Mid-scale Research Infrastructure (RI) Project Status Report (PSR)

Budget and Schedule Reporting as of June 30, 2025
Technical (Project) Reporting as of June 30, 2025

Project Title and NSF award number: NSF OPAL, PHY-2329970

Principal Investigator (PI): Jonathan Zuegel
Project Manager (PM): Elizabeth Hill
Recipient and Lead Institution: University of Rochester
NSF Cognizant Program Officer (PO): Slava Lukin

I. Summary of Project Progress in Terms of Budget and Schedule Status

[REMOVED]

II. MILESTONES

The seventh quarter of the NSF OPAL project (March 1 to June 30, 2025) focused on the Facility Conceptual Design with successful completion of a Conceptual Design Review and commencing preliminary design efforts.

A. NEAR-TERM MAJOR MILESTONES (1-6 months)

Milestone /Activity Description	WBS	Planned Date	Actual Date Forecasted Date	Variance (mths/wks/days)
Project Conceptual Design Review	WBS 1.1	03/05/2025	04/22/2025 (A)	(0/6/0)
Submit draft Annual Report	1.1	07/30/2025	07/30/2025 (F)	
Community Update Changes post CDR	1.1	08/06/2025	08/06/2025 (F)	
Submit PEP revision	1.1	09/01/2025	09/01/2025 (F)	
Submit Annual Report	1.1	09/15/2025	09/15/2025 (F)	

Variances:

- None at this time

B. LONG-TERM Milestones (1-5 years)

Milestone /Activity Description	WBS	Planned Date	Actual Date Forecasted Date	Variance (wks/mths)
Project Preliminary Design Review	WBS 1.1	9/30/26	9/30/26 (F)	

Based on a recommendation from the Site Visit Panel the project team is assessing appropriate Level-0 milestones to add to the project plan.

III. Risks Management and Contingency

Risk ID Number	Risk Title	IF/THEN	Probability	Mitigation Plan(s)
R-001	PGL Business Plan	IF PGL has to adapt their overall business plan to address changes THEN aspects of the NSF subaward may not be completed	Low (>0.1 but <0.4)	LLE to continue in-depth discussions about PGLs long-term financial constraints and succession plans so UR/LLE can react and help prioritize as needed (e.g., develop alternate options for any aspects of their process that, in principle, could be done elsewhere, such as full-aperture figuring.)
R-002	Sole-source Grating Provider	IF PGL is unable to produce gratings large enough to meet the objective requirements for on-target peak intensity THEN portions of the science case may not be possible after completion of a construction project	Low (>0.1 but <0.4)	LLE to develop plans for sub-aperture activation at reduced intensities using the largest gratings commercially available from other sources (e.g., Horiba Jobin Yvon, LLNL), where much of the critical laser & experimental activation can be completed while sources of full-aperture gratings are being developed. LLE to develop back-up concepts for achieving the full-aperture beam size by tiling two gratings at the G2 and G3 locations where additional considerations due to 20-fs pulse width such as piston error may be addressed using segmented-mirror system
R-003	Procurement Delays	IF PGL is not able to order parts for NR5 and related systems as their schedule dictates THEN insufficient progress may be made on demonstrating the viability of NR5 and the related subsystems.	High (>0.6 but <0.8)	LLE to pursue options to reduce lag-time issues with PGL's procurements (e.g., immediate invoicing by PGL), or to purchase the items directly, making them available for PGL
R-004	NNSA Complementary Efforts	IF any of the complementary efforts (meniscus coater or ion-beam figuring) funded by the LLE NNSA Cooperative Agreement are stalled or delayed THEN PGL may not be able to demonstrate 1.4m scale gratings by the end of the RI-1 period	High (>0.6 but <0.8)	Meniscus Coater: LLE to place the order as soon as possible with the up-front payments needed to secure the design services from the 3rd-party consultant (Jerry Britten), the only person suited for this task, and complete the detailed CAD Precision Stage for Full-scale Parts: PGL to continue pursuing mechanical parts required to guide the stage from vendors like Toto (Japan) that make machinable ceramics with very flat surfaces. LLE to support up-front payments, as needed, for PGL to purchase parts Fringe-locking Controls: PGL to continue testing a new board provided by MIT; find alternate microprocessor and buy a life-time supply of boards, which requires cash flow for the ~$45k order. Ion-beam Figuring: PGL to consider alternate paths to obtain finished substrates. LLE to share plans for procuring other types of large-aperture optics required elsewhere in the system.

The above table summarizes risks identified in the NSF OPAL PEP Revision C; no risks have been realized during this reporting period. The risk register is undergoing a significant update following the project CDR. The updated risk register will be included in the annual report.

See Technical Progress (design team) section below regarding risk and scope management related to the PGL subaward.

No budget contingency allocations were made during this reporting period. At least one contingency draw is expected next quarter for the OPAL Communication role.

