Nexans activities and plans on HTS materials

High-Performance Bi-2212 Tape and Bulk Conductors for Magnet Technology

1. Introduction
2. HTS activities overview
3. Bi-2212 precursor, bulk and tape

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Chemiepark Knapsack
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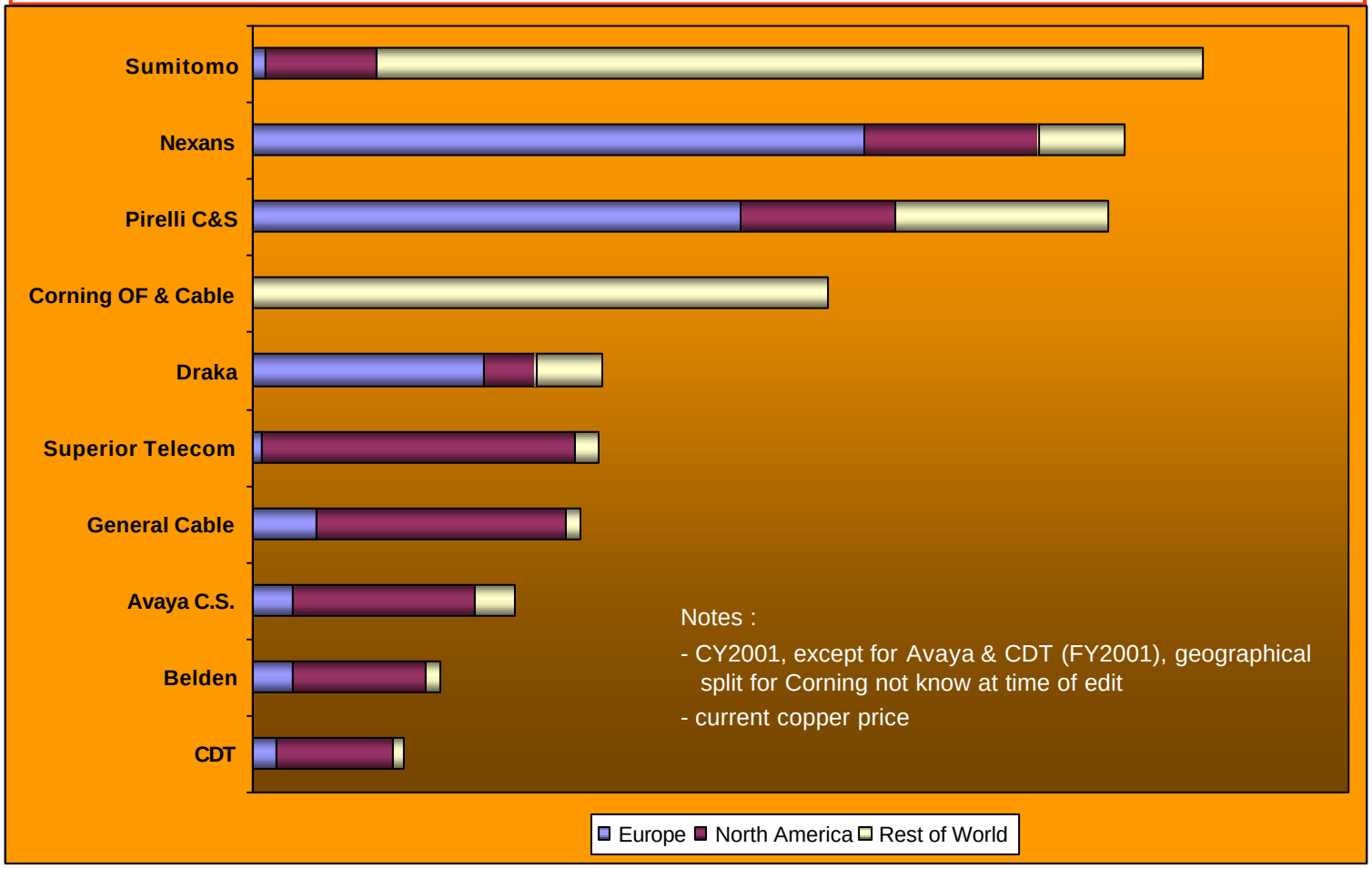
A major part of

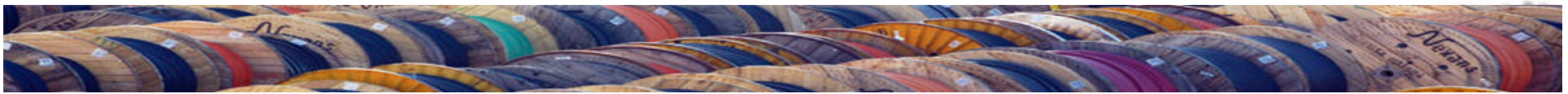
Alcatel Cables and Components

became Nexans

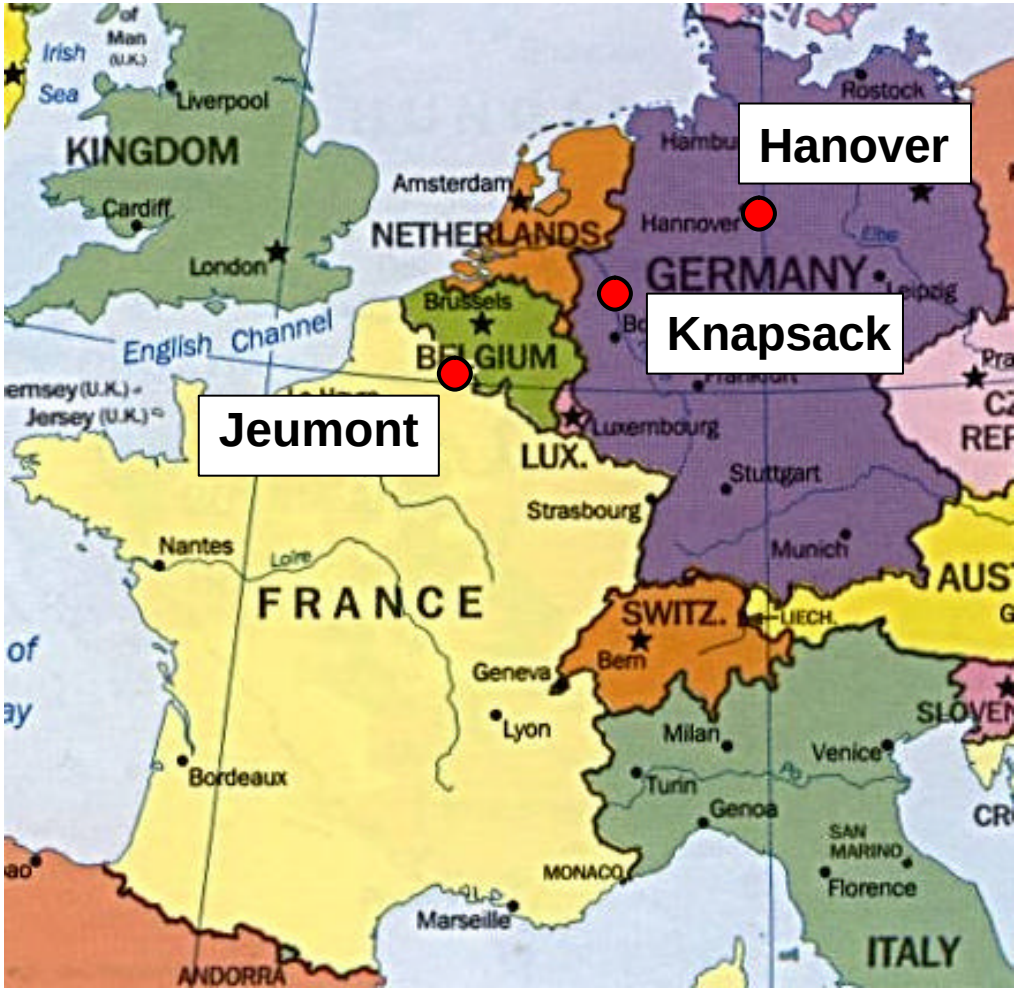
Leading positions based on customer confidence

Sales 2001 (by geography)





