

Facility Status and Expectations for FY23

FACET-II PAC Meeting

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

October 25, 2022

Emergency Information

Incident Notification

Life Threat
Smoke, Fire, Explosion
Large Hazardous Material Release

Call 911

Call ext. 5555

Supervisor

If in doubt, call 911 or ext. 5555

Incident Notification

Non-Life Threatening
Notify Immediately

Injury

M-F
(8-5)

Supervisor

Other
times

SLAC
Medical

Next business day

ext. 5555

"Off Normal" Events
(e.g., equipment damage, near misses, etc.)

Supervisor

ext. 5555

If in doubt, call 911 or ext. 5555

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.

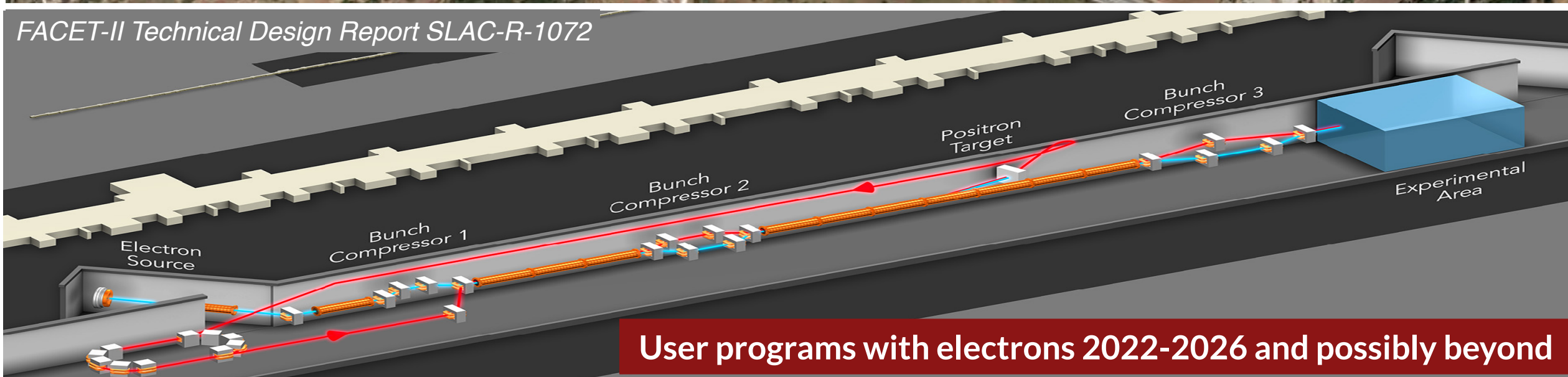
Earthquake

- 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.

FACET-II National User Facility



FACET-II Technical Design Report SLAC-R-1072

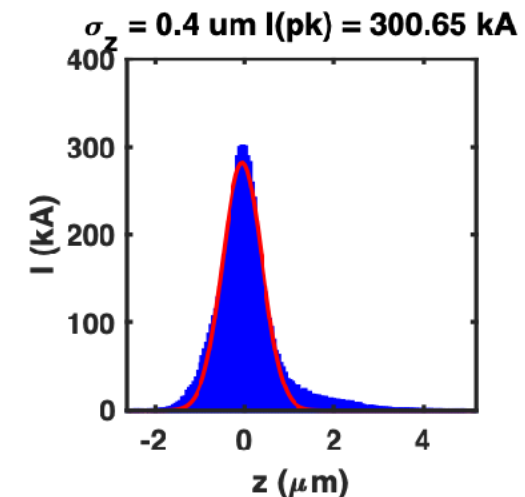
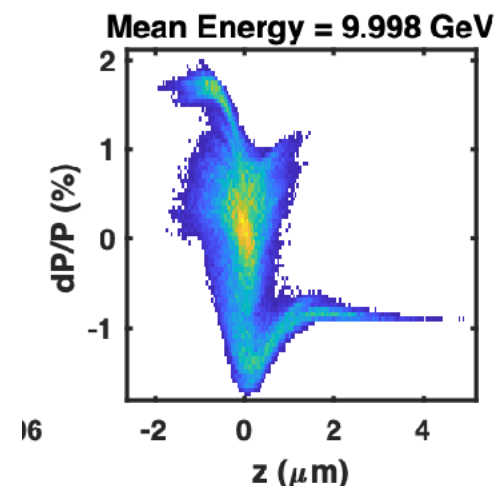


User programs with electrons 2022-2026 and possibly beyond

FACET-II is Accessing New Regimes

- $\sim 10\mu\text{m}$ Emittance
- $\sim 100\text{kA}$ Peak current (sub- μm bunch length)
- $\sim 100\text{nm}$ focal size from plasma lens
- $\sim 10^{12}$ V/cm radial electric field
- $\sim 10^{24}$ e-/cm³ beam density

<i>Electron Beam Parameter</i>	<i>Baseline Design</i>	<i>Operational Ranges</i>
<i>Final Energy [GeV]</i>	10	4.0-13.5
<i>Charge per pulse [nC]</i>	2	0.7-5
<i>Repetition Rate [Hz]</i>	30	1-30
<i>Norm. Emittance $\gamma\epsilon_{x,y}$ at S19 [μm]</i>	4.4, 3.2	3-6
<i>Spot Size at IP $\sigma_{x,y}$ [μm]</i>	18, 12	5-20
<i>Min. Bunch Length σ_z (rms) [μm]</i>	1.8	0.7-20
<i>Max. Peak current I_{pk} [kA]</i>	72	10-200



Improved longitudinal and transverse emittance from the photoinjector allows FACET-II to deliver beams with unprecedented intensities to address HEP roadmaps and open new science directions

FACET-II Science Program and Program Advisory Committee



Science Program developed through seven years of science workshops

FACET-II WebEx Meeting Agenda 21-DEC-2012

Start Time	Duration	Speaker	Title	Confirmed
9:00 AM				
9:20 AM				
9:50 AM				
10:10 AM				
10:50 AM				
10:50 AM				
11:10 AM				
11:20 AM				
11:50 AM				
12:10 PM				
12:40 PM				
1:00 PM				
1:20 PM				
1:40 PM				



47 proposals reviewed
12 invited for beam time in FY22

PAC Meetings in Fall 2018, 2020, 2022



FACET-II empowers broad user community and user community enables FACET-II

FACET-II Major Events and Timeline

- CD-0: AUG 2015; CD-1: DEC 2015; CD-2/3a: SEP 2016 & CD-2/3: JUL 2018
- FACET-II DOE REVIEW OF OPERATIONS: JAN 2019
- Major hardware installations completed by OCT 2019
- Project on stand-by; resources diverted to LCLS-II: NOV 2019
- Project resumed activities: MAR 2020
- Start of COVID-19 Pandemic and Shelter in Place: MAR 2020
- Accelerator Readiness Review: JUL 2020
- Installation complete: AUG 2020
- Start FACET-II commissioning: SEP 2020
- Threshold KPP and CD-4: SEP 2021
- Objective KPP and start of experimental programs: MAY 2022



