The HOMSC2018 Workshop in Cornell

A Brief Summary

Nicoleta Baboi, DESY
DESY-TEMF Meeting
DESY, Hamburg, 15 Nov. 2018

Overview

ICFA Mini Workshop on Higher Order Modes in Superconducting Cavities (HOMSC2018)

1-3 October 2018
Physical Science building (PSB)
America/New_York timezone

- Overview
- Scientific Programme
- Call for Abstracts
  - Call for Abstracts
- Timetable
- Contribution List
- Registration
  - Registration Form
- Participant List
- Workshop Location
- Accommodations
- Travel and Visas
- Local Information
- Committees
- Contact Information
- Photos

The objective of this workshop is to bring together researchers studying high 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.

Starts Oct 1, 2018 08:00
Ends Oct 3, 2018 20:55
America/New_York

Physical Science building (PSB)
401
Cornell University
Ithaca, NY 14853
United States

Prof. Liepe, Matthias

http://indico.classe.cornell.edu/event/185/overview

Scientific Program

- 4 working groups

  - WG 1: High-current accelerators and HOM damping requirements
  - WG 2: Numerical simulation – modelling approaches and tools
  - WG 3: Design of SRF cavities and HOM damping schemes
  - WG 4: HOM measurements, beam effects, and diagnostics

WG 1

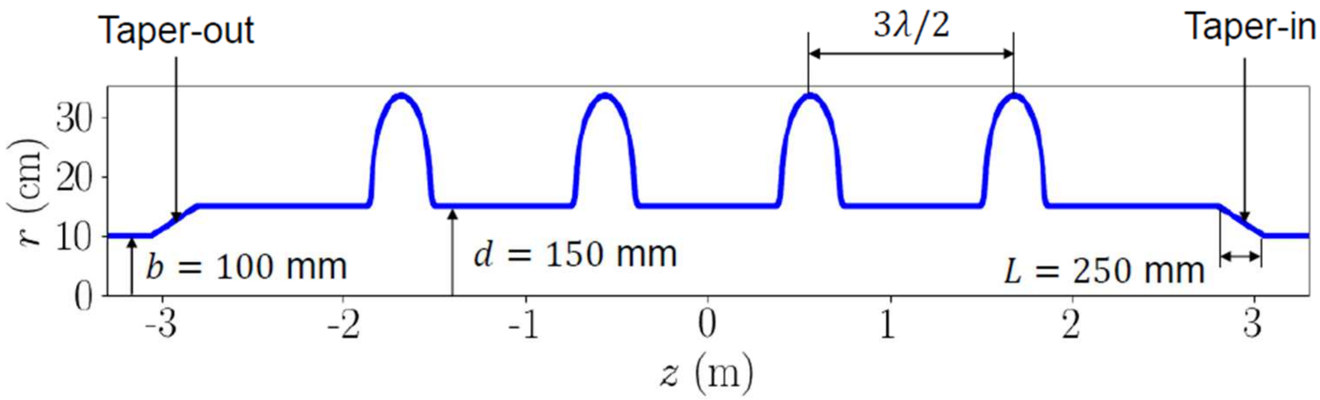
High-current accelerators and HOM damping requirements

- **HOM damping requirements for high-current option of FCCee,**
  Ivan KARPOV (CERN)
  - Low-energy Z machine

    → highest current (≈ 1.4 A)

    → most challenging for high-order mode (HOM) power extraction (max power 1 kW per HOM coupler)

    13 cryomodules with four 400 MHz single-cell LHC-like cavities



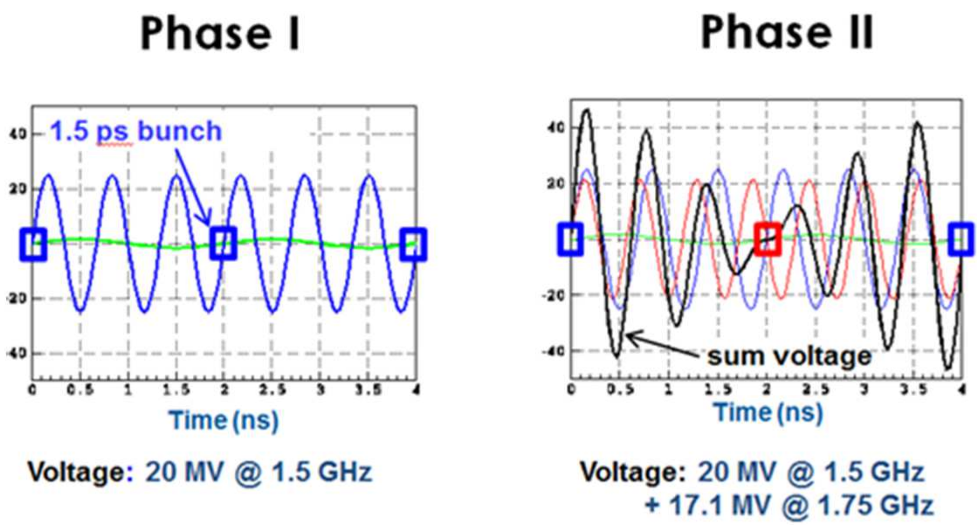
  - 1 mode below cutoff has high R/Q
  - Critical filling schemes identified

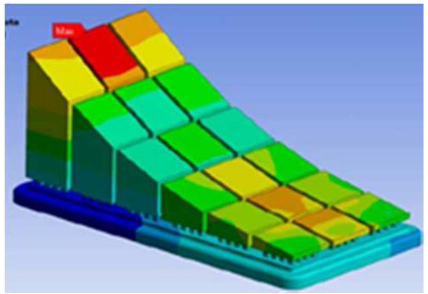
WG1: High-current accelerators/requirements

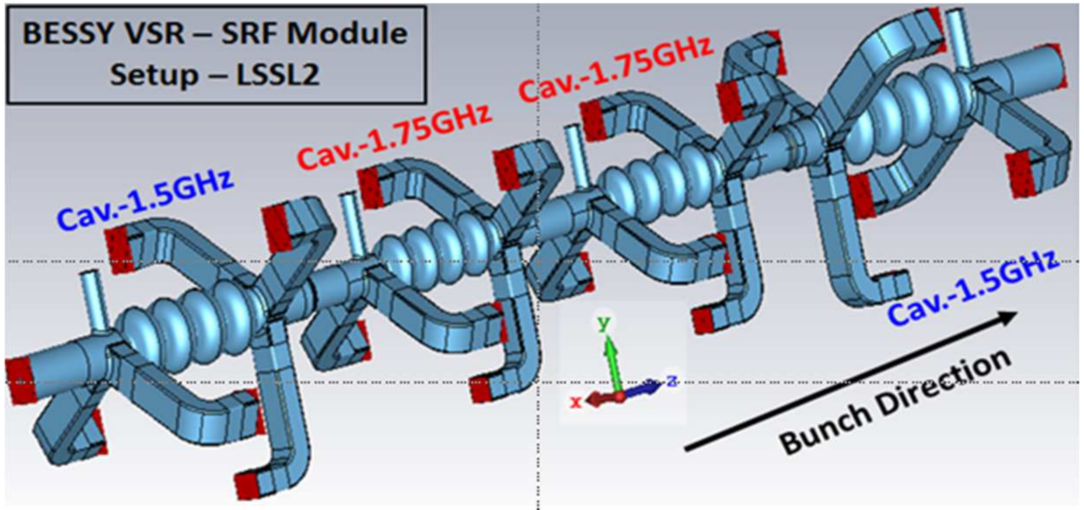
SRF Developments for BESSY VSR, *Adolfo VELEZ (HZB G-ISRF)*

BESSY VSR
Variable pulse length Storage Ring

- Challenges:
  - CW, 20MV/m, 300mA
  - Very strong HOM damping etc.
- Optimization of damping techniques, wakefields, absorbers etc.



