DESIGN STUDY OF THE MECHANICAL STRUCTURE OF THE SIS300 SUPERCONDUCTING DIPOLES

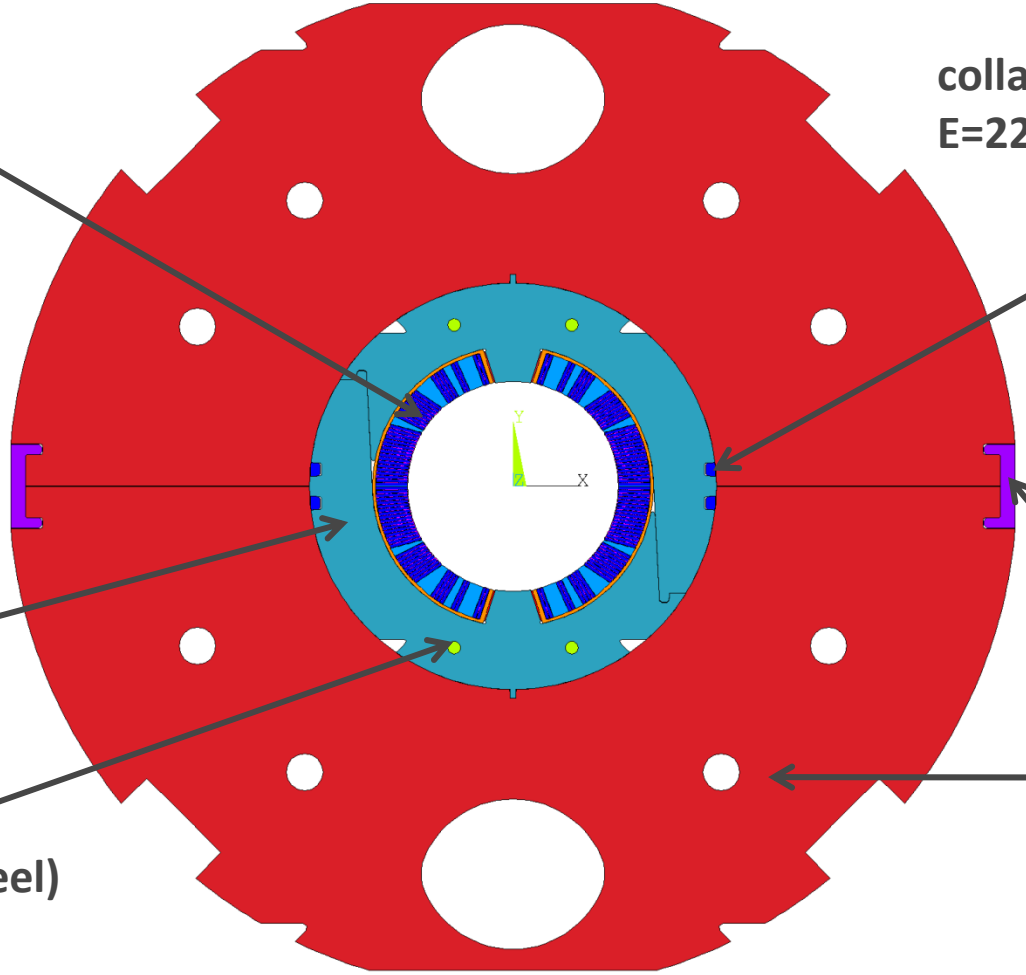
Stefania Farinon
WAMSDO08, May 22nd 2008

Introduction

- SIS300 dipole is pulsed (1.5-4.5 T)
- At a high field rate (1 T/s)
- For 10^7 cycles

