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Time-resolved energy spread studies at the ANKA storage ring

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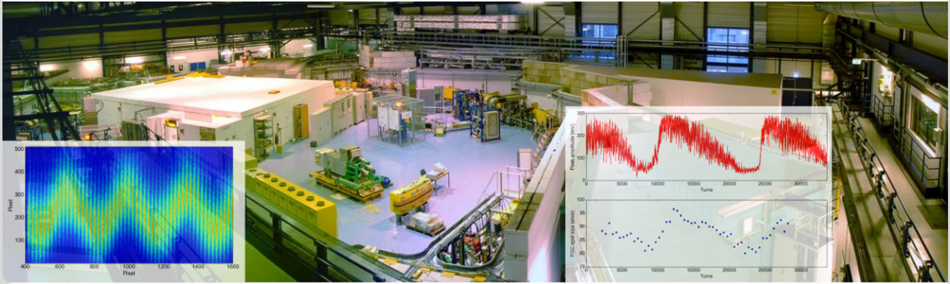
J. L. Steinmann, P. Schönfeldt, M. Schuh and A.-S. Müller**

Institute for Beam Physics and Technology (IBPT)



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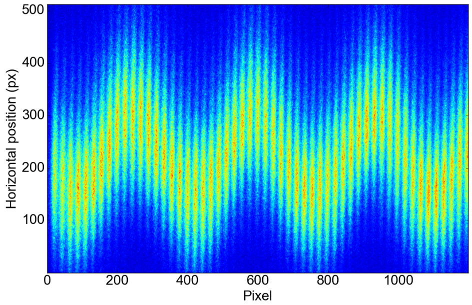
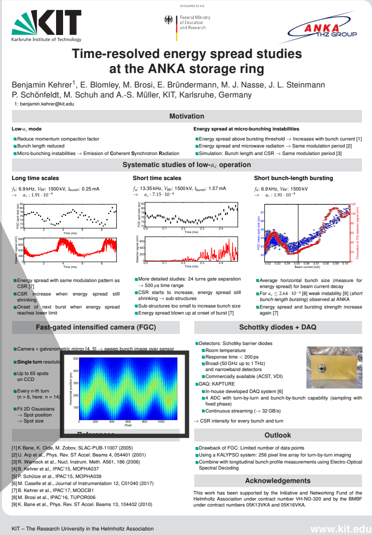
- Energy spread from hor. bunch size
  → Fast-gated intensified camera (FGC)





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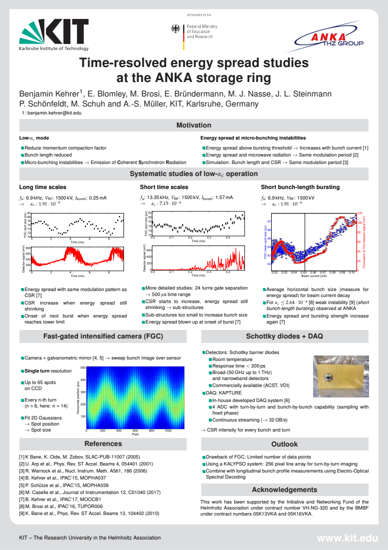
- Energy spread from hor. bunch size
  $\rightarrow$ Fast-gated intensified camera (FGC)
- Synchronized with CSR measurements



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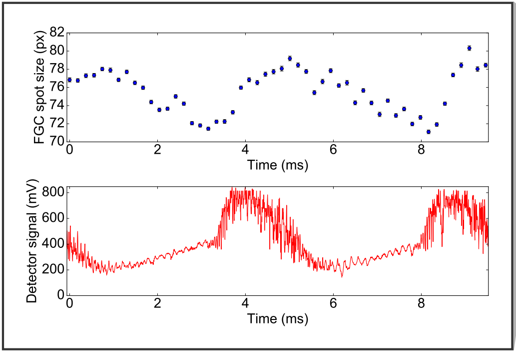
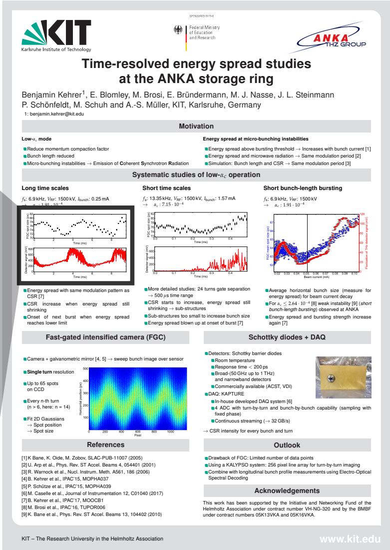
- Energy spread from hor. bunch size
  $\rightarrow$ Fast-gated intensified camera (FGC)
- Synchronized with CSR measurements
- Long time scales





