Extragalactic background light

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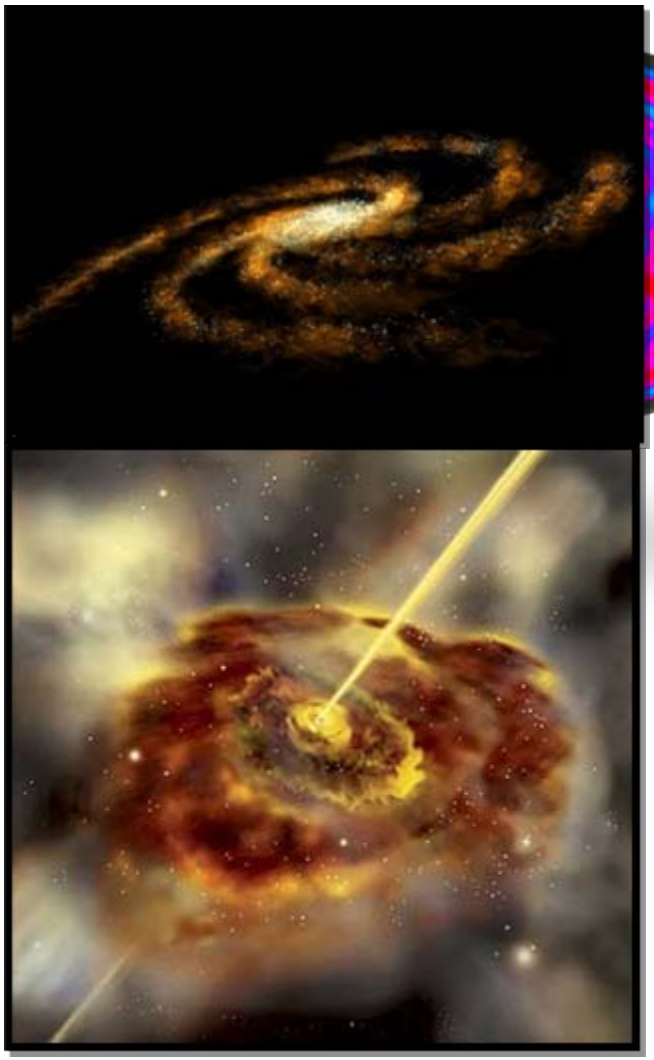
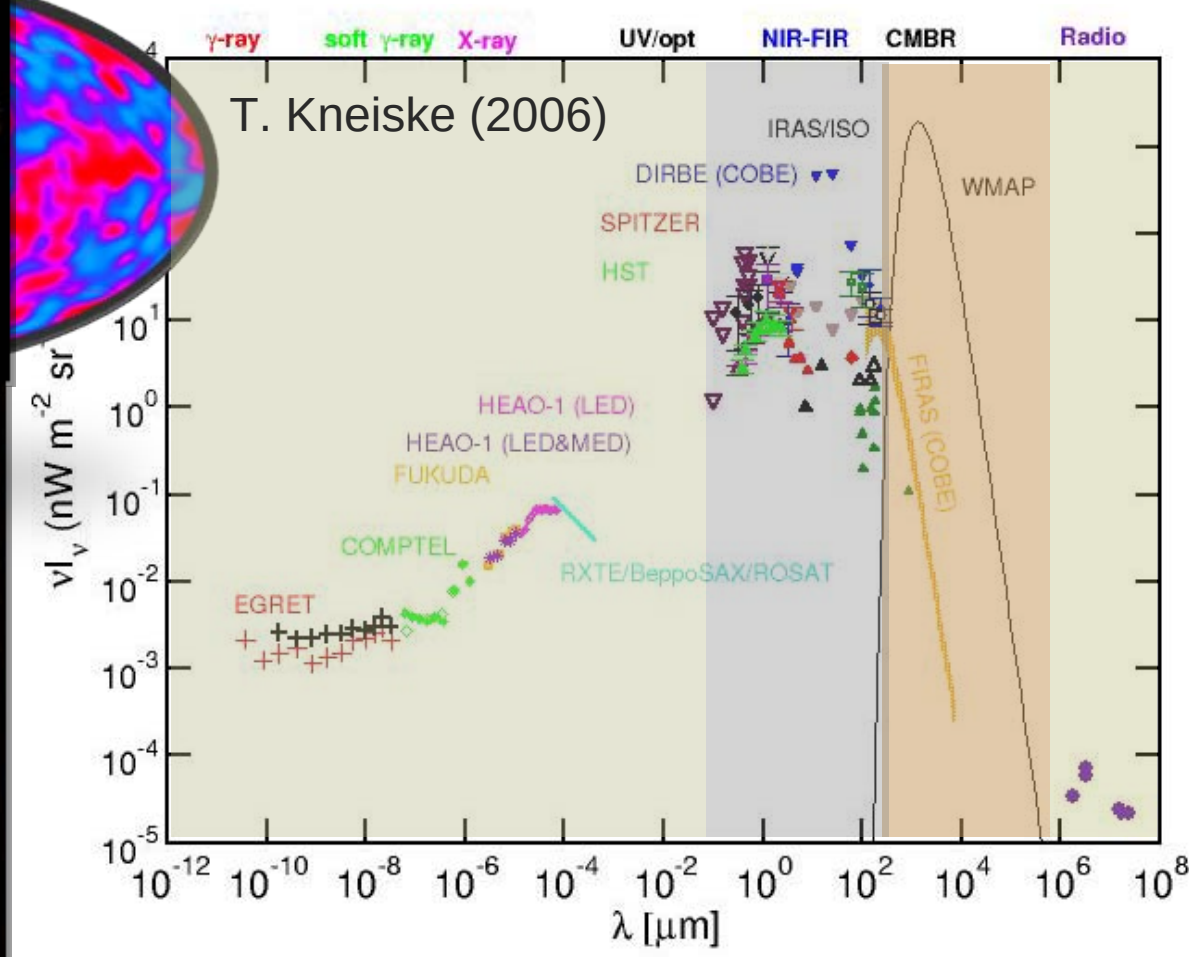
Rel. particles & EBL photons

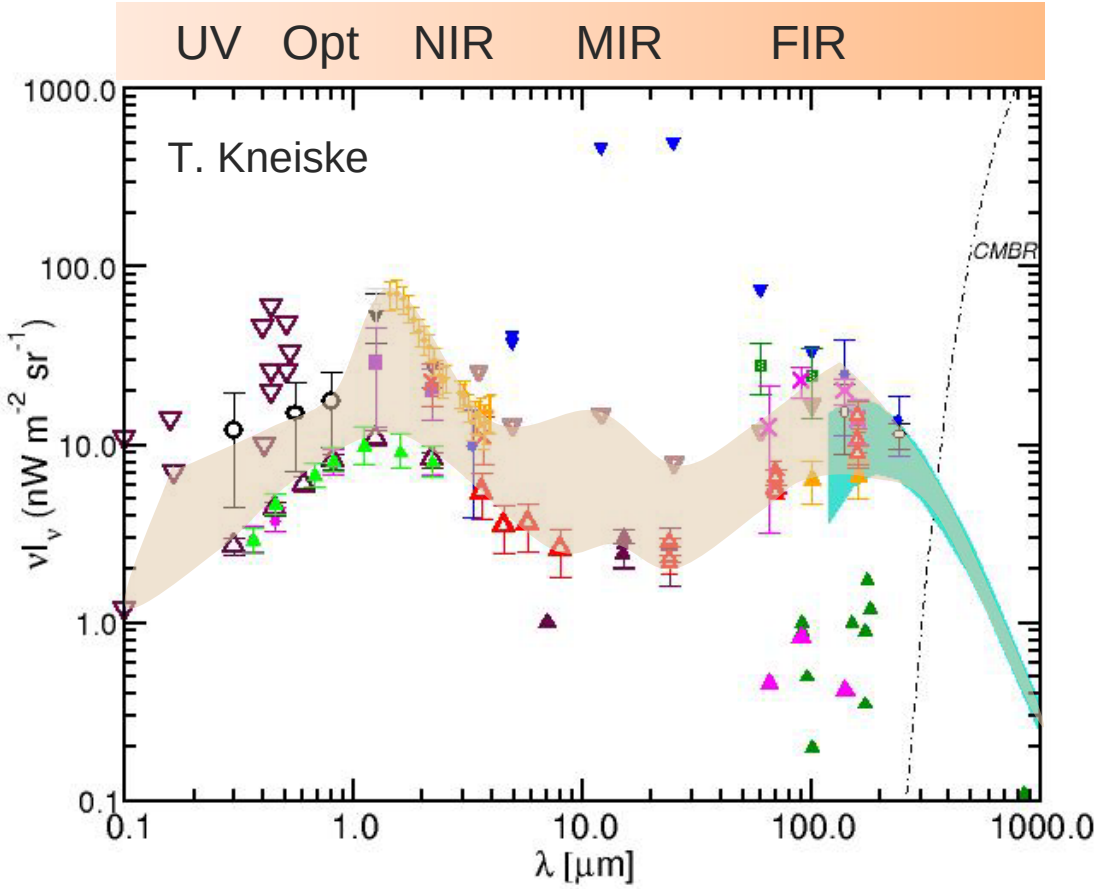
- **Electrons**
  - Inverse-Compton scattering
- **Photons**
  - Photon-photon pair production
- **Protons**
  - Pion-production
  - Bethe-Heitler pair production
- **Heavy nuclei**
  - Photo-desintegration

Extragalactic Backgrounds (z=0)



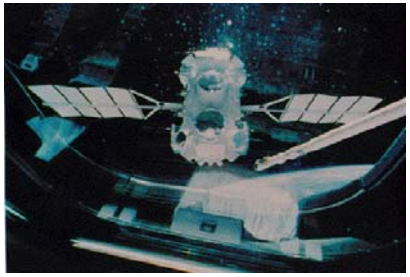


EBL – Observations & Limits

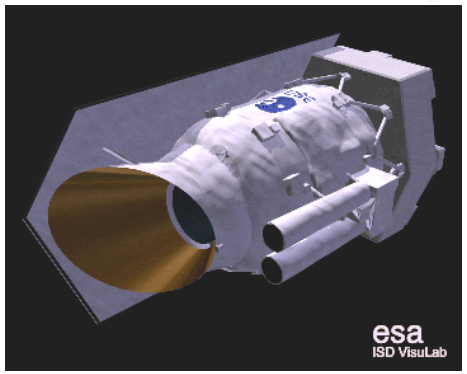


- 1) Lower limits (Galaxy counts)
- 2) Upper limits (direct detection)

