

**Dorothea  
FONNESU**

**ESR1  
WP2**

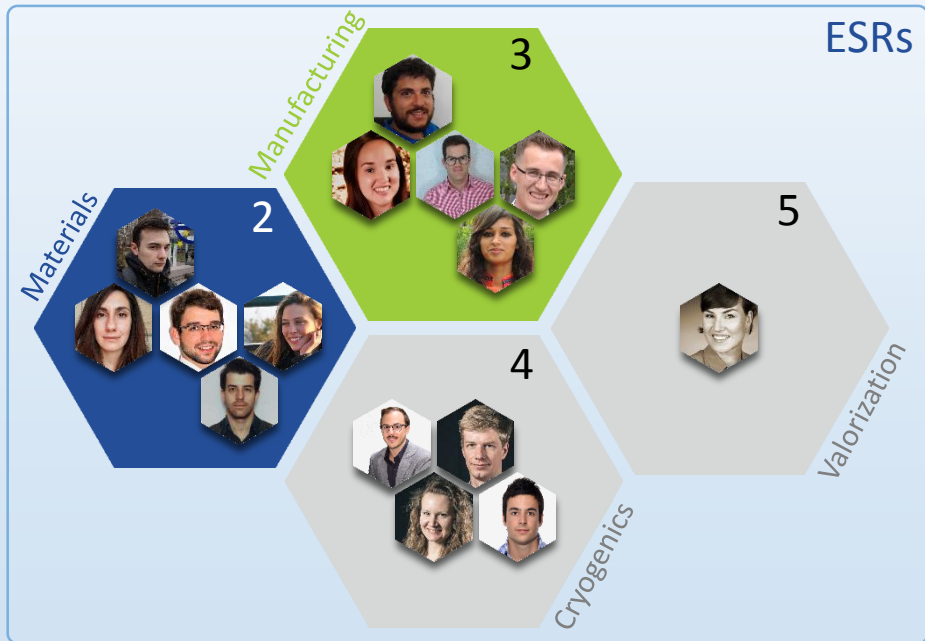
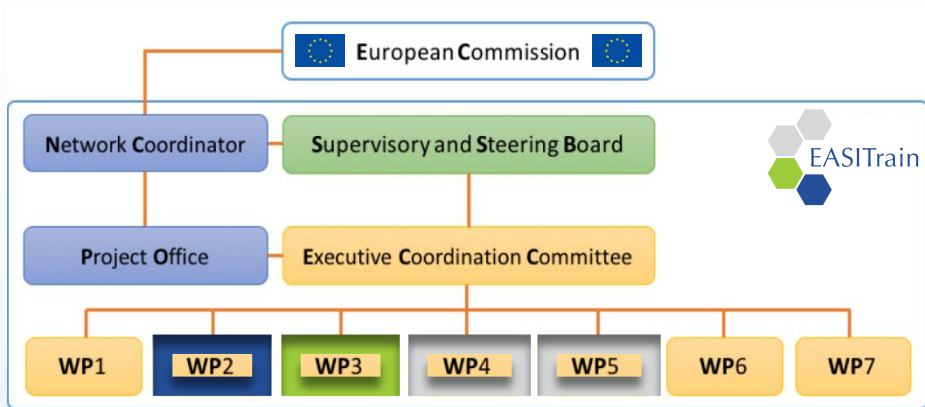
**EASITrain  
Mid-Term Check  
10 December 2018  
Brussels**

- **Bachelor thesis** in particle physics at UniCA
- **Master thesis** in low temperature particle physics at UniHD:  
approached superconductivity
- One year of PhD to keep working at master thesis research
- **Applied for ESR1 position** in EASITrain MSCA ITN, for  
the *study of cryogenic properties of superconducting thin films on copper substrate* at CERN



- **CERN Fellow contract** start date: 01.02.2018
- Host institute: CERN – TE-CRG-CI → **Cryolab**
- **EASITrain/PhD supervisors:** Johan Bremer, Torsten Koettig, Prof. Jens Knobloch
- **PhD University:** UniSiegen, Helmholtz-Zentrum Berlin
- **PhD Title:** Study on cryogenic properties of SC thin films on substrate
- **Past secondment:**
  - 08.10.2018 - 19.10.2018 INFN-LNL  
Dr. Cristian Pira, Vanessa Garcia ESR10
- **Planned secondments:**
  - 09.2019 - 10.2019 CEMECON





ESR1



WP2

## Cryogenic properties of $\text{Nb}_3\text{Sn}$ and $\text{NbN}$ superconductors on substrate

- Qualify the methods used by CERN and INFN-LNL for films deposition
  - $T_c$  test stand
- Develop a model to predict the influence of thermal properties of the film on its substrate on the performance of the superconducting film itself
- Analyse the results with ESR14 (USIEGEN) and ESR10 (INFN-LNL)

