NATIONAL ACCELERATOR LABORATORY

The FACET Facility

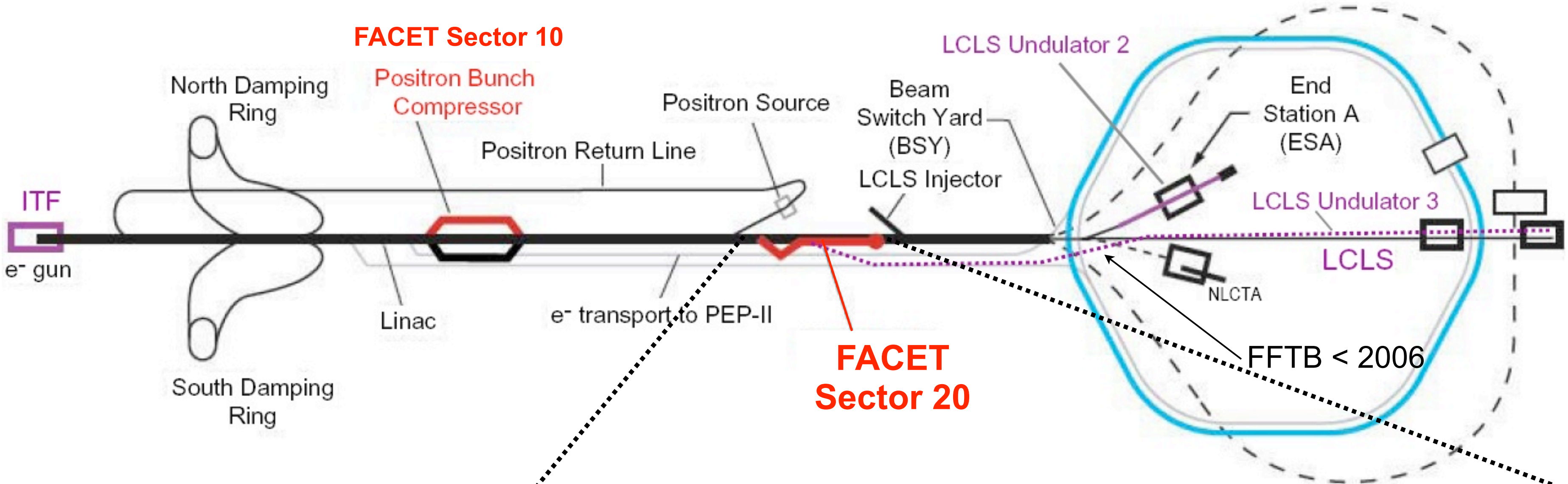
Mark Hogan

FACET Users Workshop
March 18-19, 2010

The FACET Facility

* FACET will provide high energy density electron and positron beams with peak currents of roughly 20 kA that are focused down to a 10x10 micron transverse spot size at an energy of 23 GeV.
* FACET's unique high-power beams will provide important science opportunities in many fields.
* FACET is one of two facilities that will meet the Department of Energy Mission Need Statement for an Advanced Plasma Acceleration Facility.
* With FACET, the SLAC linac will support a unique program concentrating on second-generation research in plasma wakefield acceleration.
* In addition to the plasma wakefield acceleration research, FACET will support a broad user program in accelerator science, materials science, high-energy density physics and other fields of research that can make significant advances using these intense beams and the intense fields that are generated.
* FACET construction is expected to finish in early 2011 with accelerator and beam commissioning soon after. The experimental program will begin in the Spring of 2011.

FACET in Relation to the SLAC Linac Complex



Nominal
FACET Beam Parameters

Energy	23 GeV
Charge	3 nC
Sigma z	14 µm
Sigma r	10 µm
Peak Current	22 kAmps
Species	e^- & e^+

Beam Parameters Driven by Science Needs

Delivered to 100m area with three distinct functions:

1. Chicane for final stage of bunch compression
2. Final Focus for small spots at the IP
3. Experimental Area

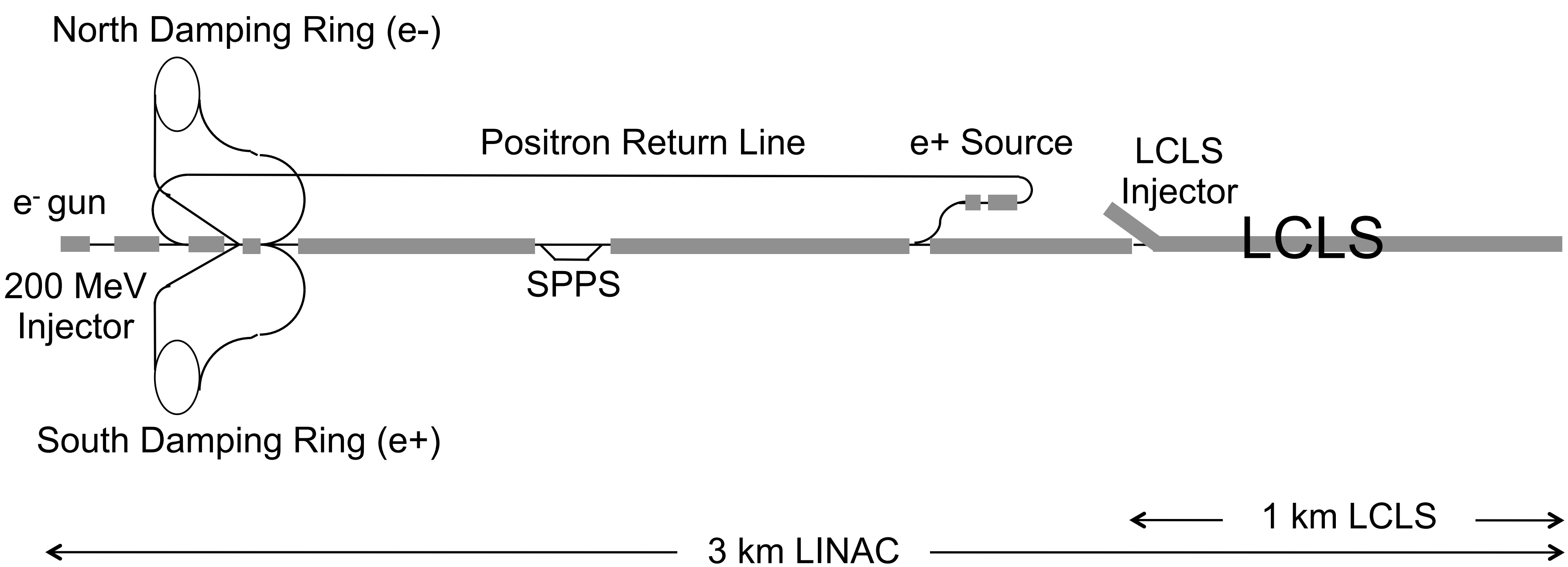
Advantageous location:

- Preserves e+ capability
- No bypass lines or interference with LCLS
- Linac setup virtually identical to SPPS/FFTB

Existing LINAC Installations

State of the systems:

- First 2/3 of LINAC (front end) turned off and in maintenance
  Successfully tested electron systems (Nov-Dec 2009)
- LCLS operational