MFD & FACET team install new experimental chamber in S20



Test Facilities personnel qualify new differential pumping system



FACET Users and Staff commission new diagnostics

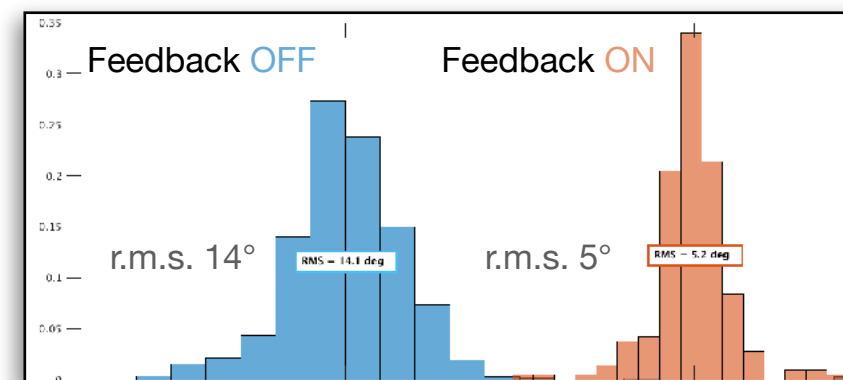
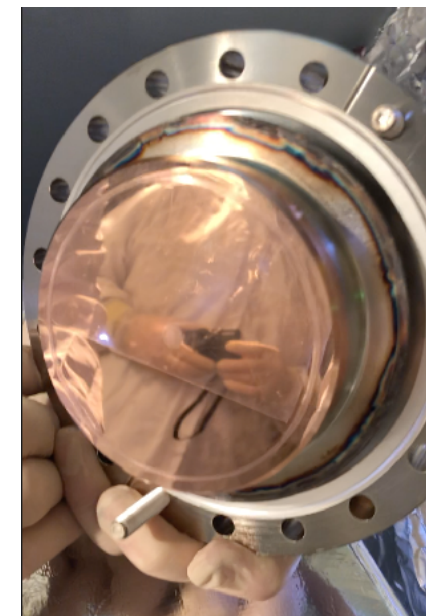


FACET Operations Crew driving for Objective KPP

The FACET-II team has persevered through resource constraints and a global pandemic to complete the project, commissioned the accelerator and began our exciting science program

From Threshold KPP to Objective KPP

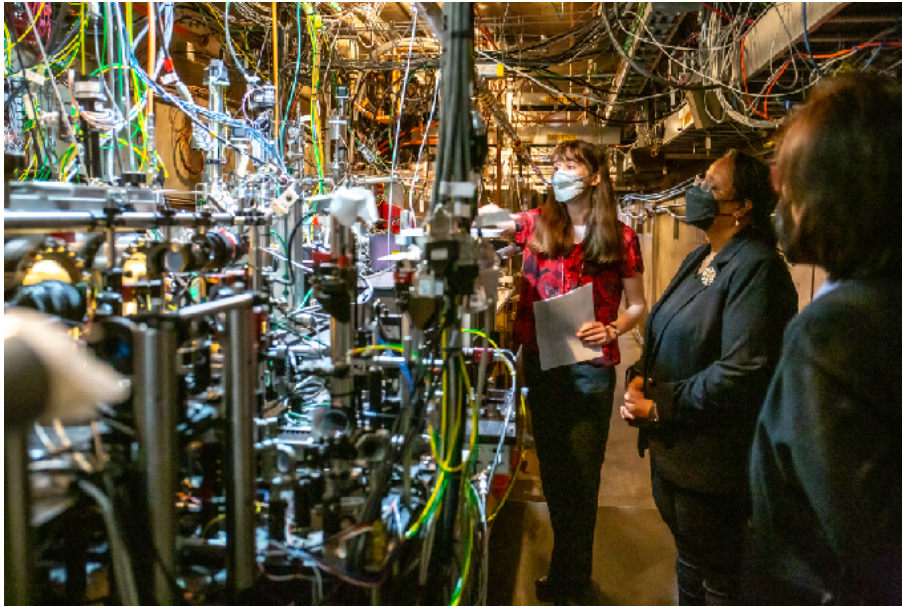
- Injector vacuum, cathode and injector laser wavelength change for stable 2nC
- Hardware and software for charge feedback
- Correct lattice issues
- Hardware and software for energy feedbacks
- SLA to get additional klystrons
- Hardware and software for bunch length feedbacks
- MDL feedback for klystron phase stability
- Hardware and software for emittance measurements



FACET-II was built by and is operated by many of the same people that operated FACET

Enormous Amount of Work to Get Ready for Experiments

- Research staff coordinate design and installation of experimental equipment, organize experimental shifts and collaboration meetings to gather requirements



- Completely rebuilt the FACET experimental area to be ready for lower emittance FACET-II beams: chambers, targets, high-power and diagnostic laser lines, differential pumping, re-located TCAV, electron beam final focus and spectrometer...

- As Brendan says “Planning is not optional”
- Progress correlates with boots on the ground

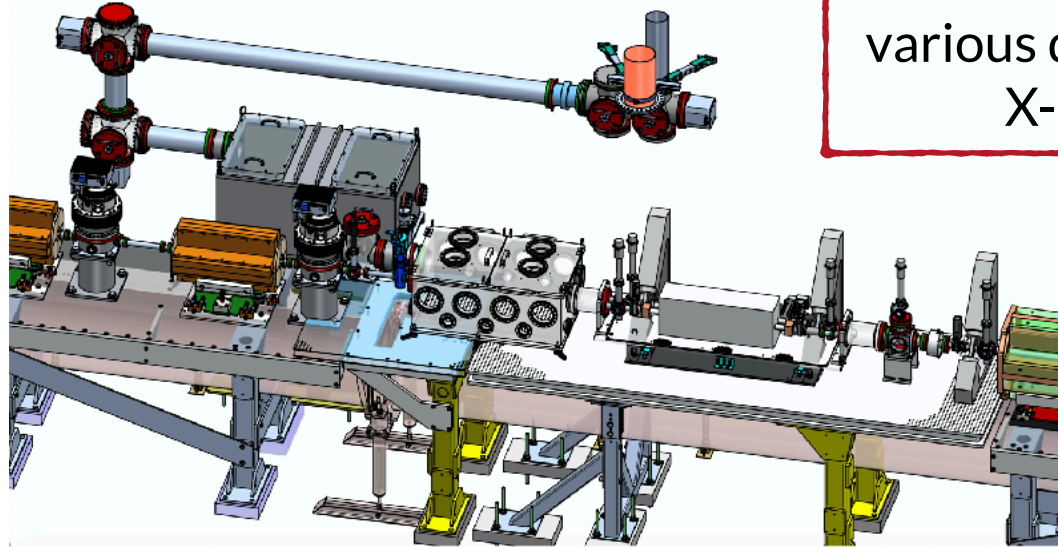
Feedback from Safety stand downs acknowledges the increased burden on existing staff to support User programs and plan and execute PAMMs safely