[REMOVED]

IV. Detailed Cost and Performance Data

[REMOVED]

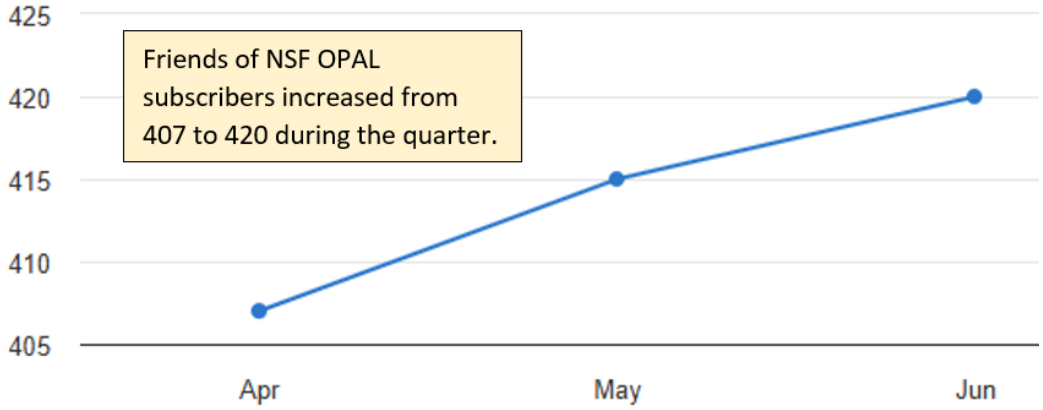
V. Financial Summary

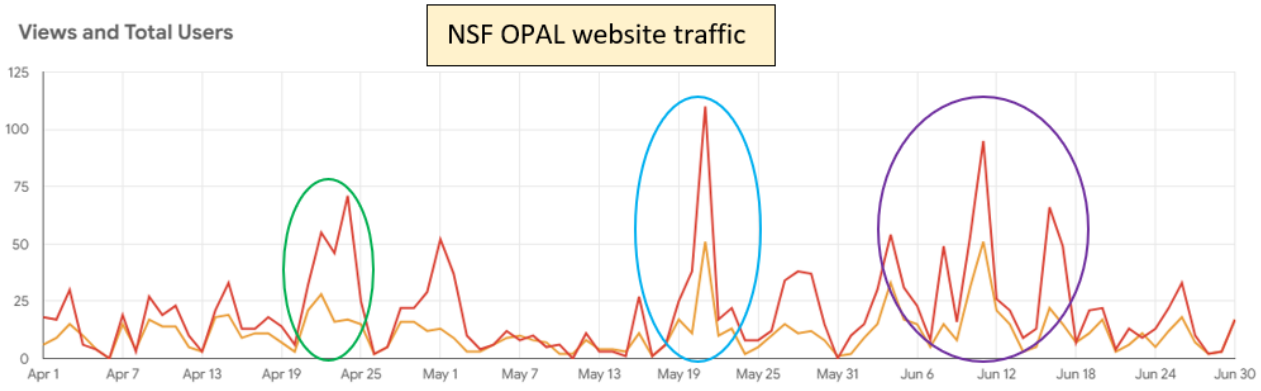
VI. [REMOVED]

VII. Project Status (technical) progress

Community engagement:

- The "Friends of NSF OPAL" mailing list subscribers increased by 13 this quarter to 420 registered participants. Subscription increases and spikes in www.nsf-opal.rochester.edu web site views correlated with holding the Conceptual Design Review in April, exposure to the OLUG community at the OLUG meeting poster session in May, and a LinkedIn posting about the CDR in June.





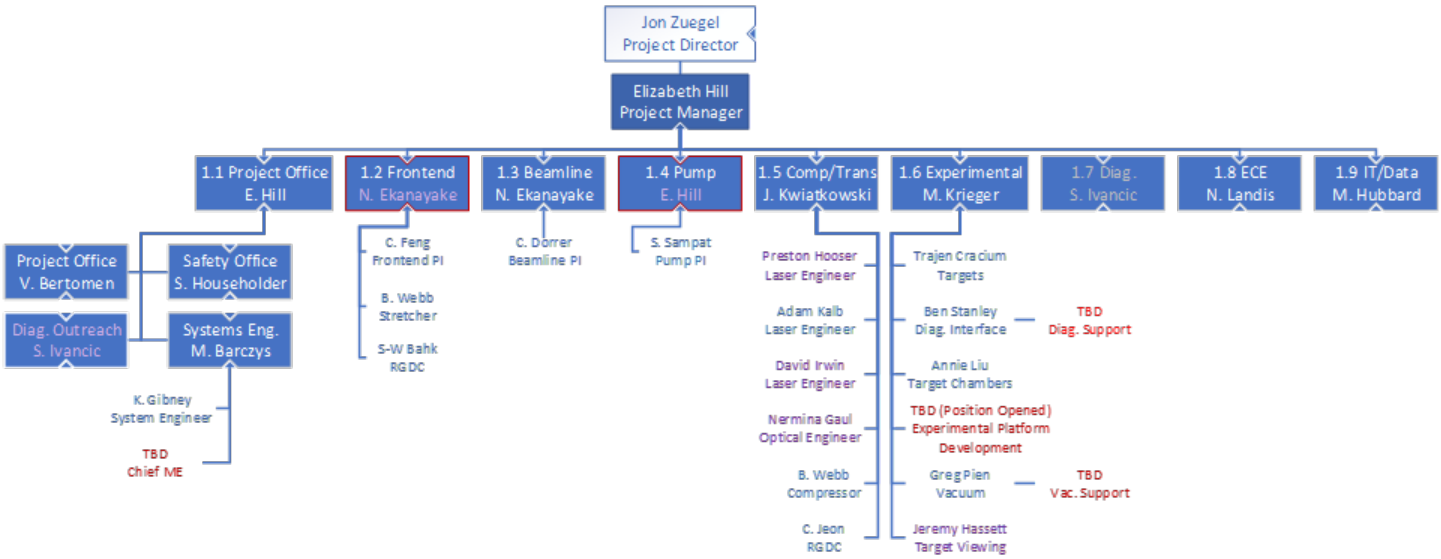
Event Timing:
22-23 Apr → CDR
20-22 May → OLUG
04 Jun → LinkedIn post about CDR

- External project communications related included:
  - seven talks and poster presentations at conferences and workshops (CLEO, OLUG, SPIE Optics + Optoelectronics, international target fabrication workshop, ELI User Meeting),
  - talks and discussions during two in-person visits to Heidelberg and Oxford universities,
  - discussions during a visit by Florida State University (FSU) nuclear physics researchers to LLE, and

- four manuscripts submitted for publication (three to a special collection of Physics of Plasmas and an invited manuscript to Plasma Physics & Controlled Fusion).

