Resolution measurements of the temporary readout electronicss of the beam position monitors in the first two undulators of TTF

R. Neumann, M. Wendt, K. Wittenburg
DESY -MDI-

Internal Note DESY MDI-99-06
14 December, 1999

Introduction

Measurements done at the TTF with the HERAe beam position monitor readout electronicss are presented. This electronics is of the type used in HERAe, PETRA and DORIS. Following a proposal of F. Peters, this electronics has been used temporarily for the readout of the BPMs in the first two FEL-undulators in TTF. The signals of the 20 BPMs (80 pickup electrodes) are multiplexed, so that only one readout channel is needed. The behavior of this readout electronics is well known after many years of experience in circular accelerators. However, its behavior in the TTF has to be studied.
In the following, we are interested in the resolution of relative measurements only, and not an absolute calibration of the BPMs. There are potentially large errors in the absolute value of the beam position due to the vacuum chamber position as well as from (additive) calibration constants in the BPM analysis. The error of the relative calibration of the BPM is expected to be about 10%.

1. Test pulse versus beam signals

For all experiments, the electronics installed at TTF was used.
For the first step of this experiment, a test pulse was split into four to simulate the four pickup electrodes and were fed into the multiplexer channel BPM 5UND2 (the 5th BPM of the 2nd undulator). The MUX was directed this channel to the readout electronics and 100 cycles of the pulser were stored. The data were processed in the usual way[1] to deliver the beam position calibrated in mm. The results are shown in Fig. 1 a, b for the horizontal and vertical planes. The histograms are fit very well by a gaussian, with a width of σ_{test} = 4 µm (horizontal) and σ_{test} = 7 µm (vertical). The different resolution in the two planes is a result of the different spacing of the pickup electrodes in the vacuum pipe. From experience in DORIS and PETRA, one can conclude, that the main source of statistical fluctuations is not generated in the readout electronics, but is generated in the test pulse generator. Therefore the width of the distributions gives an overestimate of the resolution; the resolution is expected to be somewhat better. However, currently the resolution for a single linac pulse is limited by the 8 bit ADC, where one digit corresponds to about 30 µm (horizontal) and 50 µm (vertical).

The same MUX settings were used to measure the position distribution of the linac beam. The pickup electrodes of BPM 5UND2 were connected to the MUX and the data of 100 successive shots (1 bunch with about 1nC) were analyzed. Fig. 2 a, b show the results. A gaussian fit gives a width of σ_{beam} = 48 µm (horizontal) and σ_{beam} = 26 µm (vertical). In Fig 3 a, b one can compare the readings of the beam and the test pulses. The larger variation of the data with beam is a result of a real beam jitter. One can expect that the present readout system can detect beam position variations of down to σ_{test} at TTF!

The uncertainty of $\sigma_{test, beam}$ is about 10% because of the relative calibration error.

---

[1] Like HERAe, PETRA and DORIS, except that the pickup spacing is different.

2. Some Orbits

A sample of orbits were collected during about 1 hour of "stable" linac operation. No actions were done by the operators to provide somehow stable beam conditions. 15 orbits are shown in Fig. 4 a, b for each plane. Note that the horizontal and vertical orbits of one sample are measured simultaneously and that there is no possibility of a malfunction of the BPM readout in one plane only[2]! The last curve in the figures shows the standard deviation σ for each BPM from the 15 samples. In the vertical plane σ is around 200 µm while σ is around 500 µm in the horizontal plane.

3. Conclusions

The present BPM readout system has a relative resolution of less than 7 µm in the vertical plane and less than 4 µm in the horizontal plane, by the help of averaging. This is presently much better than the linac beam orbit reproducibility. A single linac pules measurement is currently limited by the 8 bit ADC to about 30 µm (horizontal) and 50 µm (vertical).

Unfortunately, the system cannot guarantee the same reproducibility in comparing orbits, because of the multiplexing system. The experience in DORIS and PETRA shows that in most cases the error is negligible, but it may exceed 1%, or even more in case of a broken MUX channel. However, this effect occurs always in both planes simultaneously and can be detected easily.

The present BPM readout provides an excellent tool for observing the stability of the Linac beam. The uncertainty due to the MUX switching can be compensated by adding readout channels. The final BPM readout system will not rely on a MUX and the resolution will be improved by using a 14 bit ADC.

