FACET First Beam Commissioning

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For the FACET commissioning team

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Facility for Advanced aCcelerator Experimental Tests

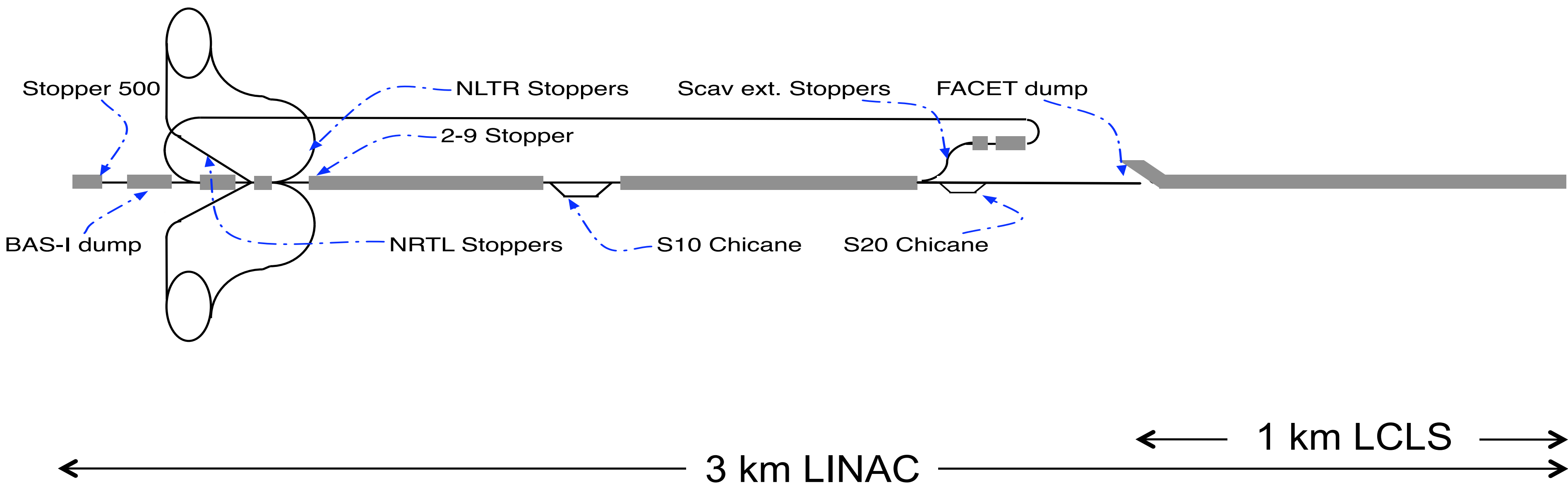
WHAT IS FACET?

The FACET Facility

Main goal—ultra-short & transversely small intense bunches

Driven by the first 2/3 of the SLAC linac. New compression chicane built in S20.

Uses e- source from SLC/PEP-II, including the North Damping Ring (NDR). Utilizes the Sector-10 chicane from previous experiments (SPPS, etc).

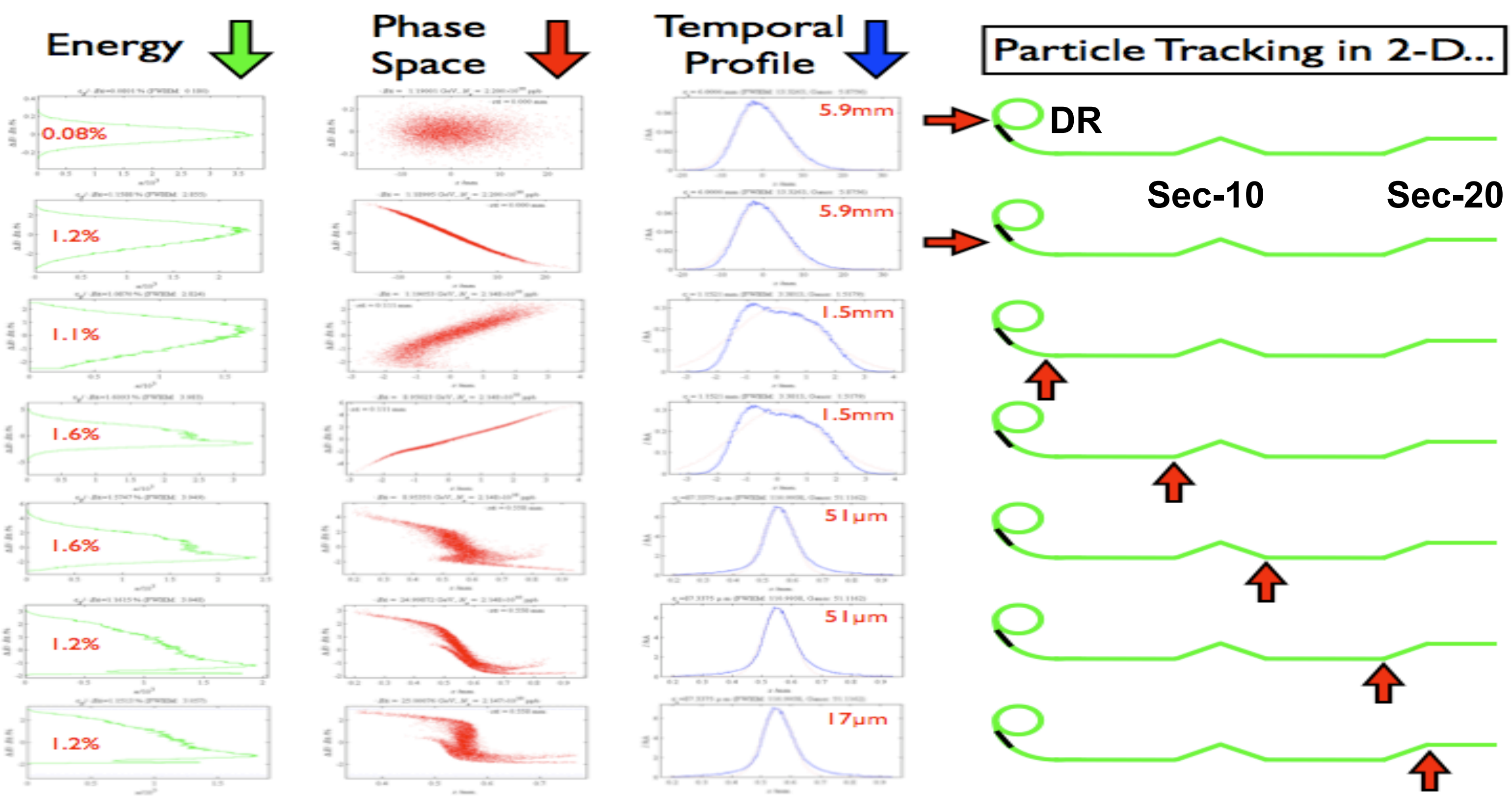


Design Parameters

	Design	Best Achieved
Energy	23.0GeV	21.0GeV
Charge per pulse (e-)	3.2nC/2e10	3.2nC/2e10
IP spot size (σ_x,σ_y)	<20μm x 20μm	20μm x 23μm(30x30 typical delivery)
Pulse length at IP (σ_z)	<20μm	20+/-5μm
Repetition Rate	1-30Hz	1-10Hz

