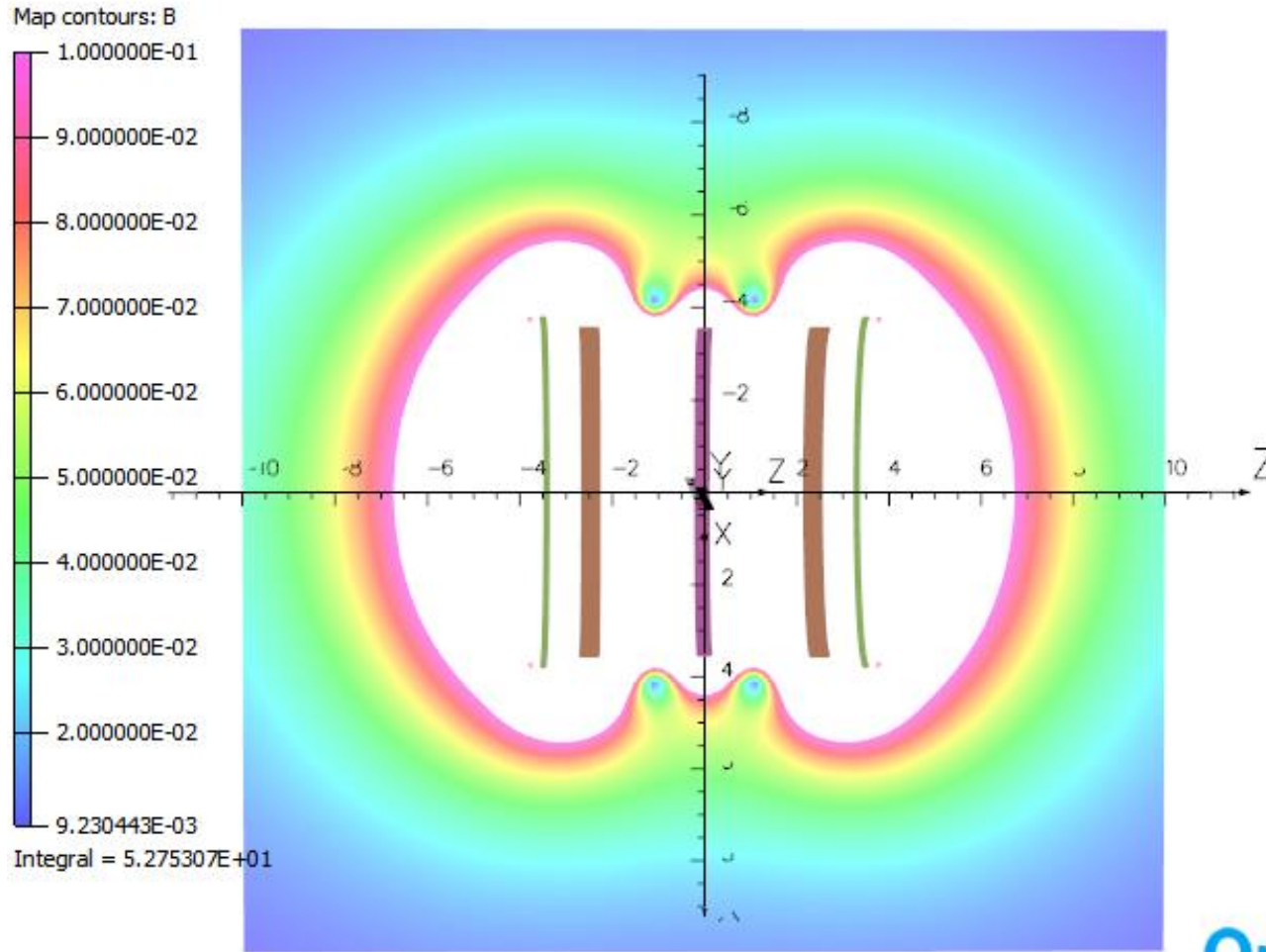
Three coil with active bucking coil Magnetic Fields in the Region of TPC



- Main coil ,Side coils and bucking coil connected in Series
- Operating current : 5200A
- Inductance : 5.48H
- Stored Energy : 83MJ
- Weight : 12 Ton

