Studies of the generation of two X-ray pulses with tunable separation in electron storage rings

XU, Haisheng

Institute of High Energy Physics, CAS, Beijing, China

08-31-2023

the 67th ICFA Advanced Beam Dynamics Workshop on Future Light Sources (FLS 2023),

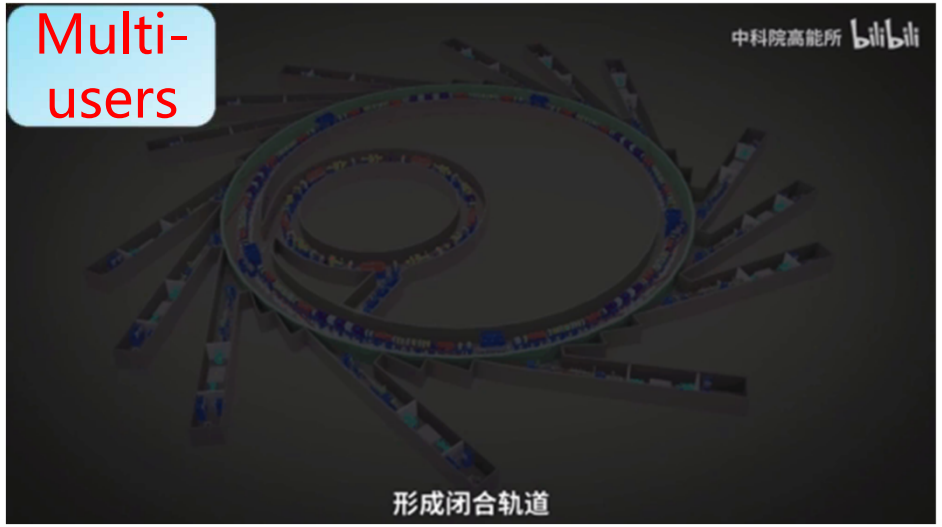
Lucerne, Switzerland, 08-27-2023 to 09-01-2023

Outlines

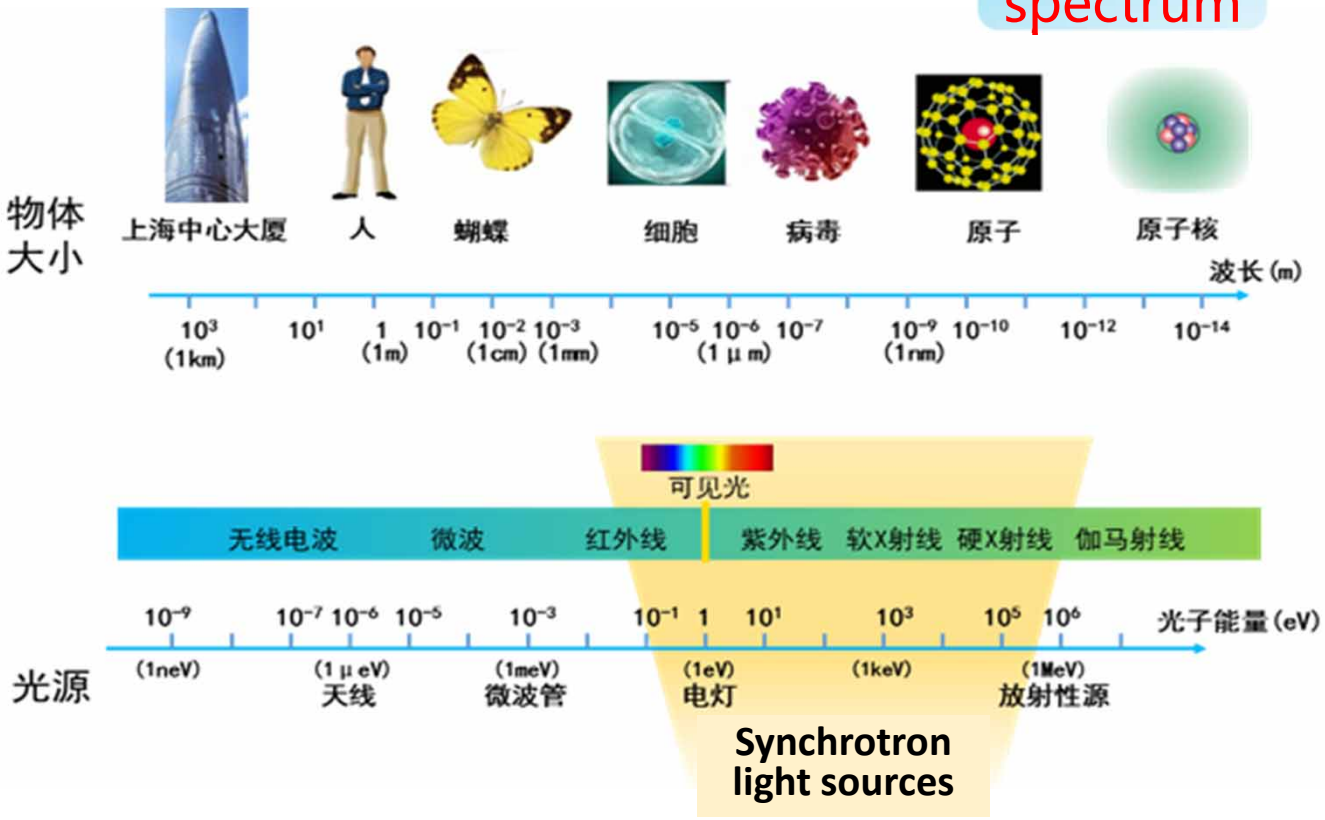
1. Background
2. Proposal of a new operation scheme
3. Summary

Synchrotron light sources

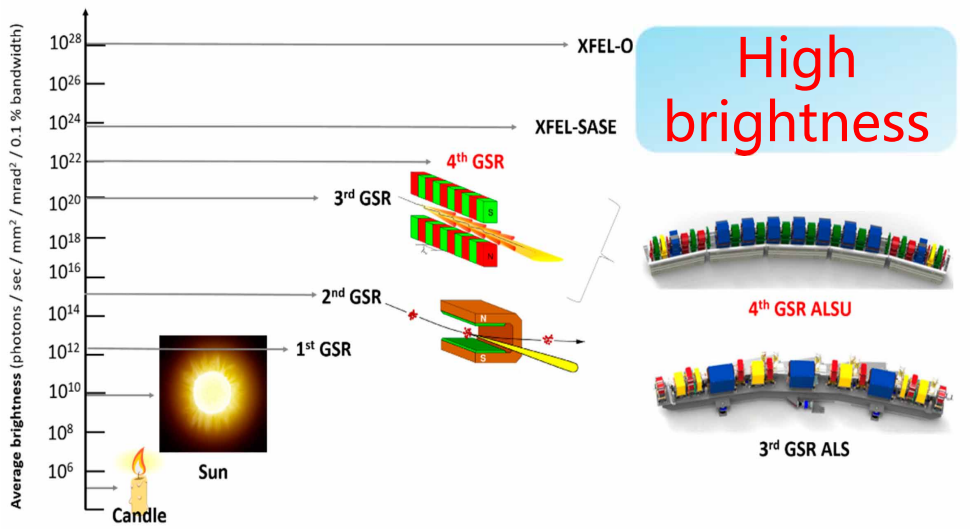
Multi-users



Wide spectrum



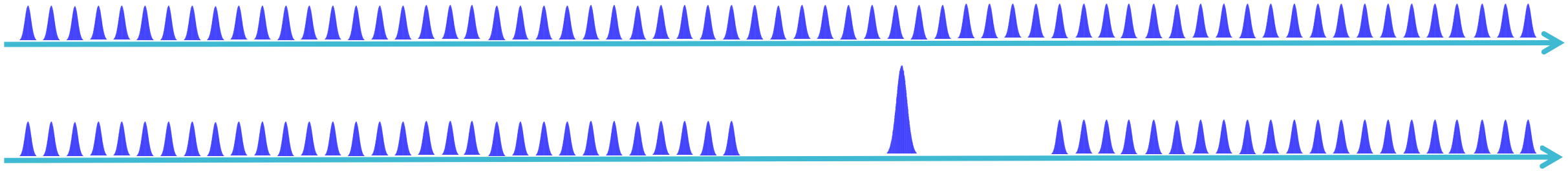
High brightness



Synchrotron light sources can provide high-brightness light from THz to X-ray region.

Variable operation schemes

- Many bunches (+ ‘camshaft’ bunch)

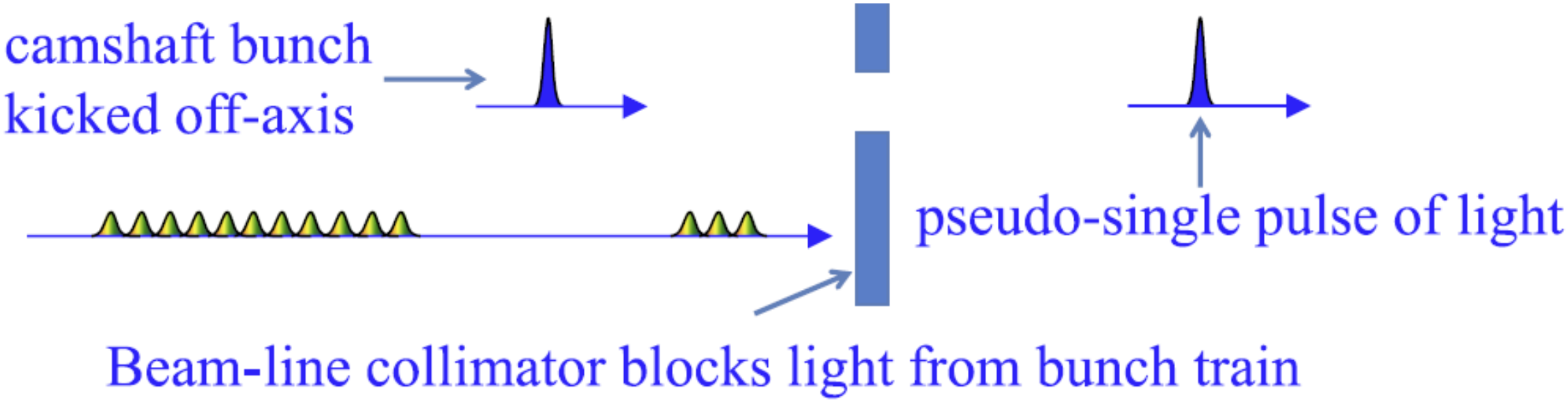


- Timing mode (fewer bunches with higher single-bunch charge)

