Non-standard neutrino spectra from Dark Matter annihilation …

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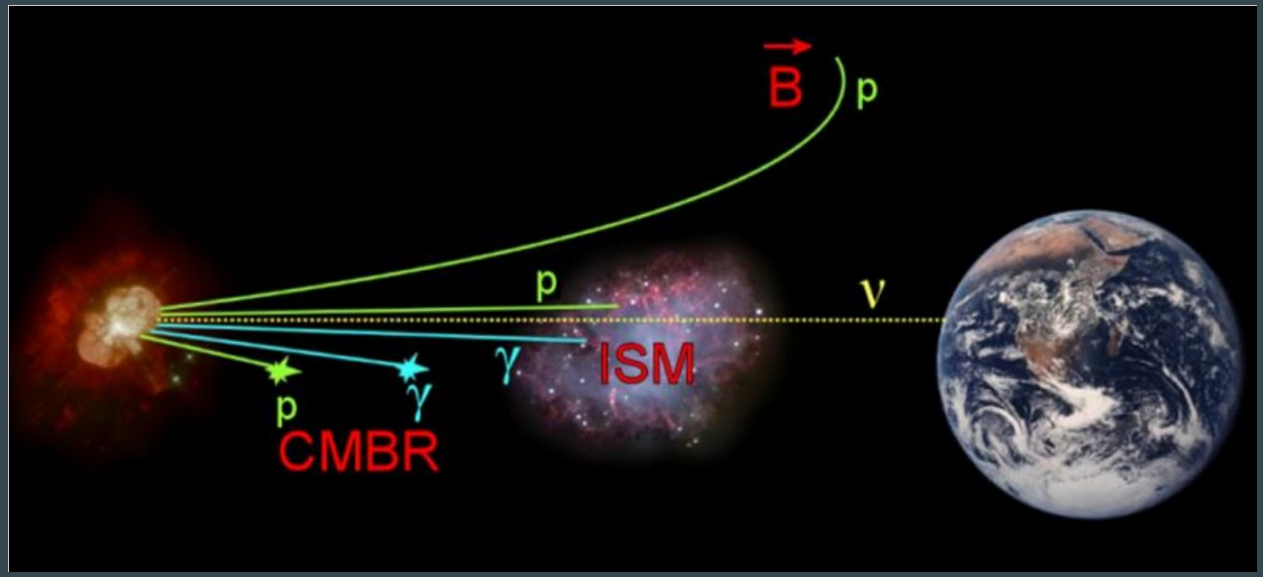
Signals from Dark Matter

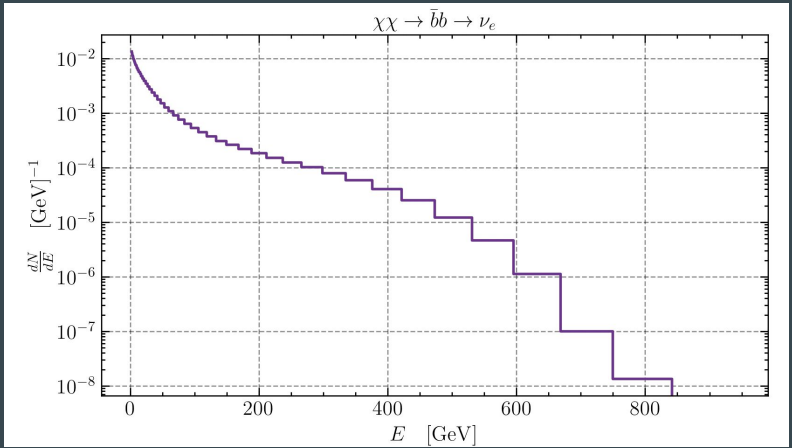
- Neutrinos from DM annihilation
- Clean Messengers
- KM3Net, IceCube, ANTARES
- DM DM $\rightarrow XX \rightarrow \nu$
  - Mass
  - $\langle \sigma v \rangle$
  - Shape dN/dx

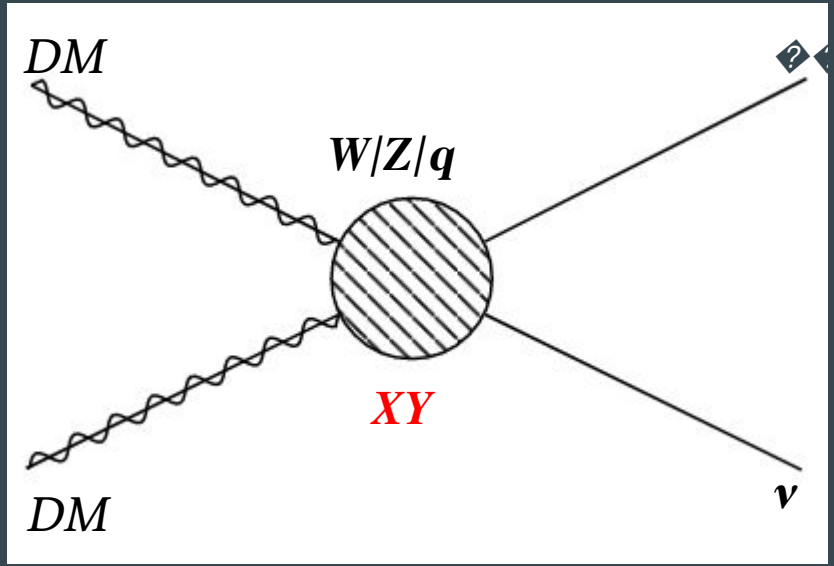


https://lecospa.ntu.edu.tw/experiment-2/experiment-i-ultra-high-energy-neutrinos-and-cosmic-rays/

