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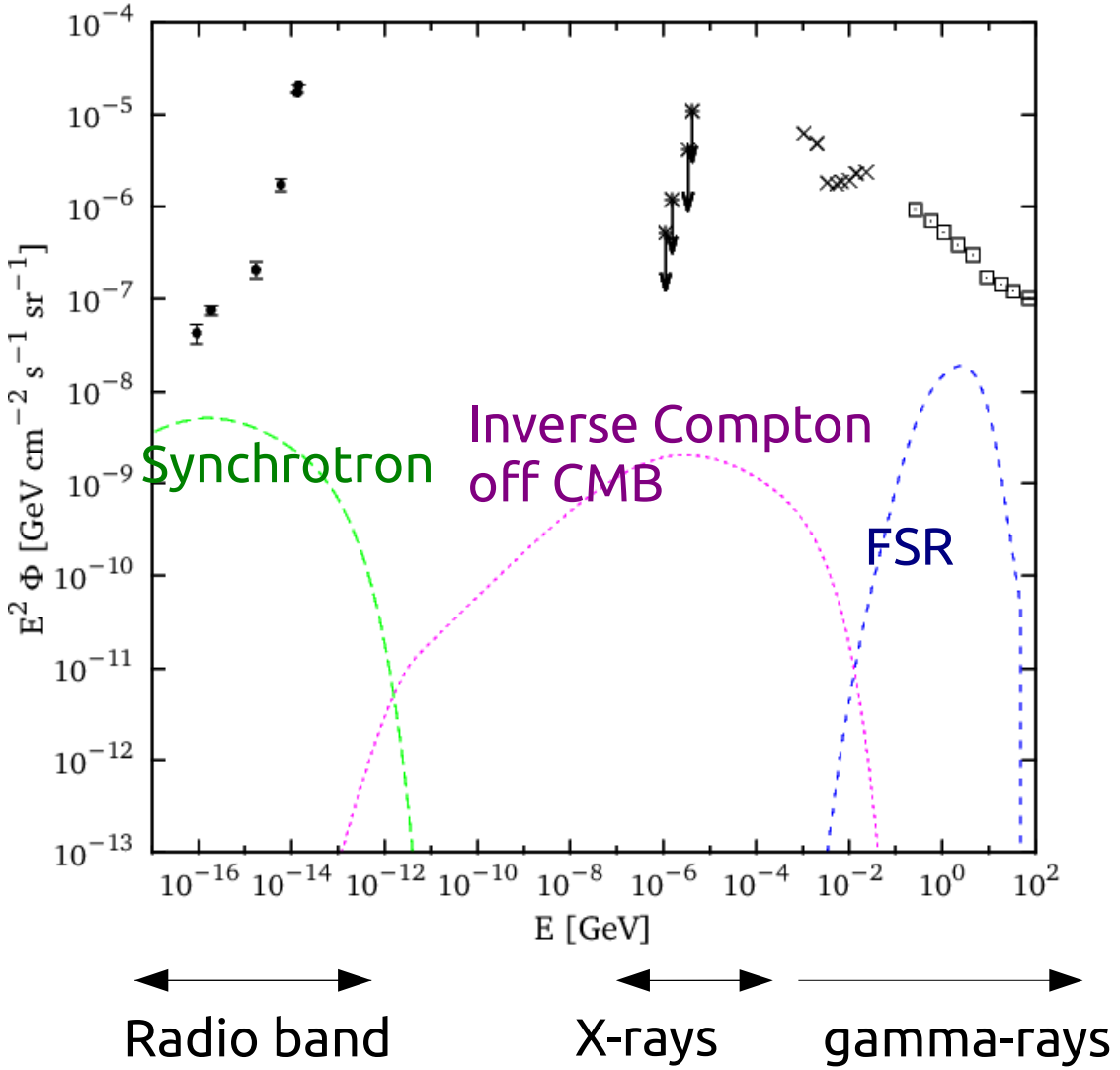
Dark Matter searches with radio observations

PASCOS 2012
Merida, Mexico

Based on PRL 107 (2011) 271302, JCAP 1201 (2012) 005, JCAP 1203 (2012) 033

with N.Fornengo, R.Lineros, M.Regis

Search for DM with astrophysical observations



Search for DM with astrophysical radio observations

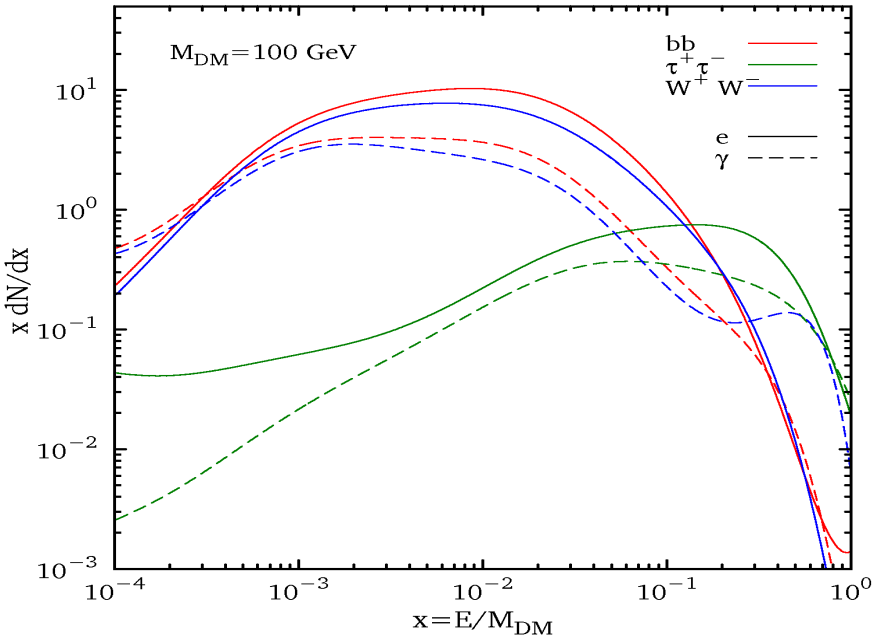
Annihilations or decays of DM

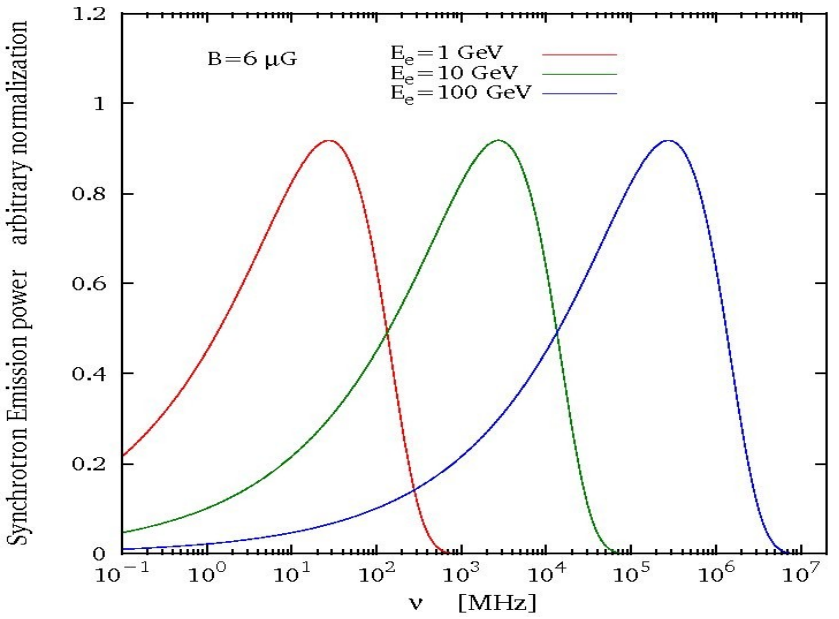
produces $e^{\pm}$

$e^{\pm}$ spiraling in the magnetic

field produce synchrotron radiation

$$\nu \sim 30 \text{ MHz} \frac{B}{6\ \mu\text{G}} \left(\frac{E_e}{1 \text{ GeV}}\right)^2$$