Technical Progress (design team):

- The RI-1 project successfully completed a conceptual design review (CDR) on April 22-23, 2025. The CDR was streamed on Zoom, in addition to in-person participation by the RI-1 design team and local subject matter experts not involved with the project, with participation by 224 members of the scientific community registered from 59 institutions.
- Based on feedback from the CDR, the project has identified two areas where additional technical risk could be pursued to reduce the potential construction project cost. To pursue these areas, the WBS 2.2 Grating subaward to PGL was paused while the project team reassessed the needed funding profile to complete the Nanoruler5 (NR5) design and to defer NR5 construction. NR5 construction costs will be redirected to (1) prototyping low-cost, lightweight, mirrors and (2) improving the Laser Induced Damage Threshold (LIDT) of Gratings and SP Transport Optics to enable smaller optics.
- The NSF OPAL facility layout progressed to a configuration that requires less space, plus additional simulations showed that less concrete radiation shielding than presented at CDR can meet requirements. Together, the reductions in concrete alone correspond to an ~$20M reduction in estimated laser and target bay construction cost. Prospects exist for realizing additional savings.
- **WBS 1.1 (Project Management & System Engineering):**
  - Project Manager (PM)/Deputy Project Manager (DPM):
    - Created a new role in the project office for Diagnostic Community Development. Efforts within WBS 1.7 will pause while the project team works to build up a diagnostic community ready to join the construction project team to do the needed diagnostic development.
    - Worked with the LLE Engineering Director and Mechanical Engineering team to identify an 'NSF OPAL Chief ME' to coordinate the internal and external recruiting of resources to support the preliminary design and provide oversight of the design process and standards.
    - Identified Nagitha Ekanayake to lead WBS 1.2 (Front End Laser Systems). Nagitha currently leads WBS 1.3 (Beamlines) and he has developed deep experience in both areas while working on the LLE FLUX project. WBS 1.2 and 1.3 were separated originally with different PIs, but a single resource can manage the project management and engineering efforts for both areas since they are inextricably linked.
    - The lead for WBS 1.4 (Pump Lasers) and WBS2.1 (ACoDA development) changed from Alex Bolognesi to Elizabeth Hill (acting). Alex decided to step back from project management roles to focus on contributing to technical matters.



  - In response to an NSF site visit panel recommendation to "implement training in project management basics for all WBS managers and other appropriate Project personnel," the Project Management Team started conducting monthly training opportunities on the following topics: Schedule Basics, Change Control Process, and Risk Management. Additional topics have been identified for training to be conducted each month. Completed the first monthly project management training on Scheduling Best Practices with all WBS Leads
  - Interviewed three candidates for the OPAL Communications role and plan to make an offer to the top candidate early in the next quarter.
- System Engineer (SE):
  - Focused primarily on CDR preparations, including:
    - Systems Engineering content preparation for three talks (Facility Overview and Requirements, Facility Concept of Operations including Safety, and Alignment Systems)
    - Slide review and quality control for all CDR talks
    - Hybrid meeting preparation and coordination (Zoom meeting and Slack channels)
    - Website updates, CDR communications and CDR content publishing
  - Published initial draft of subsystem requirements for CDR.
  - Continued implementing change-control process workflow. Completed the initial Change Request form and linked it into the Azure DevOps tool. Used the form for several initial Change Requests. Continued implementation of tools for assessing change impacts.
  - Moved the official WBS Dictionary from temporary Smartsheet to permanent Azure DevOps so that all requirements, interfaces, change requests can be directly linked to the WBS elements in the dictionary.
  - Facilitated and participated in key facility architecture discussions (including beam size, HEEL facility layout) related to post-CDR efforts to reduce cost to construct OPAL.
  - Collected WBS Level 3/4 interfaces from WBS 1.5 Compression & Beam Transport and imported into Azure DevOps. The method will be re-used with other subsystems.
  - Completed four training sessions from Modern Requirements4DevOps; increased awareness of tool capabilities that will be used to continue developing requirements and interface management, as well as Change Control processes.
  - Onboarded UR undergraduate student, Nyaradzo (Valery) Mararanje in May. Valery will work through the summer in the LLE internship program on a few projects related to Systems Engineering and Project Management for NSF OPAL. She is a Computer Science major planning to graduate in 2026.

- UR undergraduate student, Nyaradzo (Valery) Mararanje, completed a first version of an “NSF OPAL Press Kit," a set of ~10 slides for anyone associated with the project to use to give a quick project overview to any audience.
- UR undergraduate student, Nyaradzo (Valery) Mararanje, started to analyze demographics in attendance data from key NSF OPAL events since October, 2023. Initial results were presented at the most recent NSF bi-weekly oversight meeting.
- Presented poster on NSF OPAL Facility Concept of Operations at the OMEGA Laser Users Group (OLUG) Meeting on May 21.
- Participated in interviews for NSF OPAL Communications position.

▪ Community Diagnostic Development:
- Transitioning WBS 1.7 tasking into WBS 1.6
- Hosted discussion with Project team on diagnostic community workshop, topics, agenda and scheduling.
- Developing workshop format and identifying key invitees from multi-PW community.

