CESR STATUS

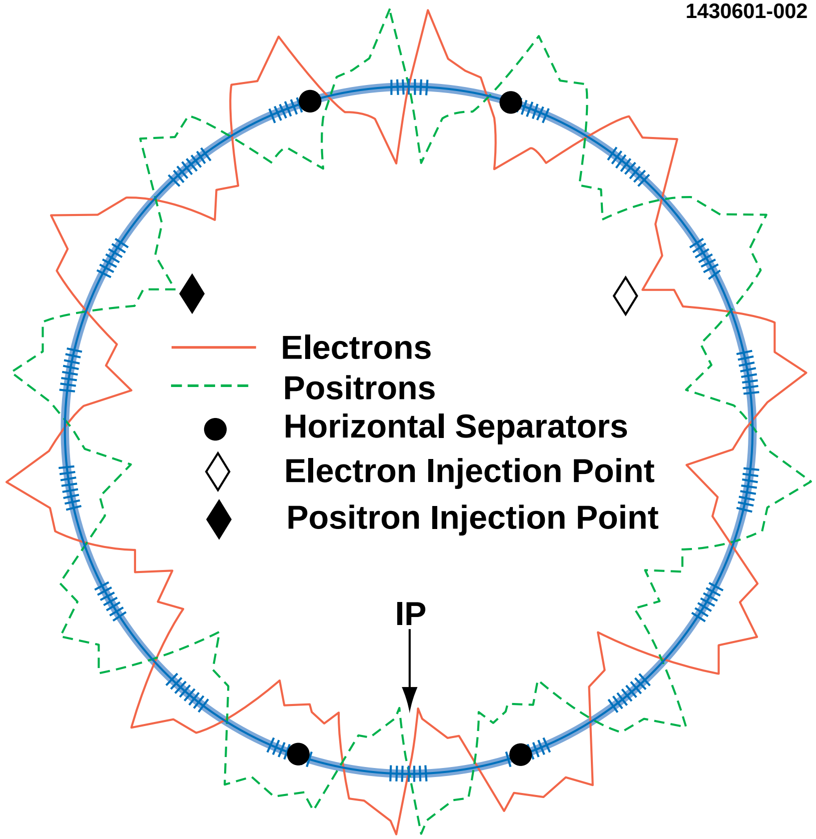
D. RUBIN FOR CESR OPERATIONS GROUP

OCTOBER 15, 2001

- Summary of 4s run
  - Machine configuration
  - Luminosity limit
- Machine Upgrade
  - Positron converter
  - Superconducting IR quads
  - x-ray beam line
- Commissioning
- Operation at $\sim$1.9GeV
- Resonance run plan

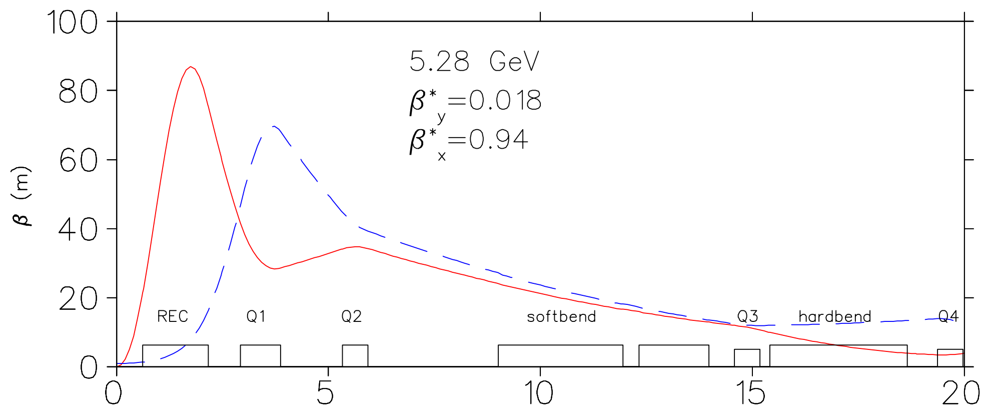
4S RUN

- Machine Configuration
  - Electrostatically separated orbits
  - Nine trains with 5 bunches/train in each beam
  - $\pm 2.5 mrad$ crossing angle
  - 8mA/bunch
  - Bunch spacing within each train - 14ns



