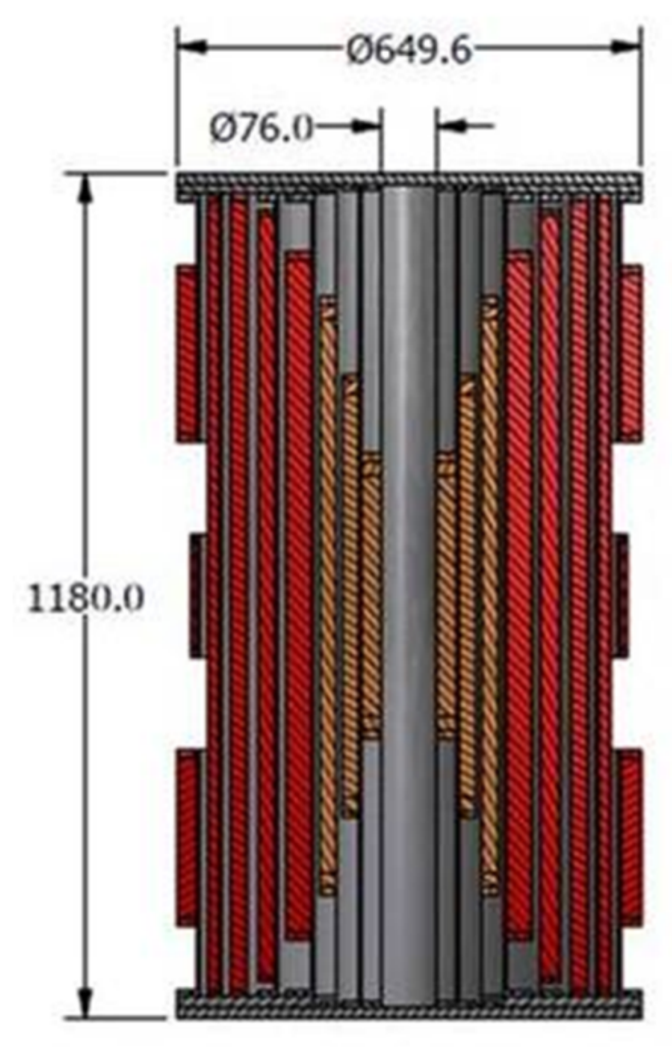
NATIONAL HIGH MAGNETIC FIELD LABORATORY

Frontiers in Magnetic Resonance: Why are we in the midst of a revolution?



Concept

30 T / 1.3 GHz NMR

15 T LTS, 15 T HTS

Greg Boebinger

MagLab Director

nationalmaglab.org

First a Literary Allusion:

All the World's a Stage
-or-
The Seven Ages of the Academic

1. The infant, mewling and puking
2. The whining schoolboy
3. The lover, sighing like a furnace
4. The soldier, full of strange oaths
5. The justice, in fair round belly
6. The sixth age, with spectacles on nose
7. The second childishness…
   sans teeth, sans eyes, sans taste

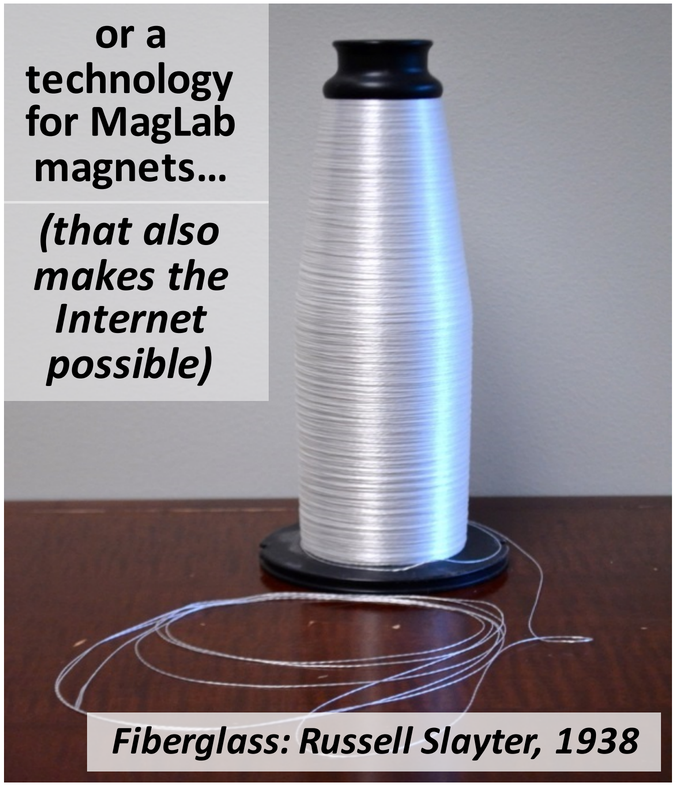
1. The undergraduate student
2. The graduate student
3. The postdoc
4. The assistant professor
5. The associate professor
6. The full professor
7. The after dinner speaker