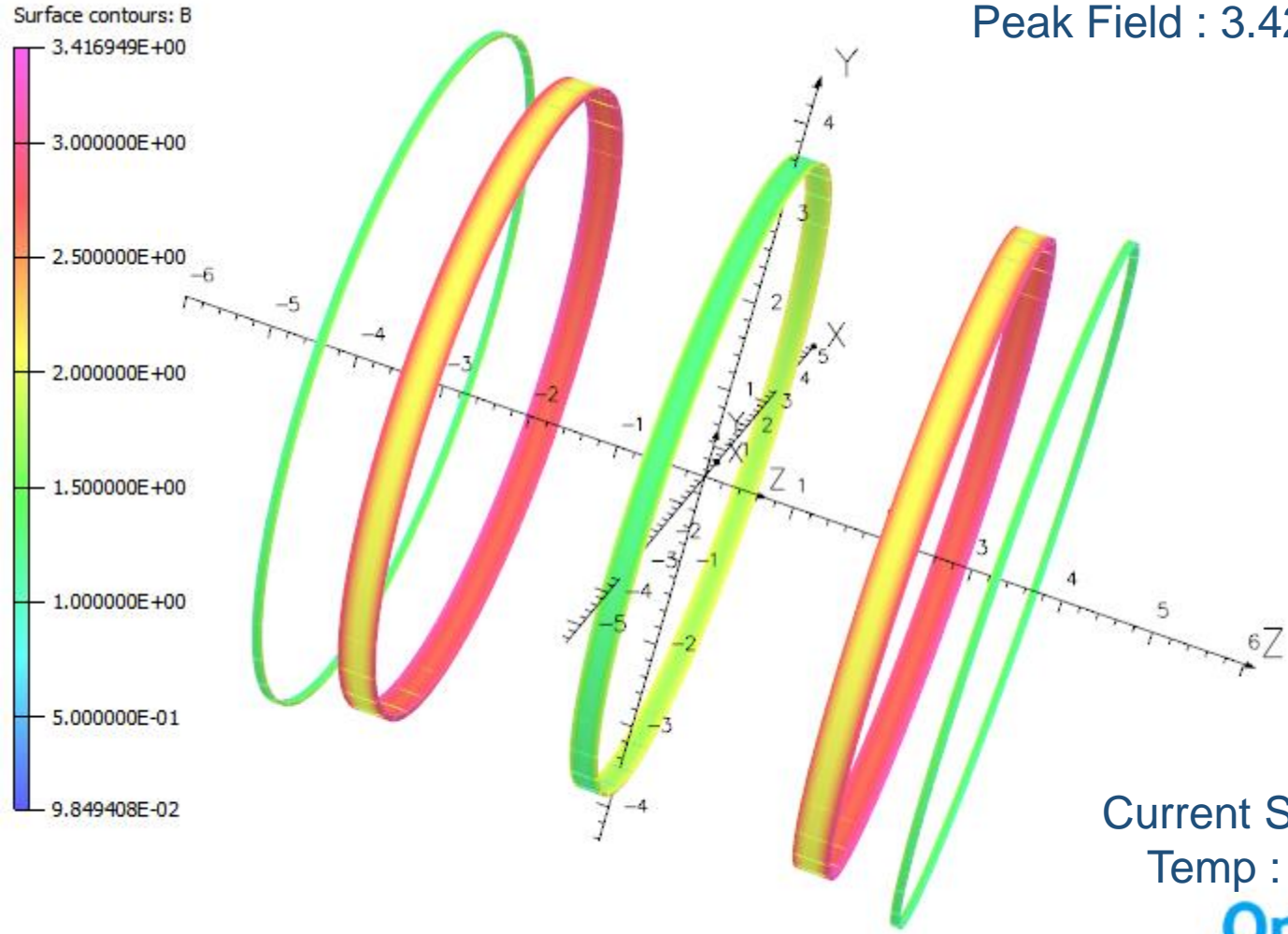
Opera
 Simulation Software
 COBHAM

Stray Magnetic Field



