Very high energy gam

Diffuse radiation fields on different scales and absorption of VHE gamma-rays

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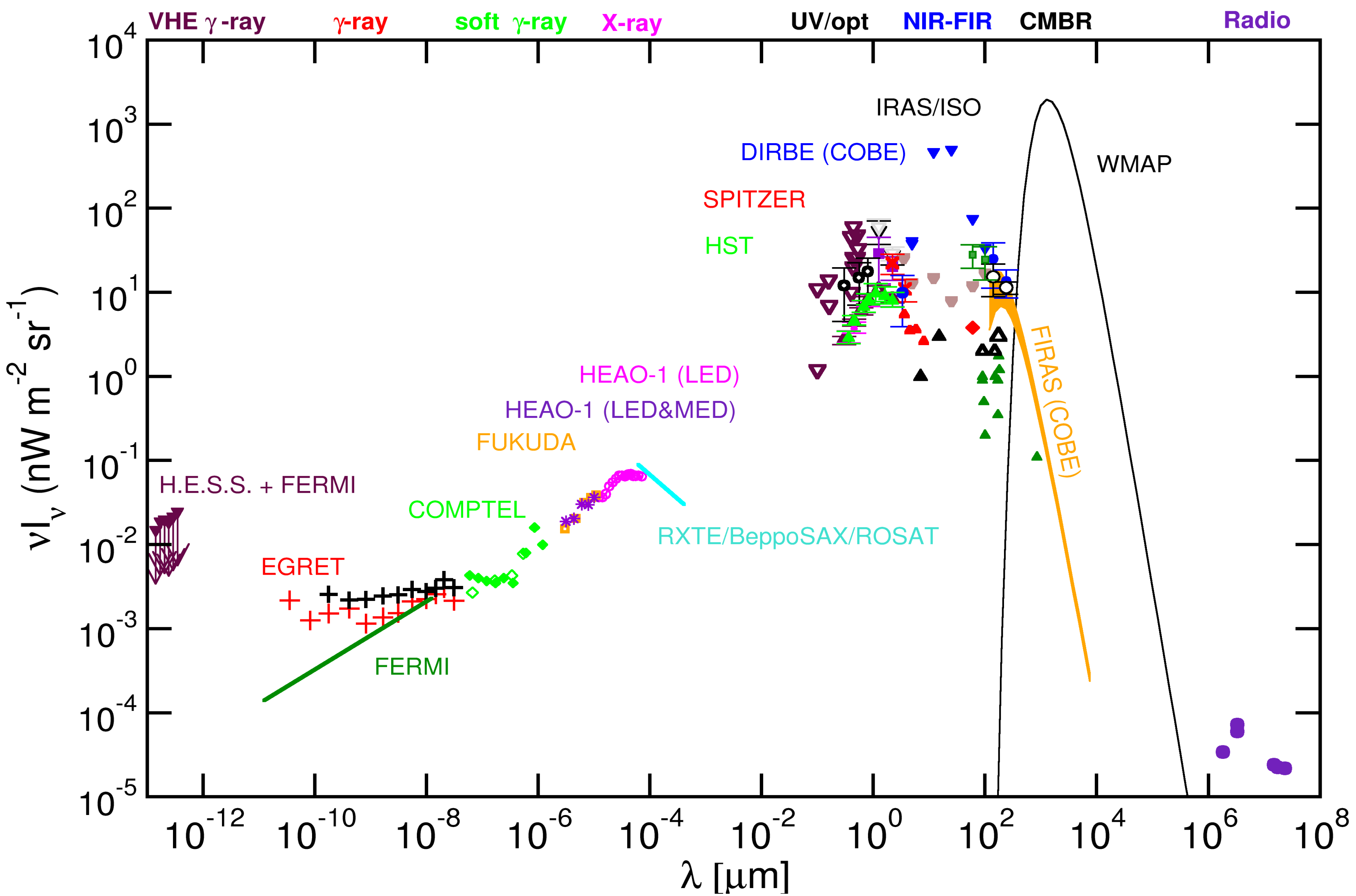
LEXI cluster meeting Hamburg
October 11-12

