# The Self-Confinement of electrons and positrons from Dark Matter

based on MR+, JCAP08(2023)030, [arXiv:2305.01999]


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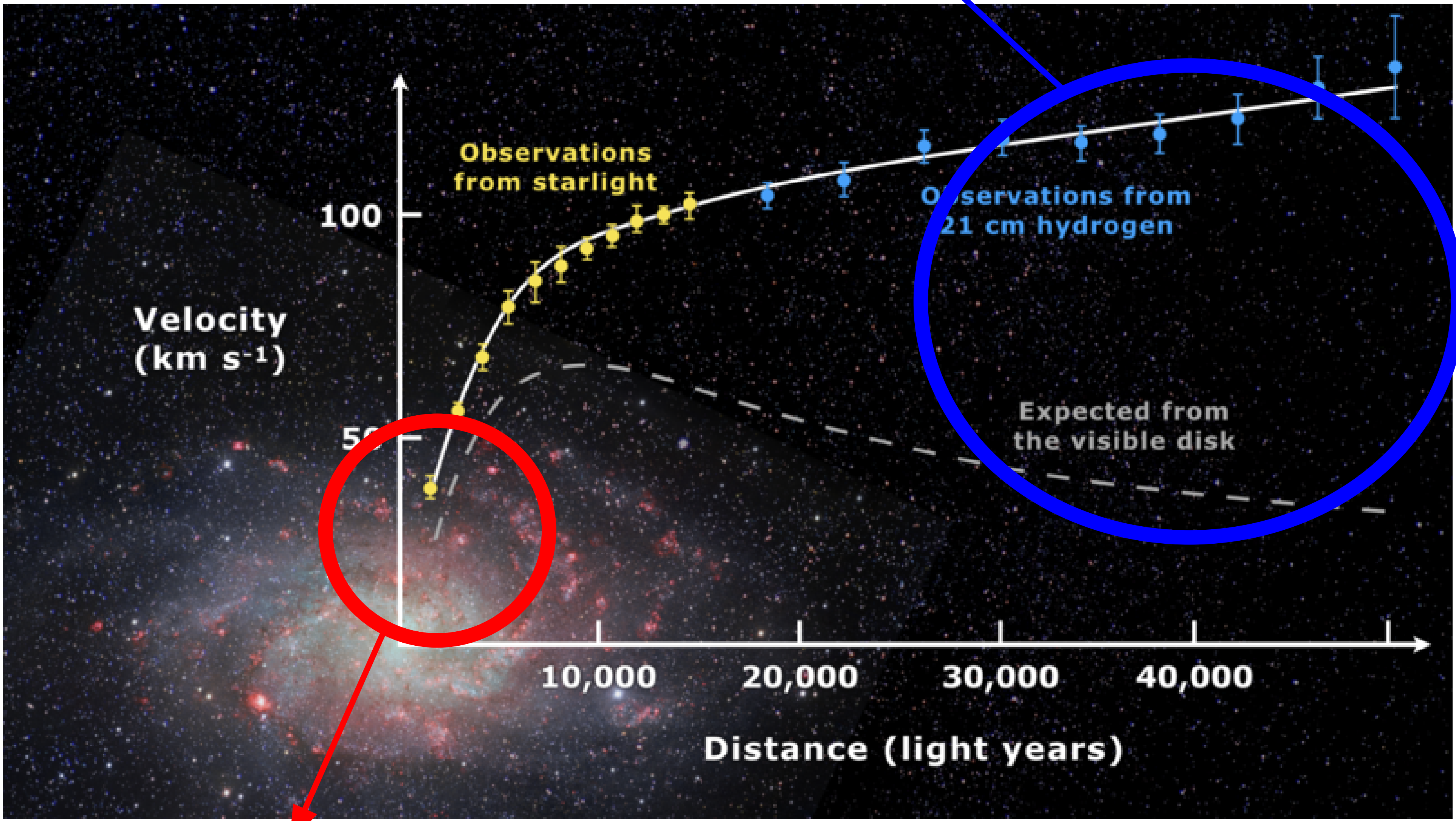
# Gravitational evidences of dark matter

