Development of 2G HTS wire production at SuperOx

Outline

SuperOx

2G HTS wire production: facility expansion

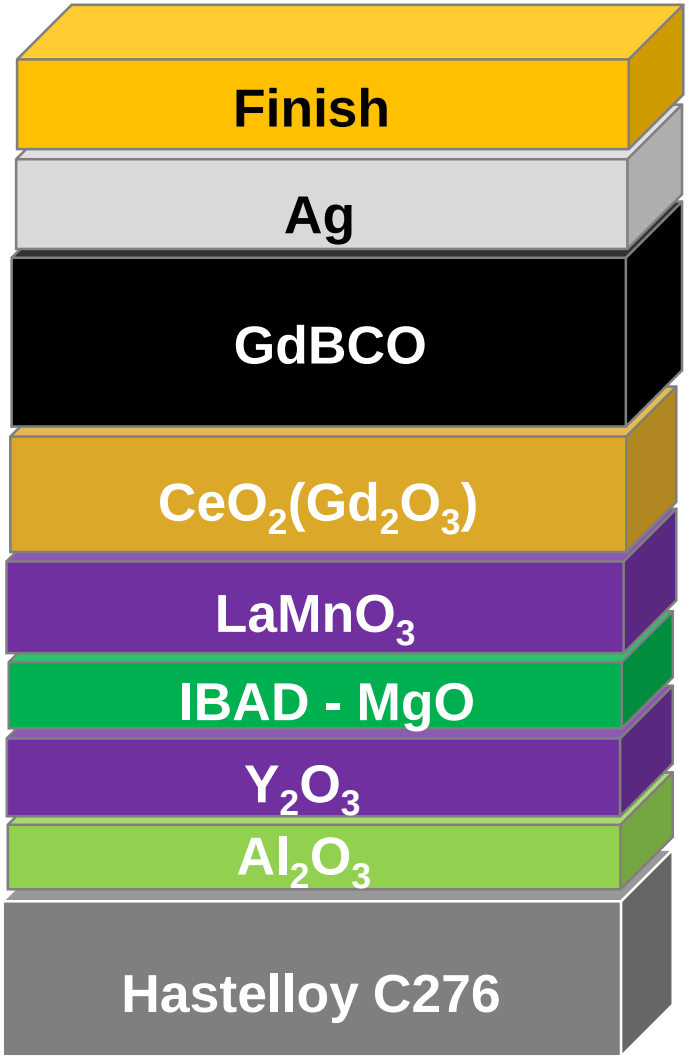
2G HTS wire performance

- Consistent performance without AP
- R&D into AP

HTS device projects

- Roebel cables
- Lightweight cable for aircraft
- Horizon 2020: HTS motor for aircraft
- FCL

2G HTS wire architecture



Customised finish tailored to application

Sputtering (custom thickness)

PLD (1-3 microns)

PLD (100-200 nm)

Sputtering (30-50 nm)

e-beam IBAD (5-7 nm) + epi (50-150 nm)

Sputtering (5-10 nm)

Sputtering (30-50 nm)

Cold rolled & electro polished
(60 or 100 microns)

Production status and development

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Originally: 2011-2015						
Moscow	Substrate			Ag	Cu	Finish
Tokyo		Buffer	HTS	Ag		

At present: 2017						
Moscow	Substrate	Buffer	HTS	Ag	Cu	Finish
Tokyo		Buffer	HTS	Ag	Cu	

Decisions to increase throughput are driven by demand

SuperOx Japan LLC: in operation since Nov 2011

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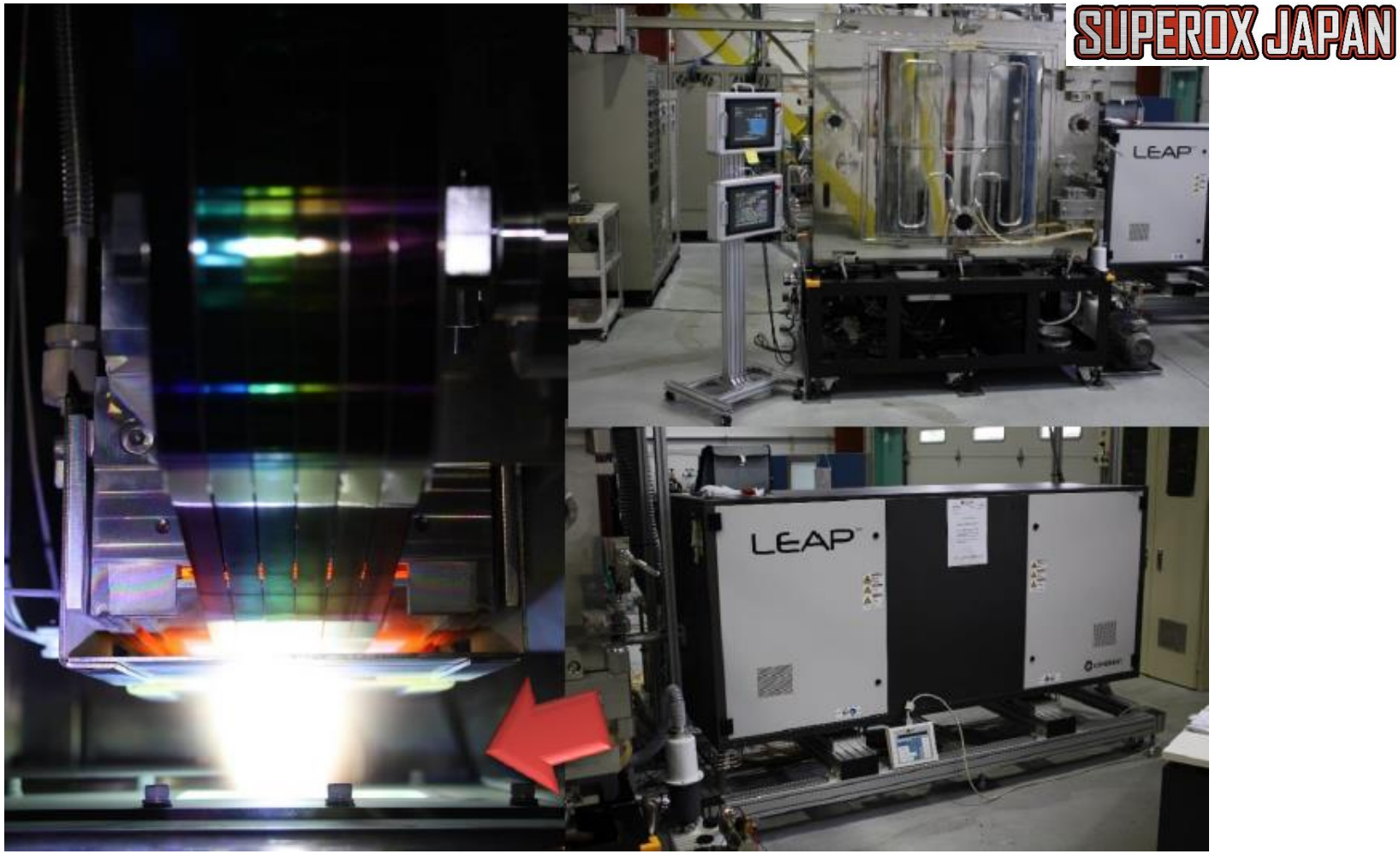

