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LABORATORY FOR ELEMENTARY-PARTICLE PHYSICS

Future Low energy Beamstrahlung detectors

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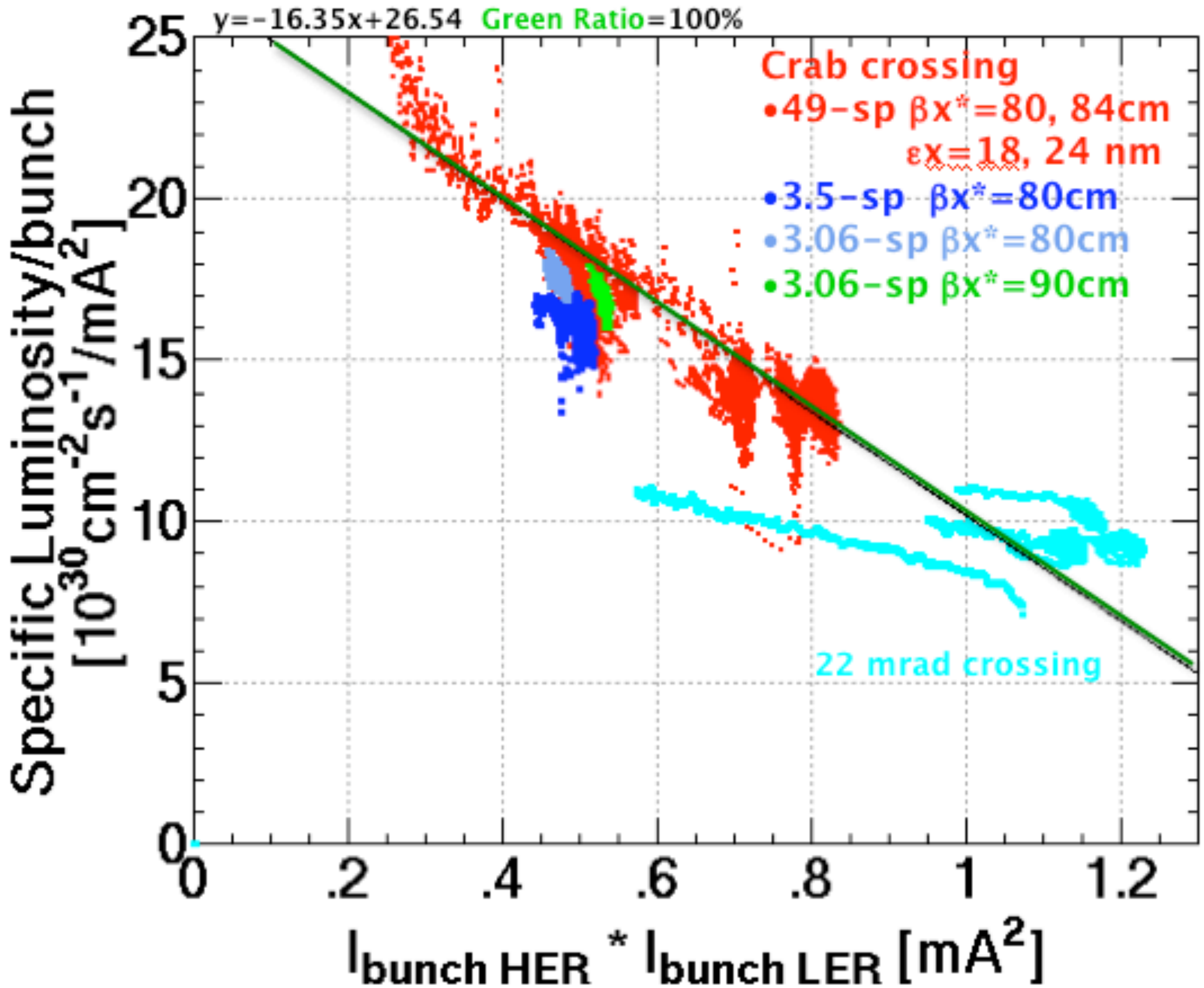
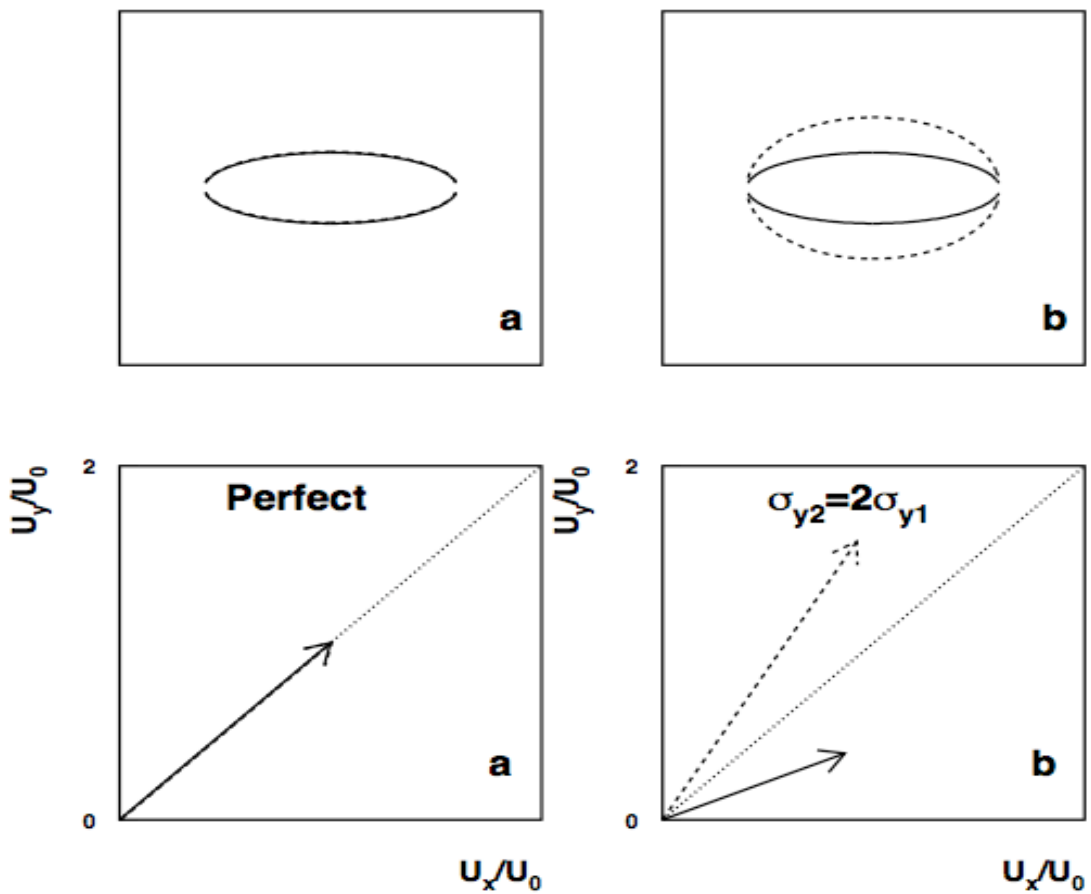
WHERE DISCOVERIES BEGIN

