Update of the reconstruction

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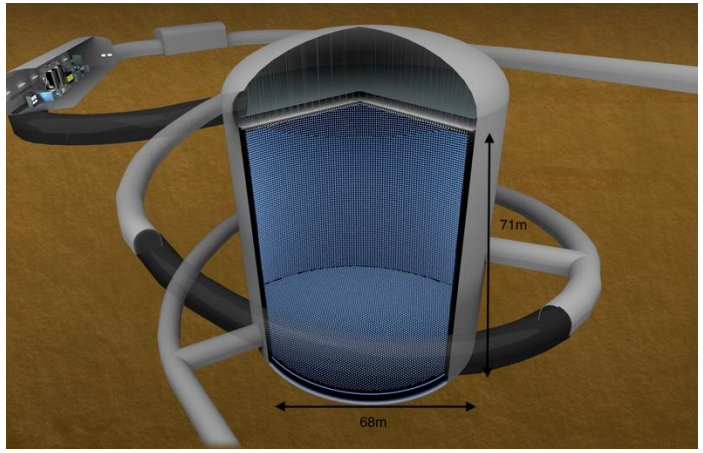
Status of the Theia reconstruction tool

- Use fiTQun which has been used in Super-K Water-Cherenkov (WC) reconstruction, and add scintillation light
- Two-step-plan:
  - Reproduce the Hyper-K (WC) reconstruction result but use ratpac-two simulation
  - Add the scintillation light, process the Theia reconstruction



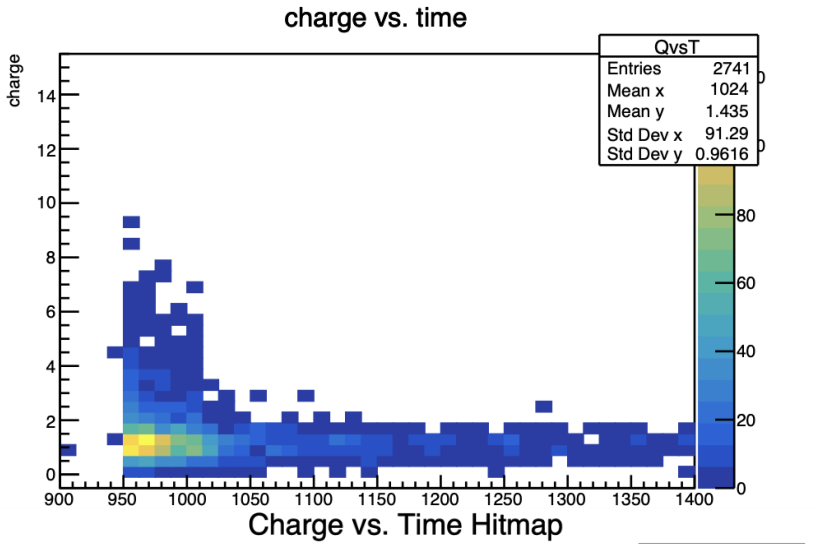
Motivation to do the fiTQun tuning with ratpac-two

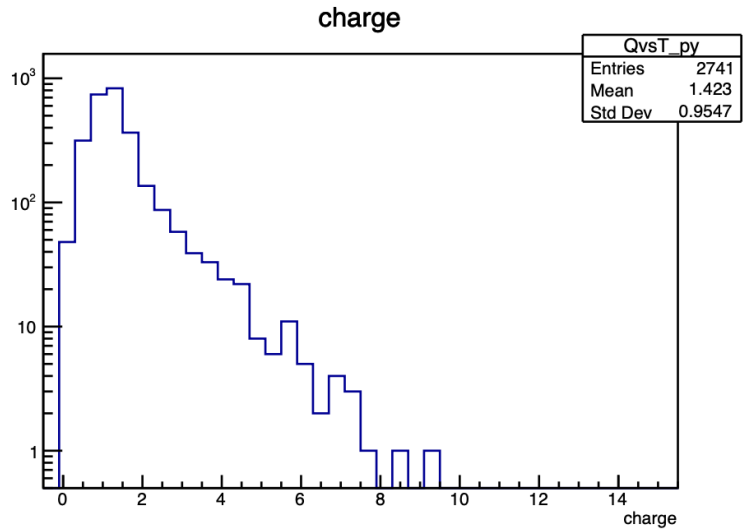
The charge distribution from ratpac-two is ~1.5* Hyper-K WCSim simulation

