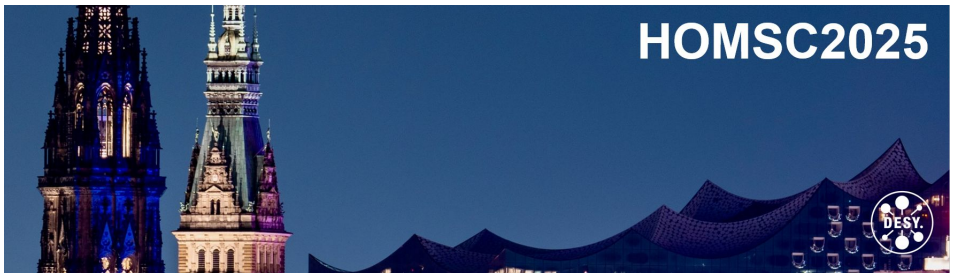
International Workshop on Higher Order Modes in Superconducting Cavities (HOMSC2025)



Report of Contributions

Contribution ID: **2** Type: **Oral contribution**

HOM Damping in 166MHz beta=1 QWR for High Energy Photon Source

Tuesday 7 October 2025 14:00 (30 minutes)

The High Energy Photon Source is a 6 GeV diffraction-limited synchrotron light source with ultra-low beam emittance. A 166.6 MHz quarter-wave superconducting cavity with a beta=1 structure has been proposed as the main accelerating cavity for the storage ring. The high beam current of 200 mA requires heavy damping of higher order modes (HOM) in the 166.6 MHz cavities to avoid coupled multi-bunch instabilities. The low HOM frequencies and the limited space of the straight sections for cavities pose significant challenges for the HOM damping design. Several design concepts have been exploited, combining dedicated HOM couplers for the first few HOMs and a beam-line HOM absorber for the remaining high-frequency modes. An enlarged beampipe scheme has also been examined, featuring a large ferrite HOM absorber on the beam line. The design optimizations and limitations of these damping schemes are elaborated and compared. This talk presents the design of the HOM damping schemes in the 166.6 MHz superconducting cavities. The HOM-damped 166.6 MHz cryomodules have been tested and are scheduled to be installed on the storage ring for beam operation in the summer. The testing and operational status will also be discussed.

Primary author: ZHENG, Hongjuan (IHEP)

Presenter: ZHENG, Hongjuan (IHEP)

Session Classification: Design of SRF Cavities and HOM Damping Schemes

Track Classification: Design of SRF Cavities and HOM Damping Schemes

Contribution ID: **3** Type: **Oral contribution**

New projects in China

Monday 6 October 2025 10:15 (30 minutes)

Large accelerator projects have been booming in China over the last decade, represented mainly by synchrotron light sources, free-electron lasers, particle colliders, accelerator-driven subcritical systems (ADS), and spallation neutron sources. Several new projects are currently being planned, while others have already begun construction. Additionally, some existing projects have been upgraded. Most new projects have adopted superconducting radio-frequency (RF) technology. High-order mode (HOM)-damped superconducting RF cavities have been developed for high-current machines. This talk will review the new projects in China.

Primary author: ZHANG, Pei (Institute of High Energy Physics)

Presenter: ZHANG, Pei (Institute of High Energy Physics)

Session Classification: HOM Damping Requirements for Future Facilities

Track Classification: HOM Damping Requirements for Future Facilities

Contribution ID: **5** Type: **Oral contribution**

Higher Order Mode Damping Assessment for Conduction-Cooled 915 MHz SRF Cavities in High-Power Industrial Electron Beam Accelerators

Monday 6 October 2025 16:30 (30 minutes)

The development of compact, high-current superconducting electron linacs for industrial applications requires balancing system simplicity, thermal management, and beam stability. In this work, we investigate the higher order mode (HOM) characteristics and damping requirements for 915 MHz superconducting accelerating structures specifically designed for conduction-cooled operation. Two cavity configurations are studied: a 2-cell cavity intended for a 5 mA, 4 MeV beam delivering 20 kW of power, and a 5-cell cavity designed for a 100 mA, 10 MeV beam with a beam power of 1 MW. Electromagnetic eigenmode simulations are performed to characterize the HOM spectra, focusing on monopole and dipole modes relevant to beam-induced instabilities. Beam breakup (BBU) analyses evaluate the threshold currents for instability under scenarios with no dedicated in-cell HOM couplers. The feasibility of relying solely on external beam line absorbers (BLAs) to extract HOM power is assessed. The results show that, given the beam quality requirements of industrial irradiation processes, sufficient beam stability can be maintained without active in-cell HOM damping. This finding opens the possibility for simplified cavity designs optimized for conduction cooling and easier manufacturability, informing future design strategies for high-efficiency, high-power industrial SRF accelerators.