INTERACTION REGION

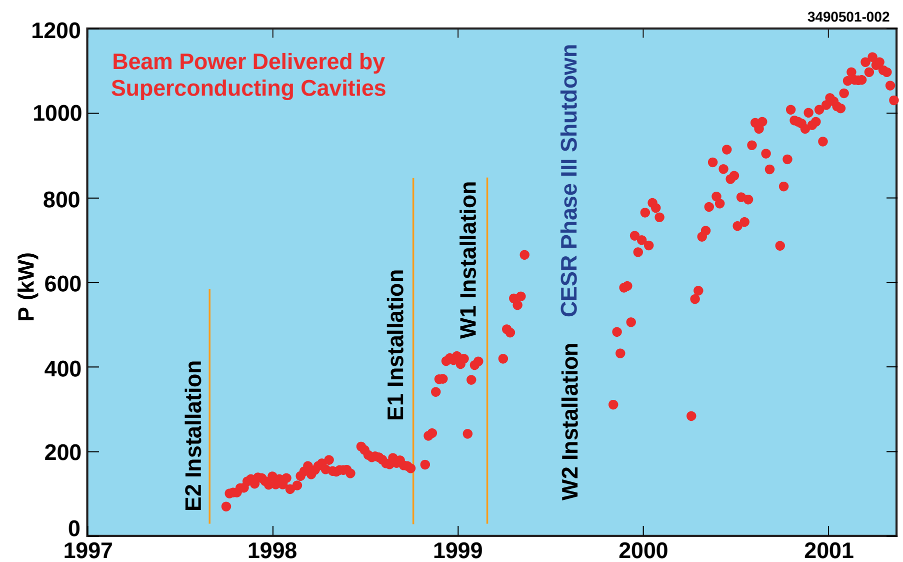
- 1.5m REC final focus quadrupole
  - Solenoid compensation by rotation of IR quads
  - $\beta_v^* = 18\text{mm} \rightarrow 21\text{mm}$
  - $\beta_h^* = 94\text{cm}$
  - $\sigma_l = 18\text{mm}$
- Parasitic crossing 2.1m from IP -
  - Largest vertical tune shift of 89. $\Delta Q_v \sim \frac{I_b \beta_v}{x^2}$



SUPERCONDUCTING RF

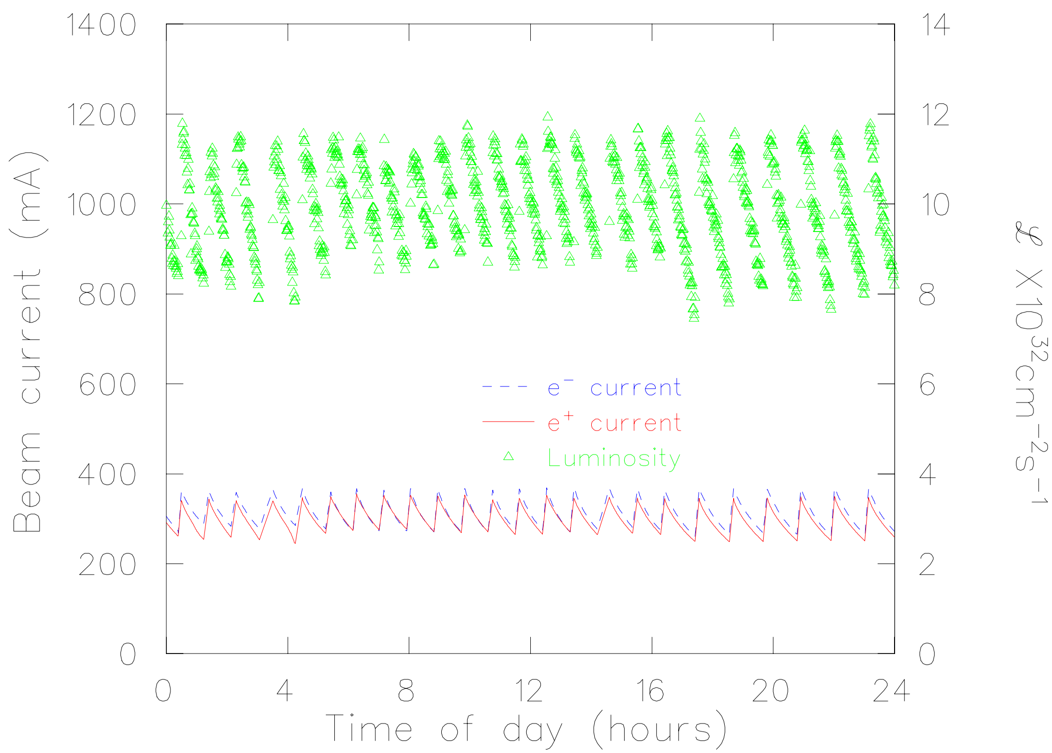
- 4- single cell - 500MHz superconducting RF cavities