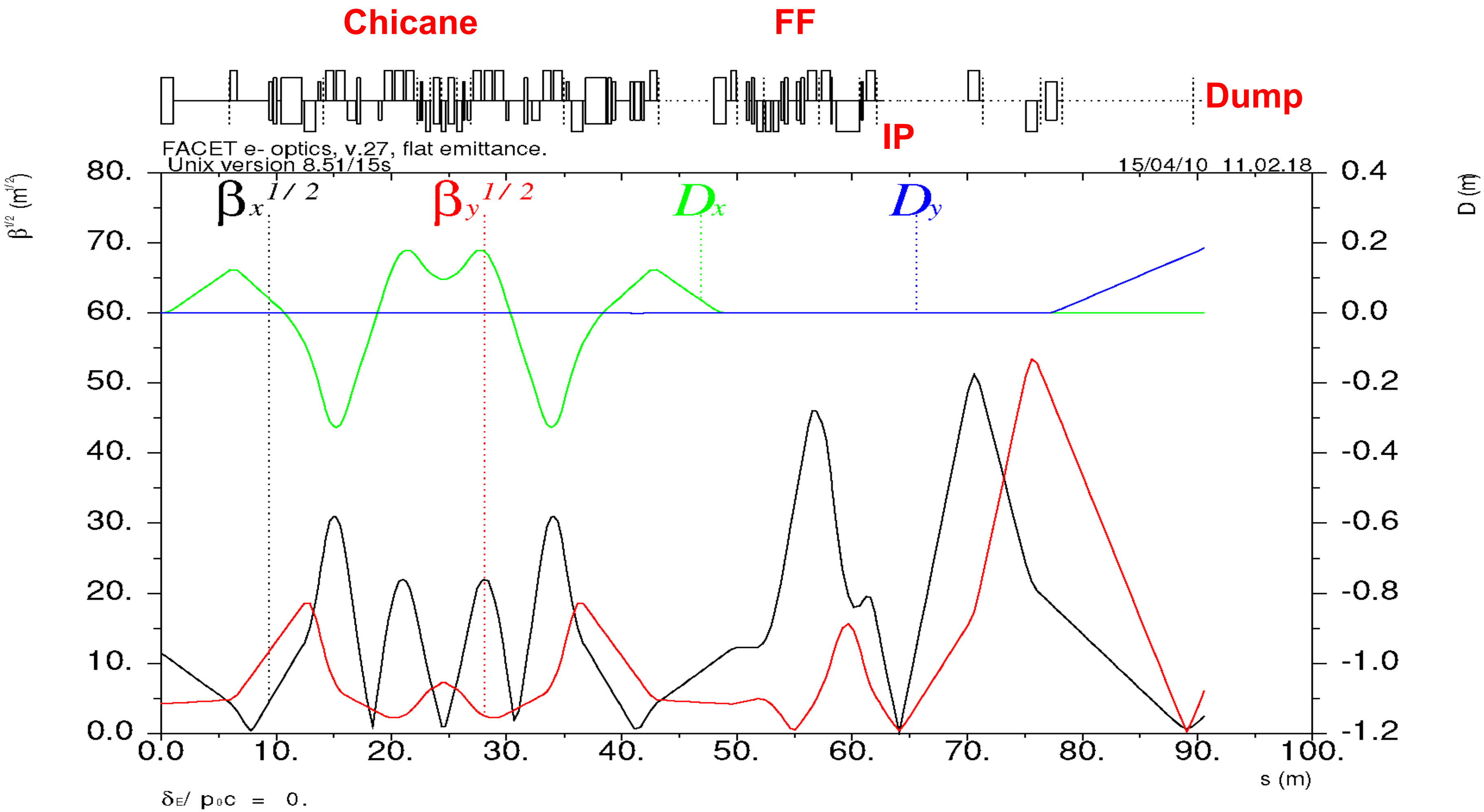
Three-Stage Bunch Compression

* Beam starts as 6mm from NDR, is over-compressed through the North Ring To Linac transport line (NRTL) to about 1.2mm. Sec10 chicane uses the RF-induced chirp from 2-10 to compress down to 50um and the final stage through the Sec20 chicane brings the beam down to 20um.



FACET Optics

* Beta functions and eta. Very strong lattice to achieve "unnatural" R56. 180deg beta phase shifts at waists makes 90deg corrector/BPM pairs difficult.