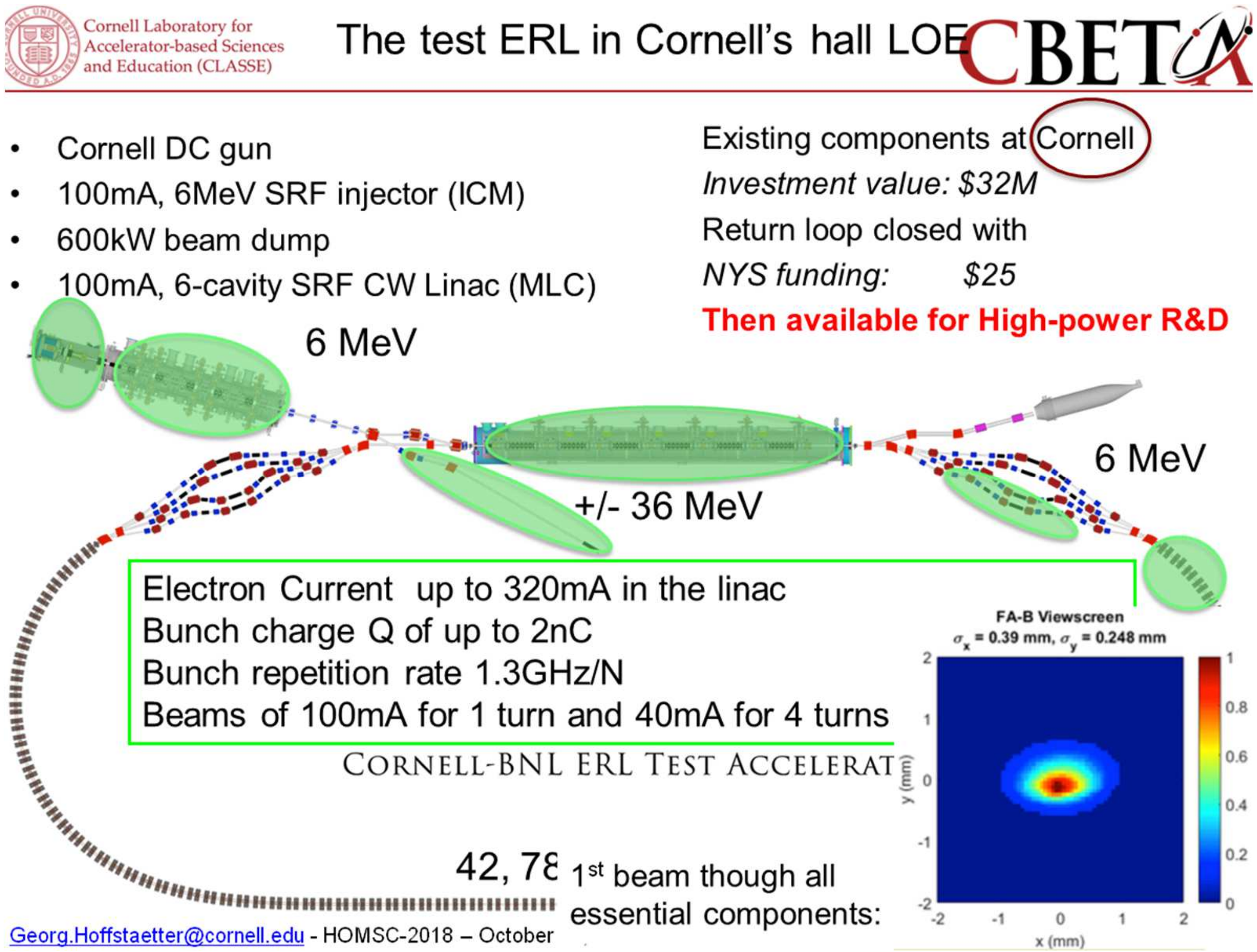




- Testing prototypes

WG1: High-current accelerators/requirements

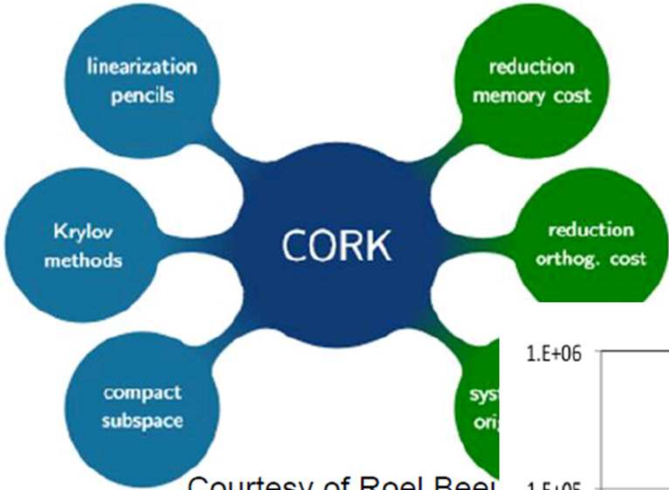
Overview of CBETA and the role of HOMs, *HOFFSTAETTER, Georg (Cornell)*



WG2: Numerical simulation

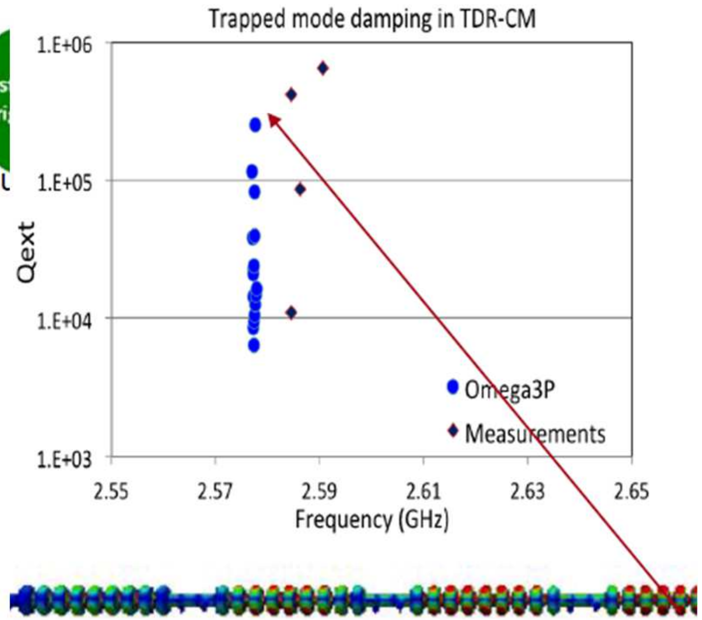
Propagating Eigenmode Simulations in SRF Multi-Cavity Crymodules Using ACE3P, *Liling XIAO (SLAC)*

Compact Rational Krylov (CORK) framework



Courtesy of Roel Beeu

8-Cavity CM for LCLS-II

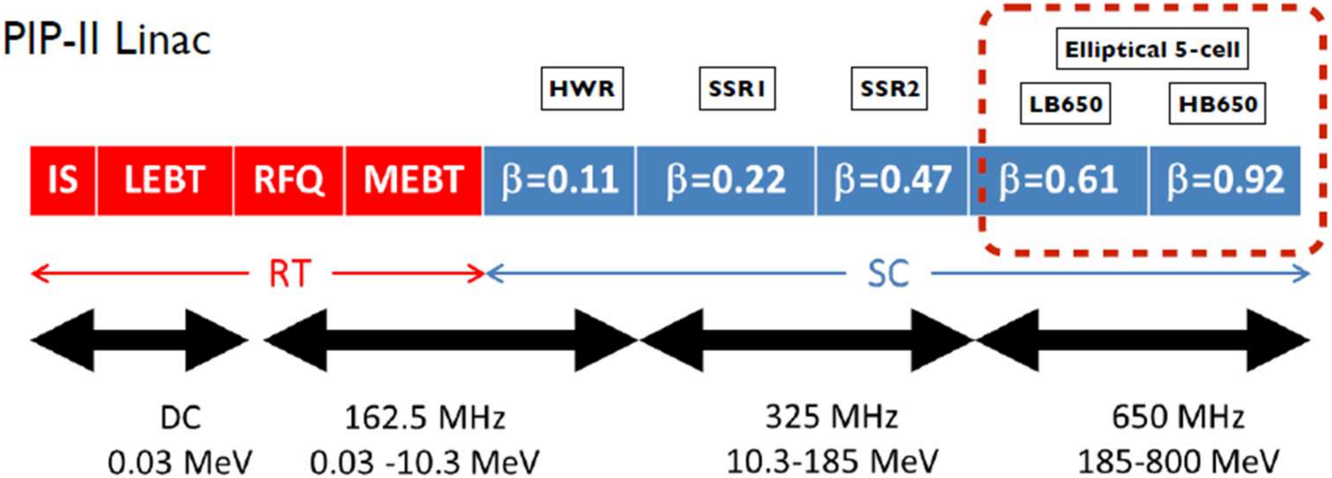


WG2: Numerical simulation

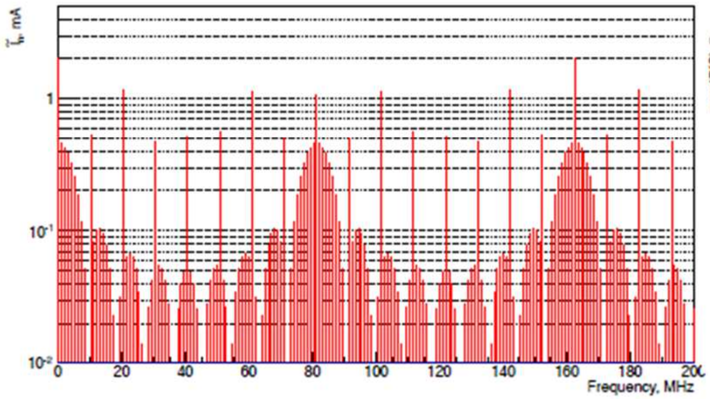
Update on HOM studies for PIPII SC linac, *Alexander SUKHANOV (Fermilab)*

