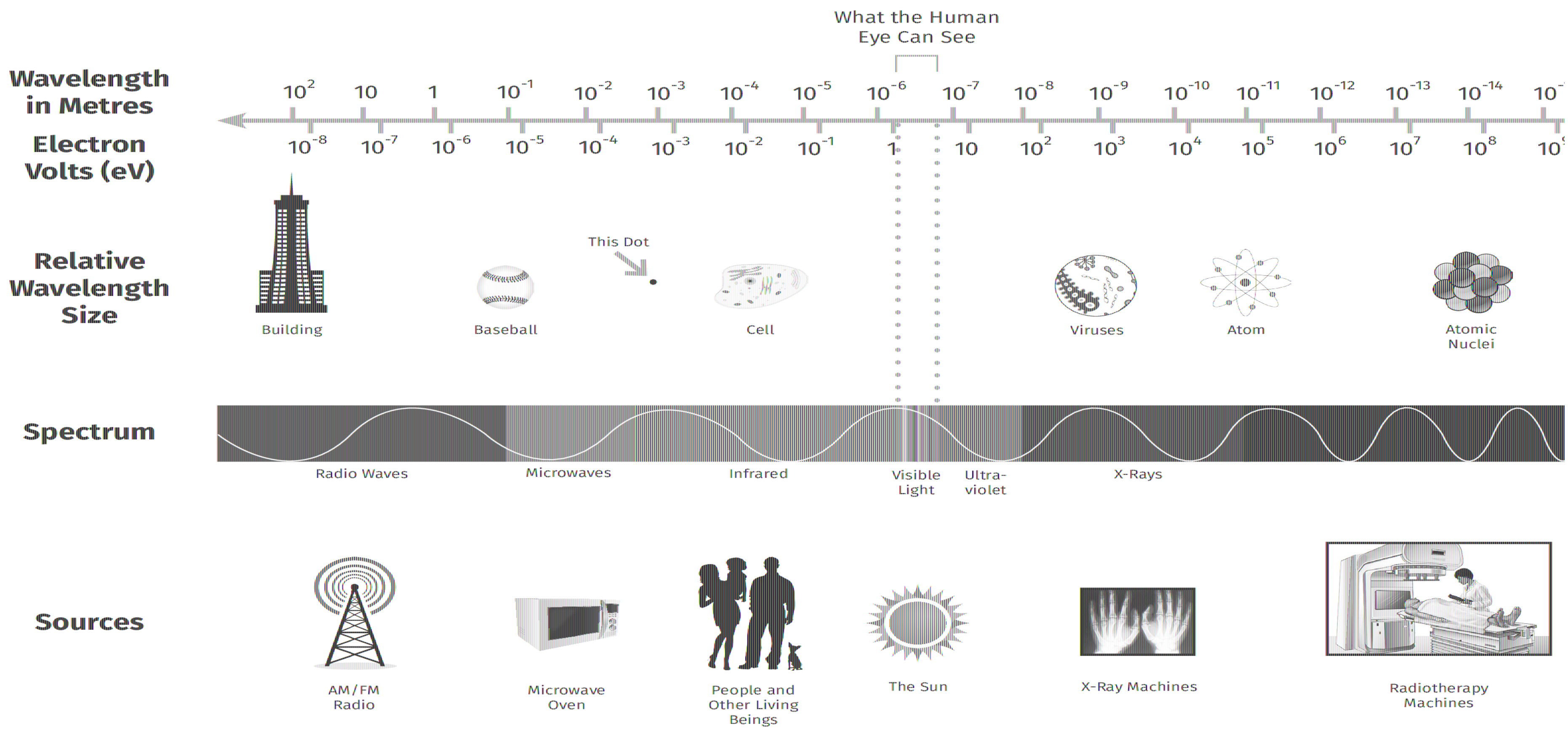
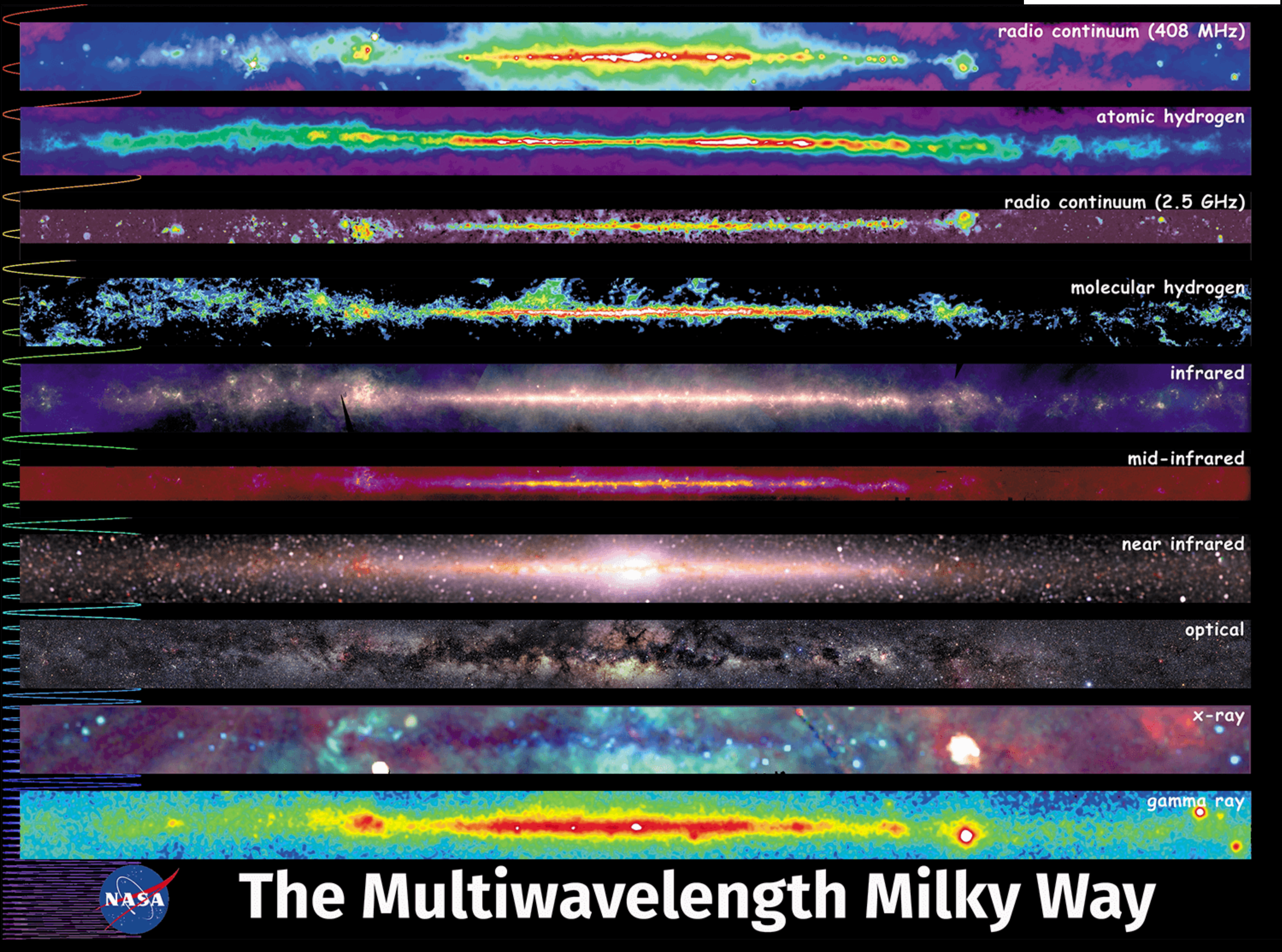
