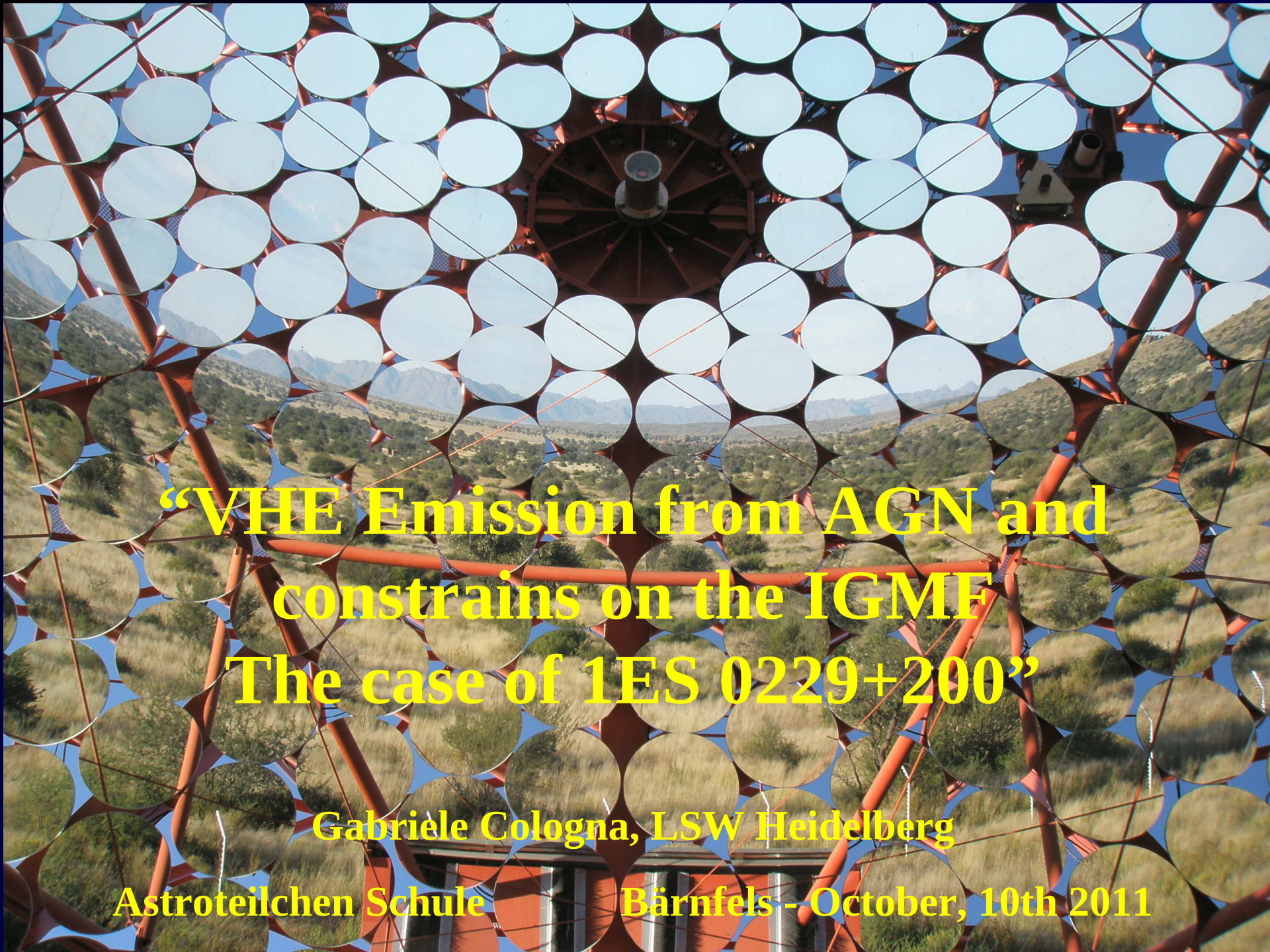


"VHE Emission from AGN and constrains on the IGMF The case of 1ES 0229+200"

