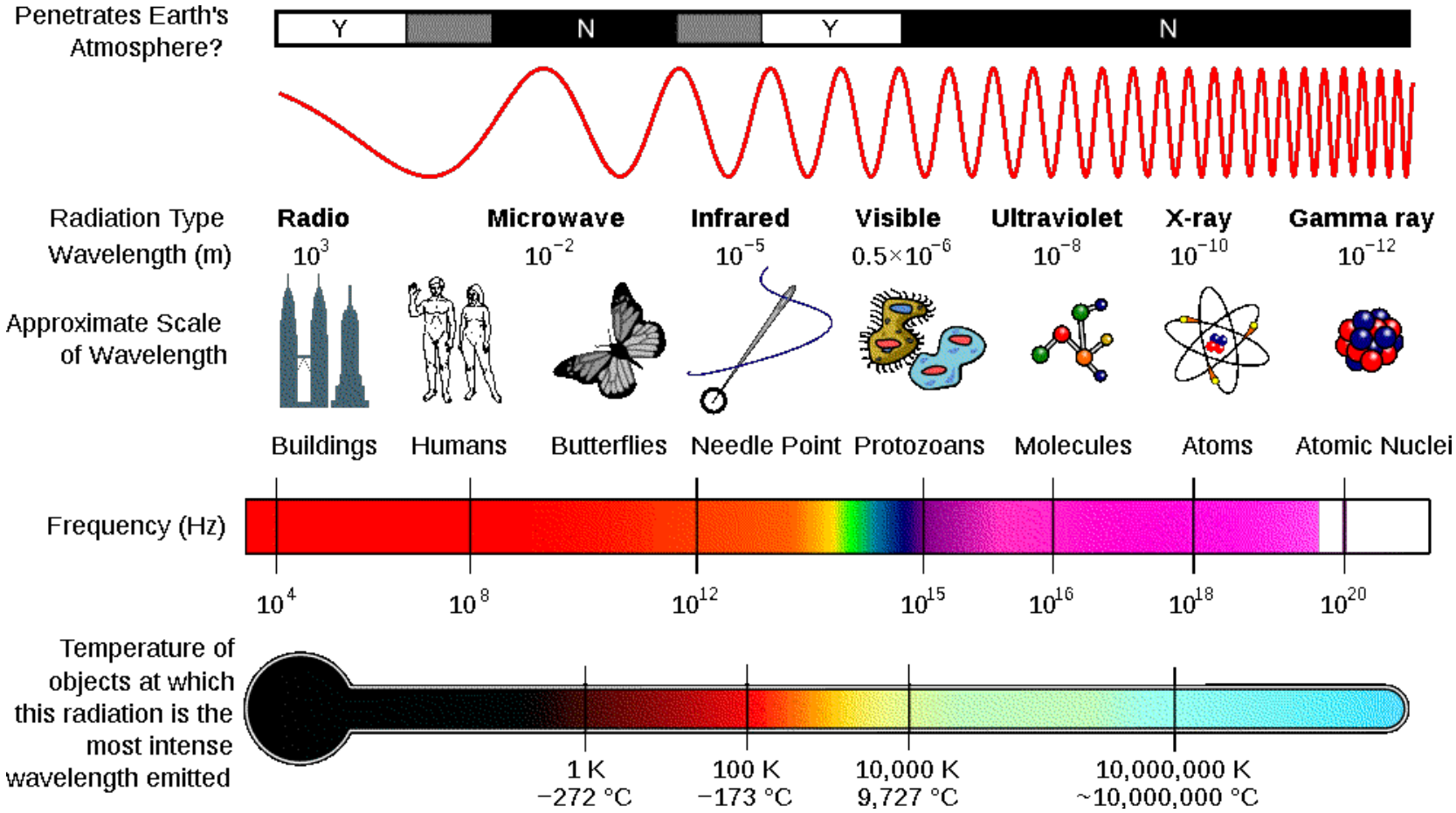
Astrophysical background
Episode II – join the bright side

Yago Ascasibar (UAM, Spain)

1st Thai-CTA Workshop on Astroparticle Physics
Chiang Mai (Thailand) 20/02/2019

Earlier, in Episode I...



$$1\ \mathrm{eV} \sim h\,(10^5\ \mathrm{GHz}) \sim \frac{hc}{10^4\ \text{Å}} \sim \frac{hc}{1\ \mu m} \sim \frac{3}{2}k\,(8000\ \mathrm{K}) \sim \frac{m_p\,(14\ \mathrm{km/s})^2}{2}$$

Cosmic ray propagation

Diffusion-loss equation

$$\frac{\partial}{\partial t}\frac{\mathrm{d}n}{\mathrm{d}\gamma}(\vec{x},\gamma) = \nabla\left[K(\vec{x},\gamma)\nabla\frac{\mathrm{d}n}{\mathrm{d}\gamma}(\vec{x},\gamma)\right] + \frac{\partial}{\partial\gamma}\left[b(\vec{x},\gamma)\frac{\mathrm{d}n}{\mathrm{d}\gamma}(\vec{x},\gamma)\right] + Q(\vec{x},\gamma)$$

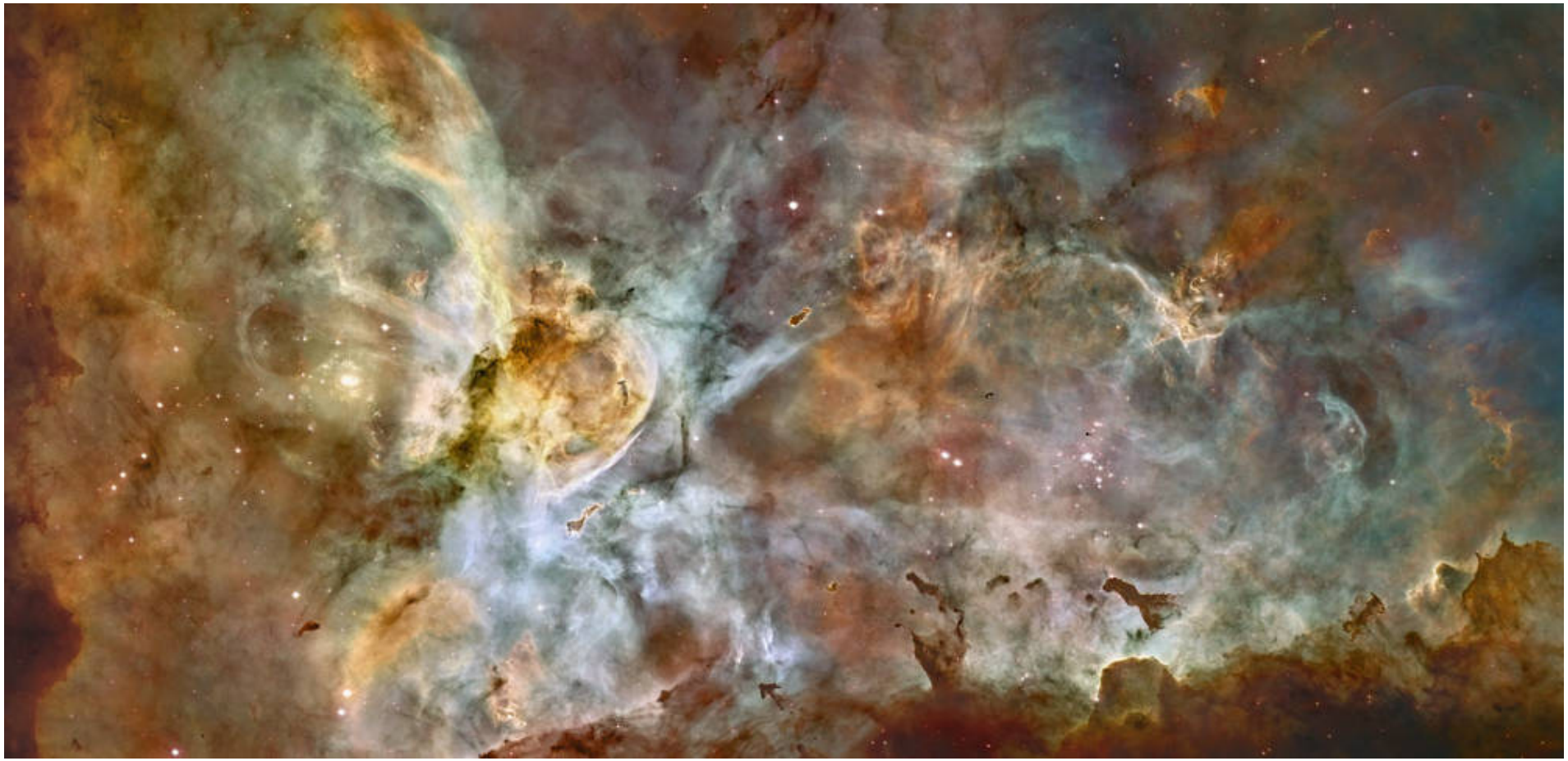
Interstellar medium (ISM)

- Density
- Temperature
- Ionisation

Electromagnetic field

- Light (ISRF)
- Magnetic field

Outline

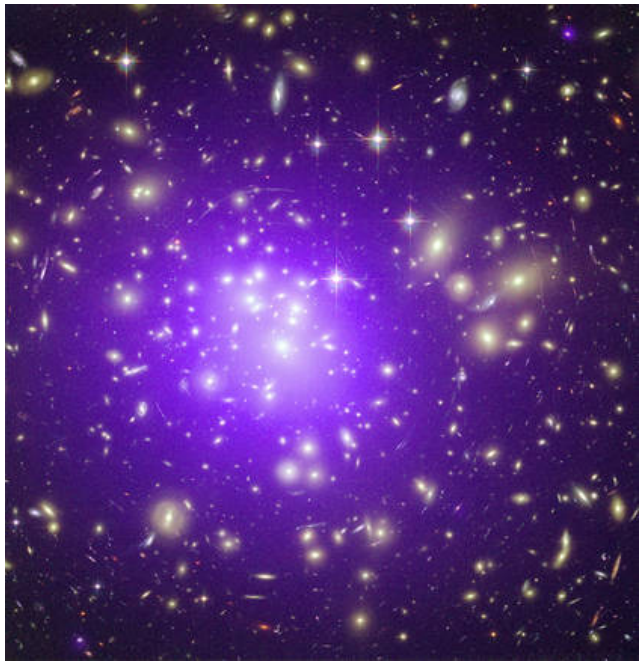


The Interstellar Medium (ISM)

