Q1BpF Design for 4K Option

Ramesh Gupta
Superconducting Magnet Division

June 30, 2020

BROOKHAVEN NATIONAL LABORATORY
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Office of Science
U.S. DEPARTMENT OF ENERGY

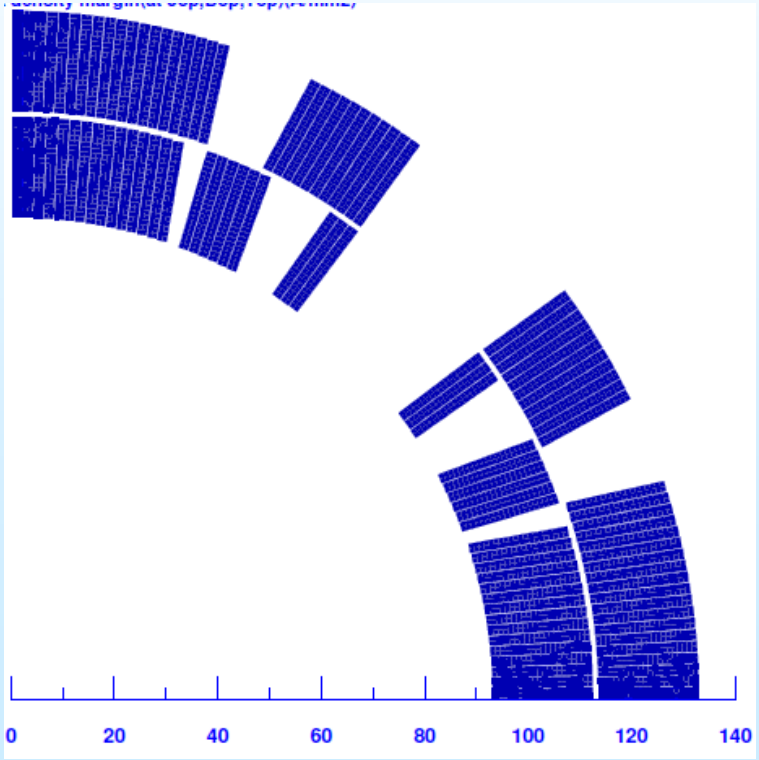
Overview

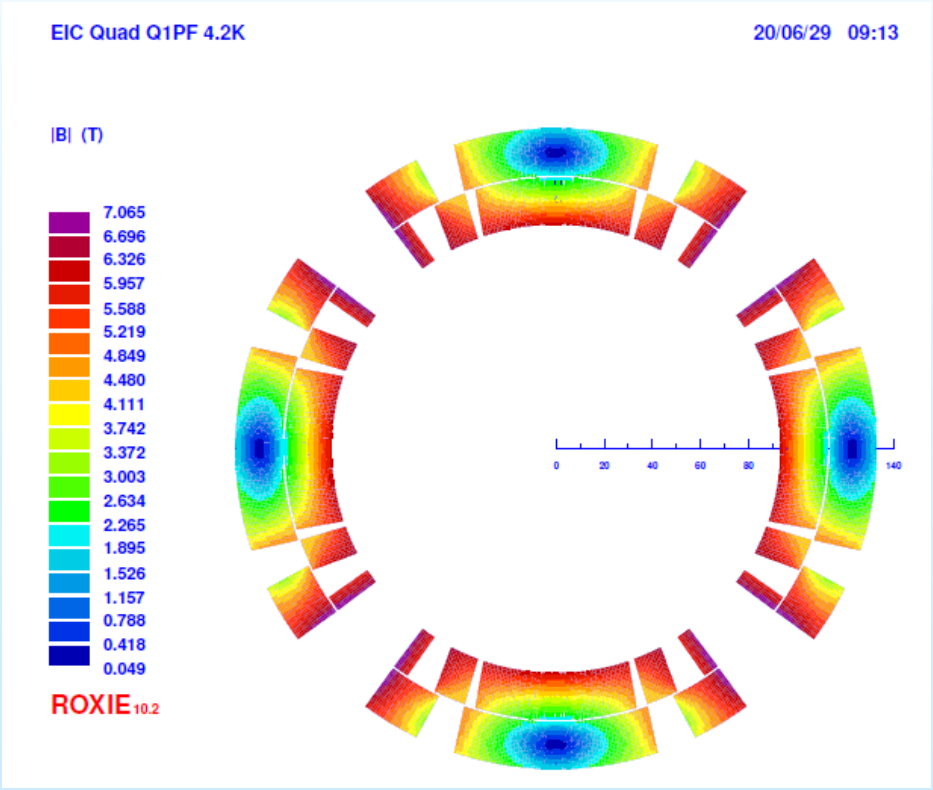
- **Initial design studies of Q1BpF for a possible 4.2 K operation. Several cases examined but only one will be presented.**
- **Peak field (margin), field quality and field in the electron beam region are being optimized.**
- **The design consider several fronts - geometric, mechanical, magnetic design. Anis will continue on further optimization.**
- **Strand/wire used: dia =1.065 mm, Cu/Sc =1.3 (new) and 1.6.**
- **Cable: 19.4 mm wide (19.7 with insulation) with 36 strands, min thickness: 1.788 mm, max thickness: 2.012 mm (same as before).**
- **As mentioned during the last meeting, we will "try" to use this cable (and RHIC dipole type cable) for all EIC magnets.**

Coil 2 Layers, Three wedges (2+1) 54 turns/pole (24 inner, 30 outer)

- **Poles of inner and outer layers aligned**
- **Coil poles have proper angles for collaring**
- **Two wedges in the inner to deal with keystone**

