FUTURE
CIRCULAR
COLLIDER

SUPERCONDUCTING THIN FILMS STUDIES AT CERN

on behalf of FCC SRF WP3

Horizon 2020
European Union Funding for Research and Innovation

Outline

1. WP3 Objectives

2. R&D Status

3. Short/Mid term plans

4. Conclusion

WP3 OBJECTIVES

Overview

Improve Substrate Surface Preparation

Improve coating technique / recipe

Qualify SRF cavities performance / sensitivity

Delivery of prototype cavities for CM

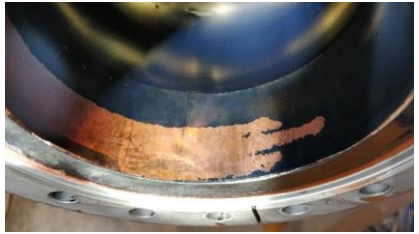
Set-up collaboration with international partners

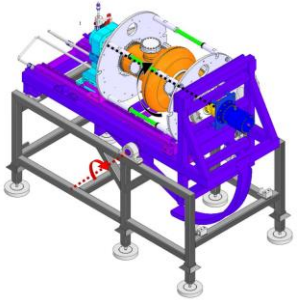
Surface Treatments

Develop and optimize 1.3GHz substrates electropolishing

Optimize Cu passivation (adhesion)

Scale-up to 400MHz / SWELL cavities





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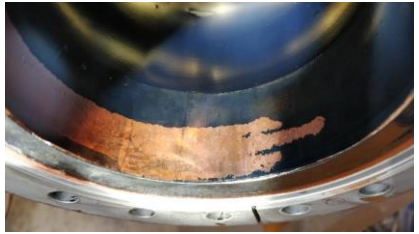
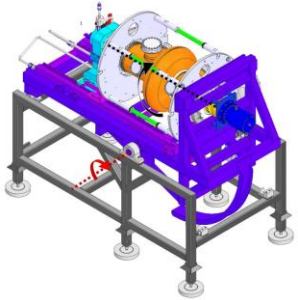




Coatings

Optimize HiPIMS recipe

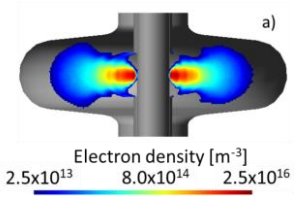
Reduce gas incorporation

Predict RF performance based on DC characterization

Mitigate Q-slope

Investigate alternative materials to Nb

Scale-up to 400MHz and SWELL cavities



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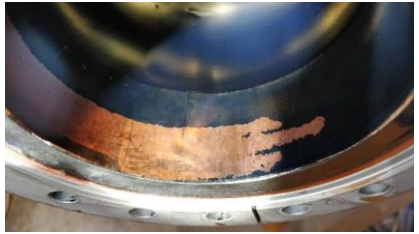

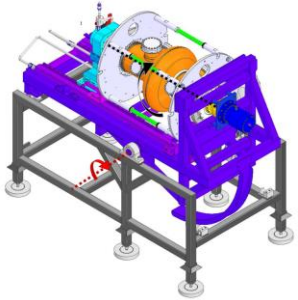

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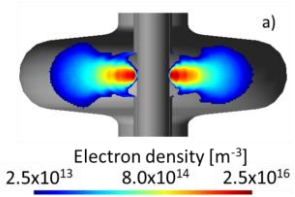


