Development of Tube Type Nb_3Sn Conductor and its Application

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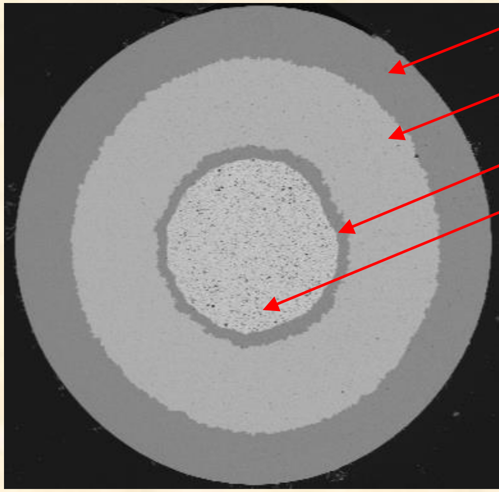
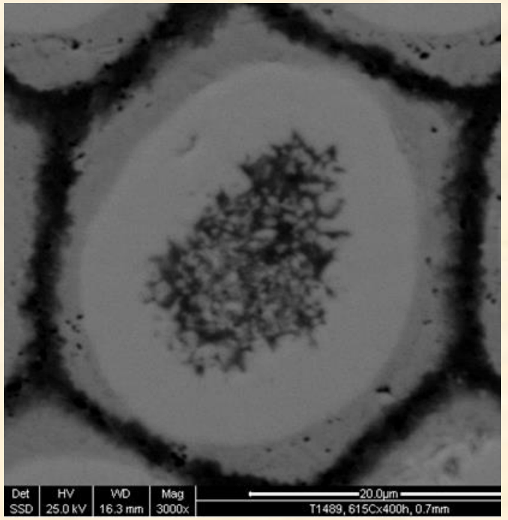
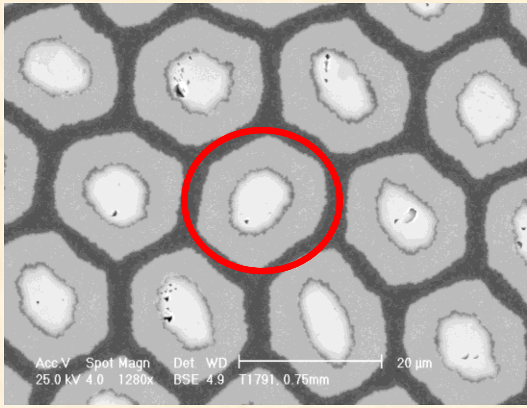
Tube Approach (TA) Nb_3Sn Strands with Solid Sn



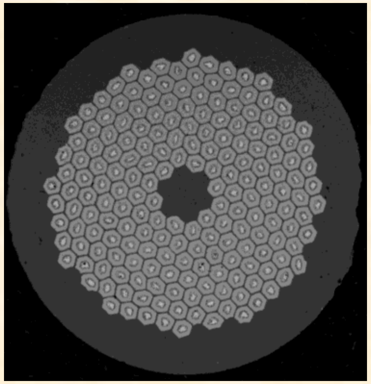
Single Subelement

A Nb7.5wt%Ta tube has inside it a Cu-clad Sn. This assembly is then inserted into a Cu tube and drawn down as a filament.

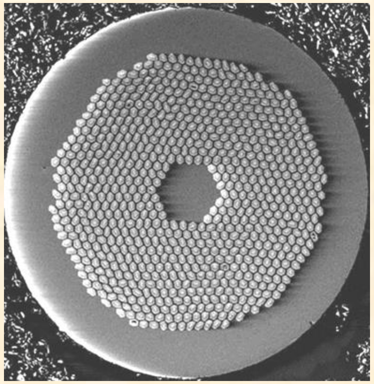




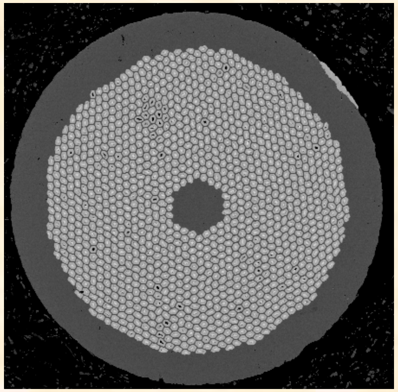
Different Count Restack (0.7 mm Strands)