Solid evidence since 1970-'80s




Bergstrom 00, superimposing RC from Corbelli&Salucci 99 and NED optical image

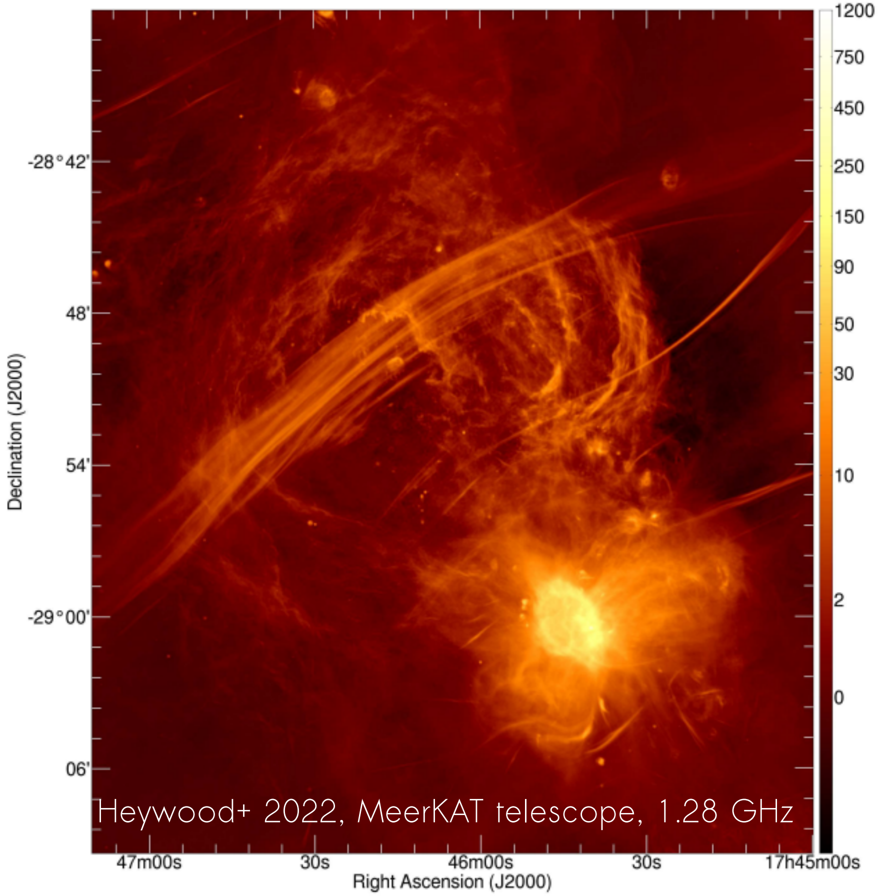
Still under debate

# Where to look for non-gravitational DM signal

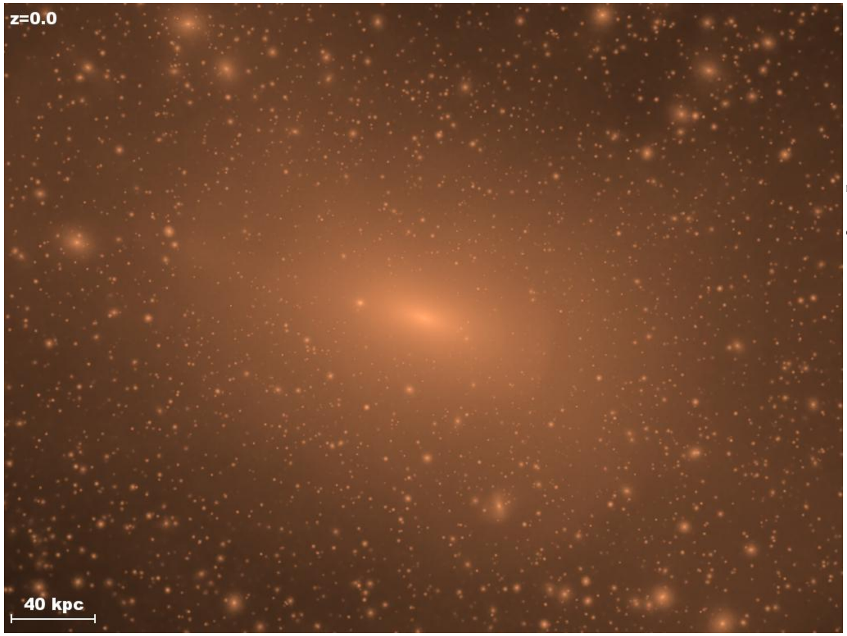
Bright signal with **bright background?**