HTS activities & sites



Nexans SuperConductors

Nexans Deutschland Industries

Knapsack (Huerth)

Nexans SuperConductors GmbH

- precursor materials
- bulk parts
- fault current limiter elements
- coated conductors

Hanover

Production Lines and Technology

- flexible cryostats
- HTS cables

Nexans France

Jeumont

Nexans Jeumont

- HTS tapes

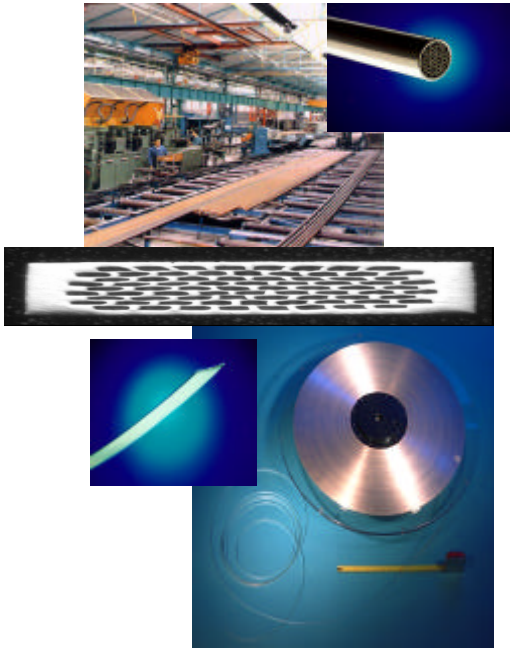
Development of components for HTS cable systems at Nexans (1)

Nexans is fully integrated for manufacturing of HTS power cables

Nexans SuperConductors Knapsack

Development and manufacturing of Bi-precursor materials

Nexans Cable Jeumont



Development (Bi-2223) and manufacturing (Bi-2212) of HTS-tapes

Nexans SuperConductors Knapsack

Development and manufacturing of coated conductor Y-123 tapes

Development of components for HTS cable systems at Nexans (2)

Nexans is fully integrated for manufacturing of HTS power cables

Nexans Deutschland Industries
Hanover

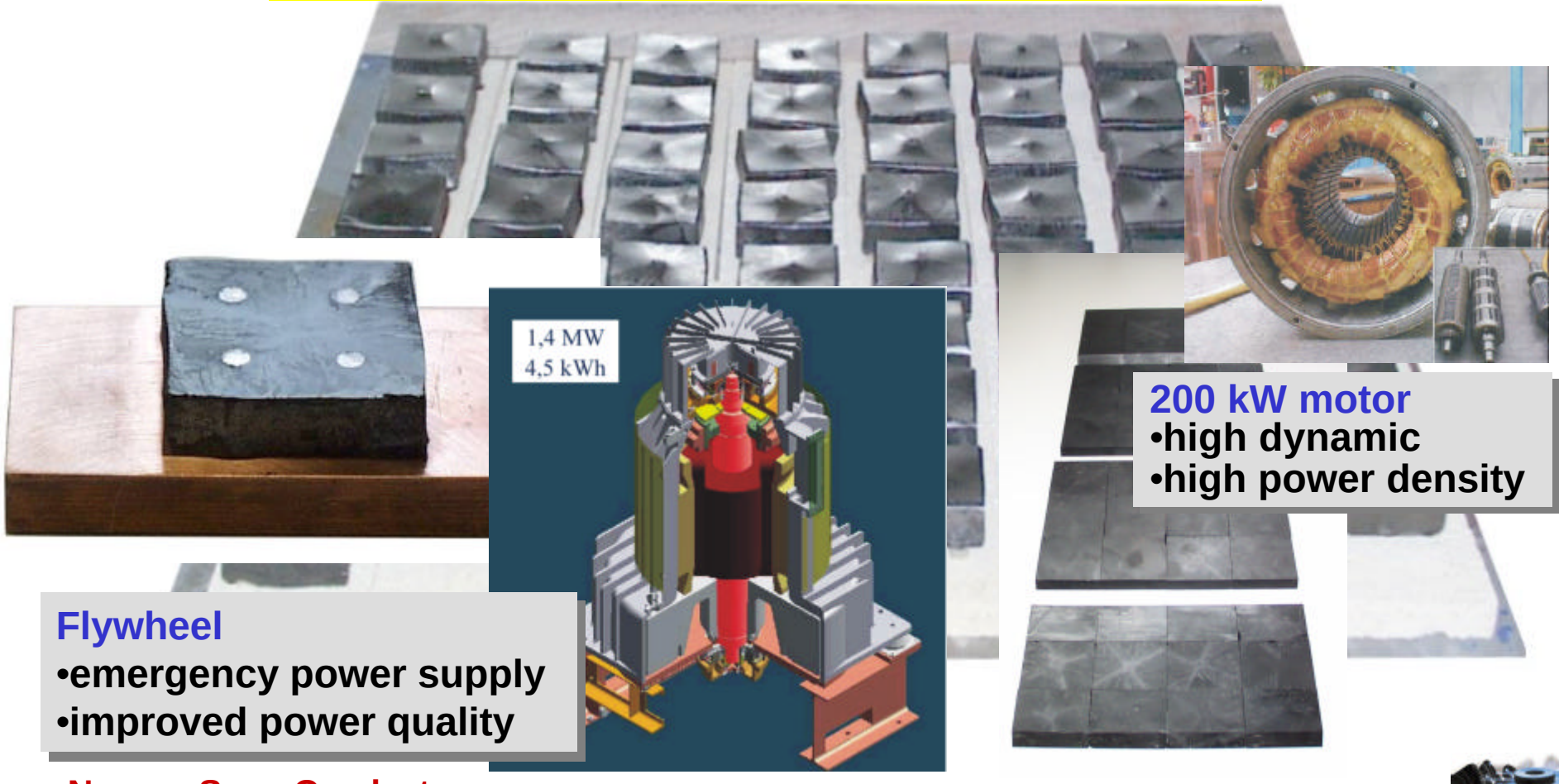
Development and manufacturing of cryo sleeves and power cables

Nexans SuperConductors
Knapsack

Development and manufacturing of FCL components

Batch production of single domain YBCO at NSC

- record batch size 64 samples (40 ´ 40 ´ 14 mm^3)
- bonding technique YBCO – Copper developed



200 kW motor
- high dynamic
- high power density

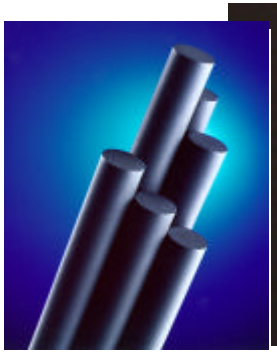
Flywheel
- emergency power supply
- improved power quality

Three sucess stories from Bi-2212 (1)

- **HTS current leads with bulk Bi-2212 rods and tubes**

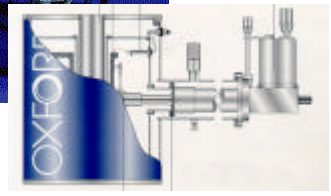
- **Superconducting fault current limiter elements based on Bi-2212 bifilar coils**

- **Bi-2212 precursors and tape conductors**



Todays Use of HTS Bulk Materials (1)

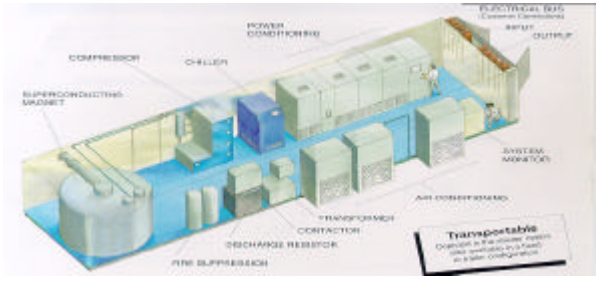
Nexans Current Leads enabled first application of HTS in electrical engineering



Oxford
("dry" magnet)

