Outokumpu Activities and Plans on LTS and HTS Materials

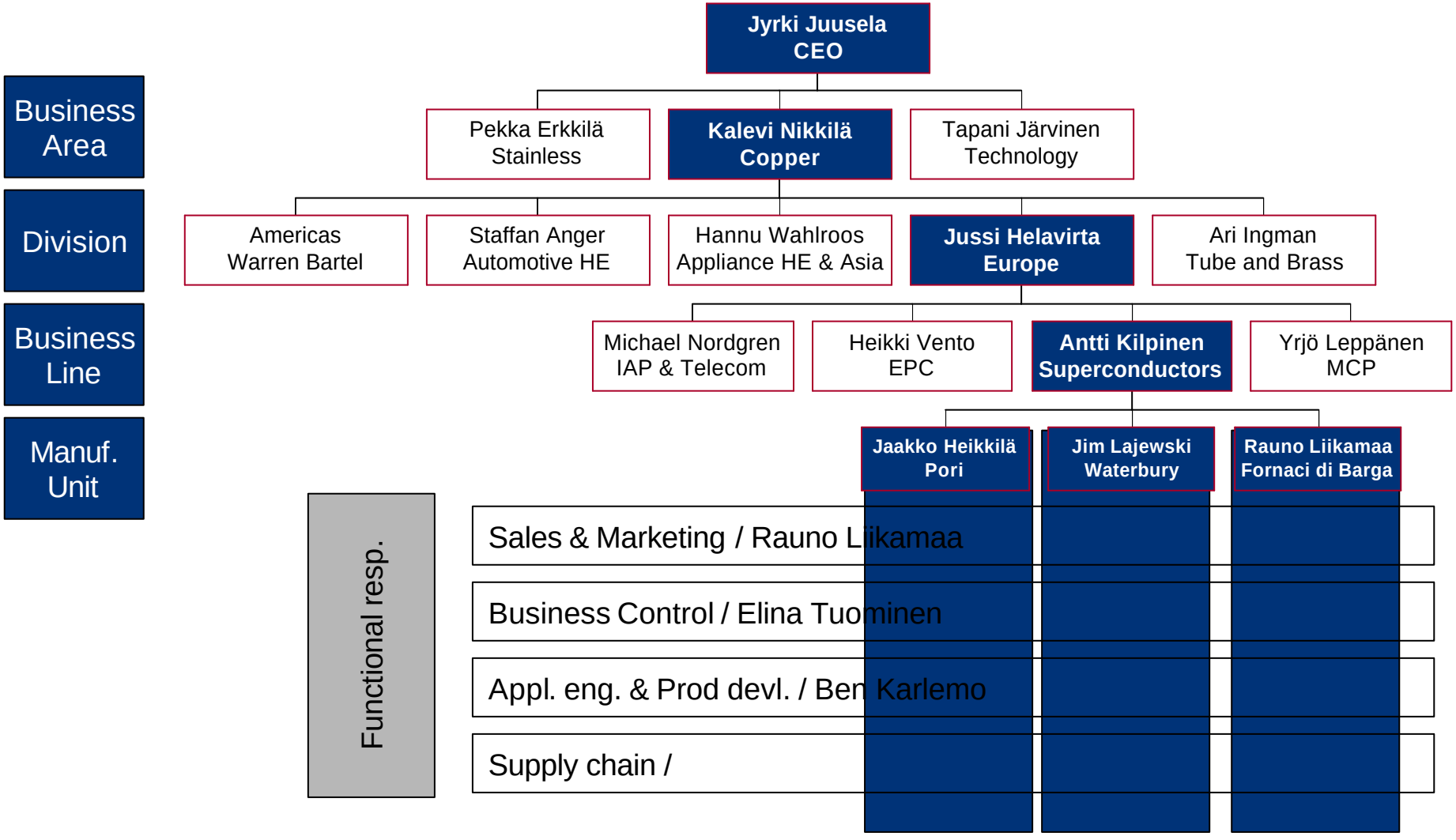
Rauno Liikamaa 23.03.2004

stainless | copper | technology

Contents

- **The Superconductors Buissness Line in Outokumpu**
- **Nb_3Sn Projects**
- **HTS Activities**

