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X Ray Diagnostics for high energy electrons using Tungsten Pellets

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A novel diagnostic technique will be presented to investigate the spatiotemporal evolution of a hot electron population in a magnetic mirror configuration on the Large Plasma Device (LAPD). This diagnostic utilizes tungsten pellet injection to measure hot electrons without perturbing the background plasma. By capturing X-ray emissions from the interaction of highly energetic (1keV<E<1MeV) electrons with injected tungsten pellets, the diagnostic enables direct measurement of the energetic electron population and how they evolve with time.

Located at the University of California Los Angeles (UCLA), the Large Plasma Device (LAPD) is a linear device that produces plasma using a pulsed DC discharge with a repetition rate of up to 1 Hz. The plasma column is 60 cm in diameter, 20 m in length, and has a density up to few 1013cm-3. In these experiments, the field is operated in a mirror configuration, and mirror trapped electrons are electron cyclotron heated by X-mode microwaves. Up to 10 kW rf power from a 2.45 GHz magnetron is introduced using a waveguide at the edge of the plasma axially near the center of the mirror region[1].

Building on prior studies[2] of fast electron dynamics and wave-particle interactions in LAPD, this X-ray diagnostic serves as a critical tool for heating and associate wave-particle interaction physics. Experiments with this configuration have shown fast electron detrapping using Alfven waves, and anisotropic velocity space instabilities in the early stages of the electron acceleration[3]. These studies connect the laboratory experiments to astrophysical plasma observations, advancing our understanding of fundamental plasma phenomena with implications for radiation belt dynamics, space weather, and runaway electrons in fusion devices. This experiment also offers a laboratory tool for studying wave interaction studies relevant to the earth's radiation belt remediation. Understanding the fast electron population dynamics is crucial for these physics studies.

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References

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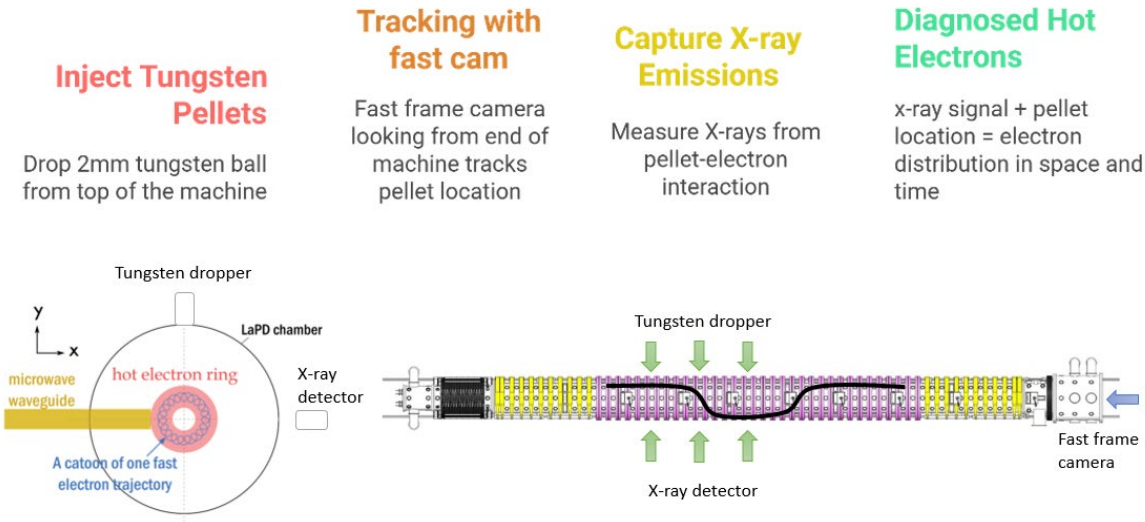

Figure 1 Overview of the diagnostic setup for measuring hot electron dynamics in LAPD's magnetic mirror configuration. Left: axial view showing tungsten pellets injected toward a microwave-heated hot electron ring. Right: side view illustrating pellet injection, fast camera tracking, and X-ray detection. Note that the diagnostic can be installed at various axial locations