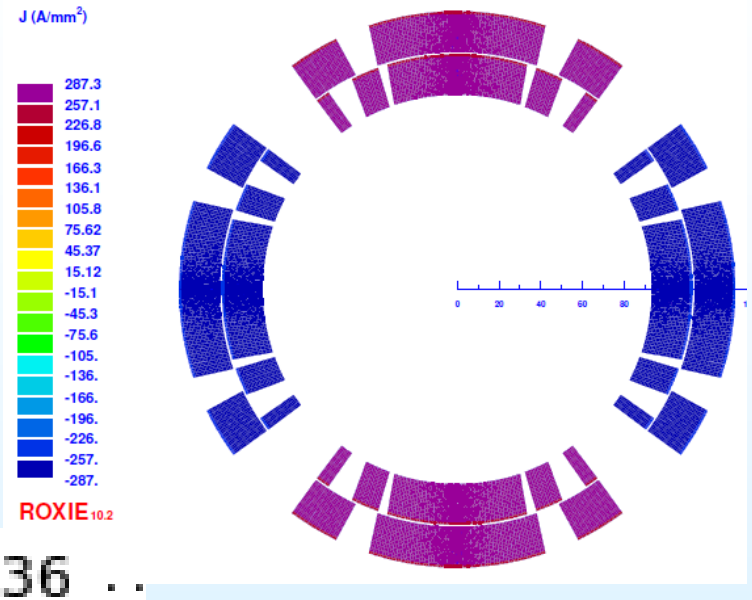
Coil radius: 93 mm (Q2B had 140 mm)





Field Harmonics in Q1BpF

A reasonably good field quality is obtained with a good mechanical design (coil radius 93 mm) (all harmonics <1 unit)



REFERENCE RADIUS (mm) . 36 ..

MAIN FIELD (T) 2.384284
MAGNET STRENGTH (T/(m^(n-1)) 66.2301

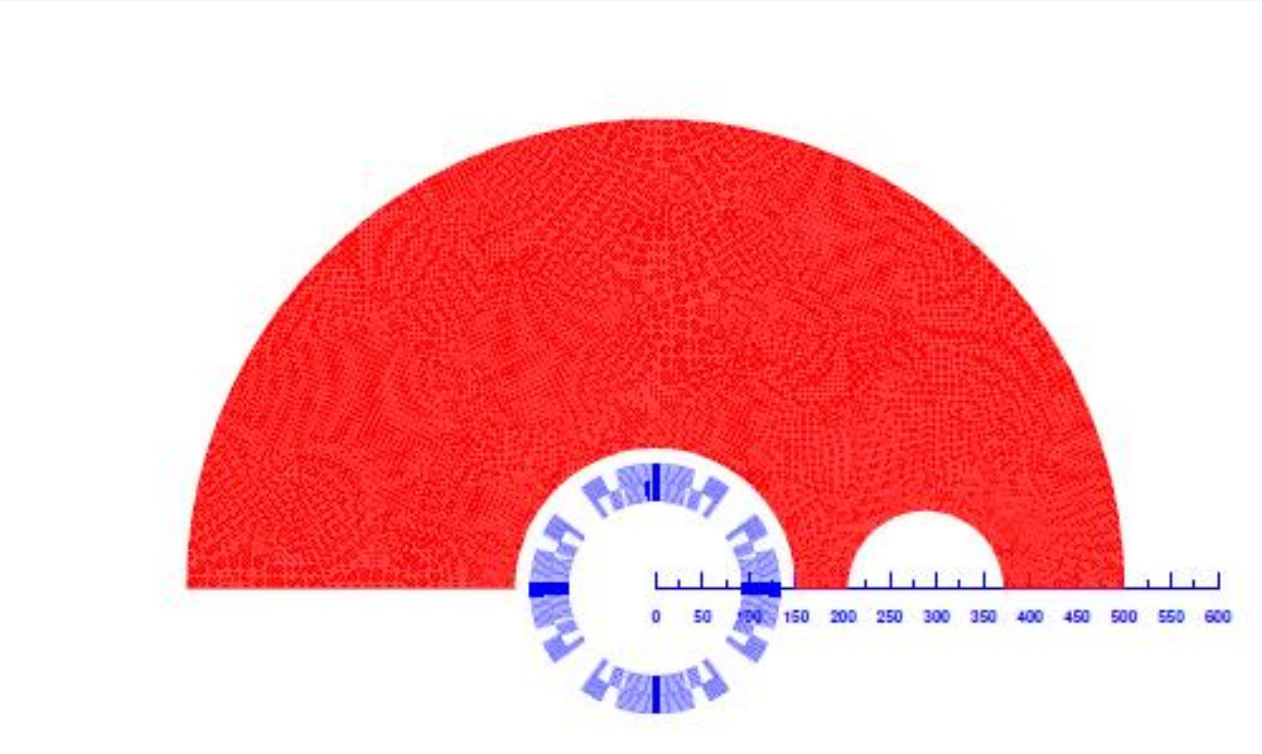
NORMAL RELATIVE MULTIPOLES (1.D-4):

b 1:	-3.92024	b 2:	10000.00000	b 3:	-0.40995
b 4:	-0.08318	b 5:	-0.02163	b 6:	-0.29828
b 7:	-0.00150	b 8:	-0.00033	b 9:	-0.00008
b10:	0.02322	b11:	-0.00001	b12:	-0.00000
b13:	-0.00000	b14:	-0.00054	b15:	-0.00000
b16:	-0.00000	b17:	0.00000	b18:	-0.00000
b19:	0.00000	b20:	-0.00000	b	

Gradient 66.2 T/m at ~10 kA

Iron Yoke – Current Design

Yoke: ir = ~150 mm; or = 550 mm (or 500 mm)
Hole@ x = 288.3 mm to 312.5 mm
Radius of hole = 83 mm (63 mm for electron beam)
Collar width = ~20 mm for 66.2 T/m