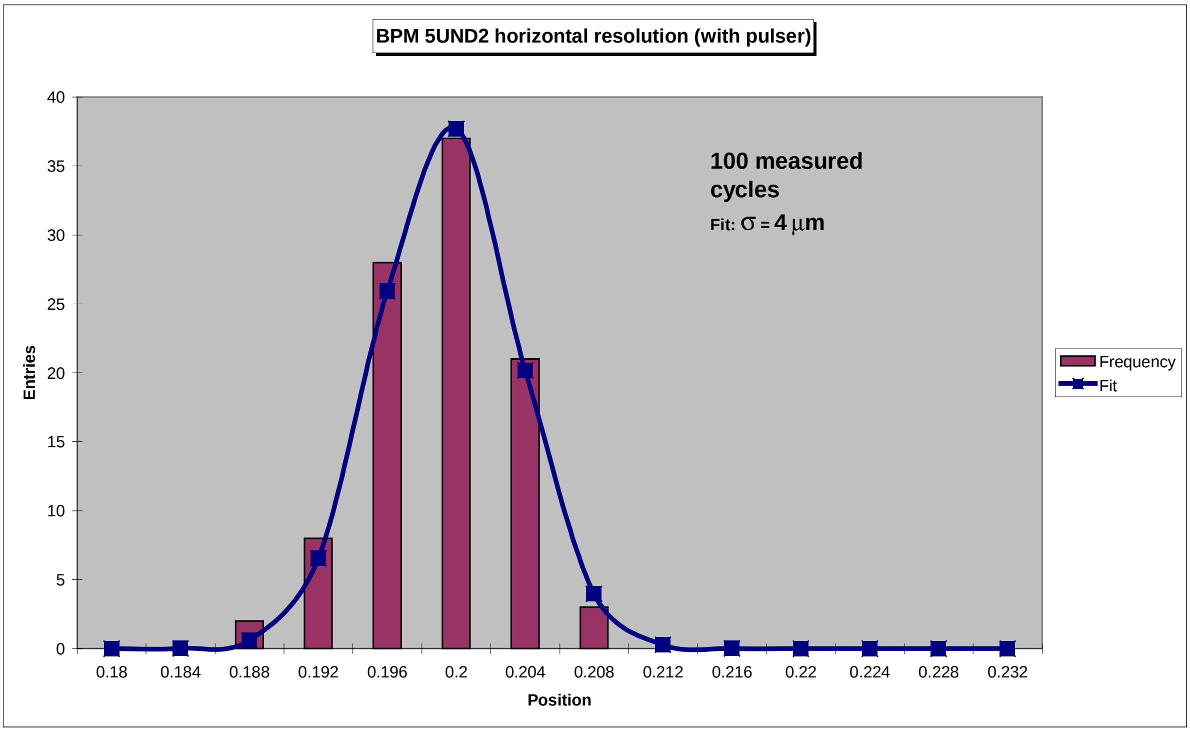
4. Acknowledgements

We would like to thank Fr. Wedtstein for her engagement in preparing the software for the display and storage of the beam positions and orbits. The initial idea for the temporary use of the HERAe BPM readout system at TTF came from F .Peters; thanks to him for many fruitful discussions.

5. Figures

See next pages.

