Searching for Dark Matter in Galaxies and Clusters with IceCube

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Astroparticle Physics: A Joint TeVPA/IDM conference

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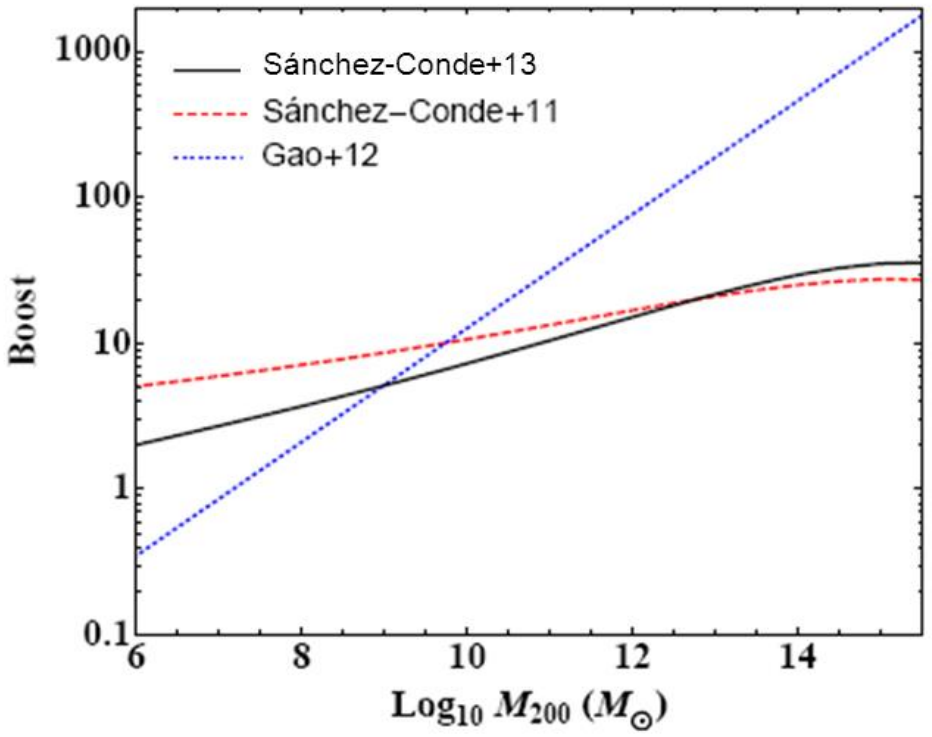
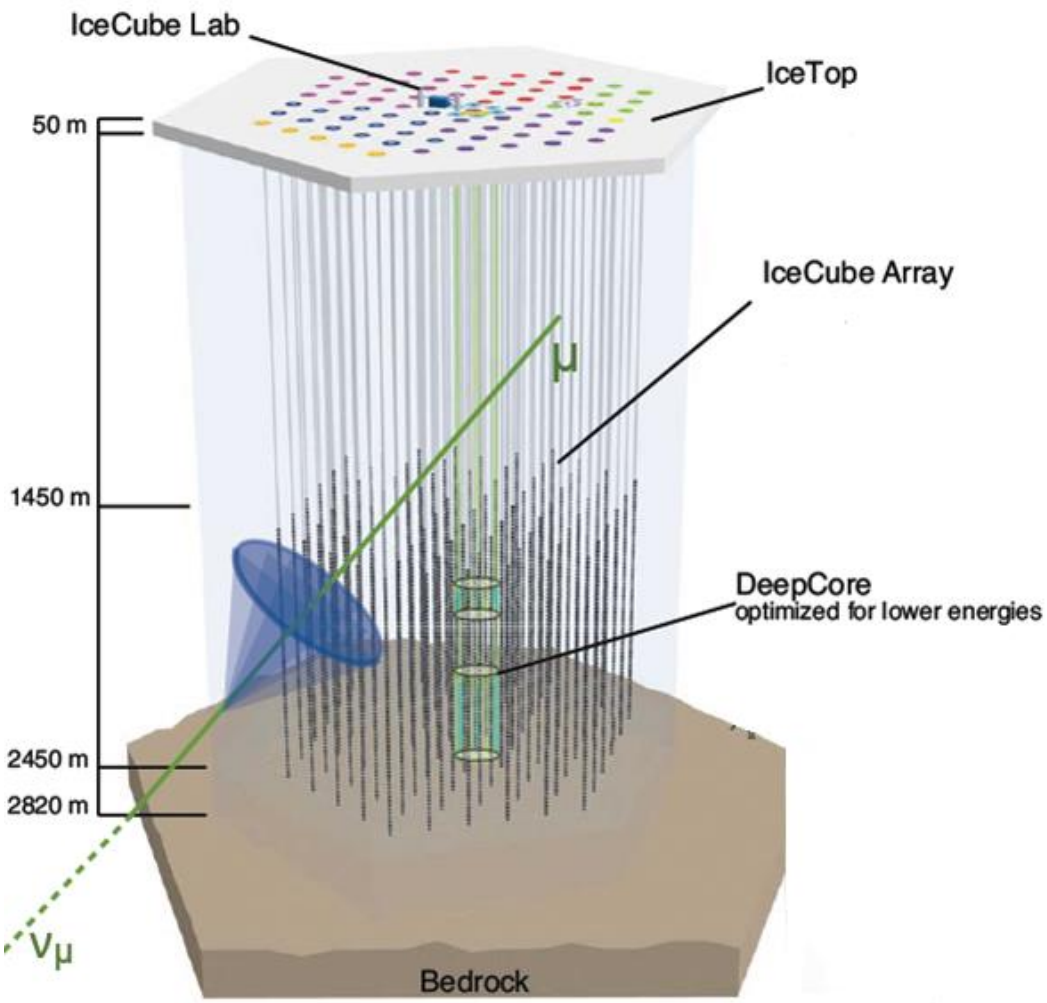
Indirect detection in galaxies and clusters

