I.FAST – 2nd Steering Committee WP8 – report – 15 .November.2021 – virtual meeting

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I.FAST WP8 (magnets) members

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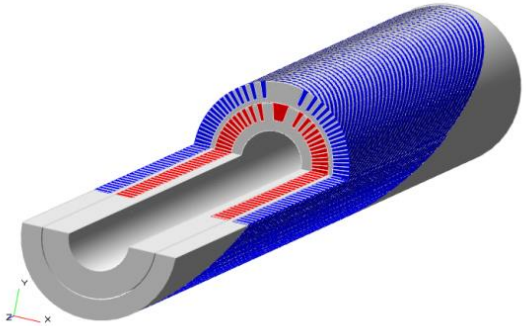
IFAST-WP8 (CCT magnets part) meetings

- Kick off meeting : 29 April 2021
- We had n.4 meetings (Last meeting : 21 October 2021)
- Regular meeting each third Thursday of each MONTH at 9h00.
- (we invite also HITRIplus members as invited)
- We build the Design work matrix

WP8 duration: from M1 to M48 !!
Scope of our WP8

- Here we want to develop technologies supporting the EU Industry that wish to learn about the CCT developed by CERN.
- We aim at something useful for advanced HatronTherapy (SEEIIST)
- → 1 HTS CCT preceeded by 1 NbTi of same dimension as “gauge”
  - 2 HTS CCT ideal: need additional effort for budget (HTS tapes -> CERN; or MgB2, but conductor procurement is also a cost issue… apart for field low))
- We would like to stay “near” the parameter of HITRI+
- Straight!, since we consider that HTS is already difficult enough!

CCT dipole
4 T operative
5 T target; Ø =60-90 mm;
500mm < L < 1000 mm



IFAST WP8 Design Option Matrix (Oct 2021)

	IFAST WP8 Design Option Matrix		2021							
		Institutes	5	6	7	8	9	10	11	12
Task 8	HTS SG	CERN-INFN								
Task 8.2	CCT - Nb-Ti	INFN-CERN-Wigner								
	CCT - Nb3Sn	No								
	CCT - MgB2	INFN- CIEMAT?								
	CCT - Bi-2212	INFNGE								
	CCT - B-2223	CERN?								
	CCT - REBCO	CEA-INFN-CERN-Wigner-Elytt								
	CCT - IBS	NO								

	10	11	12	1	2	3
	M2				D2	
					M3	

- Milestones:
  - M2 (10/2021) : Charac. of the first length of superconductor for low losses (DONE)
  - M3 (02/2022) : Decision on demonstrator layout
- Deliverable
  - D2 (02/2022): Report with complete list of parameters motivating the choice for the design.

First decision: change in the layout of the first CCT (on in LTS)

- We devised to design a curved CCT in LTS as precursor of the HTS straight CCT.
- However, a curved CCT is already foreseen in HITRI+
- All community thinks a that a combined function (dipole + quadrupole winding, superimposed) is maybe more interesting step.
- In addition, we may use very low losses SC wire
  - So straight , combined function, with low losses design (wires + former) is better that a simple curved CCT.
  - Presented Amendement request

Timeline

IFAST WP8: Innovative Superconducting Magnets
Task 8.1 - Coordination and High-Temperature Superconductor (HTS) Strategy Group
Task 8.2 - Preliminary Engineering design of combined Canted Cosine Theta (CCT) magnet
Task 8.3 - Preliminary Engineering design of HTS CCT
Task 8.4 - Construction of combined CCT magnet demonstrator
Task 8.5 - Construction of the HTS CCT magnet demonstrator
Task 8.6 - Development of ReBCO HTS nuclotron cable

Change: design of a straight combined function, low loss CCT magnet

HTS European Strategy Group 8.1 deadline shift

IFAST Deliverables

	Task	Resp.	Type	Del. In Months	Name	Description
D1	8.1	CERN	Report	12	HTS European Strategy Group	Set up of the ESG and kick off meeting with approval of program, scope, and modus operandi.
D2	8.2	INFN	Report	10	Conceptual Design of combined CCT in LTS	Report with complete list of parameters motivating the choice for the design.
D3	8.3	CEA	Report	18	First Engineering design of HTS demonstrator	Report with a set of coherent parameters of the near-to-final design
D4	8.4	BNG	Demo	38	Construction of combined CCT demonstrator	Magnet demonstrator complete with electrical termination and transport constrains
D5	8.5	Ellytt	Demo	42	Construction of HTS CCT demonstrator	Magnet Demonstrator with electrical terminations and transport constrains.
D6	8.6	GSI	Report	32	Fast-cycling Nuclotron HTS cable design	Design parameters of the HTS Nuclotron cable aiming at 6 T magnetic field cooled by two phase forced flow Helium, AC loss measurements.