Primary author: CASTILLA LOEZA, Alex (Jefferson Lab)

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Presenter: CASTILLA LOEZA, Alex (Jefferson Lab)

Session Classification: Numerical Simulations for SRF Cavities

Track Classification: Numerical Simulations for SRF Cavities

Contribution ID: **7** Type: **Oral contribution**

RF absorber development at IJCLab

Tuesday 7 October 2025 10:00 (30 minutes)

The Beam Line Absorbers (BLA) are the crucial component of high-current particle accelerators. In particular, Energy Recovery Linac (ERL) has stringent requirements on Higher-Order-Modes (HOMs) damping. In IJCLab, we are starting to develop warm BLA for FCCee and cryogenic BLA for the PERLE project. Thanks to the international collaborators and the literature, we are identifying the list of promising dielectric materials to work on. Being a laboratory for general fundamental physics, IJCLab is also working on other experiments with radiofrequency, such dark matter axion project MADMAX and Cosmic Microwave Background (CMB) satellite LiteBird. Surprisingly, cryogenic RF absorbers play a crucial role in these projects with totally different scientific goals. We are exploring the new academic research field of dielectric materials for absorbing RF in cryogenic environment. In this contribution, we show our preliminary efforts to study cryogenic RF absorbers for general purpose and perspective on building common test-stand in Université Paris-Saclay.

Primary author: Dr MIYAZAKI, Akira (CNRS/IN2P3/IJCLab Université Paris-Saclay)

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Session Classification: Design of SRF Cavities and HOM Damping Schemes

Track Classification: Design of SRF Cavities and HOM Damping Schemes

Contribution ID: **8** Type: **Oral contribution**

Progress of HOM couplers for PERLE SRF cavities

Tuesday 7 October 2025 12:30 (30 minutes)

The study presented here focuses on the progress of the HOM (High Order Mode) coupler for 5-cell 801.6 MHz elliptical Superconducting RadioFrequency (SRF) cavity designed for PERLE (Powerful Energy Recovery Linac for Experiments), a multi-turn ERL planned to be hosted at IJCLab in Orsay (France). Due to the high operating current and multiple passes of this machine, HOM damping in the SRF cavities is essential to reduce the risk of Beam Breakup (BBU) instabilities and mitigate the cryogenic losses. To limit beam induced HOM effects, several damping schemes were studies and the damping results were compared with the impedance thresholds. The solution adopted consists of two HOOK type HOM couplers installed on the cutoff tubes of the SRF cavities with respect to the first machine configurations that will best provide a 250 MeV electron beam with an intensity of 20 mA. To define and optimize the mechanical design of the coupler, several criteria were considered in order to meet the RF, thermal and manufacturing constraints: the best RF transmission of dangerous trapped HOM modes while guaranteeing a good rejection of the fundamental mode, a reliable cooling system to avoid any overheating and some geometric shapes suitable for the manufacturing.

Primary author: Ms DUCHESNE, Patricia (CNRS/IN2P3/IJCLab Université Paris Saclay)

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Presenter: Ms DUCHESNE, Patricia (CNRS/IN2P3/IJCLab Université Paris Saclay)

Session Classification: Design of SRF Cavities and HOM Damping Schemes

Track Classification: Design of SRF Cavities and HOM Damping Schemes

Contribution ID: **9** Type: **Oral contribution**

Higher-Order Mode Power Calculation of SHINE LINAC

Monday 6 October 2025 14:30 (30 minutes)

The Hard X-ray Free-Electron Laser Facility SHINE adopted 1.3GHz 9-cell superconducting (SC) cavities for electron acceleration, with a maximum bunch charge of 300 pC, a maximum repetition frequency of 1 MHz, and a minimum bunch length of 26 μm. Multiple higher-order modes (HOMs) are excited and coupled outside. HOMs above the cutoff frequency will propagate through the entire module cavity chain. Measures must be taken to suppress these modes.
The injector and main Linac of SHINE use 76 1.3 GHz SC modules and 2 3.9 GHz SC third-harmonic cavity modules. Beam-tube type HOM absorbers are installed between each cryogenic SC module, separated by 45 K cryogenic cooling to reduce heat leakage to the module's 2 K system. The HOM absorbers must have high absorption capacity or efficiency to absorb most of the HOM power, thereby reducing the HOM power shared by other module components.
This paper shows the calculation results of HOM power for each module in different sections of the SHINE linac, providing a guide for the structural design of HOM absorbers.

