National Ignition Facility
Control & Informational Systems Operational Tools

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Lawrence Livermore National Laboratory, USA

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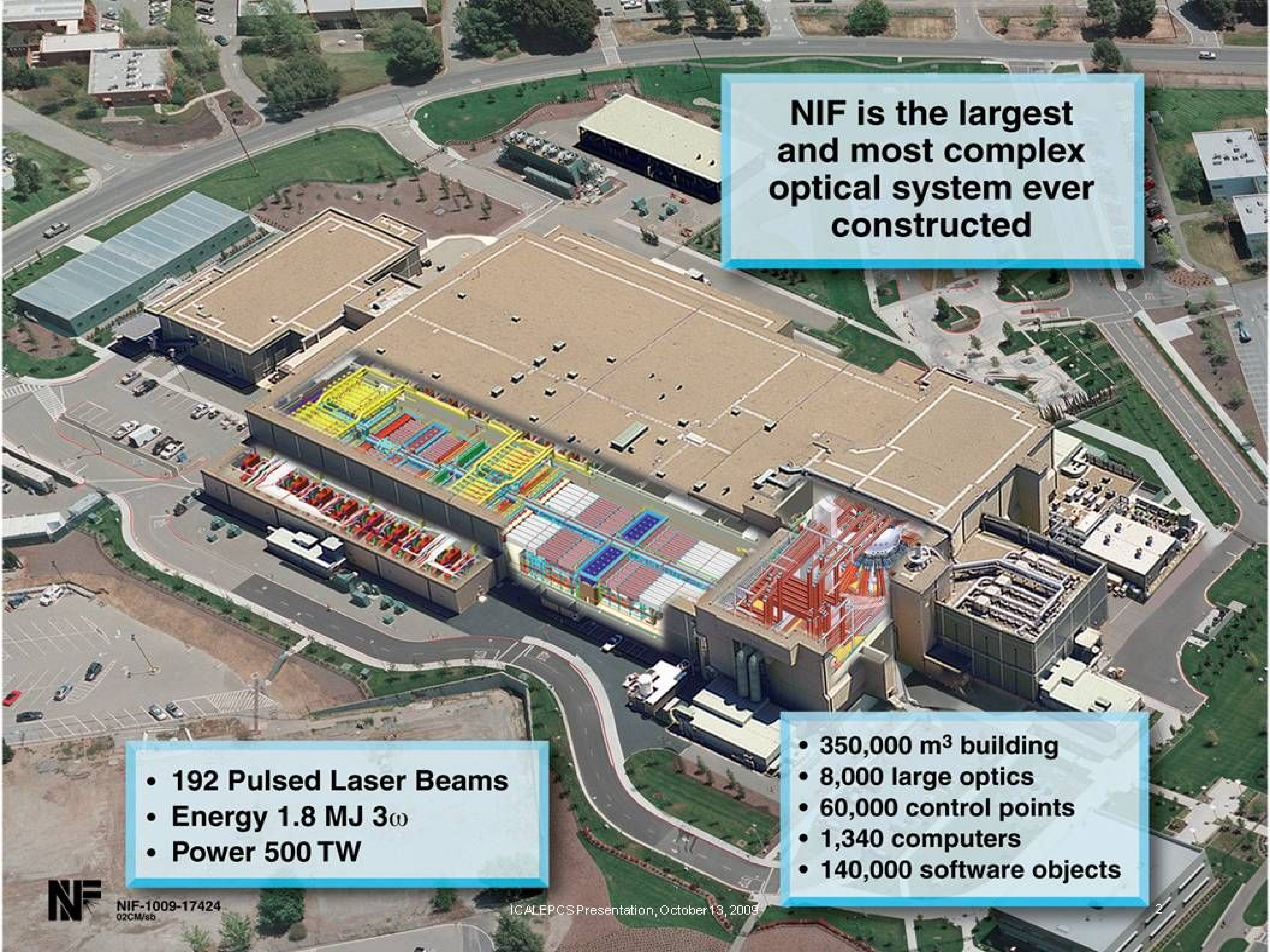
NIF is the largest and most complex optical system ever constructed
• 192 Pulsed Laser Beams
• Energy 1.8 MJ 3ω
• Power 500 TW
• 350,000 m³ building
• 8,000 large optics
• 60,000 control points
• 1,340 computers
• 140,000 software objects
NIF-1009-17424
02CM/sb

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

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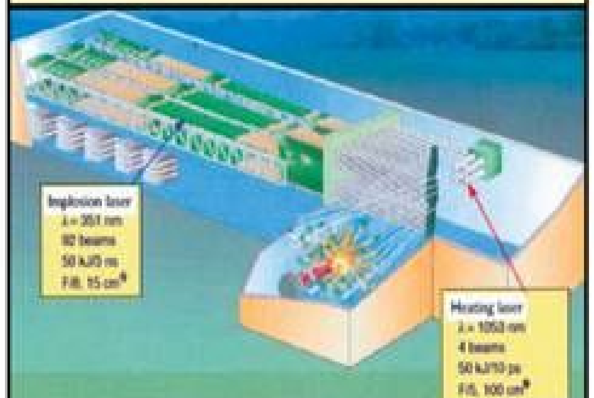
FIREX



