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.

Please remember…

- Vehicle-related accidents can and have happened here.
- We have uncommon hazards including construction projects, industrial vehicles, electric carts, and pedestrians any time of the day or night.
- Please obey the traffic rules, look out for bicyclists and pedestrians and exercise caution – especially when backing up.

FACET-II Overview

FACET-II Science Opportunities Workshops

Mark J. Hogan
October 12-16, 2015

U.S. DEPARTMENT OF ENERGY Office of Science
SLAC NATIONAL ACCELERATOR LABORATORY

Agenda for Today

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Monday | Tuesday | Wednesday | Thursday | Friday

Start Time	Presentation	Presenter	Affiliation
08:30	Breakfast		
09:00	Welcome	Lia Merminga	SLAC
09:10	FACET-II overview	Mark Hogan	SLAC
09:30	FACET-II accelerator design	Glenn White	SLAC
10:10	FLASHforward project	Jens Osterhoff	DESY
10:45	Break		
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11:45	Two-bunch generation and dynamics	Zhen Zhang	Tsinghua U./SLAC
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16:30	General Discussion		
17:30	Adjourn		

FACET: *A National User Facility based on high-energy beams and their interaction with plasmas and lasers*

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- Facility hosts more than 150 users, 25 experiments
- One high profile result a year
- Priorities balanced between focused plasma wakefield acceleration research and diverse user programs with ultra-high fields

FACET History & Goals

Primary Goal:

Demonstrate a single-stage high-energy plasma accelerator for electrons.

- Meter scale
- High gradient
- Preserved emittance
- Low energy spread
- High efficiency

Timeline:

- Commissioning (2011-2012)
- Drive & witness e^- bunch (2012-2013)
- Optimization of e^- acceleration (2013-2015)
- First high-gradient e^+ PWFA (2014-2016)

Planning for FACET-II

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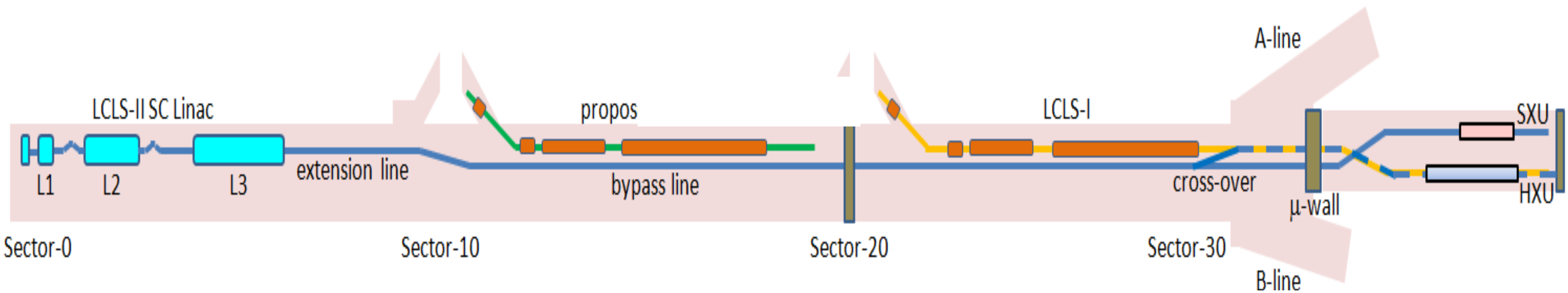
- FACET will stop running in April 2016
- Lab will then salvage needed equipment from first kilometer of linac
- Then will make it cold, dark and dry…and completely clean it out
- Over the next few years will build a new superconducting linac for LCLS-II
- At the same time we will upgrade middle kilometer for FACET-II



• electron beam photoinjector	(e^- beam only)	FY17-18
• positron damping ring	(e^+ or e^- beams)	FY18-19
• "sailboat" chicane	(e^+ and e^- beams)	FY20

FACET-II Plan

Timeline:

- Nov. 2013, FACET-II proposal, Comparative review
- CD-0 Aug. 2015
- CD-1 Oct. 2015
- CD-2/3A Aug. 2016
- CD-3B Dec. 2016
- CD-4 2022
- Experimental program (2019-2026)

Key R&D Milestones:

- Staging with witness injector
- High brightness beam generation, preservation, characterization
- e+ acceleration in e- driven wakes
- Generation of high flux THz and gamma radiation

Three stages:

