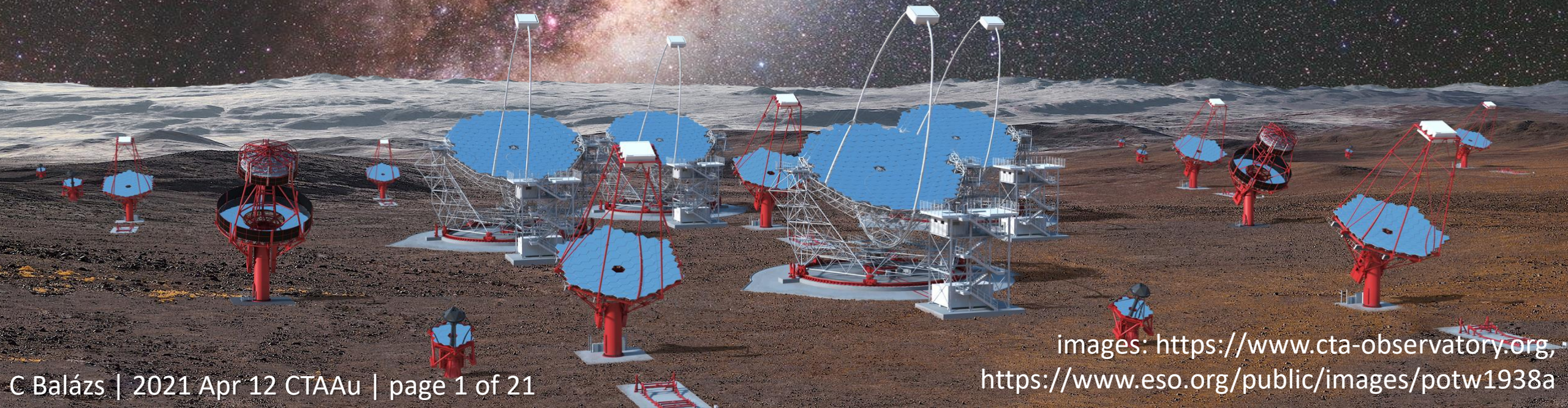
Searching for dark matter

with the

Cherenkov Telescope Array

Csaba Balázs, Torsten Bringmann, Abhi Mangipudi

MONASH University



images: https://www.cta-observatory.org,
https://www.eso.org/public/images/potw1938a

dark matter:

massive

electrically neutral

stable

nearly collisionless

Particles?

What particles?

How can we tell?

DESY 21-044, ULB-TH/21-03

Pandemic Dark Matter

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We propose a novel thermal production mechanism for dark matter based on the idea that dark matter particles χ can transform ('infect') heat bath particles ψ: $\chi\psi \to \chi\chi$. For a small initial abundance of χ this induces an exponential growth in the dark matter number density, closely resembling the epidemic curves of a spreading pathogen after an initial outbreak. To quantify this relation we present a sharp duality between the Boltzmann equation for the dark matter number density and epidemiological models for the spread of infectious diseases. Finally we demonstrate that the exponential growth naturally stops before χ thermalizes with the heat bath, corresponding to a triumphant 'flattening of the curve' that matches the observed dark matter abundance.

Introduction.— While the identity and underlying properties of the dark matter (DM) in our Universe remain mysterious, its energy density has been precisely inferred by a series of satellite missions studying the Cosmic Microwave Background (CMB). Any theoretical description of DM must therefore include a *DM production mechanism* which leads to the observed DM relic abundance of $\Omega_{\rm DM}h^2 \simeq 0.12$ [1].

A particularly appealing framework for the genesis of DM, minimizing the dependence on initial conditions, is its creation out of a thermal bath. The most commonly adopted paradigm falling into this category is thermal freeze-out from the primordial plasma of Standard Model (SM, cf. Ref. [2]) particles in the early Universe [3]. However, given the increasingly strong constraints on this setup, as well as the natural productivity of DM phe-

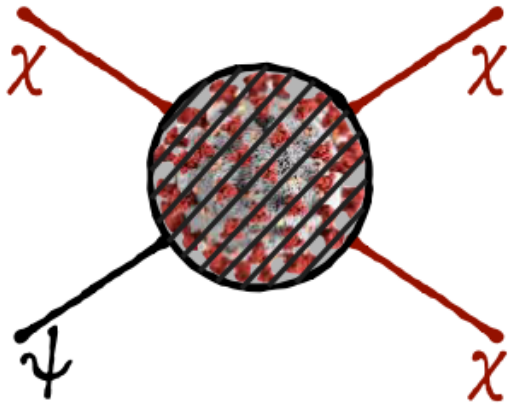
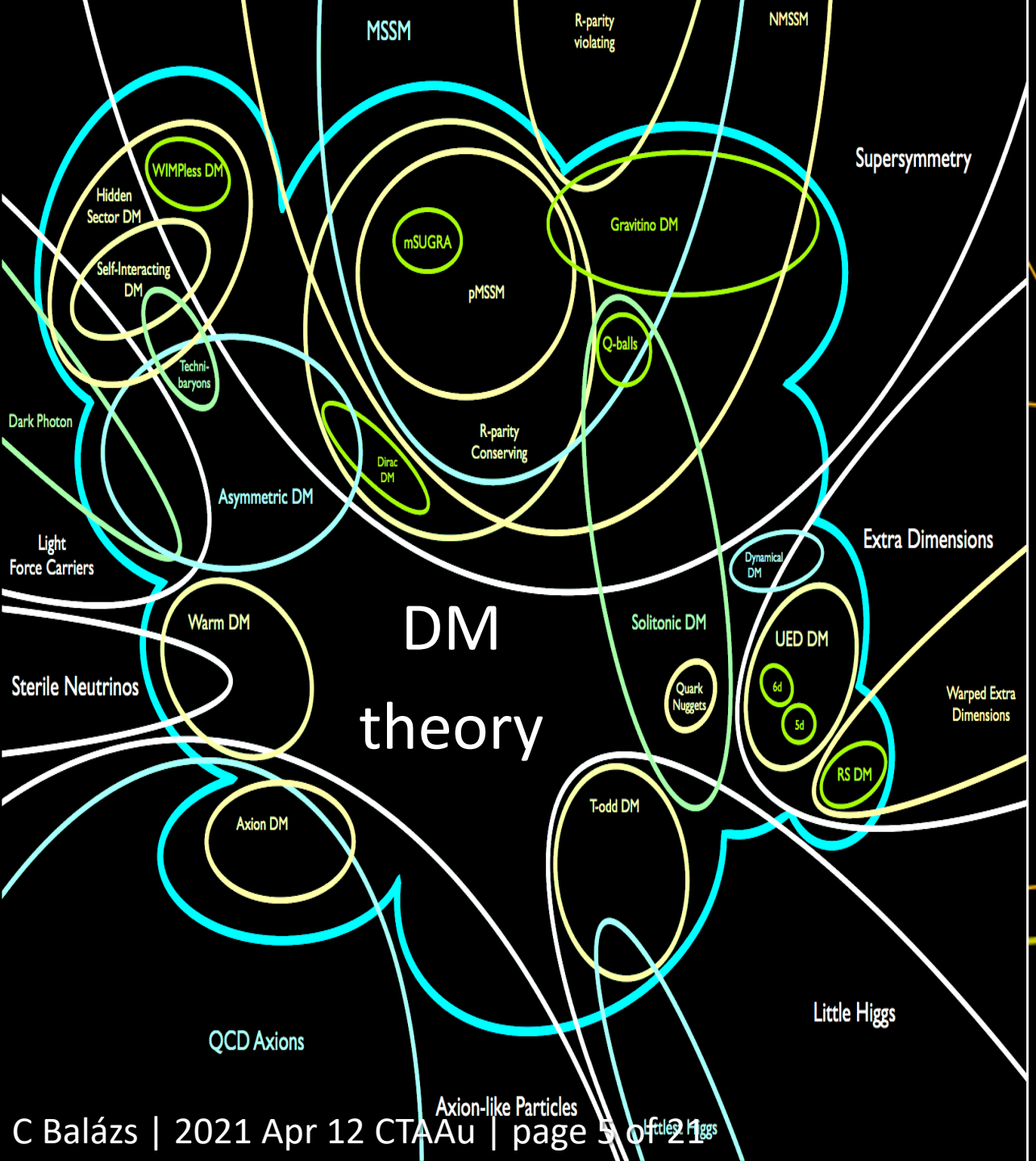
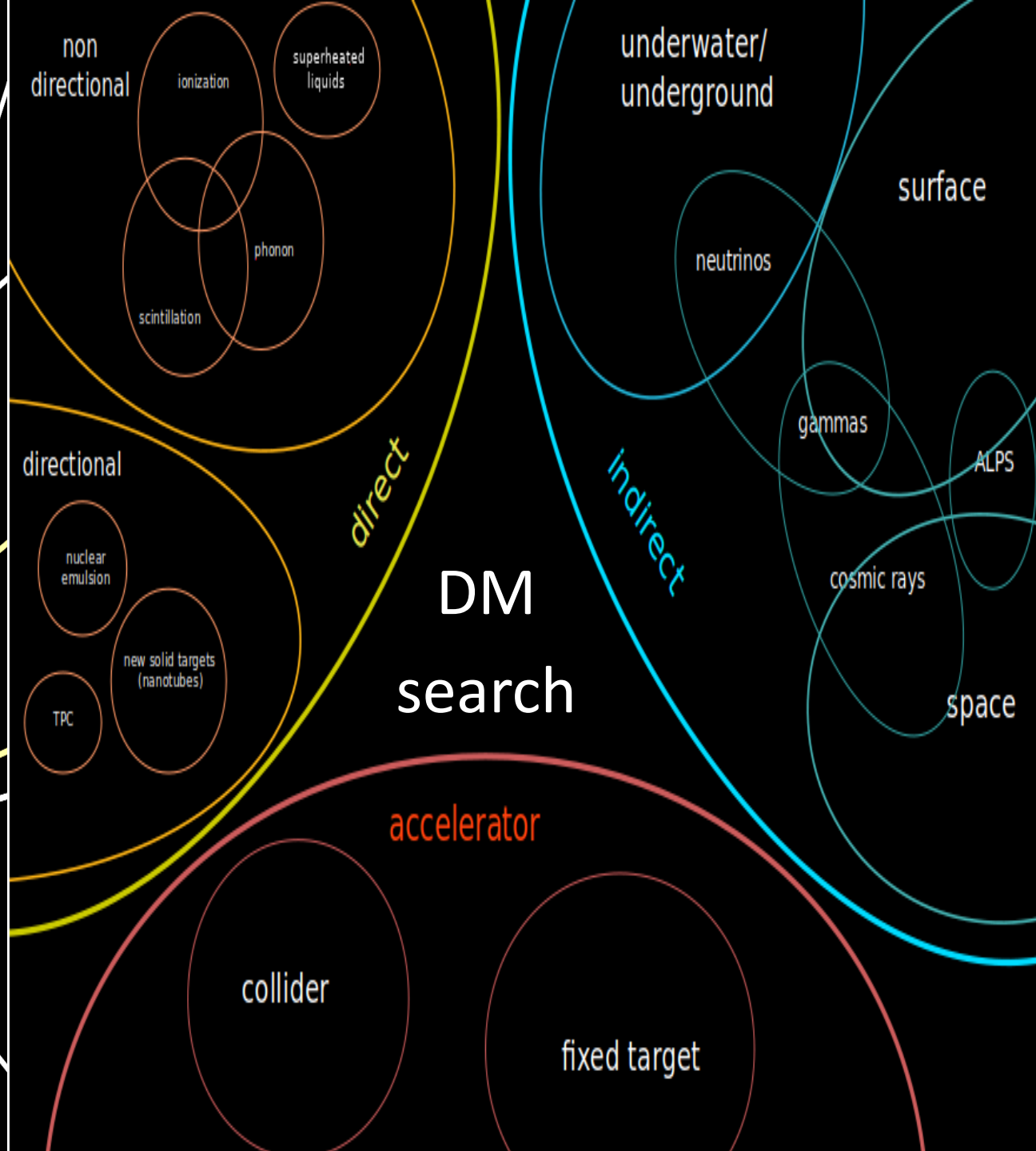