or

**Dark systems?**

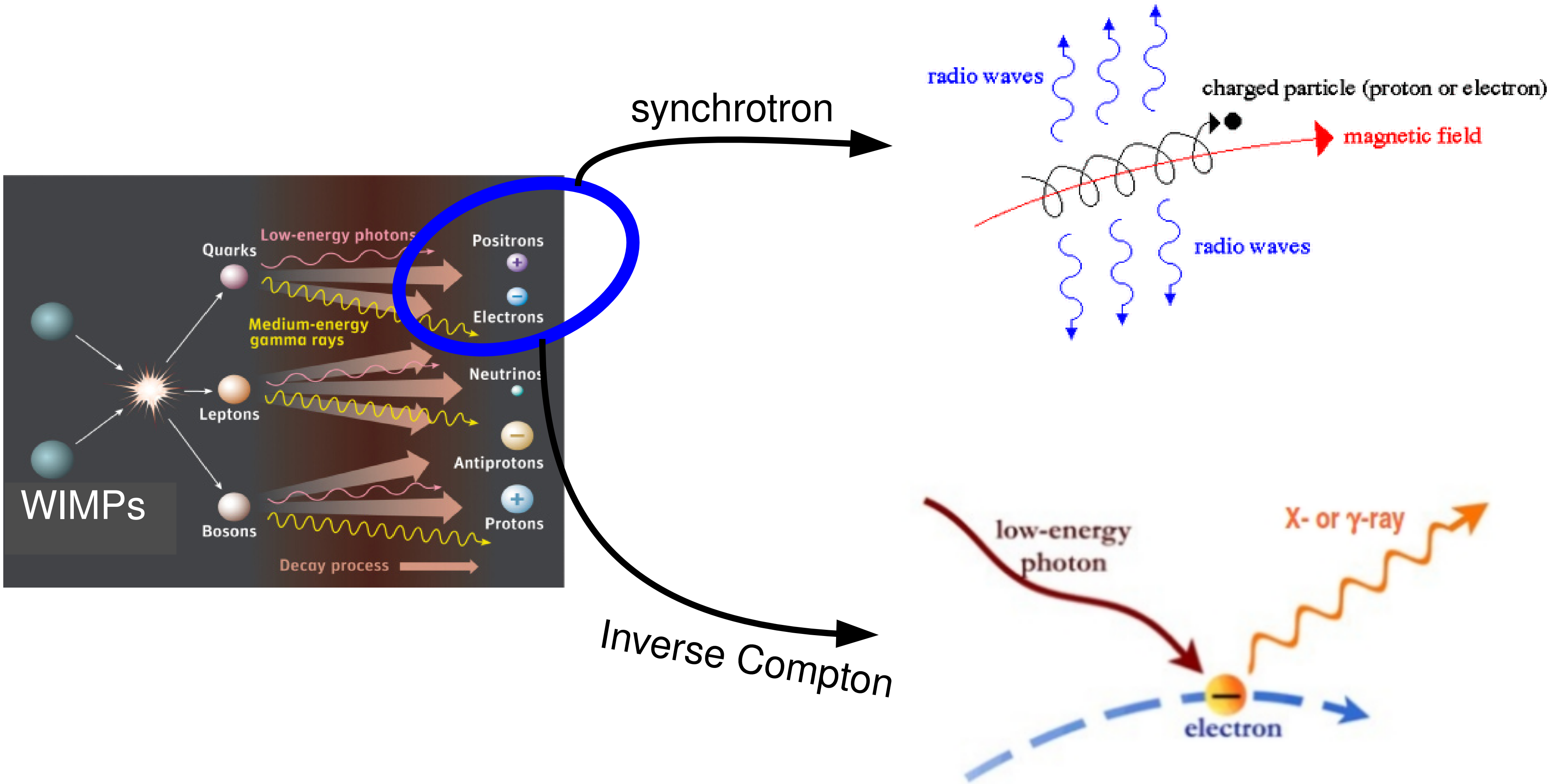


Heywood+ 2022, MeerKAT telescope, 1.28 GHz



Via Lactea project

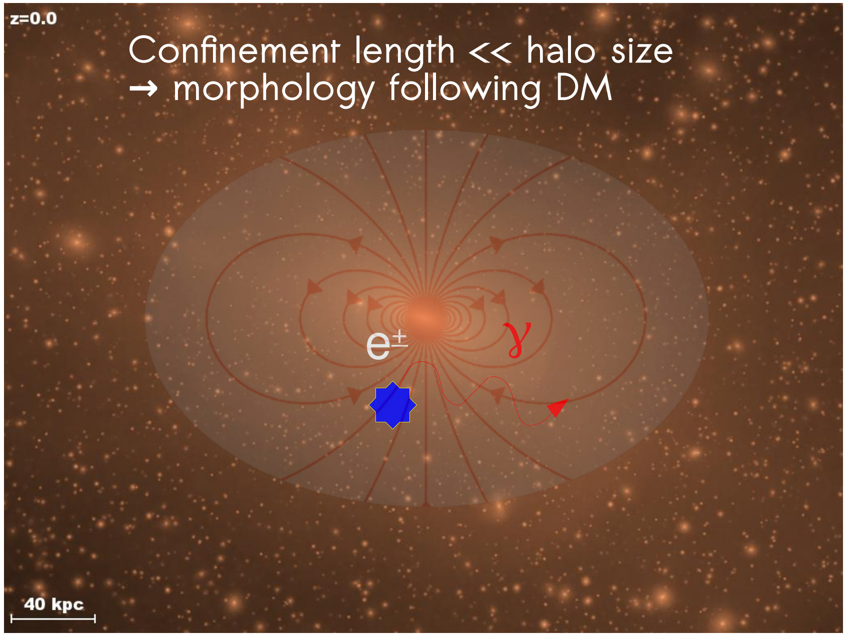
# Radiative emissions from DM

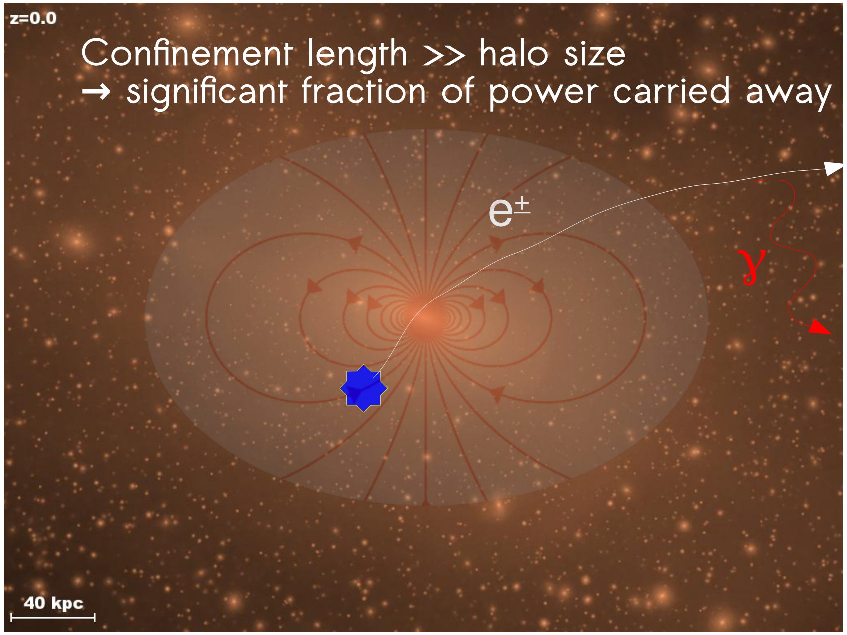


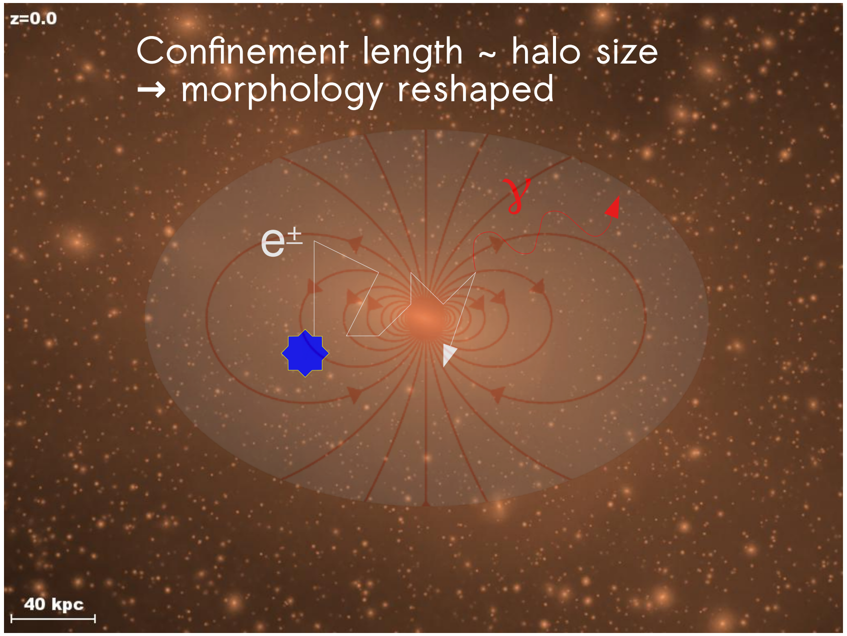

What is the **equilibrium distribution** (spatial profile and energy spectrum) of the $\mathbf{e^+}$-$\mathbf{e^-}$ injected by DM?

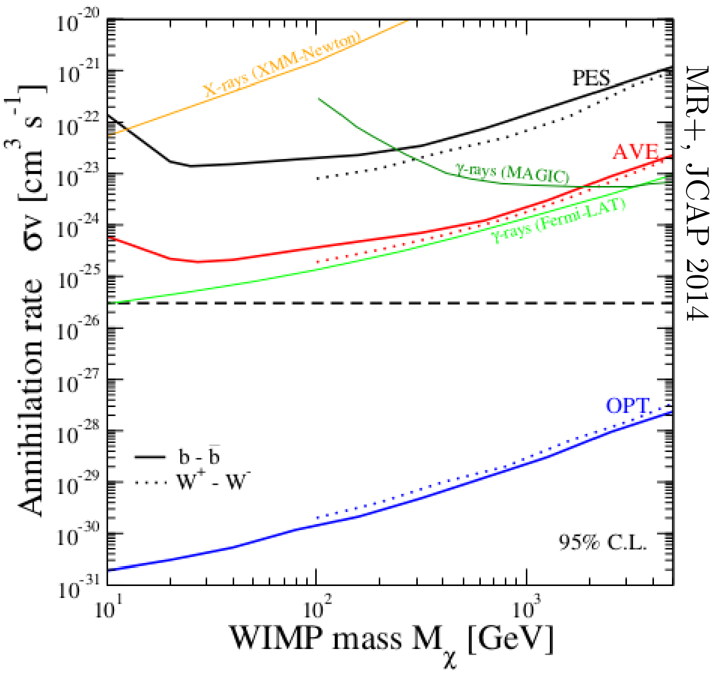
# Confinement and radiative emission

= WIMP annihilation



# Main idea of the work

The motion of charged cosmic-rays generates irregularities in the magnetic field

→ lower limit on magnetic turbulence from the $e^+$-$e^-$ injected by DM

$\rightarrow$ **SELF CONFINEMENT**

# Turbulence from dark matter

## DIFFUSION EQUATION

$$\frac{\partial n}{\partial t} = \underbrace{\frac{1}{r^2}\frac{\partial}{\partial r}\left[r^2 D \frac{\partial n}{\partial r}\right]}_{\text{Spatial diffusion}} \underbrace{- \frac{1}{r^2}\frac{\partial}{\partial r}\left[r^2 v_A n\right] + \frac{2v_A}{r}\frac{\partial}{\partial E}\left[\frac{p}{3}\beta n\right]}_{\text{Advection}} \underbrace{- \frac{\partial}{\partial E}\left[\dot{E} n\right]}_{\text{Energy losses}} + \underbrace{q_{\rm CR}}_{\text{DM source}}$$

