Facility Status and Expectations for FY24

FACET-II

Facility for Advanced Accelerator Experimental Tests

2023 FACET-II User Meeting

Mark J. Hogan/ Senior Staff Scientist / FACET and Test Facilities Division Director

October 17, 2023

SLAC NATIONAL ACCELERATOR LABORATORY

Stanford University | U.S. DEPARTMENT OF ENERGY

Emergency Information

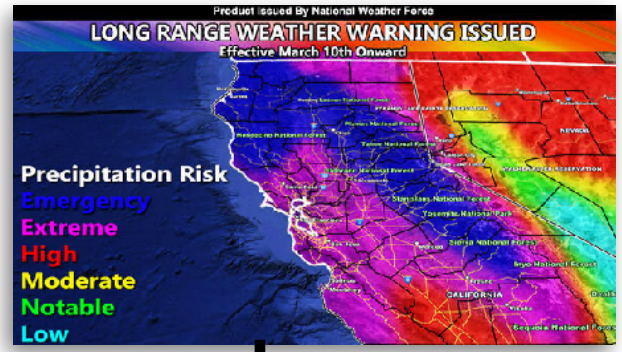
Fire

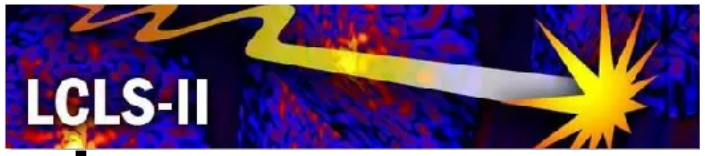
- Evacuate. Be aware of building exits.
- Follow building residents to the assembly area.
- Do not leave until you are accounted for, and have been instructed to.

Earthquake

- Remain in building: duck, cover, and hold position.
- When shaking stops: evacuate building via a safe route to the assembly area.
- Do not leave until you are accounted for, and have been instructed to do so.

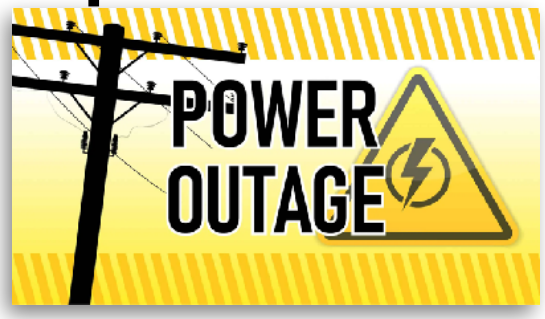
It Has Been an Eventful 2023 at SLAC





JAN FEB MAR APR MAY JUN JUL AUG SEP OCT

Corrective Action Plan (CAP)



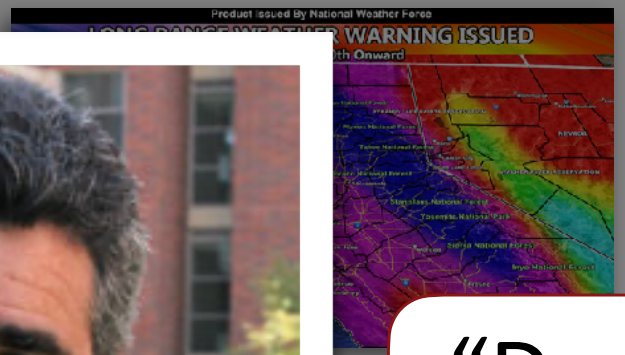
FACET-II User Meeting

LCLS

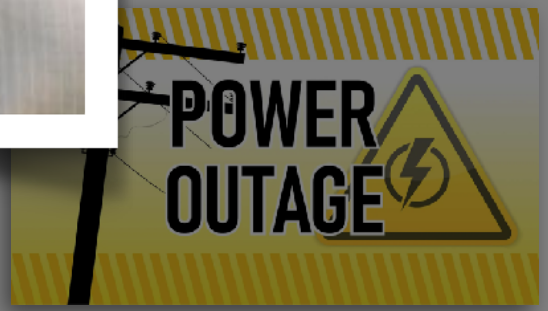
FACET-II

All SLAC Accelerators were off for 6-9 months

It Has Been an Eventful 2023 at SLAC



Action Plan (CAP)



"Don't complain and don't explain"
– Tom Katsouleas

FACET-II User Meeting

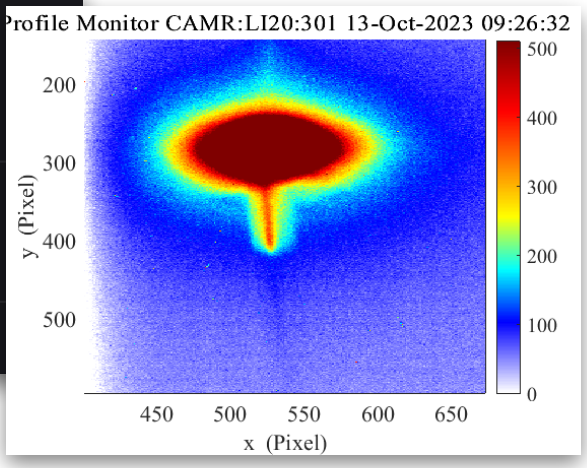
LCLS

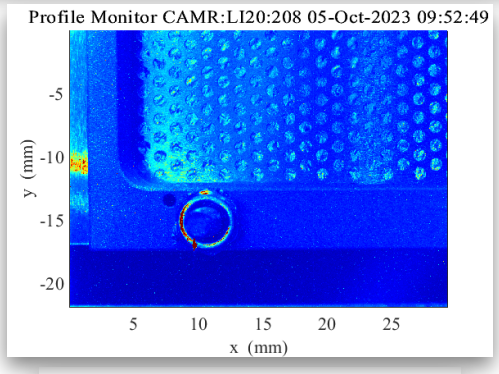
FACET-II

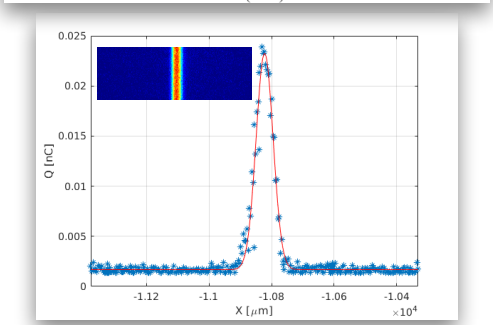
All SLAC Accelerators were off for 6-9 months

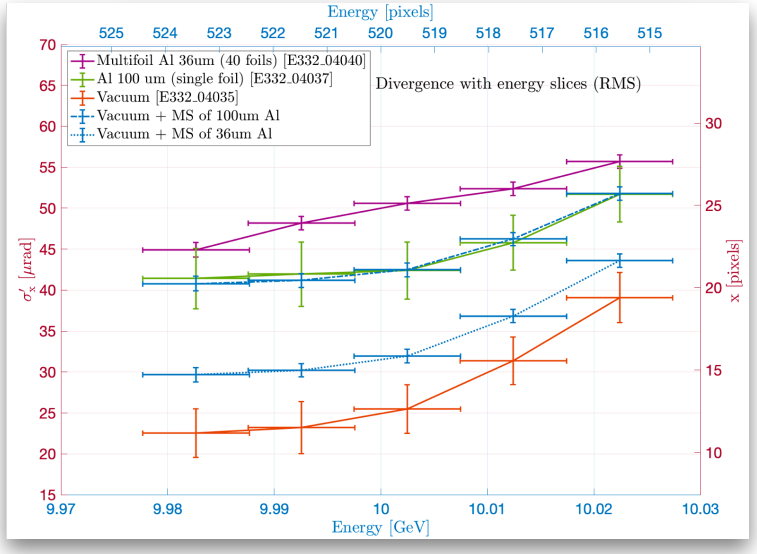
Experiments Have Resumed in S20 Experimental Area

- We restored RF and beam in the FACET-II injector end of July
- Early August recovered to 2nC in injector
- August focused on commissioning the new laser heater (talk by Claudio)
- On September 25th there was enough RF available to make 10 GeV
- Beam was transported through the Experimental area to the main beam dump with low energy spread and ~20μm spots (talk by Jerry)



