

# Simc

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# 1 Some simc output parameters

## 1.1 Normalization: Normfac & Weight

The variable Weight consists of a per-event weighing. It includes weights coming from the spectral function, DeForest cross section, Jacobian, Coulomb corrections, etcetera. Normfac is a constant scaling coefficient that only depends on the target, luminosity, etcetera (i.e. does not change per event). To get the proper normalization, we need to weigh the distributions by Normfac and Weight, and divide by the total number of entries. For example:

$$\text{histogram} \rightarrow \text{Fill}(\text{Pm}, \text{Weight} * \text{Normfac} / \text{entries}); \quad (1)$$

This is the correct normalization (i.e. yield or yield/bin) for the amount of beam charge put on the target (which is specified in the input file). For example, to get the total yield:

$$\text{yield} = \text{Normfac} \cdot \langle \text{Weight} \rangle \quad (2)$$

where

$$\langle \text{Weight} \rangle = \frac{\sum \text{Weight}}{\text{entries}} \quad (3)$$

is the average Weight. Then, if one wants to get the rate, one needs to determine the equivalent time for which the simulation was ran. We can get this by dividing the total charge (defined in the input file) by the beam current (charge / current = charge/(charge/time) = equivalent time). With this information:

$$\text{rate} = \text{yield} / \text{equivalent time} \quad (4)$$

## 1.2 e\_yptar vs. e\_yptari

A variable whose last character is an *i* is a generated variable. The same variable without the *i* at the end is the same quantity reconstructed by the spectrometers.

## 1.3 e\_yptar vs. h\_yptar

A variable whose first two characters are e\_ represent quantities corresponding to the electron in the electron arm. The same variable but with the first two characters been h\_ corresponds to the same quantity, this time for the hadron in the hadron arm.

## 1.4 Em & Ein

The variable Em describes the missing energy in units of GeV. The variable Ein describes the electron beam input energy in units of MeV.

## 1.5 Pm, Pmx, Pmy, & Pmz

Pm is the absolute value of missing momentum in units of GeV/c. In SIMC, the missing momentum is calculated as  $p_{proton} - p_q$ , which is negative the recoil momentum. Pmx, Pmy, and Pmz are the x, y, and z components of the missing momentum respectively (in GeV/c). That is  $Pm = \sqrt{Pmx^2 + Pmy^2 + Pmz^2}$ . The x, y, and z components are in the lab coordinate system (with z downstream, x vertically down, y horizontal).

## 1.6 PmPar, PmPer & PmOop

PmPar is the component of missing momentum parallel to  $\vec{q}$  (transfer momentum) in units of GeV/c. Similarly, PmPer is the component of missing momentum perpendicular to  $\vec{q}$  in the scattering plane in units of GeV/c. Finally, PmOop is the out-of-plane component of missing momentum in units of GeV/c perpendicular to the scattering plane. See fig. 1. That is  $Pm = \sqrt{PmPar^2 + PmPer^2 + PmOop^2}$ .

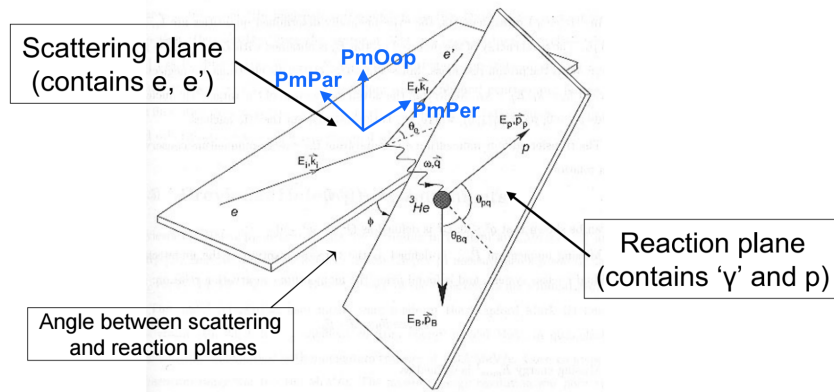


Figure 1: PmPar, PmPer & PmOop

## 1.7 q, nu, Q2

The variable q represents the transfer 3-momentum  $\vec{q}$  in units of GeV. On the other hand, the variable nu represents the transfer energy  $\nu$  in units of GeV. Finally, the variable Q2 represents minus the 4-momentum squared  $-q^2 = Q^2$  in units of  $(\text{GeV}/c)^2$ . Thus,  $Q^2 = -q^2 = \vec{q}^2 - \nu^2$ .

## 1.8 W

This variable represents the invariant mass of the final state such that:  $W^2 = m_p^2 + 2m_p \cdot \nu - Q^2$ .

## 1.9 delta

The definition of delta is:  $\delta = 100 \cdot [p - p_c]/p_c$  where  $p_c$  is the central momentum of the spectrometer. Therefore, the momentum of the particle is:

$$p = p_c \cdot [1 + \delta/100] \quad (5)$$

## 1.10 ytar

This variable is defined such that the position of the interaction vertex along the beamline,  $z_{vertex} \approx ytar/\sin \Theta_{HRS}$ , where  $\Theta_{HRS}$  is the central angle of the spectrometer. That is, ytar is horizontal position of the particle when entering the spectrometer. This corresponds to the projection of the z-position of the interaction vertex (beam direction) onto the spectrometer coordinate system according to the spectrometer angle.

