Hunting for dark matter with CTA

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image: Colin Jones https://youtu.be/mQi1NMh9CvA

outline

the WIMP

the many WIMPs

the CTA reach

intro

the Dark Matter Working Group of CTA led
the examination of the sensitivity of CTA for dark matter
in the context of a generic WIMP

this led to 2007.16129
“Pre-construction estimates of the Cherenkov Telescope Array sensitivity to a dark matter signal from the Galactic centre”

intro

now it’s time to repeat, and improve on, that work
for specific WIMP candidates

the results will factor into the inference of the plausibility of specific particle physics models featuring dark matter candidates

here, I report on a significant part of this work

dark matter properties

from observational point of view

collisionless

interacts with itself and visible matter very weakly

gravitates

creates potential wells and velocity dispersion

cold

forms large scale astrophysical structures

lasting

on the order of the lifetime of the observable Universe

dark matter properties

particle physicist ‘translation’

collisionless ↔ weakly interacting

interacts with itself and visible matter very weakly

gravitates ↔ massive

creates potential wells and velocity dispersion

cold ↔ non-relativistic

forms large scale astrophysical structures

lasting ↔ stable

on the order of the lifetime of the observable Universe

dark matter candidates

many extensions of the Standard Model feature
weakly interacting, massive, non-relativistic, stable particles

qualitatively, they could be dark matter (!)

dark matter candidates

many of these particles evolve thermally in the early universe
to reproduce the observed amount of dark matter in the Universe

additionally, they are allowed by all known constraints
(including dark matter indirect and direct detection)

quantitatively, they could be dark matter (!)

dark matter candidates

examples:

spin zero, gauge singlet

new inert Higgs-like particle

right-handed neutrinos

right-handed gauge bosons

lightest supersymmetric particles

secluded dark matter

Kaluza-Klein excitations

axions, axion-like particles … and many more

dark matter - candidates?

Is any of these particles dark matter?

Can CTA do anything about this question?

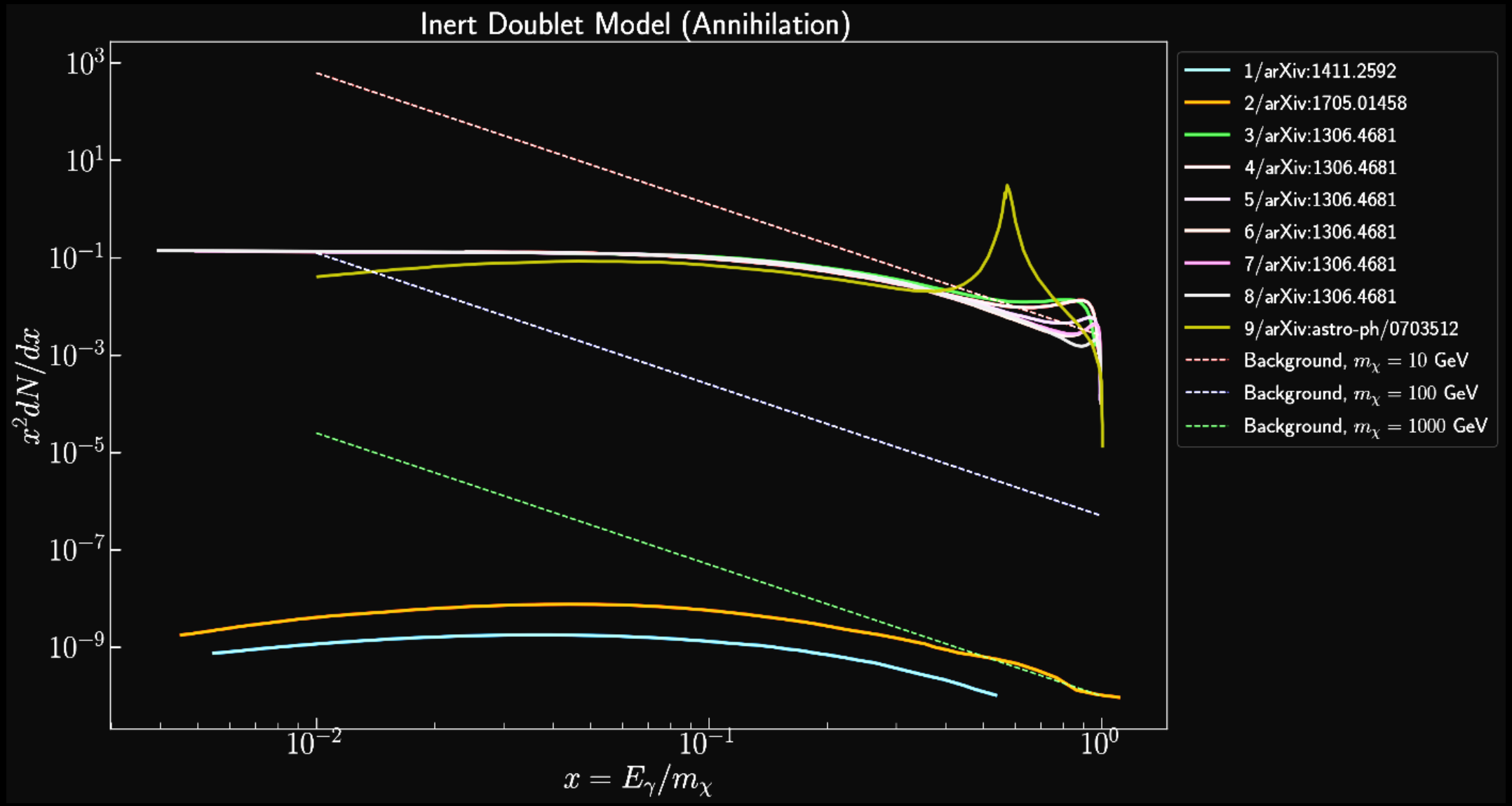
If yes, what?

