Cornell University
Cornell High Energy Synchrotron Source

CESR as Light Source

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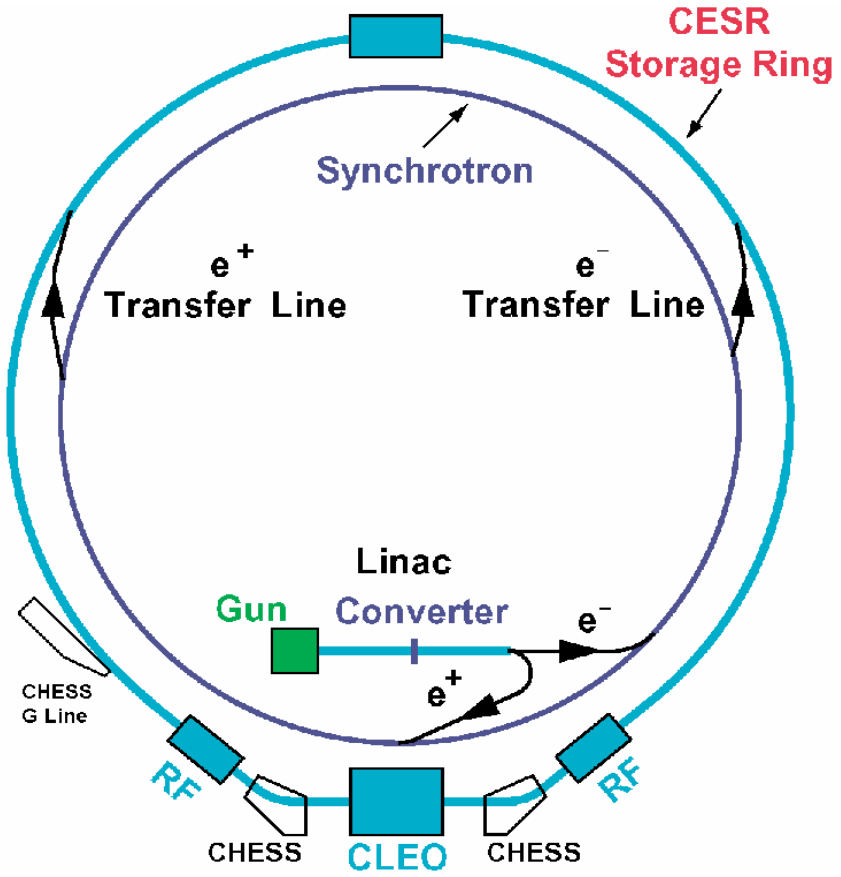
- Introduction to CESR
- CESR Operating Status
- Multi-bunch optics
- Low emittance tuning
- Single beam test optics

CESR

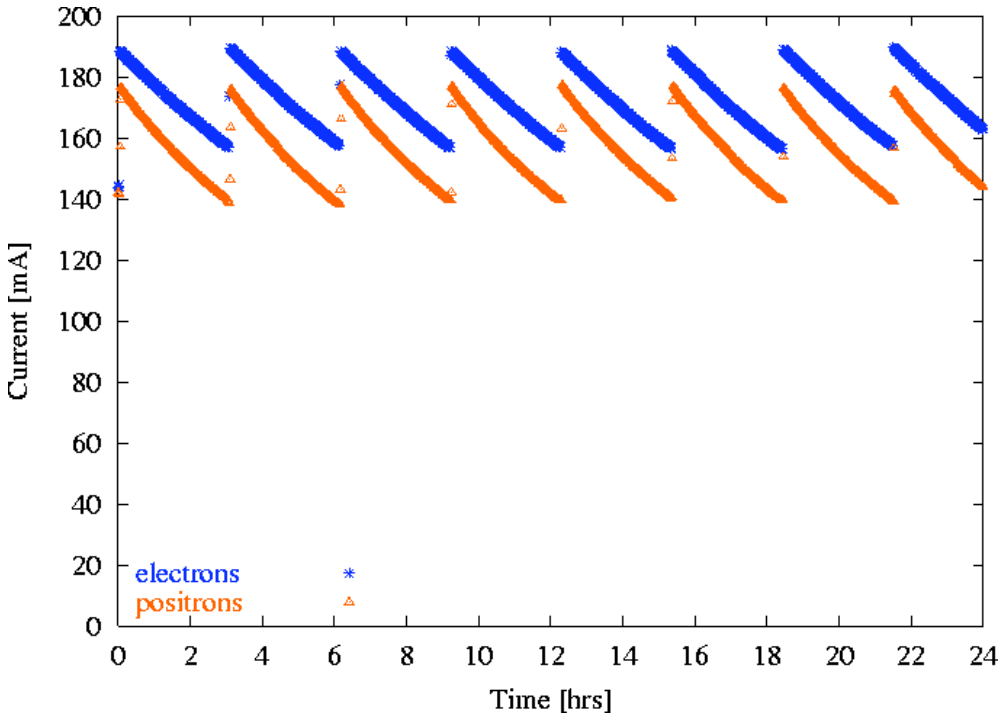
- CESR operates with counterrotating beams of electrons and positrons
  - Beam energy ranges from 1.5-5.5 GeV

