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

Budget and Schedule Reporting as of December 31, 2025
Technical (Project) Reporting as of December 31, 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): Vyacheslav (Slava) Lukin

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

[REDACTED]

Table 1. Project Summary Data Table

[REDACTED]

II. MILESTONES

The ninth quarter of the NSF OPAL project (October 1 to December 31, 2025) focused on advancing the preliminary design and kicking-off the next-generation mirror development effort. The first phase of developing next-generation, low-cost large mirrors started with placing orders with three companies to produce sub-scale mirrors using their proposed technologies. A Next-Generation Optical Materials and Components Workshop jointly sponsored by the Air Force Office of Scientific Research (AFOSR) will be held in January to identify R&D efforts that could be supported by the RI-1 project and/or complementary funding.

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

Milestone /Activity Description	WBS	Planned Date	Forecasted (F) or Actual (A) Date	Variance (mths/wks/days)
Optical Design Peer Review (part I)	1.1	10/15/2025	10/15/2025 (A)	0/0/0
ACoDA Project Status Review	2.1	11/12/2025	11/12/2025 (A)	0/0/0
NSF Site Visit	1.1	11/10/2025	12/01/2025 (A)	0/3/0
ACoDA PCU CDR	2.1	12/10/2025	12/10/2025 (A)	0/0/0
Kick-off meeting with EvolvOptic	2.5	12/17/2025	12/17/2025 (A)	0/0/0
Next-Generation Optical Materials and Components Workshop	1.1	01/12-15/2026	01/12-15/2026 (F)	
NSF OPAL Community Update	1.1	12/10/2025	02/24/2026 (F)	
External Advisory Board meeting #5 (EAB5)	1.1	03/04-05/2026	03/04-05/2026 (F)	
Multi-Petawatt Diagnostic/Detector Workshop	1.1	05/21/2026	05/21/2026 (F)	

Variances:

- The NSF site visit was delayed due to the government shutdown.
- The next NSF OPAL community update has been scheduled for February 24.

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

Milestone /Activity Description	WBS	Planned Date	Actual Date Forecasted Date	Variance (wks/mths)
RI-1 Project Preliminary Design Review	WBS 1.1	09/30/2026	09/30/2026 (F)	

III. Risks Management and Contingency

[REDACTED]

IV. Detailed Cost and Performance Data

[REDACTED]

V. Financial Summary

[REDACTED]

VI. Project Status (technical) Progress

Community engagement:

- The NSF Audience Masterlist has now grown to a total of 1680 contacts, a milestone supported by our LinkedIn community increasing to 555 followers and our 'Friends of OPAL' mailing list reaching 457 subscribers. Most notably, our Open Letter of Support has achieved a total of 836 signatures with over 300 of those signatures obtained during this quarter alone.
- J. Zuegel presented the opening keynote talk of Nuclear Photonics 2025 (NP2025) conference held October 6-10, 2025, in Darmstadt, Germany. The talk highlighted how NSF OPAL, along with the ultrashort-pulse lasers at the Extreme Light Infrastructure in Europe and the National Ignition Facility in the U.S., provide advanced laser capabilities and novel experimental opportunities.
- The RI-1 team hosted RAL-CLF target fabrication team to discuss collaboration opportunities. LLNL and GA have also expressed interest in working with NSF OPAL team.
- The RI-1 team hosted an interview by Joseph Kuczynski (Photonics Spectra) about NSF OPAL for a weekly newscast that was posted to YouTube (https://youtu.be/rQj3TgF0krs).
- A. Di Piazza taught a course, *Introduction to QED*, for ~20 graduate students at the Technical University of Eindhoven (8 lectures each of 1.5 hours).
- An NSF OPAL engineering team (Bromage, Nelson, LoMascalo) visited the ELI Beamlines and ELI NP facilities in December to learn best practices. Lots of good information shared on large optic mounts and vessel design. Plans for ongoing collaboration are underway. Debriefs were given to the OPAL team on discoveries. See photos in Sec. VII.
- M. Barczys gave a tour of Omega facilities to a group of about 10 URochester students (Chemical Engineering, Computational Biology, Data Science, Finance, Economics, and Biomedical Engineering). They discussed the existing LLE facilities in the context of similarities and differences with NSF OPAL.
- The RI-1 liquid crystal (LC) plasma mirror development team established a collaboration among OSU, the BELLA Laser Facility (LBL), and the ZEUS Laser Facility with ZEUS experiments planned in early 2026.
- A. Di Piazza participated in the ELI-NP Program Advisory Committee in Măgurele, Romania.
- J. Zuegel drafted and submitted an article about NSF OPAL to Optics and Photonics News (OPN), a magazine published by Optica for its members. The article will run in the March 2026 issue of OPN. A similar article is planned for Physics Today, published by the American Physical Society.
- Christophe Dorrer and Rhett Wampler, UR Optics PhD student, published a paper in Optical Materials Express (OMEX) about the imaging-based crystal mapping section.
- J. Zuegel visited ELI Beamlines on October 9, 2025 with LLE Director, Christopher Deeney. They toured the facility and met with the ELI team to discuss the planning, construction, user operations, and governance of a major ultraintense-laser user facility, like NSF OPAL.
- J. Zuegel participated in the Nov. 4-5, ELI ERIC ISTAC11 meeting and Nov. 5-6, "Exploring Cooperation: ELI and German Research Community in HEDP and High-Field Physics" workshop held in Dresden, Germany. The workshop included a presentation by Marvel Fusion to develop large-aperture second-harmonic generation (SHG) mirrors suitable for the L4f laser at ELI Beamlines that would demonstrate a basis for SHG mirrors used in NSF OPAL.
- F. Dollar presented a talk at APS DPP regarding recent ZEUS betatron results that relate to the NSF OPAL particle acceleration and advanced light sources (PAALS) science. Dollar also presented a talk about NSF OPAL at the HEDSA meeting during APS DPP. UCI summer undergrads also presented OPAL-related work at APS DPP.
- D. Polsin presented an invited talk at the APS DPP meeting that noted the May 20-22, 2026 MPW diagnostic workshop at U. Michigan.
- A. Aprahamian gave an invited talk at the Neutron Physics and Radiation Materials conference in Yerevan, Armenia. She also presented NSF OPAL and opportunities for potential laser-driven nuclear physics research enabled by it to students at the Yerevan State University.
- N. Valery Mararanje (UG intern) submitted a video to The Science Coalition Video Challenge that highlights her work in the NSF OPAL project and how scientific research benefits the country and the American people.

- WBS 1.6 (Experimental Systems) continued outreach to future NSF OPAL users to solicit design feedback. The team also received positive feedback on MTC design/capability from FSWG in weekly meetings.
- WBS 1.8 (Controls) personnel attended a Laser Lab Europe webinar about EMI research. The team met with visitors from Vulcan 2020 to talk about the EMI plans for their system.
- PIF2026 (Physics in Intense Fields 2026): A. Di Piazza leads the organization of the conference to be held in Rochester in July 20-24, 2026. This conference on high-field physics will be important for promoting NSF OPAL to the strong-field QED community. The financial situation has been finalized and the website prepared.

Technical Progress (design team):

