Advanced Accelerator Facilities in the US

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SLAC NATIONAL ACCELERATOR LABORATORY

Stanford University | U.S. DEPARTMENT OF ENERGY

Acknowledgements

https://arxiv.org/pdf/2203.11290.pdf

Beam Test Facilities for R&D in Accelerator Science and Technologies

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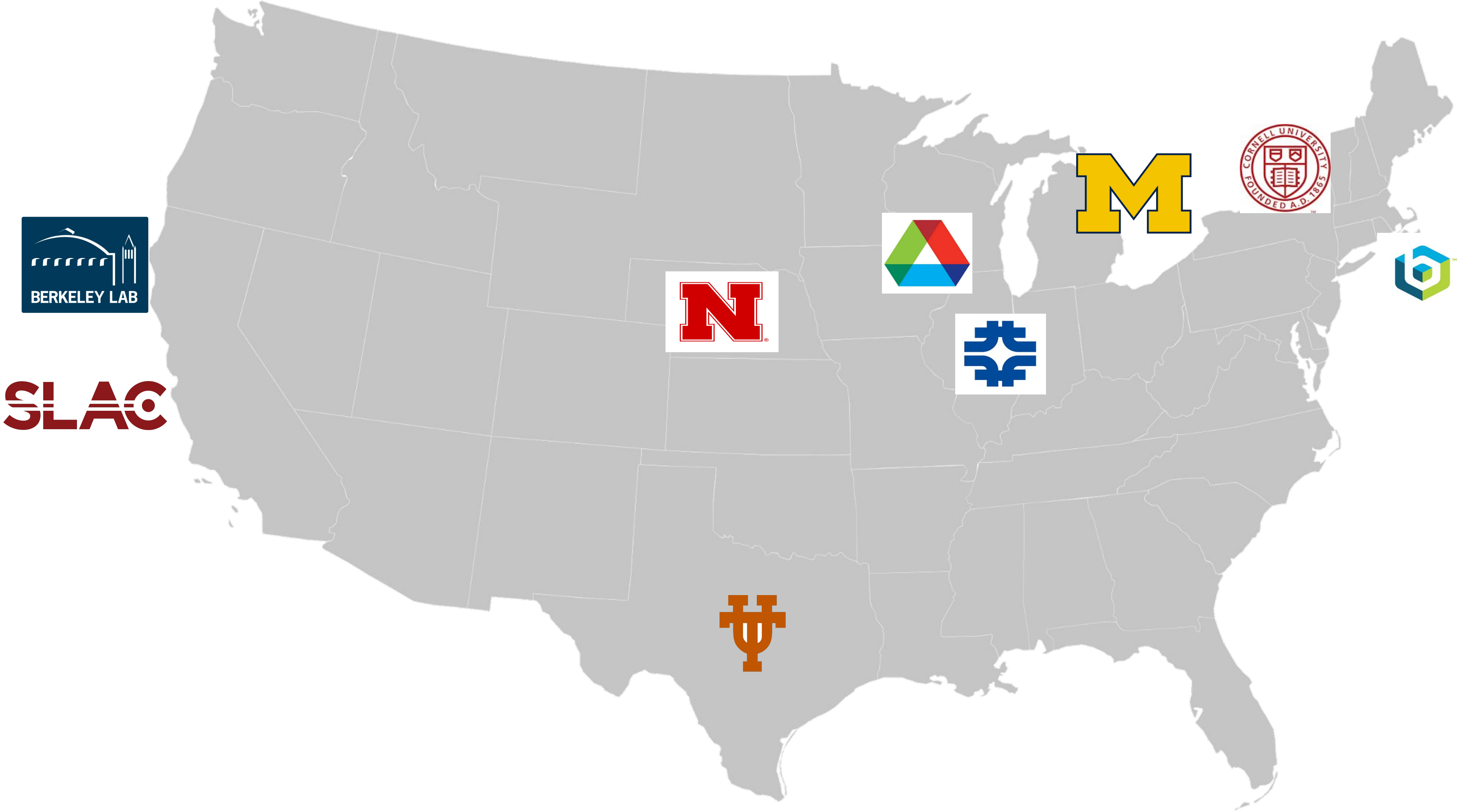
Thank you to my colleagues (especially C. Clarke and J. Power) for diligently compiling the Snowmass White Paper on US Beam Test Facilities.

Acknowledgements

https://arxiv.org/pdf/2203.11290.pdf

The capabilities of the US beam test facilities considered in this report possess one or more of the following capabilities: (O(100) MeV energy drive beams, O(10) Petawatt drive lasers, O(1) Gigawatt RF power sources, high-quality charged particle sources (e.g. low emittance electron beams), advanced beam manipulation systems (e.g. nonlinear integrable optics, optical stochastic cooling, emittance exchange) and capabilities to develop AI/ML for accelerator science.

Thank you to my colleagues (especially C. Clarke and J. Power) for diligently compiling the Snowmass White Paper on US Beam Test Facilities.


