Pathways to Laser Fusion Beyond NIF

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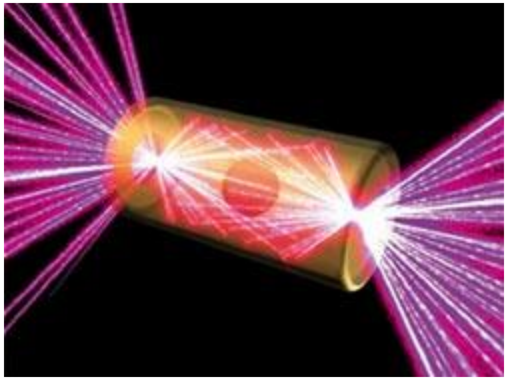
How far will NIF go towards ignition?

NIF indirect drive

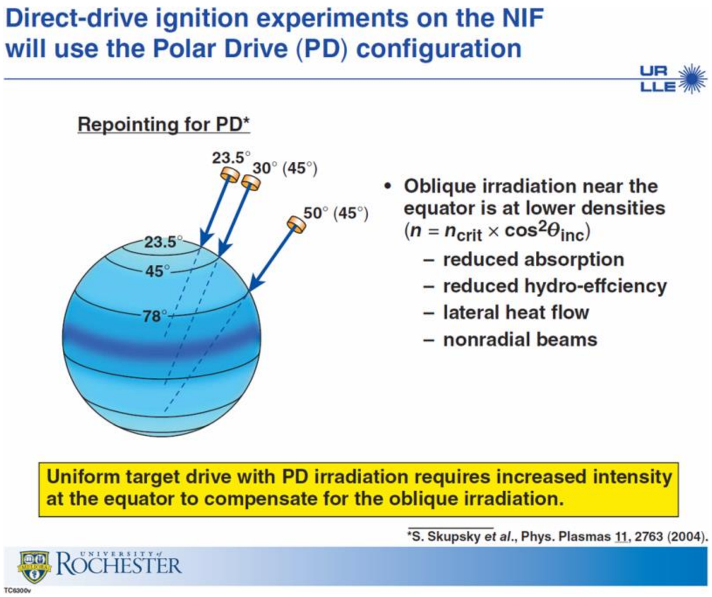
- Most explored approach
- Impressive recent progress
- Physics very complicated
- Small fraction of laser energy on capsule
- Ignition and significant yield??



