

# Search for Astrophysical Neutrino Transients with IceCube DeepCore

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## 1. Astrophysical neutrino transients

- **Choked gamma-ray bursts** (duration < 1,000 s)
  - Insufficiently energetic jet or massive surrounding envelope of material
  - May occur at a higher rate than GRBs
  - Suppressed fluence of high-energy neutrinos due to energy losses of mesons and muons before decay
  - Other unexpected transient sources from cataclysmic astrophysical events

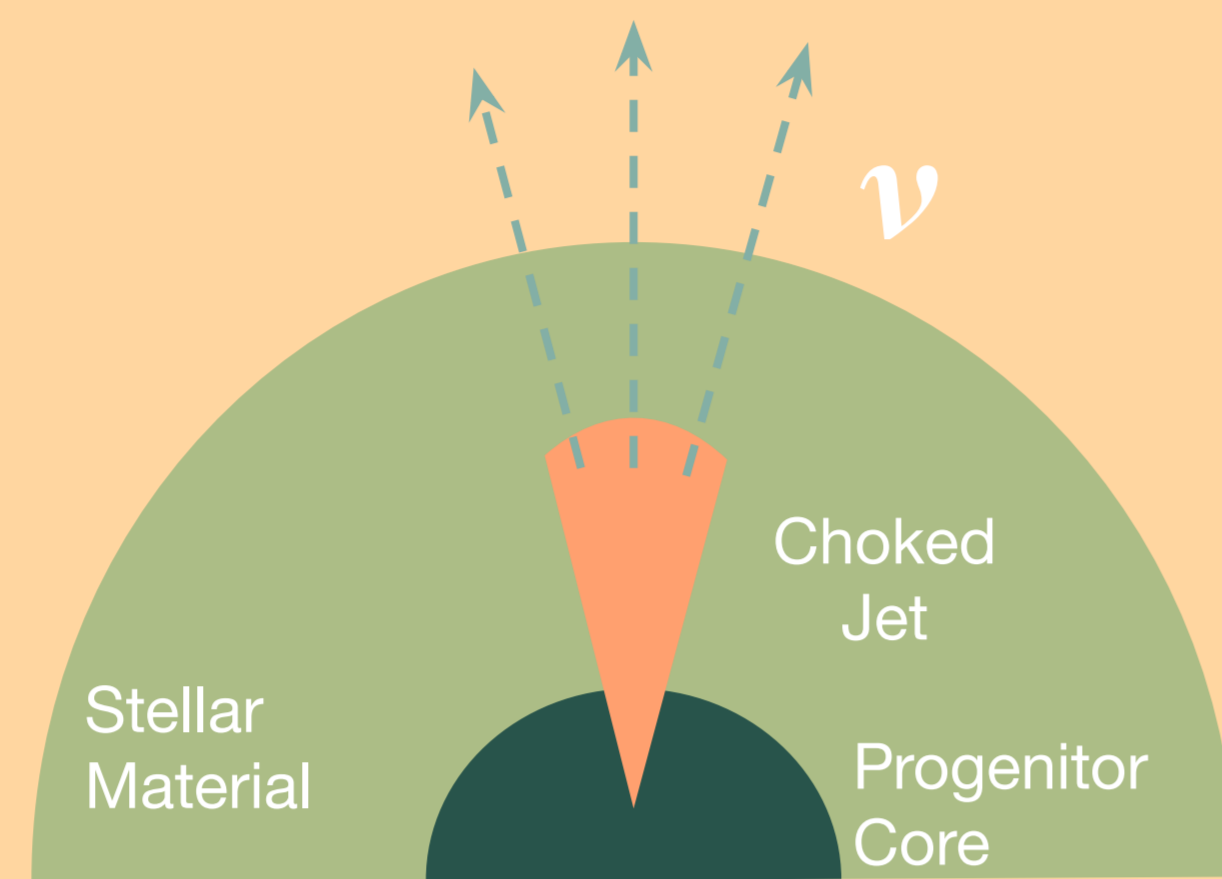


Fig 1. Simple diagram showing the choked jet

## 2. IceCube and DeepCore

- IceCube
  - km<sup>3</sup>-scale neutrino detector at geographical South Pole
  - 86 strings, 5,160 DOMs deployed in the ice
- DeepCore
  - Denser sub-detector
  - Low energy threshold ~ 10 GeV