Organization



Superconductor Business: Products and Applications

- **NbTi**
  - Monolithic wires
  - Wire in Channel
  - Cables
- **Nb_3Sn**
  - Internal Tin
  - Bronze

- **Applications**
  - MRI
  - NMR
  - Specials
  - Projects
    - LHC
    - CMS
    - ATLAS
    - Wendelstein 7-X
    - Kstar
    - Others

OUTOKUMPU

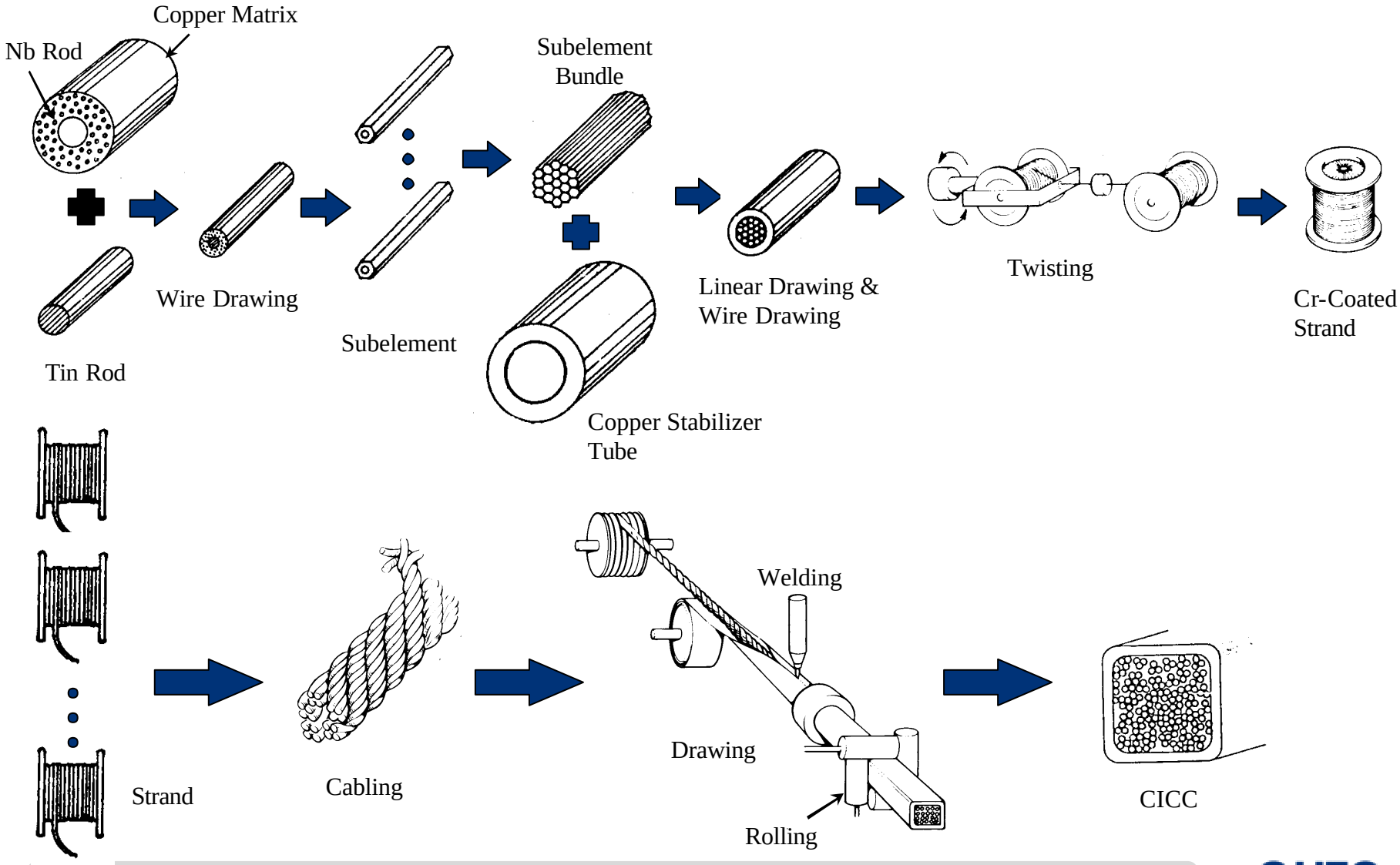
Superconductor Business: Essential Assets