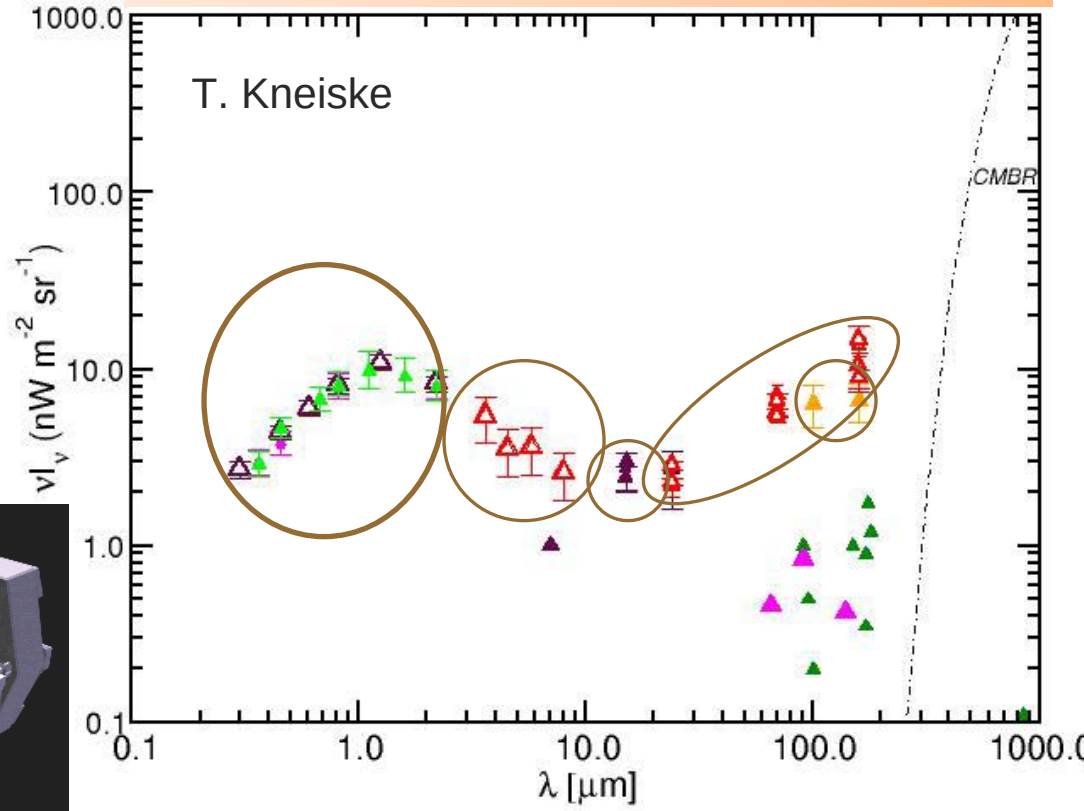
1) Lower Limits



HST

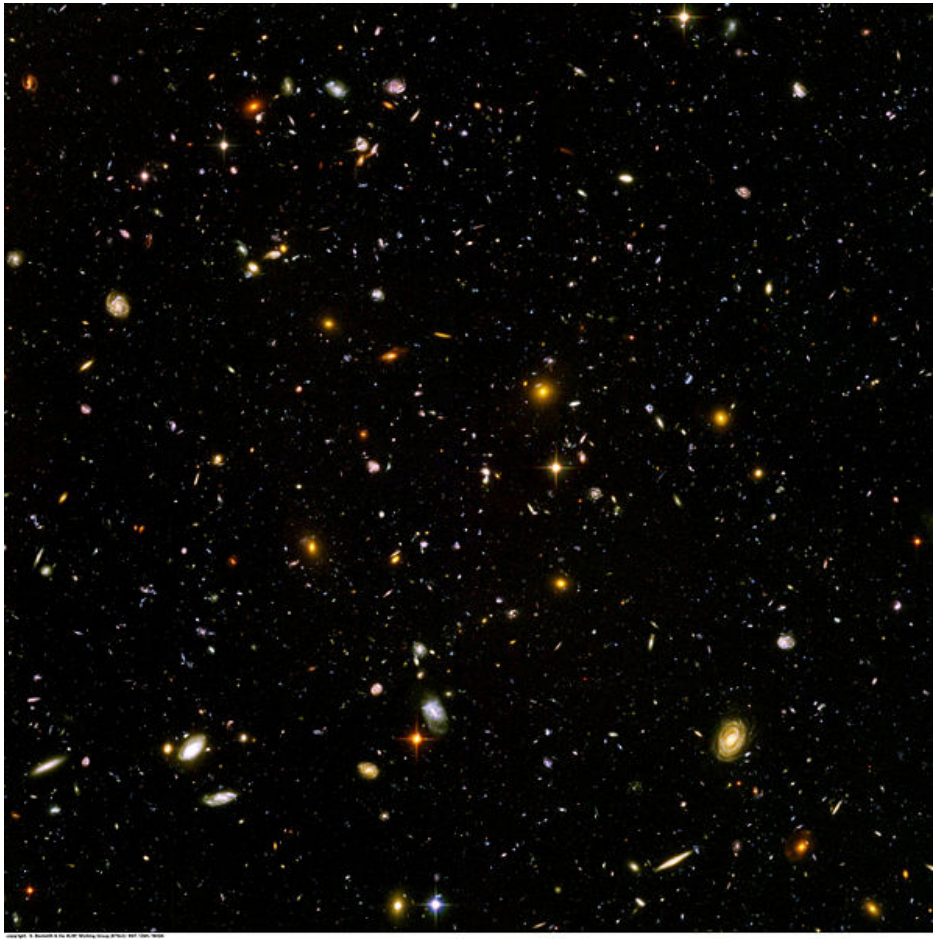


UV Opt NIR MIR FIR

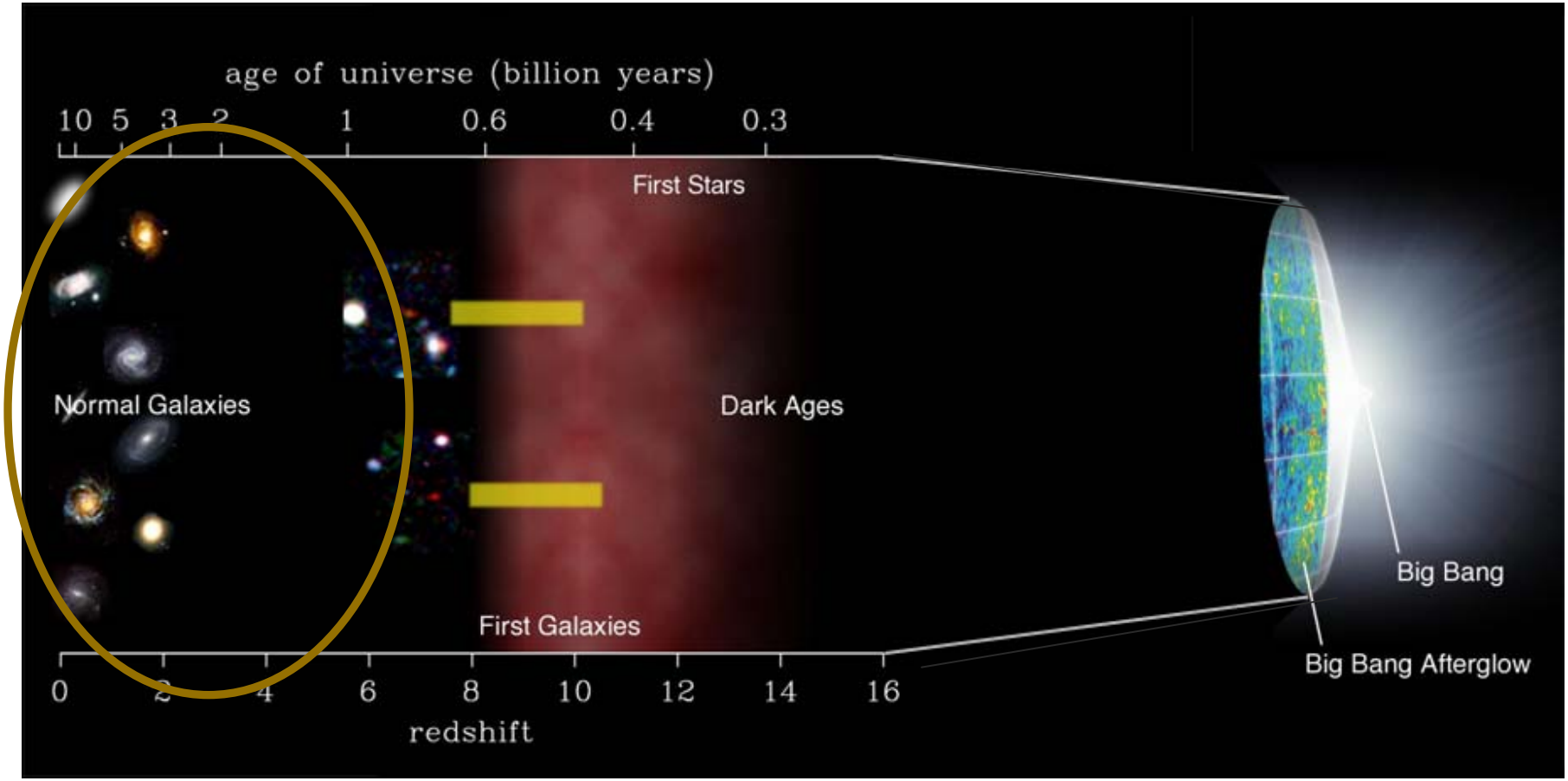


Galaxy Counts

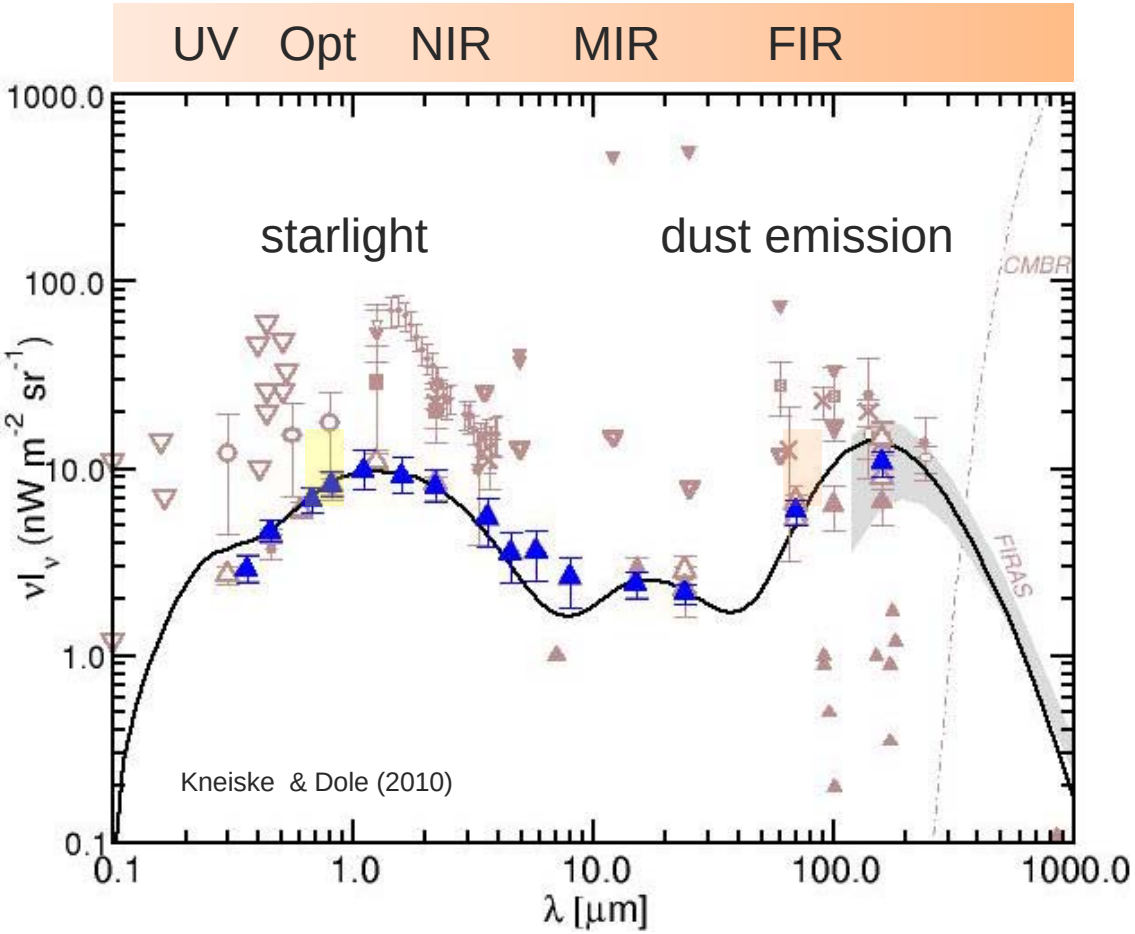
- Deep Fields
- Galaxy counts (U,V,B, IR…) ($z_{min}<z<z_{max}$)
- Extrapolation
  - Total sky
  - All redshifts
  - Low flux levels



„Normal Galaxies“ z<3(5)

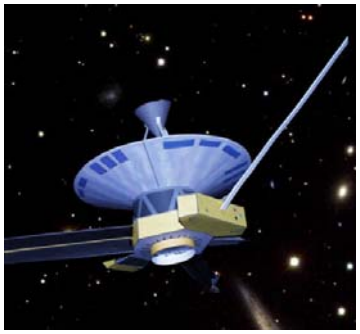


„Lower-Limit“ EBL

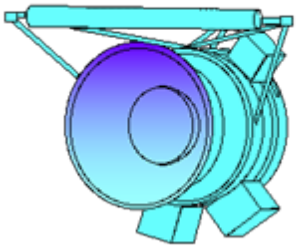


2) Upper Limits

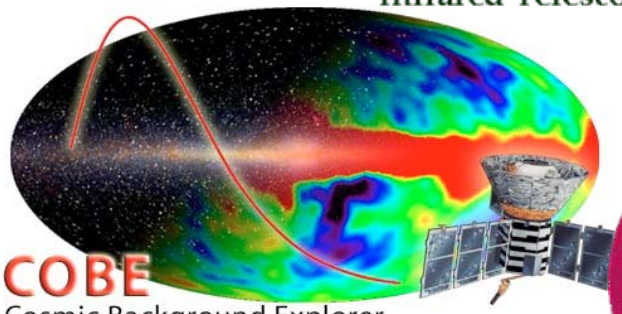
Pioneer 10, Voyager, Photometer …



IRTS



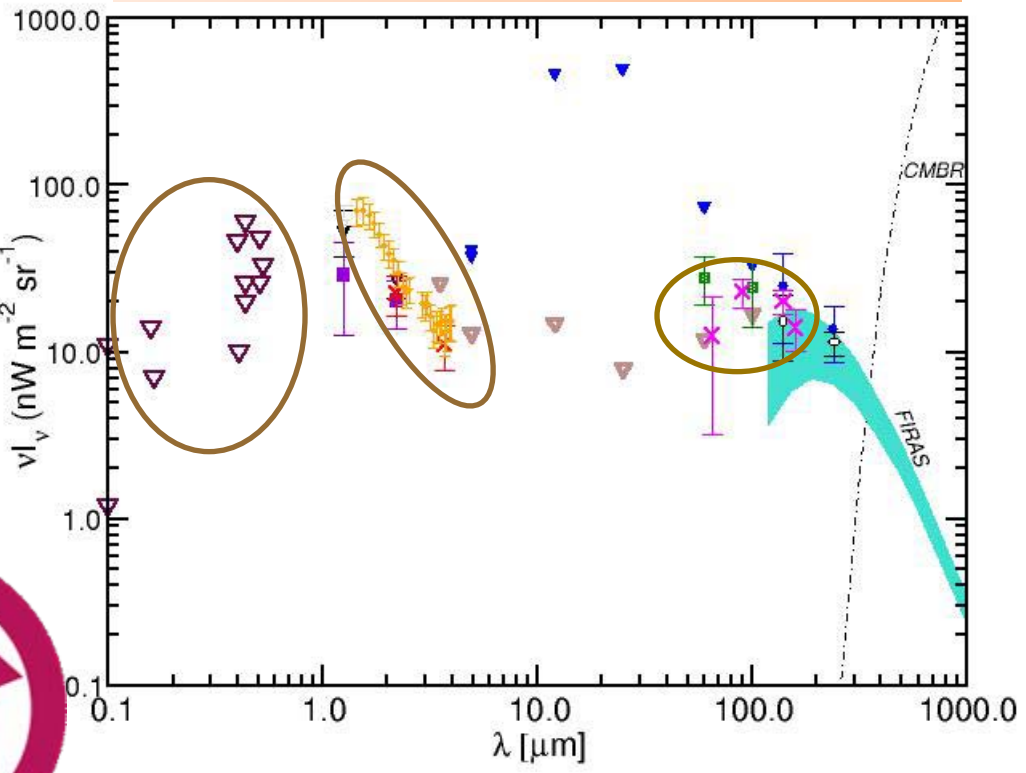
Infrared Telescope in Space



COBE
Cosmic Background Explorer

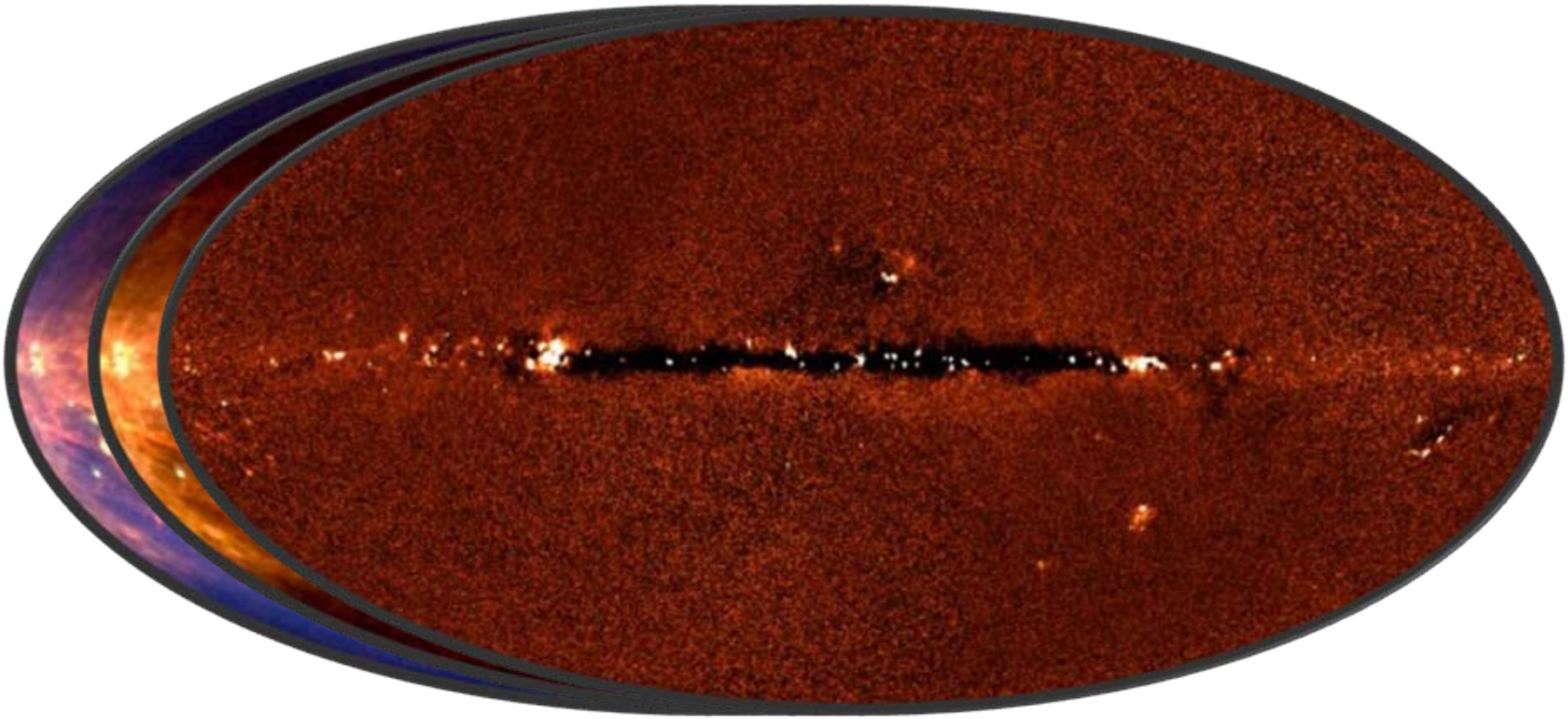
AKARI
ISAS/JAXA

UV Opt NIR MIR FIR



Kneiske et al.

Direct Observations (z=0)

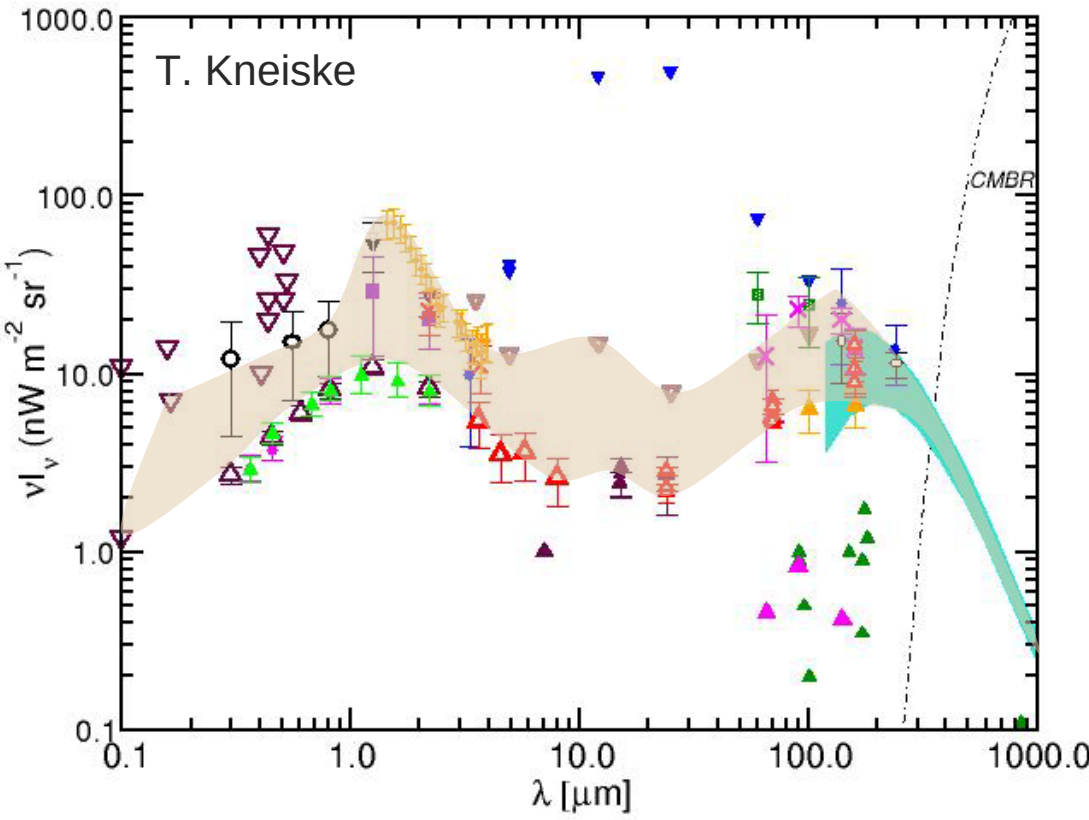


DIRBE: M.Hauser & NASA

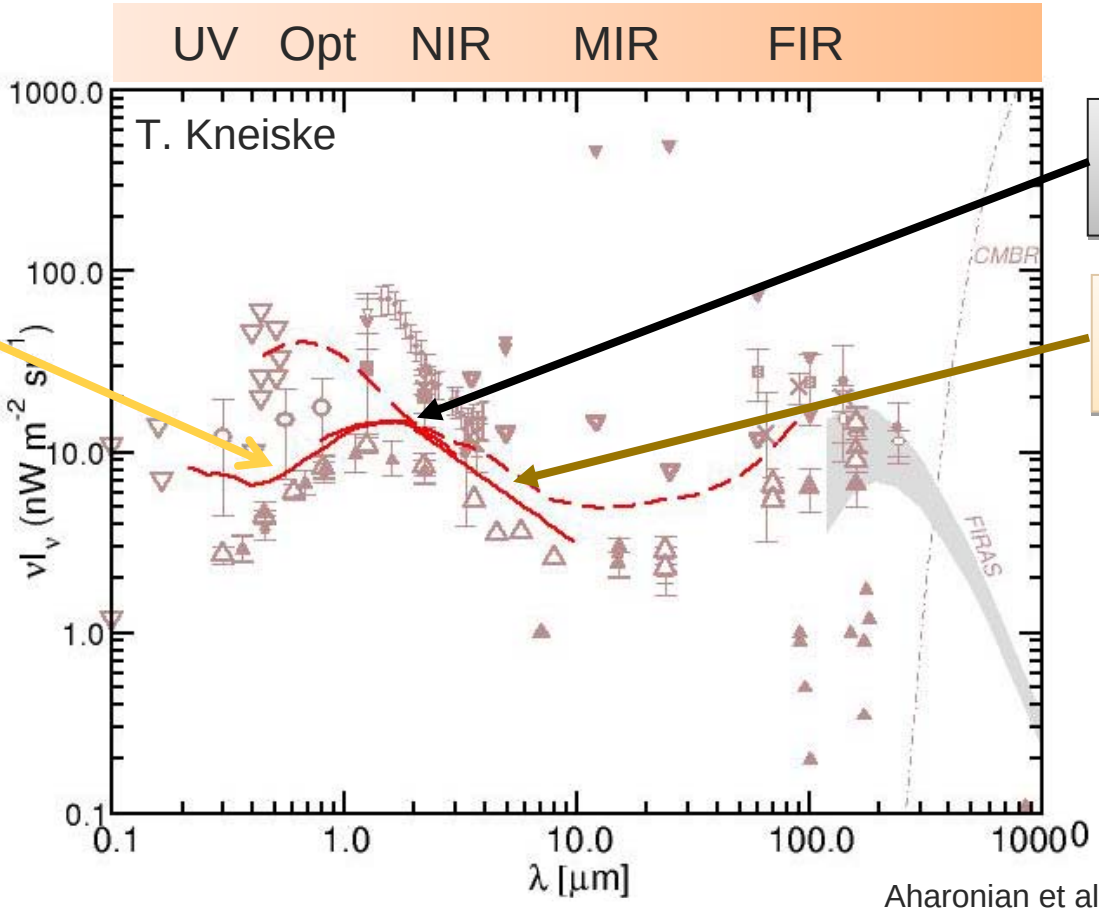
Upper vs. lower limits

- **Lower limits:**
  Stars in galaxies (z<3)

