A Facility for Accelerator Physics and Test Beam Experiments

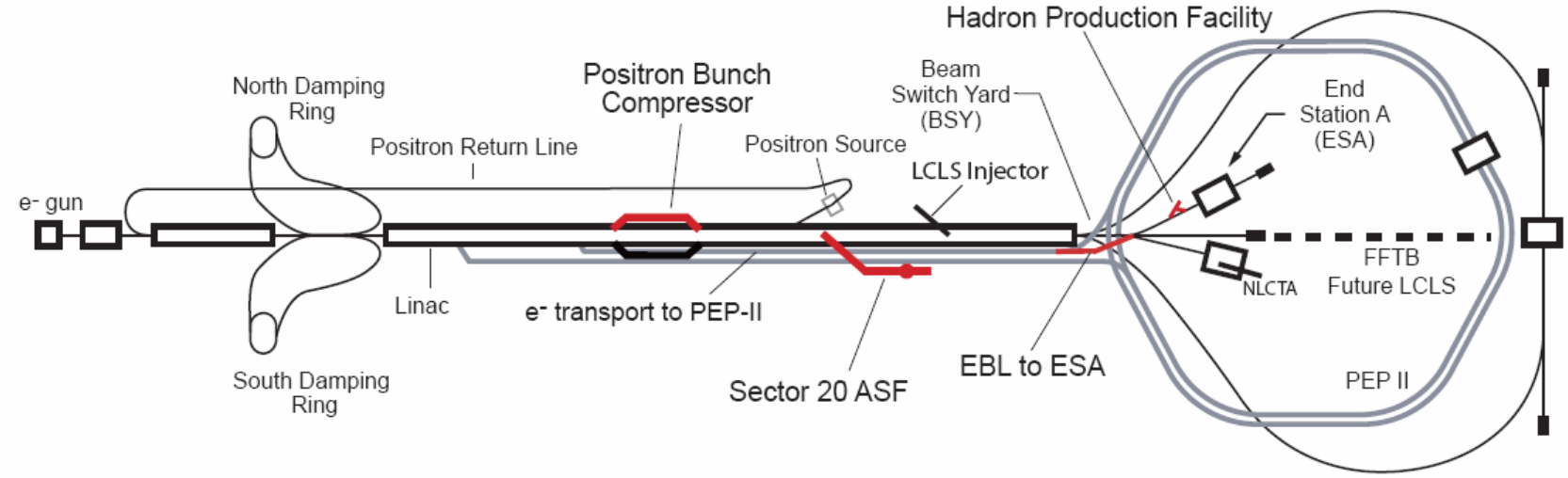
U.S. Department of Energy Review

Roger Erickson

for the FACET Design Team

February 20, 2008

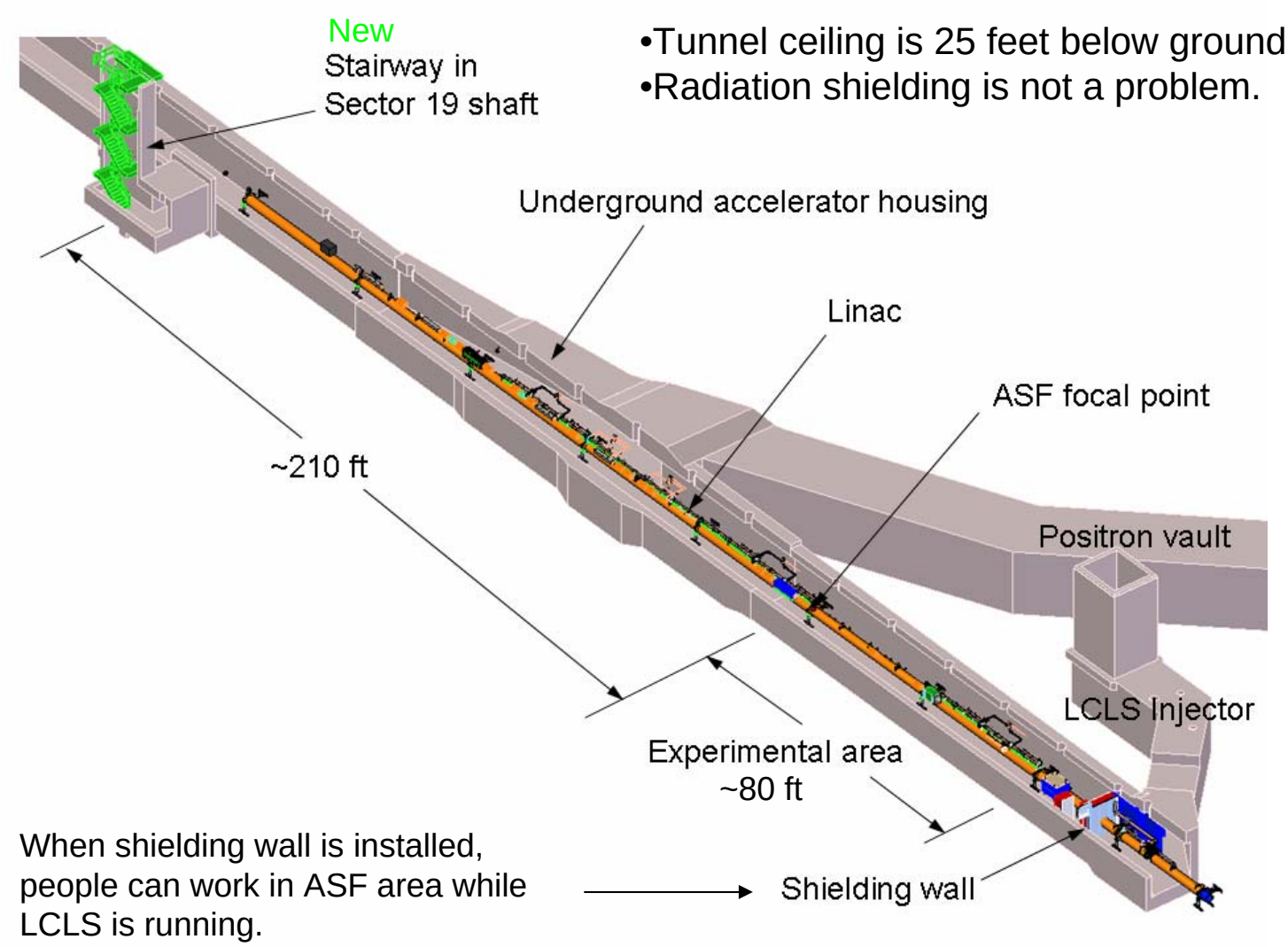
SLAC Overview with FACET



FACET consists of four main components:

1. **ASF experimental area with final focus and beam dump in the linac tunnel.**
2. **Linac Bunch Compressor upgrade to compress positron bunches.**
3. **EBL bypass line to deliver e^- beams to ESA, bypassing the LCLS.**
4. **Hadron Production Facility for secondary beams to ESA.**