http://lambda.gsfc.nasa.gov/

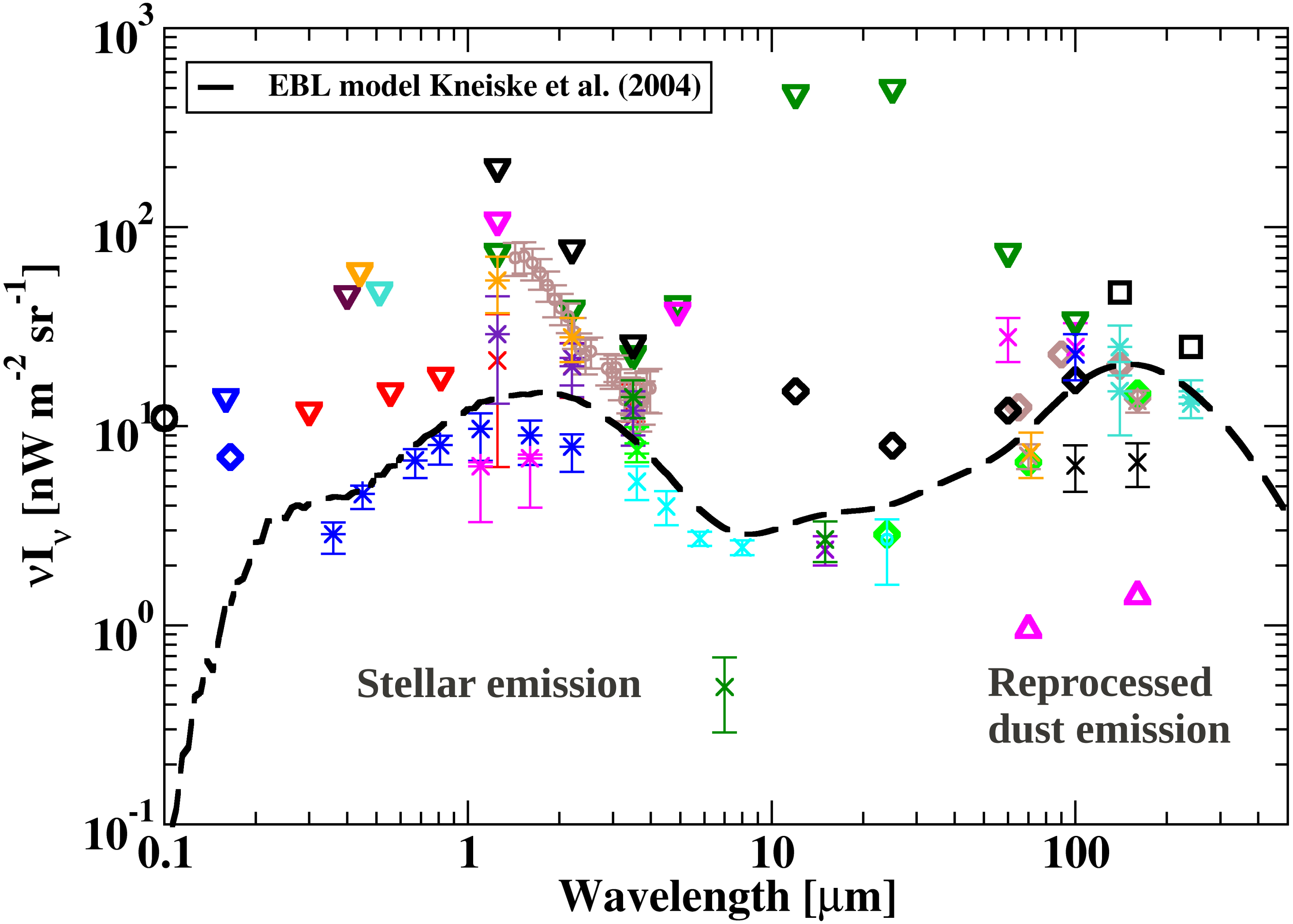
LEXI
LANDESEXZELLENZINITIATIVE HAMBURG

UHH Universität Hamburg
DER FORSCHUNG | DER LEHRE | DER BILDUNG

Multiwavelength data of diffuse background radiation



Extragalactic Background Light (EBL)



Origin: Integrated, redshifted emission from all cosmic epochs

Challenges:

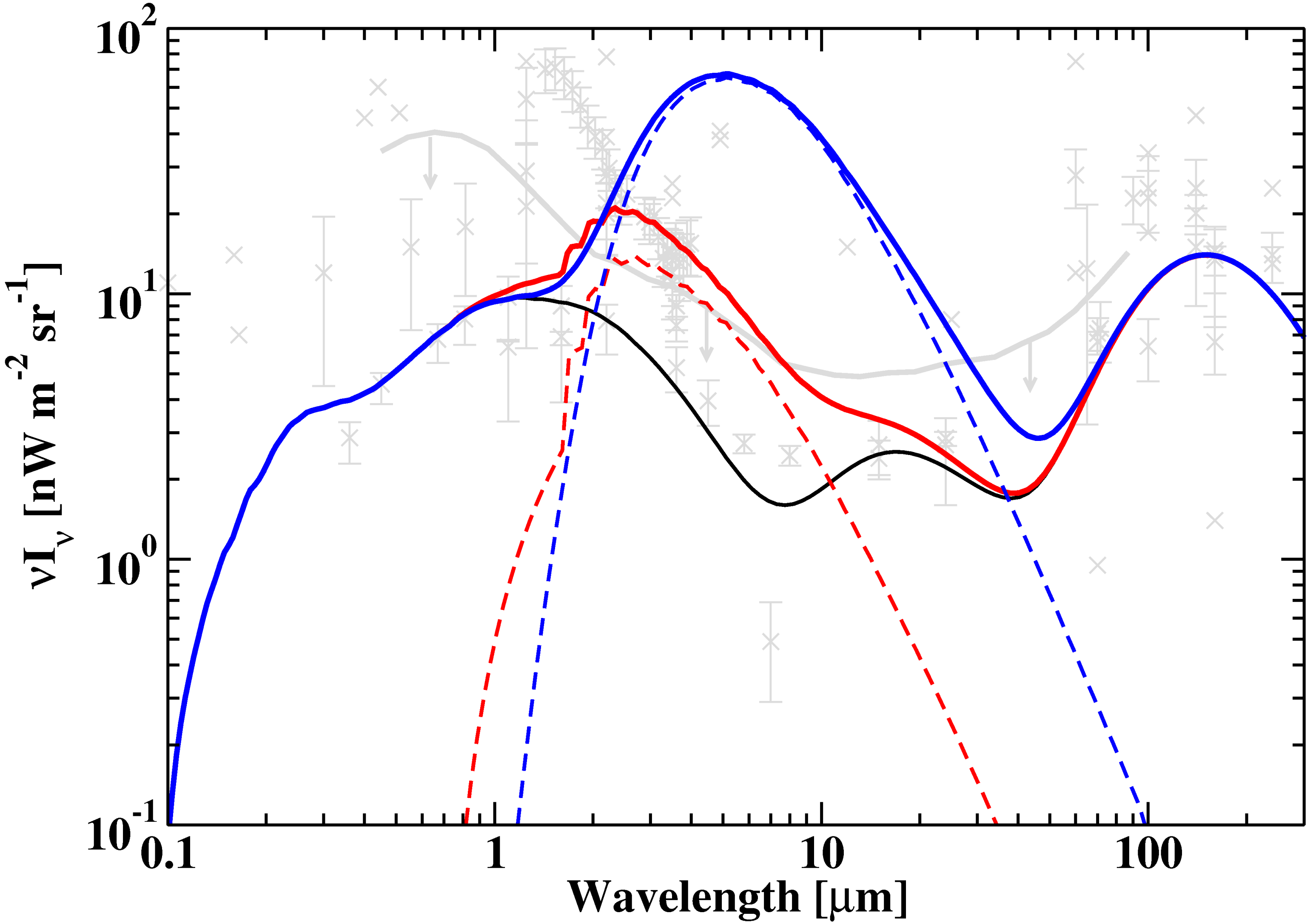
- Direct measurements suffer from strong foreground radiation(e.g. zodiacal light)
- Lower limits: Galaxy number counts (Completeness?)
- Upper Limits: Derived from VHE gamma-ray spectra → Talk by M. Meyer