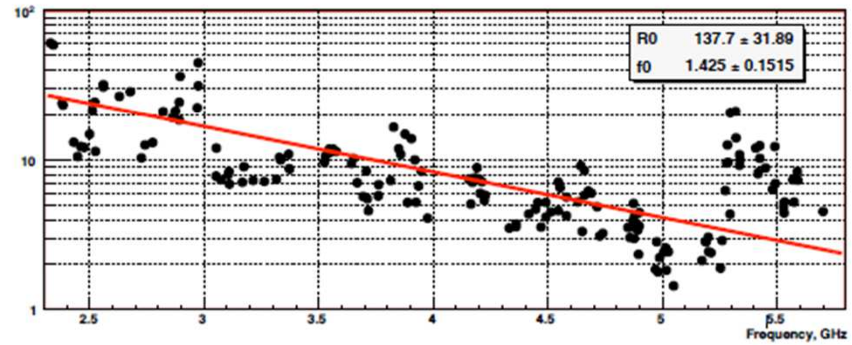
PIP-II Project

- PIP-II Linac



- Complex beam current spectrum
- No HOM couplers and dumpers (QL up to 1e7)

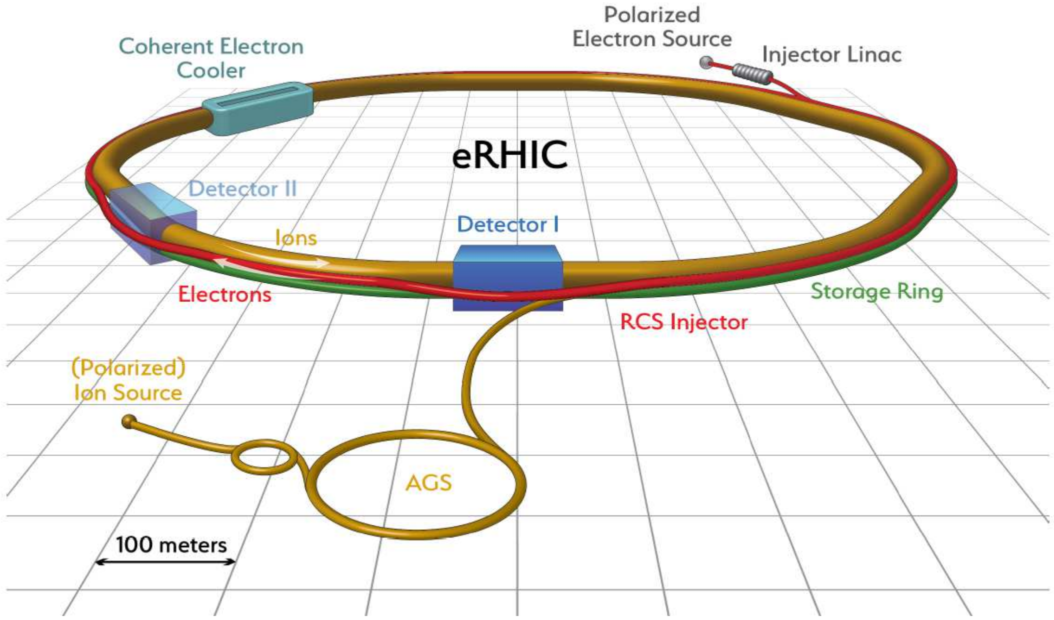


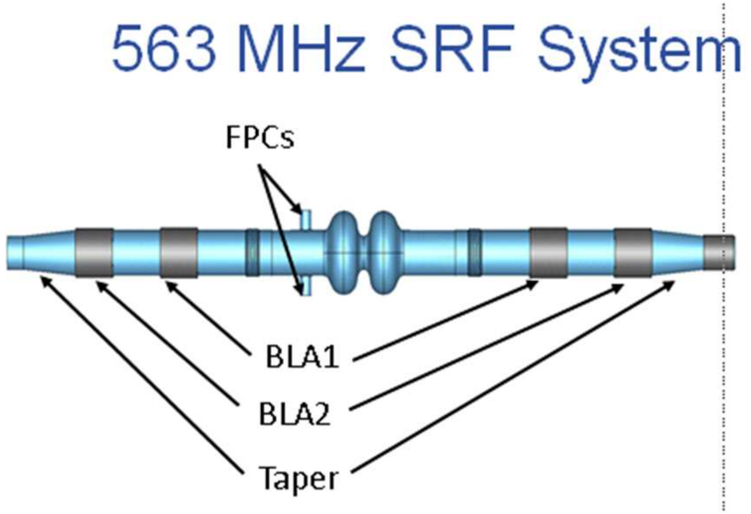


WG3: Design of cavities and HOM damping

SRF cavity design and HOM damping for eRHIC e- storage ring,

Wencan XU (bnl)





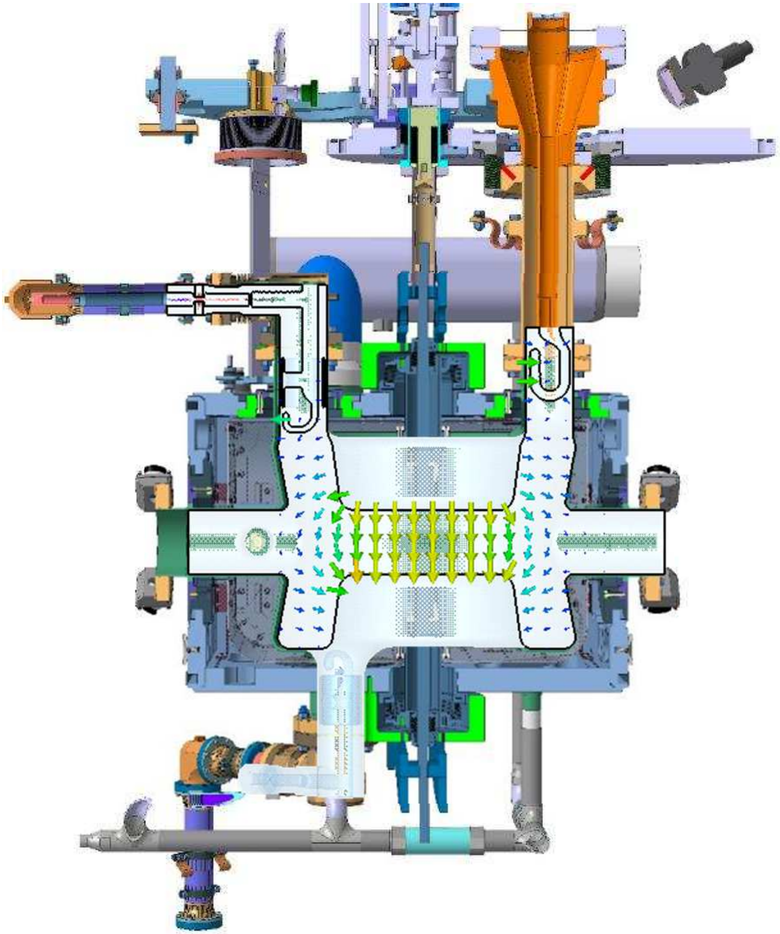
- eRHIC requires a 563 MHz fundamental SRF system for energy compensation, and a 3rd harmonic cavity for beam instability.

WG3: Design of cavities and HOM damping

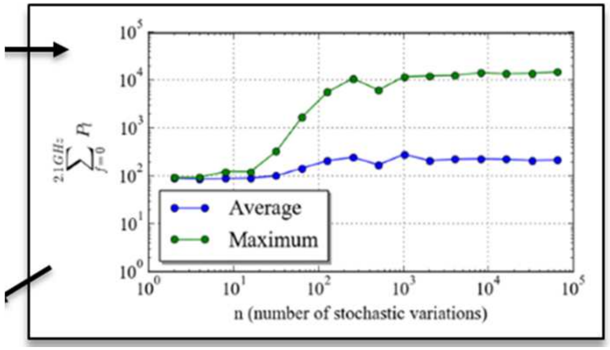
HL-LHC DWQ HOM coupler design and SPS measurements,

James MITCHELL (CERN)

DQW Crab Cavity



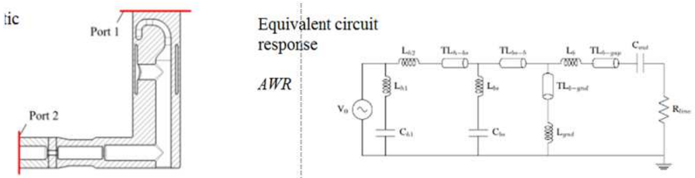
Worst case power:

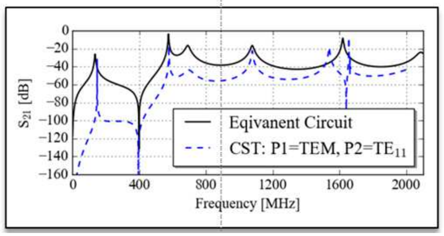


13 times larger than 1 kW limit.
Due to mode at 960 MHz – coupler needs to be altered.