Specific Luminosity at KEK

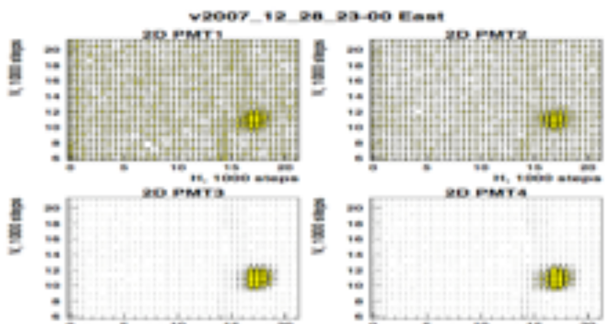


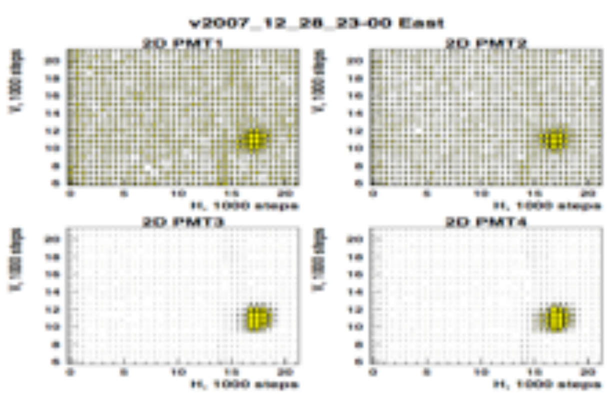


a
b
Perfect
a
$\sigma_{y2}=2\sigma_{y1}$
b
U_y/U_0
2
0
U_x/U_0
U_y/U_0
2
0
U_x/U_0

The goal: to build an instantaneous Monitor for KEKB and Frascati capable of measuring beam-beam asymmetries to 1%

What to keep





- The small azimuthally located viewport(s)
- The pointing system
- Most of the optics, with changes due to real estate constraints and new observation of multiple wavelengths
- PMT-based system

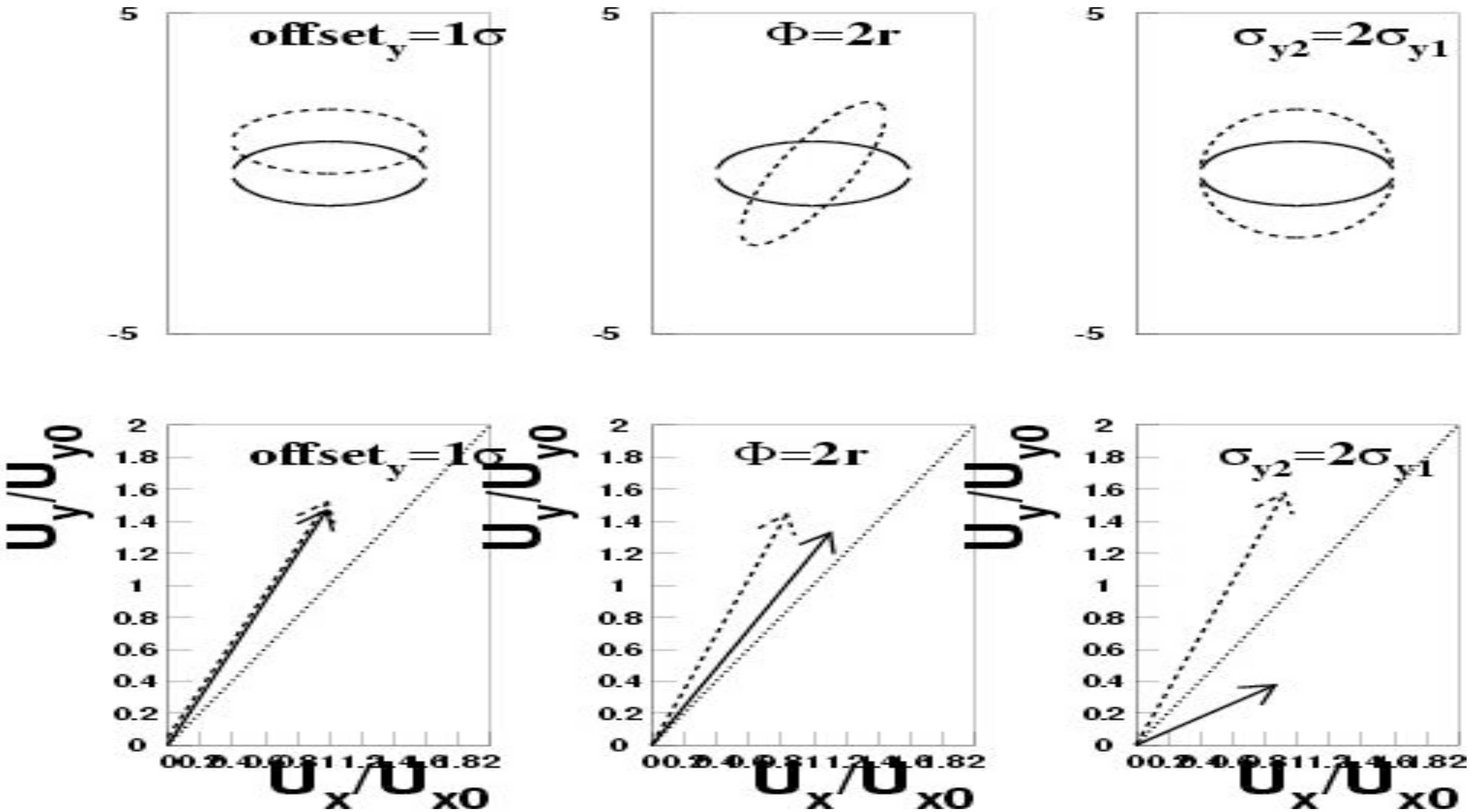
What needs change but merits no further discussion