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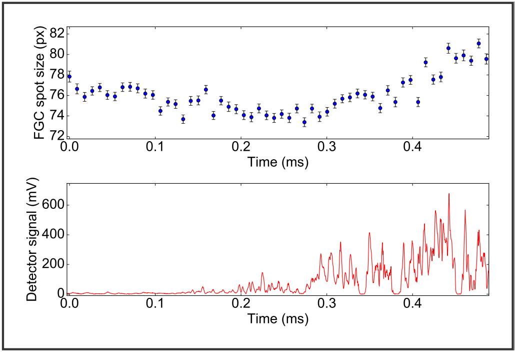

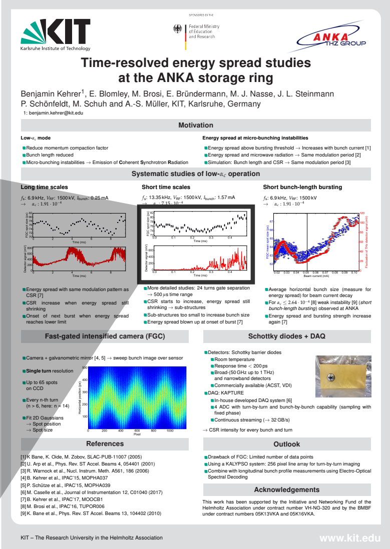

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Motivation

Low-α_c mode

- Reduce momentum compaction factor
- Bunch length reduced
- Micro-bunching instabilities → Emission of **C**oherent **S**ynchrotron **R**adiation

Energy spread at micro-bunching instabilities

- Energy spread above bursting threshold → Increases with bunch current [1]
- Energy spread and microwave radiation → Same modulation period [2]
- Simulation: Bunch length and CSR → Same modulation period [3]

Systematic studies of low-α_c operation

Long time scales

f_s: 6.9 kHz, V_{RF}: 1500 kV, I_{bunch}: 0.25 mA
→ $\alpha_c : 1.91 \cdot 10^{-4}$

- Energy spread with same modulation pattern as CSR [7]
- CSR increase when energy spread still shrinking
- Onset of next burst when energy spread reaches lower limit

Short time scales

f_s: 13.35 kHz, V_{RF}: 1500 kV, I_{bunch}: 1.57 mA
→ $\alpha_c : 7.15 \cdot 10^{-4}$

- More detailed studies: 24 turns gate separation → 500 μs time range
- CSR starts to increase, energy spread still shrinking → sub-structures
- Sub-structures too small to increase bunch size
- Energy spread blown up at onset of burst [7]

Short bunch-length bursting

f_s: 6.9 kHz, V_{RF}: 1500 kV
→ $\alpha_c : 1.91 \cdot 10^{-4}$

- Average horizontal bunch size (measure for energy spread) for beam current decay
- For $\alpha_c \leq 2.64 \cdot 10^{-4}$ [8] weak instability [9] (*short bunch-length bursting*) observed at ANKA
- Energy spread and bursting strength increase again [7]

Fast-gated intensified camera (FGC)

- Camera + galvanometric mirror [4, 5] → sweep bunch image over sensor
- **Single turn** resolution
- Up to 65 spots on CCD
- Every n-th turn (n > 6, here: n = 14)
- Fit 2D Gaussians
  → Spot position
  → Spot size

Schottky diodes + DAQ

- Detectors: Schottky barrier diodes
  - Room temperature
  - Response time < 200 ps
  - Broad-(50 GHz up to 1 THz) and narrowband detectors
  - Commercially available (ACST, VDI)
- DAQ: KAPTURE
  - In-house developed DAQ system [6]
  - 4 ADC with turn-by-turn and bunch-by-bunch capability (sampling with fixed phase)
  - Continuous streaming (→ 32 GB/s)

→ CSR intensity for every bunch and turn

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Outlook

- Drawback of FGC: Limited number of data points
- Using a KALYPSO system: 256 pixel line array for turn-by-turn imaging
- Combine with longitudinal bunch profile measurements using Electro-Optical Spectral Decoding

Acknowledgements

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