Osaka, Japan

Omega, OMEGA EP Lasers

Rochester, USA

LMJ

Bordeaux, France

Z, ZR Z-Pinch Facility

Albuquerque, USA

SGII

Sichuan, China

ORION

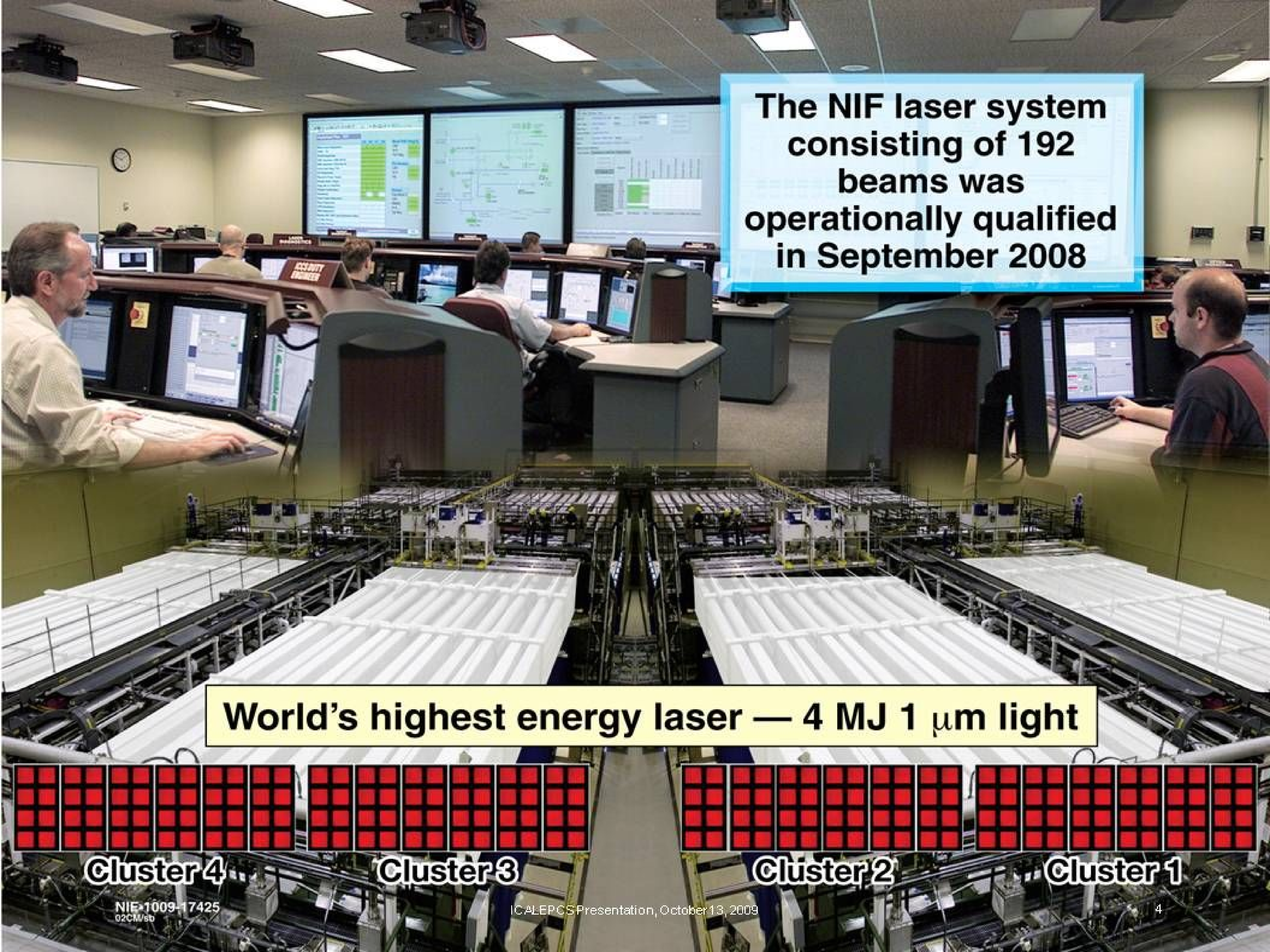
Aldermaston, UK

National Ignition Facility

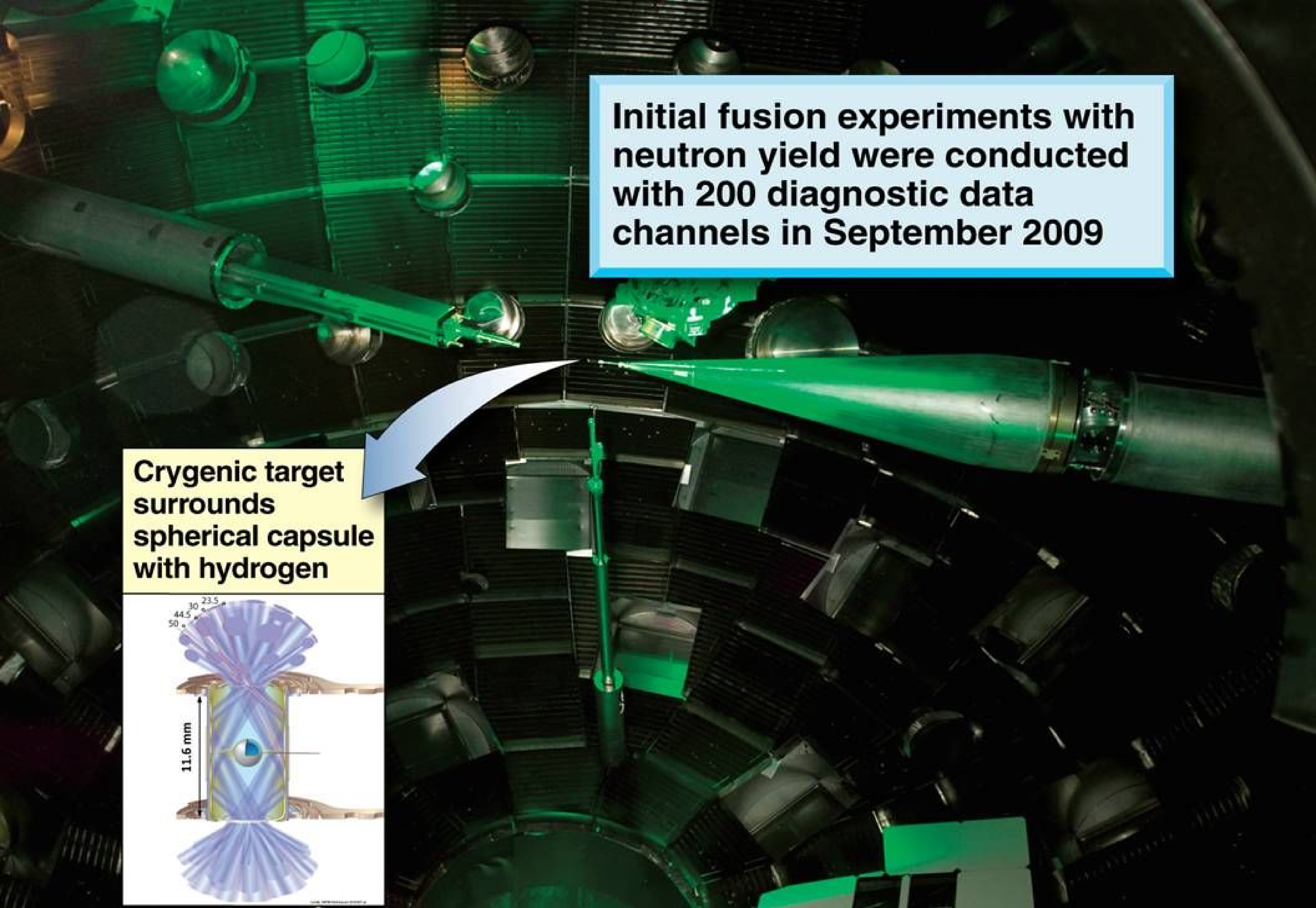
Livermore, USA

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
NIF-1009-17425
02CM/sb

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



Crygenic target surrounds spherical capsule with hydrogen

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

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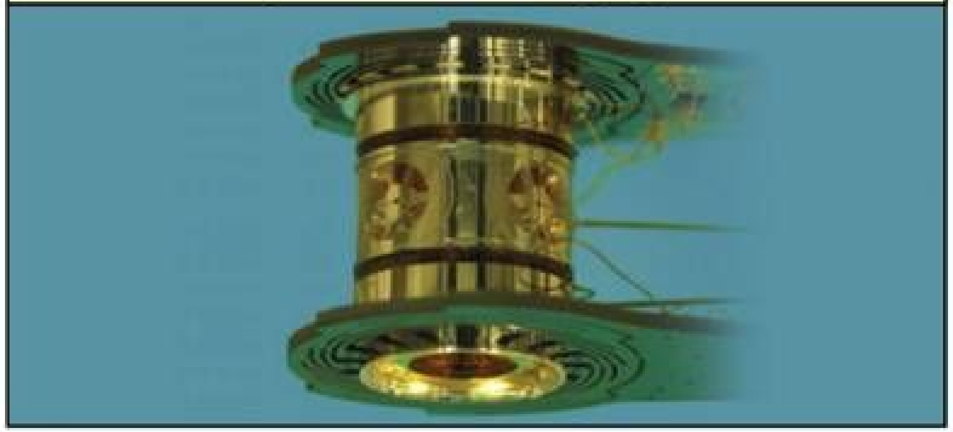
Experiment setup (t-10 to 1 days)

