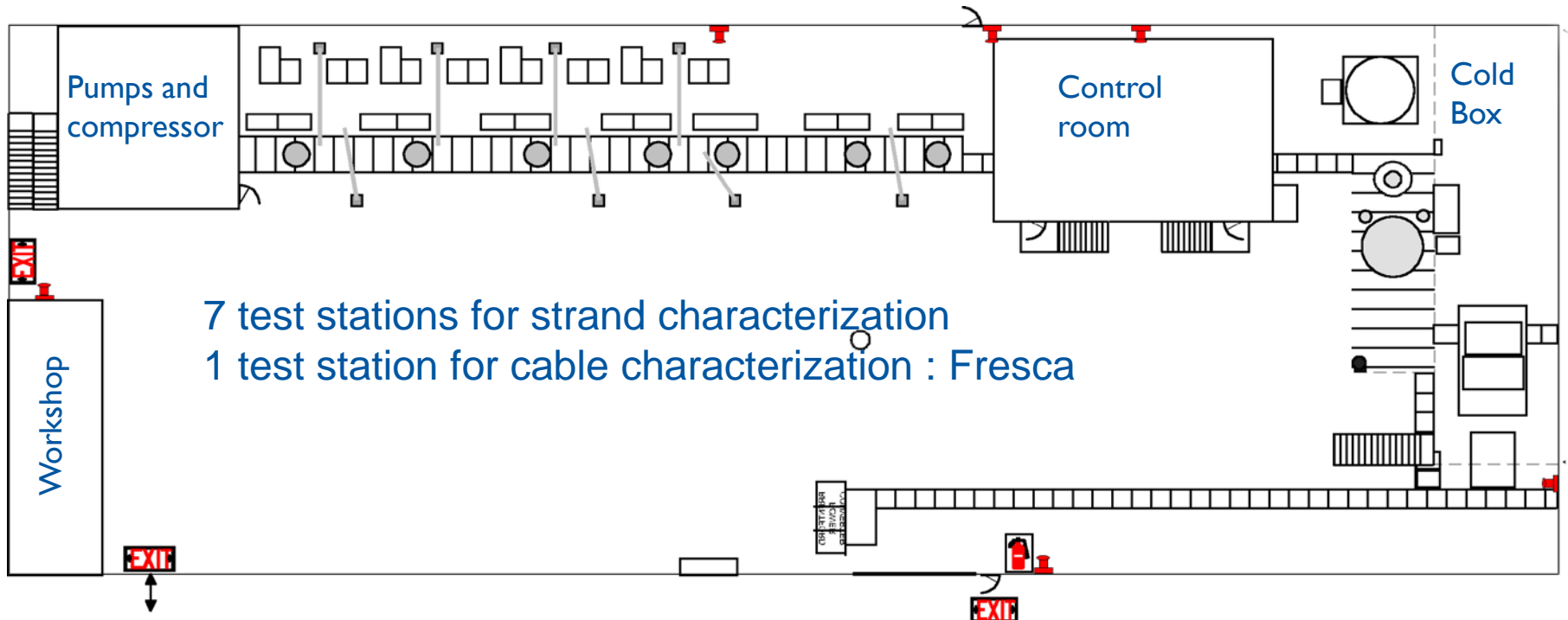


# Superconductivity lab

MSC-CMI meeting, 16/12/2013

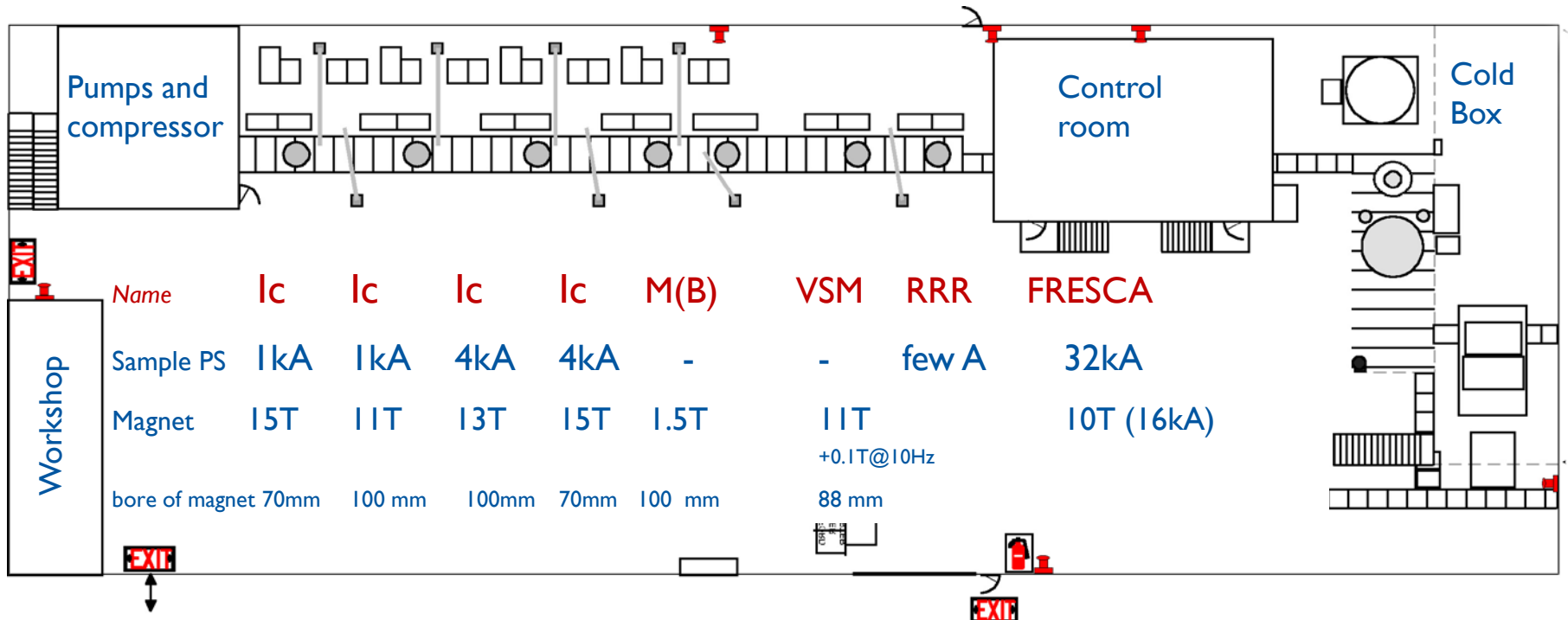
Sandrine Le Naour

# Bat 163 : Superconductivity Lab



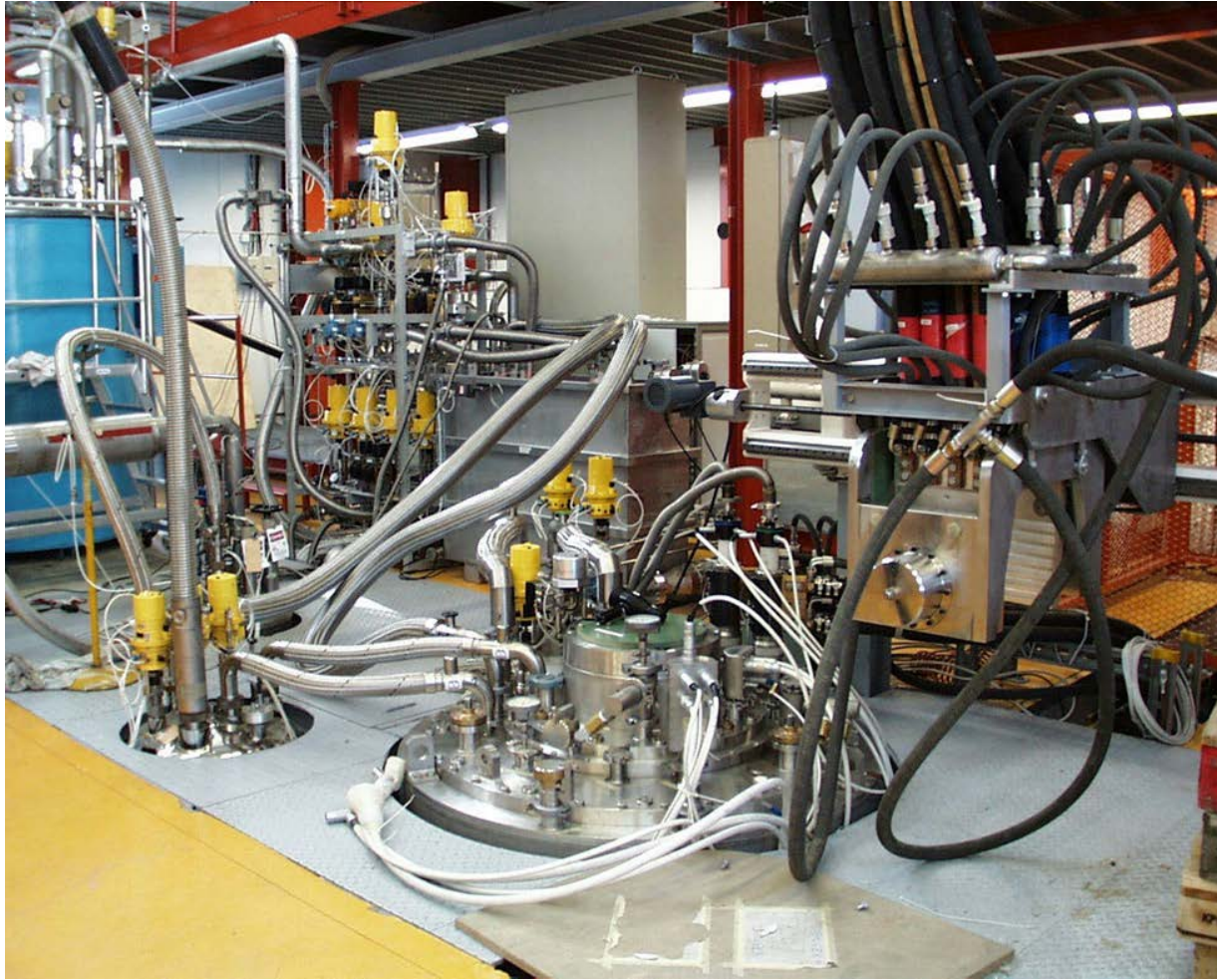
- Helium liquifier: (cold box + compressor) rate  $\sim 130\text{l/h}$
- Station of demineralized water :  $20\text{m}^3/\text{h}$
- 6 pumps for characterisation at 1.9K
- 2 furnaces for Nb<sub>3</sub>Sn reaction (Vamas)

