Multi-path Partial Scintillator Fitter

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Abstract

Multi-path partial fitter

Keywords: Multi-path fitter, partial fitter, scintillator

1. Fitter ideas

2. Likelihood functions

Notations

time of flight: t_{tof}
time residue: t_{res}
refraction index of water: n_w
refraction index of scintillator: n_s
L: water level (z value of the water level in the AV coordinate)
vertex(trial) position: $\vec{X}_V = (X_0, Y_0, Z_0)$
trial time: t_0
PMT position: $\vec{X}_P = (X_P, Y_P, Z_P)$
fD: vertex depth, depth of vertex below the water level, $fD = L - Z_0$
fH: PMT height, height of PMT above the water level, $fH = Z_P - L$
α: fractional factor of the transverse distance between water-vertex intersection
$\vec{I}$: incident light vector, pointing from the vertex point to incident point in the water-scintillator interface
$\vec{R}$: reflected light vector
P_R: reflection probability, calculated by interpolating Fresnel equation
$\vec{T}$: transmitted(or refracted) light vector
$\vec{S}$: intersection vector for calculating $\vec{R}$, $\vec{T}$
Fresnel equation: n_t, θ_t, n_i, θ_t, and $\cos\theta_t = \sqrt{1 - \frac{n_i}{n_t}\sin^2\theta_i}$

$$R_P = \left| \frac{n_t \cos\theta_i - n_i \cos\theta_t}{n_t \cos\theta_i + n_i \cos\theta_t} \right|^2$$

$$R_S = \left| \frac{n_i \cos\theta_i - n_t \cos\theta_t}{n_i \cos\theta_i + n_t \cos\theta_t} \right|^2$$

Different cases are classified by the layouts of vertex and PMT positions.

- Vertex below water level, PMT below water level
- Vertex below water level, PMT above water level
- Vertex above water level, PMT below water level
- Vertex above water level, PMT above water level

2.1. Vertex below water level, PMT below water level

In this case we consider two light paths: direct light path and reflected light path.

$\alpha = sD/(sD - fH)$,

$\vec{S} = (1-\alpha)\vec{X}_V + \alpha\vec{X}_P$, and then set $S_z = L$. As shown in figure, $\vec{I}$ and $\vec{R}$ can be calculated as:

$\vec{I} = \vec{S} - \vec{X}_V$, $\vec{R} = \vec{X}_P - \vec{S}$

For direct light path, $t_{tof,direct} = |\vec{X}_V - \vec{X}_P|/(c/n_w)$, $t_{res,direct} = t_{PMT} - t_{tof,direct} - t_0$

For reflected light path, $t_{tof,refl} = (|\vec{I}| + |\vec{R}|)/(c/n_w)$

The reflection probability P_R

The likelihood function is:

$$L = L_{Ch}(t_{tof,direct}) + P_R L_{Ch}(t_{tof,refl})$$

$$\frac{dL}{dx} = \frac{dL}{dt_{tof}} \frac{t_{tof}}{dx}$$

$$\frac{dL}{dt} = b$$

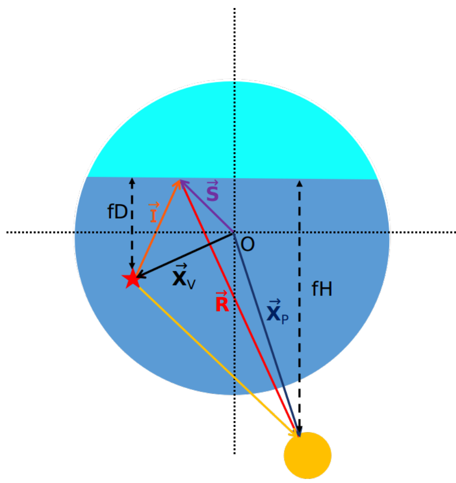

Figure 1: Layout of event when both vertex and PMT are below the water level.

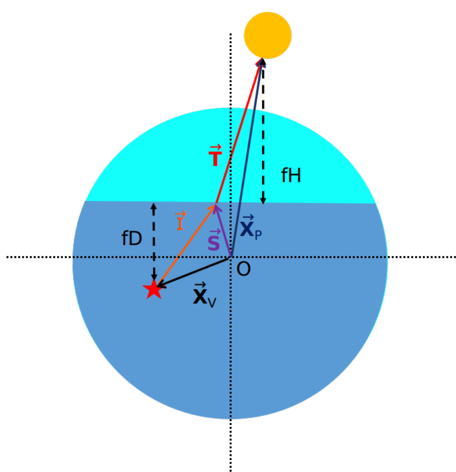

Figure 2: Layout of the event when vertex is below the water level and PMT is above.

2.2. Vertex below water level, PMT above water level

2.3. Vertex above water level, PMT below water level

$\alpha = sD/(sD - fH)$,

$\vec{S} = (1-\alpha)\vec{X}_V + \alpha\vec{X}_P$, and then set $S_z = L$. As shown in figure, $\vec{I}$ and $\vec{R}$ can be calculated as:

$\vec{I} = \vec{S} - \vec{X}_V$, $\vec{T} = \vec{X}_P - \vec{S}$,

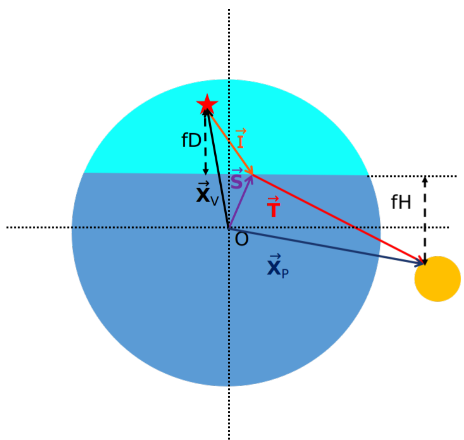

Figure 3: Layout of the event when vertex is above the water level and PMT is below.

2.4. Vertex above water level, PMT babove water level

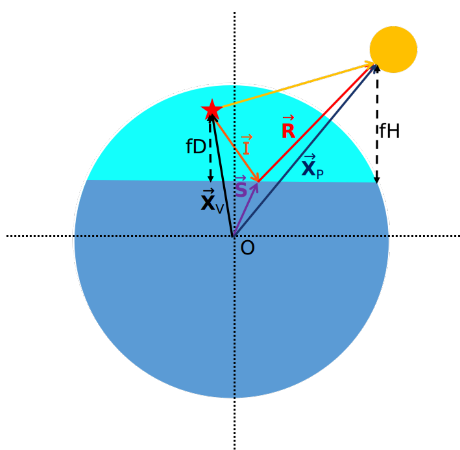

Figure 4: Layout of the event when both vertex and PMT are above the water level.

3. Monte Carlo Results

4. Conclusions

References

[1]