Non-Standard Spectra

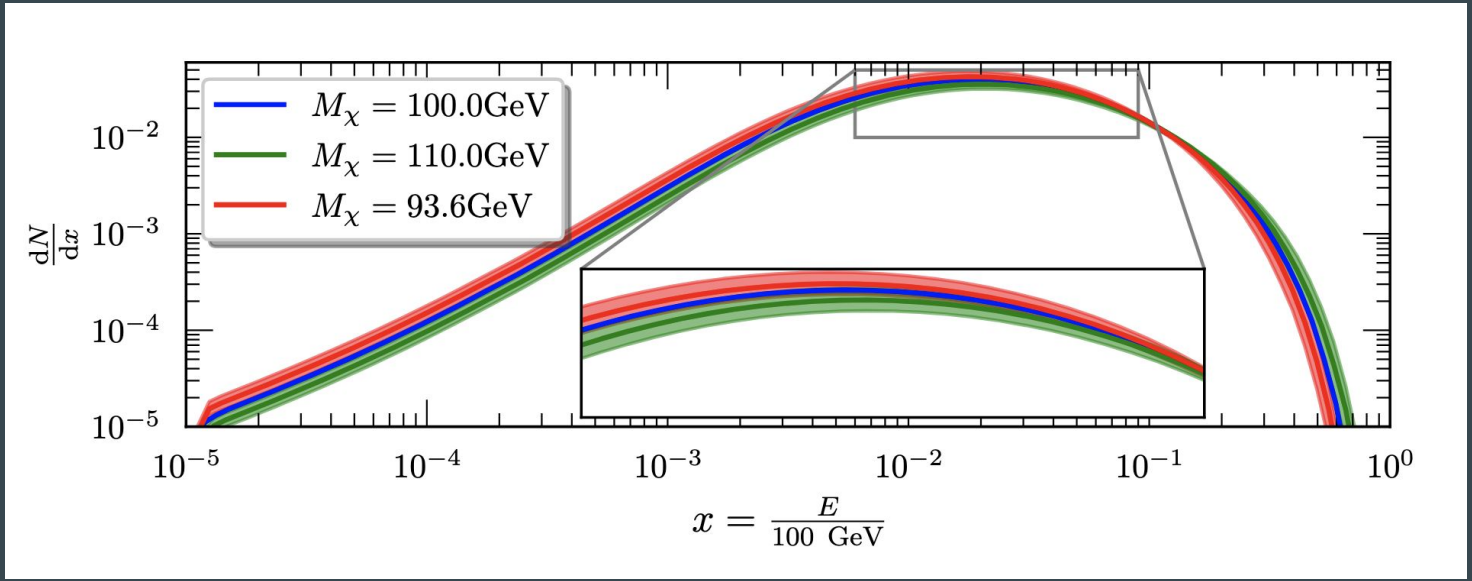
- Different spectrum shape
- Non-trivial branching ratio
- Can be made by a non-excluded model
- Possible to be detected





Shameless plug

- Standard neutrino spectra have relatively large QCD uncertainties
- Translates into DM uncertainties
- Come talk to me afterwards



The Model

- MSSM not an option
- Neutrino coupling ⇒ *B-L* already SM symmetry ⇒ Gauge Symmetry
- Dark Matter ⇒ SUSY
- Neutrino masses ⇒ Inverse Seesaw

Relevant New Particle Content

- A new *Z*-like boson from the *B-L* gauge symmetry
- 7 Neutralinos χ_i^0 (the lightest is your DM particle)
- 3 Light and 6 Heavy Neutrinos

Inverse Seesaw Mechanism

$$\begin{pmatrix} \nu_L & \nu_R & s_2 \end{pmatrix}$$

Inverse Seesaw Mechanism

$$\begin{pmatrix} \nu_L & \nu_R & s_2 \end{pmatrix}$$

$$\begin{pmatrix} 0 & M_\nu^T & 0 \\ M_\nu & 0 & M_X \\ 0 & M_X^T & \mu_S \end{pmatrix}$$

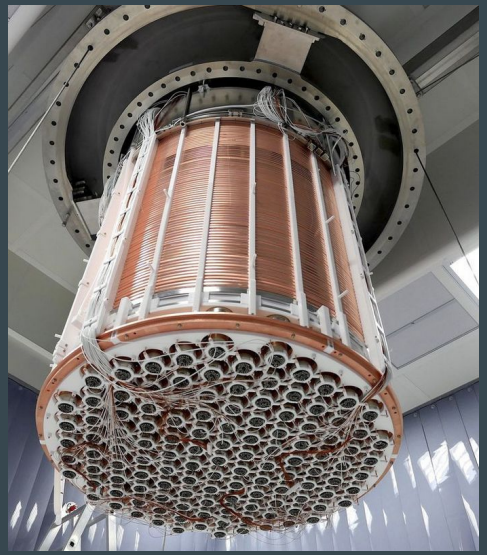
Inverse Seesaw Mechanism

$$\begin{pmatrix} 0 & M_\nu^T & 0 \\ M_\nu & 0 & M_X \\ 0 & M_X^T & \mu_S \end{pmatrix}$$