Experimental Area and Facility Are Coordinated and Planned Based on PAC Rankings

Have a look: [Video Tour](#) and [Street-view](#)

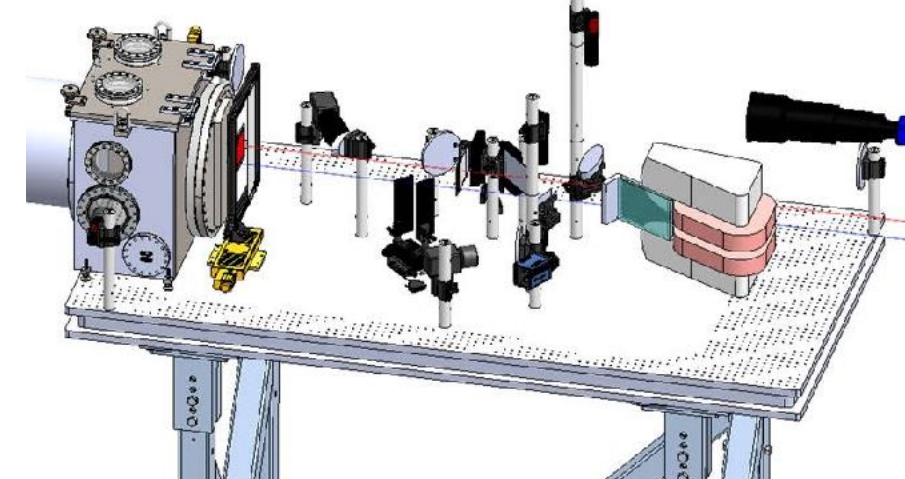
Sector 20 Experimental Area

The User Area is designed for ~17 experiments without major reconfigurations of the hardware

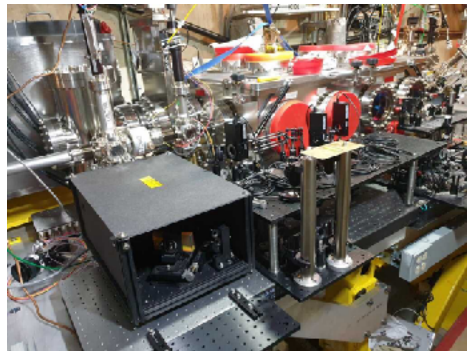
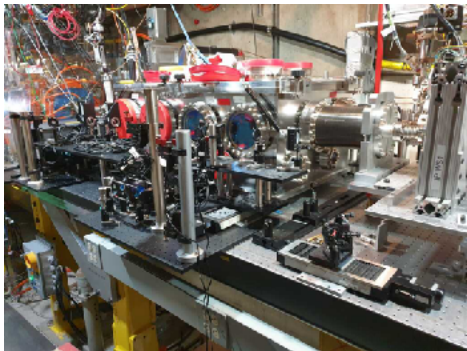


10 TW laser; solid, gas and plasma targets of various density & length; specialized electron, X-ray and Gamma-ray diagnostics

Spectrometer Diagnostic Table



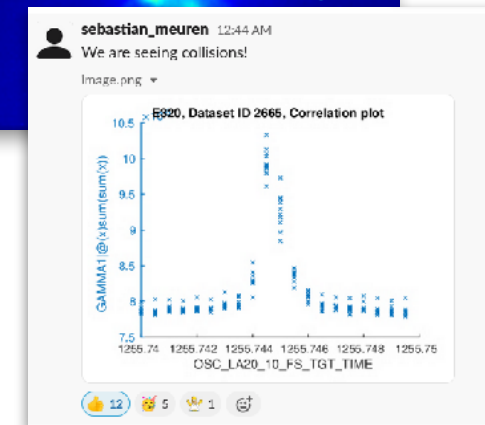
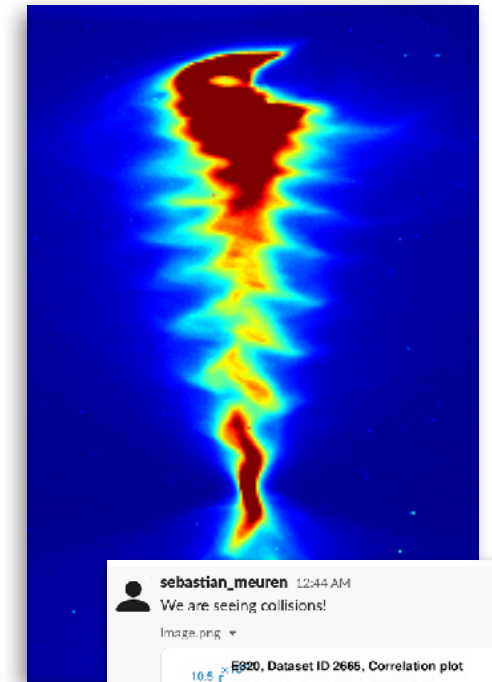
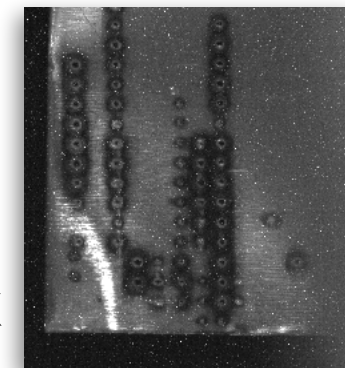
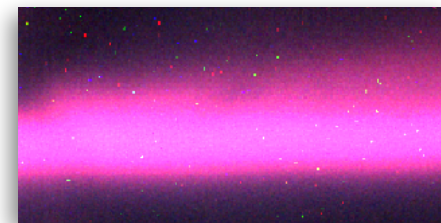
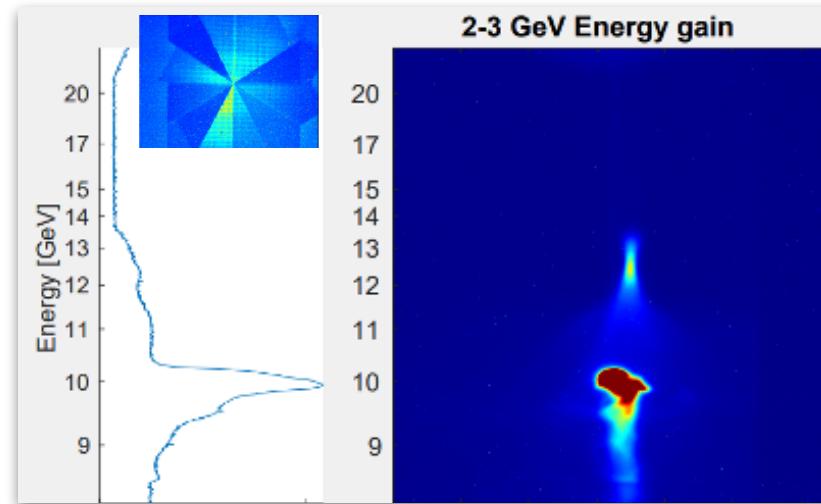
Since the 2020 PAC the User area has transformed from CAD to reality!



