ISBN: 978-3-95450-201-1 doi:10.18429/JACoW-IBIC2018-MOPB04

PROGRESS IN THE STRIPLINE KICKER FOR ELBE

C. Schneider†, A. Arnold, J. Hauser, P. Michel, HZDR, Dresden, Germany

Abstract

The linac based cw electron accelerator ELBE operates different secondary beamlines one at a time. For the future different end stations should be served simultaneously, hence specific bunch patterns have to be kicked into different beam-lines. The variability of the bunch pattern and the frequency resp. switching time are one of the main arguments for a stripline-kicker. A design with two tapered active electrodes and two ground fenders was optimized in time and frequency domain with the software package CST. From that a design has been transferred into a construction and was manufactured. The presentation summarises the recent results and the status of the project.

INTRODUCTION

The electron beam with max. 40 MeV is mainly used for conversion into secondary radiation at different end stations; infrared, terahertz, gamma, positron, neutron und electron laser interaction (Figure 1). For every beam line dedicated energies and optimized settings have to be adjusted, but not every experiment demands the full 13 MHz cw capability of ELBE.

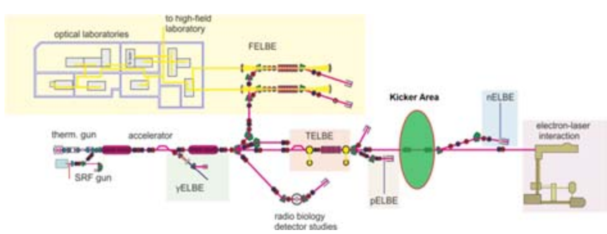

Figure 1: Overview of the ELBE layout with the position of the kicker station.

As an example the end stations from neutron an electron laser interaction are using high bunch charge but 200 kHz and 10 Hz respectively and are separated by just one beam line branch. Therefore a kicking device in front of the neutron and laser interaction beam line can serve both beam lines at a time.

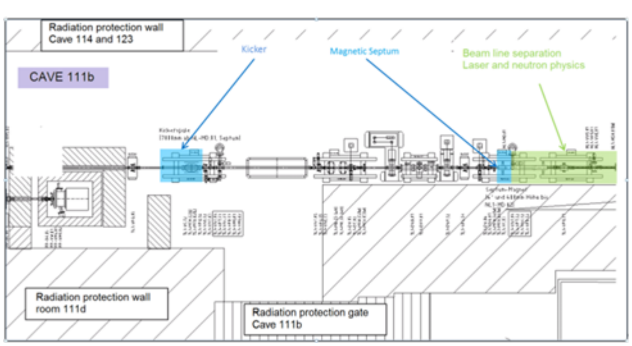

Figure 2: Detailed sketch of the ELBE kicker area.

A magnetic septum is installed to align the beam either to the neutron or laser interaction beamline (see Figure 2). The separation for the magnetic septum is about 10 mm beam displacement. The distance between kicker and septum will be around 7 m. Hence a kick angle of around 1.5 mrad must be realized. In the simulation with the CST software package a voltage of 427 V per strip-line and an electrode distance of 30 mm was used. This results in a mean kicking angle of the phase space distribution of 1.5 mrad.

DESIGN AND OPTIMISATION

The ELBE strip-line kicker design uses the common approach [1, 2, 3] with two tapered active electrodes and two ground fenders. The slightly difference is the placing of the two ground fenders in the outer area of the electrodes.

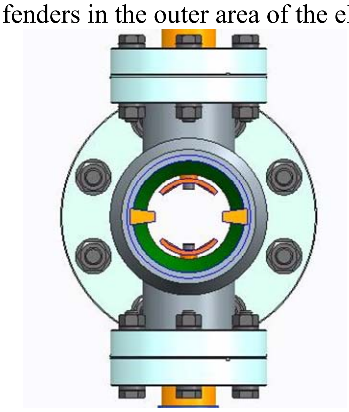

Figure 3: Sectional drawing of the ELBE kicker in the area of the connection ports.

The distance between the electrodes was chosen to 30 mm having a balance of lower HV supply and still feeding the electron beam in a homogenous field area through the kicker (Figure 3). The design was optimized with the CST package to fit best to 50 Ω impedances, for optimal S-parameters in the frequency domain as well as having best field flatness (Figure 4) in the significant area between the electrodes.

