Multi Bunch Processing - Cavity BPMs

Mark McCallum
Supervised by Alexey Lyapin

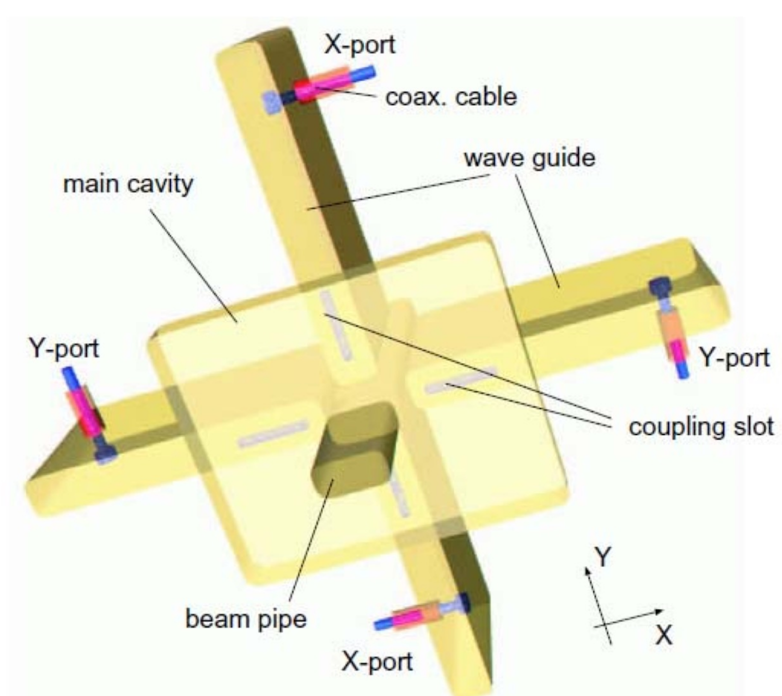
ROYAL HOLLOWAY UNIVERSITY OF LONDON

Abstract

The resolution of cavity Beam Position Monitors (BPMs) is of importance to the aims of Accelerator Test Facility 2 (ATF2), whose main aim is to is to achieve control of the beam position with nano-meter precision. In this project, I analysis data produced by cavity BPMs to find a value for the upper bound of the resolution of a cavity BPM. The results of this project have paved the way for future analyses conducted on data produced by cavity BPMs.

