Beam profile monitoring using incoherent Cherenkov Diffraction Radiation and scintillating screens at ILSF

Z. Rezaei[1], S. Mohammadi A.[1], N. Khodabakhshi[1], P. Navidpour[1],
S. Ahmadiannamin[1], Z. Pouyanrad[2], K. Noori[3]
1.Iranian Light Source Facility(ILSF), Institute for Research in Fundamental Sciences (IPM), Tehran, Iran
2.Amirkabir University of Technology, Tehran, Iran
3.Iran University of Science and Technology, Tehran, Iran

IBIC2024
Sept. 9-13, 2024 · Beijing, China

IPM INSTITUTE FOR RESEARCH IN FUNDAMENTAL SCIENCES

چشمه نور ایران
Iranian Light Source Facility

Abstract

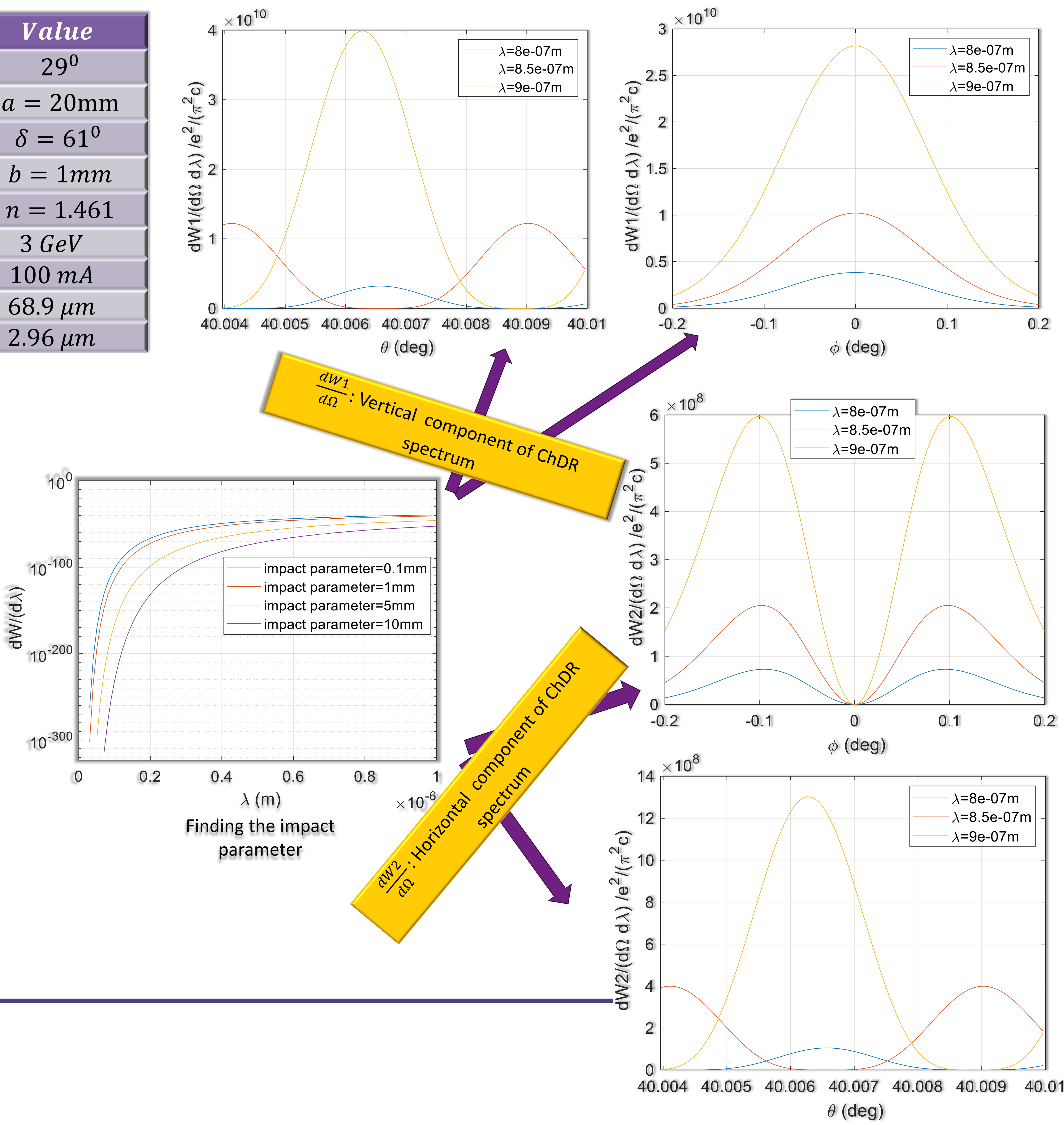
The Iranian Light Source Facility (ILSF) plays a crucial role in advancing accelerator science and applications. In this study, we explore innovative techniques for precise beam profile monitoring, focusing on two complementary methods: Incoherent Cherenkov Diffraction Radiation (ChDR) and scintillating screens. Incoherent ChDR occurs when a charged particle passes through a dielectric medium with a velocity exceeding the phase velocity of light in that medium. This phenomenon leads to the emission of electromagnetic radiation in the form of a cone. Our investigation focuses on incoherent ChDR as a powerful tool for beam position diagnostics. By analyzing the angular distribution of ChDR photons, we extract valuable information about the transverse position of the electron bunch. Our simulations demonstrate the feasibility of ChDR-based diagnostics at ILSF. We discuss optimal radiator materials, and geometries.

In addition, we examine the use of YAG scintillating screens as beam profile monitors. We present detailed considerations on screen material, thickness, and the optimal orientation of the detection system to ensure high-resolution measurements. These screens offer a robust solution for monitoring beam parameters, particularly in scenarios where Optical Transition Radiation (OTR) methods are less effective due to coherence effects at high energies.

By utilizing both ChDR and radiation from scintillating screens for comparison, we can ensure reliable and accurate beam profile measurements at ILSF.

	Parameter	***Value***
Prism Parameters	ϕ_{vertex}	29^0
	Prism length	$a = 20\text{mm}$
	Flight angle	$\delta = 61^0$
	Impact parameter	$b = 1mm$
	Refractive index of SiO_2	$n = 1.461$
Beam parameters	Beam Energy	$3\ GeV$
	Beam Current	$100\ mA$
	Horizontal Beam Size (rms)	$68.9\ \mu m$
	Vertical Beam Size (rms)	$2.96\ \mu m$

- **The impact parameter defines which λ produce more intensity.**
- **By defining the impact parameter in the millimetre region, the optical system should be optimized for optical wavelengths.**
- **The ChDR spectrum emitted from a prismatic dielectric radiator, when the electron beam moves parallel to one of its sides at a distance b, has two polarization components: vertical, which is perpendicular to beam motion, and horizontal, which is parallel to it.**



Scintillating screen

- Scintillating screens are better than OTR-based diagnostics for high-energy beams (they avoid coherence effects)
- High resolution is achieved by positioning the detector at specific angles, calculated using:
  - Snell-Descartes laws
  - Scheimpflug principles.

CONCLUSION

In conclusion, the comparison between incoherent Cherenkov Diffraction Radiation (ChDR) and scintillating screens reveals distinct advantages and limitations. ChDR provides superior resolution and non-invasive measurement capabilities, making it ideal for high-precision applications. However, it requires more complex setup and calibration. On the other hand, scintillating screens, while slightly invasive, offer ease of use and practicality for routine diagnostics. By utilizing both ChDR and radiation from scintillating screens for comparison, we can ensure reliable and accurate beam profile measurements at ILSF.