Variable operation schemes

- Pseudo-single-bunch (PSB)

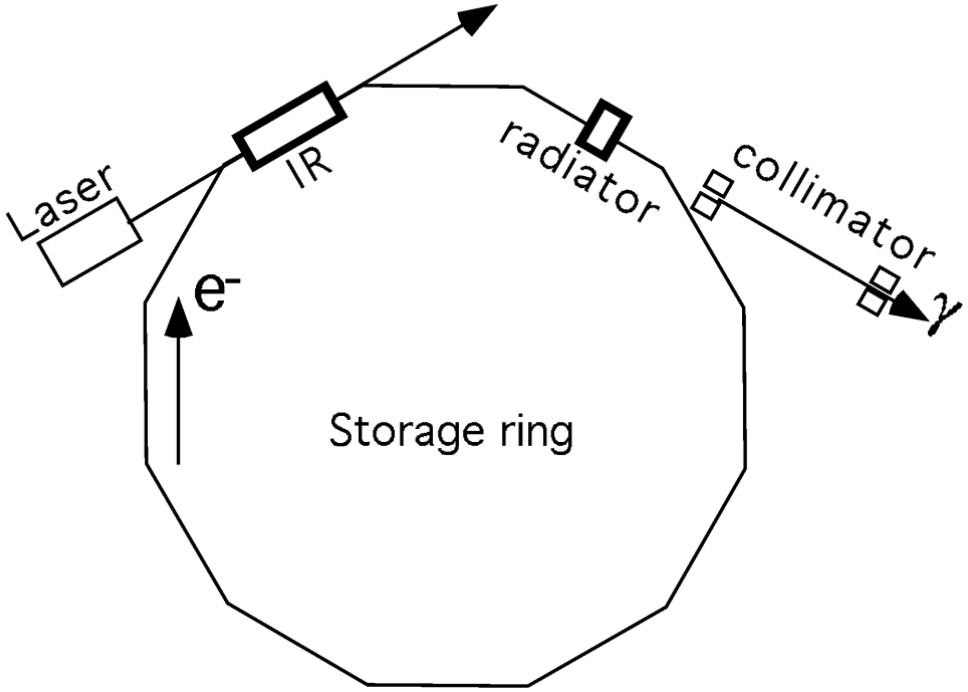
- C. Sun, et al., PRL 109, 264801 (2012)

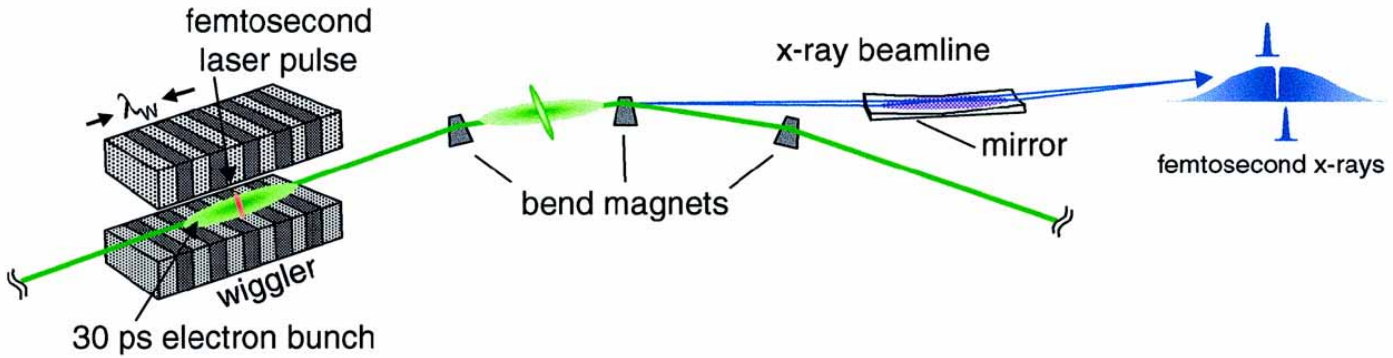


Variable operation schemes

- A. A. Zholents, M. S. Zolotorev, PRL 76 (1996) 912.
- R. W. Schoenlein, et al., Science. 2000 Mar 24;287(5461):2237-40.

- Laser slicing (ALS, BESSY, SLS, …)

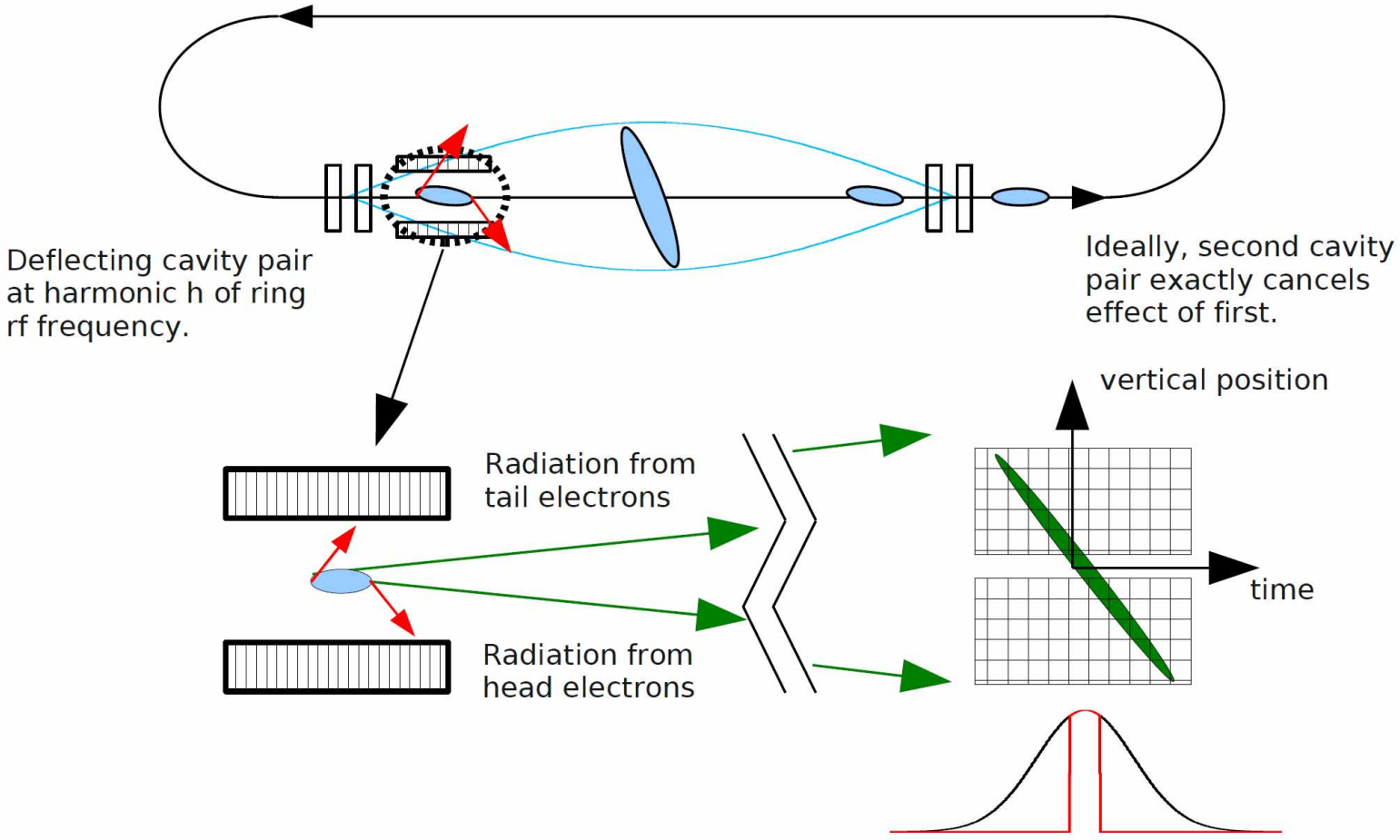




Variable operation schemes

- A. Zholents et al., NIMA 425 (1999) 385-389.
- APS Upgrade PDR, 2012.
- M. Borland, PRST-AB 8, 074001 (2005).
- Xiaobiao Huang, PRAB 19, 024001 (2016).

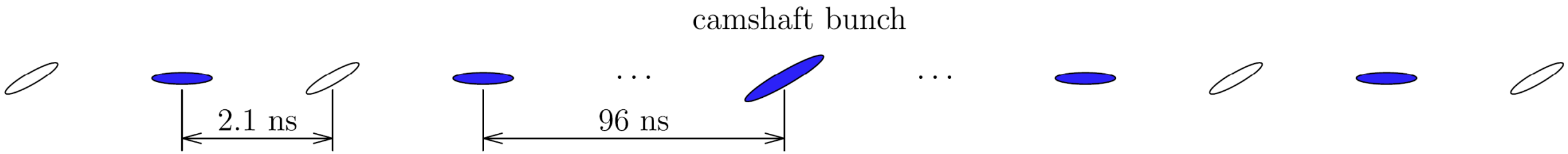
•Short Pulse X-ray (w/ deflecting cavities)



Variable operation schemes

- Short Pulse X-ray (w/ two-frequency deflecting cavities)