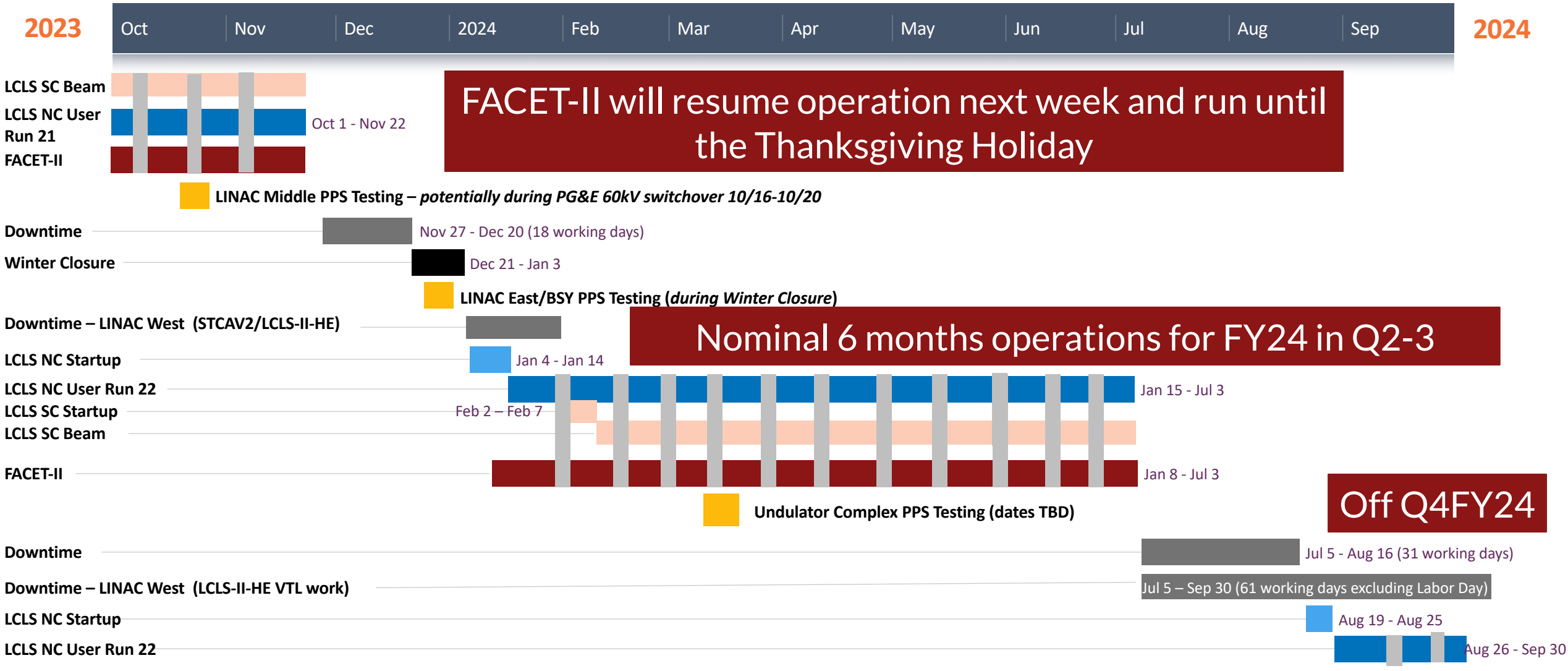






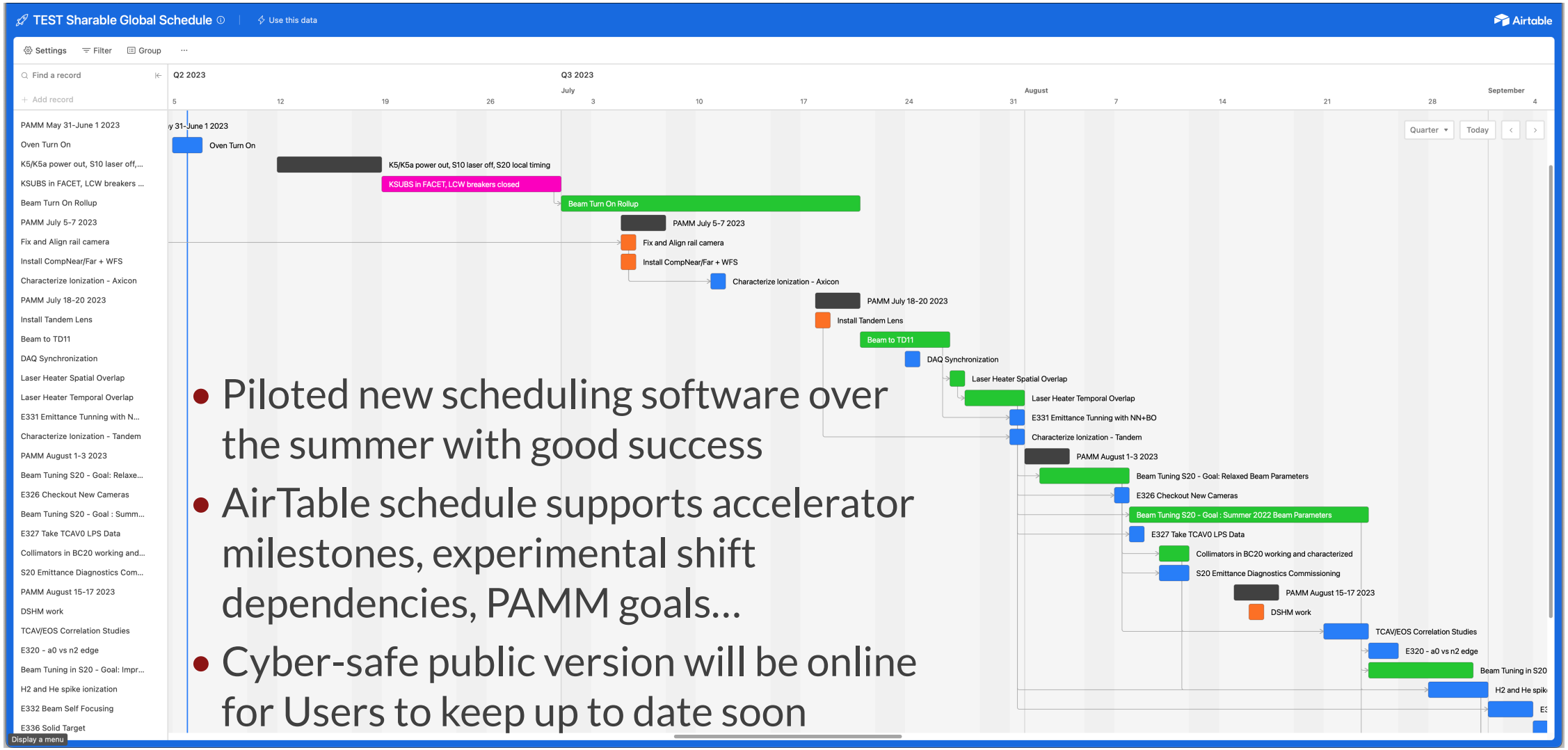
First experiments started in October

Oct 2023/Sept 2024 Accelerator Schedules & Downtimes



Next Program Advisory Committee Meeting Fall 2024

Global Schedule Under Development



- Piloted new scheduling software over the summer with good success
- AirTable schedule supports accelerator milestones, experimental shift dependencies, PAMM goals…
- Cyber-safe public version will be online for Users to keep up to date soon

