MAX-PLANCK-INSTITUT FÜR EXTRATERRESTRISCHE PHYSIK

GLAST detectability of gamma-ray emission from photon fields of luminous stars

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P17.10

ABSTRACT

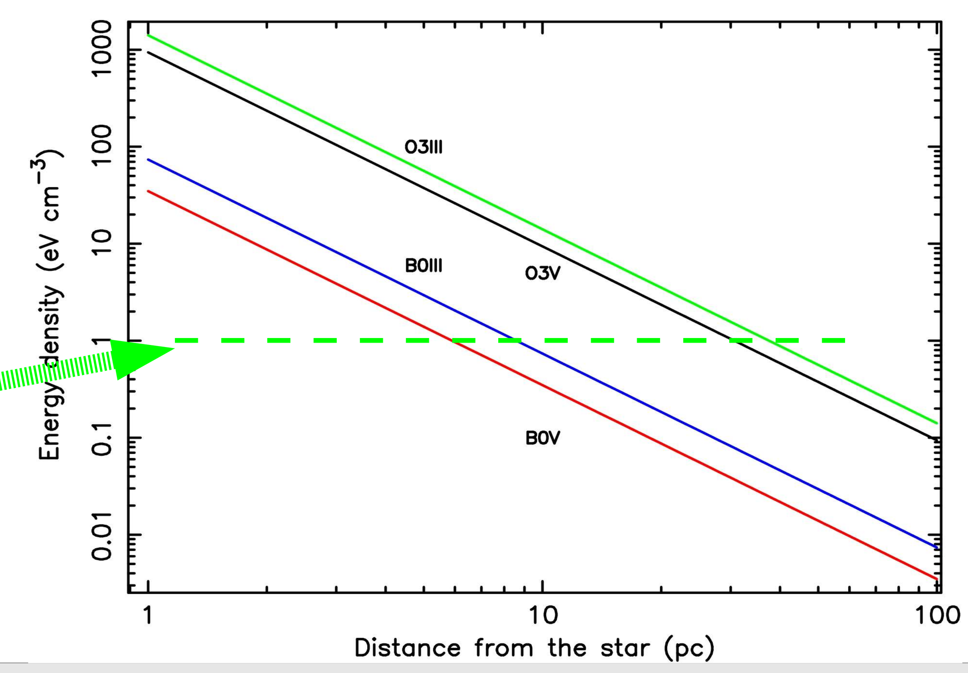
Inverse-Compton scattering by cosmic-ray electrons on the CMB and ISRF produce a major component of the diffuse gamma-ray emission from the Galaxy. The stellar ISRF is not smooth but clumpy due to the large contribution from the most luminous stars.
We have shown (Orlando, E. & Strong, A.W. (2006) http://arxiv.org/abs/astro-ph/0607563) that the gamma-ray emission from the radiation field of some individual supergiant stars could be - marginally - detectable by GLAST.
We present the basic formalism required and give possible candidate stars to be detected and make prediction for GLAST.
We also apply the theory to OB associations, showing that inverse-Compton emission produced is not negligible compared to the sensitivity of GLAST. More detailed studies and an updated list of possible candidate stars for detection, will be given in Orlando et al. 2007. Recently the extended emission from the Sun from the same process has been detected using EGRET data (see our poster P17-16).

SIMPLE ESTIMATE OF THE IMPORTANCE OF IC EMISSION FROM LUMINOUS STARS

The optical luminosity of the Galaxy is about $3\times10^{10}\,L_\odot$, and a typical O star has $10^5\,L_\odot$ i.e. about $10^{-5}\,L_{GALAXY}$. Consider such a star at 100 pc distance: compared to the entire Galaxy (distance to center = 8.5 kpc) this IC source is about a factor 100 closer and hence the inverse Compton flux is $10^{-5}\times100^2$ of the Galactic IC, suggesting it could be significant. Therefore we have pursued this subject in more detail.