Collaboration between groups to develop common hardware is necessary to address strong User demand for FACET-II in LCLS-II era with limited access to S20 experimental area

Invited Experiments and Prioritized Beam Time Based on PAC Rankings, Hardware Availability, and Beam Conditions

- Invited 12 of 47 reviewed proposals for beam time in FY22 focussed on:
 - ML/AI diagnostics
 - Plasma wakefield acceleration
 - Bright gamma-ray bursts
 - SFQED
- Steady increase in User hours per week from May to August
- Peak beam intensity at or above levels attained at FACET
- Progress will be reported and evaluated this week



We are excited to have the science programs underway and running on adrenaline. Challenge for FY23 is to settle into sustainable pace for PAMMs, operations and downtimes.

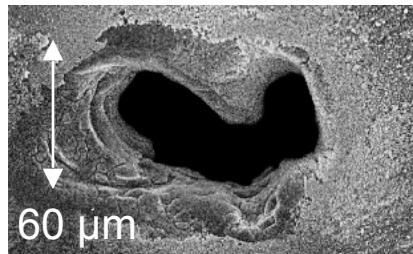
Extreme Beams Can Be Challenging

- FACET-II has unique challenges related to high intensity beams that require new approaches

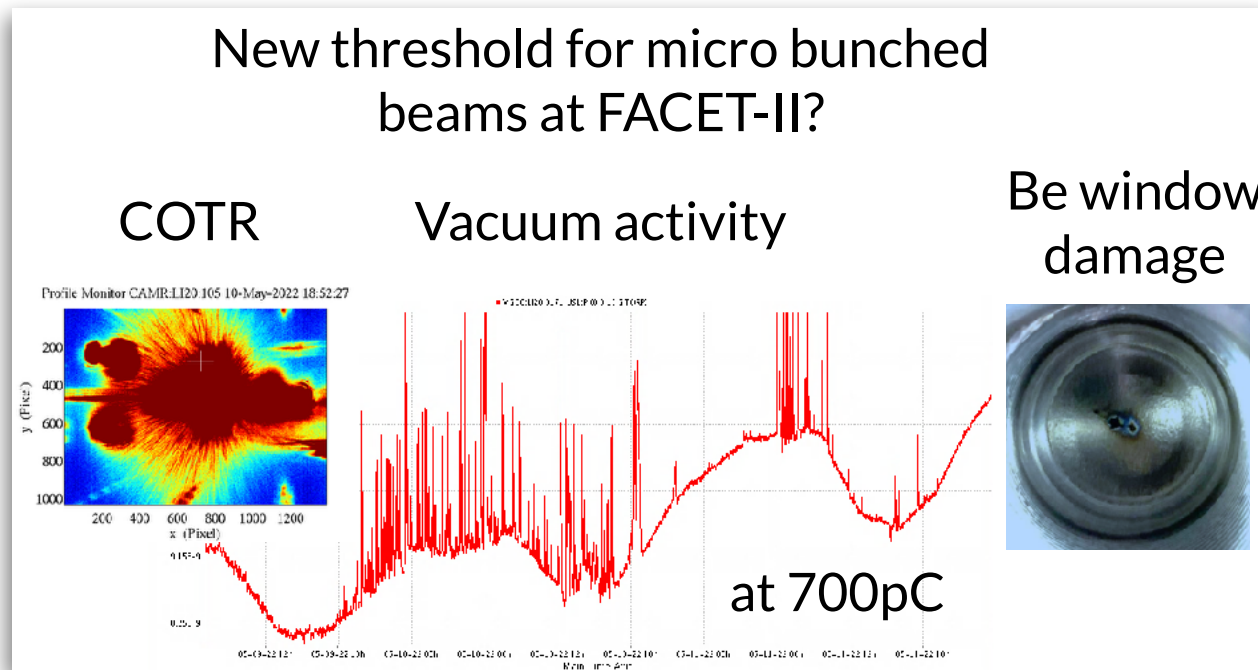
Be vacuum window damage at FACET expected for 2nC with

$$\sigma_x = \sigma_x = \sigma_x = 20\mu m$$

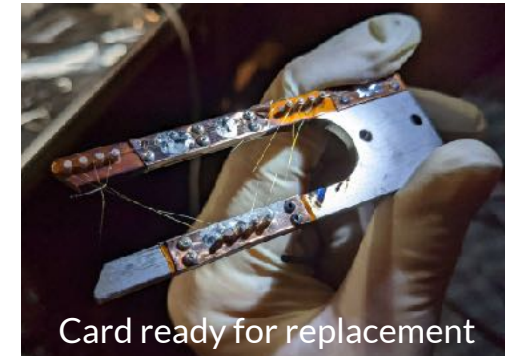
$$P \propto \frac{Q^2}{\sigma_r^2 \sigma_z^2} F(\sigma_r / \sigma_z)$$



[SLAC-PUB-15729](#)



Traditional diagnostics become consumables



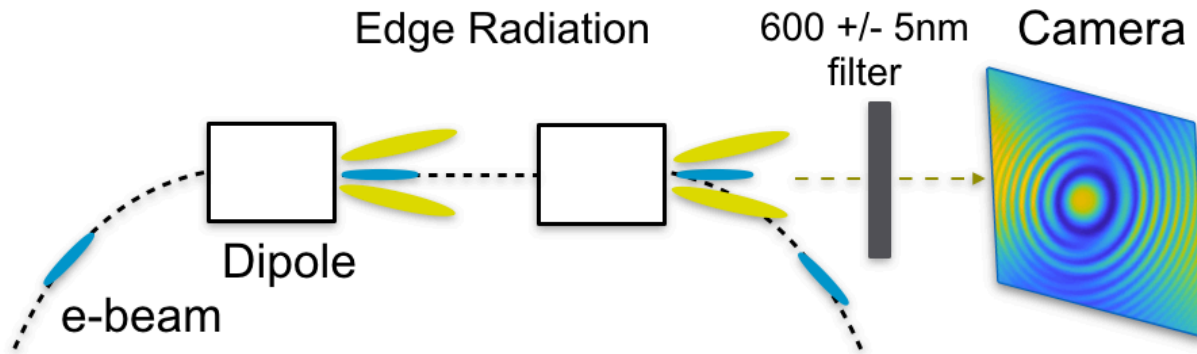
- Laser heater installation (Q4FY22) will mitigate microbunching
- Differential pumping system will remove vacuum windows from experimental area