## TURBULENCE EQUATION

$$\frac{\partial W}{\partial t} = \underbrace{\frac{\partial}{\partial k}\left[D_{kk}(W)\frac{\partial W}{\partial k}\right]}_{\text{Turbulent cascade (diffusion in k)}} \underbrace{- \frac{1}{r^2}\frac{\partial}{\partial r}(r^2 v_A W)}_{\text{Advection}} + \underbrace{\Gamma_{\rm CR}(n) W}_{\text{Source}}$$

(resonant streaming instability)

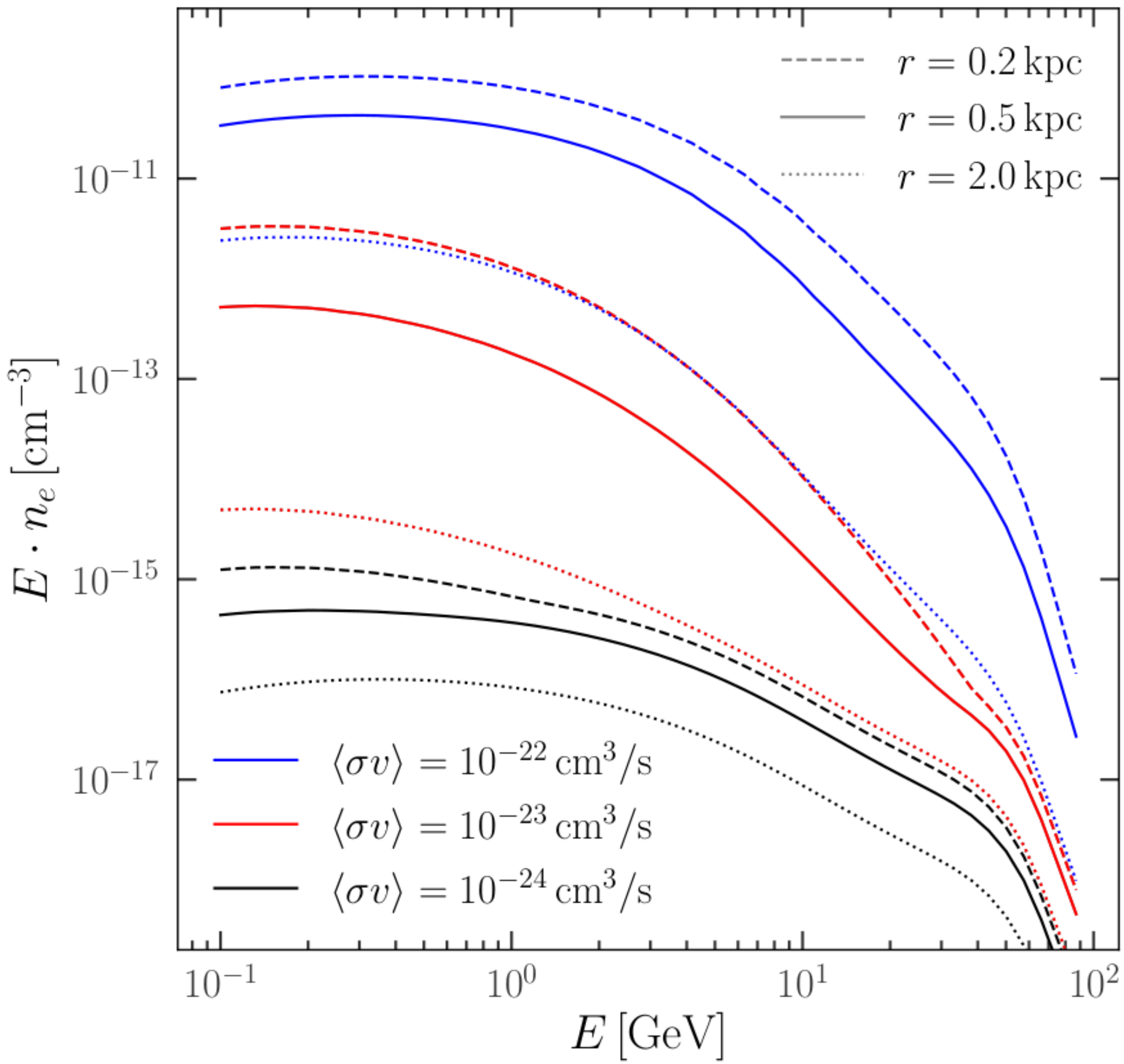
**Source of turbulence:**

$$\Gamma_{\rm CR} = \frac{4\pi\, c\, v_A}{3\, k\, W(k)\, B_0^2/(8\pi)}\left[\beta(p)\, p^4 \left|\frac{\partial f}{\partial r}\right|\right]_{p=p_{res}}$$