## 1.11 yptar, theta\_e & theta\_p

This variable characterizes the deviation of the in-plane angle from its central value in the spectrometer. It is given in radians. Therefore, to get the physical value of the in-plane angle in degrees, just do:

$$\theta = \theta_c \pm \text{TMath::RadToDeg()} * h\_yptar \quad (6)$$

Where + (-) is taken for the electron (proton) arm. However, this is an approximation. The actual expression is:

$$\cos \theta = \frac{\cos \theta_c - yptar \cdot \sin \theta_c \sin \phi_0}{\sqrt{1 + xptar^2 + yptar^2}} \quad (7)$$

Where  $\phi_0 = 270^\circ$  for the right HRS and  $\phi_0 = 90^\circ$  for the left HRS. That is:

$$\cos \theta_{LHRS} = \frac{\cos \theta_c - e\_yptar \cdot \sin \theta_c}{\sqrt{1 + e\_xptar^2 + e\_yptar^2}} \quad (8)$$

$$\cos \theta_{RHRS} = \frac{\cos \theta_c + h\_yptar \cdot \sin \theta_c}{\sqrt{1 + h\_xptar^2 + h\_yptar^2}} \quad (9)$$

## 1.12 xptar

This variable characterizes the out-of-plane angle. It is given in radians. Therefore, to get the physical value of the out-of-plane angle in degrees, just do (for example, for the proton):

$$\phi = \text{TMath::RadToDeg()} * h\_xptar \quad (10)$$

Again, this is an approximation. The actual expression is:

$$\tan \phi = \frac{\sin \theta_c \sin \phi_0 + yptar \cos \theta_c}{\sin \theta_c \cos \phi_0 + xptar} + \delta \cdot \sin \phi_0 \quad (11)$$

Where  $\phi_0 = 270^\circ$  for the right HRS and  $\phi_0 = 90^\circ$  for the left HRS. That is:

$$\tan \phi_{LHRS} = \frac{\sin \theta_c + e\_yptar \cos \theta_c}{e\_xptar} + \delta \quad (12)$$

$$\tan \phi_{\text{RHRS}} = \frac{-\sin \theta_c + h_{\text{yptar}} \cos \theta_c}{h_{\text{xptar}}} - \delta \quad (13)$$

where  $\delta = 180^\circ$  if  $x_{\text{ptar}} < 0$  and  $\delta = 0^\circ$  otherwise.

### 1.13 Coordinate systems

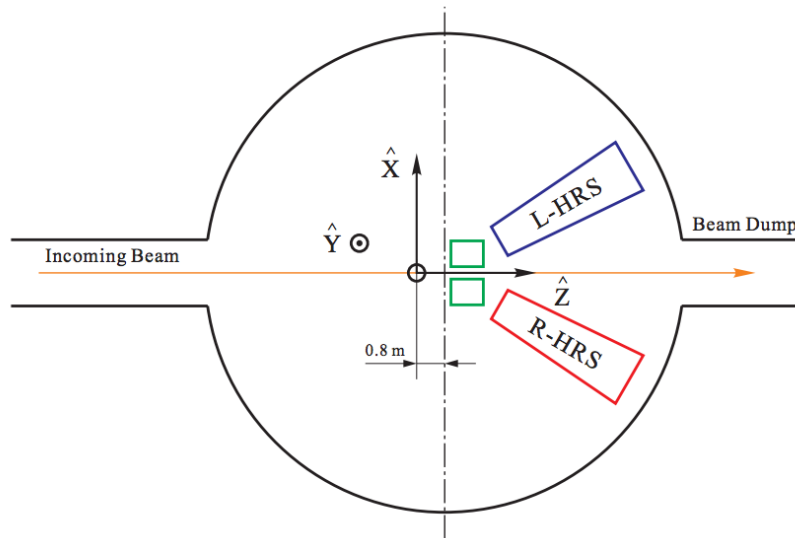


Figure 2: Hall coordinates

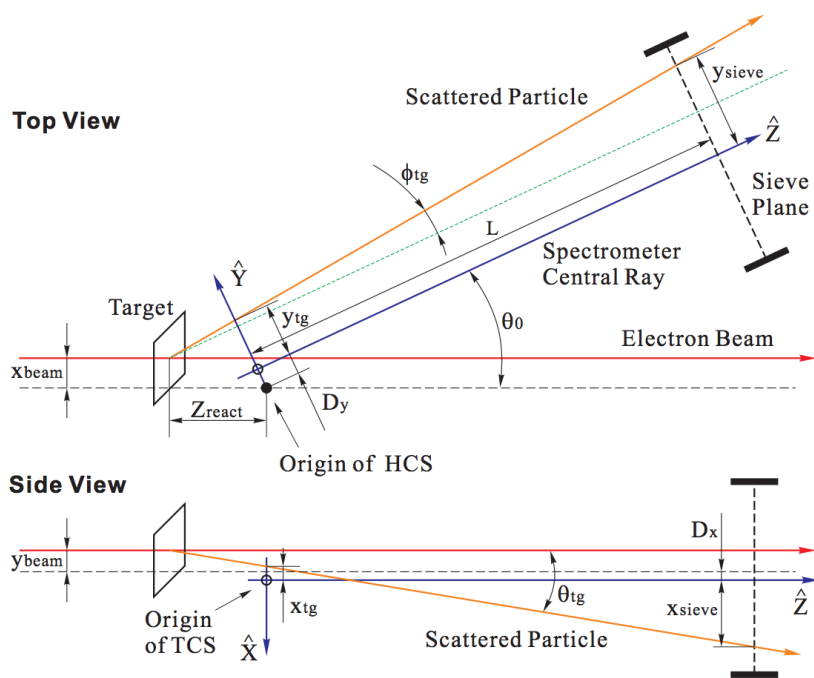


Figure 3: Target coordinates