- **Upper limits:**
  - Stars or sources (z>3) like PopIII, Dark Stars…
  - Real diffuse emission ?
  - Foreground



EBL – „AGN limits“



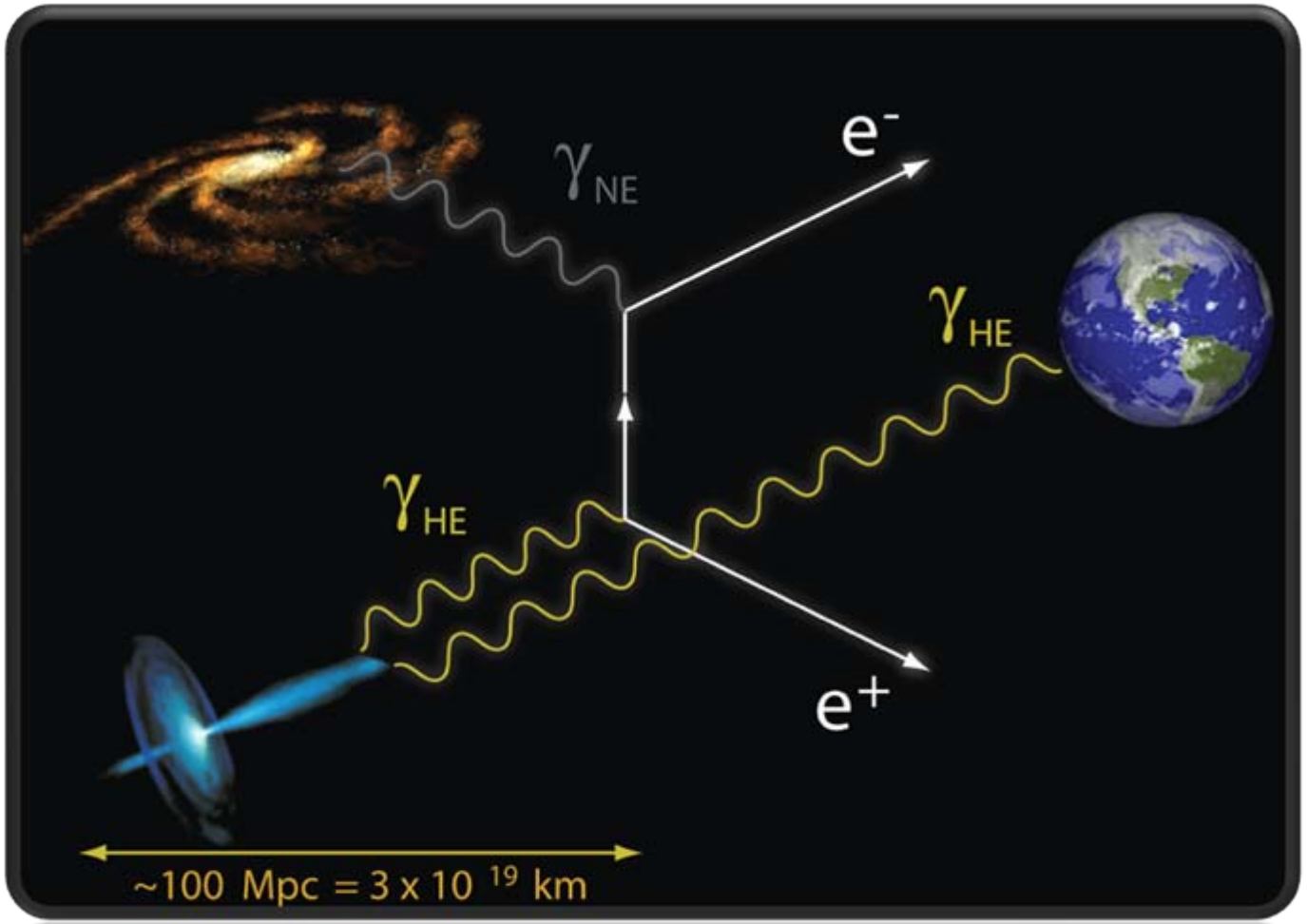
3C279 (z=0.536)

1ES 1101-232 (z=0.186)

1ES 0229+200 (z=0.1396)

Aharonian et al. (2006, 2007)
Raue & Mazin (2007)
Albert et al. (2008)

Photon-photon pair production

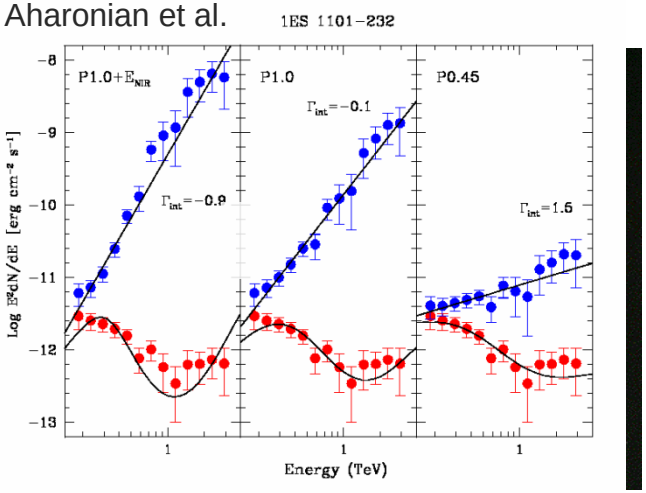


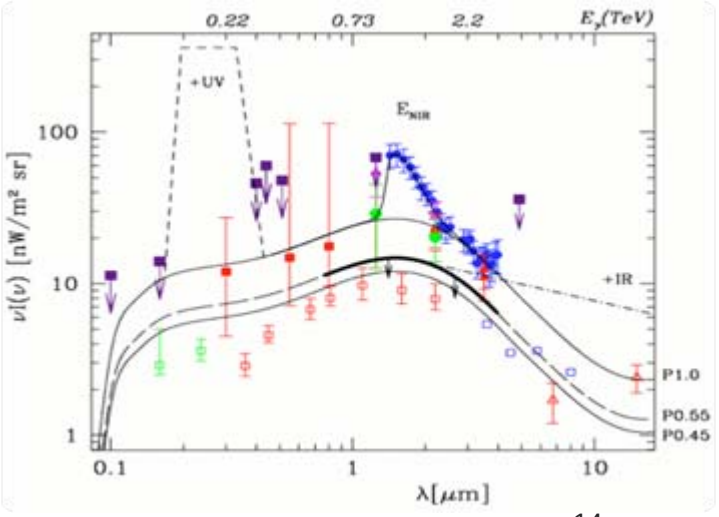
Method: „AGN limits“

- Shock accelaration of electrons: $N(E)dE \sim E^{-p}$, $p = 2$
- Synchrotron Radiation of electrons
  $s = (p-1)/2 = 0.5$
- Inverse Compton Scattering:
  $EdN/dE \sim E^{-\alpha}$, $\alpha = s = 0.5$
- $\rightarrow E^2dN/dE \sim E^{0.5}$
- **$\rightarrow dN/dE \sim E^{-1.5}$**

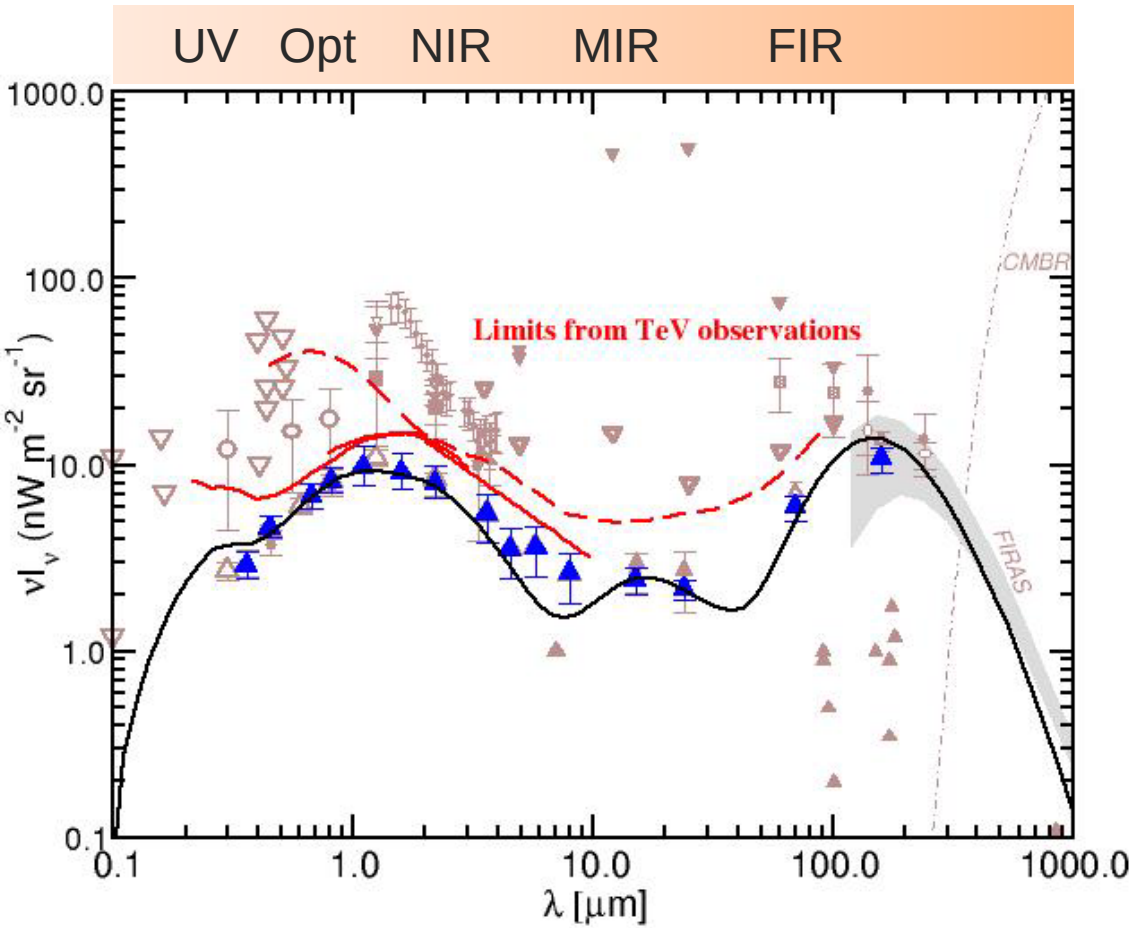
- Scaled EBL model
- Model independent: Splines

Aharonian et al.



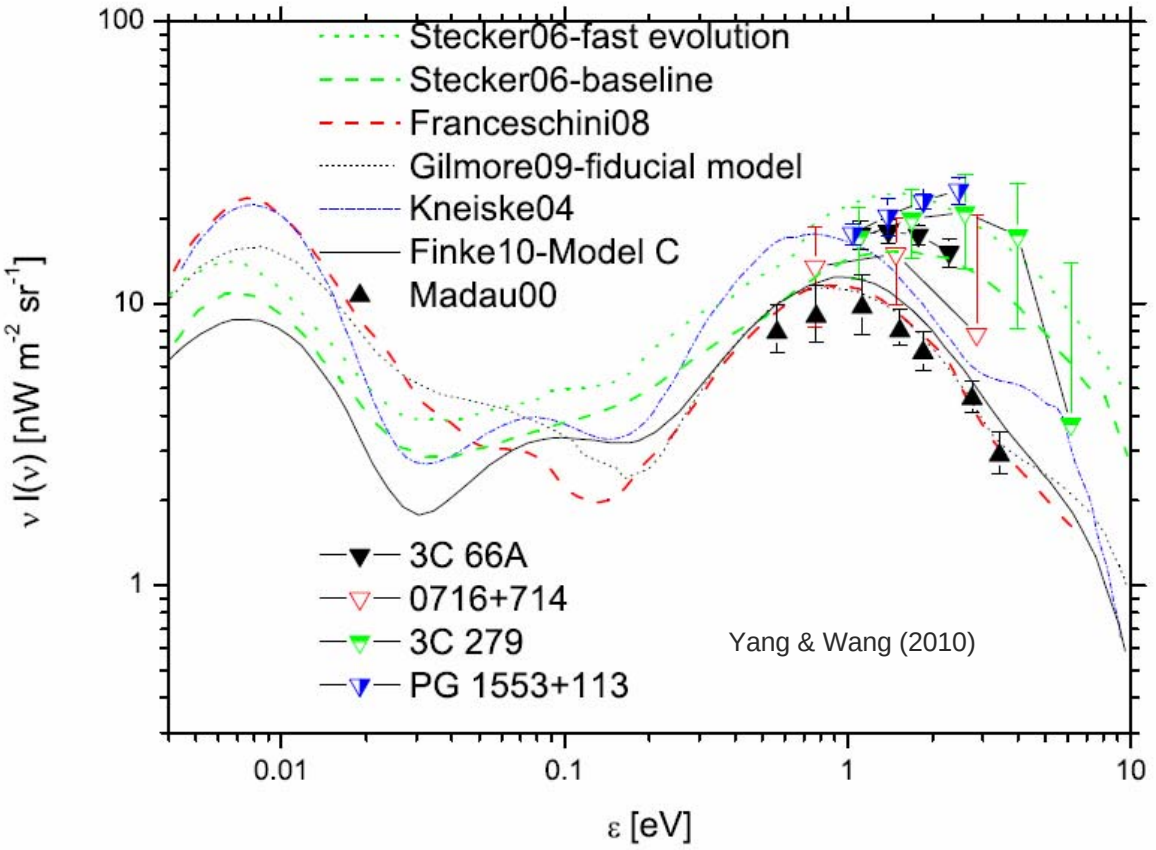


Everything is ok…

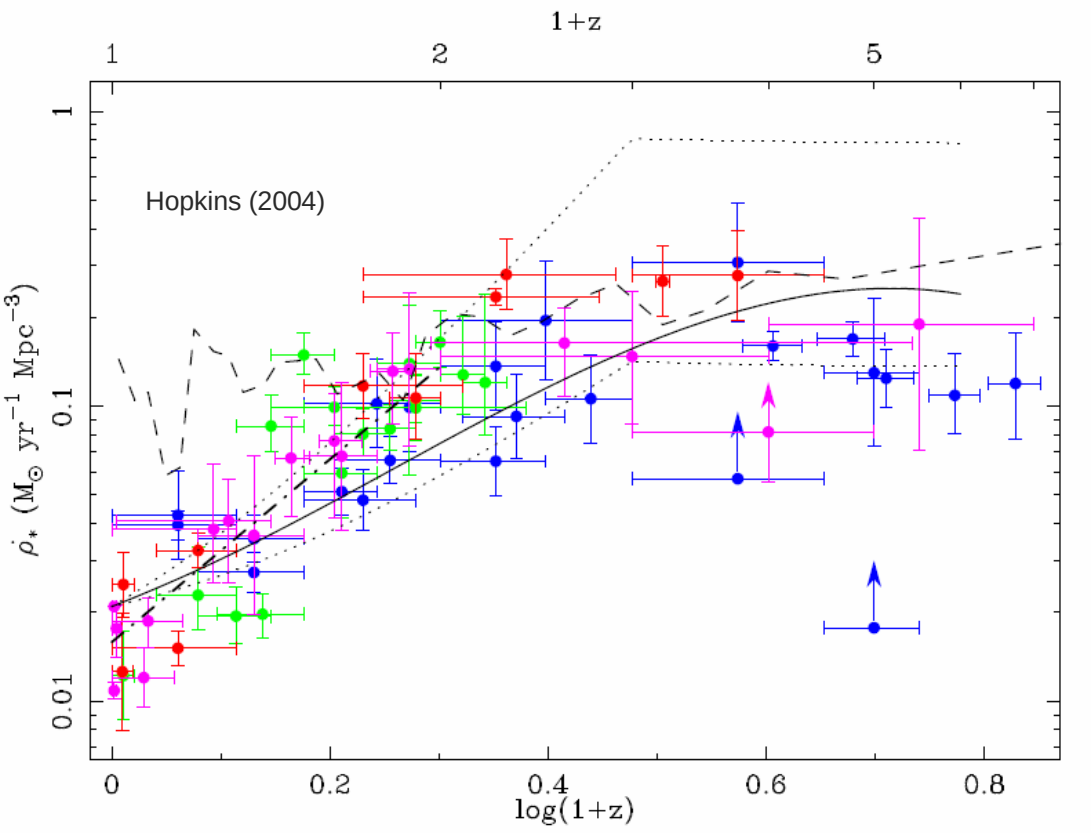


…including EBL limits from FERMI

- Georganopoulos, Finke & Luis (2010), Pks2155-304, **1ES1218+304**
- Yang & Wang (2010)

