Kinematic variables in kinfriend.c:

m_p**:938MeV**

m_e**:0.511MeV**

dp: L.rec.dp

θ_{tg}**:** Lrb.tgt_0_theta (arctan(dy/dz), unit: rad)

ϕ_{tg}**:** Lrb.tgt_0_phi (arctan(dx/dz), unit: rad)

θ_{recl}**:** L.rec.l_th

ϕ_{recl}**:** L.rec.l_ph

θ_{rec}**:** L.rec.th

ϕ_{rec}**:** L.rec.ph

D1p: from SQL, (GeV)

E**:** HALLA_P epics

E'**:** goldp=1000*D1p*(1+recdp)

ν**:** HALLA_P-goldp

First Method: use TLorentzVector class in ROOT: (P_x,P_y,P_z,**E**)

for P_{in} :

E= $\sqrt{HALLA\_P^2 + m_e^2}$

θ=$arctan(\sqrt{\theta_{tg}^2 + \phi_{tg}^2})$

$\phi = arctan(\frac{tan(\theta_{tg})}{tan(\phi_{tg})})$

$|P| = HALLA\_P$

for P_{out} :

E=$\sqrt{goldp^2 + m_e^2}$

$\theta = \theta_{recl}$

$\phi = \phi_{recl}$

$|P| = goldp$

P_{tg}**:** [0,0,0,m_p]

$q = P_{in} - P_{out}$

$W = \sqrt{(q + P_{tg})^2}$

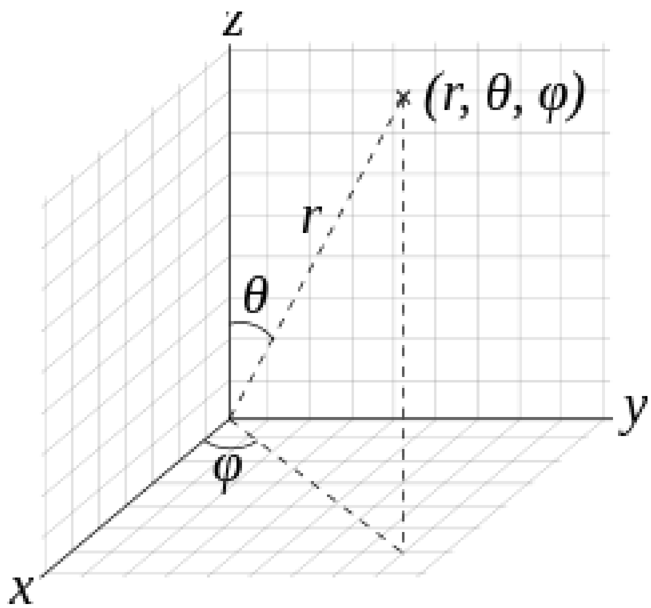

Figure 1: Spherical coordinate system

$Q^2 = -q \cdot q$

$x = \frac{Q^2}{2P_{tg}q}$

θ_{scat}**:** P_{in}.Angle(P_{out}), angle between P_{in} and P_{out}

Second Method: direct calculate

$$eb[3] = \begin{matrix} [sin(\theta_{Pin}) * cos(\phi_{Pin}), \\ sin(\theta_{Pin}) * sin(\phi_{Pin}), \\ cos(\theta_{Pin})] \end{matrix}$$

$$ef[3] = \begin{matrix} [sin(\theta_{recl}) * cos(\phi_{recl}), \\ sin(\theta_{recl}) * sin(\phi_{recl}), \\ cos(\theta_{recl})] \end{matrix}$$

$\theta_{scat} = arccos(eb_0 \cdot ef_0 + eb_1 \cdot ef_1 + eb_2 \cdot ef_2)$

$Q^2 = 4 * HALLA\_P * goldp * sin^2 \frac{\theta_{scat}}{2}$

$W = m_p^2 + 2m_p\nu - Q^2$