- **WBS 1.2 (Front-end System):**
  - Prepared for and presented at CDR.
  - Documenting system and sub-system interfaces
- **WBS 1.3 (Large-aperture OPAs):**
  - Updated NOPA-J and NOPA-k simulations with reduced beam-size requirements. In the updated configuration, the signal beam size is kept the same for NOPA-J (80 mm FWHM at output) and reduced for NOPA-k (270 mm FWHM at input). This resulted in a change in the magnification for the proposed OAP-based AIR (between NOPA-J and -k) from M=3.625 to M=3.375.
  - Updated the WBS 1.3 switchyard layout based on the updated NOPA-J and NOPA-k simulations as well as other constraints due to building size reductions, personnel access and feedback received from WBS 1.2, 1.4, and 1.5.
  - Discussed the requirements for a green-bypass beam (from WBS 1.4) for alignment purposes.
- **WBS 1.4 (OPA pump systems):**
  - Continued making improvements to the AMICA laser used in the FLUX system.
  - Made progress updating AMICA laser injection table design, started preliminary optical design, completed critical B-integral modeling of AMICA with ACoDA implemented, and completed a preliminary layout to better define the system space claim.
- **WBS 1.5 (Pulse compression/beam transport):**
  - Welcomed two new engineers, Preston Hooser and Dave Irwin, to the WBS1.5 team.
    - Preston will work on designing Transport and Focusing and In-tank Diagnostics. Started detailed mechanical design of mounts and vessels
    - Dave will work on designing Short Pulse Diagnostics and Grating Compression Chamber. Started detailed SP diagnostic package designs
  - Prototyping low-cost, lightweight large mirror substrates:
    - Met with Display Optical Technologies Inc (DOTI) and Corning. Will meet with General Atomics early in next quarter.
    - Started to identify path forward on sub scale, lightweight optic prototyping
  - Started redesign of grating pulse compressor and beam transport for new 62.0-cm beam size
    - Finalized transport layout and optical model to optimize Lower Target Bay operational access and reduce building cost
    - Started detailed large-optic transport design (structure/mounts, vibrational analysis)
    - Understand proposed higher risk scenarios in transport design
  - Updated OMEGA EP beamline model in Zemax and started modeling beam transport to target bay.

- Worked with PAALS1 experimental team on more detailed design. Considered reorientating HEEL chamber to W-E axis versus baseline N-S axis.
- Finalized baseline three-beam layout in main target chamber (MTC) for HFP-QED2 (stimulated photon-photon campaign) flagship experiment to provide needed polarization
- Started focal spot microscope (FSM) design and optical modeling
- Updated interface/subsystem documentation for PDR in mrdevops.
- Updated technical/engineering requirements for PDR.
- Updated cost-estimate for large optics.
- Liquid Crystal Devices (Douglass Schumacher, Ohio State)**:**
  - Completed design of a prototype plasma mirror with a size suitable for operating on a 4- PW laser and submitted it to OSU shops for fabrication. As machining progressed, the shops and graduate student Pedro Spingola iterated on the design, making additional improvements. Estimated completion is late June or early July. The OSU and LLE teams submitted a proposal for run-time on NSF ZEUS to perform a high-power test of the prototype and the OSU team consulted with ZEUS director Karl Krushelnick.
  - Resumed previous work to understand fundamentals of LC mixtures to improve the quality of LC films. The LLE team previously determined the smectic-nematic phase transition temperatures of the most successful mixtures and observed that we appear to be running close to the transition when we see best performance. Improved the accuracy of temperature measurements to see just how close we are.
  - Rebuilt the measurement apparatus to work with horizontal LC films (film normal vertical) to measure the effect of gravity. Completed tests using pure 8CB films and observed 0.14λ film flatness over the central 6-mm region of a 24-mm diameter in single-shot operation. Rep-rated operation typically improves significantly over single-shot, so both horizontal and vertical configurations should perform satisfactorily.
  - Two new undergraduate students joined the LLE team: Abby Bonino and Prathiksha Mangalasubaskaran. Abby started working with an Elcometer film coating machine to reproduce the coating technique for 8CB over apertures of different sizes. This should significantly speed the testing of new candidate LC materials that can then be further evaluated at OSU. Prathiksha will investigate the feasibility of casting and orienting LC materials based on blue phase LC materials, lyotropic systems based on biomaterials. These materials can be ordered into a monocrystal structure that is highly ordered and would be resistant to perturbations.
  - The LLE team awaits delivery of six columnar discotic LC materials from several vendors and researching still yet other vendors.
  - These project activities directly advance OSU graduate student Pedro Spingola towards his PhD. The experimental work on film formation is done by him with advising from Schumacher. Three undergraduate students have been or are on the project: Alex Frye (OSU), Maia Ross (LLE) and Jenny Zhao (LLE). Frye is working with Spingola. Ross and Zhao were working under the direction of Marshall and Urban.
  - Pedro Spingola will give an invited talk at the upcoming 2025 SPIE XXIX Liquid Crystals conference. He will also write a proceedings paper.

- **WBS 1.6 (Experimental Systems):**
  - Posted a position for OPAL Experimental Platform Development Lead, who will work with users to develop the new MTW-OPAL target area and work closely with NSF OPAL FSWGs to translate their requirements into designs. One very strong candidate already identified.
  - Implemented “N-S beam flip” into target bay design.

