OMEGA Laser Users' Group Meeting at APS

Tuesday, November 9th, 2021, Room 303, David L. Lawrence Convention Center

Agenda

5:05PM to 5:15PM: **Welcome, announcements**
- Johan Frenje, MIT

5:15PM to 5:30PM: **Laboratory for Laser Energetics Remarks**
- Mike Campbell, LLE

5:30PM to 5:50PM: **National Nuclear Security Admin Perspective**
- Ann Satsangi, NNSA Office of Experimental Science

5:50PM to 6:10PM: **Summary and Updates of the F&Rs from the 2021 OLUG Workshop**
- Liz Merritt, LANL
- Mario Manuel, GA

6:10PM to 6:30PM: **OMEGA Laser Facility Perspective on the F&R Status**
- Mingsheng Wei and Sam Morse, LLE

NNSA Office of Experimental Sciences (OES) Update

Presented to OLUG, November 2021

Office of Experimental Sciences, Defense Programs

National Nuclear Security Administration

Ann Satsangi

Program Manager, Office of Experimental Sciences (OES)

DOE / NNSA Leadership

Secretary of Energy

Jennifer Granholm

Under Secretary for Nuclear Security & Administrator, NNSA

Jill Hruby

Deputy Administrator for Defense Programs, NNSA

Charles Verdon

Principal Deputy Stockpile Sustainment Defense Programs, NNSA

Michael Thompson

Assistant Deputy Administrator for Research, Development, Test and Evaluation

Mark Anderson

Director, Office of Experimental Sciences (Acting)

Sarah Nelson

Our Mission Remains the Same

Defense Programs

- **Ensure the United States has a safe, secure, reliable nuclear stockpile**
- **Secure transport of special nuclear materials and equipment**

RDT&E

Science | *Engineering* | *Technology Maturation* | *Computer Simulation* | **Inertial Confinement Fusion**

for maintaining the effectiveness of the nuclear weapons stockpile, providing a technical basis for the annual assessment, developing modernization options, and quantifying the effects of aging on the stockpile

Office of Experimental Sciences

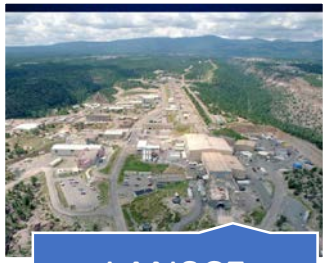
VISION: A world-class scientific enterprise for stockpile stewardship that creates and applies 21st century science capabilities to anticipate and address existing and emergent stockpile needs, and thwart unforeseen threats

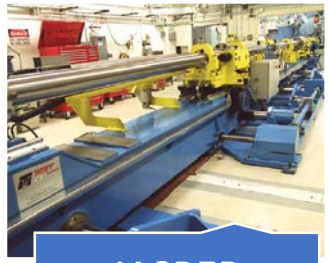
MISSION: Ensure a resilient US nuclear deterrence posture by delivering world-class data, facilities, and expertise required to undergird the effectiveness and responsiveness of the modern stockpile

NNSA Research Facilities


NIF

Z Facility


LANSCE


JASPER


Light Sources

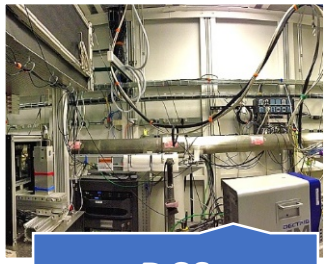

ECSE


U1a


HEAF


DARHT

Omega


DCS


HPCAT

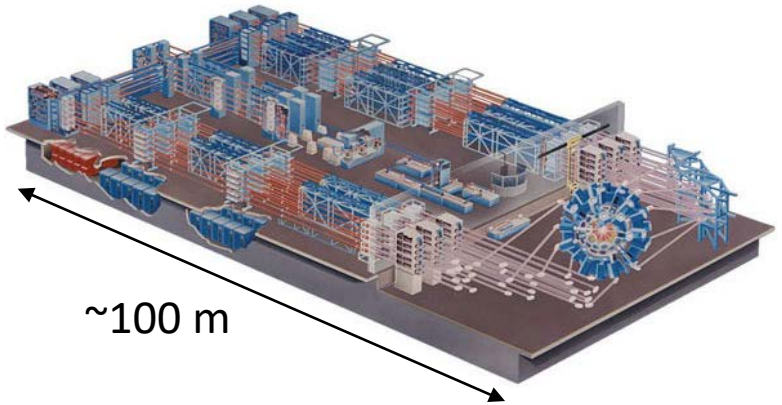

CFF


PF-4

The Omega Facility

Omega provides rapid development of new capabilities and training for NNSA researchers

Design & specifications:



- 60-beam, 30 000 Joule main laser (5x the energy of a bullet fired from a large-caliber rifle)
- 4-beam, 40 000 Joule short-pulse-capable laser (fires faster than light travels ¼ inch)
- ~160 diagnostic systems
- Rapid shot rate for 2100 experiments annually
- Invented technology enabling short-pulse lasers

Key roles for Omega:

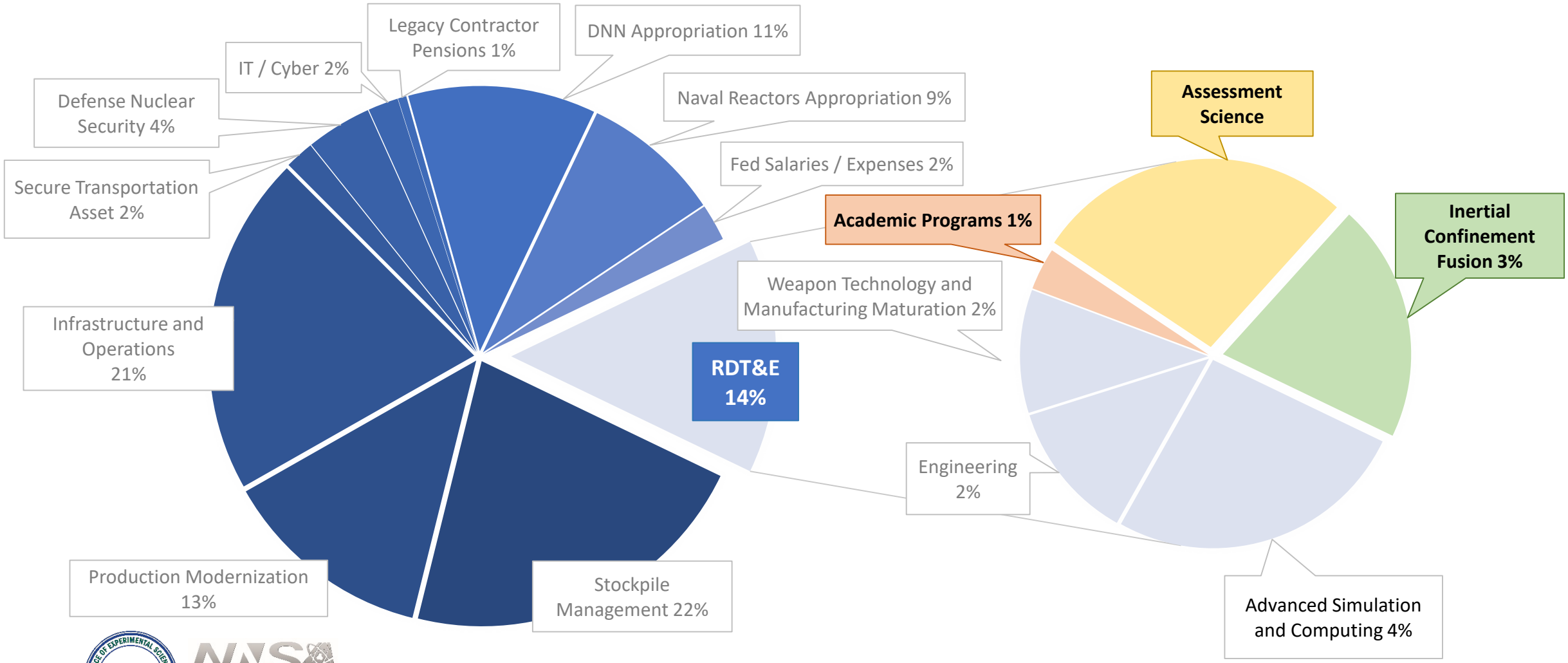
- Develop new methods and diagnostics for NIF & Z
- Phase diffraction methods (now applied to Pu on NIF and Z)
- Short-pulse radiography
- Pioneer breakthroughs in laser technology
- Develops advanced material models
- Laser-direct-drive fusion ignition approach
- Train future stockpile stewards:
  - 300+ Rochester PhDs to date
  - 400+ users from academic community
  - New HED degree program


Omega Laser User Group


UR Student

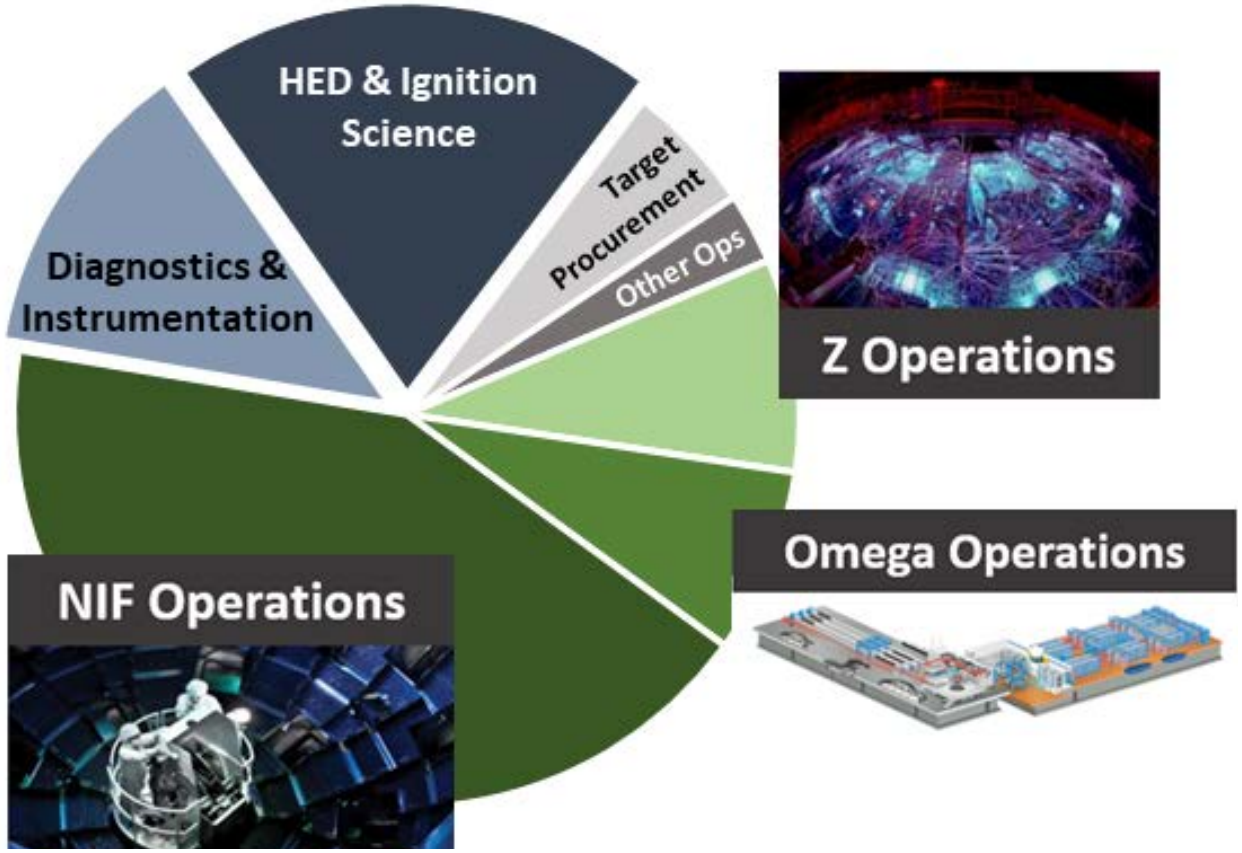
Research Development Test and Evaluation (RDT&E)

Funding at a Glance

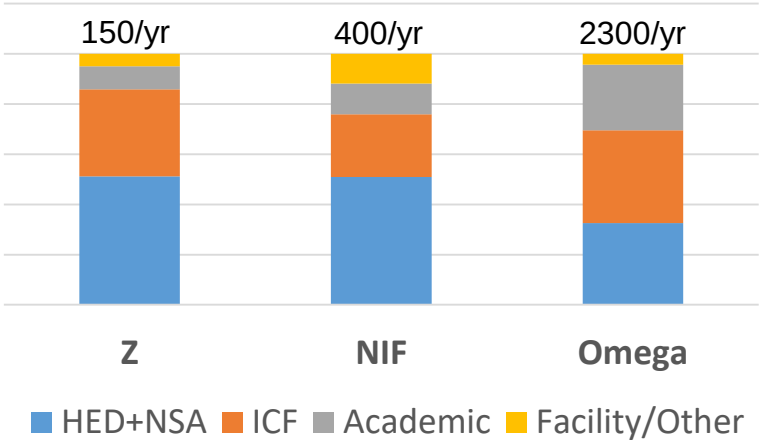


The National ICF Program

ICF FY21 ($575 M)