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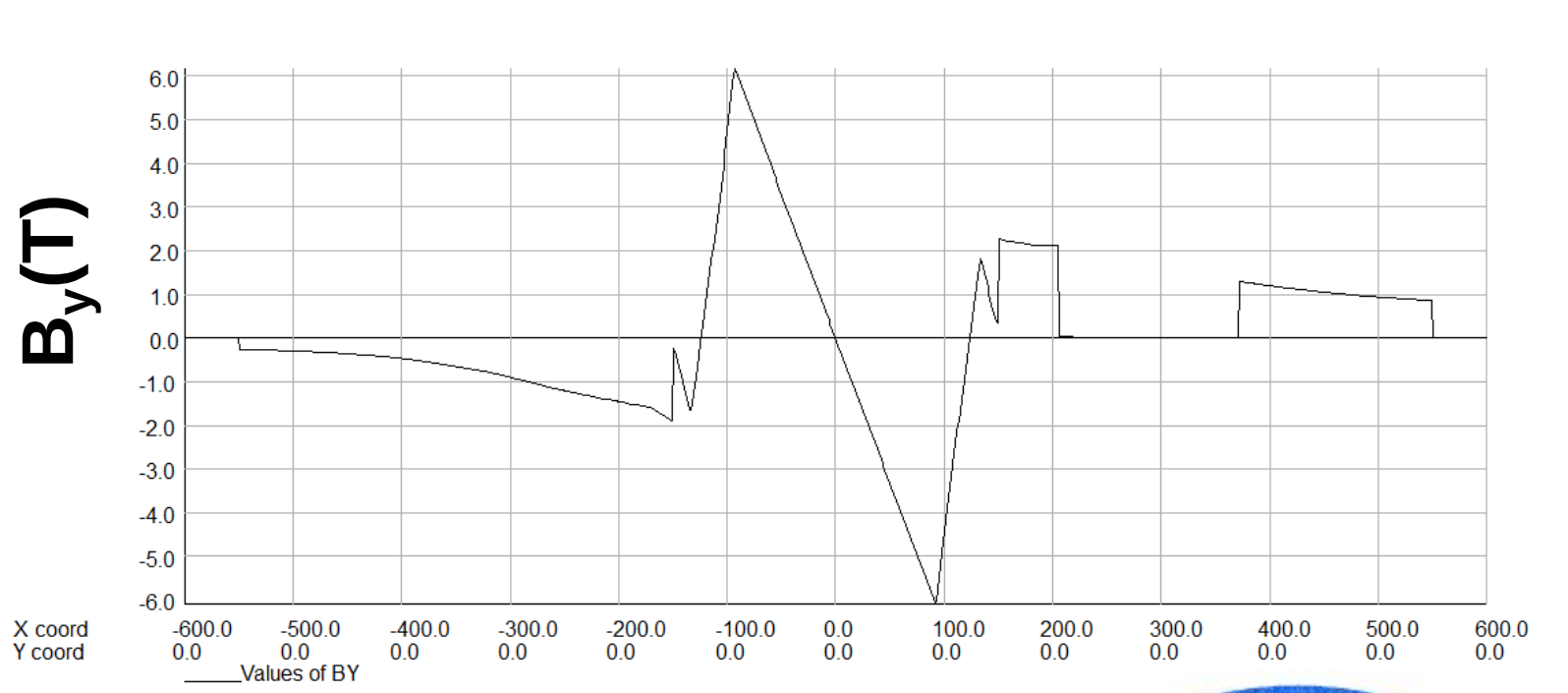
Field in the electron beam region
Yoke OR = 550 mm, Hole@288.3 mm



UNITS
Length : mm
Flux density : T
Field strength : A m^{-1}
Potential : Wb m^{-1}
Conductivity : S m^{-1}
Source density: A mm^{-2}
Power : W
Force : N
Energy : J
Mass : kg

MODEL DATA
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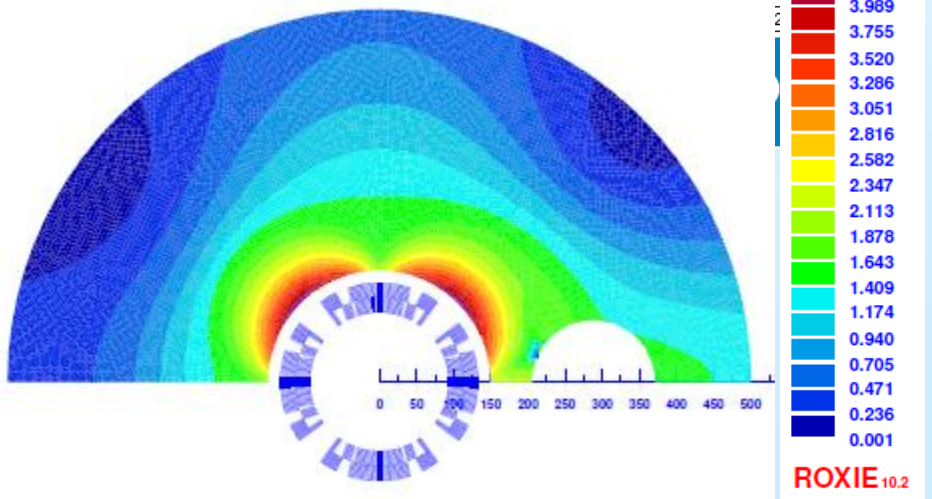
Linear elements
XY symmetry
Vector potential
Magnetic fields
Static solution
Case 2 of 2
Scale factor: 2.4
75939 elements
38272 nodes
73 regions

B(T)



