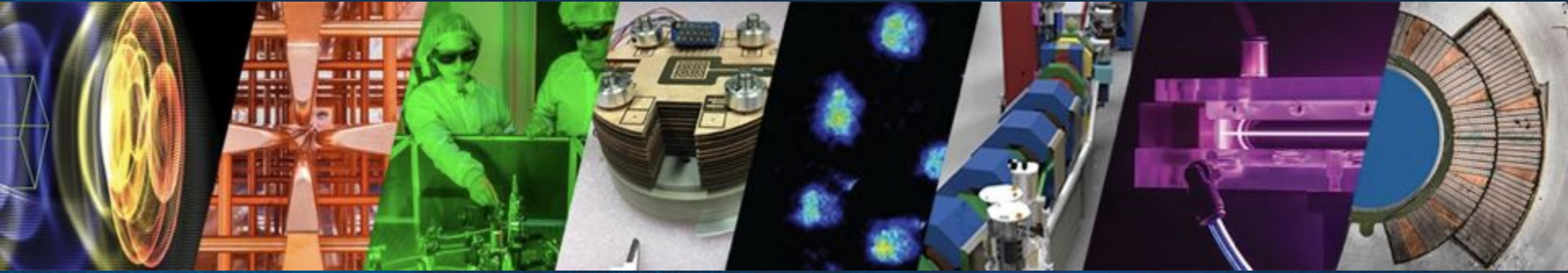


# Accelerator safety @ LBL BELLA Laser Wakefield Accelerators

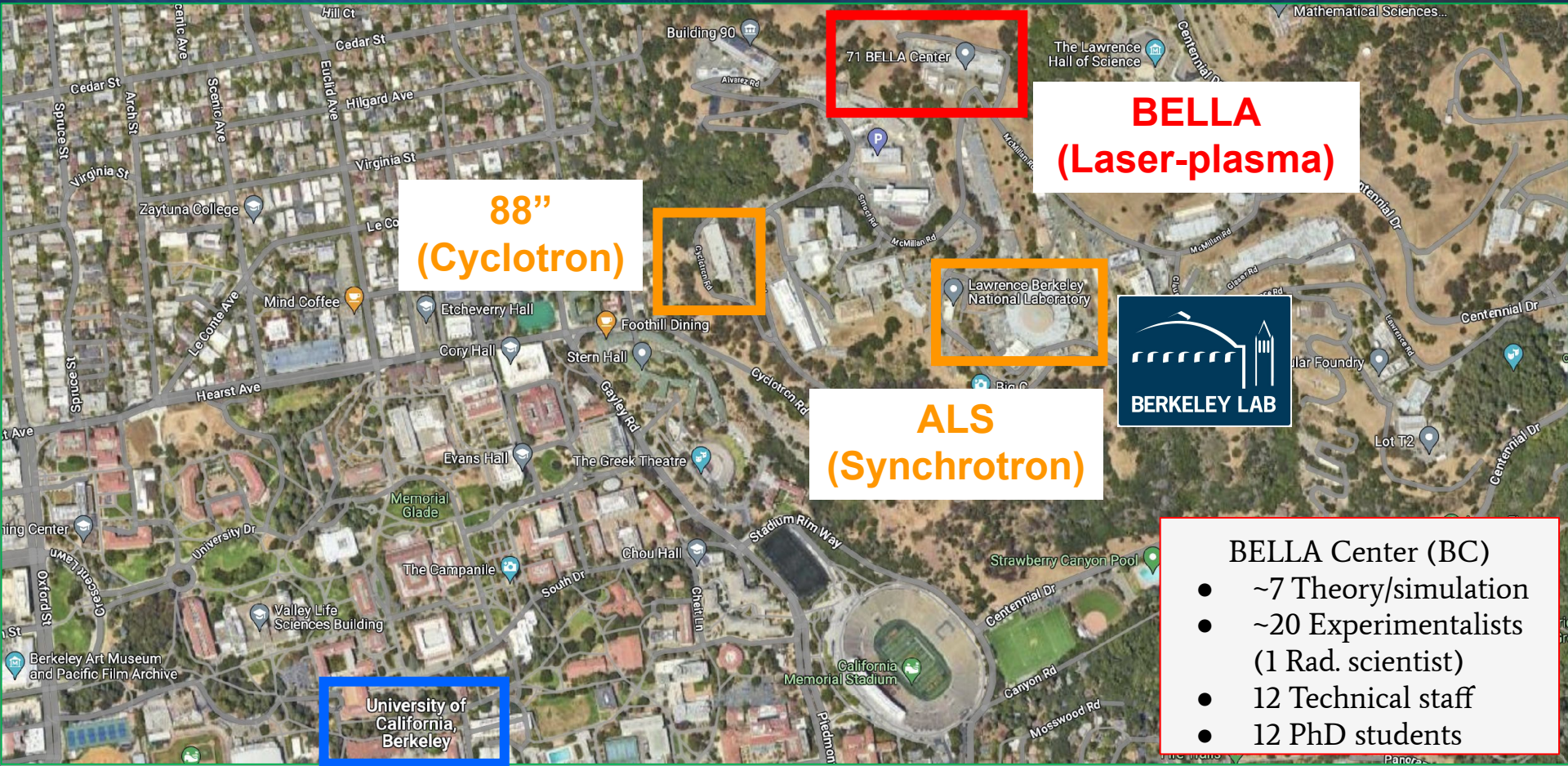


Kei Nakamura\*, Stanimir Kisyov, Jeroen van Tilborg  
\*Associate Director for Experiments at the BELLA Center,  
ATAP Division, Lawrence Berkeley National Lab.

DOE Accelerator Safety Workshop (ASW), October 2024, Brookhaven National Laboratory, NY



# BELLA Center: one of the three major accelerator facilities at LBNL



**88"**  
**(Cyclotron)**

**71 BELLA Center**

**BELLA**  
**(Laser-plasma)**

**ALS**

**ALS**  
**(Synchrotron)**



**University of California, Berkeley**

- BELLA Center (BC)**
- ~7 Theory/simulation