Additional contributions to the EBL?

- First stars may be powered by annihilation of dark matter particles [Spolyar+ 2008, Iocco+ 2008]
- These so-called Dark Stars could be:
  - Very luminous (10^5 - 10^9 L_{solar})
  - Very long lived (10^5 - 10^9 years)
  - Formed until redshift z = 5 – 15

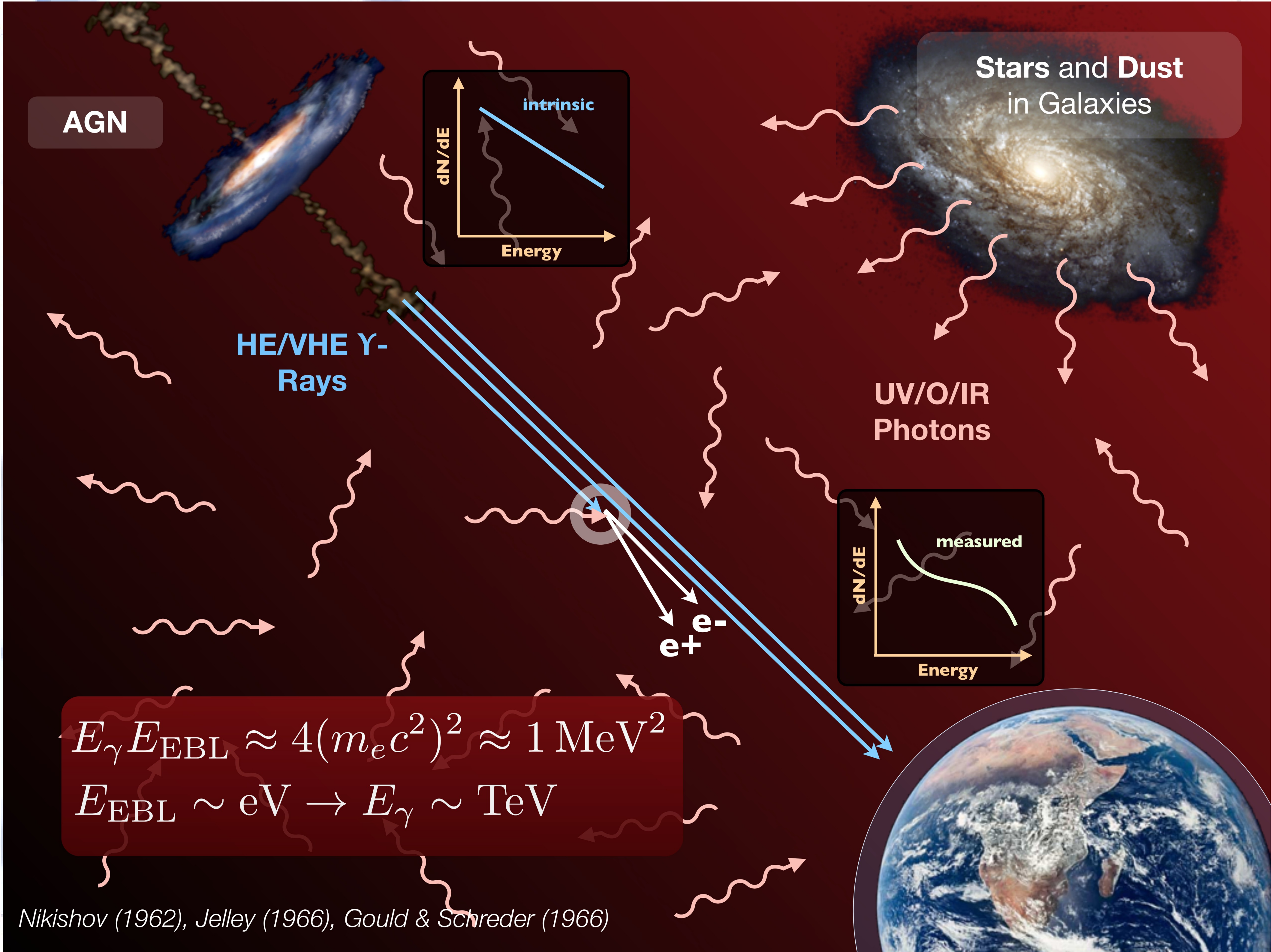
Can these objects leave an imprint in the EBL?