[2] due to the special readout scheme of the electronics



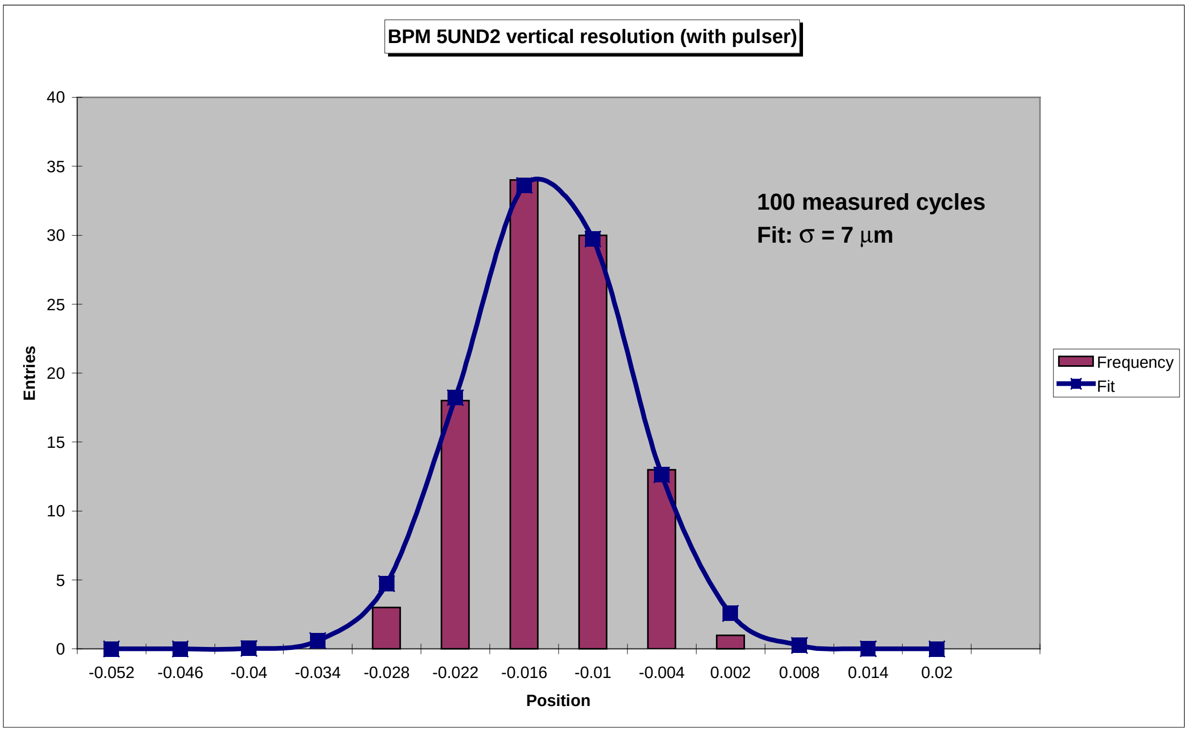


Fig. 1 a, b Resolution of the BPM readout electronics determined by 100 test pulses. The square boxes represent a gaussian fit to the data.