Gabriele Cologna, LSW Heidelberg

Astroteilchen Schule Bärnfels - October, 10th 2011

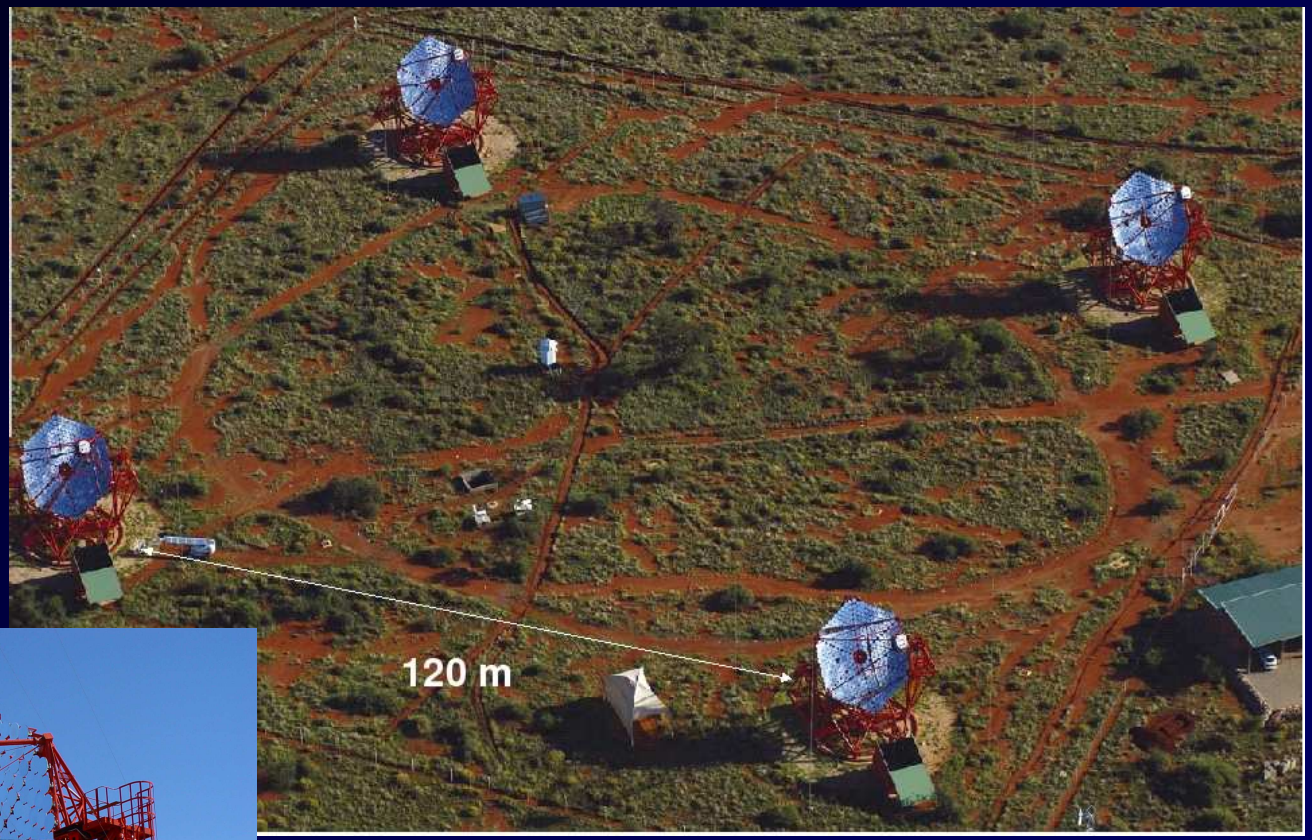
Introduction:

- The H.E.S.S. Cherenkov telescope array
- 1ES 0229+200
- Summary and conclusions

The H.E.S.S. Cherenkov telescope array

(but just because pictures are cool and fill space…)

H.E.S.S. – Phase I



H.E.S.S. II

May 2011

9 October 2011

H.E.S.S. I:

- En. thres. ≈ 100 GeV @ zenith
- Flux sens. ≈ 1% Crab Nebula ($2.3*10^{-11}cm^{-2}s^{-1}$ > 1TeV) (5σ detection in 50h)
- 13m ø / 107 m^2 refl. area
- FOV = 5°
- Ang. Res. ≈ 0.1°

H.E.S.S. II:

- En. thres. ≈ 20 GeV @ zenith
- Flux sens. ≈ 2*HESS I (together with HESS I)
- 28m ø / 600 m^2 refl. area (biggest optical telescope ever built)
- FOV = 3.5°
- Ang. Res. ≈ 0.24° - 0.28° (in mono mode)

Ready for science in July 2012 (hopefully!!!)

1ES 0229+200

Why is 1ES 0229+200 interesting?