BERKELEY LAB
SLAC
CORNELL UNIVERSITY
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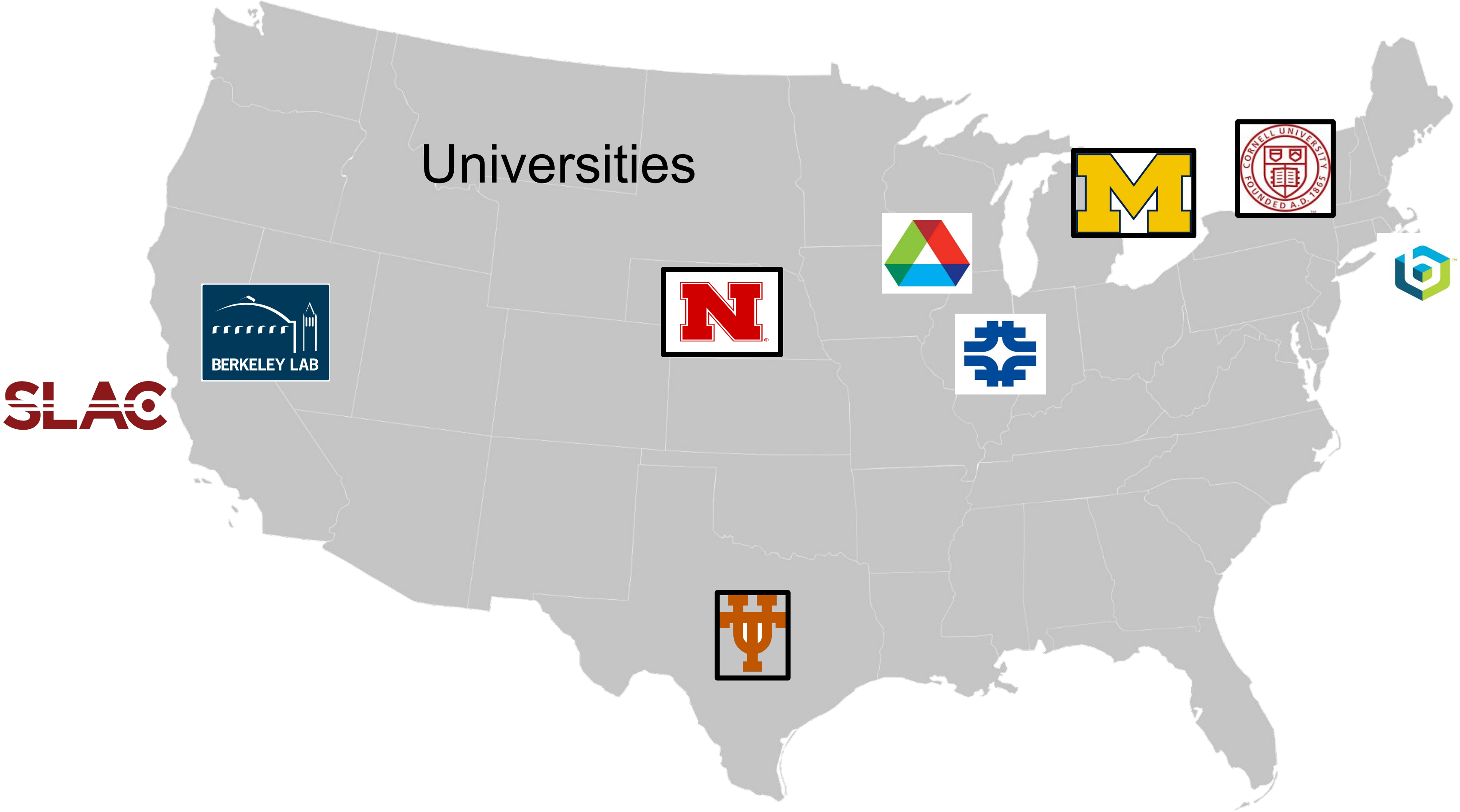
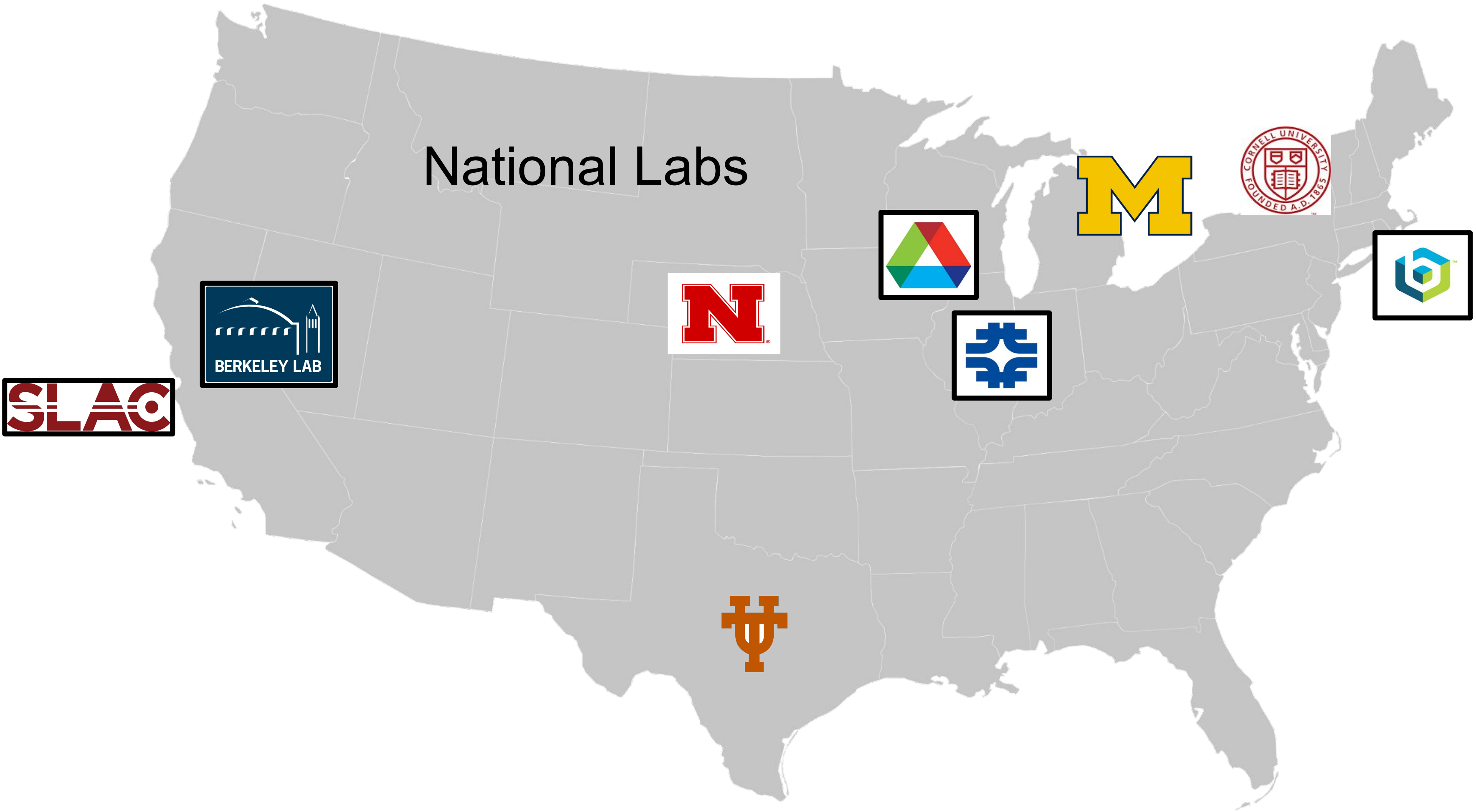
Universities