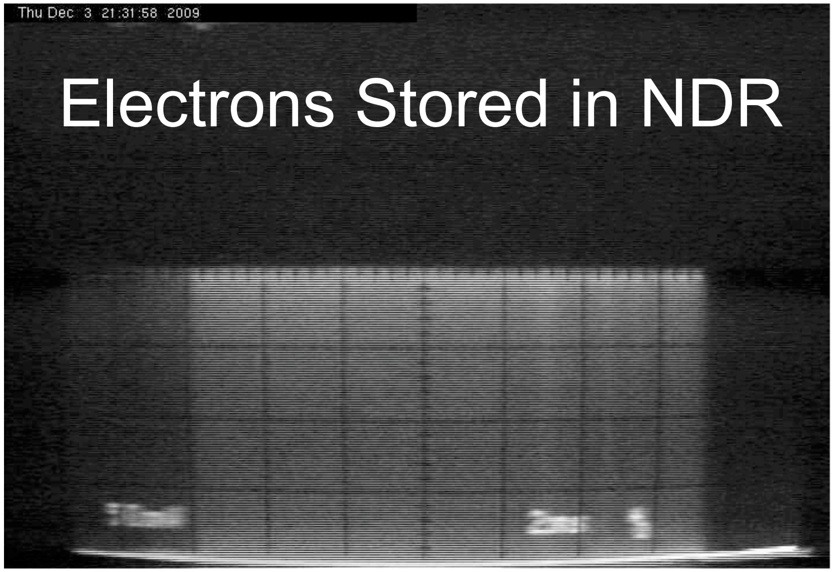


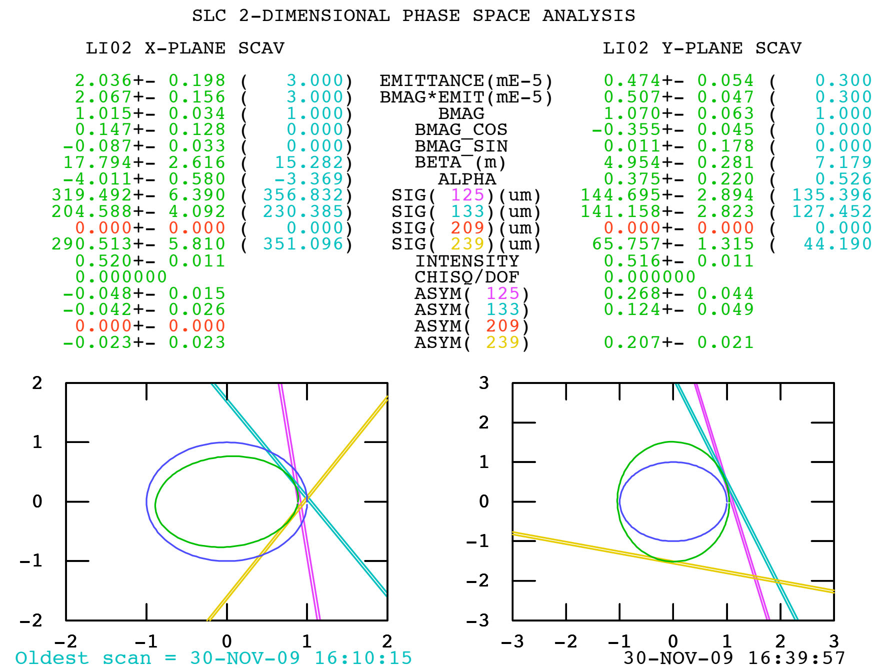
Nov-Dec 2009 Test of Linac e- Systems

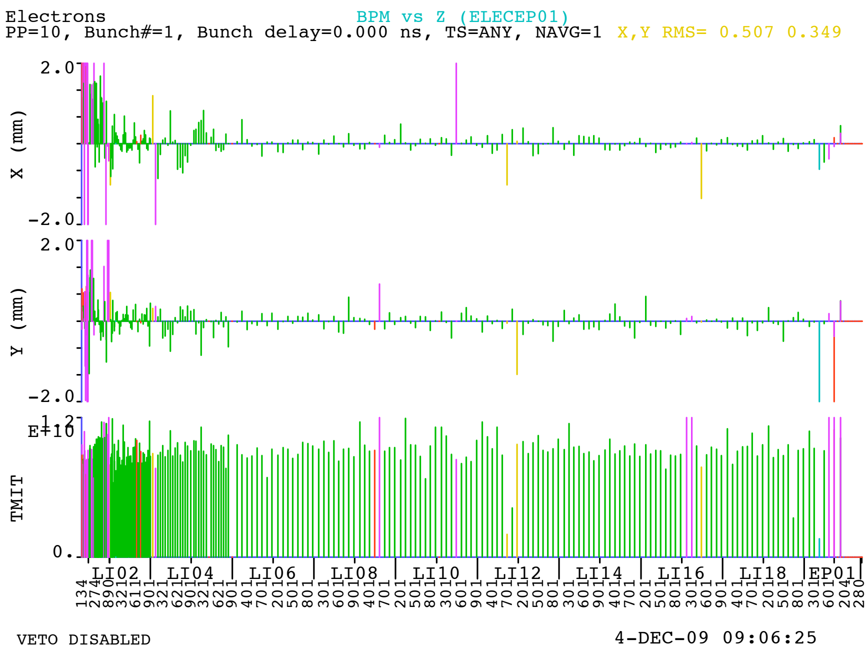
* Fall 2009 turn-on was a success
  - 23GeV electrons to just upstream of the positron source target
* About 2 Mo. from start to get 1st beam.
* A number of systems needed attention (vacuum, rf...)
  - Many jobs for next year, but manageable
* Lessons for next start-up
  - Expect next time to go much faster
* Beam diagnostics (esp. wires) needed work.
* Re-learning how to setup the beam...
* All-in-all, however, this test is quite reassuring for FACET running.
* Many thanks to all parties involved!

