Emittance Measurement Needs for CesrTF

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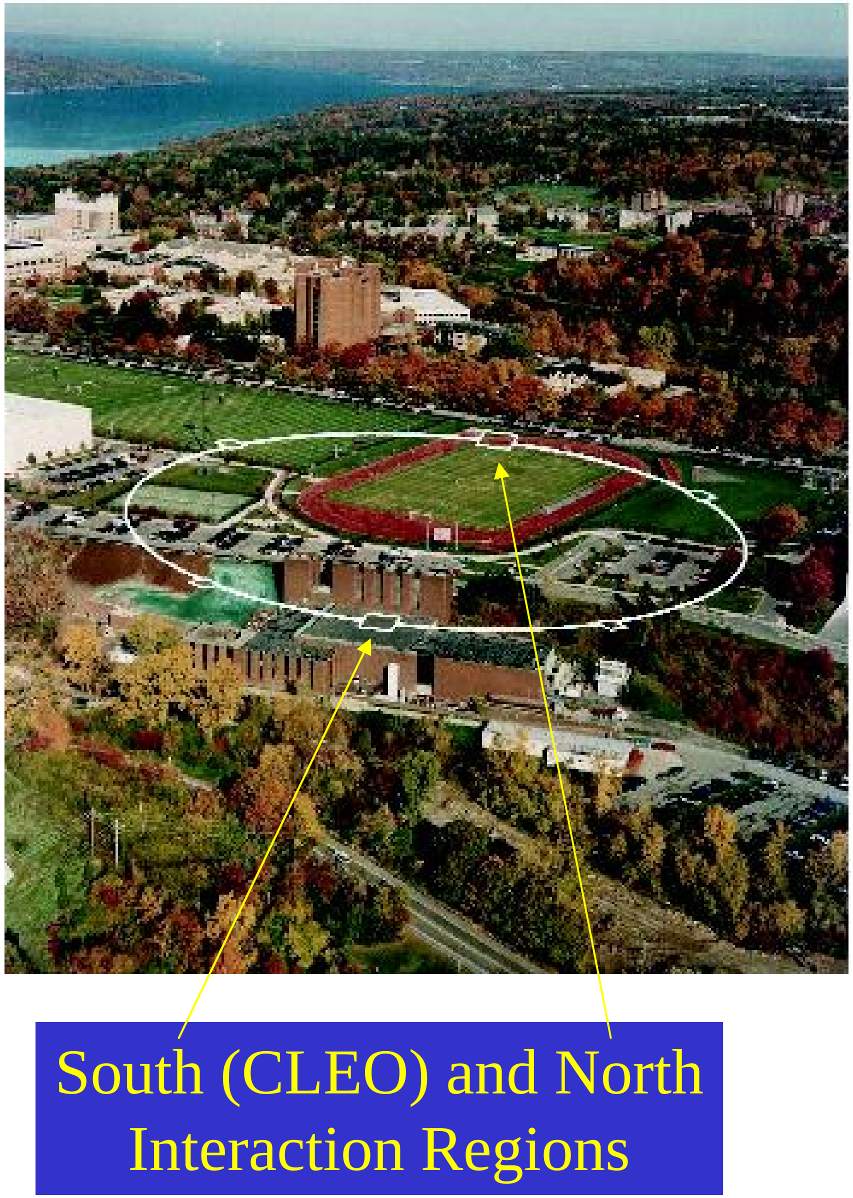
Outline

- Possibilities for CESR as an ILC Damping Ring Test Facility (CesrTF)
  - What Does CesrTF Offer?
  - CESR-c ⇨ CesrTF Conversion
    - CESR Modifications
    - CesrTF Low Emittance Optics
  - Proposed CesrTF Schedule
- Instrumentation Requirements and Options
- Conclusion

CesrTF Overview

- CESR-c HEP operations scheduled to conclude on March 31, 2008
- Design studies are presently underway to modify CESR for ILC Damping Ring R&D ⇨ CesrTF
- 4 Key Questions:
  1. What can CESR offer as a damping ring test facility?
  2. How extensive are the required modifications?
  3. What is the resulting experimental reach?
  4. Can important R&D results be provided in a timely fashion for the ILC TDR and (*hoped for*) start of construction?

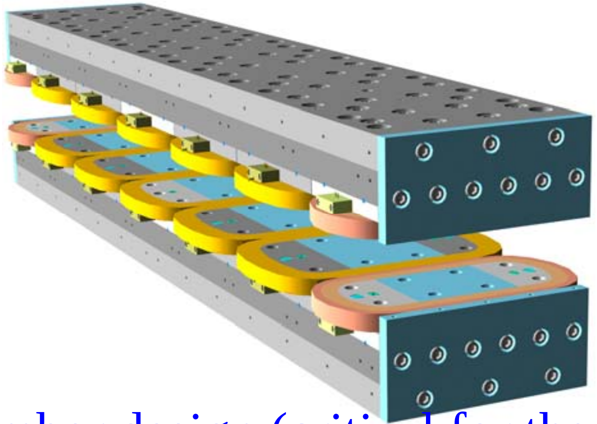


1) What Can CESR Offer?

CESR offers:

- The only operating wiggler-dominated storage ring in the world
- The CESR-c damping wigglers
  - Technology choice for the ILC DR baseline design
- Flexible operation with positrons or electrons
- Flexible bunch spacings suitable for damping ring tests
  - Presently operate with 14 ns spacing
  - Can operate down to 2 ns spacings with suitable feedback system upgrades
- Flexible energy range from 1.5 to 5.5 GeV
  - CESR-c wigglers and vacuum chamber specified for 1.5-2.5 GeV operation
  - An ILC DR prototype wiggler and vacuum chamber could be run at 5 GeV
- Dedicated focus on damping ring R&D for significant running periods after the end of CLEO-c data-taking
- A useful set of damping ring research opportunities…
  - The ability to operate with positrons and with the CESR-c wigglers offer a unique experimental reach