The coupler should be altered to:

1. **Reduce transverse impedance below threshold.**
2. **Reduce maximum foreseeable HOM power to below 1 kW.**

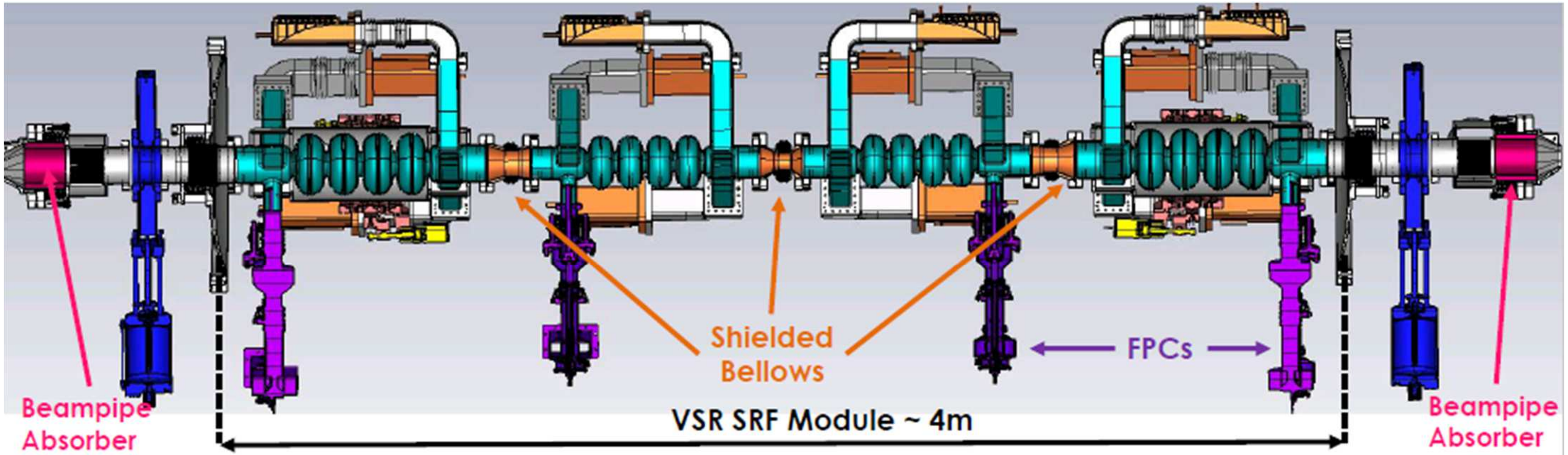




Student price!

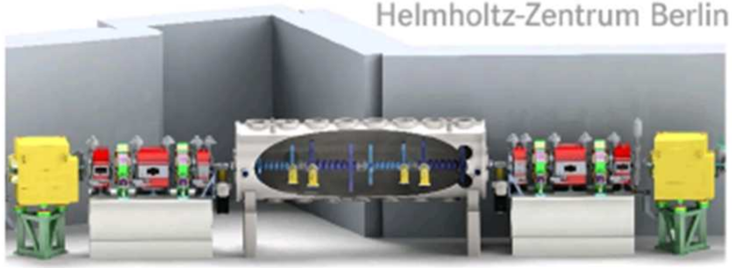
WG3: Design of cavities and HOM damping

Design of the BESSY VSR waveguide damped cavities and ancillary components for the cold string, *Andranik TSAKANIAN (HZB)*



- Shielded bellows are required due to the cavity fundamental mode losses.
- Beampipe-absorbers for more HOM damping, especially excited by interaction with warm components.
- Synchrotron light collimating bellow is required at module center.
- Every component is optimized to fulfil off-resonance condition with respect to circulating beam.

BESSY VSR
Helmholtz-Zentrum Berlin



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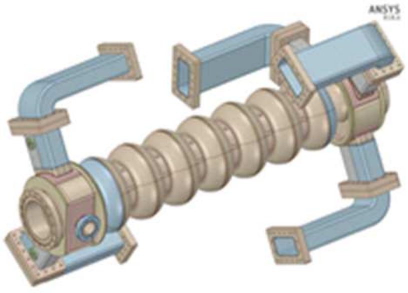
WG3: Design of cavities and HOM damping

HOM loads development at JLAB: BESSY VSR and bERLinpro,

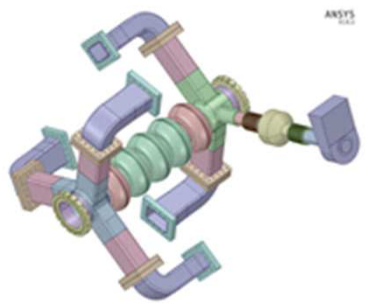
Jiquan GUO (JLAB)

bERLinpro

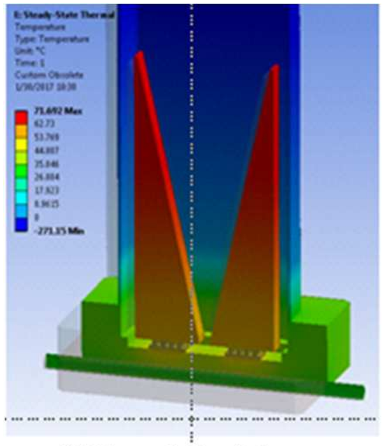


BESSY VSR (Variable pulse length Storage Ring)

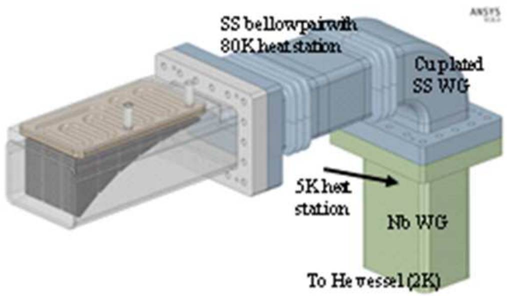
in the 1.5 GHz cavities

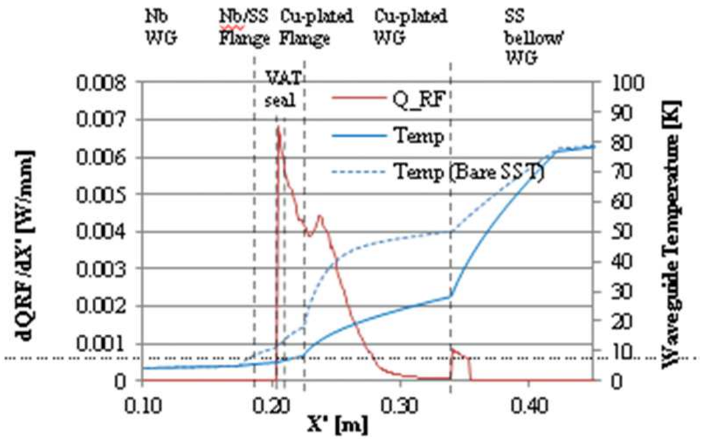


Velez's talk



RF-thermal simulation
Temperature distribution





WG3: Design of cavities and HOM damping

SRF above 1.3 GHz: Motivation and Implications for Higher Order Modes,

James MANISCALCO (Cornell)

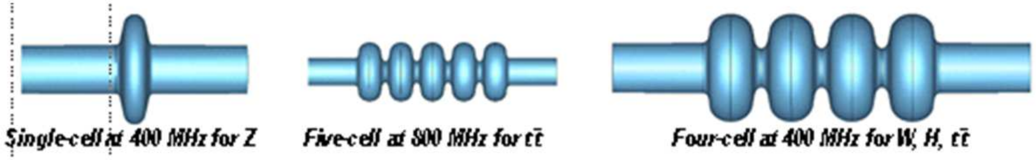
Abstract

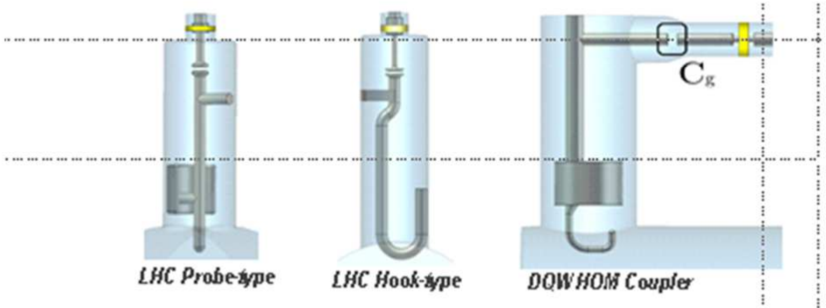
Recent research into impurity-doped niobium and Nb3Sn have pushed towards unprecedentedly high quality factors and low cryogenic power consumption for SRF accelerators. These open the way to high frequency cavities (above the 1.3 GHz standard in contemporary SRF projects such as EXFEL and LCLS-II) which could significantly decrease costs for new accelerator facilities. In this talk we provide some background on these novel surface treatments, give motivation for the move to higher frequency, and raise some points of discussion for the impacts on higher order mode consideration.