Cavity BPMs

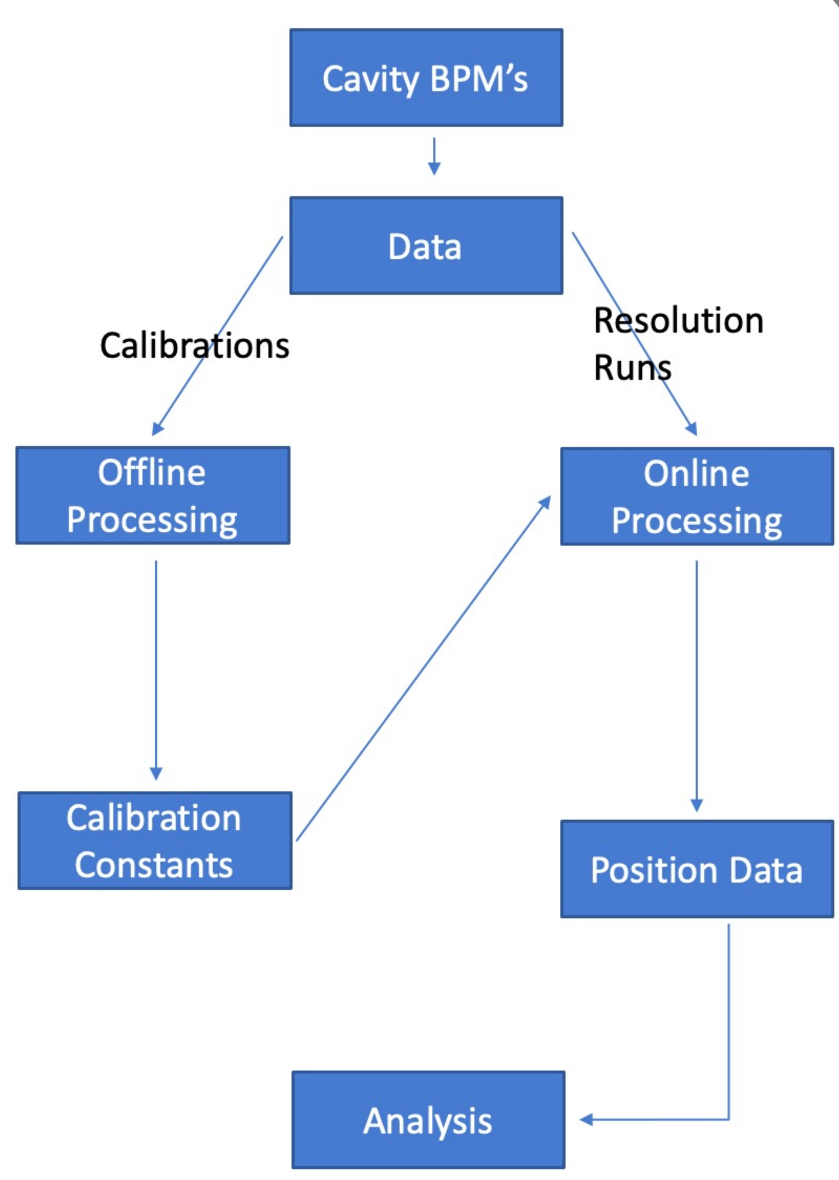
A cavity BPM consist of a beam pipe that goes through a rectangular cavity with slots that allow entry to the wave guides, as shown in the figure to the right [1]. Cavity BPMs are used in ATF2 since they offer very good stability which is key when dealing with nano-meter precision [2].



The Code

```
c = c2b.Cal2Bunch(path_data)
c.processCal()
c.plotCal(i)
bpm_info[dfn] = c.l.info
```

The above section of code is used to process the individual data files produced by the cavity BPMs. This code outputs a series of plots, and two examples of these (one good and one bad calibration) are shown in Figure 1 and 2 below.



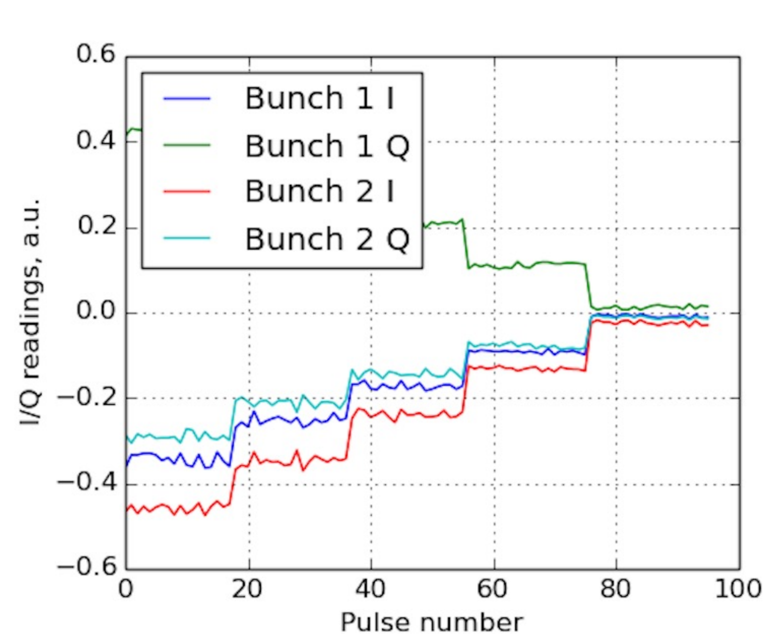


Figure 1: Example of a good calibration.