Gas density

Pressure

$$\nabla P = -\rho \nabla \phi$$



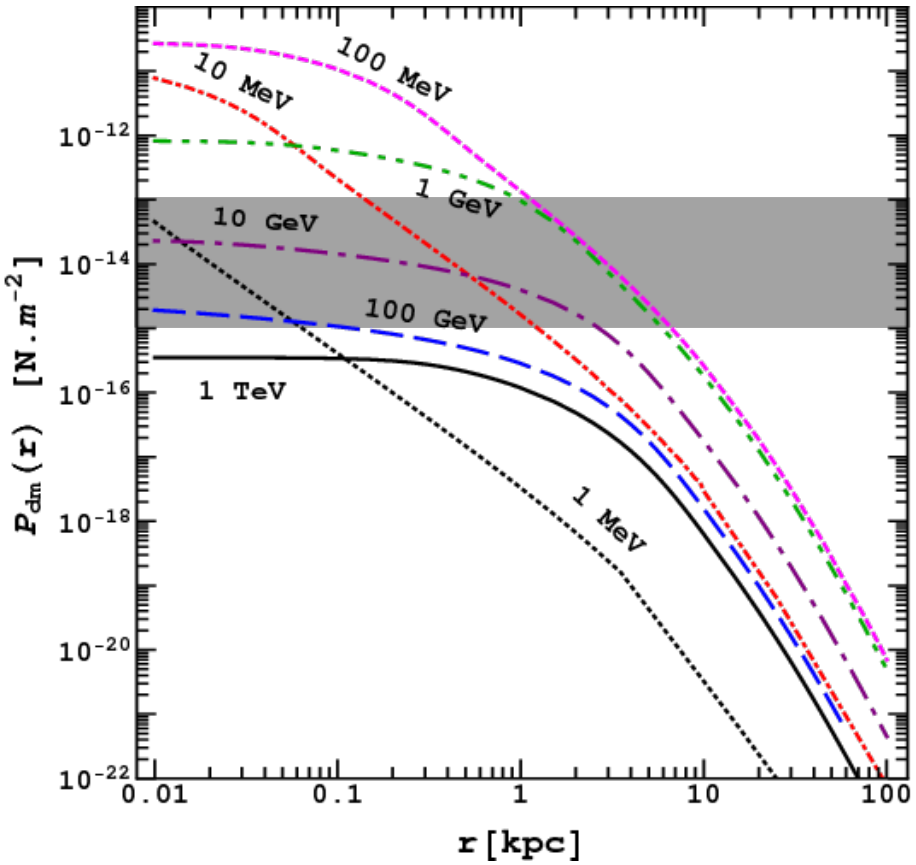
Hot spherical halo

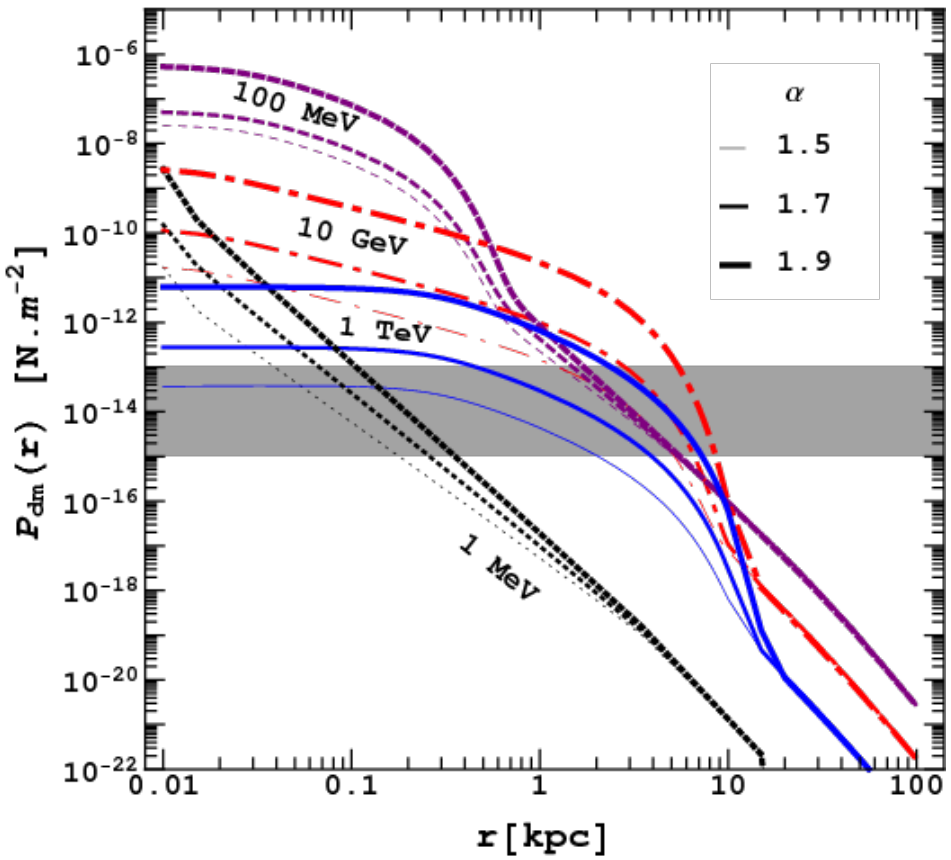
Angular momentum

$$V_{tg}/R = -\nabla \phi$$

Cold rotating disk

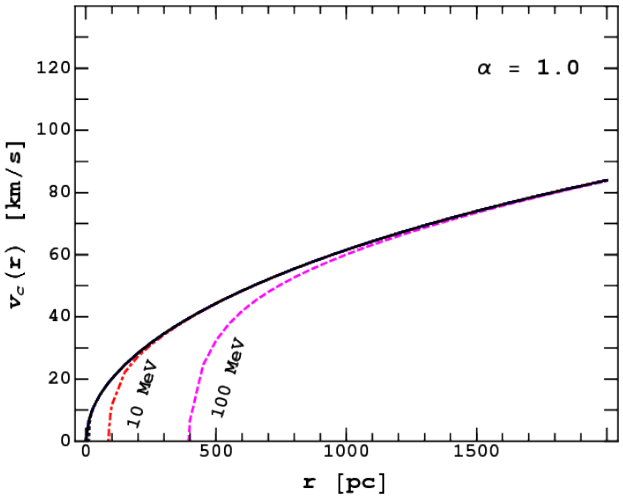
Pressure from dark matter annihilation?

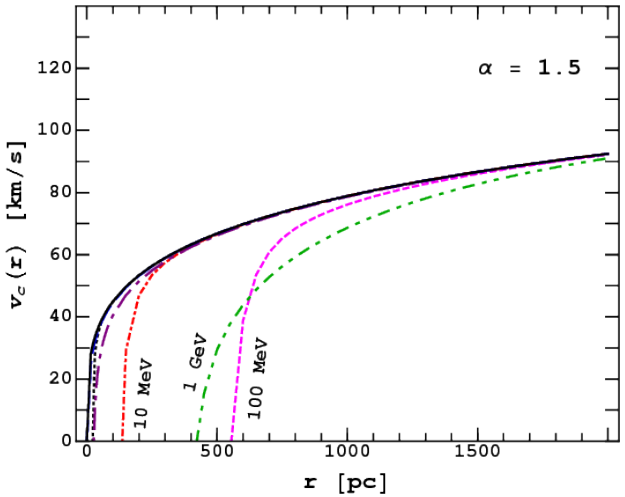


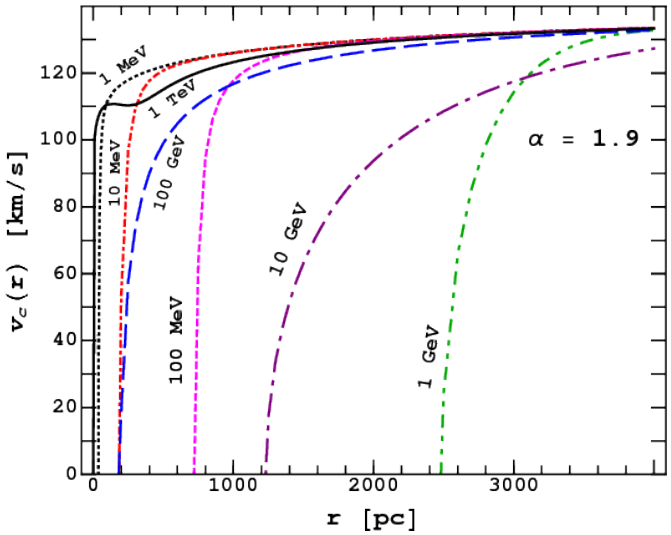


Wechakama & Ascasibar (2011)

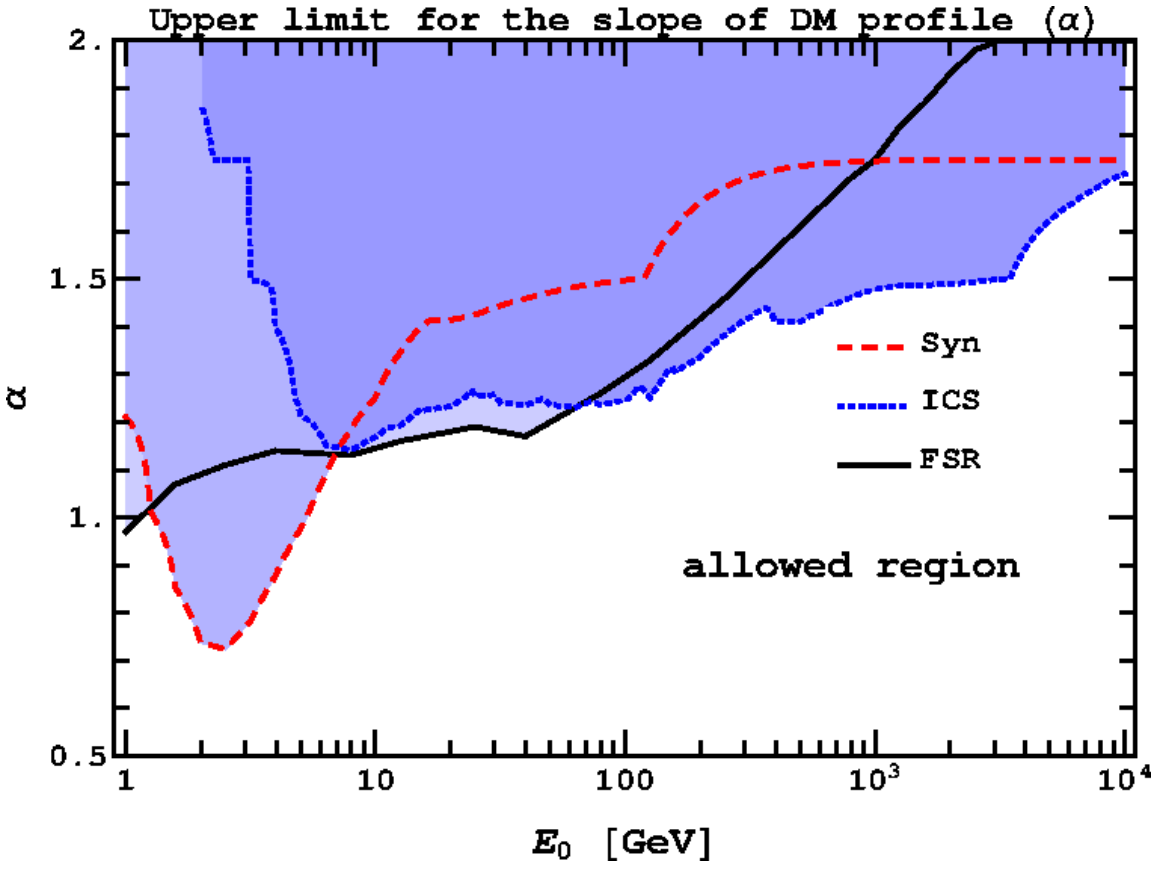
Pressure from dark matter annihilation?





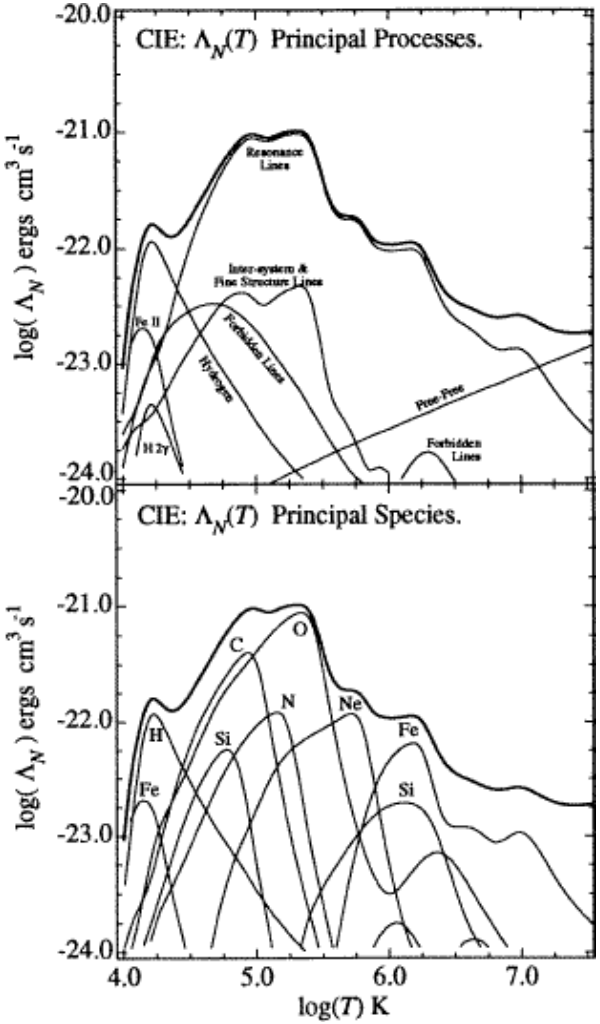


Constraints on the dark matter halo

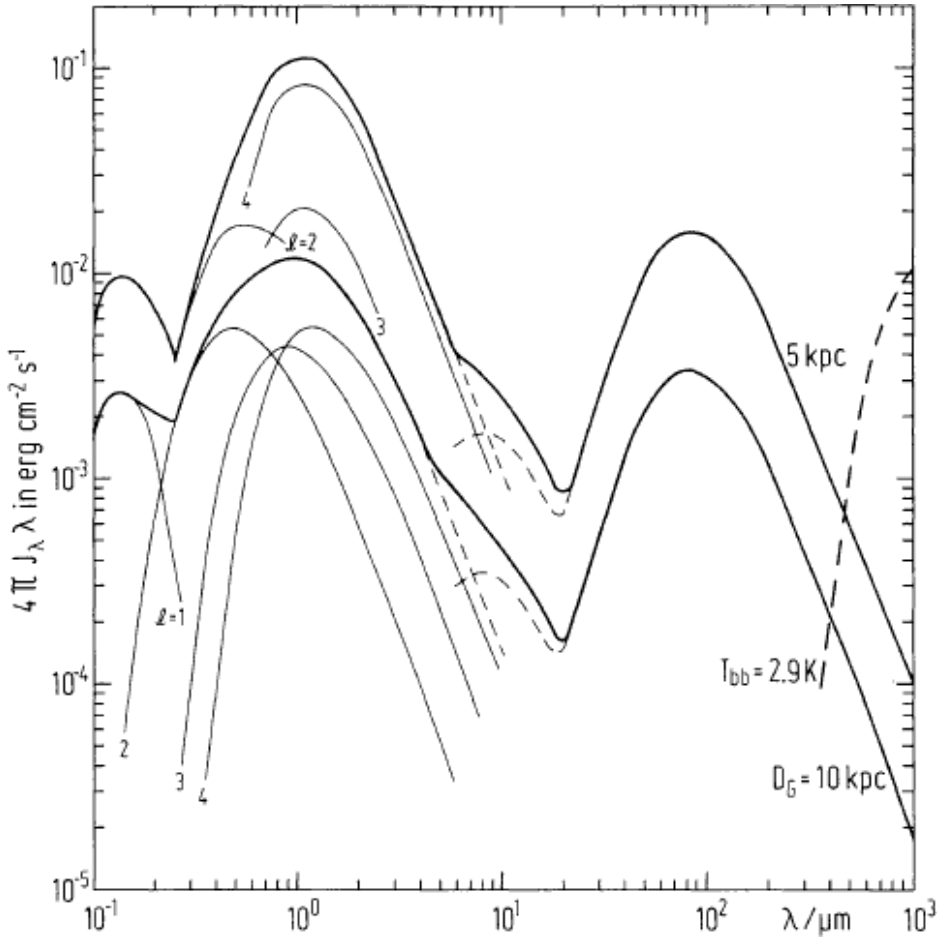


Wechakama & Ascasibar (2014)

Gas temperature

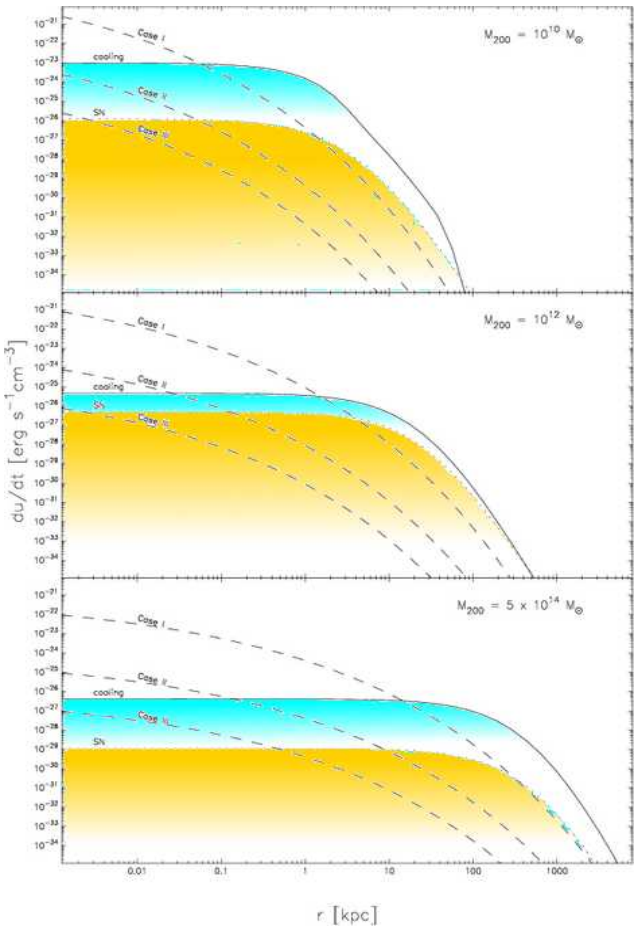


Sutherland & Dopita (1993)

