



# Meeting on CCT magnet based on NbTi for IFAST

IFAST WP8 Meeting #11

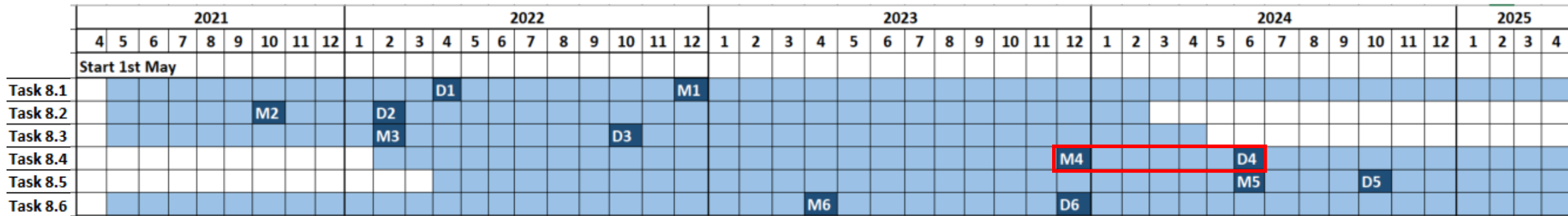
15<sup>th</sup> September 2022

Ernesto De Matteis

# IFAST WP8 Gantt & Deliverables and Milestones

<b>IFAST WP8: Innovative Superconducting Magnets</b>
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
<b>Task 8.4 - Construction of combined CCT magnet demonstrator</b>
Task 8.5 - Construction of the HTS CCT magnet demonstrator
Task 8.6 - Development of ReBCO HTS nucletron cable

<https://ifast-project.eu/wp8-innovative-superconducting-magnets>



- Milestone:
  - M4 (12/2023): Construction of the formers for combined CCT winding (Rep. Conformity Certification)
- Deliverable:
  - D4 (06/2024): Construction of combined CCT demonstrator
    - Magnet demonstrator complete with electrical termination and transport constrains

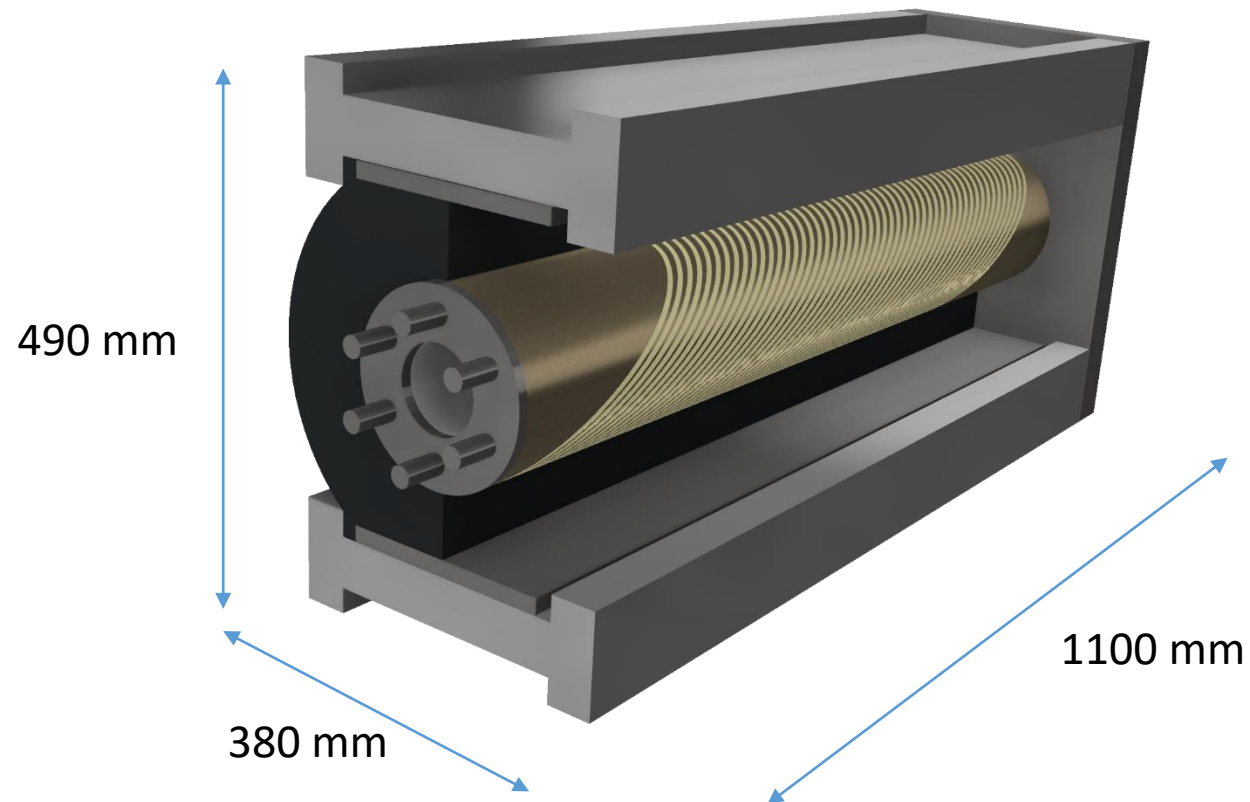
# List of target parameters

Parameters	Values	unit	Comments
Magnet type	CCT + Iron	-	Iron used as magnetic shield and mech. collar
Geometry	Straight, combined	-	Dipole + quadrupole (5 T/m)
Central magnetic field $B_0$	4	T	as HITRIplus and SGRUM demonstrators
Magnetic and physical length	0.8, 1	m	Mainly due to performance/cost optimization
Bore diameter	80	mm	as HITRIplus and SGRUM demonstrators
dB/dt	0.4	T/s	as HITRIplus and SGRUM demonstrators
Operation temperature	4.7	K	Helium gas + Cryocoolers
Loadline margin (@4.7 K) static	25	%	
Superconductor	NbTi	-	Discorap strand (III production)