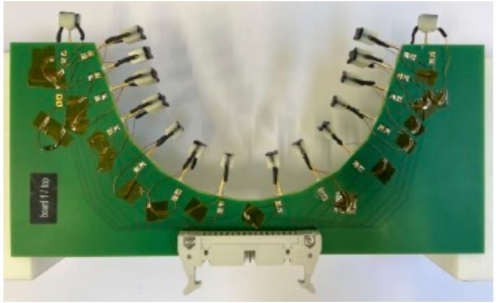
RF Testing

Assess Cavities' performance

Assess Cavities' sensitivity to trapped flux

Assess Cavities' sensitivity to thermal gradient

Develop thermal mapping for defect localization



https://indico.frib.msu.edu/event/38/attachments/158/1065/THPCAV007.pdf

R&D STATUS

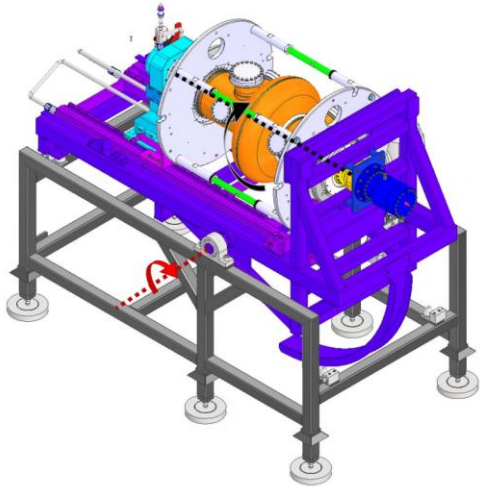
Electropolishing

Bench commissioned

Removal rate profile qualified

Currently processing 1 cavity / week

Optimization on-going



a) Copper chemical plant; b) niobium chemical plant; c) cavity handling device

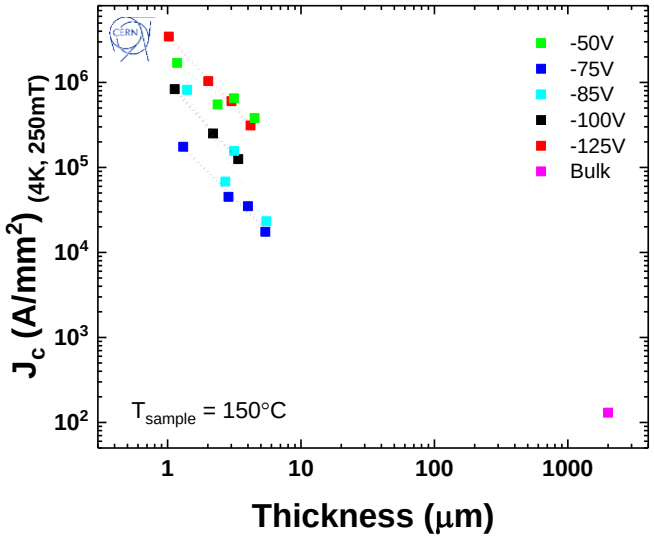
Surface state of an electropolished 1.3GHz cavity

https://indico.frib.msu.edu/event/38/attachments/158/1094/TUPFAV004.pdf

Coatings

Nb/Cu

Bias optimized based on Jc lowering



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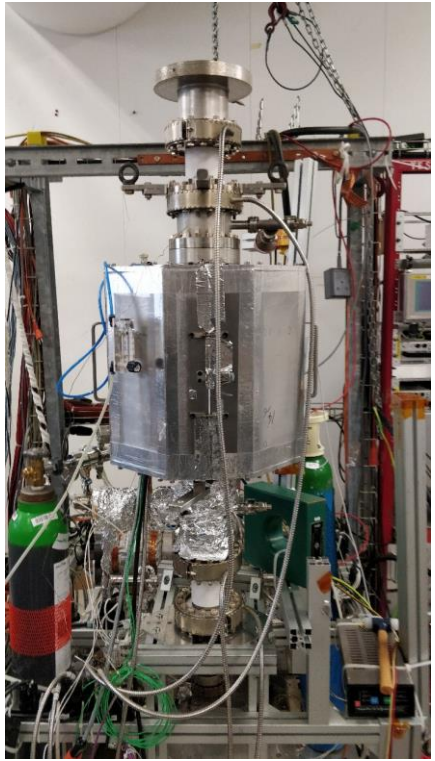
Neutral atmosphere housing for high temperature coatings



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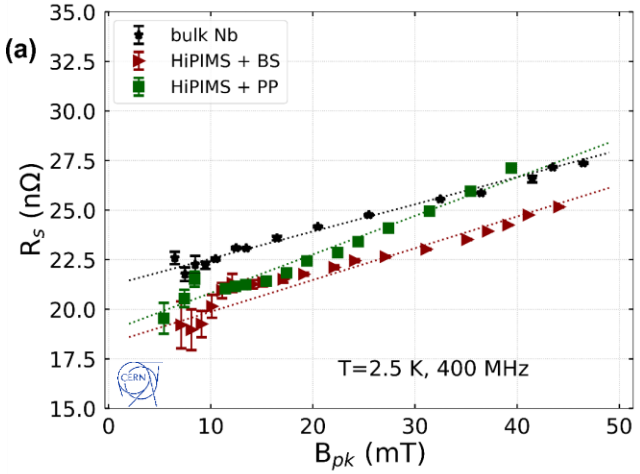
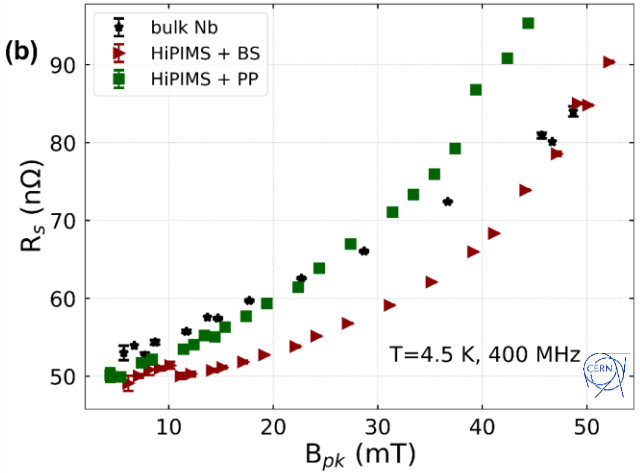
Promising performance obtained on QPR





