Thinking inside the box

Non-standard dark matter annihilation and decay spectra

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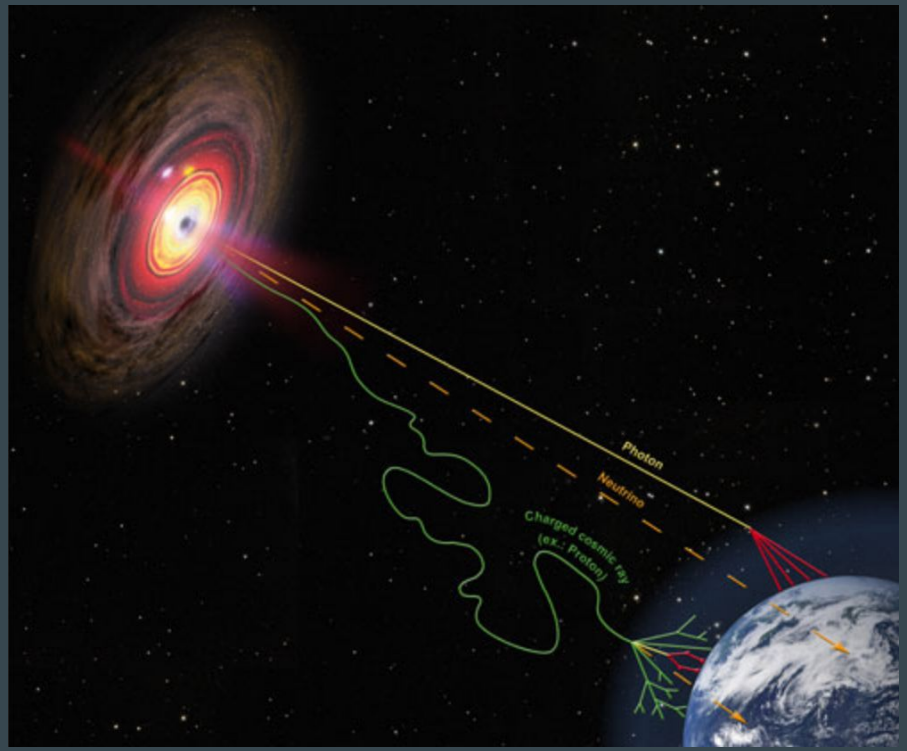
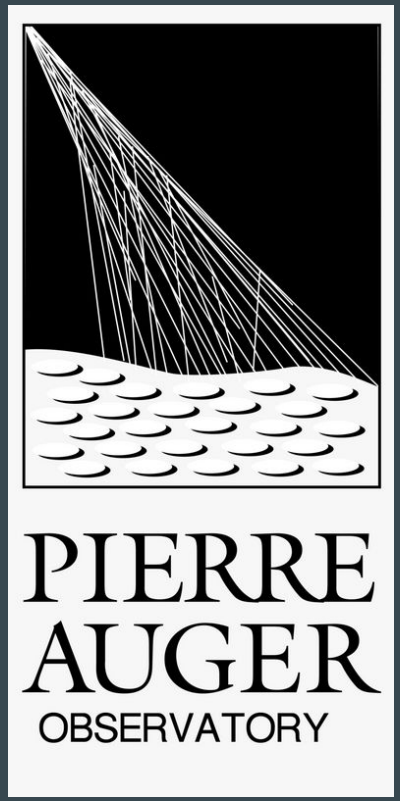
Indirect signals from Dark Matter

- Particles from DM annihilation/decay
- Neutral particles are pointing
- Retain spectral information
- DM DM → particles
  - Mass
  - $\langle \sigma v \rangle$
  - Shape $\mathrm{d}N/\mathrm{d}x$