T	4.5K
$< G >$	6.2MV/m
$\hat{V}$	7.4MV
I_{total}	750mA
P_{beam}	1.1 MW
P_{HOM}	2.75kW/load
P_{max}/cavity	294kW

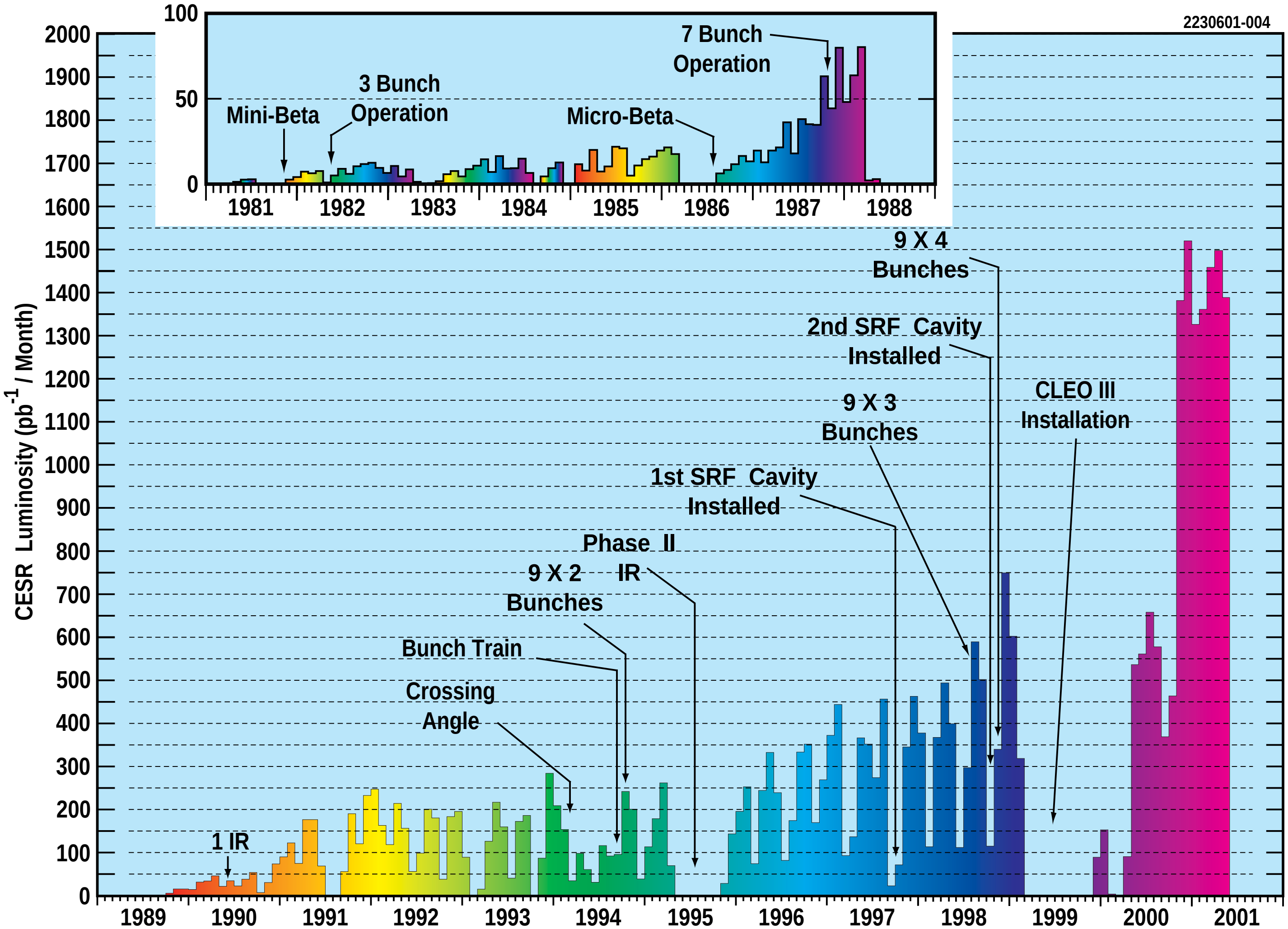


4S Performance

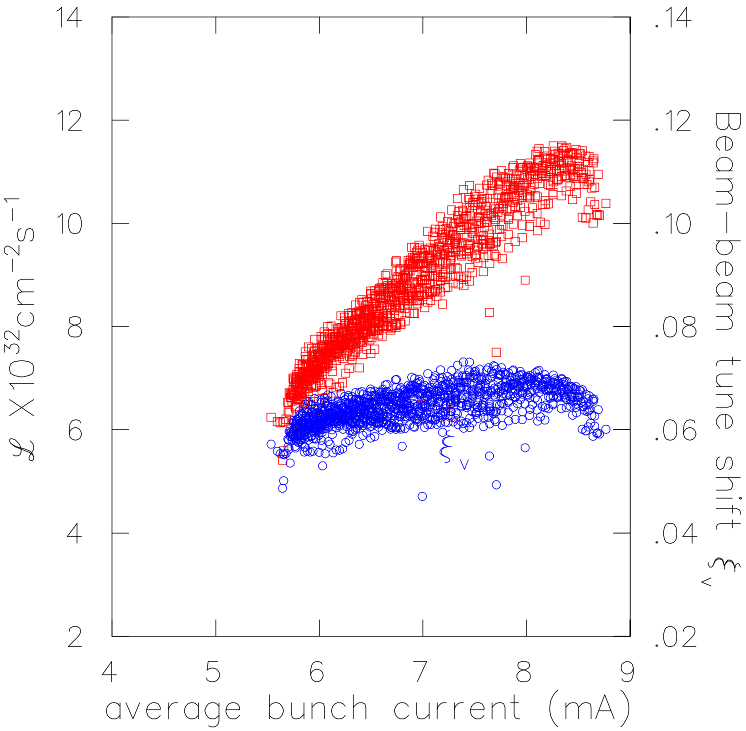
Total beam current	750mA
Non HEP time	~6 minutes/fill
β_v^*	21mm
ξ_v	0.07
Peak luminosity	$1.3\times10^{33}cm^{-2}s^{-1}$
$\int L$/day	$73pb^{-1}$
