

Bunch-Resolved 2D Measurements at BESSY II

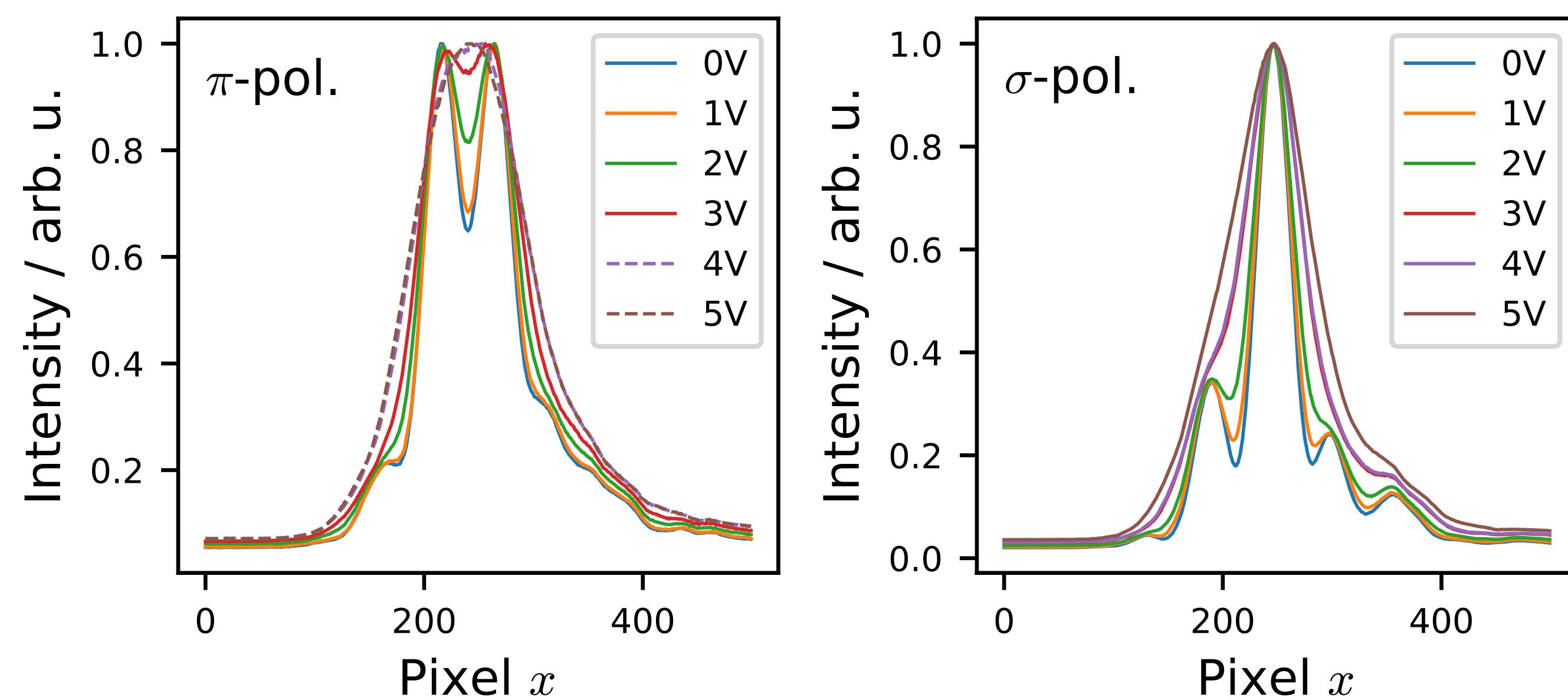
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Motivation

