Laser Fusion in Japan: Combat with global warming

Fusion Power Associates
Washington DC
2009.12.2-3

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Haunting face crying a river of tears as glacier melts into the sea
Photo By Michael Norman

Why Fusion?

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- We need large size electric power plants without warming gas emission.

- The only solution at present is atomic power.

- But, nuclear waist problems (long life safety, proliferation etc.) requires other power plants which emit non-warming gas and negligibly small amount of nuclear waist.

- Fusion energy is the ultimate large energy source.

Why Inertial Fusion

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- After 50 years from the innovation of lasers, the community is ready to ignite a fusion fuel: the first controlled fusion ignition in humankind.

- Once the ignition is achieved, the energy gain is increased simply by increasing the size of the core. The burning proceeds no matter what the fuel size is.

- Physics of reactor core plasma will be completely explored and established in this phase. This is why ignition and burn is so important.

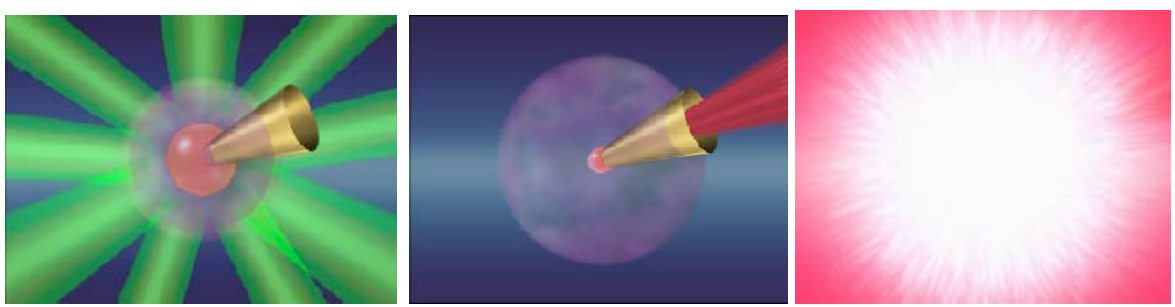
Why Fast Ignition?

- Since the fuel contains no central hot spark, the Fast Ignition can ignite with 1/10 of laser energy that is necessary for conventional central ignition.

- This compactness strongly accelerates Inertial Fusion Energy development.

Fast Ignition Realization Experiment (FIREX) Program for Inertial Fusion Energy

Implosion | Fast heating | Ignition/Burn



- Proof-of-concept: Scalable to 600 times liquid density
  Demo of 1 keV temp. by 0.5kJ/0.5ps.
- FIREX-I: Demo of 5-10 keV temperature by 10kJ/10ps.
- FIREX-II: Demo of significant burn

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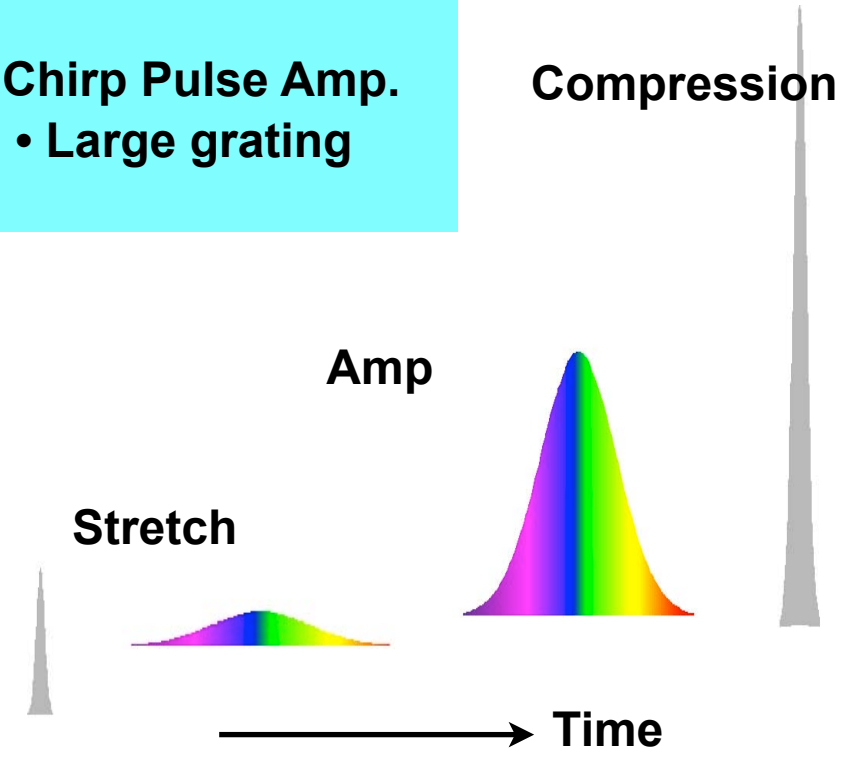
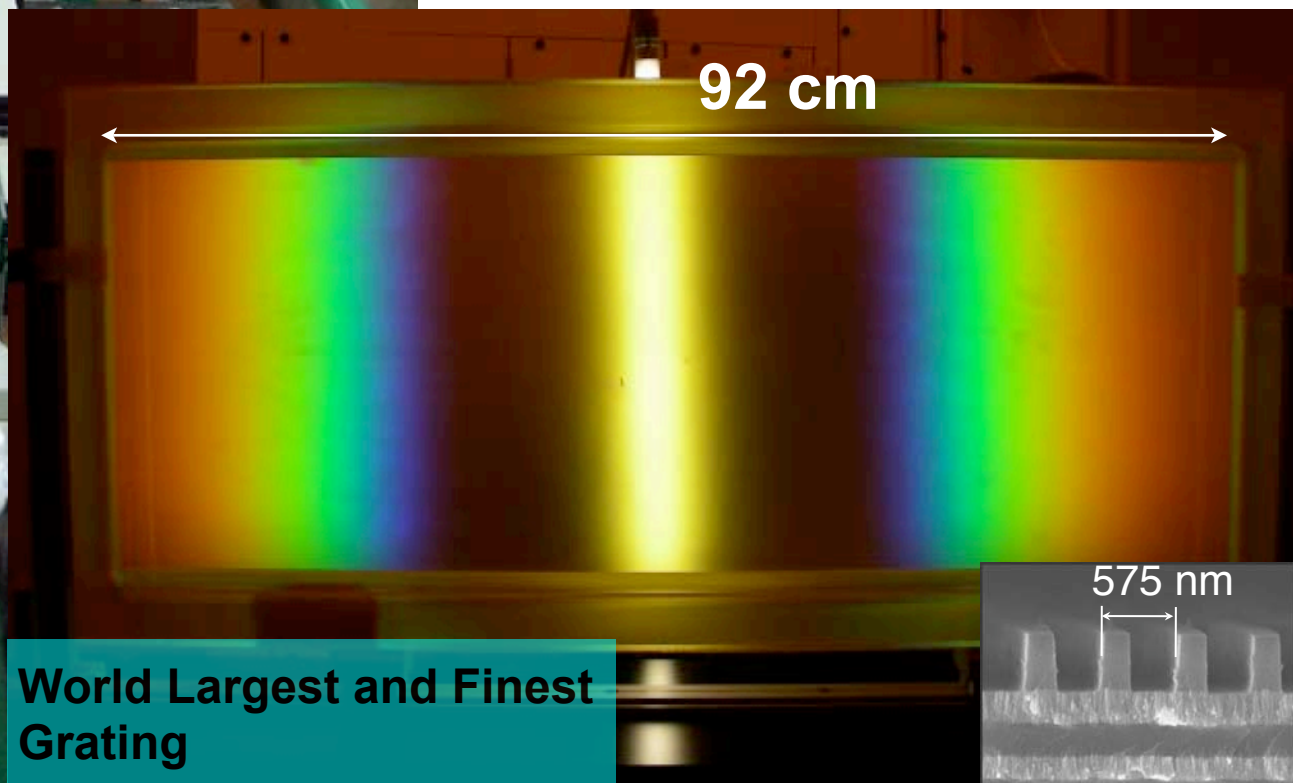
LFEX:
10-kJ Short Pulse Laser

