



# A collinear Second-Harmonic Orthogonally Polarized interferometer (SHOPi) for MITL gap plasma density measurements on Sandia's Mykonos accelerator

## Introduction

- TW-class accelerators, like Sandia National Laboratories' (SNLs) Z machine, experience current loss within their inner Magnetically Insulated Transmission Line (MITL) and convolute regions.
- ❖ Fully relativistic PIC and MHD simulations predict that electrode plasmas on the order of  $10^{15} - 10^{17} \text{ cm}^{-3}$  constitute the primary source of shunted current across the Anode-Cathode (A-K) gap [1].

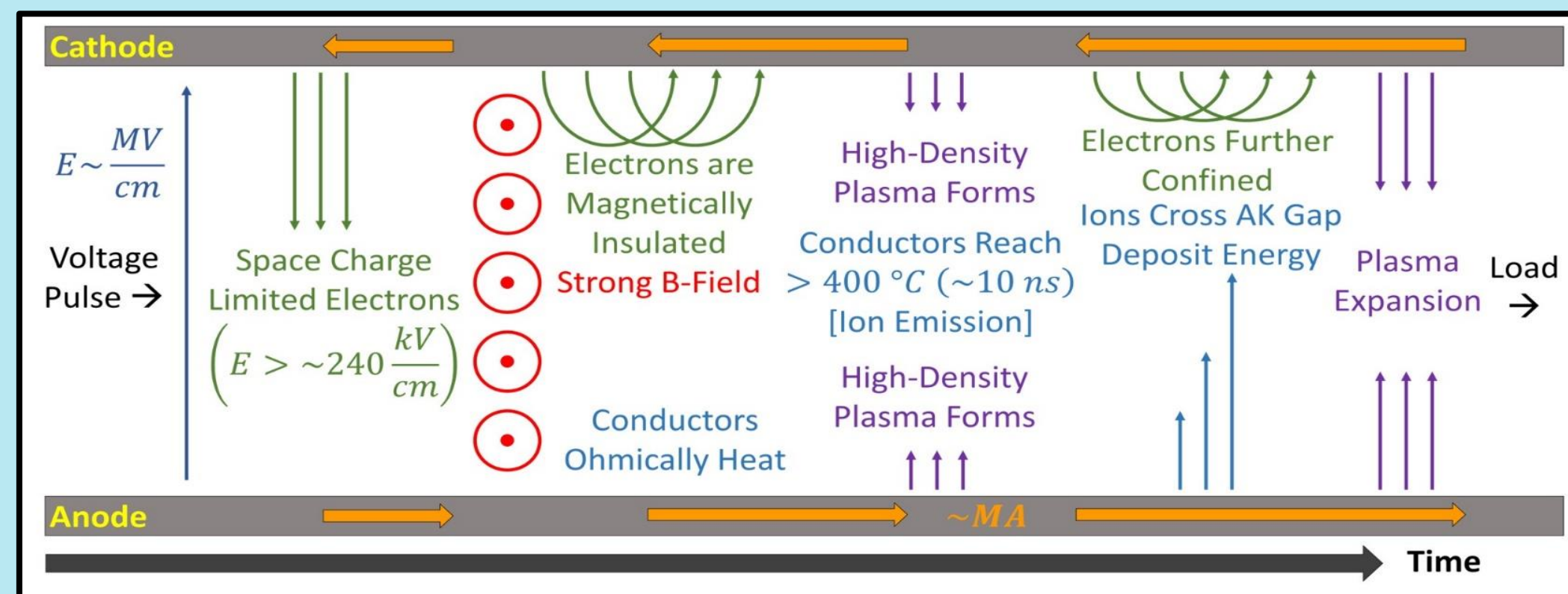


Fig. 1: Diagram of a lossy MITL

- To study similar electrode plasmas [2], a parallel plate platform has been developed [3] for Sandia's 1 MA Mykonos accelerator [4].
- To measure the free electron areal density of relatively low-density plasmas with fast time resolution, a collinear Second-Harmonic Orthogonally Polarized interferometer (SHOPi) diagnostic has been developed with a sensitivity reaching  $\langle n_e L \rangle_{\min} = 2 \times 10^{14} \text{ cm}^{-2}$  and up to  $\Delta \langle n_e L \rangle_{\max} = 2 \times 10^{17} \text{ cm}^{-2} \text{ ns}^{-1}$  [5].