IFAST Milestones

	Task	Type	Deliv. In Months	Name
M1	8.1	Review Report	20	Construction readiness of combined CCT demonstrator
M2	8.2	Measurement Report	6	Charac. of the first length of superconductor for low losses
M3	8.3	Design Report	10	Conceptual design of HTS magnet
M4	8.4	Rep. Conformity Cert.	32	Construction of the formers for combined CCT winding
M5	8.5	Rep. Test and Ass.	38	Test of mock up coils with dummy cable
M6	8.6	Lab. Test of Sample	24	HTS Nuclotron cable produced

Milestone Report done by INFN CERN, and UNIGE

Milestone MS32: Characterization of the first length of superconductor for low losses

IFAST

Innovation Fostering in Accelerator Science and Technology

Horizon 2020 Research Infrastructures GA n° 101004730

MILESTONE REPORT

Characterization of the first length of superconductor for low losses

MILESTONE: MS32

Document identifier:	IFAST-MS32
Due date of milestone:	End of Month 6 (October 2021)
Justification for delay:	Completion of the measures
Report release date:	12/11/2021
Work package:	WP8: [Innovative Superconducting Magnets]
Lead beneficiary:	INFN
Document status:	Draft 1.0

ABSTRACT

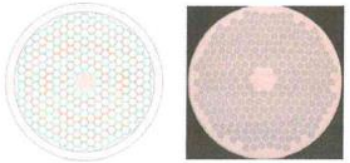
The document is a measurement report concerning the characterization of the NbTi low losses superconductor wire.

The measurement report collects the following measurements: critical current, RRR and magnetization measurements. The critical current and RRR measurements have been performed at LASA laboratory of INFN (Milan, Italy). A crosscheck measurement for the critical current has been done by CERN. The magnetization measurements have been performed by the Group of Applied Superconductivity of the Faculty of Sciences of the University of Geneva (Unige, Switzerland).

Grant Agreement 101004730 1 / 14

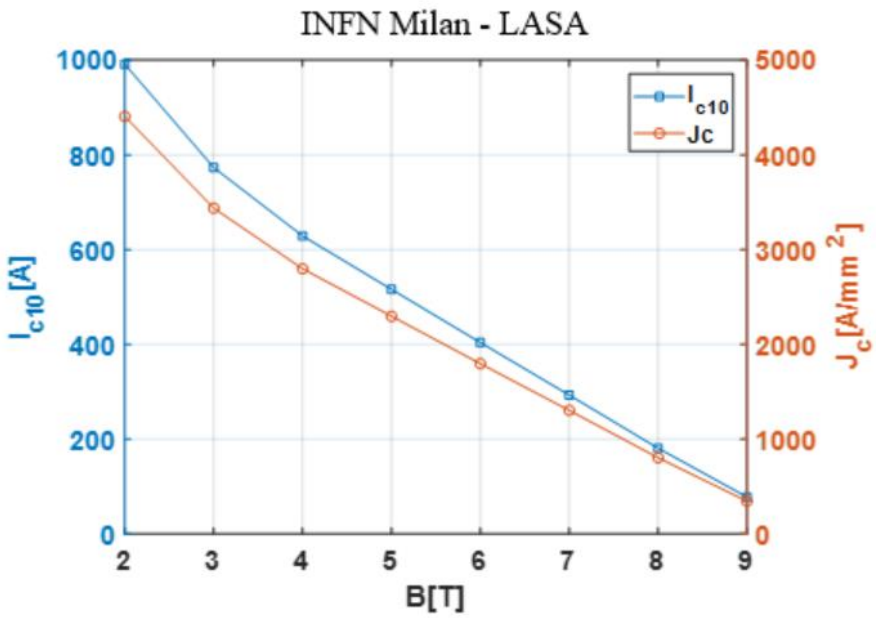
NbTi superconductor wire (originally designed according to the specifications for the DISCORAP project), produced by Bruker