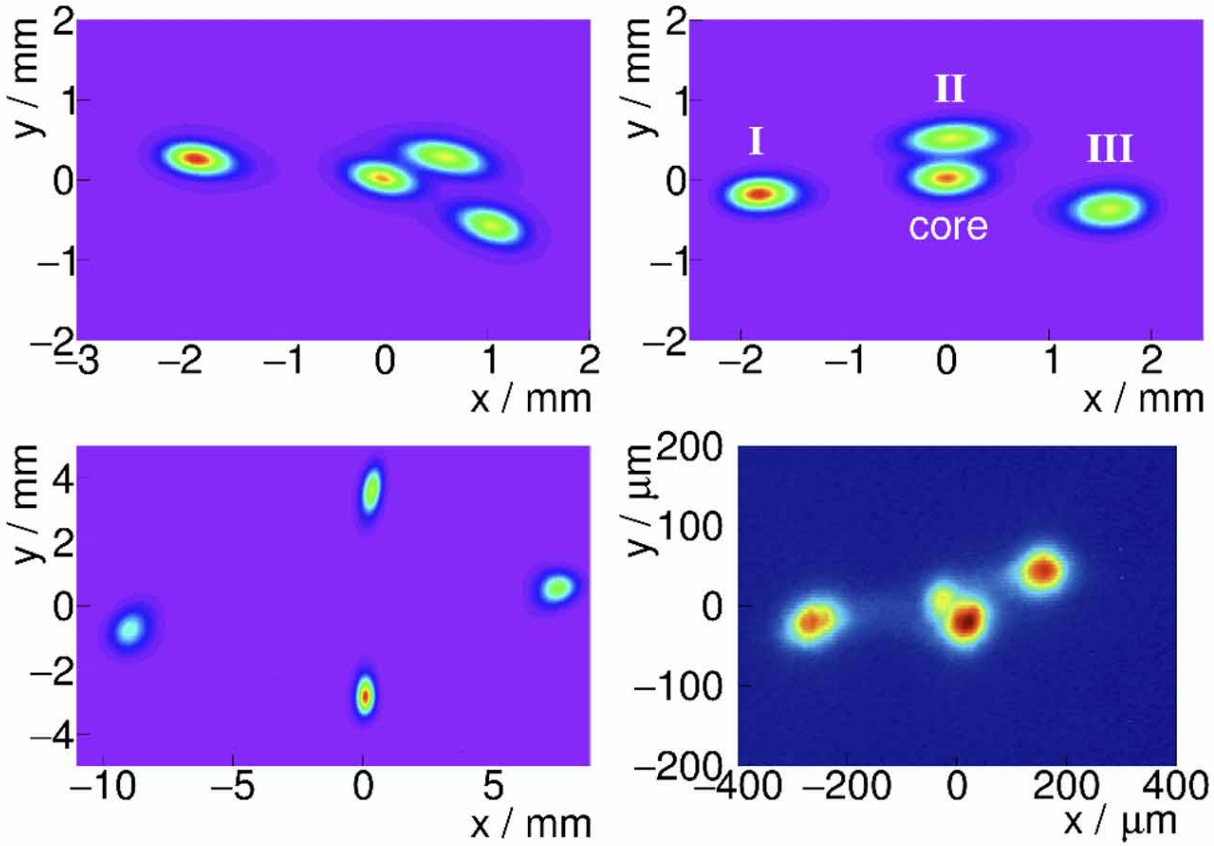
- Xiaobiao Huang et al., PRAB 22, 090703 (2019).

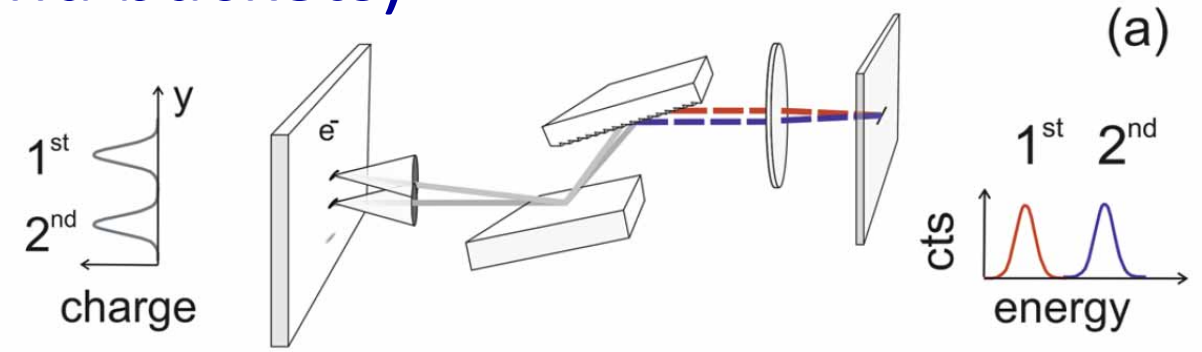


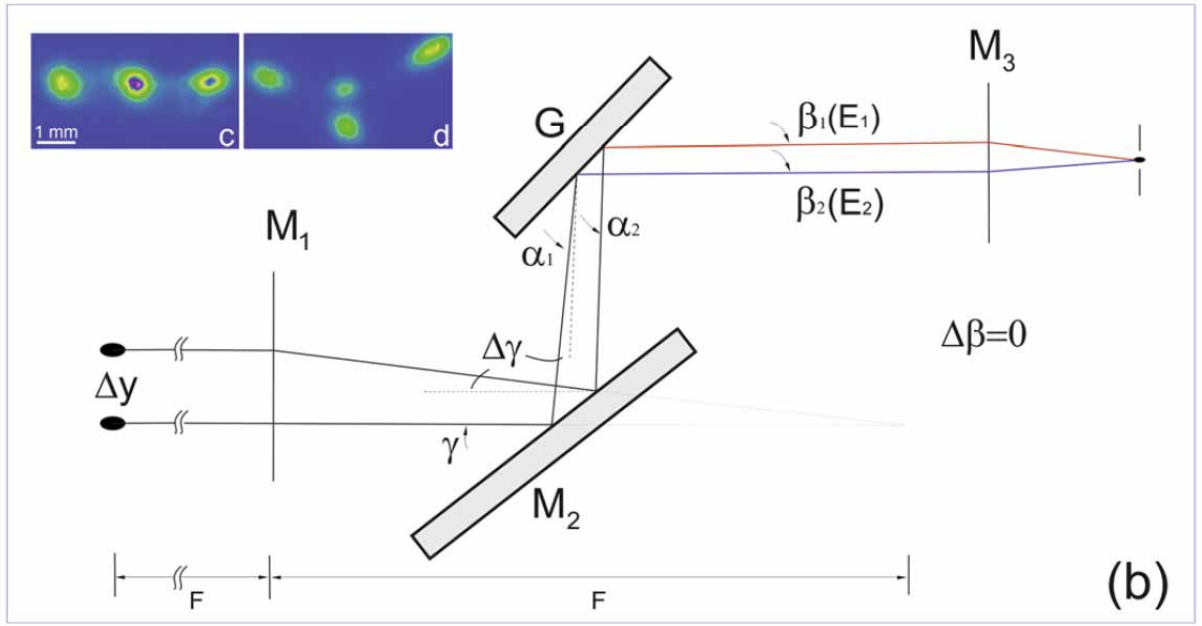
Variable operation schemes

- M. Ries et al., IPAC2015, MOPWA021.
- K. Holldack et al., Scientific Reports (2022) 12:14876.

- TRIBs (transverse resonance island buckets)



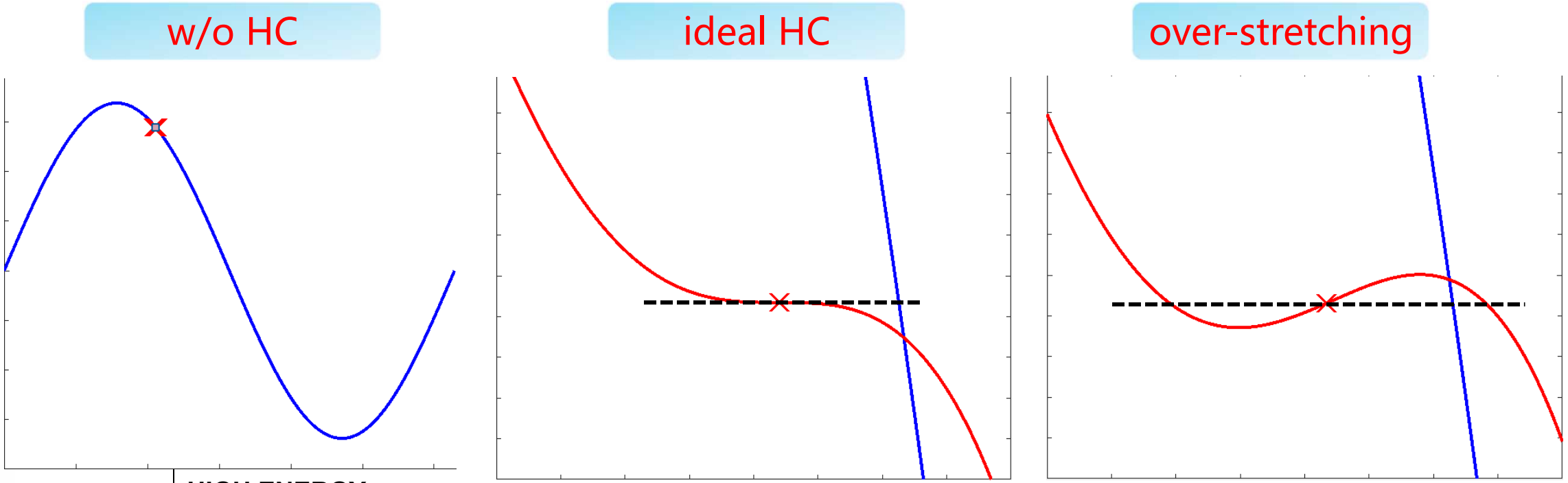




Proposal of a new operation scheme

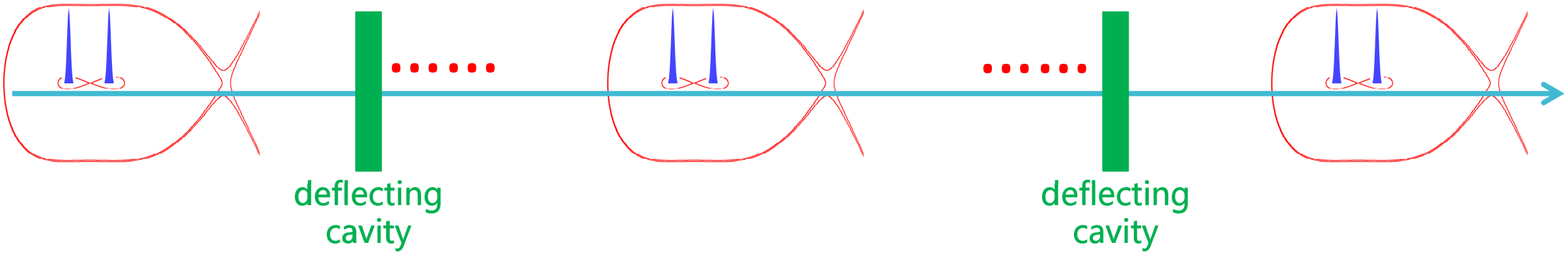
Idea of the proposed operation scheme

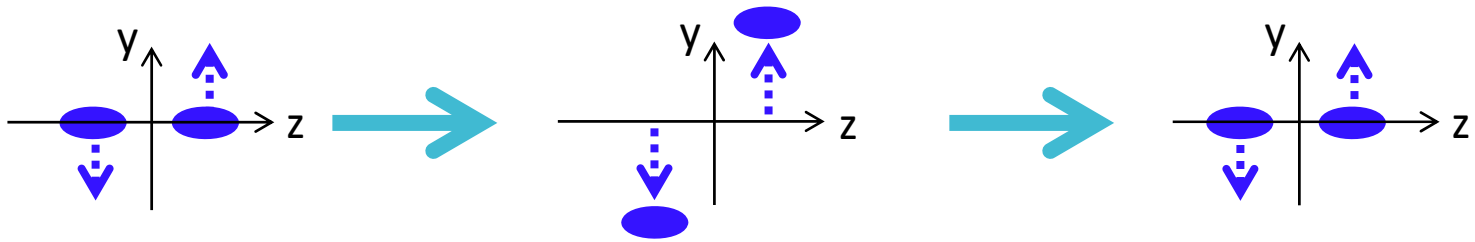
- Generating “two bunches” by double-RF system under an “over-stretching condition”
  - Fundamental cavity + harmonic cavity



