

ESTB: End Station A Test Beam

FACET @ SLAC S20

Carsten Hast

SLAC National Accelerator Laboratory

TIPP 2011, Chicago

June 11, 2011



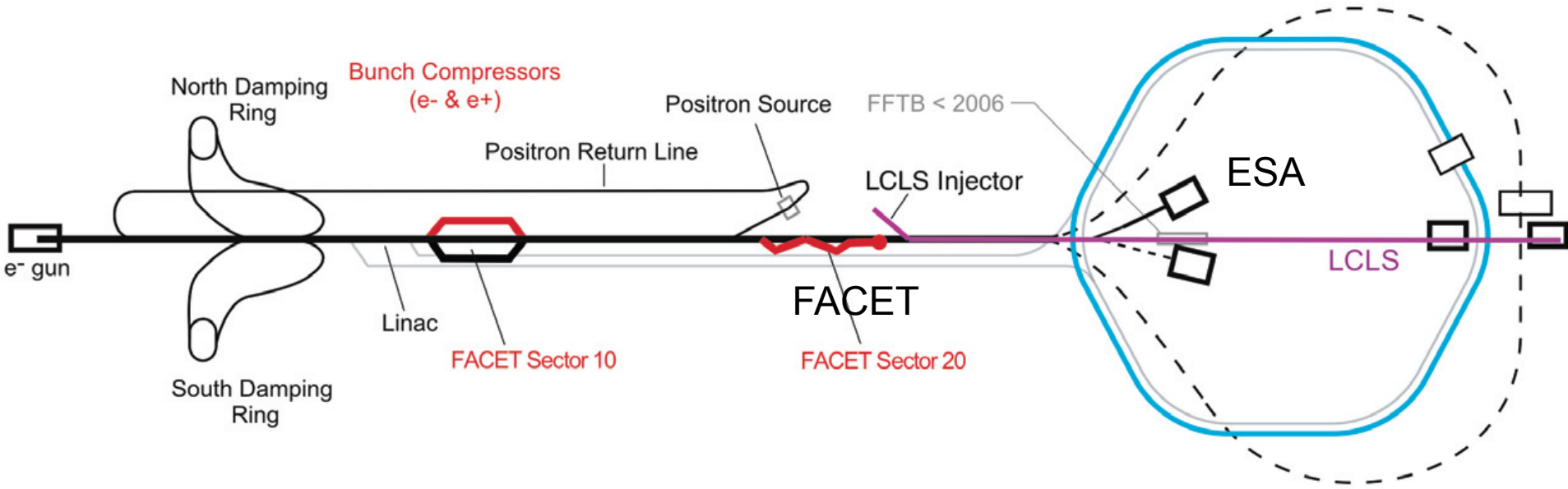
FACET uses 2/3 of SLAC LINAC

The image is an aerial photograph of the SLAC National Accelerator Laboratory. A long, straight, light-colored structure, the SLAC Linac, runs vertically through the center of the image. Three white arrows point from green text boxes to specific locations: the top of the linac, a point further down, and a large building complex at the bottom. The surrounding area includes green fields, roads, and other buildings.

LCLS uses 1/3 of SLAC LINAC

End Station A

SLAC

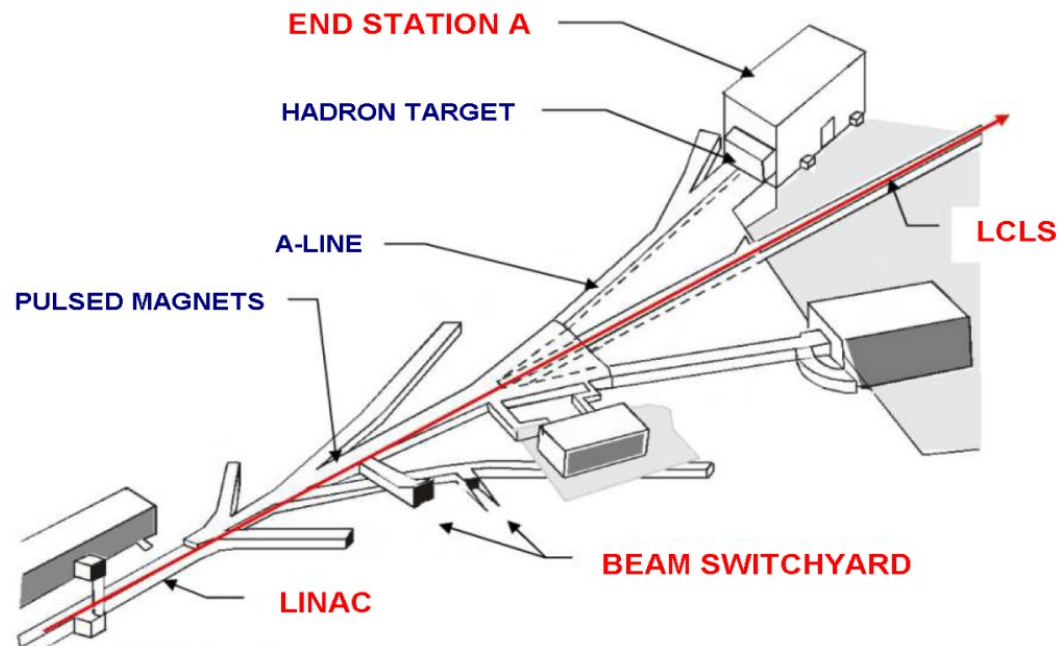


SLAC End Station A Test Beam (ESTB)

ESTB will be a unique HEP resource

- World's only high-energy primary electron beam for large scale Linear Collider MDI and beam instrumentation studies
- Exceptionally clean and well-defined primary and secondary electron beams for detector development
- Secondary hadron beam planned as an upgrade

Pulsed magnets in beam switch yard to send LCLS beam to ESA



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ESTB & FACET

LCLS/ESTB Beams

LCLS beam

- Energy: **3.5 –13.6 GeV**
- Repetition rate: **120Hz**
- Beam current: 20 to **250 pC**
- 350 pC @ 120Hz has been provided short term
- Beam availability > 95%!

ESTB beam

- Kick the LCLS beam into **ESA @ 5 Hz**
- Primary beam 3.5 -13.6 GeV
 - Determined by LCLS
 - $<1.5 \times 10^9$ e-/pulse (250 pC)
- Clean secondary electrons
 - 1 GeV to 13.6 GeV, 0.1 e-/pulse to 10^9 e-/pulse

Additional Beam Availability

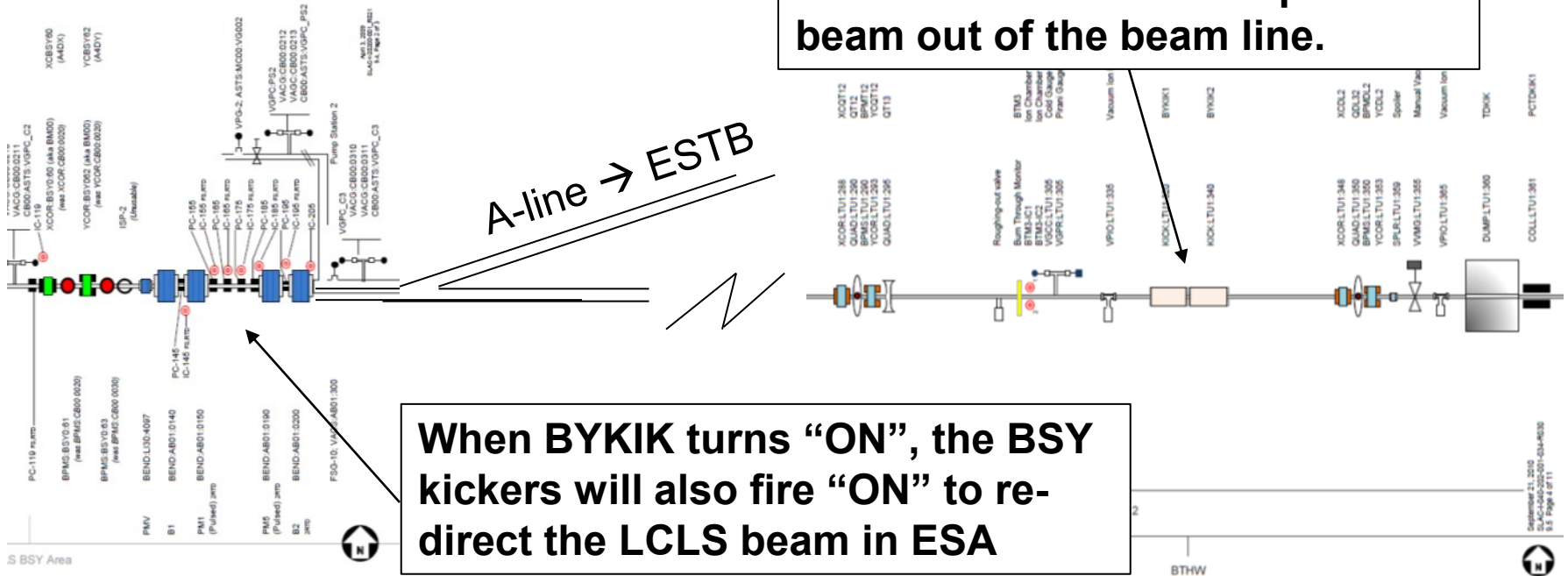
If LCLS experiments don't need full 120 Hz rate, the remaining beam is parked out

Upstream of the LCLS undulator, BYKIK kicker is used to park the beam out of the beam line.