PREPARATION AND FIRST ACTIVITIES

Timeline of commissioning

Apr 2008
PEP-II turn-off
—linac
and NDR/
source off

Nov 2009
One month hot test
e- beam to e+ target

Jun 2011
First beam
to FACET
installation

Mar 2012
Commission
-ing run and
first users

Q1-08 Q2-08 Q3-08 Q4-08 Q1-09 Q2-09 Q3-09 Q4-09 Q1-10 Q2-10 Q3-10 Q4-10 Q1-11 Q2-11 Q3-11 Q4-11 Q1-12 Q2-12

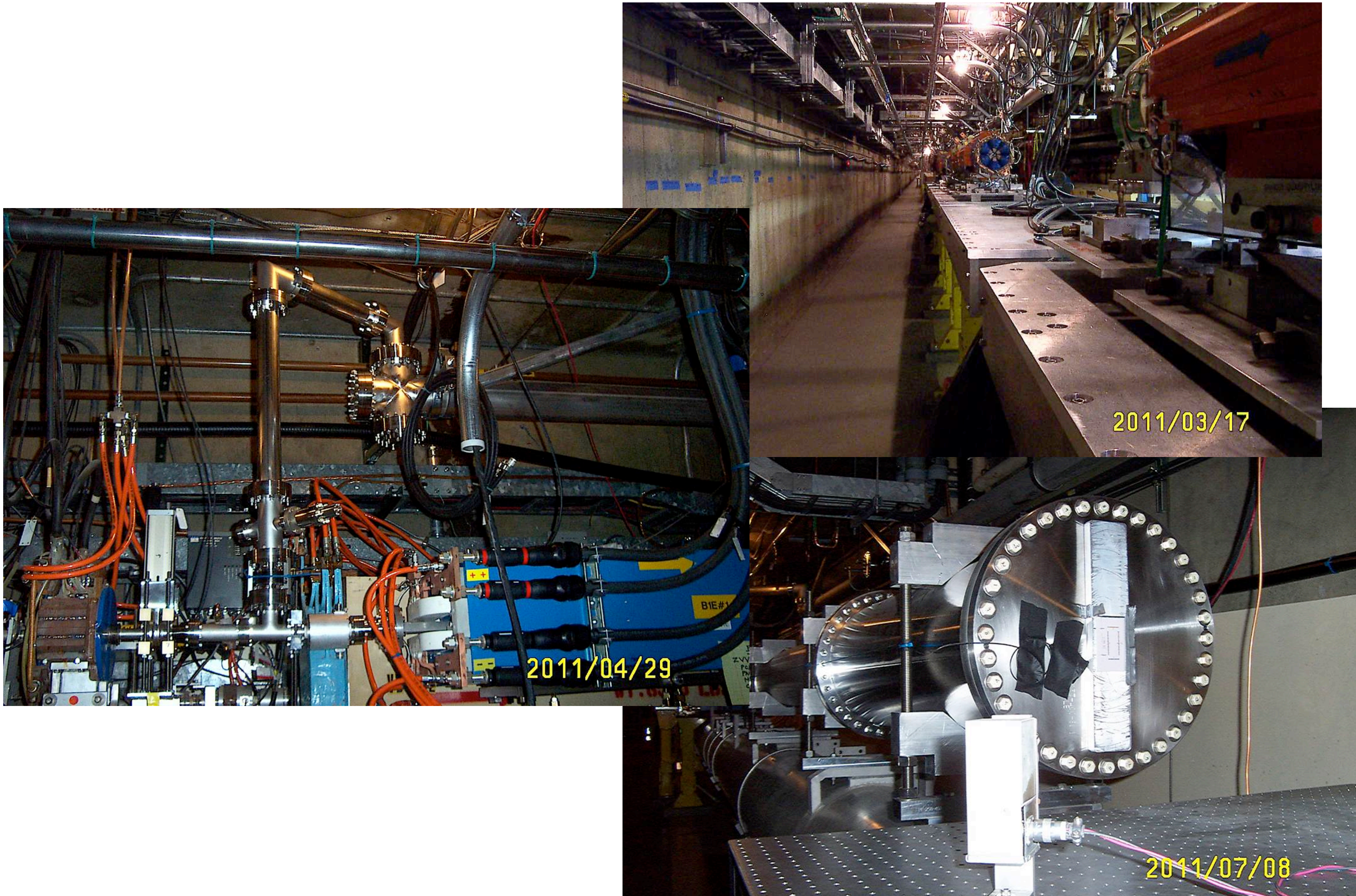
Installation activities

Very minimal
maintenance during
this period.

Identified and
corrected water leaks,
vacuum issues, etc.

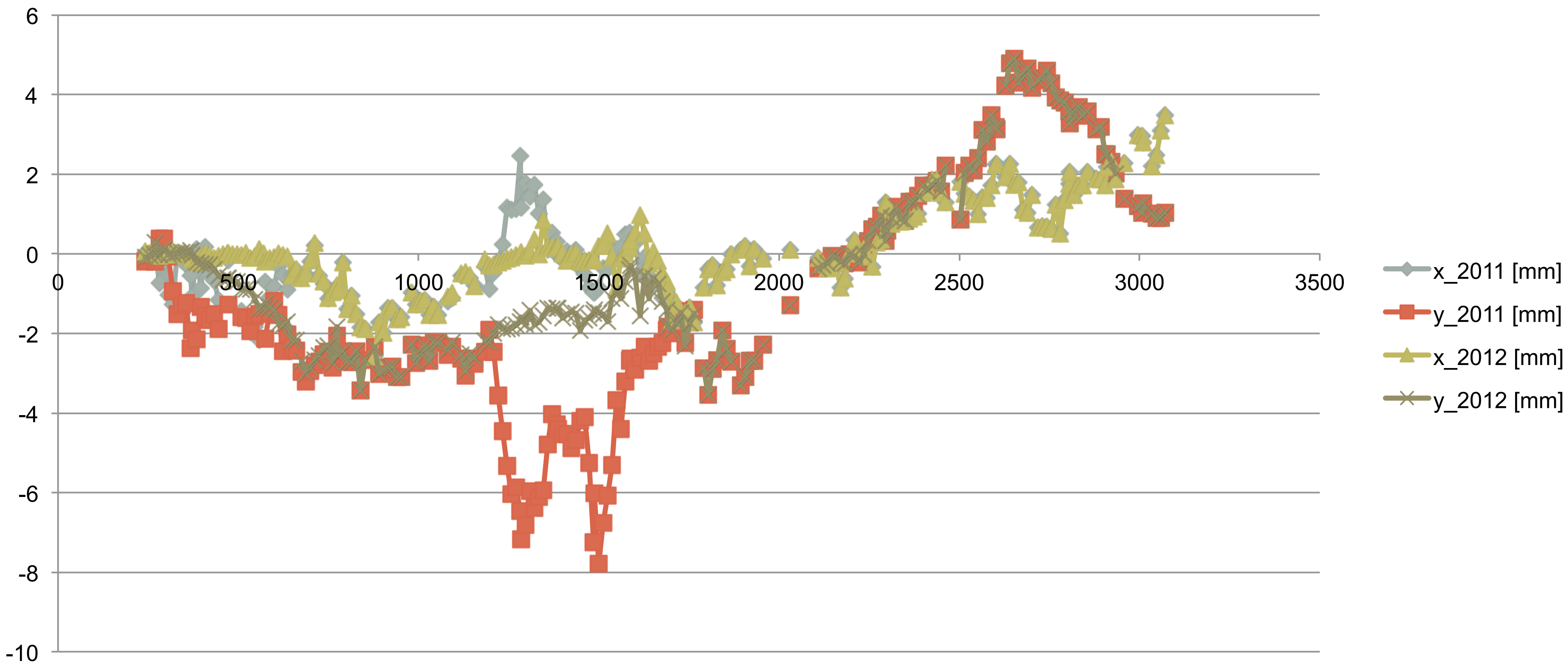
Identified problem
areas and diagnostics
needed for 2012
commissioning/user
run.

