

# Report from the Workshop on Higher Order Modes in Superconducting Cavities (HOMSC2025)

Hamburg, 6 – 8 Oct. 2025

Nicoleta Baboi , DESY

DESY-TEMF Collaboration Meeting

Hamburg, 11 Dec. 2025


HELMHOLTZ

Photo by Sergey Tomin



# Overview

## Workshop series



**HOMSC2025**

International Workshop on Higher Order Modes in Superconducting Cavities (HOMSC2025)

Oct 6 – 8, 2025  
DESY, Hamburg  
Europe/Berlin timezone

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Overview	The workshop on <b>Higher Order Modes in Superconducting Cavities</b> will take place on <b>06 - 08 October 2025</b> at DESY, Hamburg.
Scientific Program	
Call for Abstracts	
Timetable	
Contribution List	
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Participant List	
Workshop Committees	

Its objective is to bring together researchers studying higher order mode (HOM) suppression in superconducting RF cavities for applications ranging from energy recovery linacs and light sources to linear colliders. HOMs excited by a beam in superconducting cavities can create excessive heat load on the cryogenic system and dilute beam quality, giving rise to a beam break up instability in the worst case. This workshop will discuss the current status of both experimental and theoretical work in this area. Issues in electron and proton linacs, TESLA style cavities, 3rd harmonic cavities, TEM crabbing and other cavity designs will be considered. Challenges of CW operation as well as uses of HOMs will also be reviewed.

*The registration fee is 250 Euro.*

## Previous workshops

- HOMSC2018, Cornell University  
– <https://indico.classe.cornell.edu/event/185/>
- HOMSC16, Warnemunde (University of Rostock)  
– <https://indico.cern.ch/event/465683/>
- HOMSC14, FNAL  
– <https://indico.fnal.gov/event/7942/timetable/#20140714>
- HOMSC12, Cockcroft University  
– *(the webpage apparently does not exist anymore)*
- HOM10, Cornell University  
– <https://www.classe.cornell.edu/Events/HOM10/Agenda.html>
- HOMSC 2007, DESY



# Overview

## Participants, Programme

### 42 participants

local		online
22	Europe	2
6	Asia	4
3	US	5

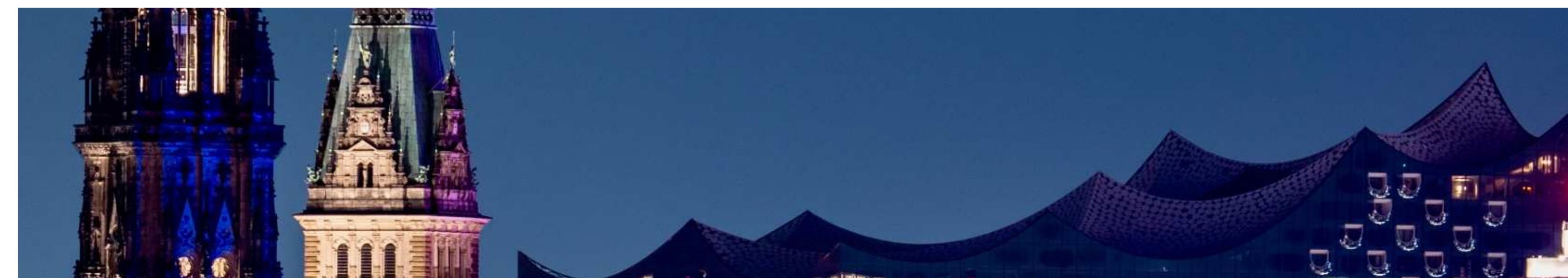
- 2 supported PhD students
- Many could not come due to financial reasons
- Hybrid format -> worked relatively well

### Scientific Programme Committee

Nicoleta Baboi, DESY  
 Dmitry Bazyl, DESY  
 Subashini De Silva, ODU  
 Thomas Flisgen, BTU Cottbus-Senftenberg  
 Roger Jones, University of Manchester/Cockcroft Institute  
 Sang-hoon Kim, MSU  
 Matthias Liepe, Cornell University  
 Michiru Nishiwaki, KEK  
 Adolfo Velez, HZB  
 Vyacheslav Yakovlev, Fermilab  
 Shahnam Gorgi Zadeh, CERN  
 Igor Zagorodnov, DESY  
 Pei Zhang, IHEP

### Local Organising Committee

Wai San Lam  
 Dmitry Bazyl  
 Igor Zagorodnov  
 Nicoleta Baboi



# Workshop Programm

## 4 Working Groups

### Programm

- [indico.desy.de/e/homsc2025](https://indico.desy.de/e/homsc2025)
- 2.5 days, followed by visit to AMTF and the European XFEL
- 37 contributions
- Partial financial support by the German Research Foundation (Deutsche Forschungsgemeinschaft – DFG)
  - Project number [568708572](#).

### HOM Damping Requirements for Future Facilities

Organizers: Dmitry Bazyl, Vyacheslav Yakovlev, Pei Zhang

### Numerical Simulations for SRF Cavities

Organizers: Thomas Flisgen, Igor Zagorodnov

### Design of SRF Cavities and HOM Damping Schemes

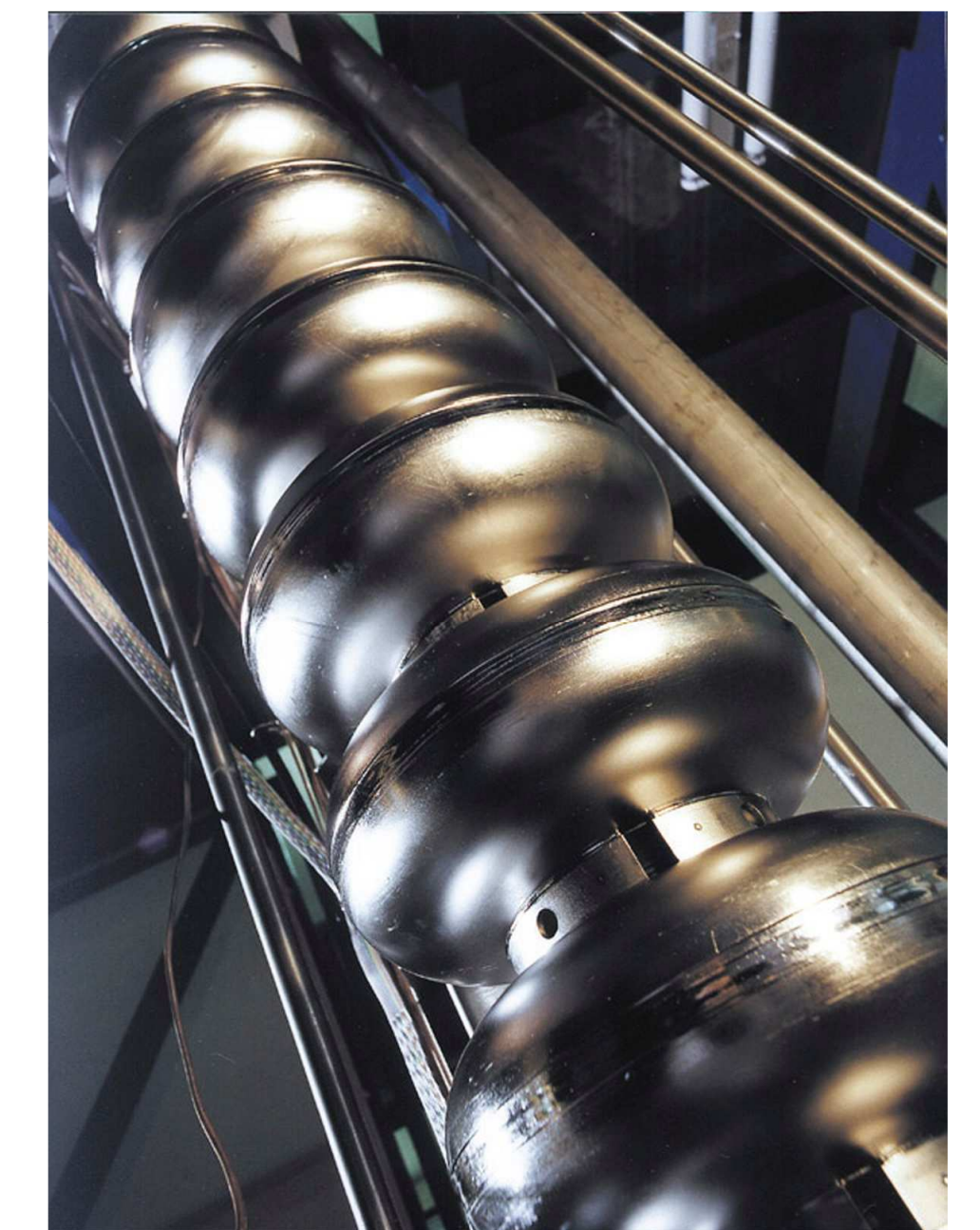
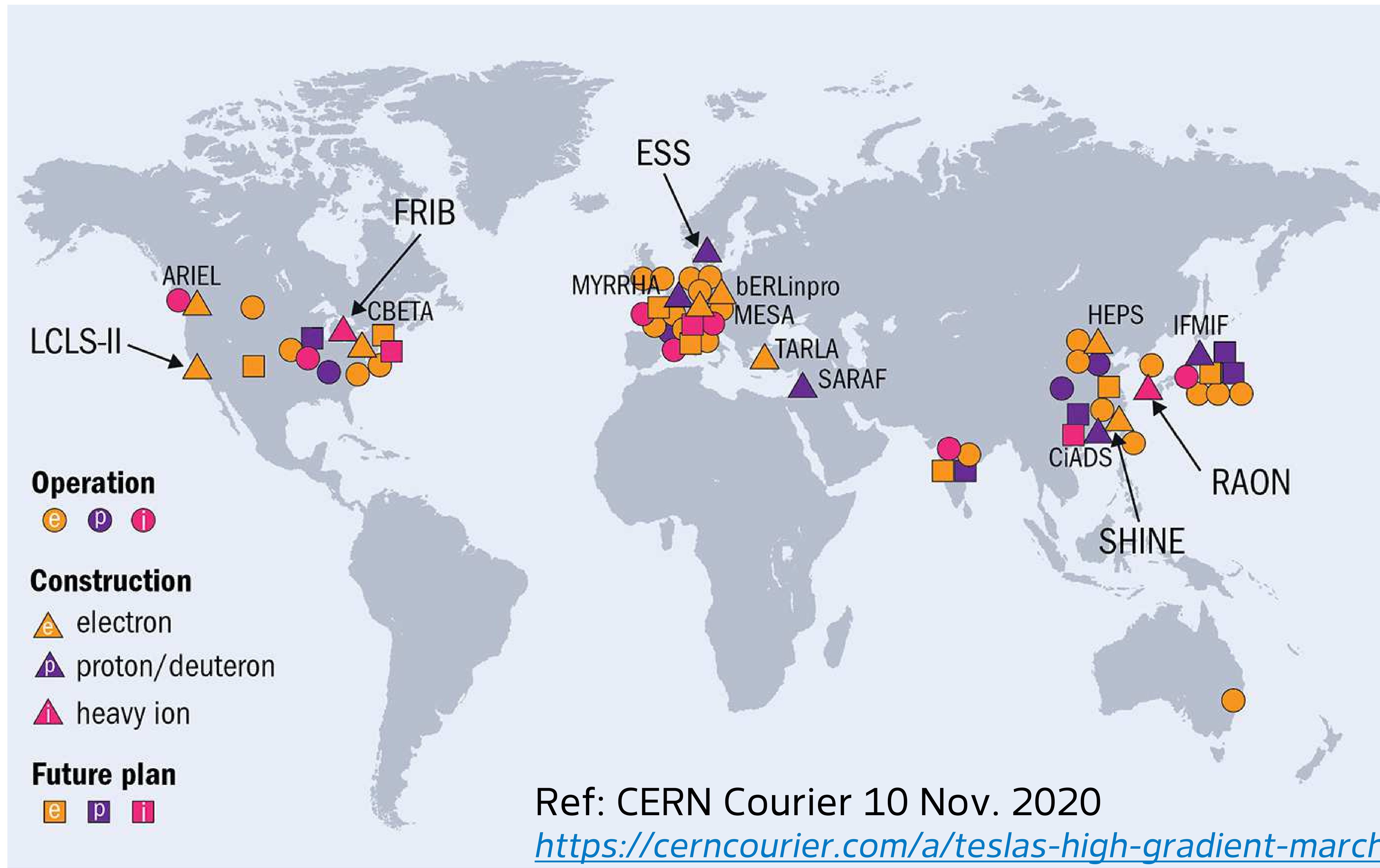
Organizers: Sang-hoon Kim, Subashini De Silva,  
Adolfo Velez, Shahnam Gorgi Zadeh

### Operation of SRF Facilities

Organizers: Roger Jones, Matthias Liepe, Michiru Nishiwaki



# Overview of SRF Facilities



# WG1: HOM Damping Requirements for Future Facilities (1)

## New Projects in China,

Pei Zhang (IHEP, CAS)