New challenges require flexibility in planning and hardware installations that allow pivoting experimental programs based on hardware availability

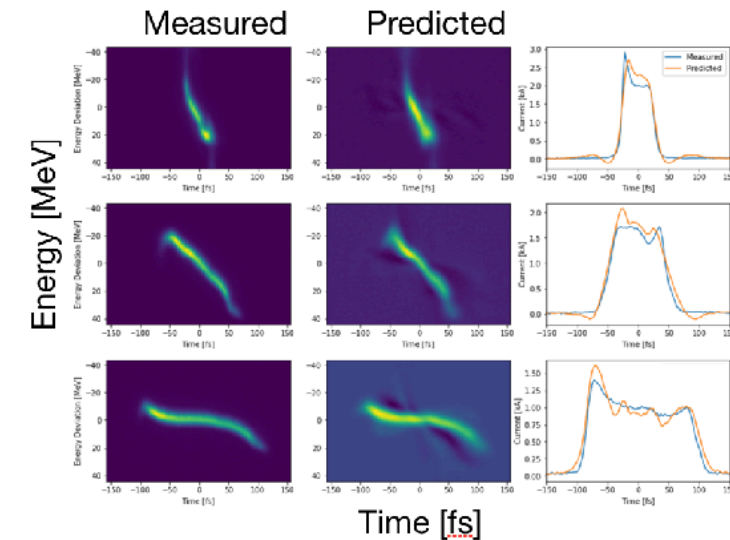
Leveraging ML/AI Techniques to Enable the Full Potential of FACET-II

- Virtual diagnostic for longitudinal phase space & peak current up to 300kA
- Single shot emittance measurements

Edge radiation for online emittance & energy spread measurement benefits nearly every experiment



Brendan O'Shea: ECA Award 2020



C. Emma – PRAB 21, 112802 (2018)

Virtual diagnostic for longitudinal phase space & peak current up to 300kA

ML efforts will improve our understanding of the complex beam dynamics of short bunches and increase efficiency and scientific throughput of FACET-II

Machine Development Will Be Interleaved with Experiments

Progressing from KPP to Beams for Science Programs Will Be a Gradual Evolution and Require New Capabilities

SLAC

Three machine configurations have been identified and are being developed to satisfy all seven experiments:

- **Two-bunch (1.3/0.6nC, 30/15kA , 150µm separation, 5-50cm betas)**
 - PWFA emittance preservation under high beam-loading (E-300)
 - PWFA hosing suppression (E-302)
 - PWFA positron injection (E-303)
 - Wake imaging (E-324)
- **Single bunch with high peak current (50-300kA, 0.1-10m betas)**
 - Filamentation & gamma-ray bursts (E-305)
 - 'Trojan Horse' Injection (E-310)
 - Wake imaging (E-324)
- **Highest Energy low backgrounds and well characterized (13GeV, $\sigma_z = 100\mu\text{m}$, 1m betas)**
 - HFQED (E-320)

Minimize configuration changes and gradually introduce new (more extreme) capabilities in the beams and hardware

Machine Development and Studies

Created by Gerold Yocky, last modified by Ryan Loney on Oct 10, 2022

[FACET-II MD Template \(Word\)](#)