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Coatings on

- bulk machined seamless cavity

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Coatings on

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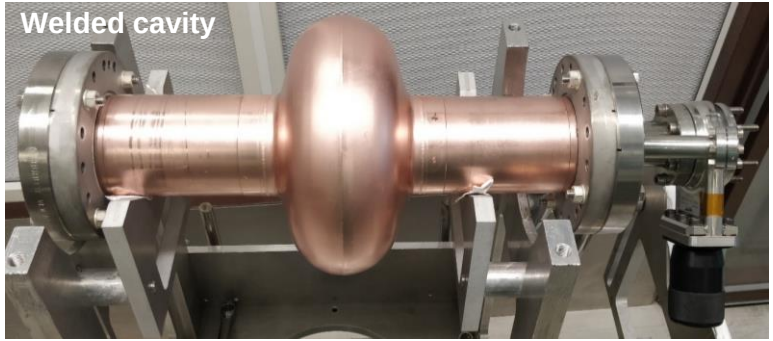
- **internal e-beam welded cavity**



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Coatings on

- **bulk machined seamless cavity**
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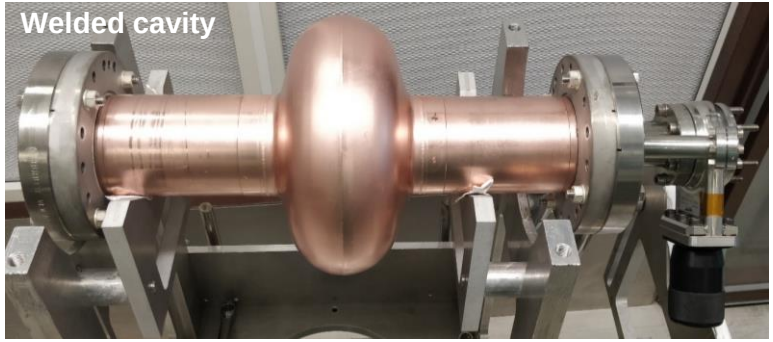
- **electroformed cavities**



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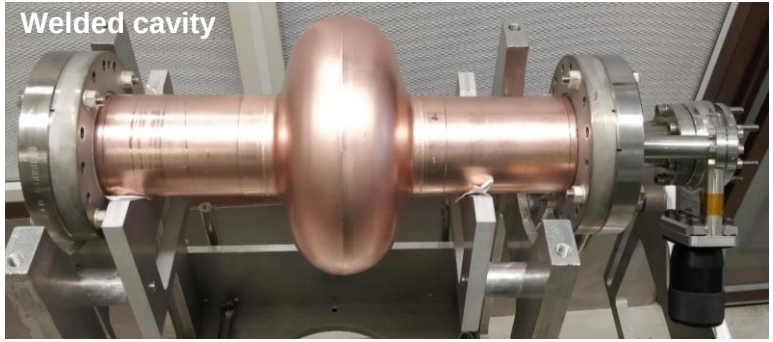

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Quantify the effect of surface damaged layer

- **by surface machining**
- **by forming**

All cavities electropolished

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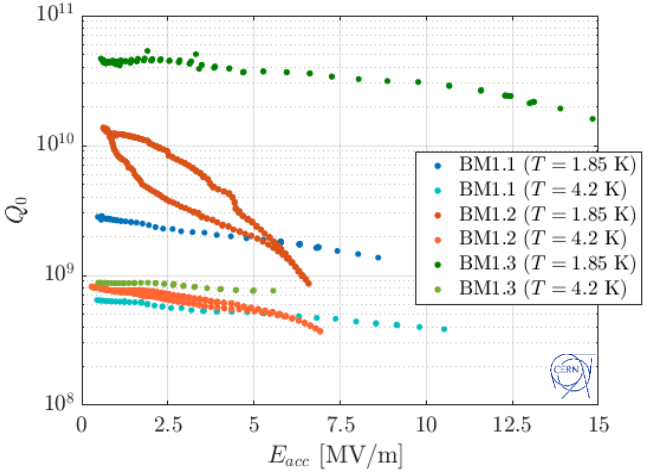

R_{res} of ~4nOhms achieved on 1.3GHz with

$Q>1.10^{10}$ up to 15MV/m

Cf: P. Vidal-Garcia talk

and:

https://indico.frib.msu.edu/event/38/attachments/158/1275/TUPTEV009_rev_3.pdf

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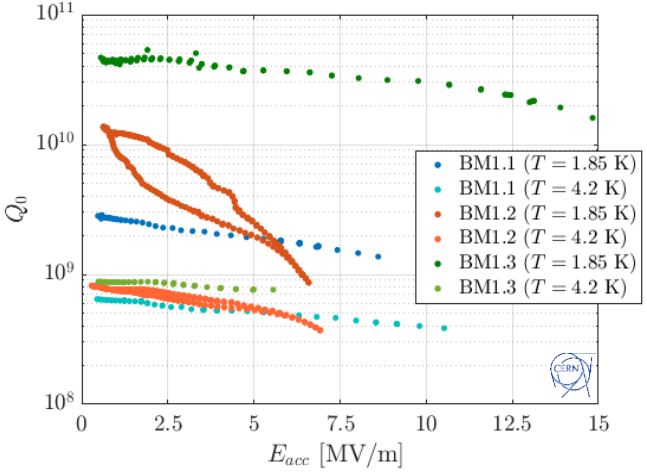

