# Shower Profiles

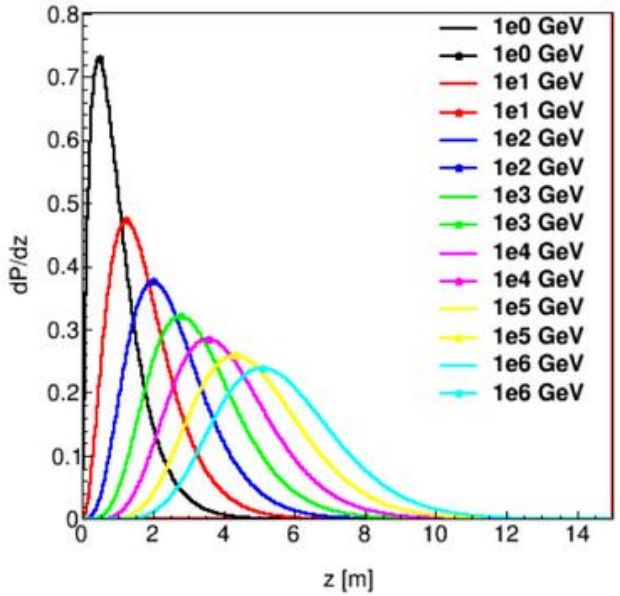
# Recap

- Current shower reconstruction assumes an emission profile that is
  1. Purely isotropic
  2. Originating from the neutrino vertex

- Depending upon energy, Bjorken-y, showers may deviate from this assumption
  - Peak emission might occur away from neutrino vertex
  - Photons may be detected earlier/later than expected

- Goal of this study is visualize the extent of these deviations
  - Starting with MC-truth files

