IMPACT OF GROUND AND STRUCTURE VIBRATIONS ON THE SOURCE STABILITY OF BESSY*

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Abstract

On a modern Synchrotron Light Source like BESSYII with its small transversal emittance the effect of nearby urban noise sources like industry and traffic could affect the SR-Stability. Therefore the influence of ground and girder vibrations on the source stability was measured under different operational conditions It was shown, that it does not affect the actual BESSYII user performance.

1 INTRODUCTION

With its very small source dimensions of routinely 20 μm vertical and 300 μm horizontal at the standard ID source points, in the middle of each second of the 16 BESSYII straight sections, the highest spectral resolutions ever recorded could be achieved at BESSYII [1]. The signal stability at the focal points at the end of the opticle beam line (located up to 30 m behind the source) is very sensitive against any kind of noise due to the tiny vertical source size. We will focus here on the impact of mechanical noise of storage ring structures on the final focus stability. We will compare the data collected along the following chain: ground noise $\rightarrow$ girder response $\rightarrow$ beam response $\rightarrow$ signal stability. This will allow to identify and evaluate the different sources of noise and to see and fight against changes in the delivered. changes of the delivered beam quality.

2 GROUND NOISE AT BESSYII

As presented in [2], the normal ground velocity level as always present at BESSY II is below 10 μm/sec vertically and 6 μm/sec horizontally. This corresponds to amplitudes of about 250nm vertical and 150 nm horizontal within a frequency range from 2 Hz to 315 Hz.

Ground noise in general is a stochastic but not a stationary process. There may occur excitations (short in time) which may exceed the mean amplitude by orders of magnitude. This events could decrease the source stability and affect experiments with SR. To quantify the occurence of these events long term measurements were performed. A trigger was set to a ground velocity amplitude of 25 μm/sec and an inductive vibration measuring system stored a 4 second ground velocity file every time the trigger was exceeded. In 24 h one gets between 600 and 1000 events.

Fig 1 shows the number of events within each 15 minute bin as function of time. In the night there are very few events while heavy noise is seen in the morning (clearly seen also the traditional construction workers morning break at 9 a.m.). Lunchtime shows a similar noise level as at the end of the night and in the afternoon there is a considerable less impact as in the morning. The events at the shop closing hour (in germany at 8 p.m.) indicates that urban traffic might be an important noise source.

A frequency analysis of the vertical motion (files aquired with a sampling rate of 2048 Hz) shows that the BESSY booster frequency of 10 Hz is dominating (50 % of all files) with booster “on”, while with the booster “off” it is a 7 Hz (35 %) line. This frequency seems a resonance of the accelerator hall.

The horizontal ground motion spectra are dominated by the 25 Hz of the membran pums pumps running in the experimental hall. The distribution of trigger counts over the

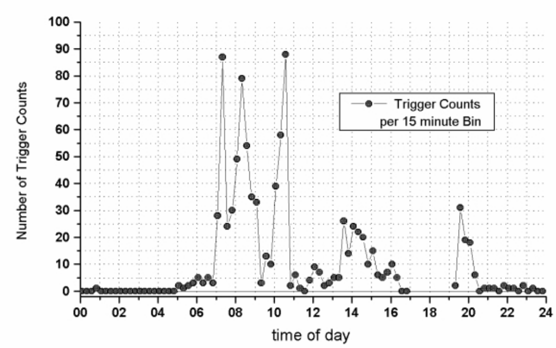

Figure 1: Number of triggercounts per 1/4h Bin over time

maximum velocity amplitude of each triggered ground velocity file is shown in Fig 2 on a normal working day. The

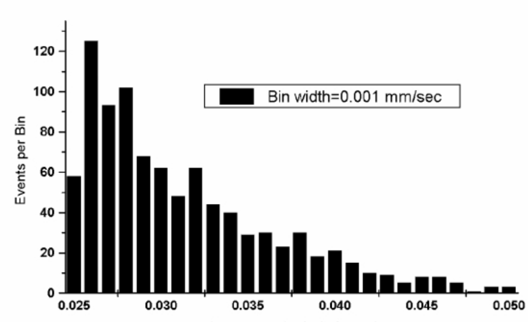

Figure 2: Number of events exceeding the velocity trigger of 0.025 mm/sec sorted by maximum amplitude. Bin width is 0.001 mm/sec

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amplitude can be determined by integration of the velocity files [2]. A statistical analysis shows that at the BESSYII site in mean a velocity of 35 μm/sec corresponds to an amplitude of about 1 μm. The correspondence factor for a single event strongly depends on its actual frequency distribution.