Primary author: Dr MA, Zhenyu (Shanghai Advanced Research Institute, Chinese Academy of Sciences)

Co-author: ZHANG, JieXi (ShanghaiTech University)

Presenter: ZHANG, JieXi (ShanghaiTech University)

Session Classification: Numerical Simulations for SRF Cavities

Track Classification: Numerical Simulations for SRF Cavities

Contribution ID: **10** Type: **Oral contribution**

Design of HOM damped SRF Cavities for CW Operation in Storage Rings

Tuesday 7 October 2025 10:30 (30 minutes)

Currently, superconducting RF (SRF) systems for high-current storage rings are generally limited to low-frequency, moderate voltage, and single-cell cavities. For a new class of cavities to be used in longitudinal beam phase-space manipulation, high-voltage third harmonic multi-cell cavities are required, resulting in very challenging impedance considerations and higher-order mode (HOM) powers of the order of several kW per cavity. Thus, cavity design requires far more attention on the HOM spectrum to be off-resonance with circulating beam harmonics. Special techniques have been developed to analyze the HOM spectrum and damping beyond the standard frequency range, which typically lies at a few GHz, as required by the VSR Demo project. The design of a four-cell 1.5 GHz SRF cavity including end-groups with multi-waveguide damping for a space-saving design capable of handling over 2.5 kW of HOM power per cavity will be presented. These cavities are designed for high-voltage operation with beam currents of at least 300 mA. The advanced optimization technique will be presented covering the control of broadband HOM spectrum as a fundamental part of the SRF cavity design specifications, which is essential for stable operation in storage rings and Linacs with high repetition rates.

Primary author: TSAKANIAN, Andranik (Helmholtz-Zentrum Berlin)

Co-authors: VELEZ, ADOLFO (HZB BERLIN); KNOBLOCH, Jens (Helmholtz-Zentrum Berlin + Universität Siegen)

Presenter: TSAKANIAN, Andranik (Helmholtz-Zentrum Berlin)

Session Classification: Design of SRF Cavities and HOM Damping Schemes

Track Classification: Design of SRF Cavities and HOM Damping Schemes

Contribution ID: **11** Type: **Oral contribution**

High-Order Mode Damping Strategies for FCC-ee Superconducting Cavities

Monday 6 October 2025 11:30 (30 minutes)

High-order mode (HOM) damping is a critical aspect of ensuring beam stability and operational reliability in the future circular collider (FCC-ee). The FCC-ee RF system must accommodate a wide range of beam parameters, covering working points from the Z energy level, with Ampere-level beam currents, up to the tt energy, with a total RF voltage of 11.3 GV. This presentation will discuss the HOM damping strategies developed for the FCC-ee superconducting cavities. For the 2-cell 400 MHz cavities used at collider working points, the damping scheme is designed to strongly suppress HOMs and extract kilowatts of HOM power, which is particularly crucial at the Z working point. This is achieved through a combination of coaxial HOM couplers and beamline absorbers (BLA). For tt operation and the booster, the smaller beam currents allow the use of 6-cell 800 MHz cavities with a damping strategy comprised of coaxial couplers and BLAs. The presentation will cover the FCC-ee RF system baseline, the damping strategy for each working point, sensitivity analysis of the cavities, and the current challenges in the design.

Primary author: GORGI ZADEH, Shahnam (CERN)

Presenter: GORGI ZADEH, Shahnam (CERN)

Session Classification: HOM Damping Requirements for Future Facilities

Track Classification: HOM Damping Requirements for Future Facilities

Contribution ID: **12** Type: **Oral contribution**

Surface Impedance of Multilayered Superconducting Cavities

Monday 6 October 2025 15:00 (30 minutes)

Bulk niobium (Nb) is the standard material for superconducting RF (SRF) cavities, due to its high critical temperature and magnetic field compared to other pure metals. However, Nb is costly, challenging to manufacture, and has relatively poor thermal conductivity. The superconductor-insulator-superconductor multilayer geometry offers an alternative, using a sputtered superconducting film to shield the bulk from accelerating fields, and enabling cheaper, more malleable, and thermally conductive bulk material such as copper or aluminium. With appropriate materials, higher accelerating fields are also achievable. We model such multilayer structure as a first order surface impedance boundary condition compatible with standard finite element methods, and discuss the reduction of a general $S(IS)^n$ structure to this impedance form.