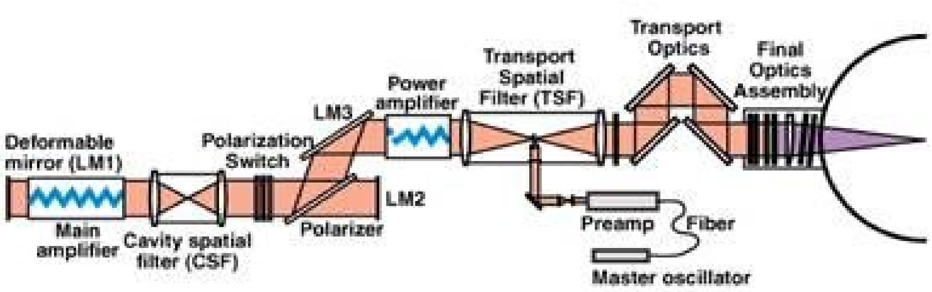


- End user input
- Laser Optimization

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

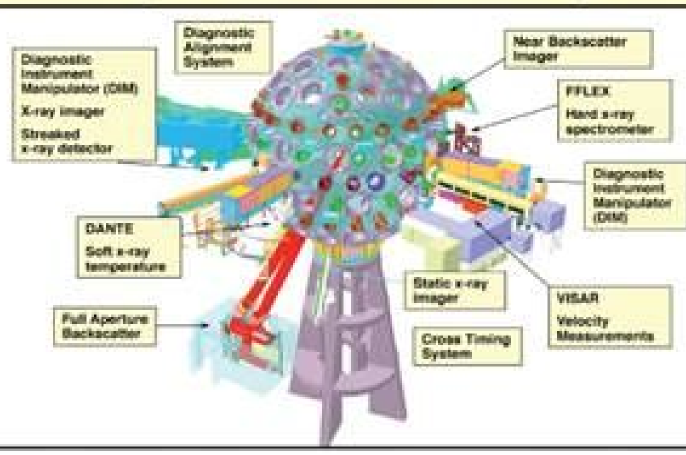
- Laser and Dianostic HW Configuration
- Operational Restrictions

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

NIF-1009-17427
30CM/sb

*Controls and Information System Architechture discussed in Carey et. al. "NIF data repository" in next session

Campaign Management Tool performs experimental setup for multiple shots

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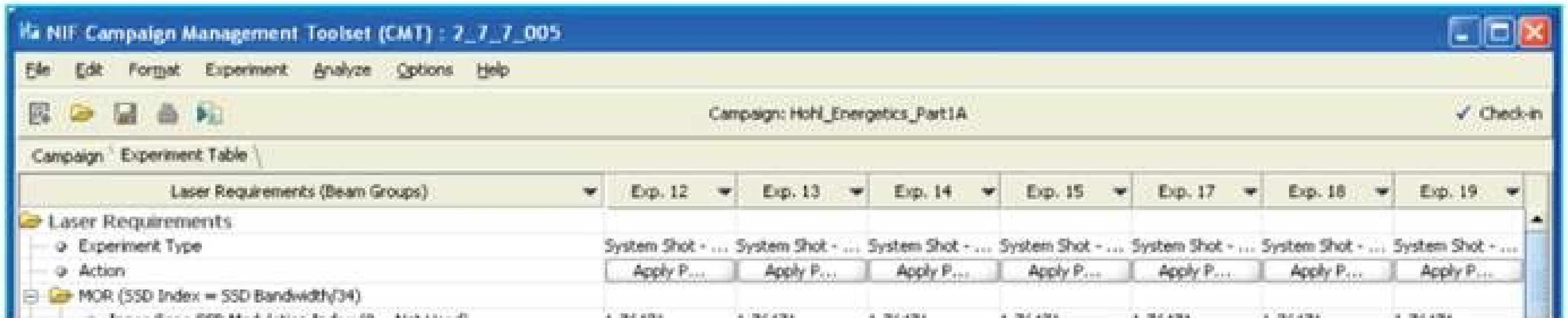

Laser

Target

Pulsed Power

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

Diagnostics

Laser Performance & Optimization Model (LPOM)