- Discriminators need to be close to PMTs. 100 ft of coaxial cables are enough to create a lot of noise
- Telescopes need a major bench calibration before installation assessing angular resolution, PMT spectral response, PMT plateaus, and transmission efficiency of the optics
- Detector should be robust against 1 mrad misalignments w.r.t. beam axis
- IR PMTs are expensive, noisy, and unneeded in the future. Ideally, use only one type of broadband PMTs with multiple filters
- PMTs scalers need a lot of bits. Our scalers saturated at 65535 and we sacrificed one viewport on each side to cover all the dynamic range. Multiple scalers on same PMTs (e.g. 0.1 sec and 0.001 sec gate times) recommended

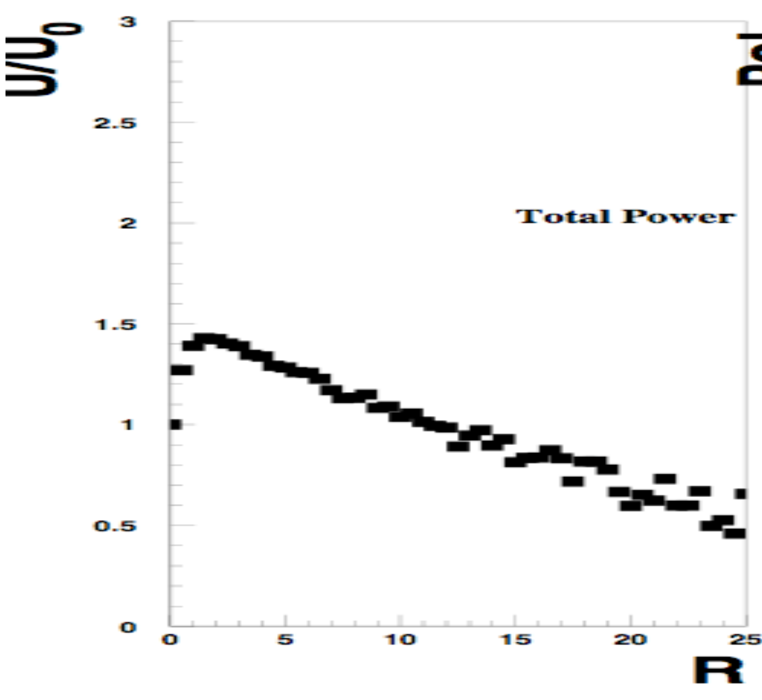
Most important change: much stronger beams at KEKB, Frascati (preliminary KEKB numbers courtesy J. Flanagan). Comparison at θ=5mrad, λ=500nm