The Installation



Linac alignment

* The 50year old 2-mile long SLAC linac has a known rate of sag where areas were backfilled during the original construction. An aggressive plan of re-aligning sectors 2-20 took place during the late months of 2011. (and reviewed again in 2012)

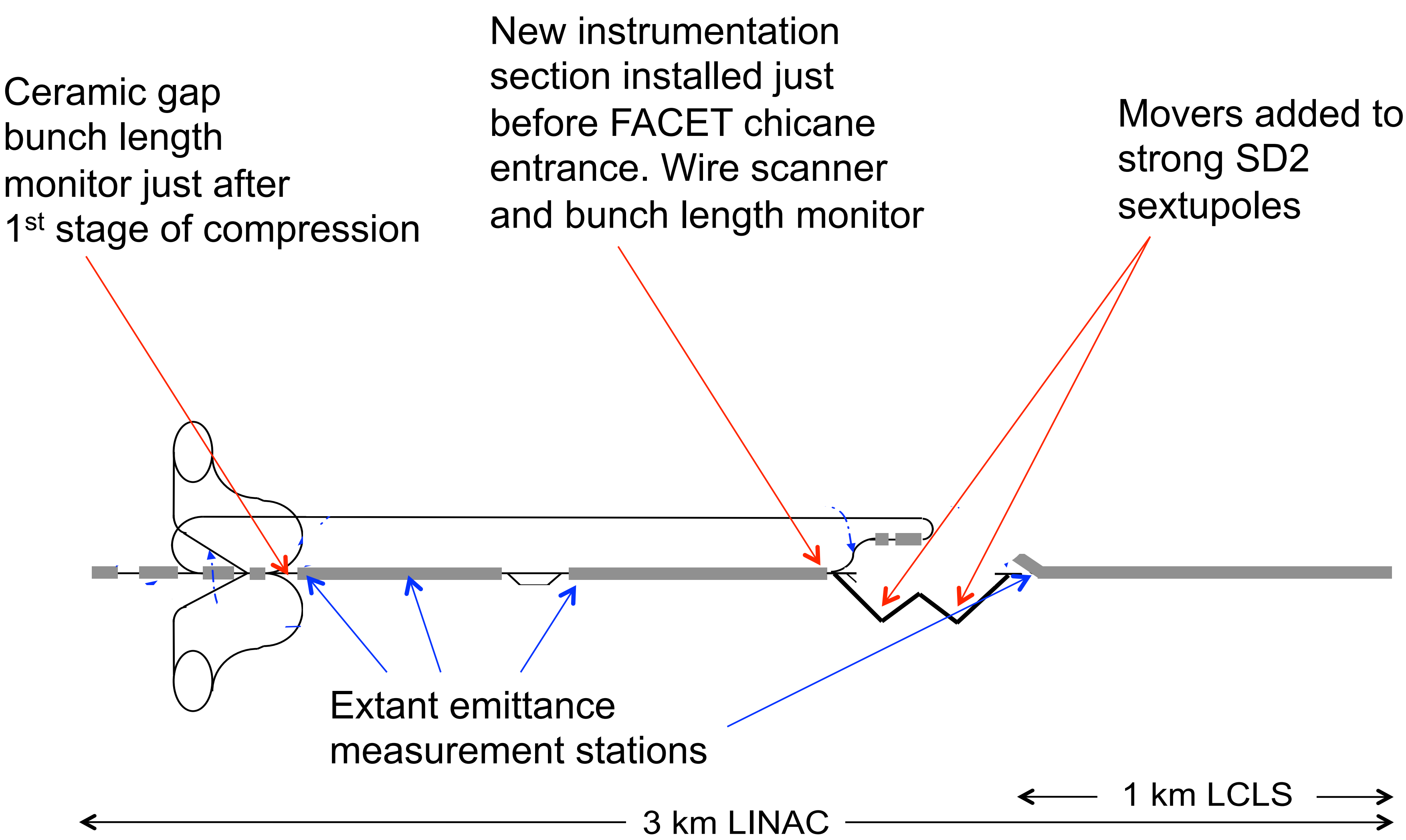


FACET Misalignment, BBA, and Ballistic data

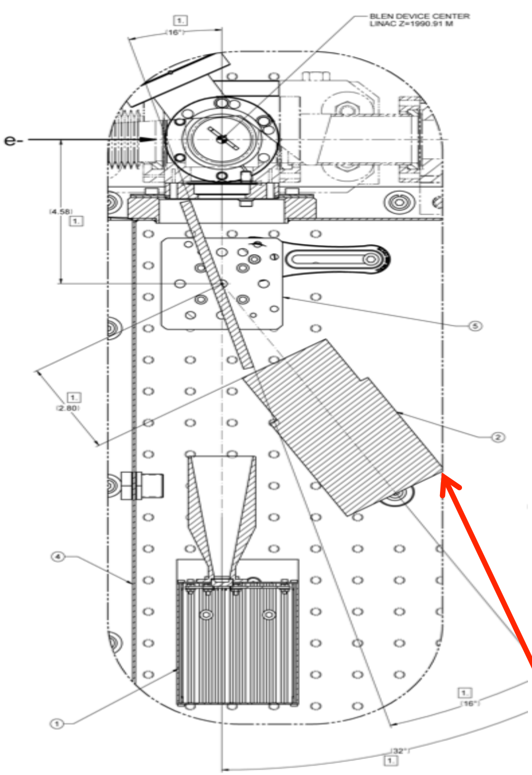
SLAC NATIONAL ACCELERATOR LABORATORY

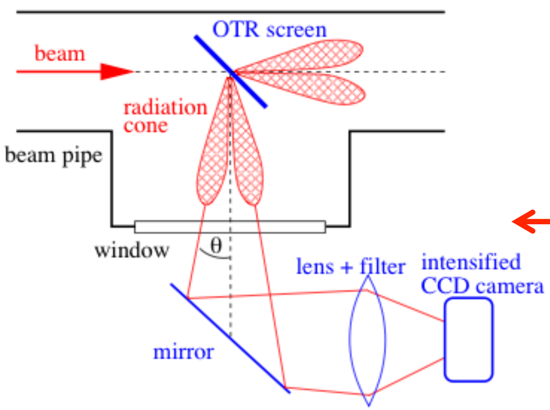
- During the 2011 commissioning run, several rounds of BBA performed.
- Ballistic data was collected with low intensity, low energy-spread beam.
- The convolution of these two data sets led us to find several areas where the vacuum chamber was mis-aligned wrt the magnets (which had already been aligned to tolerance).
  - A program of shimming, bracing, and aligning the vacuum chambers was undertaken.
  - Beam loss was much reduced in 2012 commissioning run.

