WAKEFIELD CALCULATION AND HIGH ORDER MODES ANALYSIS USING HOMEN MODEL IN ENERGY RECOVERY LINAC

S. Samsam[1,2], M. Rossetti Conti[1], A. R. Rossi[1], A. Bacci[1], V. Petrillo[3], I. Drebot [1],
D. Sertore[1], A. Bosotti[1], R. Paparella[1], L. Monaco [1], A. Passarelli[4], M. R. Masullo[4] and L. Serafini[1]

1) INFN - Sezione di Milano & LASA, Milan, Italy
2) Sapienza Università di Roma, Rome, Italy
3) Università degli Studi, Milan, Italy
4) INFN - Sezione di Napoli, Naples, Italy

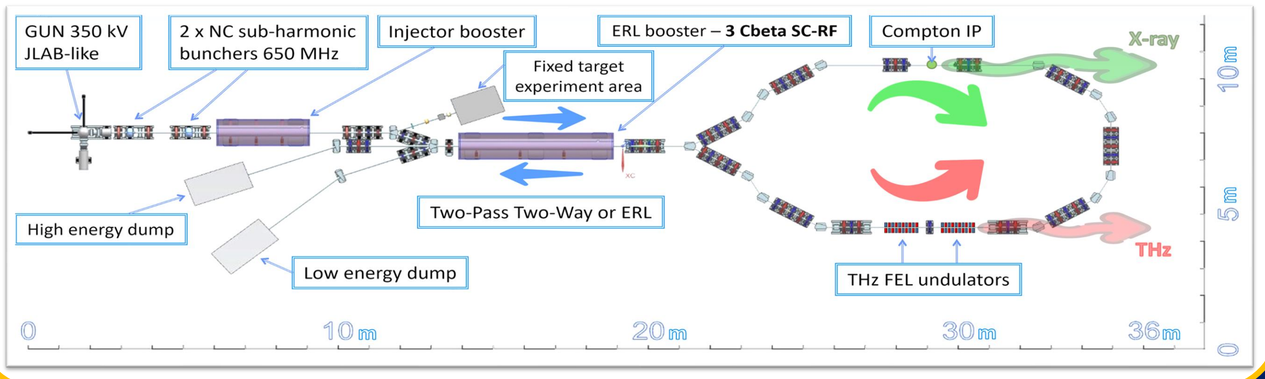
Sanae.samsam@mi.infn.it

EUROPEAN NETWORK FOR NOVEL ACCELERATORS
EuroNNAc4
NPACT supported by EU via I-FAST

Introduction

We developed a model called HOMEN to study the consequences of high order modes (HOMs) on beam dynamics and the stored energy inside a superconducting (SC) cavity, located in the main Linac of BriXSinO. Investigations about wakefield calculations and HOM damping were carried out.

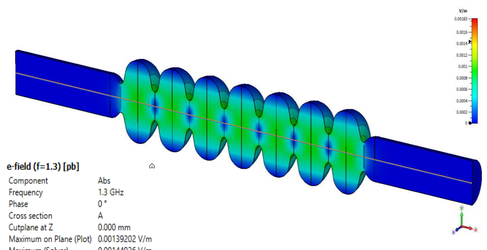
BriXSinO layout

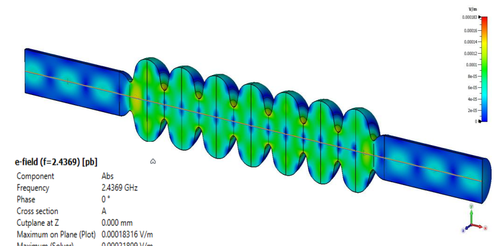


Cavity fields

Schematic of the field in the 7-cell cavity simulated by CST

Field shape in the 7-cell cavity simulated by CST

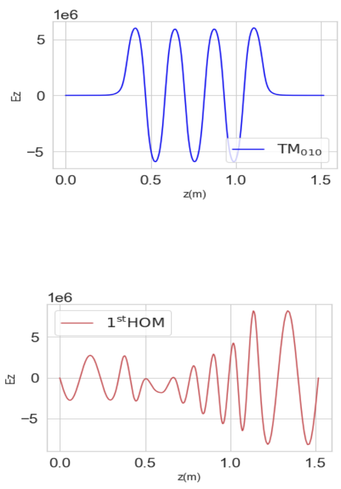




Fundamental mode

1st High Order Mode

Field profile in the 7-cell cavity simulated by SUPERFISH



HOMEN MODEL

High Order Modes *Evolution based on ENergy budget*

HOMEN

➢ The main parameters of the model are:

- The average Power to accelerate the e- bunch $P_{av} = \frac{q_i V_{acc_{i,n}}}{\tau_{cav_i}}$.
- Power lost acording to the wakefield $P_{HOM} = \frac{q_i^2 k_{loss,n}}{\tau_{cav_i}}$
- The power lost on the cavity walls: $P_{dis} = \frac{\omega_n U_n}{Q_{L_n}}$
- The Klystron Power : P_{kly}