36 μm, 192

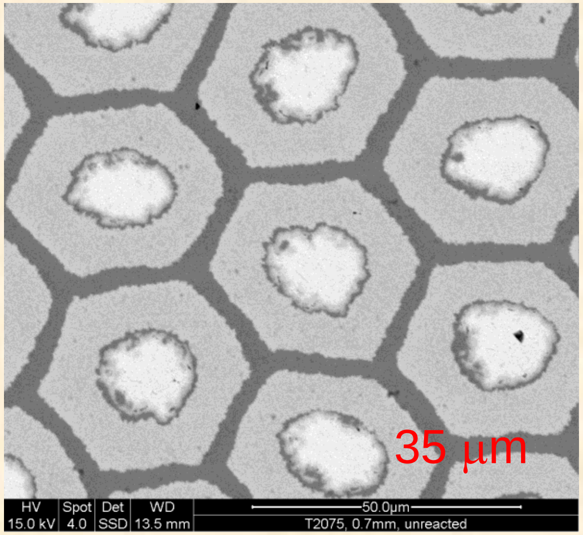


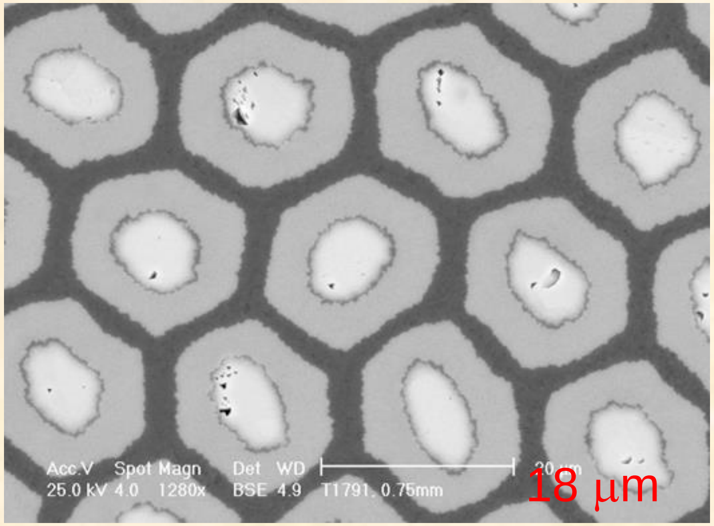
18 μm, 744

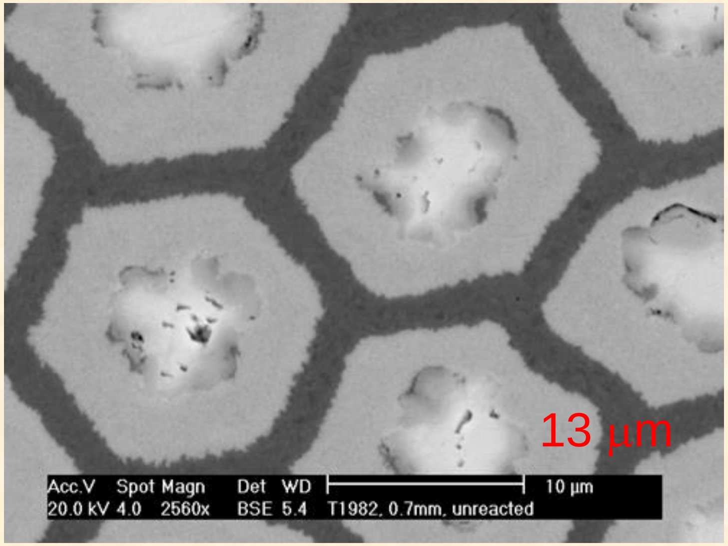


12 μm, 1248

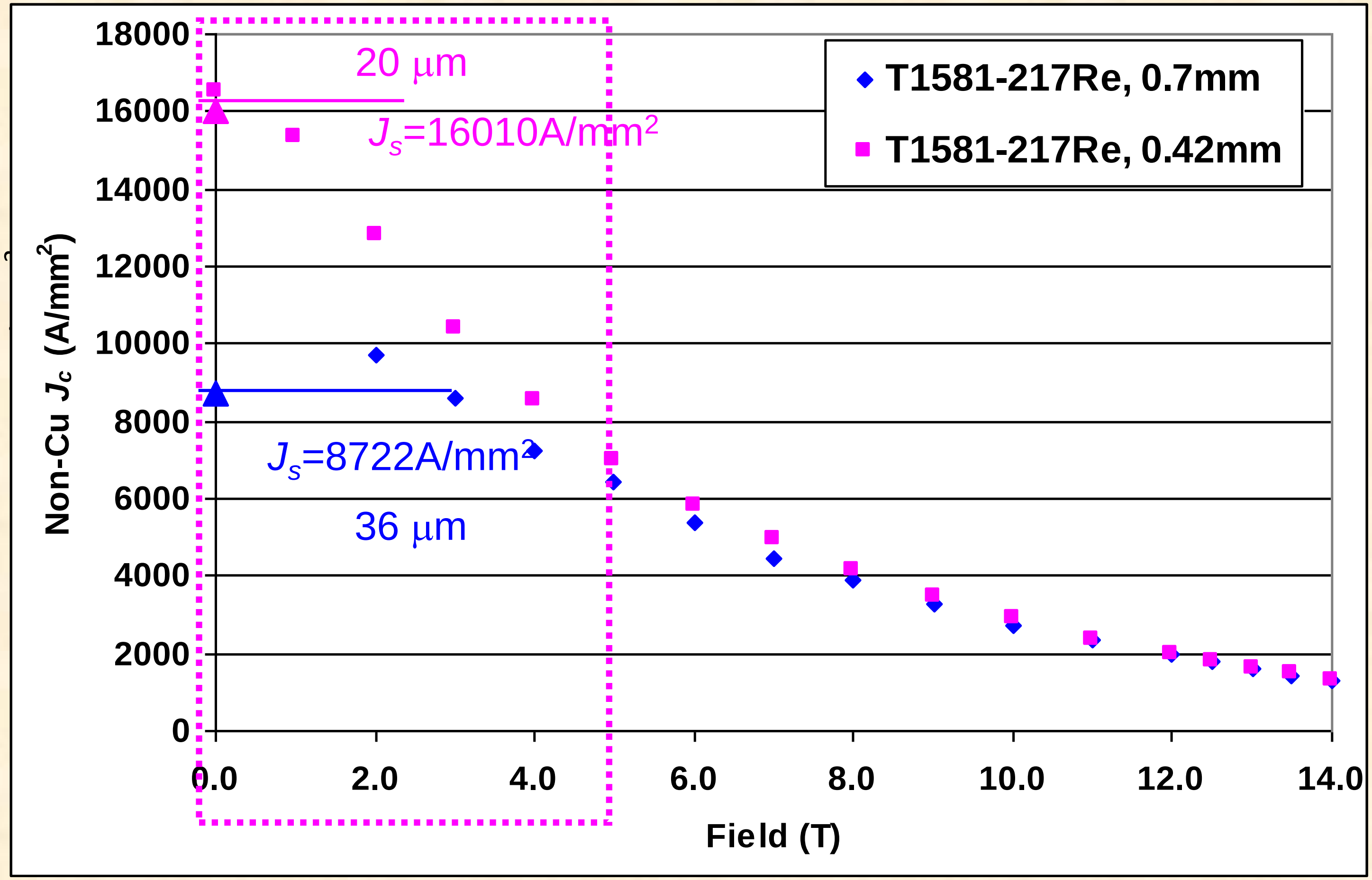
Filament Size (d_{eff})