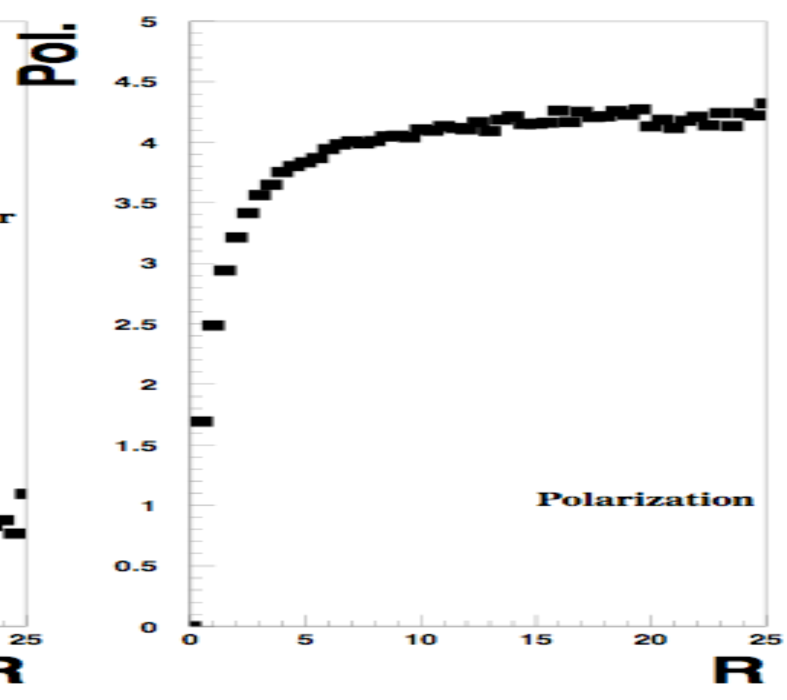
	KEKB	CESR-c	$U(5mrad)/U_0$
$\sigma_x(\mu m)$	11/6.3	350	3000
$\sigma_y(\mu m)$	0.038	2.5	1
$\sigma_z(mm)$	5	11	200
$N(10^{10})$	5.99	3	8
$R=\alpha\sigma_z/\sigma_x$	14/24	0.09	5.2/1.2(x,y)
E_b (GeV)	4/7	2/2	0.25/0.08(L,H)