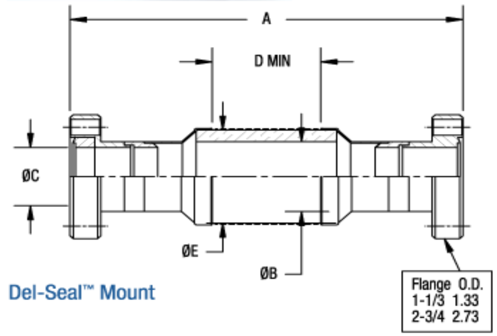
New Hardware



New Hardware

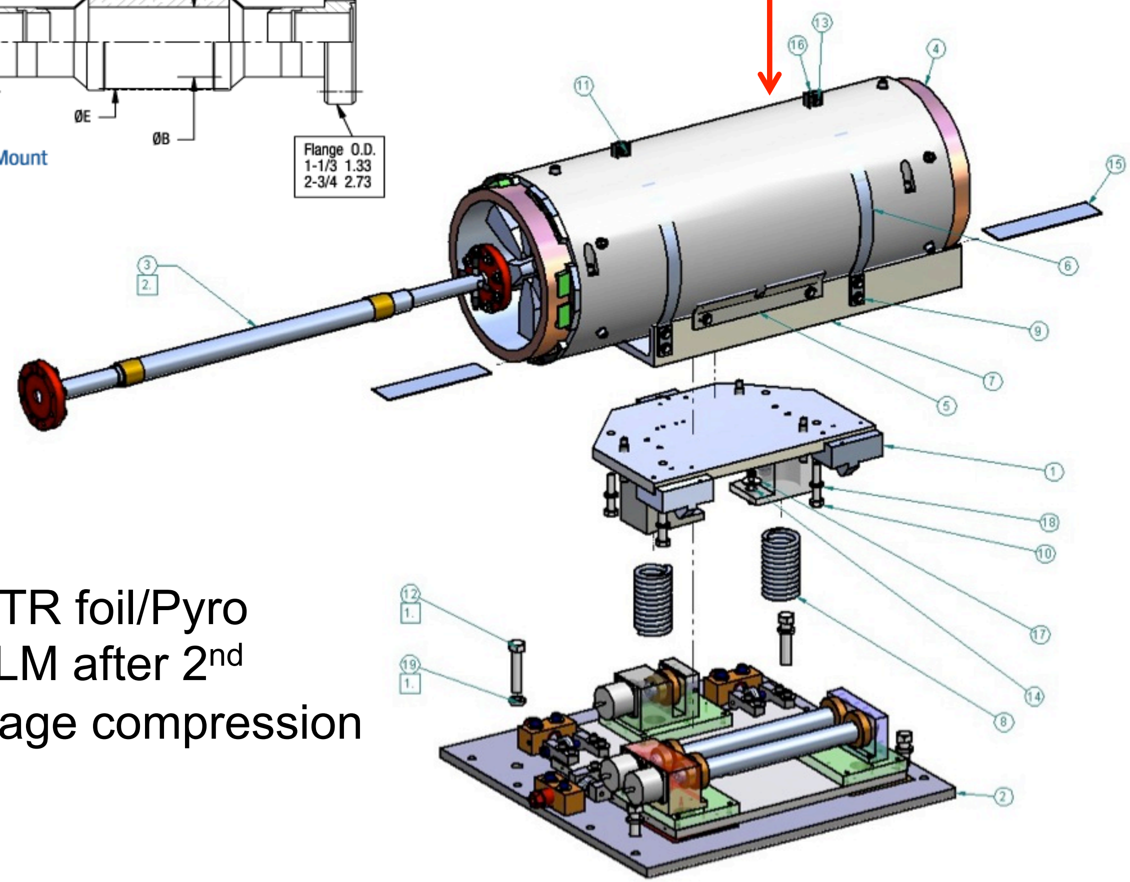






Ceramic gap BLM after 1st compression

Movers added to strong SD2 sextupoles



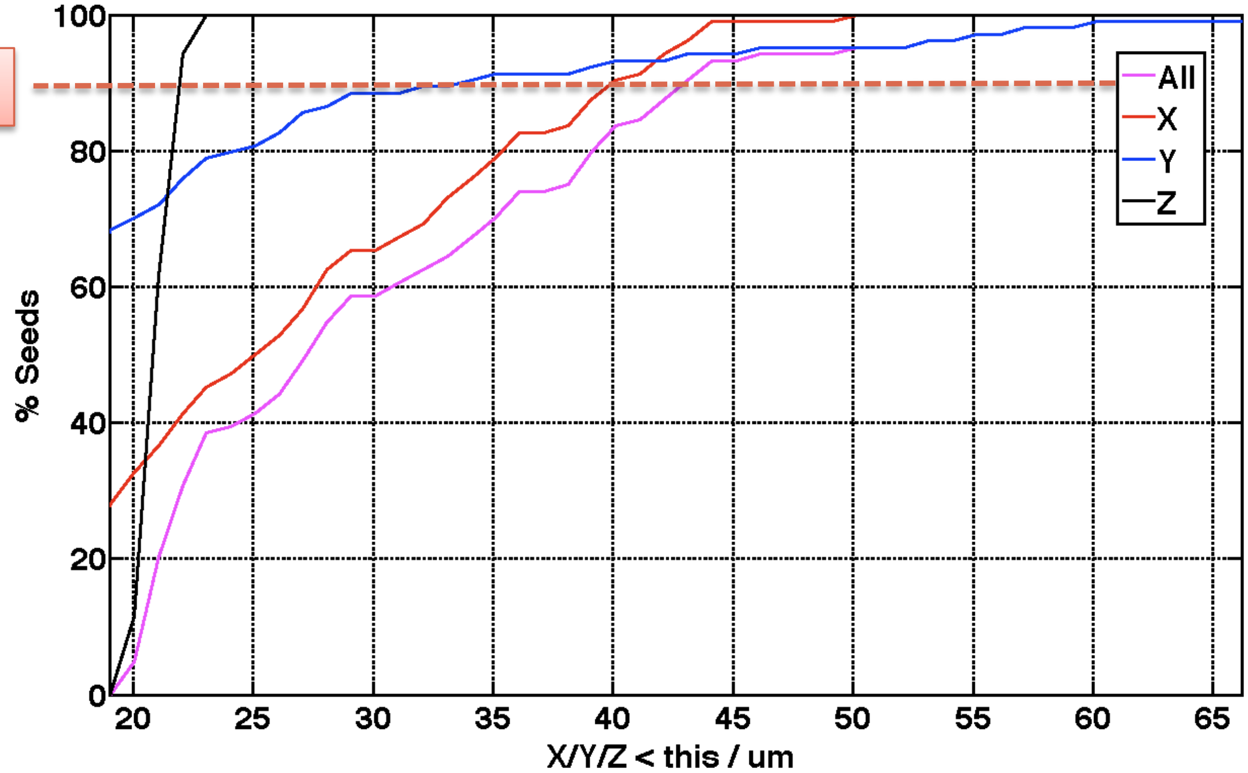
OTR foil/Pyro BLM after 2nd stage compression

