MODIFICATION OF THE SYNCHROTRON RADIATION INTERFEROMETER AT THE TPS

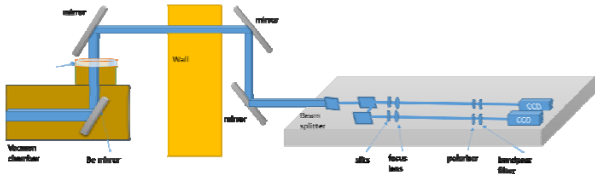
M.L. Chen, K.H. Hsu, T.C. Tseng,S.Y. Perng, W.Y. Lai, H.C. Ho, H.S. Wang, C.J. Lin, D.G. Huang, C.Y. Liao, C.K. Kuan

Organisation: National Synchrotron Radiation Research Center

Abstract

During TPS operation, the stability of beam size measurement with the synchrotron radiation interferometer (SRI) does not compare well with the older SRI at the TLS. Ground vibrations appear to transmit to the SRI optics. This paper describes how to reduce the effect of vibration and improve the system stability to improve the stability of the SRI beam size measurement dramatically. To enhance the SRI sensitivity, an intensity imbalance method is incorporated and its results are discussed.

Beamline construction



- A cooled beryllium mirror (Pascal Co., Ltd. Japan) was adopted to prevent distortion, with profile quality under 1/4 λ.
- The extraction window was purchased, with quality within $\frac{\lambda}{10}$.
- After passing the extraction window, one aluminium reflection mirror is adopted for transport through the shielding wall.

Component list

- The distance from the source point to the double slit is 22m (R).
- The focusing length of this lens is 2 m; the wavefront error is less than $\frac{1}{10}\lambda$
- The center wavelength of the bandpass filter is 500 nm with 10 nm bandwidth.
- Two CCD are applied to observe the horizontal and vertical interferograms.

SR Interferometer

Interferogram Equation

$$I(y1) = I_0\left[sinc(\frac{2\pi a}{\lambda R}y_1)\right]^2\left[1+|\gamma(v)|\cos\frac{2\pi D}{\lambda R}y_1+\varphi\right]$$

$$\rho=\frac{I_1}{I_2}$$

$$\gamma = v\frac{1+\rho}{2\sqrt{\rho}}$$

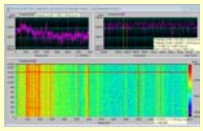
$$\sigma_{beam} = \frac{\lambda R}{\pi D}\sqrt{\frac{1}{2}\ln(\frac{1}{\gamma})}$$

- Y: visibility
- R:distance from object to double slit
- D: double slit separation
- a: half width of slit opening
- I_1&I_2:Power intensity of double slits respectively
- ρ:power imbalance ratio of double slit
- σ :beam size

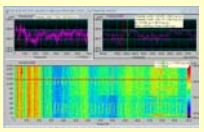
Using the power imbalance method, the visibility can be reduced by lowering the imbalance ratio ρ while bringing the interferogram fringes above the noise level and increase the dynamic range of the SRI.

Stability improvement experiment

Laboratory ground vibrations are suspected and checked by an accelerometer (PCB393B31) and velocity sensor (MST-1031). Vibrations were observed not only on the ground but also on the optical table.



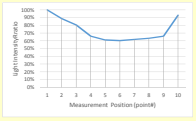
A time-frequency vibration graph of the hutch floor.



Time-frequency vibration graph of the experimental optics table.

➢ Vibration suppression

- ✓ The slit position is adjusted in the lower intensity gradient area. Furthermore, the slit separation (D) is reduced to less than the centre area.
- ✓ To absorb the vibration of the SRI opto-mechanism, vibration damping materials (Nitto D-300N) are added to the mechanisms.
- ✓ From observations, we know that the slit holder is the most sensitive part in the system. The holding design influences obviously the stability .

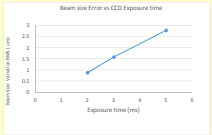


Intensity distribution of synchrotron light

	1	2	3
CCD exposure time	2ms	2ms	2ms
Wavelength bandwidth	10nm	10nm	10nm
Slit Separation (D)	50mm	50mm	50mm
Slit Opening (A)	a5	a5	a5
Holding Method	Method A	Method B	Method A
Beam size	54.20	58.49	53.30
rms	0.56	1.14	0.60

➢ CCD exposure time minimization

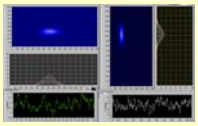
- ✓ To minimize the CCD exposure time, the slit opening (a) is enlarged from 1mm to 5mm and the exposure time is reduced to 2ms.
- ✓ The stability of the measured beam size is proportional to the exposure time and the beam size can now be measured to better than 1um.



➢ Air disturbance elimination

- ✓ The air pressure in the storage ring and experimental area is different because the air flows continuously from the tunnel to the experimental laboratory area along the optical path through the shielding wall.
- ✓ A flat optical window has been installed on the shielding wall to cut off this air flow.

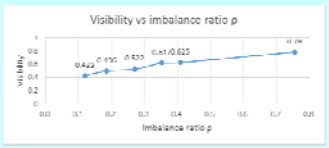
After vibration suppression, minimization of the CCD exposure time and elimination of air turbulence, the RMS beam size variation is reduced to 0.3 um and the stability is equal to that of the TLS SRI.



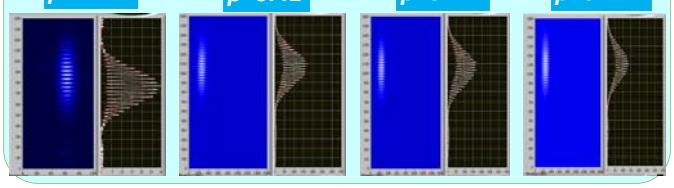
		Beam SizeX	Beam SizeY
exposure time		2ms	2ms
bandwidth		10nm	10nm
average		10	10
Double slit		D30	D45
		a5	a5
average		54.20	35.21
rms		0.56	0.35

Power Imbalance Method

- ✓ A method of power imbalance has been introduced to verify the visibility of the interferogram.
- ✓ Different transmission ND filters are used in the vertical BSM system to produce different power imbalance ratios.
- ✓ The measurement beam size variation is related to imbalance ratio. The lower imbalance ratio comes with better beam size variation.
- ✓ The vertical beam sizes is corrected from 35.8um to 35.2um when the power imbalance factor is introduced in vertical BSM system.



ρ=0.76 ρ=0.41 ρ=0.27 ρ=0.12



Summary

A SRI beam size monitor was installed in the NSRRC TPS. Ground vibrations translate to the SRI causing beam size variations. In order to improve the system stability, vibrations were suppressed, the CCD exposure time was reduced and air turbulence in the optical path were eliminated. This improved the beam size stability to 0.3um which is equal to that achieved in the TLS SRI. Introducing also an intensity imbalance method to the vertical BSM system, the beam size variation could be improved and the beam size measurements are optimized by adjusting power imbalance ratios.