National Ignition Facility (NIF)
Sustainment – Amplifier Refurbishment

Presented at:

NIF & JLF User Group Meeting

Feb 13, 2025

Matthew Jones

LLNL-PRES-872391

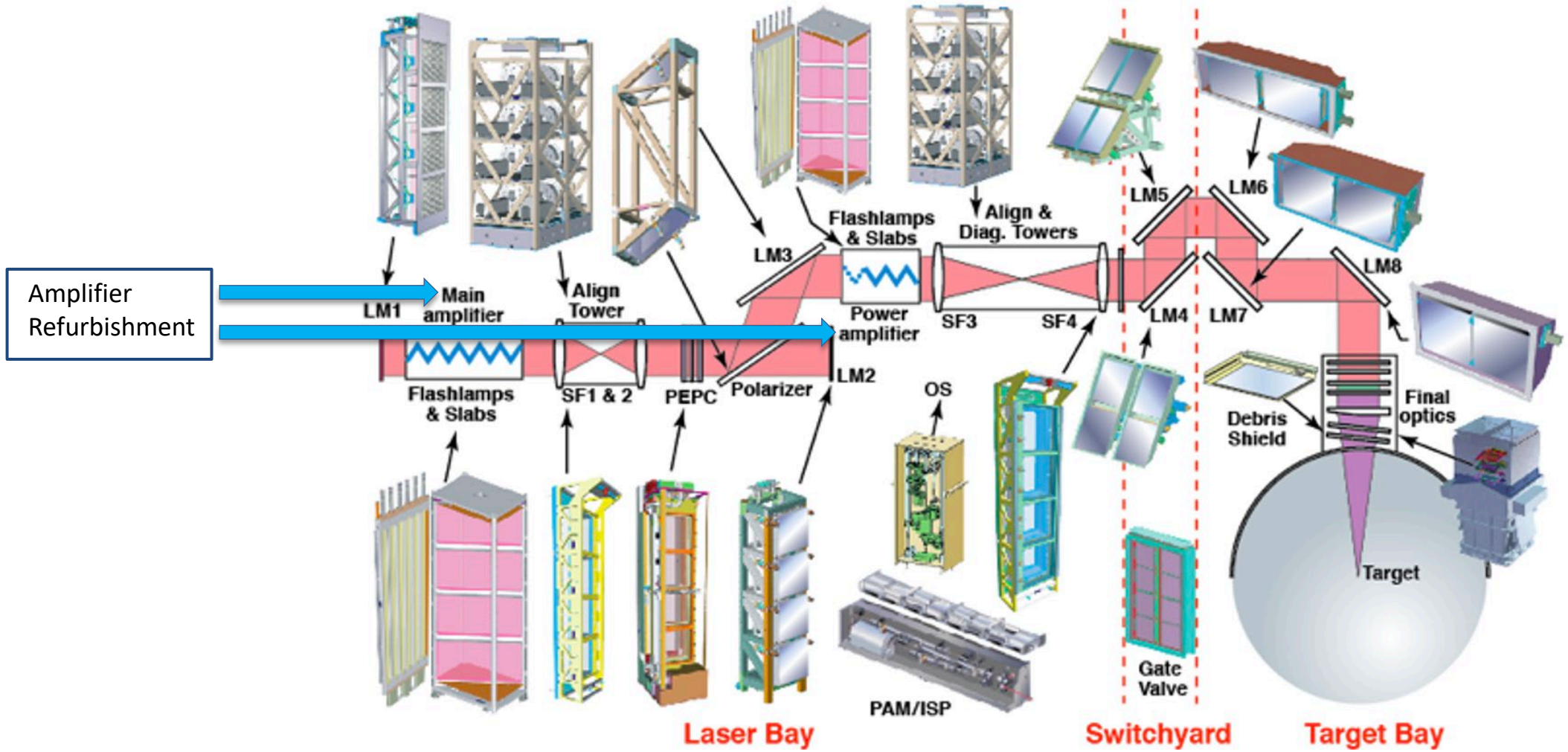
This work was performed under the auspices of the U.S. Department of Energy by Lawrence Livermore National Laboratory under contract DE-AC52-07NA27344. Lawrence Livermore National Security, LLC

Lawrence Livermore National Laboratory

Content

- Background
- Objectives
- Scope
- Top Level Challenges
  - Amp Slab Production Loop
  - Blastshield Production Loop
- Execution Timeline
- Conclusion

The NIF line-replaceable-unit (LRU) 'optical building block' architecture was key to building and maintaining NIF

