ICRC 2021
THE ASTROPARTICLE PHYSICS CONFERENCE
Berlin | Germany

37th International
Cosmic Ray Conference
12–23 July 2021

Constraining the contribution of Gamma-Ray Bursts to the high-energy diffuse neutrino flux with 10 years of ANTARES data

Additional slides

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On behalf of the ANTARES Collaboration

INFN

ANTARES

STVDIVM VRBIS

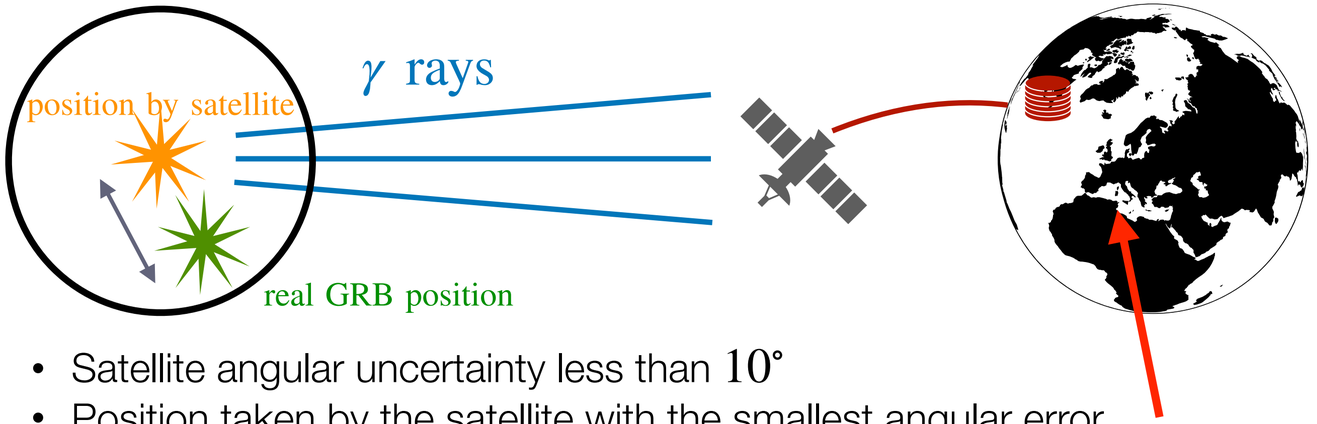
GRB selection and parameters

From available catalogues:

- Time
- Direction
- Photon spectrum
- Fluence
- Redshift

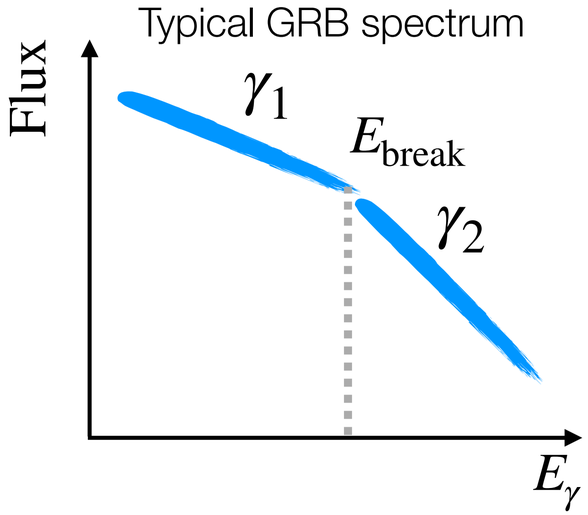
GRB SEARCH

SIMULATION of the EXPECTED NEUTRINO FLUENCES



- Satellite angular uncertainty less than $10°$
- Position taken by the satellite with the smallest angular error

Only neutrino events below the ANTARES horizon at trigger time



- We selected only GRBs with
  $\gamma_1 > -4$
  $\gamma_2 > -5$
- When γ_2 is not available from catalogues (1.4%):
  $\gamma_2 = \gamma_1 - 1$
- When E_{break} is not available from catalogues (33%):
  $E_{break} = 200$ keV