dark matter signal

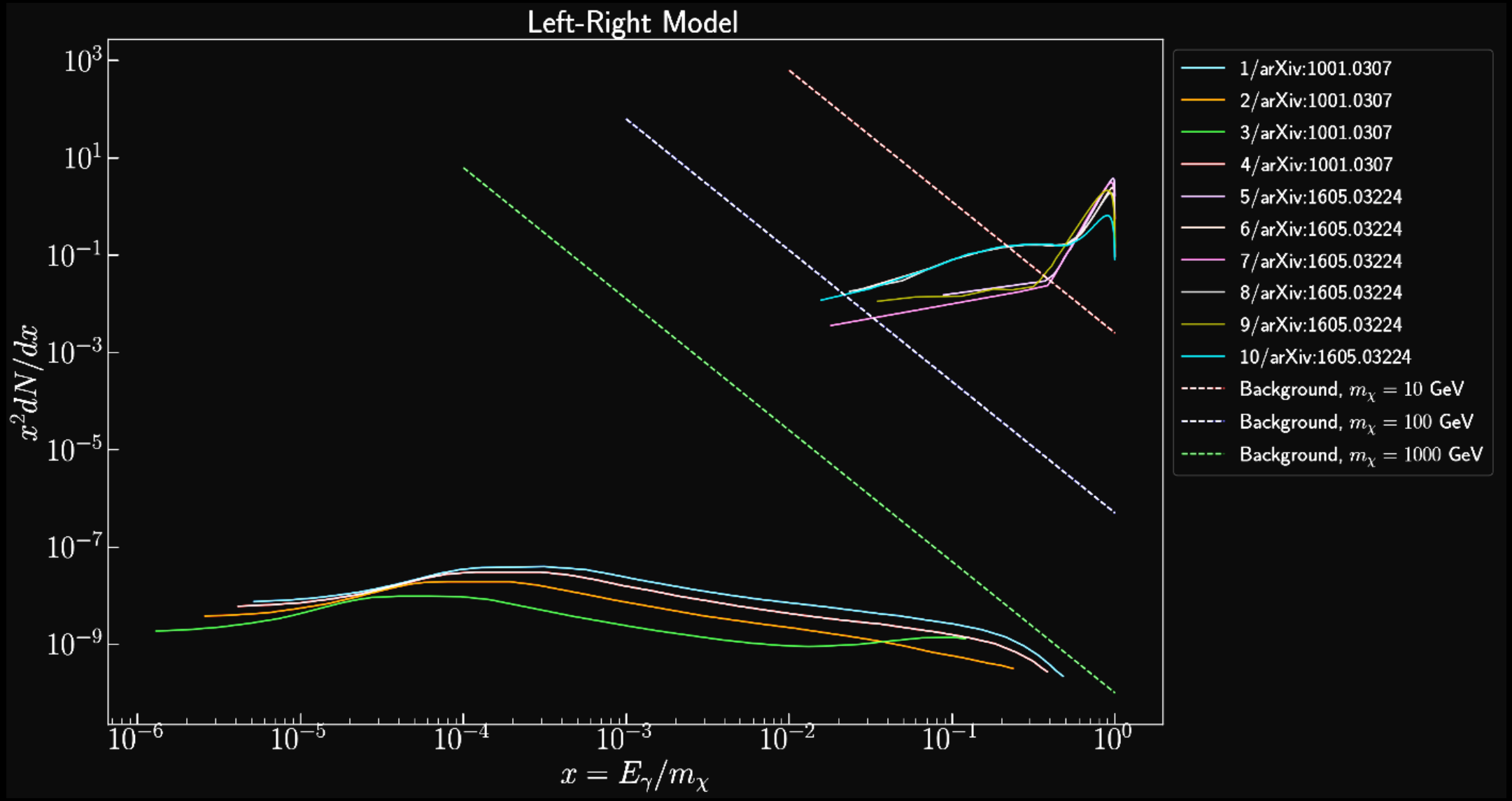
all dark matter models listed produce a γ-ray signal