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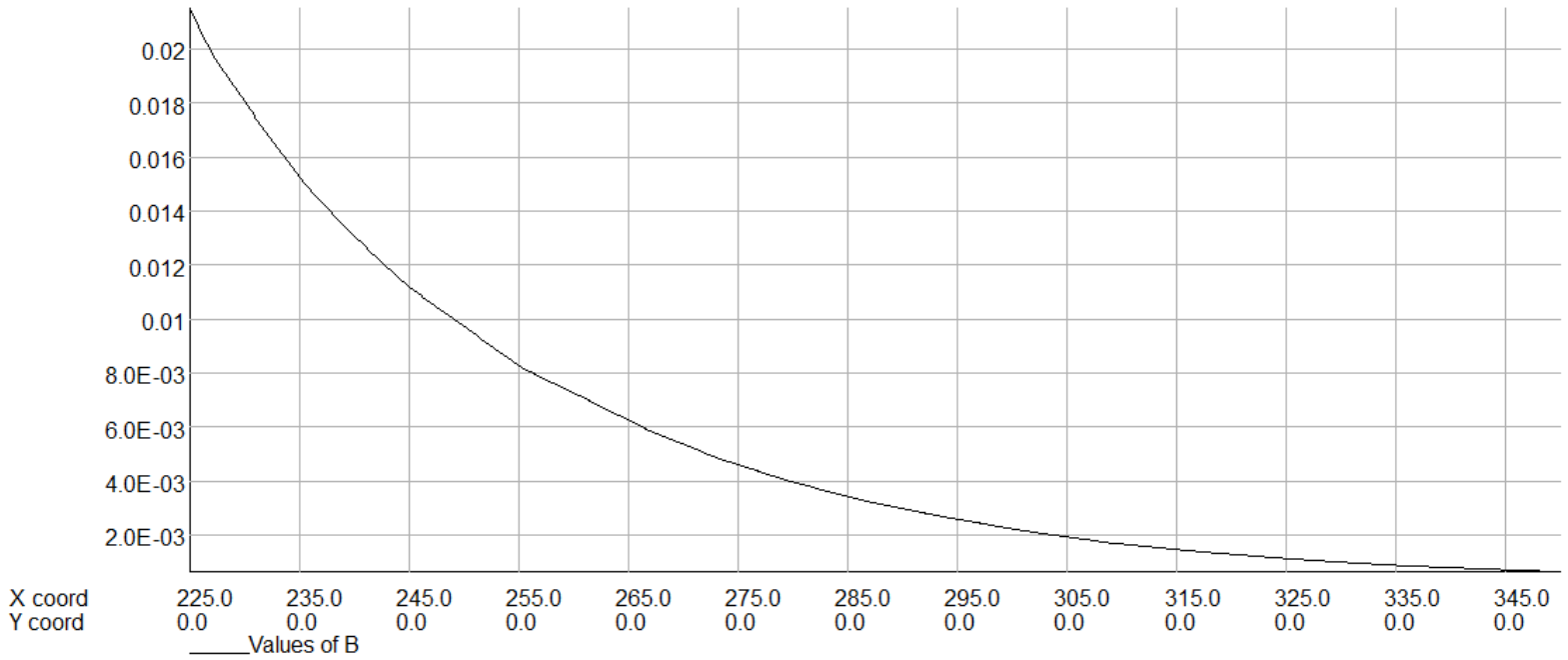

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Linear elements
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Static solution