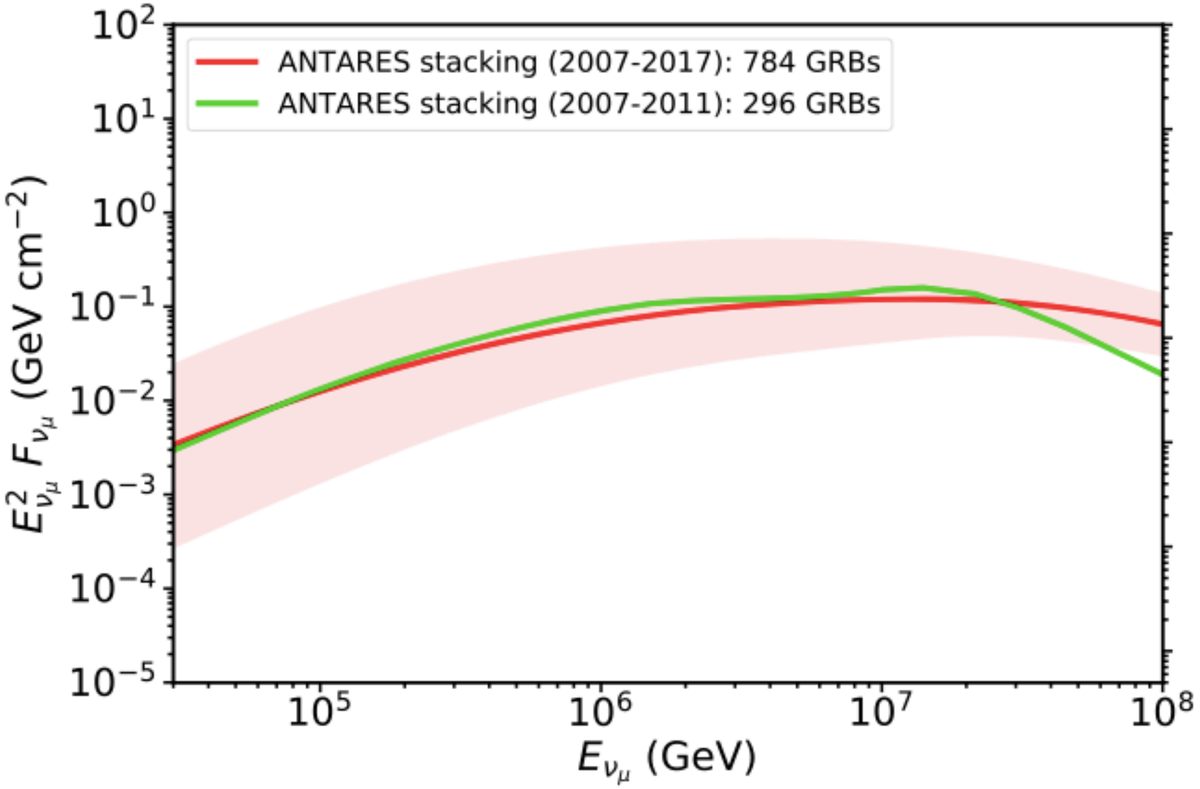
Source	Position	Spectrum
Swift	29.9%	16.7%
Swift–BAT	9.3%	
Swift–UVOT	3.4%	
Swift–XRT	17.2%	
Fermi	68.8%	71.6%
Other (e.g. Konus-Wind)	1.3%	11.7%