Get your shift plans in to Brendan

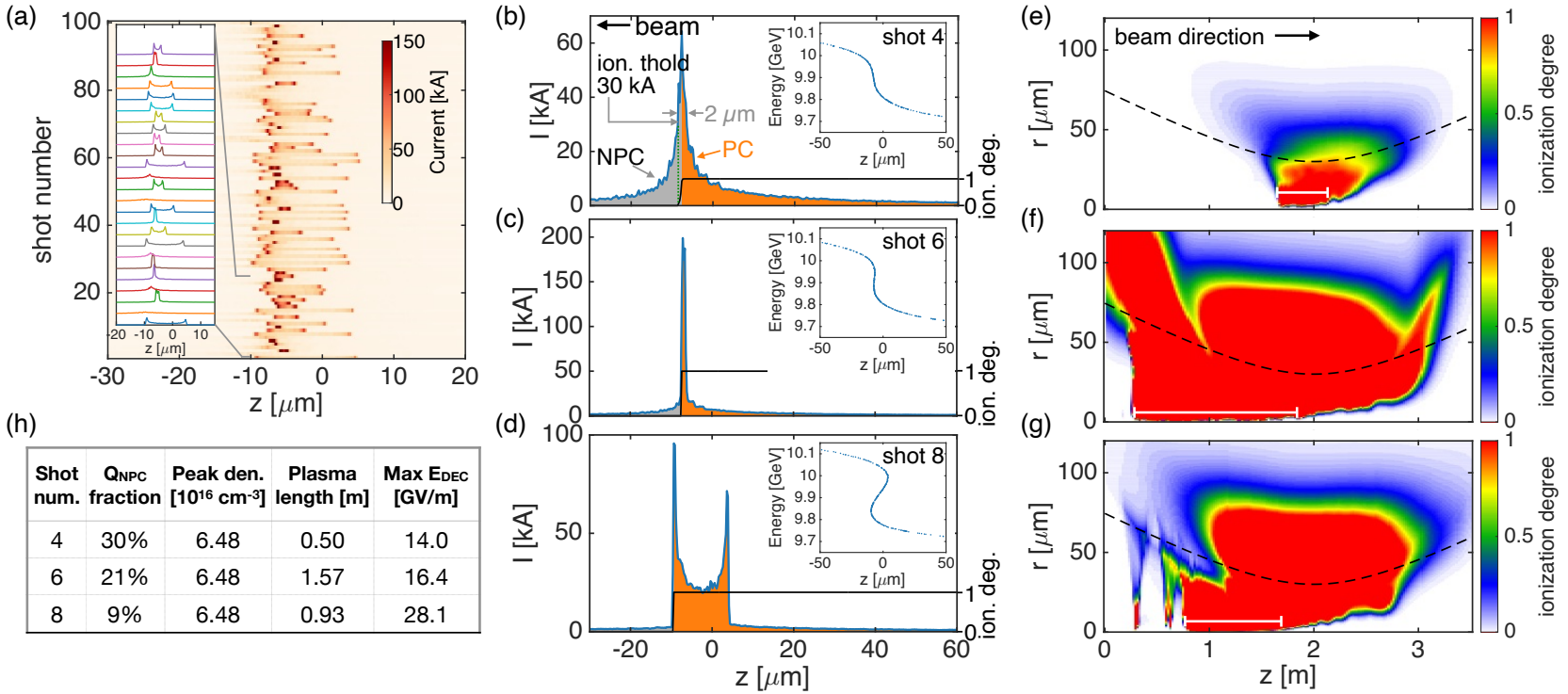
Three Basic Accelerator Configurations

- **Highest energy and low backgrounds** (13GeV, low σ_E, σ_z = 100μm, 1m betas)
  - SFQED
- **Single bunch with high peak current** (50-300kA, 0.1-10m betas)
  - Filamentation
  - NFCTR focussing
  - TH & DDR injection
  - Wake imaging
- **Two-bunch** (1.3/0.6nC, 30/15kA , 150μm separation, 5-50cm betas)
  - PWFA emittance preservation under high beam-loading
  - PWFA hosing suppression
  - Wake imaging

These configurations satisfy the experiments currently invited for beam time

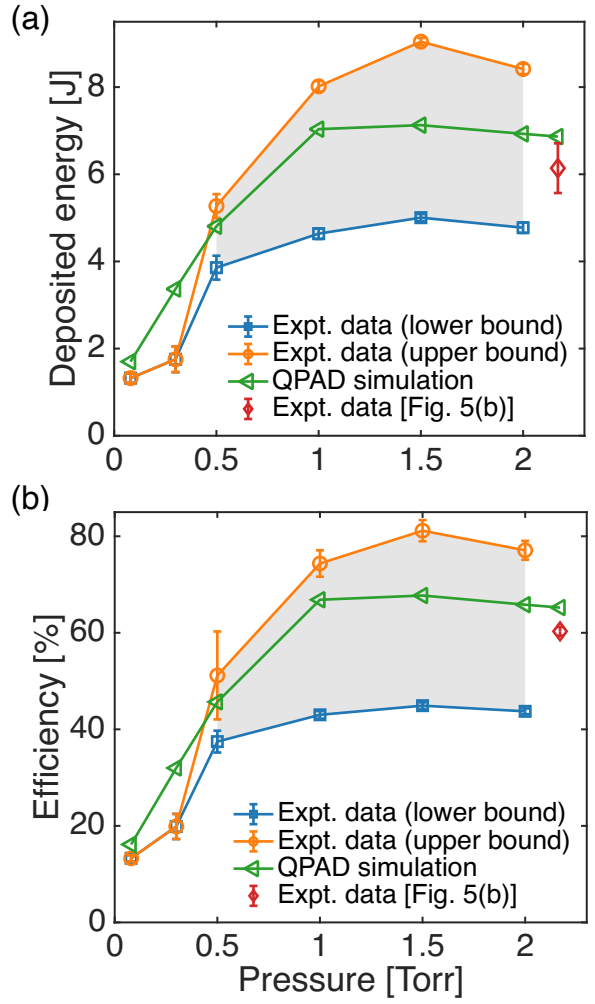
Looking Ahead to Fully Compressed Single Bunches: Plasma Accelerated Spectra Reveal Details of Incoming Beam

- Small changes to compression can lead to large change in peak current and field-ionized plasma distribution
- Participating charge and energy loss are sensitive to current profile



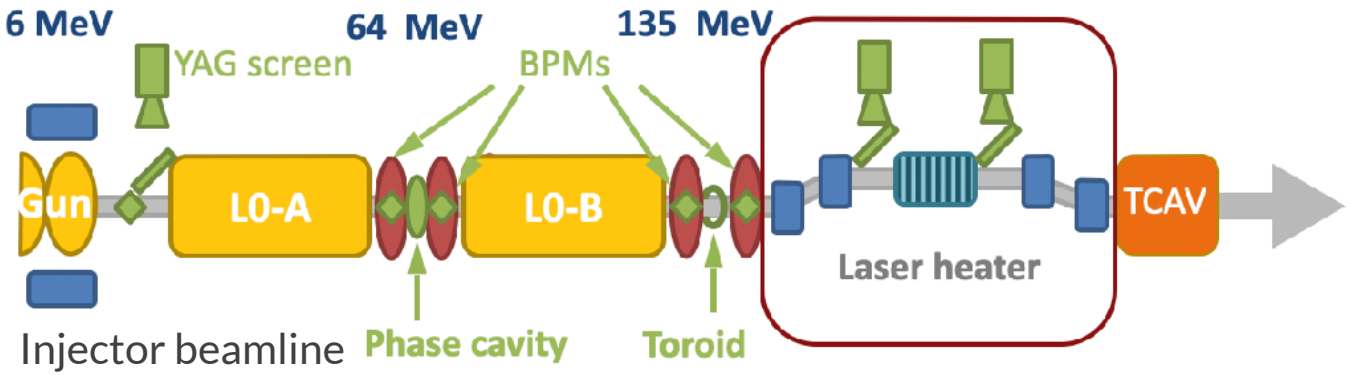
(h)

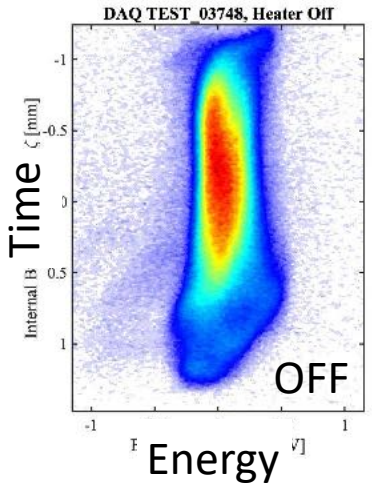
Shot num.	Q_{NPC} fraction	Peak den. [10^{16} cm^{-3}]	Plasma length [m]	Max E_{DEC} [GV/m]
4	30%	6.48	0.50	14.0
6	21%	6.48	1.57	16.4
8	9%	6.48	0.93	28.1

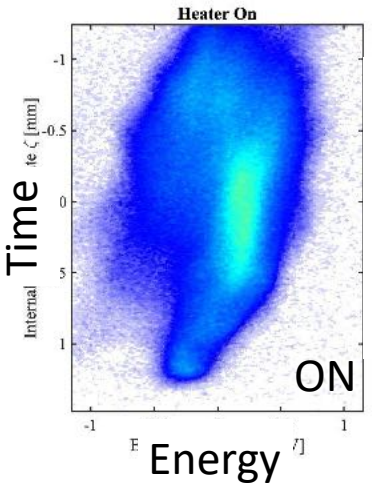


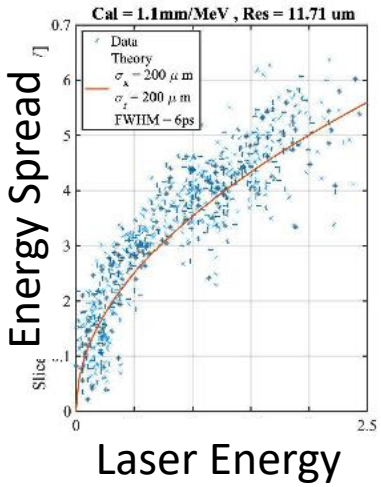
Next steps: Fall 2023 use laser heater for additional stability, pre-ionized plasma (Li and H_2) for improved efficiency, and two-bunch setup to add witness bunch to study energy gain 2024

