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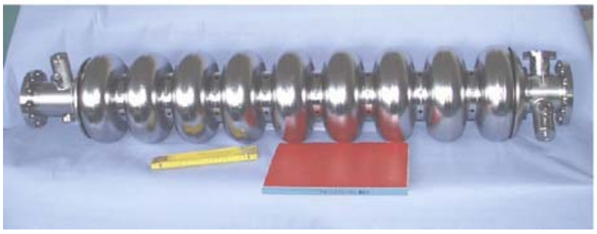

Installation and Calibration of the New Re-entrant BPM in the FLASH linac

C. Simon[(1)], M. Luong [(1)], S. Chel[(1)], O. Napoly[(1)], N. Baboi [(2)],N. Mildner[(2)], D. Noelle [(2)], N. Rouvière[(3)]

1) CEA-Saclay, DSM/DAPNIA/SACM, France
2) DESY, Hamburg, Germany
3) IN2P3-IPN, Orsay, France

Abstract

We report on the installation and calibration of the re-entrant cavity BPM located in the FLASH linac. We aim at high precision beam position measurement in single bunch mode and at qualifying a calibration procedure for this BPM.

Re-entrant BPM Installation and RF measurements

At the beginning of this year, we received the cavity BPM with the feedthroughs (Figure 1) designed the last year.

Figure 1: Cavity BPM

The antennas fulfil the conditions of Ultra High Vaccum (UHV). They are assembled to the cavity by a conflat gasket. For each antenna, a CuBe RF contact is welded in the inner cylinder of the cavity to ensure electrical conduction between the feedthrough inner conductor and the cavity, providing a magnetic coupling loop. In order to avoid hydrogen out gassing on site, a heat treatment at 280 °C for 15 days is applied to the BPM cavity body instead of the usual treatment (950 °C for 2h) which may have drastically reduced the RF contact elasticity.

Spring 2006, during the maintenance time, the reentrant BPM was installed in a warm part in the FLASH linac (Figure 2) at DESY.

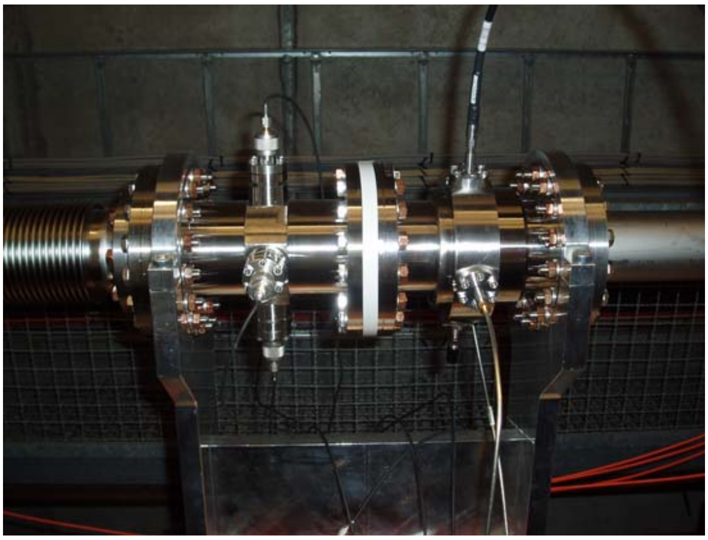

Figure 2a: Re-entrant cavity BPM (right) and button BPM (left) installed in the FLASH linac

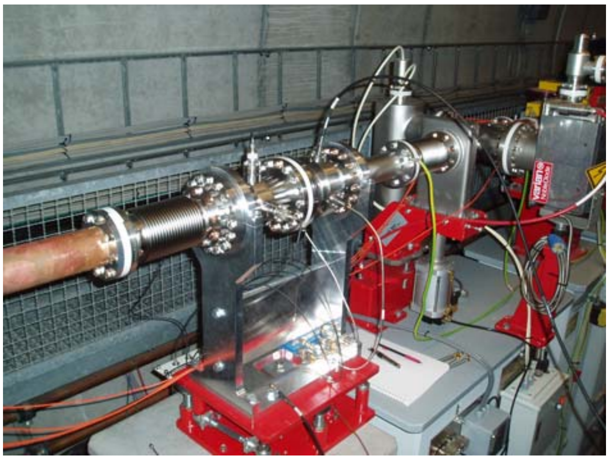

Figure 2b: Re-entrant cavity BPM and subsystem with hybrid couplers and phase shifters installed in the FLASH linac