- Impressive number of new projects, most with SRF technology

## DESY SRF R&D towards a possible

high duty cycle upgrade of the

**EuXFEL**, Hans Weise (DESY)

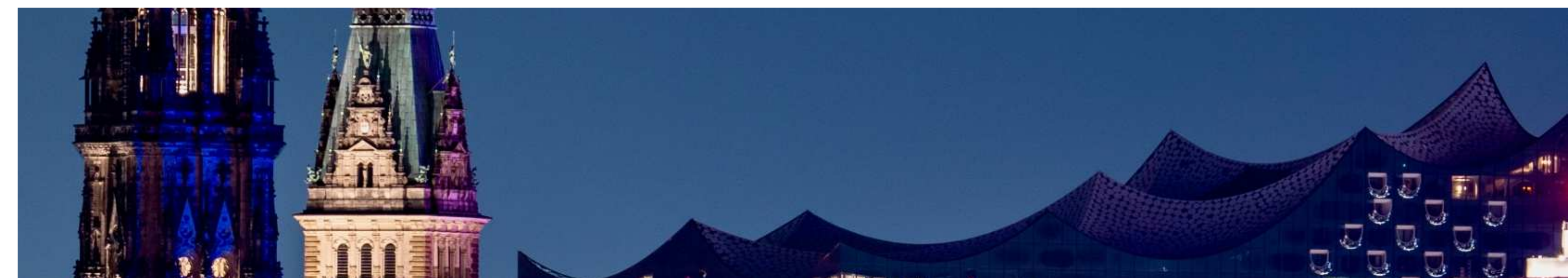
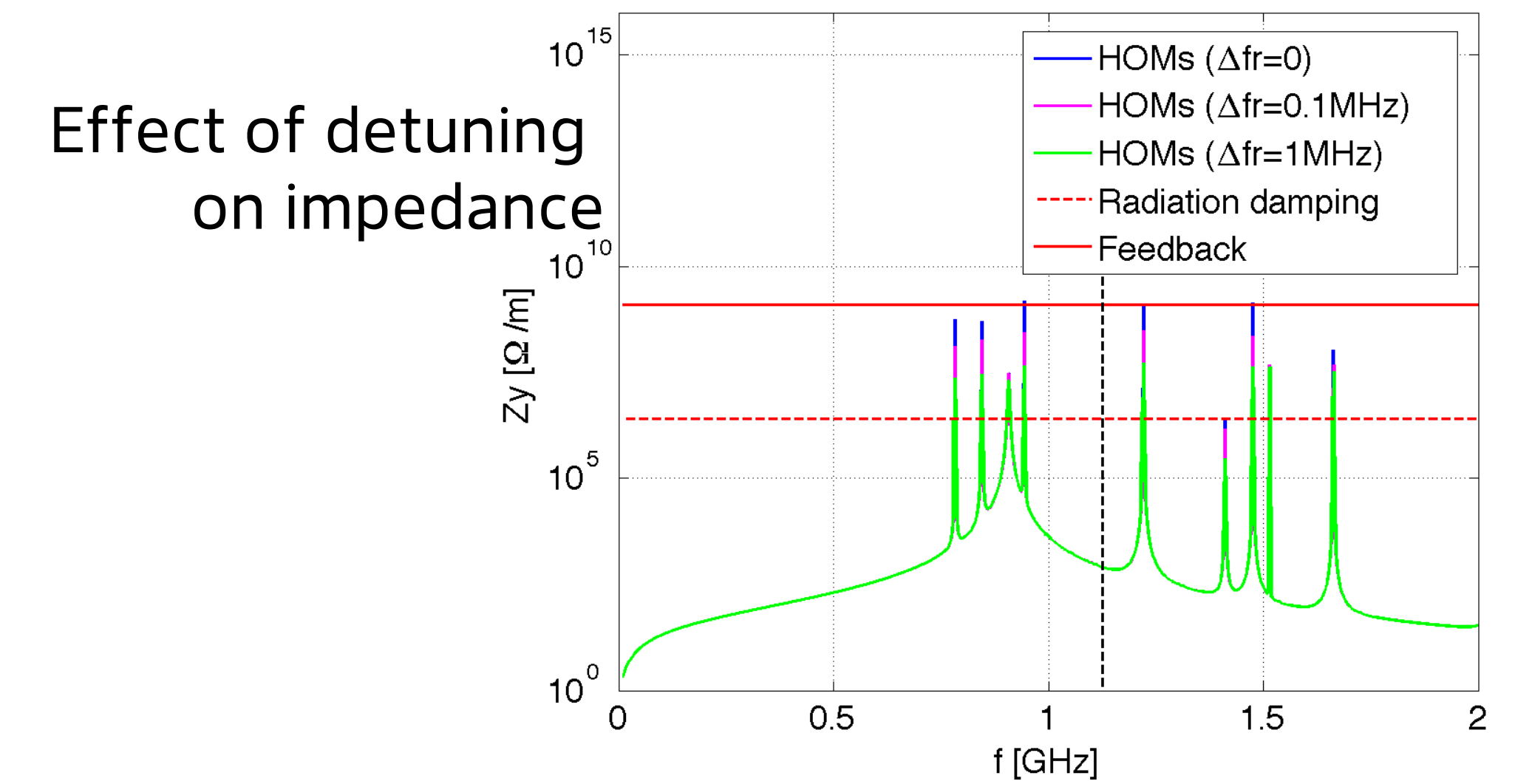
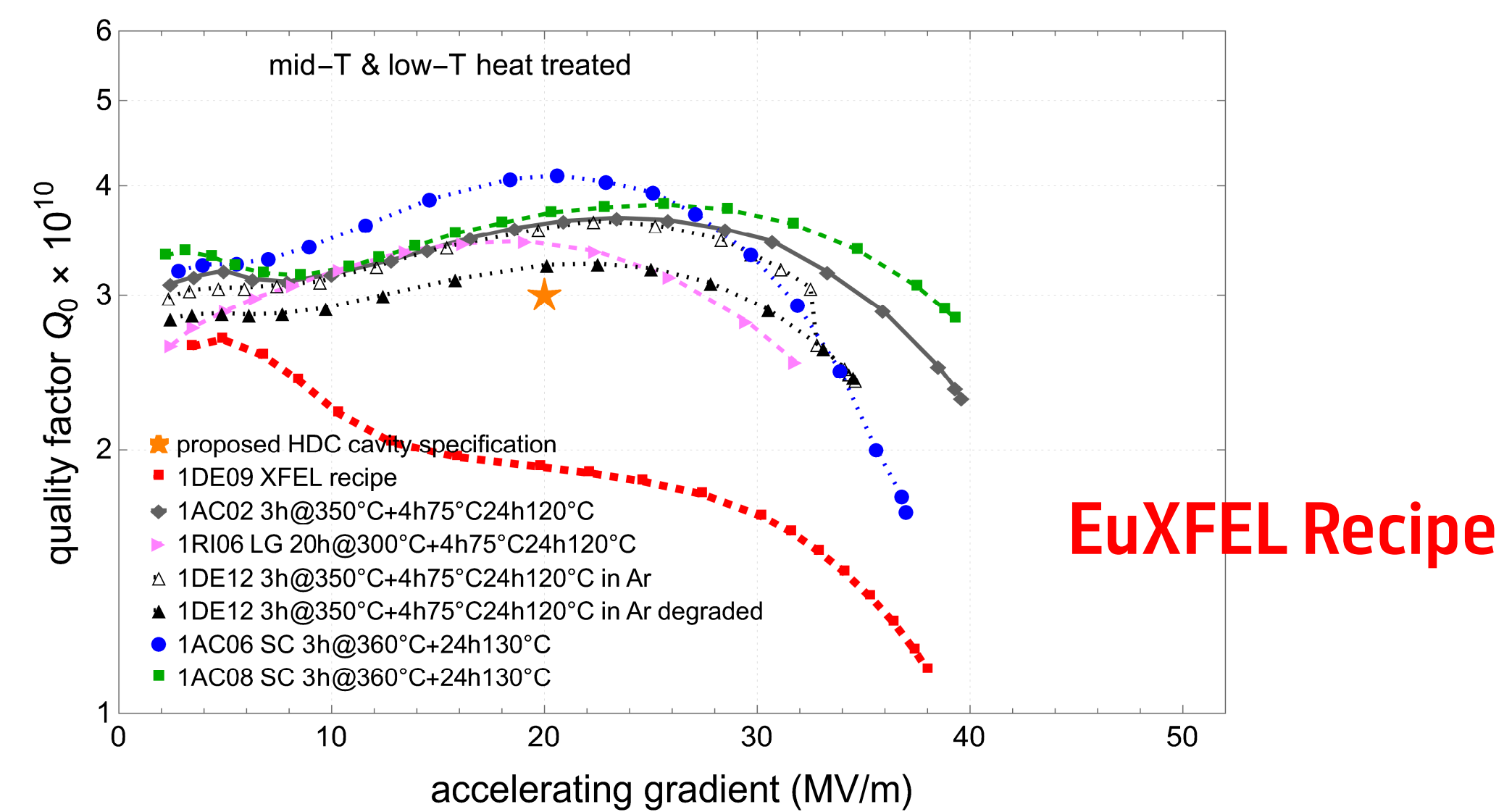
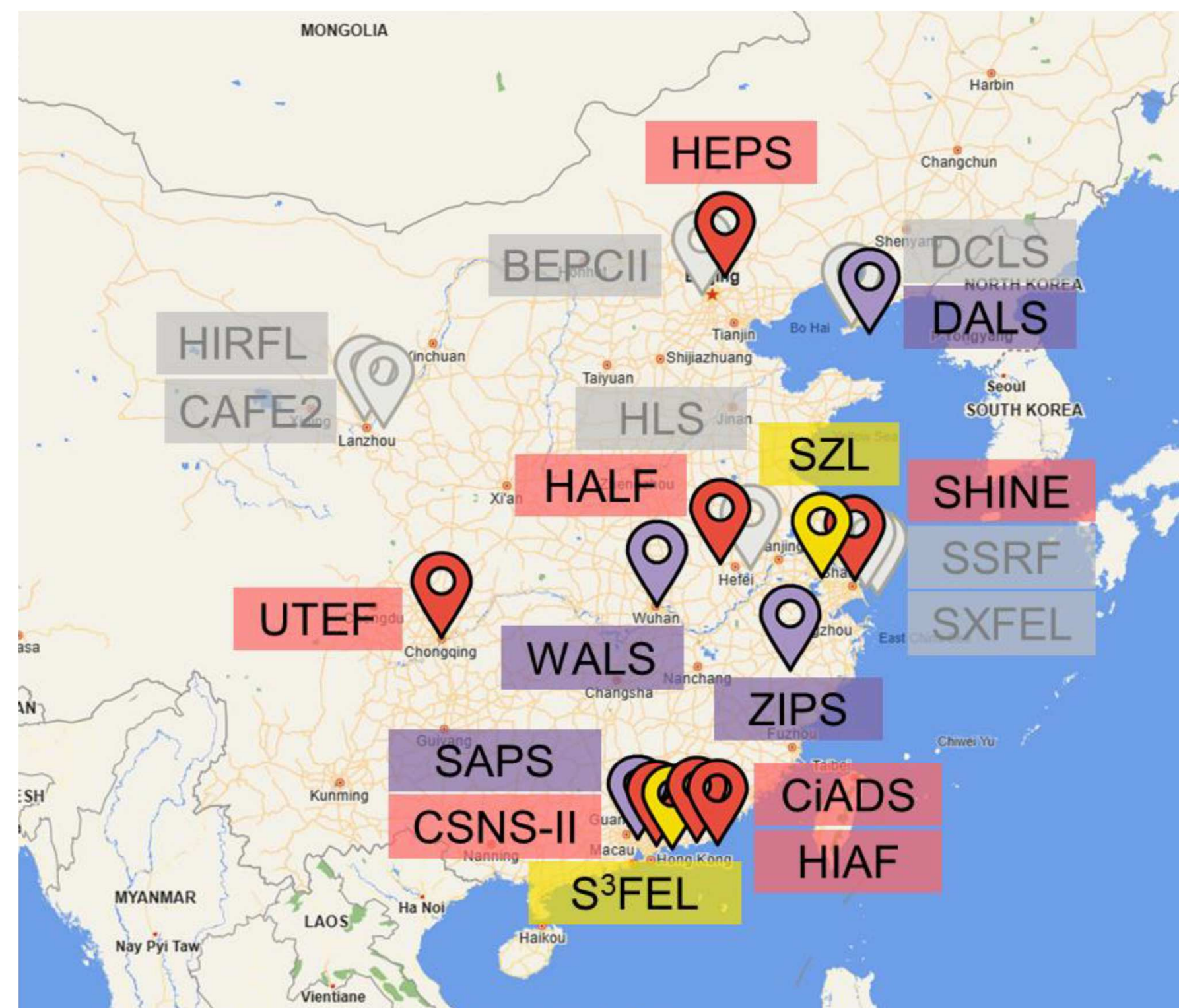
- New SRF technologies are being developed
- Promising results of cavity treatment

## HOM Damping Requirements for

New Circular Accelerators,

Na Wang (IHEP, CAS)

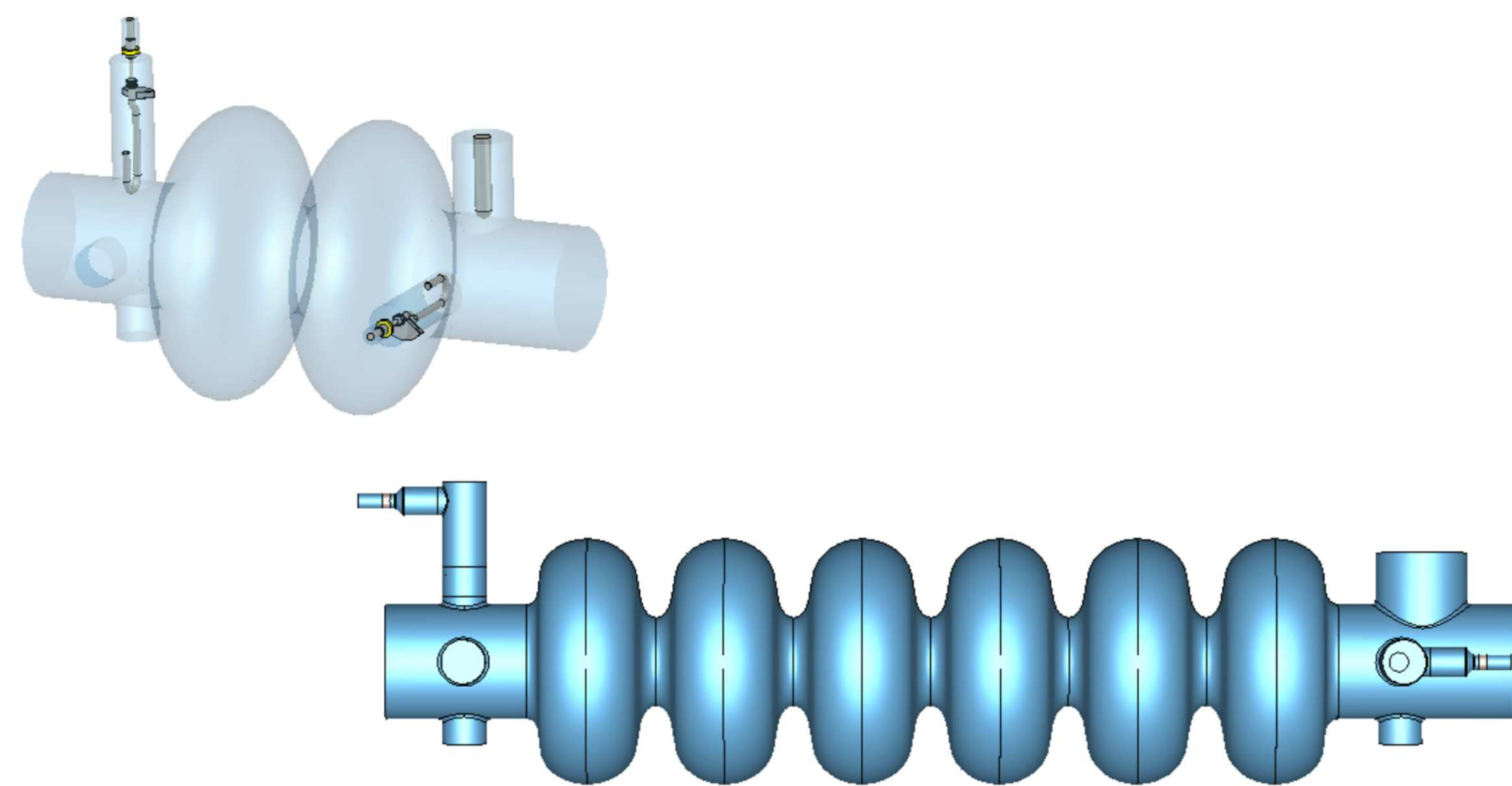
- Study for both e-p circular colliders and Synchrotron radiation facilities