- **WBS 1.1 (Project Management & System Engineering):**
  - Project Manager (PM)/Deputy Project Manager (DPM):
    - The team prepared for and hosted an NSF-only Site Visit on December 1.
    - The team set tentative dates for subsystem PDRs; started FDR resource loaded schedule.
    - Communications: continued to improve NSF OPAL exposure and connections with a broader audience.
      - Created five flyers introducing the four frontier-science working groups, plus NSF OPAL laser technology development to broaden exposure. Posted the flyers around URochester and SUNY Geneseo campuses, and at the 2025 SPIE Optifab conference. Provided PDF copies to co-PIs, subawardees and others to post at their institutions.
      - Curated nine LinkedIn posts that resulted 121 additional followers totaling over 500 connections
      - Created NSF OPAL Reddit post to expand outreach resulting in 7.3K views
      - Coordinated URochester, LLE, and DESY communications to highlight ERC Synergy Grant awarded to team including co-PI Prof. Antonino Di Piazza, LinkedIn post, and news highlights on URochester and NSF OPAL web sites
  - System Engineer (SE):
    - The project's undergraduate intern, N. (Valery) Mararanje, continued to play a key role in developing the Data Management and Sharing Plan for the project, which will incorporate aspects of cyberinfrastructure and AI. NSF OPAL design team members met with LLE AI/ML group to improve OPAL AI plans and to become more familiar with the Genesis Mission announced by the White House.
  - Community Diagnostic Development:
    - Sent announcements for the Multi-Petawatt Diagnostics Community Workshop that will be held April 20-22, 2026 after the NSF ECLIPSE meeting at U. Michigan to interested communities (e.g., OLUG, NSF ECLIPSE list, X-Lites, ZEUS user group). The workshop website now includes registration information.
    - Confirmed working group leads and continued programming plans.
- **WBS 1.2 (Front-end System):**
  - Initiated front-end preliminary optical layout design
  - Made some updates to the front-end preliminary optical design based on the feedback received at the WGM discussions
- **WBS 1.3 (Large-aperture OPAs):**
  - Reviewed the feasibility of using a metal wire grid-based attenuation for controlling NOPA-K output energy. Low damage thresholds of metals make this option less viable.
  - Met with the optical manufacturing team about optical coatings for the Beamlines section and received important feedback on setting coating requirements for the mirrors, beam splitter and attenuation optics that address all relevant wavelengths, polarizations, and tolerances for each surface of the optic. The guidance leads to additional system analysis and design concepts that might improve manufacturability. For example, changing the angle of incidence and/or polarization of the idler filter will be explored.
  - An optical designer, Maeve Bozarth, was added to the team to assist with modeling and calculations.
  - Set the post-NOPA-J switchyard baseline design to accommodate post-GCC optical path length differences that result for to baseline, minimum, and maximum delay configurations.