Chirp Pulse Amp.
- **Large grating**





World Largest and Finest Grating

First integrated FI experiment has just started.

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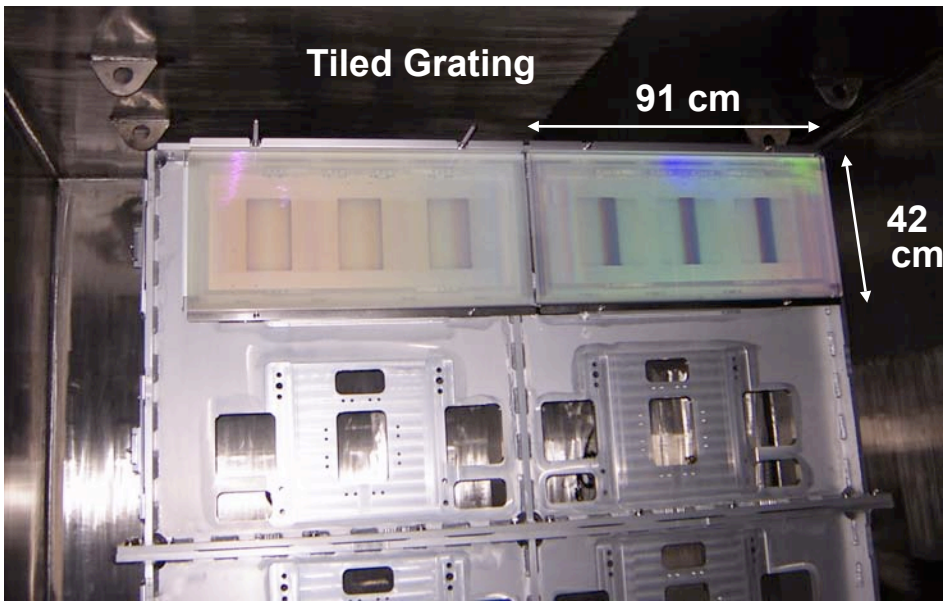
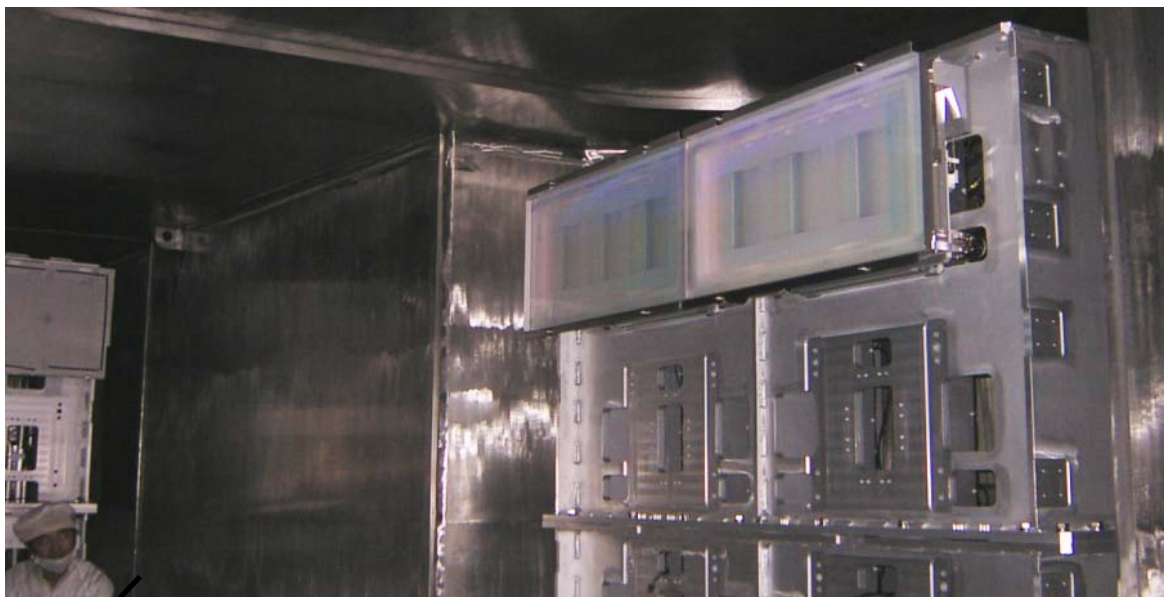
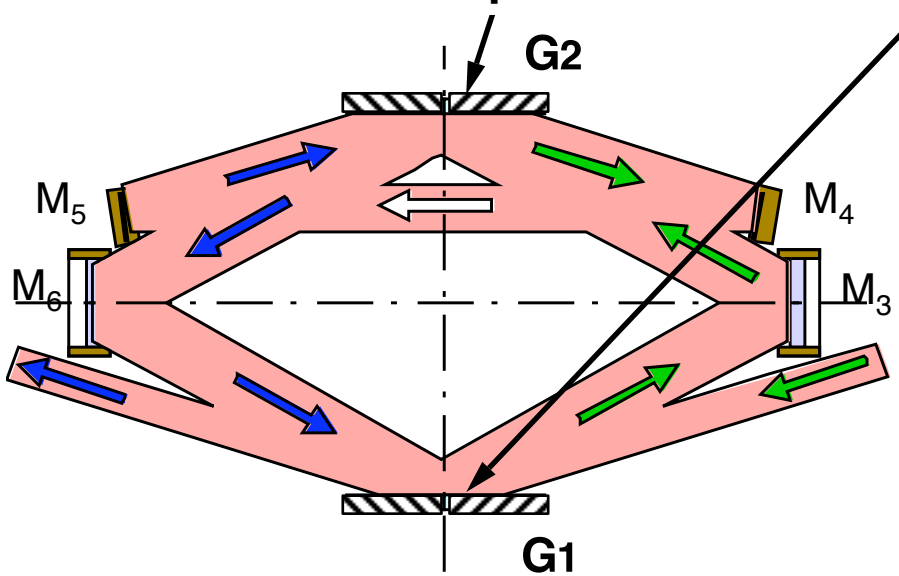
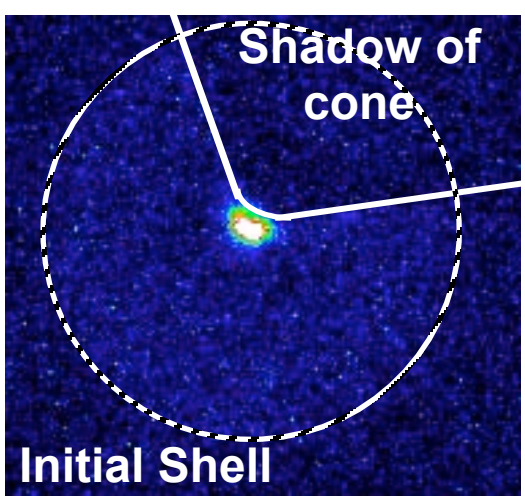