FIG. 1. The transmission process leading to exponential production of DM (χ) from the heat bath (ψ). This illustration of the effective operator was created at the Centers for Disease Control and Prevention [32].

DM

DM


MSSM
R-parity violating
NMSSM
Supersymmetry
WIMPless DM
Hidden Sector DM
Self-Interacting DM
mSUGRA
pMSSM
Gravitino DM
Q-balls
Techni-baryons
Dark Photon
R-parity Conserving
Dirac DM
Asymmetric DM
Light Force Carriers
Extra Dimensions
Dynamical DM
Warm DM
DM theory
Solitonic DM
UED DM
Sterile Neutrinos
Quark Nuggets
6d
5d
Warped Extra Dimensions
RS DM
T-odd DM
Axion DM
Little Higgs
QCD Axions
Axion-like Particles


non directional
ionization
superheated liquids
phonon
scintillation
directional
nuclear emulsion
new solid targets (nanotubes)
TPC
direct
DM search
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underwater/ underground
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neutrinos
gammas
ALPS
cosmic rays
space
accelerator
collider
fixed target

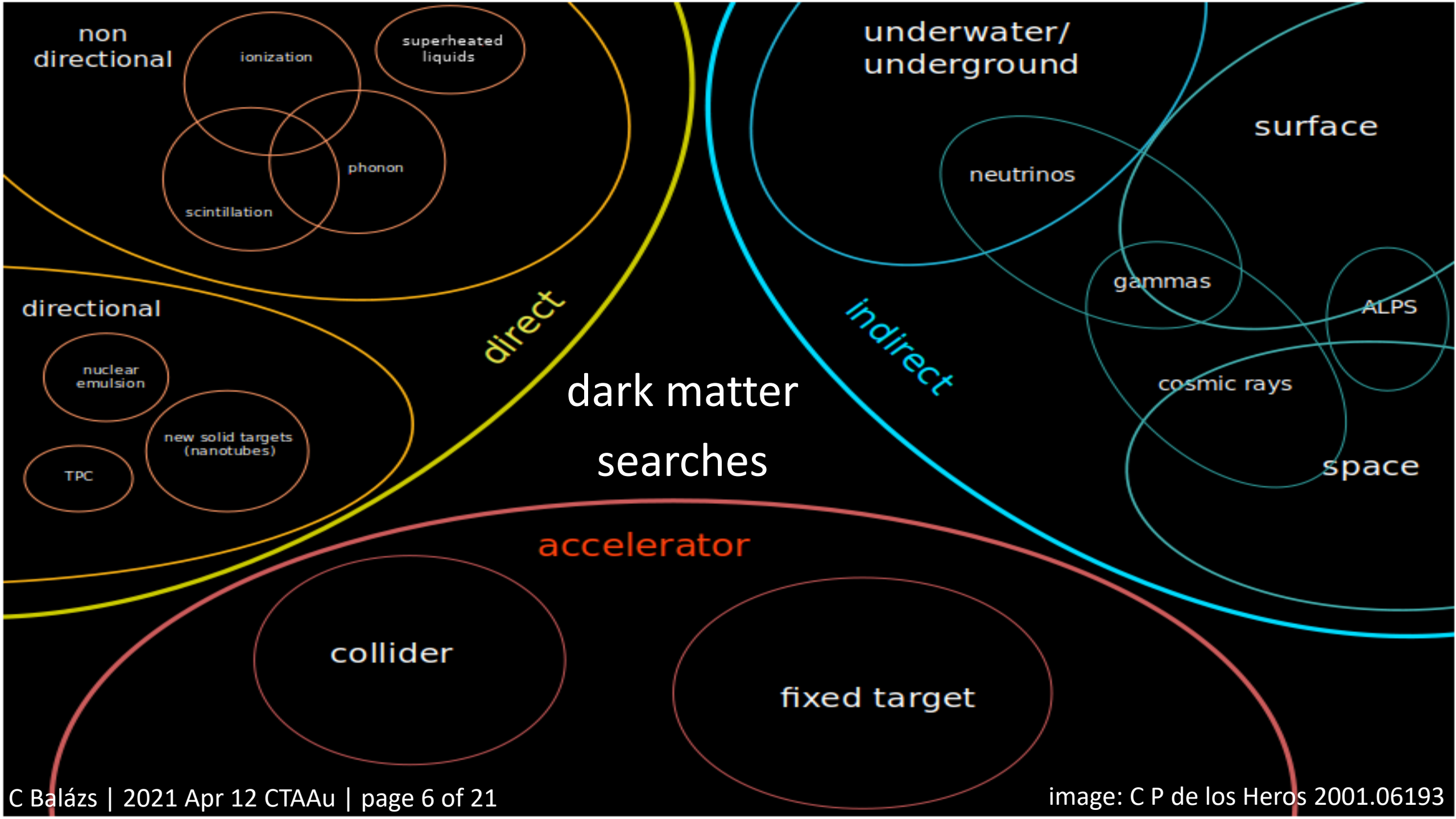
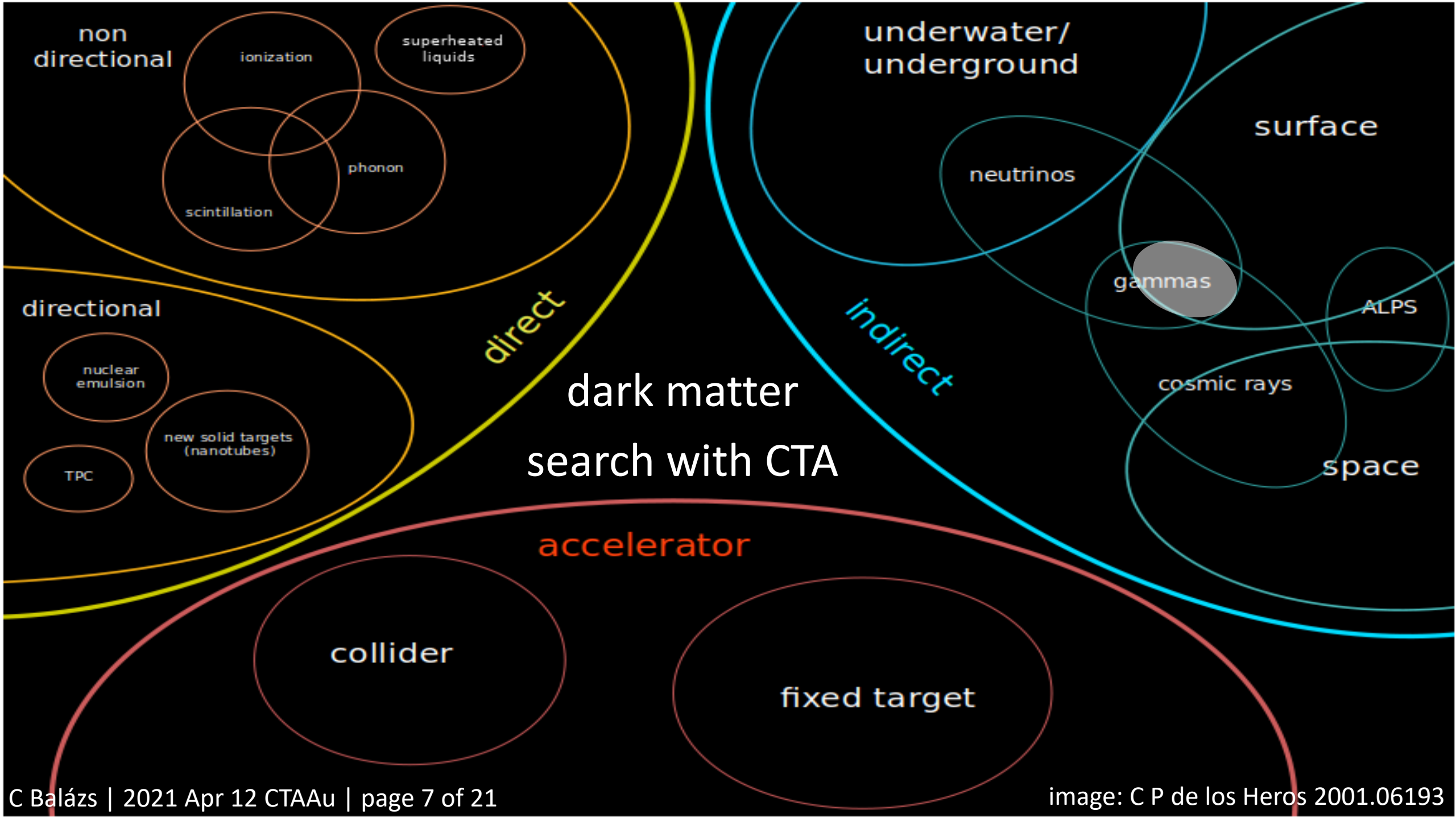