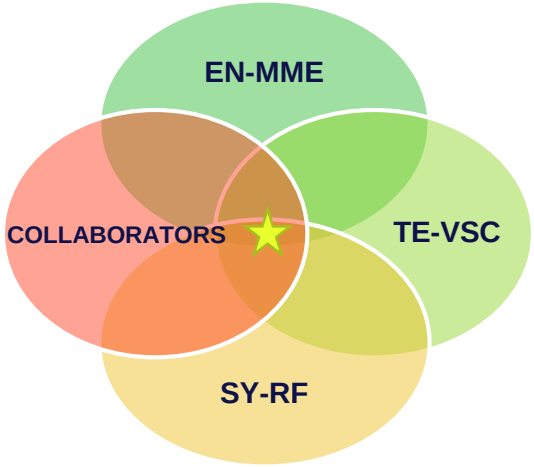

Common objective

Efficient feedback

Permanent sharing

Constant Optimization

Coatings

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Scale-up to 400MHz

Coatings

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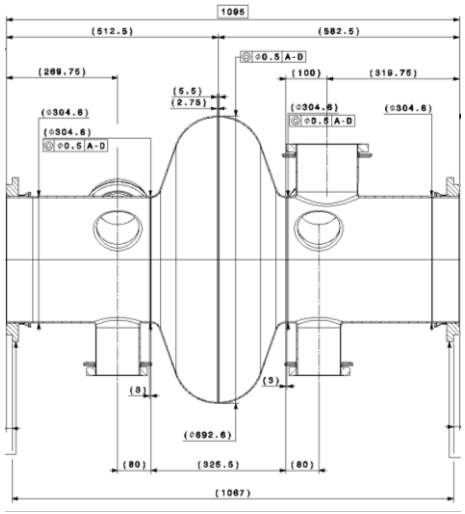
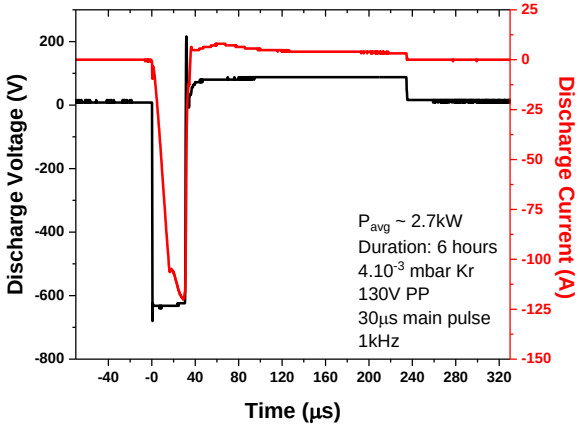
Scale-up to 400MHz – First HiPIMS coating of a 400MHz cavity





Bi-Polar HiPIMS cf: F. Manke talk (FCC week 2021)

F Avino et al 2019 Plasma Sources Sci. Technol. 28 01LT03

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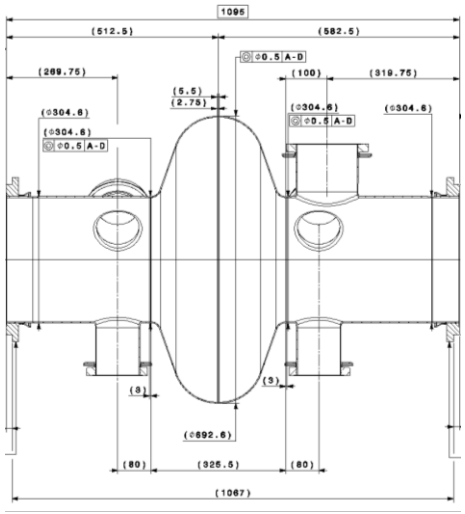

