

# Development of 2G HTS wire production at SuperOx

## 2G HTS wire production

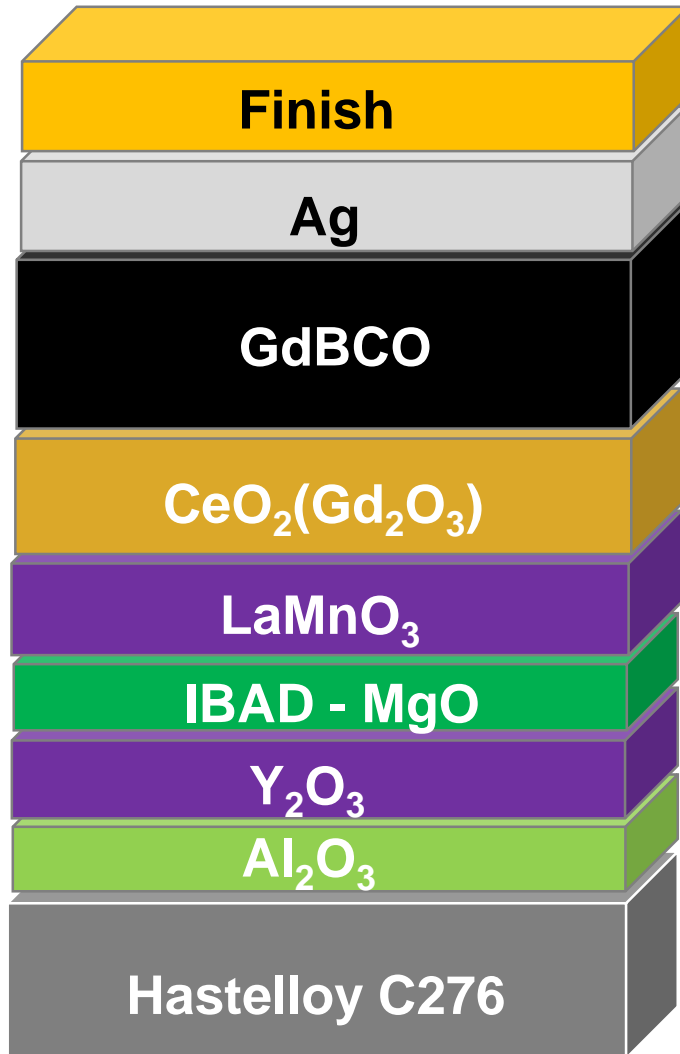
- Facility expansion
- Quality control

## 2G HTS wire performance

- Consistent performance without APC
- R&D into APC

## HTS device projects

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



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)

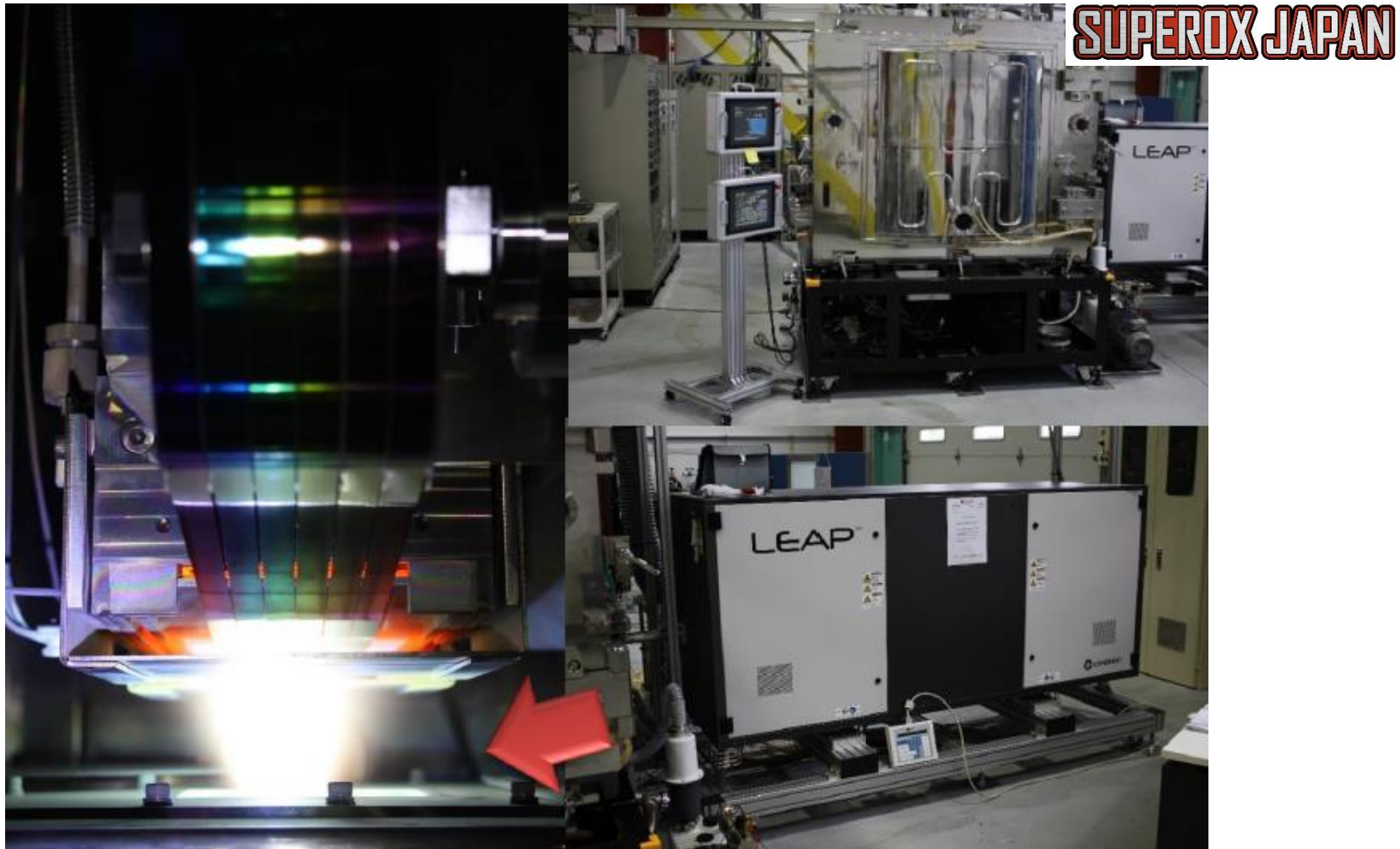
Sputtering (30-50 nm)

Cold rolled & electro polished  
(60 or 100 microns)

Originally: 2011-2015						
<b>Moscow</b>	Substrate			Ag	Cu	Finish
<b>Tokyo</b>		Buffer	HTS	Ag		

At present: 2017						
<b>Moscow</b>	Substrate	Buffer	HTS	Ag	Cu	Finish
<b>Tokyo</b>		Buffer	HTS	Ag	Cu	

Decisions to increase throughput are driven by demand

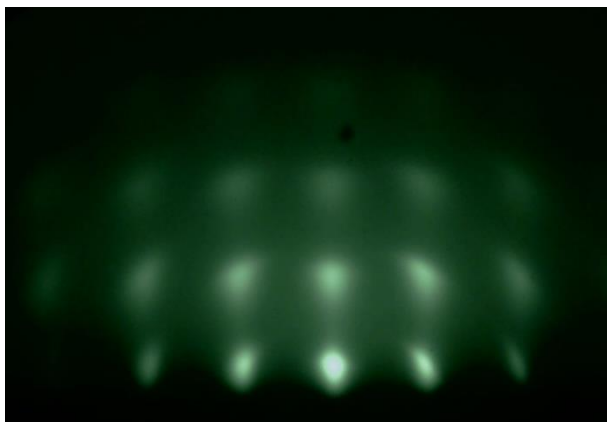


Multiprocess one-chamber sputtering/IBAD system  
Dual-chamber PLD-HTS system for  $\text{CeO}_2$  and GdBCO