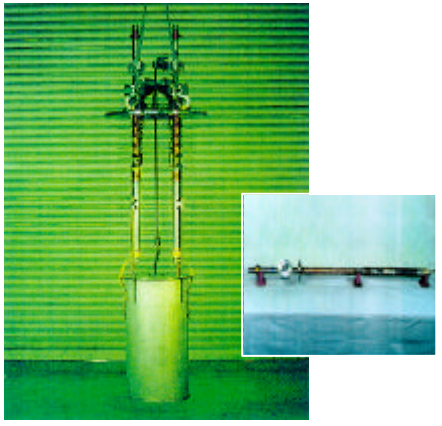
Bi-2212 for commercial use in current leads since 1995

ACCEL
(SMES-system)



IGC
(SMES-system)

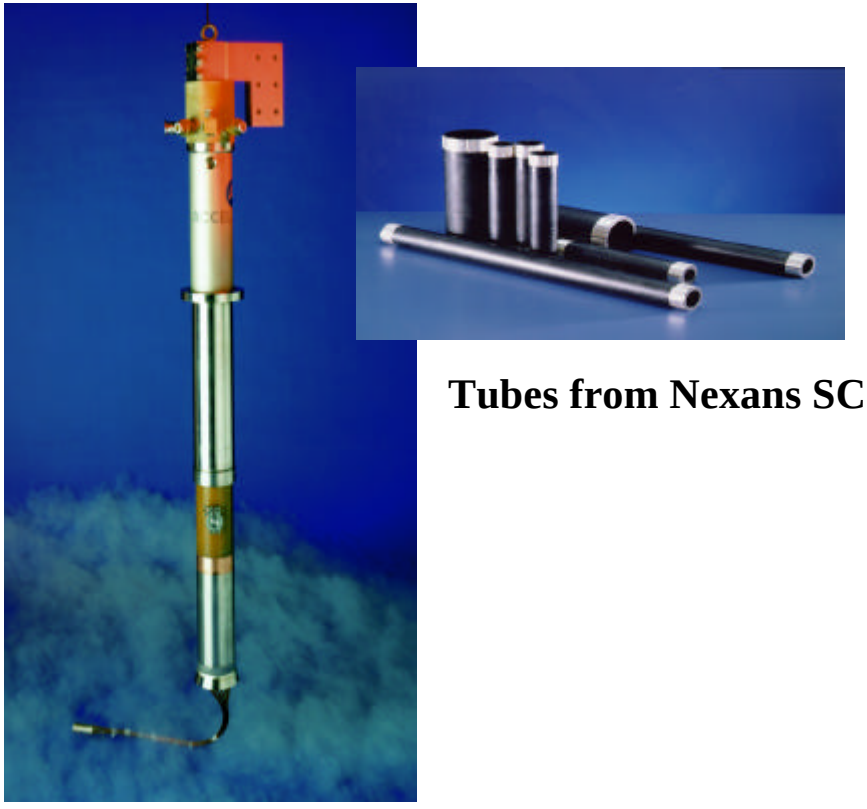
General Atomics
(Current Controller)



Fuji Electric
(SMES-system)

Todays Use of HTS Bulk Materials (2)

ACCEL and Nexans have succesfully built 13 kA leads for CERN‘s Large Haldron Collider (LHC) Project



Tubes from Nexans SC

Benefits of current leads with Nexans form parts:

Lower operating cost, through

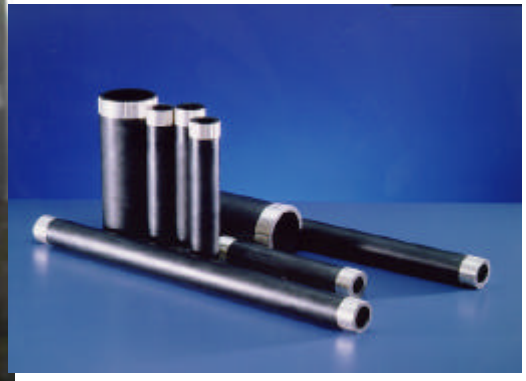
- reduced investment for refrigeration, and
- lower power consumption
  (estimated savings 4MW/y = 1,20M$/y)

ACCEL

Todays Use of HTS Bulk Materials (3)

MCP BSCCO-2212 tubes successfully tested up to 20 kA DC

20kA HTS Leads



Application case:
Fusion project in China

Applied:
MCP BSCCO-2212 tubes
(80 mm outer diameter)

Test status:
@ 77 K up to 13 kA (1µV/cm, sf)
@ 70 K up to 20 kA (1µV/cm, sf)

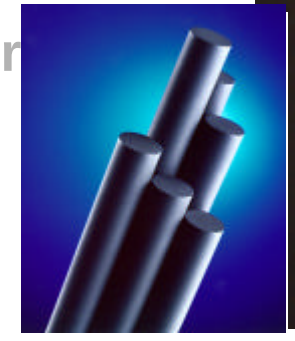
Expected current carrying capacity
@ 70 K: **24 kA!**

Three success stories from Bi-2212 (2)

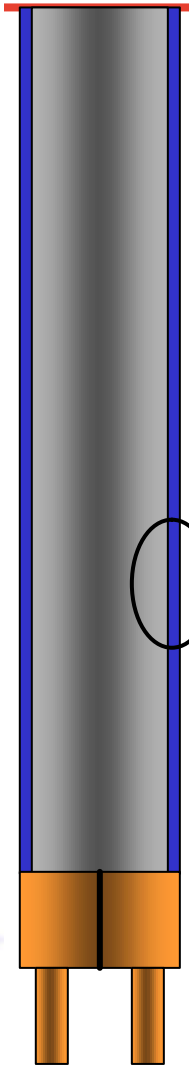
- HTS **current leads** with bulk Bi-2212 rods and tubes

- **Superconducting fault current limiter elements based on Bi-2212 bifilar coils**

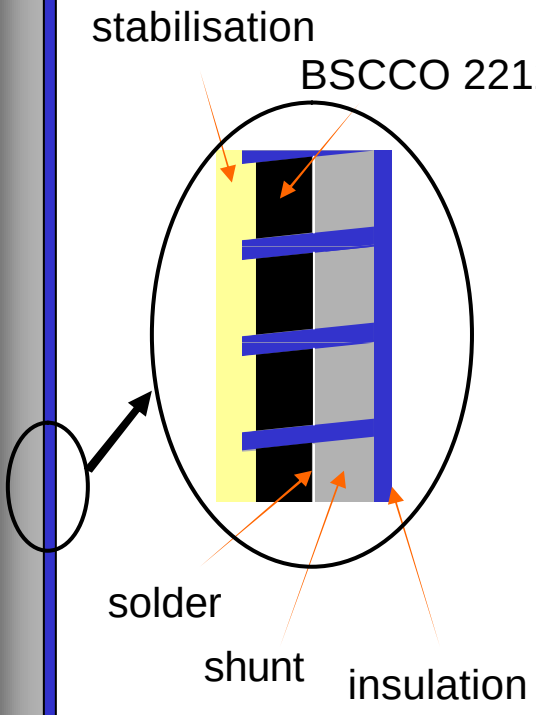
- Bi-2212 **precursors** and **tape** conductor



German BMBF project CURL10 (1)



mechanical design:



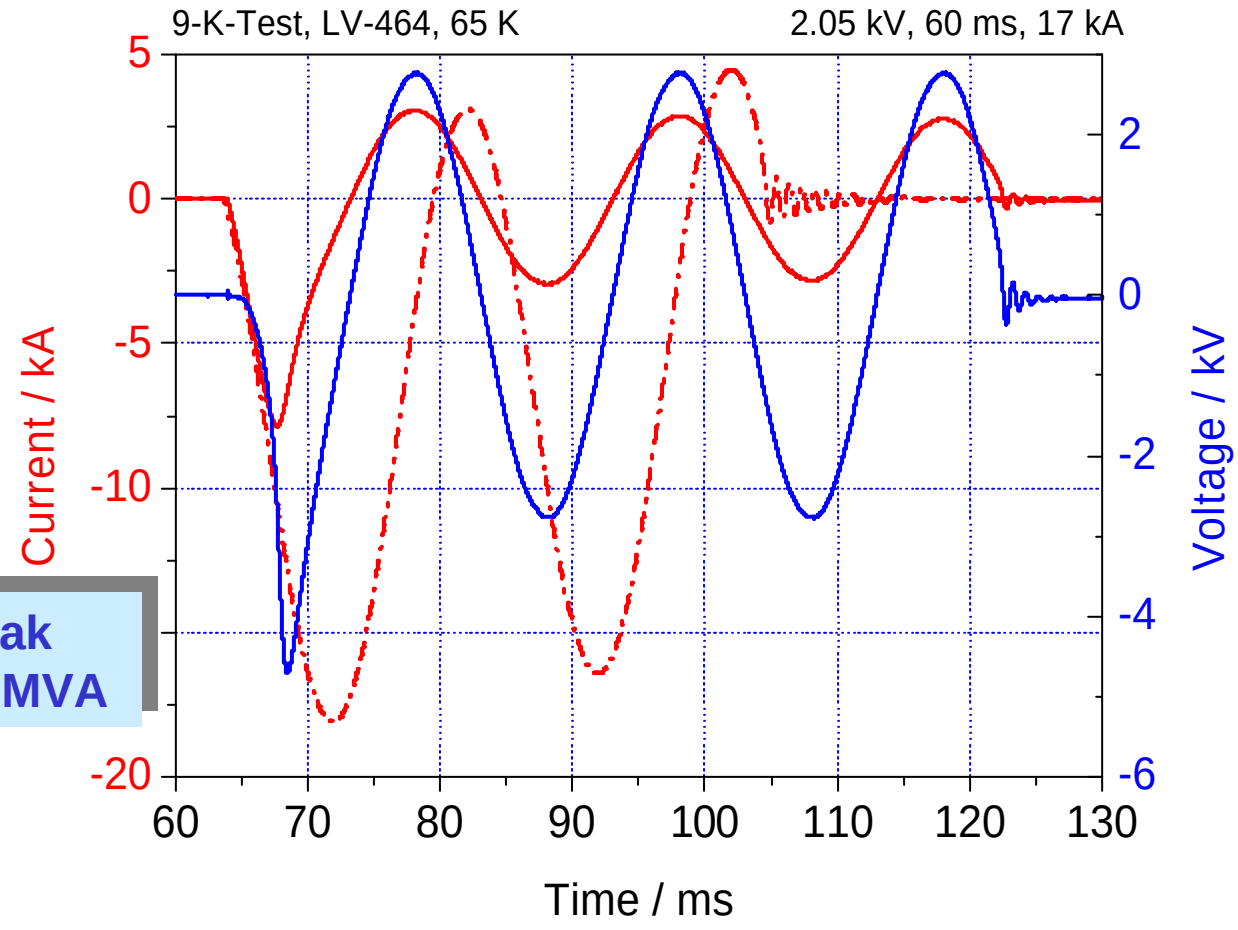
main data of the bifilar component:

outer diameter:	58 mm
superconductor - length:	5.4 m
superconductor - tube:	300 mm
superconductor - cross section:	0.24 cm²
crit. current (65K):	850 A
protected power (65K):	>130 kVA

Most powerful HTS element for resistive SCFCL!

Test results of 1.2 MVA test (2)

Prospective peak short circuit current of 17 kA

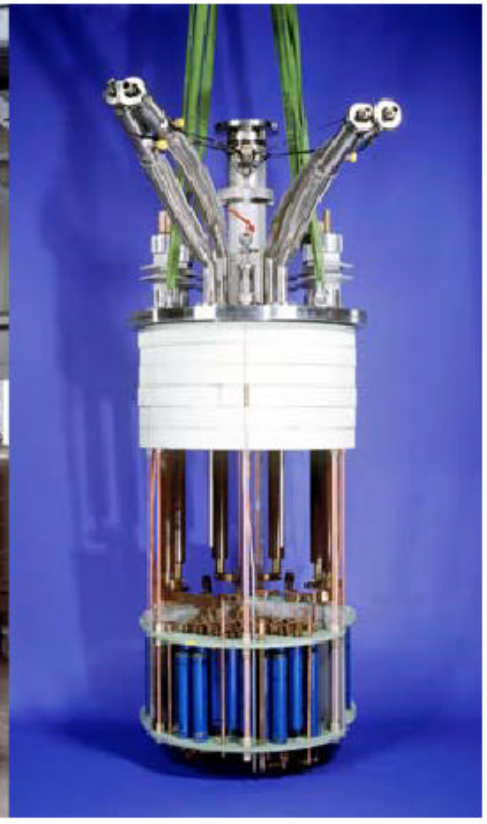


Maximum peak power of 32 MVA

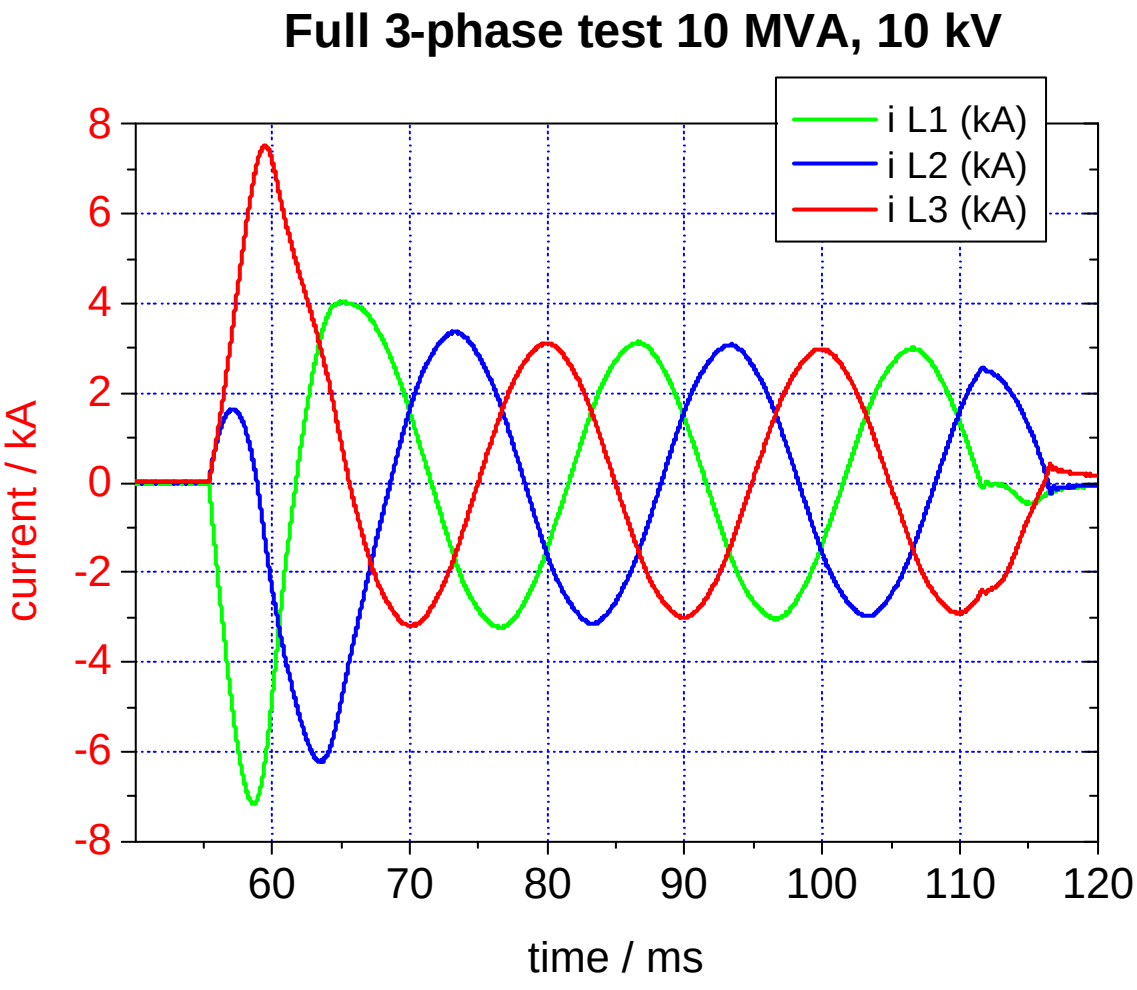
German BMBF project CURL10 (2)