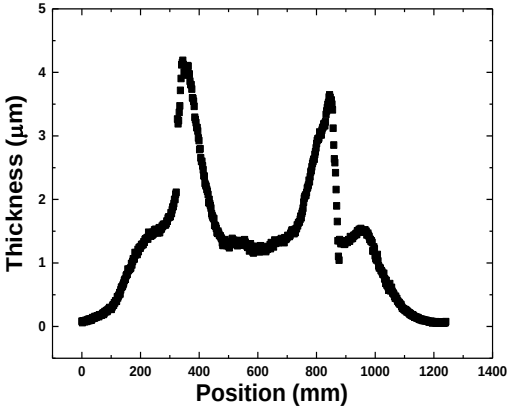

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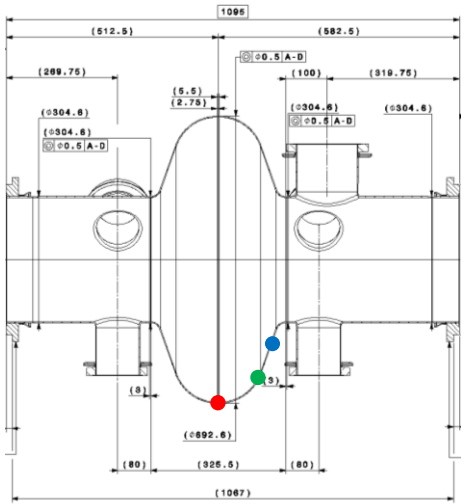
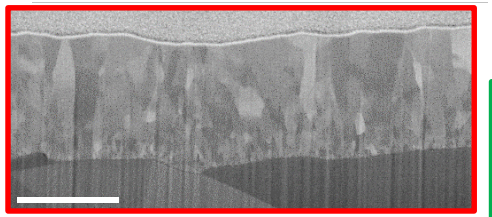
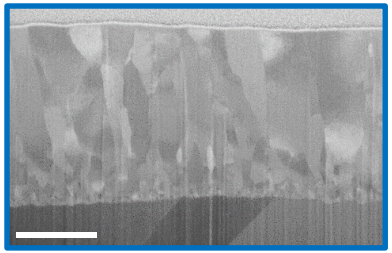
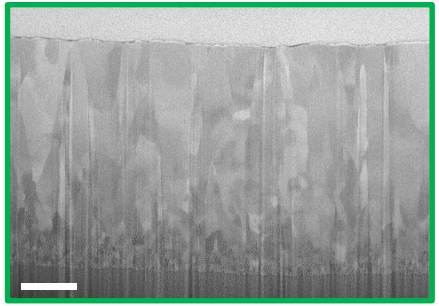
Scale-up to 400MHz Layer densification









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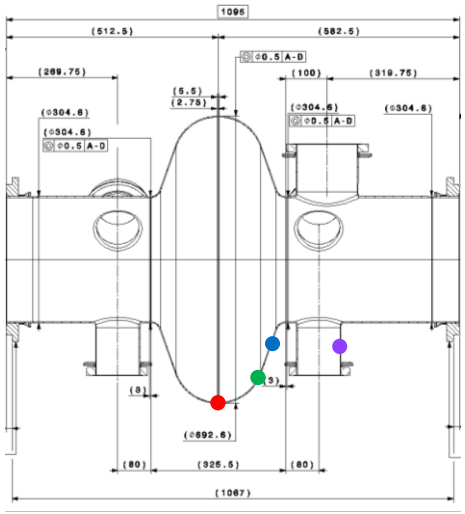

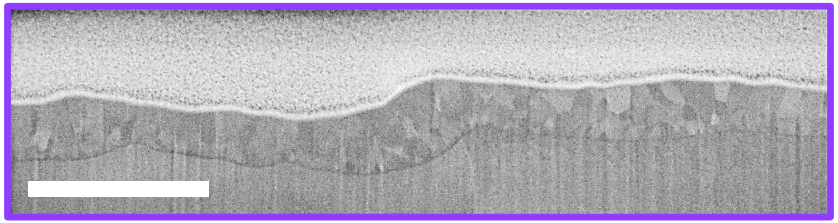

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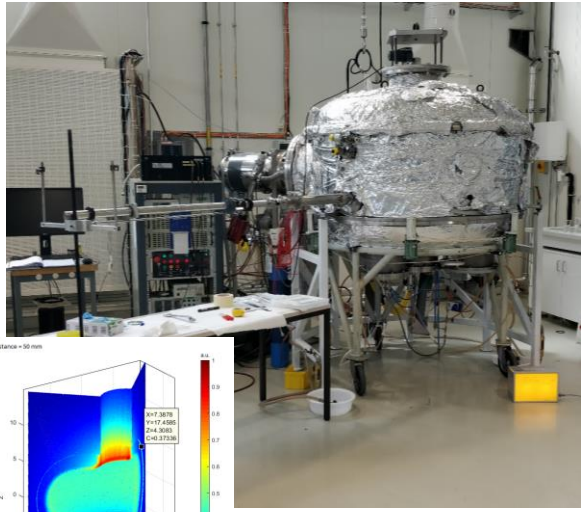
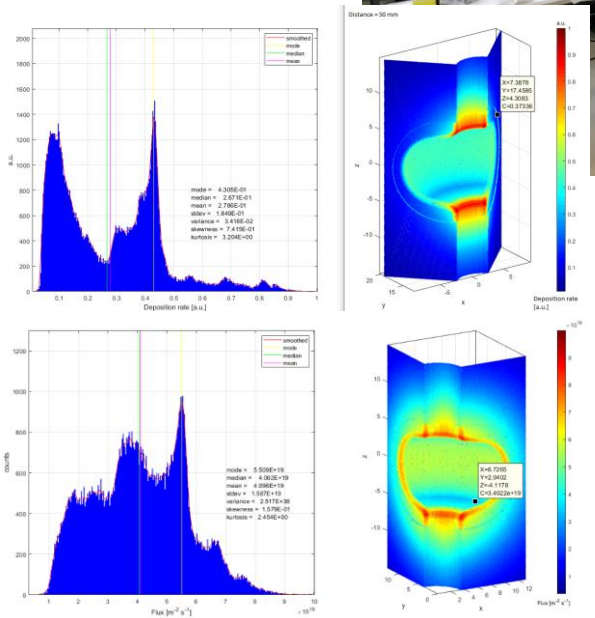
Scale-up to 1.3GHZ SWELL





