

Title: AGN Variability and HEAN in the age of VRO

Speakers: Cyril Creque-Sarbinowski

Series: Cosmology & Gravitation

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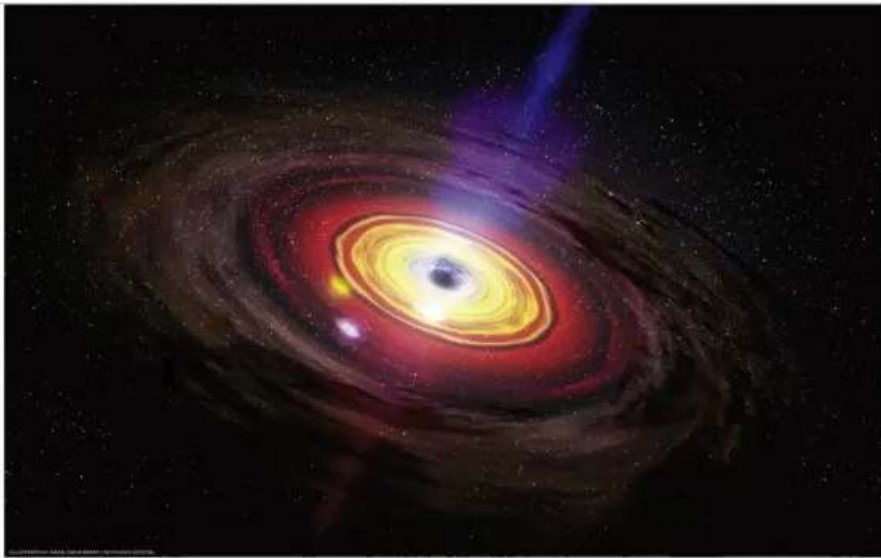
Abstract: Over the next ten years, the Vera C. Rubin Observatory (VRO) will observe ~ 10 million active galactic nuclei (AGN) with a regular and high cadence. During this time, the intensities of most of these AGN will vary stochastically. Moreover, these fluctuations may also be connected to the high-energy astrophysical neutrino (HEAN) flux observed by IceCube. In this talk, I explore the prospects to quantify these fluctuations with VRO-measurements of AGN light curves and also evaluate the capacity of VRO, in tandem with various current and upcoming neutrino telescopes, to establish AGN as HEAN emitters. I find that AGN variability measurements will be so precise as to allow the AGN to be separated into up to ~ 10 different correlation-timescale bins. I also show that if the correlation time varies as some power of the luminosity, the normalization and power-law index of that relation will be determined to $O(10^{-4}\%)$. Finally, I find that it may be possible to detect AGN contributions at the $\sim 3\sigma$ level to the HEAN flux even if these AGN contribute only $\sim 10\%$ of the HEAN flux.

AGN Variability and HEAN in the age of Rubin

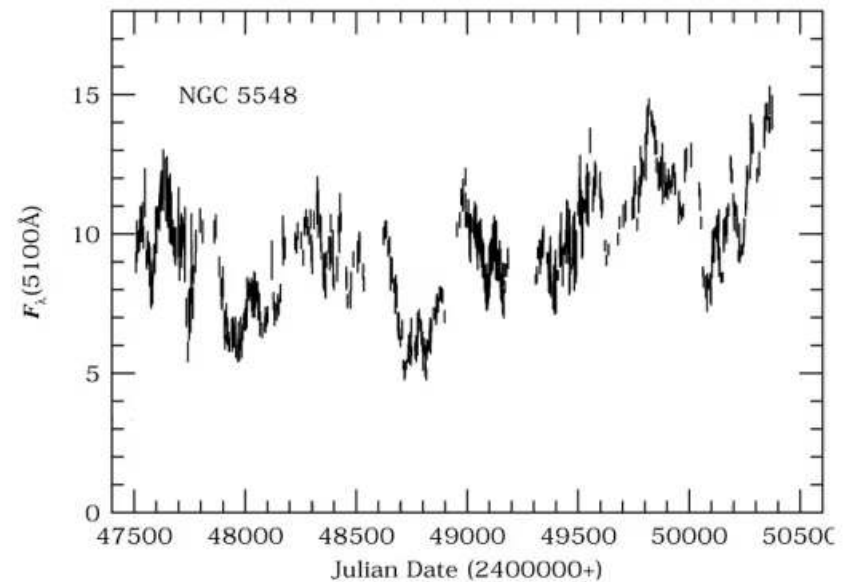
Cyril Creque-Sarbinowski
Perimeter 2021

Collaborators: Jeffrey Hyde, Bei Zhou, Marc Kamionkowski

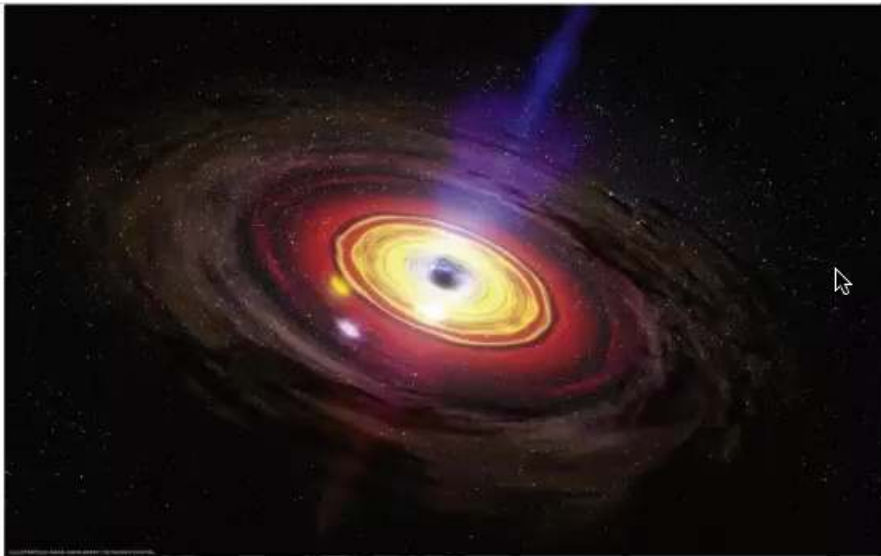
What are AGN and how do they vary?