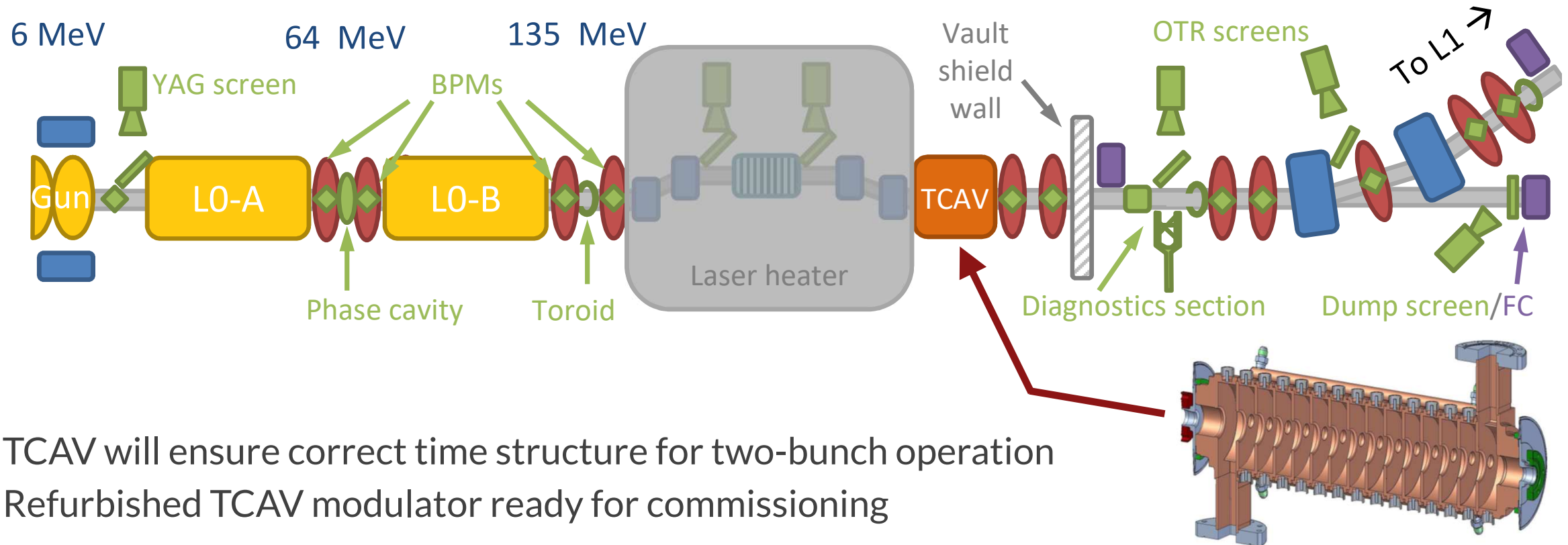
MD Priorities List

Priority	MD Item	Procedure Link	Machine Time (shifts)	Responsible Party	Needed By	Prerequisites	Notes
1	S20 BBA	Oct 13, 2022	2	Yocky			
1	Complete CRM	CRM Shift Plan		Loney			
1	Pencil beam config	Oct 13, 2022		Aisberg			
1	Linac BBA	BBA Shift Plan		Loney			
1	Linac wakefield bump (long exploration)			Yocky			
1	Commissioning Laser Heater			Yocky*			Laser Heater Commissioning Task List
2-4	Notch Collimator recommissioning		1-2				Current energy spread may not be compatible with clean cuts
2	S20 matching studies/emittance in S20	Sep 29, 2022 links	1	White		Good pencil beam config	
2	Investigate orbit dependent matching into L2			White*		BBA	FJD notes similar issue in LCLS-I likely eta from BC1
2	Tuning IP with small or beta*			Yocky			
2	Automated Steering development			White/Jill			
2	L1 orbit stability study	Oct 6, 2022		Parker			
2	RF stability (jitter, jumps, and drift)	Sep 16, 2022		Ripman			
2	130 magnet stability	Sep 28, 2022		Parker			
2	130AVD study (sig v. Sch phase, etc.)	Oct 6, 2022		Parker			
3	Injector setup for 10deg off Schottky zero crossing		3	White			Maybe investigate smaller laser spot
3	Laser spot size variation					Discussion with Glen	
3	Linac Hall ratio Data		5			Good pencil beam config	
3	S20 Hall ratio Data						
3	Individual mechanical->magnetic offsets in L2			Loney			
3	2nd running/instability investigation		2	Loney			FJD interested
3	Learning data for MFL FF / Track hardware issues	Oct 6, 2022		Aisberg			
3	Turbo rising investigation	Sep 1, 2022		Aisberg			
4	HI-N sensitivities	HI-N Sensitivity M3		Aisberg			
4	HI-kicks			Aisberg			
4	Injector RF Standby triggering			Loney			
TBD	Two-bunch prep/setup			Yocky*			

Better understanding of the accelerator will allow more predictable and stable delivery with improved performance while also broadening the array of configurations available

New Capabilities for FY23: S10 Laser Heater & TCAV

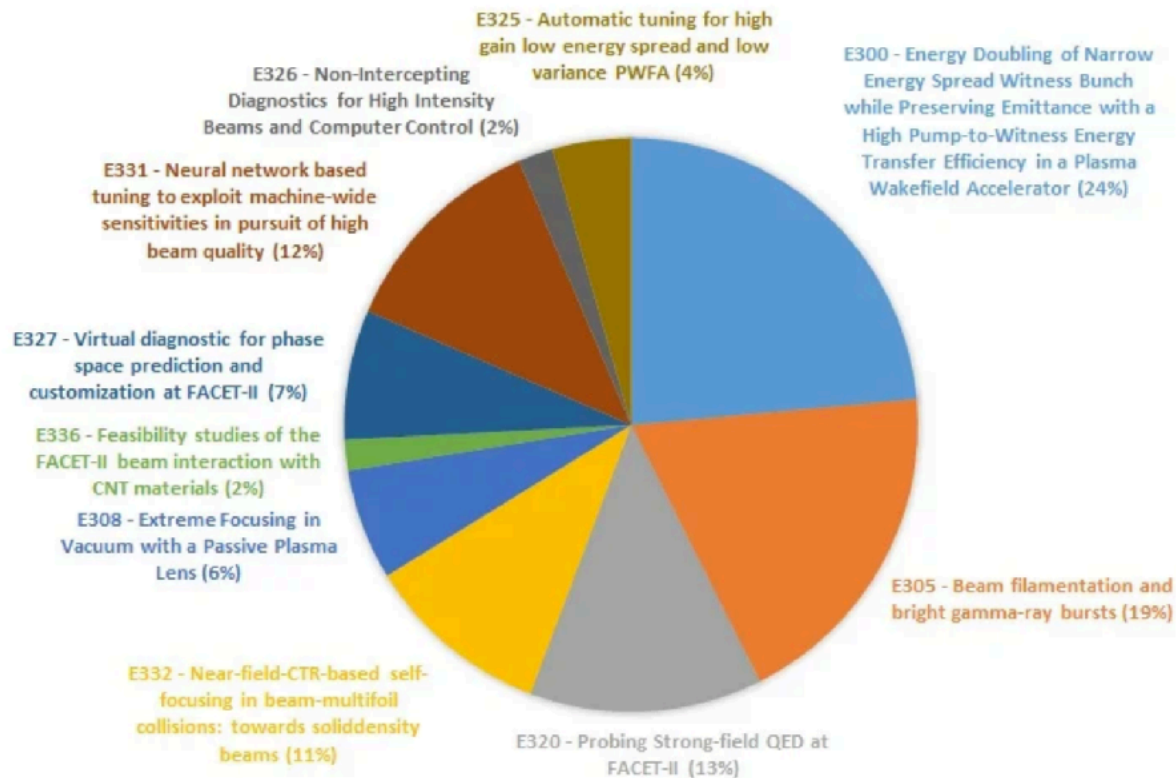
- With the Laser Heater the IFEL process increases beam energy spread to mitigate micro bunching instabilities and control maximum peak current
- Laser heater installation 80% complete – undulator being assembled by metrology group for November install



- TCAV will ensure correct time structure for two-bunch operation
- Refurbished TCAV modulator ready for commissioning

User Hours Increased Steadily in FY22

- Peak performance and hours of User delivery are increasing
- Reliability and stability of older accelerator systems remains a challenge for predictable delivery to Users, e.g. RF stability
- Hiring additional staff to support this level of delivery remains a concern



Month	User Hours	User Hours per Week	Notes
May	61	15	
June	59	20	Only three weeks (extended downtime start 6/20)
July	113	28	
August	127	42	Only three weeks (off 8/22)

FACET FY16 Run Statistics for Comparison

Time category	Oct 2015	Nov 2015	Dec 2015	Jan 2016	Feb 2016	Mar 2016	Apr 2016
FACET accelerator scheduled off [hrs]	393.6	181.8	488.6	321.5	141.4	70.1	644.5
FACET accelerator down [hrs]	33.8	40.6	30.3	125.7	42	318	5.4
FACET scheduled recovery activity	187.3	0	0	8.8	0	0	0
FACET accelerator beam tuning [hrs]	26	34.8	9.5	11.9	5.3	13.5	0
FACET accelerator config. change	24.1	7	2.6	5.7	4.6	0	2
FACET machine studies [hrs]	54.7	221.1	123.8	146.5	206.3	259.5	8.9
FACET experimental user run [hrs]	24.5	204.2	77.2	123.9	283.8	76.3	53.4
FACET experimental user off [hrs]	0	30.5	12	0	12.6	5.6	5.8
Total time for the month [hrs]	744.0	720.0	744.0	744.0	696.0	743.0	720.0
Summary: Delivered Beam [hrs]	290.6	432.3	213.1	296.8	500	349.3	64.3
Summary: Accelerator Availability [%]	82.9%	85.1%	87.6%	70.2%	92.3%	52.3%	92.3%