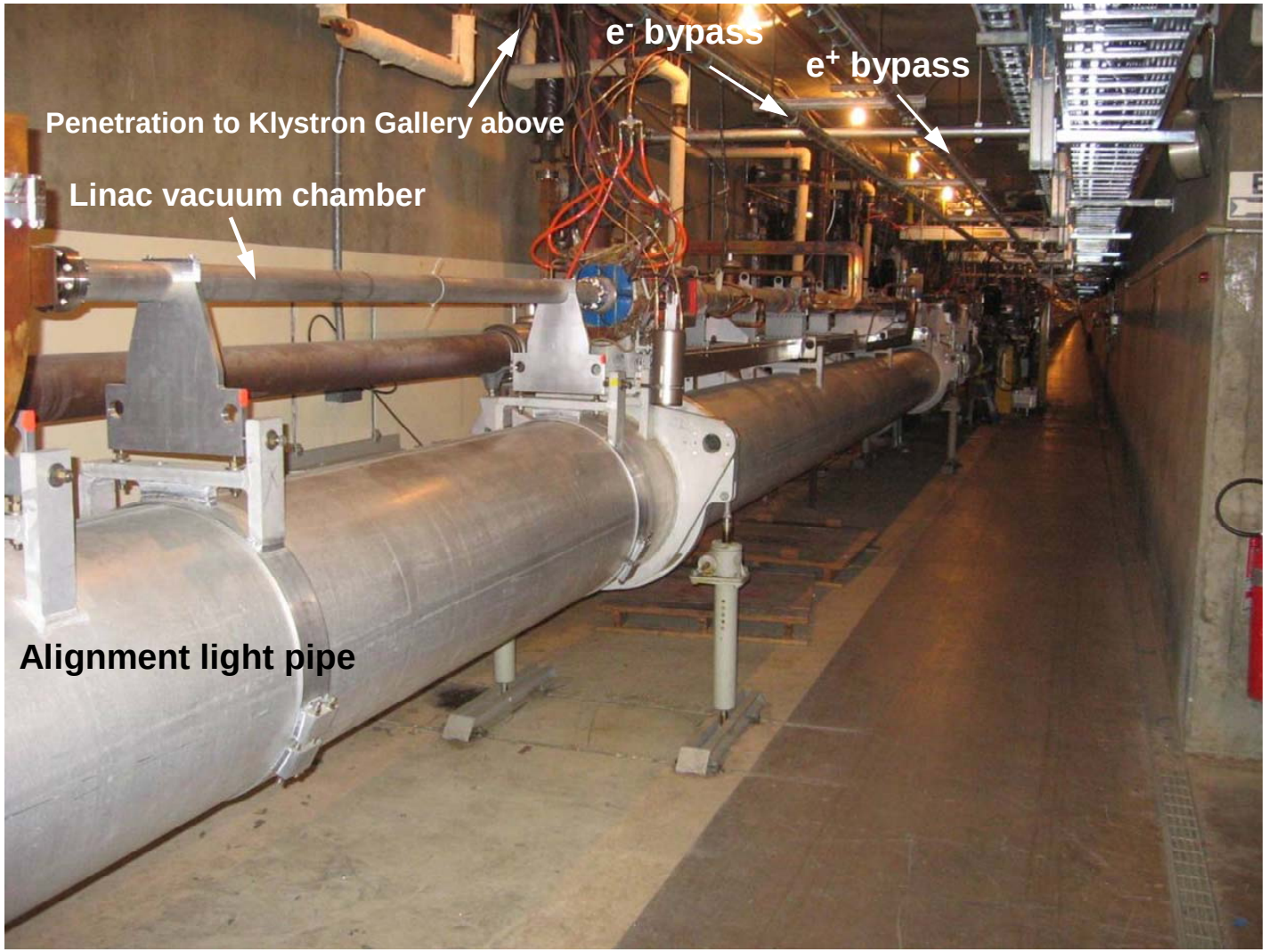
Cutaway View of ASF



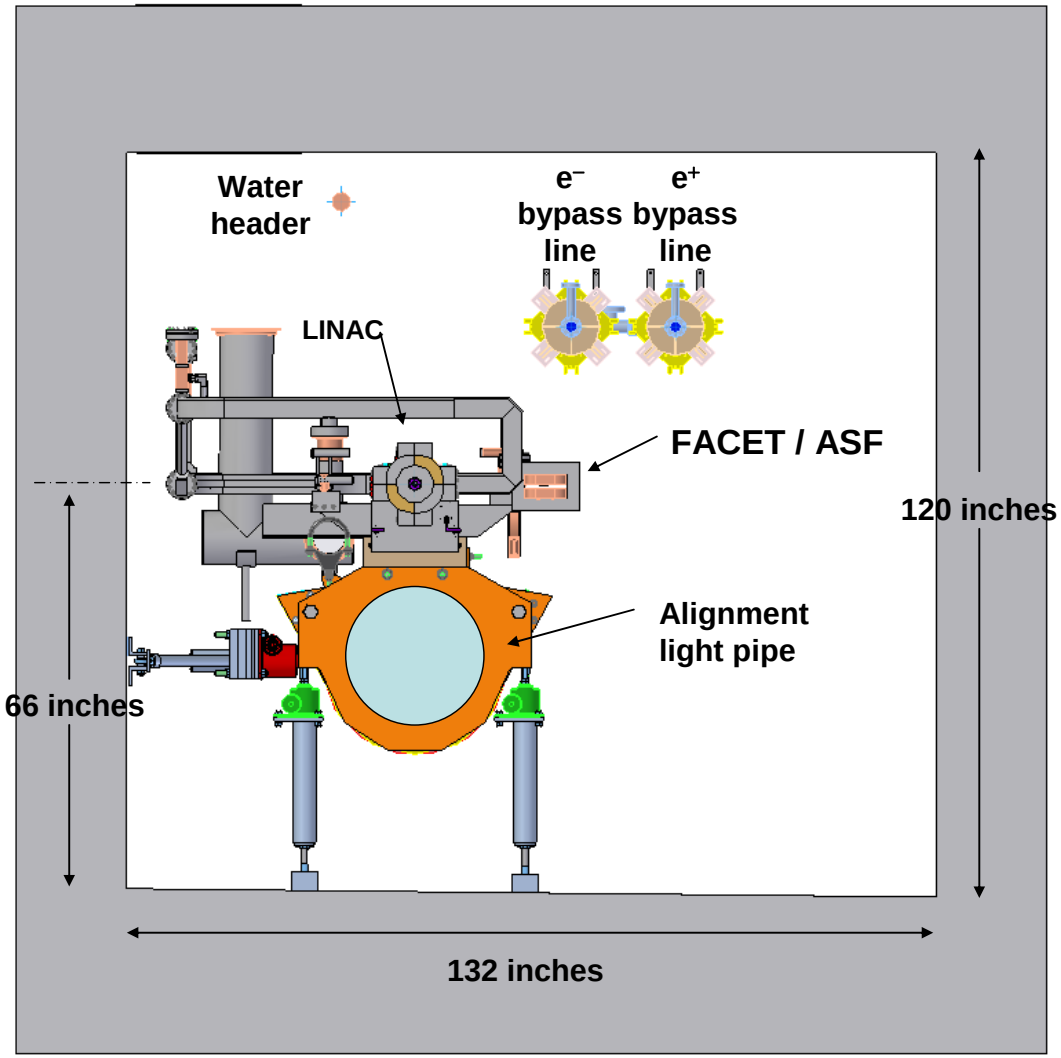
- Tunnel ceiling is 25 feet below ground surface.
- Radiation shielding is not a problem.

When shielding wall is installed, people can work in ASF area while LCLS is running.

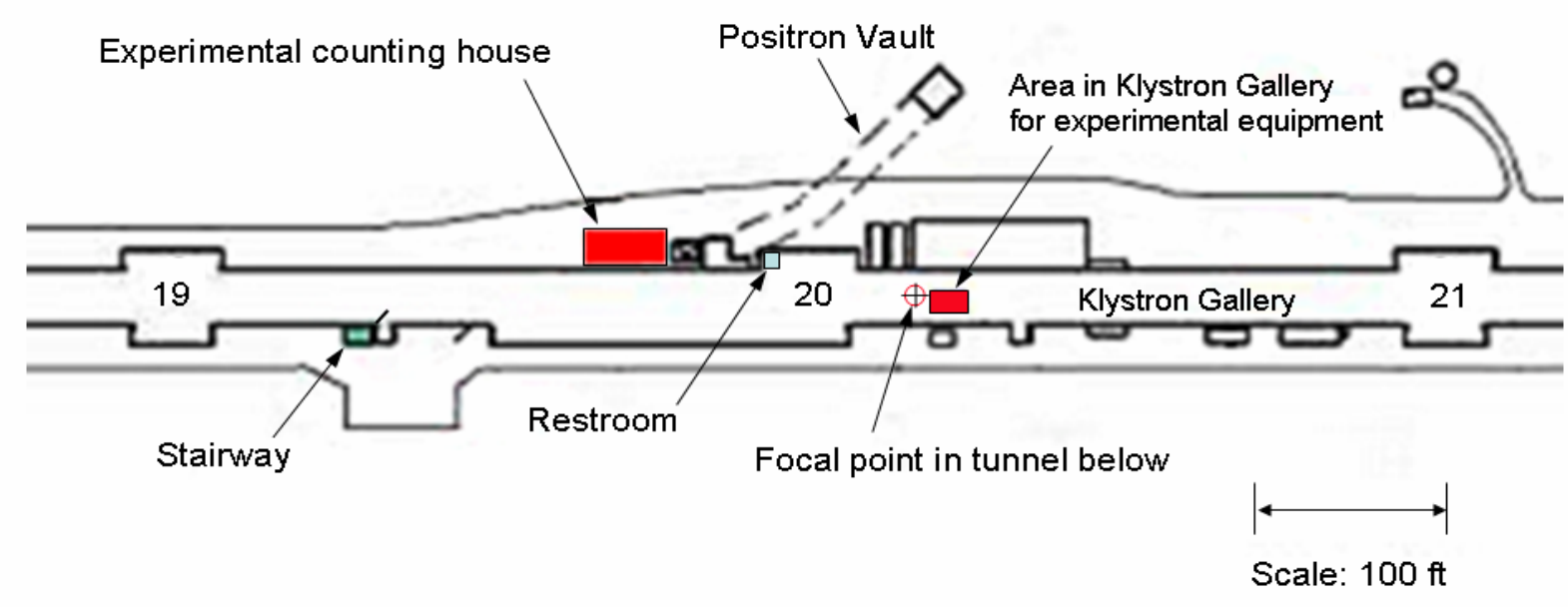
Linac Tunnel



Tunnel Cross Section Upstream of ASF

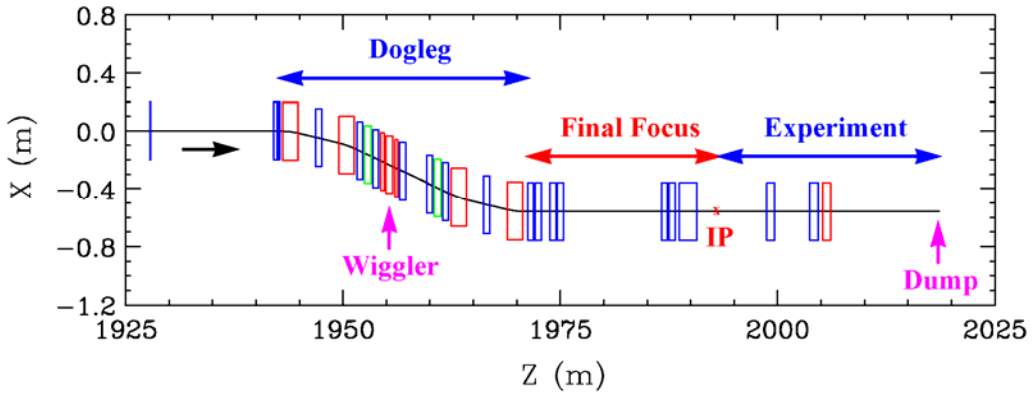


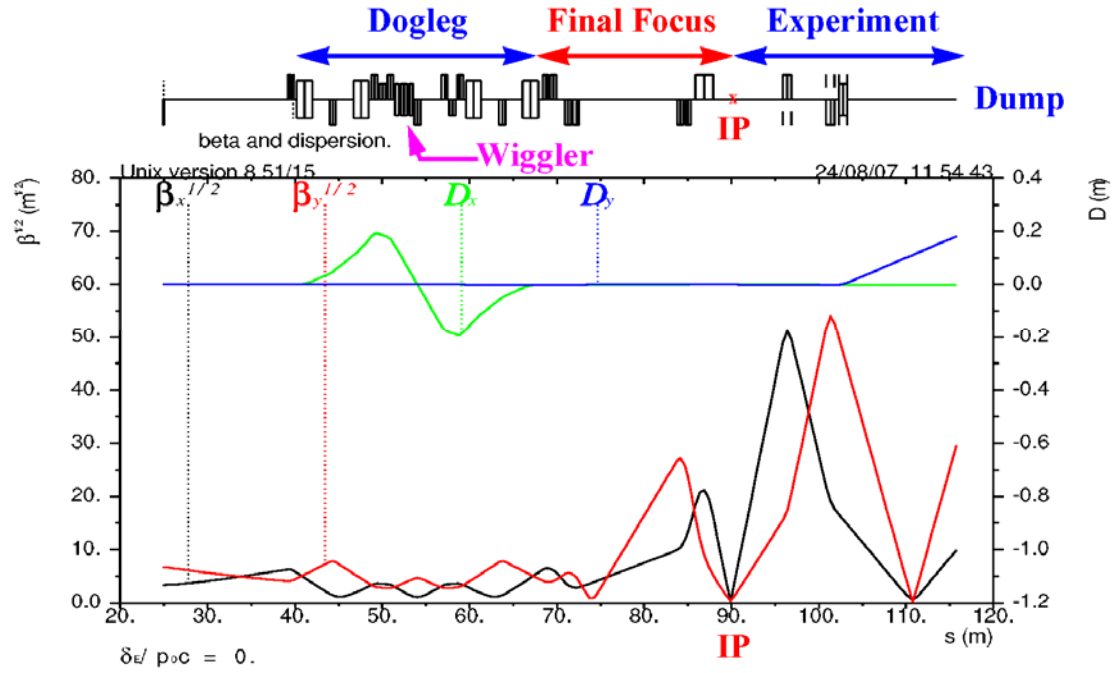
Klystron Gallery at Sector 20



- Ample space for counting house, trailers, storage containers, etc.
- Space between klystrons 20-6 and 20-7 for a room to house special equipment above focal point (suitable for optical path to focal point below).
- Ample parking space along both sides of Klystron Gallery.