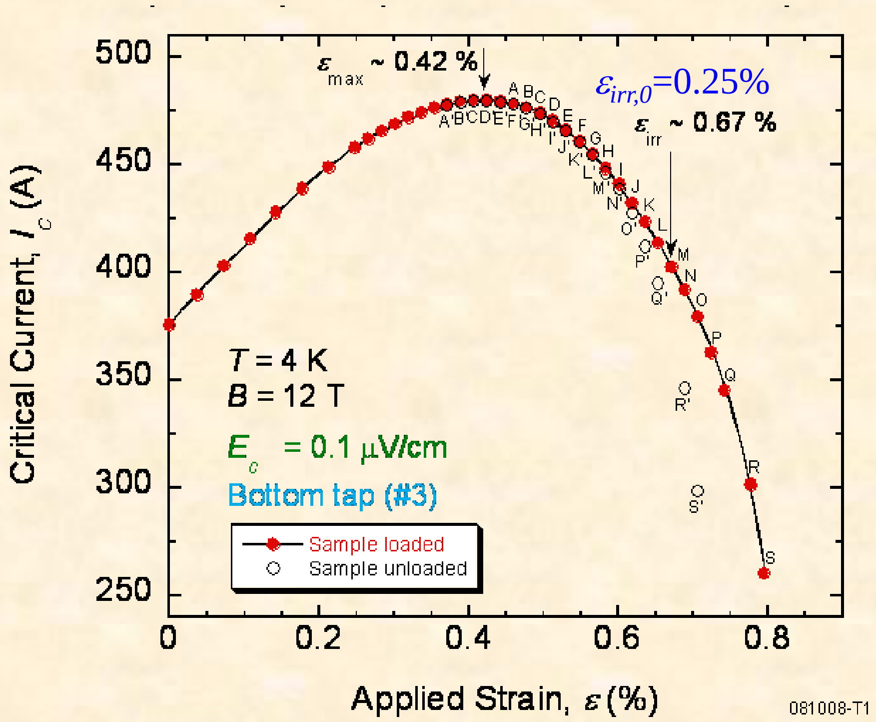
$J_c s$ Results



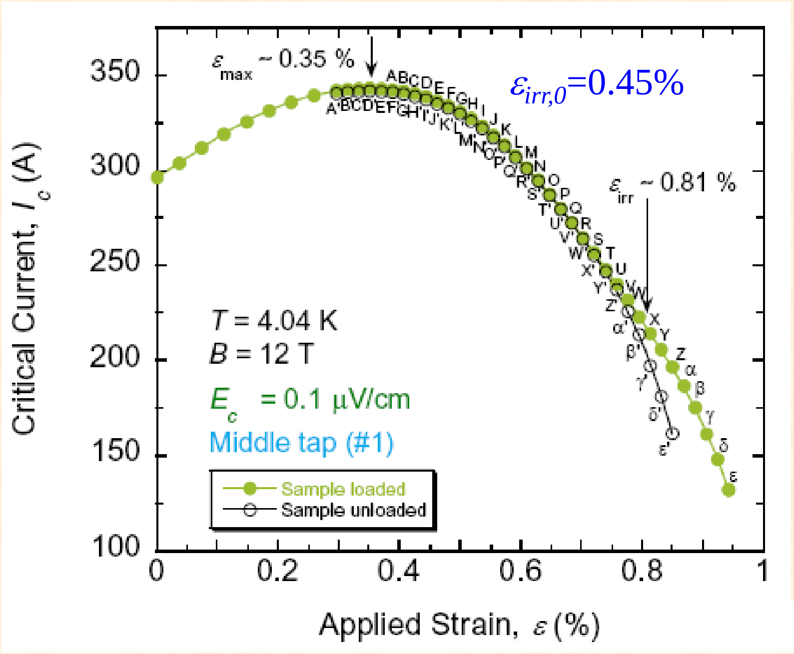
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Non-Cu J_c (A/mm^2)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
Field (T)
T1581-217Re, 0.7mm
T1581-217Re, 0.42mm
20 μm
J_s=16010A/mm^2
J_s=8722A/mm^2
36 μm

Strain Sensitivity (12 T)

