ILC Damping Ring RDR Overview

Aimin Xiao, November 5th 2007

Daresbury EDR Kick-Off Meeting

Argonne NATIONAL LABORATORY

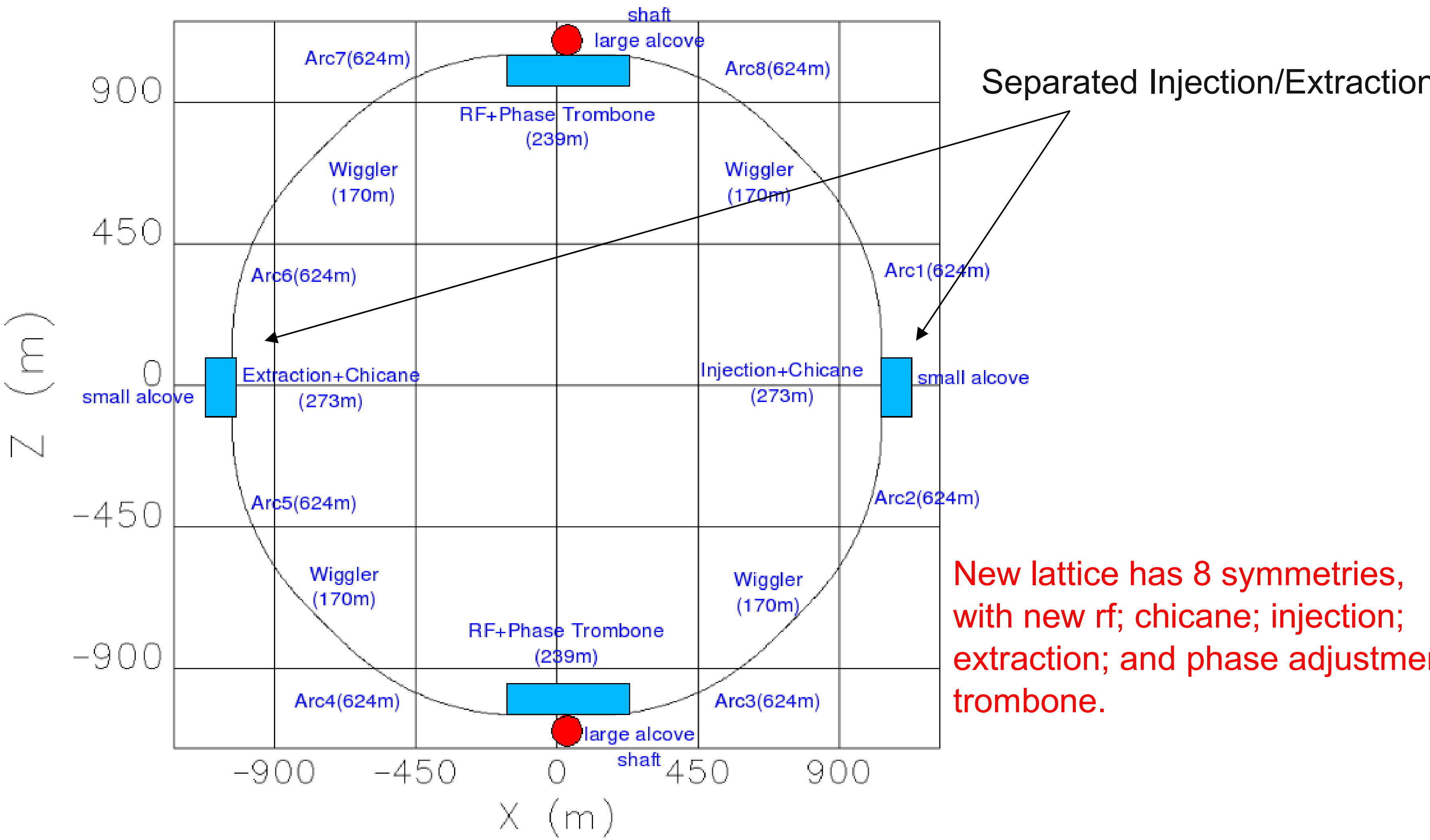
... for a brighter future

Outline

- Many Lab. and Institute have been worked on WP1 (ANL, Cornell, LBNL, LNF, IHEP …)
- Three meetings during 2007 (ILCDR07, LCWS07, GDE)
- Two latest detailed lattice design (OCS8 and FODO) had been presented at GDE meeting.
- Dynamic aperture optimization
- Possible B-factory-like ILC DR cell design
- Alternative injection/extraction region design
- Transport line lattice design
- Remain issues