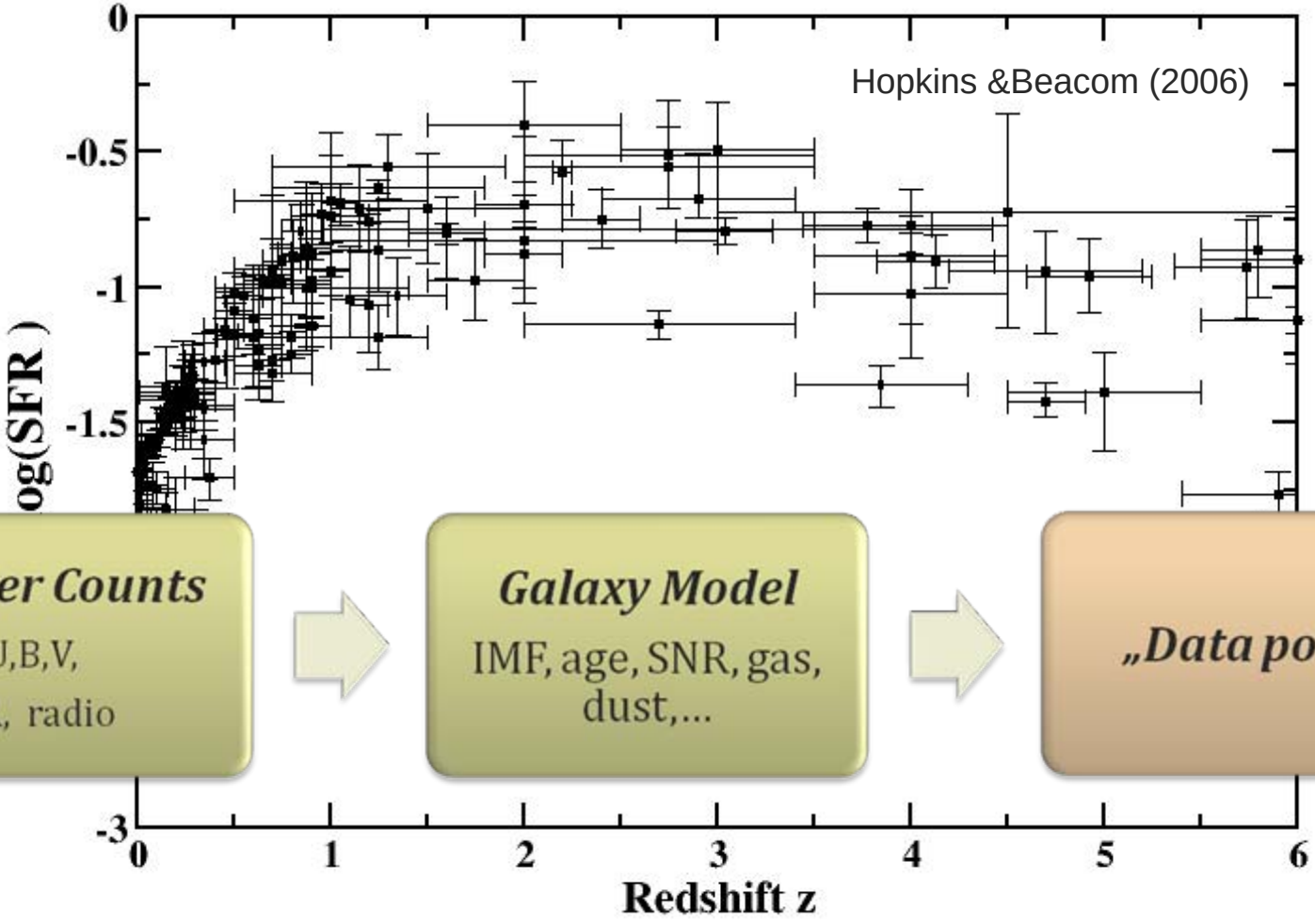


What about the Cosmic SFR?



- Blue: UV
- Green: [OII]
- Red: Hα, Hβ
- Pink: X-ray, sub-mm, FIR, radio

SFR-„Data“



Number Counts
U,B,V,
..IR, radio

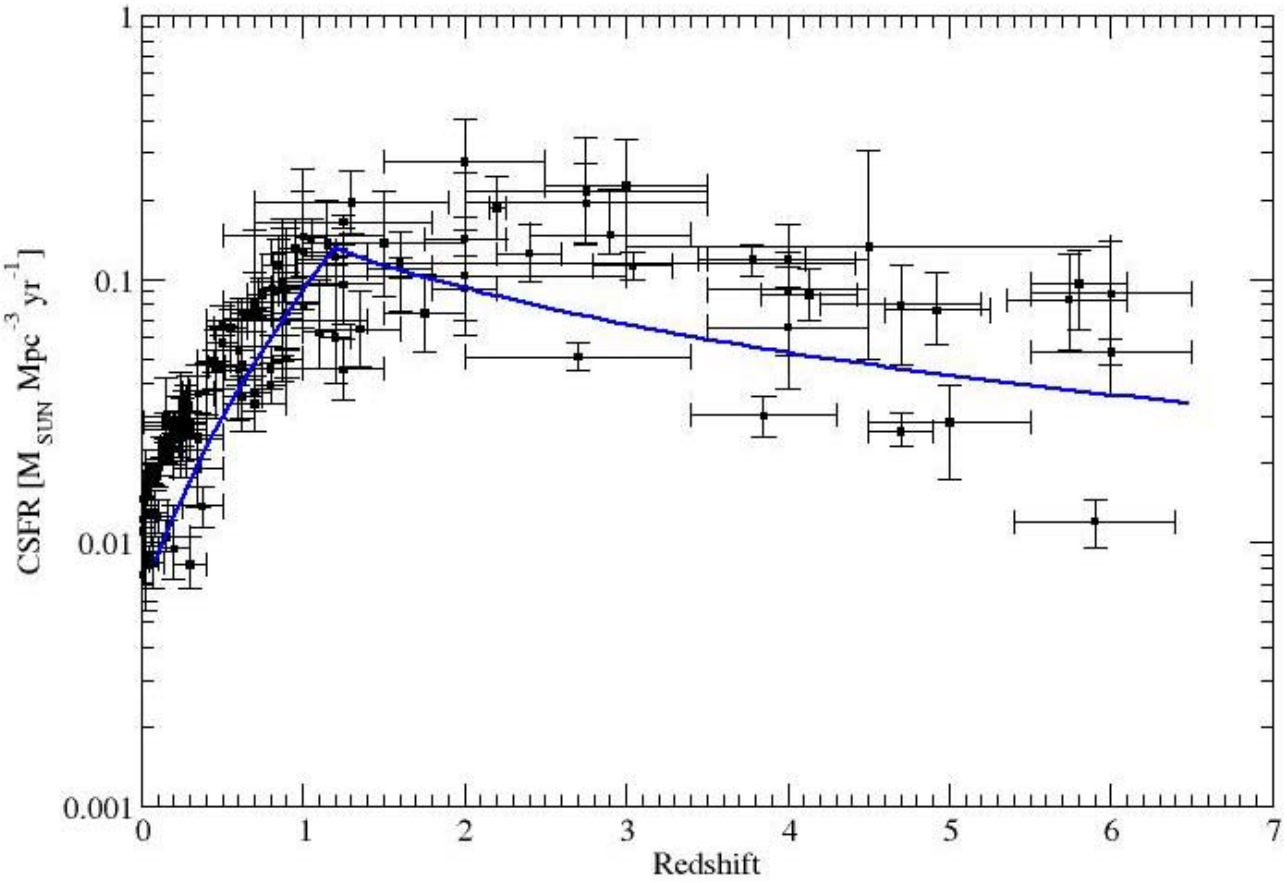
Galaxy Model
IMF, age, SNR, gas, dust,...

„Data point“

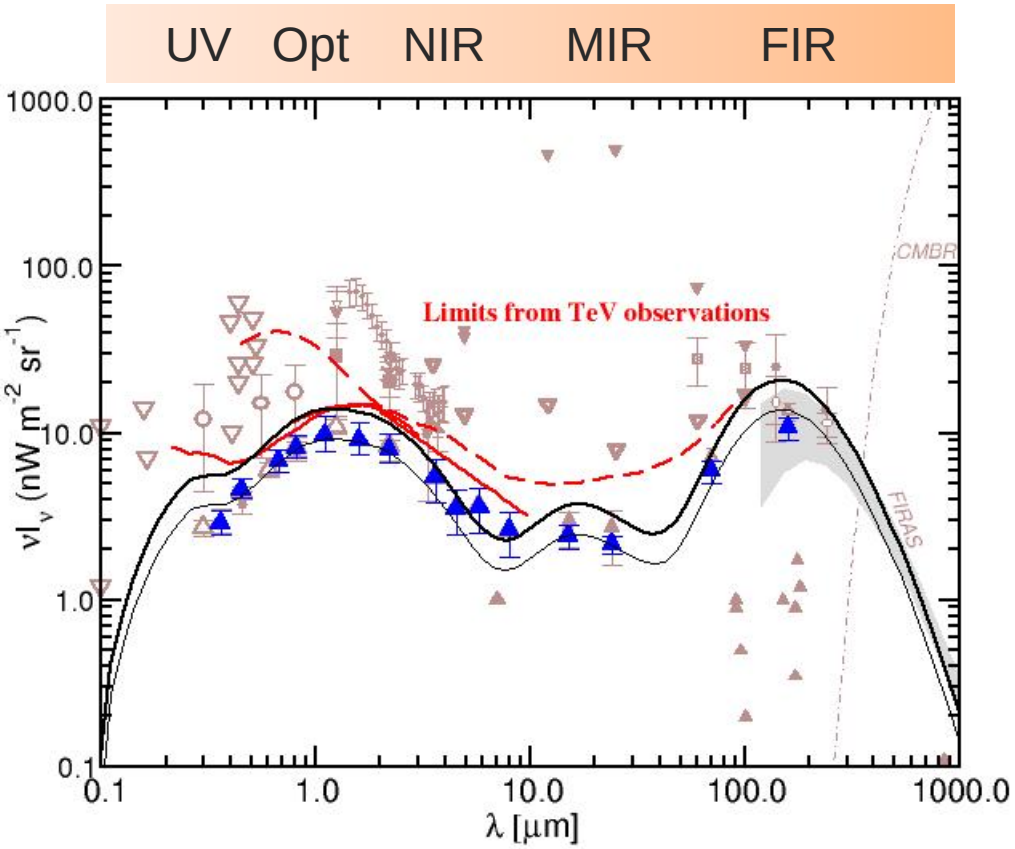
Do we really need ALPs ?

- Not up to now !
- … but… there are some hints…
  - SFR „lower limit“ *a bit* too small

„Lower limit“ SFR



EBL „lower-limit“ x 2

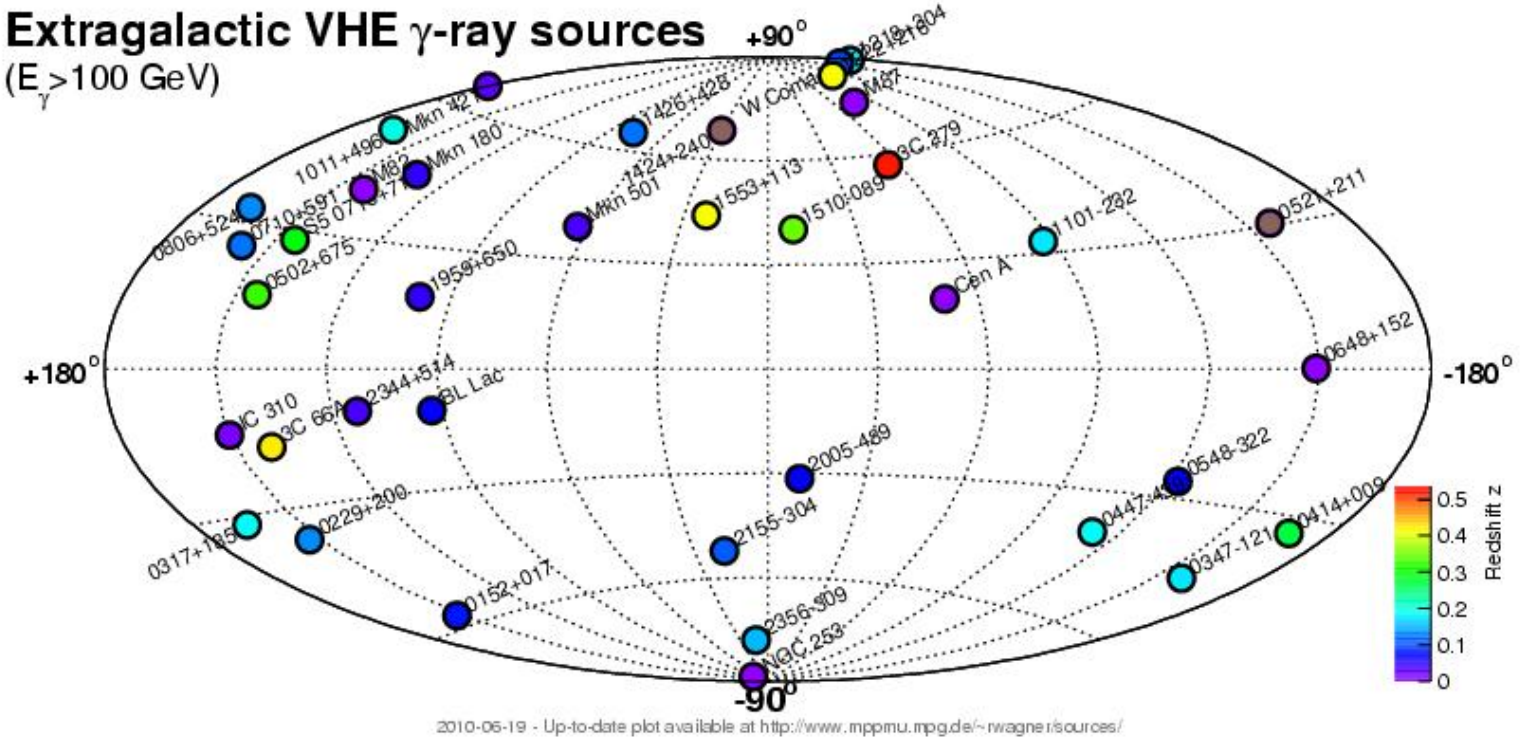


Do we really need ALPs ?

- Not up to now !
- … but …
  - SFR „lower-limit“ too small
  - Discovery of high redshifted sources

New source discovered at z>0.4

MAGIC detects 4C +21.35 (PKS 1222+21)
FSRQ @ z=0.432
(ATel #2684 *on 19 Jun 2010)*



Do we really need ALPs ?

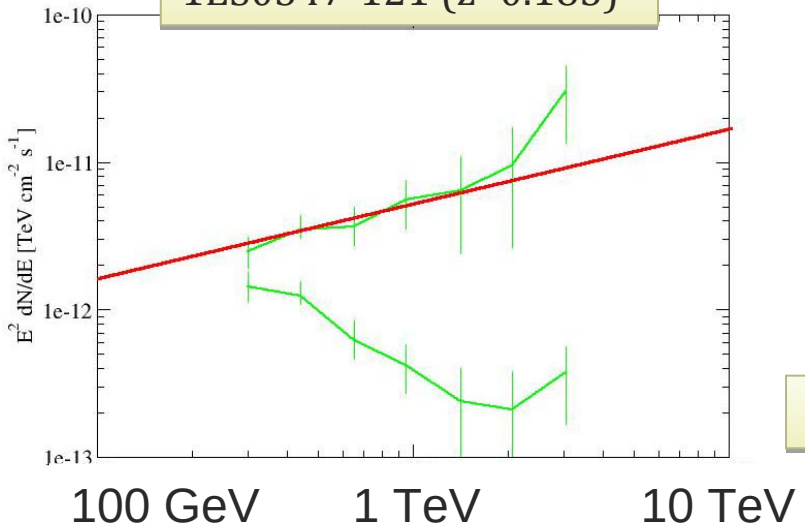
- Not up to now !
- … but …
  - SFR „lower-limit“ too small
  - Discovery of high redshifted sources
  - Features in AGN spectra (not power-laws)

Do we really need ALPs ?

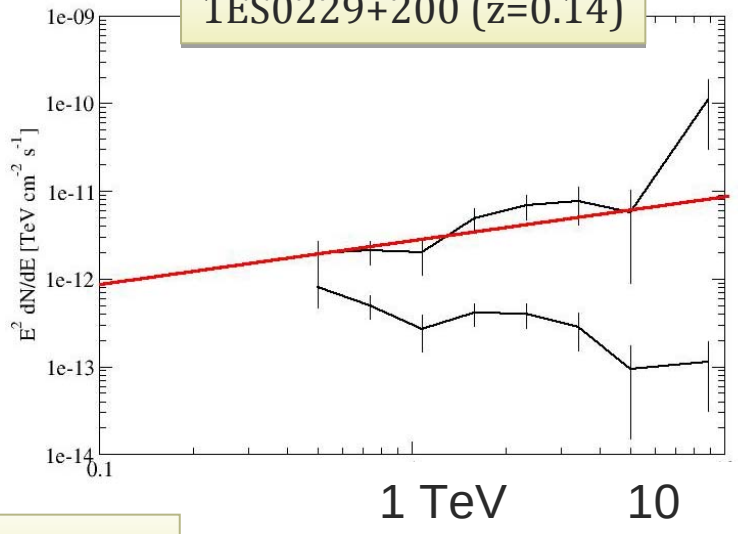
- Not up to now !
- … but …
  - SFR „lower-limit“ too small
  - Discovery of high redshifted sources
  - Features in AGN spectra (not power-laws)
  - High energy end of AGN spectra

A new „GeV/TeV crisis“ ?