# WG1: HOM Damping Requirements for Future Facilities (2)

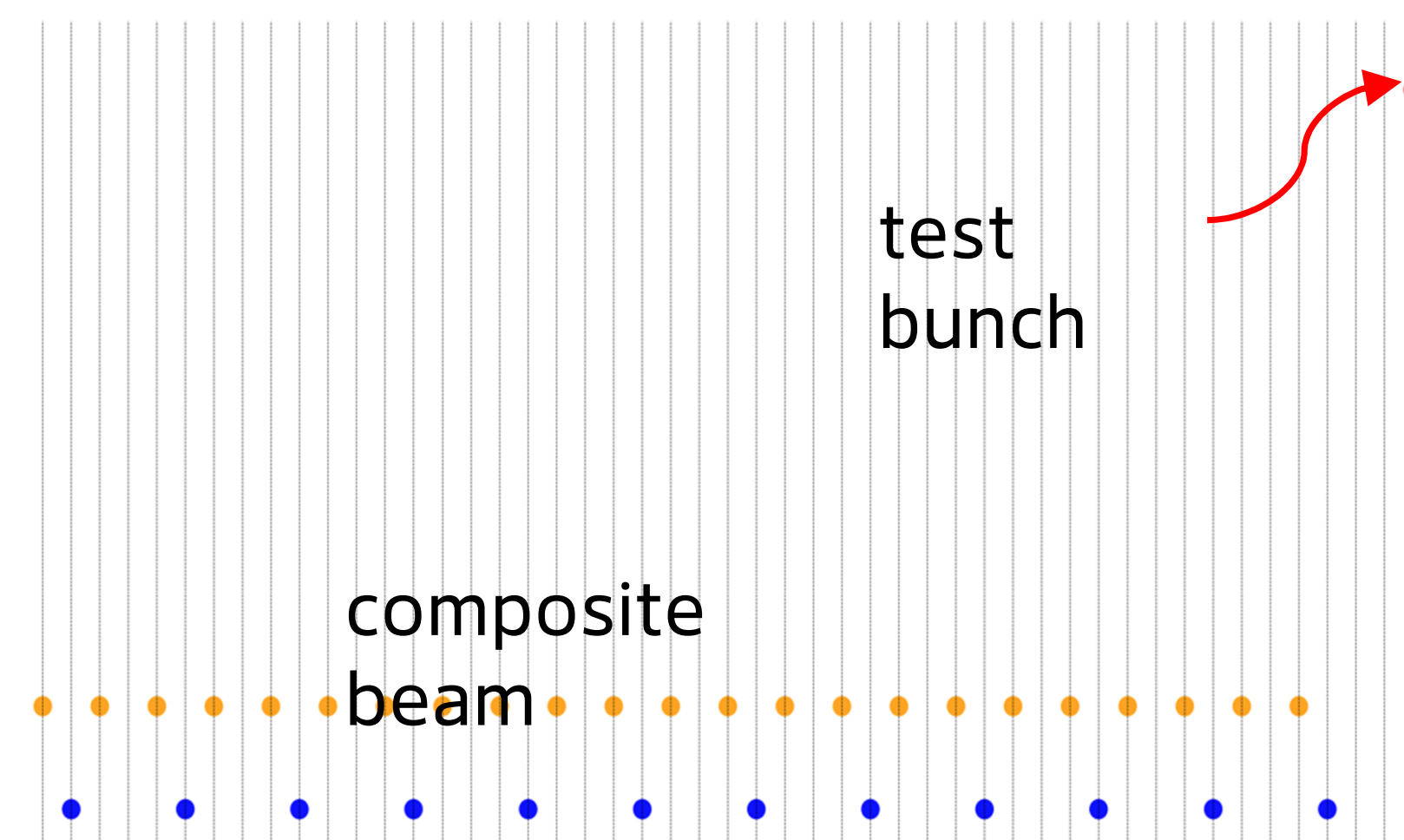
## HOM Damping Strategies for the FCC-ee SC Cavities, Shahnam Gorgi Zadeh (CERN)

- 2-cell 400 MHz and 6-cell 800 MHz cavities have been analysed, including e.g. multipacting at HOM couplers



## Dipole wakefields and beam dynamics simulations for the UK XFEL, Anthony Gilfellon (STFC)

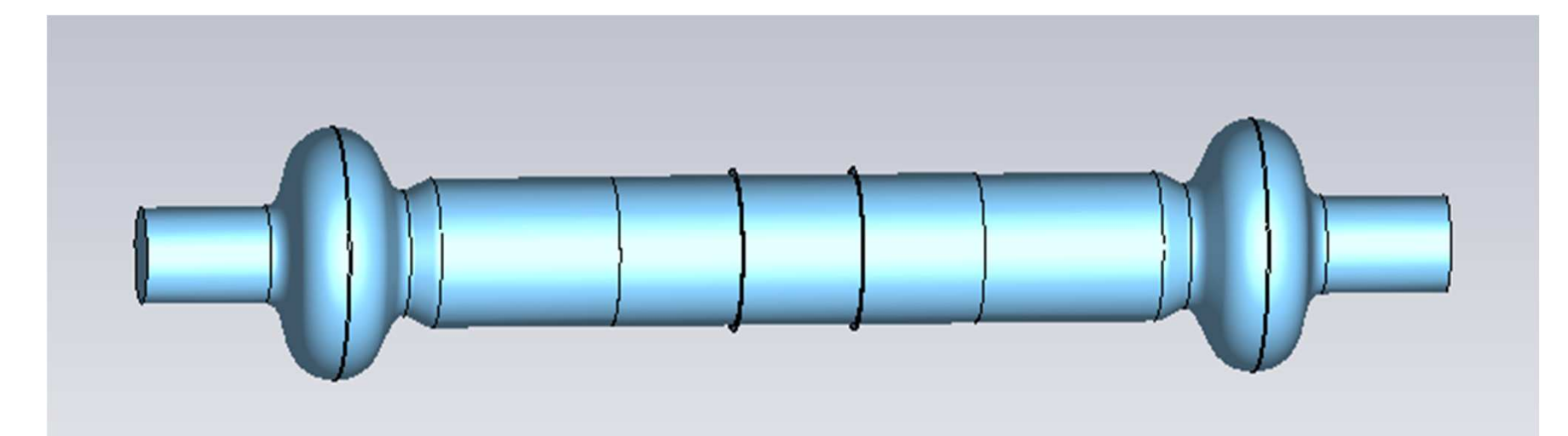
- Benchmarked tracking codes (ELEGANT, PLACET); emit. growth simulated for simple and composite beams



## Beam Stability in the EIC ESR, Alexei Blednykh (BNL/EIC)

- Contribution of the 2-cavity 591 MHz string analysed
- longitudinal damper is required; transverse one under investigation

Two back to back cavities

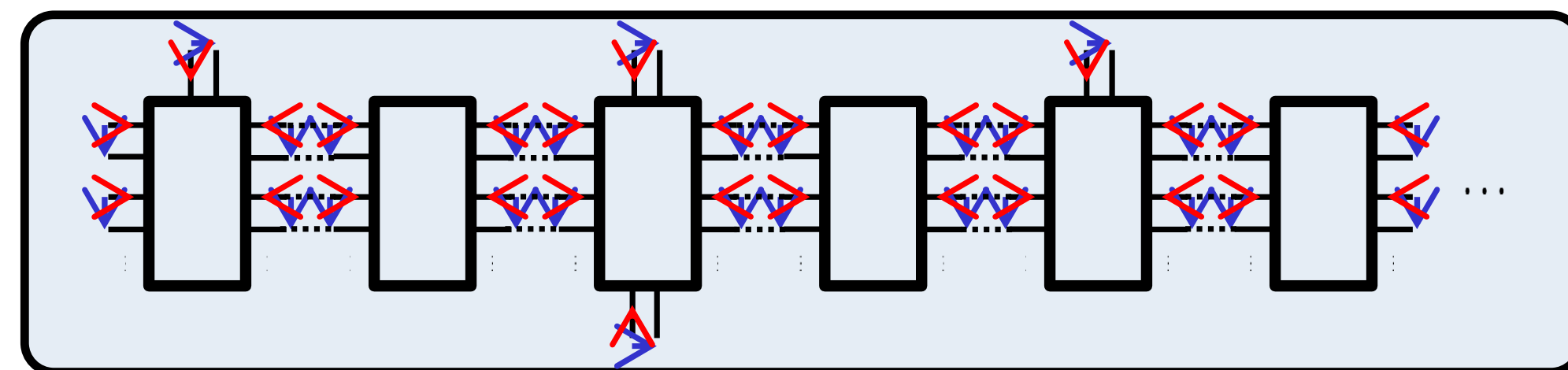


# WG2: Numerical Simulations for SRF Cavities (1)

## Concatenation Methods,

Thomas Flisgen (BTU)

- an important tool to determine HOMs in cavity chains, but sometimes difficult to get a good description of individual segments



## Status of the ECHO Code,

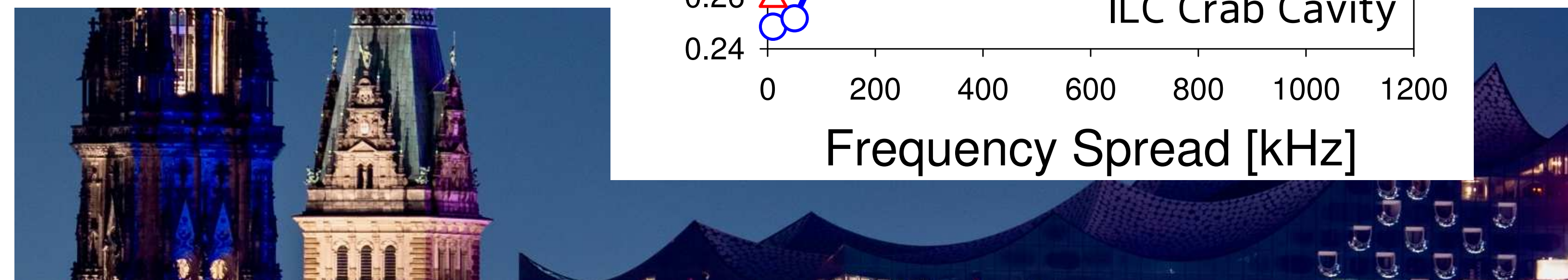
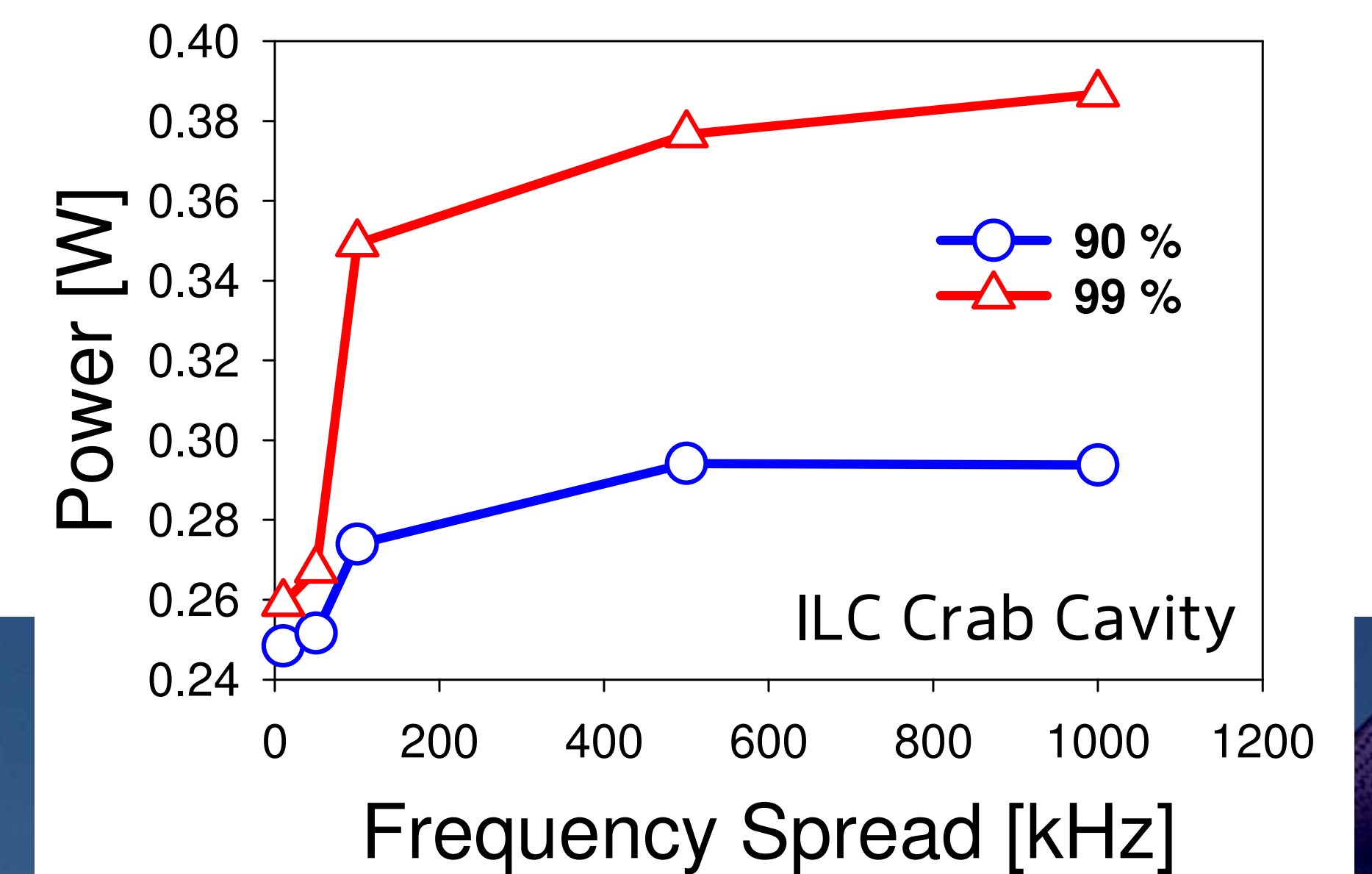
Igor Zagorodnov (DESY)