- In House High Purity Oxygen Free Copper
  - Billets, cakes, Rods
- Complete set of Machinery for Copper Cold and Hot Working
  - Several Hot Extruders
  - Hydrostatic Extruder
  - Rodex (Continuous Extrusion, Cu and Al)
  - Drawing (e.g. Europe's Longest Bench)
  - Profile Manufacturing
- Availability of Outokumpu Intellectual Property

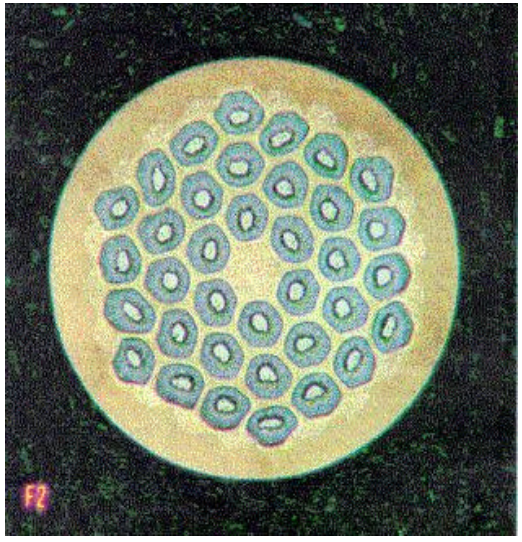
Nb_3Sn Projects

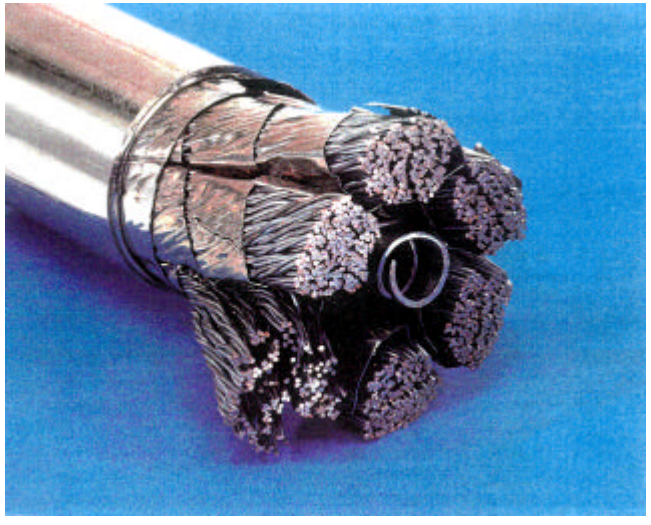
stainless | copper | technology

Fabrication Process of Internal-Tin Nb_3Sn CICC



Nb_3Sn for the TF Model Coil





- Fornaci di Barga

Diameter (mm)	0.810 ± 0.003
Twist pitch (mm)	=10
Twist direction	RHH
Cross-section (mm^2)	0.5153
Cu/nonCu ratio	1.50 ± 0.05
NonCu cross-section (mm^2)	0.2061
Cr thickness (µm)	2.0 +0.5/-0

- About 4 tonnes of strand manufactured mid 90's
- About 1 km of conductor manufactured
- Successfully tested at FZK (80 kA)

OUTOKUMPU

Projects in High Energy Physics Area:

- Conductor Development Program for High Energy Physics, Since 2002
  - Supported by U.S. Department of Energy Subcontract through Lawrence Berkeley National Laboratory
  - Highly focused on Nb3Sn (internal-tin).
- SBIR Subcontracts from small companies and national labs

In other areas:

- NHMFL (National High Magnetic Field Laboratory), Since 2002
  - 450 km of internal-tin strand for 45T-Hybrid magnet.
  - Delivery to be completed by the end of March.
- High Field DC laboratory magnets
  - High current, high strength Nb3Sn has been supplied to small magnet manufacturers.