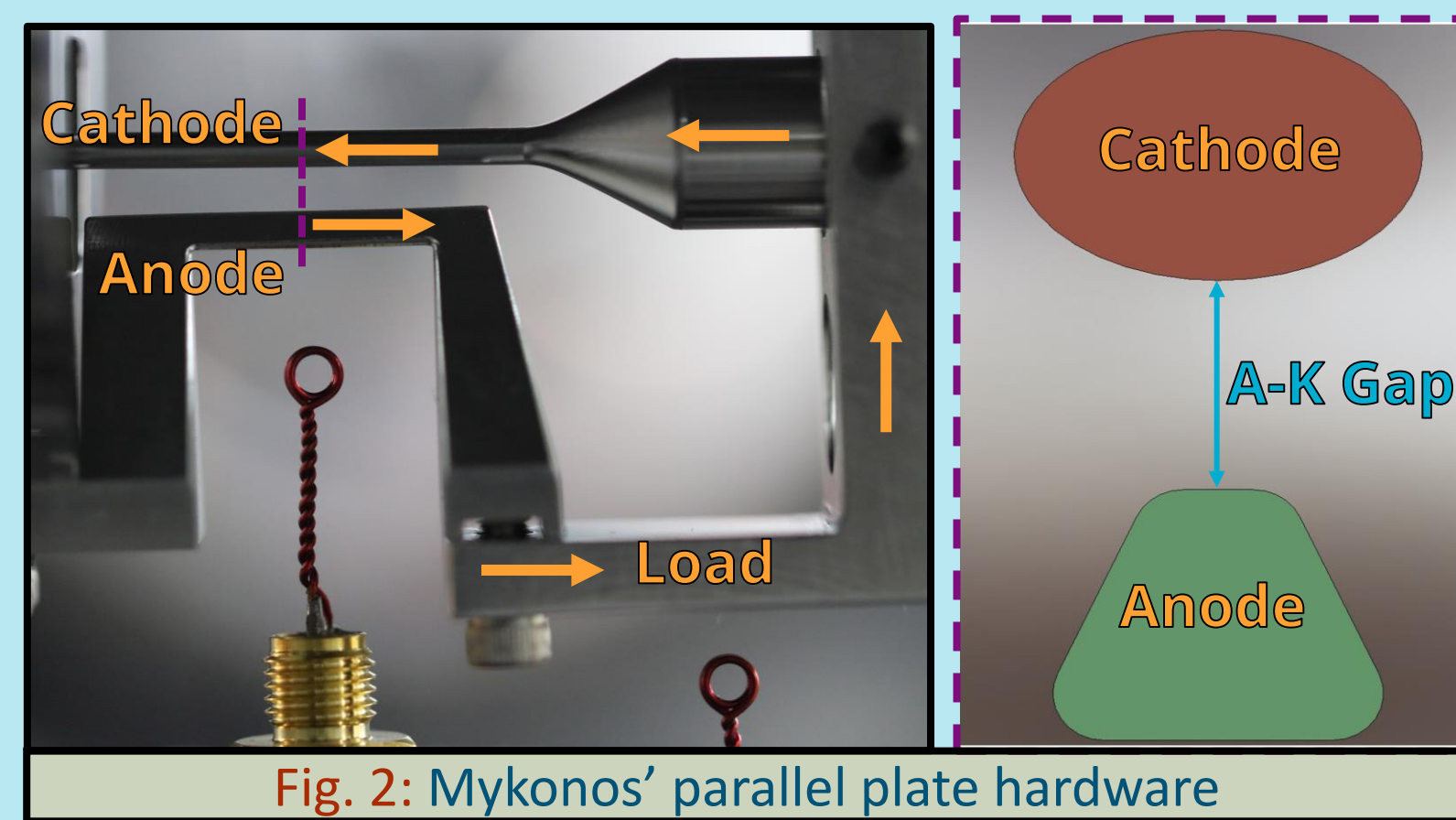


Fig. 2: Mykonos' parallel