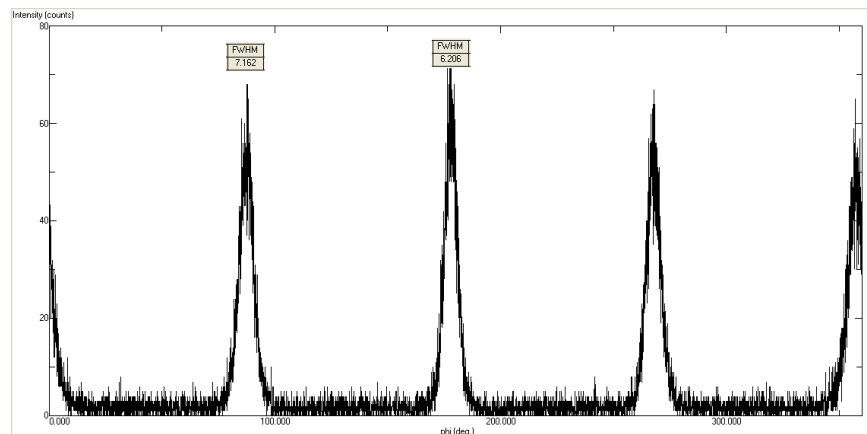


e-Polished Hastelloy substrate in  
Ready buffered tape with  $\text{LaMnO}_3$  on top out

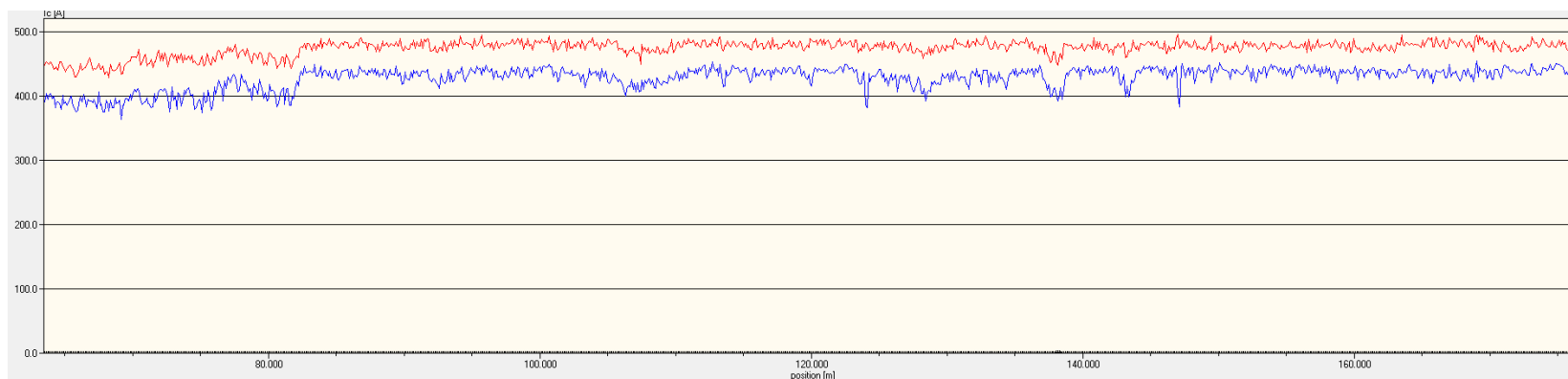
19 September 2017



Good IBAD-MgO RHEED patterns



$\Delta\phi$  (110) LMO  $< 7^\circ$



High  $I_c$  by PLD-HTS on Moscow buffer



SuperOx production capacity doubled

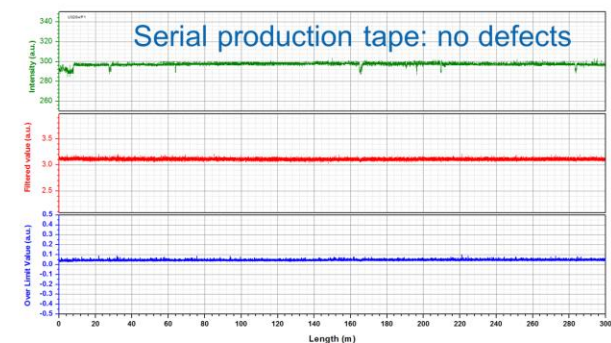
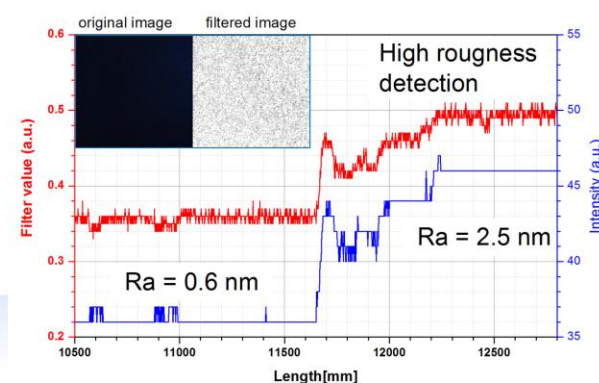
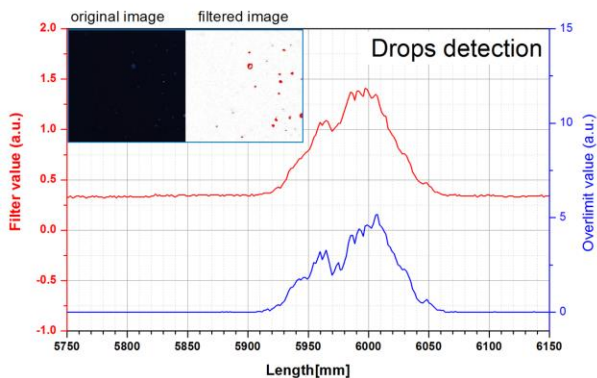
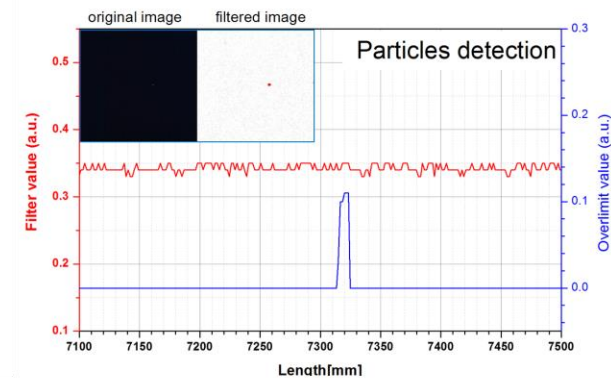
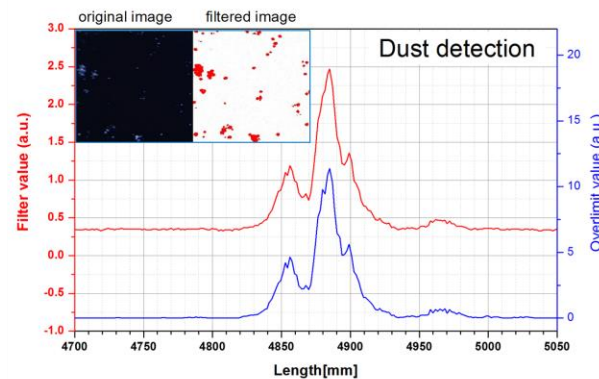
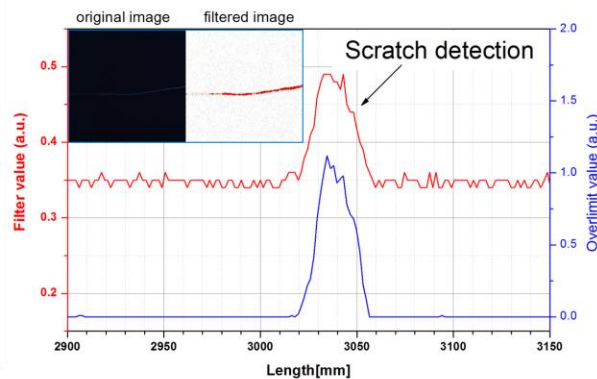
Wire produced at SuperOx in Moscow  
and at SuperOx Japan is of identical high quality



