Fast Measurements of the Electron Beam Transverse Size and Position on SOLEIL Storage Ring

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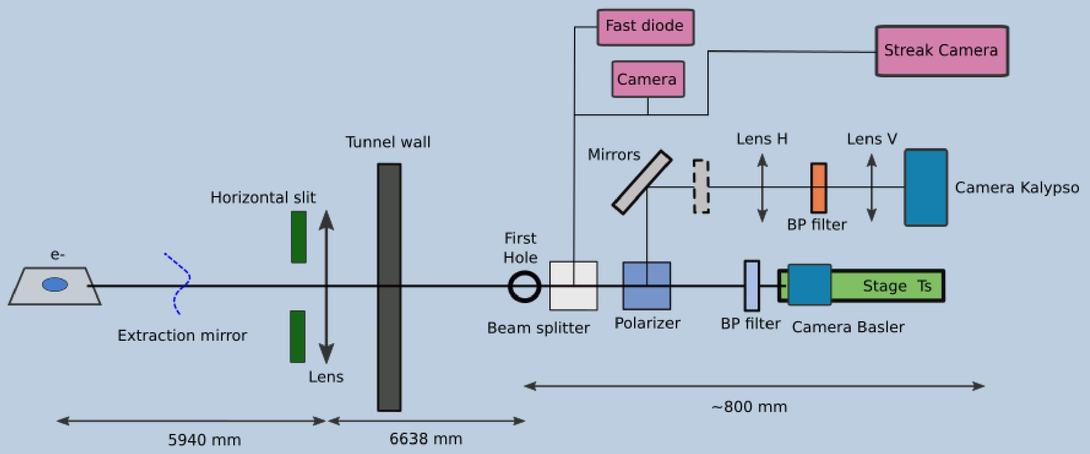
M. Labat, A. Bence, N. Hubert, D. Pédeau, M.M. Patil, M. Caselle, A. Ebersoldt, E. Brüdermann

Abstract

On SOLEIL storage ring, three beamlines are dedicated to electron beam diagnostics: two in the X-ray range and one in the visible range. The visible range beamline uses the synchrotron radiation which is emitted in one of the ring dipoles and further extracted by a slotted mirror operated in surf-mode (surfing on the upper part of the synchrotron layer). The radiation in the visible range is then transported towards a diagnostic hutch in the experimental hall, allowing electron beam imaging at the source point onto a standard CCD camera. In the perspective of prototyping works for the eventually forthcoming upgrade of SOLEIL, and for the on-going commissioning of a new Multipole Injection Kicker (MIK), we recently installed in this hutch two new branches ended by two new cameras (a KALYPSO system and a standard CMOS camera). We report in this paper the optimization we performed on the mirror mode of operation, as well as on spectral filtering, polarization selection, image plane location, fast acquisition tools, to improve the resolution and increase the speed of our initial transverse beam size measurement at source point.

Experimental layout

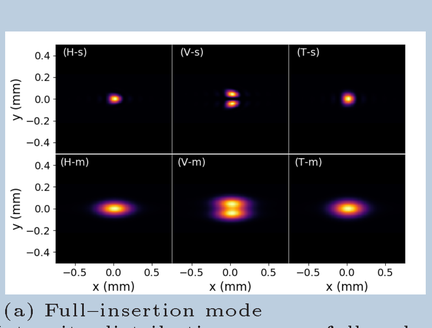
- SOLEIL storage ring:
  - High beam stability thanks to beam position (BPM) and beam size (PHCs) on–line monitoring + feedbacks
  - But need faster beam size measurements → upgrade MRSV beamline
- MRSV beamline:
  - SR extracted using a slotted mirror in surf mode (slot mode not possible)
  - SR transported by flat mirrors down to diagnostics hutch (experimental hall)
  - SR focussing with a spherical lens inside tunnel
  - Horizontal collection angle θ_x set with a horizontal slit inside tunnel
  - On optical bench: SR splitted into 3 old and 2 new branches



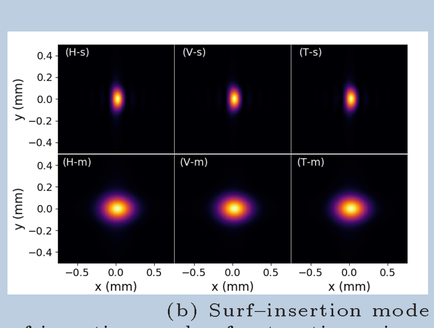
MRSV beamline with its three initial branches in pink, and its two new branches

Beamline modeling

- Beamline accurate modeling mandatory for accurate beam size measurements → SRW [1]
- Simulation of the effect of *surf* instead of *full* or *surf* insertion mode, of beamline stigmatism (due to heat load on extraction mirror) and of effect of θ_x and λ