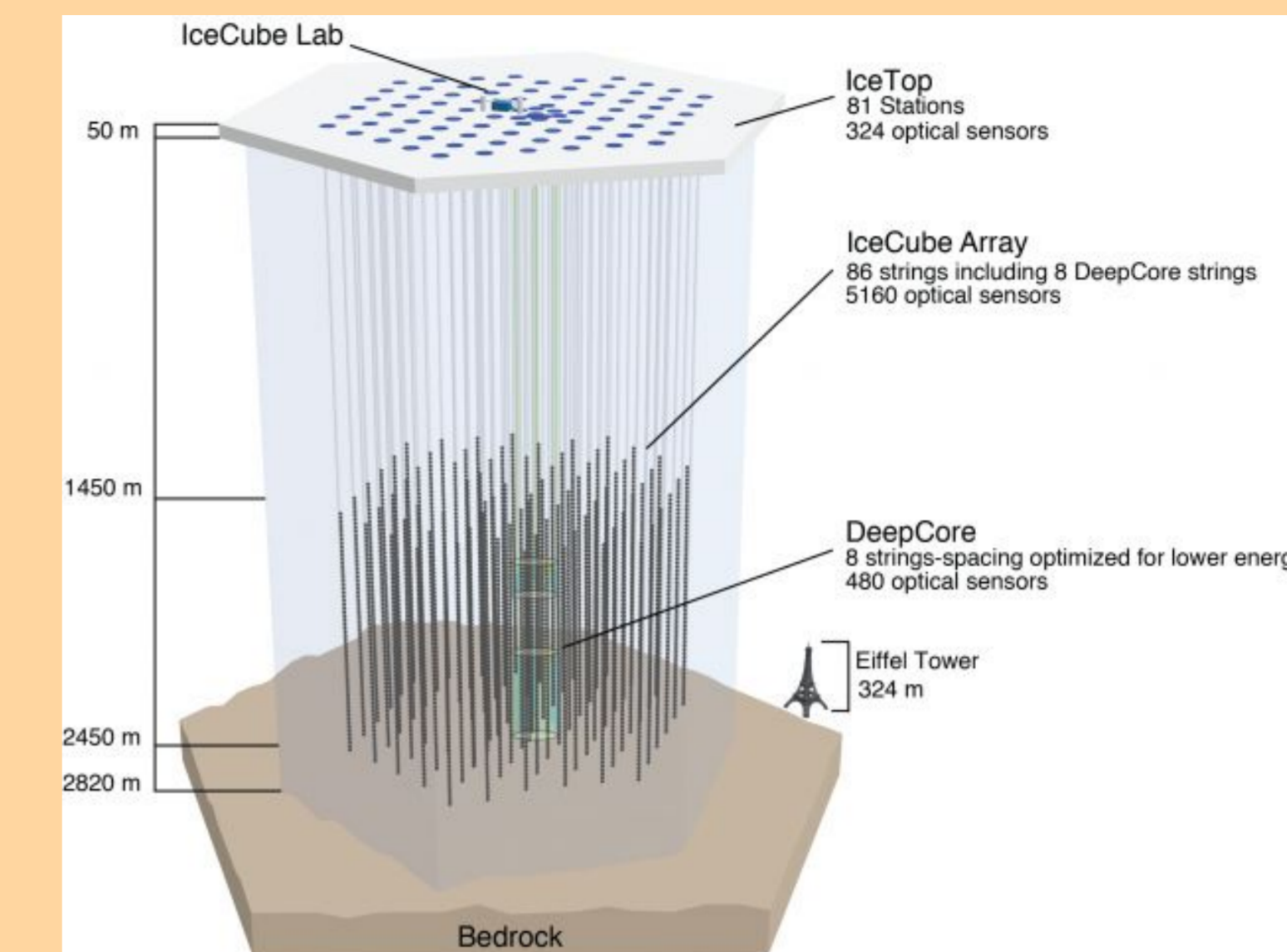


Fig 2. Diagram of the IceCube Neutrino Observatory