- for accurately modeling wake fields and impedances in diverse accelerator geometries
- highlighted recent developments, capabilities, and applications in complex component analysis

- <https://www.echo4d.de>

## Numerical Analysis of HOMs in SRF Resonators for Particle Accelerators, Andrei Lunin (Fermilab)

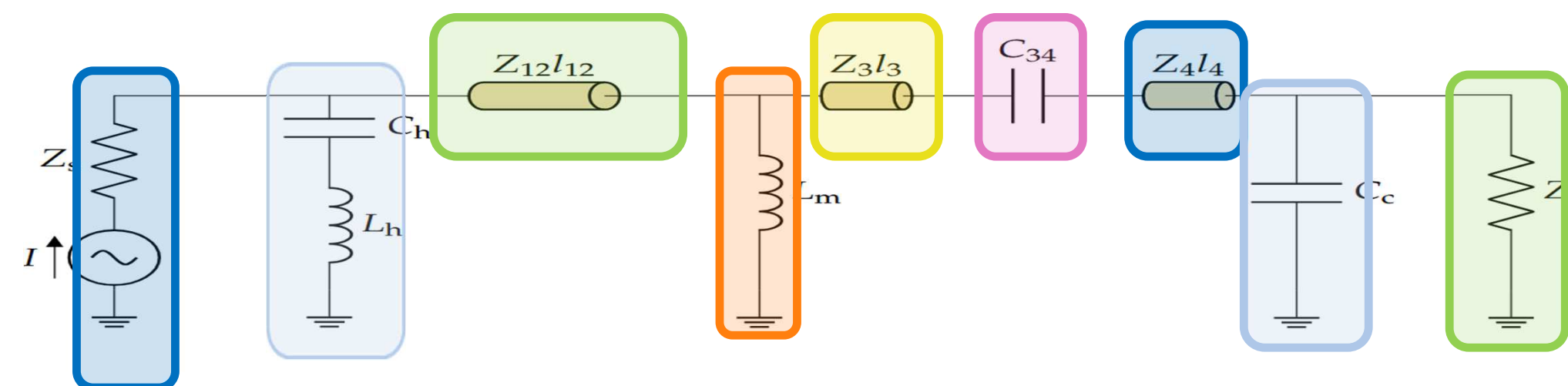
- Model the spread of HOM parameters caused by mechanical imperfections in superconducting cavities, enabling prediction of resonant RF losses and informing design for stable, efficient operation of high-current accelerators



# WG2: Numerical Simulations for SRF Cavities (2)

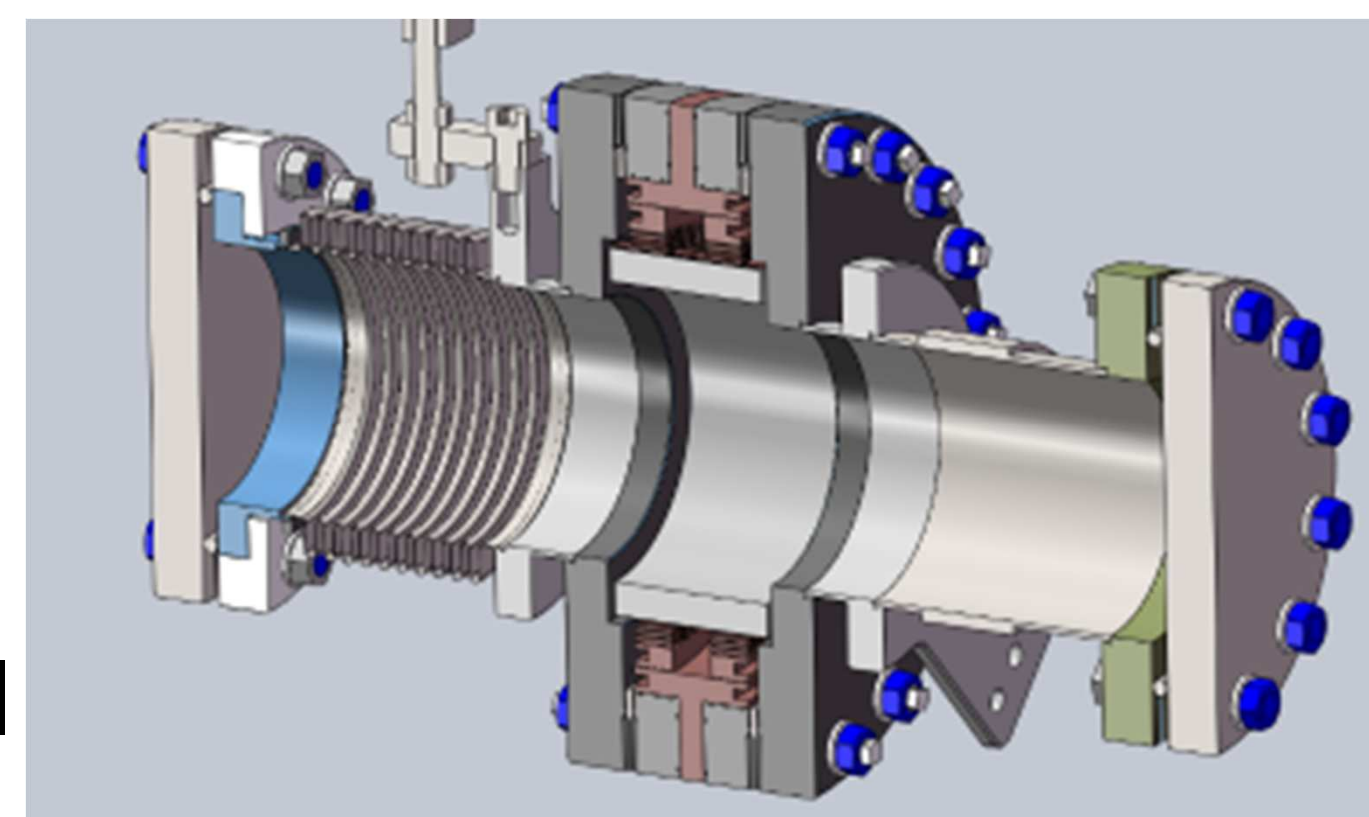
## Numerical Analysis of HOM Couplers, Sosoho-Abasi Udongwo (BTU)

- Numerical simulation methods for analyzing HOM couplers in TESLA-type SRF cavities using S-parameter analysis (3D model and circuit model), optimization, and multipacting studies



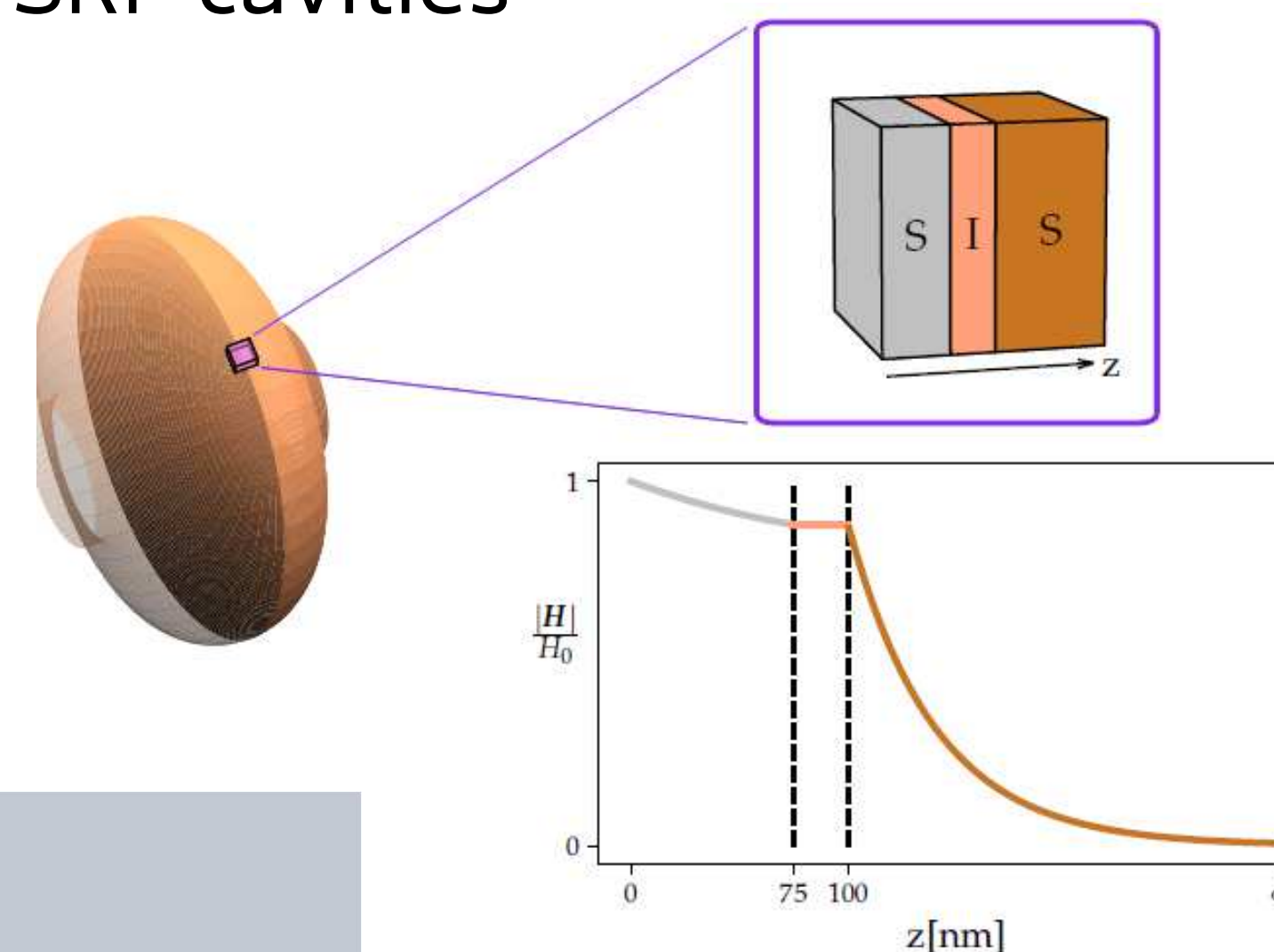
## HOM Power Calculation of SHINE, JieXi Zhang (ShanghaiTech Univ.)

- dielectric properties of absorber materials are a critical issue



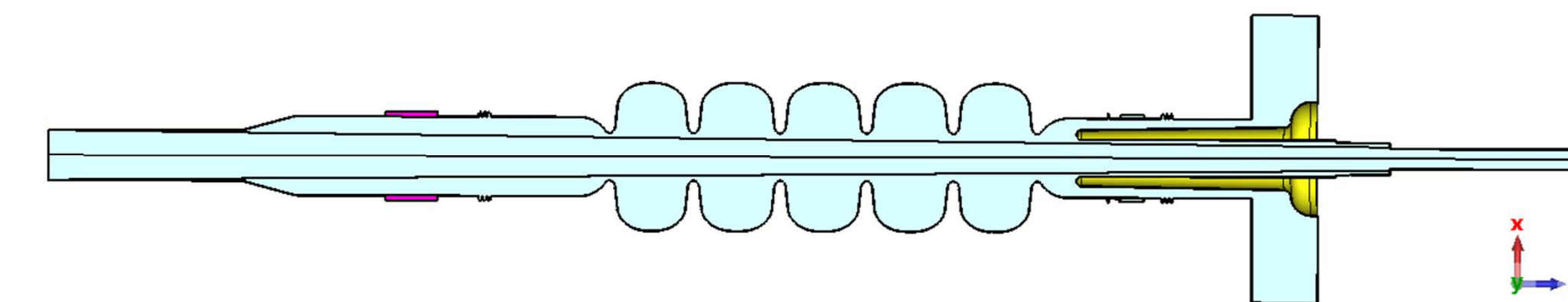
## Surface Impedance of Multilayered Superconducting Cavities, Aaron Gobeyn (TU Darmstadt)

- SIBC approach for a multilayer superconductor-insulator-superconductor as a cost-effective and higher-performing alternative to bulk niobium SRF cavities



## HOM Damping for Conduction-Cooled 915 MHz SRF Cavities in High-Power e<sup>-</sup> Beam Accelerators, Alex Castilla (JLAB)

- Assessment of HOMs in 915 MHz SRF cavities for industrial linacs, showing that stable, high-current operation is achievable without in-cell HOM couplers, enabling simpler, more efficient cavity designs for high-power applications