A. Xiao (ANL)
L. Emery (ANL)

ILC Damping Ring RDR Lattice (OCS8) – Ring's Layout

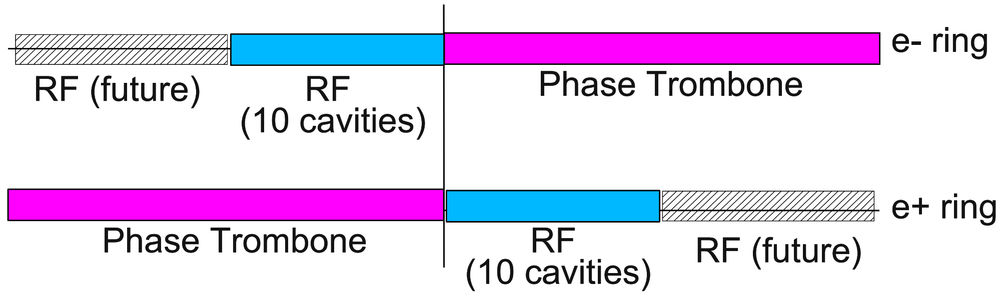


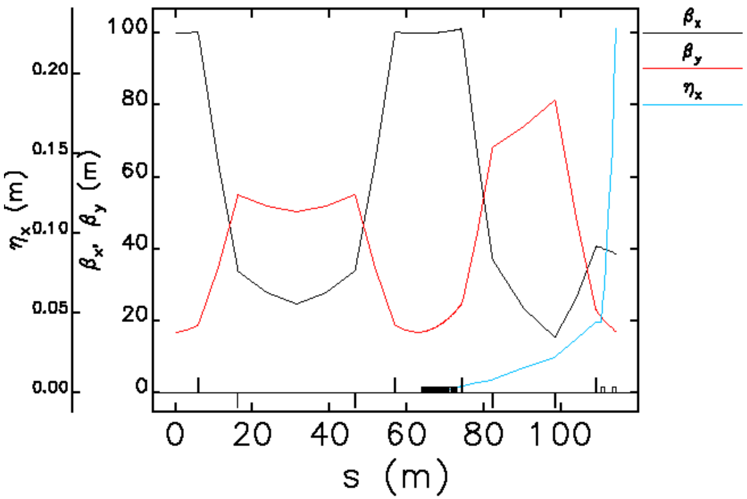
New lattice has 8 symmetries, with new rf; chicane; injection; extraction; and phase adjustment trombone.

Main Parameters

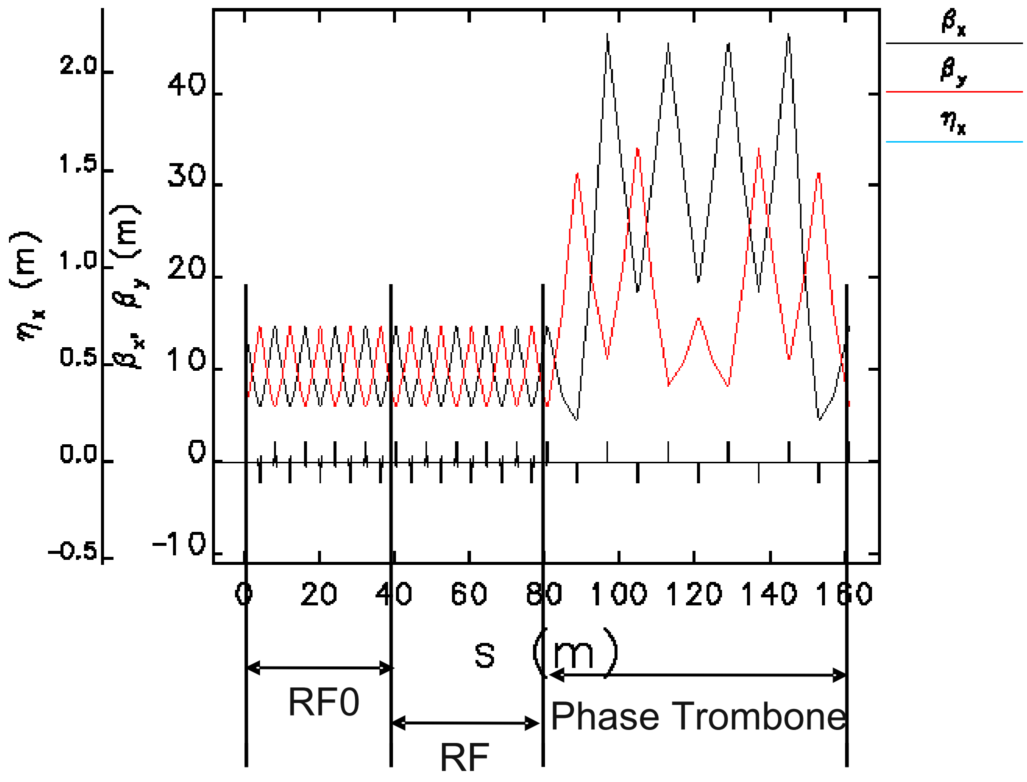
Table 1: OCS8 Principal Lattice Parameters

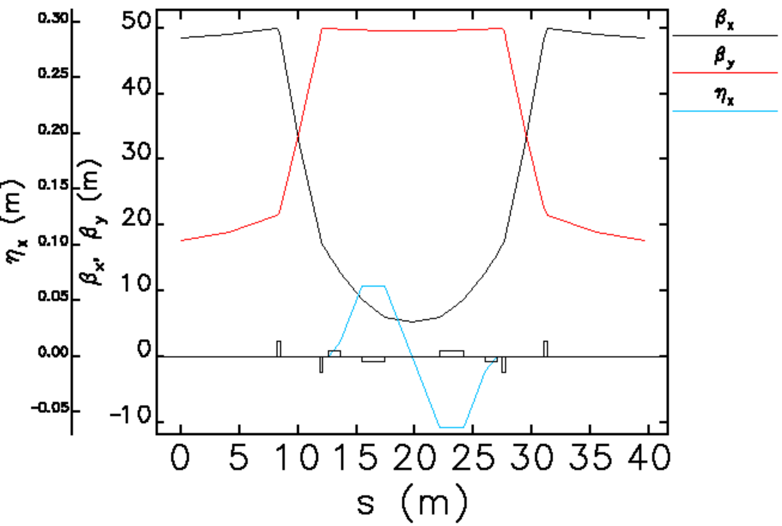
Energy	E	5 GeV
Circumference	C	6476.4395 m
Betatron tunes	ν_x, ν_y	49.23, 53.34
Chromaticity	ξ_x, ξ_y	-63.7, -63.3
Momentum compaction	α	3.96×10^{-4}
Natural emittance	$\gamma\epsilon_x$	$4.95\mu m$
Damping time	$\tau_{x(y)}$	25 ms
RF voltage	V_{rf}	21.2 MeV
Energy loss per turn	U_0	8.7 MeV
Momentum acceptance	ϵ_{rf}	1.48%
Synchrotron tune	ν_s	0.06
Equilibrium bunch length	σ_z	9mm
Equilibrium energy spread	σ_δ	0.128%