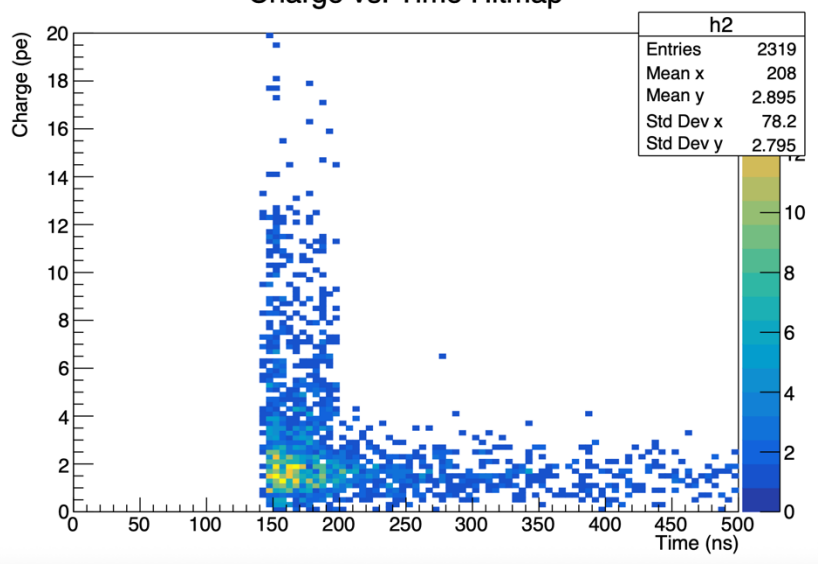
WCSim

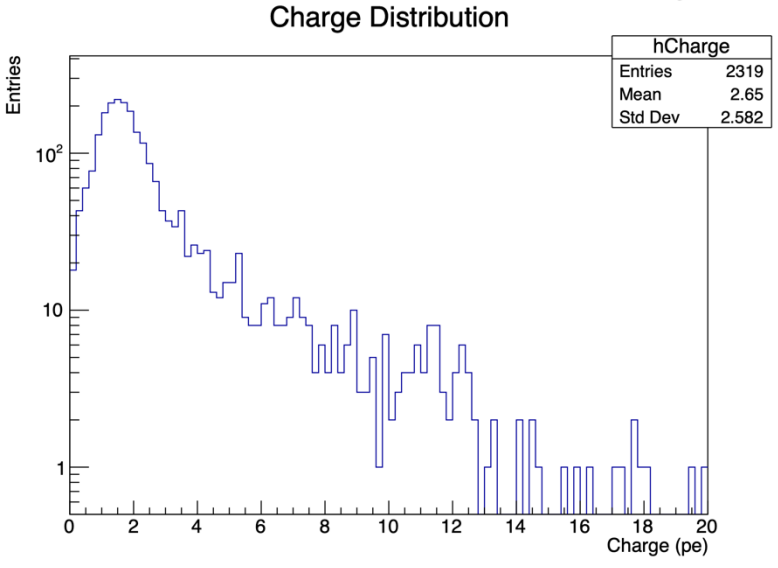
HK geo, e-,
500MeV, dir(1,0,0)

