Stresses and Deformations in 14 T Nb_3Sn Solenoid of 0.8 m I.R. and 1.0 m O.R. & Half Length

Bob Weggel

10/7/10

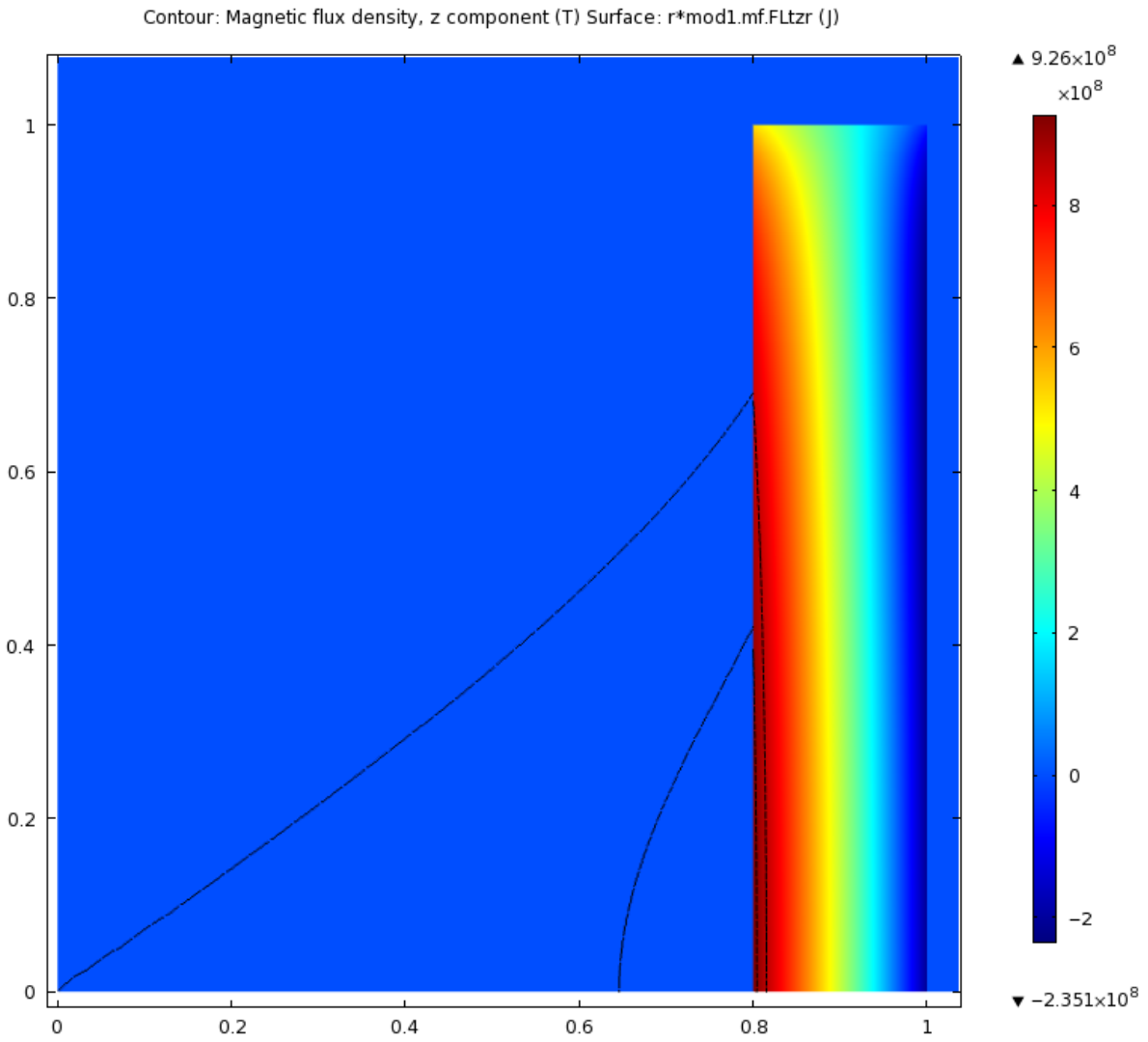
Cross section of upper half of Nb_3Sn magnet with 0.8 m I.R. and 1 m O.R. & half length

