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Superconductivity R&D at Twente University

M. ter Brake, M. Dhallé, H. ten Kate, A. Nijhuis et al.

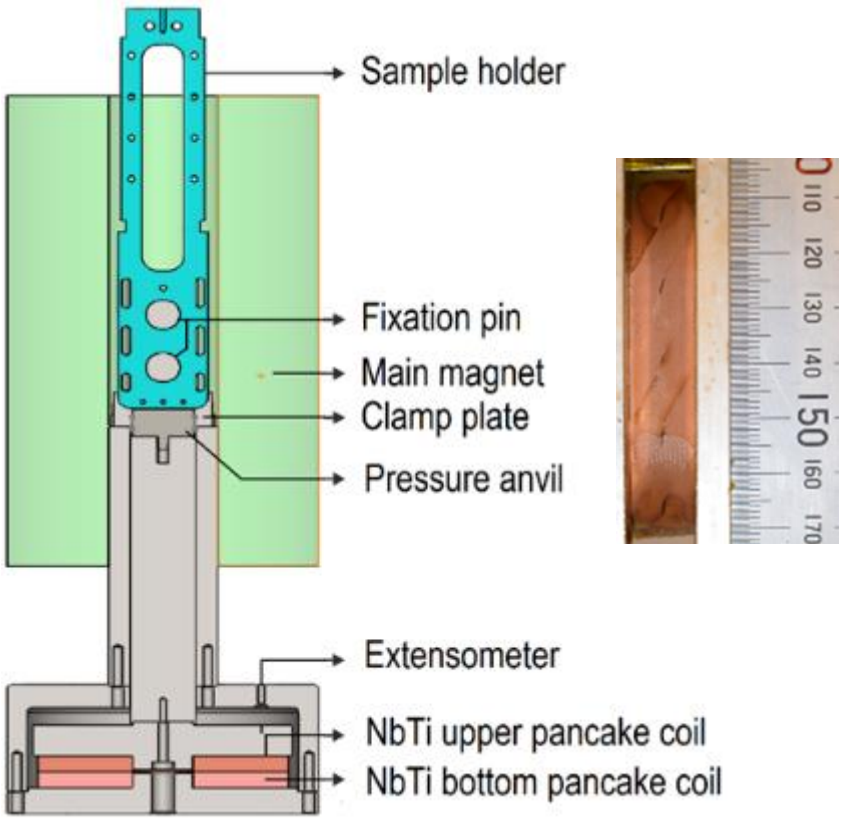
FCC WEEK 2018 – Amsterdam,
The Netherlands 09 - 13 April 2018

