

National Ignition Facility Control & Informational Systems Operational Tools

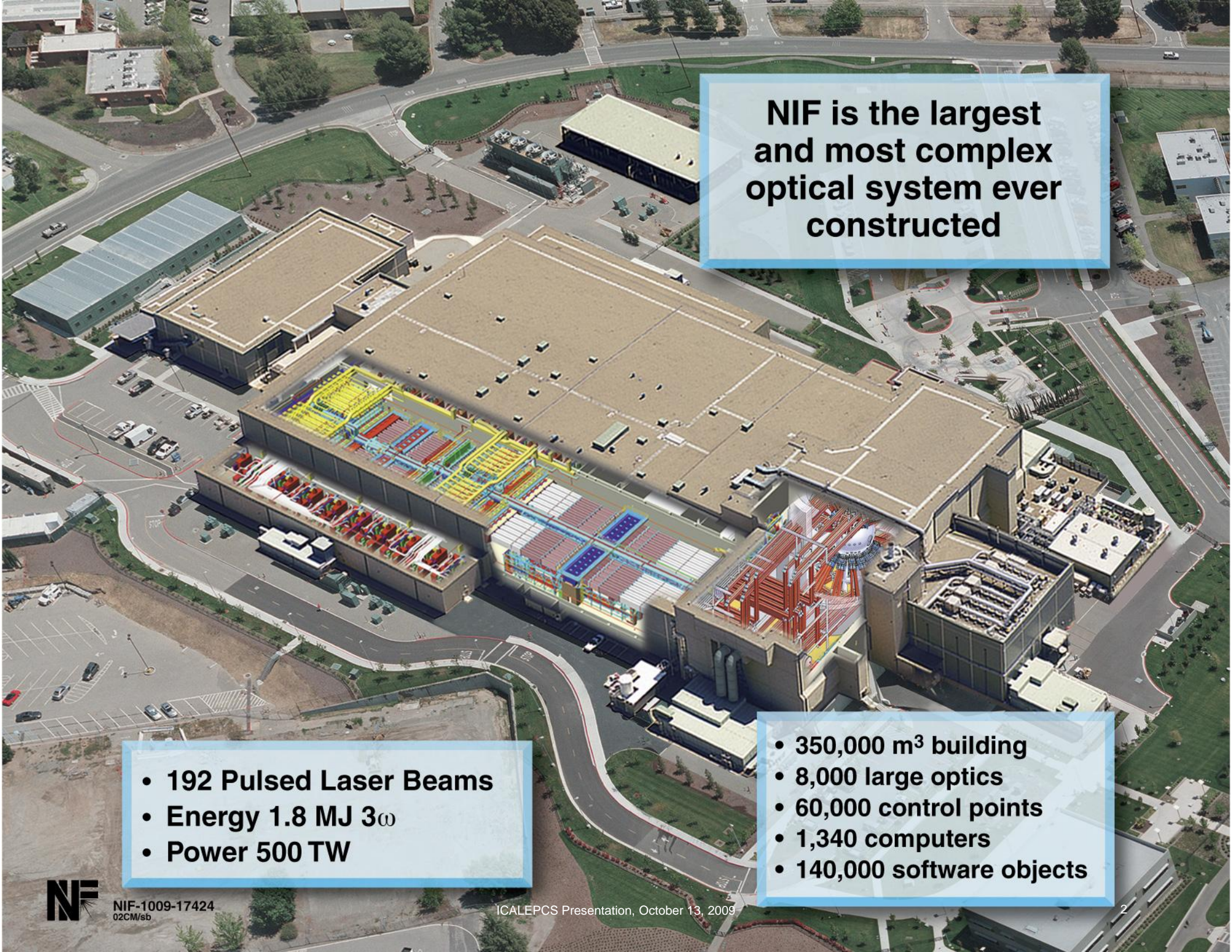
C.D. Marshall, R.G. Beeler, G.A. Bowers, R.W. Carey, J.M. Fisher, C.B. Foxworthy,
T.M. Frazier, L.J. Lagin, D.G. Mathisen, J.J. Rhodes, M.J. Shaw (LLNL)



2009 International Conference on Accelerators and Large Experimental Physics Control Systems, Kobe, Japan
October 13, 2009
Lawrence Livermore National Laboratory, USA

IM-379392

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**NIF is the largest
and most complex
optical system ever
constructed**

- **192 Pulsed Laser Beams**
- **Energy 1.8 MJ 3ω**
- **Power 500 TW**

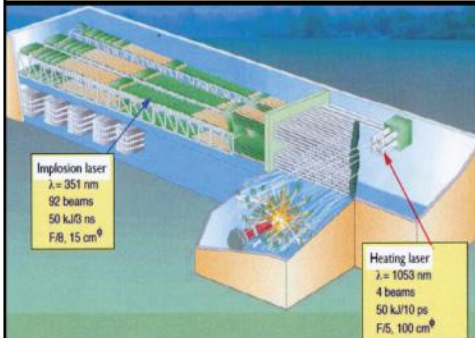
- **350,000 m³ building**
- **8,000 large optics**
- **60,000 control points**
- **1,340 computers**
- **140,000 software objects**

NIF is part of a growing international community of inertial fusion and high energy density science facilities