POC Model

FACET-II POCs May 2022

Experiment		SLAC POC	External POC
EOS/EOS-BPM	Duh	Spencer	Chris Doss
E-300	PWFA	Doug	Ken
E-305	Filimentation/Gamma	Henrik	Sebastien
E-308	Plasma lens	Henrik	Chris Doss
E-320	SFQED	Sebastian	
E-324	Plasma imaging	Henrik	Rafal
E-326	ML/AI ECA	Brendan	
E-327/331	ML/AI	Claudio and Auralee	
E-332	Near field CTR	Doug	Sebastien
E-336	XTAL	Henrik	Henryk
E-338	PAX	Claudio	Ago

- POCs collected requirements, shift plans/procedures, negotiated scheduling and shift start with Ops

For example:

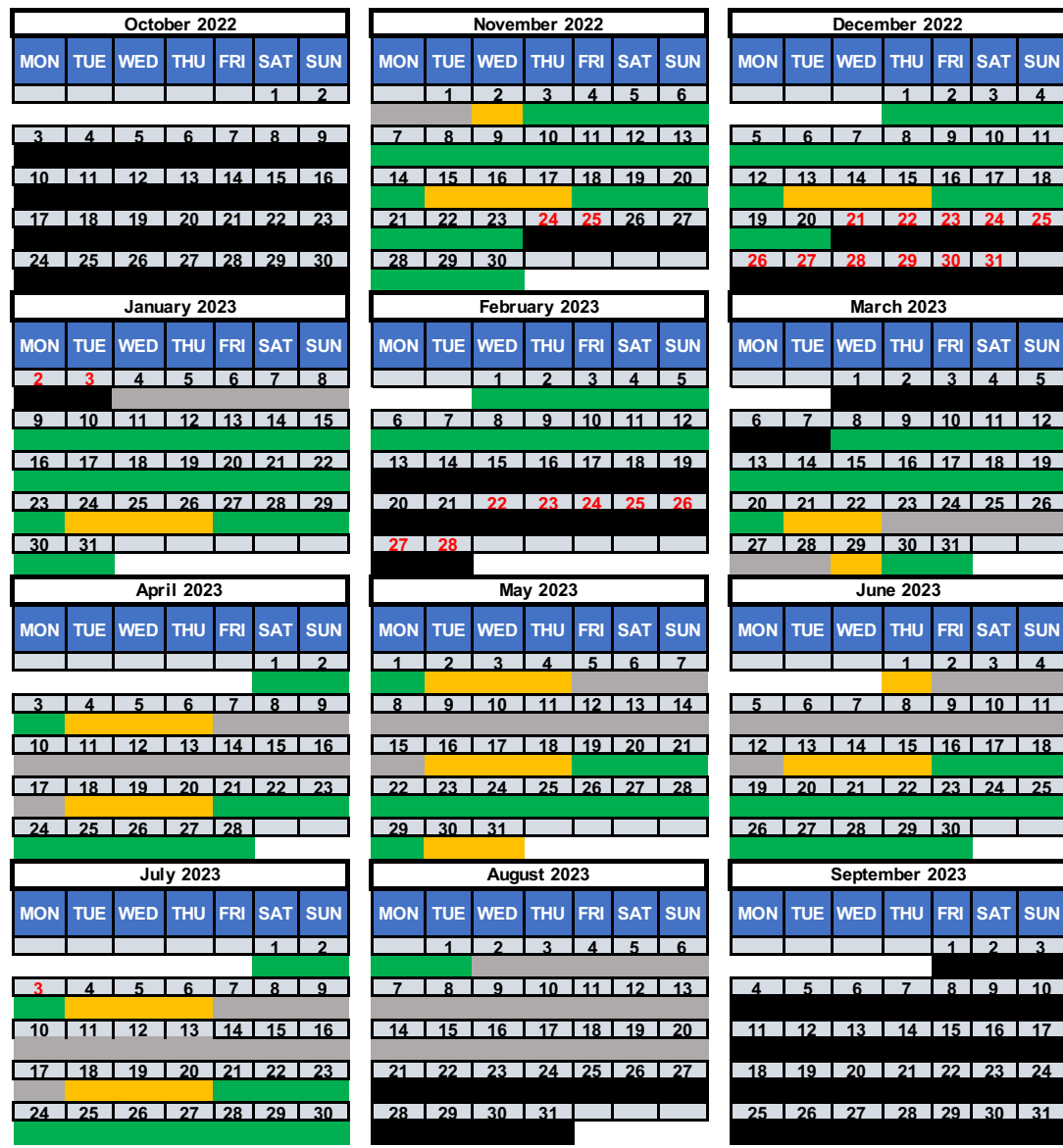
- E-300 took 16 shifts
- All coordinated & led by Doug
- Each POC also was involved in many other experiments, e.g. Doug needed for differential pumping system when being used with E-305...
- Detailed shift summaries available here: http://ad-ops.slac.stanford.edu/facet-shift-report/index/?start_date=2022-05-01&end_date=2022-08-23

Run Hours and Scheduling

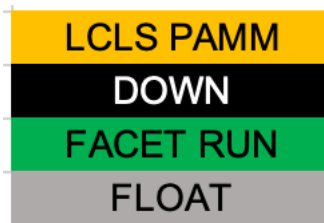
- FACET-II is expected to run for 6 months (26 weeks) per year with 80% uptime
- When delivering to Users, experimental time is expected 4-5 days per week
 - 3 day access (PAMM) every other week, 1-2 days of MD, 1-2 days to allow for possible downtime
 - The accelerator runs 24/7
 - Set-up and characterization during day shift with experiments swing/owl
- Schedule is constructed around programs with highest rankings matched with beam and hardware availability
- Boundary conditions:
 - When LCLS off, FACET-II off
 - LCLS-II in access, FACET-II can access

Recent experience with operations and feedback from our Users will guide optimization of FY23 schedule

FY23 Draft FACET-II Schedule for Six Months Operations



- Restart in November with MD activities until after AAC2022
- Downtimes: Winter, LCLS/LCLS-II post first light, Summer
- Attempting to balance between machine optimization, research staff load and time for data analysis
- Many considerations and options: limited number of PAMMs, lots of laser work, MD time, longer blocks for ‘big’ experiments, when Users can be on-site at SLAC...