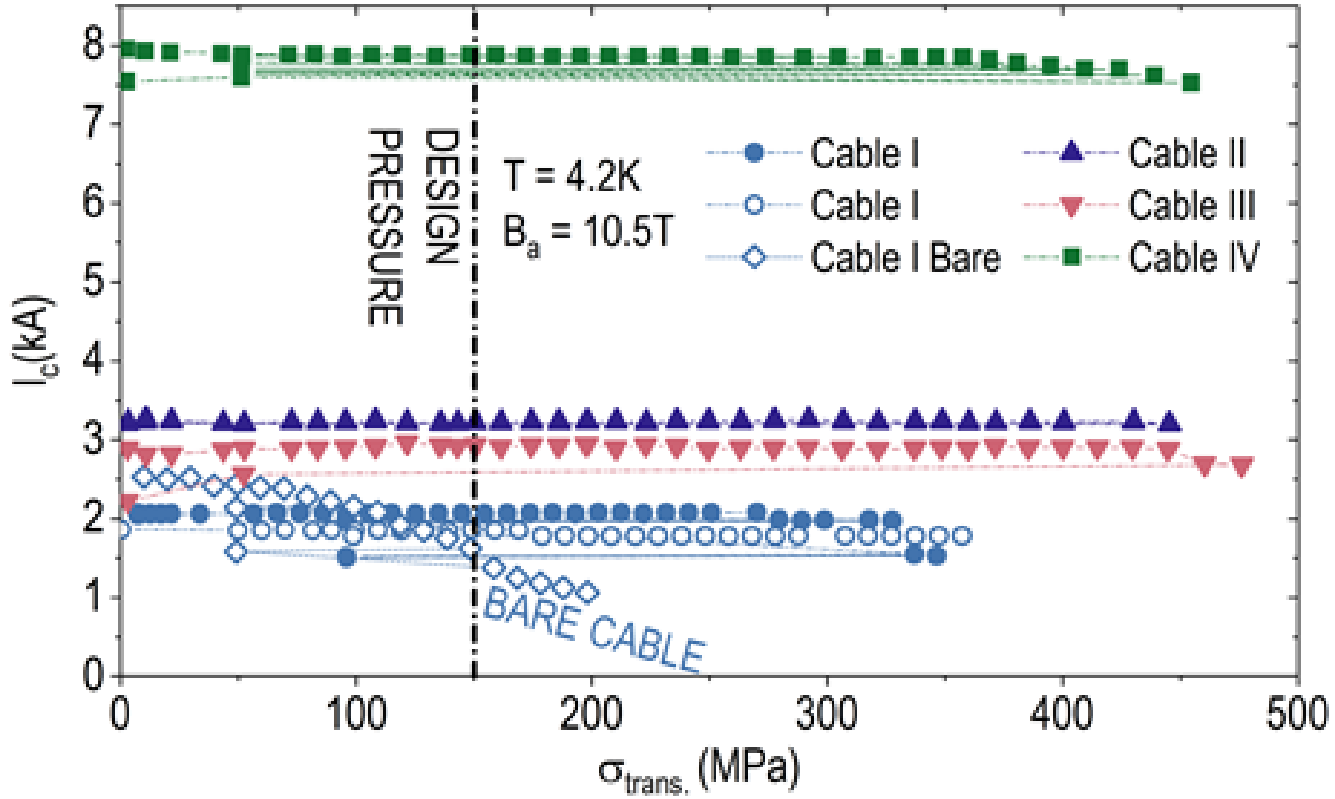
Outline

Superconductivity R&D at Twente University

- Directly FCC-oriented
- Fusion-oriented
- Industry-oriented

EuCard2 : transverse pressure dependence HTS Roebel cables

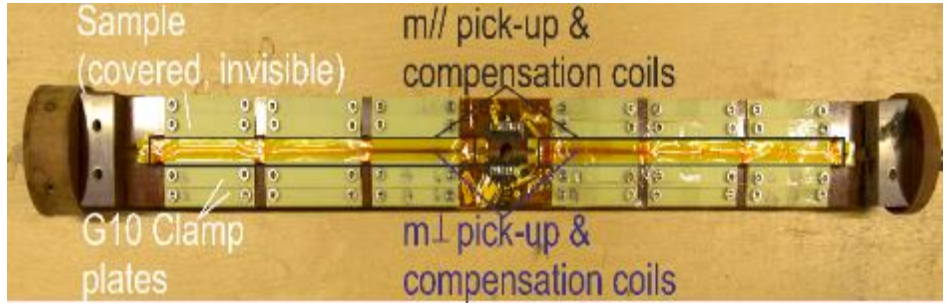


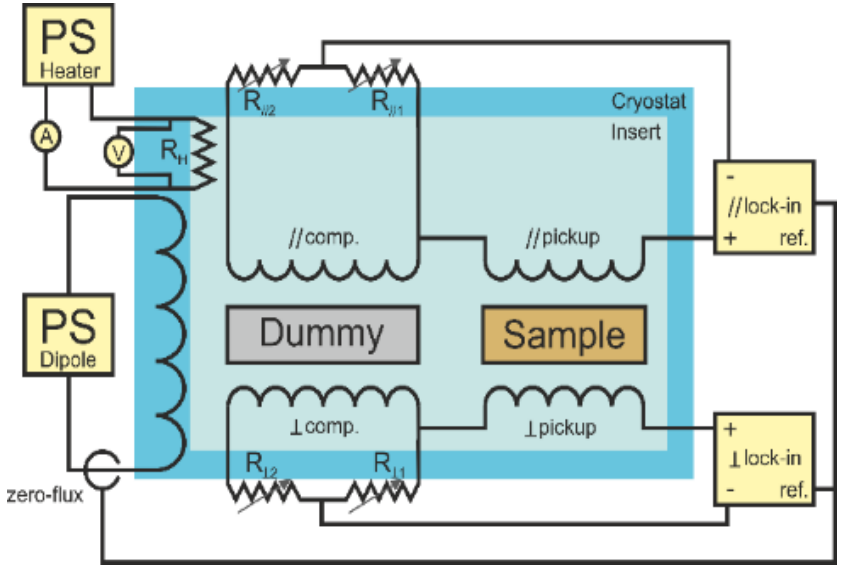


P. Gao et al., EUCAS 2017

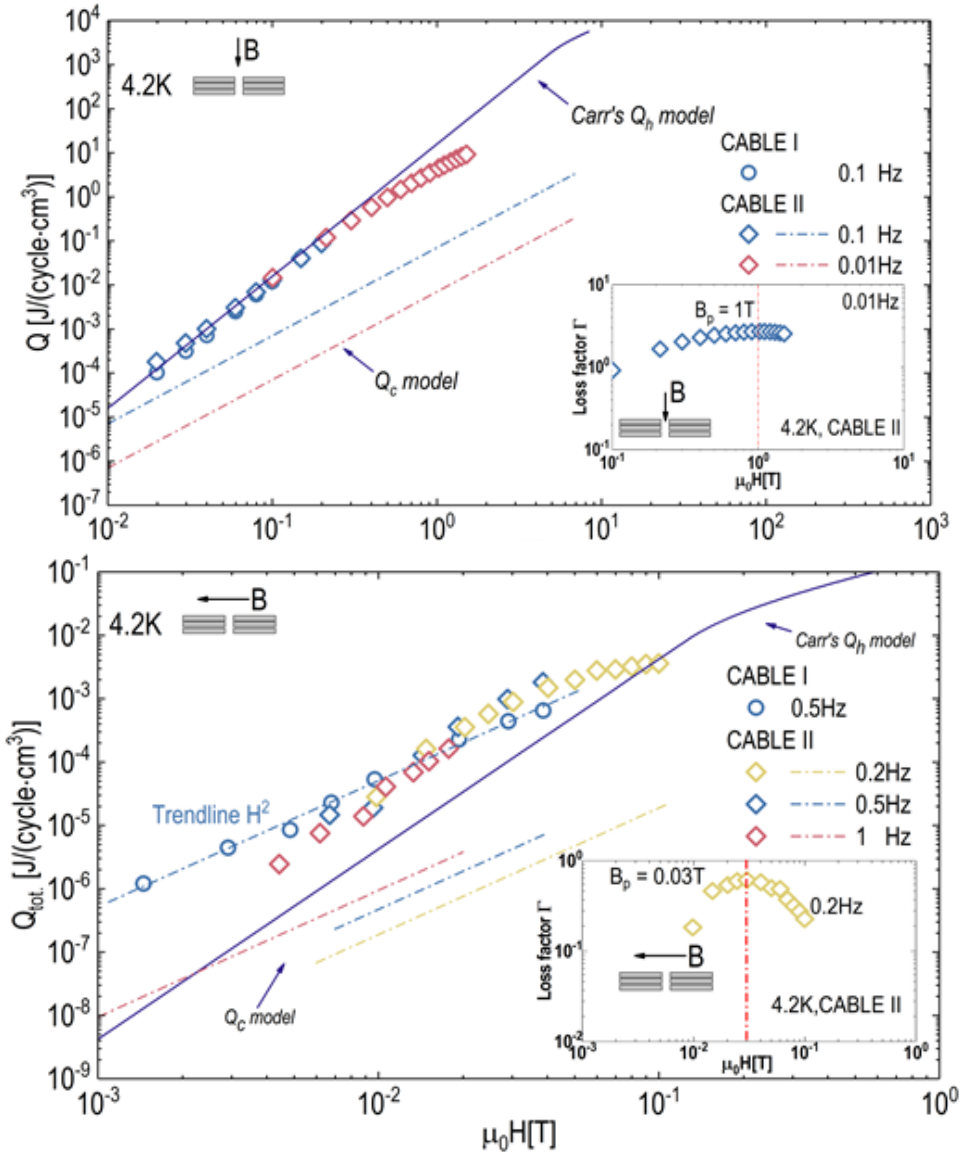
EuCARD-2 is co-funded by the partners and the European Commission under Capacities 7th Framework Programme, Grant Agreement 312453