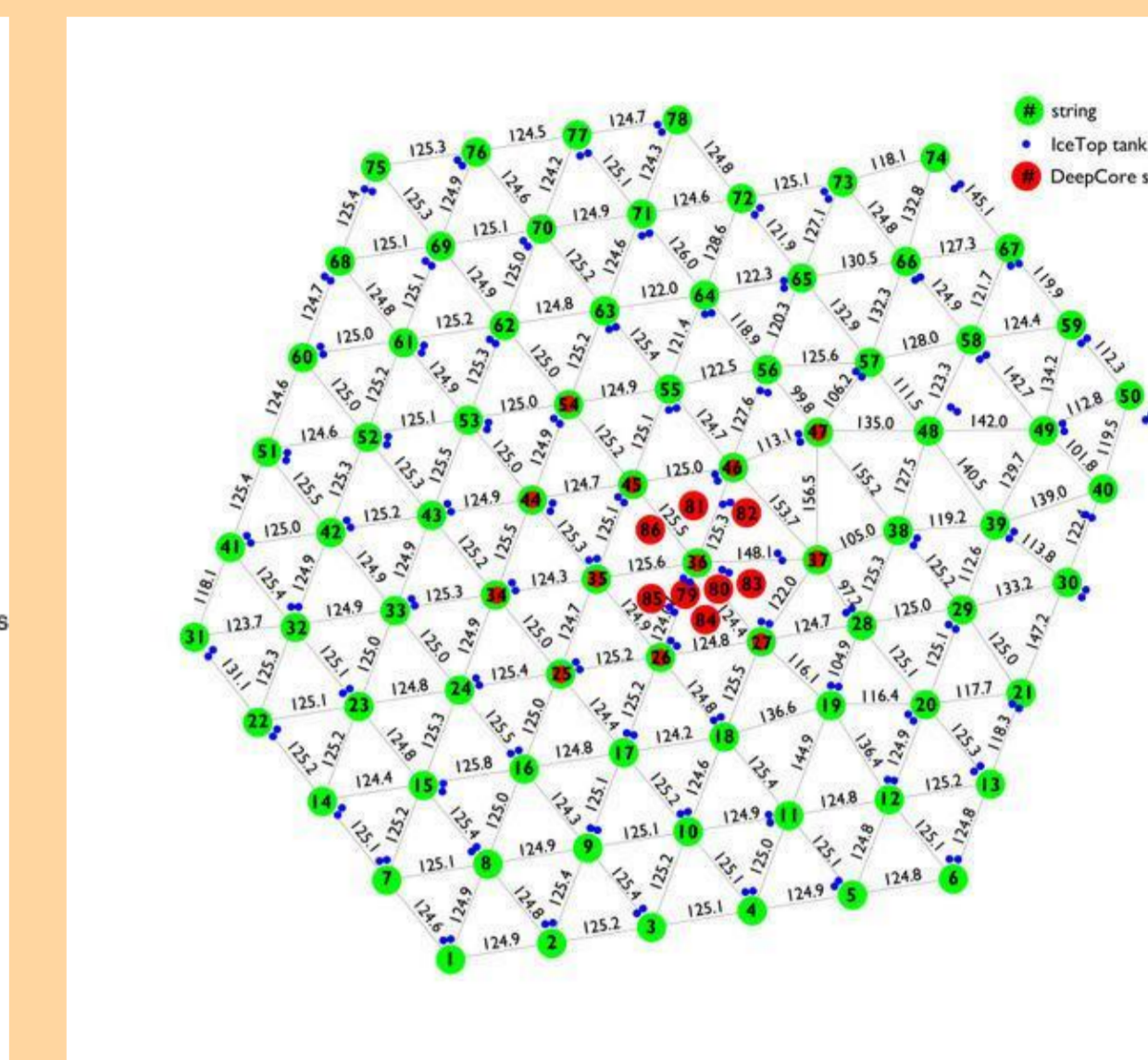


Fig 3. Top View of IceCube Arrays (red: DeepCore arrays)