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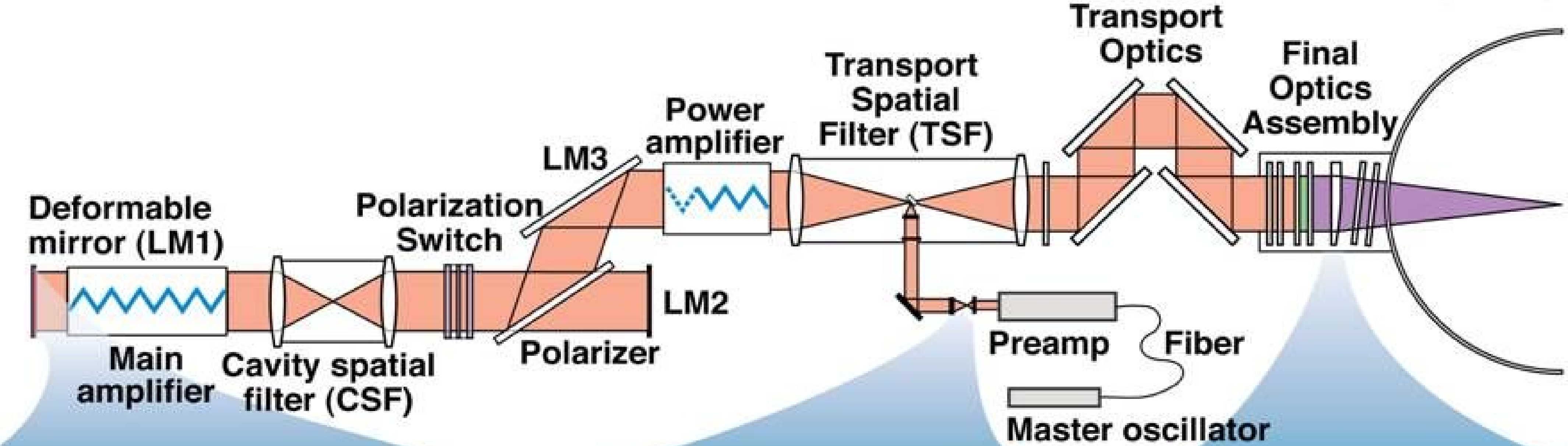
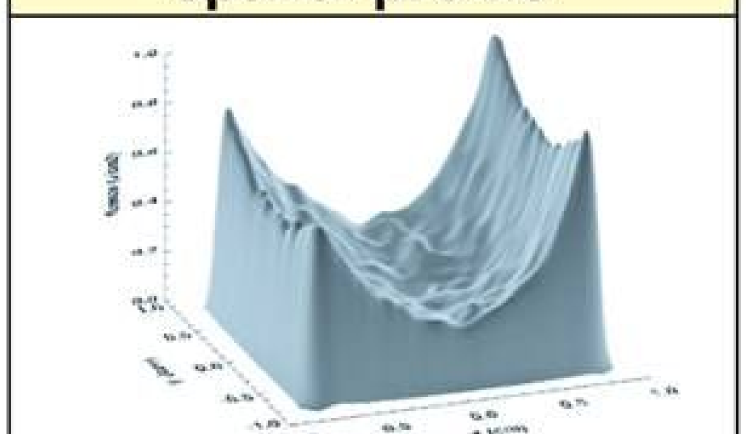
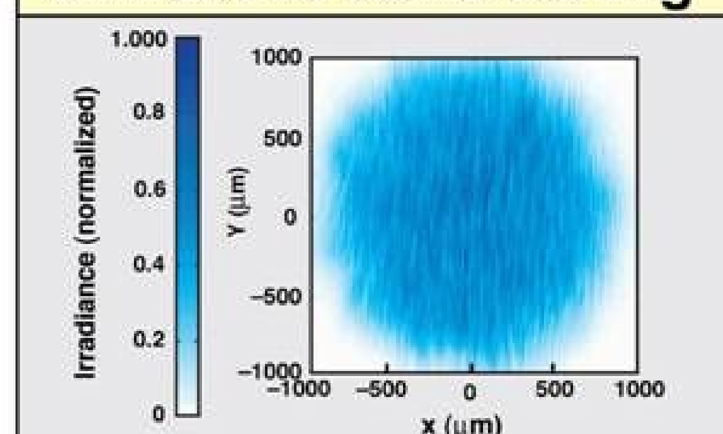


Deformable mirror (LM1)

Typical requested spatial profile



UV light focused with diffractive conditioning



- 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)

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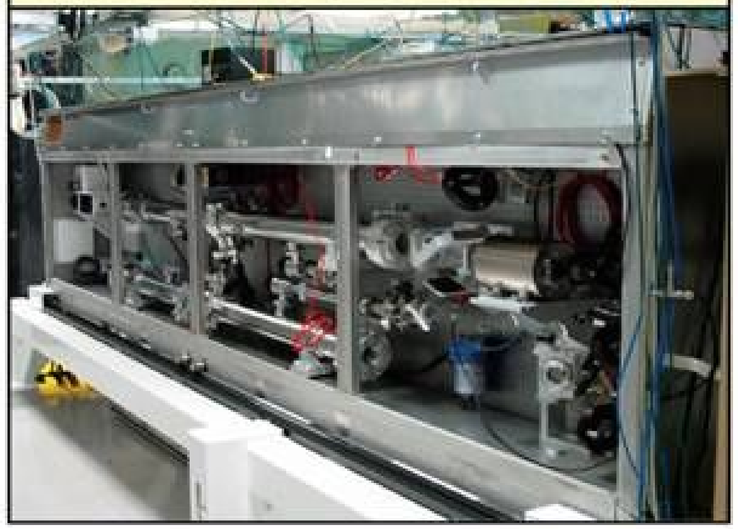
Preamplifier Modules (48)



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

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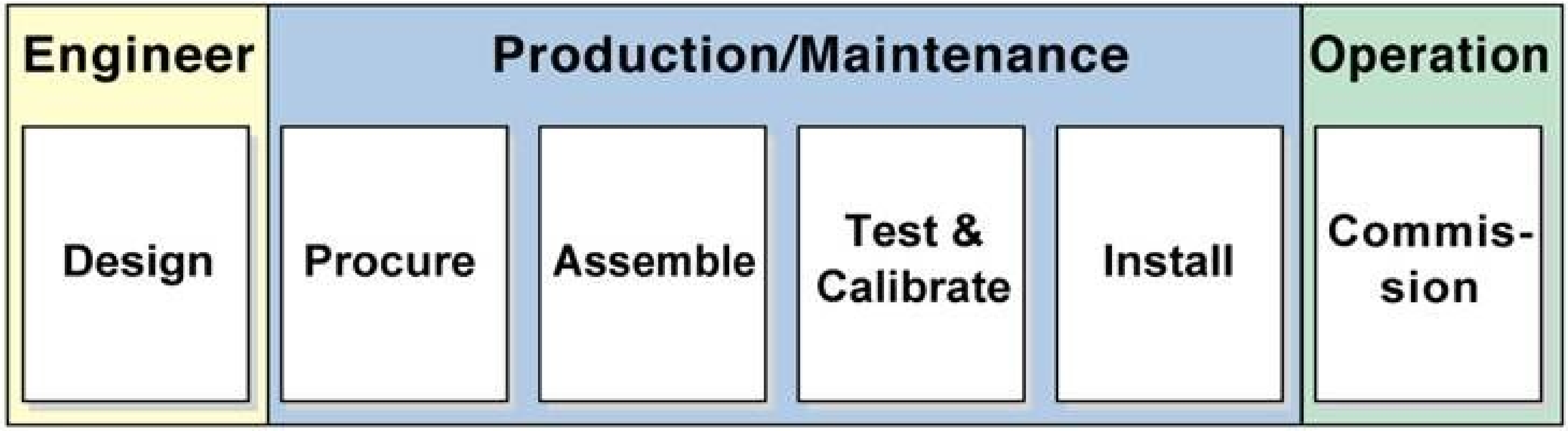
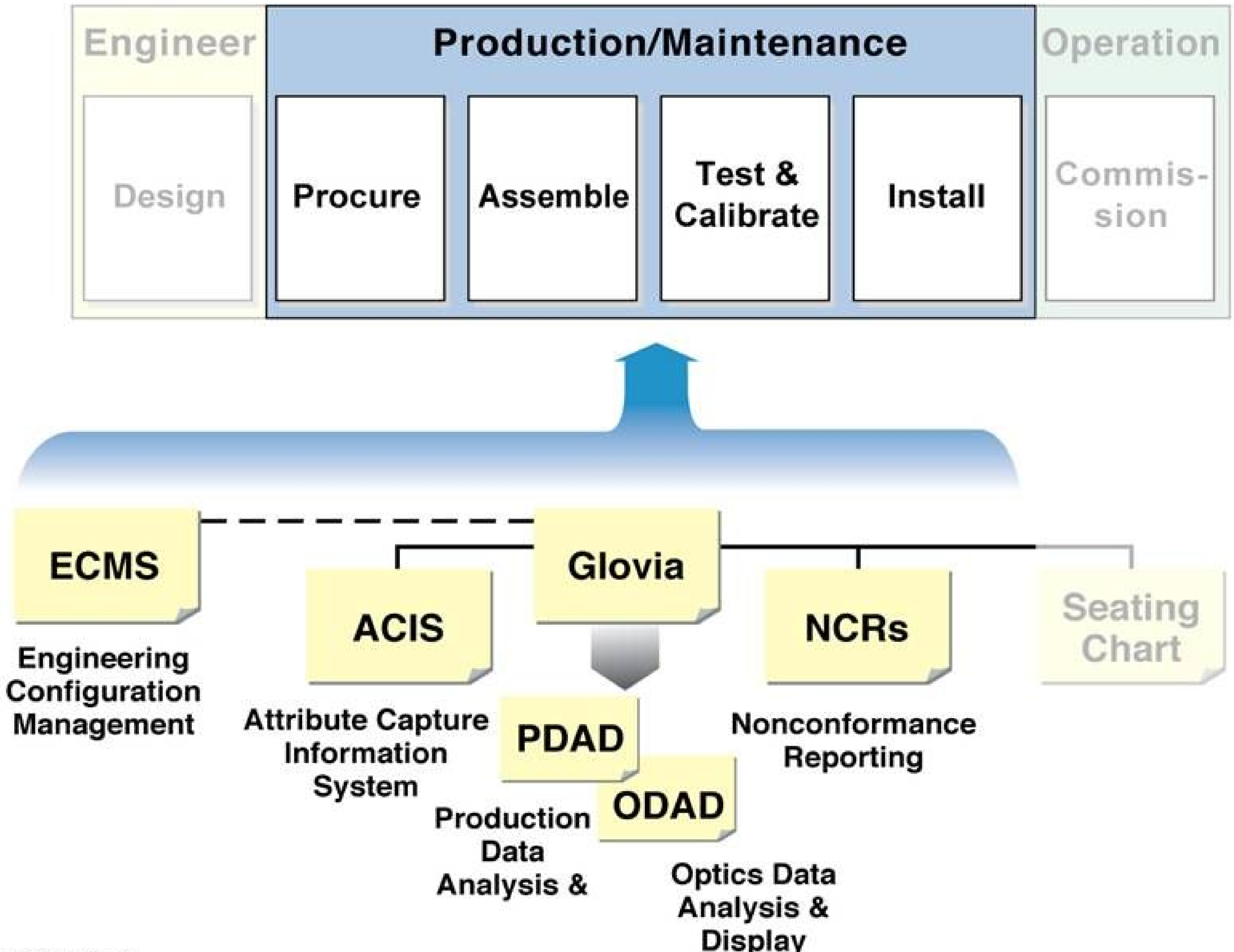