Idea of the proposed operation scheme

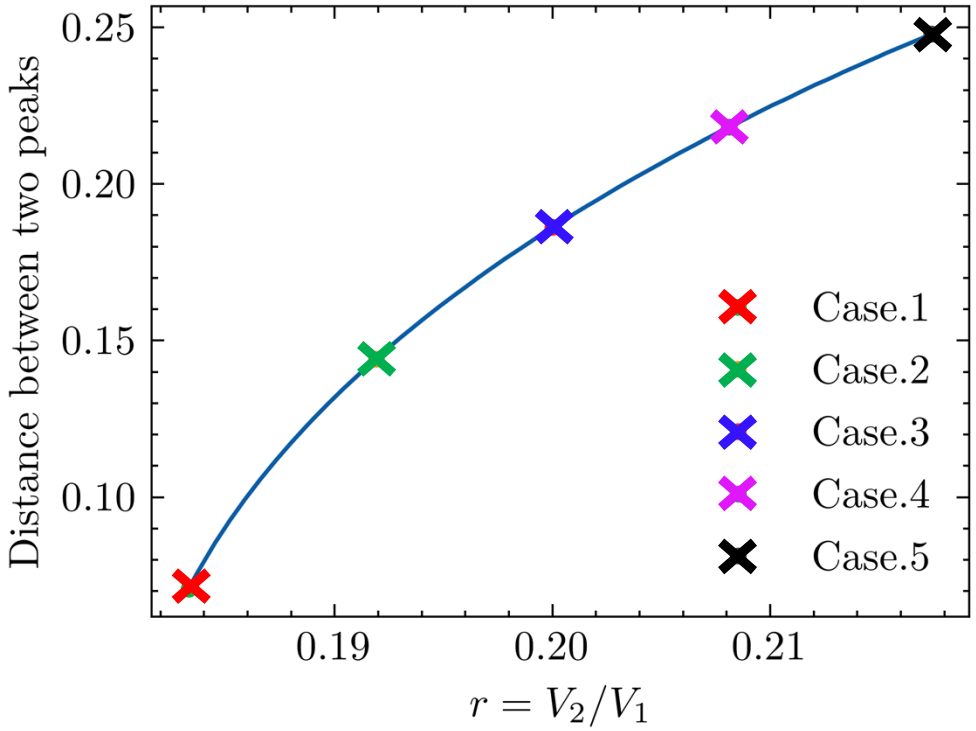
- Generating “two bunches” by double-RF system under an “over-stretching condition”
  - Fundamental cavity + harmonic cavity

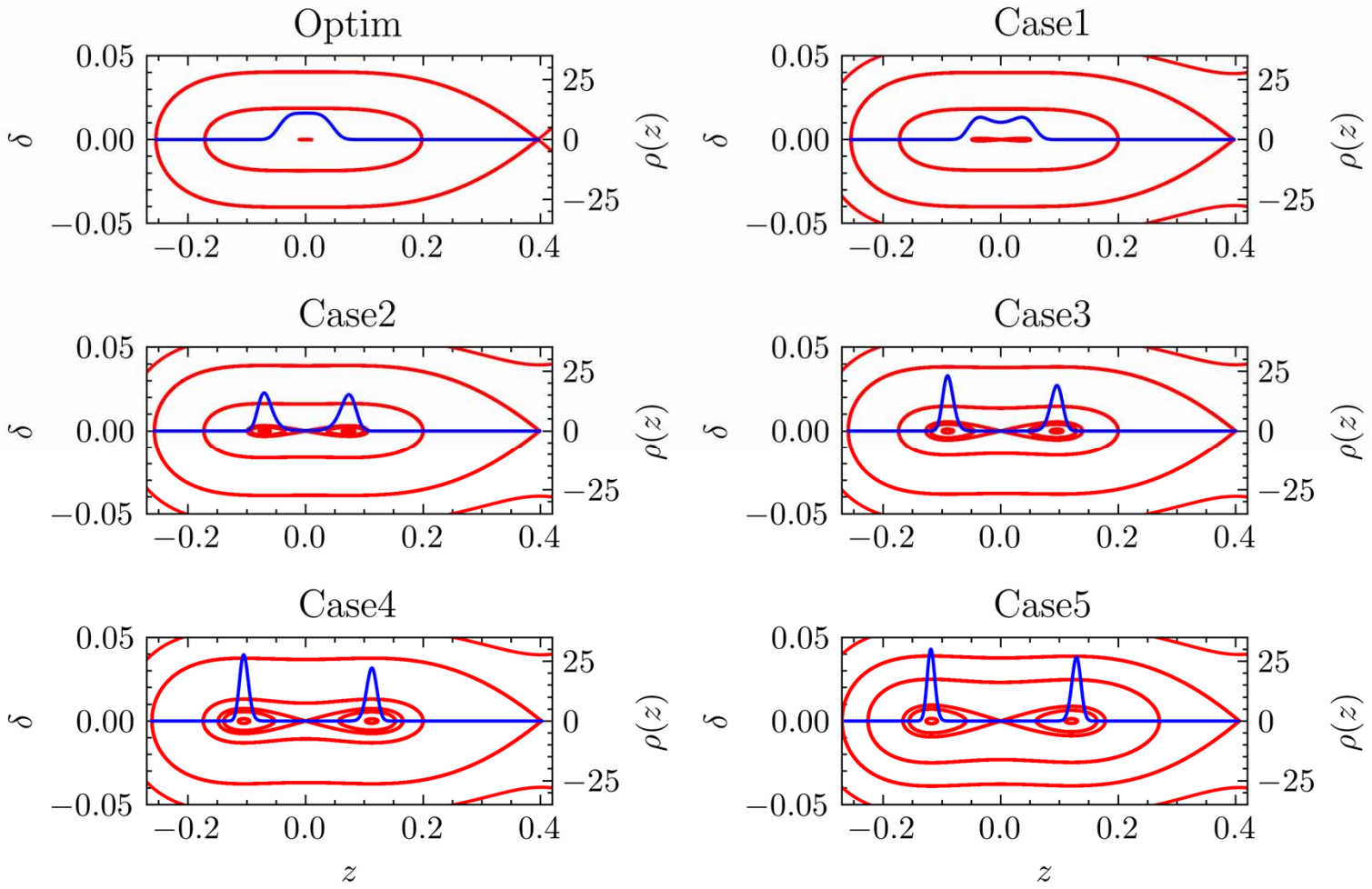




Generation of two bunches with tunable time delay

- Double-RF System
  - "Over-stretching"





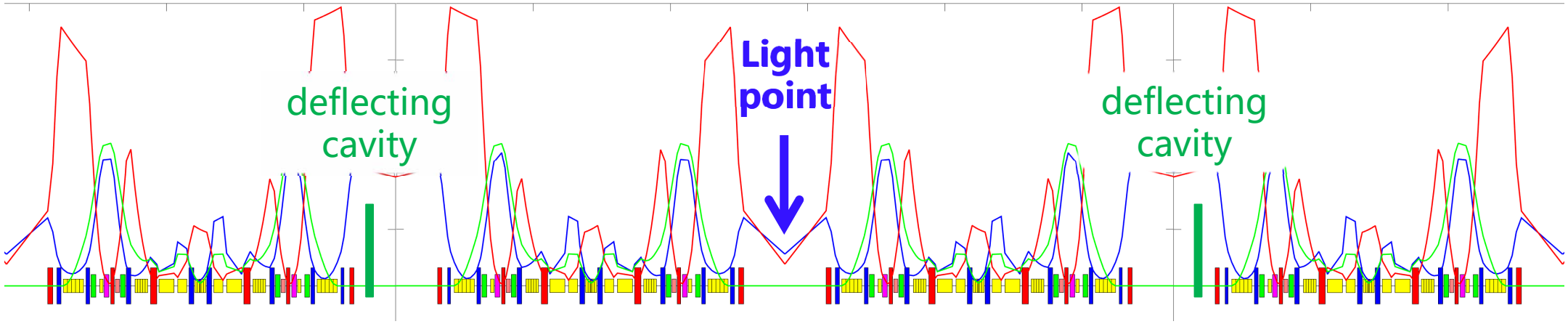
Several key issues

- Choice of parameters of the deflecting cavities
- Optimization of the interior sextupoles
- ……

The PDR lattice of HEPS storage ring was used in the following studies.

