



Combining Maximum-Likelihood with Deep Learning for Event Reconstruction in IceCube

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Why do we need the hybrid method?

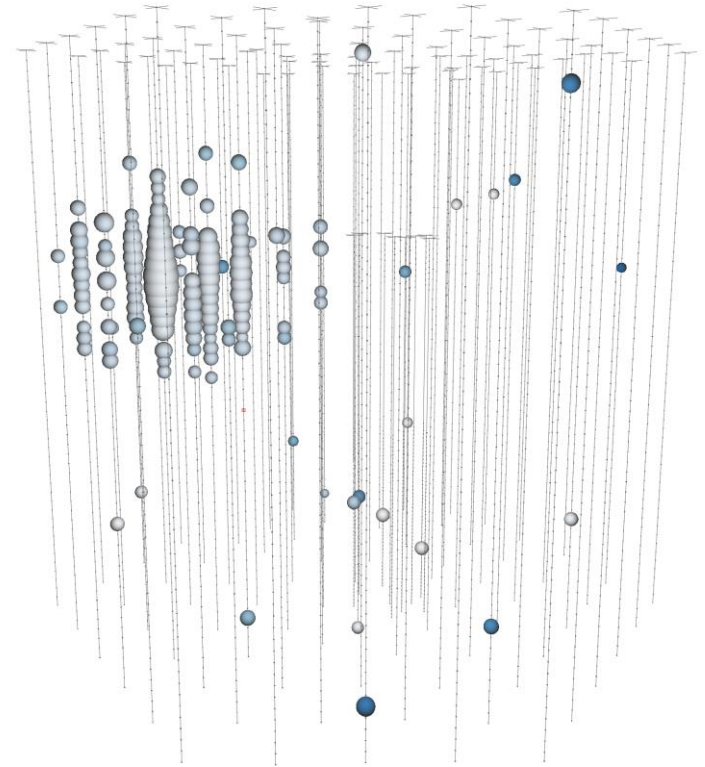
Maximum-likelihood estimation (MLE):

- ⊕ IceCube's current standard reconstruction method
- ⊕ Can utilize available domain knowledge (symmetries, physics laws, detector properties)
- ⊖ Forced to make simplifications due to computational complexity

Deep Learning based methods such as CNNs:

- ⊕ Can improve upon IceCube's standard methods
- ⊕ Fast and efficient inference, once trained
- ⊖ Cannot utilize all available domain knowledge

→ **Goal: develop hybrid method that combines strengths of MLE and Deep Learning**



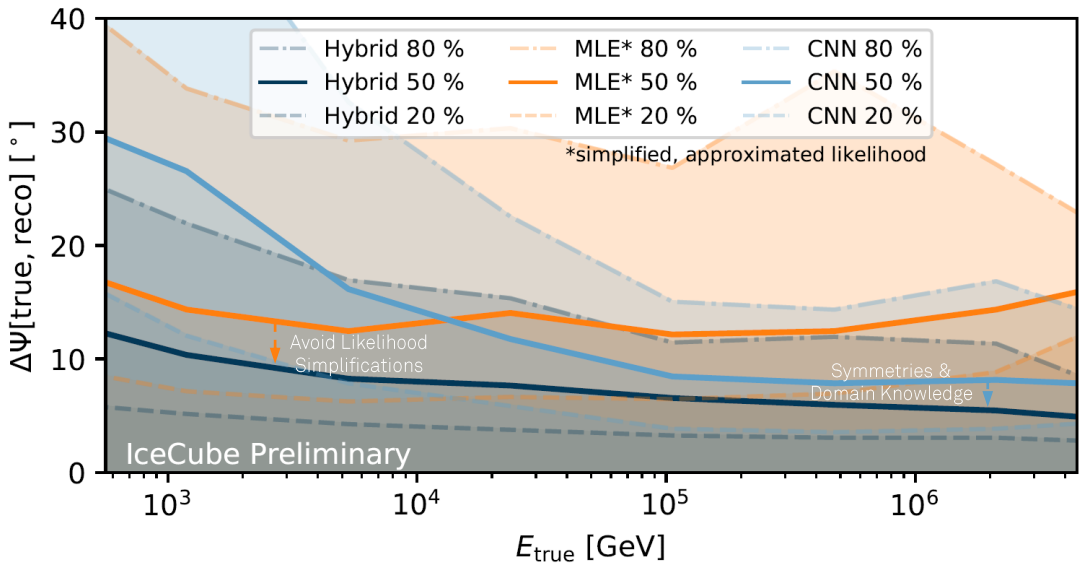
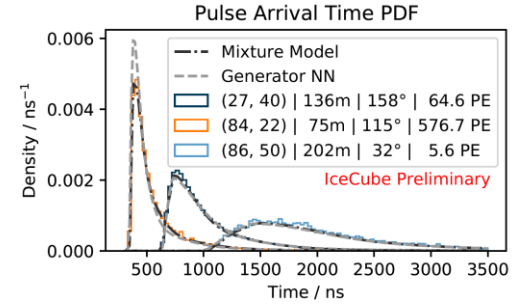
How do we get from pulses to event properties?

Combining MLE and Deep Learning

Hybrid MLE/DL method:

- Utilize generative model to approximate PDF
- Directly incorporate symmetries, physics laws and detector properties into NN architecture, analogously to simulation
- Use trained model in MLE setting for reconstruction

Generator NN to approximate pulse arrival time PDF and expected charge



Model is more interpretable: individual components can be visualized