Diamond compressor



First plasma on June 26th, '09



FIREX-I Integrated Experiment

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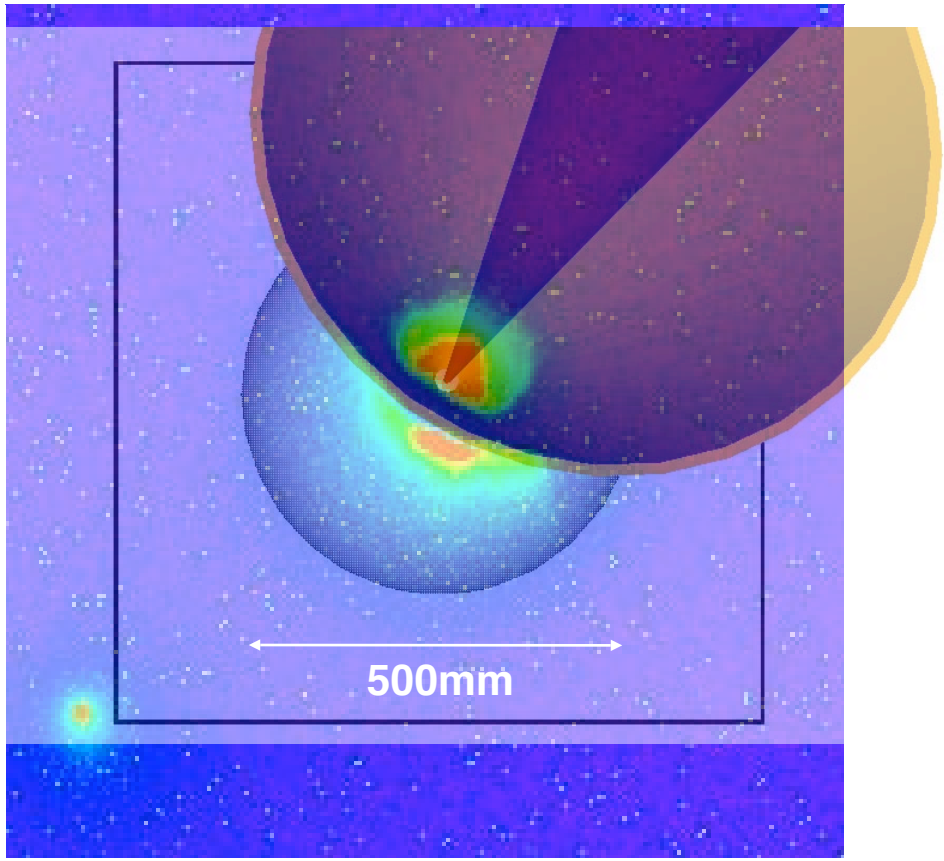
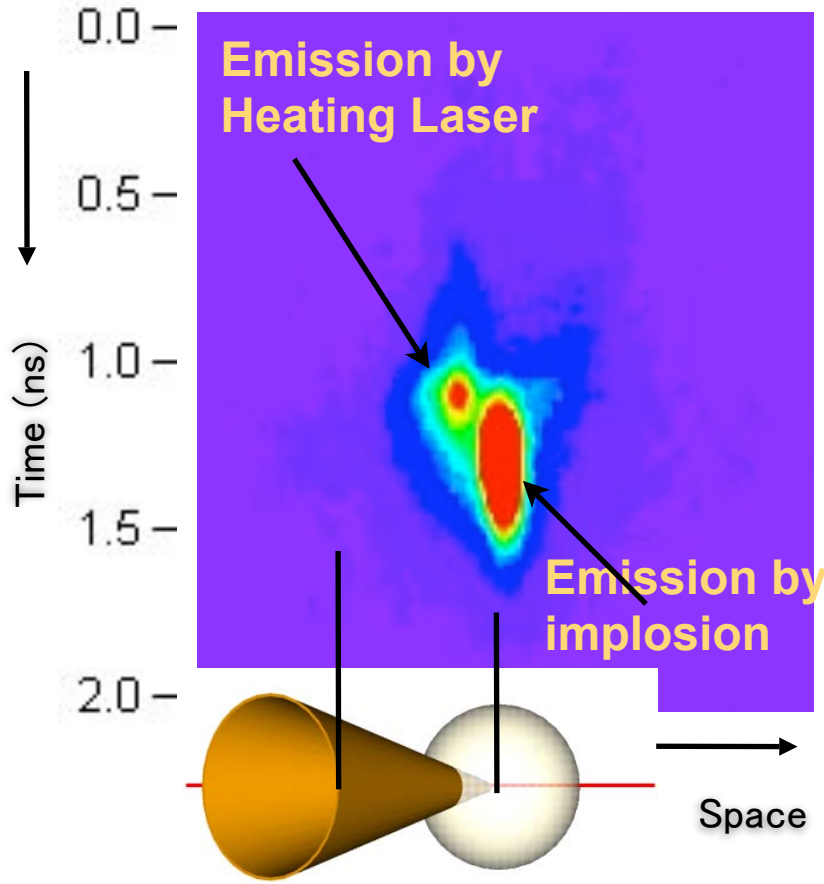
X-ray image from cone side
(Time integrated)



Heating beam (LFEX) injection