image: C P de los Heros 2001.06193



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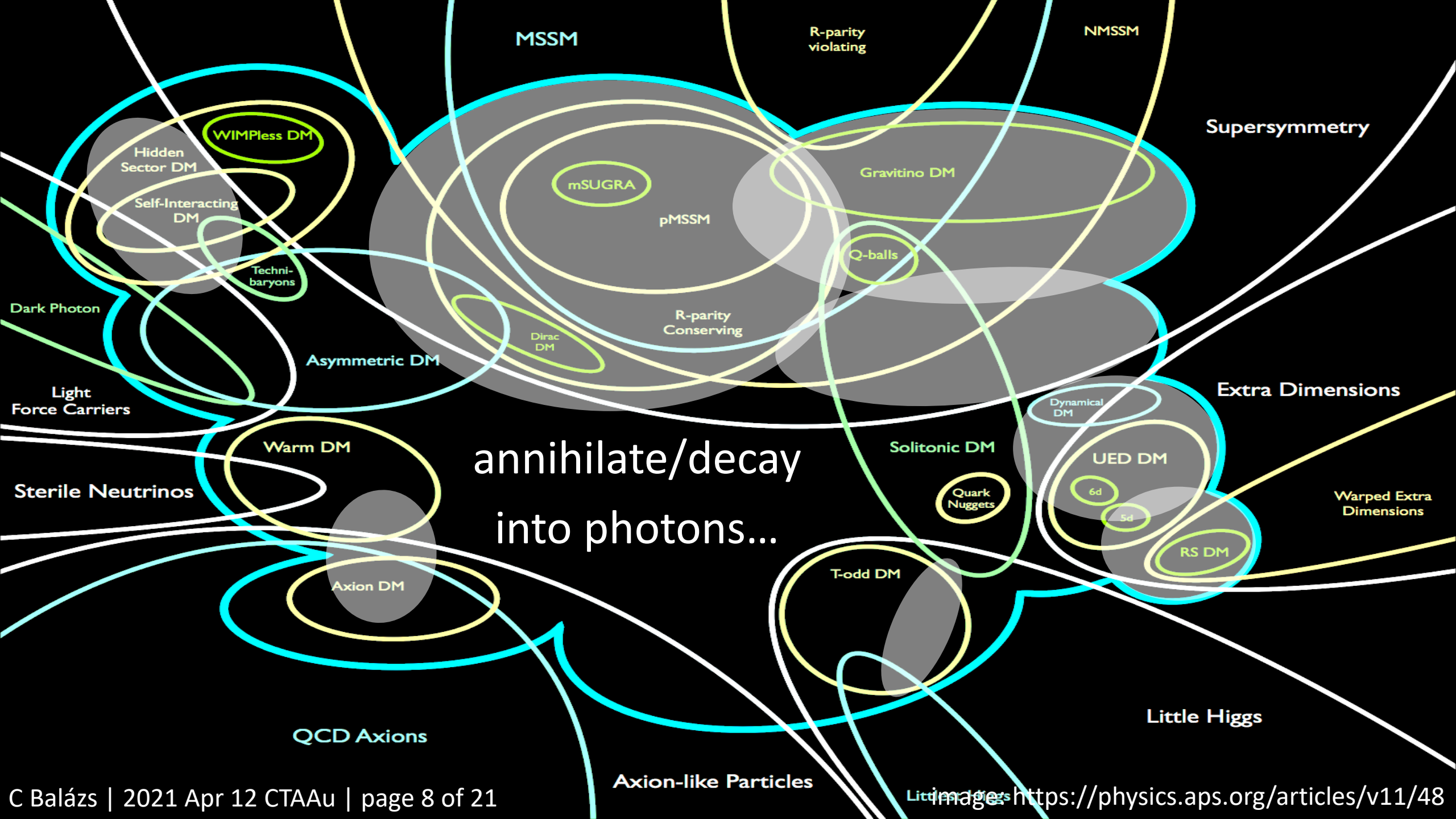
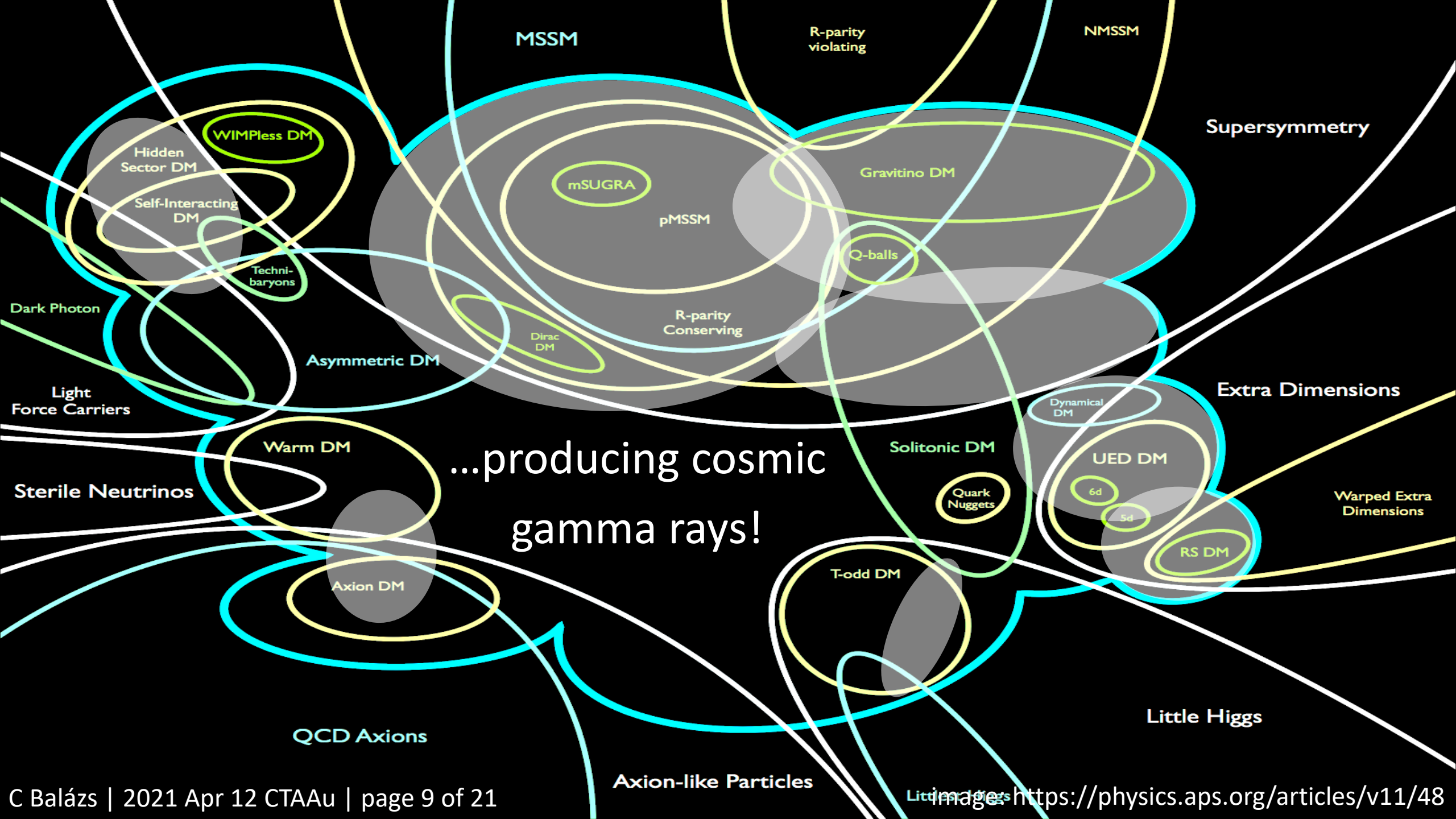