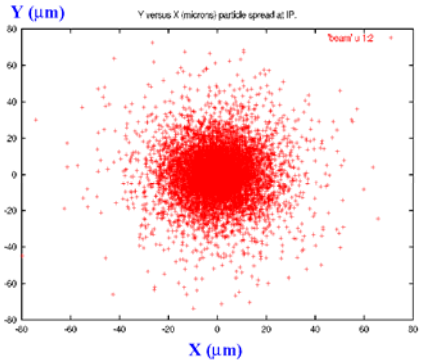
ASF Optical Layout

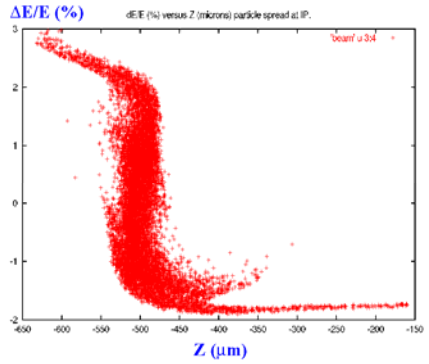


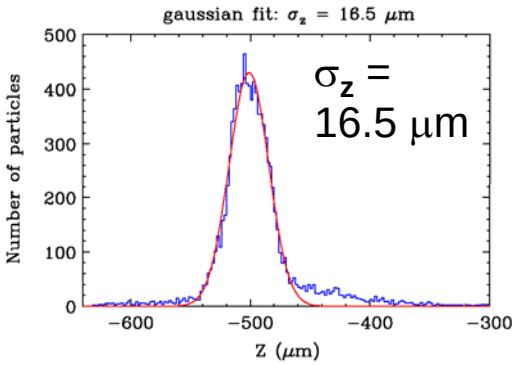


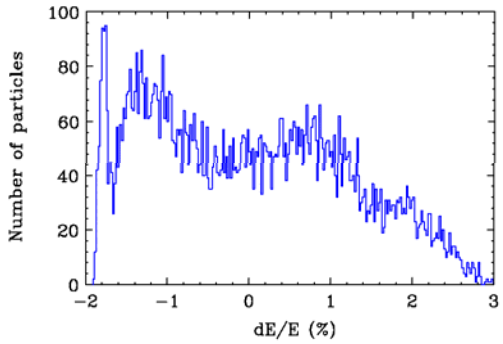
ASF Beam at Focal Point

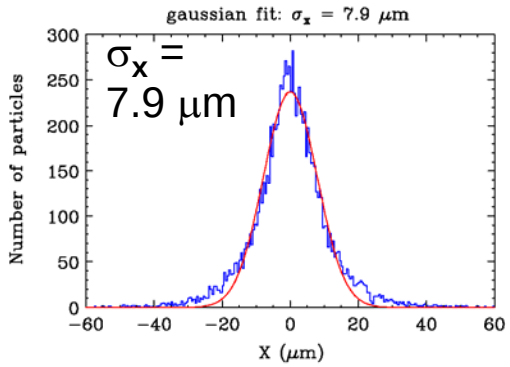
DIMAD
tracking results by
Yuri Nosochkov.

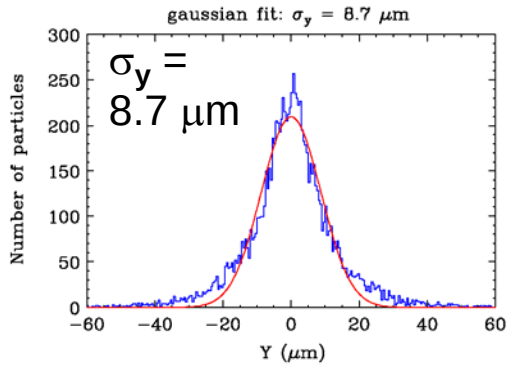




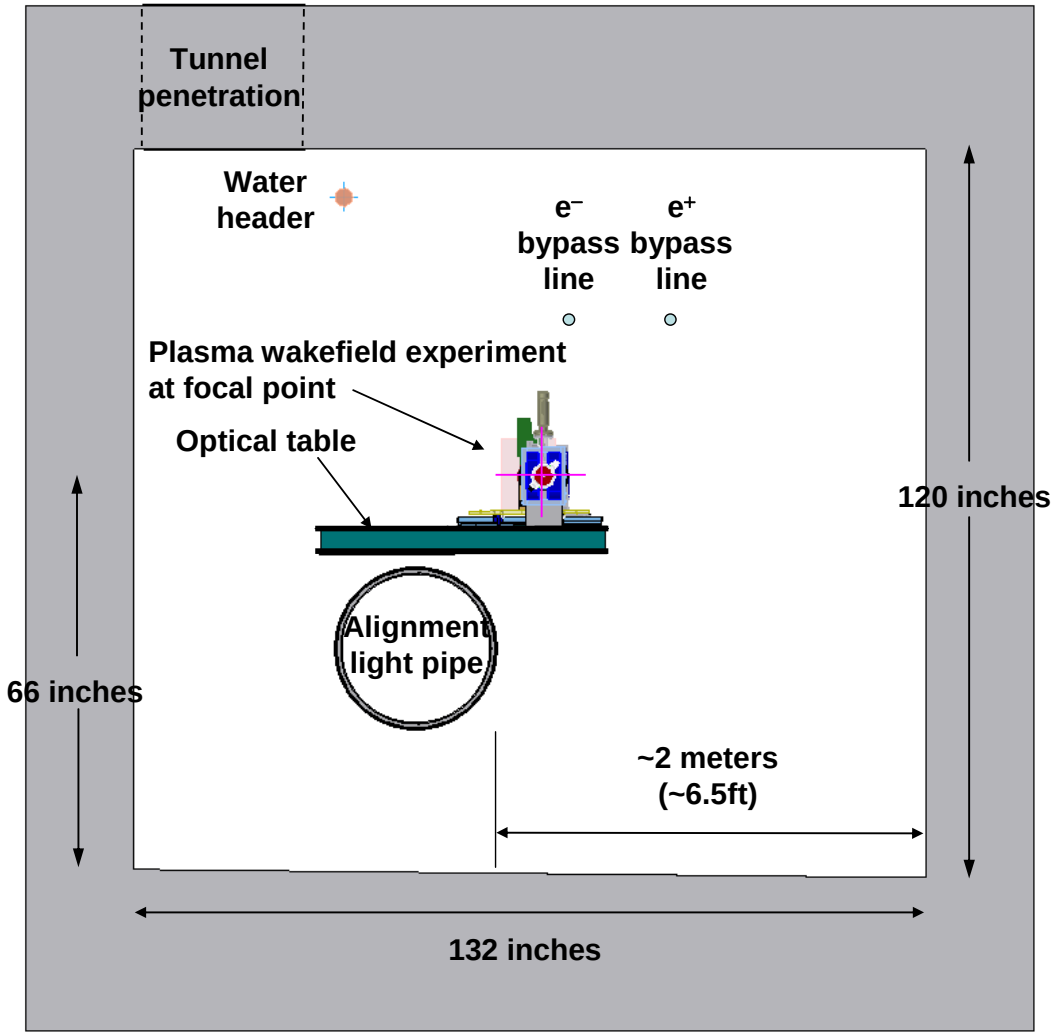






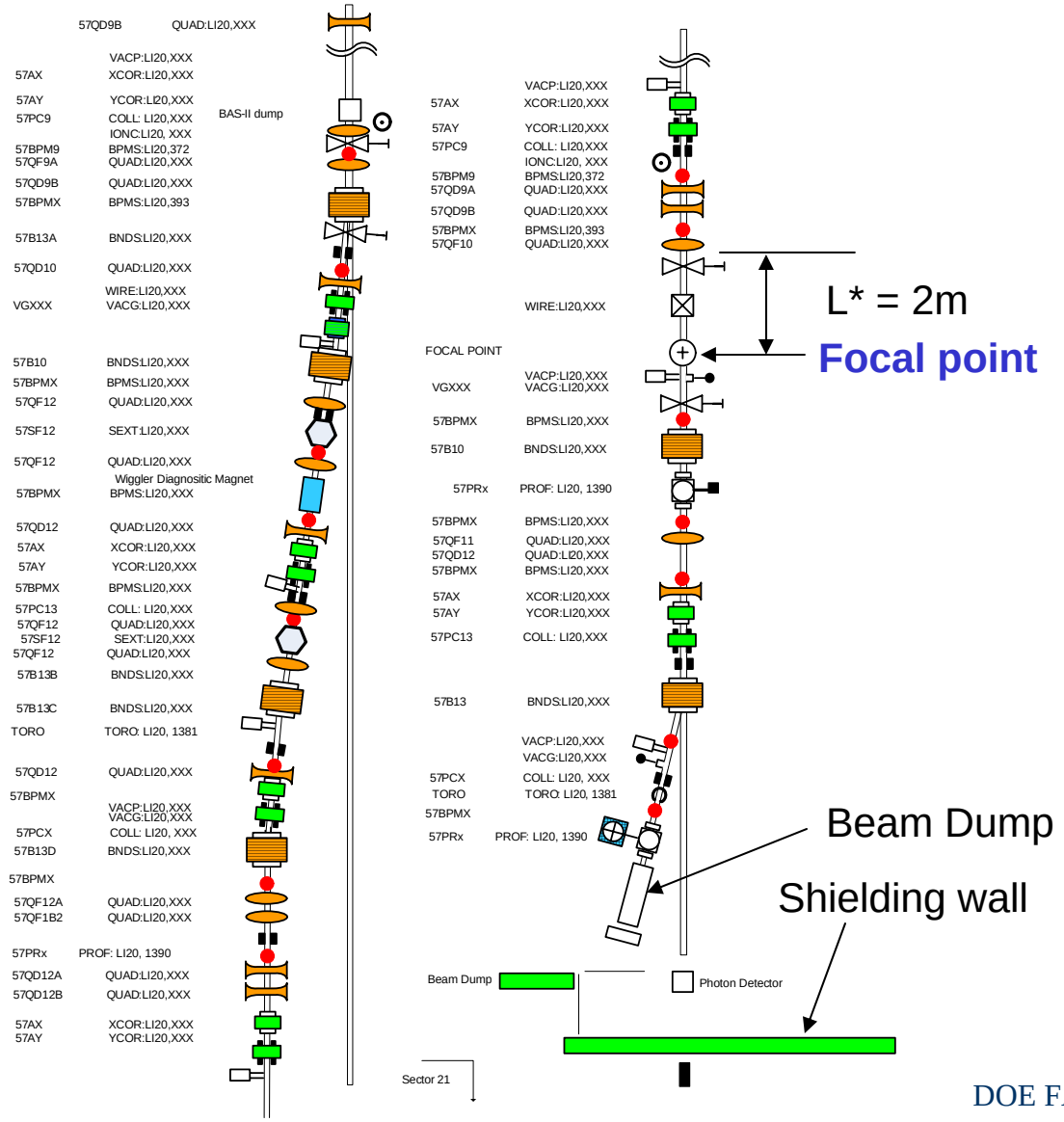


Linac Tunnel at the ASF Focal Point



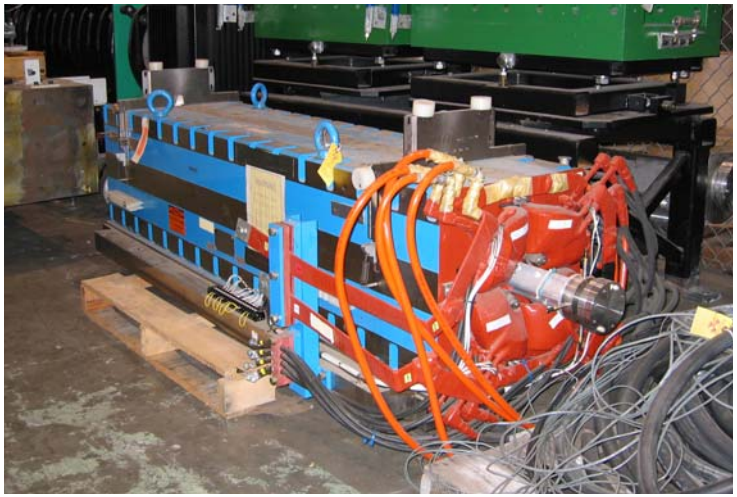
ASF Component Schematic

Most magnets and BPMs will be salvaged from the SLC Final Focus.



