SABER

A Facility for Accelerator Physics and Test Beam Experiments

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SABER Workshop

March 15, 2006

FFTB will soon be gone!

The Problem:

On April 10, 2006, the Final Focus Test Beam (FFTB) will be shut down to make room for the LCLS.

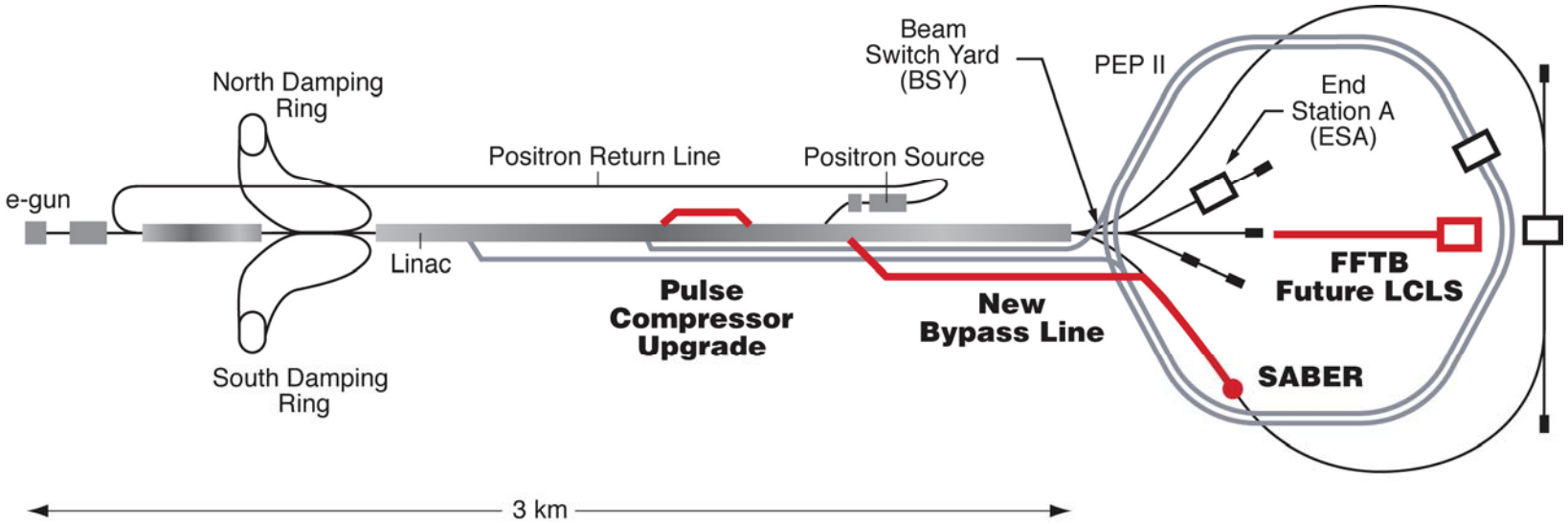
What can be done to replace its functions?

SABER: South Arc Beam Experiment Region

- A proposed facility for experiments requiring compressed, focused beams of electrons or positrons.
- To be built in the Instrument Section in the SLC South Arc tunnel.

SLAC Overview with SABER

- LCLS injector will be installed at Sector 21, downstream of existing positron source.
- LCLS transport system and undulator will displace the FFTB.



SABER consists of three main components:

- Experimental area with final focus and beam dump in SLC South Arc tunnel.
- Linac Pulse Compressor upgrade to compress positron bunches.
- Bypass Line to deliver e^- or e^+ beams to SABER, bypassing the LCLS.

Recent History of FFTB

Final Focus Test Beam (FFTB)

- Preserves small emittance.
- Delivers and compresses ultrashort (< 100 fsec) bunches.
- Strong user demand:
  - Plasma wakefield acceleration
  - SPPS
  - Laboratory Astrophysics
  - Many other unusual physics and technology measurements

Research Yard Experimental Facilities

Final Focus Test Beam Programs

The FFTB was originally built to demonstrate technology for focusing and measuring sub-micron electron beams suitable for a future linear collider.

Experiment E-166

A Proposal to Test Production of Polarized Positrons with the SLAC 50-GeV Beam in the FFTB.

An undulator-based technique applicable to a future linear collider.

Status: Data run completed. Positron polarization demonstrated.

SPPS

Ongoing program involving generation of extremely short x-ray pulses.

Status: Currently running.

E-167 Plasma Wakefield Acceleration

Ongoing program to develop new methods for achieving very high accelerating gradients, strong plasma focusing, and related technology.

Status: Next run scheduled to start March 20.

Laboratory Astrophysics

E-165 Fluorescence in Air from Showers (FLASH)

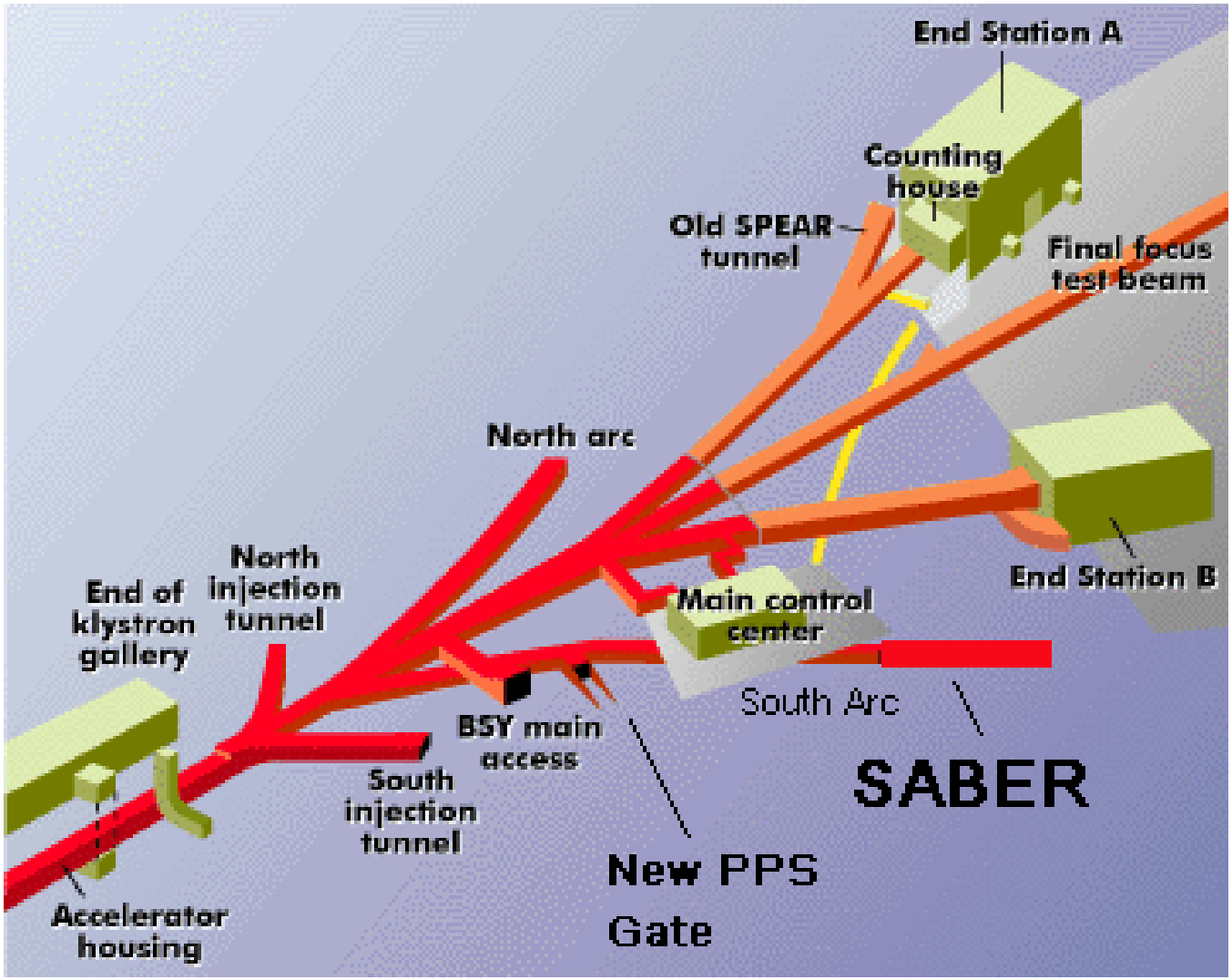
A continuing program to quantitatively understand the production of light by cosmic rays in the upper atmosphere, using controlled laboratory conditions.

