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Damping Ring Magnets Report

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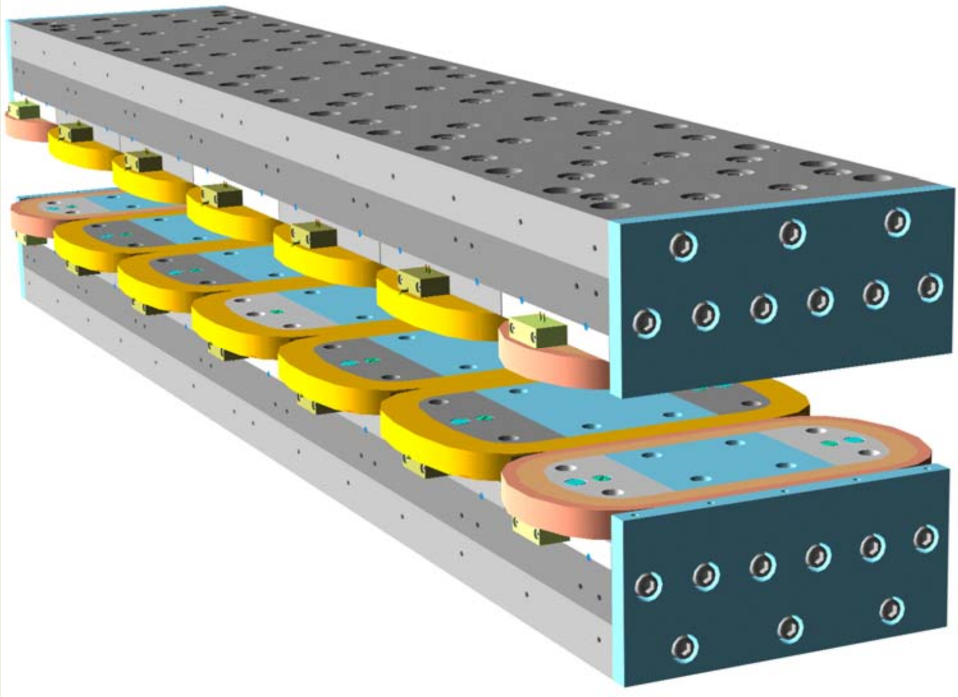
Laboratory for Elementary-Particle Physics

Outline

- Wiggler
  - CESR-c Wiggler
  - Key performance issues identified for Baseline Configuration Decision
  - Cost estimates used for BCD
  - Interface issues
- Introduction to Damping Rings Group Reference Design Report Support
  - DR Component Specification Sheets
  - Wiki site
- Brief Conventional Magnets Overview