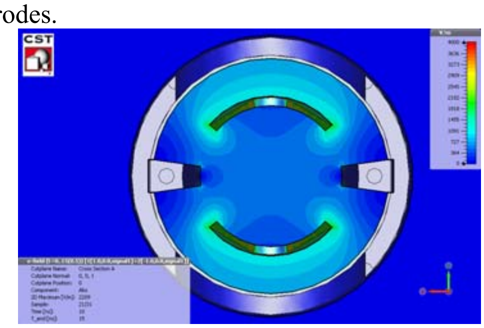

Figure 4: Sectional plot of the electric field in the medium section of the kicker structure.

KICKER SETUP AT ELBE

The kicker will be installed in the radiation shielded cave 111b (see Figure 5). The HV-device to power the kicker

* Work supported by BMBF
† Christof.Schneider@hzdr.de

ISBN: 978-3-95450-201-1 doi:10.18429/JACoW-IBIC2018-MOPB04

must be installed outside due to radiation protection reasons. Therefore two 25 m long RG213 cables are installed by special feed through into the cave. The HV-device will be connected to the ELBE synchronization system.

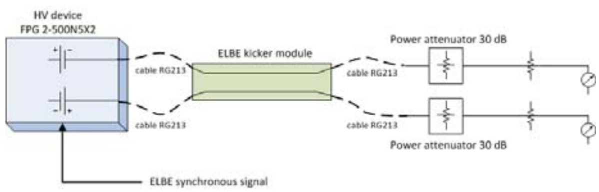

Figure 5: Basic kicker setup at ELBE.

The diagnostics for cooling water, temperature and voltage stability will be integrated into the ELBE control system

HV-DEVICE CHARACTERISATION

The primarily favoured high voltage switches from the company Belke could not brought into operation by the company. Therefore the high voltage pulse generator FPG 2-500N5X2 from the company FID had been chosen as the pulser source for the kicker. The parameters of the device are max. +/- 2 kV in a 50 Ohm load and a repetition rate of max. 500 kHz. The pulse plateau length is around 5 ns.

An important feature of the device is the voltage and time stability in the 1% range. With the setup in Figure 5 but without the kicker the stabilisation measurement had been performed with an RTO1044 from Rohde&Schwarz. The plots in Figure 6 and Figure 7 showing the measured distribution of voltage and time jitter for 1 kV and the maximum repletion rate of 500 kHz parameters of the device. The standard deviation of the voltage distribution is around 1 V and the time jitter distribution around 60 ps.

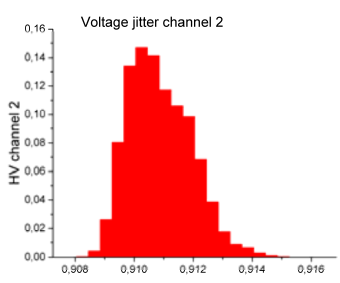

Figure 6: Voltage jitter distribution HV-pulser (SD ~ 1V).

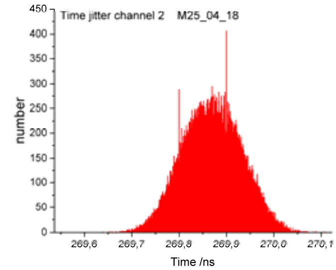

Figure 7: Time jitter distribution HV-pulser (SD ~ 61 ps).

While the voltage jitter is in the desired range the time jitter can lead to a larger voltage deviation due to the not flat pulse plateau.

NWA MEASUREMENTS

A very important step in the evaluation of the kicker design is the comparison of the measured S-parameters with that from the CST simulation. In Figure 8 and Figure 9 NWA (network analyser) measured S-Parameter in reflection and transmission are shown.

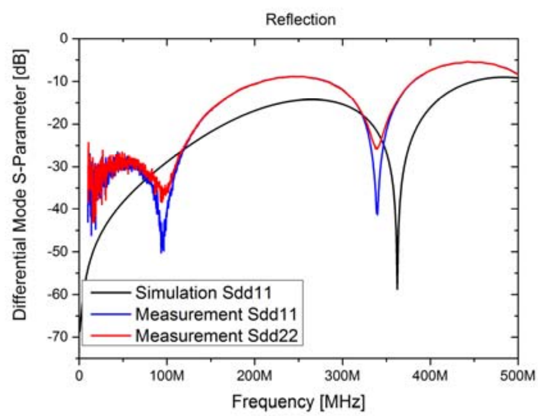

Figure 8: Comparison of measured S11 and S22 parameters in diff. mode excitation with the CST simulation.

