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FAST KICKERS FOR BUNCH BY BUNCH FEEDBACKS AT SLS 2.0 AND ELETTRA

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Abstract

The accelerator upgrades of the Swiss Light Source (SLS) and Elettra will use newly designed kickers, adapted for their small aperture beam pipes.

The striplines of the transverse kickers conform closely to the aperture of the beam pipe with special grooves to avoid synchrotron light on the blades. The multitude of trapped higher order modes, caused by a high beam pipe cut-off frequency and dangerous in terms of stability and heat up, is suppressed by lossy silicon carbide dampers. The devices feature integrated pumping ports. The transverse shunt impedance improves by a factor of four compared to the current SLS/Elettra kicker.

The longitudinal kicker is a heavily coupled cavity at 1.875 GHz (3.75 * RF) with four input and four output couplers for driver and loads. A nose cone design optimizes the shunt impedance resulting in a 20% improvement over the current SLS/Elettra kicker. Also here, the high cut-off frequency of the beam pipe caused problematic higher order modes, which needed to be damped by higher order mode couplers. A dedicated field sensor pickup will be used to synchronize the feedback to the bunch train.

INTRODUCTION

Both the Swiss Light Source (SLS) and Elettra are in the process of a machine upgrade [1, 2]. The principal goal is to transition to a state of the art multibend optics resulting in a dramatic increase in brilliance of the generated synchrotron light.

As part of the upgrade, also the bunch by bunch feedbacks [3] will be completely renewed. The original kickers, while still working without problems, will be replaced by reoptimized versions adapted to the new vacuum system and maximizing the efficiency within the constraints given by the new machine layout.

STRIPLINE KICKER

The principal transverse kicker parameters are listed in Table 1. The geometry was designed to eliminate any tapers, the stripline geometry adapts itself to the standard octagonal chamber of SLS 2.0 with an aperture of 21 mm. Other than in the SLS, where the kickers are combined in an integral structure [4], mechanical constraints require a short tube section.

Figure 1 shows the inner structure of the vertical kicker (the horizontal is the same rotated by 90 degree with the exception of a small groove in the stripline to avoid synchrotron radiation). Ceramic spacers remove any mechanical stress from the RF feedthroughs and protect them. Due to symmetry, horizontal higher order modes (HOMs) will not couple to the RF ports, as they are damped only by conduction losses and have high shunt impedances. Given the high chamber cutoff frequencies of an order of 10 GHz, even a few trapped modes in the longitudinal and vertical planes exist. This problem was solved by introducing ceramic plugs made from silicon carbide (SiC), which has pronounced dielectric losses. As a welcome side effect, these also strongly reduce any potentially dangerous RF heatup of the striplines. Where the SiC plugs absorb 25 W per plug, the RF power into the striplines is in the mW range. Heatup due to synchrotron light is below 200 mW for SLS 2.0 [5]. In ELETTRA 2.0, a small bump in the connecting taper will be used to protect the striplines from synchrotron radiation.

Driving the kicker ports in antiphase to obtain a deflection means having an odd mode travelling along the striplines. The odd mode impedance of 50 Ω together with a careful design of the transition from the feedthroughs result in an excellent RF match (Fig. 2). The even mode (both striplines at the same polarity),which is induced by the beam, is slightly mismatched with an impedance of 37.9 Ω.

Table 1: Main Parameters of the Transverse Kickers

Parameter	Value
Frequency range	DC - 250 MHz
Active length	300 mm
Transverse shunt impedance	62 kΩ

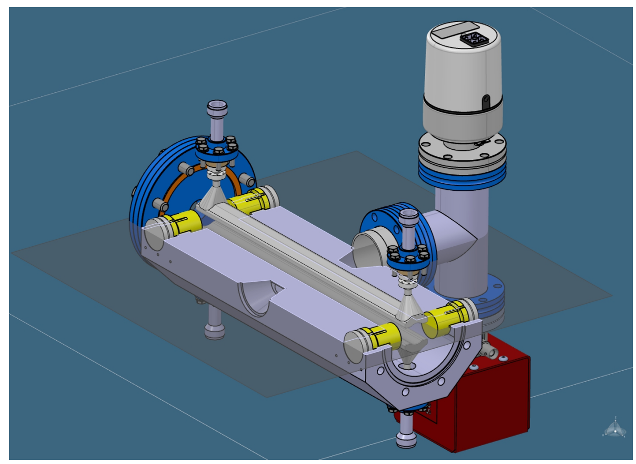

Figure 1: Inner volume of the stripline kicker with striplines, silicon carbide HOM dampers (yellow) and pumping ports

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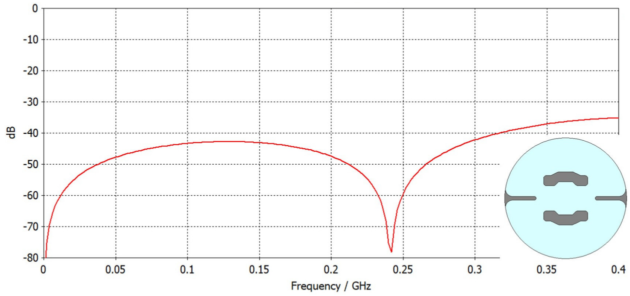

Figure 2: RF match versus frequency. Inserts show the cross section and the transition between feedthrough and stripline.