## 3. Dataset: >10 GeV energy neutrinos

- High-statistics data sample also used for neutrino oscillations.
  - Both up-going and down-going, all sky
  - Tracks and cascades: all flavors
  - Final level event rate ~ 4 mHz

See talk by M. Larson

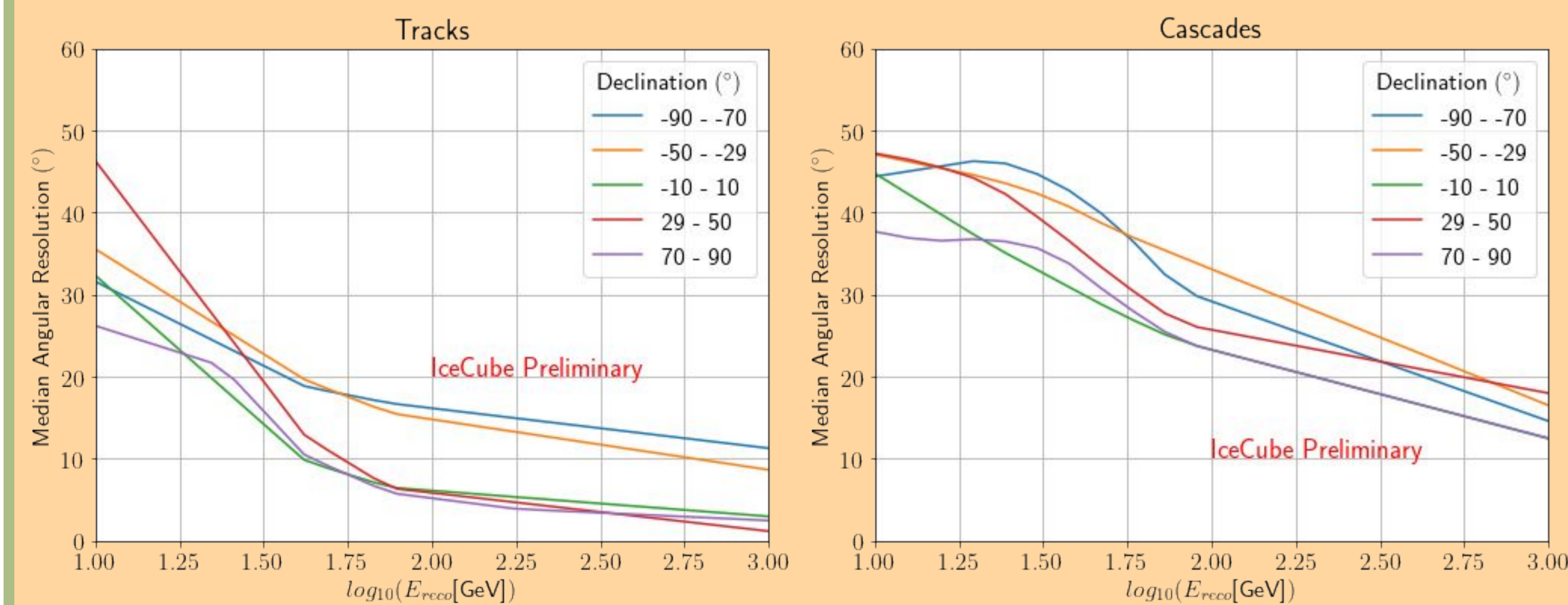


Fig 4. Per-event angular uncertainty vs. reconstructed neutrino energy at several declination

- **Event-wise angular uncertainty** (left: tracks; right: cascades)
  - Track versus cascade based on reconstructed track length
  - Per-event angular uncertainties derived from spline functions of declination and reconstructed energy

## 4. Sensitivity and discovery potential for >10 GeV transients

- Untriggered time-dependent search for flares
  - Flare in a  $\Delta T$ -width box centered at a fitted time  $t_0$
  - Best fit of number of signal events  $n_s$ , spectral index  $\gamma$ , time window center  $t_{0,fit}$  and flare width  $\omega$