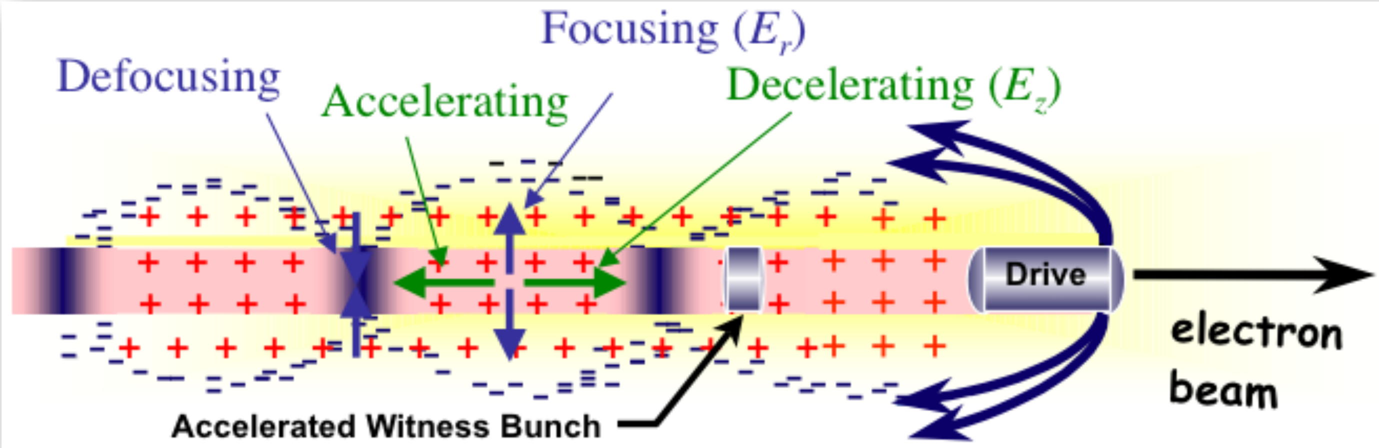
- Photoinjector (e- beam only) FY17-18
- e+ damping ring (e+ or e- beams) FY18-20
- “sailboat” chicane (e+ and e- beams) FY19-20

FACET-II will enable research for a broad user community
See talk by M.Hogan and Workshops: Oct.12-19 2015, SLAC

Nominal Beam Parameters Driven by the Needs of the Plasma Wakefield Accelerator Program

High gradients need high density plasmas

- ~10^{17} e^-/cm^3
- >10GeV/m acceleration
- >MT/m focusing



FACET-II Needs:

- **Bunch dimensions** on the order of plasma skin depth **<20µm**
- **nC** bunch charge for **blow-out** with large wake amplitude & good transport
- **Peak current** approaching I_A ~ **10kA** for strong wakes
- Need **meter-scale**, uniform high-density plasmas for extended interaction
- **10GeV** for positron production, stable delivery of high-current beams

FACET is the only facility in the world where users can do meter-scale high-gradient plasma acceleration

Proposed Key Performance Parameter Summary

Description of Scope	*Units*	*Threshold KPP*	*Objective KPP*
Beam Energy	*[GeV]*	*9*	*10*
Bunch Charge (e-/e+)	*[nC]*	*0.1/0.1*	*2/1*
Final Normalized Emittance (e-/e+)	*[μm]*	*50/50*	*20/20*
Bunch Length (e-/e+)	*[μm]*	*100/100*	*20/20*

- The threshold KPPs are the minimum parameters against which the project's performance is measured when complete
- The objective KPPs are the desired operating parameters that the project will design to with the intent that those may be achieved during steady operation
- Taking performance from Threshold to Objective requires operations staff time to optimize accelerator performance, but does not require further capital investment

Objective KPP will support the majority of the proposed science program
FACET-II flexibility allows other optimizations to meet user needs

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

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	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

Variety of Beam Parameters Possible

Table 4.1. Nominal electron beam parameters at the FACET IP and their operational ranges.

Parameter	Symbol	Unit	Nominal	Range
Final electron energy	E_f	GeV	10.0	4.0 – 13.7
Initial electron bunch charge	Q_0	nC	2	2 – 5
Final electron bunch charge	Q_f	nC	2	0.7 - 5
Pulse repetition rate	f_{rep}	Hz	30	1 - 30
Number of electron bunches per RF pulse	N_b	-	1	1 - 2
Electron transverse core beam size (x/y, rms)	σ_x/σ_y	μm	14/13	6-20/6-13
Final electron peak current	I_{pk}	kA	15	10-130
Final electron bunch length (rms)	σ_z	μm	17	1 - 20
Electron rms energy spread (rms)	σ_E/E	%	0.4	0.4 – 1.8
Max. avg. e^- beam power (10 GeV, 5 nC, 1 bunch/pulse, 30 Hz)	P_b	kW	1.5	0.1 - 4.2
Dump design for avg. e^- beam power	P_D	kW	5	-