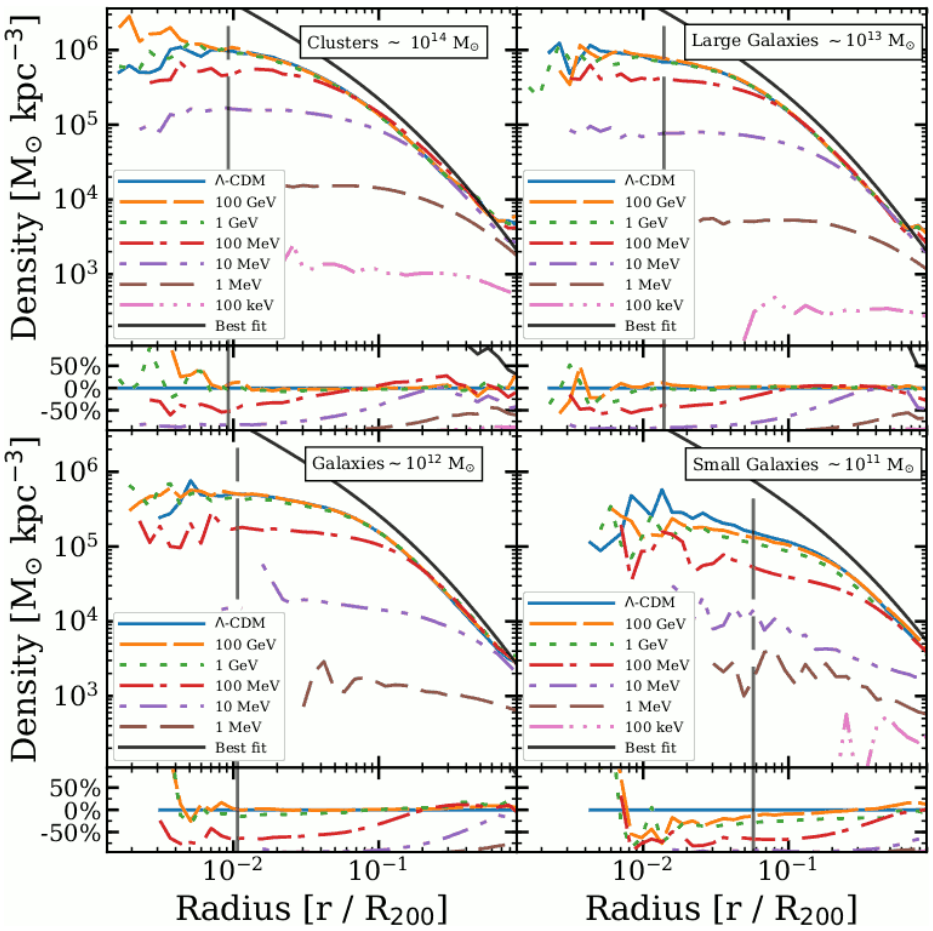


Mathis et al. (1983)

Heating from dark matter annihilation?

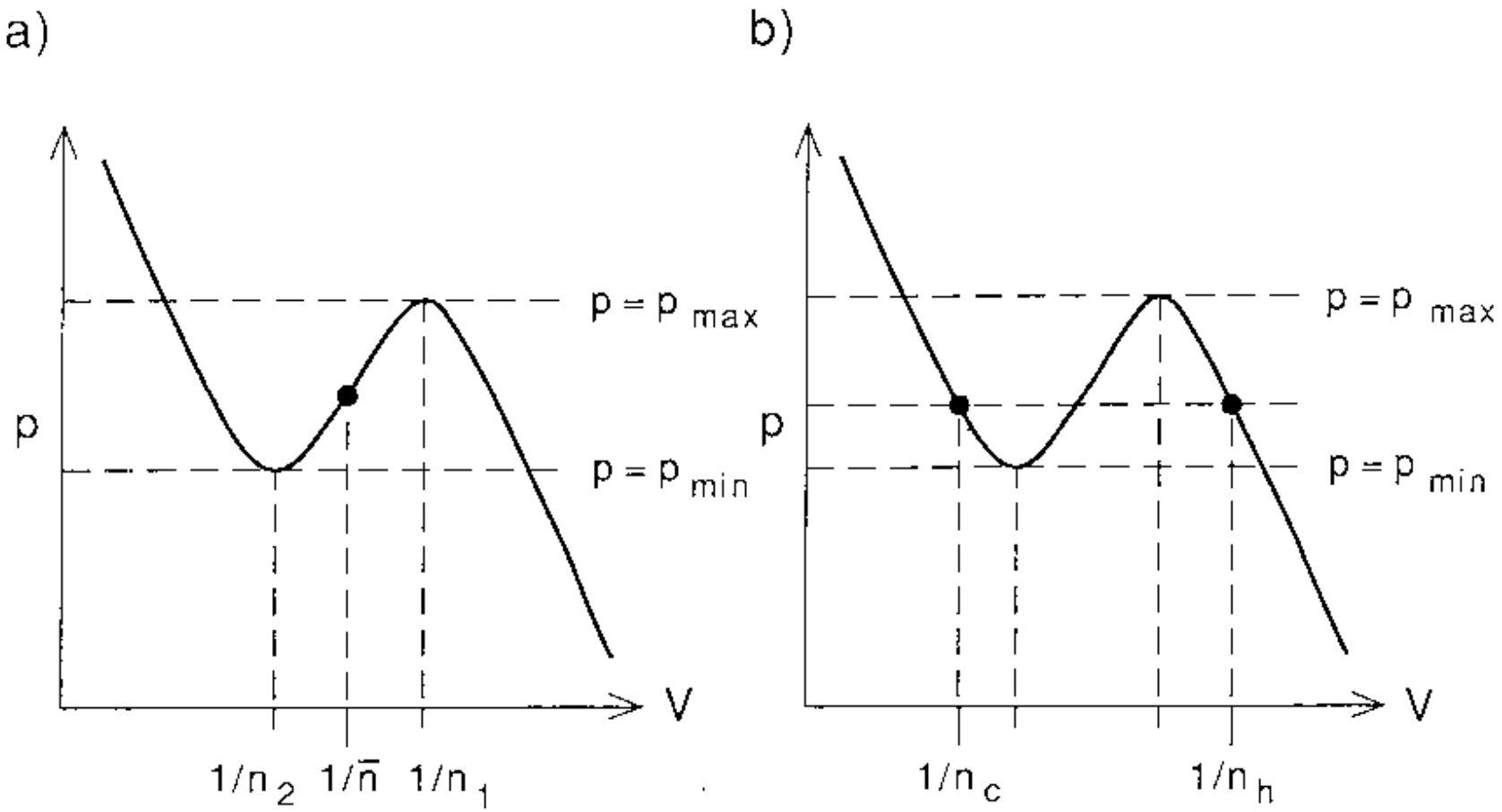


Ascasibar (2007)



Iwanus et al. (2019)

The multi-phase ISM



The multi-phase ISM

Phase	f_v	f_m	h (pc)	T (K)	n (cm^{-3})
Molecular clouds	1 %	22 %	80	15	> 100
Cold neutral medium	3 %	30 %	150	70	30
Warm neutral medium	20 %	35 %	400	8000	1
Warm ionised medium	30 %	10 %	1000	8000	1
HII regions	1 %	1 %	70	8000	> 100
Hot ionised medium	45 %	2 %	> 1000	$> 10^5$	$< 0{,}01$

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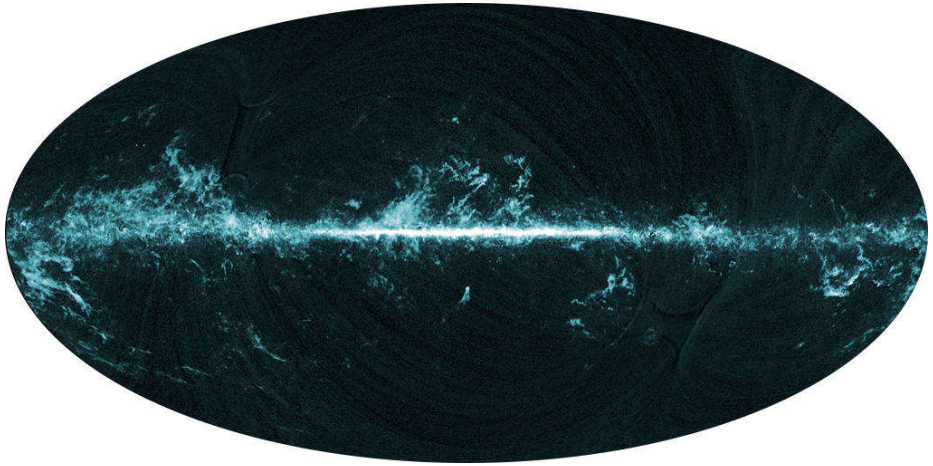

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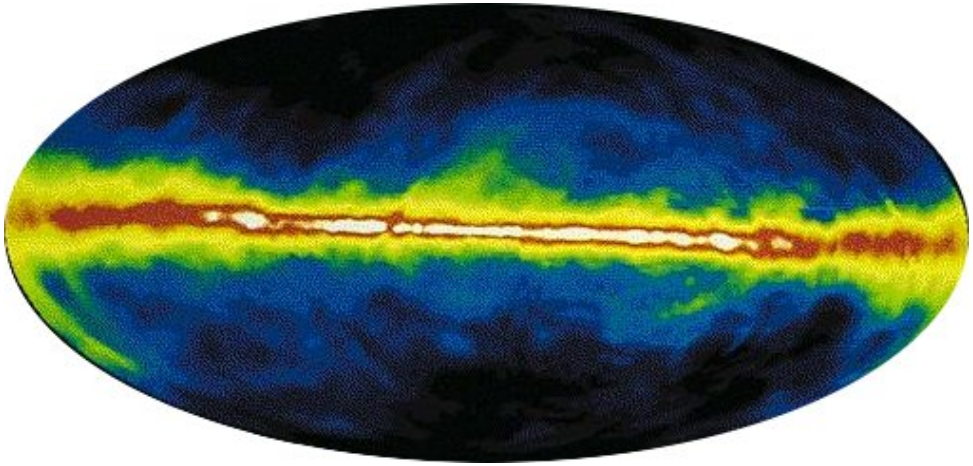

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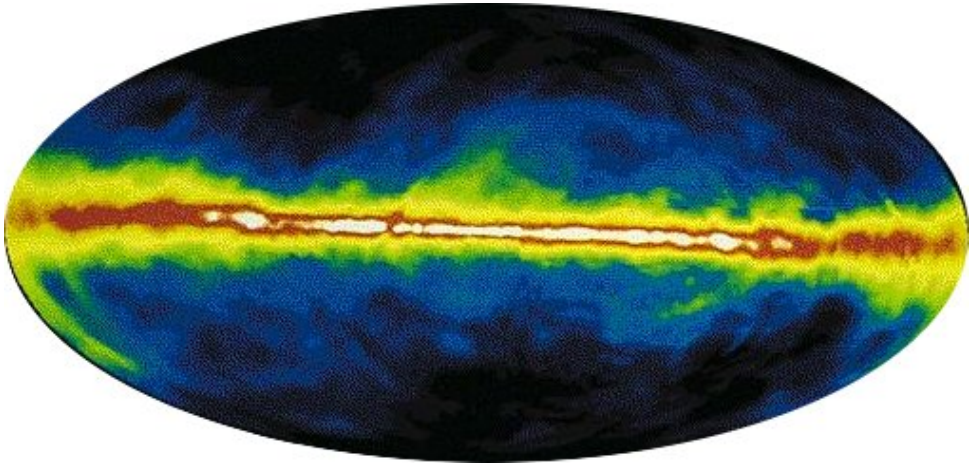

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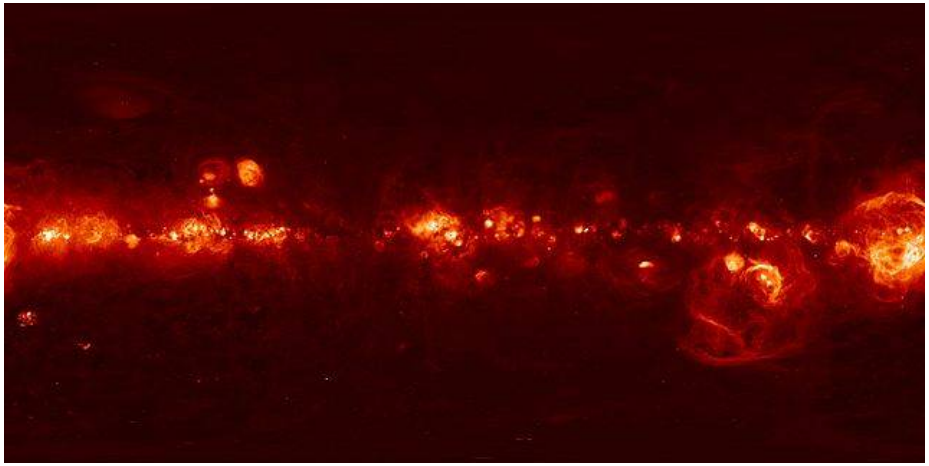