A-line → ESTB

When BYKIK turns "ON", the BSY kickers will also fire "ON" to re-direct the LCLS beam in ESA

Extra 5% of beam time at 120Hz (!) possible



ESTB Hardware Needed

- 4 new kicker magnets including power supplies and modulators, vacuum chambers, collimators are designed and components are being ordered and manufactured
- Build new PPS system and install new beam dump in ESA

A-Line Extraction:

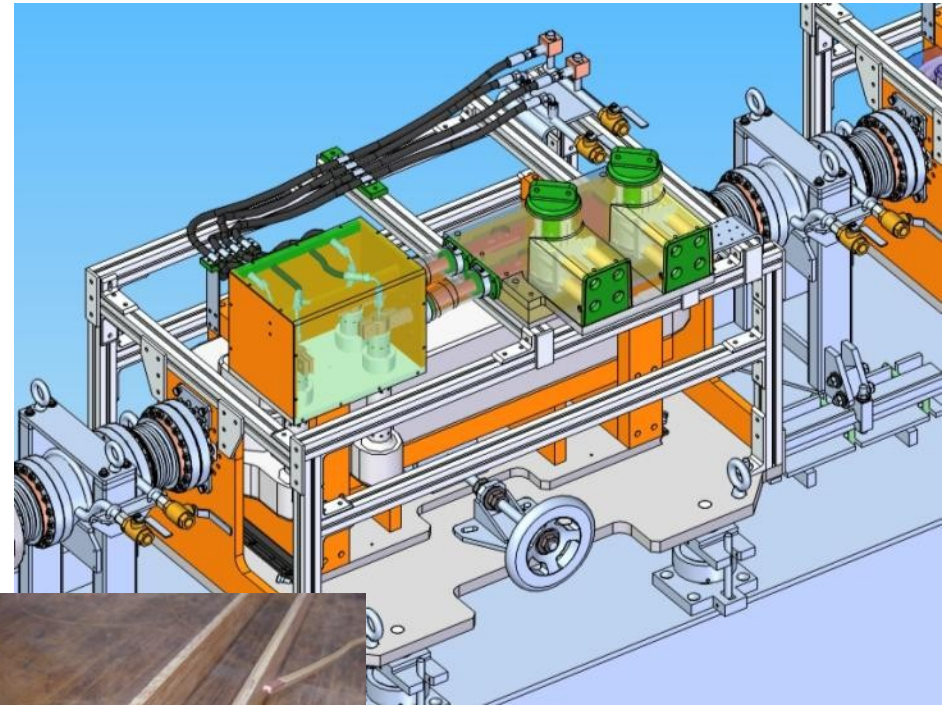
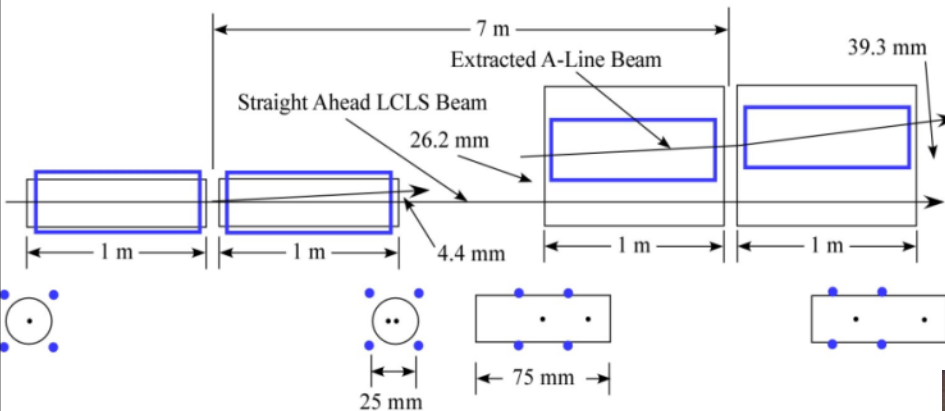
Total Kick = 8.7 mrad

2 set of bends, 4.37 mrad \Rightarrow 2.04 kG-m @ 14 GeV

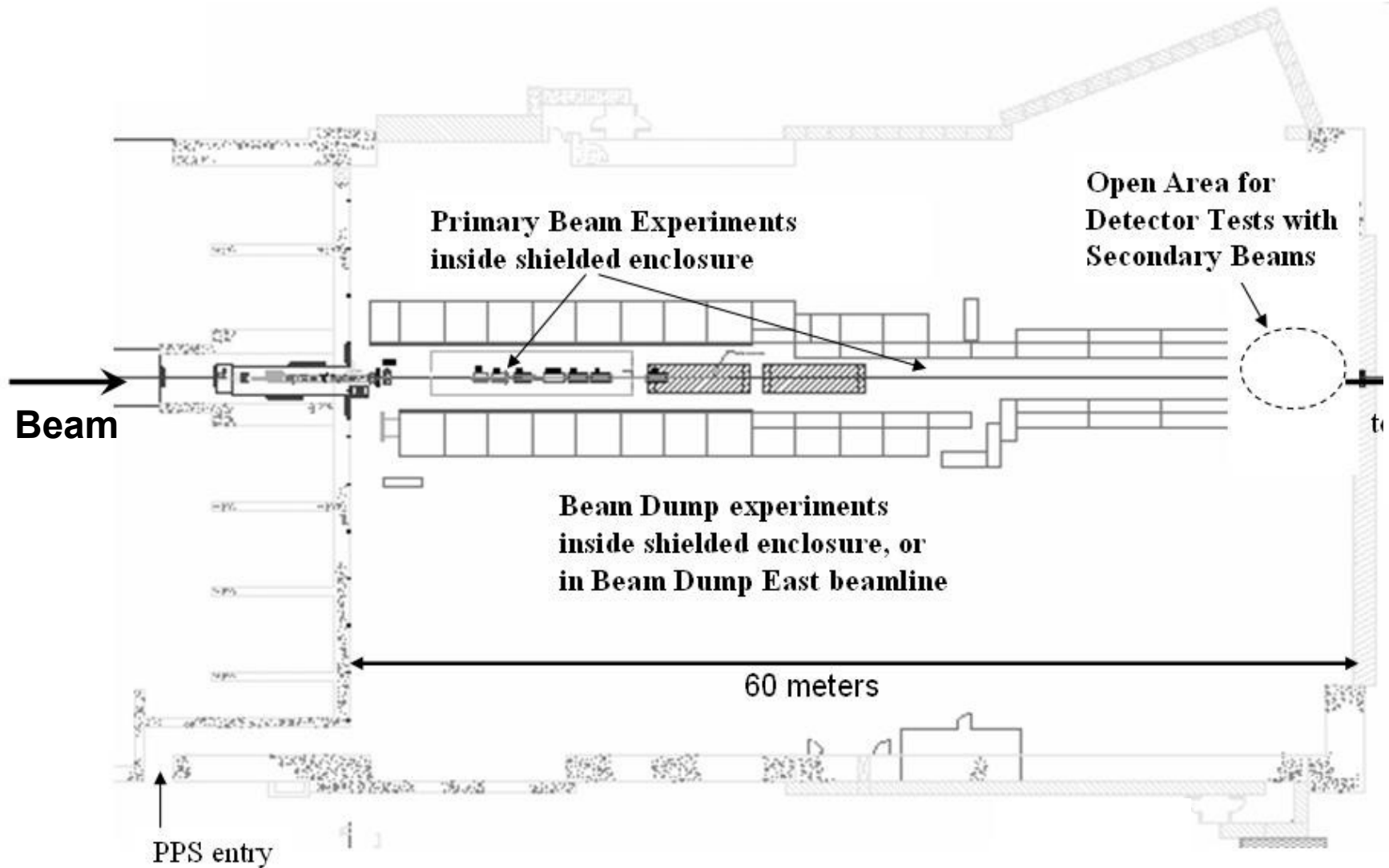
7 m between the two bends

Bends based on LCLS BYKIK: 25 mm coil diameter, air-core

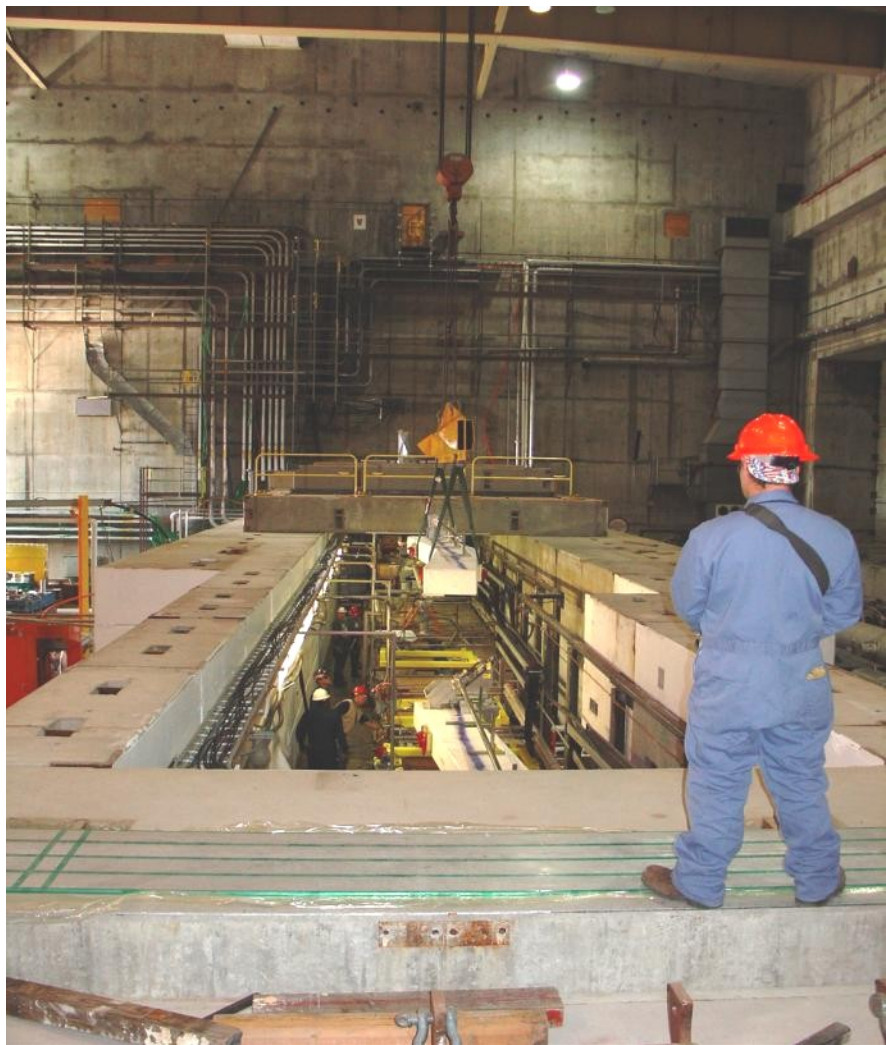
Distances and separations are approximate, need to check layout