LRU Information Technology Tools



Information tools help manage configuration and work flow processes

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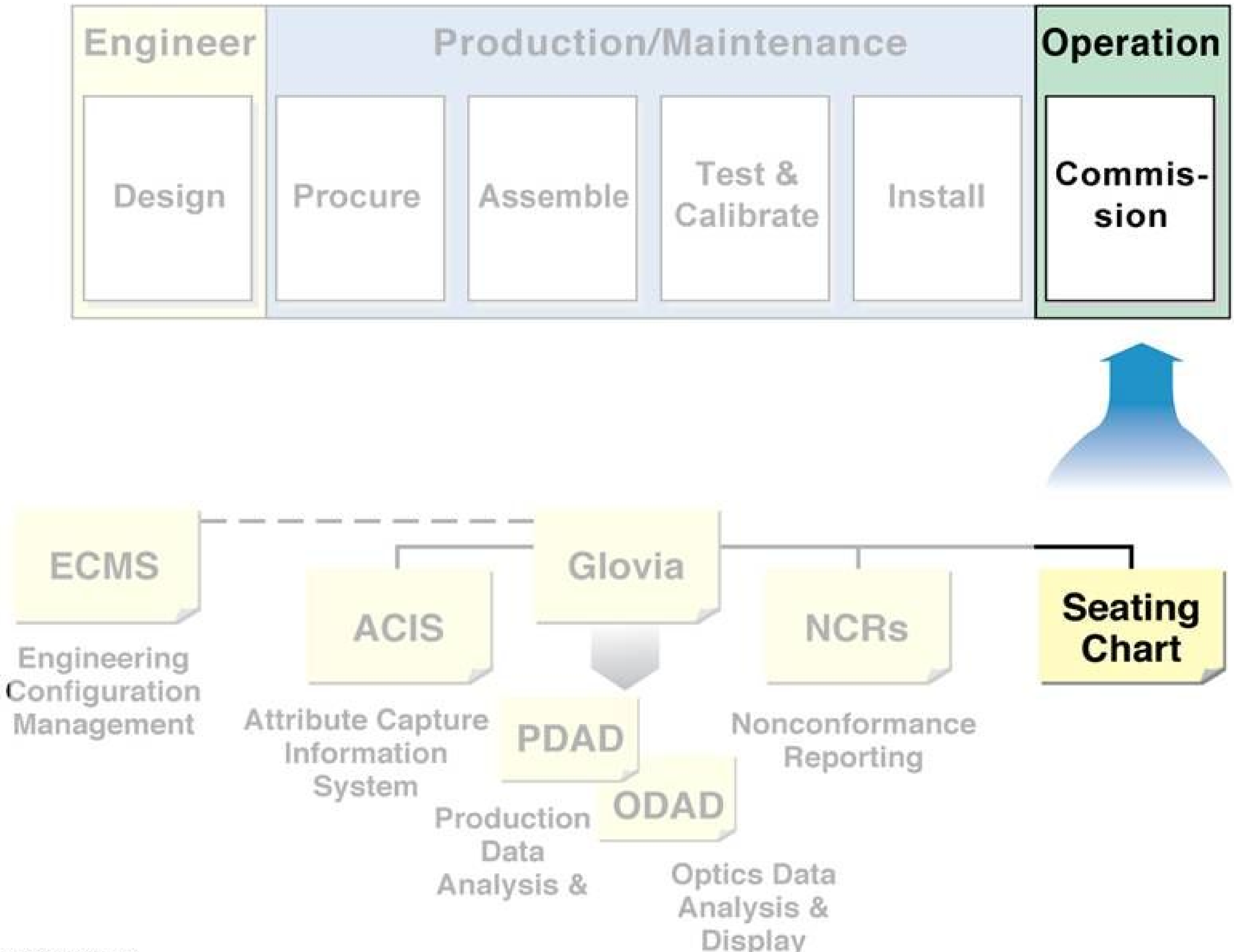
LRU Information Technology Tools



