

#### New constraints on supersymmetry using neutrino telescopes

EPS-HEP 2021 T10: Searches for New Physics: Part 1

Stephan Meighen-Berger



## The general idea

- Quite a few SUSY searches using colliders
- Can we use atmospheric particle cascades?
  - Higher energies available
  - Detectors readily available
  - Less control of the 'beam'
    - Primary model
    - Interaction model
    - Atmospheric model



Based on <u>10.1016/j.physletb.2020.135929</u>





# What does this require?

- Needs to be charged
  - Measure Cherenkov light and secondaries
- Needs to lose little energy
  - Travels through the atmosphere and the ice
- Needs to be semi-stable
  - Has to cover a few kilometers



## A possible candidate: The STau

- Long-lived in some cases
  - Gravitino LSP and STau LSP
- Production via Drell-Yan
  - Avoid model parameters except mass
- Easy inclusion in atmospheric showers via:

 $P_{\rm BSM}^h$ 



SFB 1258

Neutrinos Dark Matter Messengers

ŴŴ













#### How to use the energy loss?











#### The search region

- $\nu N \rightarrow \mu X \quad \tilde{\tau}(m = 100 \ GeV)$
- $-\tilde{\tau}(m = 200 \text{ GeV}) h \text{ N} \rightarrow \mu \text{ X}$





Reconstructed

### Reconstruction

- IceCube's reconstruction is built for muons
  - Will miss-reconstruct the STau's energy



Deposited



# Final Data Set

- After applying angular and energy cuts
  - θ > 85°
  - $E \in [100 \text{ GeV}, 1 \text{ TeV}]$ 
    - This leaves the expected signal untouched while reducing the background
- Let's use 1 year of public data
  - <u>https://doi.org/10.21234/B4F04V</u>
- This means including the effective area and introducing some angular smearing



So what about the limits?





# What are the limits?

- Invert a frequentist hypothesis test
  - 320 GeV mass limit at 95% C.L.
  - This is only one year of data!
- Extrapolate the limit assuming a longer Live Time
  - IceCube can be competitive with current collider limits



So what else can we do?





## Moving away from a generic signal

- Currently the method could be applied to any heavy, long-lived, charged particle
- The STau has some unique aspects
  - Double tracks
  - Energy loss
  - Through-going
- Assuming we can remove the background
  - 1 Year: 500 GeV!







### Take Home Messages

• We can use neutrino detectors for complimentary BSM searches

- This type of search can be applied to any long-lived, heavy, charged particle
- Including specifics improves these types of searches
- New neutrino experiments make this all the more interesting
  - KM3NeT
  - GVD
  - P-ONE
  - DUNE



Thank you for your attention! Questions?