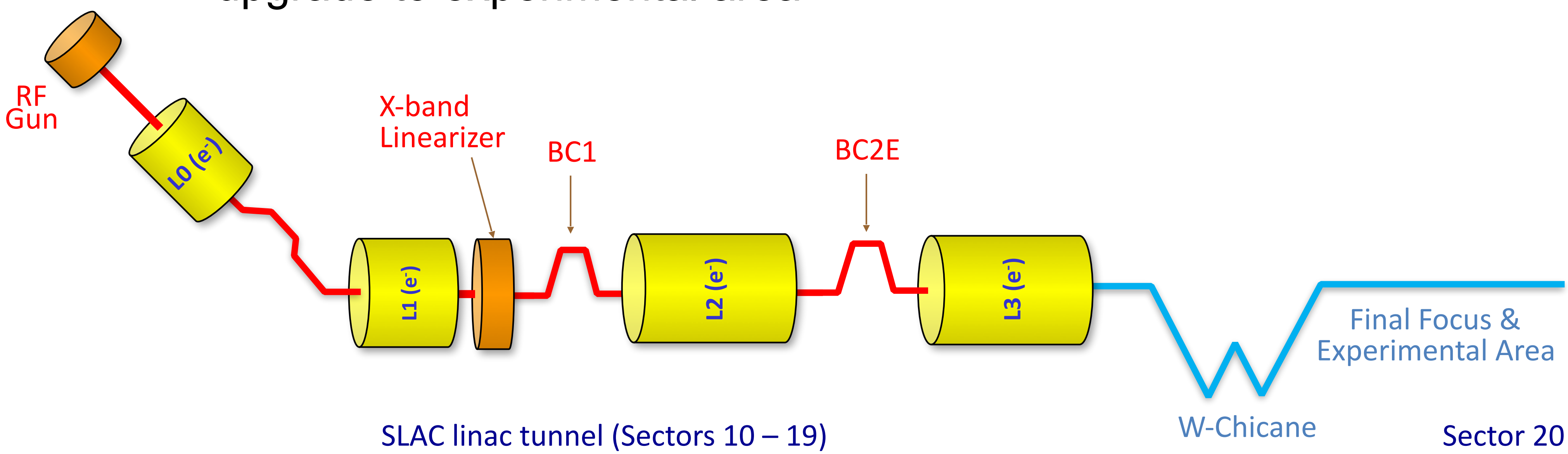
Variety of Beam Parameters Possible

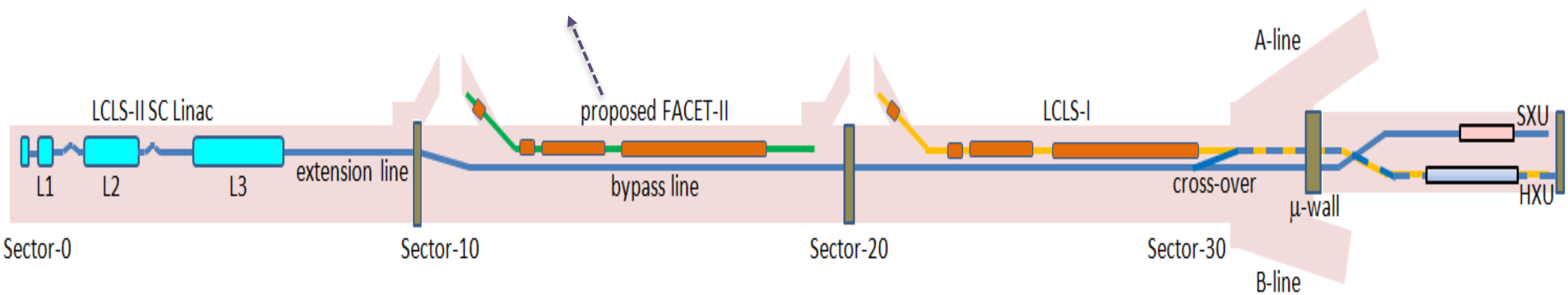
Table 4.2. Nominal positron beam parameters at the FACET IP and their operational ranges.

