Study of the Electrical Center of a Resonant Cavity Beam Position Monitor (RF-BPM) and Its Integration With the a Main Beam Quadrupole for Alignment Purposes

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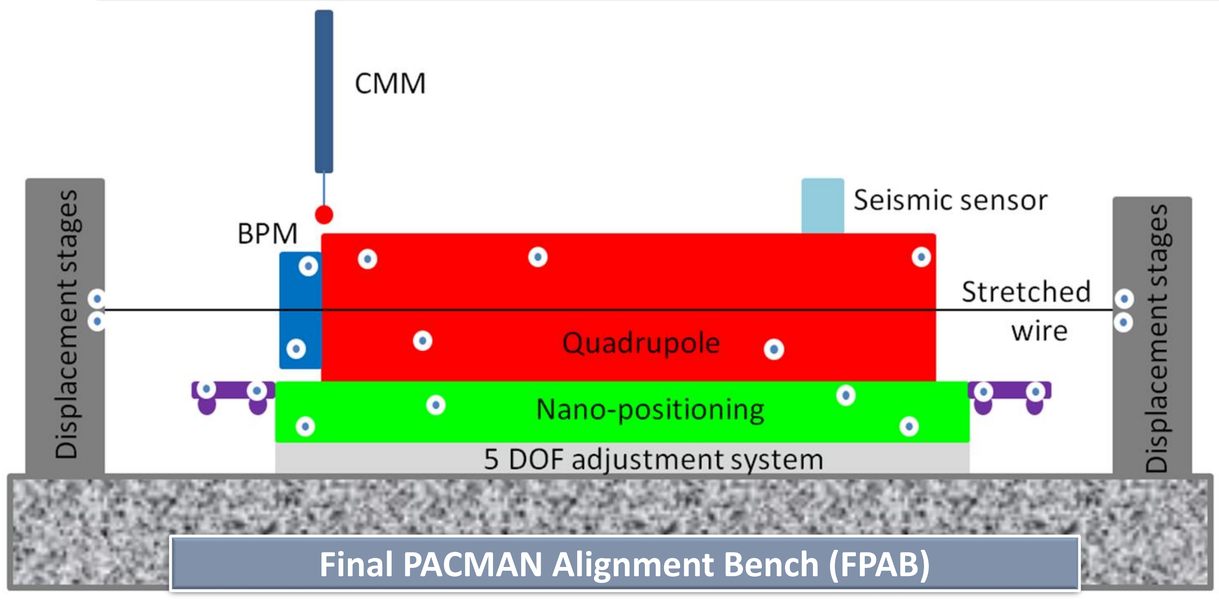
ABSTRACT

To achieve the luminosity goals in a next generation linear collider, acceleration and preservation of ultra-low emittance particle beams is mission critical and requires a precise alignment between the main accelerator components. **PACMAN** is an innovative doctoral training program, hosted by CERN, with the goal of developing **high accuracy metrology and alignment methods and tools** to integrate those components in a standalone, automatic test bench. The method will be validated on CLIC components, a proposed Compact Linear Collider currently studied at CERN. The alignment between the electrical center of the Beam Position Monitor (BPM) and the magnetic center of the associated Main Beam Quadrupole (MBQ) is of particular importance to minimize the emittance blow-up, and therefore in the focus of the PACMAN project. The two components have been independently characterized on separated test benches by stretched and vibrating wire techniques. Preliminary conclusions are presented in this paper, with emphasis on the characterization of the electrical center of the BPM.