let's look at a few of the spectra from the Galactic Centre

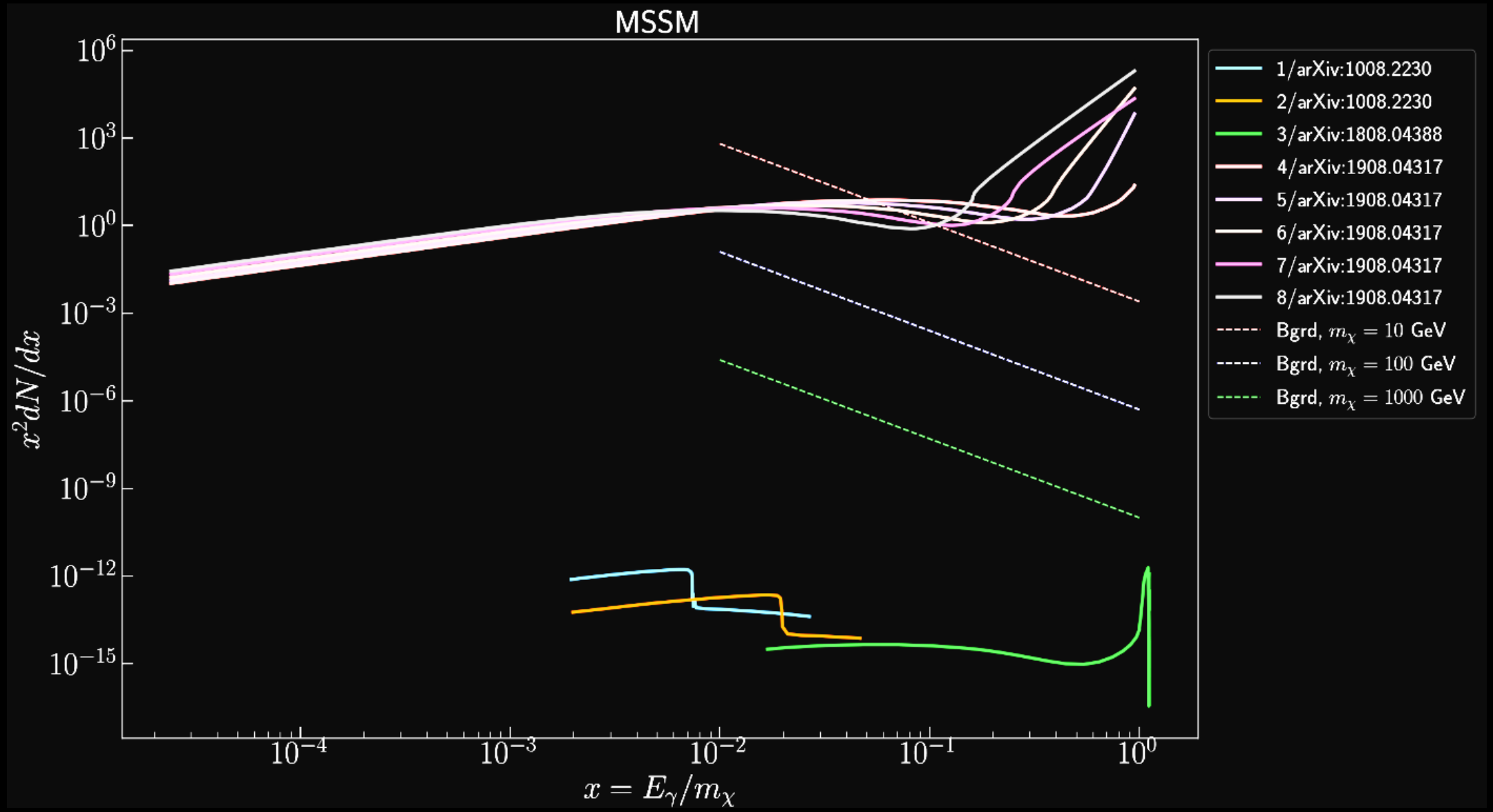