## Thin films for SRF R&D program at CERN

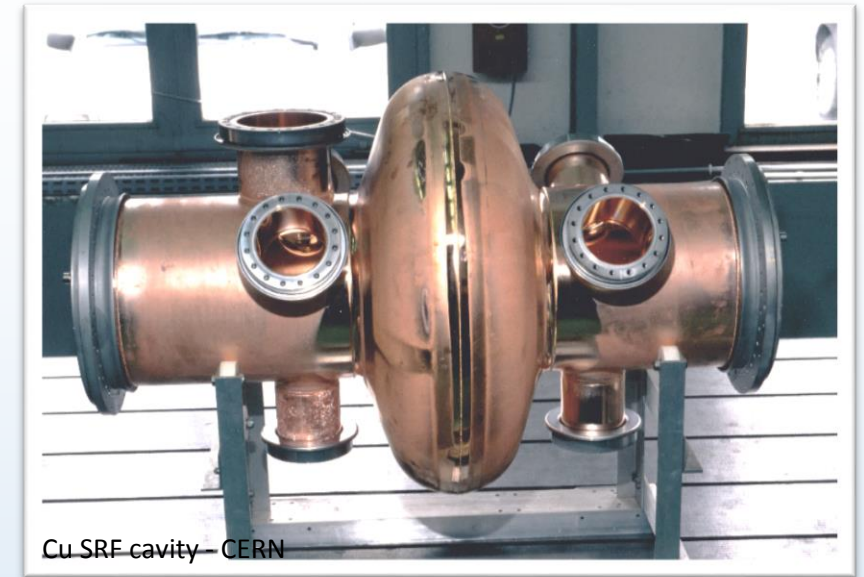
**From bulk Nb to Nb/Cu:** well established since LEP era

- Cu is a cheaper bulk material than Nb
- Cu has higher thermal conductivity at low temperatures than Nb
- Q-slope not fully understood

### **Nb<sub>3</sub>Sn/Cu:**

- Higher  $T_c$  = less cryopower: 9.3 K (Nb) vs 18.3 K (Nb<sub>3</sub>Sn)
- Lower surface resistance = less dissipated power: 45 nΩ (Nb) vs 0.4 nΩ (Nb<sub>3</sub>Sn) @ 4.2 K and 500 MHz
- Synthesize the crystalline phase
- Achieve theoretical  $T_c$  on Cu substrate
- Manage material stress and treatment affecting microstructural features i.e. RF performance
- Investigate intermediate layer (Nb, Ta, Al<sub>2</sub>O<sub>3</sub>...)