- **WBS 1.4 (OPA pump systems):**
  - Updated the schedule to PDR based on progress made by the complementary FLUX project and changes to the WBS 1.3 (large-aperture OPAs) schedule.
    - The FLUX AMICA has been fully qualified at energies relevant to the NOPA-J Pumps
    - The next shot day for FLUX is planned for the week of March 3. Preparations for this have required the engagement of multiple key resources for this WBS element. There was significant float in the schedule and this delay should not affect the project schedule
- **WBS 1.5 (Pulse compression/beam transport):**
  - Updated MTC f/# configurations to accommodate peak intensity requirement and near co-propagating geometry. Alpha N/S beams provide "high intensity" $5x10^{23}$ W/cm^2 configuration at F/1.72. Alpha W/NW beams provide "standard intensity" near co-prop configuration at F/2.31 that resolves mechanical interferences with diagnostic space envelopes. Mechanical/optical models updated with new setup.
  - Updated the Focal Spot Microscope (FSM) optical concept to move the back-end diagnostic package outside of MTC. Initial performance and sensitivity analysis looks very promising as it reduces mechanical complexity and EMI concerns. Mechanical packaging continues with new optical layout. Made good progress on the focal spot microscope (FSM) detailed design by solidifying microscope mount and stages and internal relay details. Will leave internal relay optics fixed and recover alignment for off-axis positions in the external diagnostic package.
  - Completed conceptual layout of short-pulse diagnostic package (SPDP) switchyard. Region near focal plane of Debrelay would accommodate all pre-shot, on-shot, and source paths with a single external diagnostic package. Continued optical modeling of short-pulse diagnostic package (SPDP) to map all paths in/out of diagnostic table(s).
  - Refined 2ω beam layout to minimize path length differences between Alpha1 and Alpha2, which alleviates extra requirements on WBS 1.3.
  - Proposed a simplified switchyard layout for OMEGA EP beams in target bay that reduces total number of mirrors and keep optics out of non-cleanroom space. Final decision depends on radiation analysis of the new beam hole location in the shield wall.
  - Made good progress on grating mount design and found a potential new vendor for the needed rotary stage.
  - Completed modeling of OMEGA EP IR imaging requirements. Relaxed the requirement for imaging to the frequency conversion crystals (FCCs), which allows removing the labyrinth of fold mirrors inside the OPAL Target Bay, reducing cost and simplifying beam mapping.
  - Kicked off design of co-pointing/co-timing (CoPAC/CoTAC) with working group meetings. Decided to use a small bit of the actual beam aperture for active correction pilot beams with minimal (< 1%) energy penalty, which avoids the need to oversize all optics.
  - Down selected vendors for low-cost mirrors and placed internal requisitions to develop and produce phase-1 components with EvolvOptic (Rochester, NY), Corning (Corning, NY), and Display Optical Technologies Incorporated (DOTI, Georgetown, TX). Held kickoff meetings with EvolvOptic and DOTI for low-cost mirror development. PO pending for Corning.
  - <u>Focal Spot Diagnostics (Wendell Hill, Univ. Maryland)</u>**:**
    - Completed preparations for and execution of a multi-week experiment (November 12 to December 12, 2025) at Apollon (Paris, France) "Ionization dynamics beyond 10^{22} W/cm^2: fundamental physics and in-situ intensity characterization." The goal was to measure the peak intensity by two methods: a direct measurement with a magnetic spectrometer of the maximum ejected electron energy, and a transverse kick of the parent ion measured with a time-of-flight spectrometer. See photos in Sec. VII.
    - Expected to observe electrons ejected with 300+ MeV of energy at 10^{22} W/cm^2, the published peak intensity at Apollon, at angles of 3° or less. Detected only a few electrons on detectors placed at about 5° with respect to a straight line to the focal volume without a magnet, which puts an upper bound of $\sim 2\times10^{21}$ W / cm^2 on the intensity. A transverse kick to the Argon ions was not observed as expected, which indicates the intensity was probably less than 10^{21} W/cm^2.
  - <u>Liquid Crystal Devices (Douglass Schumacher, Ohio State)</u>**:**

- Continued work on the 24-mm prototype LC film inserter that has four arms made of aluminum with wiper holders. Designed two new wiper holders and 3-D printed them with different angles of attack. These will be used experimentally to identify an optimum design. One failed to make films at all and the other formed films as good as original devices. The flatness of the 24-mm prototype LC inserter now works at the quality of the previous prototype, about 0.14 λ, but operating at much higher rep rate, about one film per minute, which would support the highest expected NSF OPAL shot rate at full power. One key issue seemed to be the changing direction of the wiper as it goes across the aperture. This always proves a factor when using a rotary geometry, but the large aperture exaggerated the effect compared to anything previously experienced. OSU graduate student, Pedro Spingola, carefully tailored the wipers to compensate for this effect successfully. See photo in Sec. VII.
- A new OSU graduate student funded by NNSA, Jonathan Wang, made on progress developing improved PIC models of plasma mirror (PM) operation in the regime relevant to pulse contrast enhancement. Modified a working PM PIC model running on WarpX to treat ionization in the multi-photon and tunneling regimes. It can handle cold, collisional plasmas with a material permittivity. The model we developed and used before this project was based on the PIC code LSP. It supported cold, collisional plasmas embedded in a material, but only had a simplistic multi-photon ionization model and ran more slowly. We are now focused on treating the formation of a pre-plasma prior to the main pulse due to pulse pedestal. 2D PIC simulations do not show the plasma mirror energy loss seen in experiment, so will switch to 3D simulations, at greater computational cost, to account for scattering effects.
- The ultimate version of an LC plasma mirror suitable for NSF OPAL at full power will need to employ a single-wipe, back-and-forth linear geometry. Such a design will be more complicated, but the overall size will likely be smaller as a bonus. Smaller versions of this type of plasma mirrors will likely prove useful for target experiments.
- Established a collaboration between OSU, the BELLA Laser Facility (LBNL), and the ZEUS Laser Facility for experimental time awarded ZEUS on the high-power TA1 beamline in 2026. It includes two weeks at the end of January and another two weeks at the beginning of April. The OSU team traveled to Michigan to discuss the project and the teams have met twice online to plan the January run, likely at 1 PW, and outline the April run, likely at 2 PW. Agreed on a basic experimental plan for January and now working to define the first run in January at the necessary level of detail (diagnostics, windows, feedthroughs, etc.). Results from January will inform the run in April. We expect that an early career scientist will join this project for the run at ZEUS.

