Cornell University
Laboratory for Elementary-Particle Physics

Introduction to the CesrTA Program
ILCDR08 – July 8, 2008

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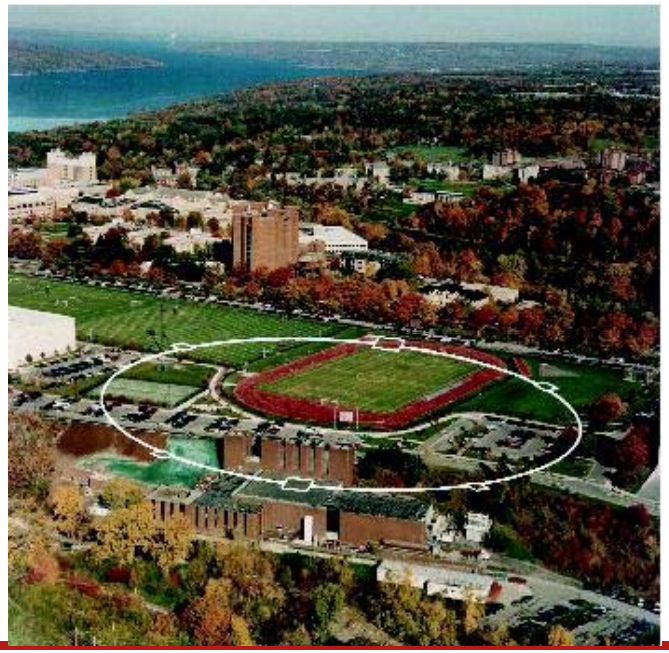
Cornell Laboratory for

Accelerator-Based Sciences and Education



Introduction

- CesrTA Program Overview
- Schedule
- R&D Program
  - Status
  - Collaboration
- Question and Answer Period

CesrTA Program I

- CesrTA project funding has been approved
  - Joint NSF/DOE funding
  - Funding spans FY08-FY10
  - Funding levels consistent with a 2 year experimental program
  - As of late February, funding agreements in place with NSF and DOE
- Note that this is a shorter experimental program than we had originally targeted

Targeted R&D in Original Proposal

ILC Damping Rings S3 Task Force – *Very High Priorities*

- Lattice design for baseline positron ring
- Lattice design for baseline electron ring
- Demonstrate < 2 pm vertical emittance
- Characterize single bunch impedance-driven instabilities
- Characterize electron cloud build-up
- Develop electron cloud suppression techniques
- Develop modelling tools for electron cloud instabilities
- Determine electron cloud instability thresholds
- Characterize ion effects
- Specify techniques for suppressing ion effects

Close collaborator involvement assumed in all areas (many expressions of interest obtained)

CesrTA Plan

- Original Plan
  - 2008-2009
    - Major focus on EC growth and suppression in wiggler, dipole and quadrupole chambers
    - Machine reconfiguration for ultra low emittance operation
  - 2009-2011
    - Work to achieve ultra low emittance operation (5-10 pm ε_y target)
    - Development of instrumentation to characterize ultra low emittance beams
    - Beam dynamics studies with electrons and positrons (EC and FII) as progressively lower emittances obtained
  - 2010-2011
    - Tests with ILC prototype chambers
  - Provide evaluations for the ILC EDR available in 2010
- De-scoped for a FY08-FY10 funding profile
  - Consistent with a 2 year experimental program

Low Emittance Parameters

Parameter	Value
$E^{\dagger}$	2.0 GeV
$N_{wiggler}$	12
B_{max}	1.9 T
ε_x (geometric)	2.3 nm
ε_y (geometric) Target	~~5-10 pm~~ → 20pm
$\tau_{x,y}$	56 ms
σ_E/E	8.1×10^{-4}
Q_z	0.070
Total RF Voltage	7.6 MV
σ_z	8.9 mm
α_p	6.2×10^{-3}
$N_{particles}$/bunch	2×10^{10}
$\tau_{Touschek}$	10s of minutes
Bunch Spacing	Multiples of 4ns and 14ns

† Operating range of 1.5 to 5.3 GeV

De-Scoped CesrTA Program

- Plan continues to emphasize
  - EC Growth and Instability Studies [G. Dugan Talk this afternoon]
  - Development of low emittance tuning techniques (target ε_y < 20pm) [D. Rubin talk this afternoon]
  - Development of x-ray beam size monitor to characterize ultra low emittance beams (1-D camera array) [J. Alexander/J. Flanagan talks during working group sessions]
  - Program to preserve a total of ~240 CesrTA operating days
- De-scoped items
  - Study of ion related instabilities and emittance dilution
  - 2-dimensional x-ray beam size camera upgrade
  - Contingency for:
    - Follow-up tests of alternative mitigation techniques
    - Tests of ILC prototype hardware
    - Further reductions in beam emittance, and further refinement of low emittance tuning methodology

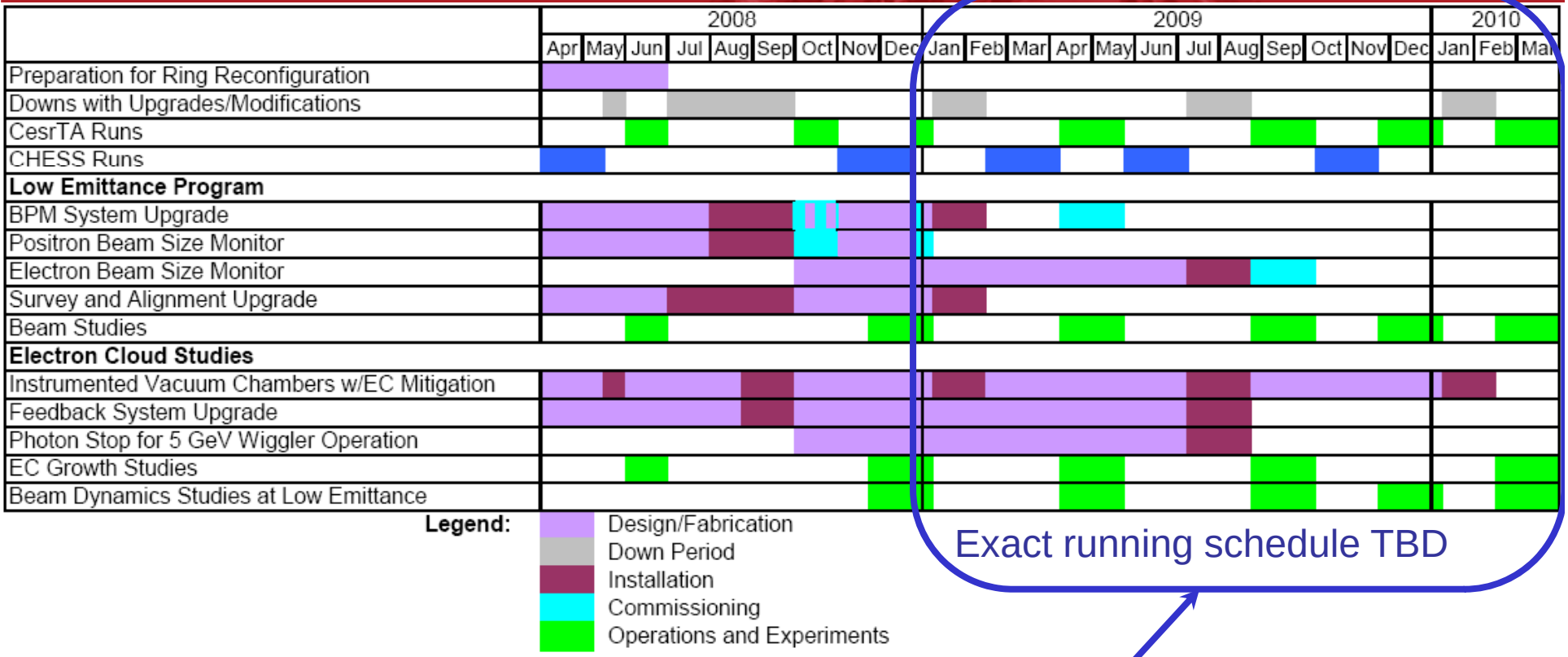
Impact of 2008 Funding Situation

- Impact on key collaborator support (UK & US)
  - Wiggler vacuum chamber design/construction
  - Chamber coating support
  - Simulation support
  - Low emittance tuning
  - Experimental support
- Layoffs and early termination of existing programs (CESR-c on March 3 & PEP-II on April 7)
- Some good news
  - KEK help with wiggler vacuum chambers ⇨ CU/KEK/LBNL/SLAC collaboration
    - Support via US-Japan funds and additional DOE funds
    - Construction underway at LBNL
  - Plans to transfer PEP-II EC experimental hardware, including diagnostic chicane and chambers, to CU to continue that program of EC tests

CesrTA Program II

- Down to reconfigure CESR ⇨ CesrTA has just started
- R&D Targets:
  - Now through mid-2009
    - Complete low emittance machine reconfiguration and upgrades
    - Deploy and commission instrumentation needed for low emittance program
    - Study EC growth studies in wigglers, dipoles, quadrupoles and drift regions in CESR
    - Initial EC mitigation studies
  - Mid-2009 through April 1, 2010
    - Work towards progressively lower emittance operation
    - Complete EC mitigation studies
    - EC beam dynamics studies at the lowest achievable emittances
    - Focus shifts much more heavily to experiment versus machine modifications
- Immediate focus:
  - Machine reconfiguration
  - Preparation/testing of EC vacuum chambers, vacuum diagnostics, and beam instrumentation

Schedule Overview



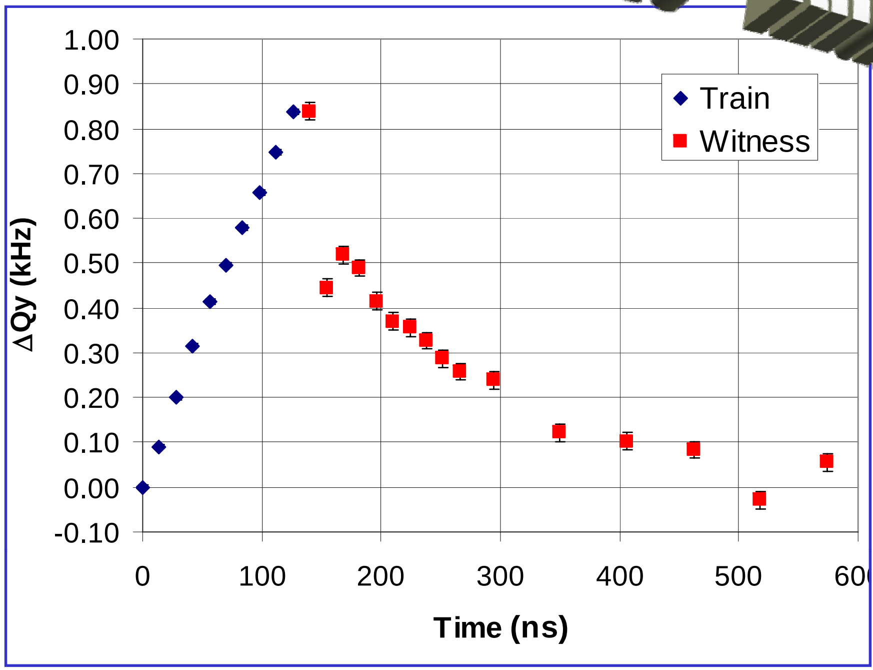
- Planned schedule as of early this year
  - Phased implementation of instrumentation
  - Phased installation of electron cloud diagnostics and support hardware
- Some adjustments are being made
  - Avoid holiday running
  - Maximize efficient use of limited resources