FACET-II Injector Laser Heater

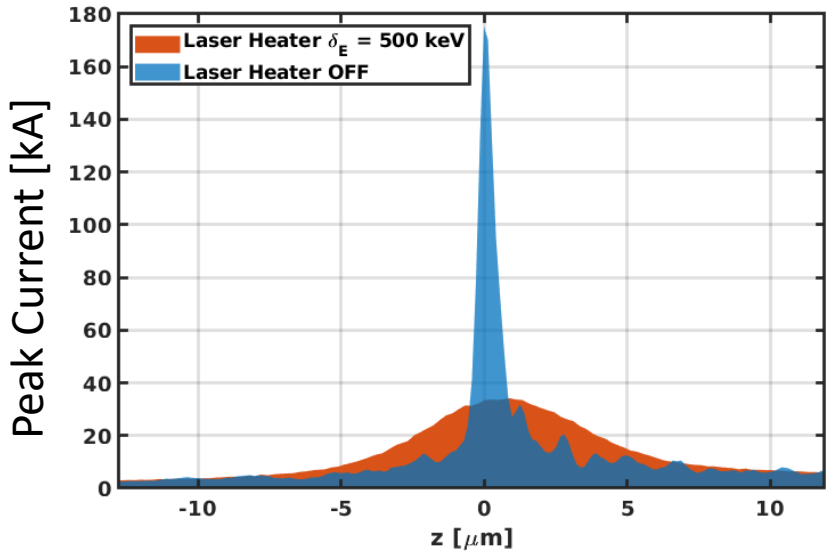


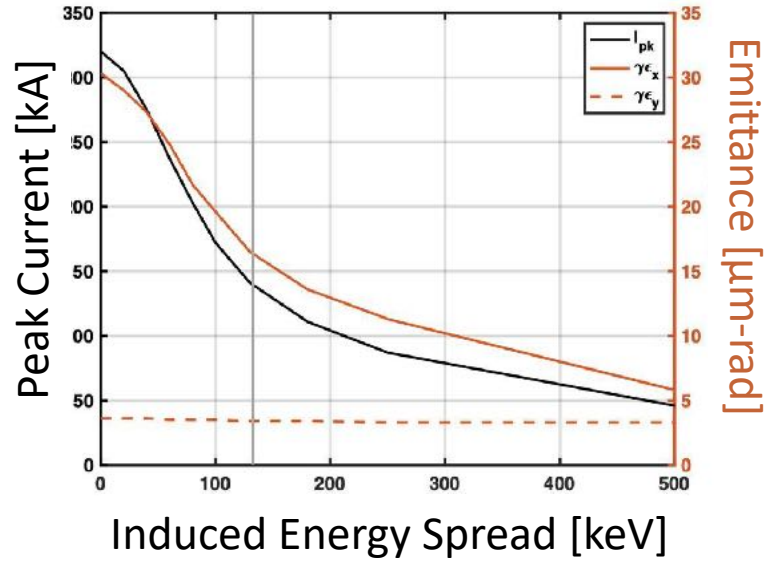






- Laser heater increases uncorrelated energy spread using inverse FEL process
  - Effective tool for limiting microbunching & CSR
  - Tunable peak current
  - Enhances stability





Injector laser heater suppresses COTR, enhances stability and provides tunable peak current

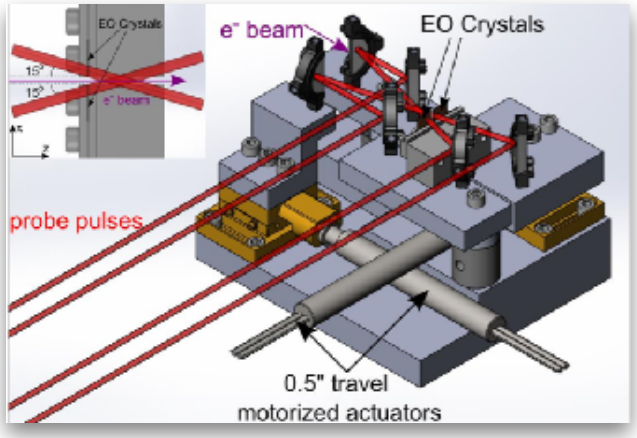
Extreme Beams are a Challenge and an Opportunity

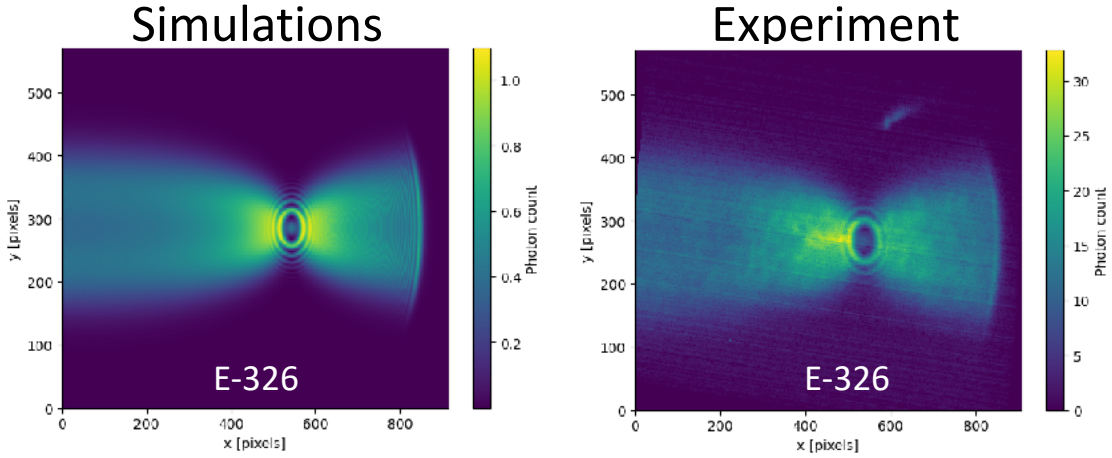
Unprecedented intensities allow us to access new regimes and explore new scientific directions

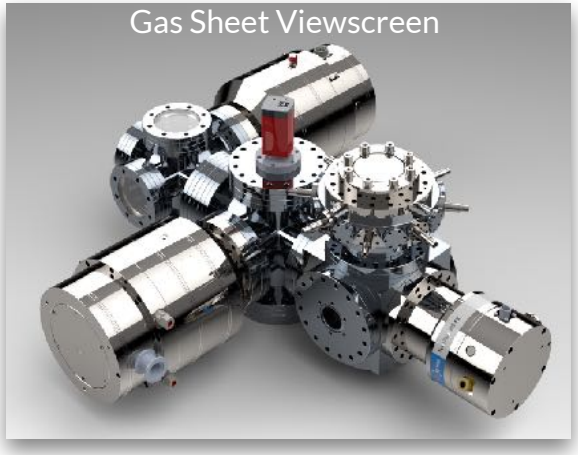
- They also drill our vacuum windows, profile monitors and wire scanners

An important part of the FACET-II program has always been developing new techniques to diagnose and control these beams

- Tuesday talk by Claire on EOS BPM progress
- Wednesday morning session on ML/AI for diagnostics and control of extreme beams: Alex (E-325), Brendan (E-326), Claudio (E-327) and Auralee (E-331)
- Novel diagnostics e.g. Wednesday Gerard on Gas Sheet Viewscreen (E-322)