# WG3: Design of SRF Cavities and HOM Damping Schemes (1)

## RF absorber development at IJCLab, Akira Miyazaki (CNRS/IN2P3/IJCLab)

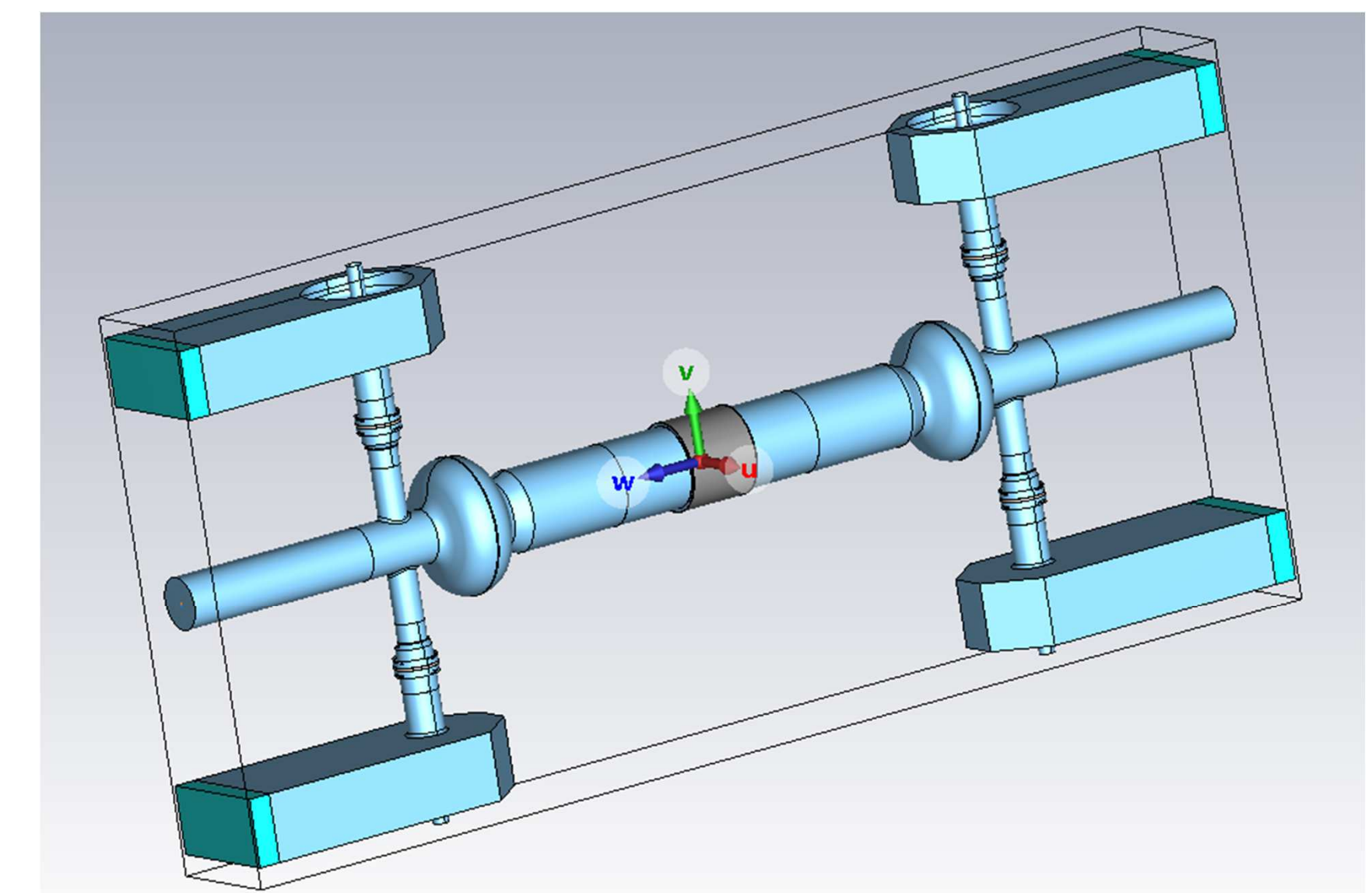
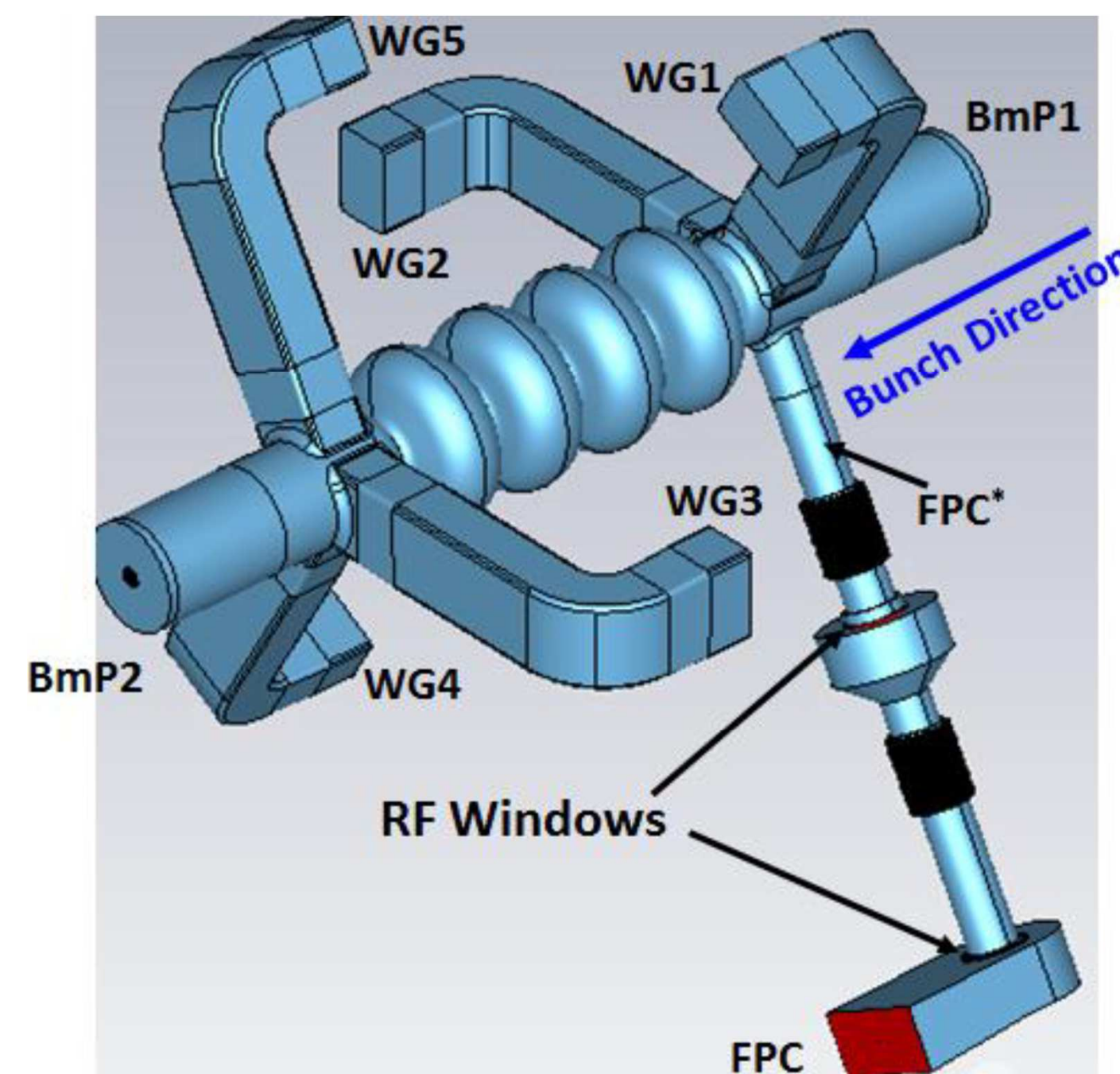
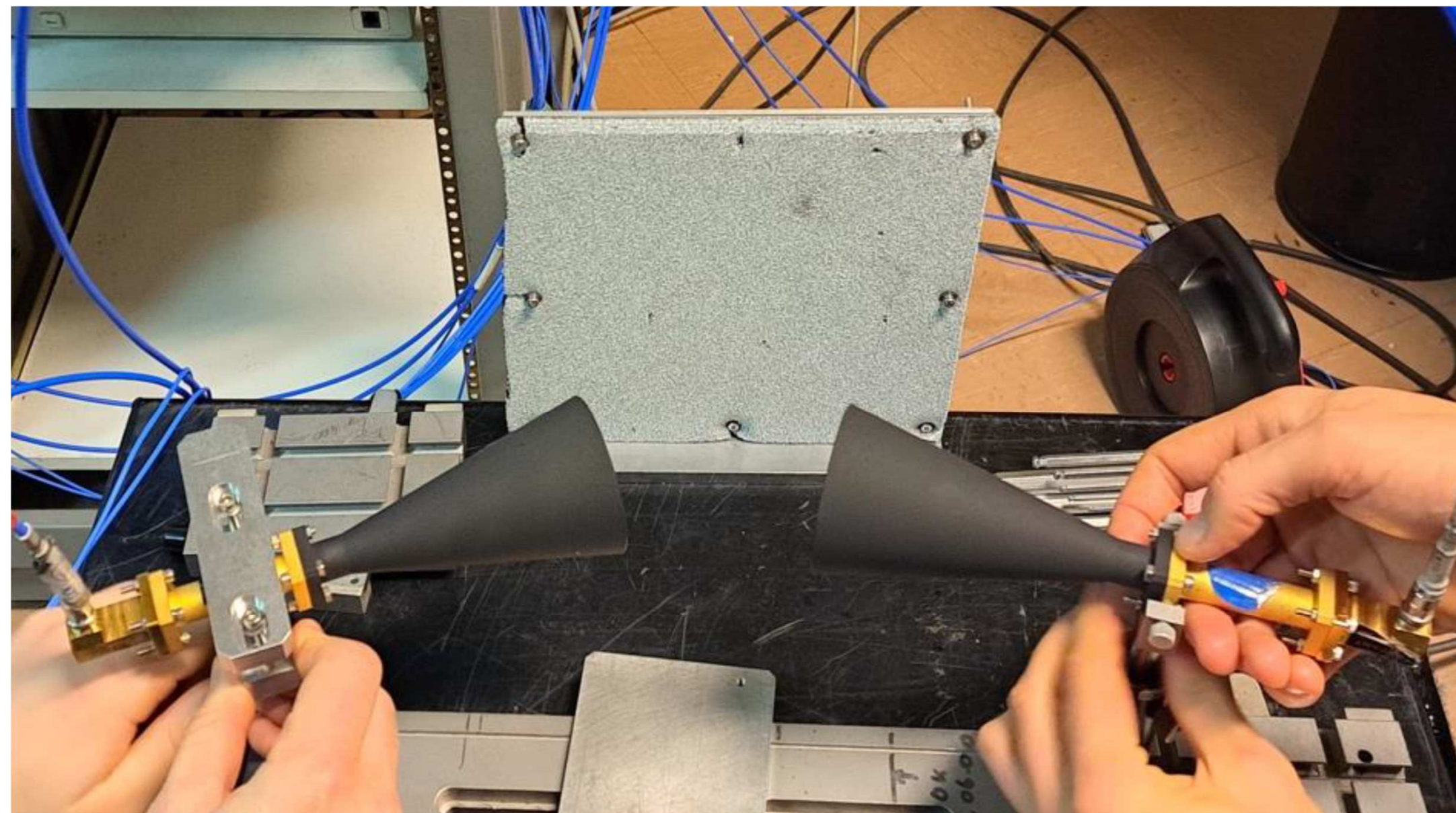
- Studies on material choice and possible vendors for the BLA in PERLE cavities at IJCLab (operating at 40 K) and the underlying theory of dielectric loss

## Design of HOM damped SRF Cavities for CW Operation in Storage Rings, Andranik Tsakanian (HZB)

- HOM power distribution analysis and the importance of integrating HOM damping early in the cavity design stage, illustrated with examples from the BESSY VSR cavity design

## HOM damping for the EIC ESR SRF Cryomodule, Jiquan Guo (JLAB)

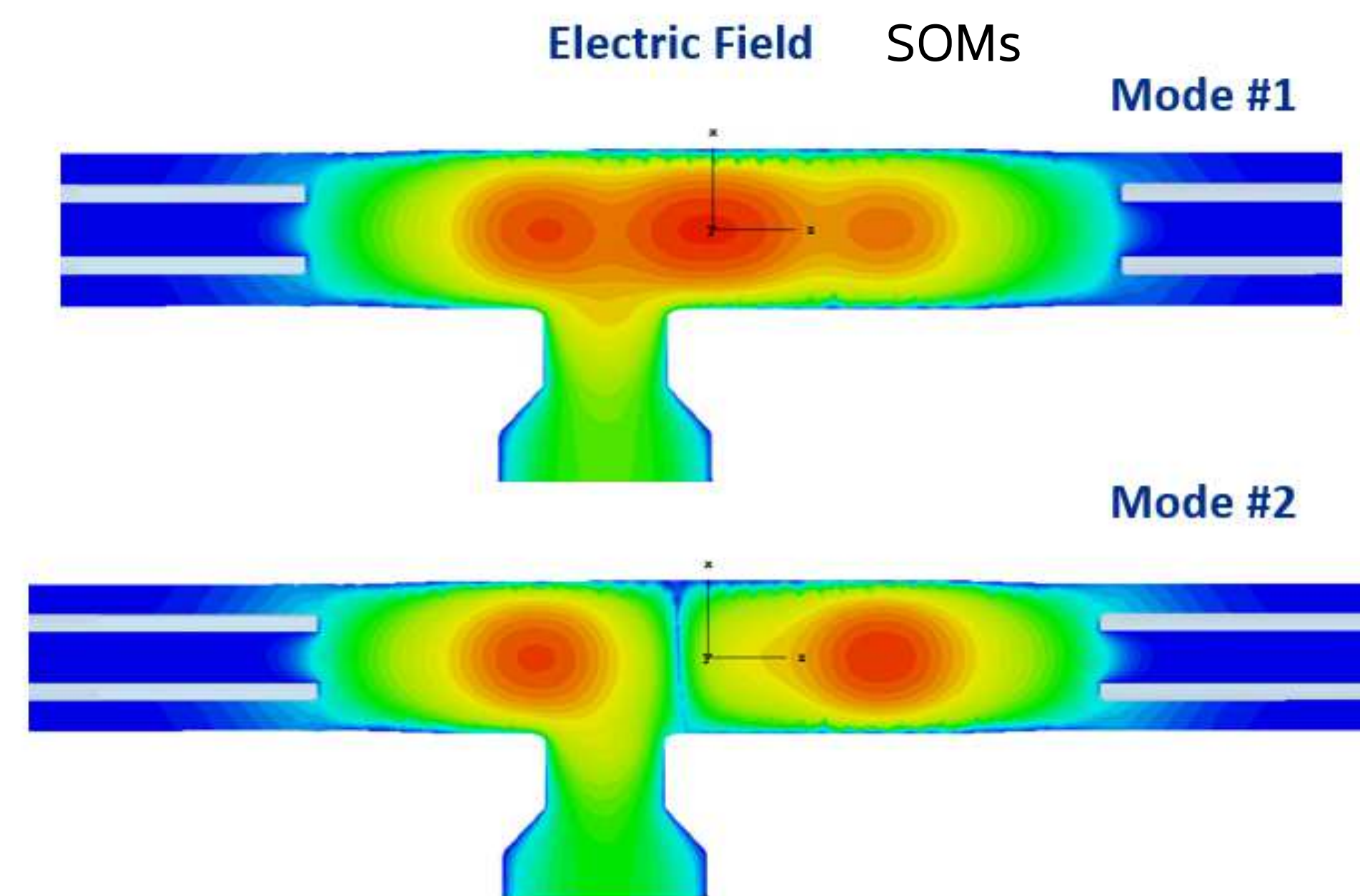
- Latest updates on the EIC cavity design, from single- to two-cavity module, addressing impedance limitations and BLA design for kW-level HOM power