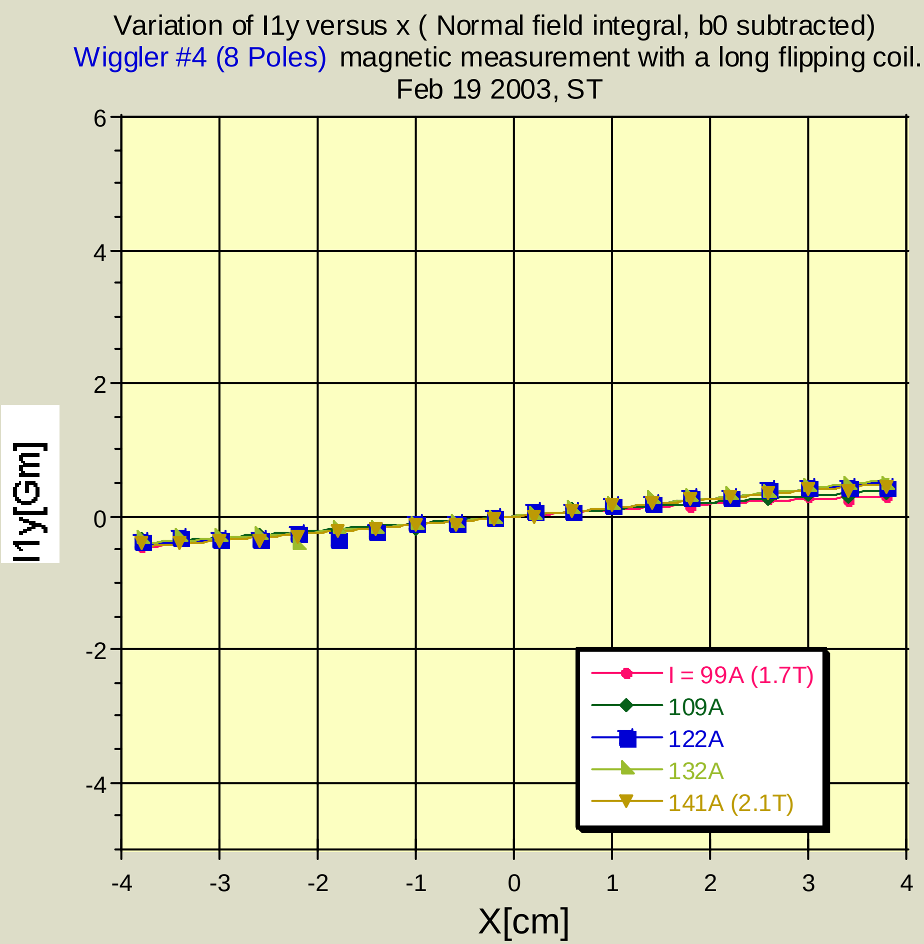
CESR-c Wigglers

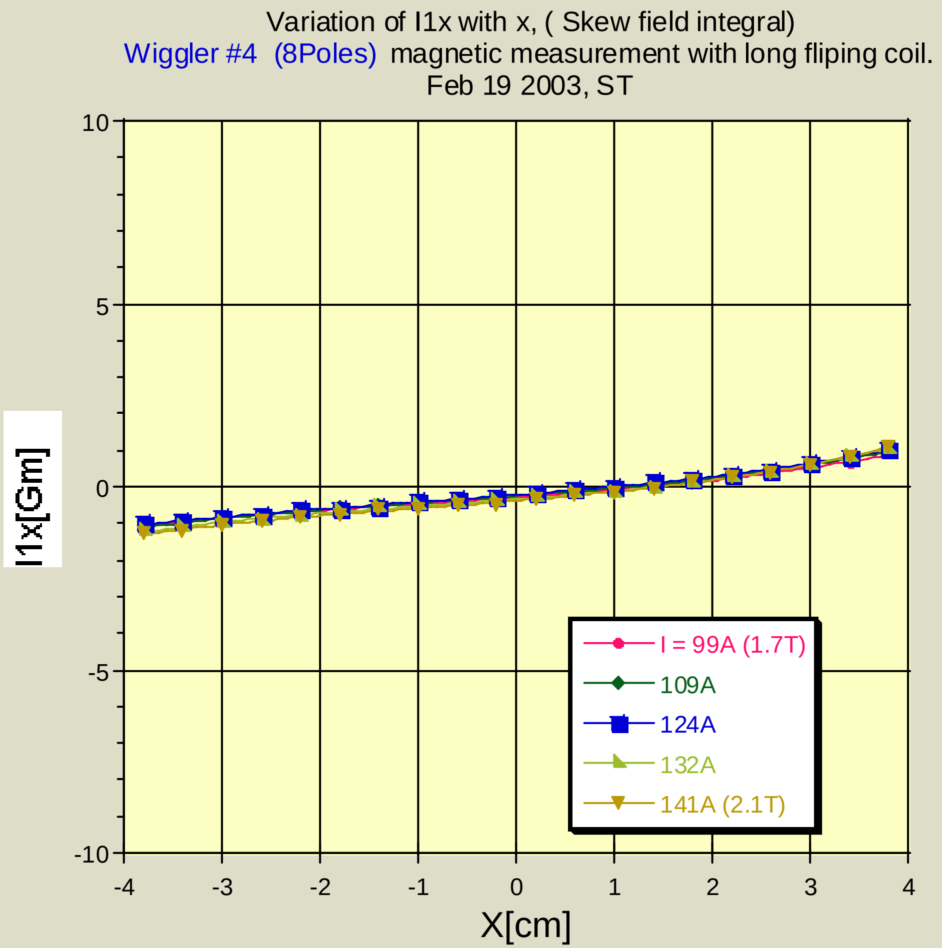
- 2.1 Tesla Peak Field
  - Damping rate vs energy spread
- 50 mm Vertical Aperture
- 0, -0.3% field uniformity
  - +/- 20 mm electrostatically separated orbits
- 8-pole design installed
  - 40 cm period
  - Offers better linearity versus excitation
  - However, has larger cubic non-linearity for fixed damping
- a_1 skew quad moment
  - Observed with both styles
  - Traced to variations in uniformity of coil geometry