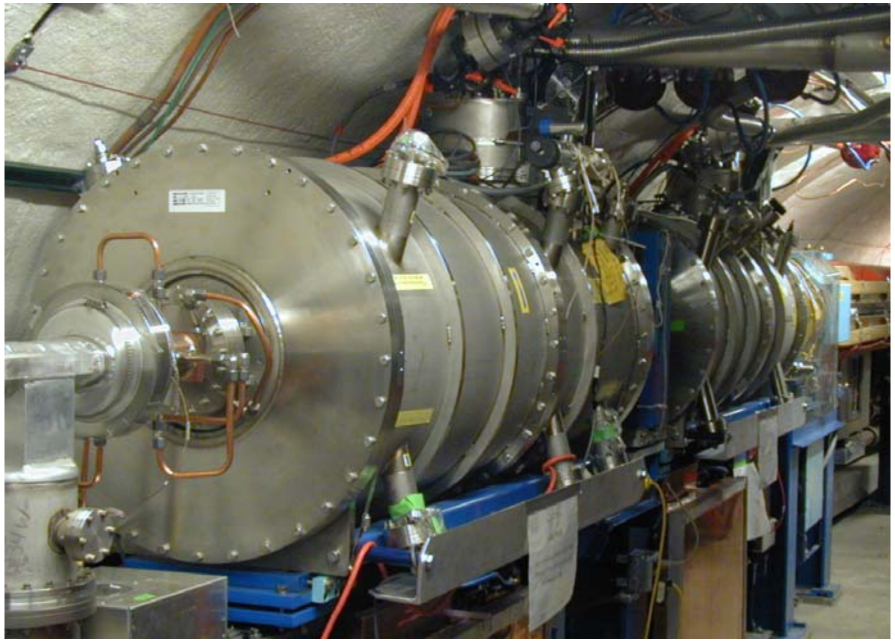
CesrTF Goals

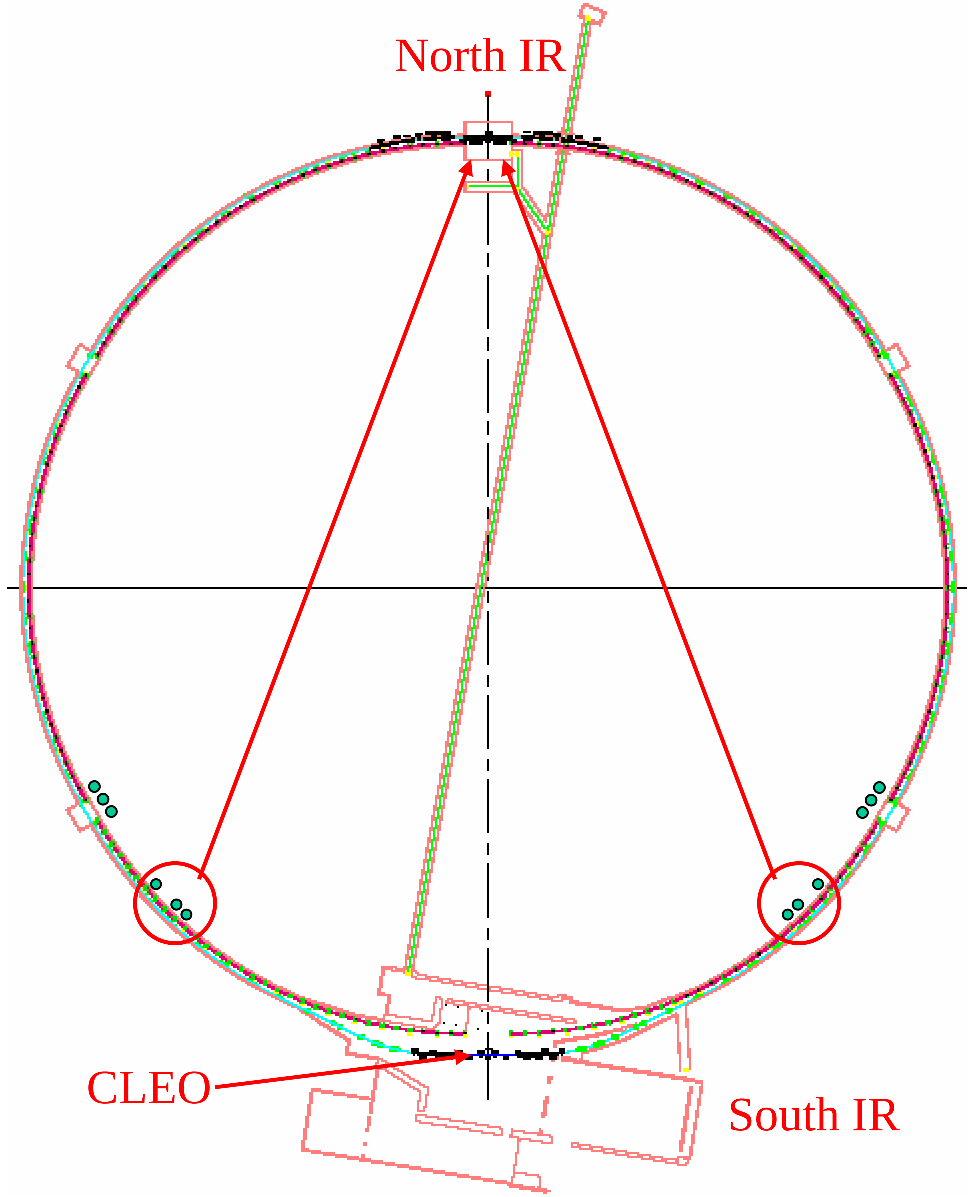


- Primary Goals
  - Electron cloud measurements
    - e^- cloud buildup in wigglers
    - e^- cloud amelioration in wigglers
    - Instability thresholds
    - Validate the ILC DR wiggler and vacuum chamber design (critical for the single 6 km positron ring option)
  - Ultra-low emittance and beam dynamics
    - Study emittance diluting effect of the e^- cloud on the e^+ beam
    - Detailed comparisons between electrons and positrons
    - Also look at fast-ion instability issues for electrons
    - Study alignment issues and emittance tuning methods
    - Emittance measurement techniques
  - ILC DR hardware testing
    - Wigglers, wiggler vacuum chamber, SRF, kickers, alignment & survey techniques, instrumentation, *etc*.

