$$\approx \frac{(E - p_z)_\psi}{2E_e} \tag{19b}$$

$$z = \frac{1 - \frac{(E+p_z)_\psi}{2E_p}}{1 - \frac{m^2_{J/\psi}}{1+m^2_{J/\psi}} \frac{(E+p_z)_\psi}{2E_p}} \tag{20a}$$

$$\approx 1 \tag{20b}$$

2.3 Reconstruction of the J/ψ meson

The J/ψ is reconstructed through the measurement of the two decay leptons. The decay process $J/\psi \to l^+l^-$ is most conveniently described in the J/ψ rest frame where l^+l^- move back to back, each with energy of $\frac{1}{2}m_{J/\psi}$, and the angle of one lepton in J/ψ rest frame, e.g., $(\cos\theta_{1'}, \phi_{1'})$ of l^+, defines the decay kinematic state. Choice of z' axis($\theta_{1'} = 0$) is not unique. Helicity frame takes $(-\vec{p'}_{CM})$ as the z' axis. Gottfried-Jackson frame takes $\vec{q}_{CM}$(photon direction) as the z' axis. Subscript CM denotes the vector as measured in J/ψ rest frame. An interesting question is how the spin state of J/ψ is correlated to that of the photon. Spin state of J/ψ can be determined from the angular distribution of the two leptons as will be explained later in this chapter. Since beam electron and proton are not measured in our experiment, we simply choose the electron beam direction as seen in J/ψ rest frame, as z' axis(this is close to Gottfried-Jackson frame).

Detection of the l^+ and l^- provides six measurements but only four nontrivial results because of the invariant mass constraint $m_{l^+l^-} = m_{J/\psi}$ and an undetermined rotation angle of l^+l^- about ep beam axis when e' and p' are not detected. The four nontrivial results are $(E \pm p_z)_\psi$ and $(\cos\theta_{1'}, \phi_{1'})$. $(\cos\theta_{1'}, \phi_{1'})$ are not relevant to the production cross section, but is closely related to the spin state of J/ψ. The issue will be discussed in the next section.