	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

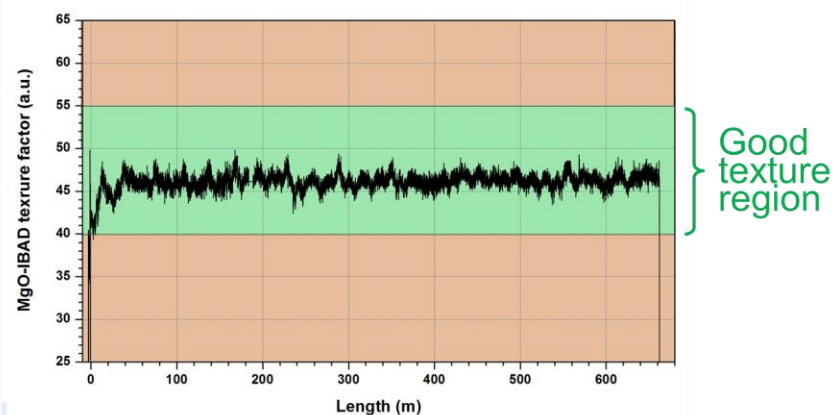
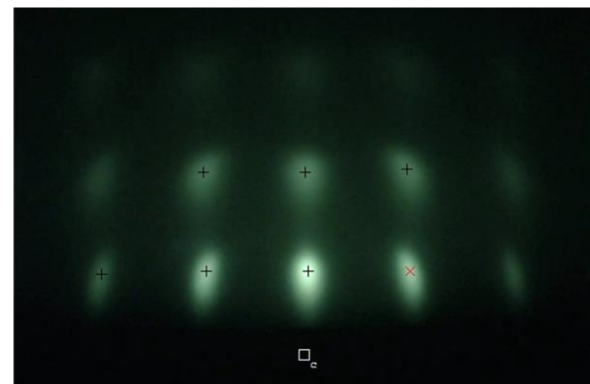
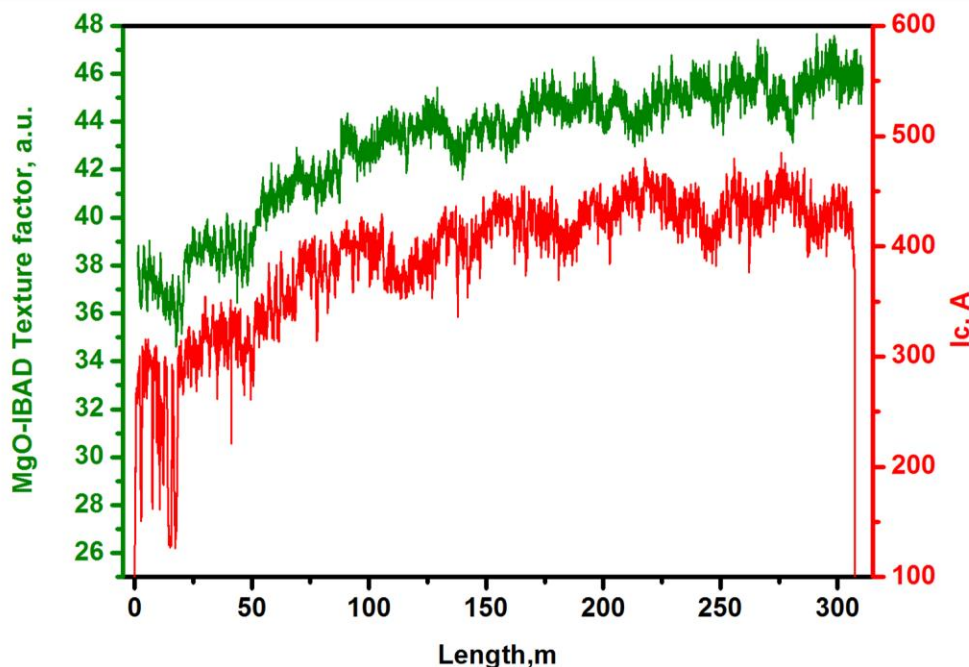
- RGB Scan: software for optical detection of various surface defects
  - The software collects images from a camera and performs digital analysis of the tape surface quality
  - Several quality parameters are derived from each image

## In-line R2R surface QC during substrate electropolishing



- GreenScan: software for digital analysis of RHEED patterns
  - Texture quality is described by a single parameter
  - Closed-loop texture quality control is implemented