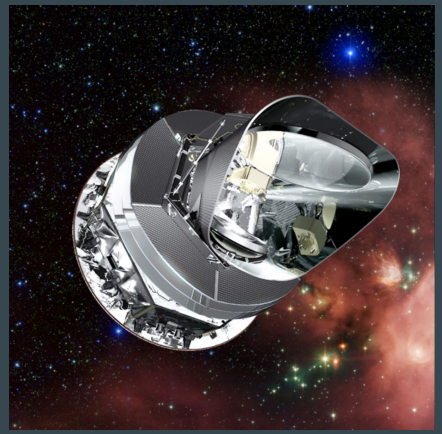
$$\nu_l \approx \frac{m_\nu^2}{m_\nu^2 + m_X^2} \mu_S$$

$$\nu_{h_1}^2 \approx \nu_{h_2}^2 \approx m_\nu^2 + m_x^2$$

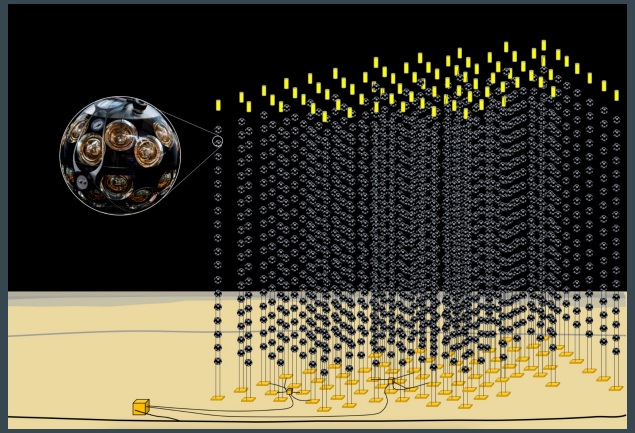
Limits



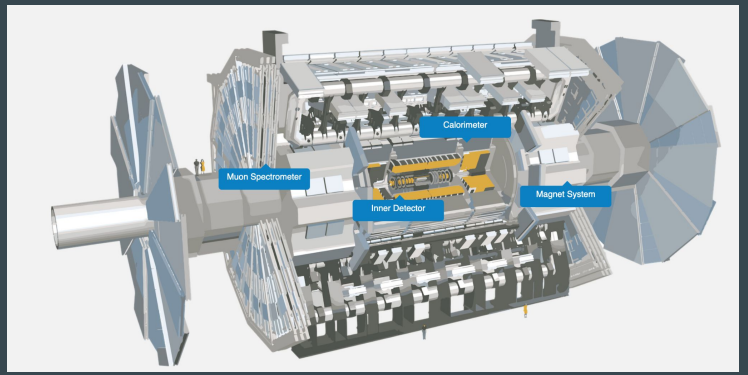
