Beam-beam monitoring using low energy beamstrahlung

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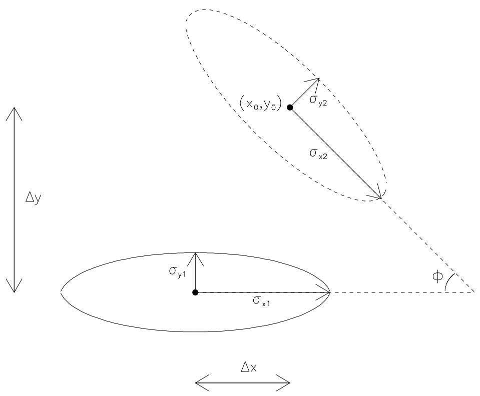
Ways to monitor the beam-beam quality.

- use a QED process with large cross section (e.g. $e^+e^- \to e^+e^-\gamma$). γ yield $\propto L \propto N_1N_2$. No information other than L

- visible beamstrahlung yield $W_1 \propto N_1N_2^2 \propto LN_2$. Much more abundant yield and much information about the beam-beam collision can be obtained from polarization

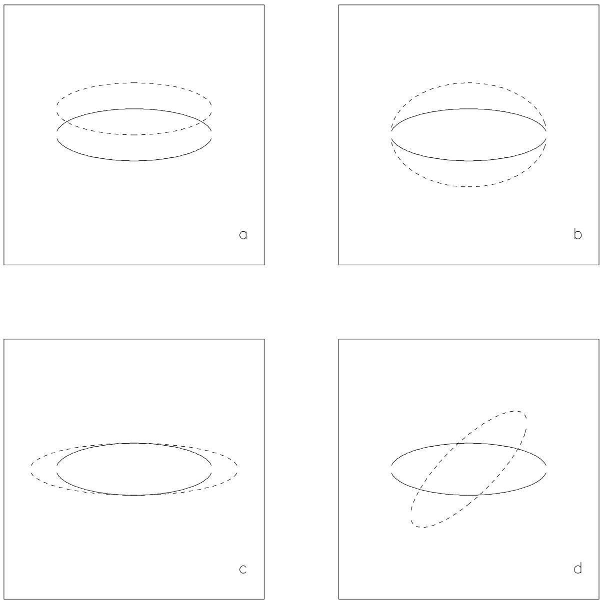
- coherent beamstrahlung $W_1 \propto N_1^2N_2^2 \propto LN_2$. Very high, background-free yield, works with very weak beams, and can measure some parameters very precisely.

Beam-beam transverse degrees of freedom..

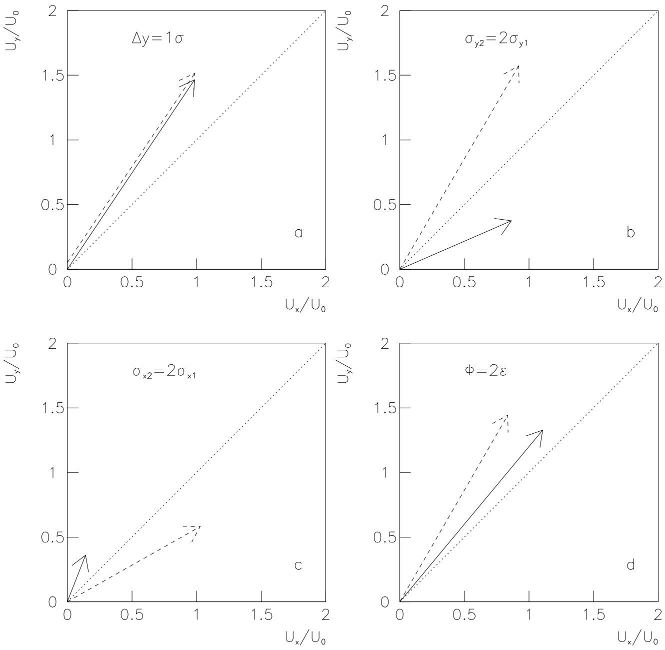


- 7 transverse degrees of freedom

Beam-beam simplest mismatches..



...and their large angle beamstrahlung patterns.