The value of the photon energy density around bright stars is above the mean interstellar (~1 eV cm^{-3}) even at 10 pc distance from the star, suggesting it contributes to the clumpiness in the IC emission. The photon density is given by

$u(r,\lambda) = 0.25\, u_{BB}(\lambda, T_{STAR})\,(R_{STAR}/r)^2$ with $u_{BB}(T_{STAR})$ black body photon density



SINGLE STAR THEORY OF IC EMISSION

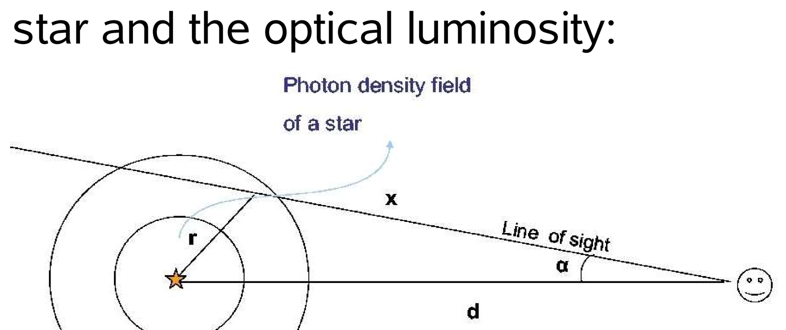
The inverse-Compton luminosity L_{IC} integrated over a volume surrounding a star goes as the radius r around the star and the optical luminosity:

$L_{IC} \sim L_{STAR}\, r$,

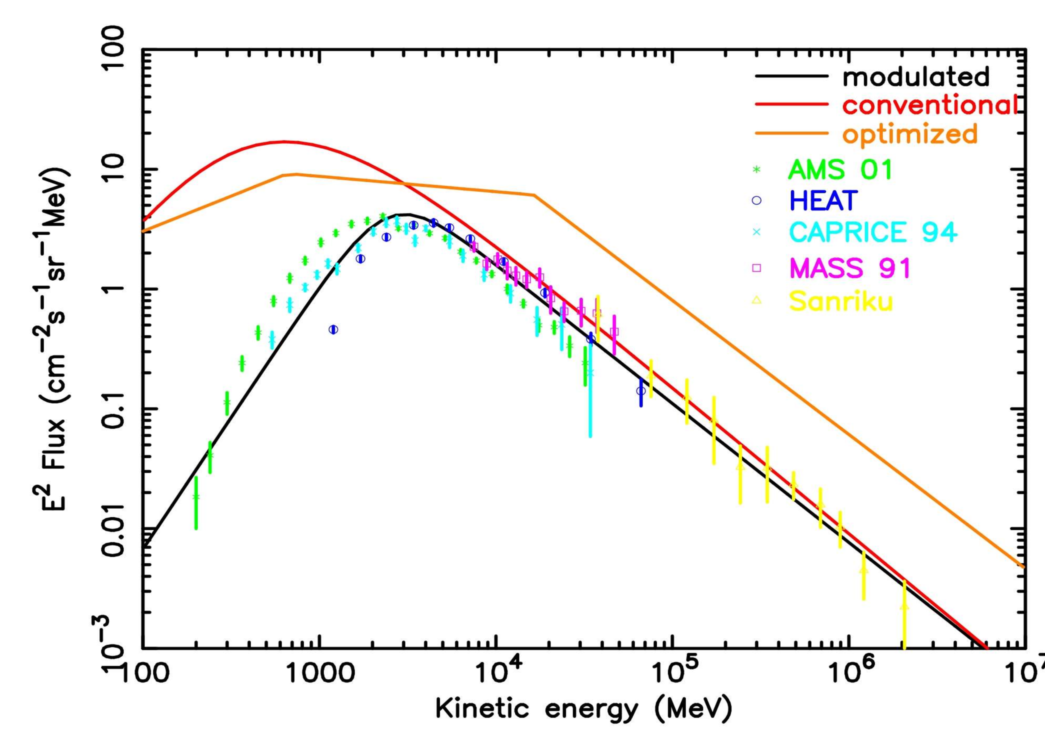
but the flux depends on the star's distance d:

$flux_{IC} \sim L_{IC} / d^2$

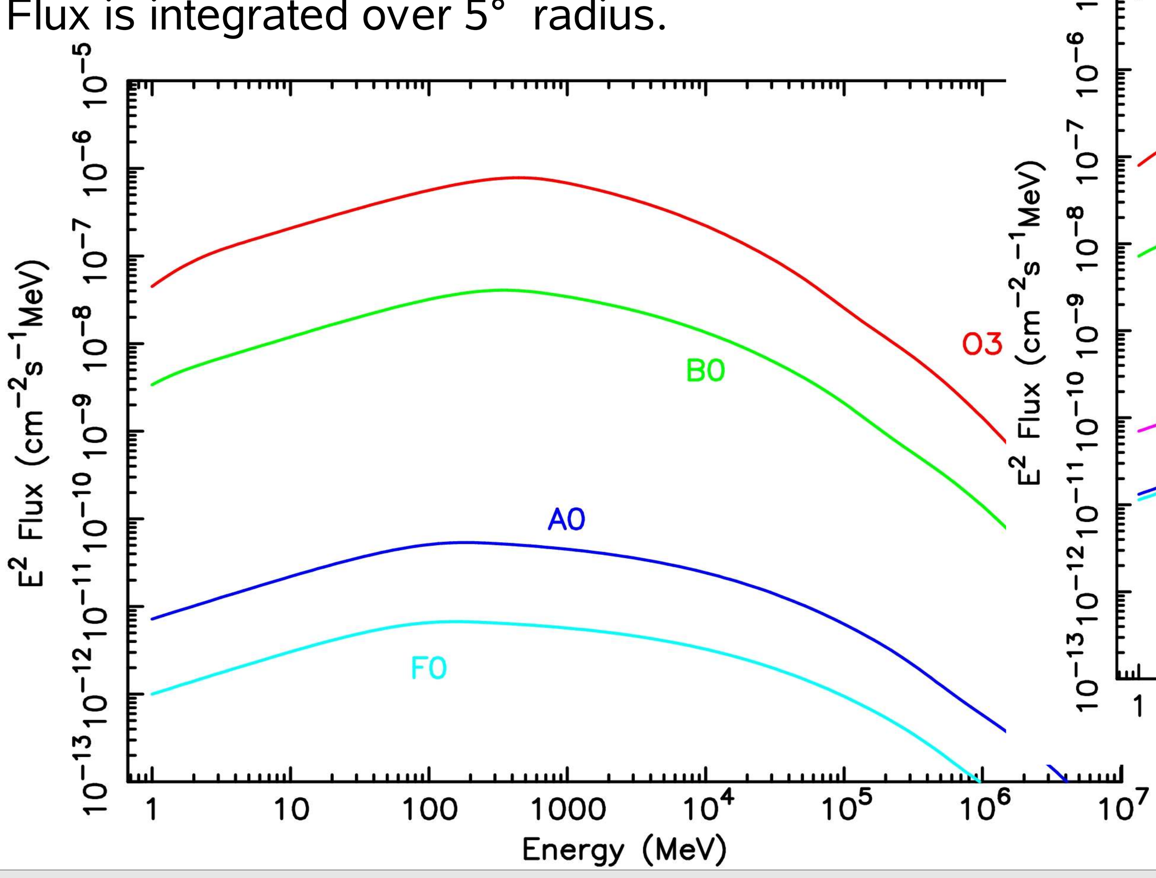
For angle α: $\alpha \sim r/d \rightarrow$ $flux_{IC} \sim L_{STAR}\, \alpha / d$