- Single pole flux tests (warm) critical for final field quality
  - 0.2 turn sensitivity
  - O(10 μm) in winding alignment
  - Pole matching

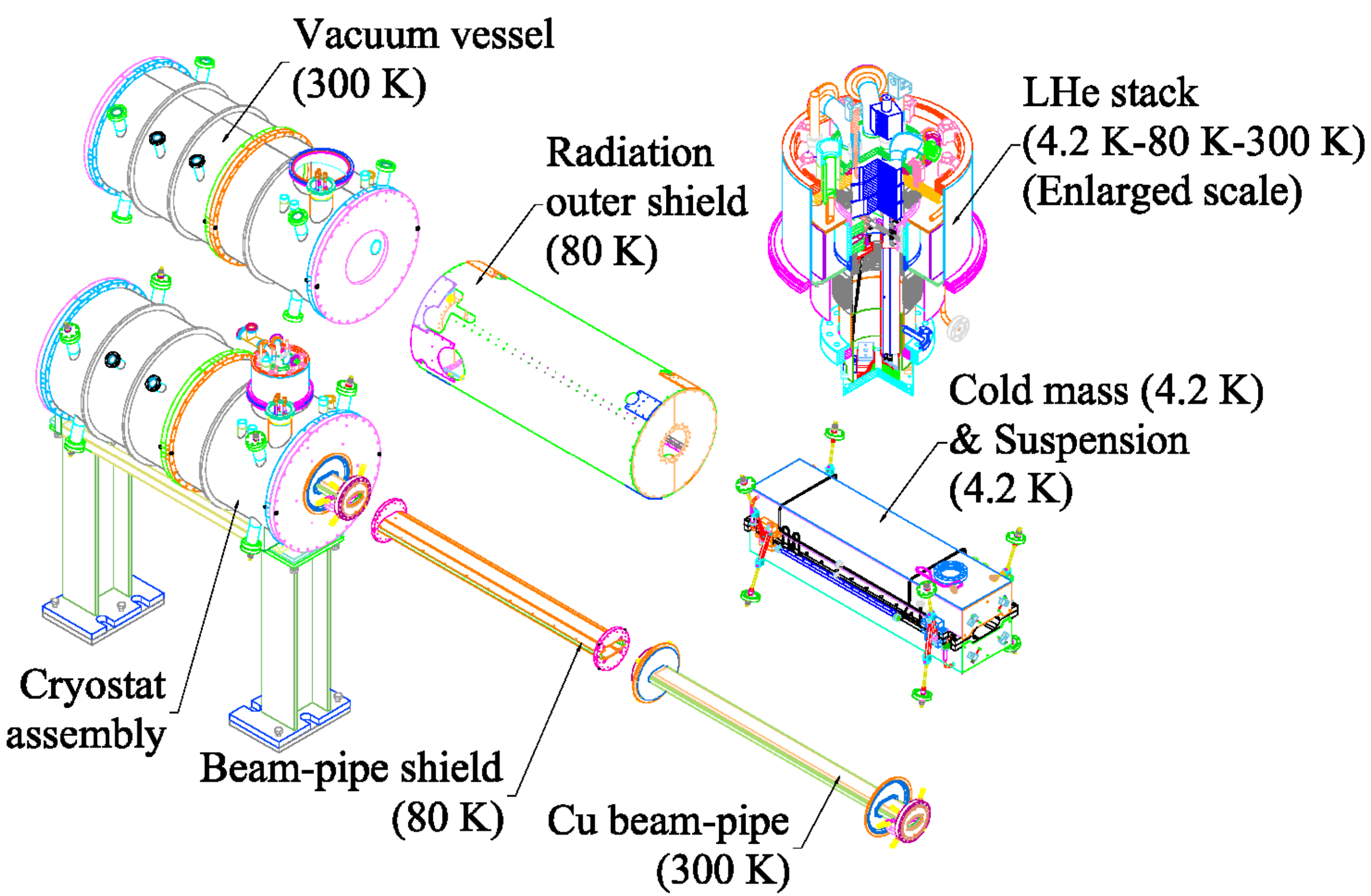
Flip Coil Measurements