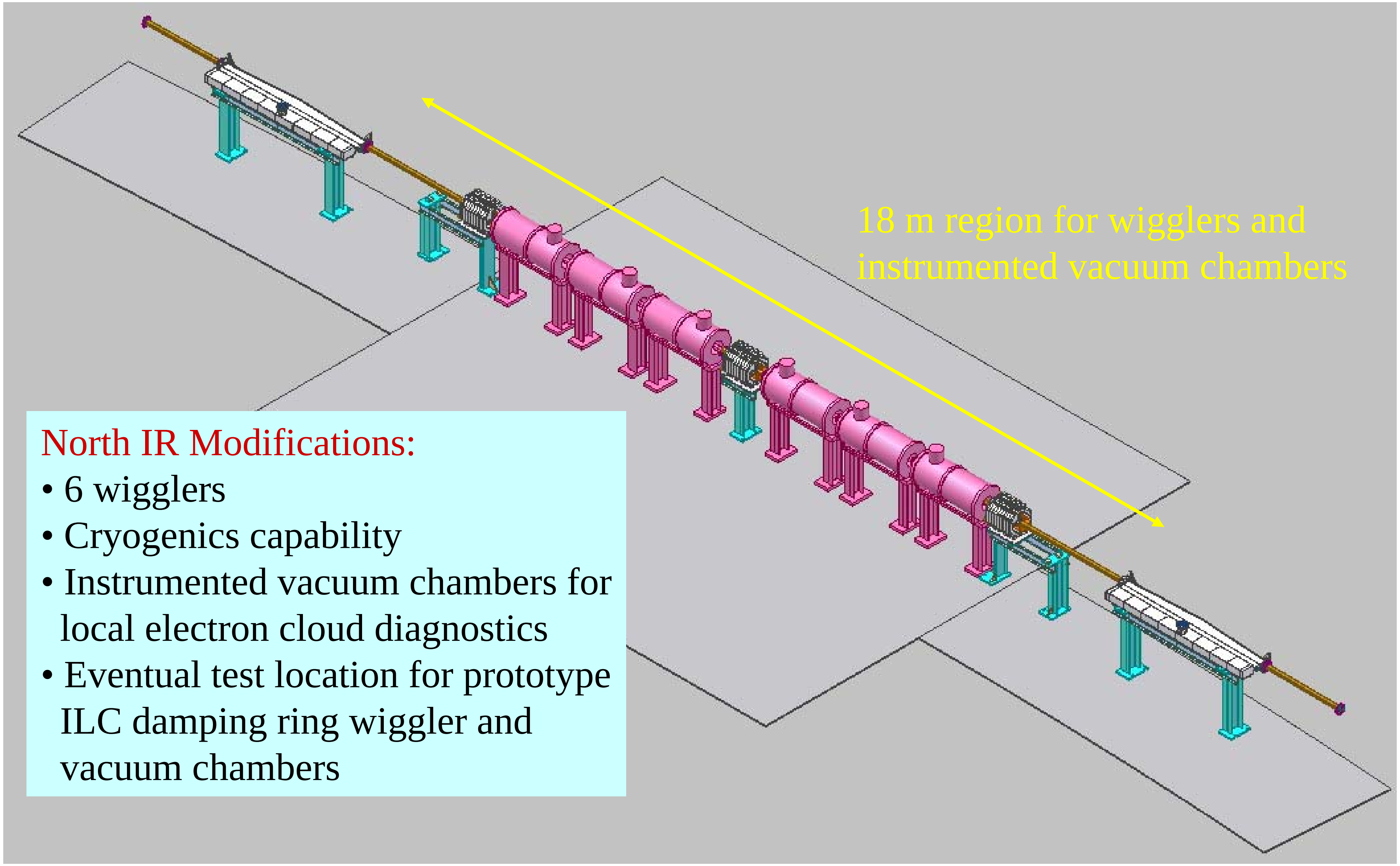
2) CESR Modifications

- Move 6 wigglers from the CESR arcs to the North IR
  - New cryogenic transfer line required
  - Zero dispersion regions can be created locally around the wigglers left in the arcs
- Make South IR available for insertion devices and instrumentation
- Instrumentation and feedback upgrades





The North IR



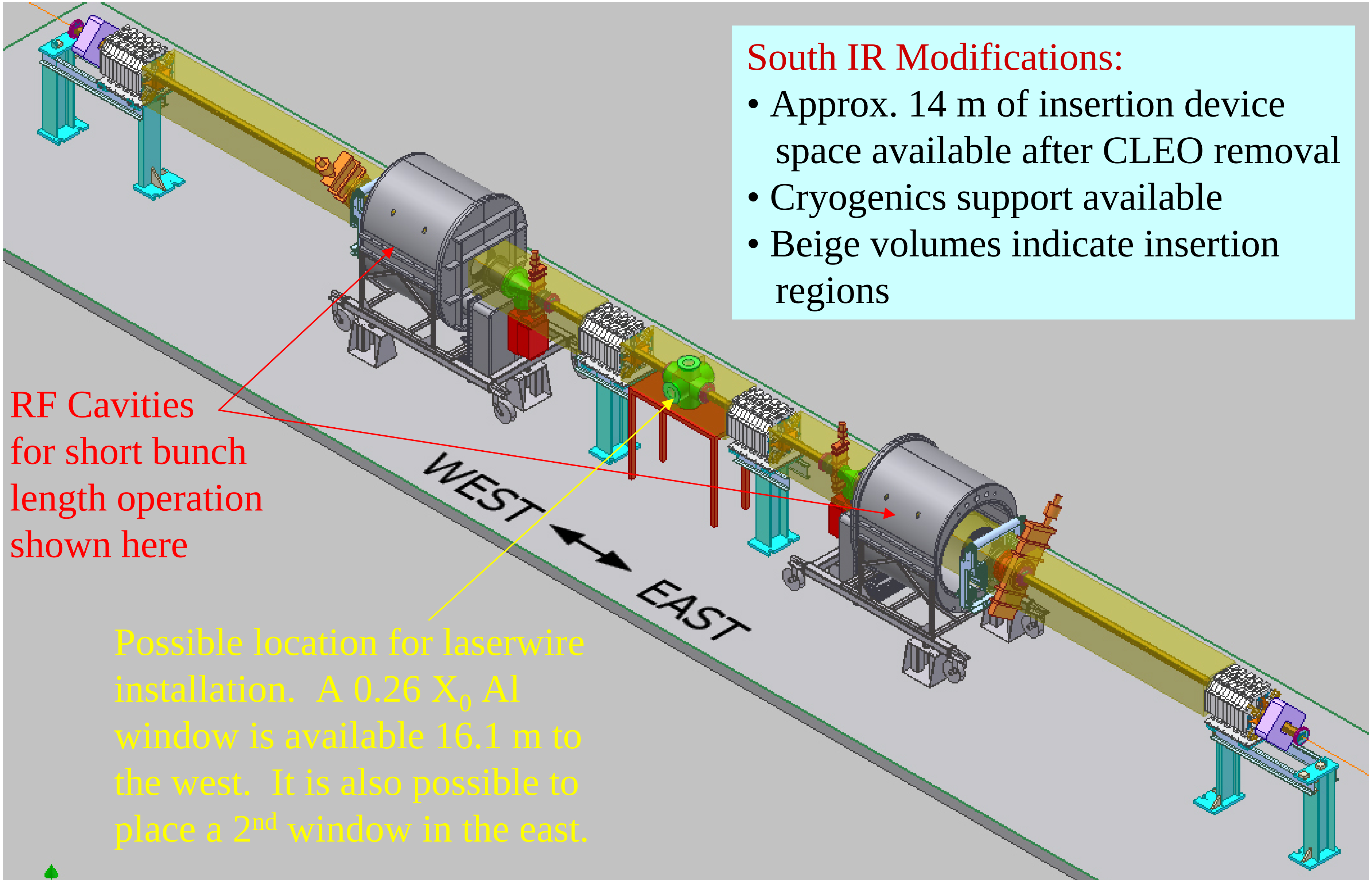
North IR Modifications:

