Modified Initial State Radiation in $D\bar{D}$, DD^*, $D^*\bar{D}^*$ etc. Generators

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April 20, 2000

OUTLINE

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Motivation

$$e^+e^- \Rightarrow \gamma(k) \quad + \quad N \quad hadrons$$

In e^+e^- collision, initial real photon radiation lows the effective hadron production energy

$$s' = s(1-k), \tag{1}$$

where

$$k = \frac{E_\gamma}{E_{beam}}. \tag{2}$$

Resonant cross section is sensitive to s', therefore, careful treatment of ISR in generator is very important in order to get real simulation,

In BESLIB, there are 6 generators to gover $D\bar{D}$, $D^*\bar{D}^*$, $D_s\bar{D}_s$ etc. production.

with ISR : dsgen.f, dssgen.f, fssgen.f;

no ISR : ddgen.f, ffgen.f, fsfgen.f.

Original scheme

The following scheme was used

$$\sigma(s) = \int_0^1 dx \frac{\sigma_0(s')}{|1 - \Pi(s')|^2} F(x, s). \tag{3}$$

Radiator $F(x, s)$ describes radiative corrections,

$$F(x, s) = \beta x^{\beta - 1} [1 + \cdots] . \tag{4}$$

Where,

$$\beta = \frac{2\alpha}{\pi} [ln \frac{s}{m_e^2} - 1] \ll 1 \tag{5}$$

so,

$$\lim_{x \to 0} F(x, s) = \infty. \tag{6}$$

In

dsgen.f, dssgen.f, fssgen.f,

soft and hard radiations were not distinguished according to the detector resolution, and then ONLY EXTREME SOFT PHOTONS RADIATE, which dose not give observable effects in Monte Carlo simulation.

