

FACET-II Long Term Planning

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January 10, 2024

Opening Discussion and Meeting Goals

- We spend a lot of time thinking about immediate goals and needs preparing for the next set of shifts
- Operational pressures also can lead to a mindset of ‘what can we do?’ as opposed to ‘what should we do?’
- Today we need to look down the road to the science we want to do and ask ourselves what it will take to get there
- A high-level summary of these goals will help us to:
 - Prioritize our efforts and resources (time and money)
 - Plan for the evolution of the facility (e.g. laser heater, differential pumping, two-bunches, new chambers, magnets, chicane, and diagnostics)
 - Communicate expectations and progress to SLAC and our sponsors
- This is a step in a continual process

Opening Discussion and Meeting Goals

- Let's hope this is our first year of 'normal' operation
- Next HEP Budget Briefing Tuesday March 19th
- GARD review in August – more next slide
- How can we video game-ify tuning?
- How do we bridge the gap between what existing diagnostics measure and what the experiments need?
- What are the priorities for the Ops team to get the most impactful science?

2018 HEP GARD Review


- Every five years
- One committee travels around to all labs
- One day at SLAC for all GARD programs
- First full week in August but date still TBD
- The website has vanished with all the Sharepoint upgrades
- Will try and locate the report to see if there are items we should highlight that we have responded to (Comments or Recommendations)
- We need to connect FACET-II to the 2023 P5 report

2018 DOE HEP GARD Lab Comparative Review at SLAC 3 August, 2018

Location: Building 053 Berryessa Conference Room, 053-2002

08:00	Executive session	LK Len
09:00	Welcome	CC Kao
09:10	Accelerator research in AD	B. Dunham
09:30	Beam Physics and Colliders	Z. Huang
10:00	PWFA overview	M. Hogan
10:30	Coffee Break	
11:00	Experimental area upgrade	D. Storey
11:15	Machine Learning at FACET-II	B. O'Shea
11:30	FACET-II: Project Status	S. Green
11:45	FACET-II: Operations Planning	G. Yocky
12:00	Direct Laser Acceleration	J. England
12:15	FACET-II: New Science Opportunities	V. Yakimenko
12:30	Lunch (15 min student talks; Nasr, Gold)	
13:30	RF Accelerator – Introduction, Vision and Impact	S. Tantawi
13:45	Advanced Computation for RF Accelerator R&D	C. Ng
14:10	The Role of Structures and Materials in the Advancement of RF Accelerators	E. Nanni
14:45	Transcending RF Source Limitations	M. Kemp
15:20	RF Accelerator Conclusion/Outlook	E. Nanni
15:30	Coffee break	
16:00	Tour	
17:00	Executive session	
18:00	Reception and Poster Session	

Can Start from High-level Goals and Capabilities for Each Experiment


FACET Long-Term Planning
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A1 *fx* Experiment