Credit Xenon 1T



Credit ESA

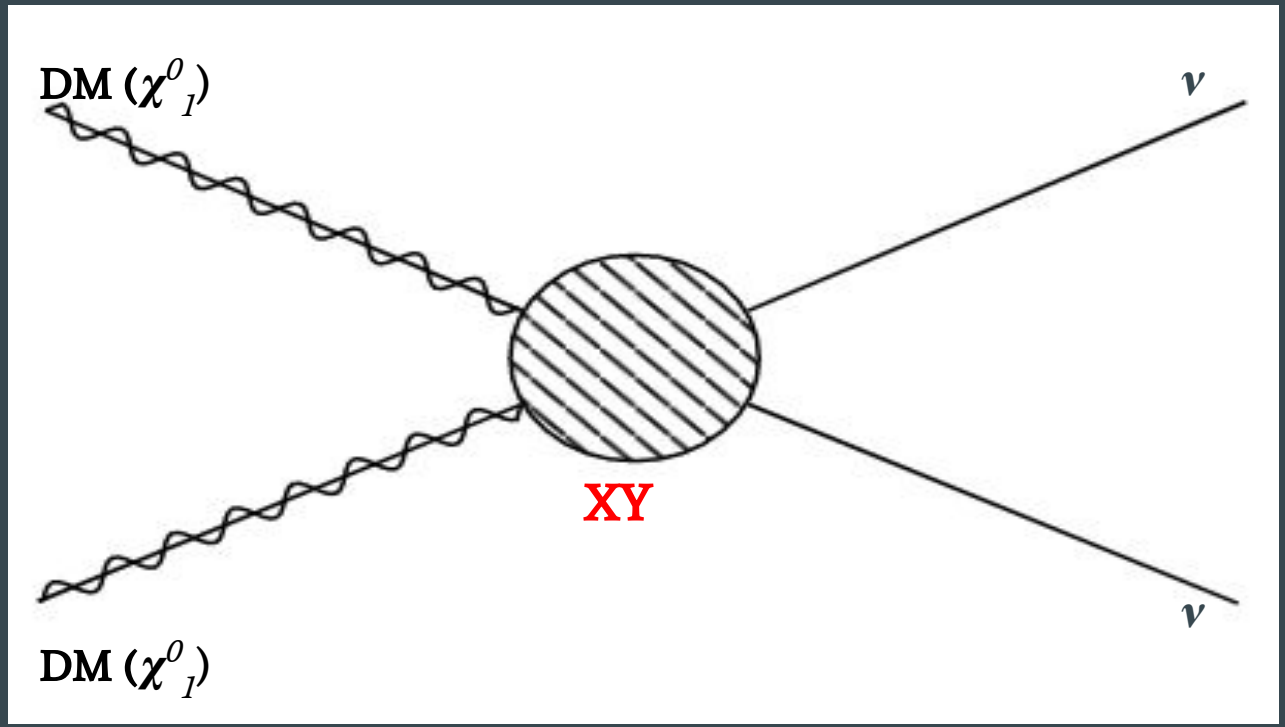


Credit KM3NeT

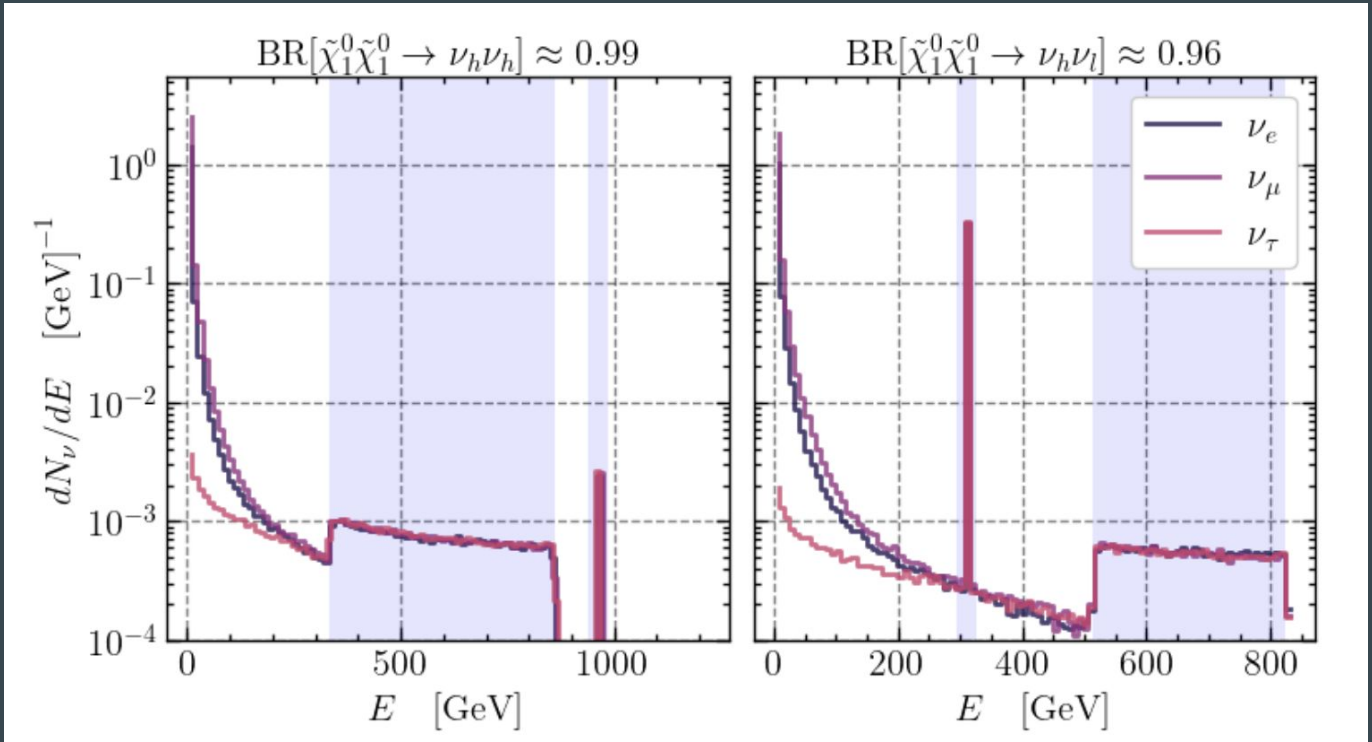


Credit ATLAS collaboration

Neutrino Spectra

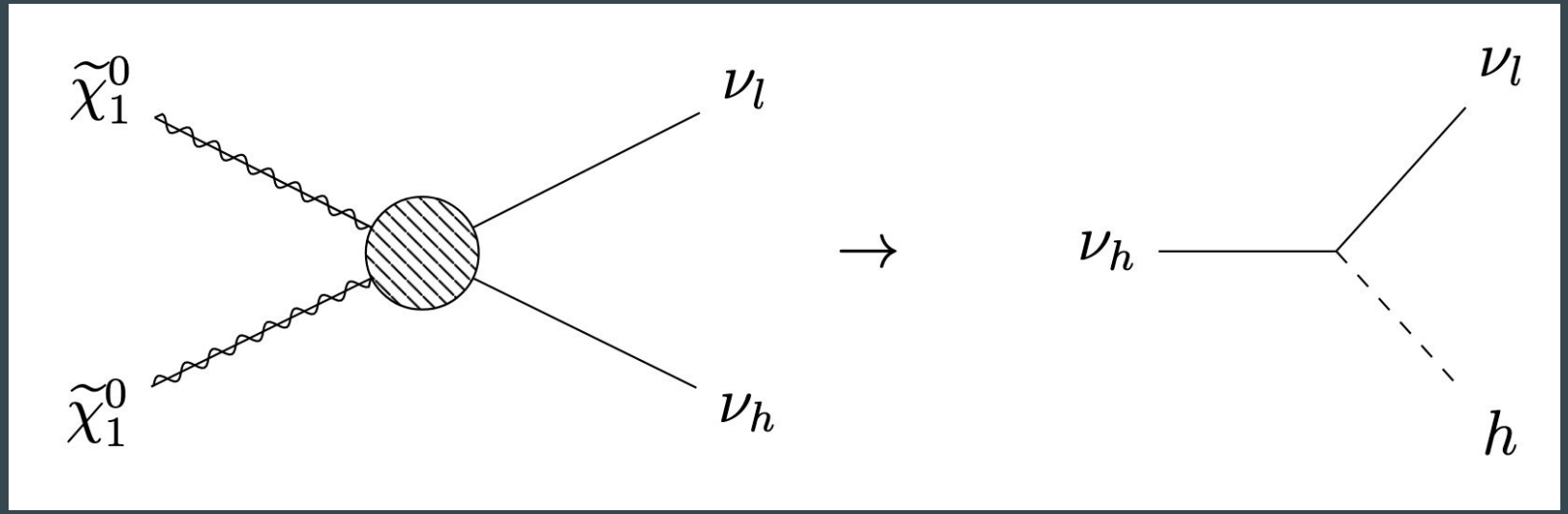