https://lasers.llnl.gov/about/nif/

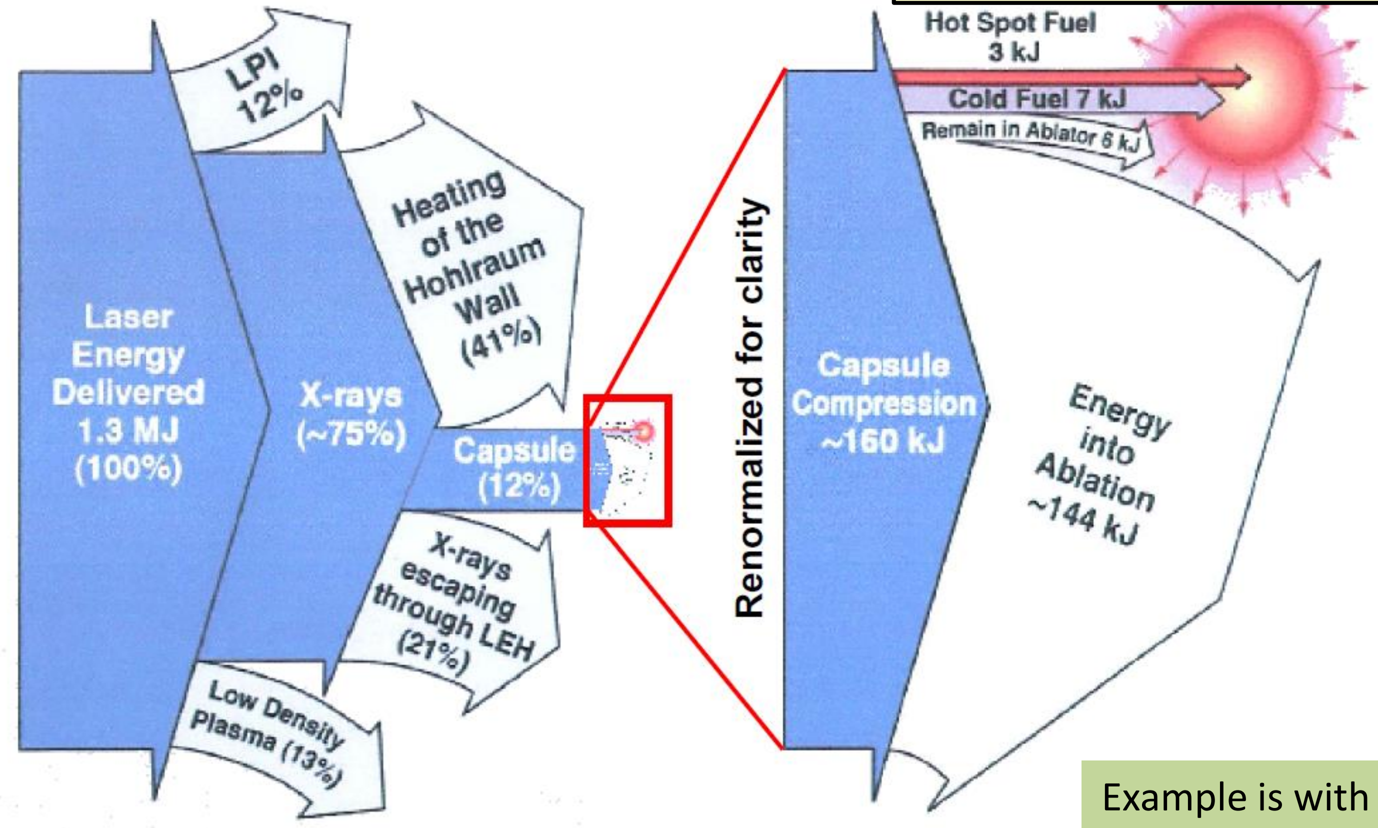
NIF Polar drive

- Much more efficient use of laser energy
- Needs to be explored
- Effort will advance physics of direct drive
- Far from optimum configuration for direct drive
- Ignition and significant yield?



Typical energy flow calculated for an igniting NIC-like target

Energy to compressed & heated fuel
~10kJ



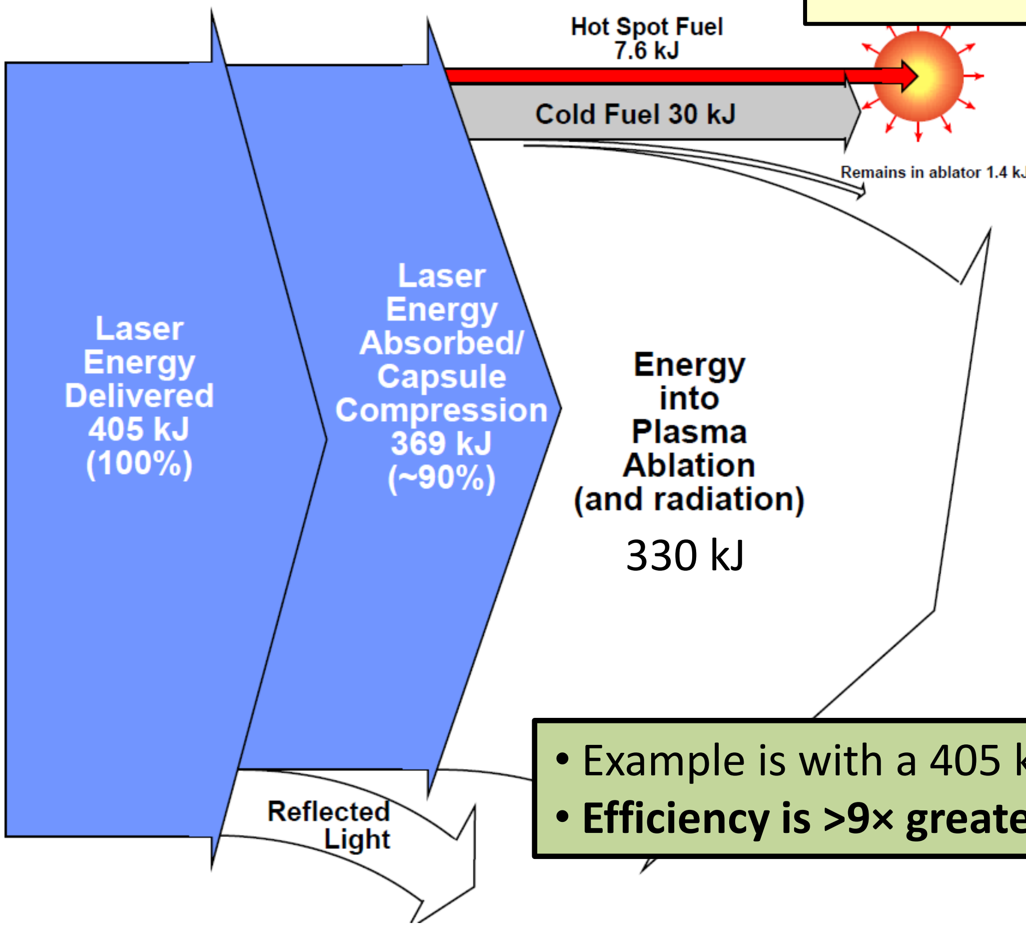
Example is with 1.3 MJ
NIF provides up to 1.8 MJ