Multiprocess one-chamber sputtering/IBAD system

Dual-chamber PLD-HTS system for CeO_2 and GdBCO

Moscow buffer layer line commissioned Jan 2016

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e-Polished Hastelloy substrate in
Ready buffered tape with $LaMnO_3$ on top out

Moscow buffer layer line commissioned Jan 2016

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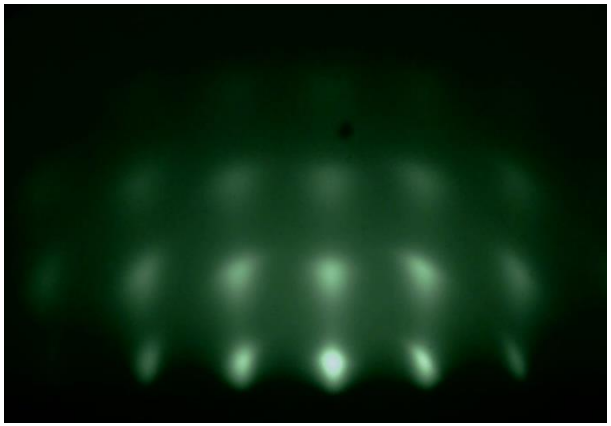
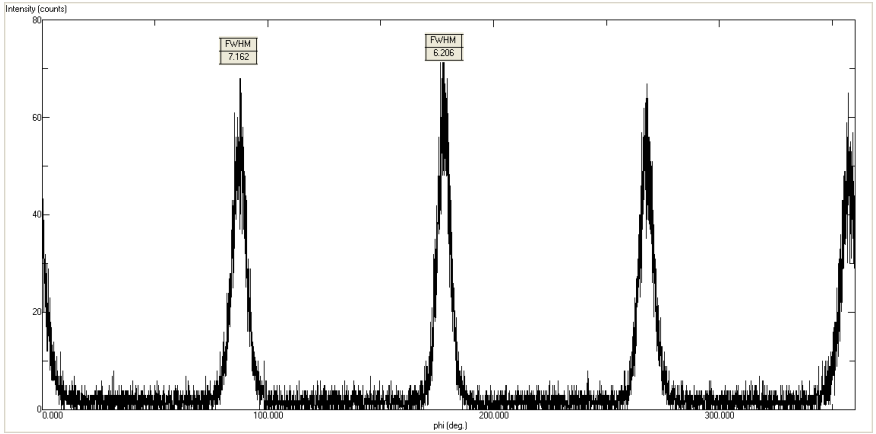
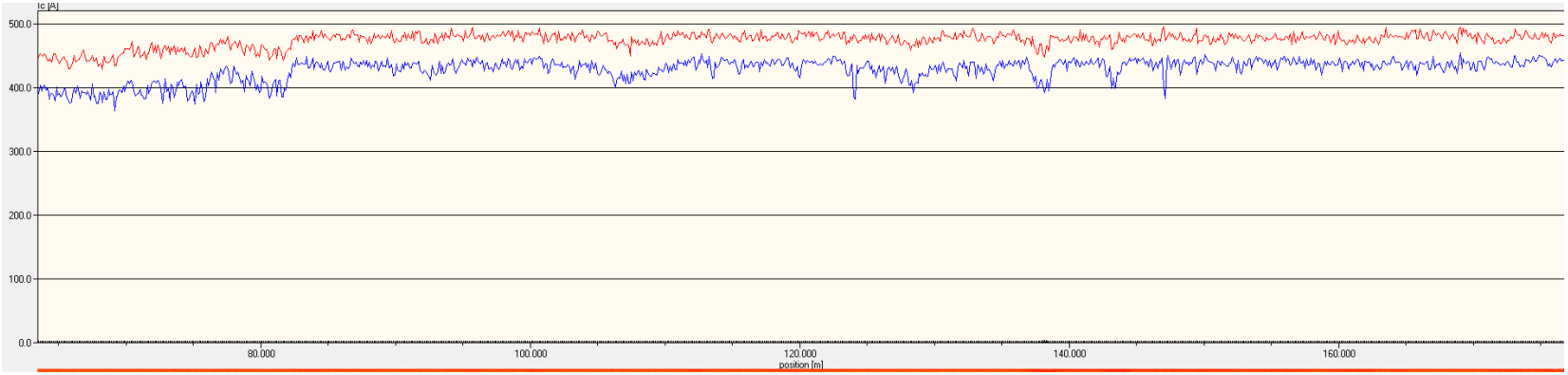