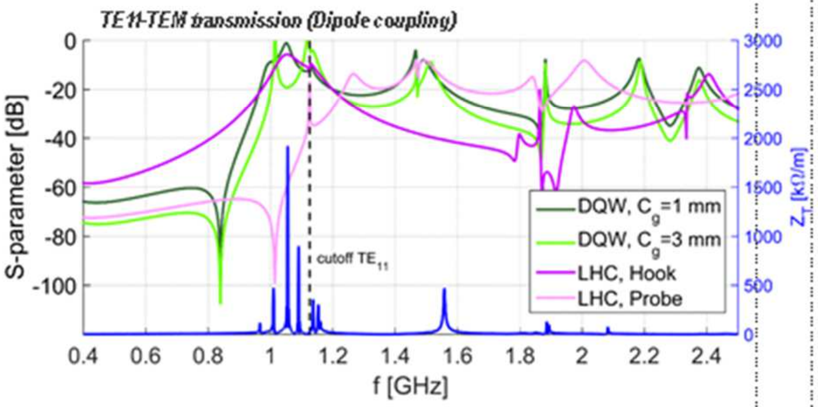
WG3: Design of cavities and HOM damping

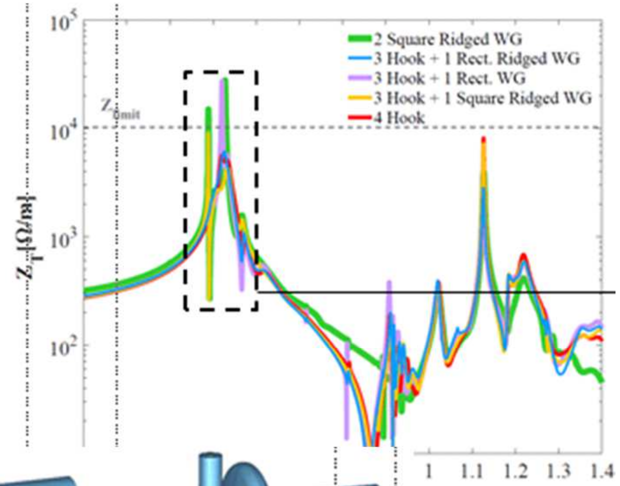
HOM damping schemes for the FCC-ee cavities,

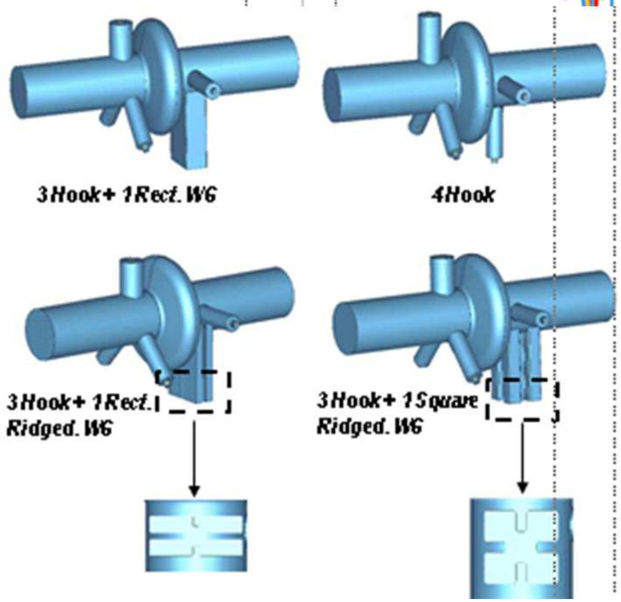
GORGI ZADEH, Shahnam (Universität Rostock)





