UNIVERSITÀ DEGLI STUDI DI MILANO

INFN Istituto Nazionale di Fisica Nucleare

ALBA

INTERNATIONAL BEAM INSTRUMENTATION CONFERENCE «IBIC 2016»

World Trade Center of Barcelona, Barcelona, Spain, September 11-15, 2016

International Beam Instrumentation Conference IBIC 11 - 15 September 2016 Barcelona

Transverse Beam Size Diagnostics using Brownian Nanoparticles at ALBA

M. Siano[1], B. Paroli[1], M. A. C. Potenza[1], U. Iriso[2], A. Nosych[2], L. Torino[2], A. N. Goldblatt[3], S. Mazzoni[3], G. Trad[3]

[1] *Dipartimento di Fisica, Università degli Studi di Milano and INFN Sezione di Milano, Via G. Celoria, 16, 20133 Milano, Italy*

[2] *ALBA-CELLS, Cerdanyola del Vallès, Spain*

[3] *CERN, Geneva, Switzerland*

Abstract

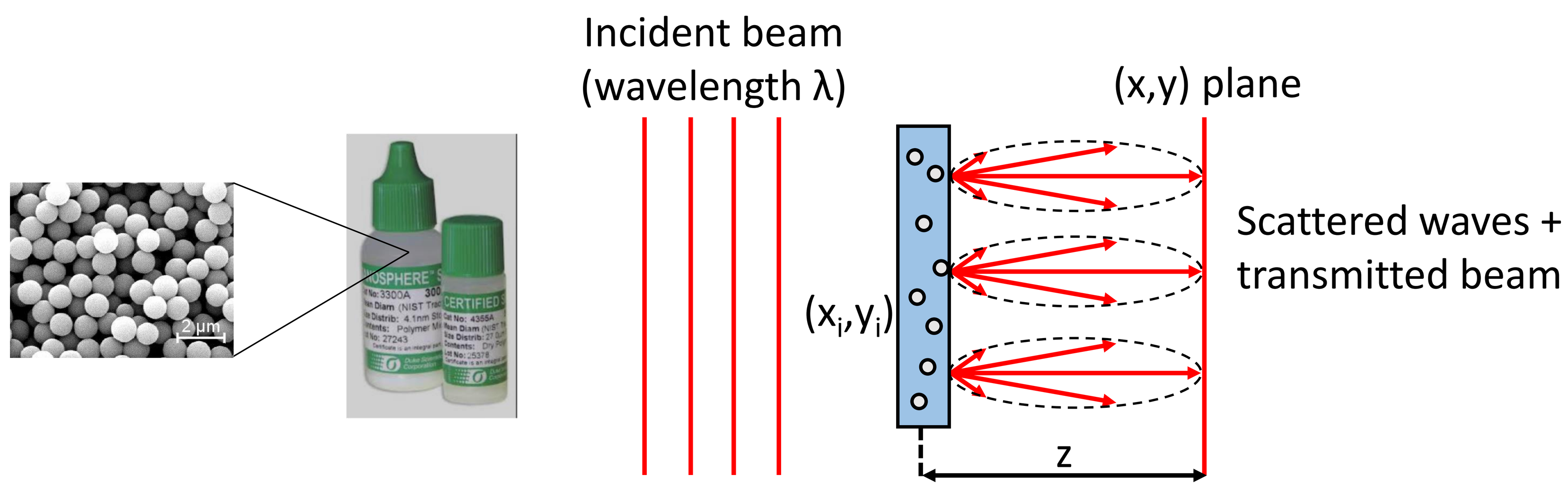
In this work we describe a novel beam diagnostics method based on coherence characterization of broad-spectrum bending magnet radiation through the Heterodyne Near Field Scattering (HNFS) technique. HNFS is a self-referencing technique based on the interference between the transmitted beam and the spherical waves scattered by each particle of a colloidal suspension. The resulting single-particle interferogram shows circular fringes modulated by the spatio-temporal Complex Coherence Factor (CCF) of the radiation. Superposition of a number of these patterns results in a stochastic speckle field, from which spatial and temporal coherence information of the source can be retrieved in near field conditions.