Down 1 and Run 1

	2008									2009												2010		
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Preparation for Ring Reconfiguration																								
Downs with Upgrades/Modifications																								
CesrTA Runs																								
CHESS Runs																								

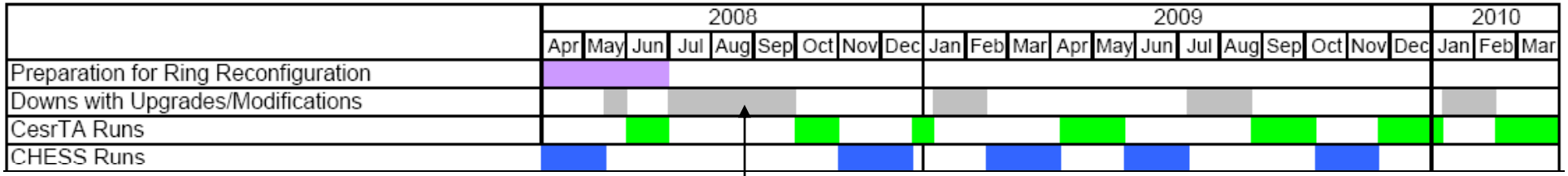
- Install instrumented CESR dipole and drift region chambers – segmented RFAs.
- Remove first wigglers from CESR Arcs

Done - Analyzing Data



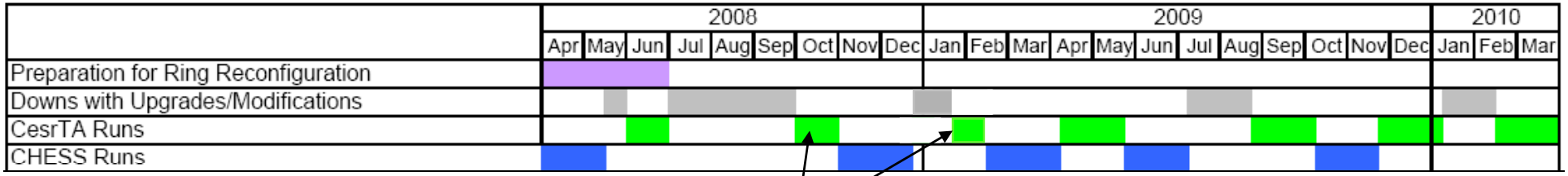
- Characterize newly installed diagnostics and cloud growth in CESR dipole chamber
  - Confirm operation of segmented RFAs
  - Explore other diagnostics (eg, microwave dispersion measurement w/LBNL)
  - Systematic growth studies versus beam parameters (bunch spacing,bunch charge, energy)
- Work with an intermediate emittance (~7.5 nm) lattice
  - Start beam-based alignment program
  - Beam dynamics studies versus beam parameters (including witness bunch studies)
- Instrumentation tests/development
  - XBSM detector
  - XBSM optics tests
  - 4ns turn-by-turn BPMs

Down 2



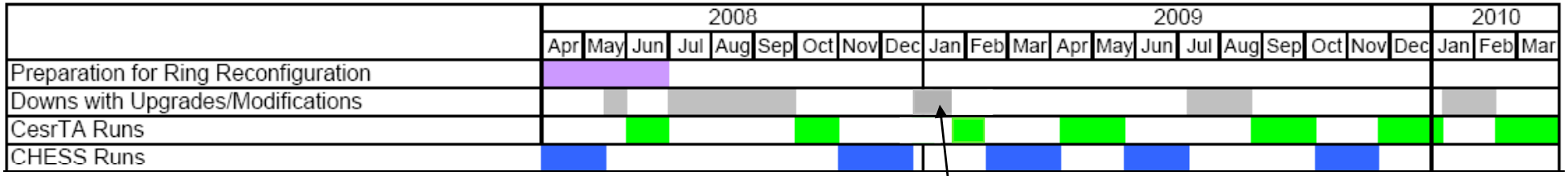
- Reconfigure CESR for ultra-low emittance
- Install positron xBSM optics line
- Start deployment of new BPM system
- Upgrade survey network and alignment hardware
- Install instrumented vacuum section in L0 (CLEO IP)
- Remove wigglers from arcs and re-deploy in L0
- Deploy first instrumented wigglers in L0 (2?)
- Install instrumented vacuum system in L3 (CUSB IP)
- Deploy L3 diagnostic chicane?
- Deploy vacuum diagnostics with with wiggler replacement chambers in CESR arcs
- Complete upgrade of transverse feedback system for 4 ns bunch spacings

"Run 2"



- "Run 2" was recently split into 2 pieces, 2a and 2b
  - Accommodates CHESS request
  - Removes stress of a single long dedicated CesrTA run
  - Adds time to think between CesrTA periods
  - Exact dates in 2009 still undergoing discussion (eg, how long do we want the January '09 down to be? May want to add a short spring '09 down for some hardware installation)
- xBSM optics commissioning
- BPM system commissioning
- Beam-based alignment effort
- Test ultra low emittance lattice for first time
- Characterize electron cloud growth in chambers around the CESR ring (wigglers, dipoles and drifts)
- CESR down through the holidays to minimize power use and manpower limitations

Down 3

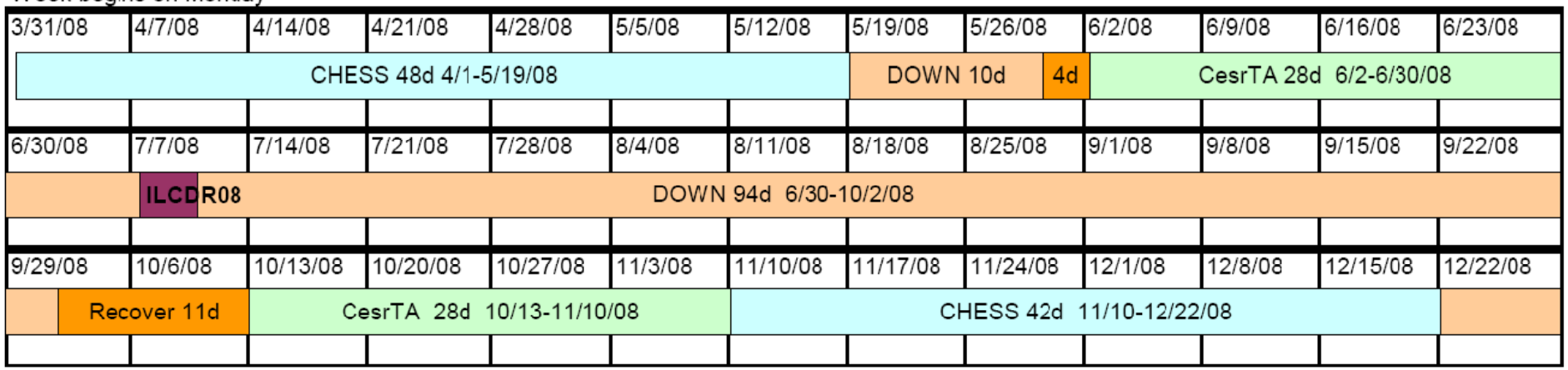


- Continue installation of instrumented vacuum chambers and chambers with EC mitigation techniques
- Finish deployment of new BPM system
- Continue upgrade of survey network and alignment hardware

Shift focus in mid-2009 from completing reconfiguration and upgrades to conducting experiments

2008 Schedule

Week begins on Monday



NOTES:

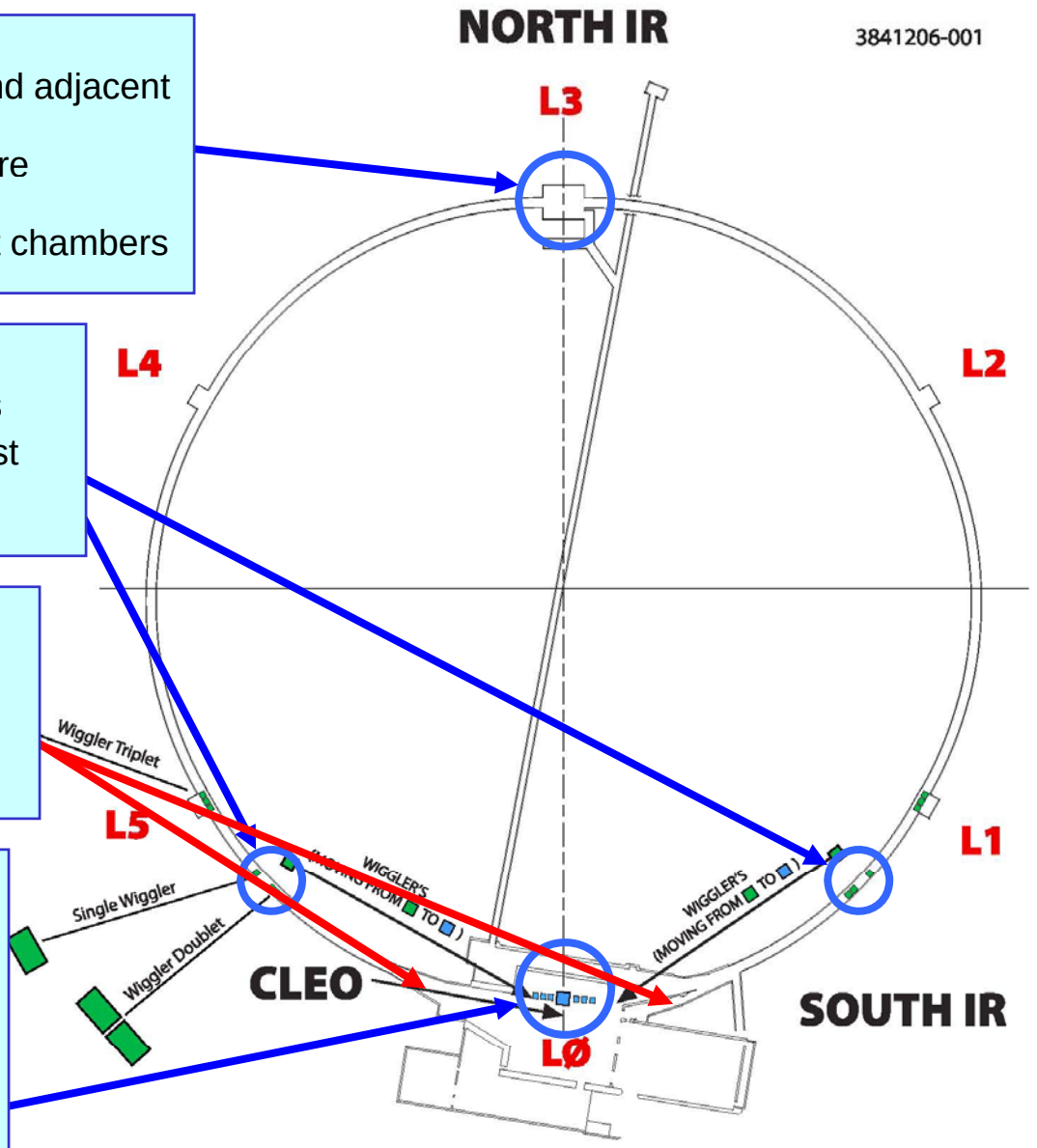
Calendar days are all inclusive - startup, production running, periodic access, machine studies, etc.