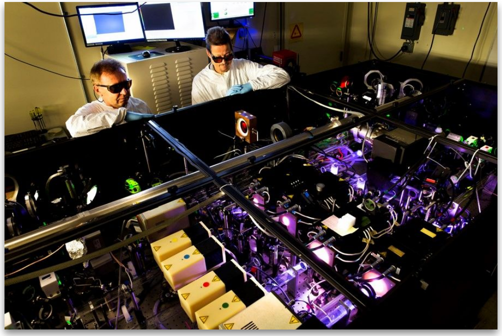
National Labs



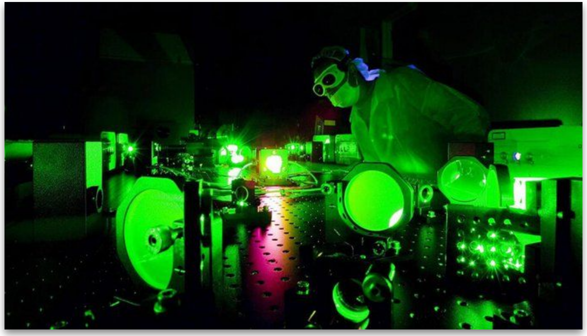
University Facilities

Cornell CBETA ERL

Michigan Zeus Laser



Nebraska Diocles Laser



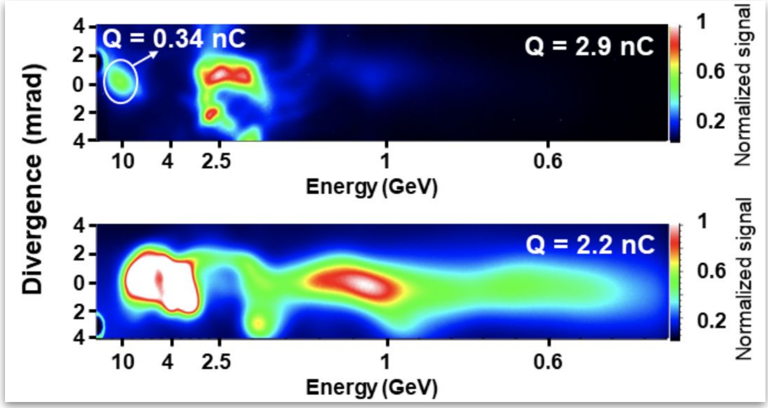
Texas Petawatt Laser

https://arxiv.org/ftp/arxiv/papers/2207/2207.11492.pdf

Ur

High-charge 10 GeV electron acceleration in a 10 cm nanoparticle-assisted hybrid wakefield accelerator

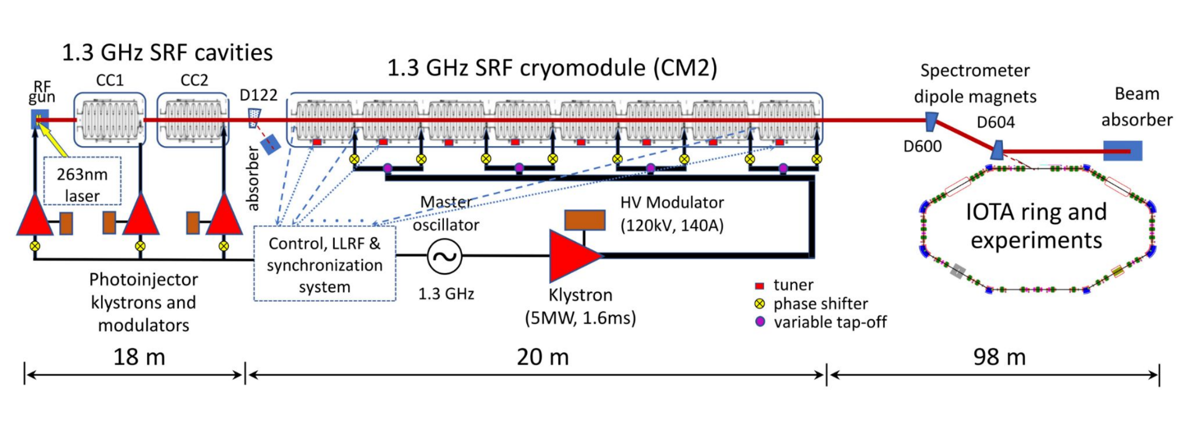
Constantin Aniculaesei[1,*,#], Thanh Ha[1,#], Samuel Yoffe[5], Edward McCary[1], Michael M Spinks[1], Hernan J. Quevedo[1], Lance Labun[1,2], Ou Z. Labun[1], Ritwik Sain[1], Andrea Hannasch[1], Rafal Zgadzaj[1], Isabella Pagano[1,3], Jose A. Franco-Altamirano[1], Martin L. Ringuette[1], Erhart Gaul[1], Scott V. Luedtke[4], Ganesh Tiwari[7], Bernhard Ersfeld[5], Enrico Brunetti[5], Hartmut Ruhl[6], Todd Ditmire[1], Sandra Bruce[1], Michael E. Donovan[1,2], Dino A. Jaroszynski[5], Michael C. Downer[1], Bjorn Manuel Hegelich[1,2,%]



Texas Petawatt Laser

FAST/IOTA

FAST/IOTA @ Fermilab

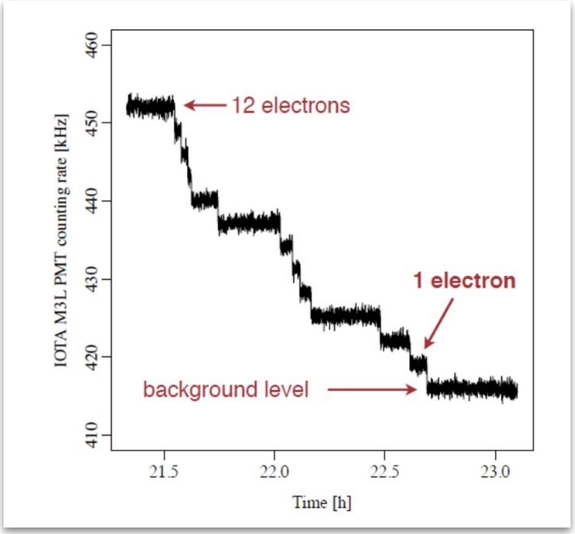


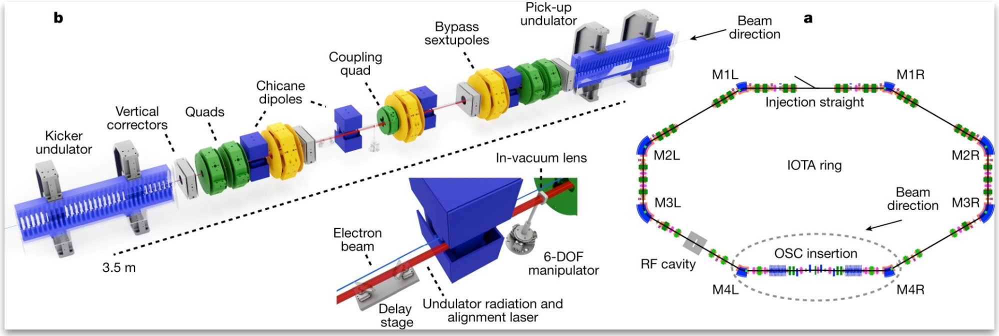
Unique Capabilities:

- Non-linear optics testing
- Single electron dynamics
- Optical stochastic cooling