- Sources in Northern Hemisphere with largest expected signal for IceCube:
  - Virgo galaxy cluster
  - M31 galaxy (Andromeda)
  - Segue 1
  - Ursa Major II
  - Coma Berenices

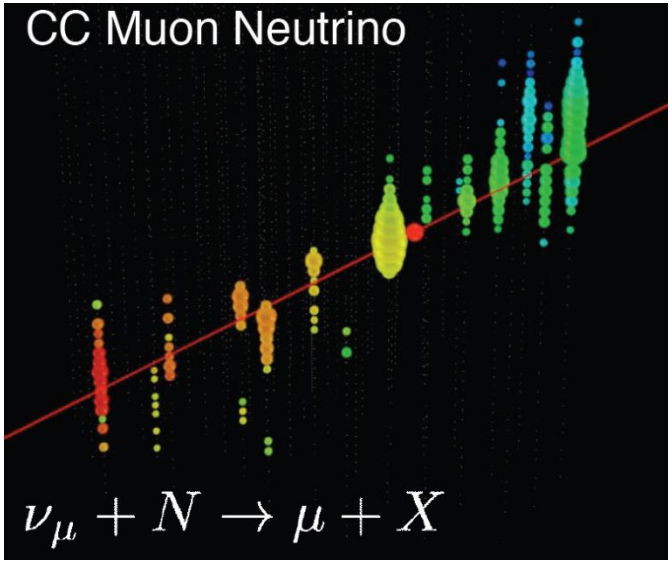
Boost factor from substructure expected [*Sánchez-Conde & Prada '13*]



The IceCube Neutrino Observatory

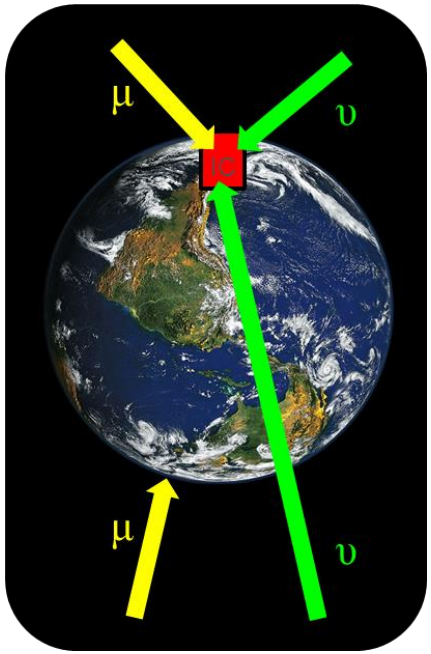


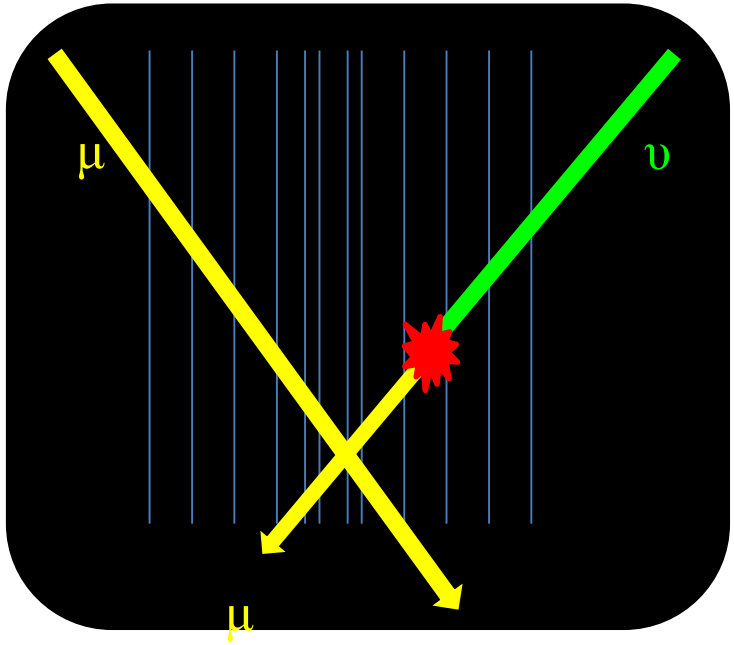
- Use tracks for this analysis, as their direction can be reconstructed well