ICF Facility Shot Allocations



HED & Ignition Science: Advances experimental platforms and understanding toward ignition and MJ fusion yield

ICF Diagnostics: Conducts the R&D for new technologies to execute and interpret HED experiments

Facility Operations: Enables safe and efficient operations of national HED facilities for all applications

Lawrence Livermore National Laboratory · Sandia National Laboratories · UR LLE · Los Alamos National Laboratory EST. 1943 · U.S. Naval Research Laboratory · General Atomics

ICF Program Overview

ICF Program provides HED science capabilities and expertise that support research and testing across the breadth of the Stockpile Stewardship Program. Its two-fold mission is to:

1. Meet immediate and emerging HED science needs to support the deterrent of today
2. Advance the R&D capabilities necessary to meet those needs for the deterrent of the future

Priorities

- **Robust, sustained HED facility operations** for data needs of modernization, assessment science, survivability, and pursuit of ignition
- Advance toward **fusion ignition and high yield to meet long-term stewardship needs**
- **Next-gen capabilities** to provide access to data at the extreme conditions of nuclear weapon operation
- **Leverage innovation** to address near-term weapons physics challenges
- Attract and challenge an **expert workforce** of stockpile stewards

FY2020: A time for Reflection

FY2021: A time for Response

ICF 2020

- Red Team Review complete (early summer 2020)
- HQ draft (September 2020)
- *HQ concurrence for internal report (July 2021)*

JASON ICF Report

- HQ response being finalized
- Unclassified Executive Summary and Full classified report
- *Delivered June 2021*

NASEM HED Science

- May 2021 kick off study
- August 2021, community meetings
- *July-Oct, site visits, international and workforce sub-groups*

ICF Fall Workshops Series

- Implement ICF 2020 key findings
- Enhance national program coordination
- Broaden and deepen connections to the expert academic/industrial community

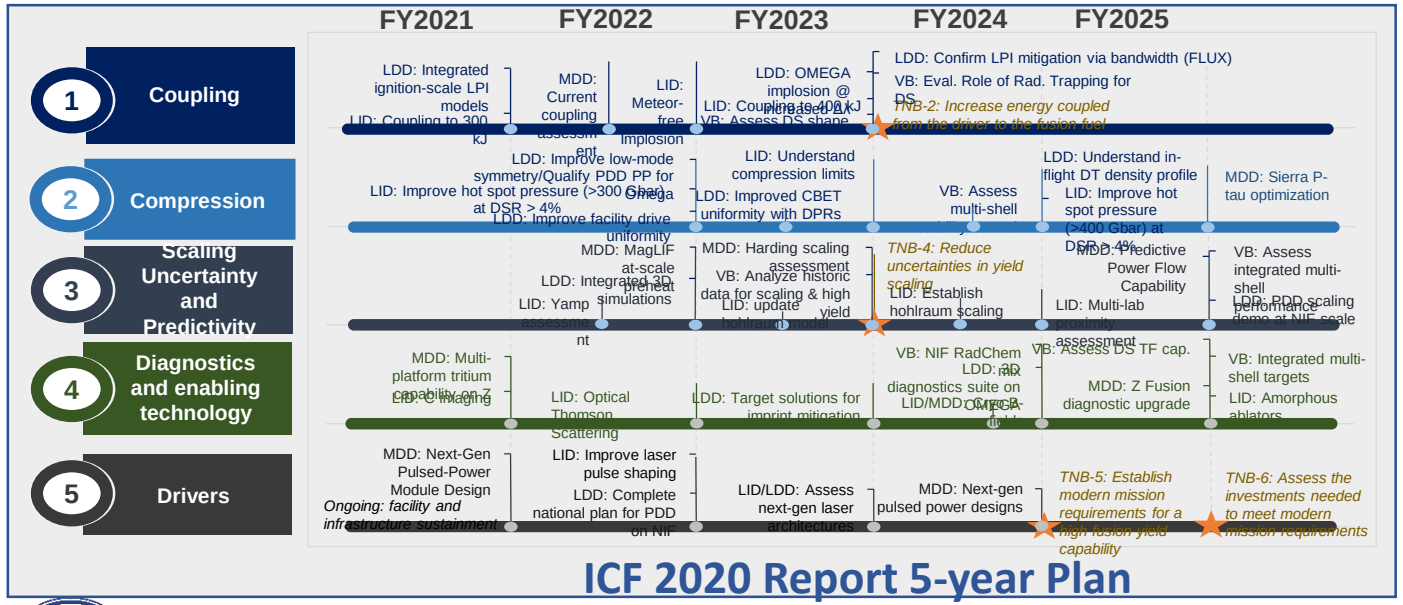
Working groups: LPI, Hohlraum Physics, Current Delivery, Compression, Hot Spot Mix, Ignition Theory, Materials, Advanced Analysis and Simulation

- Review, refine and improve key scientific questions, technical goals, and research plans of the national US ICF effort for the next 5 years
- Identify opportunities for inter-laboratory and academic collaborations to improve physics understanding and reduce scaling uncertainties towards ignition and multi-MJ fusion yield for stockpile stewardship

FY2022: A time for Action

ICF 5-Year Plan

- Reassess 5-year plan and develop a new ICF roadmap
- NNSA Defense Programs - "Getting the Job Done" goal
  - Build on knowledge and technology investments that enabled >1MJ fusion yield performance on NIF to explore reproducibility and further performance improvements.



ICF 2020 Report 5-year Plan

ICF Facilities

- An ecosystem for HED discovery and advancement
- Sustaining existing capabilities over the next 10 years
- Evaluating mission needs and requirements for the future of our ICF facilities
  - Next Generation Pulsed Power (NGPP)
  - NIF Improvements/Upgrades
  - Omega LLE renewal review

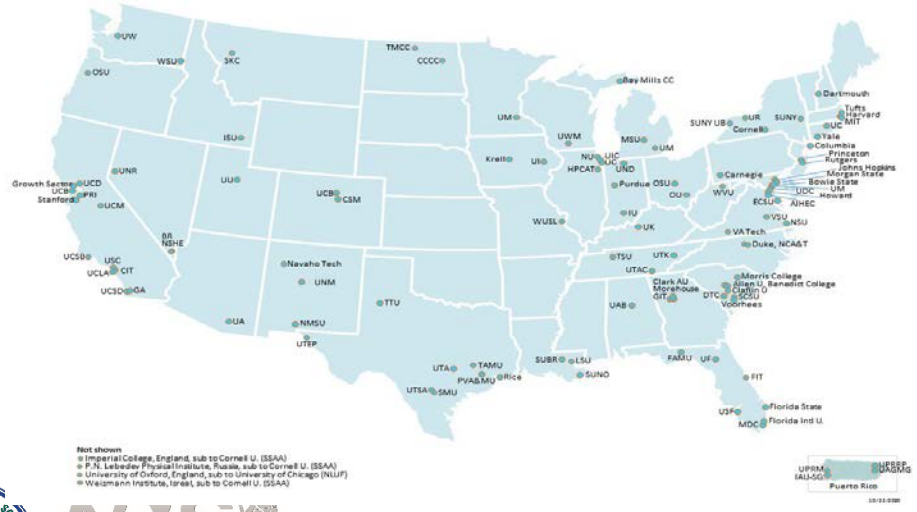
Academic Programs

- NAS 2022 HEDS Report Delivery
- Annual HEDLP FOA involvement
- Facility Access Program