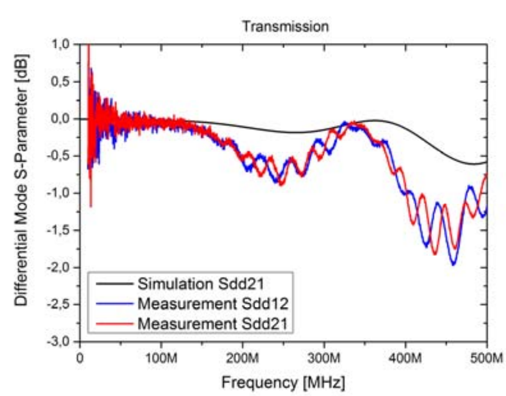

Figure 9: Comparison of measured S12 and S21 parameters in diff. mode excitation with the CST simulation.

ISBN: 978-3-95450-201-1 doi:10.18429/JACoW-IBIC2018-MOPB04

The shape and notches in the attenuation of the reflective wave, see Figure 8 are well represented by the measurement, while the amplitude is about 8 dB higher. Perhaps, the reason is a not expected behaviour of the couplers, to be clarified in a further measurement. Also the transmission, see Figure 9, represents the overall shape of the CST simulation. The main deviation starts from the area above 200 MHz. When analysing the frequency content of the signal from the HV pulser, see Figure 10, it is obvious that mainly the frequency range lower than 200 MHz matters.

Figure 10 shows the system function extracted from the NWA measurement and the frequency spectrum from the incident generator pulse. Using the argument about the relevant frequency range the system function is ~ 1. Calculating the output signal from the kicker by the system function from the 4 pole measurement and the frequency content of the incident pulse and doing the back transformation into the time domain leads to the expected output signal past the kicker. The signal is shown together with the incident pulse from the generator in Figure 11. The nearly reproducible pulse leads to the conclusion that adaption in the relevant frequency domain is like expected from the CST simulation.

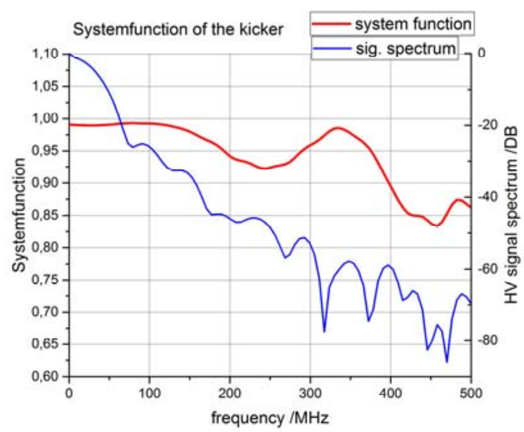

Figure 10: System function of the kicker and frequency spectrum of the incident HV pulse.

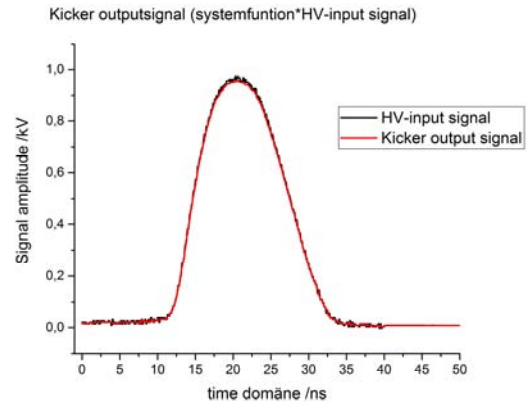

Figure 11: Incident HV pulse from the generator and estimated kicker output signal calculated with the system function from the NWA measurement.

SUMMARY

The first NWA measurement of the kicker leads to the conclusion that - despite the attenuation level of the reflected wave – the kicker performs like from the design and CST optimization expected. Finalizing the lab measurement the kicker will be installed in the ELBE beam line in the end of the year. There the final tests and characterization of the device will be performed.

REFERENCES

[1] D. A. Goldberg and G.R. Lambertson, "Dynamic devices a primer on pickups and kickers", Lawrence Berkeley Laboratory, Berkley, California 94720, Internal Report

[2] A.W. Chao. and M. Tigner, Handbook of Accelerator Physics and Engineering. Second Edition 2013, pp. 602

[3] G. Staats et al," Kicker development at the ELBE facility", in *Proc. IPAC'14*, Dresden, Germany, June 2014, paper MOPME067