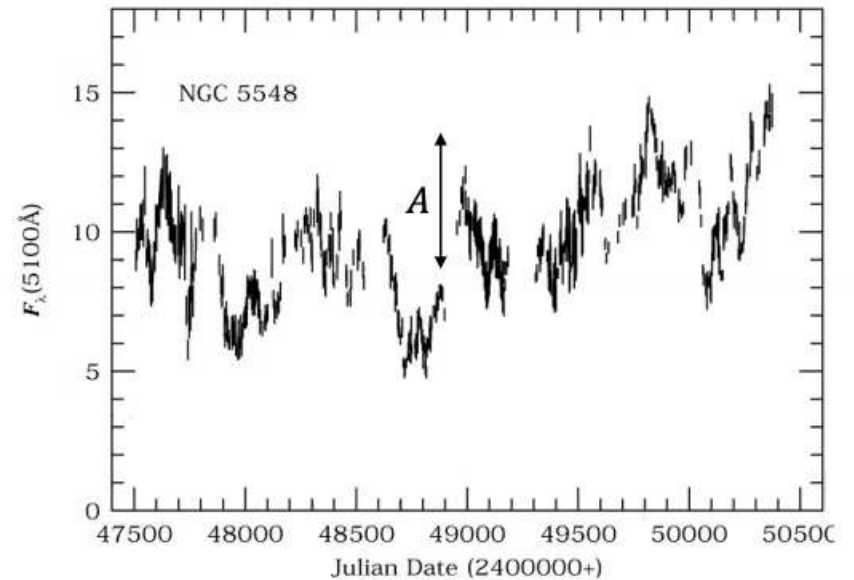
Active Galactic Nuclei (AGN)



What are AGN and how do they vary?



Active Galactic Nuclei (AGN)



What is Rubin?



Main System and Survey Characteristics

Wavelength coverage (full response)	320-1080 nm
Filter set	<i>u, g, r, i, z, y</i> (five concurrent in camera at a time)
Sky coverage	20,000 deg ² (Main Survey)

Camera

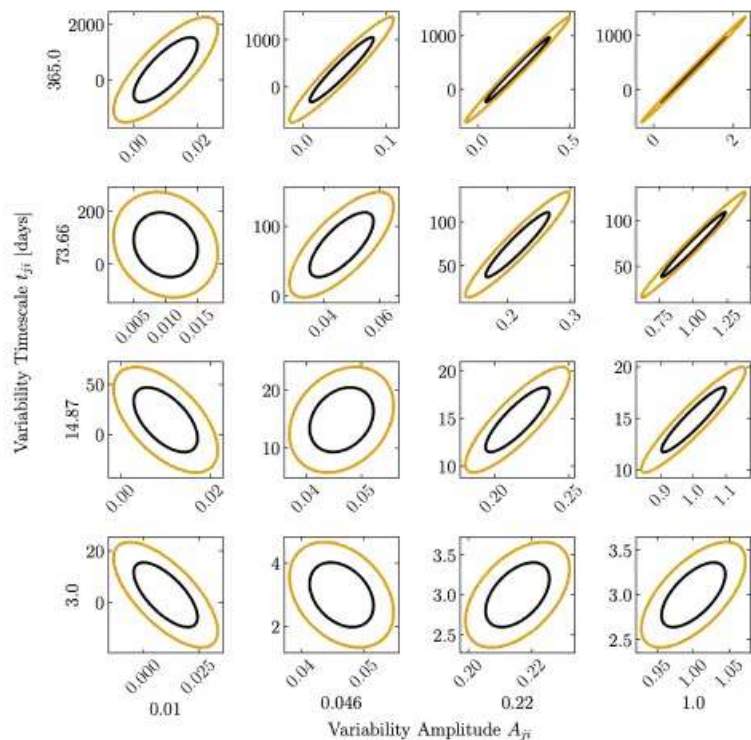
Pixel size; pixel count	10 microns (0.2 arcsec); 3.2 Gpixels
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System Capability