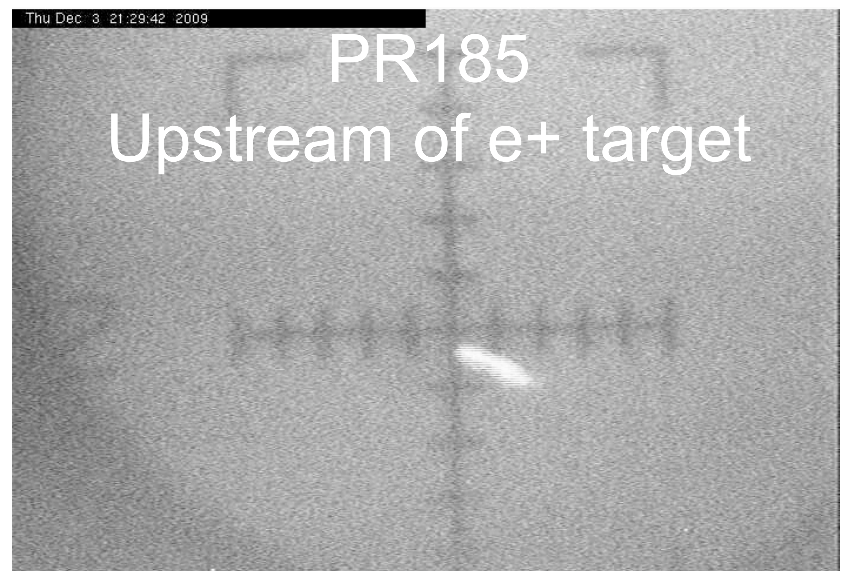
Info from Jerry Yocky & Uli Wienands

FACET Nov-Dec 2009 Test of Linac e- Systems

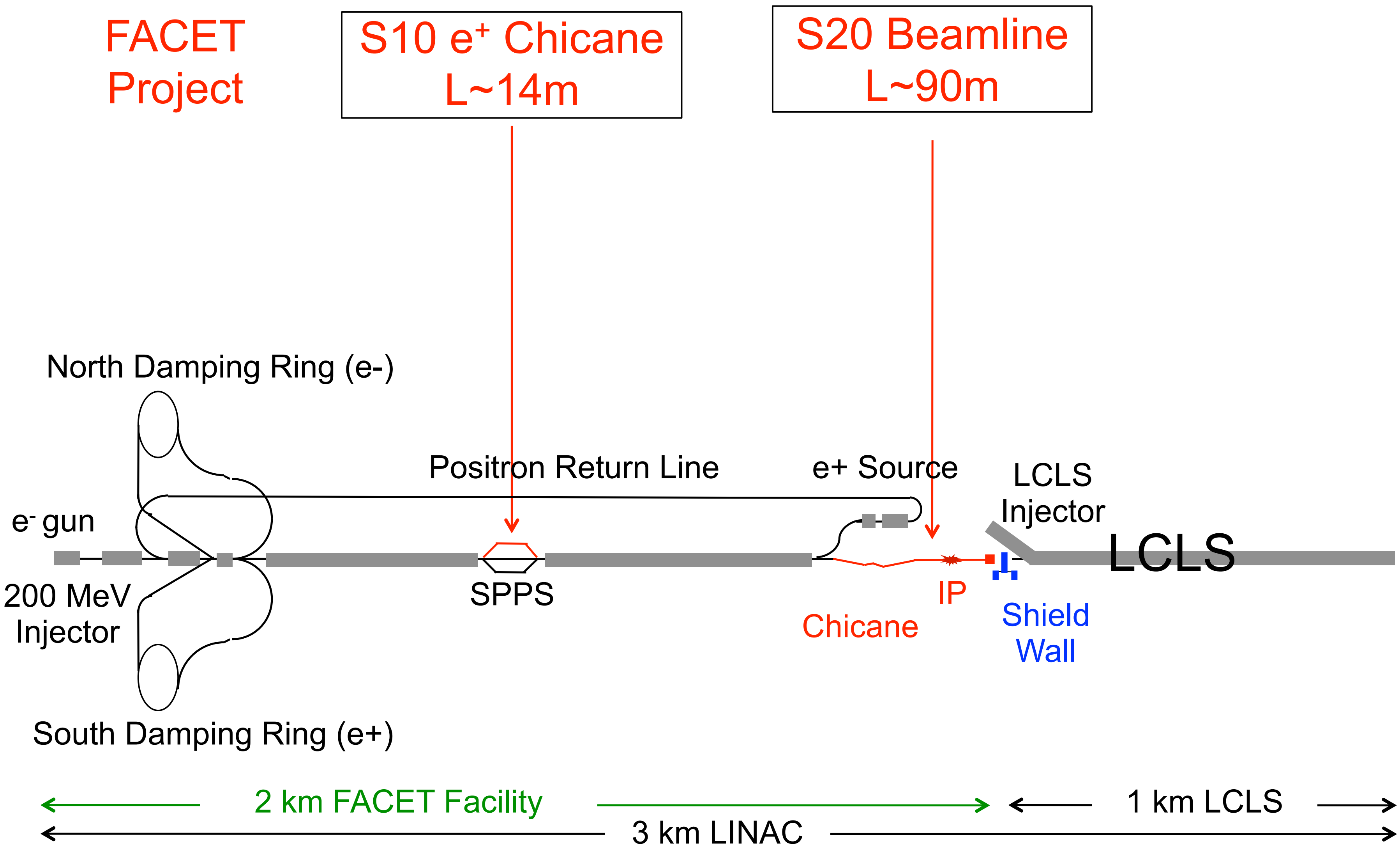




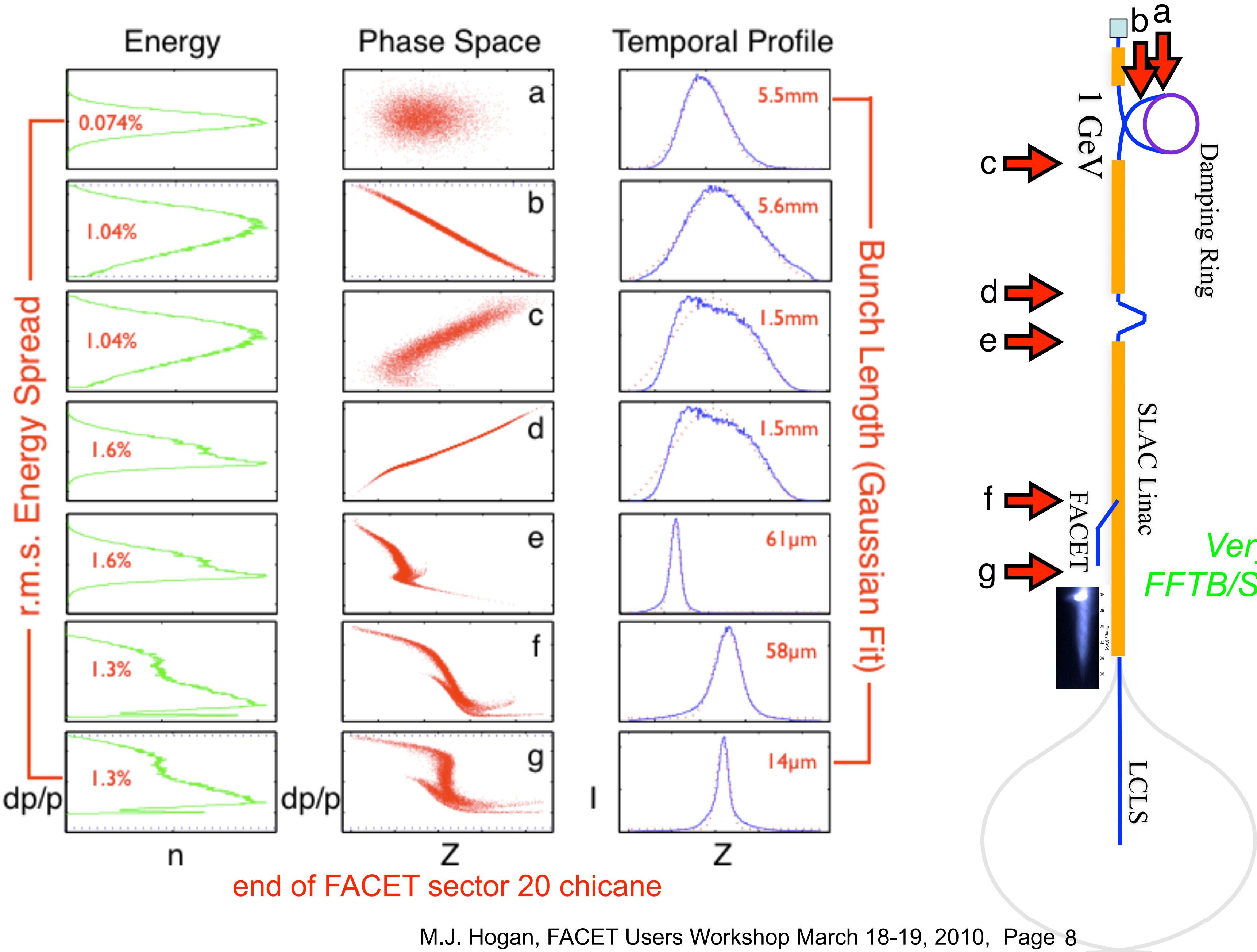




LINAC Installations with FACET



FACET Uses a Three Stage Compression Process

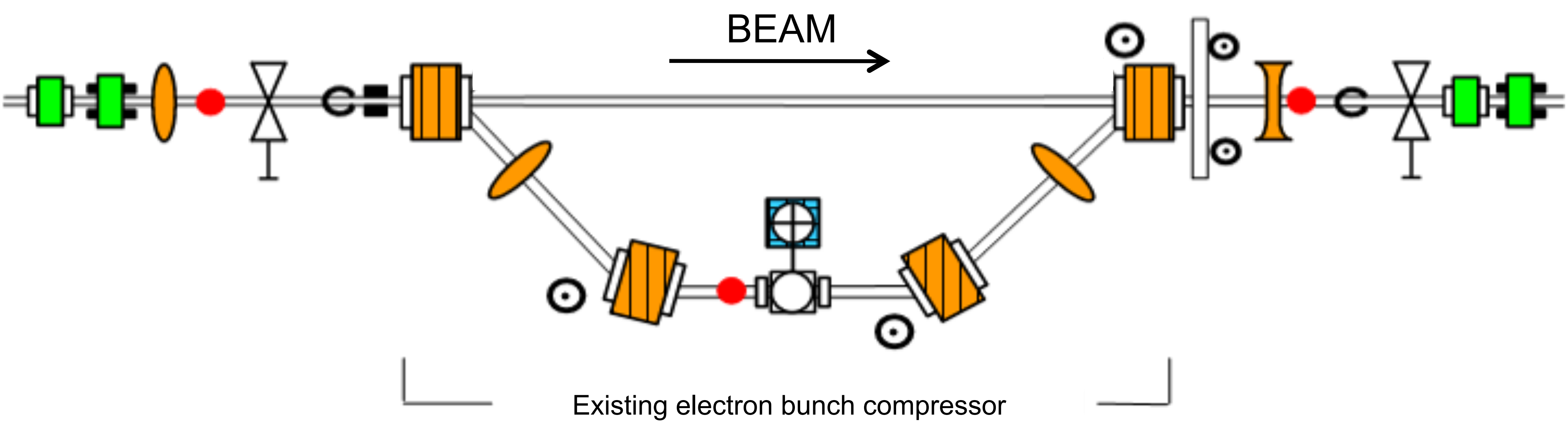


end of FACET sector 20 chicane

Very similar to FFTB/SPPS operation

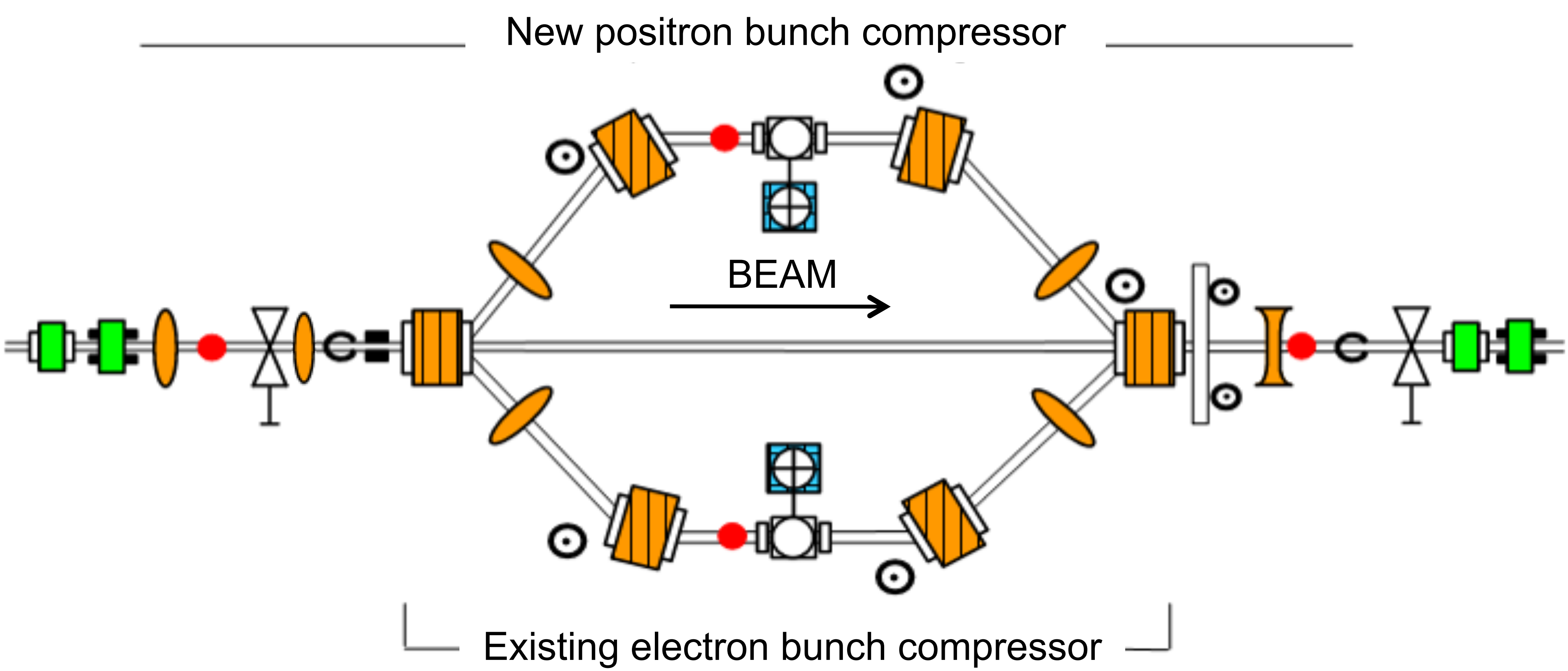
Existing Sector 10 SPPS Installation

* Secondary stage of bunch compression: 1.5 mm → 50 μm



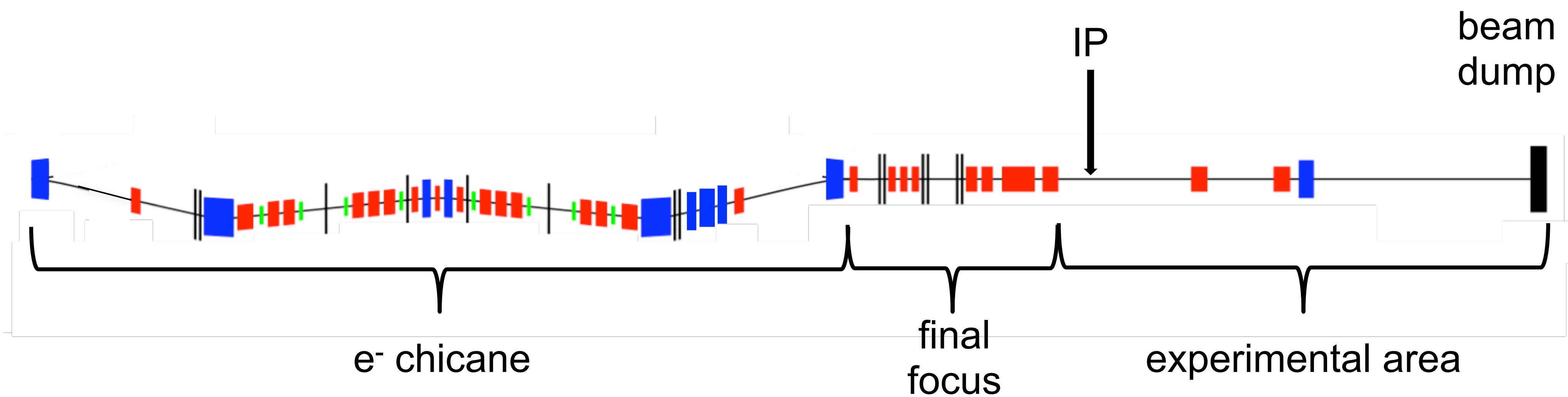
New Sector 10 Installation

* Secondary stage of bunch compression: 1.5 mm → 50 μm
* Enables compressed positron bunches (needs to pass e⁻ too to get to positron target in sector 20