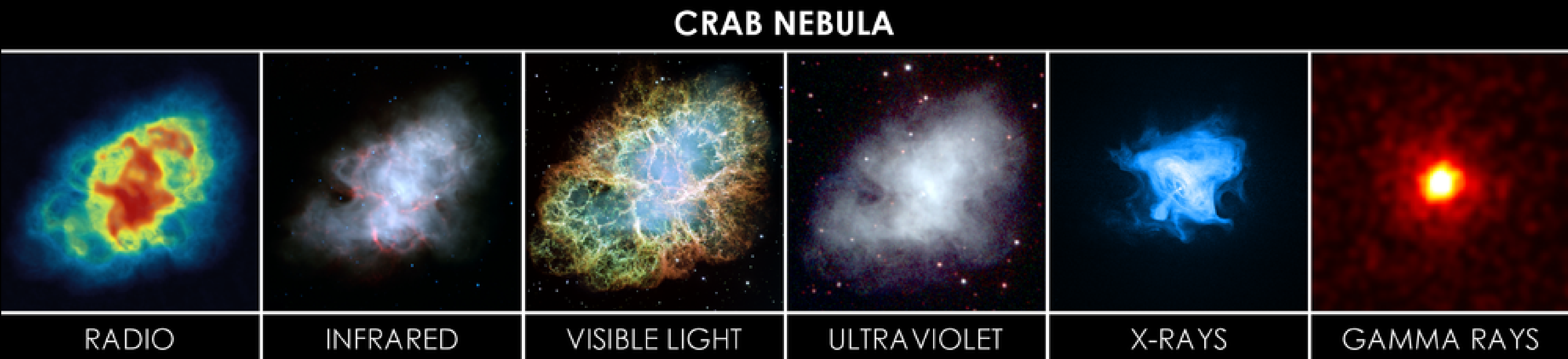
cta cherenkov telescope array

