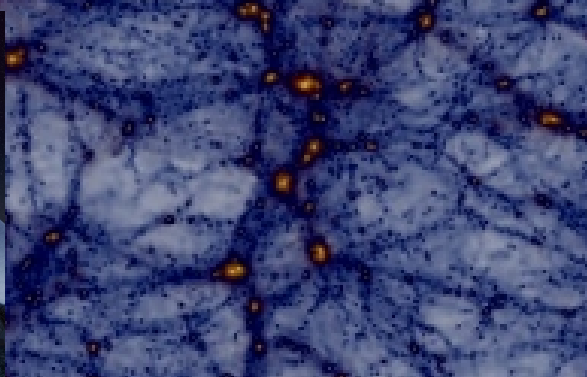


# PARTICLE DARK MATTER WITH THE SKAO




UNIVERSITÀ  
DI TORINO

Marco  
Regis



# Why Particle Dark Matter?

## Possible solutions of the DM problem:

Baryonic DM  Primordial black holes  
"QCD balls"

Modified gravity

New particle beyond  
the Standard Model

 WIMPs  
Axions (and ALPs)  
Dark Photons  
....

# Weakly Interacting Massive Particles

~ weak interactions and ~ GeV-TeV mass

→ **WIMP miracle**

but also..

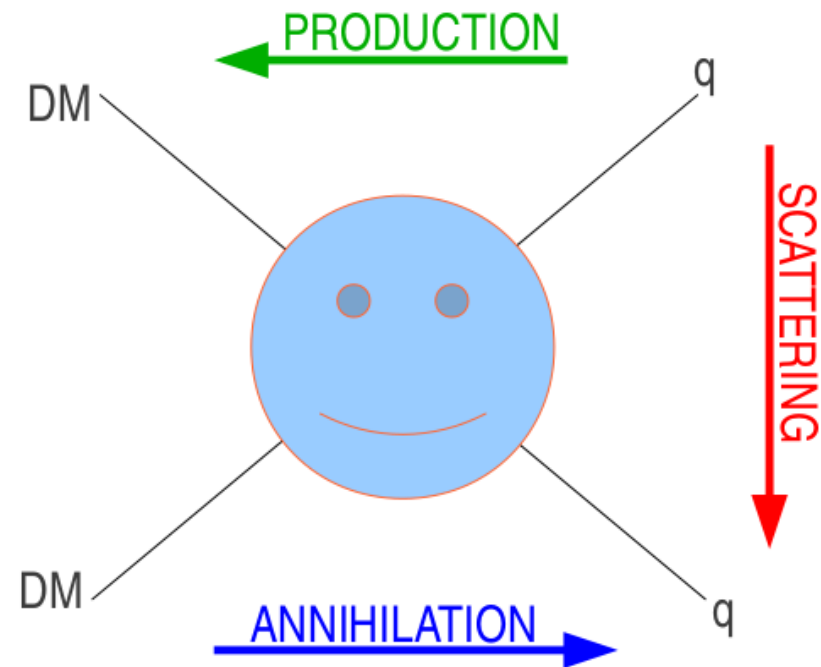
Production at colliders

Direct detection

[kinetic decoupling, capture in astrophysical objects]

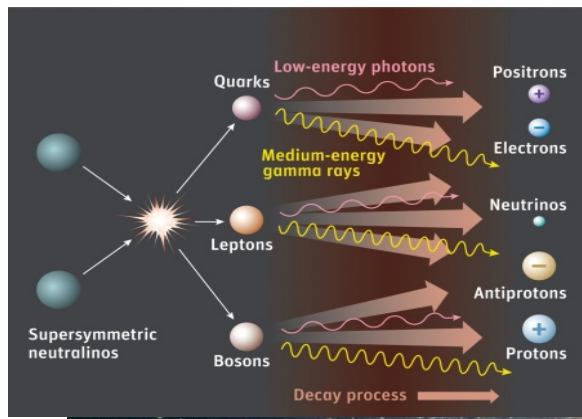
Indirect detection

[relic density, history of the Universe]