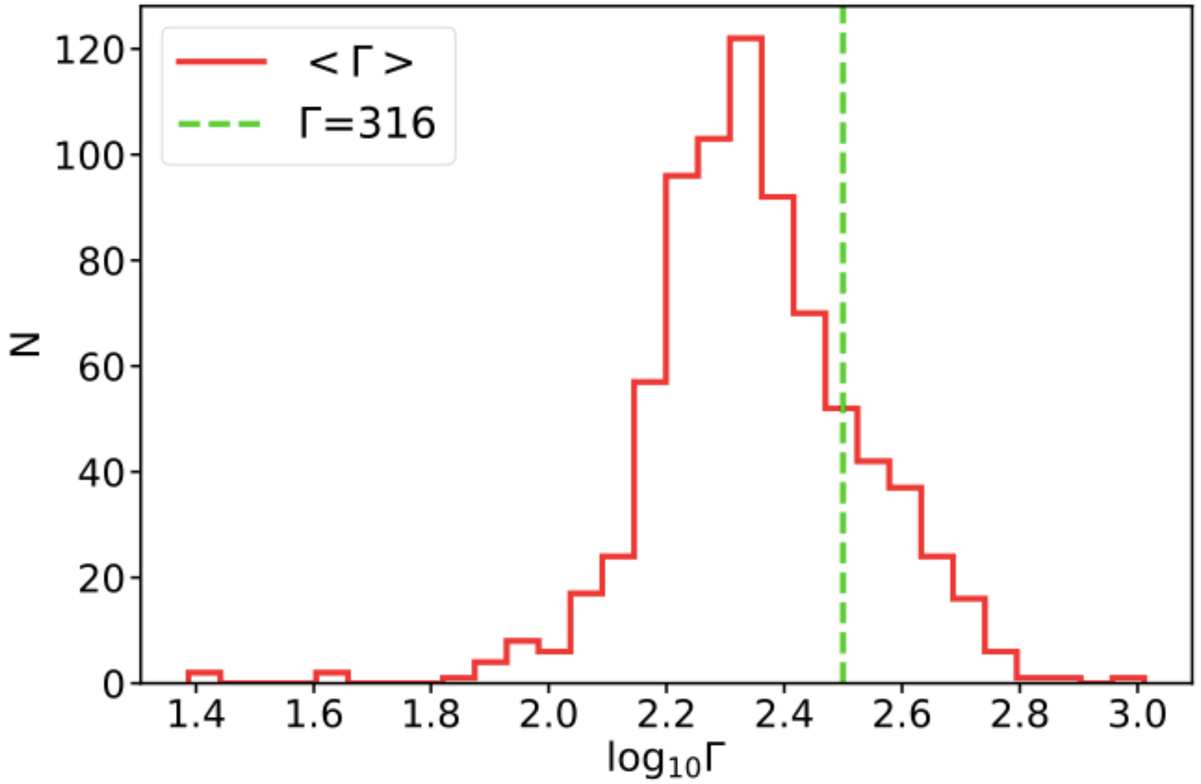
- At least one parameter among fluence and redshift known in order to reduce the uncertainties on the neutrino fluence estimation ($L_{\gamma,\mathrm{iso}}$ depends both on z and F_γ)

ANTARES Collaboration, MNRAS 500, 5614–5628 (2021)