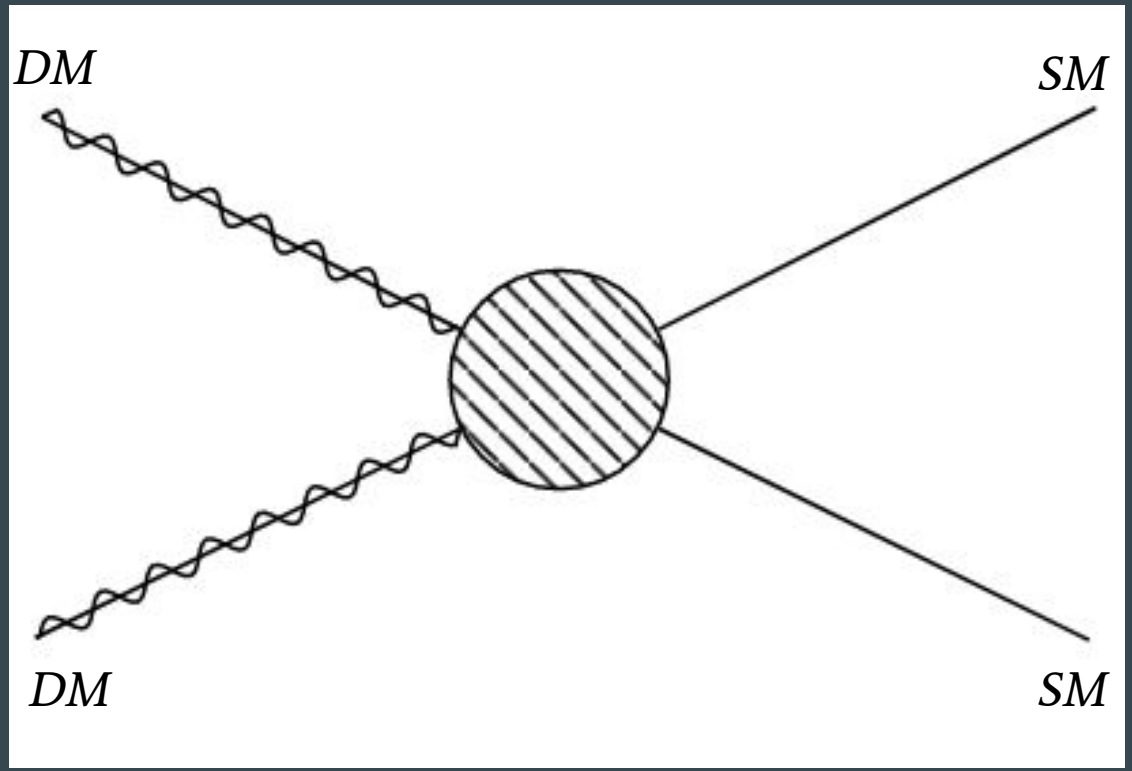


credit: HAP / A. Chantelauze

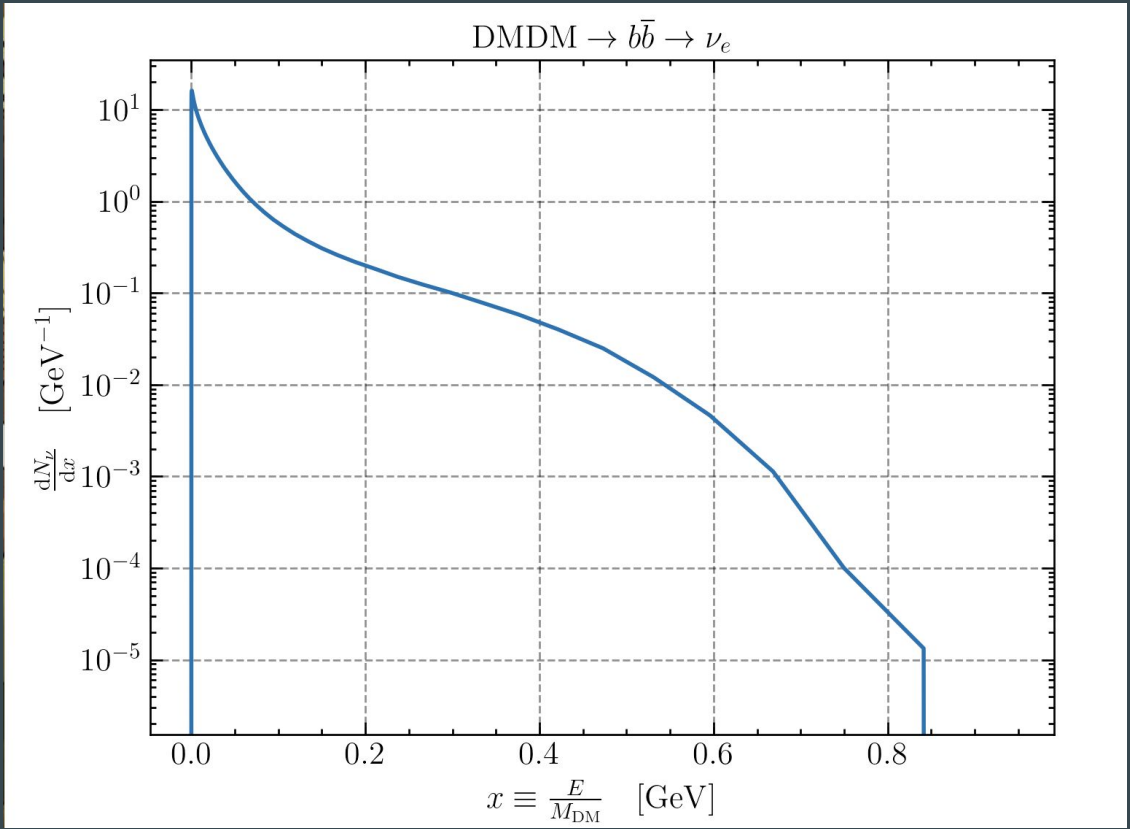
Dark Matter Searches



