Shower Profiling

Motivation

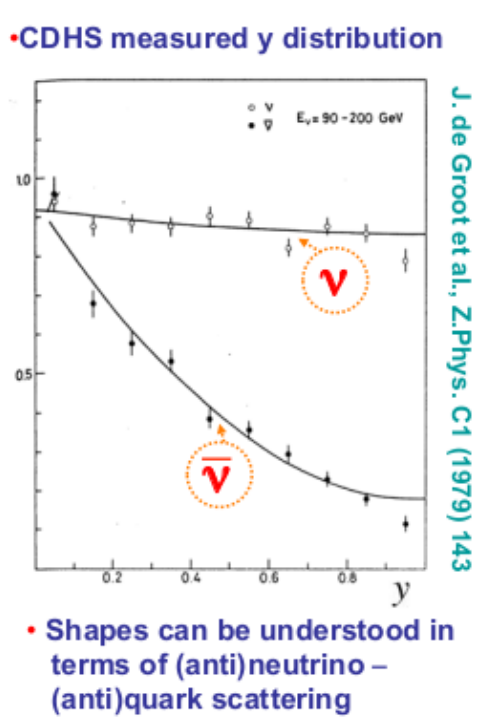
- Shower reconstruction is based on a model which assumes a light source:
  - originating at the neutrino interaction vertex
  - Propagating isotropically outward

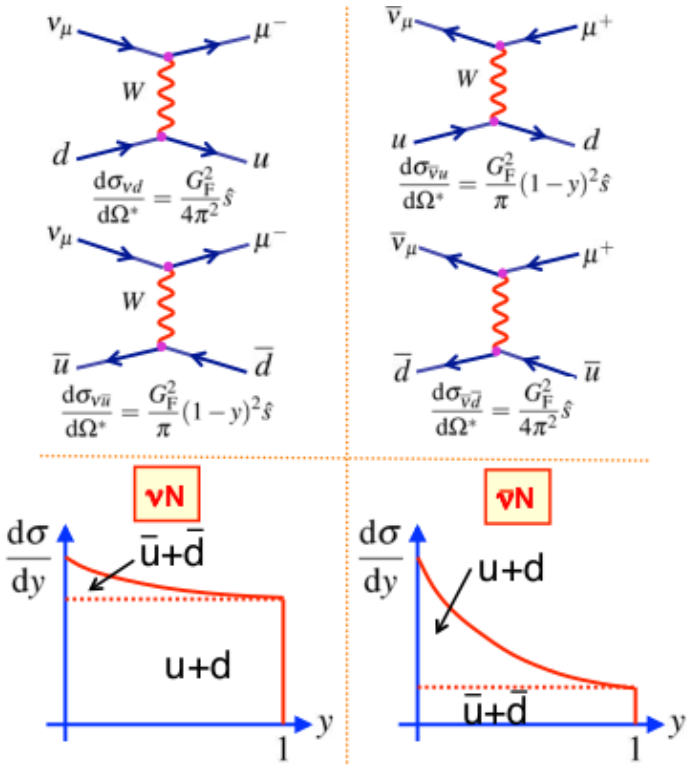
- How well do these assumptions hold?
  - For different neutrino energies or Bjorken-y?
    --> Does e.g. boosting lead to a significant difference in the shower geometry?

  - For different reaction products?

  - Between neutrinos/antineutrinos?

- Goal: exploit shower topology to enhance reconstruction
  - Study angular profile
  - Start with MC-truth, add complexity along the way