Current density j_{coil} = 74.93 A/m^2; central field B(r=0, z=0) = 14 T

Hoop stress, $\sigma_{Bjr} = B\, j_{coil}\, r$, if each turn supported its own Lorentz force

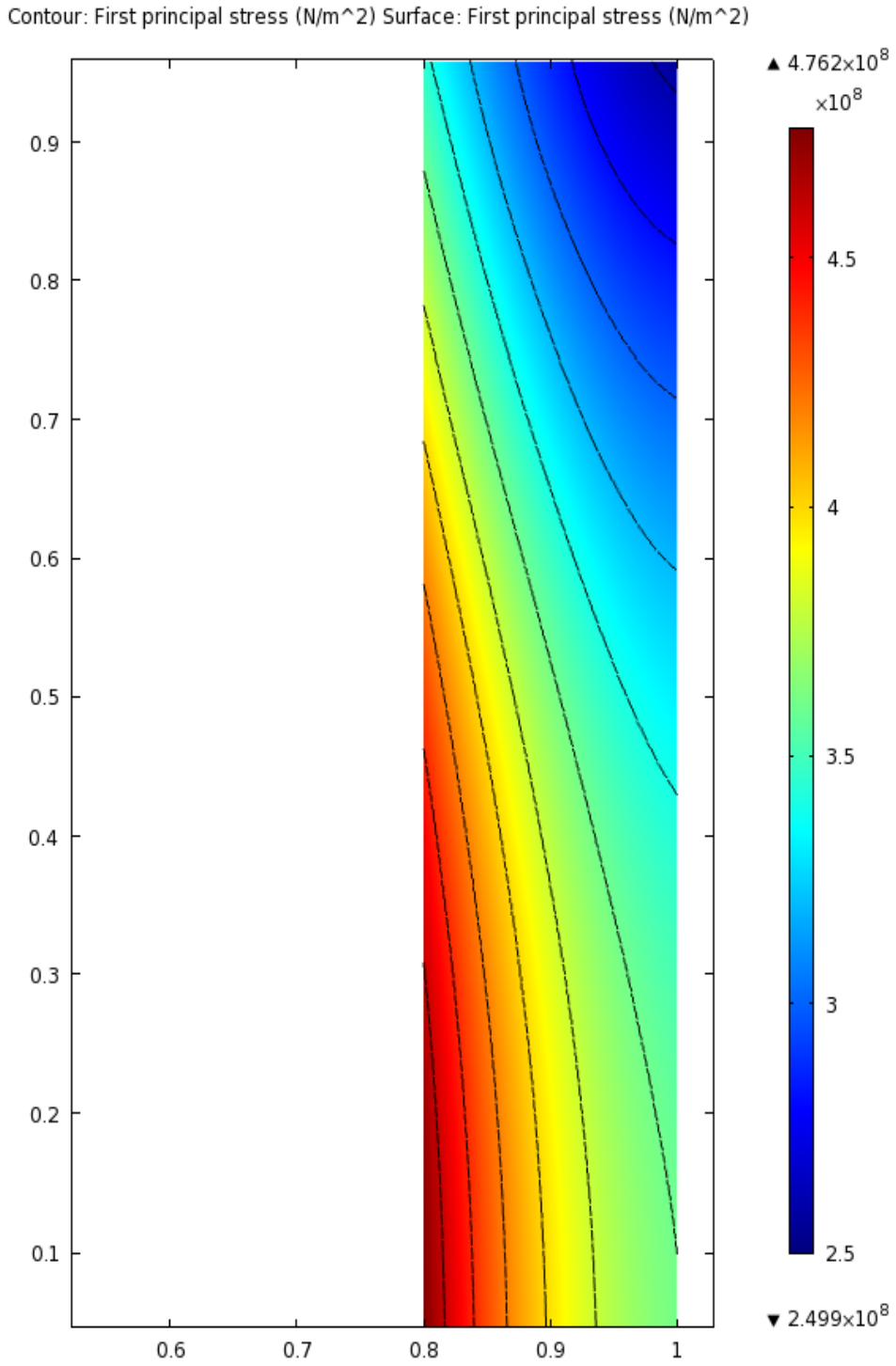
Range −235 MPa (i.e., compression) to +926 MPa