OUTOKUMPU

Projects in the Fusion area

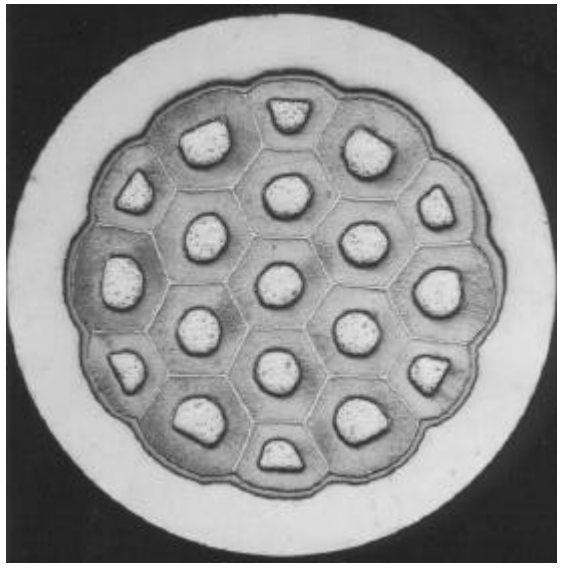
- CS Model Coil, 1993 –1997
  - Supplied 4.5 metric tons of HP-1 type internal-tin Nb3Sn strand with Cr-plating.

- LDX-F (Levitated Dipole Experiment), 1998 - 1999
  - A joint Columbia University & MIT Project.
  - 1.3 MA, 0.8 m diameter, 5 T Floating Coil Experiment for High-Temperature Plasma Experiments and Fusion Science Research.
  - Solely supplied 2 metric tons of highly customized internal-tin Nb3Sn Cable-In-Channel.
  - React & wind approach was adopted.

Projects in the Fusion area

- KSTAR (Korea Superconducting Tokamak Advanced Research), Since 1998
  - Requires high performance internal-tin Nb3Sn (HP-3 type).
  - Conductor supplied:
    - 6 metric tons of internal-tin Nb3Sn strand for TF and CS coils.
    - (12 metric tons of NbTi strand for PF coil (sole supplier).)
- ITER-EFDA, 2004
  - Pre procurement order of advanced TF Coil Nb3Sn strand.
- ITER-US
  - Pre procurement order of advanced CS Coil Nb3Sn strand under preparation by the US party.