Case 2 of 2
Scale factor: 2.4
75985 elements
38295 nodes
71 regions

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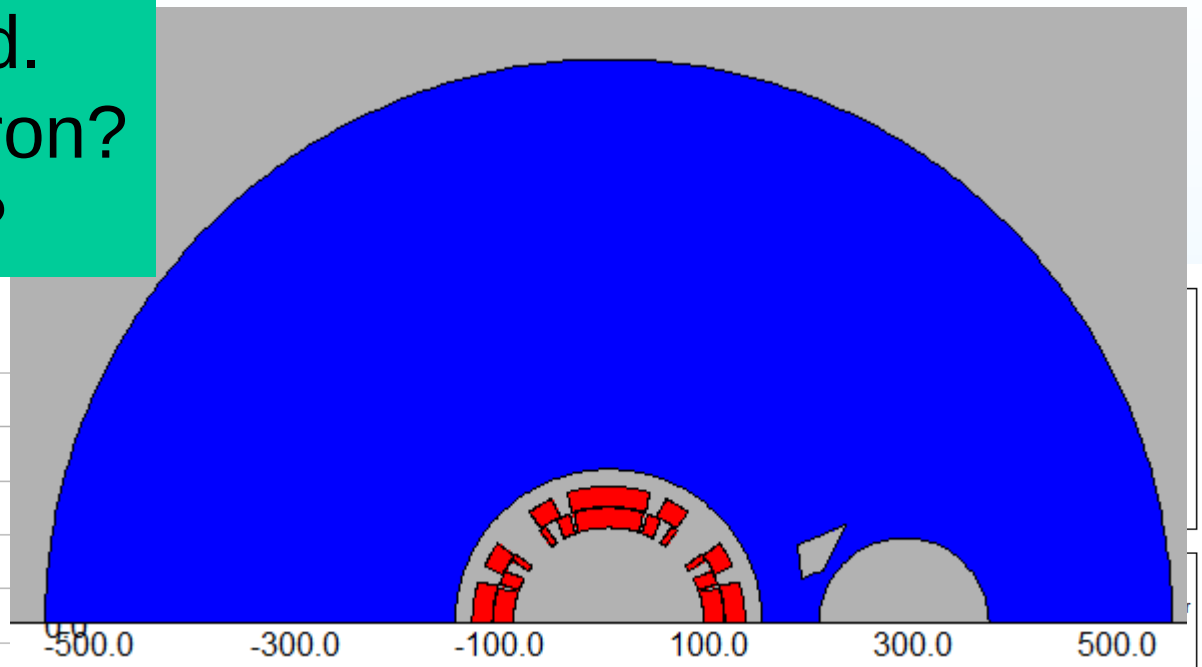
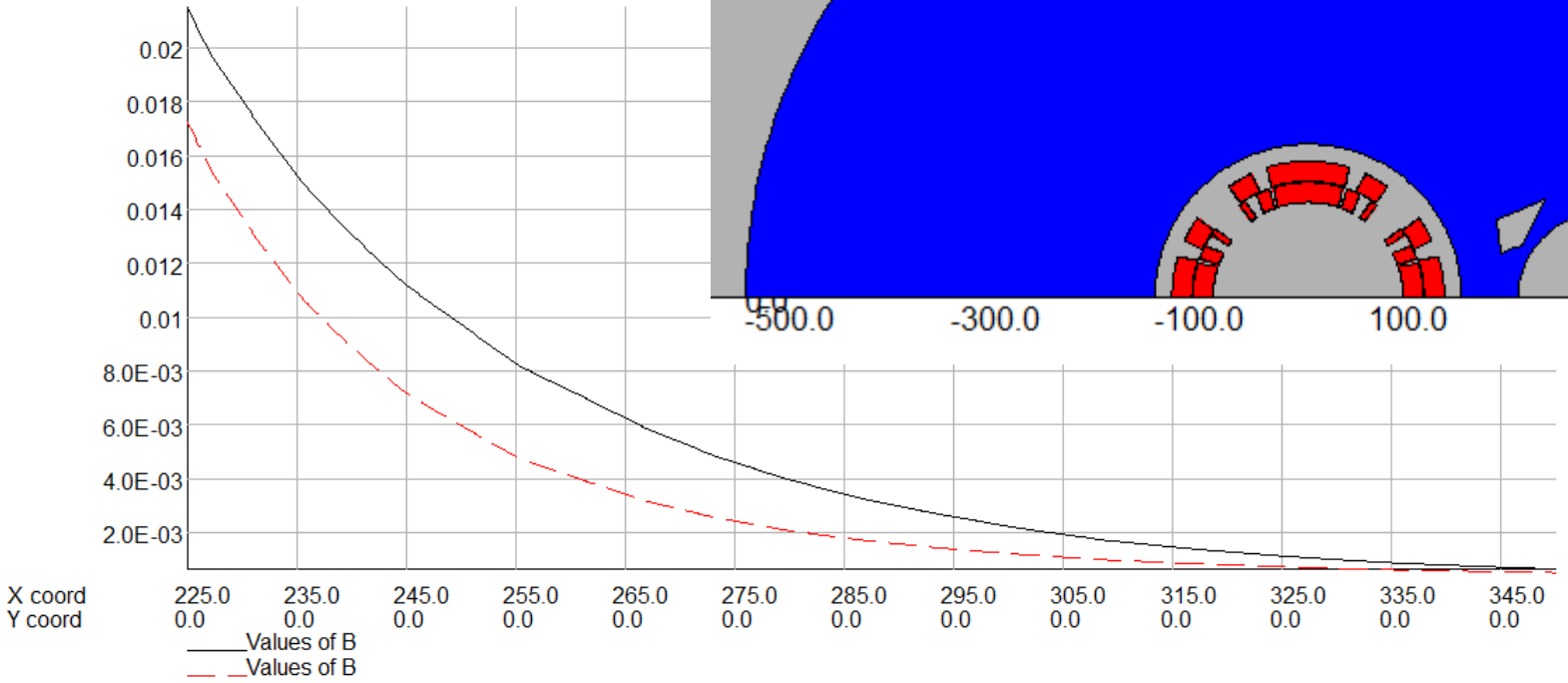
Opera