The Electromagnetic Sp



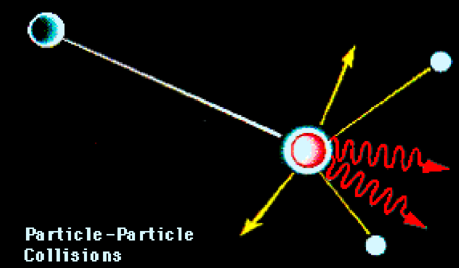

radio continuum (408 MHz)
atomic hydrogen
radio continuum (2.5 GHz)
molecular hydrogen
infrared
mid-infrared
near infrared
optical
x-ray
gamma ray
NASA
The Multiwavelength Milky Way

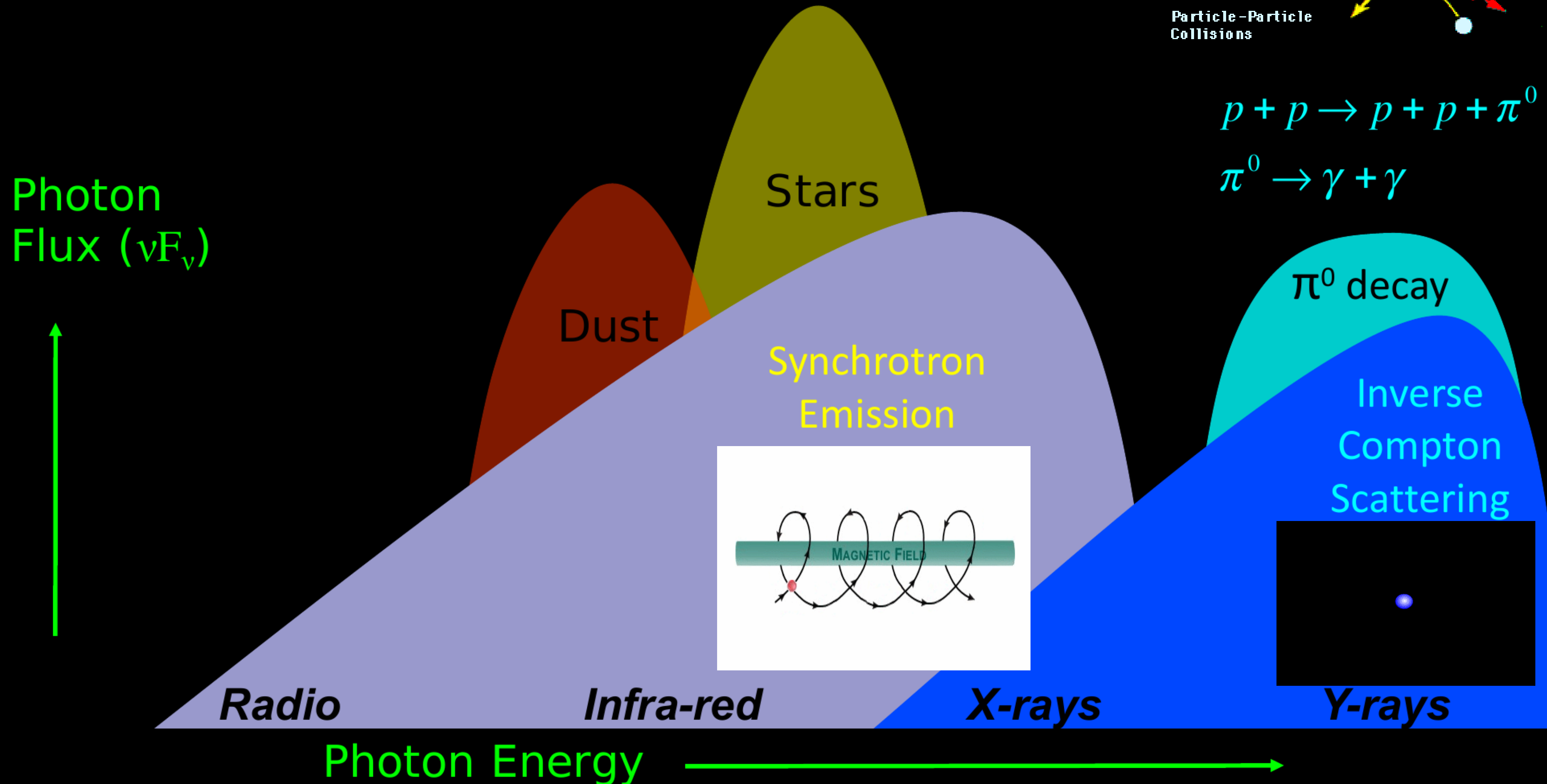


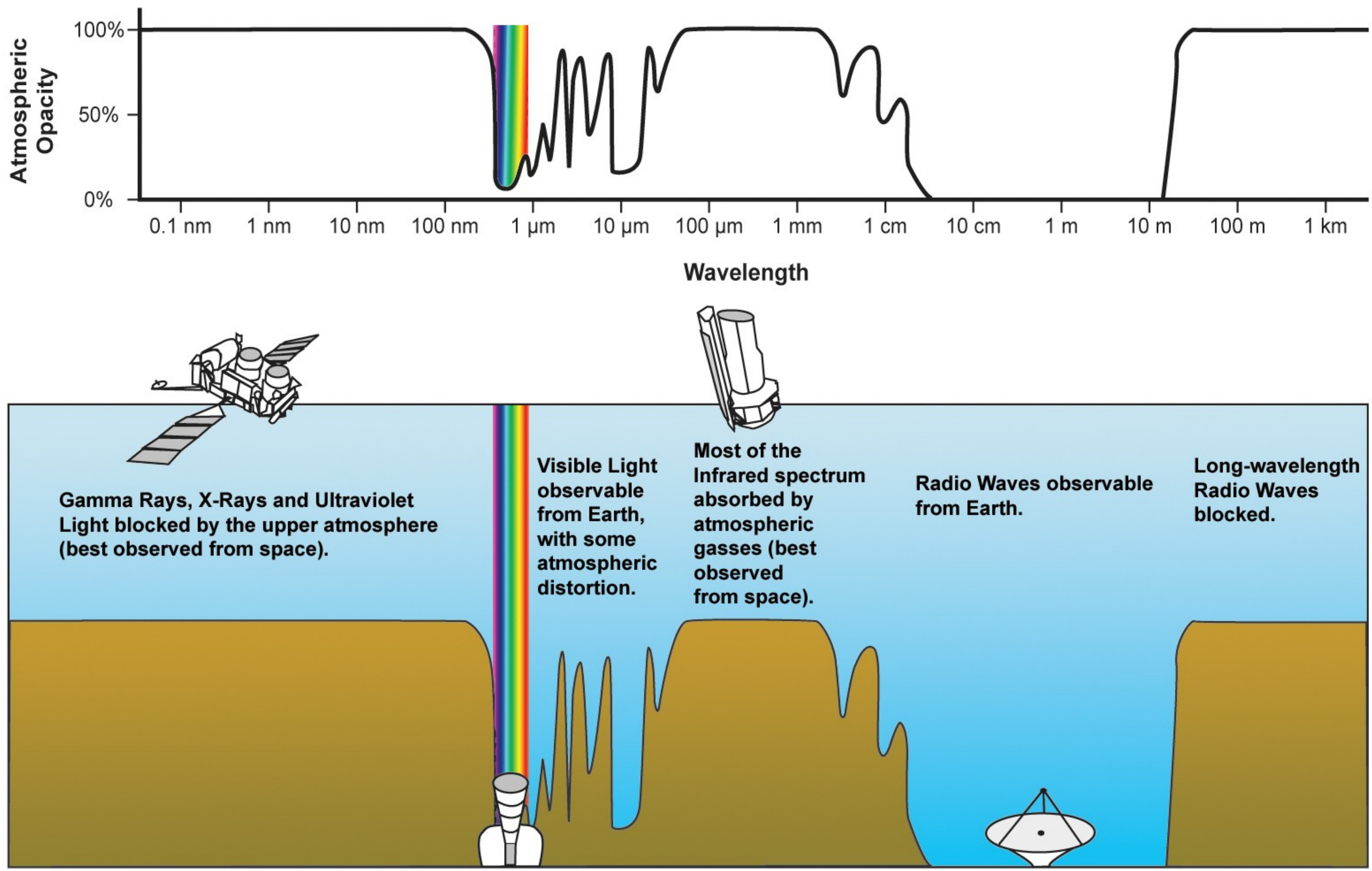
The crab nebula in radio, infrared, visible, ultraviolet, x-ray and gamma-ray wavelengths.

Sources: Radio: NRAO/AUI and M. Bietenholz, J.M. Uson, T.J. Cornwell; Infrared: NASA/JPL-Caltech/R. Gehrz (University of Minnesota); Visible: NASA, ESA, J. Hester and A.Loll (Arizona State University); Ultraviolet: NASA/Swift/E. Hoversten, PSU, X-ray: NASA/CXC/SAO/F. Seward et al.; Gamma: NASA/DOE/Fermi LAT/R. Buehler