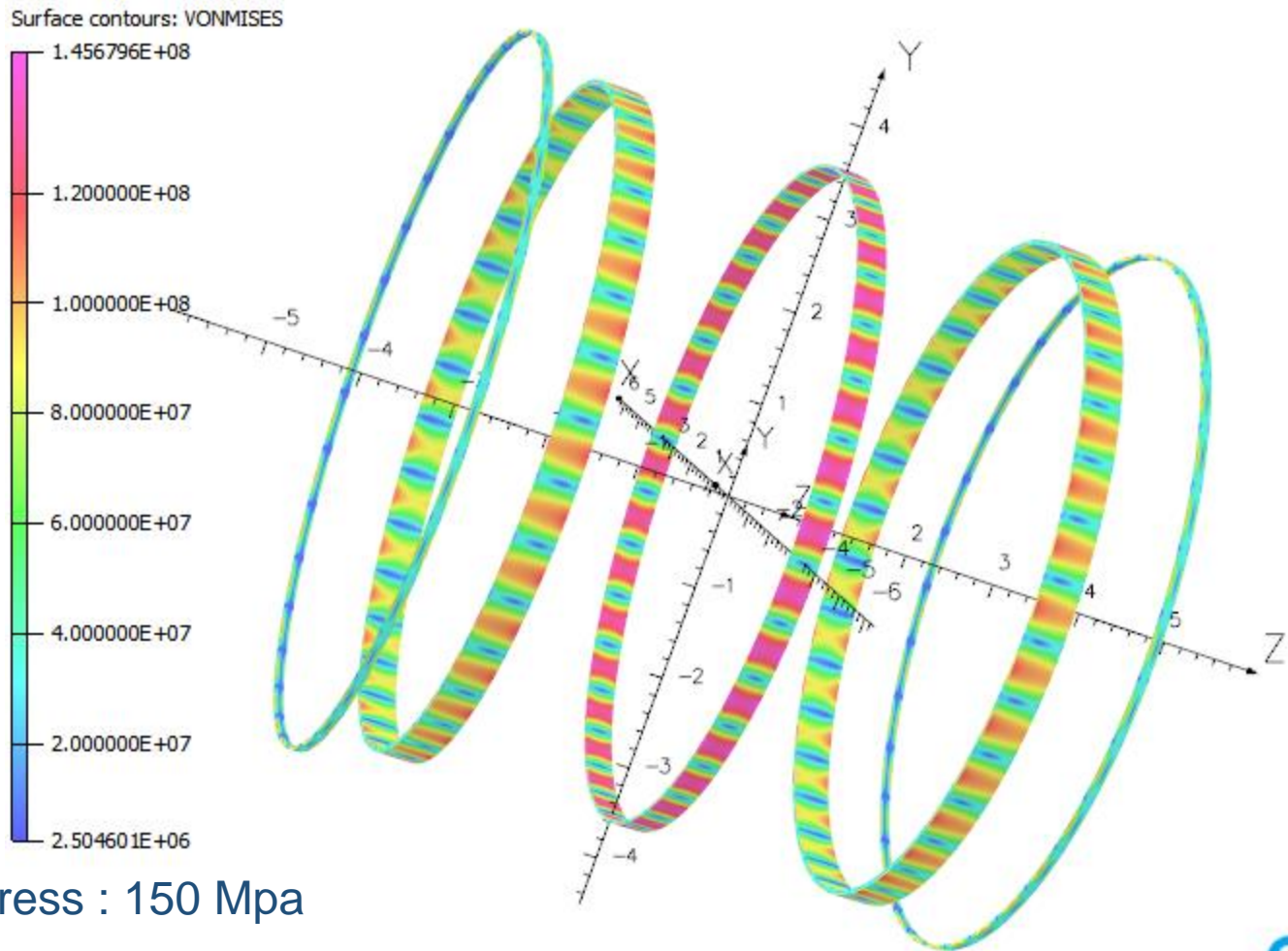
Region beyond which magnetic field is < 1000 Gauss