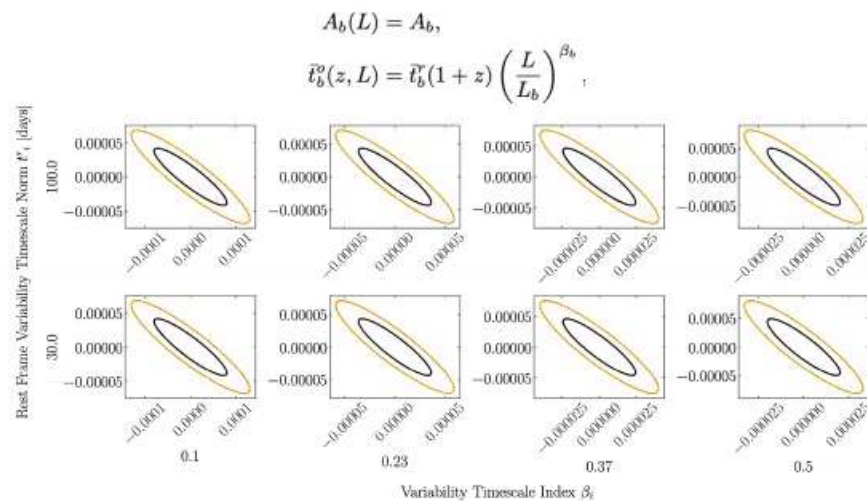
Single-visit depths (point sources; 5σ)	<i>u</i> : 23.9 <i>g</i> : 25.0 <i>r</i> : 24.7 <i>i</i> : 24.0 <i>z</i> : 23.3 <i>y</i> : 22.1 AB mag
Baseline number of visits over 10 years	<i>u</i> : 70 <i>g</i> : 100 <i>r</i> : 230 <i>i</i> : 230 <i>z</i> : 200 <i>y</i> : 200

AGN Variability Sensitivity

Single AGN

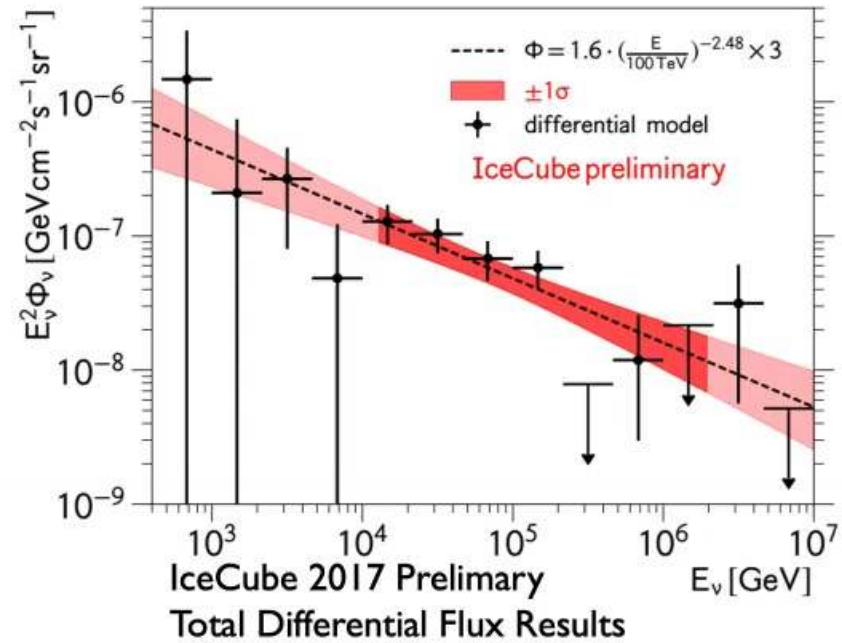
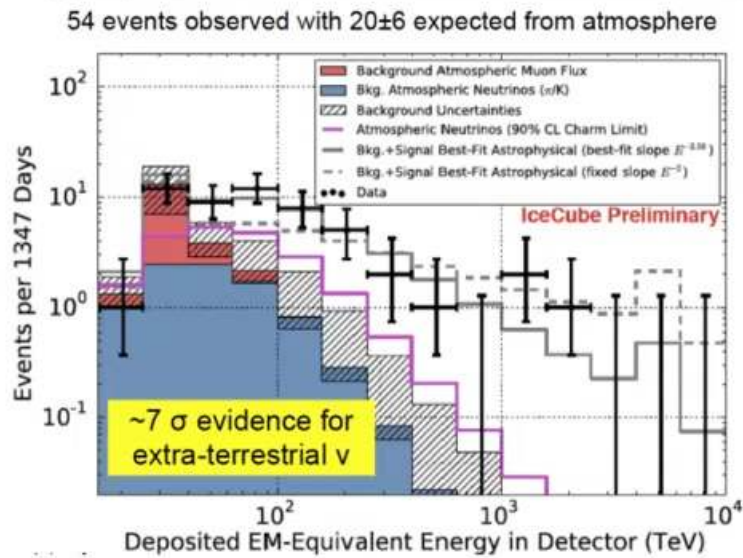


AGN Population



What are HEAN?