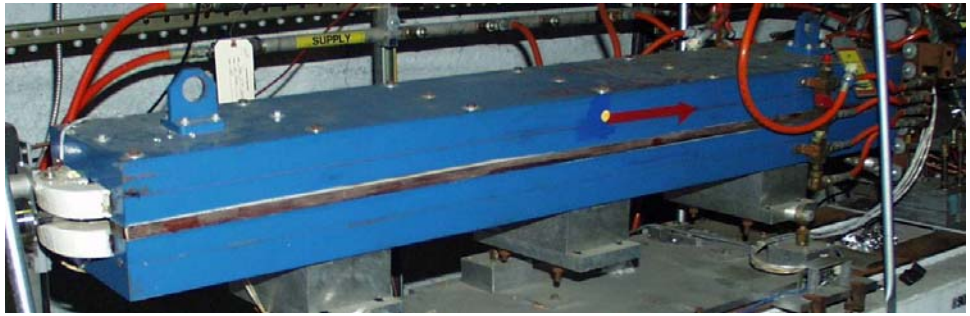
ASF Magnets

ASF quads (13) from SLC Final Focus



Final focusing quad from FFTB

Dump line quads from FFTB



The four dipoles needed for the dogleg section will be salvaged from the SLC final focus area.

Sector 19 Equipment Shaft

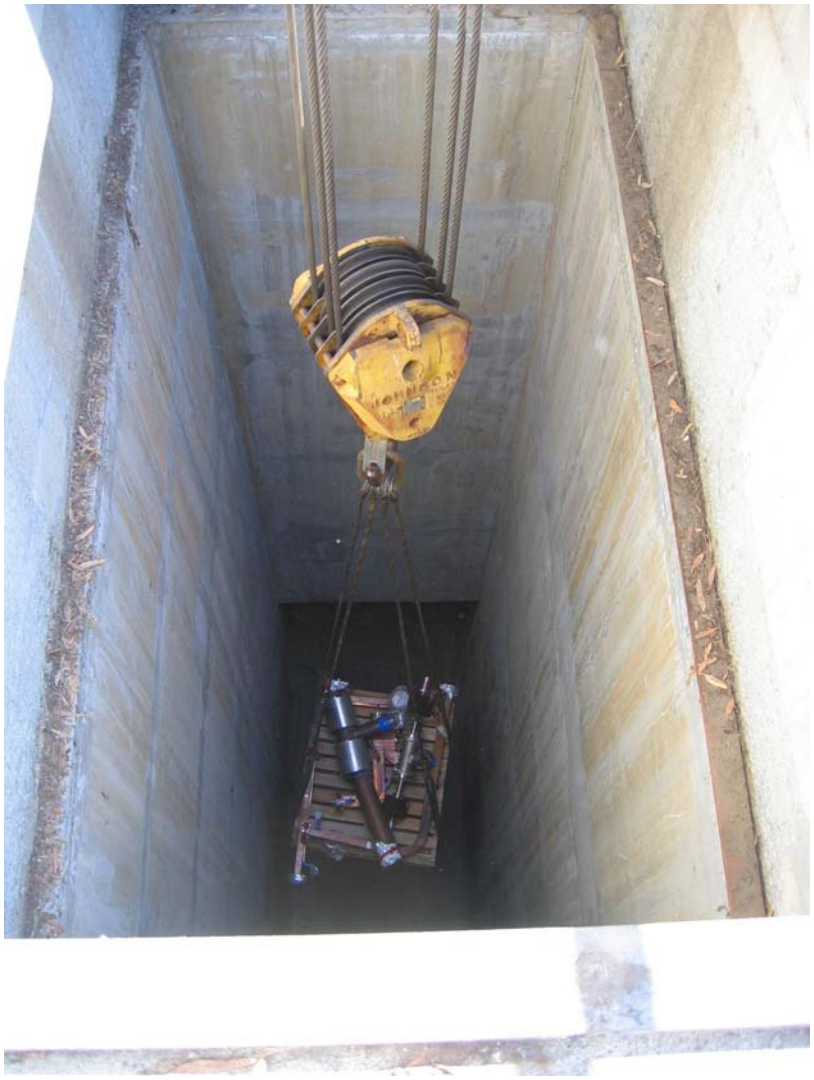
Equipment shafts exist at 5-sector intervals along the South side of the Klystron Gallery.

This shaft at Sector 19 will be converted to a personnel entrance with a stairway.

The next equipment shaft is in Sector 14.

Linac Tunnel 25’ Below

A portable crane is routinely used to move large objects into and out of the linac tunnel.



Sector 24 Stairway

A staircase was installed in the equipment shaft at Sector 24.
Entrance is equipped with PPS access control.

An identical arrangement is planned at Sector 19 to support ASF activities.

Positron Compressor Chicane

- Sector 10 compressor chicane has been used successfully for several years, but cannot be used with positrons (because electrons are required to make the positrons, and only one charge can pass through the present chicane).
- Chicane will be modified to be symmetric for electrons and positrons.
- Two new dipoles with wider poles needed for first and fourth positions.