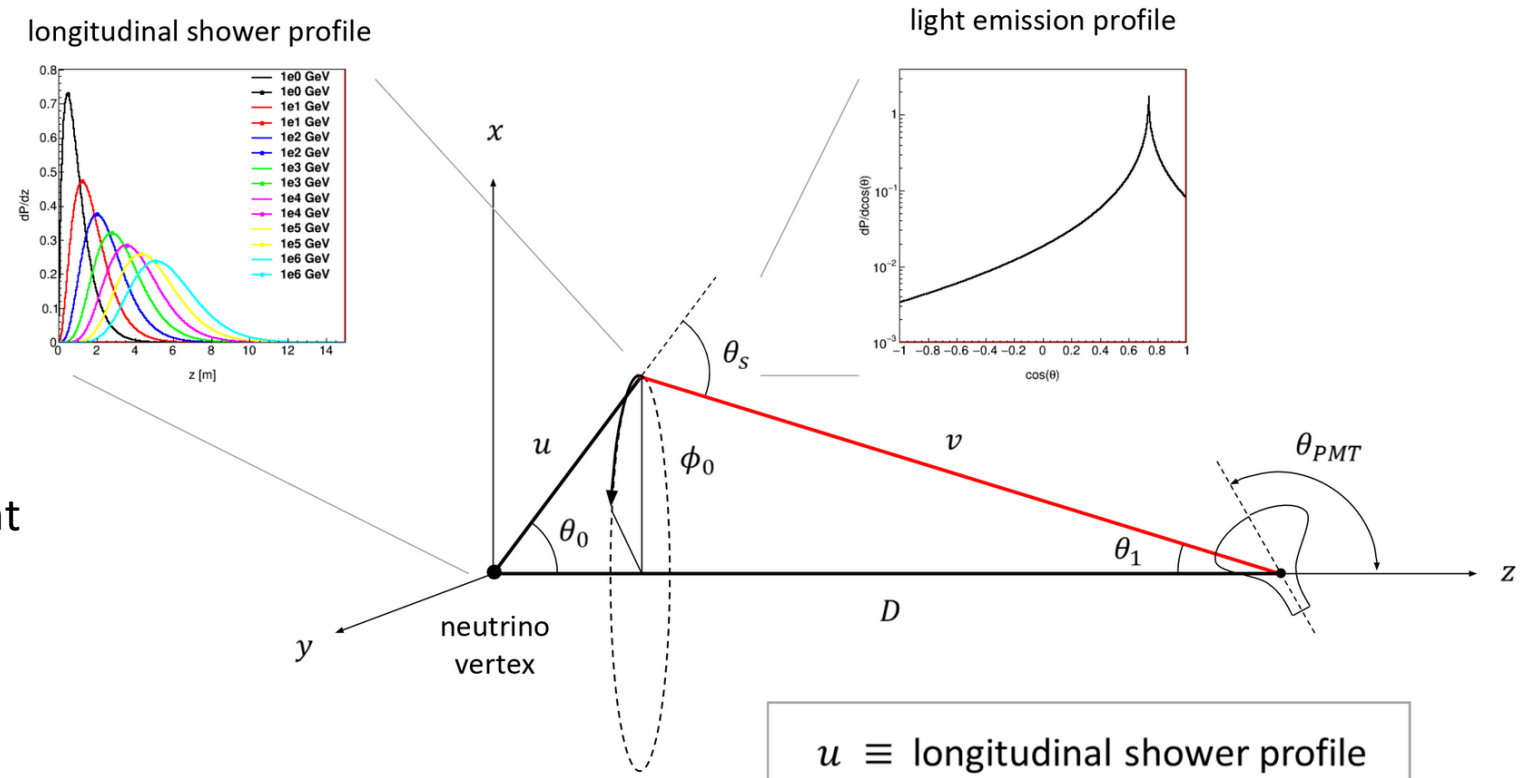




Mark Thomson (2011): Particle Physics Lectures, Handout 10

Shower Geometry

- Naively assume all light originates from neutrino vertex
- Actually there is a longitudinal profile
- True arrival time is dependent upon:
  1. Distance vertex <---> PMT
  2. Distance vertex <---> emission point
  3. Photon flight distance
  4. Incidence angle
  5. Emission angle
- Two parameters are fixed by the others
- The difference between the naive arrival time estimate and true arrival time holds information on the elongation of the shower!
  - Try to plot this difference as function of energy and distance
- See also Maarten's previous pres.