longitudinal shower profile




*Presentation Maarten 2020-04-16*

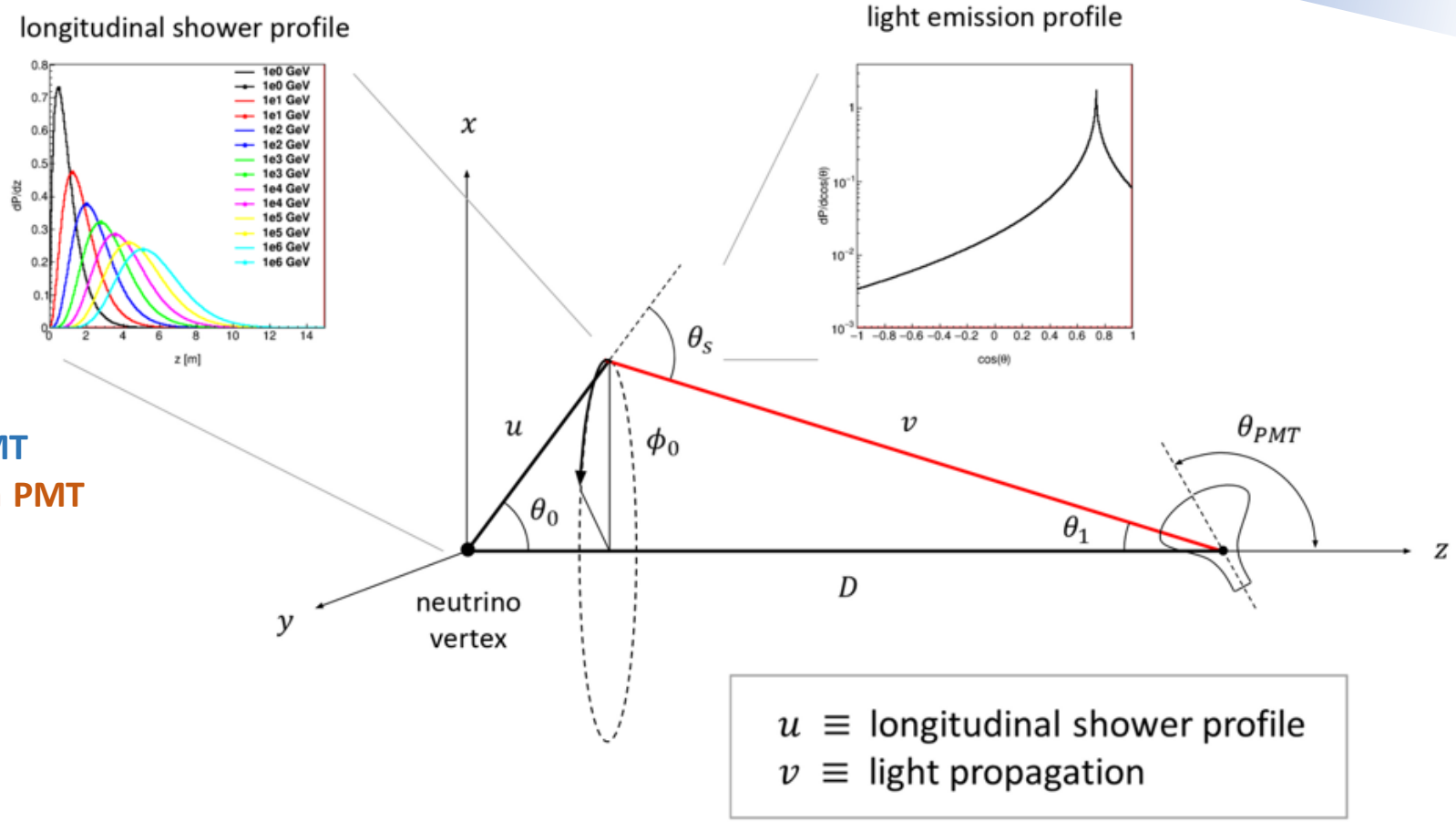
# Recap

- Difference in photon arrival times can be expressed analytically

$$c\Delta t_1 = n\left(\sqrt{D^2 + u^2 - 2Du\cos\theta_0} - D\right) - u$$
$$= \begin{cases} +u(n-1), & \cos\theta_0 = -1 \\ -u(n+1), & \cos\theta_0 = +1 \end{cases}$$

  - **Negative** when neutrino **goes towards PMT**
  - **Positive** when neutrino **moves away form PMT**