Status: Next run not yet scheduled. Candidate for first SABER experiment.

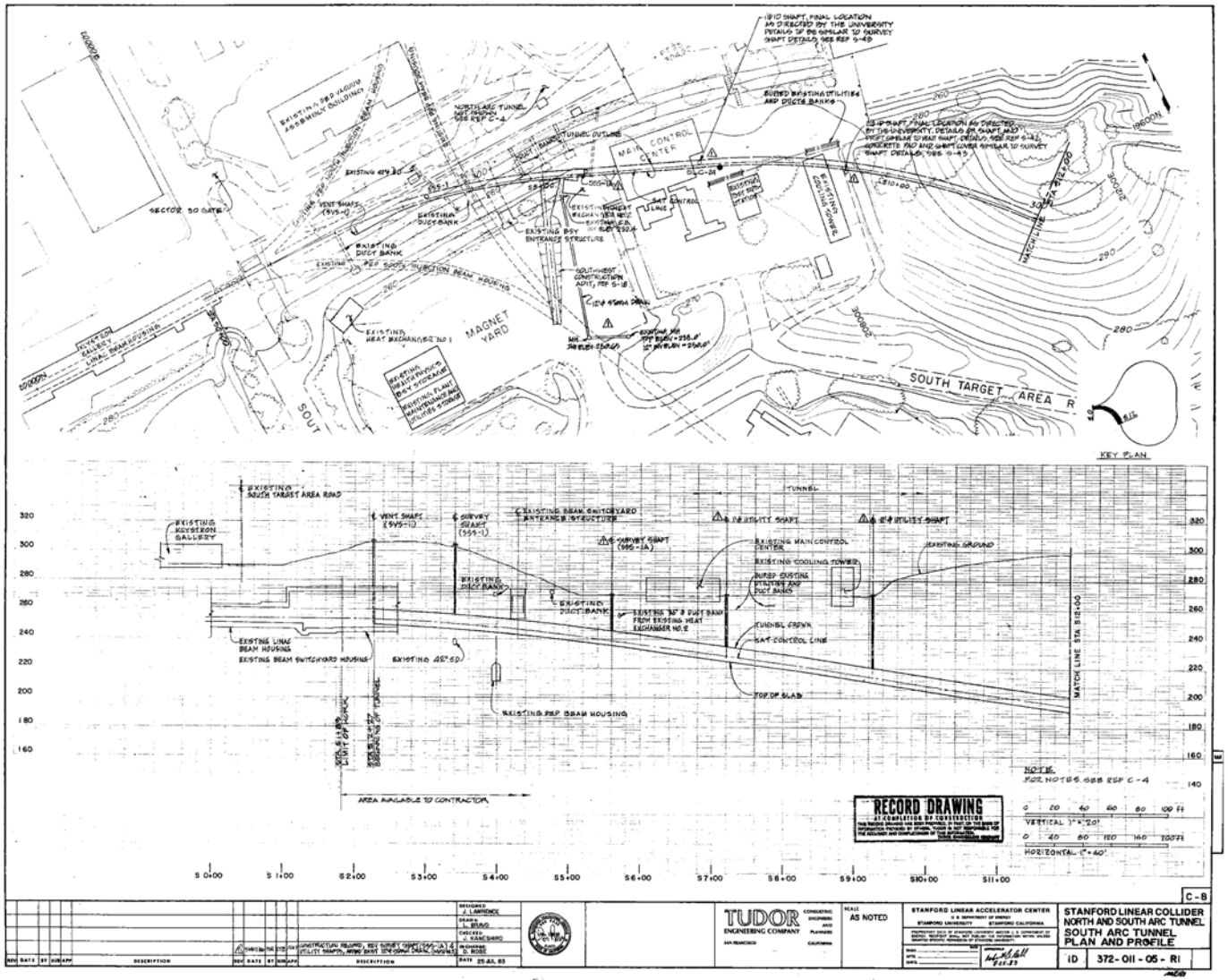
Test Beam Experiments in FFTB

T-447	Single Pulse Damage in Materials (Sept 2000)
T-448	Magnified Optical Transition Radiation Test (Oct 2000)
T-450	Damage Test in Diamond for LCLS (Oct 2000)
T-451	High Energy Neutron Spectra Measurement (March 2001)
T-452	STAR Endcap Calorimeter Detector Prototype Test (Jan 2001)
T-453	Radiation Damage in Diamond for LCLS (April 2001)
T-454	Measurement of Neutron Spectra (June 2001)
T-455	Measurement of the Calorimeter for the Local Polarimeter at Phenix/RHIC (Aug 2001)
T-456	Magnetization Dynamics in Magnetic Films (Sept 2001)
T-457	Measurement of Neutron Energy Spectra Using Bonner Multi-Sphere Spectrometer (June 2002)
T-460	Characterization of Askaryan Effect in Rock Salt (June 2002)
T-461	High Atmosphere Air Fluorescence (June 2002)
T-462	Magnetization Dynamics of Soft-Magnetic Films (June 2002)
T-464	Correlation of Linac Transverse Deflection Cavity with FFTB Streak Camera (June 2002)
T-465	Magnetization Dynamics in the Sub-picosecond Time Scale (May 2003)
T-466	UCLA Electromagnetic Calorimeter (EMC) Prototype (May 2003)
T-467	Measurement of FFTB Backgrounds for E166 (Jan 2004)
T-468	Diamond Detector Response (July 2003)
T-470	DASH: Diamond Detectors for FLASH (June 2004)
T-471	Incoherent Radio Emission from Showers (July 2004)
T-472	Neutron Energy Spectra Measurements (June 2004)
T-473	Diamond Detector Response (July 2004)
T-478	Magnetism with Ultrashort Magnetic Field Pulses (August 2005)
T-481	Ultra-high Gradient Cerenkov Wakefield Acceleration (August 2005)
T-482	XTR as an Electron Beam Diagnostic (August 2005)
T-485	Magnetism with Ultrashort Magnetic Field Pulses (January 2006)

SABER in SLC South Arc Tunnel



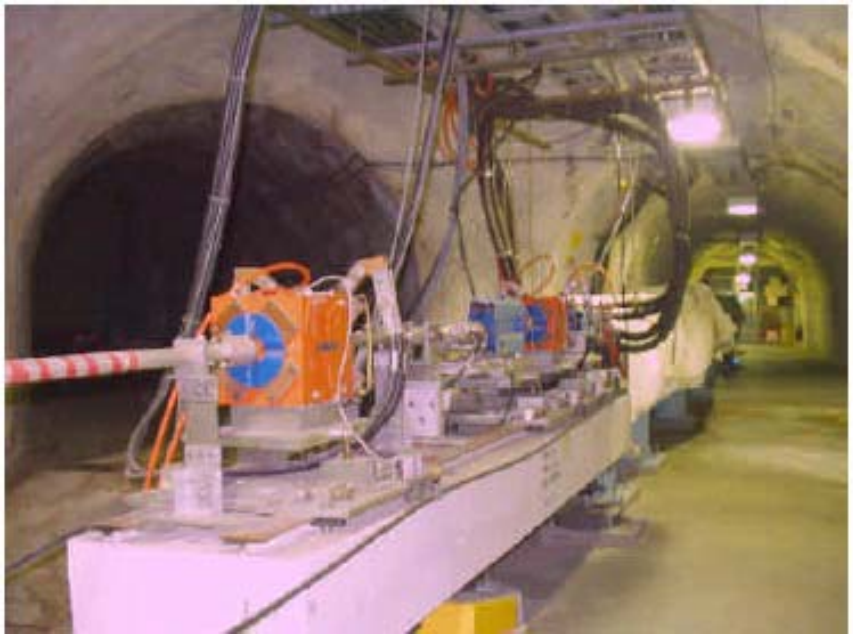
Architectural Drawing of South Arc Area



South Arc Tunnel

- People can work safely in the South Arc tunnel, independent of PEP-II or LCLS operations.
- Easy access through upgraded SW Adit entrance.
- Convenient space for user building in existing paved area beside SW Adit ramp.
- Radiation safety issues are easier than in FFTB (SABER is deep underground).