Choice of parameters of the deflecting cavities

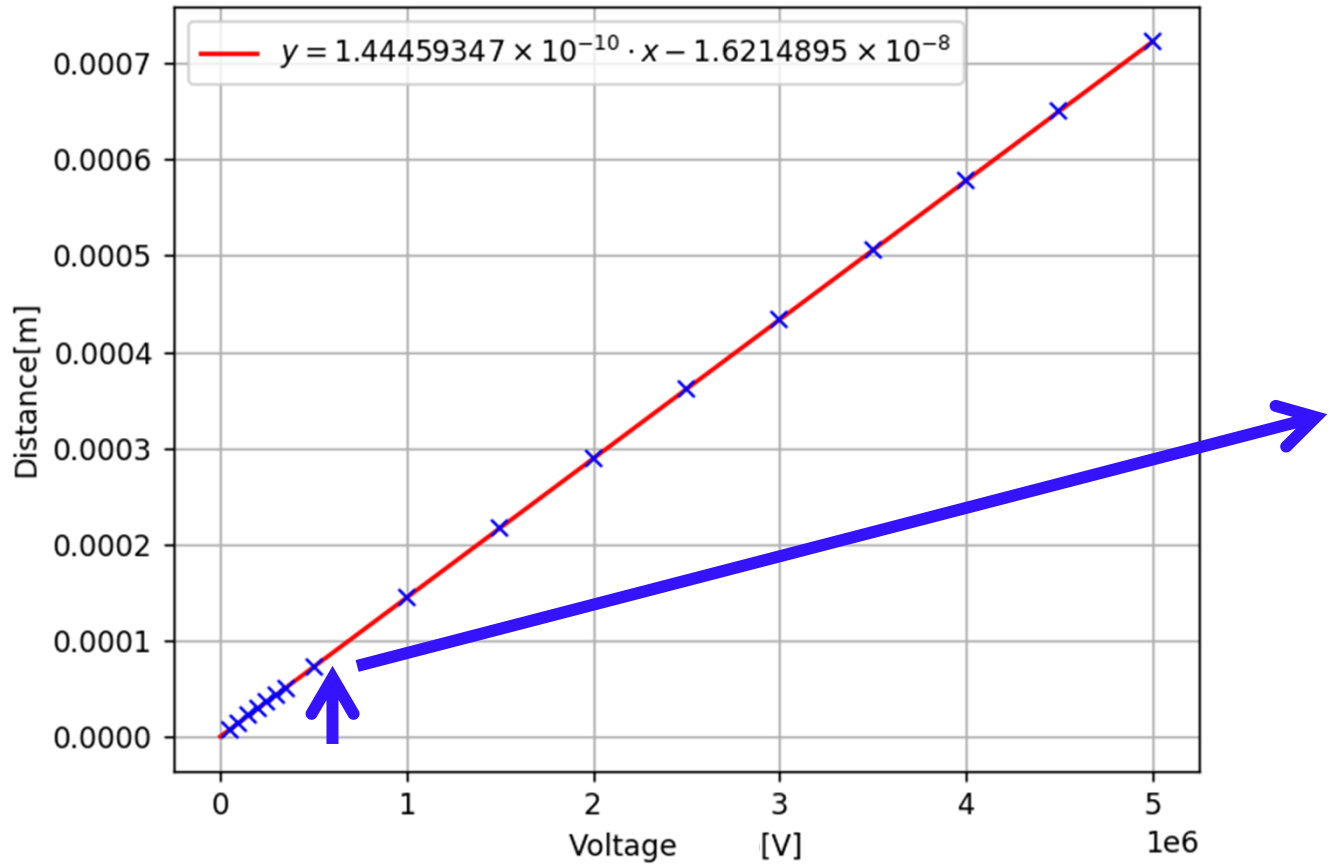
- **Frequency** of the two deflecting cavities is the same.
- **Positions** of the two deflecting cavities are symmetric according to the interior straight section.

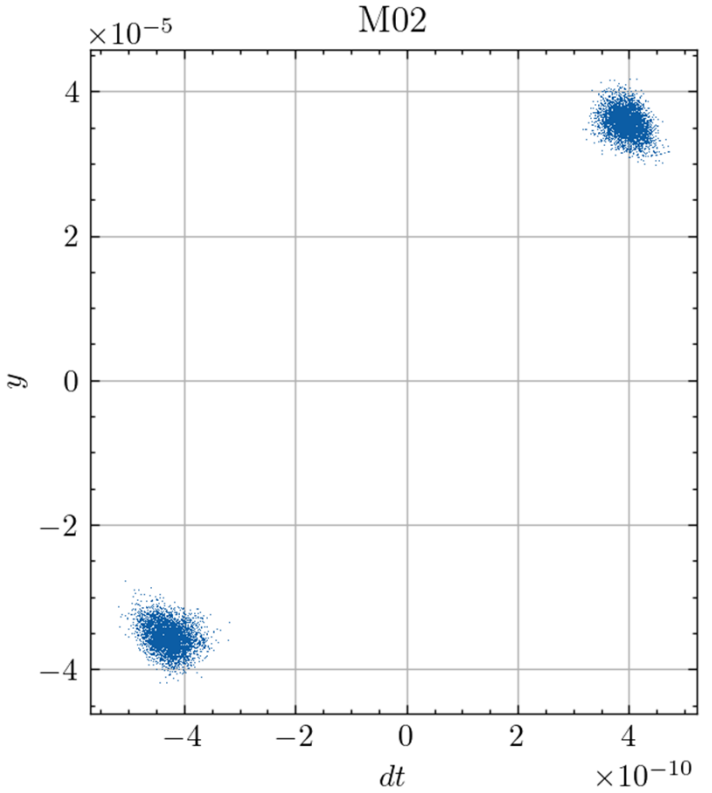


- **Peak voltages** and **phases** of the two deflecting cavities were all optimized separately.

Parameters of the 1st deflecting cavity

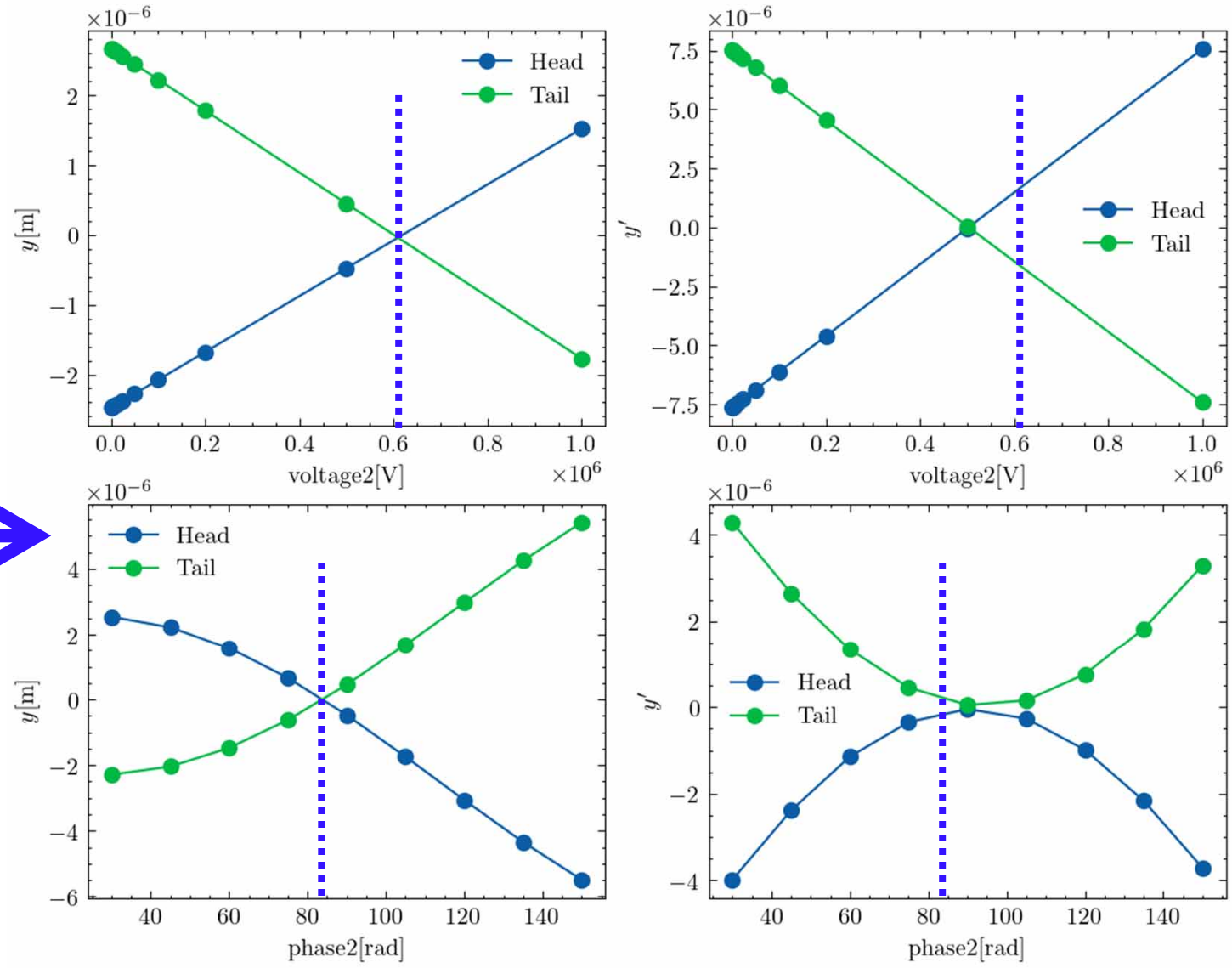
- Scan the peak voltage of the 1st deflecting cavity