- it is “extreme” and unique in several of its characteristics

- the source modeling is challenging and not yet completely understood

- gives the opportunity to give constraints on
  - Intergalactic Magnetic Field (IGMF)
  - Extragalactic Background Light (EBL)

All of these are “coupled” to and affecting each other

Let’s see more in detail

Physical properties:

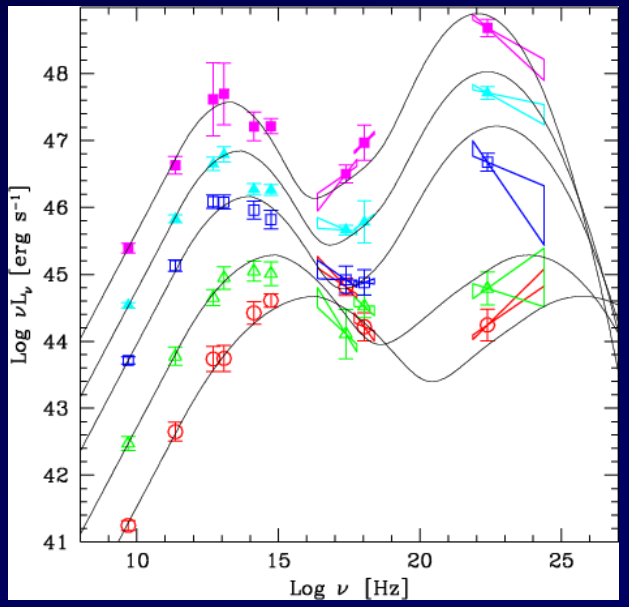
- HBL, High Frequency Peaked BL Lac Object (from X-ray / radio flux ratio)
  → VHE (E>100GeV) emission expected

- high redshift z=0.1396 → EBL absorption

- (very) hard spectrum Γ=2.50±0.19

- detected up to ≈ 10 TeV

- constant flux (no significant variability)

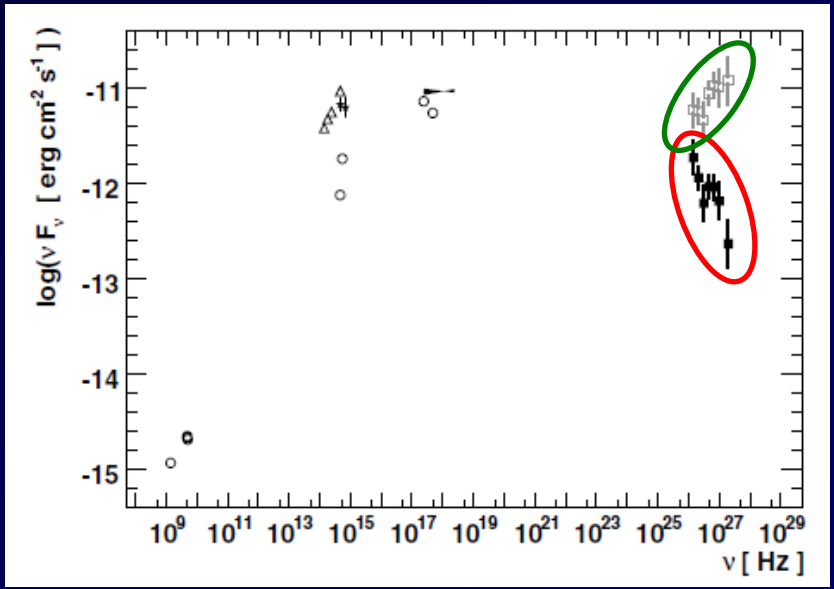


Donato et al., 2001

Source modeling

- HBL
- Hard Spectrum (Γ=2.5)
- EBL absorbtion
  → intrinsic spectrum Γ≈ 1.0 – 1.5
  (depending on EBL model)

Inverse Compton (IC) peak beyond 10 TeV
→ difficult to explain



Aharonian et al., 2007

possible explanations (among others):
- unusual high doppler factor (very unlikely)
- External IC on CMB (in addiction to the usual SSC)

What if the flux is not constant? → variability is due to changes on small scales
→ no external IC
→ no valid explanation