X-ray streak image
(Time resolved)



Heating time determination

Neutron yield increases with heating laser injection

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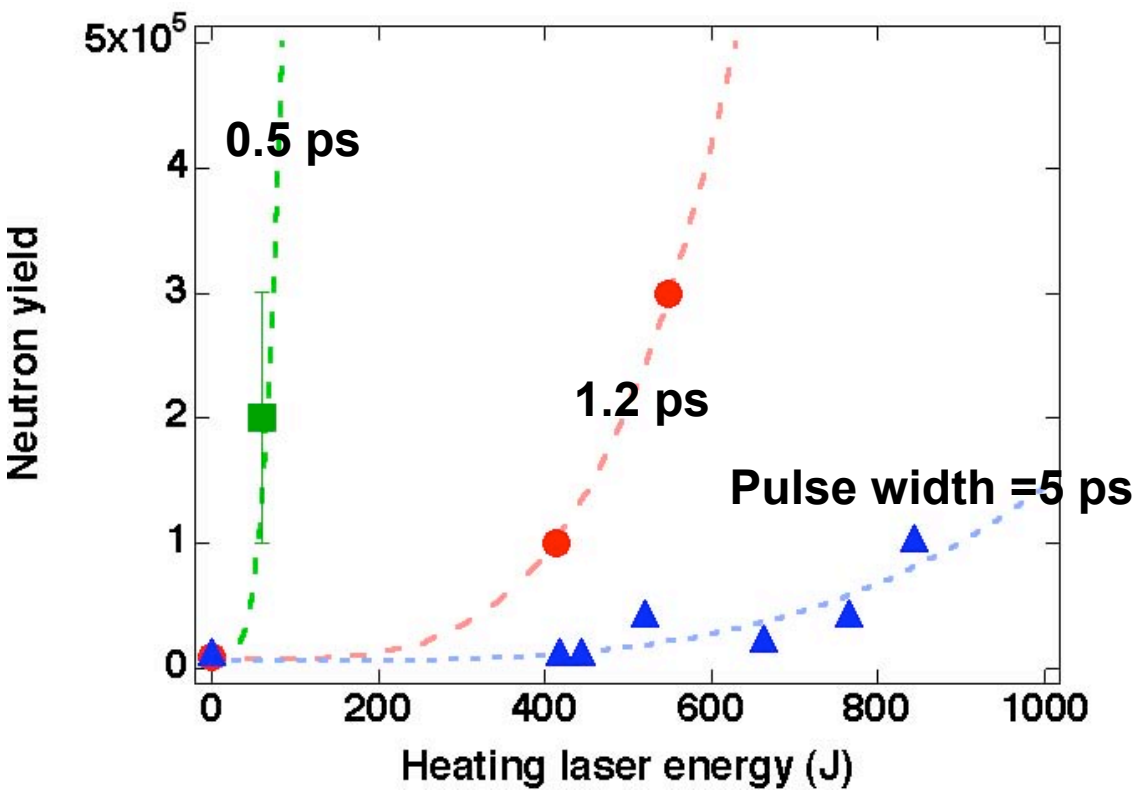
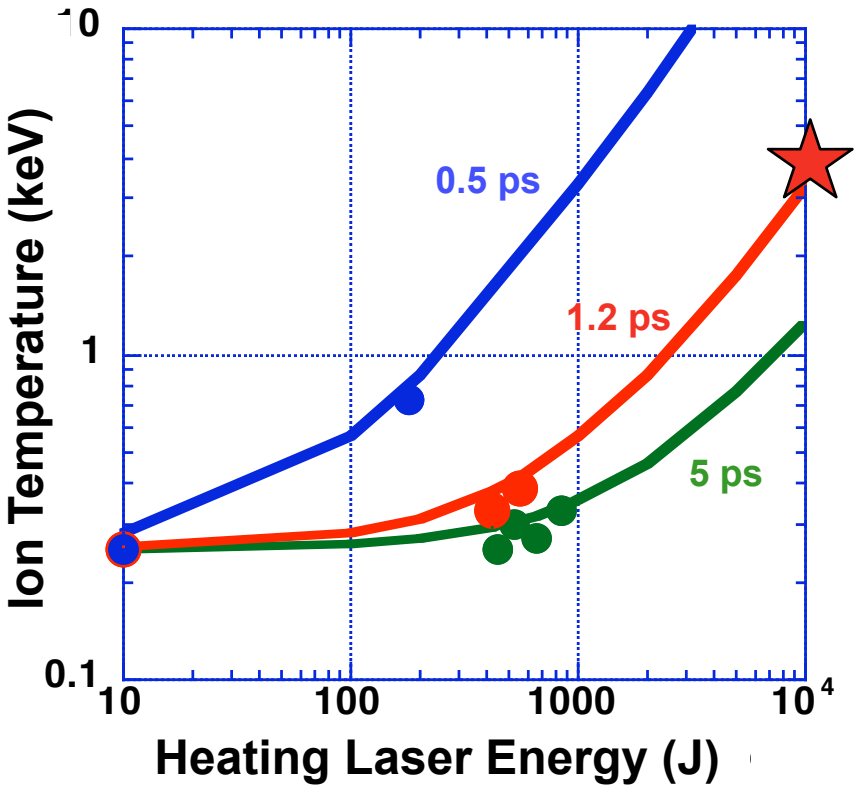
Experiments by Oct 6, 2009