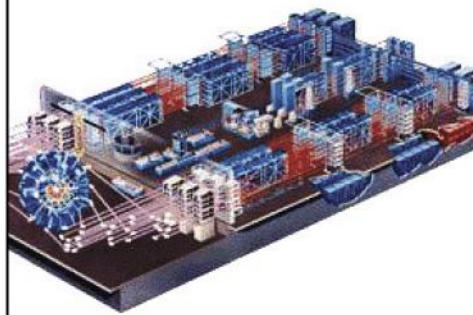
The National Ignition Facility

FIREX



Osaka, Japan

Omega, OMEGA EP Lasers



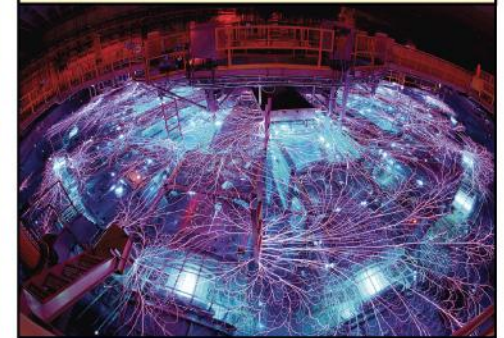
Rochester, USA

LMJ



Bordeaux, France

Z, ZR Z-Pinch Facility



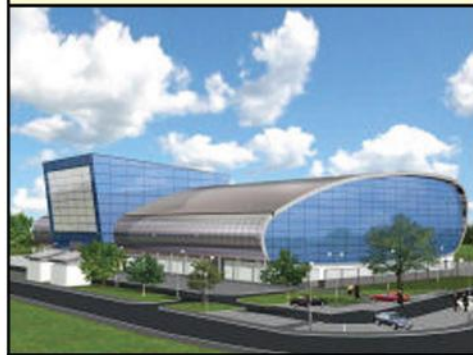
Albuquerque, USA

SGII



Sichuan, China

ORION



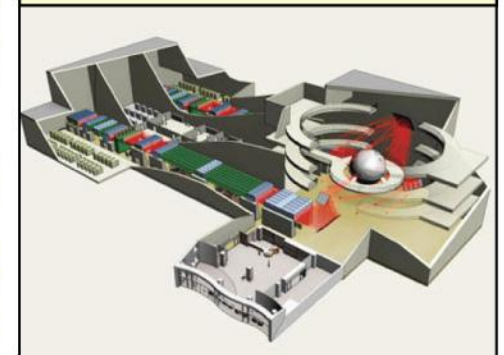
Aldermaston, UK

National Ignition Facility

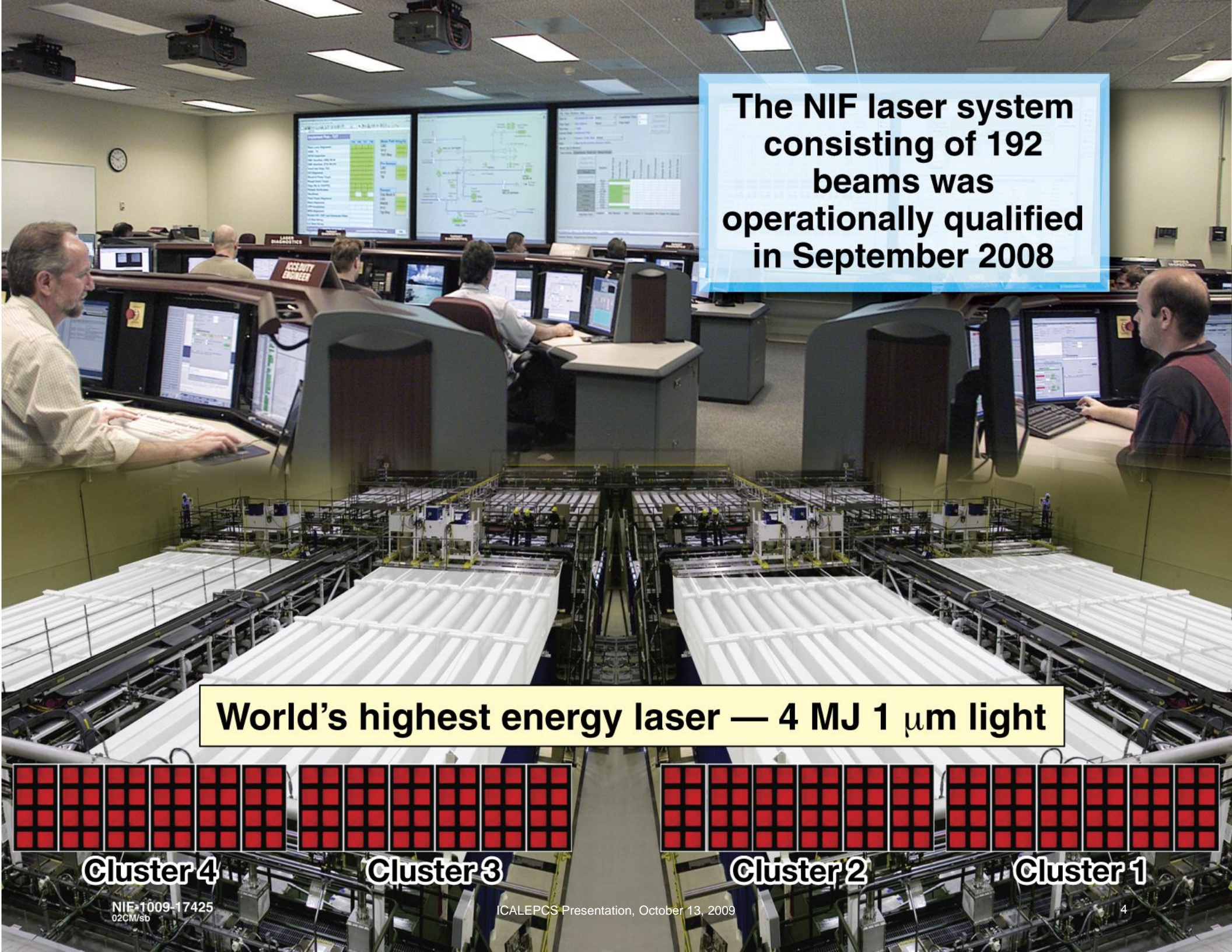


Livermore, USA

HiPER



EU



The NIF laser system
consisting of 192
beams was
operationally qualified
in September 2008

World's highest energy laser — 4 MJ 1 μm light

Cluster 4

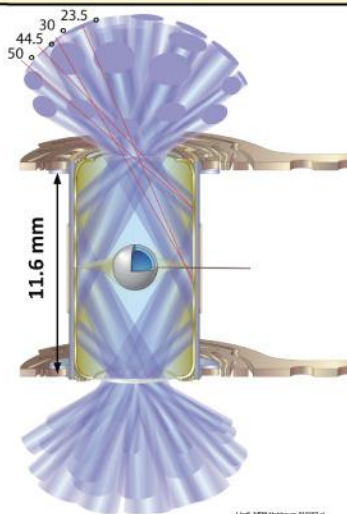
Cluster 3

Cluster 2

Cluster 1

Initial fusion experiments with neutron yield were conducted with 200 diagnostic data channels in September 2009