South Arc Tunnel



Upstream end of Instrument Section,
SW Adit visible to the left.

Southwest Adit tunnel,
leading to removable shielding wall.

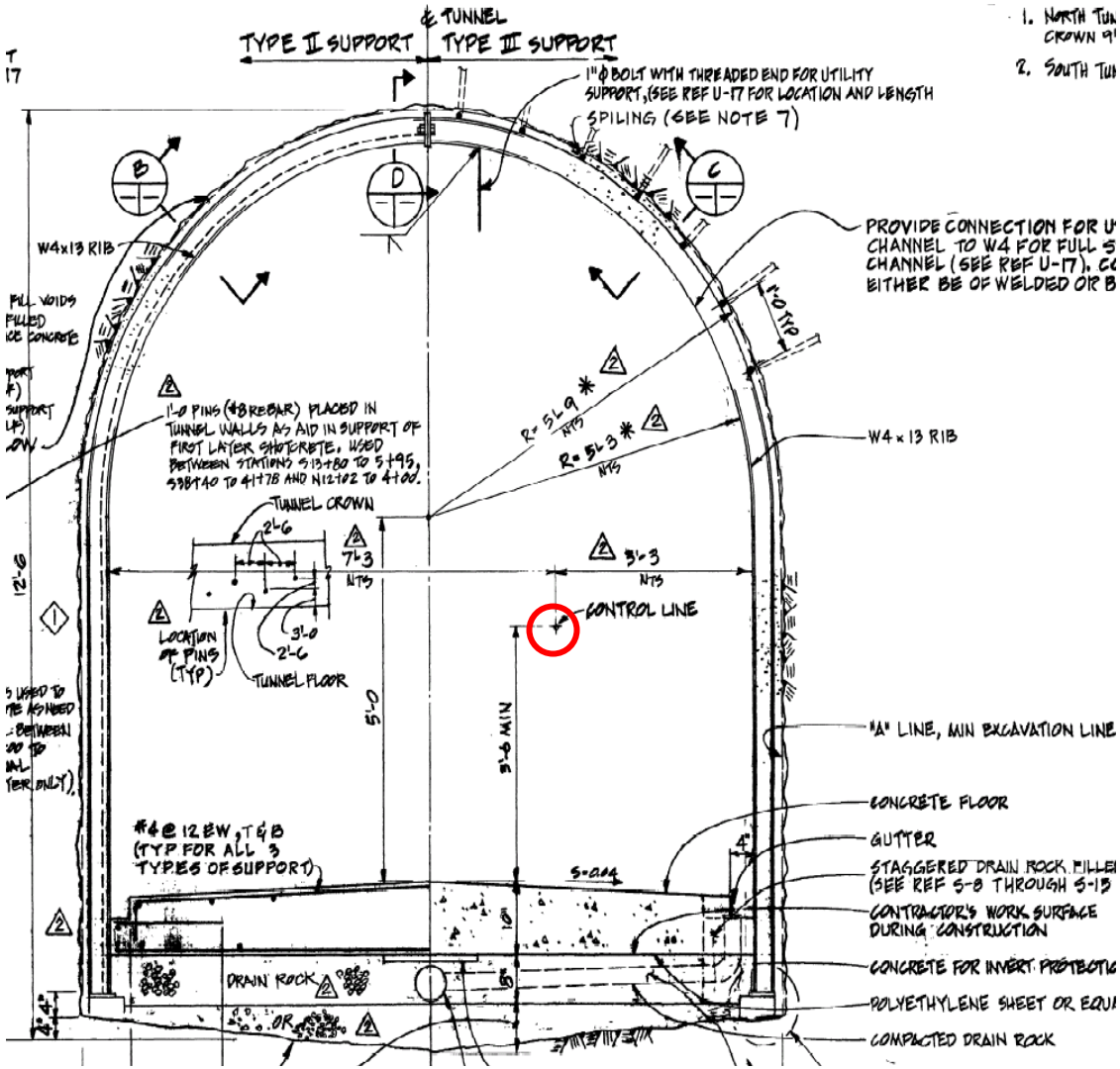
South Arc Tunnel

User experiments could be set up in this area.

Instrument Section, looking downstream. Floor slopes slightly downward.

Instrument Section, looking upstream.

South Arc Tunnel Cross Section



Current Status of South Arc

SLC ran until June 1998. South arc and Instrument Section have been well preserved.

- Plumbing and most magnets appear to be in good shape. LCW flow has been maintained, except for a few devices in the BSY. Some flexible hoses need preventive maintenance.
- Vacuum system integrity is good. System is being pumped down.
- Control system is functioning; arc magnet movers respond to control system commands.
- Evidence of radiation damage to dc cables in BSY area requires further investigation.
- PPS system has been decommissioned and requires work.
- Quadrupole magnets in the BSY zone and non-interlocked corrector magnets in the S ARC zone have been powered up.

Questions/Issues for Experimental Area

How much space is needed to accommodate experiments?

Current working design:

- **Nominal beam position:**
  - **42 inches above the tunnel floor.**
  - **39 inches from south tunnel wall.**
  - **Downward pitch 3.730 deg.**

- **Focal point is 2m downstream of face of last quadrupole.**

- **Drift following focal point is approximately 70 feet to the next arc AG magnet (where the tunnel starts to curve to the south).**

Ease of Access

- **SW Adit entrance:**
  - **Ramp is approximately 10 ft wide.**
  - **Would a 39 inch door (same as FFTB), followed by 4 ft wide PPS maze, be wide enough for equipment access?**

- **Two vertical cable penetrations , currently filled with conduits, can accommodate a few more cables. One is near the upstream end of the IS, and reaches the surface outside the west door of MCC. The other is near the proposed IP and reaches the surface outside the east door of MCC.**

- **A cable tray could be installed through the SW Adit (through the maze or above the shielding blocks) to a trailer or other building on the paved area near the SW Adit ramp. Expect total cable length approx 300 feet.**

Beam Dump Issues

- What are experimenter requirements for dump line?
- Is beam deflection required after IP to separate charged particles from photons? By how large an angle or offset?
- Should the design include spectrometer features? Are additional focusing magnet needed downstream of the IP?
- What is maximum desired beam power? This will impact dump, shielding, and MPS designs. (FFTB was never more than about 1 KW.)