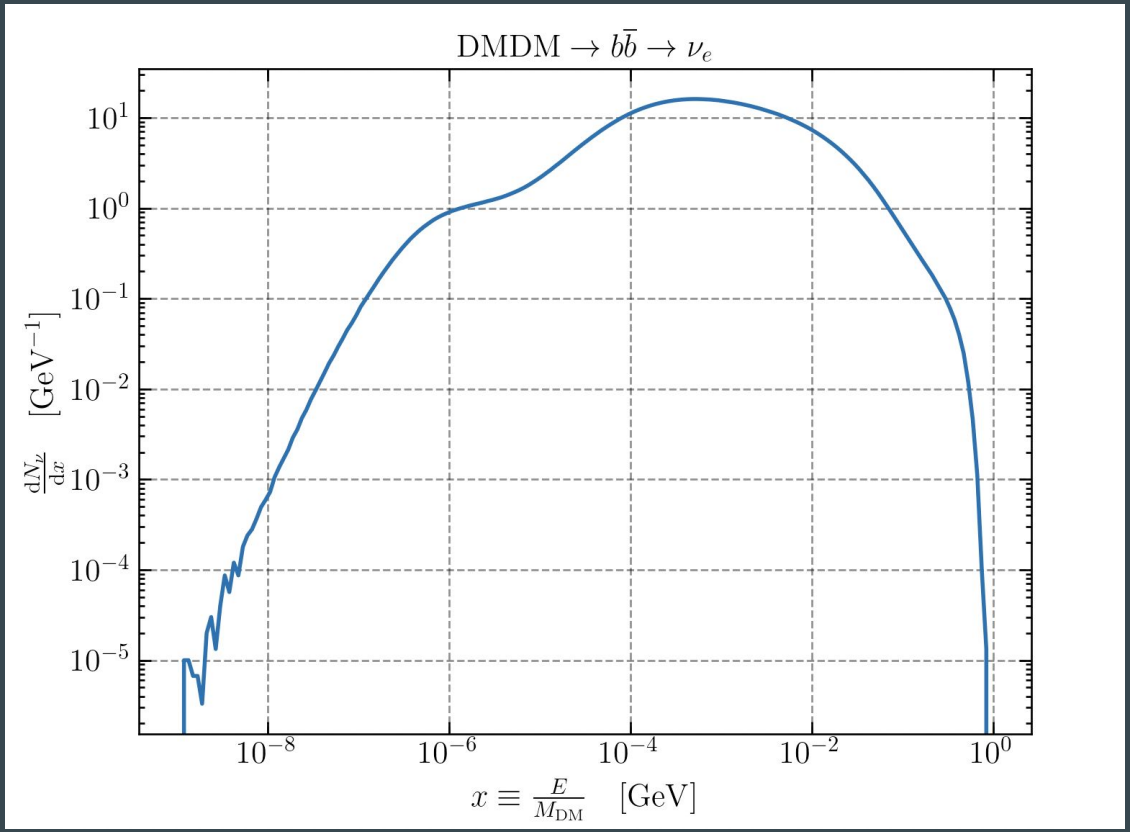
Standard Spectra



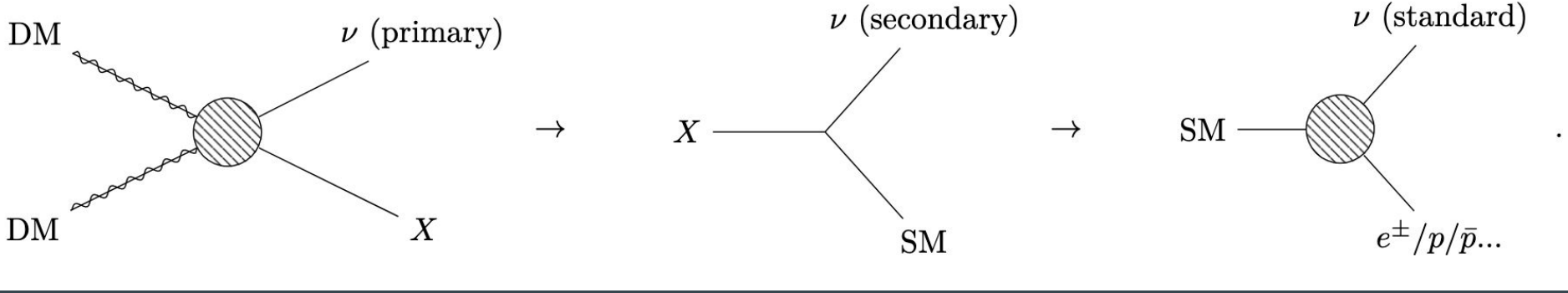
Standard Spectra



Standard Spectra



Non-Standard Spectra