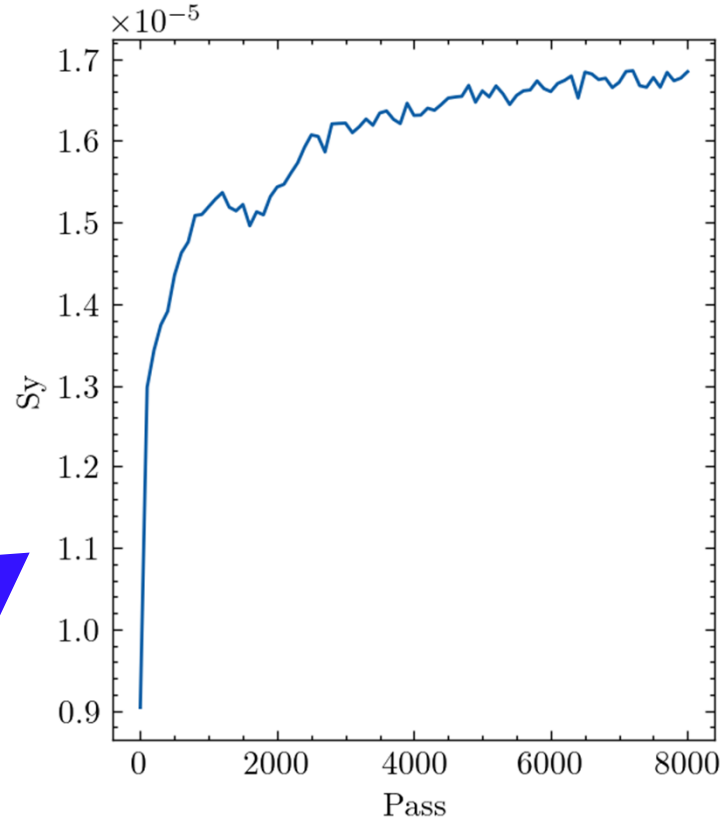
Parameters of the 2nd deflecting cavity

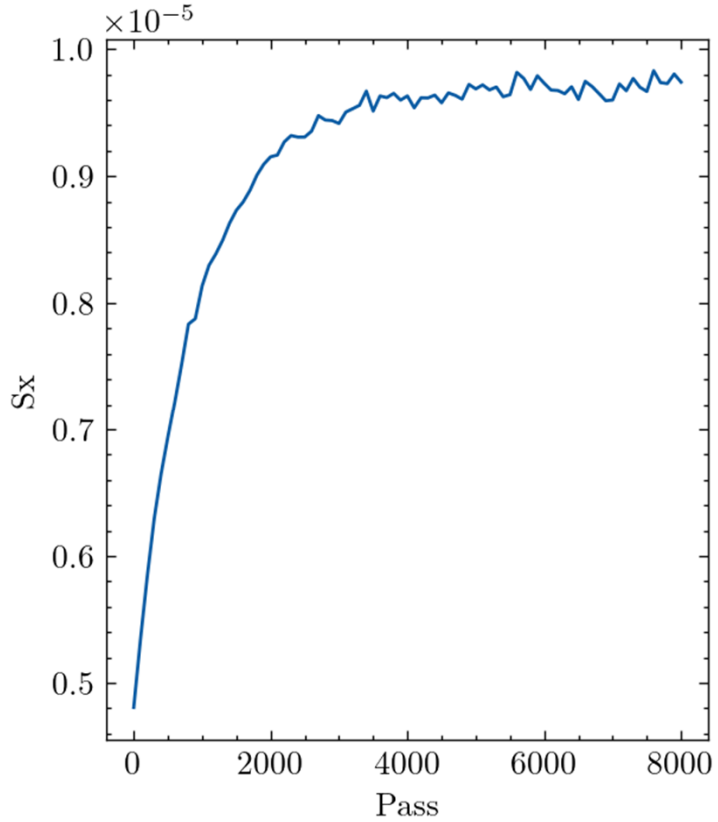
- Scan voltage and phase of the 2nd deflecting cavity
  - Optimize y and y’ at the exit of the 2nd deflecting cavity
  - Possible problem: y and y’ at the exit of the 2nd deflecting cavity cannot be 0 simultaneously.



Parameters of the 2nd deflecting cavity

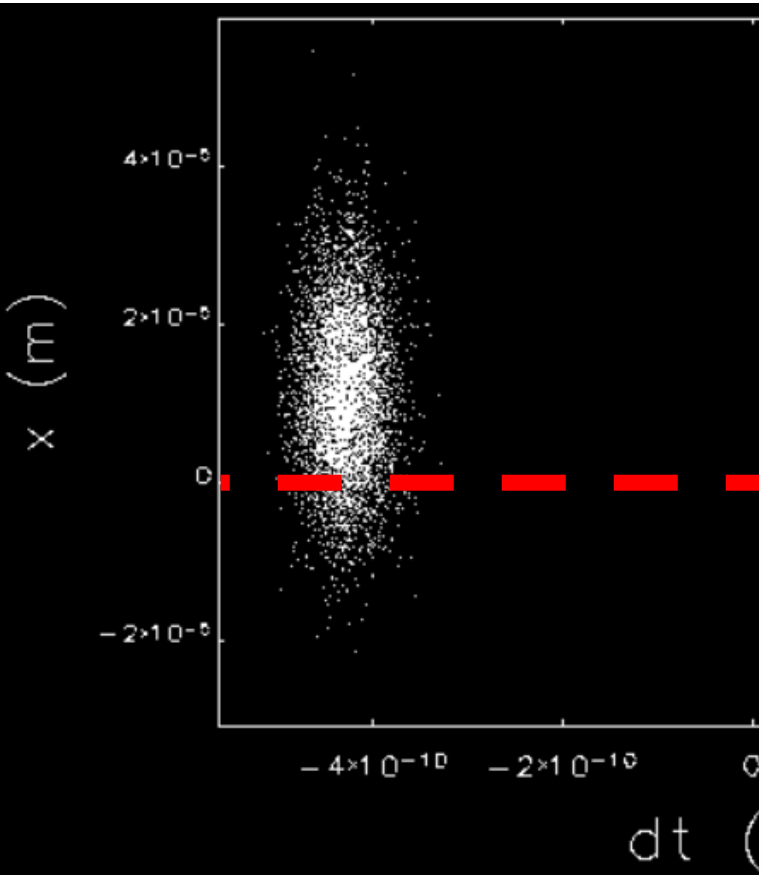
- Scan voltage and phase of the 2nd deflecting cavity
  - Optimize y and y' at the exit of the 2nd deflecting cavity
  - Possible problem: y and y' at the exit of the 2nd deflecting cavity cannot be 0 simultaneously.
  - Emittance growth (bunch size increase) can be observed after tracking for many turns.