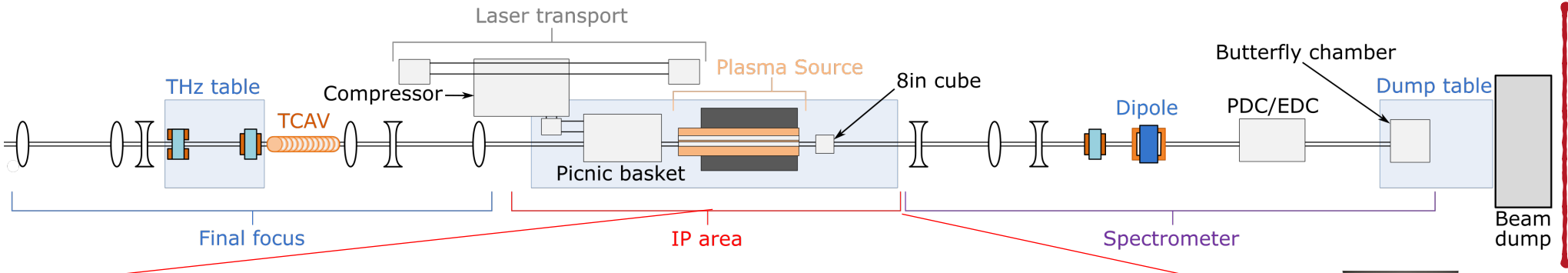




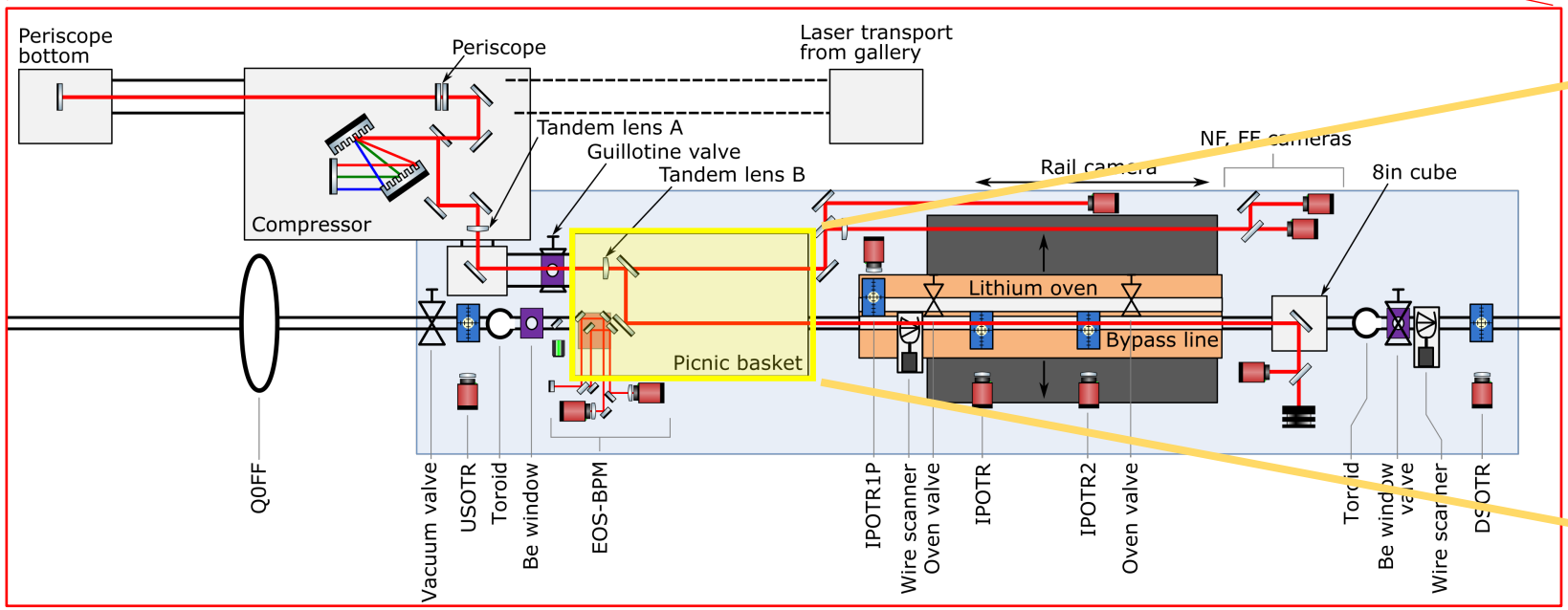


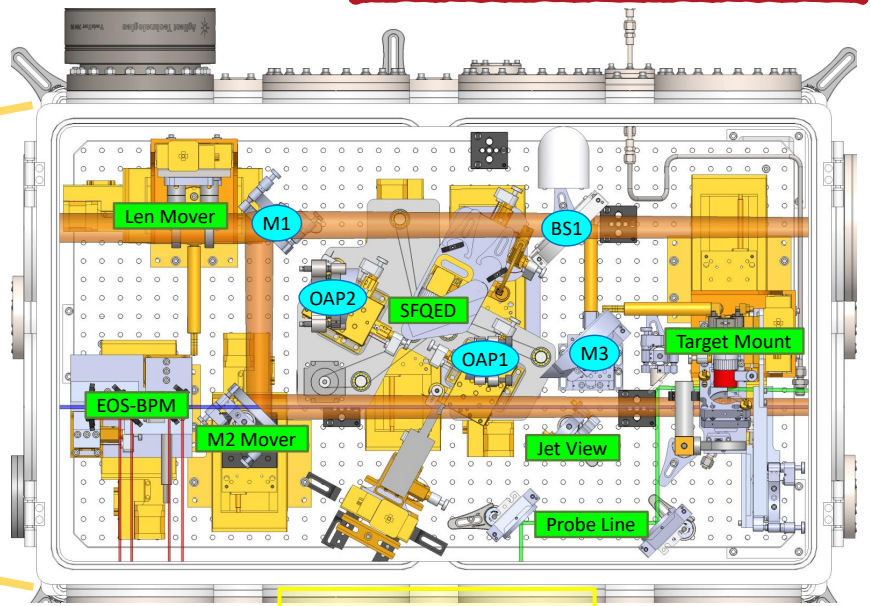
Have a look: Video Tour and Street-view

The Experimental Area Design was Coordinated with the FACET-II User Community to Accommodate Many Experiments with Minimal Reconfiguration



10 TW laser; solid, gas and plasma targets of various density & length; specialized electron, X-ray and Gamma-ray diagnostics



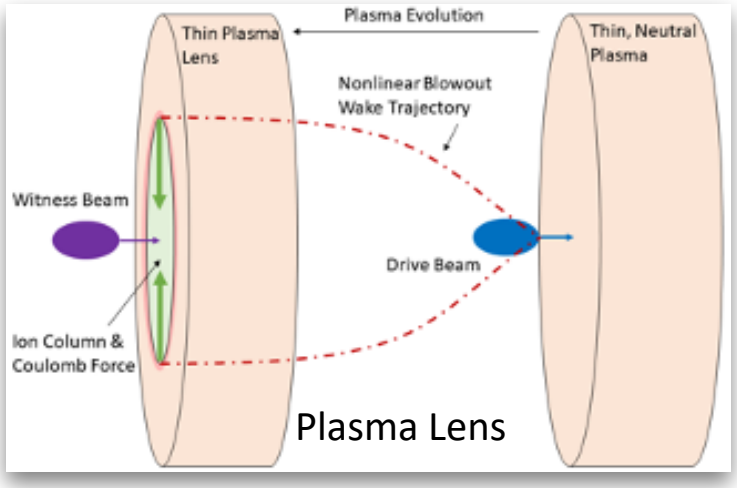


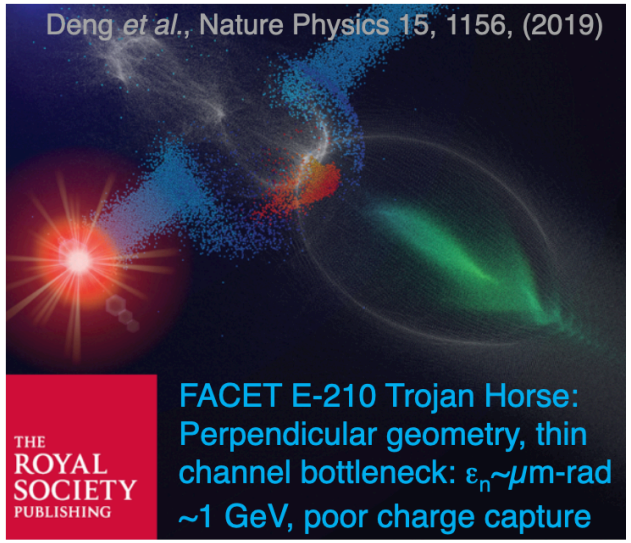
PICNIC BASKET

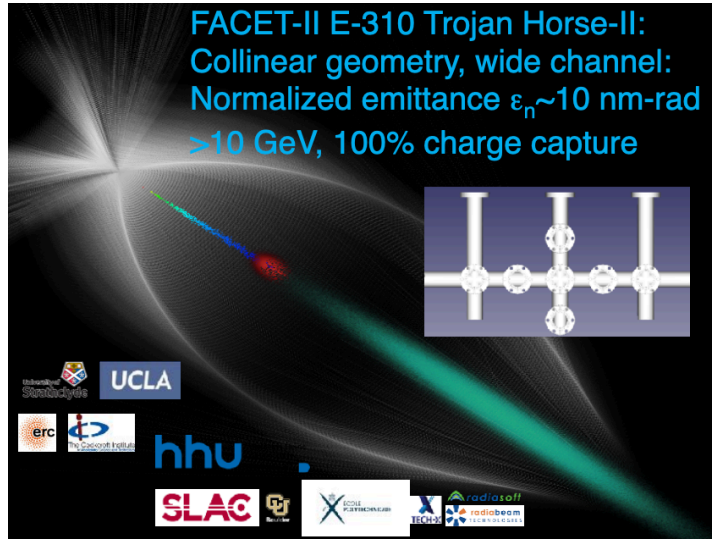
Overview talks on high power laser & Picnic Basket (Robert) and laser probe lines (Alex)