HEP Bunch configuration
- 9 equally spaced trains
- As many as 6 bunches/train with 14ns spacing
- I_{total} ~ 250 mA/beam

Injector
- Linac ~ 300MeV e^- & 150MeV e^+
- Synchrotron booster accelerates to full storage ring energy
- Linac/synchrotron cycle at 60Hz
- Electron gun pulses at up to 72MHz (one bunch every 14ns) to fill CESR with trains of bunches (~25 bunches/cycle)



CESR operations



200 mA - 30 bunches electrons

180 mA - 22 bunches positrons

$\tau \sim 12$ hours

Periodic top off ~ 3hours

(Top off in 3 minutes)

$\varepsilon_h \sim 140$ nm

$\varepsilon_v \sim 1\text{-}2$ nm

X-ray beam position stability < 30 μm.

23.5 hours beam/day

CESR multi-bunch operation

Two beam operation

To prevent collisions of counterrotating beams, 4 electrostatic kickers that deflect electrons and positrons in opposite directions are used to generate differential closed orbits

With 9 trains/ 6 bunches/train collisions at IP

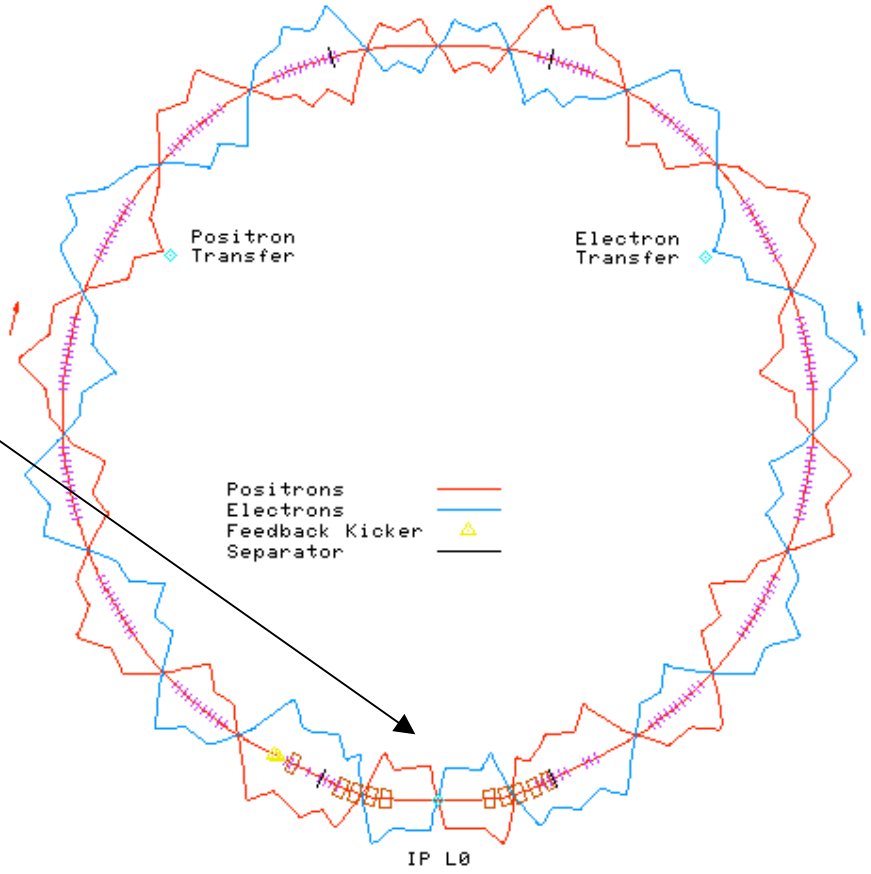
With removal of low β interaction region optics collisions are not tolerable →