192-subelement, 0.7 mm

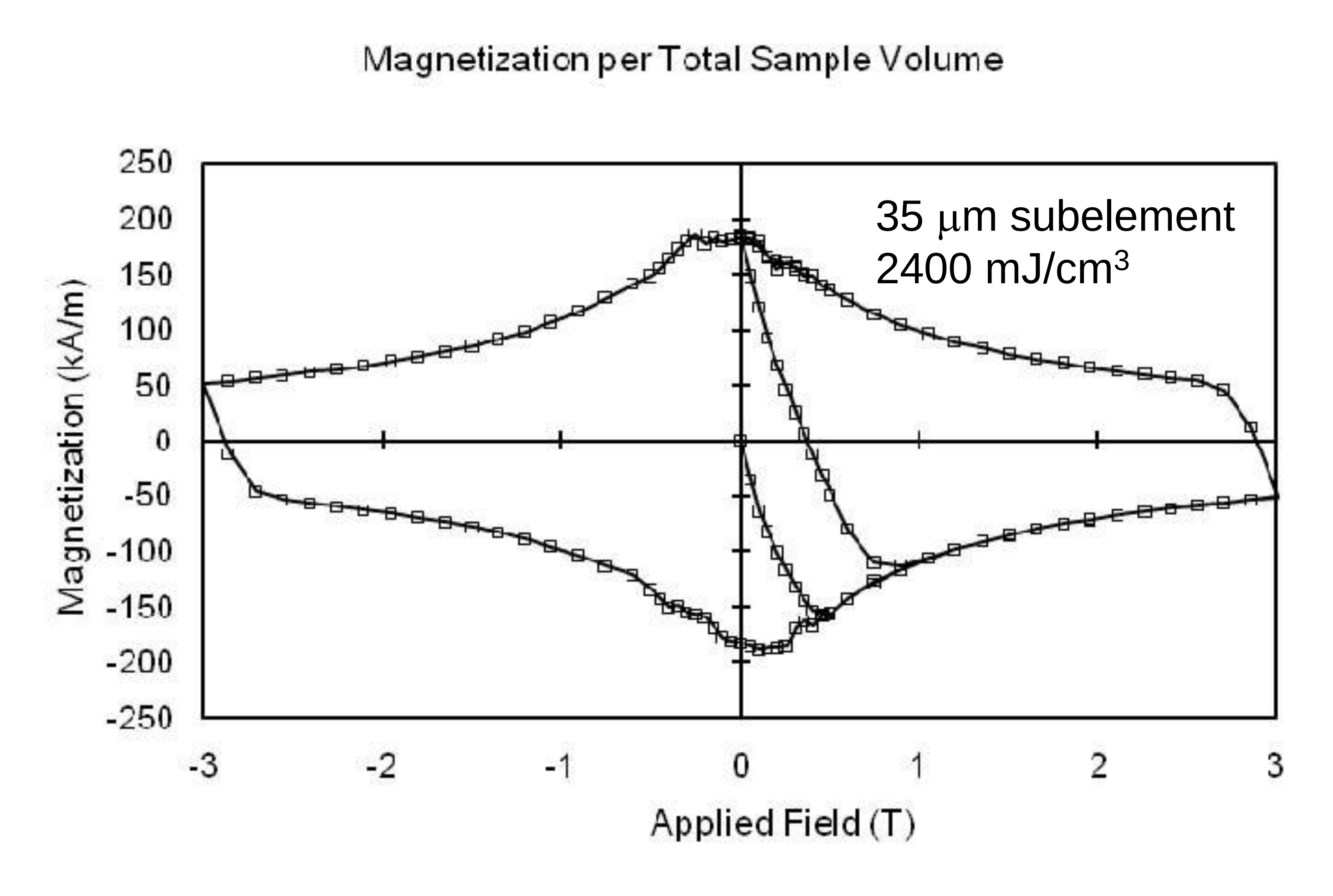


744-subelement, 0.7 mm

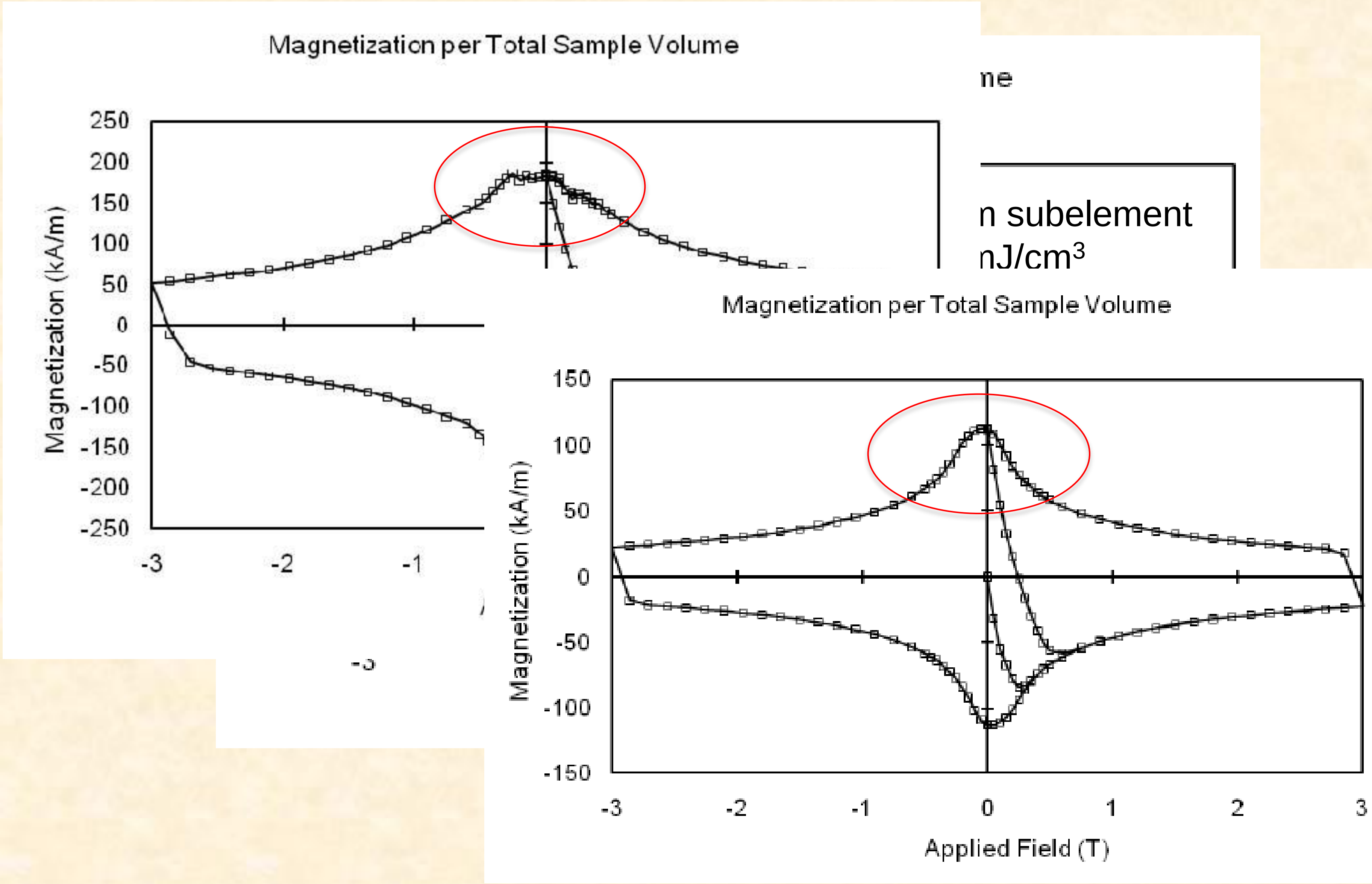


Tested by NIST

Magnetization Data of the 192-subelement Wire (0.7 mm)



Magnetization Data of the 744-subelement Wire (0.7 mm)



Potential Applications

Current Status

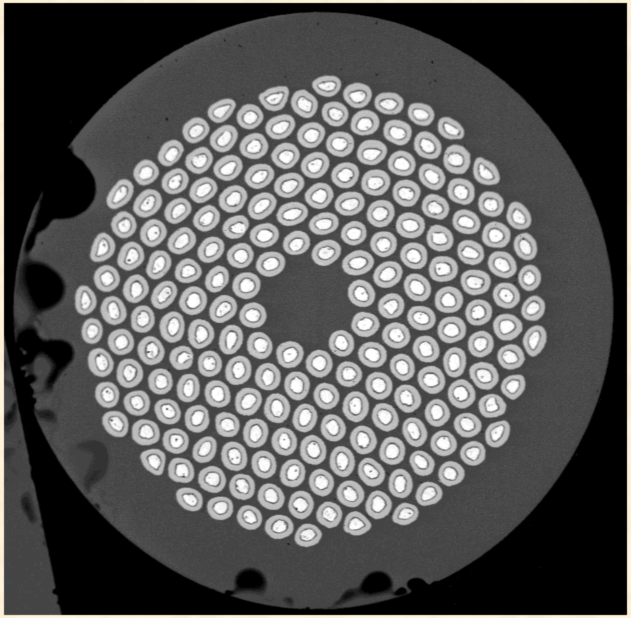
Strand	D_{eff}	Non-Cu Jc at 12 T, A/mm^2	I_c of 0.7mm strands, A	$\varepsilon_{irr,0}$, %	AC loss, mJ/cm^3
192-subelement	35 μm	2300-2600	400-450	0.24-0.26	2410
744-subelement	18 μm	1900-2200	300-350	0.43-0.48	600

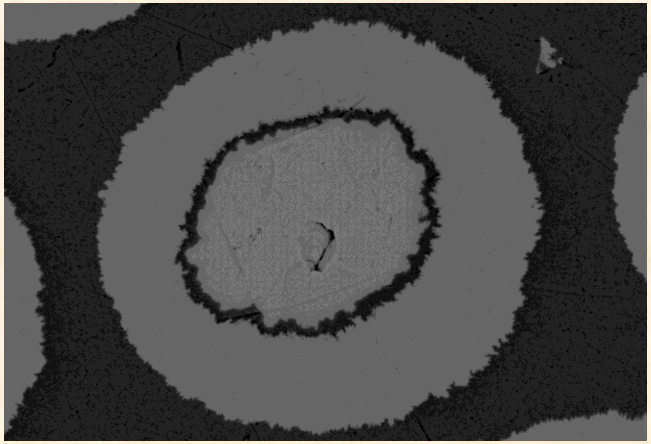
Potential Applications

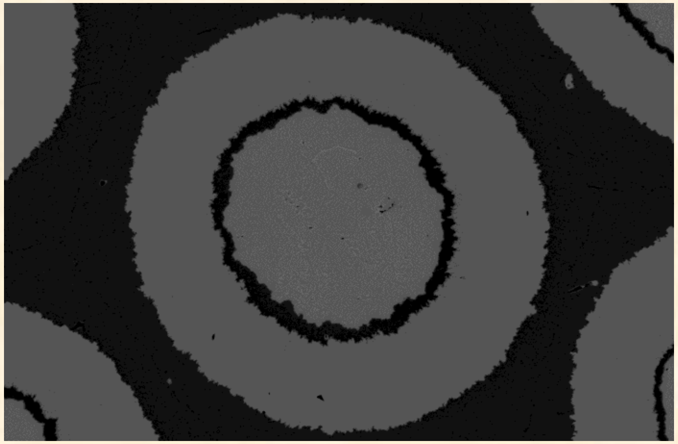
- **12-20 T Magnet;**
- **Light source: undulators;**
- **Future Advanced Fusion Projects;**
- **High Energy related projects: for example CERN upgrade. 30 μm subelement at 1 mm strand which required a 547-subelement restack.**

New Development to Increase J_c & RRR (I)

To make round Nb filaments



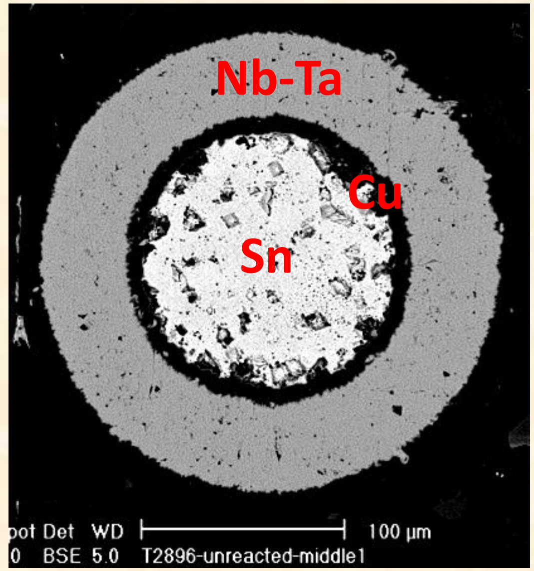


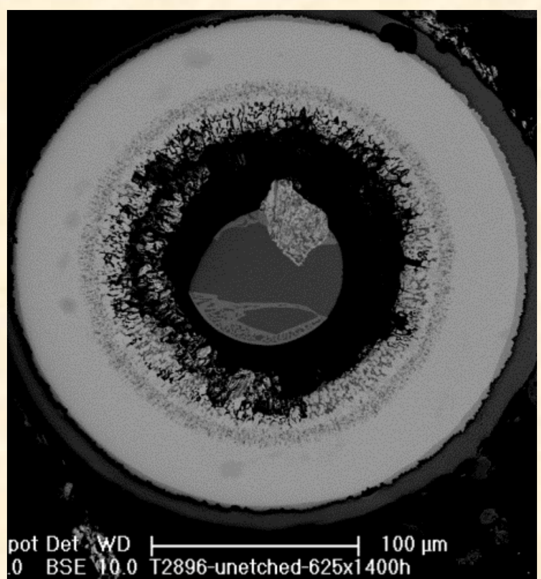


New Development to Increase J_c & RRR (II)