- **WBS 1.6 (Experimental Systems):**
  - Finalized locations for NSF OPAL and OMEGA EP beams and all major main target chamber (MTC) components, including OPAL diagnostic inserters (ODIs), and target viewing system (TVS).
  - Made good progress on preliminary mechanical designs for all WBS 1.6 areas, notably:
    - FXPI - antechamber vessel port assignments and lift stage supports. Contacted lift stage vendor to confirm compatibility. Found COTS transport cart and docking system to move platens around the facility.
    - Rapid Target Deployment System (RTDS) – encoder selection is near final and will be reworked to fit smaller form factor, stages selection process has run into space issues – looking into alternatives
    - Main Target Chamber (MTC) - port layout and deconfliction, working on access and rigging around the chamber
    - Target Viewing System (TVS) – Requirements and conceptual designs reviewed, re-entrant telescope concept added to model and will need to be deconflicted
  - Working to build simplified radiation activation model to send to Berkeley for analysis
  - <u>Radiation Shielding (Igor Jovanovic, Univ of Michigan)</u>**:**
    - Performed simulations of local shielding made of high-Z materials. The results show it to be effective; however, a cost–benefit trade-off must be considered due to the higher (cost?) of high-Z materials compared to concrete.

- Expanded activation analysis by calculating radioisotope activities after 10 years of operation. A preliminary displacement-per-atom study of the target chamber indicated no significant radiation-induced erosion from facility shots.
- Simulations of a 125-GeV electron beam from the HEEL beamline revealed substantial muon production that penetrates beyond the shielding. While muons contribute little to dose due to their weak interactions with matter, this may be of experimental interest. Shifting the NSF OPAL beam angle from 18° to 22.5° was found to effectively reduce the dose in occupied areas outside the facility.. Improved the HEEL beamline dump design that is more efficient at stopping radiation and composed of cheaper materials.
- Simulated the changes in the radiation environment from building design changes and determined that some experimental configurations will require local shielding.
- Started running simulation and designing local shielding for the north-side beam penetrations that were previously determined to require local shielding. Radiation from X-ray generation experiments contribute a negligible amount of dose compared to other source terms.
- This project supports one Ph.D. student, UM Ph.D. student Xuanqi Li, who presented a poster at the APS DPP meeting in Long Beach, CA.