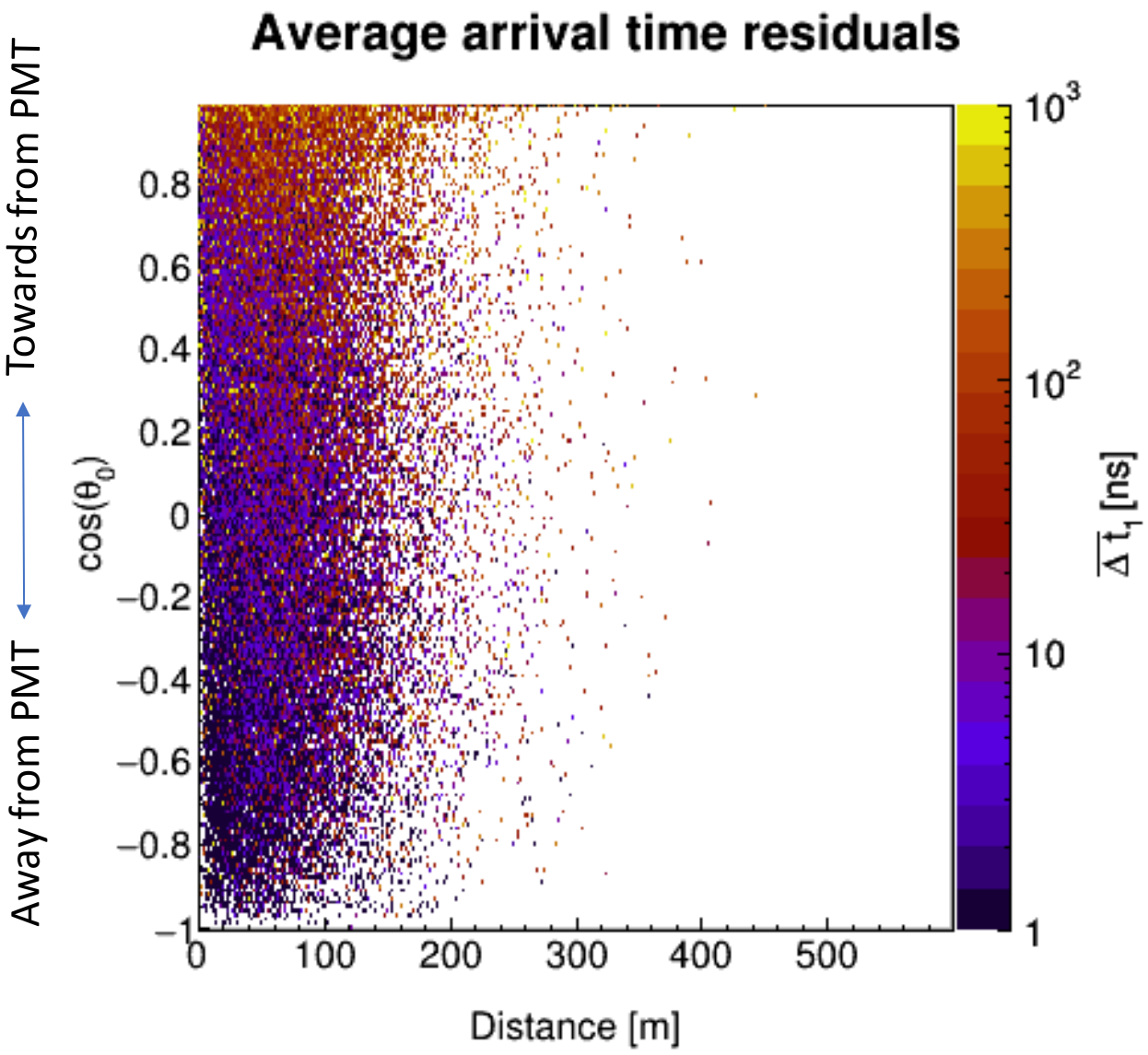


$u \equiv$ longitudinal shower profile
$v \equiv$ light propagation

Difference between 'naive' and true arrival time

$$\Delta c t_1 = n\left(D - \sqrt{D^2 + u^2 - 2Du\cos\theta_0}\right) + u$$

Preliminary results



- Arrival time residual
  - Increases as shower points towards PMT
  - Decreases as shower points away from PMT
- Distance dependence small
- More or less as expected:
  - Shower particle velocity > phase velocity light
  - Shower particles traveling in direction of PMT will generate light along the way which reaches the PMT faster than the pure neutrino vertex assumption