EuCard2 : AC loss HTS Roebel cables



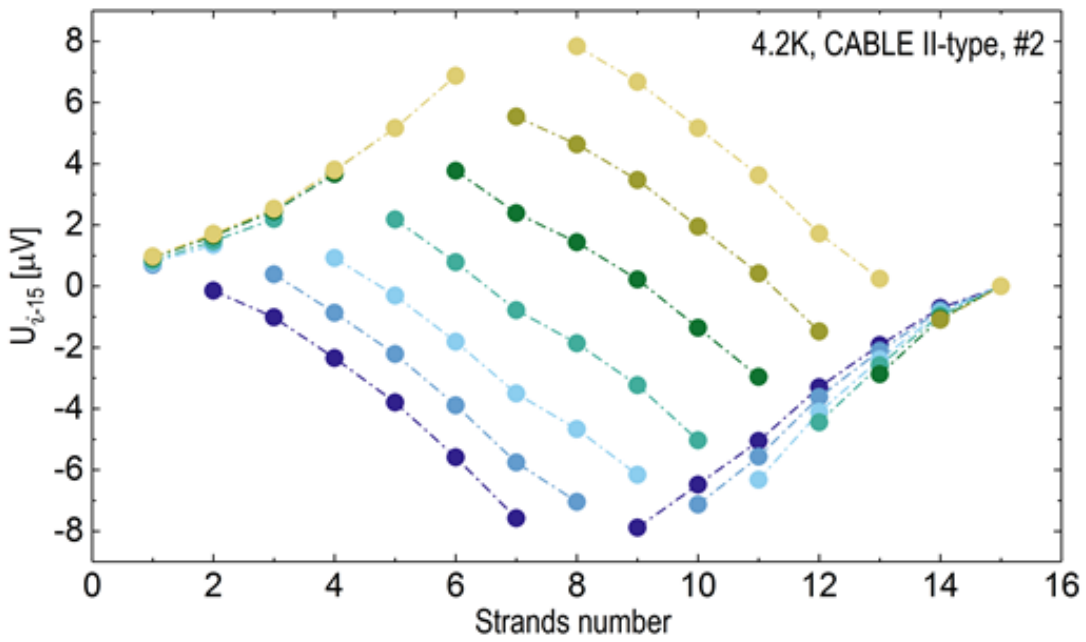


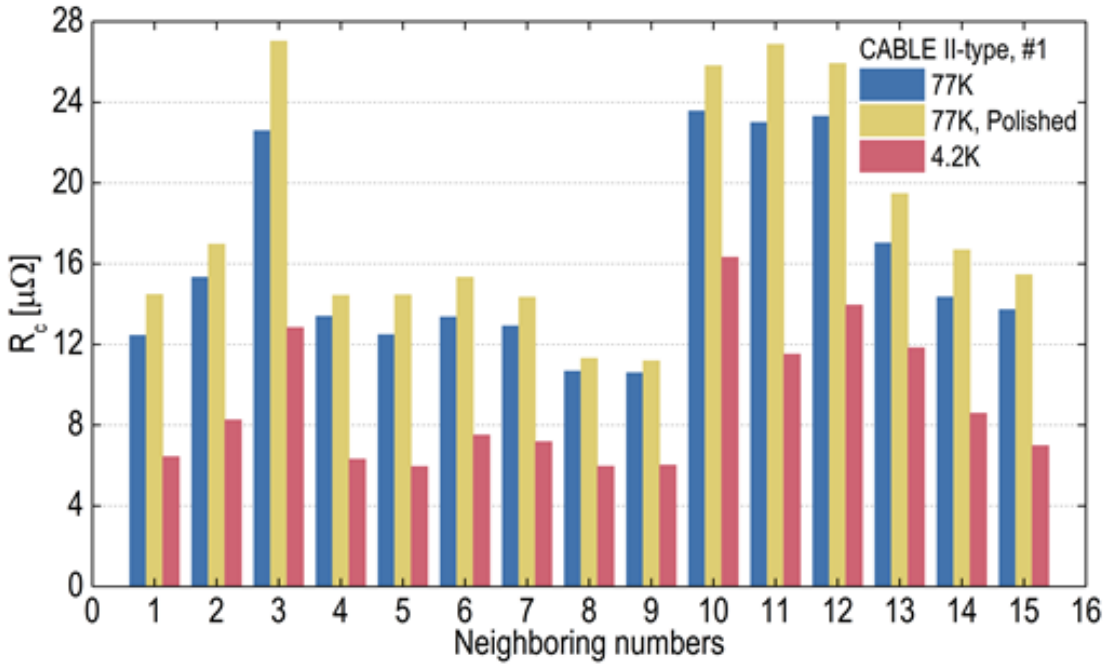
P. Gao et al., SUST 2018

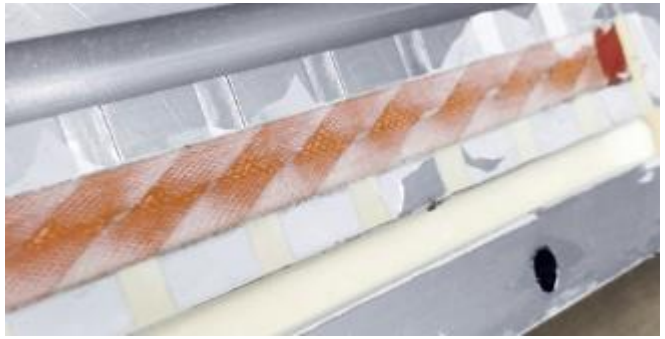


Capacities 7th Framework Programme,
Grant Agreement 312453

EuCard2 : inter-strand contact resistance HTS Roebel cables







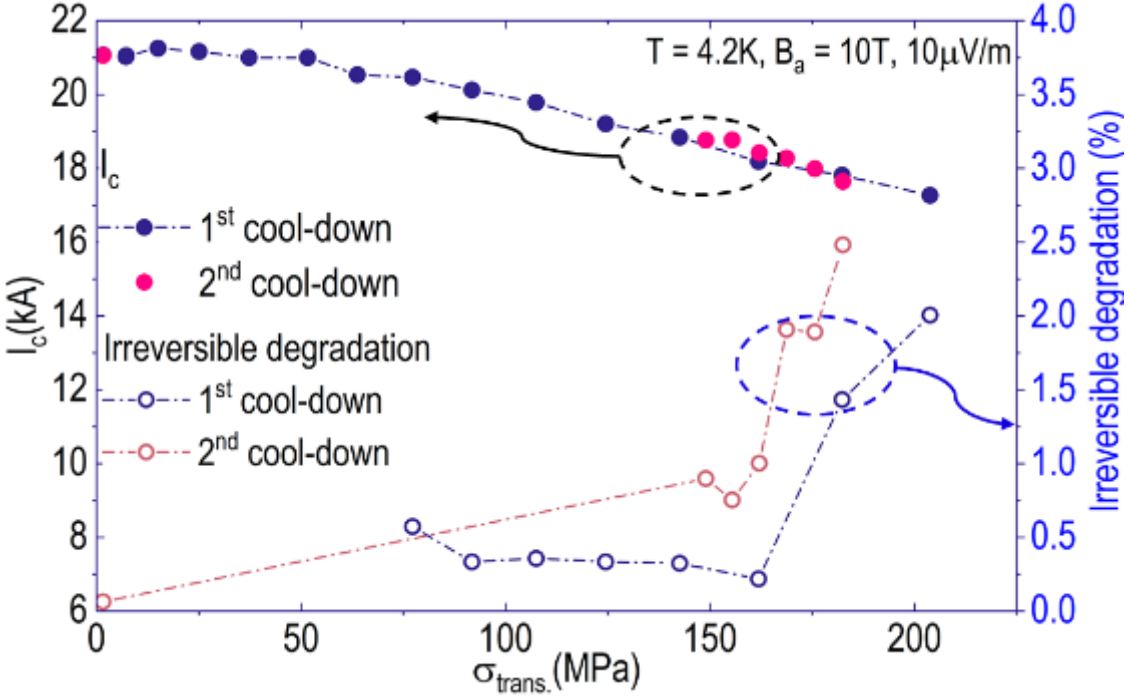
P. Gao et al., SUST 2018

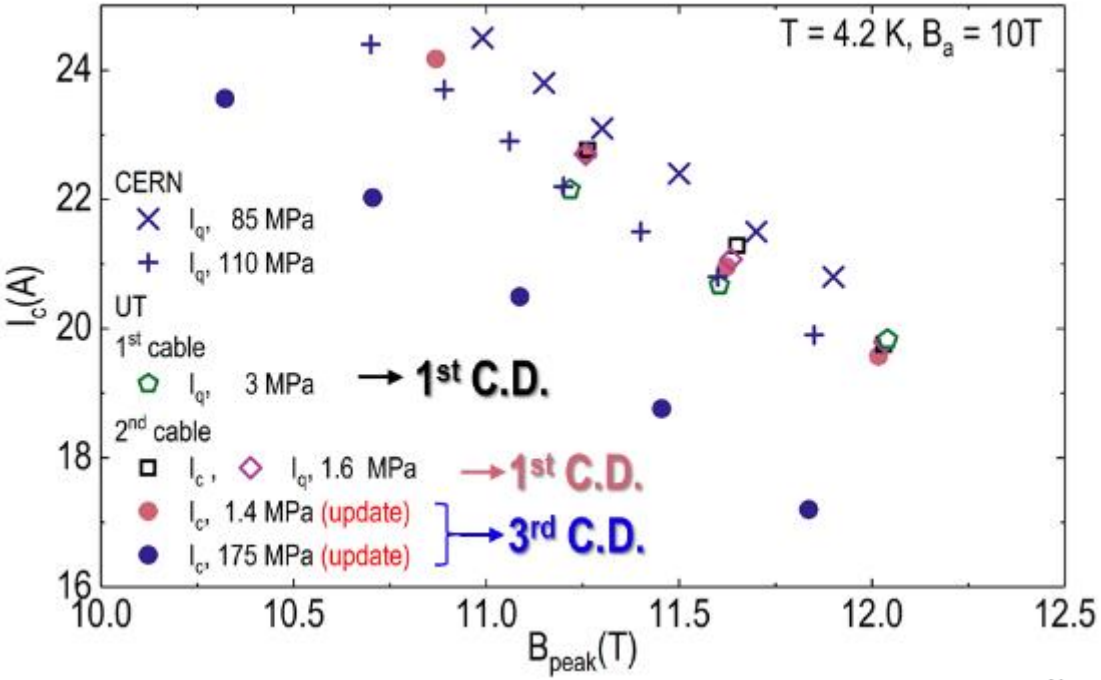
EuCARD-2 is co-funded by the partners and the European Commission under Capacities 7th Framework Programme, Grant Agreement 312453

EuroCirCol : transverse pressure dependence Nb_3Sn Rutherford cables

RRP 132/169 18strands ∅1mm

See also B. Bordini yesterday





P. Gao et al., ASC 2018

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Co-funded by the European Commission

EuroCirCol

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Outline

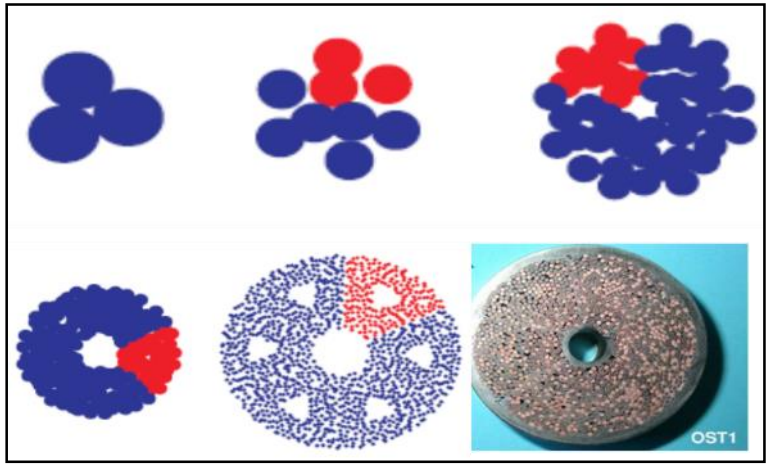
Superconductivity R&D at Twente University

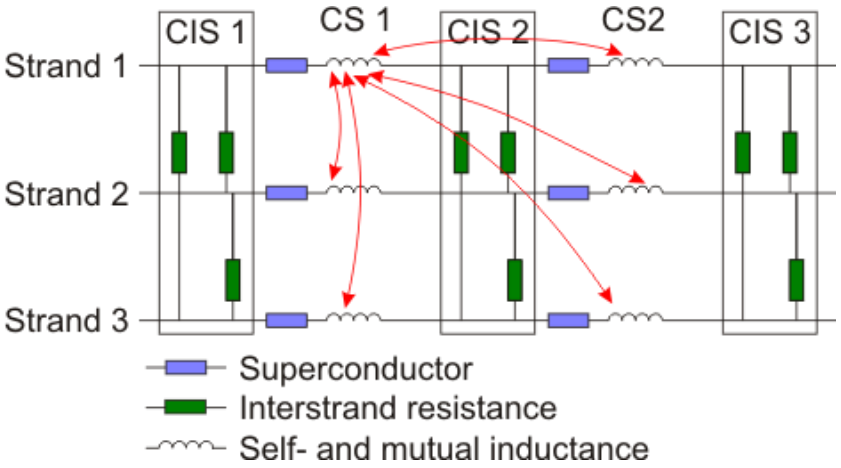
- Directly FCC-oriented
- **Fusion-oriented**
- Industry-oriented

JackPot for CICC cables

Basics about JackPot

- JackPot AC/DC model CICC describing *all* (>1000) strand trajectories.
- Strands are 1D elements in a 3D cable geometry.
- From the geometry is built the electrical network able to calculate the current distributions and power dissipations of the CICC