Parameter	Symbol	Unit	Nominal	Range
Final positron energy	E_f	GeV	10	4 – 13.7
Initial positron bunch charge from DR	Q_0	nC	1	1 - 2
Final positron bunch charge at IP	Q	nC	1	0.6-2
Pulse repetition rate	f_{rep}	Hz	5	1 - 5
Number of positron bunches per RF pulse	N_b	-	1	1
Positron transverse core beam size (x/y, rms)	σ_x/σ_y	µm	20/11	10-25/7-11
Positron peak current	I_{pk}	kA	6	6 – 15
Positron bunch length (rms)	σ_Z	µm	17	7 – 20
Positron rms energy spread	σ_E/E	%	0.8	0.5 – 1.5
Max. avg. e^- beam power (10 GeV, 1nC, 5Hz,1 bunch/pulse)	P_b	W	50	5 – 140

FACET-II Stage I FY17-18

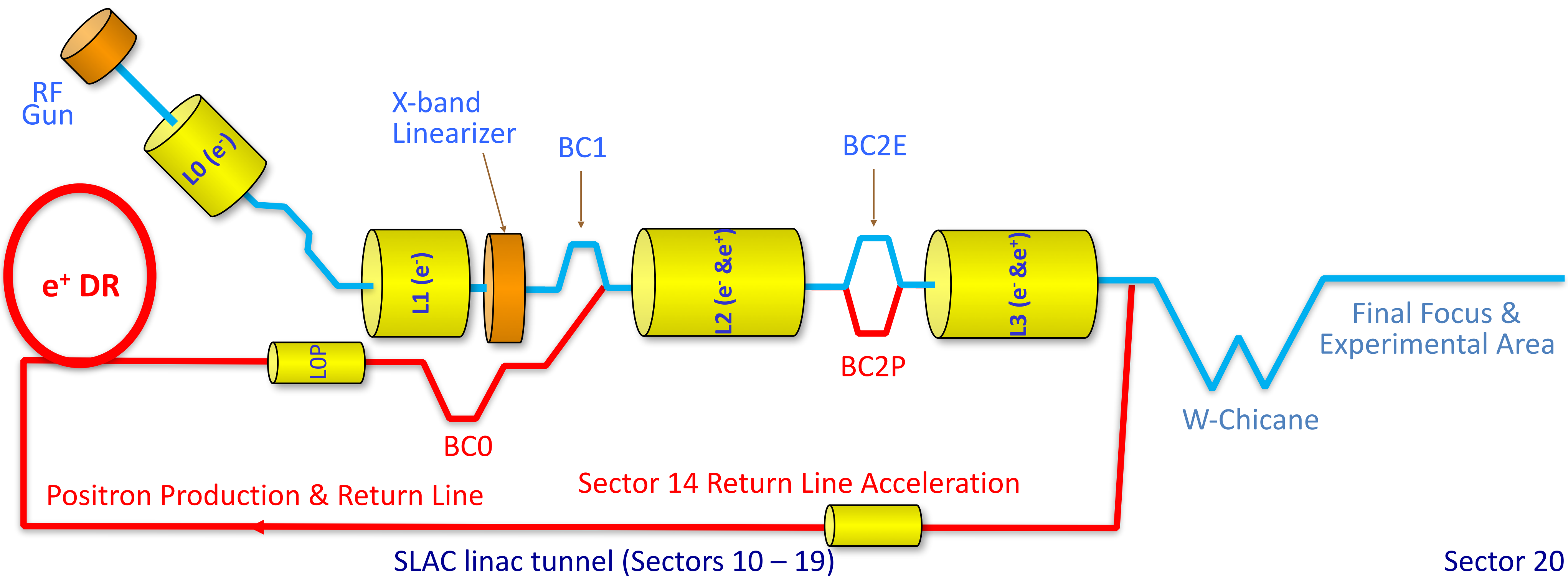
- **Goal:** deliver compressed electron beam to experiments in S20
- **Major upgrade:** Electron beam photoinjector in Sector 10
- **Scope:** Injector, Shielding wall in S10, X-band linearizer, Bunch Compressors in S11 (BC1) and S14 (BC2), beam diagnostics, upgrade to experimental area