plate hardware

## Experimental Setup

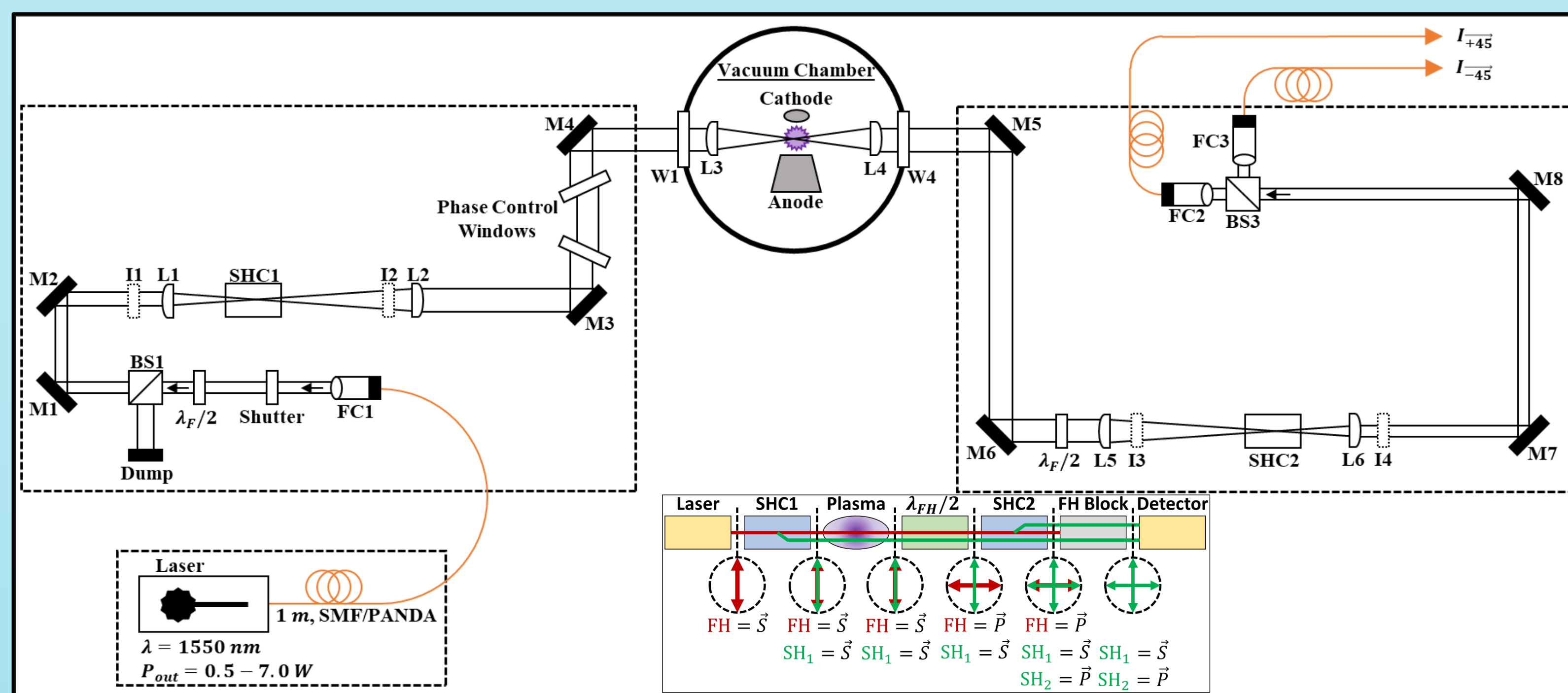
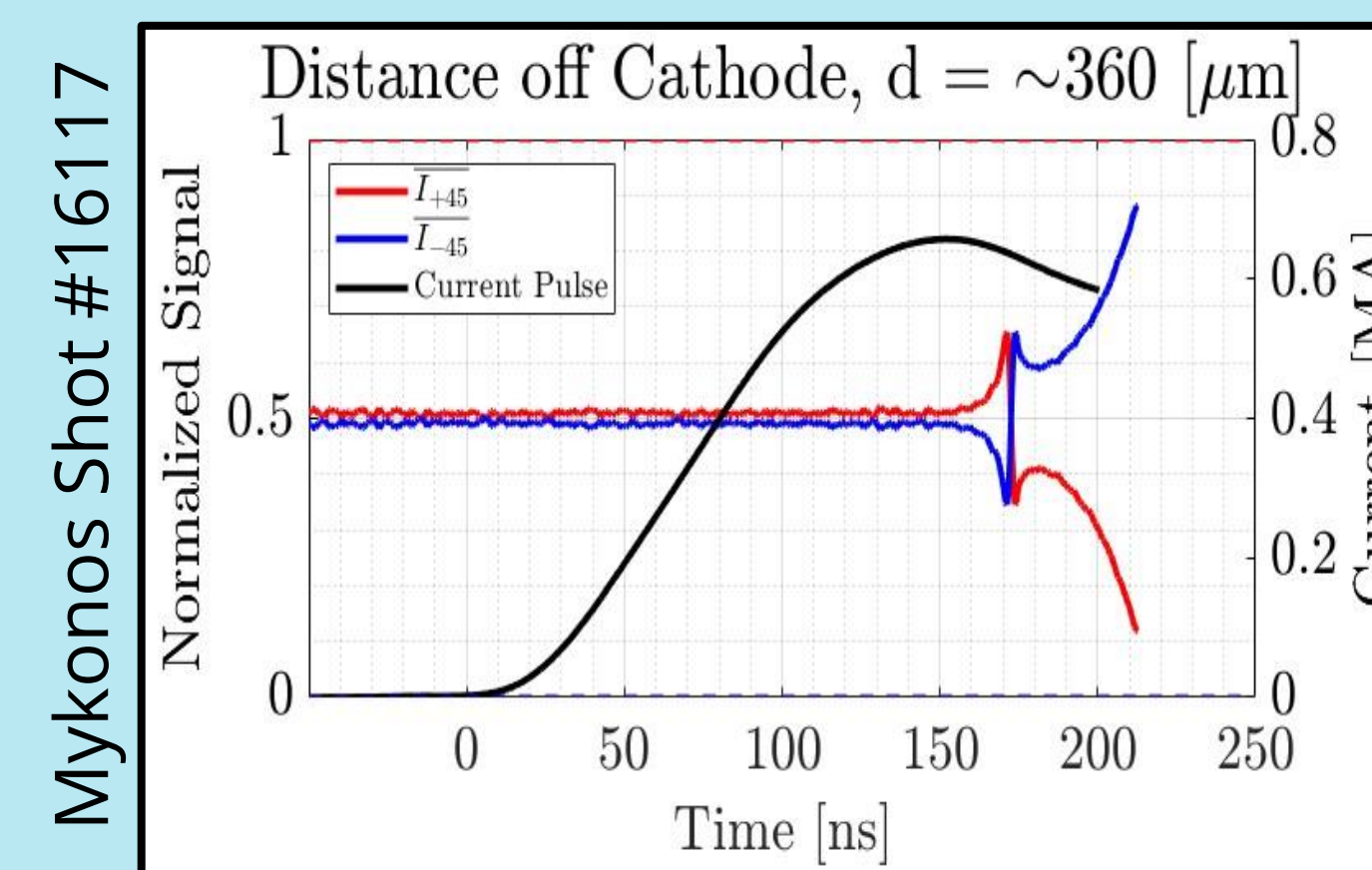