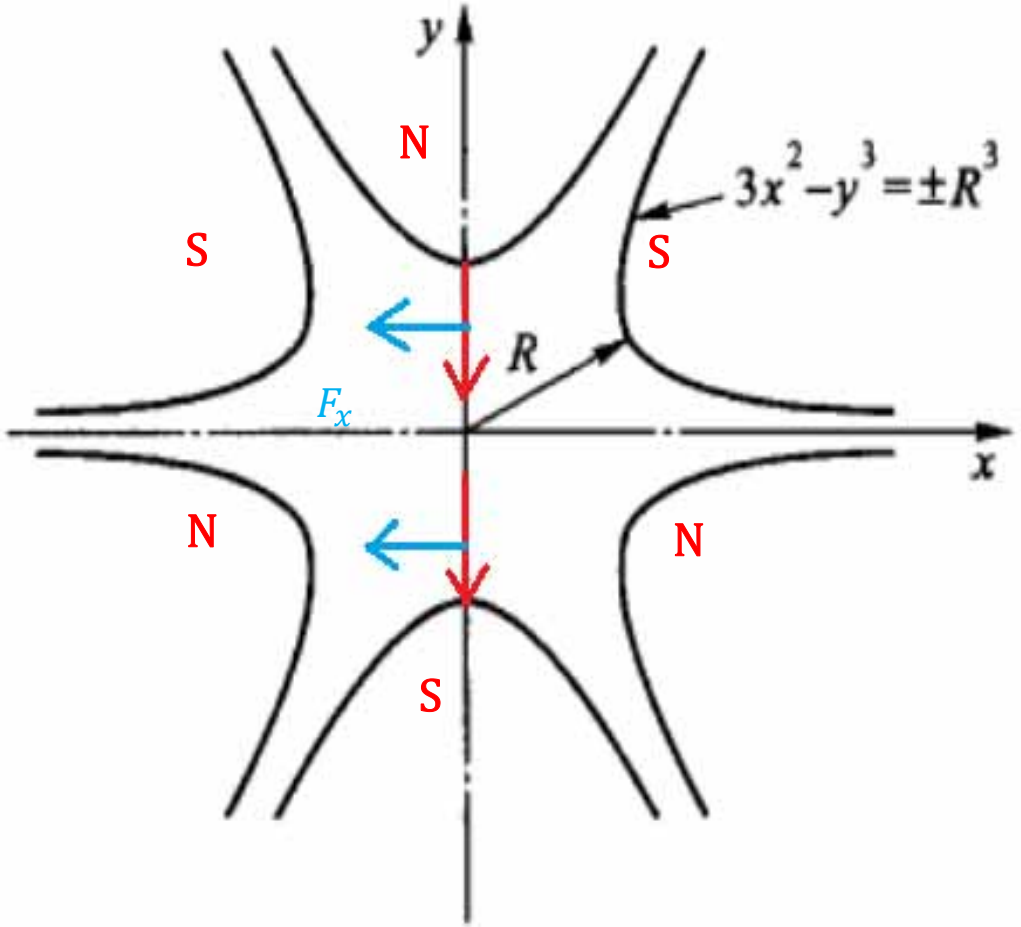


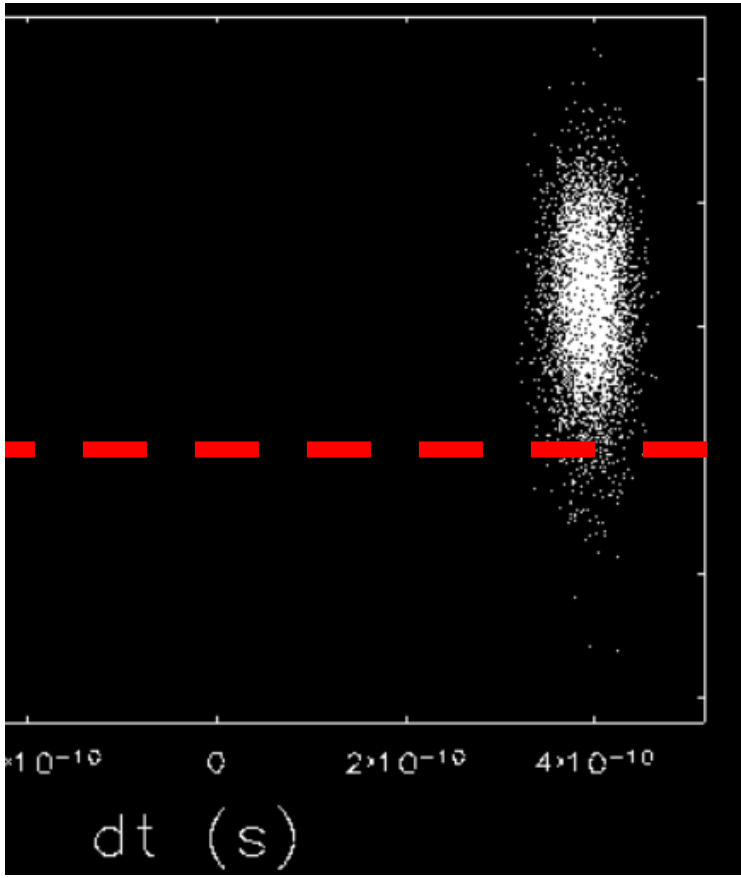


Sextupoles induced horizontal offset / angle

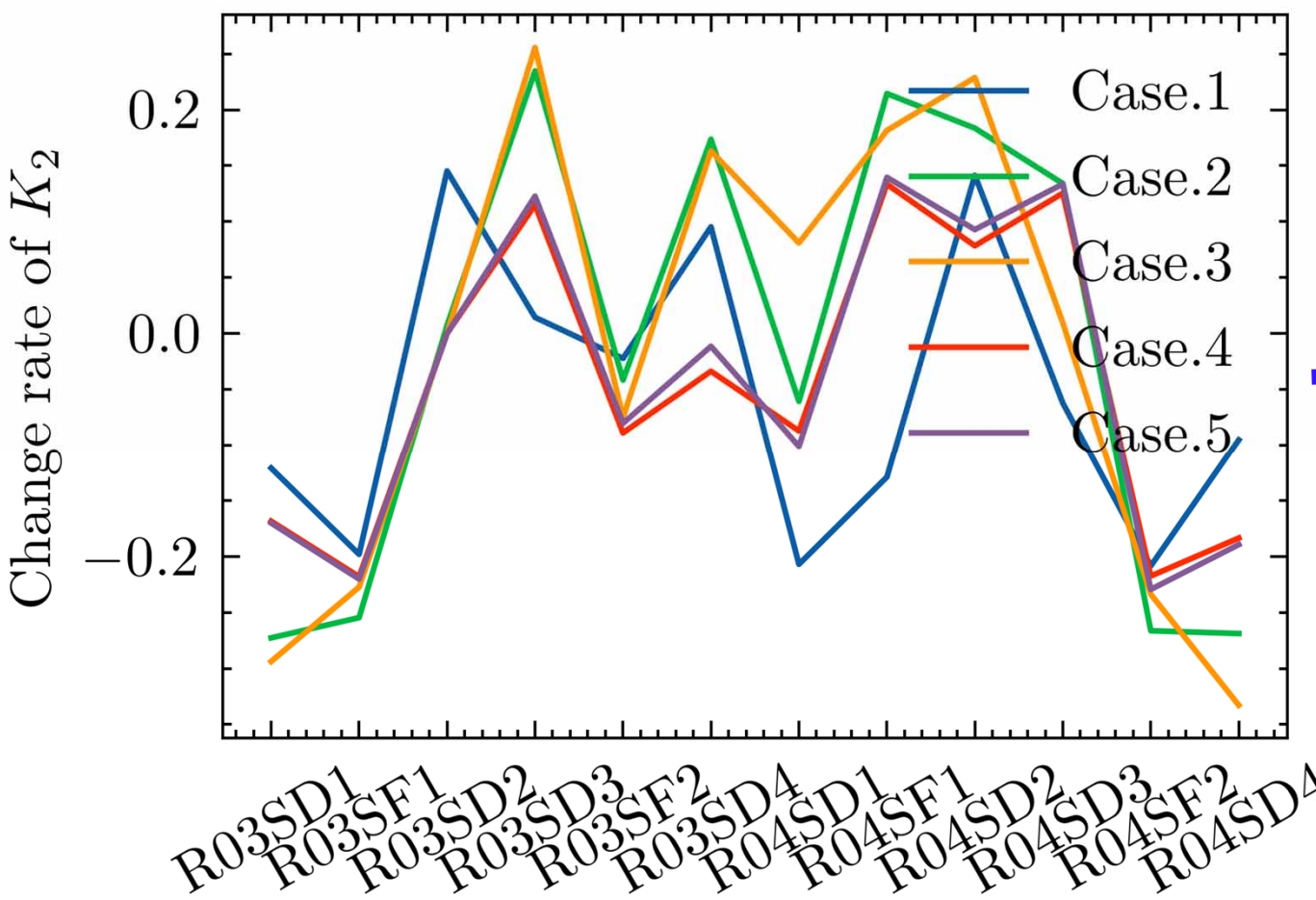
- Identify the reason of the growth of bunch size

