Statistical Analysis of 2D Single-Shot PPRE-Bunch Measurements

MOPAB296

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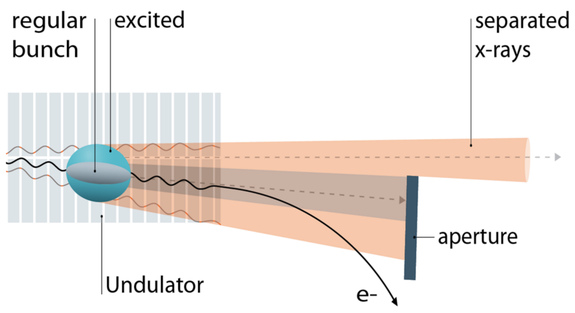
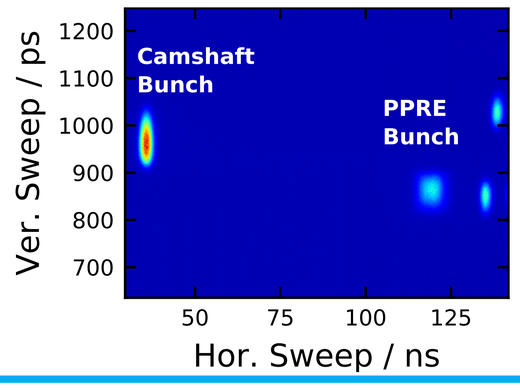
Motivation

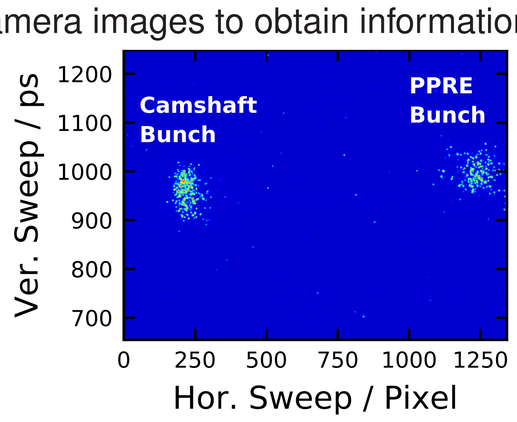
- At BESSY II pseudo single bunch radiation in a complex multi bunch fill pattern is realized by **P**ulse-**P**icking by **R**esonant **E**xcitation (**PPRE**)
- The PPRE bunch is excited in the horizontal plane to increase its emittance and the radiation can be separated by the users
- Difficult to distinguish between broadening and/or position fluctuation
- Using the potential of the new diagnostics beamline we introduce a new statistical method to study the properties of the PPRE bunch