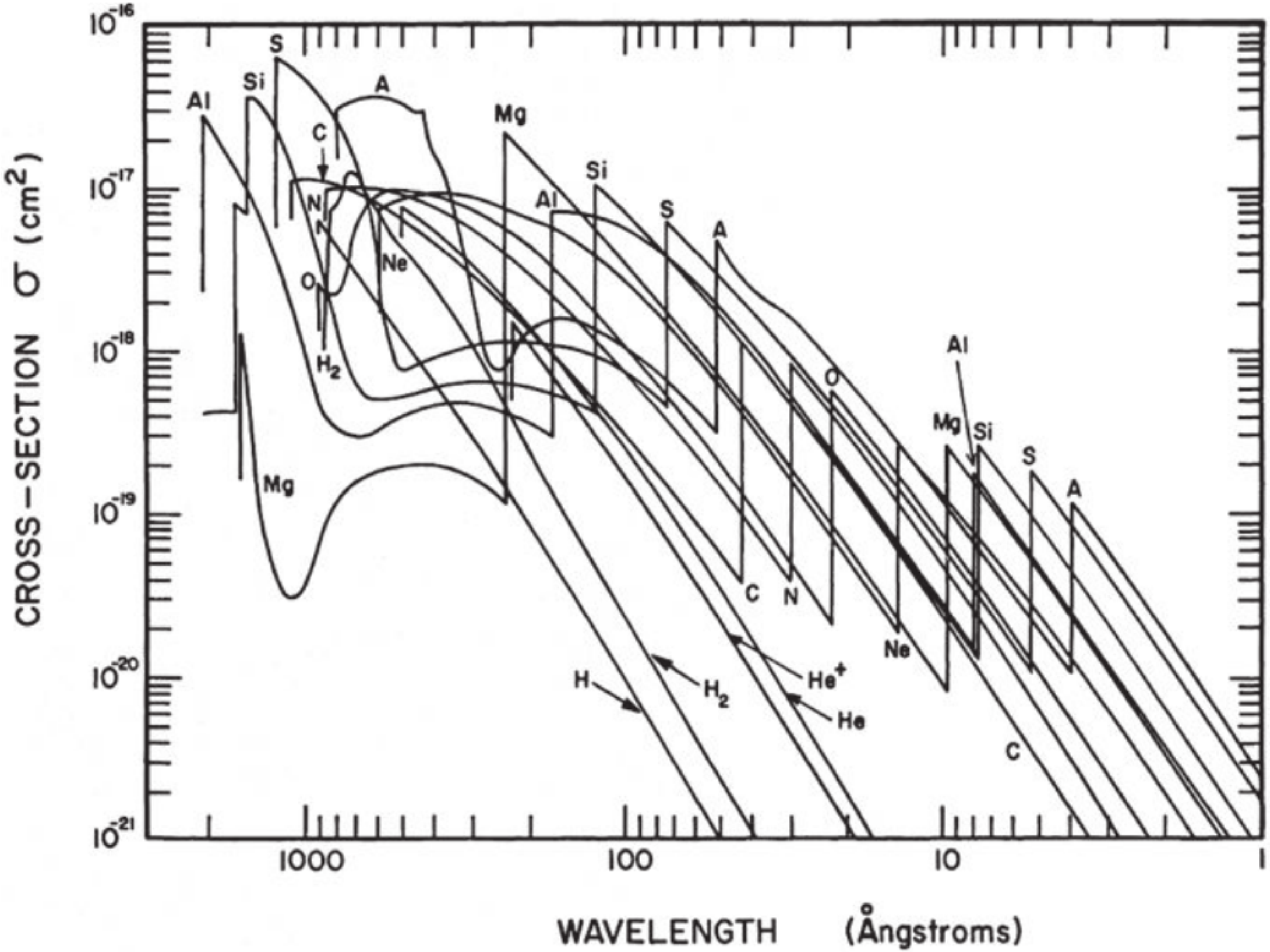
HE electromagnetic emission is only produced by **non-thermal relativistic particles**