Compressor Chicane Components

Existing components with control system nomenclature

XCOR LI10 802

YCOR LI10 803

QUAD LI10 801

BPM LI10 811

VACV – Slow valve LI11

TORO LI10 3415
COLL LI10 3419

Bend LI11 3420 + BTRM LI11 3421

QUAD LI11 3430
PIC LI10 3439

Bend LI111 3440 + BTRM LI11 3441

BPM LI10 3448

PROF LI10 3449

PIC LI10 3459

Bend LI11 3460

QUAD LI11 3470
PIC LI10 3479
Bend LI11 3480 + BTRM LI11 3481
BTM LI10 3490
PIC LI10 3491
PIC LI10 3492

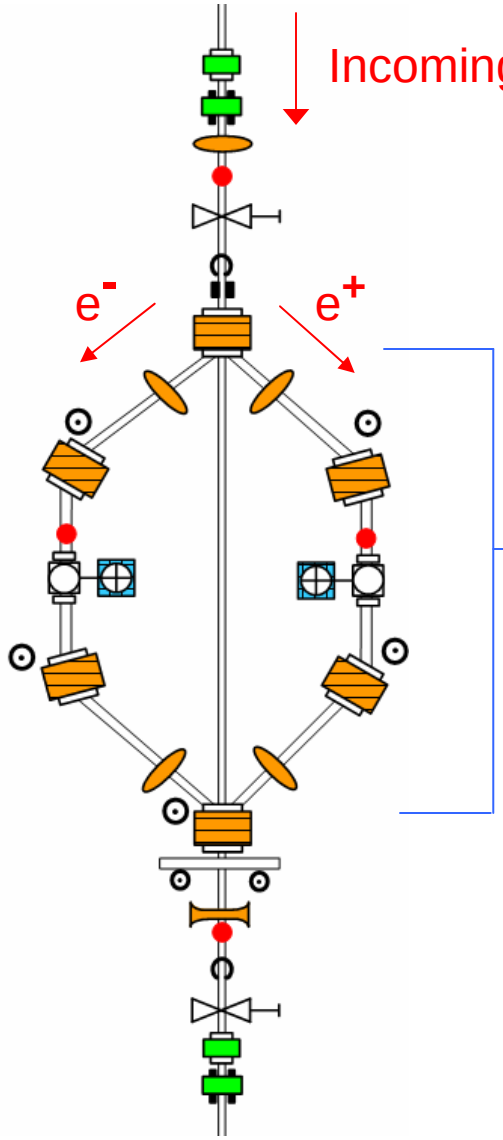
QUAD LI10 901
BPM LI10 911

TORO LI11 3495

VACV – Fast valve LI11

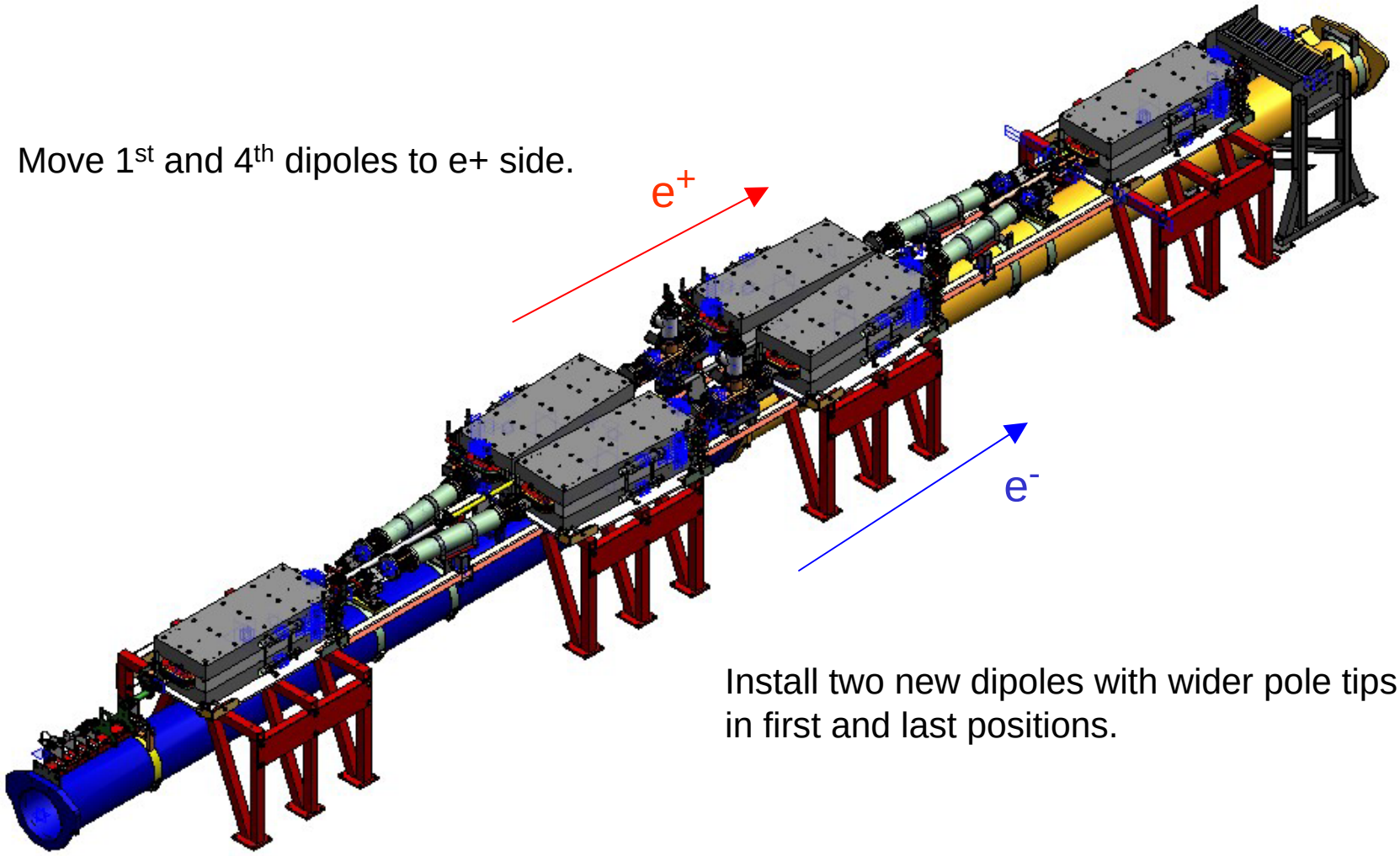
XCOR LI10 900

YCOR LI10 900



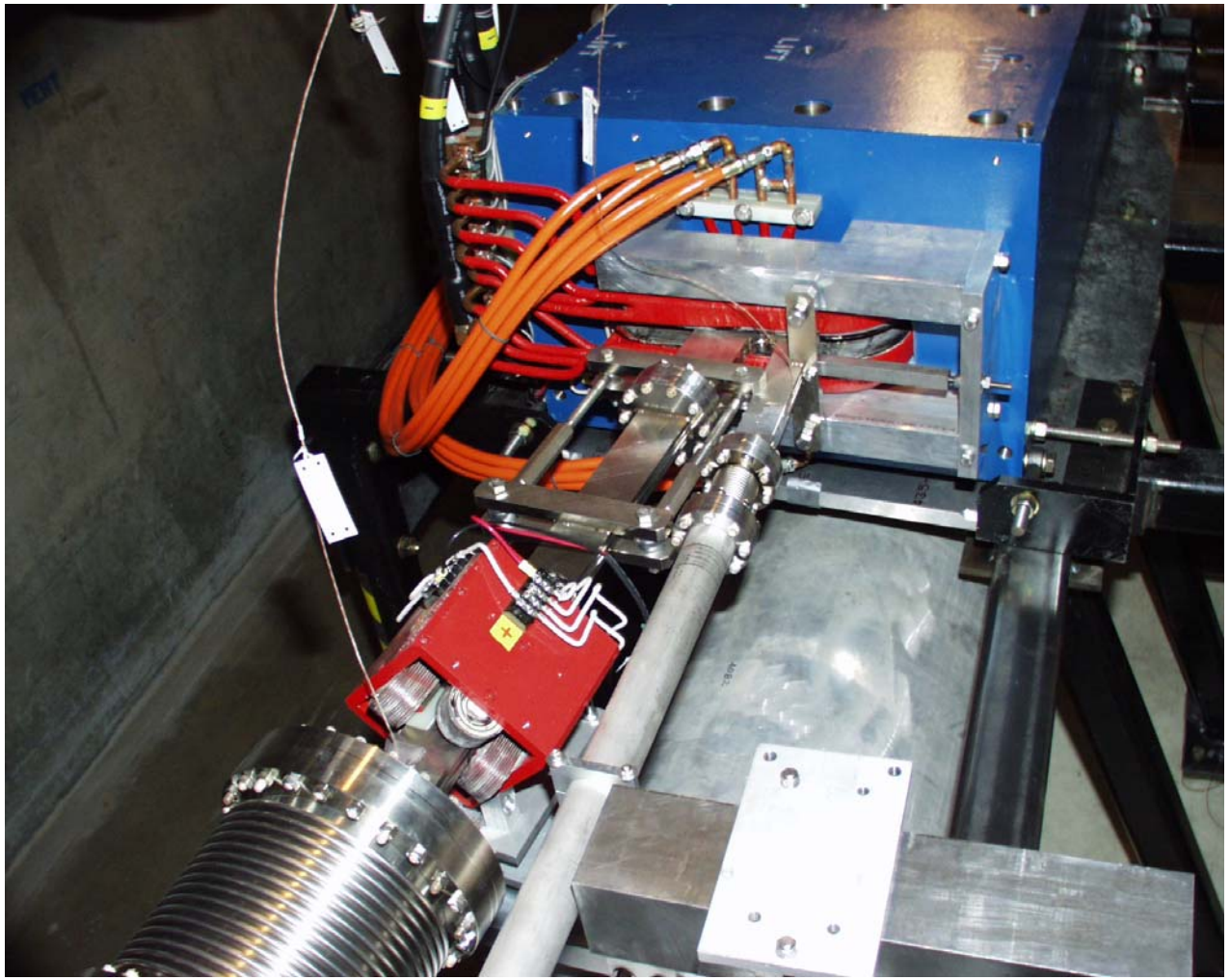
Proposed Symmetric Chicane

Move 1st and 4th dipoles to e+ side.



Install two new dipoles with wider pole tips in first and last positions.

First Dipole of Compressor Chicane



Chicane path

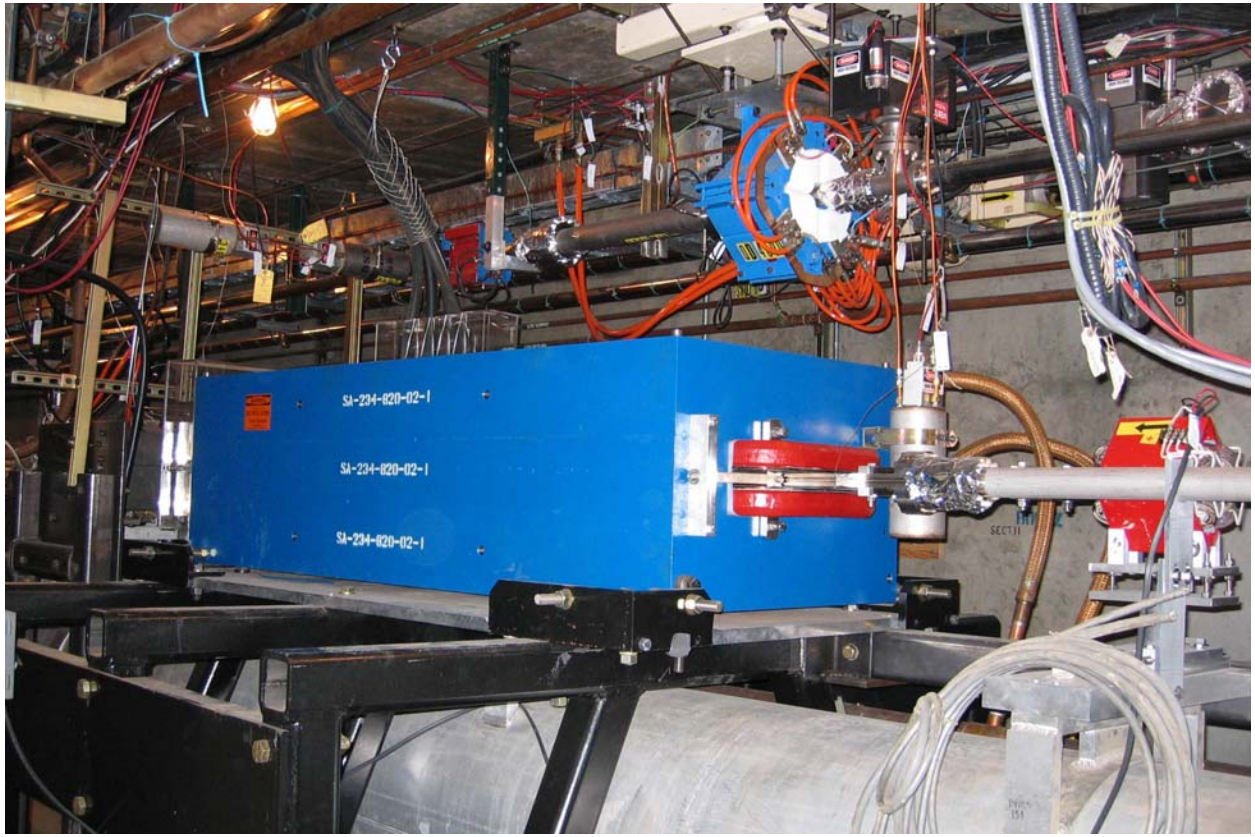
Undeflected linac trajectory

Two New Large Dipoles Needed

Eff. Length = 1.8 m

Field = 1.6 T

Gap = 50 mm



e^+ Compressor Summary

- Two new dipole magnets required.
  - Wider pole tips than existing dipoles.
  - Designed to power in series with existing dipoles.
- Power supply from SPEAR-II has been identified; may be refurbished to power full 6-magnet configuration.
- Existing support stands were designed for symmetric configuration.
- New vacuum chambers required.

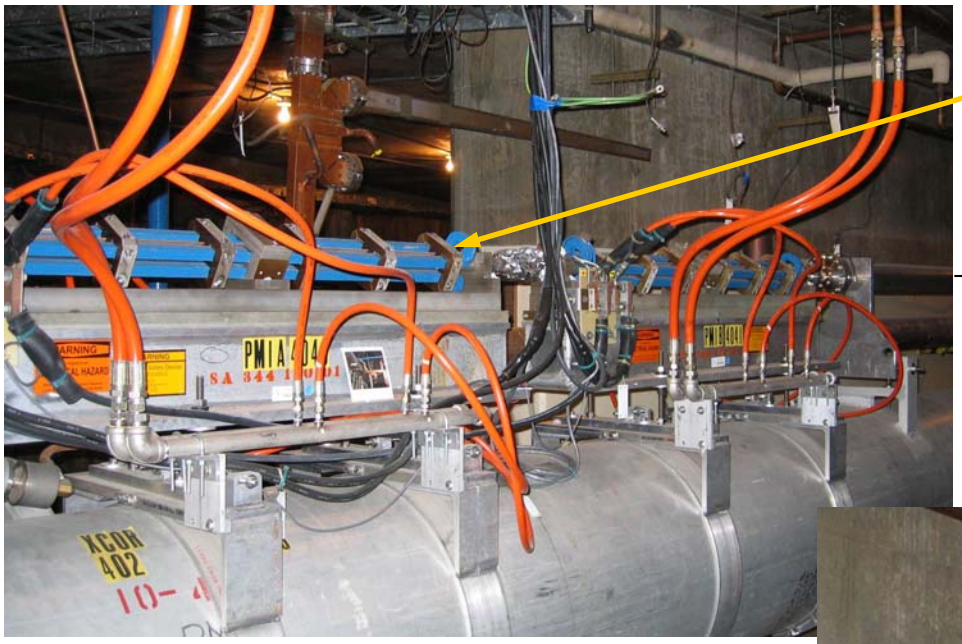
ASF Beam Parameters

Energy	**Adjustable up to 30 GeV without compression; and up to about 23 GeV with full compression and maximum peak current.**
Charge per pulse	**2 x 10^{10} (3 nC) e^- or e^+ per pulse with full compression; 3.5 x 10^{10} e^- or e^+ per pulse without full compression.**
Pulse length at IP (σ_z)	**15.5 μm with 4 % fw momentum spread; 30 μm with 1.5 % fw momentum spread.**
Spot size at IP ($\sigma_{x,y}$)	**10 μm nominal (7.9 x 8.7 μm achieved in computer simulations).**
Momentum spread	**4 % full width with full compression (3% FWHM); < 0.5 % full width without compression.**
Momentum dispersion at IP (η and η')	**0**
Drift space available for experimental apparatus	**2 m from last quadrupole to focal point; approximately 23 m from the focal point to the beam dump.**

Electron Bypass Line

- The PEP-II NIT Bypass Line from Sector 10 will be configured to deliver 12 GeV electrons to the A-Line in the BSY without passing through the last third of linac.
- ESA beams will then be independent of LCLS operations.
- No changes are needed from Sector 10 to Sector 28.
- Existing NIT magnets will be relocated to extend the transport line further into the BSY and redirect it to match the A-Line.

Extraction Point for e^- Beam to PEP-II



Pulsed magnets extract e^- beam from linac in Sector 10.

→ Linac

Beam →

Special rolled bend magnet deflects e^- beam further from linac.