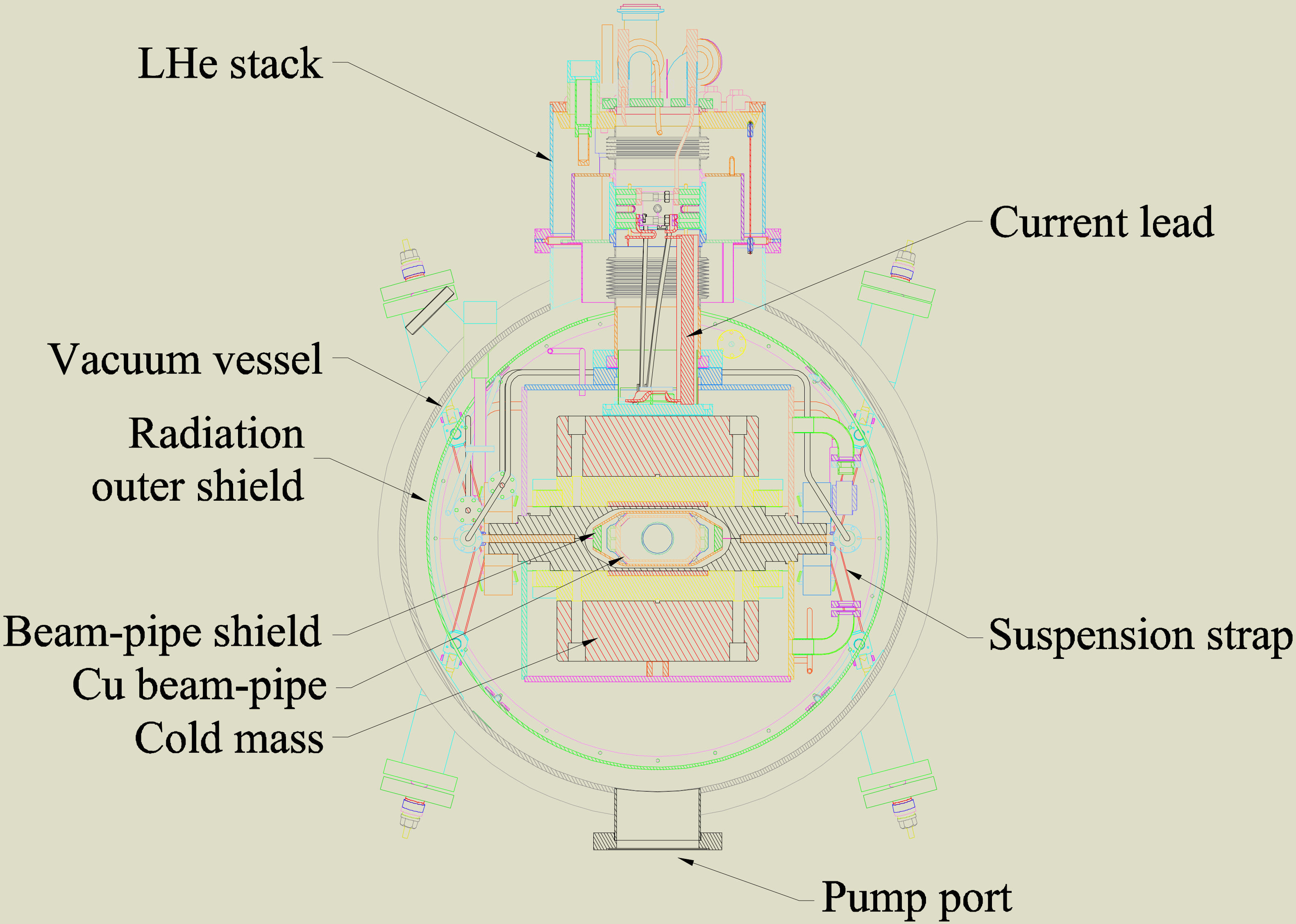


A. Temnykh

Magnet Assembly



End View


LHe stack
Current lead
Vacuum vessel
Radiation
outer shield
Beam-pipe shield
Cu beam-pipe
Cold mass
Suspension strap
Pump port