Comparison with the previous ANTARES stacking GRB analysis

Adrián-Martínez S. et al. (ANTARES Collaboration), 2013, A&A 559A





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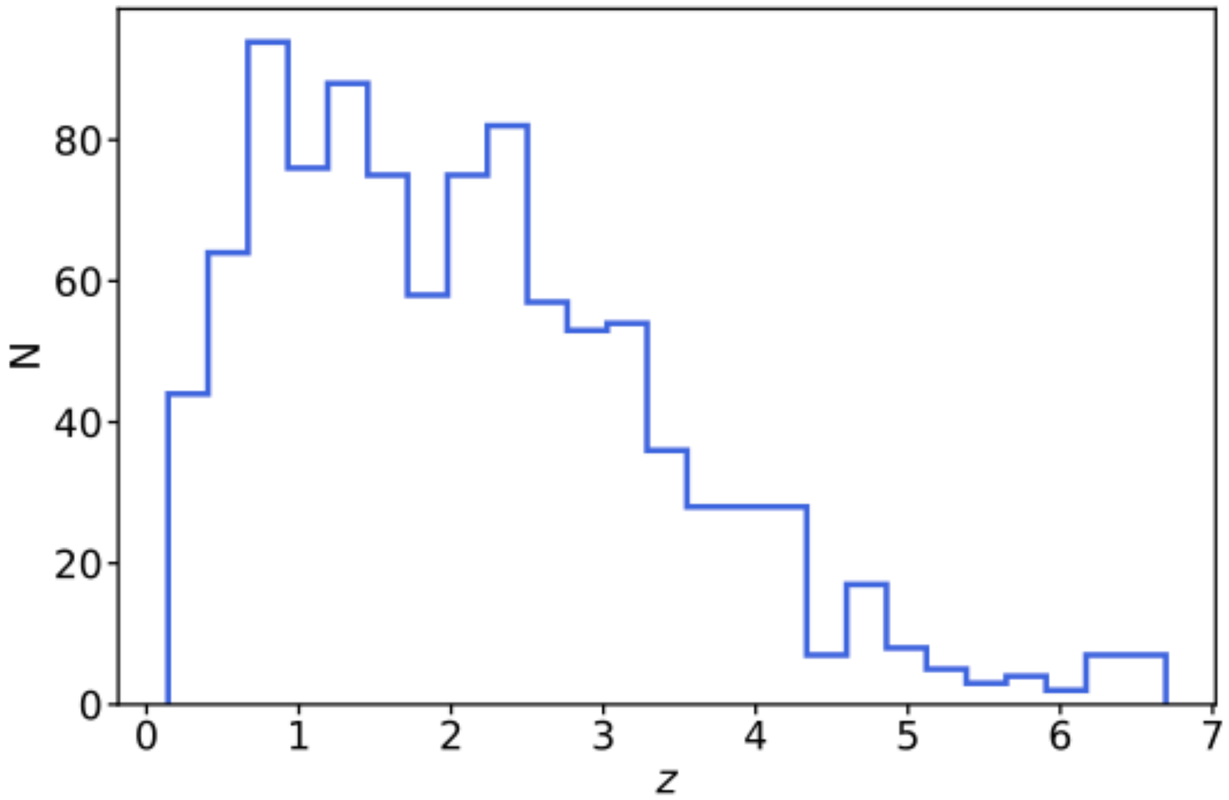
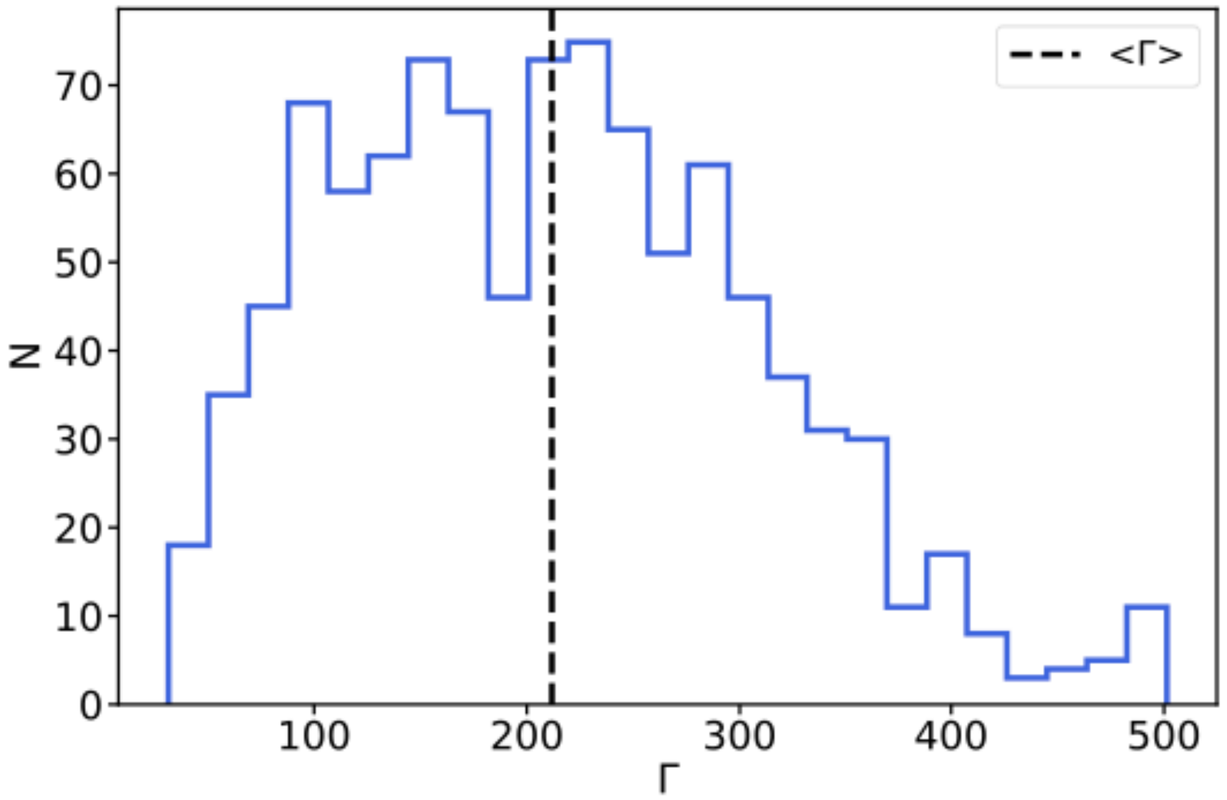
z and Γ distributions from random extractions