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Presenter: GOBEYN, Aaron (TU Darmstadt)

Session Classification: Numerical Simulations for SRF Cavities

Track Classification: Numerical Simulations for SRF Cavities

Contribution ID: **13** Type: **Oral contribution**

HOM damping for the EIC ESR SRF Cryomodule

Tuesday 7 October 2025 11:30 (30 minutes)

The Electron Ion Collider (EIC) to be constructed at Brookhaven National Lab (BNL) is a high luminosity collider as the next major nuclear physics research facility. One major new sub-accelerator of EIC is the Electron Storage Ring (ESR) to be built in BNL's RHIC (Relativistic Heavy Ion Collider) tunnel. The ESR is required to operate at 5-18 GeV with up to 2.5 A of beam current stored. A new SRF system with multiple cryomodules is needed in the ESR to replenish up to 10 MW of beam power losses from synchrotron radiation and high order modes (HOM). In this talk, we will present the challenges and solutions related to the HOM damping for this cryomodule.

Primary author: GUO, Jiquan (JLAB)

Presenter: GUO, Jiquan (JLAB)

Session Classification: Design of SRF Cavities and HOM Damping Schemes

Track Classification: Design of SRF Cavities and HOM Damping Schemes

Contribution ID: **14** Type: **Oral contribution**

Developing a Beam Spectrum for Transient Beams in the CERN Double Quarter Wave Crab Cavities

Wednesday 8 October 2025 09:00 (30 minutes)

As part of the High Luminosity project of the Large Hadron Collider (LHC) at CERN, transverse deflecting cavities (crab cavities) have been developed to compensate for the luminosity reduction caused by the collision crossing angle. Initial estimations of the cavity HOM power in 2018 were not in agreement with measurements of the prototype cavities when tested with beam. Advancements in modelling the beam spectrum have shown to compensate for these discrepancies (up to 20dBm). These studies have highlighted the importance of considering transient effects in beam dynamics when assessing HOM power. Additionally, it has been observed that RF-beam manipulation earlier in the CERN accelerator chain can leave harmonic resonances in the beam spectrum.

Primary author: MCFARLANE, Conor Euan Charles (Lancaster University)

Co-authors: Dr BURT, Graeme (Lancaster University); CALAGA, Rama (CERN)

Presenter: MCFARLANE, Conor Euan Charles (Lancaster University)

Session Classification: Operation of SRF Facilities

Track Classification: Operation of SRF Facilities

Contribution ID: **15** Type: **Oral contribution**

Cold Testing and HOM Coupler Qualification for HL-LHC Crab Cavities

Wednesday 8 October 2025 09:30 (30 minutes)

As part of the High Luminosity LHC (HL-LHC) upgrade, crab cavities will be installed near the ATLAS and CMS experiments to mitigate luminosity loss from large crossing angles. To accommodate the differing crossing planes, two compact cavity designs have been developed: the Double Quarter Wave (DQW) resonator and the RF Dipole (RFD) cavity. Both cavity types have been prototyped, built, and tested at 2 K with HOM couplers at the SM18 test facility at CERN.
This presentation focuses on the higher order mode (HOM) couplers installed on both DQW and RFD cavities, specifically their performance as measured during cold tests, with particular attention to the damping of critical modes expected to be driven by the HL-LHC beam. For the RFD cavities in particular, the evolution of HOM characteristics was tracked from dressed cavity measurements through full cryomodule integration and testing.
In parallel, the specially designed 25 Ω RF transmission lines—including flexible cables, impedance adapters, and rigid RF lines—were qualified to ensure reliable operation of the HOM coupler system within the cryomodule environment.

Primary author: EDWARDS, Amelia Veronica (CERN)

Co-author: CALAGA, Rama (CERN)

Presenter: EDWARDS, Amelia Veronica (CERN)

Session Classification: Operation of SRF Facilities

Track Classification: Operation of SRF Facilities

Contribution ID: **17** Type: **Oral contribution**

Observation and simulation on the fill-pattern dependence of HOM power in the SuperKEKB superconducting cavity

Wednesday 8 October 2025 10:00 (30 minutes)

SuperKEKB is a luminosity frontier collider for electron and positron beams. One of the highly challenging targets is the RF system handling extremely large beam loading. The design beam current of the 4 GeV positron beam is 3.6 A and that of the 7 GeV electron beam is 2.6 A. The positron beam is accelerated by twenty-two normal-conducting ARES cavities, which are three-coupled cavity systems. On the other hand, the electron beam is accelerated by the eight ARES cavities and eight single-cell superconducting cavities. The superconducting cavity has beam pipes with relatively large diameters so that higher-order modes (HOMs) propagate into the beam pipes. The harmful HOMs are strongly damped by ferrite dampers attached to the beam pipes. In the upgrade from KEKB to SuperKEKB, we added SiC dampers for mitigating power loads of downstream cavities. In recent operations, we observed a strong dependence of power absorbed by the dampers on bunch fill patterns. This implies some resonance effects between the HOM spectrum and beam spectrum. In order to investigate this phenomenon, we studied the dependence of absorbed power on the fill pattern using CST Wakefield Solver. We have developed a new method for evaluating absorbed power. Our method utilizes not wake potentials or loss factors but the electromagnetic field inside the absorbers. By this method, we are able to accurately evaluate power load of each absorber. In our presentation, we report the operation experiences especially on HOM power of the superconducting cavity and our recent simulation study.