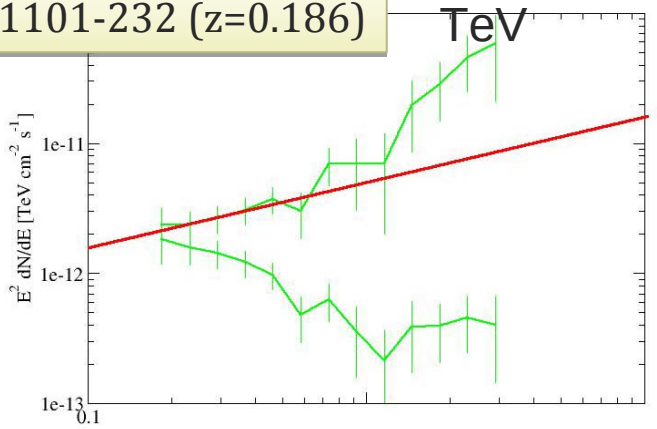
1ES0347-121 (z=0.185)



1ES0229+200 (z=0.14)



1ES1101-232 (z=0.186)



Summary and Outlook

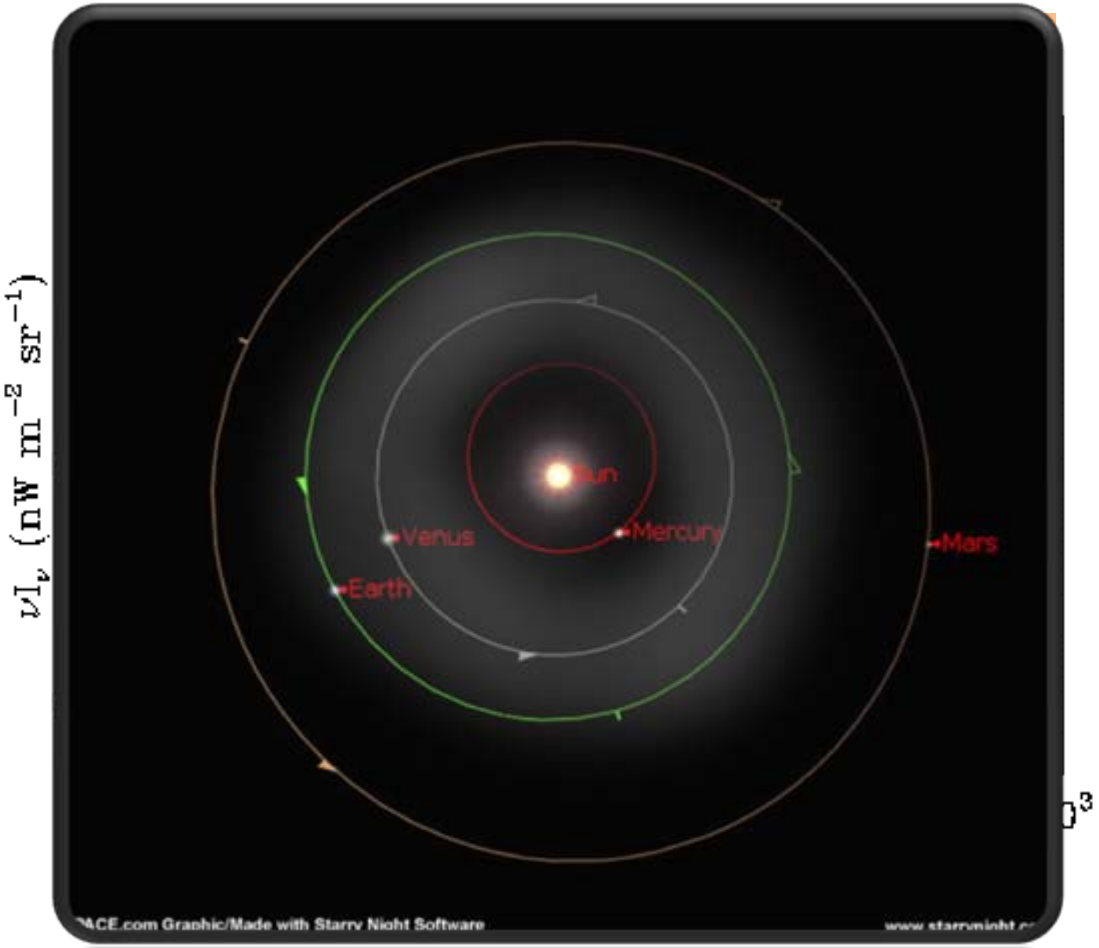
Today

- **Lower limits:**
  - Galaxies <3(5)
- **Upper limits:**
  - Stars z>5 ?
  - Real diffuse emission ?
- **AGN limits:**
  - AGN physics ?
- ***OK !***

Future

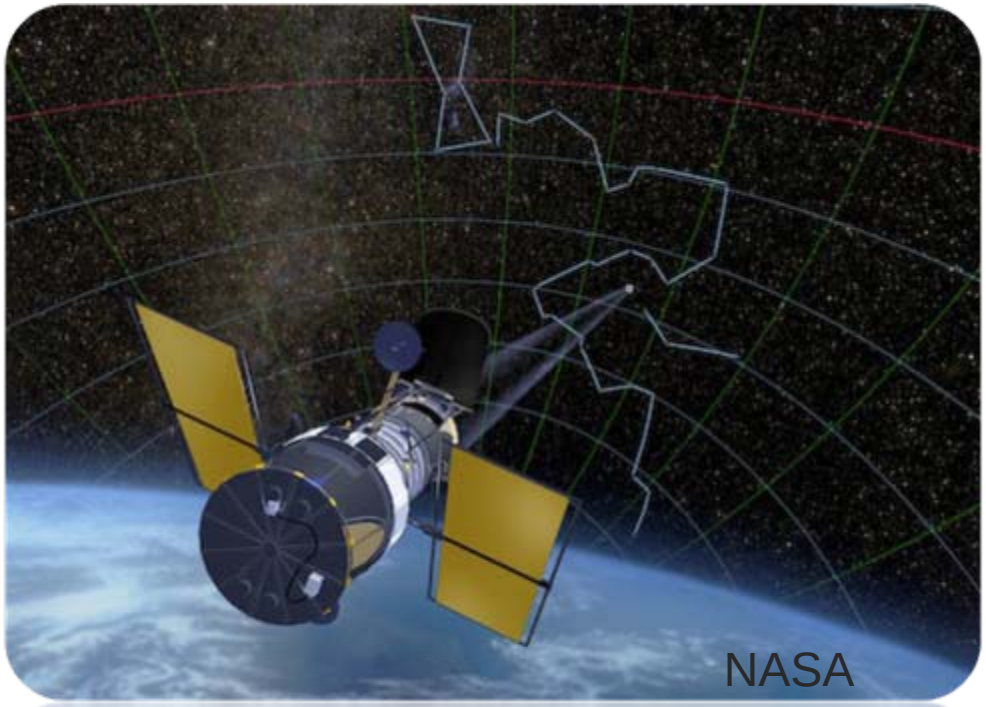
- JWST (z>6)
- MAGICII, VERITAS, CTA…
- Use ***one EBL model*** and change parameter
- ***Detailed study*** of AGN spectra

Foreground emission



- Detection (**open circles**)
- Zodiacal light (**triangle**)
- EBL (**circles**)
- Stars (**squares** & **stars**)
- ISM (diamants)
- Telescope temp., Moon, Sun, Earth…

Large scale structure



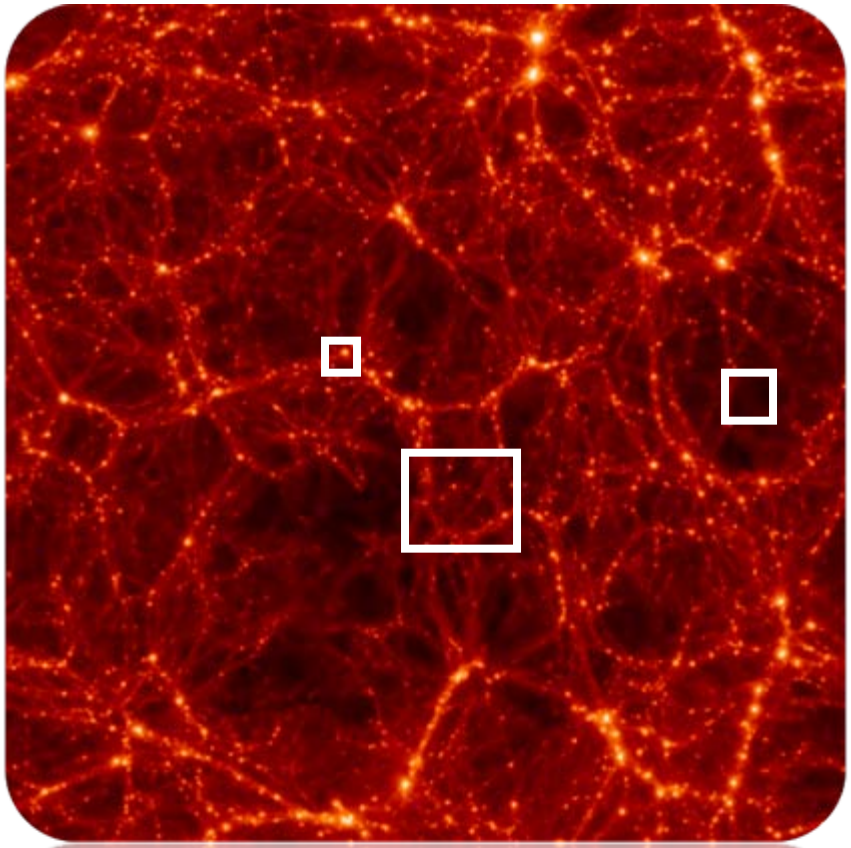
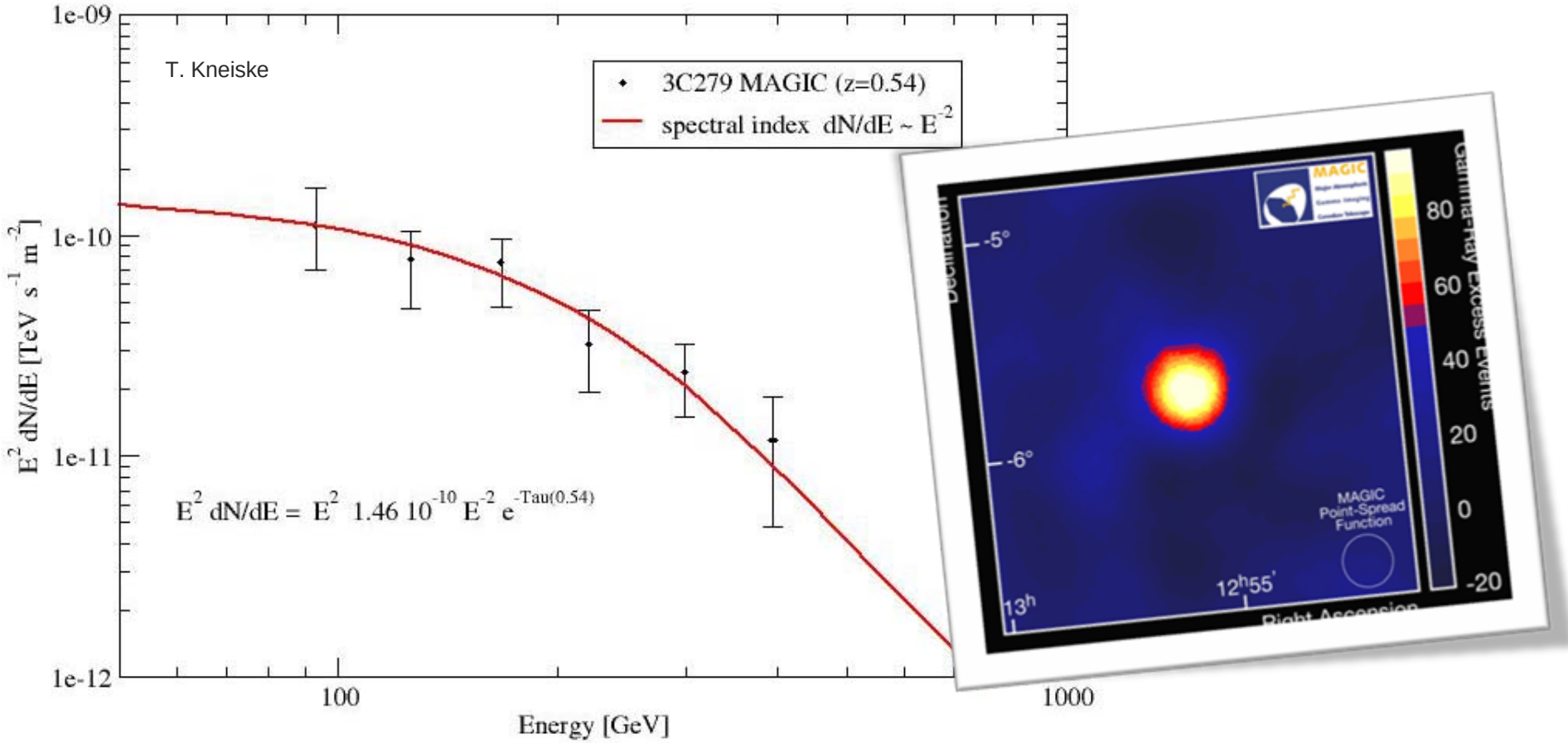


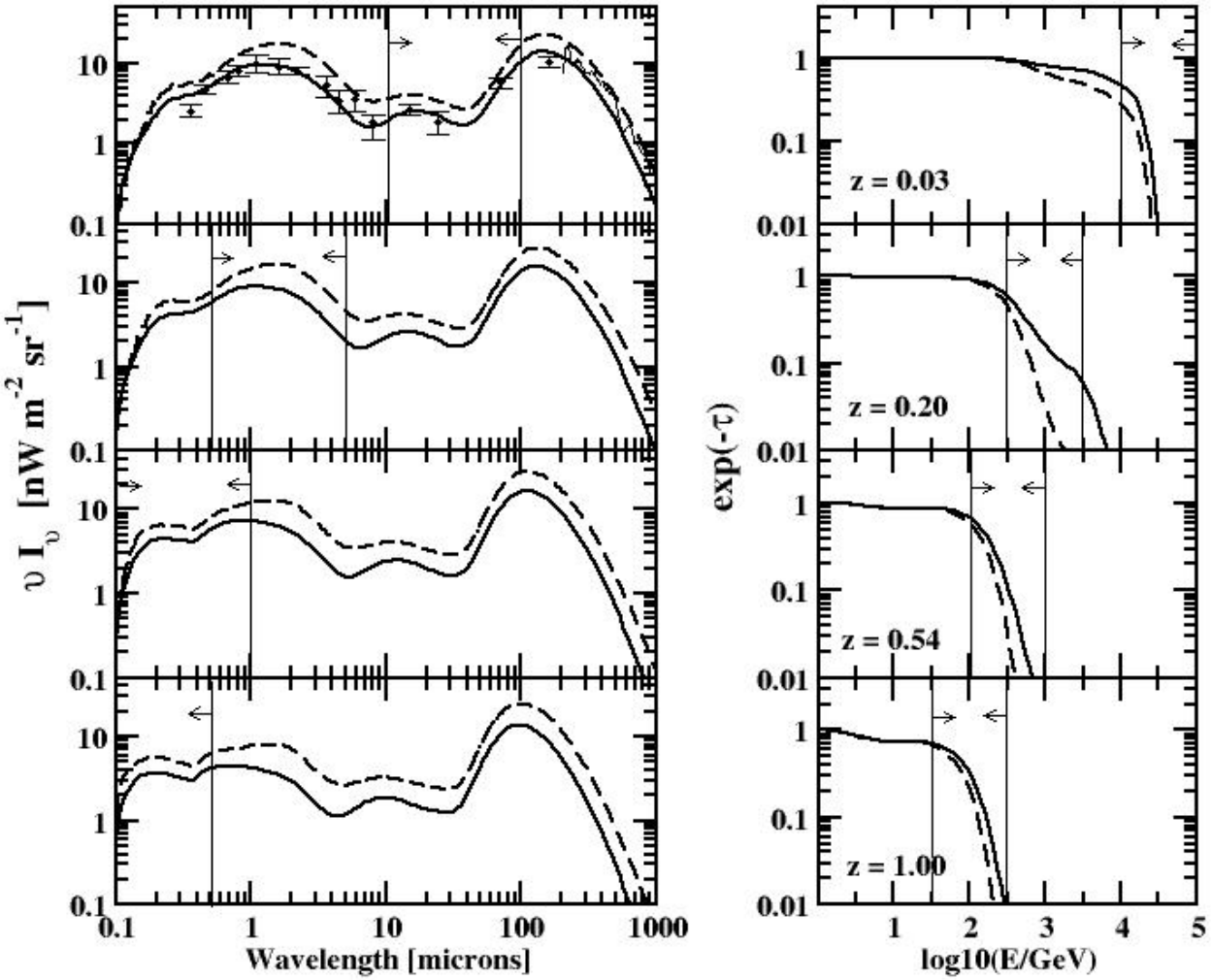
Image size


M33 © IAC/RGO/Malin
Photo from Isaac Newton Telescope Plates
by David Malin

… even 3C279 …


T. Kneiske
3C279 MAGIC (z=0.54)
spectral index dN/dE ~ E^-2
E^2 dN/dE = E^2 1.46 10^-10 E^-2 e^-Tau(0.54)
E^2 dN/dE [TeV s^-1 m^-2]
1e-09
1e-10
1e-11
1e-12
100
1000
Energy [GeV]
MAGIC
MAGIC Point-Spread Function
-5°
-6°
13h
12h55'
80
60
40
20
0
-20