Constraints on Dark Stars from the EBL



[**AM**, Raue, Kneiske, Horns, Elsässer, Hauschildt 2012]

$$(\nu I_\nu)_{\max} = 2 \times 10^{-5}\ \mathrm{nW\ m^{-2}\ sr^{-1}} \times \left(\frac{\Delta t_{\mathrm{DS}}}{10^7\ \mathrm{years}}\right) \times \left(\frac{\mathrm{SFR_{Norm}}}{10^{-5}}\right) \times \left(\frac{\mathrm{LMR}}{10^3\,\mathrm{L_\odot / M_\odot}}\right) \times \left(\frac{z_{\min}}{10}\right)^{-2.5}$$


AGN
intrinsic
dN/dE
Energy
Stars and Dust
in Galaxies
HE/VHE Υ-
Rays
UV/O/IR
Photons
measured
dN/dE
Energy
e-
e+
$E_\gamma E_{\mathrm{EBL}} \approx 4(m_e c^2)^2 \approx 1\,\mathrm{MeV}^2$
$E_{\mathrm{EBL}} \sim \mathrm{eV} \rightarrow E_\gamma \sim \mathrm{TeV}$
Nikishov (1962), Jelley (1966), Gould & Schreder (1966)

Calculation of optical depth

$$\tau_{\gamma\gamma}(E_\gamma) = \int_{\text{L.o.s.}} \mathrm{d}x \int_{-1}^{+1} \mathrm{d}\mu \, \frac{1-\mu}{2} \int_{\varepsilon_{\text{thr}}}^{\infty} \mathrm{d}\varepsilon \; n(\varepsilon, x) \; \sigma_{\gamma\gamma}(E_\gamma, \varepsilon, \mu)$$

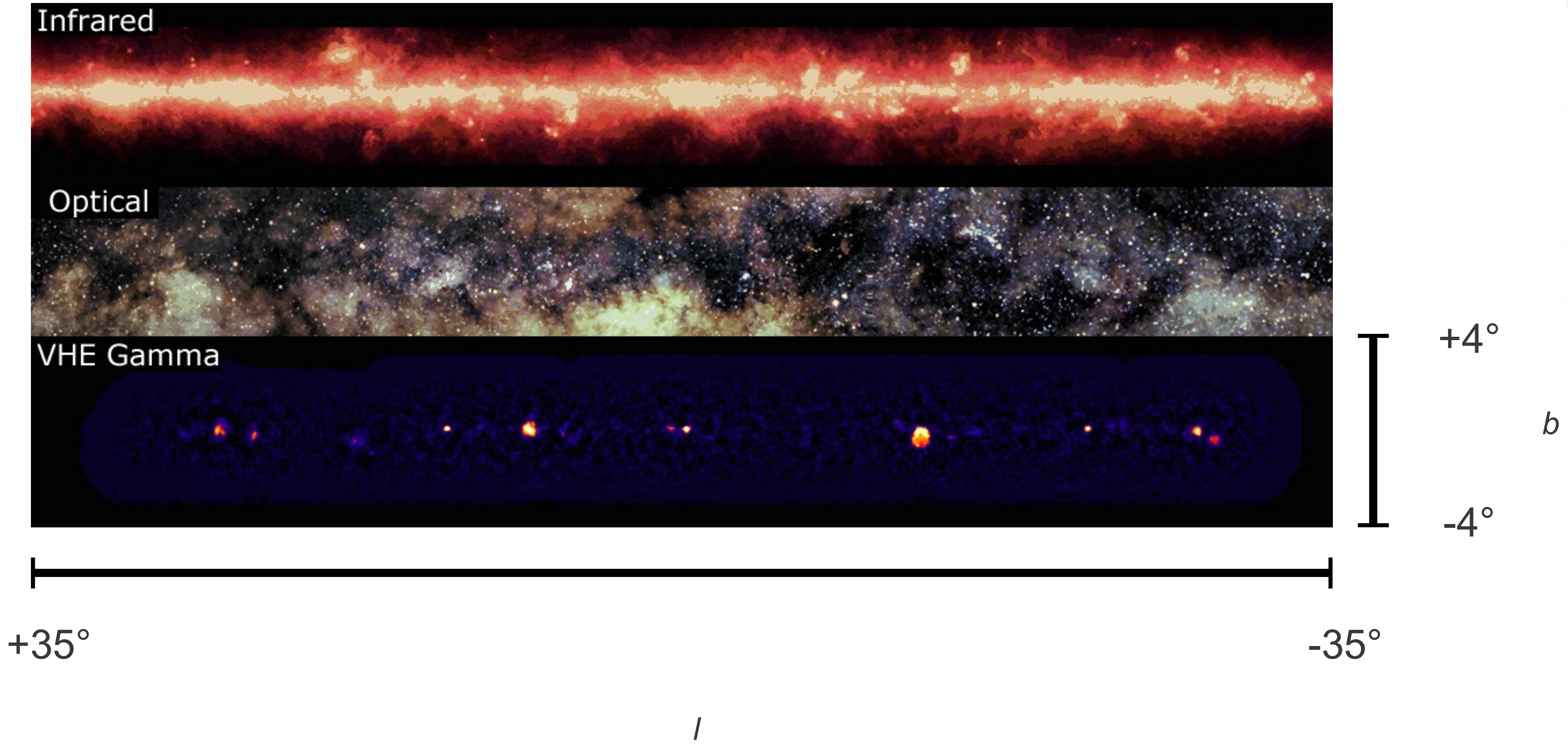
$$f(E)_{\text{obs}} = f(E)_{\text{int}} \times exp(-\tau_{\gamma\gamma}(E))$$