CESR-c Wiggler Features

- Capable of operation between 1.4 and 2.1 T
- Coils are bath-cooled
  - 4.2 K heat load is ~2W/m
- Magnets are trained
  - 2-3 quenches to reach full operating current
- High Temperature SC leads to minimize heat load
- LN_2 heat shield
  - Could be modified for cold He gas
  - What will ILC tunnel rules be?
  - Also used for pre-cool
  - LN_2 thermal load dominated by transfer lines
- Beampipe integral to cryostat assembly
  - Warm bore
  - Not bakeable

Damping Ring Considerations

- Baseline Configuration Evaluation Matrix
  - Field Quality: Exceeds requirements
    - Simulations indicate that keeping field roll-off at the ~0.1% level throughout beam envelope (3σ) is critical for dynamic aperture performance
  - Physical Aperture: 50 mm
    - Important for positron acceptance
    - Important for electron cloud performance
  - Power Consumption: Reasonable
  - Radiation Damage: Coils at large radius and well-shielded ⇨ looks OK
  - Auxilliary System: Cryogenics and Power
  - Cost: See following slides
  - Availability: See following slides

Wiggler Costing for BCD

Costing Info Removed!

Availability

- Short-term availability
  - Single wiggler fault expected to have minimal impact on operations
    - ΔQ_v~0.01/wiggler
    - Retune and continue operations with ~1% degradation in damping time and <1% change in emittance or maintain an in-ring spare
  - Superferric
    - PS failure
    - Cryogenic failure
    - Controls failure
    - Magnet failure
- Expect minimal time required in a damping ring scenario to disable a wiggler and resume operations. Defer repairs until scheduled maintenance periods

- CESR-c Wiggler Experience
  - Note: CESR wiggler fault requires full wiggler recovery before re-starting machine due to strong wiggler impact on optics (ΔQ_v~0.1/wiggler)
  - 11 wiggler faults in 300 operating days in mix of 6 wiggler and 12 wiggler operation

    ⇨ ~1 fault/250 wiggler-days of ops
    - 7 cryogenic
    - 2 power supply
    - 1 controls
    - 1 quench
  - 2 hrs 14 min avg turnaround for full repair

Modification Areas

- Unit Length
  - OCS2 specifies ~2.5 m active length – twice CESR-c
  - Longer version of CESR-c being pursued
    - Might be 2 units end to end in single cryostat
    - Reduce helium stack costs
- Beampipe
  - Separate from cryostat for greater flexibility in preparation
- Lower max field (1.67 T)
- Increase pole aperture
  - Plenty of current and field quality overhead in present design
  - Simplifies support plate fabrication
  - Potentially could be used to provide increased bore space

Some Practical Issues

- Clarify procedures for specifying and costing required modifications to CESR-c design
- Interface issues are significant
  - Procedures for interfacing between technical groups
  - Design control procedures
  - Special documentation?
- Would like to specify procedures now, not later

Damping Rings RDR Support

- http://www.lepp.cornell.edu/ilc
  - Entry point for ILC support areas (Wiki) at Cornell
  - For example: WG3b, ILC-Americas, Detector Study
- Damping Ring Support
  - https://wiki.lepp.cornell.edu/ilc/bin/view/Public/DampingRings/WebHome
  - Follow RDR link to get to documentation and Component Specification Sheets
    - Just getting started
    - Very much a work in progress
    - Supporting documentation
      - Schematics
      - Papers
      - Perhaps discussion area for interface between technical groups?

Comp Spec Sheet Example

ILC Damping Rings Component Specification Sheet

Part I – General Information

Component Description:	Electron damping ring sextupole		
Component Location (beamline):	EDR		
Document Number:	EDR-MAG-sxt-001	Date:	2006-04-03
Prepared by:	Mark Palmer (Cornell)	email:	map36@cornell.edu
Technical/Global System:	Magnets		
Technical/Global System Contact:	John Tompkins (FNAL)	email:	jct@fnal.gov
DR Area System Contact:	Jie Gao (IHEP)	email:	gaoj@ihep.ac.cn

Part II – Main Parameters

Parameter	Value	Reference
Quantity per beamline	240	[1]
Name in MAD deck	SF	[1]
Nominal integrated strength k_2L	0.146 Tm^{-3}	[1]
Effective length	0.25 m	[1]
Pole-tip radius	0.03 m	[1]
Nominal pole-tip field	0.005 T	[1]
Coil resistance		
Current at nominal strength		
Power		
Unit Cost		