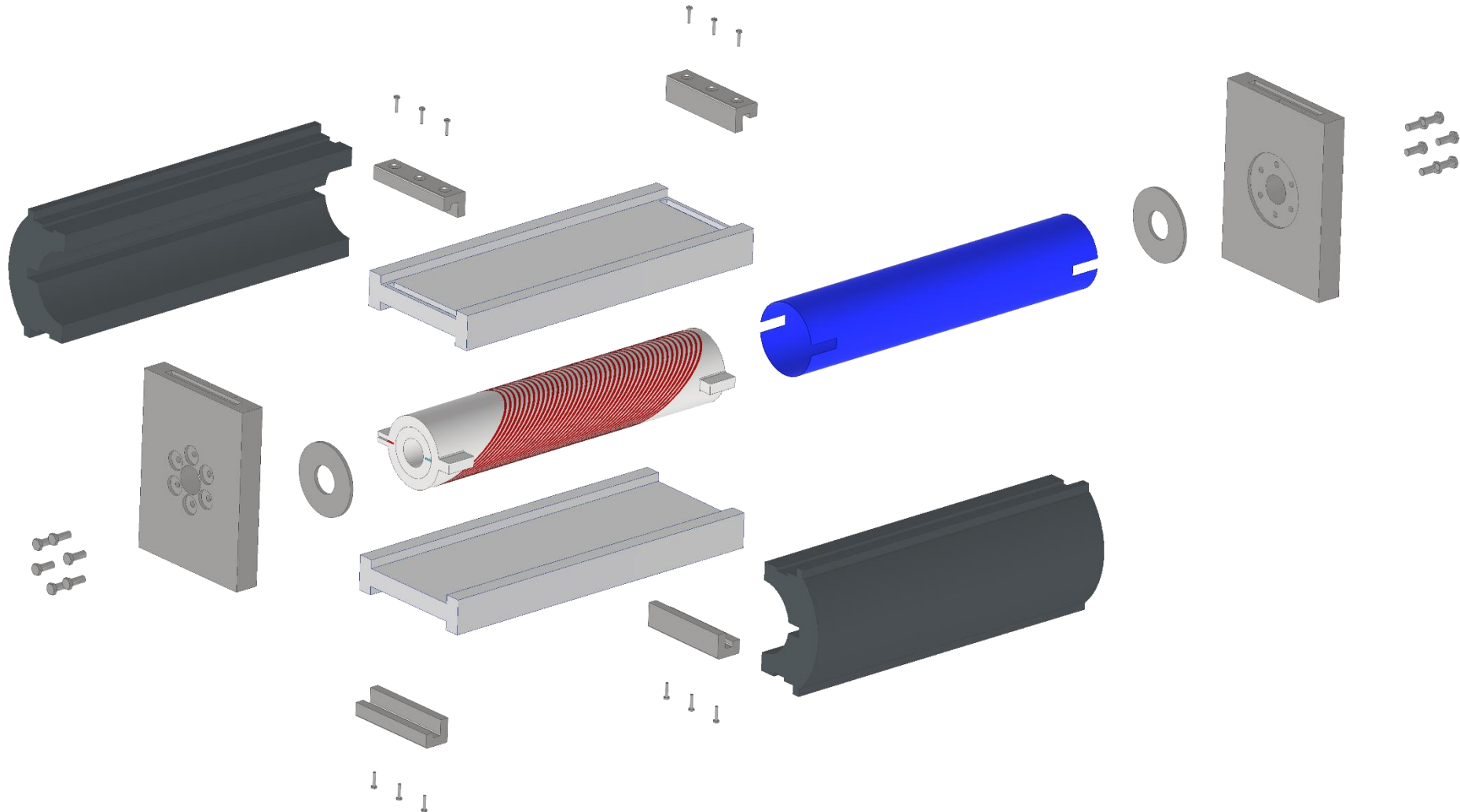
Deliverable 8.2 – Conceptual Design of combined CCT in LTS