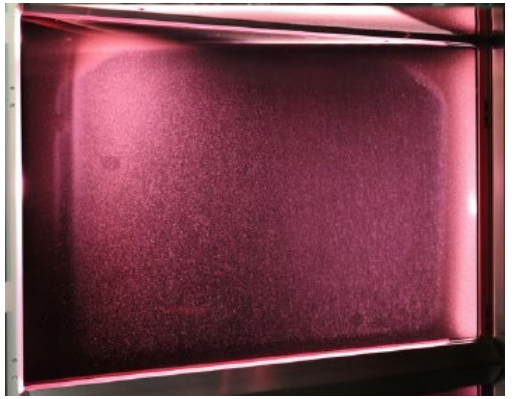


6000+ LRUs house large optics that align and amplify each laser pulse

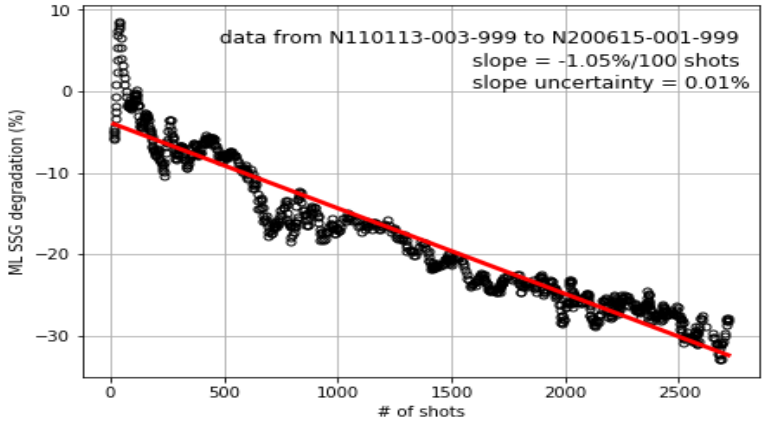
NIF's main laser amplifiers have been extremely reliable, but need refurbishment to address 2 growing concerns

- Contamination from degrading sealant exposed to flashlamp light
  - Particles have migrated to the laser slabs
  - The resultant scatter limits beam energy
- The amplifier gain is slowly degrading
  - Causes are being quantified, including solarization of flashlamps, blastshields, reflectors or laser glass
  - Currently compensated by injecting more energy from the front end

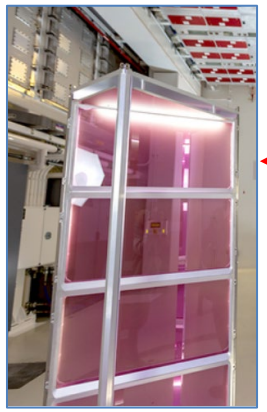
Slabs are contaminated with particles that exceed the 25 particle/sq. ft. spec



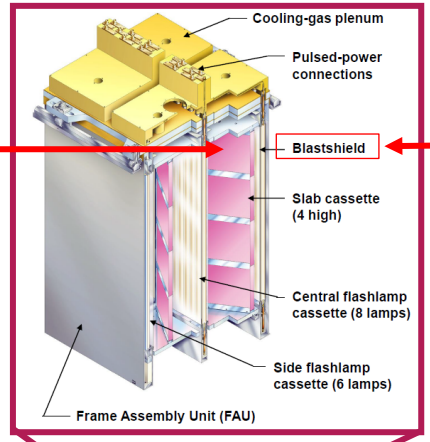
Amplifier small-signal gain has degraded by ~ 40% since the start of NIF operations



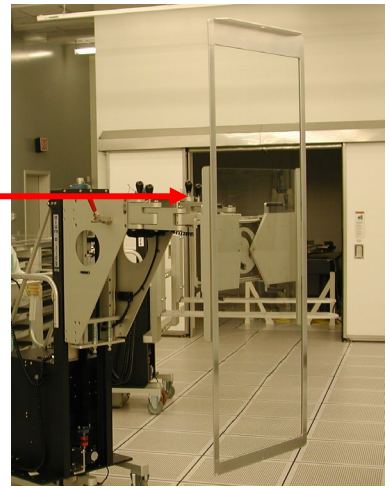
Refurbishment of Slab and Blastshield LRUs



Amp Slab LRU

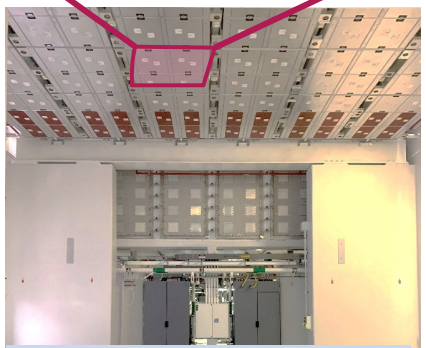


Blast Shield LRU



- <u>Amplifier Slab LRUs in NIF:</u>
  = (11 + 5) x (2 Slab LRUs) x (24 bundles)
  = 768

