WP2: Cavity design and beam/cavity interaction

Andy Butterworth

N. Schwerg, S. Gorgi Zadeh, R. Calaga, J. E. Mueller,
E. Shaposhnikova

RF R&D coordination meeting 19.10.2016

Outline

- Work package structure
- Status:
  - Cavity design
  - Beam-cavity interaction for FCC-ee
    - HOM power calculations
    - Beam stability studies
  - HOM damping studies for high intensity

Work package structure

1. Cavity design for FCC-ee
   - 1.1: Study and optimization of RF cavities for high energy operation (Rostock)
   - 1.2: Study and optimization of RF cavities for high intensity operation (CERN)
   - 1.3: Higher order mode damping scheme for high intensity operation (CERN/MEPhI?)
2. Cavity design and HOM damping for FCC-hh
3. Beam dynamics
   - 3.1 Beam stability considerations for FCC-ee (J. E. Mueller, E. Shaposhnikova)
   - 3.2 Beam stability considerations for FCC-hh (E. Shaposhnikova)
4. Low Level RF (RF-FB)
   - 4.1 LLRF for FCC-ee
   - 4.2 LLRF for FCC-hh

WP document →

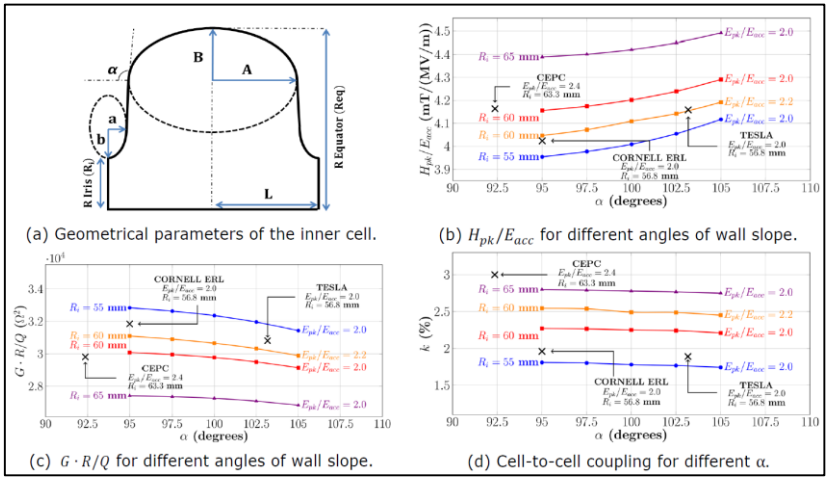
Status

Cavity design:

- FCC-hh:
  - starting point is LHC cavity (400MHz single cell λ\2.5)
  - slightly modified design (Rama) for easier tuning
  - single- or two-cell
  - also for FCC-ee high intensity (Z) mode
- FCC-ee:
  - Cavity design studies for Higgs mode ongoing at Rostock (Shahnam)
  - Converging towards 800MHz multi-cell option
    - power and real estate gradient considerations

Cavity design for H & tt (Uni. Rostock)

- Frequency, number of cells
  - 4-cell cavity at 801.58 MHz
- optimization of mid-cell shape
  - losses, E_{pk}/E_{acc} , cell-to-cell coupling, wall slope angle
- optimization of end-cells
  - field flatness
  - beam pipe transition (direct vs. corrugated): optimization of loss factor
- input power coupler positioning
  - Q_{ext} , transverse kick

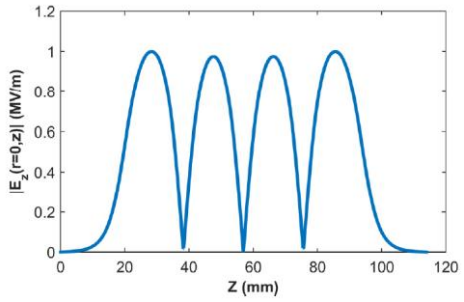


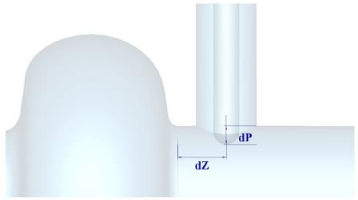
(a) Geometrical parameters of the inner cell.

(b) H_{pk}/E_{acc} for different angles of wall slope.

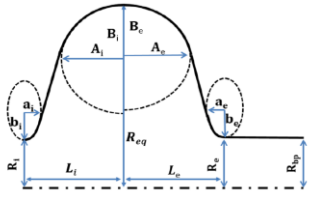
(c) $G \cdot R/Q$ for different angles of wall slope.