<https://zenodo.org/record/6389851#.Yxmp2nZByUI>

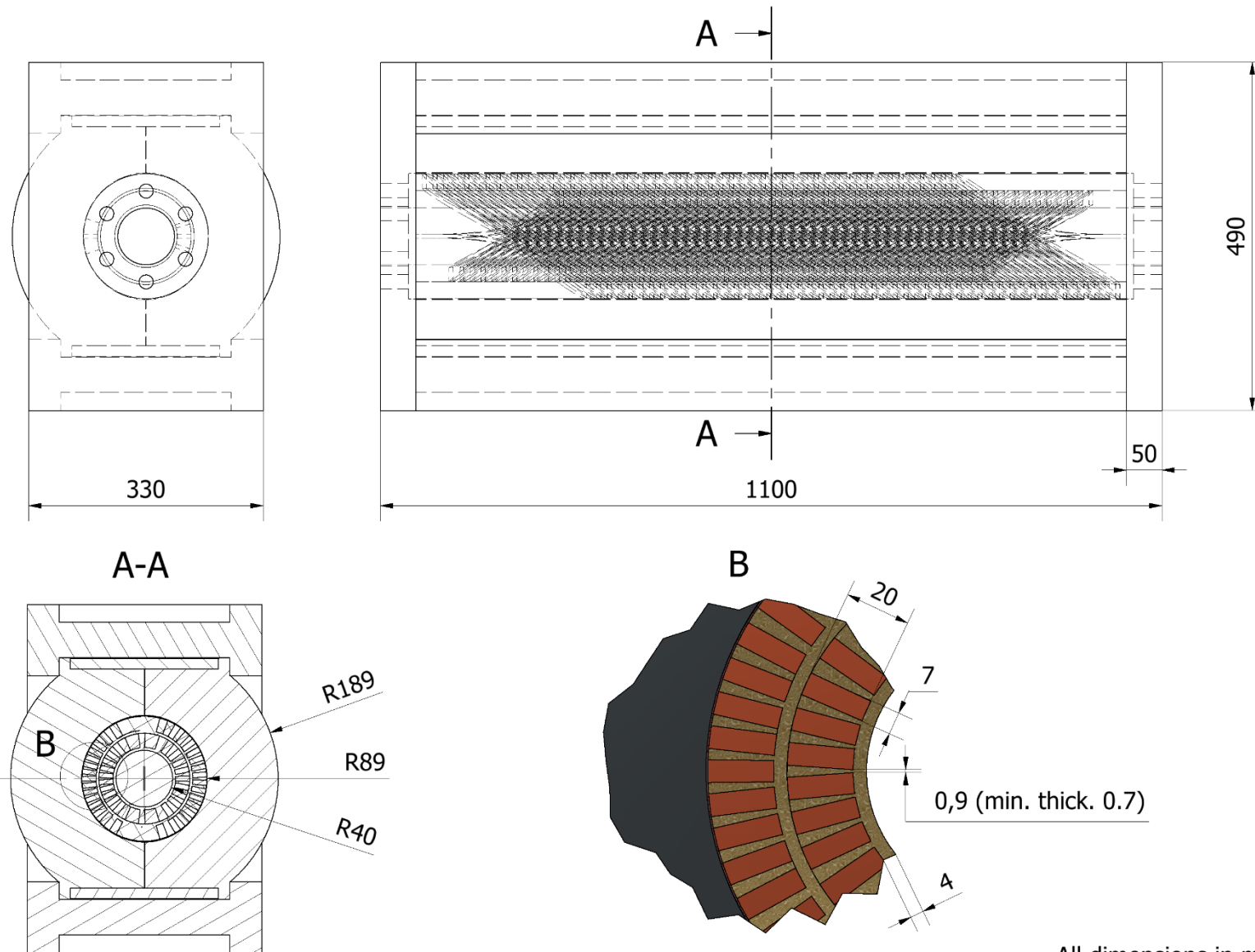
# CCT magnet based on NbTi - model



# CCT magnet based on NbTi - model



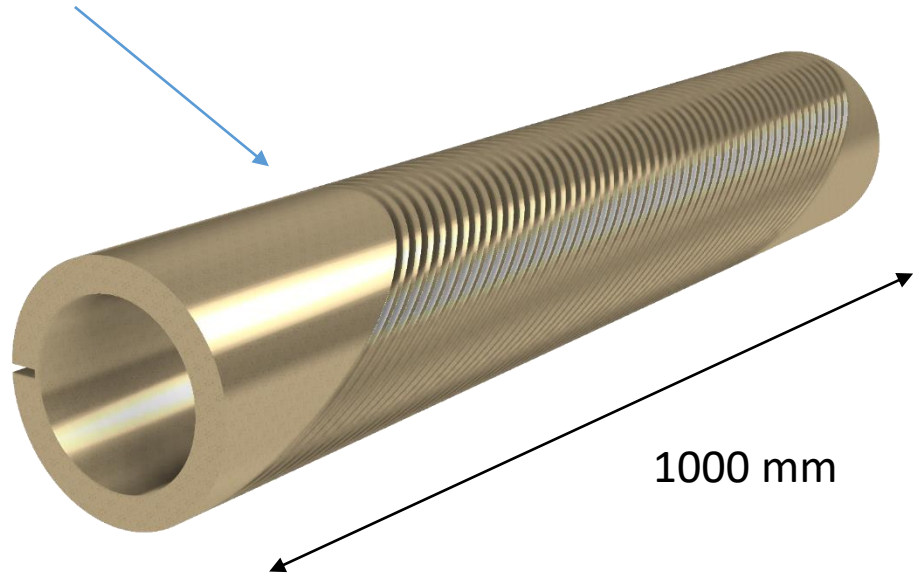
# CCT magnet based on NbTi – drawing sizes