Configuration for CHESS today is

4 positron and 5 electron trains

[6 bunches/train]

24 bunches of positrons, 30 bunches of electrons



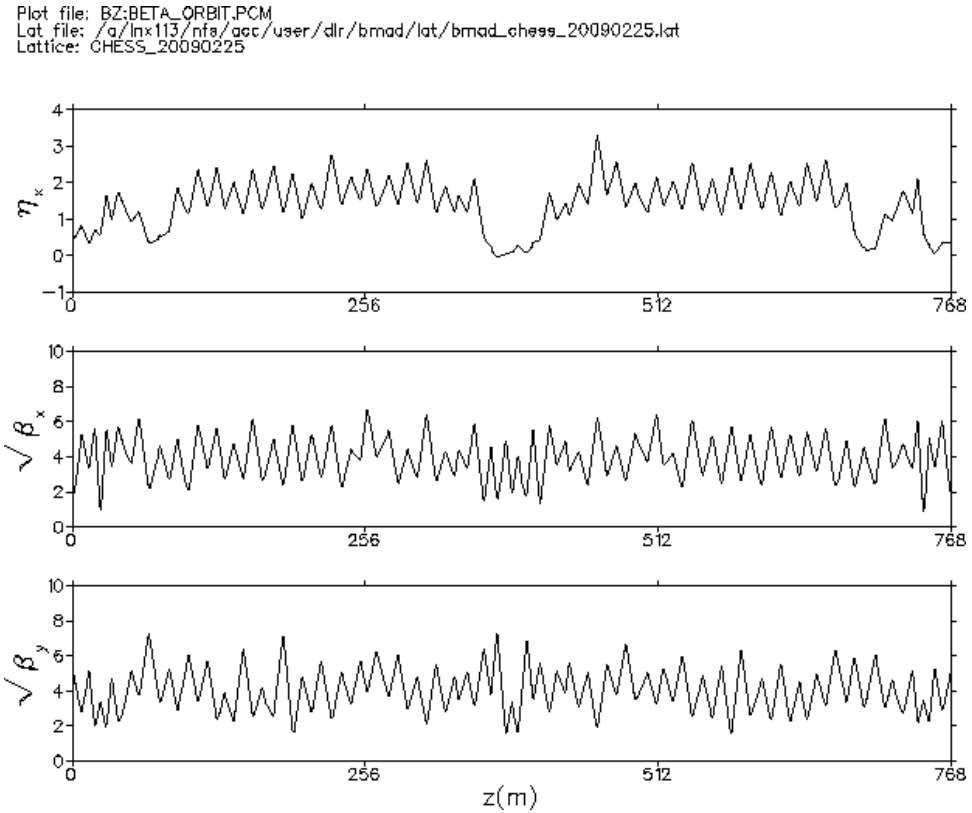
High bunch current /good lifetime/ low vertical emittance are mutually exclusive

More brilliance requires more bunches

More Bunches

CESR optics are flexible

-No periodicity
-No symmetry
-All quadrupoles (100)
and sextupoles (78)
are independently powered