- **WBS 1.7 (Diagnostic Development):**
  - Dormant
- **WBS 1.8 (Controls):**
  - Started to look at details of component selection and integration. Added an electronics and controls engineering (ECE) group member to speed up progress with specific design choices in the areas that are ready for that level of support.
- **WBS 1.9 (IT Systems):**
  - Continued design of campaign management and laser/experimental configuration systems.
  - Continued design for application deployment and cyber security of workstations and servers.
  - **<u>Technical Progress (prototyping)</u>:**
- **WBS 2.1 (Actively cooled disk amplifier, ACoDA):**
  - Held a Project Status Review on November 12 that covered the new ACoDA baseline design that uses air cooling, required material and coating development efforts, the prototype design, and plans for prototype testing. See photo in Sec. VII.
  - Completed mechanical drawings for the cassette. Expect completion of drawings for the remainder of the prototype cavity by the end of January.
  - ECE team held a Conceptual Design Review for the ACoDA Power Conditioning Unit (PCU) that will update the 'traditional' PCU design to: use a solid-state switch in place of an ignitron, optimize the pump-pulse length to reduce waste heat deposited in the amplifier.
- **WBS 2.2 (Extra-large (XL) diffraction gratings, Plymouth Grating Laboratory subaward):**
  - Progress on X-Y Stage (WBS 10.2): On hold
  - Progress on Enclosure (WBS 10.3): On hold
  - Progress on Exposure Optics/Laser (WBS 10.4):
    - Received all remaining purchased NR5 optics (including custom Optimax lenses)
    - Calibrated coater C1 for most NR5 coating designs.
    - Now coating mirrors and beam splitters for NR5; 17% of optical surfaces have been coated
    - Reactivated NR4 stage and NR4 DMI system is aligned for testing designs.
    - Optics baseplate received
    - All remaining optomechanical components received; some installed on baseplate
  - Fringe Locking (WBS 10.5):
    - Mostly on hold.
    - Suspended collaboration with Izentis pending renewed funding.
    - Continued debugging frequency synthesis cards at PGL and demonstrated a successful multi-day writing operation; need to repeat; one failure mode isolated
  - Progress on PSD Measurements (WBS 10.9): On hold

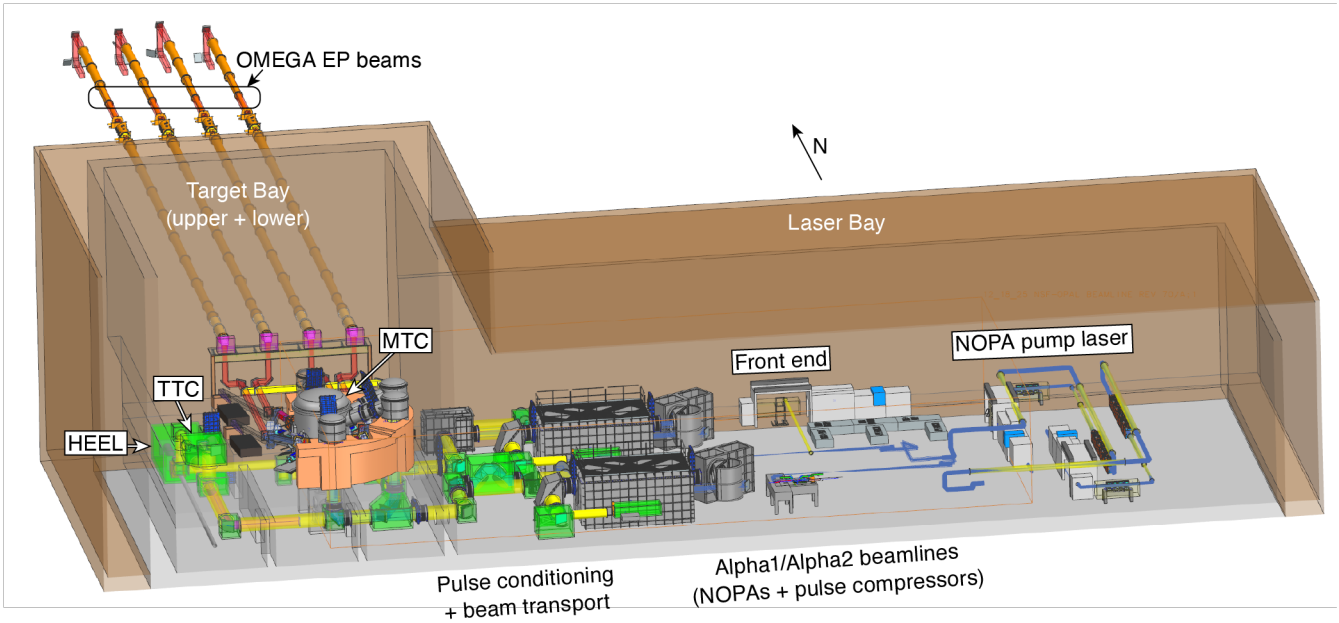
- **WBS 2.3 Large-aperture DKDP crystal production (Rhett Wampler, UR Optics PhD student)**
  - Completed investigations of the setup for directly determining the deuteration level of DKDP crystals compares well with the previously demonstrated OPA-based technique. Prepared a two-page abstract about the technique for submission to CLEO 2026.
  - Met with a company developing diffusion bonding of LBO and discussed future samples and testing. Measured phase-matching data and performed damage testing at 2ω on a diffusion-bonded LBO sample.
  - PhD student Rhett Wampler leads the experimental investigation of the deuteration metrology technique, including the assembly of a large-aperture mapping station.
- **WBS 2.4 Next-Generation Gratings/Coatings**
  - Made final preparations for the January NSF OPAL/AFOSR-sponsored workshop on Next-Generation Optical Materials and Components for High-Power Lasers.
  - Commenced baselining of current metal grating technology. PGL delivered the first eight grating test samples to LLE in late-Oct; LLE conducted LIDT and LIGT tests, and shared results with PGL; PGL provided process information details to LLE in Nov-2025; conducted LLE/PGL technical review of results on 05-Jan-2026. PGL is on track to deliver four (4) new metal grating samples in early Jan-2026.
- **WBS 2.5 Next Generation Mirrors**
  - Held a kick-off meeting with EvolvOptics and started gathering requirements. This phase will continue through January before starting material selection and identifying manufacturing approaches.