Materials Become Wonderful Despite Being Constrained by Their Properties

Starting initially in 2000 BCE, sand in the human hand…

Dale Chihuly

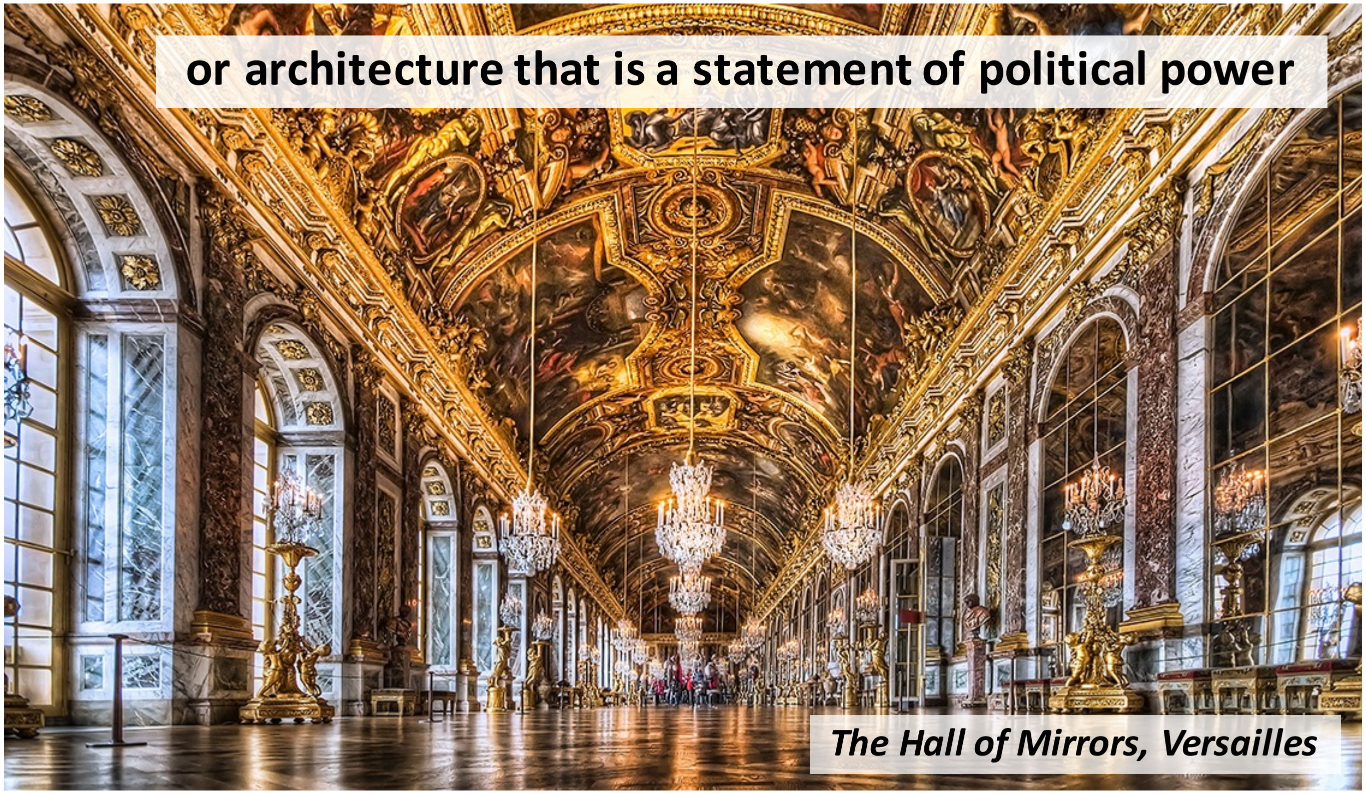
can become art



or a technology for MagLab magnets…

(that also makes the Internet possible)