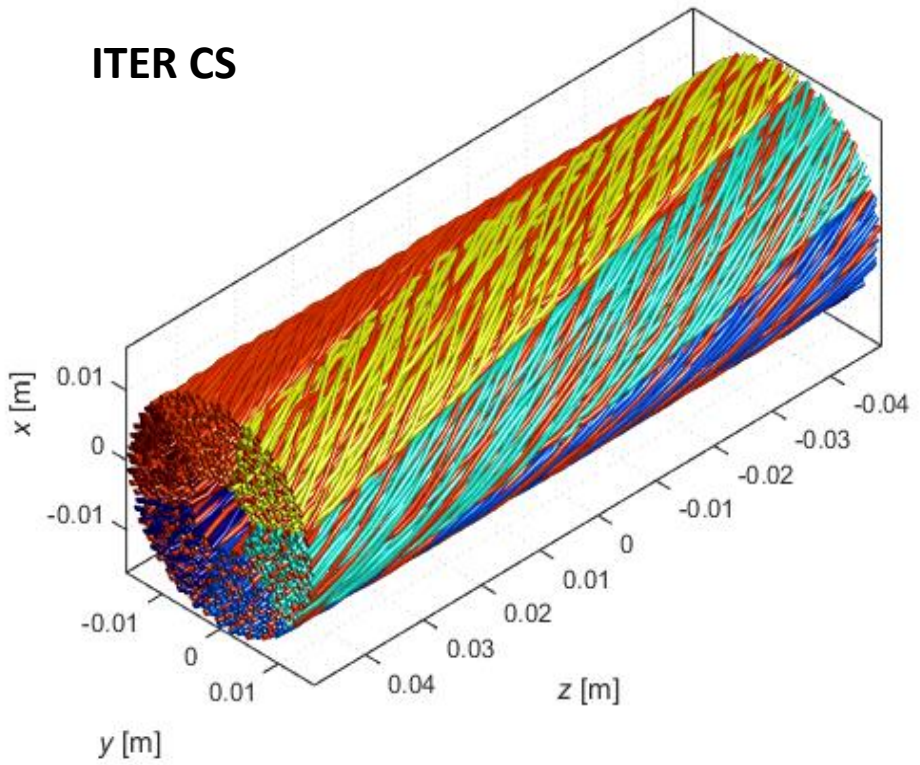


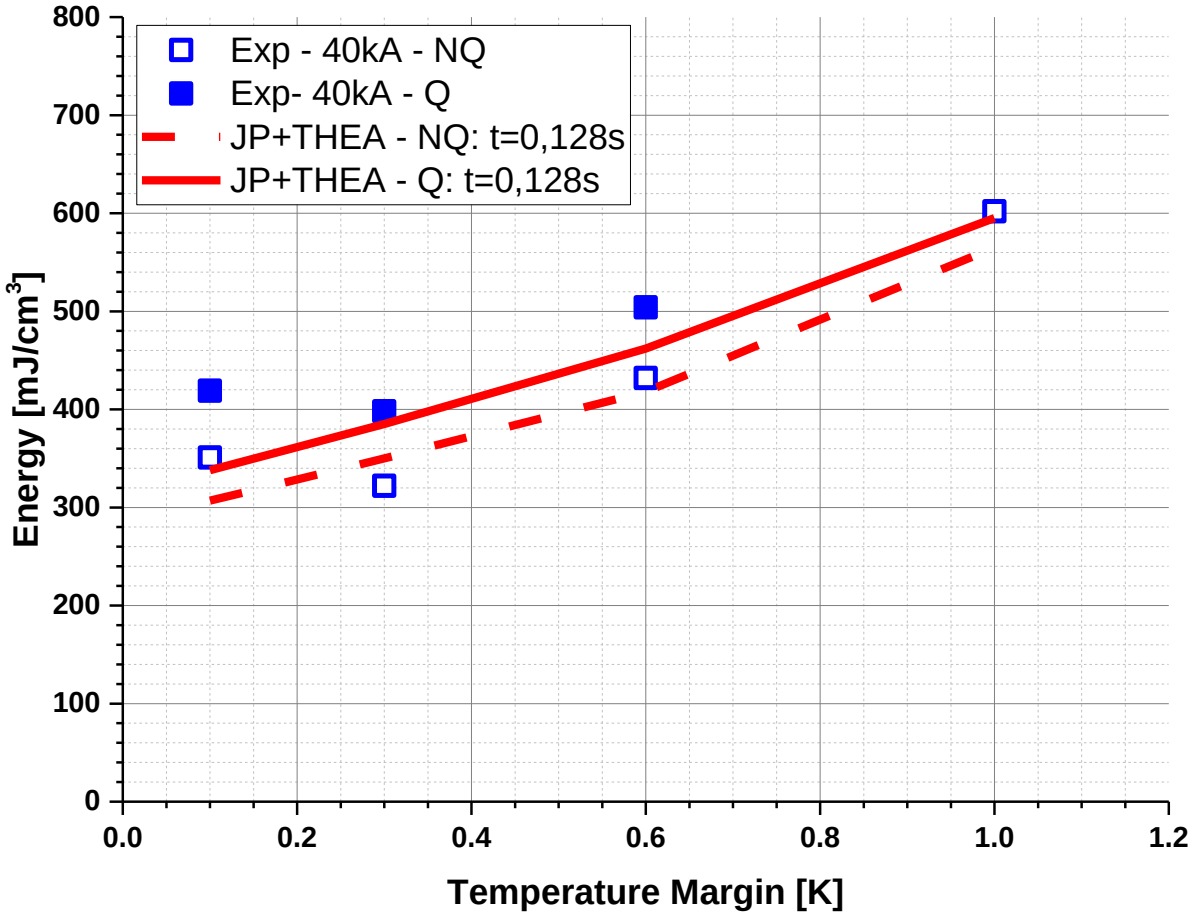
Parameters required

- Inter-strand contact resistance distribution from contact area
- Strand's mutual inductances
- Coupling with self- & background field
- strand's properties scaling law $I_c(B,T,e)$

JackPot for CICC cables

JackPot + THEA : experimental validation (SULTAN)





