

Likelihood Ingredients

$$P(\text{data}|H) = \sum_i \left[\log \int P(\text{ev}_i | x_{\text{true}}) \cdot P^{\text{det}}(x_{\text{true}}) \cdot \mu(x_{\text{true}} | H) dx_{\text{true}} \right] - \mu^{\text{tot}}(H)$$



$\mu(x_{\text{true}} | H)$ Number of expected background or signal events in our detector (can)



$P^{\text{det}}(x_{\text{true}})$ Probability to detect (=trigger) and select event



$P(\text{ev}_i | x_{\text{true}})$ Probability to obtain measured event ev_i
given a certain neutrino hypothesis x_{true}

How to solve the 9D integral?

$$P(\text{data}|H) = \sum_i \left[\log \int P(\text{ev}_i | x_{\text{true}}) \cdot P^{\text{det}}(x_{\text{true}}) \cdot \mu(x_{\text{true}} | H) dx_{\text{true}} \right] - \mu^{\text{tot}}(H)$$

- Interaction vertex position (3D)
- Interaction time (1D)
- (Neutrino) Direction (2D)
- Neutrino Energy (1D)
- Bjorken-y (1D)
- Neutrino interaction type (1D)

How to solve the ~~9D~~ 8D integral?

$$P(\text{data}|H) = \sum_i \left[\log \int P(\text{ev}_i | x_{\text{true}}) \cdot P^{\text{det}}(x_{\text{true}}) \cdot \mu(x_{\text{true}} | H) dx_{\text{true}} \right] - \mu^{\text{tot}}(H)$$

- Interaction vertex position (3)
- Interaction time (1)
 - Relatively easy once other params. are given?
 - PS: Indeed, factor 7000x faster than default method
- (Neutrino) Direction (2)
- Neutrino Energy (1)
 - Analytically?
 - PS: No, not possible due to longitudinal emission profile
- Bjorken-y (1)
- Neutrino interaction type (1)

How to solve the ~~9D~~ 4D integral!

$$P(\text{data}|H) = \sum_i \left[\log \int P(\text{ev}_i | x_{\text{true}}) \cdot P^{\text{det}}(x_{\text{true}}) \cdot \mu(x_{\text{true}} | H) dx_{\text{true}} \right] - \mu^{\text{tot}}(H)$$

- Interaction x,y position (2)
- Interaction z position (1)
- Interaction time (1)
 - Relatively easy once other params. are given?
 - PS: Indeed, factor 7000x faster than default method
- (Neutrino) Direction (2)
- Neutrino Energy (1)
- Bjorken-y (1)
- Neutrino interaction type (1)

Shower Emission Profile

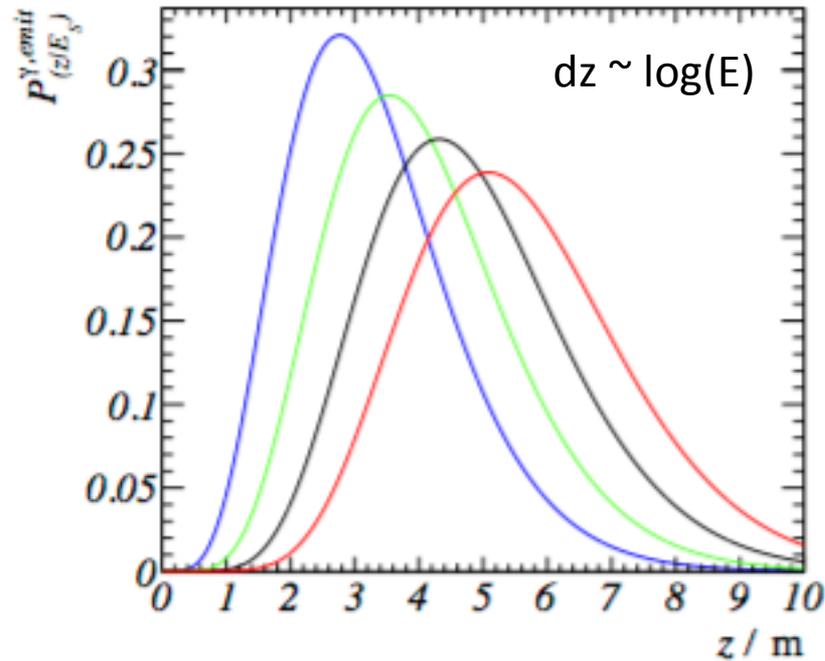


Figure 10: Longitudinal shower profile for shower energies $E_S = 10^4$ GeV (blue), 10^5 GeV (green), 10^6 GeV (black) and 10^7 GeV (red).