- 6 wigglers
- Cryogenics capability
- Instrumented vacuum chambers for local electron cloud diagnostics
- Eventual test location for prototype ILC damping ring wiggler and vacuum chambers

The South IR

South IR Modifications:

- Approx. 14 m of insertion device space available after CLEO removal
- Cryogenics support available
- Beige volumes indicate insertion regions



RF Cavities for short bunch length operation shown here

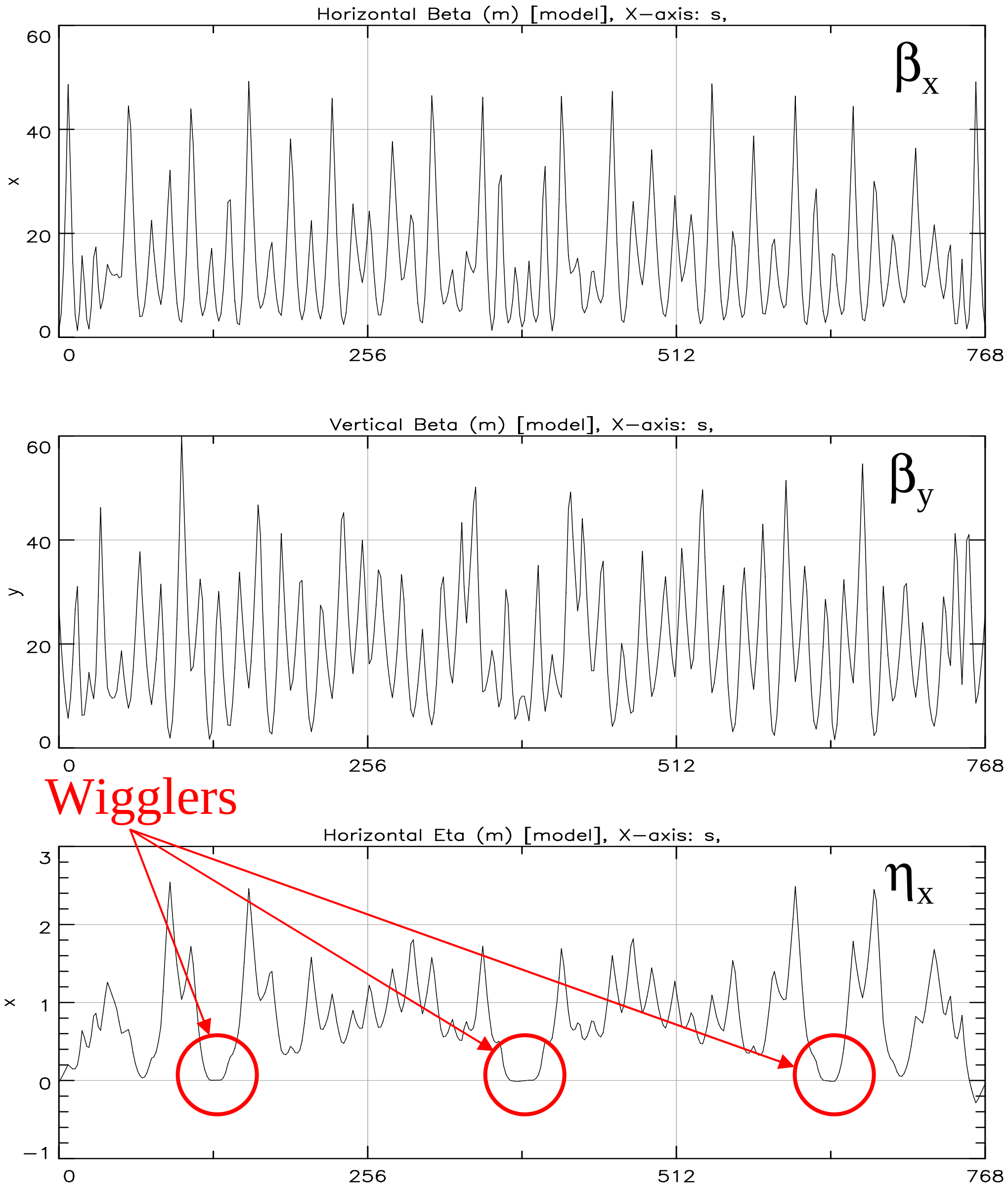
Possible location for laserwire installation. A 0.26 X_0 Al window is available 16.1 m to the west. It is also possible to place a 2nd window in the east.

CESR Modifications Summary

- Answer to question #2:
  - Substantial modifications required in the two IRs (however, certainly no more difficult than a detector and IR magnet upgrade)
  - Cryogenics transfer line must be run to the North IR
  - 6 wigglers must be moved to the North IR
  - Feedback electronics and amplifiers must be upgraded
  - Instrumentation must be upgraded
    - Extend multi-bunch turn-by-turn BPM system to entire ring (presently single sector)
    - High resolution emittance measurement techniques
- Conversion is relatively modest
  - Estimated time required is 7-9 months to carry out conversion with key preparation work carried out between now and April 2008.

CesrTF Baseline Lattice

Parameter	Value
E	2.0 GeV
$N_{wiggler}$	12
B_{max}	2.1 T
ε_x	2.25 nm
Q_x	14.59
Q_y	9.63
Q_z	0.098
σ_E/E	8.6×10^{-4}
$\tau_{x,y}$	47 ms
σ_z (with V_{RF}=15MV)	6.8 mm
α_p	6.4×10^{-3}
$\tau_{Touschek}$($N_b=2\times10^{10}$ & ε_y=5pm)	7 minutes