Neutrino Spectra

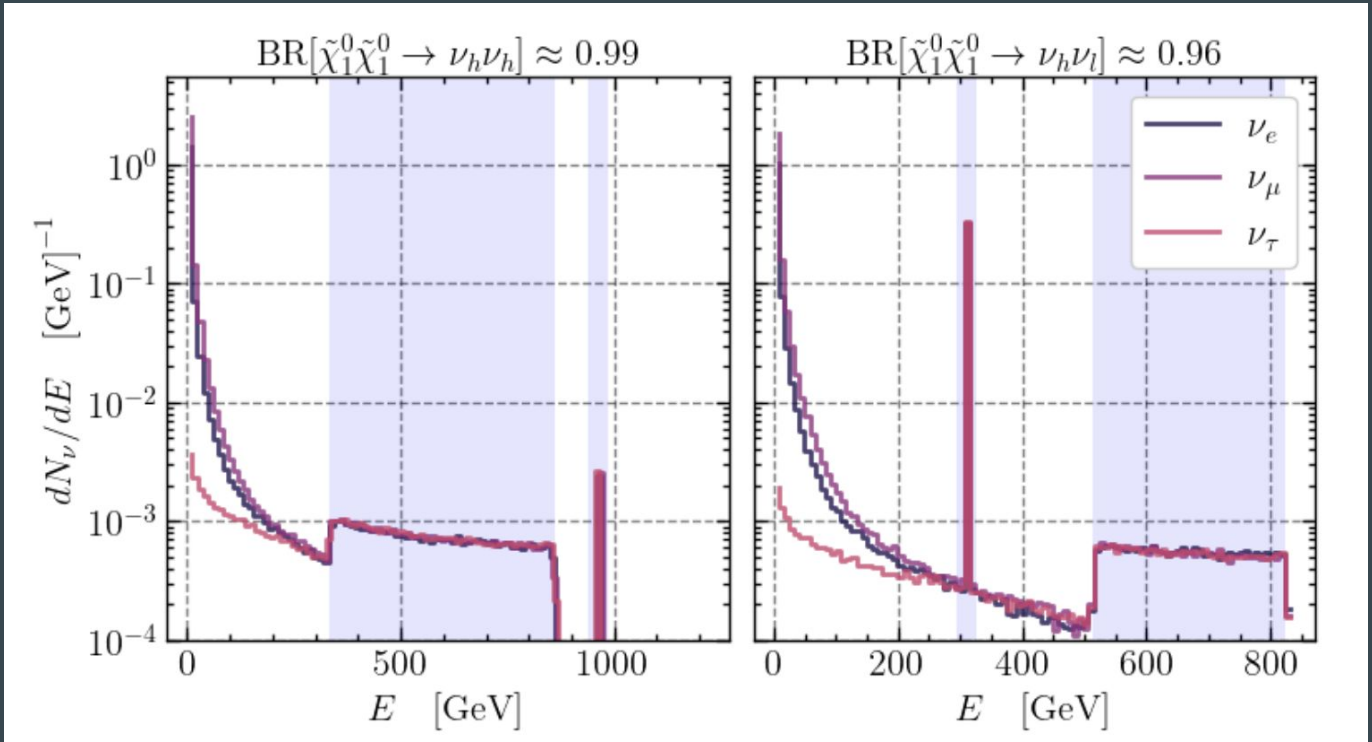


Neutrino Spectra

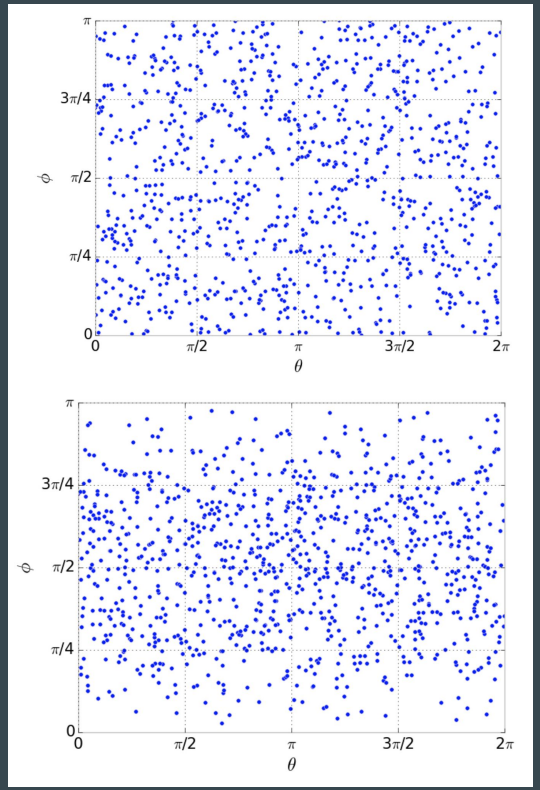
- $\chi^0_1 \chi^0_1 \rightarrow \nu_h \nu_h \rightarrow \nu$
- $\chi^0_1 \chi^0_1 \rightarrow \nu_h \nu_l \rightarrow \nu$