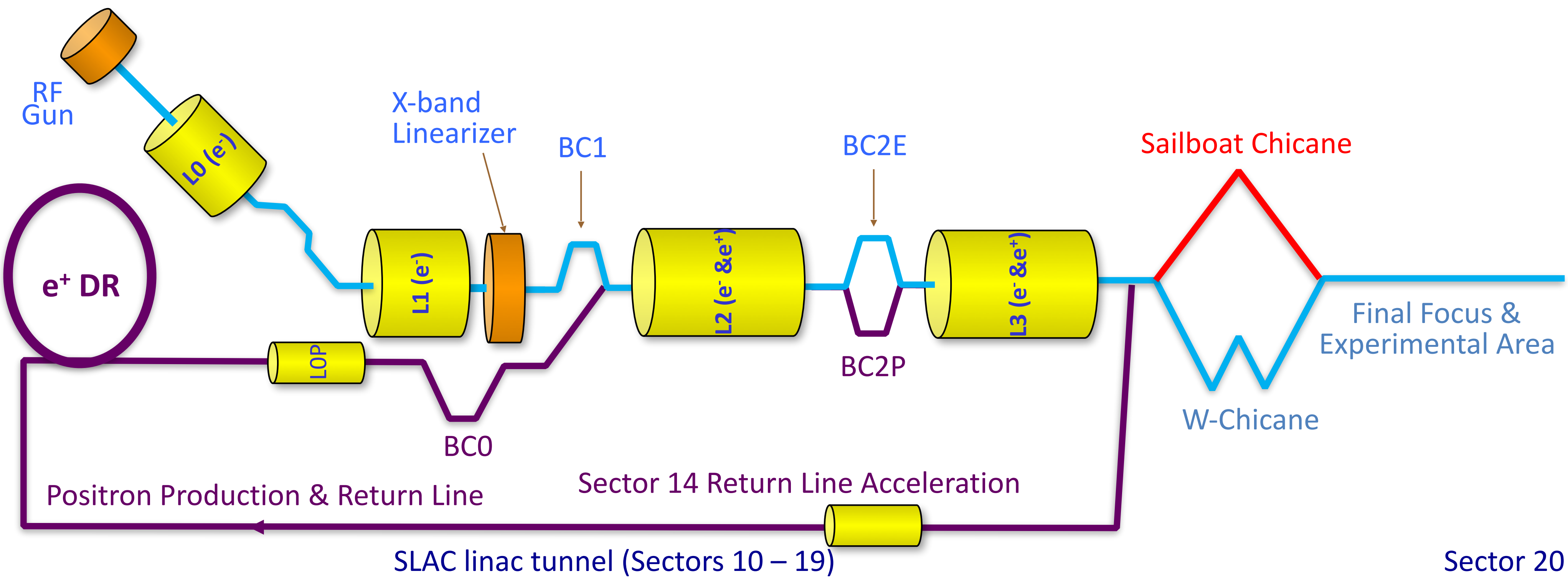
FACET-II Stage II FY18-19

- **Goal:** deliver compressed positron beam to experiments in S20
- **Major upgrade:** positron damping ring
- **Scope:** damping ring, positron bunch compressor & return line



FACET-II Stage III FY19-20

- **Goal:** deliver electron and positron beams to experiments in S20
- **Major upgrade:** Sailboat chicane
- **Scope:** Sailboat chicane



High-Level Performance Goals and Design

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Research goal	***Design***
High-Intensity driver to study Plasma Wakefield Acceleration (PWFA) relevant to Linear Colliders and user programs with intense electron beams	Photoinjector, 10 GeV linac, 3 stage bunch compressors
Positron PWFA and user programs with intense positron beams	Positron Damping Ring
Acceleration of positrons in wake of electron drive beams	Sailboat chicane
Studies of PWFA staging	**Compatibility with future witness injector installation**
High intensity gamma ray source, gamma-gamma collider studies	**Compatibility with future Compton backscattering**

FACET-II design has been motivated by needs of user community

FACET-II Science Opportunities Workshops

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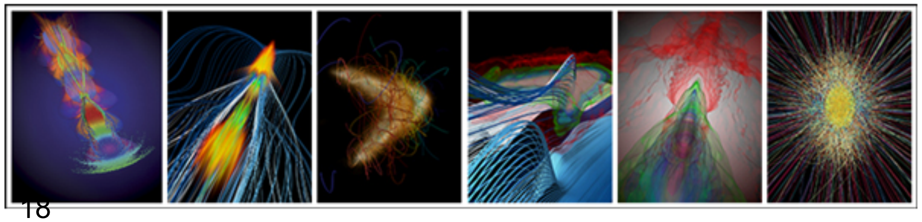
- Home
- Agenda
- FACET-II CDR
- Participants
- Register
- Accommodations
- Travel and Directions
- Meeting Rooms & Maps



FACET-II
Science Opportunities Workshops

12-16 October, 2015
SLAC National Accelerator Laboratory
Menlo Park, CA

- October 12-16, 2015
- Five Days
  - Five Workshops (one per day)
- Dual WG Leaders
  - SLAC & non-SLAC