from E. Moses, Session MR1 Review Talk: "***Overview of the National Ignition Campaign (NIC)***", American Physical Society Division of Plasma Physics 52nd Meeting, Chicago IL, 8-12 Nov 2010

Direct –drive is much more efficient

Typical energy flow calculated for a direct-drive shock ignition target

Energy to compressed and heated fuel >37 kJ



- Example is with a 405 kJ KrF driver
- **Efficiency is >9× greater than indirect drive.**

Options for more robust ignition and high yield for laser ICF

Convert NIF to symmetric direct drive

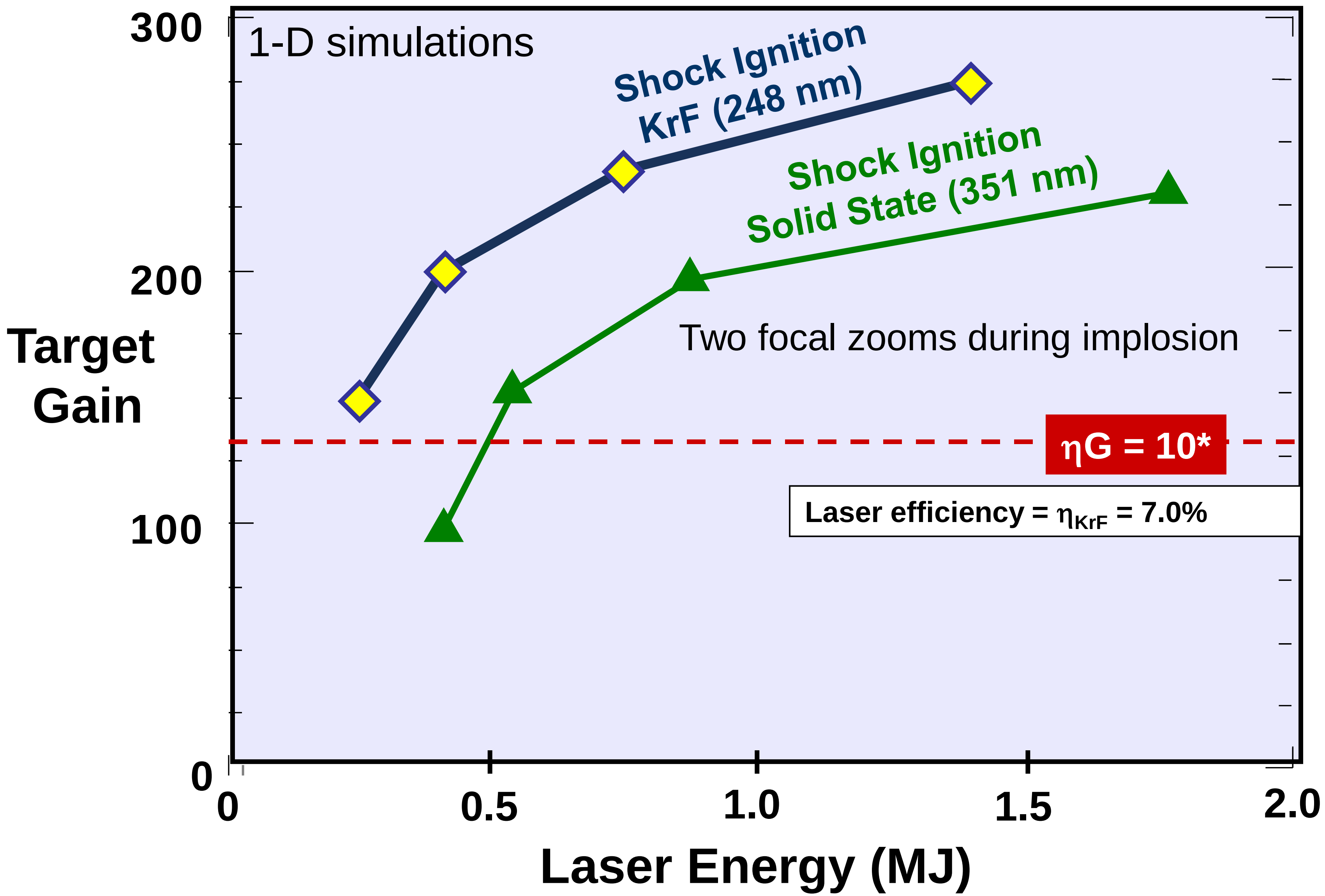
- Better illumination uniformity
- But NIF's architecture limits bandwidth and capacity to zoom focus.
- Still not optimum for direct drive