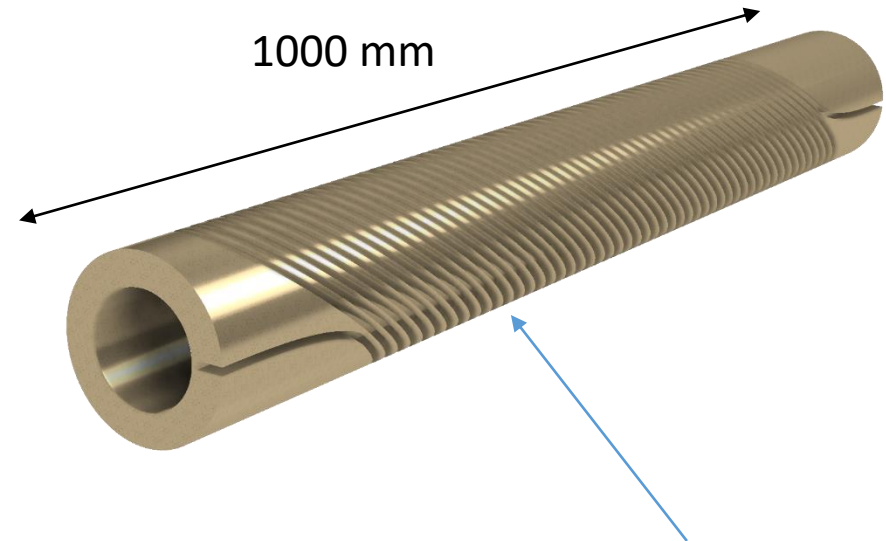
All dimensions in mm

# CCT magnet based on NbTi - Formers

Al Br Outer former



1000 mm

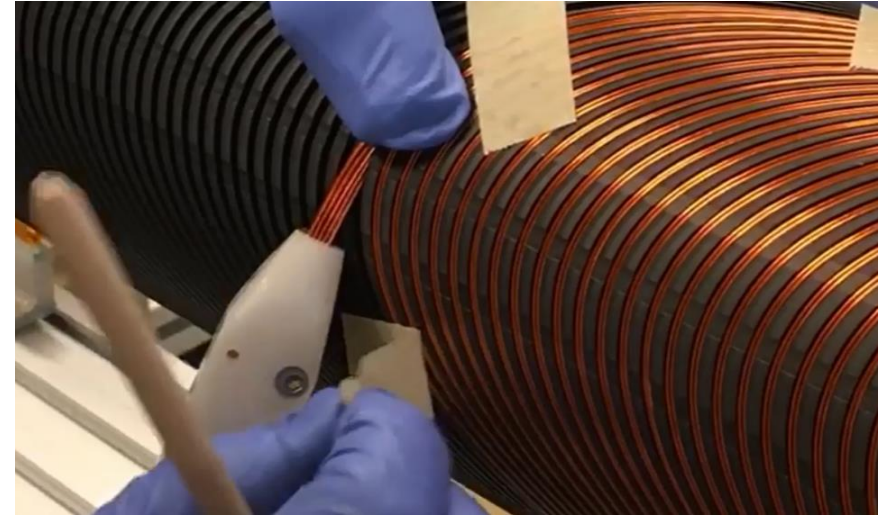
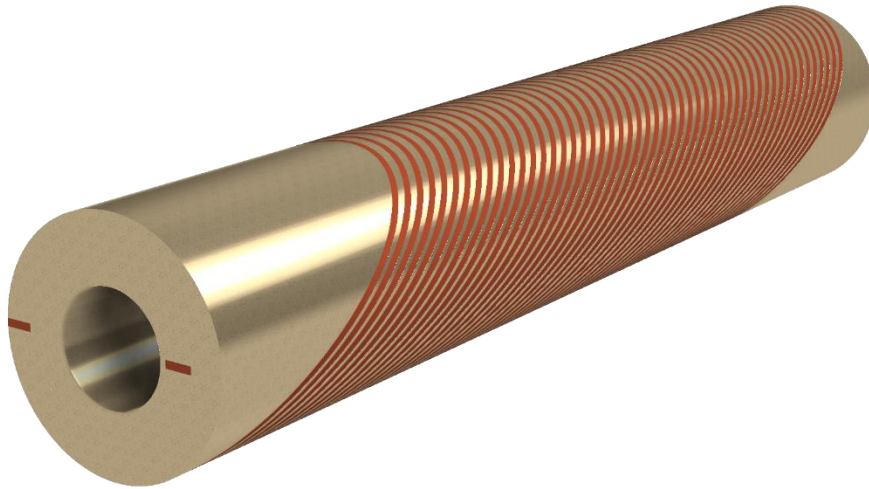


