Xcimer's approach to Inertial Fusion Energy and the HYLIFE-III chamber concept

FPA annual meeting

December 19, 2023

Susana Reyes

VICE PRESIDENT, CHAMBER AND PLANT DESIGN

XCIMER

XCIMER ENERGY CORPORATION

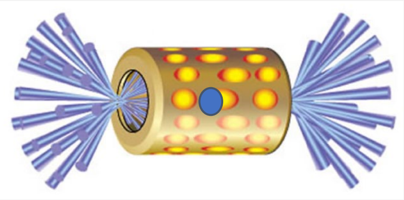
Our lasers will scale to **10s of MJs**
with flexible and reconfigurable illumination geometry
and fine-scale spatio-temporal pulse shaping

Enables
simpler and more **robust targets**

Simplifies
thick-liquid-wall chambers (HYLIFE)

Robust path to
inertial fusion energy

Utilizing only **two beams**, we will directly illuminate a larger target and couple over **30x more energy** than NIF

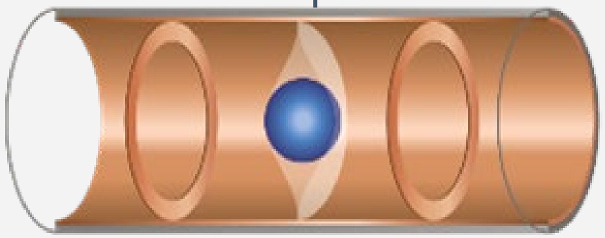


1 cm

NIF Target

~0.22 mg of DT

~250 kJ coupled



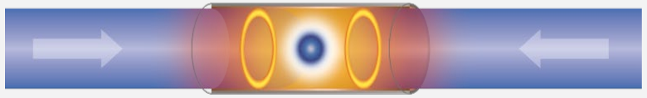
3.2 cm

Xcimer Target

>20 mg of DT

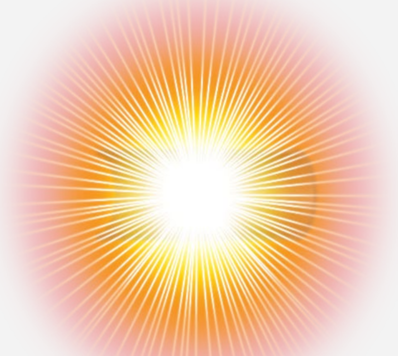
>8 MJ coupled

1. First pulse, *indirect drive* illumination

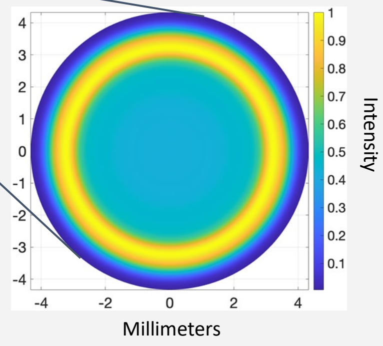


2. Subsequent pulses, *direct drive* illumination (majority of laser energy)

3. Ignition and burn