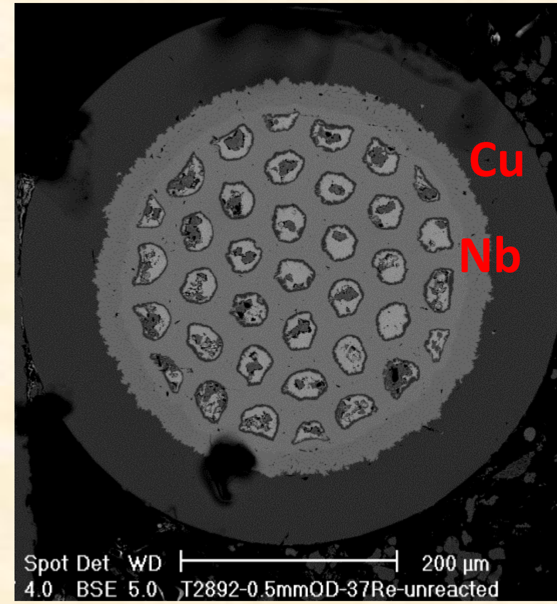
To develop high Sn content Nb_3Sn Tubular Conductor

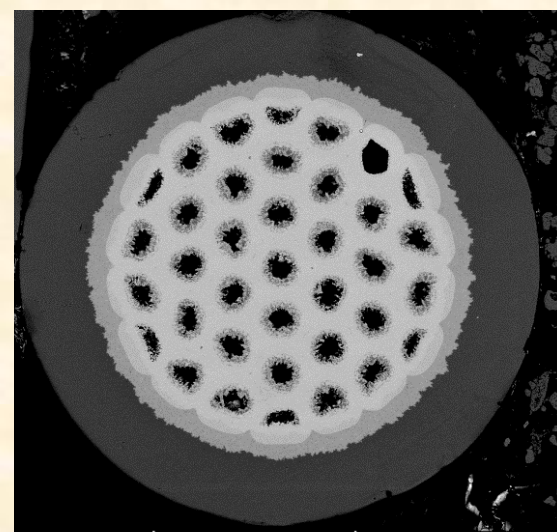
Filament



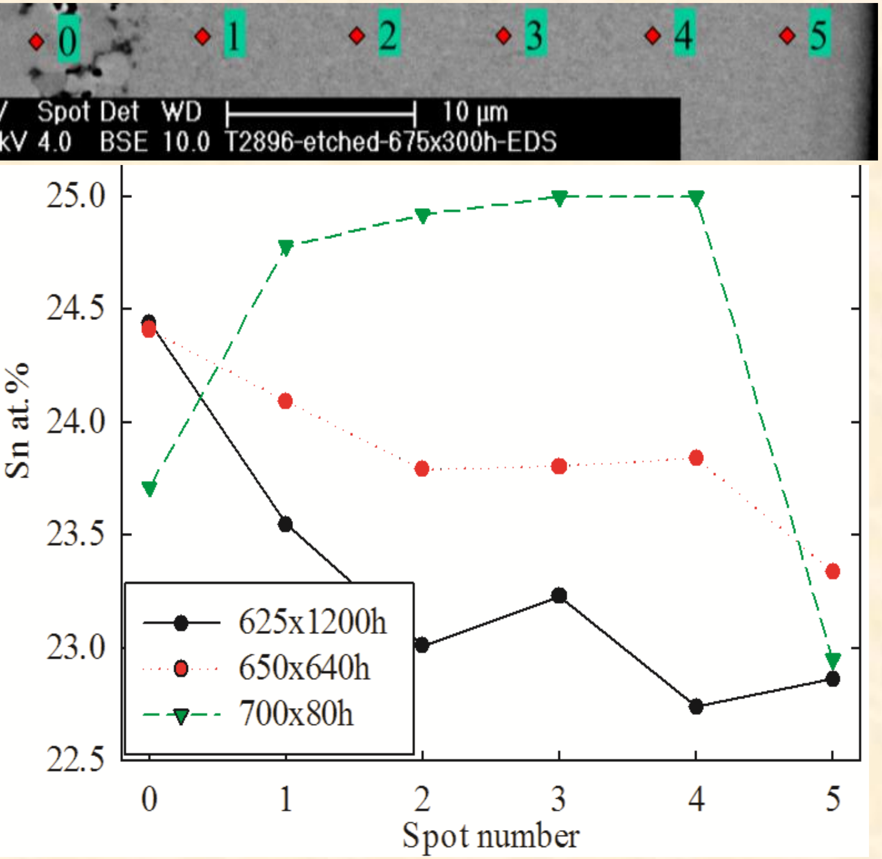


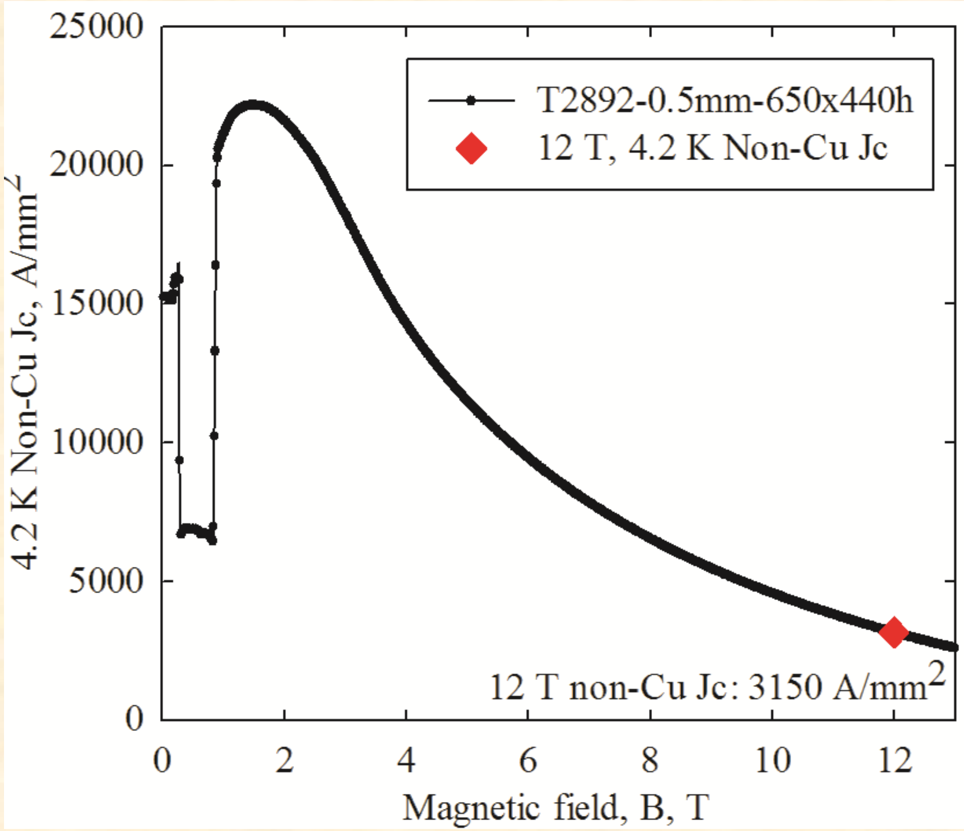
Subelement





New Development on Tubular Conductor (III)