  - ~20 Experimentalists (1 Rad. scientist)
  - 12 Technical staff
  - 12 PhD students



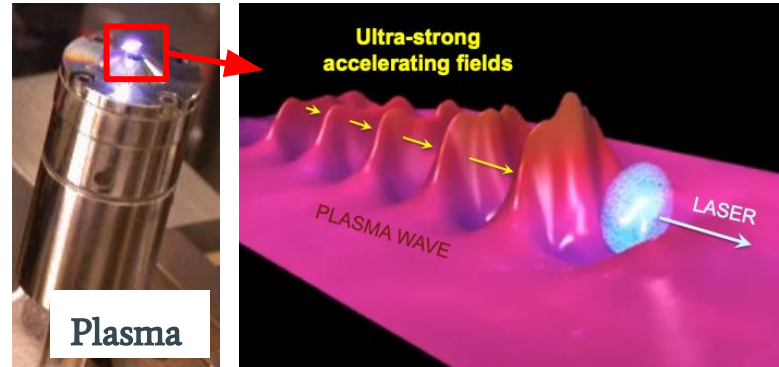
# Laser Plasma Acceleration (LPA) of electrons: Laser to drive acceleration

## Ultrahigh gradient to realize compact accelerators

Conventional rf  
linear accelerator



Laser-plasma (linear)  
accelerator





# Three Laser Systems, 2 Total Exclusion Areas (TEAs), 2 pairs of SAD / ASE

## BELLA HTW SAD / ASE (2006~)

BELLA-HTU,  
3 Joule in 30fs (100 TW @ 5Hz)

- 1 GeV class Electron Accel.
- Undulator Radiations
- Beam Transport

BELLA-HTT

- 3 Joule in 30fs (100 TW @ 5Hz)
- 1 GeV class Electron Accel.
  - Monochromatic gamma rays
  - Pump-probe X-rays