Signal and background

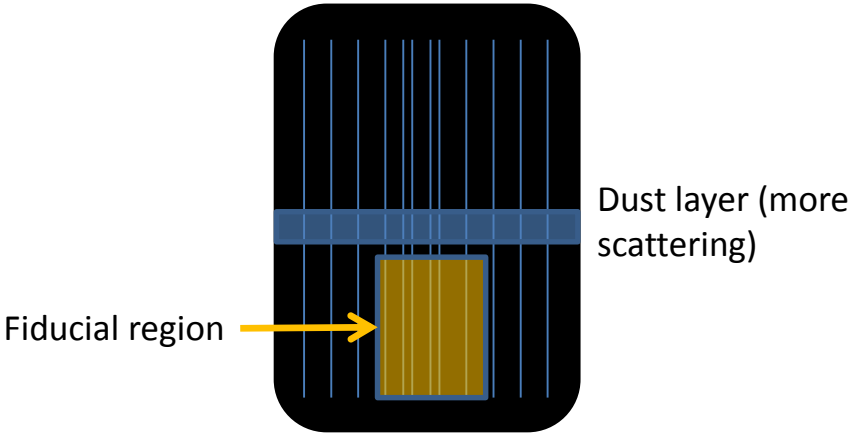
- Signal:
  - Upgoing neutrinos with energies from 10 GeV to 100 TeV (< few μHz, if at all)
- Background:
  - Atmospheric muons: downgoing (can be misreconstructed!) and entering the detector from outside (~ 2 kHz)
  - Atmospheric neutrinos: irreducible for this analysis (~ 0.02 Hz)



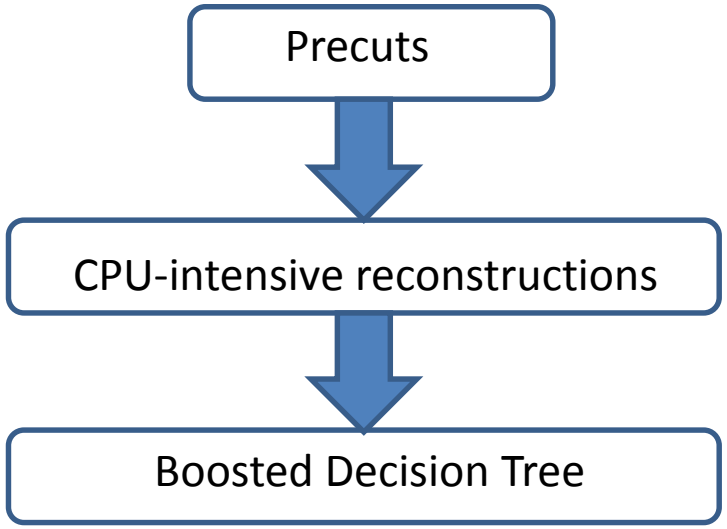


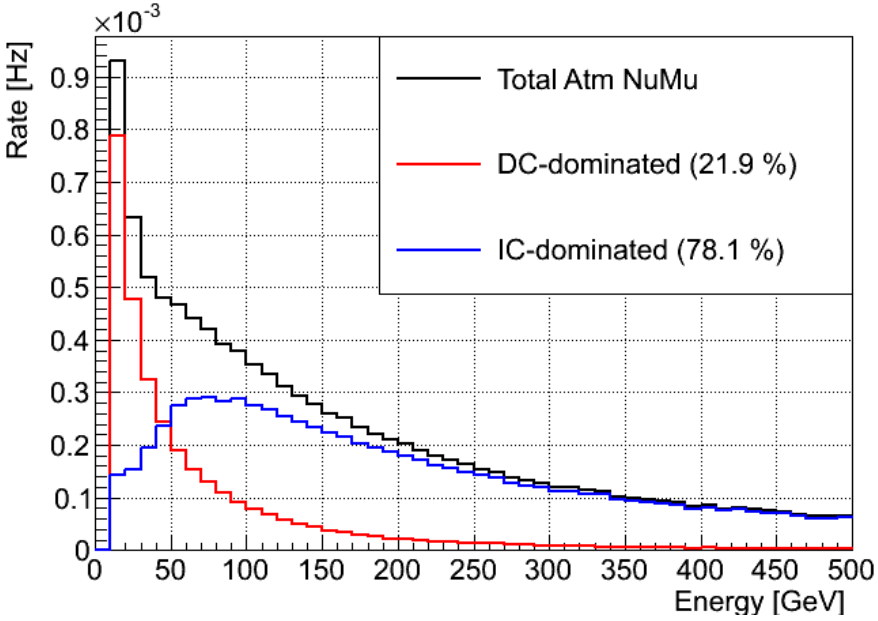
Event selection

- Two non-overlapping samples:
  - IceCube-dominated: use good direction reconstruction
  - DeepCore-dominated: use direction reconstruction & IceCube as veto