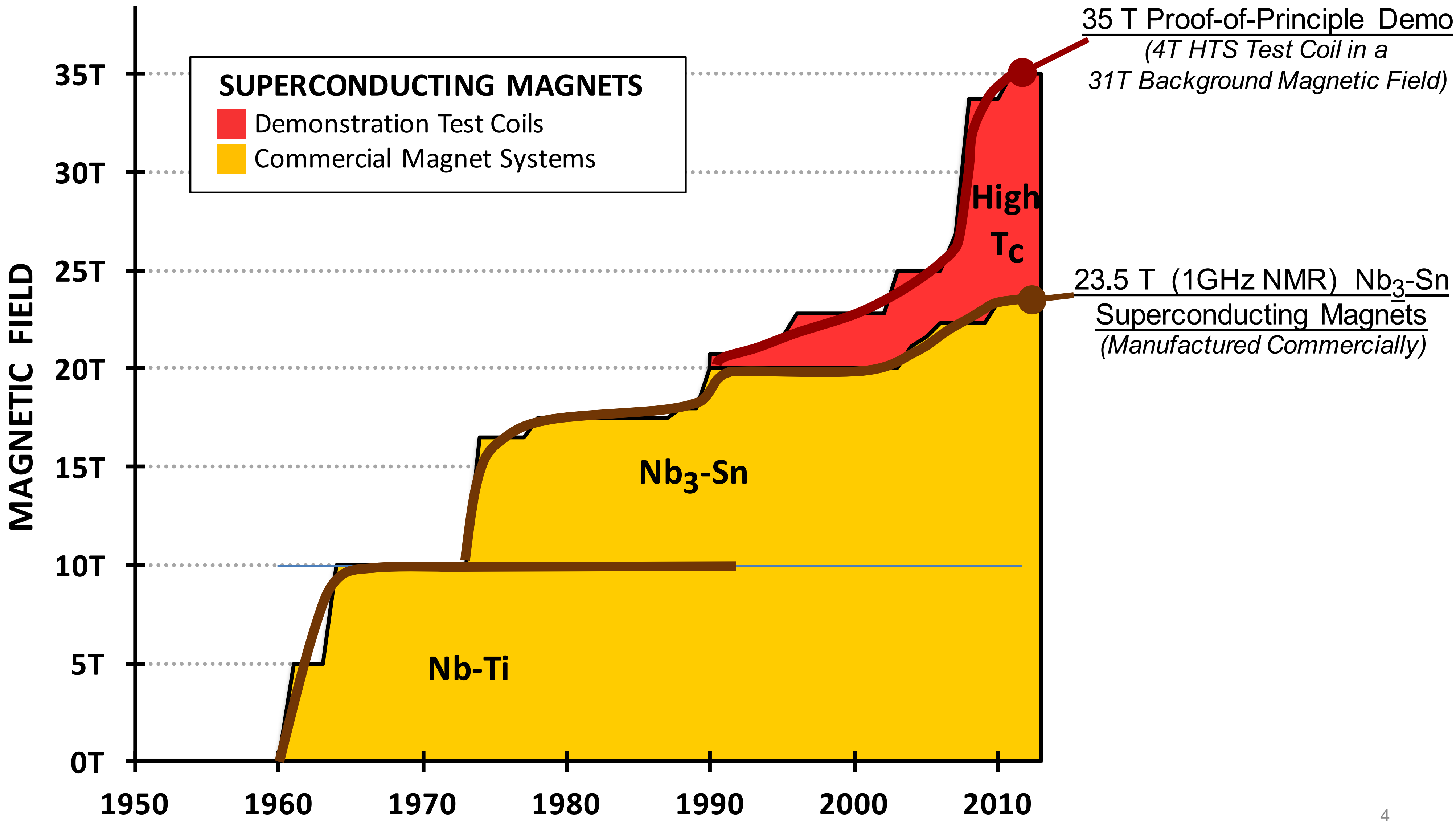
Fiberglass: Russell Slayter, 1938



or architecture that is a statement of political power

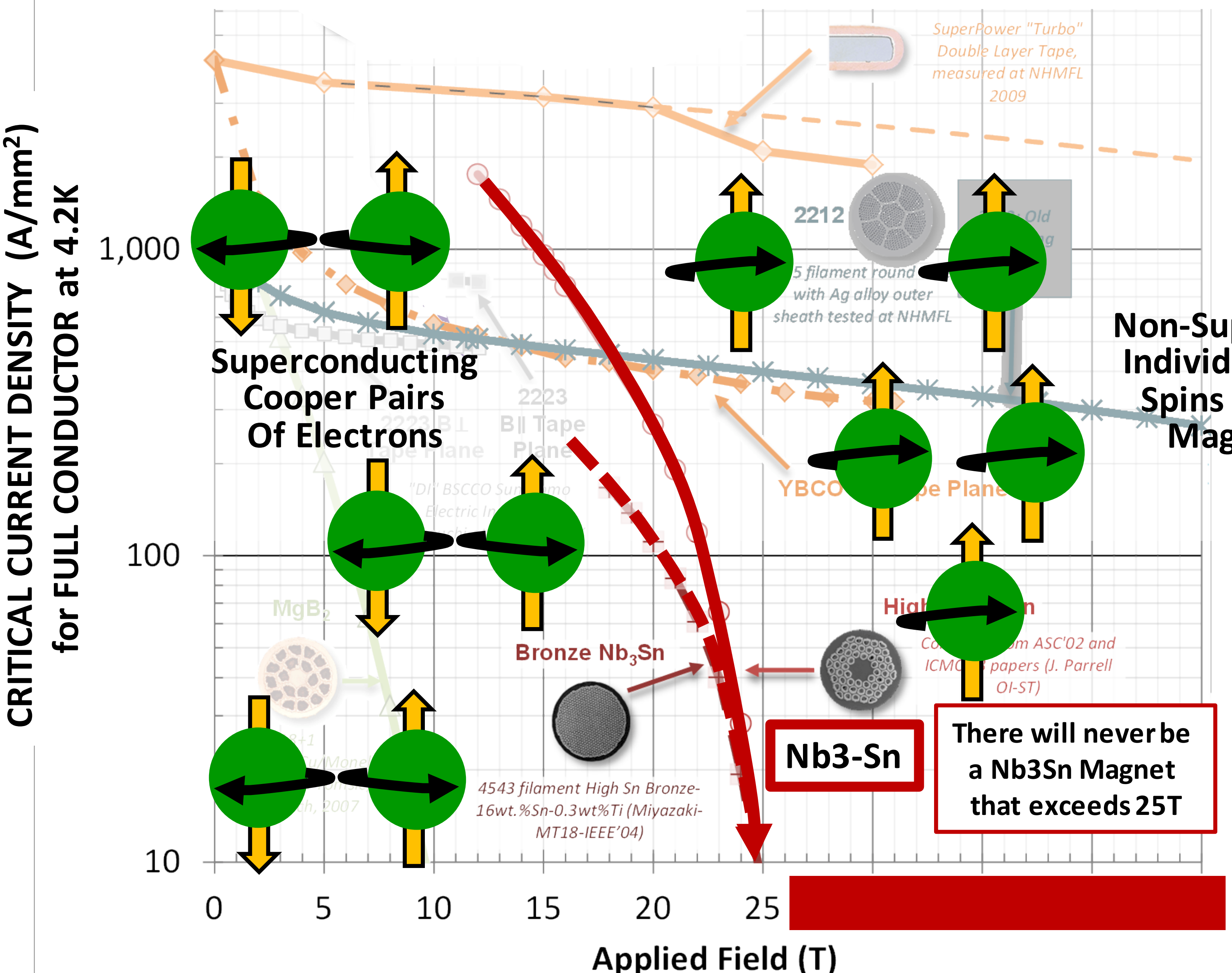
The Hall of Mirrors, Versailles

Materials Enable Magnets:
Watching a revolution in real time



Low-Tc Superconductors Have Hit a Physical Limit:

Upper Critical Magnetic Field Cannot Be Exceeded



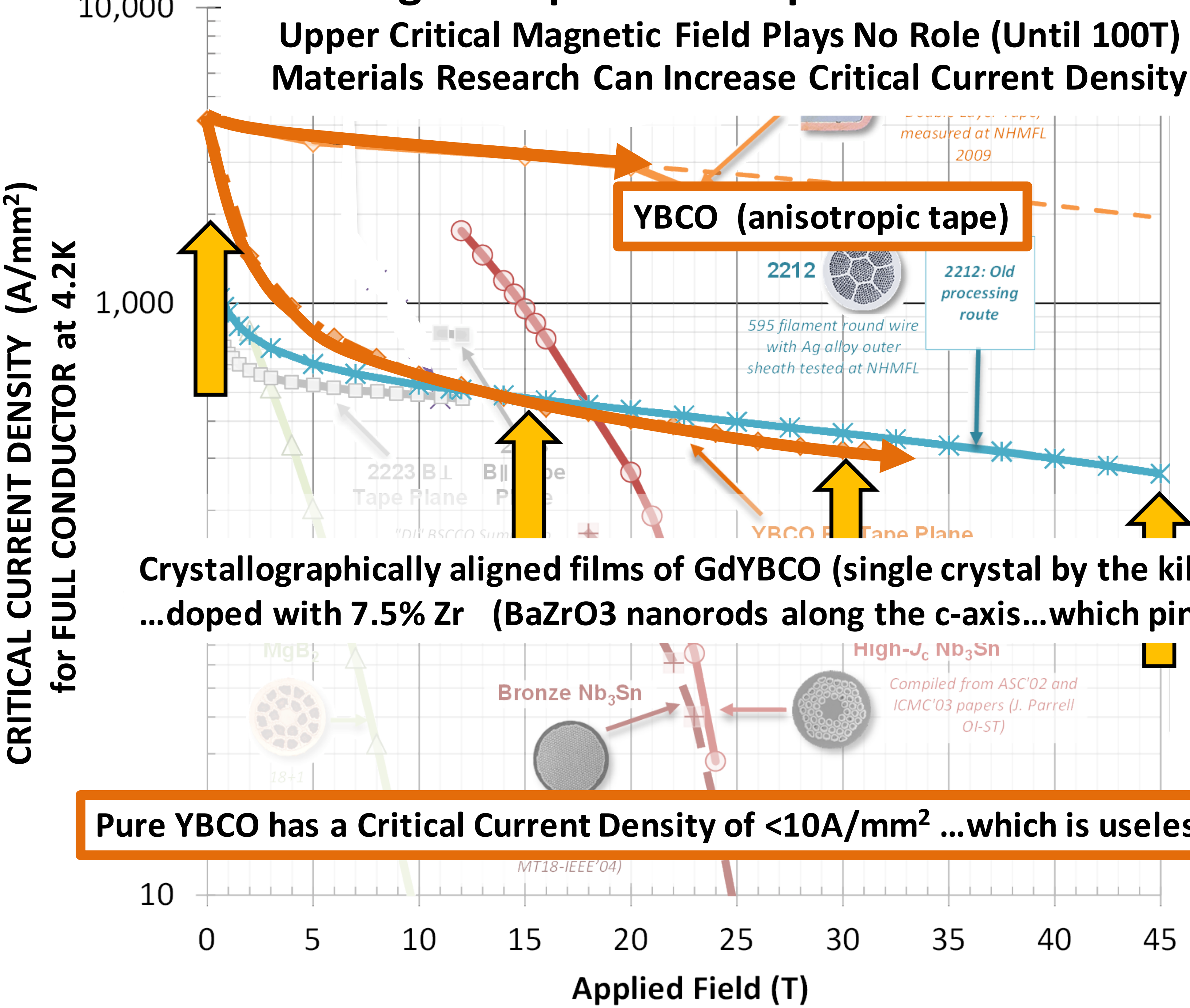
Non-Superconducting Individual Electrons: Spins Polarized by Magnetic Field