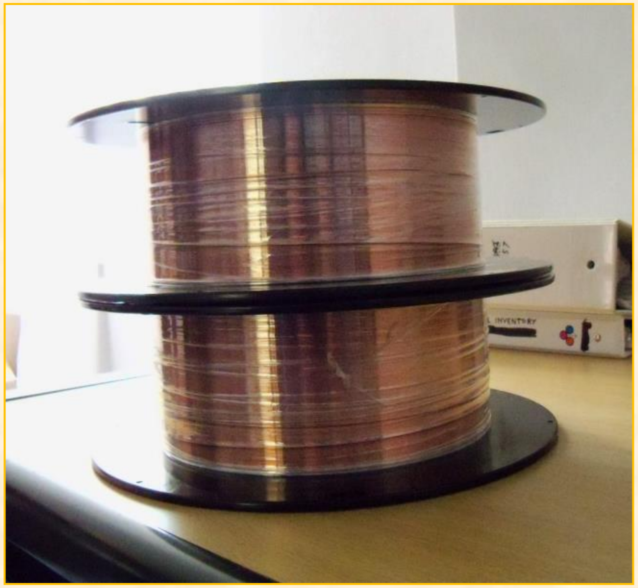




- **Optimize the Nb/Sn ratio to obtain high Sn content in subelement;**
- **Restack the subelement and make a practical strand on it.**

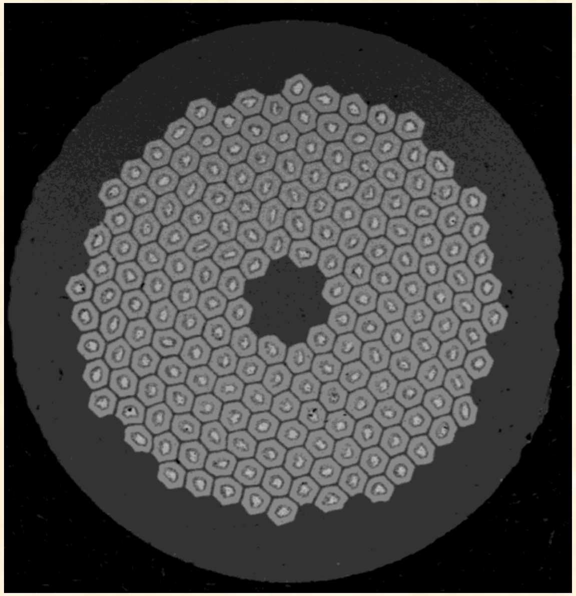
Applications on 12-20 T Magnet

Piece Length

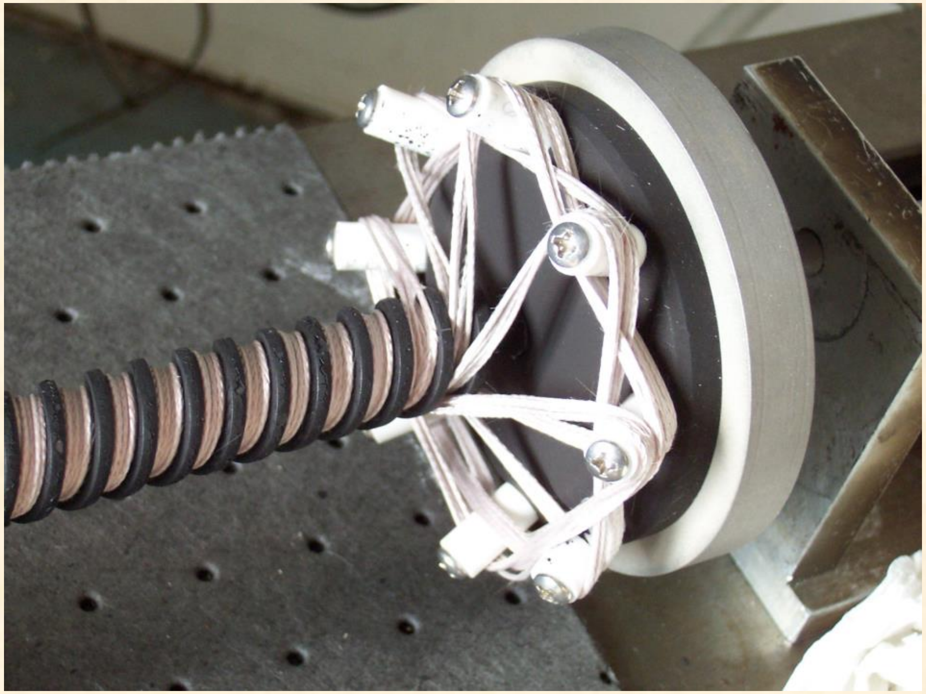


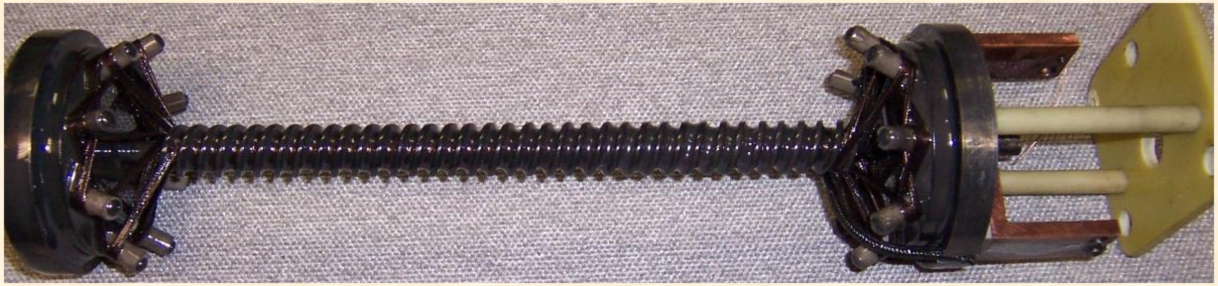
1. Kilometers piece length has been made in house for 61 and 217 subelement restack strand through improving drawing techniques and cleaning procedure.
2. Strands have been provided to magnet builder to start winding into Magnets.