Part III – Other Parameters, Information, and Drawings

Field quality specifications [2]

n	systematic field error		random field error	
	b_n	a_n	b_n	a_n
4	2.0×10^{-4}		1.0×10^{-4}	
5	1.0×10^{-4}		3.0×10^{-5}	
6	7.0×10^{-4}		1.0×10^{-4}	
7	1.0×10^{-4}		3.0×10^{-5}	
8	1.0×10^{-4}		3.0×10^{-5}	
9	1.0×10^{-4}		3.0×10^{-5}	
10	1.0×10^{-4}		3.0×10^{-5}	
11	1.0×10^{-4}		3.0×10^{-5}	
12	3.2×10^{-3}		1.0×10^{-4}	
13	1.0×10^{-4}		3.0×10^{-5}	
14	1.0×10^{-4}		3.0×10^{-5}	

ILC Damping Rings Component Specification Sheet

Document Number: EDR-MAG-sxt-001 Date: 2006-02-08

Part IV – References

[1] MAD deck (OCS v2, 23 March 2006.

[2] The multipole component is defined by:

$$\frac{\Delta B_y + i\Delta B_x}{|B(r)|} = \sum_n (b_n + ia_n)\left(\frac{x}{r} + i\frac{y}{r}\right)^{n-1}$$

A. Wolski, J. Gao, S. Guiducci, "Configuration Studies for the ILC Damping Rings," LBNL-59449, pp. 21-22 (February 2006).

New Lattice

- New lattice from ANL (OCS v2)
  - Available March 23rd
  - Have started preparing component specification sheets
- Quadrupole/Sextupole Overview

Arcs

Quad -	QFA:	N = 240	L = 0.300	K1L = 8.56e-02
	QDA:	N = 240	L = 0.300	K1L = -8.61e-02
Sext -	SF:	N = 240	L = 0.250	K2L = 1.46e-01
	SD:	N = 240	L = 0.250	K2L = -2.29e-01

Straights

Quad -	QFI:	N = 26	L = 0.150	K1L = 3.84e-02
	QDI:	N = 24	L = 0.150	K1L = -3.52e-02

Wiggler Sections

Quad -	QFWH:	N = 112	L = 0.150	K1L = 9.50e-02
	QDWH:	N = 80	L = 0.150	K1L = -8.51e-02

RF Sections

Quad -	QFRF:	N = 16	L = 0.150	K1L = 1.07e-01
	QDRF:	N = 32	L = 0.150	K1L = -9.46e-02

Dispersion Suppression Sections

Quad -	QFMA1:	N = 20	L = 0.300	K1L = 9.96e-02
	QDMA1:	N = 20	L = 0.300	K1L = -7.92e-02
Sext -	SF1:	N = 20	L = 0.250	K2L = 0.00e+00
	SD1:	N = 20	L = 0.250	K2L = 0.00e+00

Matching to Wiggler Sections

Quad -	QFMT1:	N = 16	L = 0.300	K1L = 1.46e-01
	QDMT1:	N = 16	L = 0.300	K1L = -1.76e-01
	QFMT2:	N = 16	L = 0.300	K1L = 1.79e-01
	QDMT2:	N = 16	L = 0.300	K1L = -1.87e-01

Matching to Straight Sections

Quad -	QFMS1:	N = 2	L = 0.300	K1L = 1.05e-01
	QDMS1:	N = 2	L = 0.300	K1L = -1.34e-01
	QFMS2:	N = 2	L = 0.300	K1L = 7.07e-02
	QDMS2:	N = 2	L = 0.300	K1L = -8.80e-02

Matching to Injection Section

Quad -	QFMINJ1:	N = 2	L = 0.300	K1L = 7.61e-02
	QDMINJ1:	N = 2	L = 0.300	K1L = -1.23e-01
	QFMINJ2:	N = 2	L = 0.300	K1L = 7.23e-02
	QDMINJ2:	N = 2	L = 0.300	K1L = -9.98e-02
	QFMINJ3:	N = 6	L = 0.300	K1L = 6.41e-02
	QDMINJ3:	N = 6	L = 0.300	K1L = -8.06e-02