Plot maintained by Peter Lee at:

magnet.fsu.edu /~lee/plot/plot.htm

High Temperature Superconductors:

Upper Critical Magnetic Field Plays No Role (Until 100T)
Materials Research Can Increase Critical Current Density



Crystallographically aligned films of GdYBCO (single crystal by the kilometer)
…doped with 7.5% Zr (BaZrO3 nanorods along the c-axis…which pin magnetic flux)

Pure YBCO has a Critical Current Density of <10A/mm² …which is useless for magnets

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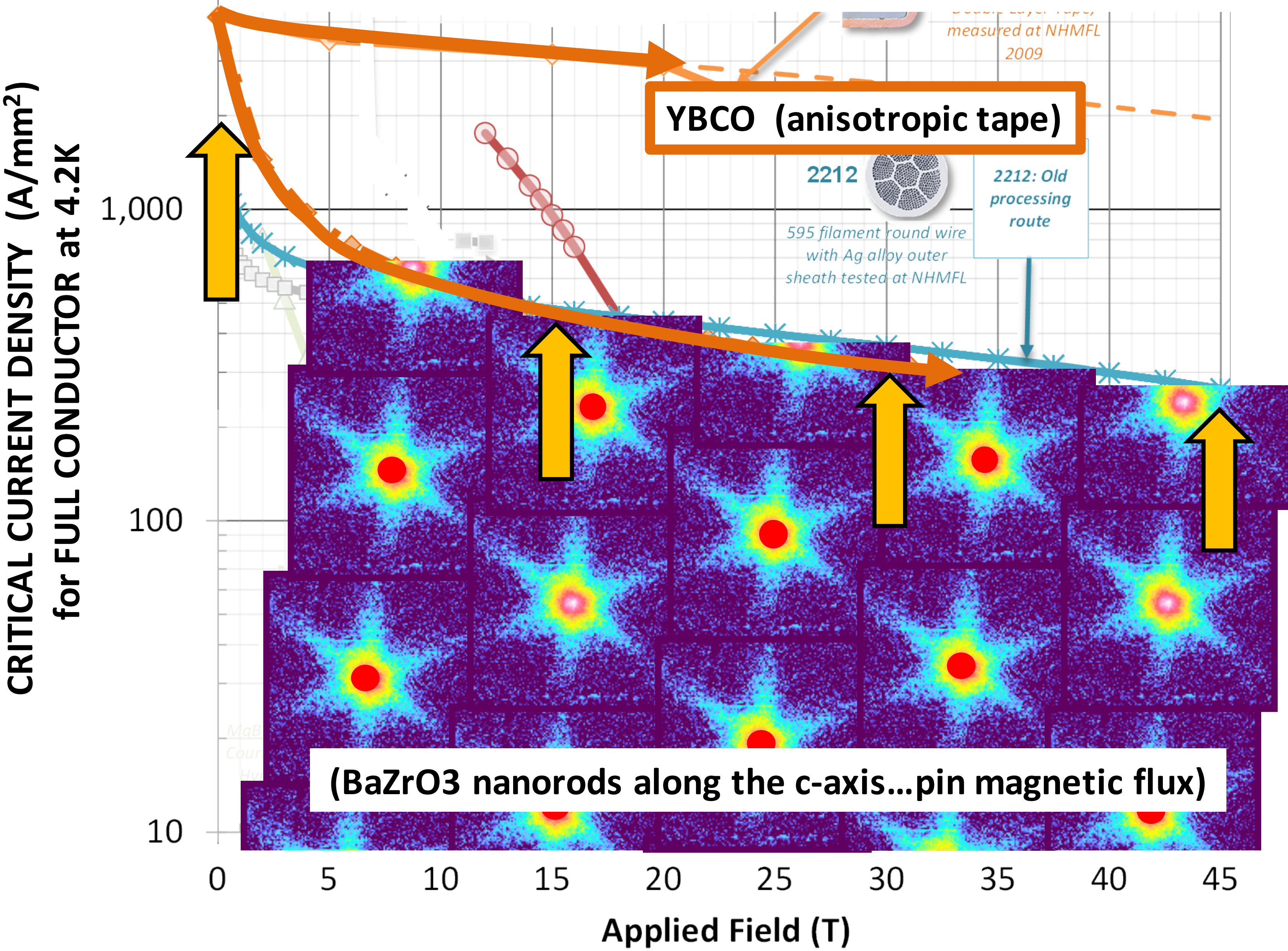