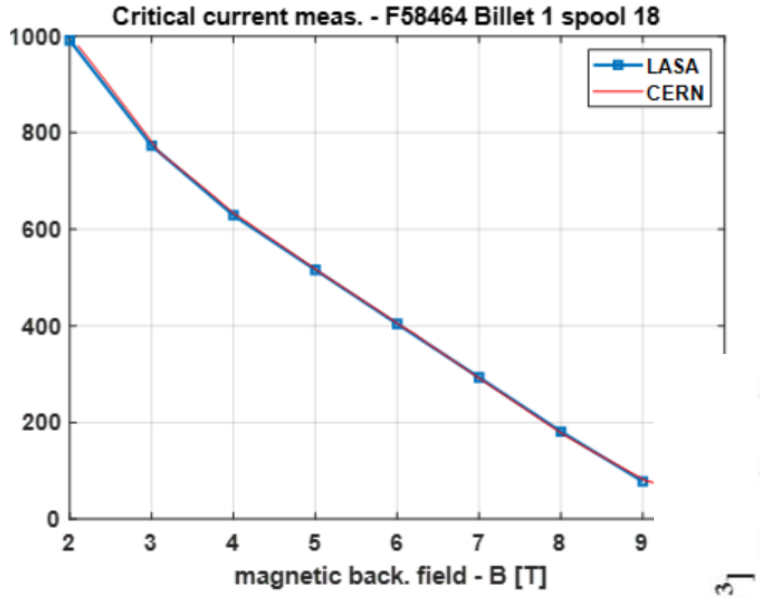
- Strand Typ LF = F58464
- SnAg5 coated strand Ø ≈ 0.821 mm
- Cu / CuMn0.5 : NbTi ≈ 1.36
- Twist length ≈ 6.6 mm



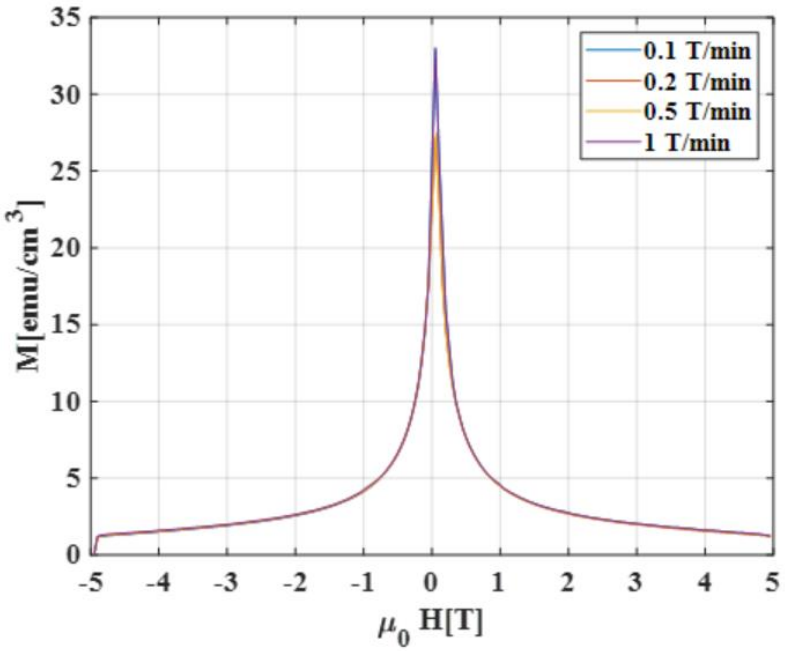
- Critical current measurements (INFN and CERN)
- RRR measurements (INFN)
- Magnetization measurements (Univ, of Geneva)

Milestone MS32: Characterization of the first length of superconductor for low losses





Minicoil for Magnetization meas.



1. Critical current (Jc= 2297 A/mm2 @ 5T, 4.2 K), about 20% less LHC02 outer layer strand.

2. Nb-Ti filaments of the order of 2.6 µm

3. RRR>130 as expected

CCT Computation Design Workshop:

Scope: the strong interest of magnet design according to the Canted Cosine Theta (CCT) concept,
pursued in both European H2020-HITRIPlus and H2020-I.FAST programs,
HITRIPlus-WP8 (Superconducting Magnet Design) and H2020-I.FAST-WP8 (Innovative Superconducting Magnet)

The workshop was held in remote and on 21 and 22 September afternoon (3.00 pm - 7.00 pm)

Attendees: I-FAST and HITRIplus partners but also other groups, as LBNL and CERN

Chair: Lucio Rossi, INFN-Milano LASA lab (HITRIPlus-W8 and IFAST-WP8 coordinator), lucio.rossi@cern.ch