New analysis and new data

And if also the spectrum is not so hard? → IC peak at lower energies

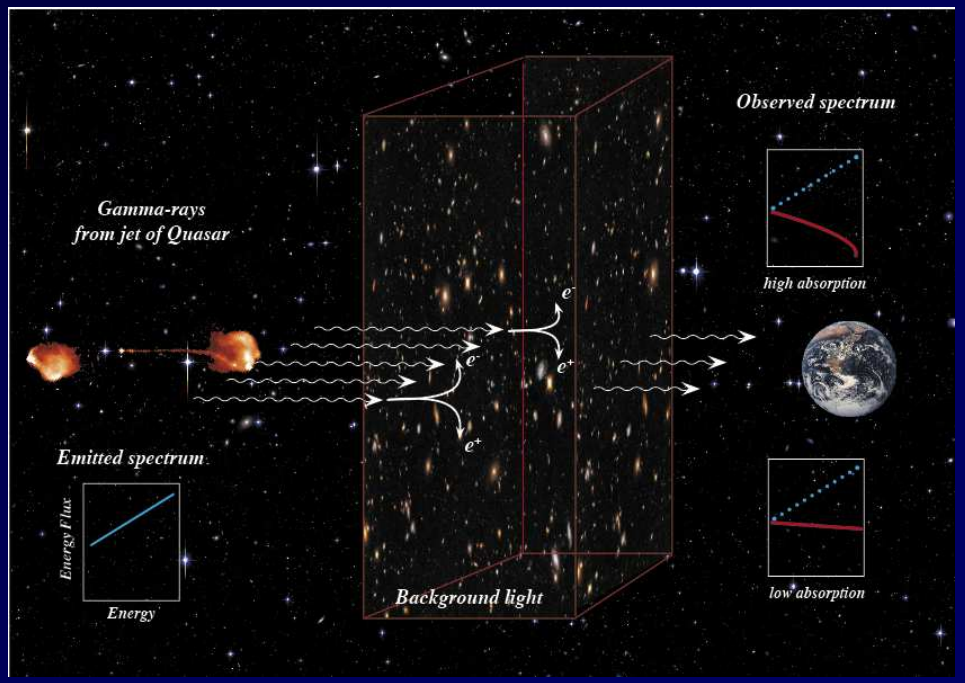
→ not so extreme BL Lac Object?

EBL absorption:

- energy dependent opacity $\tau(z,E)$

- Pair production through γ-γ interaction: $\gamma_{VHE}\gamma_{EBL} \rightarrow e^+e^-$

- γ > 100 TeV completely absorbed by the CMB



- intrinsic spectrum is modified
  $F_{obs}(E) = F_{int}(E)*e^{-\tau(z,E)}$

- cross section peak at
  $\lambda \approx 1.4\ (E_\gamma / 1\ \text{TeV})\ \mu\text{m} \rightarrow$ near to mid IR

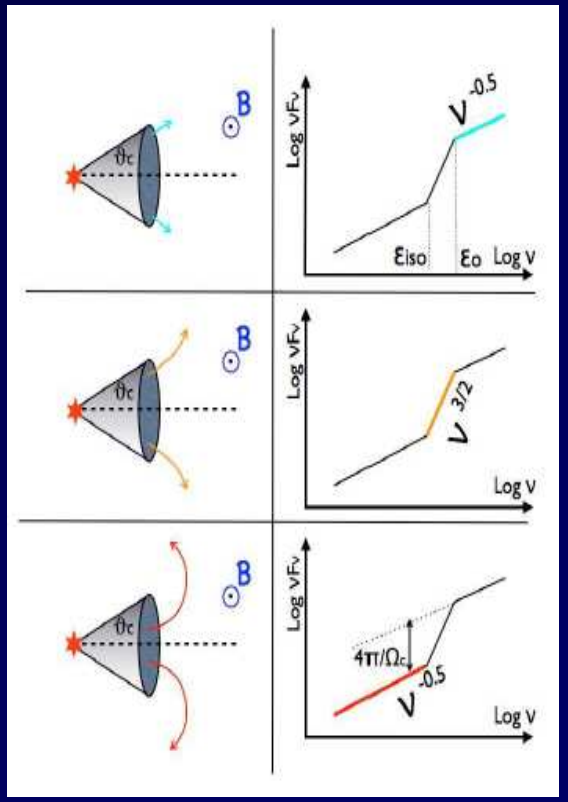
Lower limits on Intergalactic Magnetic Field (IGMF)

- e^+e^- produced during EBL absorption will emit in the GeV range (IC on CMB)

- If a IGMF is present ($B > 10^{-20}$ G), e^+e^- trajectories will be affected

- Flux will be diluted (particles are spread over larger angles)

