3S – Superconducting DC-Busbar for High Current Applications

S. Elschner[1,3], J. Brand[1], W. Goldacker[1], M. Hollik[1], A. Kudymow[1], S. Strauss[1], V. Zermeno[1], C. Hanebeck[2], S. Huwer[2], W. Reiser[2], M. Noe[1]

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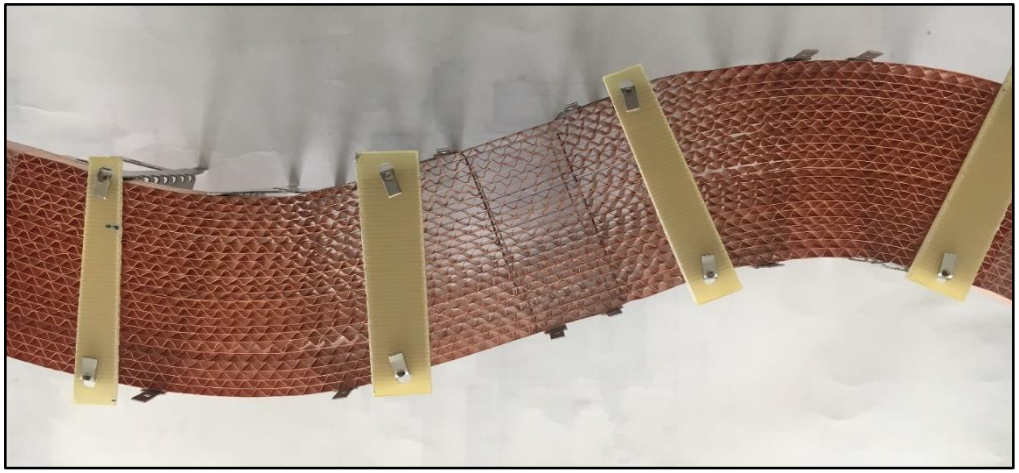
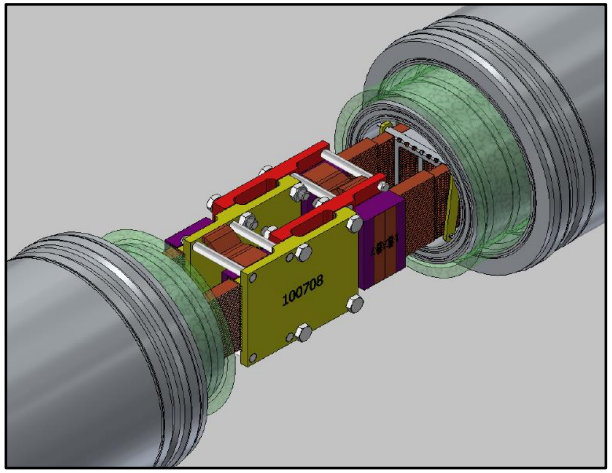
ITEP





[1] Karlsruhe Institute of Technology (KIT), Institute of Technical Physics (ITEP), Eggenstein-Leopoldshafen, Germany
[2] Vision Electrics Super Conductors (VESC), Kaiserslautern, Germany
[3] University of Applied Science Mannheim, Mannheim, Germany