# WG3: Design of SRF Cavities and HOM Damping Schemes (2)

## Compact Coaxial HOM Damper for SRF Cavities, Andrei Lunin (Fermilab)

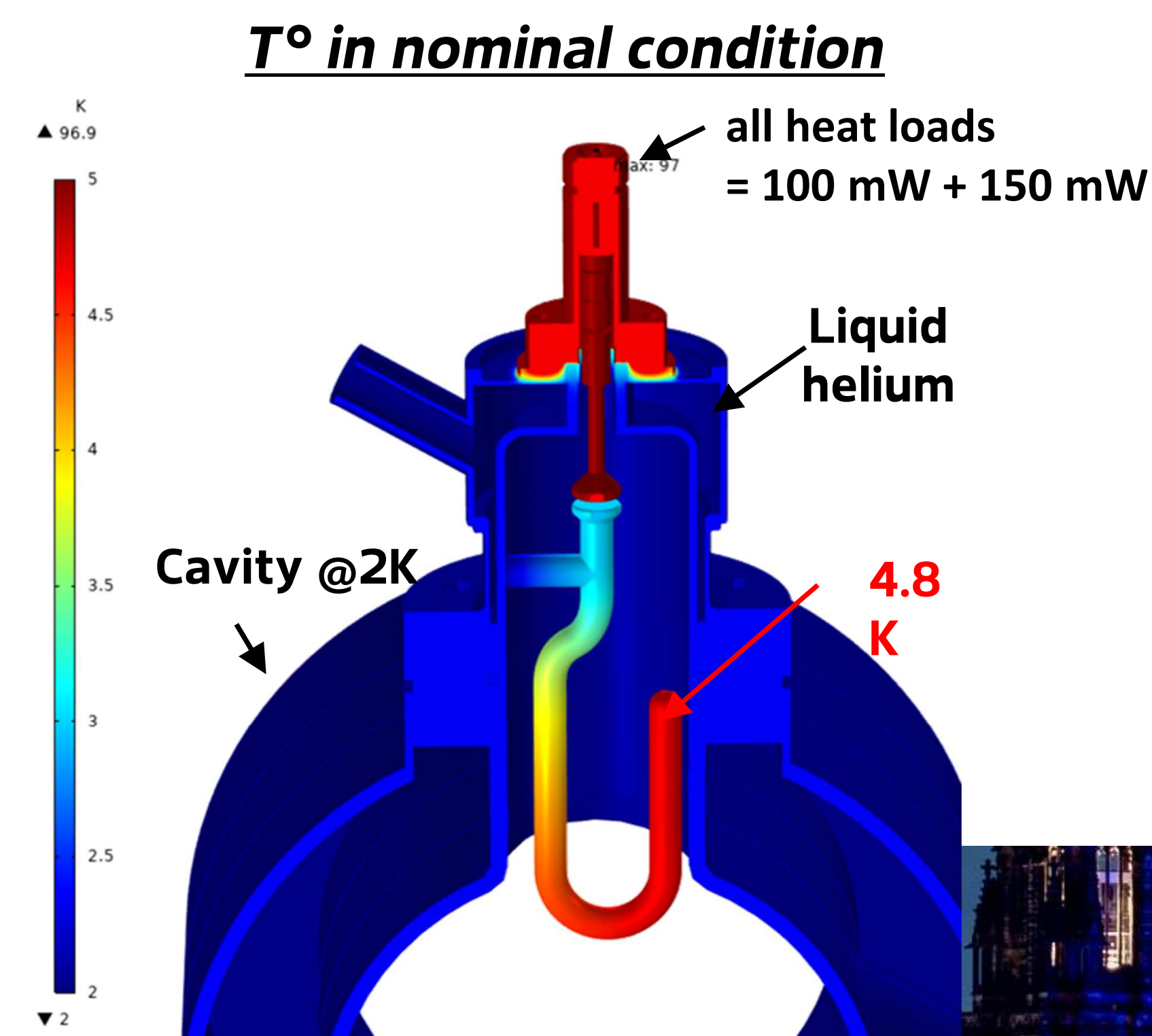
- A new compact HOM damper based on a radially sectioned coaxial design was proposed, providing effective and compact HOM suppression especially for low frequency cavities



EIC 394 MHz Crab Cavity

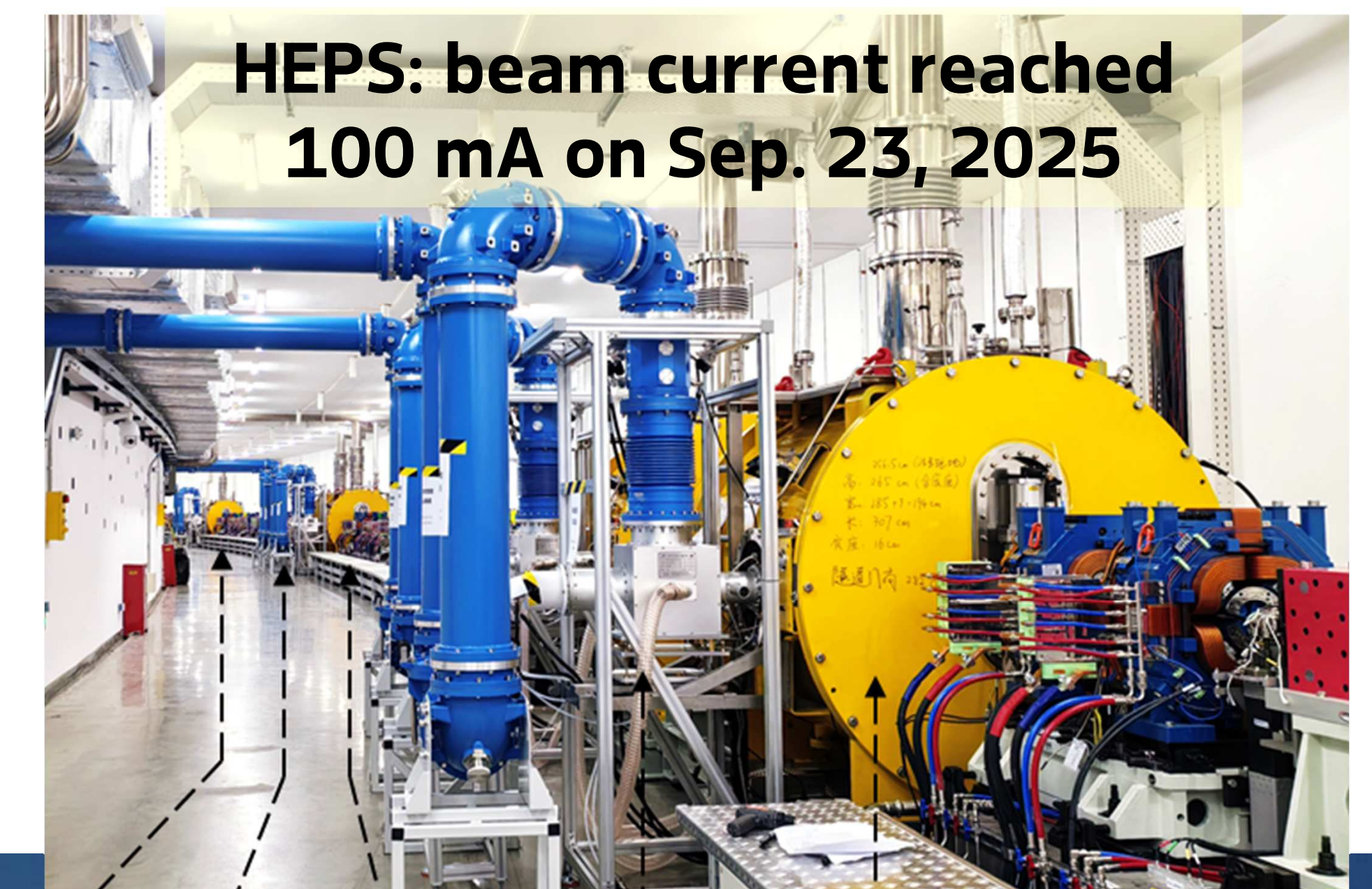
## Progress of HOM couplers for PERLE SRF cavities, Patricia Duchesne (CNRS/IN2P3/IJCLab)

- A summary of the thermomechanical analysis for SC coaxial HOM couplers, focusing on the hook-type coupler for PERLE cavities



## HOM Damping in 166MHz beta=1 QWR for High Energy Photon Source, Hongjuan Zheng (IHEP)

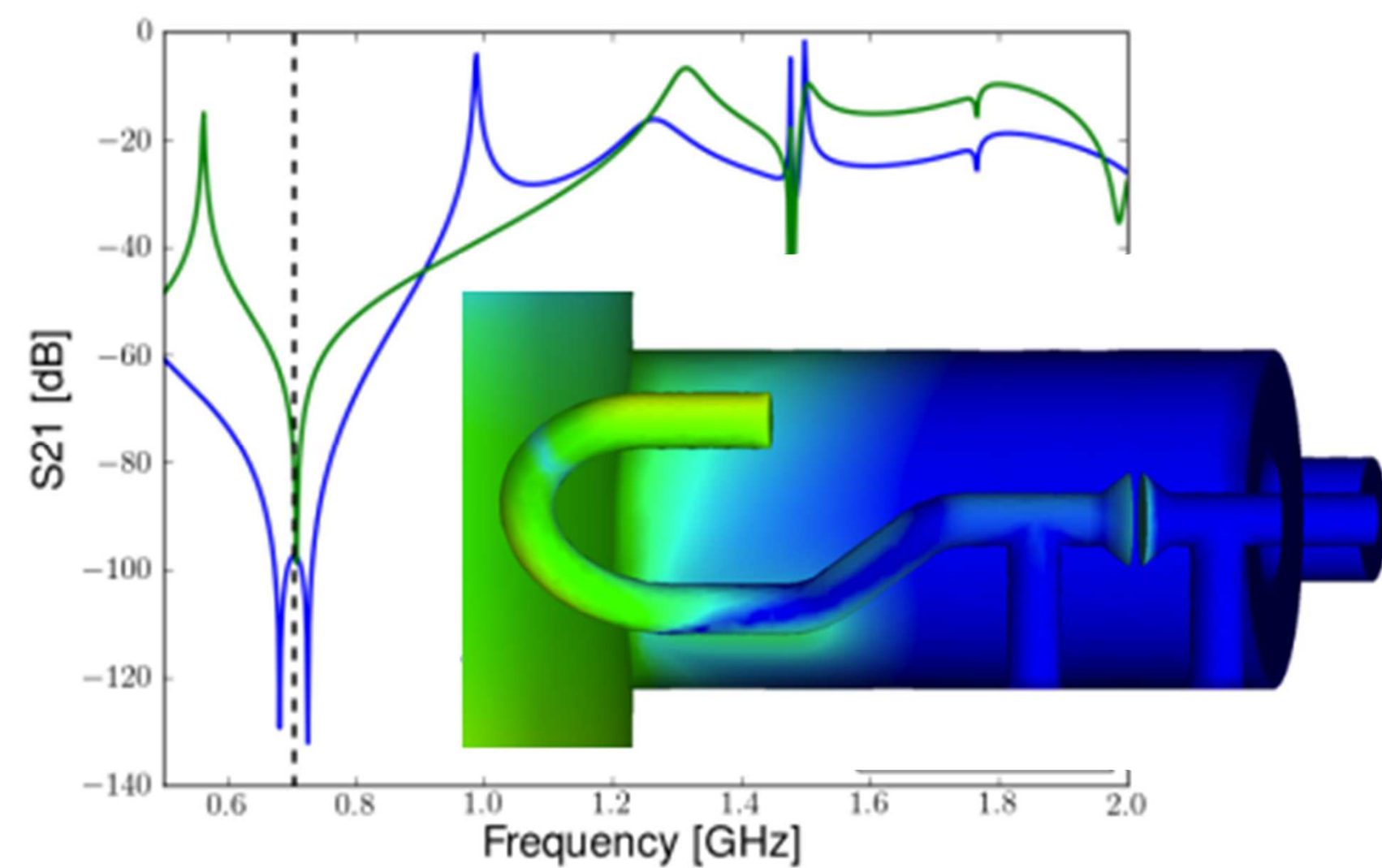
- HOM damping in 166.6 MHz cavities using large-radius ferrite absorbers, addressing challenges such as brazing, ferrite tile peel-off