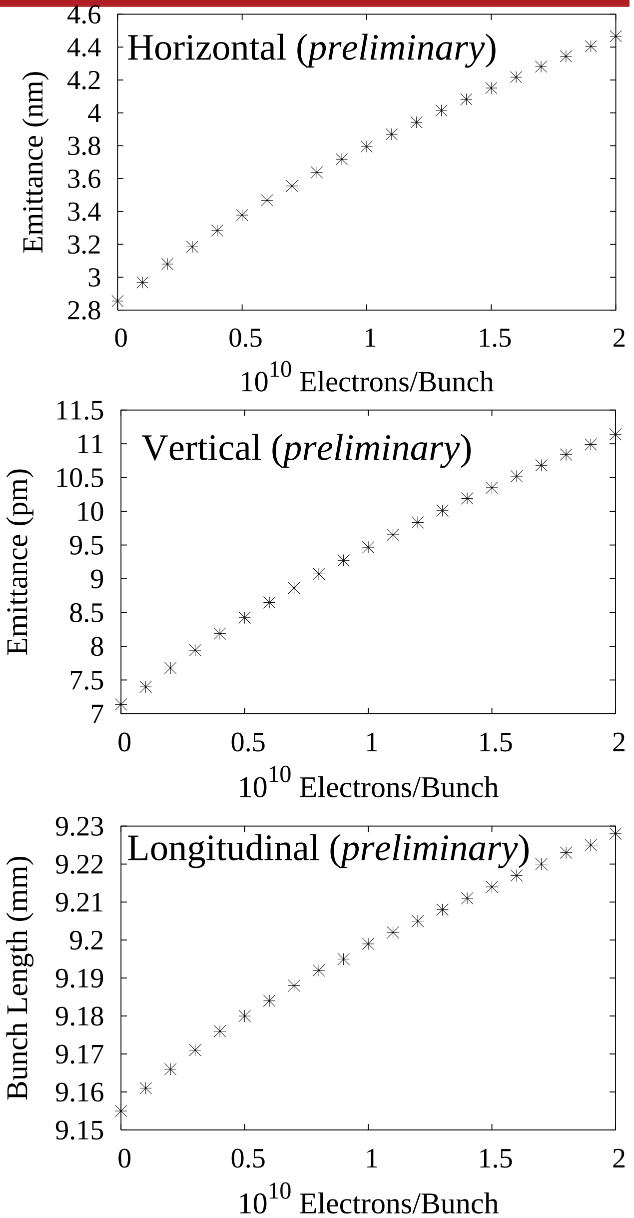


3) CesrTF Experimental Reach

- Have evaluated our ability to correct for ring errors with the above lattice
  - Goal: ε_y~5-10 pm at zero current
  - Simulation results:

Correction Type	Average Value	95% Limit
Orbit Only	10.2 pm	21.4 pm
Orbit+Dispersion	3.9 pm	8.2 pm

- Want to study ECE impact at ILC DR bunch currents
  - Plots show preliminary IBS evaluation for a 2.5 GeV lattice
  - Zero current vertical emittance chosen to be consistent with above alignment simulations
  - This emittance regime appears consistent with studying the impact of the ECE (and other effects) on emittance dilution
- Presently working towards more detailed beam dynamics simulations
- But we need to be able to measure these emittances!!



4) When Will R&D Results Become Available?

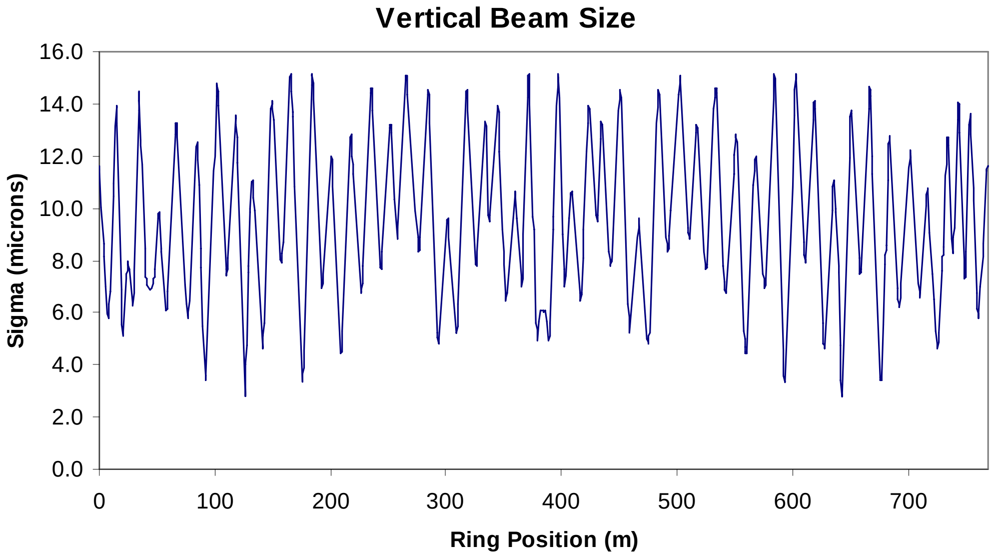
- Immediate Plans
  - Conceptual design work and validation complete by Fall
  - Proposal submission before end of year
- FY07
  - Engineering design work
  - Begin fabrication of items critical for 2008 down
- End of scheduled CESR-c/CLEO-c physics: Mar 31, 2008
- Commissioning complete by early 2009 with operation as an ILC damping ring test facility for at least 3 years
  - Alternating operation with CHESS
  - Estimate ~4 months/year of operations as a DR test facility
- This schedule is consistent with:
  - Early results before TDR completion
  - Significant program contributions before start of ILC construction

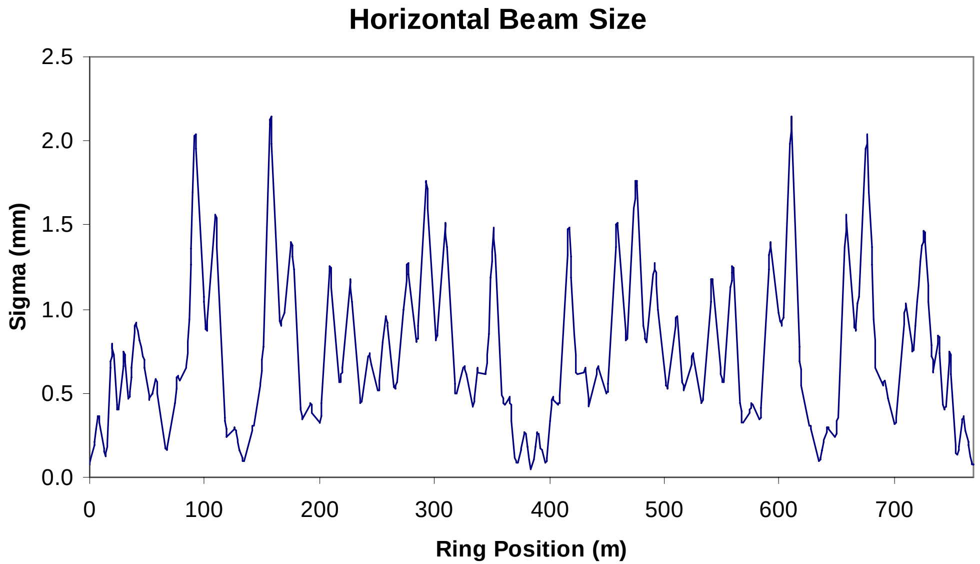
Emittance Measurements

- We would like to solicit input on system options
- Key parameters/constraints:
  - Multi-bunch measurements to study emittance growth in bunch trains
    - Bunch resolution can be handled by a fast detector
  - Touschek lifetimes measured in minutes ***but*** emittance-diluting effects are strongly sensitive to bunch currents
    - Ideally we would want to scan faster than this
      - ATF cavity-type laser setup scan time comparable to expected beam lifetime (~6 minutes in y, ~15 minutes in x)
    - Laser power limitations?
- Techniques
  - Laserwire
  - Fast x-ray monitor (GaAs pixel array with Fresnel zone plate optics)