image: https://physics.aps.org/articles/v11/48



...producing cosmic gamma rays!

image: https://physics.aps.org/articles/v11/48

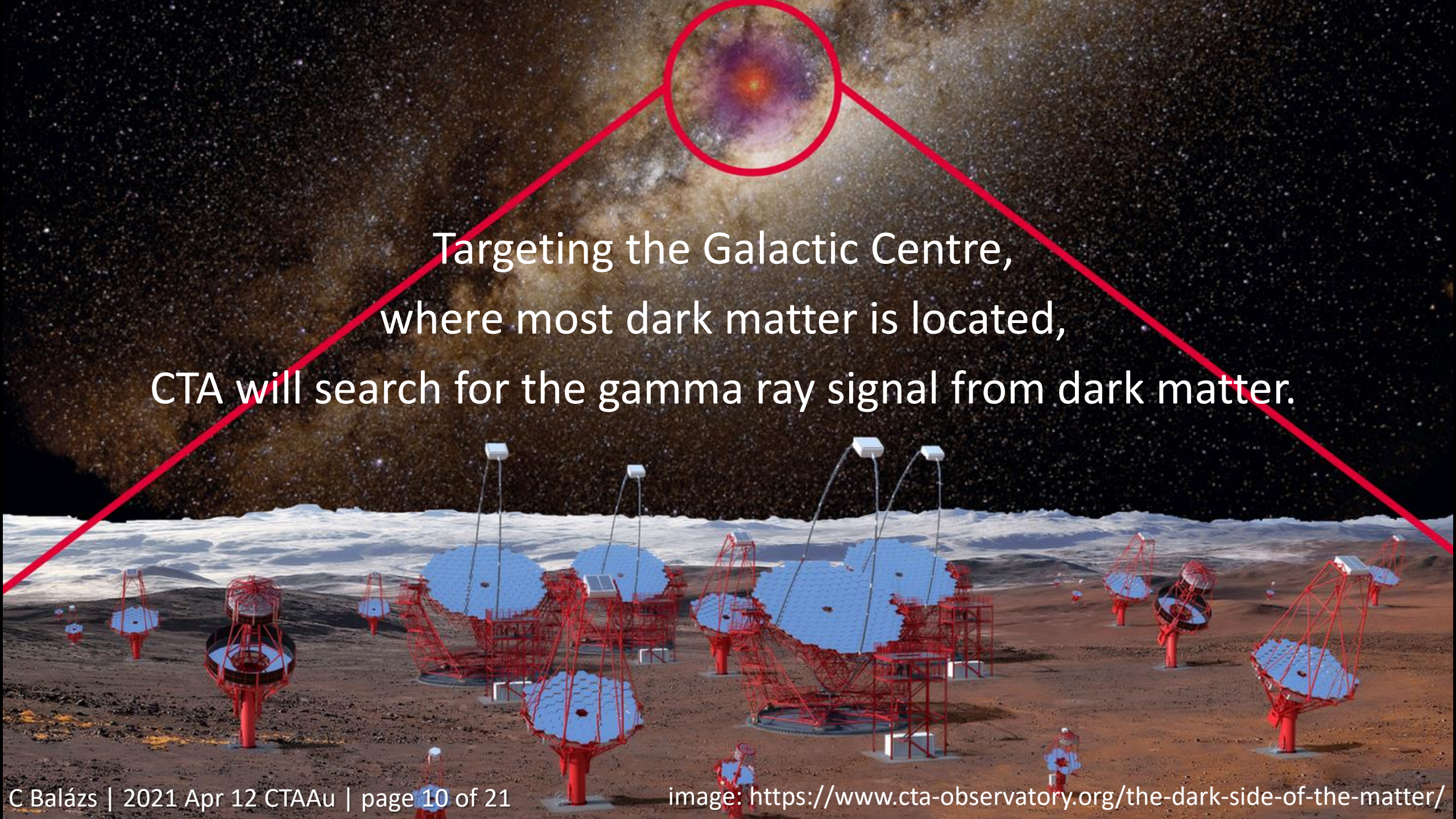


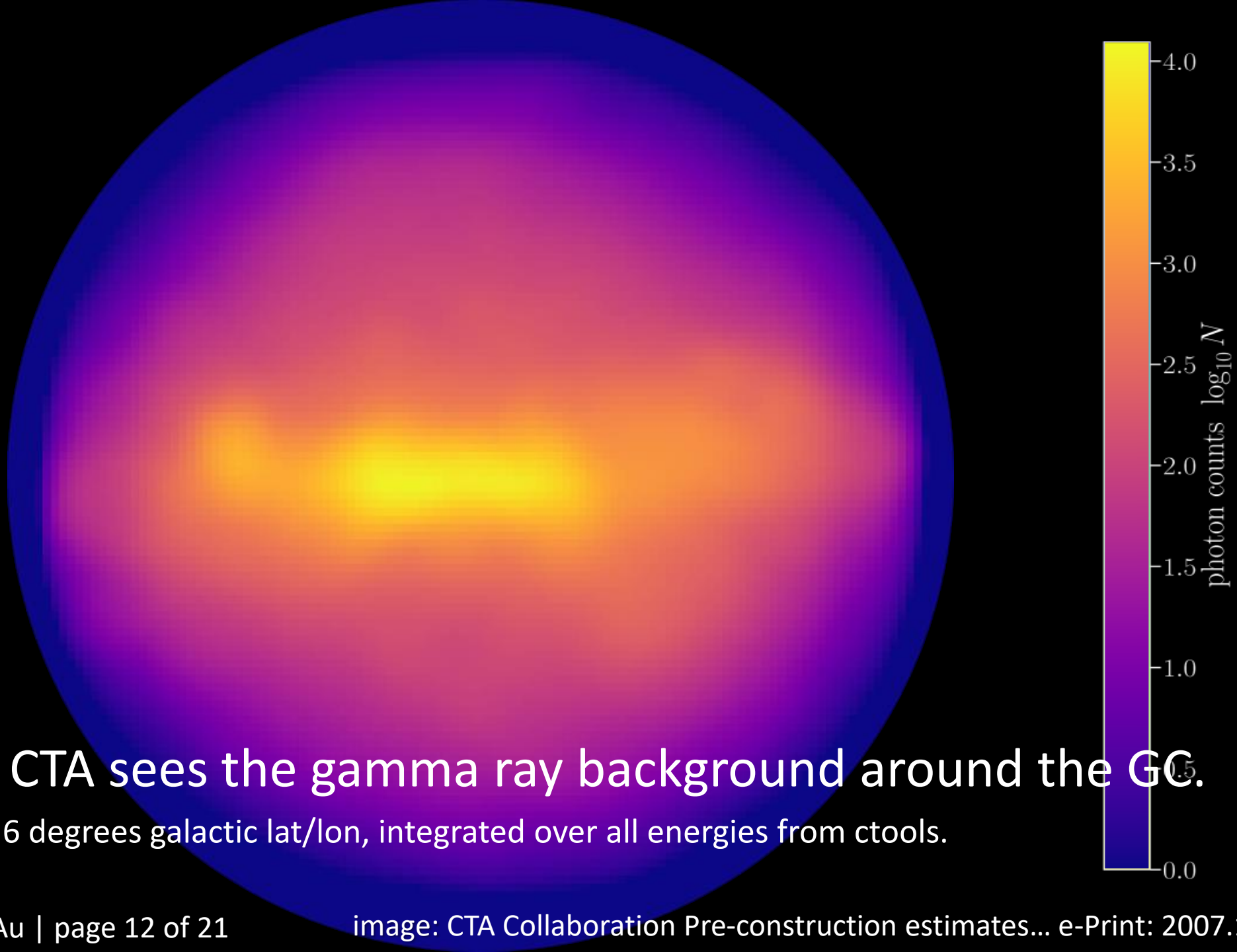
image: https://www.cta-observatory.org/the-dark-side-of-the-matter/

Target entre,

where ocated,

CTA will search for the gam rom dark matter.