Status of the CESR monitor:

- data taken over the summer showed low backgrounds and reliable pointing capabilities

- we are currently building the first 1/4 of the full system, to be installed in late february-early march

- depending on CESR-C progress, we are very confident that a signal will be observed this year

CESR pilot data

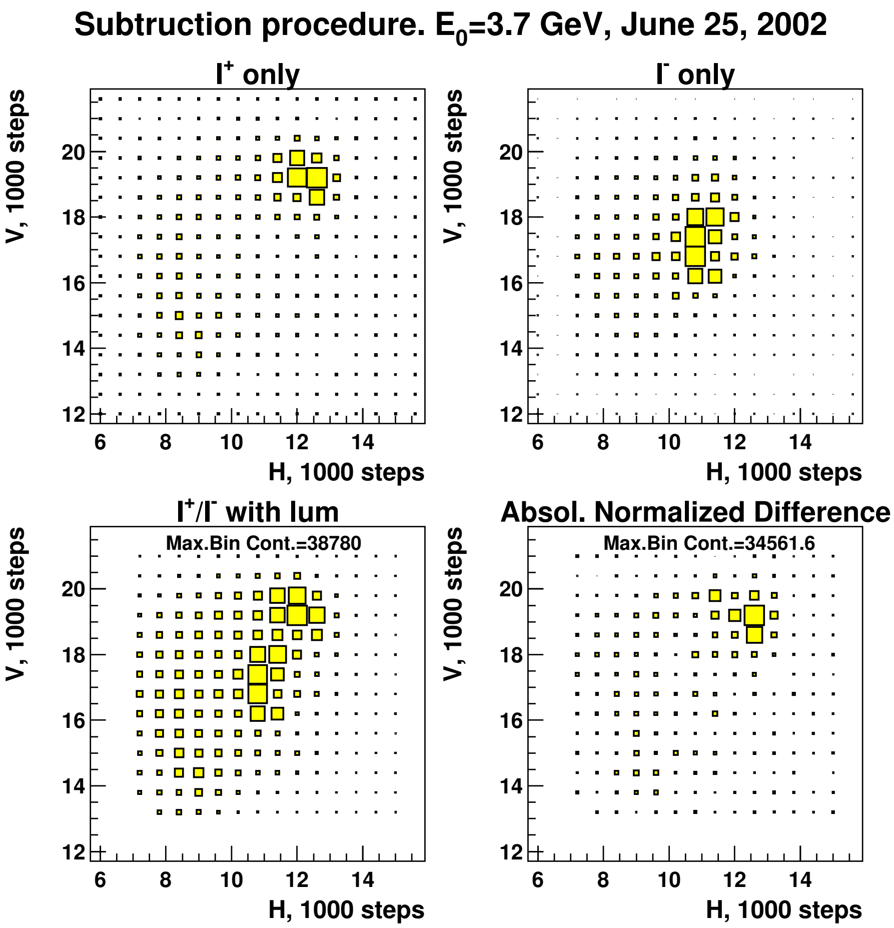


Figure 7:

Visible beamstrahlung (VB).

The main limitation is its dependence on N^3 - it has a slow turn-on which has been experienced at both the SLC and CESR. A very powerful monitor for a machine that has already progressed considerably.

Some scaling laws given:

- $W_1 \propto N_\gamma E_\gamma$, and $N_\gamma \propto B_2 \propto N_2$, $E_\gamma \propto N_2$.

- because VB is long wavelength, classical formulae for total power apply (even though they cannot be relied to calculate correctly N_γ, E_γ

- VB signal is $\propto B_2 \sigma_z$, and backgrounds are $\propto B_{magnet} L_{magnet}$

S/B separation handles at the LC:

- angular separation to beamline is now 1mrad and probably can not be used
- use a device sensitive to depth (G. Sun, CBN-98-13)
- maximize angular resolution to separate signal and SR halo
- signal is 2.83 times shorter than background (use streak camera, fit two components)
- background from quads is 90% radially polarized - detect only tangential component

Coherent beamstrahlung (CB).