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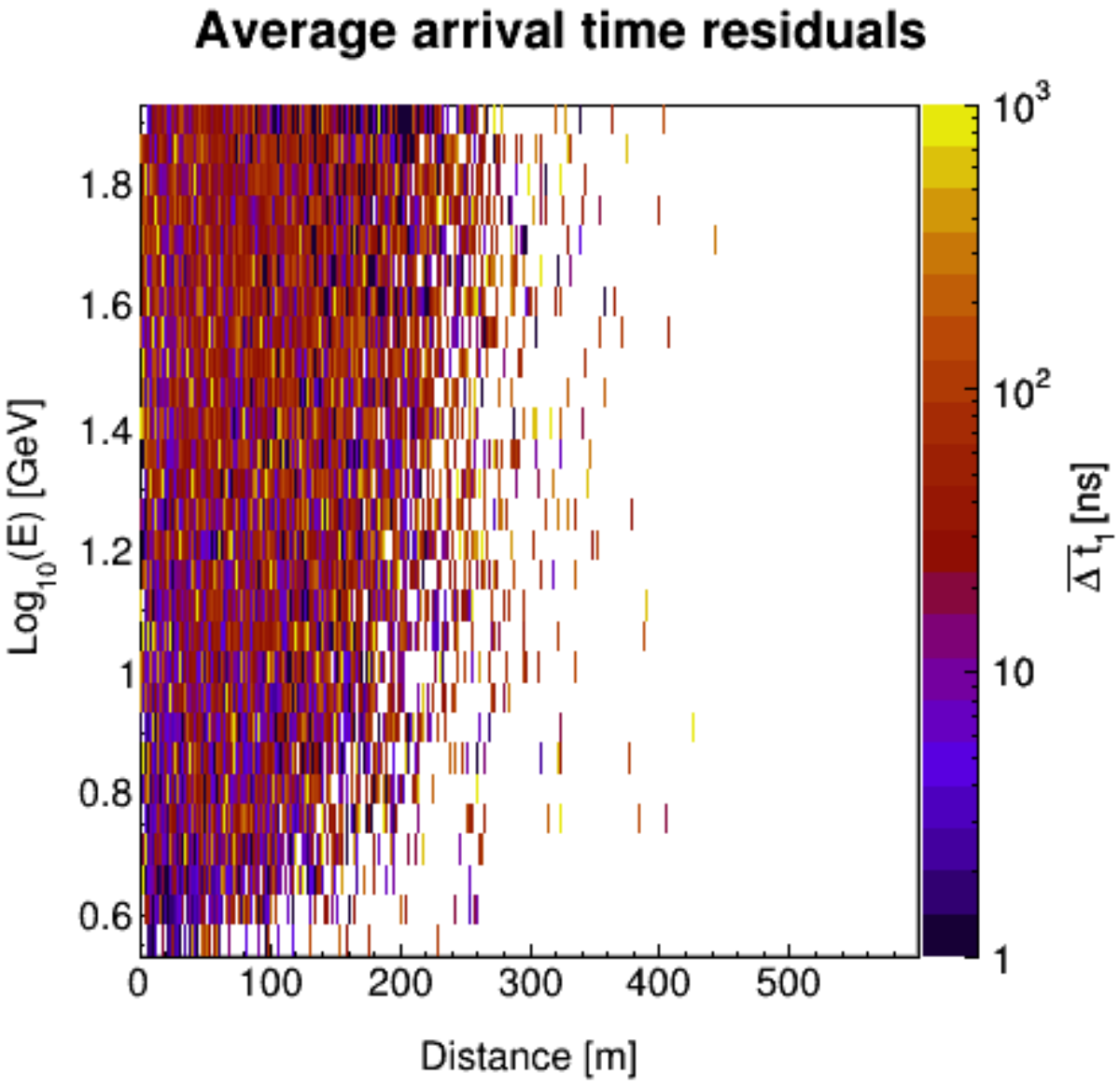