Energy Spectrum



IceCube 2020 Characterization

Energies $\sim 10^4$ GeV to $\sim 10^6$ GeV

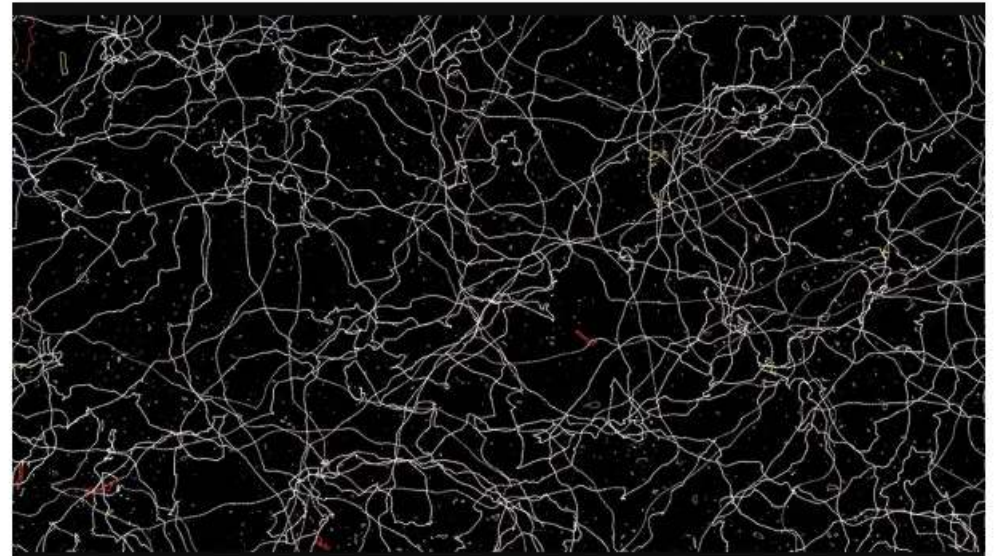
Spectral Index $\gamma = 2.53 \pm 0.07$

Flux Normalization per Flavor $\phi = 1.66^{+0.25}_{-0.27}$ at 100 TeV

Possible Sources of HEAN

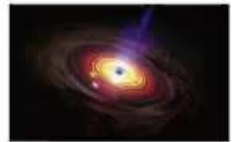


Active Galactic Nuclei (AGN)

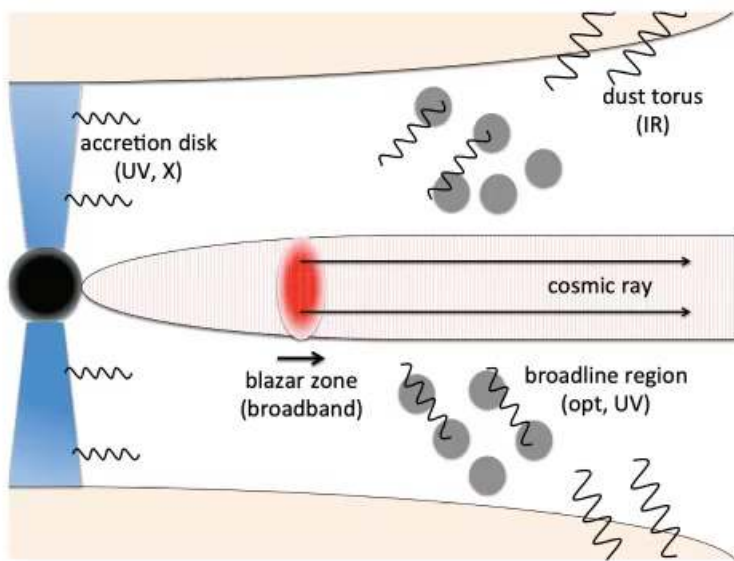


Cosmic Strings (CS)

