Fusion Lecture Summary

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Based on presentation:
"Energy Security and Frontier Science at the National Ignition Facility"
by Edward I. Moses (Principle Associate Director, National Ignition Facility and Photon Science)

Outline

National Ignition Facility (NIF)

location: Lawrence Livermore National Laboratory (LLNL)

Specifications

"it's a precise machine. . . not just a flamethrower"

- building size: $\approx$3 football fields
- target size: $\approx$1 mm^3
- lasers: 192 Nd-glass
- energy: $\approx$1.8 MJ (1.2 MJ at present)
- power: 500 TW
- pulse duration: $\approx$1 ns
- wavelength: 351 nm (3ω)
- temperature (on target): 10^8 K
- density (on target): 10^3 g/cm^3
- pressure (on target): 10^{11} atm

Timeline

- 1997 - Groundbreaking
- 1999 (June) - Target chamber installed
- 2001 (September) - Building shell finished
- 2002 (December) - First lasers installed
- 2003 (April-May) - All lasers installed
- 2003-2007 - Laser commissioning, diagnostics, targeting
- 2009 (May) - NIF dedication
- 2010 - Ignition??
- 2009-2030 - User Facility

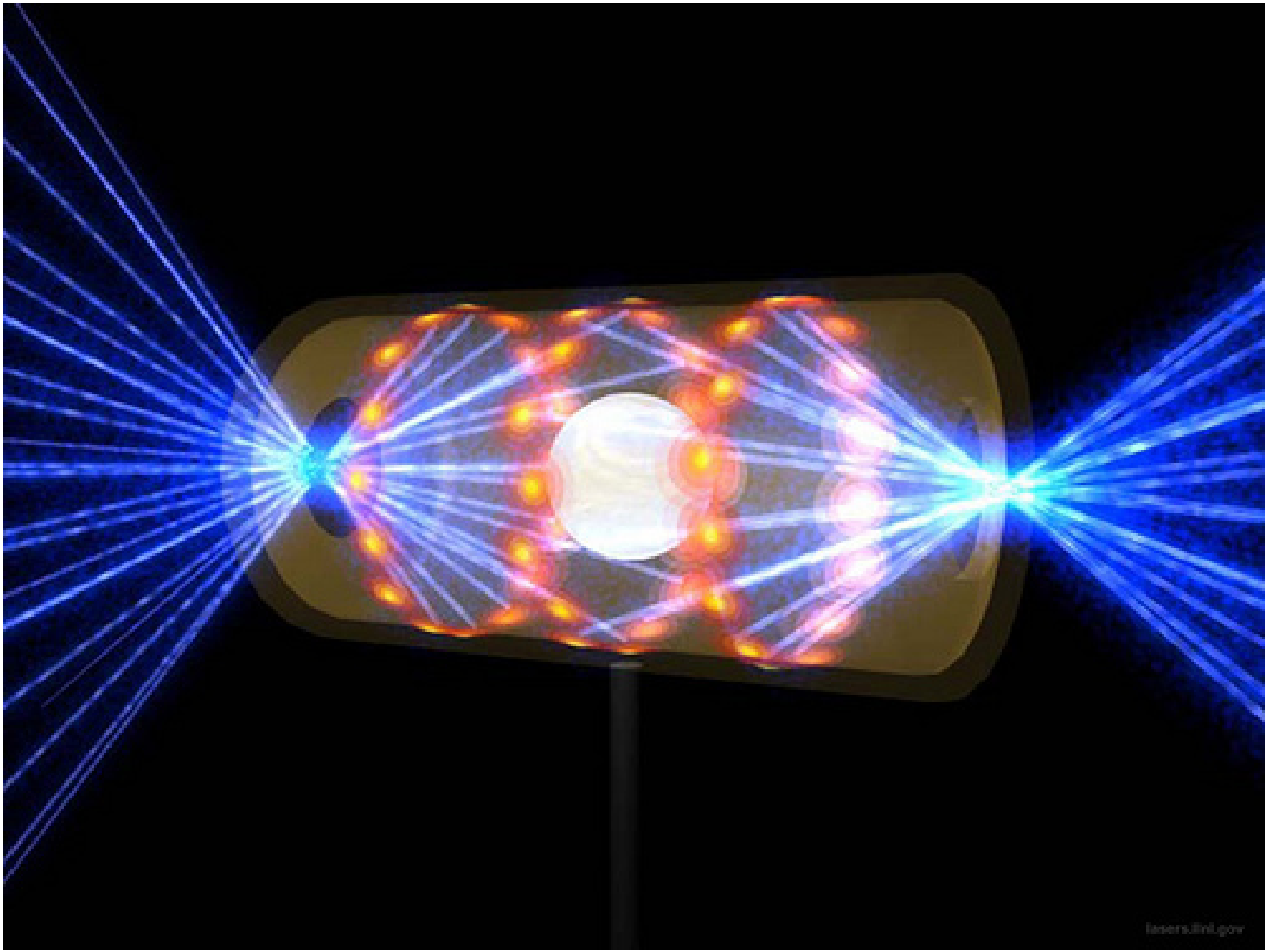
Goals

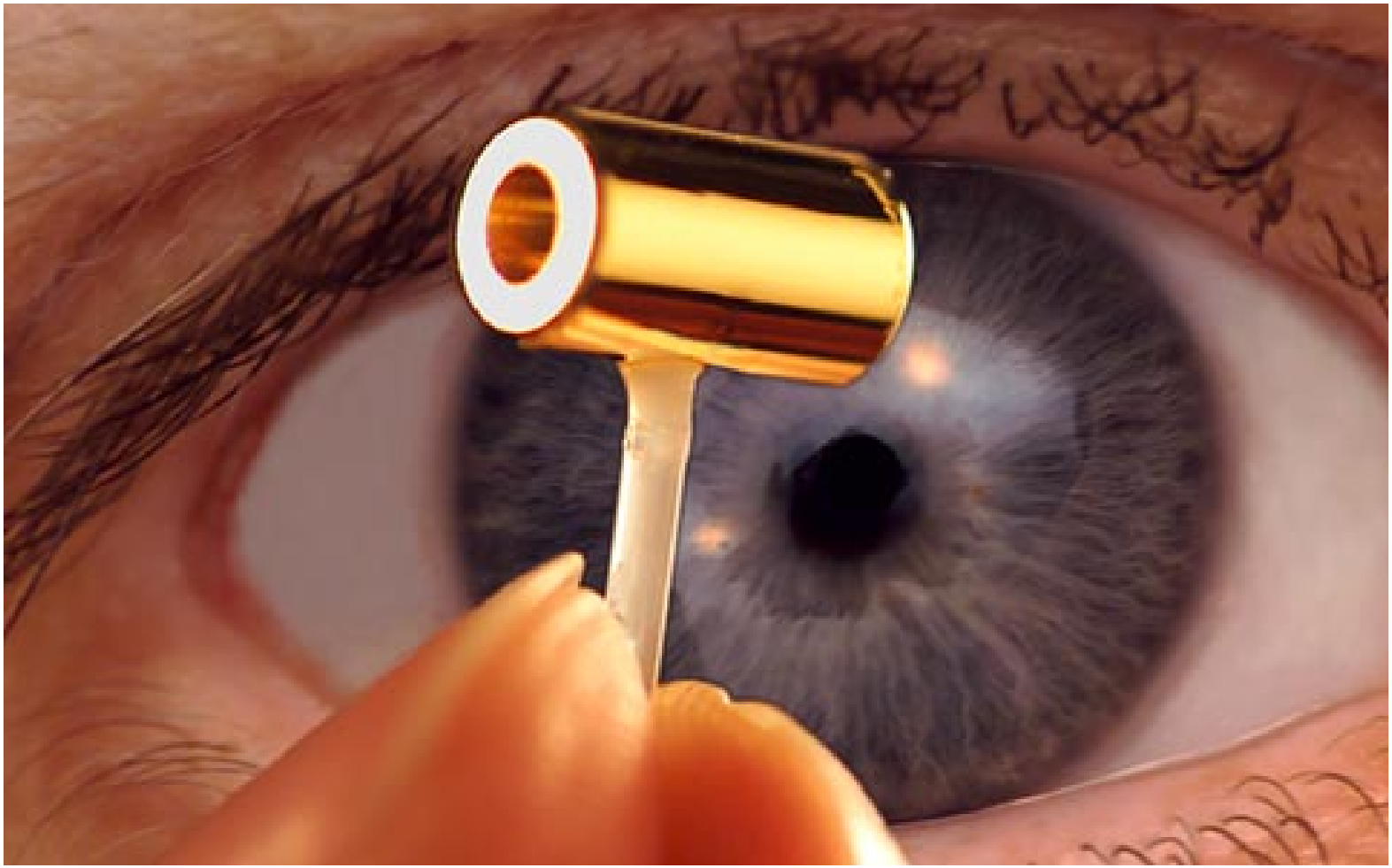
- Global stability and security (verification of state of existing nuclear weapons)
- Frontier science
- Clean energy (fusion!)
- Future generations of scientists

Inertial Confinement Fusion (ICF)

"a jelly donut in, a few hand grenades out"
(1.2 MJ in, 30 MJ out (in theory))

- IR lasers fire
- lasers pass through 3ω crystals at target chamber
- t=0 ns: beams focused on 3 rings in hohlraum (T_0=18.5 K)
- hohlraum emits xrays
- t=10 ns: target pellet absorbs xrays, compresses
- t=15 ns: ignition


lasers.llnl.gov



Science at NIF

- fusion
- element creation
- high photon pressure physics
- high pressure chemistry

Fusion and the Future

Energy is a problem.