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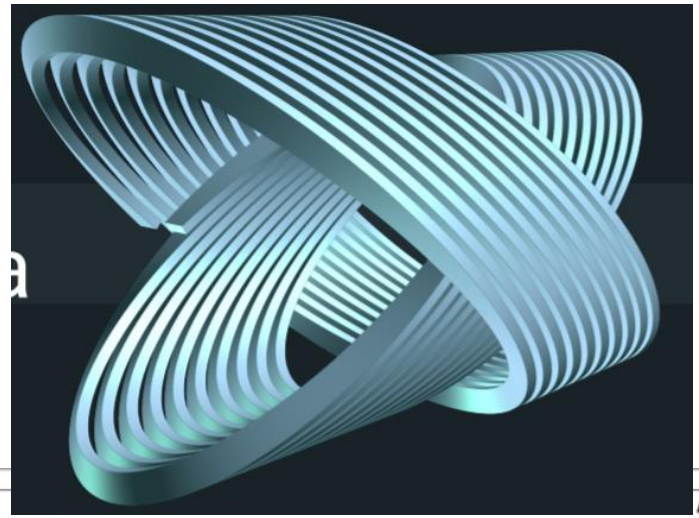
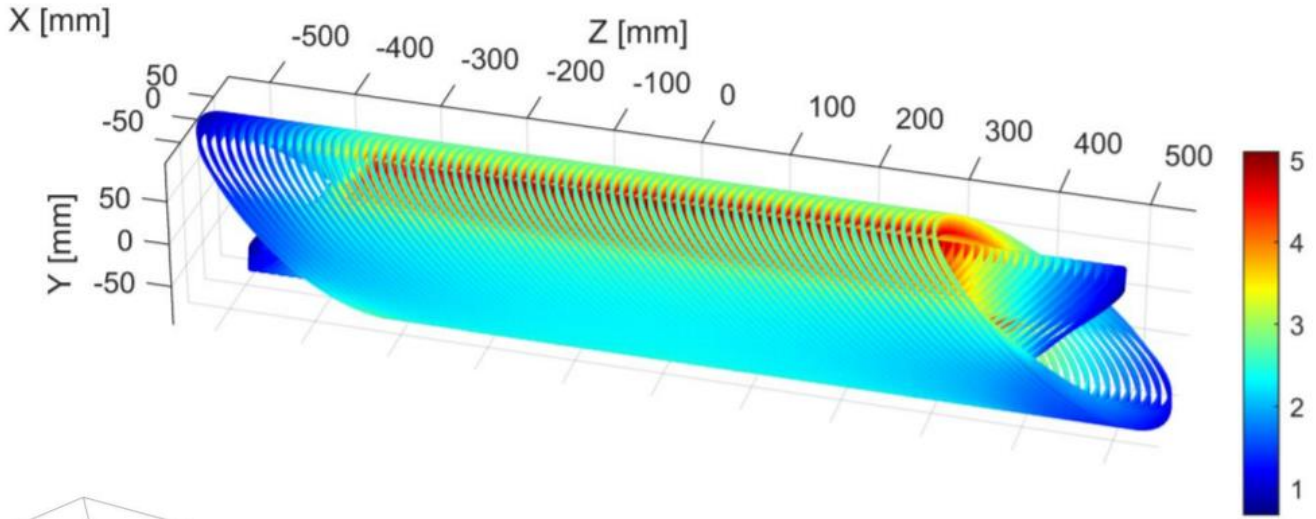
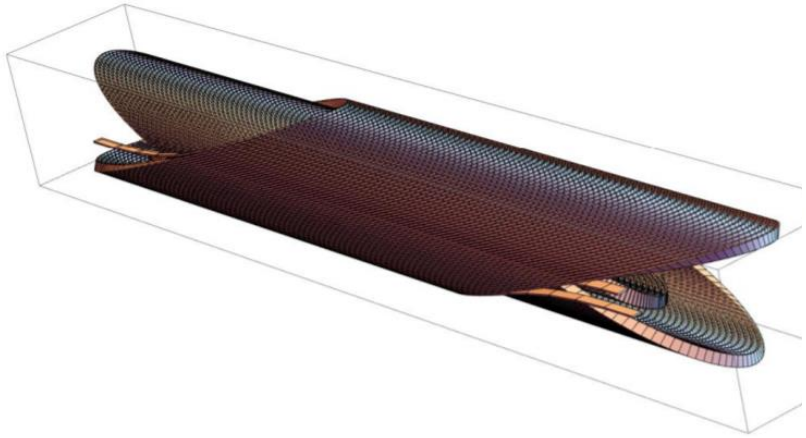
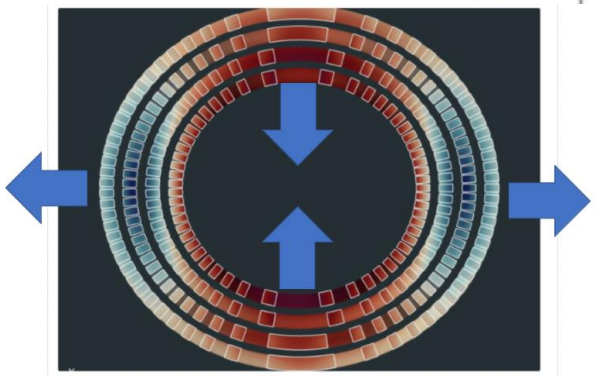
CCT-CD Workshop:Outcomes