Down period recovery days shown in orange 4d

Transitions between activities assumed to be at 8 AM unless noted.

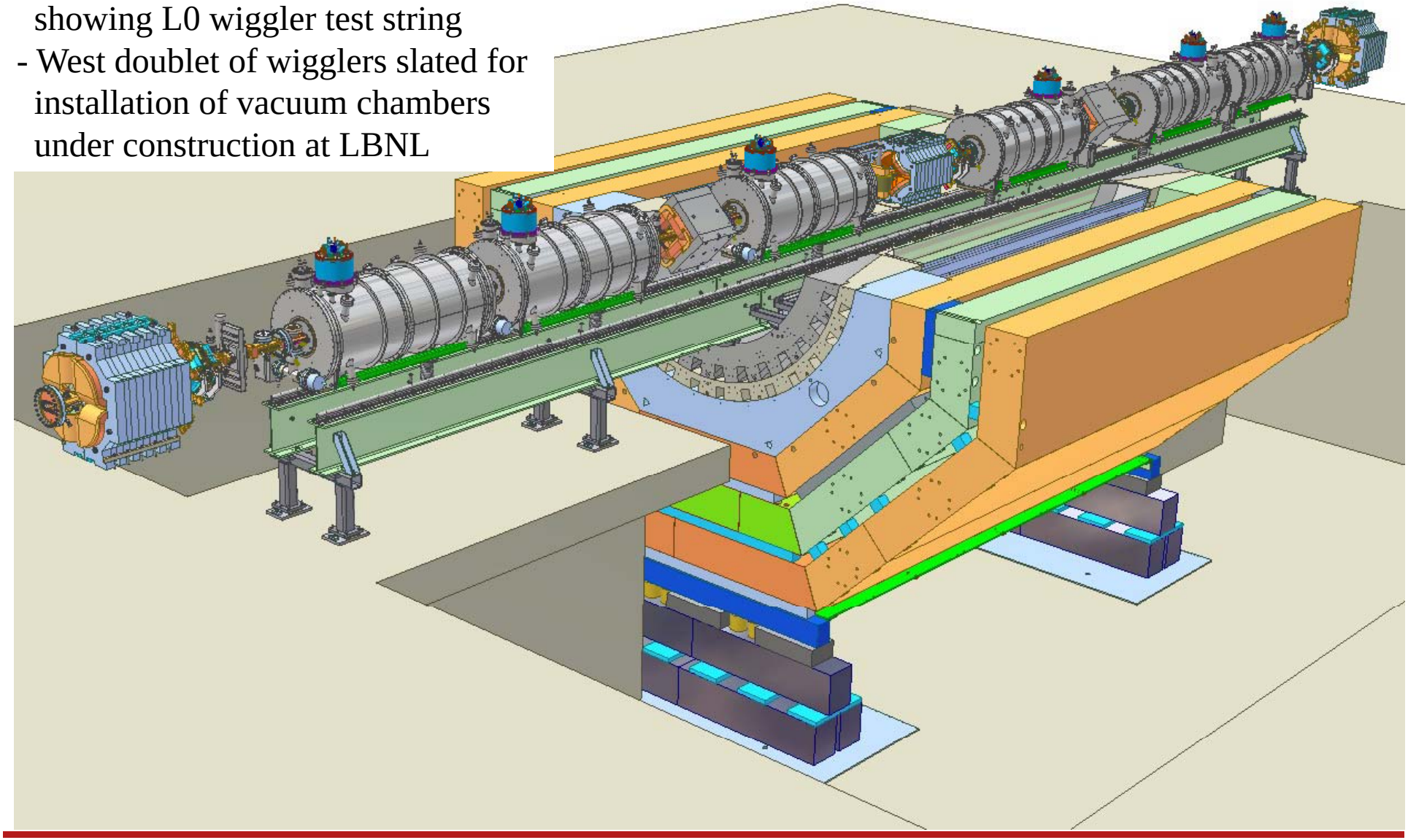
CESR Reconfiguration

- L3 Straight
  - Instrument large bore quadrupoles and adjacent drifts
  - Install of PEP-II experimental hardware (including chicane) in early 2009
  - Provide location for installation of test chambers
- Arcs where wigglers removed
  - Instrument dipoles and adjacent drifts
  - Provide locations for installation of test chambers
- CHESS line upgrades for x-ray beam size monitor
  - D-line this summer
  - C-line next year
- L0 Straight
  - All wigglers in zero dispersion regions for low emittance
  - Instrumented wiggler straight and adjacent sections

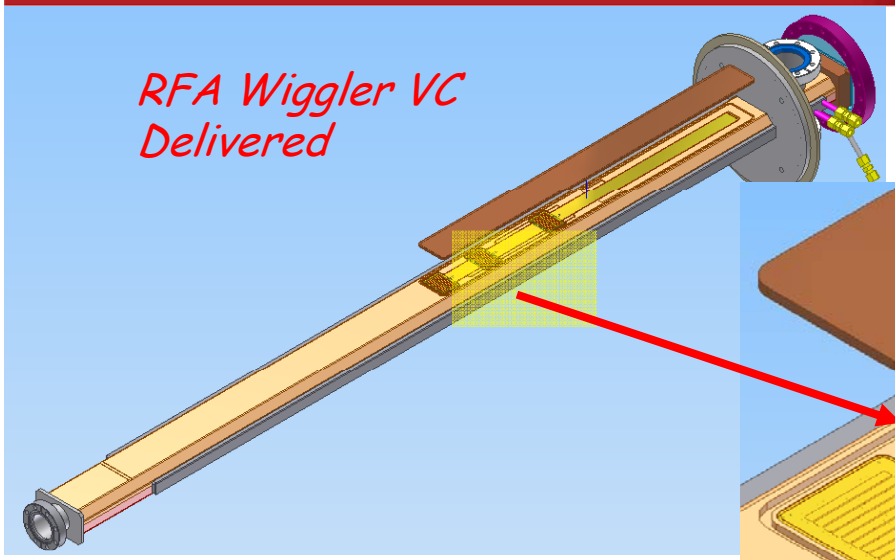


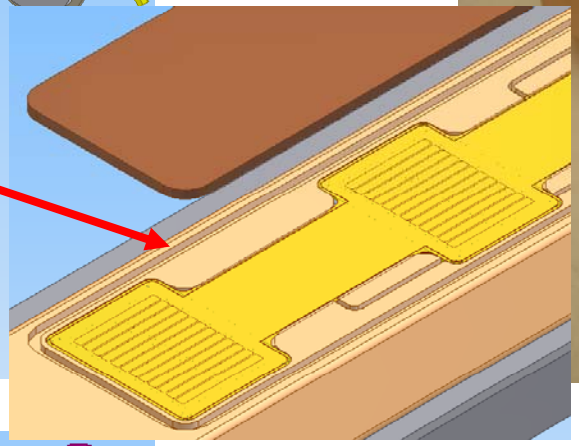
L0

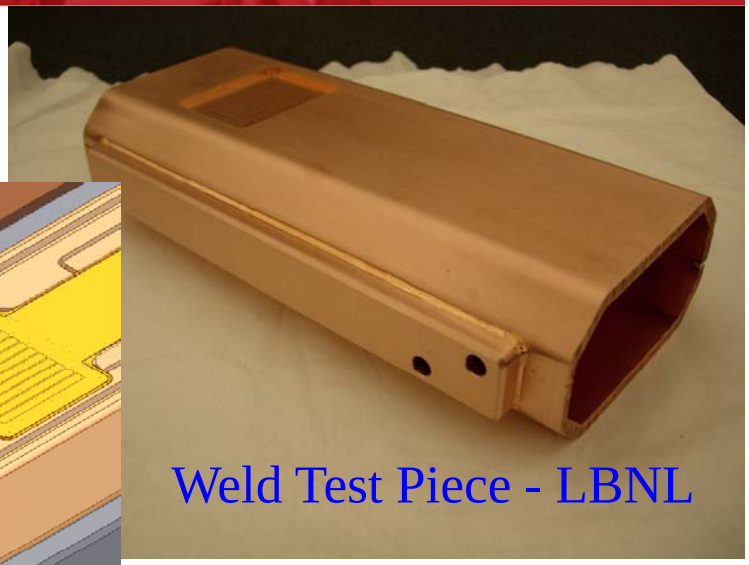
- Cutaway through CLEO iron showing L0 wiggler test string
- West doublet of wigglers slated for installation of vacuum chambers under construction at LBNL