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

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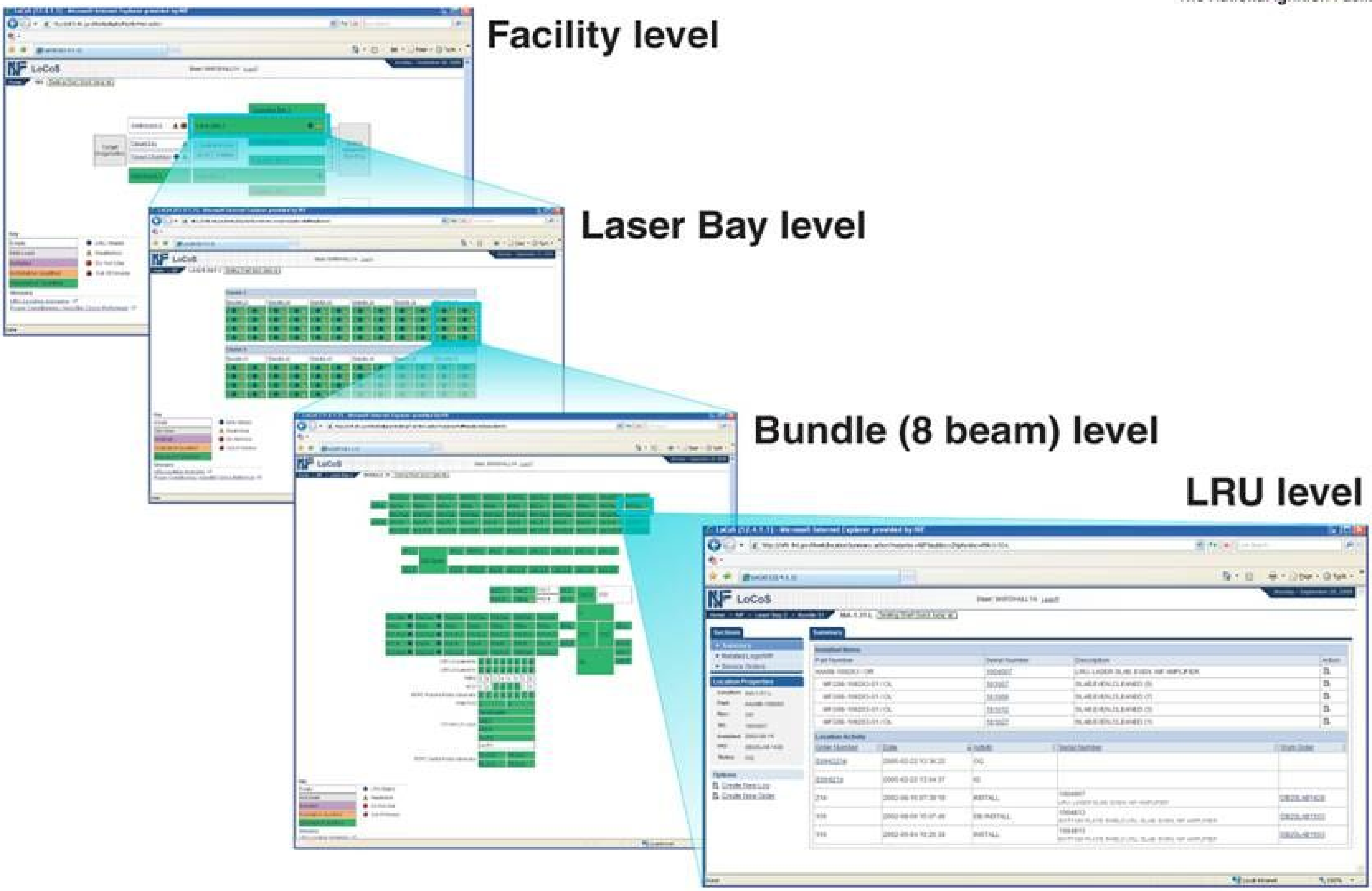

LoCoS is a hierarchical web-based application with extensive drill down from facility level to individual parts

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

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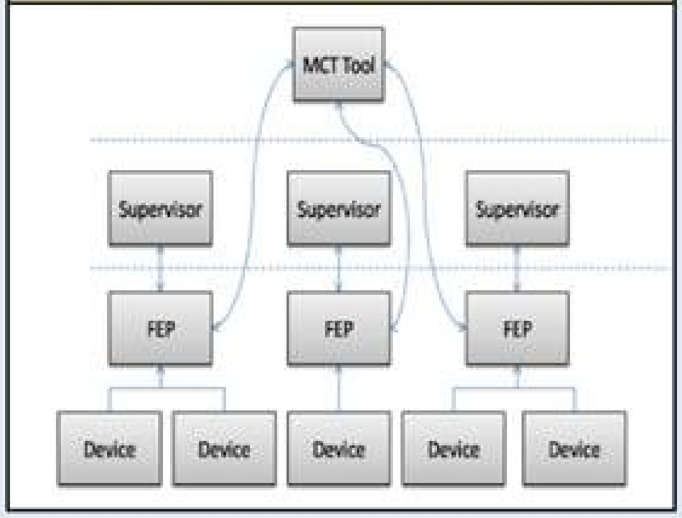
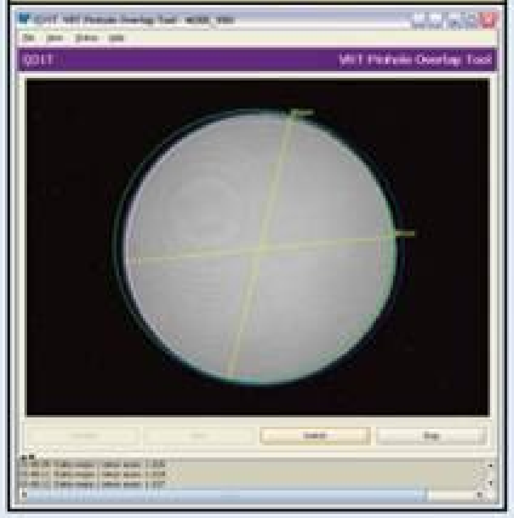
Architechture