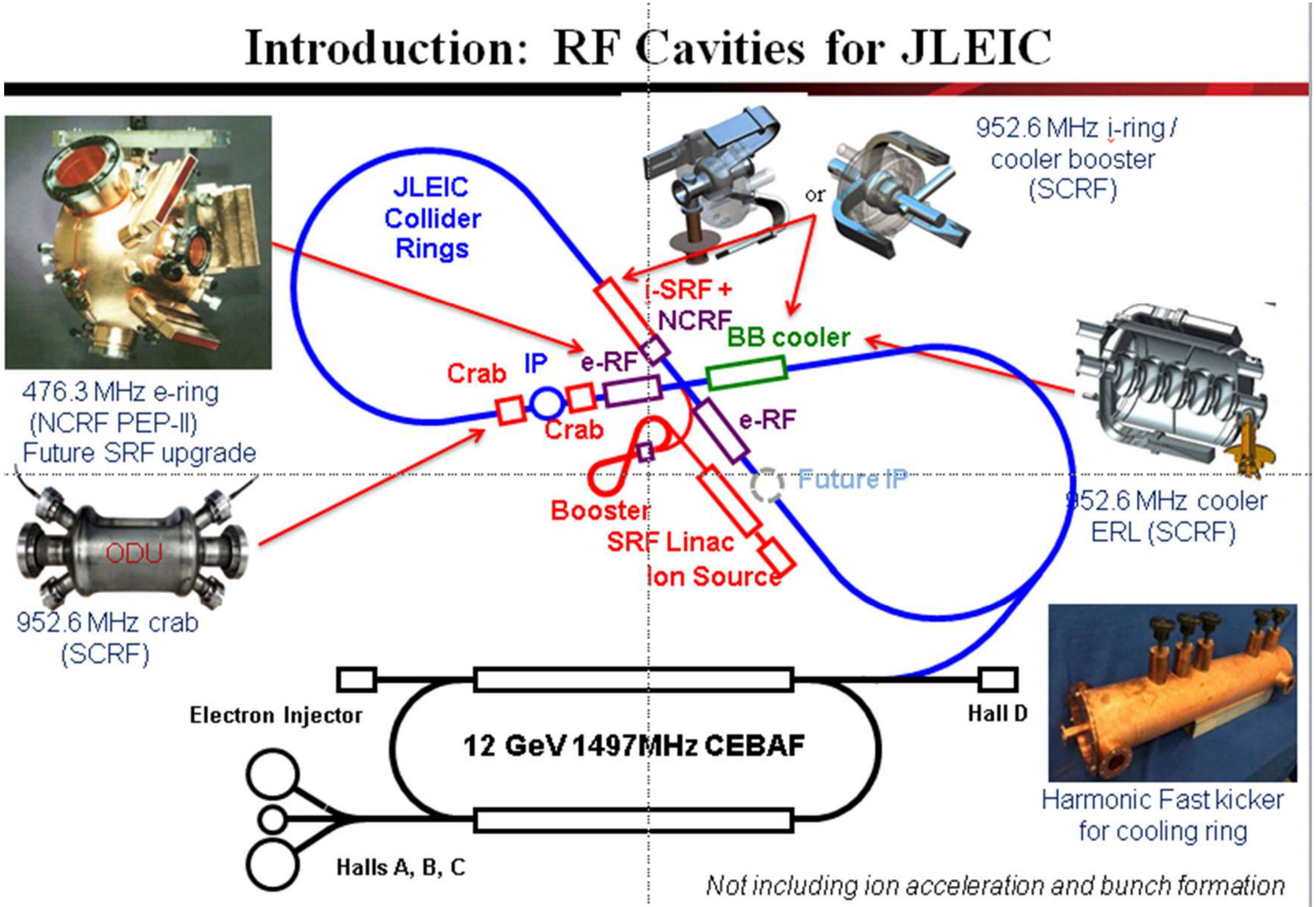






WG3: Design of cavities and HOM damping

JLEIC HOM damping study, *Jiquan GUO (JLAB)*

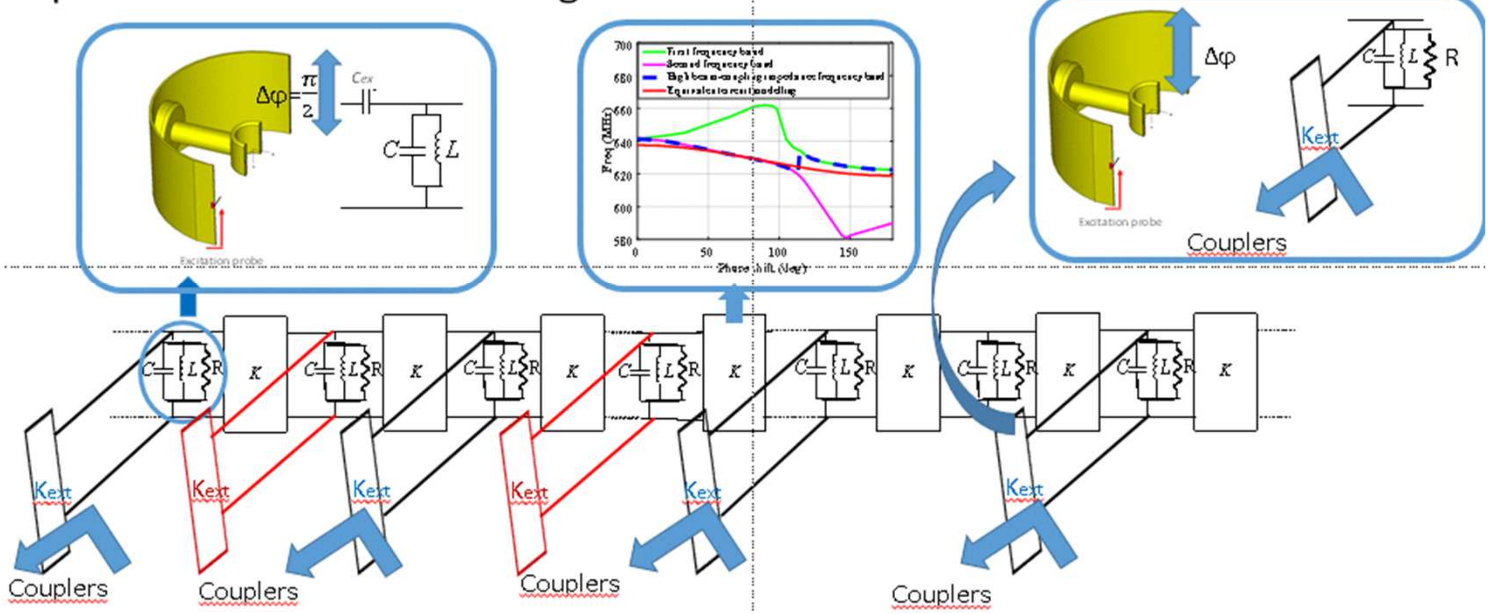


WG3: Design of cavities and HOM damping

HOM Damping in Accelerating Cavities with Large Number of Cells: Application to 44-Cell TWCs of CERN SPS, *Nasrin NASRESFAHANI (CERN)*

Parallel-bar travelling wave accelerating cavities

Equivalent Circuit Modelling

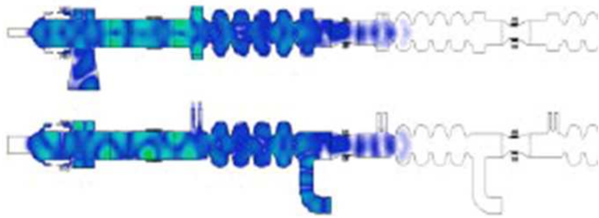


WG3: Design of cavities and HOM damping

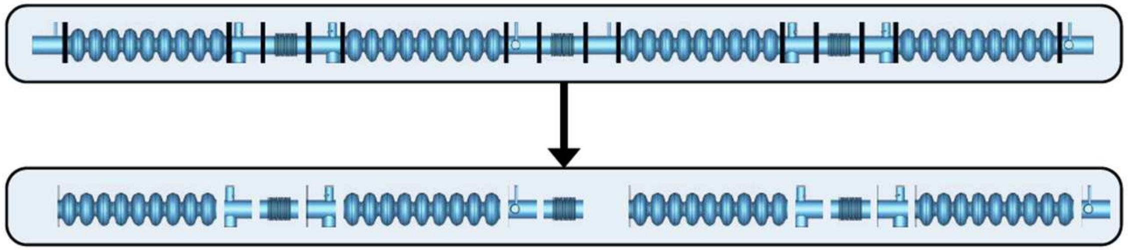
Higher Order Mode and Cavity Studies at the University of Rostock since HOMSC16, *Ursula VAN RIENEN (University of Rostock)*

State-Space Concatenations (SSC)

- Application to FLASH
- Application for BESSY VSR
- Computation of External Quality Factors

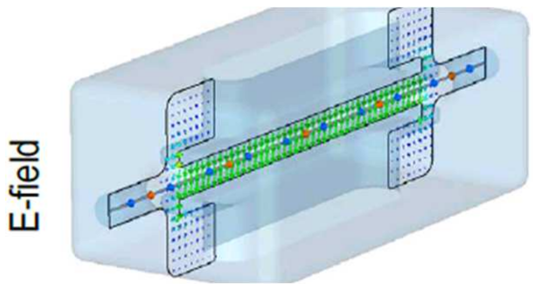


Mode resonating at 2.797 GHz



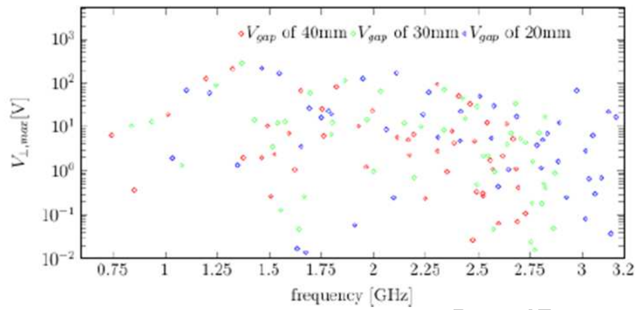
Uncertainty Quantification Techniques and Stochastic Models for SRF Cavities

Transverse deflecting cavity



Resonant HOM excitation

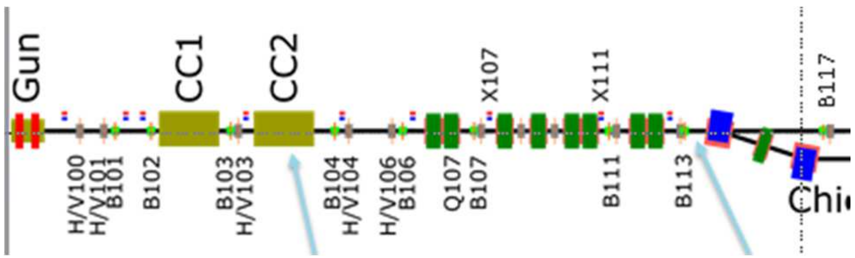
$V_{\perp,max}$ due to horizontal HOM



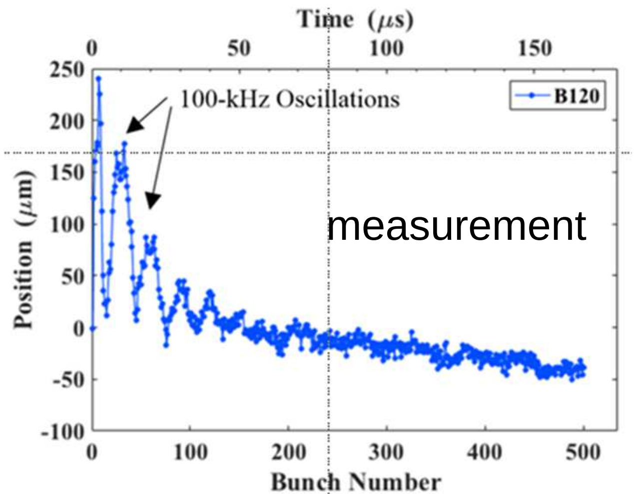
WG4: HOM measurements

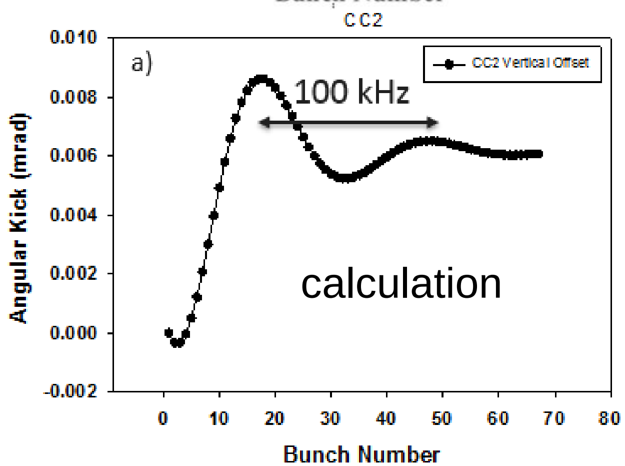
Observations of Sub-Macropulse Electron-Beam Dynamics Correlated with Higher-Order Modes in TESLA-Type Cavities, *Alex LUMPKIN (Fermilab)*

- FAST facility, TESLA cavities



- Observed transverse oscillations on multi-bunch beam (3MHz)
  - Vertical: 100kHz
    - Fits to calculations with mode at 1.87GHz
  - Horizontal: 380kHz