„Best-fit 06“ EBL

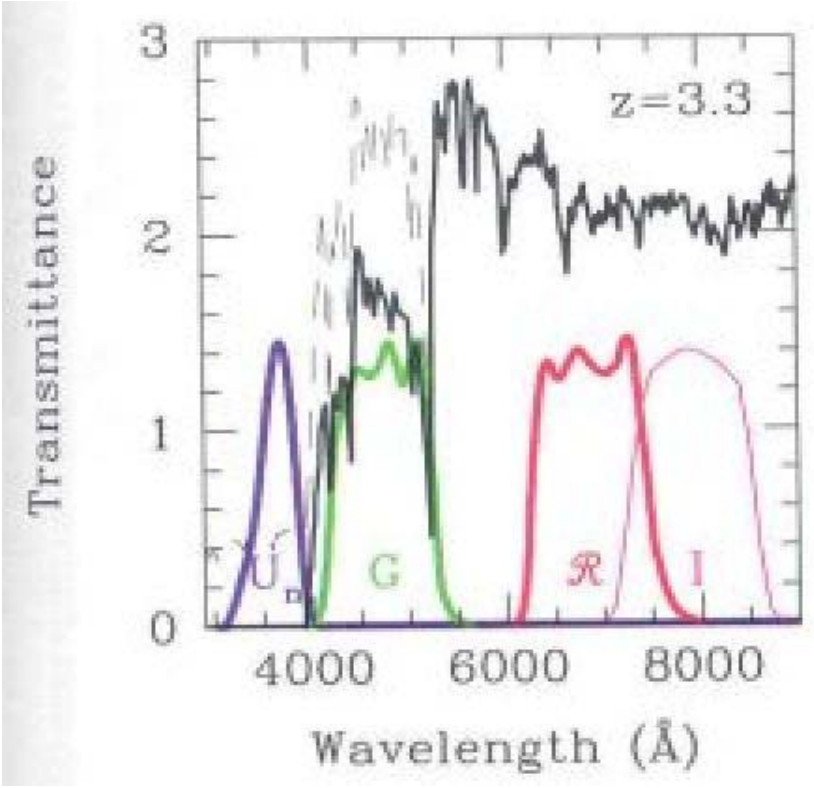


Kneiske&Dole (2010)

UV and optical SFR

UV Opt

- UV continuum
- **Lyman break galaxies (Starburst)**
- Line emission



LL: Important Deep Fields

- Lockman Hole
- **HDF-N** and **HDF-S**: Hubble Space Telescope
- **CDF-N** and **CDF-S**: Chandra
  (CDF-N = HDF-N)
- NOAO deep-wide-field (NDWFS) **Boötes**-field (north), **Cetus**-field (south) (near the galactic poles)
- …
- **GOODS Fields:**
  HDF-N (Ursa Major)
  CDF-S (Fornax)
  HST, Spitzer, Chandra,…

LL: deep fields and data

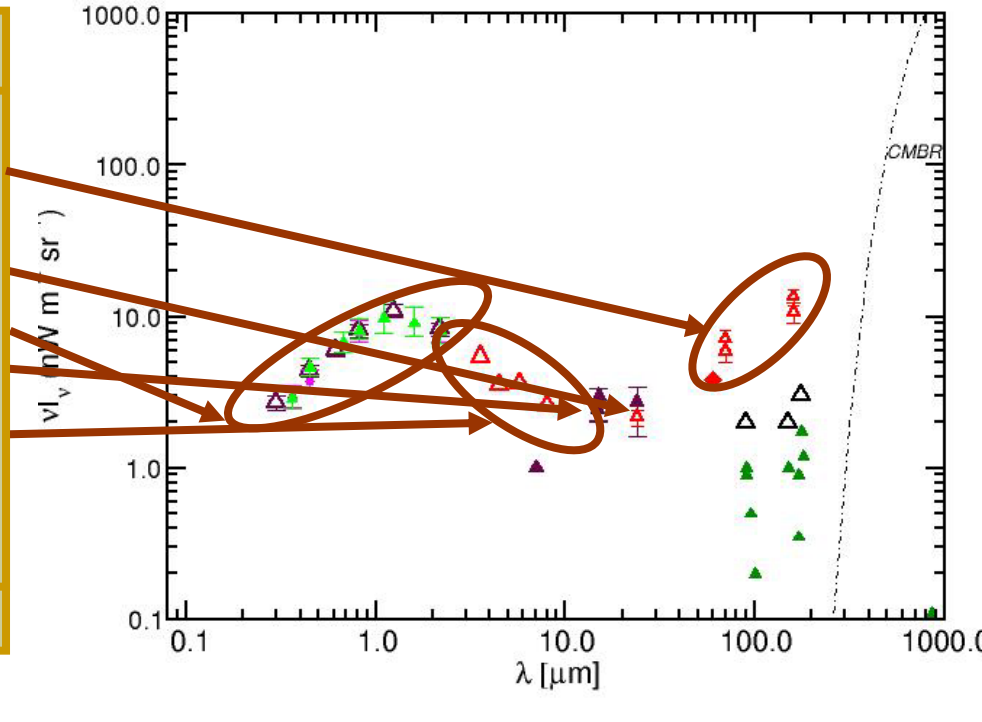
Altieri et al. (1999),

Dole et al. (2004),

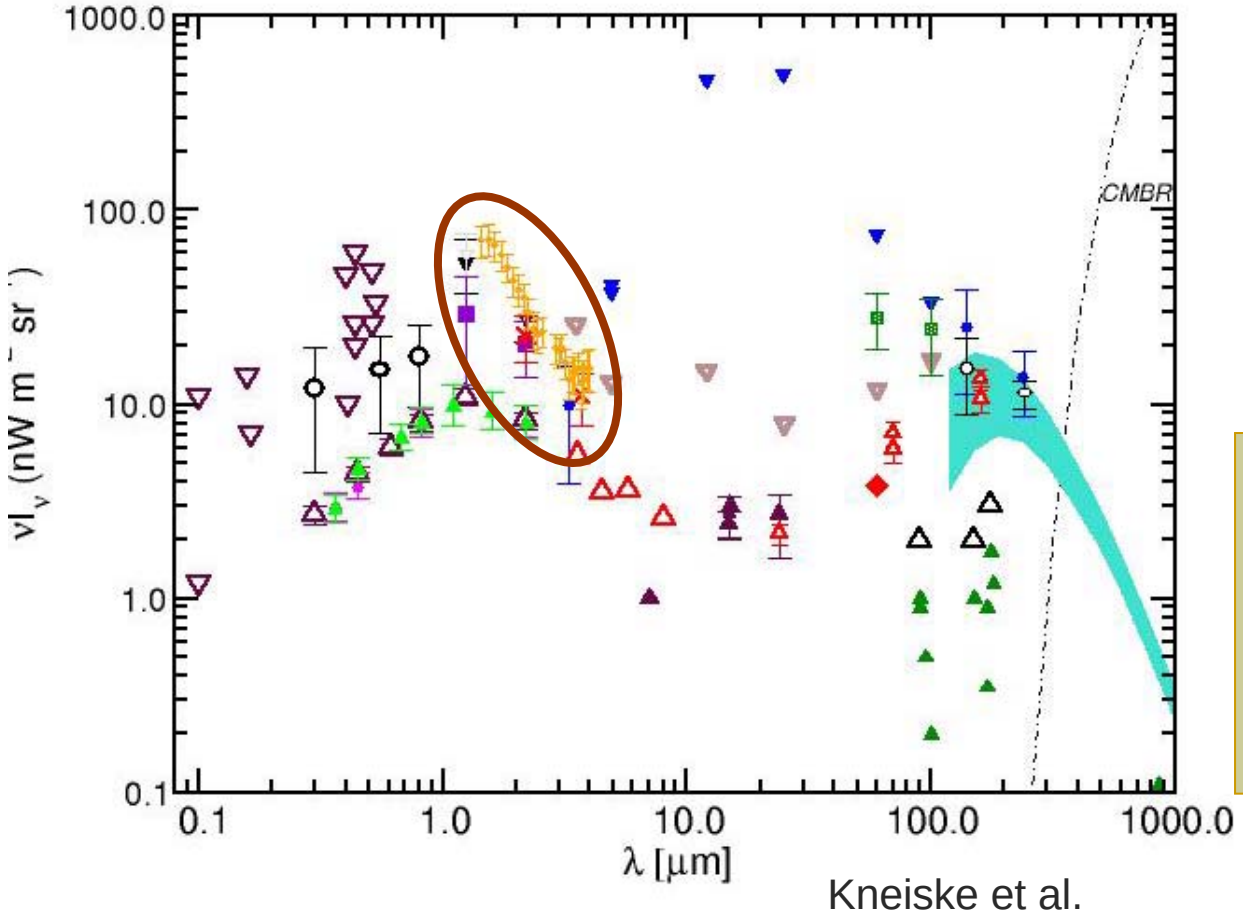
70 μm, 160 μm

- CDF-S 0.4° x 0.4°
- HDF-N 0.4° x 0.4°
- Lockman Hole 0.4° x 0.4°

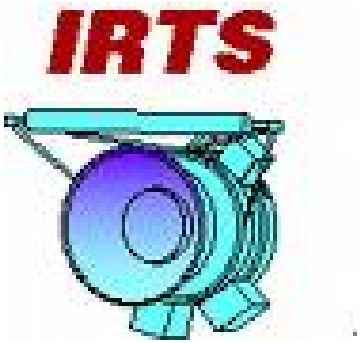
- Abell 2390



Signature of the first stars ?

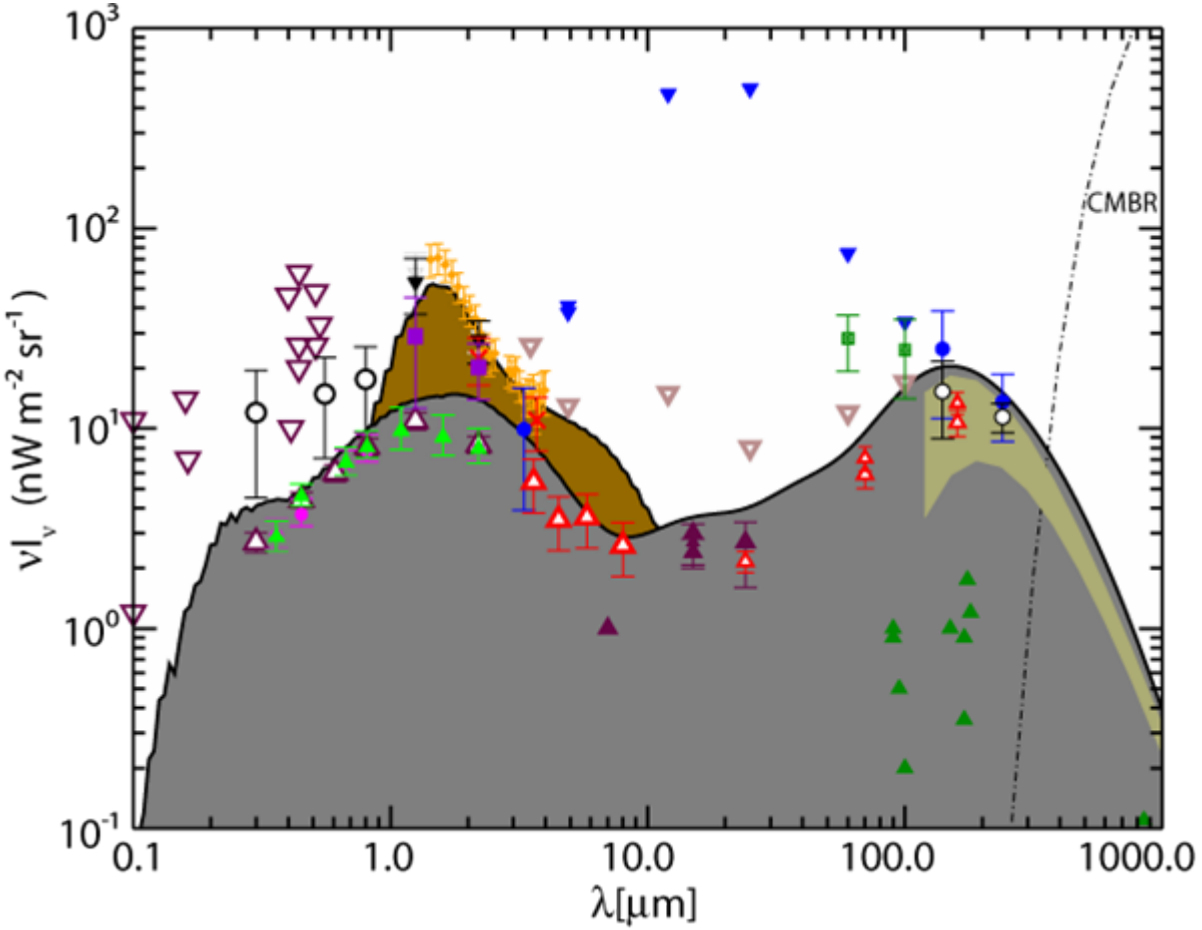


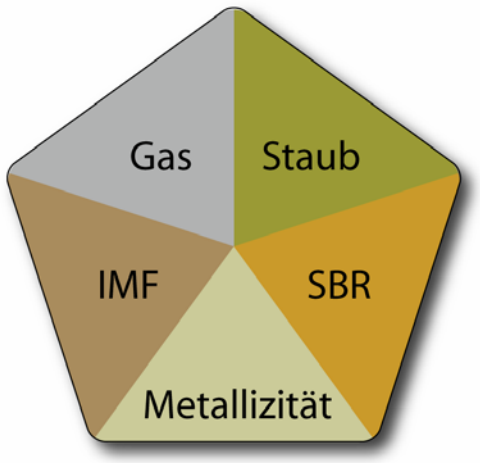
Kneiske et al.



- Lyman Kante
  z~10: (1+z) 0.1 μm ~ 1 μm
- Zodiakallicht ?

Contribution of the First Stars

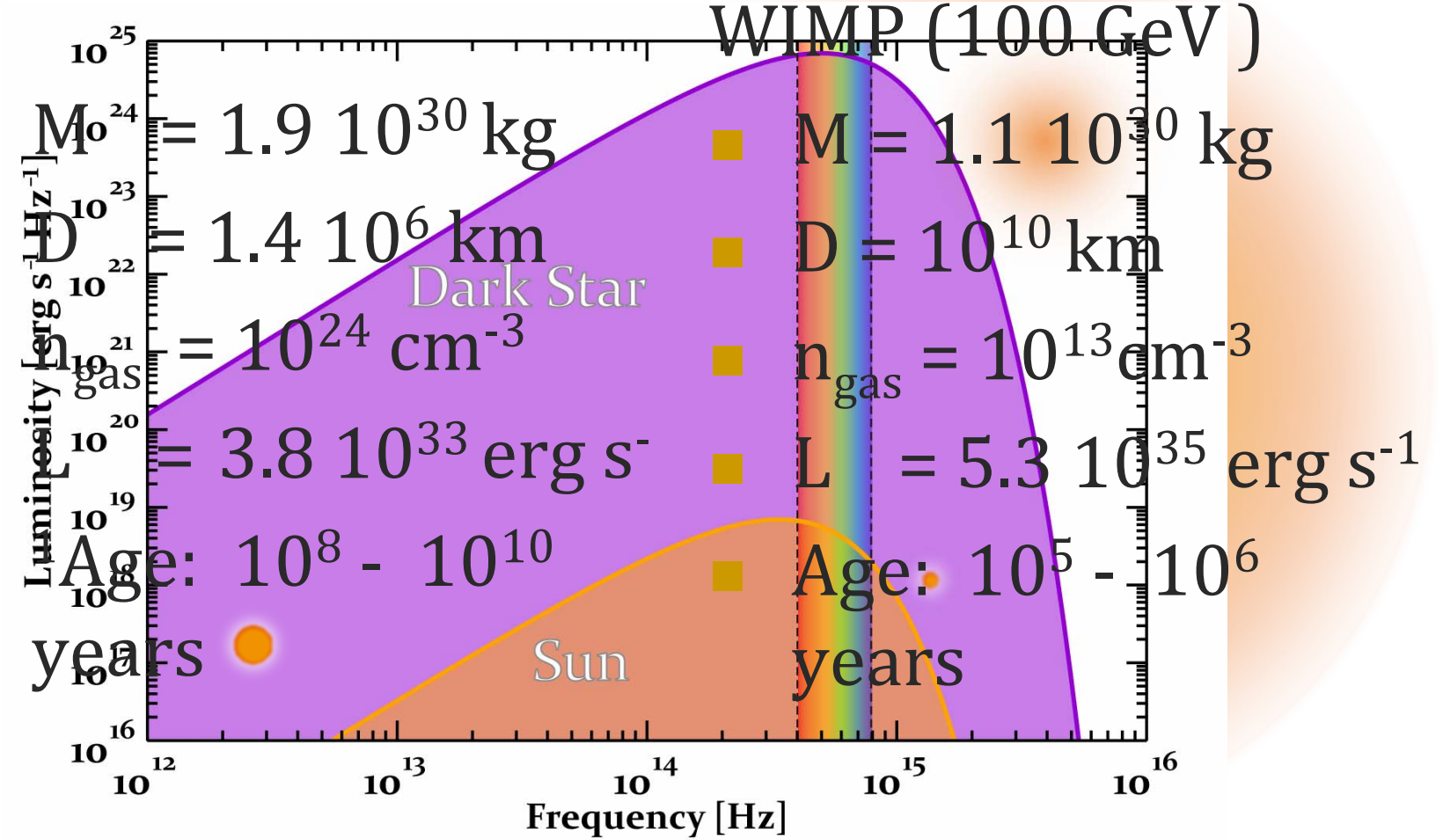




T. Kneiske (2008)

„Dark Stars“- the very first?