Sector 20 Installation

* Tertiary bunch compression: 50 μm → < 20 μm
* Collimation (remove tails), create two bunches
* Chromatic correction & final focus system
* Diagnostics
* Experimental area
* Beam dump
* Shield Wall (not shown)



FACET

Generate Two Bunches by Selectively Collimating During Bunch Compression Process

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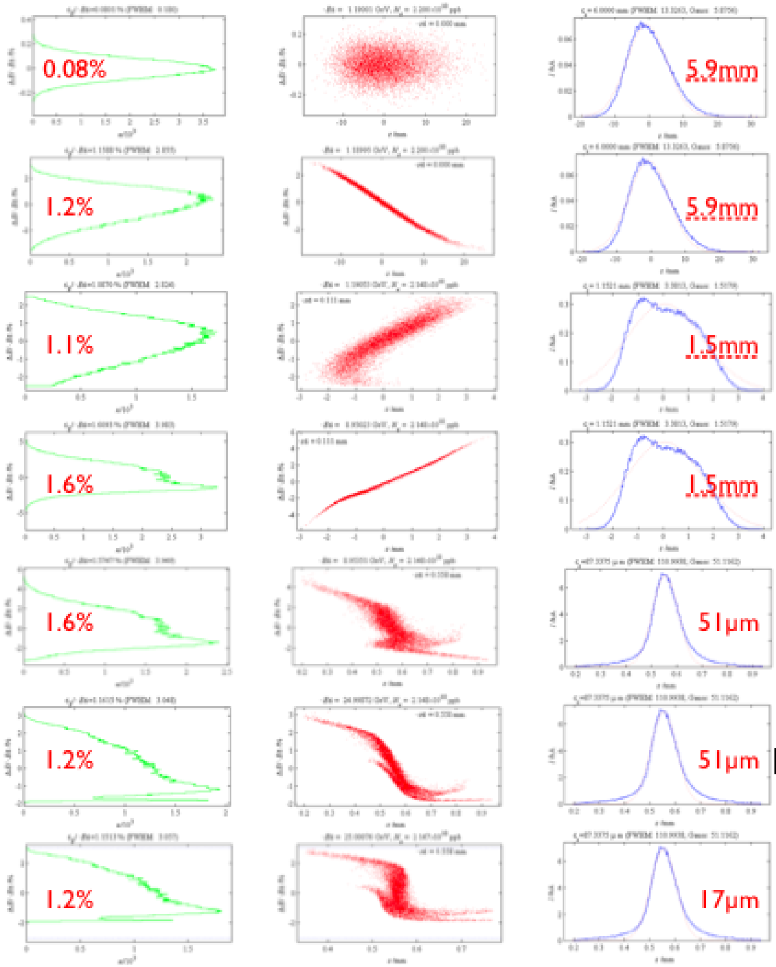
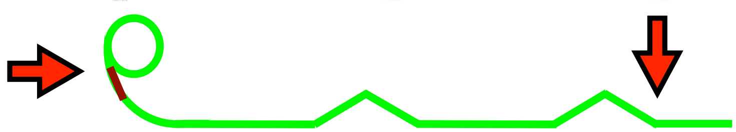
Energy | Phase Space | Temporal Profile



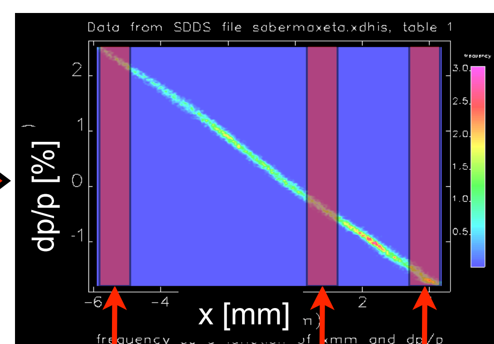


Exploit Position-Time Correlation on e⁻ bunch to create separate drive and witness bunch

Modeled using similar analytic framework (CSR) as LCLS as well as tracking/shower codes

