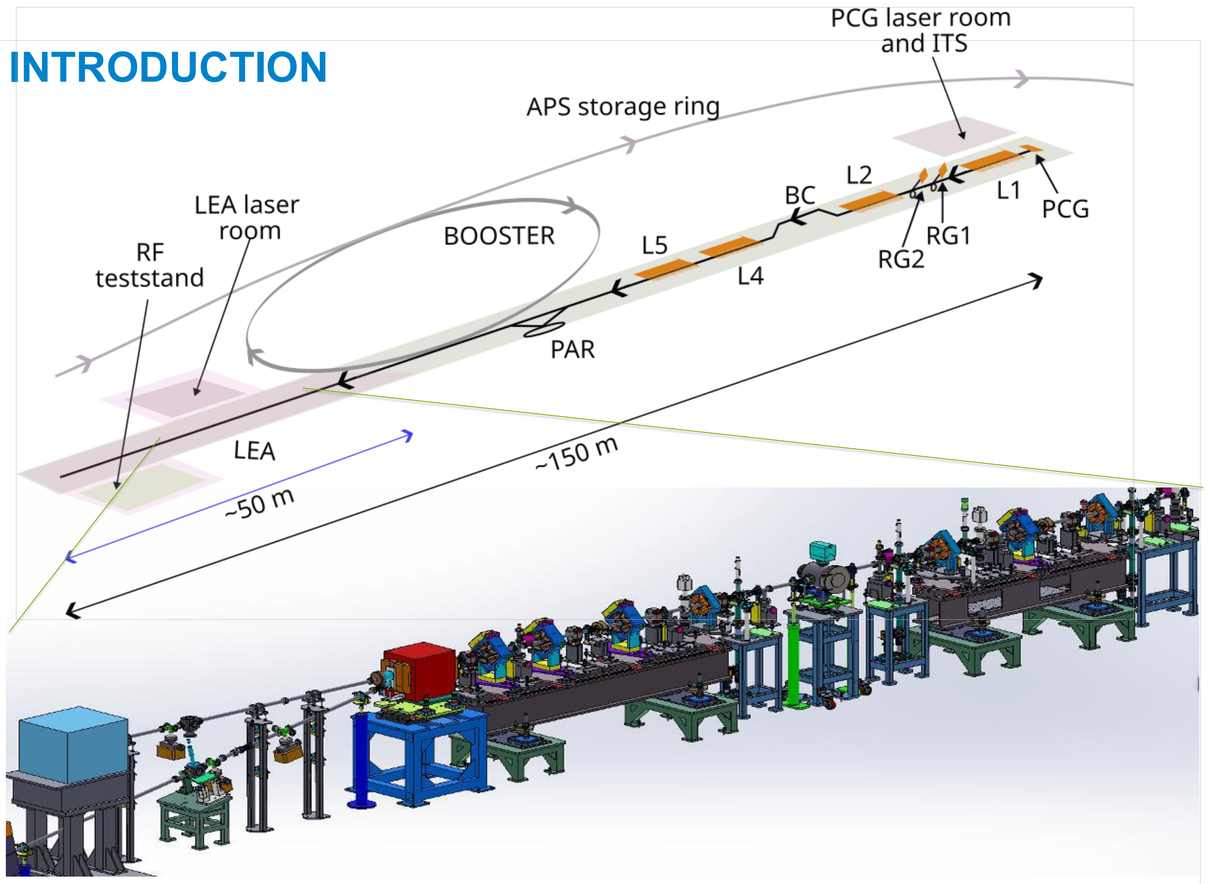
THE LINAC EXTENSION AREA (LEA) AT THE ADVANCED PHOTON SOURCE

A testbed for R&D in Accelerator Science & Engineering

P. Piot, T. Berenc, W. Berg, J. Dooling, R. Hong, A. Lumpkin, G. Shen, S. Shoaf, Y.-E Sun, T. Suzuki, G. Wang, Y. Yang, K. Wootton, A. Zholents