Tools are linked below Supervisory shot control

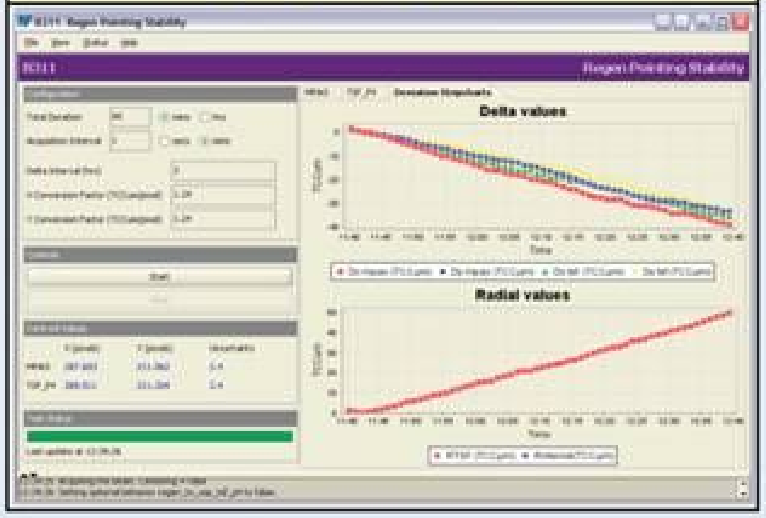


Examples

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

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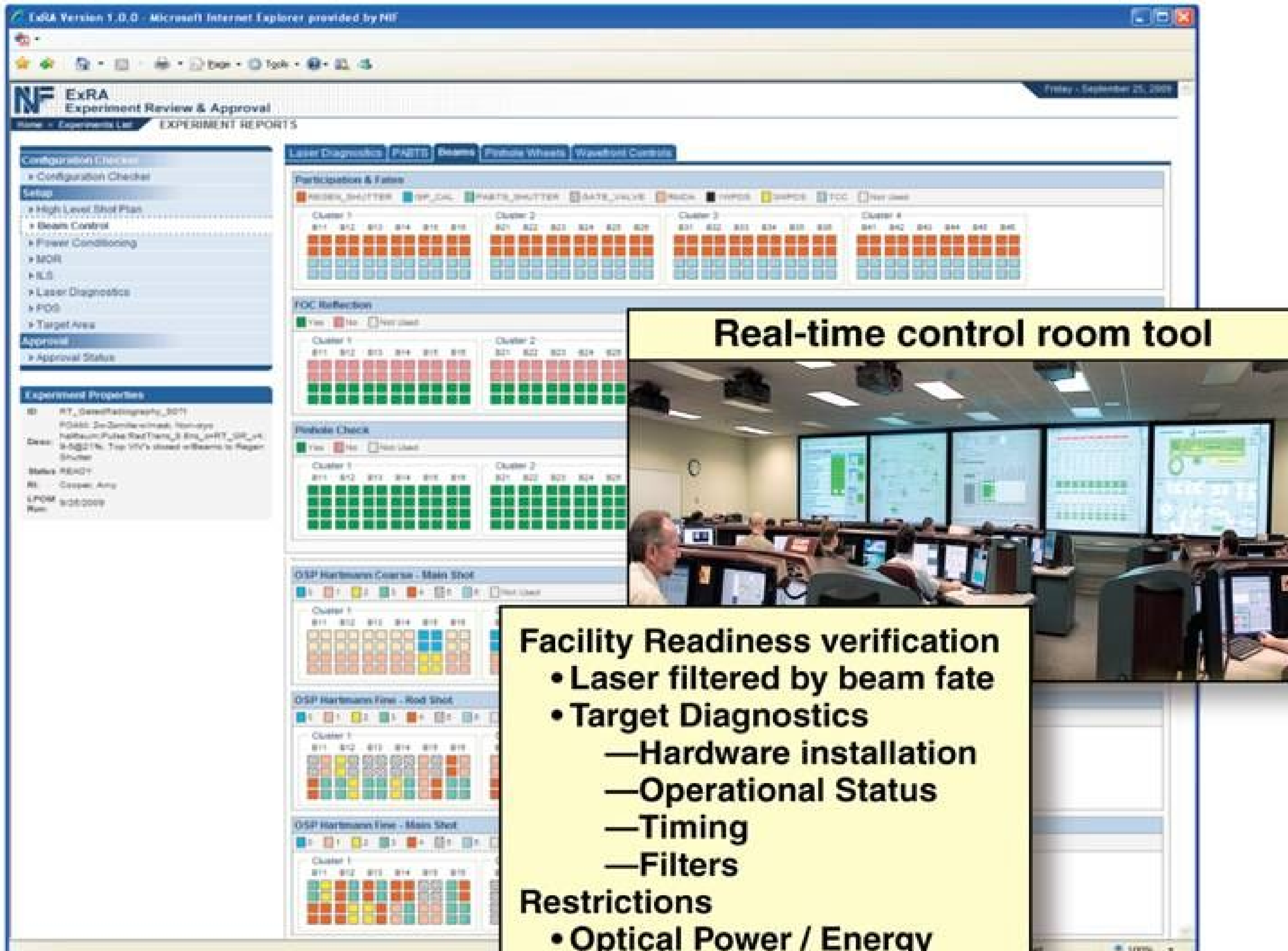

Real-time control room tool

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

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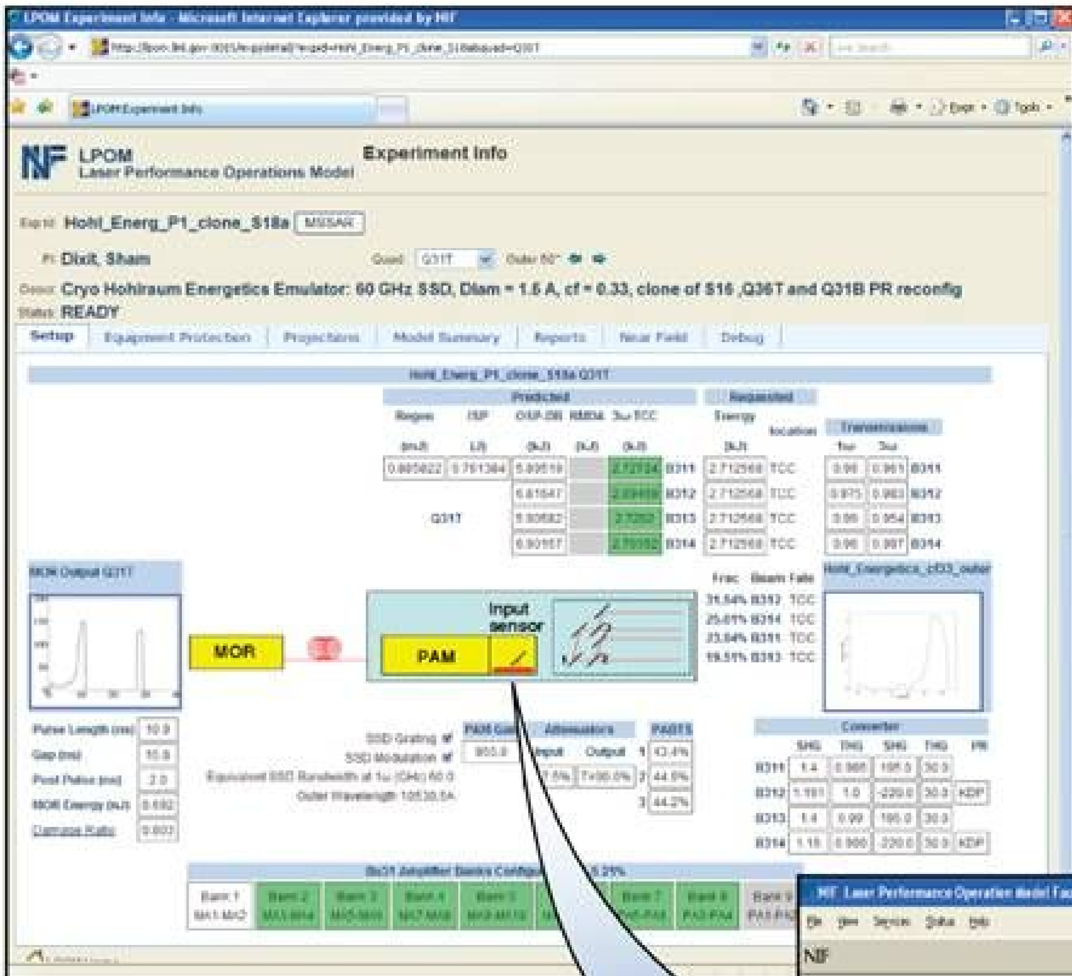

