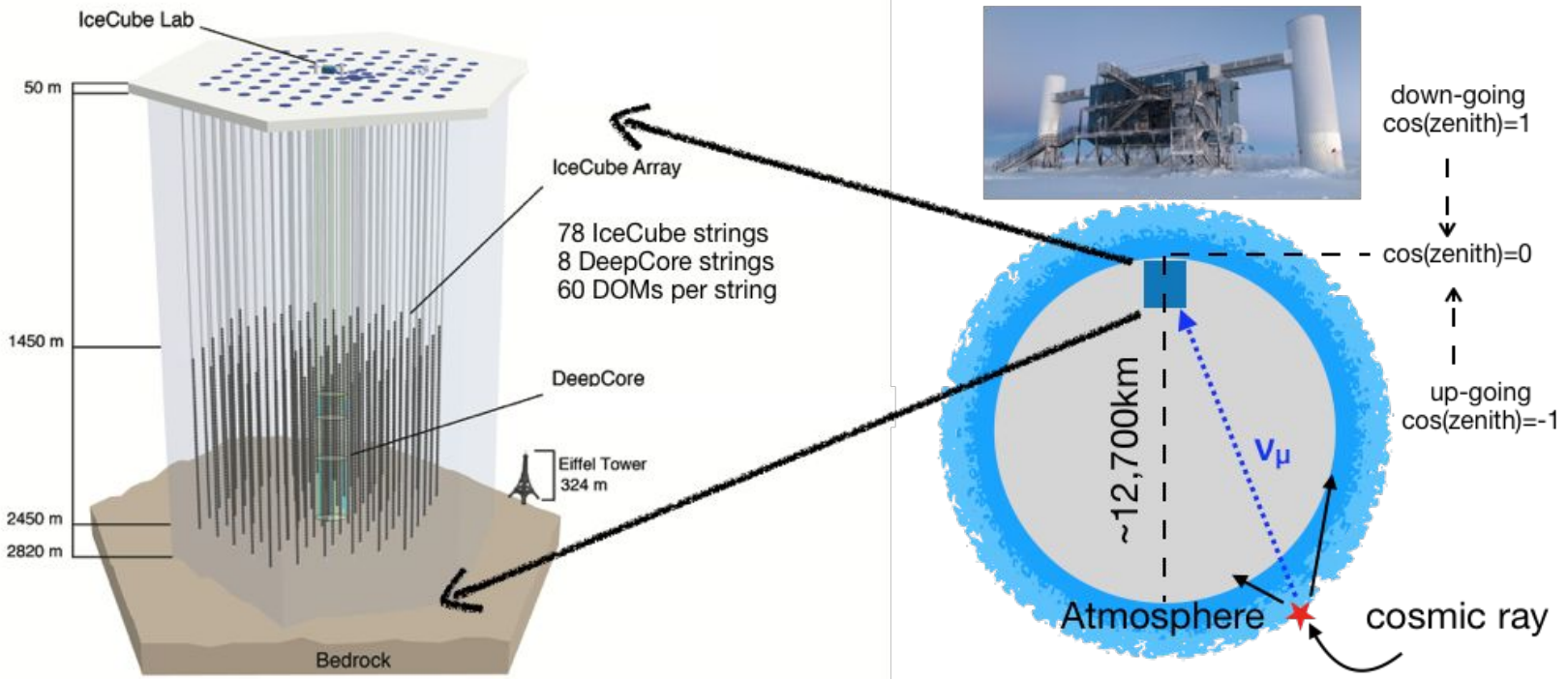
Direction Reconstruction using a CNN for GeV-scale Neutrinos in IceCube

Shiqi Yu
Michigan State University
ICRC 2021

(yushiqi2@msu.edu)

