ISBN: 978-3-95450-208-0 doi:10.18429/JACoW-IPAC2019-MOPTS030

CHARACTERISATION AND FIRST BEAM LINE TESTS OF THE ELBE STRIPLINE KICKER

Ch. Schneider†, A. Arnold, M. Freitag, J. Hauser, P. Michel, HZDR*, 01328 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 prototype has been tested in the laboratory and installed in the ELBE beam line. The presentation summarises the recent results and the first beam line test.

INTRODUCTION

The ELBE is a cw superconducting electron accelerator up to 40 MeV beam energy and max 2 mA beam current, i.e., Fig. 1. Seven different experimental end-stations are operated one at a time in the 24/7 regime. Typical usage of the end-stations in 2018 with their main parameters, i.e., Table 1. To optimize the usage of the machine because of an experiment over booking factor of around 2 to 3 the kicker project has been started to evaluate the combination of end-stations e.g. with higher current with lower current demands simultaneously.

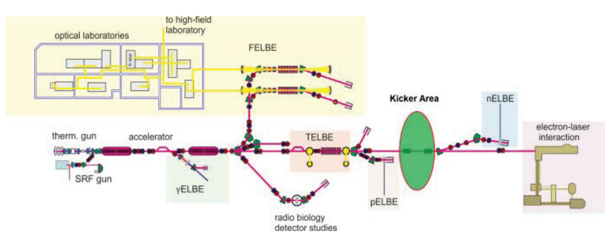

Figure 1: Overview of the ELBE layout with the position of the kicker station.

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. For commissioning the kicker was placed in front of the magnetic septum which branches either in the Neutron or Laser beam line.

Table 1: Mainly used accelerator setup parameter for different beam lines

	NP	RP	FEL	THZ	POS	NP
Usage 2018	16%	3%	26%	18%	15%	9%
E /MeV	8-16	25-30	20-32	26-32	32	32
f/ kHz	13000	100-400	13000	100	1600	100-400
A/µA	700	1	700	7	100	25

DESIGN AND CHARACTRISATION MEASURMENTS

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, i.e., Fig. 2.

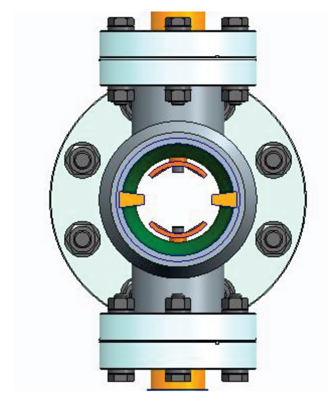

Figure 2: Sectional drawing of the ELBE kicker in the area of the connection ports.

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, i.e., Fig. 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 in the significant area between the electrodes.

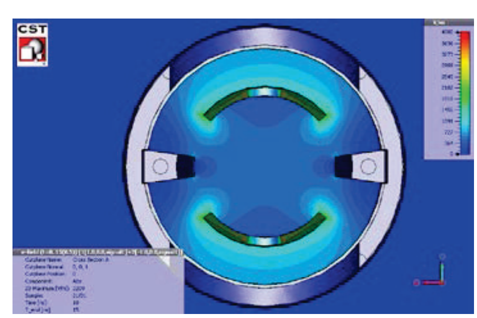

Figure 3: Sectional plot of the electric field in the medium section of the kicker structure.

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

10th Int. Particle Accelerator Conf. IPAC2019, Melbourne, Australia JACoW Publishing
ISBN: 978-3-95450-208-0 doi:10.18429/JACoW-IPAC2019-MOPTS030

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 Fig. 4 and Fig. 5 NWA (network analyser) measured S-Parameter in reflection and transmission are shown.

The shape and notches in the attenuation of the reflective wave, i.e., Fig. 4, 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. Also the transmission, i.e., Fig. 5, 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 it is obvious that only the frequency range lower than 200 MHz matters because of the rise and fall of the signal in the range of around 1ns.