Fig 2 determines the probability that a certain ground amplitude limit is exceeded during the user runs probably affecting a data aquisition.

3 STRUCTURE MOTIONS AND BEAM NOISE

3.1 Structure Motion

The structure response of the BESSY girders was already analysed in [2]. There are three different types of storage ring girders with lowest resonance frequencies at 11 Hz, 15.5 Hz and 17.5 Hz. Also the resonance frequencies of most ID's, the dipole (24 Hz) and beam line structures were measured. Most of the ID's have a lowest mode between 8 Hz and 12 Hz (with amplitudes 2-3 times larger than the storage ring girder) while the beam line structures (monochromator, slit chambers etc.) are resonant in the range 25-65 Hz. The upper part of Fig 6 shows the maximum values of the lowest modes in the transfer functions for the ring girders, the monochromator chamber and the undulator U49.

3.2 Beam noise

A dedicated experimental setup was used to measure the low frequency beam noise and its effect on the source stability at an experiment (see Fig 3). The position of the radiation cones (6) from the BESSYII U49 undulator and of the neighbouring storage ring bending magnet were recorded by means of a staggered pair monitor system (SPM) (5) [3]. After the premirror (4) and the entrance slit an additional isolated blade (3) was moved into the beam until it gave a signal high enough to be clearly detected but without reducing the signal at the end of the beam line (after the monochromator (2)). At the experimental point the internal intensity of the monochromatic beam spot was measured by a GaAs photo diode (1).

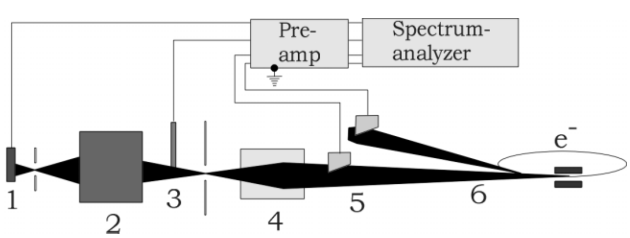

Figure 3: Experimental setup to quantify low frequency beam noise

The monitors were calibrated by moving the beam at the source points with well defined orbit bump in steps of 10 μrad. The measurement was performed at the blue steep of the 1. undulator harmonic corresponding to 400 eV photon energy (a normal operation mode during user runs) and all signals were analysed by a spectrum analyser (ONO SOKKI 6400)

Typical spectra along the beam line, averaged over 100 seconds. The dominant frequencies are depicted in Fig 4 . The 10 Hz of the booster and its harmonic at 20 Hz[1],

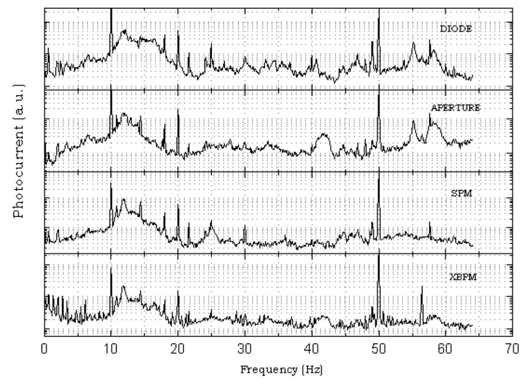

Figure 4: Comparison of SR beam spectra taken SPM's and XBPM's along the optical beam line. Signals are averaged over 100 seconds.

a broad resonance between 10-20 Hz (where the fundamentals of most storage ring structures are located), the ring bends at 24 Hz, membrane pumps at 25 Hz, the general power frequency of 50 Hz and the split mirror chambers at 60 Hz. The signal in the 10-20 Hz intervall is much stronger after the monochromator (at the diode) than that on the SPM's in the tunnel. This is due to the fact that the ground waves at this frequecies not only induce source vibrations but also act on the monochromator itself (with a lowest resonance at 25 Hz).

Integrating the spectral density one gets an estimate of the basic noise level accumulated in a certain spectral interval As the spectra were calibrated it was possible to determine the absolute and relative signal stablity (see fig. 5). The total signal/noise ratio of about 1 % is accumulated within a limited frequency range from 1 to 20 Hz with the exception of 0.1 % from the 50 Hz power frequency. The broad peak of the structure resonances (10-20 Hz) contribute 0.5 % , the booster adds another 0.1 %.

This signal stability guarantees appropiate experimental conditions for the BESSY II users. Up to now the 10 Hz excitation generated by the booster was accepted by the experiments.