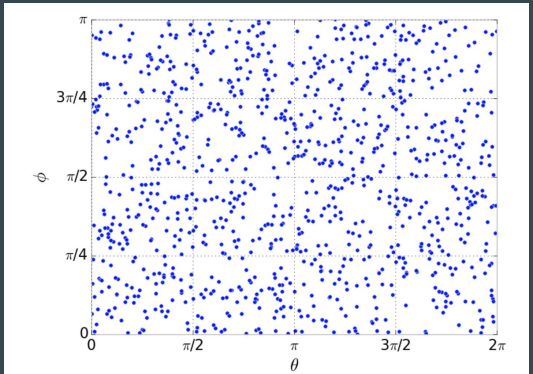


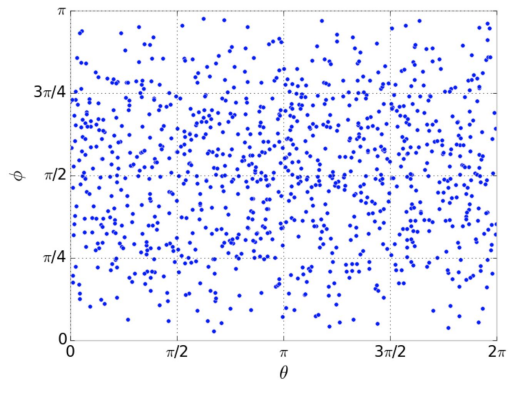
‘Peak’

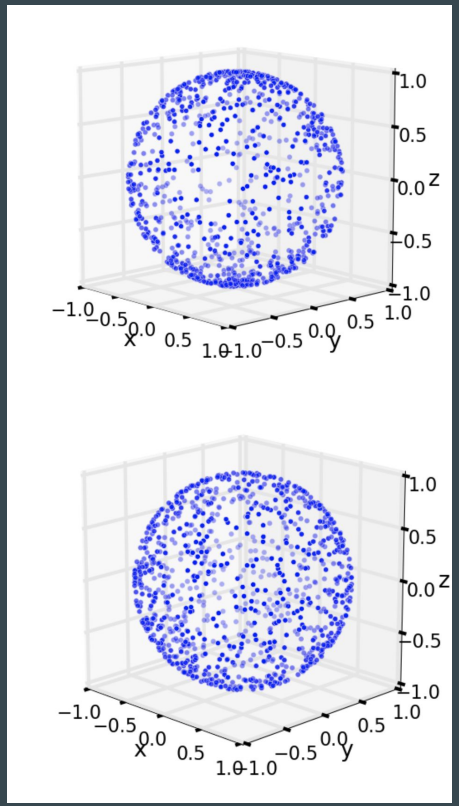
‘Box’