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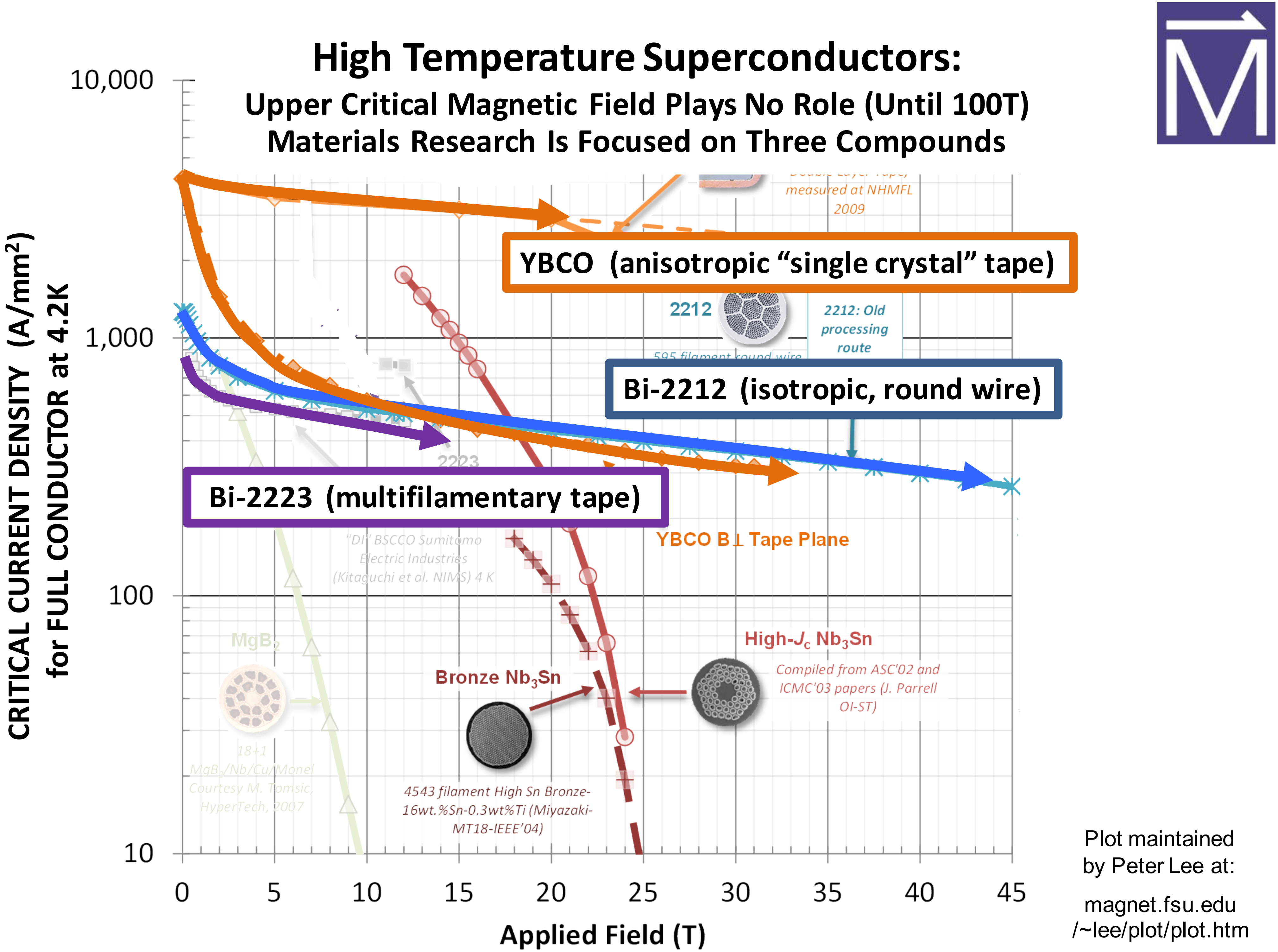

High Temperature Superconductors:
Upper Critical Magnetic Field Plays No Role (Until 100T)
Materials Research Is Focused on Three Compounds
CRITICAL CURRENT DENSITY (A/mm²)
for FULL CONDUCTOR at 4.2K
10,000
1,000
100
10
0
5
10
15
20
25
30
35
40
45
Applied Field (T)
measured at NHMFL
2009
YBCO (anisotropic "single crystal" tape)
2212
2212: Old
processing
route
Bi-2212 (isotropic, round wire)
2223
Bi-2223 (multifilamentary tape)
"DI" BSCCO Sumitomo
Electric Industries
(Kitaguchi et al. NIMS) 4 K
YBCO B⊥ Tape Plane
MgB2
High-Jc Nb3Sn
Compiled from ASC'02 and
ICMC'03 papers (J. Parrell
OI-ST)
Bronze Nb3Sn
18+1
MgB2/Nb/Cu/Monel
Courtesy M. Tomsic,
HyperTech, 2007
4543 filament High Sn Bronze-
16wt.%Sn-0.3wt%Ti (Miyazaki-
MT18-IEEE'04)
Plot maintained
by Peter Lee at:
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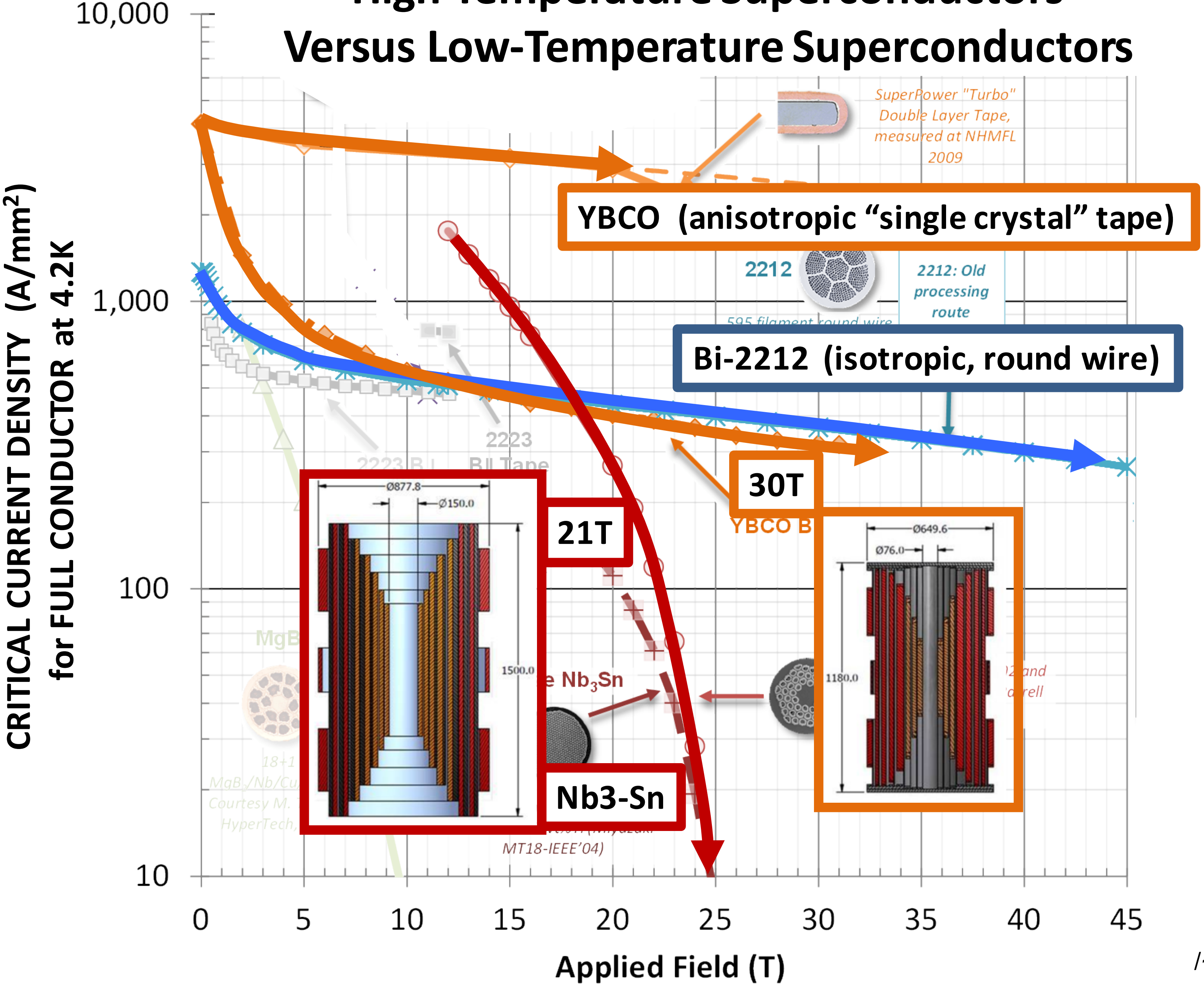
High Temperature Superconductors Versus Low-Temperature Superconductors