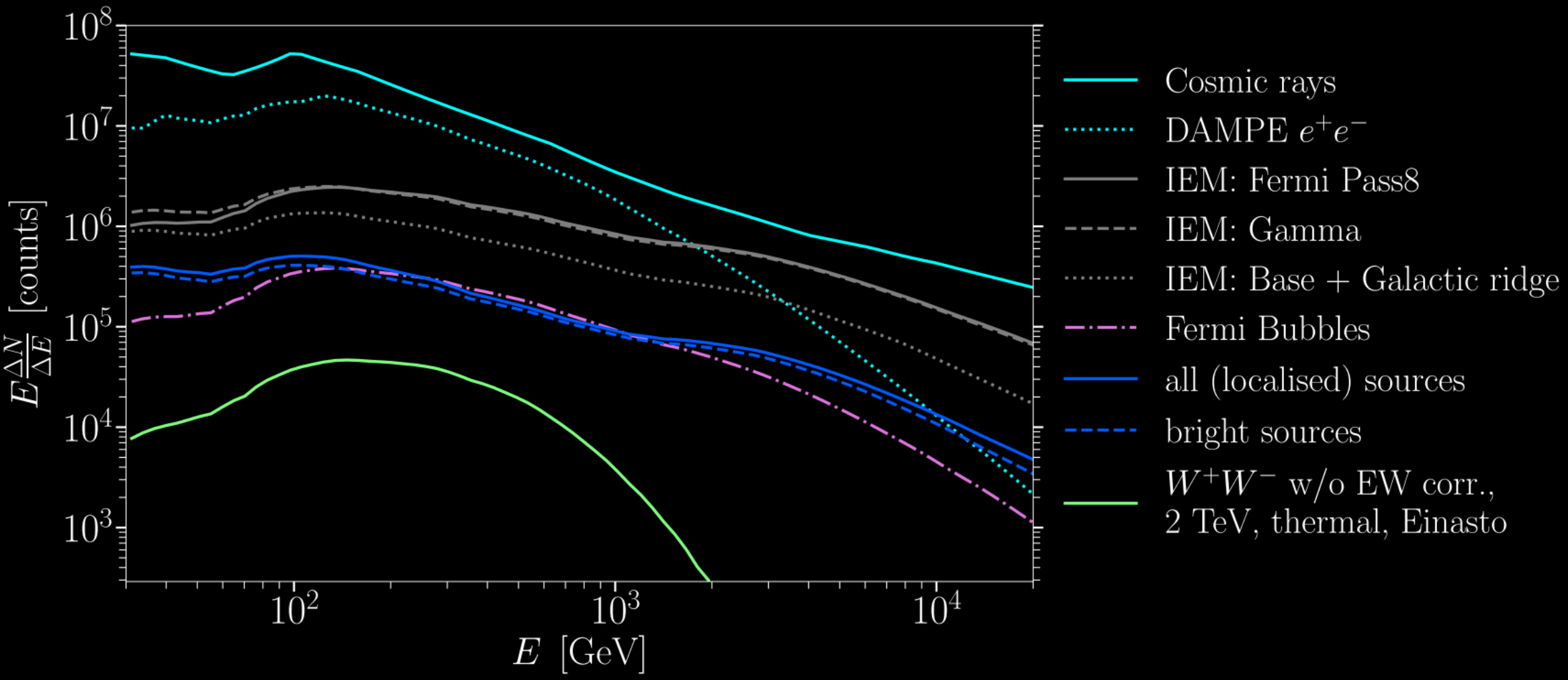
ge: https://www.cta-observatory.org/the-dark-side-of-the-matter/



This is how CTA sees the gamma ray background around the GC.

6 degrees galactic lat/lon, integrated over all energies from ctools.

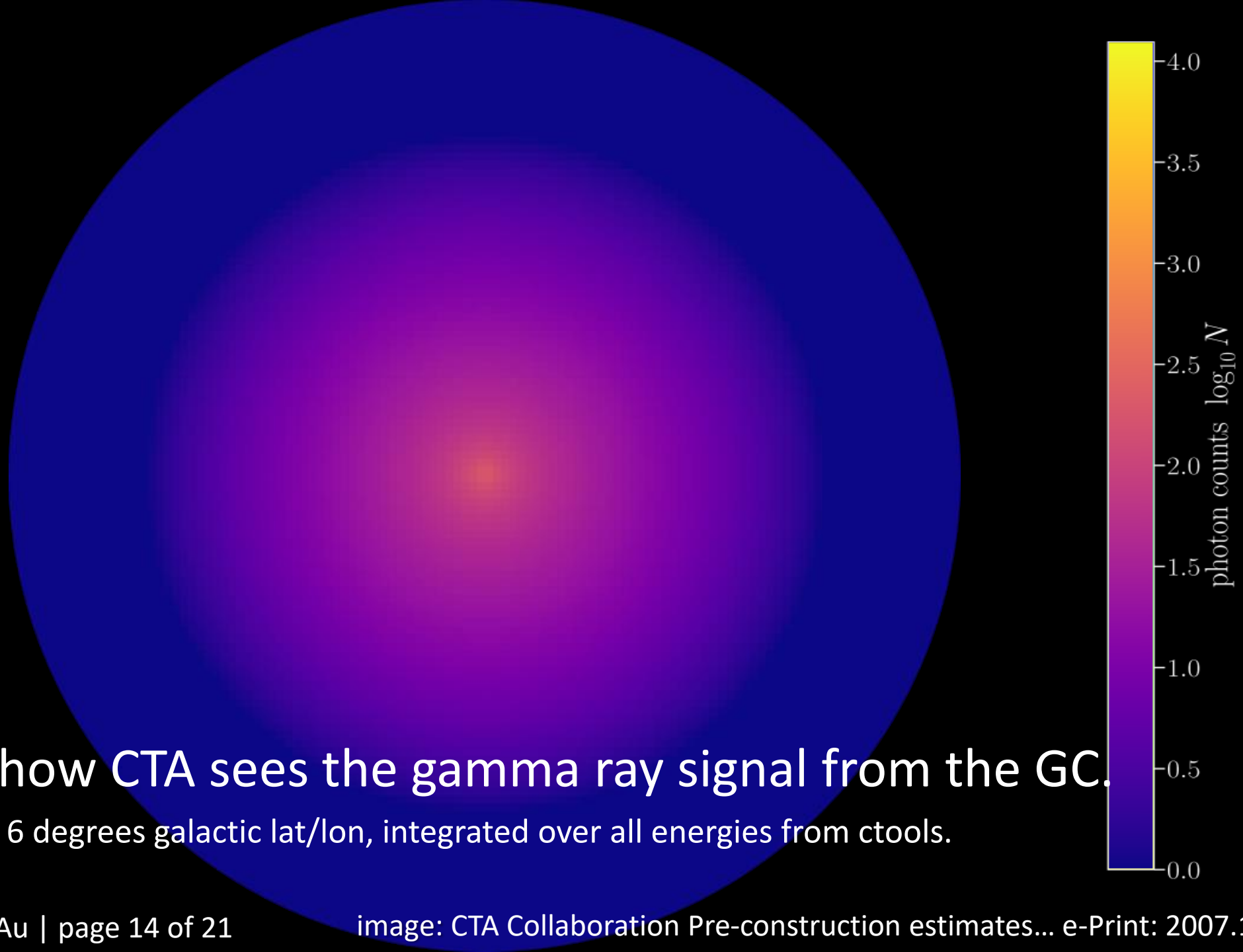
image: CTA Collaboration Pre-construction estimates… e-Print: 2007.16129



This is the gamma ray spectrum of the background around the GC.

Integrated over an observed area.