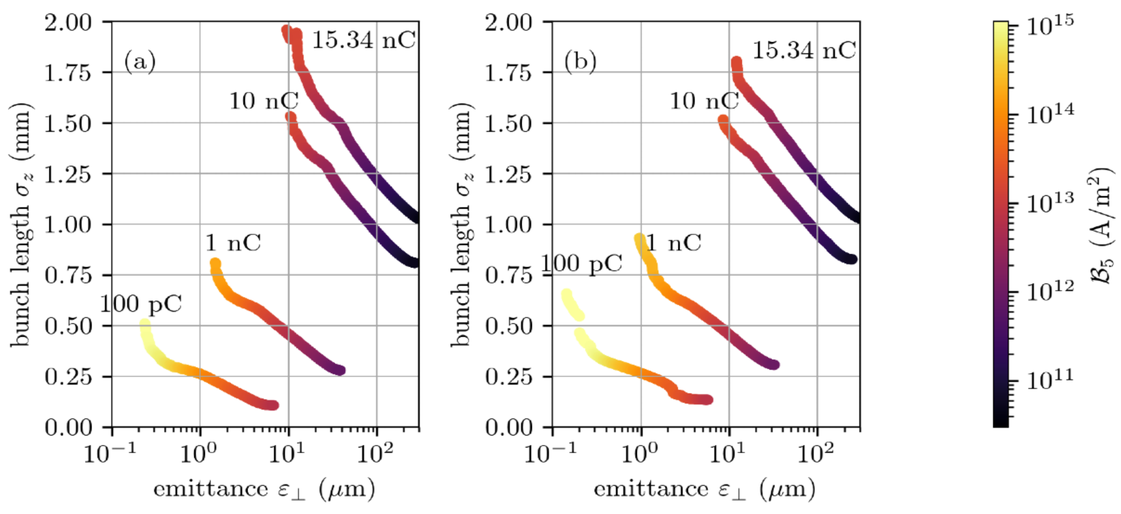
INTRODUCTION



- **Overview:** The Linac Extension Area (LEA) at the APS is a unique test bed for accelerator R&D, offering ~0.5 GeV electron-beam generated from different electron sources (single bunch or train) accelerated and compressed in the APS linac.
- **Capabilities:** ~0.5 GeV electron beams from a photoinjector or bunch train from a thermionic source, a low-beta insertion for precision testing of small-aperture components and co-located high-power RF system and laser room.

EXPECTED PERFORMANCES W/ PHOTOINJECTOR

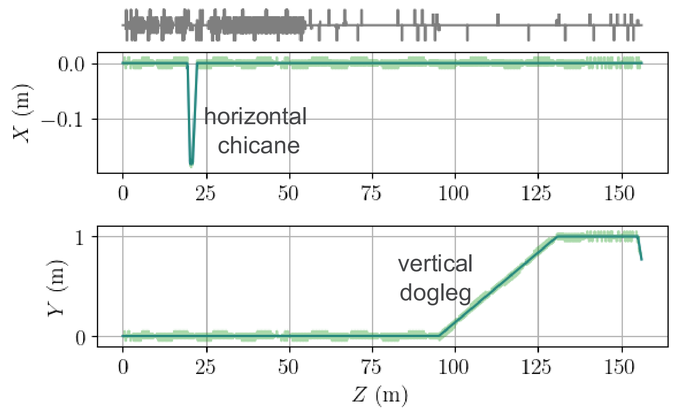
Photoinjector expected performances (uncompressed after L5): nominally limited to charges <3 nC; beam dynamics optimized up to 15.34 nC (assumes a different cathode) for possible direct injection in the booster ring to support 200 mA operation of APS



BUNCH TRANSPORT TO LEA

- The APS linac accelerates electron bunches to ~0.45 G using an SLAC-type S-band accelerating structure.

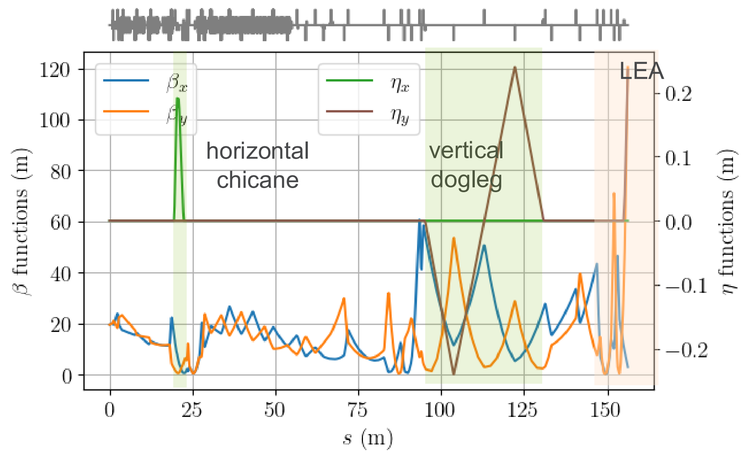
parameter (units)	thermionic	photoinjector
Energy (MeV)	420	460
repetition rate (Hz)	30	30
single-bunch charge (nC)	0.05	≤ 3
bunch/RF macropulse (-)	≤ 30	1
charge/RF macropulse (nC)	≤ 1.5	≤ 3