Distance

Pair production cross section

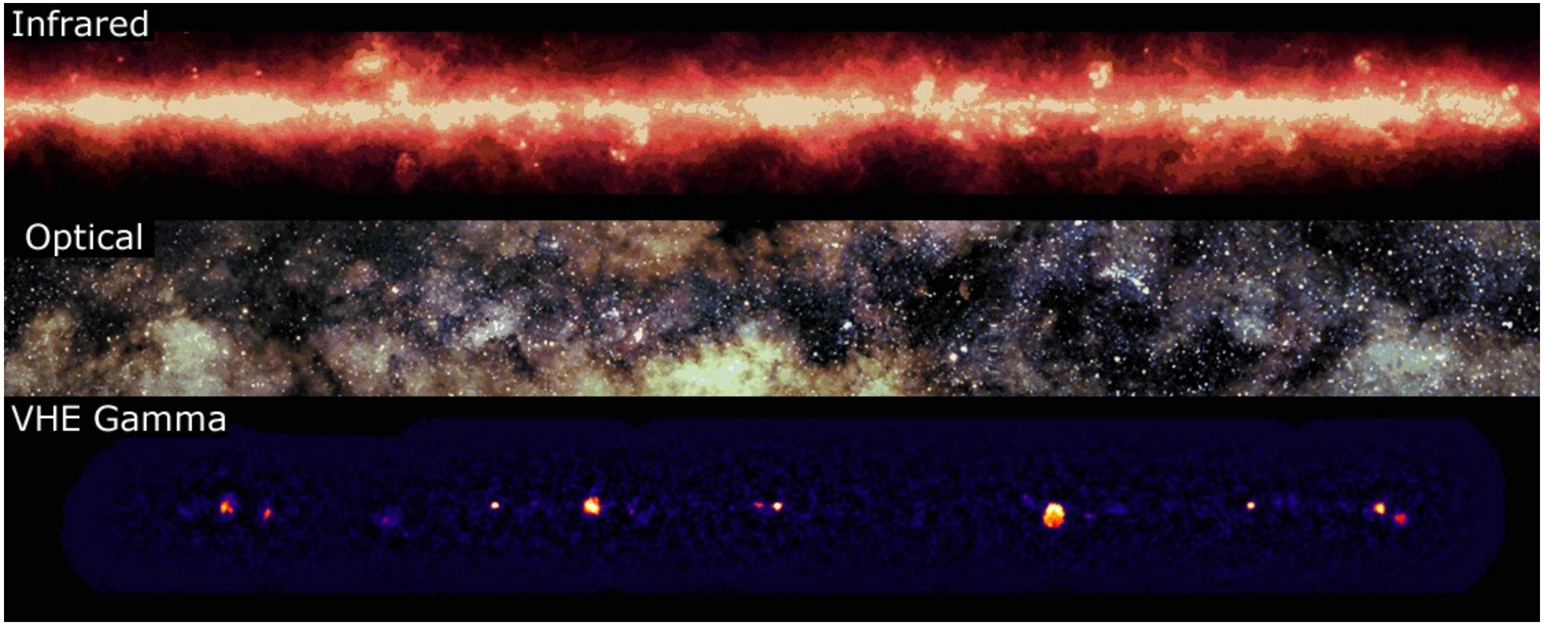
Radiation field [Strong & Porter 2005]

Galactic radiation field



Infrared: S.L. Wheelock, et al. 1994, IRAS Sky Survey Atlas Explanatory Supplement, JPL Publication 94-11
Optical: A. Mellinger, Publ. Astron. Soc. Pacific 121, 1180-1187 (2009)
VHE Gamma: HESS collaboration, Science (2005)