QPR test pending for setup qualification

E A Ilyina et al 2019 Supercond. Sci. Technol. 32 035002

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Scale-up to 400MHz Layer densification

A15/Cu

Nb_3Sn and V_3Si

E A Ilyina et al 2019 Supercond. Sci. Technol. 32 035002

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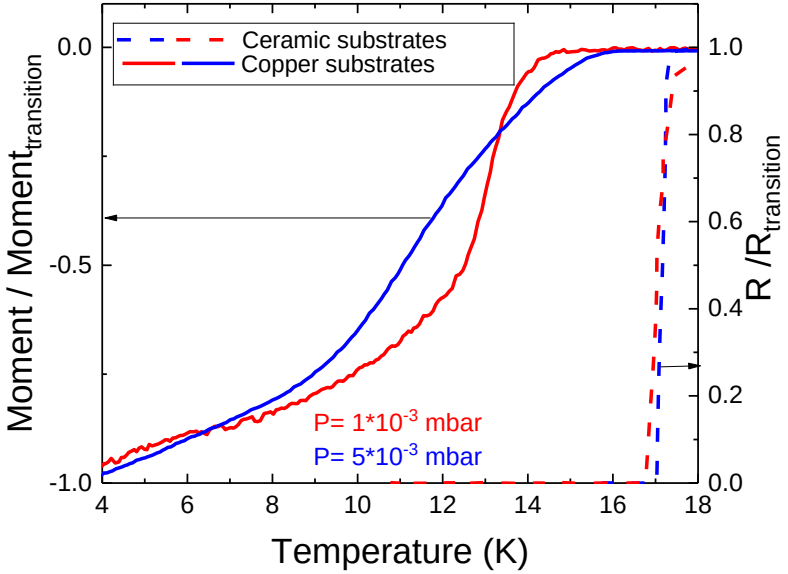
Substrate has a fundamental effect



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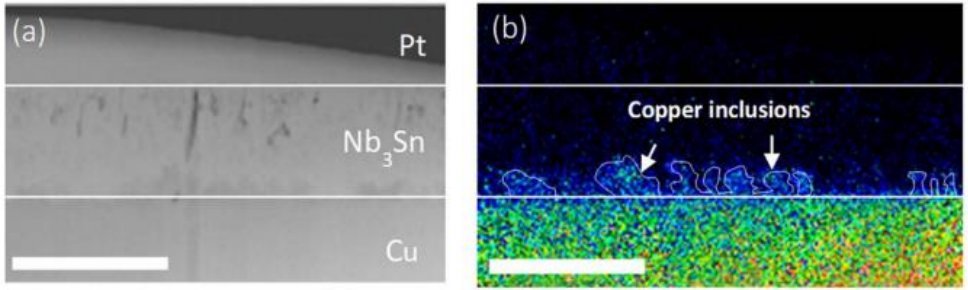

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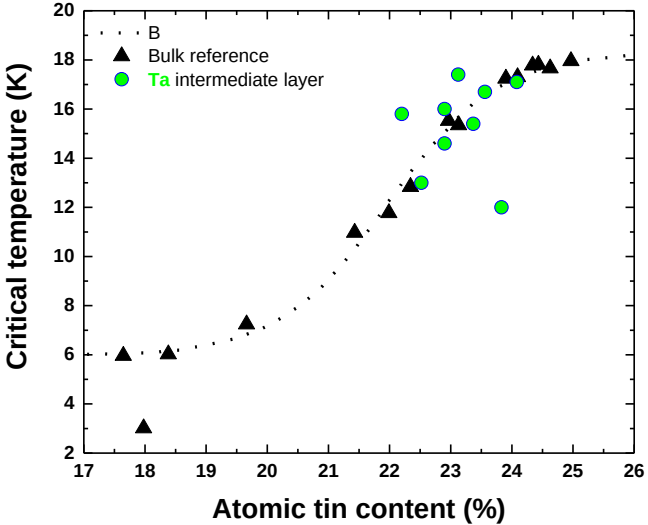
Diffusion Barrier Layer use



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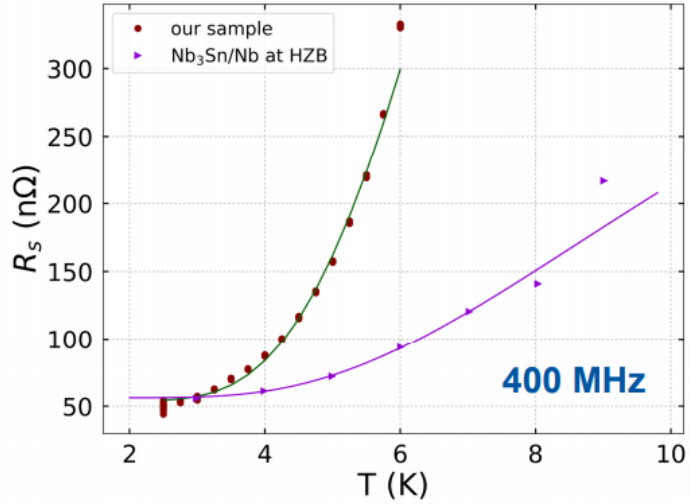