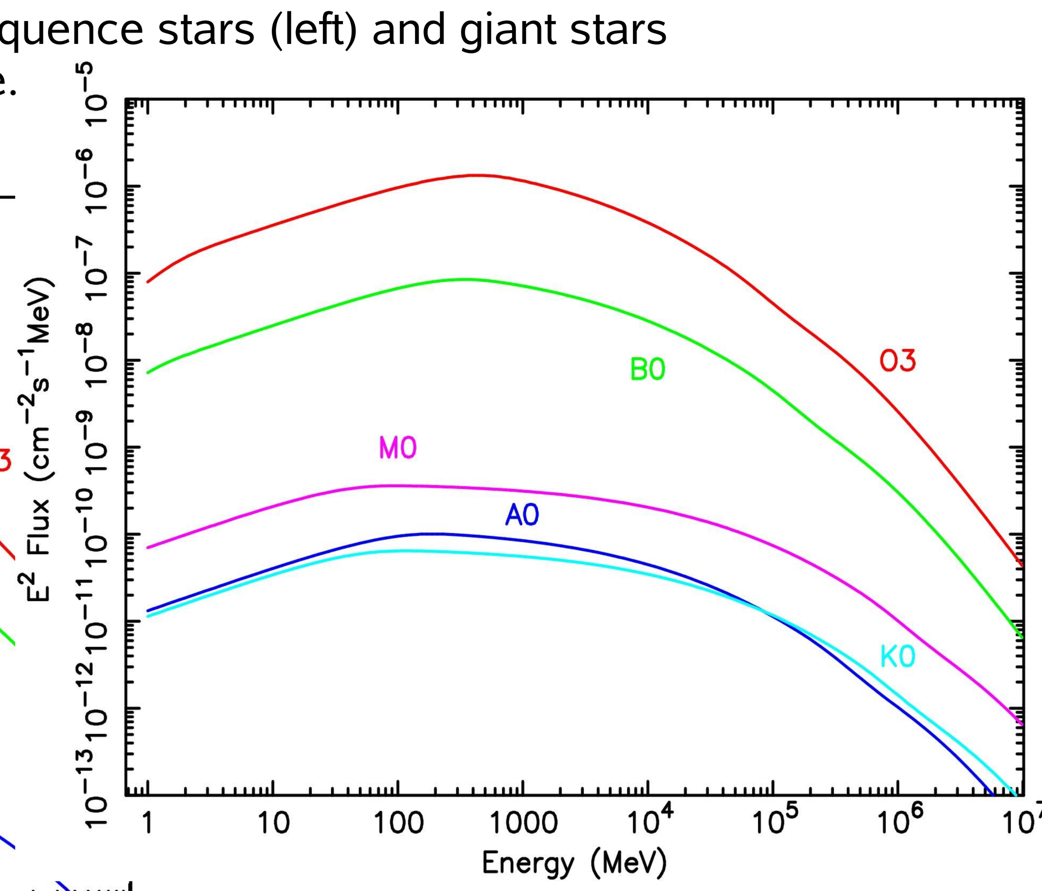


The IC has been computed using the cosmic-ray electron spectrum, the stellar photon field and the Klein-Nishina cross section. We have used the interstellar electron spectrum (in fig.: "conventional"); explaining the diffuse Galactic emission including the "GeV excess" requires about a factor 4 higher electron spectrum (Strong et al. ApJ2004, 613,962). These are therefore rather conservative estimates.