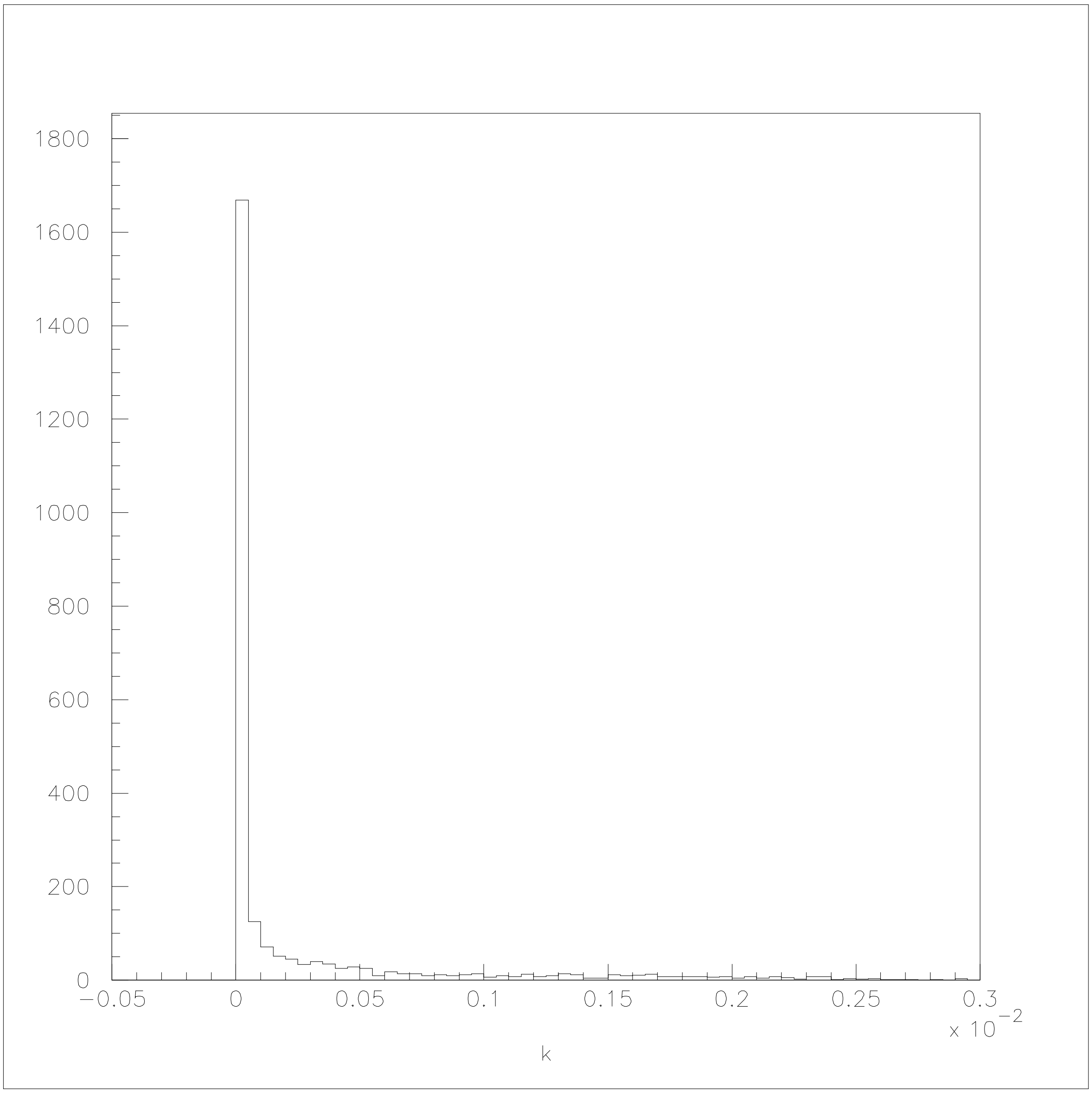

Figure 1: The energy-momentum spectrums of initial state radiation by modified original generator at energy $\sqrt{s} = 4.03$ GeV and taking $CUTOFF = 10^{-6}$, which dose not give observable emission. Notice: x is not the energy fraction carried by single photon, no equivalent in Monte Carlo.

New scheme

In experiment, zero energy and soft photon are not observable. The total cross section may be divided into two parts

$$\sigma_T = \sigma^{VS} + \sigma^H. \tag{7}$$

Up to $O(\alpha^3)$ order,

$$\sigma^{VS} = \sigma_0(s) \cdot (1 + \beta\ ln\ k_0 + \delta_{AR}) \tag{8}$$

$$\sigma^H = \beta \int_{k_0}^{k_{max}} \frac{dk}{k}(1 - k + \frac{1}{2}k^2)\sigma_0(s'), \tag{9}$$

where,

$$k_0 \sim 0.01 - 0.005, \tag{10}$$

which roughly corresponds to the minimum observable photon energy at $E_{cm} = 4$ GeV

$$E_\gamma^0 \sim 20 - 10MeV. \tag{11}$$

In our scheme, σ^{VSB} corresponds to the relative probability that producing events without initial photon emission, and σ^{HB} to the events with hard radiation spectrum

$$\frac{d\sigma^H}{dk} = \beta\frac{dk}{k}(1 - k + \frac{1}{2}k^2)\sigma_0(s') \tag{12}$$