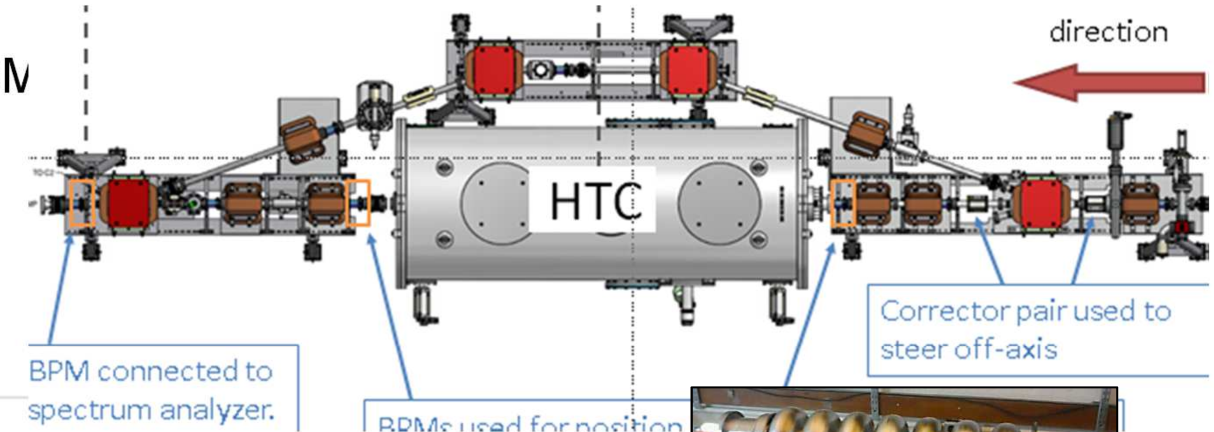


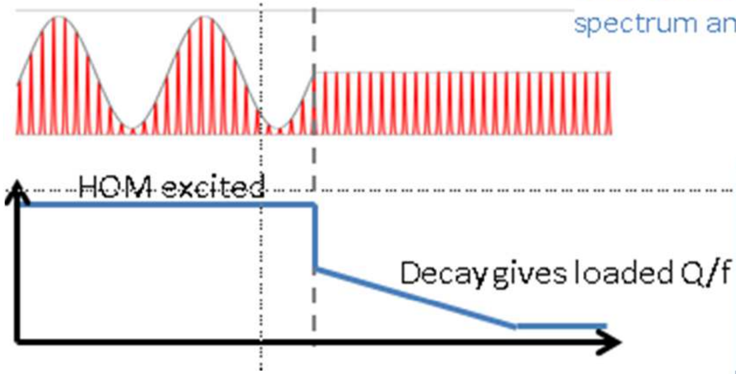
WG4: HOM measurements

Measuring HOM parameters with beam for Cornell's ERL cavities,

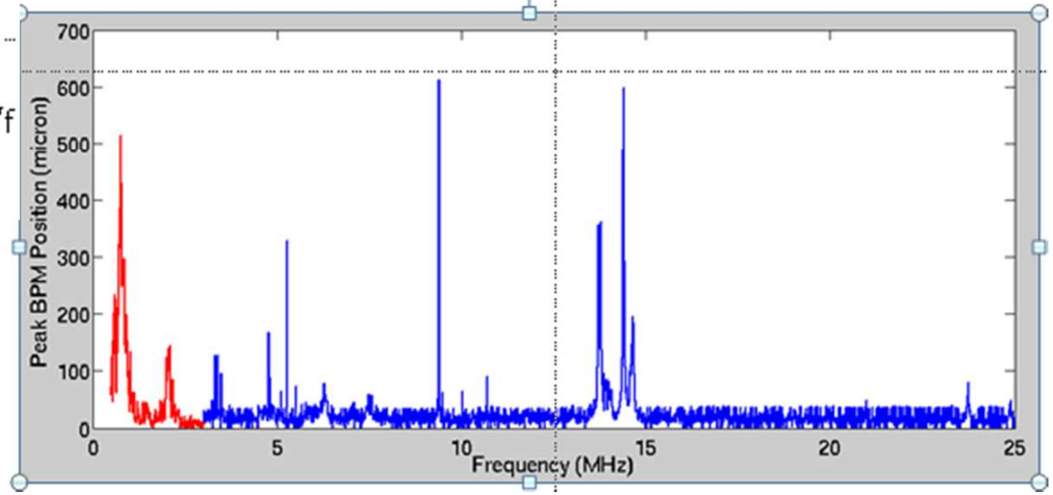
Adam BARTNIK (Cornell)

- Idea: excite single HOM by modulating bunch charge





Found lots of peaks!

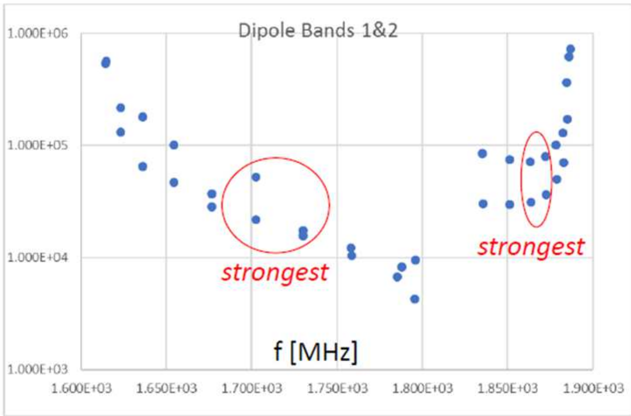


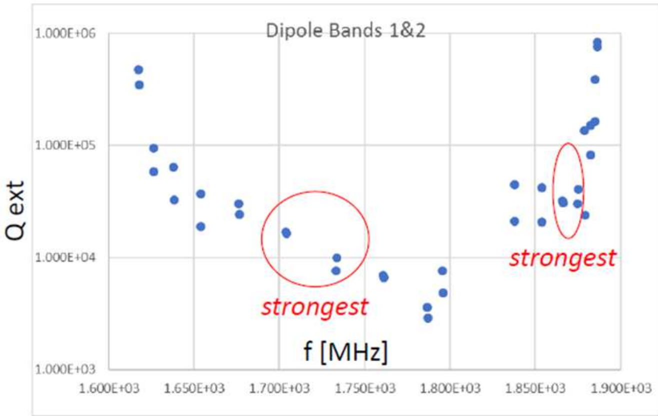
- Plan to repeat with finer step

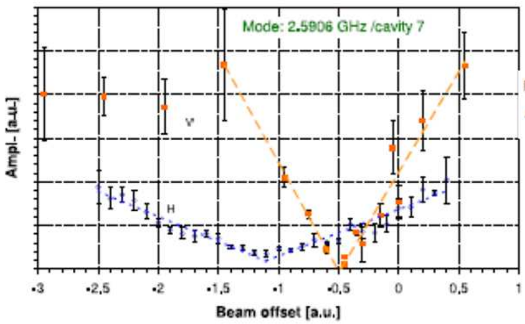
WG4: HOM measurements

HOM Beam Based Diagnostics at FAST, *Olivier NAPOLY (FNAL)*

- Proposal to investigate the HOM full potential in beam diagnostics and beam based tuning
  - achieving minimal transverse wake kicks
  - transverse beam size measurement, based on quadrupole modes
- HOMs in FAST







$77^\circ \pm 8^\circ$

e.g.: measurement at TTF (now FLASH)

WG4: HOM measurements

HOM Based Beam Diagnostics in TESLA Superconducting Cavities at FLASH, *Junhao WEI (DESY)*

- HOM based beam position measurement
- HOM based long-term beam phase measurement
- HOM based cavity tilt measurement