Inj./Ext. Optics

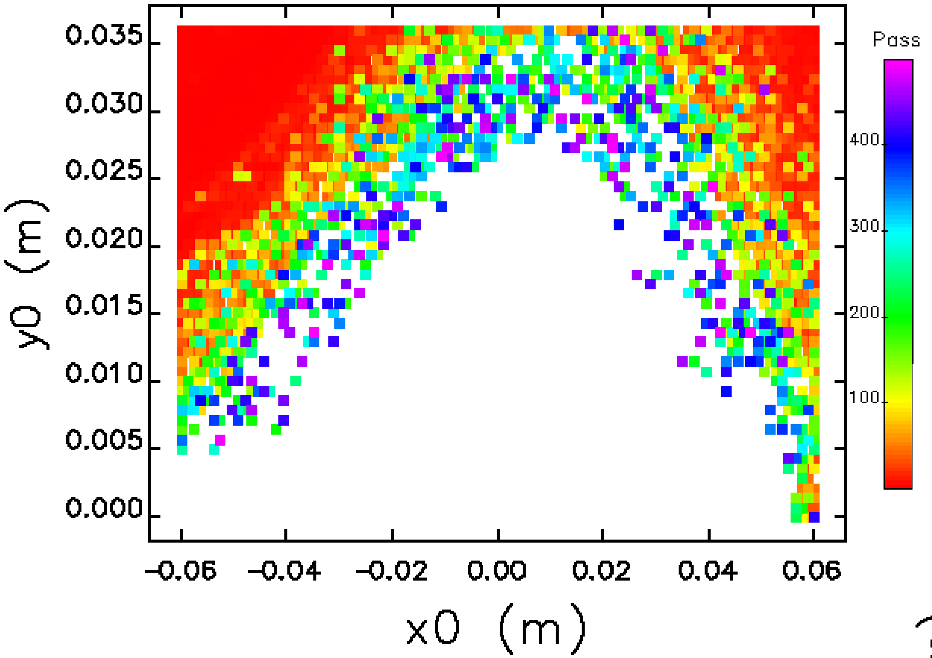


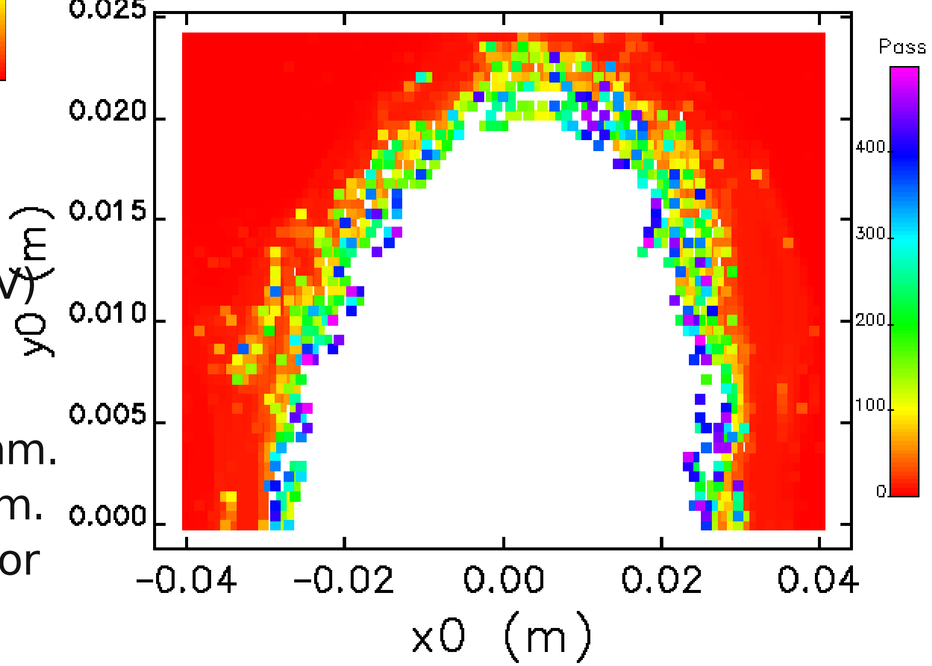


Chicane Optics

RF/Phase Trombone Optics

Dynamic Aperture





Injection beam size: 20 mm (H) x 12 mm (V)

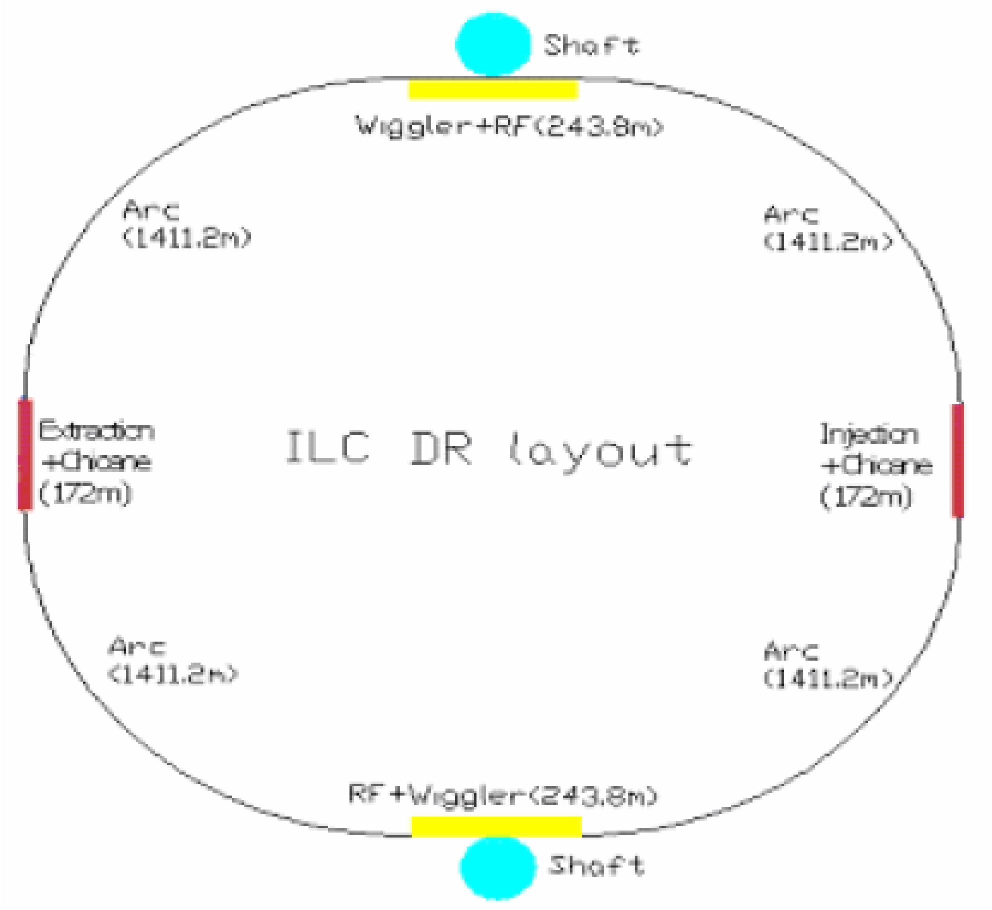
Error specified by Y. Cai (SLAC).