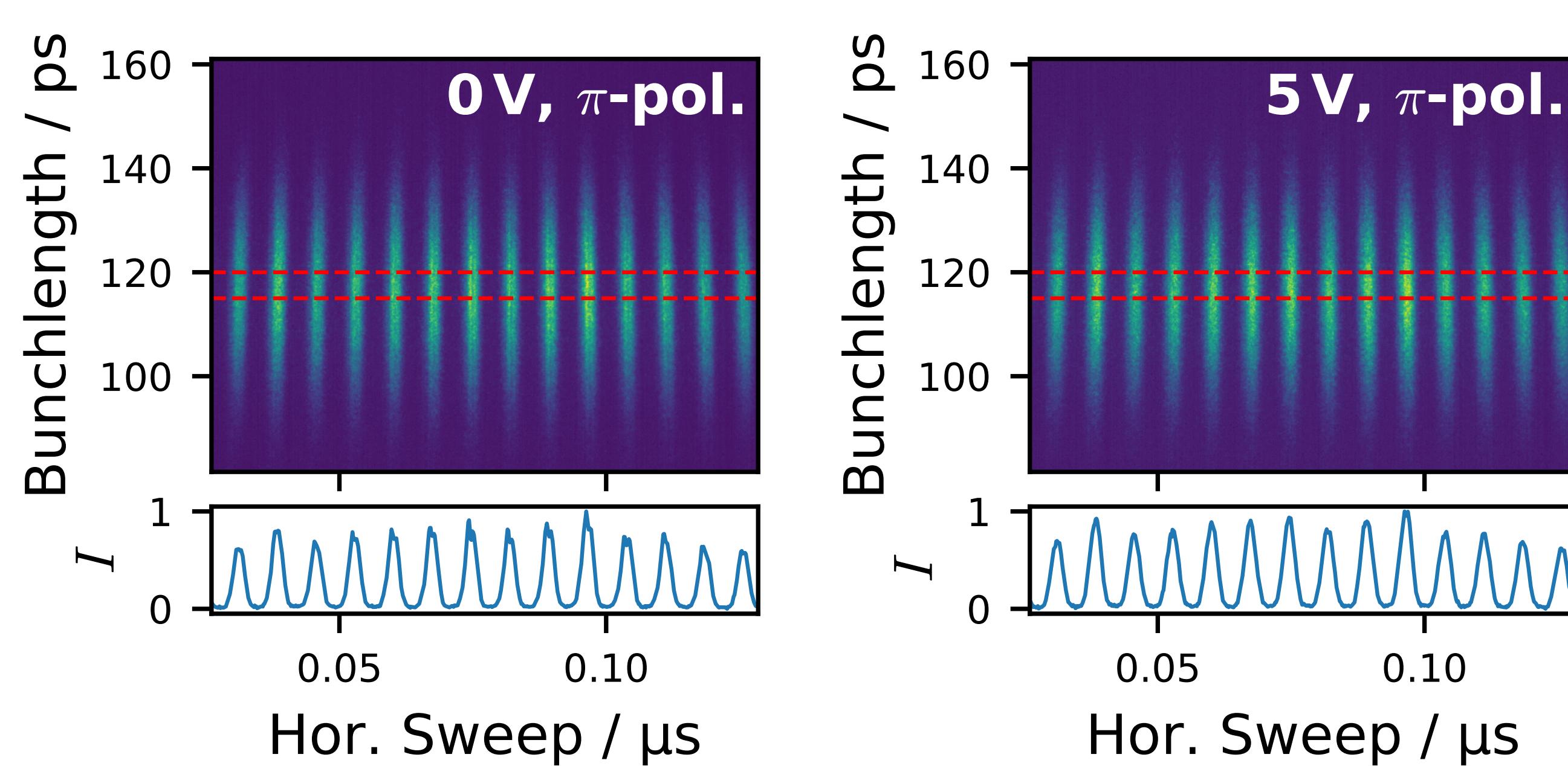
- Upgrade project of BESSY II to the Variable pulse length Storage Ring BESSY VSR
- Bunches varying in length, current, charge density over an order of magnitude and have also different transverse beam sizes
- Dedicated beamlines for bunch length measurements (successfully commissioned, in operation) and for transverse beam properties (under construction)
- Beamline and fast Streak Camera are sensitive to one additional transverse dimension → 2D studies
- 2D measurements with vertical noise excitation and the pulse picking by resonant excitation (PPRE) bunch