dark matter signal



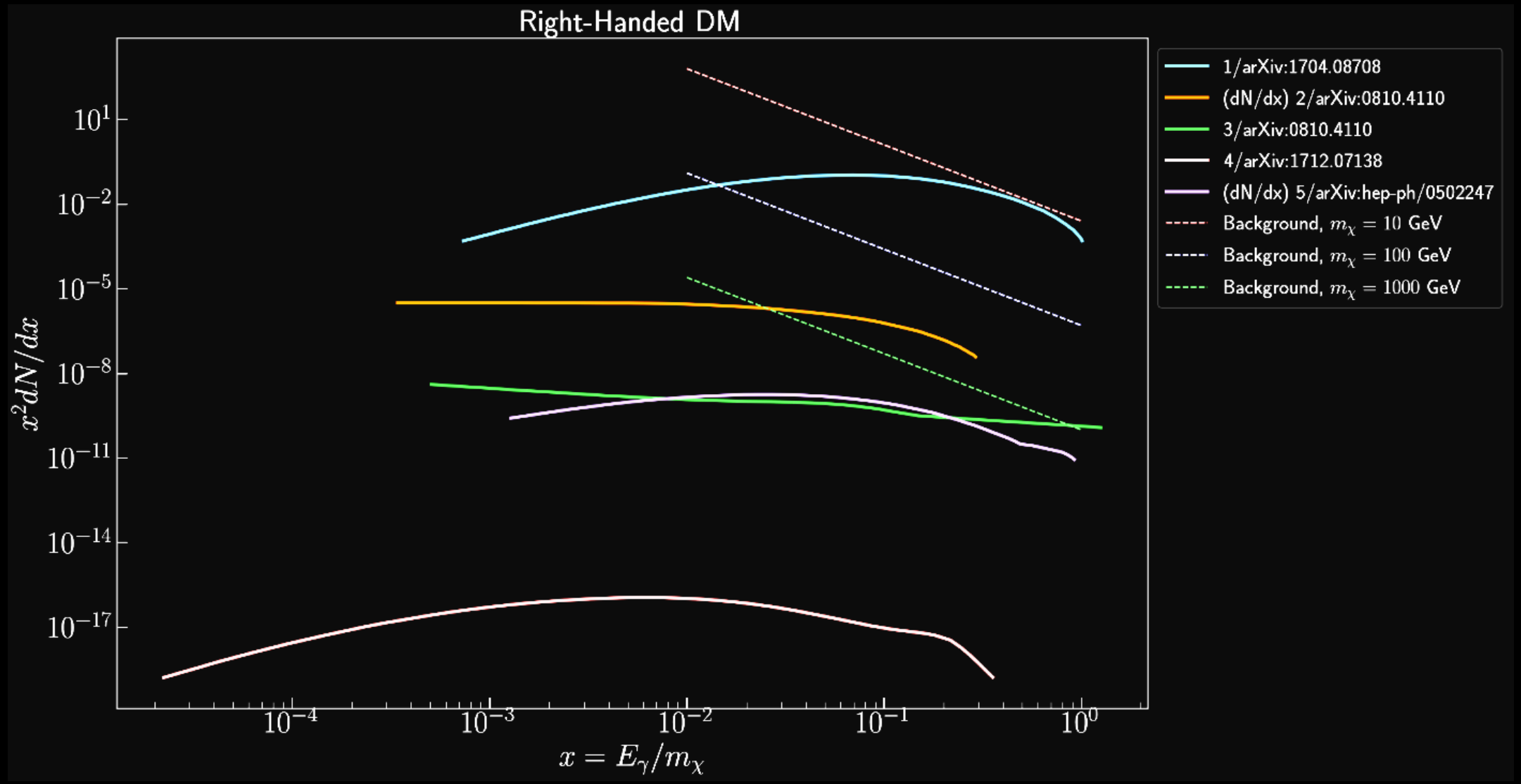
dark matter signal



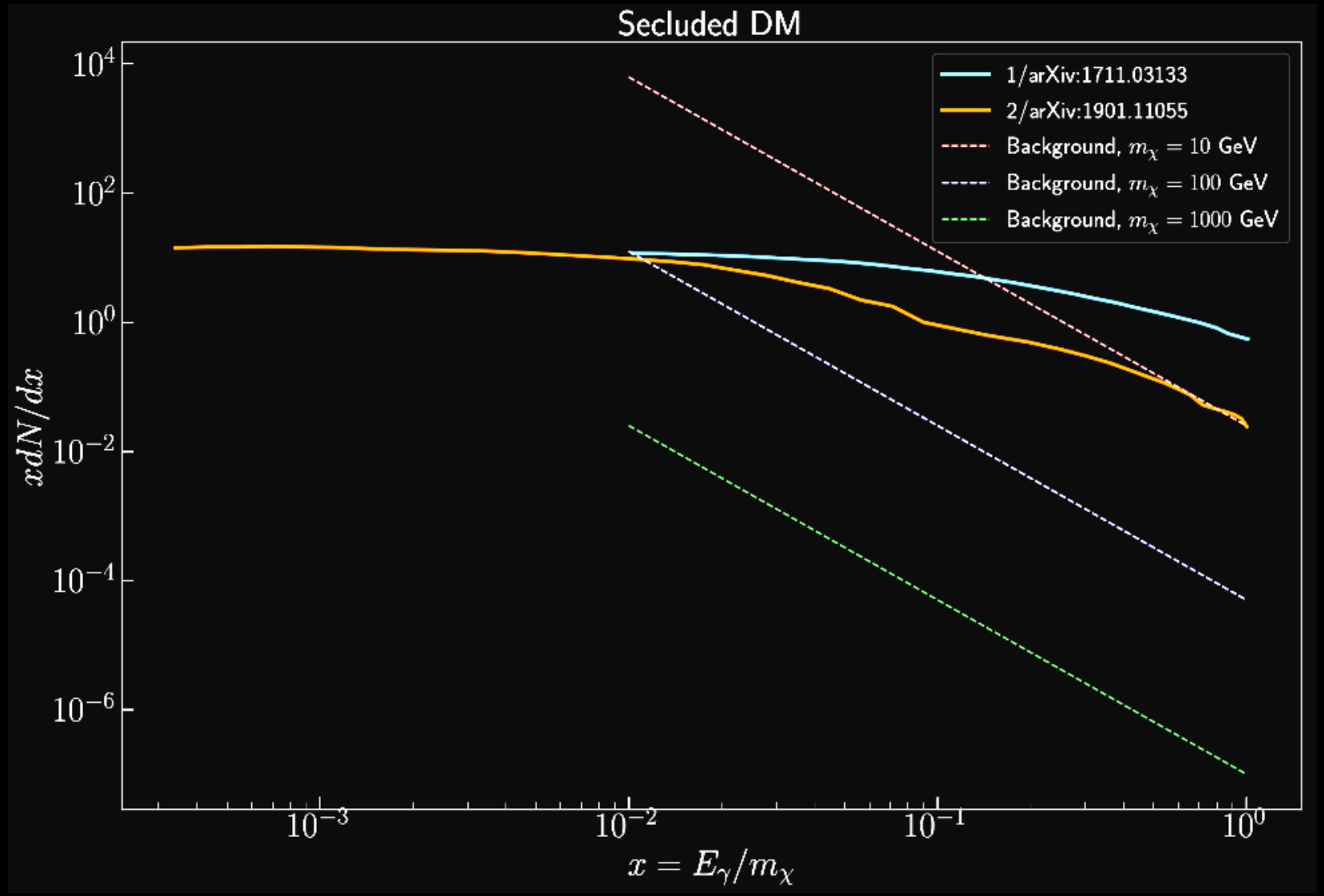