!! Toward real cavity coatings to push the limits of particle colliders



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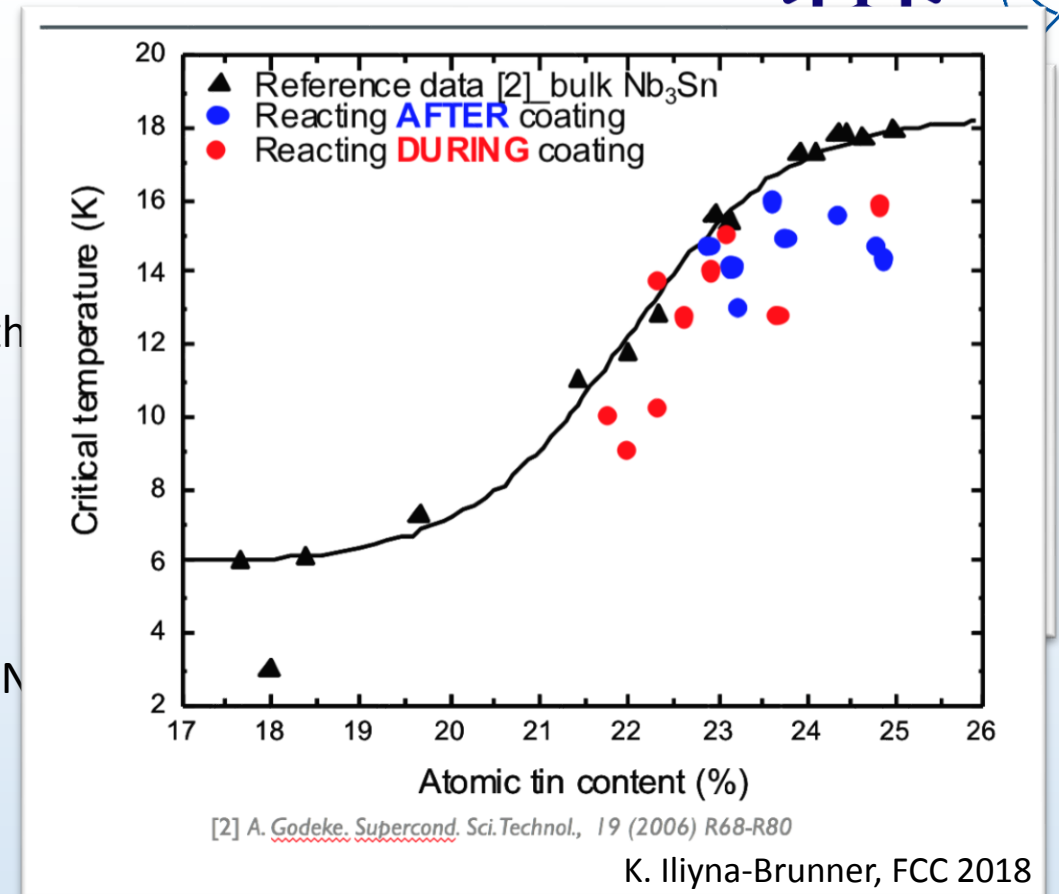
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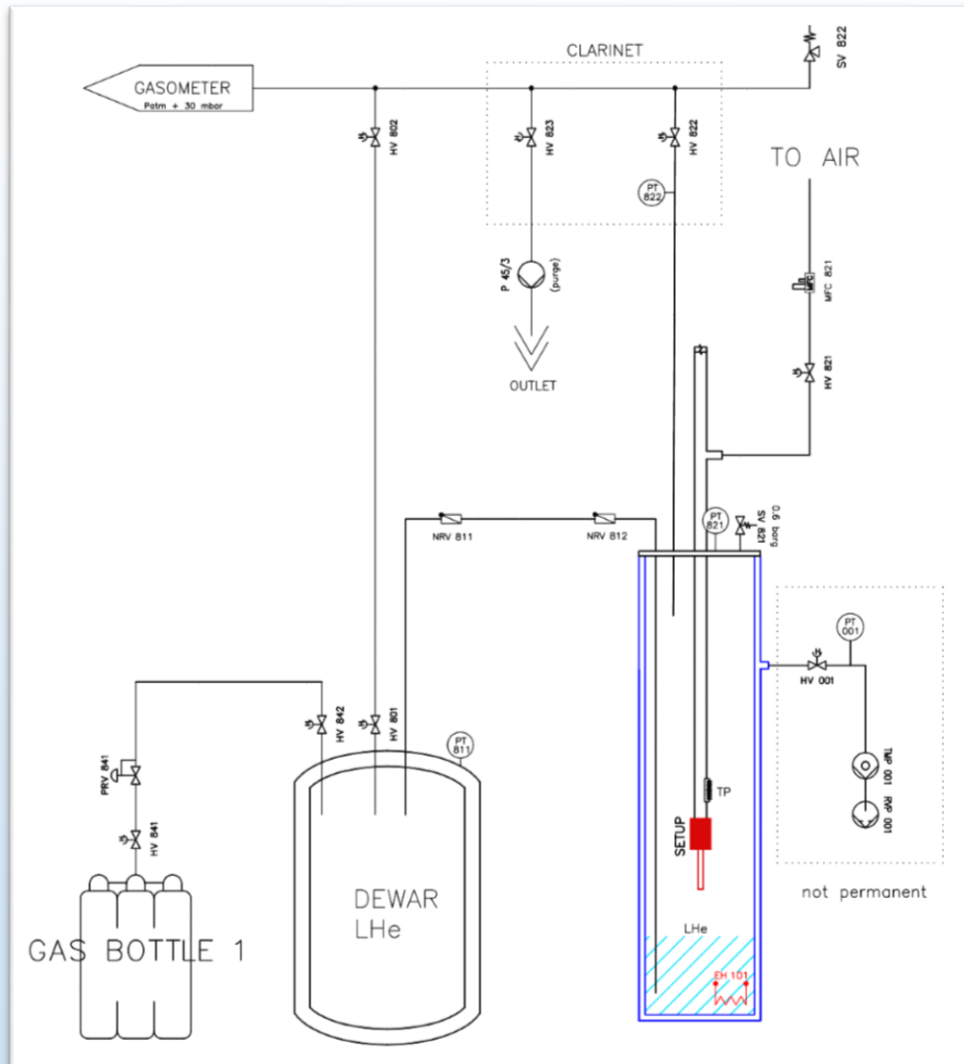
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### Nb<sub>3</sub>Sn/Cu:

- Higher  $T_c$  = less cryopower: 9.3 K (Nb) vs 18.3 K (Nb<sub>3</sub>Sn)
- Lower surface resistance = less dissipated power: 45 nΩ (Nb) vs 10 nΩ (Nb<sub>3</sub>Sn)
- Synthesize the crystalline phase
- Achieve theoretical  $T_c$  on Cu substrate
- Manage material stress and treatment affecting microstructural features i.e. RF performance
- Investigate intermediate layer (Nb, Ta, Al<sub>2</sub>O<sub>3</sub>...)