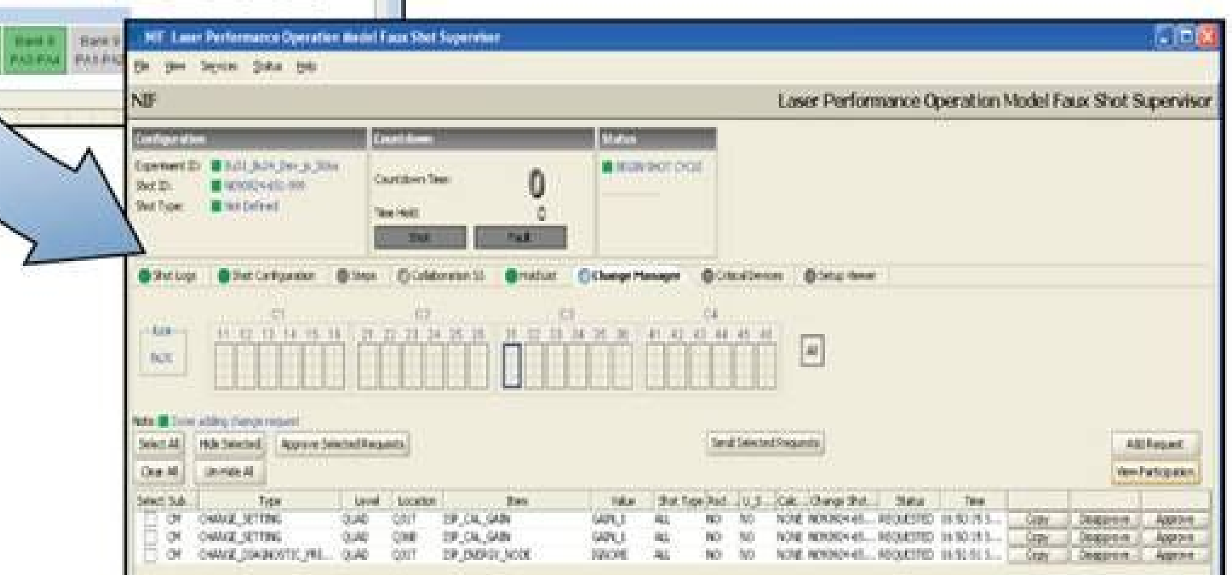

- **Laser Performance and Optimization analysis is performed during shot setup**
- **Derived setting update requests are automated (manual also supported)**
- **Requests are approved or rejected by Shot Director using change management GUI**

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

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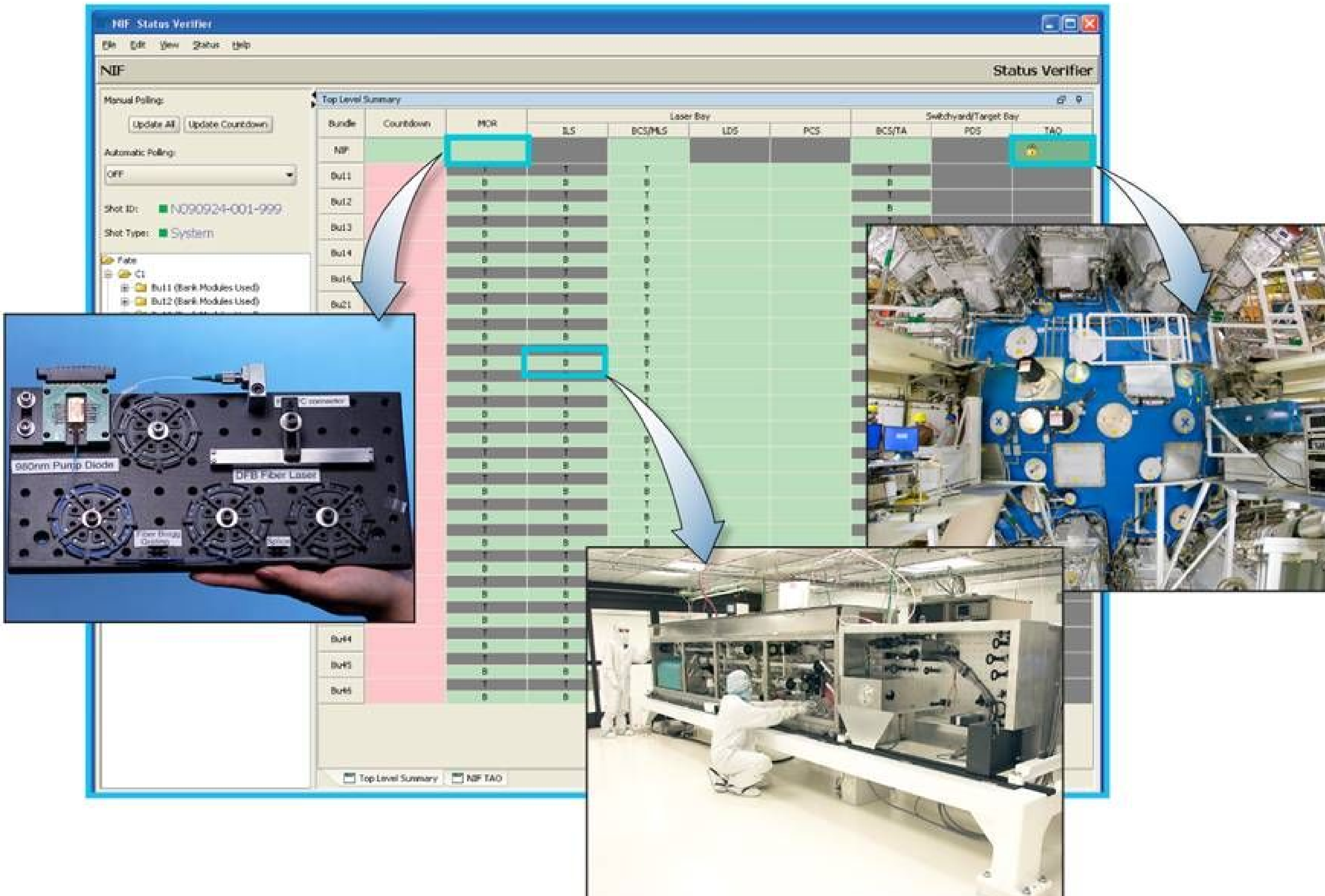

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