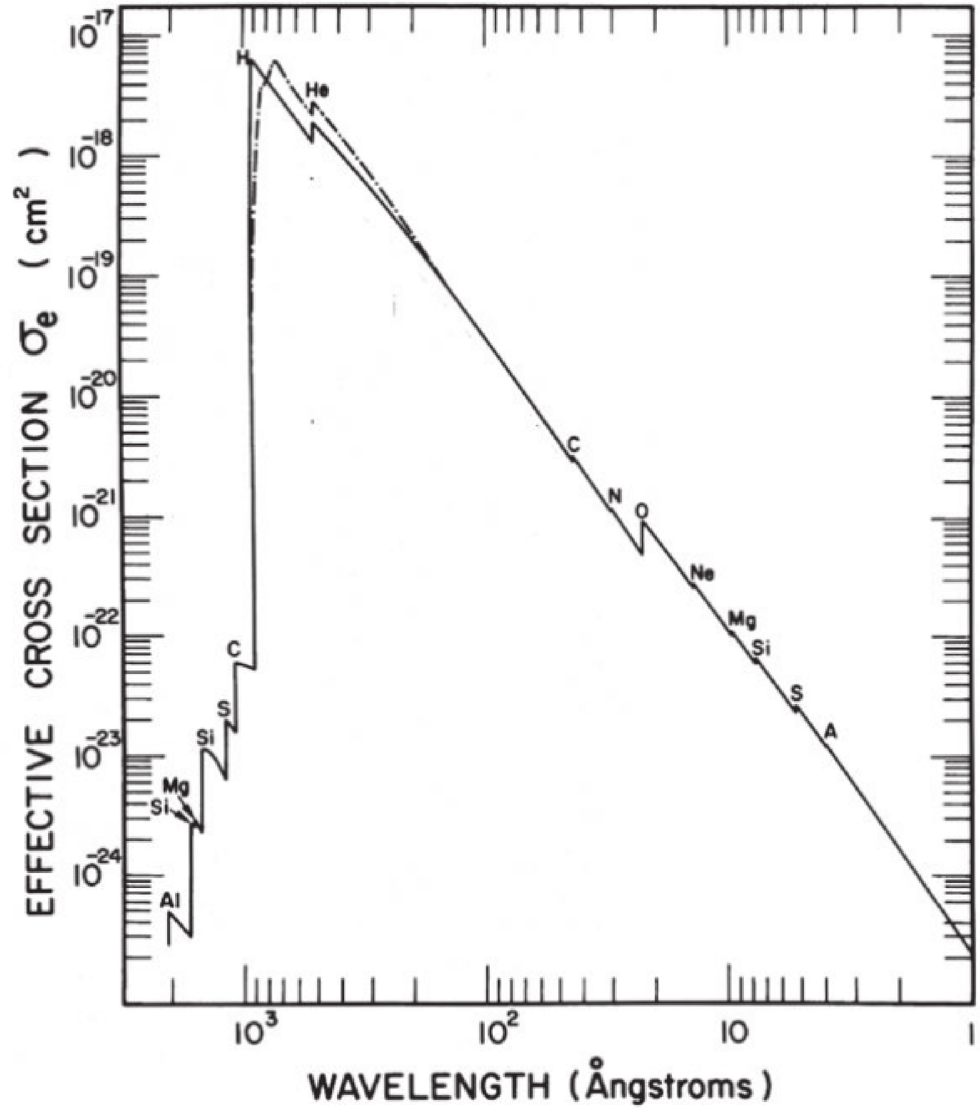




Atmospheric Opacity
100%
50%
0%
0.1 nm
1 nm
10 nm
100 nm
1 µm
10 µm
100 µm
1 mm
1 cm
10 cm
1 m
10 m
100 m
1 km
Wavelength
Gamma Rays, X-Rays and Ultraviolet Light blocked by the upper atmosphere (best observed from space).
Visible Light observable from Earth, with some atmospheric distortion.
Most of the Infrared spectrum absorbed by atmospheric gasses (best observed from space).
Radio Waves observable from Earth.
Long-wavelength Radio Waves blocked.



Photoabsorption cross-sections of the abundant elements in the interstellar medium as a function of wavelength (Cruddace *et al.*, 1974).



$$\sigma_{\mathrm{e}}(\varepsilon) = \frac{1}{n_{\mathrm{H}}} \sum_i n_i \, \sigma_i(\varepsilon)$$

The effective absorption cross-section per hydrogen atom for interstellar gas with typical cosmic abundances of the chemical elements. The solid line is for the gaseous component of the interstellar medium; the dot-dashed line includes molecular hydrogen. The discontinuities in the absorption cross-section as a function of energy are associated with the K-shell absorption edges of the elements indicated. The optical depth of the medium is $\tau_{\mathrm{e}} = \int \sigma_{\mathrm{e}}(\varepsilon) N_{\mathrm{H}} \, \mathrm{d}l$ where N_{H} is the number density of hydrogen atoms (Cruddace *et al.*, 1974). Note that the cross-section is presented in units of cm^2. For reference, 1 Å $\equiv$ 12.4 keV and 100 Å $\equiv$ 0.124 keV.