$$4\pi\, p^2\, f\, dp = n_e\, dE$$

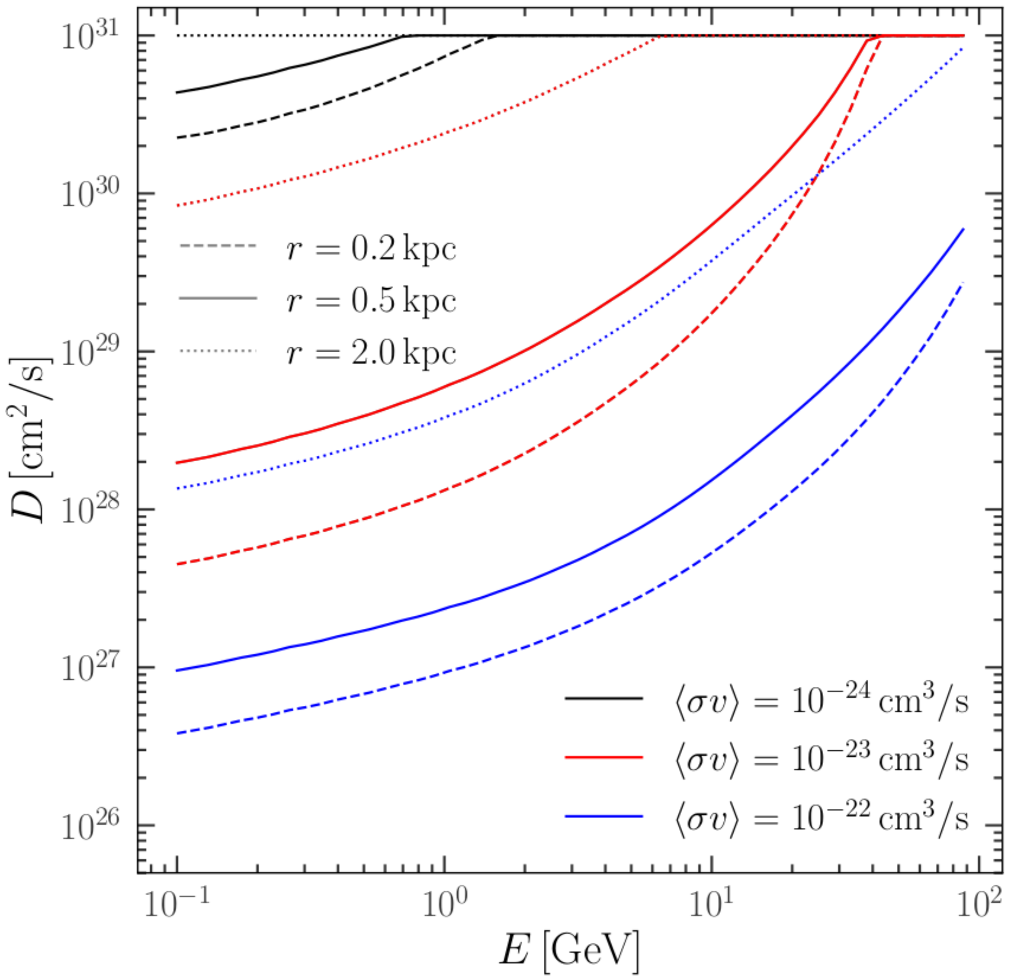
# Electron distribution

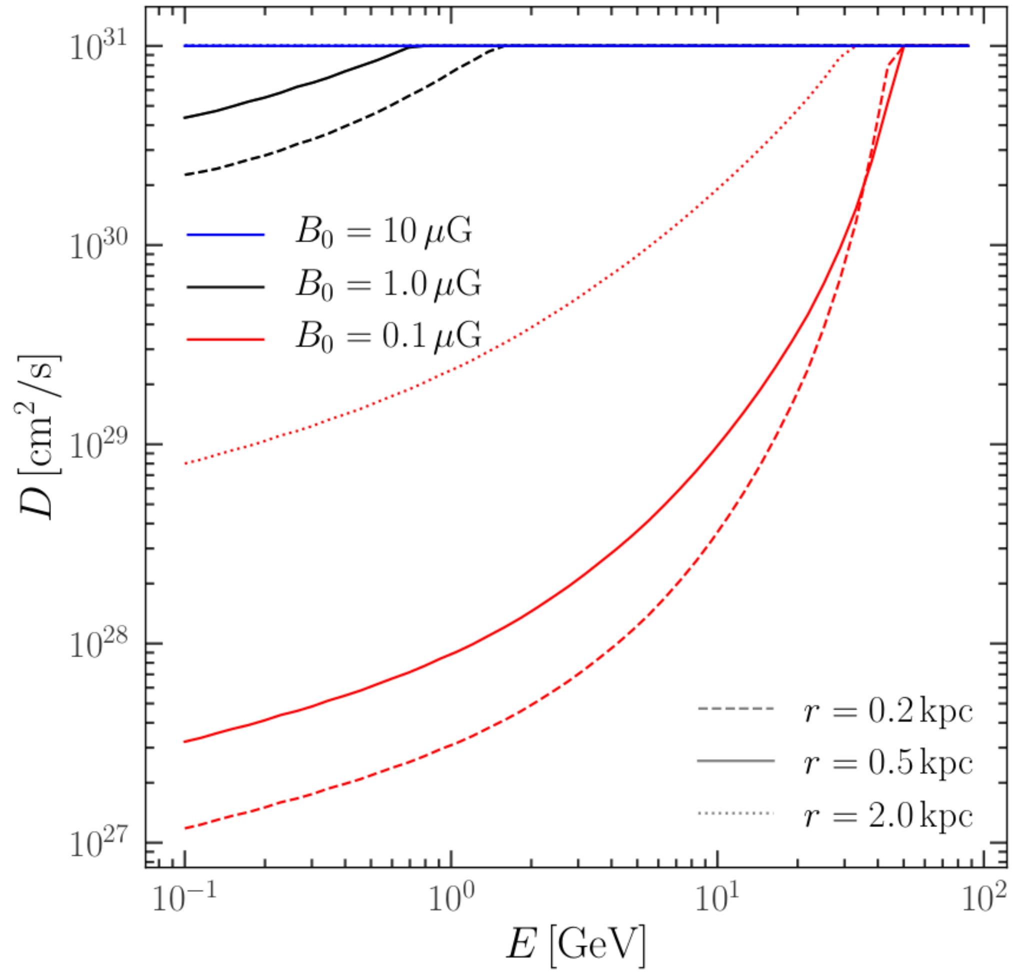
## Examples of solution of the diffusion equation