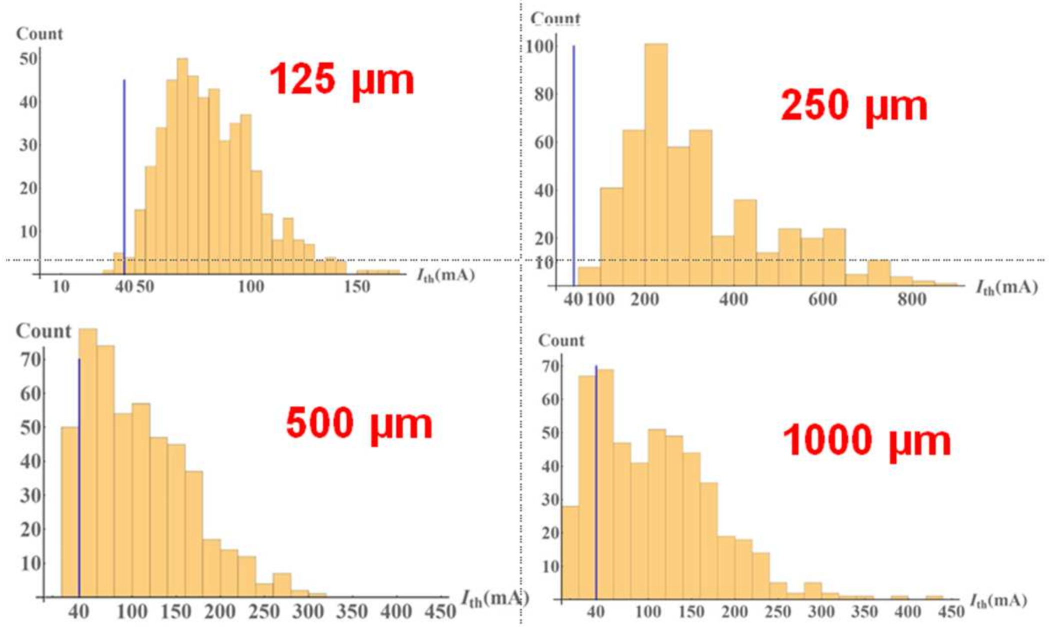
- Following talk

WG4: HOM measurements

BBU Simulation, *William LOU (Cornell)*

- Simulations for CBETA
  - Studied threshold current for various options

With various cavity shape errors



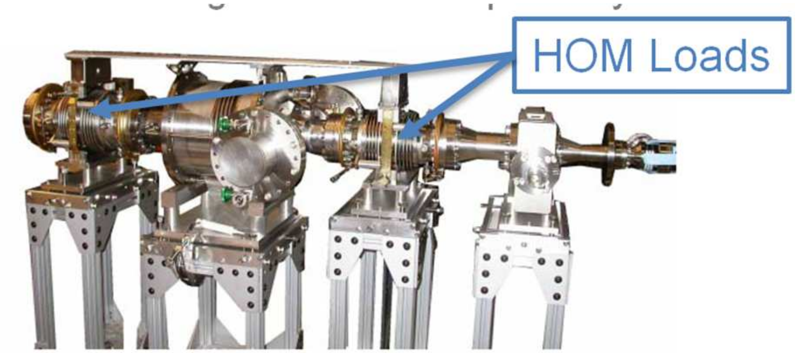
Potential ways to improve I_{th} :

1) Change bunch frequency
2) Introduce additional phase advance
3) Introduce x-y coupling

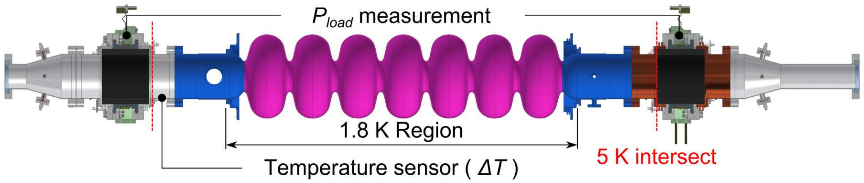
WG4: HOM measurements

HOM absorbers, HOM heating, and current limits, including measurements for CBETA, *Nilanjan BANERJEE (Cornell University)*

- Chose beamline absorbers for the ERL project
- Injector absorbers
  - ferrite tiles fixed to copper plates



- Main Linac Cryomodule absorbers
  - six 7-cell cavities
  - Silicon Carbide (CoorsTek SC3)



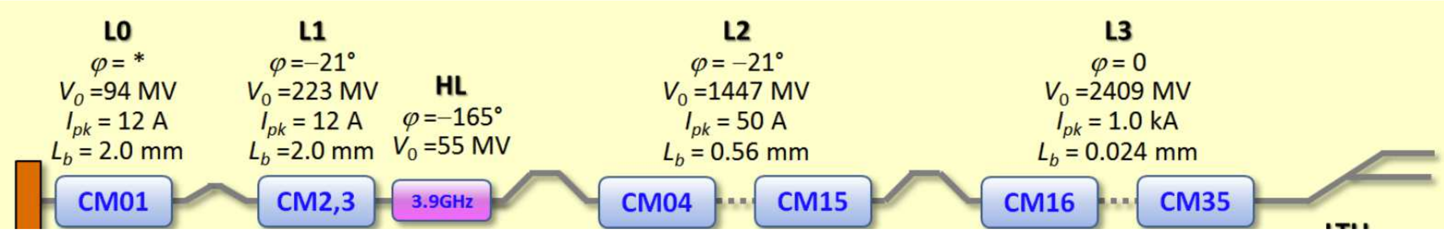
- CBETA current limits

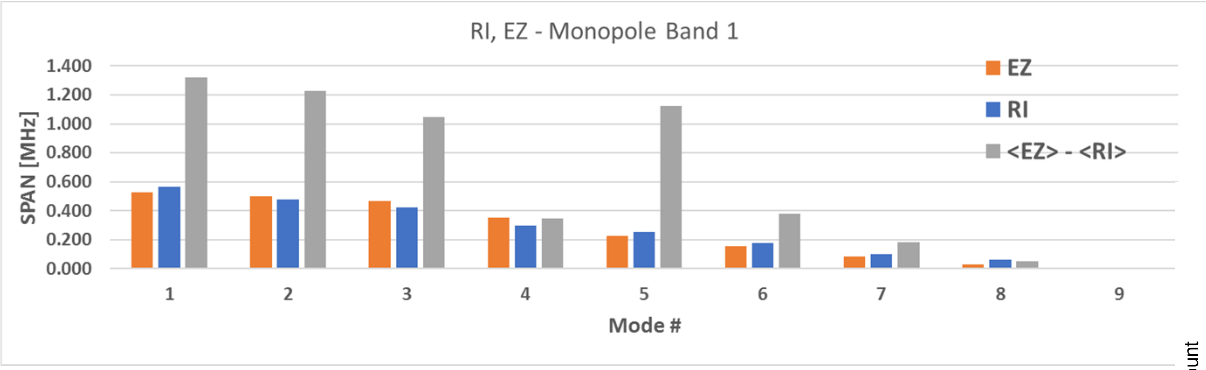
	High Current	eRHIC
Injection Rate (MHz)	325	41.9
Max Bunch Charge (pC)	123	344
Max Current (mA)	40	14.4

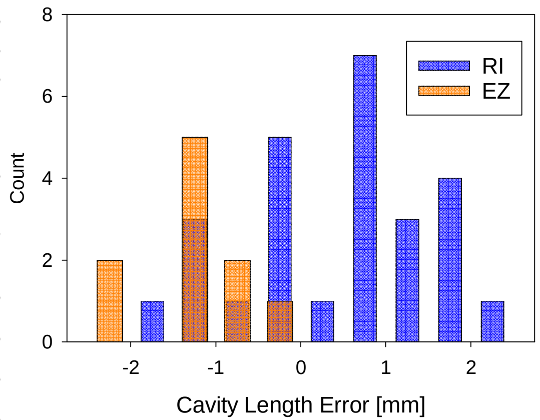
WG4: HOM measurements

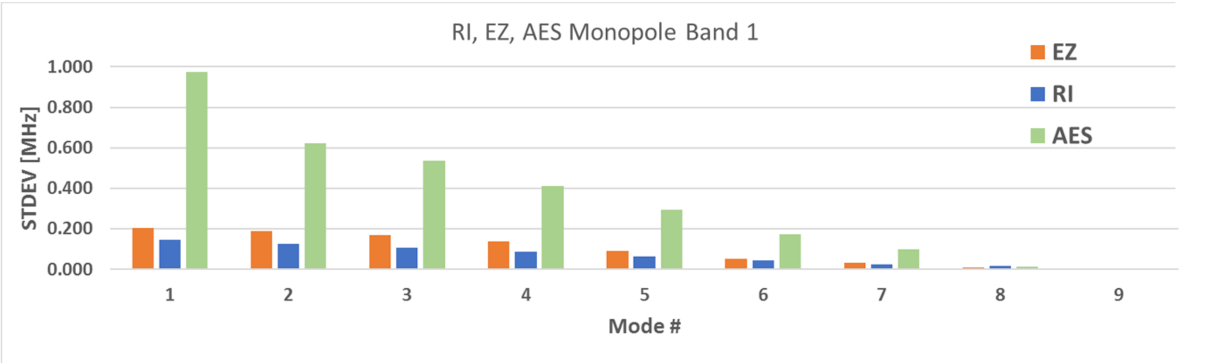
Status of HOM Spectra Measurements in 1.3 GHz Cavities for LCLS-II,

Andrei LUNIN (FNAL)









Discussion

Hot Topic

- Which directions should future HOM R&D focus on, i.e. where is rapid progress needed?

Outcome of the discussion

- How about SRF structures at frequencies $\gg$ 1.3 GHz – possibility of multi-cell structures with large number of cells? On-cell coupling? Superstructure?
- For many of absorber materials, there are issues with thermal conductivity/power density. How about completely new materials?
- HOM coupling techniques: on-cell coupling, hook/antenna coupling, absorbing tiles in beam tube, waveguide coupling.
- HOM-free cavities – need large beam pipes
- Need funding for “true R&D”, high-potential/high risk studies. This should be easier if we work together between labs/Universities $\rightarrow$ set up an interest group?
- Power levels at HOM couplers ($\approx$ 1 kW) reach similar levels as at FPC’s; similar technologies should be used/applied. Issue: ageing/cleanliness/particulates.
- HOM-based diagnostics – use the wealth of available information – also here: more money/manpower needed to deepen R&D

HOMSC2018, Cornell

27 participants

Thank you