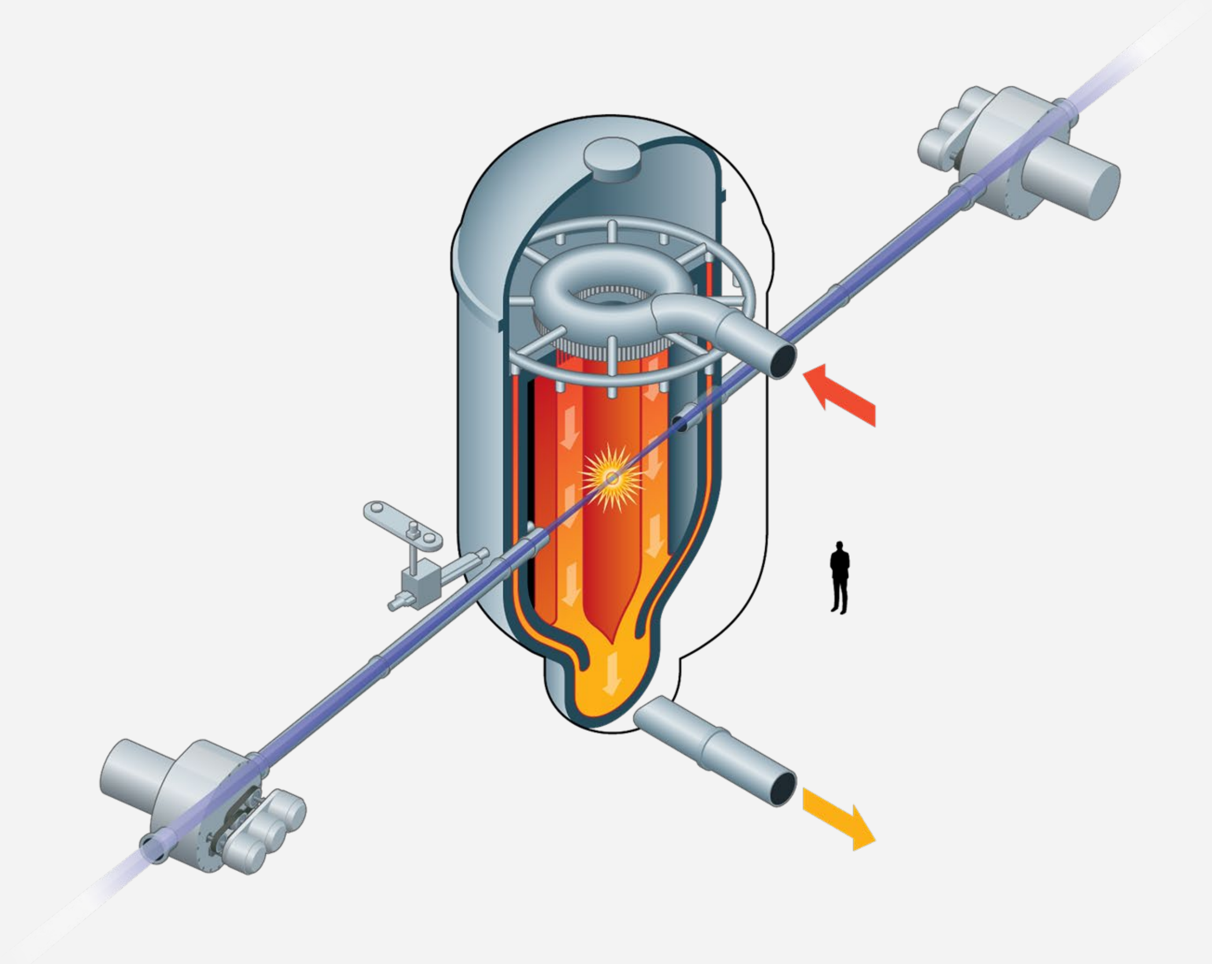


4. **Fusion burst yields >200x laser energy**
   fuel burnup ~30%



Ring-peaked laser intensity allows **spherical implosion** from **two-sided illumination**

HYLIFE chamber features mitigate fusion challenges



Waterfall of FLiBe: coolant, x-ray/debris absorber, neutron moderator, and tritium breeding material all-in-one

Liquid FLiBe directly protects first wall from x-ray/debris and 14 MeV neutrons
➢ *Key advantage over other fusion approaches*

Mitigates “first wall problem” - structural wall with longlifetime and minimum maintenance

Significantly lower activation, routine releases and waste production compared to conventional DT fusion approaches

Mitigating challenges of prior HYLIFE designs (LLNL):

- Only 0.25 - 1 Hz rep rate
- Large 50 m stand-off
- Only two beam ports ~10 cm across
- No jet oscillation required
- 30 m of 1 atm gas protects final optics

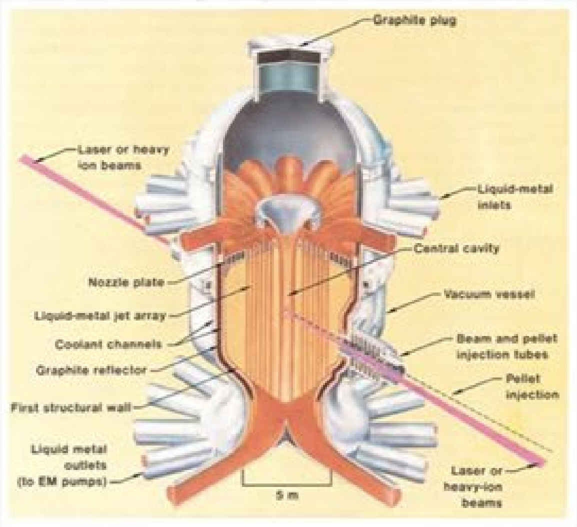
Xcimer laser enables adaptation of HYLIFE's most favorable features from previous concepts