$\int L$/month	$1500pb^{-1}$
$11/2000 \rightarrow 6/2001$	$11.24fb^{-1}$

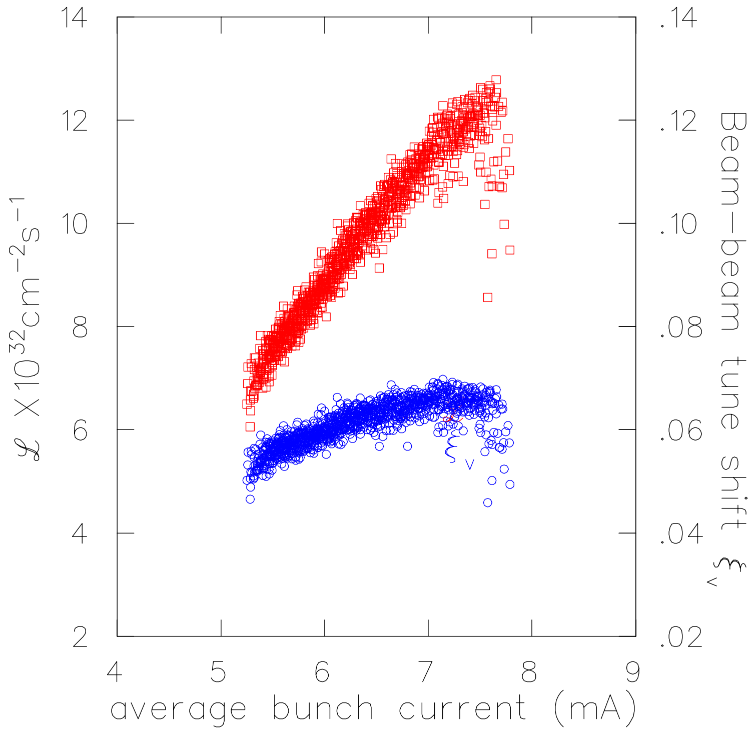


LUMINOSITY HISTORY



LUMINOSITY LIMITS





- 9 trains with 4 bunches/train
  - $\xi_v \sim 0.07$
  - Tune shift saturates at 7.5mA/bunch
  - Beam-beam limited - increased bunch current $\rightarrow$ poor lifetime and deteriorating specific luminosity