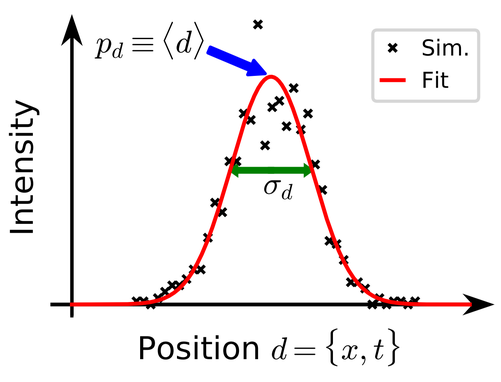




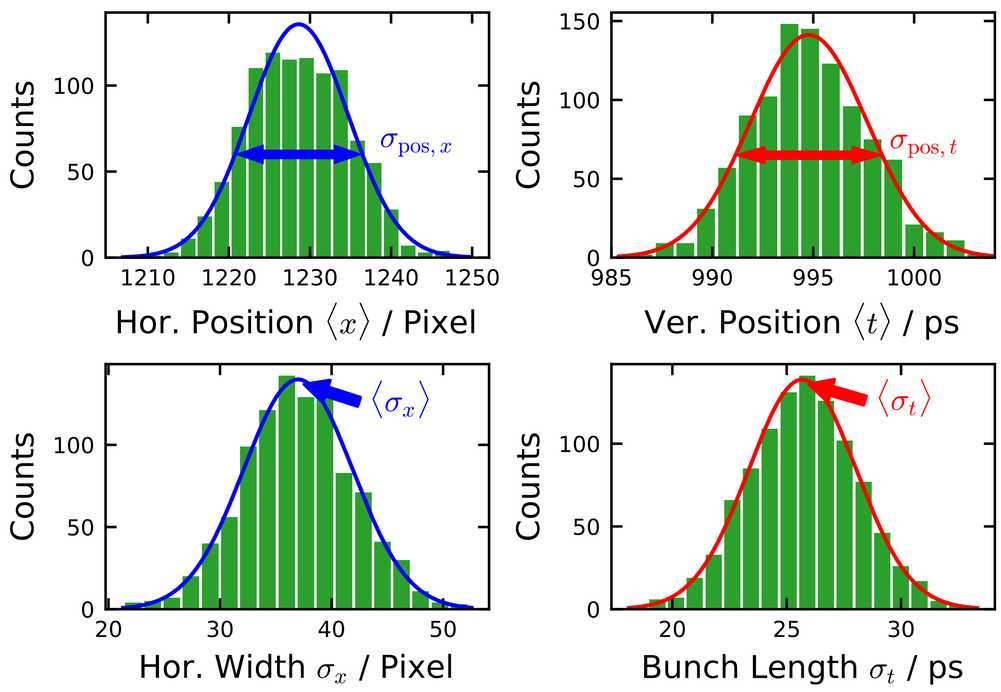
Analysis Method and Example

- Compare the photon distribution in both dimensions in single shot streak camera images to obtain information on bunch motion and bunch size





- Using Gaussian statistics leads to $\sigma_{\mathrm{pos},d} \approx \langle \sigma_d \rangle / \sqrt{N_{\mathrm{eff}}}$
- Example for the analysis of the PPRE bunch width and bunch position distributions for both streak dimensions $d = x$ and $d = t$



Variable	Hor. ($d = x$) / Pixel	Ver. ($d = t$) / ps
$\langle \sigma_d \rangle$	37.00 ± 0.15	25.69 ± 0.07
$\sigma_{\mathrm{pos},d}$	6.15 ± 0.14	2.91 ± 0.14
N^d_{eff}	~~36 ± 2~~	78 ± 7

- Expected hor. fluctuation and from that hor. motion:

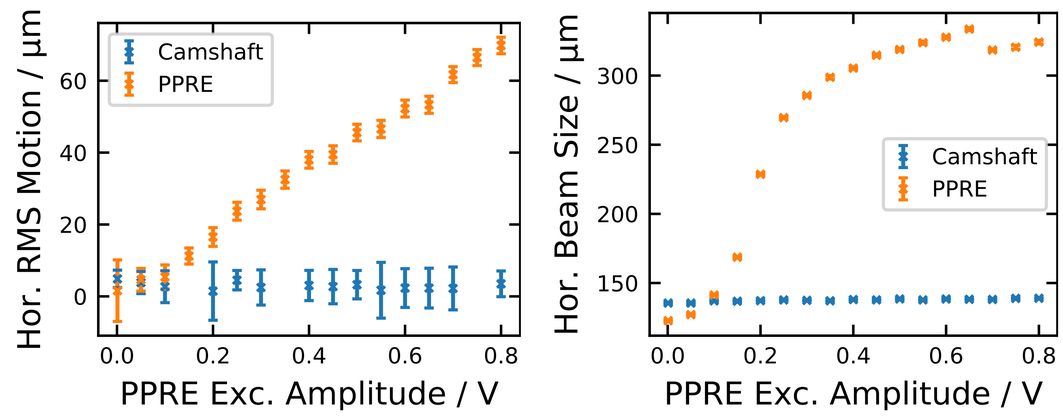
$$\sigma^{(\mathrm{stat})}_{\mathrm{pos},x} = \langle \sigma_x \rangle / \sqrt{N^t_{\mathrm{eff}}} = 4.2\,\mathrm{Pixel}$$

$$\sigma^{(\mathrm{orbit})}_{\mathrm{pos},x} = \sqrt{\sigma^{(\mathrm{meas})\,2}_{\mathrm{pos},x} - \sigma^{(\mathrm{stat})\,2}_{\mathrm{pos},x}} = 4.5\,\mathrm{Pixel}$$