# Synchrotron radiation induced by WIMPs

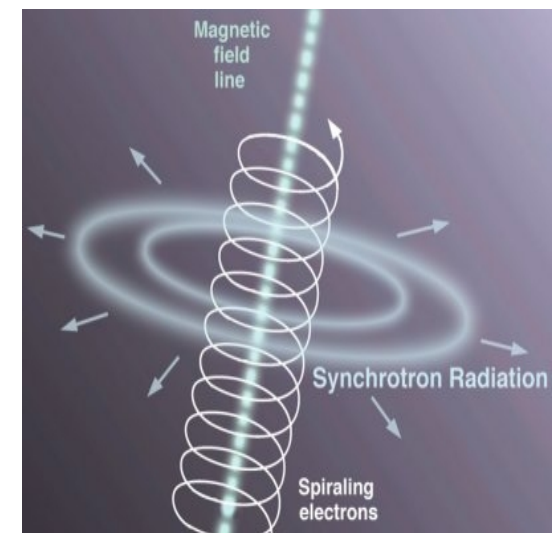


WIMP annihilations in astrophysical structures  
→ fluxes of **electrons** and **positrons** (at GeV-TeV energy).

If emitted in a medium with **magnetic field** → radio continuum diffuse emission

Energy corresponding to the peak of **synchrotron** power (in the monochromatic approximation):