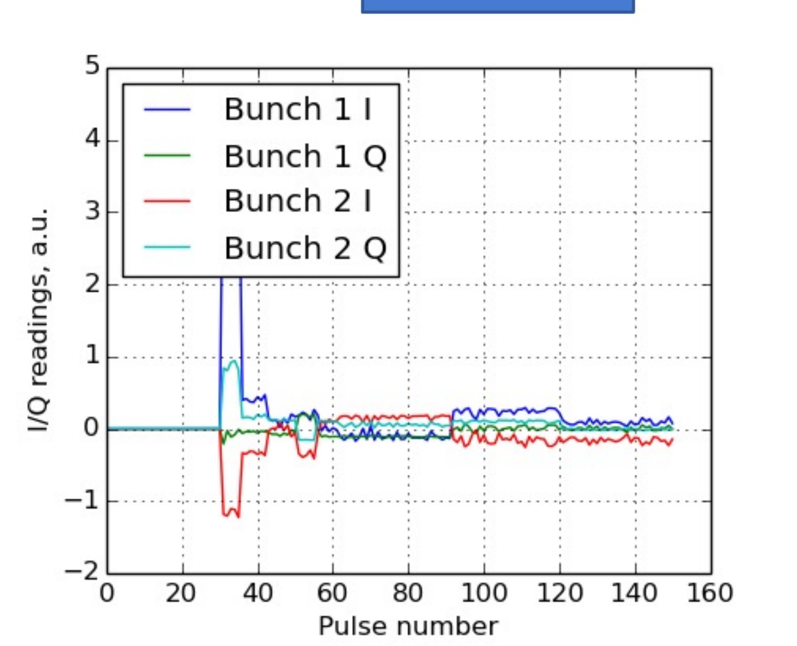


Figure 2: Example of a bad calibration.

```
# upload constants to database
cothread.catools.caput(bpm_name+bpm_dir+':iqrot',c.iqrot)
cothread.catools.caput(bpm_name+bpm_dir+':posscale',c.posscale)
cothread.catools.caput(bpm_name+bpm_dir+':tiltscale',1.0)
# calibration state
cothread.catools.caput(bpm_name+bpm_dir+':calstate','cal')
# calibration file name
cothread.catools.caput(bpm_name+bpm_dir+':tuneFileName',specific_file)
cothread.catools.caput(bpm_name+bpm_dir+':calFileName',specific_file)
```

The next step is to upload the chosen calibration constants to the online processing stage using the script shown above. This is controlled by a program called EPICS.

Analysis

For the analysis, we start by comparing the x and y positions of bunch one and two. This is to see if the two bunches are correlated. If they are, we can then proceed with the analysis.

The next step in the analysis is to work out the resolution of the cavity BPM. To do this, I worked out the root mean square (RMS) of difference between the predicted x position and measured x position using the section of code shown below.

```
bunch1_corelation = np.array(xpos1_bpm1) - np.array(x_pre_bunch1_bpm1)

#bunch 2
bunch2_corelation = np.array(xpos2_bpm1) - np.array(x_pre_bunch2_bpm1)

#Root mean square values for the two bunches
rms_bunch1 = np.sqrt(np.mean(bunch1_corelation**2))
rms_bunch2 = np.sqrt(np.mean(bunch2_corelation**2))
```

To work out the predicted x position data, two cavity BPMs are needed. A line of best fit is fitted to the position data of the first cavity BPM. Then using this fitted line and the y position form the second cavity BPM the predicted x position can be calculated.

The results of my analysis can be seen in Figure 3. Here I found an upper limit for the resolution of this cavity BPM to be 655.44 μm.