## In-line R2R IBAD-MgO texture QC



## 2G HTS wire production

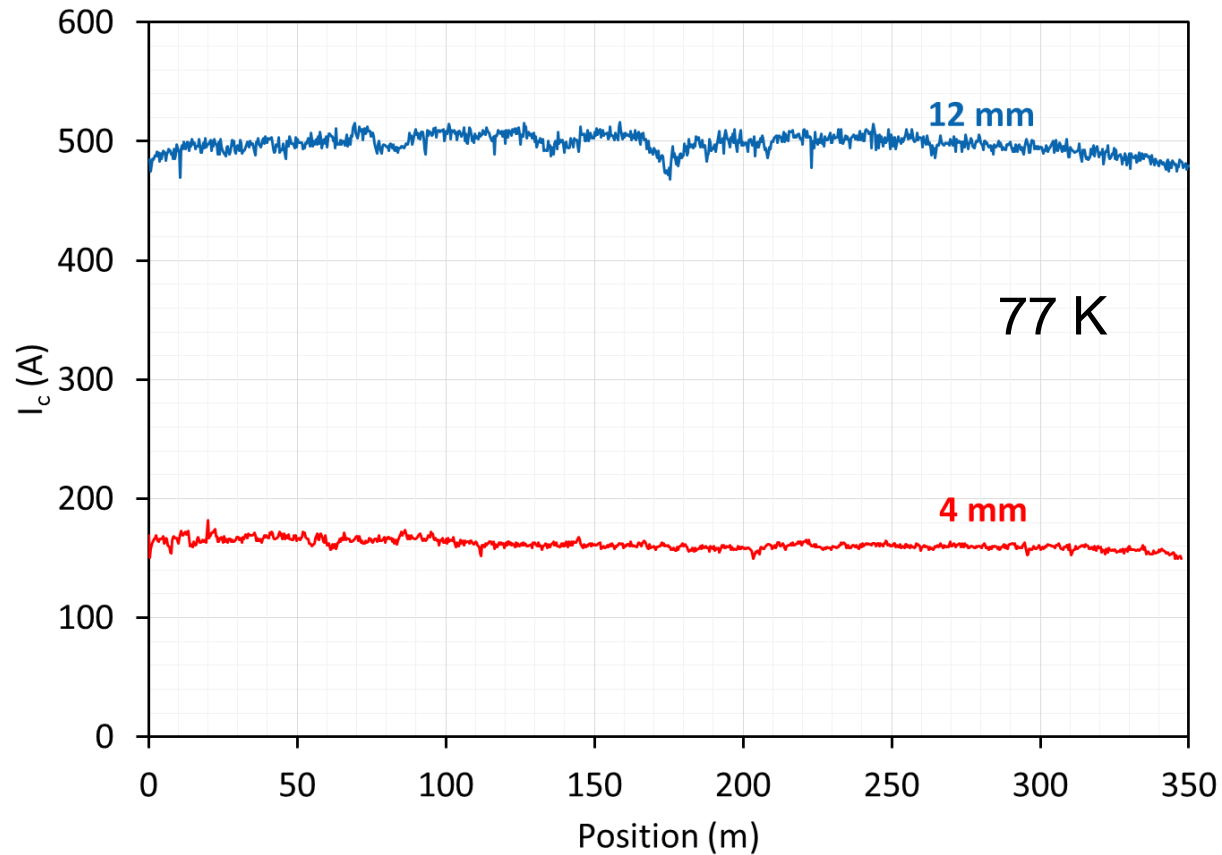
- Facility expansion
- Quality control

## 2G HTS wire performance

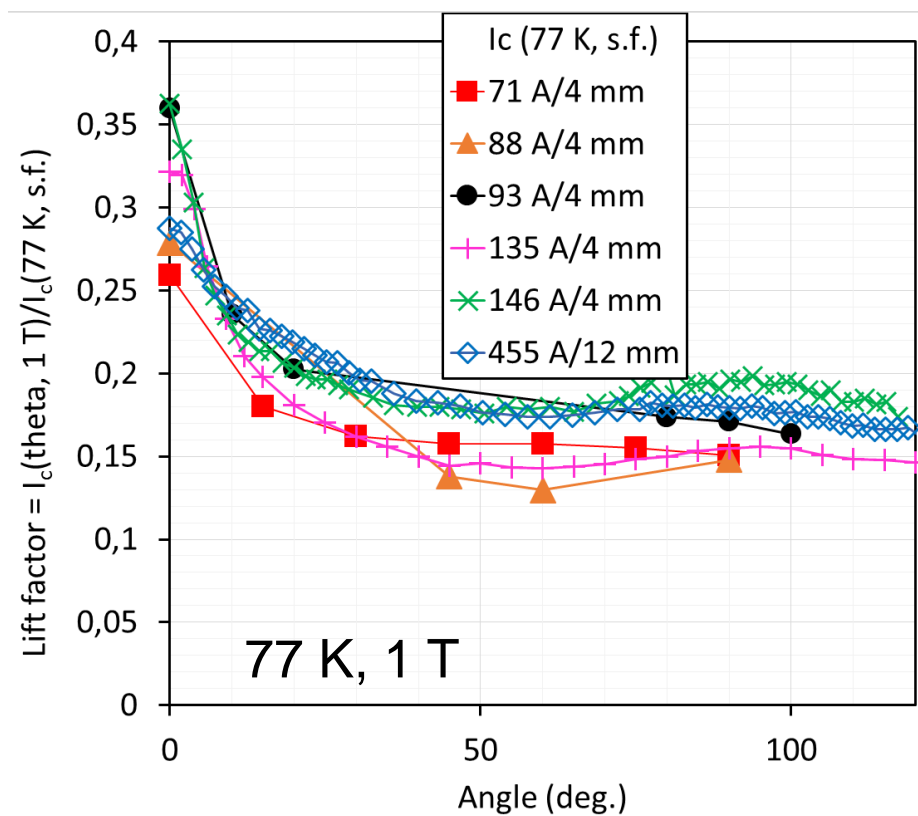
- **Consistent performance without APC**
- **R&D into APC**

## HTS device projects

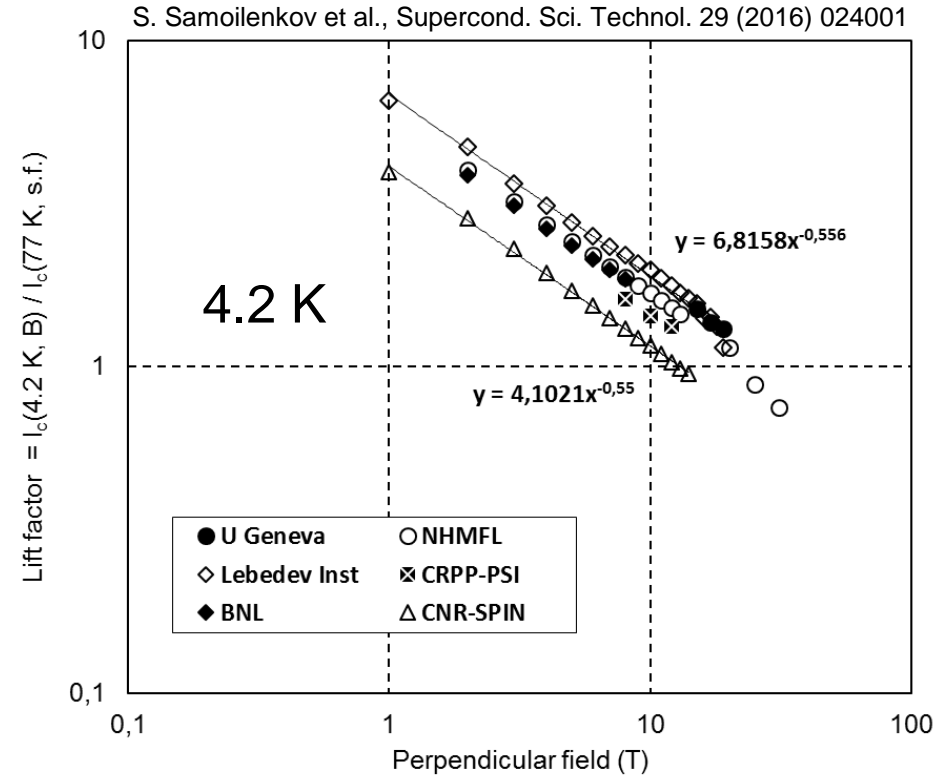
- FCL
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- Horizon 2020: HTS motor for aircraft
- Roebel cables