Cryogenic target surrounds spherical capsule with hydrogen

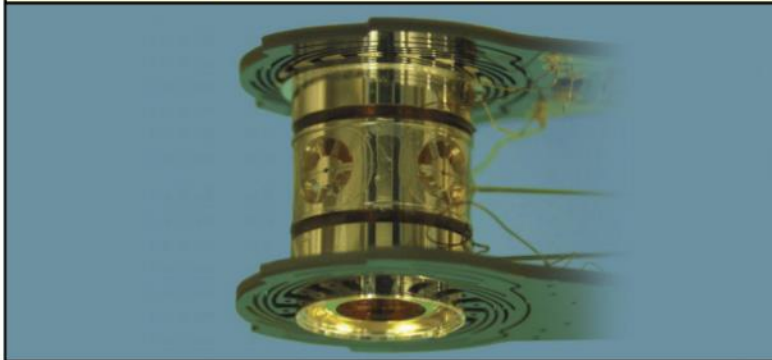


NIF core operational tools* are utilized during the entire experiment from conception to execution



The National Ignition Facility

Experiment setup (t-10 to 1 days)



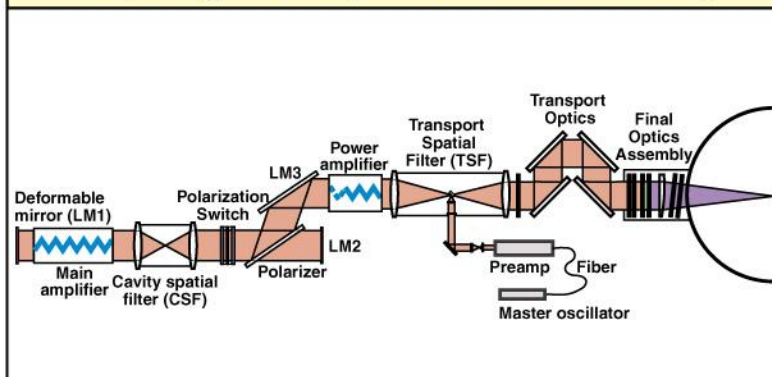
- End user input
- Laser Optimization

Pre-shot cycle Readiness (t-24 to 8 hours)



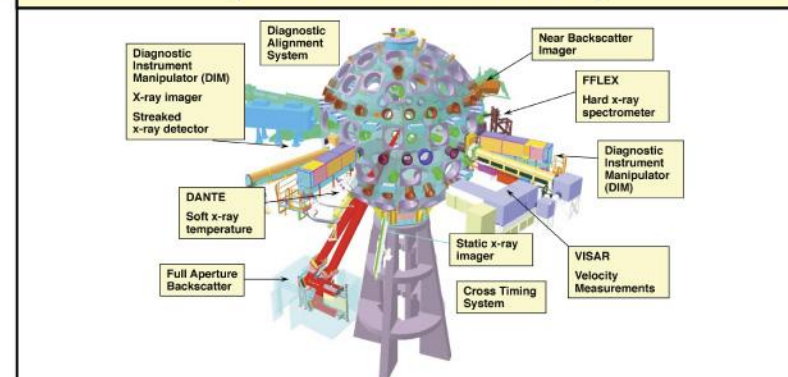
- Laser and Diagnostic HW Configuration
- Operational Restrictions

Shot cycle “turn-on” in progress (t-8 to 0.5 hours)



- Experimental goal change management

Final countdown (t-5 to 0 minutes)



- Critical device status verification redundant to main control system

Campaign Management Tool performs experimental setup for multiple shots

NIF Campaign Management Toolset (CMT) : 2_7_7_005

File Edit Format Experiment Analyze Options Help

Campaign: Hohl_Energetics_Part1A

Check-in

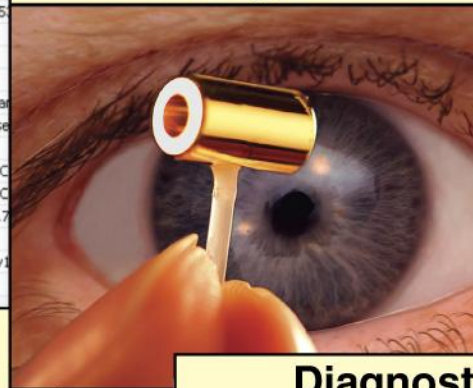
Campaign Experiment Table

Laser Requirements (Beam Groups)	Exp. 12	Exp. 13	Exp. 14	Exp. 15	Exp. 17	Exp. 18	Exp. 19
Laser Requirements							
Experiment Type	System Shot - ...	System Shot - ...	System Shot - ...	System Shot - ...	System Shot - ...	System Shot - ...	System Shot - ...
Action	Apply P...	Apply P...	Apply P...	Apply P...	Apply P...	Apply P...	Apply P...
MOR (SSD Index = SSD Bandwidth/34)							
Inner Core SSD Modulation Index (0 = Not Used)	1.76471	1.76471	1.76471	1.76471	1.76471	1.76471	1.76471
ex (0 = Not Used)	1.76471	1.76471	1.76471	1.76471	1.76471	1.76471	1.76471
10532)	10532.0	10532.0	10532.0	10532.0	10532.0	10532.0	10532.0
10529~10532)	10529.70	10531.50	10530.50	10530.50	10530.50	10530.50	10530.50
Beam Group RI...	Beam Group RI...	Beam Group RI...	Beam Group RI...	Beam Group RI...	Beam Group RI...	Beam Group RI...	Beam Group RI...
Inserted	Inserted	Inserted	Inserted	Inserted	Inserted	Inserted	Inserted
TCC (3w)	TCC (3w)	TCC (3w)	TCC (3w)	TCC (3w)	TCC (3w)	TCC (3w)	TCC (3w)
TCC (3w)	TCC (3w)	TCC (3w)	TCC (3w)	TCC (3w)	TCC (3w)	TCC (3w)	TCC (3w)
{2.31924564, ...	{2.712568, 2.3...	{2.712568, 2.5...	{2.712568, 2.5...	{2.712568, 2.5...	{2.712568, 2.5...	{2.712568, 2.5...	{2.712568, 2.5...
rev1_outer_1w	rev1_outer_1w	rev1_outer_1w	rev1_outer_1w	rev1_outer_1w	rev1_outer_1w	rev1_outer_1w	rev1_outer_1w
Angle (ur)	0	0	0	0	0	0	0
Angle (ur)	0	0	0	0	0	0	0

