One Dimensional Beam Position Monitor Prototype Using Incoherent Cherenkov Diffraction Radiation

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ABSTRACT

This paper proposes a novel advancement in both the studies of Cherenkov diffraction radiation (ChDR) and beam instrumentation. The proposed beam position monitor (BPM) consists of two identical fused Silica prism radiators, with a fibre collimator attached to each one, which in turn are connected to a photodetector via a series of optical fibres. The setup will be implemented into the booster to storage ring transfer line at Diamond Light Source - an electron light source with 3 GeV beam energy. The prototype proposed aims to test the feasibility of a full BPM utilising ChDR. If proven to be fully realisable, optical rather than capacitive BPM pickups could be more widely distributed. The paper will include the complete design and preliminary results of a one-dimensional BPM, utilising the ChDR effect.

BOOSTER TO STORAGE (BTS) TEST STAND

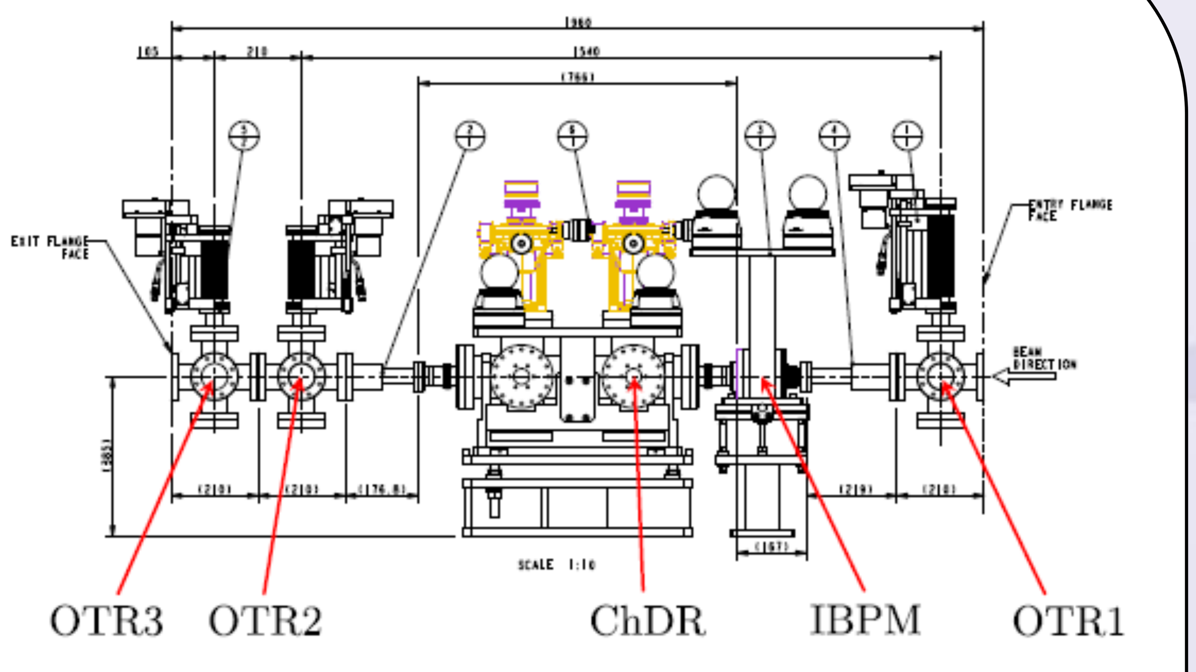

Figure 1: BTS test stand at Diamond Light Source (DLS) where the ChDR BPM is positioned.

Optical Transition Radiation (OTR) screens, Yttrium Aluminium Garnet (YAG) and Inductive Beam Position Monitor (IBPM) in BTS are used for reference beam profiles and beam position respectively.

