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Advanced IFE Target Designs with Next-Generation Laser Technologies

BETHE Kickoff Virtual Workshop
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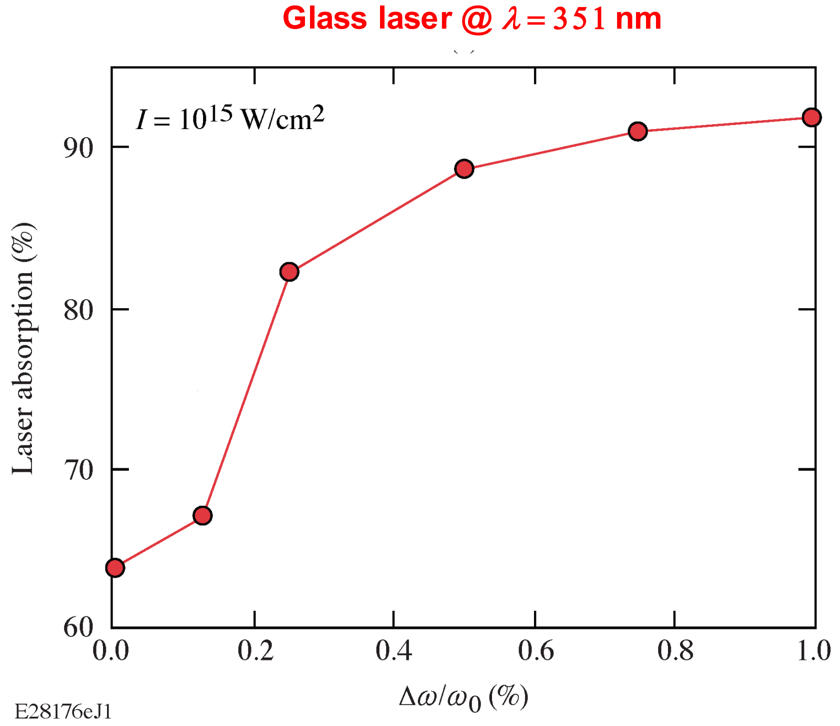
Team members and roles

- **Valeri Goncharov** – PI, project coordination, 1-D target designs for inertial fusion energy (IFE)
- **Igor Igumenshchev** – co-PI, target design and multidimensional stability analysis
- **Tim Collins** – target design and multidimensional stability analysis
- **Russ Follett** – simulation of various laser–plasma interaction (LPI) processes and the effect of new broadband laser technologies on LPI
- **Assistant Scientist /Computational Plasma physics** (open position) – simulation of the effect of broadband laser on laser coupling and thermal conduction using wave-based codes *LPSE*, *OSIRIS* [particle in cell (PIC)], and *OSHIN* (Fokker–Plank)
- **Assistant Scientist/Computation hydrodynamics** (open position) – target design and investigation of stability properties using 2-D and 3-D hydrocodes

LLE will advance laser-direct-drive designs for IFE using broadband, deep UV laser-driver technologies



Laser driver	Bandwidth	Laser absorption(%)
ArF	5 THz ($\Delta\omega/\omega = 0.3$)	90

- New laser technologies include (1) the StarDriver™ system with a large number of frequency-spaced drivers* and (2) excimer lasers (ArF)
- Laser bandwidth mitigates deleterious effects of LPI, leading to enhanced laser coupling and reduced fuel preheat due to hot electrons
- This expands the design parameter space, leading to E_L < 1-MJ high-gain designs robust to hydro instabilities
- The new designs include wetted-foam liquid DT spheres, which significantly reduce target cost

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* "Broadband Frequency Conversion of Spectrally Incoherent Pulses and Initial Laser-Plasma Instabilities Mitigation Experiments" FES-ARPA-E joint project