# WG3: Design of SRF Cavities and HOM Damping Schemes (3)

## Evanescent mode coupling in coaxial HOM filters, Kai Papke (DESY)

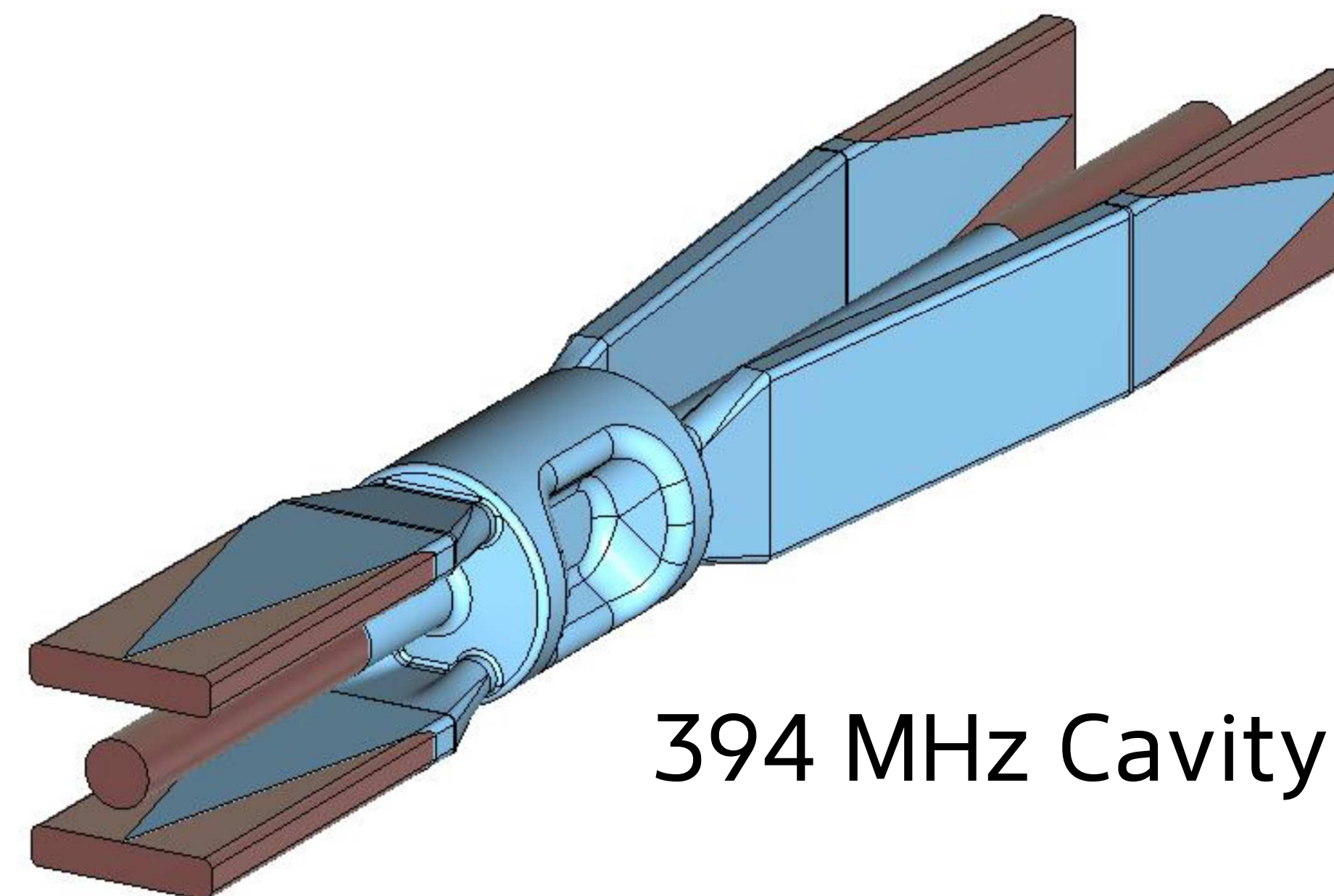
- Overview of coaxial HOM coupler design theory and a systematic design approach from filter function to 3D structure



R. Ainsworth, in Proc. IPAC2012, WEEPPB008

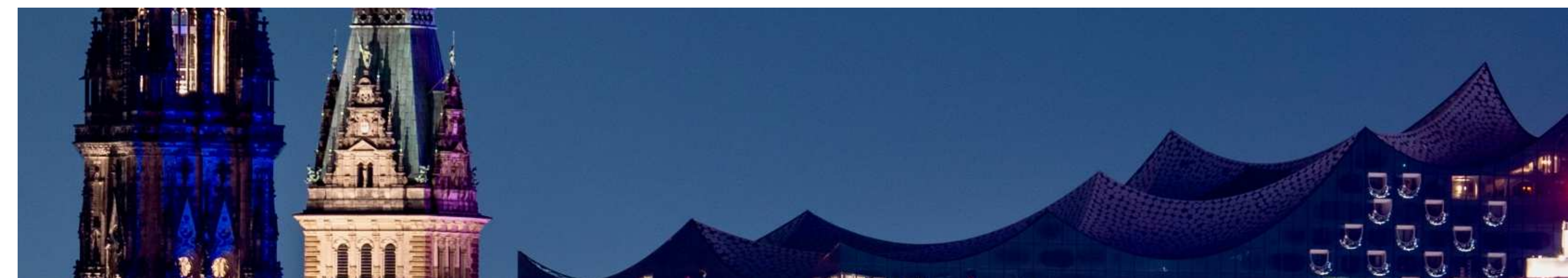
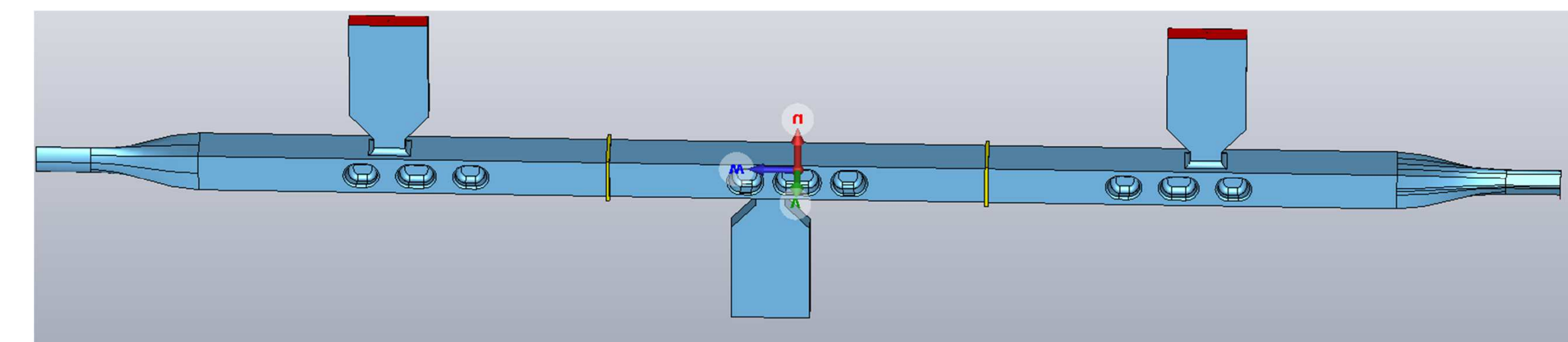
## HOM Damping for EIC Crab Cavities, Binping Xiao (BNL)

- Recent progress on HOM impedance threshold calculations and HOM damping design for the 197 MHz and 394 MHz EIC crab cavities



## QMiR Cavities RF Analysis, Nuaman Shafqat (Elettra)

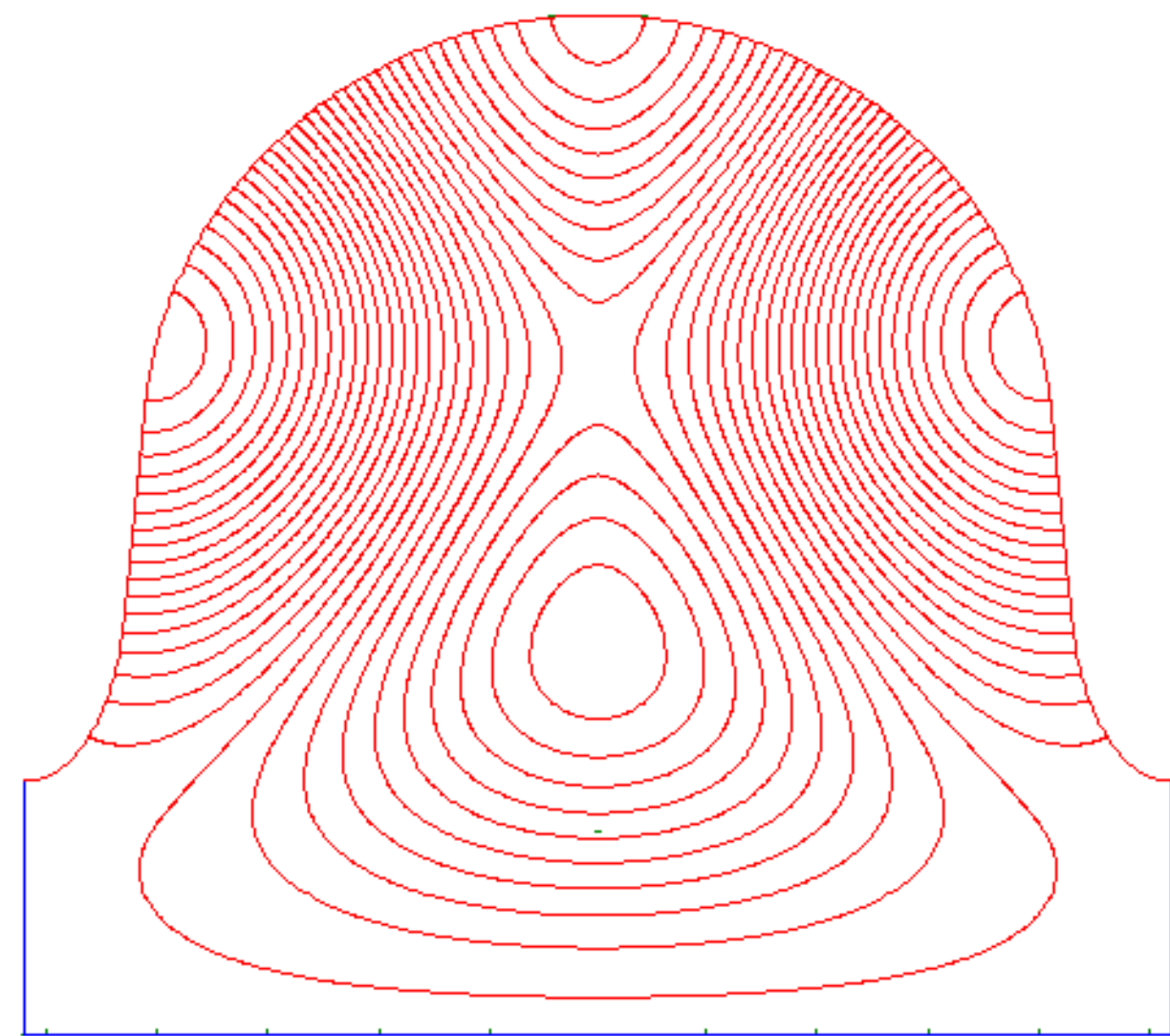
- QMiR 3.0 GHz and 3.25 GHz crab cavities for Elettra 2.0 designed without HOM couplers, with challenges from high-Q, low-R/Q HOMs trapped in the beam pipe
- Followed by discussion



# WG4: Operation of SRF Facilities (1)

## Interaction of degenerate HOMs in periodic accelerating structures, Andrei Lunin (Fermilab)

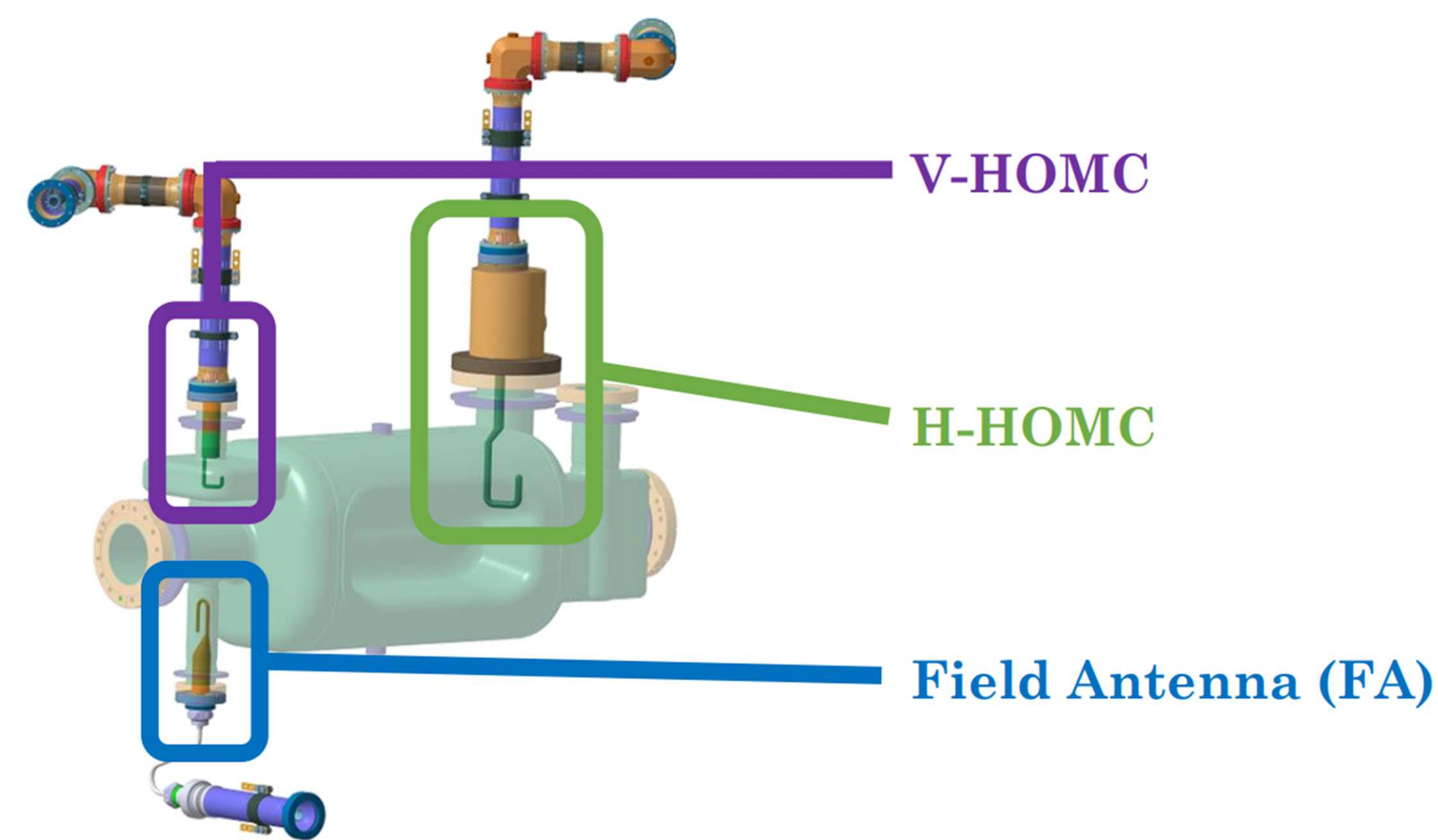
- Phenomenon of degenerate HOMs interaction in the PIP-II HB650 cavity can lead to flat passbands which should be avoided