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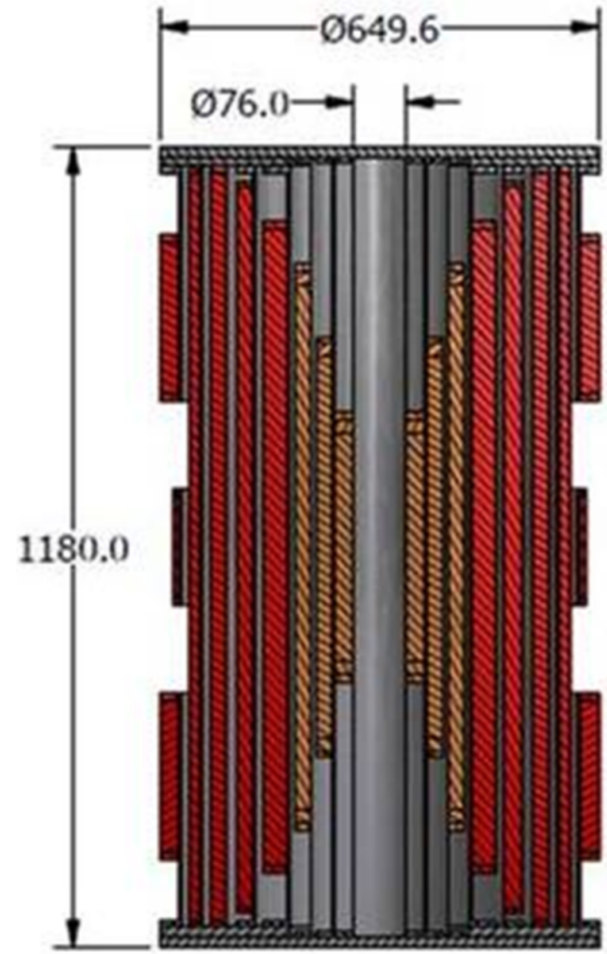
Larger Critical Current Density…
Yields Smaller Magnet Coils…
Yields Smaller Stresses

Stress = Current Density
x Radius
x Magnetic Field



MAGLAB CONCEPT

30 T / 1.3 GHz NMR
15 T LTS, 15 T HTS

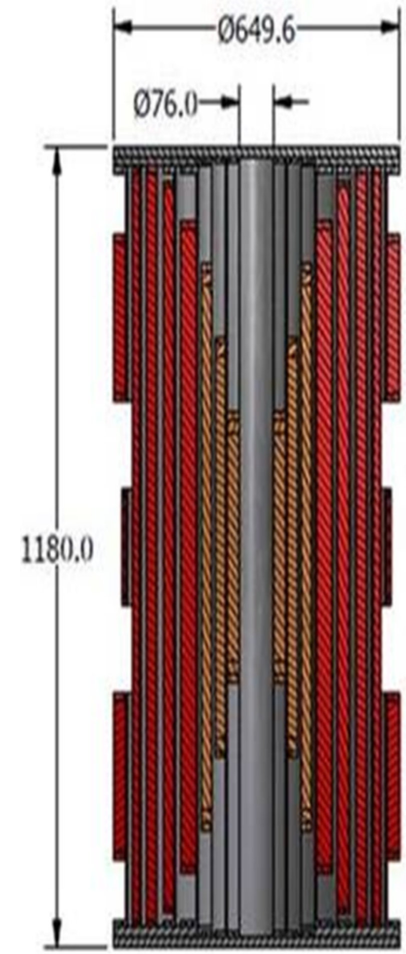
Larger Critical Current Density…
Yields Smaller Magnet Coils…
Yields Smaller Stresses

Stress = Current Density

x Radius

x Magnetic Field

Cost of Magnet is Proportional to Weight !