Academic Programs within RDT&E

Goals

- **Workforce Pipeline:** providing a diverse, skilled, technical future stockpile stewards
- **External Expertise:** assuring quality through external review, critique, challenge
- **Creative Input**: leveraging expertise in areas thinking outside the mission



- Stewardship Science Academic Alliance (SSAA)
- Minority Serving Institution Partnership Program (MSIPP); *including: Tribal Education Partnership Program (TEPP)*
- **Joint Program in High Energy Density Laboratory Plasmas (JPHEDLP)**
- Computational Science Graduate Fellowships (CSGF)
- Predictive Science Academic Alliance Program (PSAAP)

HEDLP Academic Program

HEDLP Grants

Joint FOA with Office of Science

- FY21: $4.8M, 12 new awards
- FY22: $3.8M for grants
- FY23: ~$4M for grants

MOU w NSF

- FY21: pilot test

HED Centers

- 5 HED Centers – $9.5M
  - ($3.8 HEDLP, $5.7 SSAA)

Facility Use

User programs at NNSA HED facilities

- OES program support (facility operation, targets, onsite support)
- Facility Access Program FY21 pilot

Community Development

HED Summer schools

Workshop support

- AMP Data and Workforce summer/fall 2022 at NIST

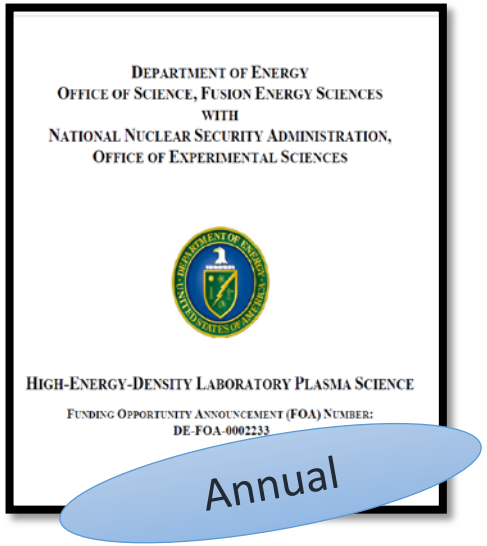
Future potential opportunities …

- 2020 Ignition Workshop needs
- Coordination w IFE efforts
- NAS HED recommendations
- Pulsed power, Targets research, Future facilities technology

Opportunities for HEDLP in NNSA Academic Programs

HEDLP

- Annual Joint NNSA and DOE Office of Science issued solicitation - **Coming Soon**



SSAA

- FY22 Grants - FOA **mid 2021 under review**

  materials, low energy nuclear, rad-chem
- FY23 Centers- FOA expected **early 2022**

Fellowships

Computational Science Graduate Fellowship

https://www.krellinst.org/csgf/

Laboratory Residency Graduate Fellowship

https://www.krellinst.org/lrgf/

Stewardship Science Graduate Fellowship

https://www.krellinst.org/ssgf/

NNSA Graduate Fellowship Program

https://www.pnnl.gov/projects/ngfp

Questions?

Summary and Updates of Findings and Recommendations from the 2020 and 2021 OLUG Workshops

Liz Merritt & Mario Manuel

Findings & Recommendation process

2020: Cancelled the April meeting due to COVID, but managed a virtual workshop in September

1. In the fall, we had **fully virtual September** OLUG F&R meeting
   i. Substitution for the April meeting F&Rs sessions
   ii. Took the place of the normal DPP OLUG Town Hall

2. Both before and during the meeting, users submitted ideas for new Findings & Recommendations

3. On Wednesday and Thursday we met for 3 hours total to discuss new F&R ideas within the OLUG community

4. On Friday morning, LLE representatives gave initial input.

We thank the community for remaining so engaged during trying times!

Findings & Recommendation process

2021: Virtual, but back on schedule!

1. In the spring, we had a **fully virtual** April OLUG Meeting
   i. Both before and during the meeting, users submitted ideas for new Findings & Recommendations

2. On Tuesday at the meeting we had a late brief on the F&Rs from 2020

3. We had an initial session on Wednesday discussing new F&R ideas within the OLUG community, and followed it up with a 2nd session on Thursday to gauge support and flesh out requests

4. On Friday morning, we presented the ideas to the LLE representatives and got initial input. The initial response from LLE was positive!

5. LLE have traditionally been very responsive to this community input – we will hear their response to this year's requests in the next talk

As we go through this and the next talk, if you think of additional improvement opportunities or capability gaps, please remember to raise them during the spring meeting

During the 2020 September OLUG workshop, we discussed 22 Findings & Recommendations from the community

Submitters are divided over many institutions:

5 Government:

- UK STFC
- General Atomics
- LLNL
- AWE
- LANL

12 Universities:

- University of Michigan
- PPPL
- Princeton
- MIT
- UCSD
- UCLA
- Oxford
- Virgina Tech
- Imperial College
- LLE
- U. of Nevada Reno
- John Hopkins

These F&R's can be loosely divided into the following categories:

- Documentation: **5** requests
- Calibration: **3** requests
- Diagnostics: **7** requests
- Target capability: **2** requests
- Laser Systems: **4** requests
- Code Improvement: **1** request

- Total: **22**

All but four of these were submitted prior to the Thursday session, but several were significantly expanded during the sessions.