	A	B	C	D	E	F	G	H	I	J	K	L
1	Experiment	Scientific Goal	Task Item 1	Item 1 Status	Task Item 2	Item 2 Status	Task Item 3	Item 3 Status	Task Item 4	Item 4 Status	Task Item 5	Item 5 Status
2	E300	Robust emittance, EOS, TCAV diagnostics	Highly tuned beam to S20, with sig_r ~20um, sig_z ~10um, Ipk ~ 15kA	Multi-scientist high-effort	Develop emittance diagnostics with high quality beam, no plasma	Multi-scientist high-effort	Reliable TCAV performance	Multi-scientist high-effort	Regain EOS capa			
3	E300	Demonstrate energy depletion of the drive beam	Demonstrate Li oven with beam	1 scientist high-effort	H2 and He spike ionization studies (LH, collimators)	Multi-scientist high-effort	High-quality axicon focus - demo laser preionization	1 scientist high-effort	Wake with < 5% unaffected charge			
4	E300	Accelerate the witness beam to high energy	Electron drive-witness pair	Multi-scientist high-effort	>30% energy transfer to witness while energy doubling	Multi-scientist high-effort						
5	E300	Emittance preservation	BBA-ed FFS quads for high res measurements	Multi-scientist high-effort	Remove Be windows and replace with straws	New infrastructure req.	Optimize beam matching/loading conditions	Multi-scientist high-effort				
6	E300	Measure transverse instabilities	Develop optics/TCAV techniques for imparting drive/witness offset	Multi-scientist high-effort								
7	E300	Make a PWFA linear collider	PWFA Higgs factory	Readily achievable								
8	E301	Demonstrate energy depletion of the drive beam	High-quality axicon focus	Readily achievable	Non-self ionizing beam (laser heater)	Multi-scientist high-effort						
9	E301	Accelerate the witness beam to high energy	High-quality axicon focus	Readily achievable	Non-self ionizing beam (laser heater)	Multi-scientist high-effort	Electron drive-witness pair	Multi-scientist high-effort				
10	E301	Preserve the emittance of the witness beam	High-quality, fully characterized tandem lens focus	1 scientist high-effort	Non-self ionizing beam (laser heater)	Multi-scientist high-effort	Electron drive-witness pair	Multi-scientist high-effort	Tandem lens tailor the drive witness produced by the accelerator			
11	E304											
12	E305											
13	E308											
14	E310-15											
15	E320											
16	E324	Observe long-term evolution of plasma	Working probe laser	Multi-scientist high-effort	Complete installation of E324 optics for single camera imaging	Readily achievable						
17	E324	Direct observation of plasma wakefield	Working probe laser	Multi-scientist high-effort	High-quality, collimated and filtered probe	Multi-scientist high-effort	Design and installation of multi-camera E324 optics	1 scientist high-effort	Online Gerchberg-Saxton algorithm			
18	E332	Observation of beam focusing from beam-foil interaction	Working foil raster scan	Readily achievable	Highly tuned beam at IP	1 scientist high-effort	BBA-ed quads for high res measurements	Multi-scientist high-effort	IP beta to 5cm			
19	E332	Characterization of Gamma photons from multifoils	Make and measure photons with currently installed equipment	Readily achievable	Update gamma2 and gamma3	1 scientist high-effort	Install compton spectrometer	New infrastructure req.				
20	E336	Send beam through nanotubes	Angular alignment feedback for nanotube holder	New infrastructure req.	Measure transverse kick imparted to beam by tilted nanotarget	1 scientist high-effort						

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Experimental Goals and Tasks
Facility Upgrades
Framework

Display a menu for "https://docs.google.com/spreadsheets/u/2/?authuser=2&usp=sheets_web"

FACET-II Has Flexibility to Deliver a Range of Parameters Tailored to the Needs of Individual Experiments

SLAC

Experiment	Stage 1	Stage 2	Stage 3	Two bunches	High charge	Witness injector	Compton source
1 PWFA with electrons	X			X			
High Transformer Ratio	X				X	X	
Super-high brightness beams	X				X		
2 PWFA with positrons		X		X			
Physics of proton driven PWFA		X					
Physics of proton driven PWFA w electrons			X			X	
3 PWFA with low charge, high brightness electrons	X						
4 Trojan horse	X				X		
5 Dielectric WFA	X			X			
6 Beams of Intense Gamma rays	X				X		X
7 Gamma-Gamma Collider			X		X		X
8 Positrons from Compton Beam	X				X		X
9 BIG - Gamma ray source	X				X		X
10 High brightness muon beams	X				X		X
11 Laboratory Astrophysics			X				
12 CLIC studies	X		X				
13 FEL R&D	X						
14 THz & Magnetic switching	X				X		
15 National Security	X				X		X

FACET-II CD-2/3A Review, May 25, 2016

...and Eventually Distilled Into Very High-level Goals per Year

FACET PWFA Milestones as Presented in 2013

SLAC

FY	Facet Run	PWFA goal
2013	2/1 - 6/30	2 beam generation, laser commissioning, 2 beams with laser -> mono energetic acceleration (all successful and more...)
2014	10/15-12/20 2/1 - 6/30	2 beams with laser-> mono energetic acceleration , positron commissioning, positron PWFA, high brightness PWFA injector (all successful & positrons!)
2015	10/15-12/20 2/1 - 6/30	positron PWFA , one stage, efficiency, high brightness PWFA injector (successful - unexpected positrons result!)
2016	10/1-5/31 ^{4/4}	Finalizing the program, emittance preservation (Single stage: energy spread, emittance, efficiency)

Steady, methodical progress according to our plan

PWFA Goals for FACET-II

SLAC

FY	FACET-II	PWFA Goals
2017	Construction (Phase 1)	Finalize FACET data analysis, prepare FACET-II experiments
2018-19	Phase 1 (e ⁻ only)	Staging studies with witness injector (synchronization, alignment), high transformer ratio (with shaped bunches)
2020-21	Phase 2 (e ⁻ or e ⁺)	e ⁻ or e ⁺ acceleration in e ⁺ wakes (physics of p driven PWFA), high-brightness beam generation, preservation, characterization
2022-23	Phase 3 (e ⁻ and e ⁺)	e⁺ acceleration in e ⁻ driven wakes, demonstration of e ⁺ acceleration stage
2024-25		Witness bunch acceleration in two PWFA stages (independently driven)