PAC evaluations will be used to guide beam time allocation

Charge & Agenda



FACET AND TEST FACILITIES DIVISION

Dr. Mark J. Hogan
Senior Staff Scientist
FACET and Test Facilities Division Director
hogan@slac.stanford.edu
+1-650-926-2951

October 20, 2022

RE: CHARGE TO 2022 FACET-II PROGRAM ADVISORY COMMITTEE

The charge of the Program Advisory Committee (PAC) is to evaluate the merit and the feasibility of proposed experiments and review the progress of the existing R&D program at SLAC's FACET-II National user facility. In addition, experiments that have already received beam time are evaluated concerning progress, effectiveness and plans for the next allocations beam time.

The committee is expected to meet approximately once per year and reports to the Head of the SLAC FACET Division. The committee is supported with ad hoc consultants as necessary.

The specific charge for the PAC is to:

- Evaluate the scientific merit and rate the technical risk of new proposals for FACET-II.
- Determine whether the new proposals are appropriate at this time or in the future.
- Review existing experimental programs. The committee should also evaluate which elements need further in-depth analysis (for example):
 - Is the science unique and is the progress compelling?
 - Is the program making effective use of the facility and lab resources?
 - Could the program be enhanced by expanding the collaboration?

In addition, the committee is requested to evaluate the FACET-II operational priorities and comment on any perceived weaknesses.

The proposals are rated using a scale: Excellent, Very Good, Good, Fair and Not well suited

The rating is based on:

- The scientific merit of the proposal, assuming successful execution
- The technical risk associated with the detailed measurements and requested beam parameters
- The suitability of the experiment for FACET-II in terms of beam energy, bunch length, beam emittances, etc.

The reviewers should note if they feel that the experiment could be more reasonably performed at an alternate facility. If additional information is still needed for a full evaluation, the review committee should note this and may make a qualified rating or may skip the review if appropriate.

Mark J. Hogan

Mark J. Hogan

SLAC NATIONAL ACCELERATOR LABORATORY • 2575 SAND HILL ROAD • MENLO PARK • CALIFORNIA • 94025 • USA
SLAC is operated by Stanford University for the U.S. Department of Energy

Tuesday, 25 October 2022

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

Start Time (PT)	Talk Duration	Title	Speaker	Affiliation
7:00 AM	60m	Executive Session		
8:00 AM	25m	Facility Status and expectations for FY23 (science goals too)		
8:30 AM	25m	User experience, processes, lessons learned from FY22, and improvements for FY23		
9:00 AM	15m	Commissioning progress and expected beam parameters for FY23		
9:20 AM	25m	Beam configurations (update with W-chicane, laser heater, and no linac)		
9:50 AM	30m	Coffee Break		
10:20 AM	15m	Picnic basket installations and upgrades		
10:40 AM	30m	S20 laser performance and possible upgrades		
11:10 AM	15m	EOS BPM		
11:30 AM	60m	Lunch		
12:30 PM	20m	Experimental area (e- and gamma diagnostics, DPS)		
12:55 PM	10m	EQU projects and Upgrades (in progress and planned)		
1:10 PM	25m	E-300 FY22 Progress and Plans for FY23		
1:40 PM	15m	E-305 FY22 Progress and Plans for FY23		
2:00 PM	30m	Coffee Break		
2:30 PM	15m	E-336 FY22 Progress and Plans for FY23 (aka E-305nano)		
2:50 PM	15m	E-322 FY22 Progress and Plans for FY23		
3:10 PM	15m	E-327 FY22 Progress and Plans for FY23		
3:30 PM	90m	Executive Session		
5:00 PM		Reception in Lobby of B52 with Wine, cheese, etc.		

Wednesday, 26 October 2022

Day 2: Progress & Plans, Potential Invites for FY23, New Proposals

Start Time (PT)	Talk Duration	Title	Speaker	Affiliation
7:00 AM	60m	Virtual Tour		
8:00 AM	20m	E-320 FY22 Progress and Plans for FY23	Sebastian Meuren	SLAC
8:20 AM	15m	E-325 FY22 Progress and Plans for FY23	Alex Schelinker (remote)	LANL
8:40 AM	15m	E-326 FY22 Progress and Plans for FY23	Brendan O'Shea	SLAC
9:00 AM	15m	E-331 FY22 Progress and Plans for FY23	Aurore Edden	SLAC
9:20 AM	15m	E-308 FY22 Progress and Plans for FY23	Mike Hirs	CU Boulder
9:40 AM	30m	Coffee Break		
10:10 AM	15m	E-301	Mike Hirs	CU Boulder
10:30 AM	15m	E-304 DDR	Chaojie Zhang	UCLA
10:50 AM	15m	E-324	Rafal Zgadaj	UT Austin
11:10 AM	25m	E-310/311/315	Bernard Hidding	University of Strathclyde
11:40 AM	60m	Lunch		
12:40 PM	15m	E-322		
1:00 PM	15m	E-334A/B		
1:20 PM	15m	E-338 PAX		
1:40 PM	30m	Coffee Break		
2:10 PM	15m	New Proposal 1 (site)		
2:30 PM	15m	New Proposal 2 (site)		
2:50 PM	15m	New Proposal 3 (site)		
3:10 PM	15m	New Proposal 4 (site)		
3:30 PM	90m	Executive Session		
5:00 PM		Reception @ The Dutch Goose		

Thursday, 27 October 2022

Day 3: Q&A and Closeout

Start Time (PT)	Talk Duration	Title	Speaker	Affiliation
7:00 AM	60m	Executive session and breakfast for committee		
8:00 AM	90m	Q&A		
9:30 AM	30m	Coffee Break		
10:00 AM	120m	Executive Session: Report Writing		
12:00 PM	60m	Lunch		
1:00 PM	20m	Closeout	Edda Gschwendtner	CERN
1:20 PM	PM	Adjourn		

We have a very full agenda the next 2.5 days. Help our reviewers do their job and be respectful of your colleagues by staying within your allocated presentation time.

Summary

- There has been a lot of progress since the last PAC – we finished the project, commissioned the accelerator and recently began the experimental programs
- In FY23 we will install and commission important hardware & capabilities (laser heater, two-bunches) as well as lots of MD for better delivery
- We are expected to run for (6+1 month) and approaching scheduling in ways that make things sustainable for staff and productive for experiments
- Optimization of capabilities in the experimental area will depend critically on on-site participation from our User Community
- We expect to communicate coarse User schedule following PAC meeting in early November with daily shift schedules two weeks in advance

The team is in place, our Users are engaged, we are excited to be beginning the science programs and we look forward to the presentations and discussions at this PAC



Questions?