Here we describe the basics of this technique, the experimental setup mounted along the hard X-ray pinhole at the ALBA synchrotron light source, and the possibility of transverse electron beam size retrieval from the spatial coherence function of the emitted dipole radiation. We also show preliminary results concerning power spectral density of visible synchrotron radiation as obtained from temporal coherence.

Heterodyne Near Field Scattering

HNFS probes the **2D field correlation function** $\mu(\Delta x, \Delta y)$ exploiting the self-referencing interference between the (strong) transmitted beam E_0 and the (weak) spherical waves E_s scattered by colloidal particles [1]:

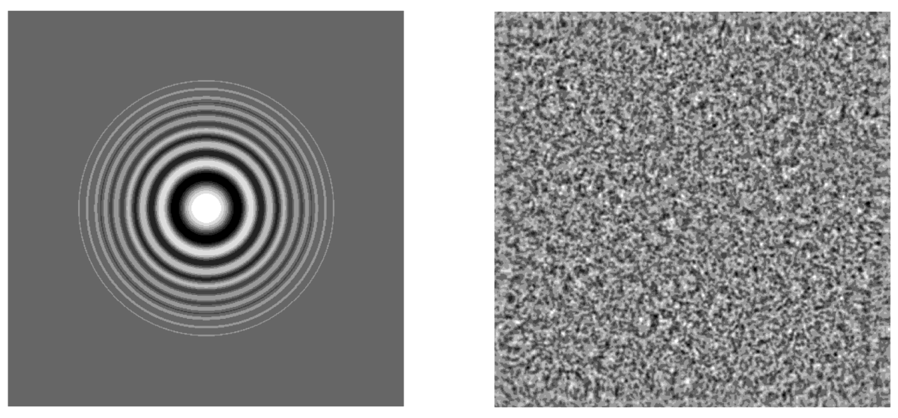
$$I = |E_0 + E_s|^2 = |E_0|^2 + 2Re\{E_0^* E_s\}$$



Superposition of many single-particle interferograms results in a stochastic speckle field:

$$I(x,y) = \sum_{particles} I_i(x,y)$$

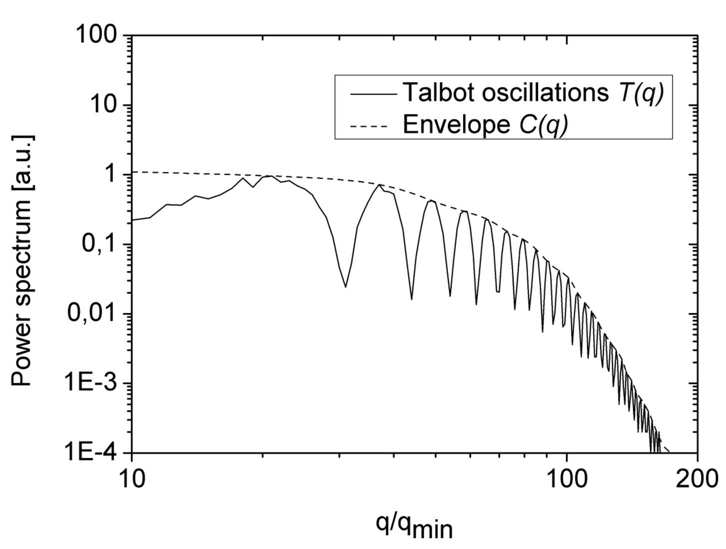
$$I_i(x,y) \propto \mu(x - x_i, y - y_i) \cos\left\{\frac{\pi}{\lambda z}[(x - x_i)^2 + (y - y_i)^2]\right\}$$



Coherence properties are retrieved through power spectra analysis [2]:

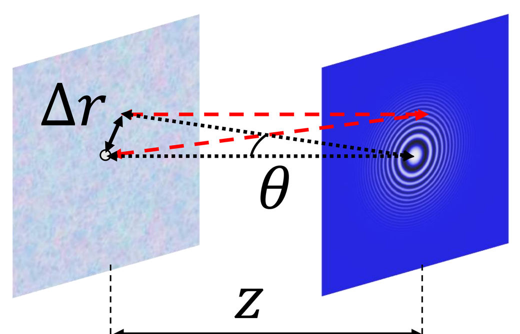
$$I(q) = S(q)T(q)C(q)H(q) + P(q)$$

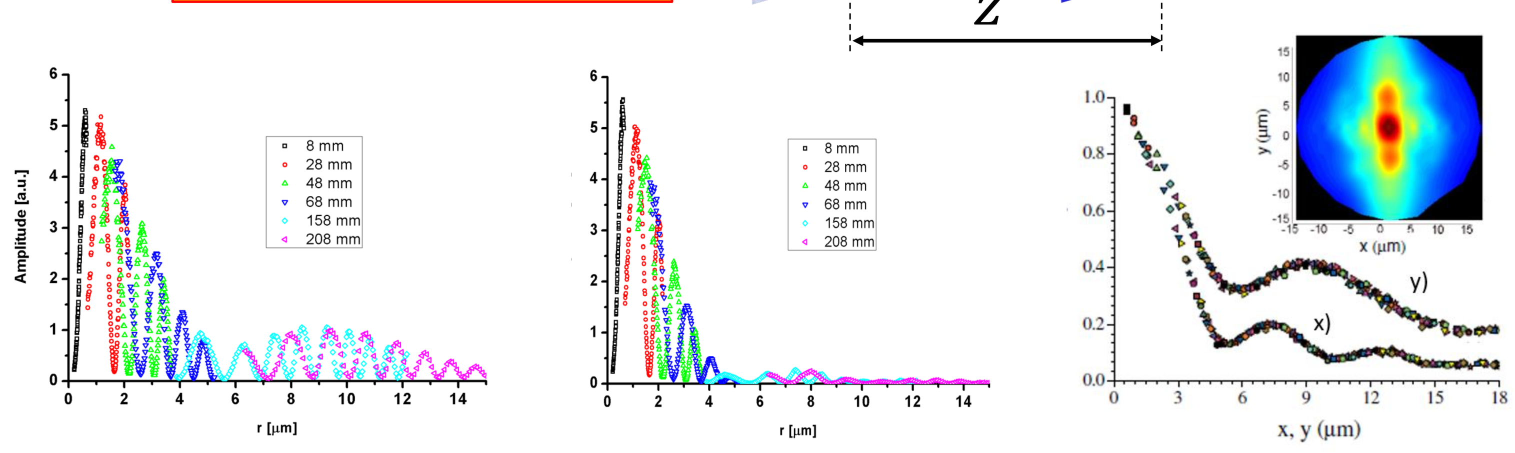
- $I(q)$: spatial power spectrum
- $S(q)$: particle form factor
- $T(q)$: Talbot transfer function [3]
- $\boldsymbol{C(q) = |\mu(q)|^2}$
- $H(q), P(q)$: system response and shotnoise contributions



Near Field scaling [2]

$$\Delta r = \frac{zq}{k}$$





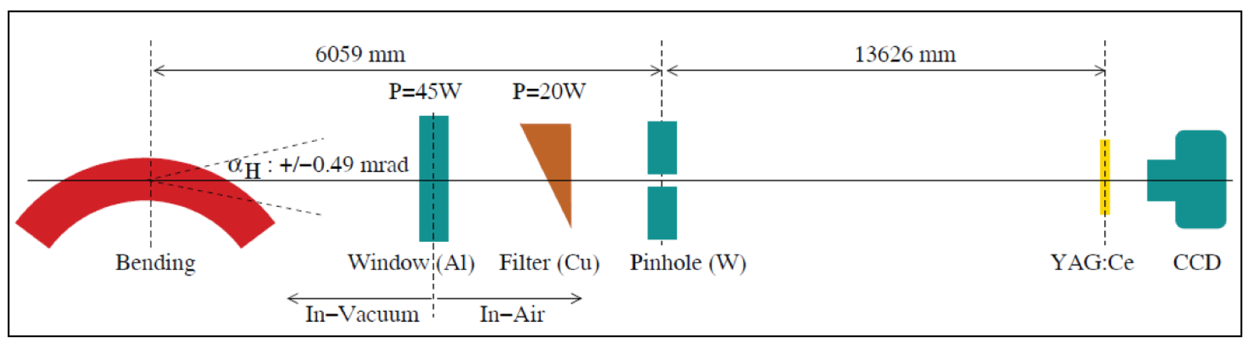
[2]