Primary author: YAMAGUCHI, Takaaki (High Energy Accelerator Research Organization)

Co-authors: Dr NISHIWAKI, Michiru; OKADA (KEK), Takafumi (SOKENDAI/KEK); KOBAYASHI, Tetsuya (KEK)

Presenter: YAMAGUCHI, Takaaki (High Energy Accelerator Research Organization)

Session Classification: Operation of SRF Facilities

Track Classification: Operation of SRF Facilities

Contribution ID: **18** Type: **Oral contribution**

Higher Order Mode Damping Requirements for New Circular Accelerators

Monday 6 October 2025 12:00 (30 minutes)

In recent years, a new generation of high-energy circular electron-positron colliders and diffraction-limited light sources have been proposed or are under construction. These advanced circular accelerators impose significantly more demanding requirements on beam performance. To meet the design objectives, the accelerator design has been pushed to a new parameter range. Among the various challenges, the management of Higher Order Modes (HOMs) in superconducting cavities is of particular concern. This article outlines the HOM damping requirements from the perspective of accelerator physics and discusses the impact of HOMs on beam quality in these next-generation circular accelerators.

Primary author: WANG, Na (Institute of High Energy Physics)

Presenter: WANG, Na (Institute of High Energy Physics)

Session Classification: HOM Damping Requirements for Future Facilities

Track Classification: HOM Damping Requirements for Future Facilities

Contribution ID: **19** Type: **Oral contribution**

Numerical Analysis of High-Order Modes in SRF Resonators for Particle Accelerators

Monday 6 October 2025 15:30 (30 minutes)

Over the past decades, superconducting technology has rapidly evolved towards high accelerating gradients and low surface resistance, making it possible to operate particle accelerators with high average beam currents and large duty factors. However, RF losses due to coherent excitation of the HOM become the limiting factor for these regimes. Unlike the cavity operating mode, which is tuned separately, the HOM parameters can significantly vary from one cavity to another due to finite mechanical tolerances during the manufacturing process. Thus, it is of utmost importance to know the HOM parameter spread in advance in order to predict unexpected cryogenic losses, overheating of beam line components and maintain stable beam dynamics. In this paper, we present a method for generating cavity geometry with an arbitrary spread of mechanical imperfections and numerically evaluating HOM statistics. Knowing the spread of HOM parameters, we calculated the probability of resonant HOM losses in SRF accelerating cavities used in CW beam current machines such as the PIP-II and LCLS-II linacs, as well as for the SRF crab-cavity for the ILC project. Finally, we present experimental results of HOM spectra measurements in hundreds of 1.3 GHz cavities installed in LCLS-II cryomodules. Studying the effects of HOM excitation results in specifications of the SRF cavity and cryomodule and can significantly impact the efficiency and reliability of the machine operation.

Primary author: LUNIN, Andrei (FNAL)

Co-authors: SUKHANOV, Alexander (Fermilab); Dr YAKOVLEV, Vyacheslav (Fermilab)

Presenter: LUNIN, Andrei (FNAL)

Session Classification: Numerical Simulations for SRF Cavities

Track Classification: Numerical Simulations for SRF Cavities

Contribution ID: **20** Type: **Oral contribution**

Compact Coaxial HOM Damper for SRF Cavities

Tuesday 7 October 2025 12:00 (30 minutes)

SRF technology enable particle accelerators operate with greater average beam currents and higher duty cycles. In these regimes parasitic excitation of the cavity HOM spectrum become the limiting factor due to extra RF losses and instabilities appearing in the beam. We discuss the limitations of HOMs for large accelerator projects as the Fermilab MI upgrade and the proposed future circular and linear colliders EIC and ILC. A new compact HOM damper concept is suggested providing required HOM suppression. The idea is based on an oversized coaxial line with radial sections, which is directly connected to the axial region of the SRF cavity. Such radially sectioned coaxial works as a filter for the operating mode, while being transparent for the HOMs. Implementations of this design for the accelerator and crab cavities developed for the MI and EIC machines, respectively, are discussed.