AlBr inner former

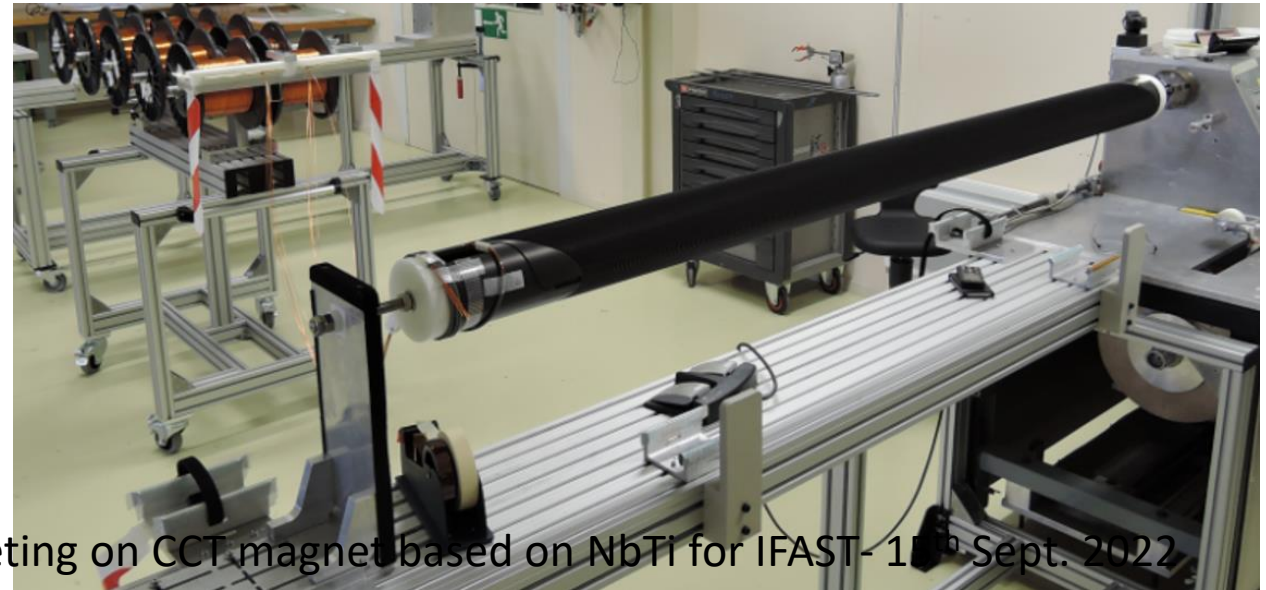
M4 (**12/2023**): Construction of the formers for combined CCT winding  
(Rep. Conformity Certification)



# CCT magnet based on NbTi - Winding



Hilumi CCT method applied to ropes?





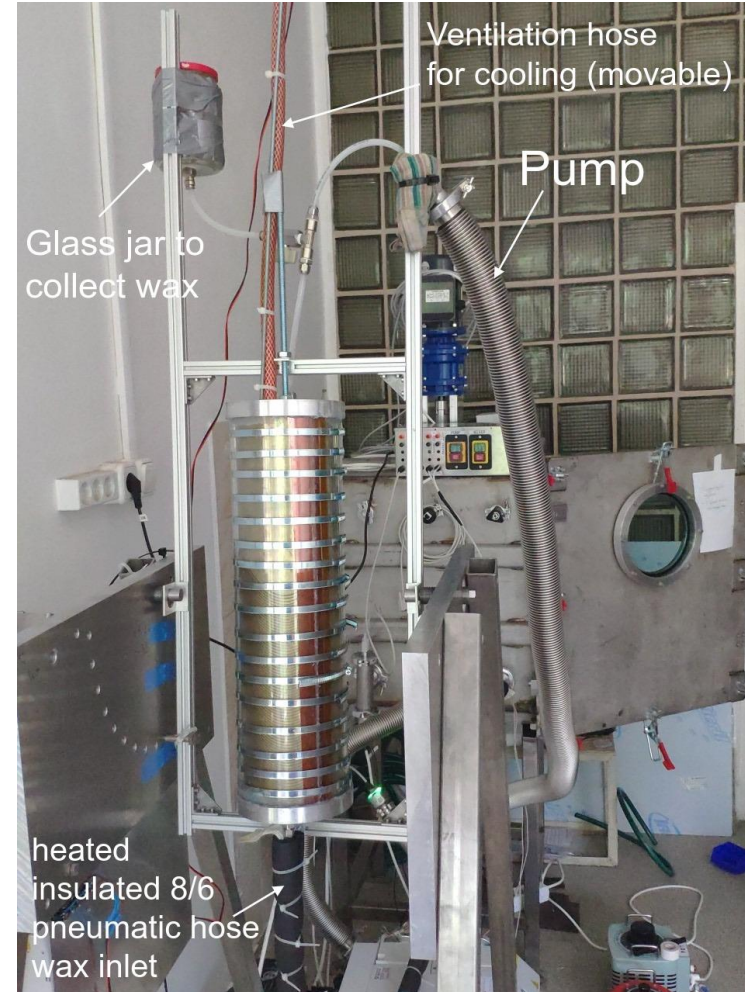
# CCT magnet based on NbTi - Impregnation

