Measurements on critical current and bending strain tolerance for ex-situ MgB_2 wires and tapes under high field up to 8T

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Presentation

- ✓ MgB_2 is a simple and light binary compound with easily available material
- ✓ MgB_2 can be processed into bulks, wires, tapes and thin films of long lengths by different methods (PIT, IMD...)
- ✘ MgB_2 wires critical current low under high magnetic field and very sensible to tensile stress
  - ➥ Find the MgB_2 irreversible strain (ε_{irr})
  - ➥ Study the effect of mechanical stresses (bending) on the critical current
  - ➥ Measure the Jc and Je of new pre-industrialized wires from Columbus SpA

Wire characteristics

❖ Four types of Columbus SpA pre-industrialized Monel clad, carbon-doped *ex situ* Powder in Tube (PIT) processed wires and tapes

	A	B	C	D
Shape	Tape	Tape	Wire	Tape
Wire cross-section [mm^2]	2 × 1	3 × 0.5	1.81	2 × 1
Filling-factor [%]	**34**	18	**28**	
Number of filaments	19	19	**6 + 1 Cu central**	
Sheath (matrix)	Ni	**Fe**	Ni	Ni

❖ Designed for the winding of medium/high field MRI magnets

❖ Fe-sheathed tape could also be used in the switch device for persistent mode MRI

Experiment settings

Test facility

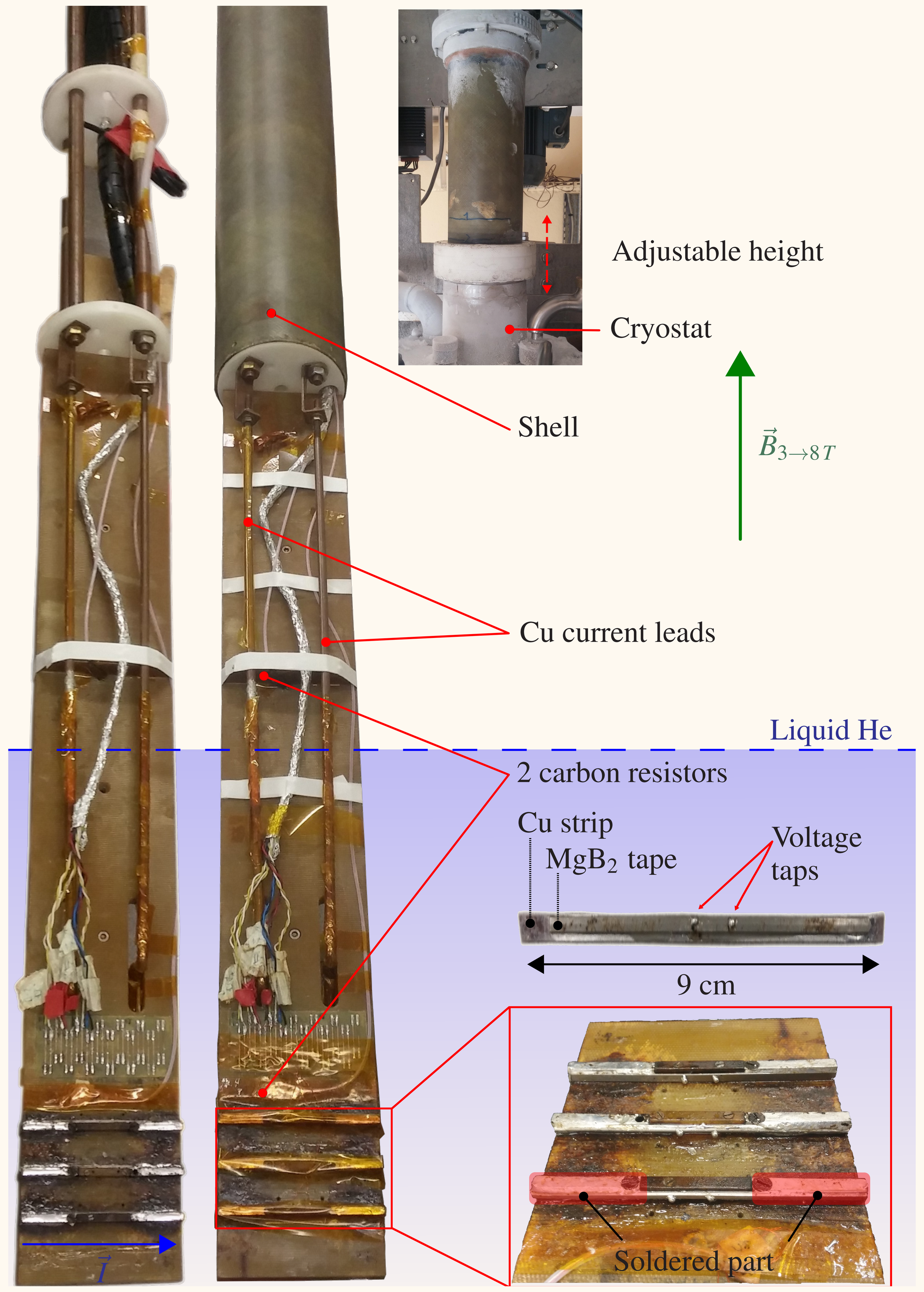
❖ Tested at LNCMI Grenoble at field ranging from 3 to 8 T

