Optimization of Beam Instrumentation for Light Sources

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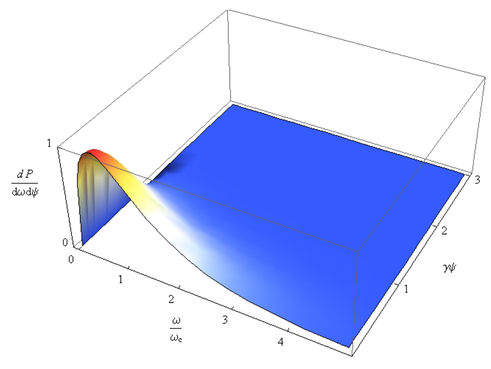
Alba Synchrotron Light Source

Alba is a 3 GeV third generation synchrotron light source located in Cerdanyola del Vallès (Barcelona) and operative since 2012. By the end of this year Alba is going to operate in Top-Up mode that will provide a constant current and consequently a constant flux of radiation. A further upgrade in the near future foresees a bunch by bunch top-up in which the refill will be selective starting from the emptiest bunches. This will provide a flat filling pattern and improve the beam stability.

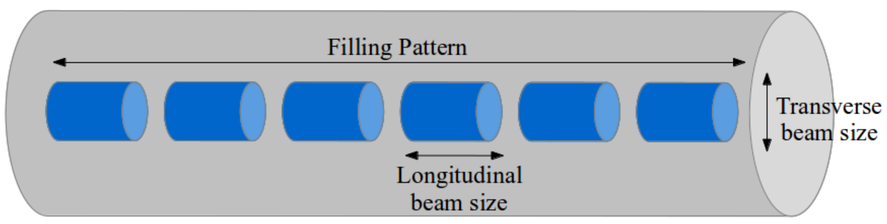
Syncrotron Radiation

$$\frac{\mathrm{d}^2 P_{ob}(\omega,\psi)}{\mathrm{d}\omega \mathrm{d}\psi} = \frac{4\pi c r_0 \dot{p}_T^2 \gamma^3}{3\omega_c m c^2}(F_\sigma(\omega,\psi) + F_\pi(\omega,\psi))$$

- ψ: Emission angle
- ω: Radiation frequency
- c: Speed of light
- r_0: Classical electron radius
- p_T: Transverse momentum
- γ: Lorentz factor
- ω_c: $\frac{3c\gamma^3}{2\rho} = \frac{\varepsilon_c}{\hbar}$
- F: Combination of Airy functions



Beam Characterization Using Synchrotron Radiation



→**Transverse:** Imaging the radiation (directly or indirectly) it is possible to obtain the beam size

→**Longitudinal:** Temporal distribution of the radiation is the same as the one of electrons in the beam

Transverse

Synchrotron radiation source ⇒ Beam size ≃ tens of μm or smaller

⇕

Diffraction limited using visible radiation

⇓

$$d = \frac{\lambda}{2n\sin\theta} \simeq 100\mu\mathrm{m}$$

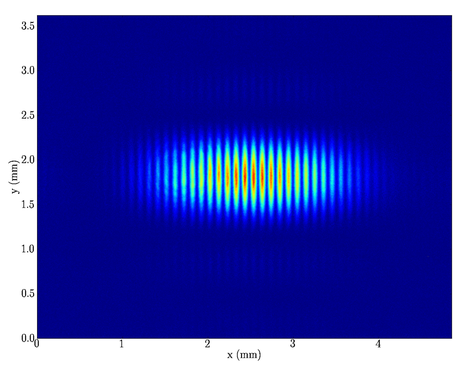
Direct imaging is not possible

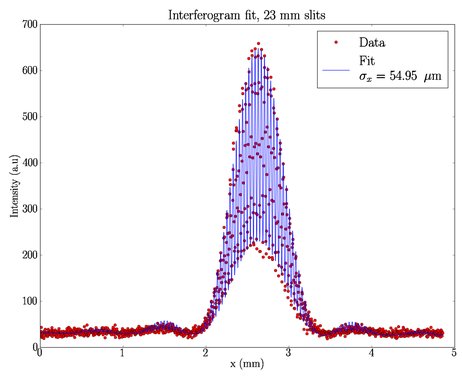
Longitudinal

Needs of measure the longitudinal beam distribution, the **filling pattern**, and to have a quantitative estimation of the current per bunch to drive the selective refill in the top-up operation