Tests – 10 MVA test

Complete system and insert



German BMBF project CURL10 (3)



voltage:	10 kV_{RMS}
current:	600 A_{RMS}
fault limitation:	60 ms
temperature:	66K
E-field:	0,6 V/cm

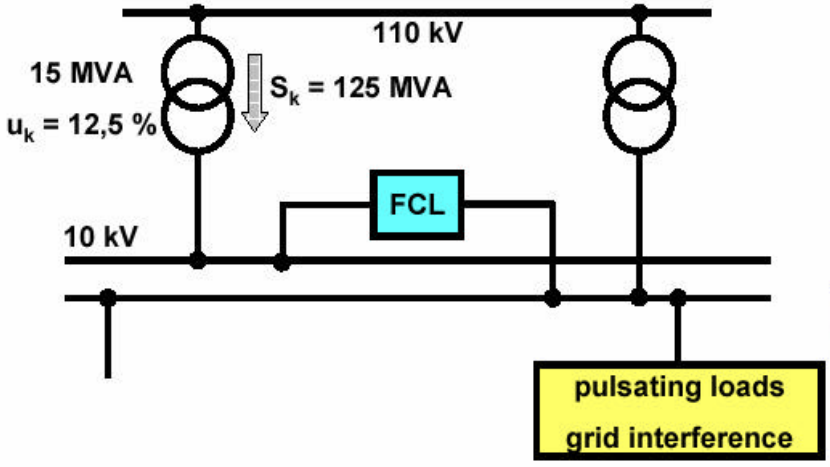
Safe handling of 3 phase fault current!

German BMBF project CURL10 (4)

RWE

Tests - Field test at RWE Netphen

CURL10



Application case:
10 kV grid coupling

...worldwide first testing of a resistive HTS fault current limiter ...

Nexans

US/ DOE SPI Project

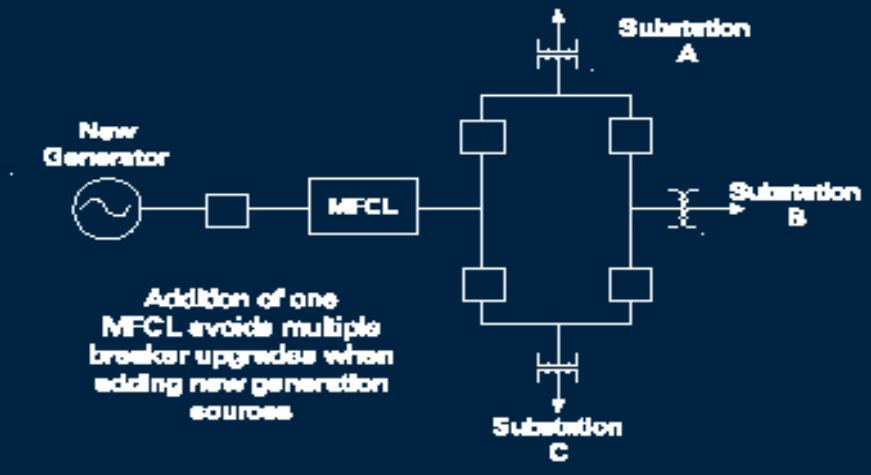
Matrix Fault Current Limiter (MFCL) Project

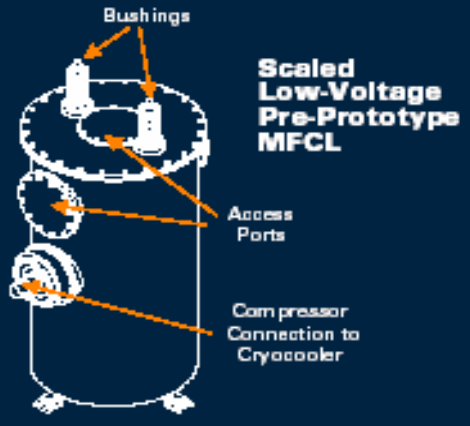
SuperPower • U.S. Department of Energy • EPRI

Program Specifications:
- $12.2M total cost
- Three-phase, 138 kV transmission-level
- Fabricated from bulk BSCCO – 2212 superconductors

Milestones:
- Four-year program
- 2004: Single-phase scaled pre-prototype
- 2005: Single-phase, Alpha prototype
- 2006: Three-phase Beta prototype

HTS MFCL Benefits:
- Modular and scaleable
- Transparent during normal operation
- Passive
- Reliable
- Low cost
- Environmentally benign
- Provides fast response to fault currents





SuperPower Inc. HTS Solutions for a New Dimension in Power

A Subsidiary of Intermagnetics General Corporation

Nexans SuperConductors

Three sucess stories from Bi-2212 (3)

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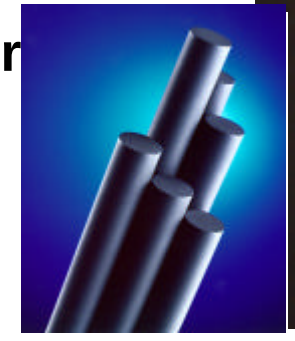
- Superconducting **fault current limiter** elements based on Bi-2212 bifilar coils

- **Bi-2212 precursors and tape conductor**

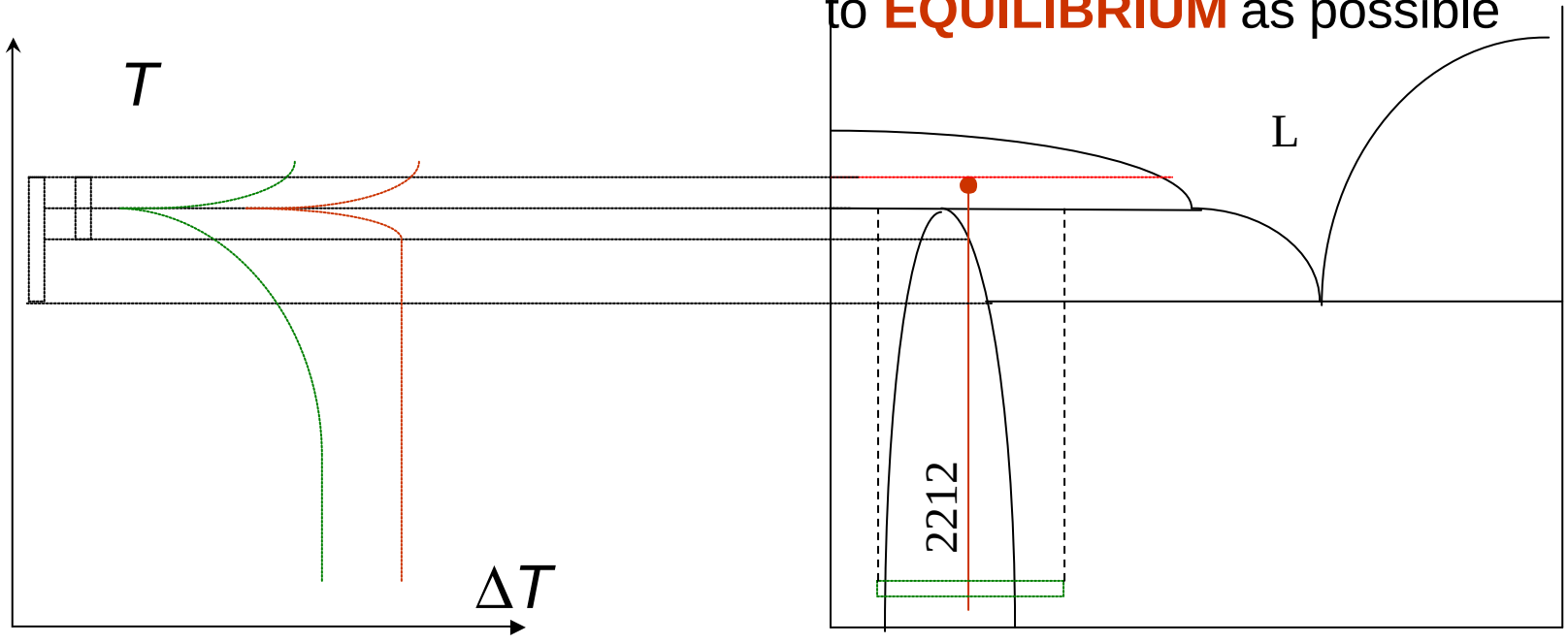


The concept of "EQUILIBRIUM" precursor for Bi-2212

New concept developed for partial melting of Bi-2212 conductors

PHASE SEPARATION during the melting step strongly depends on precursor characteristics