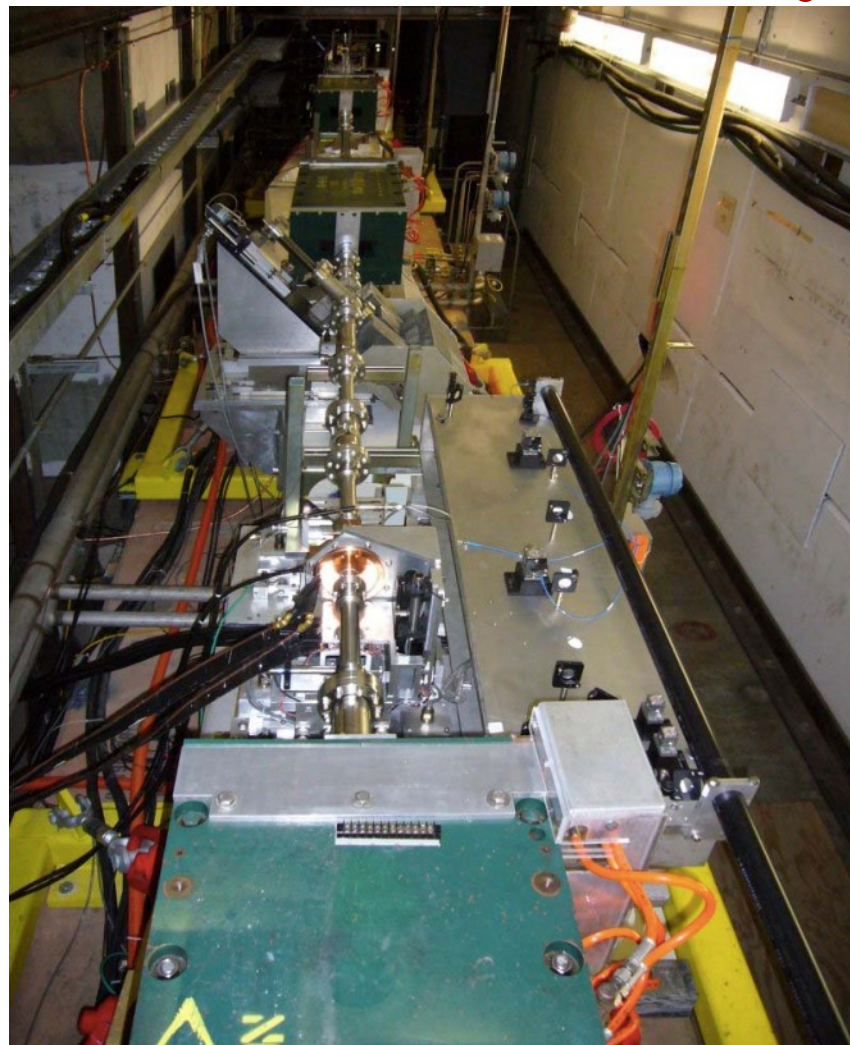
Building 61: ESA



End Station A Experimental Area



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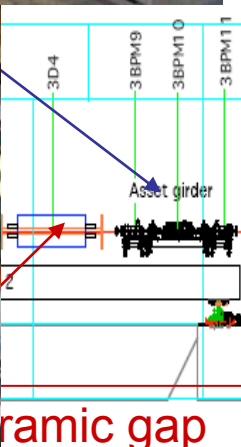
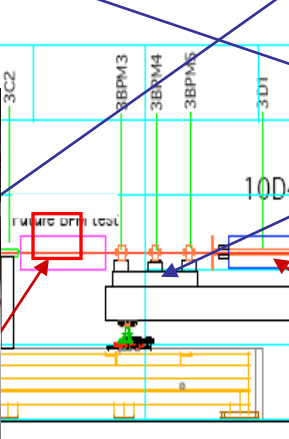
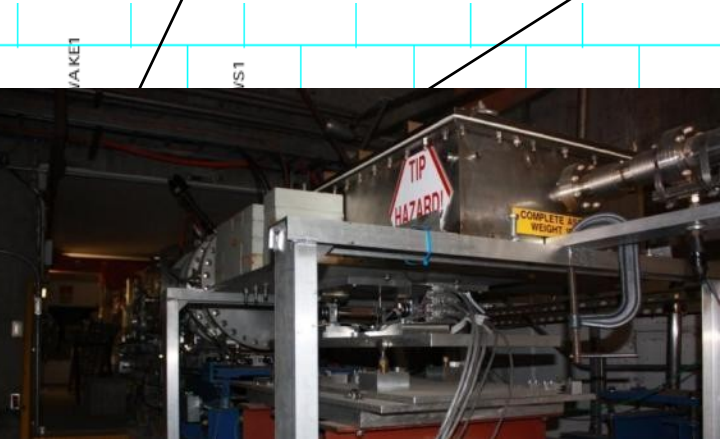
ESTB & FACET

ESA Past Experiments

Wakefield box

Wire Scanners

“IP BPMs” T-488



T-487: long. bunch profile

ceramic gap for EMI studies

Energy Spectrometer: Dipoles + Wiggler

- BPM energy spectrometer (T-474/491)
- Synch Stripe energy spectrometer (T-475)
- Collimator design, wakefields (T-480)
- Bunch length diagnostics (T-487)
- Smith-Purcell Radiation

- IP BPMs—background studies (T-488)
- LCLS beam to ESA (T490)
- Linac BPM prototypes
- EMI (electro-magnetic interference)
- Irradiation Experiments



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ESTB & FACET

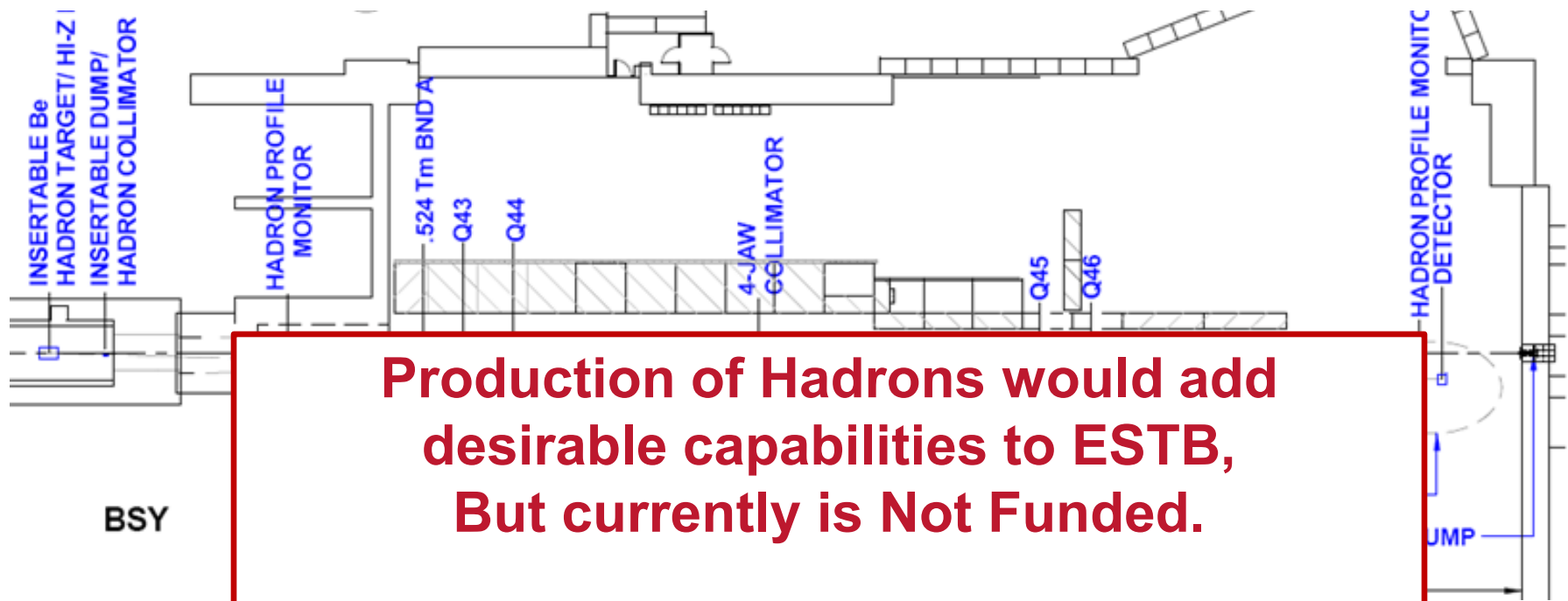


ESTB Stage I: Primary and Secondary beams

- **Primary e- Beam operations**
 - Full intensity, 4 - 14 GeV, LCLS beam into ESA
- **Secondary e⁻ beams**
 - 4 - 13 GeV, up to 10^{-4} momentum resolution
 - 1 GeV (maybe) and 2 GeV (most likely)
 - Adjusting 2 collimators: $0.1 - 10^9$ electrons/pulse
- **Tagged photon beams**
 - developing the needed infrastructure

ESTB Stage II: Hadron Production

- Add Be target, beam dump, analyzing magnet, momentum slit, and quadrupole doublets to produce a secondary hadron beam
- Production angle = 1.35° and Acceptance = $10 \mu\text{sr}$



Production of Hadrons would add desirable capabilities to ESTB, But currently is Not Funded.