- For u = 4m, n = 1.38:
  - u(n + 1) / c = 32 ns
  - -u(n - 1) / c = -5 ns

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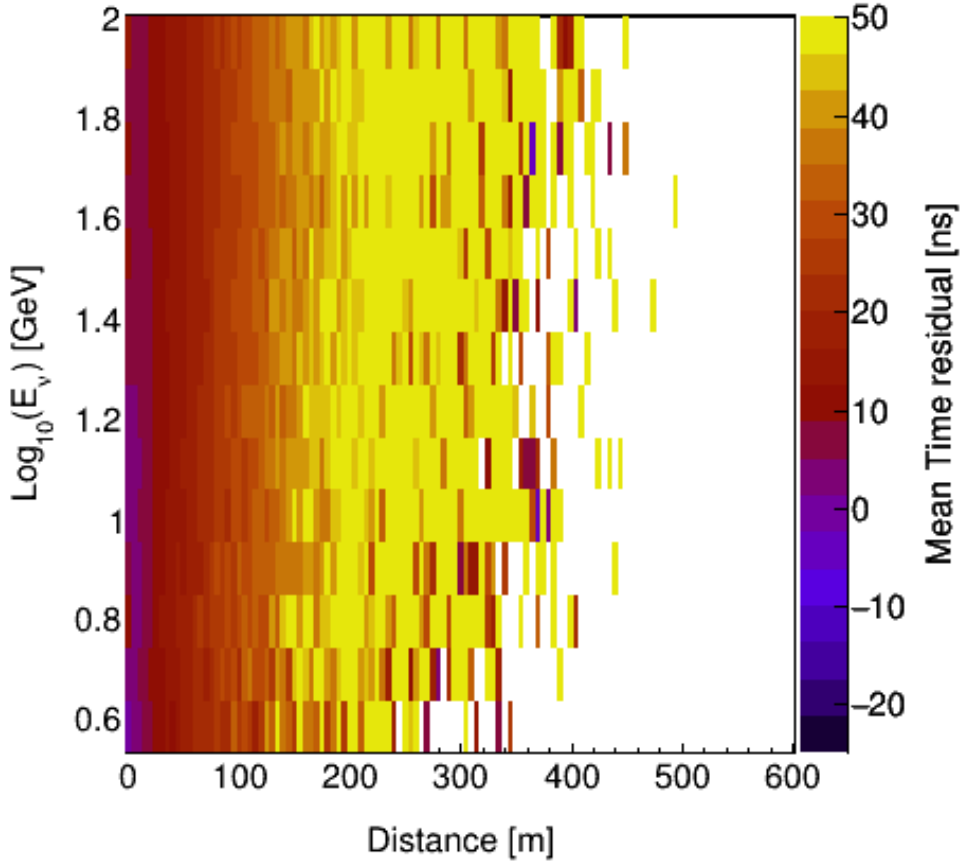
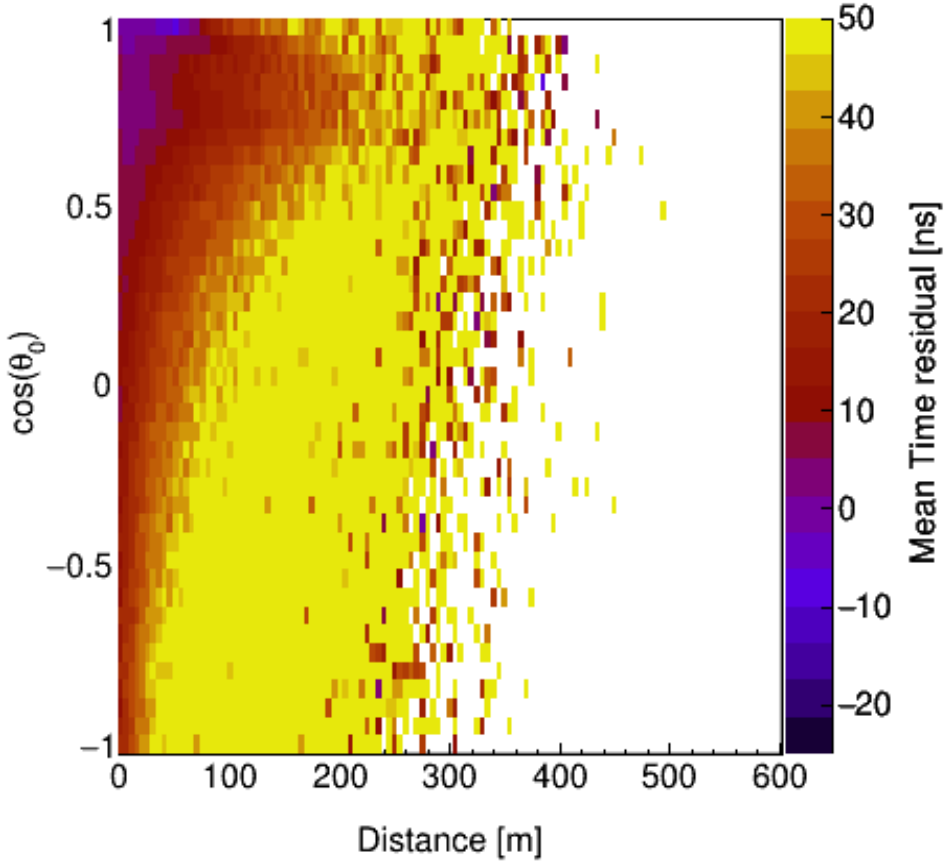
# Angular profile