JackPot for CORC

Mechanical modeling

- Bending & winding at room temperature
- Tape degradation at strain >0.45%

Production process

↓

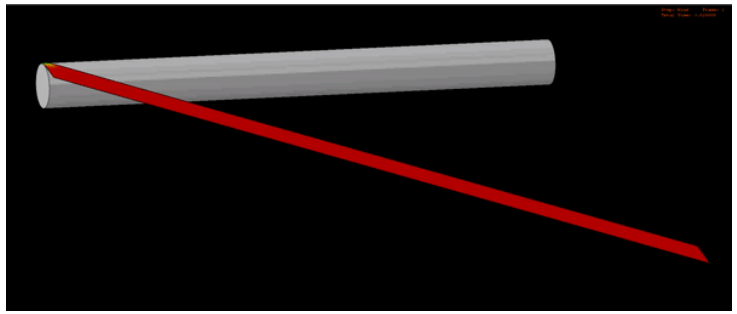
Winding different layers

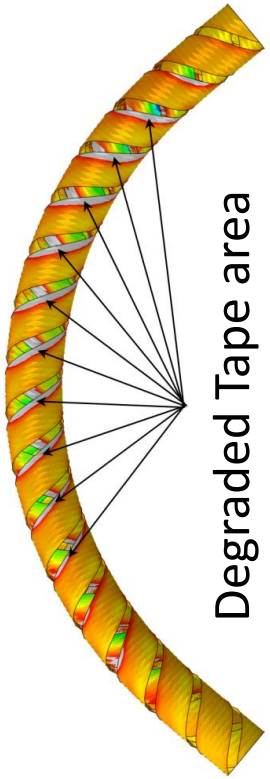
↓

Stress-Strain transfer to full CORC geometry

↓

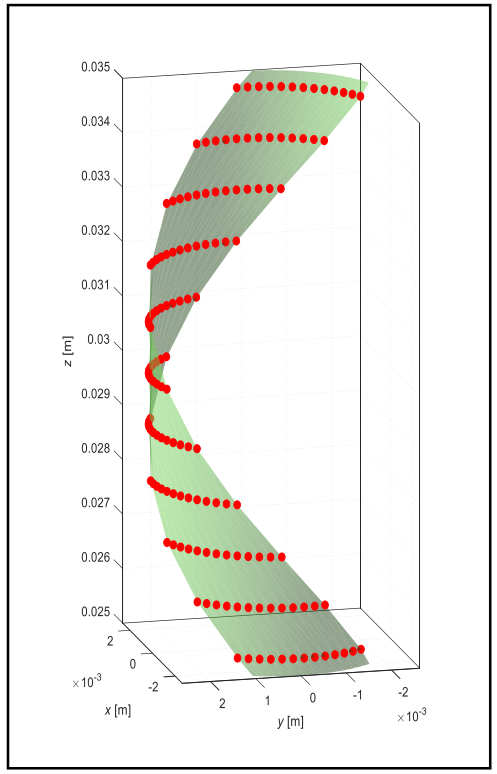
Bending

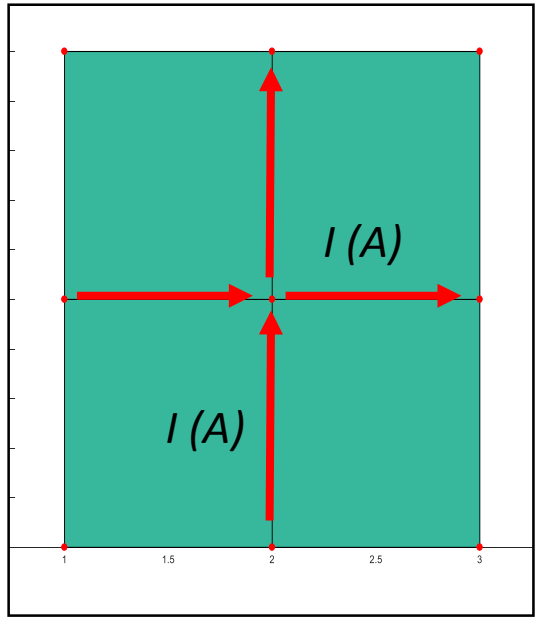


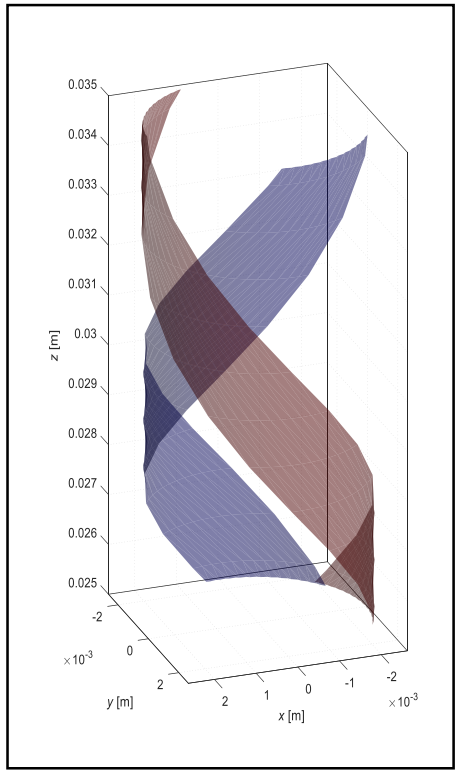


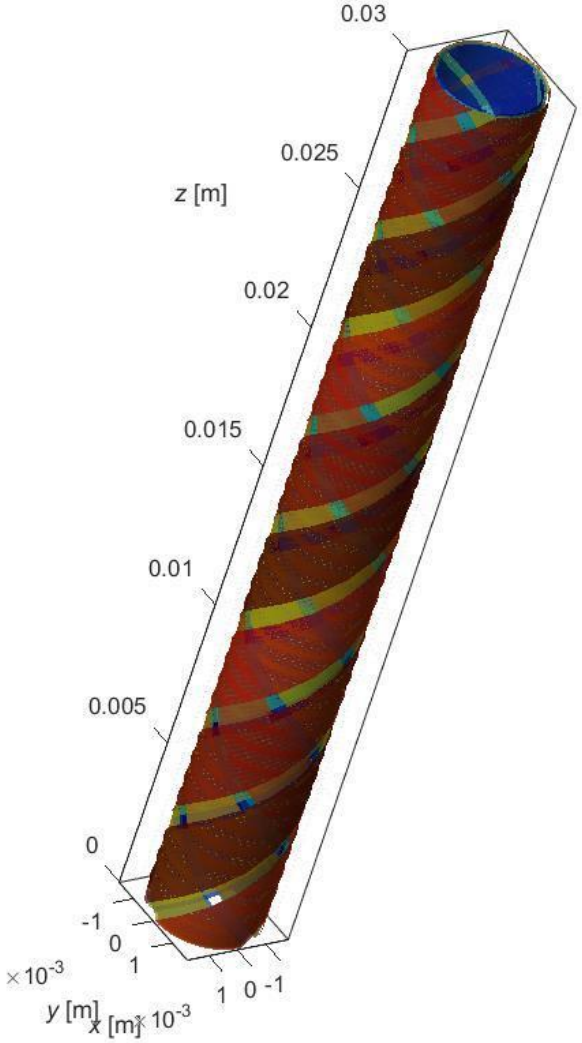
JackPot for CORC

- The CORC geometry is imported from the FEM model for mechanical stress-strain simulation.
- Using the strain distribution from the FEM model is possible to calculate a critical current dependent from the tape deformation.
- The tapes have a 2D structure. The current can flow in transvers and longitudinal direction.
- The contact resistance is proportional to the surface overlap between tapes.







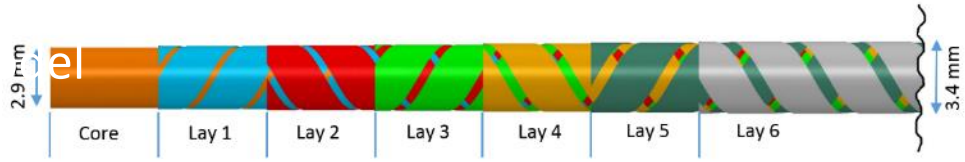


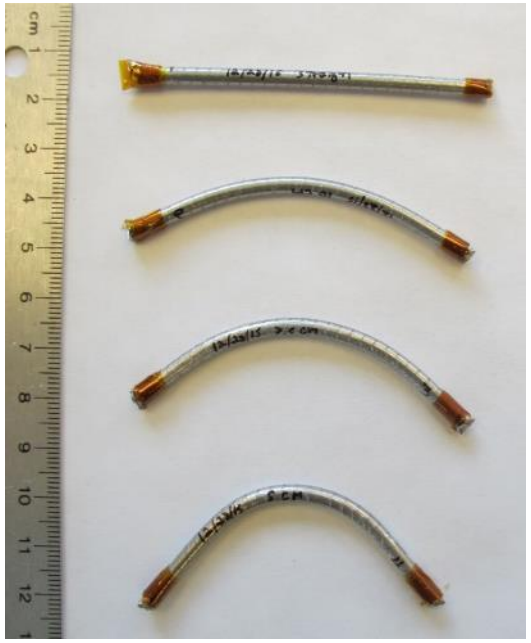
JackPot for CORC

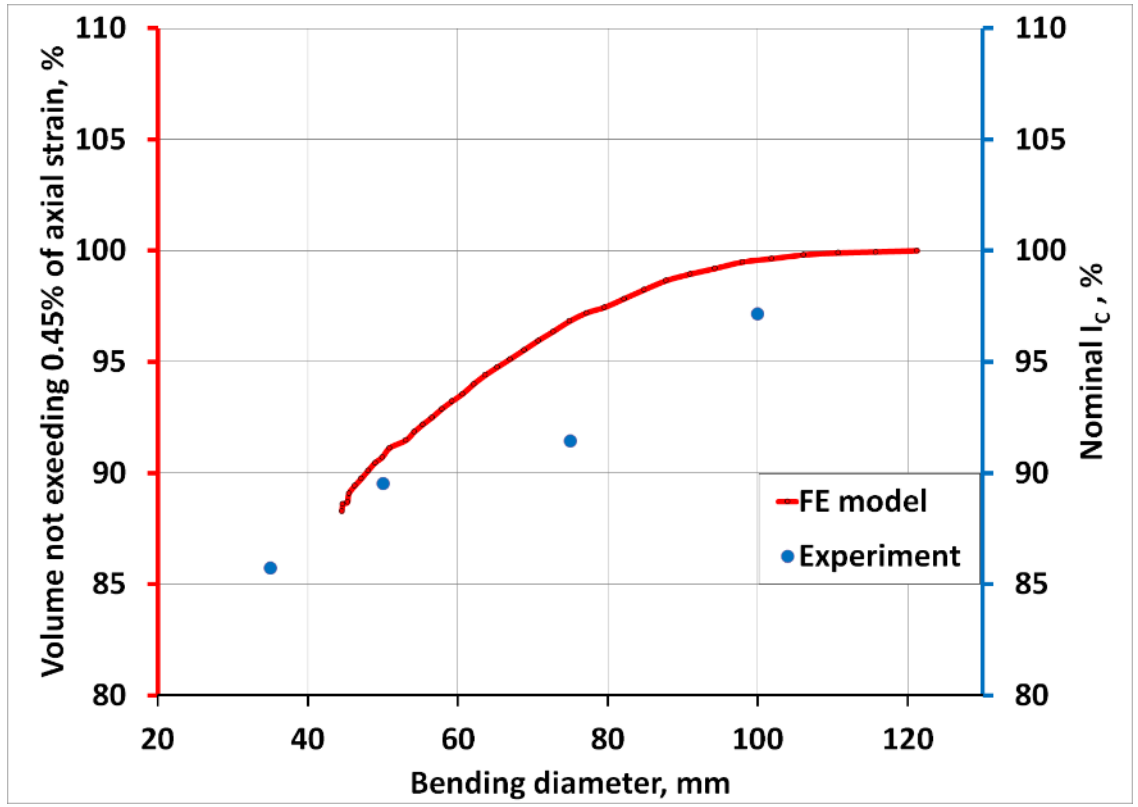
Experimental validation (with D. van der Laan)

Cable configuration:

- 6 layers, 2 tapes per layer
- Total cable diameter: 3.4 mm
- Substrate thickness: 30 µm
- 2 mm wide tapes
- Winding angle: 60^0
- Copper plating: 5 µm







Outline

Superconductivity R&D at Twente University

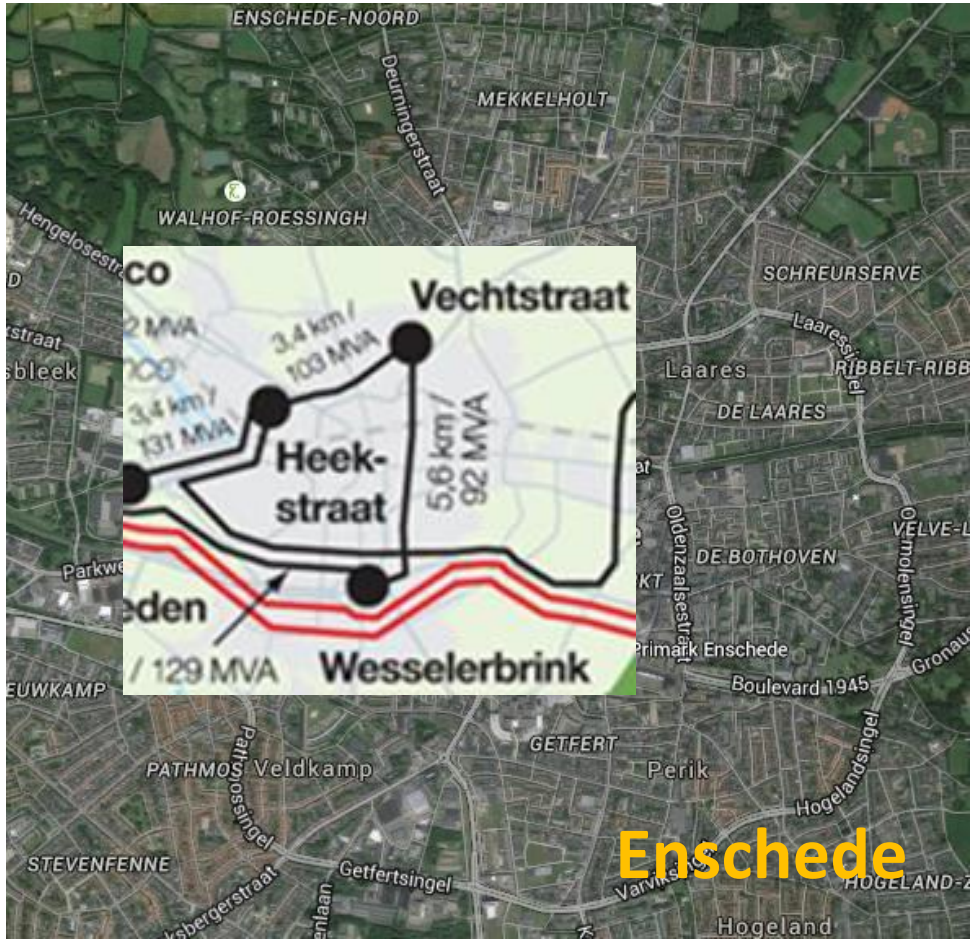
- Directly FCC-oriented
- Fusion-oriented
- **Industry-oriented**
  - **SuperNet NL** (power cable)
  - **SMDS** (recycling)
  - **HTSM** (linear motor)
  - **EcoSwing** (wind generator)