2D Diagnostics of Vertical Excitation

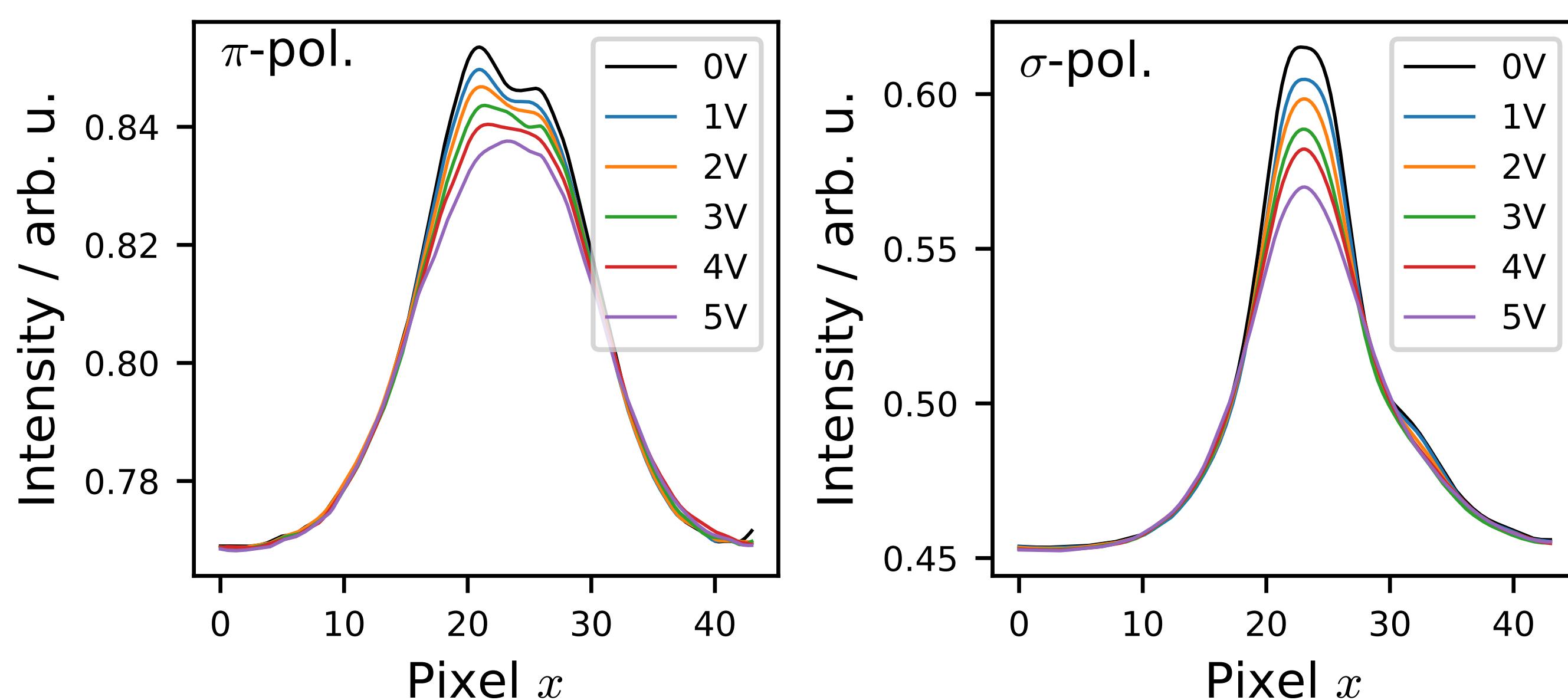
- Beam profiles from direct imaging with CCD for π and σ -polarisation



- Horizontal profiles of bunches on streak camera for π -polarisation correspond to vertical beam size