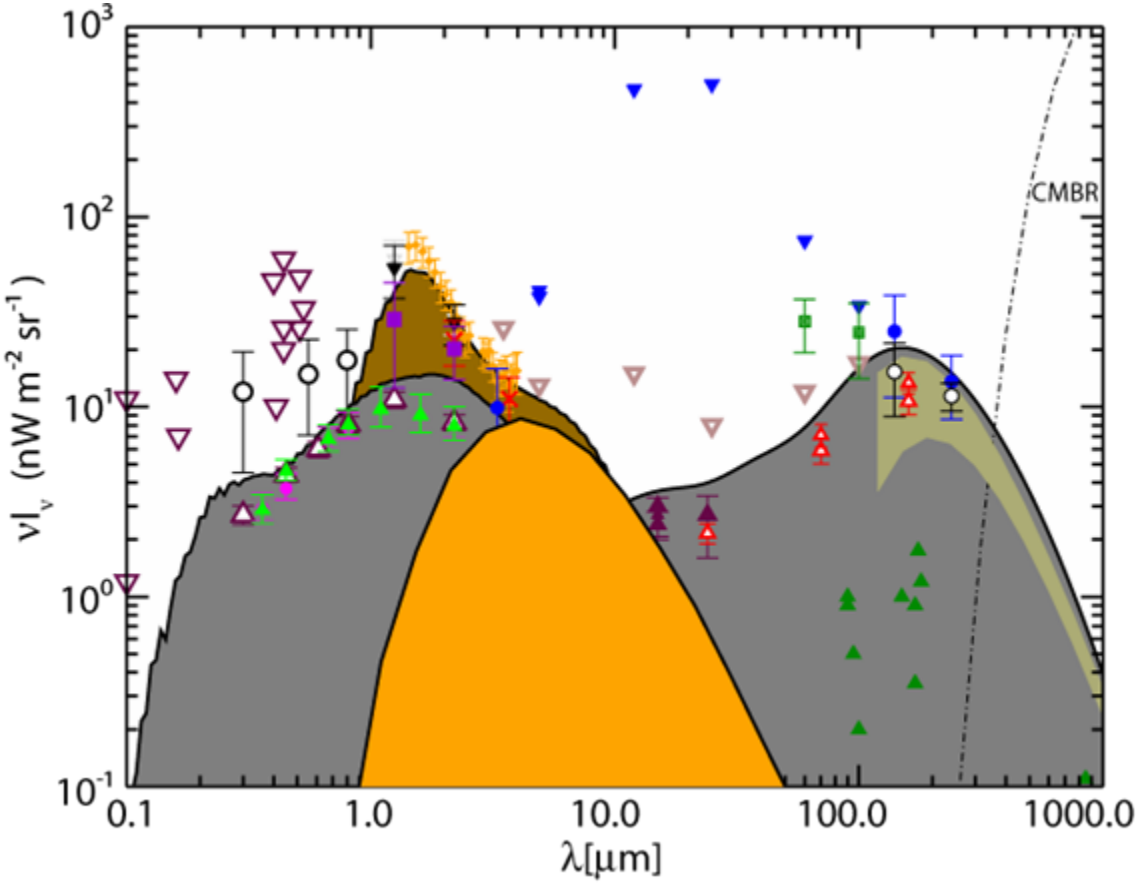
- $M_{\odot}$ = 1.9 10^{30} kg
- D = 1.4 10^{6} km
- n_{gas} = 10^{24} cm^{-3}
- L = 3.8 10^{33} erg s^{-}
- Age: 10^{8} - 10^{10} years

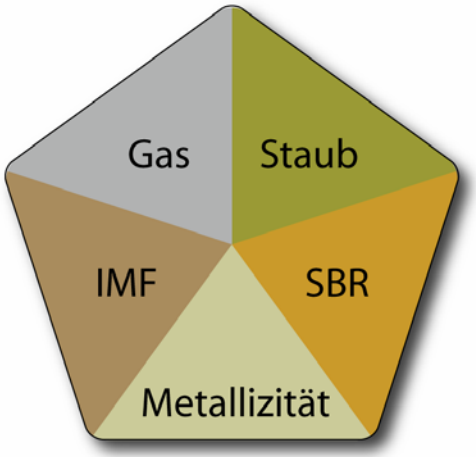


WIMP (100 GeV)

- M = 1.1 10^{30} kg
- D = 10^{10} km
- n_{gas} = 10^{13} cm^{-3}
- L = 5.3 10^{35} erg s^{-1}
- Age: 10^{5} - 10^{6} years

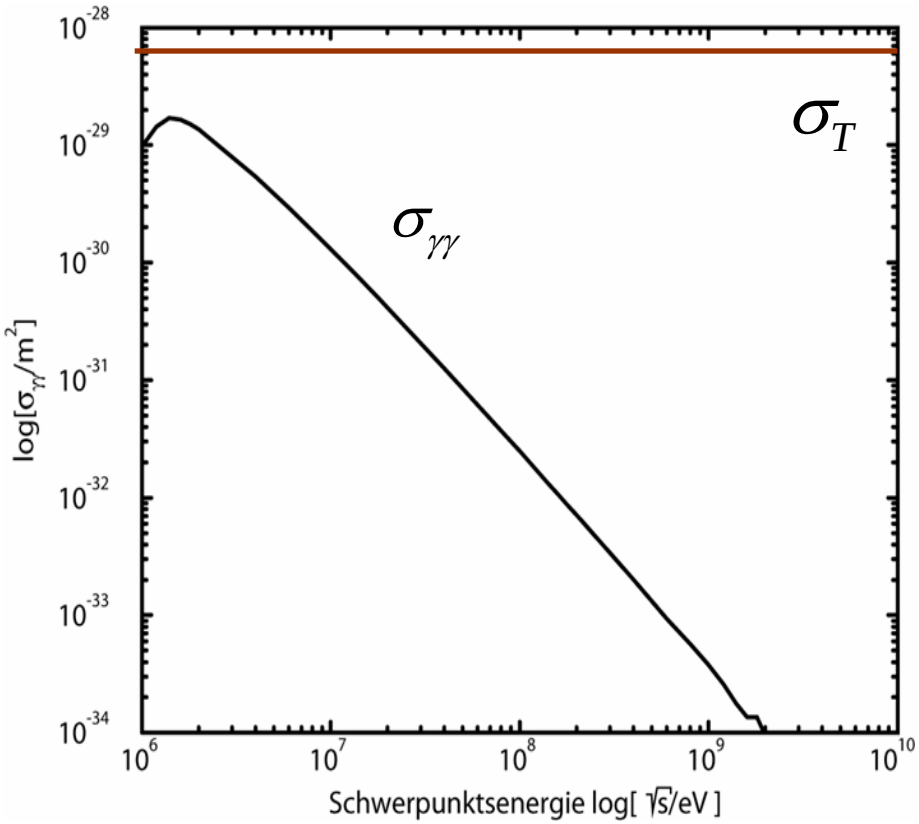
Contribution of „Dark Stars“





Maurer et al. (in prep)

Photon-photon Pairproduction



$$\sqrt{s} > 2m_e c^2 \approx 10^6 eV$$

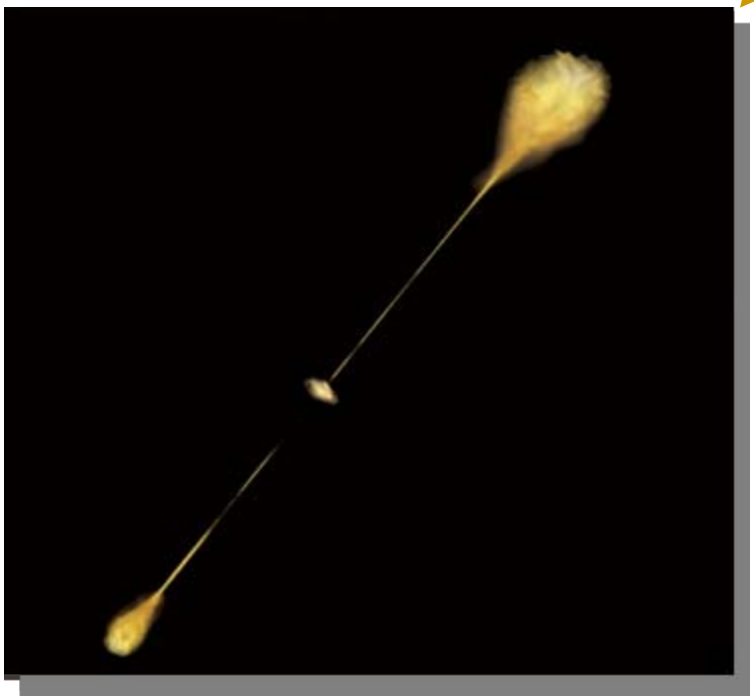
Center of mass energy

$$E_{HE} \cdot E_{LE} > 2\left(mc^2\right)^2 \approx 10^{12} eV^2$$

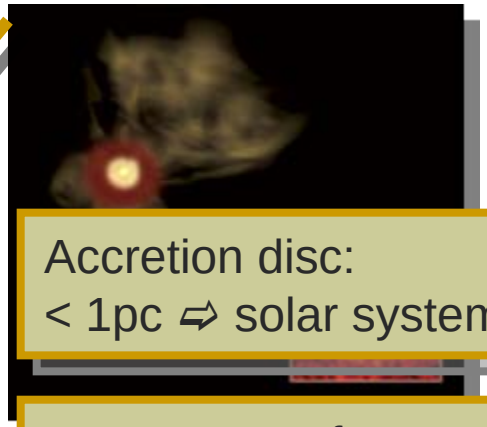
$$E_{HE} \approx 10^{12} eV \Rightarrow E_{LE} \approx 1eV \approx 1\mu m$$

Infrared (IR) ⇨ **TeV**

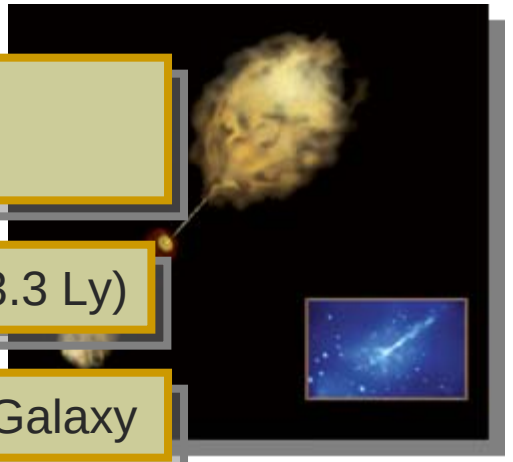
Aktive Galactic Nuclei (AGN)



NASA E/PO, Sonoma State University, Aurore Simonnet

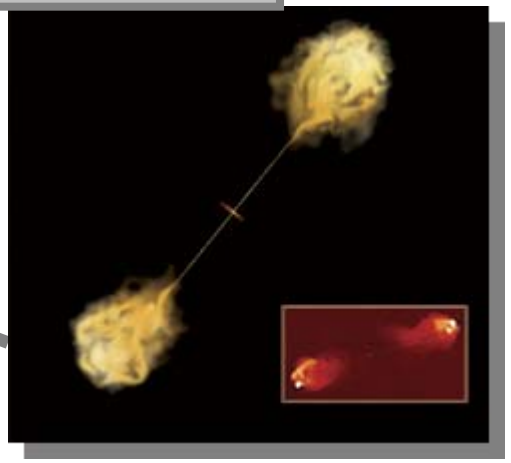


Accretion disc:
< 1pc ⇨ solar system



Dust torus: a few pc (~3.3 Ly)

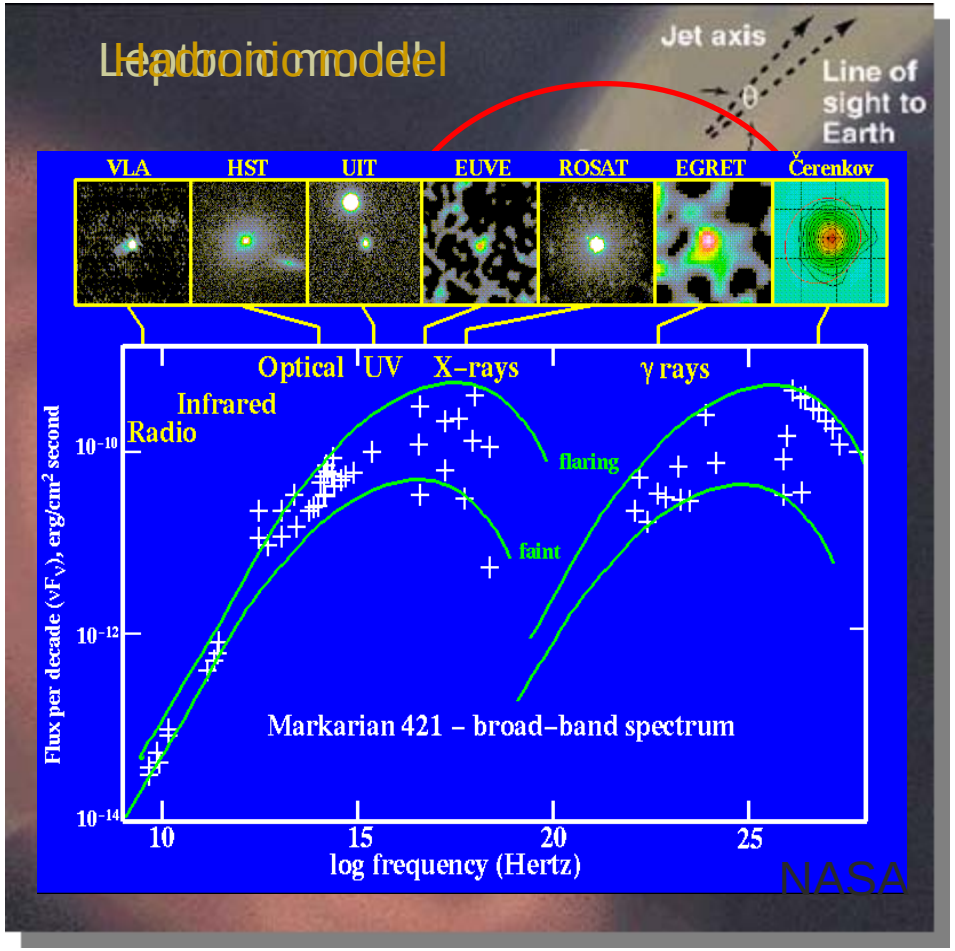
Radiojets: Kpc-Mpc⇨ Galaxy



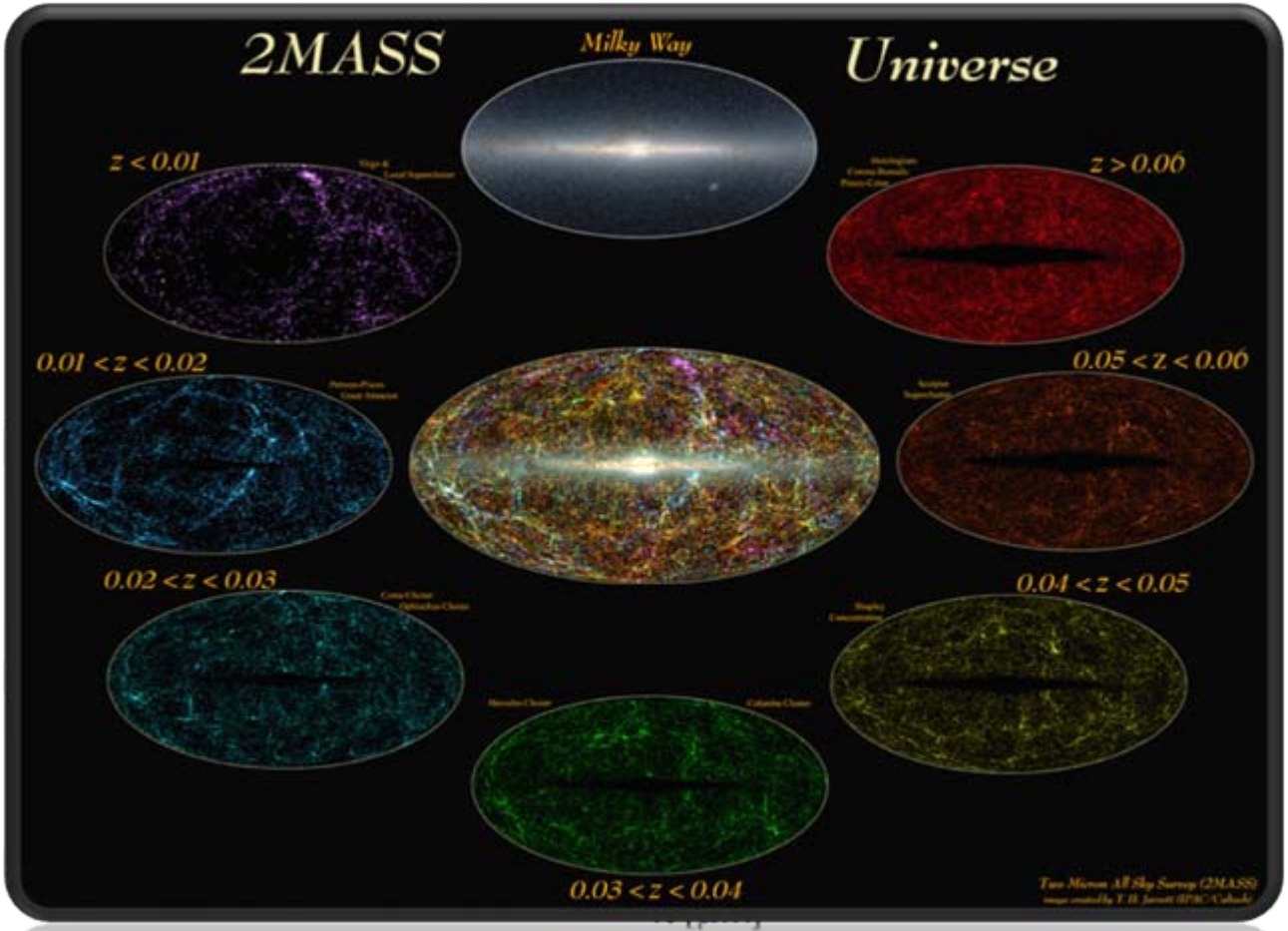
Production of high-energy gamma radiation