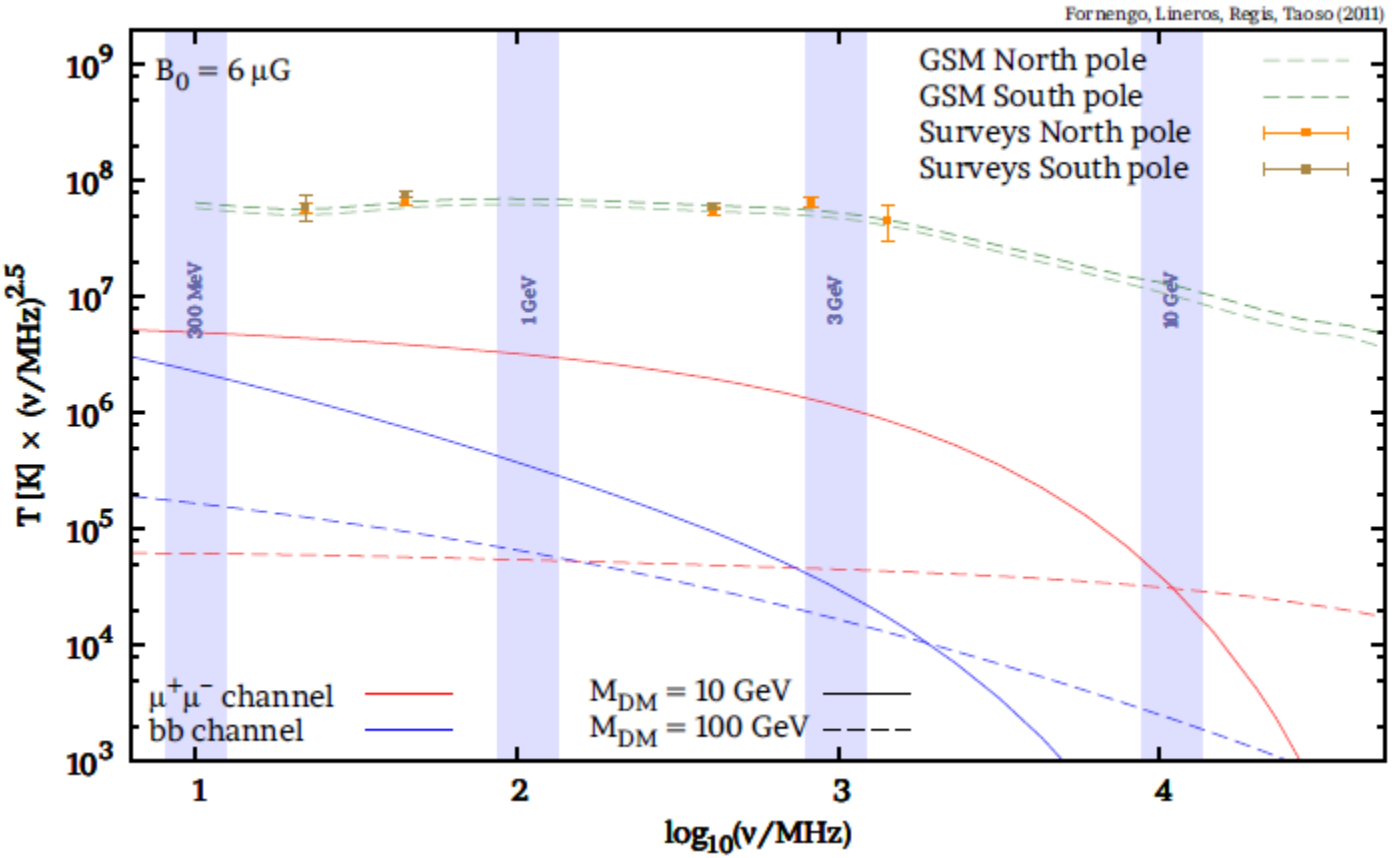




Galactic DM radio signal at different frequencies

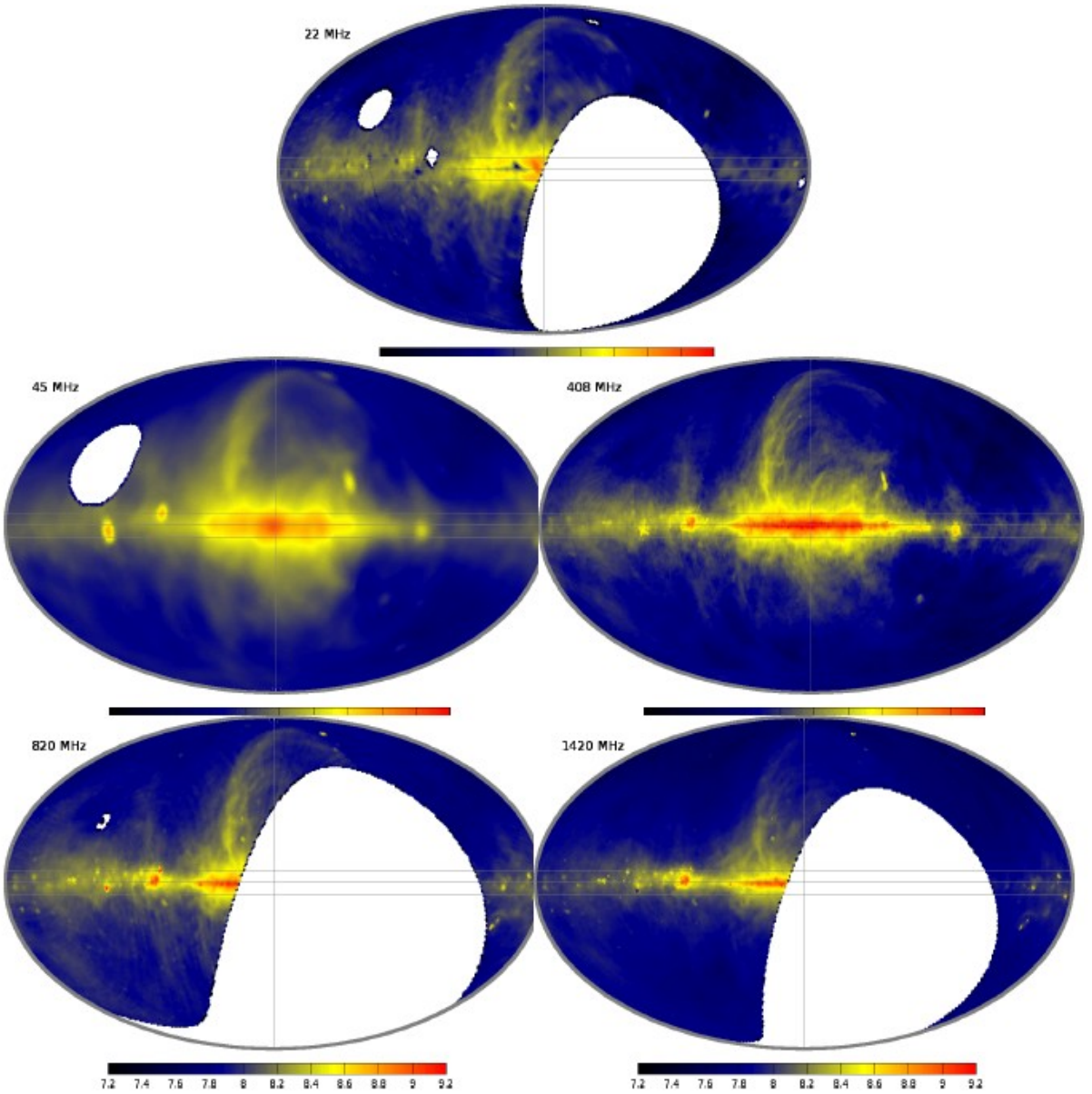
Look at low frequencies for light DM

Synchrotron from DM possibly softer than CRs radio emission



N.Fornengo,R.Lineros,M.Regis,MT 2011

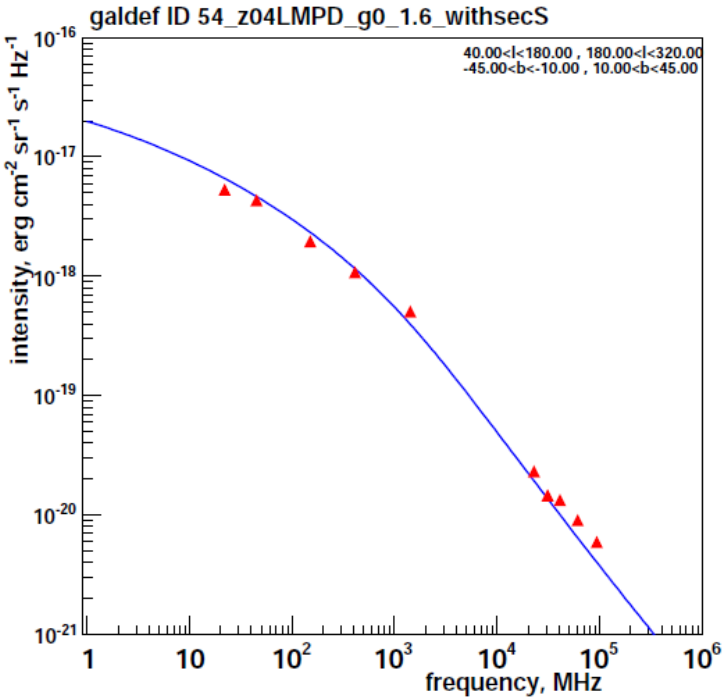
Radio surveys from 22MHz to 1420 MHz



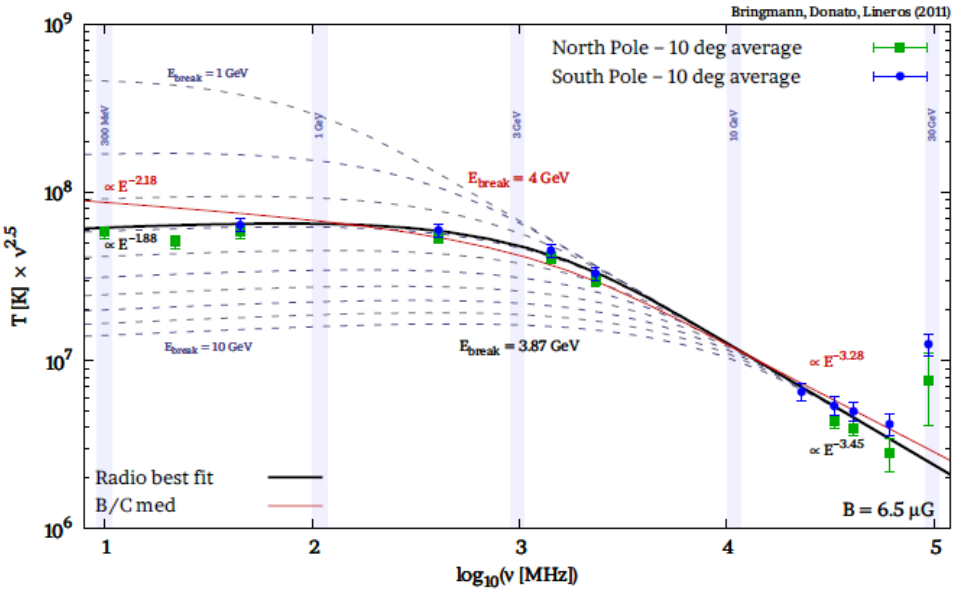
Radio maps: a tool to study CRs and magnetic fields

Synchrotron from Cosmic-Rays dominates the diffuse emission below GHz

Radio maps can constrain CRs diffusion models & magnetic field

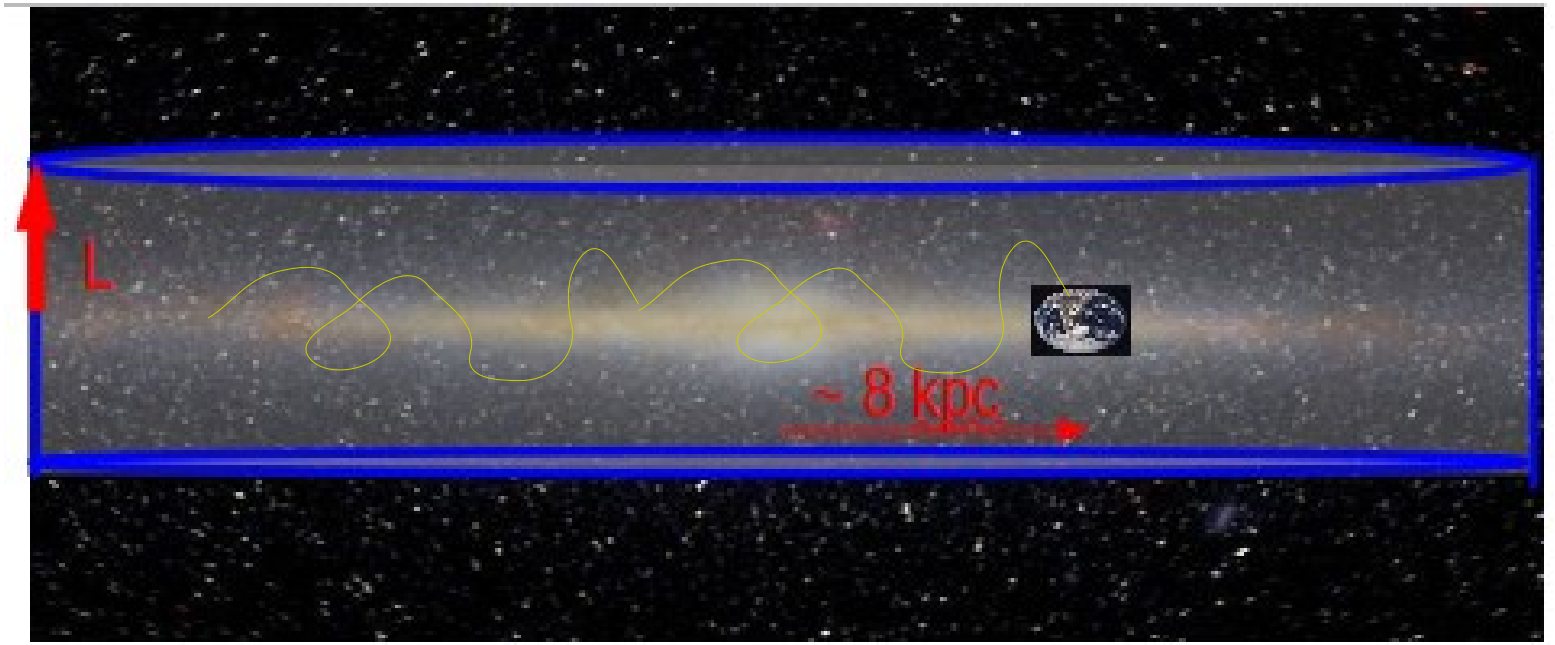


Strong, Orlando, Jaffe 2011



Bringmann, Donato, Lineros 2011

Cosmic-rays propagation



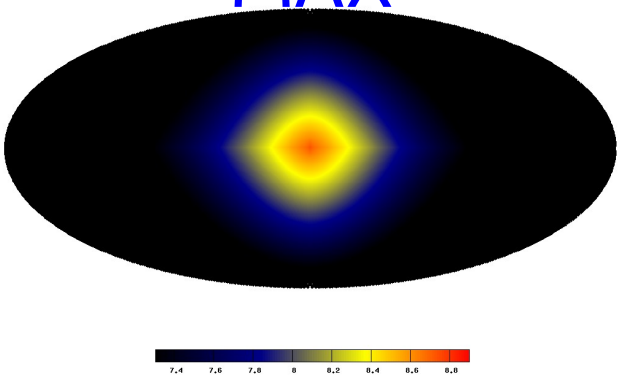
- Evolution of the CRs contained in the transport equation

$$\partial_t \mathcal{N} - \boldsymbol{\nabla} \cdot \{K(E) \boldsymbol{\nabla} \mathcal{N}\} + \partial_E \left\{ \frac{dE}{dt} \mathcal{N} \right\} = \mathcal{Q}(E, \boldsymbol{x}, t)$$