‘Standard’

Sampling a Sphere

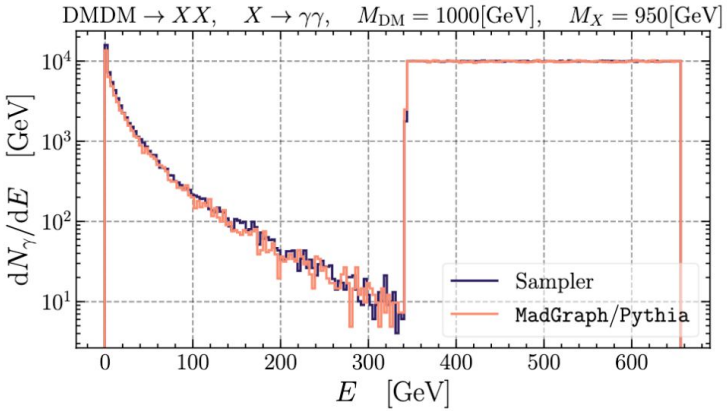


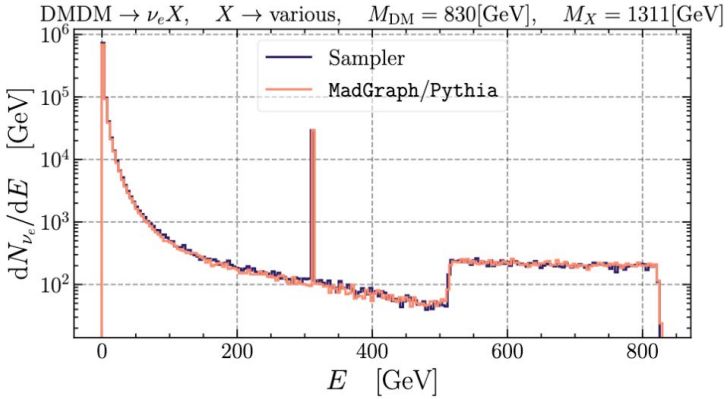


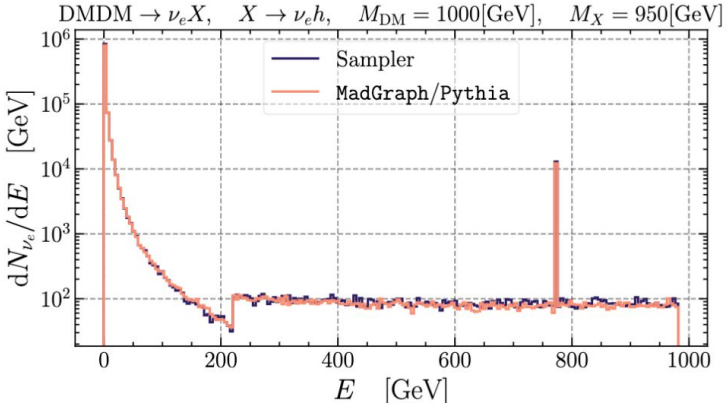


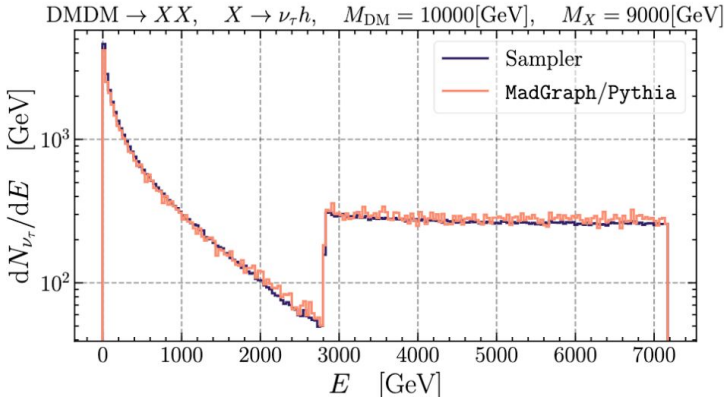
http://corysimon.github.io/articles/uniformdistn-on-sphere/