- Shock acceleration of electrons to TeV energies
- Synchrotron radiation of electrons
- Inverse Comptonscattering results in TeV photon emission

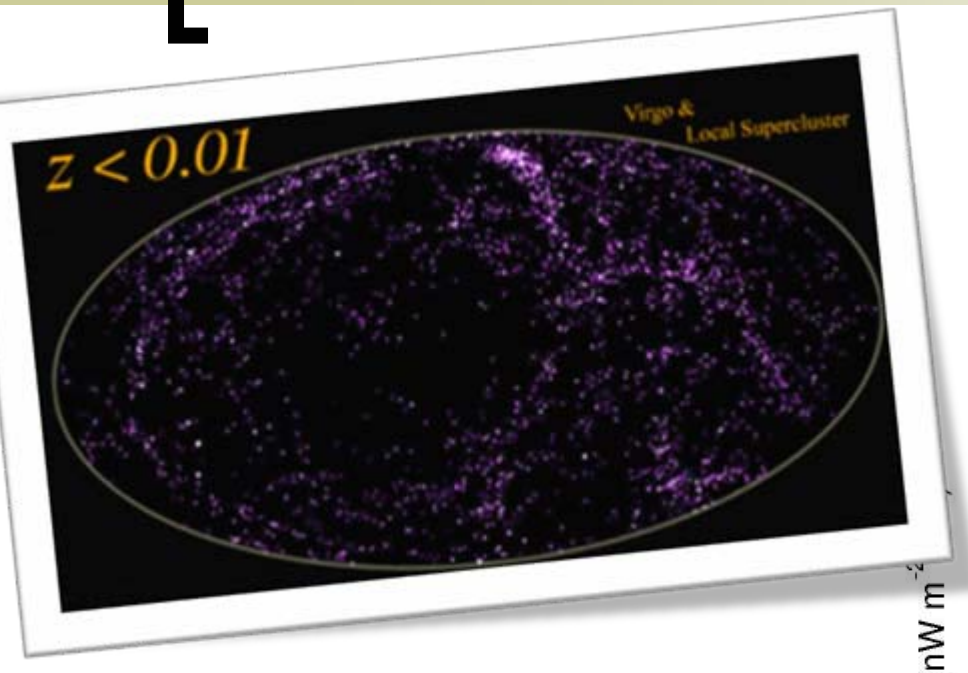
- Shock accelatration of protons up to 10^8 TeV (10^{20} eV) energies
- Pion-production results in particle cascades and TeV photon emission

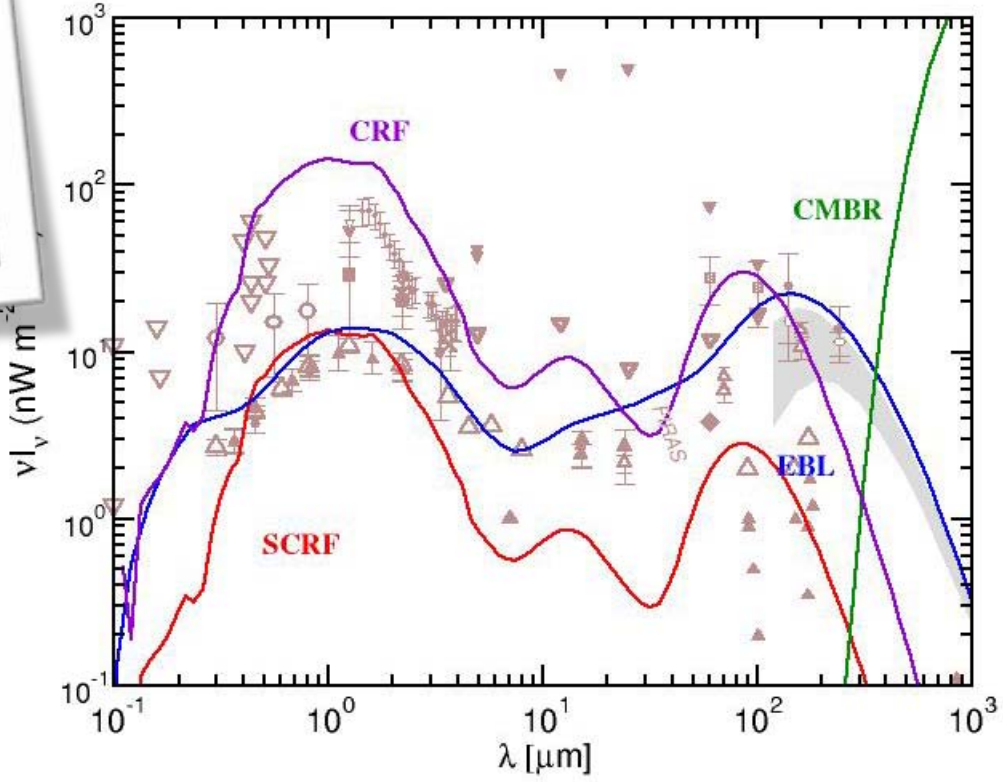


Local Radiation Fields



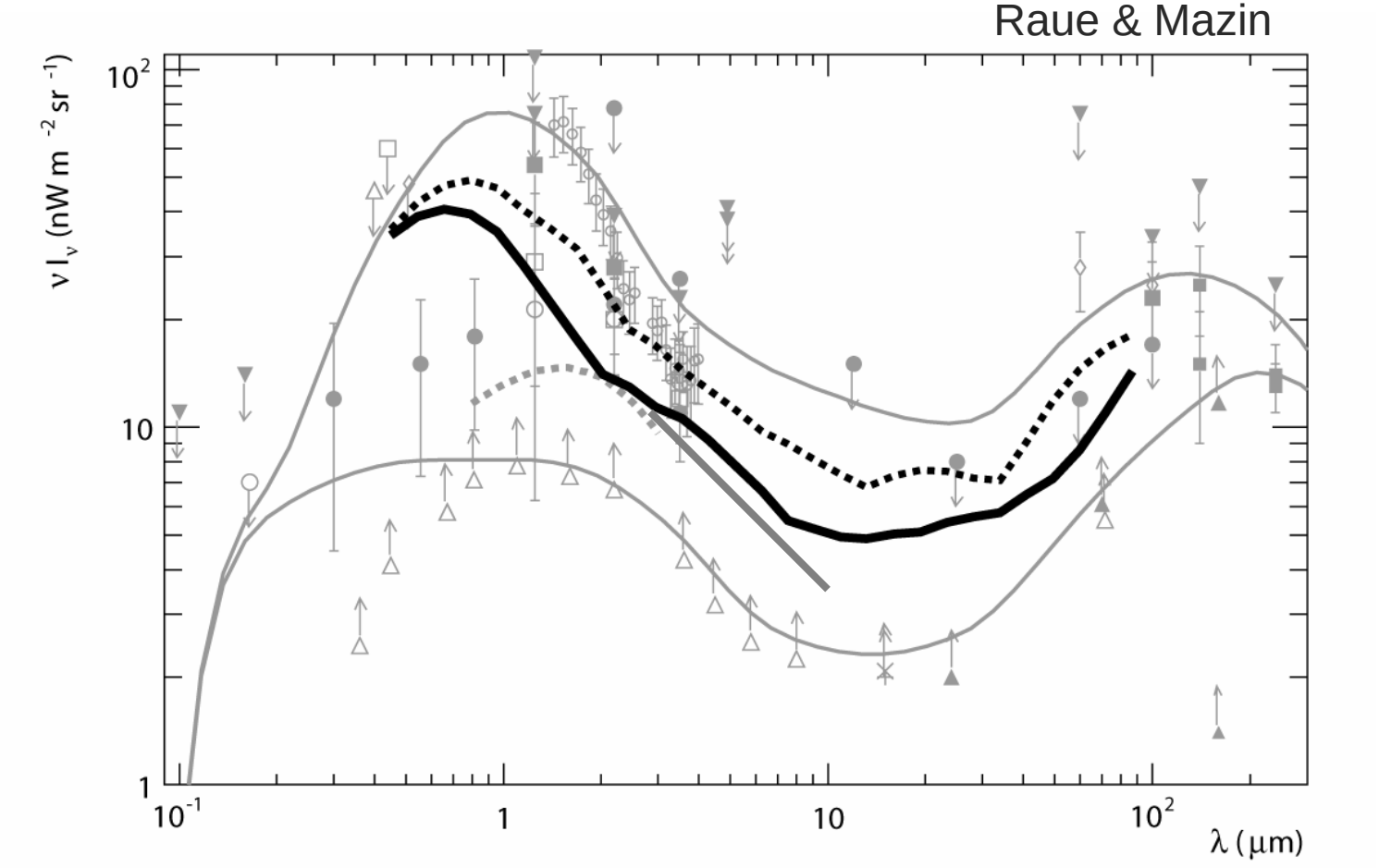
Local photon fields



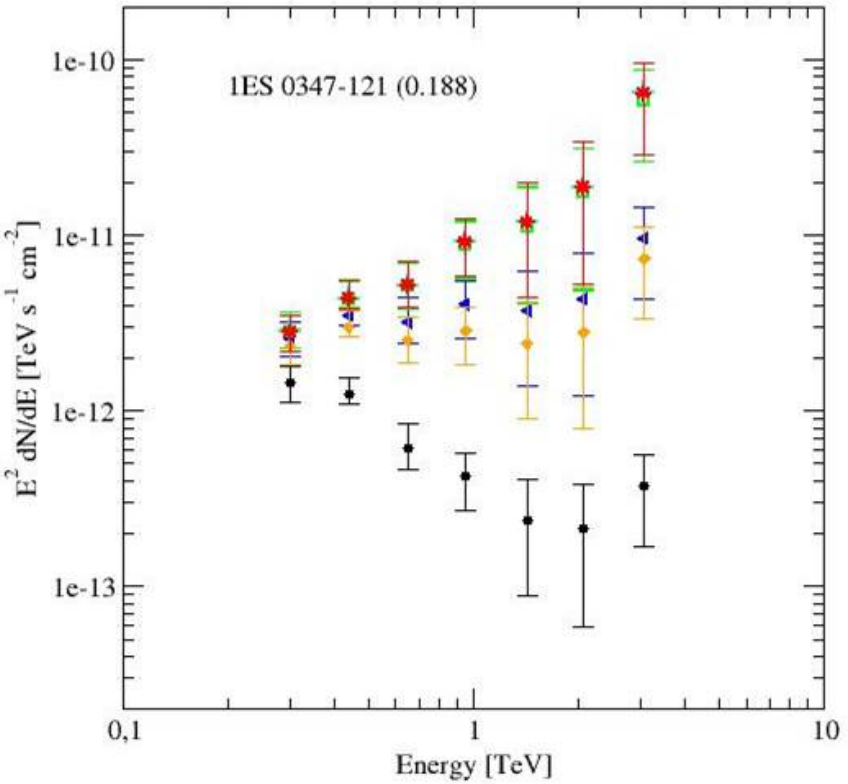


„AGN limits“

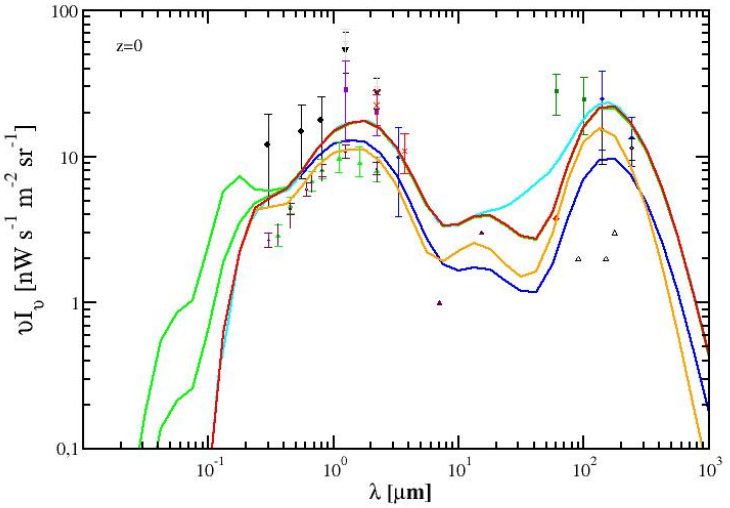
Raue & Mazin



Corrected (TeV) blazar spectrum



$$\frac{dN}{dE}_{\text{int}} = \frac{dN}{dE}_{obs} \cdot \exp\left(\tau_{\gamma\gamma}\right)$$



Kneiske et al. (2004)

Input for the SFR „data“

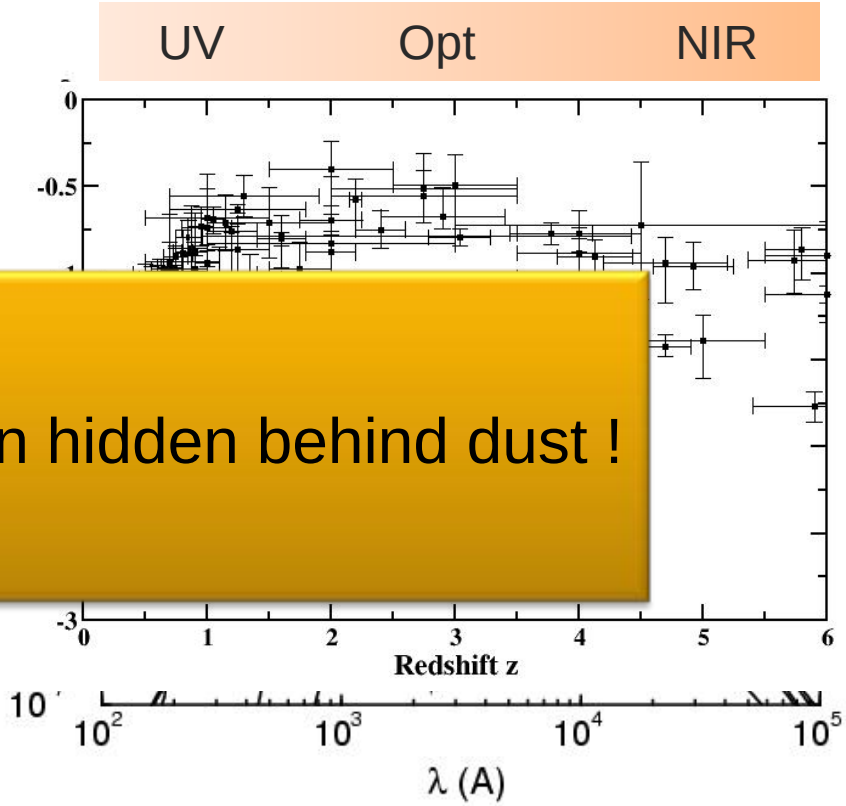
- UV continuum
- Lyman break galaxies
- Line emission
- FIR
- Sub-mm
- Radio (1.4 GHz)
- X-Ray (keV)

- Stellar evolution model
  - (age, Metallicity, IMF)
- +HII regions, dust (line)
- +Dust (continuum)
- +redshift evolution
- Supernova rate, magnetic field
- X-ray binaries, Pulsars

UV and optical SFR

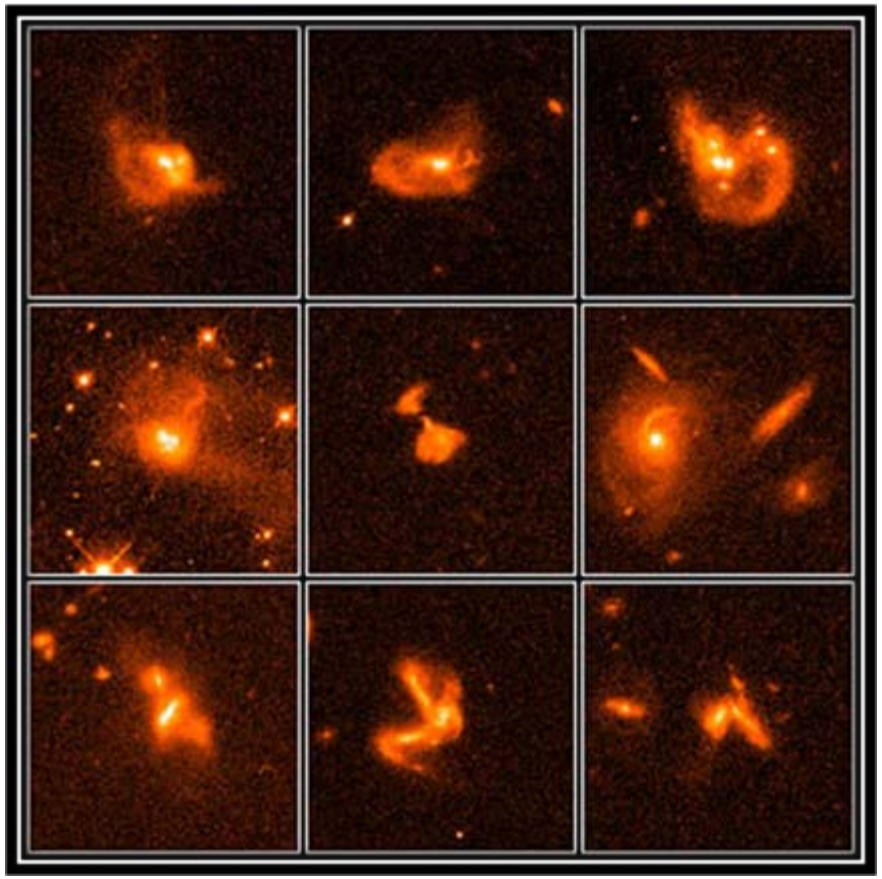
- **UV continuum**
- Lyman break galaxies (Star
- Hα-L

What about star formation hidden behind dust !



IR, radio, sub-mm, …

- IR: „Correction factor“ for low redshift optical data
- **IR:** (ultra) luminous galaxies (LIGs)
- Sub-mm: Redshifted LIGs
- Radio: rel. Electrons from Supernova



Luminous infrared galaxies (IRAS)

EBL feature in AGN spectra ?