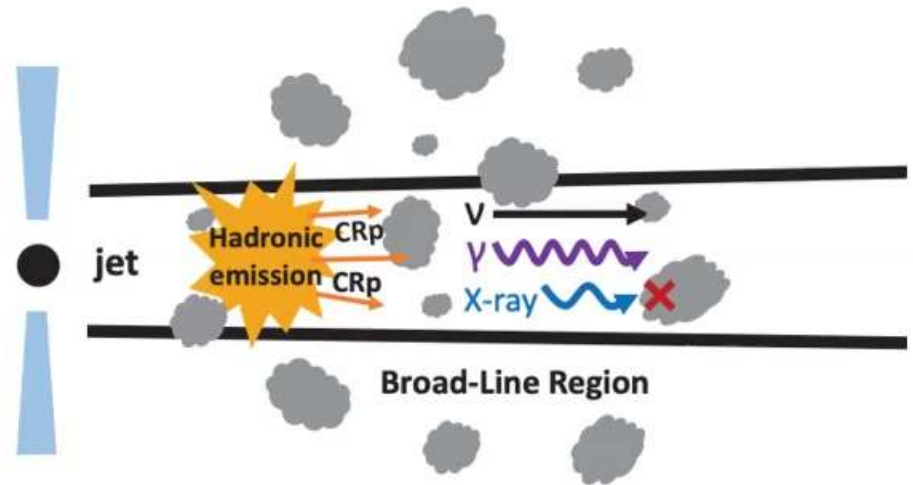
AGN HEAN Mechanisms of Production



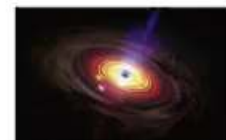
Photohadronic



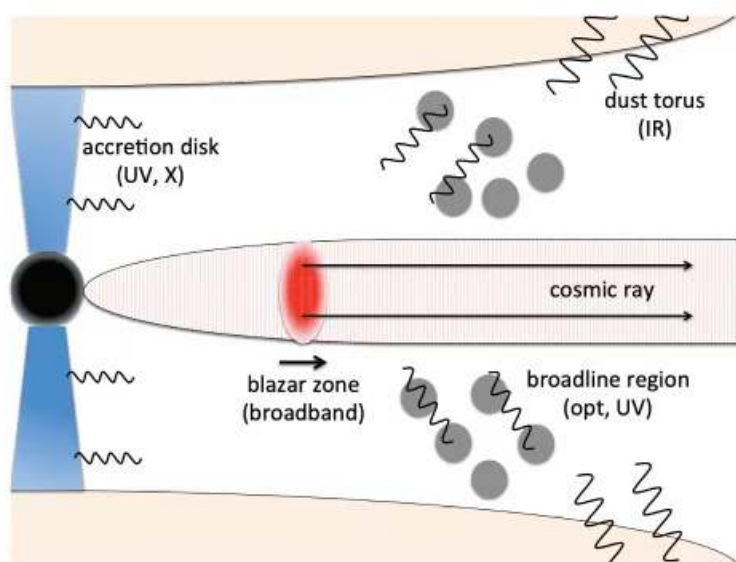
Hadronuclear



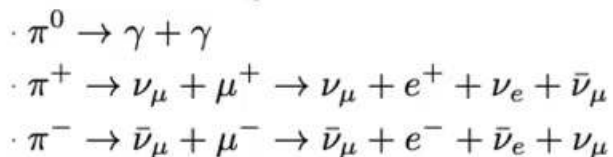
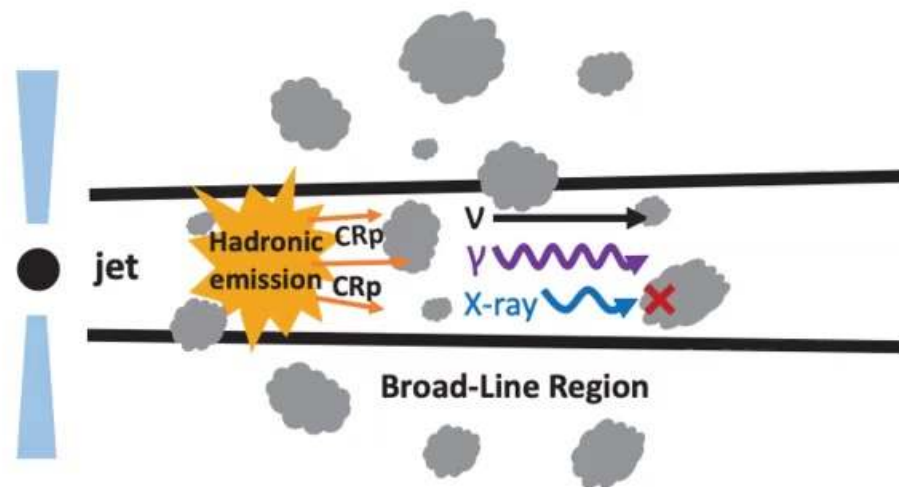
AGN HEAN Mechanisms of Production



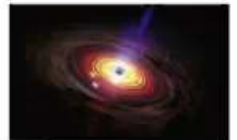
Photohadronic



Hadronuclear

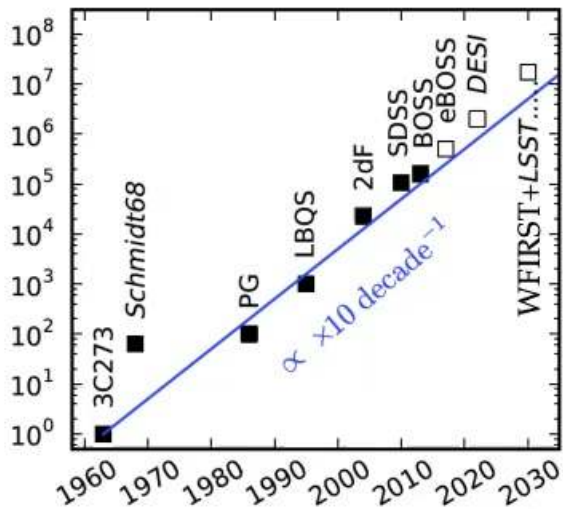


AGN/HEAN Analysis

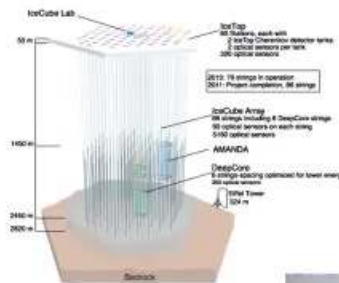


WFIRST+LSST ~ 10 million AGN \Rightarrow
 $\sim 10\times$ Increase

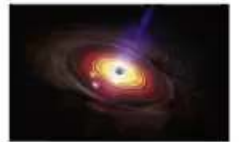
IceCube, KM3NeT, Baikal-GVD $\sim 3\times$
 Collection Rate + $2\times$ Angular Precision