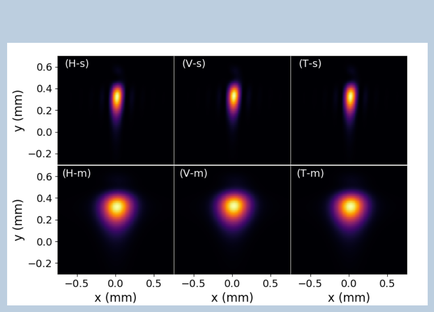


(a) Full–insertion mode

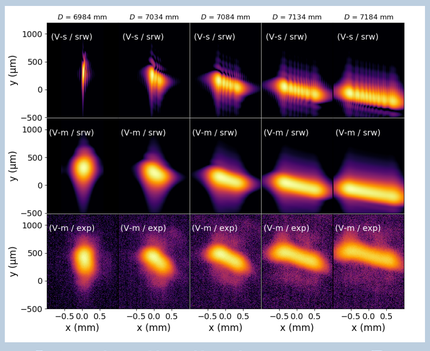


(b) Surf–insertion mode

Intensity distributions versus full and surf insertion mode of extraction mirror.



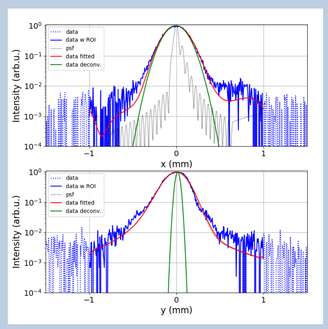
Intensity distributions with stigmatic focussing.



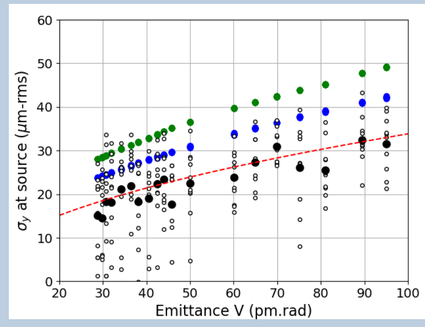
Intensity distributions versus D.

First new branch: NB#1

- SRW optimization for beam size retrieval → λ=400 nm (smallest), θ_x=10 mrad (largest)
- NB #1: θ_x=10 mrad, BP filter @400 nm + V polarizer + Basler ace1920 CMOS camera
- Beam size retrieval method: pseudo–PSF + correction for mirror residual distortion
- Final test: simultaneous record of σ_y on NB#1 and PHCs
  → Good measurement in average...
  → BUT ultra–high level of fluctuations !!!
  → Most probably due to in–air long transport....



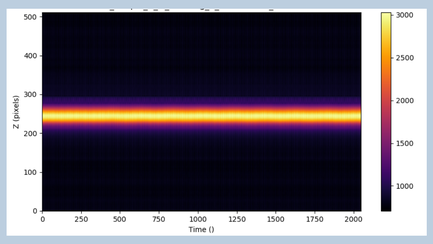
Example of beam size retrieval from measured images.



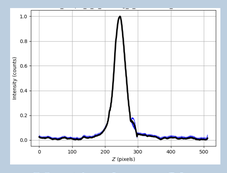
σ_y from (●) NB #1 and PHCs (green and blue dots)

Second new branch: NB#2

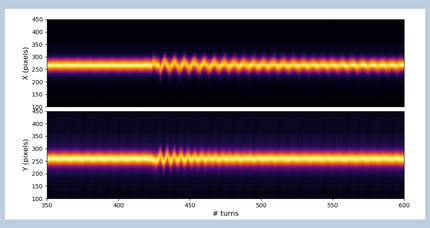
- NB #2: θ_x=10 mrad, BP filter @600 nm + H polarizer + KALYPSO [2] camera
- KALYPSO image =
  → Transverse distribution along vertical axis
  → Arrival time along horizontal axis (up to 3 MHz rep. rate)
  → Allowing the following of ultra-fast (turn–by–turn) phenomena !!!
- First single shot following of effect of injection on beam position / size



Typical Kalypso image



Vertical profile from Kalypso image



Kalypso image at injection

Conclusion

- Two new branches for accurate / fast beam size measurements at SOLEIL to complete PHCs
- Encouraging agreement SRW / measurements eventhough difficult conditions for extraction mirror operation
- Mainly suffering instability from in–air transport
- Major improvments expected from forthcoming upgrade of extraction mirror + further forthcoming new in–vacuum beamline

References

[1] O. Chubar, P. Elleaume, Accurate And Efficient Computation Of Synchrotron Radiation In The Near Field Region, Proc. of the EPAC98 Conference, 22-26 June 1998, p.1177-1179 (1998).
[2] M. Caselle et al., Ultrafast linear array detector for real-time imaging, Proc. of SPIE Vol. 10937, 1093704-1 (2019).

Acknowledgements

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