- Finalized top-level (large component) layout and integrated into architectural floor plan.
- Started mechanical design effort for several WBS1.6 subsystems
- Started working group meetings to address preliminary design efforts in the following areas:
  - PAALS1 in HEEL chamber
  - HFP/QED
  - target systems
  - target chambers
  - diagnostic interfaces
- Radiation Shielding team presented first quarterly technical review
- Presented two posters at the Omega Laser User Group (OLUG) workshop:
  - "NSF OPAL Experimental Systems Design" (M. Krieger)
  - "An Introduction to Target Deployment Systems for NSF OPAL" (T. Cracium)
- Hosted ~20 undergraduate physics students for tours at LLE that included discussions of NSF OPAL project. There was a lot of interest in future participation.
- Radiation Shielding (Igor Jovanovic, Univ of Michigan)**:**
  - Established a workflow for converting and importing CAD models into both the MCNP and FLUKA Monte Carlo simulation frameworks. Also identified and shared which solid types tend to cause issues during conversion, helping improve communication and model preparation going forward.
  - Imported the updated NSF OPAL geometry into FLUKA and streamlined the workflow for future imports and developed a graphical tool to assist with processing and visualizing FLUKA outputs more efficiently. Also imported the new geometry into Blender, enabling a more intuitive 3-D view of the setup, including support for a VR interface.
  - Performed preliminary simulations on the radiation environment for monoenergetic neutrons at 20 MeV.
  - Conducted a series of simulations and used the results to compile a table showing the highest dose levels around the facility, under different wall thickness and beam configurations, both inside and outside the outer wall. This table will support the building team in determining appropriate wall thicknesses.
  - Started conducting preliminary sky-shine simulations using varying roof thicknesses.
  - This project supports one PhD student at the University of Michigan.

- **WBS 1.7 (Diagnostic Development):**
  - Started transitioning WBS 1.7 elements into WBS 1.6 "Experimental Platform Development" and WBS 1.1 " Diagnostic Community Outreach"
  - Focal Spot Diagnostics (Wendell Hill, Univ of Maryland)**:**
    - The team submitted two papers for publication:
      1. “Ponderomotive-expulsion: toward creating an electron-free volume," Smrithan Ravichandran, et al., Physics of Plasmas.
      2. "The focus of an ultraintense laser," Luis Roso, et al., Progress in Ultrafast Intense Laser Science XVIII, Topics in Applied Physics.
    - Continued preparations for an Apollon experiment now scheduled for November 2025. Assembled all components of the magnetic spectrometer and calibrated the magnetic field. Designed mounts for the MiniPIX particle trackers and now simulating the response of spectrometer and trackers to ejected electron trajectories incident on the spectrometer.
    - Completed theoretical analysis of the vector field associated with the a tightly focused flat-top pulse, which will allow completing data analysis of the ZEUS prototype measurement of the

energy as a function of ejection angle of electrons born in the focus and accelerated and ejected from the focal volume.
  - — Responded to reviews of a manuscript submitted for publication on analysis of tightly-focused, flat-top vector pulses from an off-axis parabola and began simulating electron dynamics in this focus, which will be applied to our ZEUS measurements.
  - — Have started engaging ELI-NP staff regarding beam time on NP on ponderomotive clearing of the focal volume as a follow-up to a proof-of-principle experiment.
  - — U.Md. graduate student Smrithan Ravichandran competed and won first place in the campus-wide Three-Minute Thesis (3MT) presentation award.
  - — Smrithan Ravichandran was selected to receive a travel grant to attend the 2025 ELI User meeting at ELI-ALPS in Szeged, Hungary in June. He gave a poster presentation about work related to the HFP-QED2 flagship experiment that was awarded "Most Innovative Idea" award.
  - — Smrithan Ravichandran was selected to the HED Summer School at UCSD in July.
- **WBS 1.8 (Controls):**
  - Reviewed the initial staggered support timeline to understand the implications to controls support. Developed a plan that lines up with the staggered needs of the system ramp up
  - Started planning expected ECE effort based on the functional need-based timing estimates for each subsystem. Developed new plan in SmartSheets.
  - Developed summary of best design practices for a high-EMI environment and researched expected NSF OPAL EMI conditions
- **WBS 1.9 (IT Systems):**
  - Made limited progress while other WBS designs make progress related to IT/Software.
  - Reviewed operating system patching and maintenance procedures, application versioning, and application deployment strategies with IT team.

Technical Progress (prototyping):

- **WBS 2.1 (Actively cooled disk amplifier, ACoDA):**
  - Continued ACoDA flow testing with candidate liquid coolant.
  - Advanced ACoDA prototype design to prepare for procuring parts. Started vendor selection for cutting ACoDA laser glass.
  - Completed critical B-integral modeling of AMICA with ACoDA implementation.
  - Revisited laser amplifier disk configurations that do not need cladding in response to an exorbitant quote from Zygo to clad laser disks.
    - — The leading option would replace liquid coolants with air cooling, which allows using an AR coating on the laser disks and thermally decoupling the cladding from the laser glass. Initial modeling indicates that this approach would still meet a 5-minute shot rate.
    - — Eliminating liquid coolants enables design that do not require windows for each disk cassette, which will significantly reduce the total system B-integral.
    - — Optical Manufacturing started testing sol-gel AR coating on spare laser glass samples.
    - — Mechanical Engineering started looking at ways to mount disks without windows.
  - An RIT co-op undergraduate student worked on ACoDA-related R&D.