Some examples of Large Angle BMST pattern recognition

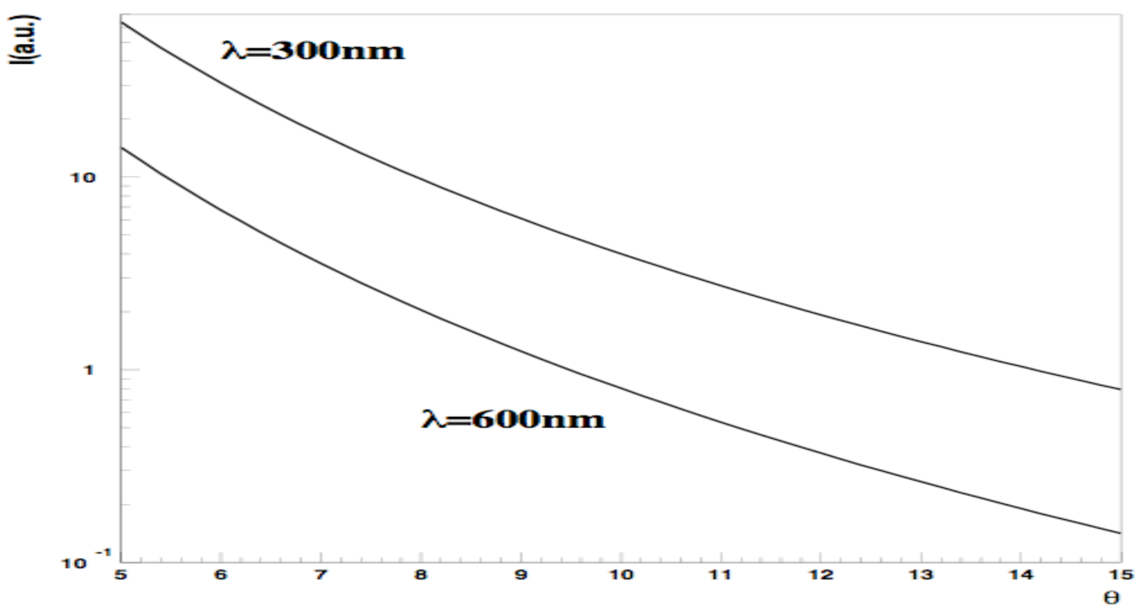


MC calculation of beamstrahlung parameters versus R



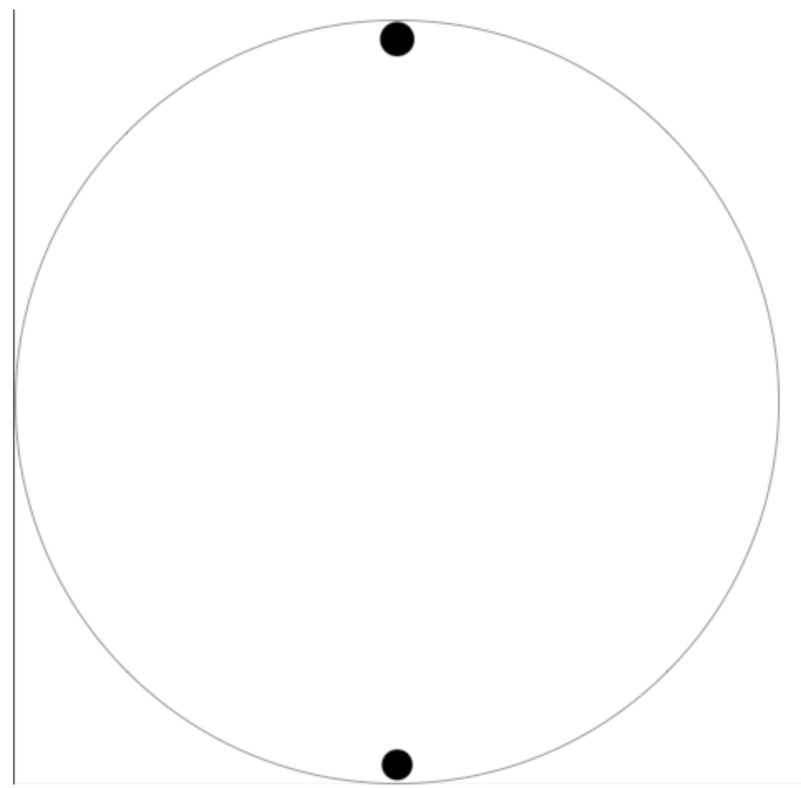


Numerical calculation - Signal spectrum (R=24) versus large theta for two different wavelengths.