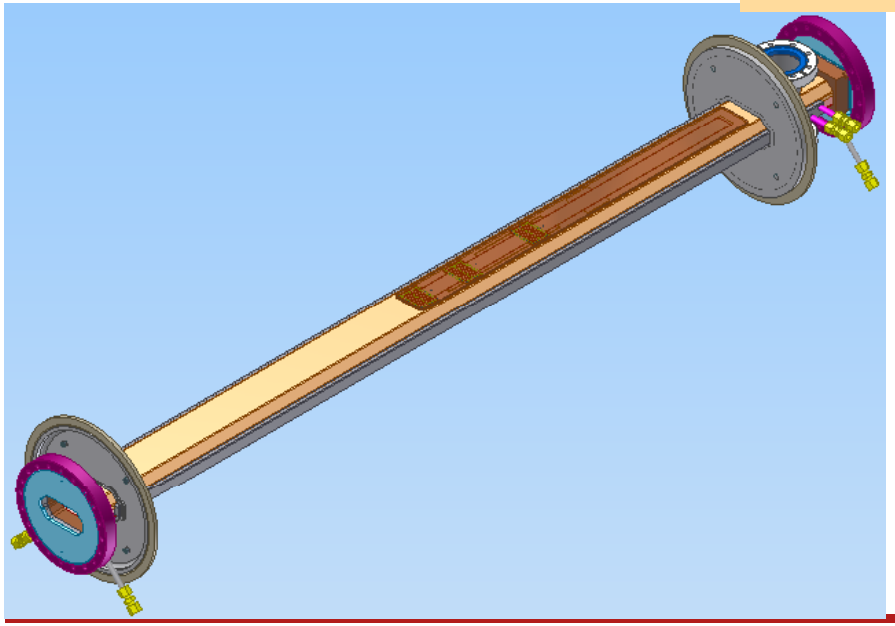


Chambers with Thin RFAs



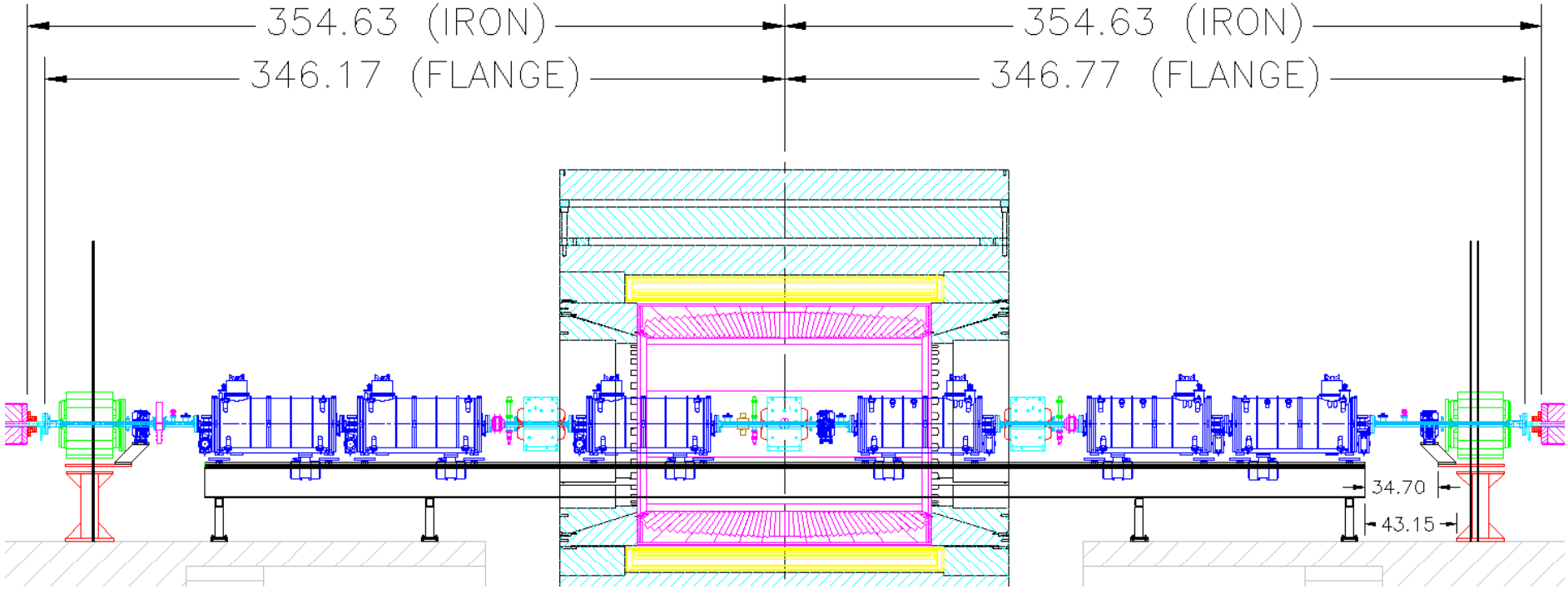






- Loss of US collaborators impacted development heavily
  - Cornell has picked up detailed design
  - Now ready for final design review
  - E-beam welding of first 2 chambers now complete at LBNL as part of CU-KEK-LBNL-SLAC collaboration

L0 Wiggler Region



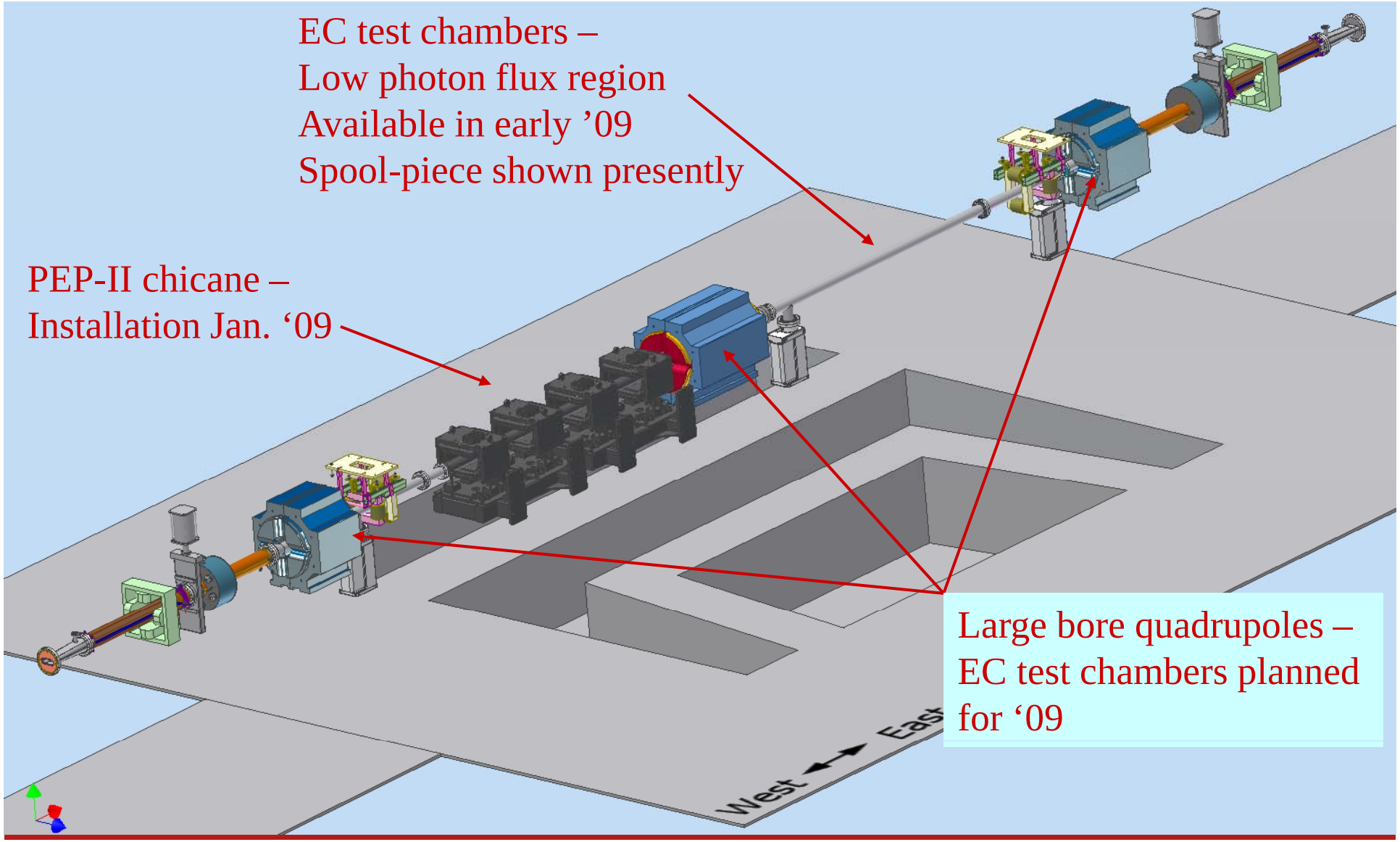
MAIN COMPONENT POSITIONS

- L0 wiggler experimental region reconfiguration underway
  - Installation during July-September down
  - Heavily instrumented throughout with vacuum diagnostics
  - First diagnostic wiggler vacuum chambers just back from E-beam welding at LBNL
- Note: Part of CLEO will remain in place
  - At present unable to remove full detector
  - Time savings