Fig. 3: SHOPi Diagnostic optical diagram.

## Mykonos Data



- The detected intensities are a function of the relative phase of the two interfering second-harmonic beams,  $\Delta\phi$ , via

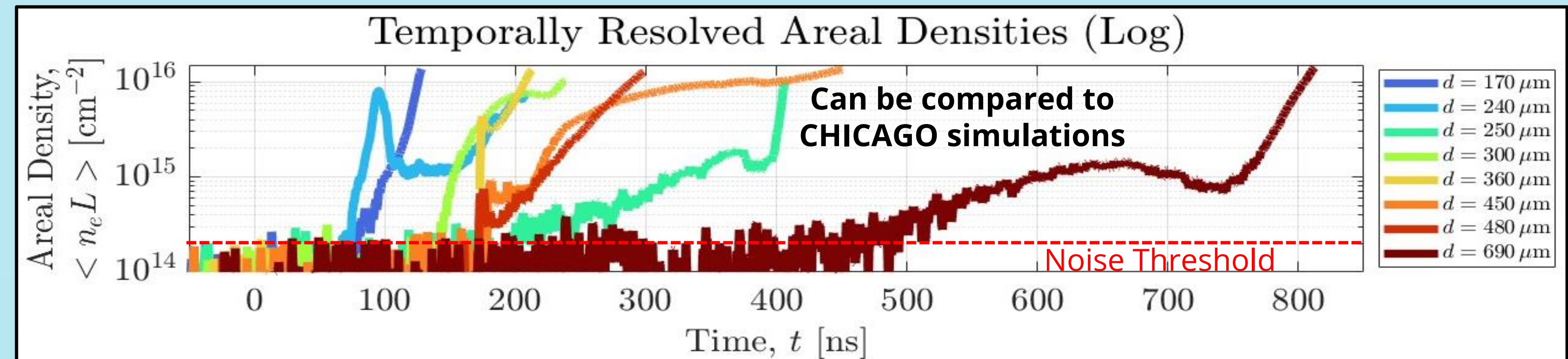
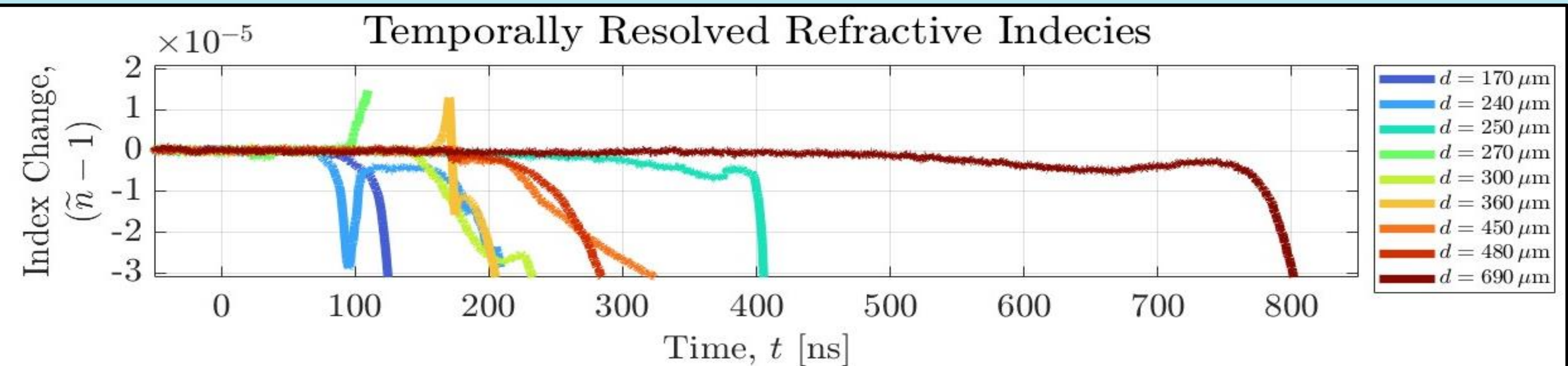
$$I_{\pm 45} = \frac{I_{SH1}}{2} + \frac{I_{SH2}}{2} \pm \sqrt{I_{SH1} I_{SH2}} \cos(\Delta\phi),$$