- 1850: 100% carbon-based energy
- 2010: 90% carbon-based energy
- 2030: tipping point?
- projected energy supplies in 2100: 200 billion barrels of oil equivalent
- projected energy demand in 2100: 300 billion barrels of oil equivalent

Laser Inertial Fusion Engine (LIFE)

- sustainable, non-proliferating, modular, compact
- fusion-fission hybrid: neutrons (10^{19} 14.1 MeV neutrons per shot) from fusion drive fission
- (optimistic?) projected timeline:
  - 2020: prototype
  - 2030: commericial plant
  - 2050: incorporation into utility fleets (SimCity 2000. . .)

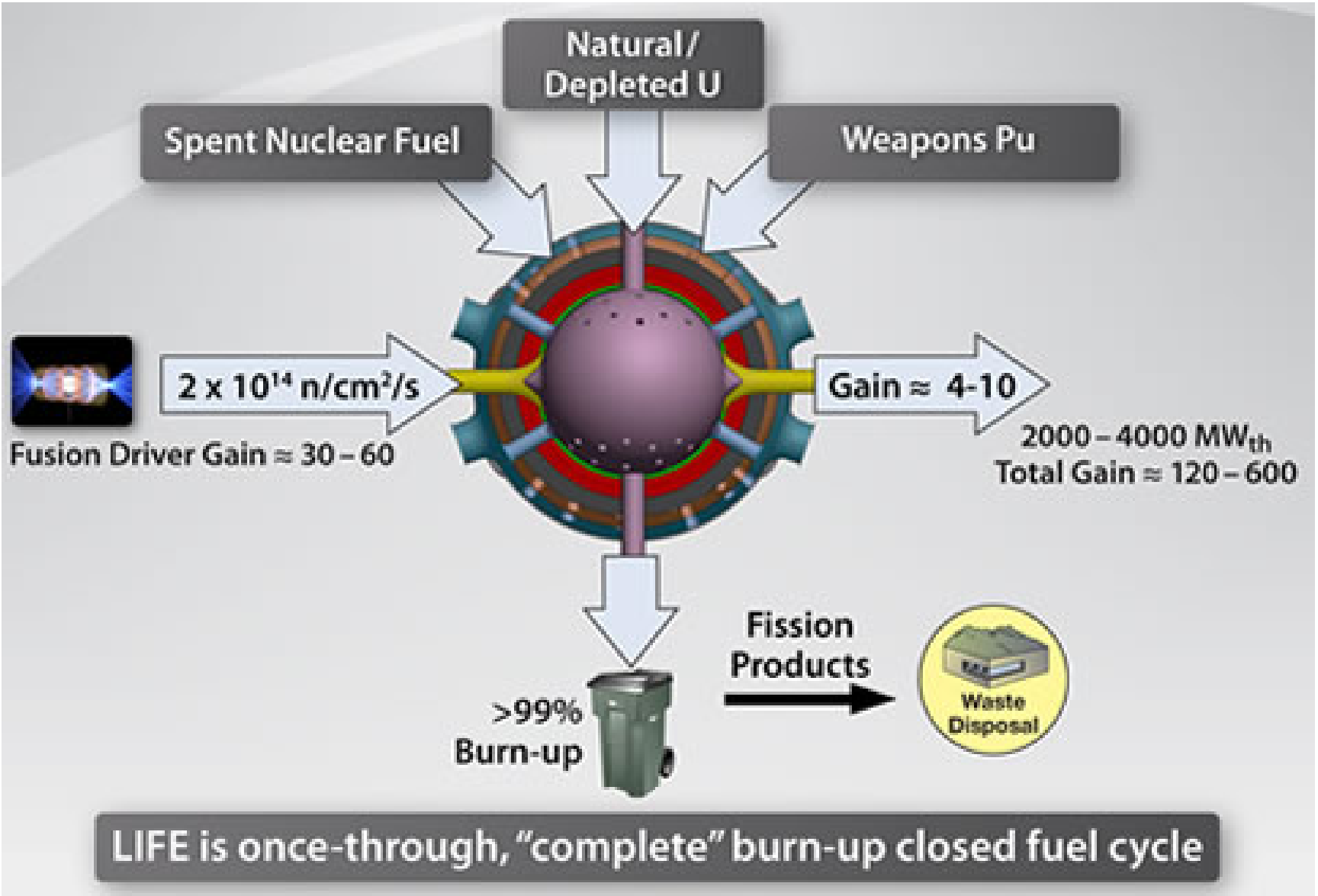


Illustration of LIFE process

Final Thoughs

- fusion: the most important technology of the 21st century
- things to do:
  - handle heat generation
  - mass produce pellets
  - mass produce laser diodes for pumping
- the future:
  - miniaturization?
  - unlimited clean energy
  - redistribution of world power
  - space exploration

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- Edward I. Moses