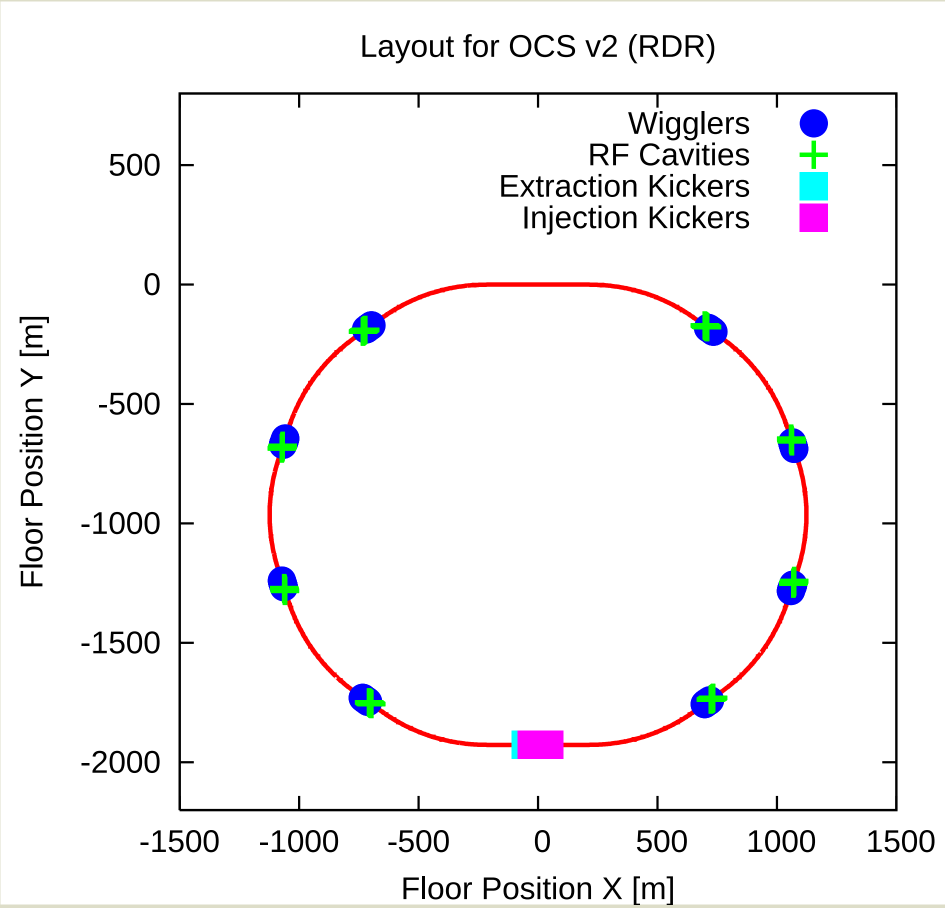
Injection Section

Quad -	QFINJ1:	N = 8	L = 0.300	K1L = 1.69e-01
	QDINJ1:	N = 8	L = 0.300	K1L = -2.17e-01
	QFINJ2H:	N = 8	L = 0.150	K1L = 1.41e-01
	QDINJ2:	N = 2	L = 0.300	K1L = -1.16e-01
	QFINJ3:	N = 2	L = 0.300	K1L = 9.11e-02
	QDINJ3:	N = 0	L = 0.000	K1L = 0.00e+00
	QFINJ4H:	N = 4	L = 0.000	K1L = 0.00e+00
	QFINJ5H:	N = 0	L = 0.000	K1L = 0.00e+00

Totals: n(QUAD) = 934 (32 types) ~783 physical quads
n(SEXT) = 520 (4 types)

OCS v2 Lattice

- Simulations with PEP-II multipole errors look satisfactory
  - Bend/Quad/Sext
  - Baseline error specification
- 8 wiggler/RF sections
  - 8 cavities
  - 10 wigglers



Summary

- Wigglers
  - Detailed design and costing information available for CESR-c wiggler
  - Need to quantify modifications for ILCDR use
    - Evaluate engineering/design issues
    - Specify procedures for design adjustment
    - Specify procedures for costing adjustment
- General Magnets
  - RDR support page up and running
  - Component specification sheets will appear over next few weeks
  - Supporting documentation will be provided simultaneously