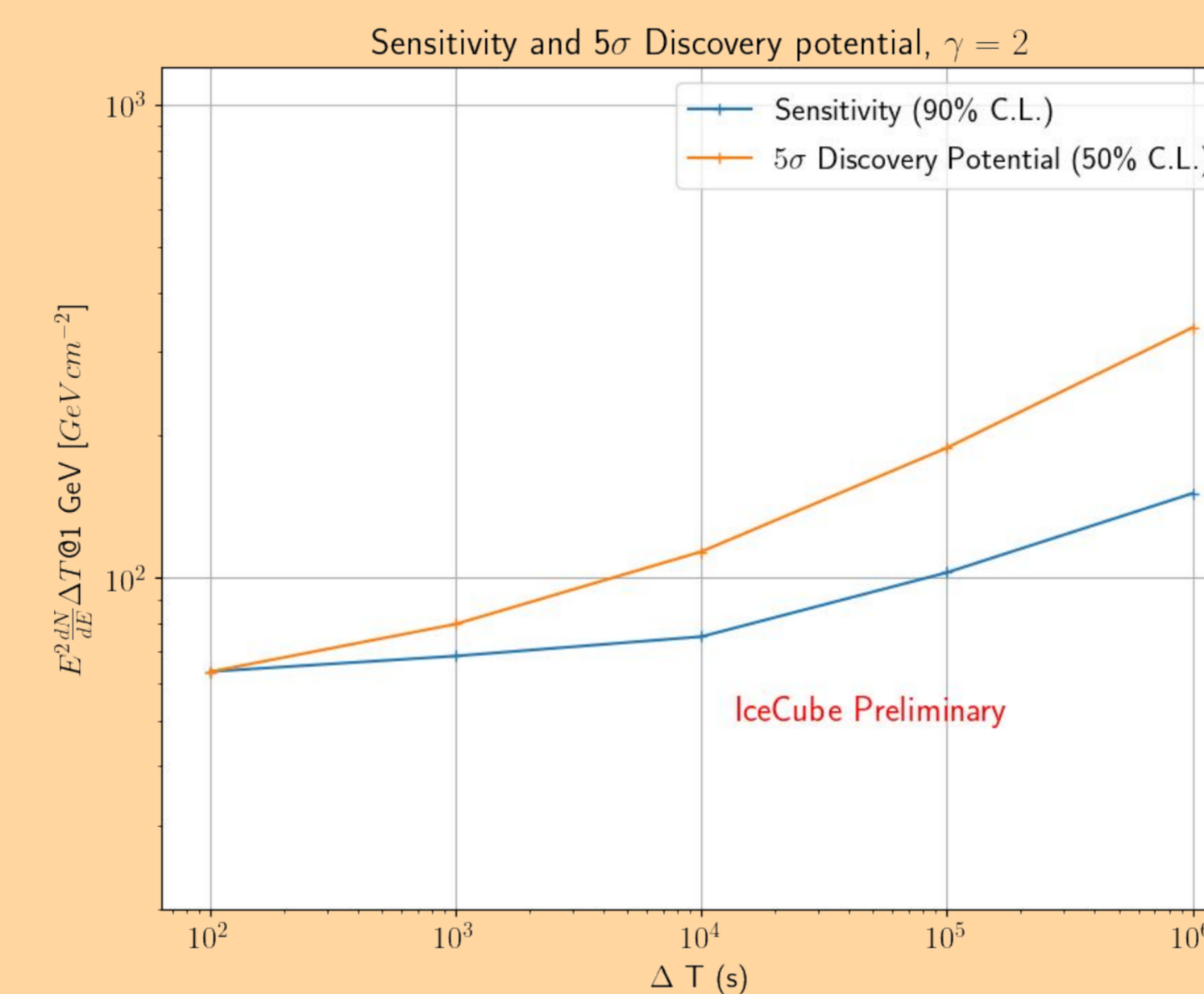


Fig 5. Results from different  $\Delta T$ s

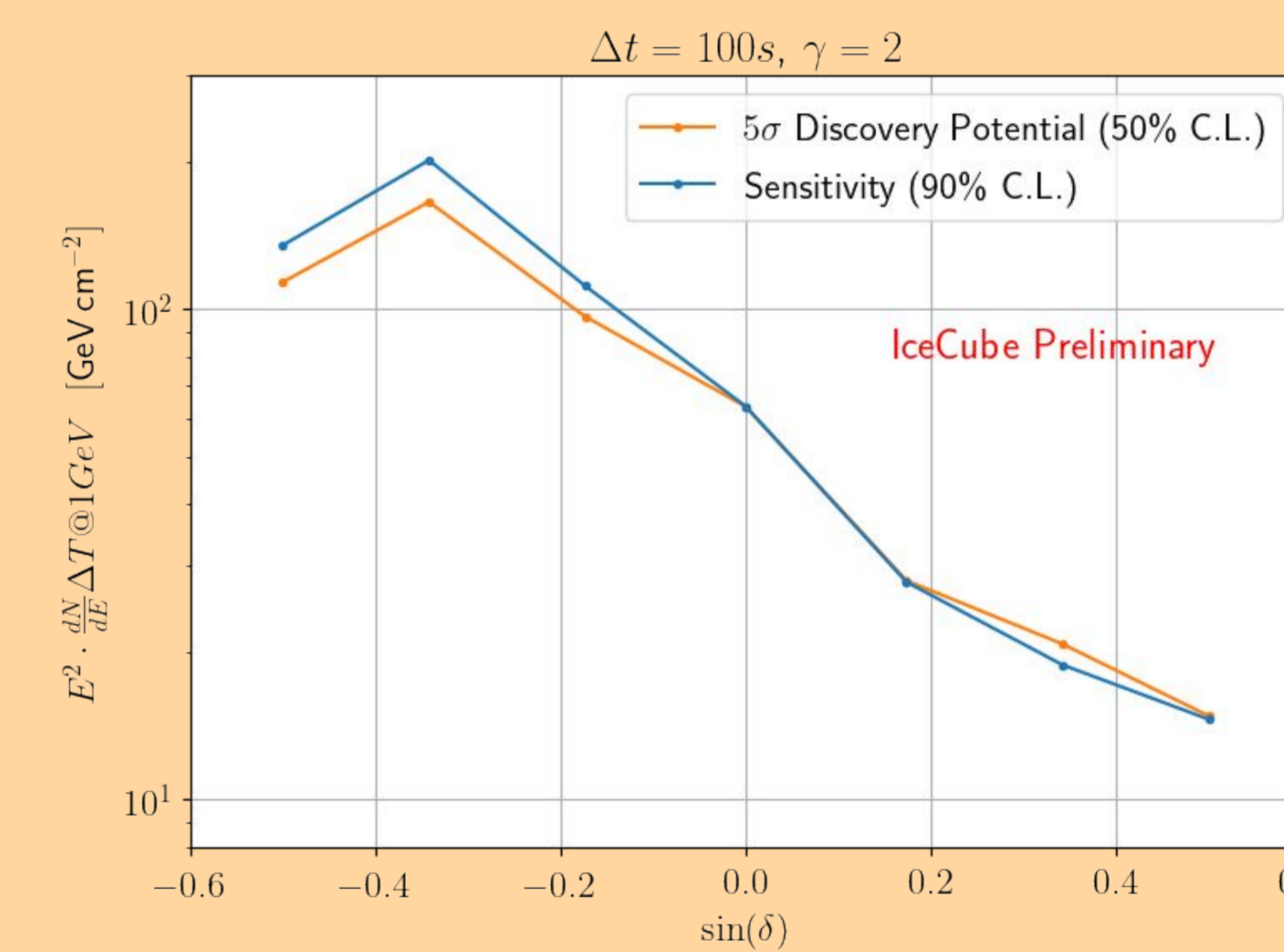


Fig 6. Results at different declinations

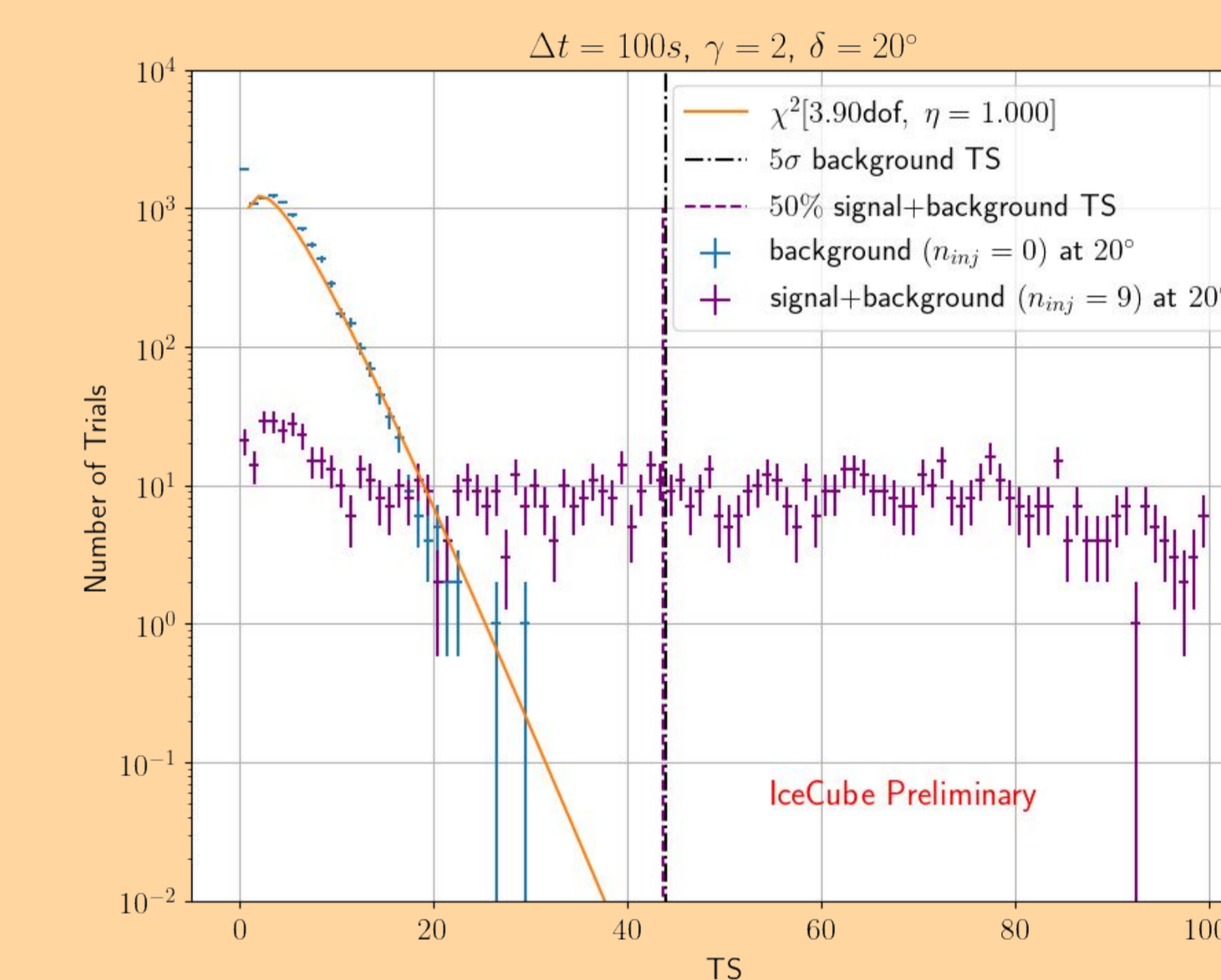


Fig 7. An example of TS distributions

- **Time-integrated flux** (the 5 $\sigma$  background TS is estimated using Wilk's theorem)
  - **Left:** fluence sensitivity and 5 $\sigma$  discovery potential as a function of injected time window width at declination = 0 $^\circ$
  - **Middle:** results at different declinations (half of the whole sky) when injected time window width is fixed as 100 seconds. For declinations near poles, results are not reliable due to large angular uncertainties
  - **Right:** an example graph of background test statistic (TS) distribution and signal + background TS distribution when injected time width is fixed to 100 seconds at declination = 20 $^\circ$

## 5. Discussion

- Less sensitive compared to triggered searches
- Better options for profiling the event angular resolution
- All-sky archival searches for GRBs
- Tend to improve previously published work

## References

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- [2] Abbasi R *et al.* arXiv:2011.05096. 2020.
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