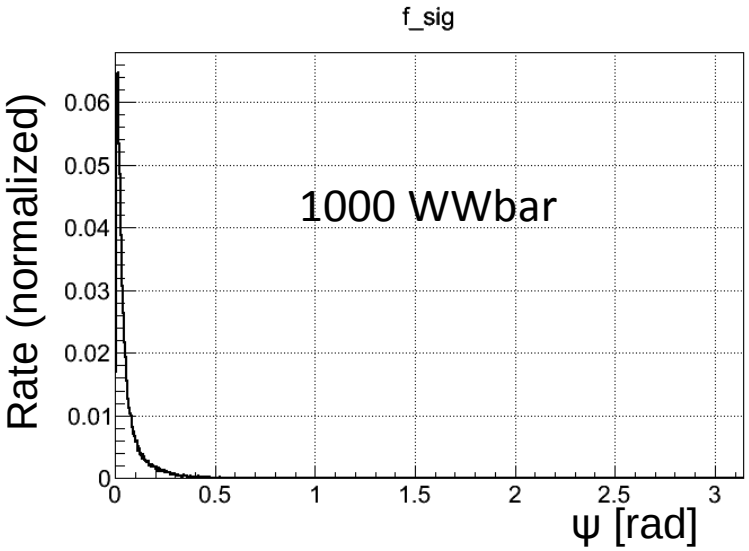
- For each sample:

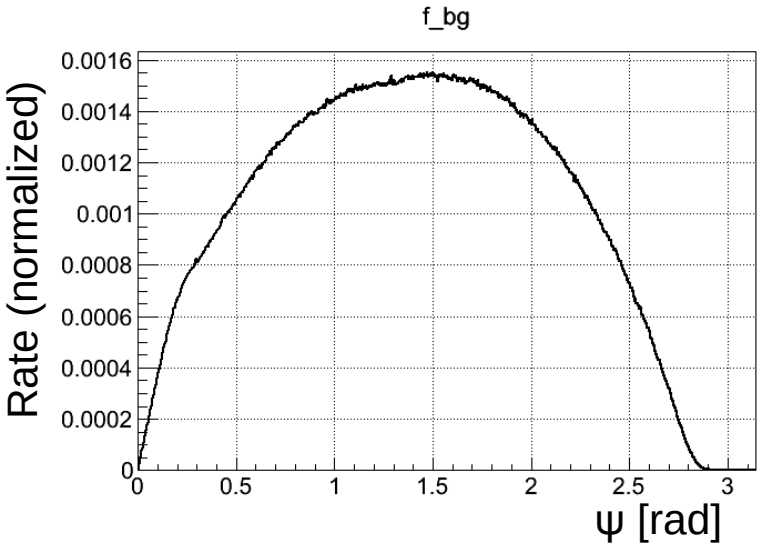




Analysis method: likelihood

- Probability distributions $f_s(\psi)$ and $f_{bg}(\psi)$ to observe signal or background event with angle ψ between source and reconstructed direction





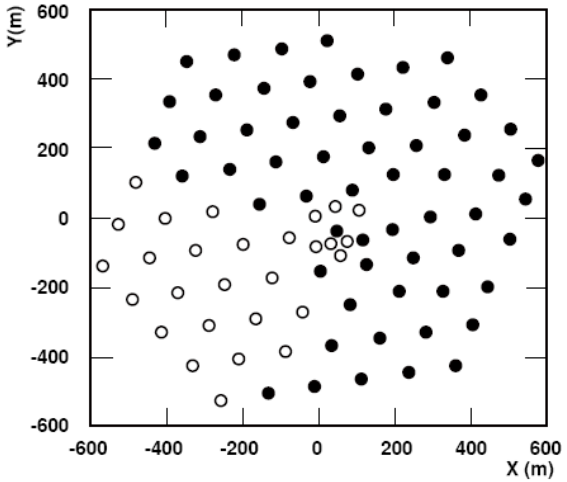
- Combined probability density to observe ψ for an event when μ signal events are present within n_{obs} observed data events:

$$f(\Psi|\mu) = \frac{\mu}{n_{obs}} f_s(\Psi) + (1 - \frac{\mu}{n_{obs}}) f_{bg}(\Psi)$$