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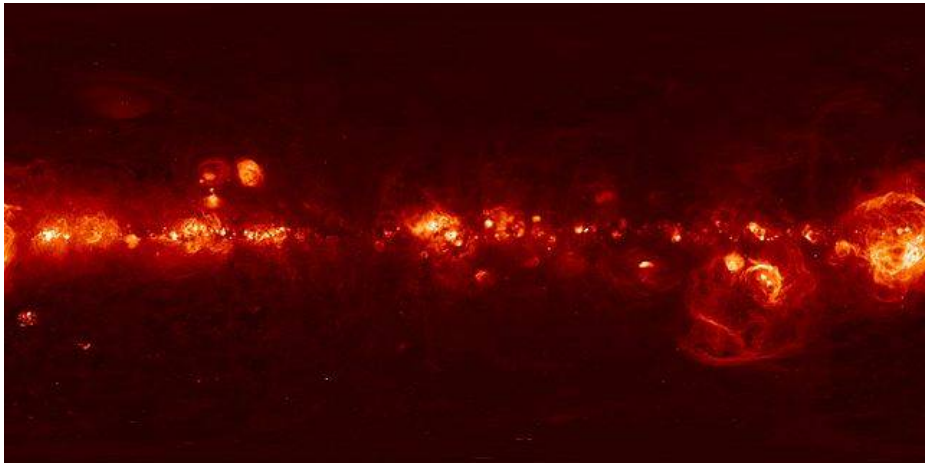

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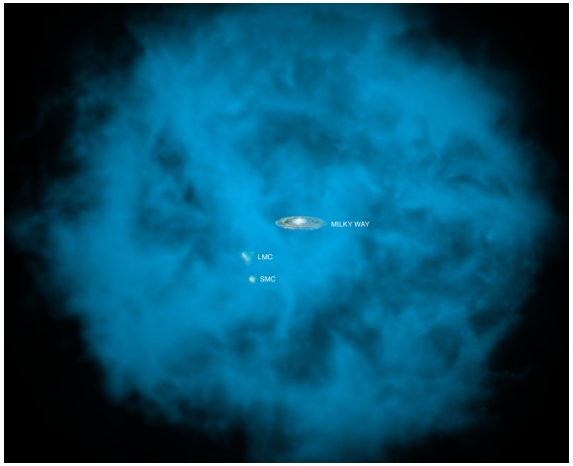

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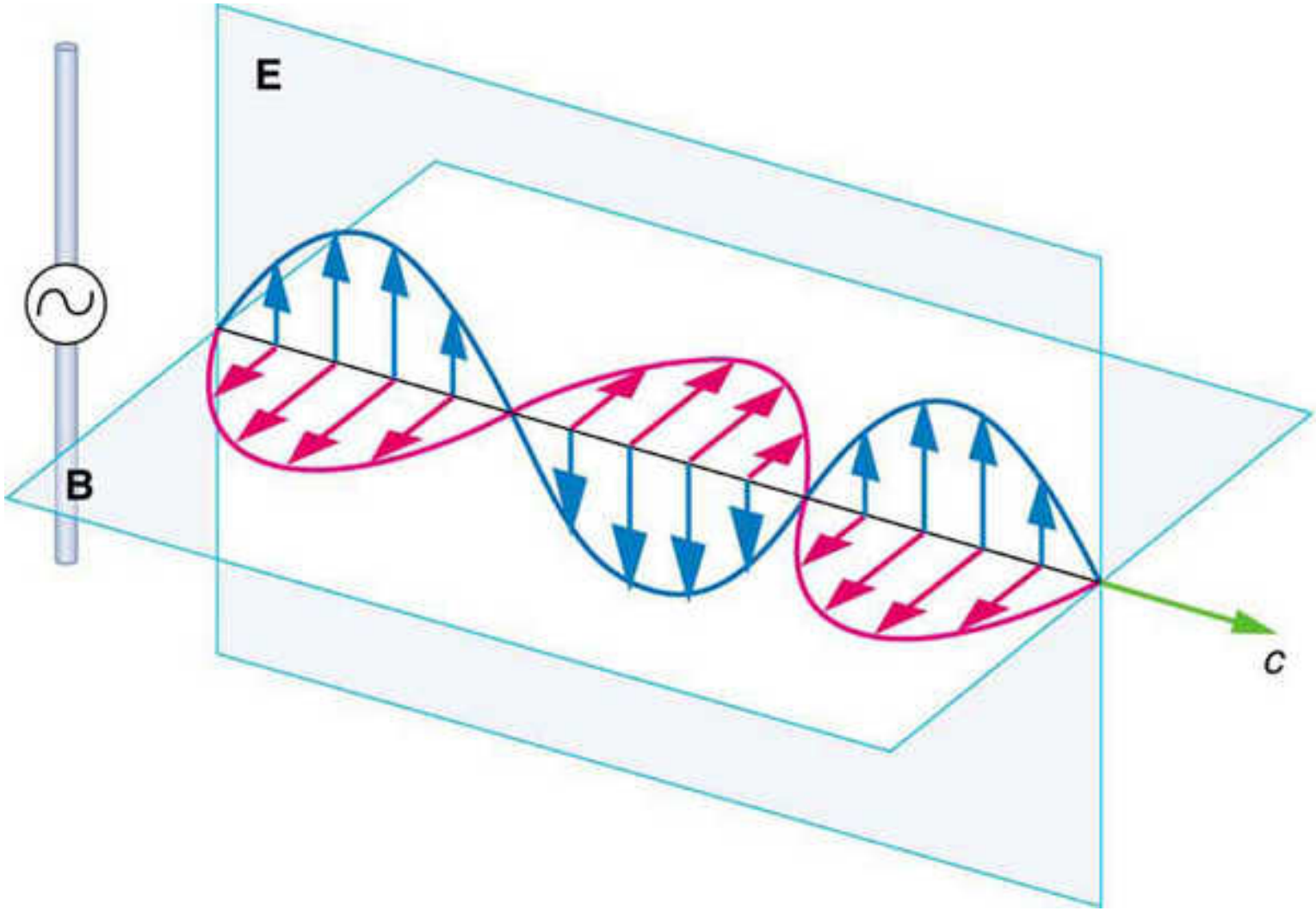
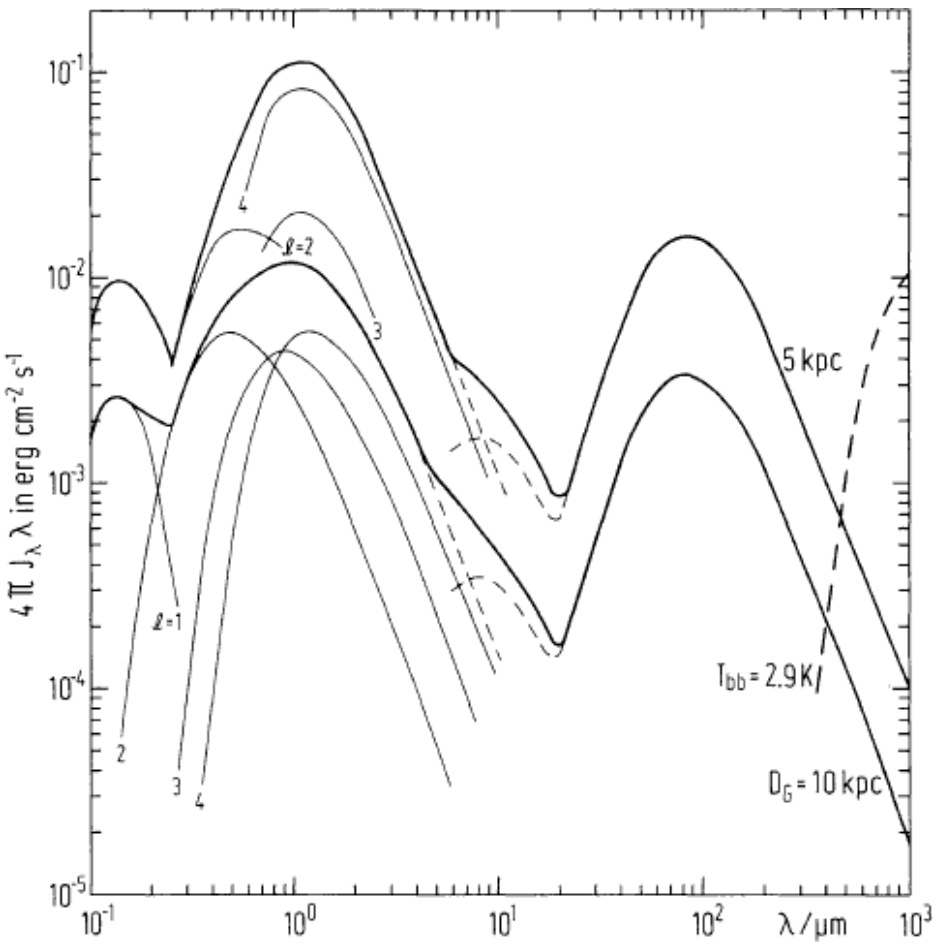


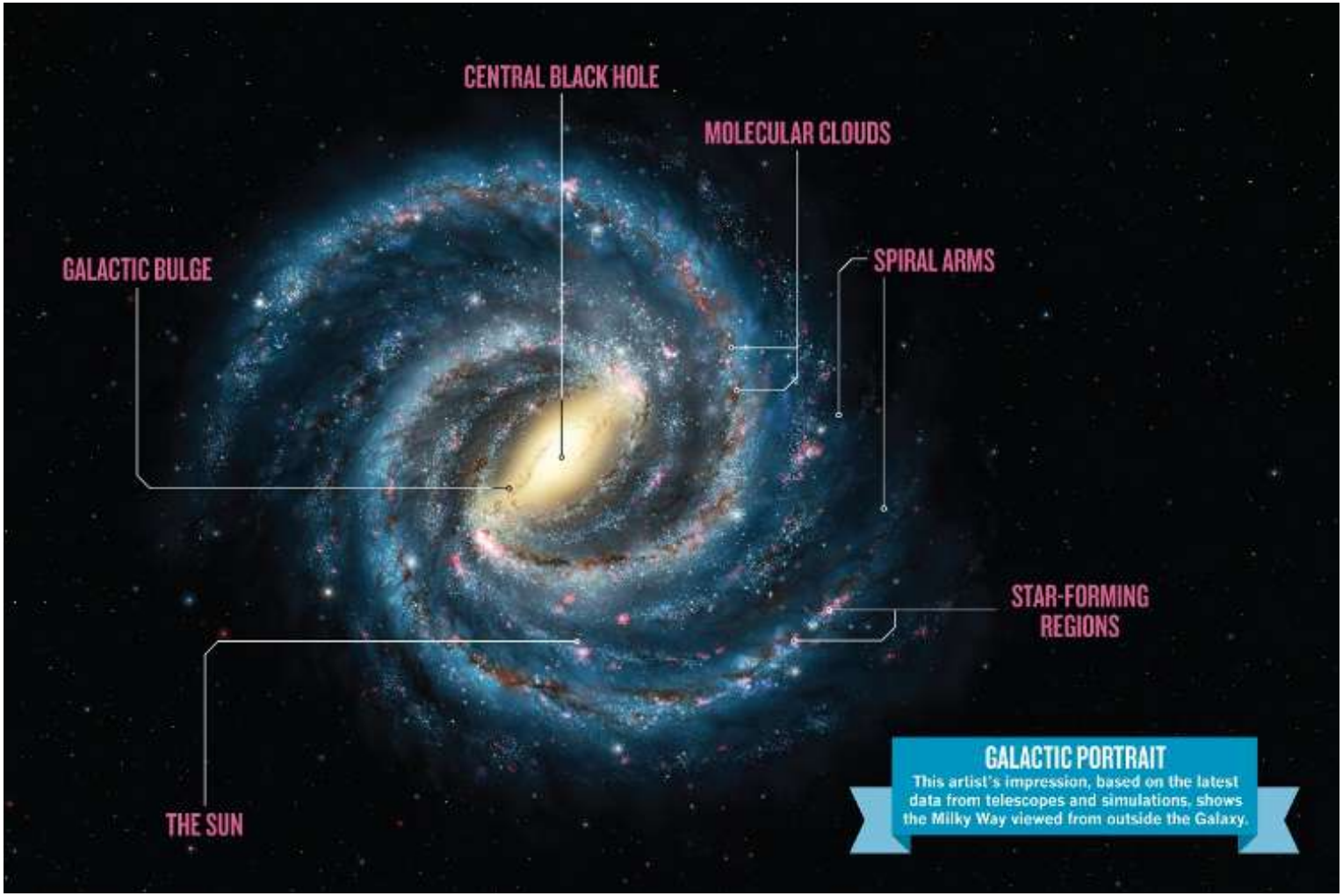
Electromagnetic field

Interstellar radiation field (ISRF)