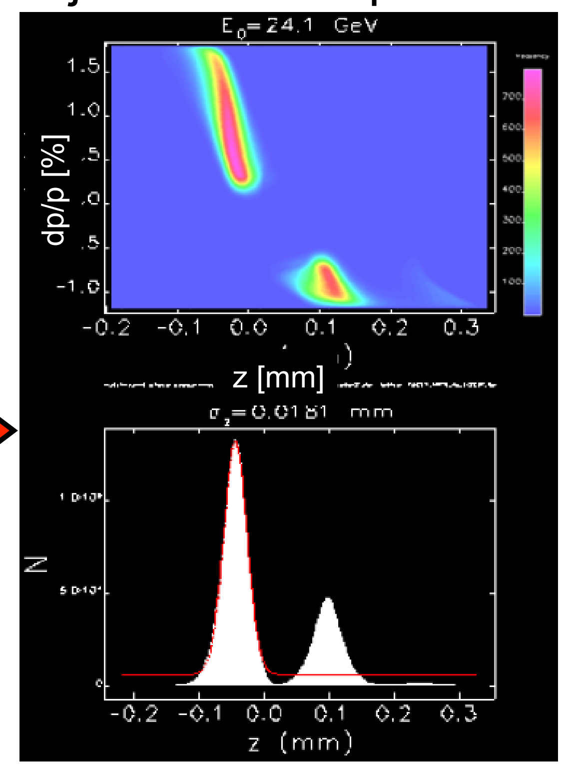
Disperse the beam in energy

$$x \propto \Delta E/E \propto t$$



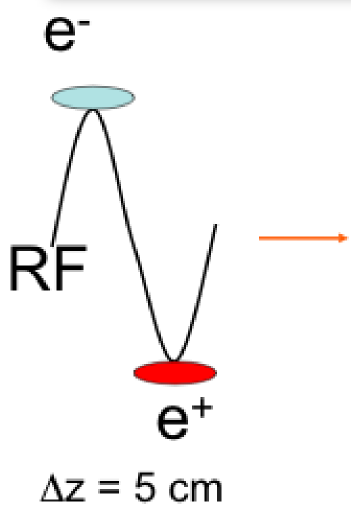
...selectively collimate

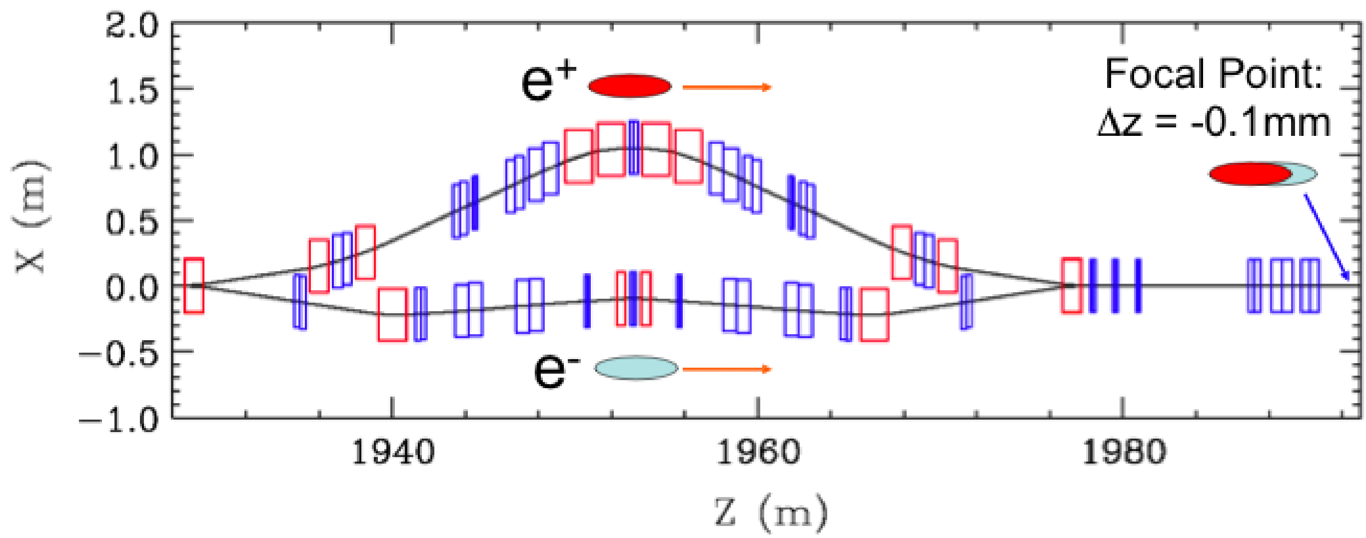
Adjust final compression



FACET Design is Forward Looking and Flexible, e.g. Sailboat Chicane Upgrade

- Extract e- & e+ from damping rings on same linac pulse
- Accelerate bunches to sector 20 while 5cm apart
- Use 'Sailboat Chicane' to put them within 100μm at entrance to plasma
- Large beam loading of e^- wakes with high charge e^+ beams



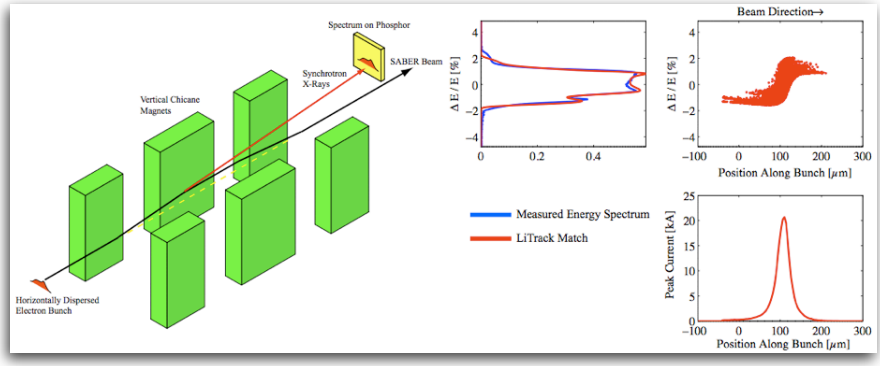


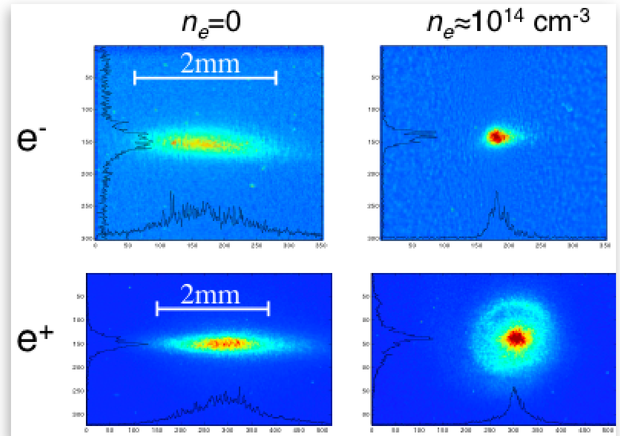
Opens up many new avenues of research:
- Positron acceleration on electron driven wakes
- PD-PWFA
- Fast magnetic switching with delay between opposite field signs

Diagnostics

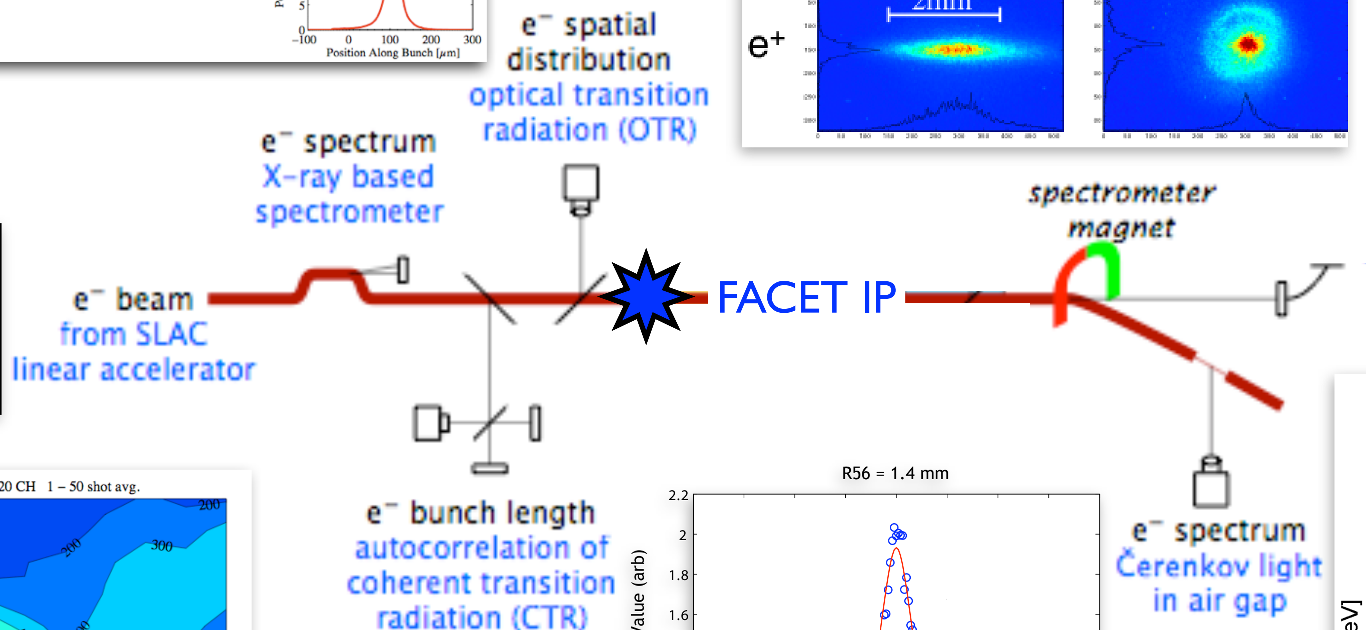
* Many needed diagnostics are still there from the SLC/FFTB/PEP-II programs:
  – BPM's, Torroids, Wire scanners, Feedbacks, GADCs, triggers
* Developed many diagnostics for FFTB program that will be incorporated into FACET facility
* Profile monitors to measure the beam transverse distribution before and after the IP
* Transverse emittance at the IP (average measurement)
* Energy and energy spectrum before and after the IP
* Bunch length. Relative bunch length shot-to-shot with average absolute bunch length also available.
* Unless otherwise noted all diagnostics are single shot running at 30Hz

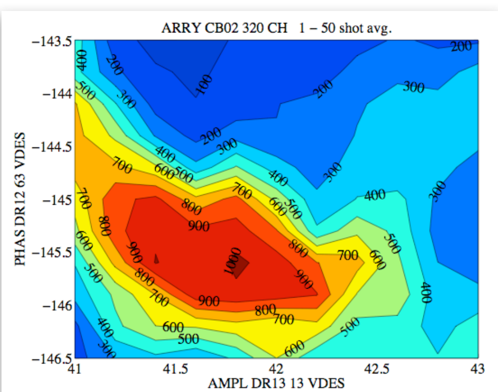
FACET Will Incorporate Many of the Single Shot Diagnostics Developed in the FFTB Plasma Program