# 2G HTS wire: consistent performance



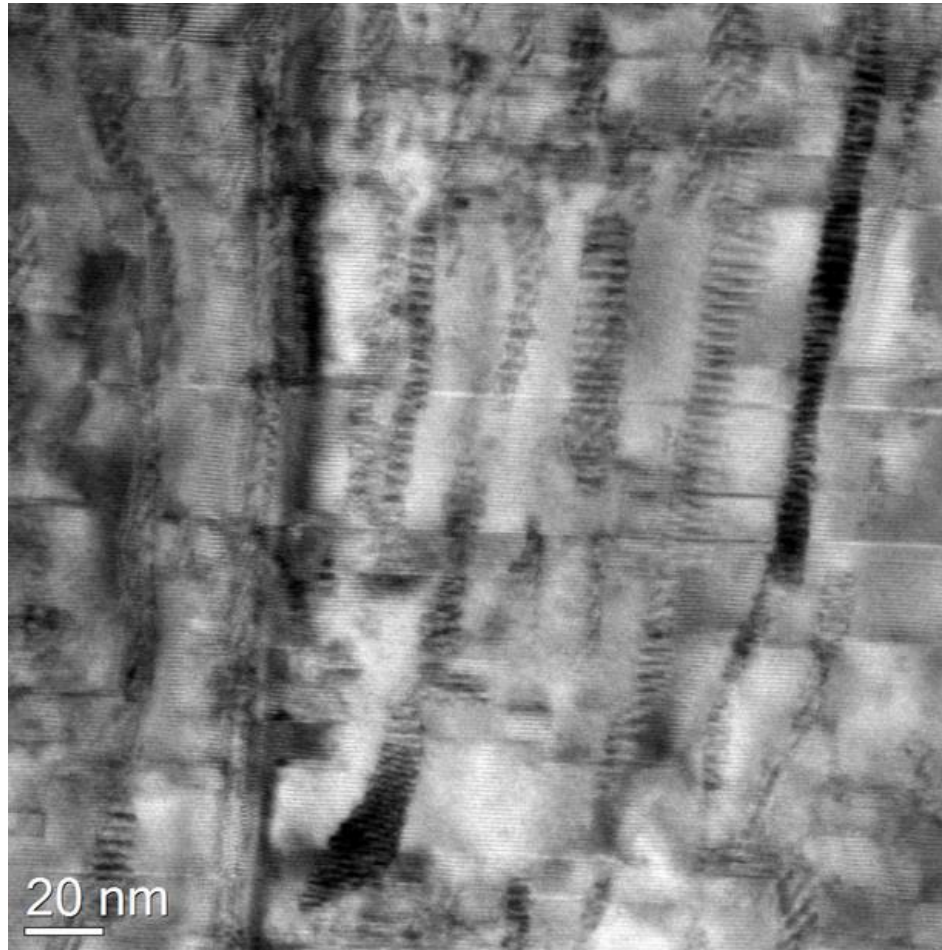
Low angular anisotropy



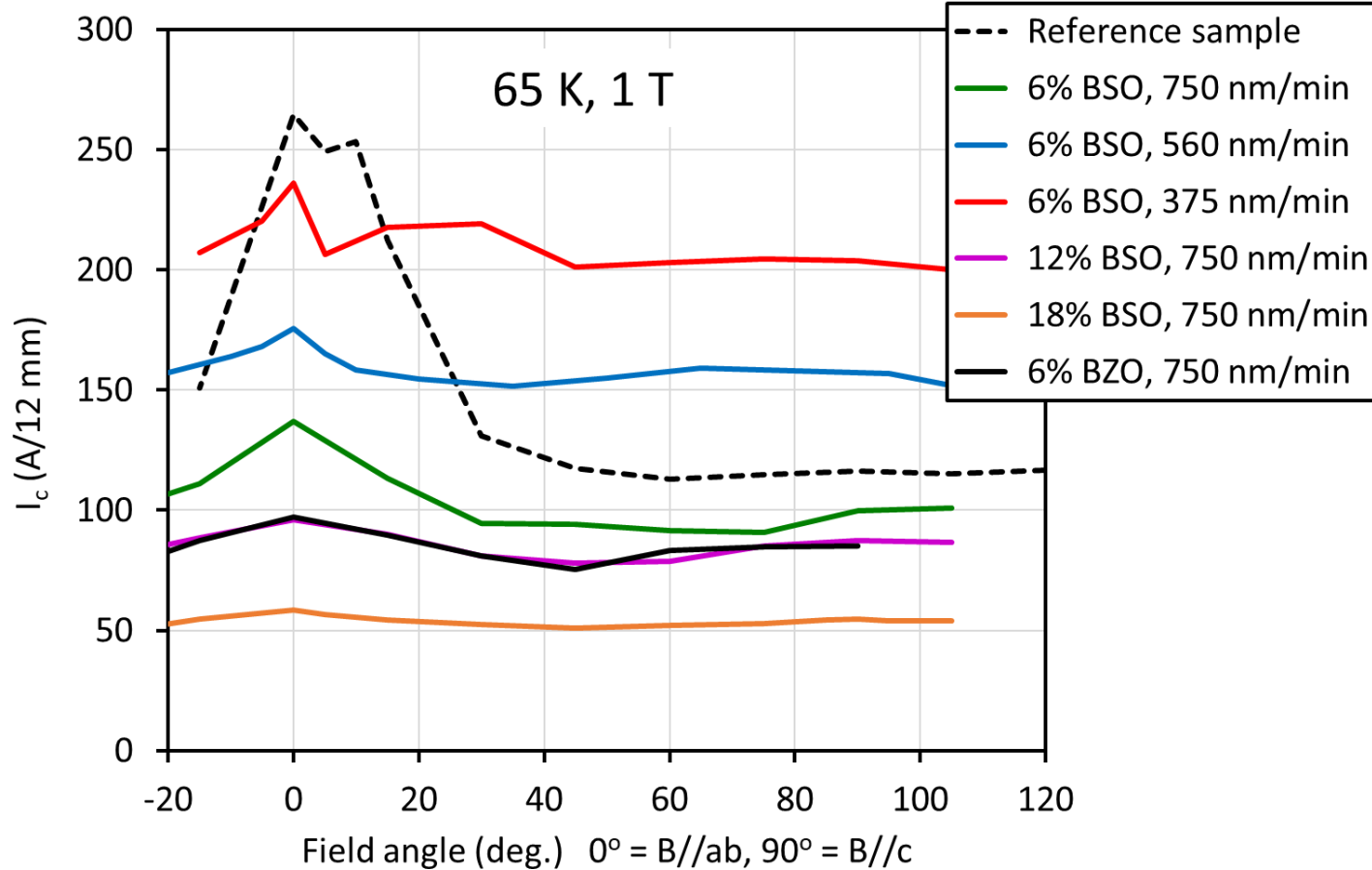
Reproducible lift factors

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/>



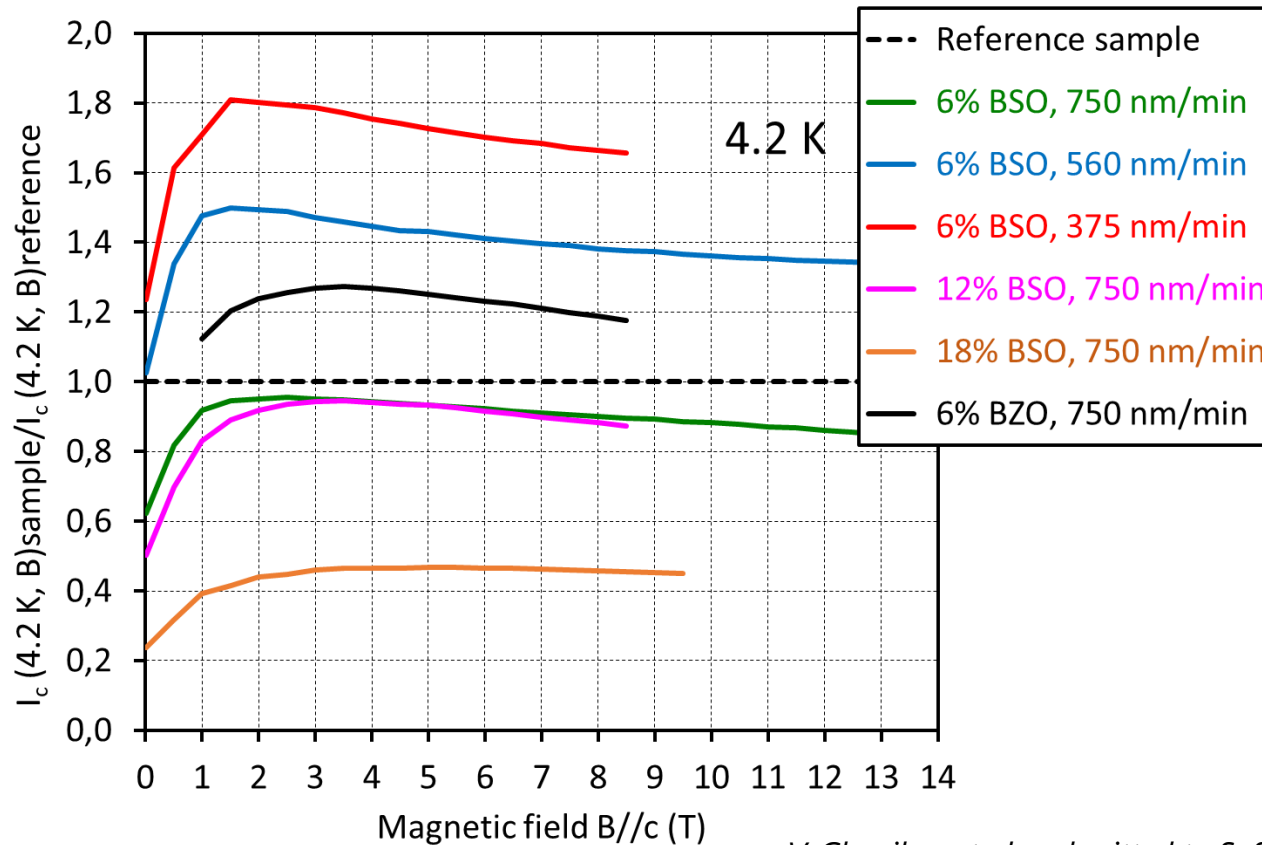
Production rate PLD. Classic nanocolumns of perovskite AP centres.



V. Chepikov et al., submitted to SuST special issue

Less anisotropy and higher min.  $I_c$  in field with pinning





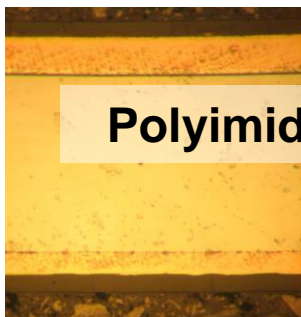
V. Chepikov et al., submitted to SuST special issue

Higher  $J_c/I_c$  in liquid helium

Next steps:

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

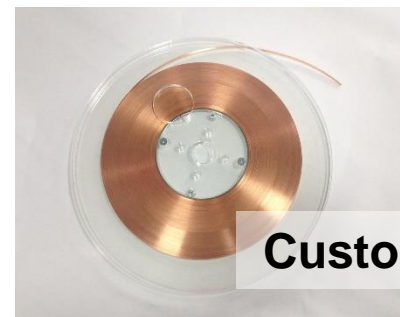
Manufacturer	Customisation options							
	Silver	Copper plating	Lamination	Surround polyimide	Polyimide wrapping	Solder plating	Tape stacks	Filaments
AMSC	•		•		•			