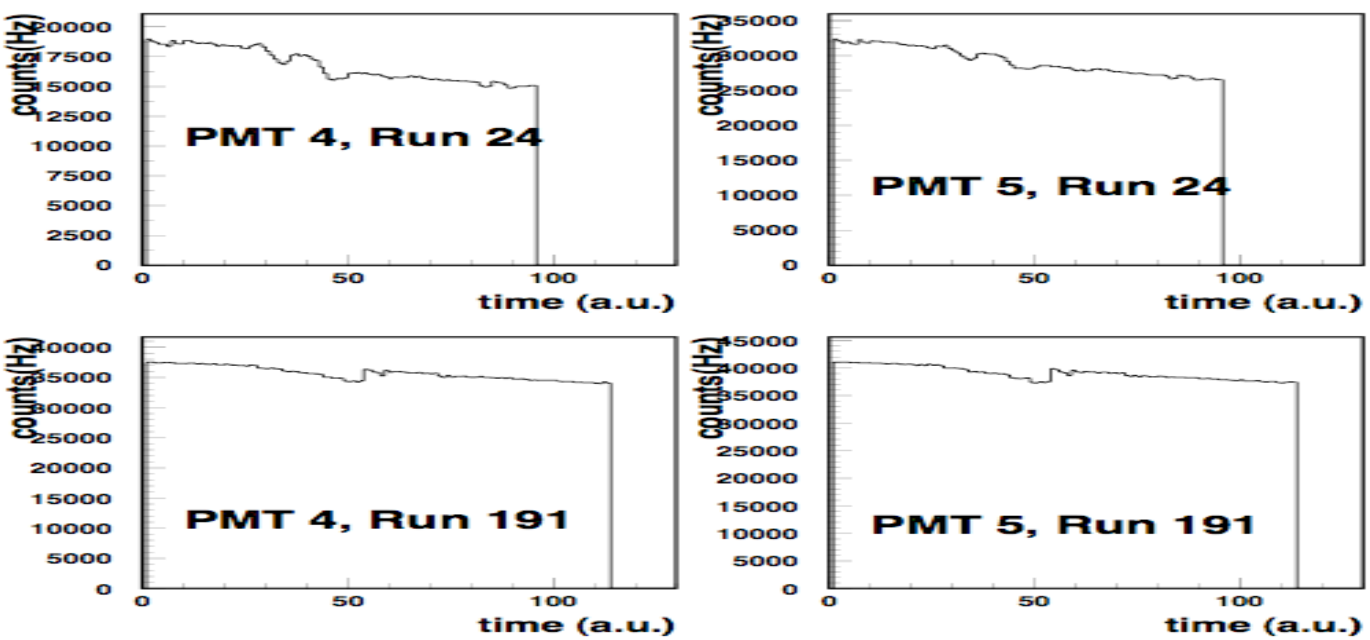


First major hardware change: new viewport arrangement

- 2 viewports at +-90 degrees provide three crucial advances:
- minimal backgrounds according to more advanced MC
- insensitive of beam motion, insensitive of beam pipe alignment
- At 90 degrees, x-polarization measures U(x), y-polarization measures U(y). Rotation error is minimized



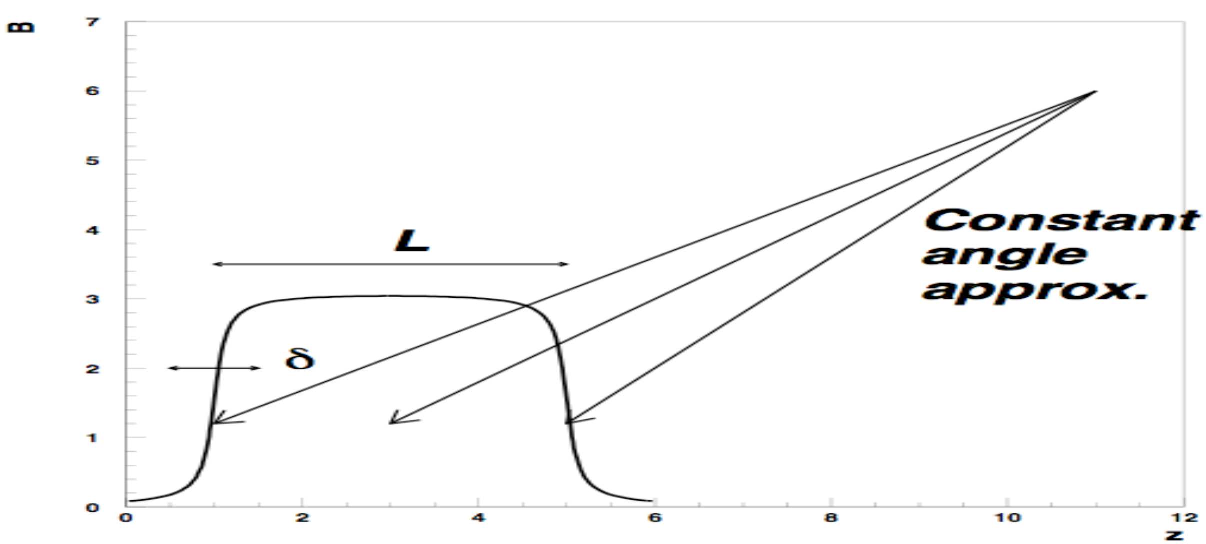
Beam motion at CESR-c. Light curves for two VIS West PMTs during noisy runs



2nd major change: much better event record

- CESR record contained BMST data, bunch-by-bunch currents, luminosity monitors, independent measurements of vertical heights, energy, as well as other unused quantities. Beam length and beam horizontal size were computed by measuring size of luminous region using CLEO hadronic events.
- Need at least Beam Position Monitors near the IP to monitor beam shifts both in quads and in detector-beam axis angle

Short magnet approximation for the background (quadrupoles)