$$E \simeq 15 \sqrt{\nu_{\text{GHz}} / B_{\mu\text{G}}} \text{ GeV}$$



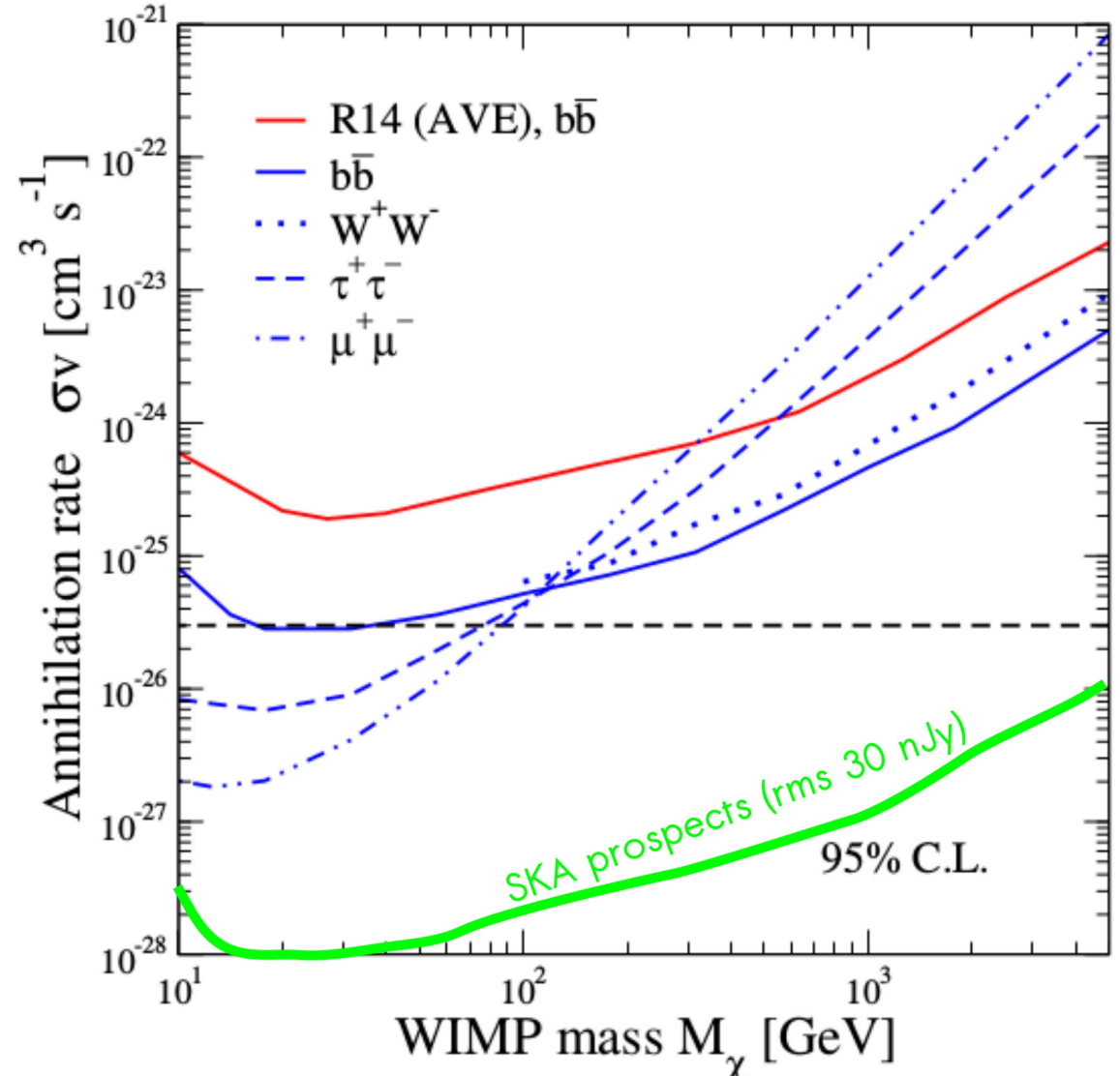
# Example I: dwarf spheroidal galaxies

ATCA observations (two campaigns - 2011 and 2016)

16 cm band

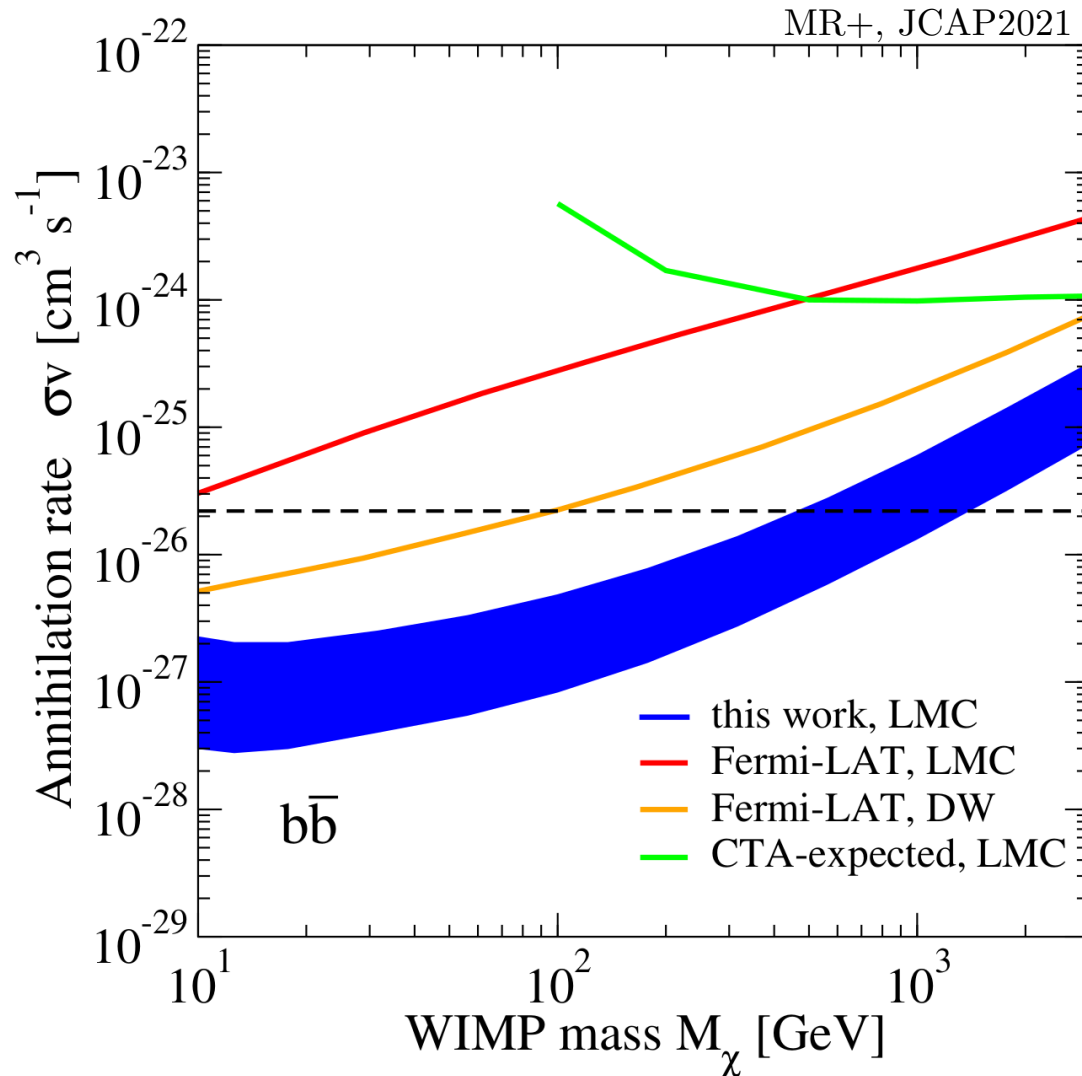
**Targets:** BootesII, Carina,  
Fornax, Hercules,  
ReticulumII, Sculptor,  
Segue2