During the 2021 April OLUG workshop, we discussed 29 Findings & Recommendations from the community

Submitters are divided over many institutions:

4 Government:
- LANL
- LLNL
- AWE
- General Atomics

5 Universities:
- MIT
- Princeton
- PPPL
- U. of Nevada Reno
- Oxford

Several other institutions also voiced support:
UCSD, UCLA, Umich, HZDR, GA, IMP, and LLE itself

These F&R's can be loosely divided into the following categories:

- Documentation: **3** requests
- Calibration: **6** requests
- Diagnostics: **13** requests
- Target capability: **1** requests
- Laser System: **5** requests
- Code Improvement: **1** request

- Total: **29**

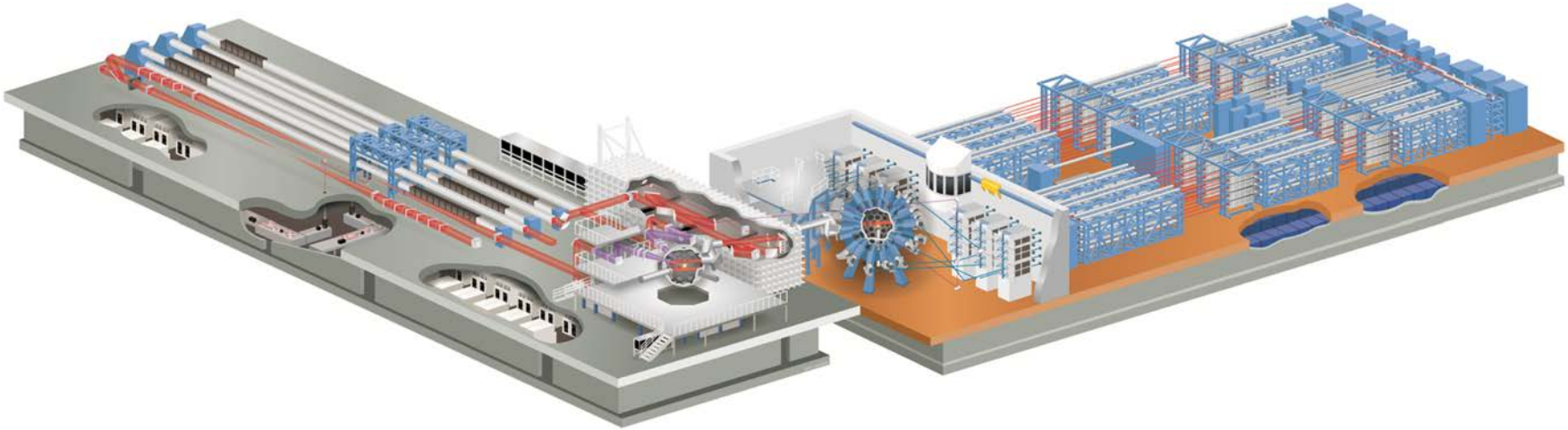
All but four of these were submitted prior to the Thursday session, but several were significantly expanded during the sessions.

Keep any ideas you have in mind, and please submit them for the spring session

This process WORKS!

The next talk will go through each request in detail!

Status of the FY21 OLUG Findings and Recommendations



Mingsheng Wei, Sam Morse
University of Rochester
Laboratory for Laser Energetics

APS DPP OLUG Update
Pittsburgh, PA
9 November 2021

Summary

OLUG APS-DPP update - LLE continues to address needs and concerns of Users

UR LLE

- **Progress continues on prior year OLUG Findings and Recommendations (F&Rs)**
- **LLE has developed a sustainment plan to extend Omega into the 2030's as part of the next Cooperative Agreement**
- **Plans are in place to address many of the 2021 F&Rs**
- **Summary of Basic Science calls for proposals:**
  - NLUF FY22-23 (27 projects) in process, next solicitation will be issued in early 2023 for experiments in FY24-FY25
  - LBS call for FY23 experiments will be in early 2022
  - LaserNetUS cycle 4 proposals are due 10 Dec for experiments July 2022 to July 2023
- **An LLE building expansion is in final design**

Status of Omega Basic Science User Programs

- Omega Basic Science users (NLUF, LBS and LaserNetUS) obtained a total of 620 target shots in FY21
- 27 NLUF projects led by 25 PIs from 15 different institutions were awarded Omega beam-time for experiments at the Omega Laser Facility in FY22-23
  - More than 50% are led by early career scientists
  - ~40% of the NLUF projects are led by women
- FY22 LBS program awarded 15 new projects led by scientists from LLNL, LLE, PPPL and SLAC
  - Many LBS projects involve students and postdoc researchers
- 4 projects from LaserNetUS Cycle 3 will be conducting experiments on OMEGA EP in FY22 including one led by an international PI
  - LLE has completed a total of 99 target shots for 9 LaserNetUS projects.

More than 60 graduate students are conducting their theses research supported by Omega Basic Science User Programs.

The Diagnostic Development and Integration Group Supports many diagnostic projects

- Omega continues to be a hub of diagnostic innovation
- The DD&I group (led by S. Ivancic, siva@lle.Rochester.edu) leads integration projects
- LLE is committed to a number of new and/or modified diagnostics for FY22 shots

FY21 Diagnostics:

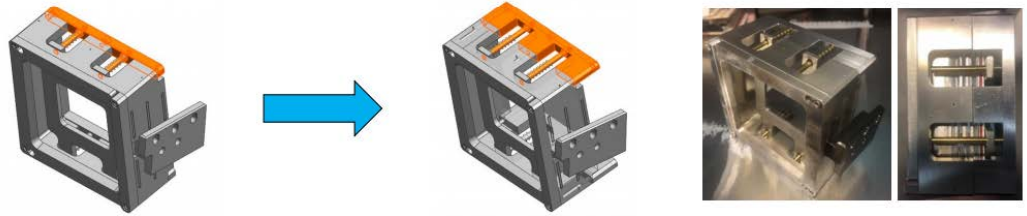
Scattered Light Uniformity Imager (SLUI)
LLNL –Vacuum Cherenkov Detector (VCD)
Terahertz Background Energy Measurement
LANL Time Resolved Neutron Imaging
Port P9 Full Aperture Backscatter Station
Port H2 nTOF
MIT- MagSpec
Fresnel Zone Plate (FZP) – TIM14 qual
Gas Jet System-High Pressure (1500 PSI)
Gas Jet System –TIM4,TIM-5 – Fixed Arms
JHU EP-Talbot-Lau X-ray Deflectometer 2, 3
ARPA-E- nTOF diagnostics (three)
Fast PMT Mount
SXS w/XRCCD1
Mini-B-Dot
LLNL- EPPS-shielded

FY22 Diagnostics:

OMEGA High Resolution Velocimeter
LLNL Scattered Light Diode
Terahertz
E-Rad EPPS Nose modification
Schlieren Spherical Crystal imager
Chicane Diagnostic
FABS P9
Time Resolved x-ray CMOS