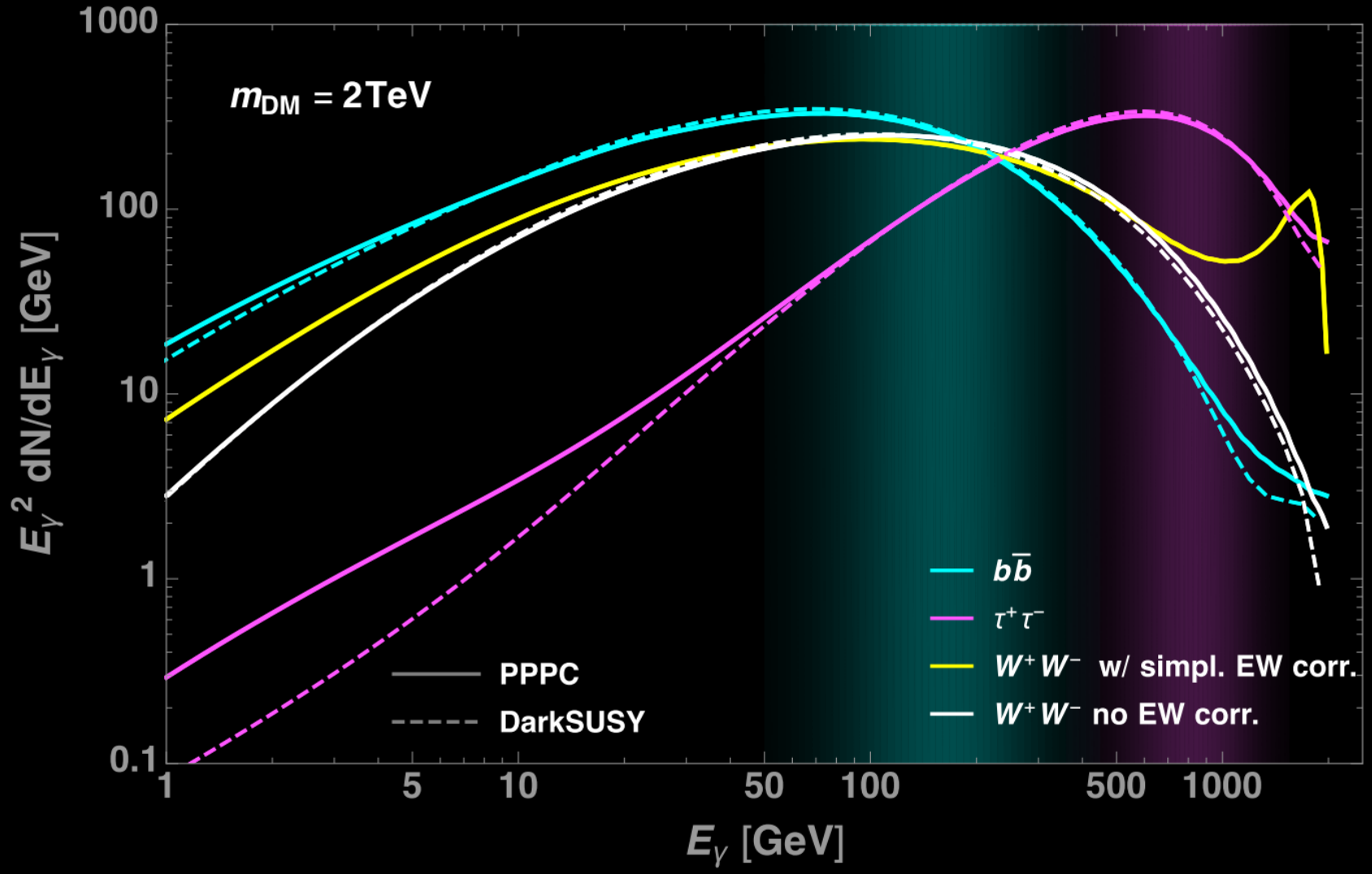
graphics: CTA Collaboration Pre-construction estimates… e-Print: 2007.16129



This is how CTA sees the gamma ray signal from the GC.

6 degrees galactic lat/lon, integrated over all energies from ctools.

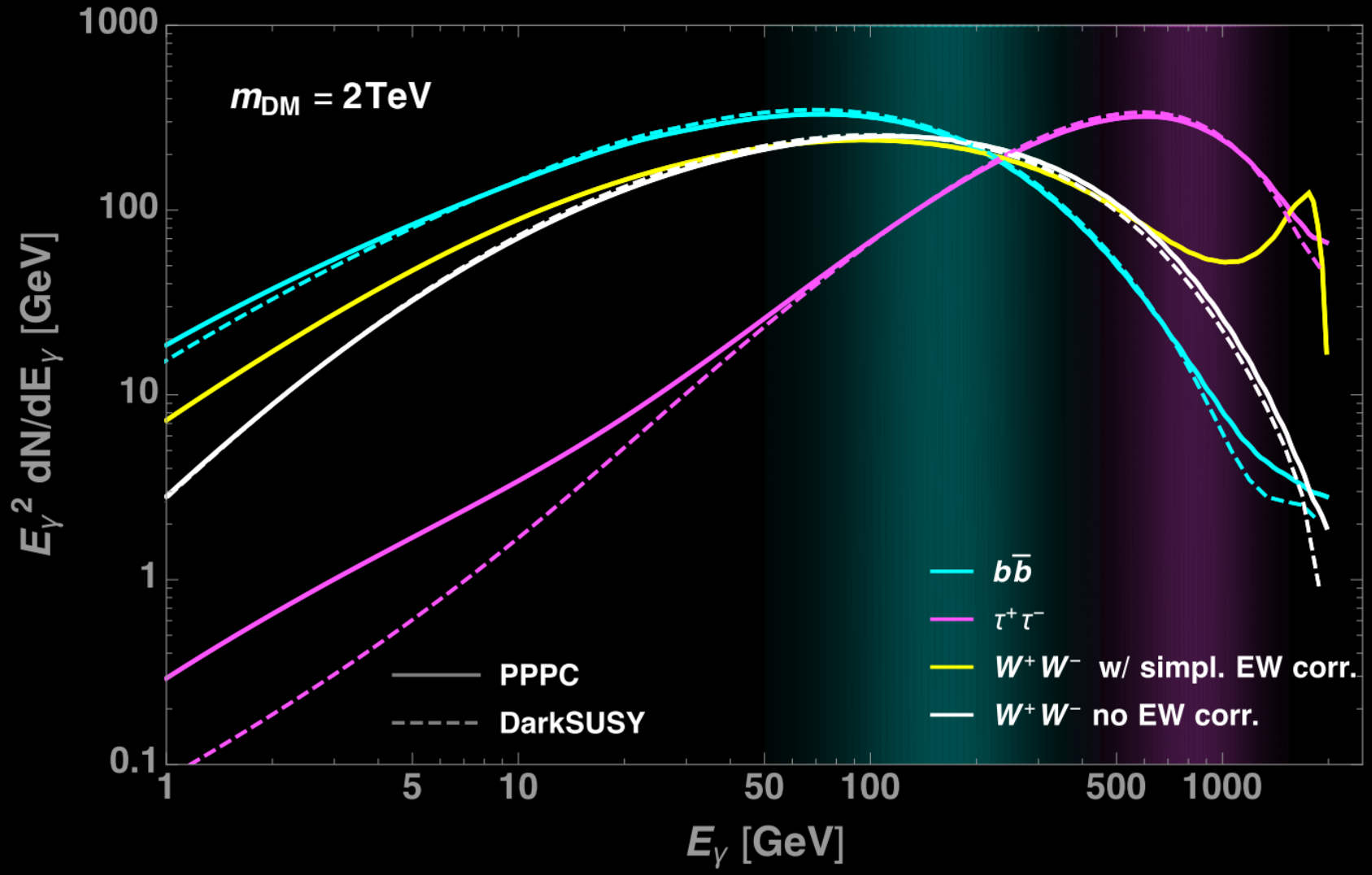
image: CTA Collaboration Pre-construction estimates… e-Print: 2007.16129



This is the gamma ray spectrum of a generic DM signal.