Laser



Target



Pulsed Power

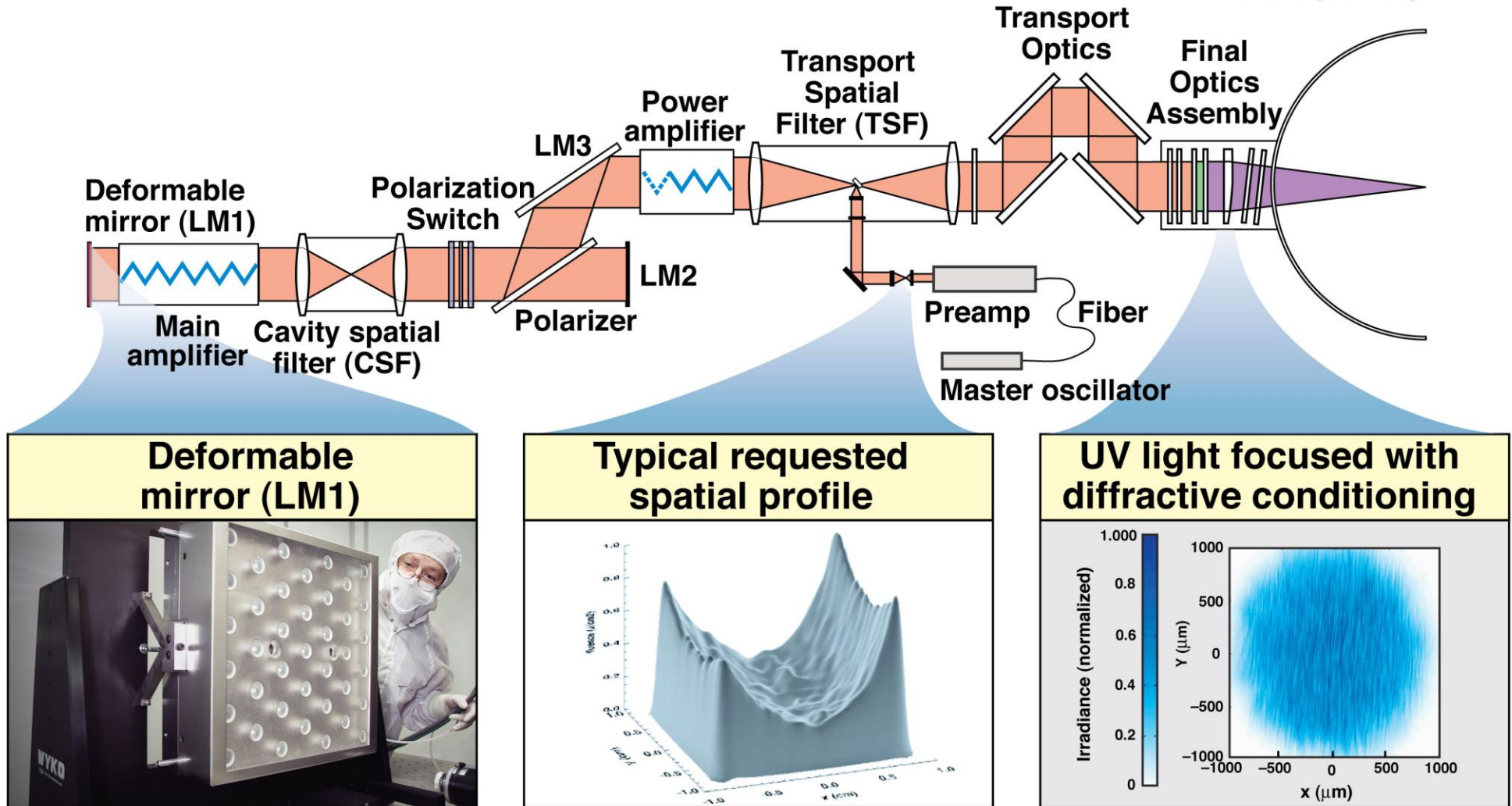


- Template shots
- Derived setup
- Rule enforcement
- Apply defaults
- Visual setup aids

Diagnostics



Laser Performance & Optimization Model (LPOM)



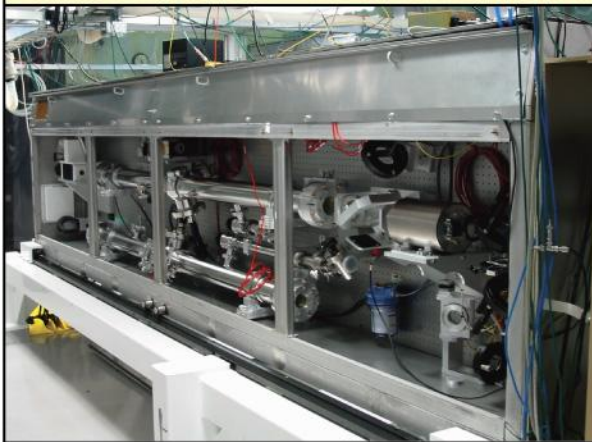
- Laser performance is optimized to meet experimental goals for each shot
- Independent machine safety verification

NIF is comprized of 6,200 Line Replaceable Units (LRUs)