Simulations & Software

* Tuning techniques and procedures were developed using the Lucretia code (see following slide).
  – Simulation also shows how difficult design parameters are to achieve.
* Longitudinal sensitivities simulated for the new bunch-length devices in LiTrack and Elegant.
* New software developed from experience of 2011 run and additional codebases.
    - BBA GUI
    - Eta GUI
    - Klystron phasing GUI
    - etc.
  – Focus is on reproducibility of results and ease of use.
  – Many tools adapted from extant LCLS physics software.

Lucretia Simulations (G. White)

90% CL



Percentage of seeds that tune in simulation to less than the indicated size at the IP

Shown for all of X/Y/Z that tracks to below the indicated size, also for each dimension independently.

@ 90% CL

All < 43 um / X < 40 um / Y < 35 um / Z < 22 um

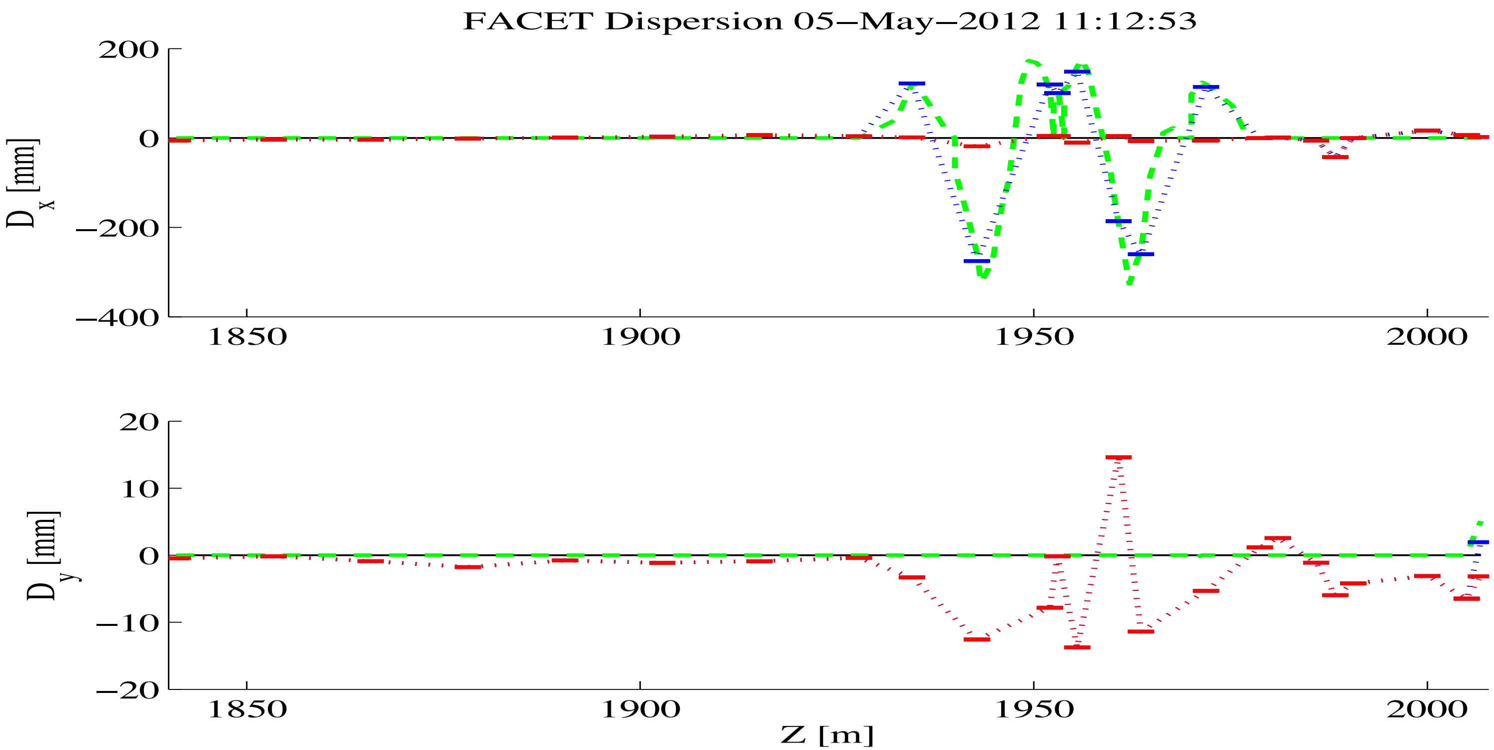
Reviews, Procedures, and Training

* Last commissioning run reviewed
* Dozens of procedures developed for both the initial startup settings of the accelerator as well as tuning techniques and measurements.
  – Data acquisition stream-lined
  – “Known” techniques canonized
  – All online for physicists and operations staff to reference
* Operations staff given comprehensive review of the physics and machine tuning techniques.