Beam Sizes

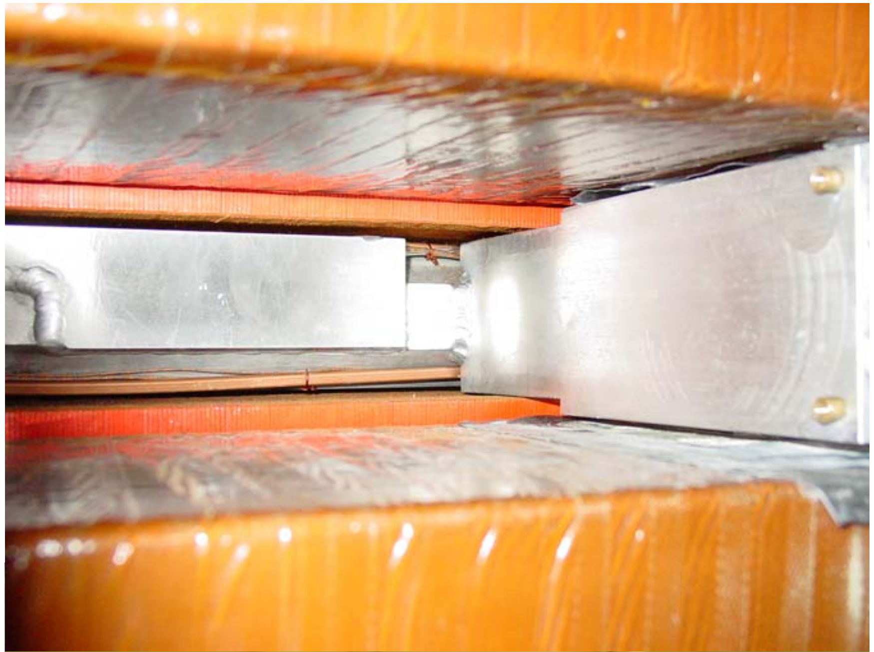
- Nominal beam sizes
  - Vertical assumes perfect dispersion correction
  - Values at center of South IR:
    - $\sigma_y \sim 11.6\ \mu m$
    - $\sigma_x \sim 79\ \mu m$
    - Compton scattering from the positron beam can be viewed through the present CESR-c luminosity monitor window

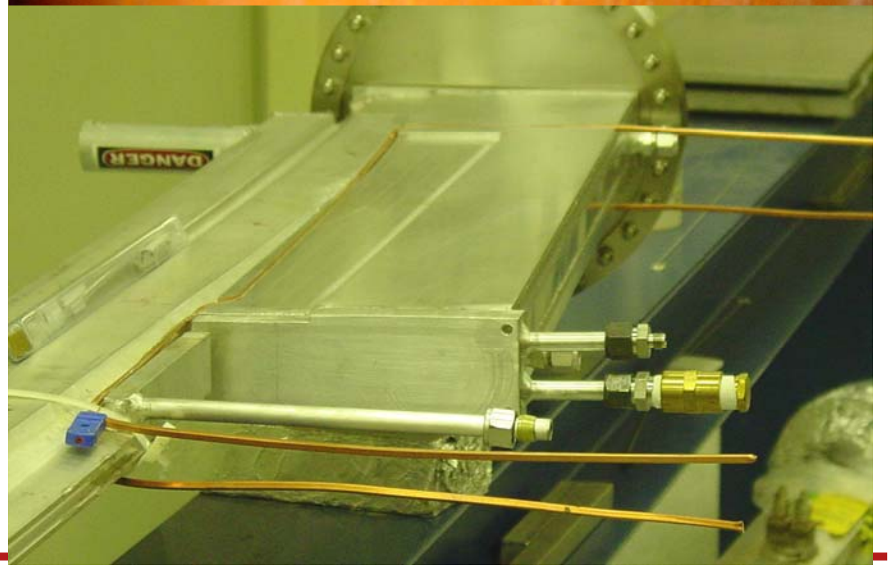




Luminosity Monitor Window

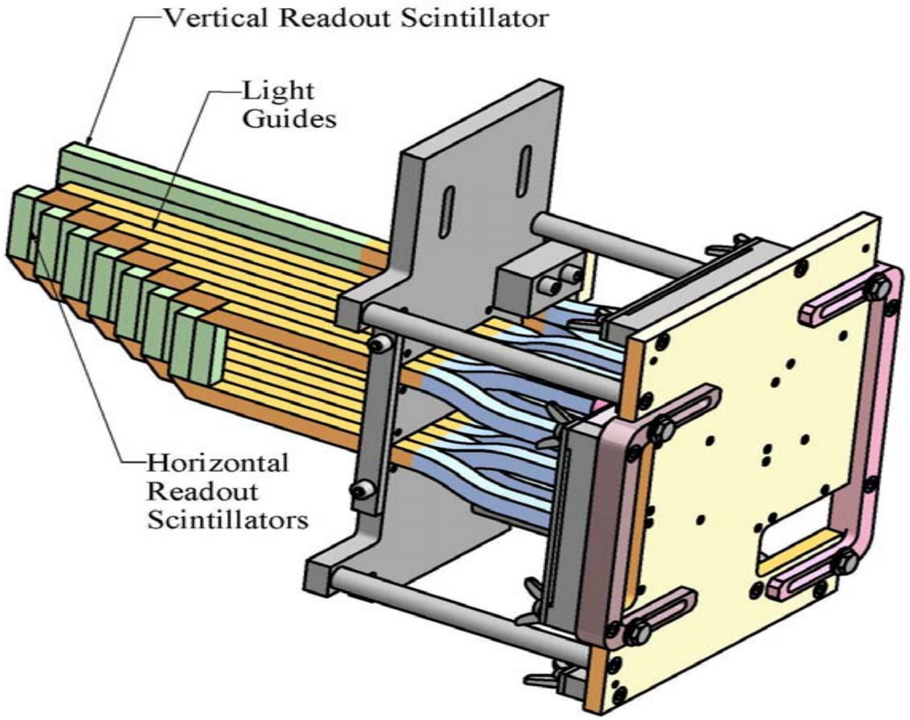
- Aluminum γ Window
  - Faces into South IR
  - ~1 in thick (0.26 X_0)
  - 16.1 m from center of CesrTF insertion region
  - Looks at e^+ beam
  - Aperture (for 16.1 m):
    - +/- 1.7 mrad vertical
    - -7 to +2 mrad horizontal (negative is to inside of ring)
- A similar window, but with smaller horizontal aperture, could potentially be added for electrons