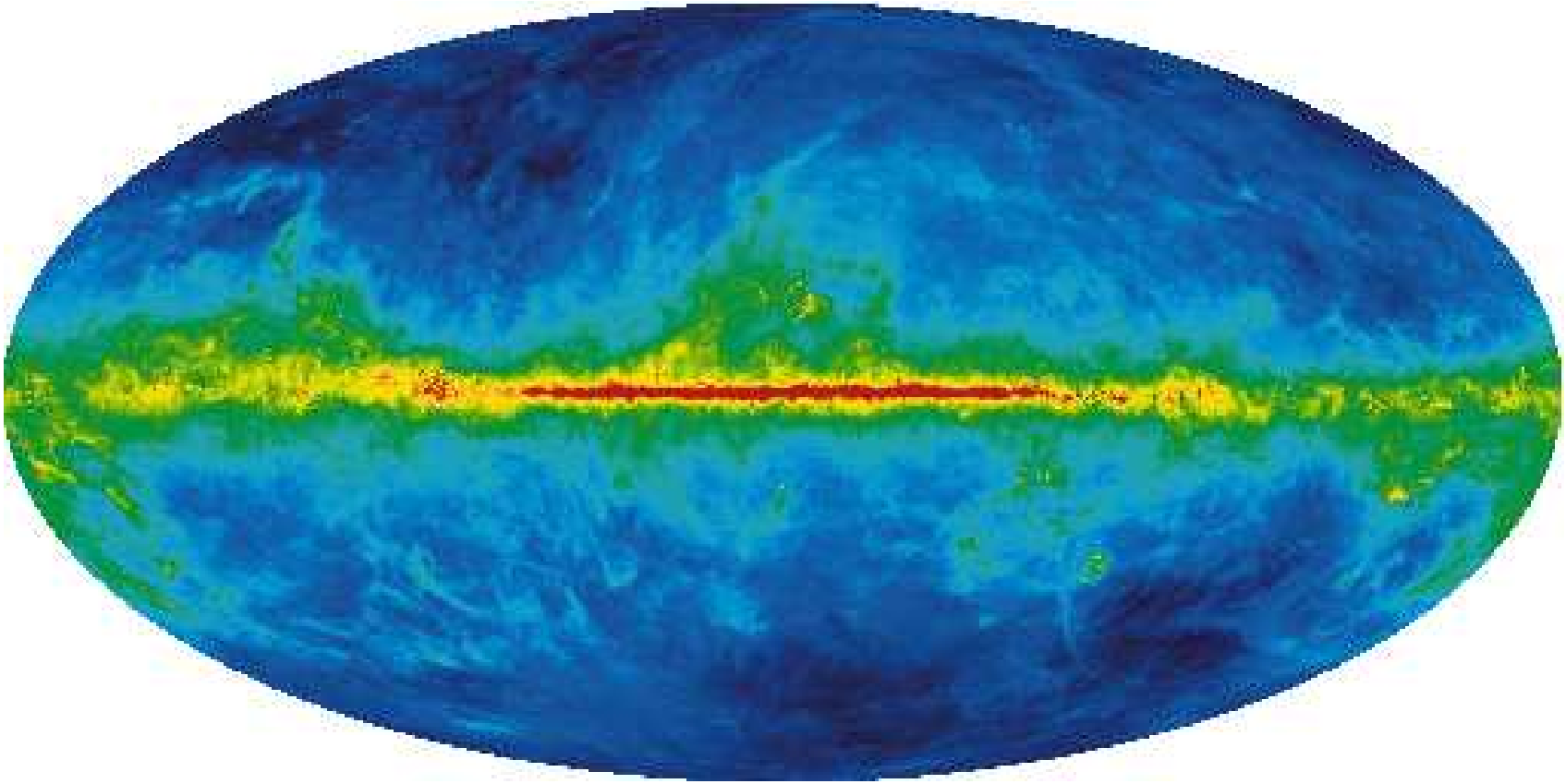
Mathis et al. (1983)

Stars



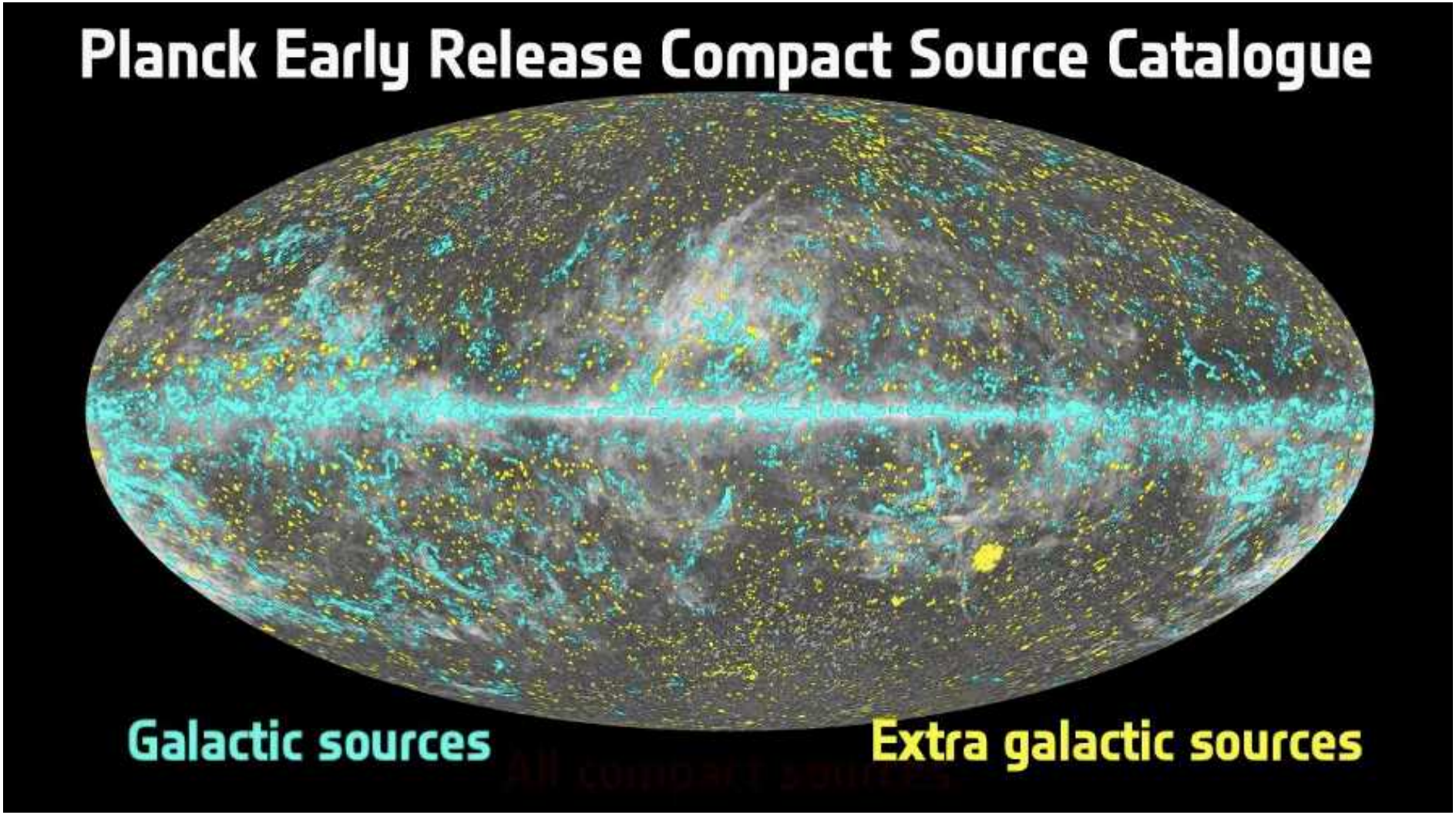
Finkbeiner (2012)

Dust absorption



Schlegel et al. (1998), obtained from LAMBDA

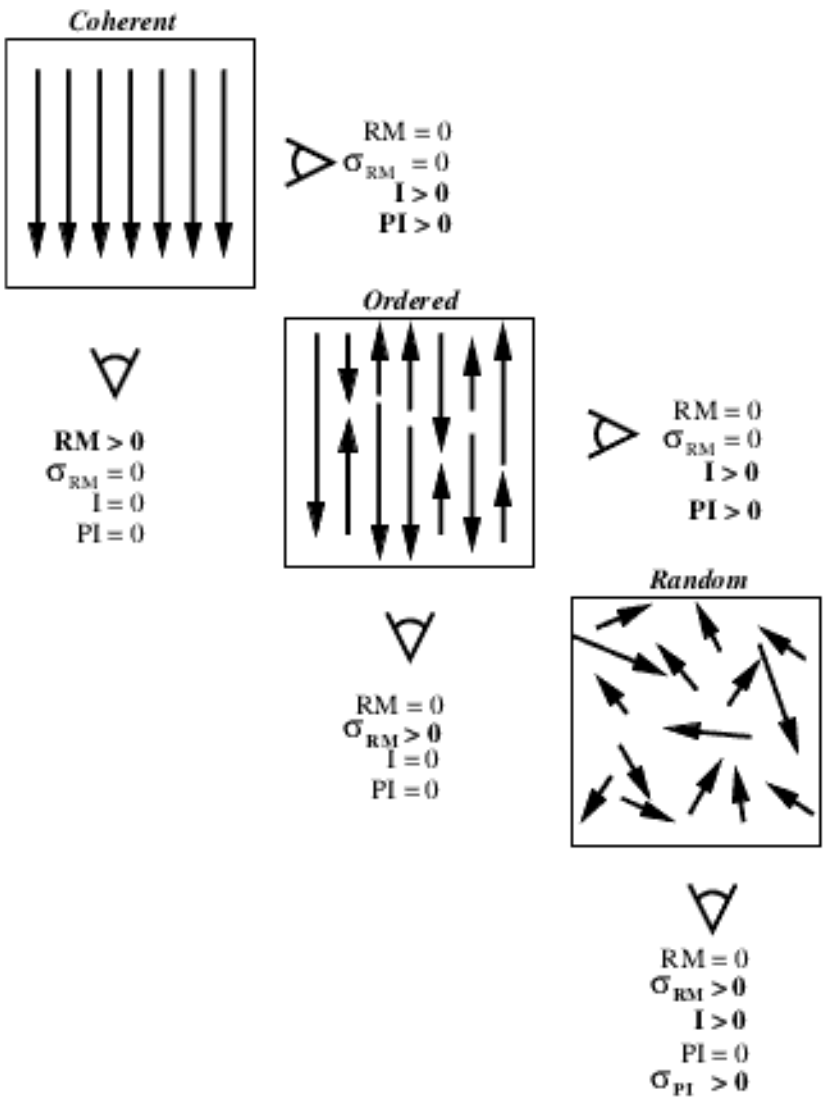
Dust emission



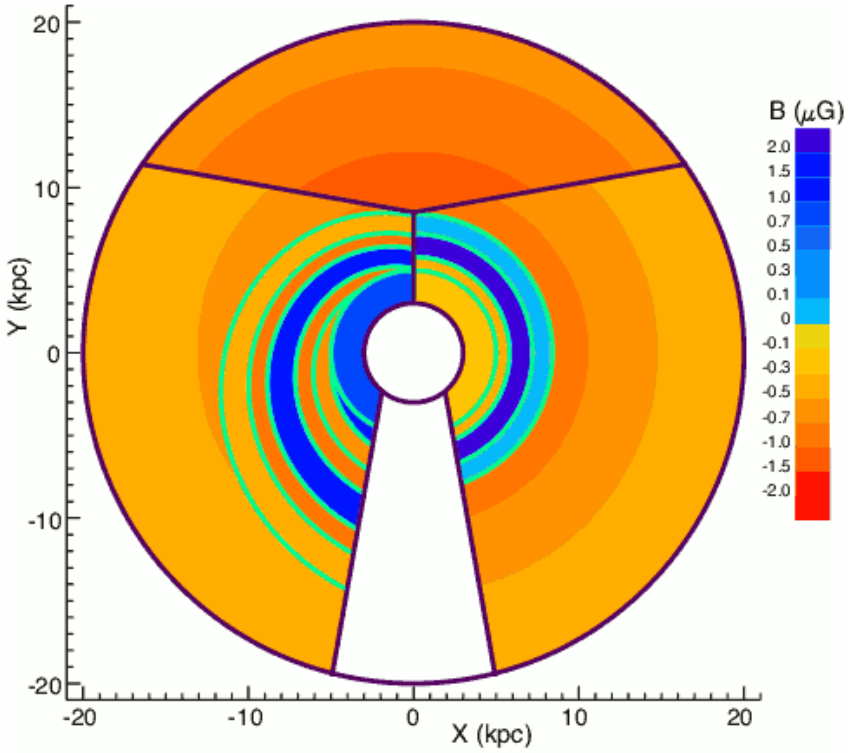
Magnetic field

Signatures

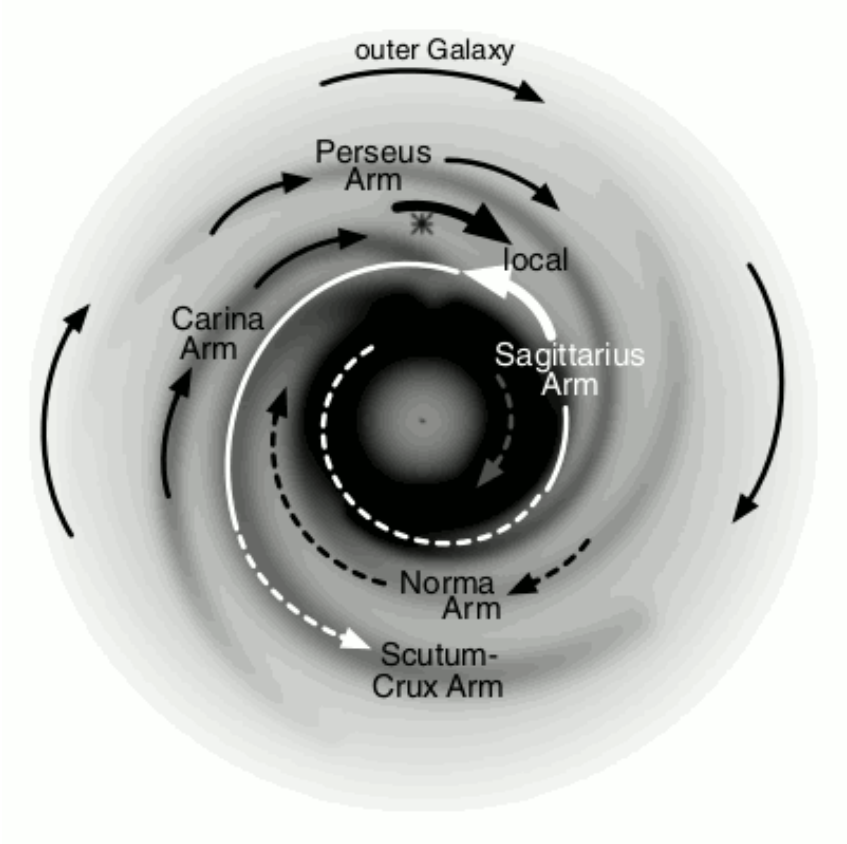
- Zeeman efect
- Faraday rotation
- Synchrotron emission
  - intensity
  - polarisation
- Polarisation
  - by dust absorption
  - of dust emission



Magnetic field



Van Eck et al. (2011)