Higher Energy indirect drive laser facility (10MJ?)

New dedicated symmetric direct drive facility

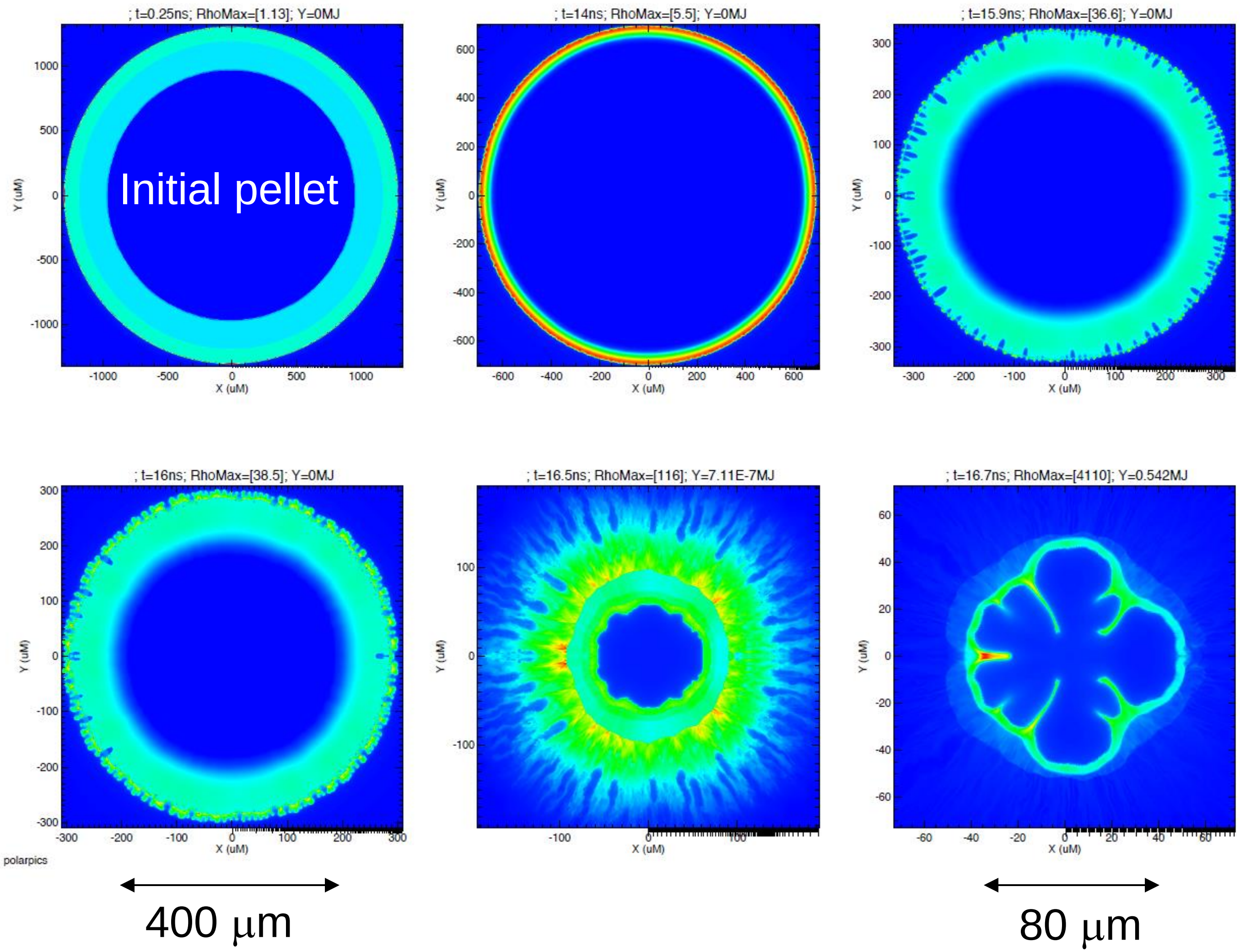
- KrF or advanced solid state
- Much higher repetition rate (1 shot per minute)
- Many physics shots at >10x lower cost/shot (less costly targets)
- < 1MJ may suffice