LLE is making progress on a number of prior year F&Rs

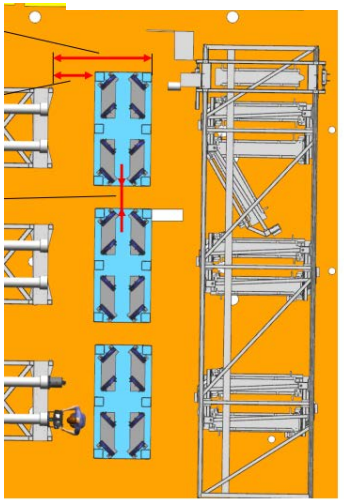
- **User Request: Increase magnetic fields to 30T (and up to 50T)**
  - 50T achieved in FY21 with dual MIFEDS (generation 2.x)
  - A single 19T (1 cm^3) system will be completed in FY22
  - Dual MIFEDS
- **Beam Delay Extenders (10 beams of OMEGA-60 to have increased delay of 4ns available)**
  - on track to deliver in Q4 FY22
- **Thicker film packs for Near Target Arm – first use 11/18/21**
  - Film packs up to 30mm supported (original max was 18mm)

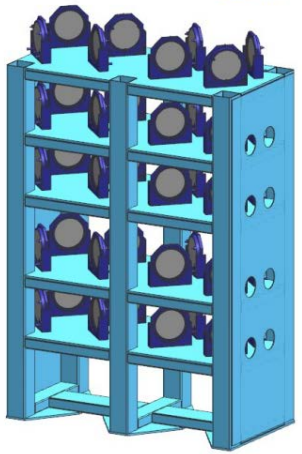


"Original" Pack Assembly
(D-TX-B-324)

"Extended" Pack Assembly
(D-TX-B-331)

Beam Delay Extender structures





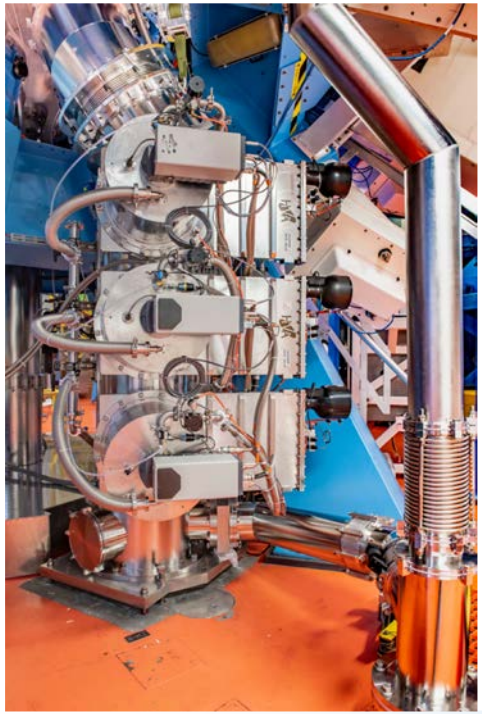
The OMEGA Sustainment plan includes a surge of activities

- The plan boosts sustainment over the period of the next Cooperative Agreement (CA), FY24-28.
- Laser, diagnostic, and target sustainment activities beyond periodic preventive maintenance are required to replace equipment and controls that are no longer supported
- Additionally, many systems need to take advantage of modern technology to ensure that the lasers operate with high efficiency, effectiveness, and availability into the mid 2030's
- $50 million, ~$10 million/year, will be requested during the FY24-28 CA period for this activity. The total cost of all the activities described in this plan is $76 million over the next 10 years

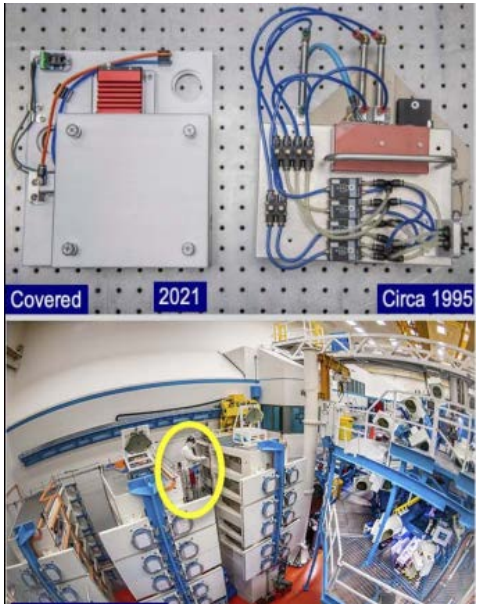
FY21 Sustainment highlights featured a few projects to improve performance and reliability

UR LLE

Cryopump isolation



Stage-F Alignment Sensor Package

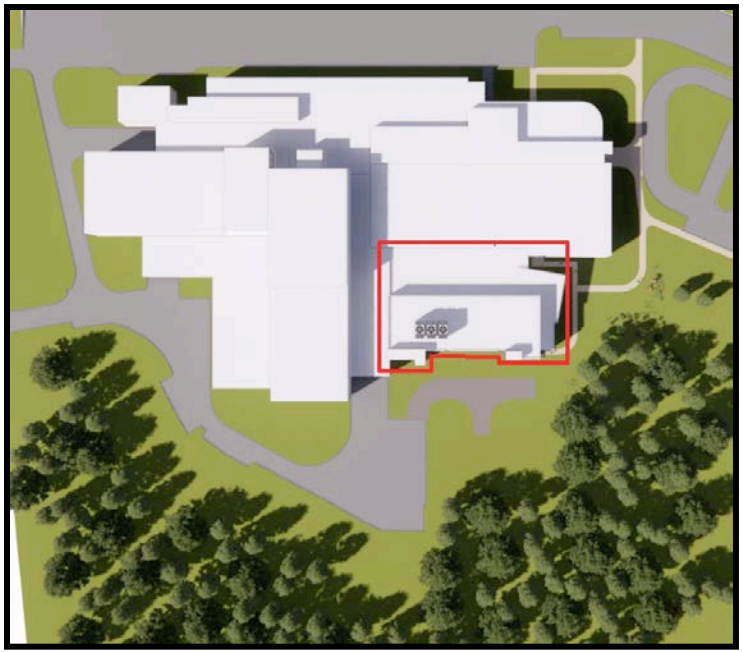


Generator and switchgear replacement

An office and lab expansion project is in final design stages

An office and lab expansion project is in final design stages

A planned building expansion at LLE supports existing and future activities

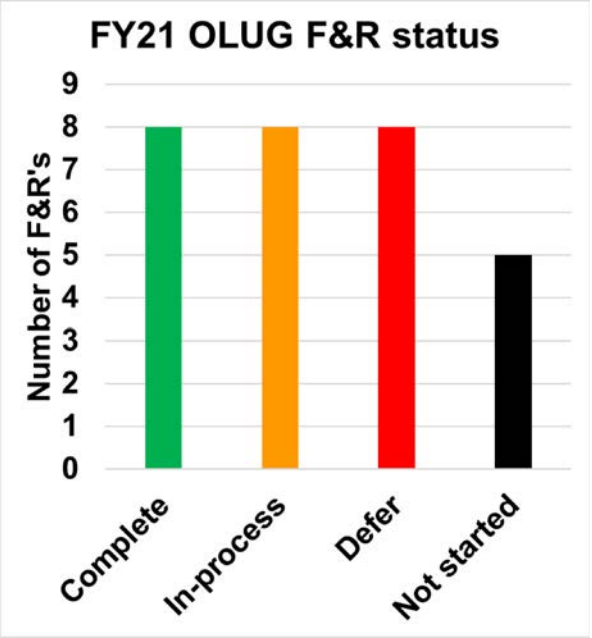


- A 60,000 sqft laboratory/office addition connected to the LLE building
- To build and test the MEC-U laser, increase target fabrication space, increase other laser and engineering labs, add offices, and support campus researchers
- Omega has operated in parallel with construction projects in the past and LLE will work to minimize the impact
- System availability will be impacted during high vibration activity on the construction site (eg: 5 vs 7 target shots per day on OMEGA EP)
- Ground breaking is planned for spring 2022