After this mounting, the first RF measurements were carried out to check the proper feethroughs mounting on the cavity. The resonant cavity was, first, simulated with the software HFSS (Ansoft) to determine its modes and coupling then, it was measured in laboratory and finally on the linac. The RF measurements, presented in Table 1, provide a comparison that gives information on the sensitivity of the RF characteristics to the mechanical mounting and operating environments.

	F (MHz)			Q_l		
	Calculated	Measured in lab.	Measured on the linac	Calculated	Measured in lab.	Measured on the linac
Monopole mode	1250	1254	1.255	22.95	22.74	23.8
Dipole mode	1719	1725	1.724	50.96	48.13	59

Table 1: RF characteristics of the re-entrant BPM

The difference on Q factors can be explained by the boundary conditions which are not the same during the measurements in laboratory and in the tunnel.

The crosstalk was measured to be around 33 dB instead of 41 dB measured in laboratory. This difference could be explained by the fact that the BPM has a rotation/tilt (11.25 degrees) with a button BPM which is very close.

The reflexion measurement on each pick up gives nearly the same results with only ±0.07 dB. The four pickups mounted on the BPM are therefore quite identical.

Calibration of the electronics

First, the two electronics subsystem were calibrated:

- a subsystem with hybrid couplers, phase shifters and one combiner was installed in the tunnel during the maintenance day.

Tuning of the phase shifters gives a high common mode rejection (30 dB at 1.25 GHz).

- the second subsystem (Figure 3) was installed in AN-14 bench. Housing the synchronous and direct detectors, as well as amplifiers and limiters for protection were adjusted to have a linearity range around +/- 10 mm.

Figure 3: BPM subsystem located in the hall

The measurement of the "sum" signal peak power is around 36 dBm for 0.9 nC, it is of the same order of magnitude compared to simulations. The spectrum analysis of the "delta" signals from the 180° hybrid coupler output shows good common mode rejection. Phase tuning for the synchronous detection was refined while visualizing the delta/sigma signal on a scope

The video amplifier gain was adjusted to +/- 1V to avoid saturation from ADCs. Figure 4 shows the signals from video amplifier outputs of Δx and Δy channel.

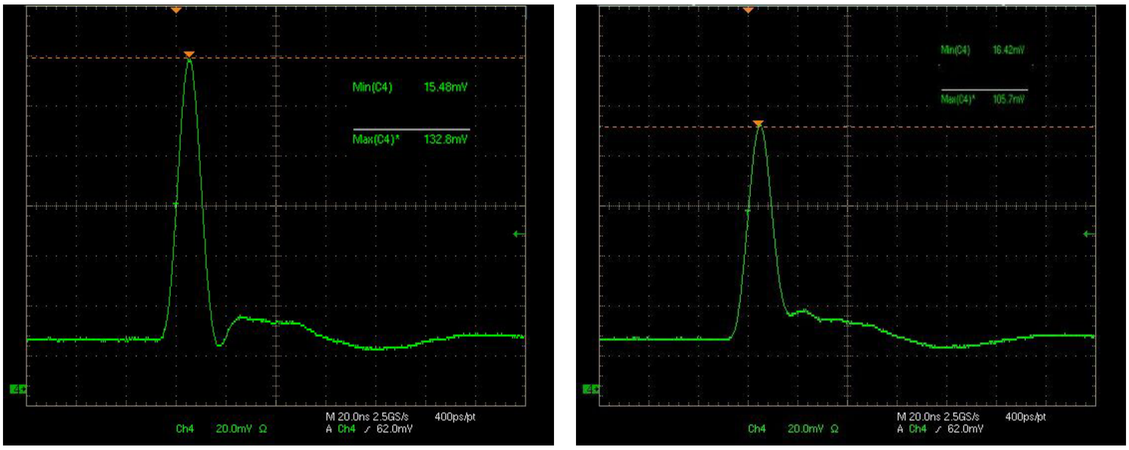

Figure 4: Signals at video amplifier outputs, Δx (left) and Δy (right).