(MR et al., MNRAS 2015,  
JCAP2014, JCAP 2017)



# Example II: Large Magellanic Cloud

## ASKAP observations



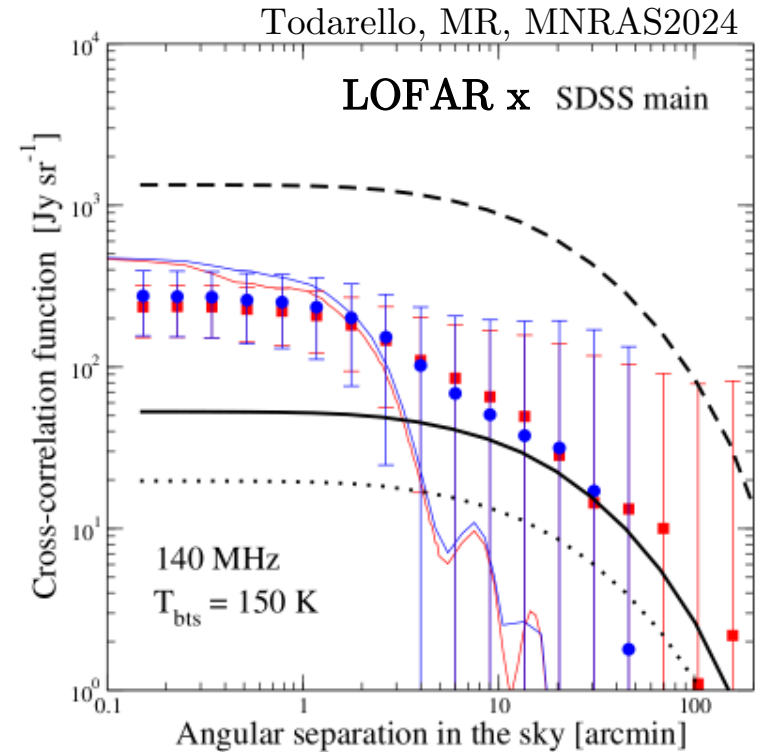
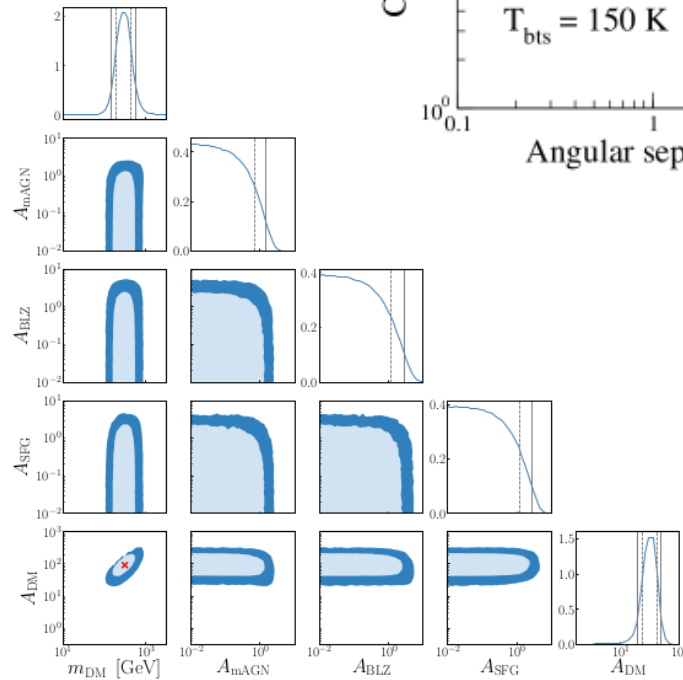
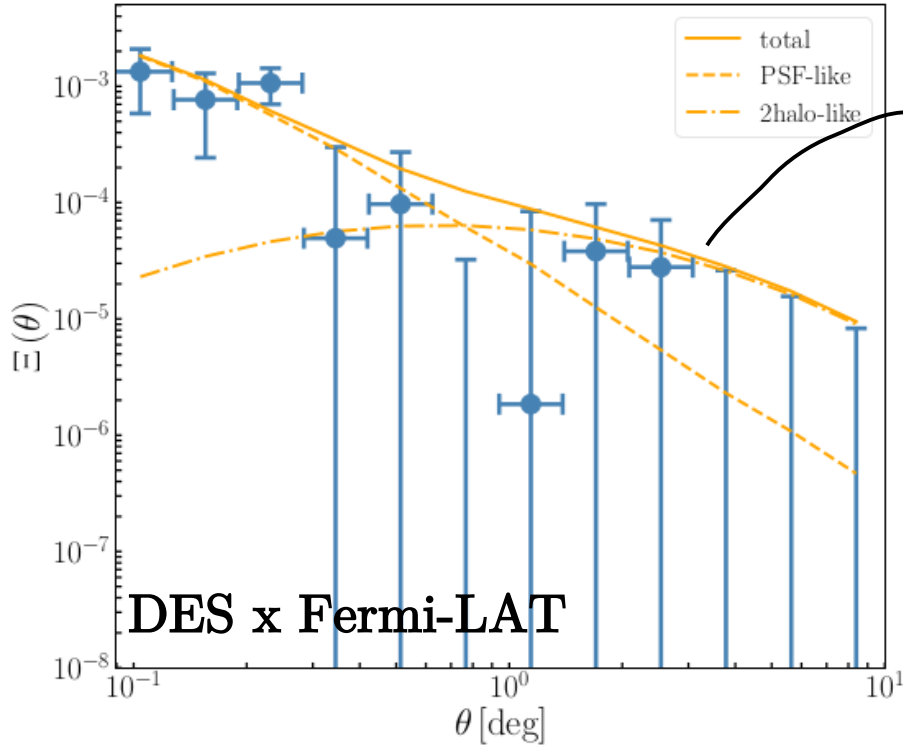
Very competitive  
bounds!