Positron Compressor Chicane

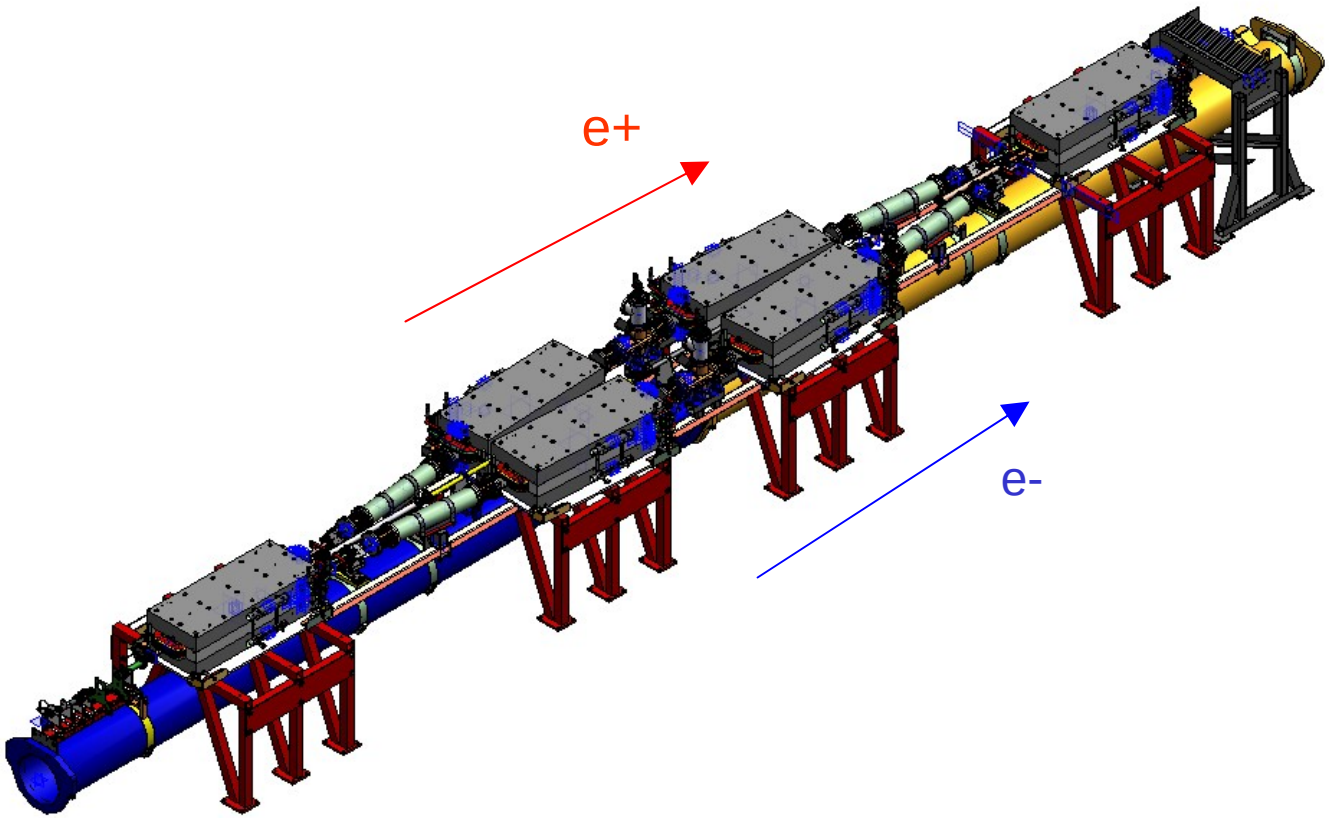
- Sector 10 compressor chicane has been used successfully for several years, but cannot be used with positrons (because electrons are required to make the positrons, and only one charge can pass through the present chicane).

- Chicane can be modified to be symmetric for electrons and positrons.

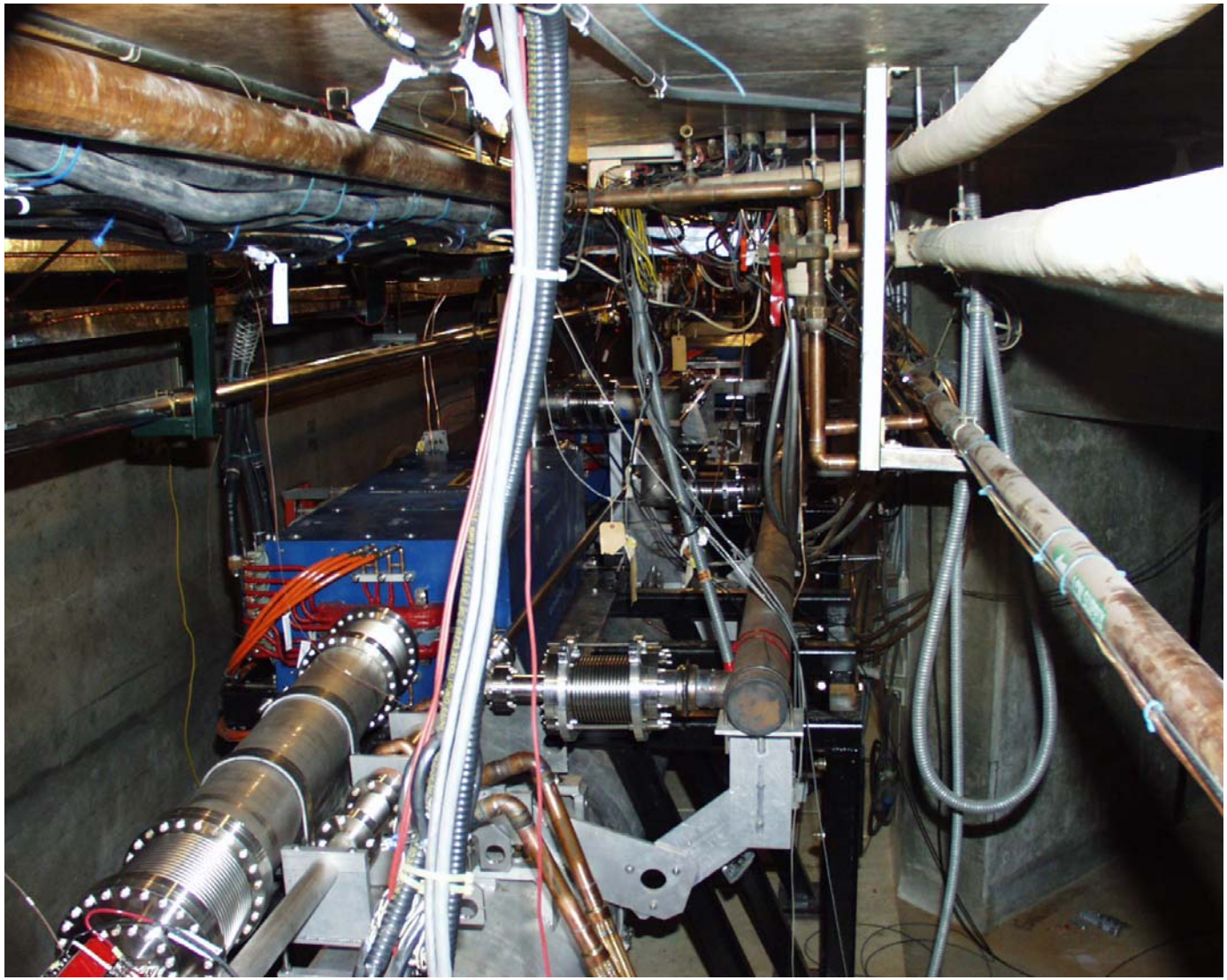
Issues:

- Beam matching: beta x and beta y are interchanged between e+ and e- in the linac. Does this create a matching problem?
- Pole width of first and fourth dipole magnets may be marginal if used for both e+ and e^-.