Good IBAD-MgO RHEED patterns

$\Delta\phi$ (110) LMO < 7°



High I_c by PLD-HTS on Moscow buffer

Moscow PLD-HTS line commissioned Dec 2016

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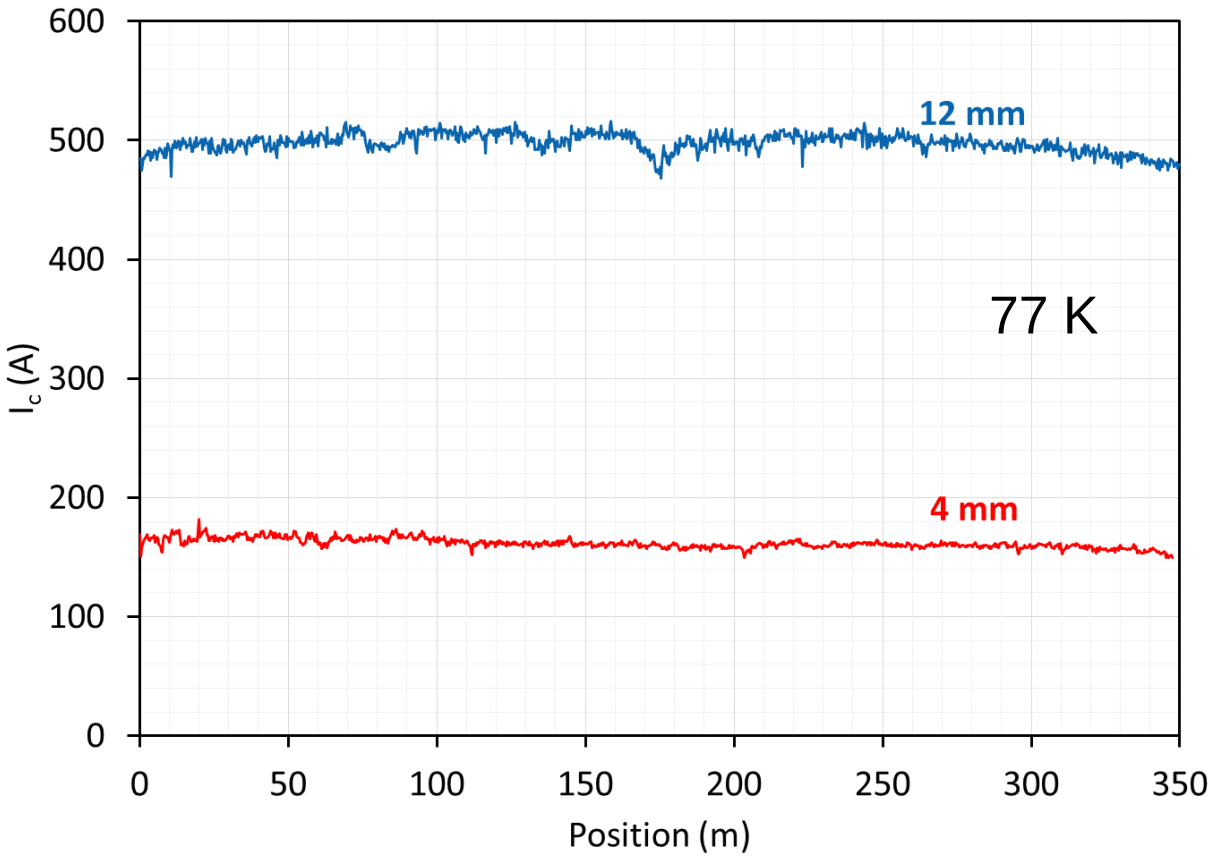
SuperOx production capacity doubled

Quality control

SuperOx

	Substrate	Buffer	HTS	Ag	Cu	Finish
In-line	Optical	RHEED	Optical			
Off-line, full length				Non-contact I_c	Non-contact I_c	Non-contact I_c
Off-line, segments	AFM	XRD	XRD SEM EDX	Transport I_c	Transport I_c	Specific tests

2G HTS wire: high I_c over long length



2G HTS wire: consistent performance

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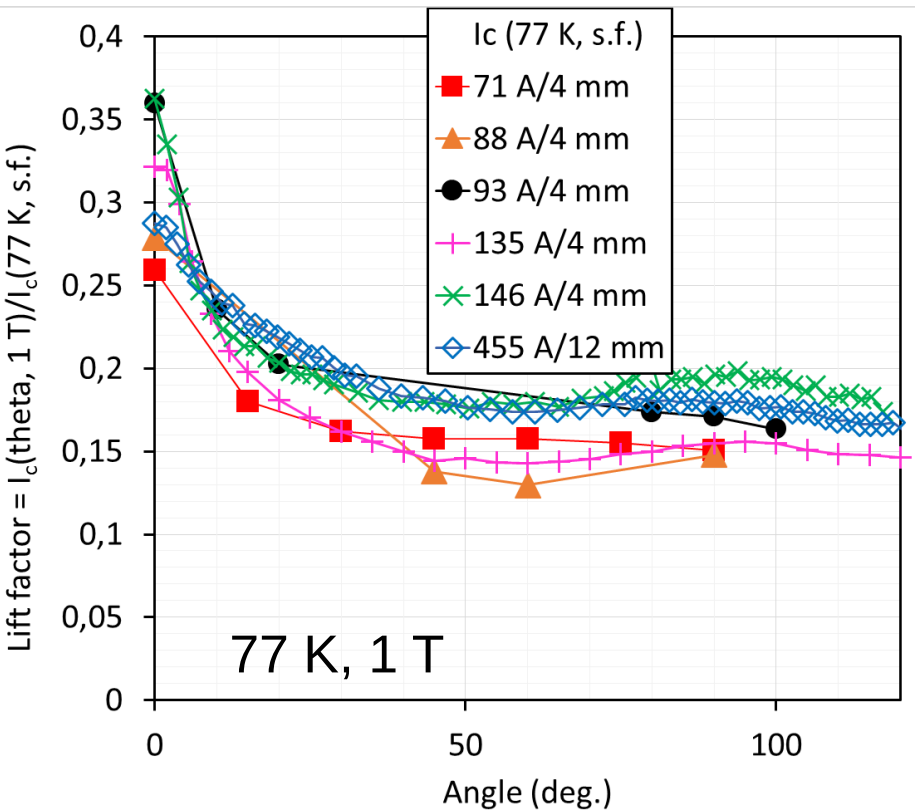
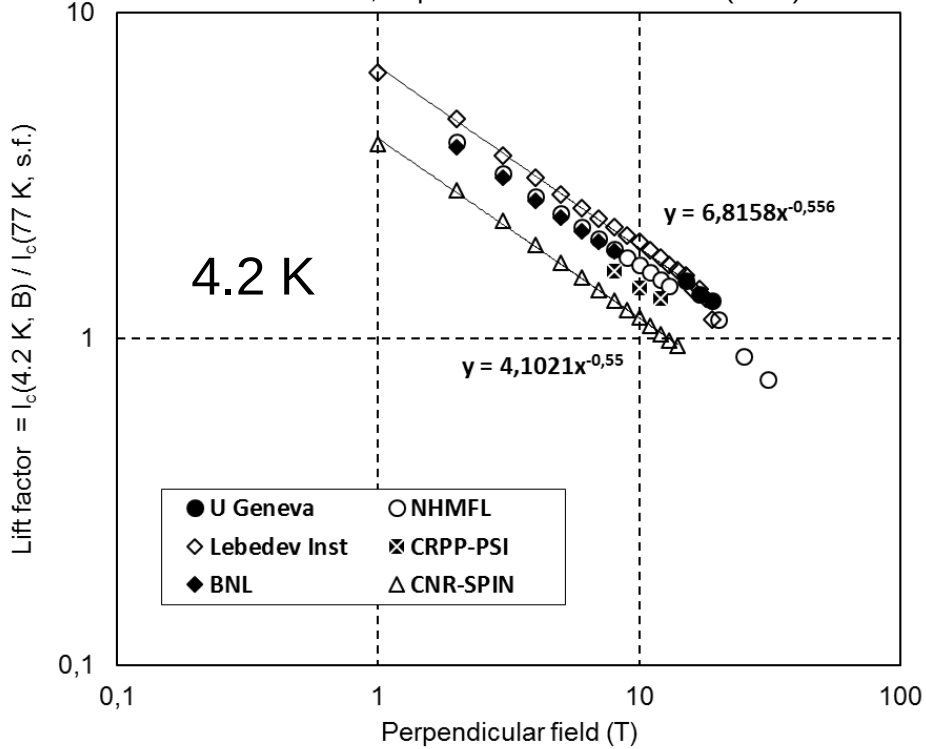