Deduced ion temperature



Strong pulse width dependence was found.
It seems 5-keV heating is plausible.

Near Term Schedule and Future Plan

FIREX-I Timetable

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FY	Laser Construction	Milestones
2009	One-beam operation	Repeat *Nature* exp't
2010	Two-beam operation	Surpass Nature exp't
2011	Four-beam	CD heating (5keV)
		Goal of FIREX-I
2012	Wavefront control	Advanced targets CD heating (>5keV)
		Excess achievement

Nest Step 1: Ignition and Burn by Fast Ignition

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2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018

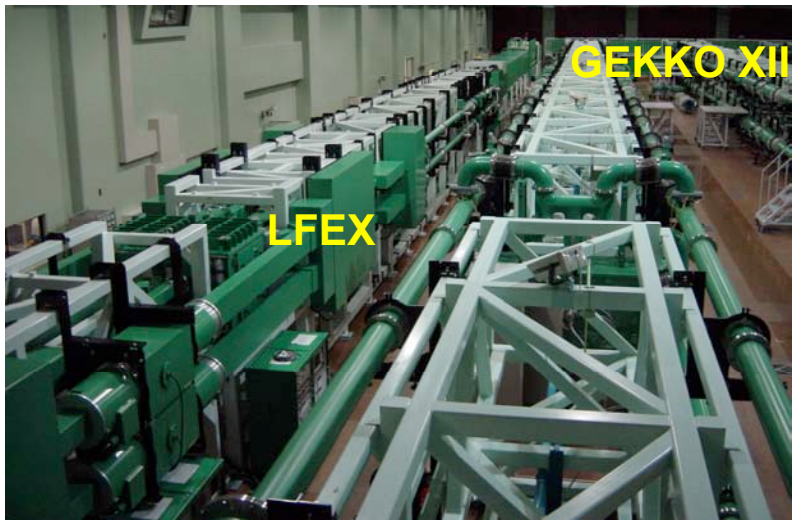
FIREX-I

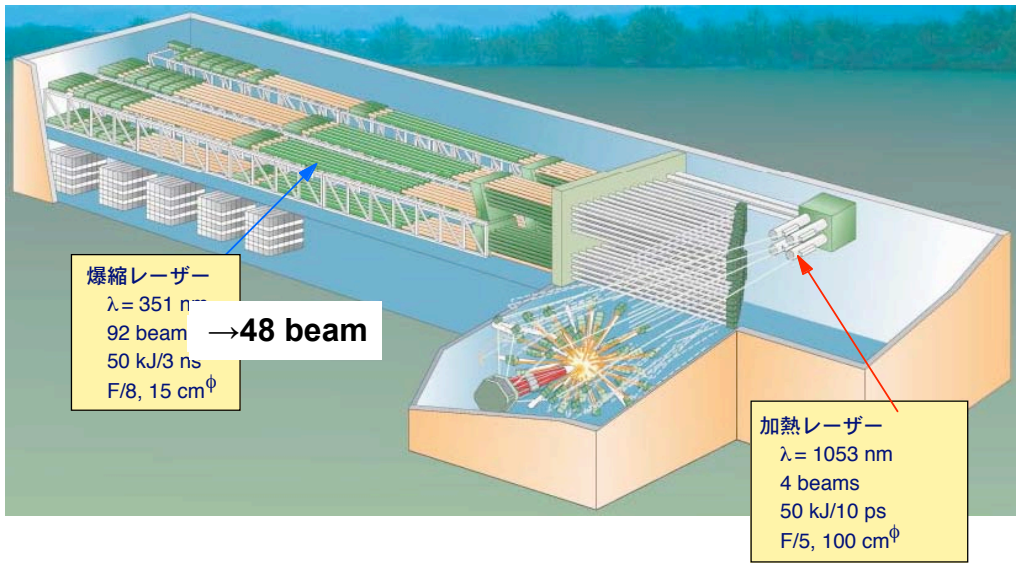
Heating upto T ≈ 5keV

NIF ignition

FIREX-II

Ignition Q ≈ 5





Atomic Energy Commission of Japan reported (Oct. 2005):
"Based on its (FIREX-I) achievement, decide whether it should be advanced to the second-phase program aiming at the realization of ignition and burning"

It's time to bring a paradigm shift in inertial fusion.