Minimize PHASE SEPARATION by
- choosing proper composition;
- making precursor as close to **EQUILIBRIUM** as possible



The performance of Nexans Bi-2212 precursor at OST (1)

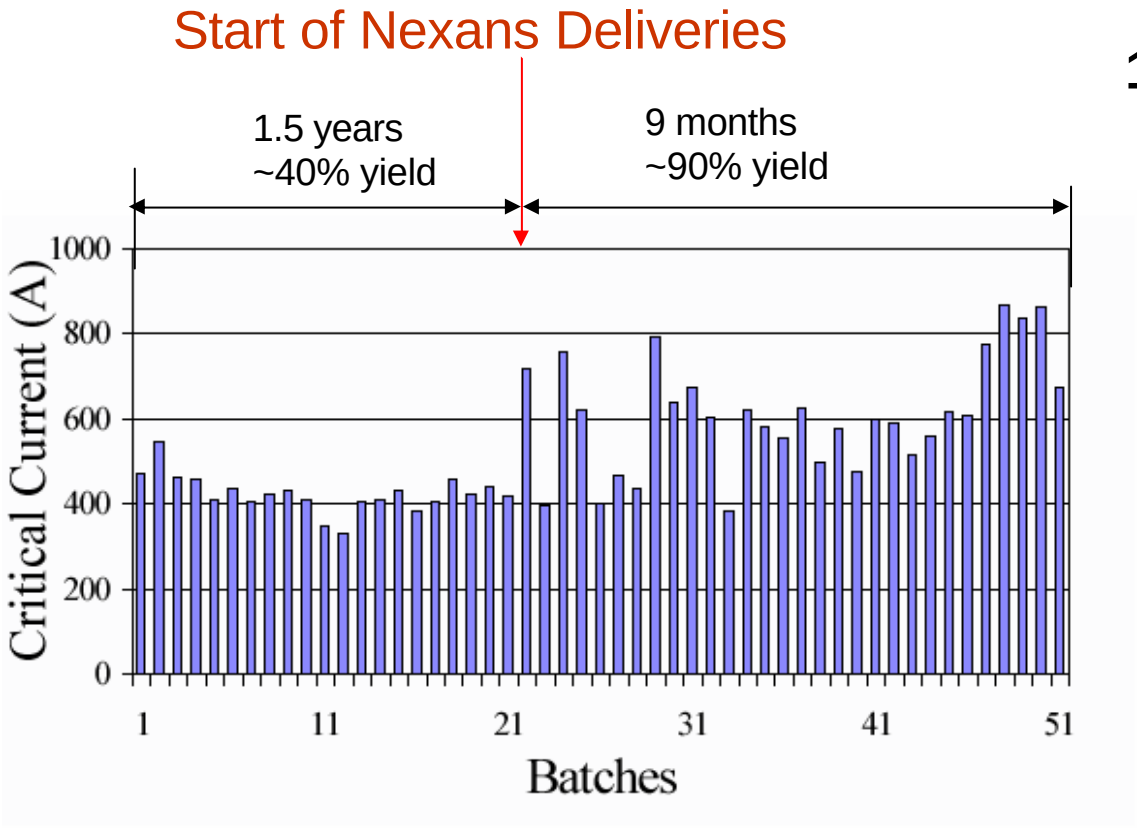


FIGURE 1. Chronological I_c (4.2 K, 0 T) values obtained in batches of 19 filament tapes recently fabricated for 5 T insert

19 filament PIT tapes

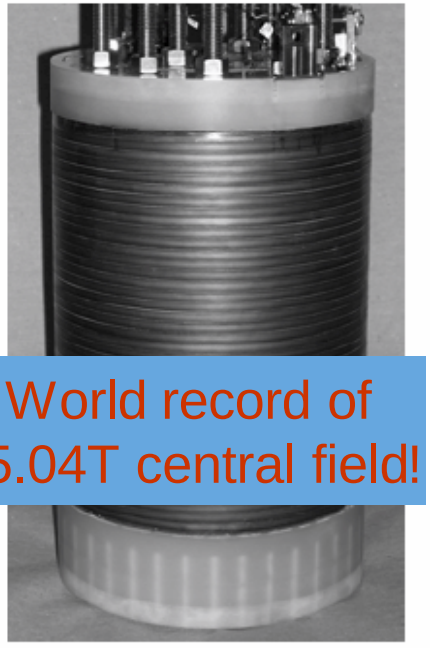
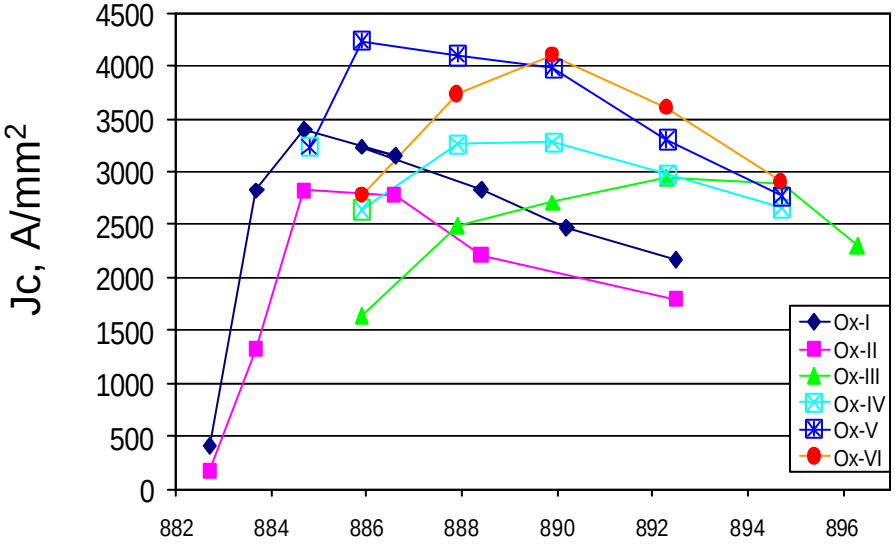


FIGURE 2. The 5 tesla insert magnet which achieved 25 T central field.

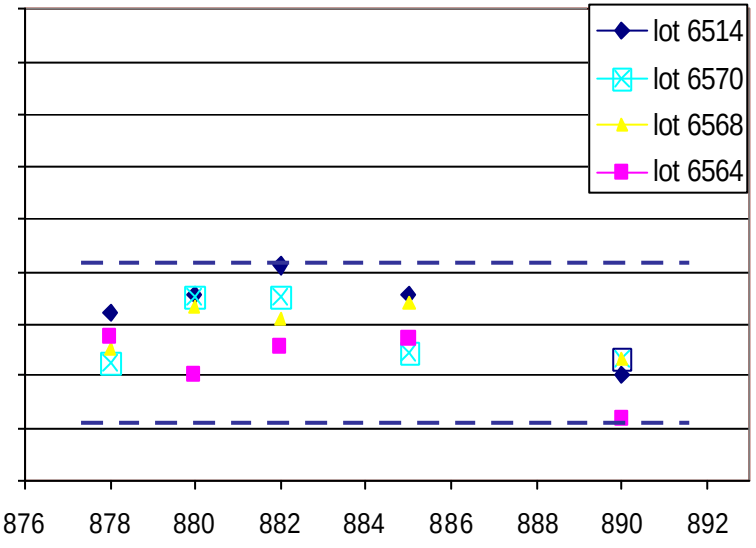
The performance of Nexans Bi-2212 precursor at OST (2)

Evaluation of DIP-coated tapes

Optimization of Nexans **"Equilibrium"** Powder Lots



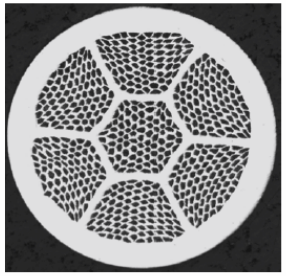
Evaluation for **non-Equilibrium** Powder Lots