We need User requests!

ESTB Workshop at SLAC

1st ESTB User Workshop in March 2011

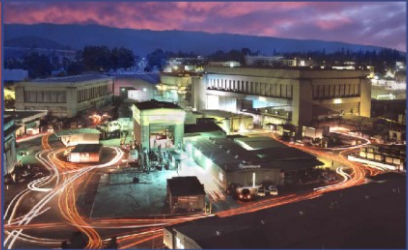
- 50 participants from 16 institutions and 5 countries
- 13 short presentations for proposed test beam uses
- 8 requests received (already before the workshop)

**Underlines the broad
interest by the community**



ESTB 2011 Workshop
March 17, 2011
SLAC National Accelerator Laboratory

SLAC is reviving test beams in End Station A. The End Station Test Beam (ESTB) 2011 Workshop will take place on March 17, 2011 at SLAC National Accelerator Laboratory, Menlo Park, California, USA, for discussions of the new electron test beam planned for first operation in Summer 2011. The test beam will provide the full range of electron energies up to 13.6 GeV, and intensities from single particles to 25 nC/bunch, and will be useful for detector R&D and machine developments.




The Workshop program will include the status of ESTB preparations, a review of test beam capabilities, and time to learn who is interested in using the test beam and what beam properties and infrastructure support are needed for future tests.

The meeting is conveniently scheduled just before the ALCPO11 Workshop in Eugene, Oregon. The meeting will be held in the ROB Room on the SLAC site overlooking picturesque bay area hills. The workshop will include a tour of the End Station A facility.

Program Committee:
Carsten Hast (SLAC) John Jaros (SLAC)
Mauro Pivi (SLAC) Erik Ramberg (FNAL)

<http://www-conf.slac.stanford.edu/estb2011>

SLAC
Supported by the U.S. Department of Energy and the SLAC National Accelerator Laboratory



Proposals

- Test of the SSD Electronics for STAR HFT Upgrade
 - Pixel Sensors for ATLAS Upgrades
 - STAR Pixel Detector
 - Fermi Large Area Telescope
 - LC detector: Silicon-Tungsten Calorimeter
 - Super B R&D
 - **Energy Spectrometry**
 - **CLIC Wakefield Collimator Studies**
 - Radiation Physics Beam Tests
 - Beamcal Radiation Damage Study
 - Geosynchrotron Radio Emission from Extensive Air Showers
 - SuperB DCH
 - Askaryan Effect in High Energy Showers
- Howard Matis, LBNL (*)
- Philippe Grenier, SLAC (*)
- Leo Grenier, LBNL (*)
- Elliott Bloom, SLAC (*)
- Ray Frey, University of Oregon (*)
- Jerry Va'Vra, SLAC
- Mike Hildreth, Notre Dame University (*)
- Roger Jones, Cockcroft/Manchester U
- Mario Santana, SLAC
- Bruce Schumm, UC Santa Cruz
- Konstantin Belov, UCLA
- Mike Rooney (*)
- Peter Gorham, Hawaii U. (*)

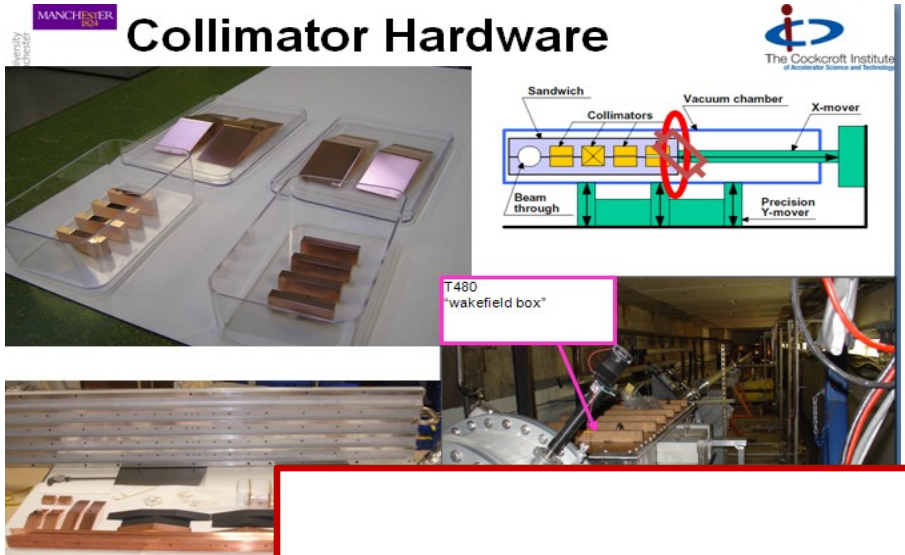
(*) proposal received

Collimator Wakefield Measurements

R.M. Jones, D. Schulte, R. Tomas, W. Wuensch for the CLIC team

Motivation

- Collimator wakefields may limit CLIC performance
- CLIC parameters sit close to limit of formulae applicability
- Previous experiments in ESA (T-480)^a show discrepancies with model (is the lack of bunch length measurement the culprit?)
- Non-linear components?

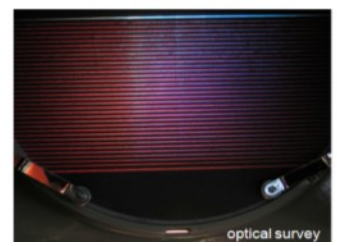
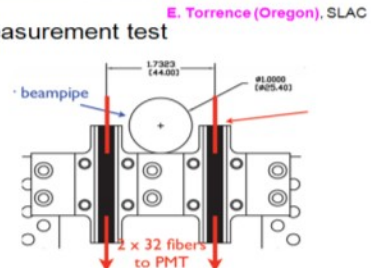
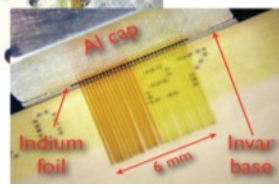


Energy Spectrometer Tests at End Station A

Mike Hildreth

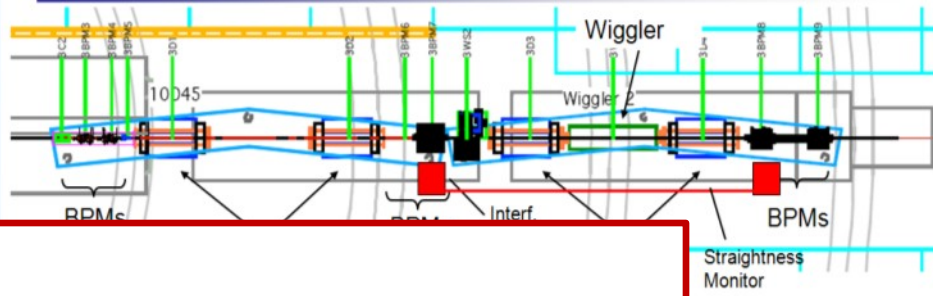
New SR Stripe Detector

- Next-generation prototype for Energy Measurement test
 - schedule advanced in anticipation of ESA closure/hiatus due to LCLS



March 17, 2011

Next Steps for ESA



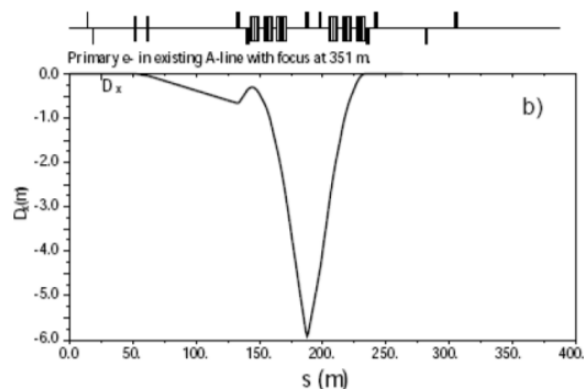
We need rf BPMs possibly LCLS-II type

- Bunch length optic bunch length
- Need BPM resolution in the 100 nm level (partially contributed by CERN)

- more new hardware/electronics for better resolution/stability
- aim for 1×10^{-4} relative measurement, cross-calibration
- Finish what we started!