UR is funding the ~$40 million addition

Plans are in place to address many of the 29 2021 OLUG F&Rs

1. Ensure that users have access to detailed, and up to date documentation on diagnostics – working on user guides and updating where appropriate
2. Improved Navigation on the Diagnostic Usage Page (add links to the shot days for easier navigation to RIDs with diagnostic setups)
3. Make EP UV optics transmission measurements readily available to users (Final testing this week)
4. Dante maintenance and documentation improvement
5. Make calibration data readily available on PI portal
6. Characterization of Gas Jet Nozzles



Plans are in place to address many of the 2021 OLUG F&Rs

UR LLE

7. Characterization of Standard Proton Source on EP
8. Calibrate CPS 1, CPS 2 and MagSPEC with a Ra-221 source
9. Bragg crystal inventory and characterization for SXS
10. Add a timing fiducial to Dante – will consider in Dante sustainment with LLNL
11. Fix SSCA UV timing fiducial – available only on OMEGA-60
12. ASBO/SOP on EP TIM14
13. Add OTS Diagnostic to EP
14. More Streak Camera Options for time-resolved x-ray spectroscopy
    –SSCA modernization will include additional x-ray streak cameras – more in spring OLUG
15. Upgraded detector-finger holders for CPS1 and 2
16. Time resolved x-ray history measurements in high neutron-yield environments
17. Capability to infer directional flow vector on D2-gas-filled or low DT yield implosions on DT shots for compatibility with DT3He backlighter

Plans are in place to address many of the 2021 OLUG F&Rs

18. 3rd VISAR leg on ASBO at EP and/or OMEGA – will investigate during sustainment project
19. Additional photocathode options for PJX2 and PJX3
20. Improve accuracy of SSCA data acquisition time
21. Bragg crystal inventory and characterization for SXS
22. Implement quick-look for CR-39-based proton radiography
23. Add planar Cryo on EP
24. Increase UV power on EP
25. OMEGA: Any beam, any delay (or at least a 3rd leg)
26. Opposing EP beams
27. Smaller DPPs on EP
28. SSD on EP
29. Shared VisRad License for Basic Science Users from US Universities

Summary/Conclusion

OLUG APS-DPP update - LLE continues to address needs and concerns of Users

UR LLE

- Progress continues on prior year OLUG Findings and Recommendations (F&Rs)
- LLE has developed a sustainment plan to extend Omega into the 2030's as part of the next Cooperative Agreement
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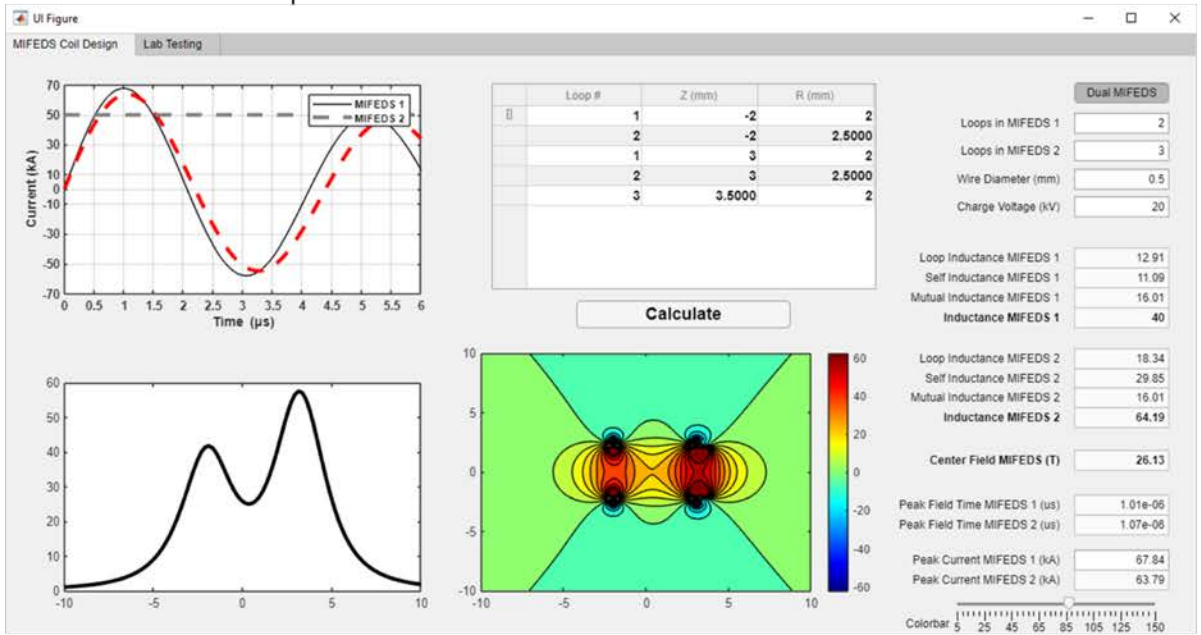
- An LLE building expansion is in final design

Extra slides

A Matlab GUI design tool has been developed for MIFEDS magnetic field calculations

- **MATLAB GUI-based tool calculates the B-field profile for user-designed coil configurations**
  - Single or dual MIFEDS
  - Number of loops, location and size of each loop

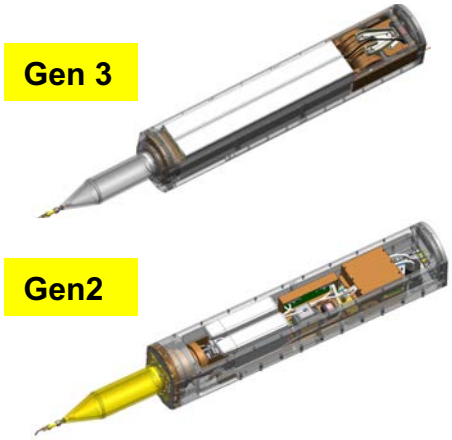


Contact Jonathan Peebles for information:
jpeebles@lle.Rochester.edu

Upgrades to the MIFEDS system – OLUG 2016 recommended higher field in larger volume