Magnetic Fields on the coil



Opera
Simulation Software
COBHAM

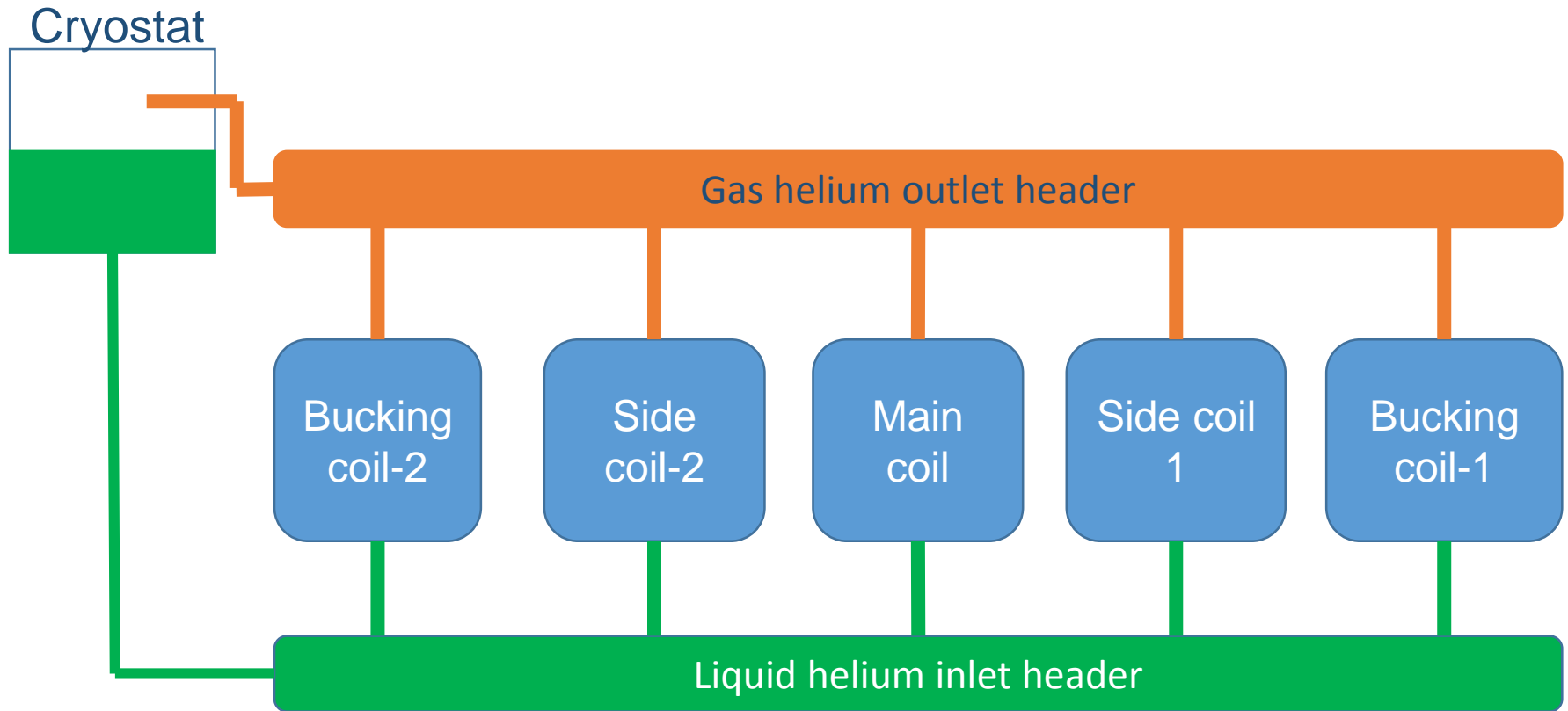
Operating Stresses on the magnet coils



- Max Hoop stress : 150 Mpa
- OFHC Cu with 20% Cold work : 330 Mpa at 4K (Yield stress)
- Self supporting Magnet

Cooling Scheme

- The coils will be conduction cooled through pipe which are wounded on its OD.
- Indirect cooling through two phase thermosiphon cooling loops



