

# First Results of the High Resolution Wire Scanners for Beam Profile and absolute Beam Position Measurement at the TTF

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## Abstract

In the TESLA Test Facility (TTF), wire scanners are used to measure the electron beam profile and position. Especially the intended use of the wire scanners to centre the electron beam in the Free Electron Laser (FEL) undulator needs a precise alignment of the wire scanners in respect to the undulator axis.

The wire scanners should define a reference axis with respect to the external reference system of the undulator with an accuracy better than 30  $\mu\text{m}$ .

The wire scanners allow a beam profile measurement which will be used to optimise and match the beam optics for the undulator. First experimental results of beam position and profile will be presented and discussed.

## 1. INTRODUCTION

The undulator at the TTF-FEL consists of three undulator modules.

The narrow space between and at both ends of the undulator modules is used for diagnostic.

Two types of monitors are included in a so-called diagnostic block.

RF type cavity monitors for horizontal and vertical beam position measurement and vertical and horizontal wire scanners allow to measure the beam profile and position [1].

The beam position can be measured with respect to external reference marks so that the position of the beam before, after and in between the undulator segments at several fix points is known.

Figure 1 shows a photograph of the diagnostic block between two undulator sections.

The principle set-up of the wire scanners is sketched in figure 2. Each wire scanner fork (wire holder) is equipped with 3 wires. One tungsten wire of a diameter of 20  $\mu\text{m}$ , and two carbon wires of a diameter of 5  $\mu\text{m}$ . This allows to select the wire as a function of beam size, beam intensity and required resolution. Electrons hitting a wire produce scattered electrons, which are detected by scintillation counters.

Behind each pair of wire scanners, a scintillation counter is installed covering nearly  $360^\circ$  around the beam tube [2].

The main difficulties that had to be overcome were:

- *The cleaning and assembly of the complicated diagnostic block.* Together with the attached components like rf Feedthroughs, the assembly had to take place under clean room conditions according to TTF specifications (clean room better than class 100) [3].
- *The alignment and stretching of wires.* The tightening of the wires in the fork is very critical. It is difficult to stretch the wires to a straight line and fix them. After installation the wires have to pass the narrow rf shielding slit (width 1.5 mm) in the diagnostic block during the scan of the beam profile. The alignment is extremely crucial since small deviations from the centre of the slit cause the damage of all wires.
- *The calibration of the wire scanner in the diagnostic block.* The goal of this calibration is to measure the position of the wires with respect to the reference planes of the diagnostic block smaller than  $30\text{ }\mu\text{m}$  in both planes. This calibration was done using a vertical coordinate measuring machine (CMM). A local clean room was installed in front of the machine. The diagnostic block was under clean room conditions during the entire calibration measurement. To measure the wire position a microscope was mounted to the CMM. It allowed to see the thin wires and to measure the distance of the wires to the reference planes. Reproducibility was achieved by a linear encoder connected to the linear driving system of the wire scanner.

## 2. RESULTS

Figure 3 presents the results of all eight wire scanner measurements recorded during FEL operation of the TTF linac. The electron beam profile measurements were done with the  $20\text{ }\mu\text{m}$  thick tungsten wire. The tungsten wire was chosen to get sufficient intensity on the scintillation counter.

The signal from the carbon wires was too small to be detected. By reducing the background (less beam loss before and inside the undulator area) and reducing the electron beam spot size, the signal-to-noise ratio can be improved.

The measured profiles indicate that the beam offset along the entire undulator stays below 300

$\mu\text{m}$  during SASE operation.

The spot size is somewhat larger than expected. Measurements have shown that a part of the spot size is generated by dispersion.

Each undulator has a superimposed FODO structure of 10 quadrupoles per undulator [4]

In addition to the wire scanners ten beam position monitors (BPM), which allow the measurement of the beam position inside the quadrupoles, are installed along the undulator chamber [5].

Figure 4 gives a comparison between the beam position measured by the wire scanners and the BPMs inside the first two undulators. It is clear that the BPMs show some random position deviations due to the fact that they had not been calibrated. The fit of a betatron motion to both, the 20 BPMs and the four wire scanner readings, results in a similar betatron amplitude and phase of the beam motion.

The measurement of a difference orbit, implemented by a kick before the undulator, allows to verify the beam optics inside the undulator by comparison of the expected and measured betatron motion.

Figure 5 shows the good agreement of the measured and calculated difference orbits.

The betatron motion is just fitted in amplitude and phase to the measured difference orbit.

Both measurements (wire scanner and BPMS) result in the same difference orbit. The agreement with the calculated betatron motion is very good ( $\sim 50 \mu\text{m}$ ).