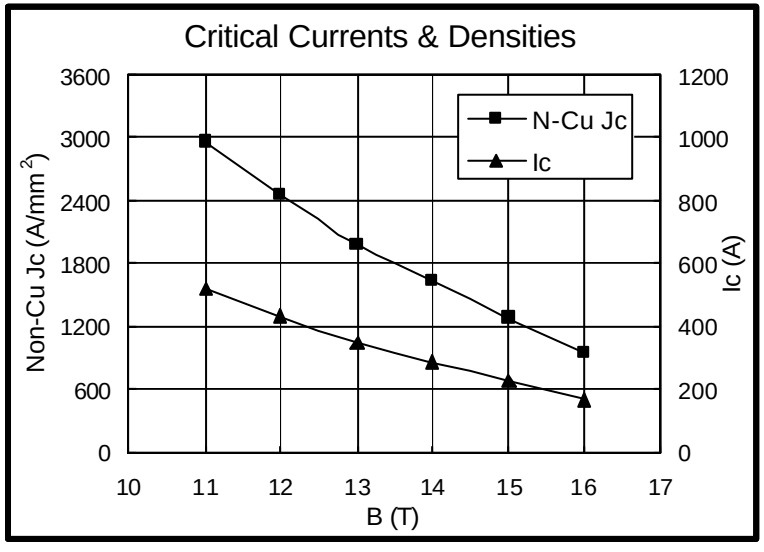
OKAS-Nb_3Sn for High Energy Physics



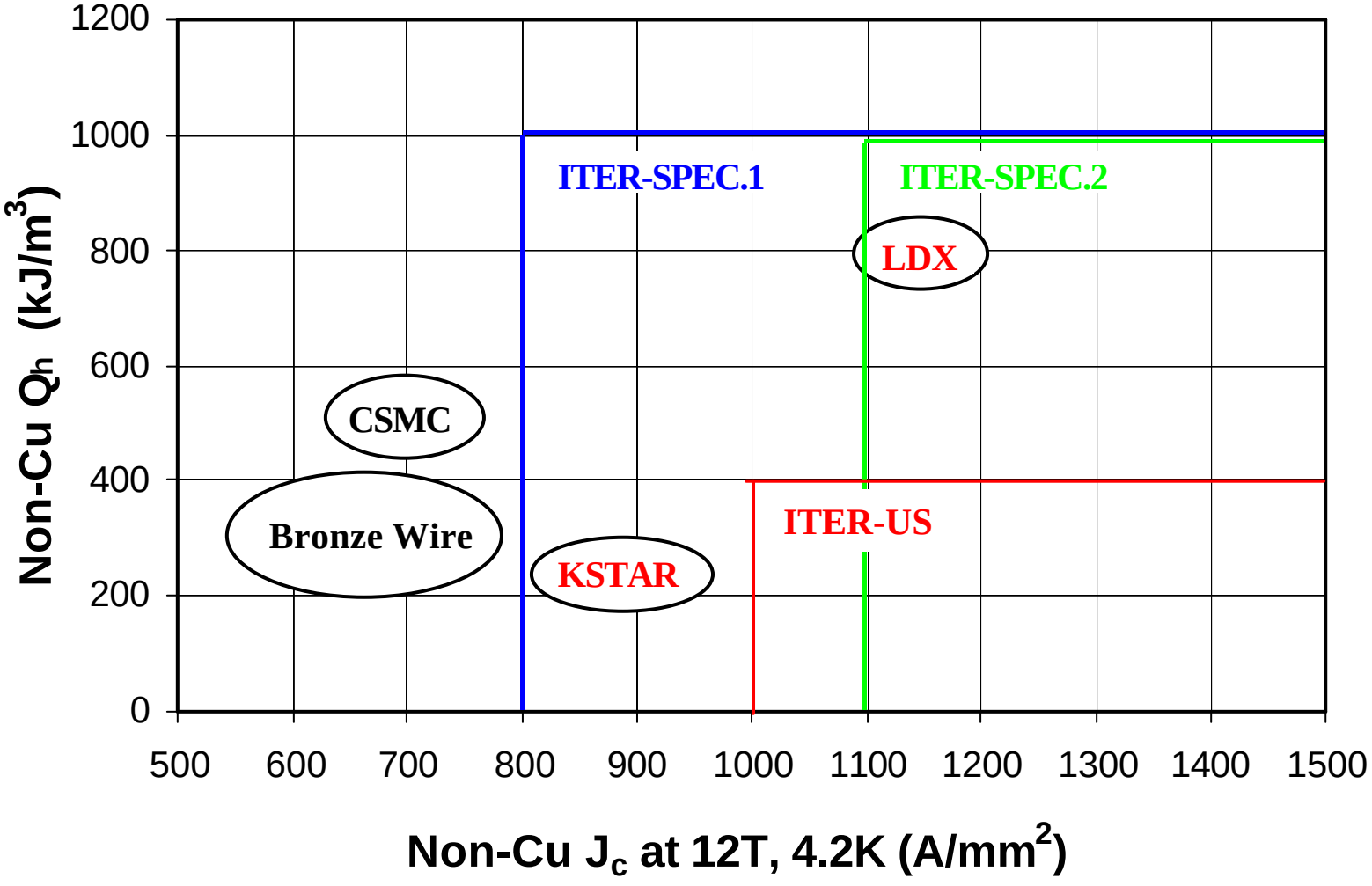
Conductor Characteristics	
Bare Dia. (mm)	0.60
Cu/non-Cu Ratio	0.6
No. of Filaments	26000
Filament Dia. (μm)	2.0
Non-Cu Q_h (kJ/m^3)	6210
D_{eff} (μm)	

Measurement Criteria
I_c: 0.1μV/cm,
n-value: 0.1~1.0μV/cm

B (T)	11.0	12.0	13.0	14.0	15.0	16.0
I_c (A)	517	431	348	287	224	166
n-value						
N-Cu J_c (A/mm^2)	2952	2460	1985	1640	1277	949



Current Density & Hysteresis Loss



Summary

- Need for the Further Nb_3Sn development
  - Both non-Cu Jc and AC loss have been improved.
  - Further improvement is required to secure higher margin.
  - More aggressive (higher temp.) heat treatment for reaction is necessary to optimize Jc.
  - Scale-up of both sub-element billet and restack unit is in progress.

HTS Activities

- Joint project with CNR-IMEM and Edison to develope coated conductors
- 16:30 Today Dr. Zannella will give a presentation about this subject.