SuperNet NL (HTS power cable)

Coordinated by TenneT (Dutch TSO)

- 3.4 km long
- 64 / 110 kV; 150MVA

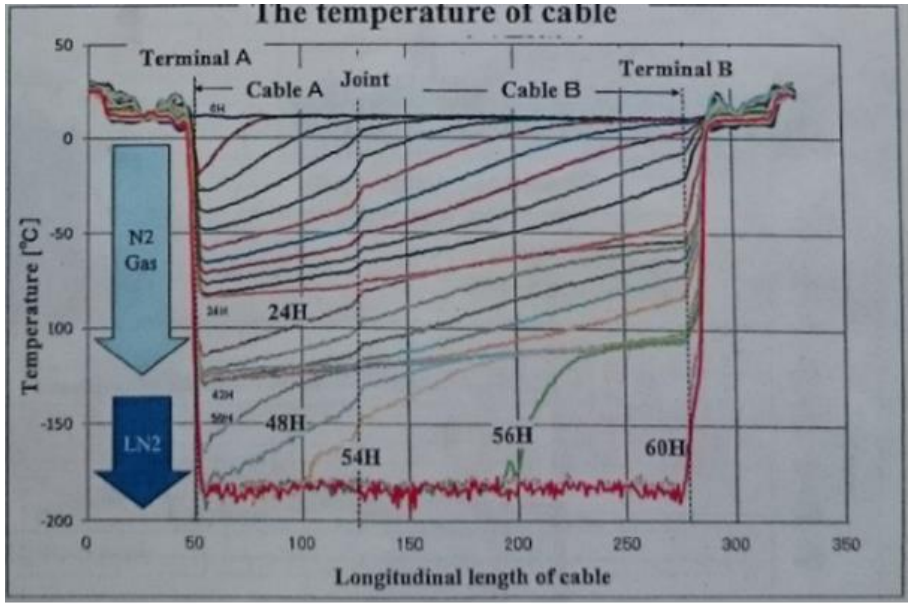
- Feasibility
- Cost-effectiveness
- Reliability & repairability



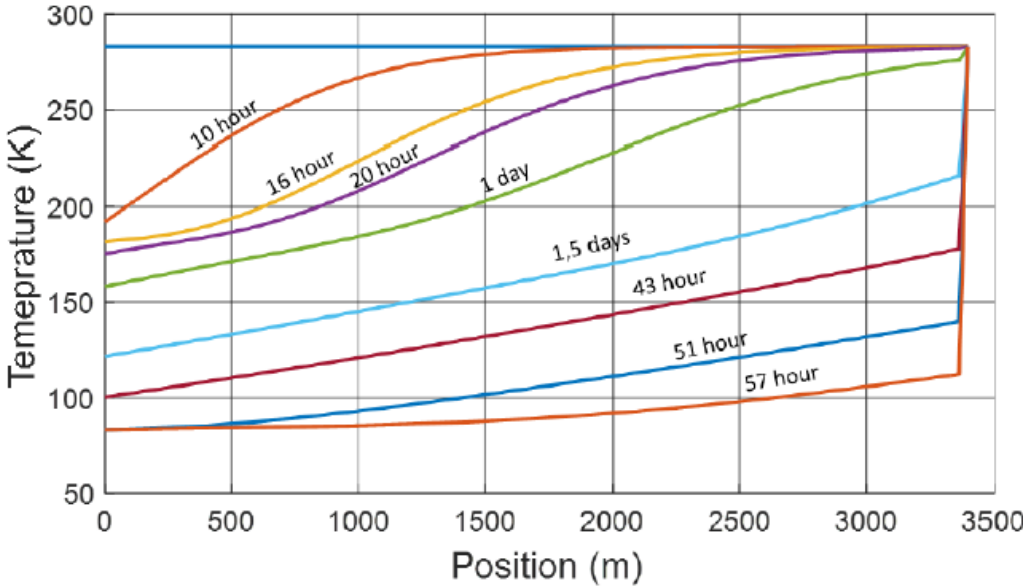
Gesponsord door RvO
Agentschap van het NL Ministerie van Economische Zaken en Klimaat

SuperNet NL (HTS power cable)

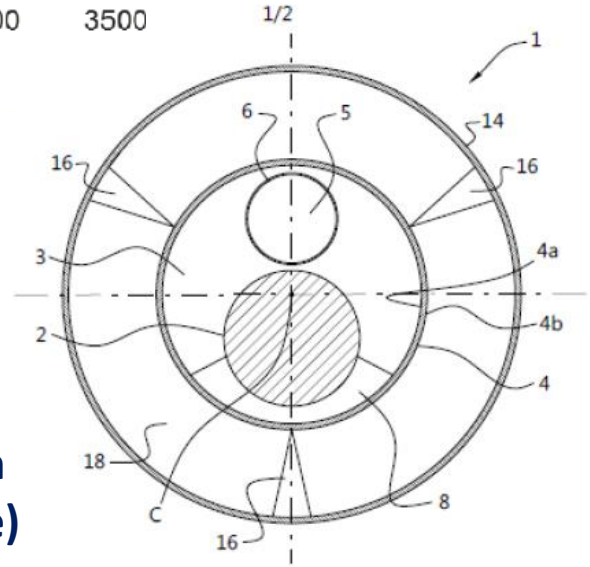
Repairability & down-time
(cool-down!)



Asahi cable data (JP)



SuperNet NL (modelled)



Patented design
(IWO / Utwente)

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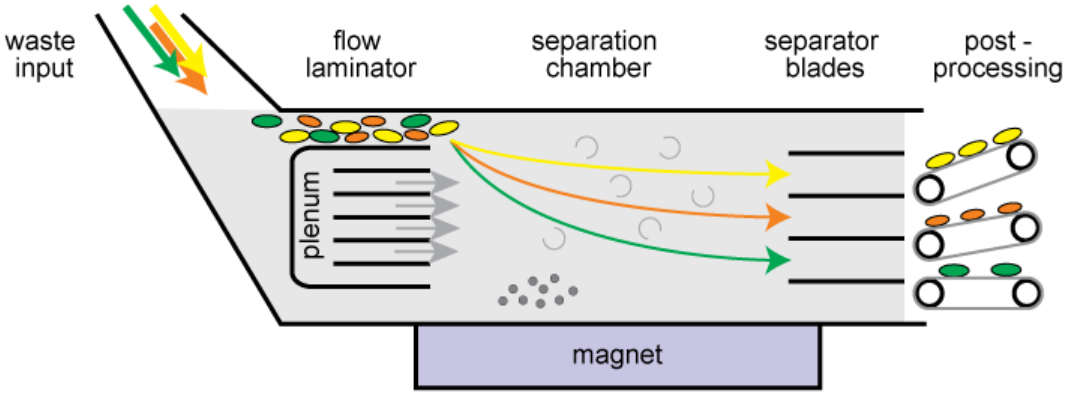
Magnetic Density Separation

Coordinated by TUDelft



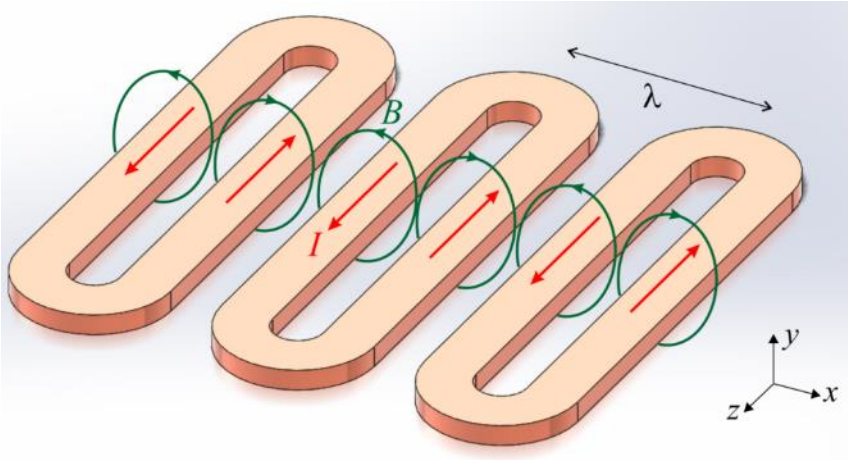
Stream a ferrofluid over a high-gradient magnet, on the left, feed in a **non-magnetic** particle mix on the right, extract them in different bins

PM-based prototype (TUDelft)