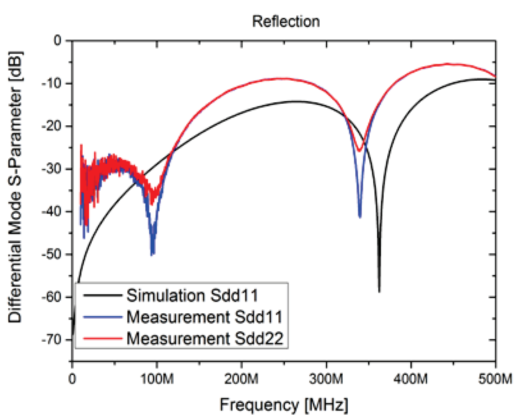

Figure 4: Comparison of measured S11 and S22 parameters in diff. mode excitation with the CST simulation.

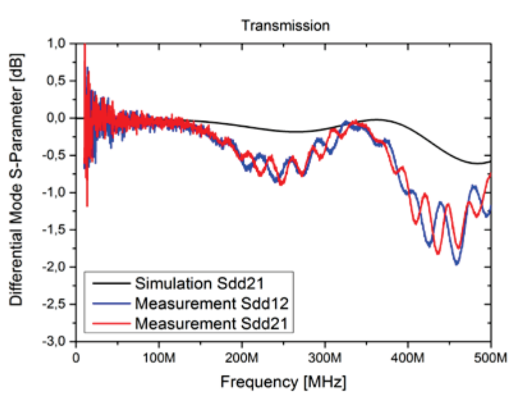

Figure 5: Comparison of measured S12 and S21 parameters in diff. mode excitation with the CST simulation.

KICKER COMMISSIONING AT ELBE

The kicker was installed in the radiation protected cave 111b at ELBE in the Neutron/Laser interaction beam line, i.e., Fig. 6) and is connected through two LCF78 cables with very low damping. The length of the cables is around 20 m because the HV-Device (FPG 2-500N5X2 from FID) is placed outside the radiation area. The trigger signal for the HV-device is connected through a fibre and a SRS DG645 to the ELBE master trigger system. The kicker was successfully put into operation and the beam displacement at the septum in 7 m distance was measured as a function of HV, i.e., Fig. 7. The diagram shows the expected linear behaviour. A slightly smaller HV is needed for a beam energy of 30 MeV as expected from simulation calculations with the program CST.

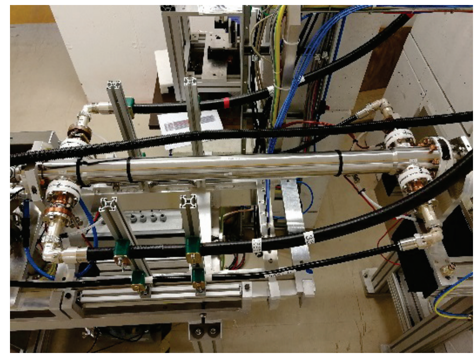

Figure 6: Picture of the kicker installation on the ELBE beam line.

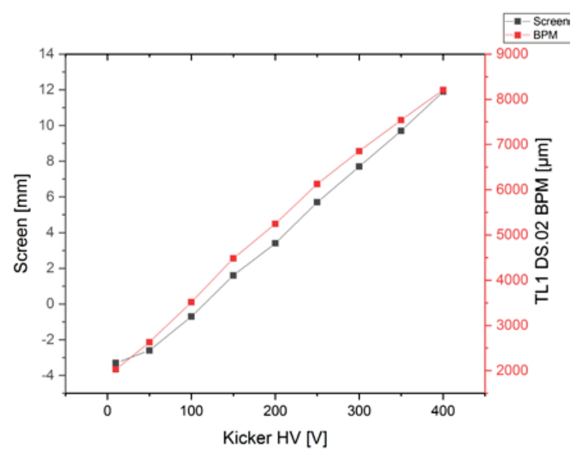

Figure 7: Displacement of the electron beam after 7 m at the magnetic septum as a function of HV.