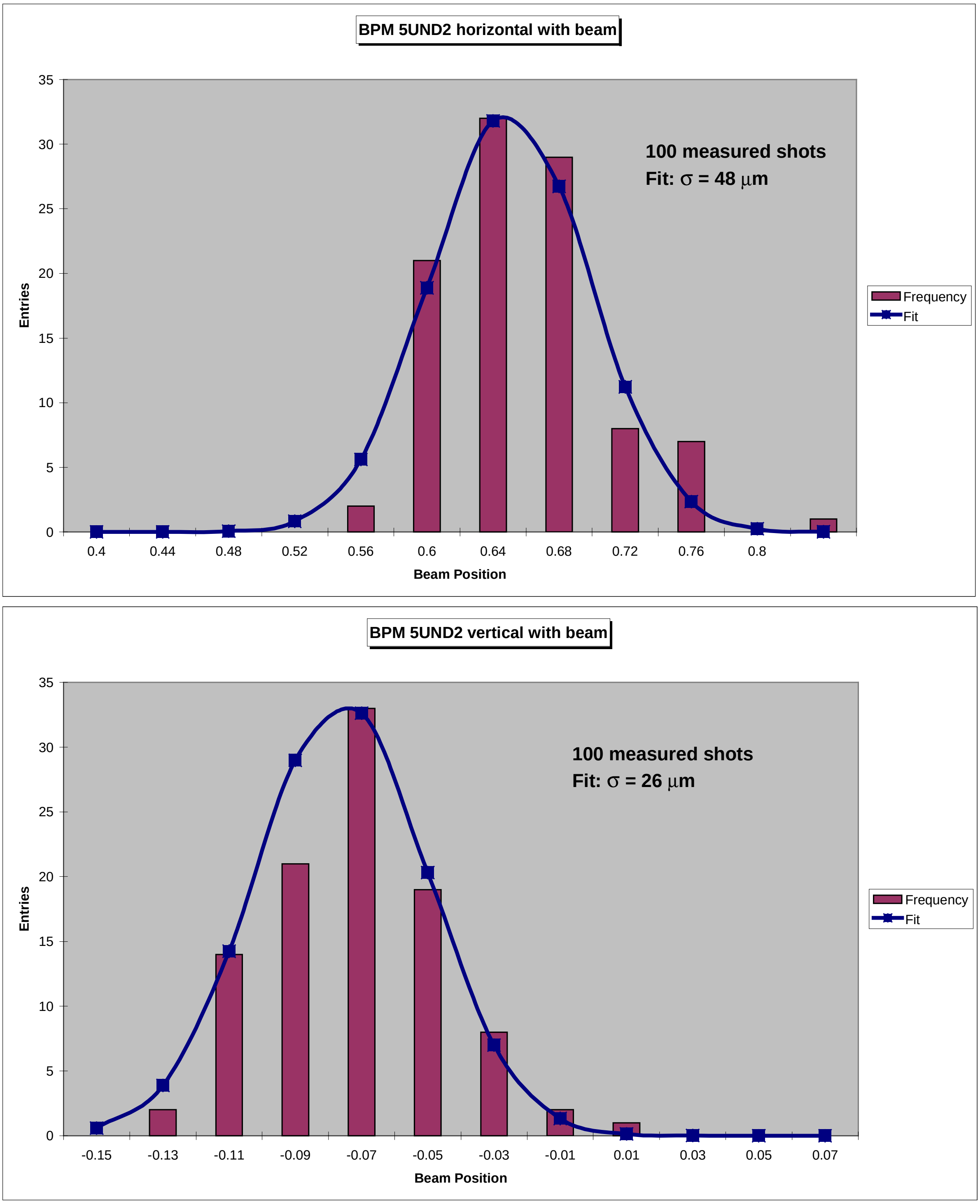
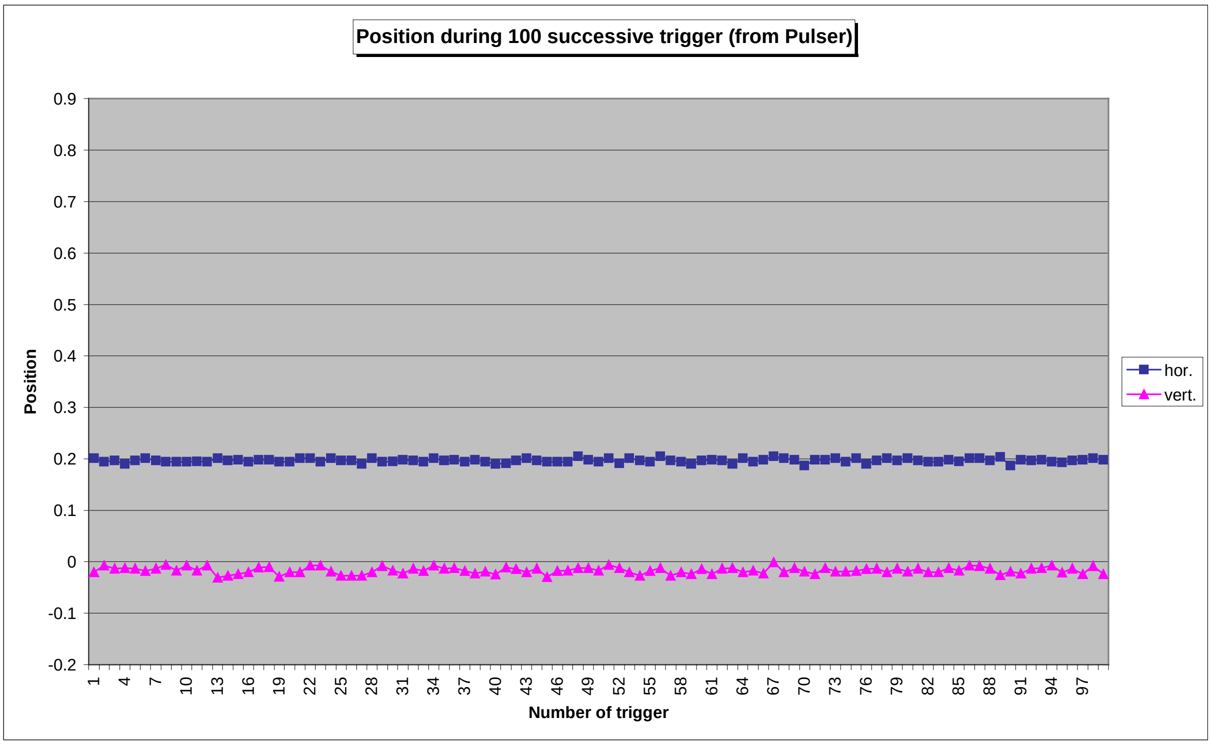


Fig. 2 a, b: Measured position distribution of the linac beam. The square boxes represent a gaussian fit to the data.