Signal delays were adjusted with cables for simultaneous acquisition with the Doocs ADC board. The calibration for offset on the Doocs ADC board was made and the trigger delay adjusted to 102.5 on Doocs. Afterward, a period of test followed. The H10ACC6 and V10ACC6 steerers were used to move the beam, and the magnets were switched off.

Method and results

We began with a horizontal steering then a vertical steering. Results are given in Figure 5.

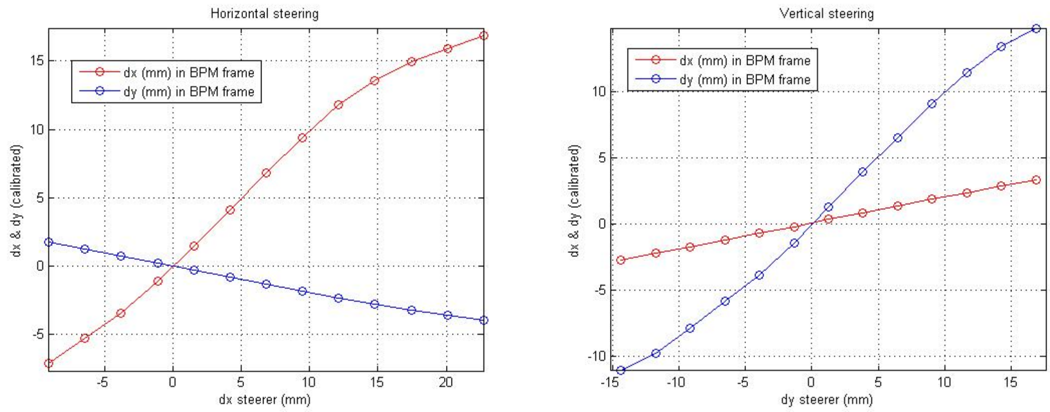

Figure 5: Calibration results in BPM frame from horizontal (left) and vertical (right) steering

The reentrant BPM has, on the X and Y channels, a good linearity in a range 15 mm but there is an asymmetry and the linearity is better for a positive deviation. This effect is not yet well understood; it may be related to the steering magnets (residual field or saturation).
The reentrant BPM is mounted with a tilt angle of 11.25° with respect to the horizontal direction. A frame rotation change is therefore necessary. Calibration results after this correction are displayed in Figure 6.

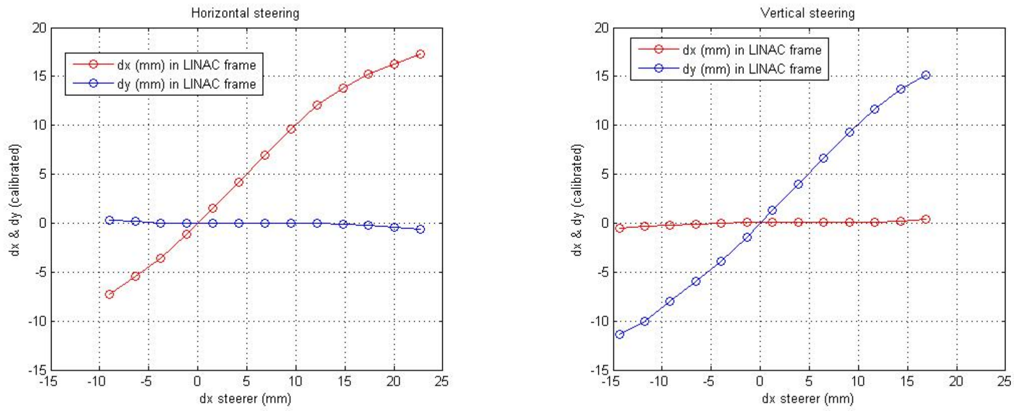

Figure 6: Calibration results in LINAC frame from horizontal (left) and vertical (right) steering

The standard deviation of the calibrated position measurement was plotted for the horizontal and vertical steering (Figure7).