- **WBS 2.2 (Extra-large (XL) diffraction gratings, Plymouth Grating Laboratory subaward):** Based on feedback from the CDR, the project identified two areas where additional technical risk could be pursued to reduce the potential construction project cost. To pursue these areas, the WBS 2.2 Grating subaward with PGL was paused while the project team reassessed the needed funding profile to complete the Nanoruler5 (NR5) design and to defer NR5 construction. NR5 construction costs will be redirected to (1) prototyping low-cost, lightweight, mirrors and (2) improving the Laser Induced Damage Threshold (LIDT) of Gratings and SP Transport Optics to enable smaller optics. NR5 design efforts resumed.

  X-Y Stage (WBS 10.2):
  - Met with prospective granite and air bearing vendors
  - Performed FEA on box beam structure model. Redesigned box beam structure.
  - Y-Axis Guide Beam; design 99% complete; received very competitive quote from US-based supplier (CoorsTek)
  - X-Axis Guide Rail received from THK
  - PO being prepared for granite (vendor = Tru-Stone)

  Enclosure (WBS 10.3):
  - Fan control module built and tested, and fan balancing performed by Lindskog Balancing

  Exposure Optics/Laser (WBS 10.4):
  - Successfully wrote a CEA focusing 3w grating on NR2 using solid-state Genesis laser. Continuing its use for grating production to demonstrate long-term suitability. Continued using Genesis laser on NR2 for grating production. Made design changes to NR5 optics based on experience.
  - All remaining optical and opto-mechanical components ready to be ordered.

  Fringe Locking (WBS 10.5):
  - Major BSL software bug discovered and resolved. Now able to fringe lock on test platform!
  - Began programming of Highland Technology analog card.
  - Continued testing of new frequency synthesis cards (FSCs) at Izentis; two cards received in June. Ordered Rev 2 FSC board spin; will include modern/faster MCU, status LEDs, and USB interface for improved troubleshooting

  PSD Measurements (WBS 10.9):
  - Tested MESO Shack-Hartmann sensor at Imagine Optics. Met with Imagine Optics technical expert at Laser Munich.

  Key decisions upcoming: Focused on placing orders for as many fully specified items as possible in FY2025 but now holding back on most Pos, except time-critical items (e.g., granite block, DSP and FSC boards)
- **WBS 2.3 Large-aperture DKDP crystal production (Rhett Wampler, UR Optics PhD student)**
  - PhD student R. Wampler submitted a manuscript on image-based mapping technique to Optical Materials Express (OMEX)
  - C. Dorrer gave two talks at CLEO:
    - "Mapping the Phase-Matching Conditions of the Crystal Sector Boundary in Partially Deuterated KDP"
    - "Seamless LBO Bonding for Large-Aperture, High-Energy Laser Applications"
  - Ready to implement large-aperture mapping station once the large reference wedge is received
  - Worked on OPAL beamlines design and LBO aperture scaling.
  - Designed and implemented an experiment to determine the deuteration level of DKDP samples and started to characterize the deuteration levels (D between 70% and 98%)
  - Started testing of a new batch of diffusion-bonded LBO crystals from Gamdan.

Technical Progress (co-PIs):

- **Antonino Di Piazza, University of Rochester (UR, co-PI and leader of HFP/QED FSWG)**

- Continued working on QED cascade precursor paper.
- Introduced Kale Weichman (UR/LLE) to the collaboration on the flagship on cascades precursors and they will present their alternative and promising experimental configuration that uses micro-cone targets. The project with Bernardo Barbosa will be put forward too. Finally, my students will either continue (Reshad) or start (Adrian and Thomas) their projects.
- Established a connection to be part of the strong-field QED part of the Vulcan 20-20 Science Case and participated in the first meeting discussing possible experiments at that facility.
- PhD student Reshad Rahman continued making progress in his project on the production of electron-positron pairs with an high-intensity flying focus beam.
- Two students (Adrian Hosak and Thomas de Vos) received the Horton fellowship and planned the first steps in their projects, which are both related to NSF OPAL.
- Started a new project with John Palastro and a visiting student (Bernardo Barbosa) on the head-on collision of an ultra-relativistic electron beam and high intensity laser pulse in a micro channel.
- Responded to referees' comments on the photon-photon scattering paper and resubmitted it.
- Presented an invited colloquium at the College of William and Mary that included NSF OPAL project.

- **Franklin Dollar, University of California at Irvine (UCI, co-PI and leader of PAALS FSWG)**
  - Started ZEUS multi-PW experiments related to PAALS flagship. Performed a ZEUS 2-PW experiment related to PAALS Flagship 1. We performed the first multi-petawatt experiments in the US with up to 2 PW of peak power in a LWFA experiment. Measured betatron x-ray production and looked at novel geometries such as two-stage LWFA and long f/number filaments.
  - Worked with Frontier Science Working Group to determine effective means of tracking and collecting PAALS relevant results, conferences and workshops. Discussed potential forums where PAALS can better interact with other venues to broaden reach. Coordinated with FSWG on how to better convey results, workshops, and OPAL related events to the community
  - Recruited and onboarded two undergraduate students for summer research. Students will participate in simulation studies to better understand the capabilities of the NAF OPAL Beta beam for secondary source production.
- **Eva Zurek, University at Buffalo (UB, co-PI and leader of LAAP FSWG)**
  - Finalized section of a roadmap article on warm dense matter that was submitted for publication.
  - Recruited Ed Marley (UR/LLE) to serve on the LAPP working group. He brings expertise in time-resolved spectroscopic characterization of high-temperature, high-density plasmas from performing experiments at the National Ignition Facility and Jupiter Laser Facility (Titan and Comet lasers) at LLNL, and the Orion laser at the Atomic Weapons Establishment in the United Kingdom.
  - Gave an invited talk at the WATOC2025 meeting (World Association of Theoretical and Computational Chemists) on topics related to LAPP in a session on high pressures and magnetic fields. Discussed NSF-OPAL with other speakers in this session.
  - Eva will present at the CMAP school for undergraduates, and her presentation will feature NSF-OPAL. https://cmap.rochester.edu/education-outreach/ug-summer/
  - Started writing and invited forward-looking essay for PRL on topics related to LAPP and NSF-OPAL.
- **Ani Aprahamian, Notre Dame University (NDU, co-PI and leader of LDNP FSWG)**
  - Gave a seminar at the University of Rutgers Physics Department on tritium-beam experiments that generated much enthusiasm from the nuclear physicists.
  - Established collaborations with Hungary to enable nucleosynthesis calculations that involve tritium reactions.
  - Gave a colloquium and a seminar at the Rutgers University Department of Physics and Astronomy to enlist people interested in carrying out the tritium reactions from the nuclear physics components.