Low angular anisotropy

S. Samoilenkov et al., Supercond. Sci. Technol. 29 (2016) 024001



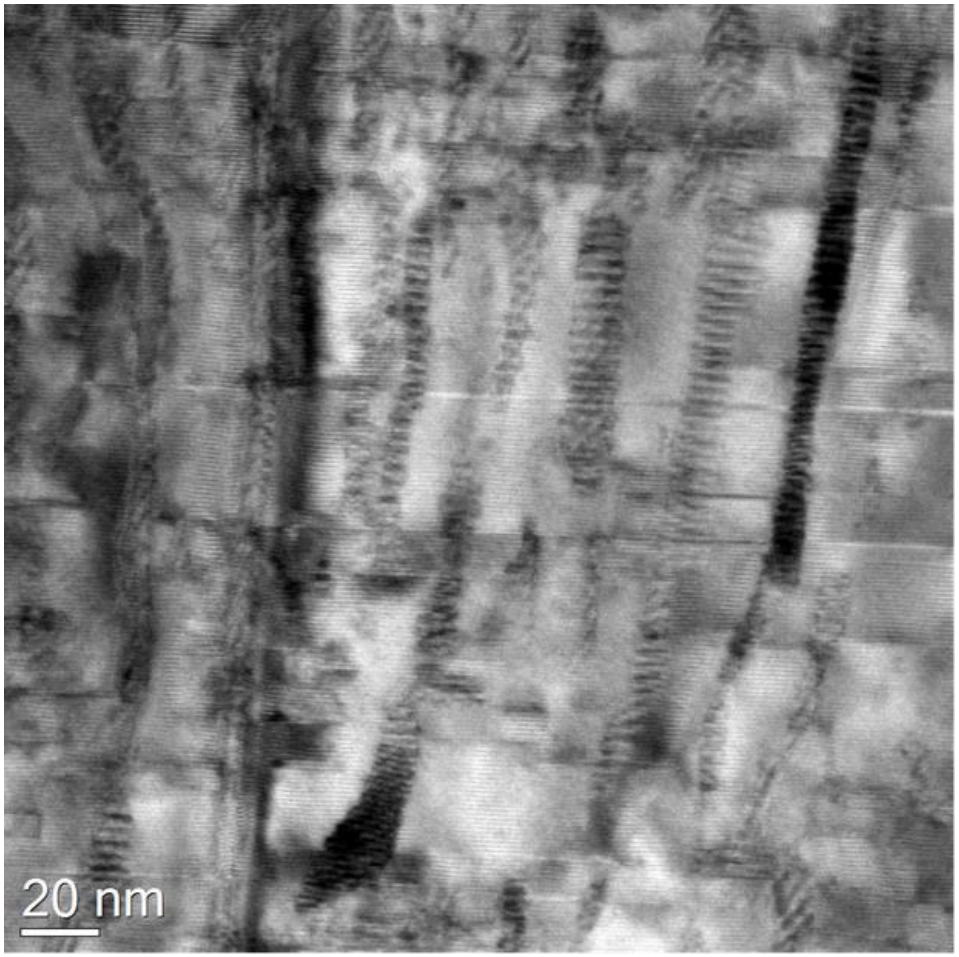
Reproducible lift factors

NO artificial pinning centres, only intrinsic Gd_2O_3 nanoparticles due to excess Gd

Data updated regularly, available for download at
http://www.superox.ru/en/products/974-vtspprovod/