It is important for us to have simple and clear messages like these to help DOE (and SLAC) evaluate progress and understand our needs for the future

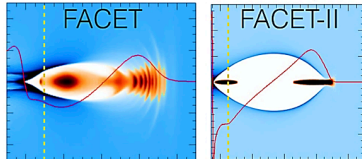
Can Be Summarized as Tables or More Graphically

PWFA Research Priorities at FACET-II Stage 1 Funded. Stage 2 & 3 will Fully Exploit the Potential of FACET-II SLAC

Emittance Preservation with Efficient Acceleration FY19-21

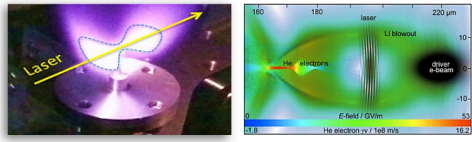
- High-gradient high-efficiency (instantaneous) acceleration has been demonstrated @ FACET
- Full pump-depletion and emittance preservation at μm level planned as first experiment

Stage 1



High Brightness Beam Generation & Characterization FY20-22

- 10's nm emittance preservation is necessary for collider apps
- Ultra-high brightness plasma injectors may lead to first apps



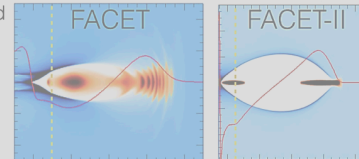
Stage 1

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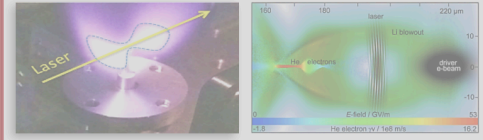
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Stage 1



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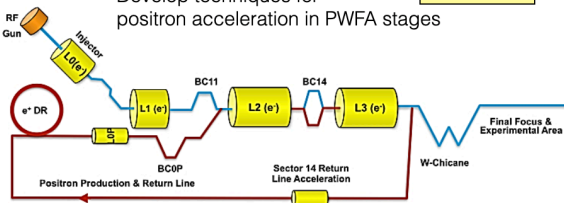


Stage 1

Positron Acceleration FY21-24

- Only high-current positron capability in the world for PWFAs research will be enabled by Phase II
- Develop techniques for positron acceleration in PWFAs stages

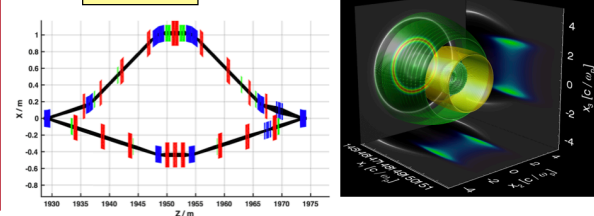
Stage 2



Simultaneous Deliver of Electrons & Positrons FY22-25

- Positron Acceleration on Electron Beam Driven Wakefields

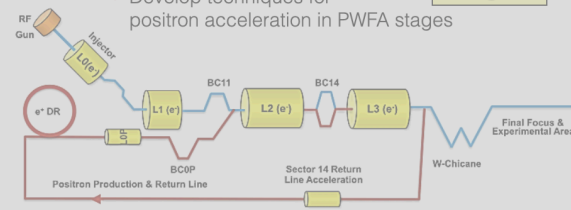
Stage 3



Positron Acceleration FY21-24

- Only high-current positron capability in the world for PWFAs research will be enabled by Phase II
- Develop techniques for positron acceleration in PWFAs stages

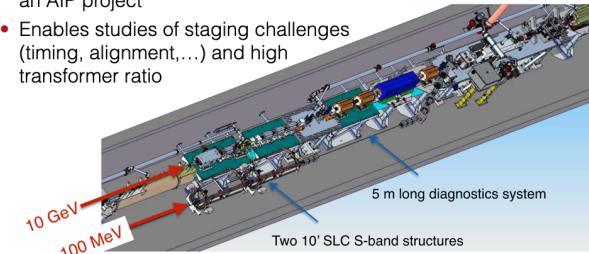
Stage 2



AIP Project

Staging Studies FY22-25

- Independent witness injector planned to be added to FACET-II as an AIP project
- Enables studies of staging challenges (timing, alignment,...) and high transformer ratio



FACET is a highly recognized and very productive User Facility for Advanced Accelerator R&D. FACET-II will continue leadership in this field.

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Ask yourself – what are the first Nature paper(s) and what do we need to do to get there?