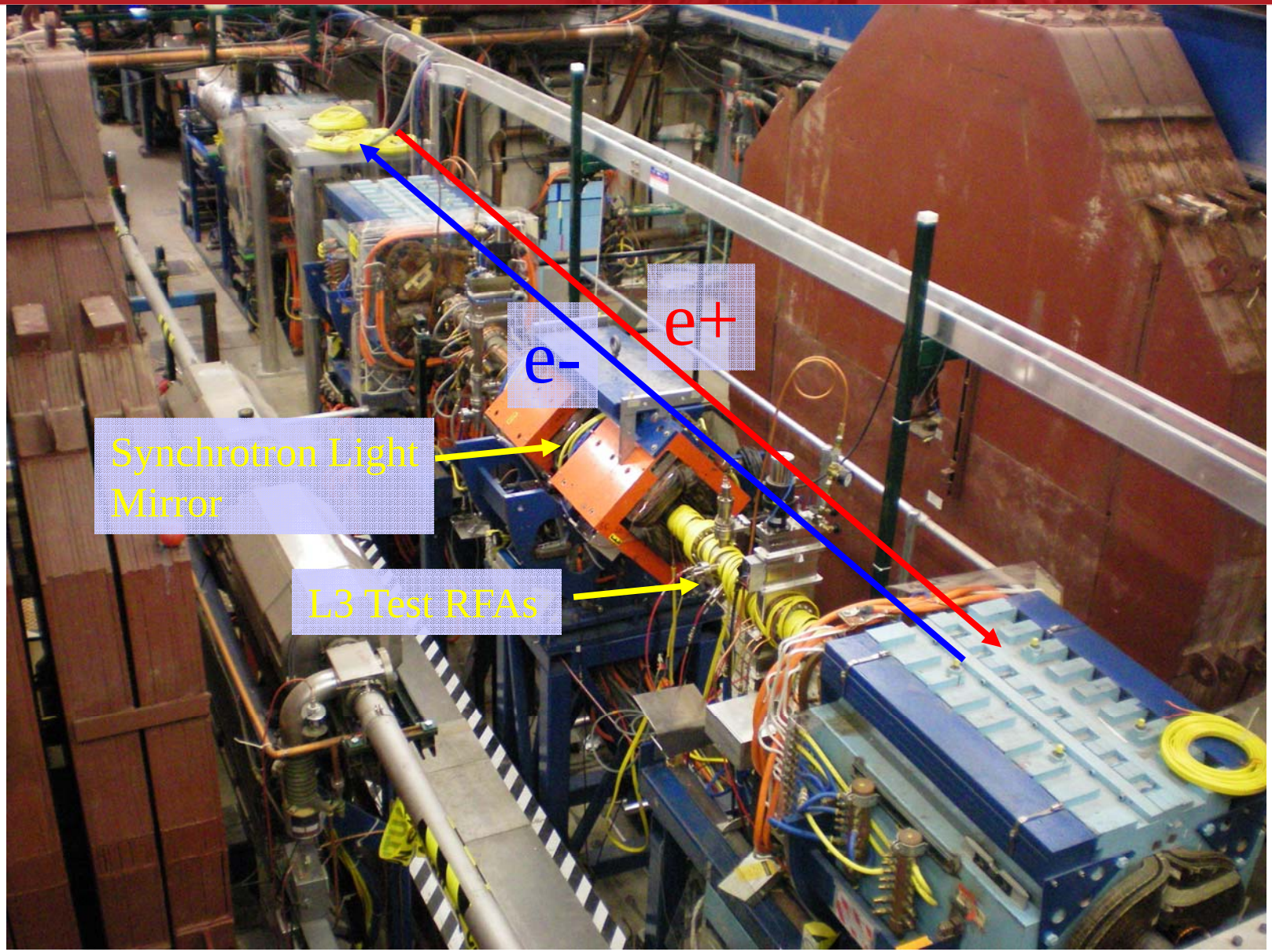
L0 Program Overview

- October 2008
  - Reconfiguration complete
  - First two instrumented wiggler chambers installed
    - One control chamber (uncoated Cu surface)
    - One chamber with TiN coating
  - Instrumentation support for a variety of EC experiments
- 2009
  - Further development based on results of initial tests
  - Follow-on wiggler chambers for additional mitigation tests (targeting chamber #3 to be constructed with a clearing electrode)
  - 5 GeV performance tests (requires addition of photon stop at end of L0 straight)

L3

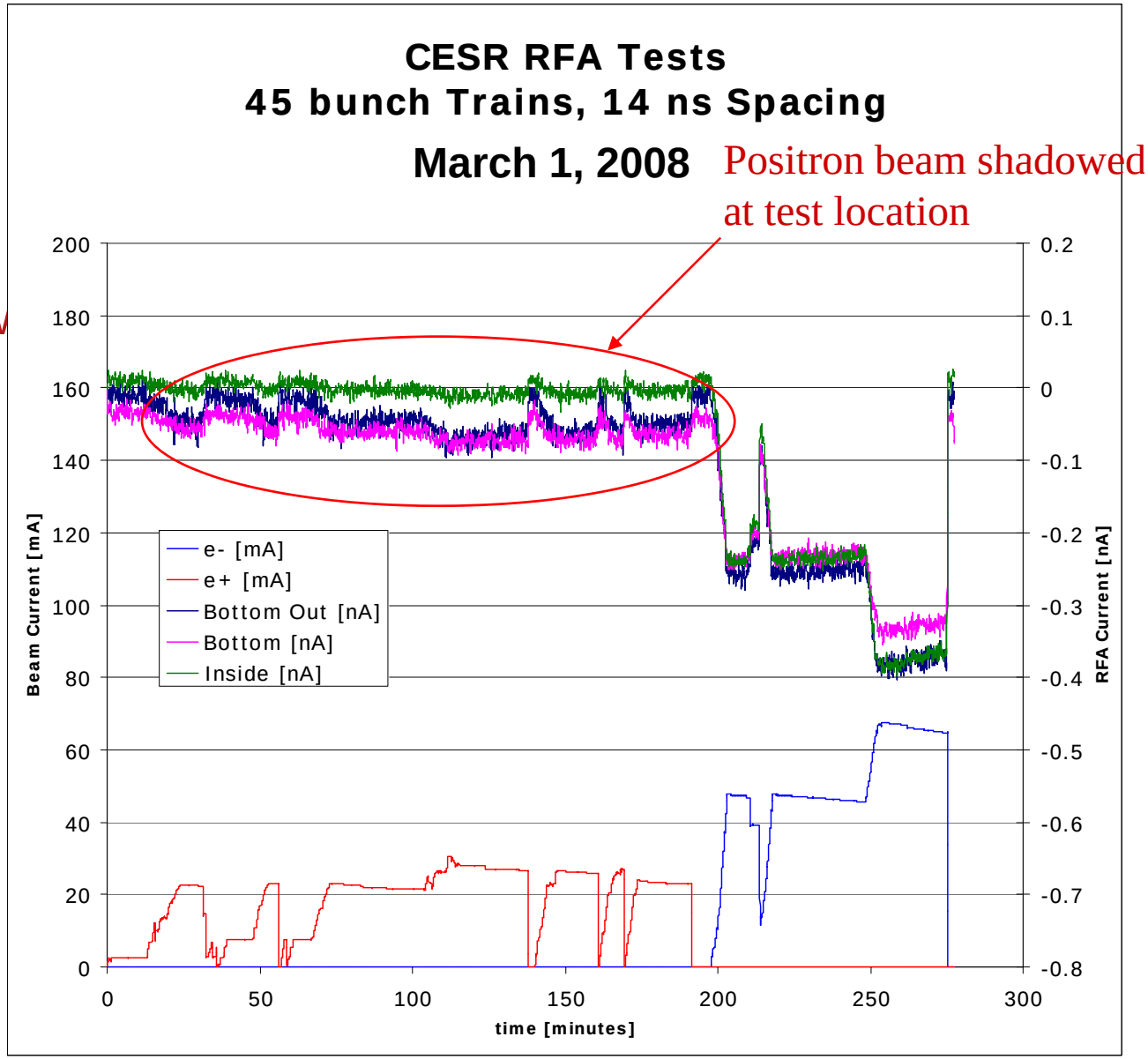

EC test chambers –
Low photon flux region
Available in early ’09
Spool-piece shown presently
PEP-II chicane –
Installation Jan. ‘09
Large bore quadrupoles –
EC test chambers planned
for ‘09
West
East

L3 Now



Retarding Field Analysers

- Prototype readout electronics for large channel count RFAs designed and fabricated based on these initial tests in low photon flux environment (~50pA resolution)
- Thin RFA structure performance comparable to APS-type RFAs
- First tests with segmented detectors (drift and dipole) now complete

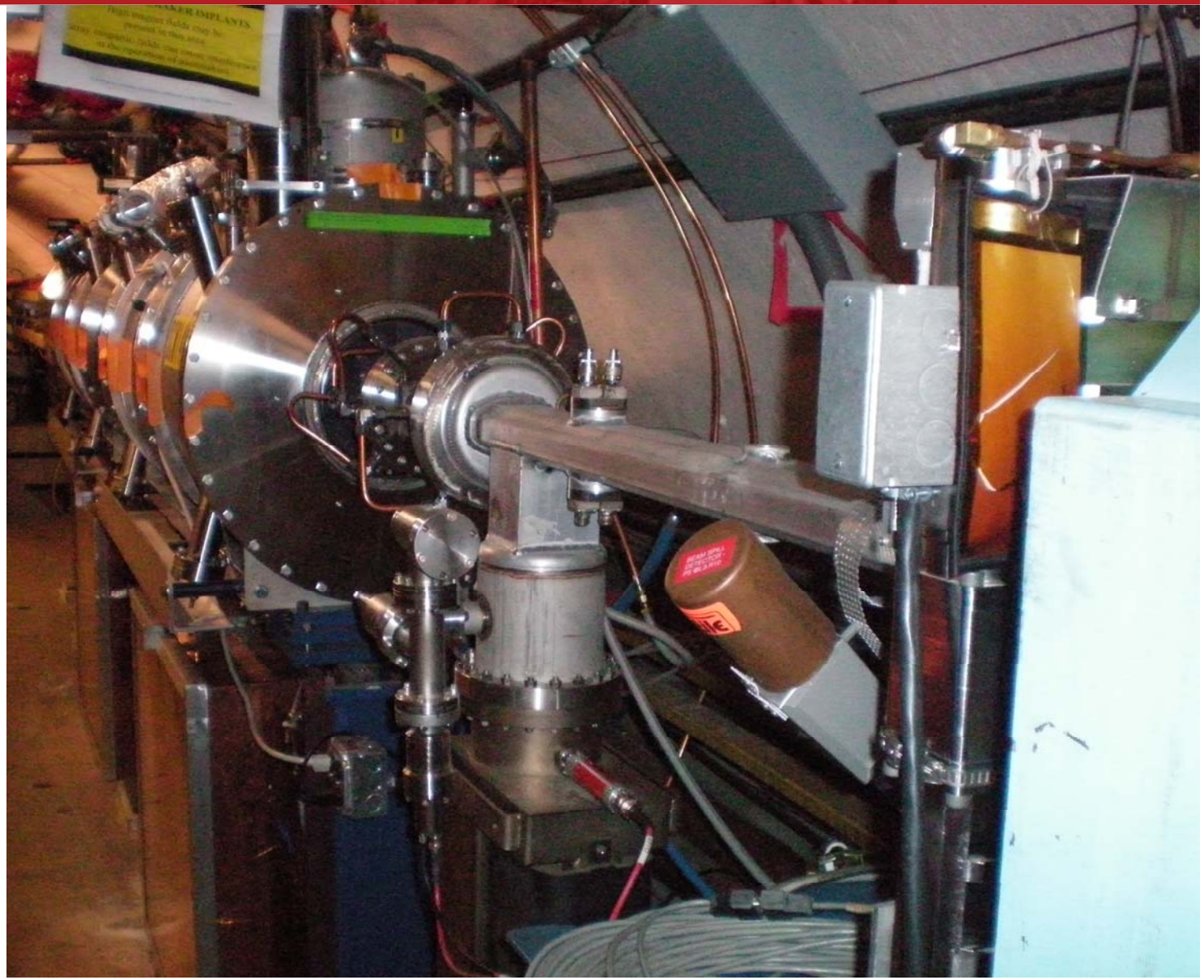


L3 Program Overview

- Schedule
  - Preparatory work during summer 2008 down
  - January 2009
    - Targeted for installation of PEP-II chicane
    - Targeted for installation of first test chambers
  - Mid-2009
    - Targeted for installation of instrumented quadrupole chambers
- Space available for collaborators starting in early 2009