# Bat 163 : Superconductivity Lab

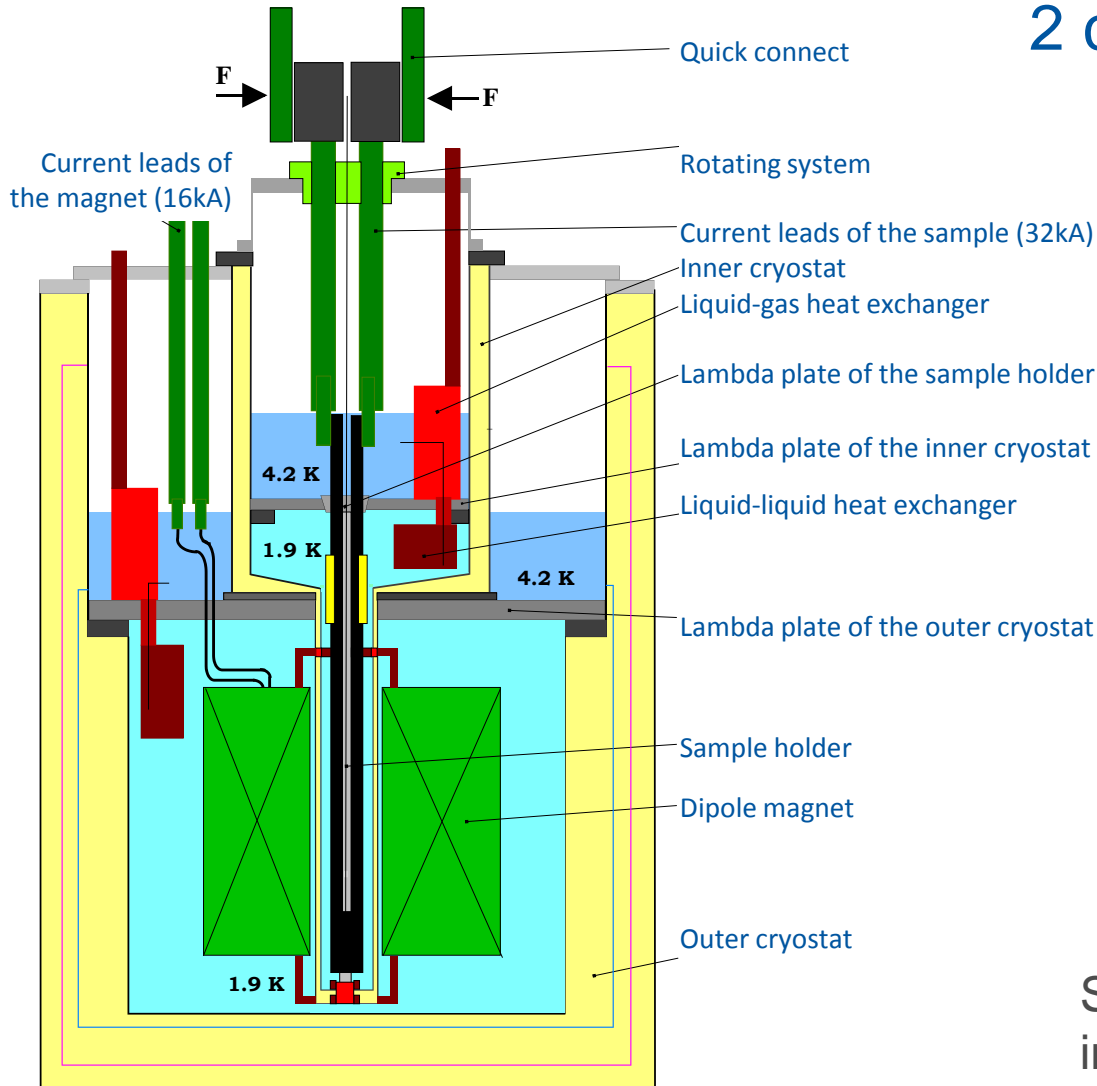


- 4 test stations for Ic on strands
- 2 test stations for Mg on strands
- 1 test station for RRR
- Fresca

# Fresca



# Fresca



## 2 cryostats :

### Outer cryostat :

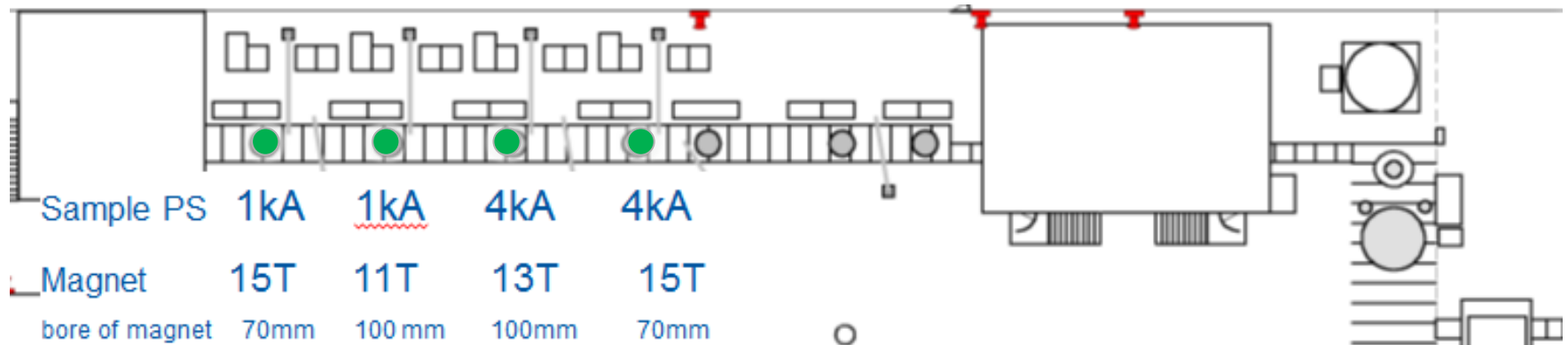
- NbTi dipole magnet of  $\sim 10\text{T}$  if operated at 1.8K.
- Uniform field on 600mm

### Inner cryostat :

- $\Phi_{\text{int}} : 72\text{mm}$ ,  $\sim 2\text{m}$  long
- Sample powered up to 32kA,
- The sample can be cooled down at 4.3K or 1.9K

Sample preparation to be seen in the preparation zone...

# Critical current test stations



First dedicated to LHC strand qualification for NbTi strands (55000 samples measured over 5 years with Mg and RRR), now most of the measurements are done for Nb3Sn conductor.