	Before	After
Electron	$\boldsymbol{P} = [\gamma m_{\mathrm{e}} c, \gamma m_{\mathrm{e}} \boldsymbol{v}]$	$\boldsymbol{P}' = [\gamma' m_{\mathrm{e}} c, \gamma' m_{\mathrm{e}} \boldsymbol{v}']$
Photon	$\boldsymbol{K} = \left[\frac{\hbar\omega}{c}, \frac{\hbar\omega}{c}\,\boldsymbol{i}_k\right]$	$\boldsymbol{K}' = \left[\frac{\hbar\omega'}{c}, \frac{\hbar\omega'}{c}\boldsymbol{i}_{k'}\right]$

$$\boldsymbol{P} + \boldsymbol{K} = \boldsymbol{P}' + \boldsymbol{K}'.$$

$$\frac{\omega'}{\omega} = \frac{1 - (v/c)\cos\theta}{1 - (v/c)\cos\theta' + (\hbar\omega/\gamma m_e c^2)(1 - \cos\alpha)} .$$

$v = 0, \gamma = 1$

$$\frac{\omega'}{\omega} = \frac{1}{1 + (\hbar\omega/m_e c^2)(1 - \cos\alpha)}$$

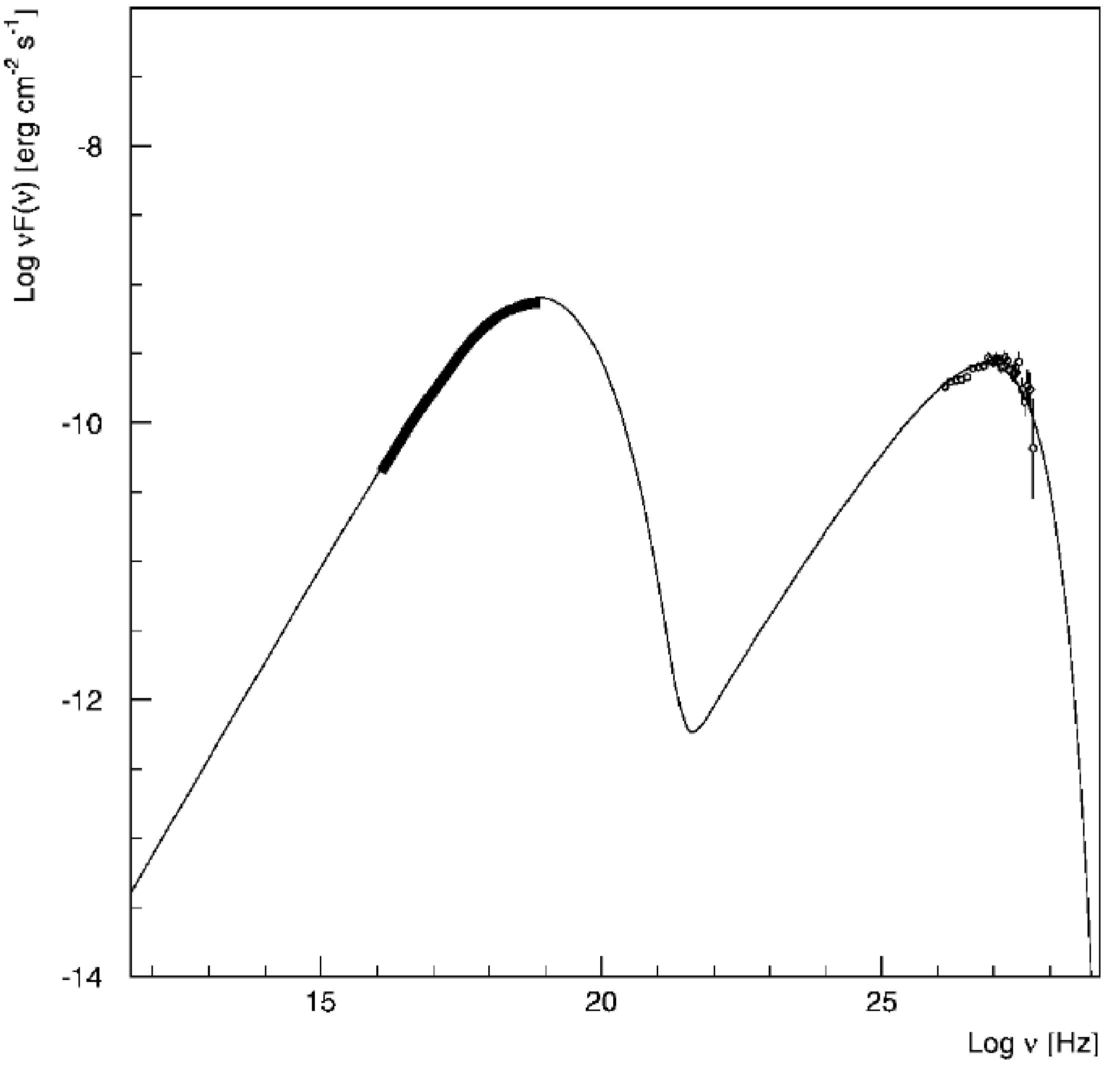
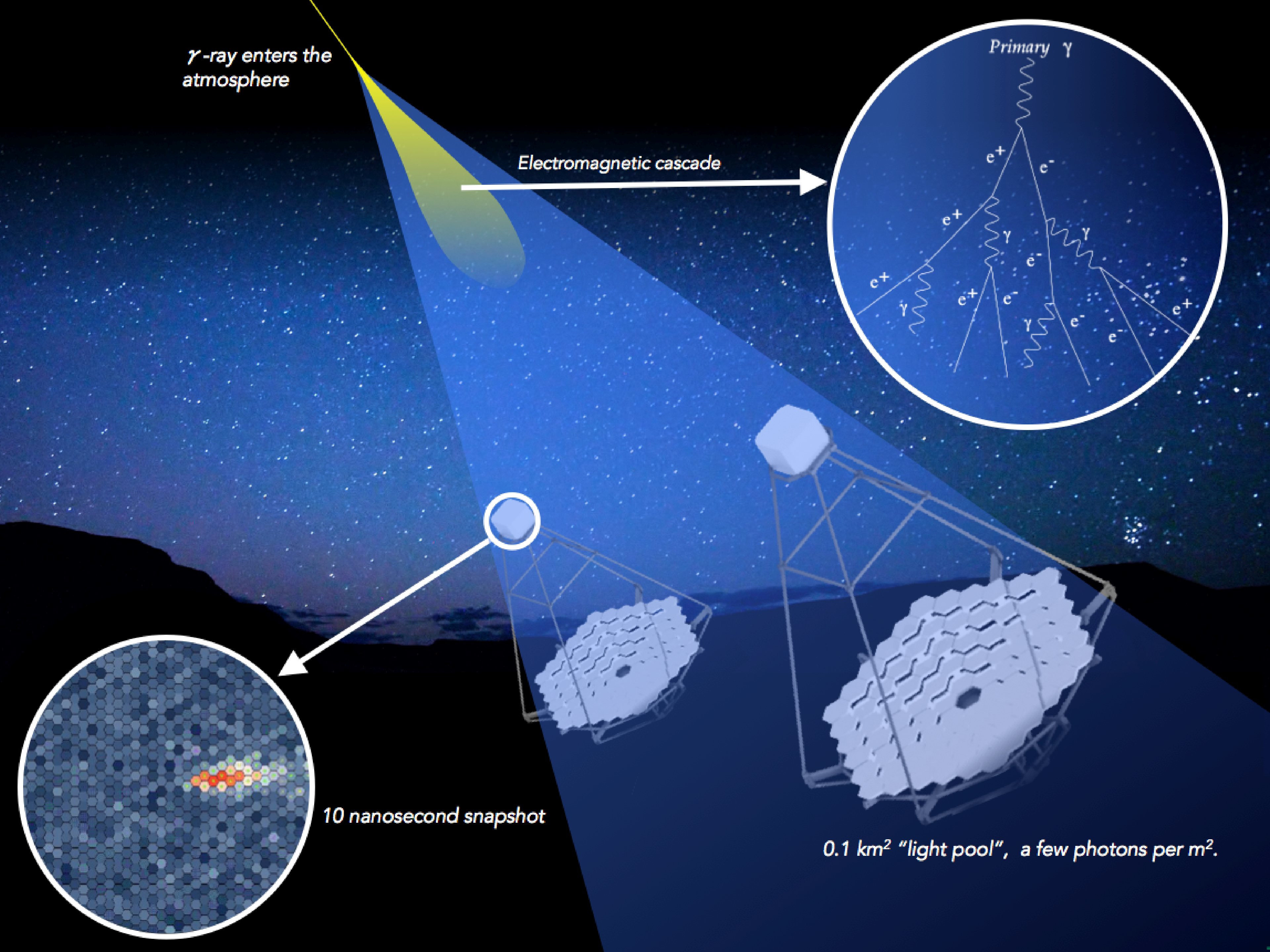


FIG. 7.—Combined X-ray/TeV γ-ray spectrum of Mrk 501 together with the best-fit SSC model.

Konopelko et al. (2003)



γ -ray enters the atmosphere
Electromagnetic cascade
Primary γ
e+
e-
γ
10 nanosecond snapshot
0.1 km² "light pool", a few photons per m².

Aula 02: estudar Seções 9.1 e 9.2 do Longair.

Quem quiser revisar os conceitos de relatividade especial, recomendo “The Feynman Lectures on Physics” Vol. 1, cap 15-17:

https://www.feynmanlectures.caltech.edu/I_15.html
https://www.feynmanlectures.caltech.edu/I_16.html
https://www.feynmanlectures.caltech.edu/I_17.html

Aula 03: estudar Seções 6.3, 6.4, 6.5.1, 9.8, 9.9 e 9.10 do Longair.

Quem quiser revisar os conceitos relacionados ao espectro de corpo negro, recomendo “The Feynman Lectures on Physics” Vol. 1 cap 41, e Vol. 3 cap. 4:

https://www.feynmanlectures.caltech.edu/I_41.html
https://www.feynmanlectures.caltech.edu/III_04.html