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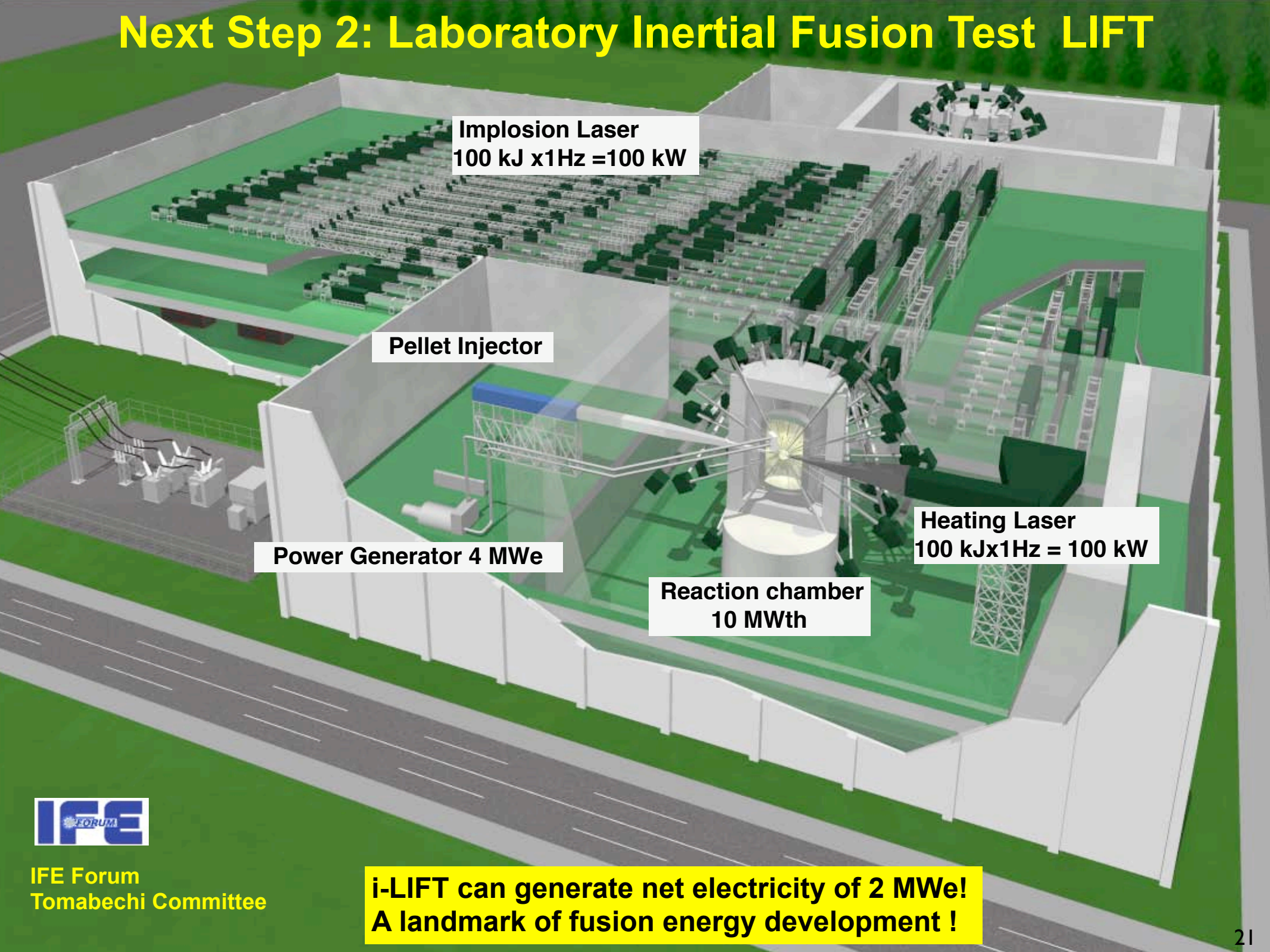
- By the time of NIF ignition, it will have passed more than 20 years since the end of the Cold War.
- Global warming is becoming the serious problem.

A flagship program is necessary to lift up inertial fusion community's spirits.