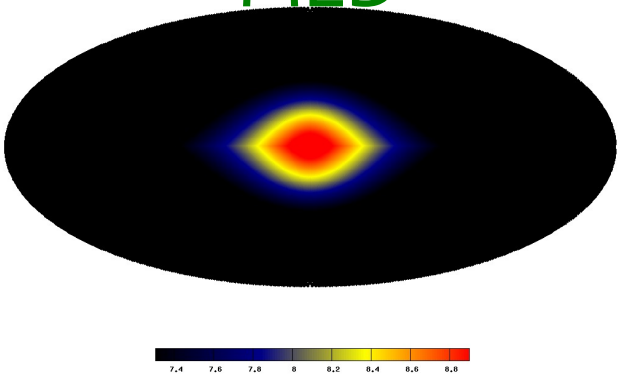
- Propagation parameters inferred from CRs data

Galactic DM radio signal & propagation models

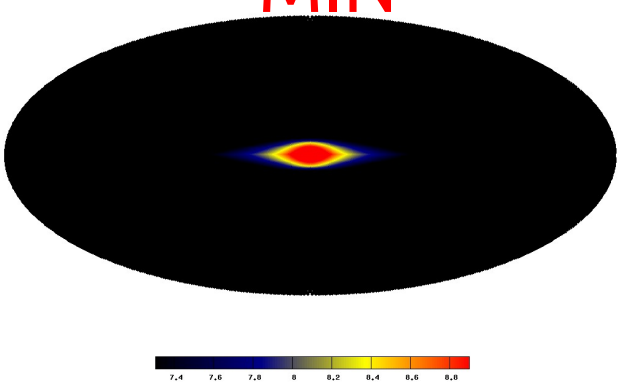
MAX



MED

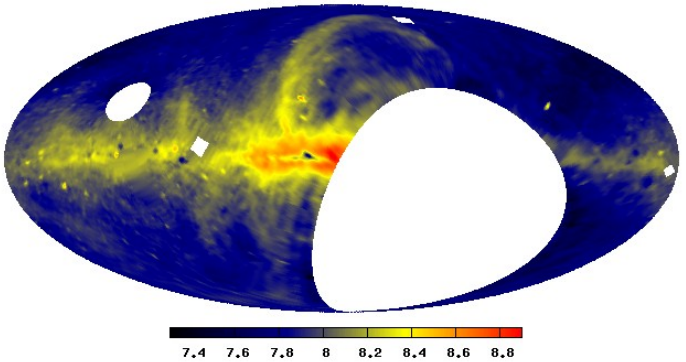


MIN



Model	propagation parameters		
	L_z [kpc]	$K_0 \left[\frac{\text{kpc}^2}{\text{Myr}}\right]$	δ
MIN	1	0.0016	0.85
MED	4	0.0112	0.70
MAX	15	0.0765	0.46

DM signal for different propagation models @ 22 MHz

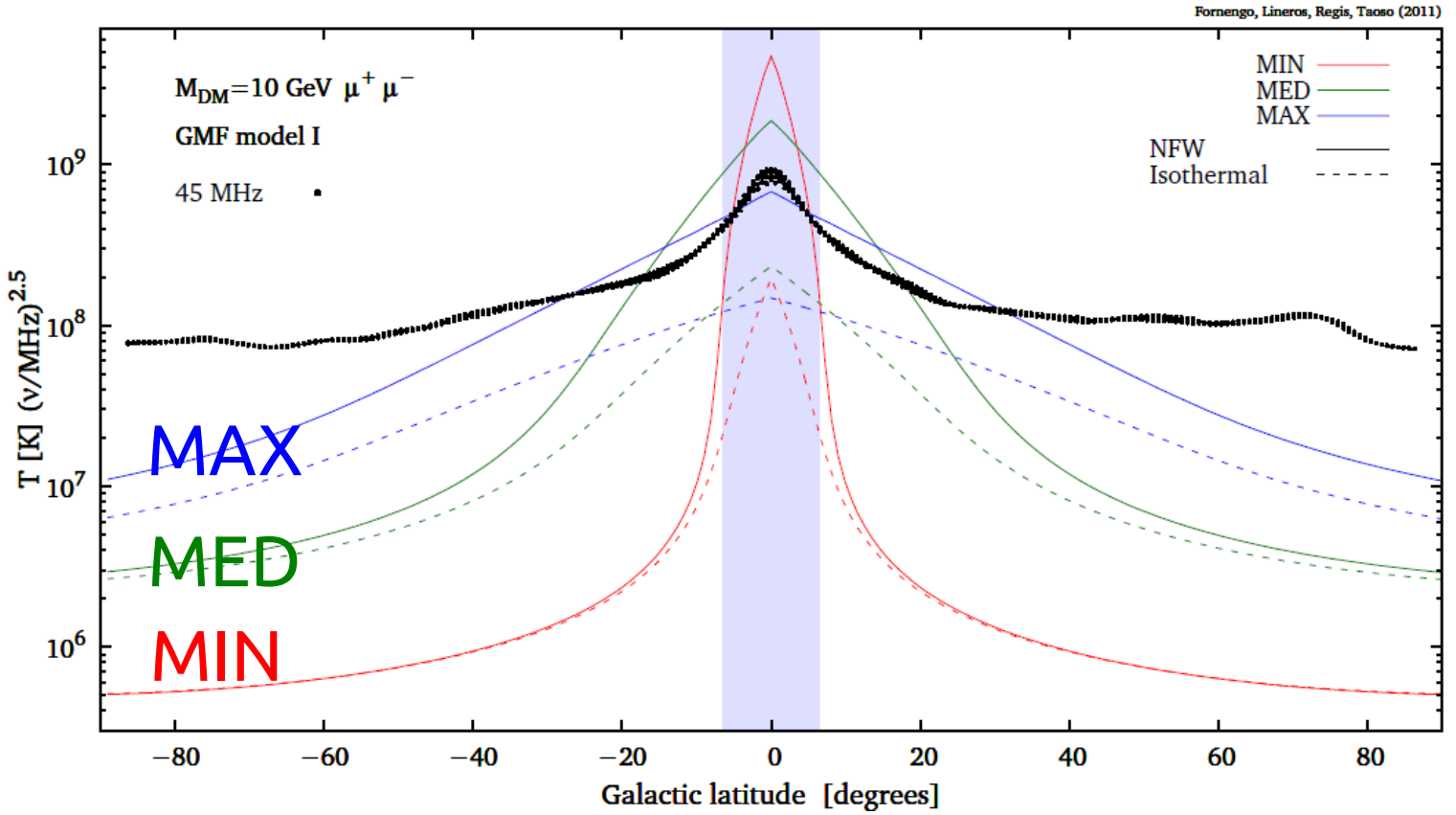


DRAO 22 Mhz

Galactic DM radio signal

10 GeV thermal WIMP: flux comparable to obs in Galactic Center region

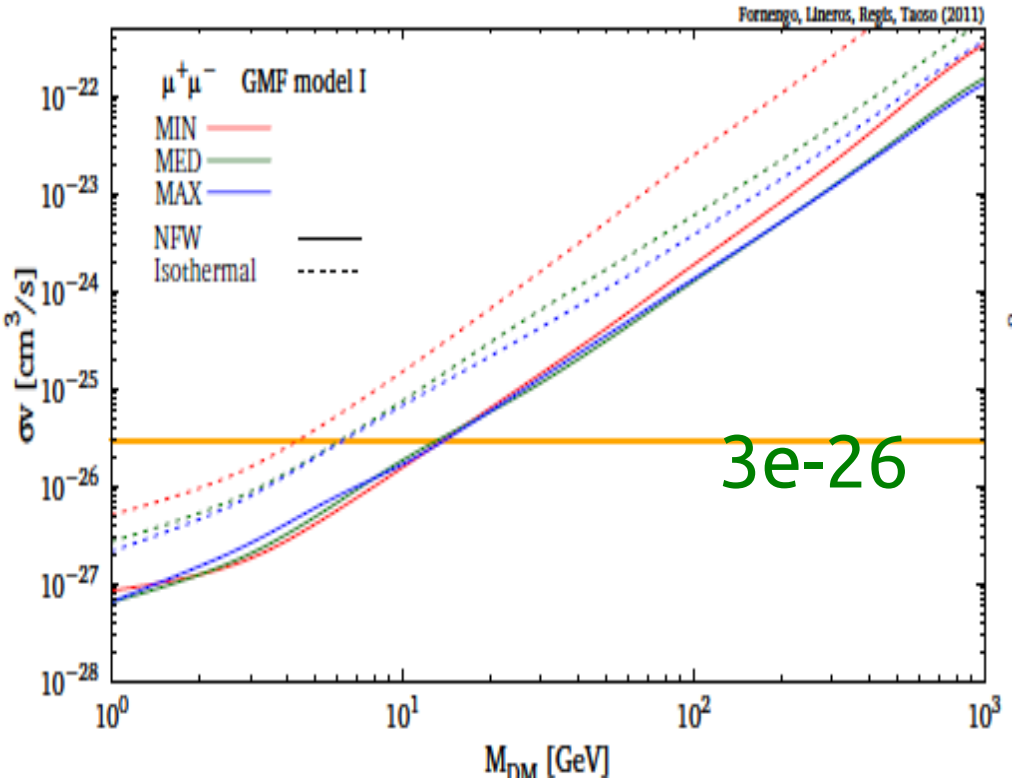
Realistic B field and DM density profile