2G HTS wire: artificial pinning in high rate PLD

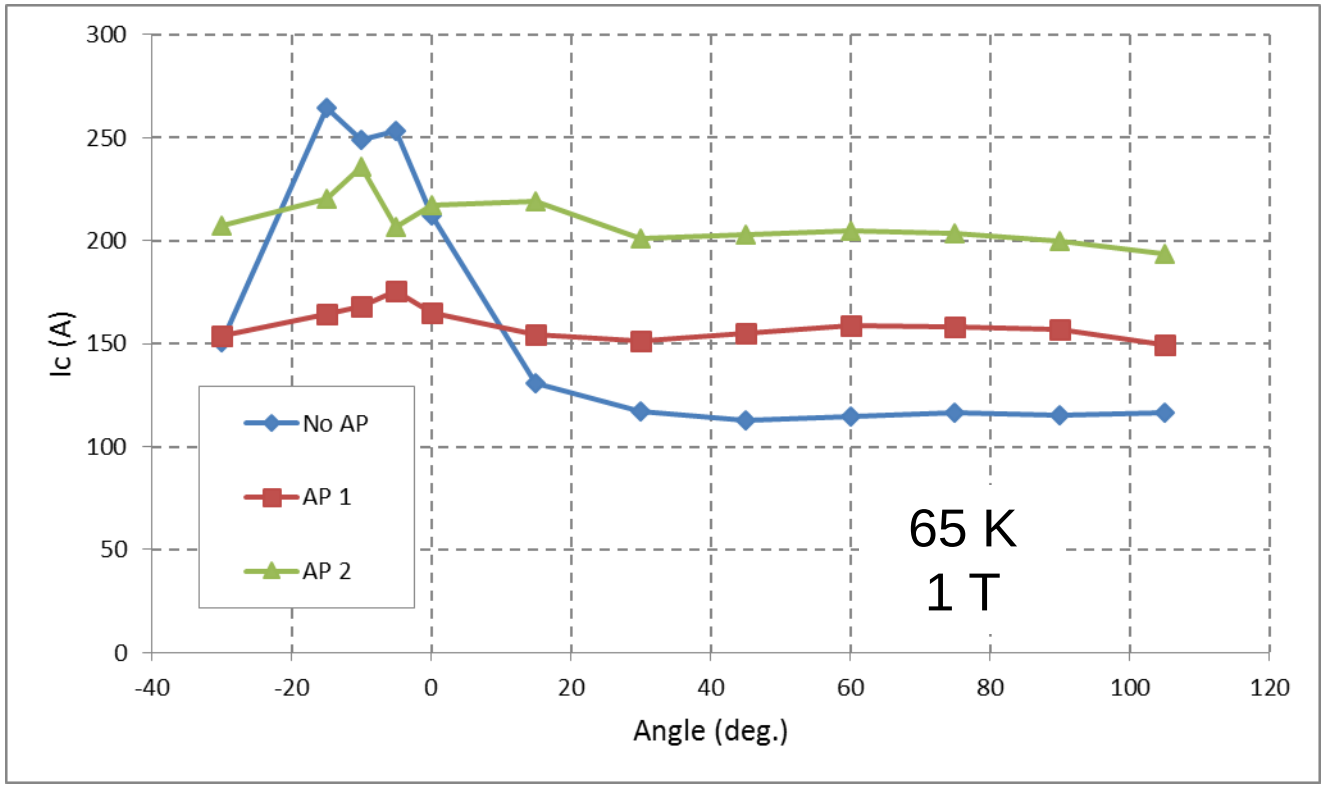
first R&D results



Production rate PLD. Classic nanocolumns of perovskite AP centres.

2G HTS wire: artificial pinning in high rate PLD

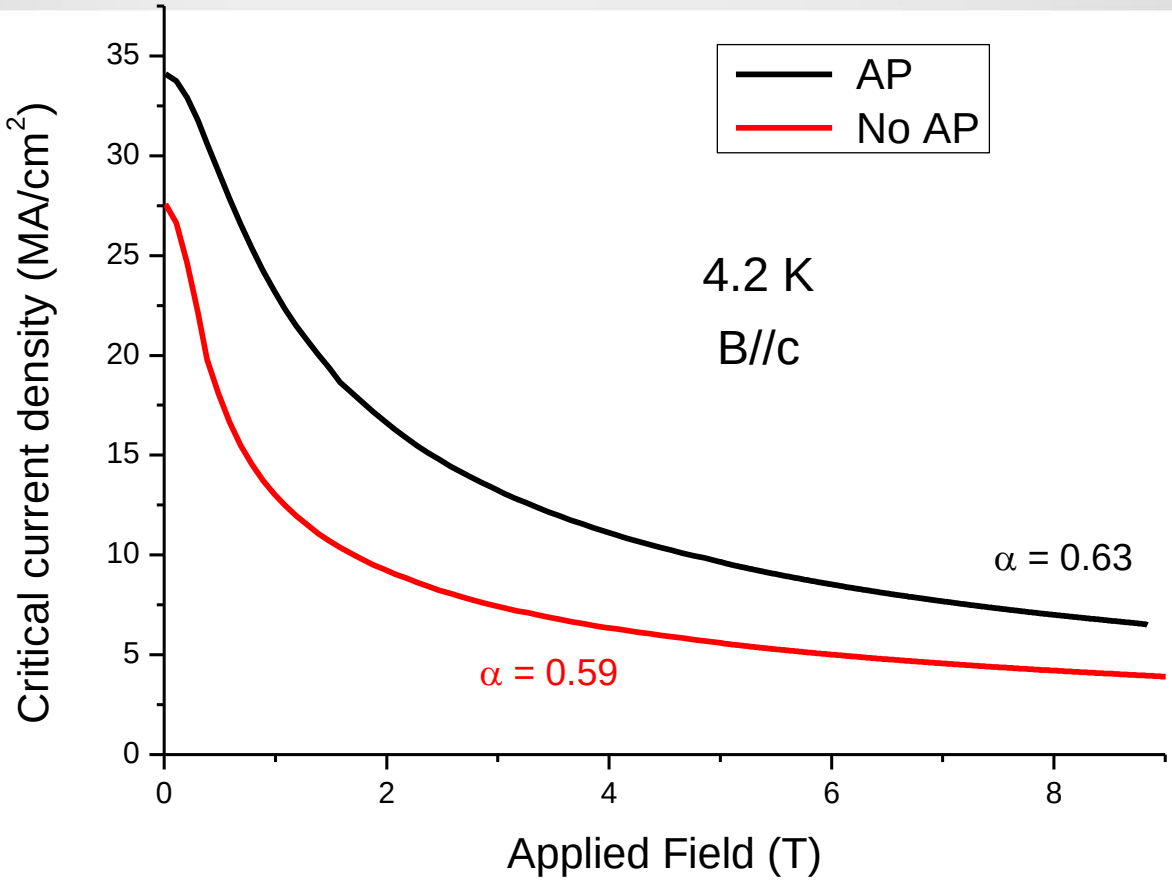
first R&D results



Less anisotropy and higher min. I_c in field with pinning

2G HTS wire: artificial pinning in high rate PLD

first R&D results



Higher J_c/I_c in liquid helium

Next steps:

- ❑ Optimise for specific T, B
- ❑ Verify reproducibility in production wires

Talk M3OrC

2G HTS wire: customisation

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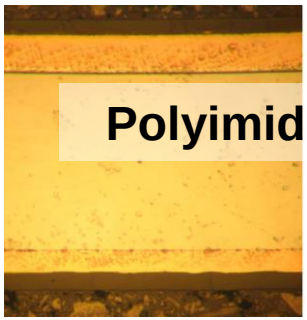
Manufacturer	Customisation options							
	Silver	Copper plating	Lamination	Surround polyimide	Polyimide wrapping	Solder plating	Tape stacks	Filaments
AMSC	●		●		●			
Fujikura	●		●		●			
SuNAM	●	●	●		●			
SuperOx	●	●	●	●	●	●	●	●
SuperPower	●	●	●		●	●		



Polyimide deposition

Custom solder plating

Custom copper plating

2G HTS wire: specifications

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Parameter	Value		
Substrate Thickness	60 or 100 µm		
Tape width	4 mm	6 mm	12 mm
Critical Current @ 77K, s.f.	80-150 A	120-200 A	250-500 A
J_e at 4.2 K, 20 T	> 400 A/mm^2	> 400 A/mm^2	> 400 A/mm^2
Current Uniformity	±10%	±10%	±10%

Customisation:

+ Variable silver thickness
+ Variable copper thickness
+ Lamination
+ Insulation
+ Solder plating
+ Low resistance splices
+ Filaments
+ … just ask