FAST/IOTA @ Fermilab

Research Highlights



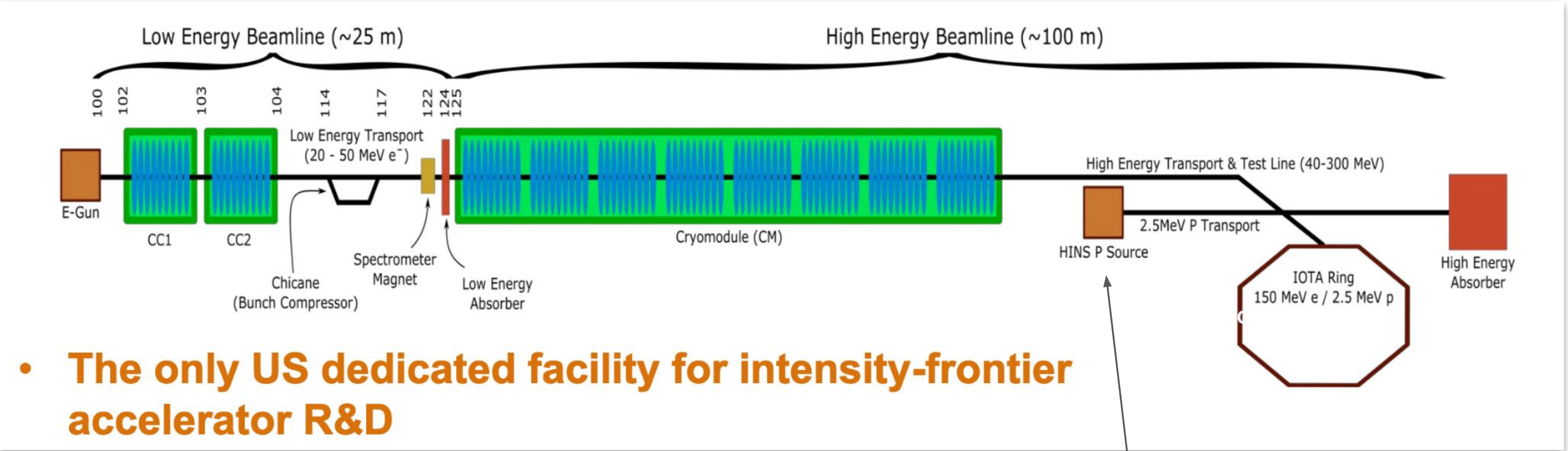


Experimental Study of a Single Electron in a Storage Ring via Undulator Radiation
S. Nagaitsev et. al., IPAC2019-MOPRB089
https://accelconf.web.cern.ch/ipac2019/papers/moprb089.pdf

Experimental demonstration of optical stochastic cooling
J. Jarvis et. al., *Nature* (2022)
https://www.nature.com/articles/s41586-022-04969-7

FAST/IOTA @ Fermilab

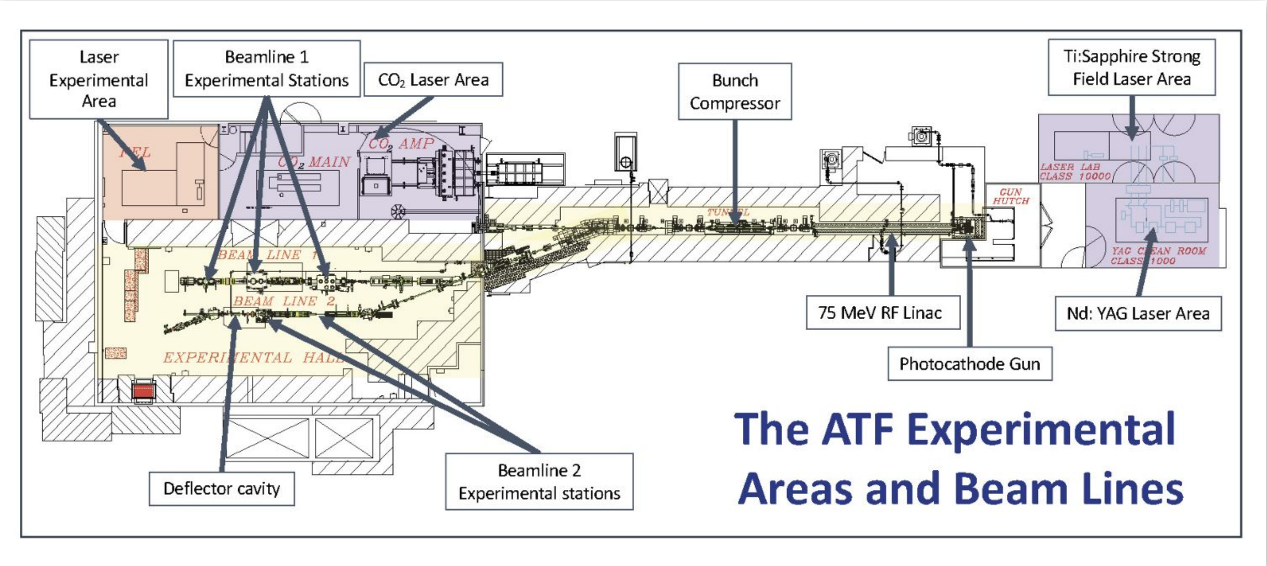
Upgrades



Proton injector


ATF

ATF @ Brookhaven

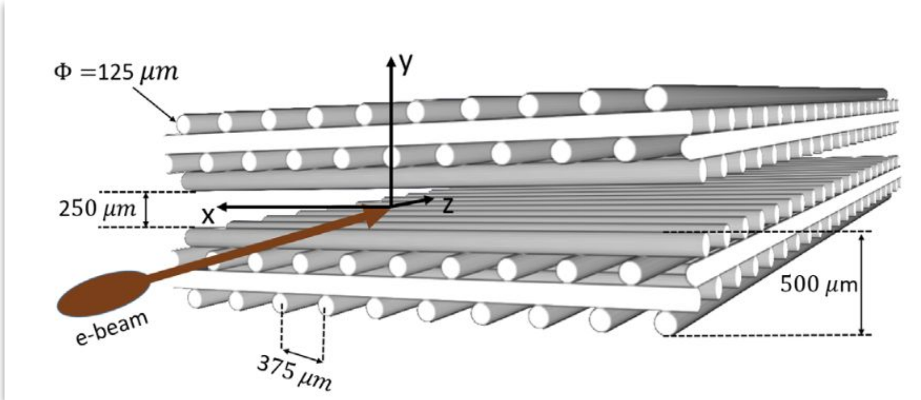


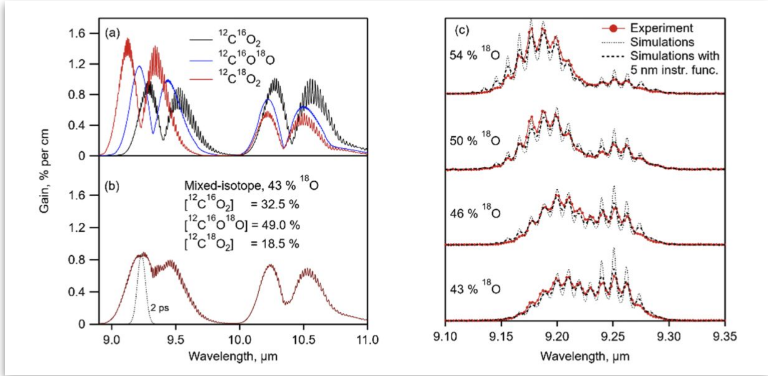
Unique Capabilities:

- 10 μm CO_2 laser

ATF @ Brookhaven

Research Highlights





Experimental Characterization of Electron-Beam-Driven Wakefield Modes in a Dielectric-Woodpile Cartesian Symmetric Structure
P.D. Huang et. al., *PRL* (2018)
https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.120.164801