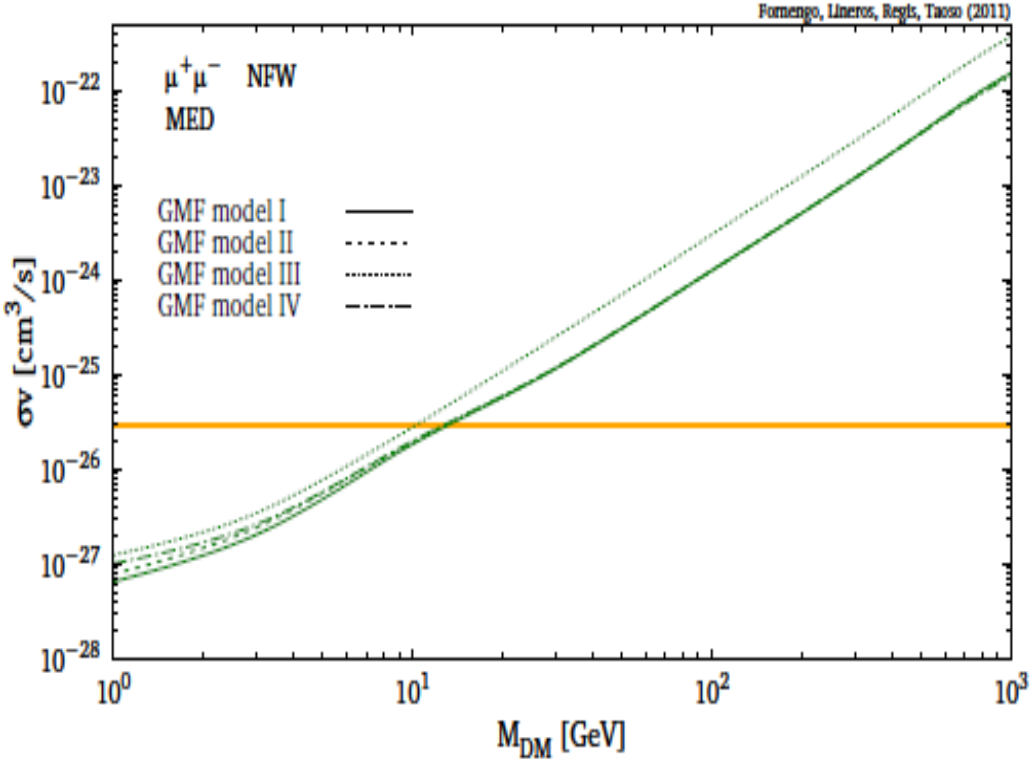


Constraints on DM

WIMPs models constrained at low DM masses

Warning: astro uncertainties in the calculations, Bfield,...



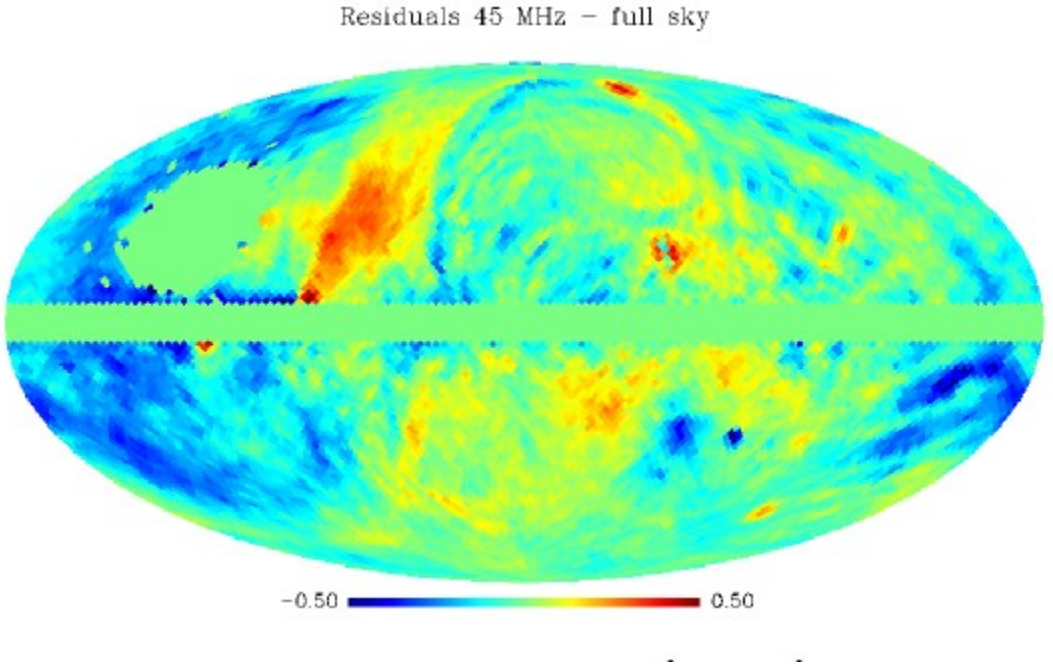


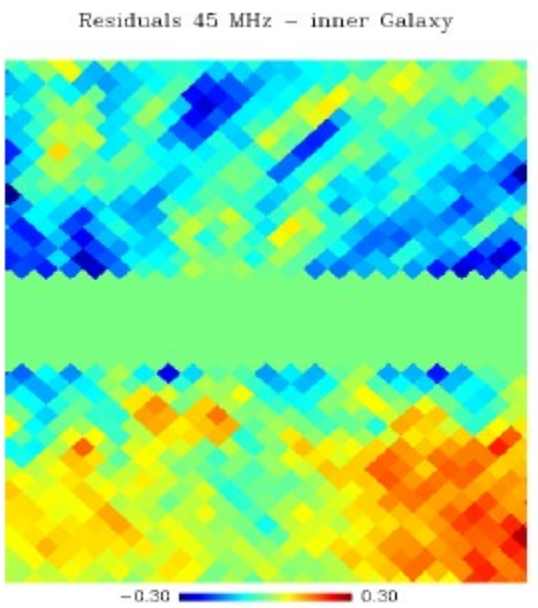
Are there DM signals hidden in the maps?

Use 408 MHz map as a spatial template at lower frequencies to look for a DM signal with soft spectrum. DM should give spherical spot around GC

At a first look no evidence for DM signals in the residuals.

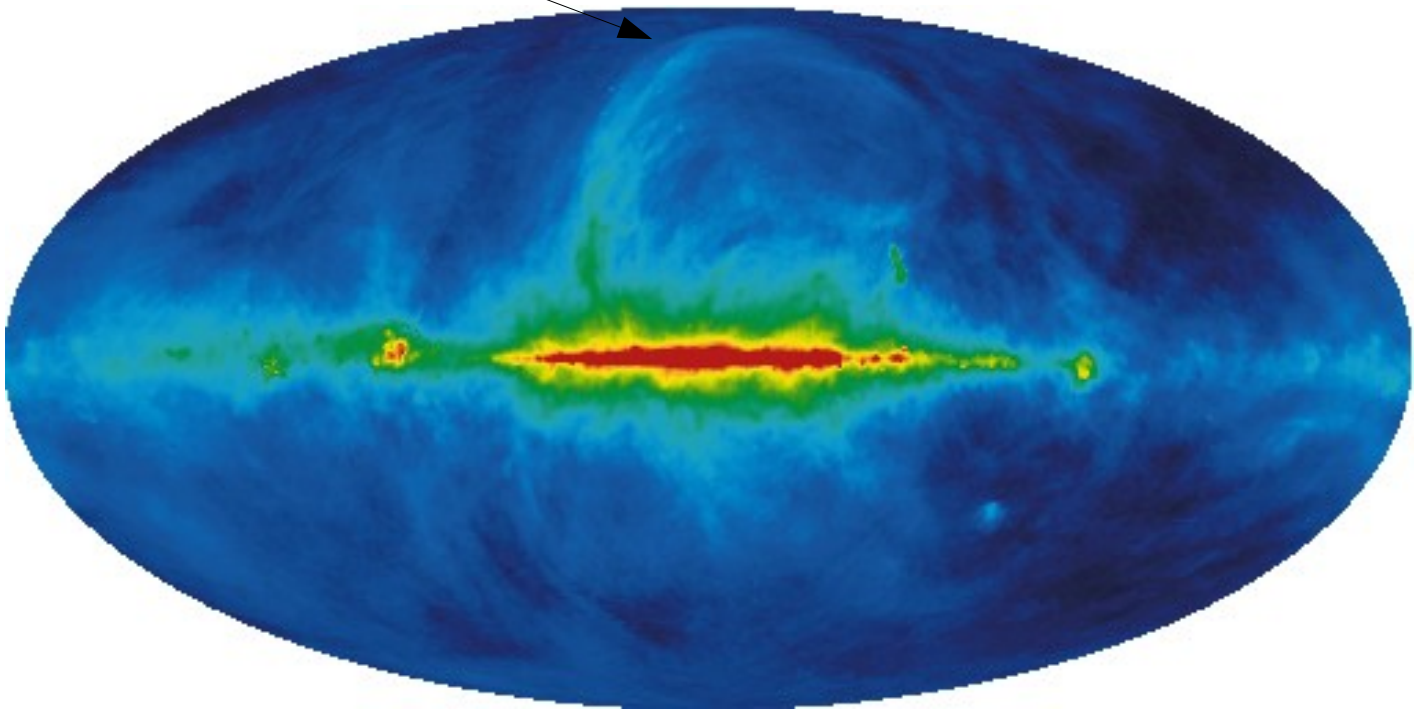
Better templates might be needed (e.g. LOFAR)





Where to look for DM signals?

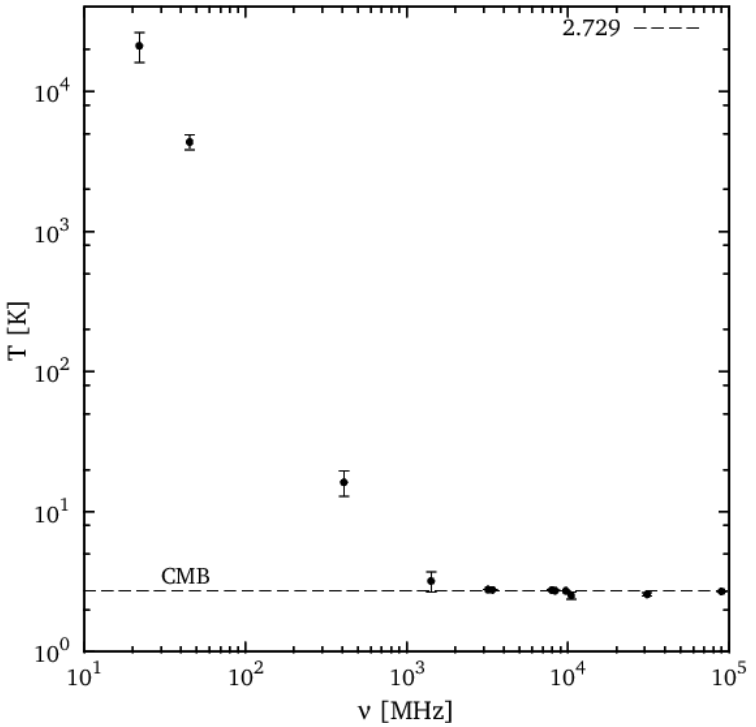
Diffuse extragalactic radio emission can be extracted from the maps looking at high latitudes



Extragalactic isotropic radio background

ARCADE-2 collaboration employs two indipendent method to extract the extragalactic bkg from their data and maps at low frequencies

(Fixsen et al. 2009)