INTENSITY SIMULATIONS

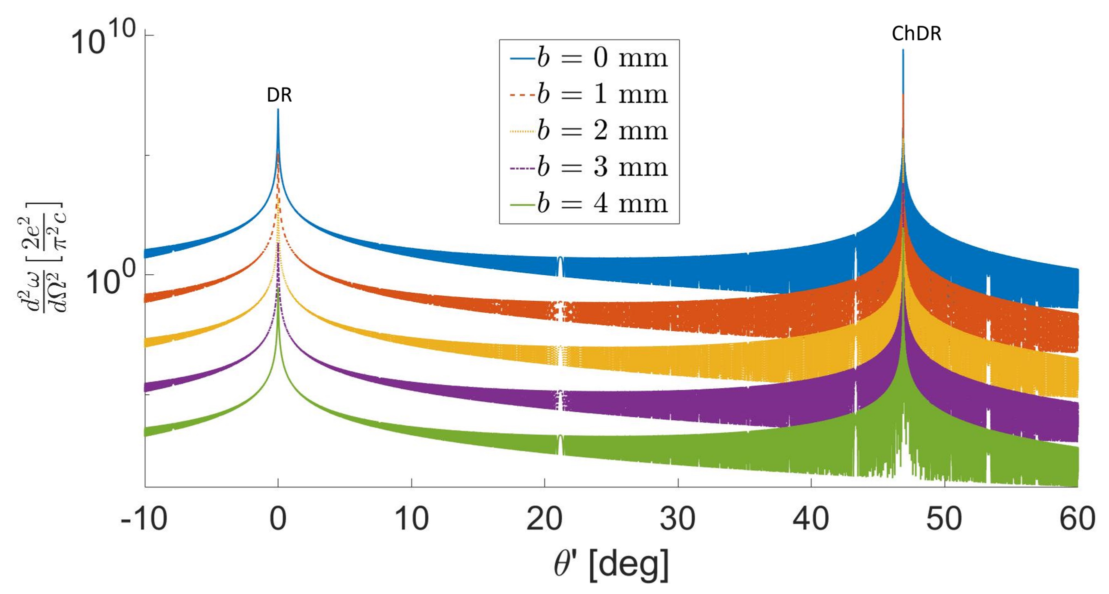

Figure 2: Intensity simulation using equation 16 from [1]

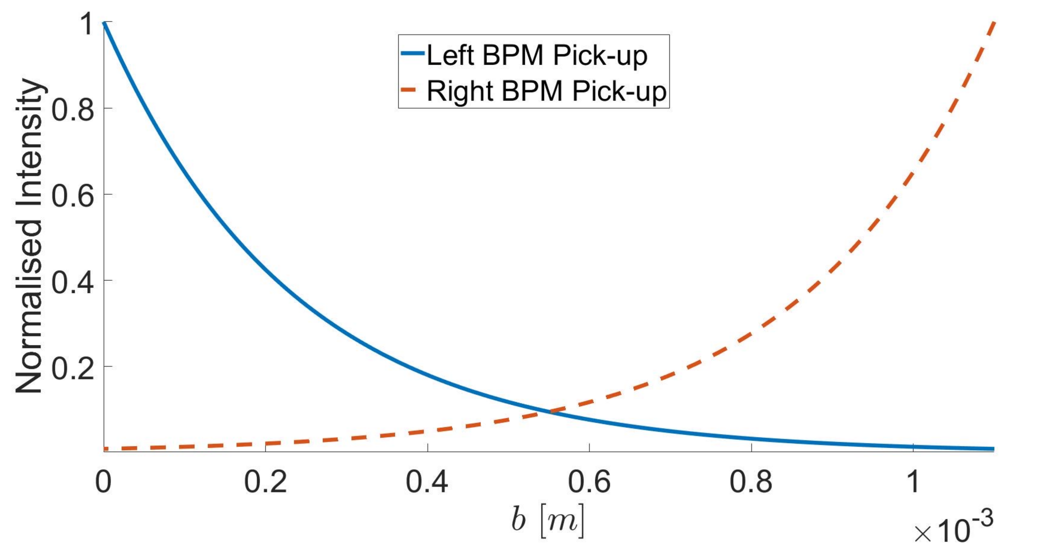

Figure 3: Decay simulation of two identical targets either side of a beam

Simulations performed for fused Silica targets shown in Figure 6, with DLS beam energy of 3 GeV for 500nm ChDR emission. The pick-ups have a vertical size of 32 mm, which as this is greater than $10\,\gamma\lambda$, the decay is predicted to be exponential.