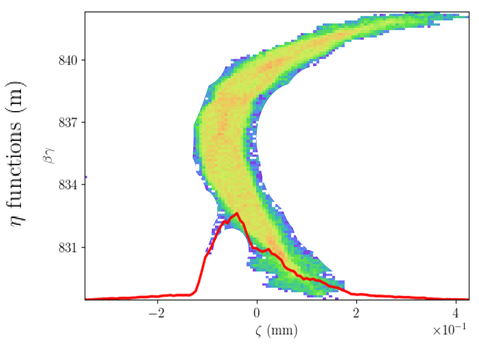
The linac features two dispersive sections for compression and collimation:

- a chicane (variable R56; nominal value of -20 mm) at ~140 MeV
- a dogleg at the final energy, just upstream of LEA (fixed R56=+2 mm).

- The APS linac accelerate bunch up to ~0.45 GeV using an SLAC-type S-band accelerating structure
- The linac include 2 dispersive sections for compression (and collimation): a chicane at ~140 MeV and a dogleg at final energies before beam entering LEA.

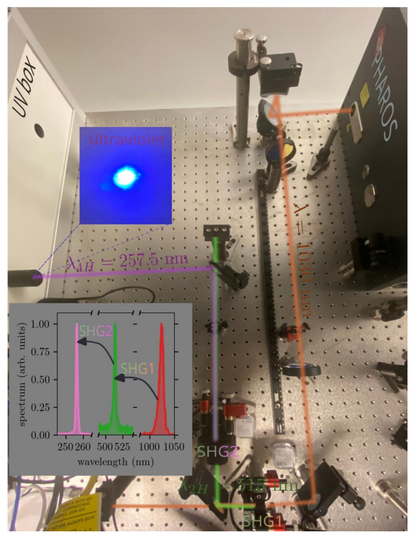


1 nC bunch compressed



STATUS

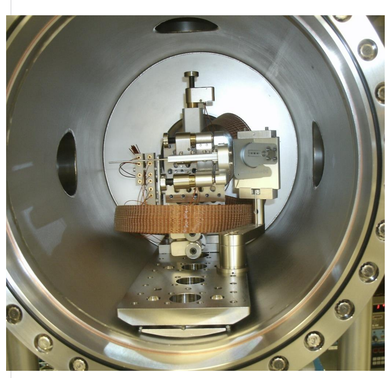
- **First Beam (Thermionic Electron Source):** Achieved in Spring 2023.
- **New Photocathode Laser System Installed:** A 4-mJ PHAROS laser from LightConversion was successfully commissioned in July 2025.
- **Photoinjector RF conditioning:** Completed in April 2025.
- **Photoinjector Beam:** Expected to be operational early in FY26 (October 2025).
- **Beam Availability for Experiments:** Anticipated during CY2026.



ADVANCED-ACCELERATION TECHNIQUES

Enabling R&D on Structure-Wakefield Acceleration (SWFA) in the Sub-THz Regime (Complementing R&D at AWA):

- **Early Experiments (CY27):** Initial studies will focus on investigating breakdown phenomena in corrugated waveguides.
- **Next Stage:** Research will shift to exploring transition regions designed to outcouple harmful modes excited by the beam during acceleration.
- **Ultimate Goal:** The final phase will integrate beam manipulation capabilities from the APS linac with masking techniques to develop methods for controlling beam-break-up (BBU) instabilities in SWFA systems.



PHOTON SCIENCE

Novel Insertion Device Testing: The APS Insertion Device Group is developing innovative undulators designed for rapid polarization switching and wavelength tuning, with some prototypes planned for testing at LEA.

- **THz Generation for Sample Pumping:** In collaboration with the Materials Science Division, for samples pumping experiments.
- **Laser-Laser and Laser-RF locking:** R&D on precise synchronization systems between lasers and RF sources to support experiments on seeded FELs.

COLLABORATIVE SCIENCE

beamNetUS
accelerating beam-based research

- Starting FY26, LEA will be added in as one of the test facilities available to collaborator for experiment within the BeamNetUS network of US facilities.
- Beam available to external collaborator during CY2026 with first experiment expected before October 1st, 2026.

U.S. DEPARTMENT of ENERGY
Argonne National Laboratory is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC.
Argonne NATIONAL LABORATORY