2 TeV Weakly Interacting Massive Particle (WIMP) annihilating into W^+W^-.

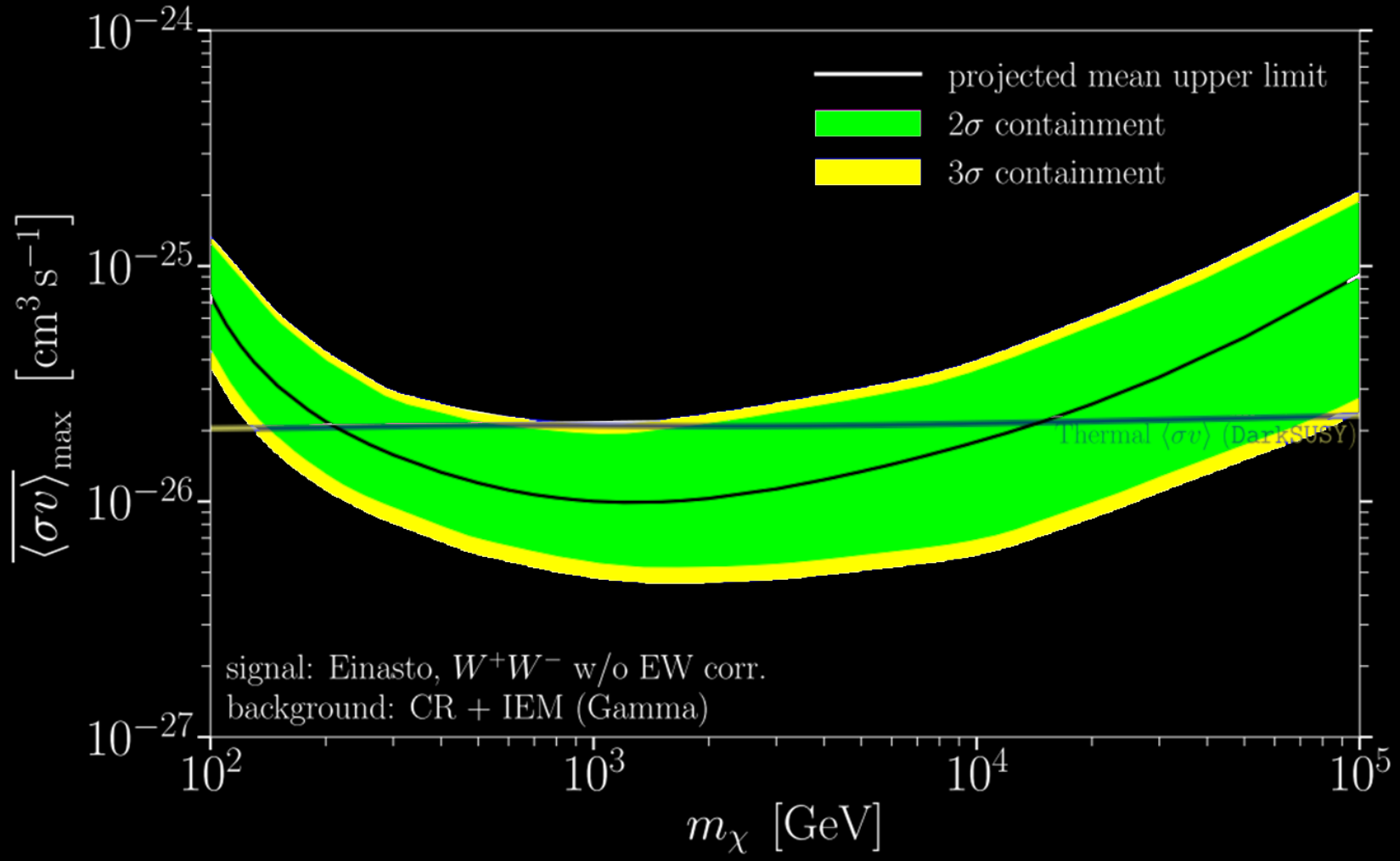
image: C. Balazs et al. based on arXiv:1512.02801



This is the gamma ray spectrum of a generic DM signal.

Shaded regions show where the signal is most important if the background falls like $E^{-2.7}$.

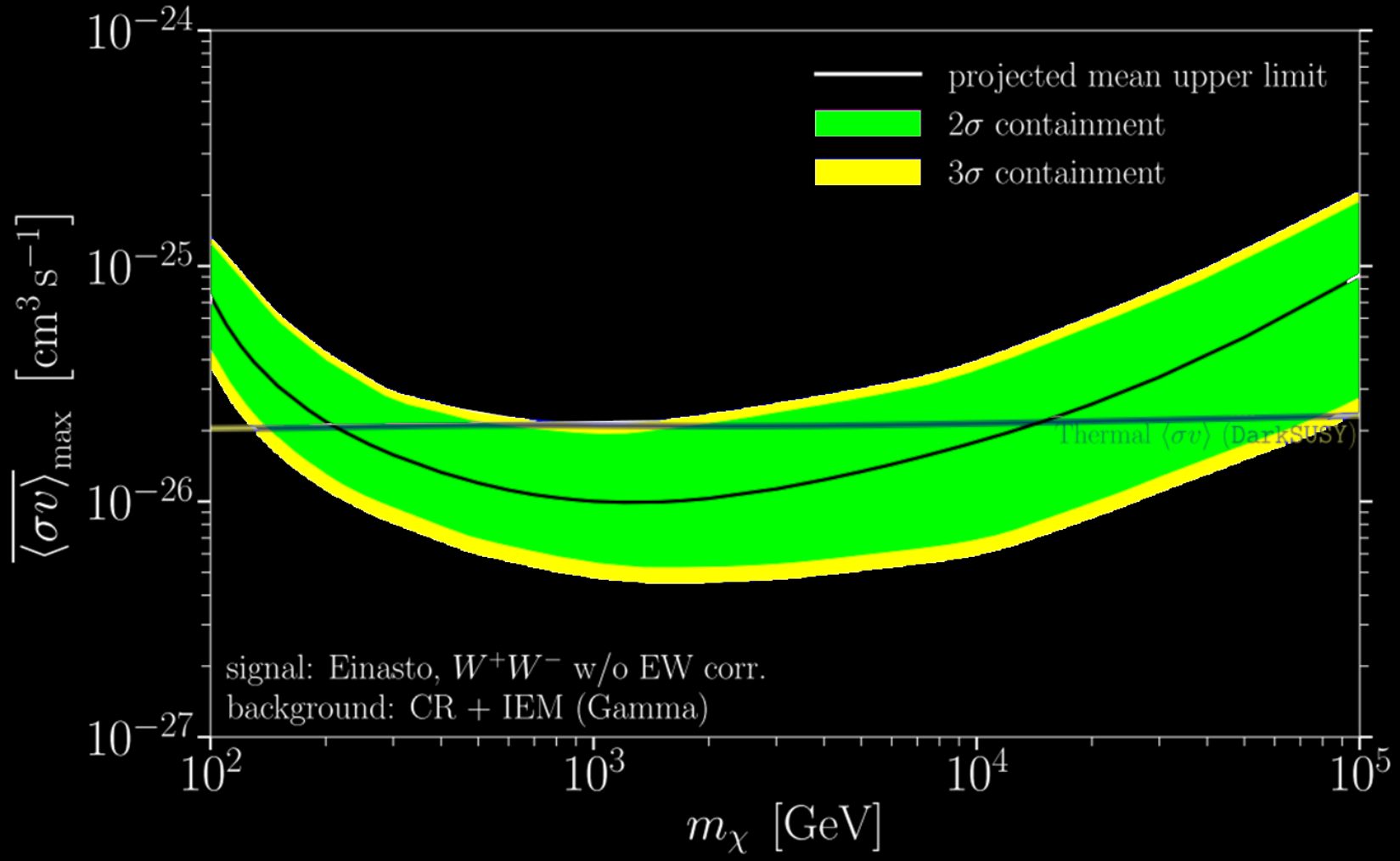
image: C. Balazs et al. based on arXiv:1512.02801



This is the projected sensitivity of CTA for a generic WIMP.

WIMP annihilating into W^+W^-. Region above solid curve is observable.

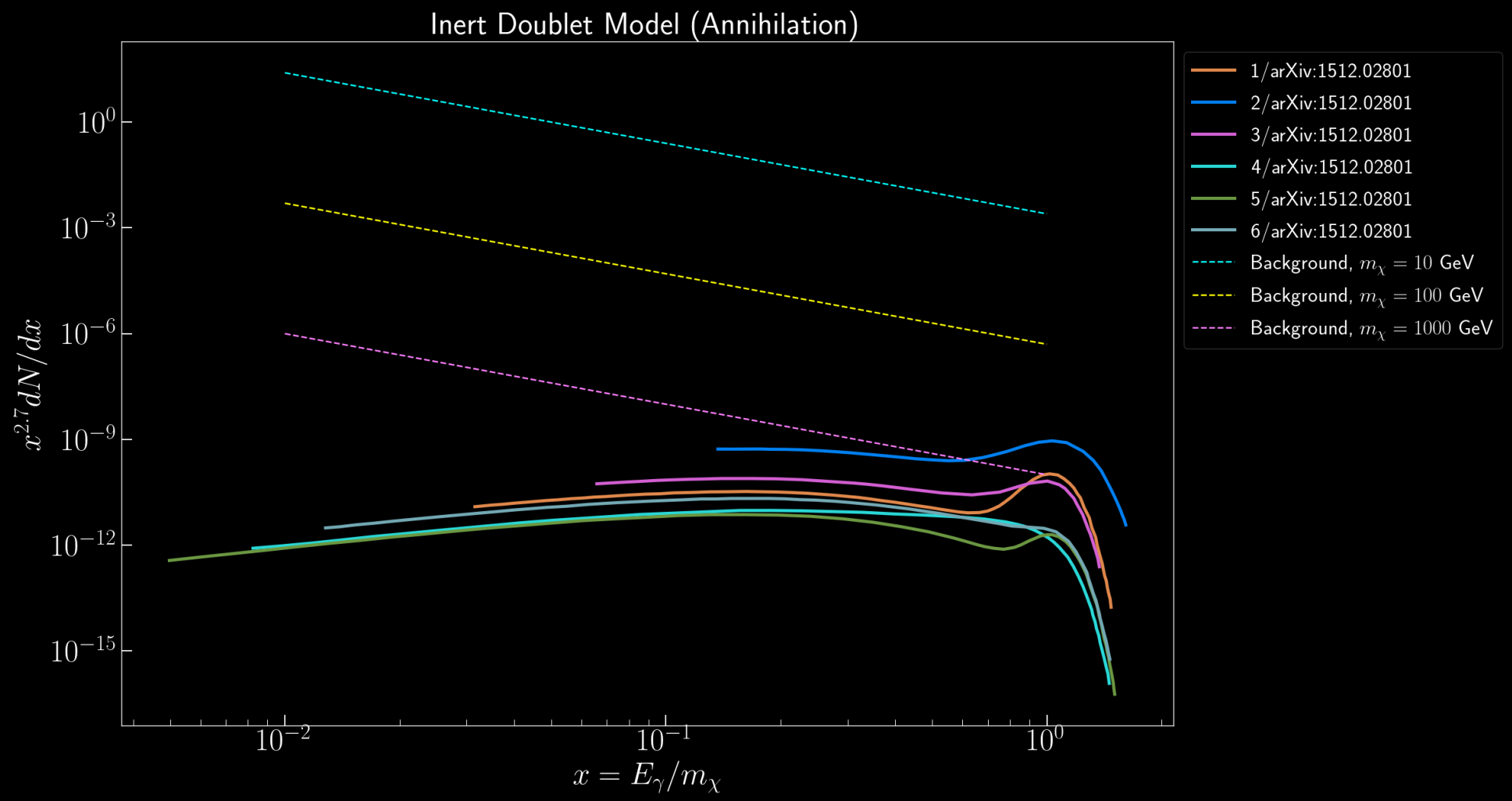
image: C. Balazs et al. based on arXiv:1512.02801