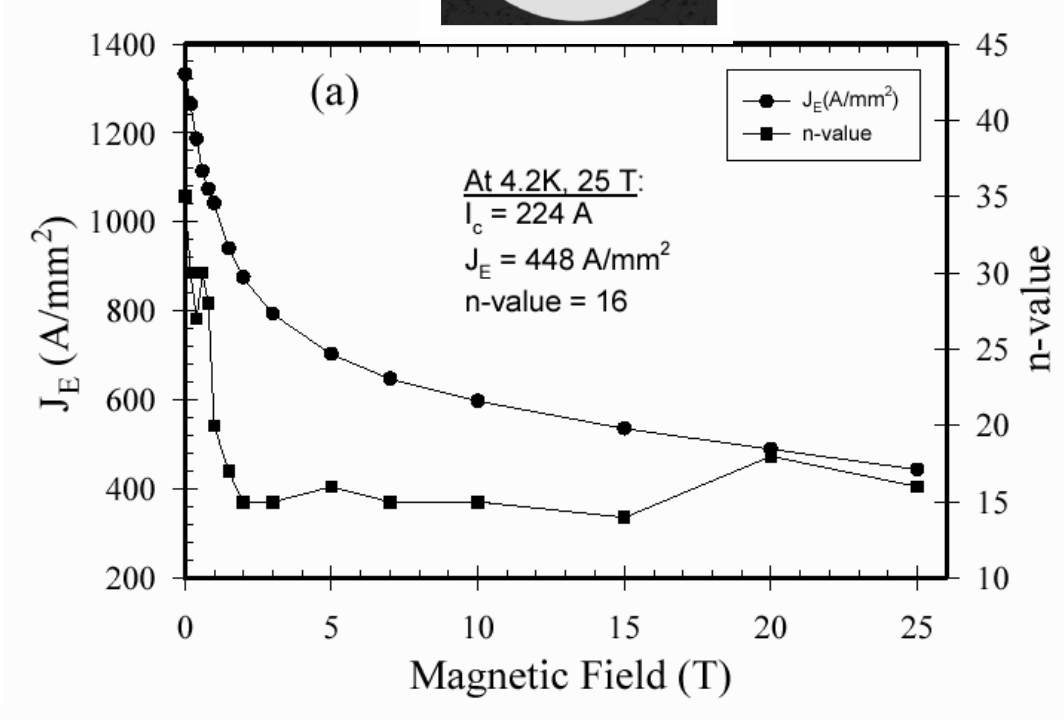


(Courtesy of Dr. K. Marken)

The performance of Nexans Bi-2212 precursor at OST (3)

Magnetic field dependence of OST round wire



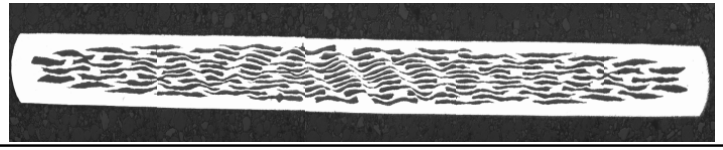


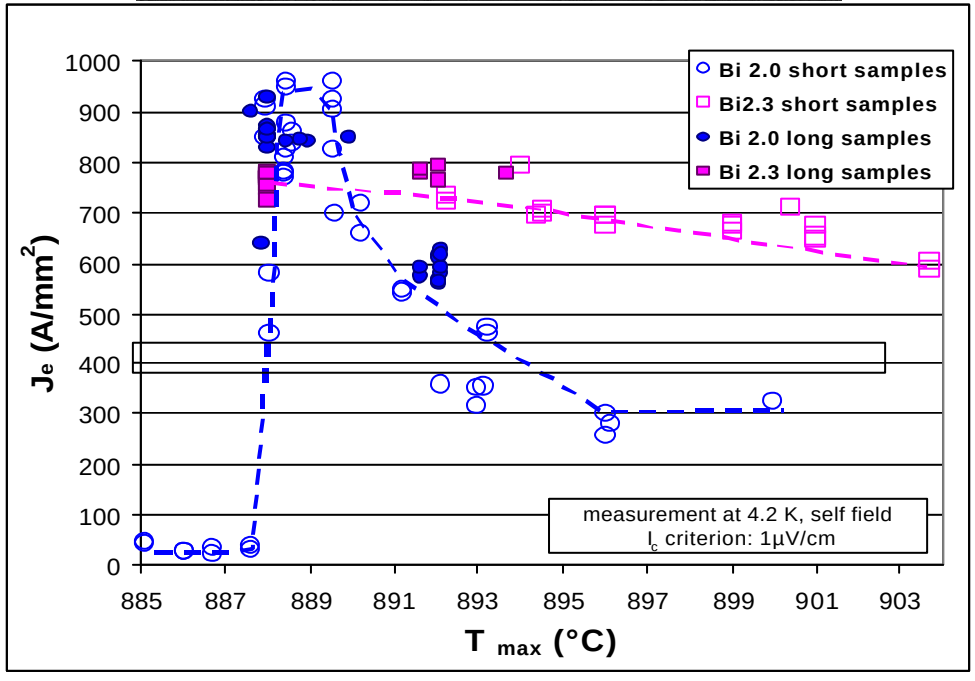
Significant improvement is anticipated from optimizing

- conductor design
- overall composition
- preannealing, melting and solidification steps of heat treatment

(Courtesy of Dr. K. Marken)

Optimization of Je for 85-filamentary tape, 10 m length

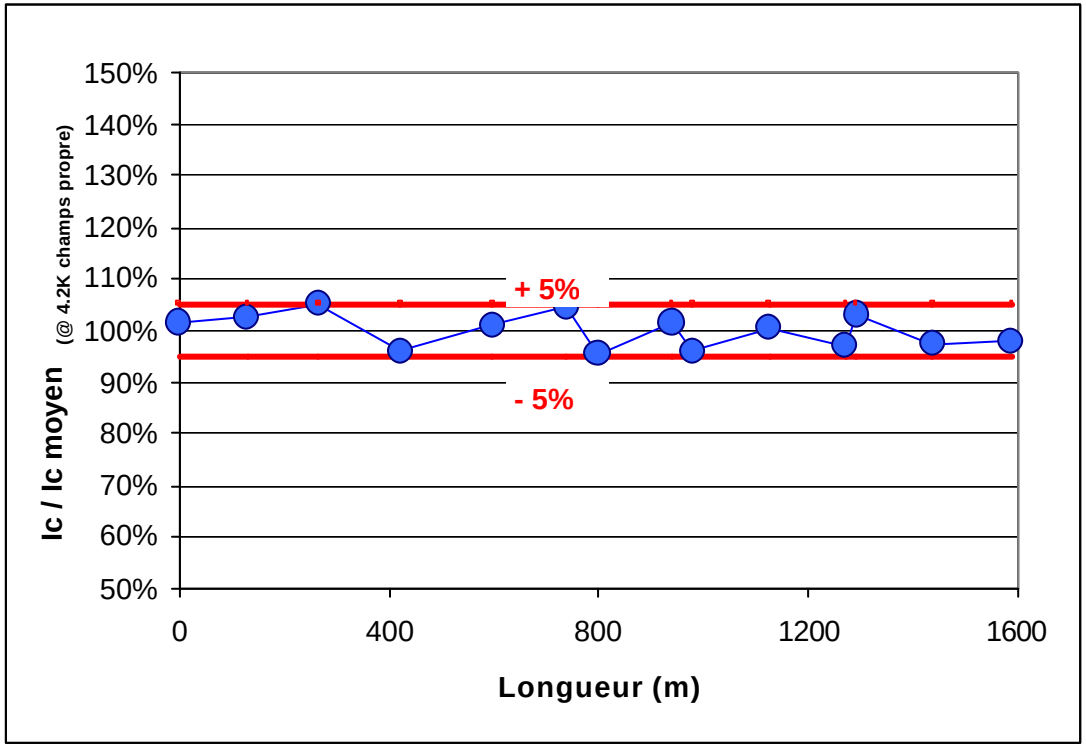




= previous level attainable with nonequilibrium precursor and another HT

Performance of 2212 conductors
Nexans, December 2003

Maximum
J_e= 1180 A/mm²
(4.2K, self field)