Next Step 2: Laboratory Inertial Fusion Test LIFT



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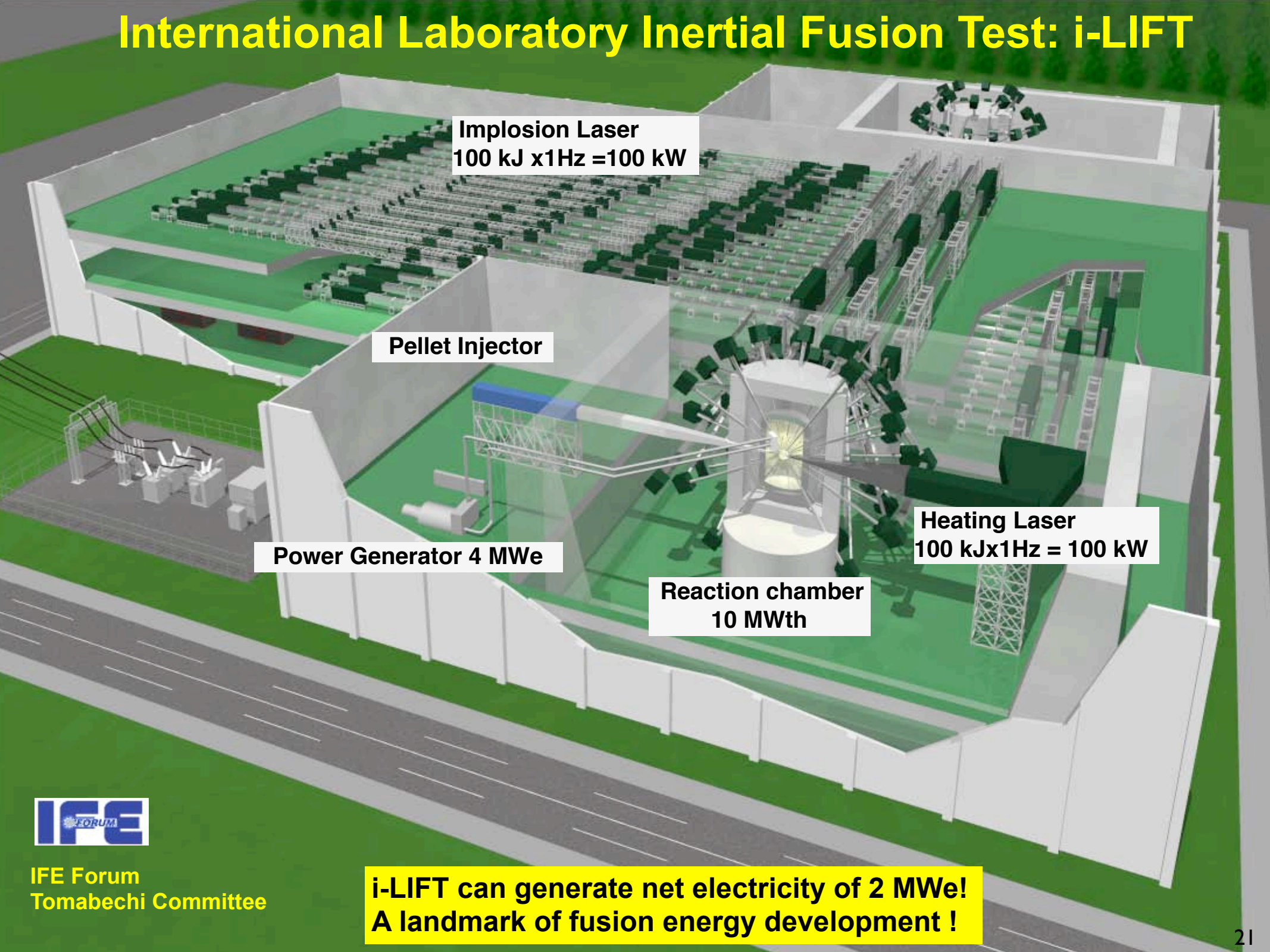
Tomabechi Committee

i-LIFT can generate net electricity of 2 MWe!
A landmark of fusion energy development !

International Laboratory Inertial Fusion Test: i-LIFT



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i-LIFT can generate net electricity of 2 MWe!
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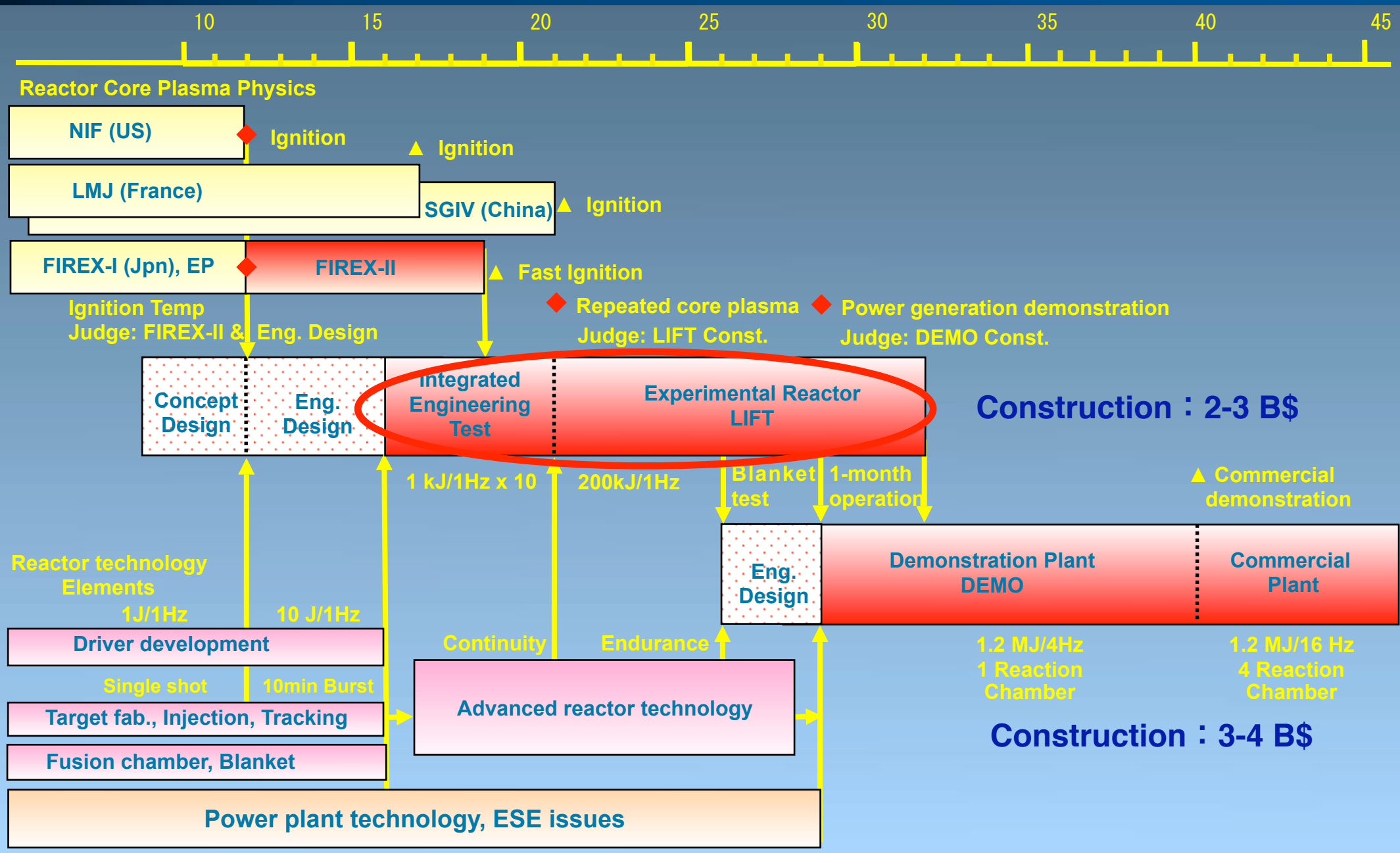
Experimental reactor i-LIFT integrates all physics and engineering activities.