dark matter signal



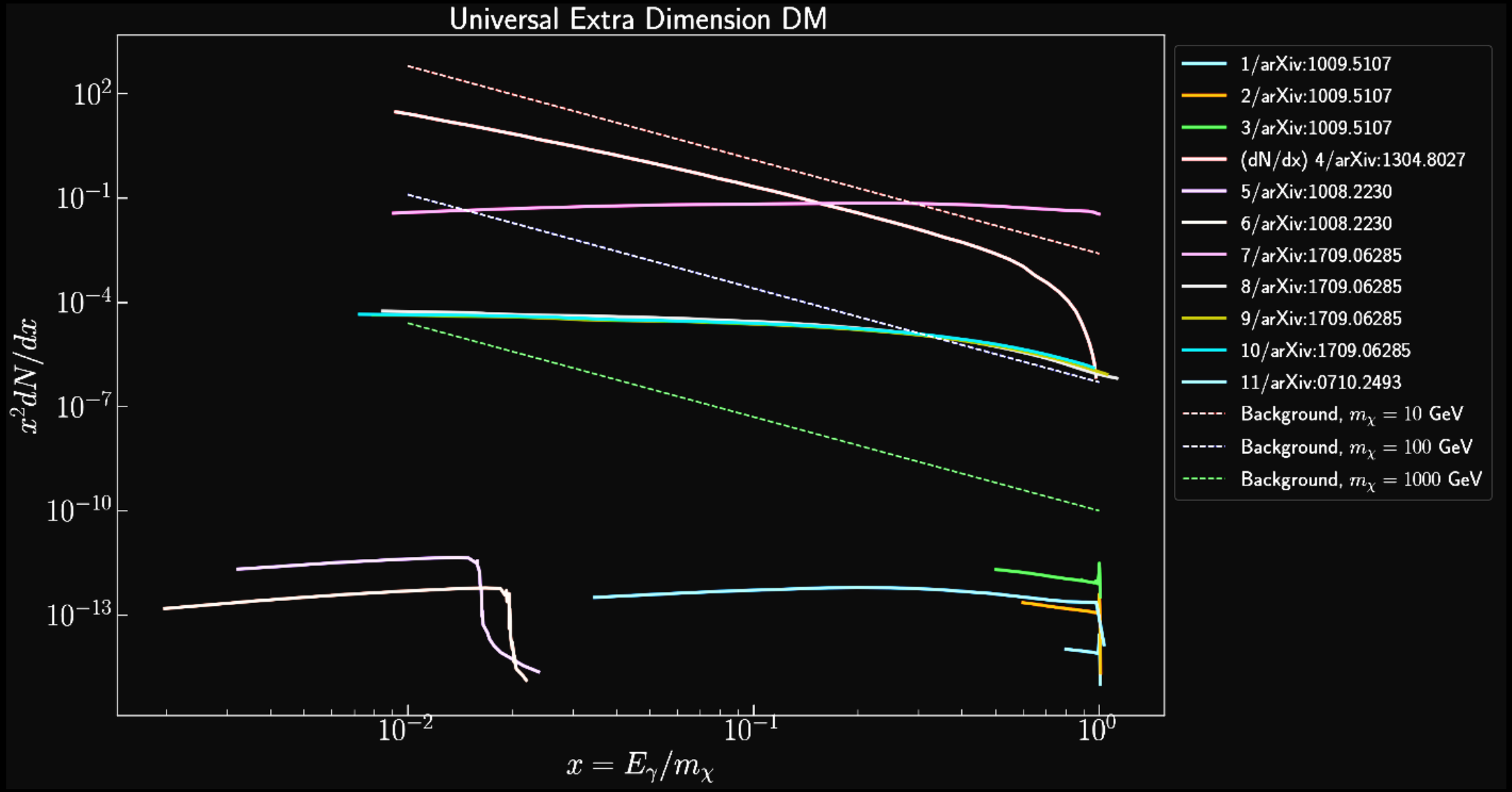
dark matter signal



dark matter signal



dark matter signal



dark matter detection

Can any of these γ-rays be detected by CTA?