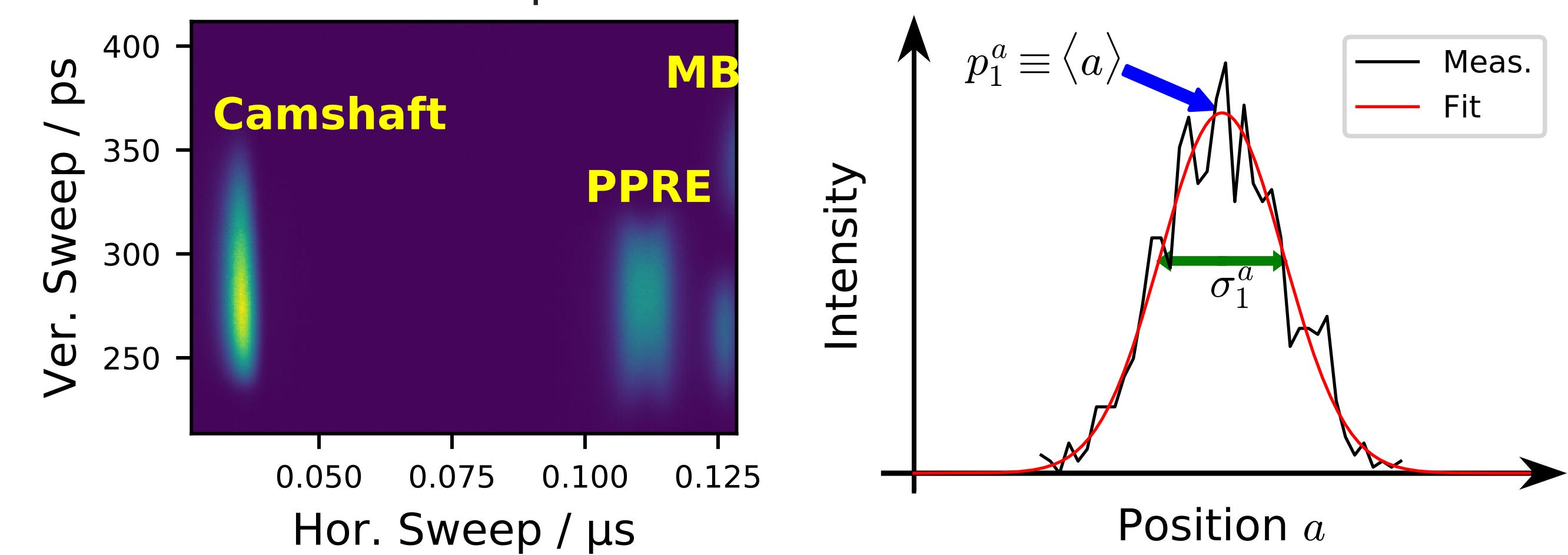
- Averaged bunch profile for π and σ -polarisation at streak camera



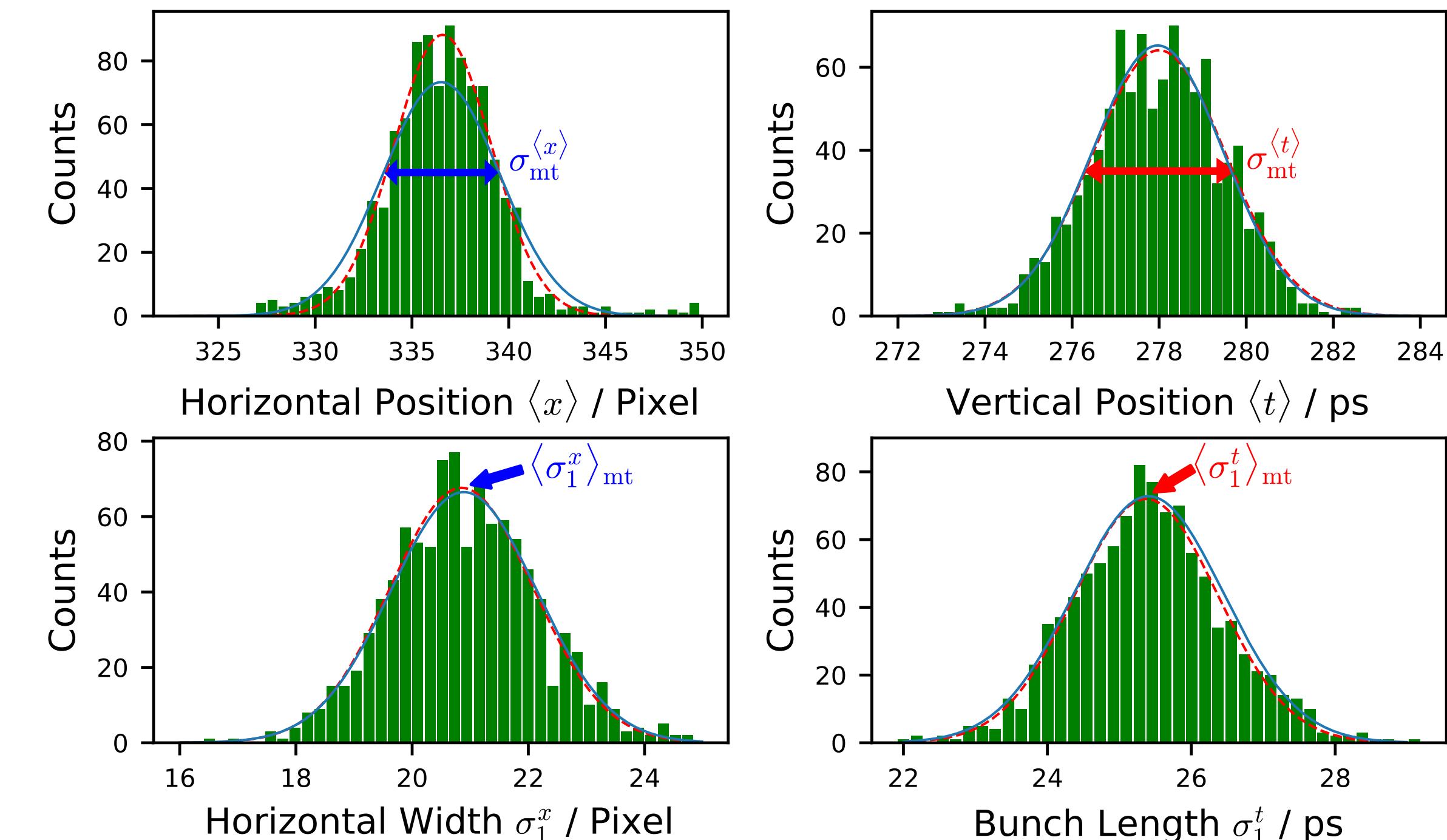
- Qualitative results, but quantitative analysis in progress