DC - busbars

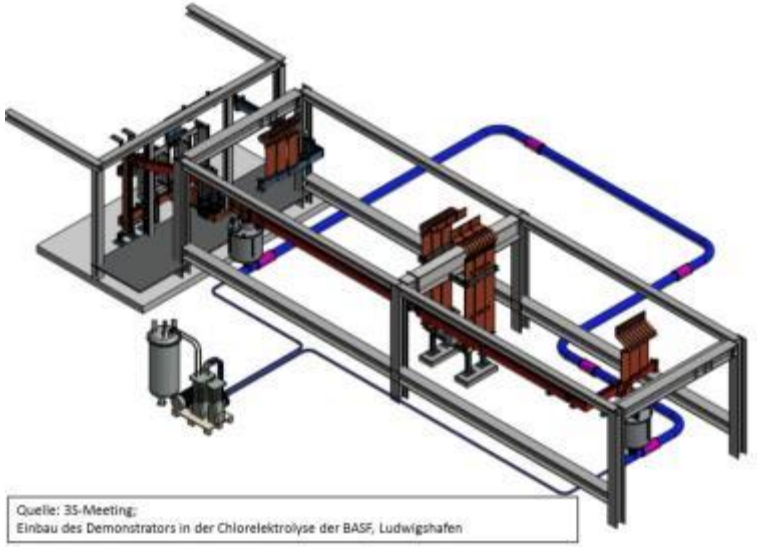
Application	Current	Length
NaCl-electrolysis	20 kA	30-300 m
Data Centers	15 - 40 kA	40 – 200 m
Cu-electrolysis	40 – 80 kA	200 – 400 m
Al-smelters	Up to 500 kA	100 – 500 m

Superconducting DC – busbars

- Small ohmic losses
- 10:1 gain in weight and cross section
- Small AC (ripple) losses

3S – project

- Industrial NaCl – electrolysis
- Total length: 25 m
- Nominal current: 20 kA
- 7 stiff elements (prefabricated)
- Short circuit current: 33 kA
- Test for one year at BASF-site



Partners:

VESC: Component development and manufacturing

KIT: Contact development

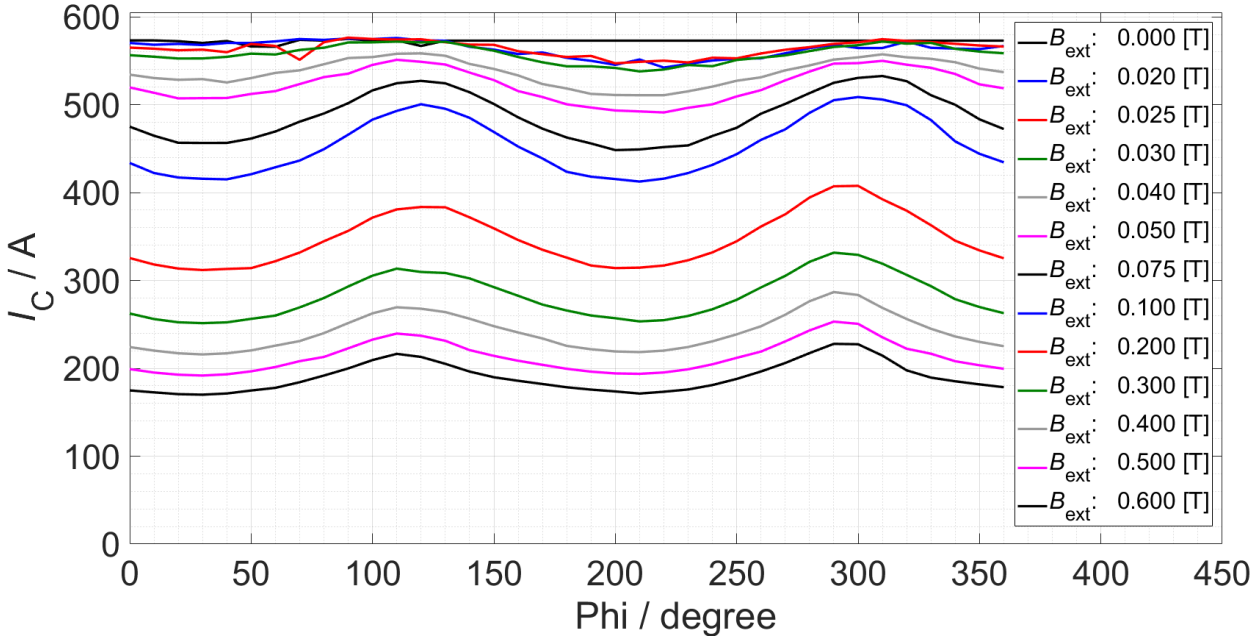
ILK: Cryogenics

Current leads: VESC, Univ. Kaiserslautern, Poster 4LP2-11

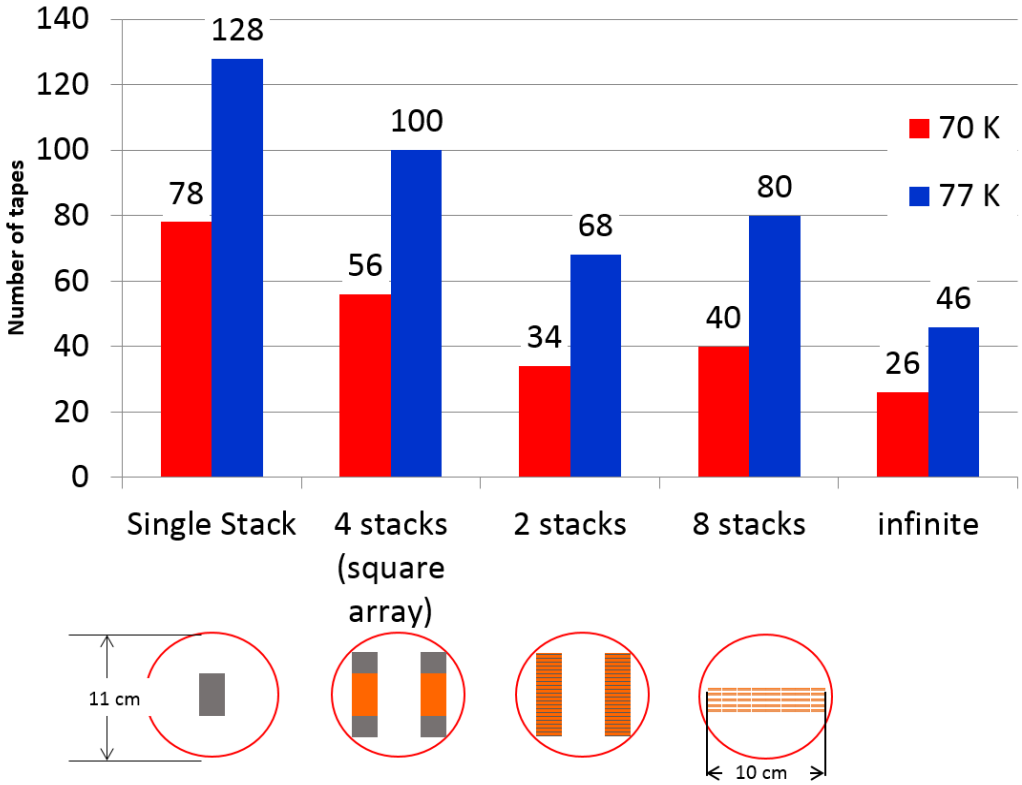
Funding: German Government, Federal Ministry for Economics and Energy , Grant Nr. 03ET7525B

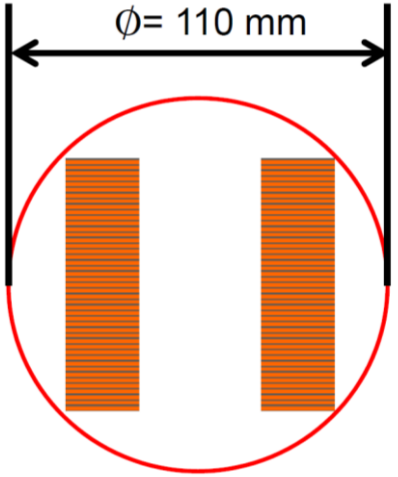
tapes

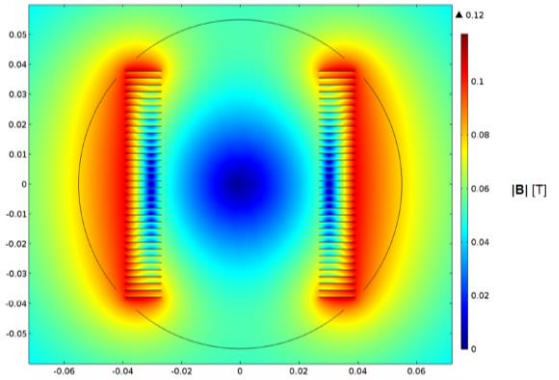
- moderate critical current (Ic ≥ 450 A)
- Short pieces needed
- Small orientation dependence
- Cu- stabilization depends on short circuit requirements
  (in 3S: 2 x 20 µm copper)
- Substrate 100 µm Hastellov
- Width: 12mm