## BELLA PW SAD / ASE (2012~)

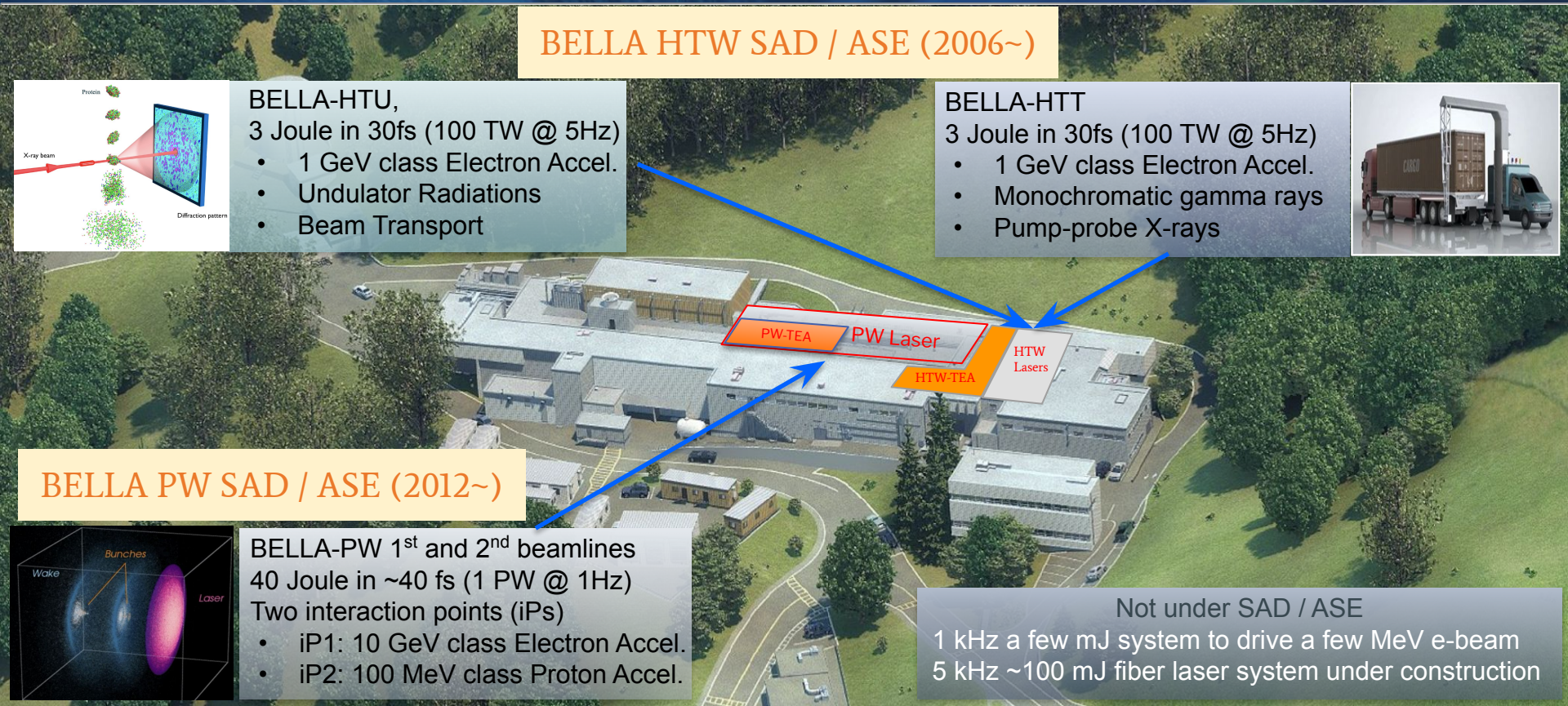
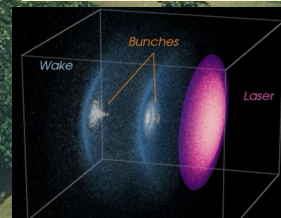
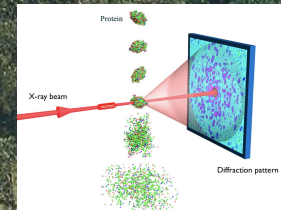
BELLA-PW 1<sup>st</sup> and 2<sup>nd</sup> beamlines  
40 Joule in ~40 fs (1 PW @ 1Hz)

Two interaction points (iPs)

- iP1: 10 GeV class Electron Accel.
- iP2: 100 MeV class Proton Accel.

Not under SAD / ASE

1 kHz a few mJ system to drive a few MeV e-beam  
5 kHz ~100 mJ fiber laser system under construction



# Internal Safety Committee to Lead ASO Compliance Efforts

## BELLA Center Safety Committee (BCSC)

- Oversees BC accelerator safety (compliance with DOE ASO)
  - SAD / ASE
  - Safety issues (BobCAT)
  - Periodic tests
  - WPC activities
  - Credited Control Implementing Procedures (CCIPs)
  - Assurance activities (Triennial Review)
  - Training profiles, OJTs

## Members

Director for experiments  
Division safety coordinator  
Radiation Scientist  
Lead Scientists for  
Radiological work (RWA)  
Laser work