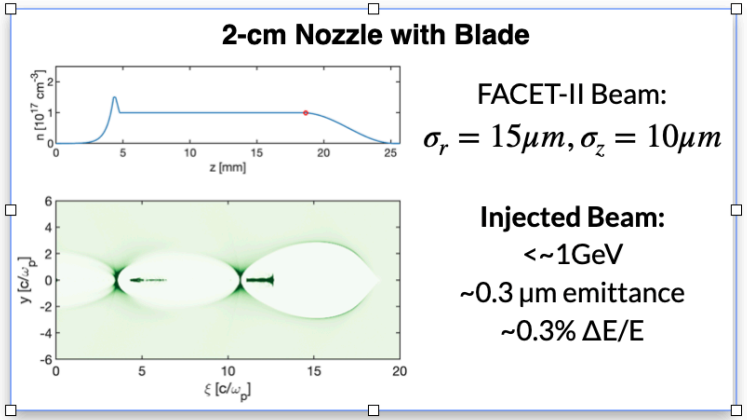
Talks by Mike (E-308), Bernhard & Andrew (E-310 et al), Chaojie (E-304) and Ago (E-338)

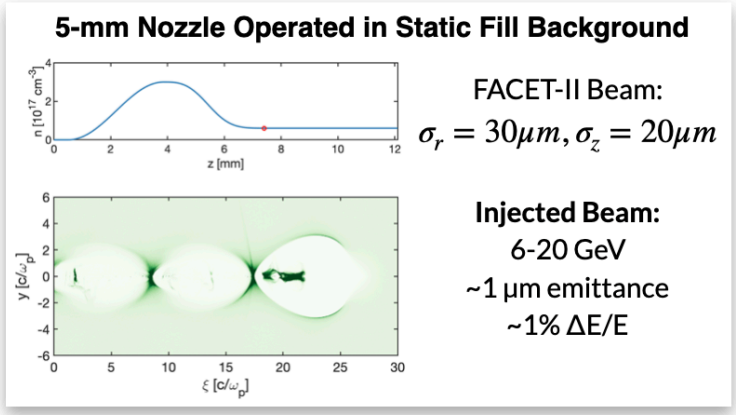
Novel Focusing, Injector and Radiation Generation Concepts

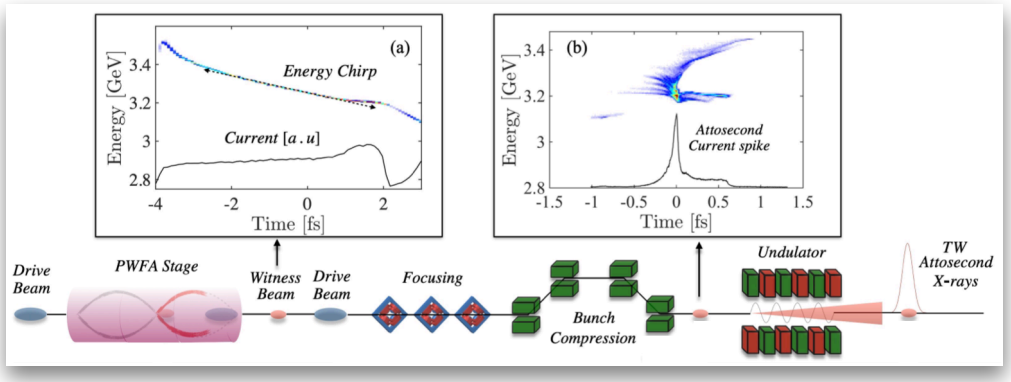






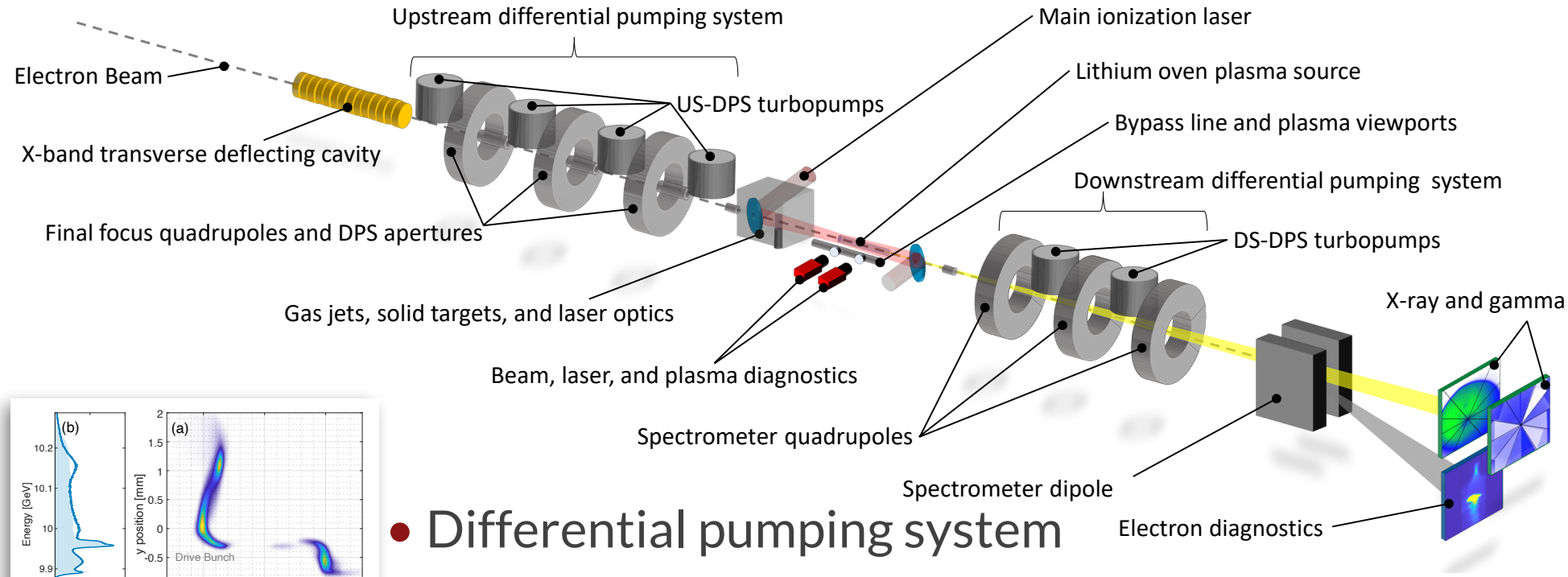


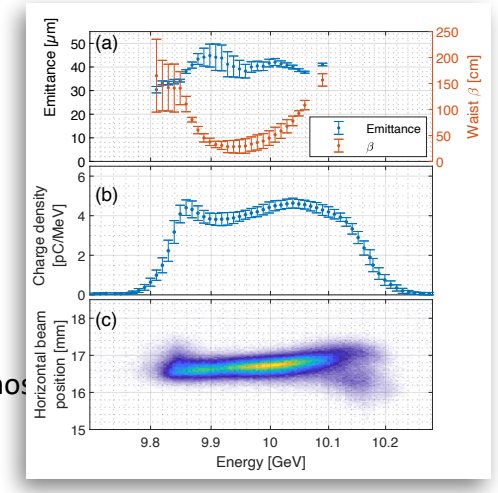


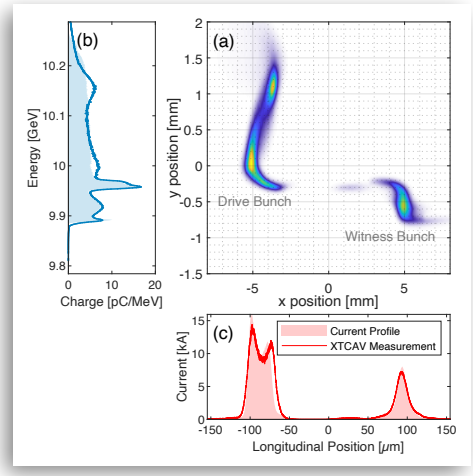


Bringing the full compliment of Picnic Basket and Laser Probe capabilities online will enable extreme focusing, ultra-bright beam generation and novel radiation source experiments

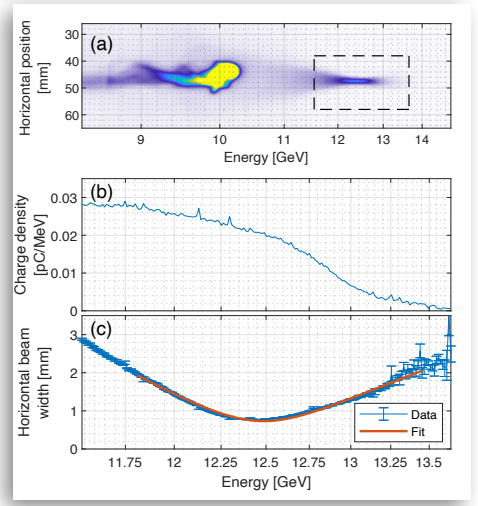
Systems are in Place to Begin Two-Bunch PWFA in 2024