THE PACMAN BENCH



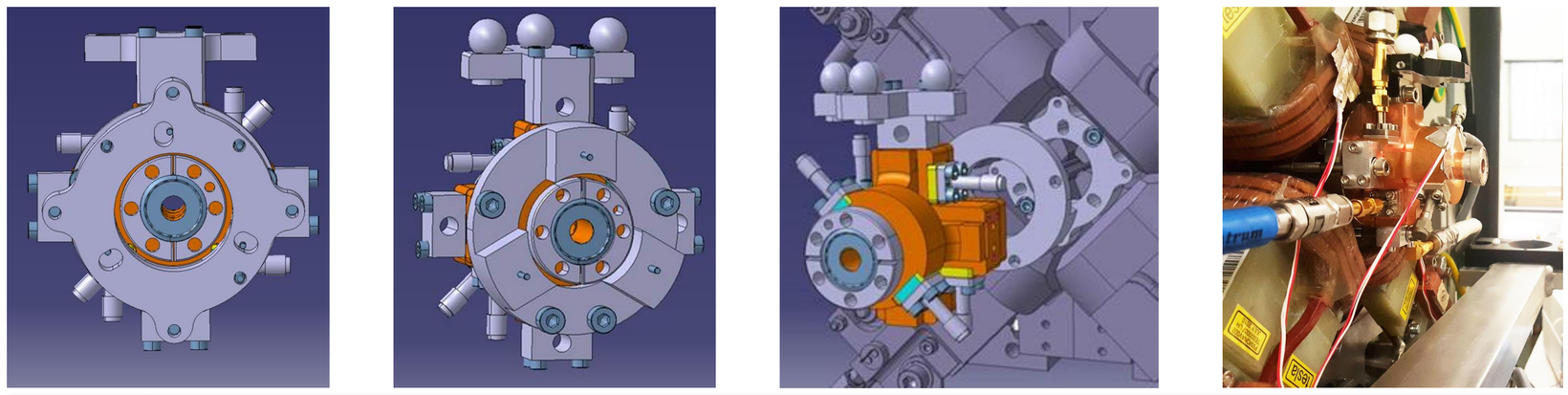
Final PACMAN Alignment Bench (FPAB)

The following steps were taken to achieve the **MBQ-BPM pre-alignment** result and measure the electromagnetic offset between the two devices:

1. The single components are **separately characterized and calibrated**. The MBQ by means of vibrating wire techniques, and the BPM using the stretched-wire;
2. The BPM and the MBQ are **mechanically aligned on a common axis**;
3. The assembly is firstly studied in a laboratory environment and then moved on the CMM platform, in a temperature controlled and clean room;
4. The magnetic center of the MBQ and the electrical center of the BPM are located, each with the respective measurement method;
5. Through non-contact sensors two wire positions are recorded, one in the MBQ magnetic center, the other in the BPM electrical center.

By the knowledge of the **offset calibration constant** between the magnetic center of the quadrupole and the electrical center of the position cavity BPM, the beam position measurements will be referenced to the quadrupole magnetic center and allow to **detect beam misalignments** with reference to this point. Moreover, an **active nanopositioning** system is added to correct the magnet position and recenters the beam.

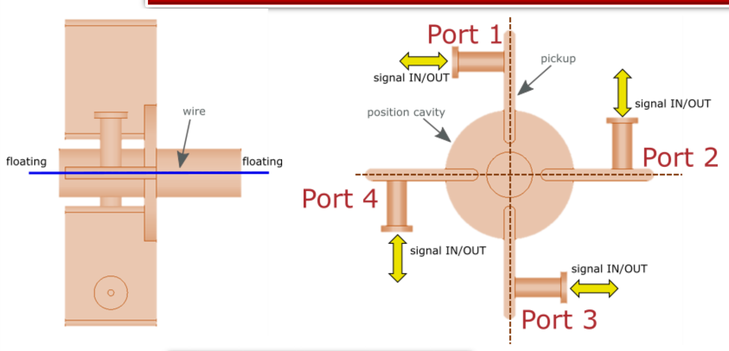
MECHANICAL INTEGRATION



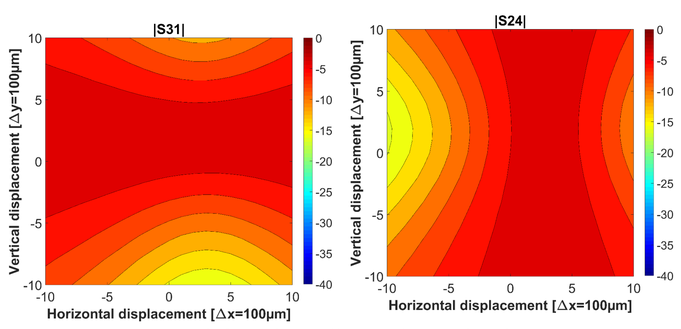
BPM-BMQ INTERFACES

Two **complementary mechanical parts to attach the BPM and the MBQ** were designed and manufactured. The former attached to the quadrupole has three concentric ellipses that center the mechanical axis of the quadrupole; the latter interfaces the BPM through three pins matching the slotted holes on the complementary part.