Commercialization (Urban Mining Corp)

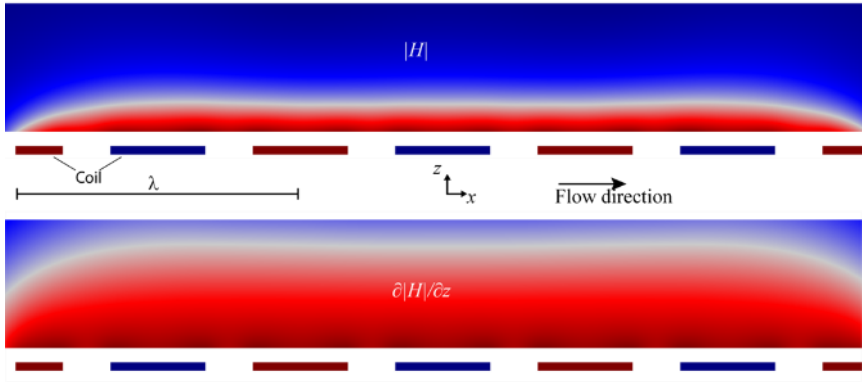
Magnetic Density Separation

Superconducting implementation (UTwente)



Project 1: NbTi demonstrator

- *achievable range & ferrofluid savings*
- *E-waste*



Project 2: MgB_2 prototype

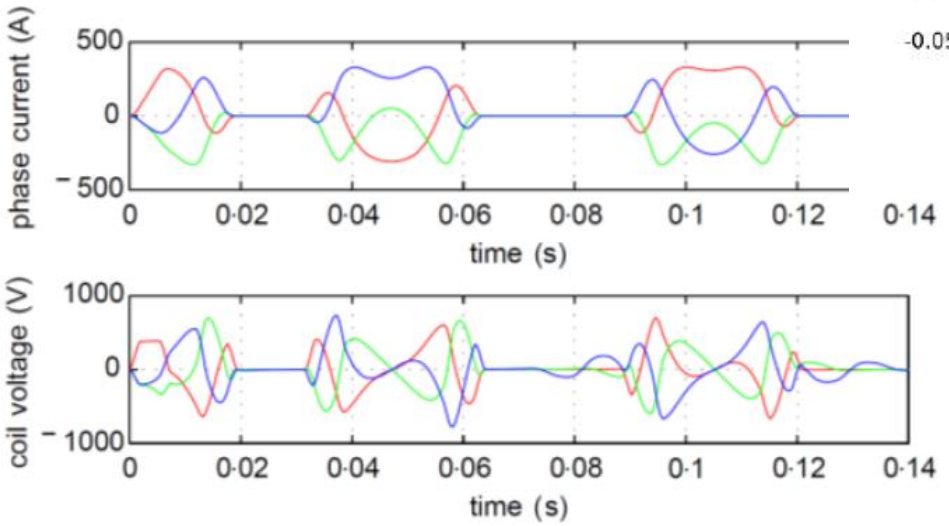
- *throughput & resolution*
- *Plastics*

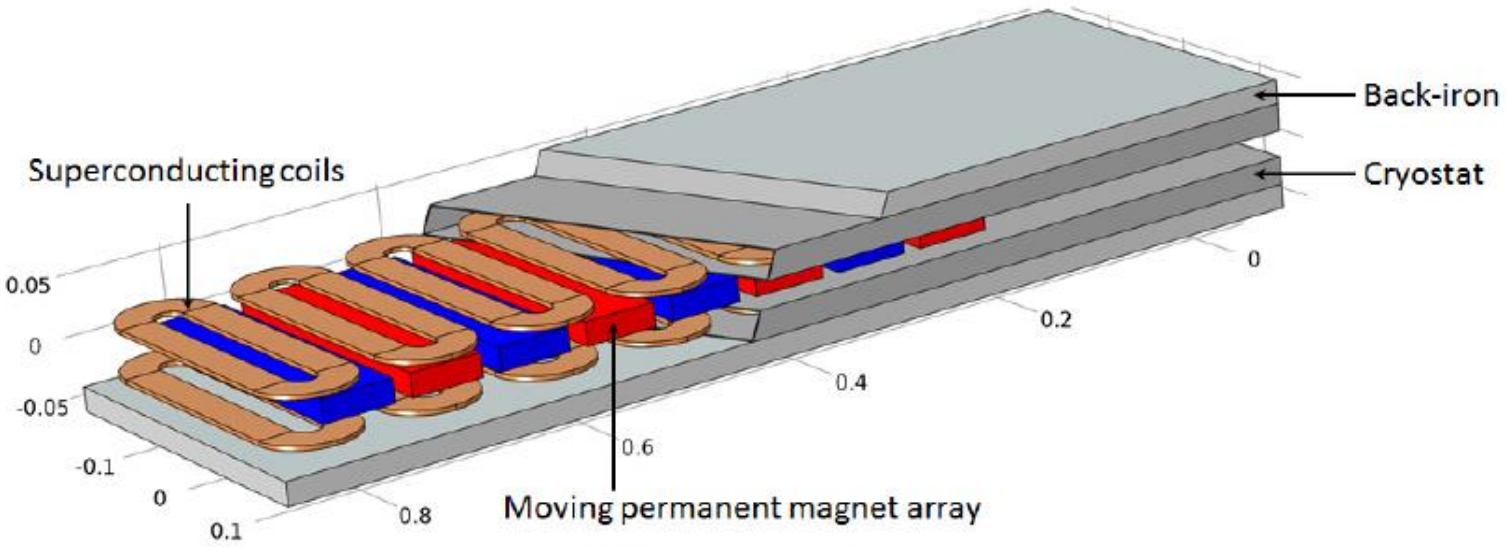
Columbus Superconductors

High-dynamic Superconducting Linear Motor

Coordinated by TUEindhoven

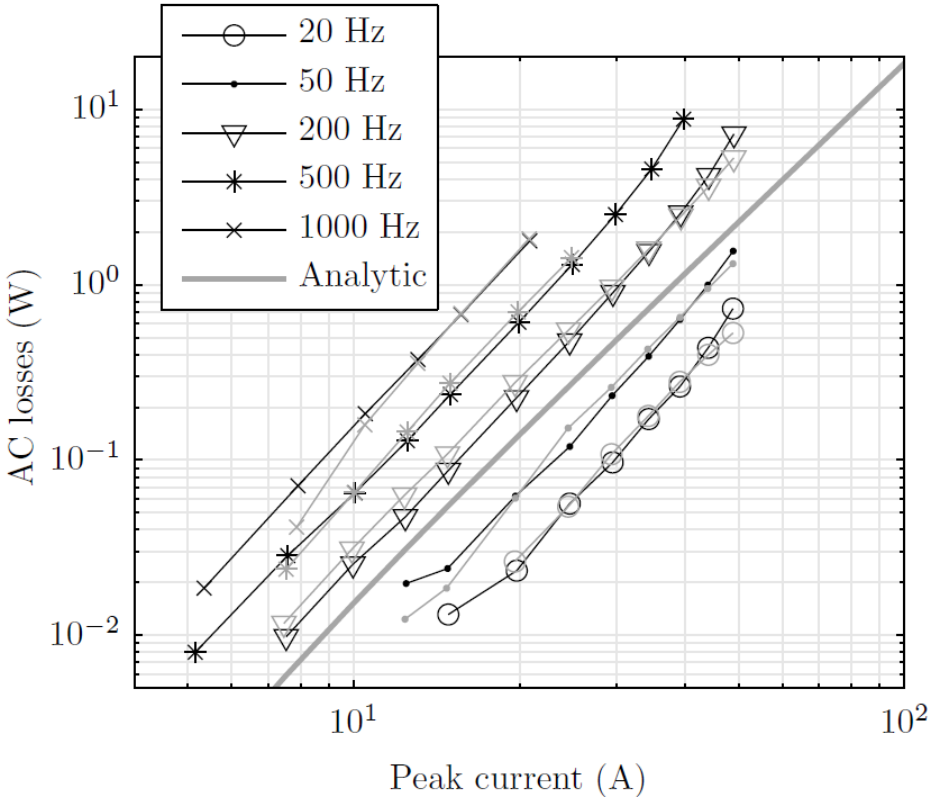
- End-user semiconductor industry (wafer steppers)
- Air-gap field 2-3T instead of 0.4T
- Accelleration 100g instead of 15g