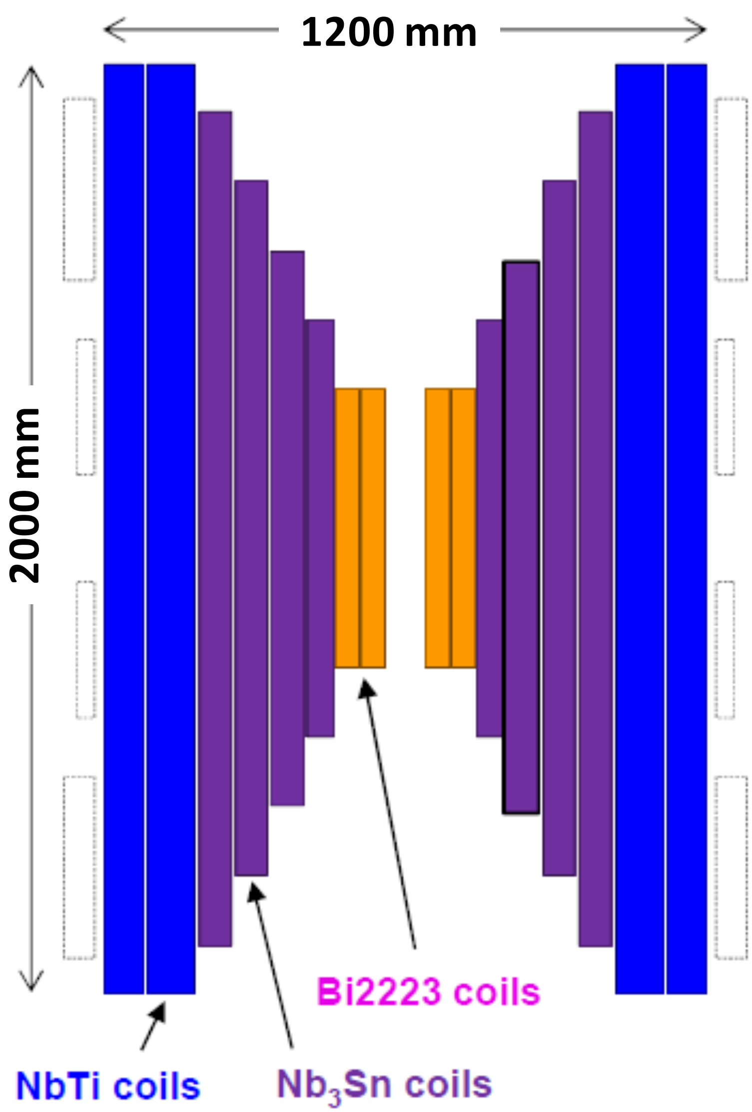


MAGLAB MANAGER CONCEPT

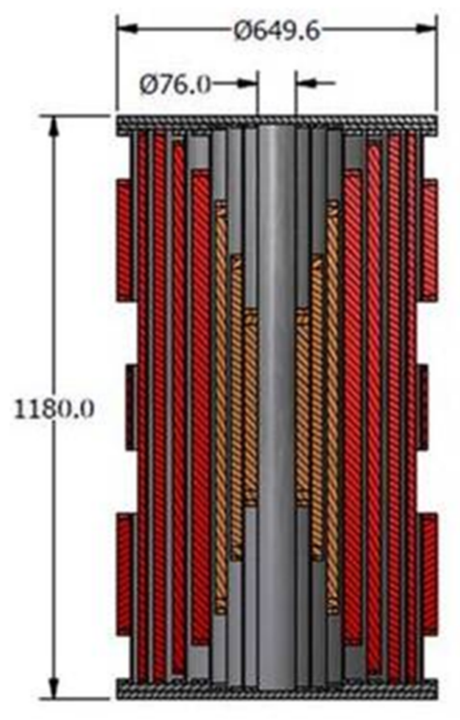
30 T / 1.3 GHz NMR

15 T LTS, 15 T HTS

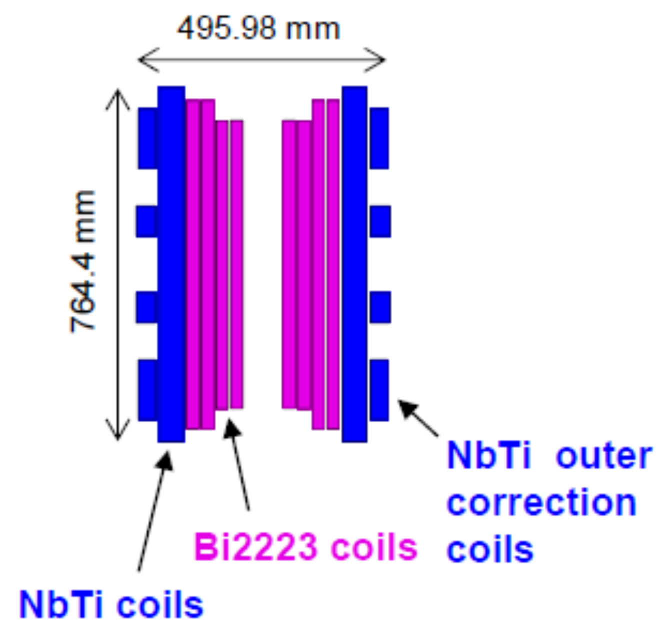
The Benefits of “Big HTS” Coils Over “Little HTS” Coils:
Enabling the Exploitation of Future Improvements in Materials Properties
to place us directly on the road to 1.6GHz (37.5T) NMR Magnets



RIKEN CONCEPT
28 T / 1.2 GHz NMR



MAGLAB CONCEPT
30 T / 1.3 GHz NMR
15 T LTS, 15 T HTS



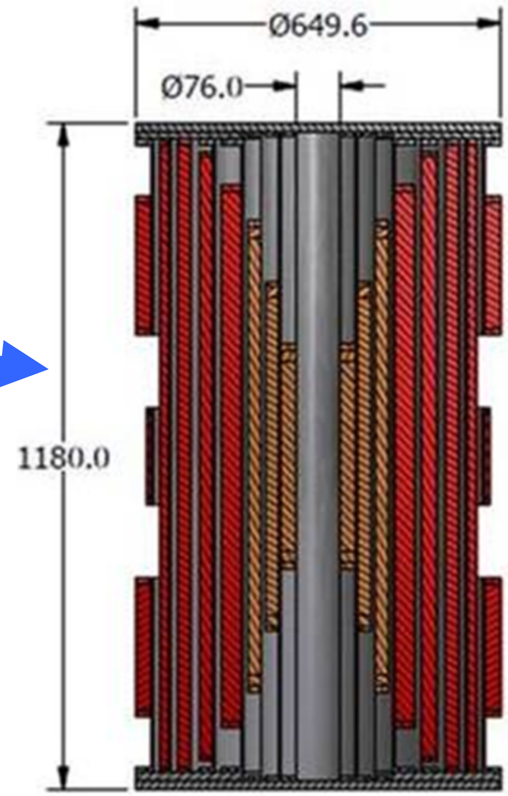
RIKEN CONCEPT
With high-strength Bi2223
28 T / 1.2 GHz NMR

In Summary…from the perspective of someone who has never built an NMR magnet and only done one NMR experiment in his life.