Demonstration of a 2 ps, 5 TW peak power, long-wave infrared laser based on chirped-pulse amplification with mixed-isotope CO2 amplifiers
M. Polyanskiy et. al., *OSA Continuum* (2020)
https://opg.optica.org/osac/fulltext.cfm?uri=osac-3-3-459&id=427803

ATF @ Brookhaven

Upgrades:

- Further development of CO_2 laser.
    - Near term goal = 25 TW

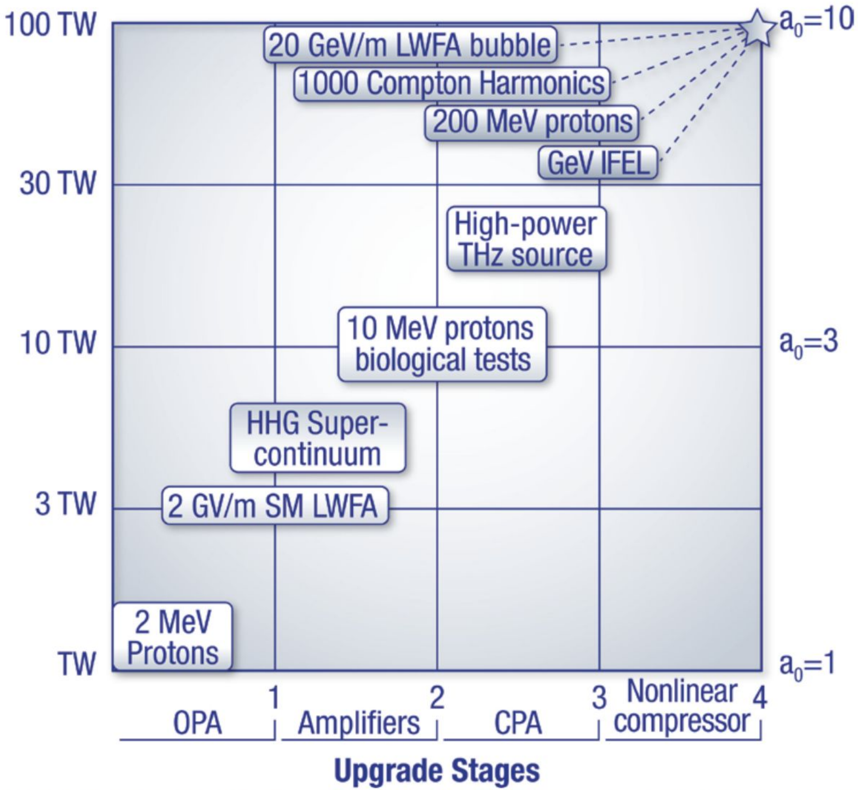
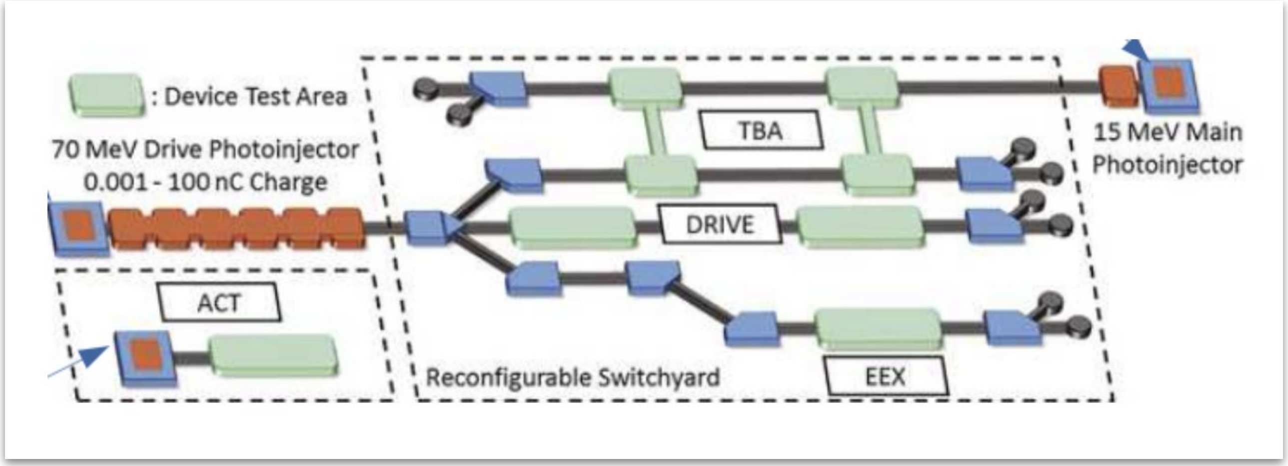


Figure 2-2. *Opportunities for new science outreach at different stages of the CO_2 laser upgrade.*


AWA

AWA @ Argonne

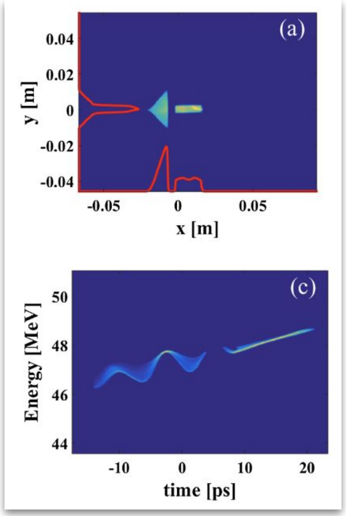


Unique Capabilities:

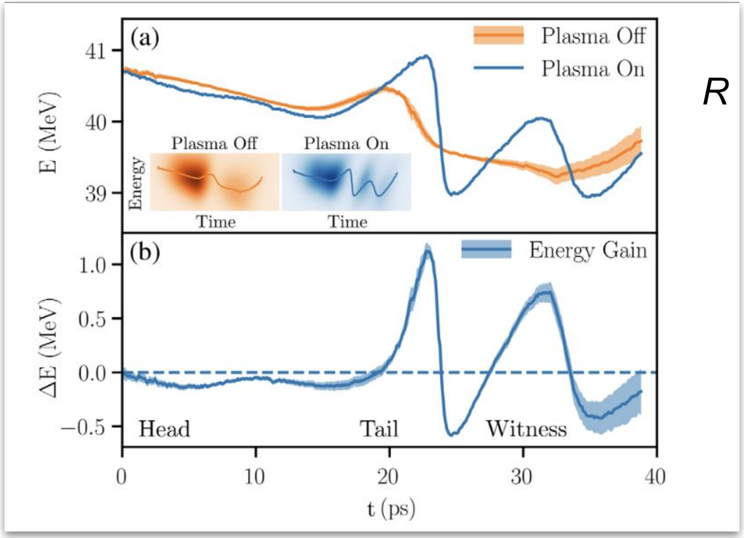
- Two-Beam acceleration
- High-gradient structures
- Bunch shaping and emittance exchange