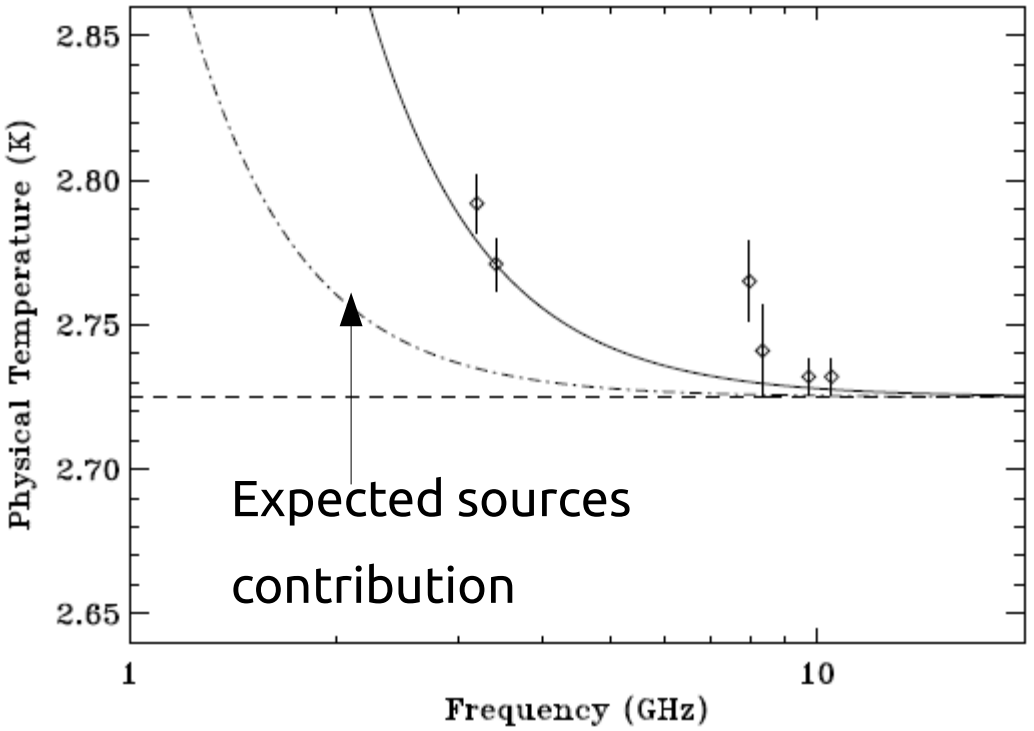


Removing the CMB monopole the extragalactic bkg is detected < 10 GHz

Contribution from astro sources

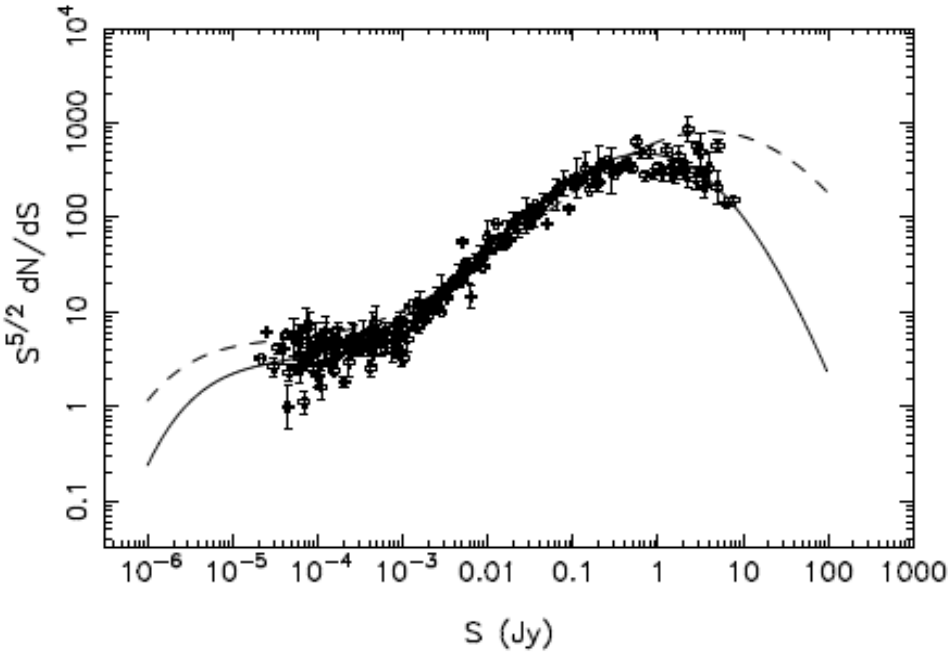
ARCADE-2 measurements

(Fixsen et al. 2009)



Differential sources
number counts

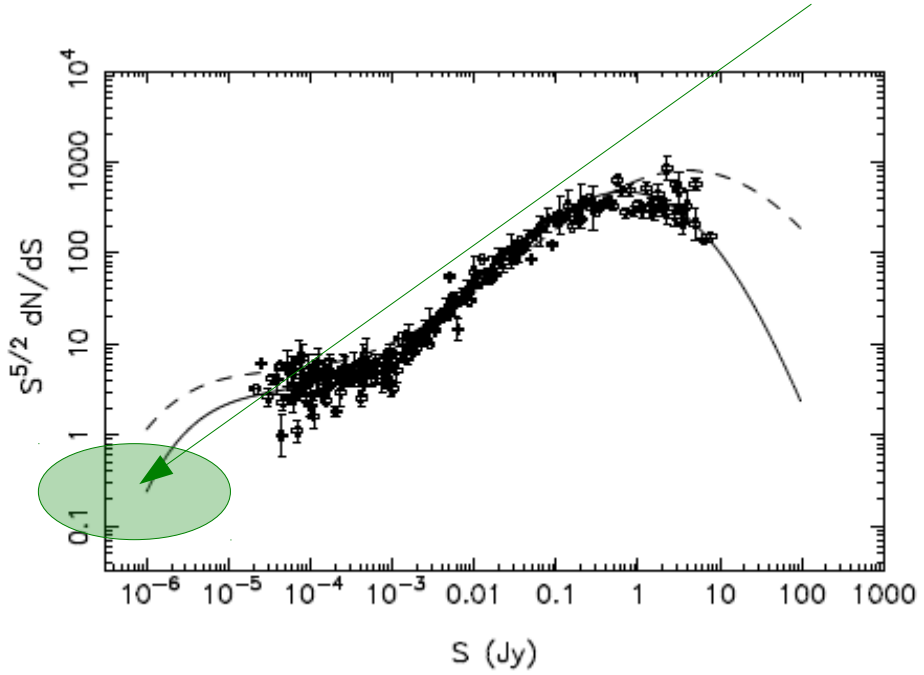
Vernstrom et al. 2010



Extragalactic background a factor 6 higher than extrapolations from sources number counts (Seiffert et al. 2009, Gervasi 2008 et al., ...)

Possible explanation of the ARCADE excess

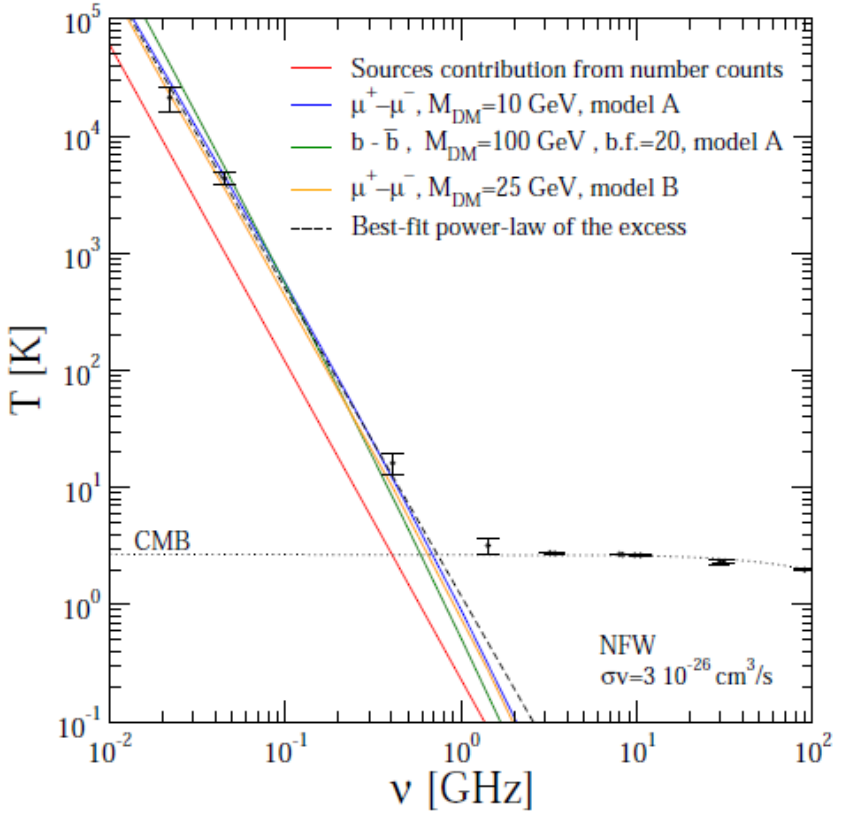
Undetected population of radio sources with < μJy fluxes



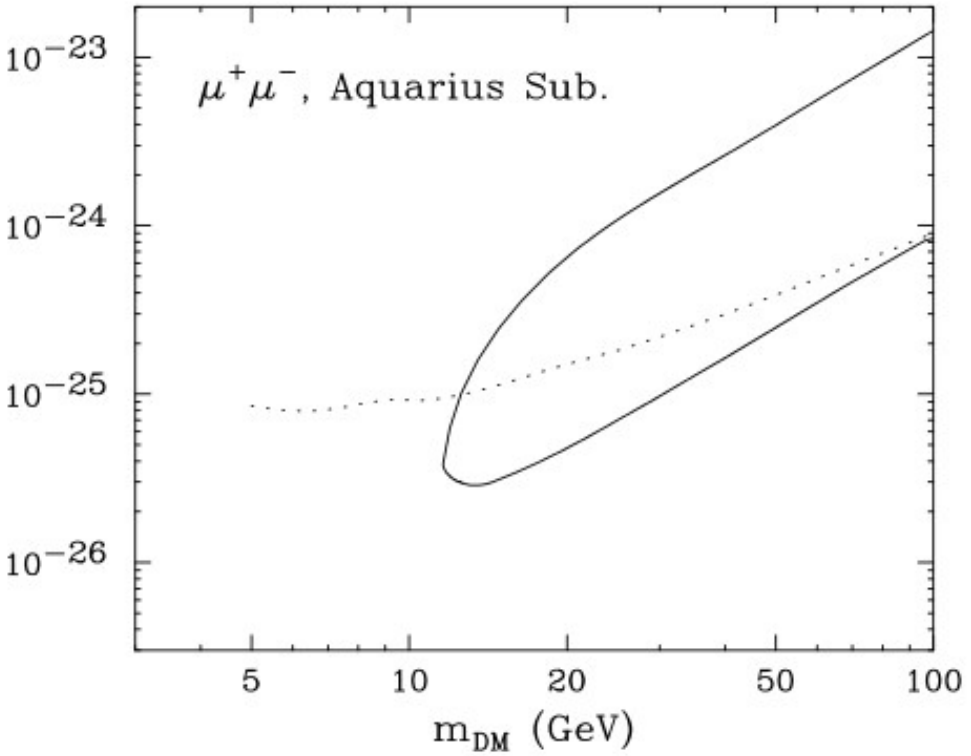
Potential problems with standard astro-sources, e.g. constraints from gamma and X-rays (diffuse emission intragalactic) or Infrared (for Star Forming galaxies)