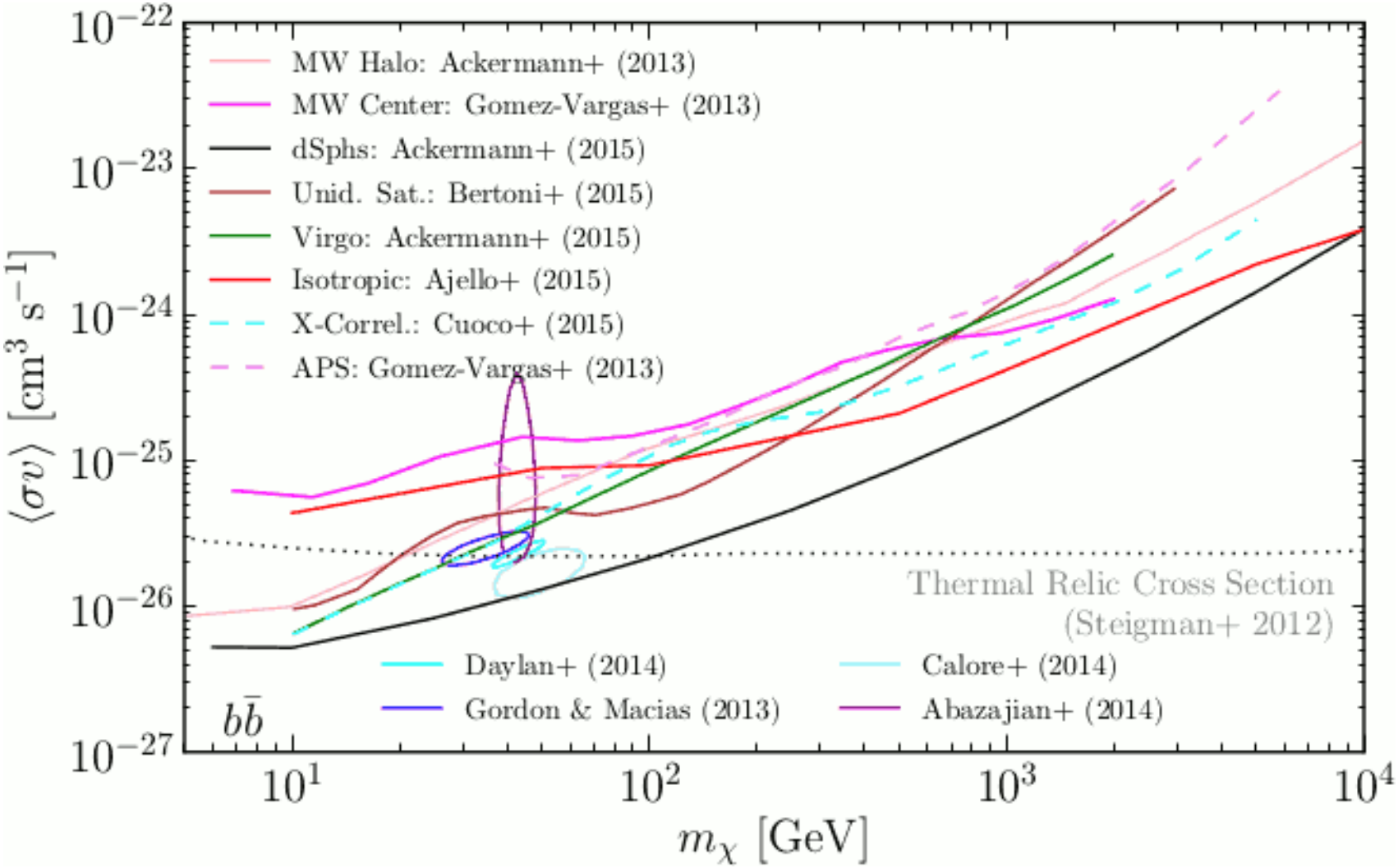


Observational evidence

Gamma rays

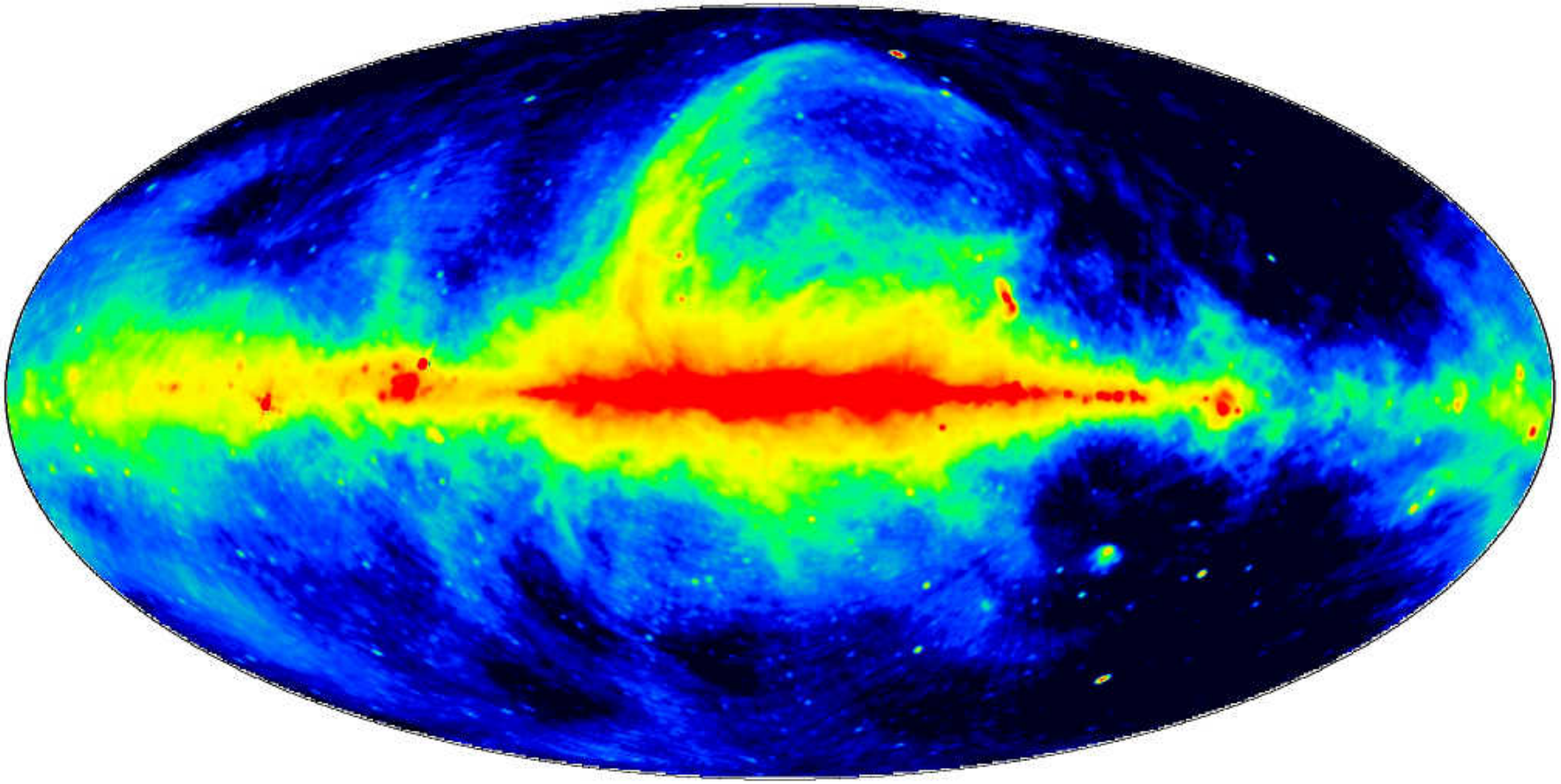
Gamma rays

Charles et al. (2016)