- <u>Amplifier slabs in NIF (individual optics):</u>
  = 768 x 4
  = 3,072

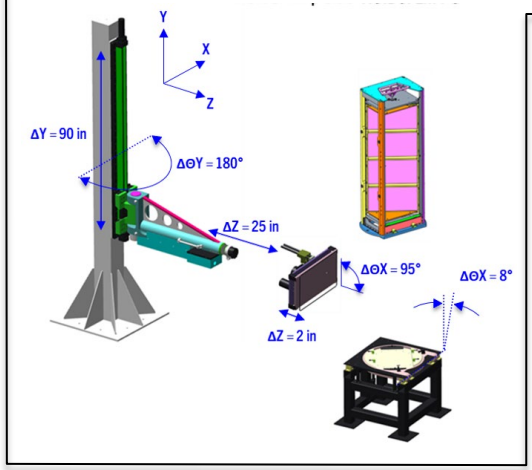


Power Amplifiers (PA)

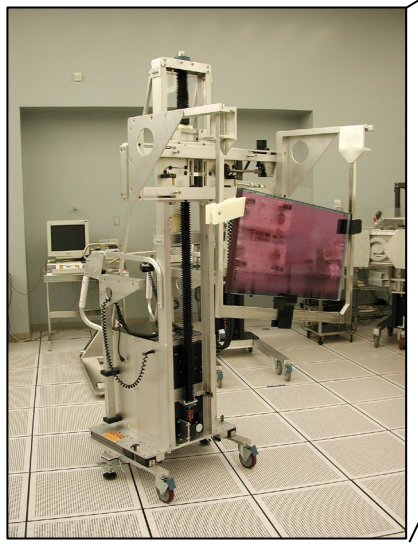
- <u>Blastshield LRUs in NIF:</u>
  = (11 + 7) x (4 Blastshield LRUs) x (24 bundles)
  = 1728

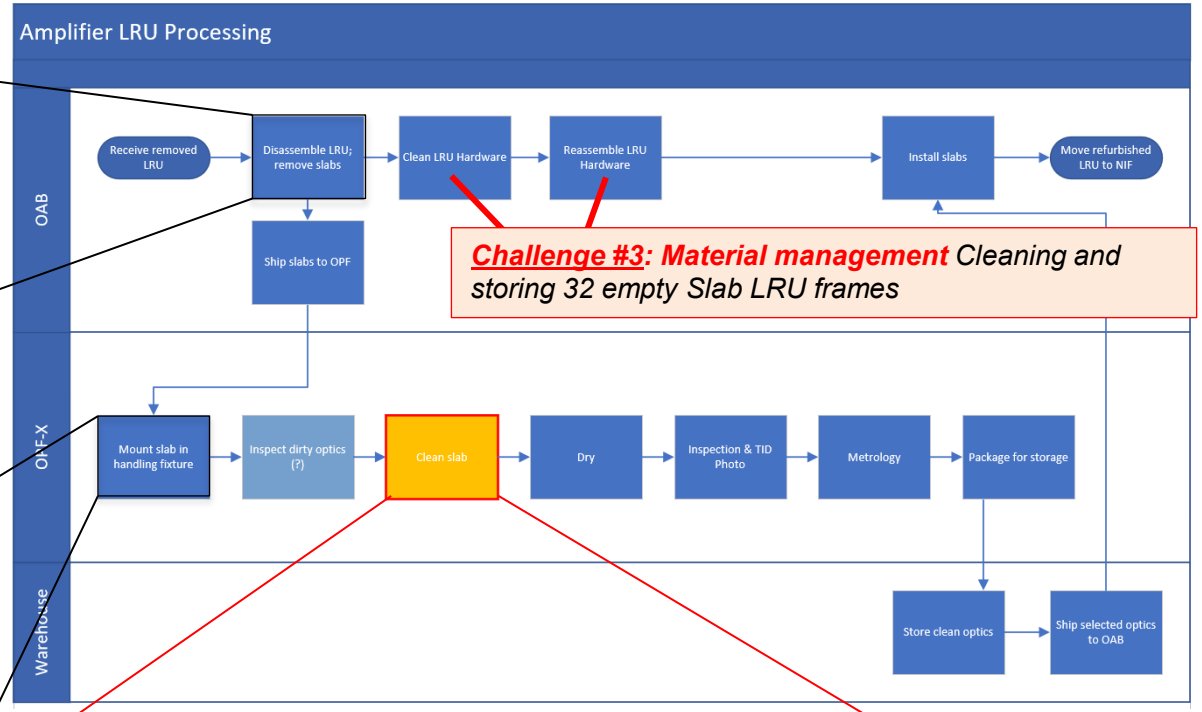
Amp Slab Production Loop – High Level Challenges