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Diffusion Barrier Layer use

More QPR testing on their way

Scale-up to 1.3GHz

- **Process temperature**
- **Structural stability**

E A Ilyina et al 2019 Supercond. Sci. Technol. 32 035002

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Scale-up to 1.3GHz

- **Process temperature**
- **Structural stability**

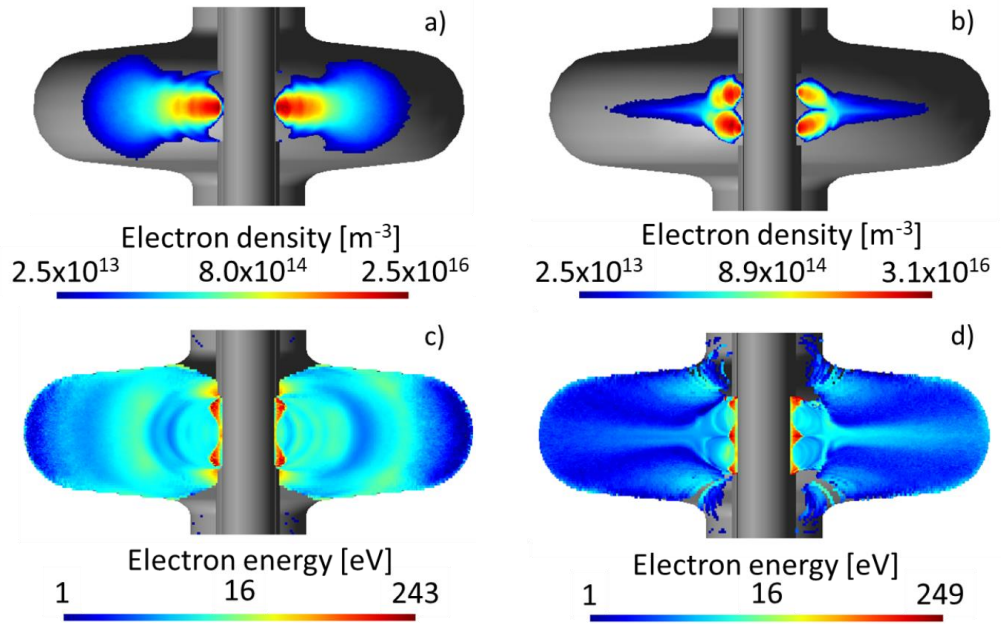
Started HiPIMS investigation

Achieved T_c of 15K on Nb_3Sn

Coatings

Plasma simulations

Optimization of plasma coating sources
https://indico.jlab.org/event/405/contributions/8107/



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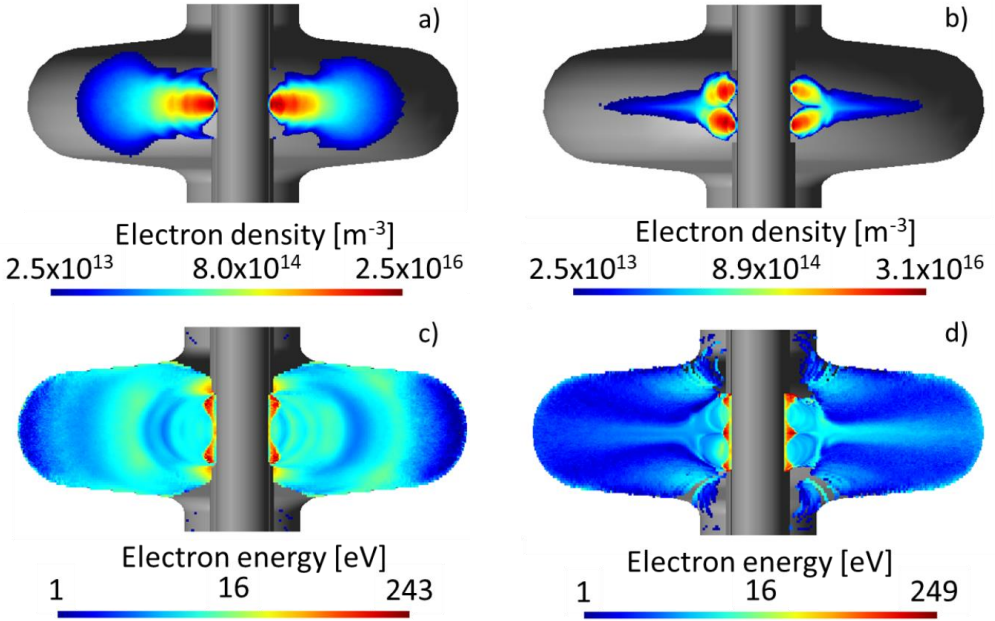
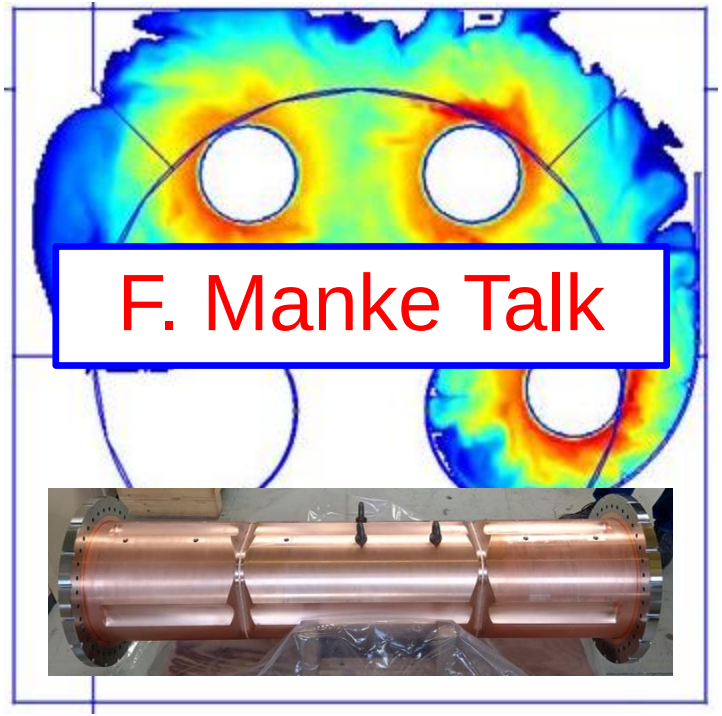