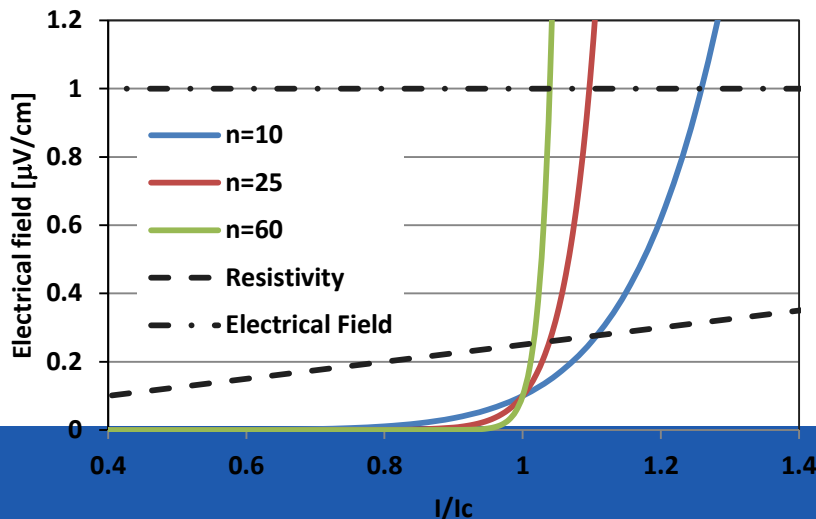


Standard ITER Ic barrel with periodic slots along two inner turns.

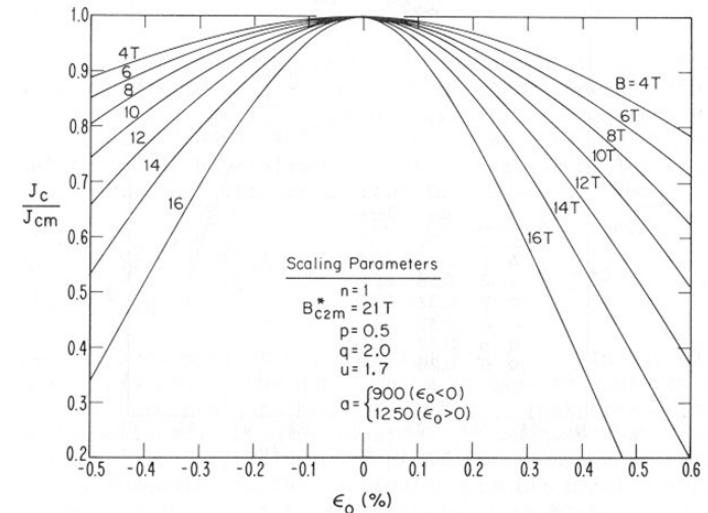
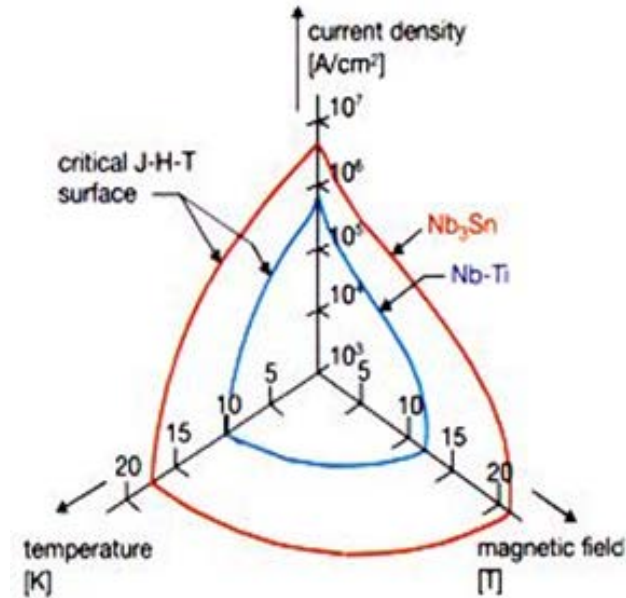
# Critical current density values

For a critical current, different parameters must be given such as :

- Temperature
- Magnetic field (intensity, direction)
- Criteria (electric field or resistivity)
- Strain
- Specify if  $I_c$  over matrix or not