- Dilution will depend on IGMF and on photon energy

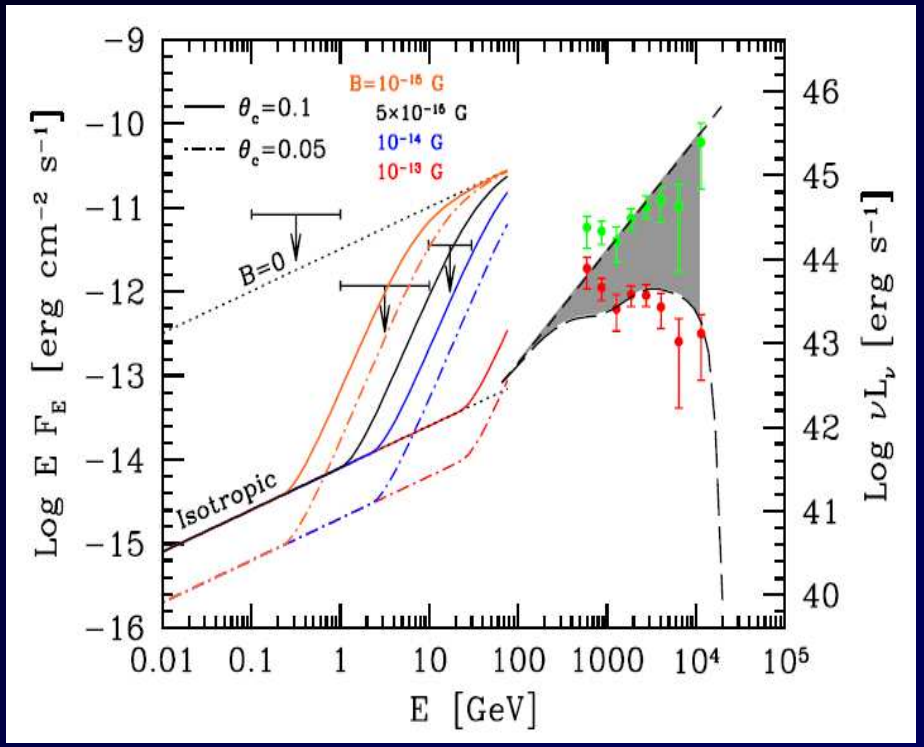


Tavecchio et al., 2010

The expected quantity of reprocessed radiation can be measured

Time delay between TeV and reprocessed GeV > 10^6 years (for B≈10^{-15}G)

→ constant flux needed! (in reality it is ok also if GeV integration time > TeV variation)



1ES 0229+200, Tavecchio et al., 2010

Value of IGMF depends also on
- time in which the flux is constant (lower values for smaller times)
- jet opening angle

Dermer: B > 10^{-18} G
Tavecchio: B > 2*10^{-15} G
Neronov: B > 3*10^{-16} G

Summary and Conclusions

Summary

- the H.E.S.S. telescope array (phase I and II) has been briefly presented

- the BL Lac Object 1ES 0229+200 has been described

Conclusions

- the modeling of 1ES 0229+200 is challenging (no simple standard explanation)

- estimation on the EBL spectra and energy density can be done

- lower limits on the IGMF can be derived

Thank you for your attention

F. Aharonian et al., “New constraints on the mid-IR EBL from the HESS discovery of VHE γ-rays from 1ES 0229+200”, A&A 475, L9-L13, 2007

D. Donato et al., “Hard X-ray properties of Blazars”, A&A 375, 739-751, 2001

A. Franceschini et al., “Extragalactic optical-infrared background radiation, its time evolution and the cosmic photon-photon opacity”, A&A 487, 837-852, 2008

F. Tavecchio et al., “The intergalactic magnetic field constrained by FERMI/LAT observations of the TeV blazar 1ES 0229+200”, MNRAS 406, L70, 2010

A. Neronov, I. Vovk, “Evidence for strong Extragalactic magnetic Fields from FERMI observations of TeV Blazars”, Science 328, 73, 2010

C. Dermer et al., “Time delay of cascade radiation for TeV Blazars and the measurement of the Intergalactic Magnetic Field”, ApJL 733, L21, 2011