Flibe molten salt protects FW from x-ray/debris/neutrons - can possibly last 30-year-design lifetime

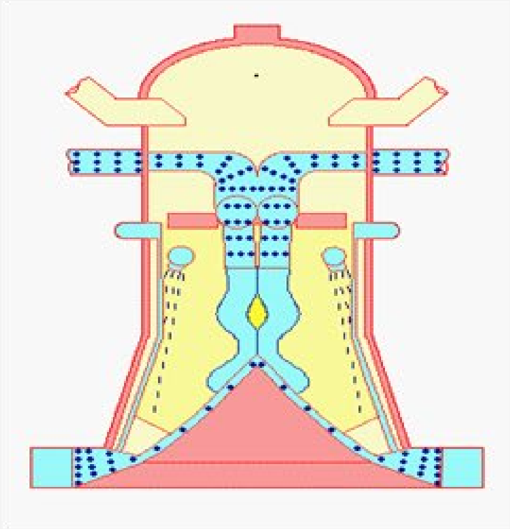
HYLIFE-II studies show that dissociation upon condensation, showing recombination, condensation and jet establishment feasible in <200 ms

HYLIFE-III operation at <1 Hz with 2 beam ports relaxes chamber clearing requirements

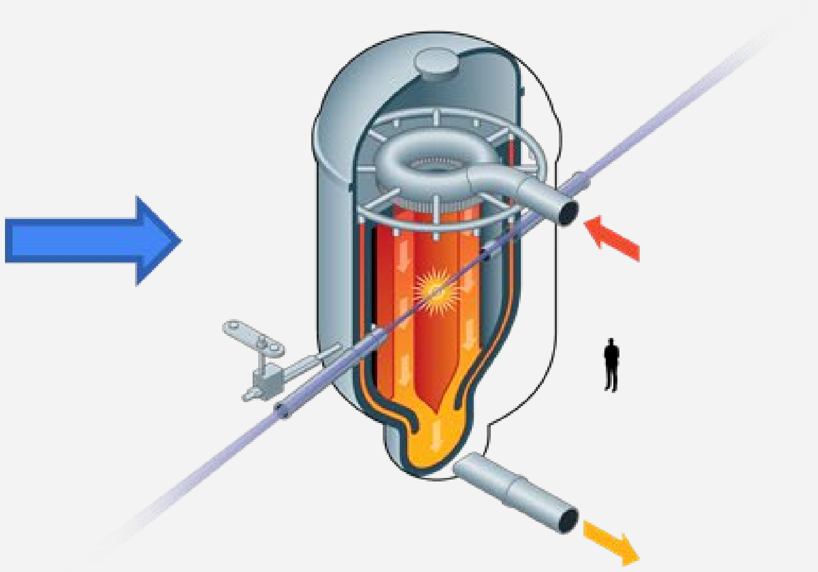
HYLIFE-III final optics stand-off at 50 m, with 30 m of 1 atm gas, stops x-rays and debris



HYLIFE-I (1975)



HYLIFE-II (1990)



HYLIFE-III (2023)

Initial neutronics analyses for HYLIFE-III show promising results, confirm reduced FW damage and gas production

FLiBe thickness will be set to limit the dpa/yr and He production to allow the simplest path for first wall material qualification