- The original data is for bore radius of 50mm.
- We scaled the data to bore radius of 30mm.
- Larger magnet size (= weak multipole error strength) gives larger dynamic aperture.

FODO Lattice

LAYOUT

Y. Sun (IHEP)
J. Gao (IHEP)



4 arc sections.

4 straight sections, one for injection, one for extraction, and the other two for RF/wiggler.

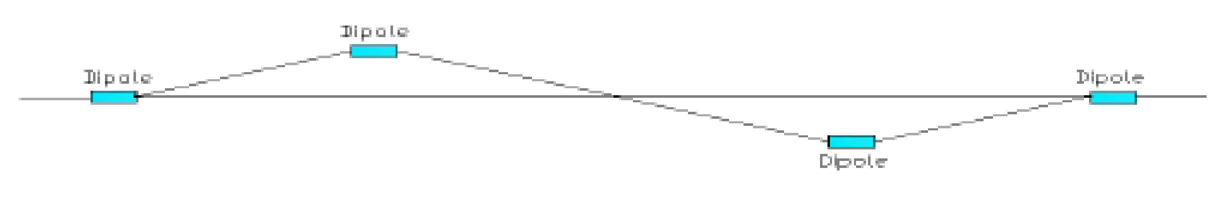
Two shafts in all and no TL.

Beam is counter-rotating.

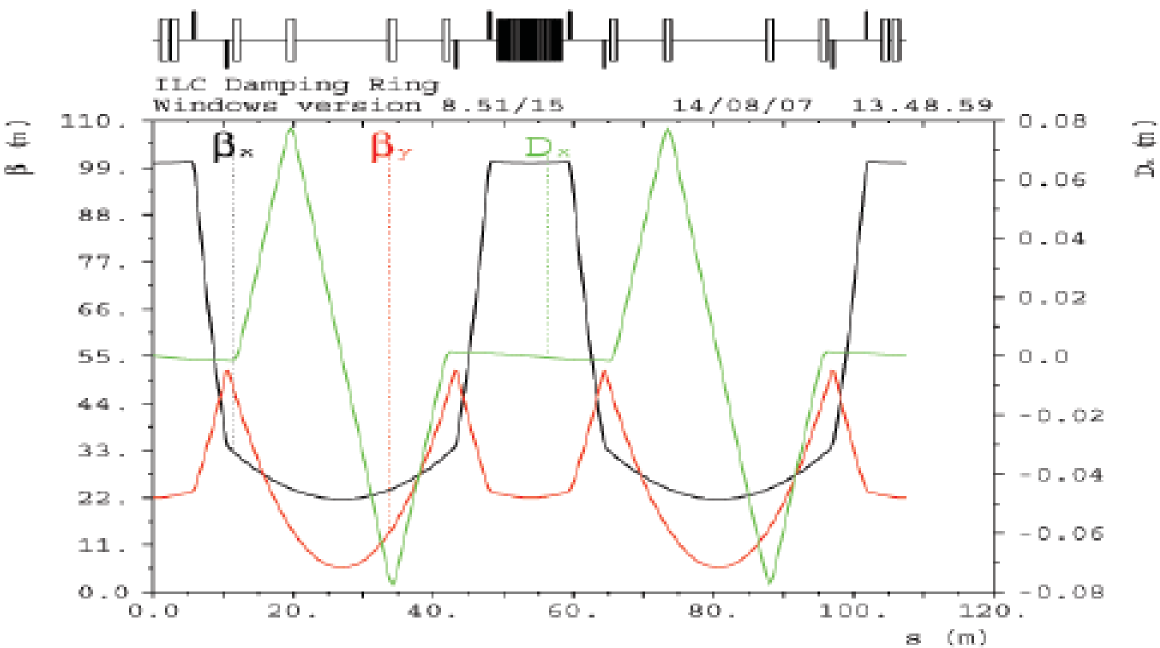
TOTAL PARAMETERS OF THREE CRITICAL MODES

Parameter	$\alpha_p=2\times10^{-4}$	$\alpha_p=4\times10^{-4}$	$\alpha_p=6\times10^{-4}$
Circumference [m]	6476.439v	6476.439	6476.439
Harmonic number	14042	14042	14042
Energy [GeV]	5	5	5
Arc cell	FODO	FODO	FODO
Tune	58.29 / 57.25	48.29 / 47.24	41.29 / 40.25
Natural chromaticity	-74 / -73	-56 / -56	-46 / -46
Momentum compaction [10^{-4}]	2	4	6
Transverse damping time [ms]	25 / 25	25 / 25	25 / 25
Norm. Natural emittance [mm-mrad]	3.36	4.2	5.4
RF voltage [MV]	15	22	31
Synchrotron tune	0.038	0.061	0.091
Synchrotron phase [°]	145	157	164
RF frequency [MHz]	650	650	650
RF acceptance [%]	1.21	1.48	1.65
Natural bunch length [mm]	9	9	9
Natural energy spread [10^{-3}]	1.28	1.28	1.28