(d) Cell-to-cell coupling for different α.

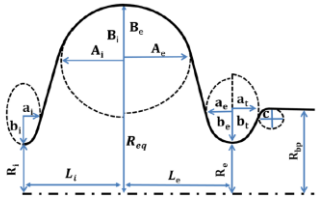




(a) Input coupler-tuning parameters.



(a) Direct transition of the end-cell to beam pipe.



(b) End-cell with corrugated beam pipe.

Shahnam Gorgi Zadeh, “Preliminary Cavity design for FCC-ee”, EDMS 1612380
Shahnam Gorgi Zadeh, “Preliminary cavity design for the Higgs running mode of FCC-ee”, EDMS 1720028

Beam stability FCC-ee

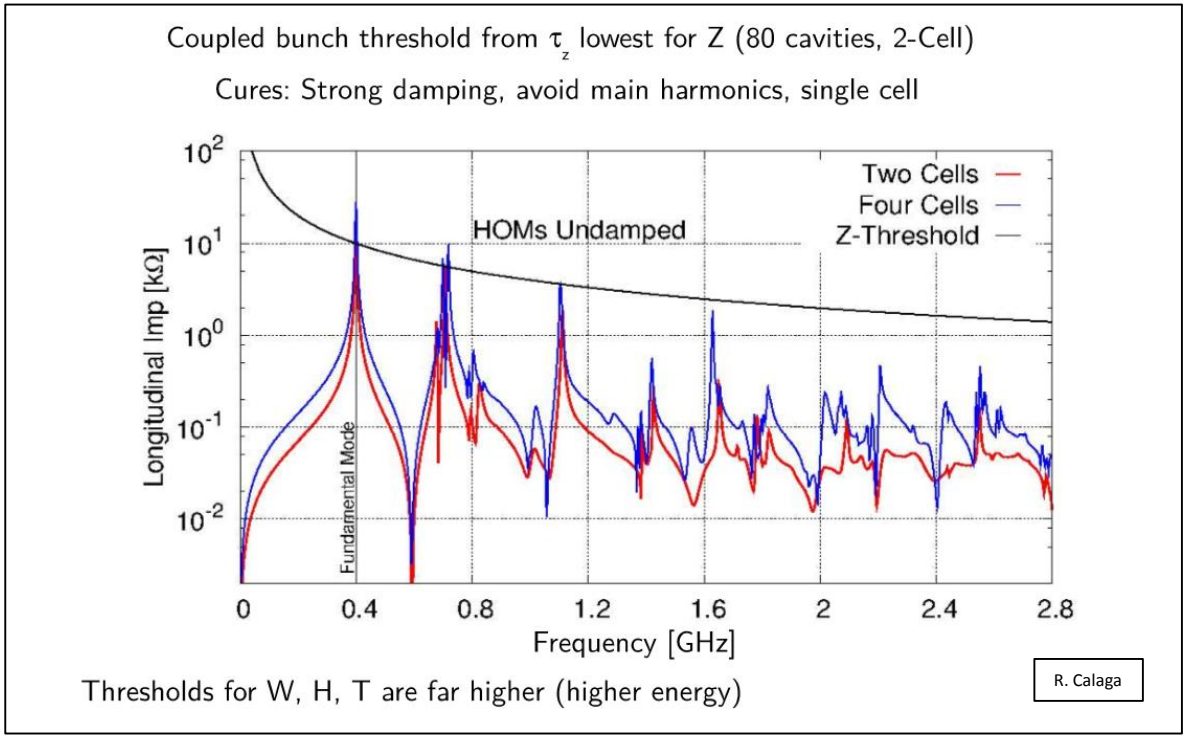
- Single bunch
  - can be modelled using BLonD
  - needs well-defined impedance model (cavities, beam pipe etc.)
  - cavity part of this information has to come from the cavity designer
  - needs representative set of beam parameters (RF voltage, bunch charge, etc.)

  - tells us if cavity impedance within the limits for single-bunch stability

  - Juan has been concentrating on single-bunch stability for electron beams
  - modelling quantum excitation and radiation damping in BLonD