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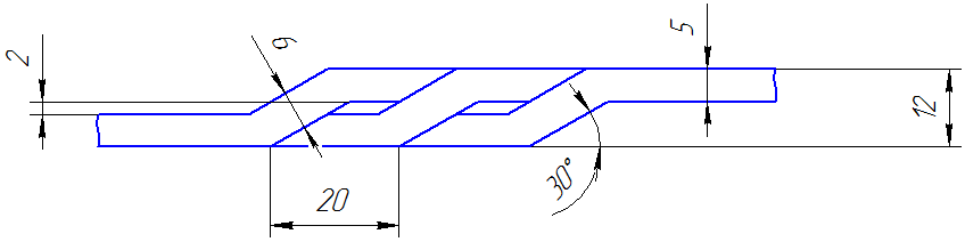
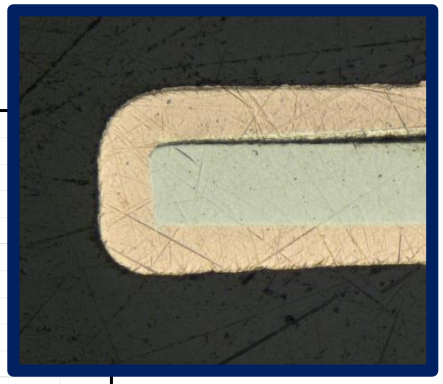
HTS device projects

- **Roebel cables**
- **Lightweight cable for aircraft**
- **Horizon 2020: HTS motor for aircraft**
- **FCL**

2G HTS Roebel cables

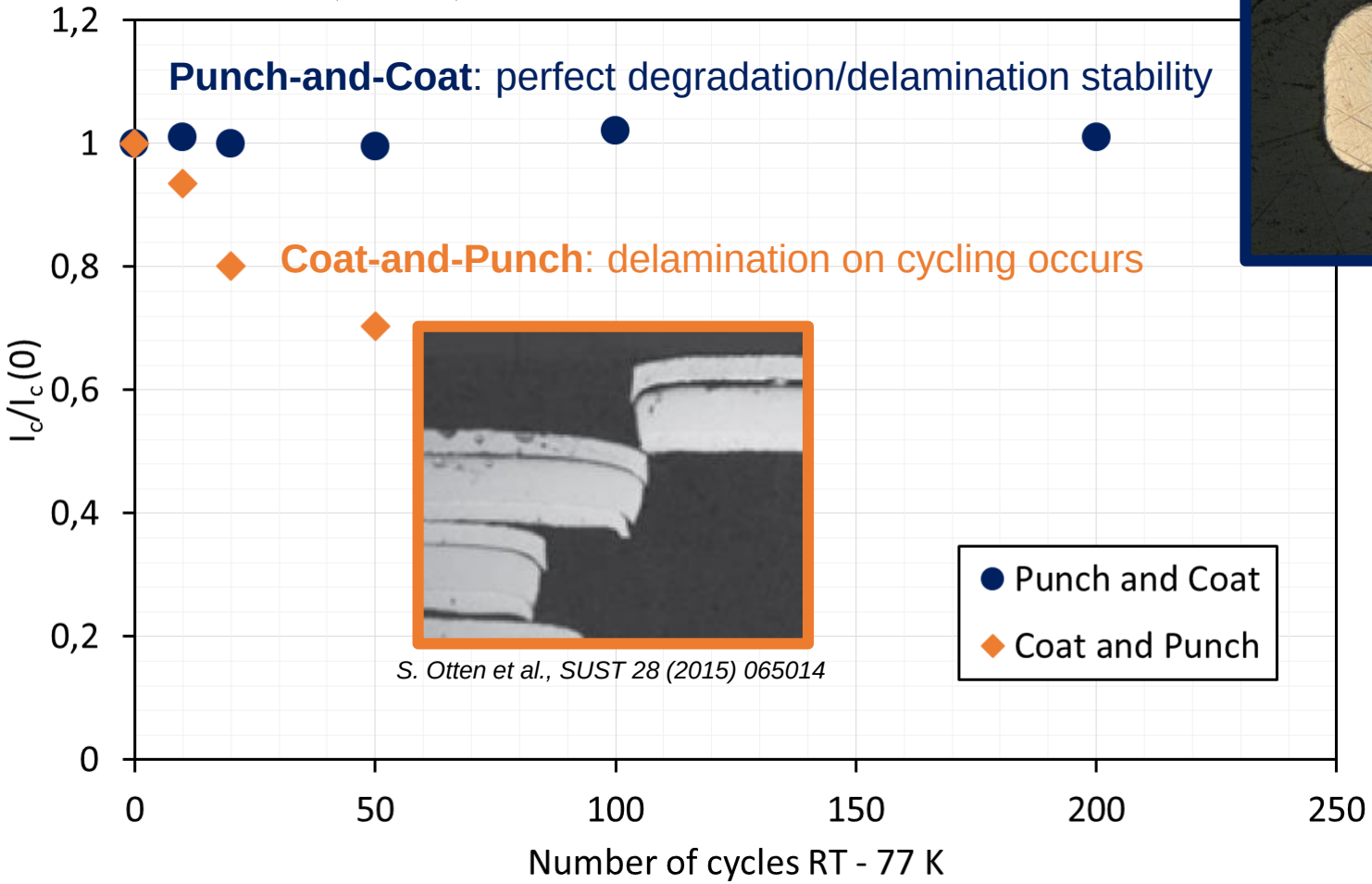




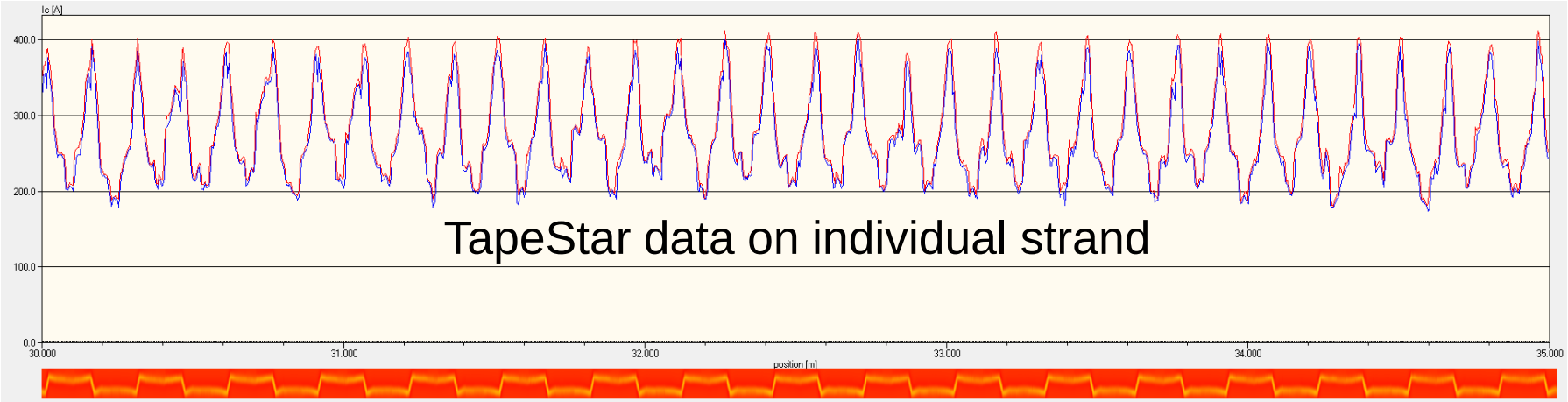
Punch-and-Coat: perfect degradation/delamination stability