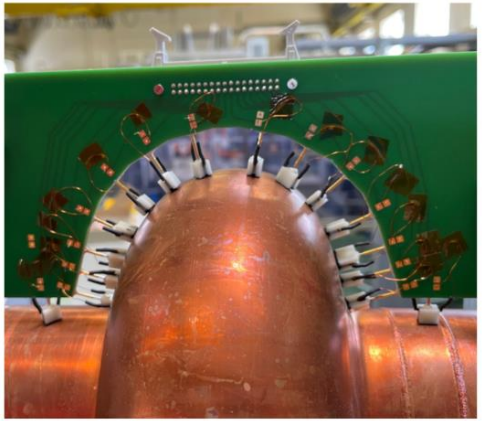
WOW Cavity (FCC hh)



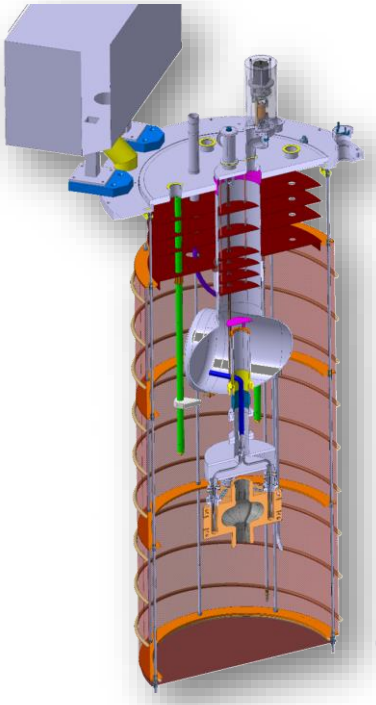
RF Testing

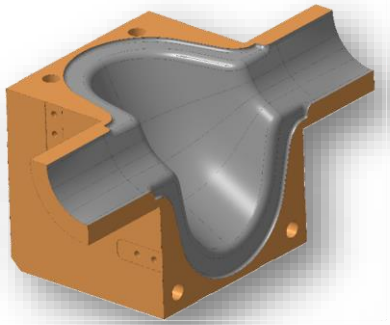
1.3GHz elliptical cavities

Please stay for P. Vidal-Garcia talk



1.3GHz SWELL Cavity





Cryogenics studies and simulation on going

Cf: F. Peauger and S. Atieh talks

SHORT/MID TERM PLANS

Plans

Nb/Cu

- push 1.3GHz cavities toward Q~1.10^{10} @ 20MV/m
- assess the performance of various manufacturing techniques
- Produce additional electroformed cavities (https://www.comsol.com/paper/download/855161/Lucia_Lain_COMSOL_Europe.pdf)
- fundamental understanding of process parameters effect on Nb layer properties
- Q4 2021: First HiPIMS coating on 400MHZ cavity for RF testing / transfer 1.3GHz recipe
- First coating of a 1.3GHz SWELL prototype
- Q4 2021: First coating test on WOWcc

A15/Cu

- Optimization of bi-polar HiPIMS coatings
- Increase QPR coating rate
- Propose a scale-up strategy

RF Testing:

- Evaluate the full potential of the first successful 1.3GHz cavity
- Sustain strong diagnostic capability

Expanding collaborations (TU Wien, Helsinki University, UniGe…) for more fundamental studies

Conclusion

Significant progress on 1.3GHz Nb/Cu cavities

- No fundamental limit of that technology
- Strong synergy between the actors is key to success (manufacture, surface treatments, RF testing, collaborators)

A15/Cu: Still strong efforts needed – more complex than Nb/Cu (… and it is already a hard task)

Scale-up on going and encouraging

Solid basis for SWELL demonstrator.

FCC

Thank you
for your attention.

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