Mitsuhashi Interferometer

Measurement of the first order of spatial coherence of the synchrotron radiation using a double slit interferometer





$$\sigma = \frac{\lambda d_0}{\pi D}\sqrt{\frac{1}{2}\ln\frac{1}{V}}$$

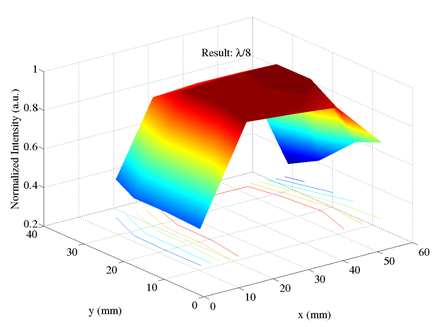
- σ: Beam size
- d_0: Slits separation
- D: Distance between the source and the slits
- V: Visibility

Challenges

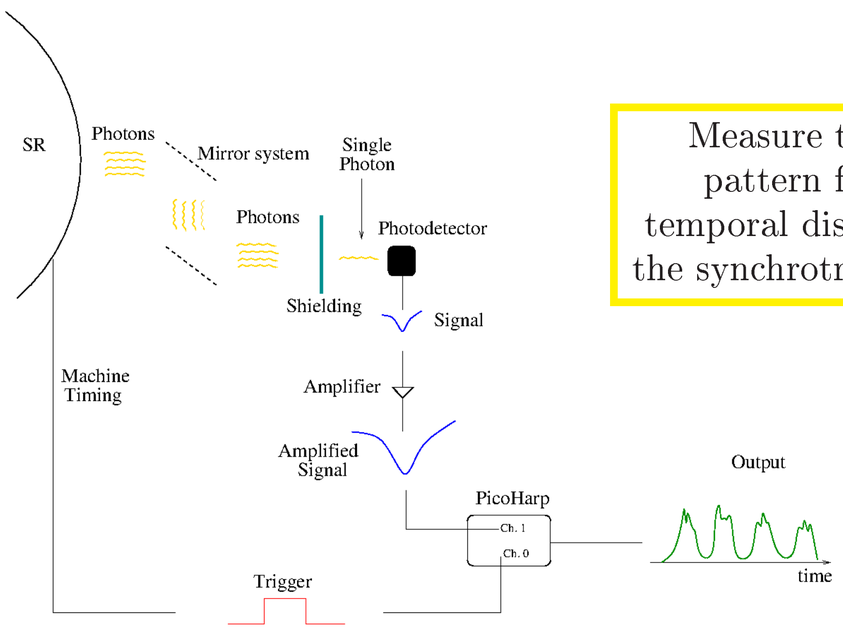
→ Improve the optical elements

→ Improve the data analysis

→ Use the Fast Gated Camera to perform Bunch by Bunch measurements for beam instabilities studies



Time Correlated Single Photon Counting



Measure the filling pattern from the temporal distribution of the synchrotron radiation

Photomultiplier H10721-210 by Hamamatsu used as photon detector

PicoHarp 300 by PicoQuant used as photon counter

Dynamic Range achieved better than 10^4

Challenges

→ Mount the setup inside the tunnel using x-rays

→ Annex the measurement output to the control system to use the results as input for the selective top-up injection

→ Improve the dynamic range to perform bunch purity measurements when operating in single bunch

References

[1] F. Perez, "First Year Operation of the ALBA Synchrotron Light Source", IPAC2013, Shanghai, June 2013, MOPEA055 (2013)

[2] L. Torino and U. Iriso, "Filling Pattern Measurements at ALBA using Time Correlated Single Photon Counting", IPAC'14, Dresden, June 2014, THIPME162 (2014)

[3] T. Mitsuhashi "Measurement of small transverse beam size using interferometry" DIPAC01, Grenoble, May 2001, IT06 (2001)

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