Longitudinal and transverse beam impedance are strongly dominated by the dielectric losses in the SiC plugs (Figs. 3 and 4). All the resonances stay well below the stability thresholds. Shown here is only the horizontal impedance. As mentioned, vertical wakes see the additional effect of the couplers resulting in even flatter beam impedance.

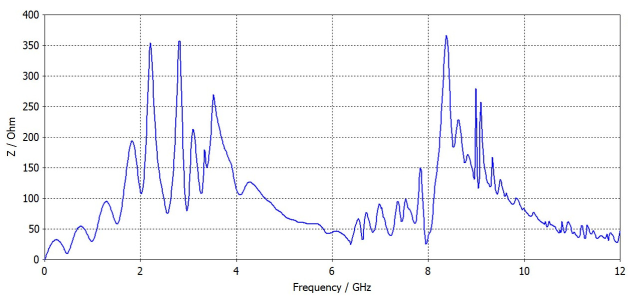

Figure 3: Stripline kicker: Longitudinal beam impedance (threshold: 24.8 kΩ GHz).

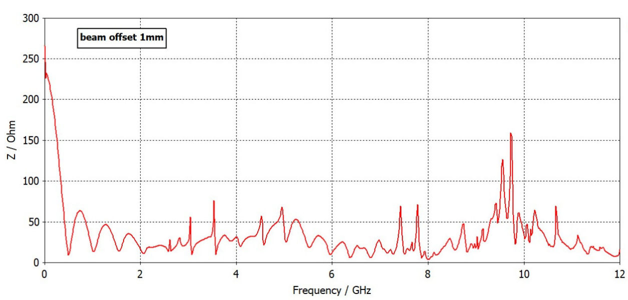

Figure 4: Stripline kicker: Horizontal beam impedance at 1 mm beam offset (threshold: 27.6 MΩ/m).

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Figure 5 shows the full assembly of the kicker pair including the connecting beam pipe and vacuum pumps.

LONGITUDINAL KICKER

The design of the longitudinal kicker follows the same approach as for the stripline in adapting well to the vacuum chamber layout to eliminate transitions (Fig. 6). Table 2 shows its main parameters.

As in the original kicker for SLS [6] and his historic model [7], the cavity runs in a pseudo-travelling mode with

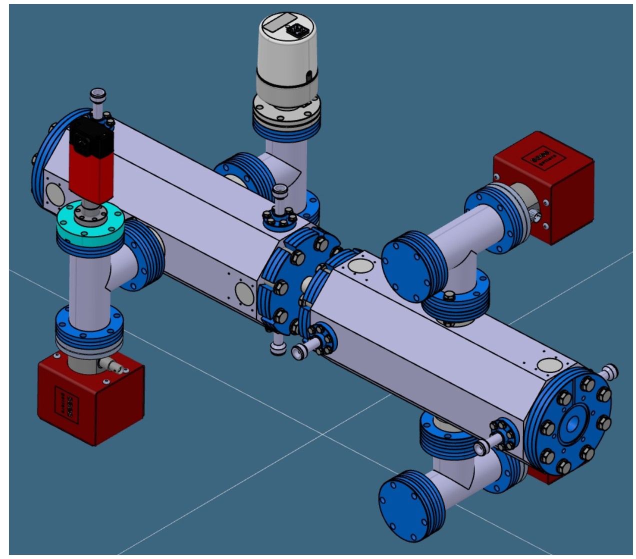

Figure 5: Mechanical model of the kicker pair including pumps.

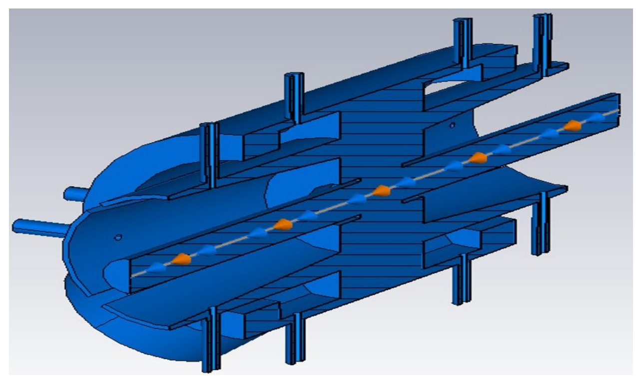

Figure 6: Inner volume of the kicker showing input and output couplers for the main RF as well as couplers for the HOM damping. Nose cones are used to improve the shunt impedance.