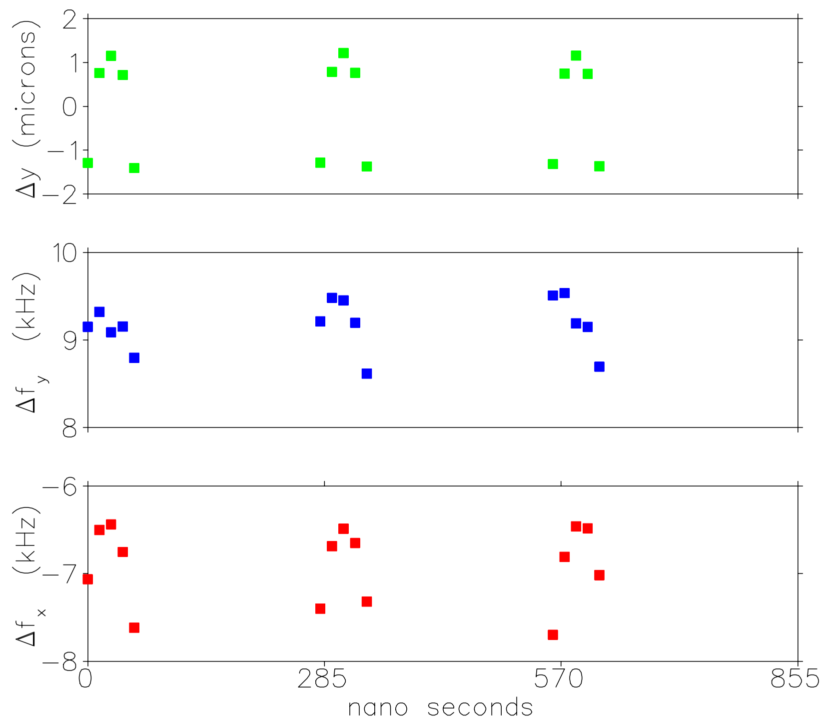
- 9 trains with 5 bunches/train
  - $\xi_v \sim 0.065$
  - Tune shift saturates at 7mA/bunch
  - Specific luminosity decreases with increasing current

Parasitic beam-beam interaction

- Uneven spacing ⇒ bunch dependent tune and closed orbit
  - Closed orbit $x(s) \sim a\sqrt{\beta_h(s)}\sin(\phi_h(s)-\phi_0)$
  - Long range beam-beam tune shift
    $\Delta Q_h \sim \frac{I_b\beta_h}{x^2} = \frac{I_b}{\sin^2(\phi_h(s)-\phi_0)}$

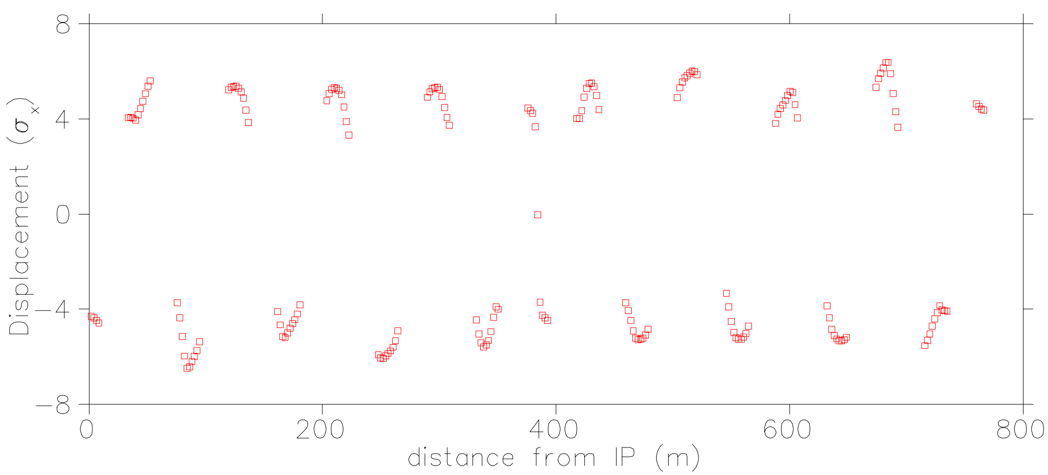
Bunch dependent electron positron orbit difference at IP for first 3 trains with 7.5mA/bunch. $\sigma_y \sim 4\mu$. →

Bunch dependent tune shift for first 3 trains with 7.5mA/bunch. →



PARASITIC BEAM-BEAM INTERACTION

- Horizontal tails
  - Minimum separation $\sim 7\sigma_x$
  - Tails of the bunch approach core of counterrotating bunch $\rightarrow$ large vertical tuneshift and particle losses
- Bunch dependent luminosity
  - Bunches at center of train yield 25% higher luminosity than bunches at ends of the train



Separation at parasitic crossing points in units of horizontal rms beam size

Parasitic beam-beam interaction

- Compensation of bunch dependent tune and orbit
  - Orbit correction with fast kicker
    - Adjust closed orbit independently for each bunch
    - $\sim 1\mu m$ capability
    - Mixed result
  - Tune correction with RFQ
    - $f_{RFQ} = 9 \times f_{ref}$
- More closely space bunches
  - Reduce bunch spacing to 6ns and 8ns from 14ns
    - Sufficient separation near IP?
    - Simulation indicates tune spread increases more rapidly than total current.