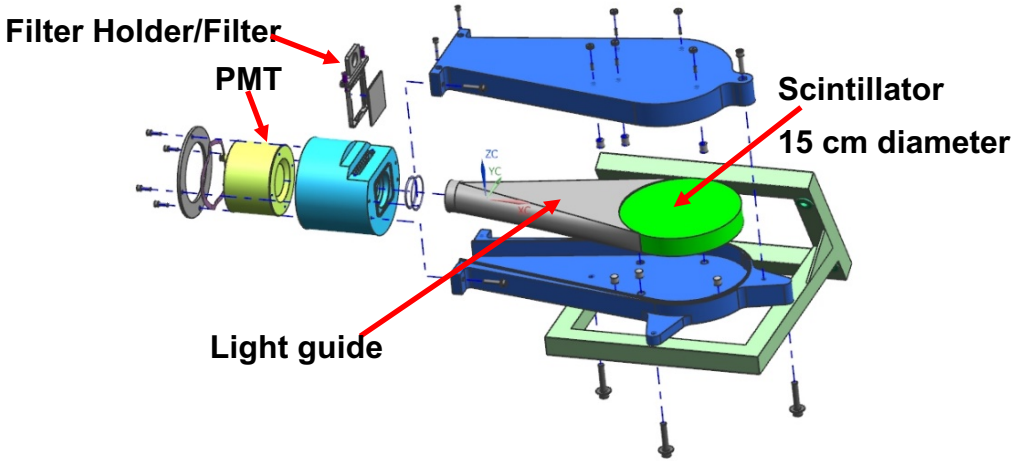
- **Generation 3 of MIFEDS underdevelopment will have more than 10 times of the energy storage of Gen 2**
  - Gen 3 qualification in process
- **Some improvements of Gen 3 will be backwards compatible with Gen 2.x**
  - MIFEDS Gen. 2.x is available
- **MIFEDS gen 2 and 2.x will keep current magnetic field capability as gen 3 comes online**

	MIFEDS 2 (3 avail.)	MIFEDS 2.x (upgrades)	MIFEDS 3 (completely new)
Distinguishing characteristics	**Qualified design**	**Higher capacitance, modified T-line, Coil holder**	**New design, External charger**
Stored energy (J)	**200**	**450**	**2200**
Rise time (μs)	**0.5**	**0.7**	**0.9**
Max op. voltage (kV)	**20**	**20**	**30**
Field over 1 cm^3 (T)	**4.3**	**9.0**	**18.6**



LLE developed and built three neutron diagnostics for the ARPA-E fusion program

Three plastic scintillator based neutron detectors: 7x4, Large, Fast for increasing yields, Fast can determine neutron-averaged ion temperature.
(Contact Jonathan Davies, jdav@lle.Rochester.edu for details)



Key Properties	
Plasma parameter range	> 10^2 incident neutrons, >10^4 for ion-temperature measurements
Resolution (time)	0.1 ns
Resolution (energy)	0.1 keV
Form factor: operation	Detector(s) plus cables to digitizer, scope and HV supply
Other characteristics	Active areas: 7x4 248 cm^2, Large 177 cm^2, Fast 100 cm^2
Transportable	Ships in Pelican cases 31.28 x 24.21 x 17.48 in

The OMEGA EP laser facility participates in the LaserNetUS research network

- First experiments were in 2019
- Five shot days are scheduled in FY22, cycle 3 underway
- Cycle 4 shot time starts in July 2022, proposals due 10 December 2021
- EP provides four kJ-class beamlines
  - Two short-pulse capable (0.7-100ps)
  - Flexible experimental configurations
  - Optcical, x-ray, and particle diagnostics
- Supported by the Office of Fusion Energy Sciences

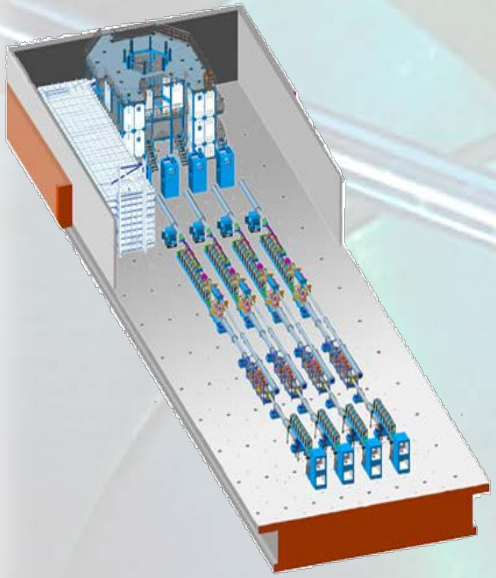
https://lasernetus.org/

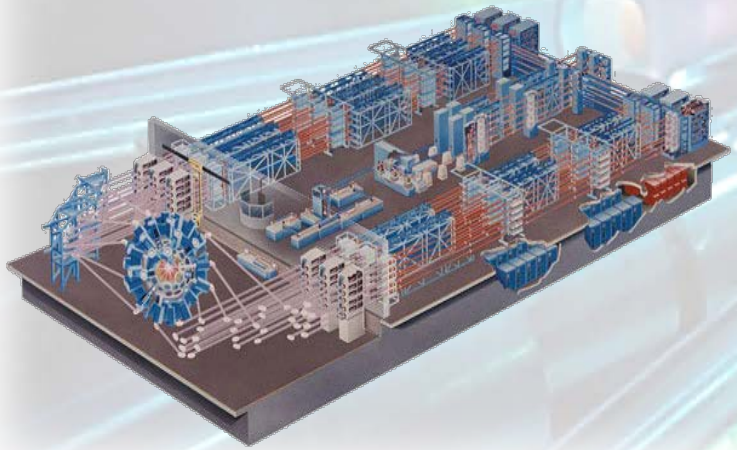
QUESTIONS ?

Join us at the

13th OMEGA Laser Users Group Workshop

27-29 April, 2022, Rochester, NY





- ***Outstanding invited talks on HED science and the OMEGA facility***
- ***Review progress on the* Findings & Recommendations from the 2021 Workshop**
- ***Poster Sessions on diverse HED Science and Technology***
- ***Student-postdoc Town Meeting with Facility Recommendations***

Tour of OMEGA EP Facility

2018 Workshop Attendees

For student & postdoc Workshop scholarships, contact either
Johan Frenje (jfrenje@psfc.mit.edu) *or* Pia Valdivia (mpvaldivialeiva@ucsd.edu)