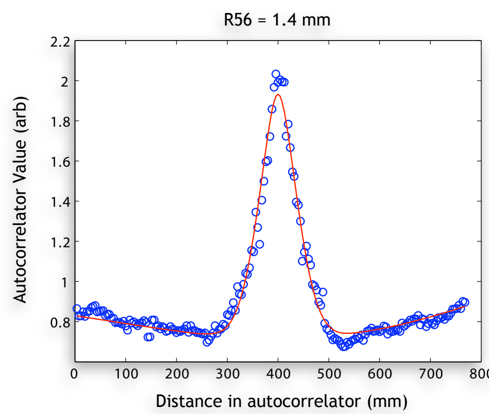


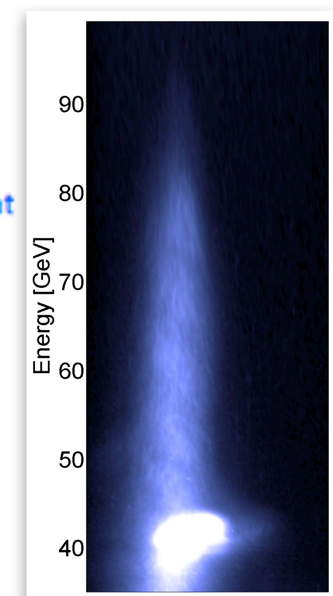


SLAC linac:
BPM's, Torroids, Feedbacks, GADCs, triggers



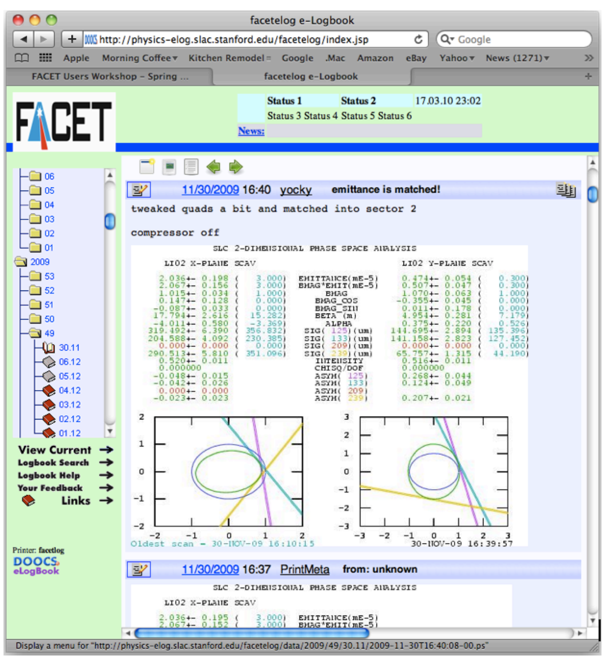


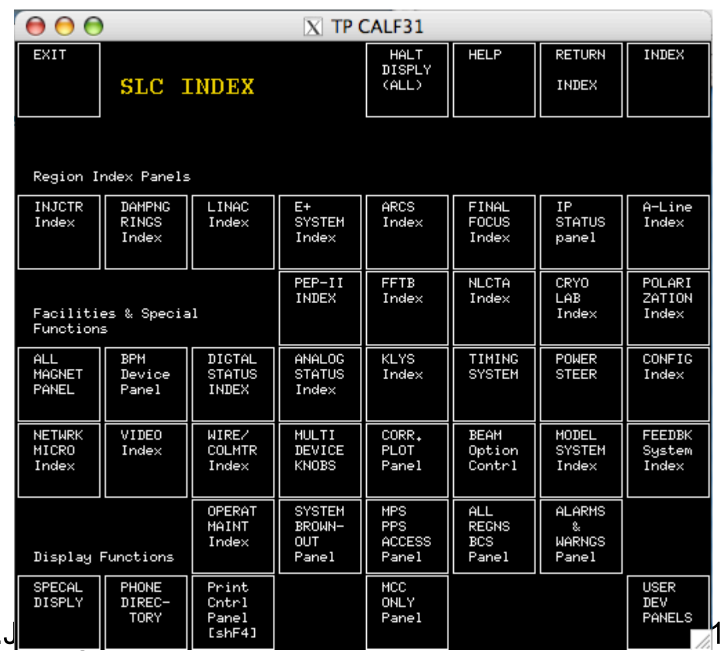


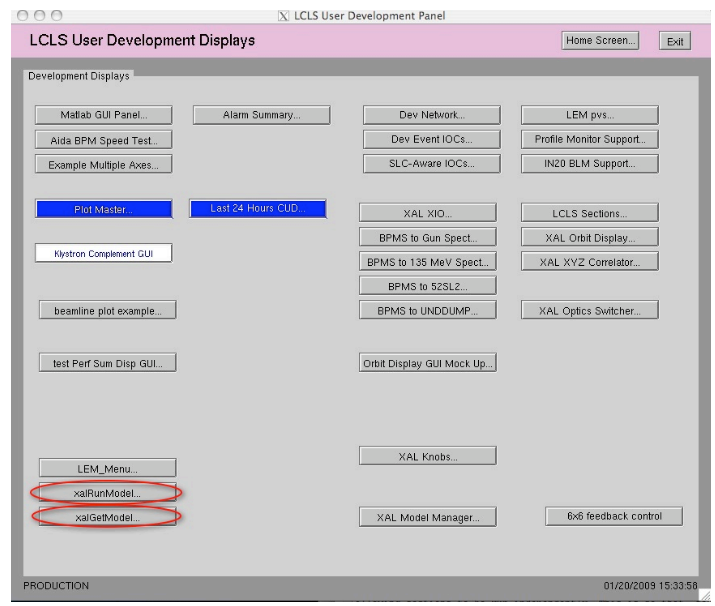


Data Acquisition & Control

- SCP data acquired with Correlation Plot Utility or Buffered Data
- Synchronize with additional DAQ (LabVIEW, MATLAB, etc) with SCP/EPICS issued triggers
- EPICS data (including cameras) acquired with Beam Synchronous Acquisition
- Camera support: Facilities for users to implement image acquisition for supplied diagnostics in a timely and cost effective manner.
- Gated Analog to Digital Converters (GADCs) with independent triggers per channel.
- Timing: Coarse timing adjustable by increments of 10ns or better, fine timing steps of ~25ps or better, both with less than 25ps jitter.
- Stepper motor support: Available with some models
- Electronic Logbook