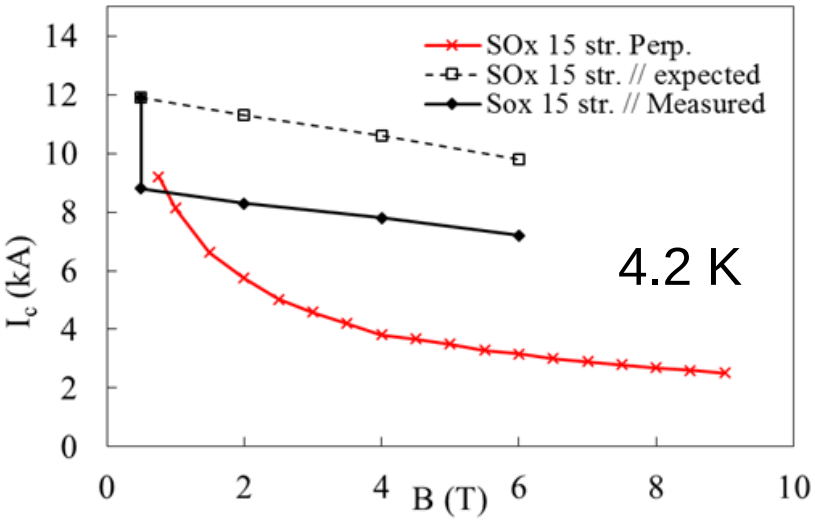
Coat-and-Punch: delamination on cycling occurs