!! Toward real cavity coatings to push the limits of particle colliders

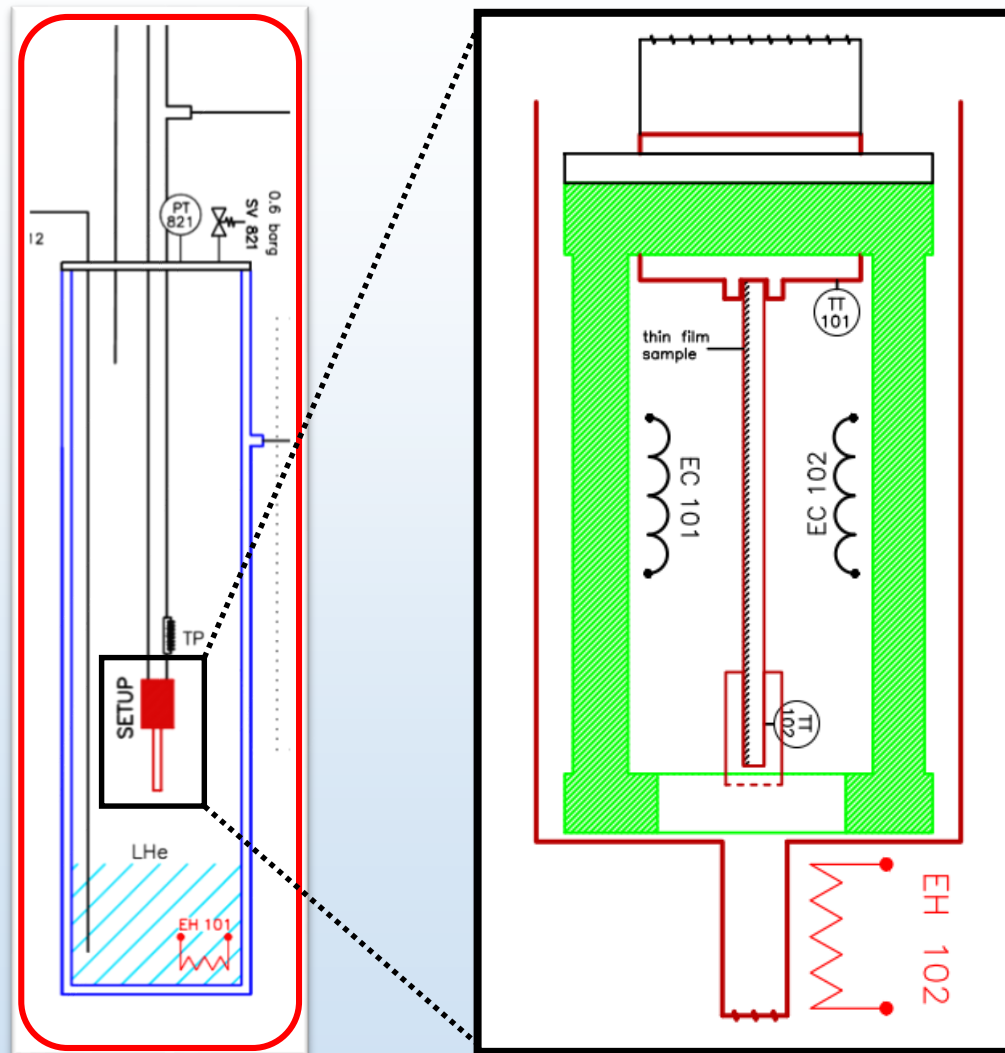




## Contactless, inductive measurement of the critical temperature of SC thin films deposited on a Cu substrate

### Measurement principle:

- He vapour environment
- Sample (film on Cu) in between **active** drive coil and **passive** pickup coil
- Temperature sensors placed at top and bottom of sample
- AC current signal fed into drive coil = AC B-field
- **Below  $T_c$** : film becomes superconducting and screens B, voltage induced in pickup coil has amplitude  $A'$
- **Above  $T_c$** : B “does not see” the sample and induces AC voltage in pickup coil of amplitude  $A \gg A'$
- Voltage amplitude “jump” in pickup coil is the sign for state transition!
- Film temperature monitored in parallel during transition allows extraction of  $T_c$
- Electrical heaters help adjusting the temperature of the He vapour flow and hence the temperature of the sample
- Materials: Cu, bulk Nb (test phase),  $Nb_3Sn$ ,  $V_3Si$ , ... (operation phase)