CHICANE



Adjustment of one Chicane: $\pm 2\theta^2 (l_c + 0.5 l_B)$

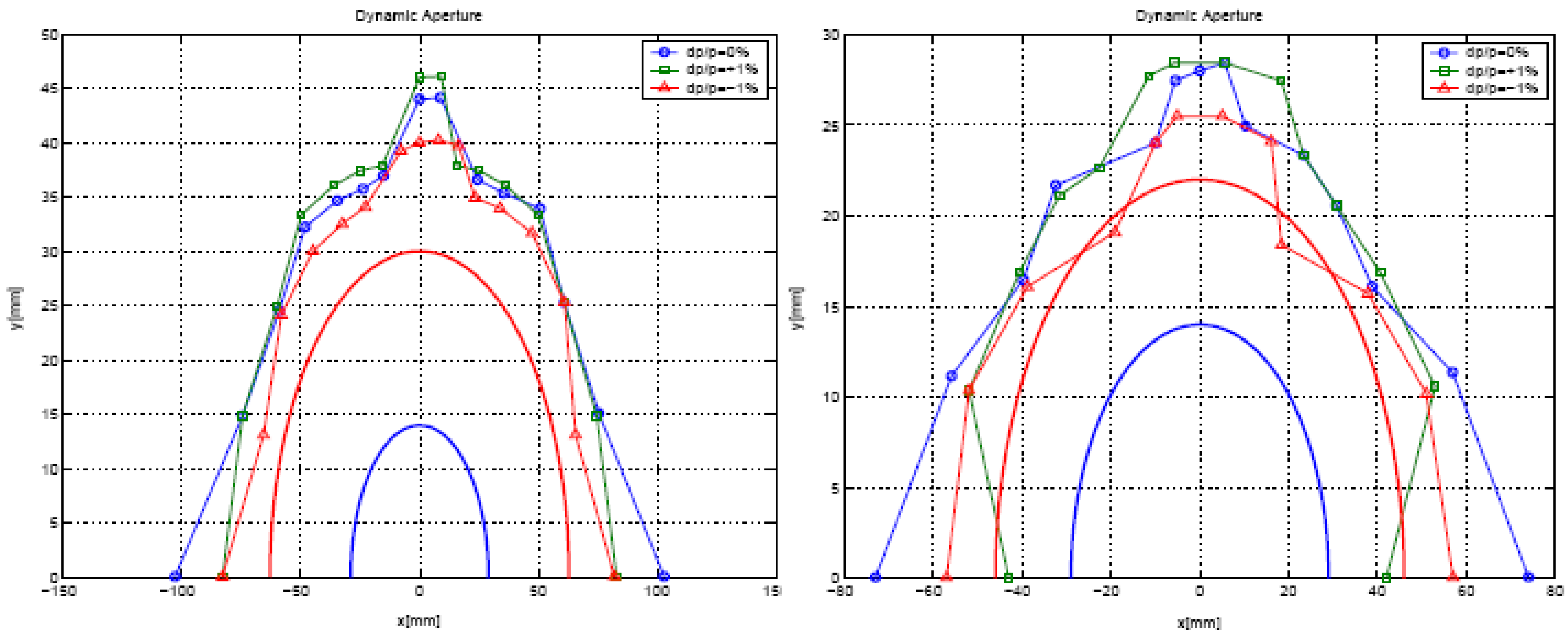


10^{-6} adjustable

4 Chicane

Emittance +9.2%

Dynamic Aperture 4×10^{-4} Alpha Case



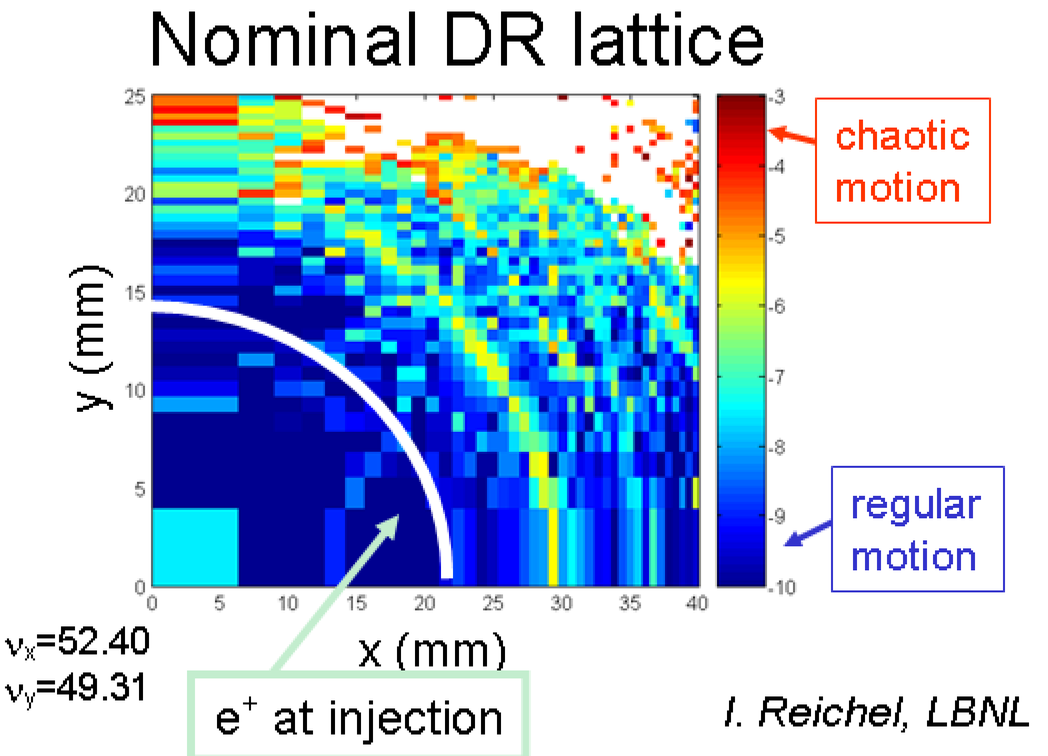
Left: no errors; Right: with high order magnets errors