Fujikura	•		•		•			
SuNAM	•	•	•		•			
SuperOx	•	•	•	•	•	•	•	•
SuperPower	•	•	•		•	•		



**Polyimide deposition**



**Custom solder plating**



**Custom copper plating**

Parameter	Value		
Substrate Thickness	60 or 100 $\mu\text{m}$		
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	$> 400 \text{ A/mm}^2$	$> 400 \text{ A/mm}^2$	$> 400 \text{ A/mm}^2$
Current Uniformity	$\pm 10\%$	$\pm 10\%$	$\pm 10\%$

## Customisation:

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

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## **HTS device projects**

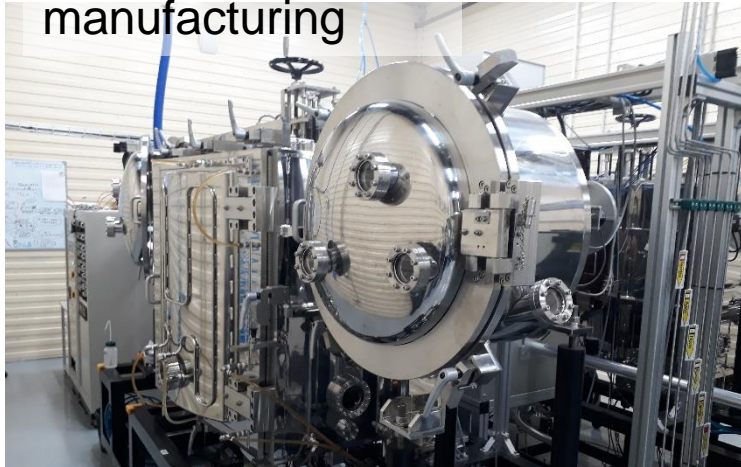
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- **Horizon 2020: HTS motor for aircraft**
- **Roebel cables**

# 220 kV FCL for Moscow City grid

## Scope

- First SFCL in Russian Power Grid
- 220 kV – class
- In operation in 2018
- SuperOx manages full project