# Task for the Cosmology SWG

## Angular cross-correlation of radio background with DM tracers

Same approach as for gamma-ray studies

Ammazzalorso, MR, Camera, + PRL2020

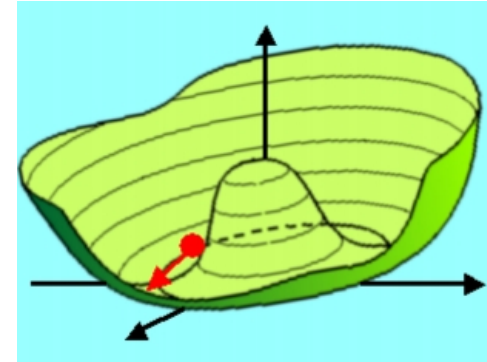


Todarello, MR, MNRAS2024



# ALPs (axion-like particles)

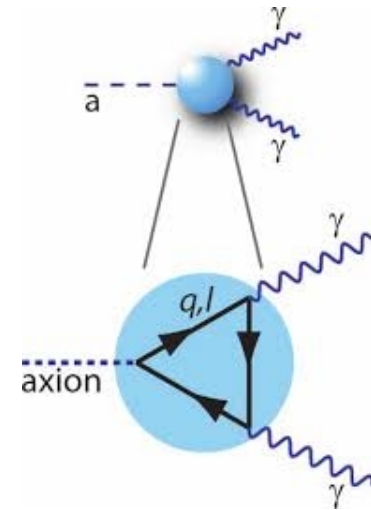
(pseudo-)scalar particles  
mainly pseudo-Nambu-Goldstone bosons  
(QCD axion, “stringy” axions, ...)



