**UNIVERSITY OF TWENTE.**

**2PoCA-09: Transverse pressure dependence of the critical current in Nb$_3$Sn Rutherford cables**

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**Objectives**
- Understand the transverse pressure dependence of the critical current in various Nb$_3$Sn Rutherford cables;
- Establish the irreversible transverse stress limit and hence operational margins;
- Study the detailed effects of strand- and cable architectures.

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**Introduction**
- **Cable 1:** 40-strand ($\phi = 0.7$ mm) cable, (14.7 x 1.25) mm$^2$, 0.75° keystone, 100 mm twist pitch;
- **Cable 2:** 40-strand ($\phi = 0.7$ mm) cable, (15.0 x 1.30) mm$^2$, 0.71° keystone, 100 mm twist pitch;
- Cables for CERN-FNAL program 11T Nb$_3$Sn Dipole Demonstrator (DS magnet);
- Expected performance under operational $B_{\text{applied}}$, $T$ conditions?

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**Experimental (1): Cable Impregnation**

Sample holder with Nb$_3$Sn Rutherford cable  
Before impregnation  
After impregnation

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**Experimental (2): Measurement set-up**

**Electromagnetic press**
- Double NbTi pancake; $F_{\text{max}} = 260$ kN
- Steel 50 µm kapton anvil; (45 x 15.2) mm$^2$, $\sigma_{\text{max}} = 340$ MPa

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**Results (1): cable Ic**

**Virgin witness strands $I_c$**

**Initial cable training**

**Cable $I_c(B_{\text{applied}})$**

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**Results (2): transverse pressure dependence**

**Cable $I_c(\rho)$**

**Measurement sequence: Cable 1**

- Cable 1: 1% fully reversible reduction at 150 MPa (design value)
- No irreversible degradation until ~220 MPa
- Cable 2: significant irreversible degradation starting at ~80 MPa

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**Conclusions**
- $I_c(\rho)$ and $I_c(\sigma)$ full-sized Nb$_3$Sn cables successfully tested with short-sample set-up;
- $I_c(\rho)$ well above required values ($I_c=12$ kA, $B_{\text{applied}}=11.7 T$) for cable 1:
  - $I_c(11.5T) = 19.3kA$, $I_c(11.9T) = 17.6 kA$ (6% reduction compared to witness strand after first cool-down, 3% after thermal cycle)
  - Cable 2: $I_c(11.1T) = 17.0 kA$ (15% reduction compared to witness strand after first cool-down, 15% after 3-time thermal cycle)
  - Stability verified along entire load line;
- Cable 1: transverse pressure sensitivity well within design requirements: $\rho_{\text{max}} = 150$ MPa (fully reversible) Irreduction of 1%, but no irreversible degradation, irreversible degradation only observed above $\rho \approx 220$ MPa;
- Cable 2: 1% irreversible reduction already at 40 MPa; $\rho_{\text{max}} = 80$ MPa.