CHALLENGES AND SUCCESSES

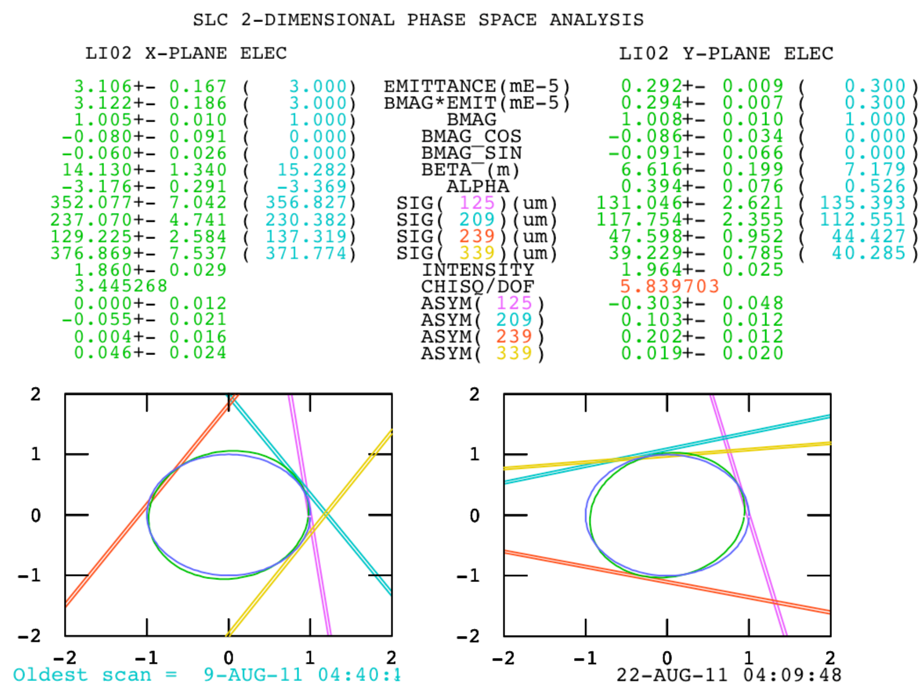
The Good

* Front end and NDR came up with little trouble after the extensive maintenance and tuning of the prior runs.
  – Provides the required intensity and phase-space density.
* Sextupole movers prove to be worthwhile investment
  – Dispersion in FACET chicane more controlled



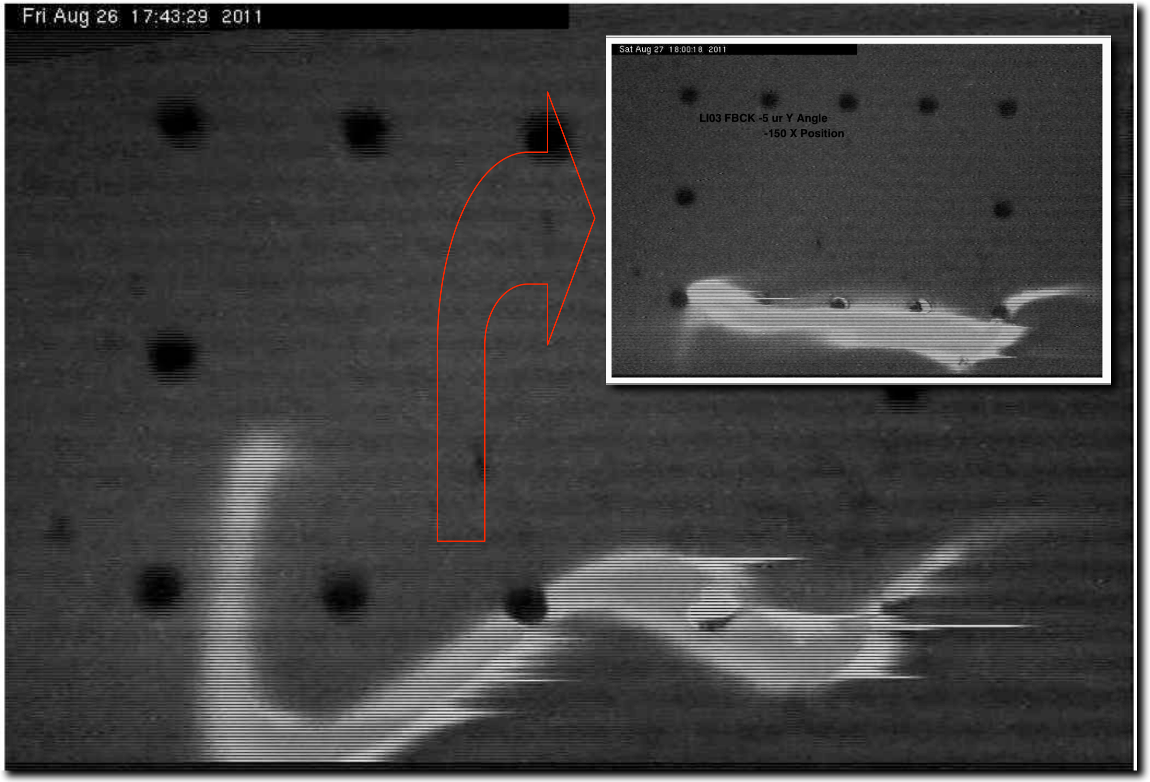
Longitudinal and Transverse

* Longitudinal setup robust.
  - New BLMs in Sec2 and Sec18 provide a finer level of control
  - See N. Lipkowitz—TUPPC052: Longitudinal Beam Tuning at FACET, these proceedings.
* Incoming linac emittance robust and relatively straightforward to achieve.
  - The NDR and NRTL perform admirably given their age.
  - However, the high charge, long bunch-length, and strong linac lattice makes this difficult to propagate…



