Update of the reconstruction

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Add the Scintillator light to the Cherenkov Reconstruction

ϵ: Angular response
T: transmission of the media and PMT glass
Ω: solid angle factor
Φ: event-energy-dependent light yield

$$\mathcal{L}(\mathbf{X}) = \prod_{j}^{n_{\mathrm{unhit}}} P(\mathrm{unhit}|\mu_j) \prod_{i}^{n_{\mathrm{hit}}} (1 - P(\mathrm{unhit}|\mu_i)) \, f_q(q_i|\mu_i) \, f_t(t_i|\mathbf{X})$$

Charge PDF   **Time PDF**

Already exist in Water Cherenkov reconstruction

Predicted charge from Cherenkov light

$$\mu_{\mathrm{Ch}} = \Phi_{\mathrm{Ch}} \int_{-\infty}^{\infty} ds \, \rho_{\mathrm{Ch}}(s) \, \Omega(s) \, T_{\mathrm{Ch}}(s) \, \epsilon(s) \, g(\cos\theta(s); s)$$

Cherenkov profile   angular emission profile

Predicted charge from indirect light

$$\mu_{\mathrm{sci}} = \Phi_{\mathrm{sci}} \int_{-\infty}^{\infty} ds \, \rho_{\mathrm{sci}}(s) \, \Omega(s) T_{\mathrm{sci}}(s) \epsilon(s) [1 + A_{\mathrm{sci}}(R(s), \cos\Theta(s))]$$

Scattering table

Updates

What should be added in WbLS reconstruction

Predicted charge from Scintillation light

$$\mu_{\mathrm{sci}} = \Phi_{\mathrm{sci}} \int_{-\infty}^{\infty} ds \, \rho_{\mathrm{sci}}(s) \, \Omega(s) \, T_{\mathrm{sci}}(s) \, \epsilon(s) .$$

Scintillator profile

Since producing MC for tuning is very time consuming, we first demonstrate the fiTQun tuning in the BNL30ton Geometry to test the pipeline and validate the software.
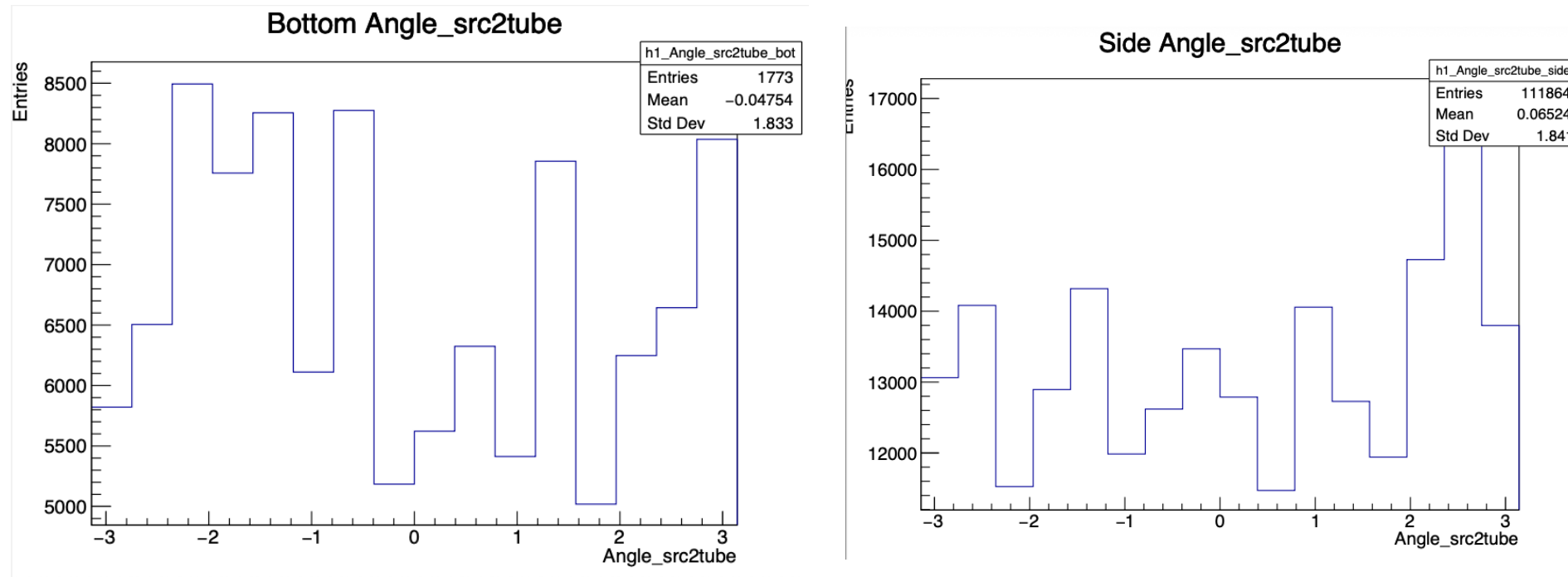
Scattering Table