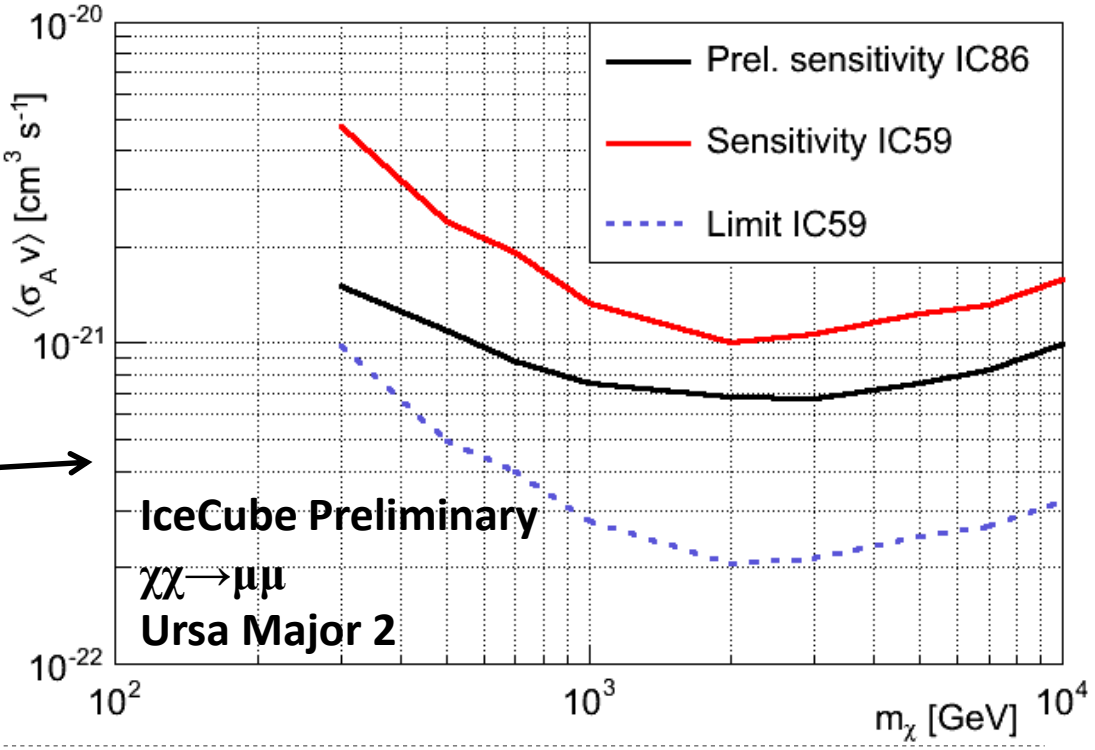
- So maximize $\mathcal{L}(\mu) = \prod_i^{n_{obs}} f(\Psi_i|\mu)$

Sensitivity

- Changes with respect to IC59 analysis:
  - Larger detector
  - Likelihood method
  - Improved direction reconstruction
  - Improved event selection
- Future plans:
  - More data (3 years)



Using only IceCube-dominated sample!