Backup slides

1ES 0229+200 – EBL absorption

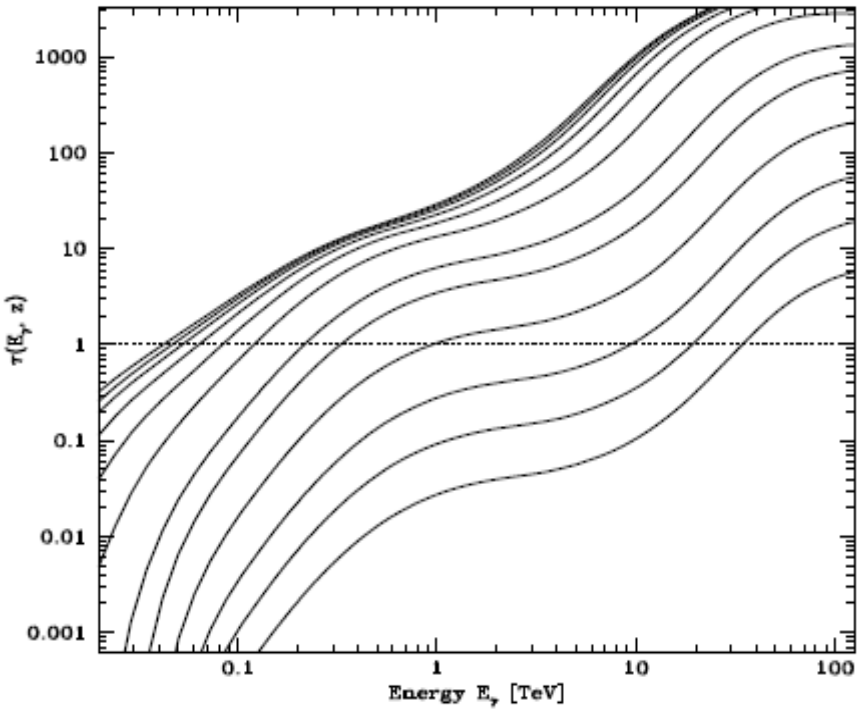
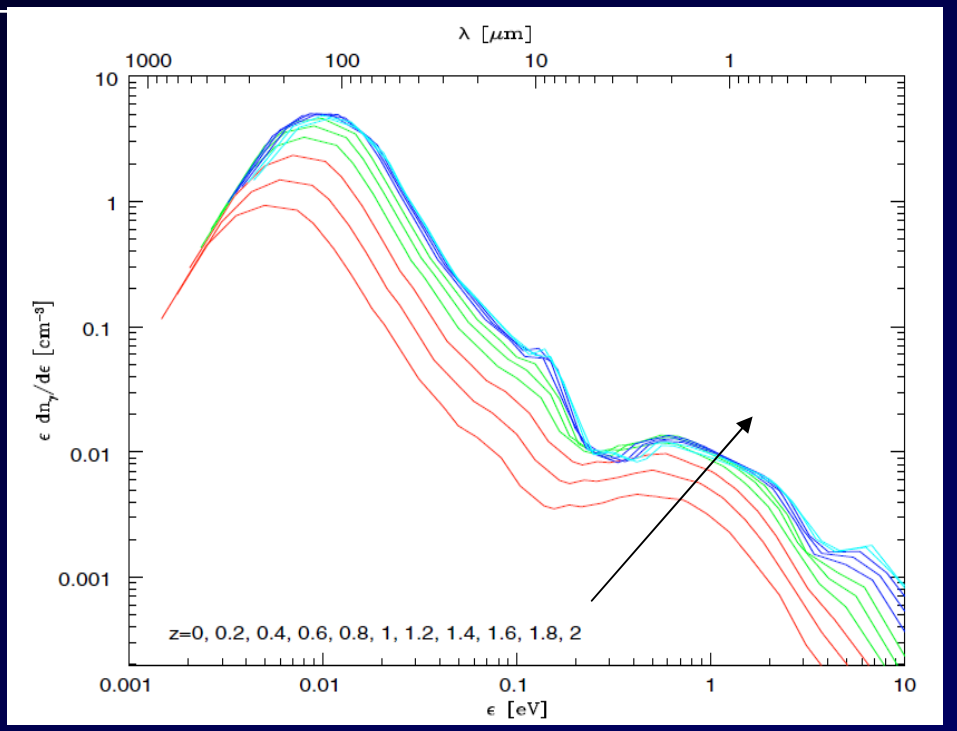


Fig. 7. The optical depth by photon-photon collision as a function of the photon energy for sources located at z = 0.003, 0.01, 0.03, 0.1, 0.3, 0.5, 1, 1.5, 2, 2.5, 3, 4 *from bottom to top*.



Franceschini et al., 2008

Results for 1ES 0229+200 (Aharonian et al., 2007):

F (10μm) = 2.15 nW m^{-2} sr^{-1} for Γ_{int} = 1.5

limit F (10μm) = 3.1 nW m^{-2} sr^{-1} for Γ_{int} = 1.15

EBL SED 2-10μm $\alpha \geq 1.1 \pm 0.25$