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Synchrotron Backgrounds for Laserwire Detector In Upstream Polarimeter Chicane

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Abstract

Synchrotron radiation (SR) backgrounds for the Laserwire Detector in the upstream "Polarimeter" chicane are estimated, due to the first dipoles in the chicane. For nominal (RDR design) operation at 250 GeV, the SR critical energy is 4.1 MeV and the total SR power incident on the laserwire detector is ~$5.5 \cdot 10^{-6}$ of the beam power. A laserwire detector in the 0-degree line will have unacceptably large backgrounds. A preferred solution is to instead detect the Compton-scattered electrons.

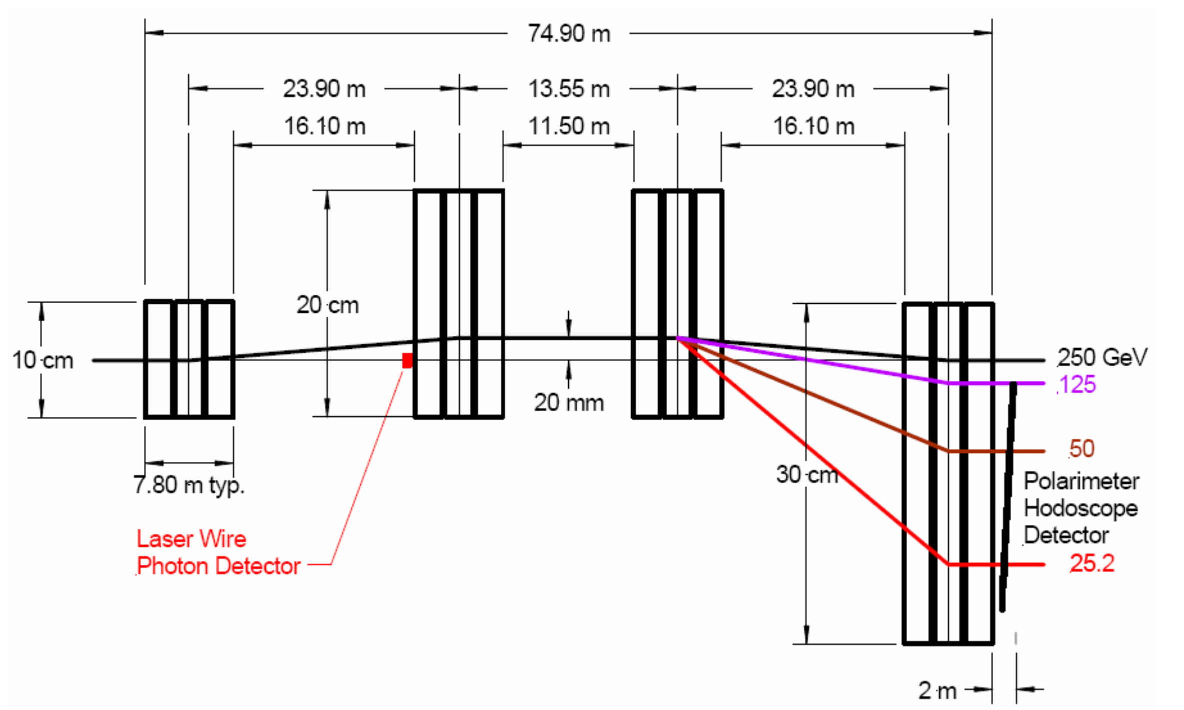

Figure 1: Upstream "Polarimeter Chicane" configuration. Taken from talk by P. Schuler.[1]

The upstream polarimeter chicane configuration is shown in Figure 1. The first bend is composed of 3 dipoles, each with length l=2.4m and B-field, B=0.0982 T. We consider here the synchrotron radiation produced for a beam energy, E, of 250 GeV. The bend radius for an electron passing through this magnet is given by

$$\rho = \frac{m\gamma}{eBc}$$

For a 250 GeV electron we find ρ = 8,486m. The SR power by 1 electron emitted in a bend magnet, in units of GeV/m, is given by[2]

$$P_{SR} = \frac{C_\gamma E^4}{2\pi\rho^2},$$

where $C_\gamma = 8.85 \cdot 10^{-5}\ (\mathrm{m\text{-}GeV^{-3}})$. The fractional beam power, f_{SR}, radiated by the 3 dipoles of the first bend in the chicane is given by

$$f_{SR} = \frac{P_{SR} \cdot 3l}{E} = 2.2 \cdot 10^{-5}.$$

About 1/4 of the SR photons generated by these dipoles will hit the laserwire detector which is expected to subtend ~±5mm. The critical energy for the SR photons is given by

$$u_c = \frac{3h\gamma^3 c}{4\pi\rho} \approx 4.1 MeV.$$

The laserwire Compton signal is expected to be ~20,000 Compton gammas per bunch for vertical spotsize measurements with perfectly overlapped beams for laser and electron beams each with 1-micron rms spotsizes (statistics will be less for horizontal spotsize measurements).[3] If we assume the average Compton photon energy in the laserwire detector is ~1/2 the beam energy, E, then the Compton signal power normalized to the beam power will be