Applications on Short Period Helical Undulators



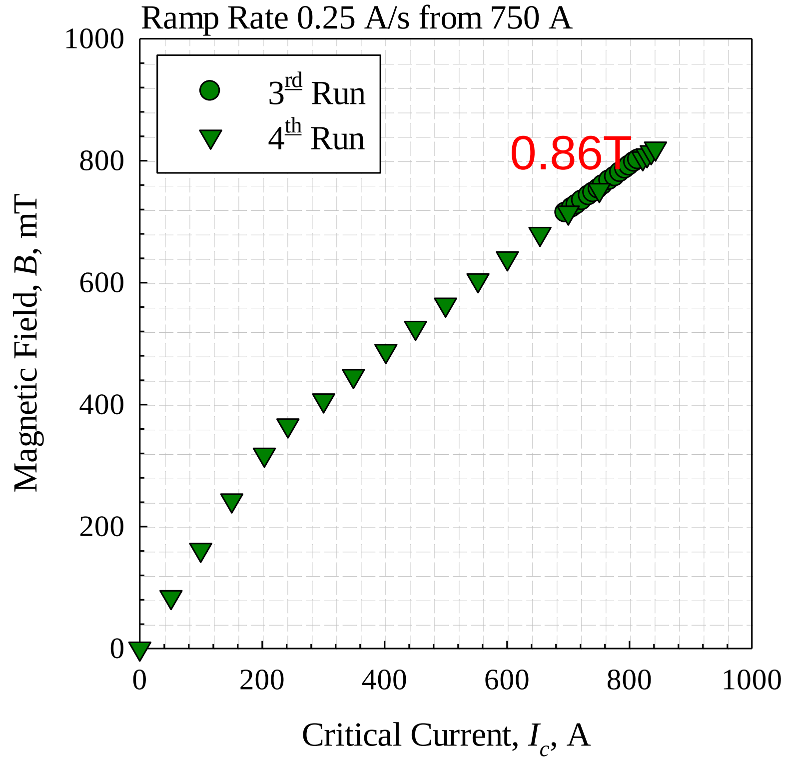
192 restack wire at 0.5 mm
(filament size of 24 μm)

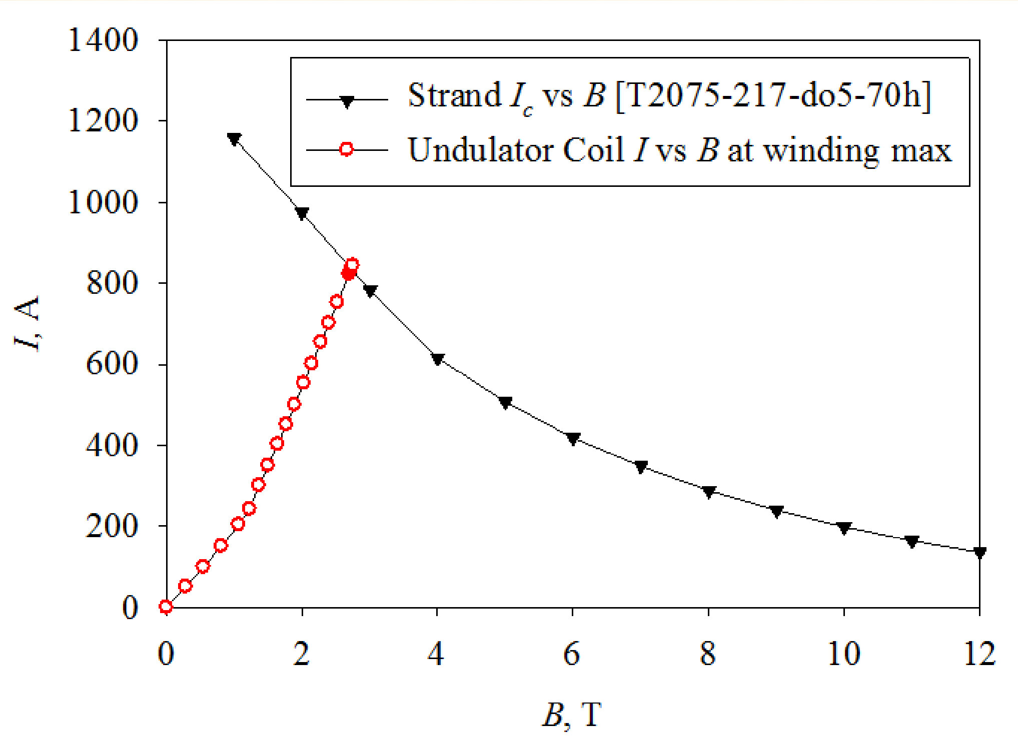




Period (λ)	14 mm
Winding bore	8.0 mm
Beam aperture	7.0 mm

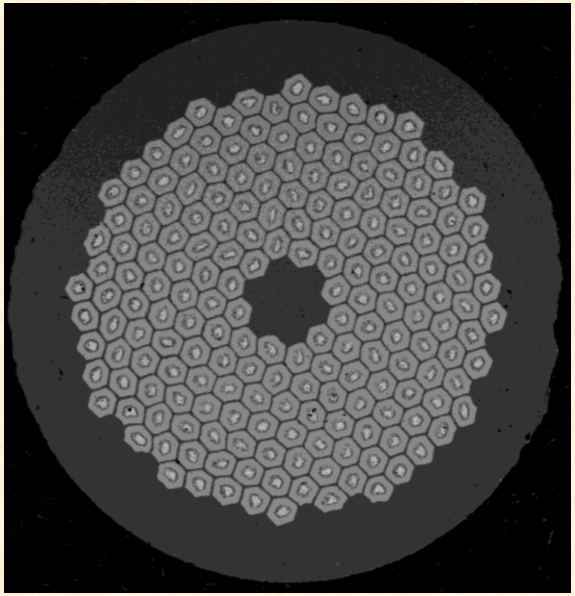
Test Results of the Short Period Helical Undulator





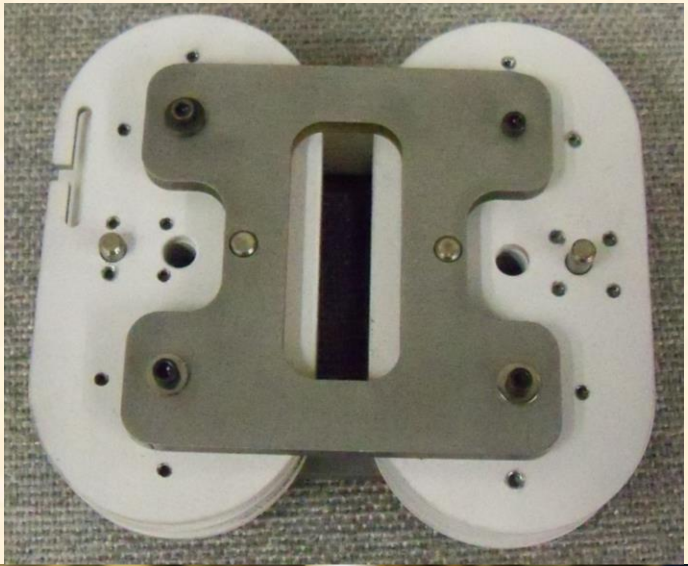
- **The undulator reached the target field of 0.8 T at the bore**
- **The property of the coil reaches that of the short ITER Barrel sample**
- **12 mm, 10 mm period coils has been constructed (1 T) and for testing in OSU**

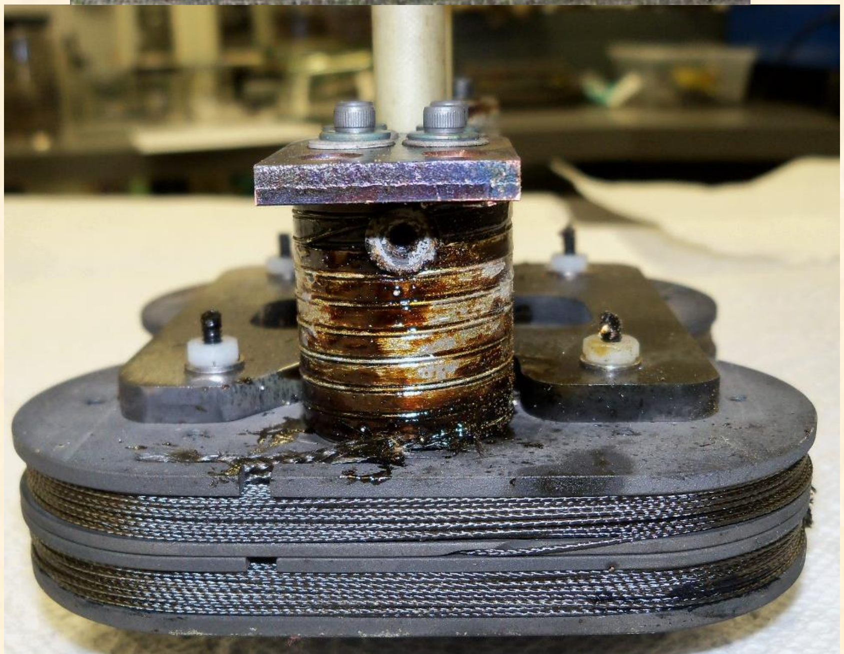
Applications on Short Period Planar Undulator