The National Ignition Facility

**Preamplifier Modules
(48)**



**Laser Amplifiers
(672)**



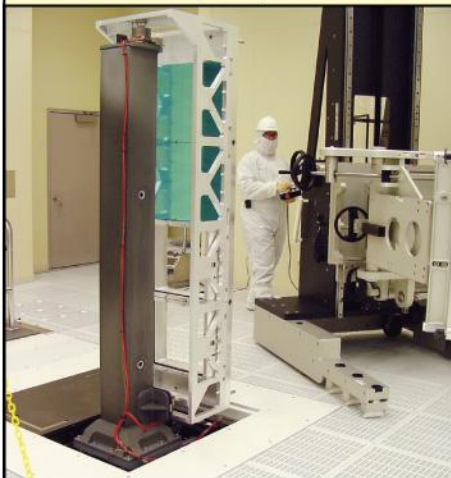
**Final Optics Assemblies
(960)**



**Laser Mirrors
(656)**



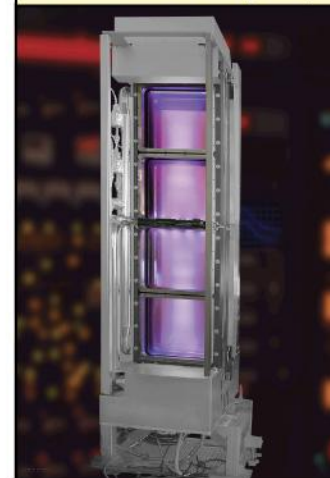
**Spatial Filter Lenses
(960)**



**Spatial Filter Towers
(72)**



**Plasma Electrode
Pockels Cell (192)**

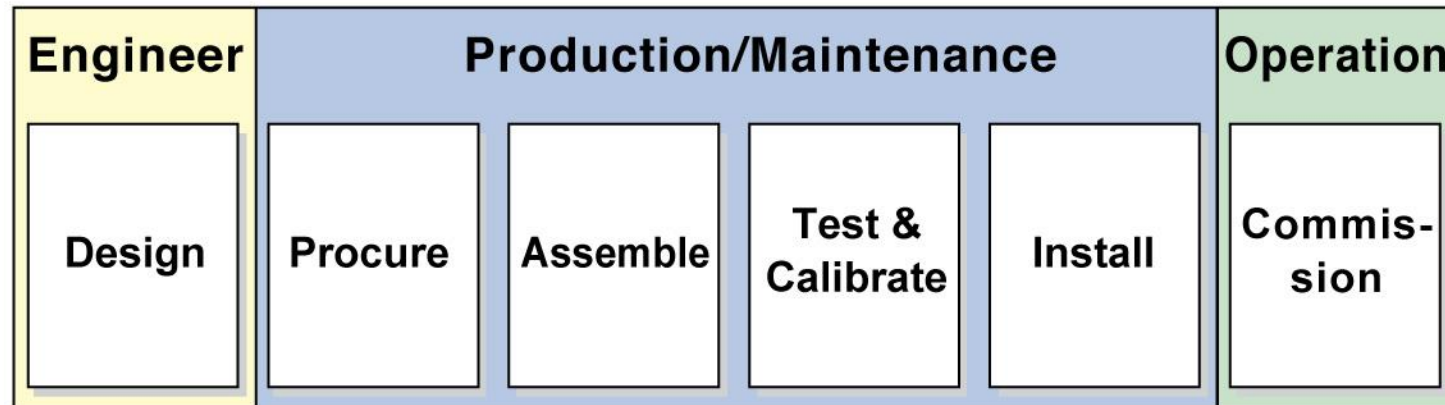


**Flashlamps
(1008)**

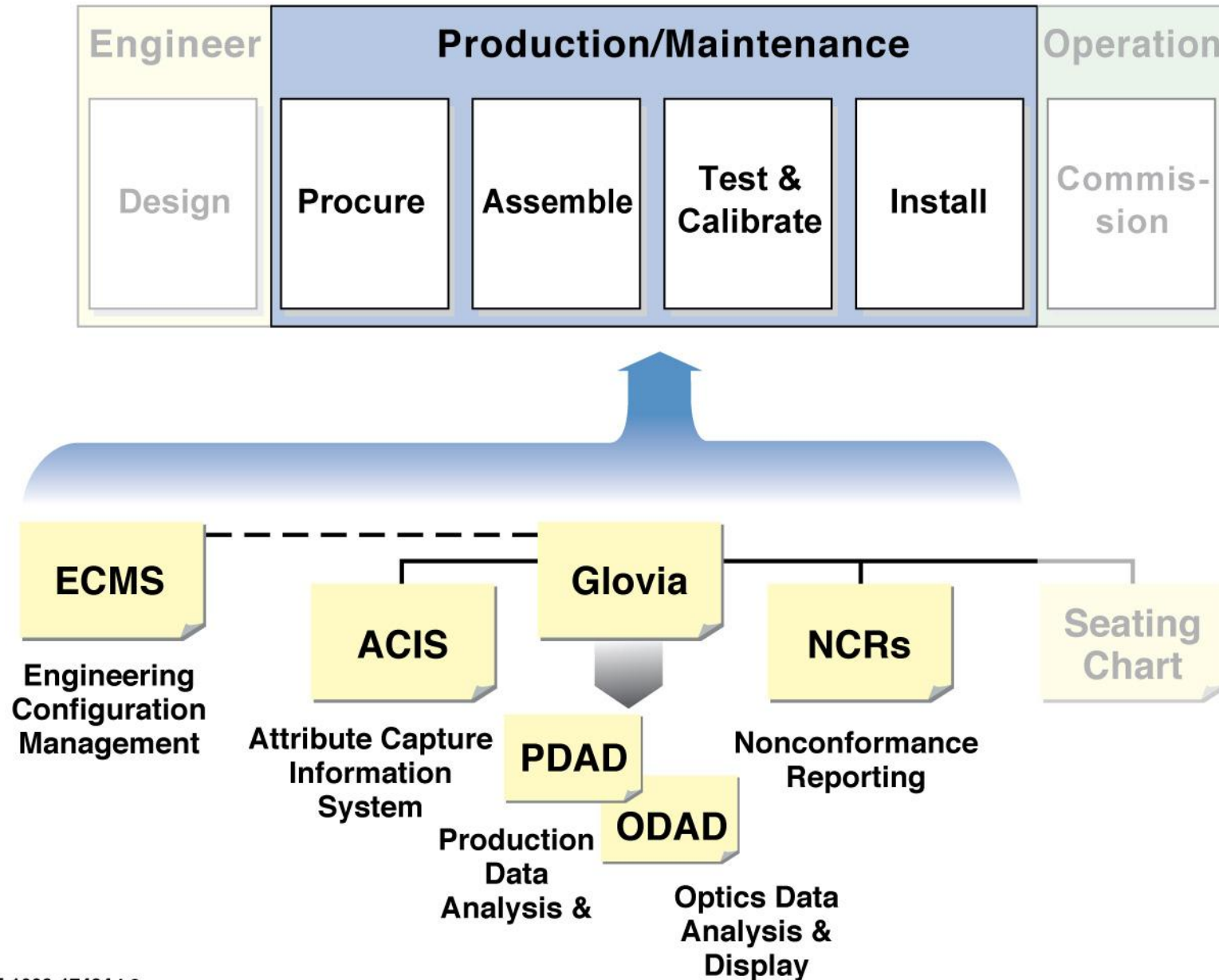


Managing the installation and operational status of LRUs requires information tools

LRU process life cycle



LRU Information Technology Tools



Information tools help manage configuration and work flow processes



Internet Explorer provided by NIF

Live Search

Page Tools

Wednesday - September 30, 2003

APPLICATIONS SUPPORT COMPUTER SECURITY

Work Control

- Campaign Management
- CDAD
- Data Downloaders
- Data Visualization
- ECMS
- Glovia
- LoCoS**
 - NIF Livelihood (RMS)
 - NPS
 - ODAD
 - PDAD
 - PORT

Commissioning Activity

- Create New Log
- All Issues
- Actions
- Problems
- NCRs
- Restrictions
- Ops
- Notes

Work Authorization

- Create New Work Permit
- Work Permits
- LoCo Configuration
- IWS Administration
- NIF Site Forms
- Unified System Hierarchy

Work Activity

- Create New Order
- Service Orders
- Work Orders
- Install Orders
- Remove Orders

Datasets

- Add Calibration Data

Commissioning Activity

- 1st Commissioning Flow Diagram
- 3rd Commissioning Flow Diagram
- Commissioning Activity
- LRU Summary
- Control System FEP
- ECM Message Explorer
- SIS Status