$$f_{Compton} = \frac{20{,}000 \cdot E/2}{2 \cdot 10^{10} E} = 5 \cdot 10^{-7}$$

The SR power incident on the laserwire detector is found to be ~10 times greater than the Compton signal. If a calorimeter is used, longitudinal segmentation of the laserwire detector will be unable to sufficiently suppress the lower energy SR photons wrt the high energy Compton gammas, because the attenuation length for MeV photons is not sufficiently shorter than for the high energy Compton gammas (see Fig. 27.16 in the Particle Data Book[4]).

If instead a threshold gas Cherenkov detector is used (as assumed in Reference [3]), with a threshold of 10-20 MeV, the laserwire detector signal will be proportional to the number of Compton gammas. The SR background to this signal will be determined by the number of SR photons with energies greater than the Cherenkov threshold. The SR spectrum is shown in Figure 2. Above the critical energy, u_c, the number spectrum is proportional to $\varepsilon^{-1/2}\exp(-\varepsilon)$, where $\varepsilon = u/u_c$ and u is the SR photon energy. Figure 2 indicates that ~50% of the SR power is at energies higher than the critical energy of 4.1 MeV. The SR number flux with $u > u_c$ will be greater than 10^9 per bunch and the flux at 20 MeV will be ~0.3% of the flux at 4 MeV. Thus, the SR background in a gas Cherenkov counter with 20 MeV threshold will also be at least 10x greater than the Compton laserwire signal.

There will be additional backgrounds due to synchrotron radiation from upstream quadrupoles and upstream beam losses. It will likely be impossible to operate a detector in the proposed 0-degree laserwire detector location (see Figure 1) that has line-of-sight to upstream beam elements. A much better detector solution will be to measure instead the Compton-scattered electrons. This will facilitate a common use of this chicane for polarimetry, since a laserwire detector in the 0-degree line will also very likely cause unacceptable backgrounds for a polarimeter detector.

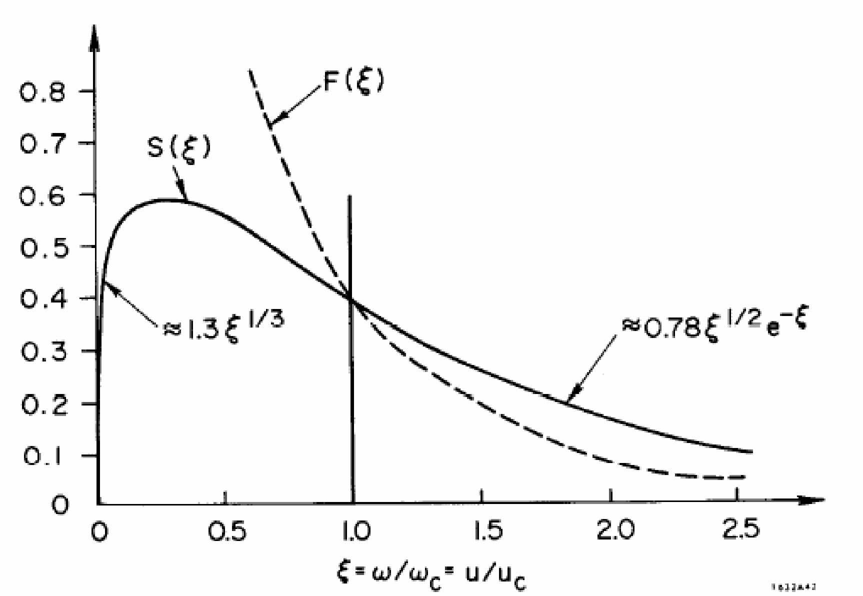

Figure 2: Normalized power spectrum, S, and photon number spectrum, F, of synchrotron radiation. Figure is reproduced from Fig. 42 in Ref. [2].

References:

[1] Talk by P. Schuler at BDS Meeting, Nov. 29, 2007; http://ilcagenda.linearcollider.org/conferenceDisplay.py?confId=2399.

[2] M. Sands, SLAC-121 (1979); http://www.slac.stanford.edu/pubs/slacreports/slac-r-121.html.

[3] Talk by G. Blair at BDS Meeting, Nov. 28, 2007, http://ilcagenda.linearcollider.org/conferenceDisplay.py?confId=2380; *Beam emittance measurement with laser wire scanners in the International Linear Collider beam delivery system*, I. Agapov, G.A. Blair and M. Woodley, Phys. Rev. ST Accel. Beams 10, 112801 (2007), http://prst-ab.aps.org/abstract/PRSTAB/v10/i11/e112801

[4] Particle Data Book, passage of particles through matter, http://pdg.lbl.gov/2007/reviews/passagerpp.pdf.