Primary author: LUNIN, Andrei (Fermilab)

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Presenter: LUNIN, Andrei (Fermilab)

Session Classification: Design of SRF Cavities and HOM Damping Schemes

Track Classification: Design of SRF Cavities and HOM Damping Schemes

Contribution ID: **21** Type: **Oral contribution**

Dipole mode wakefields and beam dynamics tracking simulations for the UK XFEL main accelerating Linacs

Monday 6 October 2025 12:30 (30 minutes)

The baseline design for the proposed UK XFEL (United Kingdom X-ray Free Electron Laser) facility includes main linear accelerating linacs, which are comprised of 600 9-cell TESLA style superconducting RF cavities, which will accelerate a 1 MHz repetition-rate irregularly spaced composite electron beam comprised of varying bunch charges up to an energies of 8 GeV. Here the TESLA cavities are simulated and the dipole modes excited by the beam are characterised in order to calculate the transverse long-range wakes. We track the particles through 1 km under the influence of these wakefields using the PLACET code and evaluate the transverse emittance dilution of the electron beam. Mitigation strategies are also explored to enhance the beam quality.

Primary author: GILFELLON, Anthony (UKRI / STFC / ASTeC)

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Session Classification: HOM Damping Requirements for Future Facilities

Track Classification: HOM Damping Requirements for Future Facilities

Contribution ID: **22** Type: **Oral contribution**

CW operation characteristics of the spare Eu-XFEL third harmonic cryomodule

Wednesday 8 October 2025 11:30 (30 minutes)

The study investigated the continuous-wave (CW) performance of the spare 3.9 GHz third harmonic cryomodule for the European XFEL. While pulse mode operation exceeded specifications with high accelerating gradients, CW tests revealed strong limitations. The main issue was overheating of the first HOM coupler. Additional challenges included tuner backlash and mechanical resonances at 18.6 Hz affecting LLRF stability. The results indicate that, although well suited for pulsed operation, the cryomodule requires design modifications to HOM couplers to achieve reliable CW performance.

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Presenter: KASPRZAK, Karol (MSL (Supraleitende Beschleuniger Technologie))

Session Classification: Operation of SRF Facilities

Track Classification: Operation of SRF Facilities

Contribution ID: **23** Type: **Oral contribution**

The UK XFEL project: conceptual design

Wednesday 8 October 2025 10:30 (30 minutes)

The conceptual design of the UK XFEL facility responds directly to user community requirements for a next-generation X-ray facility. Surveys and consultations highlighted the need for higher repetition rates, near-transform-limited pulses, broader photon energy coverage, and the capacity to serve many experiments simultaneously. Current facilities typically offer only 1–3 source points, leading to limited access and high experiment costs. The proposed design addresses these needs by combining a high-repetition-rate (~1 MHz) superconducting linac with flexible distribution of electron bunches to 6–10 FELs, each capable of operating independently at ~100 kHz. Embedded within this structure are lower-repetition, higher-charge bunches that can be boosted to 12–15 GeV,enabling experiments requiring extreme photon energies and pulse energies. This irregular bunch structure offers unprecedented flexibility, supporting both high-throughput and flagship single-shot experiments. The modular design ensures adaptability to future upgrades, while dvanced synchronisation, AI-driven data management, and environmental sustainability measures positionthe UK XFEL as a facility uniquely tailored to user-defined scientific ambitions.

Primary author: GILFELLON, Anthony (UKRI / STFC / ASTeC)

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Session Classification: Operation of SRF Facilities

Track Classification: Operation of SRF Facilities

Contribution ID: **24** Type: **Oral contribution**

DESY SRF R&D towards a possible High Duty Cycle upgrade of the European XFEL

Monday 6 October 2025 09:45 (30 minutes)

The construction of the European X-ray Free-Electron Laser (XFEL) in Hamburg was finished in 2017. Since then the facility is successfully operated and delivers photon beam for many scientific experiments. The XFEL is driven by a 17.5 GeV superconducting linac, a machine which is the worldwide largest installation based on superconducting radio-frequency acceleration. Other large-scale projects like LCLS-II at SLAC, SHINE at Shanghai, and others are based on the important developments made for the European XFEL. The so-called TESLA technology is a great effort of the worldwide SRF community. Based on the meanwhile eight years of extremely successful operation, DESY is looking into the future and studies possible upgrade scenarios with emphasis on High Duty Cycle operation. This talk will highlight new ideas, present plans and –in a non-exhaustive way –will also give results on cavities, accelerator modules and SRF gun development.