- The manuscript “Nucleosynthesis with Tritium” was accepted by Journal of Physics G: Nuclear and Particle Physics.
- Convinced one of our graduating seniors to apply for graduate school to study plasma physics at UR, MIT or Cornell. They accepted an admission offer from MIT.
- Planning for experiments in collaboration with OMEGA, NIF, and the tritium beam being developed at FSU's nuclear science laboratory.
- Planned summer research student talks on the potential for NSF OPAL at several institutions or summer schools:
  - 2025 summer REU program at Notre Dame University
  - 2025 NP3M Summer School at Indiana University (June 9-13, 2025)
  - 2025 Exotic Beam summer school at LBNL, June 22-28, 2025
  - 2025 National Nuclear Target Development School at Texas A&M, College Station, Aug. 15-19
- Discussed the tritium project with potentially interested groups.
- Sent an abstract on the tritium paper to the DNP Fall meeting.
- Also discussing some tritium-related experiments at Notre Dame ahead of the NSF OPAL project. Collaborating with scientist leading an effort at the US Air Force AETC AFIT/ENP (Air Education and Training Command (AETC) and the Air Force Institute of Technology's (AFIT) Department of Engineering Physics (ENP)).

VIII. Current Photos with descriptions

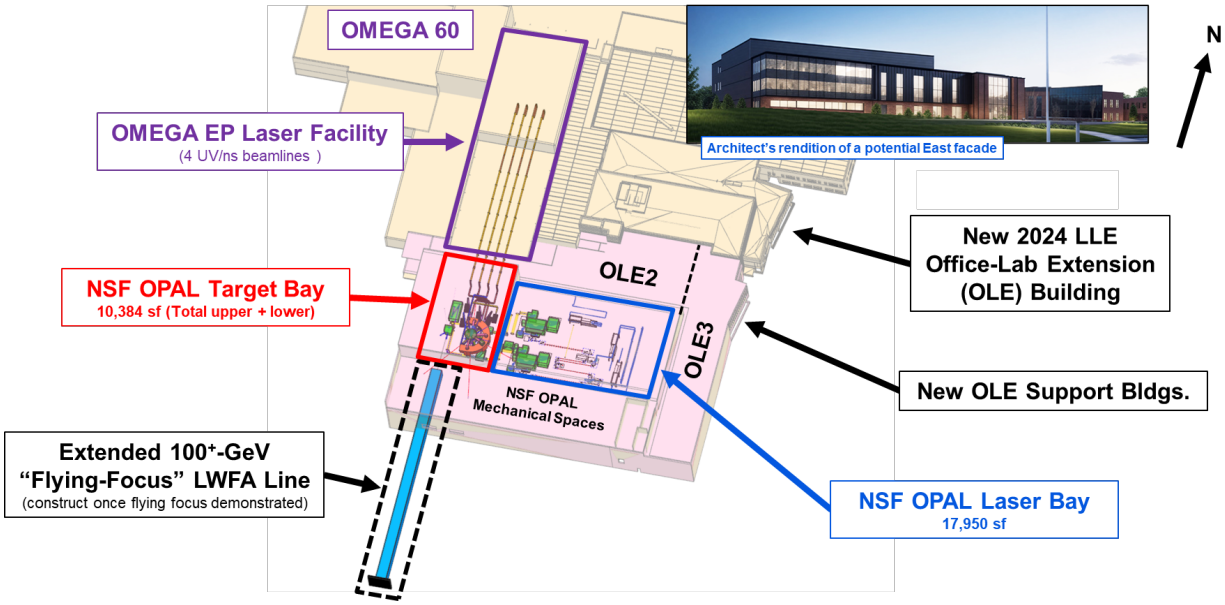


Figure 1 – The conceptual design of new construction added to the existing UR/LLE facility that houses the OMEGA-60 and OMEGA EP lasers. The construction includes the NSF OPAL user facility (laser and target bays) and associated mechanical spaces, plus new office-lab extensions (OLE2 and OLE3, potentially built sequentially) to provide NSF OPAL support spaces, offices, labs, and an open-access entrance. The inset shows an architect's rendition of a potential East façade of the new construction.