UPGRADE

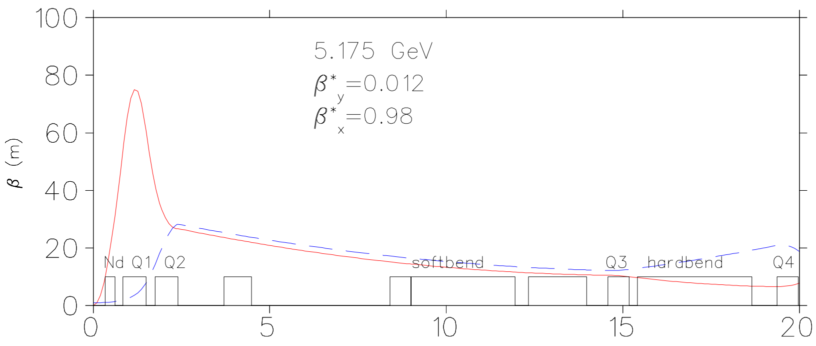
- Superconducting IR quads
  - Energy reach
- Positron Converter
  - Increased positron production rate
- x-ray beam line

SUPERCONDUCTING IR QUADS

- Objectives
  - Extend energy reach
  - Reduce β_v^* from 18mm to < 1cm and β_v at parasitic crossing nearest IP
  - Electromagnetic vs PM quad $\Rightarrow$ capability for precise correction of final focus optics and solenoid compensation
- Parameters
  - V and H focus quad in each cryostat
  - Gradient - 48.4T/m
  - Peak field - 6 T
  - $I \sim 1225$A
  - Length - 65cm
  - All quads rotated 4.5° (solenoid compensation)
  - Superimposed skew quadrupoles (fine tuning of solenoid compensation)
  - Superimposed dipole (orbit correction)
  - Support and remote positioning of cryostat by eccentric cam bearings

Superconducting quadrupole status

- Installed in IR - August-September
- Field quality
  - Skew sextupole moment in Q2 cancelled with resistive corrector located adjacent to cryostat
  - Sextupole moment in Q1 introduces tonality (differential tunes) that is corrected with chromaticity sextupoles



COMMISSIONING

- Alignment of IR quads is critical
- 0.5mm vertical displacement of Q01 $\rightarrow$ 22mm orbit error
- Startup optics
  - E_{beam}=5.3 GeV
  - $\beta^* \sim$ 10m
  - k_{Q1}= -0.1 (5% nominal)
  - Store beam (10/6) -
    - Low injection efficiency
    - Loss of injected particles near IR $\Rightarrow$ high CLEO radiation
    - Due to high vertical β adjacent to IR low β_h at injection point, coupling
  - Measure and correct orbit
    - Align IR quads to minimize steerings near IR
    - Zero all correctors

COMMISSIONING

- Load low β (luminosity optics) at 5.3GeV
  - Measure and correct orbits
  - Measure betatron phase and coupling and begin analysis
  - Calibrate: Measure betatron phase and coupling vs magnet strength
  - $I > 240$mA
- Load 5.175GeV Υ_{3S} optics 10/15?

G-LINE

- New x-ray beam line
  - x-rays from electron beam accessible in already existing facility
  - x-rays from positron beam accessible in newly constructed facility, through new opening in tunnel wall

- Wiggler parameters

Number of poles	50
Period[cm]	12
Peak magnetic field[T]	0.8
Gap[cm]	4
Pole width[cm]	11