- Discuss scientific opportunities
- Refine the technical requirements
- Ensure maximum impact at startup and into the future

October 12-16, 2015	WG Leaders	Workshop
Monday	Pietro Musumeci (UCLA) Zhirong Huang (SLAC)	Accelerator Physics of Extreme Beams
Tuesday	Ioan Tudosa (U. Penn.) Jerome Hastings (SLAC)	Material Interactions with Extreme Fields
Wednesday	Andrei Seryi (JAI) Jean-Pierre Delahaye (SLAC)	Plasma Acceleration Based Linear Colliders
Thursday	James Rosenzweig (UCLA) Erik Hemsing (SLAC)	Plasma Acceleration Based XFELs
Friday	Vladimir Litvinenko (Stonybrook) Carsten Hast (SLAC)	Application of Compton Based Gamma Rays

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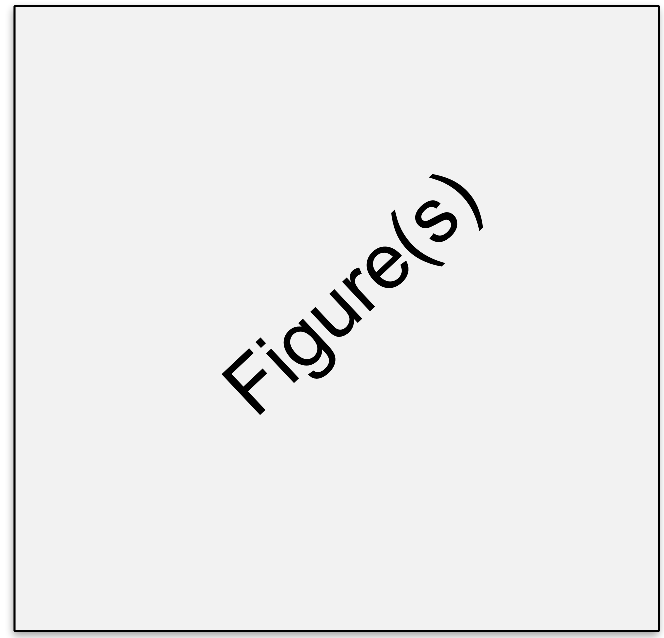
Short Contribution Title Goes Here

- **Science Challenge/Opportunity**
  - –What is an important open science question in your field that can be advanced by the capabilities of FACET-II?
  - –What is impeding progress?, Why now – why is this timely?
- **Significance & Impact**
  - –What is the potential broader impact if we can answer this question (i.e. why is it important)?
- **FACET-II Strengths & Challenges**
  - –What is the expected result or key advance from FACET-II? i.e. What essential information or insight might be provided by FACET-II that is not available from other means?
  - –Highlight essential FACET-II capabilities required

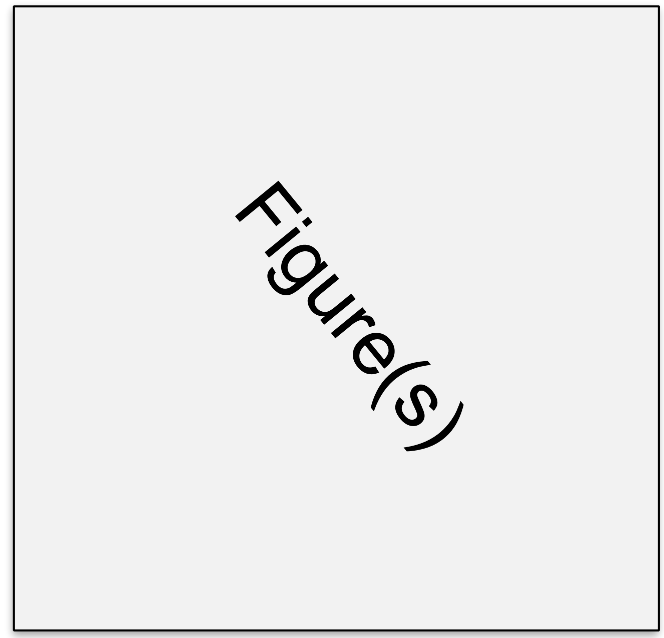


short figure caption or label

Your Name **Workshop** (Extreme Beams, Extreme Fields, Collider, FEL, Gammas)

Experimental Approach

- **Techniques(s)**
  - –What physical properties will be explored in this research?
  - –What are the most relevant experimental methods or techniques?
- **Tools**
  - –What are the experimental tools required?
  - –What are significant additional challenges: beam/plasma/laser requirements, detector requirements, instrumentation R&D etc.?
  - –Reference any relevant existing tools or highlight needs for further development
- **Alternatives**
  - –What are the most viable other methods being used to address this question?