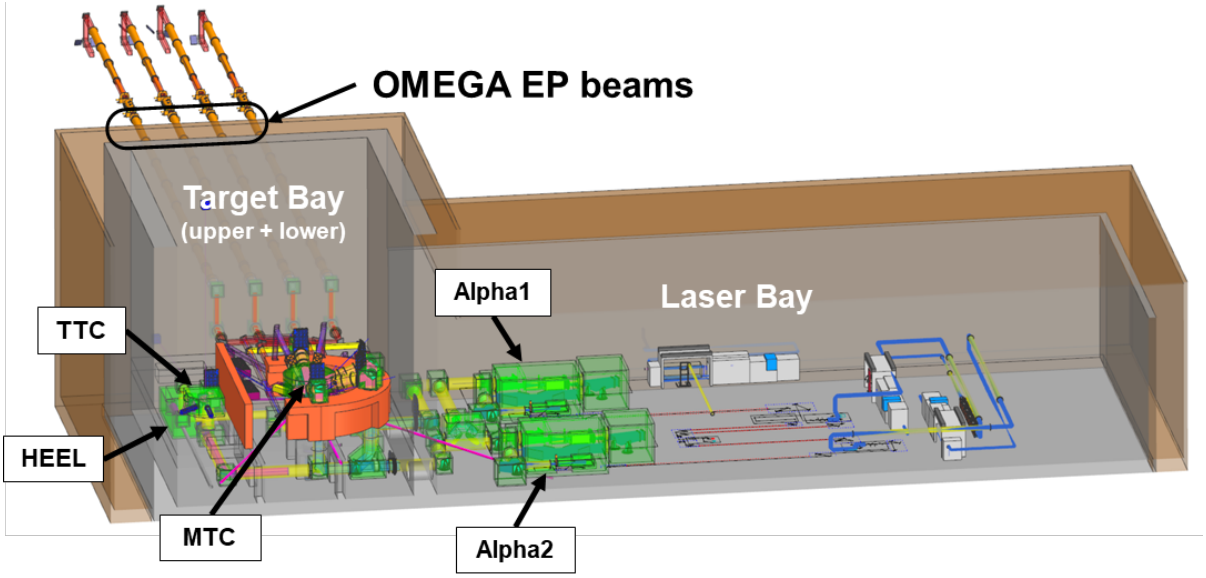
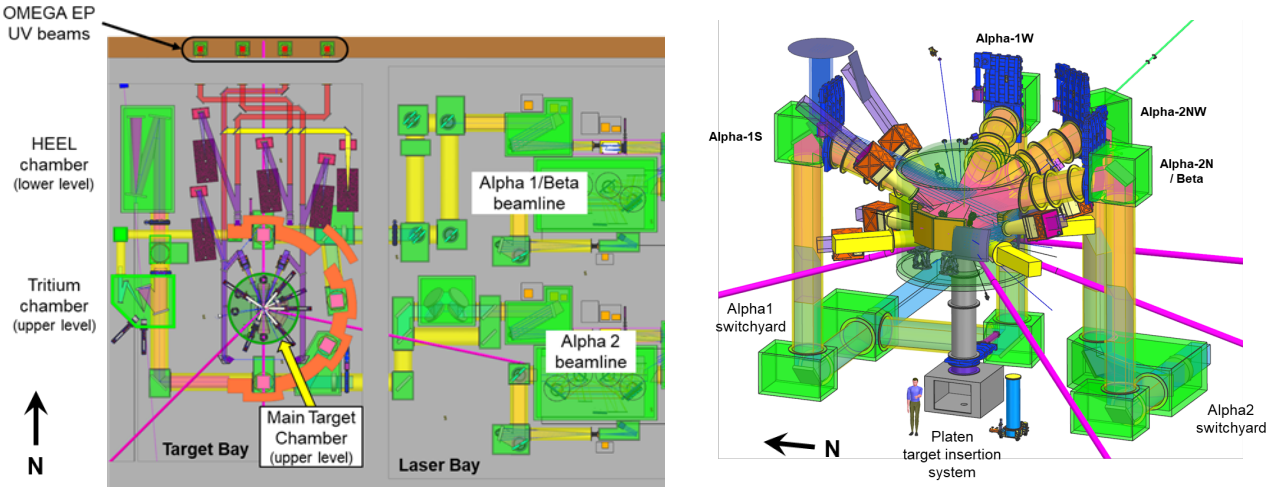


Figure 2 – NSF OPAL user facility design. The user facility comprises a laser bay with two 25-PW "Alpha" beams (optical design partly developed in three-dimensional mechanical design) and a two-level target bay. The upper target bay includes a main target chamber (MTC) that receives both OPAL "Alpha" beams and four nanosecond/UV beams delivered from OMEGA EP to perform to perform a range of experiments (LAPP1 and HFP-QED2 flagship experiments), as well as a tritium target chamber (TTC) that receives one "Alpha" beam and a 2-PW "Beta" beam to perform nuclear physics experiments (LDNP1 flagship). The lower target bay includes the high-energy electron line (HEEL) interaction chamber for laser wakefield acceleration experiments (PAALS1 flagship) that receives one "Alpha" beam, plus laser-beam transport to all target/interaction chambers, and an MTC "platen" target-insertion system.



(a) (b)

Figure 3 – NSF OPAL layouts. (a) Plan view of target and laser bays (upper target bay floor removed to show lower target bay). The two OPAL beamlines run East to West from their respective grating compression chambers with vacuum beam transport into the lower target bay at grade level. The beam transport delivers beams to the main target and tritium target chambers in the upper target bay, and the high-energy electron line (HEEL) in the lower target bay. A semi-circular concrete structure (orange) supports the OPAL beam transport and provides additional radiation shielding in the eastward direction. (b) Isometric view of main target chamber with switchyards that direct each Alpha beam to one of two configurations designated by the direction of the beam towards target chamber center. A platen target insertion system in the lower laser bay provides an air lock to deliver platforms pre-configured for experiments.

IX. **Appendices** - none