Galactic radiation field



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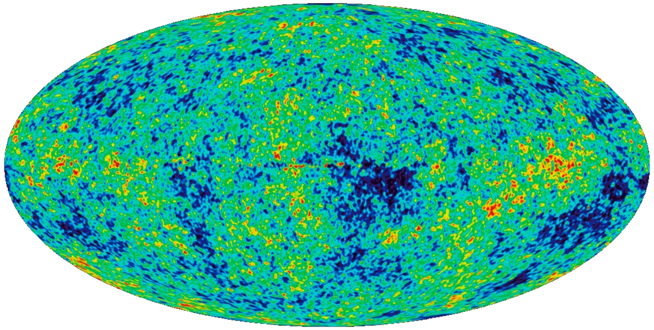
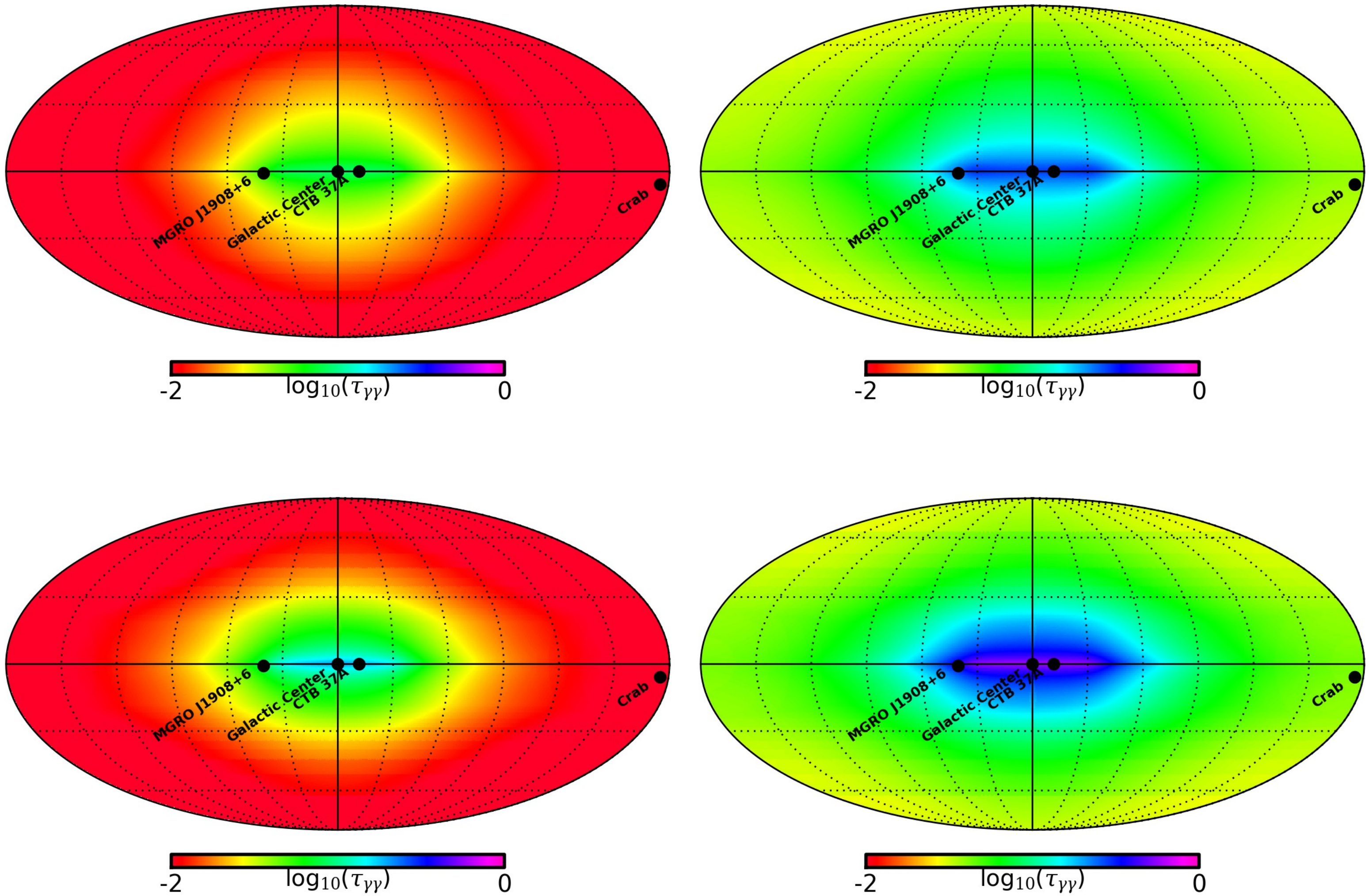