BPM ASSEMBLY

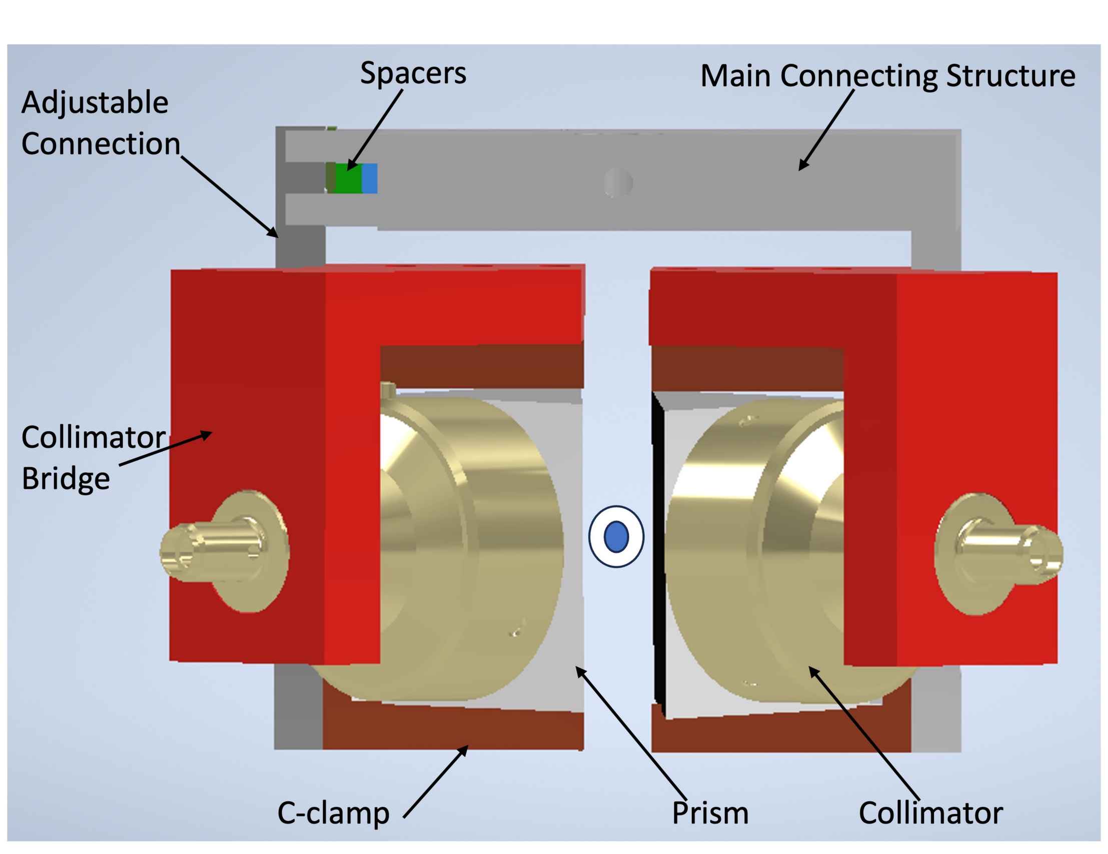

Figure 4: Showing 3D rendering of ChDR BPM assembly with indication of beam direction.