Singal et al- 2010, Lacki 2010, Ponente et al. 2010

DM interpretation of the ARCADE excess



N.Fornengo, R.Lineros, M.Regis, M.T. 2011

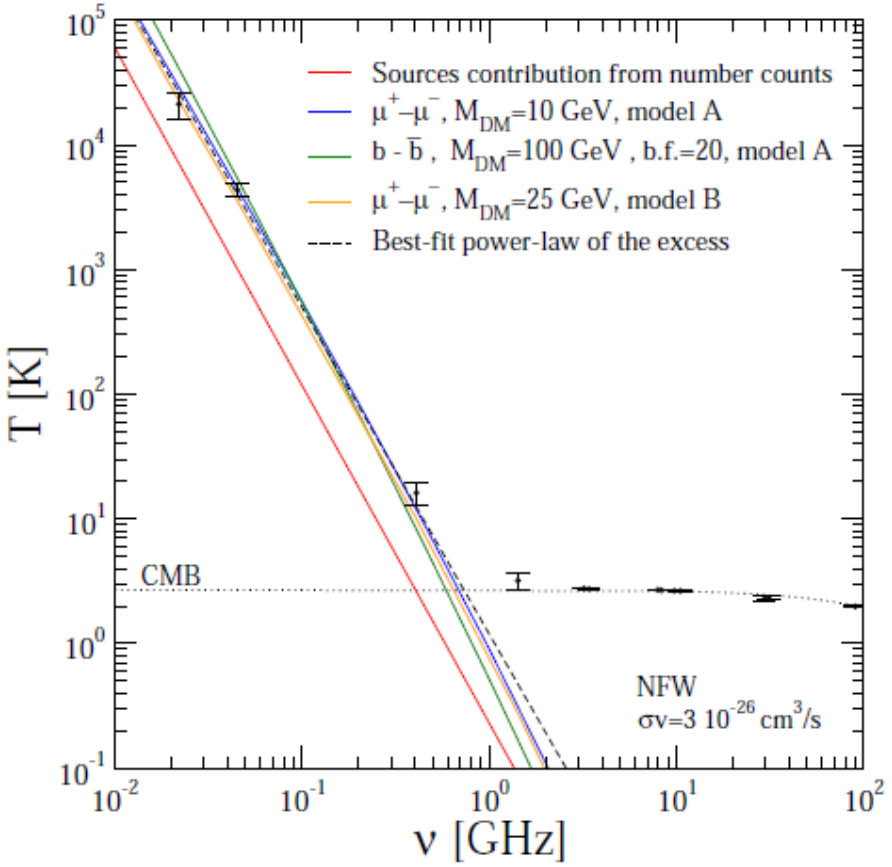


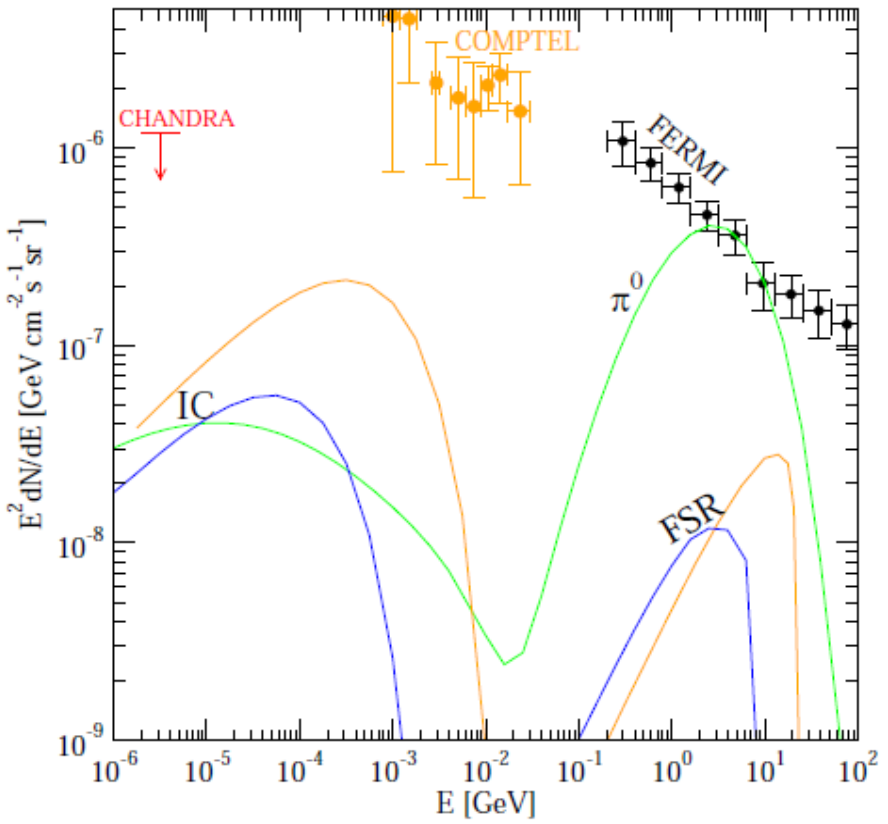
Hooper Belikov, Jeltema, Linden, Profumo, Slatyer 2012

Faint and numerous extragalactic DM halos can explain the excess.

Good fit only with leptonic channels.

DM interpretation of the ARCADE excess



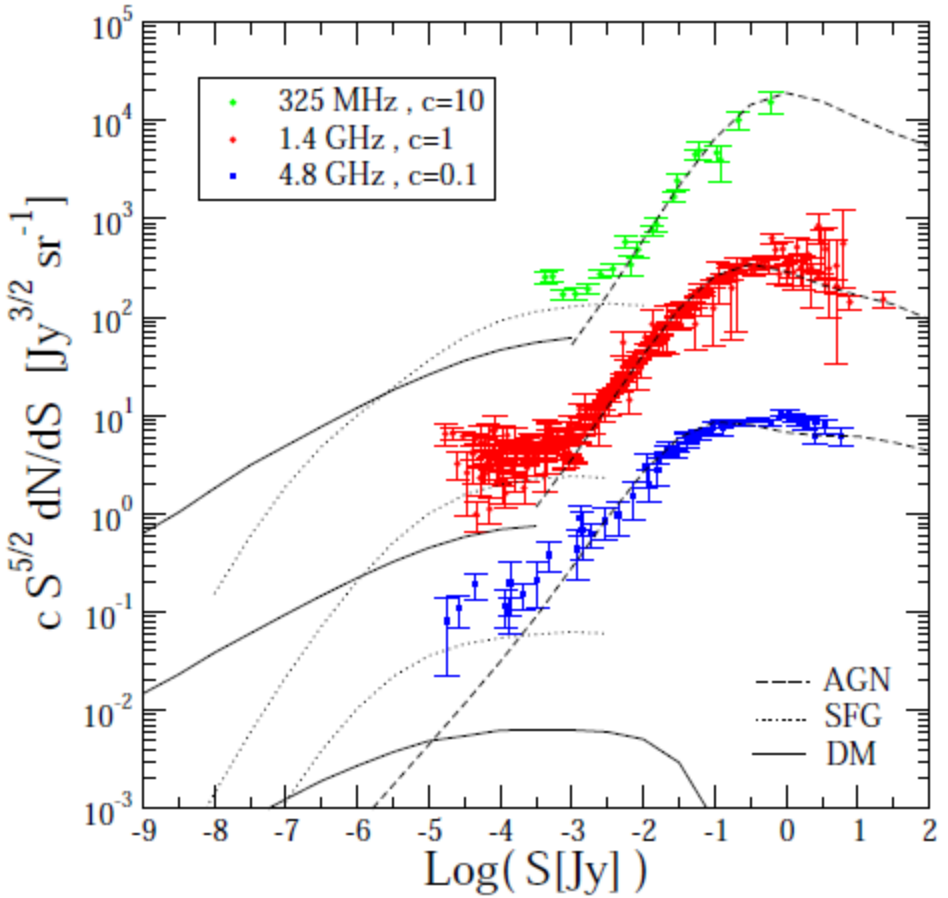


Extragalactic DM signal can explain the excess.

Ok with gamma-ray constraints.