Initial Design. What is acceptable?

Field in the electron beam region
Yoke OR = 550 mm, Hole@288.3 mm

Tricks to reduce field.
Use holes, special iron?
What is acceptable?





Vector potential
Magnetic fields
Static solution
Case 2 of 2
Scale factor: 2.4
75939 elements
38272 nodes
73 regions

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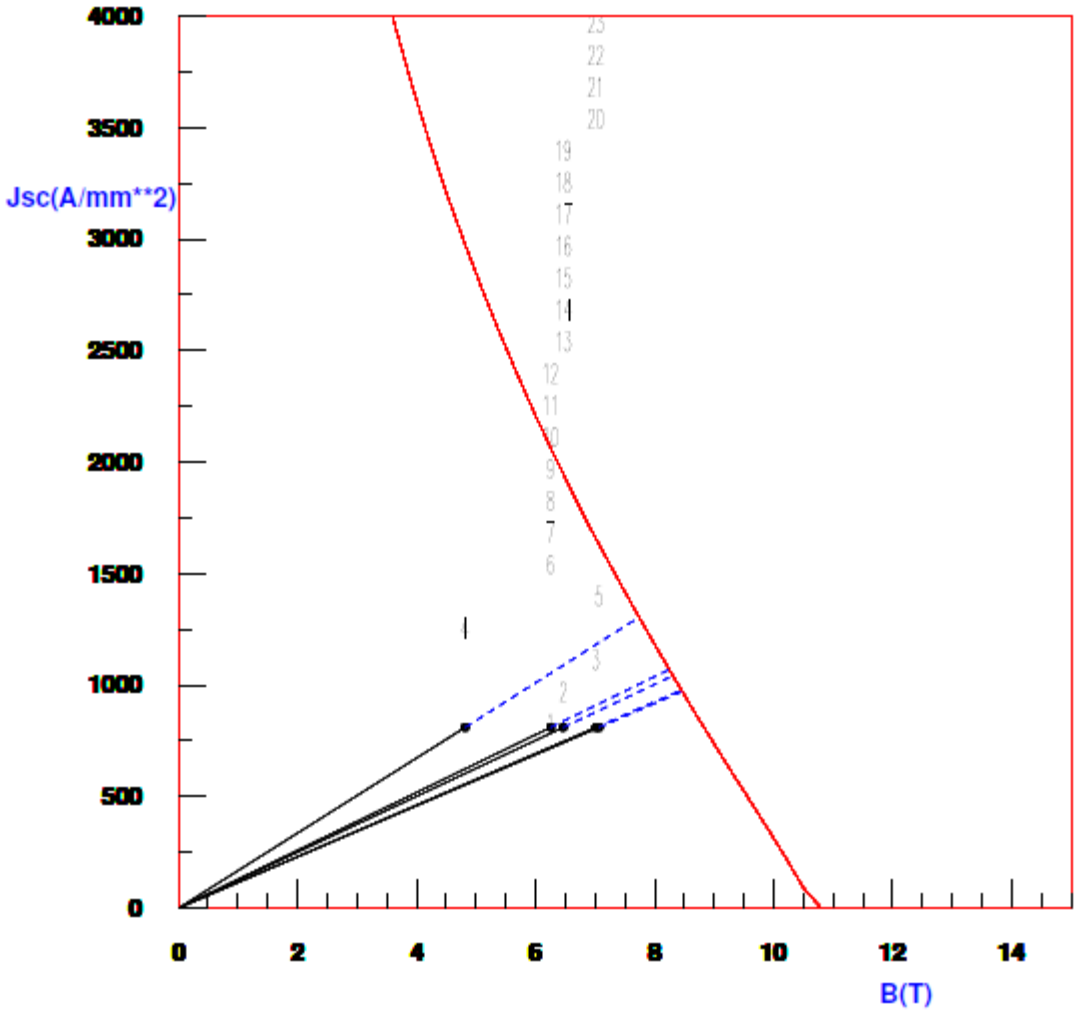
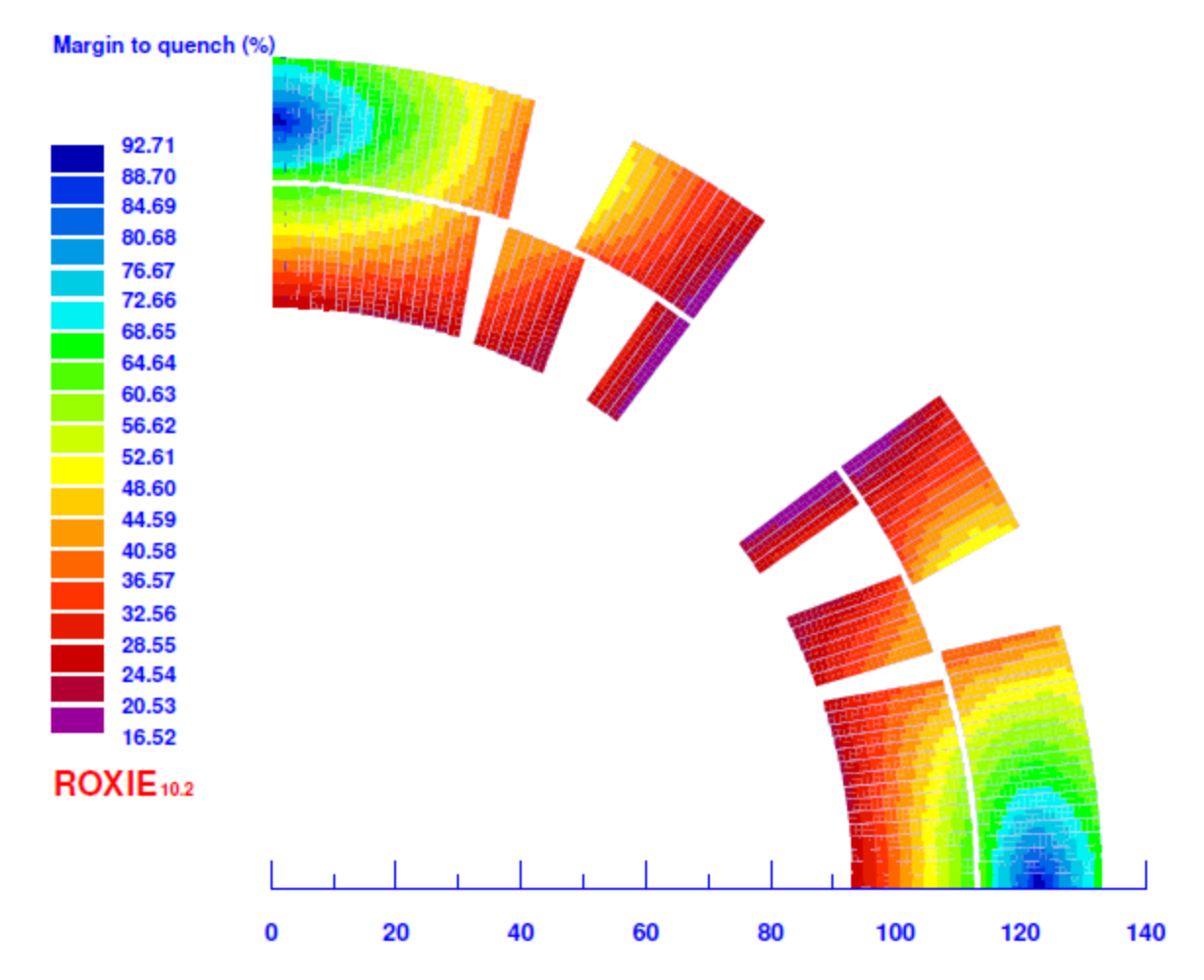
Opera