$$A(s) = A(x_{PMT}, z_{vtx}, R_{vtx}, \varphi, \theta, \phi) \equiv \frac{d\mu^{sct}}{d\mu^{iso,dir}}$$

- The ratio of the differential predicted charges deposited from point s along the track, by the indirect Cherenkov light from the charged particle in concern and the direct light from the imaginary isotropic source at point s.

- Mostly repeat the work did in https://github.com/fiTQun/Utilities/tree/master/scattable

- Adapt to 30ton (cylinder) geometry

- In the future the scattering table need to be modified to do the box shape detector
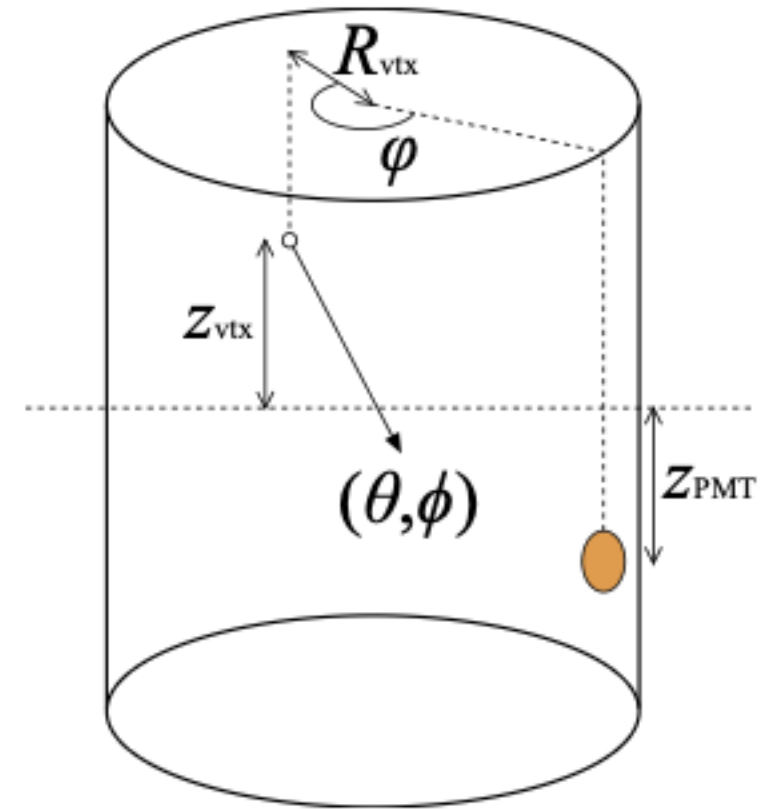
Validation of the scattering table

- Check the 1-D projections for each dimension to make sure there is no empty bins

- This scattering table can be further validated with fiTQun reconstruction (ongoing)

Status of the reconstruction

- Cherenkov Profile was not identical between WCSim & ratpac-two
    - The fitting has some issue when the geometry changed to 30ton size. The best solution is producing the MCs in the large tank (like theia geometry instead of 30ton). This won't effect the Cherenkov profile (which does not rely on geometry) but will fix the fitting issue.

- Time PDF & scattering table is completed but more validations are needed
    - Plans of fiTQun validation:

MC direct light only	Time PDF ❌ scattering ❌	Time PDF ✅ scattering ❌
MC direct &indirect light	Time PDF ❌ scattering ✅	Time PDF ✅ scattering ✅

- Will conduct the whole reconstruction with ratpac-two MCs for the water phase.