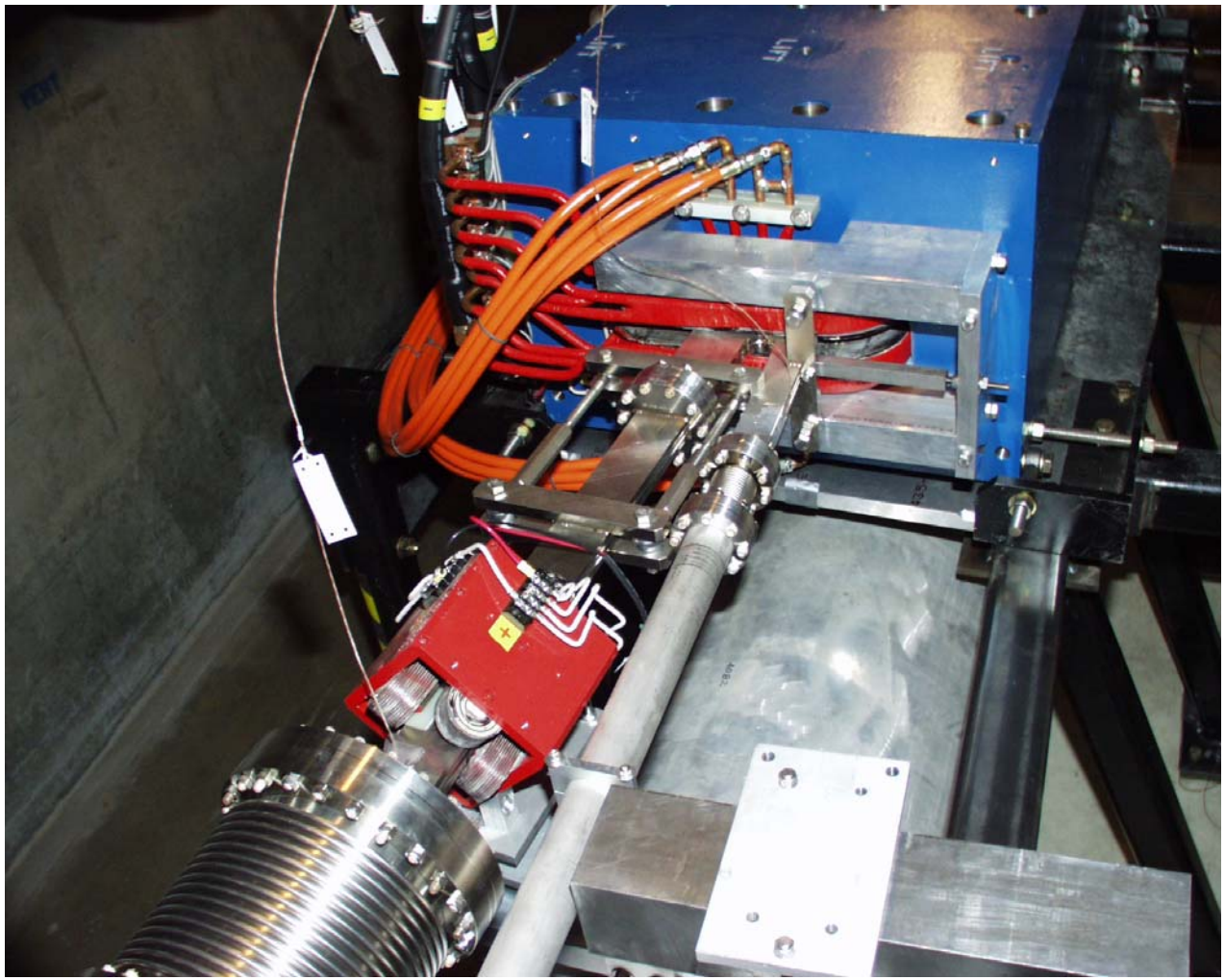
Proposed Symmetric Chicane



Sector 10 Electron Compressor Chicane



First Dipole of Compressor Chicane



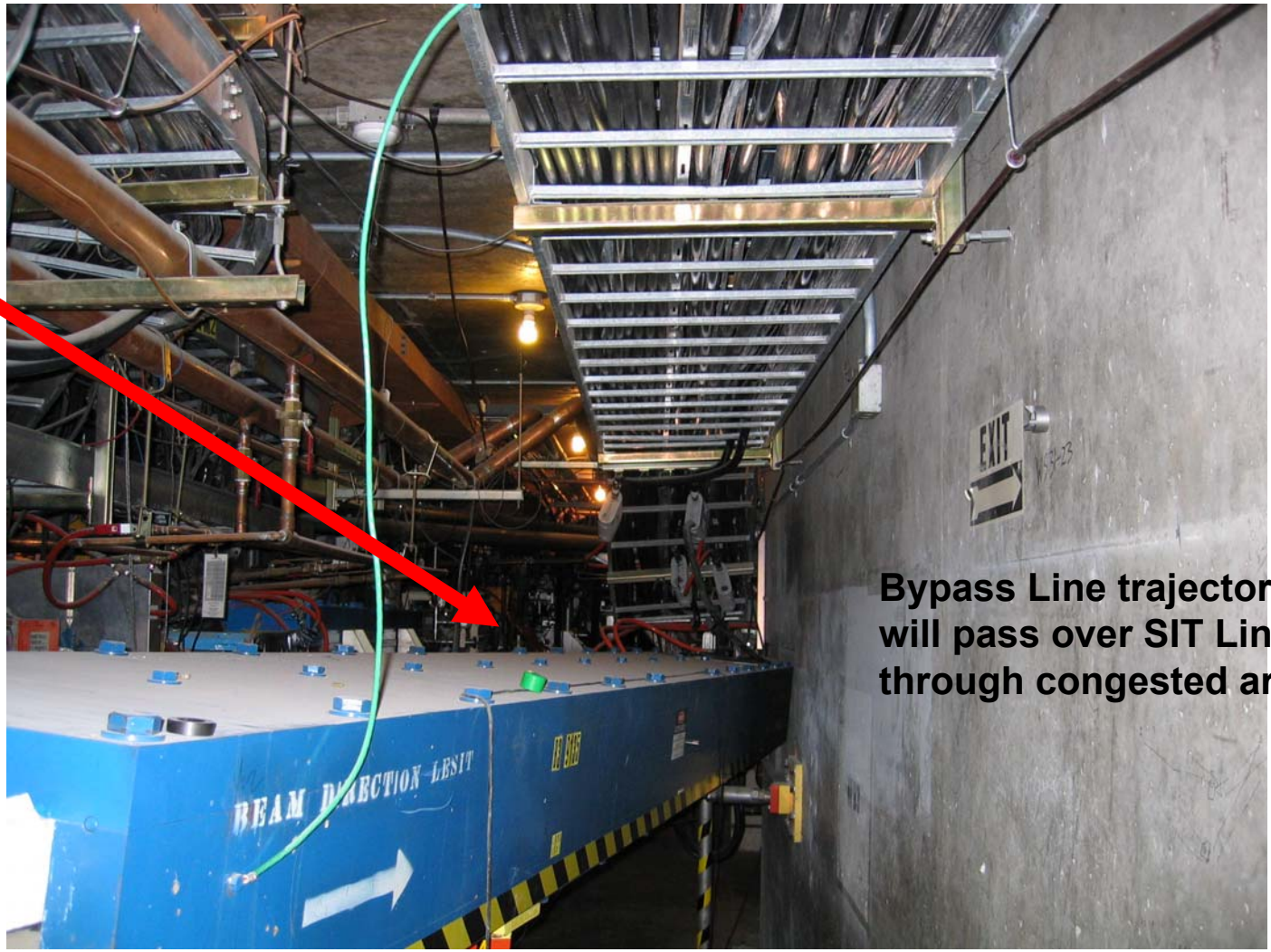
Notice that straight-through beam is off center.