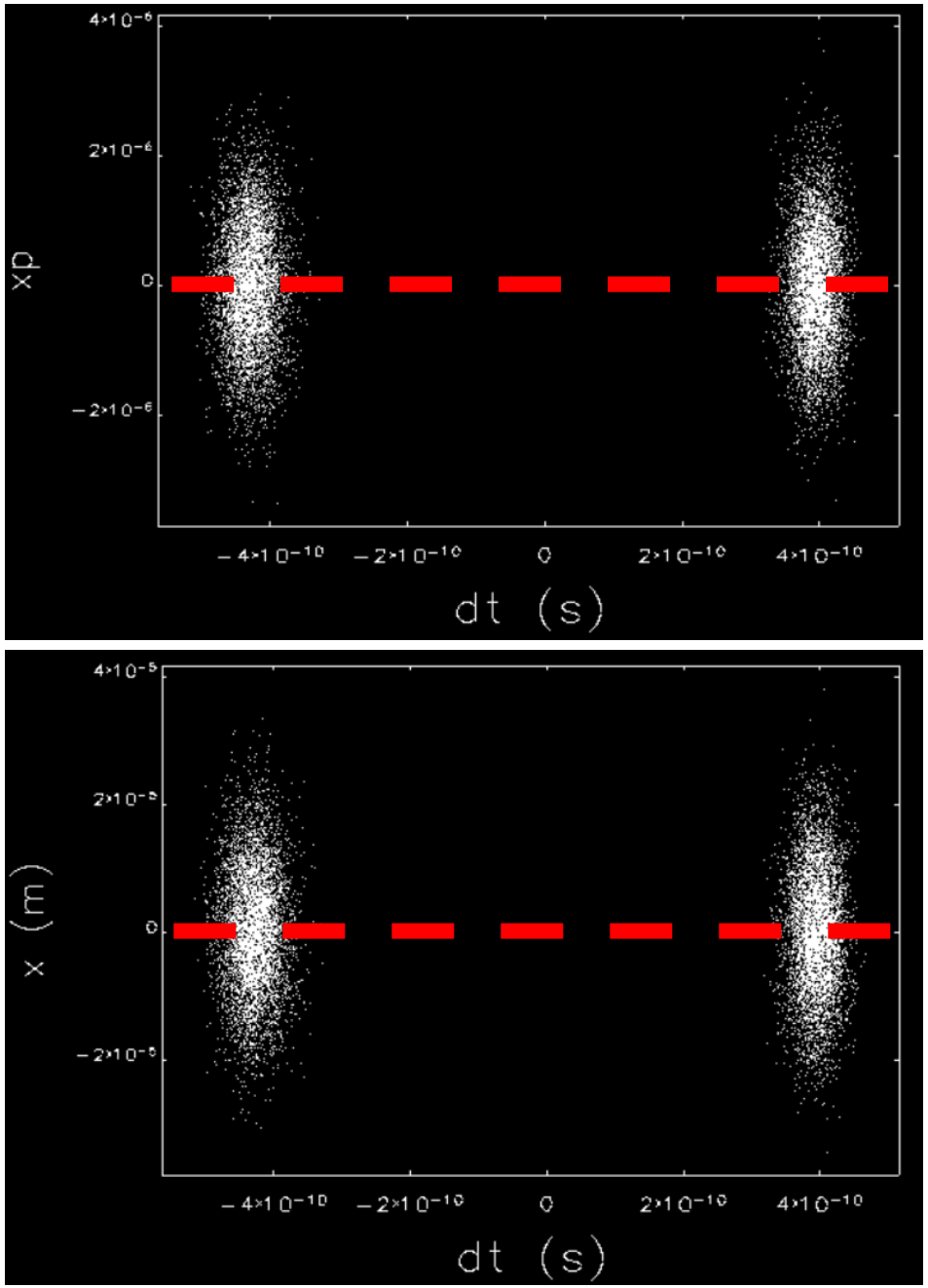






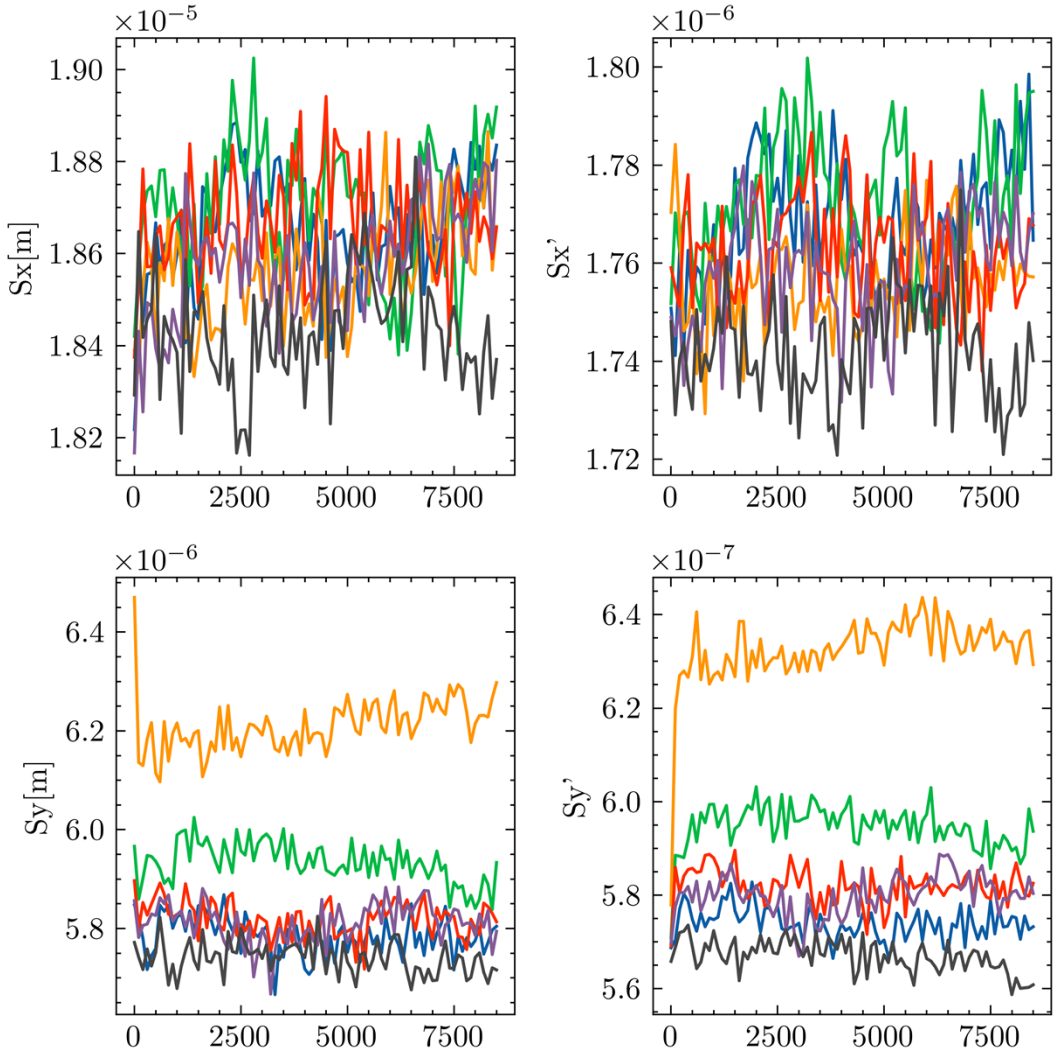
Optimize interior sextupoles





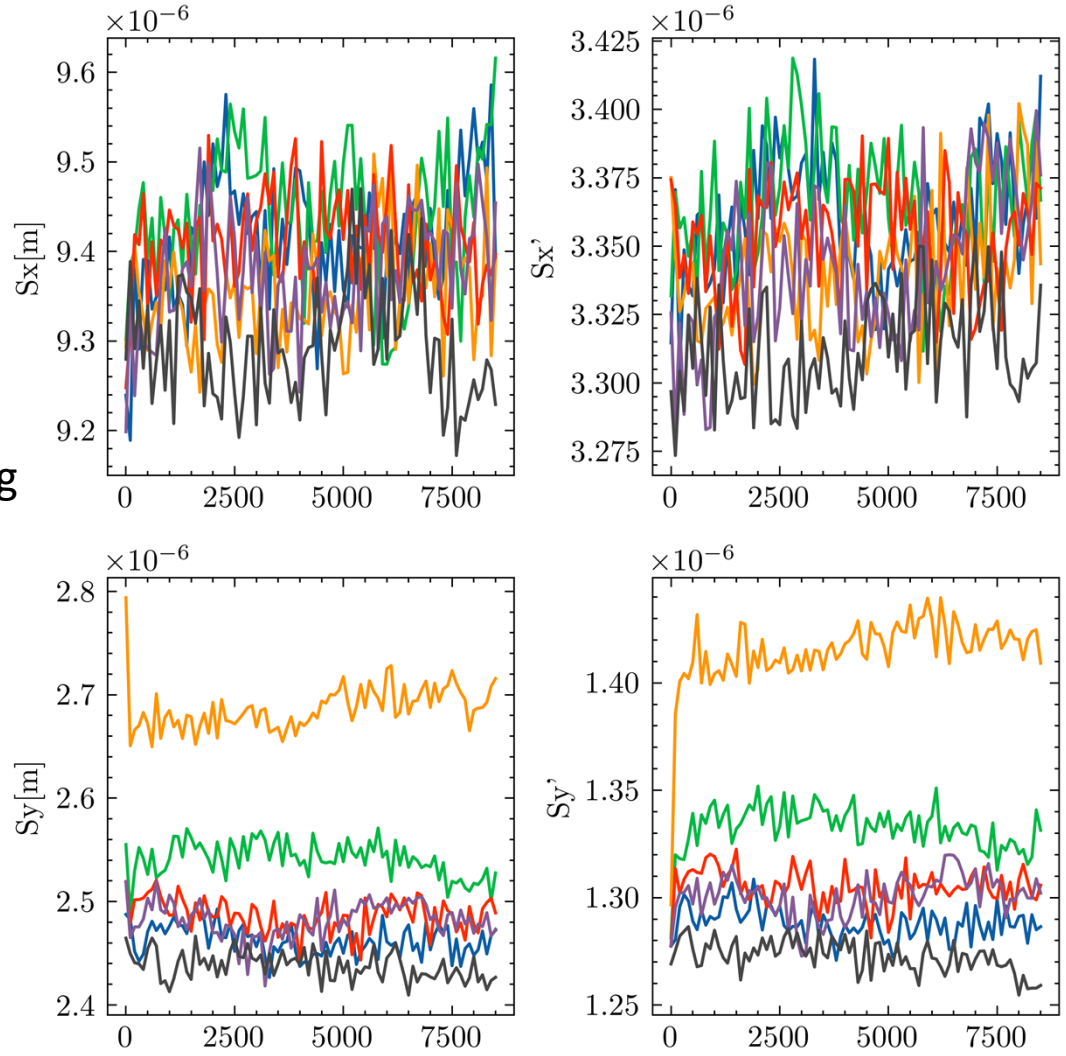
Tracking results of multi-turns

Transverse beam size and divergence at the exit of the 2nd deflecting cavity



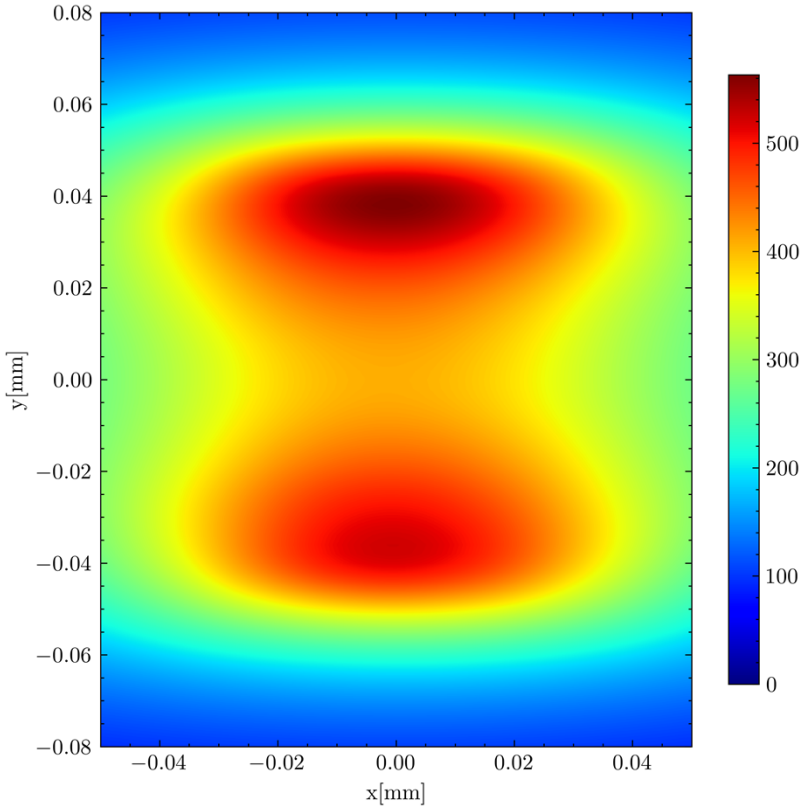
w/o deflecting cavity
Case.1
Case.2
Case.3
Case.4
Case.5

Transverse beam size and divergence at the center of an outer straight section

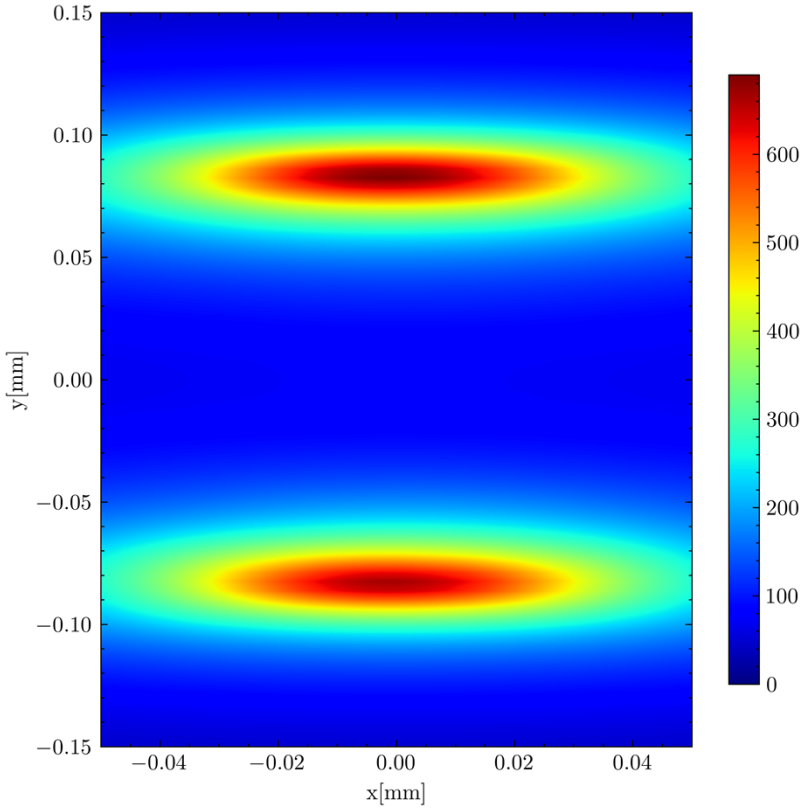


Synchrotron radiation spot

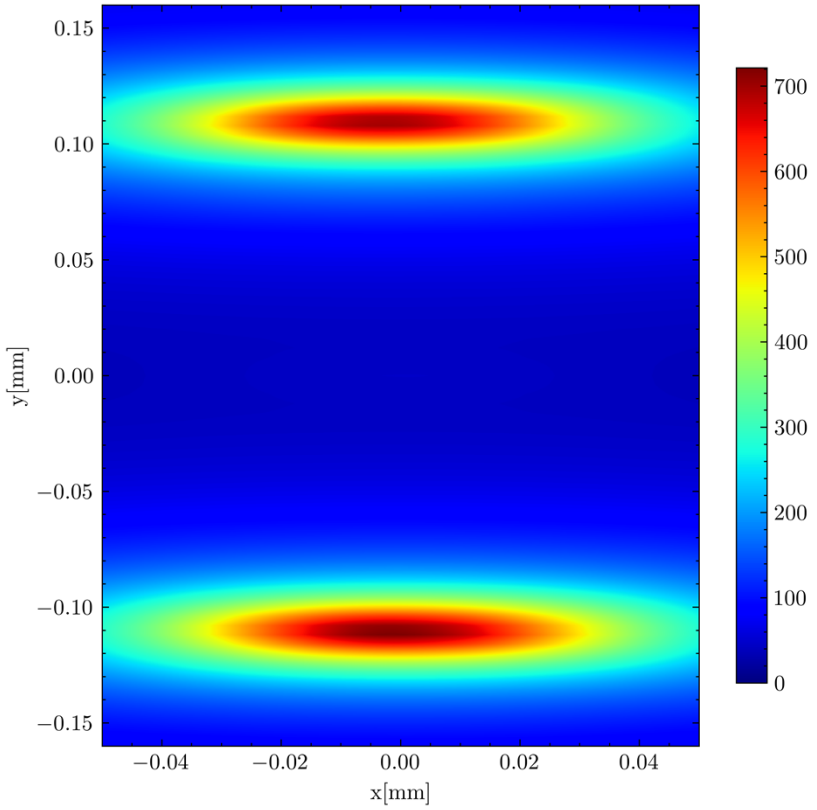
- Computed by SPECTRA



Case.1



Case.2



Case.3

Summary

- An operation scheme which can provide two X-ray pulses with tunable separation (vertically and longitudinally) was presented.

- We hope that the proposed scheme would provide new opportunities to the users of synchrotron light sources.


Thanks for you attention!