Experiment settings

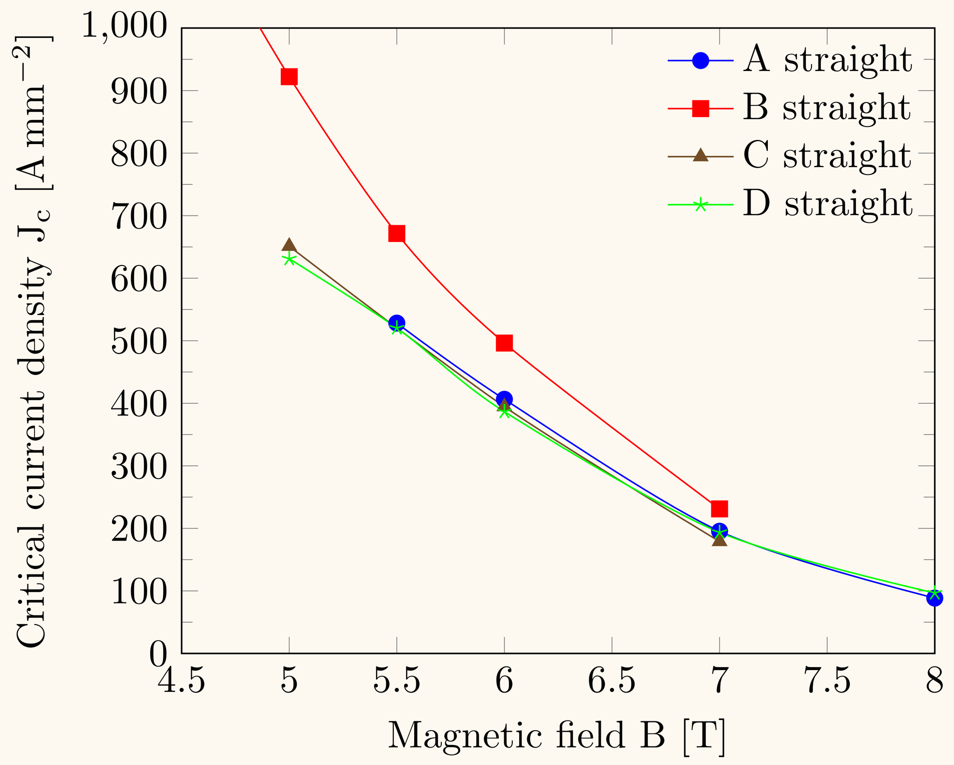
❖ Ic measured by the four-probe method with the 0.1 μV/cm criterion

❖ One sample powered and measured each test in the center field (adjustable height)