Bypass Line

- A Bypass Line from Sector 20 would allow delivery of 30 GeV electrons to BSY without passing through last third of linac.
- SABER would then be independent of LCLS operations.
- Optics design is compatible with connection to the South Arc, but trajectory and engineering details must be refined to minimize interference with existing equipment.
- Trajectory past Sector 30 and NIT/SIT breakout point passes through a congested area, but can be built with careful planning.
- Cost could be significantly reduced by converting one of the PEP-II injection transport lines for this purpose.

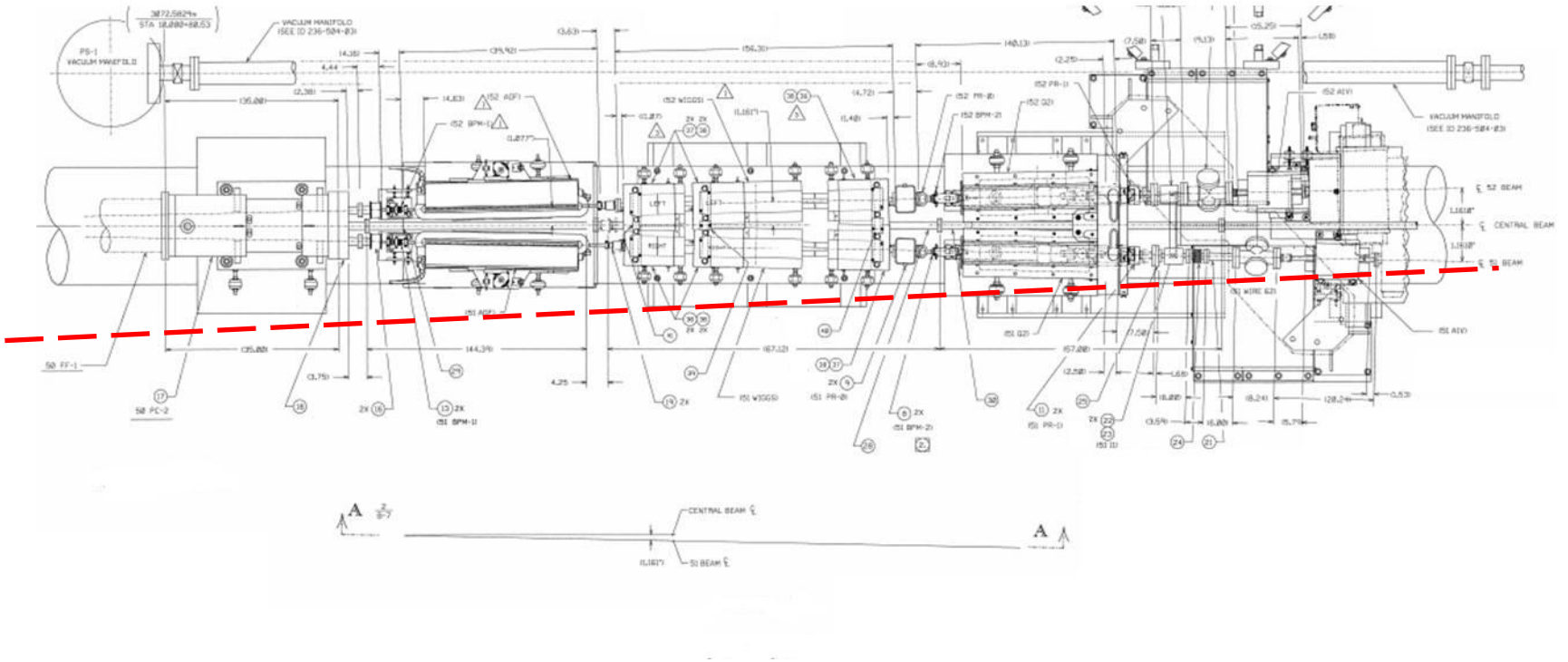
PEP-II Transport Lines in Linac Tunnel

Linac Tunnel Approaching BSY

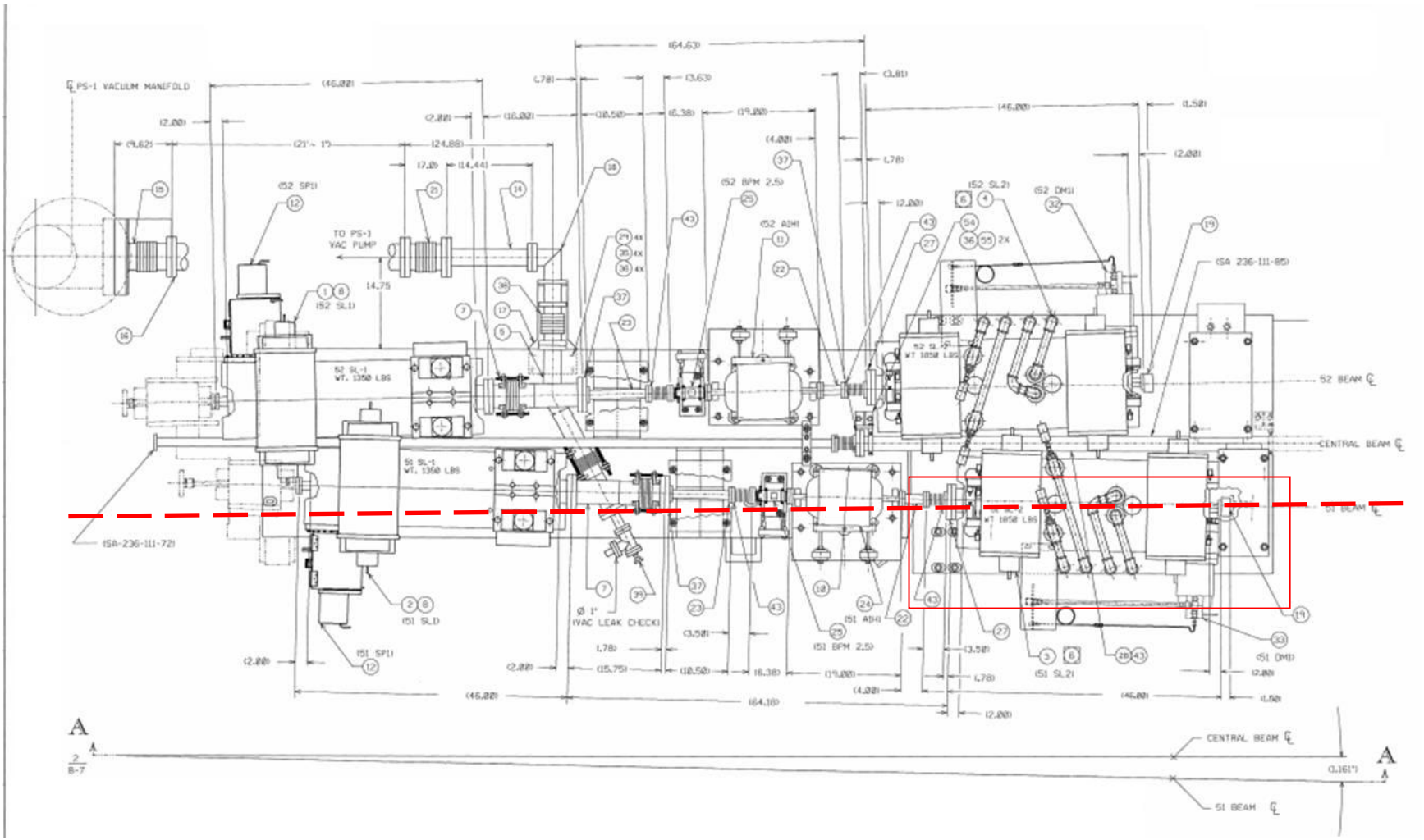


Bypass Trajectory near 51AGF

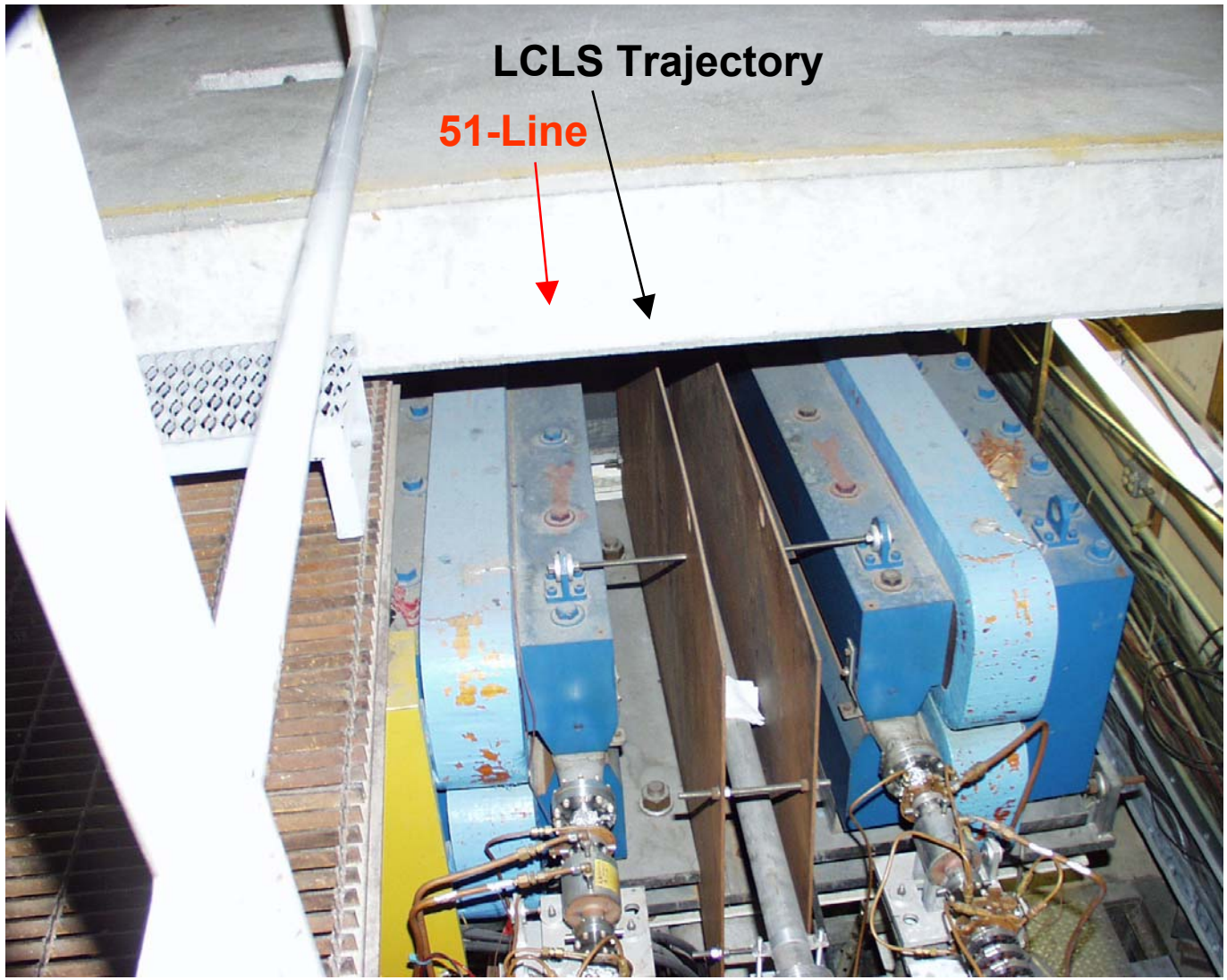
Can we find a way to preserve the direct linac-to-SARC connection with the bypass?