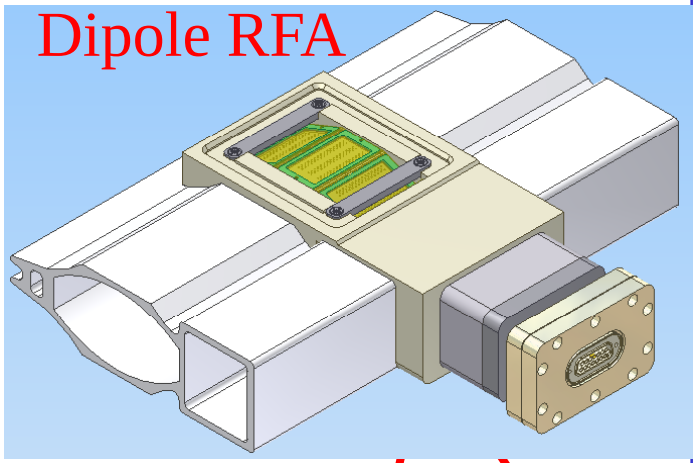
Arc Regions

- First step: Remove wiggler pairs
- Install instrumented chambers

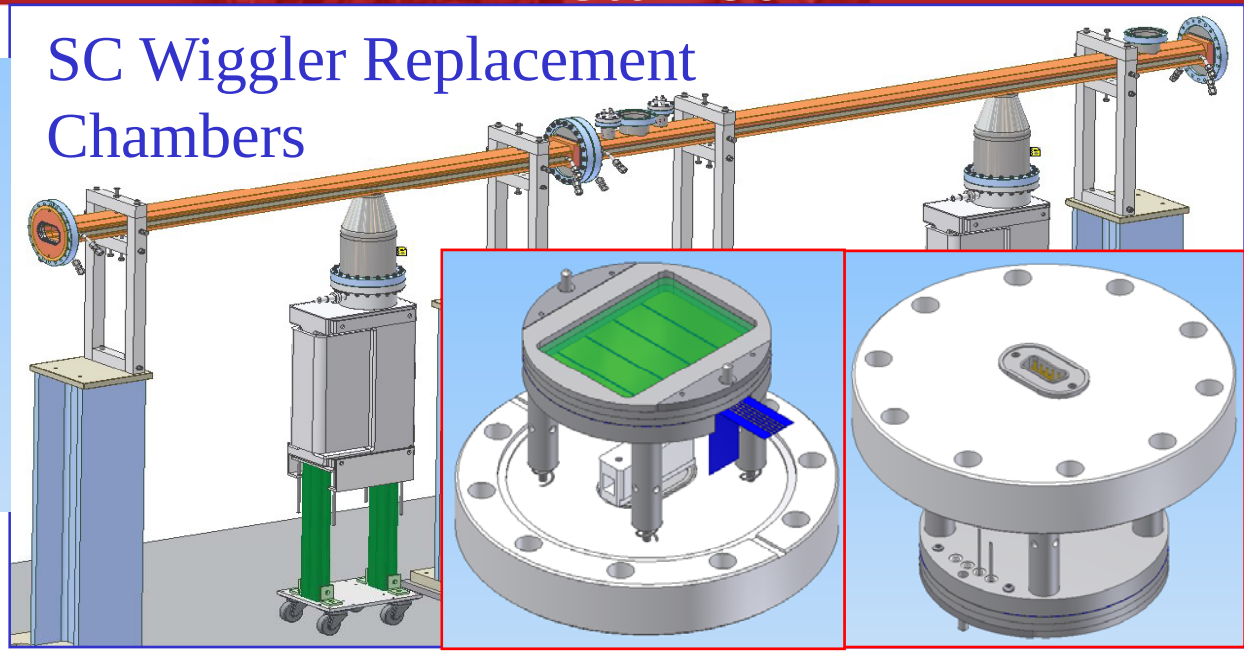


Instrumented Chambers Installed

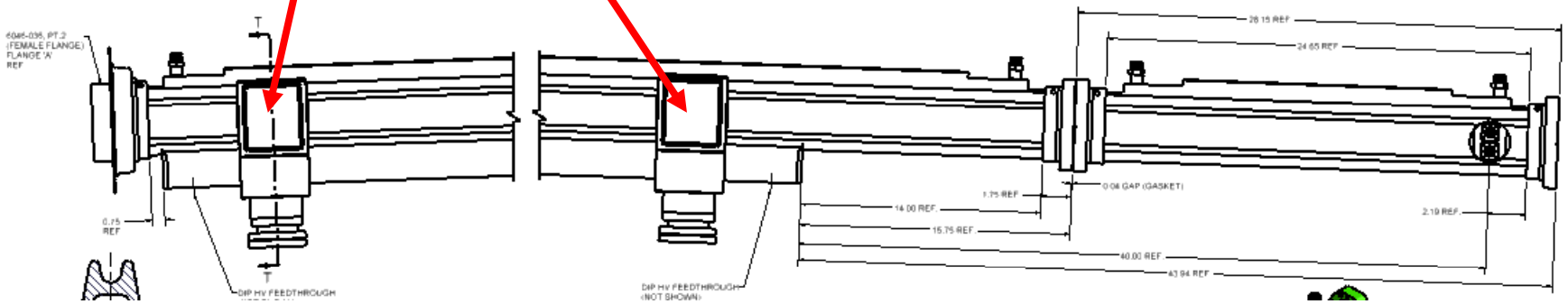
Dipole RFA



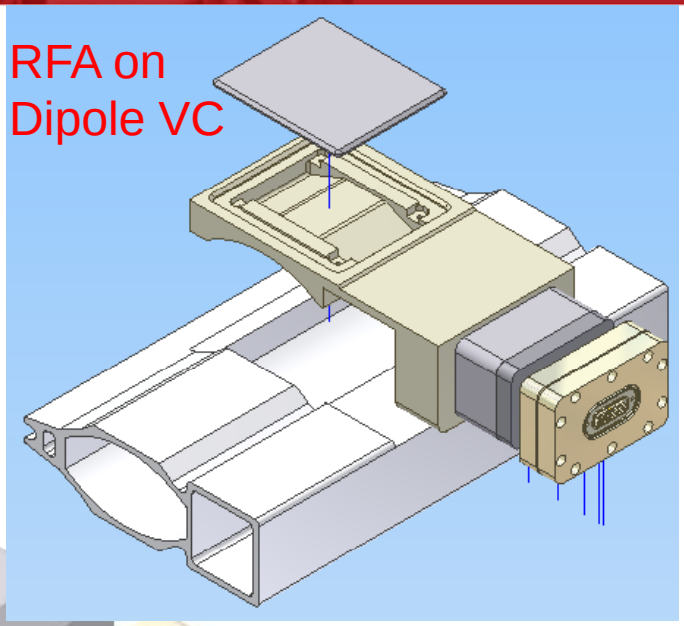
SC Wiggler Replacement Chambers



B12W Dipole Replacement Chamber



CESR Dipole Chamber RFA



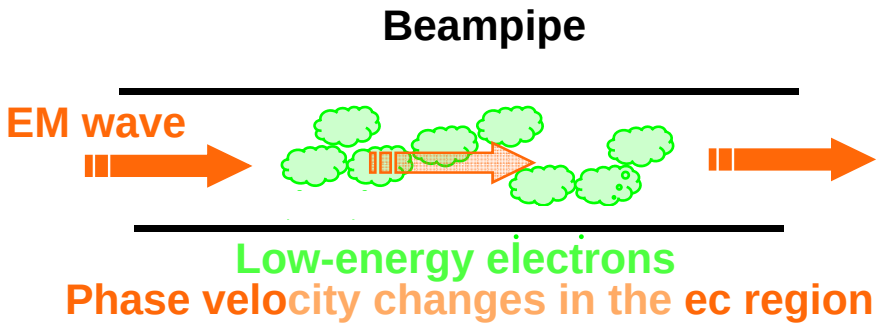
Successfully installed at end of May

First Results

- See Gerry Dugan's talk this afternoon

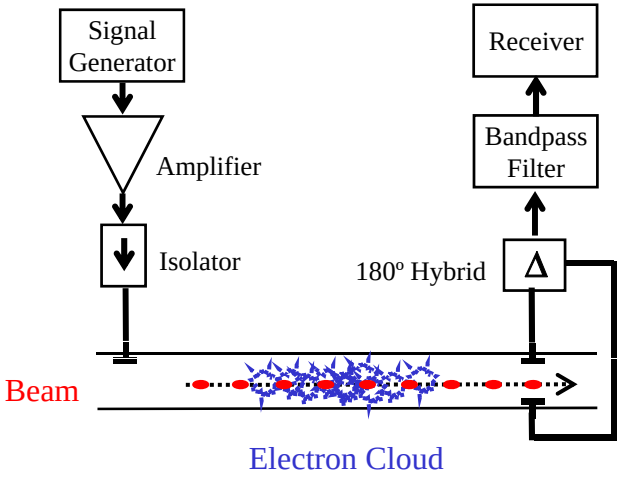
E-Cloud Measurements on Cesr-TA

Induced phase modulation in the propagation of EM waves through the beampipe

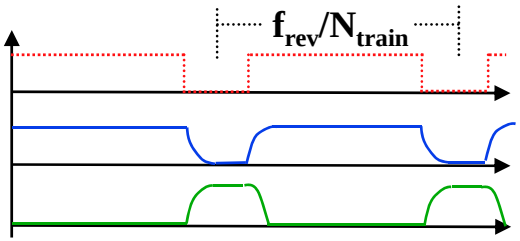


$$k^2 = \frac{\omega^2 - \omega_c^2 - \omega_p^2}{c^2}$$

plasma frequency
$2c(\pi\rho_e r_e)^{1/2}$



Experimental apparatus



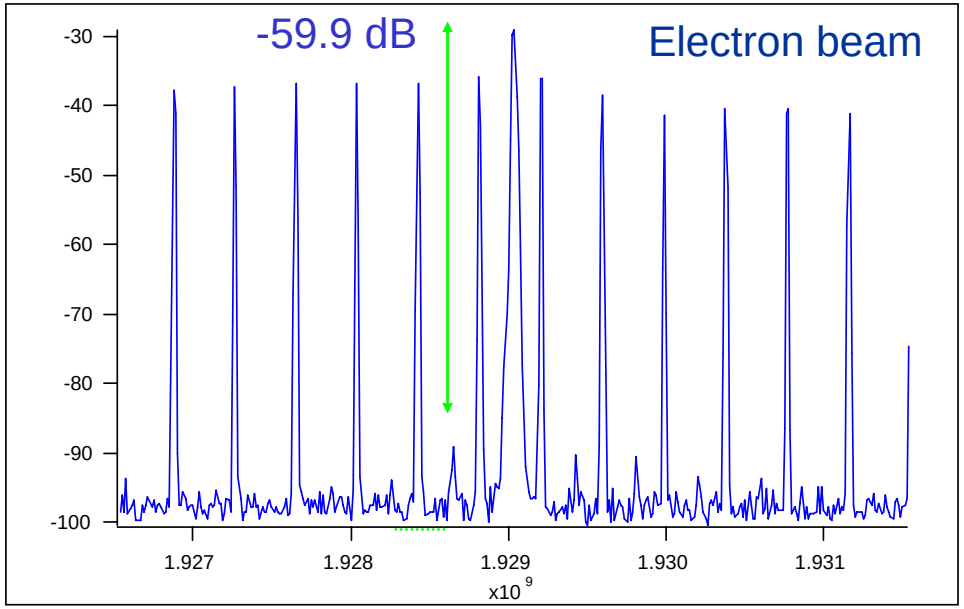
Gaps in the fill pattern set the fundamental modulation frequency (1st sideband). Higher order components depend on the transient ecloud time evolution during the gap passage.