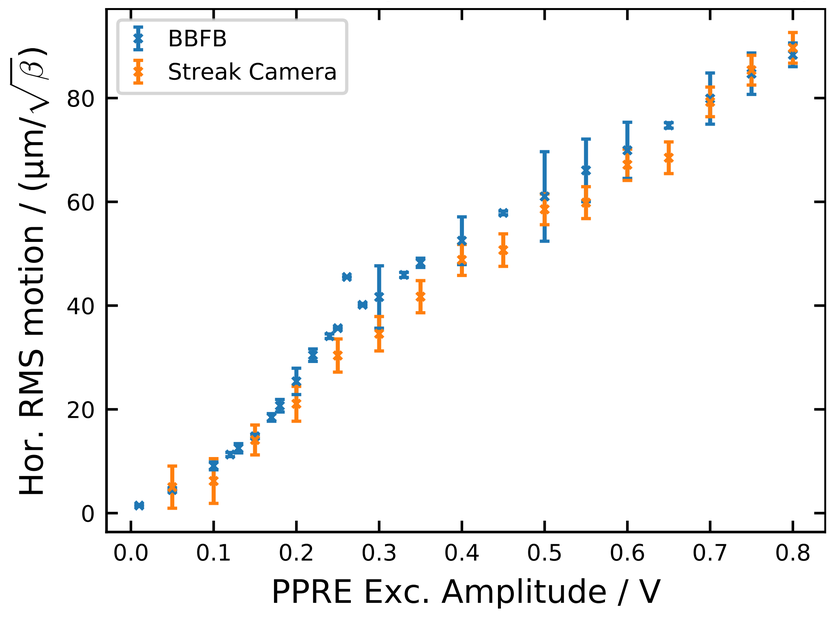
- Important result: Less orbit fluctuation compared to hor. bunch size $\langle \sigma_x \rangle$

Measurement vs. Excitation Amplitude

- Measurement of horizontal PPRE bunch motion and size for variable excitation amplitude (standard is at 0.5 V)
- Results converted to actual bunch units by orbit calibration
  $\Rightarrow$ 1 Pixel at streak camera $\approx$ 10 µm at bunch orbit
- Results for PPRE and camshaft bunch (res. limit for low size)

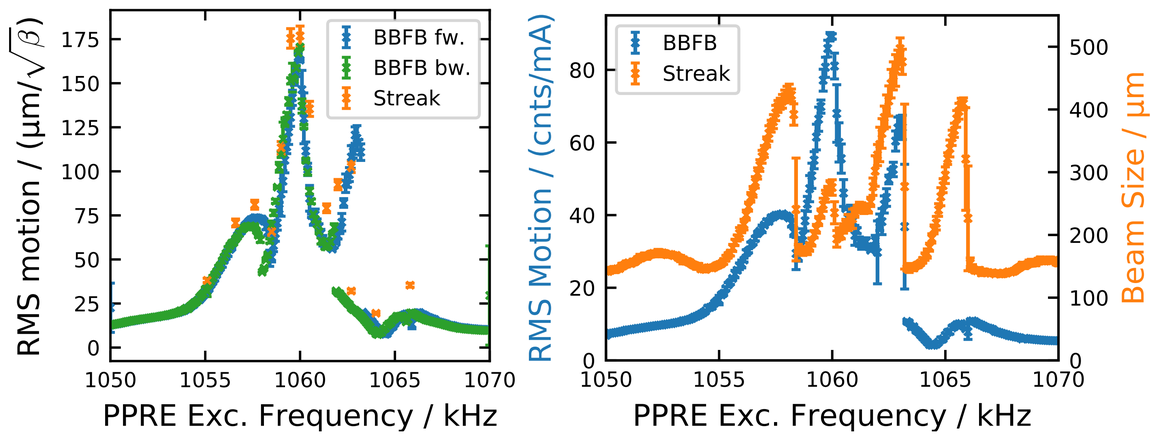


- Comparison of the PPRE bunch motion with bunch-by-bunch feedback (BBFB) system data, normalized by hor. β-function at source point



Measurement vs. Excitation Frequency

- Similar as above: PPRE bunch size and hor. motion measured as function of the excitation frequency (standard is at 1057.607 kHz)
- Comparison of normalized hor. motion measured with streak and BBFB and hor. beam size measured with streak camera



- Peak structure from horizontal tune at 1060 kHz and sidebands (from synchrotron tune): At the horizontal tune the motion is maximized, while bunch size is largest at the synchrotron sidebands

Summary and Outlook

- PPRE Motion and beam size can be detected simultaneously with the 2D single shot measurements using the streak camera
- Important tool to ensure that the orbit fluctuation is low compared to hor. beam size in user operation
- Successful excitation amplitude and frequency tests, results agree with measurements with the bunch-by-bunch feedback (BBFB) system

KEY REFERENCES

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