Test facility



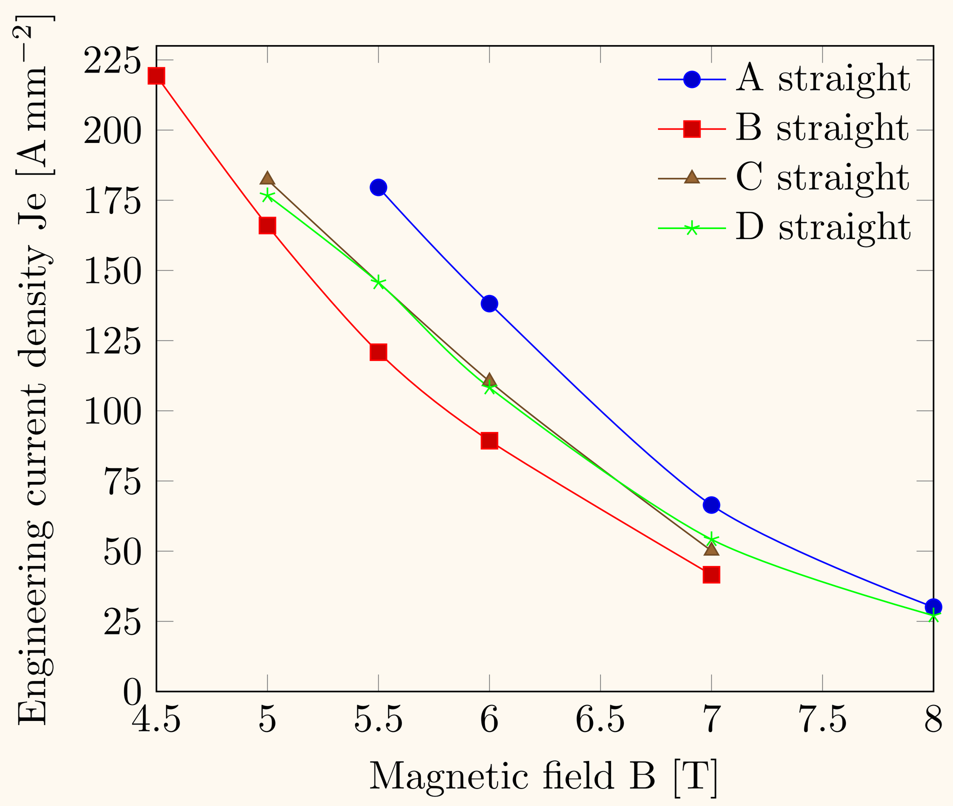
Critical current density and engineering current density measurements



❖ Sample B exhibits the highest Jc → 922 A mm^{-2} at 5 T
- ✓ Fe sheath higher hardness compared to Ni sheath → better compaction of the grains in the MgB_2 matrix → ↗connectivity ↗Jc
- ✘ Higher dependence to magnetic field ? → Fe + B chemical reaction → FeB_2 pollution

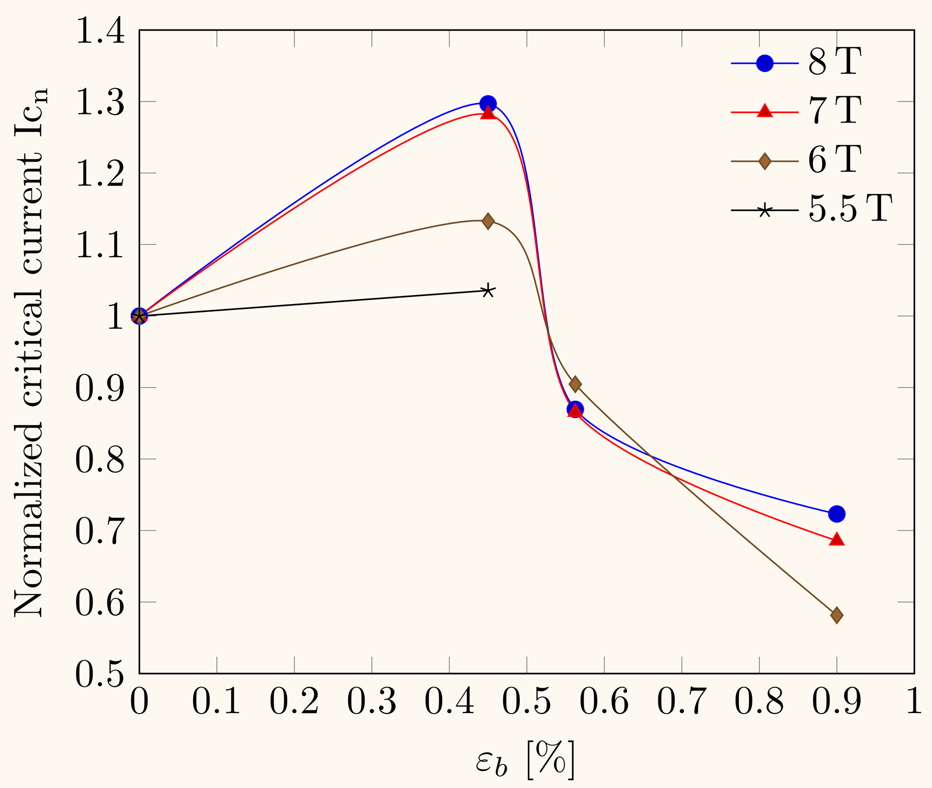
✘ Ni sheath limits the compaction of the SC MgB_2 phase during the cold-work of the wires/tapes