Field Margin at 4.2 K

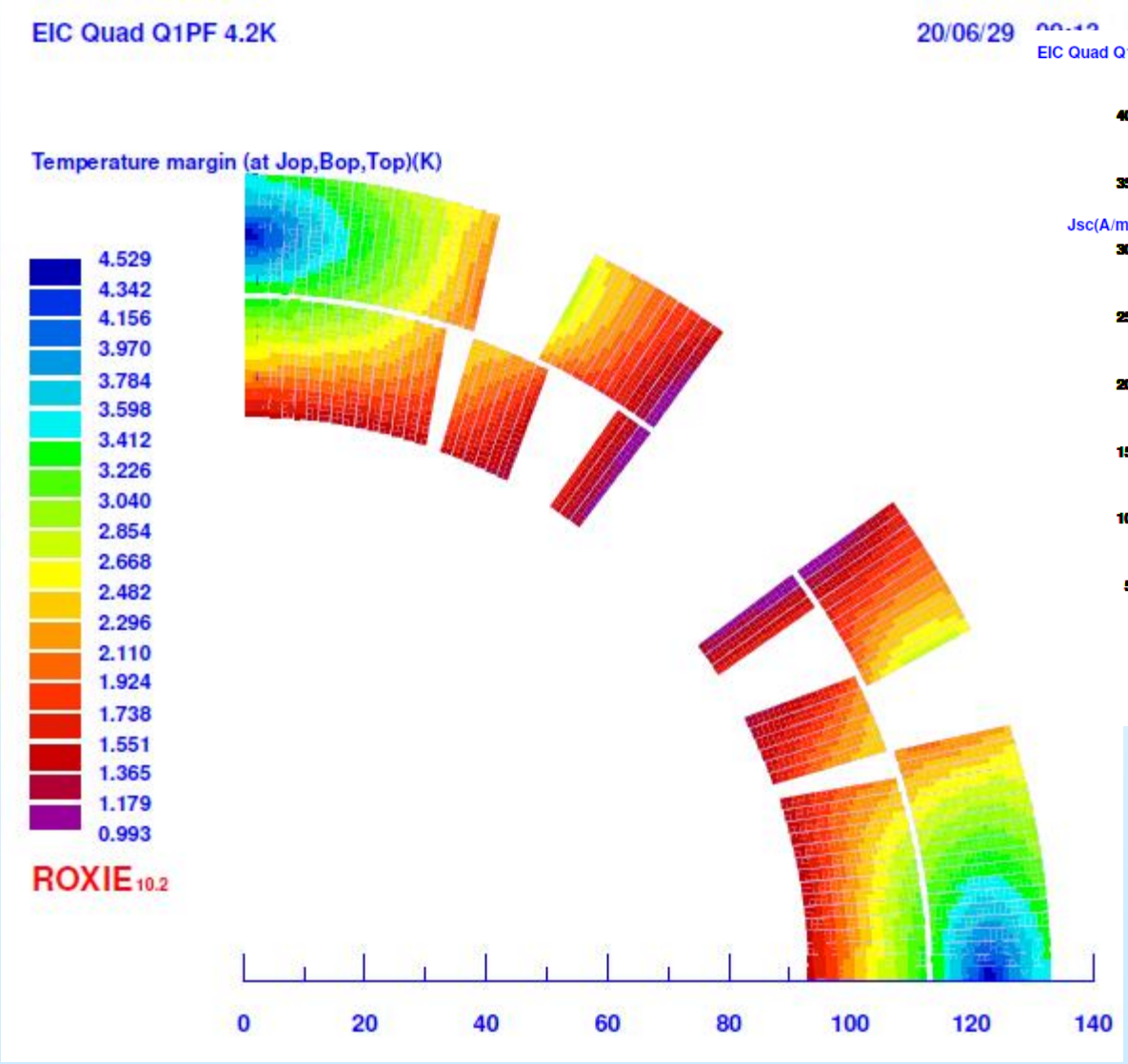


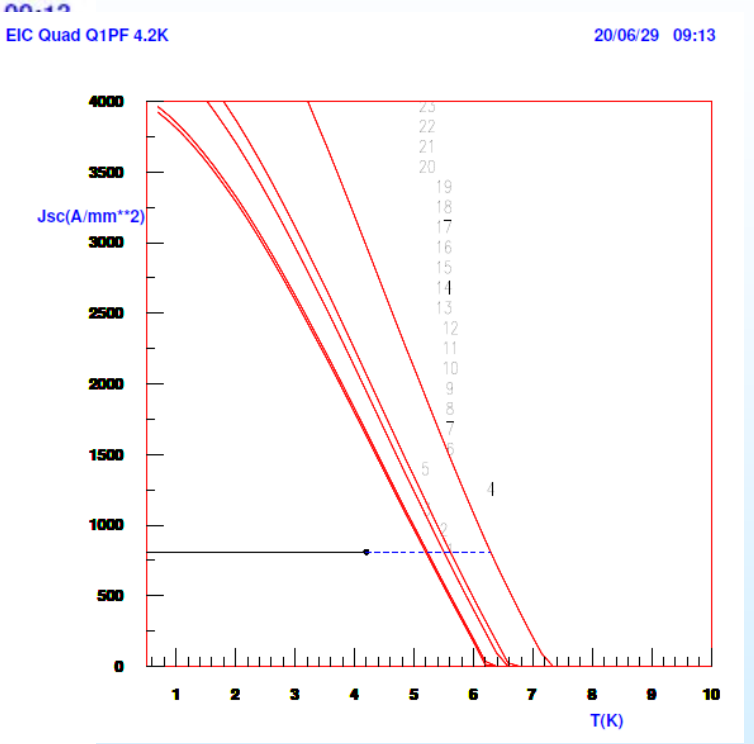
Healthy Margin: ~20% over 66.2 T/m at 4.2K For Cu/Sc of 1.6 (83% on loadline)