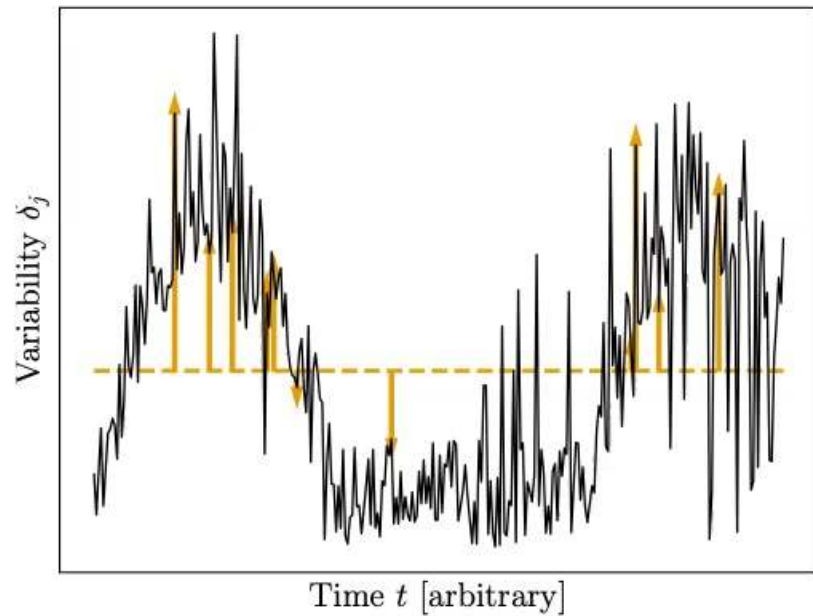
+



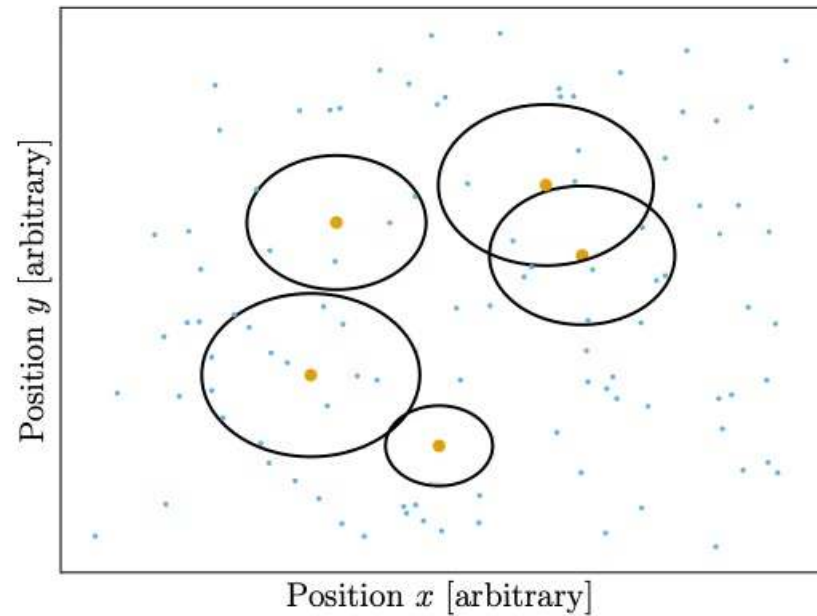
AGN/HEAN Cross Correlation



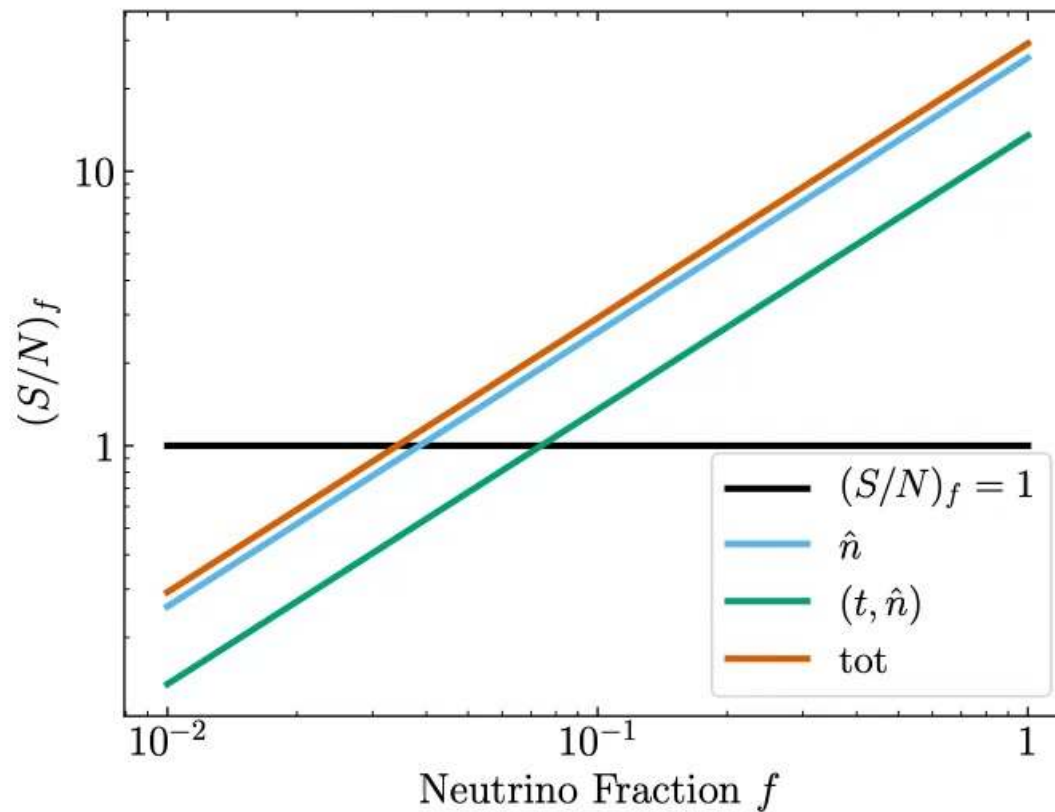