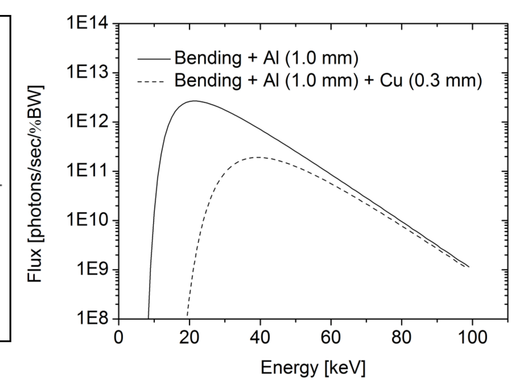
HNFS setup at ALBA

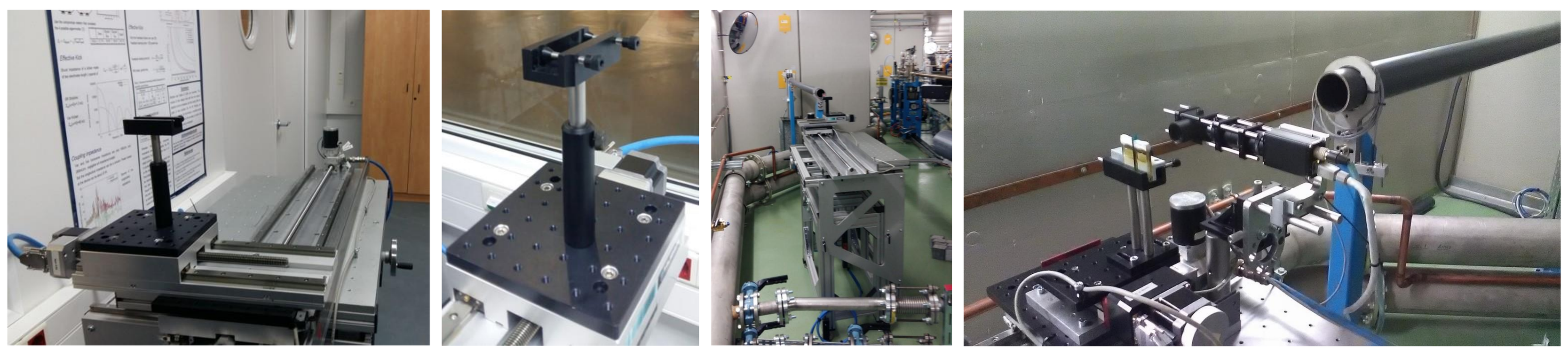
The main parameters of ALBA are summarized in the following table:

Hor beam size	$\sigma_{el,hor}$	60 μm
Ver beam size	$\sigma_{el,ver}$	30 μm
-	β_x (at pinhole)	0.3 m
-	β_y (at pinhole)	25.08 m
Dispersion (at pinhole)	D	0.0387 m
Emittance	ε	4.6 nm rad
Coupling	-	0.53 %
Beam current	I_{beam}	130 mA

The HNFS diagnostics is installed alongside the already existing X-ray pinhole camera beamline [4], at 15 m from the source.







Coherence areas are expected to have linear dimensions of:

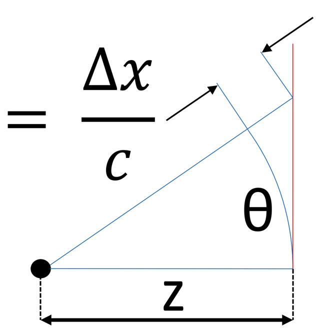
$$\sigma_{coh,hor} \sim \frac{\lambda z}{\sigma_{el,hor}} = 6.9\ \mu m$$

$$\sigma_{coh,ver} \sim \frac{\lambda z}{\sigma_{el,ver}} = 13.7\ \mu m$$

Measurements of power spectral density of visible synchrotron radiation

Temporal coherence measurements [5] have been performed at the Xanadu beamline [6] on visible synchrotron radiation in order to retrieve the emitted spectrum.