Technical Progress (co-PIs):

- **Jonathan Zuegel, University of Rochester (Project Director and Lead PI)**
  - Met with members of the ELI Beamlines and Marvel Fusion (MF) on October 9, 2025 to outline a three-way collaboration for developing second-harmonic generation (SHG) mirror technology for kilojoule-class ultrafast lasers. NSF OPAL (500 J, 20 fs) and the L4f laser (1.5 kJ, 150 fs) have the same compressed pulse beam size (60×60 cm^2), which is far larger than existing SHG technology can handle. The collaboration would start by developing and demonstrating single-aperture and tiled SHG mirrors for MTW and MTW-OPAL, which are midscale lasers (~10×10 cm^2 beam) before scaling the technology to implement full-size SHG mirrors for L4f. Future development would extend this technology to NSF OPAL. The NSF OPAL stimulated photon-photon scattering (HFP-QED2) flagship experiment requires SHG, as do other critical LAPP experiments requiring ultrahigh temporal contrast that would be enabled by SHG mirrors.
  - Prepared a presentation about SHG mirrors for an ELI workshop in Dresden, Germany scheduled for November 6-7, 2025 with follow-up interactions with MF and Gooch & Housego (G&H), supplier of needed KDP crystals. The workshop aims to identify projects that the German government.
  - Met with LAPP team members to plan for an NSF site visit with NNSA observers scheduled for November 10, 2025 that would include unclassified presentations describing how NSF OPAL could provide new capabilities needed for NNSA programmatic needs. The visit was rescheduled to January 27-28, 2026 due to the federal government shutdown.
- **Antonino Di Piazza, University of Rochester (UR, co-PI and leader of HFP/QED FSWG)**
  - Contacted by a graduate student in the group of Prof. Peter Norreys in Oxford to start a joint project on the accurate characterization and simulation of the NSF OPAL beams in the stimulated photon-photon scattering flagship experiment.
  - Initiated discussions with Kale Weichman (LLE) about a project to observe prolific pair production in the collision of two NSF-OPAL like laser beam using two micro-conic targets.
- **Franklin Dollar, University of California at Irvine (UCI, co-PI and leader of PAALS FSWG)**
  - F. Dollar produced a California 175th Birthday video in collaboration with the CA governor's office about what it means to be part of the University of California. The video drew attention to intense lasers, PAALS science, and the role he plays in it as a Native American.
  - F. Dollar was selected as the inaugural chair of the NSF ZEUS Users Group (ZUG).