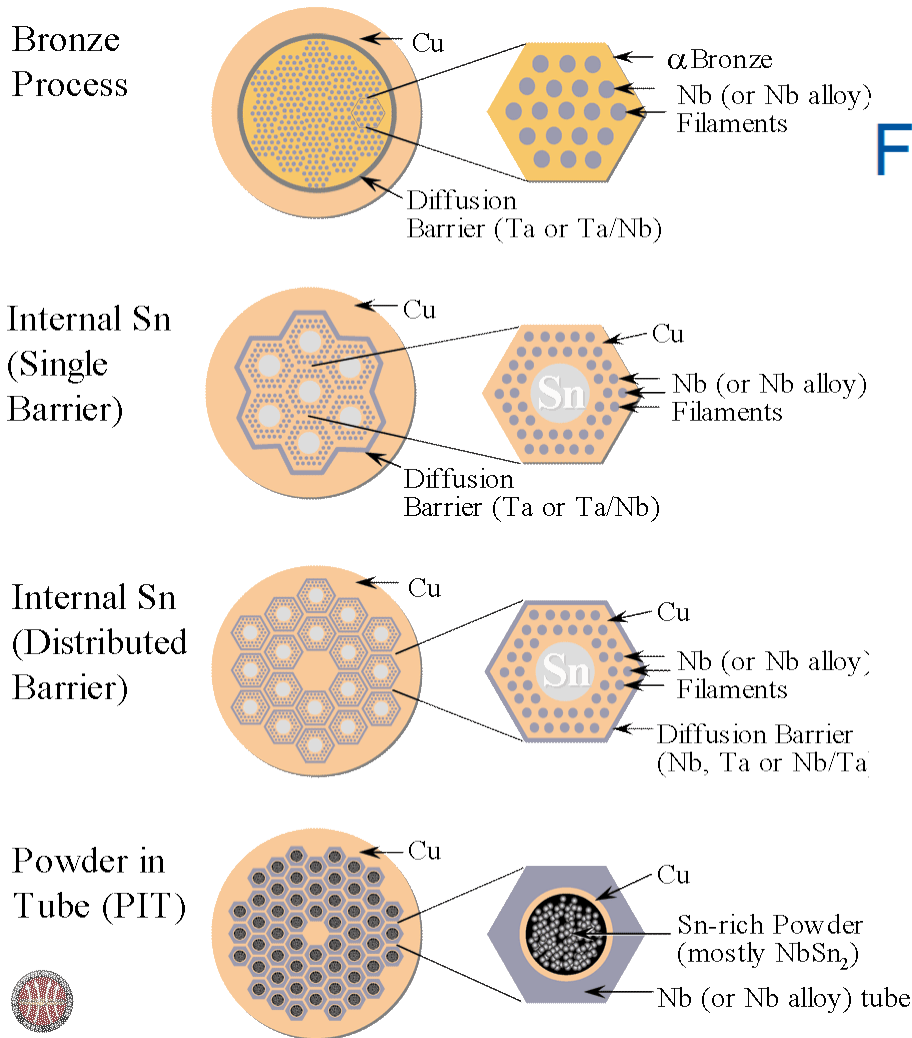
## NbTi and Nb<sub>3</sub>Sn



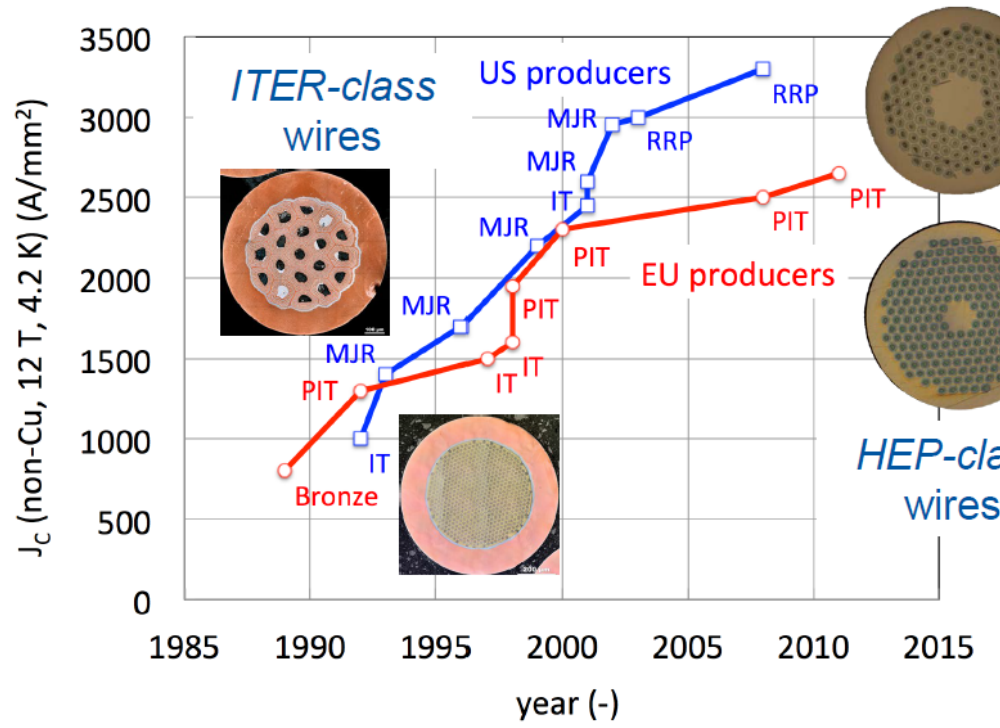
Relative critical-current density  $J_c/J_{cm}$  as a function of intrinsic strain  $\epsilon_0$  ( $\Xi\epsilon - \epsilon_m$ ) for different magnetic fields, evaluated using Eq. (3) and the typical set of scaling parameters indicated in the figure.