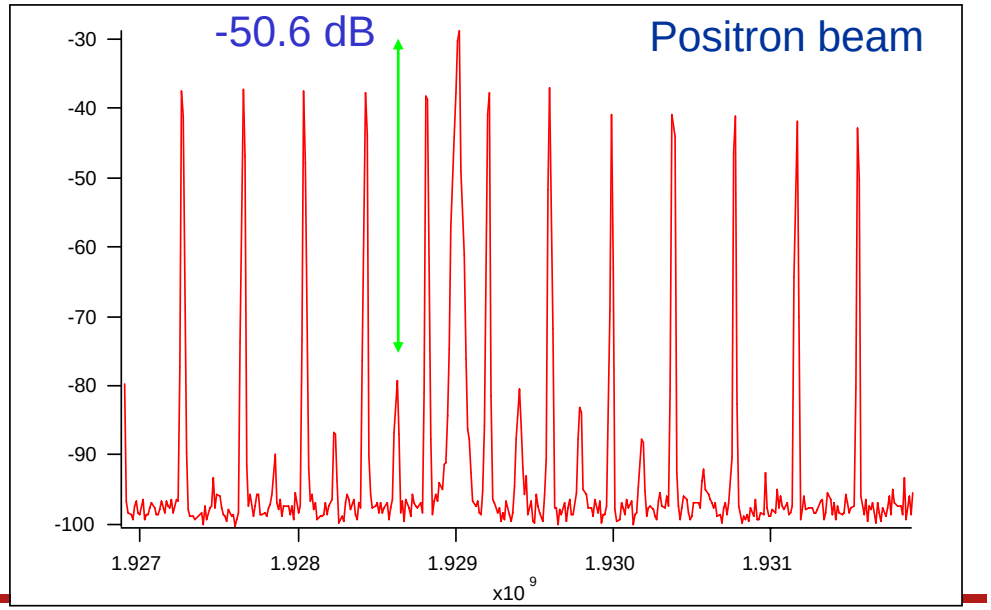
2 GeV - Dipole region (Q12W-Q13W) 10 bunches x 1 mA

Example of measurement:

Difference in the relative sideband amplitude between electron and positron beam, in otherwise identical machine conditions.

The low-energy electron density in the presence of a positron beam has a ~3 times higher value than with an electron beam.
This effect is due to the multiplication of secondary electrons caused by resonant interaction of beam and e-cloud.





Arc Experimental Region

- Remaining wigglers to be removed during summer down and replaced with instrumented chambers (one including EC mitigation)
- 2 spool pieces will be inserted at locations which would support testing of chambers of up to ~1m in length in a region exposed to synchrotron radiation from the CESR dipoles
- Region will have nearby gate valves for rapid swapping of test chambers

xBSM and Optics Line

Activities:

5.3 GeV beam studies to validate operational parameters, set up and check pinhole optics, do preliminary checkout for coded aperture, compare performance of two photodiode technologies, explore lowest signal sensitivity. First performance studies with 2.0 GeV beam.

Basics:

e^- beam energy= 5.3 GeV (to be followed by 2.0 GeV)
bunch current: ~5mA
bunch spacing: 14ns
critical energy = 10.4keV (0.56 keV with 2.0 GeV beam)
white beam

Optical elements:

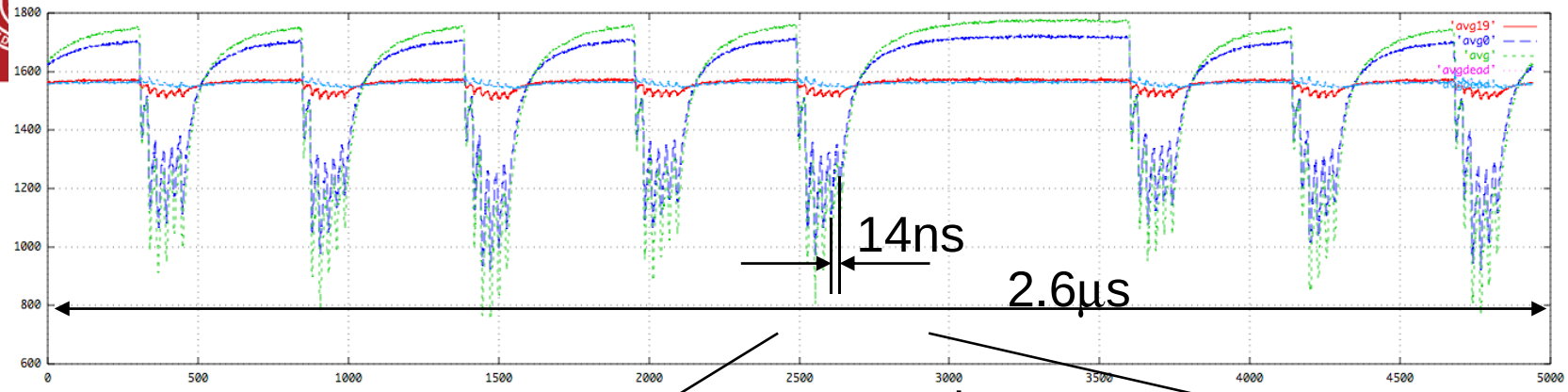
location: z=10.5m
pinholes: 5 slits, 50-250μm height
coded aperture: ready, not yet deployed.

Detector and electronics:

detector location: z=14.5m
32 channel InGaAs photodiode array, pitch = 25μm
32 channel parallel readout
optional DC current readout

Cornell University

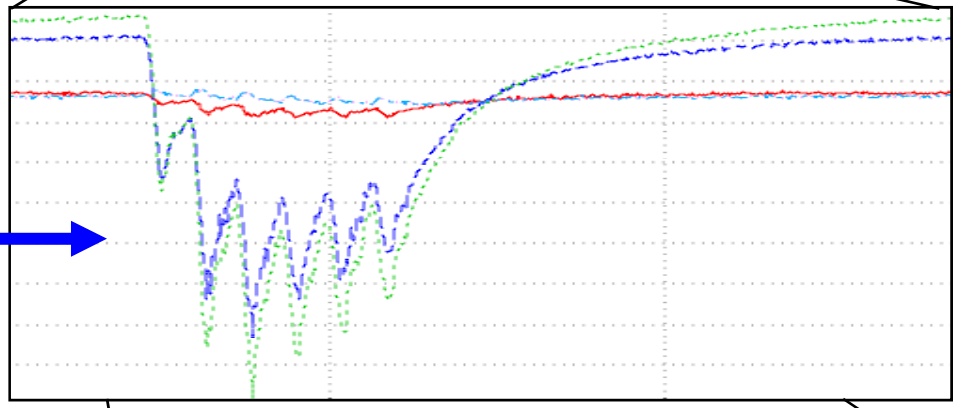
CesrTA train and bunch structure. (8x6)



Extract train…

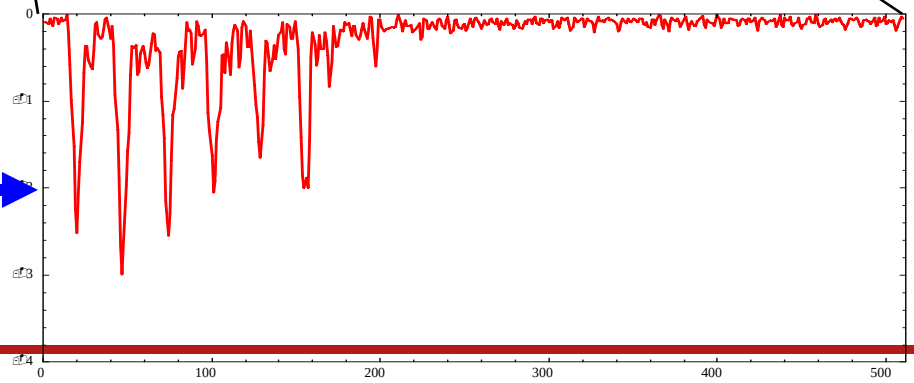
Hamamatsu InGaAs
Photodiode array.