Validation

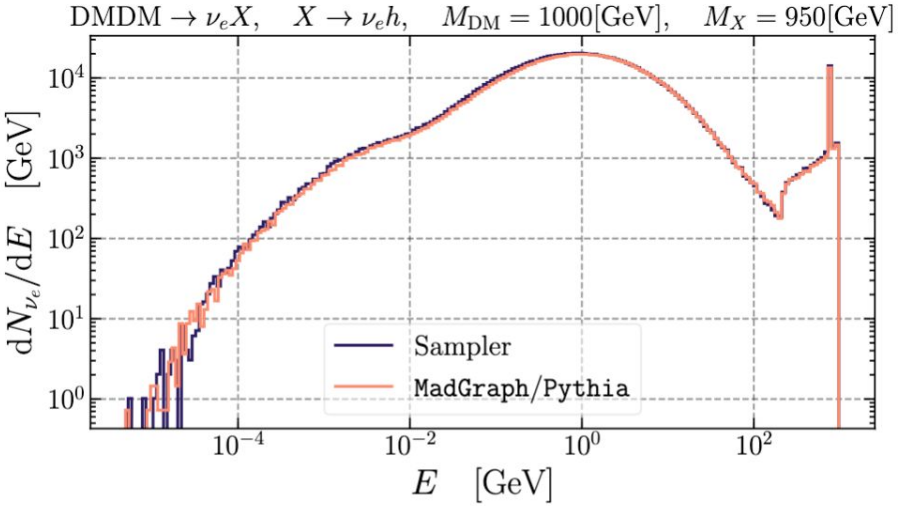

DMDM → XX, X → γγ, M_{DM} = 1000[GeV], M_X = 950[GeV]
dN_γ/dE [GeV]
E [GeV]
Sampler
MadGraph/Pythia

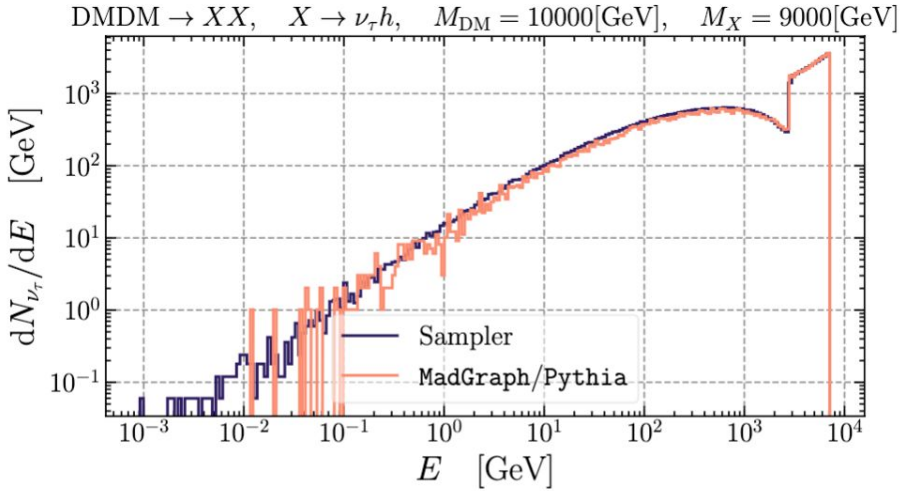

DMDM → ν_eX, X → various, M_{DM} = 830[GeV], M_X = 1311[GeV]
dN_{ν_e}/dE [GeV]
E [GeV]
Sampler
MadGraph/Pythia


DMDM → ν_eX, X → ν_eh, M_{DM} = 1000[GeV], M_X = 950[GeV]
dN_{ν_e}/dE [GeV]
E [GeV]
Sampler
MadGraph/Pythia