This sensitivity changes for a specific WIMP.

A specific WIMP produces various final states, thus a different gamma ray signal.

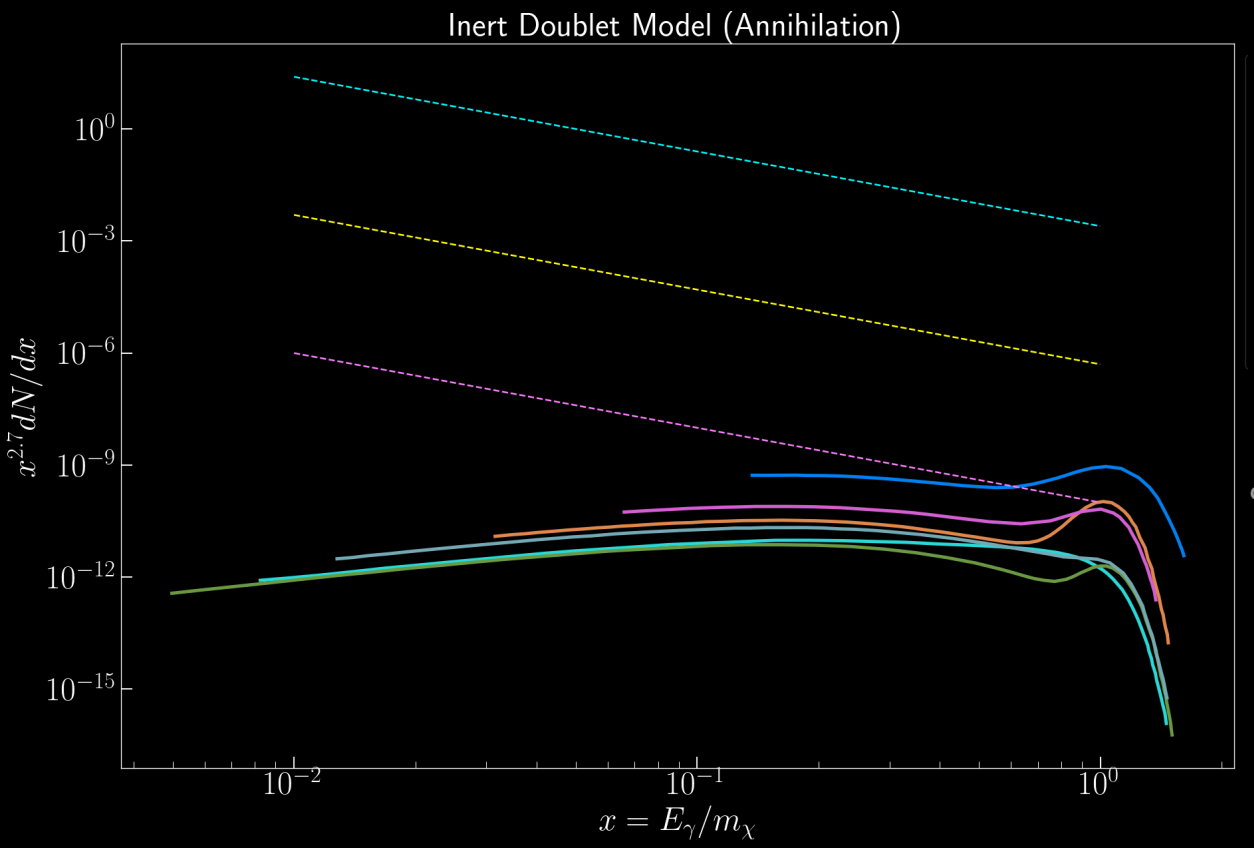
image: C. Balazs et al. based on arXiv:1512.02801

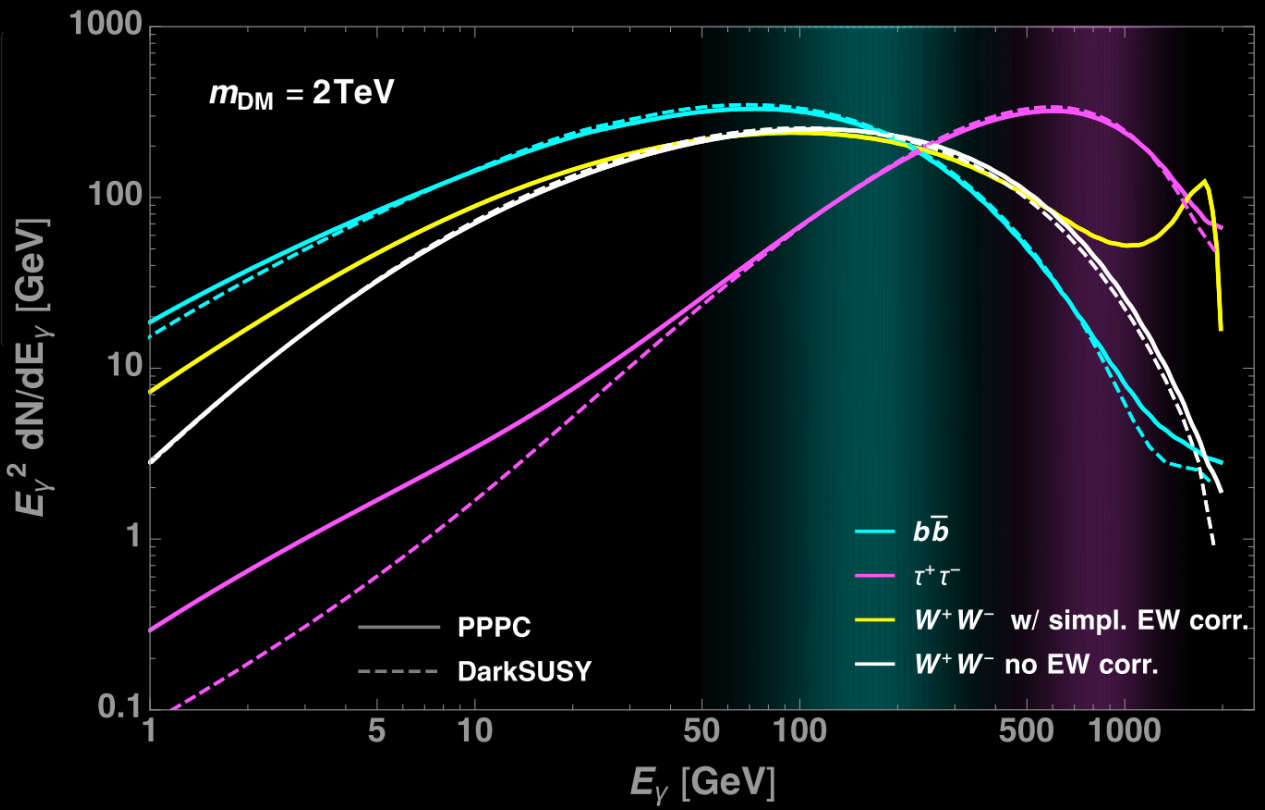


This is the gamma ray spectrum of an inert Higgs doublet.

The approximate background is shown in dashed.

image: C. Balazs et al. based on arXiv:1512.02801





We're in the process of reevaluating the CTA sensitivity for this...

...and several other specific WIMP models, such as right-handed neutrinos, Left-Right model, the MSSM...

image: C. Balazs et al. based on arXiv:1512.02801

CTA will be crucial in the hunt for dark matter.

It will be able to discover or rule out various WIMP candidates.

The CTA sensitivity is highest for 100 GeV – 1 TeV WIMPs.

Results of our analysis are coming soon!