AWA @ Argonne

Research Highlights



R = 5



R = 7.8

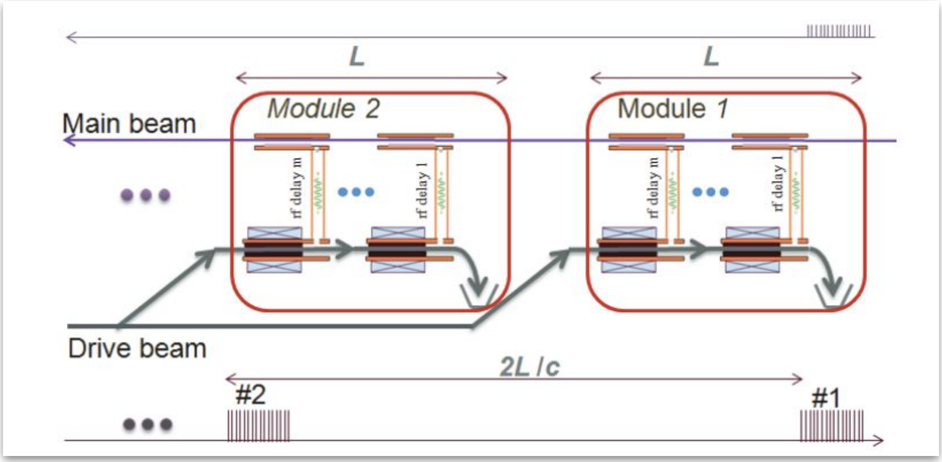
Observation of High Transformer Ratio of Shaped Bunch Generated by an Emittance-Exchange Beam Line
Q. Gao et. al., *PRL* (2018)
https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.120.114801

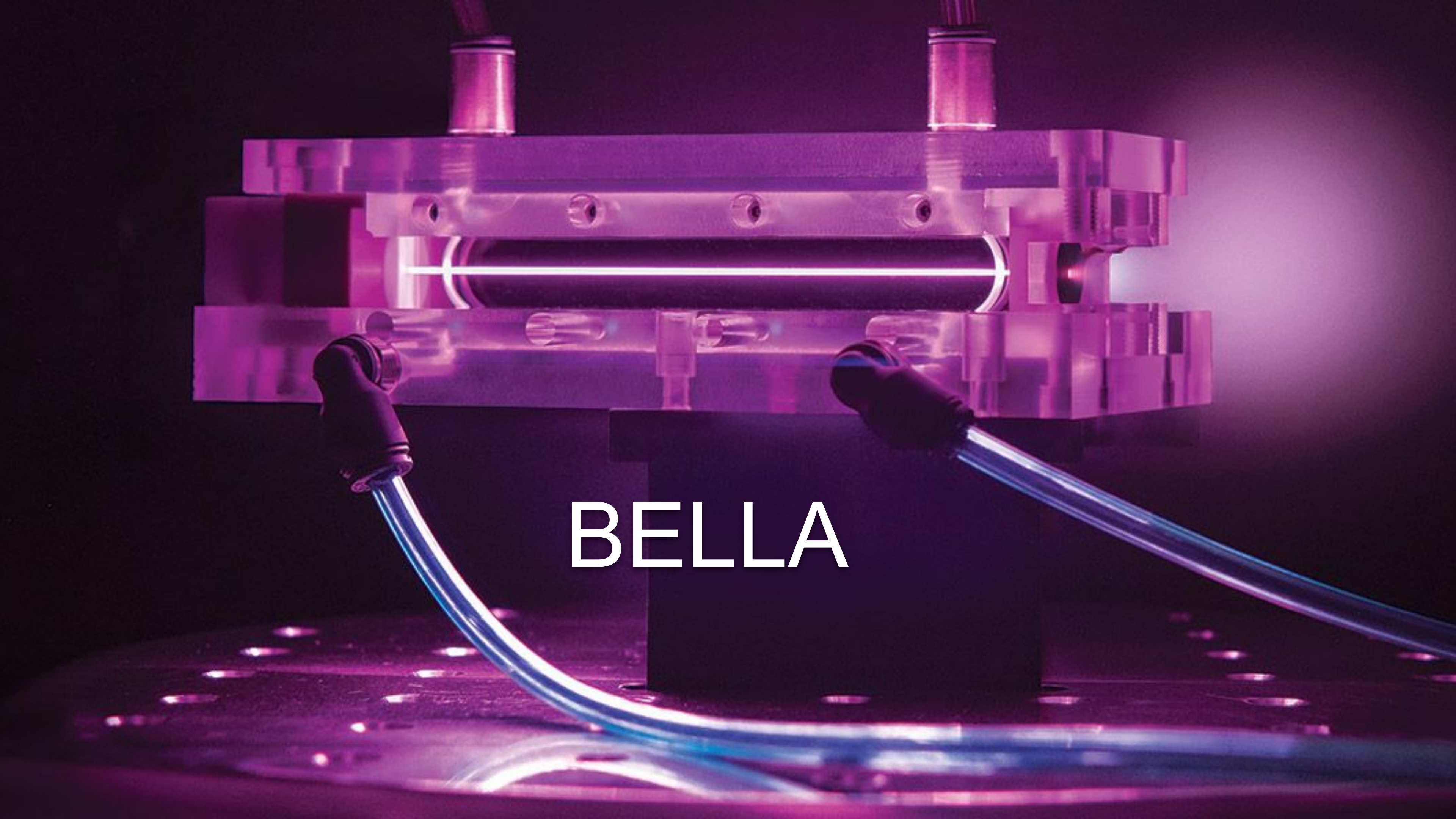
Single Shot Characterization of High Transformer Ratio Wakefields in Nonlinear Plasma Acceleration
R. Roussel et. al., *PRL* (2020)
https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.124.044802

AWA @ Argonne

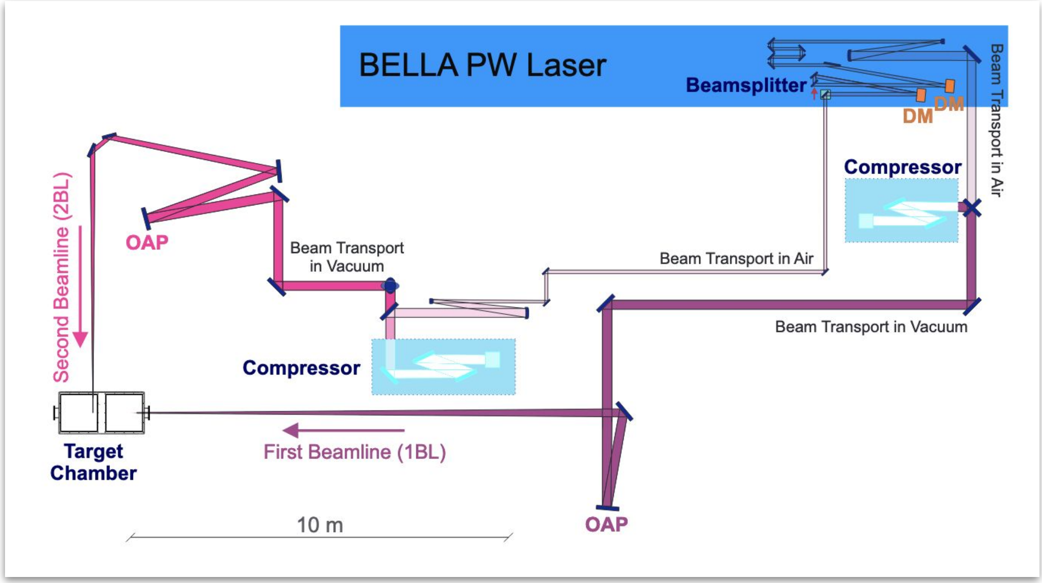
Upgrades

- Expand AWA bunker for AWA-HE (high-energy) using a staged approach.