→ Main issue is fatigue

SIS300 dipole mechanical structure



winding
E=7.5 GPa

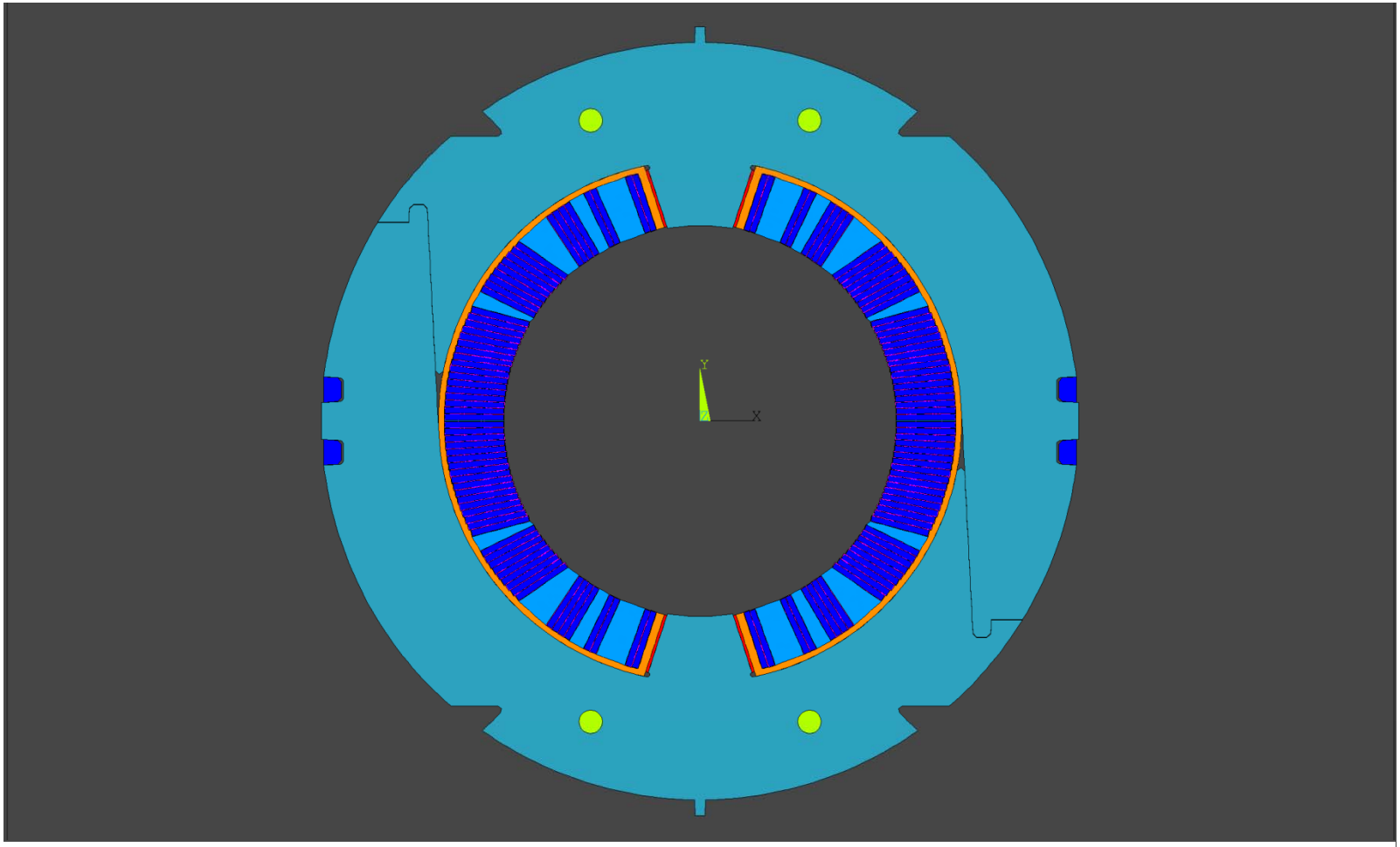
collar keys (stainless steel)
E=220 GPa

collars (Nitronic 40)
3 mm lamination
E=192 GPa

C-clamps (Al alloy)
E=80 GPa

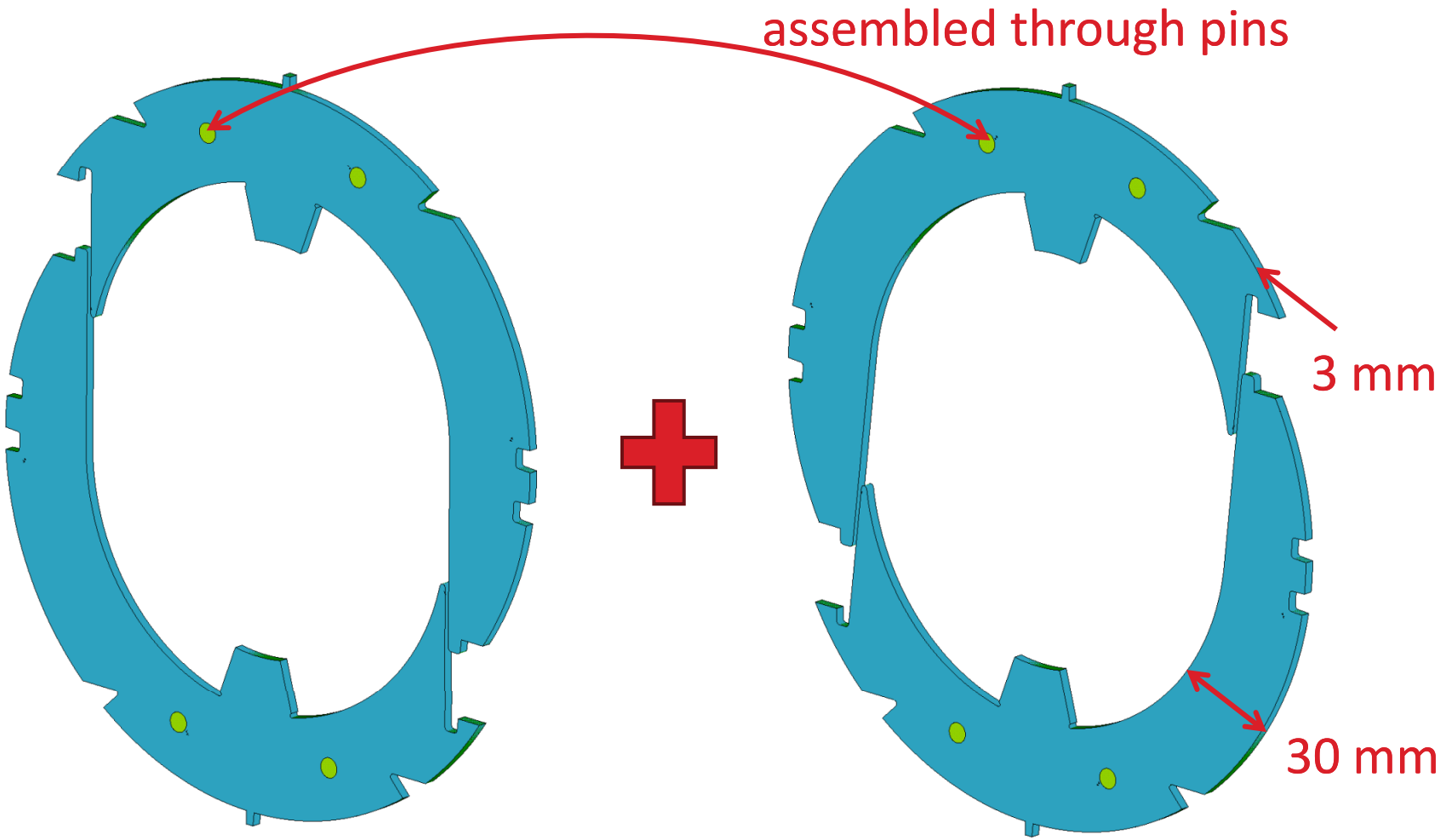
iron yoke
1 mm lamination
E=200 GPa

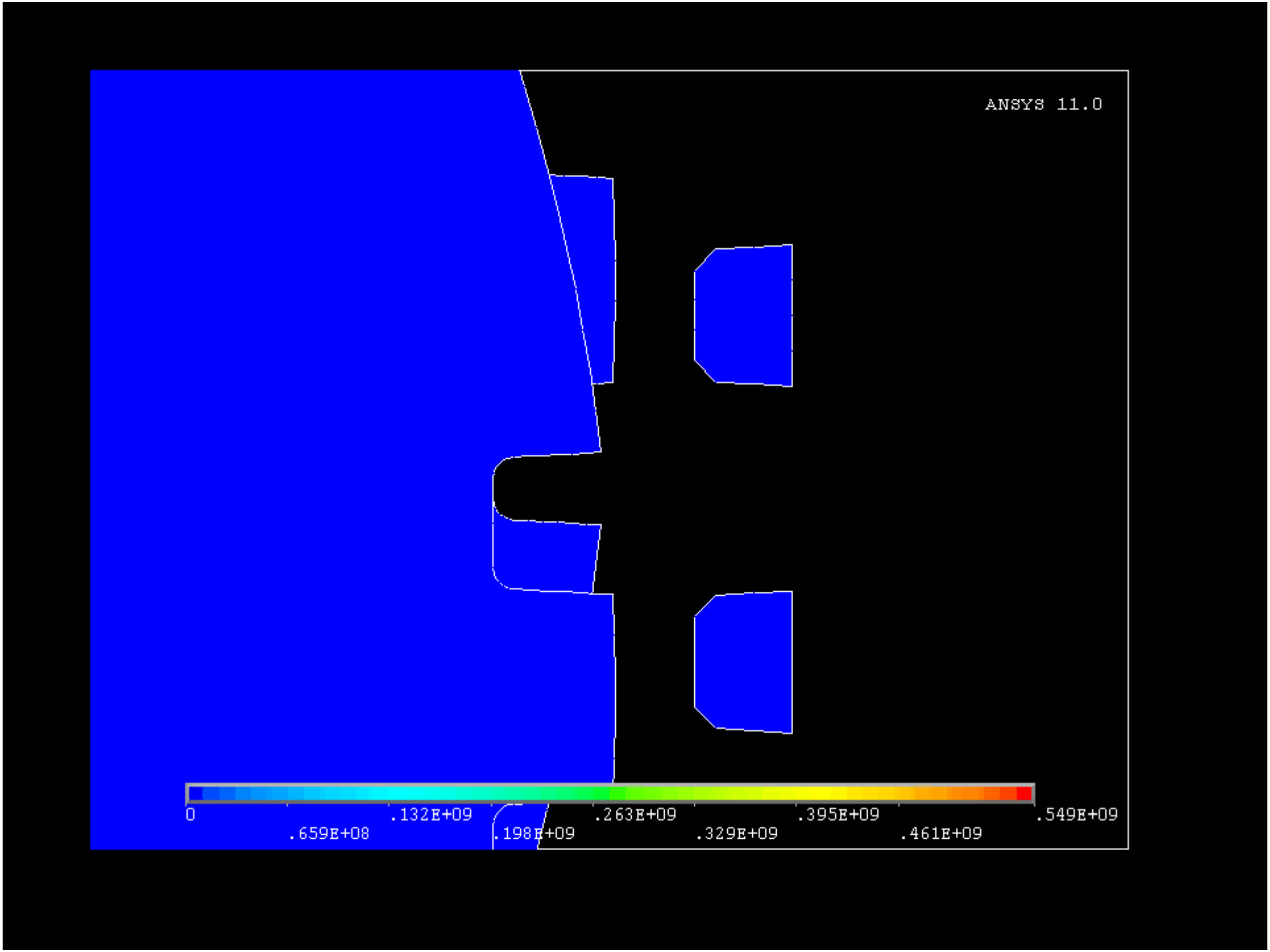
pins (stainless steel)
E=220 GPa



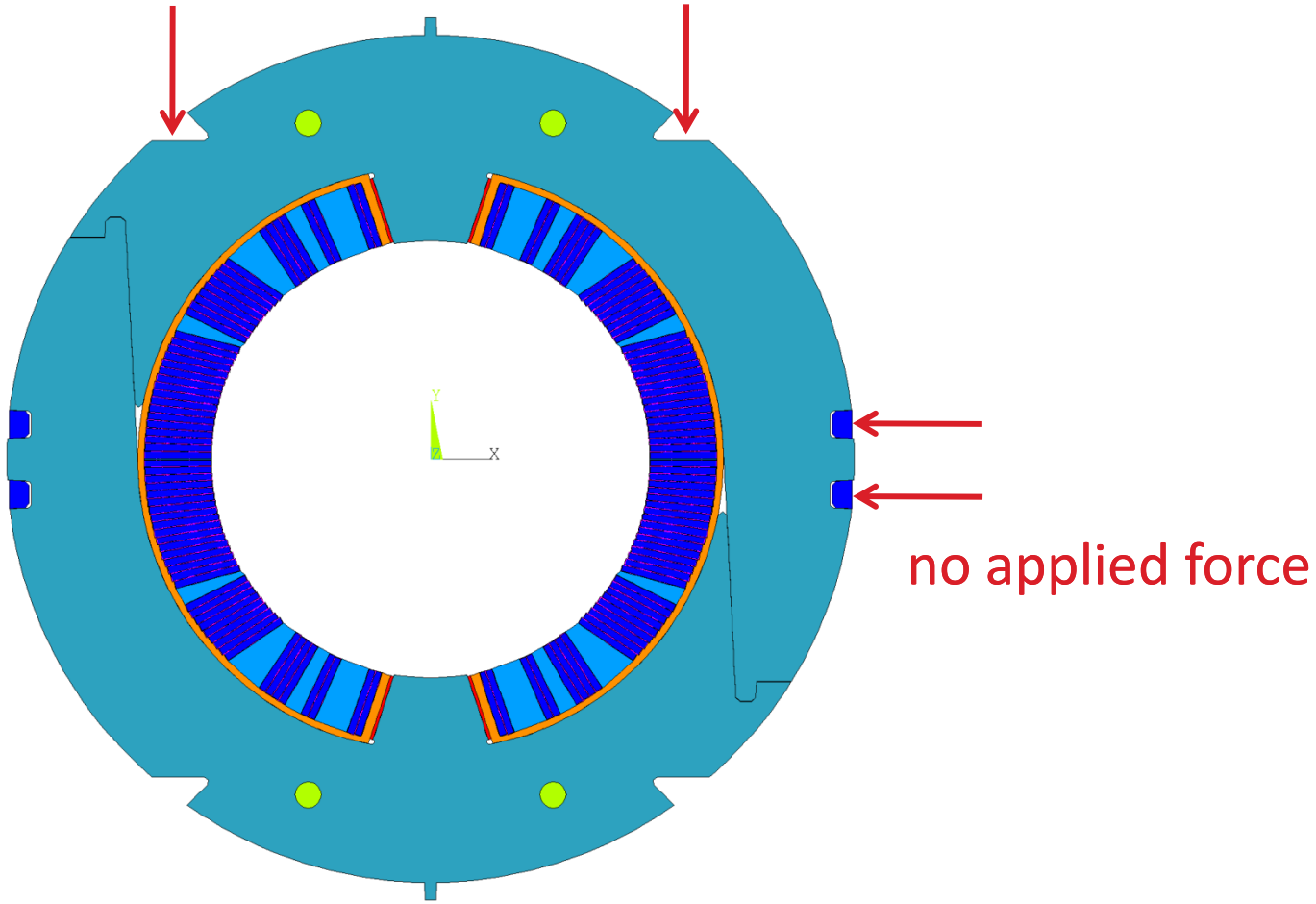