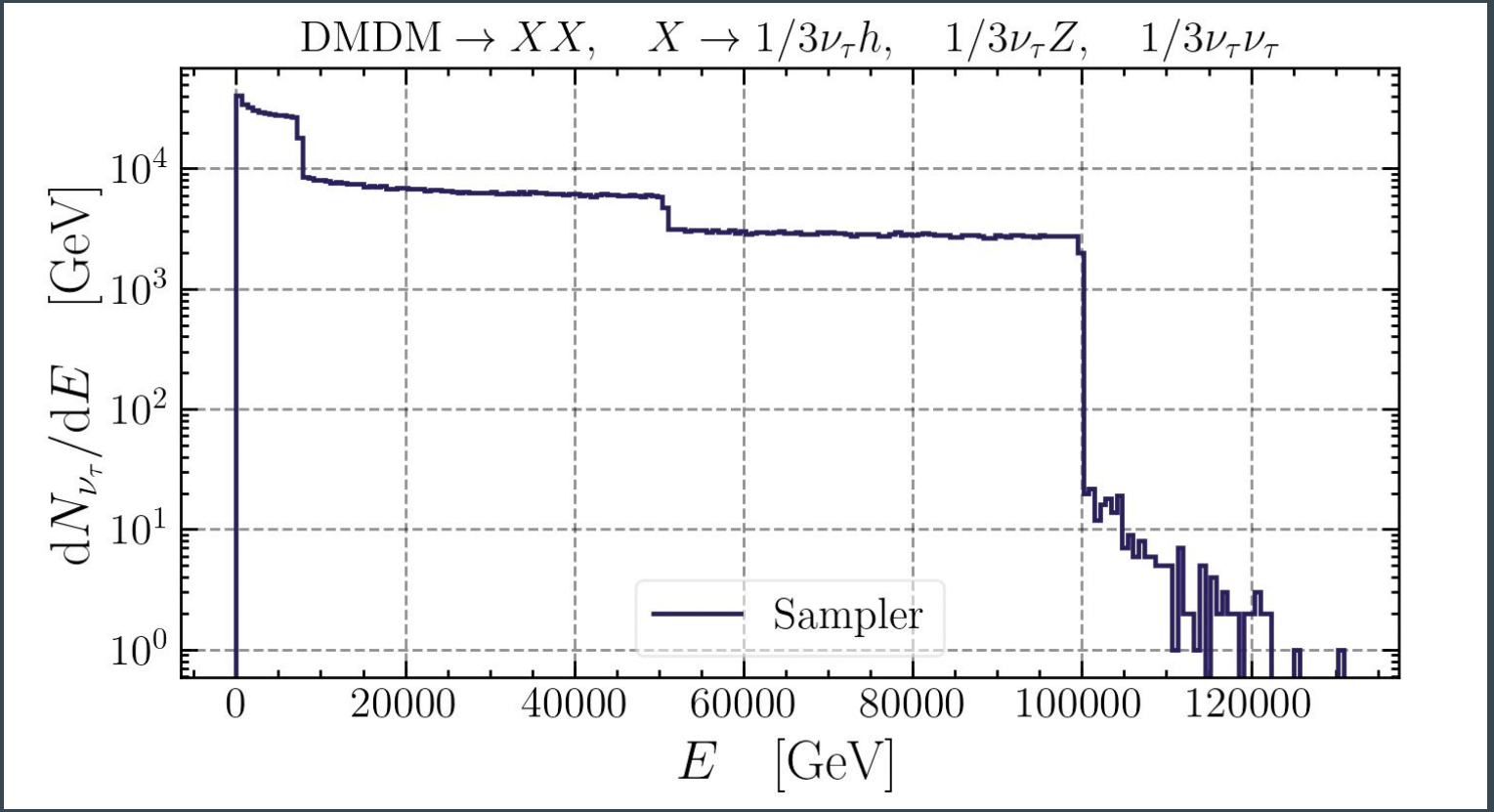

DMDM → XX, X → ν_τh, M_{DM} = 10000[GeV], M_X = 9000[GeV]
dN_{ν_τ}/dE [GeV]
E [GeV]
Sampler
MadGraph/Pythia