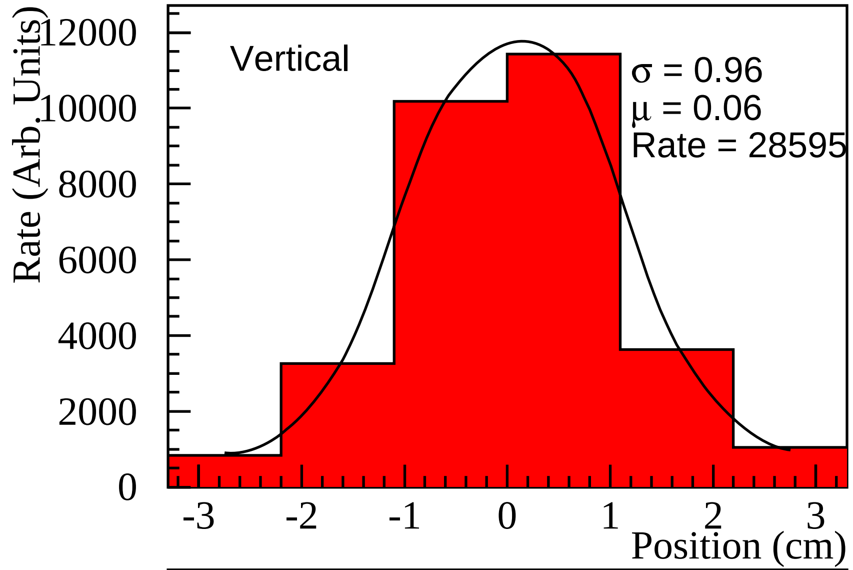


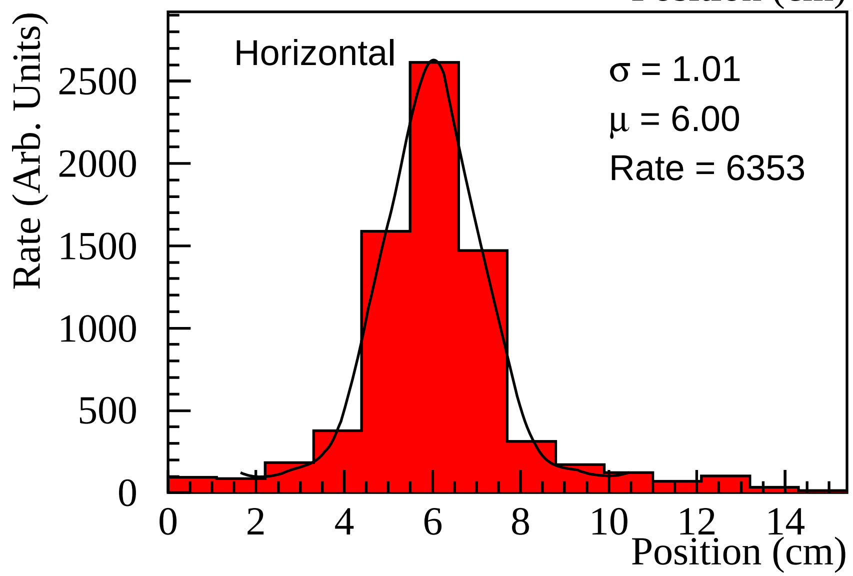


Radiative Bhabha γ Detector ⇨ Compton γ Detector ?

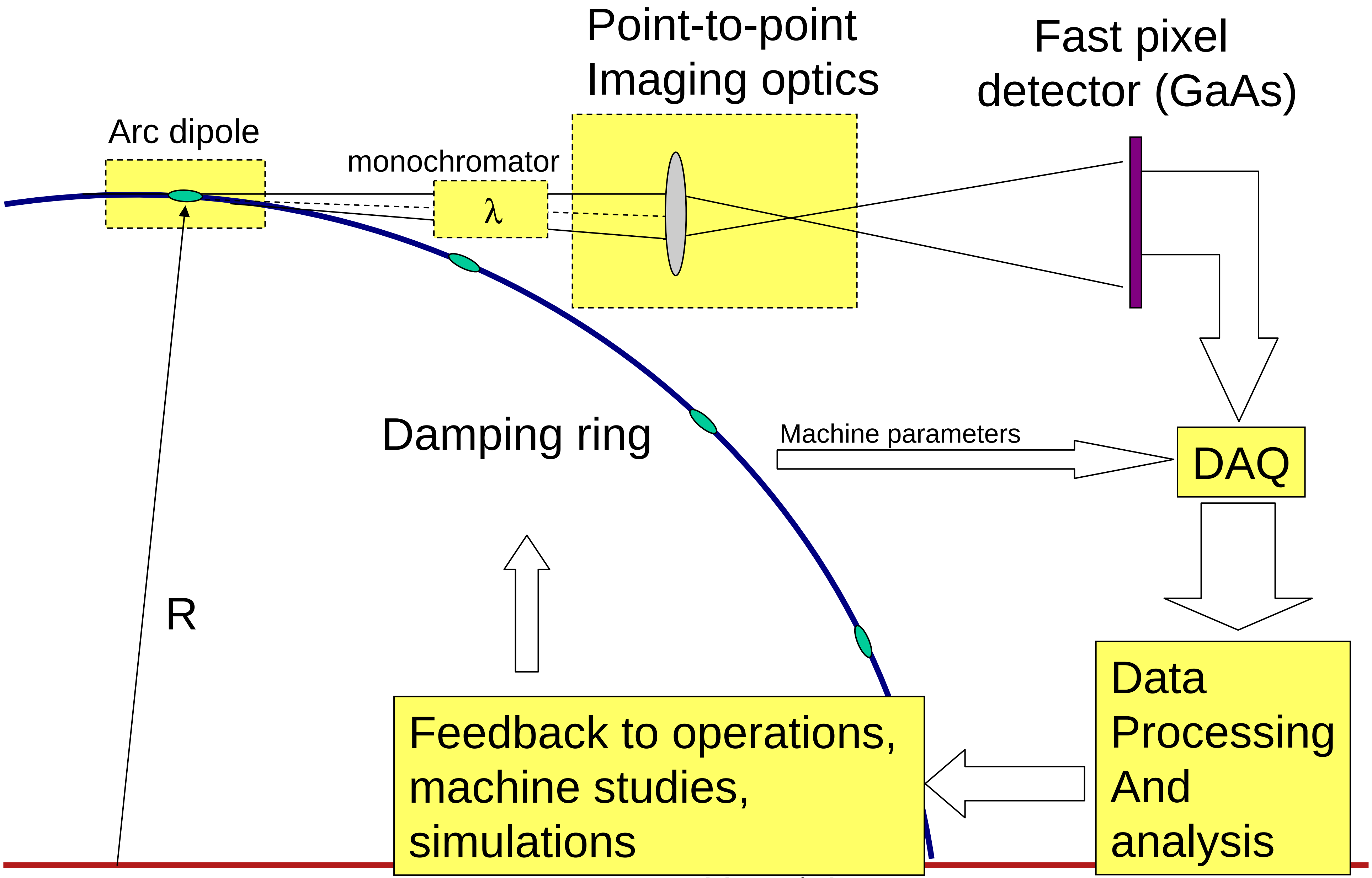
- Segmented Scintillator Detector
  - Offers possibility of more detailed signal analysis with background suppression
  - Fast R7400 PMTs offer bunch-by-bunch response
  - Well-understood operation