# Nb<sub>3</sub>Sn wires: Different process

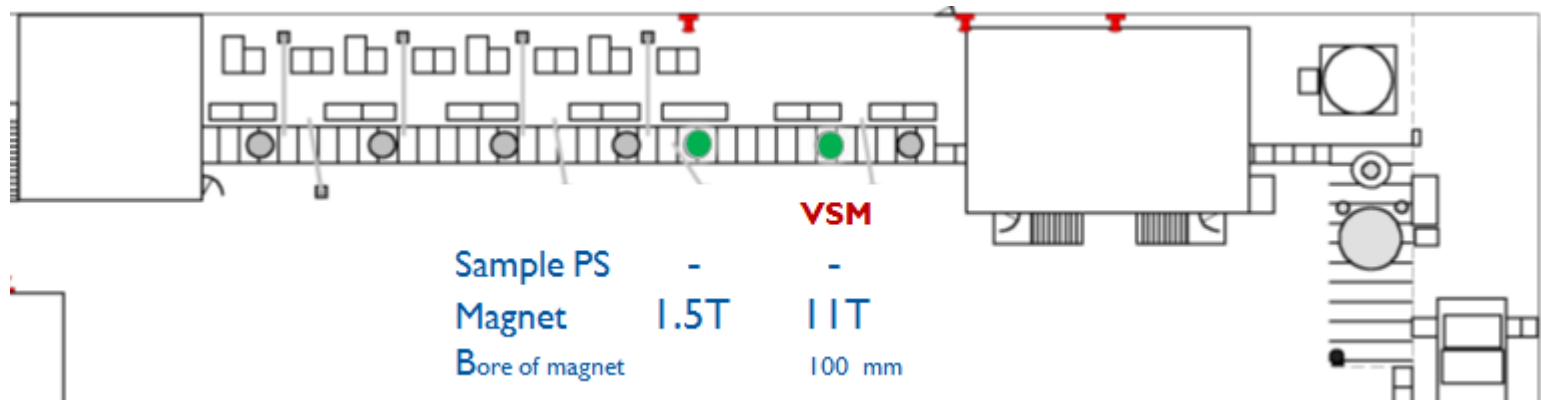


## From ITER- to HEP-class Nb<sub>3</sub>Sn



Graph from Luca's presentation at EUCAS 13

# Magnetization test station

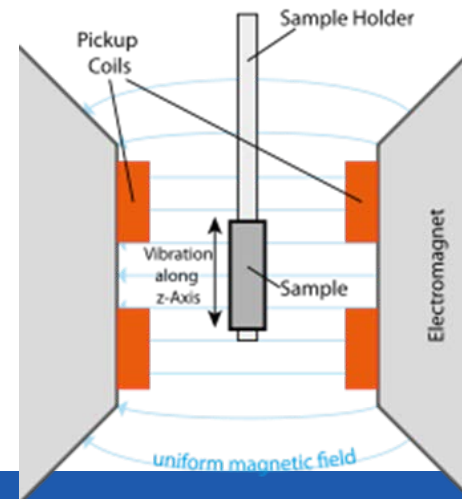


## VSM (Vibrating Sample Magnetometer)

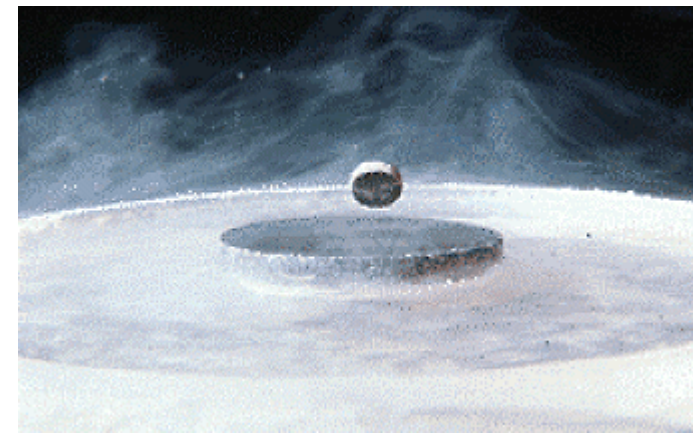
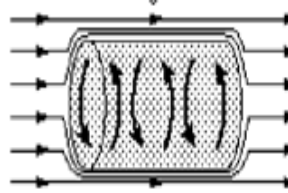
With a VTI (variable temperature insert) : 1.9K -> 300K

Magnetic field : 10.5 T

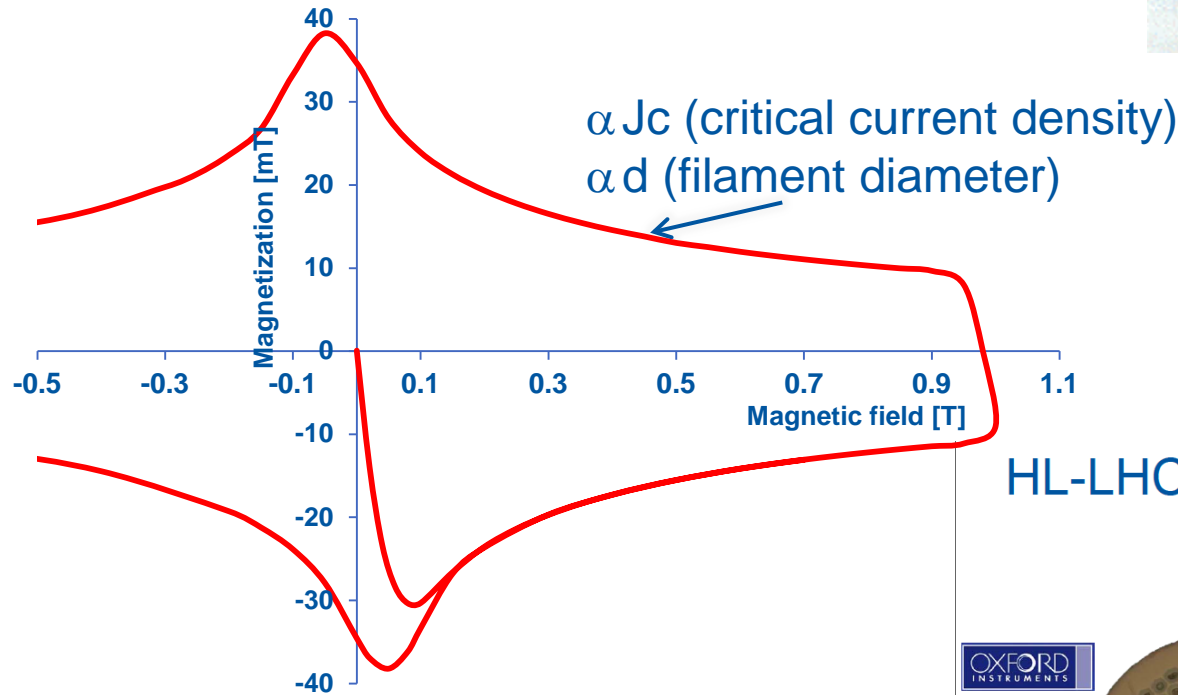
Sample vibration : 20Hz



# Magnetization

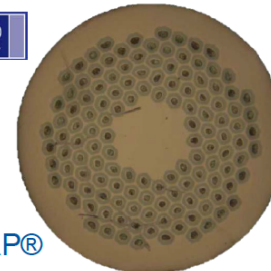


Superconductor : diamagnetic propriety

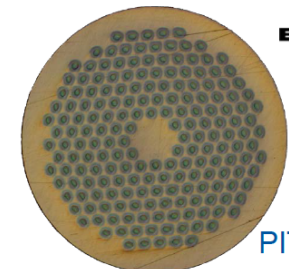


HL-LHC Nb<sub>3</sub>Sn wires (CERN view)