Field Margin at 4.2 K

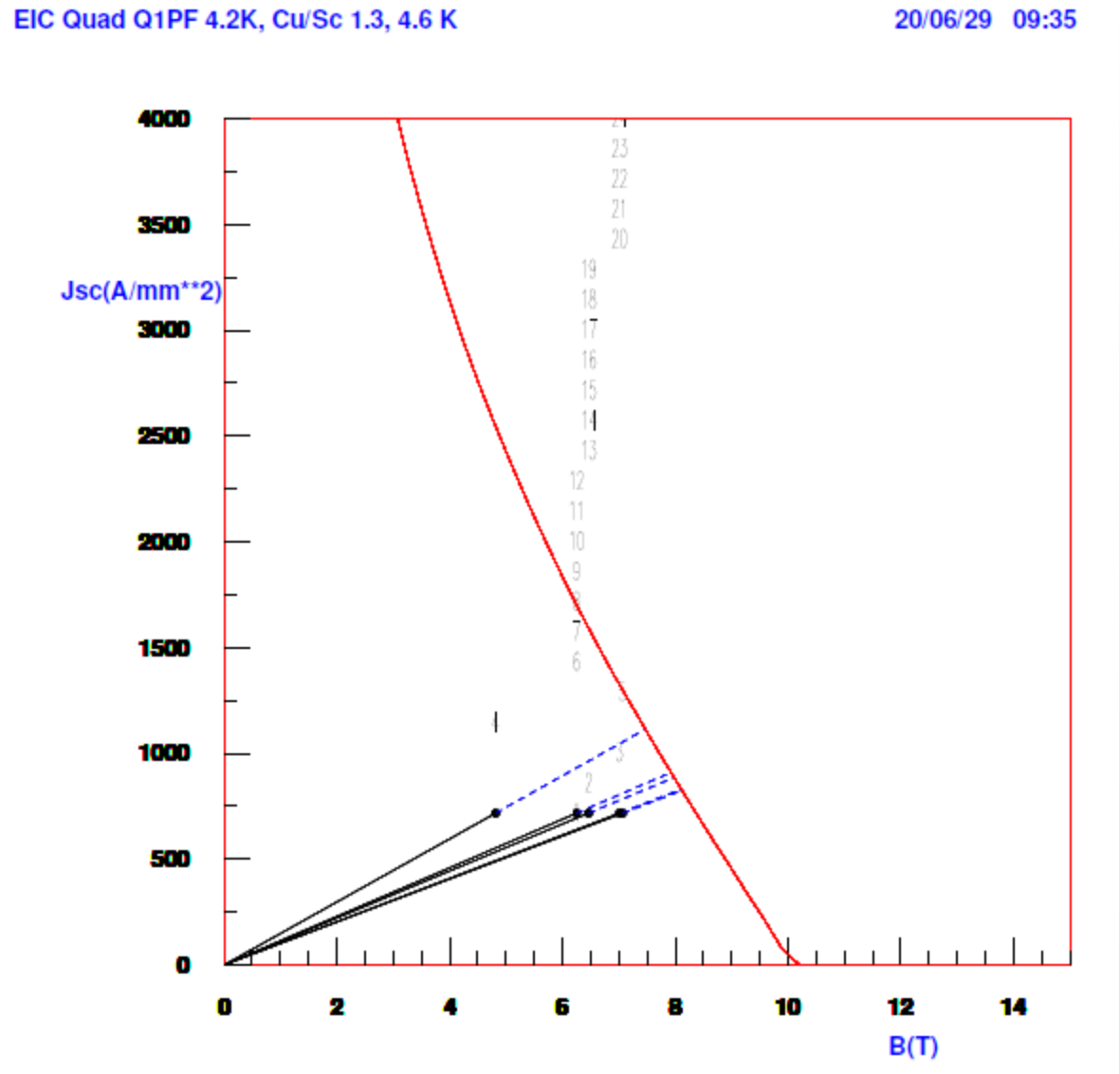


Temperature Margin at 4.2 K Over Different Blocks

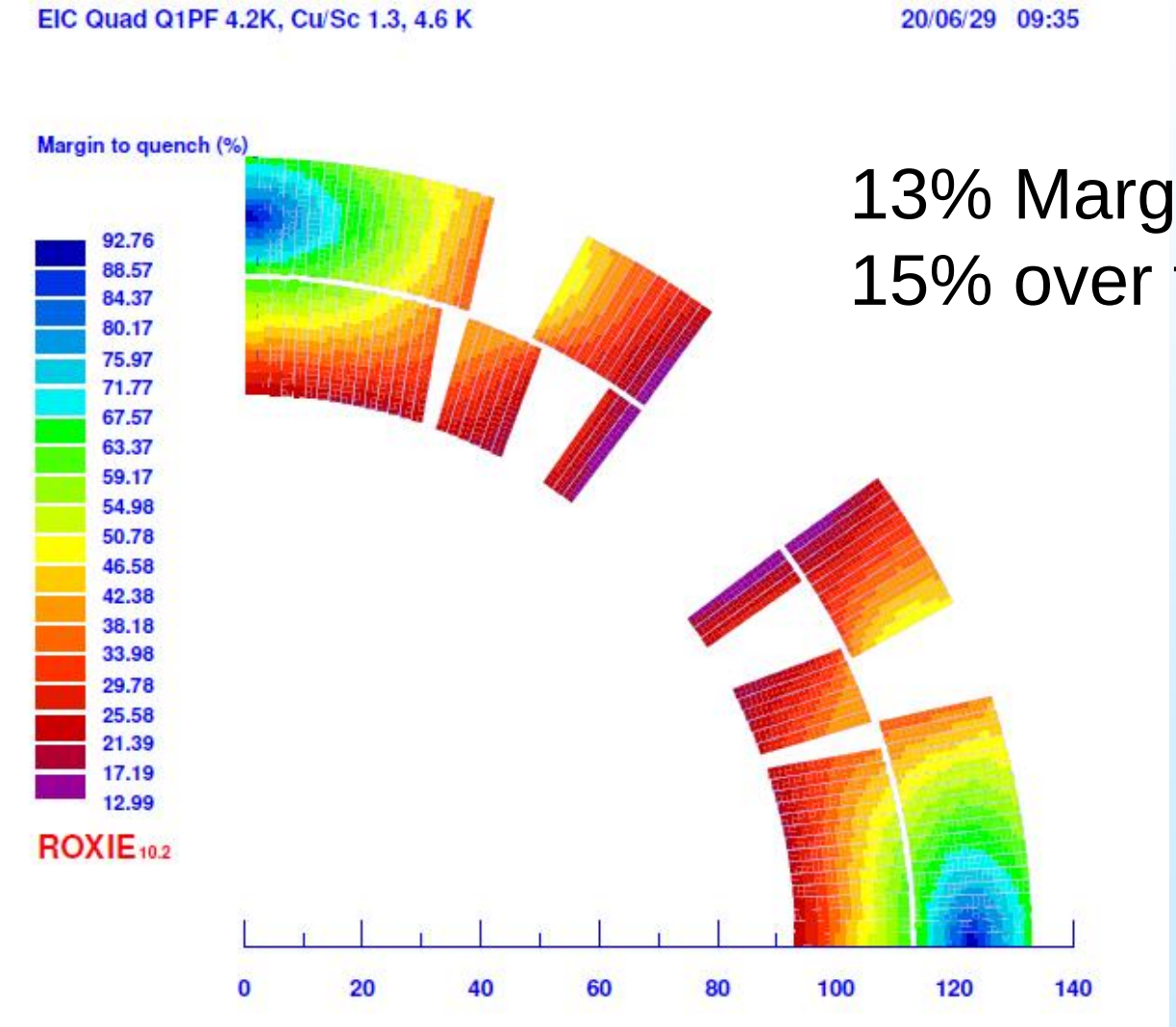




Field Margin at 4.6 K, Cu/Sc =1.3



Field Margin at 4.6 K, Cu/Sc =1.3



13% Margin on the loadline
15% over the design field

Discussion

- **Initial run indicates a possible solution for a 4.2 K operation (may not be yet fully acceptable)**
- **Field quality is good.**
- **Margin is marginal. Check with the machine physicist for some tweaking in the optics. Such interactions produce an overall optimized design for the machine, optimized for the budget and performance (not just for one component of the machine)**
- **What is the acceptable value of field in the electron beam region? Some tricks and use of special material may be able to reduce the field further.**
- **Peak field (margin) and field in the electron beam region are still being optimized.**