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Backup Material

FACET-II Science Opportunities Workshops

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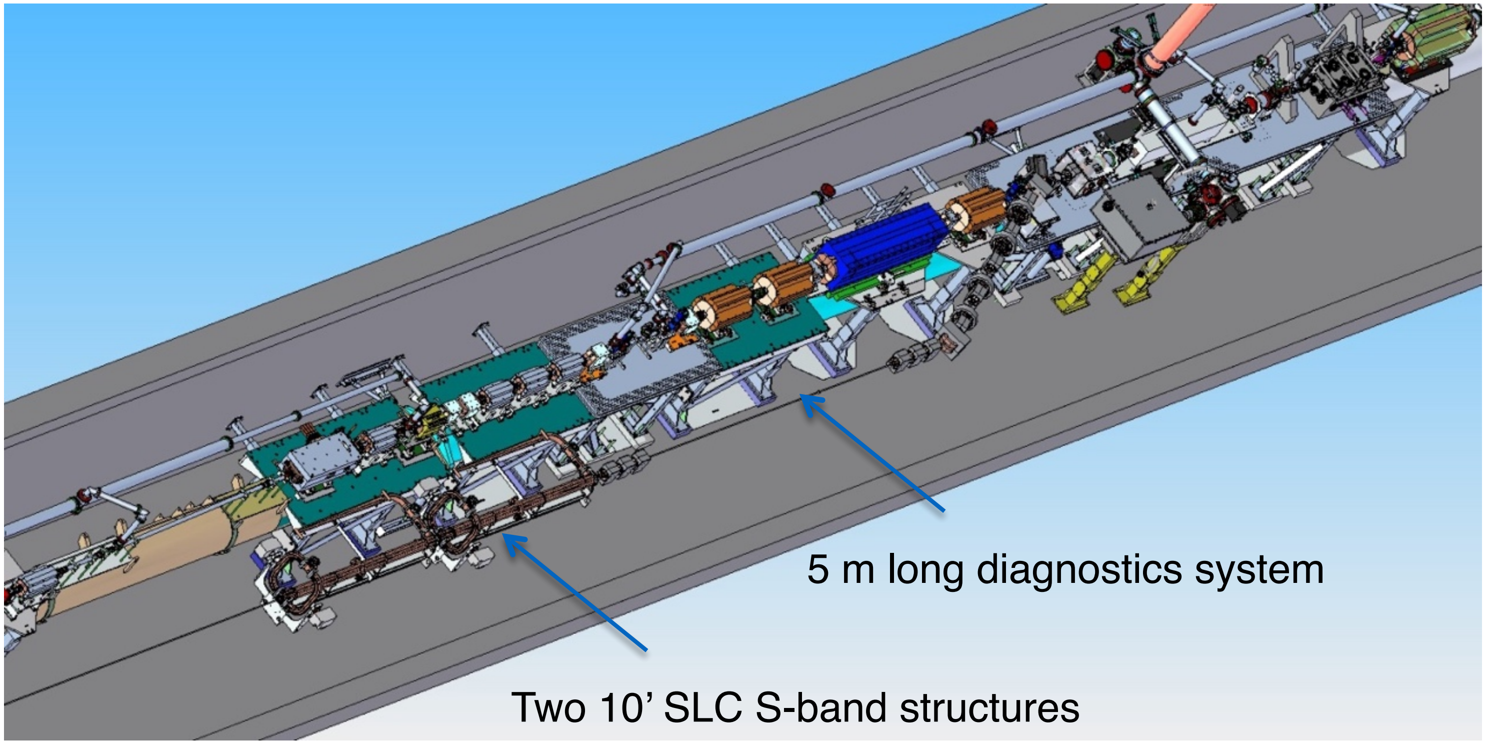
Witness Bunch Injector Tunnel Installation