High yields and gains are predicted for energies <1 MJ with direct-drive shock ignition.



High resolution 2-D simulations predict high gain with expected target and laser nonuniformities.

(Shock ignition with 530 kJ KrF driver)



138 x gain

Imploded pellet (magnified scale)

A few reminders on KrF's superior capabilities for ICF

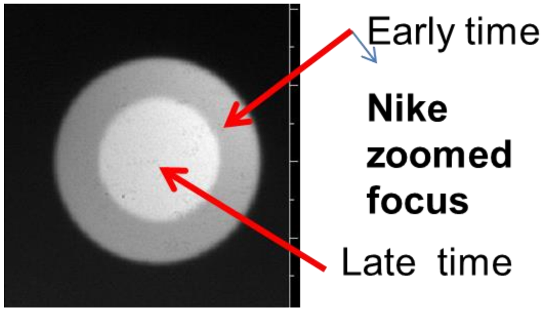
Shorter λ than frequency tripled Nd:glass

- Increases absorption and hydrodynamic efficiency
- Reduces risk from hydro and all laser plasma instabilities

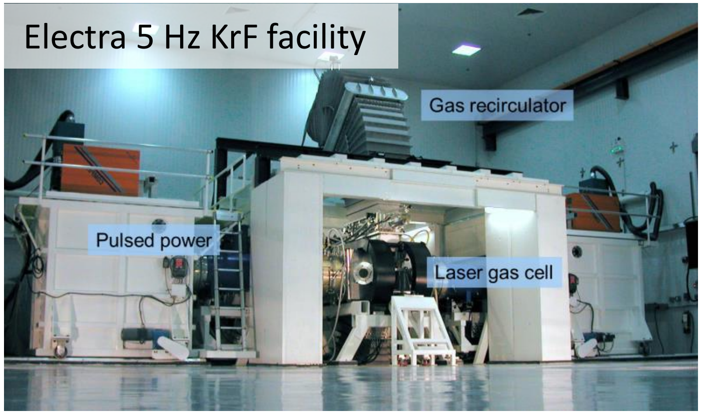
Broader bandwidth enables superior beam smoothing

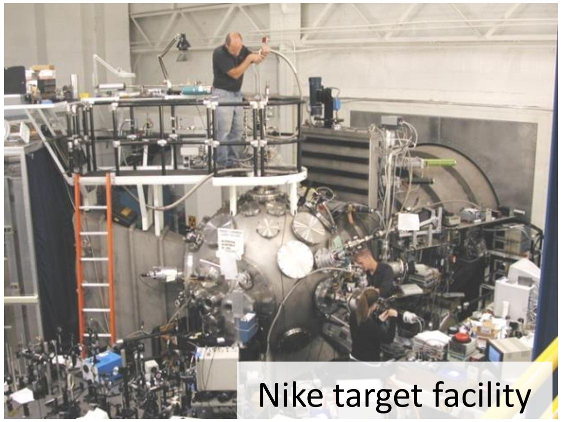
Multi-stage focal zooming is trivial with KrF

- Further increases absorption efficiency
- May be critical to suppress Cross Beam Energy Transport



Paths to high energy and high rep rate demonstrated on NRL KrF laser facilities





We still think there should be a modest IFE program, but realize that we need to get our act together in ICF physics.