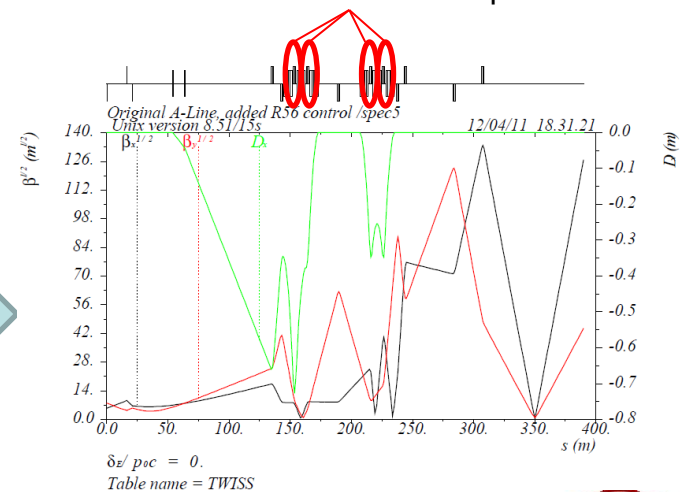
Development: Short bunch length

- Interest for short bunches $\sim 50\mu\text{m}$ (CLIC, accel. R&D.)
- LCLS beam: $10\mu\text{m}$ and smaller
- In A-line, bunch length increases to $280\mu\text{m}$ due to 24.5° bend, large dispersion and large R56
 - Reduce LCLS beam $\sigma_E \sim 0.02\%$ (Z. Huang) $\rightarrow 100\mu\text{m}$
 - Install 4 QUADs in A-line to reduce R56 (T. Fieguth, M.Pivi)
 - **bl = $50\mu\text{m}$ or shorter in ESA**



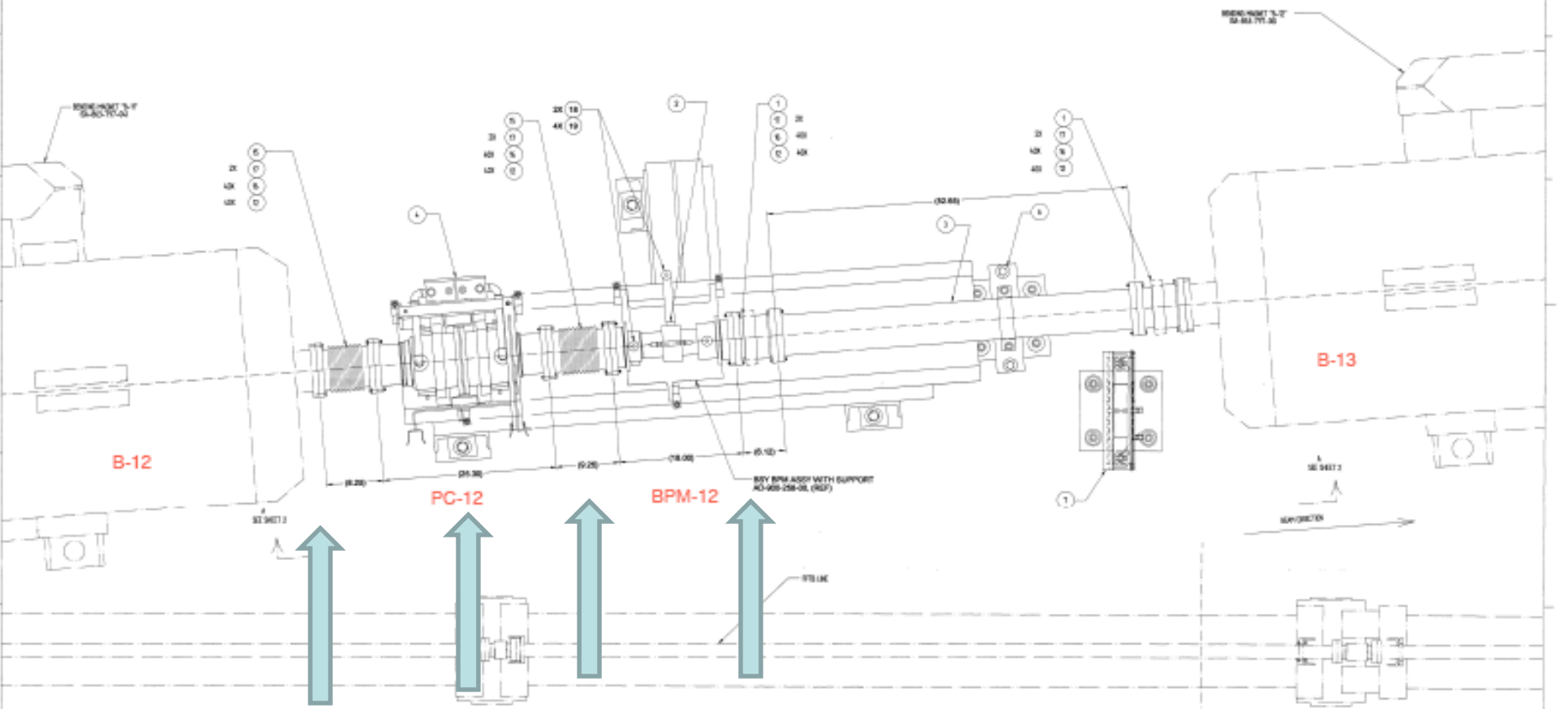
Existing optics

R56 ~ 0.46



R56 < 0.1

REV	DESCRIPTION	CHK	APP	DATE
1	ISSUE DESIGN	HS	ST	22/05/10
2	REV BY THE DESIGN, REV 9 & 9	AC	ST	22/05/10



Removal existing instrumentation in the A-line to make room to 2 m long quadrupoles

- NOTES:
1. FOR MOUNTING DIMENSIONS SEE IS-12-100-01
 2. FOR ELECTRICAL CONNECTIONS SEE IS-12-100-01
 3. SEE REF A-LINE MECH UTIL HIGH-PRESSURE SW
 4. SEE REF A-LINE MECH UTIL SW/PRESSURE SW
 5. SEE REF A-LINE MECH UTIL SW/PRESSURE SW
 6. SEE REF A-LINE MECH UTIL SW/PRESSURE SW
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 50. SEE REF A-LINE MECH UTIL SW/PRESSURE SW

ITEM NO	QTY	DESCRIPTION	STY
18	43	201-300	28
19	PP	800-475	33
20	NO	STOCK OR PART NO.	

ITEM NO	QTY	DESCRIPTION	STY
11		DIAPHR. SPRAY COPPER, 5 BY 1/2	8
12		FLG BOLT, SST, 1/2" DIA, 3/16" THK, 5/16-24 X 2-1/4	180
13		FORWARD BELLOW, SST, 1" PCD, 1/2" DIA, 1/2" THK	2
14	95	510-001	02
15	55	551-002	02
16	480	480-000	35
17	85	290-014	11
18	85	290-002	11
19	82	280-002	14
20	PP	200-111	14
21	SA	800-426	35
22	SA	800-426	65
23	SA	800-220	01
24	SA	800-790	24
25	SA	800-790	05
26	SA	800-790	01
27	SA	250-297	01
28	SA	250-297	01
29	SA	250-297	01
30	SA	250-297	01

SCALE: 3/16" = 1"

DO NOT SCALE DIMENSIONS

STANDARD LINEAR ACCELERATOR CENTER
LANSING MI 48060

STANDARD PARTS
STANDARD PARTS

50 GEV A-LINE
INSTRUMENT STAND
IS-12 INSTALLATION

ID-863-797-05

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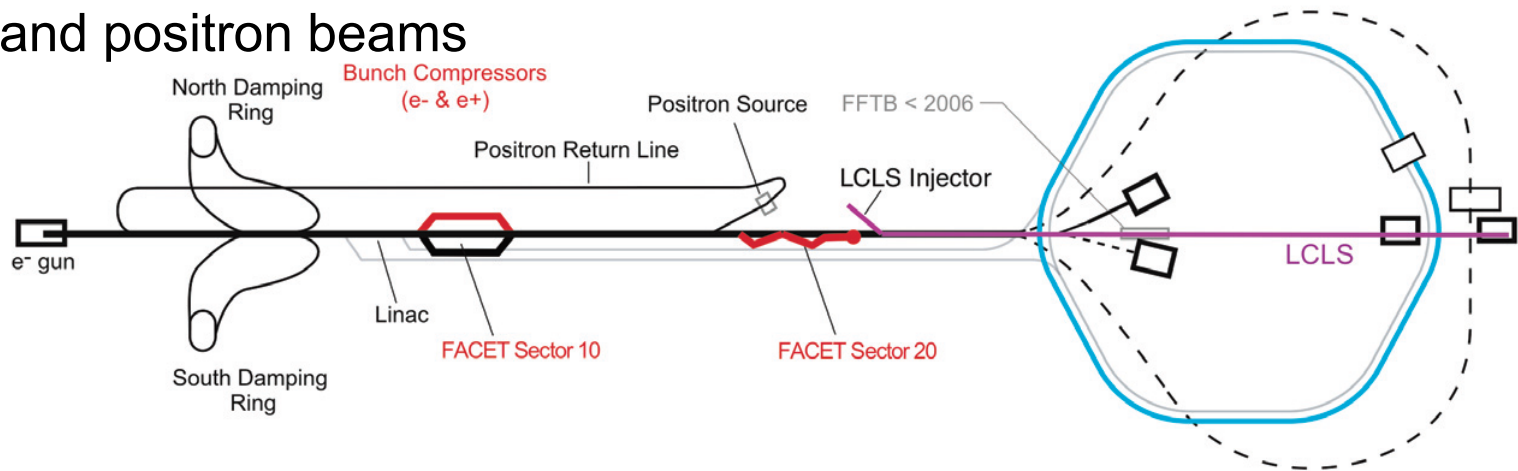
ESTB Schedule

- July install one kicker in BSY
- August ESTB can do first test of kicking a 4GeV beam into A-line
- ESA PPS becomes available this summer
 - 4GeV primary beam to ESA
 - 4-14GeV secondary electron beam to ESA
- Commissioning of ESA infrastructure September/October
- Oct 25th – Nov 1st install 4 BSY kicker magnets with ceramic chambers
- ESTB commissioning run in November and December
- LCLS off from Christmas to end of January
- ESTB running starts February 2012
- SLAC downtimes are in Aug/Sept and over Christmas for the next years

- For MDI proposal we tie into the FACET Review process (October 2011)