Major tasks, technical risks milestones, and desired project outcomes

Major milestones

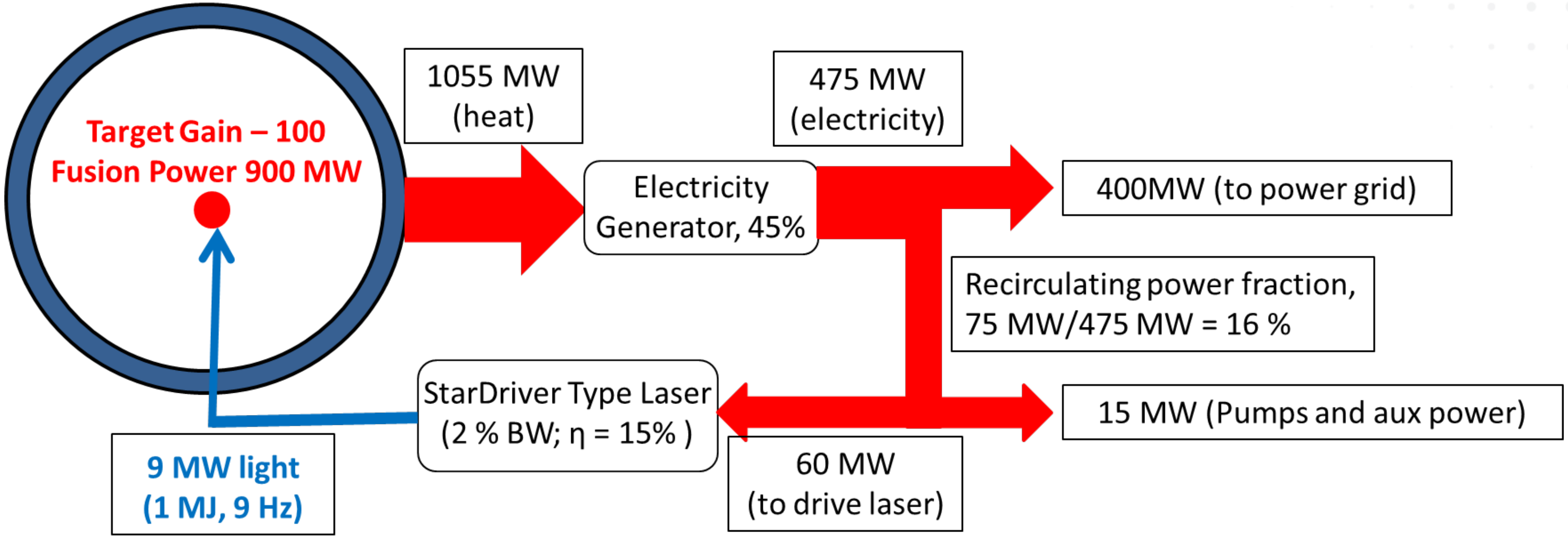
- M2.1-2.6 – Design gain > 100 IFE designs and study their stability properties using 2-D and 3-D hydrocodes
- M3.1 – Calculate cross-beam energy transfer and hot-electron mitigation as function of bandwidth using code *LPSE*
- M3.3 – Calculate the effect of broad bandwidth and laser wavelength on thermal conduction using first-principles (FP) code *OSHUN;* refine thermal conduction model in hydrocode

Risks

- **Laser imprint (hydro stability risk)** – High-*Z* overcoat and foams have been demonstrated to mitigate imprint; broadband also reduces imprint
- **High intensity,** $I > 5 \times 10^{15}$ W/cm^2 (LPI risk) required for shock-ignition (SI) design – The ArF laser operates at a shorter wavelength (193 nm), which raises the threshold for LPI; designs with liquid DT spheres will allow “nominal” designs without an SI spike to be more uniform, leading to higher convergence and yields

The project will deliver robust, high-yield IFE designs using new high-bandwidth laser technologies and innovative target concepts with <1 MJ of input laser energy.

A diode-pumped broadband StarDriver™ (2% fractional bandwidth) is expected to support a 400-MW plant with cost <$2B



Total direct costs (TDC)	$1,123M
Laser system (based on LIFE cost analysis)	$300M
Reactor plant	$203M
Balance of plant	$620M
Indirect costs (60% of TDC)	$674M

- **Current estimate: Overnight capital cost: $1,797M, Capital cost of electric power: 4.5 $/W**
- **More in-depth cost studies will be performed in coordination with NRL and other LLE awardees**