Υ Resonance Run Plan

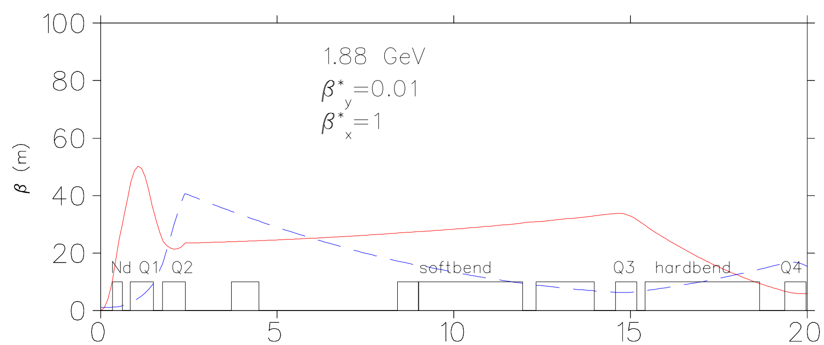
$\Upsilon_{3s}, \Upsilon_{1s}, \Upsilon_{2s}$, 11/01 $\rightarrow$ 7/02

	Υ_{3S}	Υ_{1S}	Υ_{2S}	Follow up
Beam Energy[GeV]	5.175	4.7	5.	?
Luminosity[pb^{-1}/day]	33	23	25	?
Start date	15-Nov-01	1-Feb-02	1-May-02	25-Jun-02
Total [fb^{-1}]	1.2	1.2	0.7	?

- August 2002 - begin transition to 1.9GeV operation with installation of first of 14 1.3m long, 2.1T wigglers
  - Installation of 14 wigglers complete June 2003

MACHINE DEVELOPMENT - ψ'' (1.89GEV)

- IR
  - 20cm permanent magnet quad
    $k = -5.09m^{-2}$
  - Q1 - $k = -1.92m^{-2}$
  - Q2 - $k = 1.32m^{-2}$
  - CLEO solenoid @ 1.0T
  - All IR quads rotated 4.5° about axis
  - skew quad coils superimposed on Q1 and Q2 permit compensation of coupling over wide range



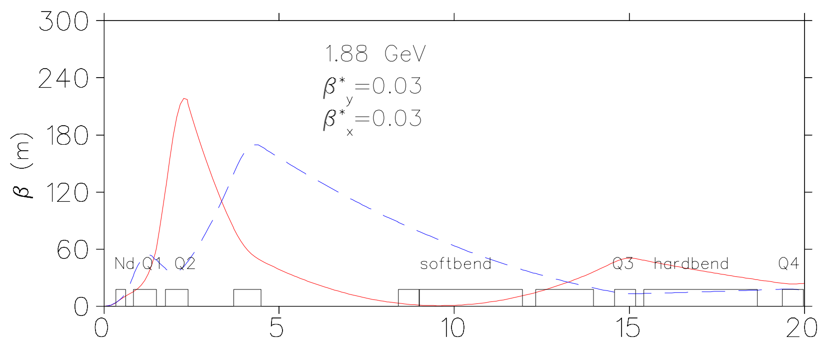
- Radiation damping
  - $\frac{1}{\tau} \propto E^3 \rightarrow$ 1/2 second
  - $\varepsilon \propto \frac{1}{E^2} \rightarrow (\frac{1.89}{5.3})^2 \varepsilon_{5.3} \sim 25nm$
  - Lower emittance $\rightarrow$ reduced long range beam-beam

Machine development - Round Beams

$$\xi = \frac{Nr_e}{\gamma}\frac{\beta}{4\pi\sigma^2} = \frac{Nr_e}{\gamma}\frac{1}{4\pi\varepsilon} \qquad (1)$$