N.Fornengo, R.Lineros, M.Regis, M.T. 2011

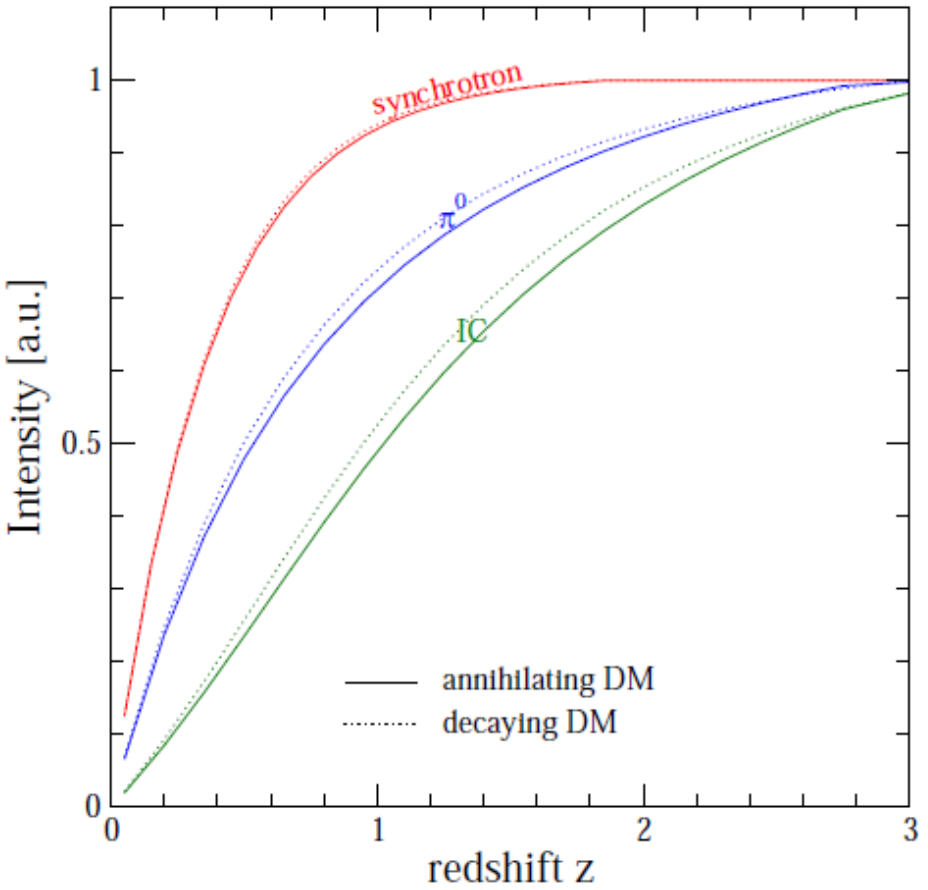
Sources number counts

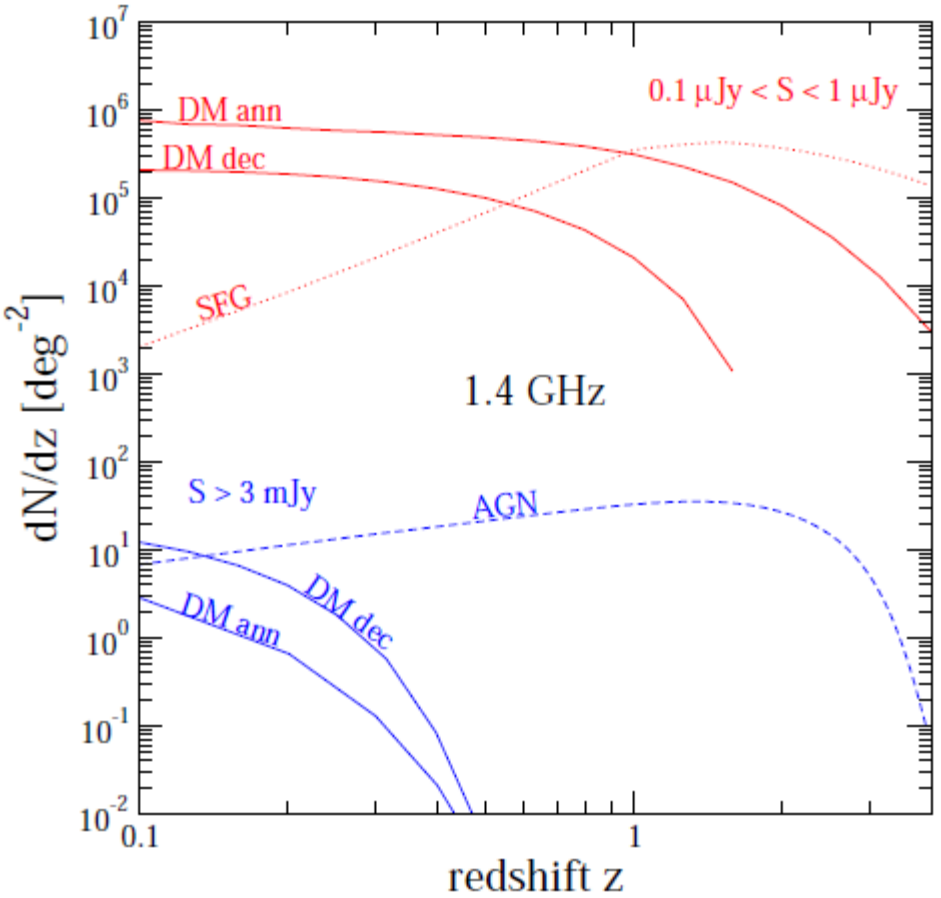


At high fluxes number counts dominated by AGN.

DM can dominate number counts at sub μJy fluxes

Sources number counts

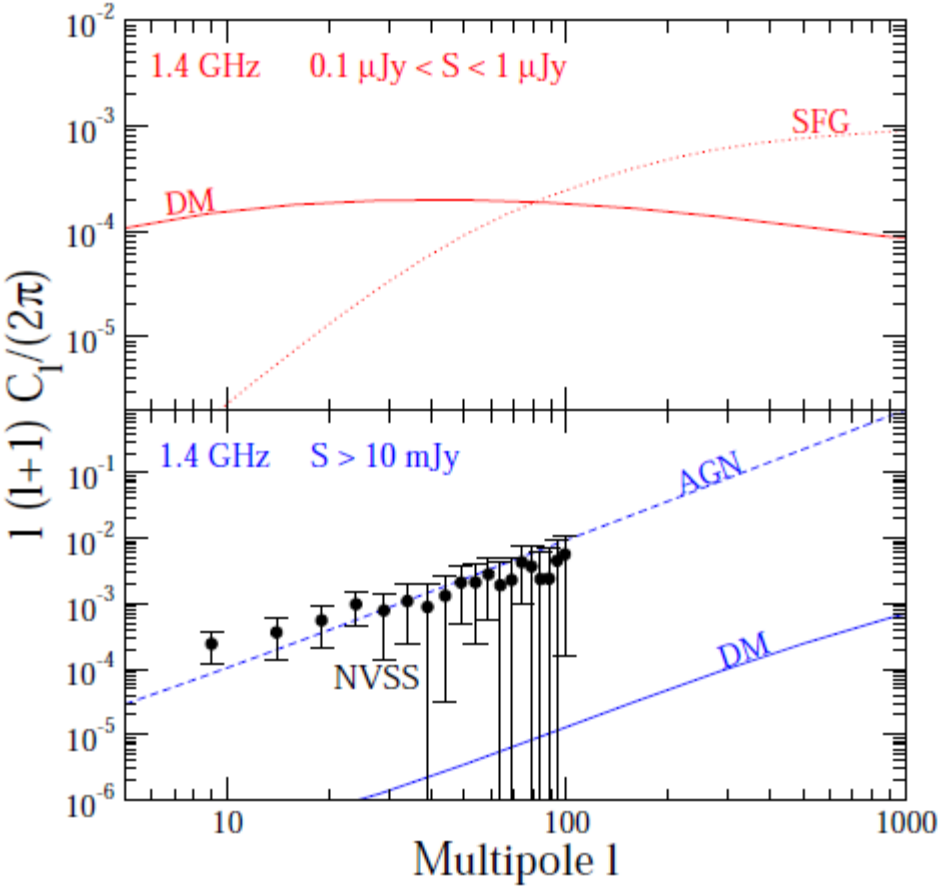




Synchrotron emission peaks at low z

Redshift evolution might be different from that of Star Forming galaxies

Angular anisotropies



DM might dominate angular power spectrum and correlations for small fluxes

Only achievable with future surveys (e.g. SKA). Present data are not relevant

Conclusions

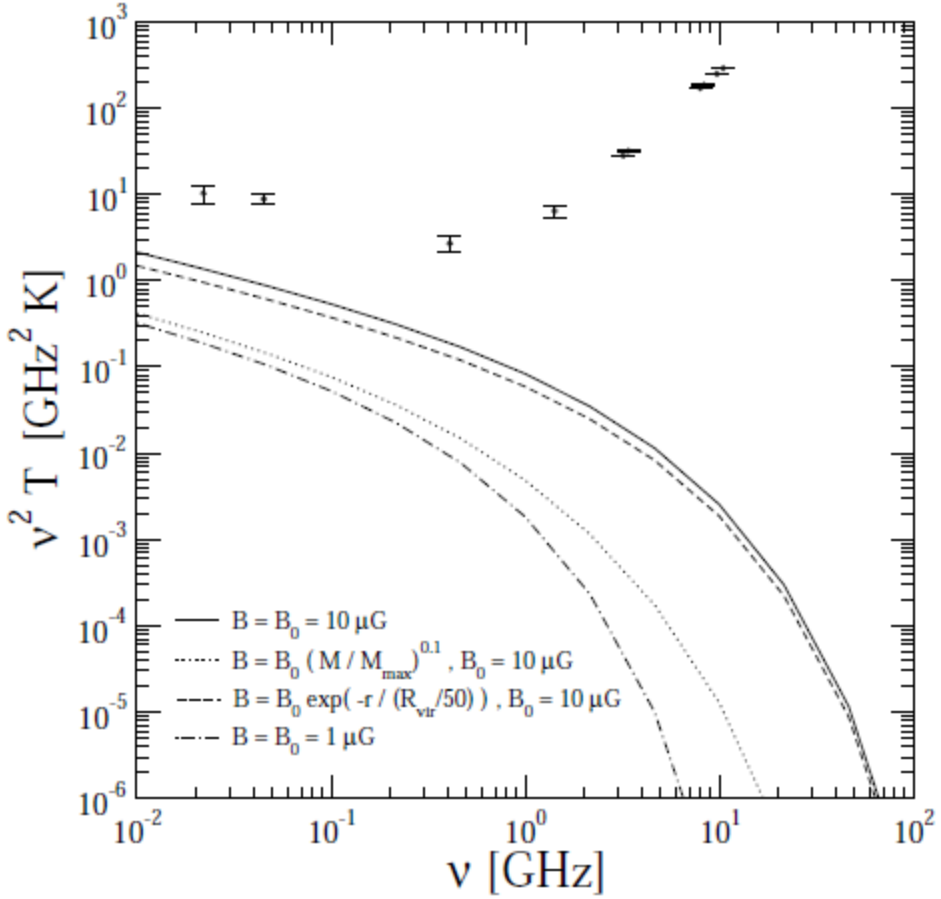
Radio observations set interesting constraints on the DM parameters

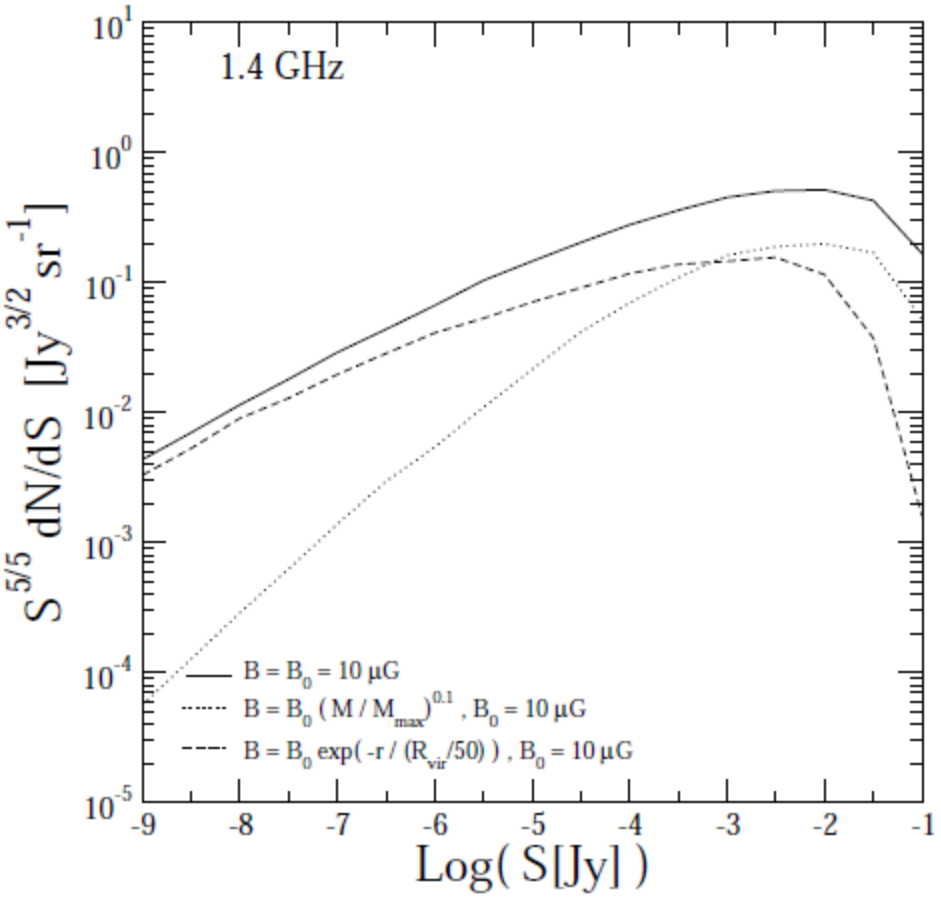
Potentially interesting prospects for extra-galactic DM searches with future surveys.