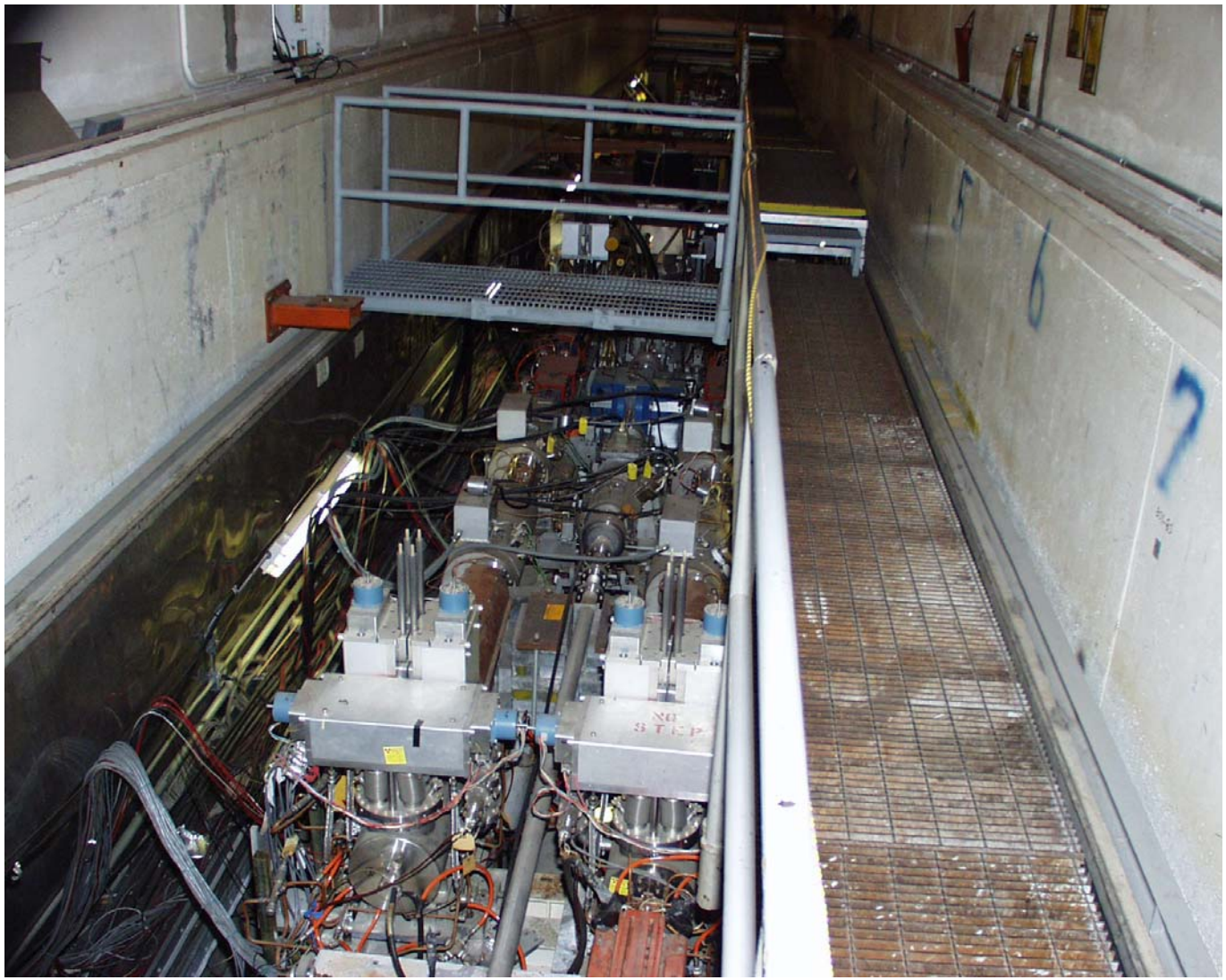
Bypass Trajectory into 51B2



B2 Dipoles in 51- and 52-lines



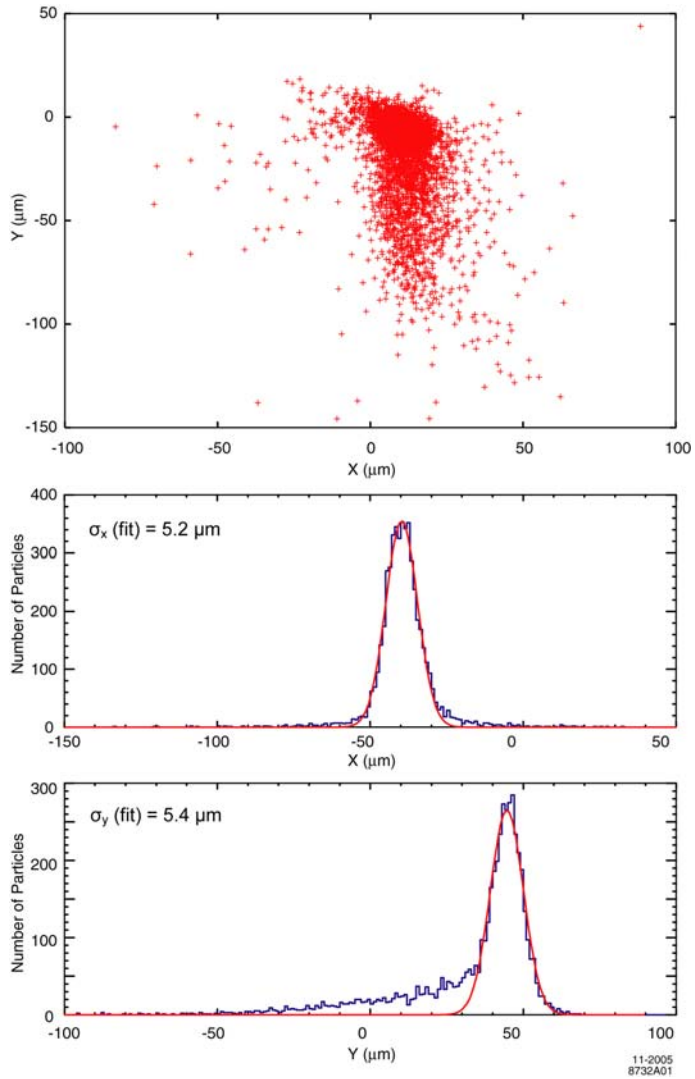
Diverging Beam Lines in BSY



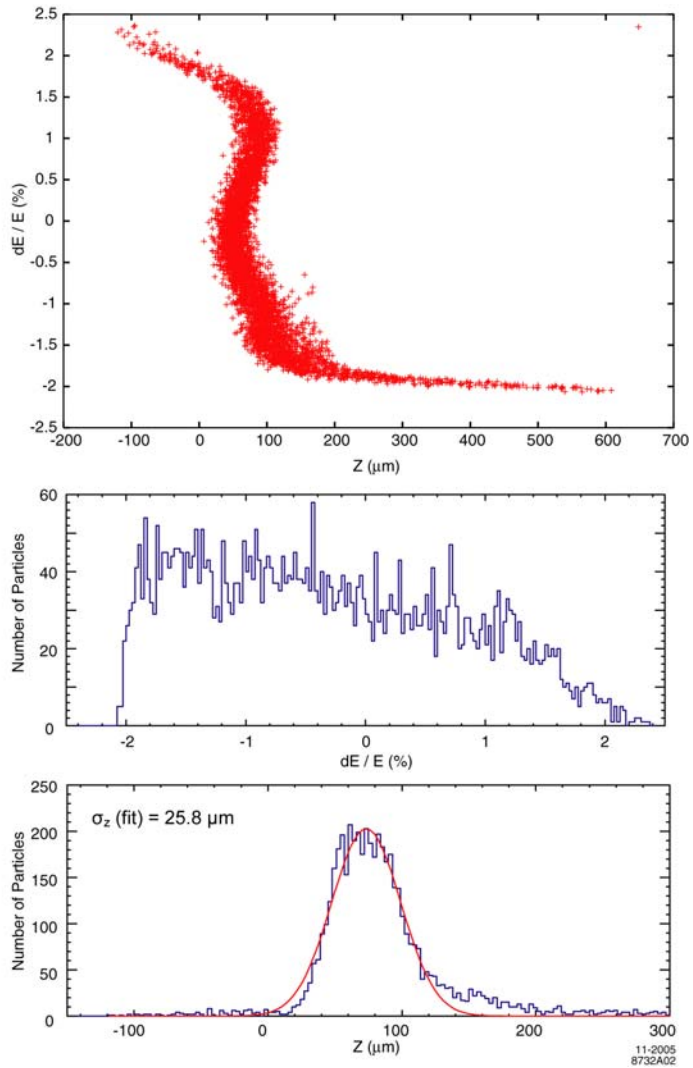
SABER Beam Parameters

- **Energy:**
  - 28.5 GeV with PEP-II or LCLS with bypass line.
  - Up to 50 GeV with full linac (but not with bypass line).
- **Charge per pulse:**
  - 2 x 10^{10} e^- or e^+/pulse with full compression.
  - 3.5 x 10^{10} e^- or e^+/pulse without compression.
- **Pulse length:**
  - σ_z = 30 μm with 4% momentum spread.
  - σ_z = 42 μm with 1.5% momentum spread.
- **Spot size at IP:**
  - 10 μm nominal;
  - $\sigma_{x,\,y}$ = 5.2 x 5.4 μm achieved in computer simulations.
- **Momentum spread:**
  - 4% full width with full compression.
  - < 0.5% full width without compression.
- **Momentum dispersion at IP:**
  - $\eta = 0.$
  - $\eta' = 0.$

Focused Beam



Bunch length vs energy spread



Proposed Schedule

- Refurbishment work in BSY; tie in with PPS: August – October 2006. First electrons to the SLC Instrument Section in December.
- First beam – positrons or compressed electrons through the full linac, interleaved with PEP-II injection pulses, to a dump in the SLC Instrument Section – in 2007.
- Installation of positron compressor chicane in linac: Sept – Oct 2007.
- Positron beam, fully compressed and focused in 2008.
- Bypass line in 2009.
- SABER experimental programs can coexist with PEP-II and LCLS programs.
- This schedule depends on the availability of engineering manpower and other resources.

Summary

- We have seen a constant demand for electron and positron beams in the FFTB from a wide variety of users.