The IceCube Neutrino Observatory

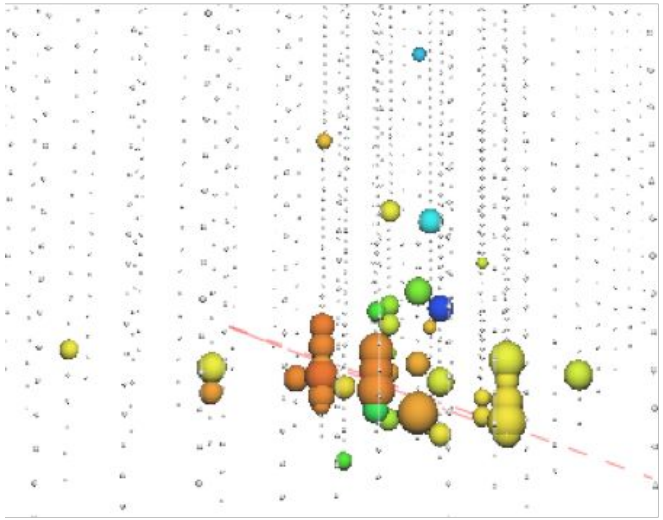


- Cosmic ray atmospheric interactions abundant source of neutrinos
- O(10^4) km baseline (L) inferred using arrival direction (zenith)
- Neutrino interactions in ice produce particles emitting Cherenkov radiation
- Optical modules detect photons, denser instrumented DeepCore detects O(GeV) events

Event Display

Track-like Event:

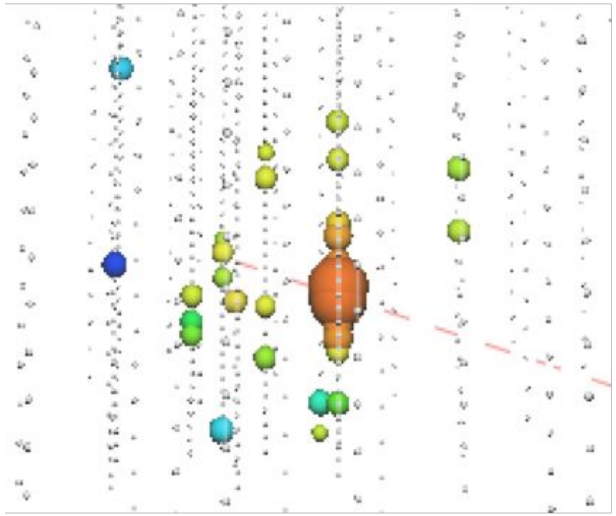
ν_μ charged-current interaction (CC) and 17% ν_τ CC



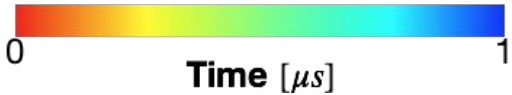
$\nu_{\mu(65.4GeV)} \rightarrow \bar{\mu}_{(62.7GeV)} + hadrons$

Cascade-like Event:

- Neutral current interaction
- ν_e CC and 83% ν_τ CC



$\nu_{e(67GeV)} \rightarrow \bar{e}_{(57.5GeV)} + hadrons$

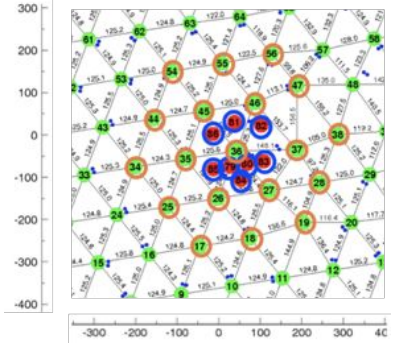


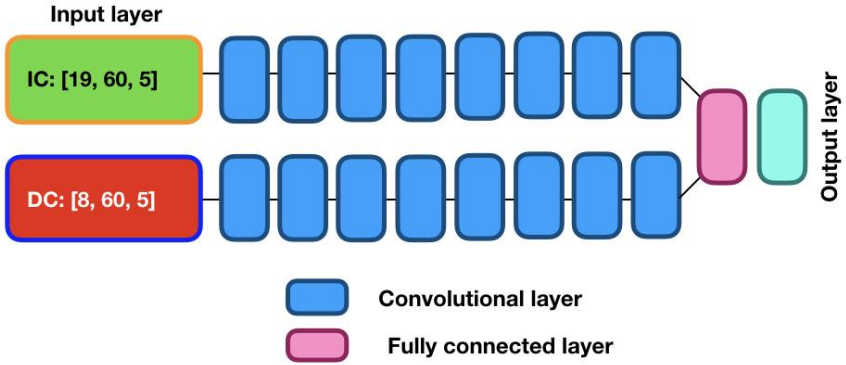
Zenith Reconstruction

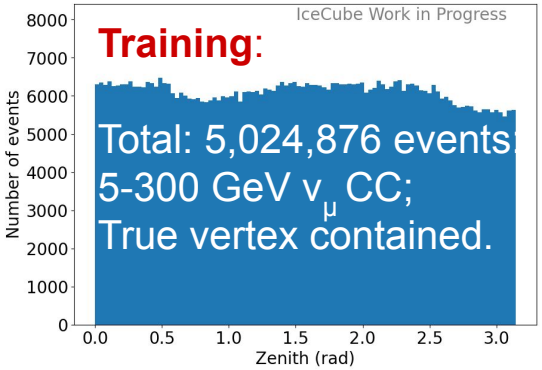
Input: sum of charges; time of first (last) hit; charge weighted mean (std.) of time.

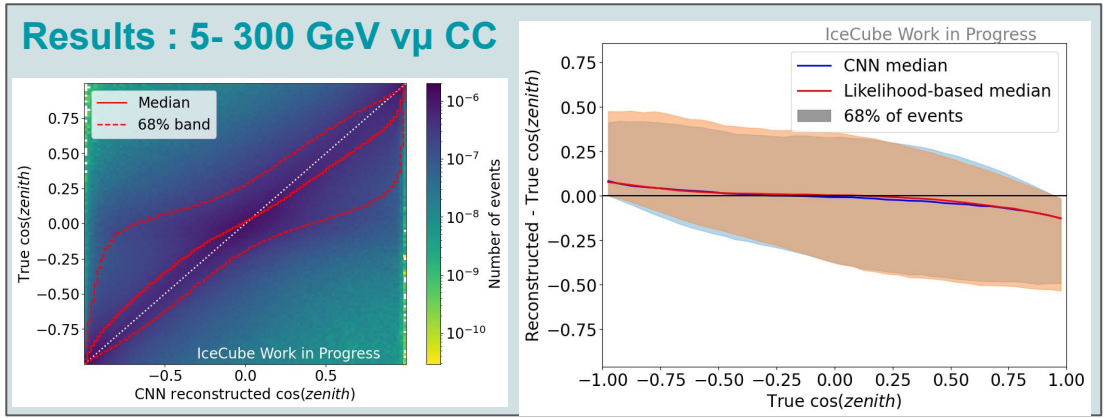
8 DC (or 19 IC) strings x 60 DOMs x 5 variables

Output: value of zenith from 0 to π



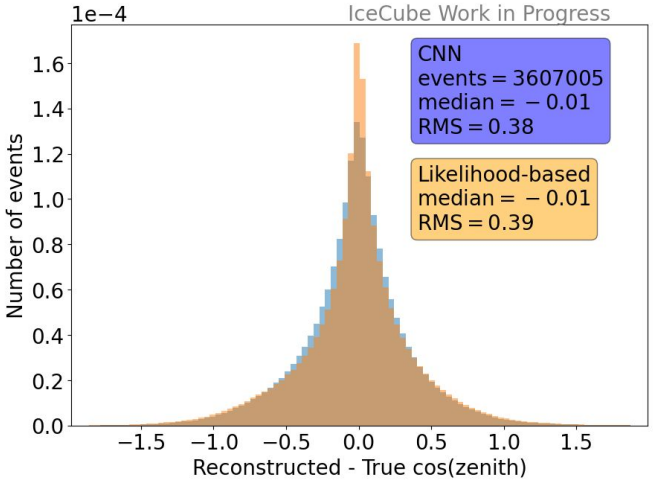






Summary and Future

Time (s) /Event	GPU	CPU
CNN	0.0044	0.108
Likelihood-based	—	44.97



- Up to 10,000 times faster than current processing
- Improved overall RMS by 2.5%
- Comparable bias against true and reconstructed cos(zenith)
- Investigating improvements to systematic uncertainties