Reactor Lasers

Pumping: from Flash Lamps to Laser Diodes

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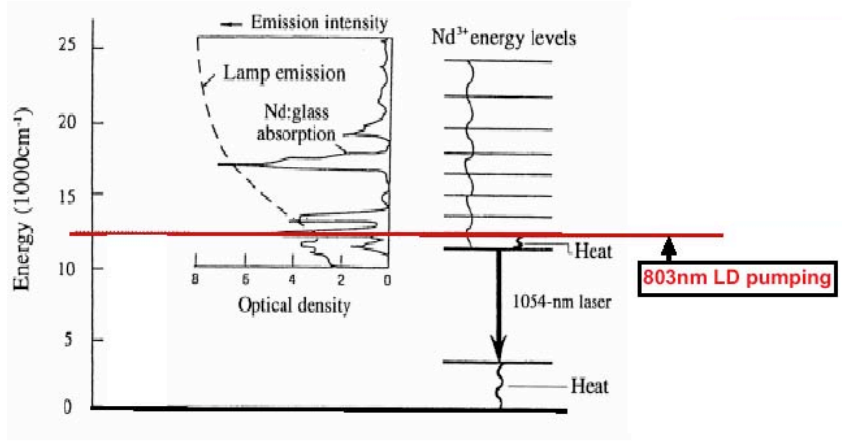
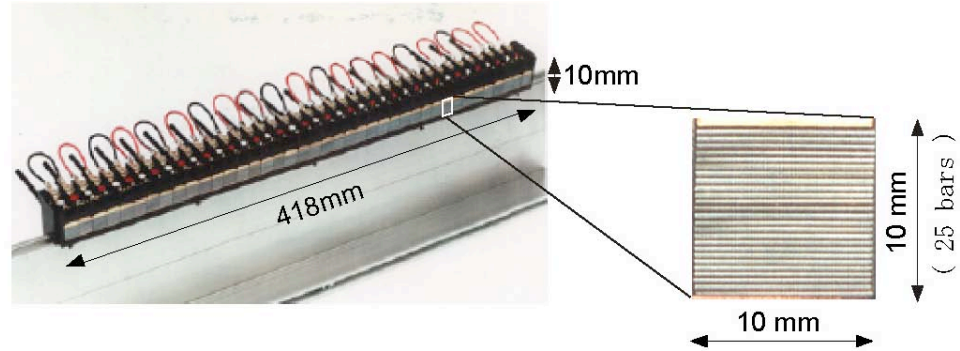
Laser absorption lines and Pumping Source spectra



Flash Lamps

Most energy goes into heat

Laser Diodes



100 W/bar
Present 3$/W→Goal 0.1$/W

Emission line can coincident with absorption line

Laser Diode Pumping opens the possible high-rep high efficient lasers

Laser medium: from glasses to ceramic crystal

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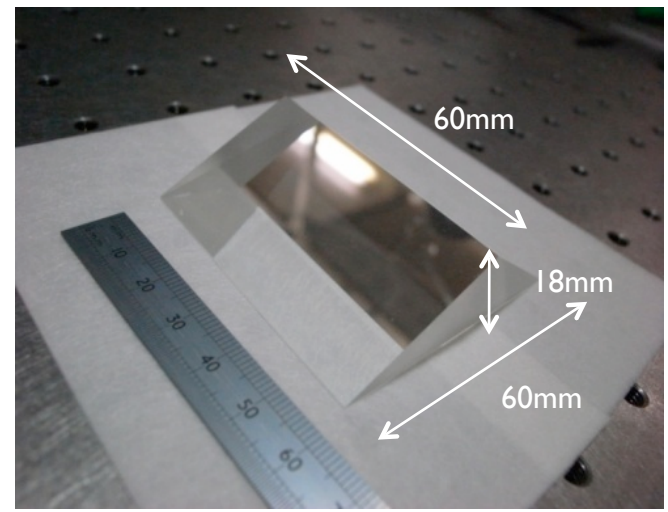
Laser glasses

- Glass→Large optics
- Glass→Very low thermal conductivity

Cooled Ceramic Crystal



- Crystal→High thermal cond.
- Ceramic→Large optics

Several 100s increase of thermal conductivity enables 100 Hz rep rate, much higher than reactor requirement.

Summary

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- After 50 years journey, the IFE community is ready for ignition at NIF.
- Compactness of fast ignition will accelerate inertial fusion energy development.
- IFE physic and engineering programs would converge onto an experimental reactor, i-LIFT, that will lift up people's spirits.

ILE/Osaka, as a National Joint Research Facility, strongly encourages national and international collaborations.