

The background of the slide is an aerial photograph of a Swiss landscape. A river flows through a valley, surrounded by green hills and forests. In the distance, snow-capped mountains are visible under a blue sky with light clouds. A large red rectangular box is overlaid on the right side of the image, containing the title text.

# Superconducting Magnets: Exercise 1

A dark grey rectangular box is centered over the middle of the slide, containing the name Kamil Sedlak.

Kamil Sedlak

A white rectangular box is located in the bottom-right corner of the slide, containing the date 11/03/2025.

11/03/2025

## 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

# 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,  $\varnothing = \mathbf{50mm}$
- Length of the solenoid  $\lambda = \mathbf{500mm}$
- Thin (single?) layer winding
- NbTi composite: **cu:non-cu = 2**,  $\sigma_y = \mathbf{300 MPa}$
- Suggested criteria for engineering margins:

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

# 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  $T = T_{bath} + \Delta T = 4.7 \text{ K}$
- Calculate from scaling law  $J_{NbTi}$
- Normalize  $J$  to strand area
- Calculate total strand area

# Number of turns and operating current

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