## RWA 5129 (AA-0014)

### LPA operation Lead and designees

- Oversees radiation safety
- BC-USI process
- EIC trainings - BCTM
- Configuration management
- RPG/RSC communication
- Safety Software Quality Assurance

## AA-0018 Laser work

### Lead and designees

- Oversees laser safety
  - Laser hazard table - BCTM
  - Laser registration
  - LSO communication

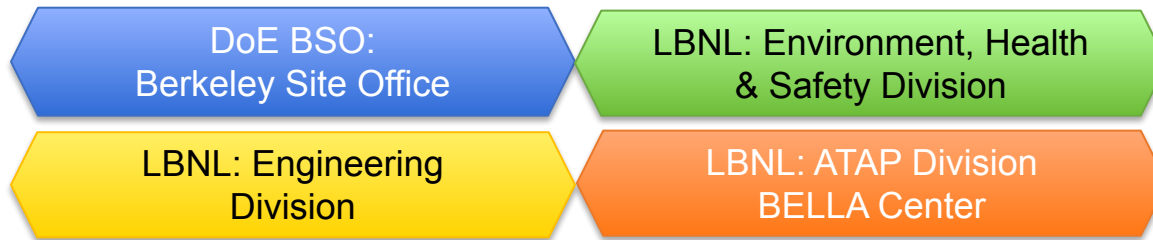
## Experimenter in Charge (EIC)

- Oversee LPA operations
- Potentially activated materials

- BELLA Safety Website
- Daily 9:15 meeting with experimentalist / technical staff
- Weekly Center-wide meeting
- Monthly BCSC meeting
- AA-0014 (co)leads twice/week

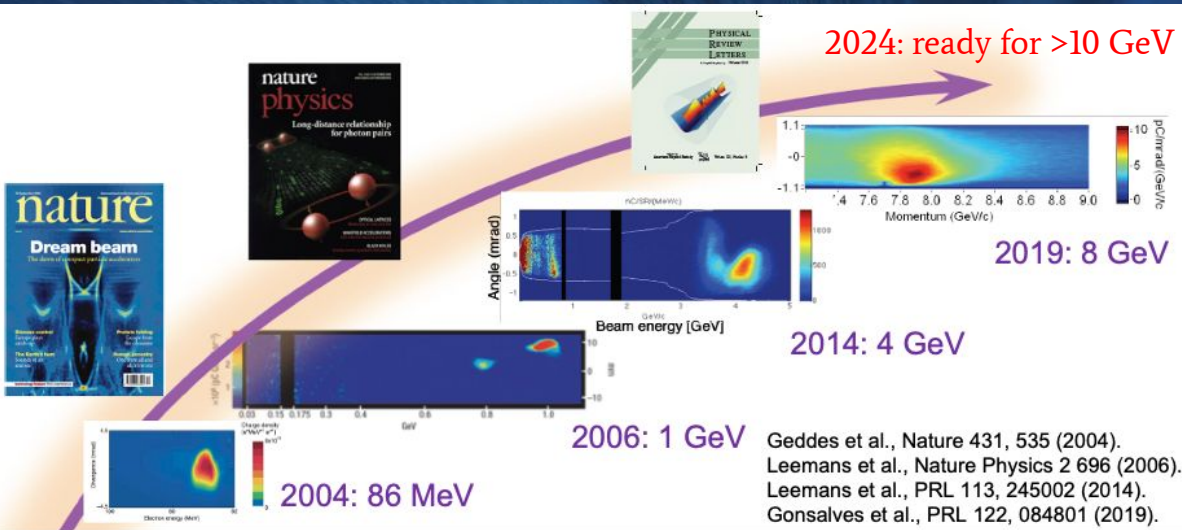


# BELLA Center works closely with ATAP, Engineering, EHS divisions and BSO to support mission and safe operations



- keeps close communication with BSO through RPG for accelerator safety,
- works closely with EHS especially with RPG, LSO, and EHS Liaison helping to address mitigation strategies for new hazards (e.g. weekly communication with HP),
- collaborates with engineering division for projects and safety implementations,
- applies ISM integrated with ATAP with support from Division Safety Coordinator,
- utilizes lbl-wide Work Planning and Control (WPC) system for effective implementation of ISM

# Research on acceleration physics, structure, mechanisms, etc.: challenges to support fast changes



Geddes et al., Nature 431, 535 (2004).  
 Leemans et al., Nature Physics 2 696 (2006).  
 Leemans et al., PRL 113, 245002 (2014).  
 Gonsalves et al., PRL 122, 084801 (2019).