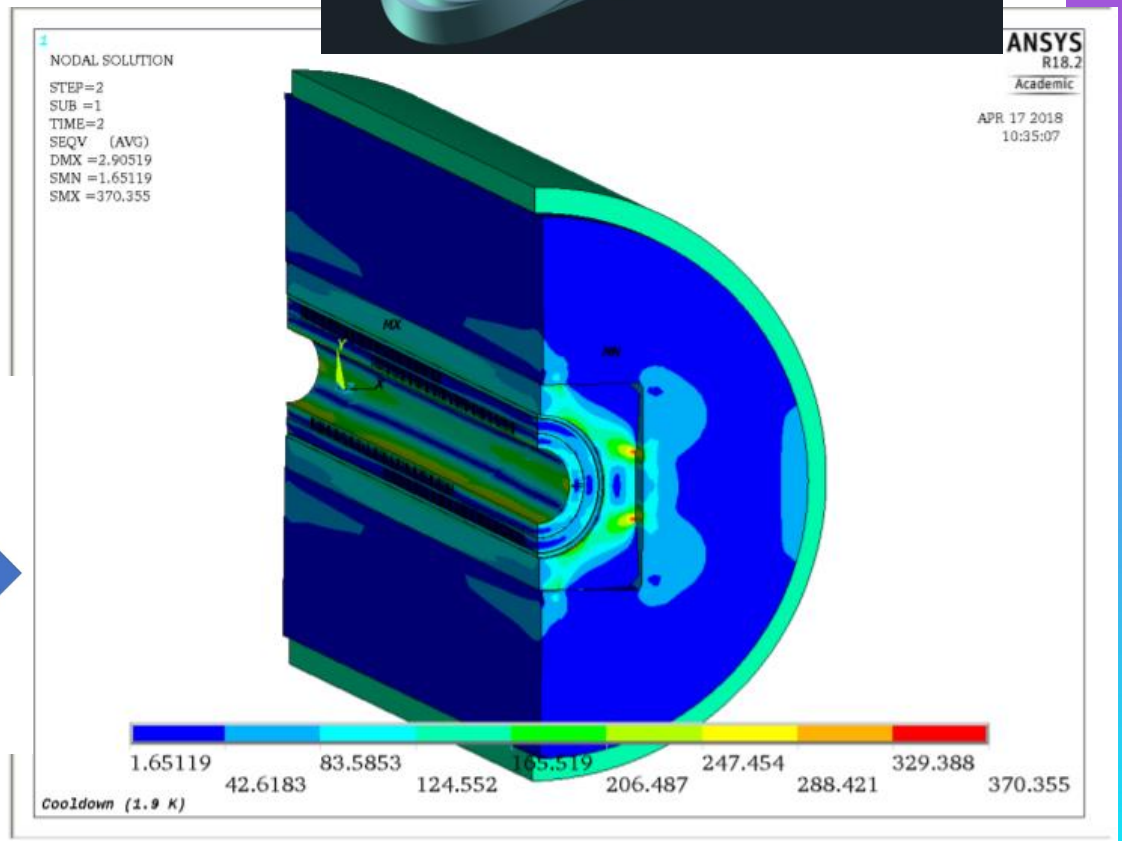
- Design and Computation Tools





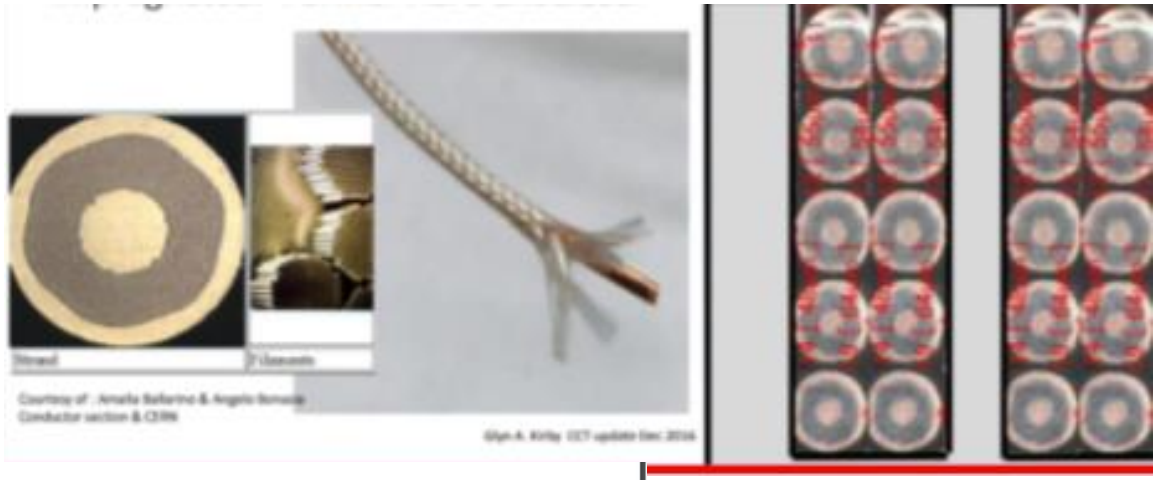


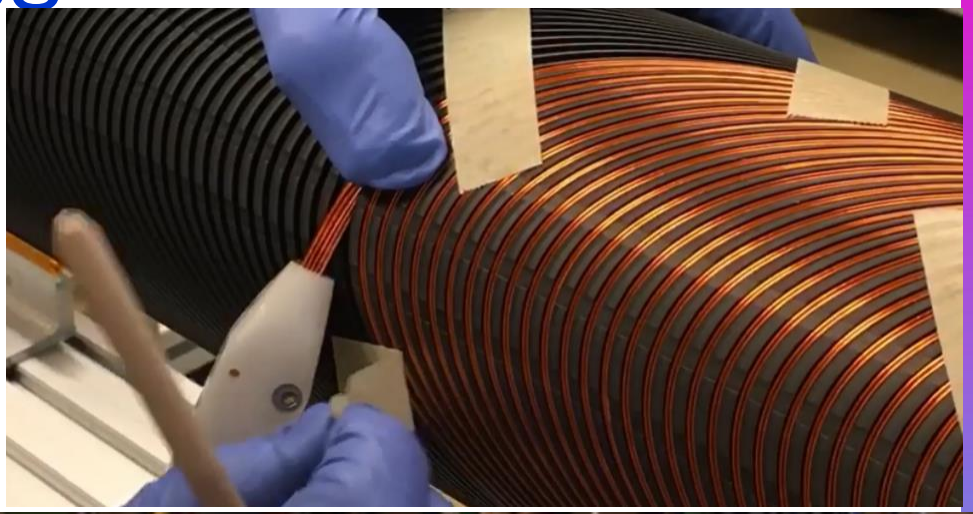


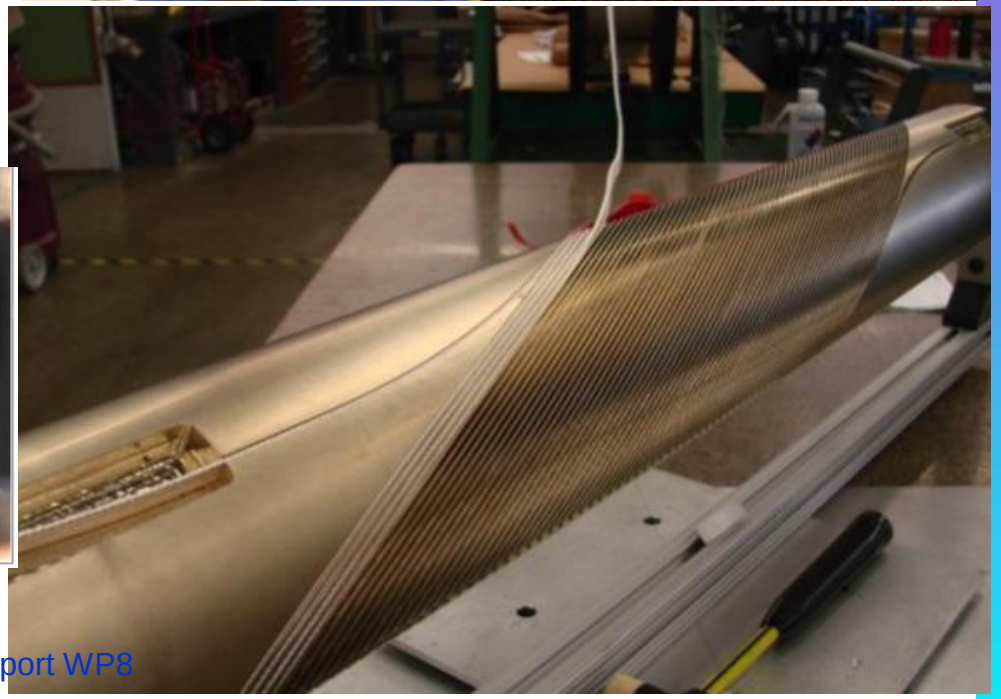


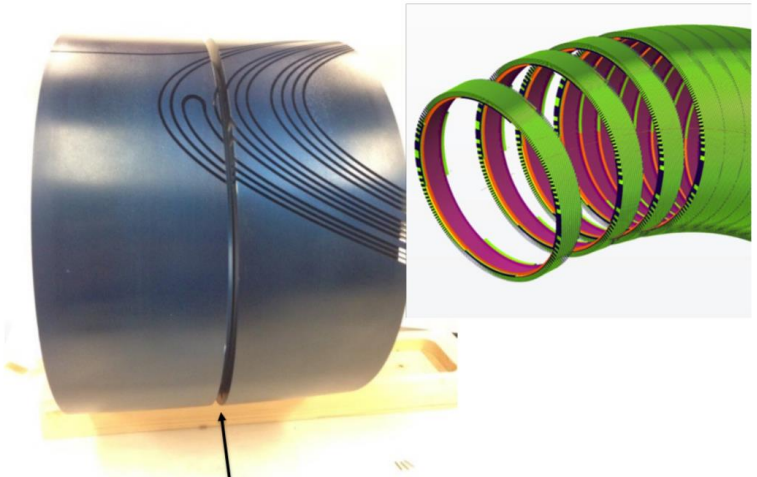
CCT-CD Workshop:Outcomes

- Technology for CCT

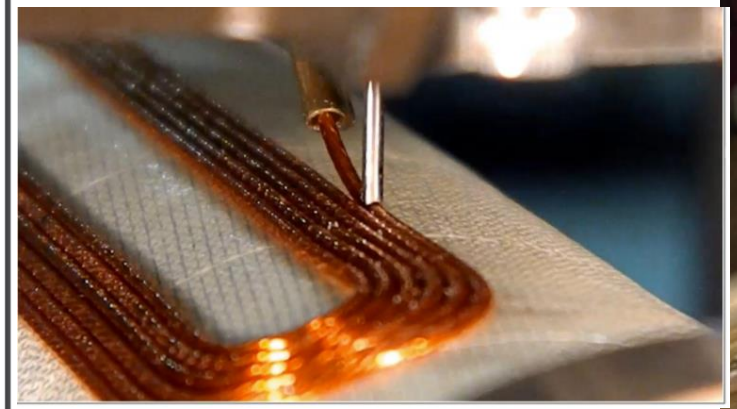




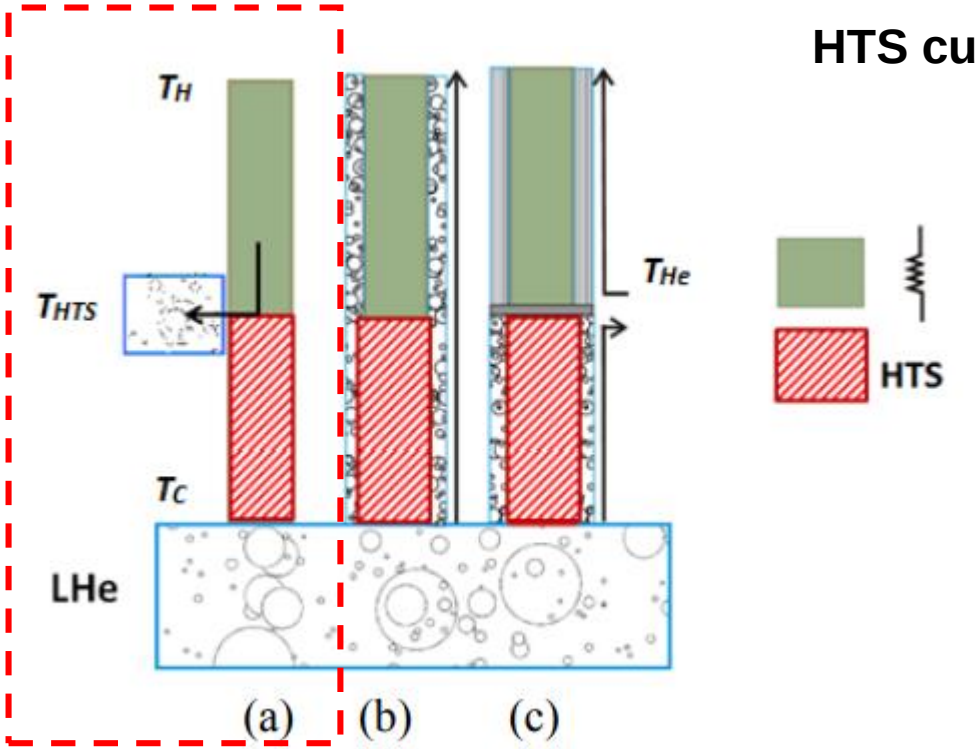




Matching parts



Focus on Power consumption of Current leads (Last IFAST/HITRIplus meetings)