where

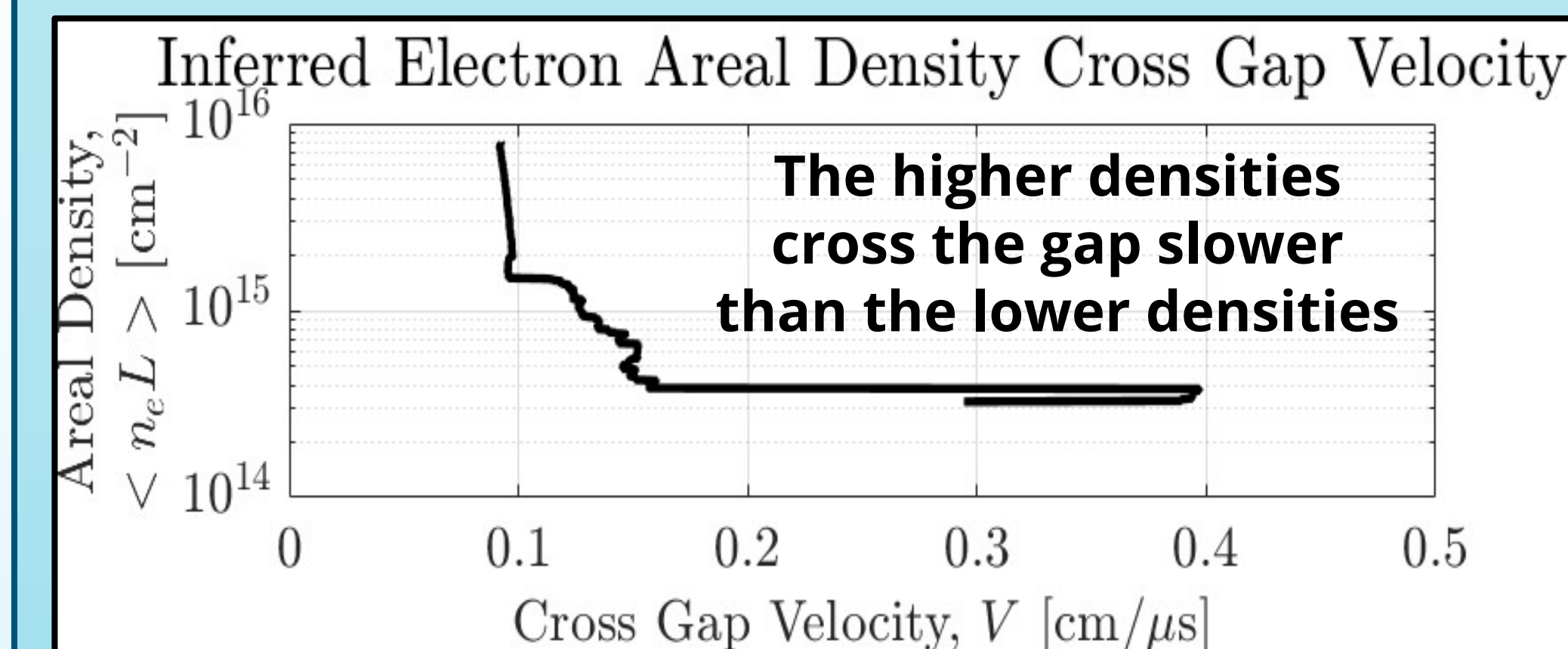
$$\Delta\phi = 2\phi_{FH} - \phi_{SH}.$$

- The free electron areal density,  $\langle n_e L \rangle$ , can be calculated from the tracked phase,  $\Delta\phi$ , of detected signals,  $I_{+45}$  and  $I_{-45}$ , via

$$\langle n_e L \rangle \approx \frac{2.366 \times 10^{19}}{\lambda_{FH}} \Delta\phi.$$



- Using the above temporally resolved areal density data in conjunction with the probing beams' distance off the electrode surface, an inferred electron areal density cross gap velocity can be calculated.



## References

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3. D. Lamppa, et al., Assessment of Electrode Contamination Mitigation at 0.5 MA Scale, SAND2021-12691, Sandia National Laboratories, Albuquerque, NM, (2021).
4. M.G. Mazarakis, et al., High-current linear transformer driver development at Sandia National Laboratories, IEEE transactions on plasma science, 38 (2010) 704-713.
5. N.R. Hines, et al., A fiber-coupled dispersion interferometer for density measurements of pulsed power transmission line electron sheaths on Sandia's Z machine, Review of Scientific Instruments, 93 (2022) 113505.