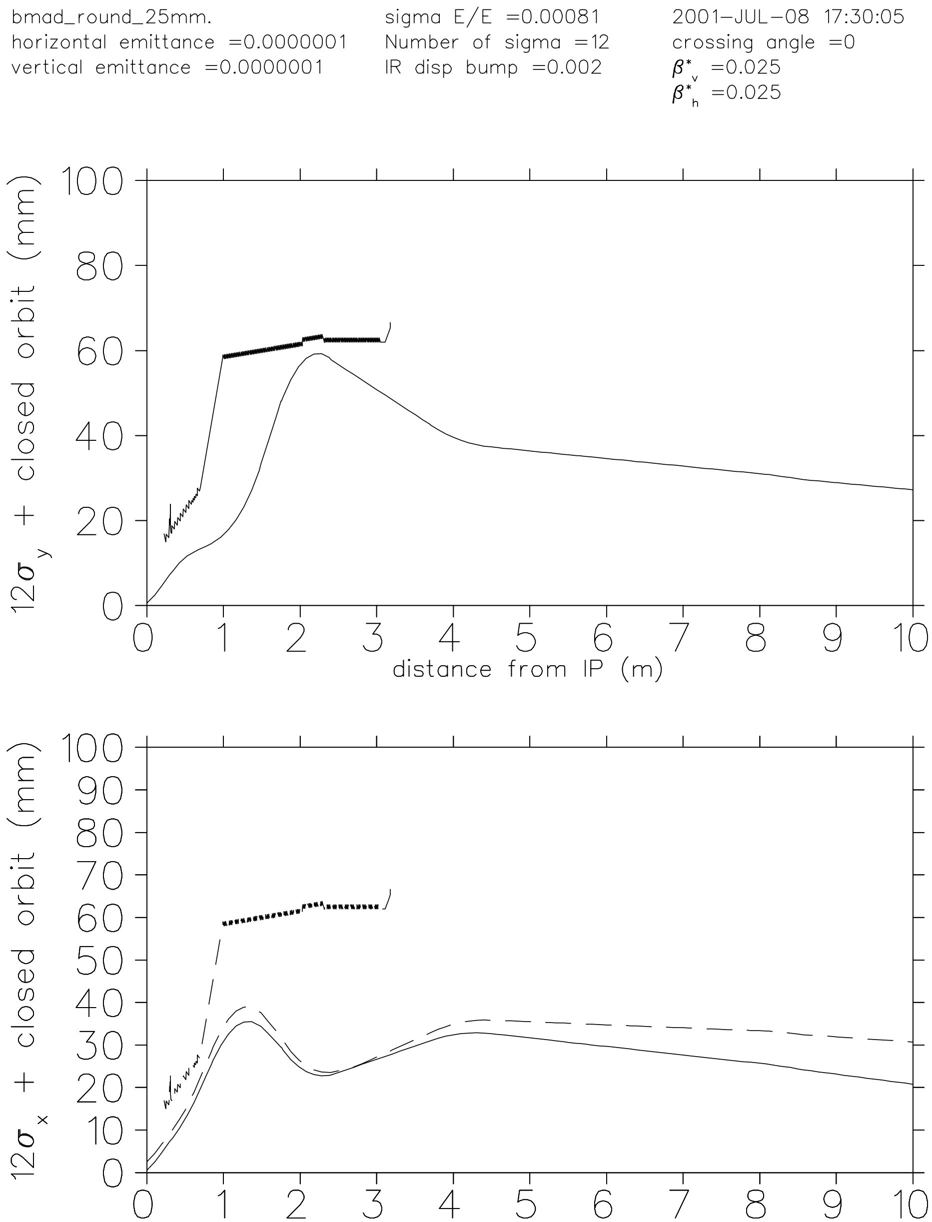
$$\Rightarrow L = \frac{N\gamma f_c}{r_e\beta}\xi \qquad (2)$$

- Emittance limited by IR aperture
- Possible parameters
  - ε=100nm
  - ξ =0.1
  - β^*=30mm
  - E=1.88GeV



$\Rightarrow$

- $N = 1.64 \times 10^{11}$, ($I_b = 10.3$mA)
- $L_b = 2.75 \times 10^{31} cm^{-2}s^{-1}$
- $N_b = 7, \rightarrow L = 1.9 \times 10^{32} cm^{-2}s^{-1}$ (head on)



Solid line is displacement of closed orbit + 12σ. Vertical emittance is equal to horizontal.

CESR-c Run Plan

- August - September 2002
  - Install full size wiggler prototype
  - Remove one pair of arc dipoles to make space for wigglers
  - Install CLEO vertex detector
- October - December 2002
  - Beam tests with wiggler
  - Explore operation at J/ψ
  - Run CESR at 5.3GeV for x-ray physics
- January-February 2003
  - Install 6 additional wigglers
  - Complete installation of cryo-distribution
- March - April 2003
  - Beam tests with wiggler
  - Explore operation at J/ψ, small energy spread
- May - June 2003
  - Install 7 remaining wigglers

- July 2003 - June 2004
  - ψ'' (3.78GeV) - 2.55 fb^{-1} :255days
  - 5.3GeV/beam for x-ray physics :110days
- July 2004 - June 2005
  - ψ'' (3.78GeV) - 0.5 fb^{-1} :50days
  - Above ψ'' (4.11GeV) - 2 fb^{-1} :205days
  - 5.3GeV/beam for x-ray physics :110days
- July 2005 - June 2006
  - Above ψ'' (4.11GeV) - 1 fb^{-1} :100days
  - J/ψ (3.1GeV) - 1 fb^{-1} :155days
  - 5.3GeV/beam for x-ray physics :110days
- June 2006 - November 2006
  - Follow up