Lay –out of tapes







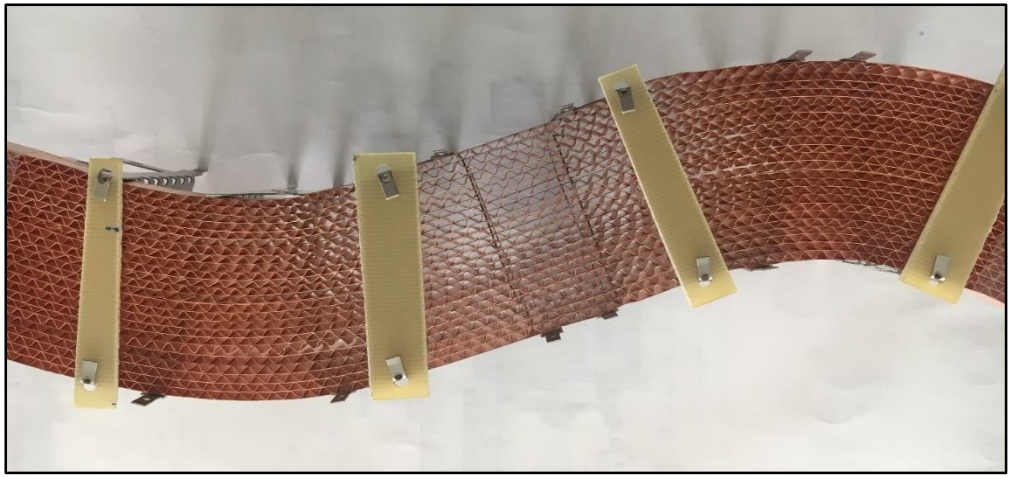
Simulations of needed numbers of tapes, T = 70/77 K

=> 2 x 23 tapes, gap between tapes 2.5 mm, between stacks 40 mm

Superconducting stack

Thermal contraction (Hastelloy)
ΔL(293 K -> 77 K) = 0.216 %

- 23 tapes
- spacer (2.5 mm) between tapes: Corrugated Cu-tape
- Wave form arrangement of the stacks
- Arbitrary angles possible

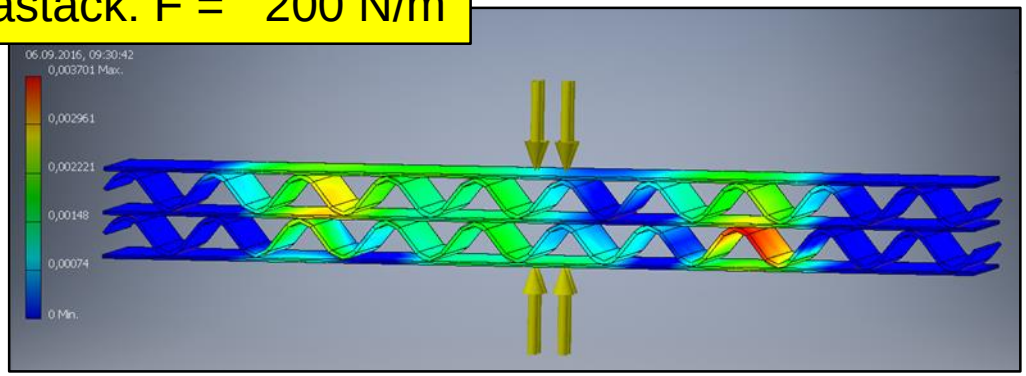


Lorentz forces

Cage-type structure

Expected:

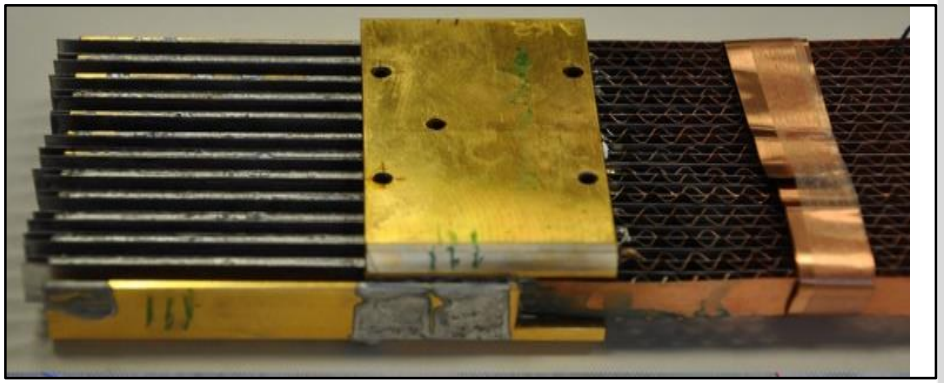
interstack: F = 1000 N/m
intrastack: F = 200 N/m



Corrugated copper tapes

Joints between stacks

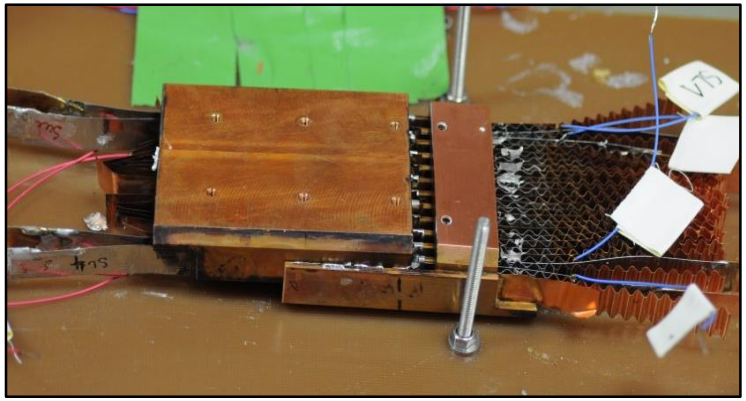
Requirements
- Low resistance (1nΩ => P = 0.4 W)
- Applicable on the installation site
- Restricted place
- Good cooling properties
- Costs (no indium)



Preliminary tests:

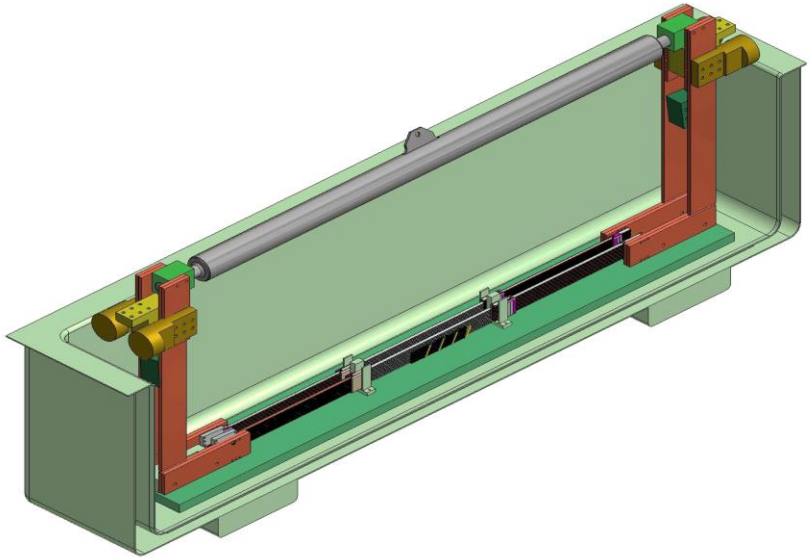
⇒ face-to face contacts between individual tapes needed