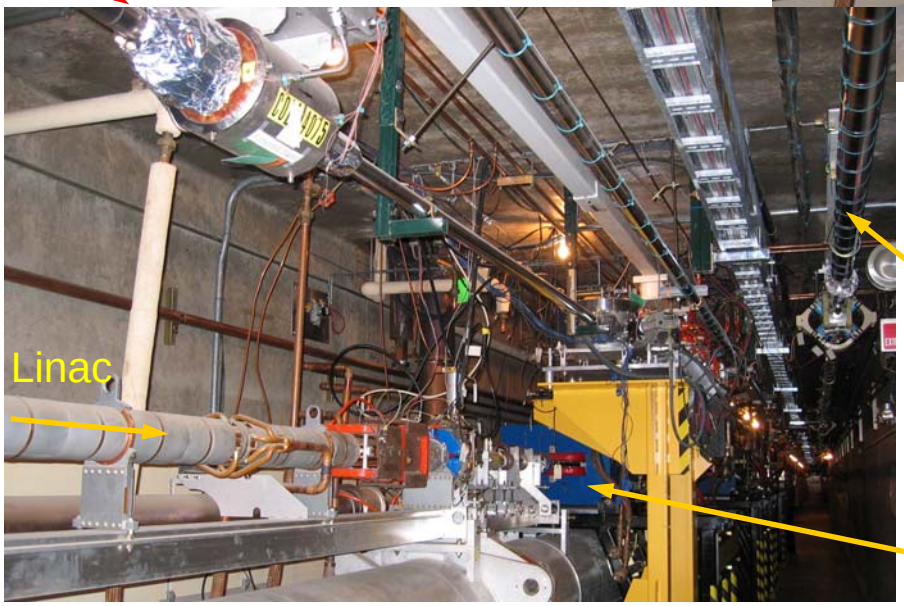
Transport Line Diverges from Linac

e^- Beam to PEP-II

PEP-II injection line can transport 12 GeV electrons from Sector 10 to the BSY.

Linac

e^- Beam to PEP-II



Protection Collimator

Bend Magnets

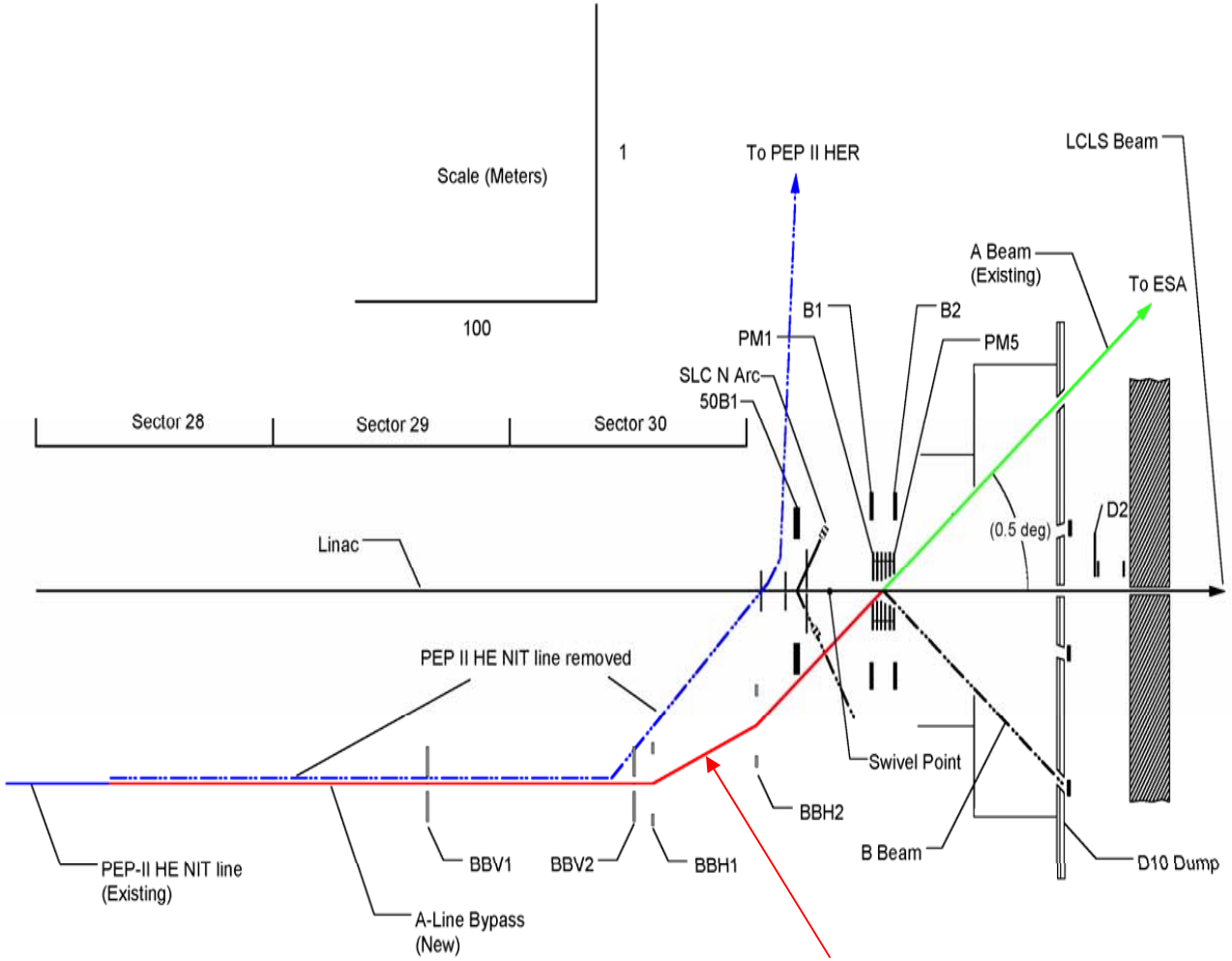
e^+ Return Line
(only upstream of Sector 19)

First Dipole of Compressor Chicane

PEP-II Transport Lines

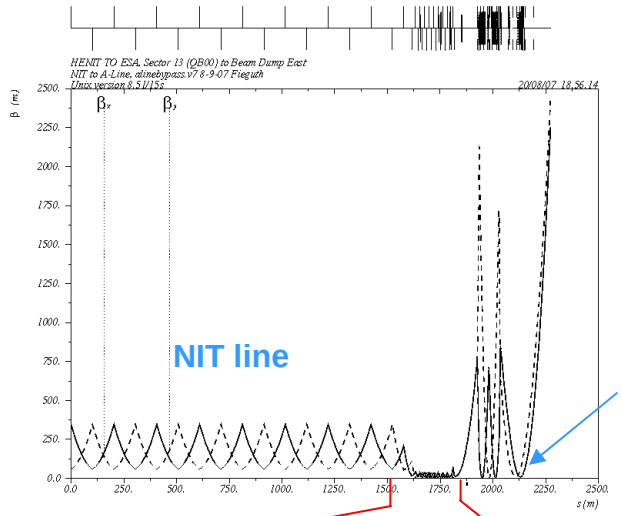
View looking upstream in linac tunnel.