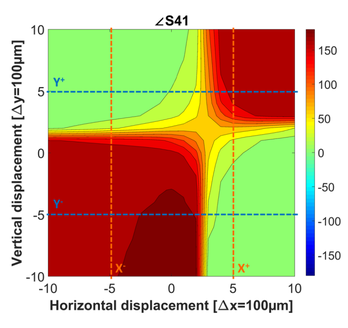
LOCATION OF THE ELECTRICAL CENTER OF THE BPM



BPM



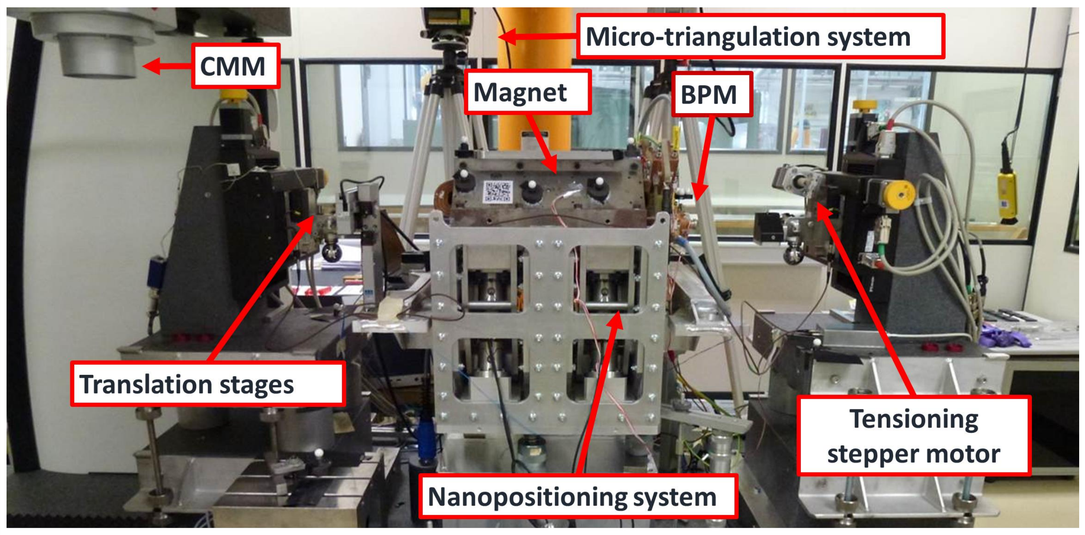
MAGNITUDE

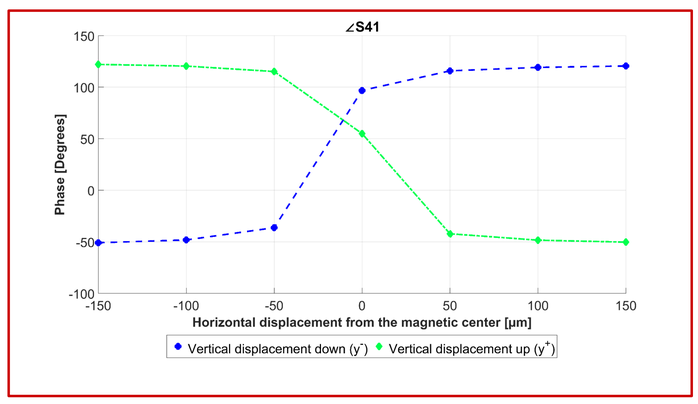


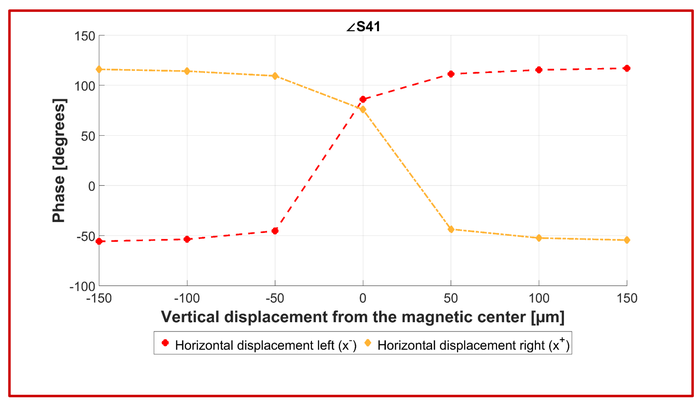
PHASE

While sweeping the wire through the cavity on the horizontal and the vertical axis, the dipole electrical field can be reconstructed by looking at the magnitude argument between opposite ports. Tthe most sensitive argument is the phase between adjacent ports, which demonstrates a **linear phase transition crossing the electrical center**.

BPM MREASUREMENTS ON THE FPAB







The **electrical center coordinates are located** by observing the phase transition between adjacent ports. The cross point is **referred to the magnetic center of the quadrupole**.

PACMAN is founded under the European Union's 7th Framework Program Marie Curie Actions, grant PITN-GA-2013-606839