Table 2: Main Parameters of the Longitudinal Kicker

Parameter	Value
Operating mode	TM010
Center frequency	1.875 GHz
	(3.75 f_{RF})
Bandwidth	250 MHz
Q	7.6
Shunt impedance	1800 Ω

the RF power fed into four couplers on one side and getting terminated on the other side. The advantage of this configuration is, whereas the shunt impedance is affected only by the four output ports, damping of HOMS will be by all eight in- and output couplers. Profiting from the changed chamber cross section with its higher cutoff, the center frequency of the cavity was increased by one RF harmonic to 1.875 GHz, resulting in a small cavity and an improved shunt impedance,

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further improved by the nose cone design. When examining synchrotron radiation effects in the layout for ELETTRA 2.0, we saw significant heating effects on these cones, which required the use of OFHC copper of the inner parts instead of stainless steel.

In the original kicker, coupling to the main RF coupler combined with the additional damping by the field sensor antenna attached to the outer wall of the cavity was sufficient to suppress HOMs to acceptable levels. With the high cutoff of the vacuum chamber, this did not work anymore. Separate HOM damping wave guides were introduced on both sides. As a result both longitudinal and transverse beam impedances are well controlled (Figs. 7 and 8).

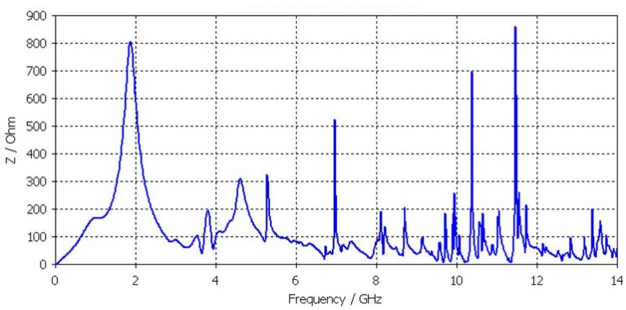

Figure 7: Longitudinal kicker: longitudinal wake impedance (stability threshold for SLS 2.0 24 kΩ GHz)

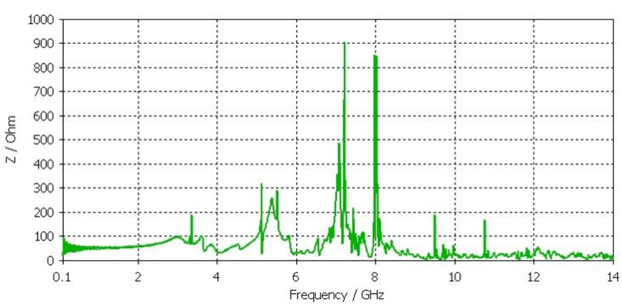

Figure 8: Longitudinal kicker: transverse wake impedance at 1 mm beam offset (stability threshold in SLS 2.0: 26.4 MΩ/m).

Figure 9 shows the mechanical design. The structure is pumped via integrated pumping ports. Not visible is a small field probe antenna, which couples to the fundamental mode with -35 dB attenuation and is required to synchronize the beam to the RF pulses of the feedback.

SUMMARY

New optimized longitudinal and transverse bunch by bunch feedback kickers have been designed for the machines upgrades of SLS and ELETTRA. They feature high shunt impedances and have special features to suppress higher order modes. Mechanical fabrication has started and laboratory tests are expected in summer.

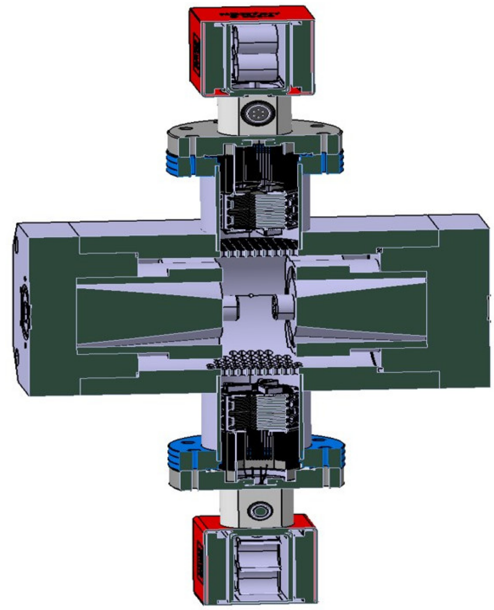

Figure 9: Mechanical CAD model: The kicker has integrated pumping ports, not visible is a field probe antenna important to synchronize the feedback kicks to the beam.

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