However many uncertainties both in the modeling of DM signal and astro-background

THANKS

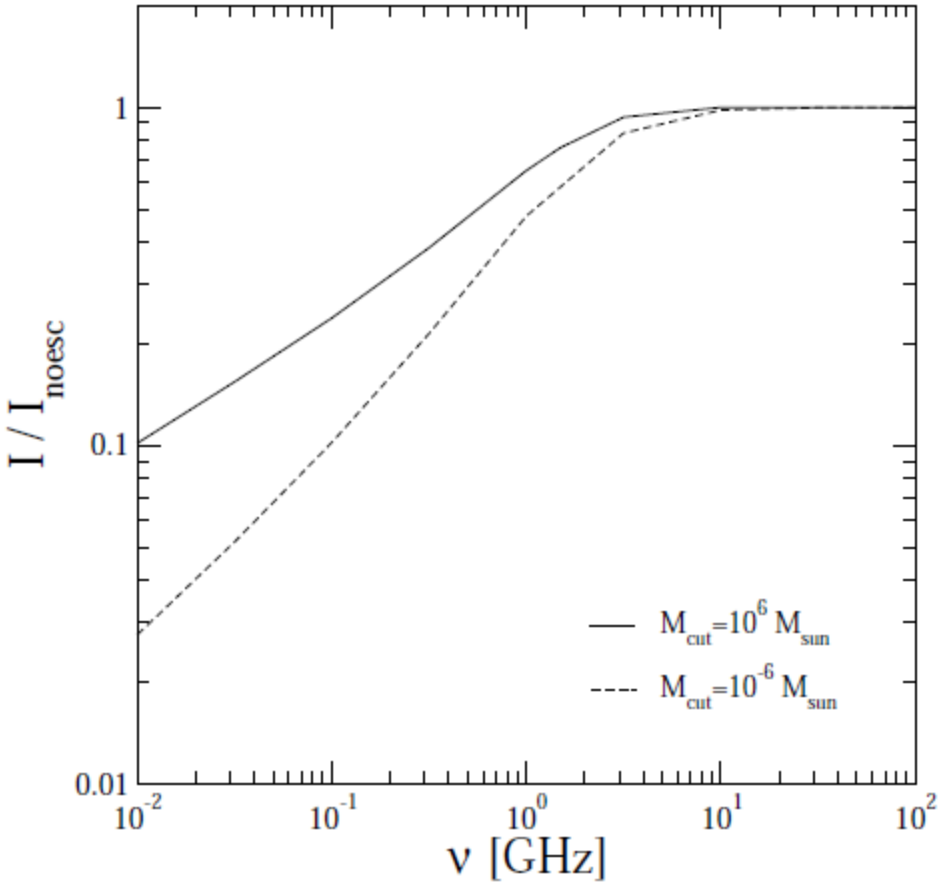
Uncertainties

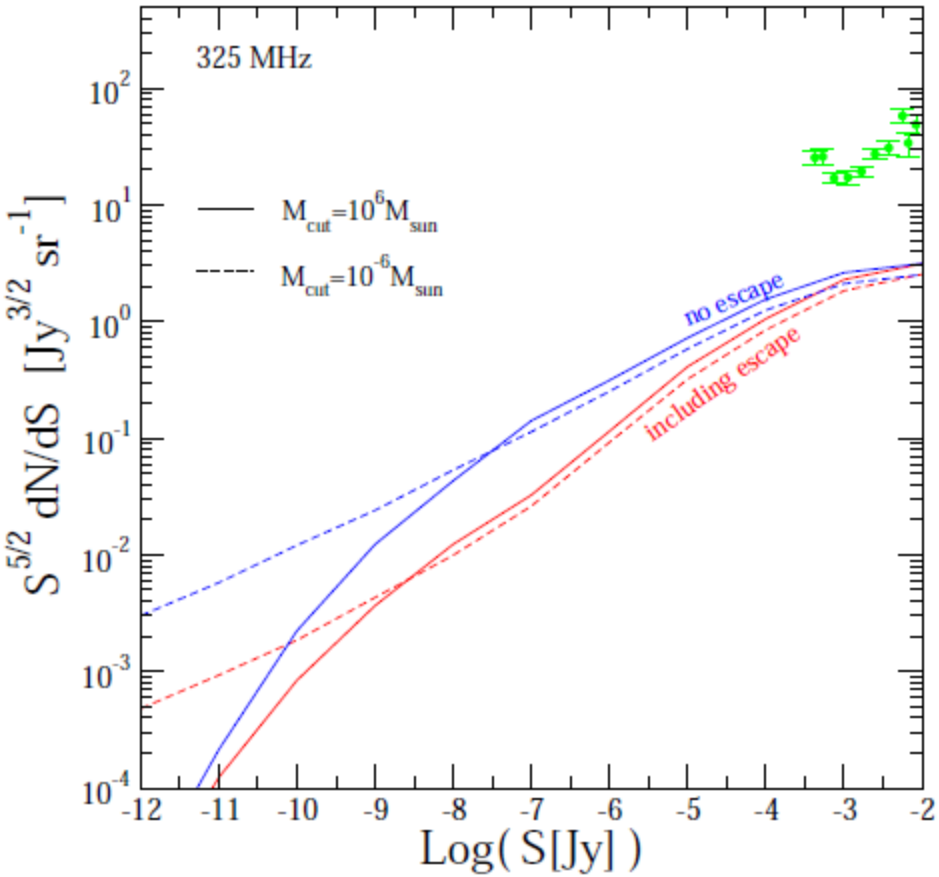




DM clustering, magnetic field and electrons propagation introduce significant uncertainties

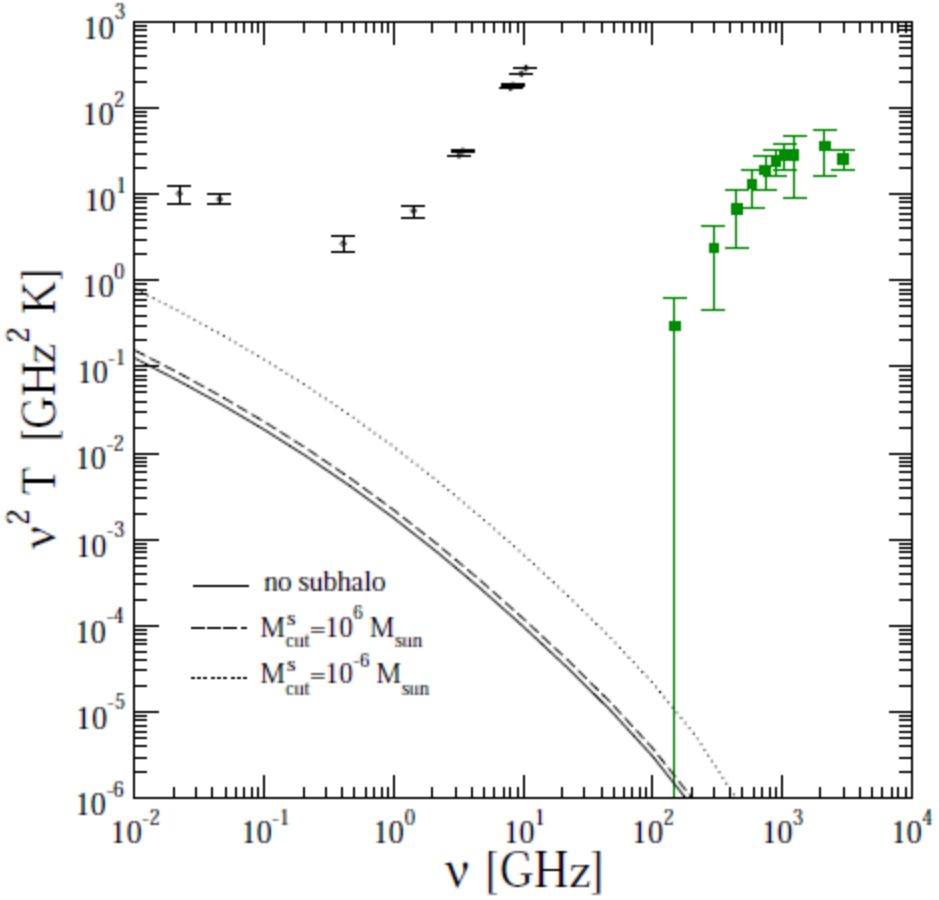
Uncertainties

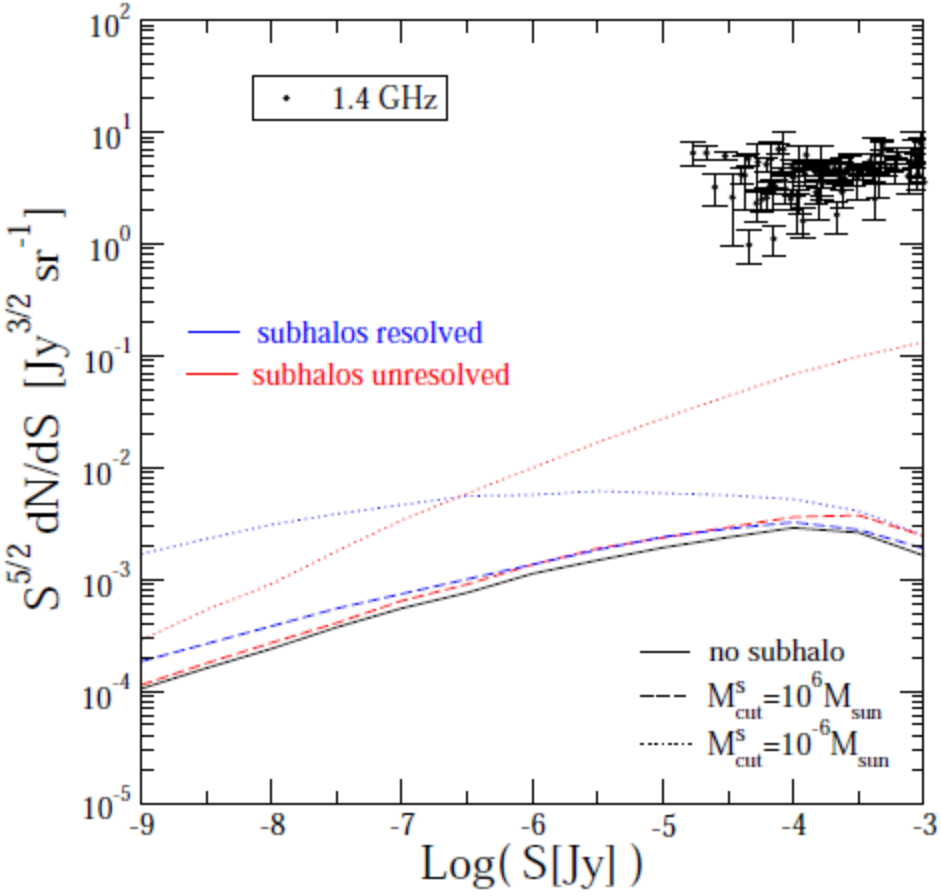




DM clustering, magnetic field and electrons propagation introduce significant uncertainties

Uncertainties





DM clustering, magnetic field and electrons propagation introduce significant uncertainties

Radio surveys from 22Mhz to 1420 Mhz