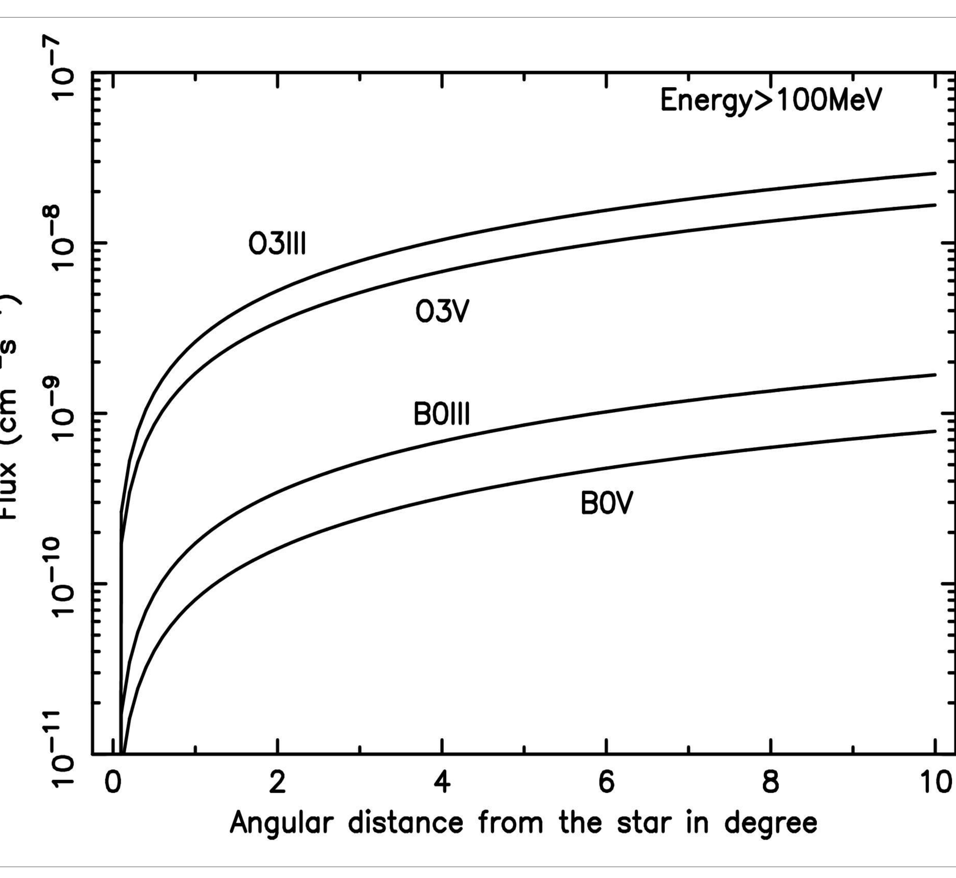


The plots below show the IC spectrum of main sequence stars (left) and giant stars (right) of different spectral type at 100 pc distance.
Flux is integrated over 5° radius.