Strand diameter: 0.7...1.0 mm  
 Cu:non-Cu: 1.15...1.25  
 UL > 400 m ... 800 m



RRP@

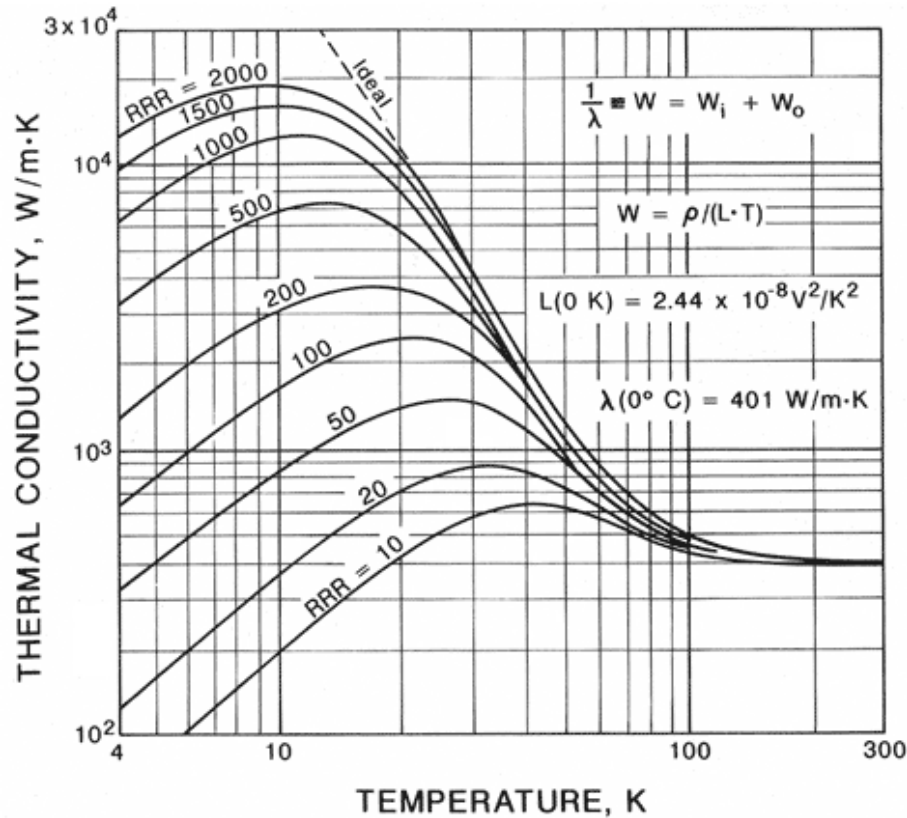


PIT

Filament diameter: **40...60  $\mu\text{m}$**   
 Number of sub-elements: 108...132  
 $J_c$  (15 T, 4.2 K) > **1575 A/mm<sup>2</sup>**  
 RRR > 150

Filament diameter: **35...50  $\mu\text{m}$**   
 Number of sub-elements: 114...192  
 $J_c$  (15 T, 4.2 K) > **1350 A/mm<sup>2</sup>**  
 RRR > 150

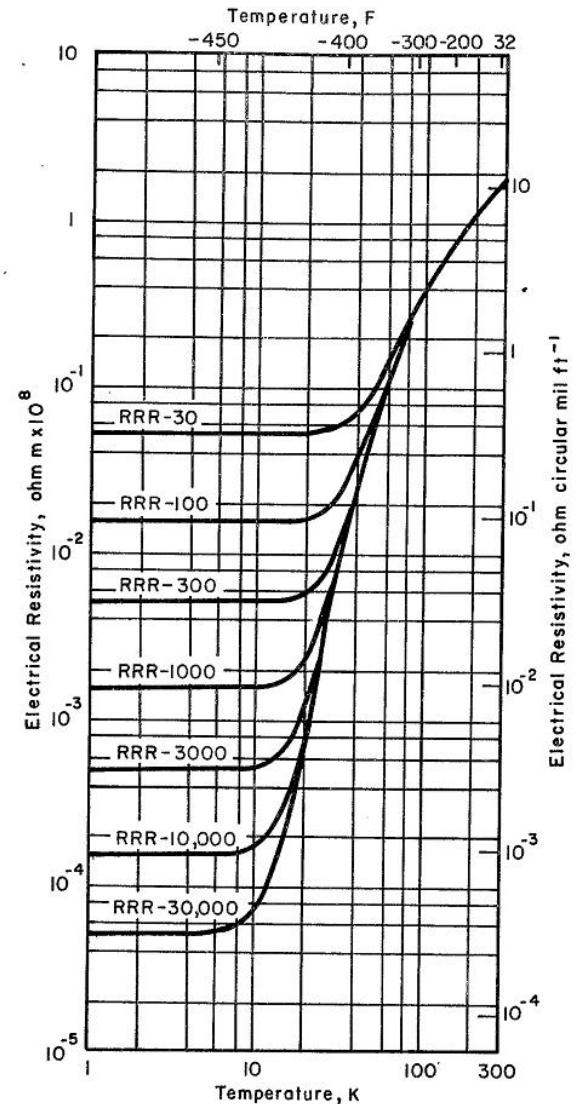
$$RRR = \rho_{300\text{ K}} / \rho_{>T_c}$$