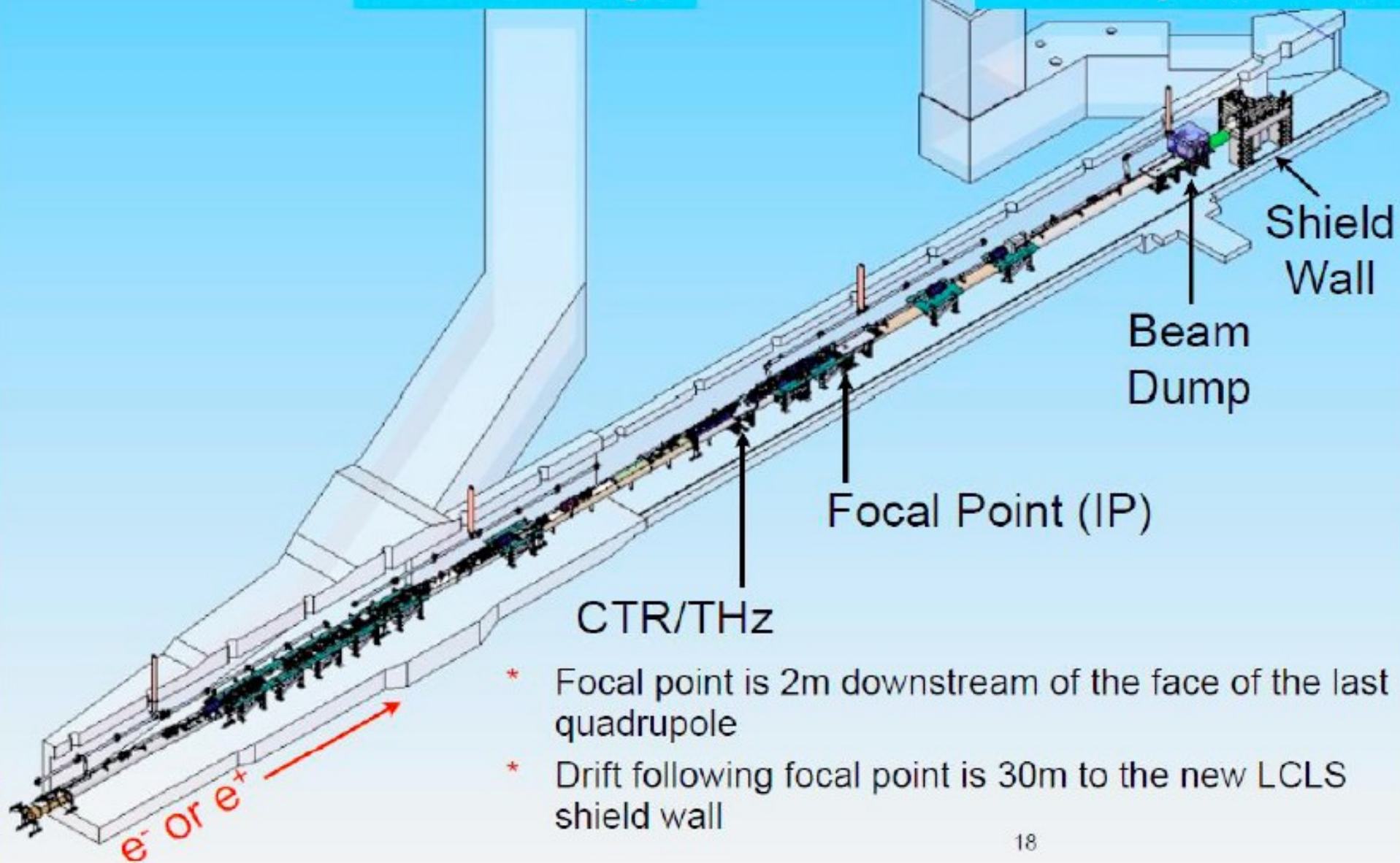
FACET at Sector 20

- FACET uses the first two-thirds of the SLAC Linac
- Energy = 23 GeV
- Charge 3.2 nC
- $\Sigma_x = 14 \mu\text{m}$
- $\Sigma_y = 6 \mu\text{m}$
- $\Sigma_z = 14 \mu\text{m}$ minimum (20 μm typical)
- Bunch length can be increased up to a factor of 3
- Electron and positron beams



Positron Target

LCLS Injector Vault



- * Focal point is 2m downstream of the face of the last quadrupole
- * Drift following focal point is 30m to the new LCLS shield wall

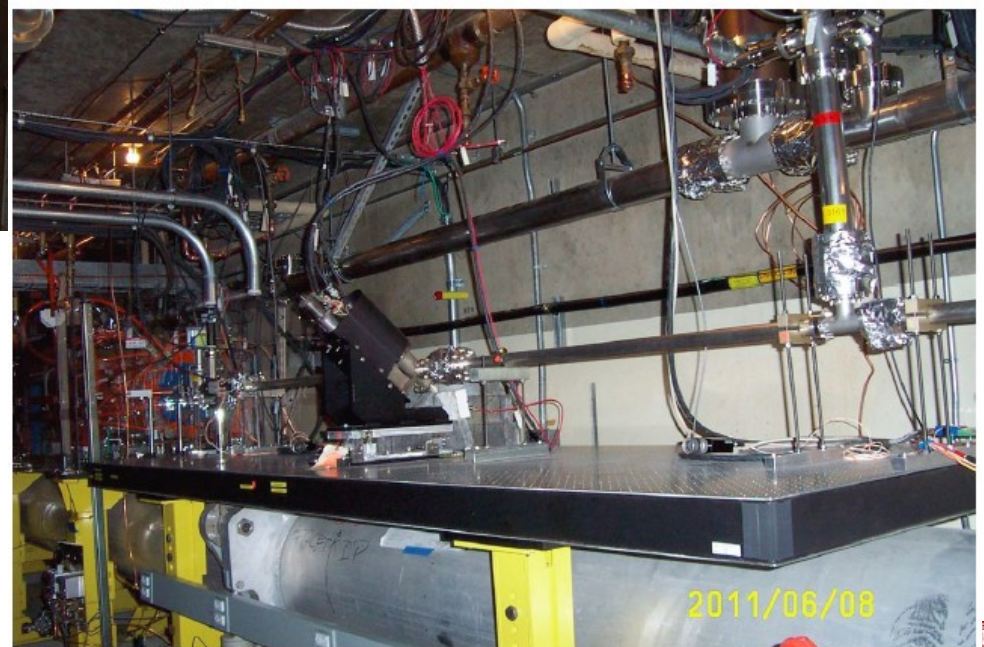
THz and IP Optical Tables



↑
THz Table (looking east
towards dump)

Magnets installed meanwhile...

IP Table



- FACET, Sec. 20, dedicated linac beam
- ESTB, ESA, LCLS beam
- NLCTA, 0.5 GeV, dedicated accelerator
- ASSET, ≈ 2 GeV, Sec. 2, long (1.5 mm) bunches

	FACET	ESA (ESTB)
Energy	23 GeV	4 – 13.6 GeV
Charge per pulse	$0.5 - 2.0 \times 10^{10} e^-$ or e^+	$0.15 \times 10^{10} e^-$
Pulse length at IP (σ_z)	15 – 40 μm	100 μm (44 μm)
Typical spot size at IP ($\sigma_{x,y}$)	10 – 20 μm	$\gamma\varepsilon = 4$ pm-rad by 1 pm-rad
Repetition rate	1 – 30 Hz	5 Hz
Momentum spread	4 – 0.5%	0.06 – 0.02% (?)
Momentum dispersion at IP	$\eta < 10^{-5} \text{ m}$	0 (?)

FACET Schedule

- June 16th start of beam operation
- July 7th (or so) installation of experiments (one week or so)
- Mid July to July 31st more beam tuning
- August 1st to 31st “User Assisted Commissioning”
 - We will have 4 experiments installed
 - Plasma Wakefield Acceleration
 - Smith Purcell
 - Magnetic Switching
 - Wakefield acceleration in dielectric structures
- FACET User Meeting August 29/30
- Call for proposals in October
- 1st User Run February to March 2012 and May/June

Summary

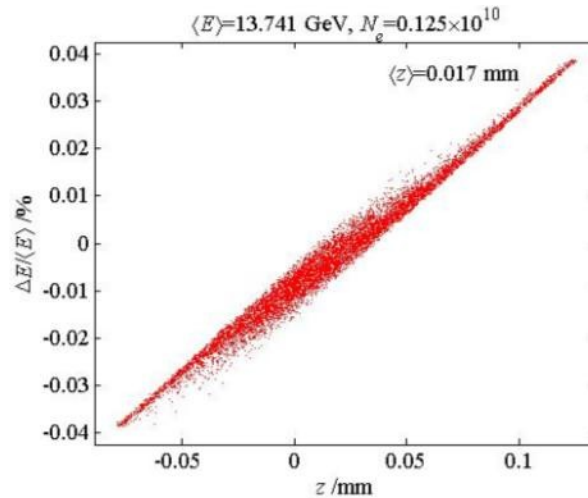
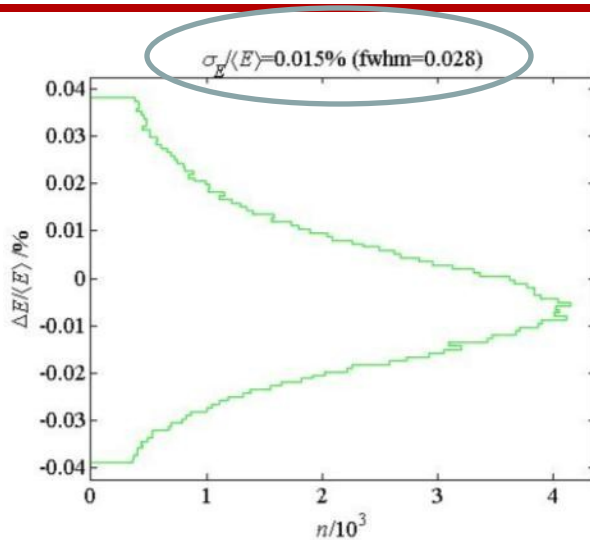
We are excited (and slightly overworked...)

