Modeling and Simulation of Plasma-Liner Formation and Implosion for the PLX-α Project

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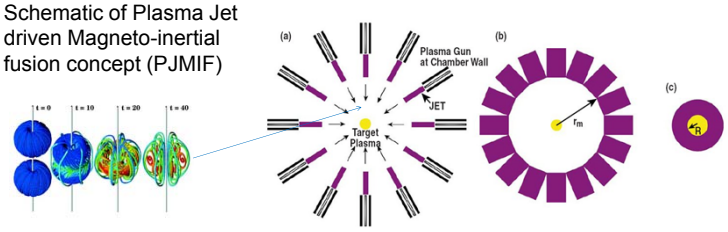
Introduction

The project develops spherically imploding plasma liners as a standoff driver for a plasma-jet-driven magneto-inertial fusion (PJMIF) concept, in which a plasma liner formed by merging supersonic plasma jets compresses a magnetized plasma target to fusion conditions. PJMIF aims to achieve/exceed Lawson conditions with pulsed-power stored energy of ~30–50 MJ and burn times of order 0.1 μs , and to use low cost coaxial plasma guns to form/accelerate plasma jets.

PJMIF can in principle use a compact-toroid (CT) target, as in solid-liner concepts. But the most favorable PJMIF embodiments (enabled by PJMIF's fast implosion speed) prefer novel targets with high pre-compression ratio of thermal-to-magnetic pressure β≈10, inertial confinement, and *in situ* target formation by a subset of the same plasma guns used to form the plasma liner.

Schematic of Plasma Jet driven Magneto-inertial fusion concept (PJMIF)



Experimental and Simulation Program

Schematic of PLX experiment under construction at LANL

• **Multi-institutional collaboration called PLX-Alpha funded by ARPA-E** (project started in August 2015)

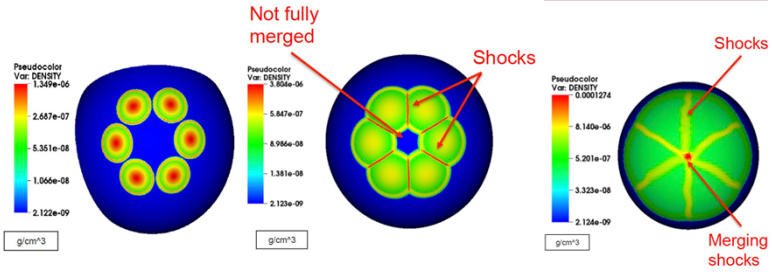
Roles of team members:

- Los Alamos National Laboratory: build experimental equipment and conduct plasma liner experiments
- Hyper-V Technologies: design and build plasma guns
- U. New Mexico: design and implement diagnostic equipment
- BNL, Tech-X, U. Alabama in Huntsville: modeling and numerical simulations
- Prism Computational Sciences: atomic and EOS codes and data bases

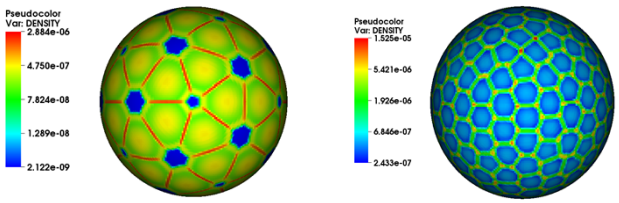
• SNU / BNL task: explore PLX-Alpha concepts via high performance computing:

- simulations of plasma jets, their merger and formation of plasma liners, and compression of targets with resolution of radiation, atomic processes, and relevant scales

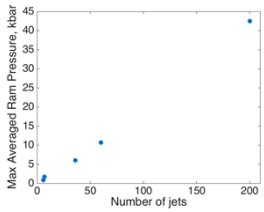
BNL Simulation Results



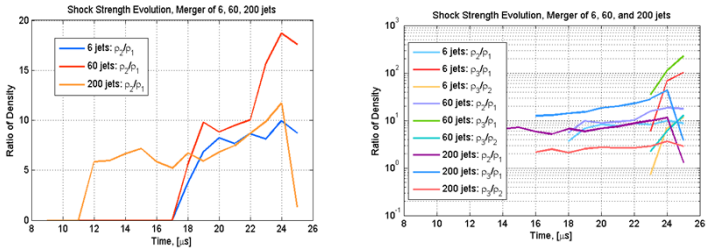
Distribution of density on spherical slices of data from 6 jet merger simulation using FronTier. Slices are selected at the leading edge of jets / liners (defined as the location of maximum average ram pressure).



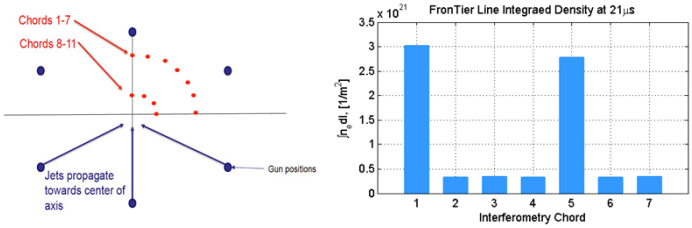
60 (left) and 200 (right) jet merger



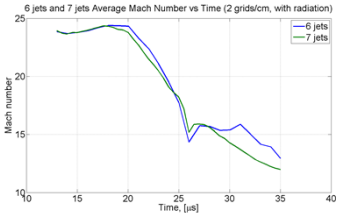
Scaling of Ram Pressure at Full Implosion



Characterization of Liner Non-uniformities:
Strength of Primary and Secondary Shock Waves



The merging jets will be probed with 11 end-on interferometry chords.



Degradation of Mach number during compression in liners obtained by merger of 6 and 7 plasma jets.