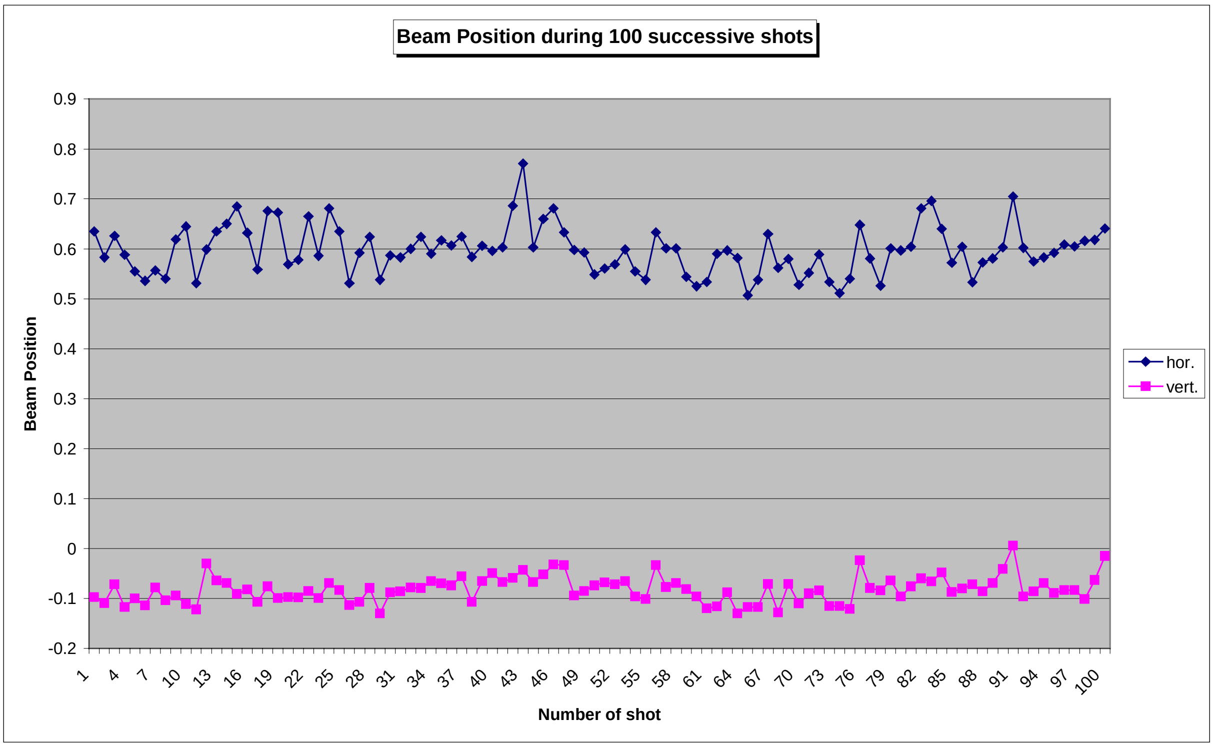
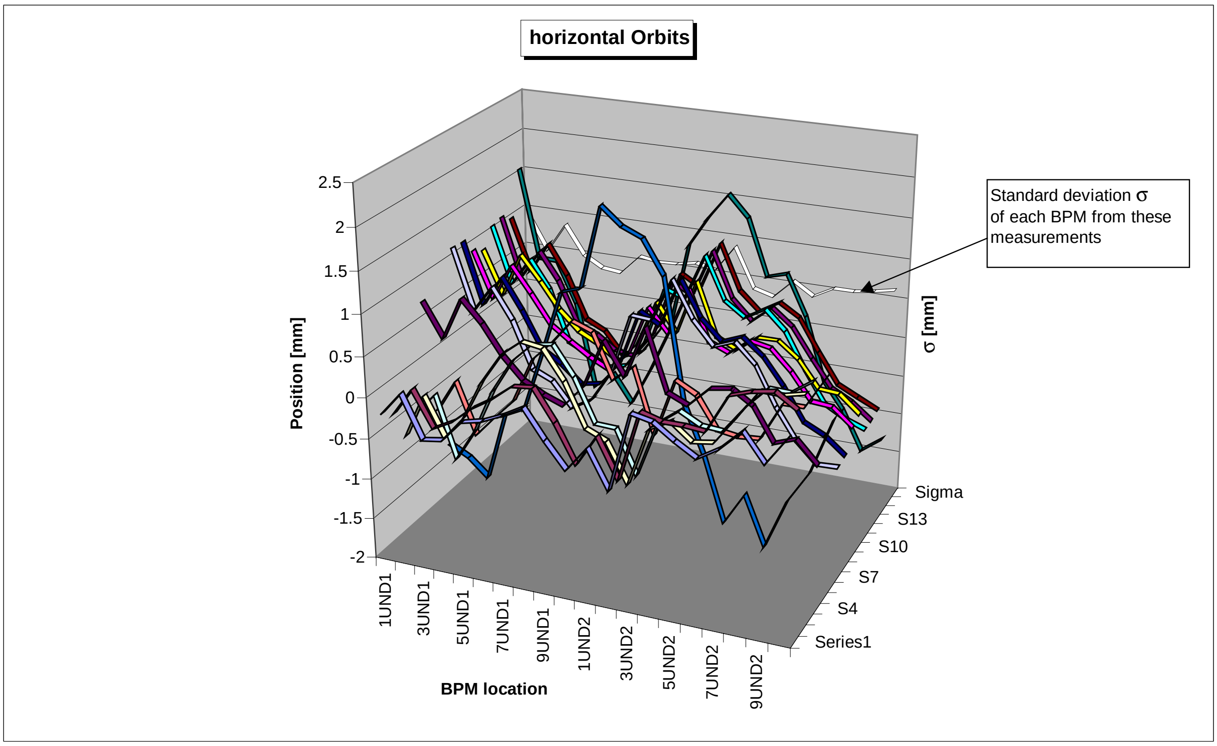