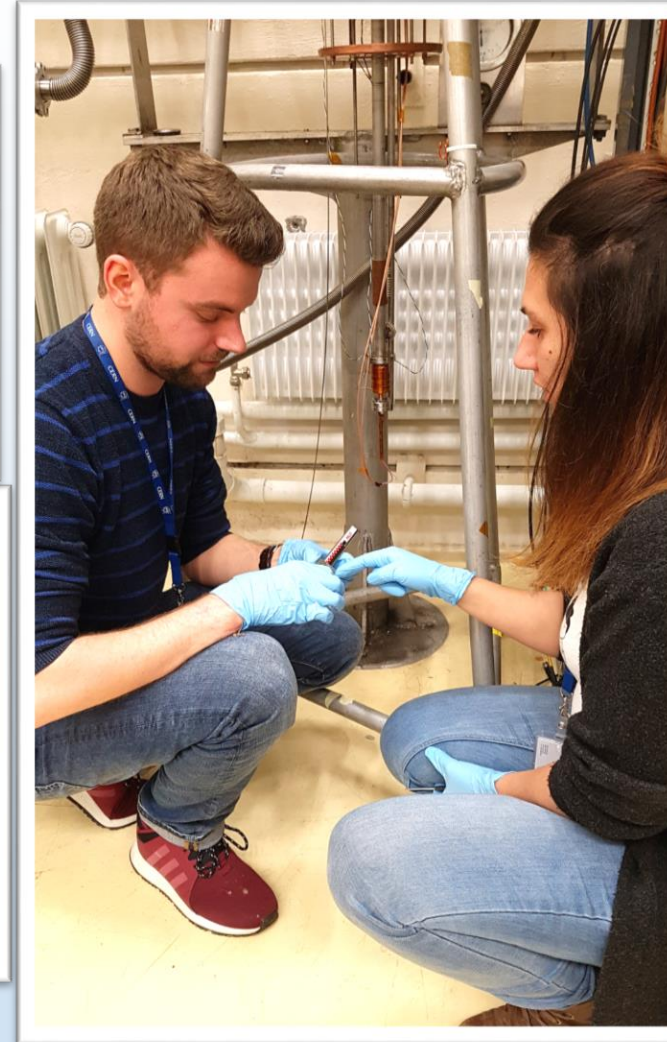
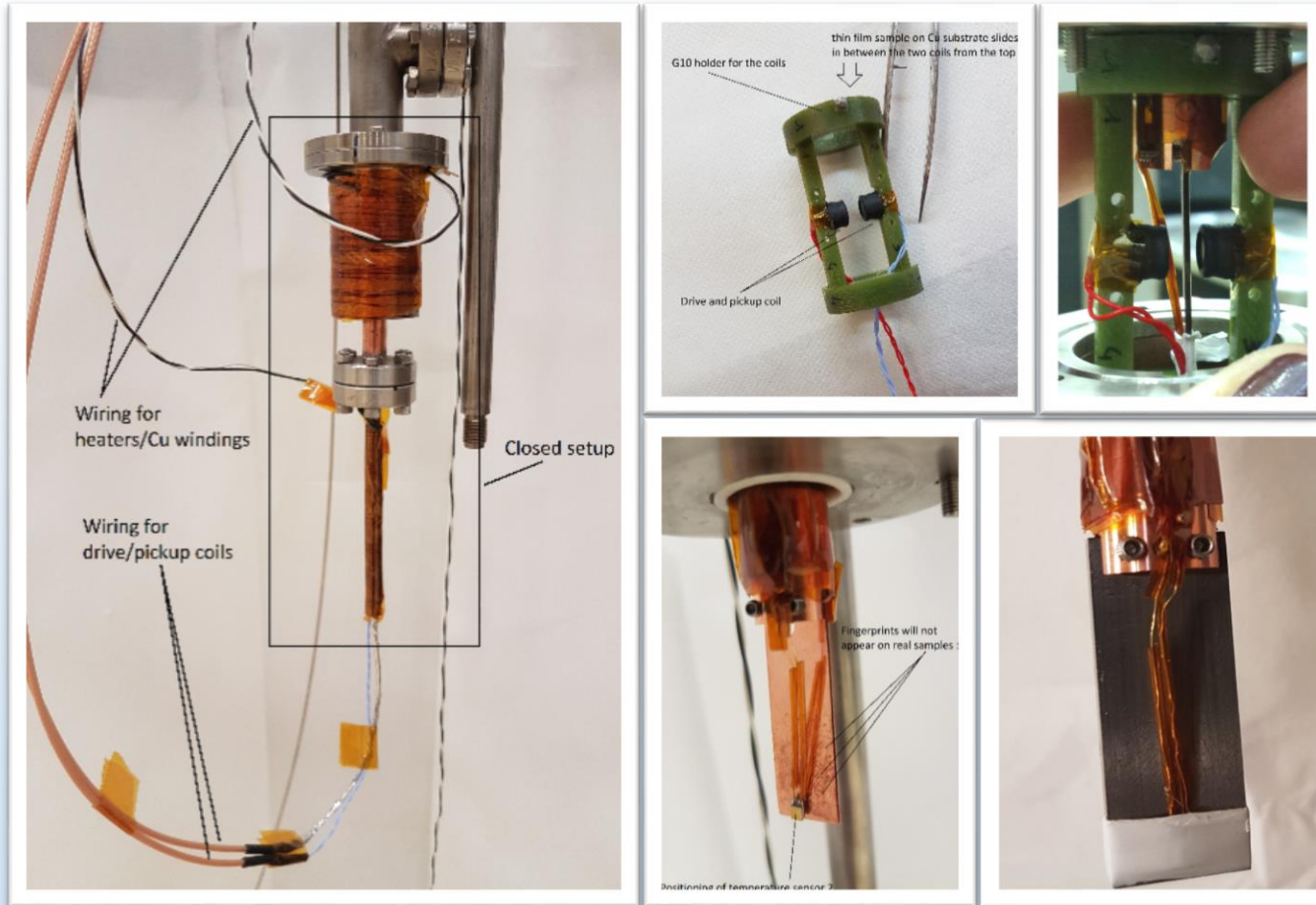


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# $T_c$ test stand – Results so far



Not on the pictures:

Cabling

Geometry and parts size

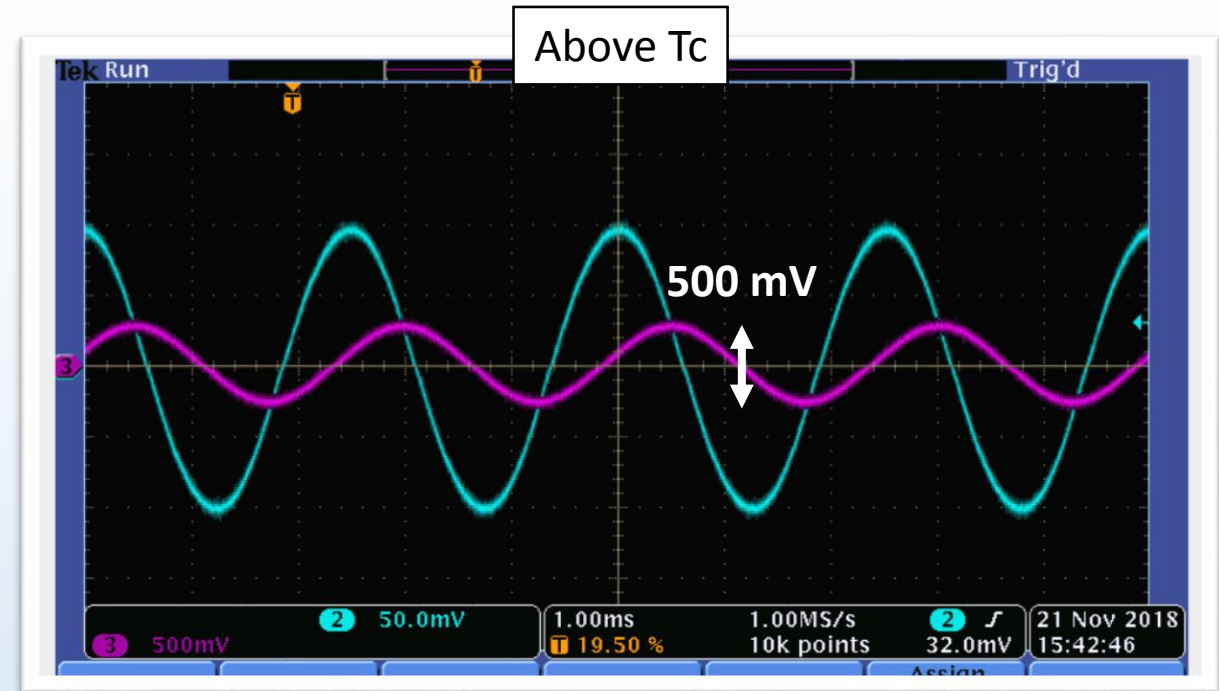
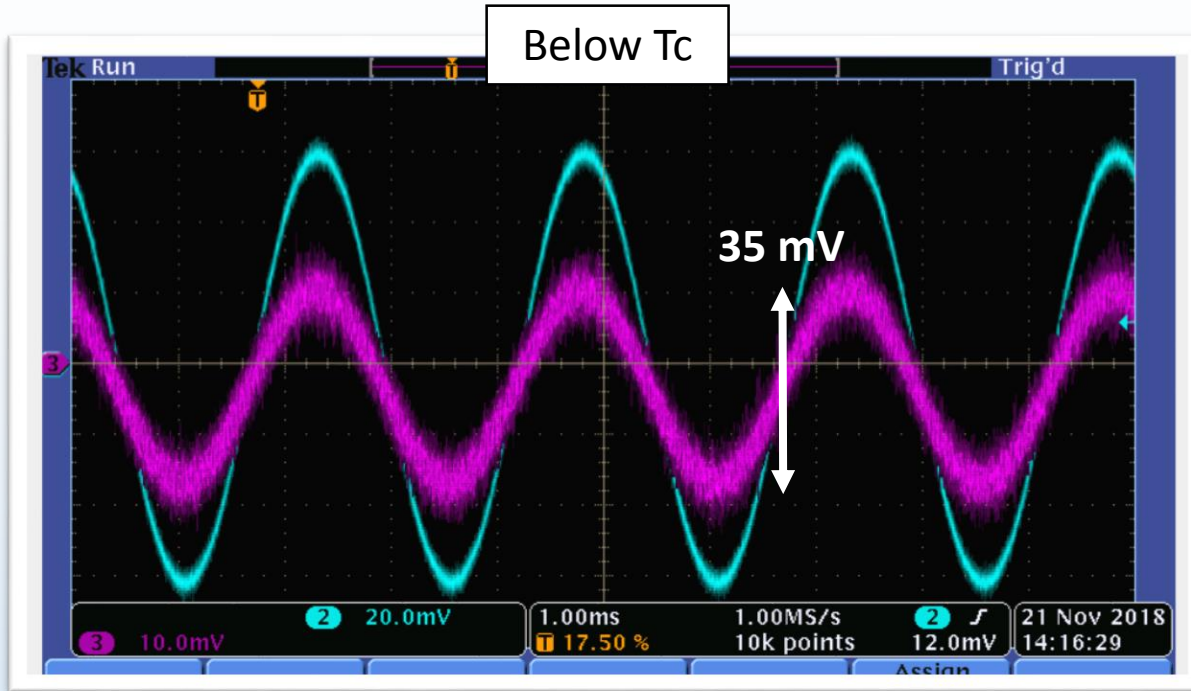
T sensors, heaters, coils