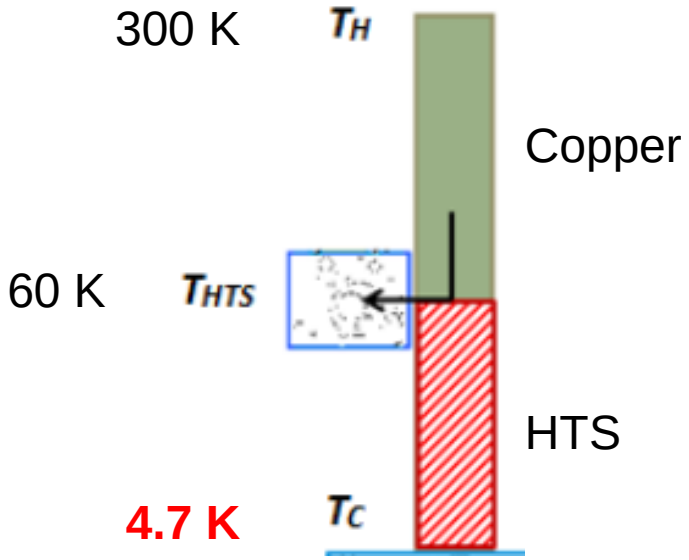
HTS current leads : cooling scheme[1]

(a) HTS conduction-cooled current lead;
(b) HTS self-cooled current lead;
(c) HTS gas-cooled current lead.

T_{HTS} is the temperature at the top end of the HTS part

[1]Amalia Ballarino, ‘‘Current Leads, Links and Buses’’, CAS-CERN Accelerator School: Superconductivity for Accelerators, Erice, Italy, 24 April - 4 May 2013