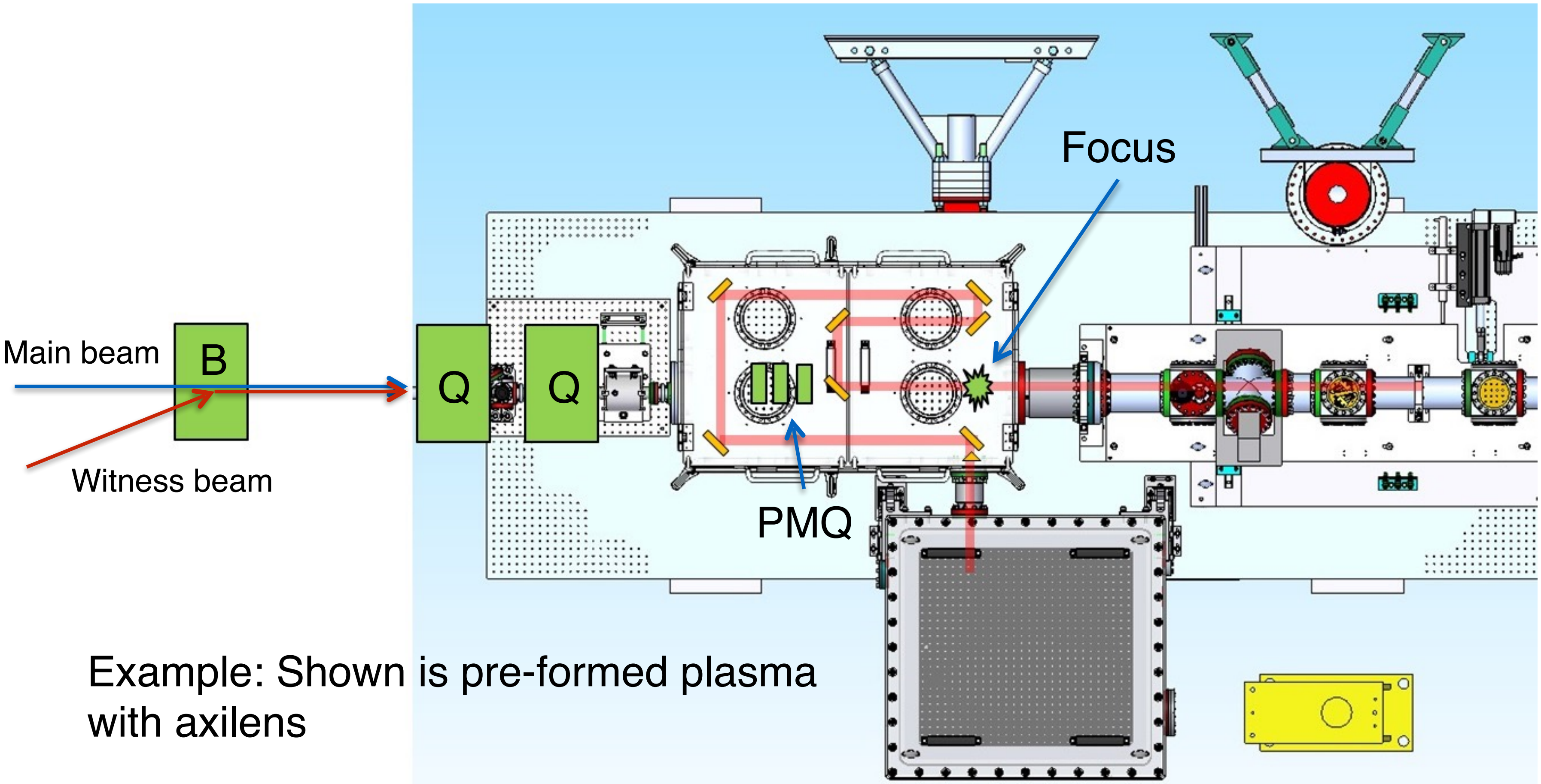
- Gun and injector RF placed near last BC3 bend
- Horizontal dog-leg to compress bunch to <10 um
- Quadrupoles focus < 10 um



Witness Bunch Injector concept is a possible solution compatible with FACET-II design

Experiment integration

- Final quad triplet are small permanent magnets (PMQ)



Coordinate with experimenters to design apparatus (e.g. plasma source) to be used with witness bunch injector

2-bunch delivery

- Collimation (current 2-bunch method) has some limitations
- If this cannot satisfy experiment needs, is there a new method?

Table 10.2: Key parameters and features of the witness bunch injector design

Parameter	Symbol	Value
Drive Beam Energy	E_d	10.0 GeV
Witness Bunch Final Energy	E_w	100 MeV
rms Transverse Final Spot Size	σ_x / σ_y	< 10 / 10 um
rms Longitudinal Final Bunch Length	σ_z	< 10 um
Final Bunch Charge	Q_f	100 pC
Final Peak Current	I_{pk}	3,000 A
Final Beta Functions	β_x / β_y	5 x 5 mm
System Length	s	18 m
Injection Bend Angle	Φ	25.78 degrees

Could a new injector in sector 20 provide witness bunch for wakefield experiments?