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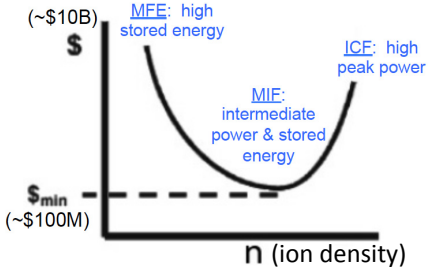
Fusion: The Green Nuclear Energy

Los Alamos NATIONAL LABORATORY

Plasma-Jet-Driven Magneto-Inertial Fusion (PJMIF): A potentially faster and lower-cost pathway to economical fusion power

BACKGROUND & MOTIVATION

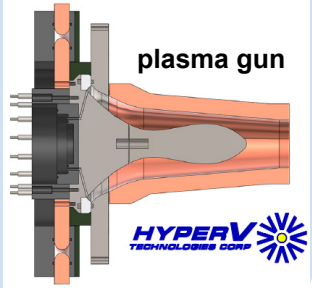
Nuclear fusion potentially offers carbon-free, affordable, safe, baseload electricity, as evidenced by a growing number of privately funded fusion ventures. Magneto-inertial fusion (MIF) is a low-cost "sweet spot" in fusion parameter space for exceeding energy breakeven, with ion density (*n*) in between those of the much costlier mainstream approaches of magnetic fusion energy (MFE) and inertial confinement fusion (ICF).



INNOVATION

PJMIF uses plasma jets formed by inexpensive plasma guns to form "plasma liners" that repetitively compress a magnetized plasma to fusion conditions

- Avoids repetitive hardware destruction inherent in many other MIF concepts
- Enables cheaper, faster R&D
- Enables high repetition rate in a reactor and economical power-reactor designs
- Possible spin-off applications of plasma guns for early revenue



DESCRIPTION

Extensive initial numerical modeling and experimental results show that PJMIF is scientifically feasible and that plasma-gun capabilities are ready for a demonstration of plasma-liner formation:

- Modeling has informed us of the required plasma-jet parameters needed to attain fusion conditions
- Single- and multi-jet experimental studies have helped benchmark our computer codes and identified the important plasma-liner-formation issues needing further study
- Ongoing ARPA-E project will demonstrate the viability and scalability of plasma-liner formation with up to 60 plasma jets (reactor may use hundreds of jets)

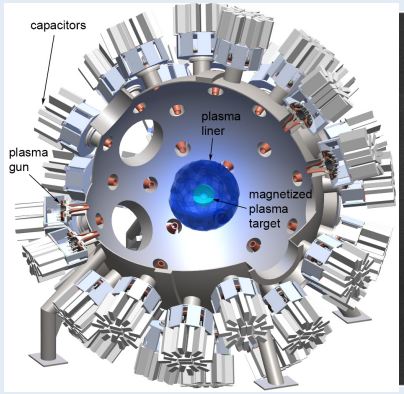
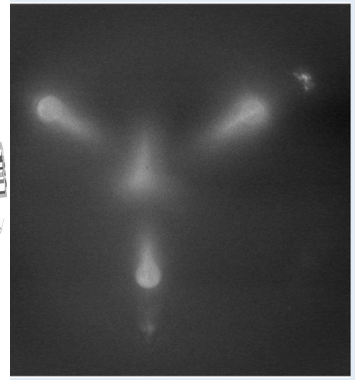


Illustration of plasma-liner experiment with 60 jets.



Visible-light image of 3 jets merging (heading out of page).

Current Technology Readiness Level (TRL) 2

- Theoretical issues identified; full-system modeling underway; experimental proof of concept initiated.

ANTICIPATED IMPACT

PJMIF represents a high-shot-rate, low-cost development path toward economical fusion power that is well-matched to private development

- Aims to satisfy quantitative cost and shot-rate metrics of ARPA-E's ALPHA Program
- If PJMIF is successful, potentially enables:
  - ~15-year timeline to a demonstration reactor costing ~50× less than mainstream-fusion approaches
  - Penetration of centralized-electricity marketplace by midcentury (not likely with mainstream-fusion approaches)

PATH FORWARD

PJMIF phased development path:

I. Plasma-liner formation to 10-million-atm peak pressure, and demonstration of plasma-target formation

II. Plasma-liner compression of plasma (fusion-fuel) target to 10 million degrees

III. Fusion breakeven (~100 million degrees)

IV. Single-shot, reactor-relevant energy gain

V. Full-scale demonstration reactor with continuous, repetitive operation

VI. Prototype fusion power plant delivering electricity to the grid

VII. Production fusion power plants

Potential End Users: Centralized power generation (utility companies)

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