- **Eva Zurek, University at Buffalo (UB, co-PI and leader of LAAP FSWG)**
  - D. Polsin and E. Marley (LLE) met with the design team about the dense plasma spectroscopy platform, set up the experiment using the experimental use case template introduced at the CDR and identified how the current NSF OPAL design could be optimized for it.
  - D. Polsin and E. Marley met with Brendan Kettle (Imperial College London) after connecting at the APS DPP meeting. Brendan gave an overview about "Probing femtosecond electron dynamics with ultrafast X-ray absorption spectroscopy using a laser-plasma accelerator." His experiments are currently performed at Gemini (CLF, UK). They discussed how the current OPAL geometry could be modified to implement a LWFA based X-ray source including a plasma lens approach to get the appropriate f-number.
- **Ani Aprahamian, Notre Dame University (NDU, co-PI and leader of LDNP FSWG)**
  - Prepared and submitted a proposal to NSF to measure tritium-induced reaction cross-sections in the laboratory in forward and time-reversed reactions related to the LDNP1 nucleosynthesis flagship experiment. The proposed experiment improve understanding of the OMEGA tritium reactions and future NSF-OPAL studies with tritium in plasma environments. Scientific motivations include: explosive astrophysical scenarios; Big Bang Nucleosynthesis, and core collapse supernovae with reassembly of remnants that lead to heavy-element synthesis. Discussed with URochester and MIT folks interested in these reactions.
  - Recruited two graduate students.

VII. Current Photos with descriptions

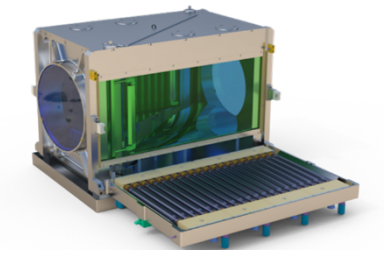


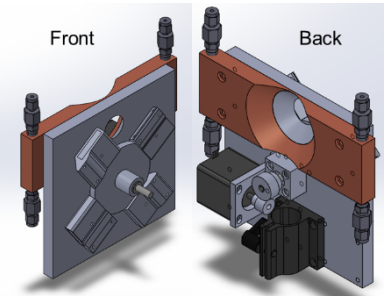
CAD rendering of the current state of the NSF OPAL facility design included in an article submitted to Optics & Photonics News that is scheduled for publication in March 2026.

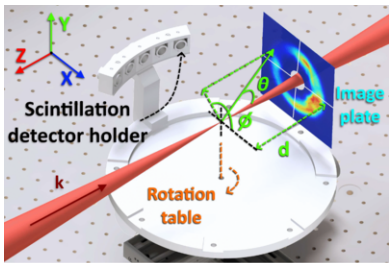
CAD model of LLE prototype ACoDA module

Liquid-crystal plasma mirror technology at OSU

High-energy focal spot characterization at UMD







(a) (b) (c)

NSF OPAL RI-1 project progress. (a) CAD model of a prototype actively cooled disk amplifier (ACoDA) module design that will enable high shot-rate, kilojoule-class lasers. (b) A prototype LC plasma mirror assembly. The films are formed by the four rotating wipers on the back side. (c) Experimental scheme for testing ways to measure high-energy focal intensities using the trajectory of electrons ejected at the focus and the transverse kick experienced by the ions.

(a)

(b)

(c)

NSF OPAL RI-1 project team visits to (a,b) ELI Nuclear Physics and (c) ELI Beamlines.

Focal-spot diagnostic experiment at the Apollon laser facility. Sebastian Meuren (left, École Polytechnique), Sarah Grimm (Technische Universitat Darmstadt student) and Wendell Hill (U. Maryland, experiment PI w/ arm visible) setting up instrumentation in the Apollon short-focal length chamber. Shown are the f/2 parabola, pellicle shield and focal-spot imaging and electron tracker apparatus under the foil. The flange protruding from the top leads to the MCP detectors for the ion TOF detector. The electron tracker (not shown) is ~1.25 m to the left from the focal point outside the chamber.

VIII. Appendices - none