For discussion

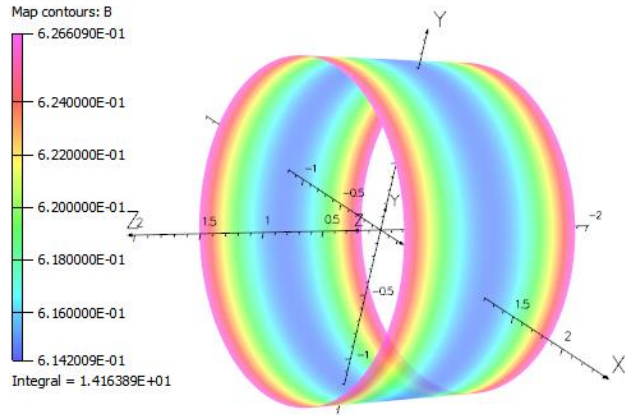
- Field uniformity requirement
- Stray magnetic field restriction
- Maximum diameter of cavern shaft
- Inner bore diameter required for HPgTPC

Thank you

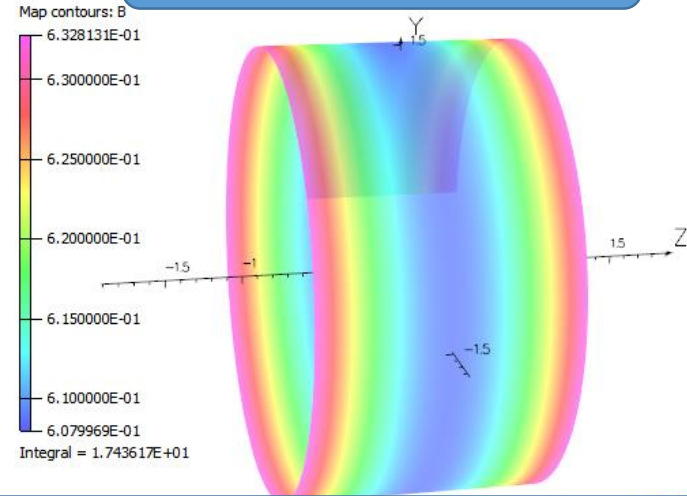
Back up slides

Magnetic Field uniformity

Helmholtz Coil

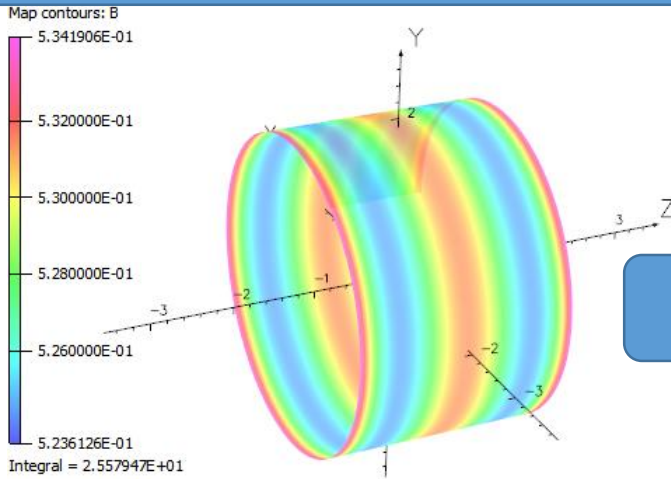


Opera

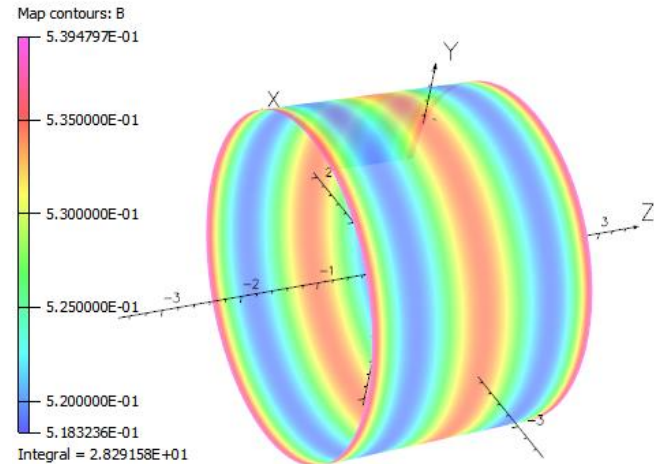


1% Field Uniformity , Dia : 2.4m , Len : 1.5m

2% Field Uniformity , Dia : 2.95m , Len : 1.8m



Three Coil



1% Field Uniformity , Dia : 3.8m , Len : 2.4m

2% Field Uniformity , Dia : 4m , Len : 3.75m