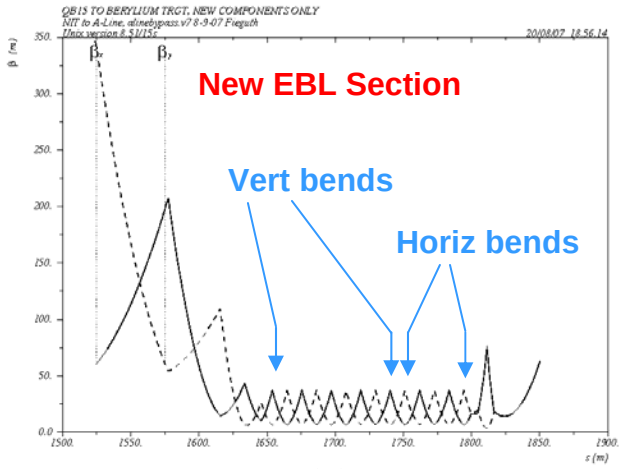
Transition from NIT to A-Line



EBL Optical Functions

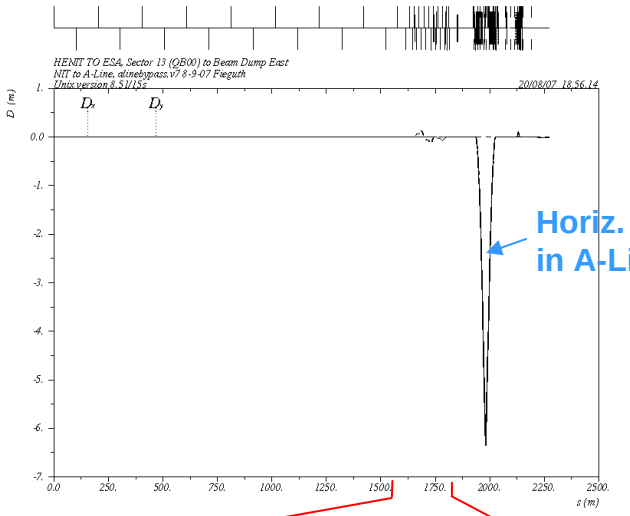
Beta functions

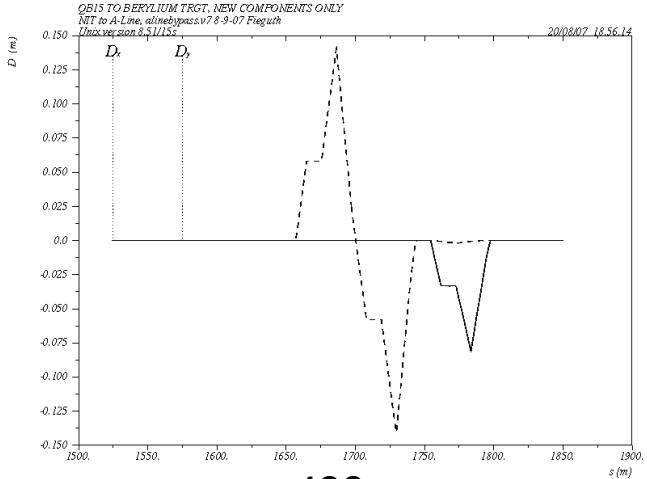




400 m

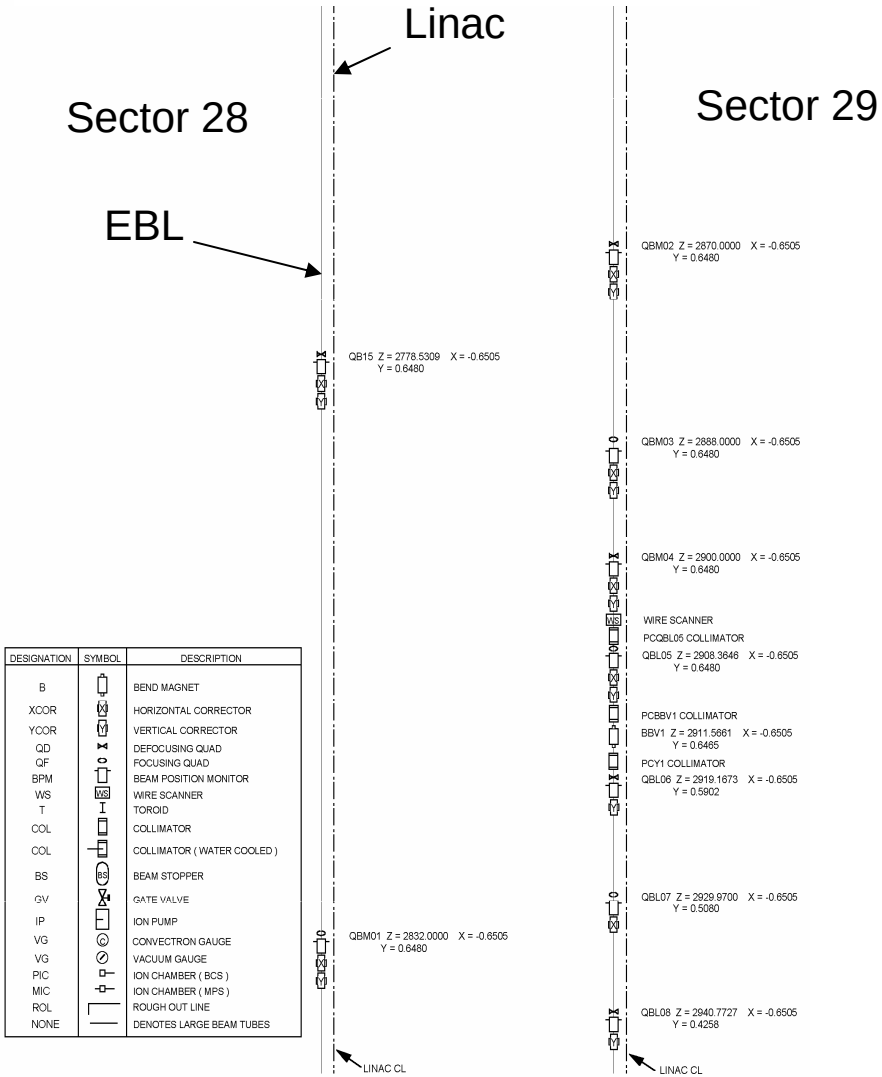
Dispersion





400 m

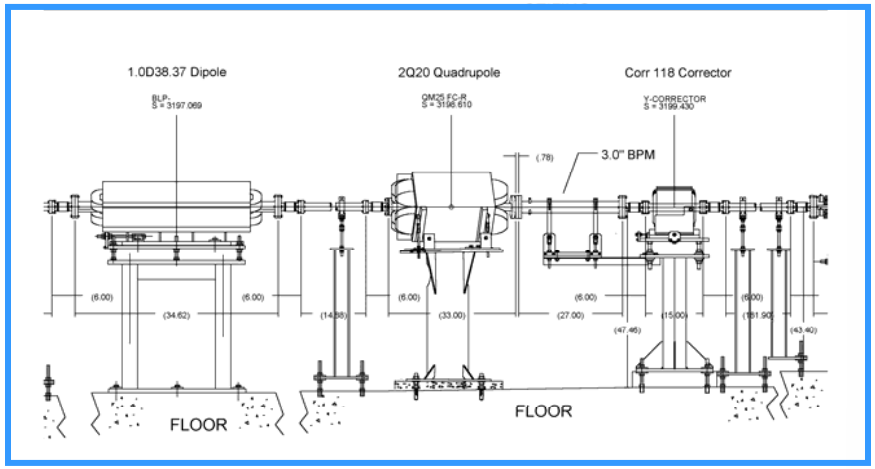
EBL Mechanical Layout
Sectors 28 and 29



DESIGNATION	SYMBOL	DESCRIPTION
B		BEND MAGNET
XCOR	X	HORIZONTAL CORRECTOR
YCOR	Y	VERTICAL CORRECTOR
QD		DEFOCUSING QUAD
QF		FOCUSING QUAD
BPM		BEAM POSITION MONITOR
WS	WS	WIRE SCANNER
T		TOROID
COL		COLLIMATOR
COL		COLLIMATOR (WATER COOLED)
BS	BS	BEAM STOPPER
GV		GATE VALVE
IP		ION PUMP
VG	C	CONVECTRON GAUGE
VG		VACUUM GAUGE
PIC		ION CHAMBER (BCS)
MIC		ION CHAMBER (MPS)
ROL		ROUGH CUT LINE
NONE		DENOTES LARGE BEAM TUBES

EBL Mechanical Layout
Sector 30 and BSY

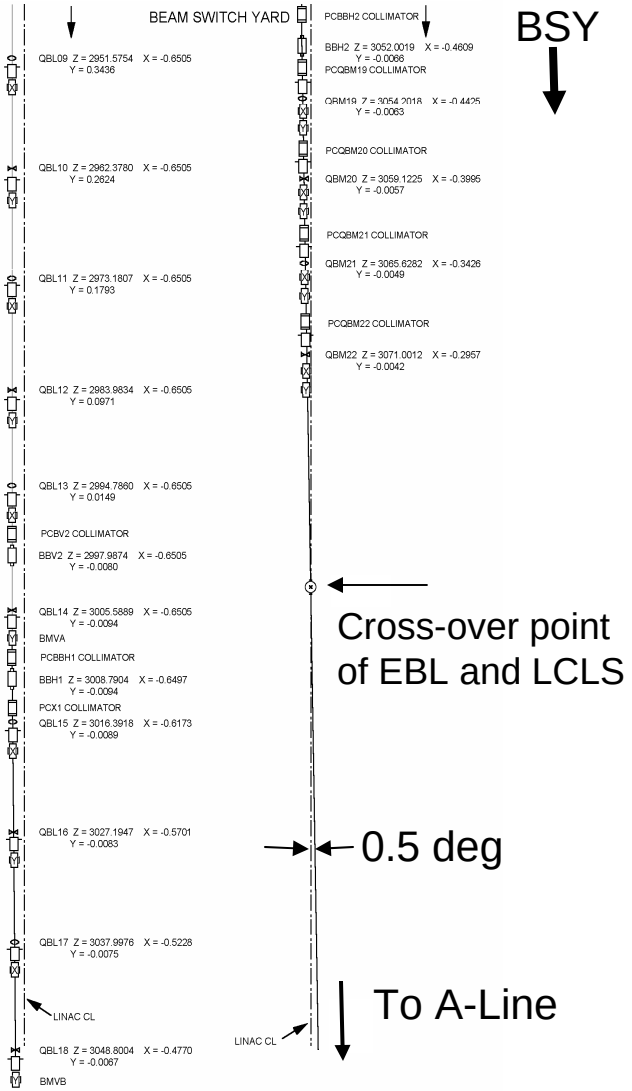
Typical beamline construction using components saved from PEP-II NIT.



NIT stands will be relocated and modified (e.g., vertical height) for use in EBL.

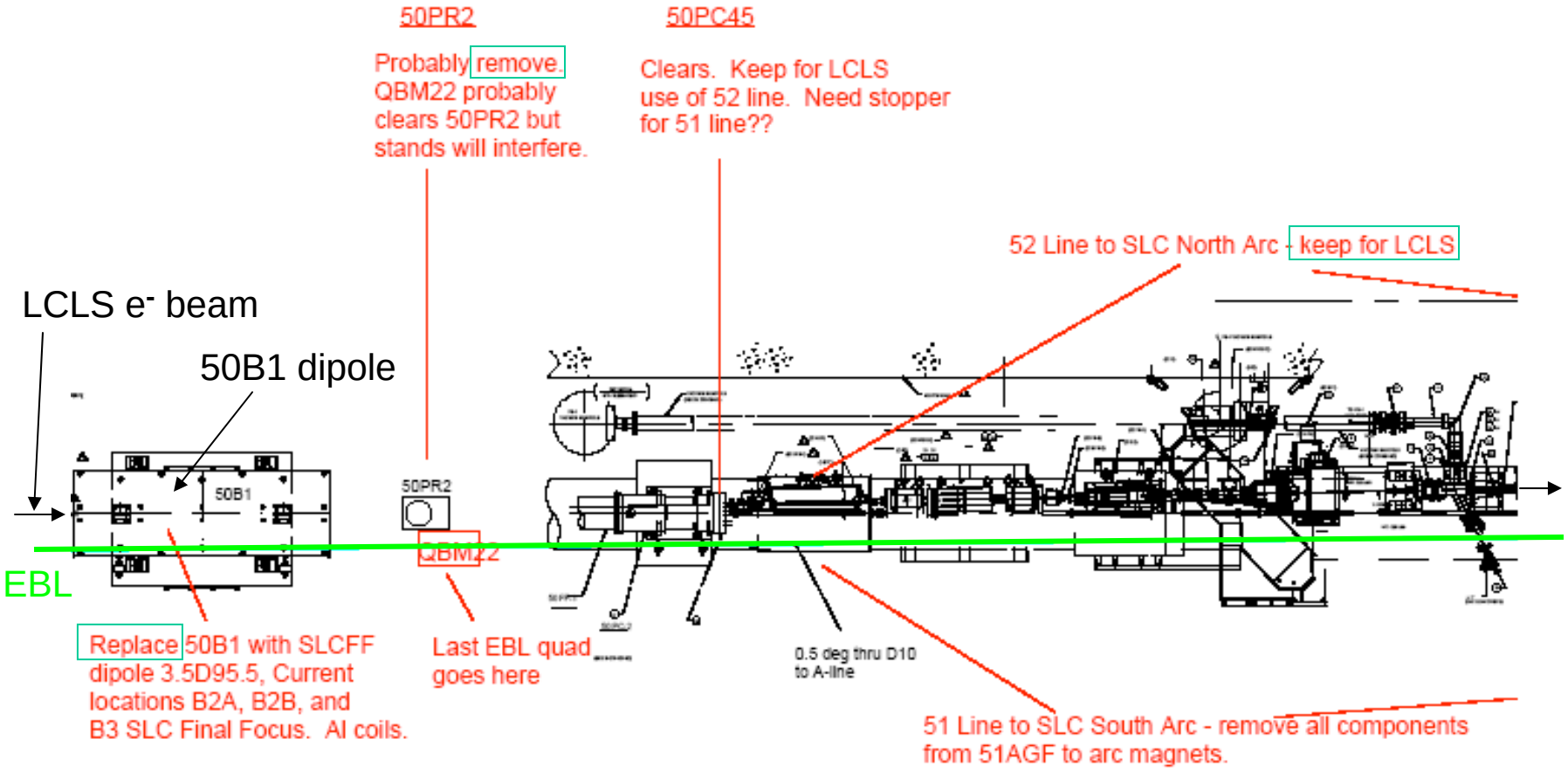
DESIGNATION	SYMBOL	DESCRIPTION
B		BEND MAGNET
XCOR		HORIZONTAL CORRECTOR
YCOR		VERTICAL CORRECTOR
QD		DEFOCUSING QUAD
QF		FOCUSING QUAD
BPM		BEAM POSITION MONITOR
WS	WS	WIRE SCANNER
T		TOROID
COL		COLLIMATOR
COL		COLLIMATOR (WATER COOLED)
BS	BS	BEAM STOPPER
GV		GATE VALVE
IP		ION PUMP
VG		CONVECTRON GAUGE
VG		VACUUM GAUGE
PIC		ION CHAMBER (BCS)
MIC		ION CHAMBER (MPS)
ROL		ROUGH OUT LINE
NONE		DENOTES LARGE BEAM TUBES