Example for GRB08102853





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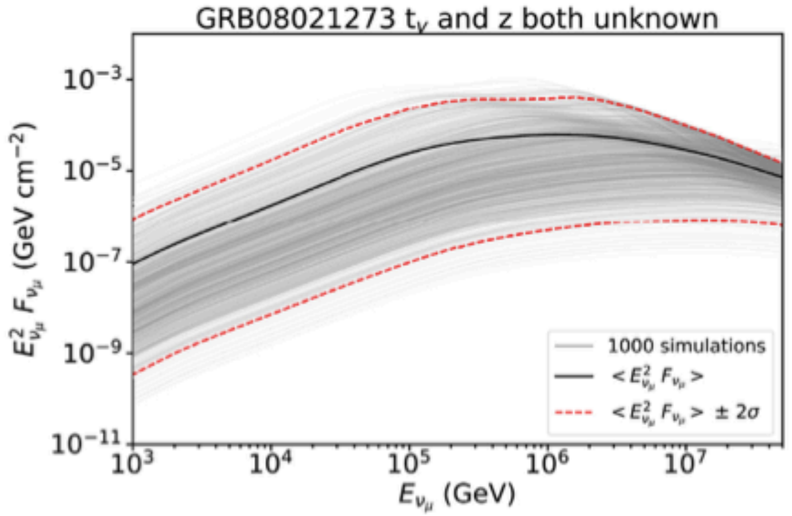
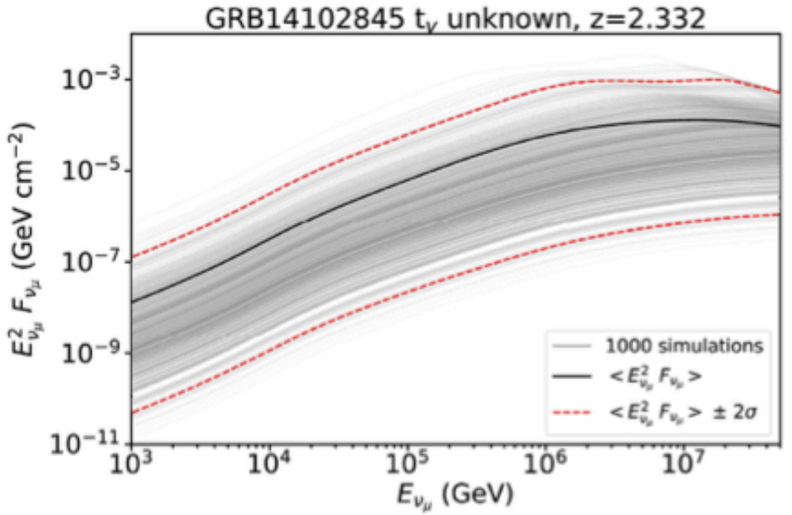
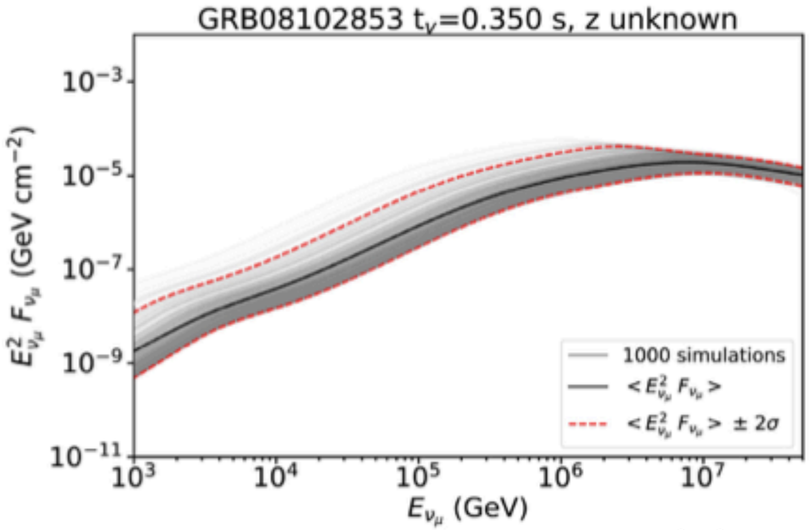
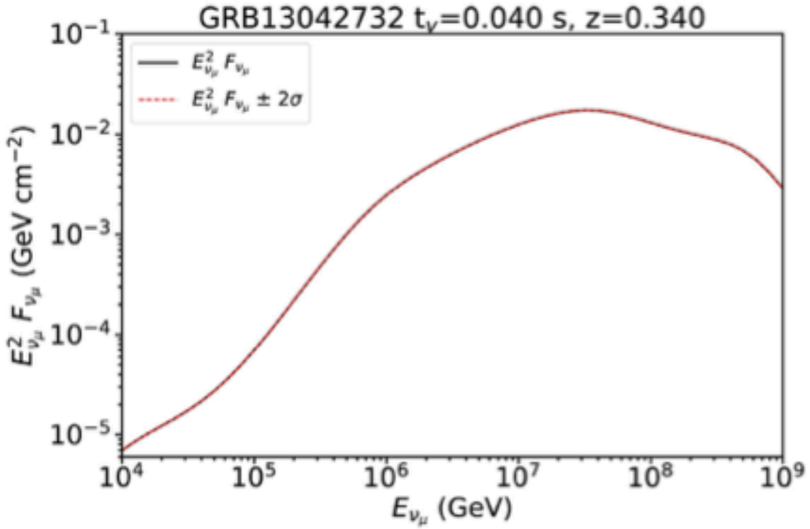
Systematic uncertainties on neutrino flux expectations









