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FCC-ee Arc Half-Cell Mock-up Project: Dynamic stability analysis

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Abstract

A dedicated study is being undertaken at CERN, together with the FCC Feasibility Study collaborators, to propose a robust configuration for the FCC-ee arc half-cell considering all integration aspects of the elements. This study includes engineering analyses performed to design the supporting system of the booster and of the collider. The proposed layout must meet requirements in terms of stiffness, static alignment and dynamic stability. It must also take into consideration pre-alignment, handling and installation operations, as well as remote re-adjustment and maintenance. Finally, given the very large scale of the facility, a robust and cost-effective design must be proposed that is suitable for large-scale industrialization. This document presents the methodology related to the dynamic stability analysis implemented to help in the design of the supporting system of the collider short straight section.

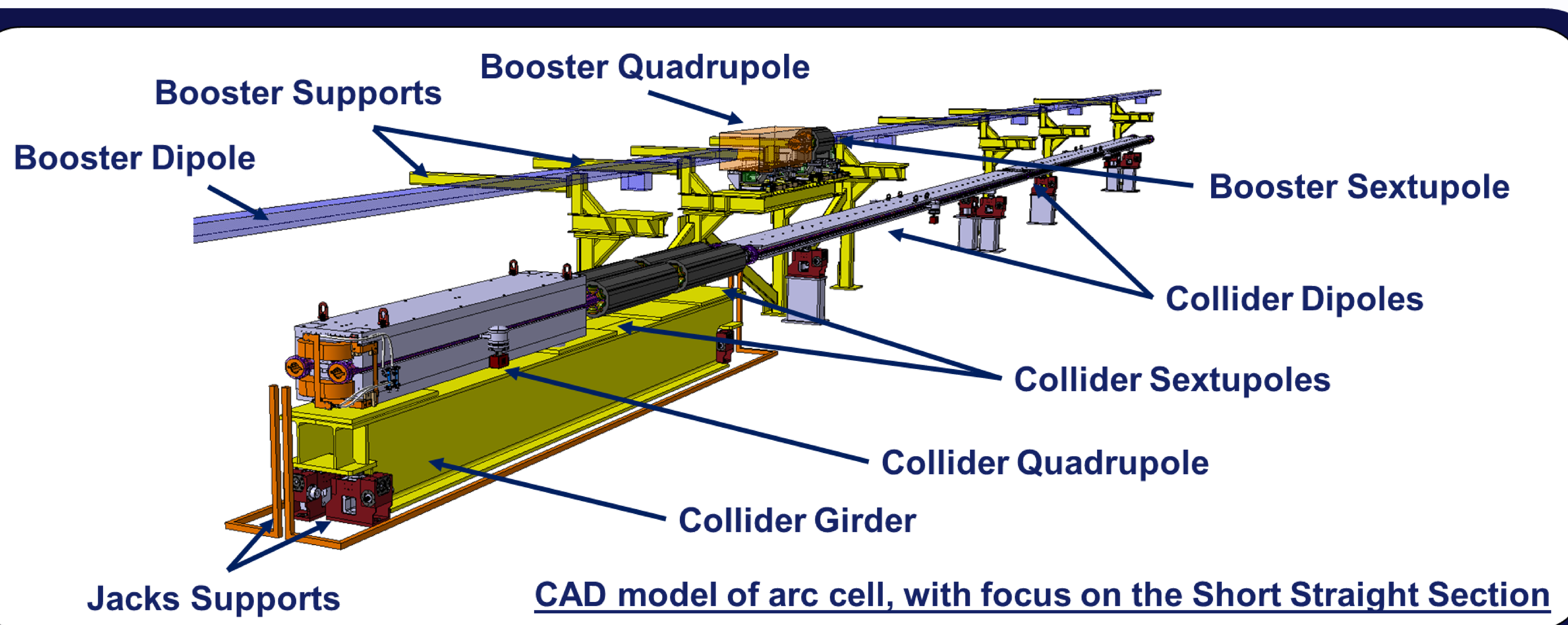
Introduction

FCC-ee: 90 km, 77 km are arc cells

Arc cell = the most repeated region of mechanical hardware in the tunnel

→ The idea: construct a **half arc cell mock-up** to test aspects related to:

- Fabrication
- Integration
- Assembly
- Stability inspection
- Transport
- Installation
- Alignment
- Maintenance

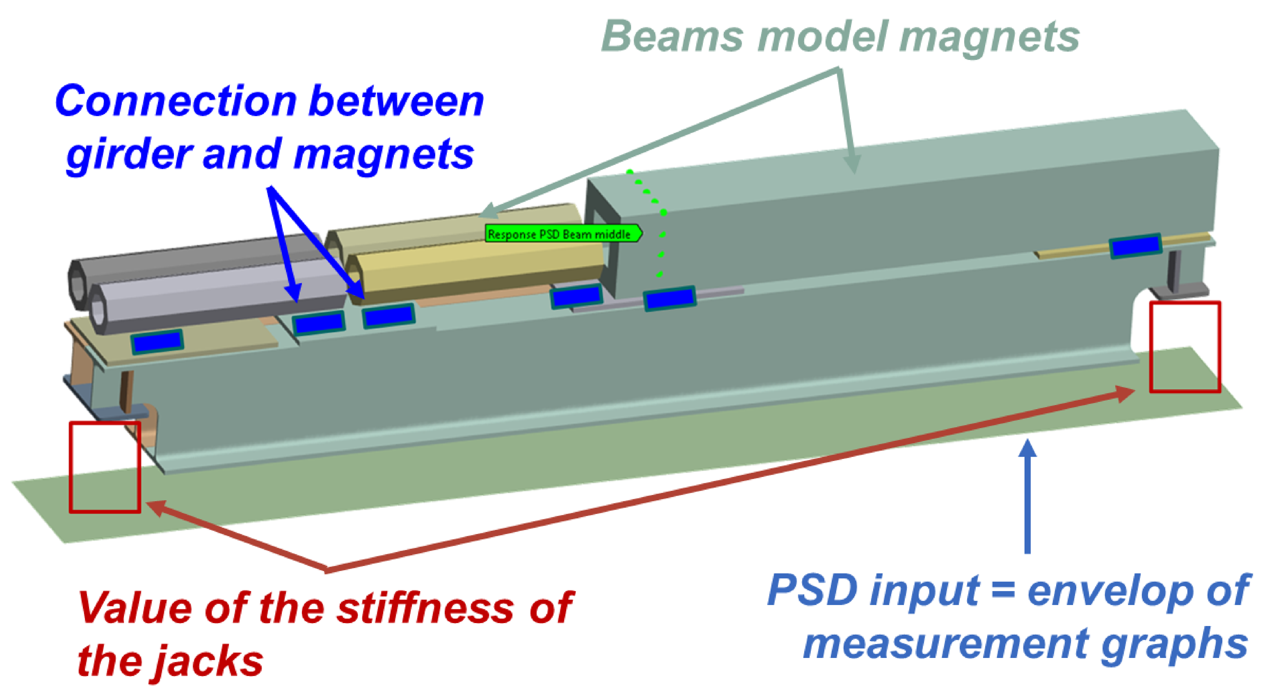


CAD model of arc cell, with focus on the Short Straight Section

Dynamic stability and vibrations

The dynamic stability of the collider and booster support needs to be assessed. The methodology based on simulations obtained by finite element analysis is described below. The method consists of modelling the support, the magnets and the jacks using simplified springs. The model is excited by the Power Spectral Density (PSD) of the ground displacement and the PSD of the beam displacement is computed as an output. The integrated Root Mean Squared (RMS) displacements at the level of the magnetic center are then computed and compared to the specifications.