### 1. Superconductor manufacturing



### 2. Engineering and production

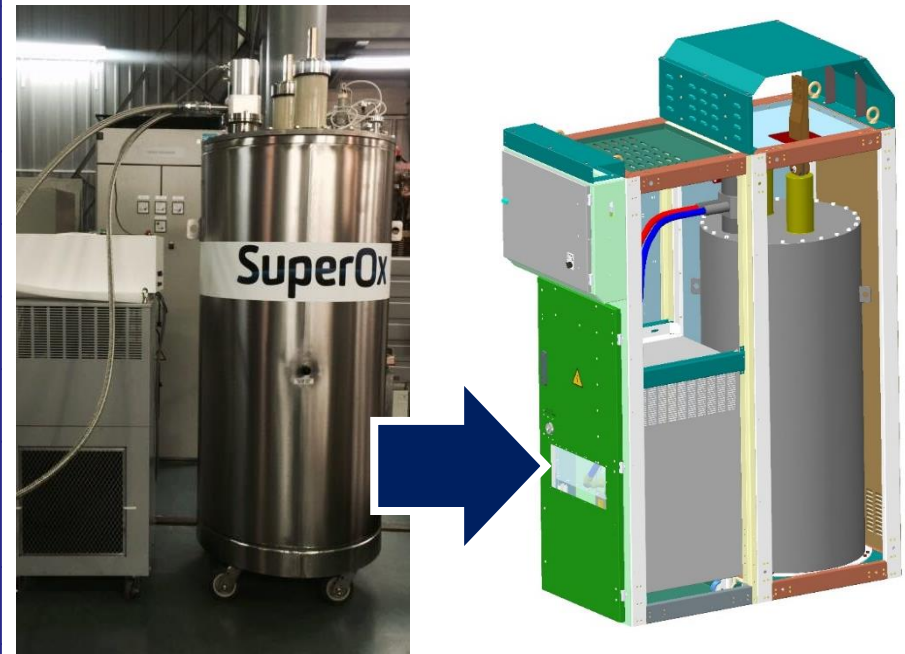


### 3. Onsite construction



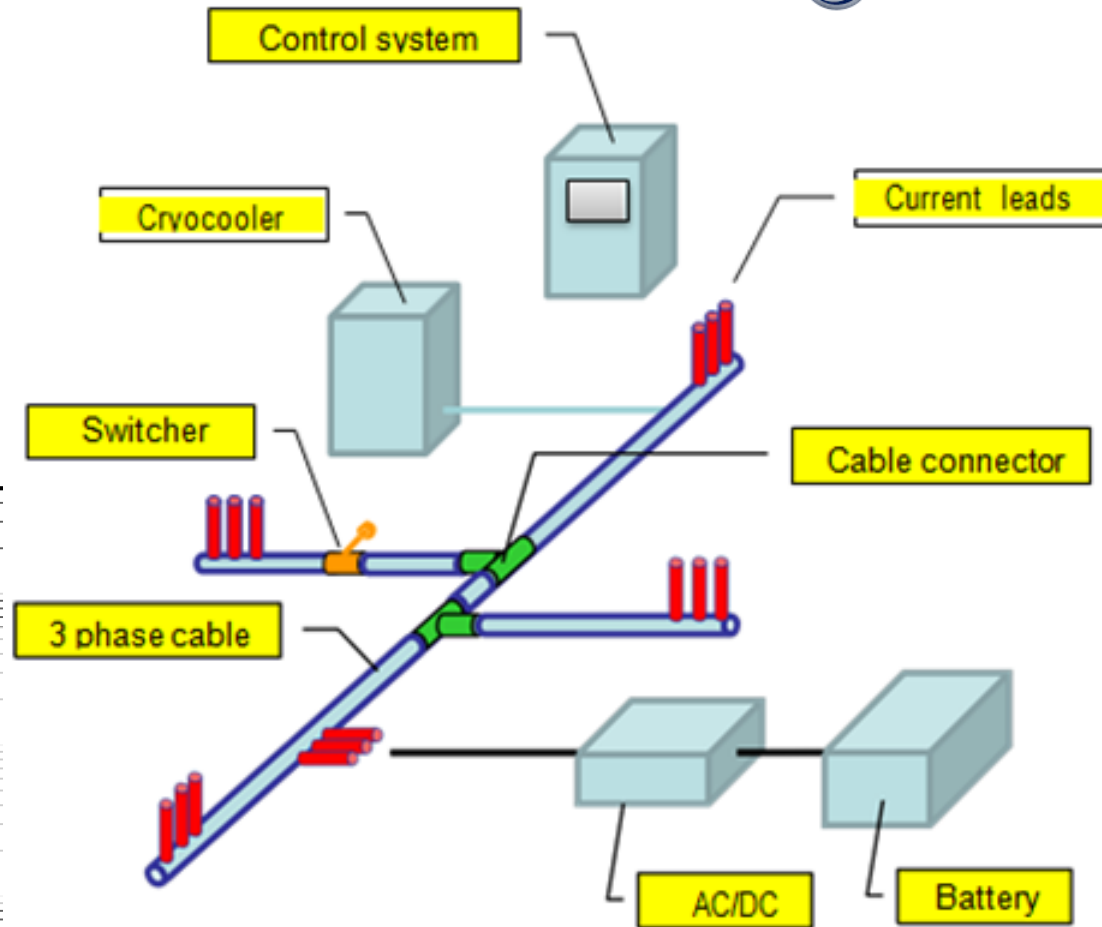
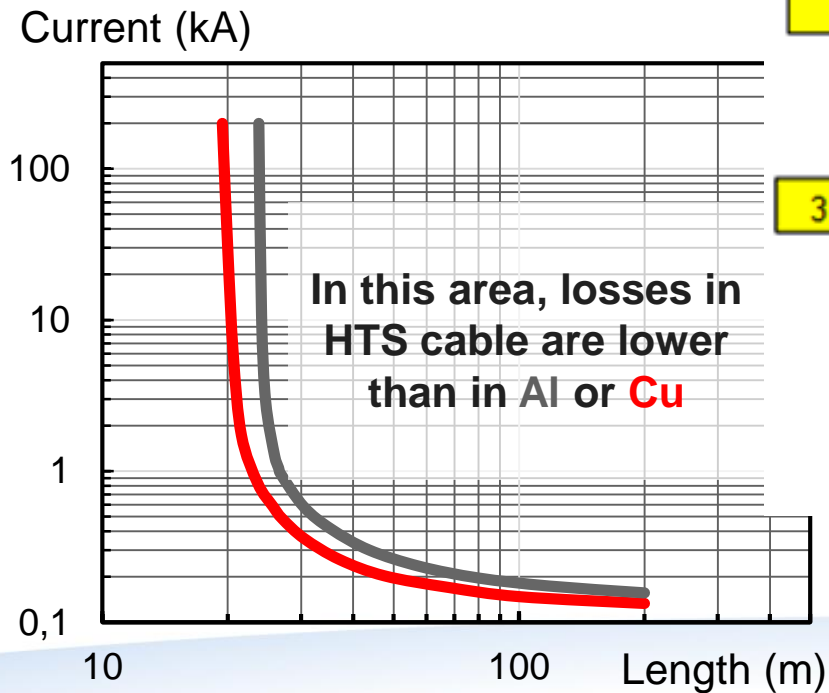
- Medium-voltage DC
- Retrofitted into a standard switchbox
- Joint project with «NIIEFA-ENERGO», LLC (St.Petersburg)