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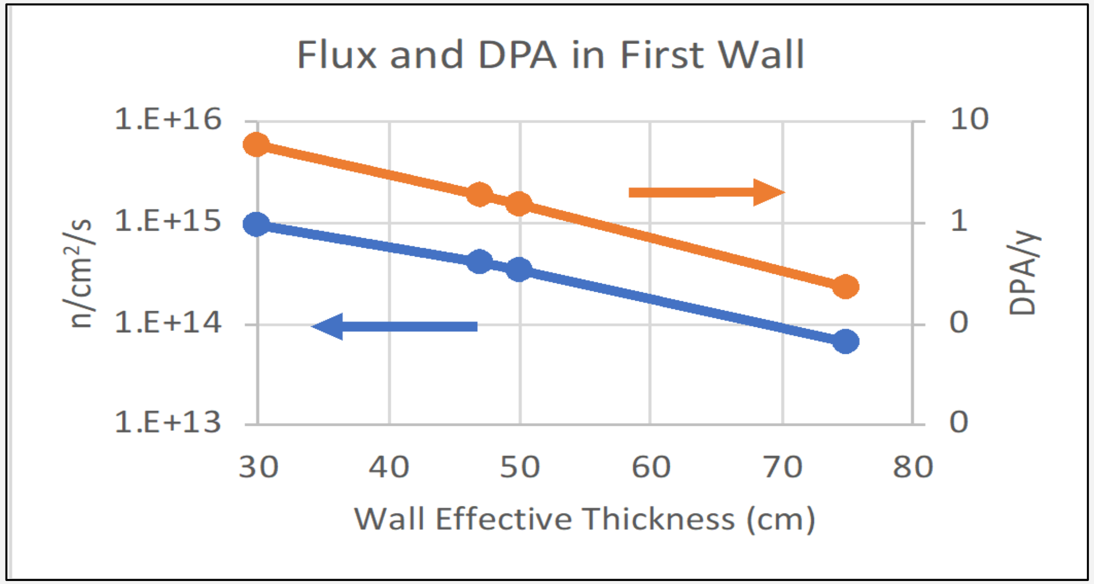
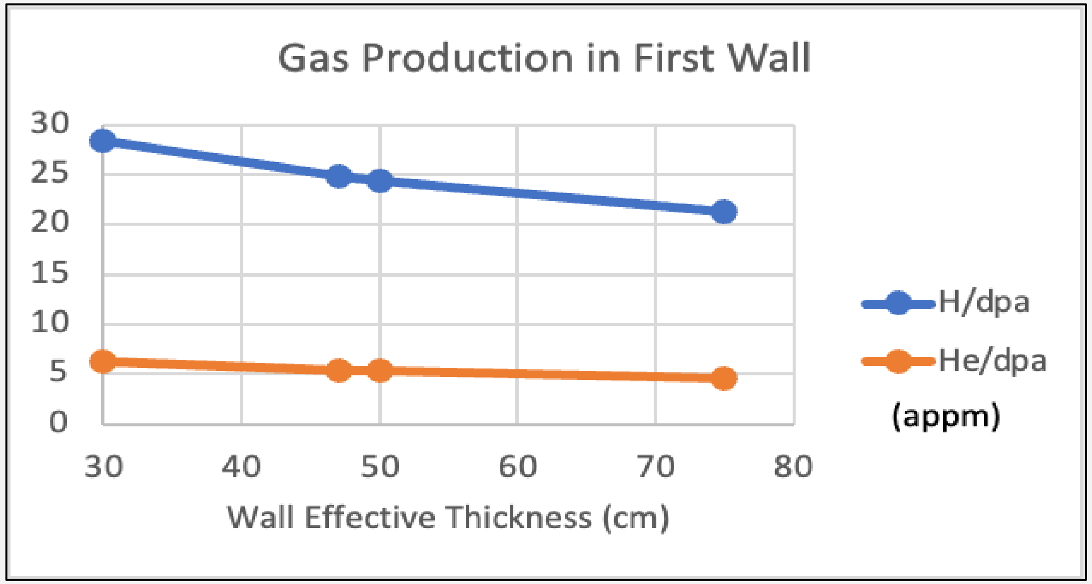
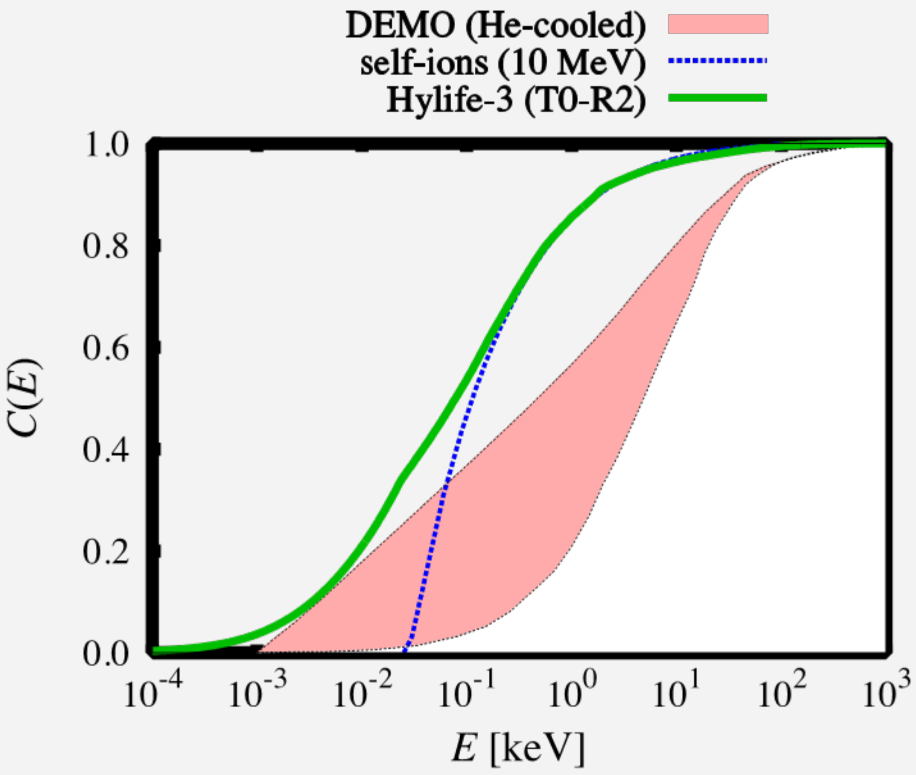