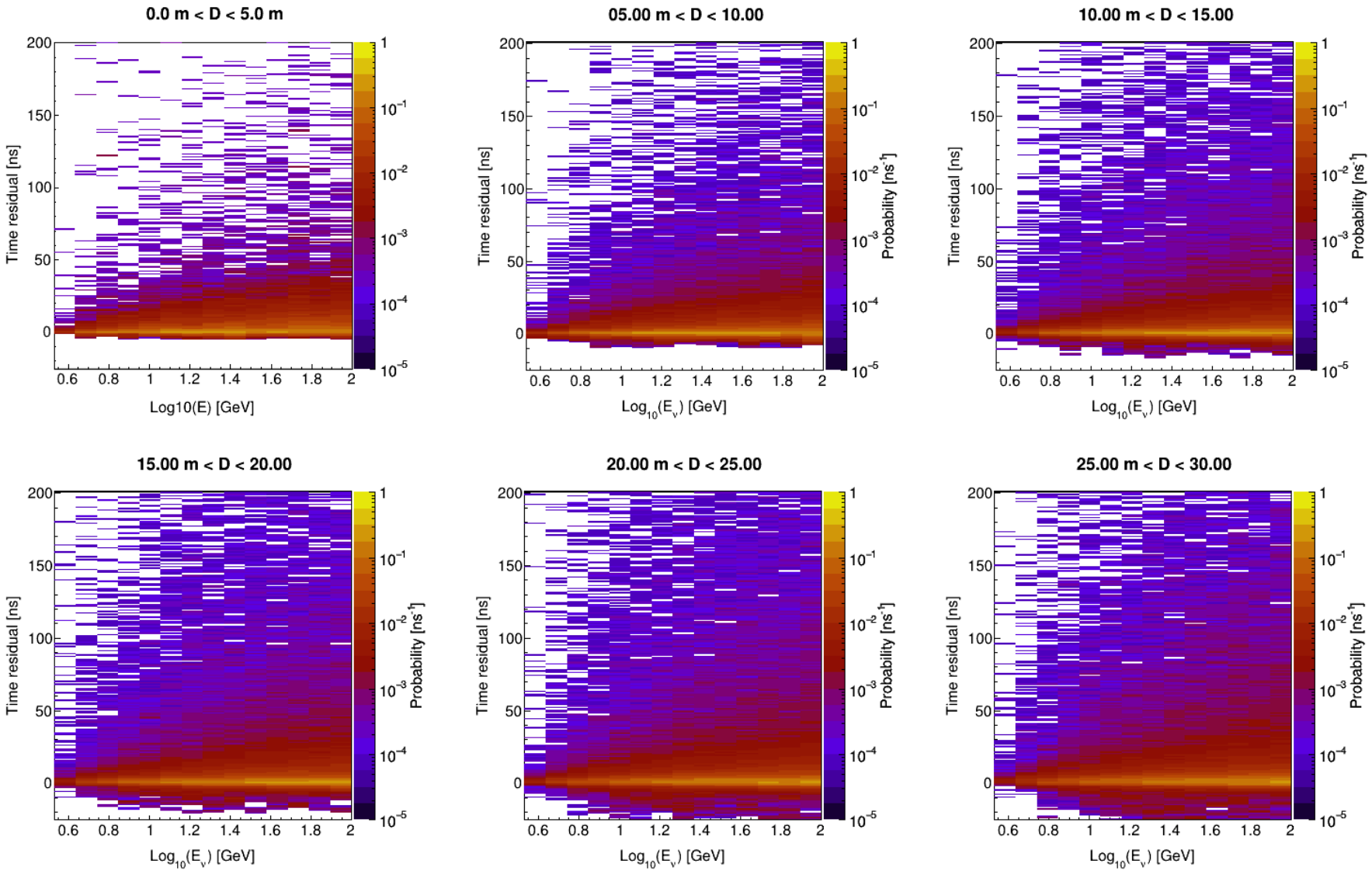
- Mean arrival time differences ("time residuals") confirm this expectation
  - **Negative** time residuals around cos(th0) = -1

- Note that scattering drives the time residuals upwards beyond ~30 m



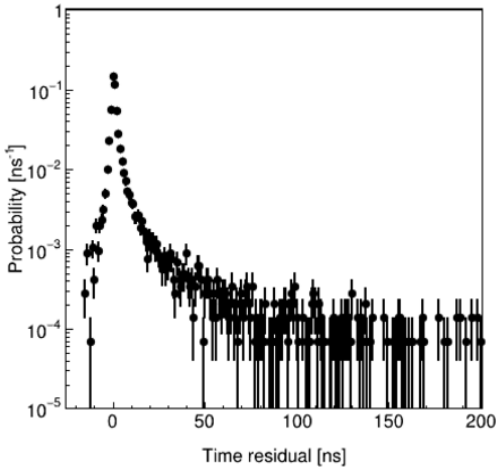
# Energy profile



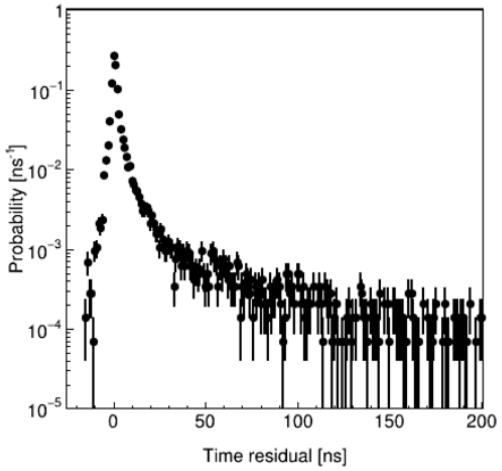

- Distribution widens as:
  - Energy goes up
  - Distance goes up
- Very extended tails!