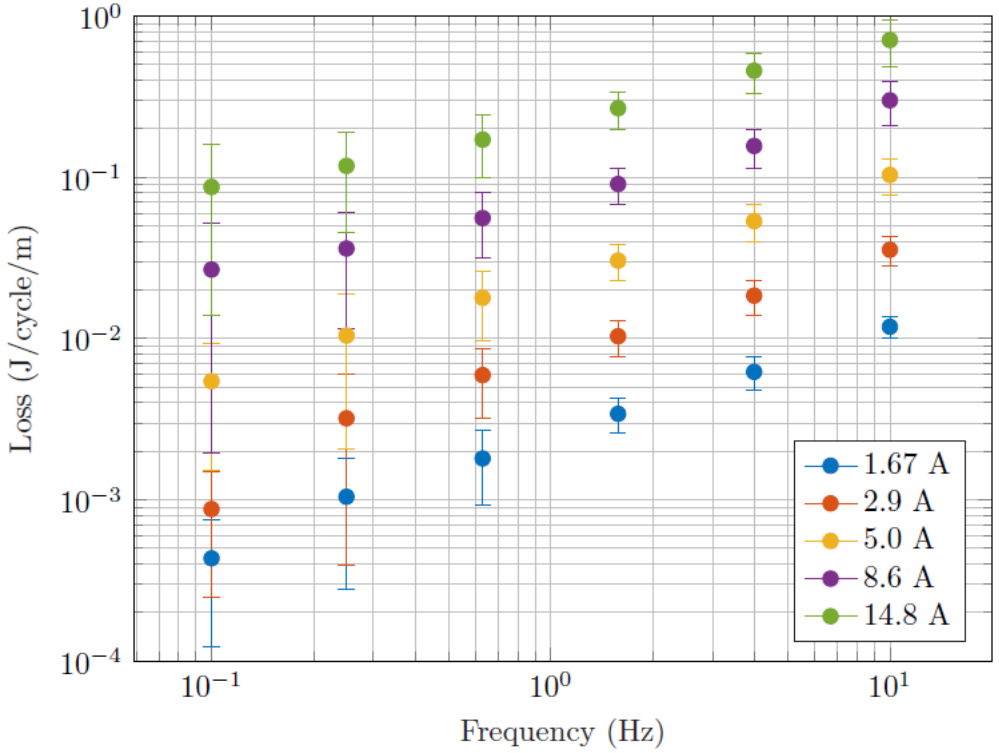


High-dynamic Superconducting Linear Motor

Main challenge: AC loss / thermal stability



B. de Bruyn (TUe)



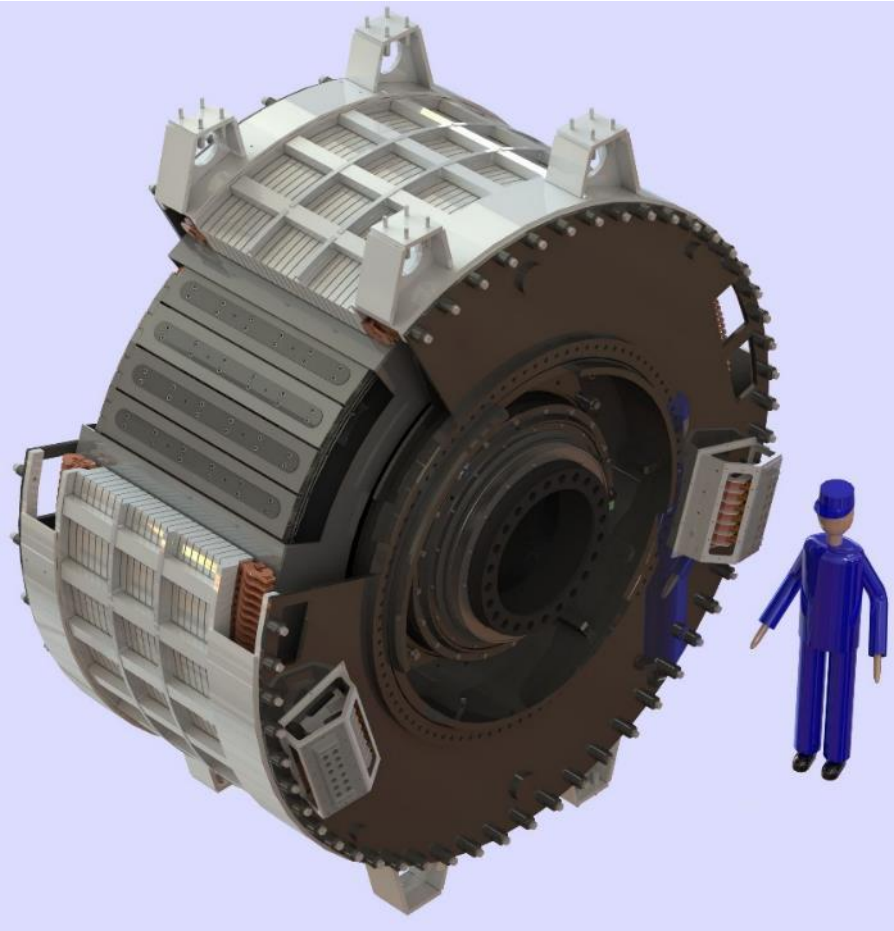
T. Klünder (UTwente)

EcoSwing generator for wind turbine

Coordinated by Envision Energy / ECO5

- Full-scale 3.6 MW
- High-torque (15rpm)
- Field test in turbine
- 40% weight reduction

www.ecoswing.eu



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Horizon 2020
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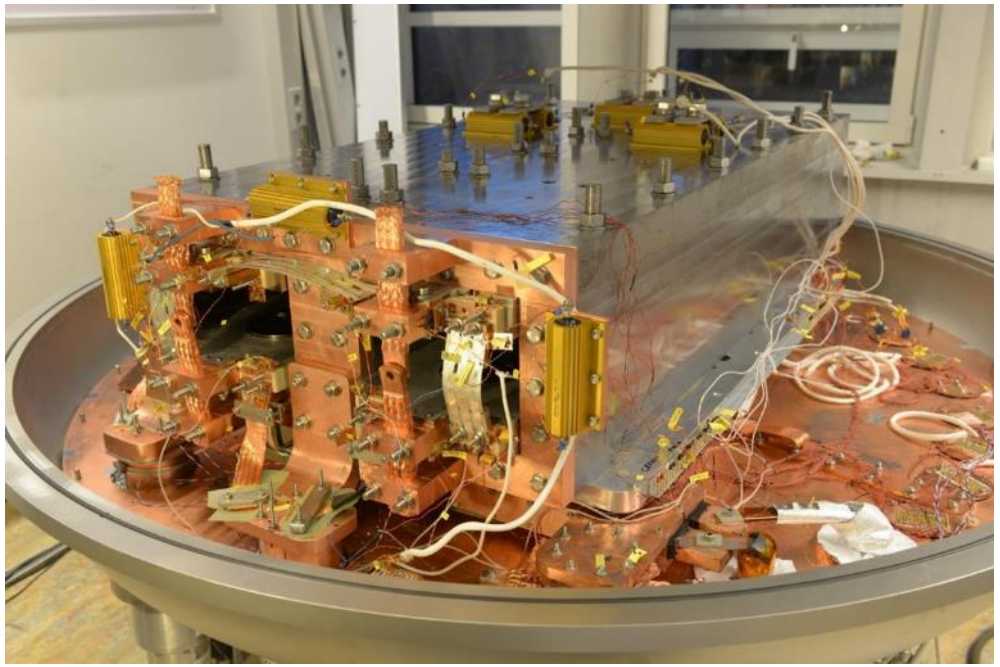
EcoSwing generator for wind turbine

- ~ 20km HTS tape (THEVA)



Acceptance tests 40 THEVA coils

- Conduction cooled, rotating GM (Sumitomo)

Rotor assembly by mixed UTwente / Jeumont Electric team

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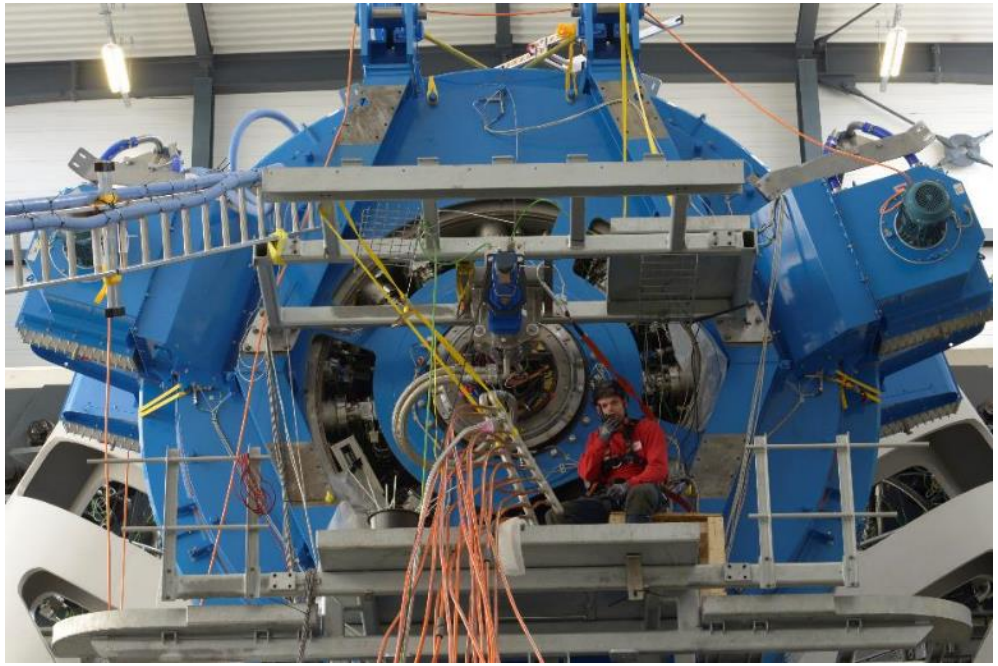
EcoSwing generator for wind turbine

Transport Jeumont → IWES Frauenhofer



'Ground-based' testing at IWES

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Conclusions

- **Directly FCC-oriented**

  Transverse pressure tolerance Nb_3Sn and ReBCO can be ensured through proper impregnation.

- **Fusion-oriented**

  Proper combination of modeling & experiment allows for reliable HTS cable design tools.

- **Industry-oriented**

  Clear increasing willingness to explore / adopt superconducting technology.