Ratpac-two









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

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

Charge PDF — Time PDF

Already exist in Water Cherenkov reconstruction

Predicted charge from Cherenkov light

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

Cherenkov profile ← angular emission profile

Predicted charge from indirect light

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

Scattering table

What should be added in WbLS reconstruction

Predicted charge from Scintillation light

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

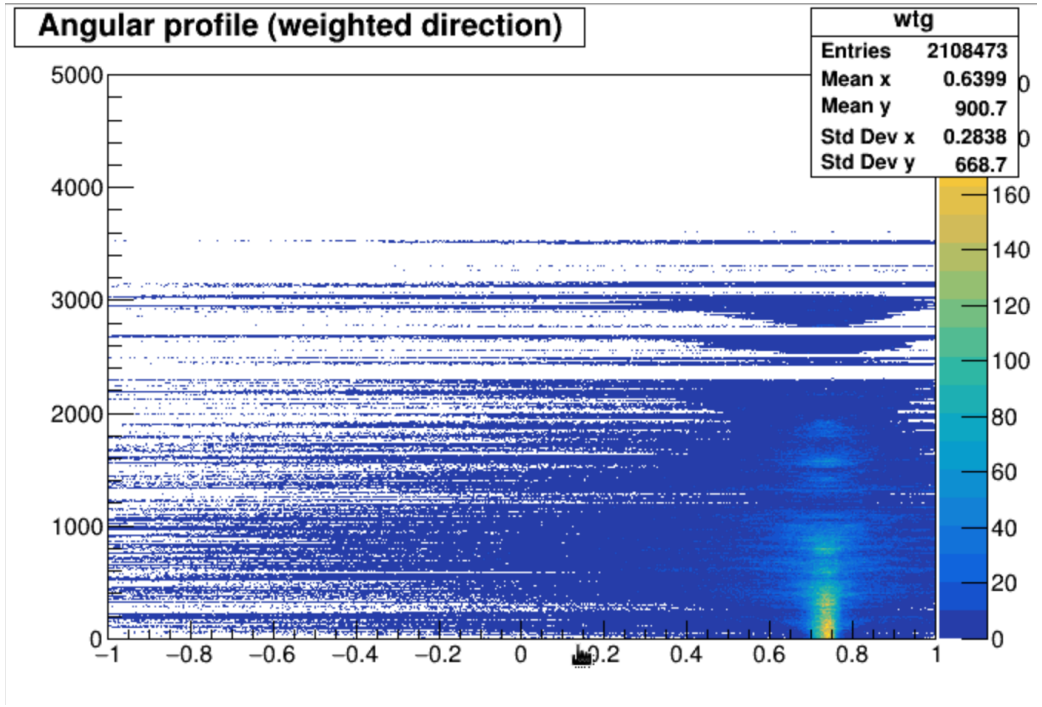
Scintillator profile

Cherenkov Profile

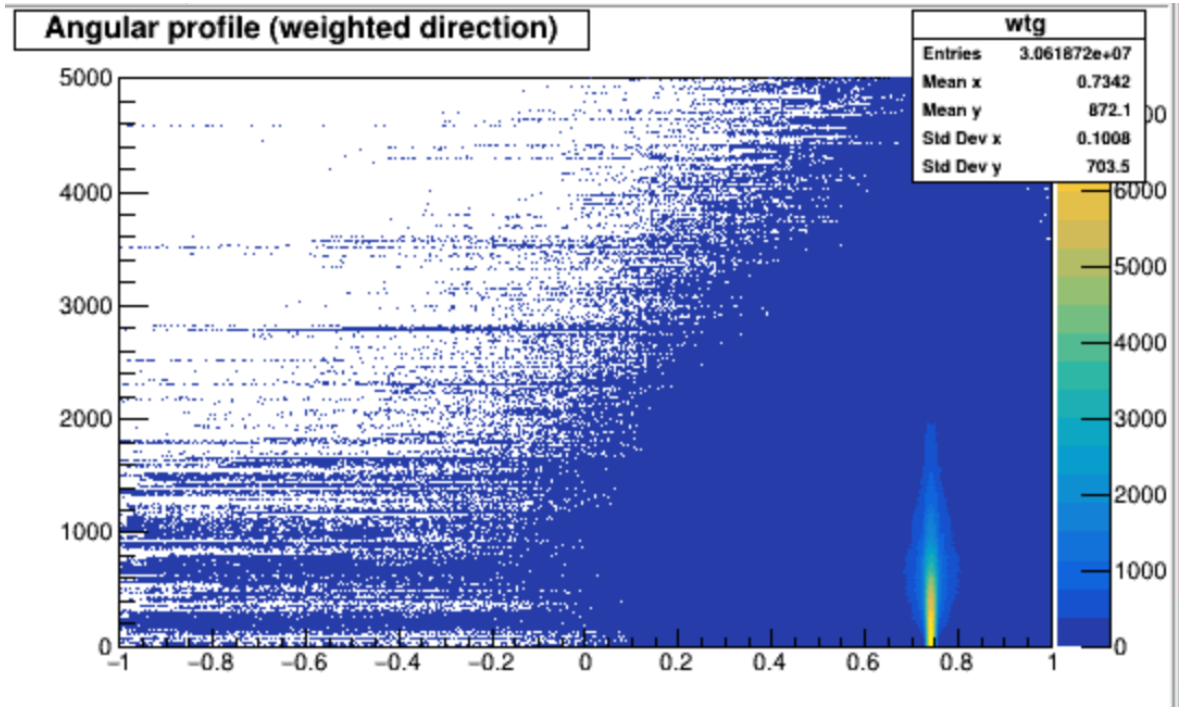
Ratpac-two, 10 events

Electron, 500 MeV

WCSim, 1000 events



Optical photons 2E6



Optical photons 3E7

Validation

Two stage validations

There are two stages of fit in the precious WCSim tuning for fiTQun:

1. MC -> histogram of the the angle and length emitted photon
   Compare ratpac-two result with WCSim
2. Hist -> fitted parameters as a function of momentum etc
   Input the same histogram to validate the two fitted outputs are exactly the same
   In this way we don’t need to compare the WCSim result for a validation because the momentum bins in the proper tuning are very fine and generating MC is very time consuming

Summary and Plans

- Ratpac tuning for fiTQun is under progress

https://github.com/ZhenxiongXie/RATfQTuner

(Please send me your username if you want to have the access to this code)

- Cherenkov profile
  - Almost done and need more MC to do validation
- Angular distribution is under progress