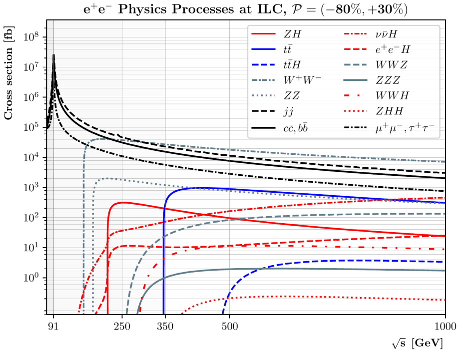
Remarks related to Luminosity

- Targets
- $e^+e^- \to \gamma\gamma$ applied to WW
- $e^+e^- \to \gamma\gamma$ considerations
- Other possibilities for absolute and relative luminometers.

Aims, Targets, Goals for Absolute Luminosity Precision



$$\sigma_{WW}\ (\sqrt{s} = 250\ \text{GeV}) = 37\ \text{pb}$$

- Match statistical precision of the accelerator. Denominator normalizing processes ideally should have cross-sections exceeding the numerator.
- Example 1 (ILC): WW at 250 GeV. With 0.9 ab^{-1} (LR) $\rightarrow 1.7 \times 10^{-4}$.
- Example 2 (10^{12} Z with FCC) $\rightarrow 1.0 \times 10^{-6}$.

What is realistically achievable is another matter.

New Luminosity Treatment for ILC

- Prior study assumed that the absolute luminosity can be measured to 0.1% using low angle Bhabhas (LABH). Main issues: theory and acceptance definition (including beam-beam).

Now,

- Model LABH with $\sigma_{161} = 12$ nb. Use for relative luminosity (per scan point).
- Use QED process $\mathrm{e^+e^-} \to \gamma\gamma$ for absolute luminosity. Currently assume $\sigma_{161} = 37.5$ pb (35 mrad), and systematic precision of 0.01%. (See CCMNP arXiv:1906.08056 for theoretical justifications). At WW threshold, the $\mathrm{e^+e^-} \to \gamma\gamma$ cross-section is about 10 times the unpolarized WW one.
- Model the event counting statistics for Bhabhas and $\mathrm{e^+e^-} \to \gamma\gamma$.

Key Complementary Features of $\mathrm{e^+e^-} \to \gamma\gamma$

- Lowest angle acceptance not so critical. $d\sigma/d\cos\theta \sim \frac{1+\cos^2\theta}{\sin^2\theta}$
- $A_{LR} = 0$. But only $-+$ and $+-$ beam helicities. ($\mathrm{e^+e^-}$ also has $--, ++$). So LR, RL cross-sections are 75 pb each!
- Aids in measuring polarization! Constraints on Bhabha backgrounds to $\gamma\gamma$.
- No beam-beam. Need e/γ discrimination in LCAL to exploit lowest angles.

$e^+e^- \to \gamma\gamma$ at $\sqrt{s} = 161$ GeV

Minimum polar angle (°)	$\sigma_{\gamma\gamma}$ (pb)
45	5.3
20	12.7
15	15.5
10	19.5
6	24.6
2	35.7

- Unpolarized Born cross-sections. Typical higher order effects 5 – 10% increase.
- Note not negligible electroweak box effects near WW threshold. (1.2% at widest angle).
- electron-photon discrimination can be aided by much better azimuthal measurements given the bending of the electrons in the B-field. Figure of merit: Bz_{LCAL}. Here ILD has 7.7 Tm. OPAL was 1.04 Tm.

Dusting off LEP era Monte Carlos

I now have RACOONWW, RADCOR ($\mathrm{e^+e^-} \to \gamma\gamma$), BHWIDE, and TEEGG working. TEEGG deals with the radiative Bhabha process $\mathrm{e^+e^-} \to \mathrm{e^+e^-}\gamma(\gamma)$ in QED dominated t-channel configurations.

- There are 3 main configurations: ETRON, GAMMA, and EGAMMA where either only 1 electron, 1 photon, or an (electron-photon) pair is visible at wide angle, and the other particle(s) are unobserved at low angle.
- Cross-sections are not too shabby. At $\sqrt{s} = 91.2$ GeV.
- $\sigma_{e\gamma} = 1.0$ nb (5°, 25 mrad)
- $\sigma_e = 52$ nb (5°, 25 mrad, $x_e > 0.025$)

I am particularly intrigued by $e\gamma$. This is quasi-real Compton scattering and is more statistically powerful than $\mathrm{e^+e^-} \to \gamma\gamma$, and features coplanar $e\gamma$ with mass between $0.5\sqrt{s}$ and $\sqrt{s}$.
[Does anyone have a working BABAMC configuration?]