EPFL

Superconducting Magnets: Exercise 1

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Fusion and industrial Plasma Technologies

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Dimensioning of a superconducting solenoid

Exercise 1

- Requirements
- Calculate the overall current
- Suggest number of turns and operating current

Exercise 2

- Calculate the self inductance
- Calculate the hoop load
- Estimate the need of structural support

Exercise 3

- Discuss the discharge requirement in case of quench
- Discuss the hot spot temperature
- Discuss an option for graded conductor

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Requirement and input data

- *Generation of 4 T inside the solenoid*
- *Bath cooling (4.2 K)*
- *Use NbTi superconductor (scaling law -> current density)*
- *Free bore of the solenoid, ø = 50mm*
- *Length of the solenoid λ = 500mm*
- *Thin (single?) layer winding*
- *NbTi composite: cu:non-cu = 2, σ_y = 300 MPa*
- *Suggested criteria for engineering margins:*

$$\Delta T = 0.5\ K \qquad \sigma_{op} \leq 2/3\ \sigma_y \qquad T_{hot\ spot} \leq 150\ K$$

Calculate overall current

- *Apply Ampere law to find the overall current*
- *Use “long solenoid” approximation*

Calculate the current density at operating conditions

- *Retain approximately B_c as B_{op} for the conductor*
- *Retain $T = T_{bath} + \Delta T = 4.7\ K$*
- *Calculate from scaling law J_{NbTi}*
- *Normalize J to strand area*
- *Calculate total strand area*

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Number of turns and operating current

- *Discuss the implications of the selections*
- *Is a single layer realistic?*