### 3 CONCLUSION

The eight wire scanner allow to measure the beam profile and the beam position with high reproducibility and accuracy (better than  $30 \mu\text{m}$ ). Good agreement between the calculated and measured phase advance inside the undulator was observed. The position measurements of the wire scanners are in good agreement with the 20 distributed BPMs.

### 4 REFERENCES

- [1] U. Hahn, J. Pflüger, G. Schmidt, Nucl. Instr. Meth. A429 (1999) 276.
- [2] S. Striganov, G. Schmidt, K. Wittenburg, Estimation of the Signal from the Wire Scanner in the TTF, TESLA Report, TESLA 99-08.

- [3] D. Edwards et al., Proposed cleaning procedures for the Vacuum Components for the TESLA Test Facility, TESLA Report 15 (1997)
- [4] Y. Nikitina and J. Pflüger, Nucl. Instr. And Meth. A375,325 (1996)
- [5] Hahn et al., Design and Performance of the Vacuum Chambers for the Undulator for the VUV FEL at the TESLA Test Facility at DESY, Proceedings FEL Conference 2000.



Fig.1: Diagnostic block between two undulator sections.

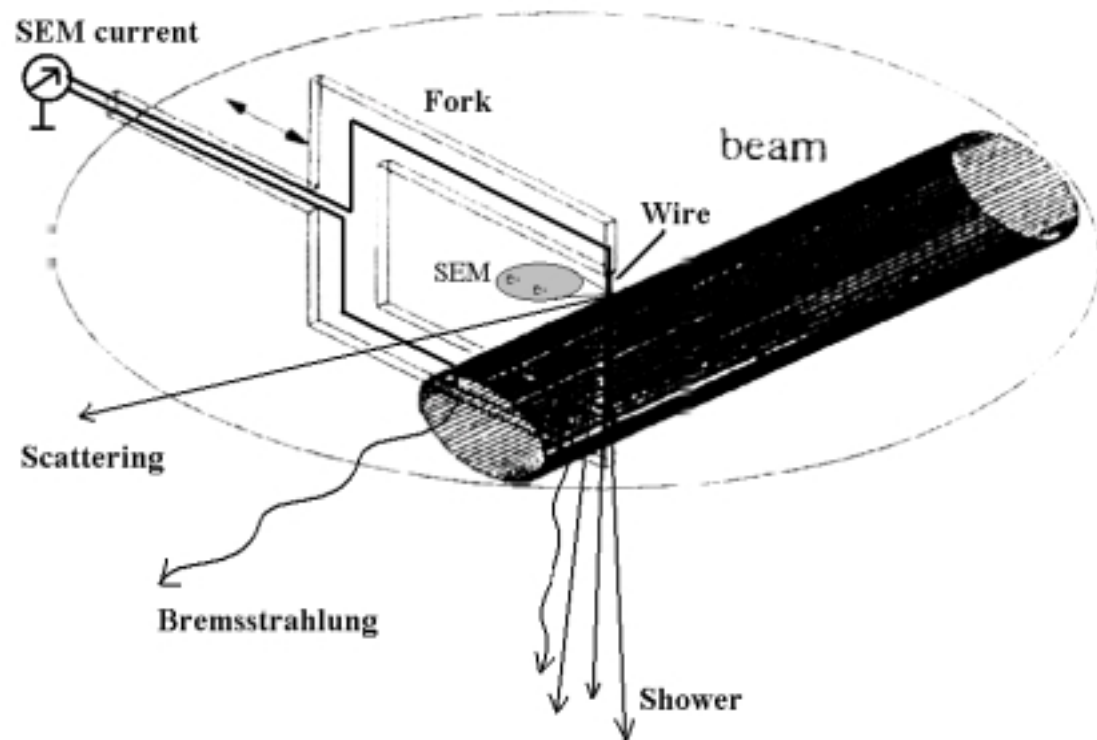


Fig.2: Possibilities to detect the wire scanner signals

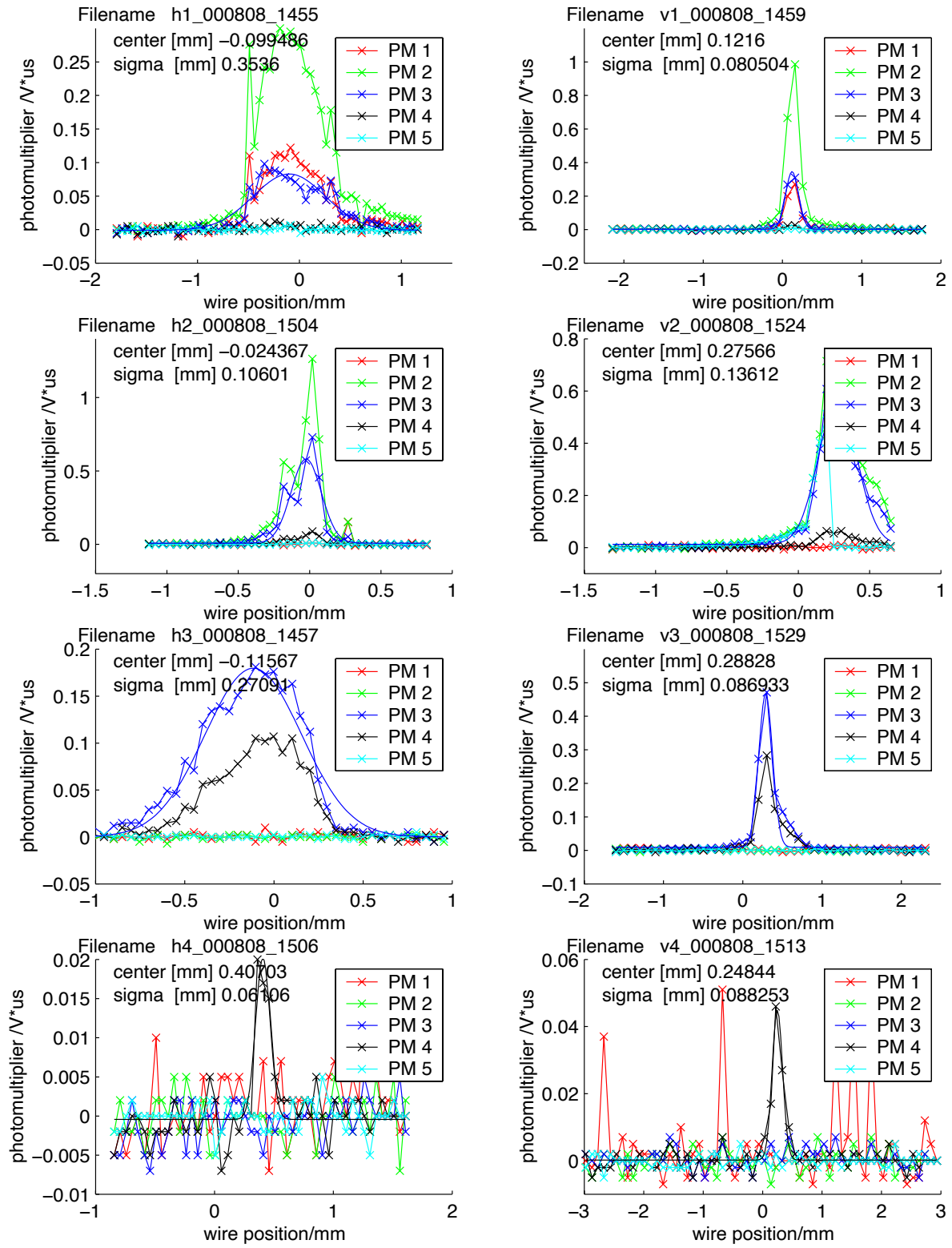


Fig . 3: Measurement of beam profiles using the wire scanner.