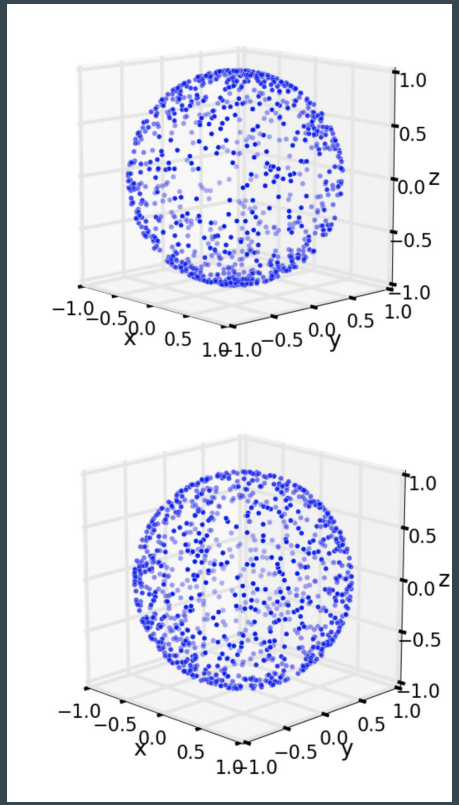


Neutrino Spectra



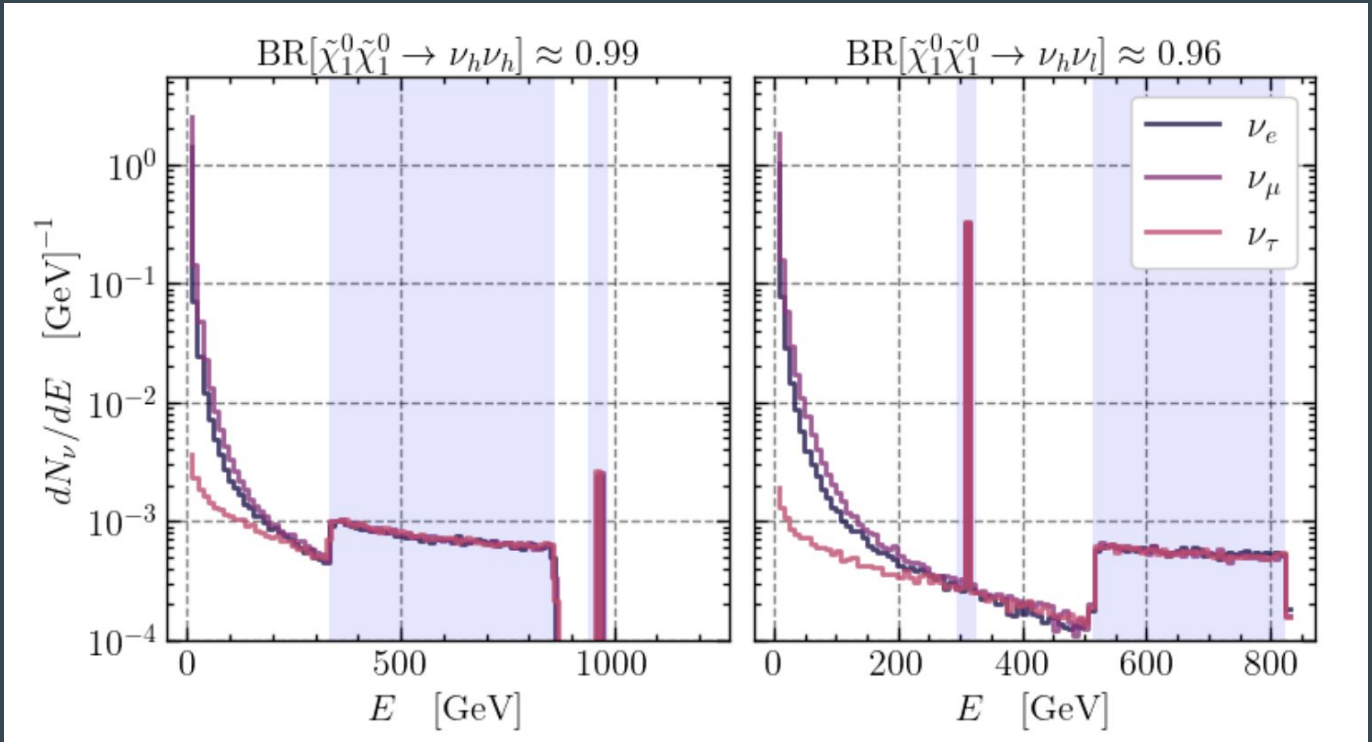
Sampling a Sphere



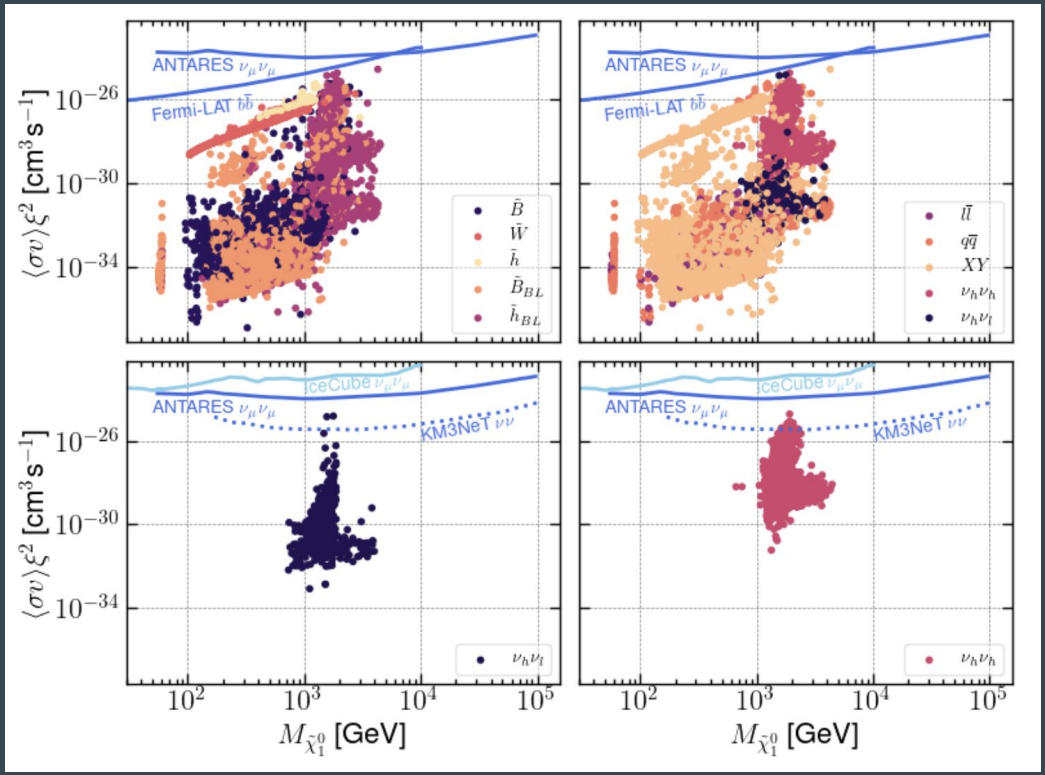


http://corysimon.github.io/articles/uniformdistn-on-sphere/