## USI Log

#	planning started	in-action finished	Result	Folder
8	4/30/2024		RSI w/ new hazard	<a href="#">2024 0425 PW Laser Power Credited Control</a>
7	9/12/2023			<a href="#">2024 9999 Am</a>
6	1/2/2023		USI-Negative	<a href="#">2023 1101 A-cave kHz RGD</a>
5	5/13/2024	5/24/2024	RSI no new hazard	<a href="#">2024 0513 Neutron Detector</a>
4	4/2/2024	4/13/2024	Non-USI	<a href="#">2024 0412 Probe Laser Line</a> <a href="#">2024 0222 PW incorrect ebeam analysis</a>
3	2/22/2024	2/27/2024	RSI no new hazard	
2	2/1/2024	2/1/2024	Non-USI	<a href="#">2024 0201 HTW</a>
1	1/22/2024	1/23/2024	Non-USI	<a href="#">2024 0123 HTT magnet</a>
13	11/1/2022	1/6/2023	USI-Negative	<a href="#">2023 0105 IP2 1Hz</a>
12	5/1/2018	11/2/2022	USI-Negative	<a href="#">2022 1025 HTU</a>
11	10/3/2022	10/5/2022	USI-Negative	<a href="#">2022 1005 IP2</a>
10	9/6/2022	9/8/2022	USI-Negative	<a href="#">2022 0906 PW gamma</a>
9	8/22/2022	8/25/2022	USI-Negative	<a href="#">2022 0822 PW Gamma</a>

## It is critical to have well-thought ASE/SAD and to maintain RPG/BSO well-informed to support our mission

- Introducing new technologies (new hazards) are part of the mission.
- External user experimental campaigns (LaserNetUS, BeamNetUS): a few campaigns in ~1 year cycle.
- Many projects (grants) are a few years.

## USI/RSI can be frequent

- USI/RSI processes, SAD revisions are usually multi-month long process (SoW, HA, implementation plan, reviews...)
- ASE revision can be a year-long process (ARR).

**Accelerator Safety elements can be the main cost and time driver for new projects**

# Currently working towards PW-ASE revisions: Replacing one of the credited controls to support mission better

One of the current Credited Control for PW ASE

(5)...the electron energy is limited to 10 GeV +/- 5%.

Limit with accelerated beam parameters.



Proposing...

(5) Laser Facility Power: The particle beam power delivered by the Laser-Plasma Accelerator is constrained by the facility's available laser power.

Limit with accelerator driver (laser) available power

## Timeline

- 2023: Initiate conversations with RPG / BSO.
- 4/2024: USI / RSI started, RSI w/ new hazard.
- 4/2024: Radiation Hazard Analysis beyond 10 GeV while conserving the particle beam power.
- 8/2024: Technical review on Radiation Hazard Analysis above.
- 10/2024: Accelerator Radiation Safety Committee to review SAD / ASE revisions.

Note: the change stems from >12 year operation (long-term relationship) and mutual understanding among the facility, RPG and BSO.



# Summary

- The BELLA Center is one of three major accelerator facilities in LBL, with ~50 people working.
- The BC facility houses 3 laser systems to drive LPAs and two TEAs, each with own ASE / SAD pair.
- The BC has an internal safety committee to lead ASO compliance efforts.
- The BC work closely with BSO, EH&S-RPG, and Engineering to support mission and safe operations.
- There are challenges to support fast-changing accelerator research.
- Safety is a culture, and there is always room for improvements. Long-term relationships with RPG and BSO are also important to support mission in timely manner.

# Back up



# Mission: [atap.lbl.gov](http://atap.lbl.gov)



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## Accelerator Technology & Applied Physics at Berkeley Lab

ABOUT ATAP [→](#)

### MISSION

**Invent, develop, and deploy particle accelerators and photon sources to explore and control matter and energy**



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## Berkeley Lab Laser Accelerator (BELLA) Center

Driving advances in laser-plasma accelerators and their enabling technologies

The laser-plasma accelerator, or LPA, is a revolutionary technology already starting to fulfill its promise of making particle accelerators smaller and more affordable and delivering beams with unique properties.