# Spatial diffusion coefficient

$$D(r,p,t) = \frac{D_{\rm B}(p)4/\pi}{kW(r,k,t)} \quad \text{with} \quad D_{\rm B}(p) = r_{\rm L}(p)c\beta/3$$

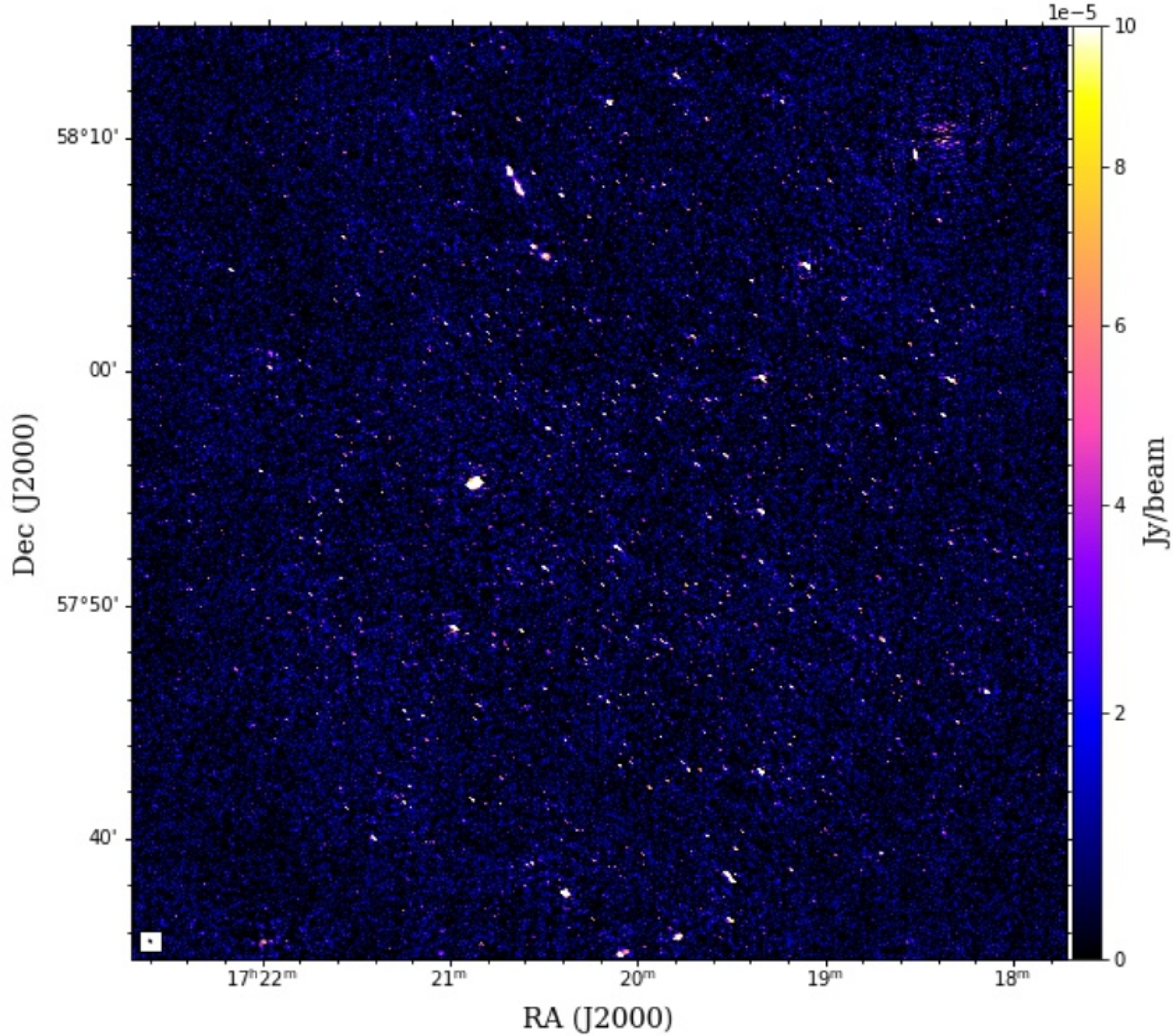


# The case of Draco dSph

<u>Radio observations</u>

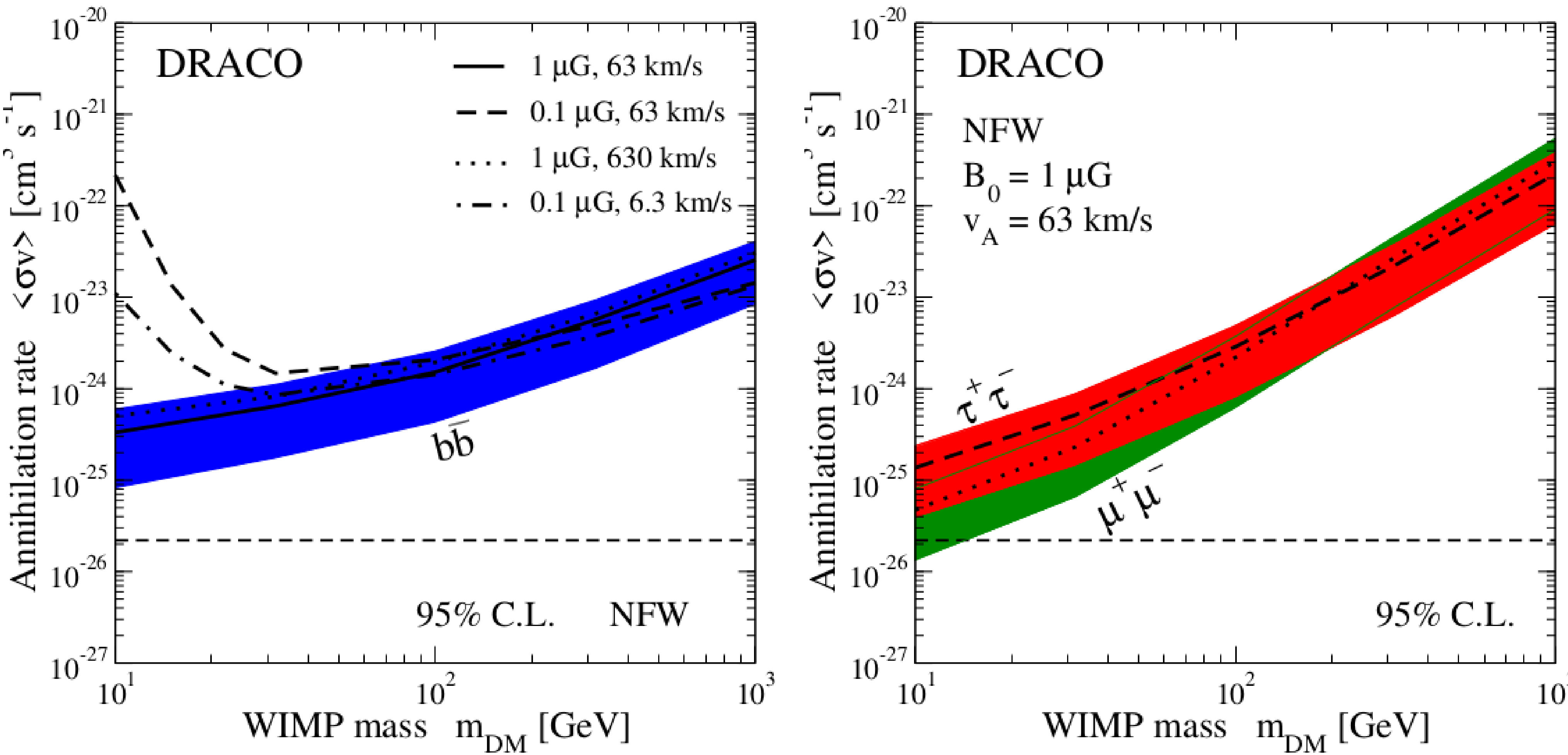
GMRT Telescope @ 650 MHz
(noise level ~10 μJy/beam)




looking for DM-induced synchrotron emission

$$j_{syn}(\nu, r) = \int dE \, P_{syn}(r, E, \nu) \, n_e(r, E)$$

# DM bounds




- advection is negligible (unless assuming unrealistic $v_A > 10^3$ km/s)
- since $n_e \sim B^{-2}$ and $P_{synch} \sim B^2$, there is little dependence of the bounds on B

## → data driven bounds!

# Conclusions

Electrons and positrons injected by DM
can induce a non-negligible level of turbulence
→ **minimum (unavoidable) confinement time**
**in any DM structure**

→ **robust bounds on WIMPs**
**from synchrotron emission**

→ being able to exploit the **wealth of forthcoming radio data**
(LOFAR2.0, ASKAP, MeerKAT, SKAO, ...)

**MR+, JCAP08(2023)030, [arXiv:2305.01999]**

# Backup

## Examples of synchrotron emission at 650 MHz in a dSph

$$j_{syn}(\nu, r) = \int dE \, P_{syn}(r, E, \nu) \, n_e(r, E)$$