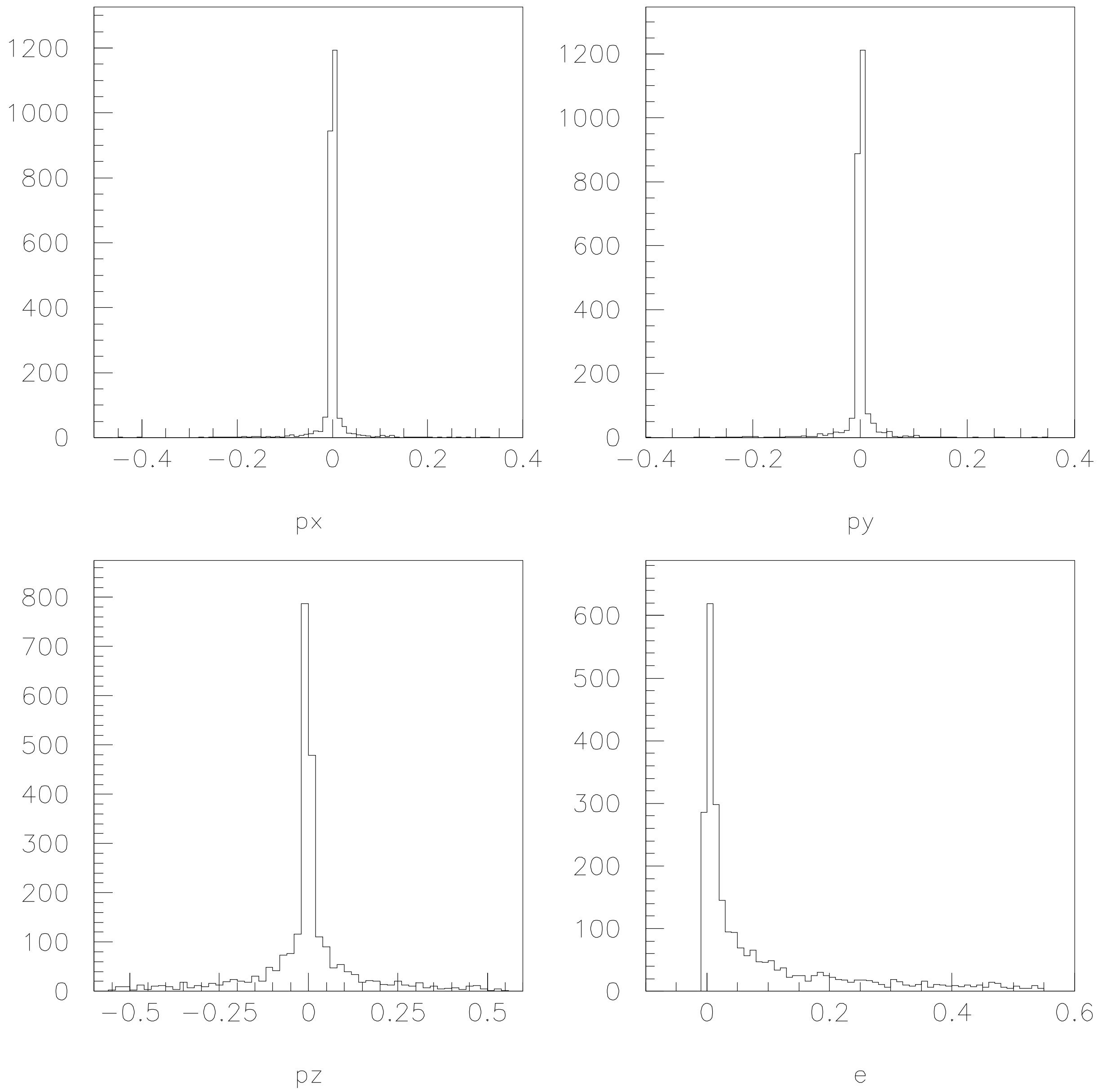

Figure 2: The energy-momentum spectrums of initial state radiation by modified DD generator at energy $\sqrt{s} = 4.6$ GeV and taking $k_0 = 0.001$

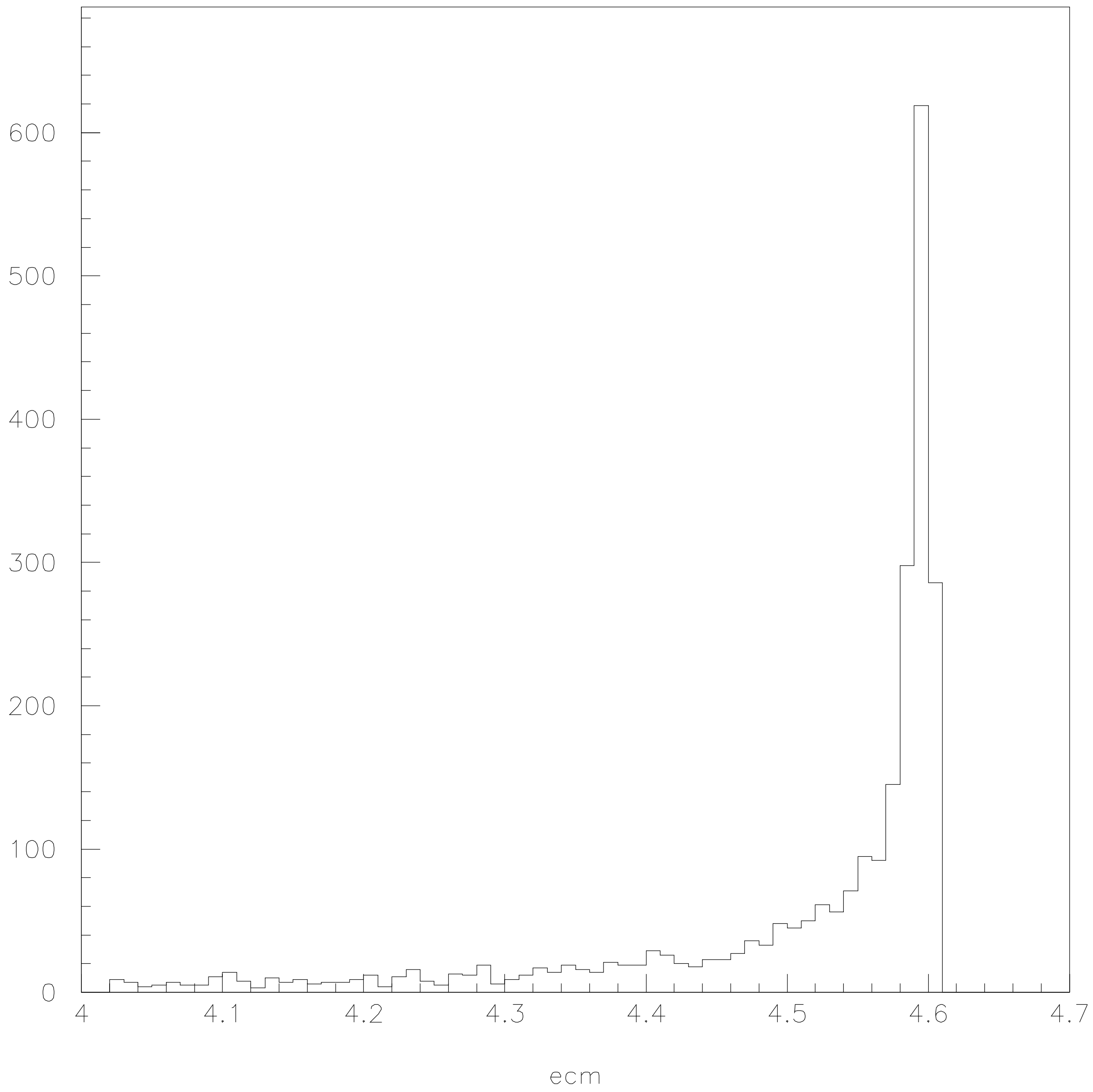

Figure 3: The effective hadron production energy E'_{cm} after initial state radiation by modified DD generator at energy $\sqrt{s} = 4.6$ GeV and taking $k_0 = 0.001$