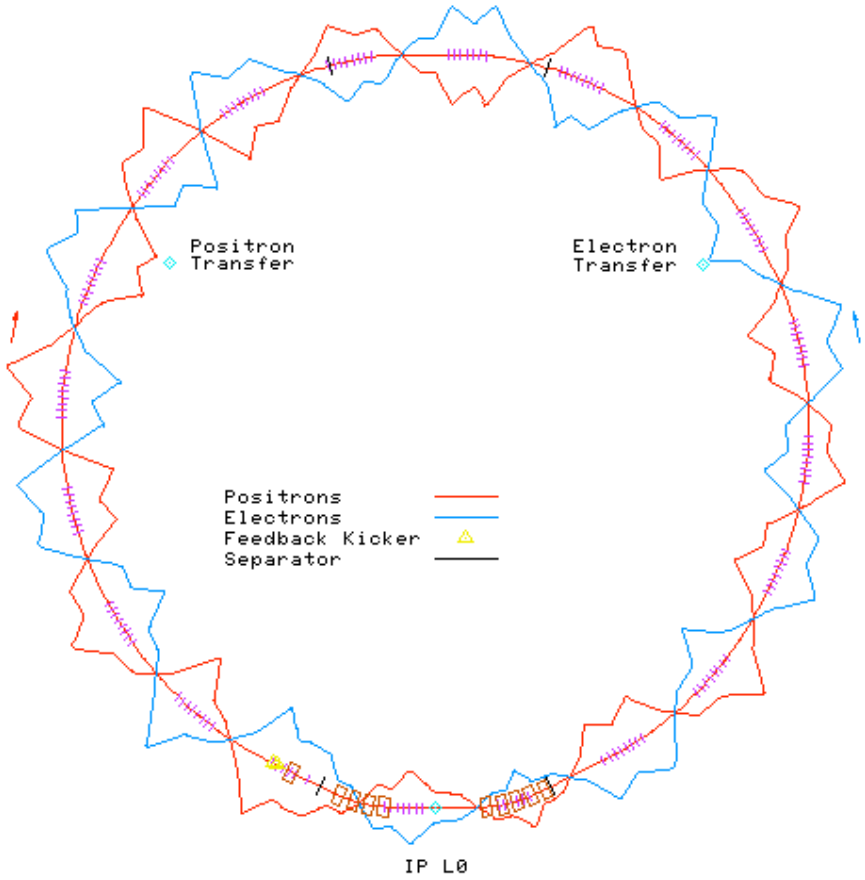
9X5 optics

CESR multi-bunch operation

10X4 optics

Rearrange β-phase advance
-Electron and positron closed orbits
accommodate 10 trains (20 lobes)
with 4 bunches/train

→ 40 bunches/beam



10X4

Development of 10X4 optics is underway
in machine studies
Anticipate 10X4 operation beginning
with next CHESS run - September 2009

Low Emittance Tuning *(grad students Jim Shanks and Walter Hopkins)*

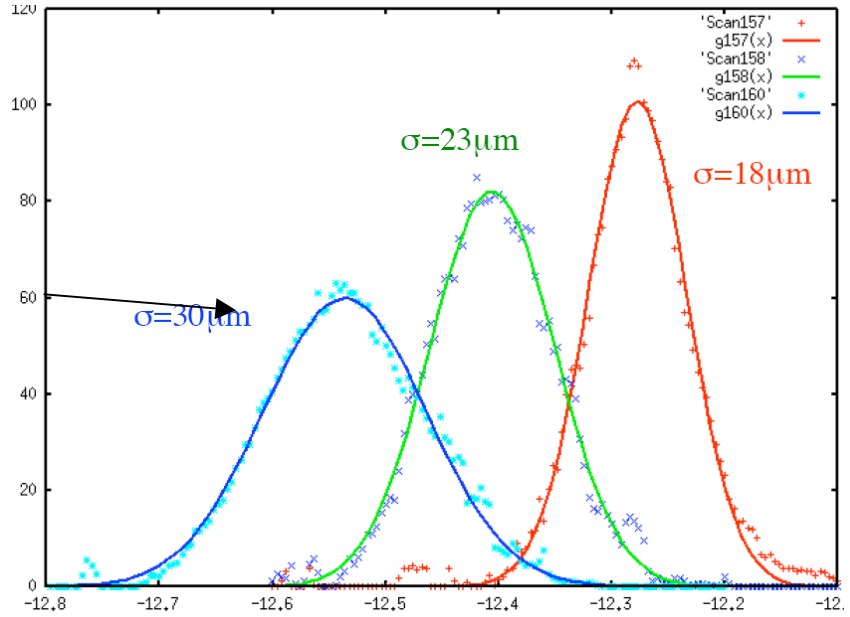
Having removed the low-β interaction region optics
including CLEO 1.5T solenoid, rotated IR quadrupoles, vertical separators
we have eliminated principle sources of transverse coupling, vertical dispersion and vertical beam size

Instrumentation

-New survey and alignment network
laser tracker/digital level
→ faster and more precise alignment

-Upgrade from analog to digital beam position monitor electronics will permit single bunch/single pass/real time/nondestructive measurement of
Orbit , β-functions, Transverse coupling ,Dispersion