Multi-scale material damage studies confirm effectiveness of thick liquid protection

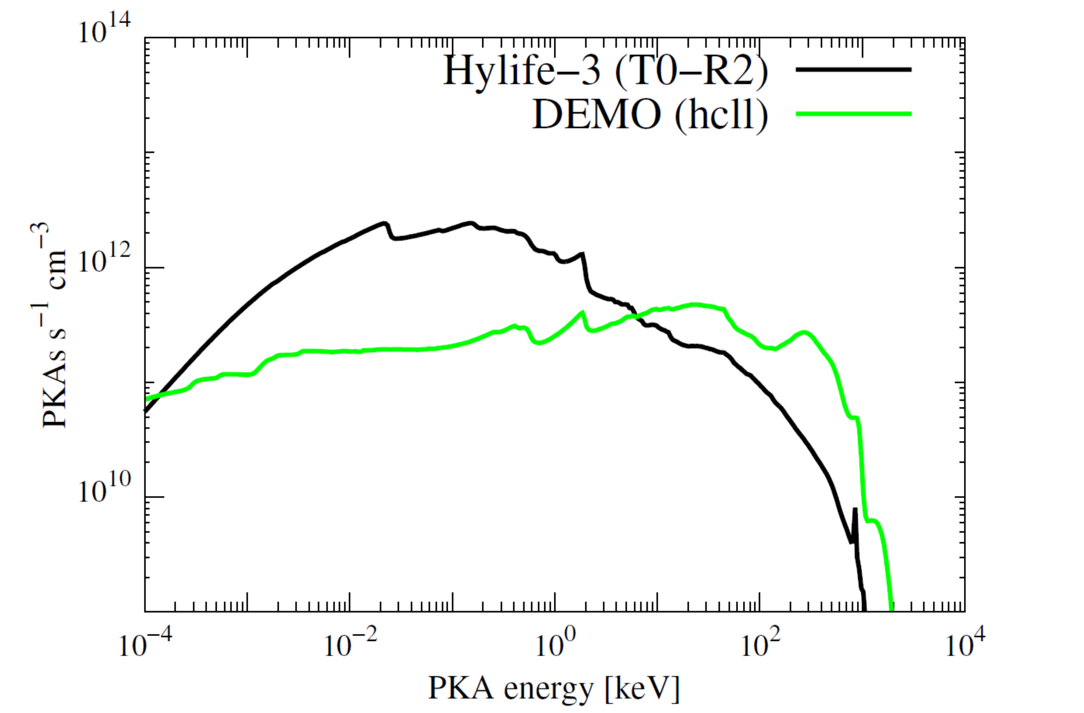
Cumulative PKA energy distribution function: it indicates how 'damaging' is each neutron.