***NOID (refurbished/upgrade)** – custom electric crane in the OAB*



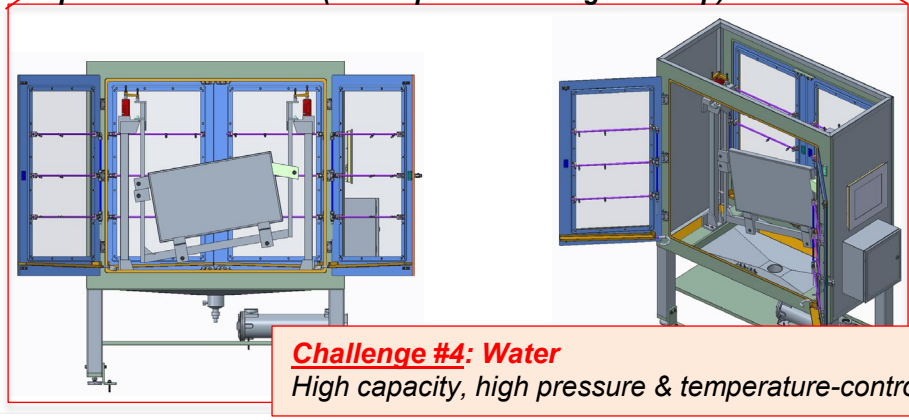
***FHLE (existing/buy again)** – custom electric Alum-a-Lift*





***Challenge #3**: Material management Cleaning and storing 32 empty Slab LRU frames*

Amp Slab Wash Station (developed from the ground-up)



***Challenge #1**: Throughput*
Requires two assembly, wash and metrology stations with high reliability

***Challenge #2**: Humidity control*
Exposure to ambient to be less than 10 days; new Enclosed SLIC (ESLIC)

***Challenge #4**: Water*
High capacity, high pressure & temperature-controlled DI water supply

Blastshield Production Loop – High Level Challenges

Challenge #2: Cleaning
Baikalox (aluminum-grit cleaning slurry) disallowed in clean room, clean room contamination, UNP

Challenge #3: Coating
Alignment, >97% transmission, UNP, sol gel formulation, sec-butanol vapor irritant, class 1 div 1/2, <35% RH

Challenge #1: Glass
B270 vs Borofloat vs FS; solarization, sol gel adhesion

receive blast shield glass → clean glass → sol gel meniscus coat glass → Ammonia cure coating → Pot glass into LRU frame with LPU-2

Receive clean hardware from OAB

Prepare LPU-2

Challenge #4: LPU-2
Mercury catalyst replacement, <35% RH, wet vs gasket design; cure time increase, potting process & assembly

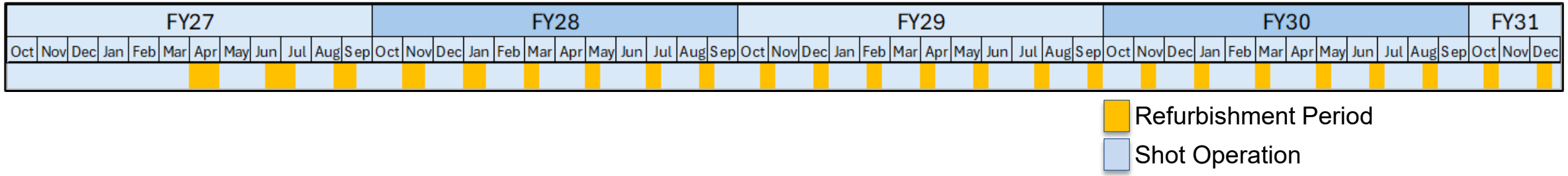
Install mask → Cure LPU-2 → Leak test → Inspect → Ship to Storage or NIF

Challenge #5: T&H
Limited space dictating assembly conops, EDSS seismic compliance

Challenge #6: Transportation & Storage
Cleanly & safely transport, storage for 72 LRUs; seamless conops with NIF installation

Timeline Proposal – NIF extended FM&Rs

- Increased maintenance periods start in FY27 and extend to end of refurbishment in Q1FY31-2wks every 2 months after the first 4 periods



- Timeline of a bundle (1 MA + 1 PA) in 2 weeks. MA: Main Amplifier. PA: Power Amplifier. Bundles = 24.

Tentative Schedule	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Day 16
Remove Slabs																
BS Exchange																
In-situ clean																
FL Cleaning																
Install Slabs																
Commissioning																

BS: Blastshield
FL: Flashlamp

Amplifier Refurbishment Conclusions

- Amplifier Refurbishment will
  - Restore small-signal gain
  - Clean the amplifier slabs of contamination
  - Prevent future contamination from the sealant by physically shielding it from flashlamp light and by using new sealant
- This refurbishment lays the ground-work for upcoming Project Enhanced Yield Capability (EYC) by restoring the amplifiers' conditions as close to baseline (15+ yr ago) as possible

Lawrence Livermore
National Laboratory