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Investigating Radial Wire Array Z Pinches as a Compact X-ray Source on the SATURN Generator

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Abstract—**Radial wire array z pinches, where wires are positioned radially outwards from a central cathode to a concentric anode, can act as a compact, bright x-ray source that could potentially be used to drive a hohlraum. Experiments were performed on the 7 MA Saturn generator using radial wire arrays. These experiments studied a number of potential risks in scaling radial wire arrays up from the 1 MA level, where they have been shown to be a promising compact x-ray source. Data indicates that at 7 MA radial wire arrays can radiate ∼ 9 TW with 10 ns full width at half maximum from a compact pinch.**

I. INTRODUCTION

Wire array z-pinches have been explored for a number of years as a powerful source of soft x-ray emission, primarily motivated by the potential for them to drive an Inertial Confinement Fusion (ICF) hohlraum [1]–[4]. On the 1 MA MAGPIE generator [5] at Imperial College London a modification of the wire array z-pinch has been developed: the radial wire array (Fig. 1). This consists of wires strung radially outwards from the central cathode to a concentric outer anode. Initially this setup was developed for studying wire ablation in a magnetic field and for laboratory astrophysics studies of a stellar jet launching through a magnetic tower geometry [6], [7]. During these MAGPIE experiments it was also found that radial wire arrays had potential as a high power, compact x-ray source [8]–[10].

In this paper we discuss experiments with radial wire array z pinches performed on the Saturn generator at Sandia National Laboratories (7MA, [11]). Experiments were performed in both the Saturn long-pulse mode (150 ns risetime) and the short pulse mode (50 ns risetime). Experiments addressed some of the possible issues with performing this type of experiment at the multi-MA level, including the effect of mounting a high number of wires on a 6-12 mm diameter electrode while maintaining good wire contact. MHD simulations played a key role in designing experiments, informing experiment tradeoffs and providing insight into differences from experiments on MAGPIE. Experiments studied the optimal wire number, electrode diameter and wire diameter in order to obtain high power density (and hence higher predicted hohlraum temperatures).

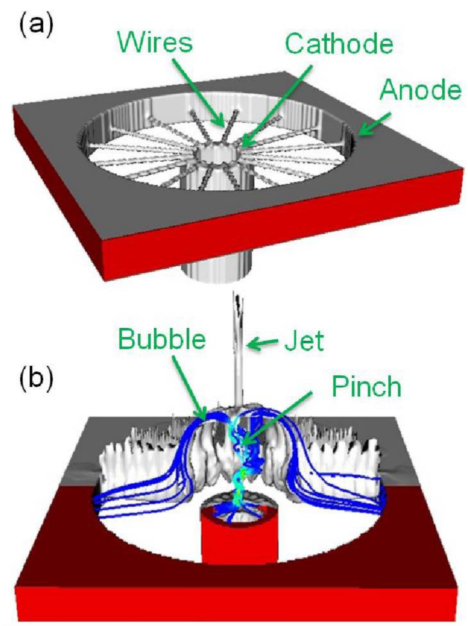

Fig. 1. Radial wire array setup. (a) Wires are strung radially outwards from a central cathode to a concentric anode. (b) simulation showing the current distribution at stagnation for a radial wire array.

In Section 2 we discuss some background hohlraum scaling and the motivation for a compact x-ray source to drive a hohlraum. In Section 3 we then discuss details of the experimental setup, including the hardware used to field the radial wire arrays and the diagnostics used in the experiments. Section 4 describes data obtained in Saturn's long pulse mode, including general implosion dynamics and the effects of variations in electrode geometry, mass and wire number. In section 5 we discuss simulations of the experiments. Details of the Gorgon [12] code are presented, along with details specific to modeling radial wire arrays on Saturn. Comparisons between pre-shot simulations of radial wire arrays using Saturn long-pulse and experimental data indicate a need to shift to experiments in Saturn's short pulse mode, as described in Section 6. We conclude in Section 7 with a discussion of the

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