Measuring Hor. PPRe Motion (σ -Pol.)

- Using Gaussian statistics to separate the single shot width and the shot-to-shot motion of the PPRe peak



- Statistics leads to $\sigma_{\text{mt}}^{(a)} \approx \langle \sigma_1^a \rangle_{\text{mt}} / \sqrt{N_{\text{ph}}}$
- Example for the analysis of the PPRe width and position distributions for both streak dimensions $a = x$ and $a = t$



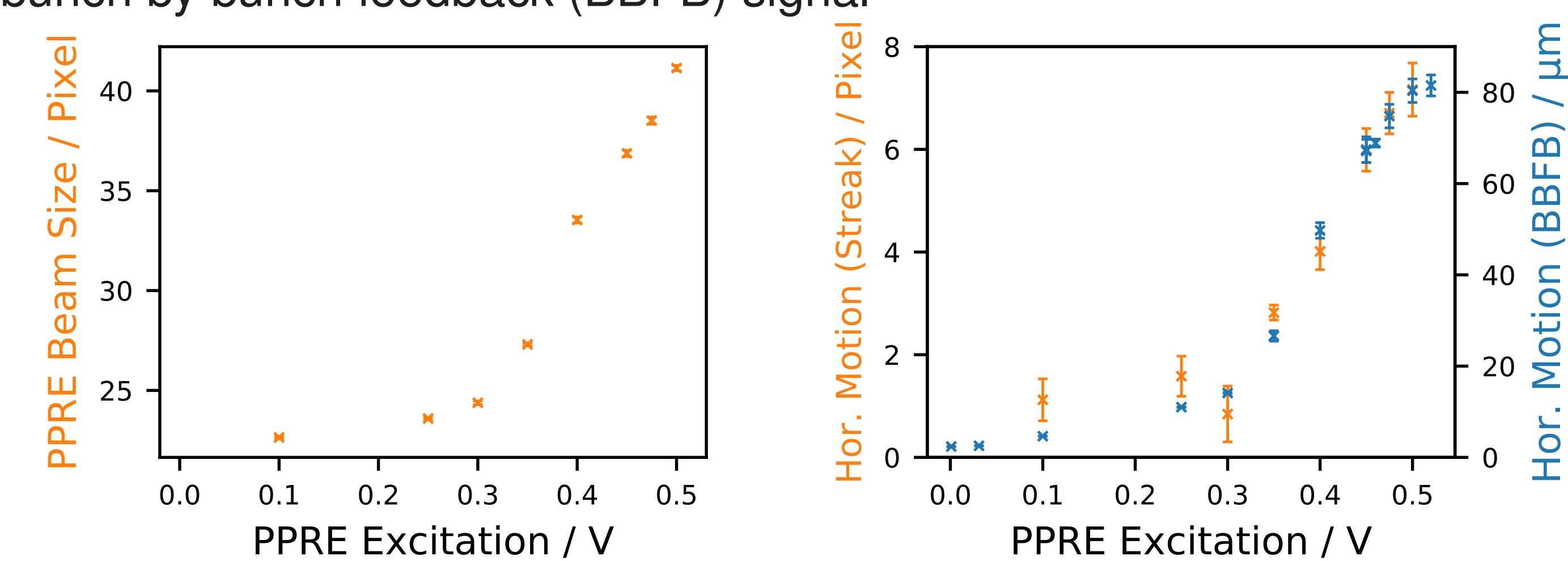
Variable	Hor. ($a = x$) / Pixel	Ver. ($a = t$) / ps
$\langle \sigma_1^a \rangle_{\text{mt}}$	20.9 ± 0.04	25.39 ± 0.03
σ_{mt}	2.52 ± 0.07	1.53 ± 0.05
N_{ph}^a	69	272