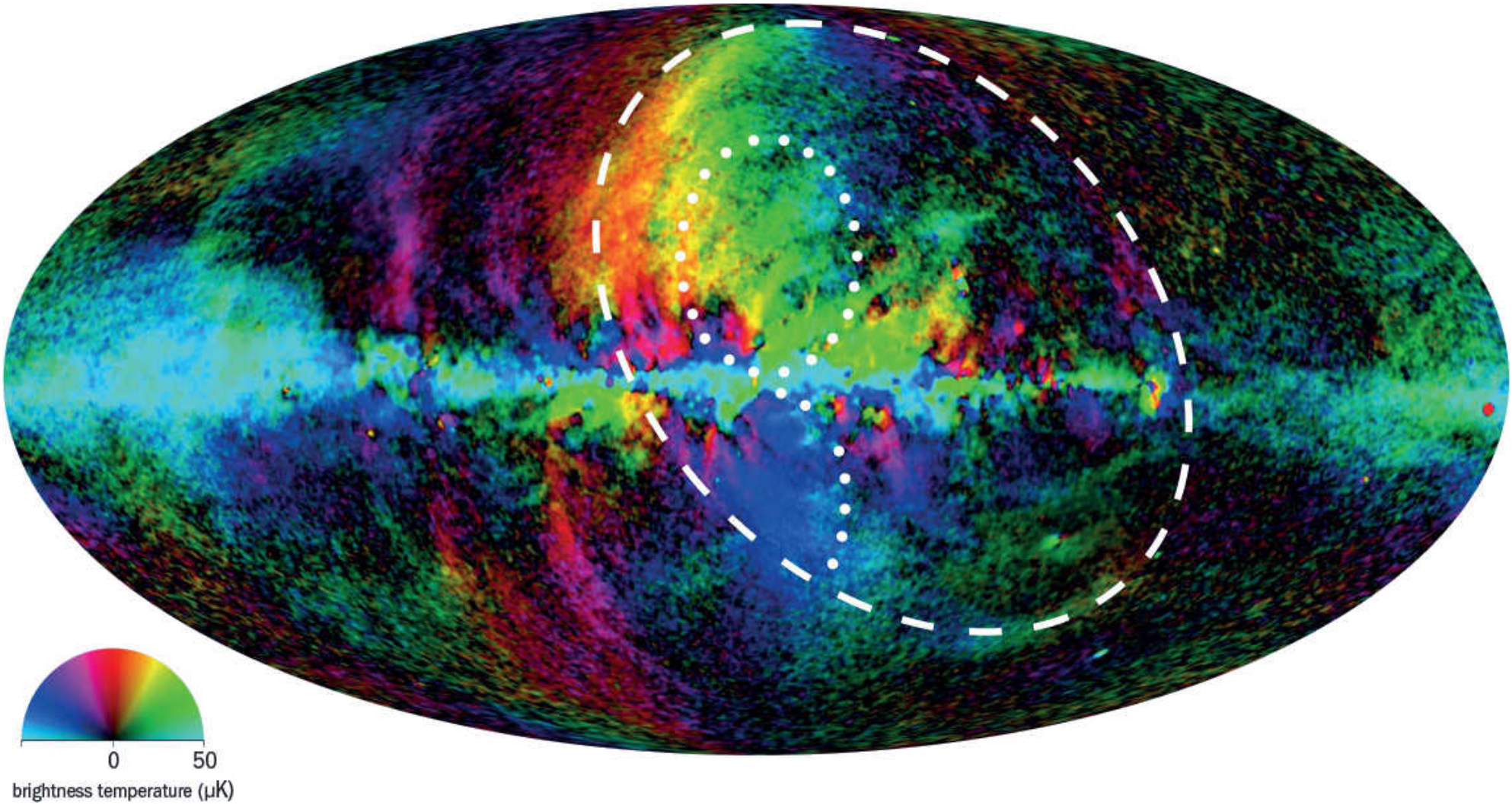
Synchrotron radiation

408 MHz

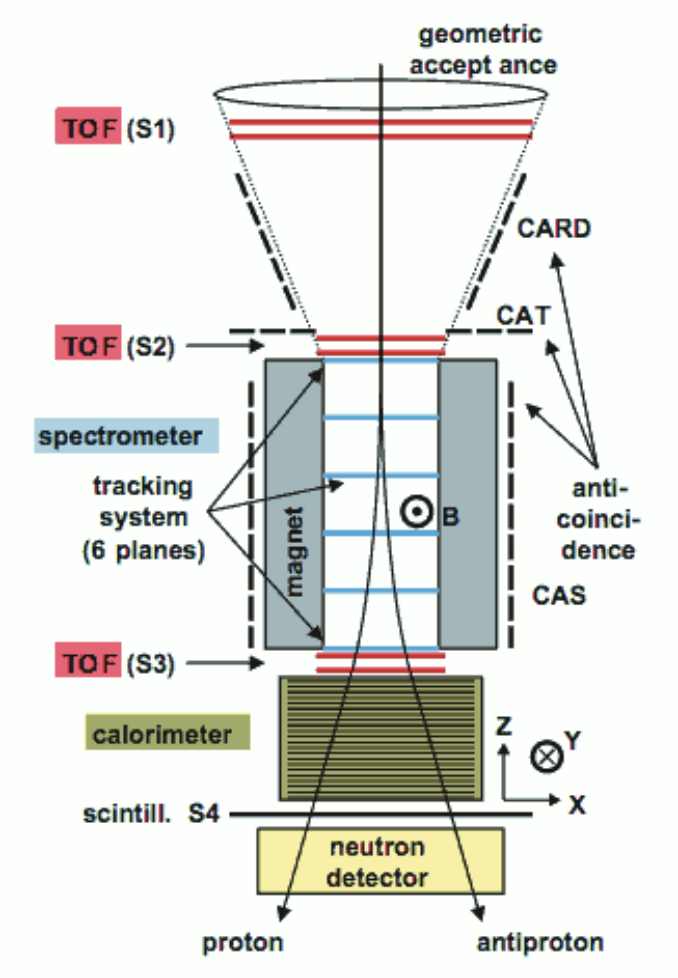


Jodrell-Bank 250-feet + Effelsberg 100-m + Parkes 64-m

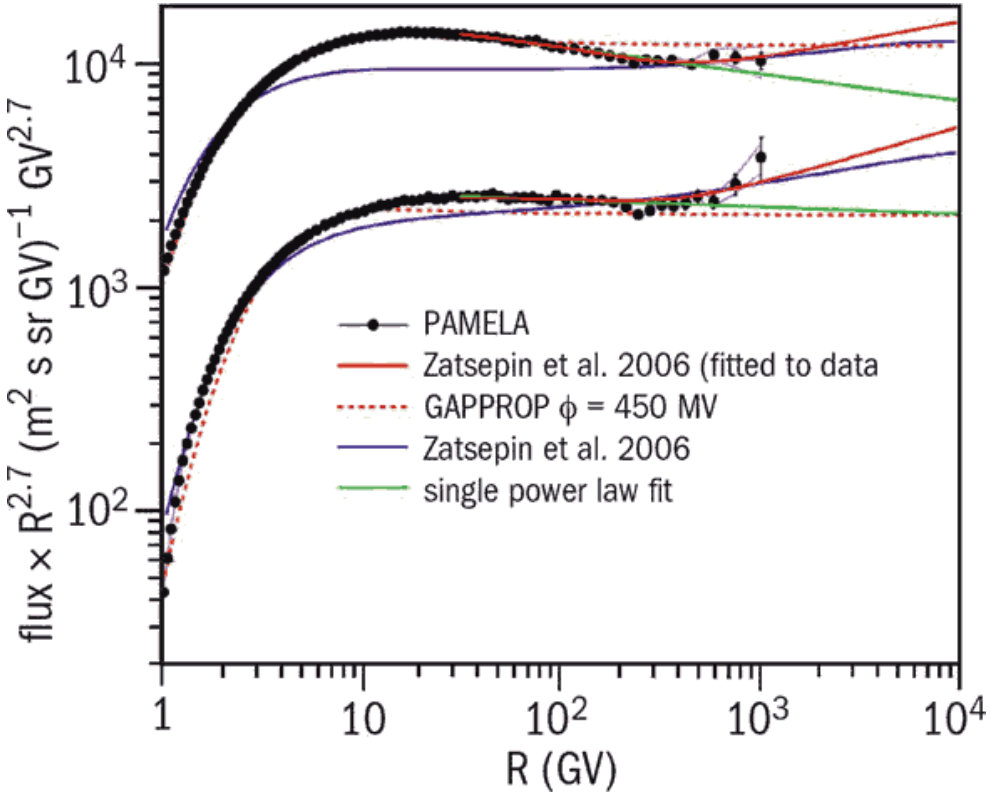
Synchrotron radiation



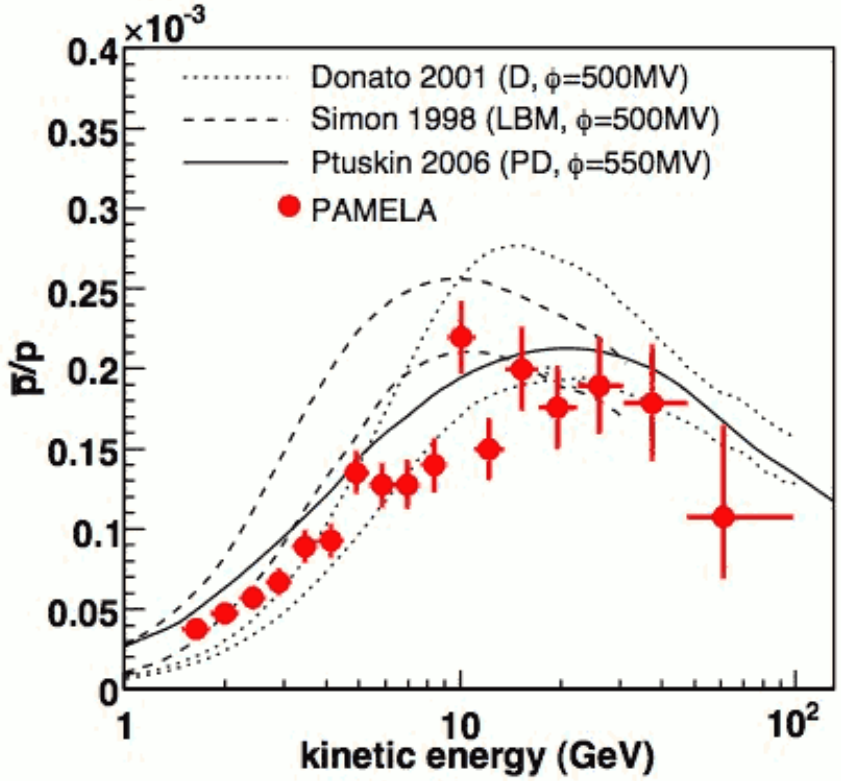
Cosmic rays


geometric
accept ance
TOF (S1)
CARD
CAT
TOF (S2)
spectrometer
tracking
system
(6 planes)
magnet
B
anti-
coinci-
dence
CAS
TOF (S3)
calorimeter
Z
Y
X
scintill. S4
neutron
detector
proton
antiproton

Nucleons



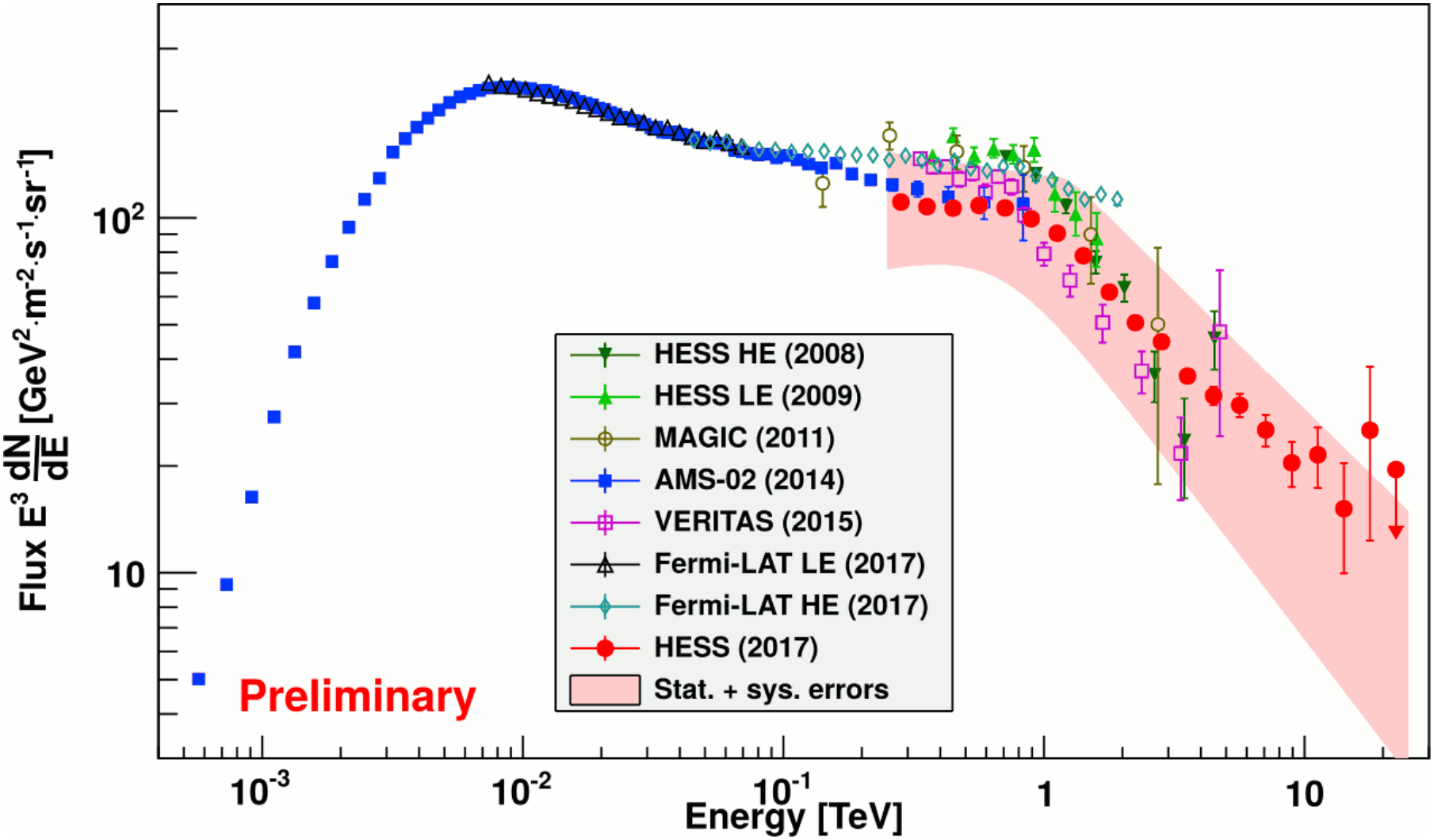
Adriani et al. (2011)



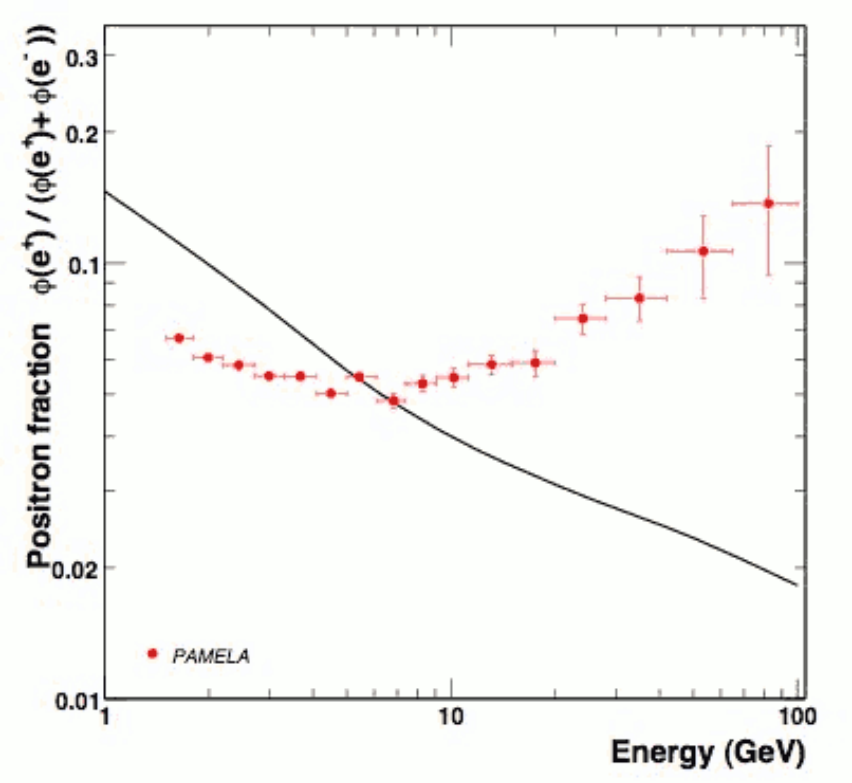
Adriani et al. (2009a)

Leptons ($e^+ + e^-$)

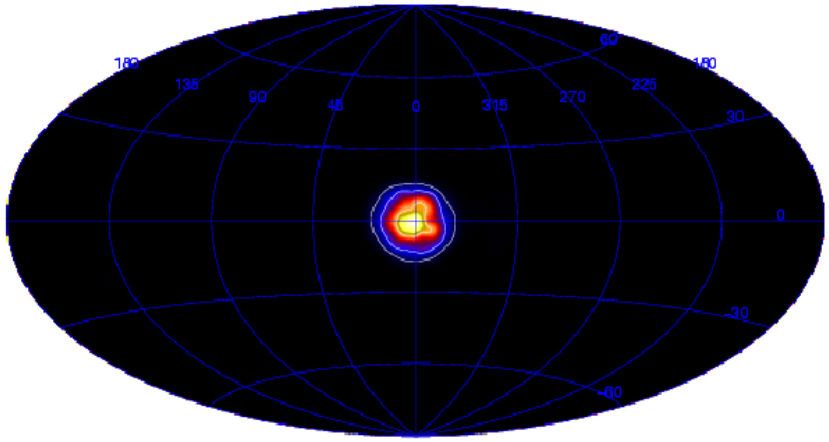
https://www.mpi-hd.mpg.de/hfm/HESS/pages/home/som/2017/09/



Positrons

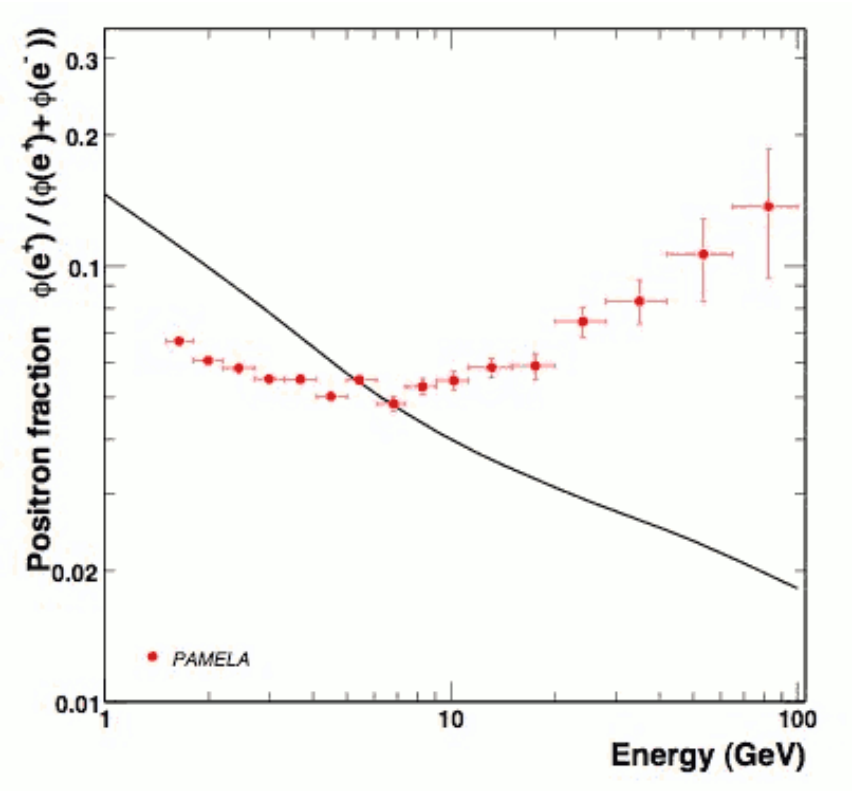


Adriani et al. (2009b)