Temporal



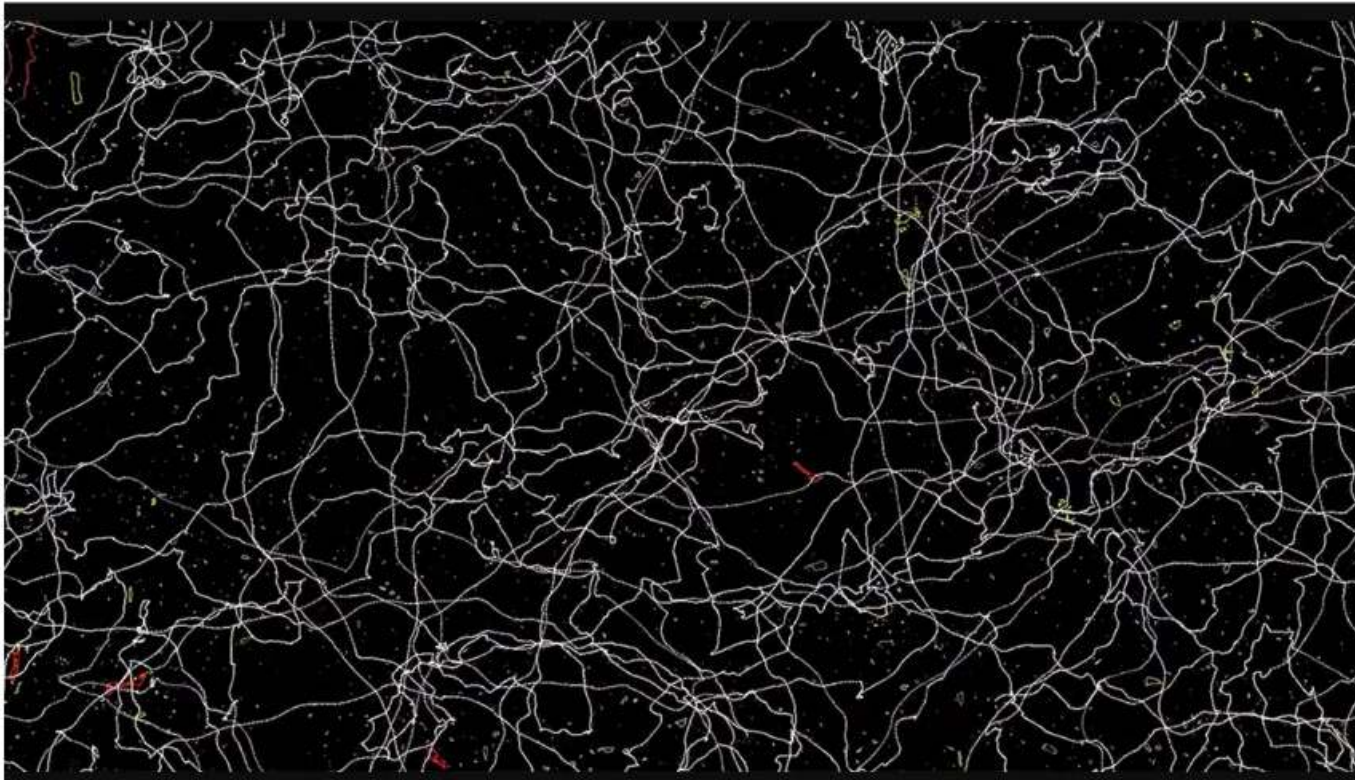
Spatial



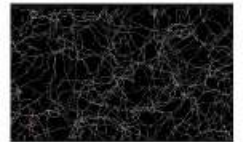
AGN/HEAN Measurement Forecast



What are CS?