Phase I:
Basic IFE Science and Technology

Phase II:
Develop full size components

Phase III:
Fusion Test Facility
- Demonstrate integrated physics / technologies for a power plant.
- Tritium breeding, fusion power handling.
- Develop/ validate fusion materials and structures.
- **READY FOR PILOT POWER PLANT**

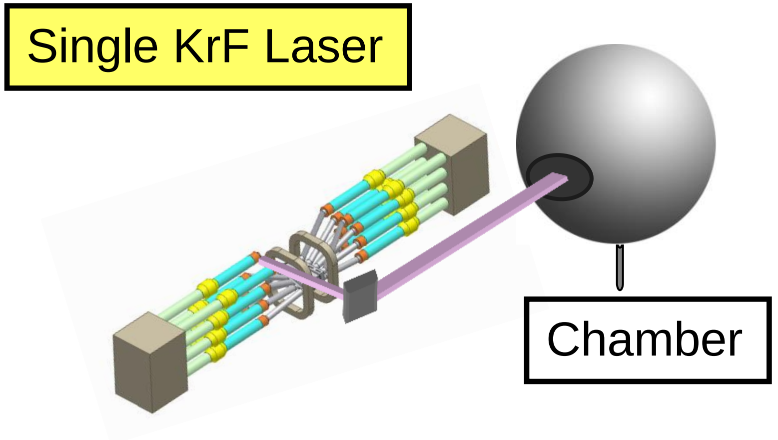
Increasing size
Increasing performance
Decreasing scientific risk
Increasing Industry Partnership

Additional slides

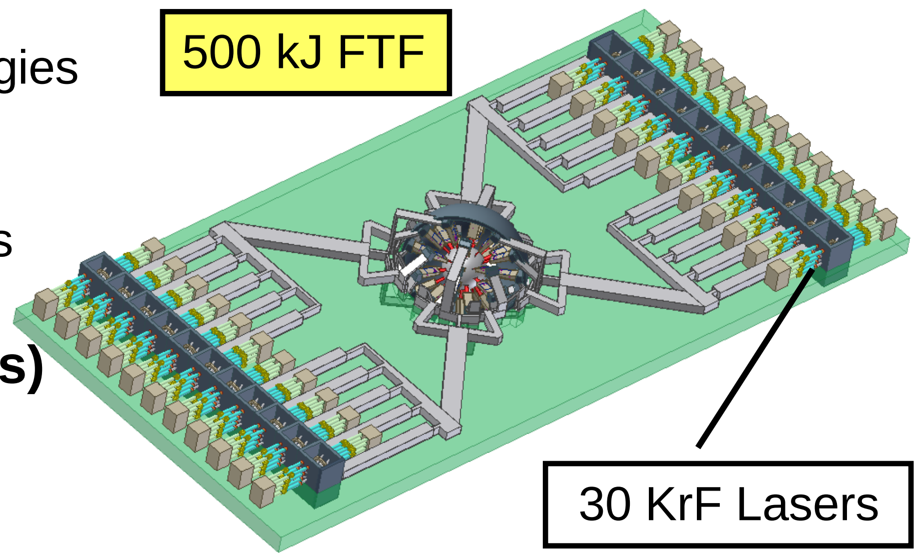
Example: development plan for IFE with KrF

Phase I – Complete full performance subscale KrF system

Phase II Develop full size components
- Single 5 Hz 18 kJ KrF laser beamline
- Target fabrication /injection /tracking
- Chamber, optics technologies
- Refine target physics



Phase III Fusion Test Facility (FTF) ~250 MW Fusion (thermal) power
- Thirty 18 kJ KrF laser beamlines
- Show integrated physics / technologies
- Gain (about) 100
- Tritium breeding, power handling
- Develop fusion materials /structures



Phase IV Prototype Power plant(s)
- Electricity to the grid