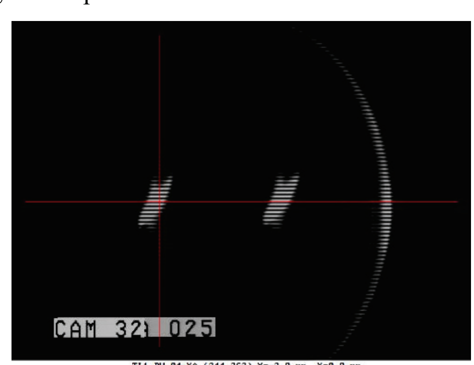

Figure 8: Screen picture from a 50/50 kicked an unaffected beam at micro pulse level at 100 kHz beam rate.

ISBN: 978-3-95450-208-0 doi:10.18429/JACoW-IPAC2019-MOPTS030

CHECK OF A 2 BEAM SETUP

In Fig. 9 the schema of the two branching Neutron and Laser interaction beam lines at the septum are represented in the view of the ELBE operator interface. A 100 kHz beam rate setting for the unaffected beam in the straight laser interaction beam line was performed, see left picture of Fig. 10. Then the beam was kicked with a 50/50 rate at micro bunch level, i.e., Fig. 8, and set through the Neutron beam line, see right picture of Fig. 10. Setting up both beam lines is slightly more difficult because changes on the magnetic septum for the adjustment of one beamline affects the other setting. Therefore a higher effort has to be taken into account.

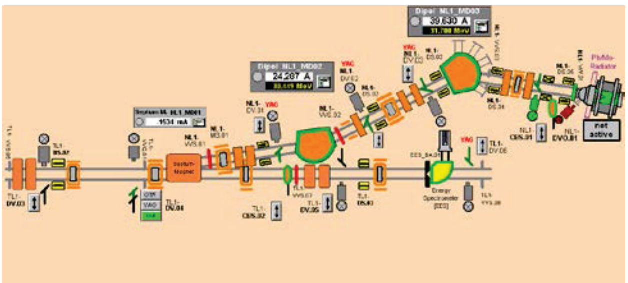

Figure 9: Schema of the beam lines (ELBE operator interface). Neutron (upper beam line) and Laser interaction (straight beam line) are branching at the septum.

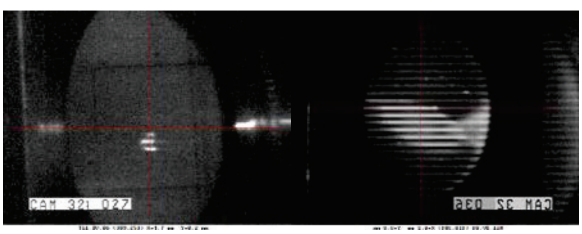

Figure 10: Screen picture of the last screens in the Laser interaction (left picture) and Neutron beam line (right picture) with a 50/50 kicked beam.

SUMMARY

The kicker has been successful designed, manufactured and commissioned. The real parameters are slightly better than expected from the CST simulations. To set up two beams at a time is slightly more difficult because adjustment of the septum magnet affects both beam lines.

Since the used parameter, e.g.: length of the kicker 650 mm, beam energy 30 MeV, distance to septum 7 m are operational with a voltage of only 300 V (HV-device up to 2 kV) at every electrode gives far more space for using the kicker with a more advanced setup.

REFERENCES

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

[2] Chao, A. W. and M. Tigner, *Handbook of Accelerator Physics and Engineering*, Second Ed., World Scientific Publishing Company, 2013, p. 602.

[3] G. S. Staats *et al.*, "Kicker Development at the ELBE Facility", in *Proc. 5th Int. Particle Accelerator Conf. (IPAC'14)*, Dresden, Germany, Jun. 2014, pp. 520-522, **doi:10.18429/JACoW-IPAC2014-MOPME067**