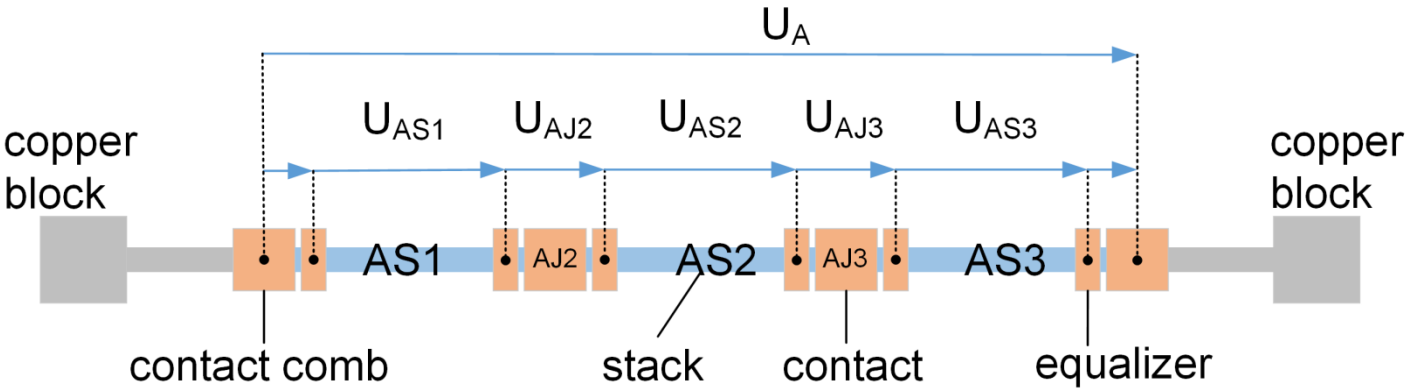
Solution:
Stacks ending on **comb-type contacts**.
Tapes soldered with their substrate side (back) on the teeth of the comb