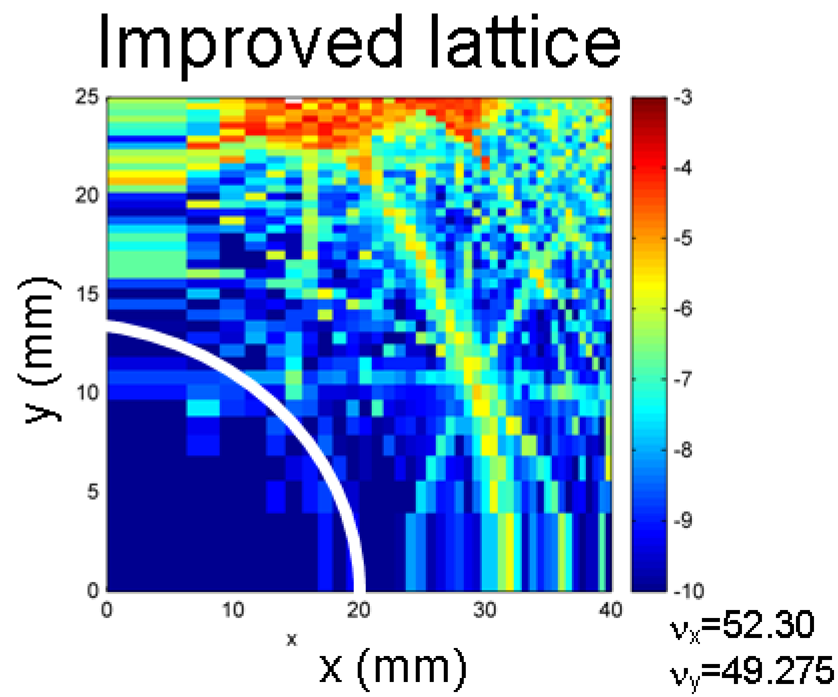
COMPARISON WITH OCS6

	OCS8 (2007.06)	*FODO-4*
Circumference [m]	6695	6476.439
Arc cell	TME	FODO
Phase advance of arc cell	90/90	60/60~90/90
Momentum compaction [10^{-4}]	4	2~6
Quadrupoles in all	**682**	**448**
Dipoles in all	114 × **6** m +12 × **3** m	368 × **2** m
Sextupoles in all	**480**	**368**
Number of wiggler straights	**4**	**2**

Dynamic Aperture Studies

I. Reichel (LBNL)





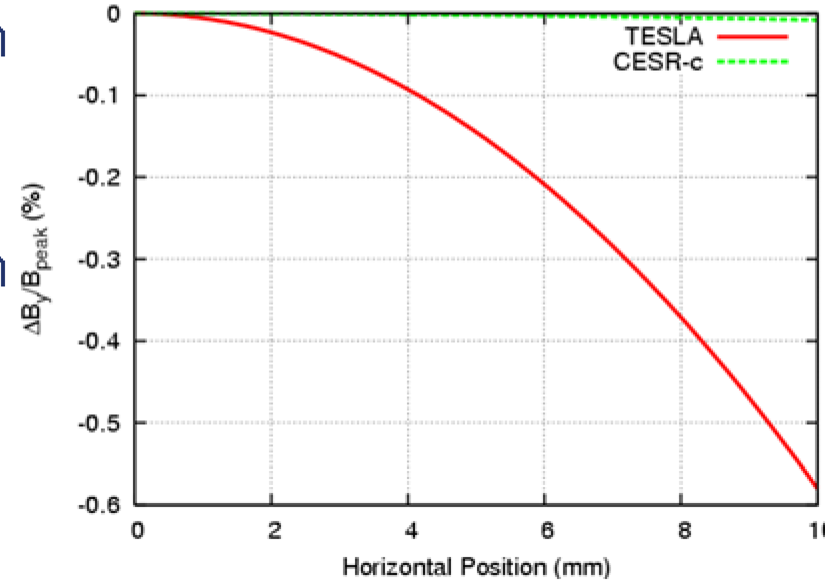
- Frequency maps indicate presence of harmful resonances and suggest ways for lattice optimization
- OCS6 lattice suffers from reduced degree of symmetry
  - different working point and harmonic sextupoles improve dynamic aperture