Also, contour lines
B_z =14 T & 15 T



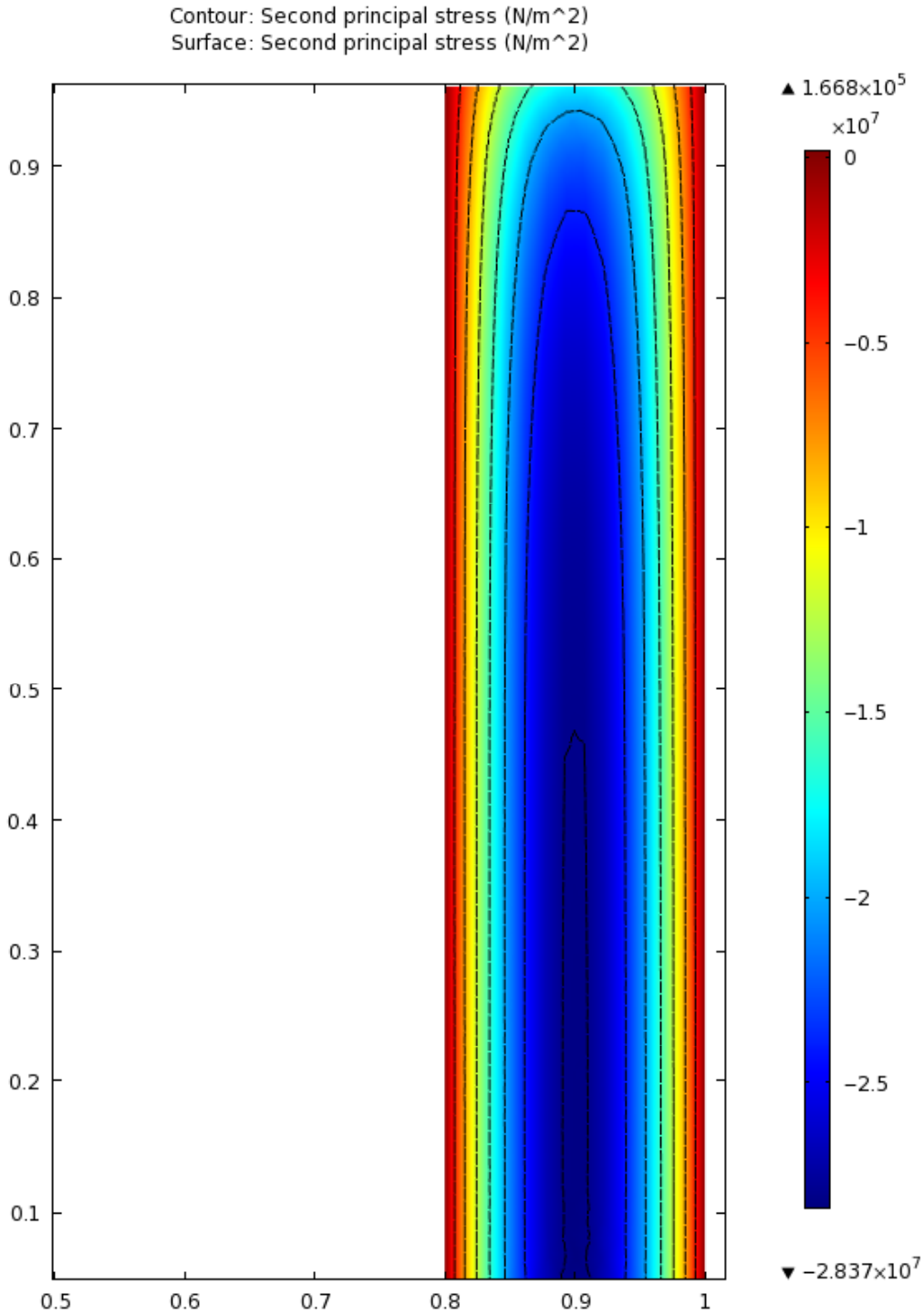
1st principal stress, σ_ϕ, with isotropic winding pack