Mode mixing in elliptical multicell cavities

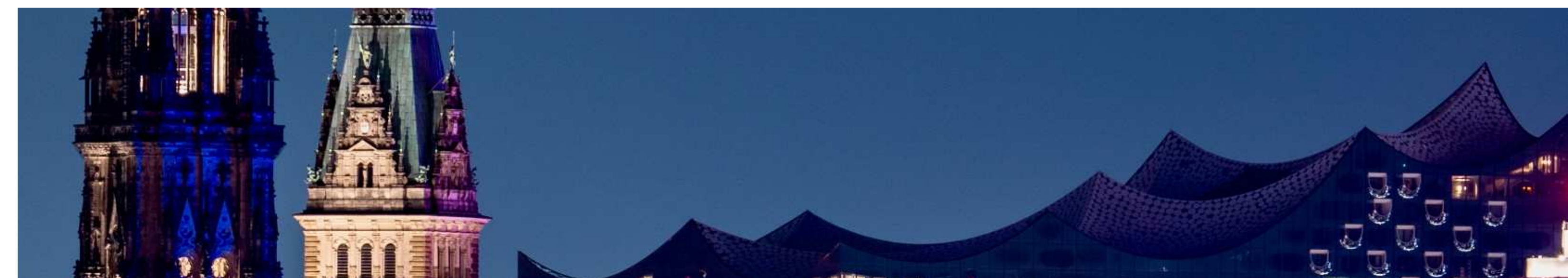
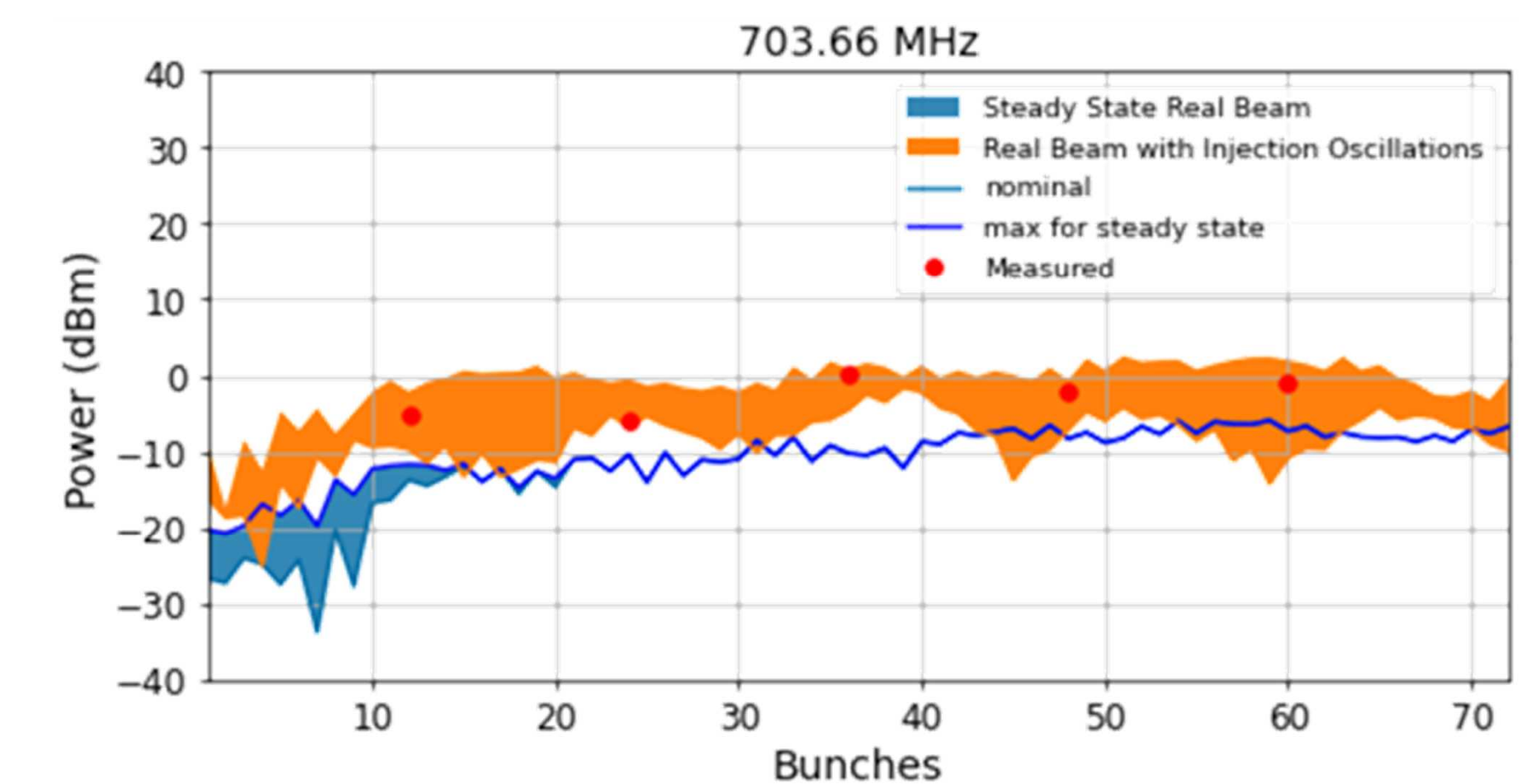
## Cold Testing and HOM Coupler Qualification for HL-LHC Crab Cavity Systems, Amelia Edwards (CERN)

- HOM couplers for HL-LHC crab cavities well into production stage and being integrated into cavities and modules



## Developing a Beam Spectrum for Transient Beams in the CERN Double Quarter Wave Crab Cavities, Conor McFarlane (Lancaster University)

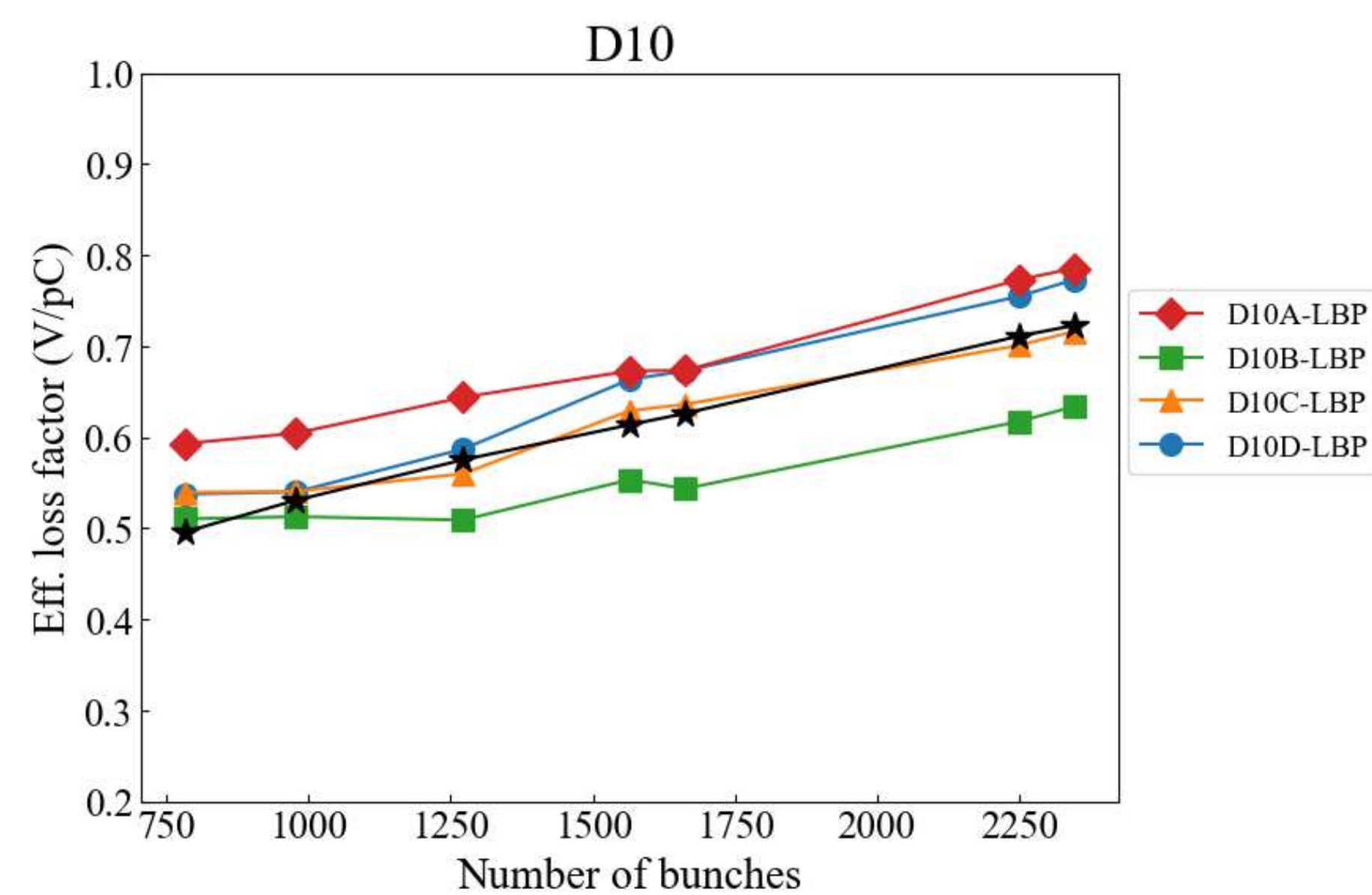
- There were large discrepancies between measurements of crab cavities and the predictions
- => Transient beam conditions should be considered for HOMs!



# WG4: Operation of SRF Facilities (2)

**Observation and simulation on the fill-pattern dependence of HOM power in the SuperKEKB SC cavity,**  
Takaaki Yamaguchi (KEK)

- An advanced method for evaluating HOM power
- the EM fields inside materials are directly used



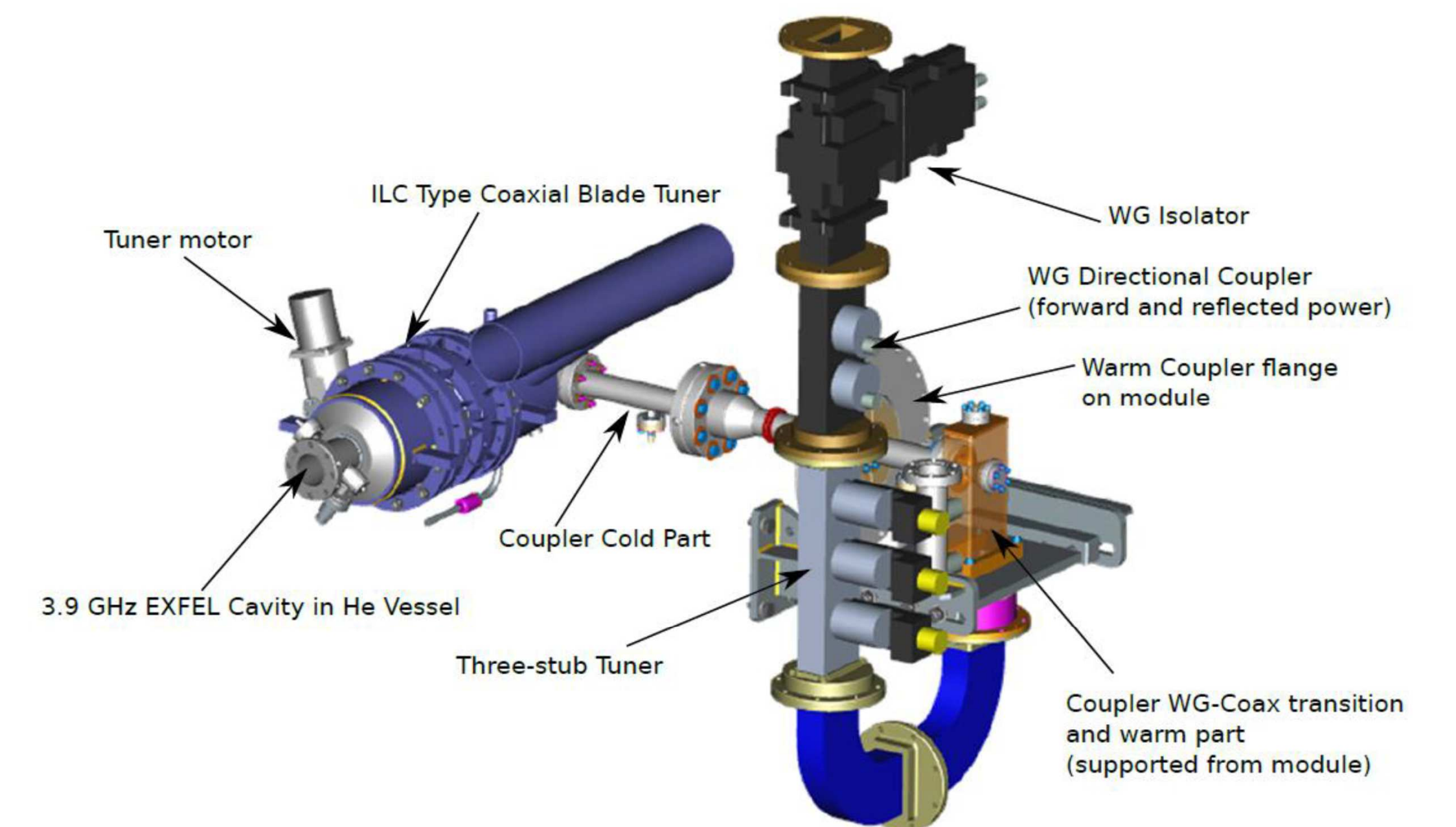
**The UK XFEL project: conceptual design,** Anthony Gilfellon (STFC)

- Nice overview!



**CW operation characteristics of the spare Eu-XFEL 3<sup>rd</sup> harmonic module,** Karol Kasprzak (DESY)

- A modified design of HOM Couplers is required for the CW upgrade



# Conclusion

There is an **increasing number** of facilities using superconducting RF

There is a clear need of discussion in the field of HOMs in superconducting cavities  
The workshop was a place for exchange, for looking for answers for challenges

The **hybrid** format worked well, but **in-person participation** is preferable

Hopefully the community can meet soon at the **next HOMSC Workshop!**

- Should take place **in 2028** (avoid years when an SRF conference takes place)
- Continue in 2 year rhythm (as before the pandemics)