S. Otten et al., SUST 28 (2015) 065014

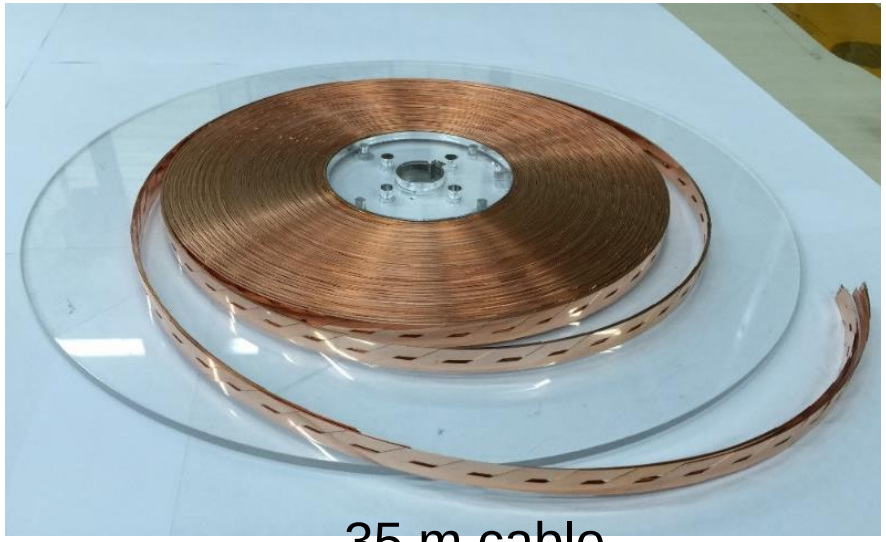


2G HTS Roebel cables





J. Fleiter et al. CERN Internal Note 2017_15, EDMS: 1757653



35 m cable
now in Feather 2 coil at CERN

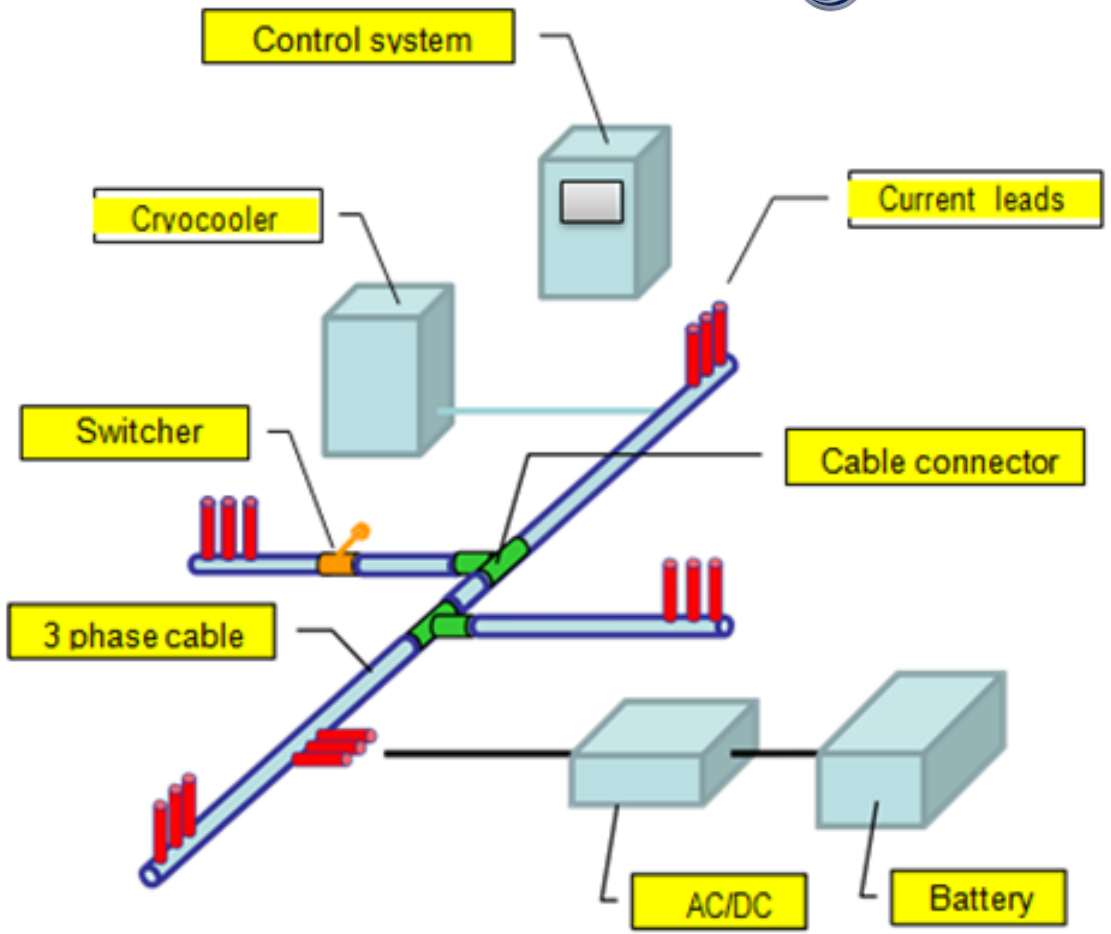
Poster M1PoB

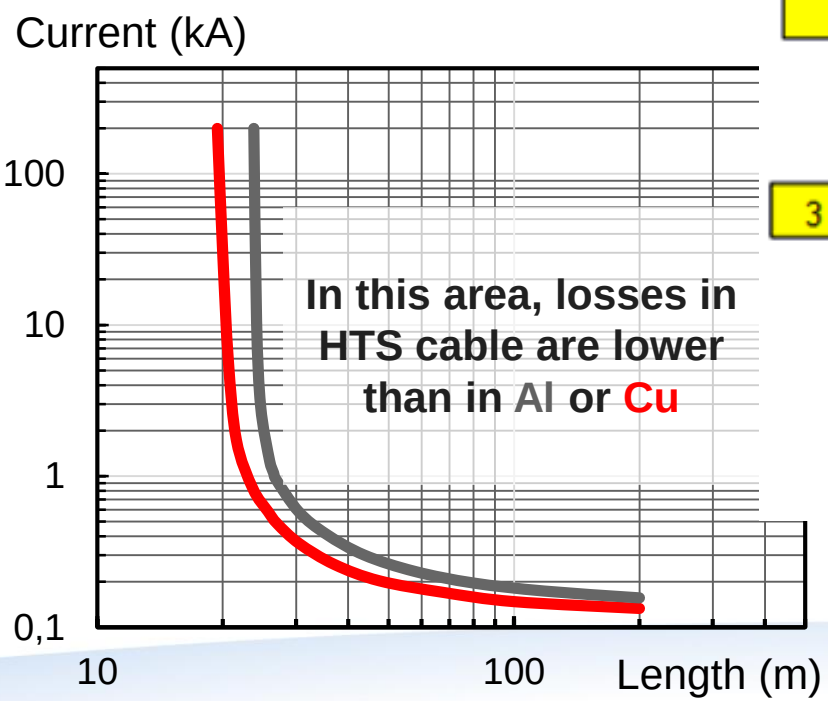
HTS cable system for Airbus

SuperOx

AIRBUS

Total power	0…12 MW
Length	30…40 m
Voltage level	5…5000 V
Frequency	0…400 Hz





HTS motor for aircraft. Horizon 2020 consortium

SuperOx

ASuMED

Funded by the European Commission Grant No 723119

Advanced Superconducting Motor Experimental Demonstrator

Source: Airbus Group Innovations

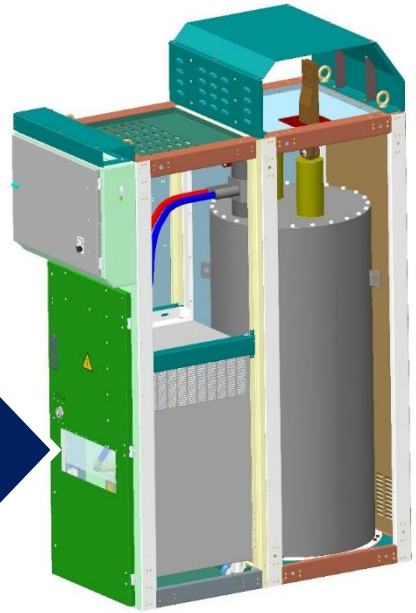
OSWALD · Rolls-Royce · UNIVERSITY OF CAMBRIDGE · DEMACO · AIR LIQUIDE · SuperOx · KIT Karlsruhe Institute of Technology · hochschule aschaffenburg university of applied sciences · K·S · Slovak Academy of Sciences

3.3 kV DC FCL for railway grid

SuperOx

- Medium-voltage DC
- Retrofitted into a standard switchbox
- Joint project with «NIIEFA-ENERGO», LLC (St.Petersburg)

Specification	
Rated voltage	3.3 kV
Rated current	Up to 5 kA
Limitation speed	100 ms
Resistance w/o fault	0.001 Ohm
Resistance during fault	1 Ohm
Power consumption	< 6 kW
Cryo-system	Closed type, cryocooler
Dimensions (mm)	800 x 1740 x 2100
Weight, kg	700

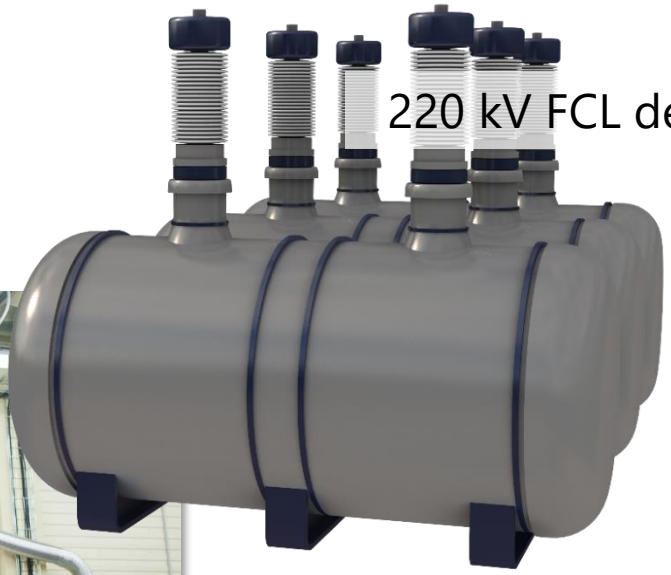


220 kV FCL for Moscow City grid

SuperOx

- SuperOx runs a contract for Moscow City-owned grid company UNECO, for the first high-voltage FCL in Russia
- Huge long-term benefits for the Moscow city grid from FCL use

Substation view



220 kV FCL design

With the Mayor of Moscow
Sergey Sobyanin
Presentation of FCL project

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THANK YOU FOR YOUR ATTENTION

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