If the angle can be considered large and constant…

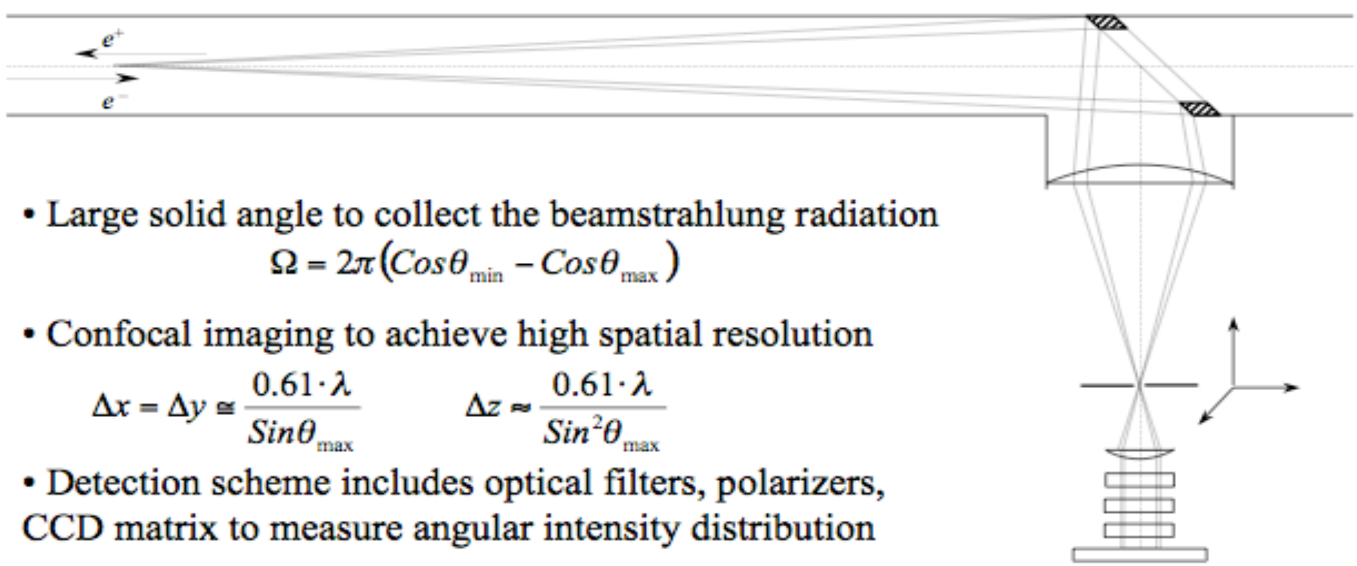
- Assuming (atan(z/δ)+atan((L-z)/ δ) as the field profile, one gets (u=γθ, s,c=cos,sin(φ))

$$\frac{d^2P}{d\Omega d\omega} \propto \frac{(1-uc)^2+(su)^2}{(1+u^2)^6}\frac{1}{\omega^2}\exp(-\omega\delta\theta^2/c)$$

- Originally, we sought to evaluate a sloping signal against a flat background (sloping and flat vs wavelength)
- In fact, at future accelerators the signal will be flat, whereas the background will be sloping. The final choice of wavelength ranges should be done only after the background spectrum has been computed. The number of wavelength bands to be measured depends on the number of d.o.f. of the background. OBSERVATION IN 4 BANDS IS SUGGESTED.

ILC concept

Hollow mirror imaging system for detection of beamstrahlung radiation



- Large solid angle to collect the beamstrahlung radiation

$$\Omega = 2\pi\left(Cos\theta_{\min} - Cos\theta_{\max}\right)$$

- Confocal imaging to achieve high spatial resolution

$$\Delta x = \Delta y \cong \frac{0.61 \cdot \lambda}{Sin\theta_{\max}} \qquad \Delta z \approx \frac{0.61 \cdot \lambda}{Sin^2\theta_{\max}}$$

- Detection scheme includes optical filters, polarizers, CCD matrix to measure angular intensity distribution

Conclusions

- The much stronger beams of KEKB and Frascati should make the detection of beamstrahlung much easier
- Large angle beamstrahlung characteristics change at large R
- Vast reduction of systematic errors expected from Second Generation device. 1% measurement of beam-beam parameters possible
- Technology to be fully mature at the ILC