Facility Status

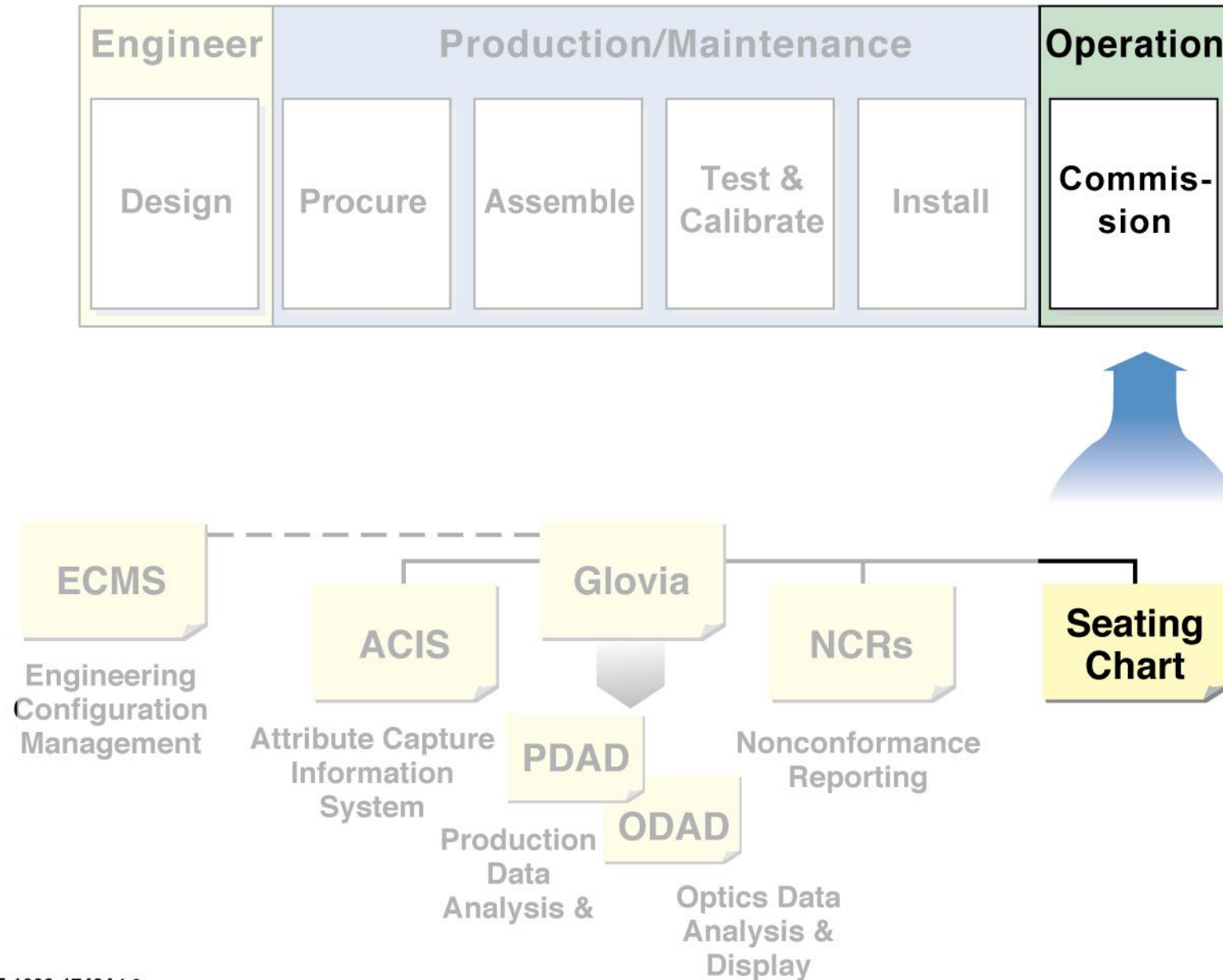
Reporting

Reports

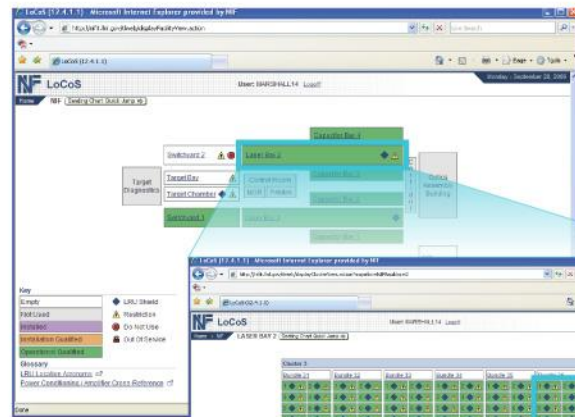
- LoCoS Reports

Local intranet 100%

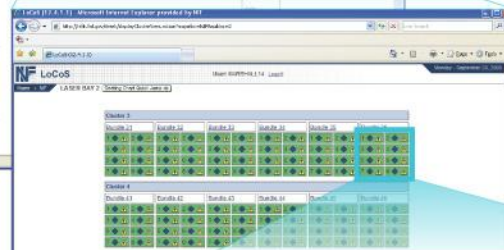
LRU Information Technology Tools



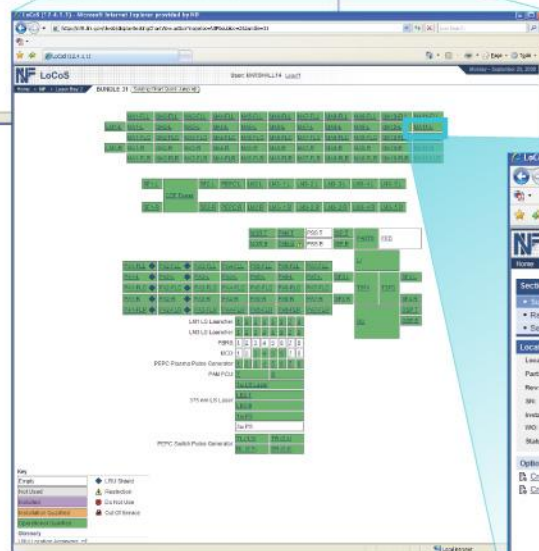
Location and Component System (LoCoS) tool tracks the status of all 6,200 LRUs



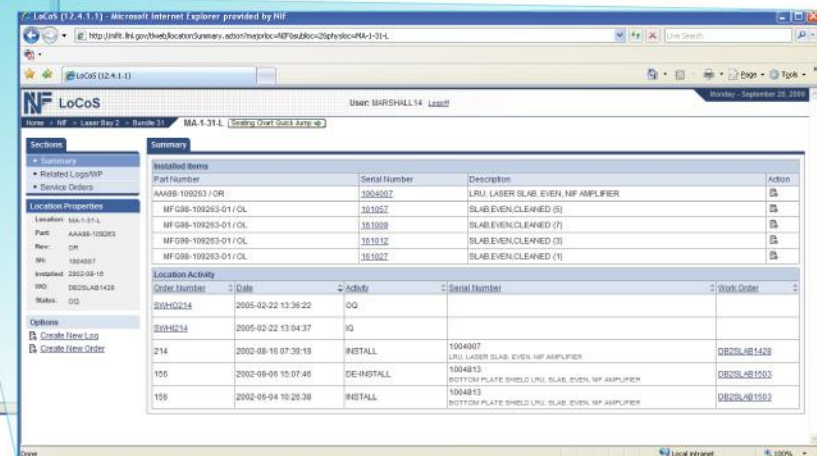
Facility level



Laser Bay level



Bundle (8 beam) level



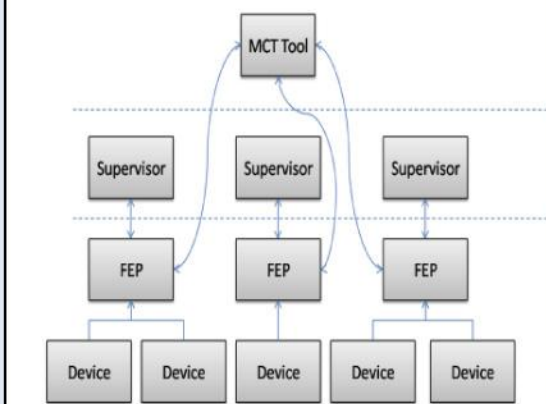
LRU level

LoCoS is a hierarchical web-based application with extensive drill down from facility level to individual parts