T sensors calibration



He vapour flow

Cu substrate

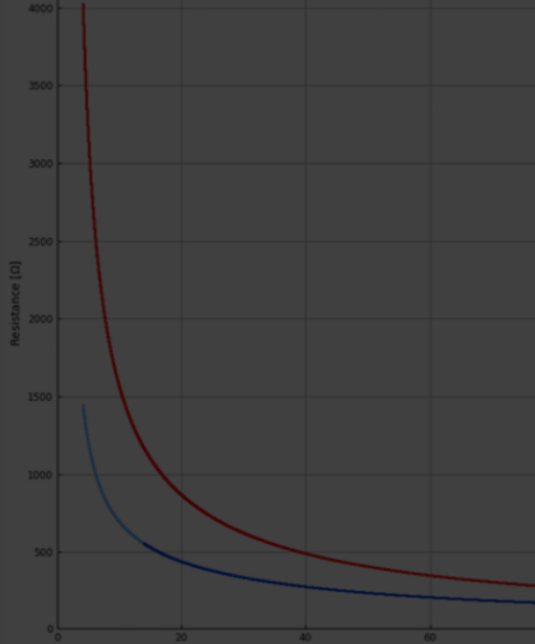
# $T_c$ test stand – Results so far



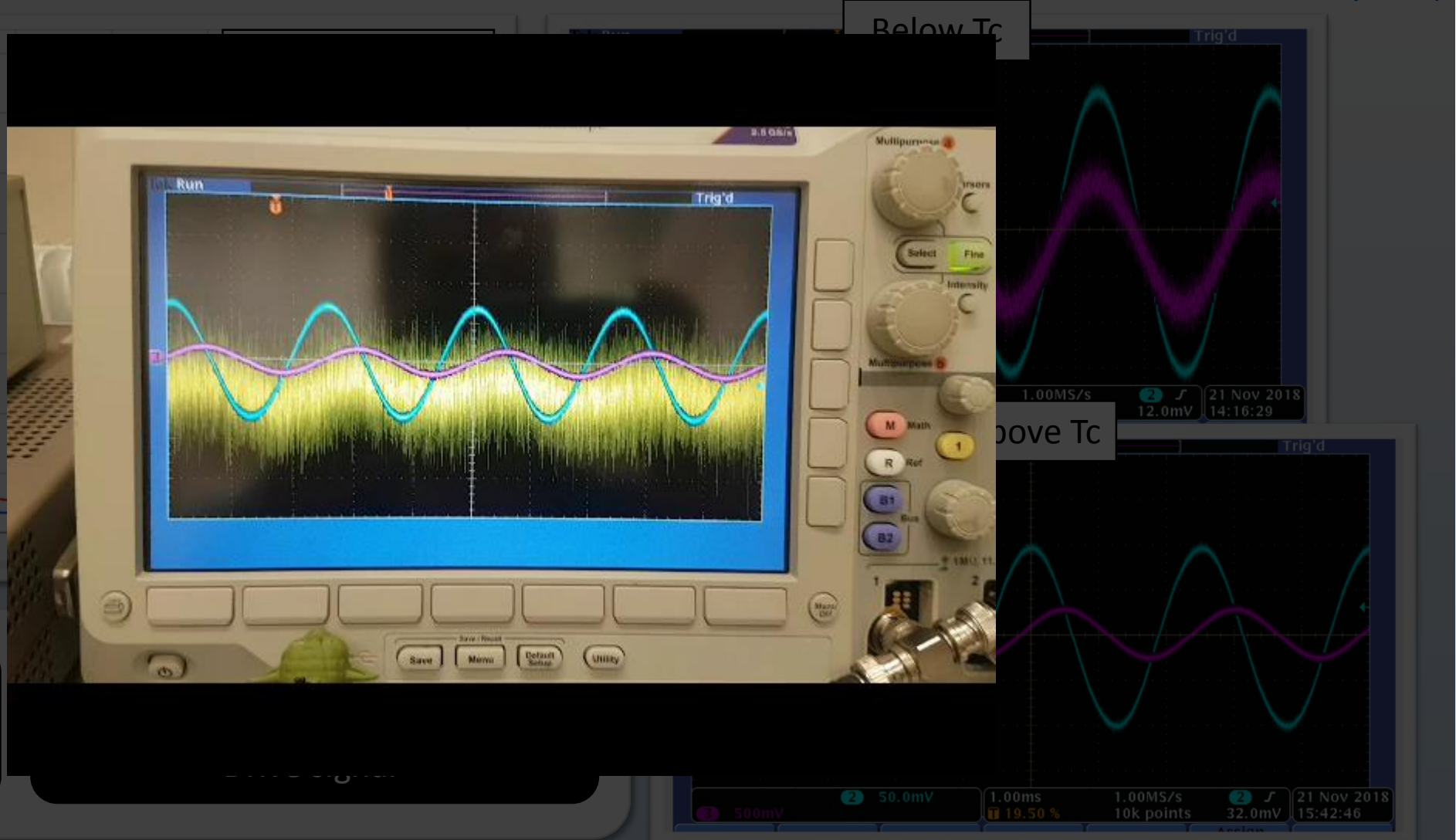
Bulk Nb sample  
Below  $T_c$ : 10 mV/div  
Above  $T_c$ : **500 mV/div**