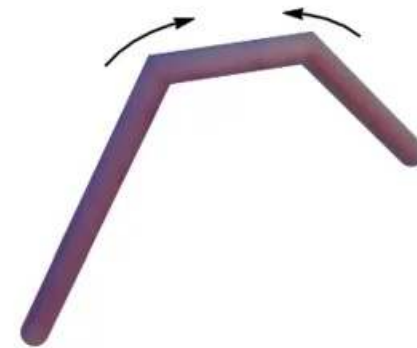
CS HEAN Mechanisms of Production



Cusp



Kink

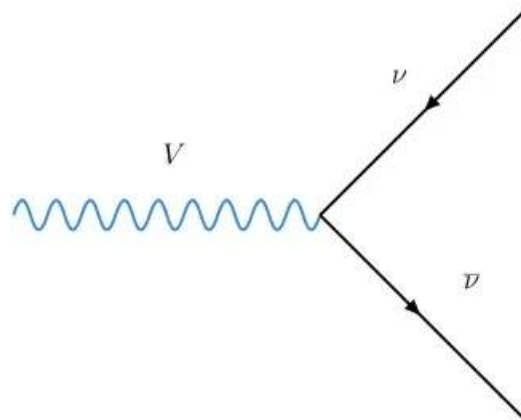


Kink-Kink Collision

CS HEAN Phenomenology

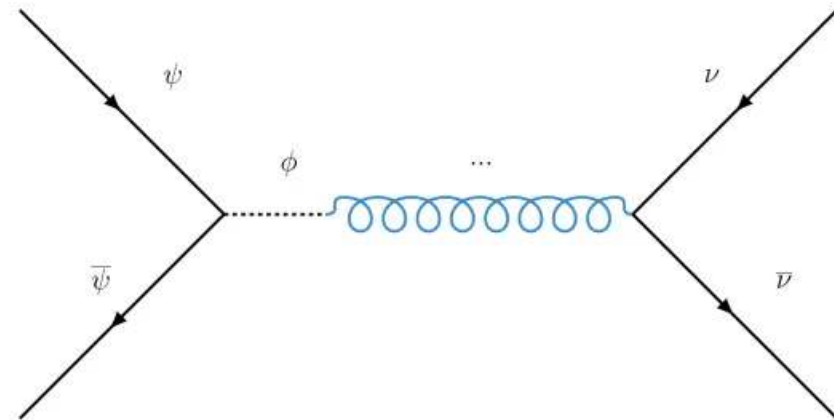


Direct Emission



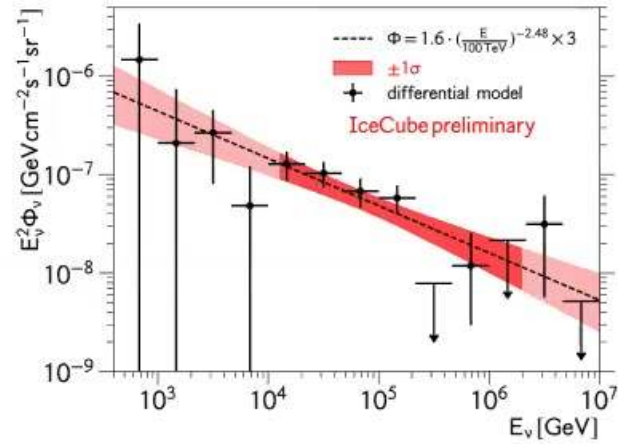
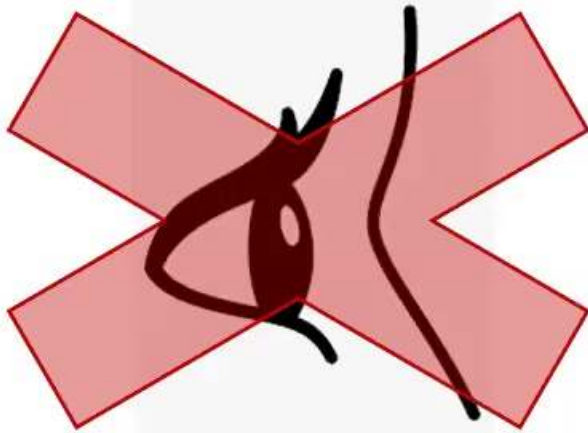
AB Coupling

Indirect Emission

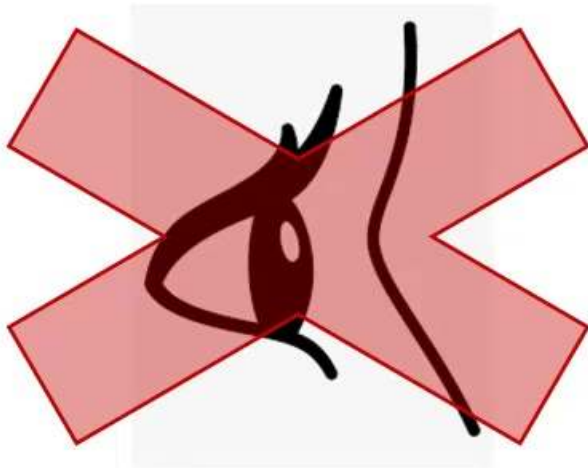
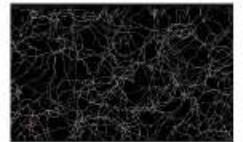


Scalar Coupling

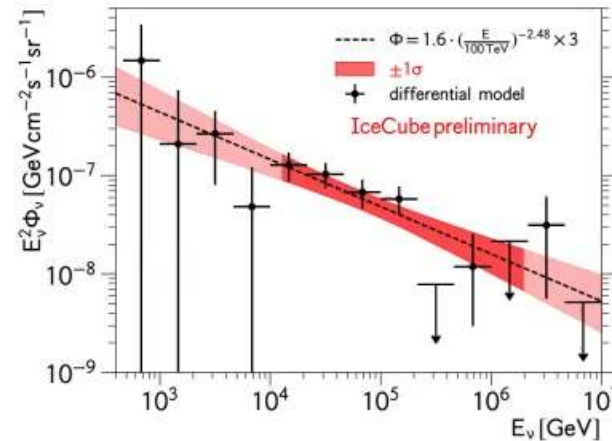
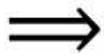
CS HEAN Analysis



CS HEAN Analysis



Spectrum Comparisons



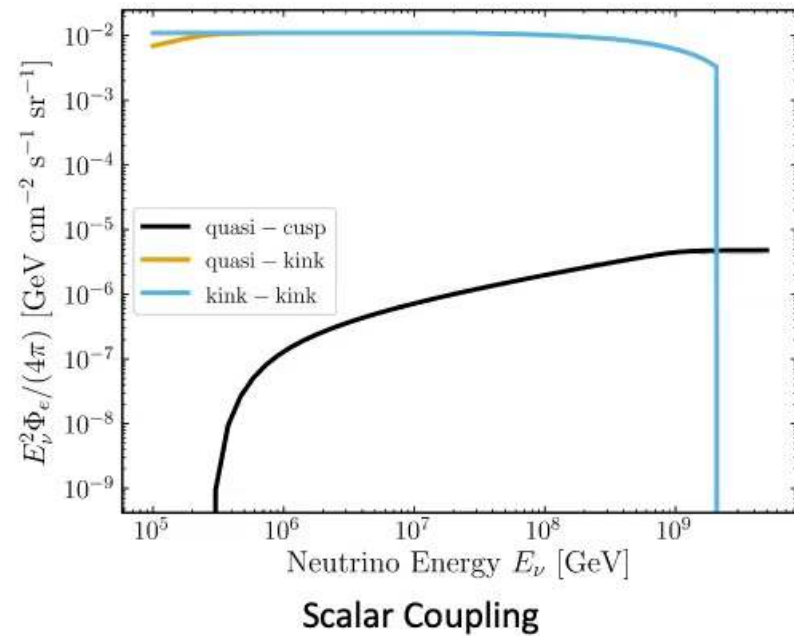
Theoretically, how many HEAN come from CS?
What are the distinct spectral features?

CS HEAN Spectra



WIP

AB Coupling



Future Directions



- 1) AGN as a Cosmological Tool
- 2) Further Characterizing HEAN