Beam stability FCC-ee

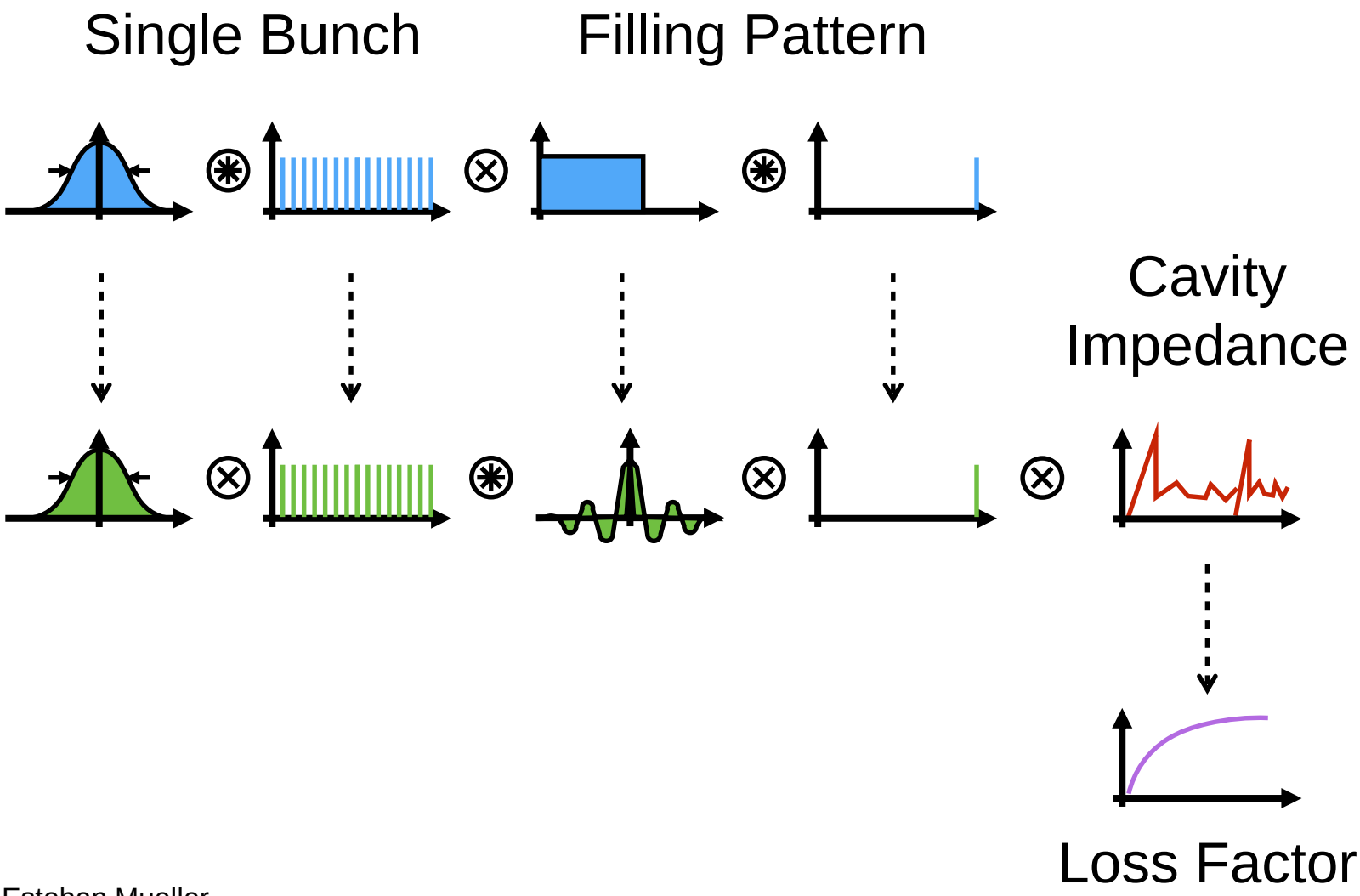
- Coupled bunch
  - driven by narrow band impedances (fundamental and HOMs)
  - analytical expression giving the maximum permissible R_{shunt} for any cavity mode
    - dependent on mode frequency
    - for a given set of beam parameters



Beam stability FCC-ee

- Coupled bunch
  - also driven by the fundamental in the presence of the large detuning needed with high beamloading.
  - as (more?) important as single bunch
  - Juan and Elena will start looking at coupled-bunch (and second Robinson?) first before returning to the study of single-bunch

Beam Cavity Interaction



BlonD

- Extend BlonD for multiple bunches (N>100)
- Extend BlonD for Gaussian Bunches

HOM damping

- Tentative contact with MEPhI
  - (Moscow Engineering Physics Institute)
- Possible collaboration on design of HOM damping scheme for high intensity
- For a given cavity design
  - single cell 400 MHz “LHC-like”
  - avoid opening up a big effort of cavity optimisation
- Study the available damping schemes (loop couplers, waveguides, warm absorbers etc.) and make a proposal
- To be done at CERN before proceeding further:
  - HOM power and stability calculations to define requirements on damping scheme (limits on narrow band HOM impedances)
  - results in next few weeks