a meaningful answer can be formulated in the language of statistics

dark matter detection

given N_S/N signal event ratio, the probability of d_i,
a single γ-ray event in CTA, is

$$N\,\mathcal{L}(d_i|N_S) = N_S\,\mathcal{L}_{DM\,signal}(d_i) + (N - N_S)\,\mathcal{L}_{background}(d_i)$$

the probability of observing the data set d is

$$\mathcal{L}(d, N|N_S) \sim 'Poisson' * \prod_{i=1\ldots N} \mathcal{L}(d_i|N_S)$$

dark matter detection

drawing signal and bg γ-rays from templates generated with ctools

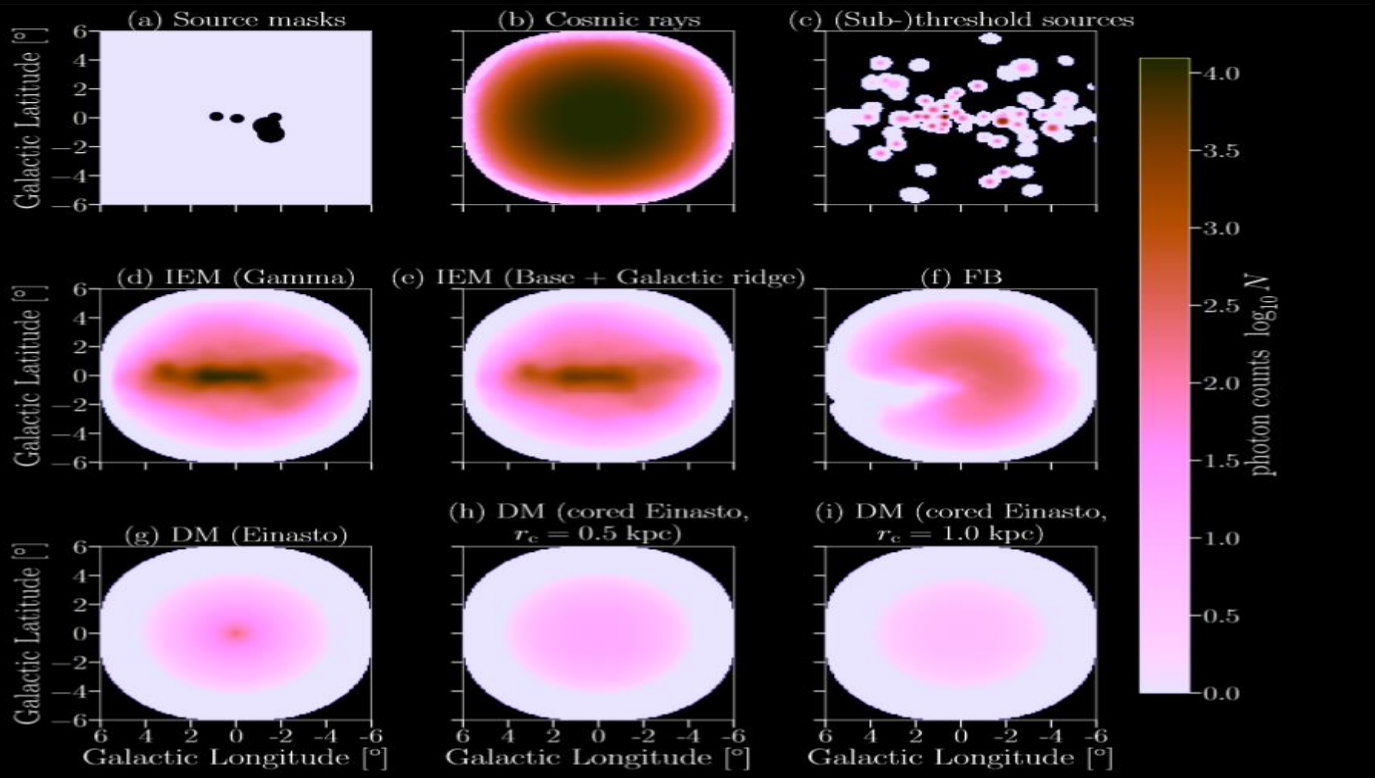


Figure 3: Background and signal templates computed by ctools for the GC survey observation, showing the expected photon counts in the energy range from 100 to 500 GeV. The

we can evaluate and then MC sample the likelihood function

summary

work in progress…

we began a systematic hunt for WIMP dark matter using CTA

presently determining the sensitivity of CTA for dark matter
in the context of various specific WIMP models

stay tuned…

backup