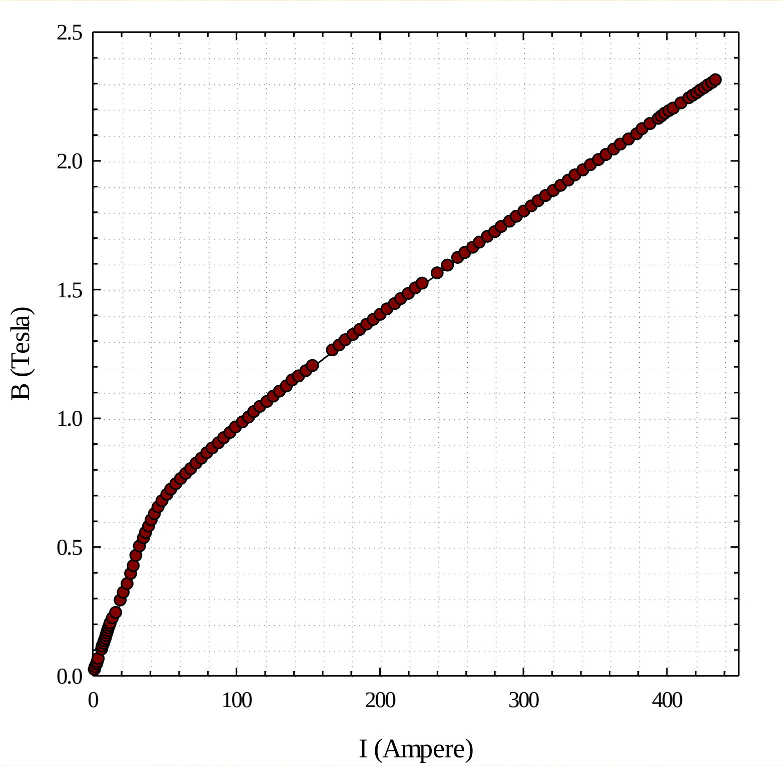
192 restack wire at 0.5 mm
(filament size of 24 μm)

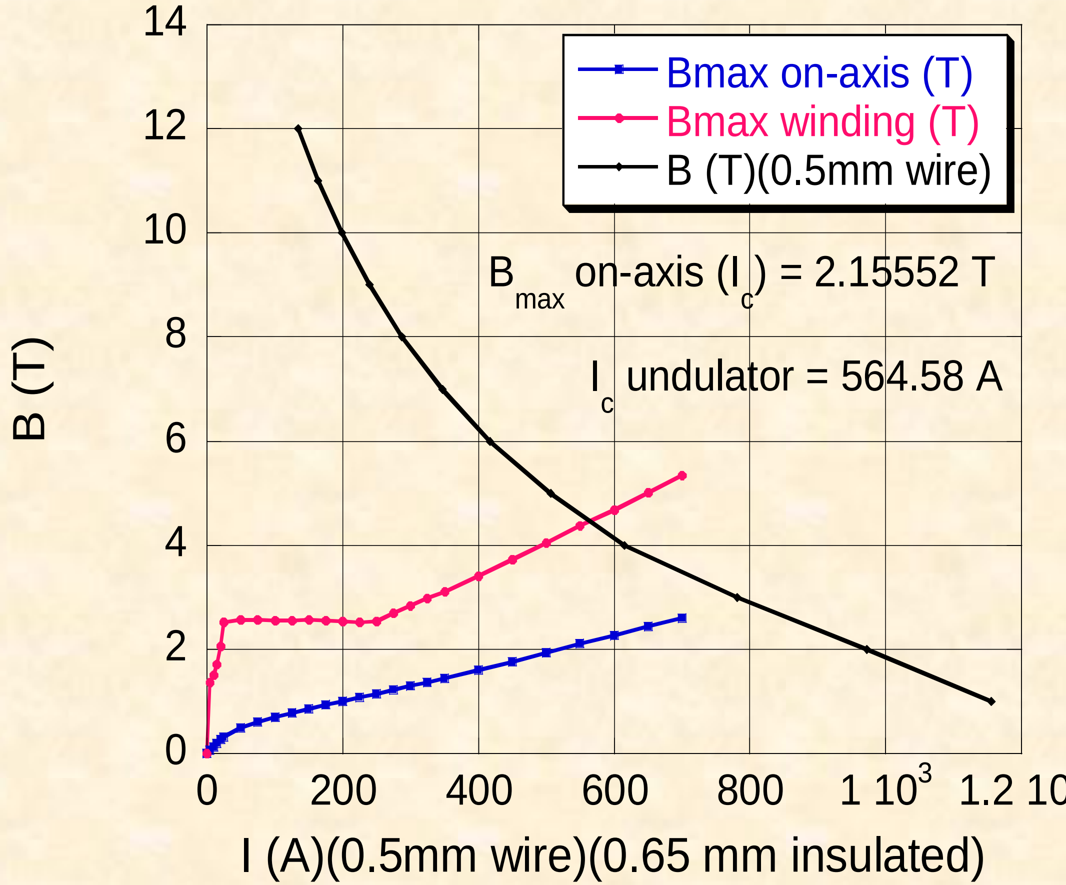
Period (λ)	14.5 mm
Beam aperture	7.0 mm





Test Result of the Short Period Planar Undulator





- ❖**This undulator coil reached a field of 2.3 T in the bore, which is almost three times the reported highest field of 0.8 T at the bore for a previously reported similar Nb_3Sn undulator coil.**
- ❖**Another coil with higher J_c strand are being constructed. (2.5T)**

To Summarize

Current Status

Tube Type Strand	D_{eff}	Non-Cu Jc at 12 T, A/mm^2	I_c of 0.7mm strands, A	$\varepsilon_{irr,0}$, %	AC loss, mJ/cm^3
192-subelement	35 µm	2300-2600	400-450	0.24-0.26	2410
744-subelement	18 µm	1900-2200	300-350	0.43-0.48	600

Potential Applications

1. Future Advanced Fusion Projects: Triple the current ITER J_c Spec, similar AC loss, Cost effective.

2. 12-20 T Magnet: High J_c, stable, long length.

3. Undulators: High J_c, stable in the low field, long length.

*** 12 mm and 10 mm period helical undulator (1 T)**

*** 14 mm period planar undulator using higher J_c conductor (2.5 T)**

4. High Energy related projects: for example CERN upgrade. Call for 30 µm subelement at 1 mm strand which required a 547-subelement restack. Currently tubular approach conductor is the only one to get long piece length meeting this requirement.