- To start FACET this month
- To re-start ESA test beams later this year
- Unique high energy electron (positron) beam lines in the US
- With plenty of infrastructures and SLAC support for Users

Keep Your Proposals Coming

Back-up

Using LiTrack: example

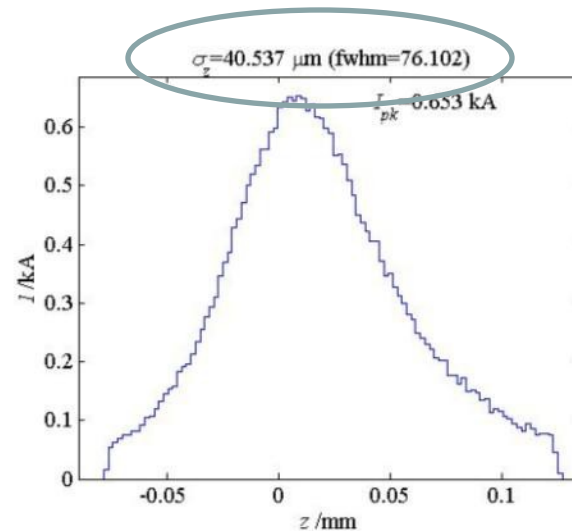


LiTrack simulations (Z. Huang):

- $\delta_E \sim 0.015\%$
- applied 10% energy cut
- R56 = 0.23 m (not 0.1 yet!)
- got $\sigma_z = 40$ μm

source: lcls_200pC_6MeV_560um.zd

Elegant (MADX?!) simulations of whole beam line on the way

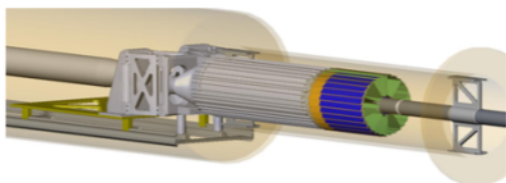


LiTrack (SLAC)

STAR Pixel Detector

A MAPS based vertex detector for STAR

Short description of the detector and why we need test beam



LBL
 Leo Greiner, Eric Anderssen, Howard Matis,
 Thorsten Stezelberger, Joe Silber, Xiangming
 Sun, Michal Szelezniak, Chinh Vu,
 Howard Wieman

UTA
 Jo Schambach

IPHC Strasburg
 Marc Winter CMOS group

LC Detector: Silicon-Tungsten Electromagnetic Calorimeter R&D Collaboration

M. Breidenbach, D. Freytag, N. Graf, R. Herbst, G. Haller, J. Jaros, T. Nelson
 SLAC National Accelerator Center

- KPIX readout chip
- downstream readout
- mechanical design and integration

J. Brau, R. Frey, D. Strom,
 P. Radloff (grad student),
 undergraduates
 U. Oregon

- detector development
- readout electronics

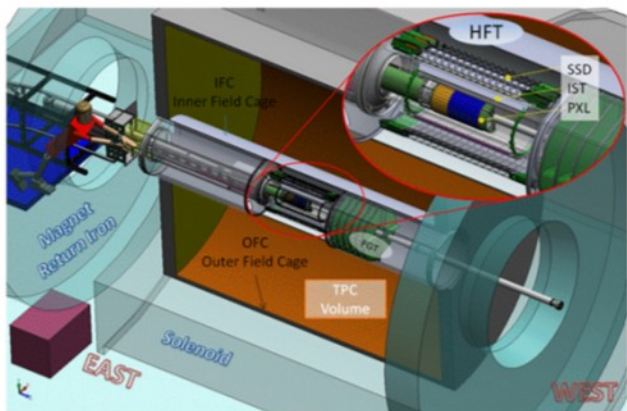
B. Holbrook, R. Lander, M. Tripathi,
 M. Woods (grad student)
 UC Davis

- cable development
- bump bonding

R Frey ESTB2011

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Inner Detector Upgrades

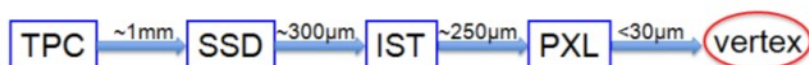


TPC – Time Projection Chamber (main tracking detector in STAR) efficiency and spatial resolution sensors

HFT – Heavy Flavor Tracker

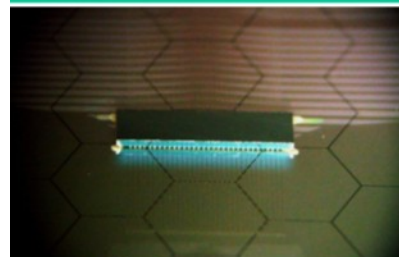
- SSD – Silicon Strip Detector
 - $r = 22$ cm
- IST – Inner Silicon Tracker
 - $r = 14$ cm
- PXL – Pixel Detector
 - $r = 2.5, 8$ cm

We track inward from the TPC with graded resolution:

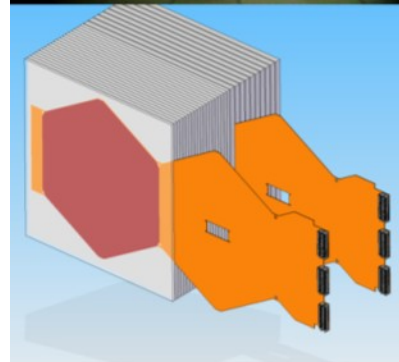


Solenoid Tracker at RHIC: search qg plasma.

Silicon-Tungsten R&D and test beam module



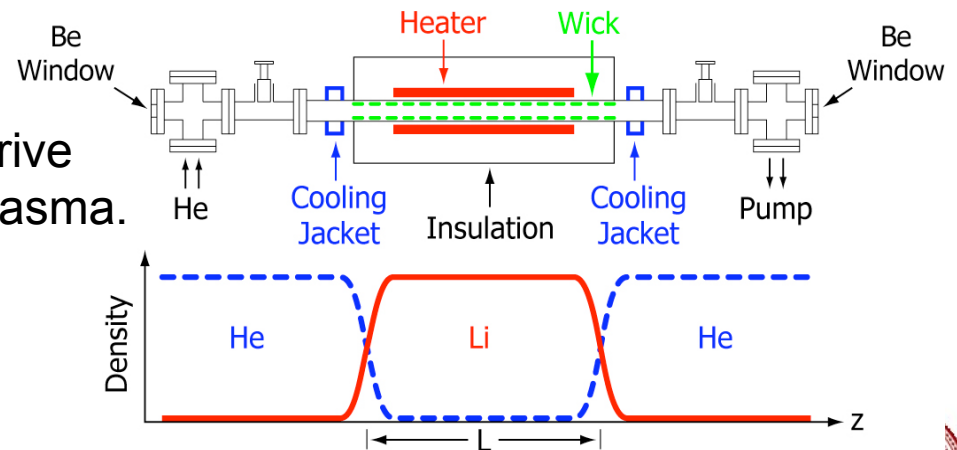
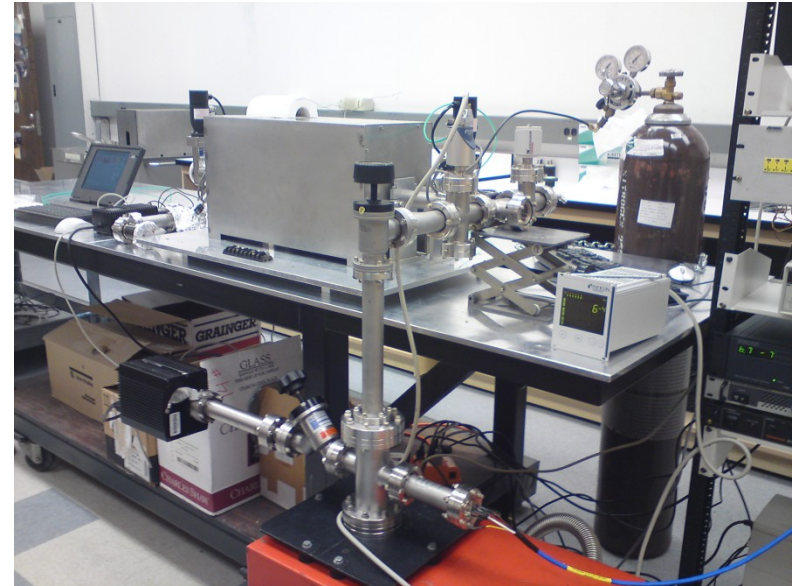
- 15 cm silicon sensors
 - 13 mm² pixels
- 1024-channel KPIX readout chip
 - Bump-bonded to sensor
 - One digital output
 - Large dynamic range
 - Power pulsing



R&D project goal: Produce full-depth (30 layer) module which uses appropriate technologies for a collider detector (and test it). (expect it to be ready ~ summer)