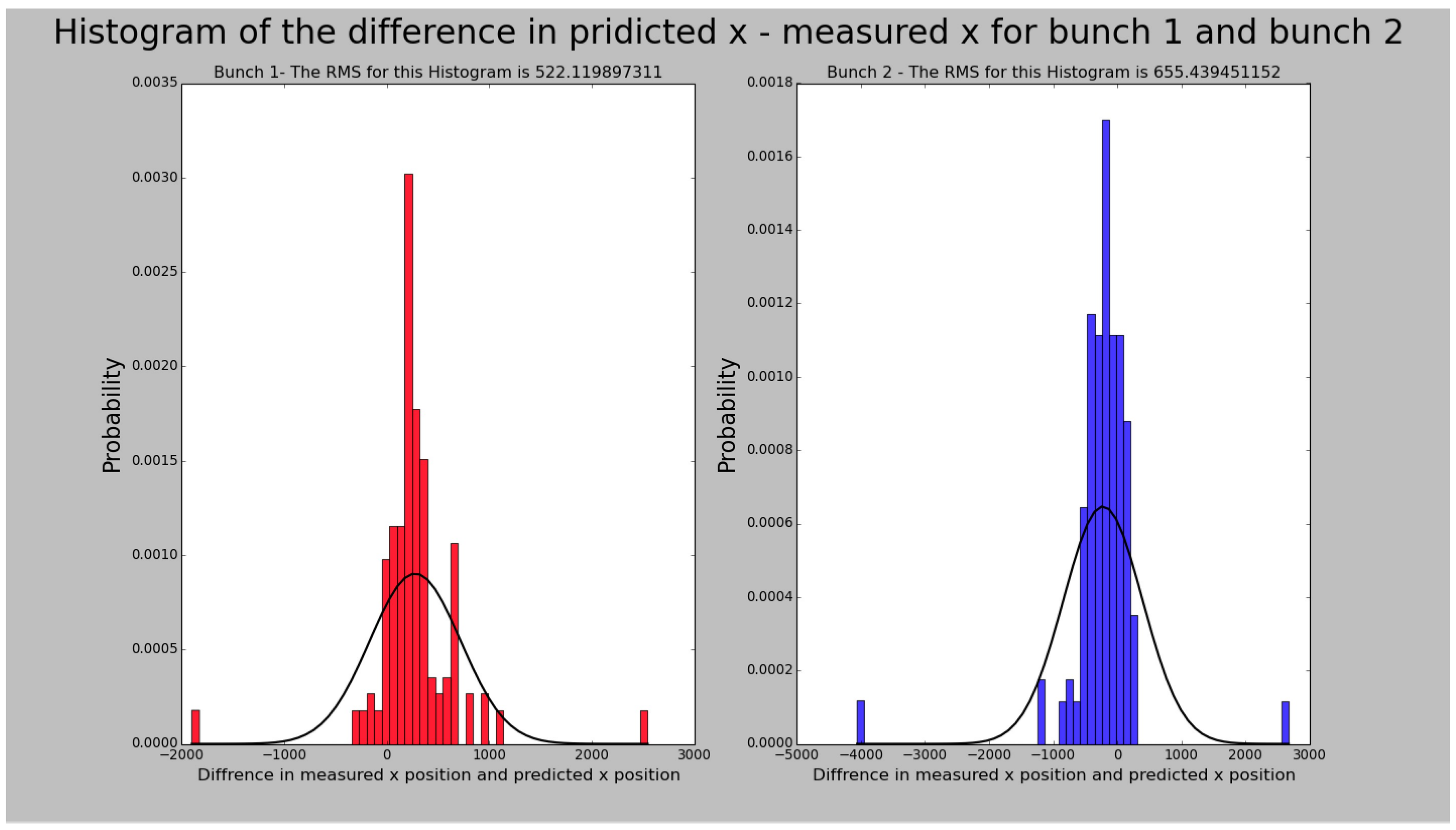


Figure 3: Histograms showing the distribution of the difference in the measured and predicted values of x.

Future analyses

At present, the signals of bunch one and two are overlapping, and thus further analysis could be conducted on the waveform of the two bunches in order to separate their signals. This would give more detail on the beam.

Conclusion

During this project I have shown a method for going from raw cavity BPM data to an upper bound for the resolution of a cavity BPM. The measurement that I have achieved have shown that there is more work to be done to the analysis process which could help to get a better upper-bound for this measurement. During the data compiling stage, I was able to process and visualise data that had not been visualised before, therefore creating a useful tool to be used in the future.

References

[1] Nakamura, 2008, MSc thesis, The University of Tokyo
[2] Kim et al., 2012, Physical Review Special Topics - Accelerators And Beams.