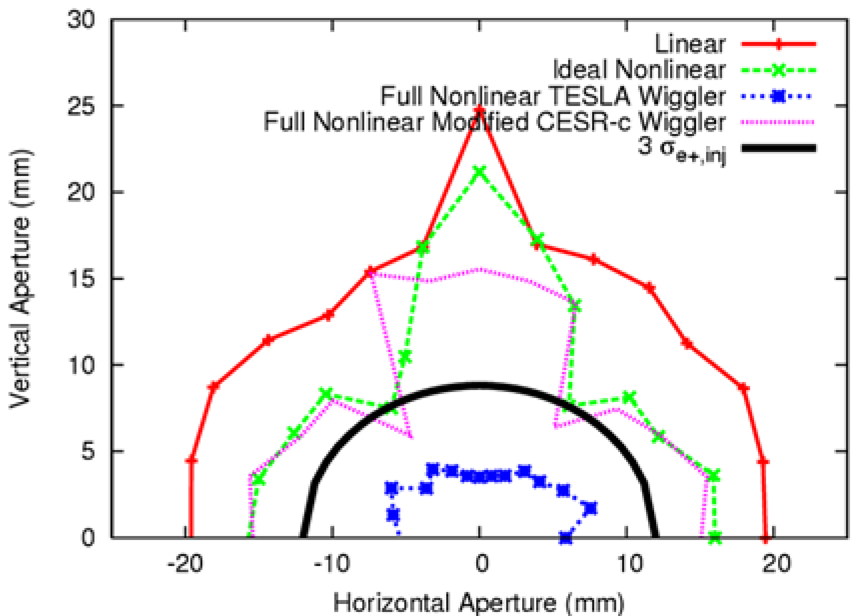
Wiggler Comparison

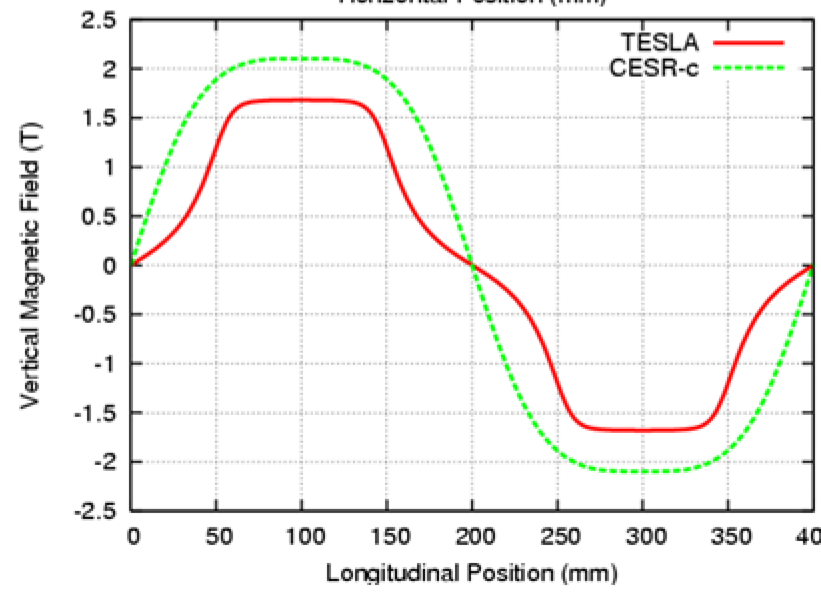
J. Urban (Cornell)

	TESLA	CESR-c	Modified CESR-c
Period	400 mm	400 mm	400 mm
$B_{y,peak}$	1.67 T	2.1 T	**1.67 T**
Gap	25 mm	76 mm	76 mm
Width	60 mm	238 mm	238 mm
Poles	14	8	**14**
Periods	7	4	**7**
Length	2.5 m	1.3 m	2.5 m

J. Urban

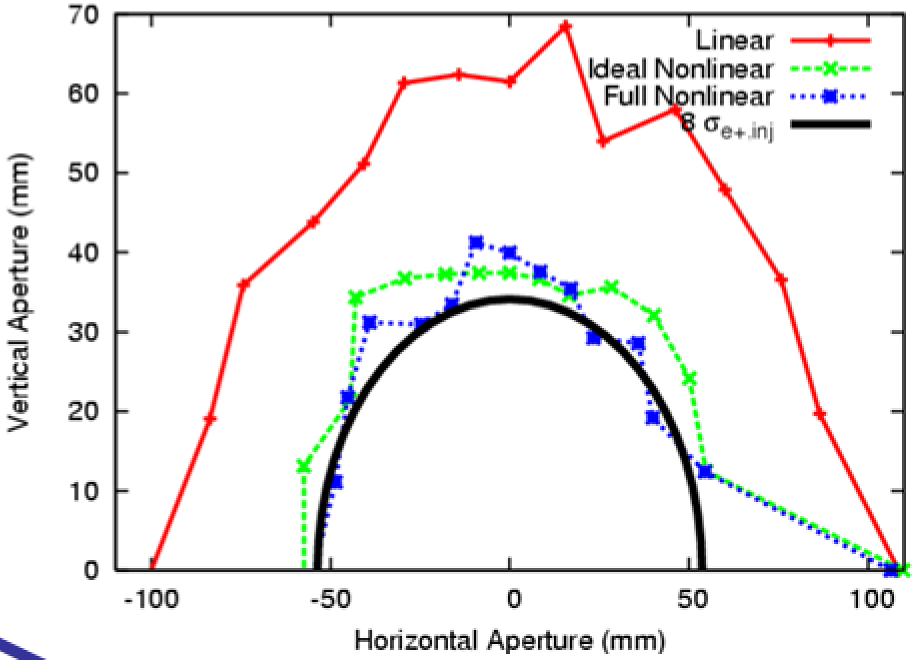






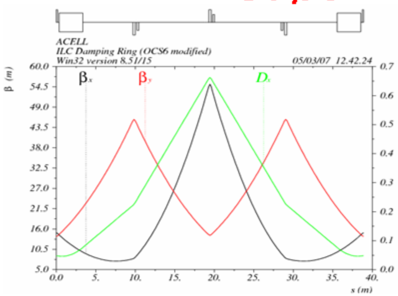
Optimized Wiggler

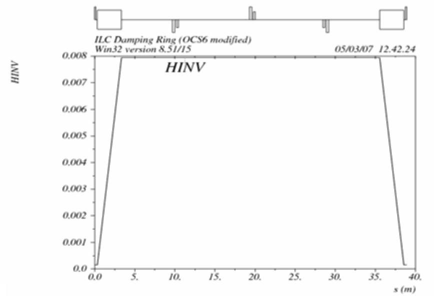
- Superferric ILC-Optimized CESR-c Wiggler
  - 12 poles
  - Period = 32 cm
  - Length = 1.68 m
  - $B_{y,peak}$ = 1.95 T
  - Gap = 86 mm
  - Width = 238 mm
  - I = 141 A
  - τ_{damp} = 26.4 ms
  - $\varepsilon_{x,rad}$ = 0.56 nm·rad
  - σ_δ = 0.13 %



Misses nominal target (25 ms)