Validation

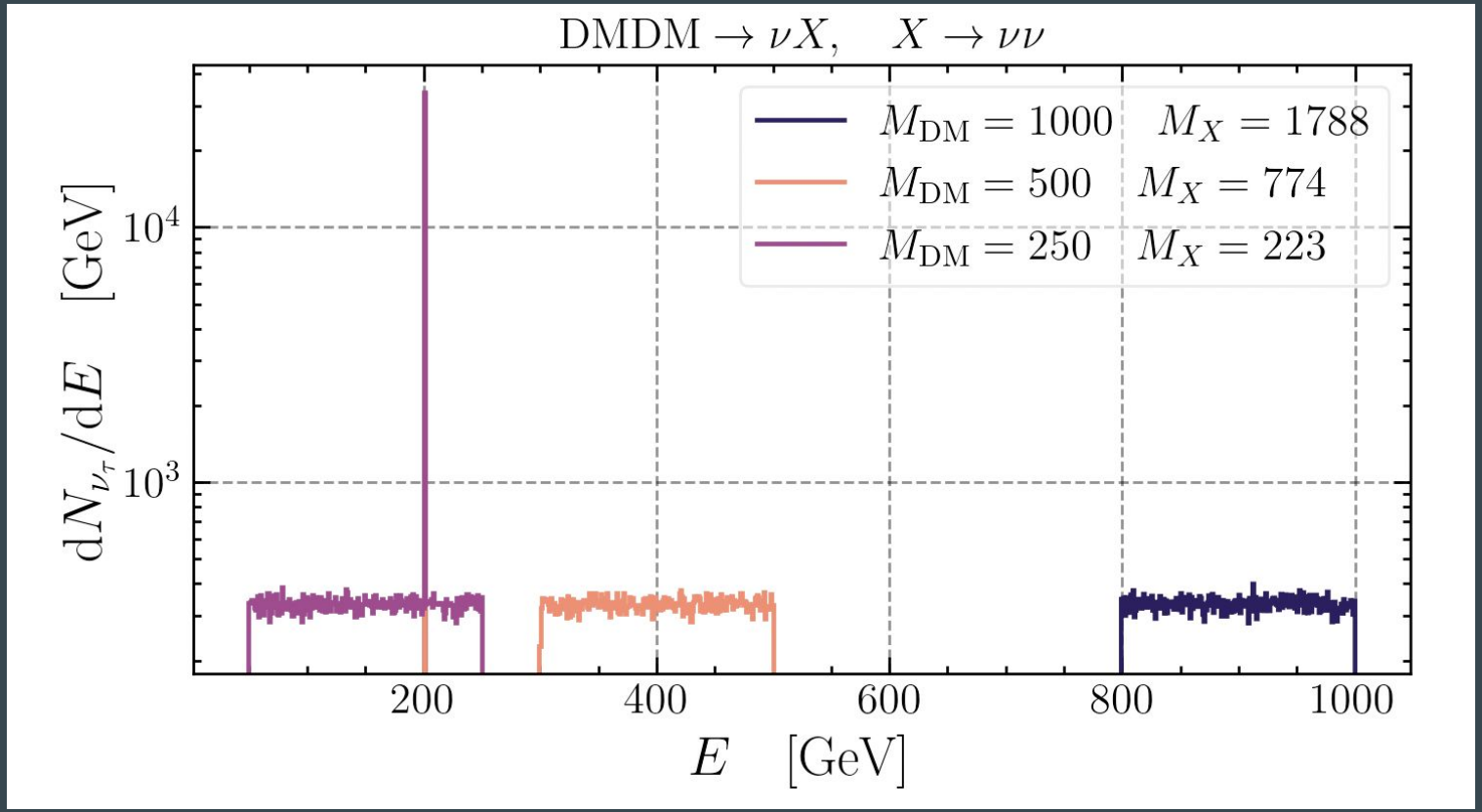

DMDM → $\nu_e X$, $X \to \nu_e h$, $M_{\rm DM} = 1000$[GeV], $M_X = 950$[GeV]
$\mathrm{d}N_{\nu_e}/\mathrm{d}E$ [GeV]
E [GeV]
Sampler
MadGraph/Pythia


DMDM → XX, $X \to \nu_\tau h$, $M_{\rm DM} = 10000$[GeV], $M_X = 9000$[GeV]
$\mathrm{d}N_{\nu_\tau}/\mathrm{d}E$ [GeV]
E [GeV]
Sampler
MadGraph/Pythia

Spectra examples



Spectra Examples



Model examples

- EFT-like approach
  - All particles except DM and X are integrated out
- Generic Heavy neutrino extension
  - DM introduced by hand
  - X is an ‘unstable’ heavy neutrino
- B-L-SSM-IS
  - DM is the first neutralino
  - X is a heavy neutrino
- U(1)_(L_μ-L_τ) Extension of the Standard Model
  - DM is a scalar particle
  - X is the Z’ boson

Conclusions

- Introducing a single particle X can have a profound impact on particle spectra
- Even the best-case scenario is a two-parameter problem
- Only finding a peak does not necessarily give the DM mass
- These spectra have no inherent scale
- So far largely overlooked
- Always check what's in the box

Thank You