## Materials:

- Wax or Bees Wax;
- Epoxy resin

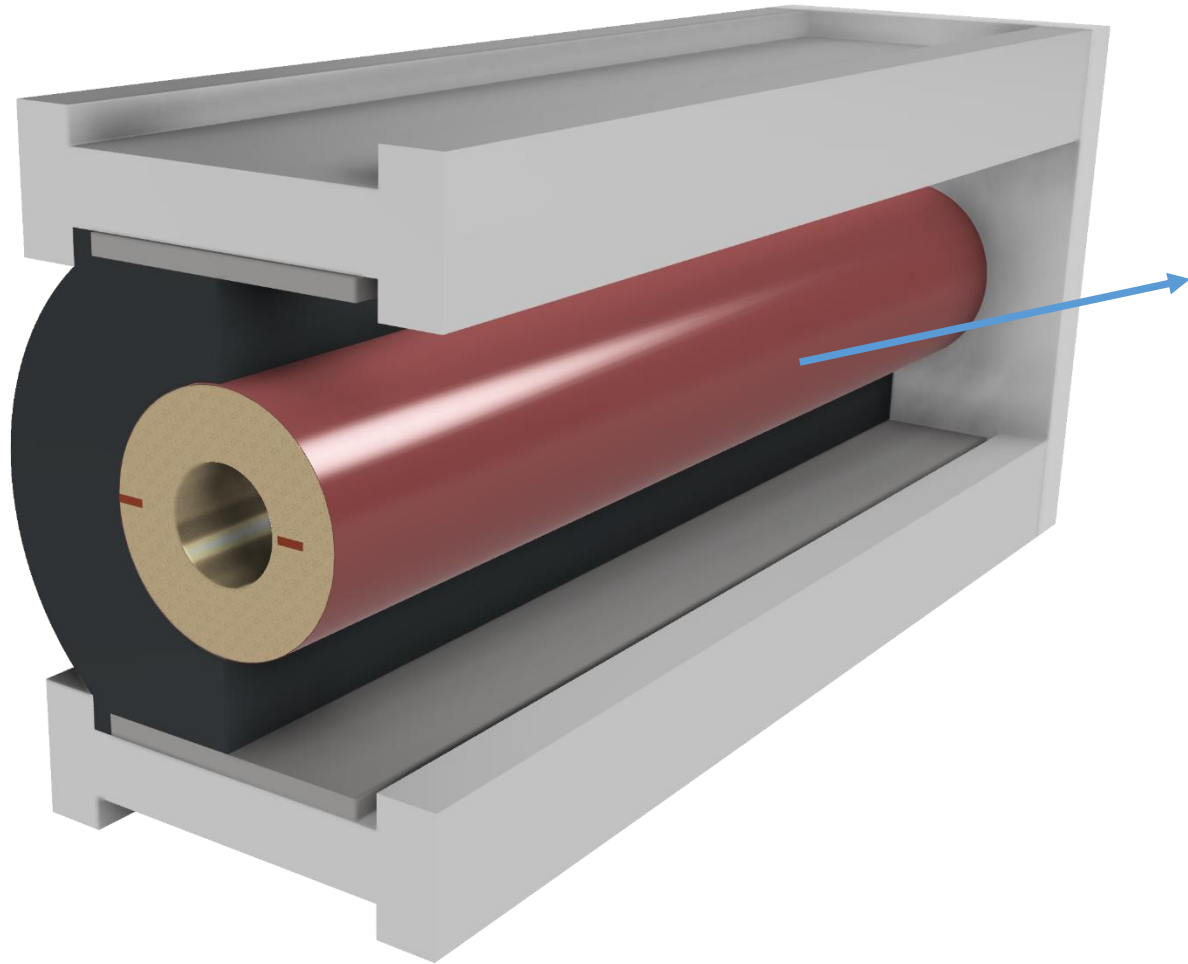
## Vacuum oven:

- Wax temperature range btw 55°-65°
- Resin temperature range up to 130°



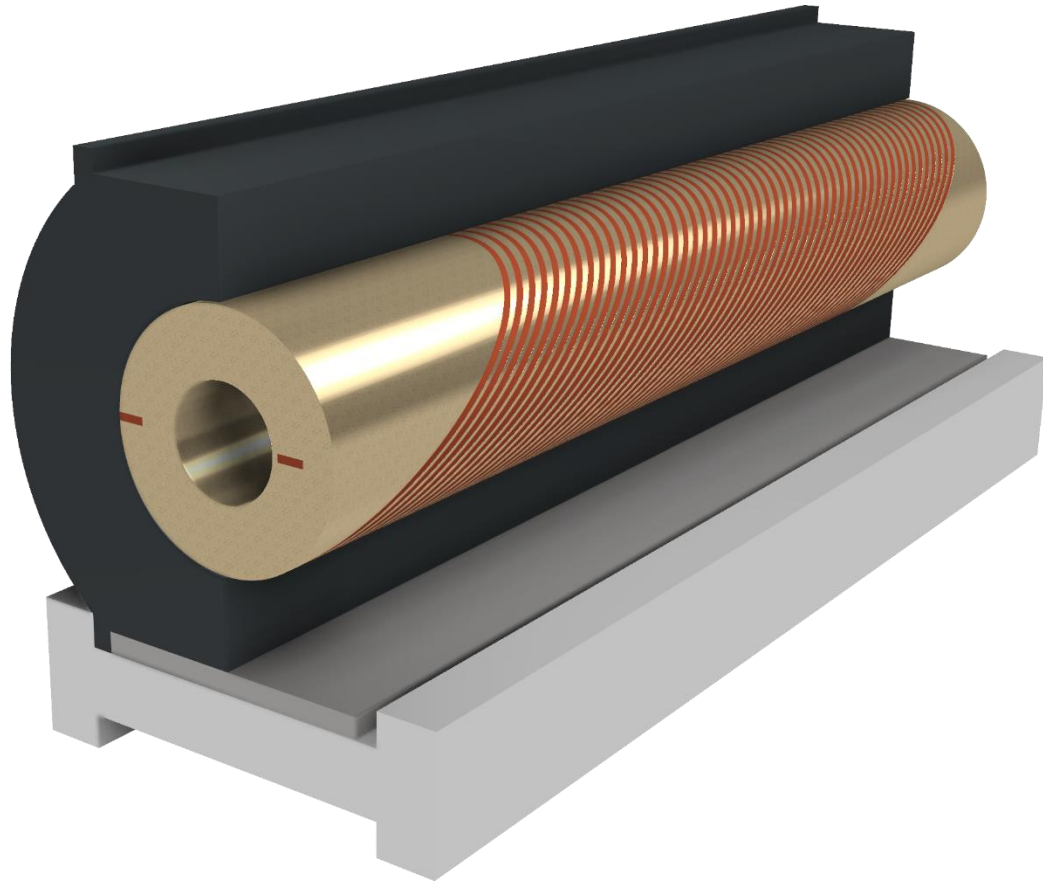
D. Barna – wax test setup (Wigner Institute)