Assumptions:

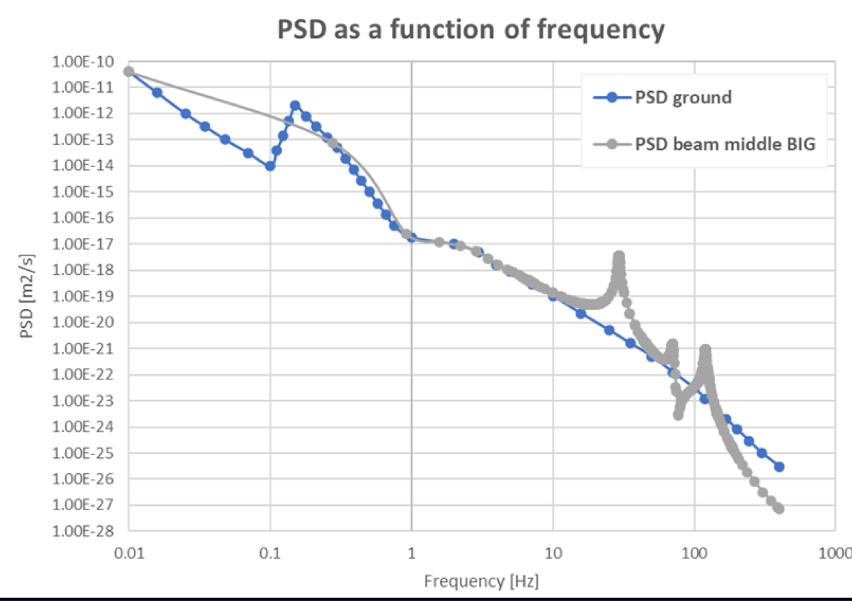


Damping of material = 2%

Monitoring:

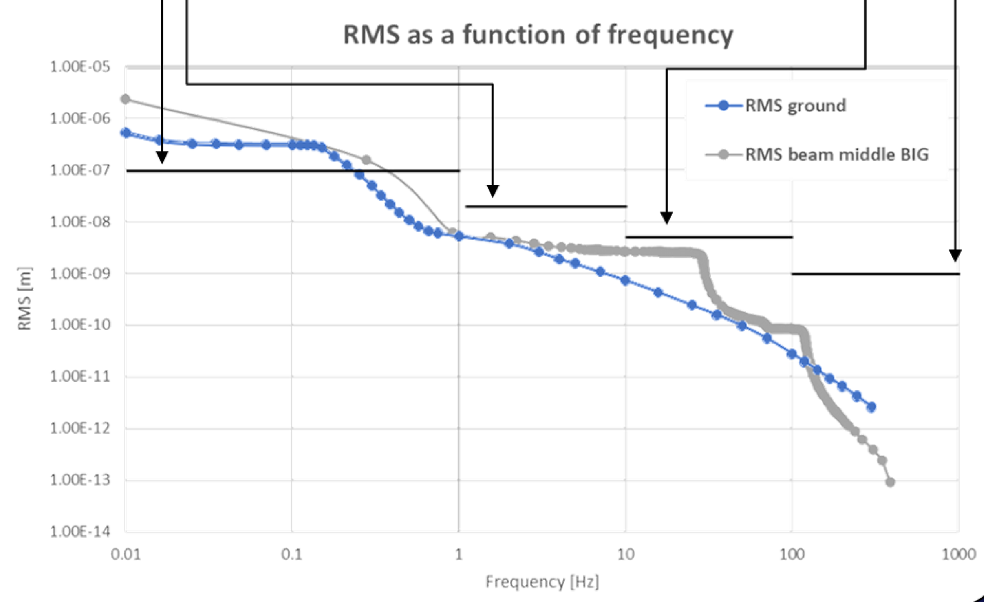
→ PSD of the ground motion (LHC tunnel measurements)

→ PSD of the displacement at the magnetic center



Specifications comparison:

Frequencies	Tolerance
1 > f > 0.01 Hz	100 nm
10 > f > 1 Hz	20 nm
100 > f > 10 Hz	5 nm
f > 100 Hz	1 nm



Conclusion

A methodology has been implemented to evaluate the amplification factor between the ground motion and the magnetic center motion. Different mechanical design options or alignment configurations can be compared using this methodology. The first results have shown that the mechanical design of the support system must be optimized to fulfill the dynamic stability requirements. An extensive experimental campaign is planned to measure the transfer functions of already existing sub-components such as jacks, adjustment platforms, and girders to refine the assumptions used in the simulations.

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