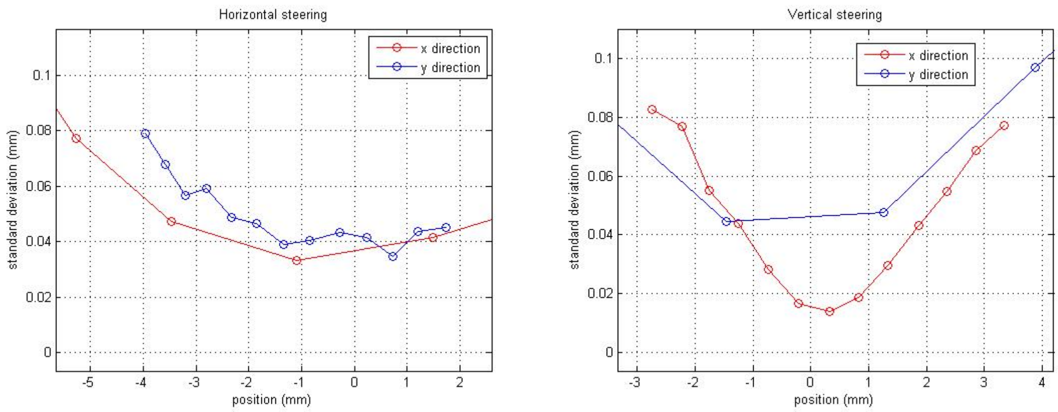

Figure 7: Standard deviation of the position measurement (calibrated)

The raw RMS resolution of the system directly measured by the standard deviation of the readings from the reentrant BPM (14ACC7) can reach 20 µm on the X channel and around 40 µm on the Y channel, at the BPM center. But those results depend on the beam jitter, too. With simulations, the resolution of this system was determined around 15µm.

A second test period was necessary to validate the first results: the same steerers were used, the deviation range was limited to ±4 mm for a more accurate calibration (Figure 8, 9, 10).

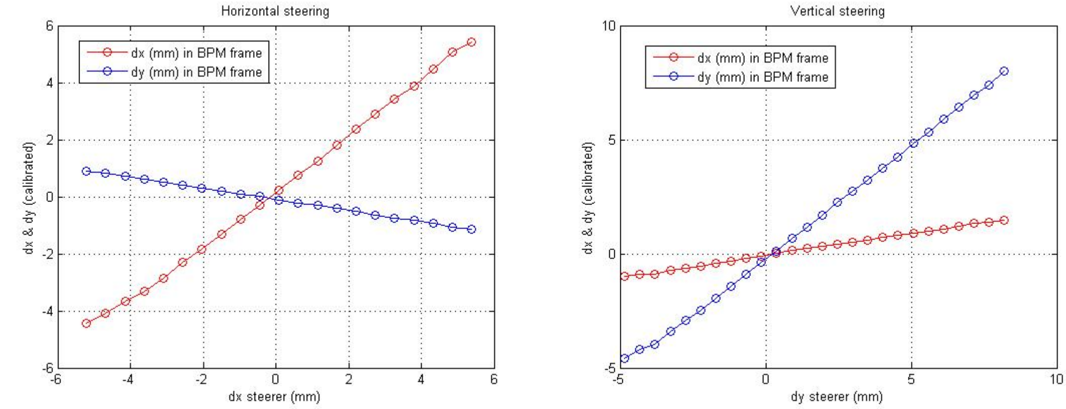

Figure 8: A more accurate calibration results in the BPM frame from horizontal (left) and vertical (right) steering