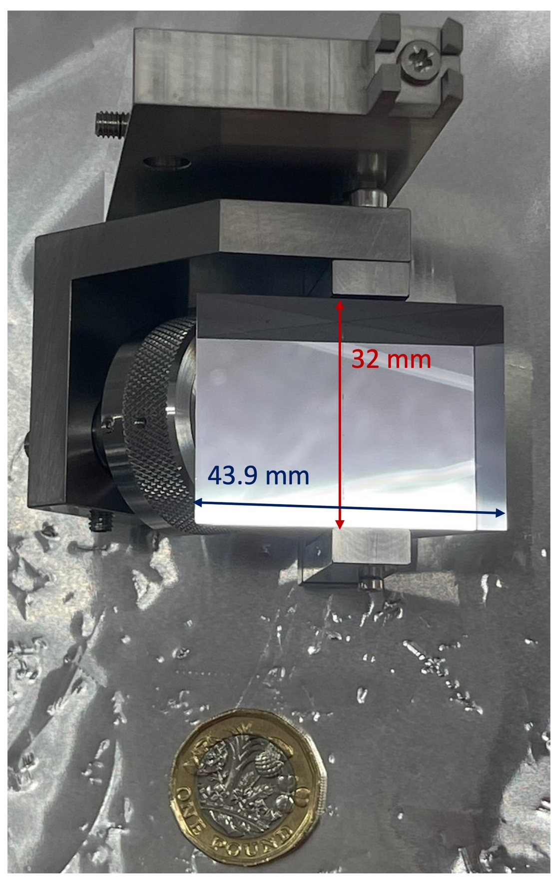

Figure 5: Picture of one pick-up ChDR BPM assembly

As the beam passes through the gap between the two prisms, ChDR is emitted and collected via the two collimators. For initial experimentation, only one side of the assembly is inserted into the BTS.