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



# HTS cable system for Airbus

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





Funded by the  
European Commission  
Grant No 723119

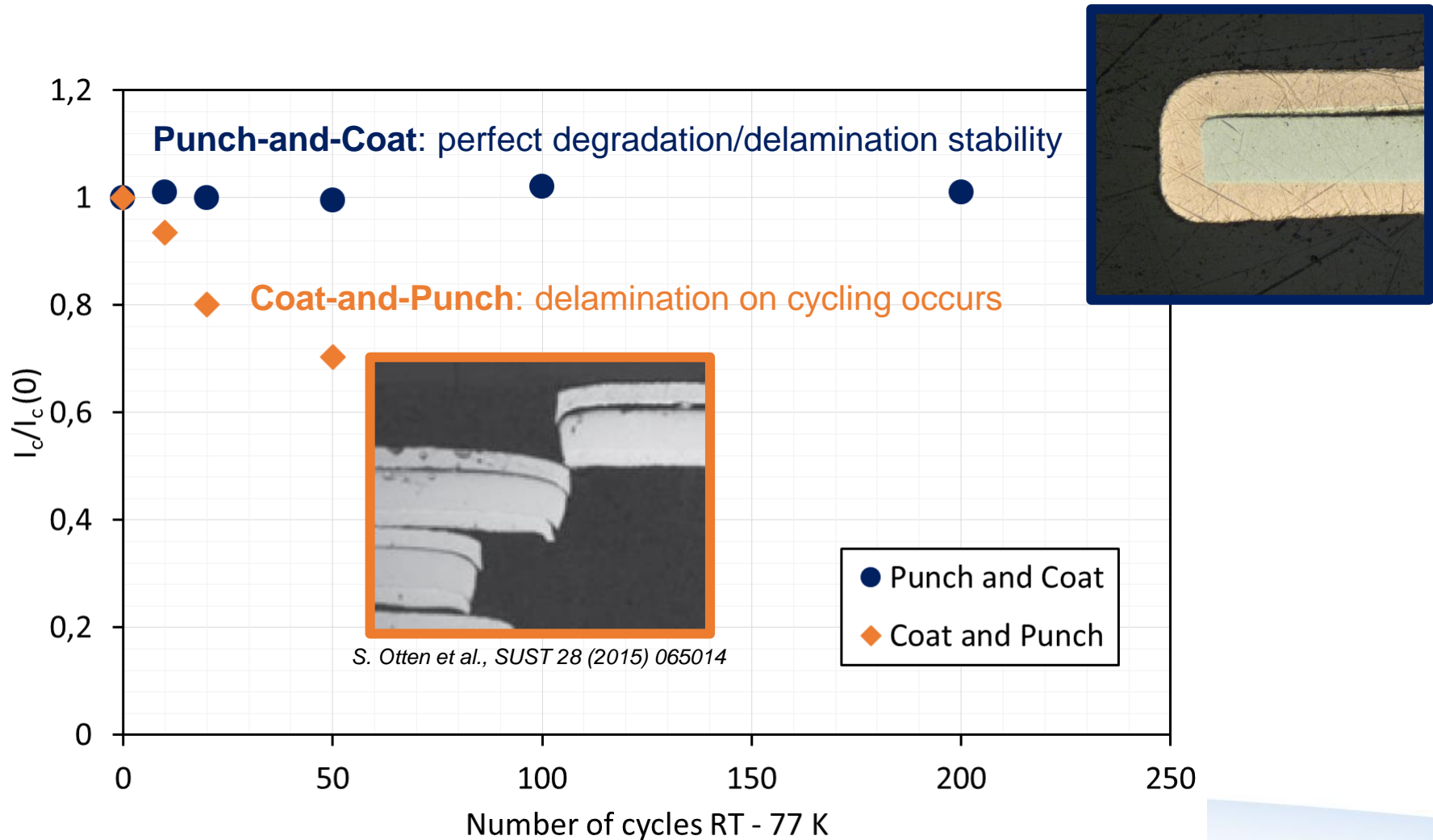
## Advanced Superconducting Motor Experimental Demonstrator

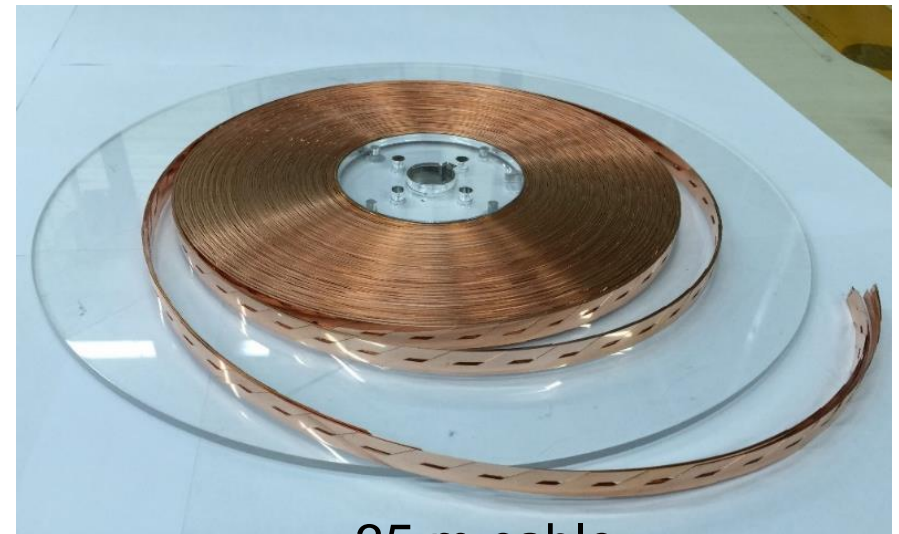
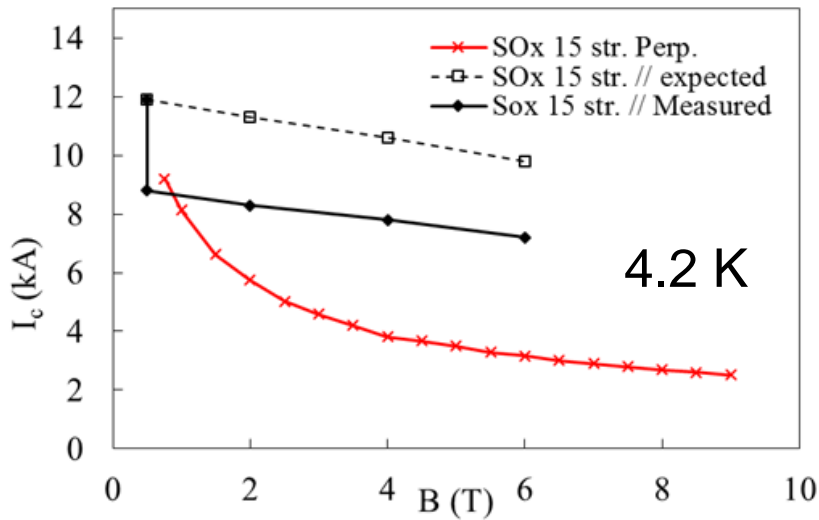
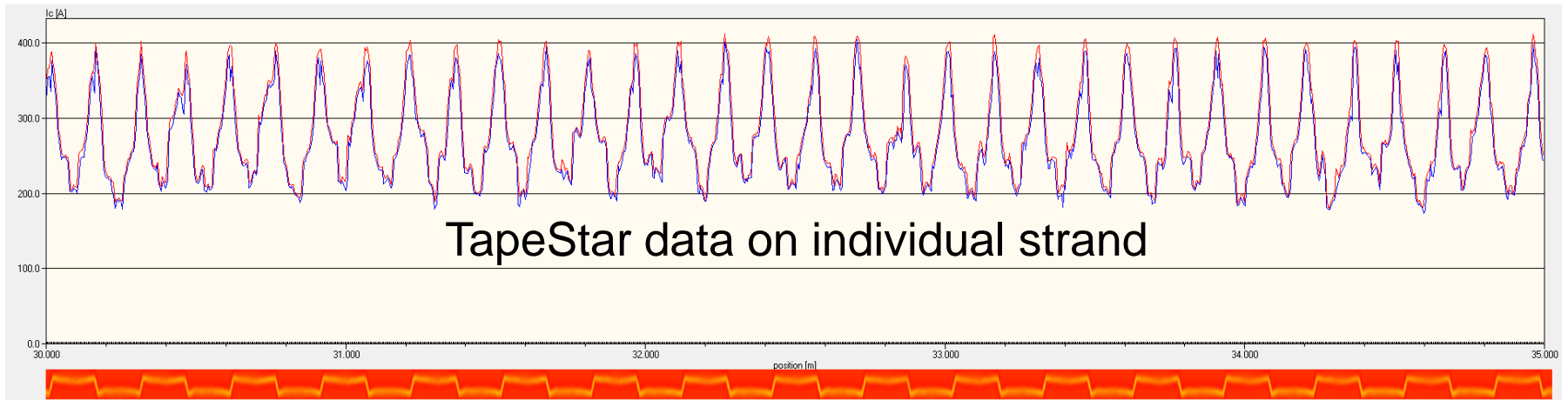


Source: Airbus Group Innovations









now in Feather 2 coil at CERN

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THANK YOU FOR YOUR ATTENTION

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[www.superox.ru](http://www.superox.ru)