Sector 30



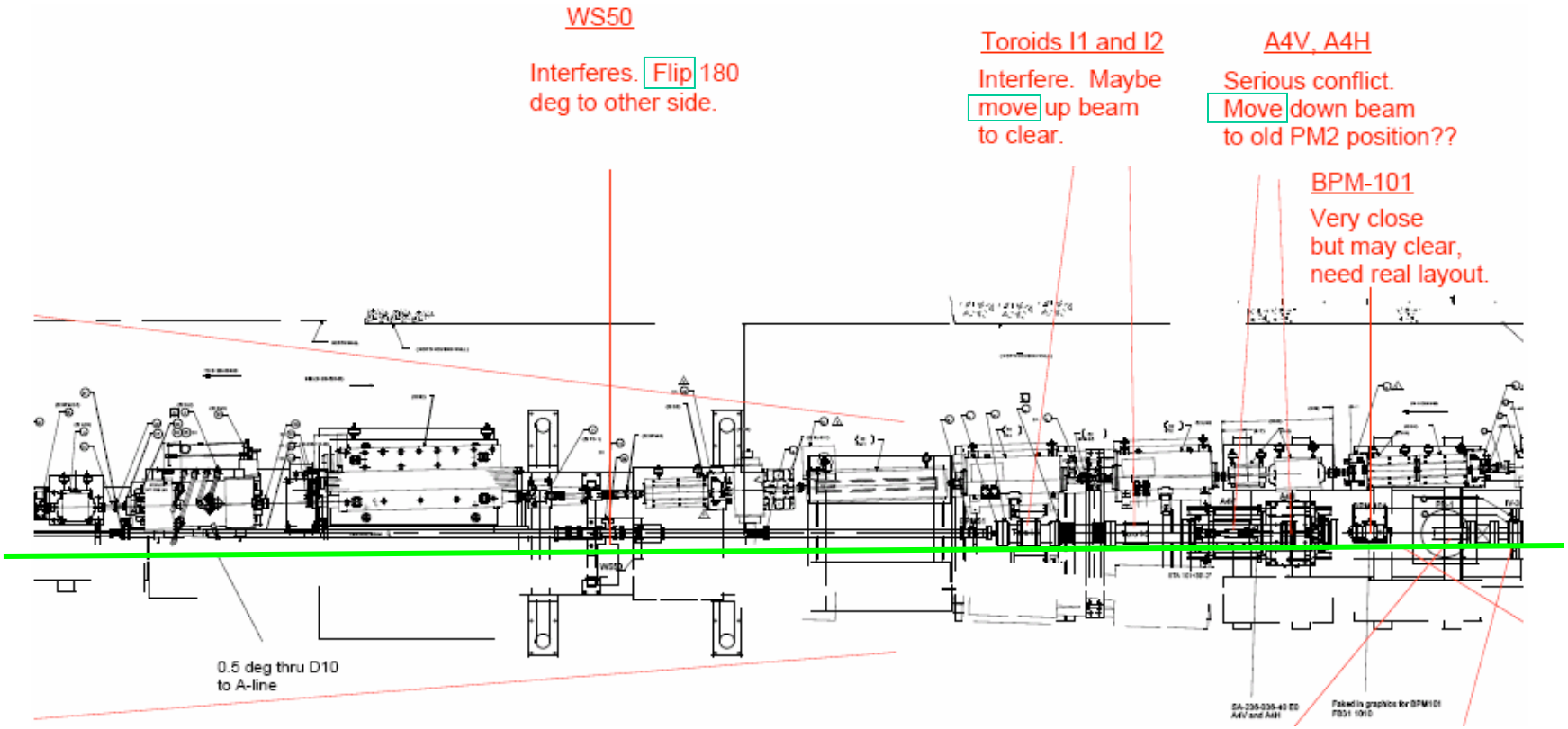
EBL Trajectory Near Common Line

EBL beam near SLC split.

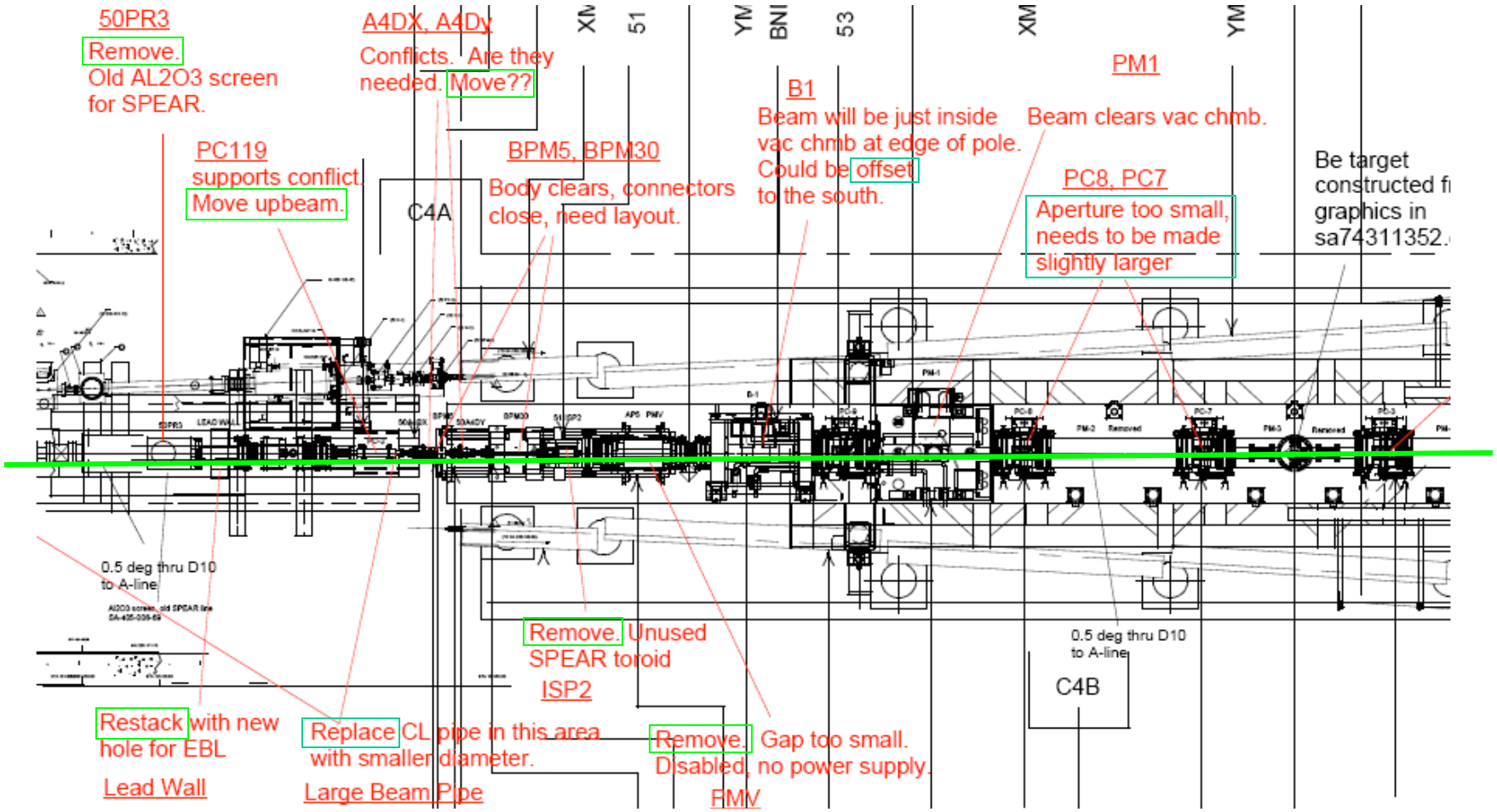


EBL Trajectory Approaching Common Line

Several mechanical conflicts can be solved by moving devices.



EBL Passes through Common Line

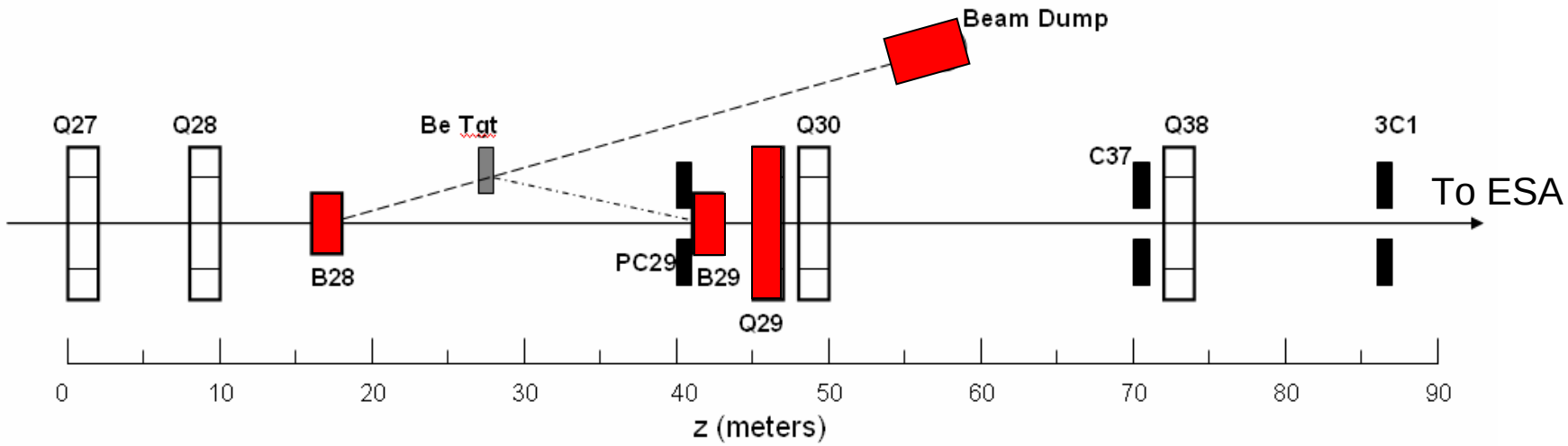


ESA Beam Parameters with EBL

Energy	**Adjustable up to 12 GeV nominal; 24 GeV achievable as a future upgrade by moving the extraction point to Sector 18.**
Charge per pulse	**0.1 to 3.5 x 10^{10} (3 nC) e^- in the single-bucket mode; up to 3 x 10^{11} e^- in the undamped long-pulse mode.**
Pulse length at IP (σ_z)	**1 mm nominal with 1 % fw momentum spread; pulse trains up to 360 ns without damping ring.**
Spot size at IP ($\sigma_{x,y}$)	**< 1 mm nominal**
Momentum spread	**<1% full width**
Momentum dispersion at IP (η and η')	**0**
Drift space available for experimental apparatus	**60 m**

Hadron Production Facility

- Two dipoles and one quadrupole will be installed in the existing A-Line.
- Production target, collimators, and beam dump will be relocated from other areas.
- Vacuum components, instrumentation, and radiation shielding (not shown) will also be required.



Magnets for Hadron Facility

The dipoles were salvaged from the original 15-line to SPEAR.

The quadrupole was used in an earlier configuration of the A-Line.

A support stand made for this type quadrupole has been saved and will be refurbished.

A water-cooled W-Cu dump unit has also been saved, along with support stands.

Summary

- FFTB experience proved that low-emittance beams of electrons or positrons can be accelerated, focused to small spots, and compressed longitudinally to < 100 fsec.
- A final focus system can be built in the linac tunnel.
  Electrons or positrons can be delivered to users, independently of LCLS operations.
- The electron bunch compressor chicane in the linac can be modified to compress positron bunches, opening up new areas of physics.
- The PEP-II NIT Line from Sector 10 can be redirected to deliver electrons to ESA, independently of LCLS.
- FACET will be constructed using equipment saved from the FFTB, the SLC Final Focus, and the PEP-II NIT injection line.

References

- **SABER White Paper (December 2005, revised August 2006)**
  http://www.slac.stanford.edu/grp/rd/epac/LOI/SABER.pdf

- **SABER Workshop (March 2006) presentations:**
  http://www-conf.slac.stanford.edu/saber/present/default.htm

- **FACET – A Proposal for a Multi-Purpose Experimental Research Facility using Electron and Positron Beams at SLAC,**
  FACET Study Group: R. Arnold, K. Bane, L. Bentson, S. DeBarger, R. Erickson, T. Fieguth, M. Hogan, J. Jaros, N. Li, D.B. MacFarlane, Y. Nosochkov, J. Seeman, T. Raubenheimer, D. Walz, and M. Woods (November 12, 2007)