Collaring

collars assembly

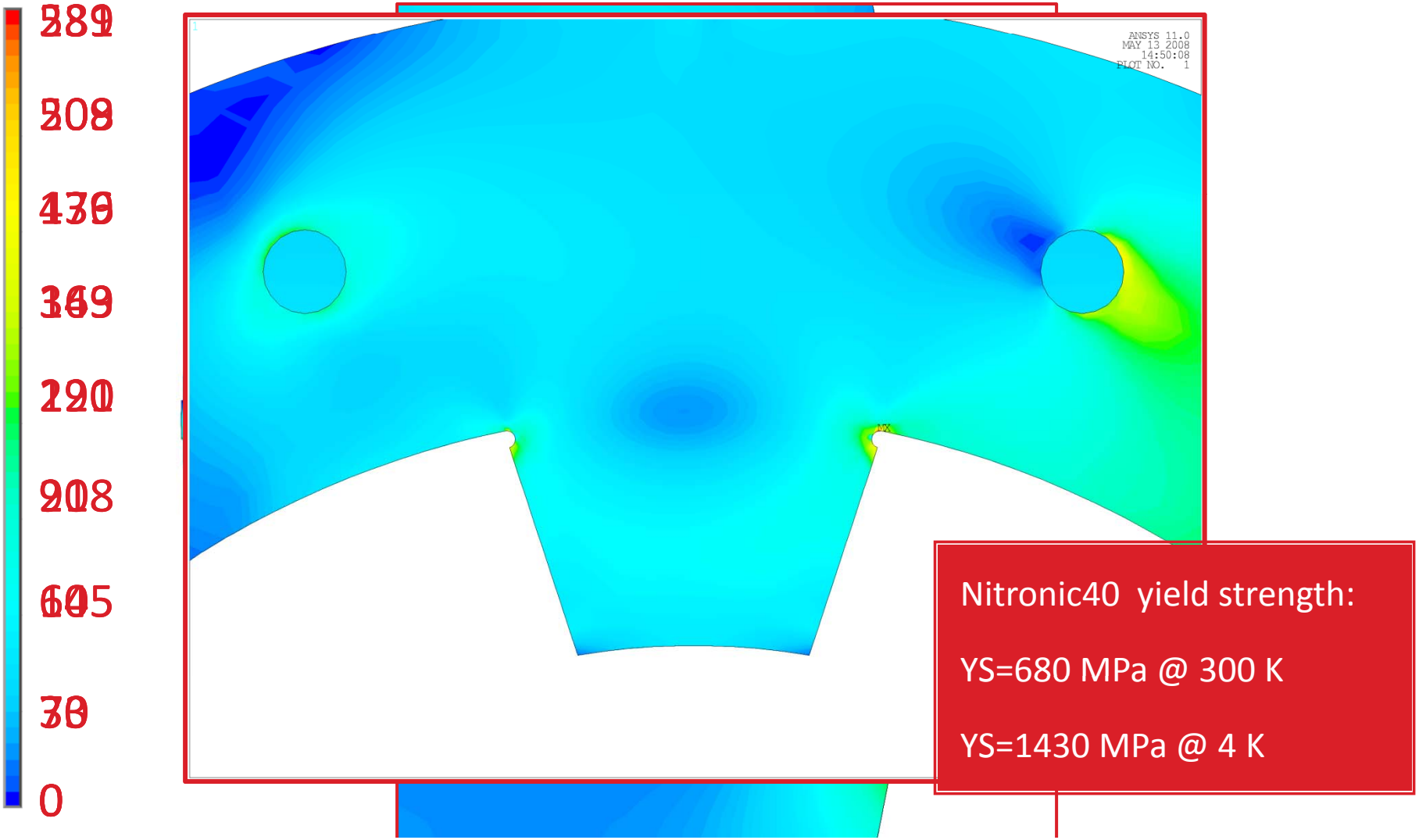



ANSYS 11.0
0
.659E+08
.132E+09
.198E+09
.263E+09
.329E+09
.395E+09
.461E+09
.549E+09

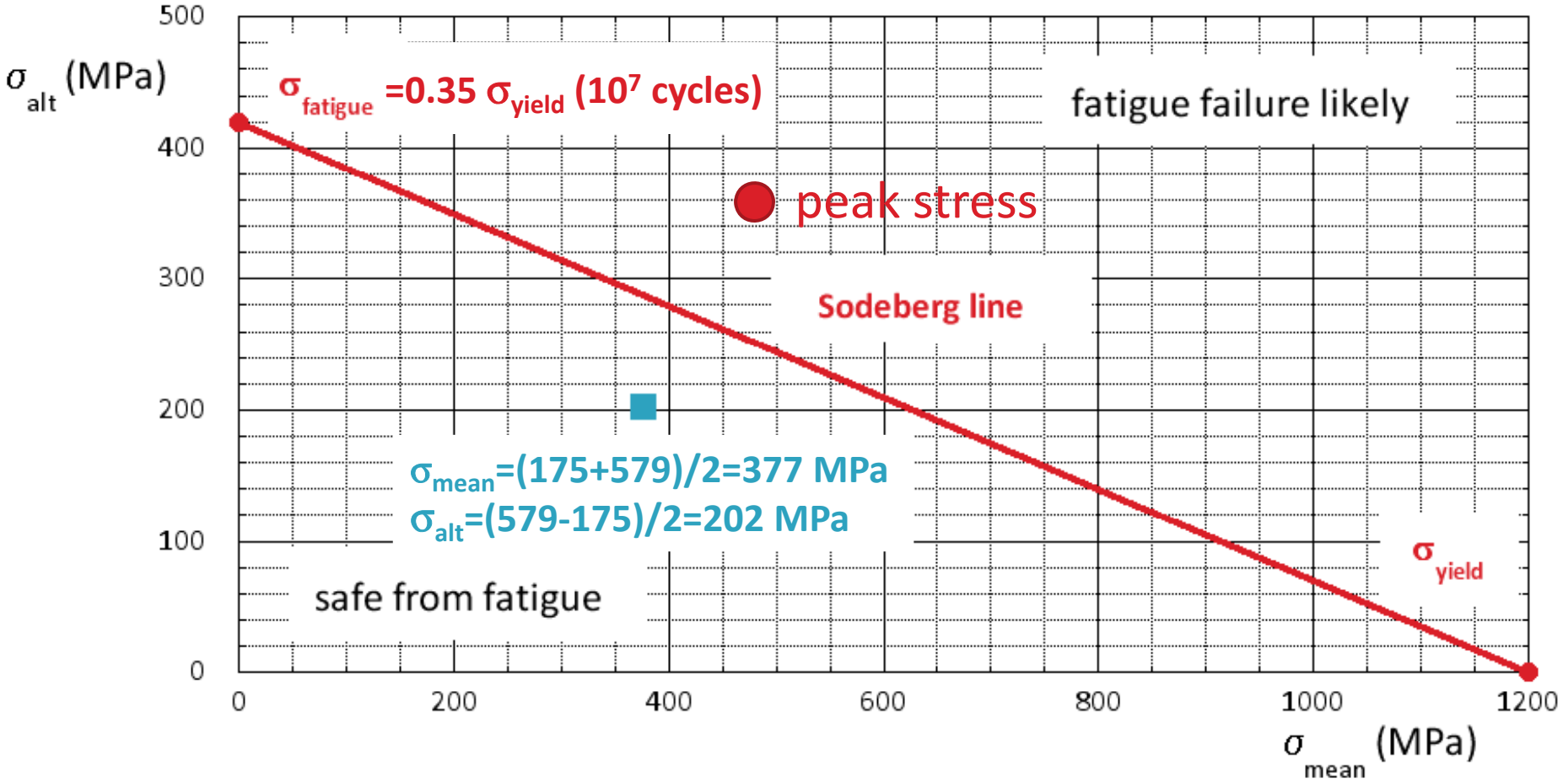
collaring operation

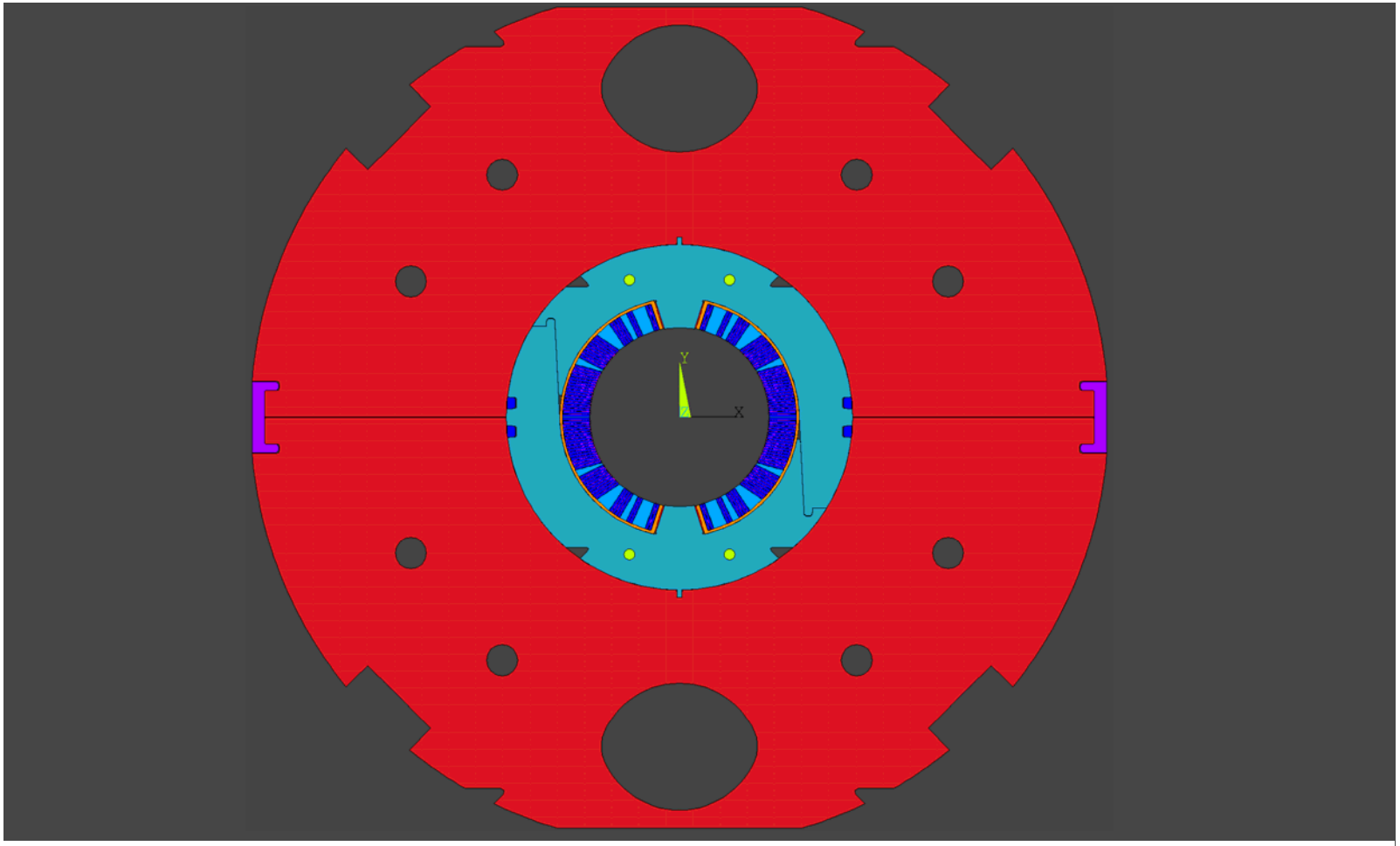


Von Mises stress after collaring (MPa)



cool-down and energization of collared-only windings (without iron)





Iron yoke assembly

iron yoke constraints