Neutrino Spectra



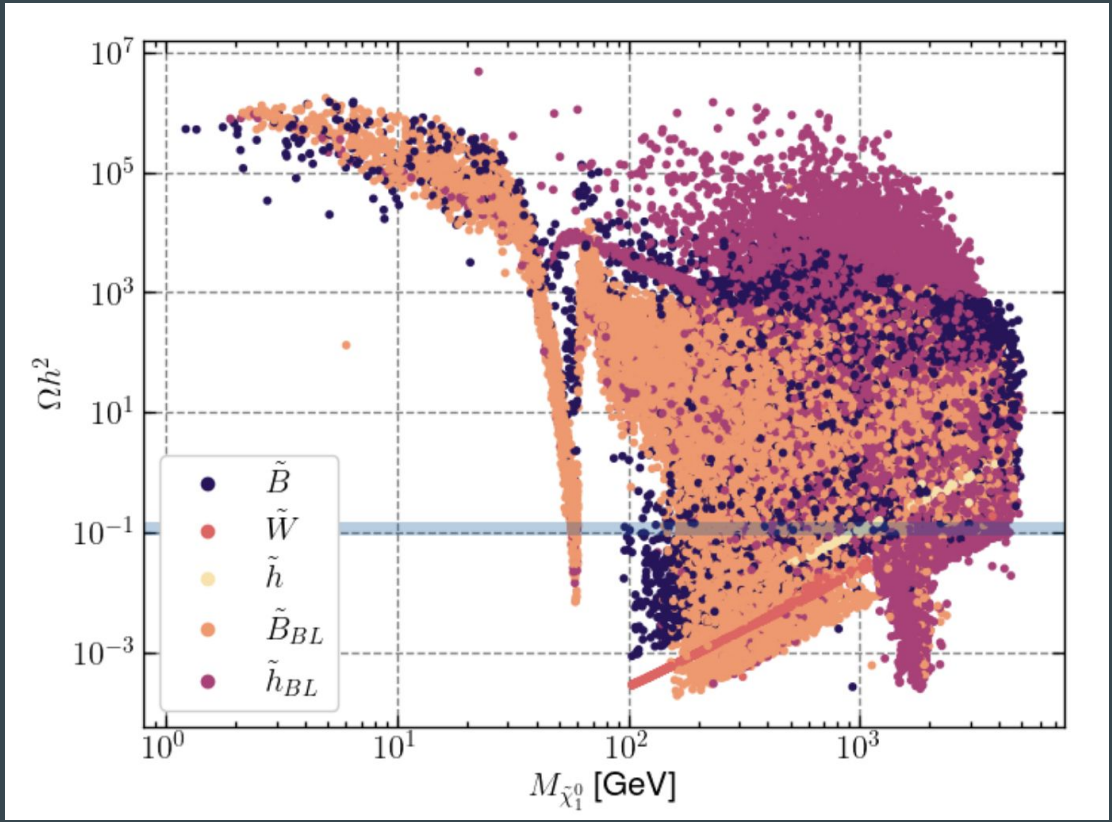
Detectability



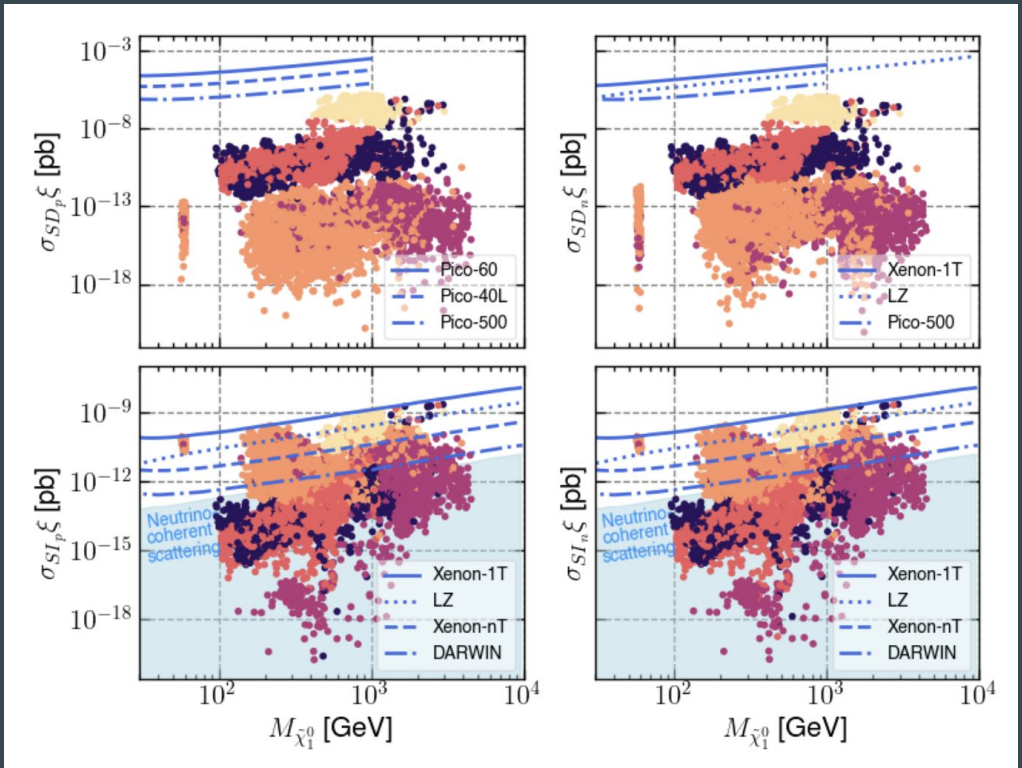
Conclusions

- Spectrum might be ‘unexpected’
- A potential signal from KM3NeT could be from this model
- Only finding a peak does not necessarily give the DM mass
- Both a peak and a box are needed

Relic Density



DM Direct Detection



LHC Production