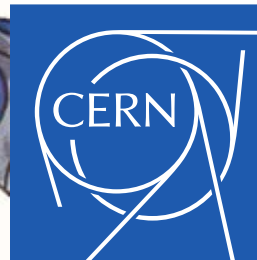
$$\frac{\kappa}{\sigma} = LT \quad \text{or} \quad L = \frac{\kappa}{\sigma T} \quad \text{Wiedemann-Franz Law}$$

$\kappa$  = thermal conductivity       $\sigma$  = electrical conductivity

$L$  = Lorenz number



ELECTRICAL RESISTIVITY VERSUS TEMPERATURE FOR COPPER



[www.cern.ch](http://www.cern.ch)

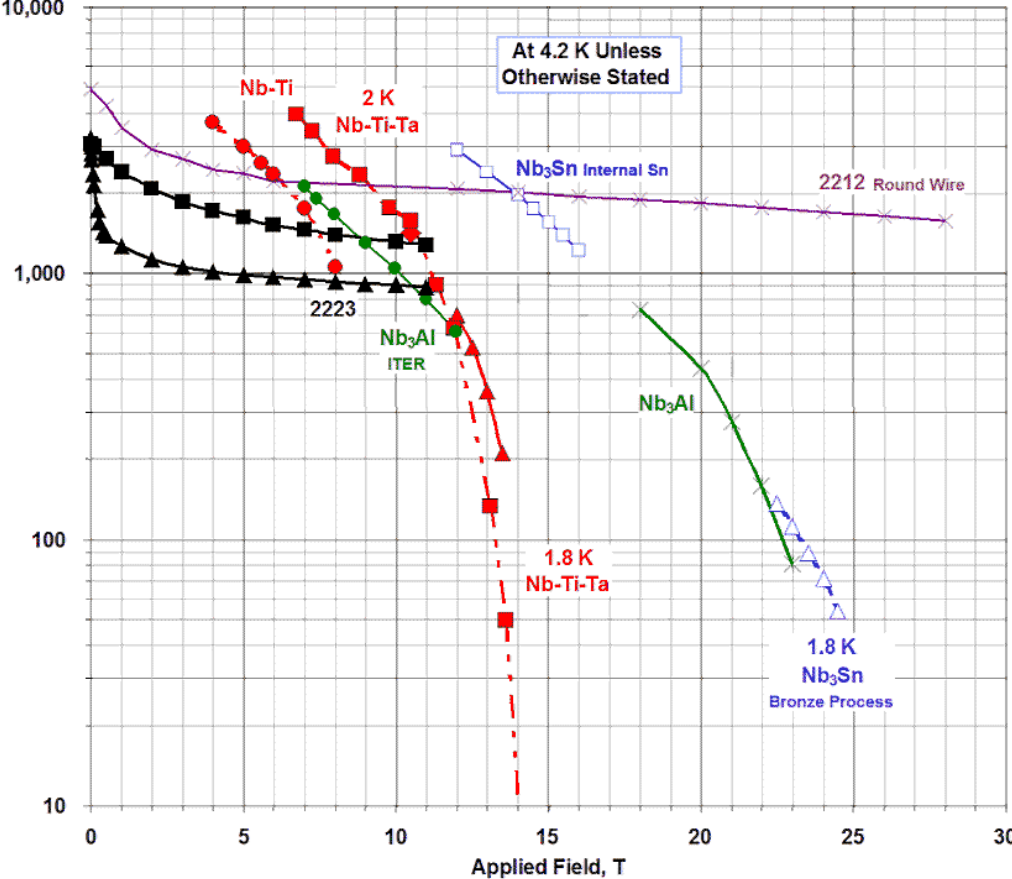
Super conductor Tyranno

# Critical current measurement comparison

## Advancing Critical Currents in Superconductors

University of Wisconsin-Madison  
Applied Superconductivity Center  
December 2002 - Compiled by Peter J. Lee

Critical Current  
Density, A/mm<sup>2</sup>



- Nb-Ti: Example of Best Industrial Scale Heat Treated Composites ~1990 (compilation)
- ◆ Nb-Ti(Fe): 1.9 K, Full-scale multifilamentary billet for FNAL/LHC (OS-STG) ASC'98
- ▲ Nb-44wt.%Ti-15wt.%Ta: at 1.8 K, monofil. high field optimized, unpubl. Lee et al. (UW-ASC) '96
- Nb-37Ti-22Ta: at 2.05 K, 210 fil. strand, 400 h total HT, Chernyl et al. (Kharkov), ASC2000
- △ Nb<sub>3</sub>Sn: Bronze route VAC 62000 filament, non-Cu 0.1μW m 1.8 K J<sub>c</sub>, VAC/NHMFL data courtesy M. Thoener.
- Nb<sub>3</sub>Sn: Non-Cu J<sub>c</sub> Internal Sn OI-ST RRP #6555-A, 0.8mm, LTSW 2002
- × Nb<sub>2</sub>Al: Nb stabilized 2-stage JR process (Hitachi,TML-NRIM,IMR-TU), Fukuda et al. ICMC/ICEC '96
- Nb<sub>2</sub>Al: JAERI strand for ITER TF coil
- × Bi-2212: non-Ag J<sub>c</sub>, 427 fil. round wire, Ag/SC=3 (Hasegawa ASC2000+MT17-2001)
- Bi 2223: Rolled 85 Fil. Tape (AmSC) B||, UW'6/96
- ▲ Bi 2223: Rolled 85 Fil. Tape (AmSC) B<sub>⊥</sub>, UW'6/96