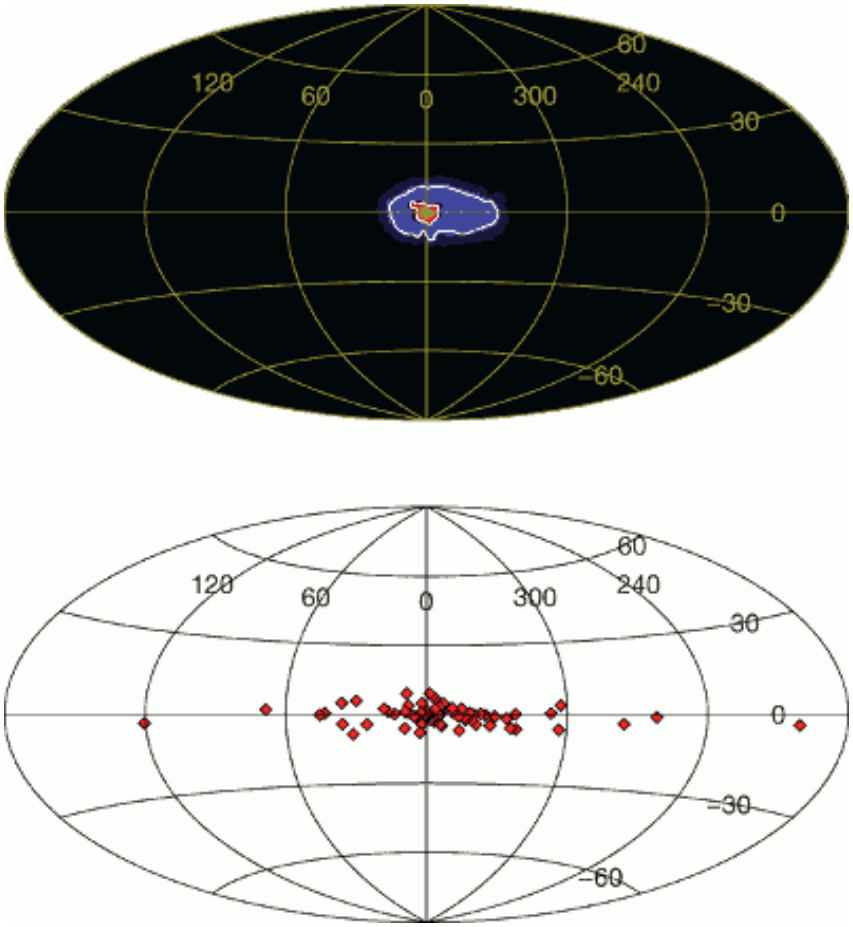


Knödlseder et al. (2005)

Positrons

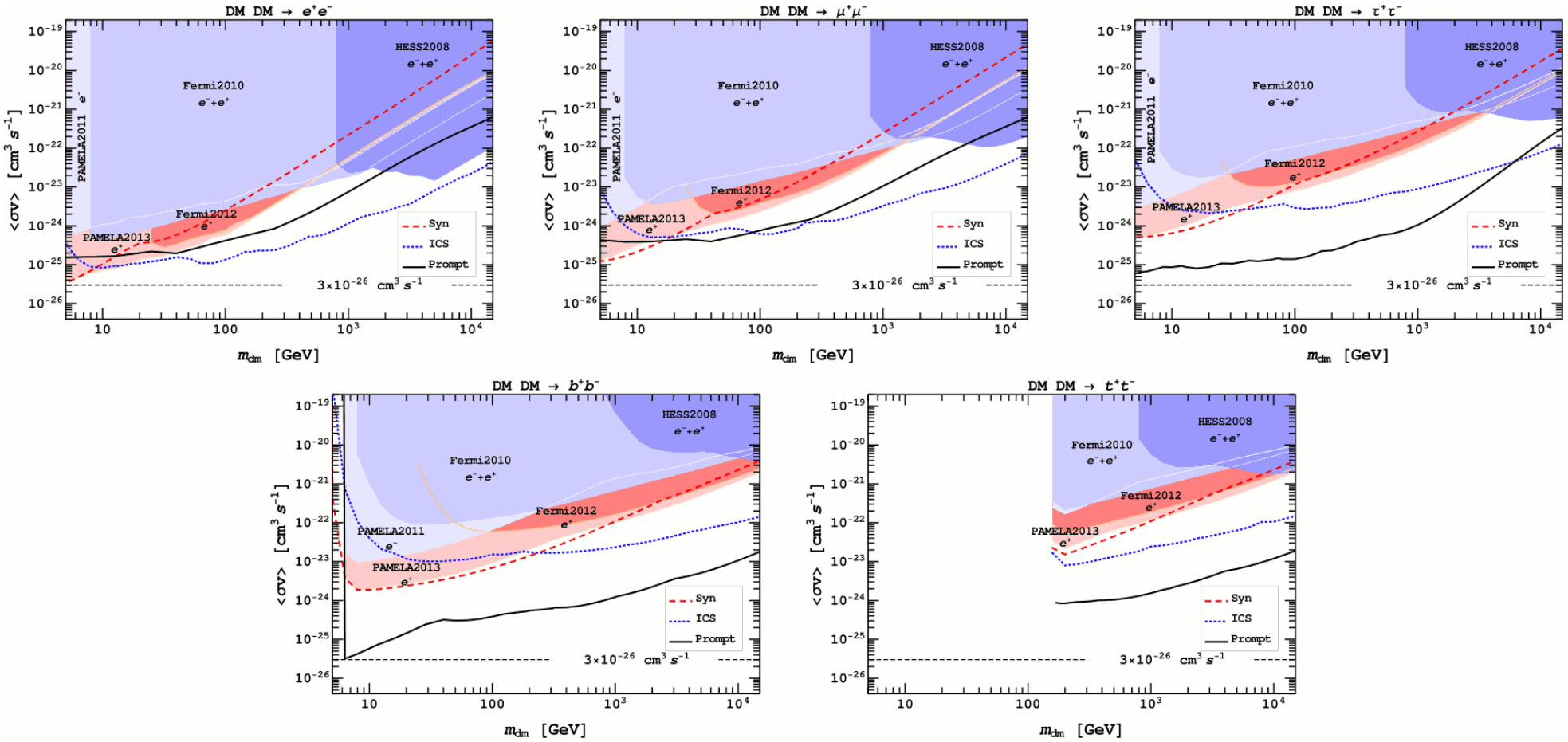


Adriani et al. (2009b)



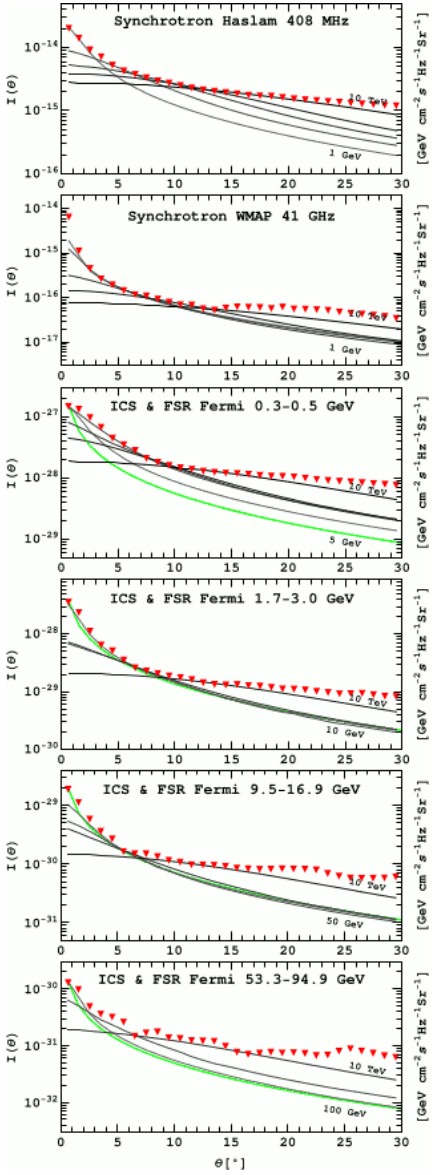
Weidenspointner et al. (2008)

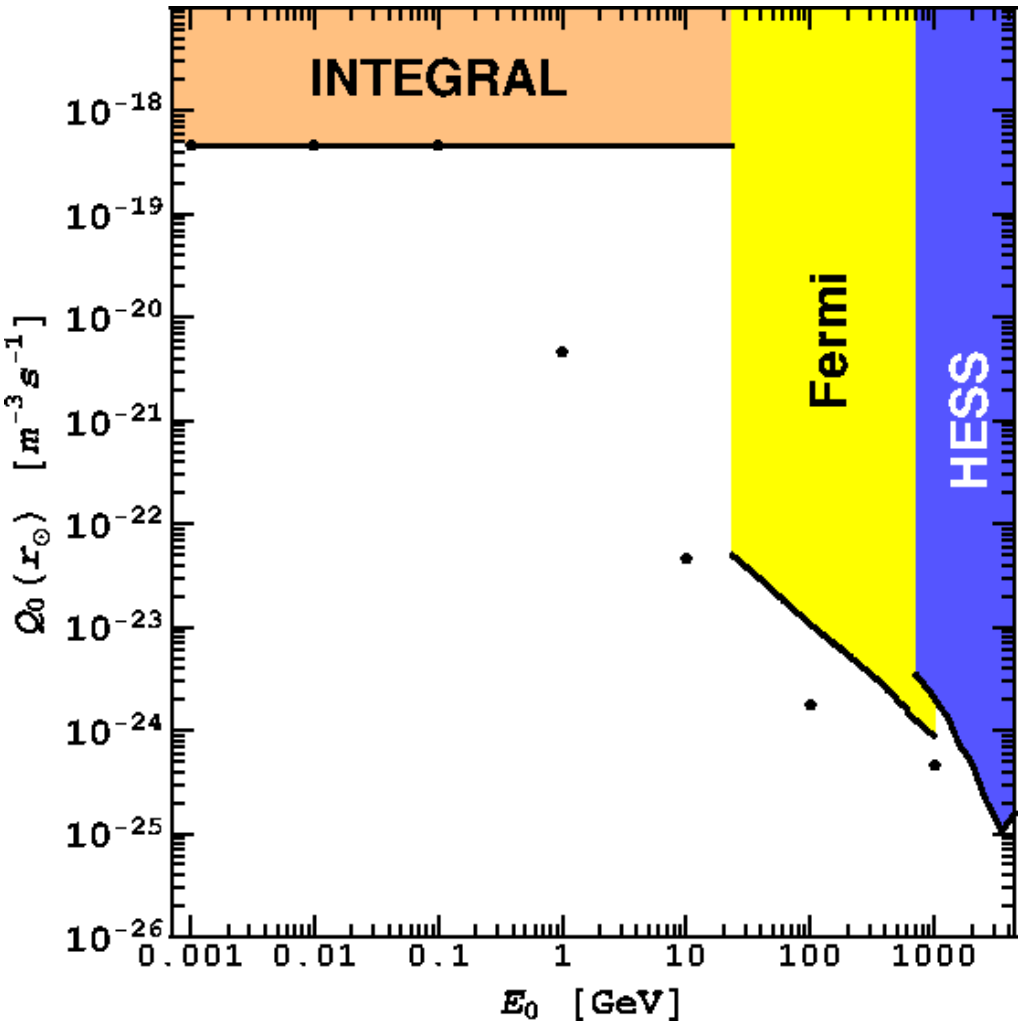
Multi-messenger constraints



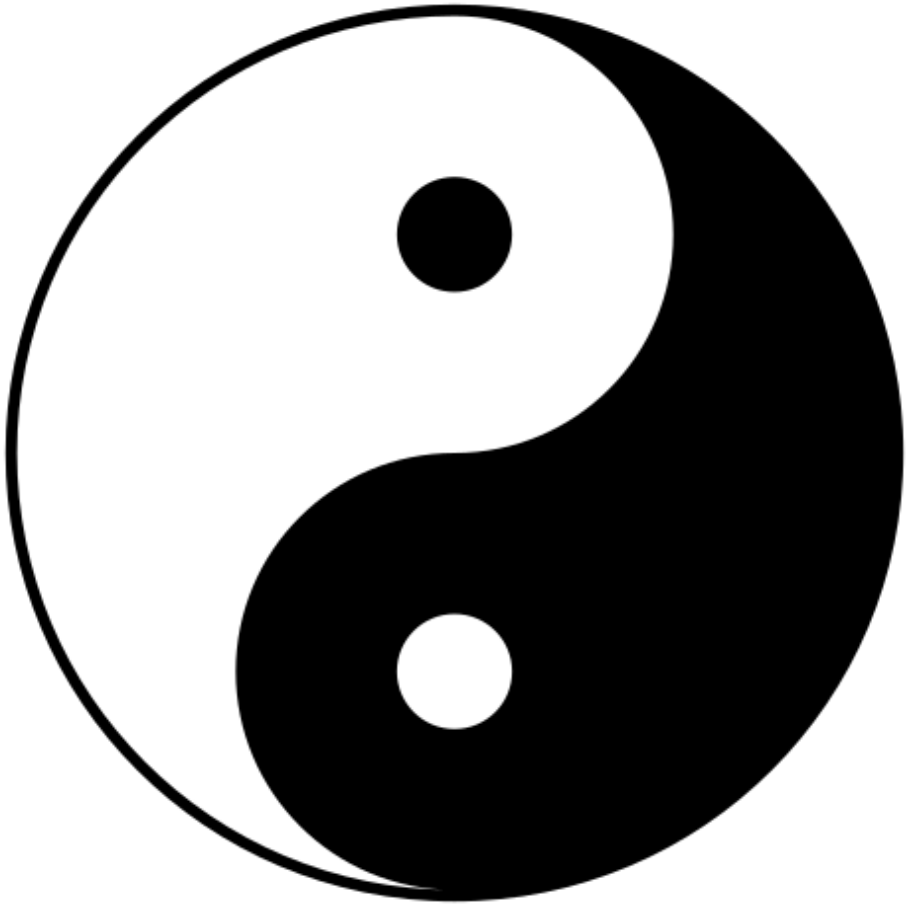
Wechakama & Ascasibar (2014)

Multi-messenger **Astrophysics**





Conclusion?



Have fun!