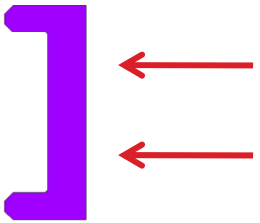
The goal is a side containment to collars.
We should:

- avoid making a second collaring operation on the winding

force to close the iron yoke

w
y

close the iron
the collars:



C-clamps are heated to be inserted without any applied force

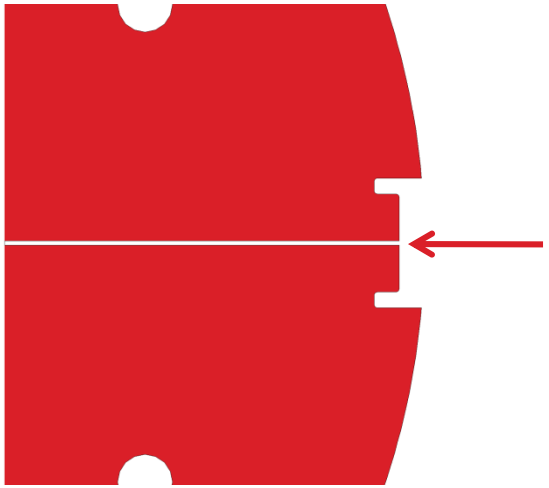
iron yoke constraints

The goal is a side containment to collars.
We should:

- avoid making a second collaring operation on the winding
- take into account the effect of the different thermal contractions of stainless steel and iron

effect of differential thermal contractions (α_{iron}~$1.8 \cdot 10^{-3}$, $\alpha_{Nitronic40}$~$2.4 \cdot 10^{-3}$)

- we apply a pre-stress to the collared coils through the iron yoke:



80 μm are removed from the midplane

- C-clamps are made of Al-alloy ($\alpha_{Al\ alloy}$~$4.3 \cdot 10^{-3}$)