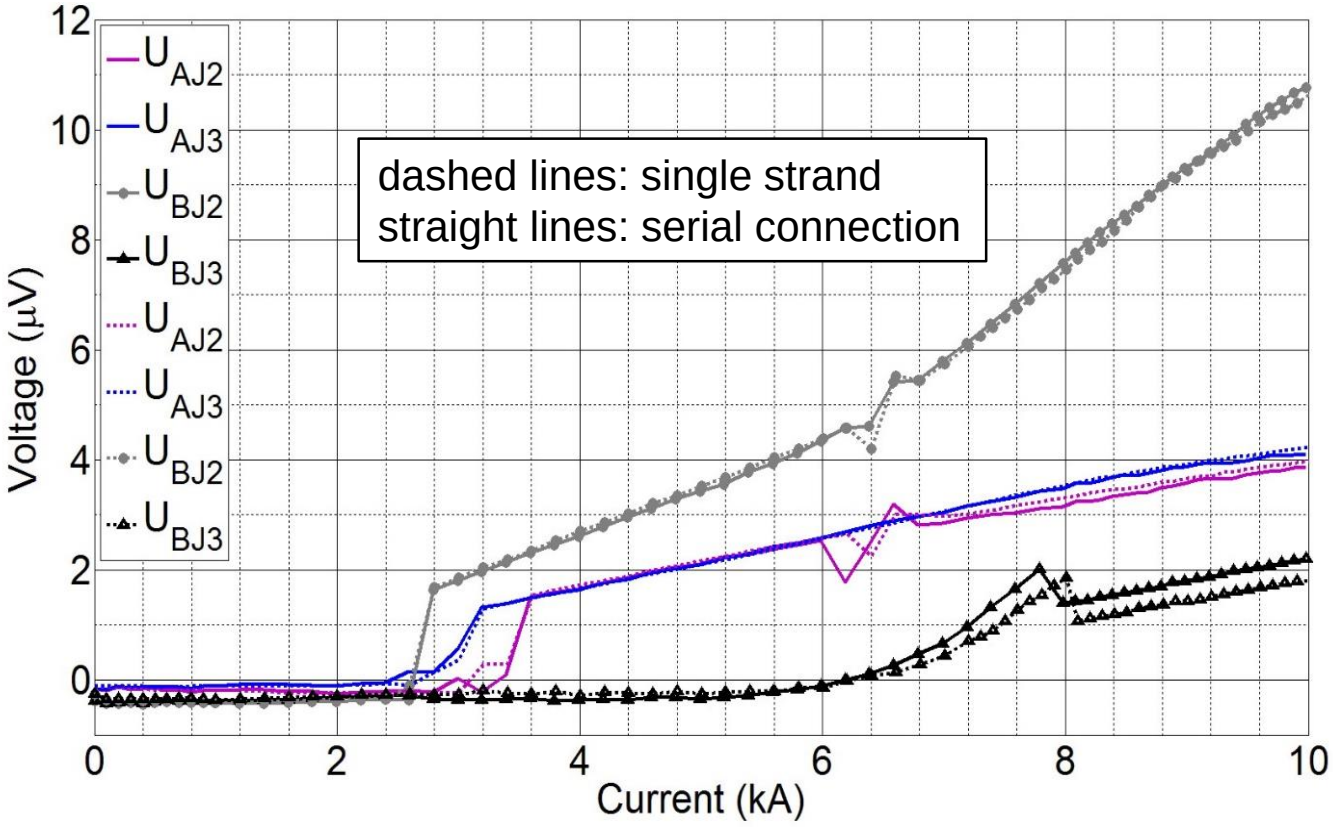
Subscale prototype

- cross section full scale
- 2 strands, 2 x 23 tapes
- 3 elements , 70 cm each
- Two joints
- Operation in open bath cryostat (77 K)
  - strands alone
  - strands in series
  - strands in parallel
- Tests up to I = 10 kA (single strand)





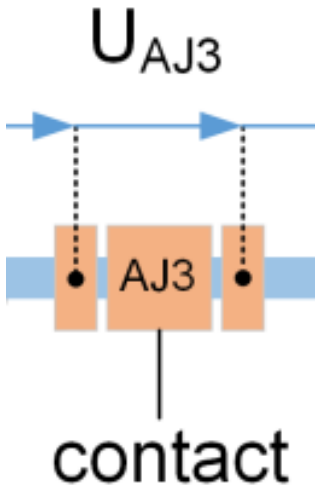
Contact resistances



4 joints:

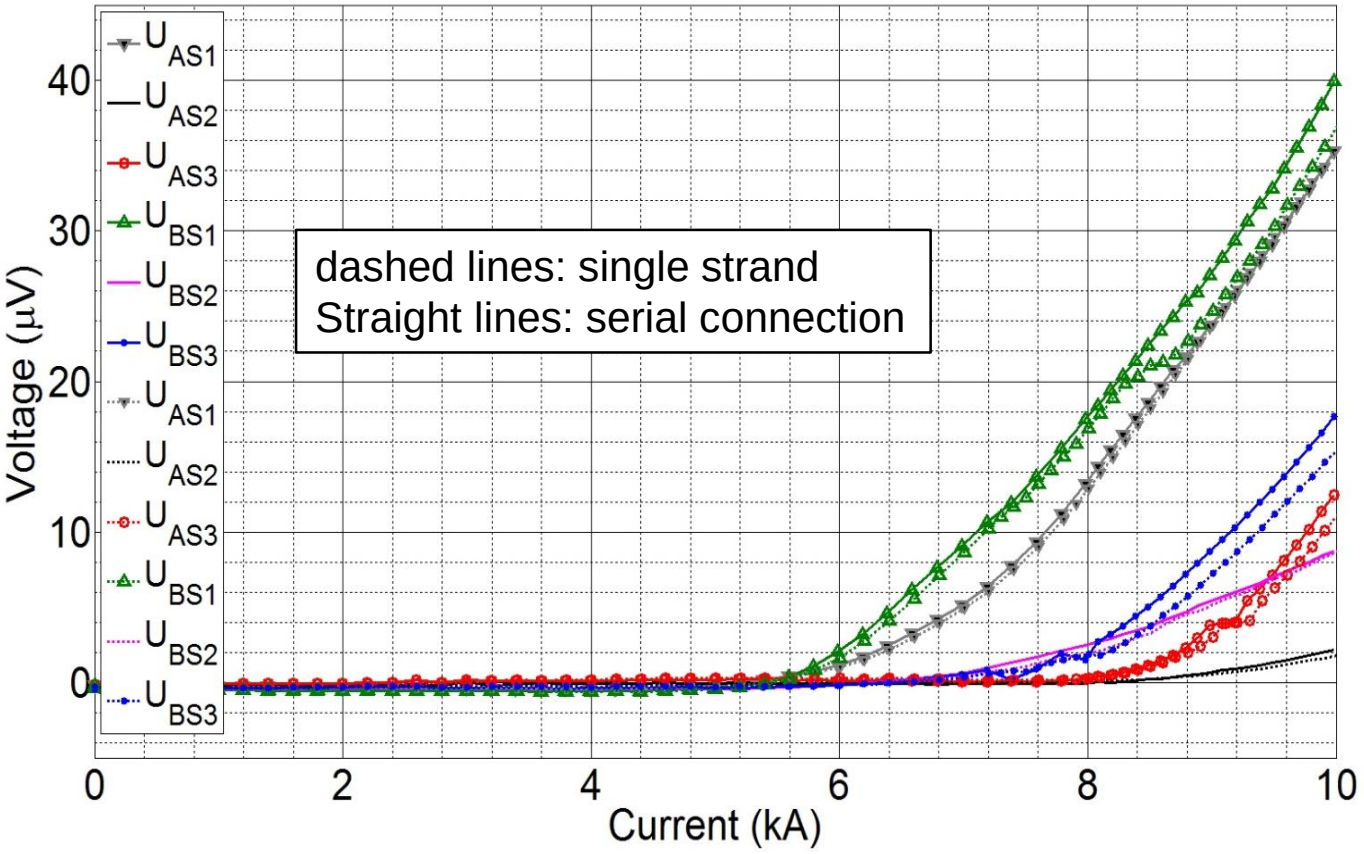
R ≤ 1 nΩ

P (@20 kA) ≤ 0.2 W

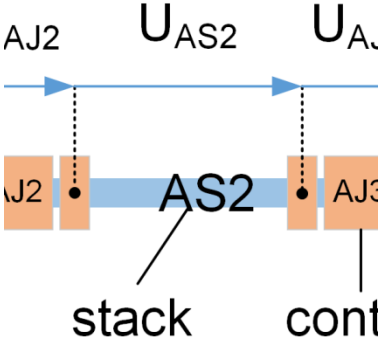


U(I)-characteristics

6 segments
L = 55 cm
E < 1µV/cm



U(single strand)
≤ U(serial)



Prototype 2-strand busbar: I = 20 kA at 77K (projected: 70 K)

Summary and outlook

Aim: DC busbar 25m, 20 kA
Concept: stiff elements to be joint on the installation site

Done:
- Identification of suitable tapes
- Lay-out of tapes
- Mechanical solutions for thermal contraction and Lorentz-forces
- Low resistance electrical contacts with P < 0.2 W
- Subscale model tested with the projected current I = 20 kA
- *Simulation of ripple-losses ($P_{ripple} < P_{cryostate}$)*
- *Cryogenic concept (T = 70 K)*

Next steps:
- Parallel operation
- Short circuit tests (33 kA, 100 ms)
- Manufacturing of elements
- Installation on electrolysis site (first tests 2018)