X-ray Beamsize Concept



GaAs Detector

First bunch-by-bunch beam size data in CHESS conditions ⇨

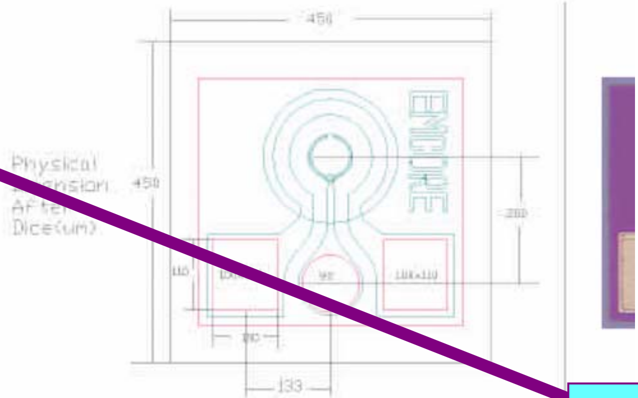
10 Gbps GaAs PIN Photodiode*

Product Description

EMCORE's 10 Gbps Gallium Arsenide (GaAs) PIN photodiode is designed for multimode fiber
EMCORE's own state-of-the-art MOCVD wafer foundry and device fabrication facility guarantees
fabrication source of package ready die to meet the growing needs of fiber optic component ma
device performance and robust operation makes this the superior device for high speed multimode
applications.

Features

- Data rates of 10 Gb/s
- Excellent responsivity
- Large aperture size
- Low capacitance
- Low dark current

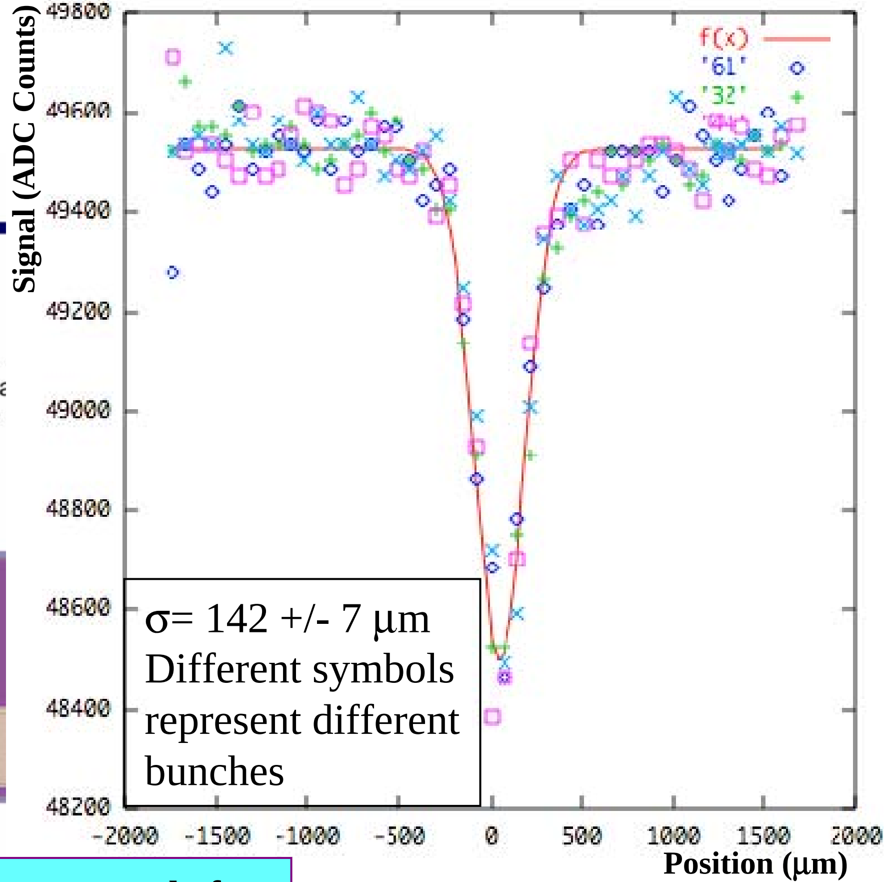


Product Specifications

Electro-Optical Characteristics (T = 30°C)

	Conditions	Min.	Typical	Ma	
Speed	-1.6 V		8.5		
Responsivity	3 to -26 dBm, 850 nm Epoxy coated, n=1.6		.5		
Active Area (aperture)	-		60		µm
Rise/Fall Time	20% / 80%, -1.6 V bias		30/35		ps
Dark Current	-1.6 V, -70 dBm		<.2	1	nA
Capacitance	-1.6 V, 1 MHz		.28		pF
Reverse Breakdown	1 µA	20	50		V
Reflectivity	Epoxy coated, n=1.6			1	%

Fast enough for single bunch resolution



Pinhole camera setup

Summary

- CesrTF conceptual design work is ongoing
  - The machine offers unique features for critical ILC damping ring R&D
    - CESR-c wigglers
    - Operation with positrons
    - Flexible bunch configuration
  - Simulations indicate that the emittance reach is suitable for a range of damping ring beam dynamics studies
  - The conversion schedule will allow timely results for ILC damping ring R&D
  - A *critical* planning and conversion issue is identifying and preparing suitable methods of emittance measurement
- We would like to extend an open invitation for anyone interested in collaborating on this project

Lattice Comparisons

	CesrTF	ATF	TESLA	ILC 6 km
Cicumference (m)	768	139	17000	6114
Energy (GeV)	2.0	1.28	5.0	5.066
Horizontal Emittance (nm)	2.25	1.0	5.1	5.5
Vertical Emittance (pm)	5.0 (target)	4.5	1.4	1.4
Energy Spread ($x10^{-3}$)	0.86	0.55	1.3	1.5
J_x	1.0	1.6	1.0	1.0
J_y	1.0	1.0	1.0	1.0
Q_x	14.53	15.141	76.310	56.584
Q_y	9.59	8.759	41.180	41.618