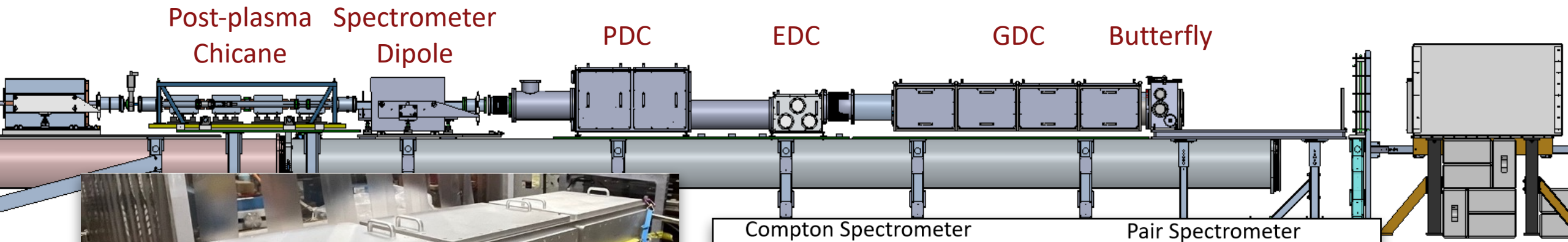
- Differential pumping system fully commissioned with Li oven, gas jets and static fill H_2 and He (laser and beam ionized)
- Diagnostics for emittance (single and multi-shot)

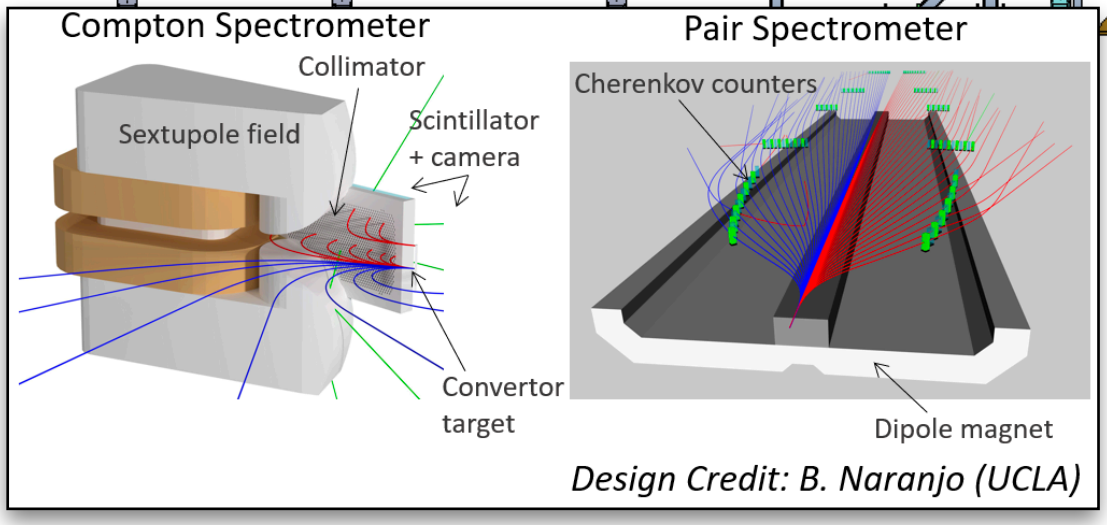


Collaboration has created robust infrastructure where progress for individual programs benefits the whole community

New Additions to the User Area

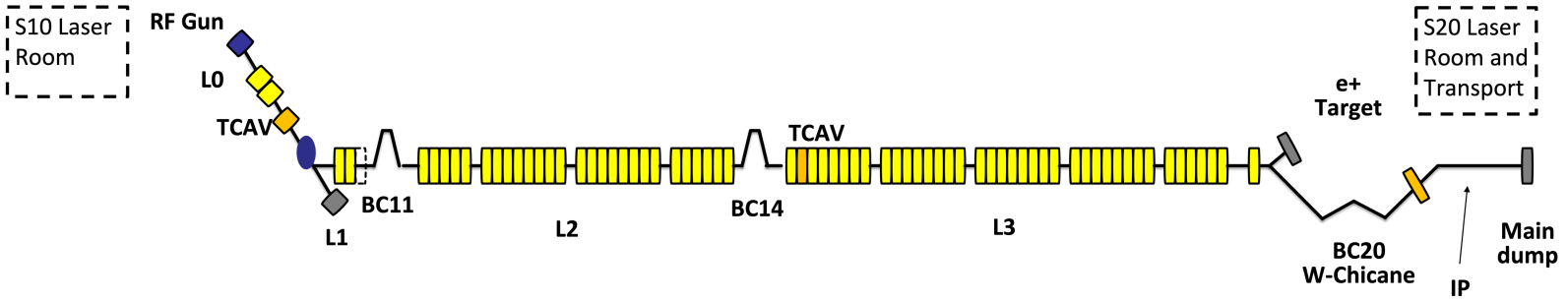
- We continue to look to the future as we plan for upgrades e.g. Post-plasma Chicane, Gamma Detection Chamber and spectrometers



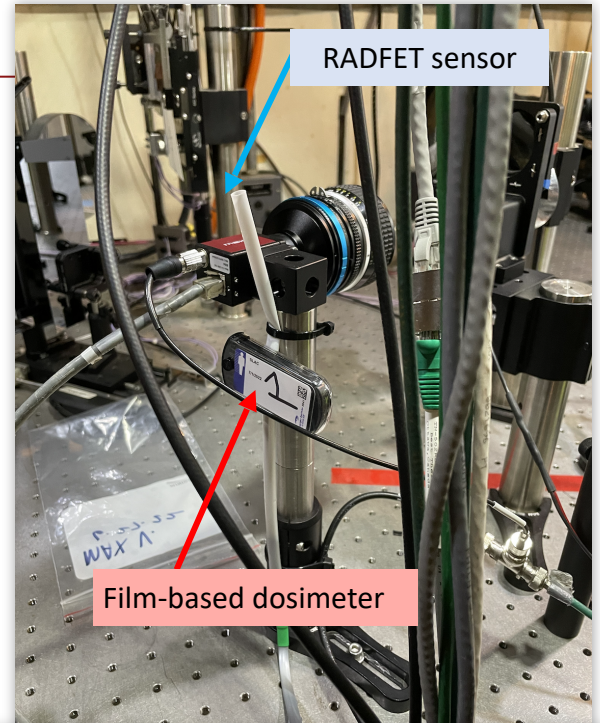


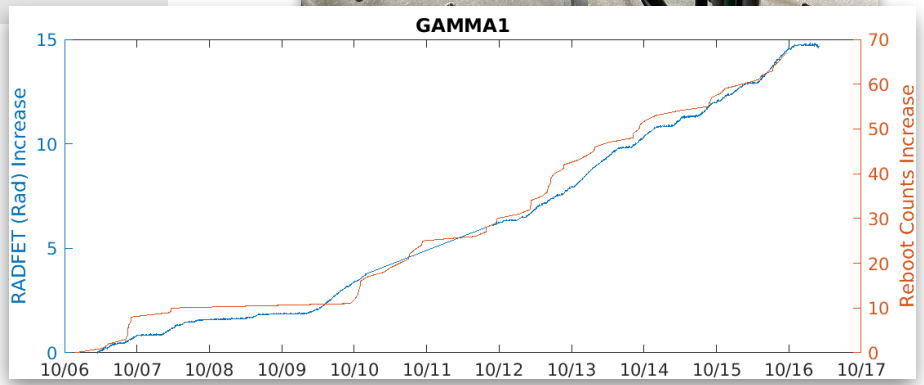
The Experimental Area will continue to evolve to meet the needs of the User Community

FACET-II Camera Diagnostics



Region	S10 Laser	Injector	L1 and BC11	L2 and BC14	BC20	S20 Laser	IP Area	EDC/ Dump	Total
Deployed (2022)	7	3	6	3	2	21	24	12	78
Deployed (2023)	9	8	9	3	2	24	24	13	92
Planned	11	8	11	6	5	24	30	16	111





- Digital cameras are the main diagnostic for experiments at FACET-II
- Their uptime and performance are critical to the success of the facility

Camera Watchdog software and RADFET sensors to monitor camera performance in the radiation environment

FACET and Test Facilities Division

Advanced Accelerator Research

- Organize and participate in science program aligned with HEP Roadmaps

Test Facilities

- Takes care of Users

FACET-II Operations

- Makes the machine work for you

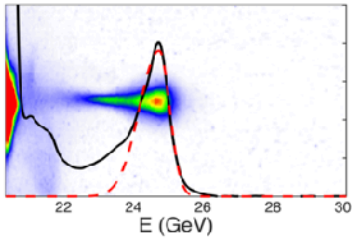
New staff are bringing energy and creative ideas

FACET-II Positron Upgrade

- Positrons represent a unique scientific opportunity with global enthusiasm
  - Snowmass preparations, European Strategy updates and recent workshops (AAC/EAAC)