Range = 250 to 476 Mpa, 51% the peak σ_{Bjr} stress



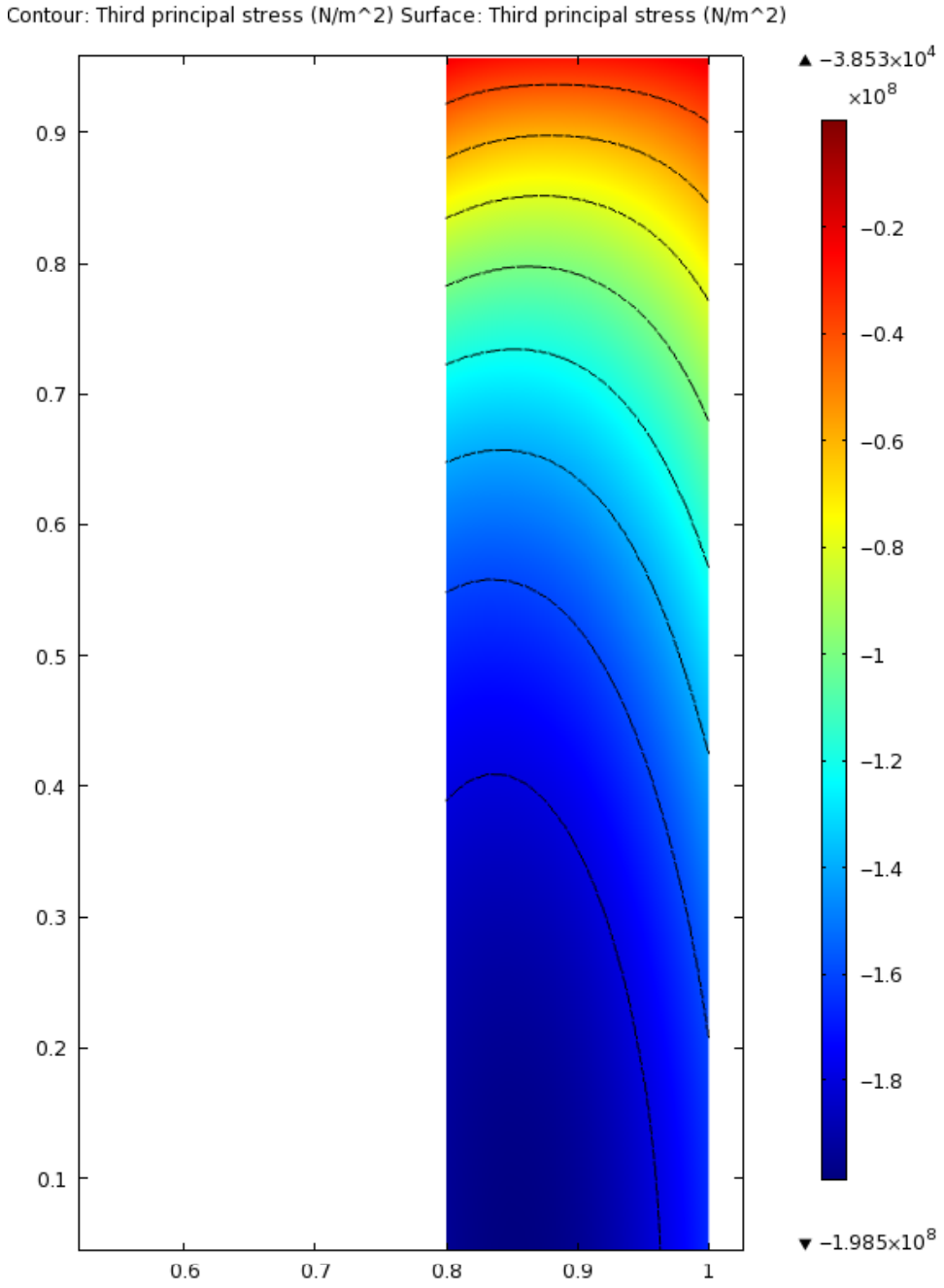
2nd principal stress, σ_r

Maximum magnitude ≡ σ_{max} = 28 MPa, compression



3rd principal stress, σ_z

σ_{max} = 198 MPa, compression

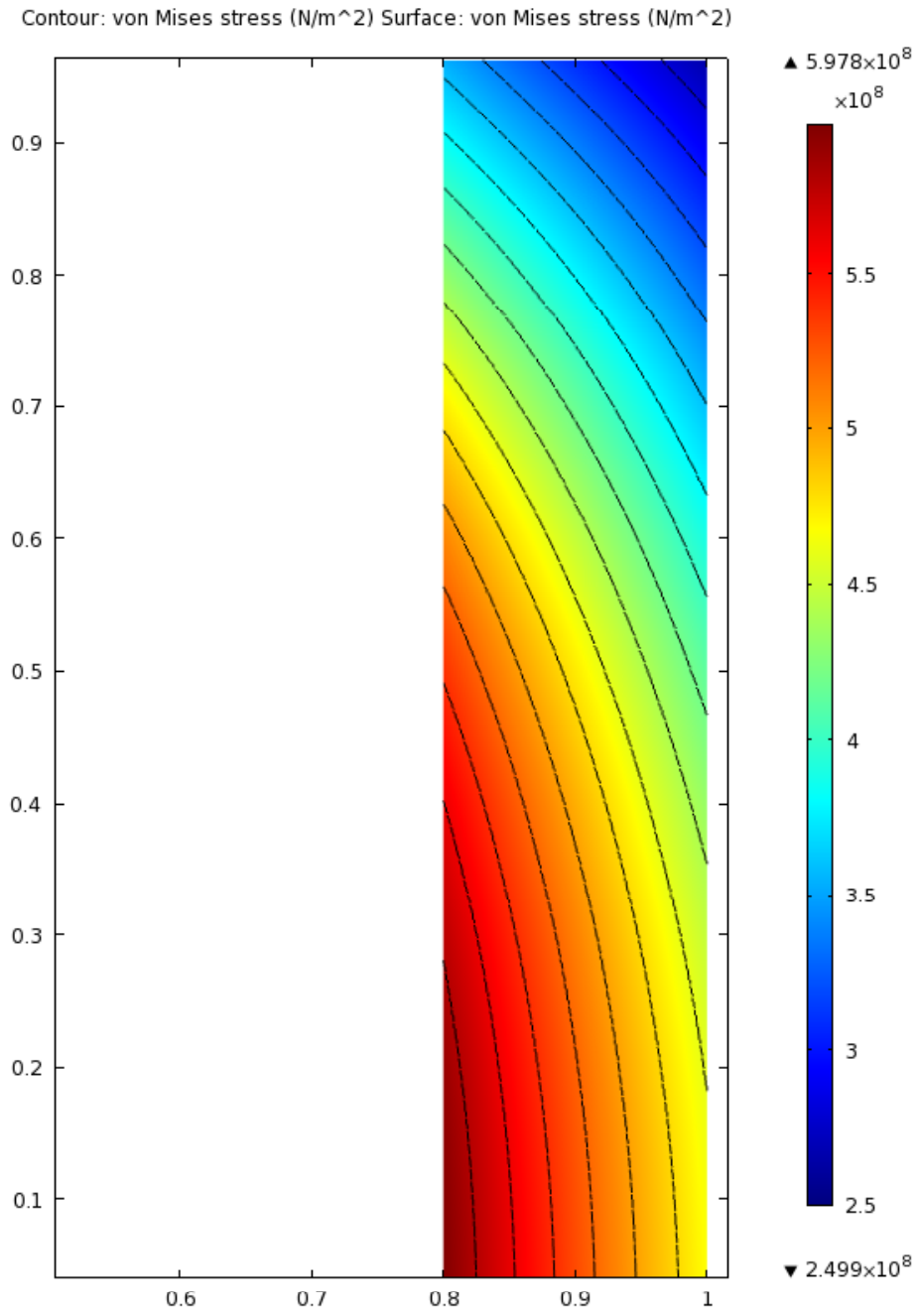


Von Mises ductile-material yield criterion,

$\sigma_{vM} \equiv \mathrm{sqrt}\{\frac{1}{2}\,[(\sigma_\phi - \sigma_r)^2 + (\sigma_\phi - \sigma_z)^2 + (\sigma_r - \sigma_z^{\,2})]\}$

Range = 250-598 MPa,

65% of the peak σ_{Bjr} stress



Deformation, exaggerated tenfold, with isotropic winding pack of 100 GPa Young's modulus

Range: 2.63-3.42 mm