# CCT magnet based on NbTi – Former protection



- Protective layer between mandrel-conductor and iron yoke:
- Overlapped strips of fiberglass, and/or Kapton?

# CCT magnet based on NbTi – Iron yoke laminations

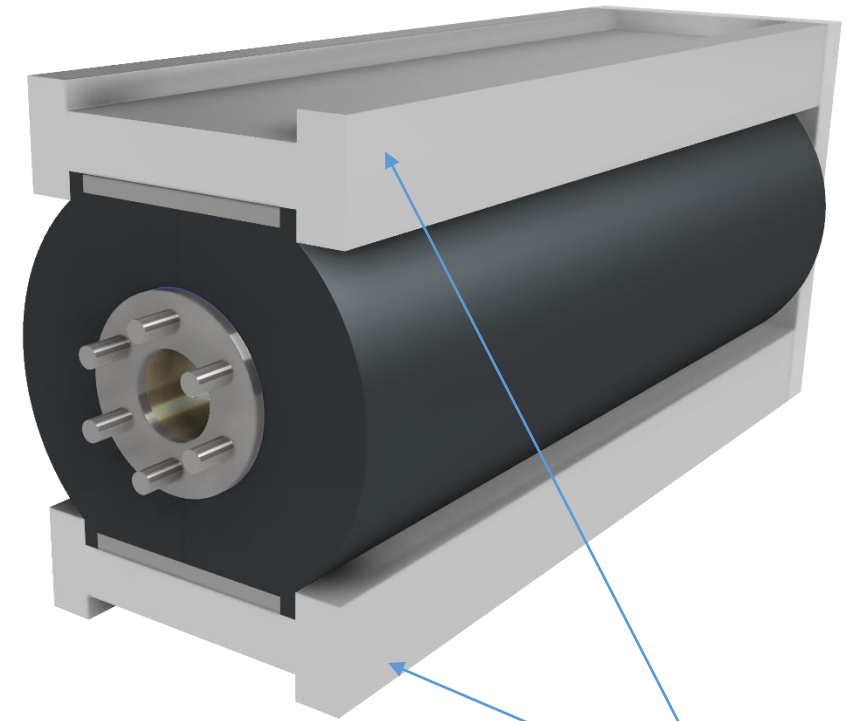
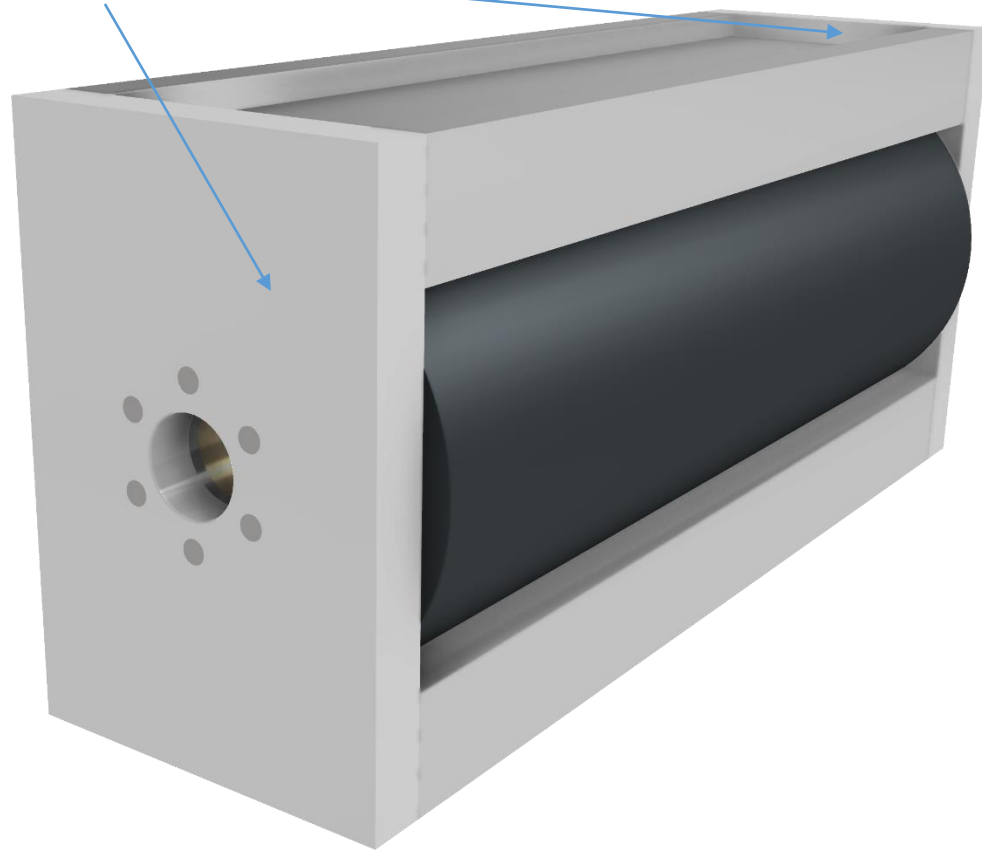