Average Fe PKA energy (Xcimer) = 2.7 keV

(Average Fe PKA energy (DEMO) = 18.8~20.5 keV)

Number of PKA per unit time per unit volume:



Based on results, HYLIFE-III would deliver ~1.4 dpa/yr (5.8×10^{-8} dpa/s) to the FW.
In DEMO, 10-30 dpa/yr would be received by the FW.

Results courtesy of Prof. Jaime Marian, UCLA, September 2023

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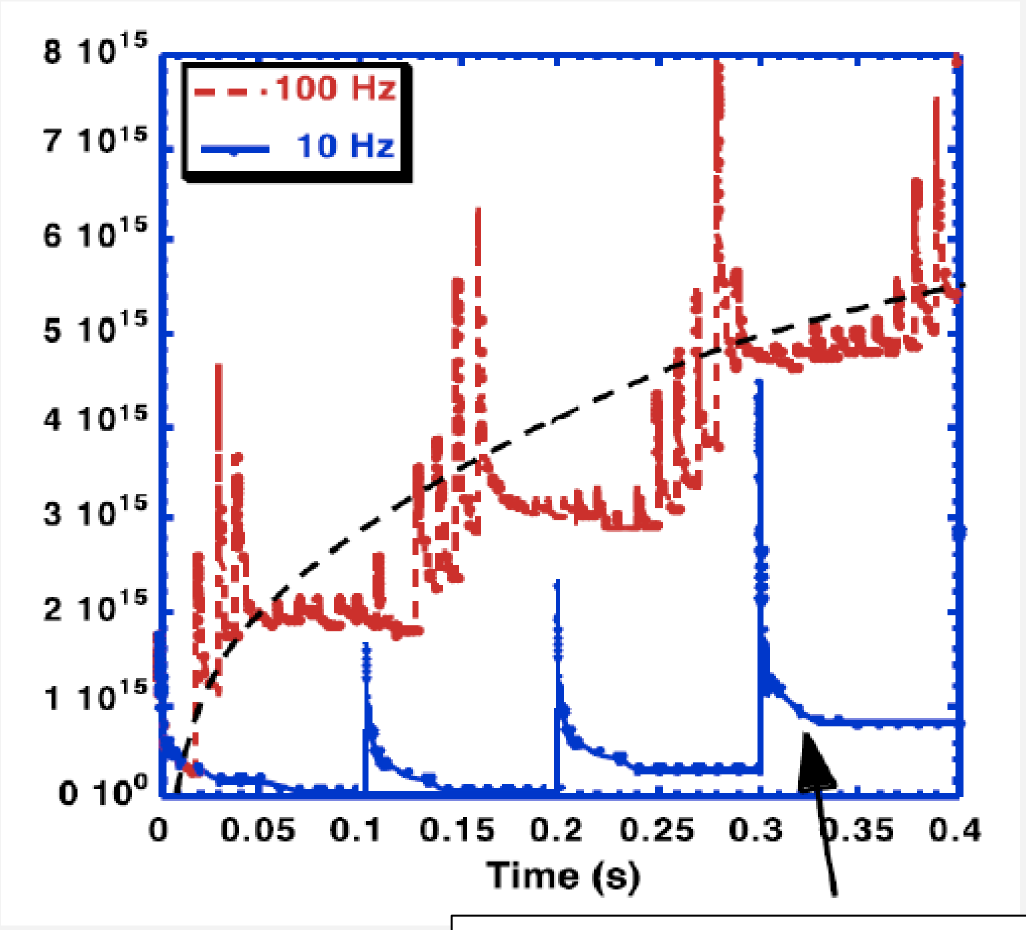
Furthermore, damage accumulation models show possible annealing between pulses in IFE concepts



Concentration of V Clusters (cm^{-3})

- Stochastic damage accumulation methods can provide detailed estimates of materials evolution during intercalated build-up and cool-off periods under pulsed irradiation conditions.

- Identify bifurcation time at which repetition rate matches continuous irradiation in functionally identical conditions.

Results by J. Marian and M. J. Caturla suggest that full annealing might occur between shots for < 1 Hz repetition rate – detailed simulations ongoing for HYLIFE-III conditions

“Comparative study of damage accumulation in iron under magnetic and inertial fusion conditions “, E. Alonso et al, Journal of Nuclear Materials 283-287 (2000) 768-772

Milestone program includes national institutions to accelerate our efforts

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