## photon coupling:

ALP-photon coupling described by the low-energy

effective Lagrangian:  $\mathcal{L} = -\frac{1}{4}g_{a\gamma\gamma} a F_{\mu\nu} \tilde{F}_{\mu\nu}$



→ decay/conversion into photon(s)

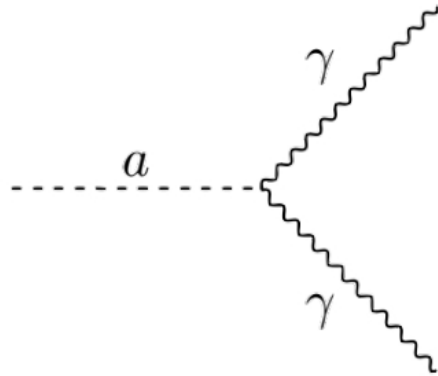
→ “monochromatic” emission for non-relativistic ALPs



# ALP phenomenology (photons)

The ALP-photon coupling  $\rightarrow$  phenomenology related to

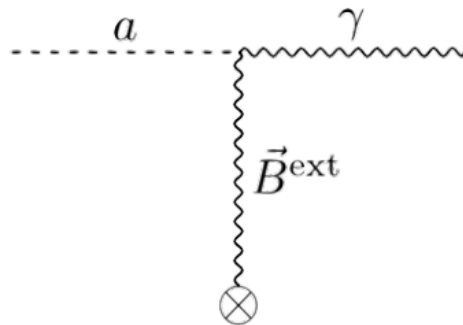
**decay**



**Stimulated decay**

$\rightarrow$  needs large background field

**conversion**



needs **large magnetic field**

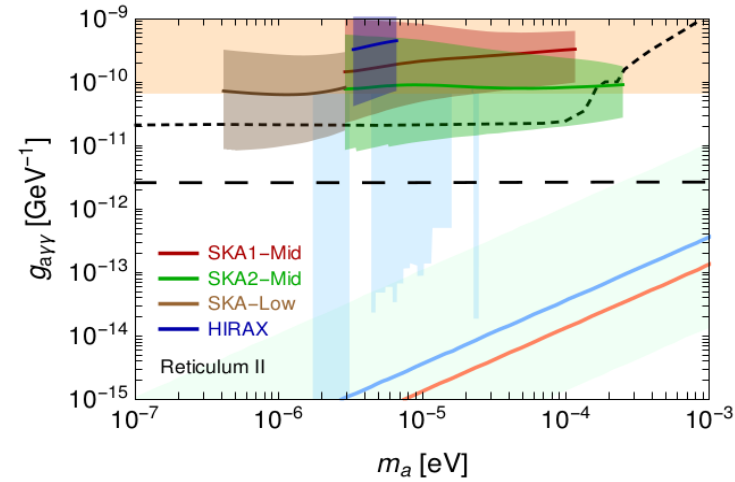
(e.g. neutron stars, Sun)

(Similar phenomenology for the conversion of dark photon into visible photon)