LRUs are commissioned & maintained with tools that update calibration, alignment, imaging, & timing

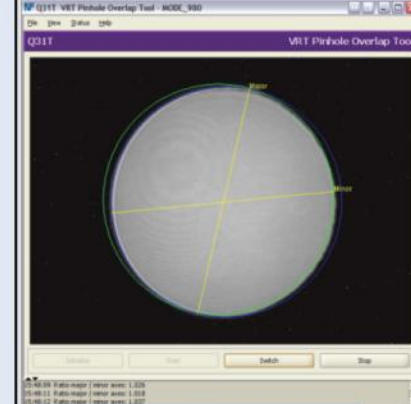
Architecture

Tools are linked below
Supervisory shot control

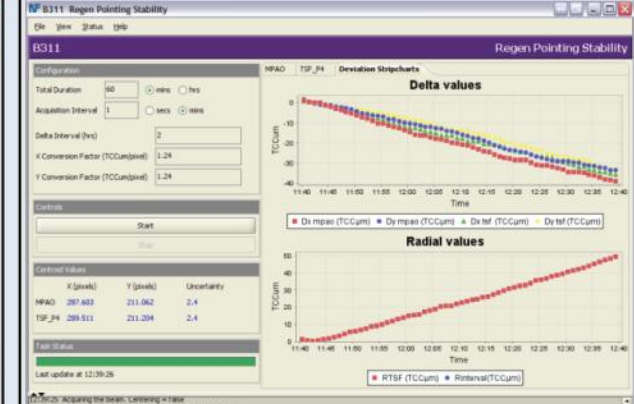


Examples

Pinhole overlap tool



Injection laser pointing stability tool



- **25 Automated Maintenance and Commissioning Tools in use**
 - Substantial time savings
 - Reduced operator error
 - Reduced operator subjectivity
 - Codified verifiable algorithms
 - More frequent use
 - Consistent detailed logs