# Energy profile

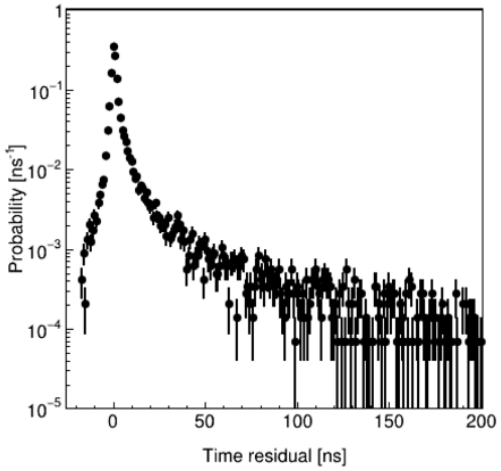
0.8 < log10(E) < 1.0



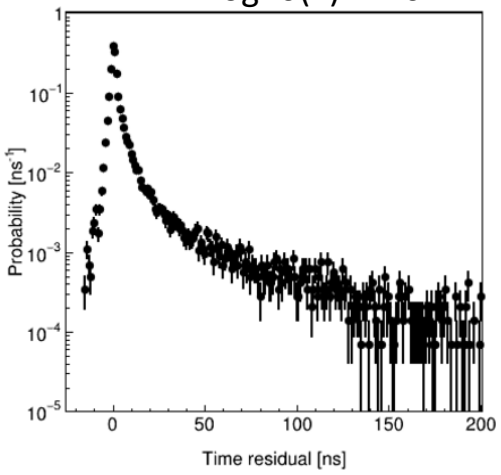

1.0 < log10(E) < 1.2



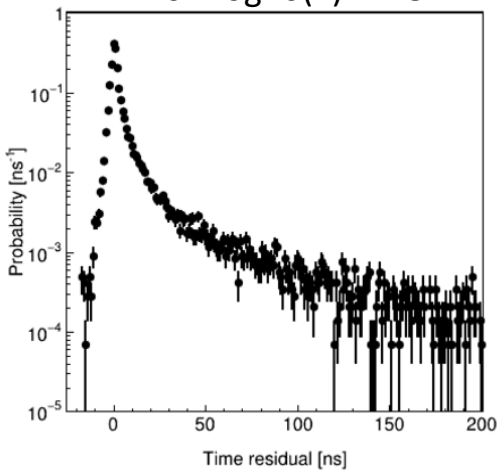

1.2 < log10(E) < 1.4



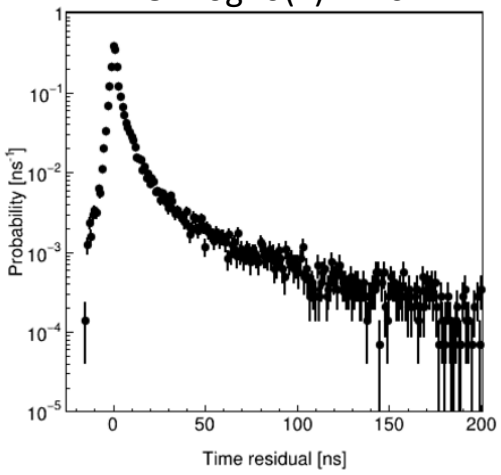

1.4 < log10(E) < 1.6




1.6 < log10(E) < 1.8




1.8 < log10(E) < 2.0




10.00 m < D < 15.00 m

- Distribution widens as:
  - Energy goes up
  - Distance goes up
- Very extended tails!
  - Exponential fall-off at high dT

# Conclusions

- Showers will deviate from the isotropic emission scenario as:
  1. Neutrino direction becomes parallel to PMT-vertex direction
  2. Distance increases
  3. Primary neutrino energy increases

- Typically expect residuals of:
  - +10^1 ns when neutrino moves directly towards PMT
  - -10^0 ns when neutrino moves away from PMT

- Tails of time residuals are very extended!
  - Reaching up to 200 ns and beyond


KM3NeT