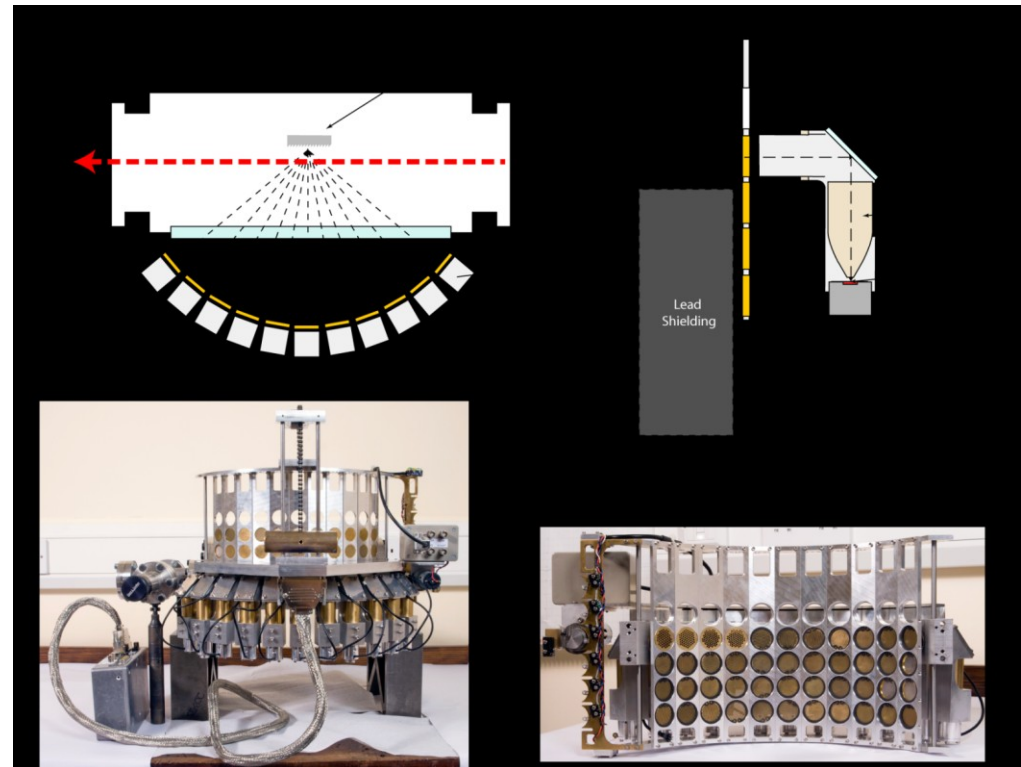
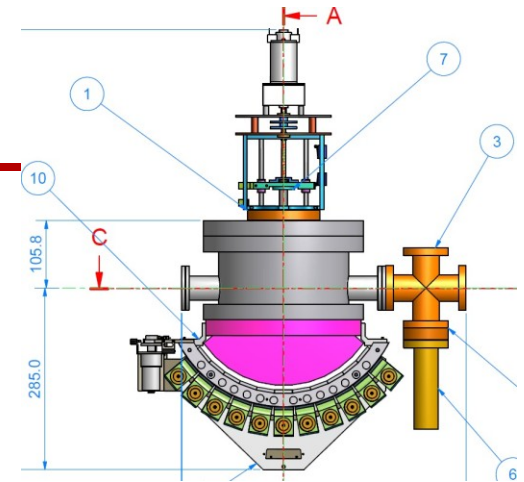
Plasma Wakefield Acceleration

- Continuation of very successful FFTB experiments
- Heat-pipe oven to be installed this July
- Lithium metal vaporized at 800°C
- Length of plasma controllable by controlling heaters and pressure of helium buffer gas
- Phase One: Begin with single electron bunch in field ionized lithium plasma.
- Phase Two: Single bunch in field ionized cesium plasma.
- Phase Three: Use Notch Collimator.
- Phase Four: Two electron bunches (drive and witness) in field ionized cesium plasma.
- After first year, pre-ionized plasma, positrons, positrons and electrons.



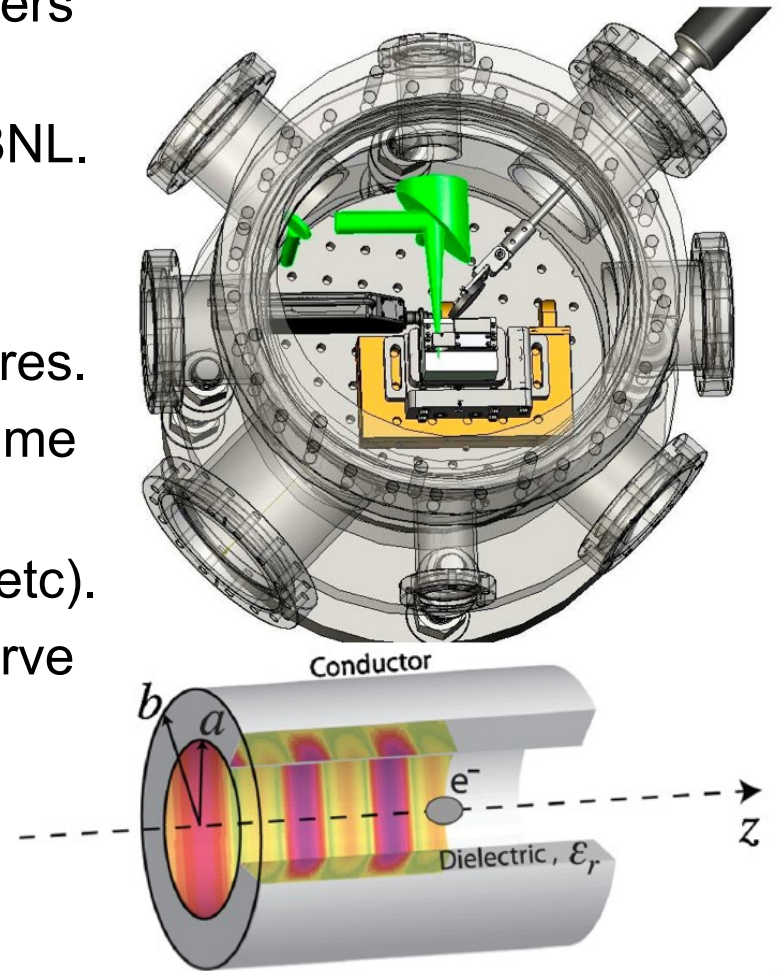
Smith Purcell

- Bunch Time Profile measurements with Coherent Smith-Purcell Radiation
- Moderate band-width terahertz
- Beam passes by grating which has a dispersive effect
- Continuation of experiment at ESA
- Not sensitive to beam spot size (will be situated upstream of IP).
- Non-destructive (parasitic running).



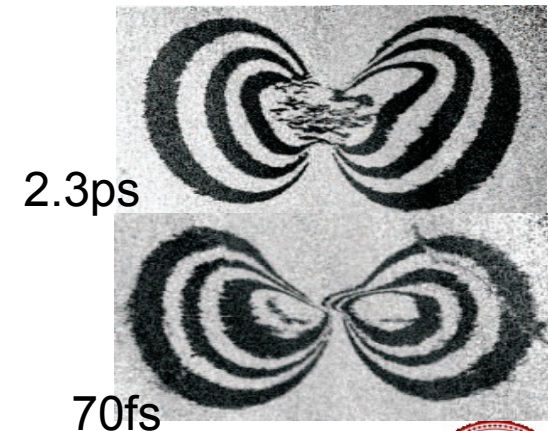
Wakefield Acceleration in Dielectric Structures

- GV/m class DWA for use in linear colliders and future light sources.
- Previous work at FFTB/SLAC, UCLA, BNL.
- High gradient regime at FACET.
- FACET beam sent through prototype dielectric wakefield acceleration structures.
- Parametric breakdown studies and lifetime effects.
- Vary structures (dimensions, materials etc).
- Use drive and witness bunches to observe acceleration.
- Use coherent Cerenkov radiation
- Next year, use protons.



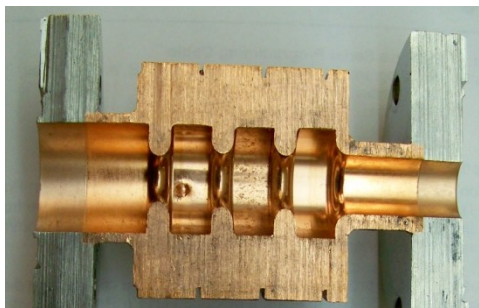
Ultrafast Magnetic Switching

- Continuation of FFTB work.
- Change in magnetization of a sample on ultrafast timescales
- Change pulse-lengths with constant Q - do longer pulse-lengths have more energy deposition?
- Expose sample to electron bunch
- Then image with spin-sensitive scanning electron microscope.
- Different patterns on same film indicate different physical processes.
- Chaos cannot be explained
- Need to rule out experimental artefacts.

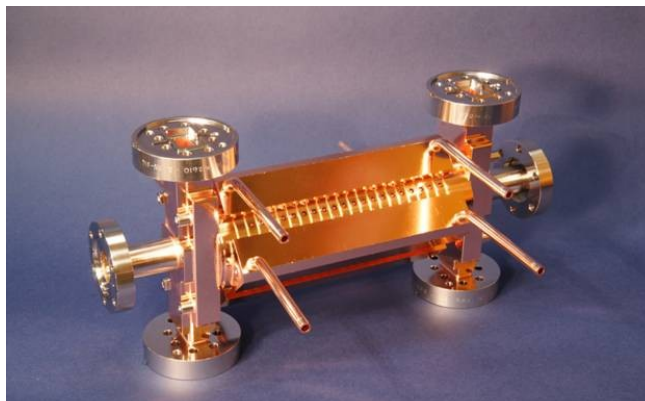


Additional Experiments

- Metallic Periodic Structures (Accepted Proposal)
 - Short-pulse, high fields to study breakdown physics.
- High gradient dielectric wakefield measurements (Accepted Proposal)
 - dielectric based collimating systems
- CLIC Studies (letter of intent)
 - Dispersion-free steering
 - Accelerating structure Wakefield Studies
 - Collimator Wakefield Studies
- THz extraction (expression of interest)
 - Extract radiation to an experimental area



Short Metallic Accelerating Structure



30cm High Power test structure (CLIC Studies)