Fig. 3 a, b: Comparison of the readings of the beam and the test pulses.



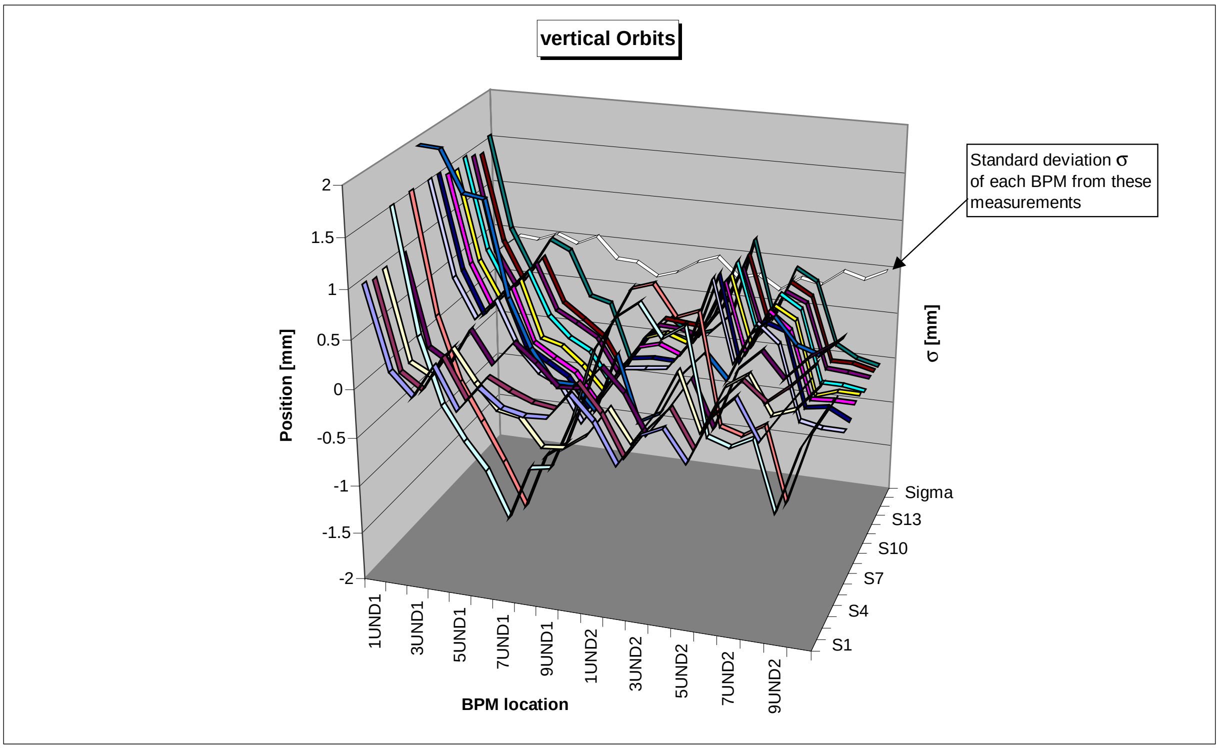


Fig. 4 a, b: Different orbits measured within one hour of "stable" beam operation.