3.3 Beam Response to Girder Vibrations

In Fig 6 the spectral density on the diode at the end of the U49 beam line is compared with the tranfer functions of

[1] For operational convenience the BESSYII booster is usually running stand by during user runs

the storage ring girder and the main beam line components. All measured resonances are found in the beam spectra so that the individual impacts of the different structures under investigation to the beam noise are known. Up to now there was no need to take special measures for reducing the noise impact of a specific structure.

3.4 Impact of shock Events, Instabilities

The spectral analysis of stochastic process by mean values and integrals over spectral densities is valid only for stationary noise. As mentioned above ground noise is **no** stationary process because during normal working hours there are always ground shocks. For the non-stationary behaviour (events with large amplitudes) a distortion probability for a specific experiment at a given daytime has to be applied to correct the mean amplitudes mentioned in this section. This is done by evaluating long term observation of the type plots as in Fig 2.

Also coherent beam instabilities may give a considerable decrease of the integrated noise/signal stability (at BESSYII 4% with excited beam instead of 1 %) at the experiment. This effect is amplified due to the sensitivity of the beam line optics to time dependent changes of the source size always accompanying instabilities. For this reason it is important to stabilize the beam by an active feedback (as it is done now [4]) or by a high enough chromaticity (as it was done before).

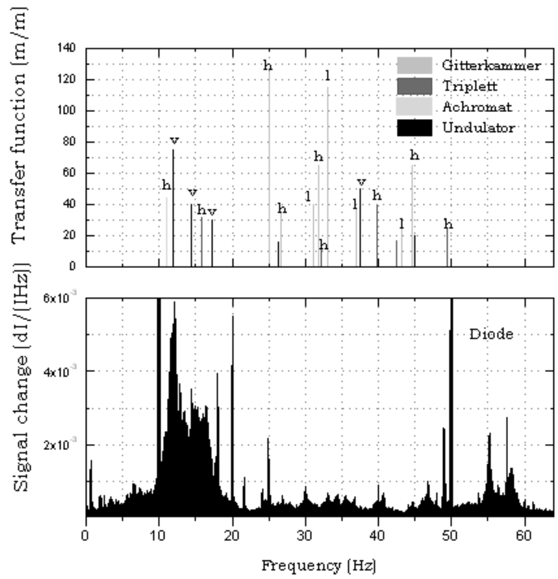

Figure 6: Comparison of beam intensity spectra at the end of the U49 beam line with the lowest modes of mechanical structures.

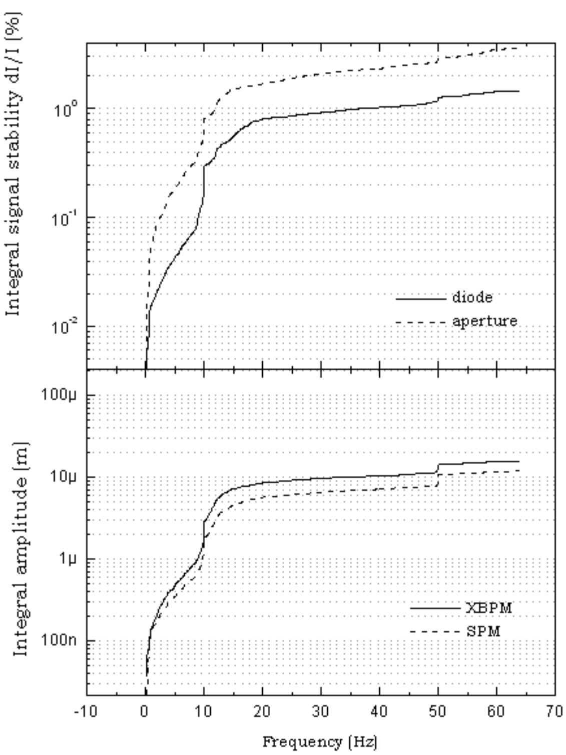

Figure 5: Integrating spectral amplitudes of Fig 4 over frequency as function of upper integration limit in absolute units (μ m, above) and expressed as relative signal stability (below).

4 SUMMARY

The low frequency noise content of the delivered synchrotron radiation at BESSY II during normal user operation was measured and quantified. The different contributing sources could be identified. Under normal conditions (feedback or chromaticity struggling coherent instabilities) the source stability has guaranteed appropiate experimental conditions. In case of any changes it is now possible to monitor an eventually increased source noise and find the responsable component.

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