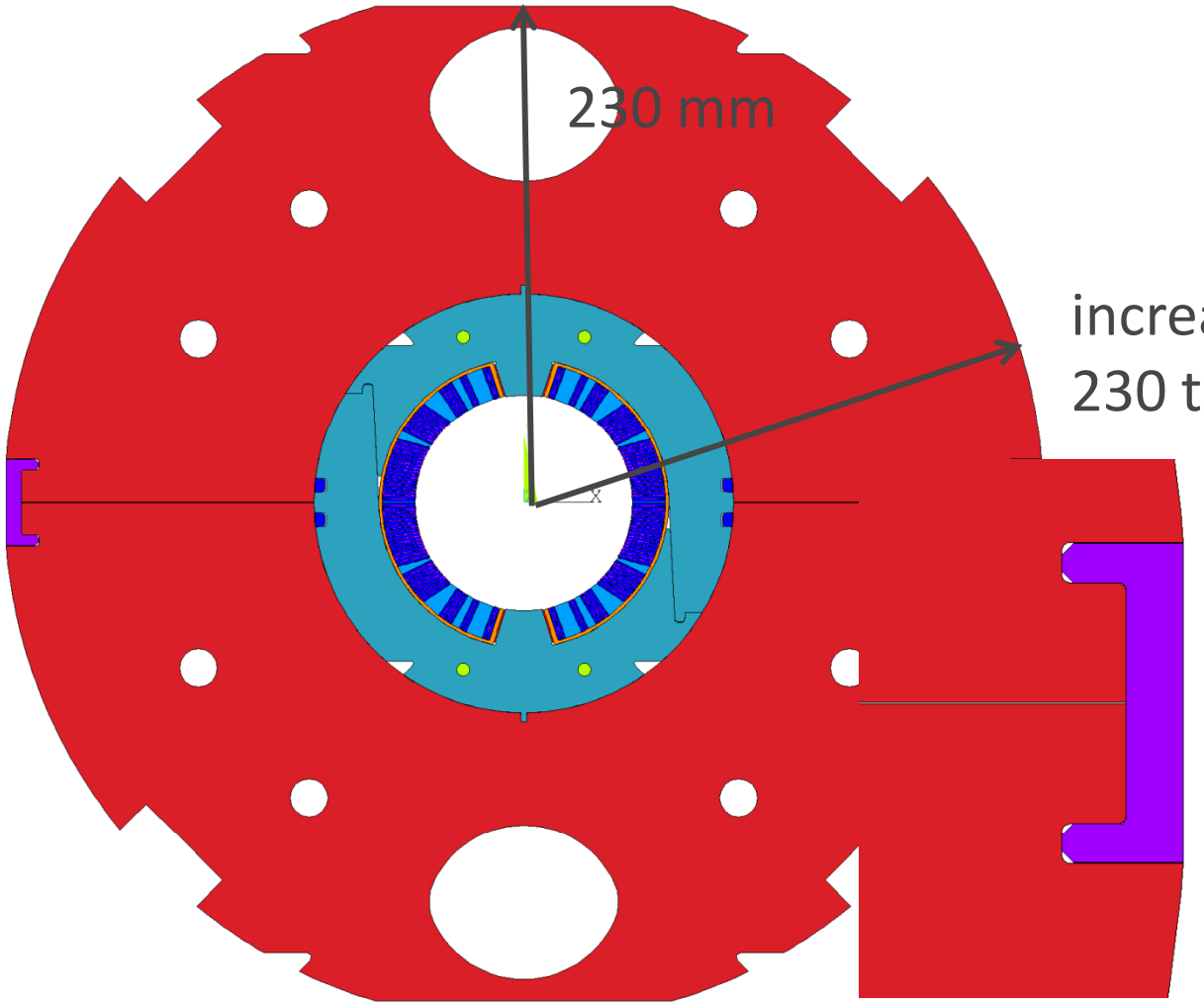
they keep closed the iron yoke

iron yoke constraints

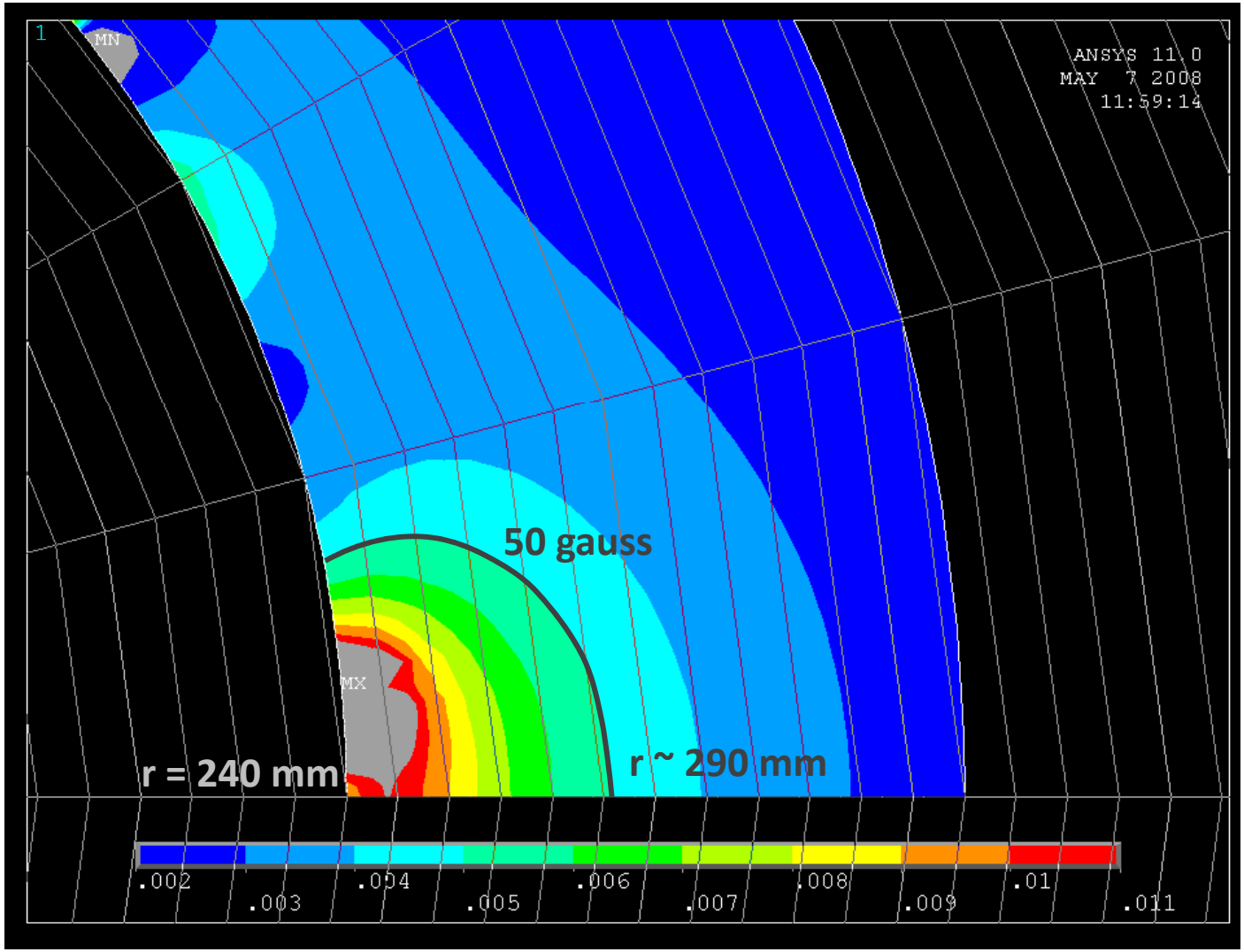
The goal is a side containment to collars.
We should:

- avoid making a second collaring operation on the winding
- take into account the effect of the different thermal contraction of iron and stainless steel
- limit the fringe field increase

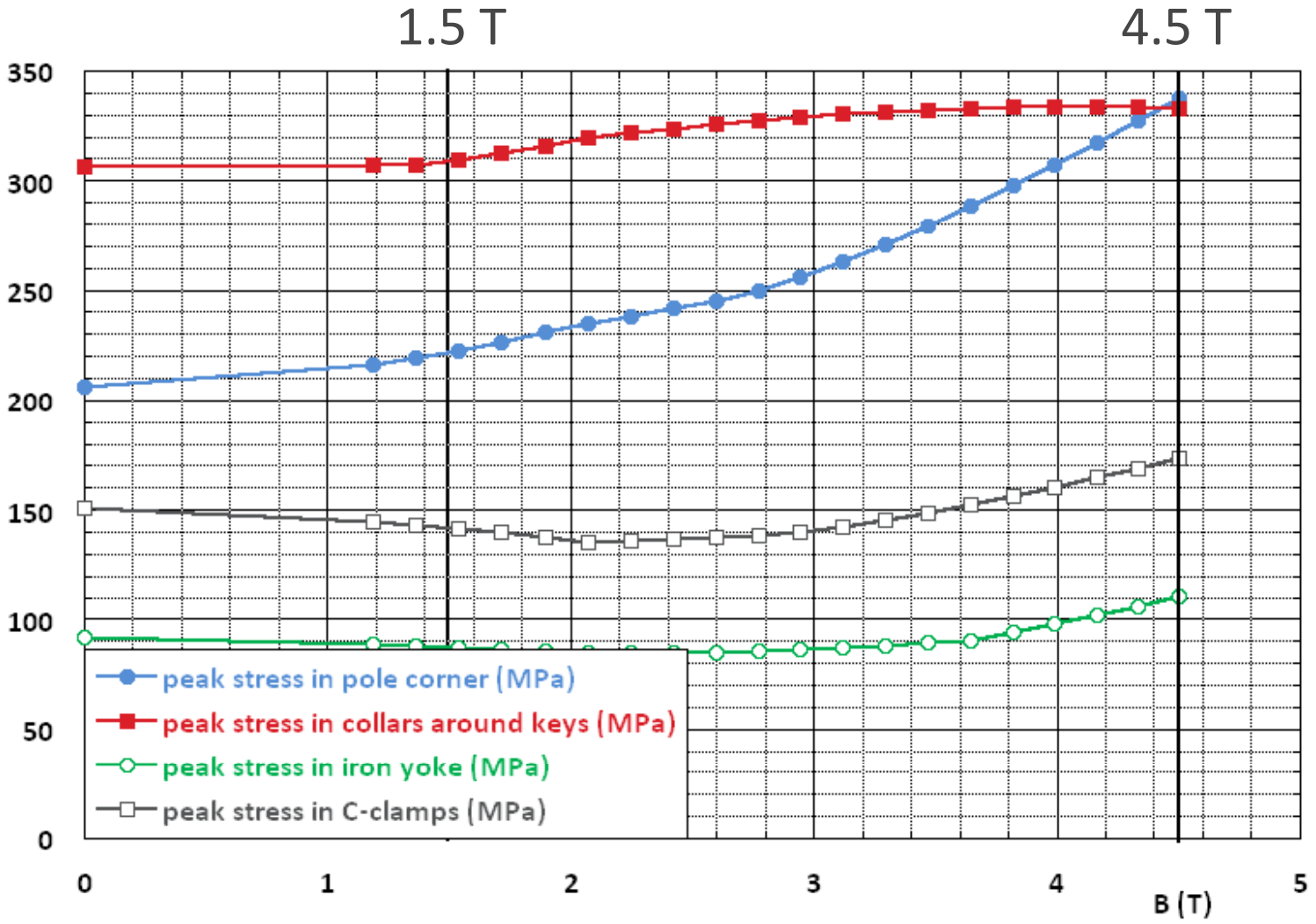
fringe field



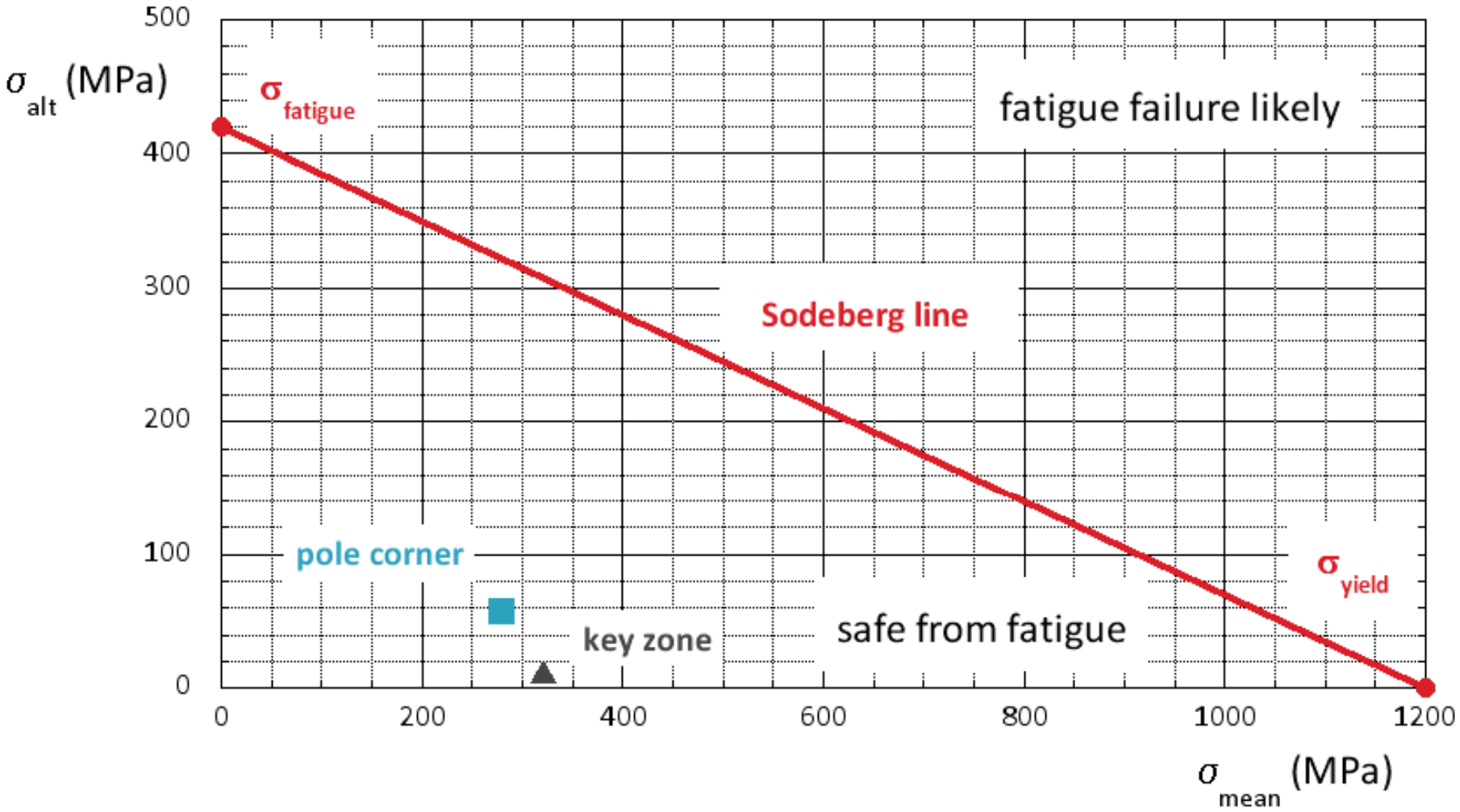
fringe field

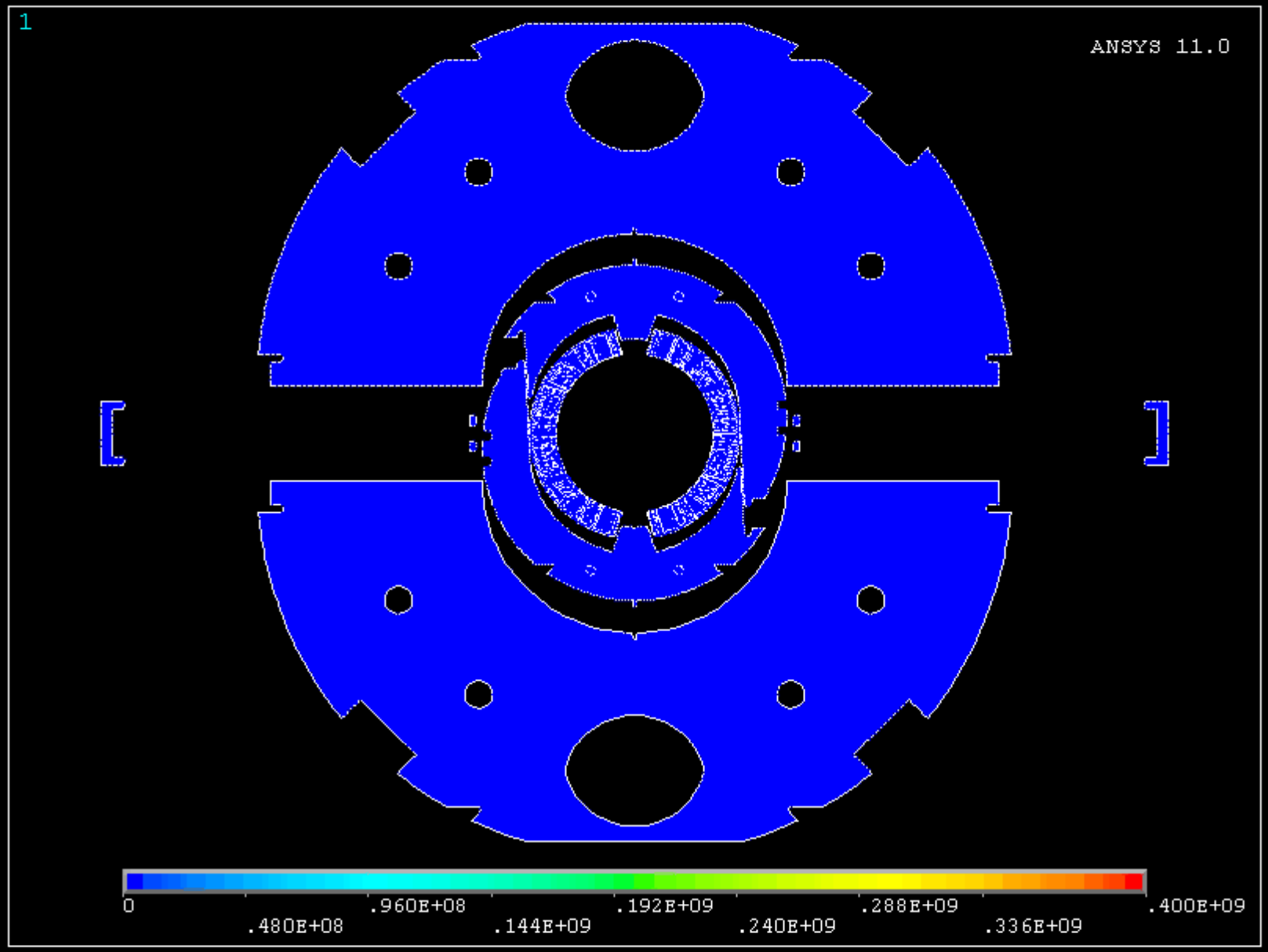


peak Von Mises stress (MPa)



fatigue limit in the range 1.5-4.5 T




1
ANSYS 11.0
0
.480E+08
.960E+08
.144E+09
.192E+09
.240E+09
.288E+09
.336E+09
.400E+09

Conclusions

- The mechanical design requires necessarily both the collars and the iron yoke to limit the stresses
- The peak stresses (MPa) are:

	collars	keys	iron yoke	C-clamps
T=4 K, B=0 T	307	102	92	151
T=4 K, B=4.5 T	338	92	111	175

- The fatigue behaviour is especially critical in this project. The largest stress variation in the collar is 116 MPa, well within the limit of the Sodeberg diagram for 10 millions cycles