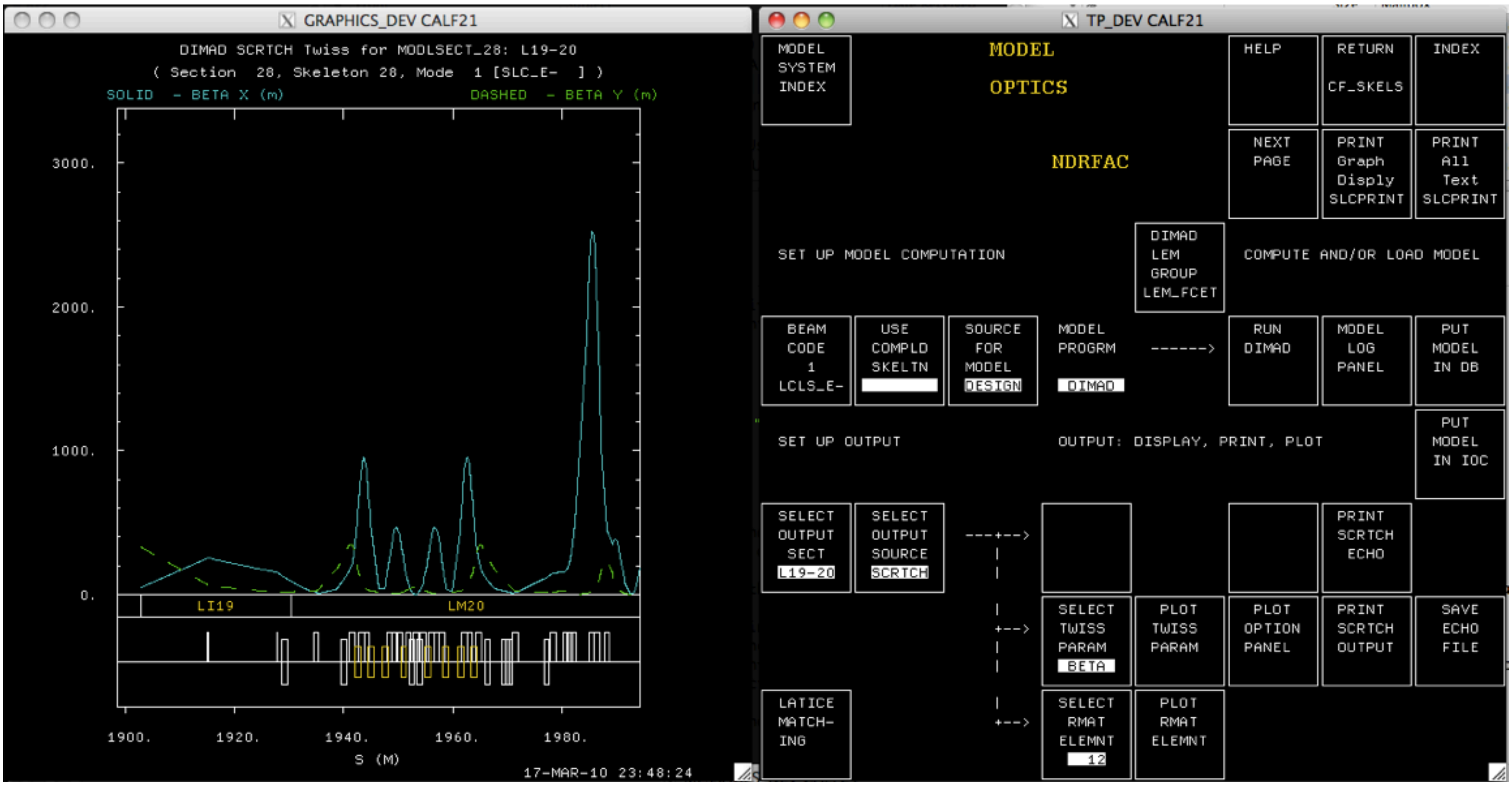




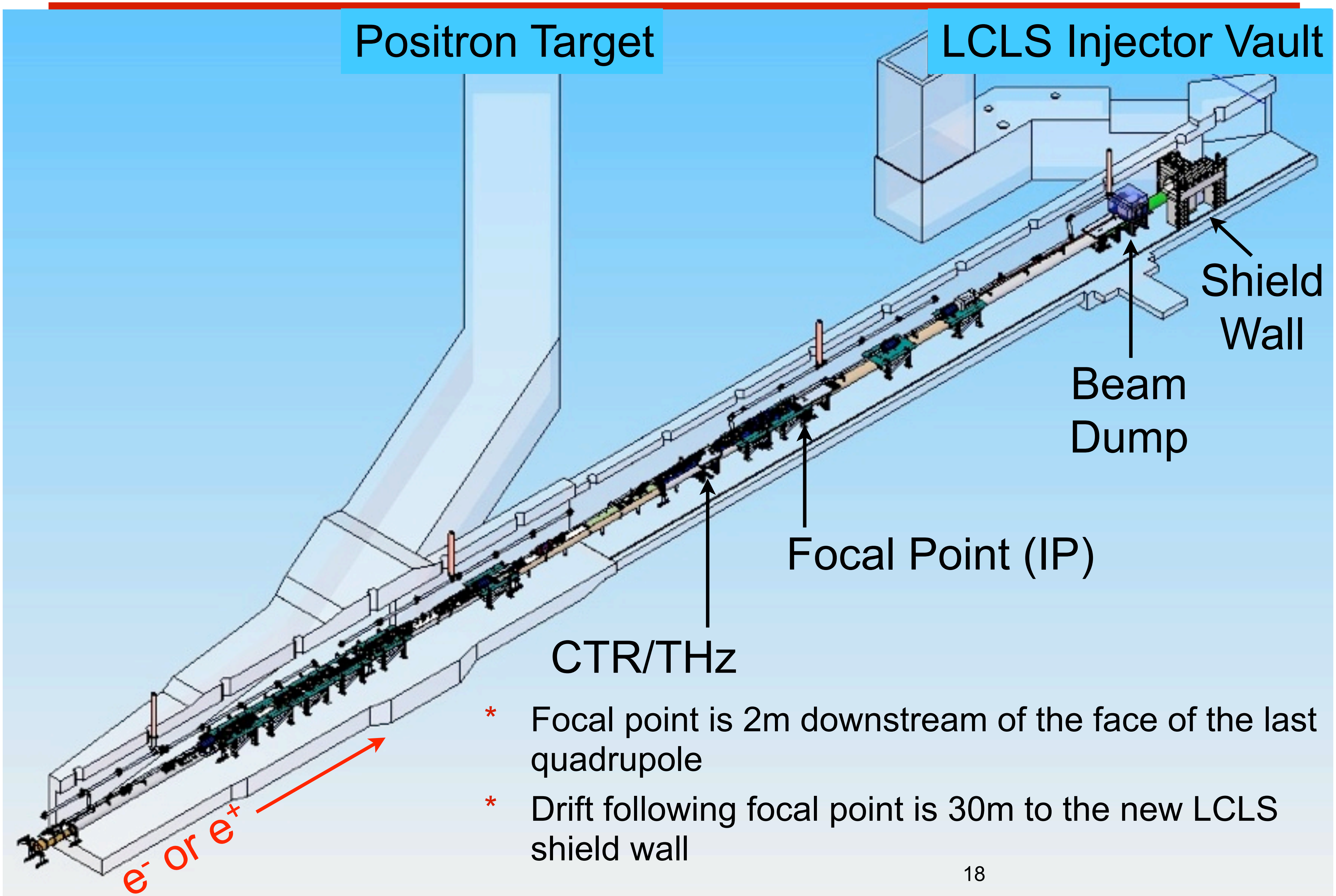


Online Modeling

- Immediate information about TWISS parameters, R matricies for both design and ‘as is’ lattice
- Simple multi-knob & orbit bump creation



Physical Space – Overview

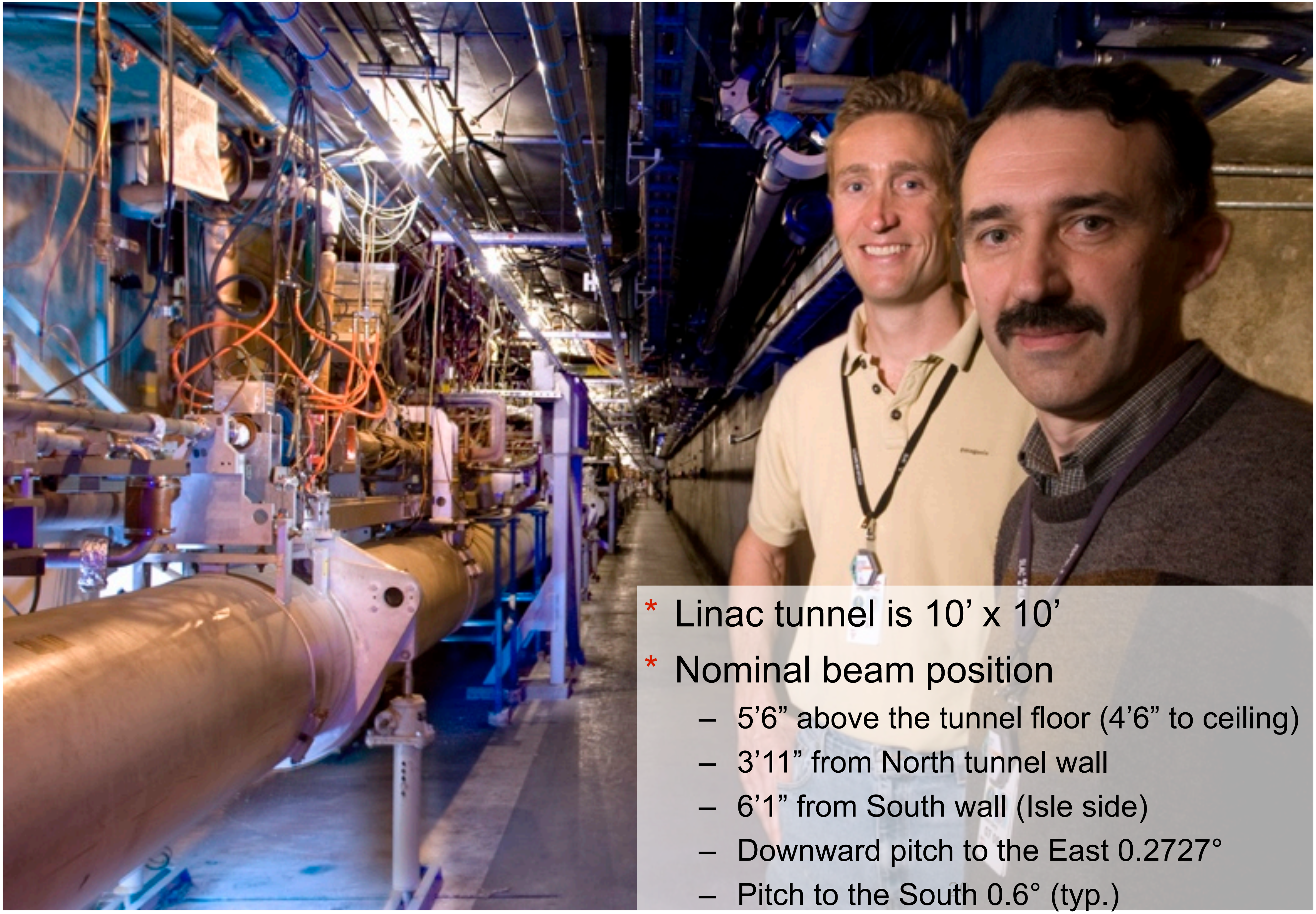


- Focal point is 2m downstream of the face of the last quadrupole
- Drift following focal point is 30m to the new LCLS shield wall

Provided Platforms to Mount Experiments

* Goal is to provide a generic platform for different user groups to come and mount experiments
* The IP, the beam dump and CTR locations will have an optical table for users to mount experimental hardware.
  – Each table will have a clear volume (minus beam pipe) defined by the table surface area extending upwards approximately 4 feet.
* The tables are as follows:
  – All optical tables have 1/4” x 20 holes tapped at 1” increments.
  – IP table 12’ long x 4’ wide with a row of holes aligned 9” below and parallel to the beam vector.
  – Table upstream of the beam dump area 8’ long x 4’ wide with a row of holes aligned parallel to the beam vector.
  – Table at CTR location 6’ long x 4’ wide with a row of holes aligned 9” below and parallel to the beam vector.
* Areas around the optical tables will have elevated flooring to bring table surface to ~36” above floor height

Linac Tunnel Cross Section



* Linac tunnel is 10’ x 10’
* Nominal beam position
  – 5’6” above the tunnel floor (4’6” to ceiling)
  – 3’11” from North tunnel wall
  – 6’1” from South wall (Isle side)
  – Downward pitch to the East 0.2727°
  – Pitch to the South 0.6° (typ.)