FUSED SILICA PRISM

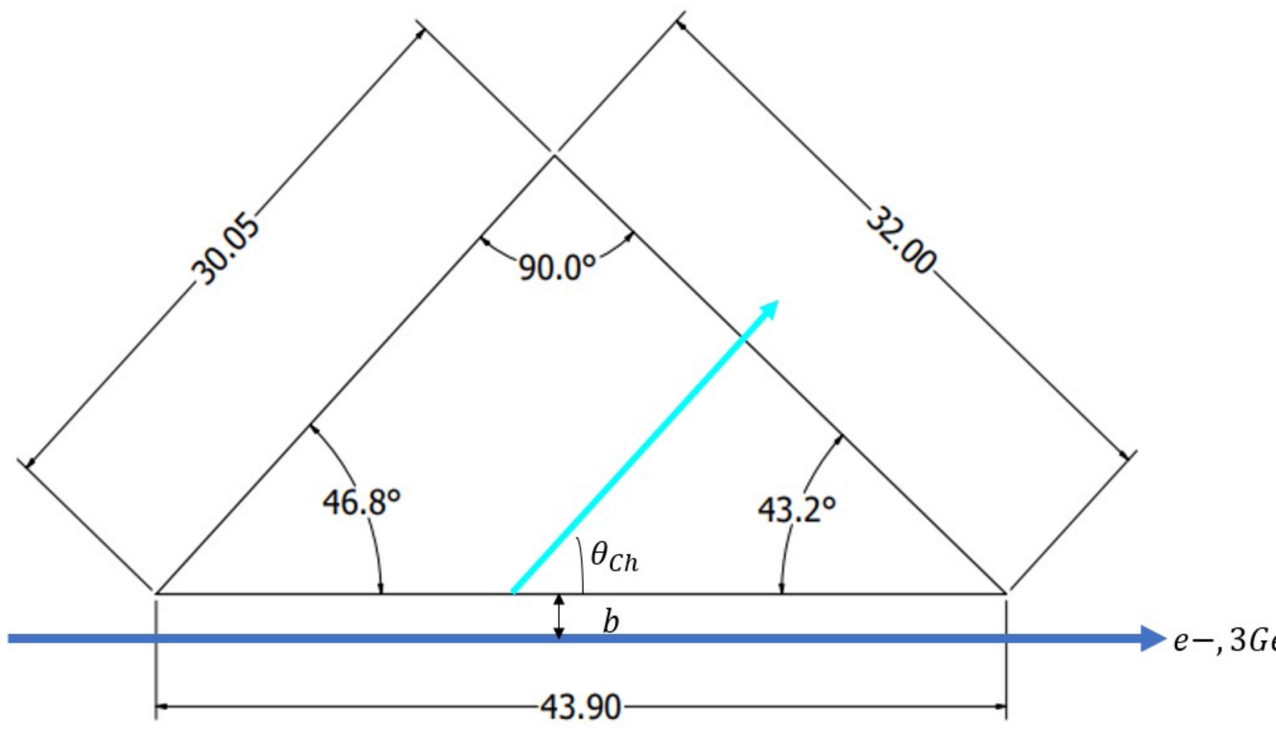

Figure 6: Showing 2D rendering of the ChDR target with beam direction and ChDR emission.

The prisms have output faces angled at $90 - \theta_{Ch}$ to ensure the emission wavefront is parallel to the output face, as indicated by the cyan ChDR arrow.

PRELIMINARY RESULTS USING ONE CHDR PICK-UP

The one pick-up ChDR BPM assembly has been installed and commissioning is underway. Figure 7 shows the beam profile on the YAG screen located at OTR 2 (see Fig. 1), shadowed by the ChDR pick-up. Confirming that an impact parameter of zero can be achieved between the electron beam and the pick-up. Figure 8 shows the corresponding output signals from the IBPM and the ChDR detector. The shadowing of the electron beam by the pick-up means this detected signal will be a combination of Cherenkov radiation and ChDR. This confirms that radiation emitted at the Cherenkov angle is successfully captured by the collimators and transmitted through the fibre system

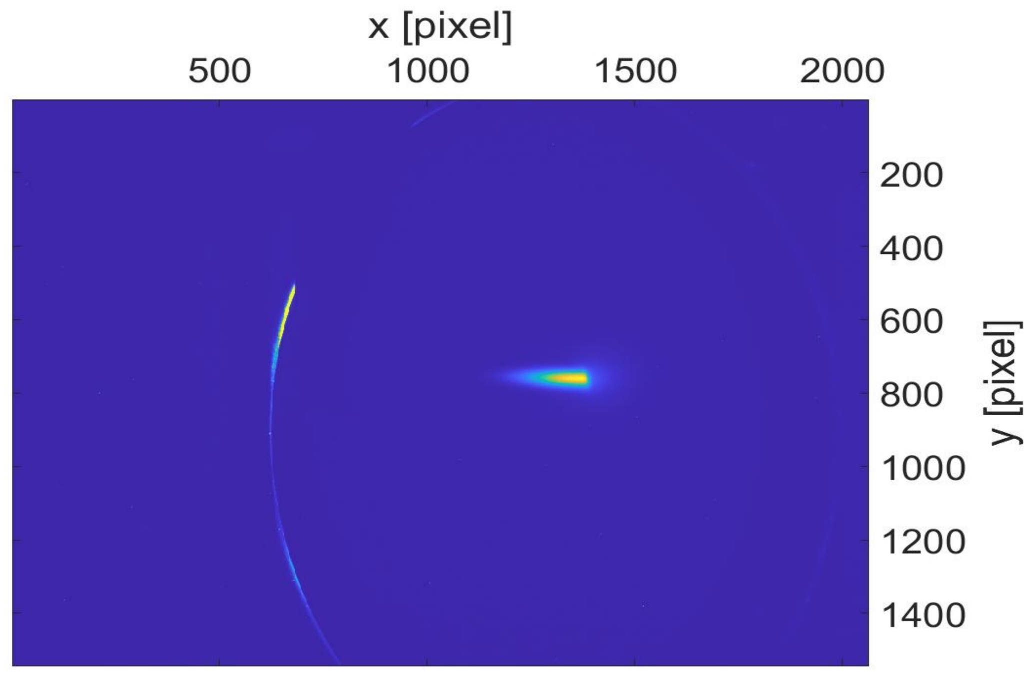

Figure 7: YAG image of the beam profile being shadowed by the ChDR assembly.