<u>To evaluate the statistical uncertainty on the neutrino fluence</u>, we:

1. Calculate the mean of these 1000 simulations;
2. Use percentiles to infer $\sigma(E^2_{\nu_\mu} F_{\nu_\mu})$;
3. Quote $E^2_{\nu_\mu} F_{\nu_\mu} \pm 2\sigma$.

The 2.28% of the values at the right and at the left of the $E^2_{\nu_\mu} F_{\nu_\mu}$ distributions have been excluded (in each energy bin)
-2σ is the 2.28th percentile
$+2\sigma$ is the 97.72nd percentile

The statistical error around the neutrino fluence of the GRBs with known values of t_ν and z were obtained by propagating t_ν and z uncertainties on $E^2_{\nu_\mu} F_{\nu_\mu}$

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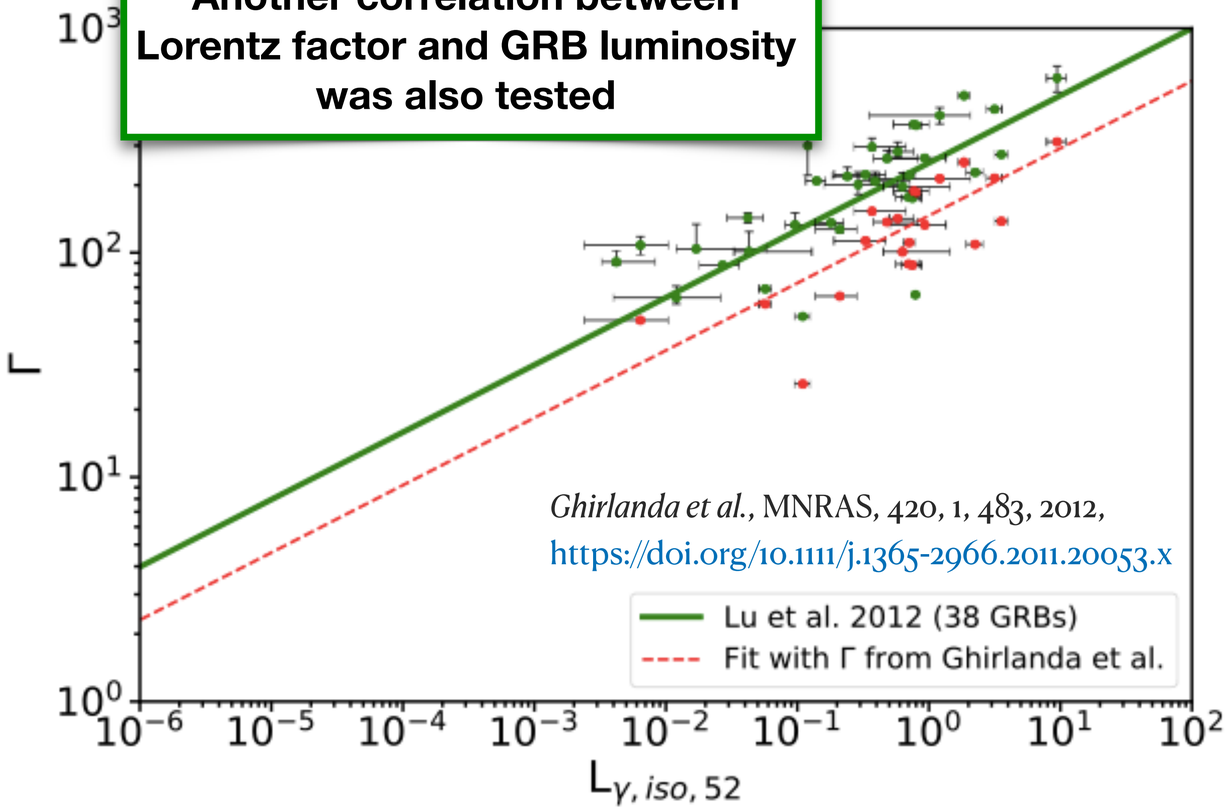
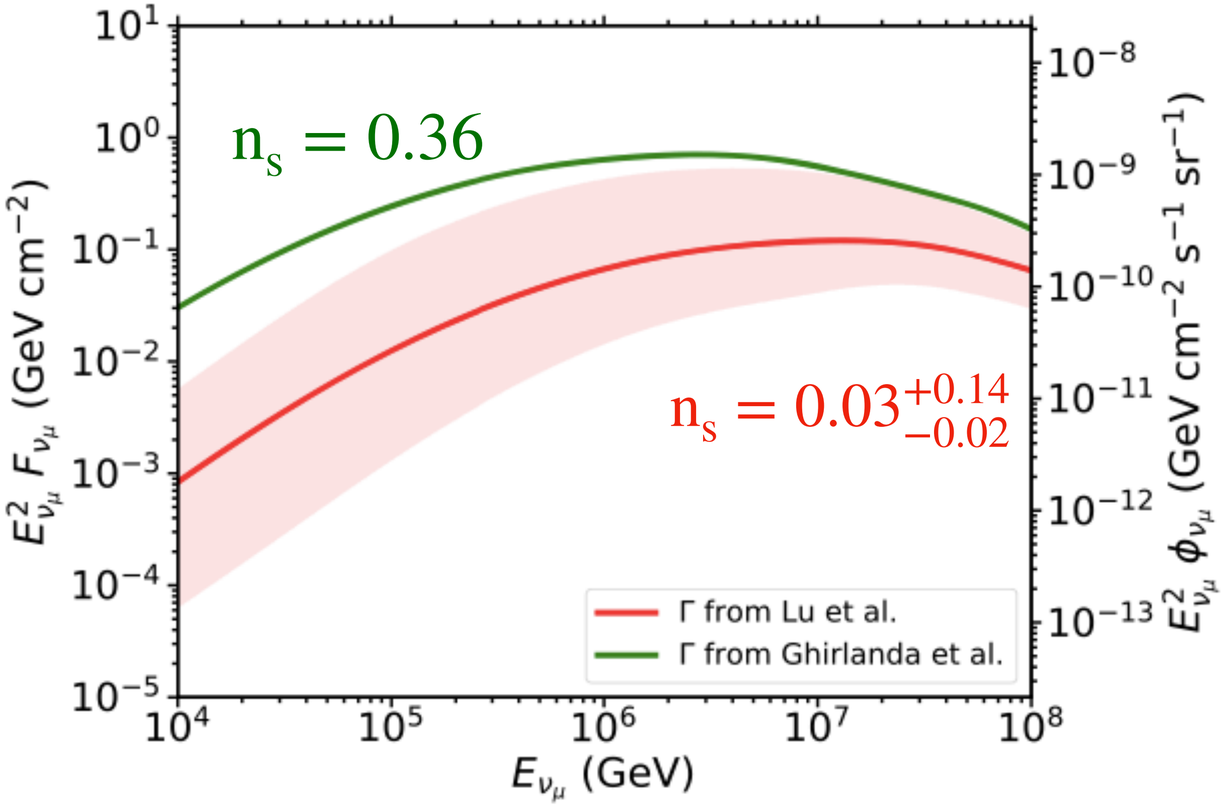
Systematics on treatment on Lorentz factor Γ

Another correlation between Lorentz factor and GRB luminosity was also tested





- By using the Ghirlanda et al. 2012 method to estimate Γ, **the stacking neutrino fluence would increase at lower energies;**
- The new analysis optimization results into an **expected number of neutrino events increased by a factor ~ 10.**

ANTARES Collaboration, MNRAS 500, 5614–5628 (2021)