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

$$\sigma_{\text{mt,stat}}^{(x)} = \langle \sigma_1^x \rangle_{\text{mt}} / \sqrt{N_{\text{ph}}^t} = 1.26 \text{ Pixel}$$

$$\sigma_{\text{mt,jitter}}^{(x)} = \sqrt{\sigma_{\text{mt,sum}}^{(x)2} - \sigma_{\text{mt,stat}}^{(x)2}} = 2.18 \text{ Pixel}$$

- Beam motion for different excitation amplitudes and comparison to the bunch by bunch feedback (BBFB) signal



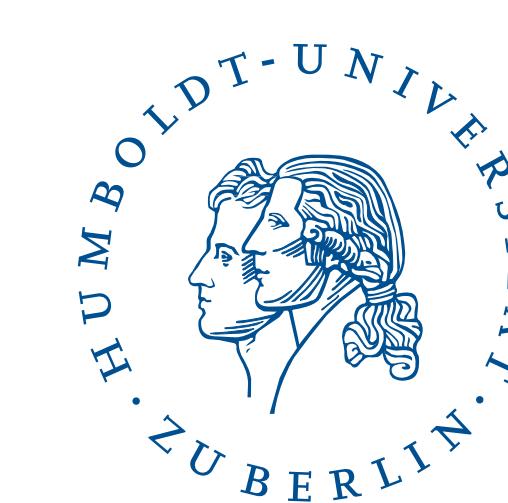
Summary and Outlook

- Successfully performed 2D experiments for additional horizontal and vertical bunch profile information on the streak camera at the BESSY VSR beamline dedicated for bunch length measurements
- Qualitative results for the vertical bunch size with π and σ -polarisation
- Horizontal motion of the PPRe bunch can be measured using single shot images applying statistics
- Further effects to be studied (e.g. injection, multiple orbits)

KEY REFERENCES

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- [2] M. Koopmans et al., "Vertical Beam Size Measurement Methods at the BESSY II Storage Ring and their Resolution Limits", in Proc. IPAC'19, Australia, Melbourne, May 2019, paper WEPG012, pp. 2491 – 2494.
- [3] G. Schiwietz et al., "Overview of Bunch-Resolved Diagnostics for the Future BESSY VSR Electron Storage Ring", in Proc. ICIC'19, Sweden, Malmö, September 2019, paper MOC004.
- [4] J.-G. Hwang et al. "Analytical and numerical analysis of longitudinally coupled transverse dynamics of Pulse Picking by Resonant Excitation in storage rings serving timing and high-flux users simultaneously", in Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, vol. 940, pp. 387 – 392, 2019.
- [5] K. Holdack et al. "Single bunch X-ray pulses on demand from a multi-bunch synchrotron radiation source", in Nature Communications, vol. 5, pp. 4010/1-7, 2014.

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MORE INFORMATION



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