Amplified pickup signal   
Drive signal 

# $T_c$ test stand – Results so far



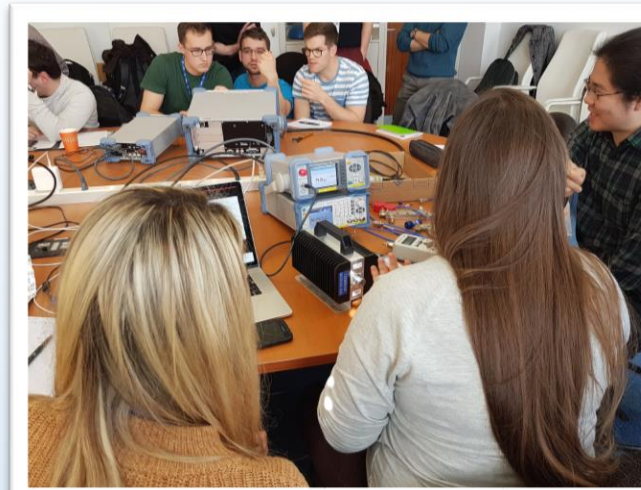
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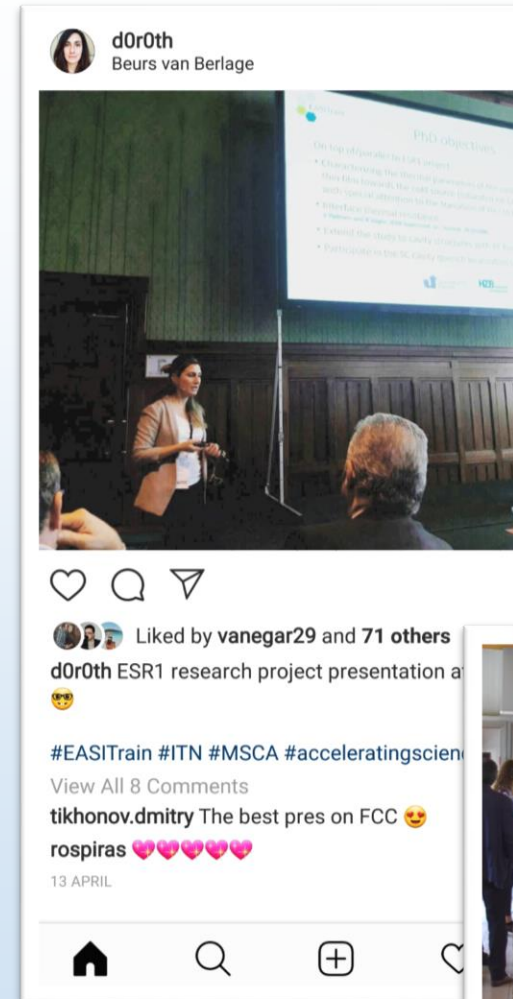
# $T_c$ test stand – Next steps

- Expected transition for bulk Nb ( $9.3 \pm 0.1$  K) observed: **apply test to thin film samples**
- Measured **samples from VSC group as reference** are ready
- Further investigations to predict film/Cu behavior: **B-field vs T**
- Start **systematic tests**: queue is already long!
- Study of **further thermodynamic properties** of films/Cu with bigger samples inside QPR
  - Toward the understanding of film/Cu **thermal behavior in RF field**

- ✓ 06.03.2018 - 06.03.2018 - Consulting Group training (Sharepoint) at CERN
- ✓ 07.03.2018 - 07.03.2018 - Indico - Organizing Scientific Conferences at CERN
- ✓ 08.03.2018 - 09.03.2018 – EASITrain Safety trainings at CERN:
  - General Safety
  - Cryogenic Safety Fundamentals
  - Fire Extinguisher and risk analysis
  - Ionising Radiation Safety
  - General Electrical Risks
  - Radiofrequency Safety
  - Magnetic Fields Safety
- ✓ 19.03.2018 – 22.03.2018 – EASITrain Project Management lectures at CERN
- ✓ 23.05.2018 - 02.08.2018 - French Integration course for beginners at CERN
- ✓ 06.07.2018 - 06.07.2018 - Cryogenic Safety - Helium Transfer at CERN
- ✓ 10.09.2018 – 11.09.2018 – Project Management part 2 at WUW Vienna
- ✓ 12.09.2018 – Media Training at Terra Mater Factual Studios Vienna
- ✓ 13.09.2019 – 14.09.2019 – Innovation Management and Technological Competence Leveraging part 1 at WUW Vienna



- ✓ 05.03.2018 – 23.03.2018 - EASITrain Lectures  
Spring 2018 at CERN
- ✓ 09.04.2018 – 13.04.2018 - FCC Week 2018 in  
Amsterdam
- ✓ 31.05.2018 – 01.06.2018 - #3 CERN SRF Workshop  
at CERN
- ✓ 30.08.2018 – 14.09.2018 – EASISchool 1 / ESAS  
Summer School Workshops in Vienna
- ✓ 08.10.2018 – 10.10.2018 – 8th International Workshop  
on Thin Films and New Ideas for Pushing the Limits of  
RF Superconductivity at INFN-LNL
- ✓ 08.11.2018 – 09.11.2018 – TTC/ARIES Topical Workshop on  
Flux Trapping and Magnetic Shielding



## Outreach

- ✓ LN<sub>2</sub> show at Cryolab
- ✓ Instagram
- ✓ Planned: seminar + practical demonstration at high school in hometown



## Dissemination

- ✓ Talk at FCC 2018
- ✓ Planned: SRF 2019, more...
- ✓ Private tours of lab to CERN colleagues from different fields

## Networking

- ✓ ThinFilms Workshop 2018
- ✓ TTC/ARIES Topical Workshop at CERN 2018

## Science and society

- **Future circular colliders**
- **Smaller scale accelerators** (e.g. for medical applications), and many more...

## Personal life and career

- Network of industries and academic institutions **linked via the ESRs**
- **Networking** and **gain of know-how**
- **Expertise on a wider range** than the traditional academic formation
- “What have you enjoyed the most during this experience?”