Provided Infrastructure

* 120VAC electrical service distributed in 'numerous' individual receptacles/ outlets in and around the IP.
* Air: >80psi air supply for pneumatic actuators. Manifolds for 1/4" tubing connections at the IP, CTR and beam dump.
* LCW (Linac Cooling Water)
* Vacuum
* Networking: Wired (CAT6) GB Ethernet with taps at IP, CTR and beam dump areas. Wireless 802.11n throughout the experimental area.
* Laser PPS system to allow experimenters to install and operate (with appropriate training, PPE etc) lasers rated Class IIIb or higher.
* Rack space: 3ea w/42U/per in tunnel
* Cable trays. Cable trays for general purpose signal cable routing from the CTR location to the IP, the IP to the beam dump area, the IP to the penetration up to the Klystron gallery and from the Klystron gallery to the user support building (see next slide).
* General purpose 50 & 75 ohm cables (RG58, LMR400, RG59) routed from the IP to the user support building, from the IP to the beam dump area, and from the IP to the CTR area.

FACET User Support Building @ Sector 20

Single Wide Office Buildings

- A place near sector 20 for the experimenters
- Purchase/Rent modular building for experimenters and locate at sector 20 near 'new' experimental staircase
- Reuse "Building" 407C as additional FACET experimenter storage.
- Additional staging & storage space available in central research yard

Multi - Sectional Office Buildings

FACET

Access to Linac Tunnel

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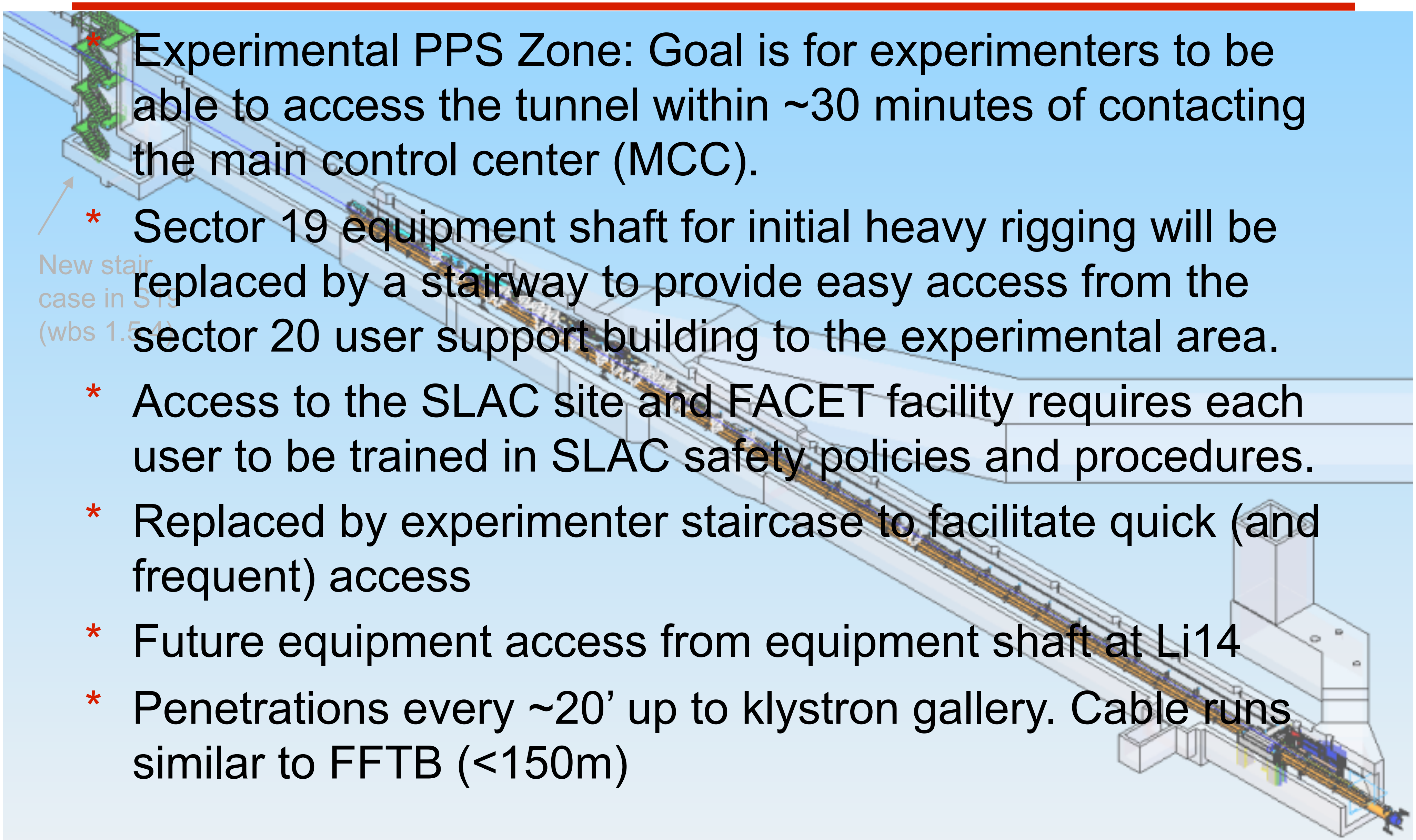
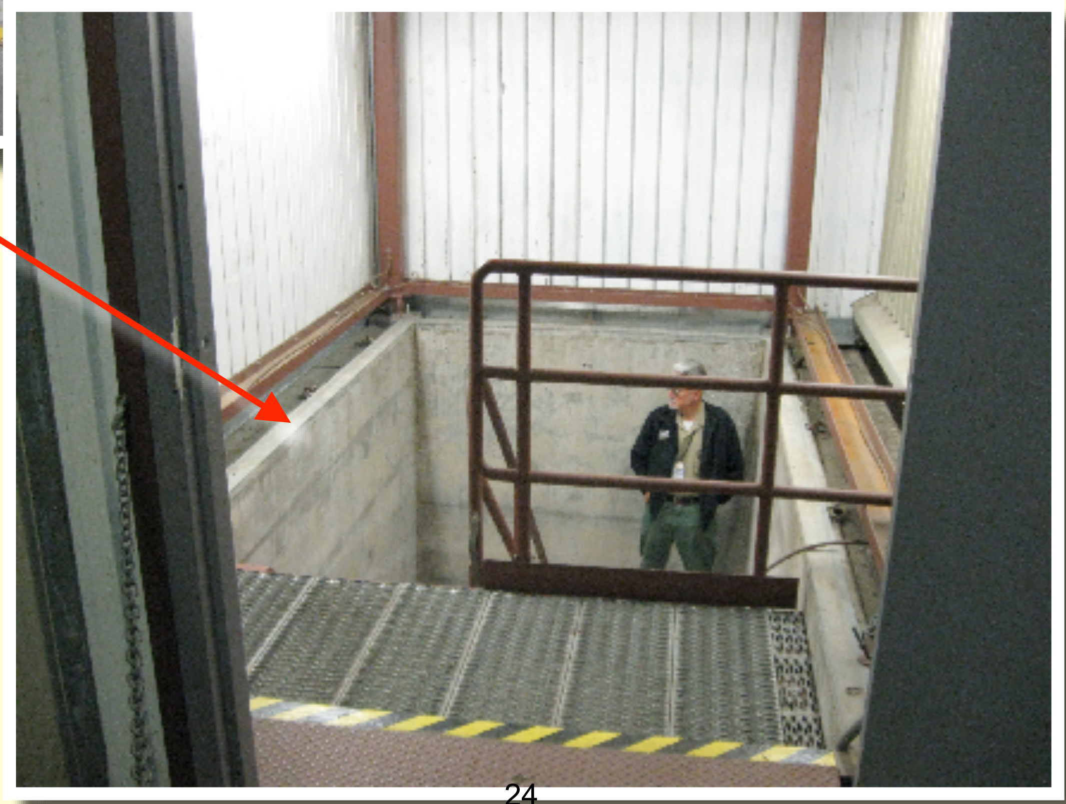


* Experimental PPS Zone: Goal is for experimenters to be able to access the tunnel within ~30 minutes of contacting the main control center (MCC).
* Sector 19 equipment shaft for initial heavy rigging will be replaced by a stairway to provide easy access from the sector 20 user support building to the experimental area.
* Access to the SLAC site and FACET facility requires each user to be trained in SLAC safety policies and procedures.
* Replaced by experimenter staircase to facilitate quick (and frequent) access
* Future equipment access from equipment shaft at Li14
* Penetrations every ~20’ up to klystron gallery. Cable runs similar to FFTB (<150m)

Ex: S19 Staircase



Summary

* FACET will provide high energy density electron and positron beams with peak currents of roughly 20 kA that are focused down to a 10x10 micron transverse spot size at an energy of 23 GeV for experiments in many fields
* FACET will have conditions similar to FFTB: work area, utilities etc
* Integrated many experimentally developed diagnostics into FACET facility (BLM, OTRs, X-ray stripe) for improved reliability and shared benefit
* Beam parameters are flexible and adaptive to a wide range of users
* Good access for people and equipment
* Flexible area for experimenters with space to accommodate new hardware/ideas
* The SLAC linac is alive and well (just a bit sleepy!)
* FACET construction is expected to finish in early 2011 with accelerator and beam commissioning soon after. The experimental program will begin in the Spring of 2011.