Pre-shot Experiment Readiness Checker compares requirements with current configuration

Real-time control room tool

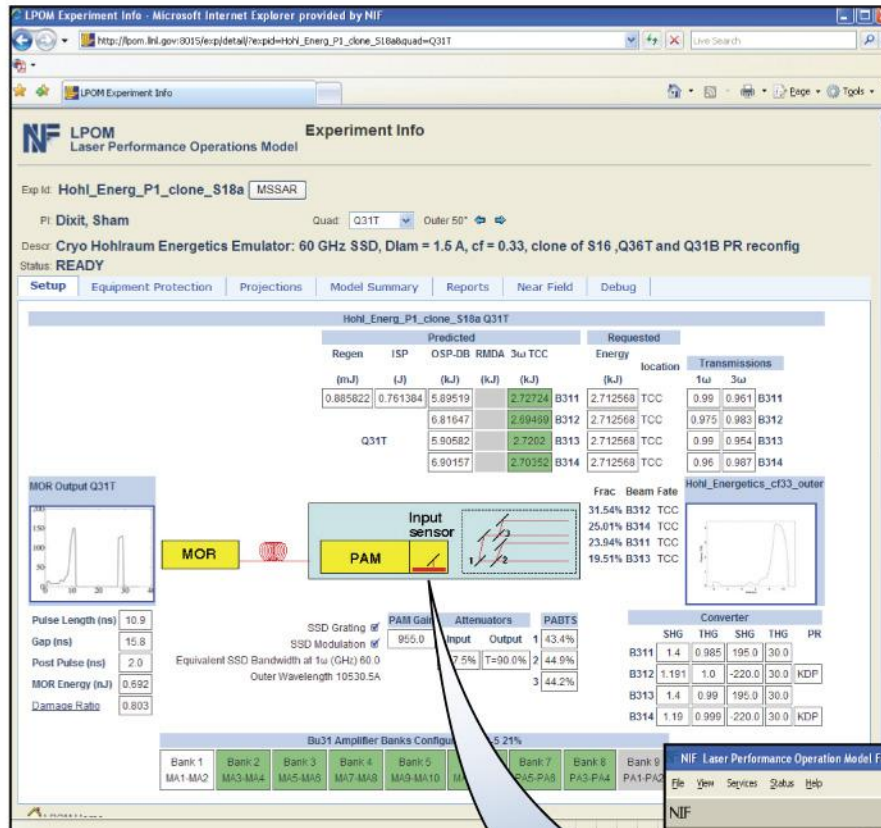
Facility Readiness verification

- Laser filtered by beam fate
- Target Diagnostics
 - Hardware installation
 - Operational Status
 - Timing
 - Filters

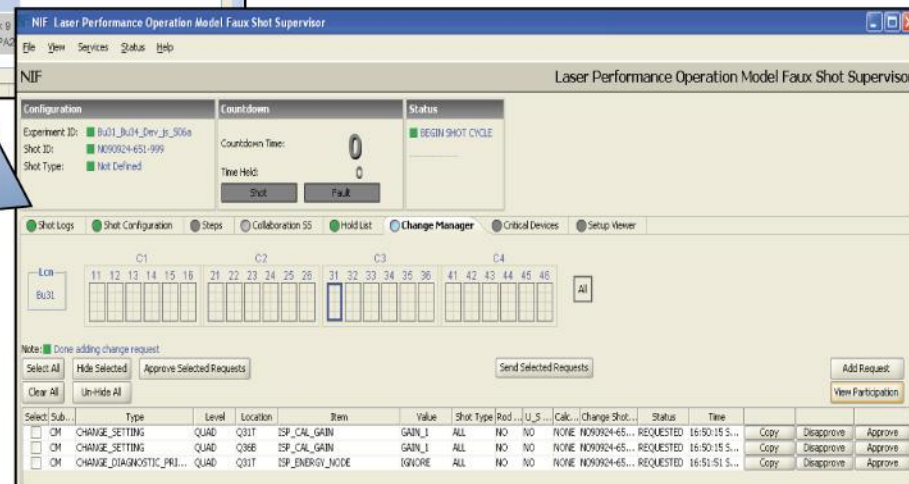
Restrictions

- Optical Power / Energy
- Beam Pointing

Shot in progress experimental goals are optimized with shot operations change management



- Laser Performance and Optimization analysis is performed during shot setup
- Derived setting update requests are automated (manual also supported)
- Requests are approved or rejected by Shot Director using change management GUI



Status Verifier Tool independently verifies the machine safety and device lock-out of 6,600 devices at shot time

NIF Status Verifier

Manual Polling:

Automatic Polling:

Shot ID: ■ N090924-001-999

Shot Type: ■ System

Fate

- ☒ C1
- ☒ Bu11 (Bank Modules Used)
- ☒ Bu12 (Bank Modules Used)

Bundle	Countdown	MOR	Laser Bay				Switchyard/Target Bay		
			ILS	BCS/MLS	LDS	PCS	BCS/TA	PDS	TAO
NIF									
Bu11									
Bu12									
Bu13									
Bu14									
Bu16									
Bu21									
Bu44									
Bu45									
Bu46									

Top Level Summary ☒ NIF TAO

980nm Pump Diode, DFB Fiber Laser, Fiber Bragg Grating, Splice, C connector

Top Level Summary ☒ NIF TAO