- Xray vertical beam size monitor (bunch by bunch)
- Developing techniques and software for online analysis of beam based data
→ preserve minimum emittance and stable beam position



Undulator Test optics

CESR optics are flexible but:

- Two beam optics severely constrained to preclude collisions
  - Number of bunches/beam limited
  - Impedes low emittance tuning
    (beam is off axis and in fringe field in most magnets)
  - Complicates injection
    (injected bunch collides with opposite species stored beam)

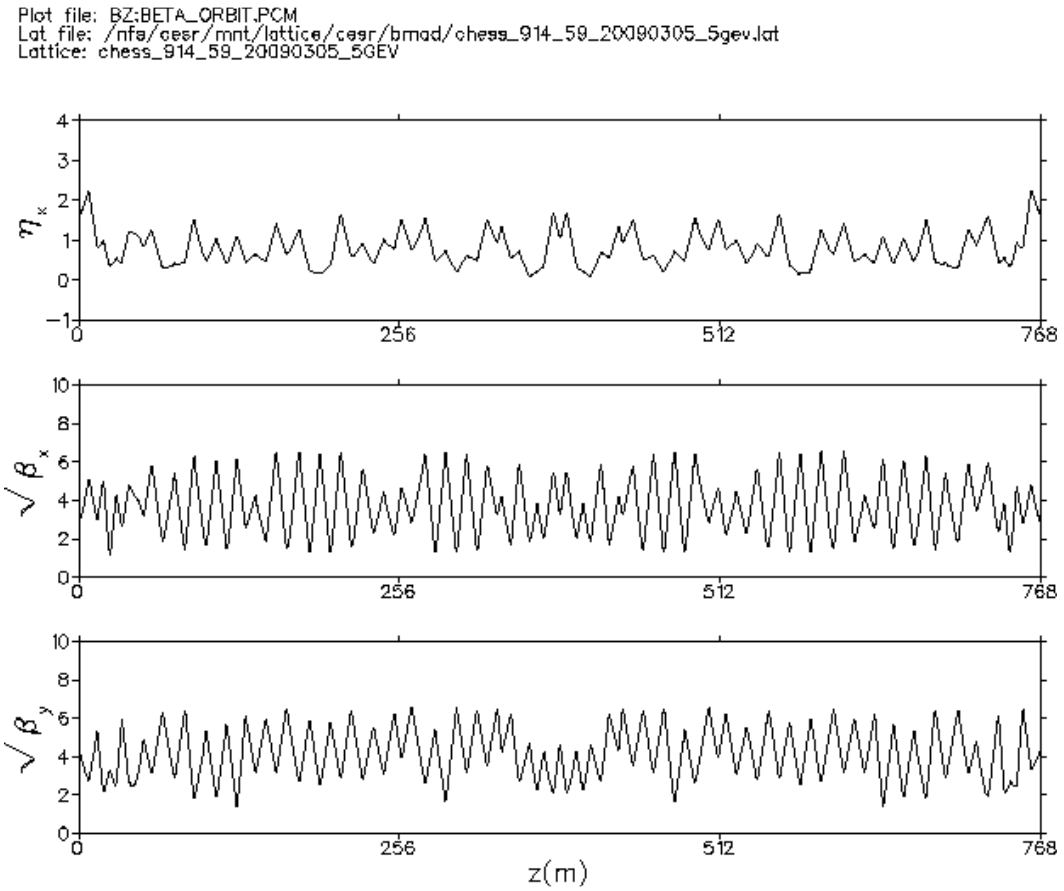
Single beam optics - no "pretzel" constraint

- Lower horizontal emittance optics
- More bunches (lower bunch current, smaller vertical beam size, longer lifetime)
- More efficient injection (top off ?)
- Reduced vertical emittance

Single beam optics

Undulator test optics

5GeV
Positrons
>180 bunches
I = 250mA
ε_h = 50nm
ε_v ~ 200pm



Summary

CESR Parameters	Today	September 2009	Single beam Machine studies	
Energy[GeV]	5.3	5.3	5.3	2.0
Emittance[nm] (h/v)	140/1	110/1	52/0.2	2.5/0.02
Bunches	30/22	40/40	>180	>180
Current/beam [mA]	175	225	250	>250
Particle species	e^+ & e^-	e^+ & e^-	e^+ or e^-	e^+ or e^-
Horizontal Tune	10.57	10.21	14.57	14.57