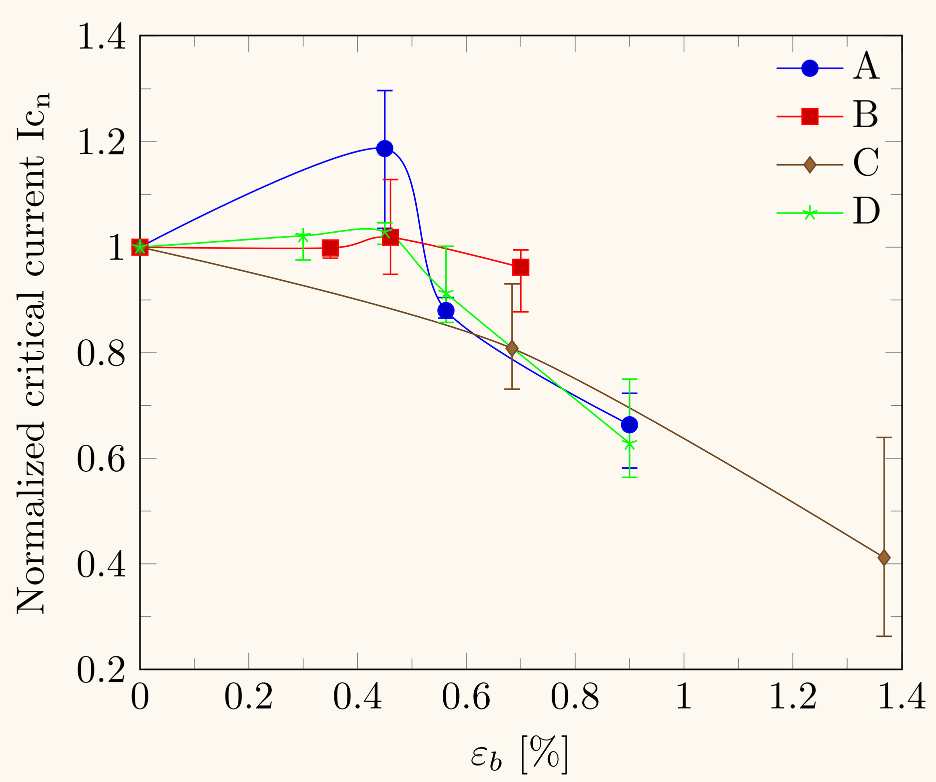
✓ The process seems mastered as new types of pre-industrialized wires are produced with no severe Ic degradation

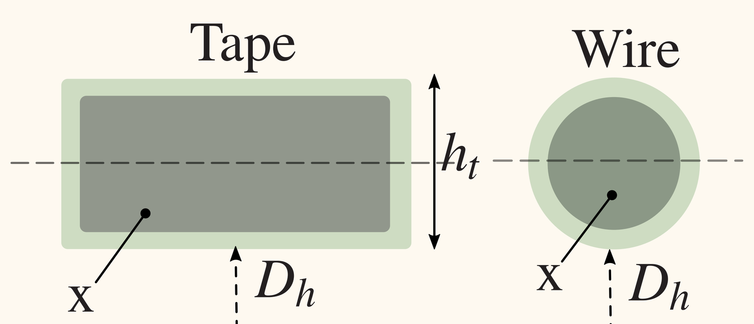


❖ The engineering current density follows the order of the wire filling factors. Sample A (FF = 34 %) → 180 A mm^{-2} at 5.5 T
- ➥ Increase the Sample B (with Fe) filling factor ?
- ➥ Effect on the Jc ?

Results of critical currents vs bending strain







$$\varepsilon_b = \frac{x \times h_t}{D_b} \quad \begin{cases} h_t & \text{Tape thickness or wire diameter} \\ D_b & \text{Bending diameter} \\ x & \text{Correction coefficient} \end{cases}$$

❖ The normalized critical current ($Ic_n = Ic/Ic_0$) vs ε_b was plotted
- ✘ Low number of points for each wire (example for sample A on the left)
- ➥ As ε_{irr} is not magnetic field dependent → for each wire, normalized current Ic_n vs strain at averaged field were plotted on the same graph (right)

❖ Same Ic degradation for sample A, C and D at ε_b = 0.45 %

✓ No degradation for Fe sheathed sample (usually degradation is expected around 0.3 %)

✓ Fe sheath allows more strain hardening than Ni sheath during the manufacturing process (cold-work)

➥ ↗ Grain connectivity due to ↗ MgB_2 density

➥ ↗ Mechanical properties → ↘ Cracks in SC MgB_2 phase