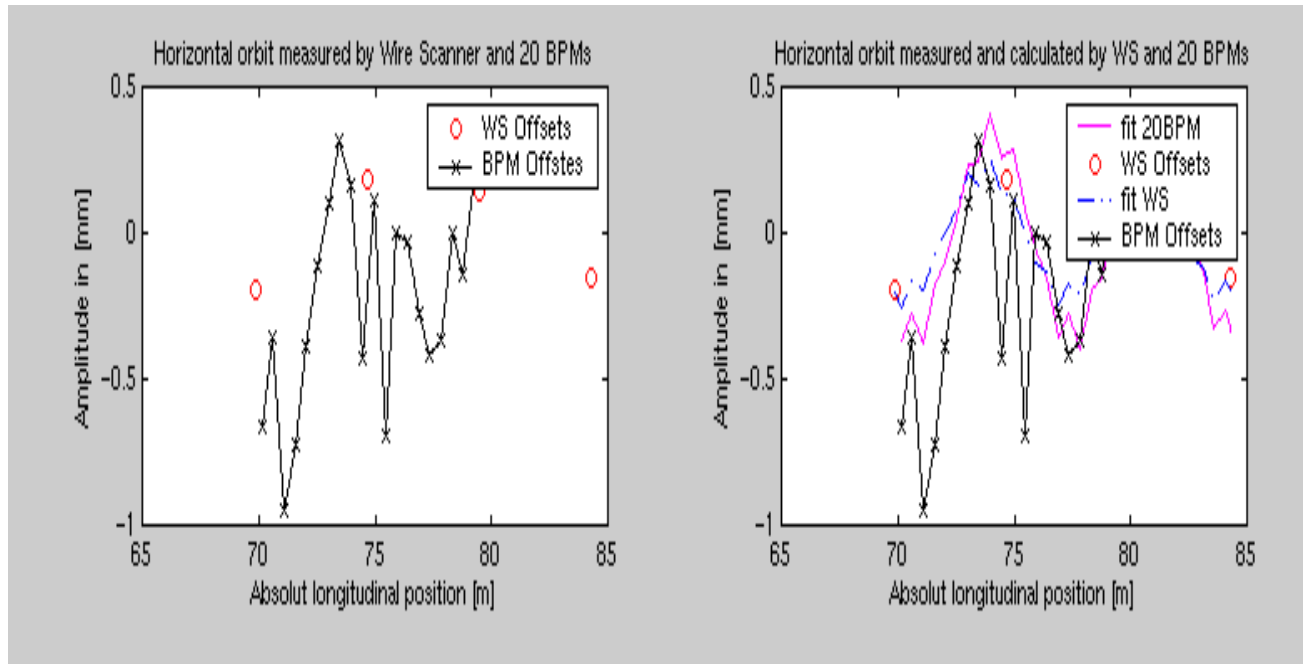


Fig.4: BPM and Wire Scanner Measurement

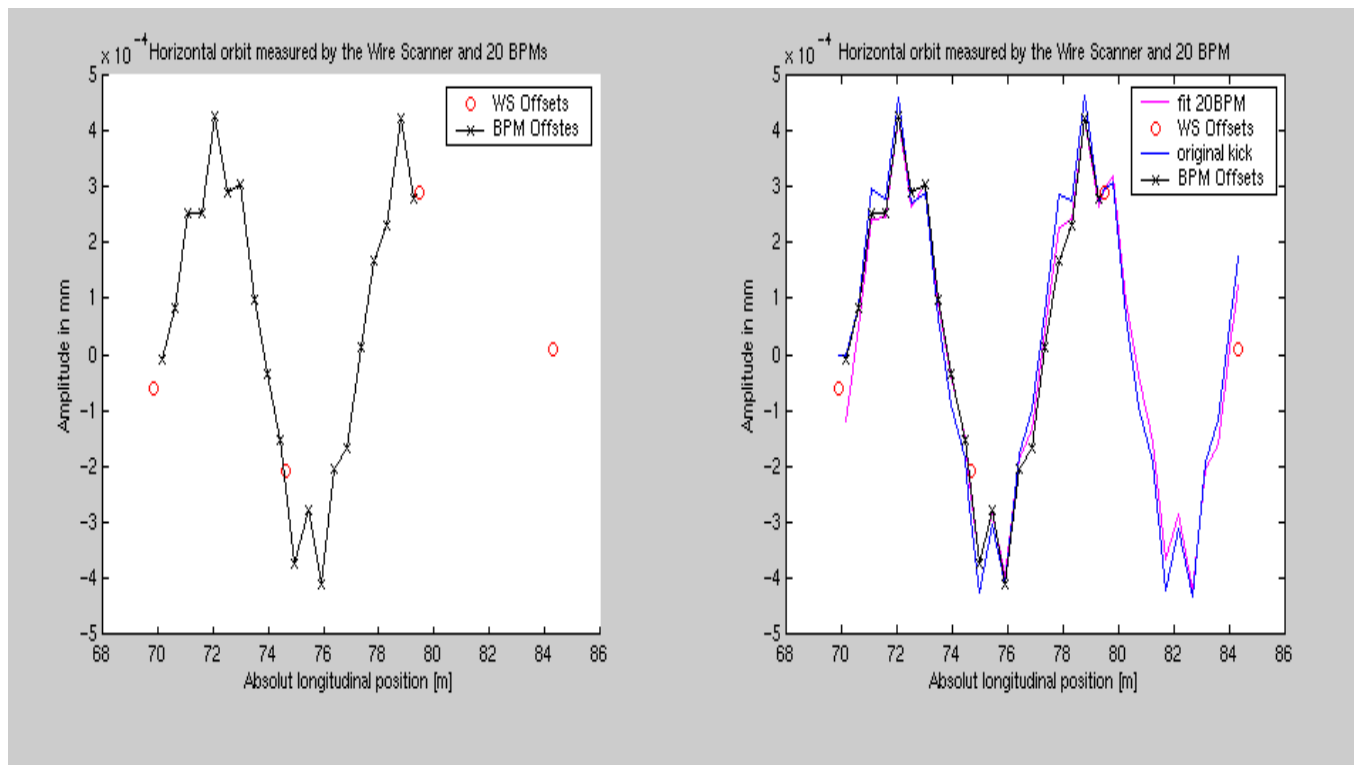


Fig.5: Difference orbit by implementing a kick to the beam before it enters the undulator