CMB

http://map.gsfc.nasa.gov

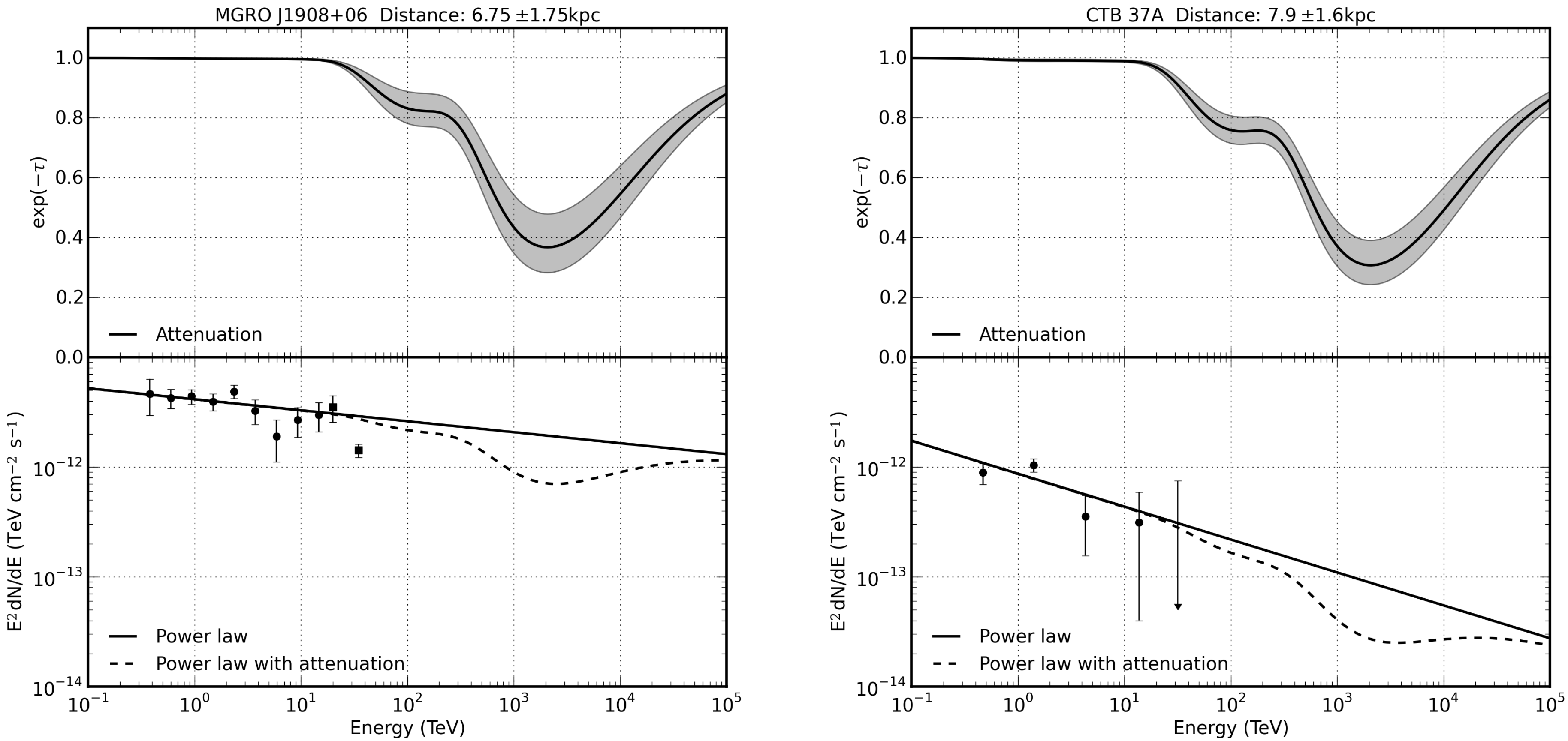
Optical depth for VHE gamma-rays



Skymaps in Galactic coordinates showing optical depths for different gamma-ray energies (30 TeV: left column; 100 TeV: right column) and different distances (8 kpc: upper row; 16 kpc: lower row).

[**AM**, Becerra-Gonzalez, Raue, Horns 2013]

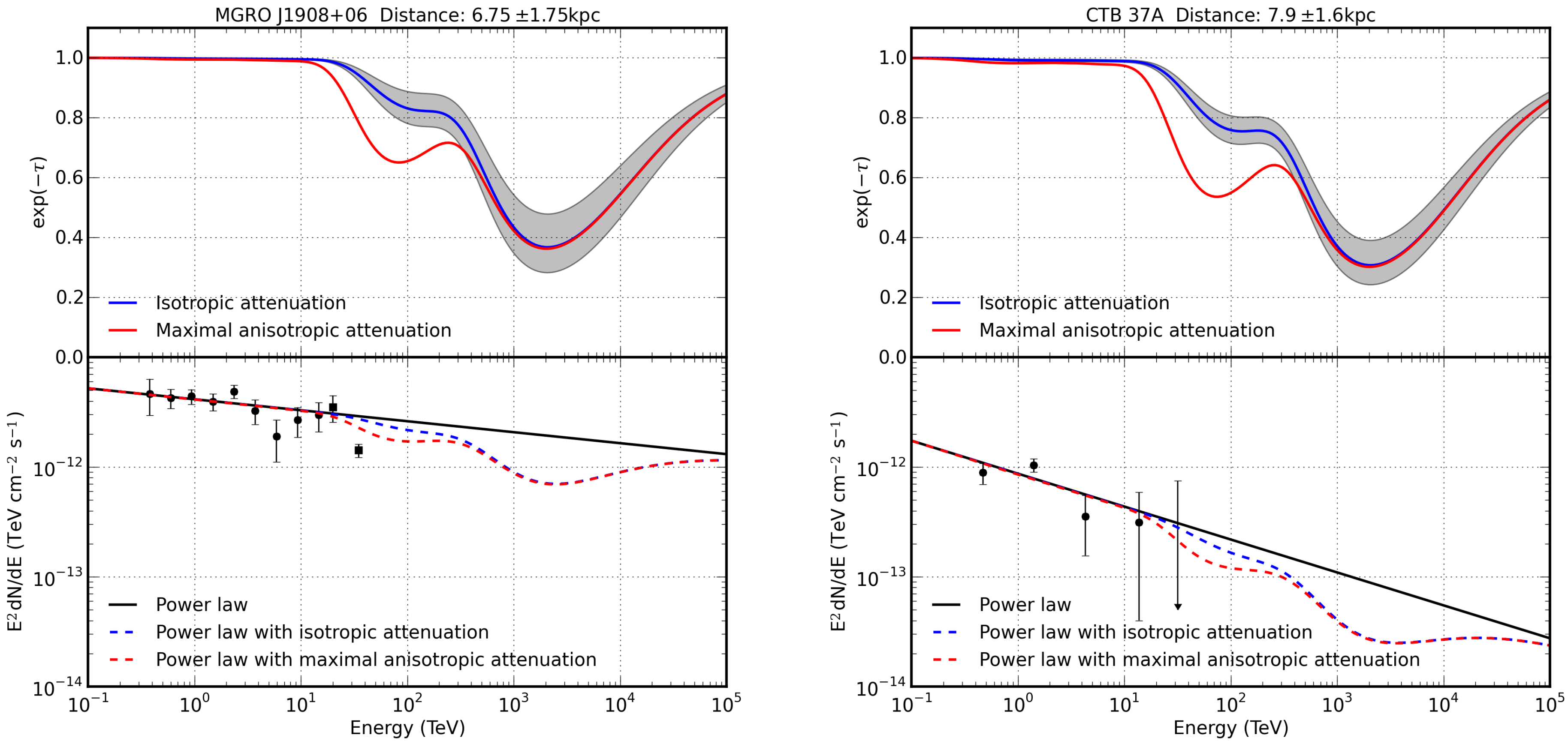
Attenuation of VHE gamma-rays



Upper panels: Attenuation for two VHE galactic gamma-ray sources (MGRO J1908+06 and CTB 37 A) due to the GRF and CMB. The shaded regions show the distance uncertainty.
Lower panels: Data from H.E.S.S. (circles) and Milagro experiment (squares) and power law fit to the data with and without attenuation.