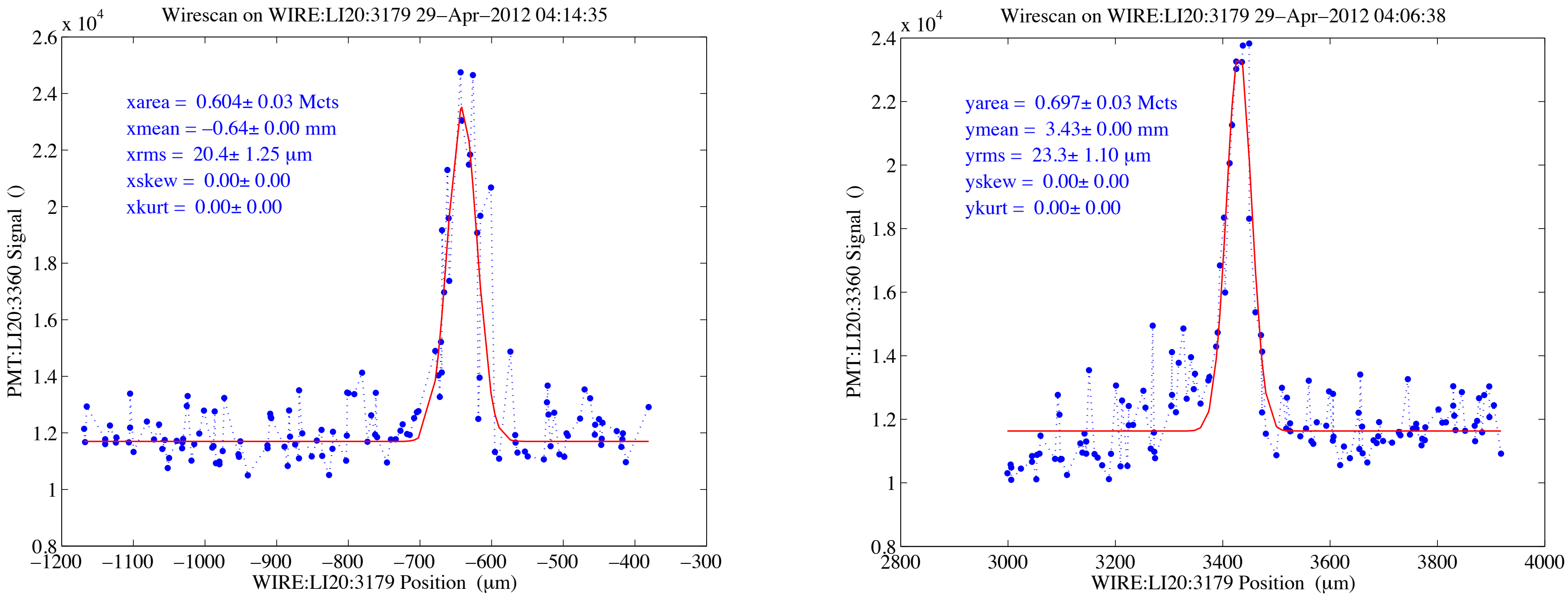
Linac Transverse Beam Size

- Wakefield and dispersive effects in the linac cause large beam blowup.
  - See FJ Decker—WEPPR040 Intensity Effects of the FACET Beam in the SLAC Linac, these proceedings.
  - Large tails can form in the linac, spoiling the emittance and causing background
  - New wire scanner helps diagnose this issue, but blowup is still persistent.



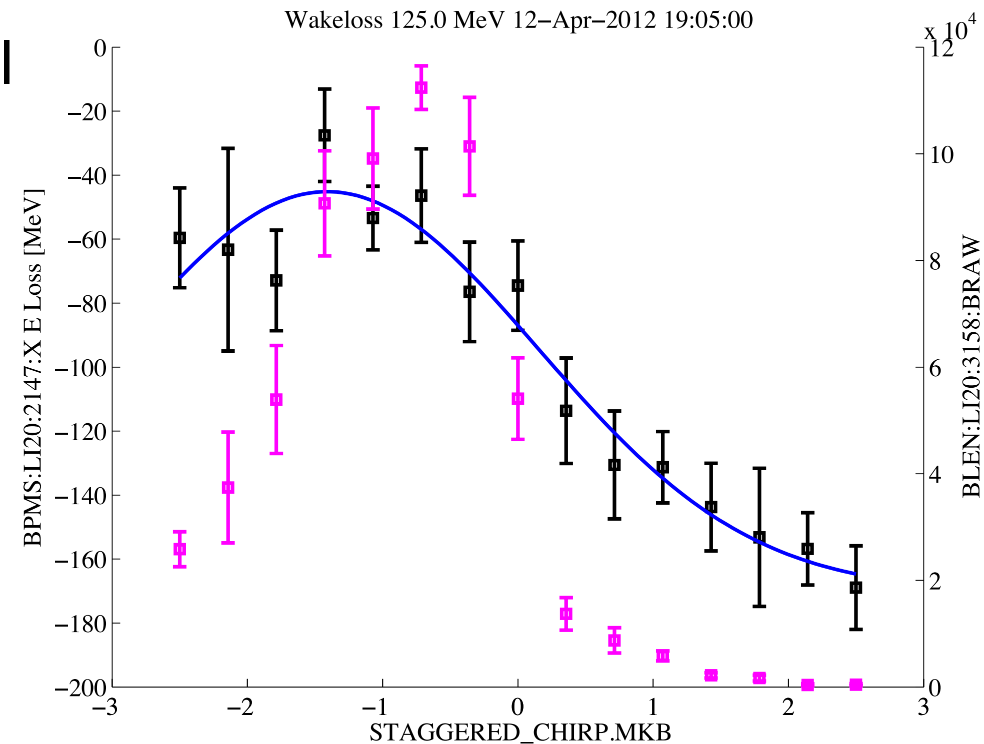
IP Transverse Beam Size

* We've achieved ~20 micron transverse spots on the IP wire, but difficult to maintain. Regular delivery to users is typically in the 30 micron range.



IP Bunch Length

- Wake-loss scans in the linac show about a 120MeV loss at 2e10 e-/bunch.
  - FFTB PWFA experiments showed about twice that with twice the linac to lose energy
- Initial scans from the Smith-Purcell experiment indicate a sigma_z of between 18-25 micron.
- Definitive measurement will be made once the X-Band transverse deflecting cavity (XTCAV) is commissioned.



* FACET is currently in the middle of user runs providing very high peak current beams at ~20GeV.
  - Plasma Wakefield Acceleration
  - Wakefield Acceleration in Dielectric and Metallic Structures
  - Materials and THz Studies
  - Bunch Length and Profile Measurements
  - See C. Clarke—WEPPP010: FACET: SLAC's New User Facility, these proceedings.

* Thanks to the commissioning team, Accelerator Operations, and the SLAC maintenance and engineering teams for the extraordinary effort in the re-commissioning of 2/3 of the SLC accelerator and the start-up of a new beam-line.

FACET Commissioning Team

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