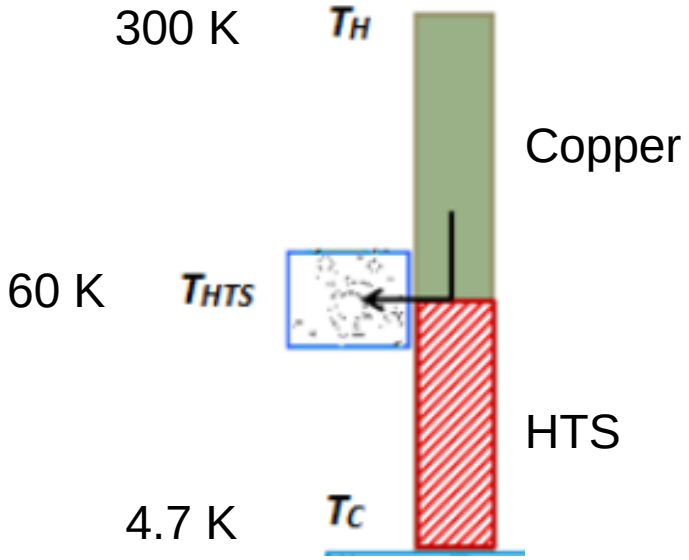
CCT configuration: HTS conduction-cooled current lead



The CLs consist of a copper resistive part between room temperature and 60 K, and an HTS part between 60 K and 4.7 K.

The 60 K temperature should be provided by a cryo-cooler, which acts as heat-sink for the upper resistive part of the leads

CCT configurations: current leads power consumption



Resistive part between 300 K and 60 K:

$$\frac{Q_{c,min}}{I} = 46\left[\frac{W}{kA}\right]$$

2 x Rutherford cables (I ~10 kA)

2 x 10 ropes (I ~1.5 kA)

$Q_{c,min} \sim 460\ W$

For each CL

$Q_{c,min} \sim 70\ W$

Are there available cryocoolers?

Current Limitations for NbTi and Nb3Sn superconductors

The same CL at zero current absorbs the 50% of the nominal power (nominal current) if made by phosphorus deoxidized copper (much more if made by pure copper).

Thanks for the attention!!!