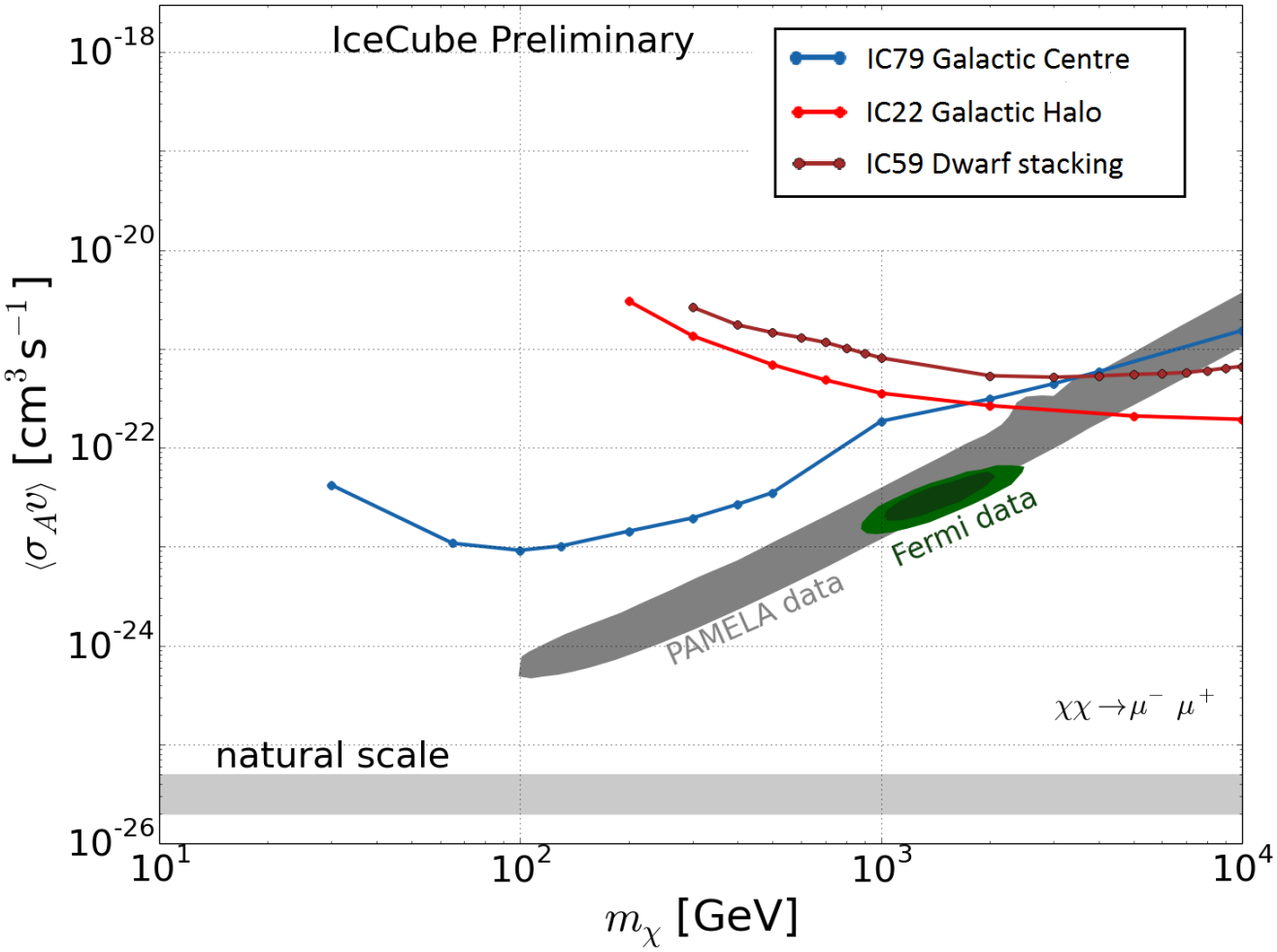
Summary and outlook

- A neutrino flux could originate from dark matter annihilations in galaxies and galaxy clusters
- Latest IceCube limits are from IC59, first search using data from the complete detector is ongoing
- Significant improvements with respect to IC59 limits are expected
- Stay tuned for results!