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Presenter: WEISE, Hans (DESY MSL (Supraleitende Beschleuniger Technologie))

Session Classification: HOM Damping Requirements for Future Facilities

Track Classification: HOM Damping Requirements for Future Facilities

Contribution ID: **25** Type: **Oral contribution**

Radio frequency design ad higher mode analysis of superconducting Quasi-Waveguide Multi-cell Resonator crab cavities for the production of picosecond X-ray pulses for Elttra 2.0

Tuesday 7 October 2025 16:30 (30 minutes)

Picosecond-long X-ray pulses of moderate intensity and high repetition rate are highly sought after by the light source community, especially for time-resolved fine spectroscope analysis of matter in the linear response regime. As part of the upgrade of the Elettra 2.0, two radio frequency deflecting cavities with slightly different frequencies will be installed to produce time-dependent orbit deflection to a few dedicated electron bunches with no effect on the regular bunches. This paper reports the radio frequency design of super-conducting deflecting crab cavities operating at 3.0 and 3.25 GHz. The design is based on a Quasi-waveguide Multicell Resonator (QMiR), firstly developed for Advanced Photon Source, which uses a trapped dipole mode for the crabbing of the bunches. QMiR has heavily loaded Higher Order Modes (HOMs) resulting in a sparse HOMs spectrum thus eliminating the need for HOMs couplers simplifying the cavity mechanical design. Results of the detailed electromagnetic analysis, including HOM damping, particle tracking through the field map, thermal and mechanical simulations are presented. The material chosen for the construction of the deflecting cavities is pure Nb. This article reports both static and dynamic thermal loads. A conceptual design for "0 boil off" cavity cool down at 4.2K or lower is presented.

Primary authors: FABRIS, Alessandro (Elettra - Sincrotrone Trieste S.C.p.A.); GRUDIEV, Alexej (CERN); Mr KARANTZOULIS, Emanuel (Elettra Sincrotrone); GERIGK, Frank (CERN); Mr MODICA, Marco (Elettra Sincrotrone); SHAFQAT, Nuaman (Elettra Sincrotrone); CALAGA, Rama (CERN); DI MITRI, Simone (Elettra Sincrotrone Trieste)

Presenter: SHAFQAT, Nuaman (Elettra Sincrotrone)

Session Classification: Design of SRF Cavities and HOM Damping Schemes

Track Classification: Design of SRF Cavities and HOM Damping Schemes

Contribution ID: **26** Type: **Oral contribution**

Evanescent mode coupling in coaxial HOM filters

Tuesday 7 October 2025 14:30 (30 minutes)

A new class of HOM couplers is introduced based on the coupling of evanescent modes in coaxial waveguide structures, a mechanism that provides great flexibility for the implementation of notch and high-pass filter. Conventional HOM couplers and design approaches are reviewed prior to the new class of filters. Several evanescent field coupling mechanisms are analyzed. Their particular properties in the context of HOM couplers and high-pass filters are derived. A systematical design from the filter function to the three-dimensional structure is sketched by means of an example.

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Presenter: PAPKE, Kai (MIN (Hochfrequenz))

Session Classification: Design of SRF Cavities and HOM Damping Schemes

Track Classification: Design of SRF Cavities and HOM Damping Schemes

Contribution ID: **27** Type: **Oral contribution**

Numerical analysis of higher-order mode couplers

Tuesday 7 October 2025 09:00 (30 minutes)

This talk presents numerical methods for analysing Higher-Order Mode (HOM) couplers in elliptical TESLA-type superconducting radio-frequency (SRF) cavities. Emphasis is placed on practical simulation approaches, including S-parameter calculations, basic optimisation, sensitivity analysis and uncertainty quantification, and multipacting studies. The discussion will show how these tools can be used together to evaluate damping efficiency, check design robustness, and guide the design process.

Primary authors: UDONGWO, Sosoho-Abasi (Brandenburgische Technische Universität Cottbus-Senftenberg); Prof. FLISGEN, Thomas (Brandenburgische Technische Universität Cottbus-Senftenberg)

Presenter: UDONGWO, Sosoho-Abasi (Brandenburgische Technische Universität Cottbus-Senftenberg)

Session Classification: Numerical Simulations for SRF Cavities

Track Classification: Numerical Simulations for SRF Cavities

Contribution ID: **28** Type: **Oral contribution**

Concatenation Methods

Monday 6 October 2025 14:00 (30 minutes)

Concatenation methods are powerful tools to compute the electromagnetic properties of large accelerating structures, i.e., chains of cavities with HOM- and input couplers. The talk will review the methods CSC, SSC and $\mathrm{CSC}^{\mathrm{BEAM}}$, which have been predominantly developed at the University of Rostock. Common features as well as the differences between the three methods will be discussed and application examples will be provided.