SuperB-like cell

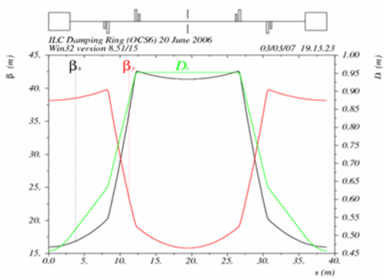


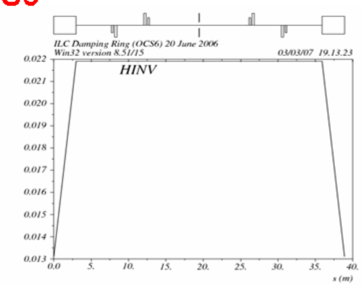


$\mu_x = .5$, $\mu_y = .25$

$\mathcal{H}$(cell) = $\mathcal{H}_{OCS6}$(cell)/4

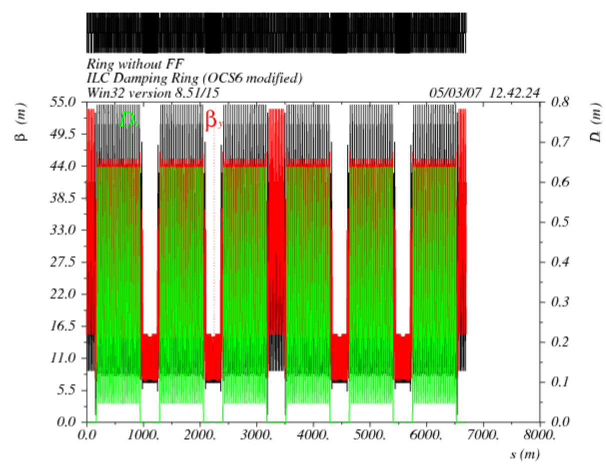
OCS6





M. Biagini (LNF-INFN)

Ring



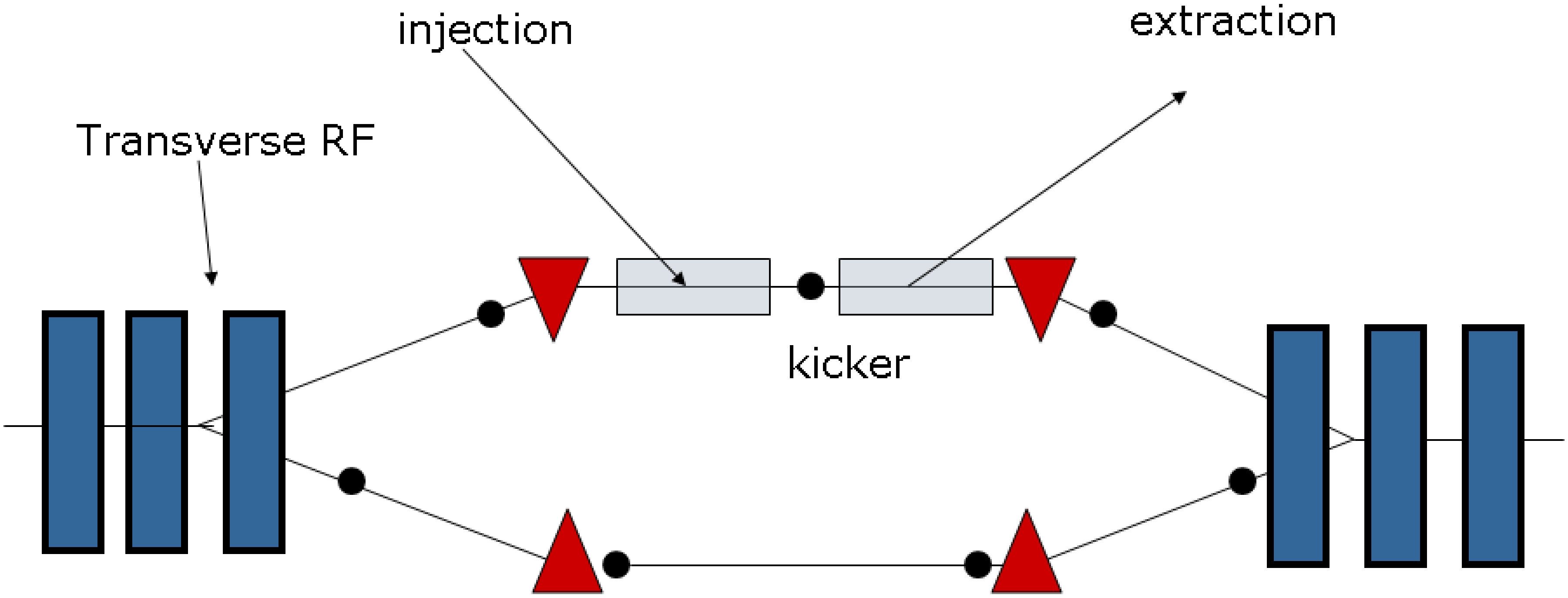
$\varepsilon_x = .29$ n
$\tau_s = 12.8$

Conclusions

- This lattice has:
  - higher chromaticity
  - no injection section for now)
  - tunes not optimized
  - α_c=.5e-4 → too small
- Improvements can be made :
  - increase bending angle --> similar emittance and α_c as OCS6
  - less cells → shorter ring
  - lower chromaticity
- Worthwhile to continue this study ???

D. Rubin, R. Helms (Cornell)

In the event that an injection/extraction kicker with pulse width of 6ns is not practical, then we can increase effective bunch spacing with RF separation



Discussion of Lattice Issues

- Many items covered during Monday afternoon discussion
- Key action items (short term):
  - Additions to lattices (Aimin Xiao and Yi-Peng Sun)
    - Timescale: Implement as much as possible by LCWS07
    - List:
      - ✓ » Need to update RF configuration
      - ✓ » Circumference Adjustability
      - This is easy… » Abort dump
      - ✓ » Phase Trombone
      - ✓ » Lumped Injection/Extraction Kickers
      - ✓ » Implement separated injection/extraction straights
      - ✘ » Add correctors (dipole and skew quad) to lattice definition for LET studies
      - ✘ » Add BPM locations
      - ✘ » Nomenclature for naming elements around ring
      - ✓ » Specify apertures
      - ✓ » Return to greater symmetry in the ring

M. Palmer at ILCDR07

Remain Issues

- Re-do injection/extraction line design
  - Reduce strip-line kicker strength to 75% (+/- 7.5 kV for each strip-line)
  - Increase clearing distance between beam edge and strip-line plate
    - *Keep beam inside good field region*
    - *Need input from hardware design*
    - *Need simulation results on beam loss*
  - Use DC septum or Lambertson (need input from hardware design)
- Re-do transport line design
- Implement varied momentum compaction factor lattice
- Continuing dynamic aperture optimization
- Comparing of TME and FODO lattice
- Update lattice as requested