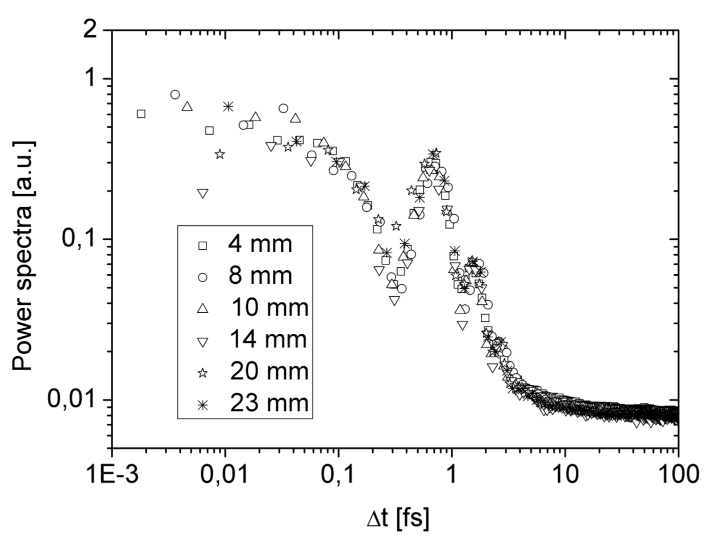
$$\Delta t = \frac{\Delta x}{c}$$

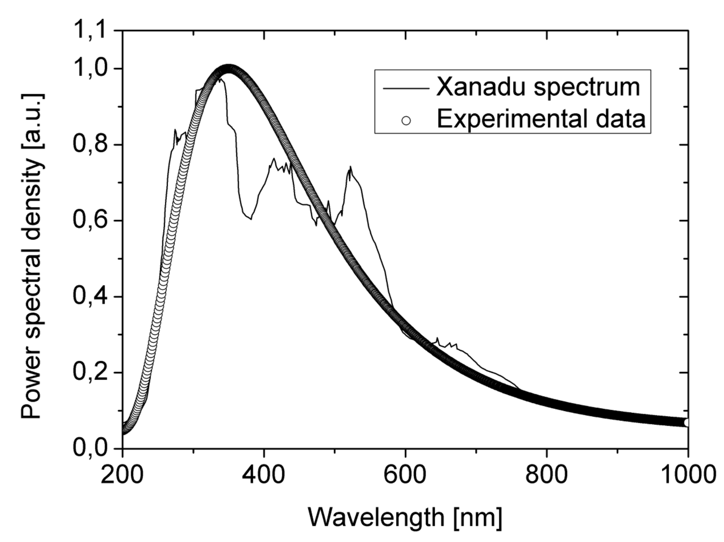


Near Field scaling

$$\Delta t = \frac{zq^2}{2k^2c}$$

Limited temporal coherence has a clear signature in HNFS power spectra: besides collapsing, power spectra exactly superimpose upon the described scaling.





[1] F. Ferri, D. Magatti, D. Pescini, M. A. C. Potenza, and M. Giglio, *Phys. Rev. E*, **70**, 041405 (2004)
[2] M. D. Alaimo, M. A. C. Potenza, M. Manfredda, G. Geloni, M. Stzucki, T. Narayanan, and M. Giglio, *Phys. Rev. Lett.*, **103**, 194805 (2009)
[3] M. A. C. Potenza, K. P. V. Sabareesh, M. Carpineti, M. D. Alaimo, and M. Giglio, *Phys. Rev. Lett.*, **105**, 193901 (2010)
[4] U. Iriso and F. Perez, *Proc. of EPAC 2006* (2006)
[5] M. Siano, B. Paroli, E. Chiadroni, M. Ferrario, and M. A. C. Potenza, *Opt. Express*, **23** (26) (2016)
[6] L. Torino, U. Iriso, and T. Mitsuhashi, *Proc. of IBIC 2014* (2014)