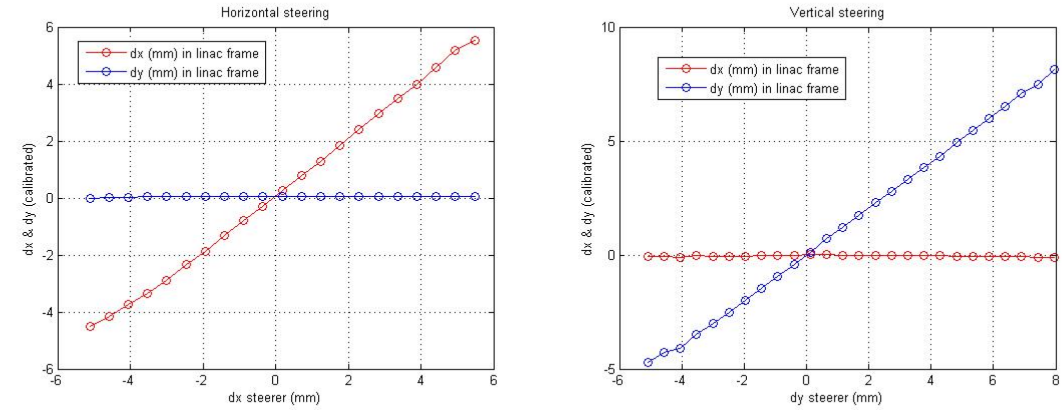

Figure 9: A more accurate calibration results in the LINAC frame from horizontal (left) and vertical (right) steering

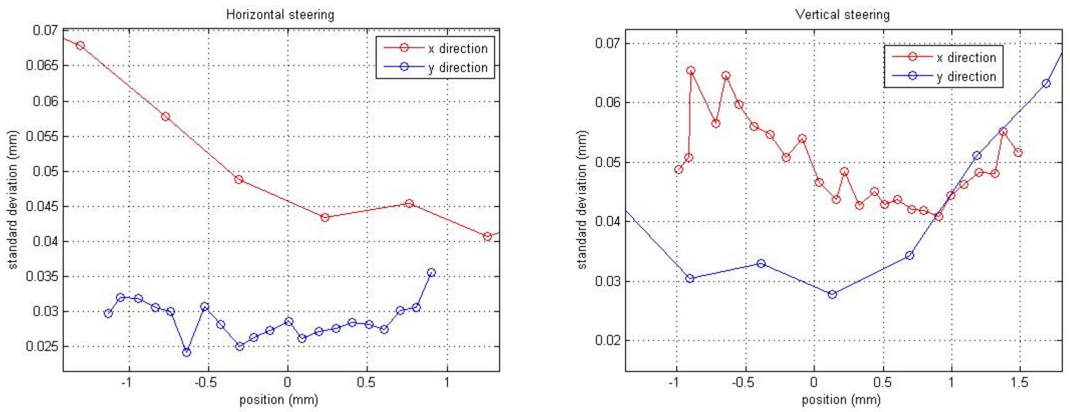

Figure 10: Standard deviation of the position measurement (calibrated)

This second measurement corroborates the first calibration. The linearity in this calibration range is very good for both channels. The minimum standard deviation of the measurements at the BPM center is around 40 µm for X channel and around 30 µm for Y channel.

Future work

We need to know the resolution of the BPM with this dynamics range to compare and validate the simulations. Some resolution measurements could be combined with the 'DESY' Button BPM which is close to the re-entrant BPM.
Then the electronics system and in particular the gain on each channel will be modified to improve the resolution but the dynamics range will be reduced.

To improve the resolution of the BPM and keep a dynamics range around +/- 5mm, the mixer which is used in the electronics installed in DESY could be replaced by a new one which accepts a high power RF input (around 16 dBm instead of 0 dBm).

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