Primary author: FLISGEN, Thomas (Brandenburgische Technische Universität Cottbus-Senftenberg / Ferdinand-Braun-Institut gGmbH)

Presenter: FLISGEN, Thomas (Brandenburgische Technische Universität Cottbus-Senftenberg / Ferdinand-Braun-Institut gGmbH)

Session Classification: Numerical Simulations for SRF Cavities

Track Classification: Numerical Simulations for SRF Cavities

Contribution ID: **29** Type: **Oral contribution**

Status of the ECHO Code

Tuesday 7 October 2025 09:30 (30 minutes)

The ECHO code family provides advanced numerical tools for calculating wake fields and impedances in accelerator components. In recent years, the codes have been extended to cover a wide range of geometries: rotationally symmetric (ECHOz1, ECHOz2), rectangular and 2D structures (ECHO2D), fully 3D models (ECHO3D), and anisotropic waveguides (ECHO1D). Key implementations include low-dispersive and conformal schemes, moving mesh approaches, and indirect integration techniques to ensure accuracy and efficiency. Recent applications demonstrate reliable modeling of complex accelerator components. This talk presents the current status, capabilities, and ongoing developments of the ECHO codes.

Primary author: ZAGORODNOV, Igor (MPY (Beschleunigerphysik))

Presenter: ZAGORODNOV, Igor (MPY (Beschleunigerphysik))

Session Classification: Numerical Simulations for SRF Cavities

Track Classification: Numerical Simulations for SRF Cavities

Contribution ID: **30** Type: **Oral contribution**

HOM Damping for EIC Crab Cavities

Tuesday 7 October 2025 15:00 (30 minutes)

The interaction region (IR) crab cavity system is a special RF system to compensate the loss of luminosity due to a 25 mrad crossing angle at the interaction point (IP) for electron ion collider (EIC). There will be six crab cavities, with four 197 MHz crab cavities and two 394 MHz crab cavities, installed on each side of the IP in the proton/ion ring, and one 394 MHz crab cavity on each side of the IP in the electron ring. In this paper, we show recent progress of the HOM impedance threshold calculation, as well as the HOM damping design, for 197 and 394 MHz crab cavities.

Primary author: XIAO, Binping (Brookhaven National Lab)

Presenter: XIAO, Binping (Brookhaven National Lab)

Session Classification: Design of SRF Cavities and HOM Damping Schemes

Track Classification: Design of SRF Cavities and HOM Damping Schemes

Contribution ID: **31** Type: **Oral contribution**

Beam Stability in the EIC ESR: Contribution of the 591 MHz RF Cavities

Monday 6 October 2025 17:00 (30 minutes)

The Electron-Ion Collider (EIC) Electron Storage Ring (ESR) will circulate high-intensity electron beams, making beam–cavity interactions and higher order mode (HOM) effects a central concern for stability. This work presents wakefield and impedance simulations of the ESR cryomodule containing two back-to-back 591 MHz single-cell RF cavities and associated beamline components. The contribution of the cavities to the overall impedance budget is quantified through detailed wakefield calculations and pseudo–Green function analysis. Multi-particle tracking with ELEGANT was employed to evaluate microwave instability thresholds, while coupled-bunch instability growth rates were estimated using the HOM spectra of the cavities. The results demonstrate that while the cryomodule impedance remains within design requirements, HOM-driven longitudinal instabilities require a bunch-by-bunch feedback system. The analysis highlights the critical role of the 591 MHz RF cavities in ESR beam stability and provides guidance for HOM damping and feedback strategies necessary for reliable collider operation.

Primary author: BLEDNYKH, Alexei (BNL/EIC)

Presenter: BLEDNYKH, Alexei (BNL/EIC)

Session Classification: HOM Damping Requirements for Future Facilities

Track Classification: HOM Damping Requirements for Future Facilities

Contribution ID: **32** Type: **Oral contribution**

Welcome

Monday 6 October 2025 09:30 (15 minutes)

Presenter: BABOI, Nicoleta (MDI (Diagnose & Instrumentierung))

Contribution ID: **33** Type: **Discussion topic**

Discussion

Monday 6 October 2025 17:30 (30 minutes)

Session Classification: HOM Damping Requirements for Future Facilities

Contribution ID: **34** Type: **Discussion topic**

Discussion: Suppression/extraction of dangerous HOMs in superconducting crab cavities

Tuesday 7 October 2025 17:00 (30 minutes)

Session Classification: Design of SRF Cavities and HOM Damping Schemes