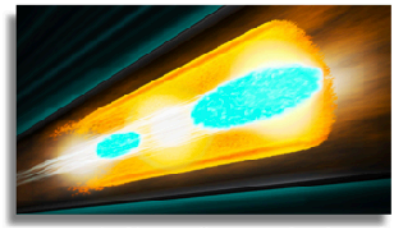
Demonstrated @ FACET

Non-linear wakes in self-loaded regime of PWFA

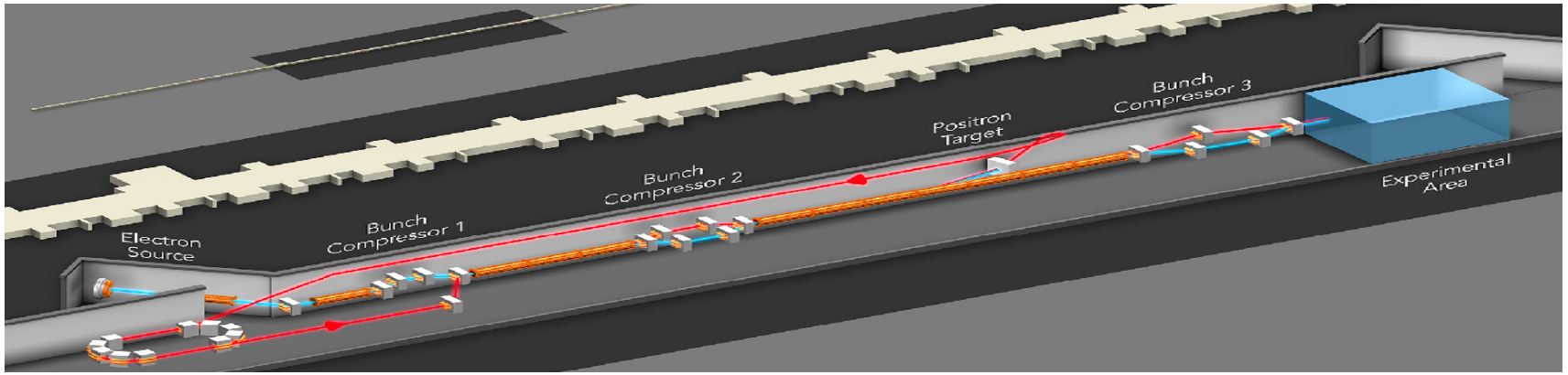


Corde et al., ***Nature*** August 2015

Hollow Channel Plasma Wakefield Acceleration

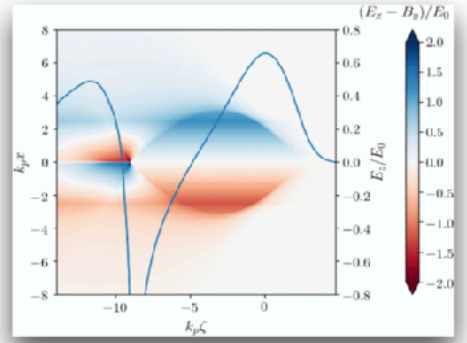


Gessner et al., ***Nature* Communications** 2016
Lindstrom et al., ***Phys. Rev. Lett.*** 2018



Proposed @ FACET-II

- Finite-channel plasmas are predicted to preserve emittance
- LBNL, DESY, CU Boulder and SLAC collaboration



S. Diederichs et al., Phys. Rev. Accel. Beams 22, 081301 (2019)

Potential for experiments on positron PWFA has stimulated creative new ideas – focus of the Thursday session

Will re-examine options with DOE HEP once P5 report is available. With a commitment and strong support from SLAC the plan could be executed on 5 year time scale without interruption of existing user program.

Agenda for the Next Three Days

Day 1, October 17, 2023: Facility Status, capabilities and upgrade plans and Experimental Progress and Plans

Start Time (PST)	Duration	Title	Name	Affiliation
9:00 AM	25m	Facility Status and Expectations for FY24	Mark Hogan	SLAC
9:25 AM	15m	Meet your new User Coordinator	Ivan Rajkovic	SLAC
9:40 AM	20m	Commissioning progress and expected beam parameters for FY23		
10:00 AM	20m	Beam configurations: updated simulations with W-chicane, linearizer, plans for two-bunches		
10:20 AM	20m	Laser heater commissioning		
10:40 AM	**30m**	**Coffee Break**		
11:10 AM	20m	S20 Laser High power performance and possible upgrades		
11:30 AM	30m	Transfer to S20		
12:00 PM	45m	Tour of S20 Experimental Area		
12:45 PM	30m	Return to Sycamore Room		
1:00 PM	**30m**	**Lunch**		
1:30 PM	20m	S20 laser and diagnostic probe lines		
1:50 PM	20m	Experimental area (e- and gamma diagnostics, DPS, Li oven)		
2:10 PM	20m	Picnic basket configurations and possible upgrades		
2:30 PM	20m	EOS BPM Progress and Plans for FY24		
2:50 PM	20m	EQU projects and Upgrades (in progress and planned)		
3:10 PM	**20m**	**Coffee Break**		
3:30PM	45m	E-300 Progress and Plans for FY24		
4:15 PM	30m	E-305 and E-332: from beam filamentation, bright gamma r		
4:45 PM	30m	E-308 Progress and Plans for FY24		
5:15 PM	15m	Discussion and Adjourn		
6:00 PM		**No Host Reception @ The Dutch Goose**		

Day 2, October 18, 2023: Experimental Progress & Plans

Start Time (PST)	Duration	Title	Name	Affiliation
9:00 AM	40m	E-320 Progress and Plans for FY24	David Reis	Stanford
9:40 AM	30m	Beyond E-332: New tools and opportunities for strong-field QED and extreme plasma physics	Matteo Tamburini	MPI NP
10:10 AM	20m	E-336 Progress and Plans for FY2	Max Gilljohann	LOA
10:30 AM	**30m**	**Coffee Break**		
11:00 AM	20m	E-325 Progress and Plans for FY24	Alex Scheinker	LANL
11:20 AM	30m	E-326 Progress and Plans for FY24	Brendan O'Shea	SLAC
11:50 AM	20m	E-327 Progress and Plans for FY24	Claudio Emma	SLAC
12:10 PM	30m	E-331 Progress and Plans for FY24	Auralee Edelen	SLAC
12:40 PM	**50m**	**Lunch**		
1:30 PM	20m	Gamma Detection: Compton and Pair Spect		
1:50 PM	20m	E-301 Plans for FY24		
2:10 PM	20m	E-304 Plans for FY24		
2:30 PM	20m	E-324 Plans for FY24		
2:50 PM	**30m**	**Coffee Break**		
3:20 PM	40m	E-310/311/315		
4:00 PM	20m	E-338 PAX		
4:20 PM	20m	E-322		
4:40 PM	20m	PetaVolts per meter plasmonics		
5:00 PM		**Reception in the lobby of Building 52**		

Day 3, October 19, 2023: Positrons

Start Time (PST)	Duration	Title	Name	Affiliation
9:00 AM	45m	Positron beam loading in uniform regime	Shiyu Zhou	Tsinghua
9:45 AM	45m	Plasma Temperature Effects in Positron PWFA	Severin Diederichs	DESY
10:30 AM	**30m**	**Coffee Break**		
11:00 AM	30m	Energy recover in positron PWFA wake	Max Varverakis	Cal Poly
11:30 AM	60m	Positron PWFA review and scaling laws	Gevy Cao and Carl Lindstrom	
12:30 PM	**30m**	**Lunch**		
1:00 PM	30m	Beam-based laboratory astrophysics	Gianluca Gregori	Oxford
1:30 PM	20m	Electron trapping in positron driven wakefields	James Allen	SLAC/Stanford
1:50 PM	10m	Discussion	Mark Hogan	SLAC
2:00 PM		**Adjourn**		

- We are happy we can provide coffee, cookies and lunch without registration
- Tonight the Dutch Goose
- Wednesday Reception in B52
- When it's time to present, connect to zoom and share your slides so remote participants can follow along
- Please provide a copy of your slides to Nadya to attach to the agenda

Summary and Outlook

- There has been a lot of progress since the last PAC – data analysis has yielded fresh insights, first publications and steady progress improving systems in the experimental area
- 2023 presented some challenges but our collaborations have made steady progress and are ready for more beam
- FACET-II is delivering high-intensity beams that open new scientific directions strongly aligned with HEP roadmaps for plasma acceleration
- FACET-II is leveraging SLAC ML/AI initiatives to develop new methods to diagnose and control extreme beams
- We are installing and commissioning important hardware & capabilities to benefit the experimental programs: laser heater, LLRF for more stable delivery, Gamma Detection Chamber, and two-bunches from the FACET-II injector

We are excited to be re-starting the science programs and we look forward to many face to face discussions here at the 2023 User Meeting