BELLA

BELLA @ Berkeley

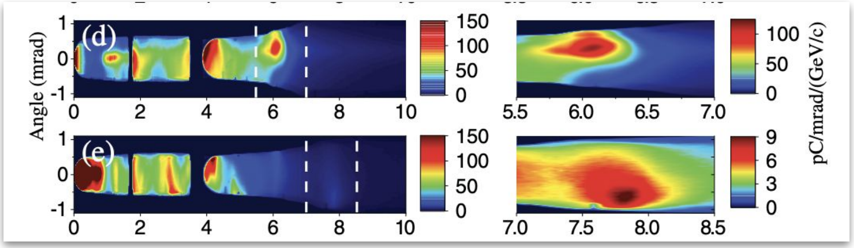


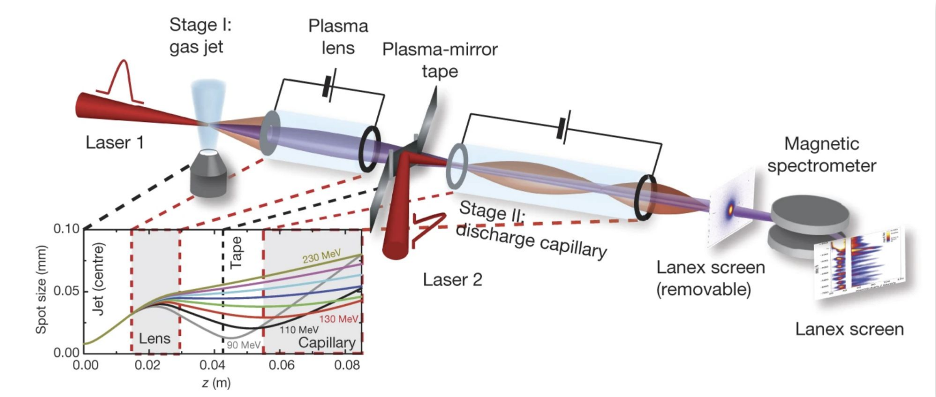
Unique Capabilities:

- Petawatt-class, high-quality laser for LWFA

BELLA @ Berkeley

Research Highlights





Petawatt Laser Guiding and Electron Beam Acceleration to 8 GeV in a Laser-Heated Capillary Discharge Waveguide
A.J. Gonsalves et. al., *PRL* (2019)
https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.122.084801

Multistage coupling of independent laser-plasma accelerators
S. Steinke et. al., *Nature* (2016)
https://www.nature.com/articles/nature16525

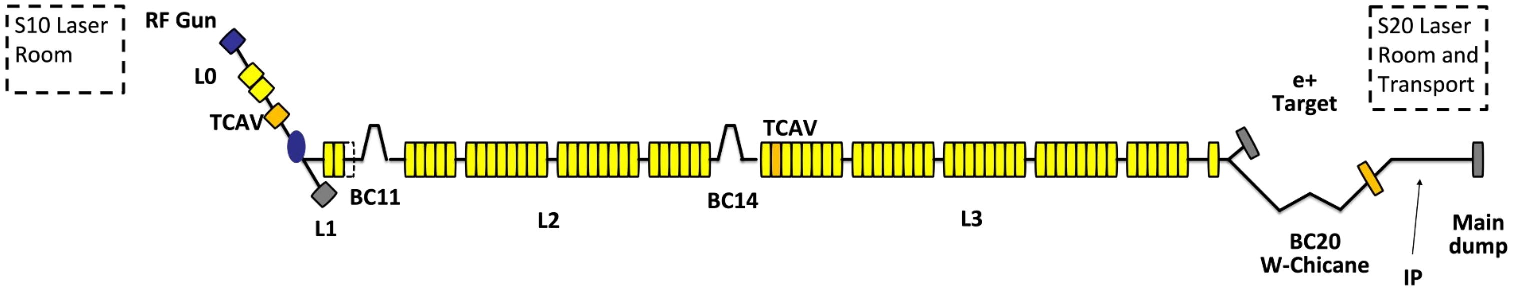
BELLA @ Berkeley

Upgrades

- Staging of two GeV-class LWFA stages.
- BELLA -> k-BELLA using kHz laser technology.


FACET-II

FACET-II @ SLAC



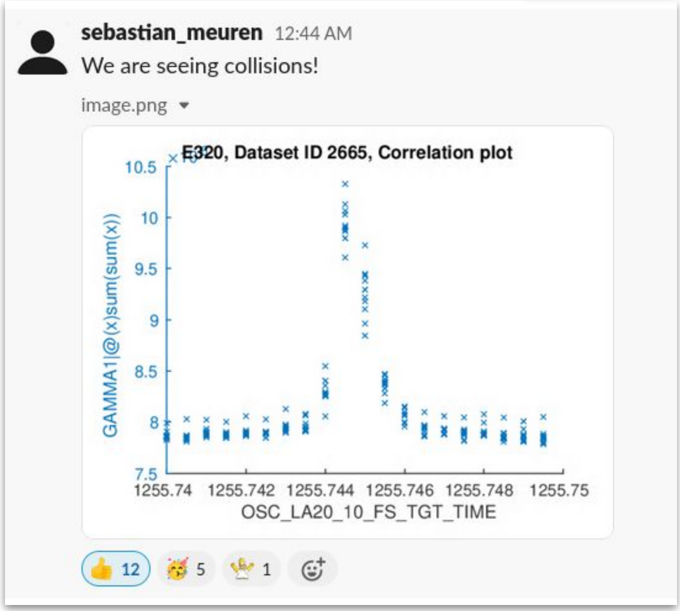
Unique Capabilities:

- 100 kA-class beams
- Laser for non-linear QED
- Positron PWFA

Slide courtesy C. Clarke

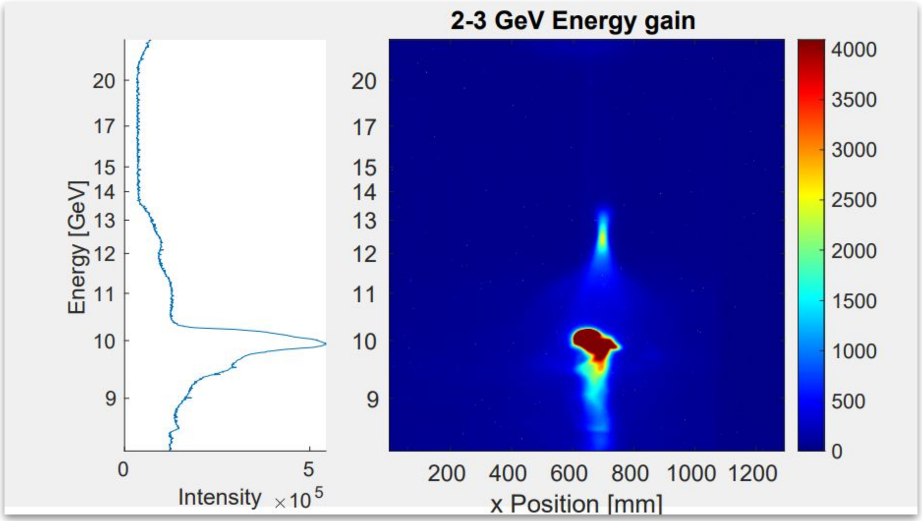
FACET-II @ SLAC

First Results from 2022! (Preliminary)



First signs of electron-gamma collisions with a laser timing scan

2-3 GeV acceleration of electrons in a Hydrogen plasma

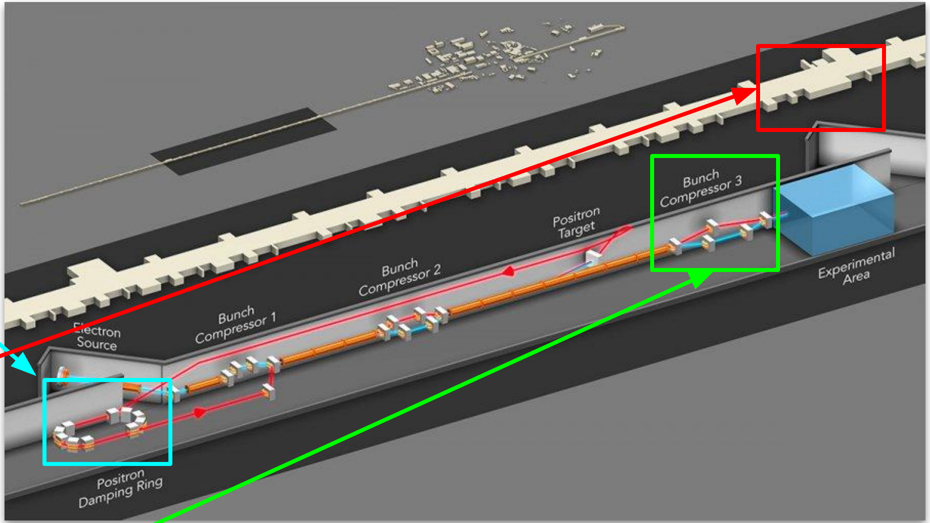


Color image of meter-scale H2 plasma

FACET-II @ SLAC

Upgrades

- Positron PWFA
    - Would be the only facility with electron driven wakefields for positron acceleration.
- Laser upgrade from 20 TW to 200 TW to access highly non-linear QED regimes.
- Reconfigure final bunch chicane for higher-quality beams.



Job Description

Previous Job | **Research Associate - AARD** | Next Job

Previous

Apply for Job

Job ID	5057	**Full/Part Time**	Full-Time
Location	SLAC - Menlo Park, CA	**Regular/Temp…**	Temporary

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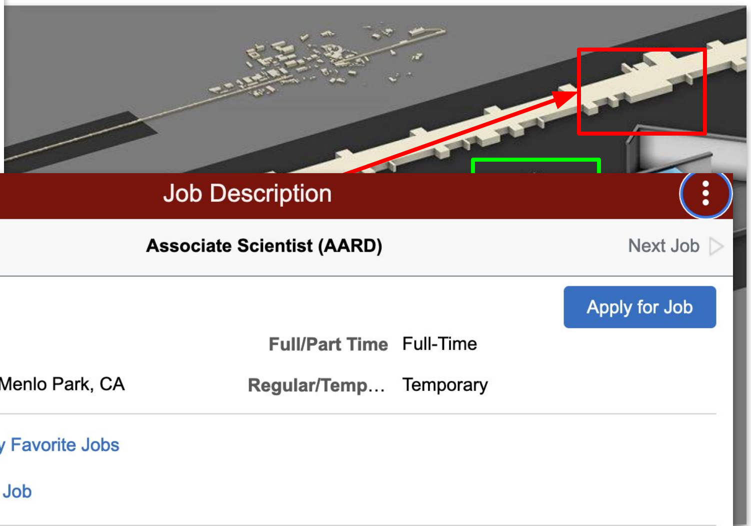
SLAC Job Postings

Position Overview:

SLAC National Accelerator Laboratory seeks a Research Associate to join the Advan Department within the FACET and Test Facilities Division of the Accelerator Directorate. T Research Department develops and executes experiments in high-gradient plasma acce facilities at the SLAC National Accelerator Laboratory. FACET-II (Facilities for Experimental Test beams at SLAC) will study plasma acceleration, using short, intens positrons from the middle kilometer of the SLAC linac. The successful candidate will w postdocs, and graduate students from SLAC and external collaborators to develop, conduc at FACET-II.



Job Description

Previous Job | **Associate Scientist (AARD)** | Next Job

Apply for Job

Job ID	5140	**Full/Part Time**	Full-Time
Location	SLAC - Menlo Park, CA	**Regular/Temp…**	Temporary

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SLAC Job Postings

Position Overview:

SLAC National Accelerator Laboratory seeks an Associate Scientist to join the Advanced Accelerator Research Department within the FACET and Test Facilities Division of the Accelerator Directorate. The Advanced Accelerator Research Department develops and executes experiments in high-gradient plasma acceleration using the unique facilities at the SLAC National Accelerator Laboratory including FACET-II. FACET-II is a National User Facility in the middle kilometer of the SLAC linear accelerator facility that supports experimental programs combining high energy electron beams and their interaction will lasers, plasmas and solids. The successful candidate will work with other physicists, postdocs, and graduate students from SLAC and external collaborators to develop, conduct and analyze experiments at FACET-II.

- Reconfigure final bunch chicane for higher quality beams

Go to https://careers.slac.stanford.edu/ and search for jobs #5057 and 5140.

Conclusion/What's Next?

Accelerator Test Facilities in the United States have produced world-class research and results over the past decade.

Current facilities are debuting new capabilities aimed at developing technologies for a future collider based on Advanced Accelerator concepts.

Staging is critical!

- Currently pursued by BELLA (LWFA) and AWA (SWFA).
- Need a demonstration facility for PWFA. Something to follow FACET-II?

Final Focus and Beam Delivery is also critical!

- Research could be carried out in conjunction with ATF2@KEK.