Baseline recovery
issues are evident…



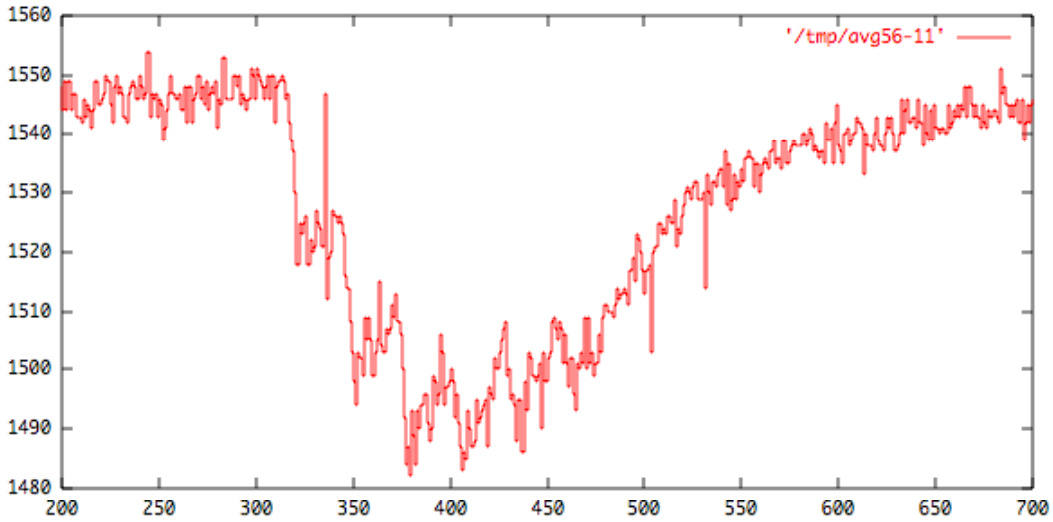
Deconvolve tail function

Underlying signals
can be reconstructed
by deconvolution:

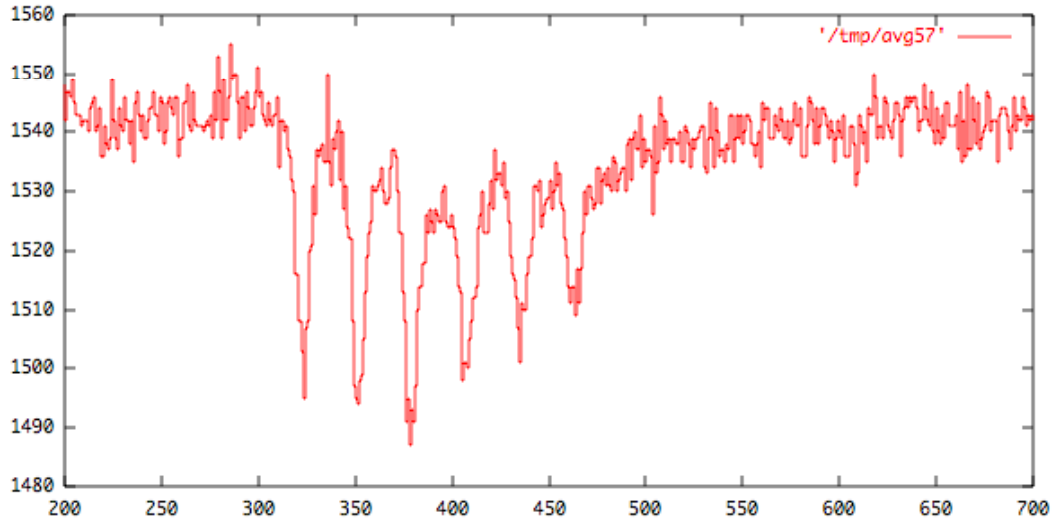


A Tale of Two Technologies

Hamamatsu InGaAs
512 photodiode array
25um pitch

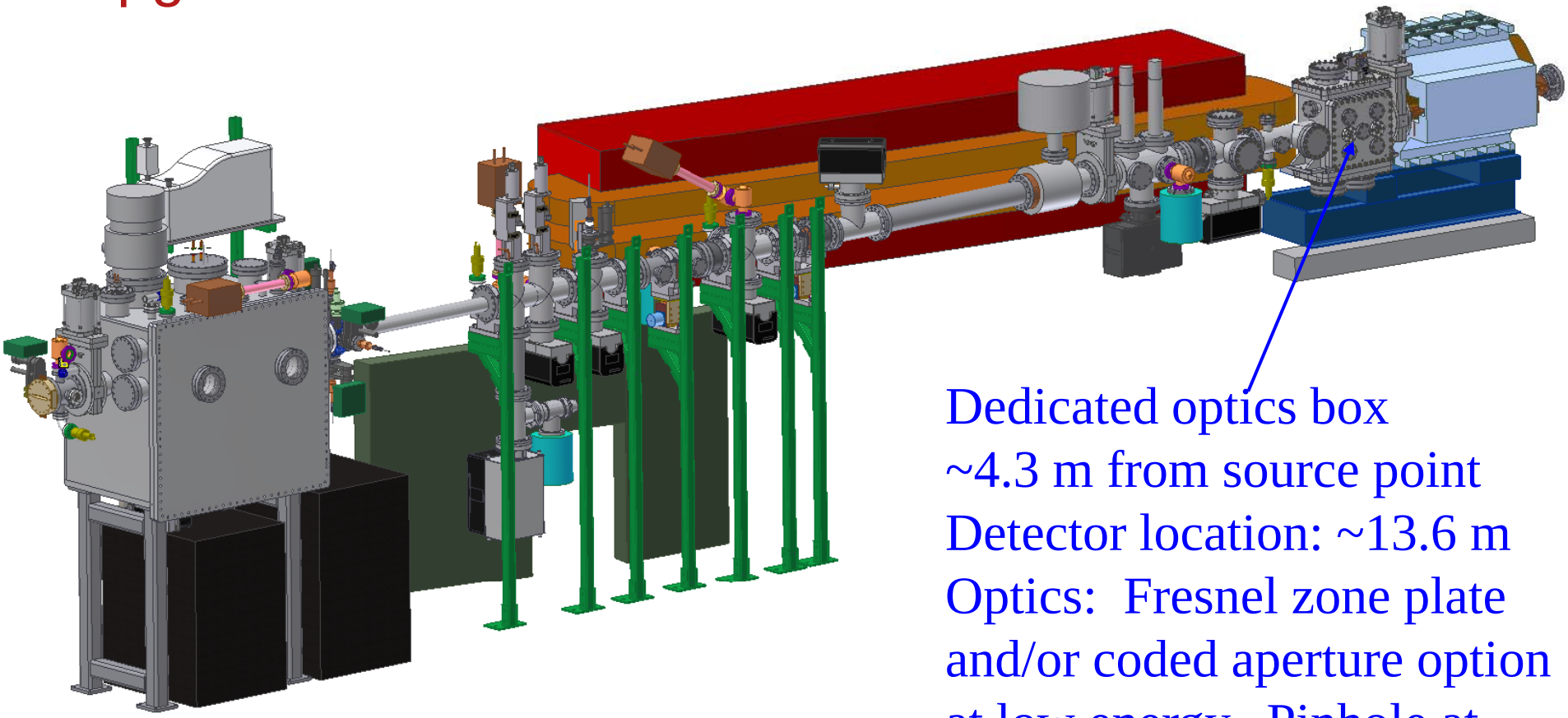


Emcore GaAs
singleton photodiode
46um diameter



CHESS D-Line Upgrade

- Positron Monitor
- Upgrade of CHESS D-line to all vacuum line



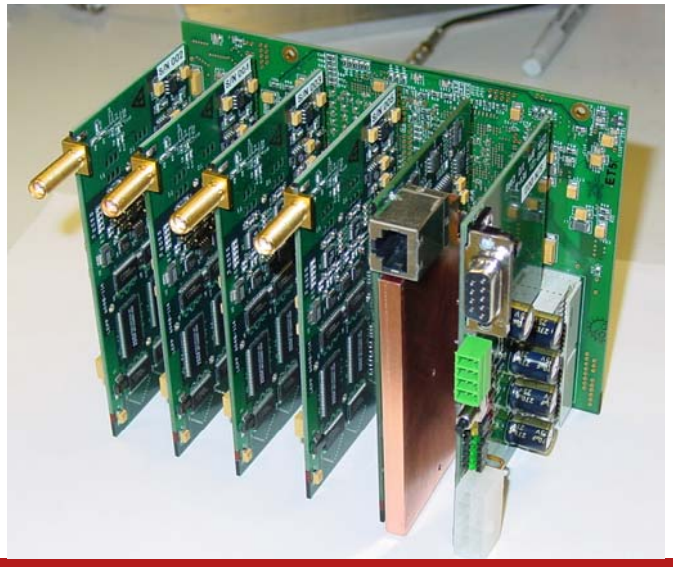
Dedicated optics box
~4.3 m from source point
Detector location: ~13.6 m
Optics: Fresnel zone plate and/or coded aperture option at low energy. Pinhole at high energy.

xBSM Summary

- Positron optics line available in Fall
  - Expect extended commissioning period
  - Configured for testing a wide range of optics
  - Tests of detector technologies
- Will upgrade a second beam line for electron beam measurements in mid-2009
  - Will build upon what is learned from the positron line
  - Will enable detailed species-dependent comparisons

Other Areas of Effort

- Support for low emittance program
  - 4ns BPM upgrade
  - Upgraded survey network and tools for improved machine alignment
- Support for 4 ns operation
  - Transverse feedback system upgrade
  - Longitudinal feedback system upgrade
- All in progress



R&D Priorities

CesrTA will address critical R&D items for a linear collider damping ring

- Ultra low emittance operation with positrons
  Target 20 pm for *positrons* in a *wiggler dominated ring*
- Characterize electron cloud build up
  - Dipoles, drifts, quadrupoles, and *wigglers* in 2-5 GeV range
  - *For both electrons and positrons*
- Develop and test electron cloud suppression techniques
  - *In superferric wigglers at 5 GeV*
  - *Also in other chambers*
- Characterize modeling tools for electron cloud instabilities
- Determine electron cloud instability thresholds
  - *For positrons in the ultra-low emittance regime*

- Work will be matched to the time frame of the ILC TDP-I
- Collaboration and input into the program is strongly desired
- How can we best interact with other R&D efforts?

Collaboration

- During the first CesrTA run we have had collaborators from Alfred Univ., FNAL, KEK and LBNL participate in experiments
  - We hope everyone enjoyed their stay!
  - We greatly appreciate all of the help we received!
- Ongoing electron cloud simulation collaboration
- A major goal over the summer is to improve our tools for communicating data, analysis work, and planning with everyone
  - The first run period has definitely pointed out areas where we can do better
  - Please bear with us as we switch to a very new mode of operation…

Collaborator Information

- Who to contact:
  - Mark Palmer for EC studies (map36@cornell.edu)
  - Dave Rubin for LET work (dlr10@cornell.edu)
- Where to look:
  - Main CesrTA Wiki Page:

https://wiki.lepp.cornell.edu/ilc/bin/view/Public/CesrTA/

  - CesrTA Collaboration Meetings Page:

https://wiki.lepp.cornell.edu/ilc/bin/view/Public/CesrTA/CollabMeetings

- Many areas restricted to the “CesrTA Collaboration”
  - Need to register for ILC Wiki
- Mailing List
  - CesrTA Collaboration Mailings via the new mailing list
  - Can subscribe from the main CesrTA Wiki page

Questions and Answers

- Would like to open up the remainder of the session for questions and answers
- A couple common questions have been:
  - When can I/we participate in an experiment?
  - Can I/we deploy experimental hardware?

- Dave and I are available to answer further questions…