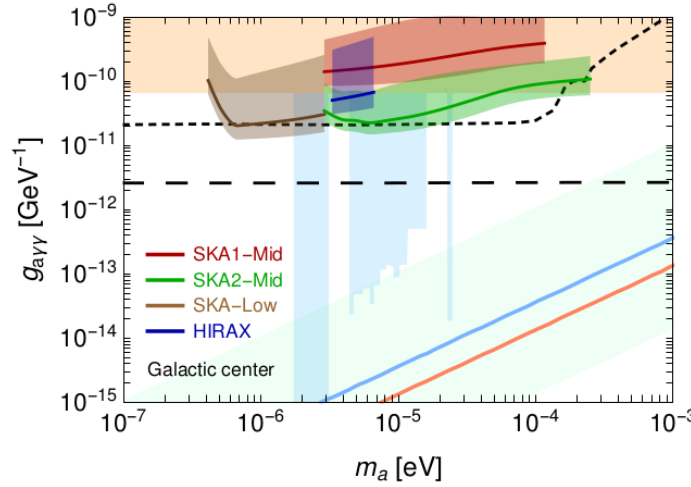
# Some examples

Caputo, MR, Taoso, Witte JCAP2019

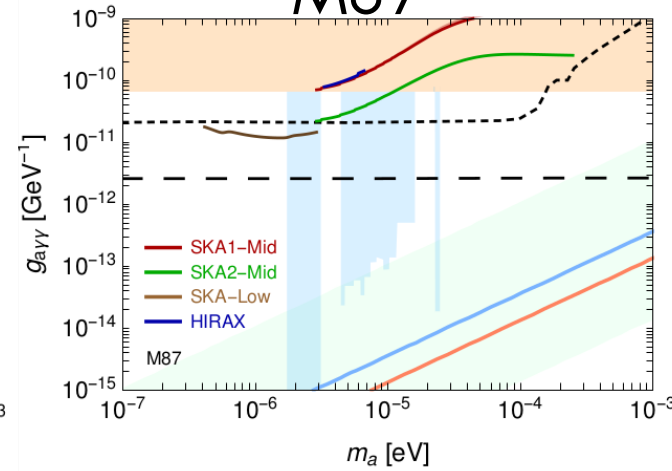
## dSph galaxy



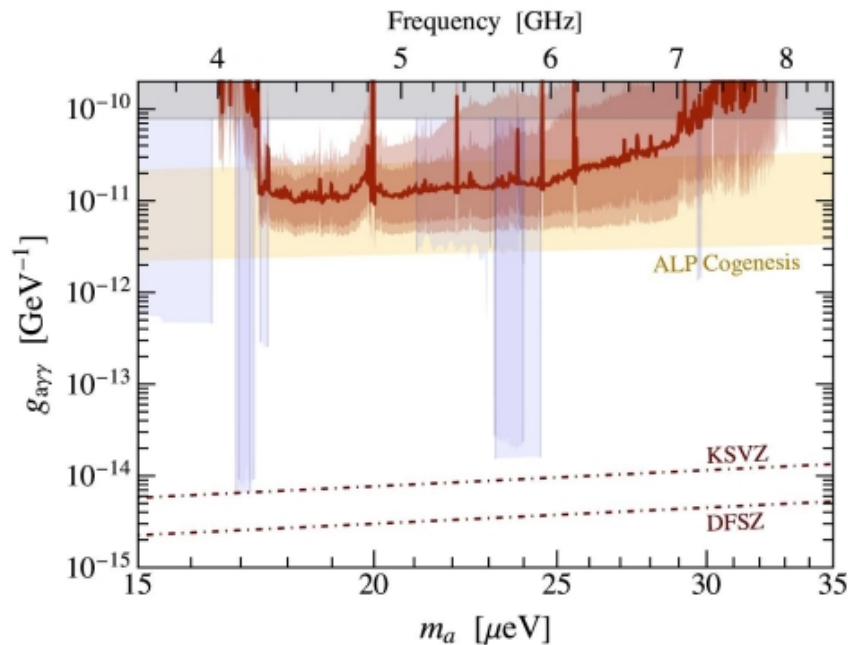
## Galactic Center



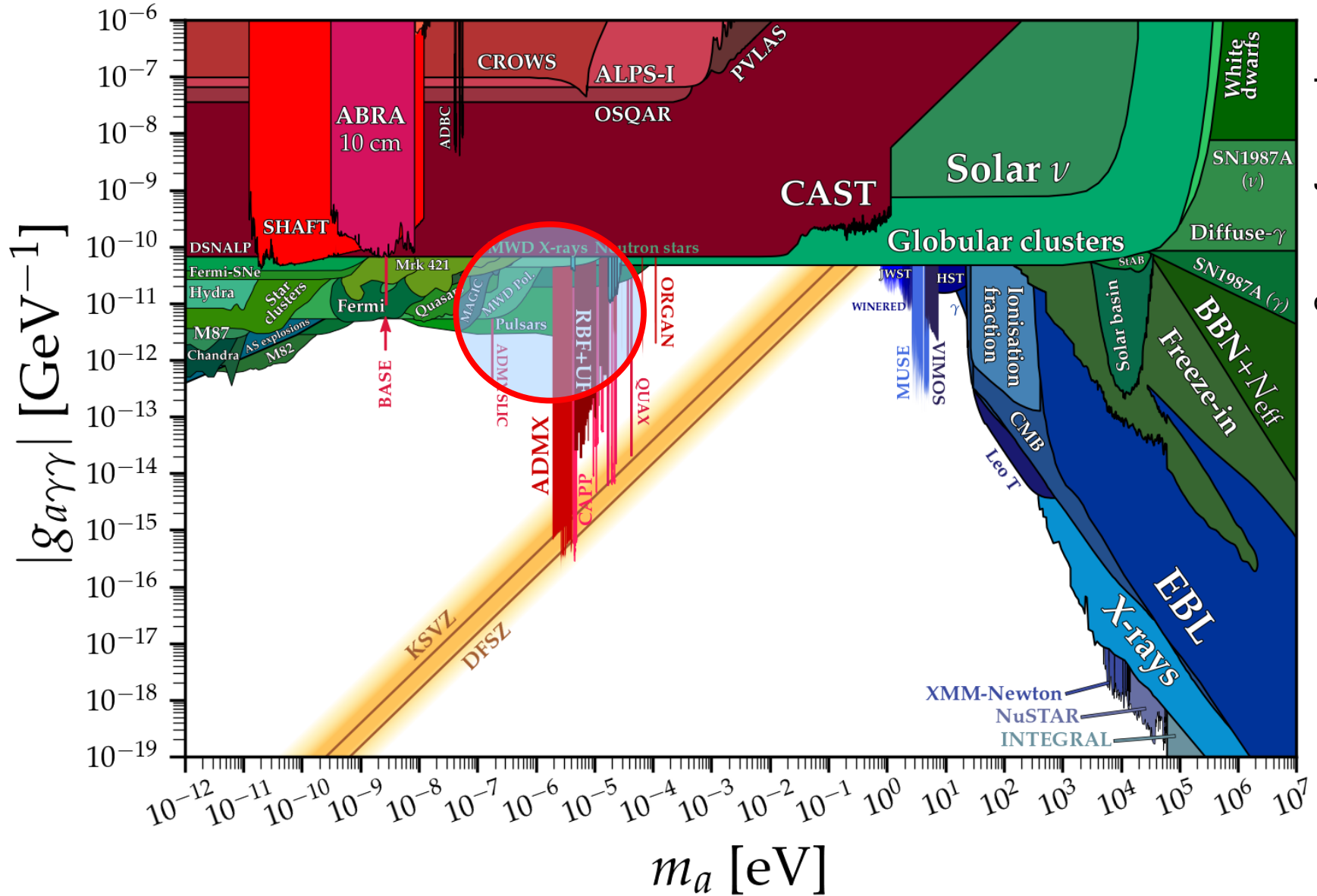
## M87



GBT observations  
Galactic Center  
Foster+, PRL2022



# $\mu\text{eV}$ ALPs $\rightarrow$ radio



<https://cajohare.github.io/AxionLimits/>

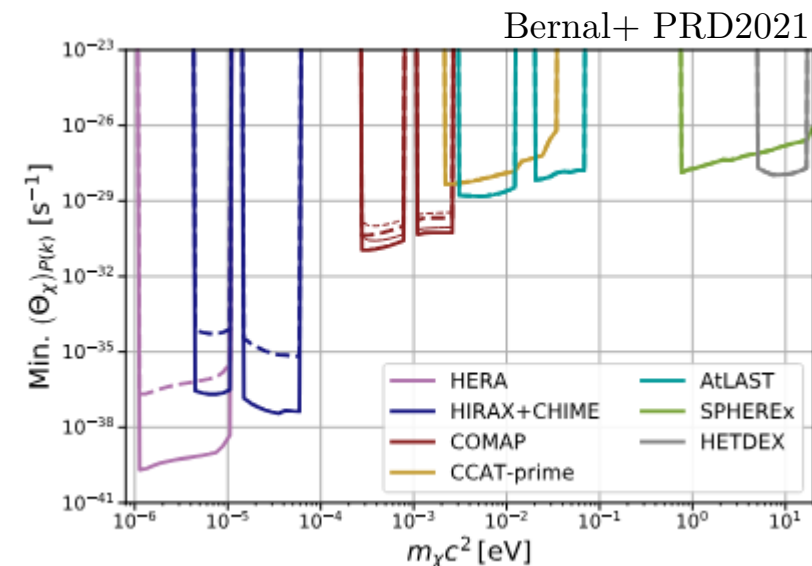
# Task for the Cosmology SWG

## Intensity mapping with the axion line

(Cosmological radio emission from decay of axion-like particles in DM halos)

→ collection of lines at different wavelength and each line corresponds to a given redshift

→ cross correlation of the radio emission line signal with the spatial position of galaxies in redshift surveys





## Probing the fundamental nature of Dark Matter with the SKA

Update of the 2014 chapter “Probing the nature of Dark Matter with the SKA”, Colafrancesco, MR, +

### SWGs somehow involved

- Magnetism
- Cosmology
- Extragalactic Continuum
- Extragalactic Spectral Line

Current participants: MR, G. Bernardi, G. Beck, P. Marchegiani, ...