BACKUP SLIDES

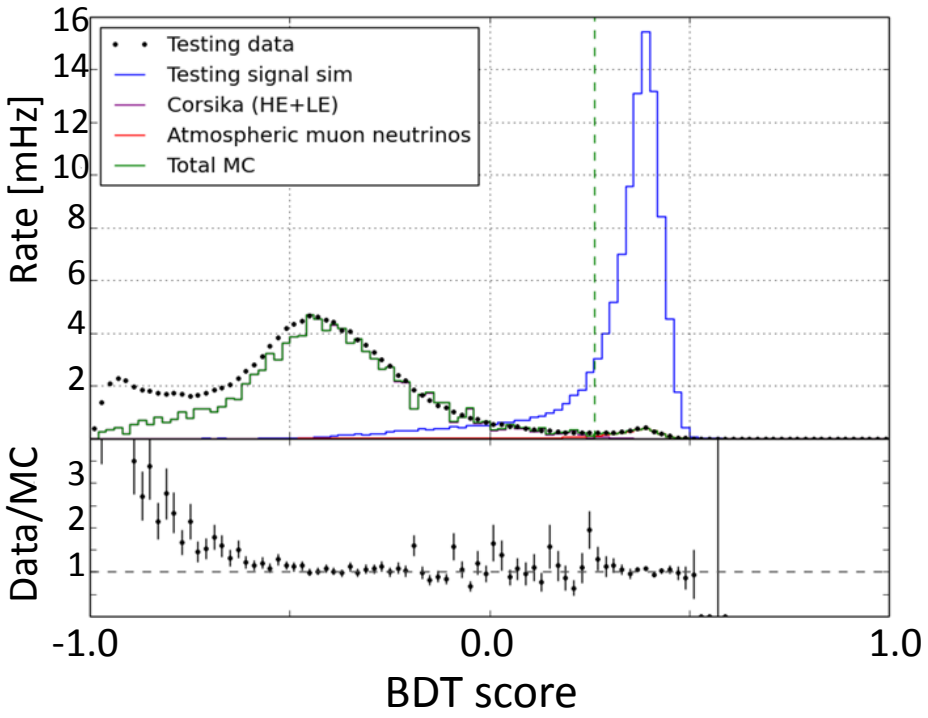
slide 9

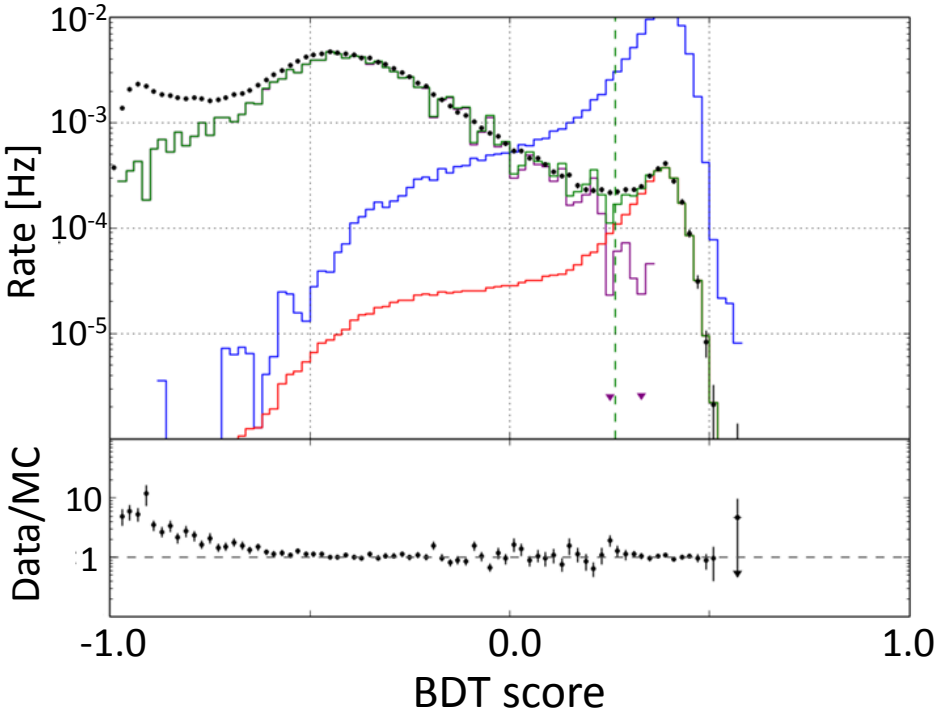
Current limits from IceCube



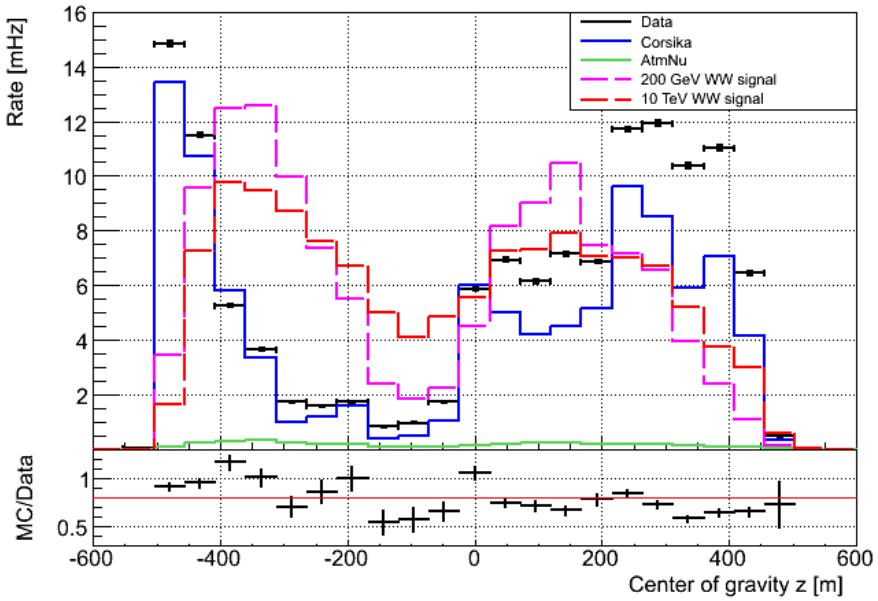
Event selection: method

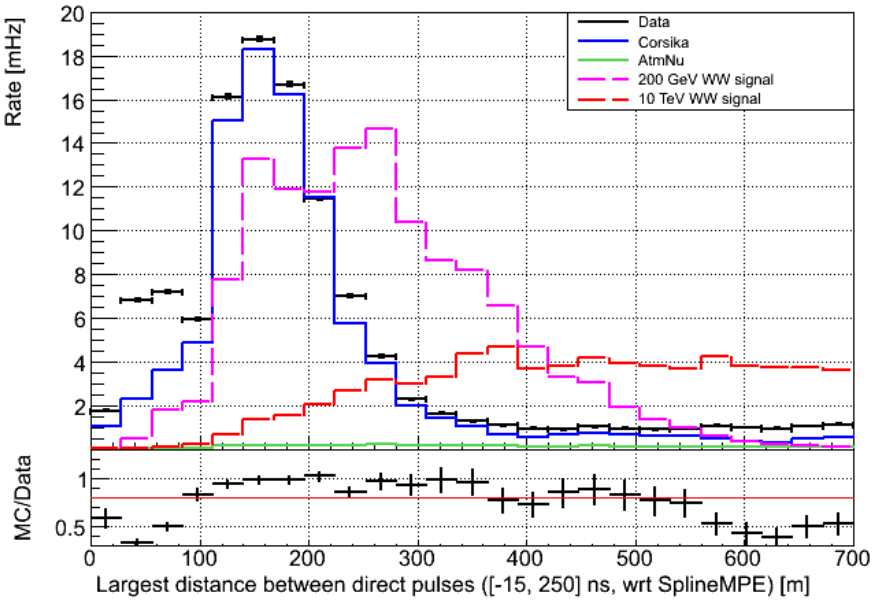
- Precuts → CPU-intensive reconstructions → train BDT to separate signal and background events
- Important to have data/simulation agreement in signal region
- Resulting BDT for IceCube-dominated sample:

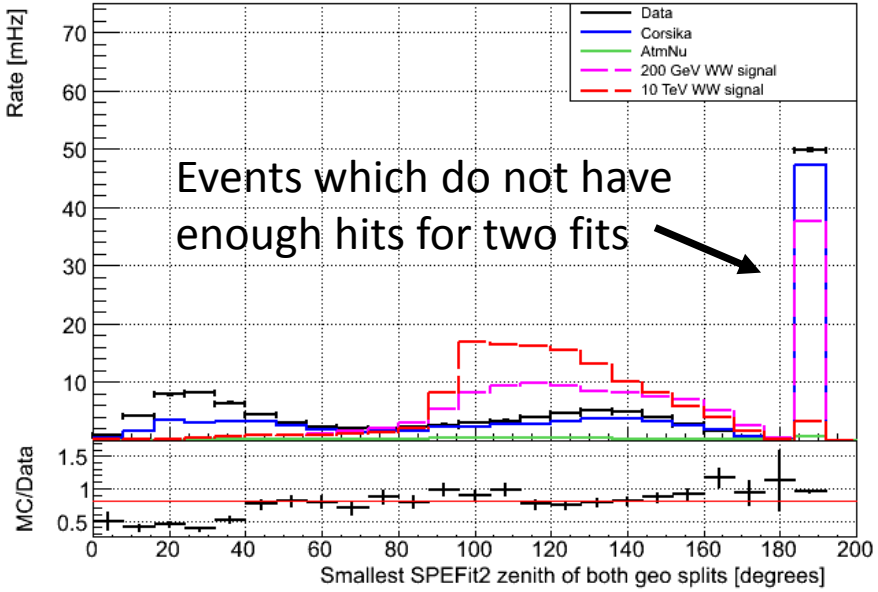


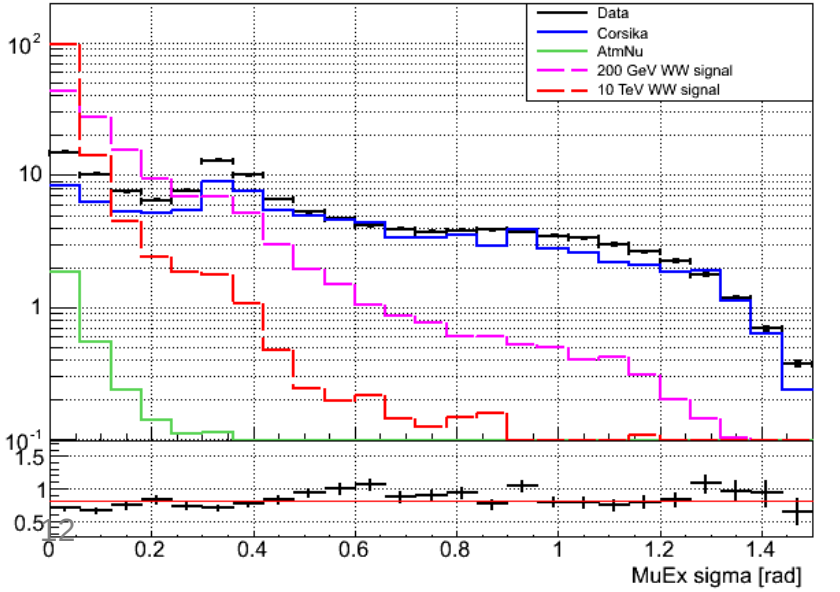


BDT variables I









BDT variables II