- The FFTB will be dismantled in a few weeks to make room for the Linac Coherent Light Source (LCLS). We have been exploring replacement options.
- A new facility to replace the FFTB can be constructed in the SLC South Arc tunnel. A proof-of-principle study shows that low emittance, compressed bunches can be delivered to users.
- The electron bunch compressor chicane in the linac can be modified to compress positron bunches, opening up new areas of physics.
- A Bypass Line from Sector 20 to the BSY can be built to deliver beams to SABER, independent of LCLS.
- A strong show of interest from the user community will ensure the success of this program!

Acknowledgements

Special thanks to:

- **Yuri Nosochkov, who has developed optical solutions for SABER.**
- **Karl Bane, who has been investigating wake field effects and demonstrated bunch compression in the South Arc.**
- **Lynn Bentson, who has done the preliminary engineering studies and cost estimates.**
- **Paul Emma, who did initial optics and tracking simulations for the FFTB and has helped in exploring other options.**
- **Mark Woodley, who has assisted with design and tracking studies.**
- **Patrick Krejcik, who revived our interest in the South Arc option and demonstrated its feasibility.**
- **Ted Fieguth, whose dedication to SLAC's test beam activities has kept these programs alive and who has provided invaluable advice and perspective.**
- **John Seeman, who has consistently supported and encouraged these studies.**
- **Al Baker, Martin Berndt, Alex Chao, Scott DeBarger, Rick Iverson, Paul Miller, Alyssa Prinz, Mike Saleski, and the MFD and CPE staff members who have been helping assess the feasibility of SABER.**