- No obvious structure as of yet...
- Would naively expect neutrino events of greater energy to yield more elongated showers, increasing the arrival time residuals
- Running with more statistics
- Use Bjorken-y

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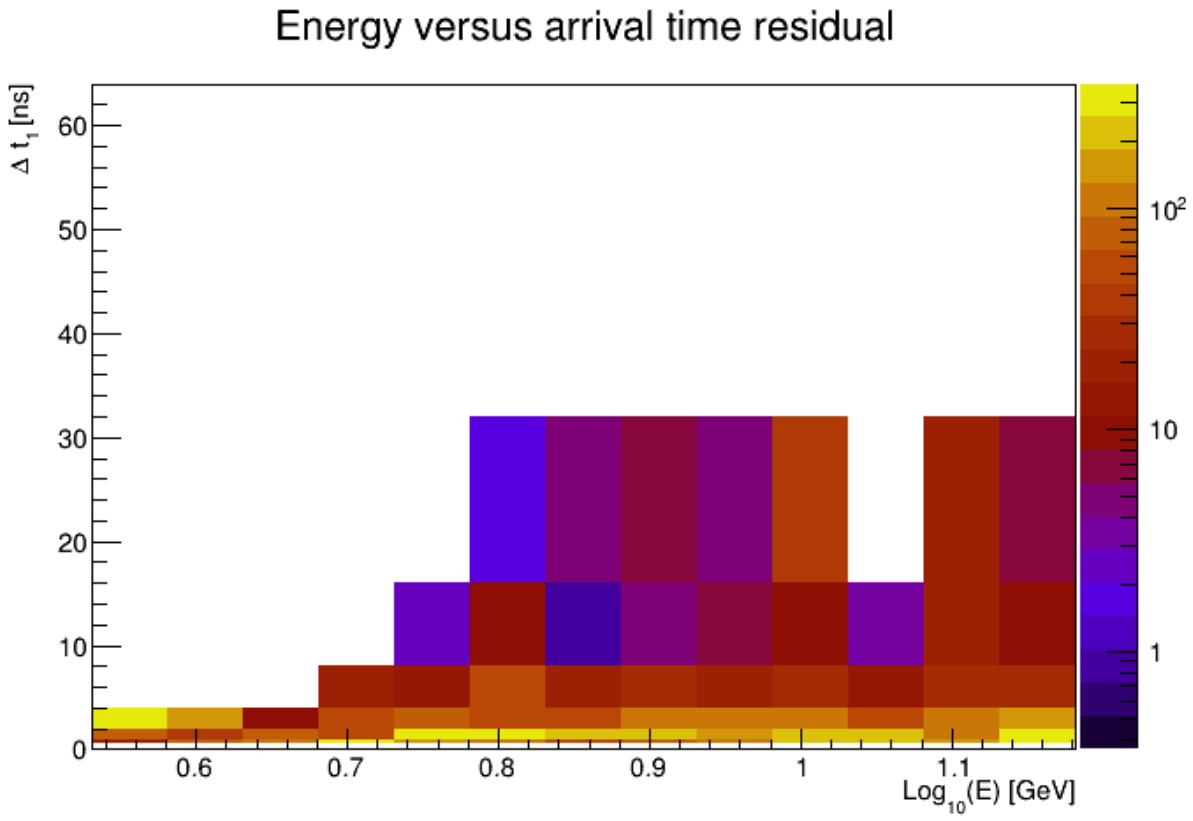

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Plans

- More statistics
- Involve Bjorken-y
- Distinguish different hit originators (i.e. different shower particles)
  - Already started; need more statistics
- Think of proper way to visualize the data
  - Number of histograms quickly grow out of hand...