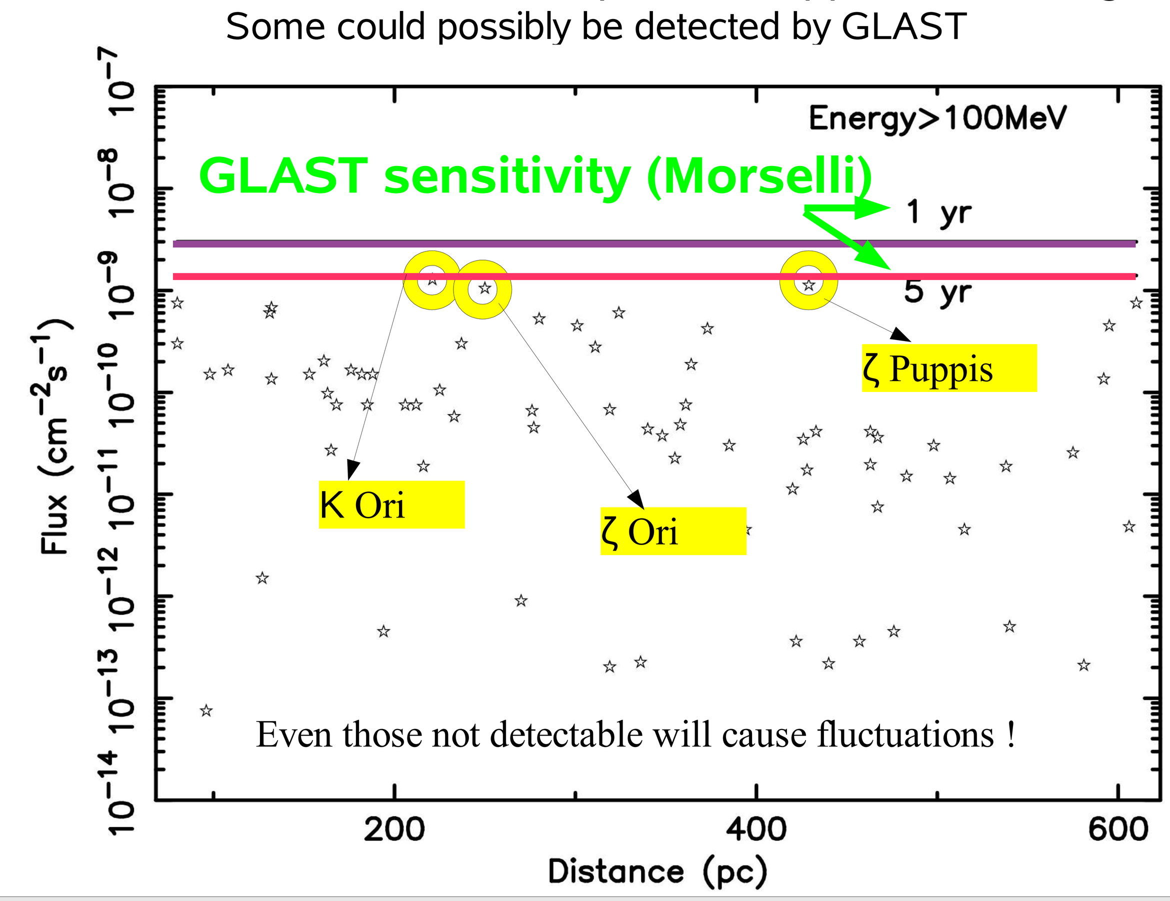


Gamma flux integrated over solid angle from stars at 100 pc distance as a function of angle for E >100 MeV . *Note that the main contribution to the emission comes from more than about a pc from the star and hence is mostly beyond the influence of stellar winds.*



PREDICTED FLUXES FROM BRIGHT STARS

(70 most luminous within 600 pc from Hipparcos catalogue)
Some could possibly be detected by GLAST



FLUX ESTIMATE FOR OB ASSOCIATIONS : CYGNUS OB2

distance=1.7 kpc

"Conservative" assumptions:

120 O9V stars
(T_e=33000 K , L= $9\times10^4 L_\odot$)
2489 B9V stars
(T_e=10500 K , L= 95 $L_\odot$)

Flux~4.8×10^{-9} $cm^{-2}s^{-1}$
(100 MeV-100 GeV)
Flux~5×10^{-10} $cm^{-2}s^{-1}$
(1 GeV-100 GeV)
Flux~2×10^{-11} $cm^{-2}s^{-1}$
(10 GeV-100 GeV)

"Realistic" assumptions:

120 O6V stars
(T_e=41000 K , L= $4.2\times10^5 L_\odot$)
2489 B5V stars
(T_e=15400 K , L= 830$L_\odot$)

Flux~1.8×10^{-8} $cm^{-2}s^{-1}$
(100 MeV-100 GeV)
Flux~1.9×10^{-9} $cm^{-2}s^{-1}$
(1 GeV-100 GeV)
Flux~5×10^{-11} $cm^{-2}s^{-1}$
(10 GeV-100 GeV)

ESTIMATION OF POSSIBLE STELLAR CANDIDATES FOR GLAST

η Carinae

T_e=30000 K; L~ $7\times10^6 L_\odot$; distance = 2.3 kpc;
Flux(<5°)~ 2.2×10^{-9} $cm^{-2}s^{-1}$ (100 MeV-100 GeV)
Flux(<5°)~ 1×10^{-10} $cm^{-2}s^{-1}$ (1 GeV-100 GeV)
Flux(<5°)~ 0.5×10^{-11} $cm^{-2}s^{-1}$ (10 GeV-100 GeV)

ζ Puppis

T_e = 42400 K; L~ $10^{5.9} L_\odot$; distance = 429 pc;
Flux(<5°)~ 1.1×10^{-9} $cm^{-2}s^{-1}$ (100 MeV-100 GeV)
Flux(<5°)~ 0.5×10^{-10} $cm^{-2}s^{-1}$ (1 GeV-100 GeV)
Flux(<5°)~ 2×10^{-12} $cm^{-2}s^{-1}$ (10 GeV-100 GeV)

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