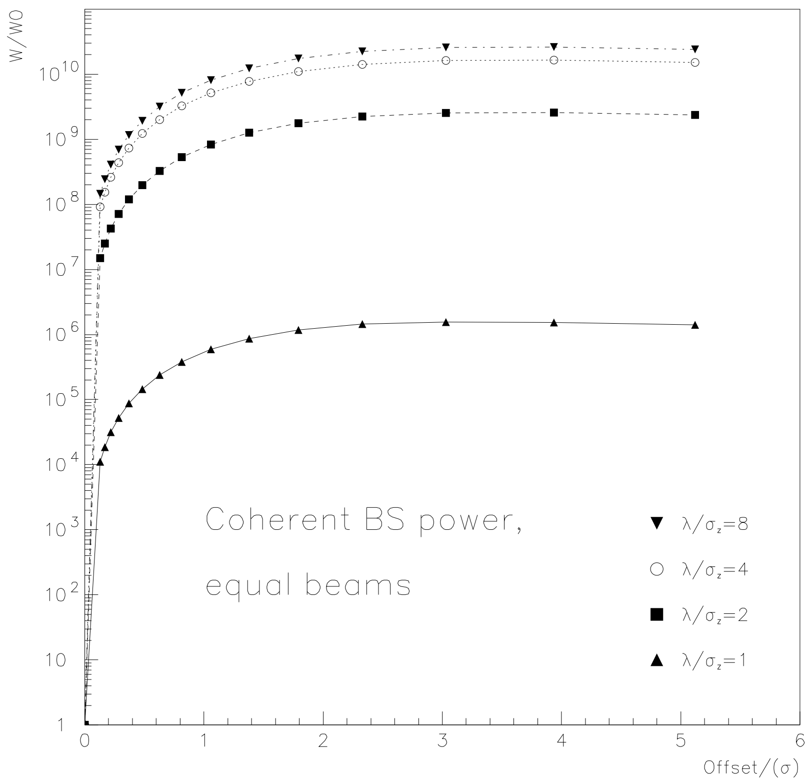
- $\propto N_1^2 N_2^2$, enormous (up to 1 μW) signals (practically background free)

- present when $k \cdot x \sim 1$, where k is the photon 4-momentum and x is the size of the emission region. In practice, $\lambda \sim \sigma_z$.

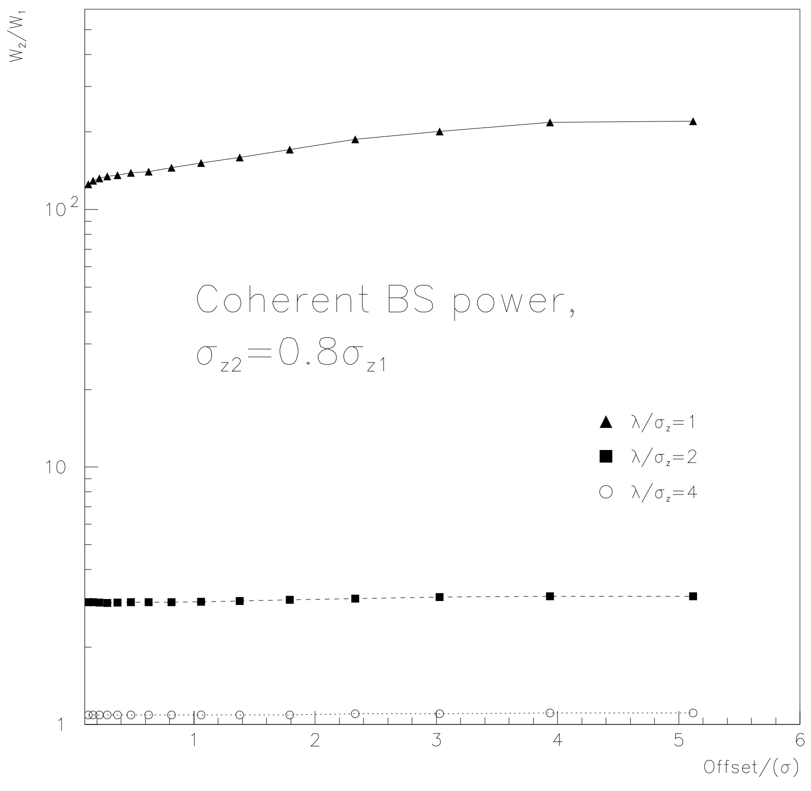
- the beams must also be offset for a coherent beam motion to happen. Only the $y-$component is coherent.

- the machine must also have a beam pipe diameter greater than the beam length for CB to be usable (CESR not a good place).

Coherent beamstrahlung yield vs beam offset.



Coherent beamstrahlung yield vs beam offset, unequal beams.



Conclusions.

- CESR large angle detector on schedule

- two-pronged approach to LC monitoring. CB works immediately, is background free, and can measure beam-beam offset and beam lengths very precisely

- VB has slow turn-on, measures AND DIAGNOSES all kinds of beam-beam mismatch. Can aid in determining dL/dE. Design is more challenging.