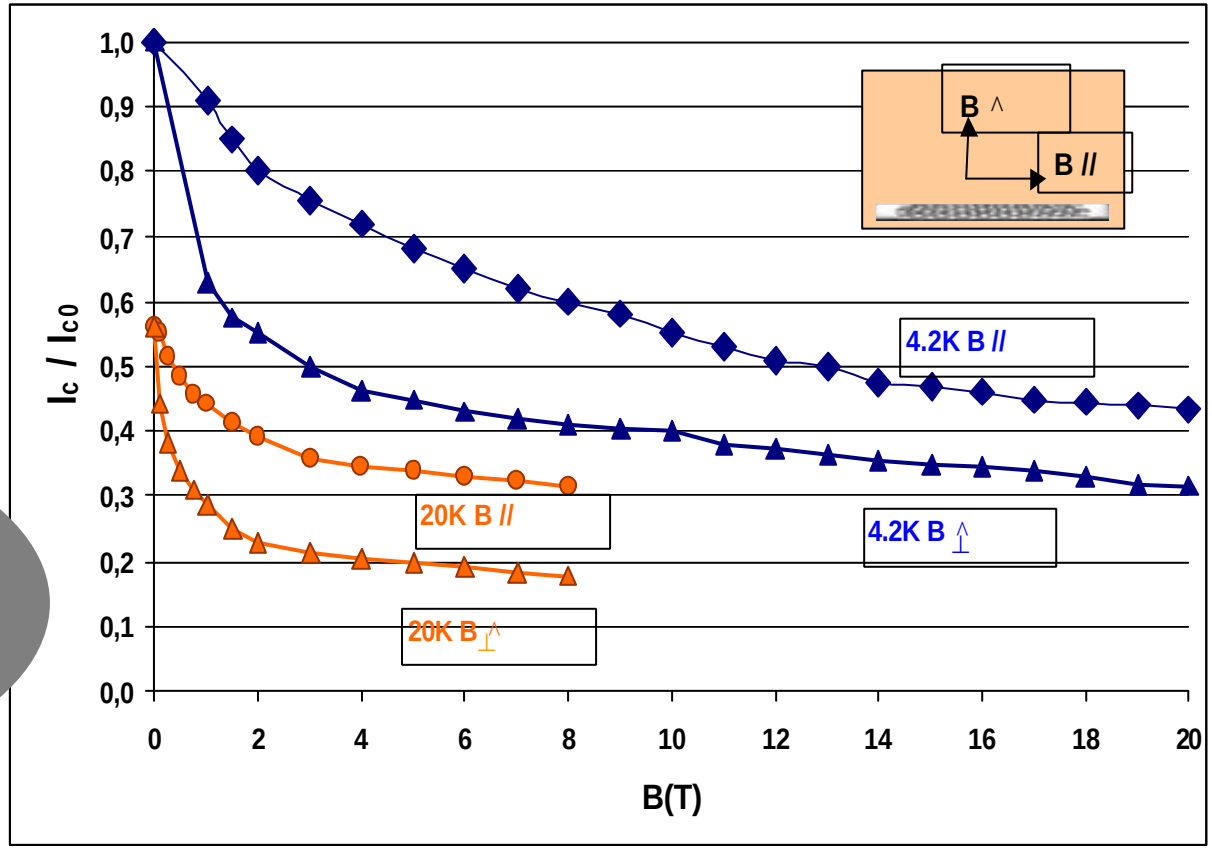


Magnetic field dependence
Nexans, January 2004

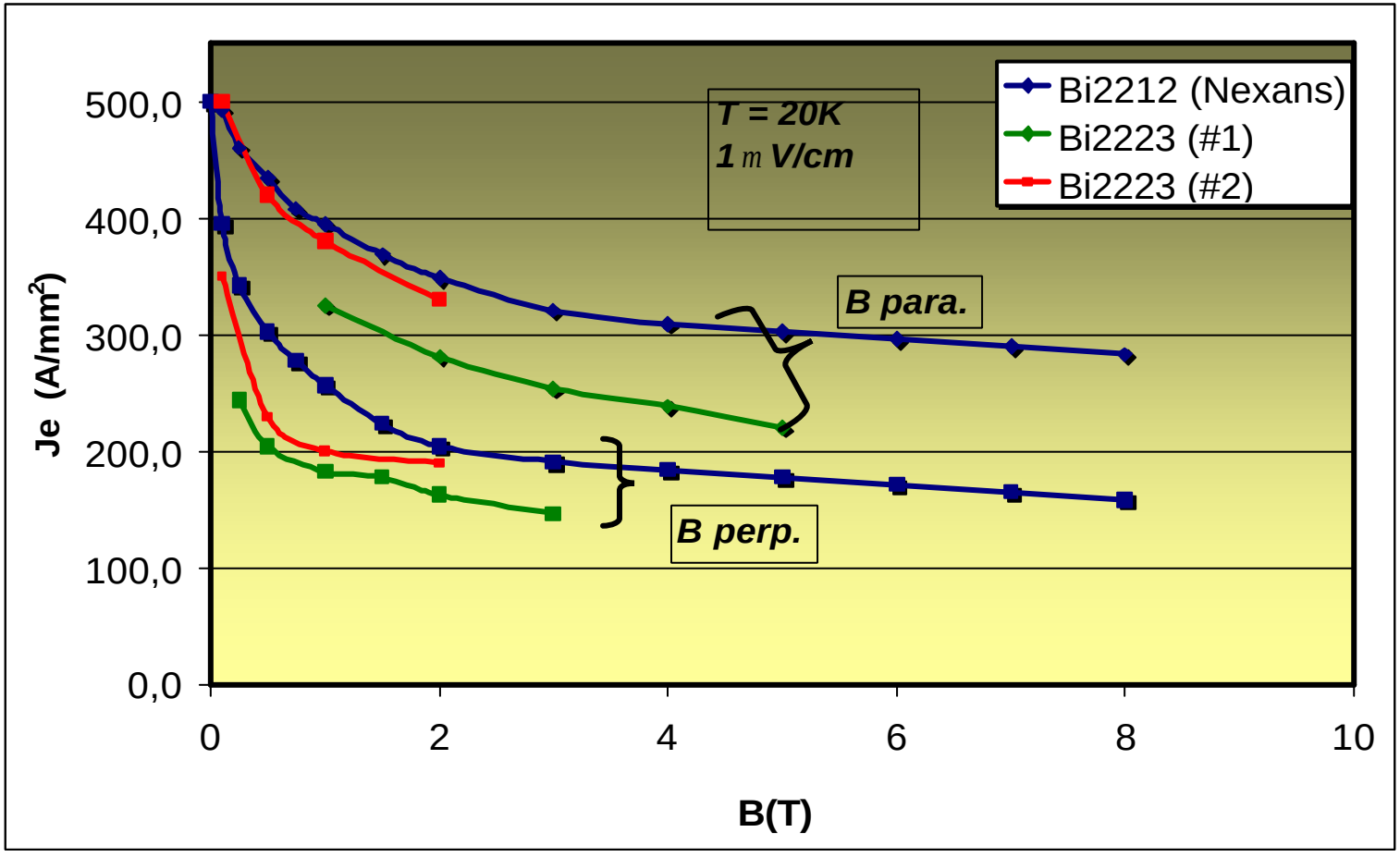
J_e = 1180 A/mm^2
4.2K, self field

J_e>500 A/mm^2
4.2K, 20T//

J_e> 300 A/mm^2
20K, 5T//



Performance at 20 K
Comparison with Bi-2223 tape



Summary

- With Bi-2212 tubes used in current leads up to 20 kA (70 K, self field) were achieved
- Worlds first resistive fault current limiter (10 MVA/ 10 kV) is based on Bi-2212 bifilar coils and goes now on line
- Nexans Bi-2212 equilibrium precursor used for new record insert coils with 25 T inner magnet field
- Current Status of Bi-2212 Tape Performance at Nexans
  - J_e(4.2K, self field) ~ 1200 A/mm^2
  - J_e (20 K, 5T//) ~ 300 A/mm^2
  - in 1500 m length