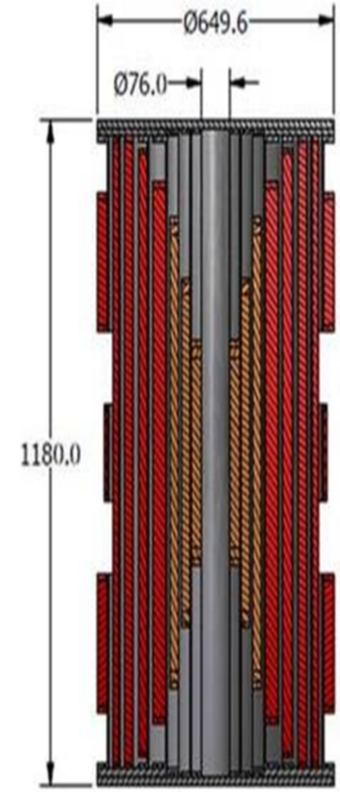
(…to whom you aren't paying any honorarium…)

This is why there is a "High Tc" revolution in the making

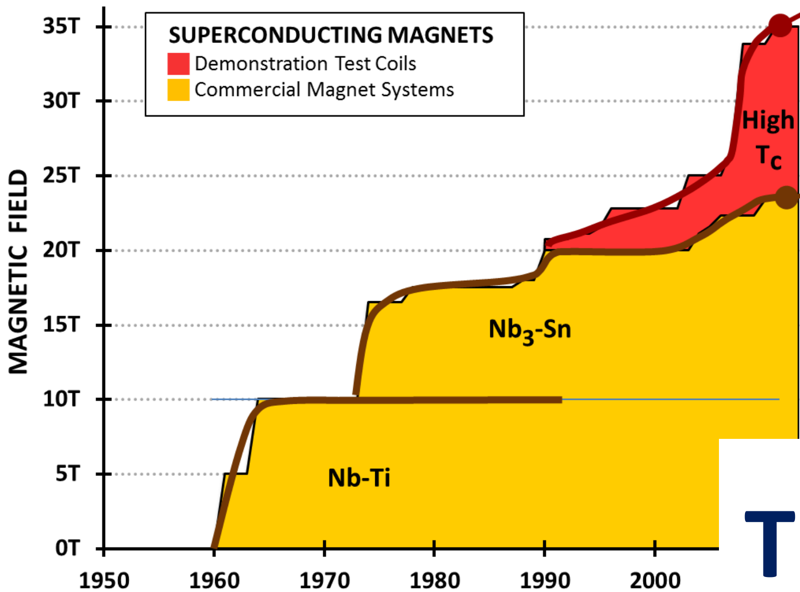
This is why we're at a "Low-Tc" Impasse



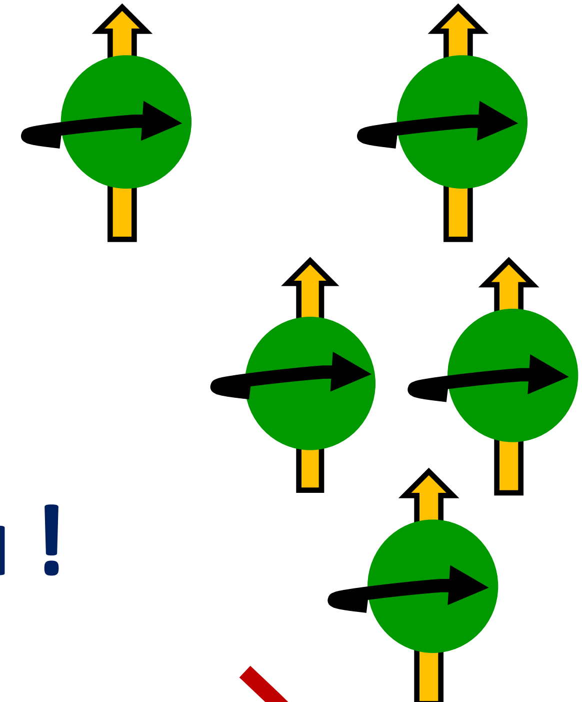
The "Big HTS" Philosophy Yields Smaller Higher-Field Magnets…

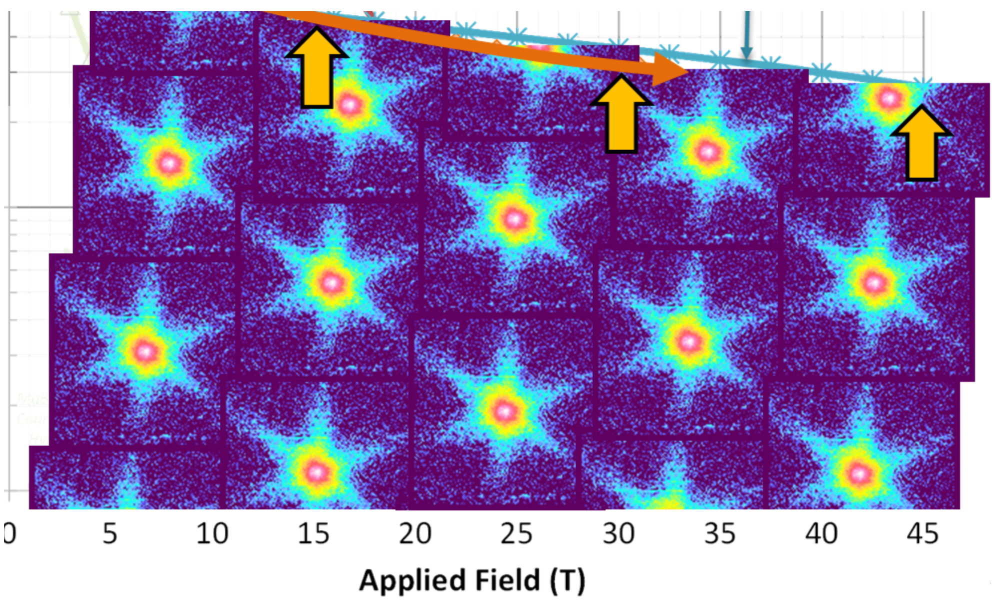


…which will continue to improve as HTS materials improve



Thank You !





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