Iron laminations:

- Thickness of 5- 6 mm;
- ARMCO (99.9% of iron);

# CCT magnet based on NbTi - model

End plates in stainless steel



Clamps in aluminum

# NbTi conductor parameters (D2 – IFAST)

Parameters	Values	unit
Strand type	Round	-
Diameter	0.821	mm
(Cu/NoCu) $\alpha$	1.36	-
Jc (5T @ 4.2 K)	2300	A/mm <sup>2</sup>
Ic (5T @ 4.2 K)	516	A
RRR	135	-
Filament diameter	3.15	$\mu$ m

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

<https://zenodo.org/record/5901601#.YxmnQ3ZByUI>



**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**

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**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:** WPS: [Innovative Superconducting Magnets]  
**Lead beneficiary:** INFN  
**Document status:** Draft 1.0

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**ABSTRACT**

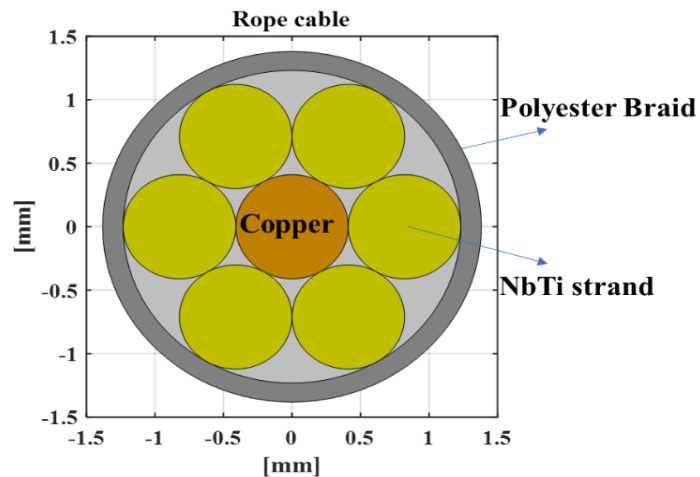
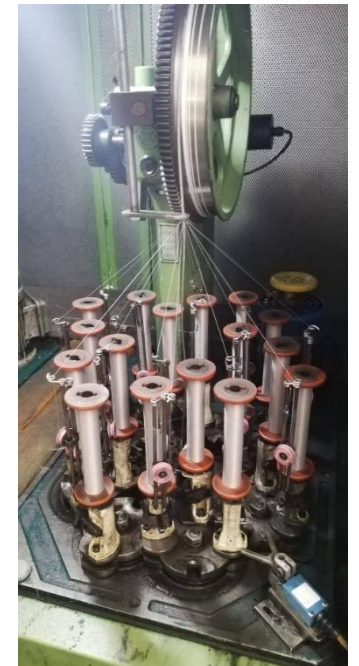
The document is a measurement report concerning the characterization of the NbTi low losses superconductor wire.  
 The measurement report collects the following measurements: critical current, RRR and magnetization measurements. The critical current and RRR measurements have been performed at LASA laboratory 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 (Geneva, Switzerland).

Grant Agreement 101004730 1 / 14

# Cable parameters

Parameters	Values	unit	Comments
Type	Ropes (6+1)	-	Central strand in copper or in NbTi?
Total current (5 T @ 4.7 K)	1500	A	
$J_{\text{rope}}$ (5 T @ 4.7 K)	235	A/mm <sup>2</sup>	
Insulating thickness	0.12 – 0.13	mm	Double braid of polyester

Test rope made of 7 NbTi strands and a single **polyester braid**





# CCT parameters (D2 – IFAST) Inner and Outer

Parameters	Values	unit	Comments
Pitch	15	mm	
Winding angle	26°		
Groove width	5.7 (2.85 mm x 2)	mm	The final ones will be decided after the winding test
Groove height	20 (2.85 mm x 7)	mm	
Minimum ribs thickness	0.7	mm	Post mechanical tests
Spar	4	mm	
# ropes per groove	14		
# turns per layer	51		
Iron, Former distance	2	mm	Iron is used as collar
Max external field $B_{ext}$	0.5	mT	at 2 m of distance from the magnet
Former material	Aluminum Bronze	-	Main constraint from the eddy currents