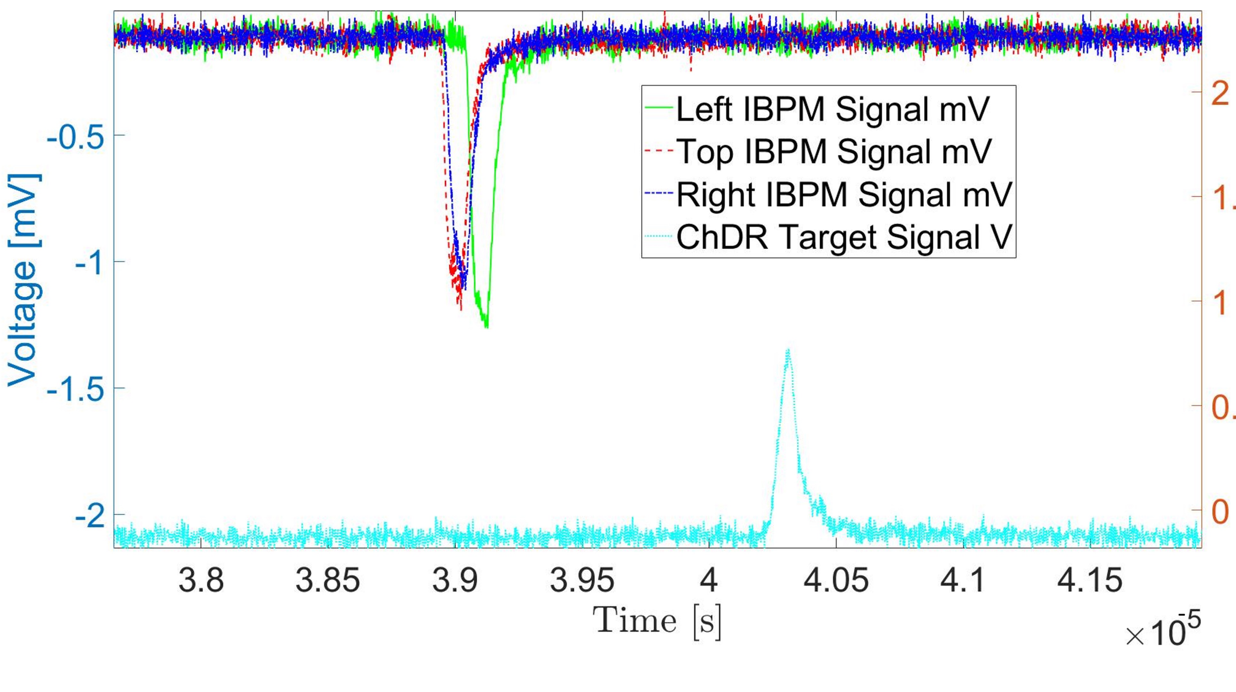

Figure 8:Detected output signal of the three IBPM connections and the ChDR detector. Voltage divisions of 50 mV and 0.5 V for the IBPM and ChDR signals, respectively.

CONCLUSION

In conclusion a 1D BPM utilising incoherent ChDR has been designed and characterised in the lab. The assembly has been installed with one pick-up in place on the BTS transfer line at DLS. Initial commissioning tests have been performed and first signals have been detected.

ACKNOWLEDGEMENTS

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REFERENCES

[1] M. Shevelev and A. S. Konkov, "Peculiarities of the generation of Vavilov-Cherenkov radiation induced by a charged particle moving past a dielectric target," Journal of Experimental and Theoretical Physics, vol. 118, no. 4, pp. 501–511, Apr. 2014, doi: https://doi.org/10.1134/s1063776114030182.

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