Likelihoods & Derivatives

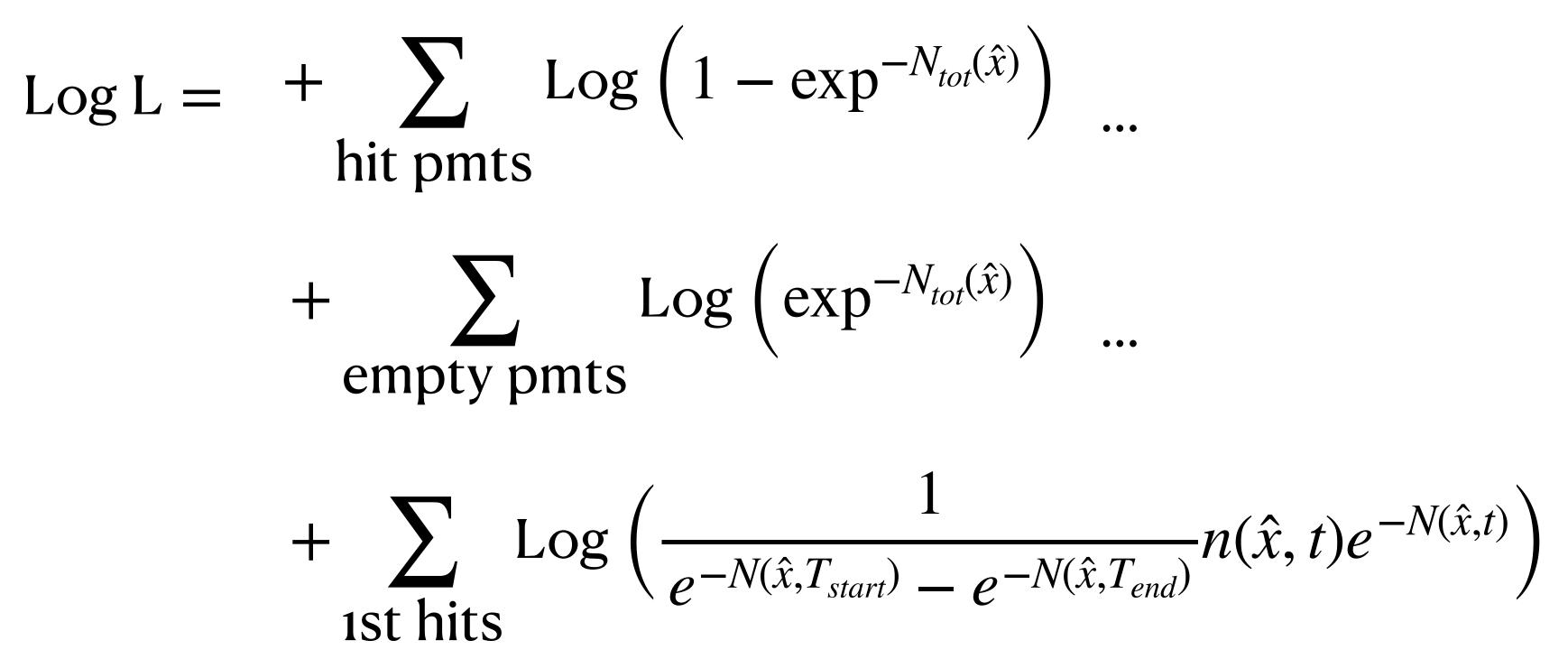
Full likelihood fit of 1 shower

- Shower hypothesis with variables [x, y, z, t, zenith, azimuth, E] fitted using the full likelihood
- Hypothesis is converted to Jpp coordinates (relative to a PMT) $[E, d, cd, \theta, \phi, r]$

Maximise the full likelihood!



The full likelihood



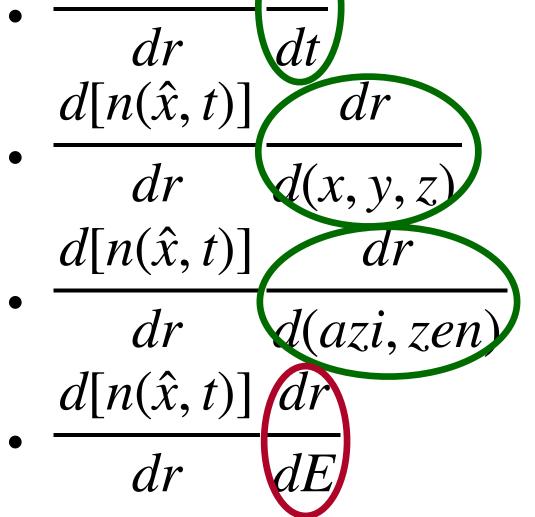
Where $\hat{x} = E, d, cd, \theta, \phi$, and $N_{tot}(\hat{x}), N(\hat{x}, t), n(\hat{x}, t)$ are PDF calls



Derivatives of the likelihood

Maximisation of Log L improves when including $\frac{d(\text{Log L})}{d(x, y, z, t, zen, azi, E)}$

- Jpp PDFs return derivative with respect to residual time for free!
- Calculate Jacobean to fitted parameters yourself: $d[n(\hat{x},t)]dr$



Becomes clear when choosing z as supposed shower direction and using dz/dx, dz/dy as fitted direction parameters

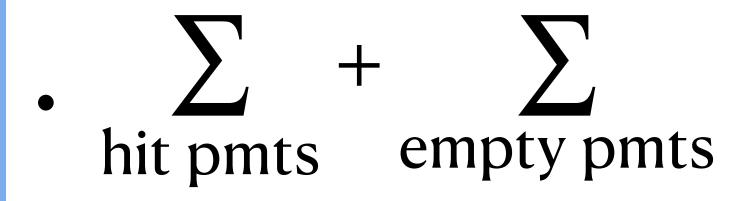
No dependence energy-time





• PDF of the shower depends linearly on the energy

Typically: fit the energy separate when other parameters are fixed using the amplitude information:



Questions

information?

- Terms of N_{tot} in the likelihood that do not depend on time —> no derivatives • You still need to assume an energy (and two in the case of a double bang):
- estimation/prefit/something else?

What if you want to fit the direction, but you want to use the amplitude AND timing