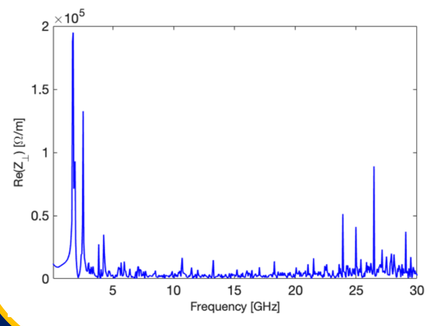
$$\frac{dU_n}{dt} = P_{kly} - P_{dis} - P_{av} + P_{HOM}$$

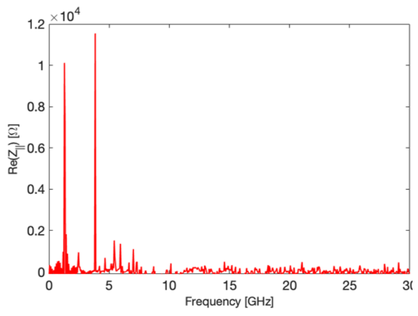
$$\frac{dA_n}{dt} = \frac{A_n}{2U_n}\frac{dU_n}{dt}$$

$$\frac{d\gamma}{dt} = \frac{e}{m_e c^2 \tau_{cav}} \sum_{n=1}^{N_{RF}} V_{acc_n}$$

Beam Impedance

- Wakefield simulations are done by CST.
- The real part of the longitudinal and transverse Impedances show important peaks relative to the parasitic HOMs.
- The calculated loss factor parameter for each HOM are shown in the table below.



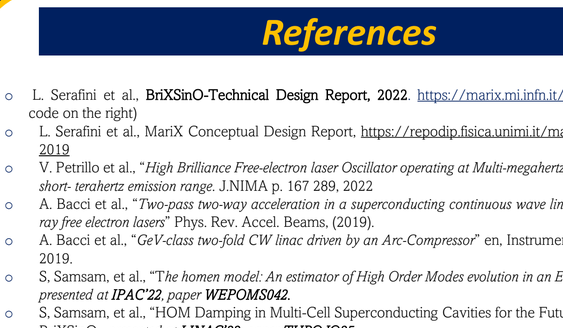


HOMs	Frequency [GHz]	k_{loss} [V/pC]
Mode 1	2.46	0.60
Mode 2	3.84	0.61
Mode 3	5.45	0.33
Mode 4	5.93	0.17
Mode 5	6.70	0.15
Mode 6	7.01	0.47
Mode 7	10.70	0.51

Table 1: Frequencies and k_{loss} values of HOMs

HOM Analysis

- The calculated loss factor parameter shows a better results for the stored energy variation inside the cavity.
- For a high order mode with (ν_n = 2.46 GHz), $t_{ch,n} = \frac{Q_n}{\omega_n} = 12.91$ ms , the stored energy reach equilibrium with a higher value in case of high loss factor.
- The variation of the bunch energy gain at the cavity exit shows that the relative energy spread decrease from 2×10^{-3} in case of $k_{loss} = 0.90\ V/pC$ to 1×10^{-3} for $k_{loss} = 0.60\ V/pC$.
- Good improvement for the FEL injection which is located in the arc of BriXSinO machine.



HOM Damping

- HOM damping leads to store less energy in the cavity in a shorter time.
- The loaded quality factor used in this simulations is in the order of 10^7.
- Without damping, the stored energy U_n takes longer time to reach the equilibrium.
- An absorbing material like SiC composie results in damping almost all the parasitic modes.
- A comparaison between the longitudinal impedance for 3 caes: 3 coupled cavities with and without SiC absorber and 3 times one single 7-cell cavity module.

Summary & Perspectives

- The excited wakefields of the HOMs were evaluated in the 7-cell SW cavity of the main Linac of BriXSinO.
- The results show that the proposed model and the approaches followed in the simulations works for a TPTW ERL scheme.
- The HOMs can be damped with SC-35 from Coorstek, the results showed that the absorbers work as it is designed.
- The obtained results are intended to be used for further beam dynamics simulations including the full cavity system of BriXSinO.

References

- L. Serafini et al., **BriXSinO-Technical Design Report, 2022**. https://marix.mi.infn.it/brixsino-docs/ (QR code on the right)
- L. Serafini et al., MariX Conceptual Design Report, https://repodip.fisica.unimi.it/marix/MariX_CDR.pdf, 2019
- V. Petrillo et al., "*High Brilliance Free-electron laser Oscillator operating at Multi-megahertz repetition rate in the short- terahertz emission range.* J.NIMA p. 167 289, 2022
- A. Bacci et al., "*Two-pass two-way acceleration in a superconducting continuous wave linac to drive low jitter x-ray free electron lasers*" Phys. Rev. Accel. Beams, (2019).
- A. Bacci et al., "*GeV-class two-fold CW linac driven by an Arc-Compressor*" en, Instruments, vol. 3, no. 4, Dec. 2019.
- S, Samsam, et al., "*The homen model: An estimator of High Order Modes evolution in an Energy recovery linac," presented at **IPAC'22**, paper **WEPOMS042**.*
- S, Samsam, et al., "HOM Damping in Multi-Cell Superconducting Cavities for the Future Electron Source BriXSinO , *presented at **LINAC'22**, paper **THPOJO25**.*

ACKNOWLEDGMENT

This poster presentation has received support from the European Union's Horizon 2020 Research and Innovation programme under Grant Agreement No 101004730.

EuroNNAc Special Topics Workshop. Isola d'Elba, Italy. Sep 18-24, 2022

BriXSinO

SCAN ME