[**AM**, Becerra-Gonzalez, Raue, Horns 2013]

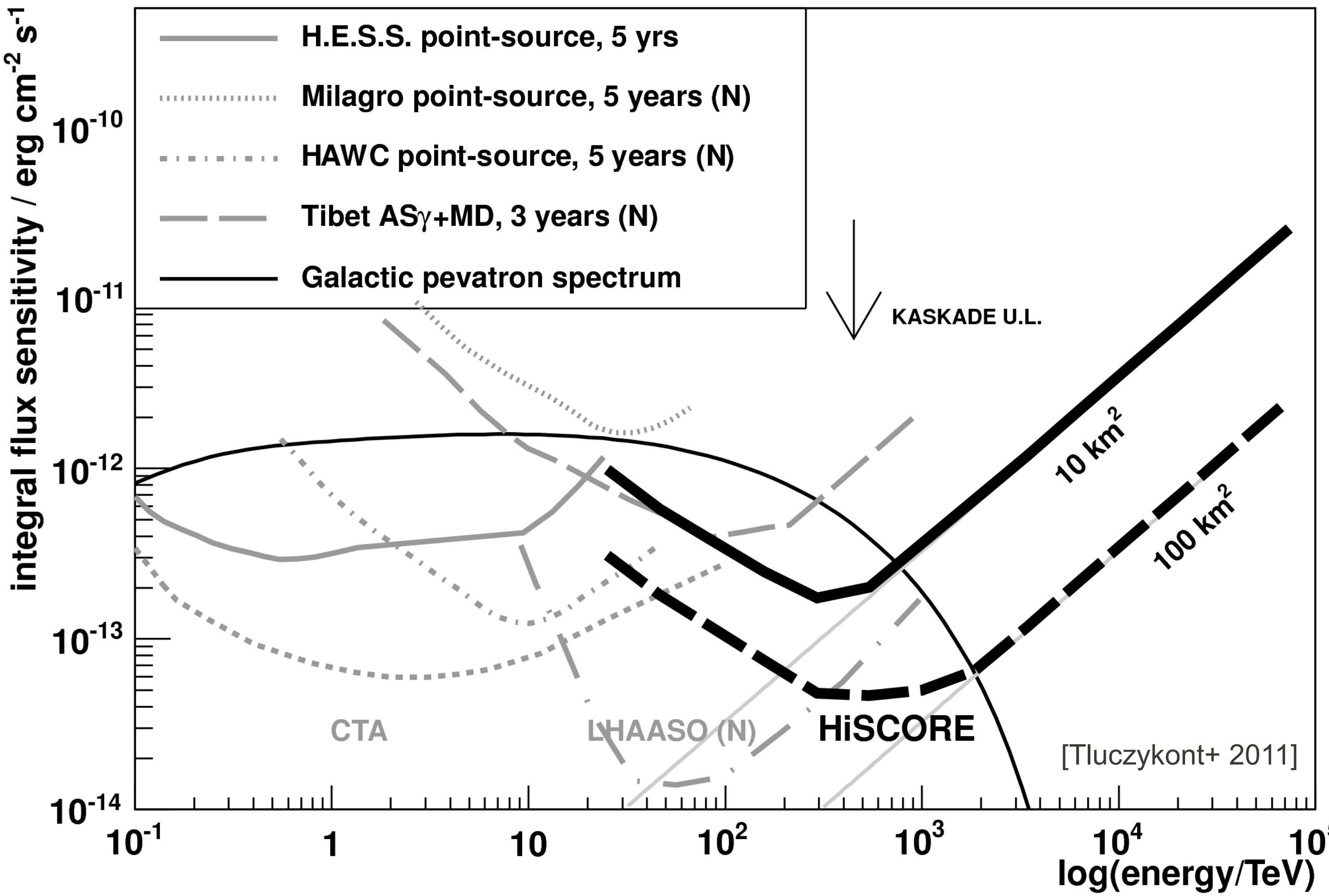
Influence of anisotropic radiation field



Upper panels: Attenuation for two VHE galactic gamma-ray sources (MGRO J1908+06 and CTB 37 A) due to the GRF(isotropic:blue; maximal anisotropic:red) and CMB. The shaded regions show the distance uncertainty.

Lower panels: Data from H.E.S.S. (circles) and Milagro experiment (squares) and power law fit to the data with and without attenuation.

Why is galactic absorption an important issue?



Next generation of VHE gamma-ray detectors aim for the detection of VHE sources above 100 TeV and will have high sensitivities at multi-TeV energies.

Summary and Outlook

- The Extragalactic Background Light can be used to derive constraints on Dark Stars in the early universe
- The attenuation of VHE gamma-rays via the diffuse Galactic radiation field is an effect detectable by the next generation of instruments like CTA and HiSCORE
- Localized diffuse radiation fields on other scales (cluster, filaments) can possibly cause VHE gamma-ray attenuation
- Attenuation of gamma rays can be used to test new particle physics (→ Talk by M. Meyer)