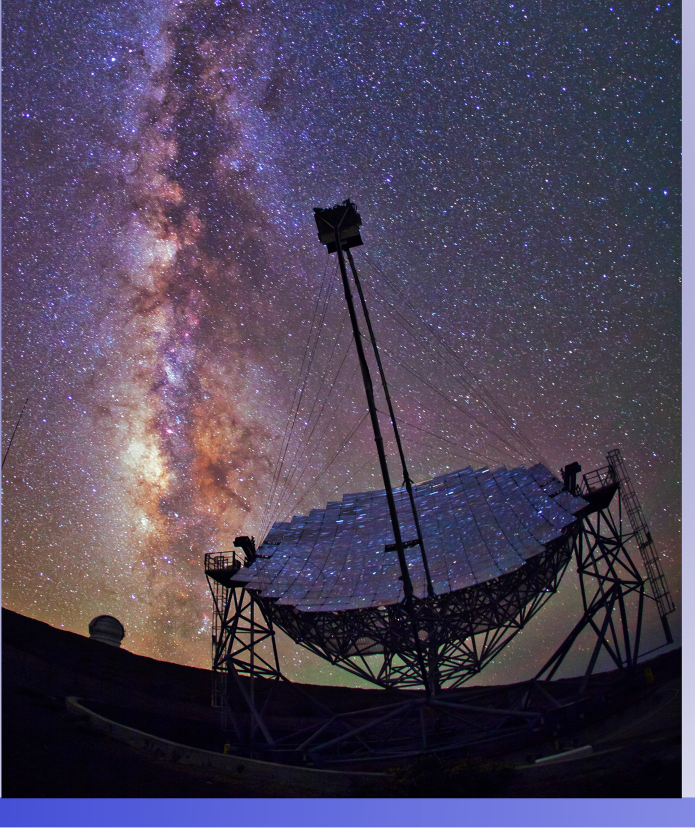

Follow-up observations of GW170817 with the MAGIC telescopes

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INAF ISTITUTO NAZIONALE DI ASTROFISICA

MAGIC Major Atmospheric Gamma Imaging Cerenkov Telescopes

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Gravitational Wave counterparts at >100 GeV energies

GW170817

- originated by a binary neutron star merger
- first GW event with electromagnetic emission from a *short GRB* and a kilonova.
- X-ray and radio counterpart did emerge in the days after the burst, later identified as the GRB afterglow non-thermal emission, peaking at 155 days [1]
  - The late increasing afterglow emission is expected by the interaction of an off-axis jet (i.e. not aligned by several degrees with the line of sight) with the surrounding medium [2]

VHE emission from GRB

- GRBs afterglows emit very-high energy (VHE, > 100 GeV) gamma-rays,
  - e.g. GRB 190114C and the short-GRB 160821B by MAGIC [3, 4] and GRB 180720B and GRB 190829a by H.E.S.S. [5, 6].
- The GeV-TeV emission from GRB 190114C clearly points to a new energetic component.

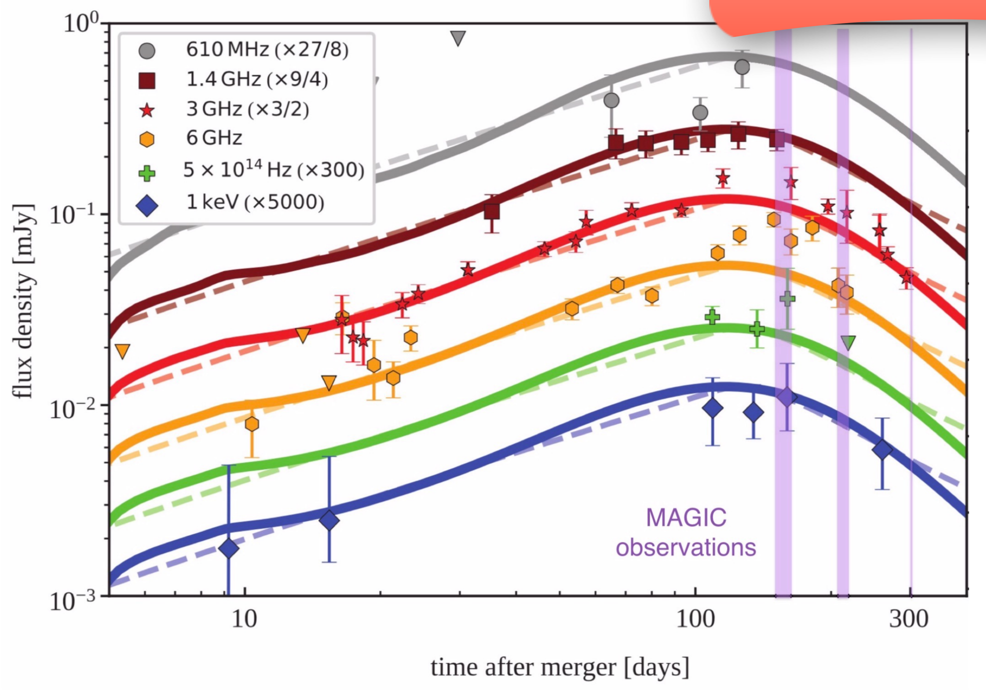
The Very-high-energy gamma-ray emission from GRB 201216C detected by MAGIC
S. Fukami et al., this conference

MAGIC observations of the nearby short GRB 160821B
K. Noda et al., this conference

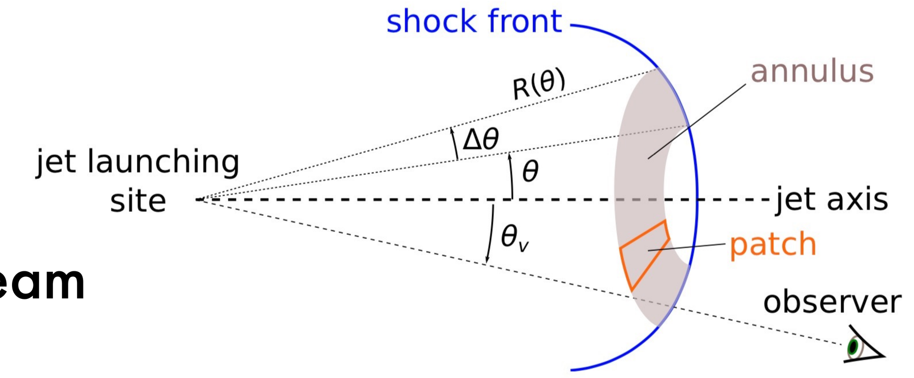
Very high energy emission from gamma-ray bursts detected by MAGIC
F A. Berti et al., this conference

MAGIC follow-up observations on GW170817

- MAGIC follow-up observations collected 10 hours, from January to June 2018. The resulting UL calculated for E > 400 GeV is 3.6×10 erg/cm²/s
- Multi-wavelength spectral energy distribution (SED), built using available the radio, optical and X-ray data gathered in [7].
- Radio to X-ray data are well described by a single power-law component, without an indication of a turnover up to ~10 keV.

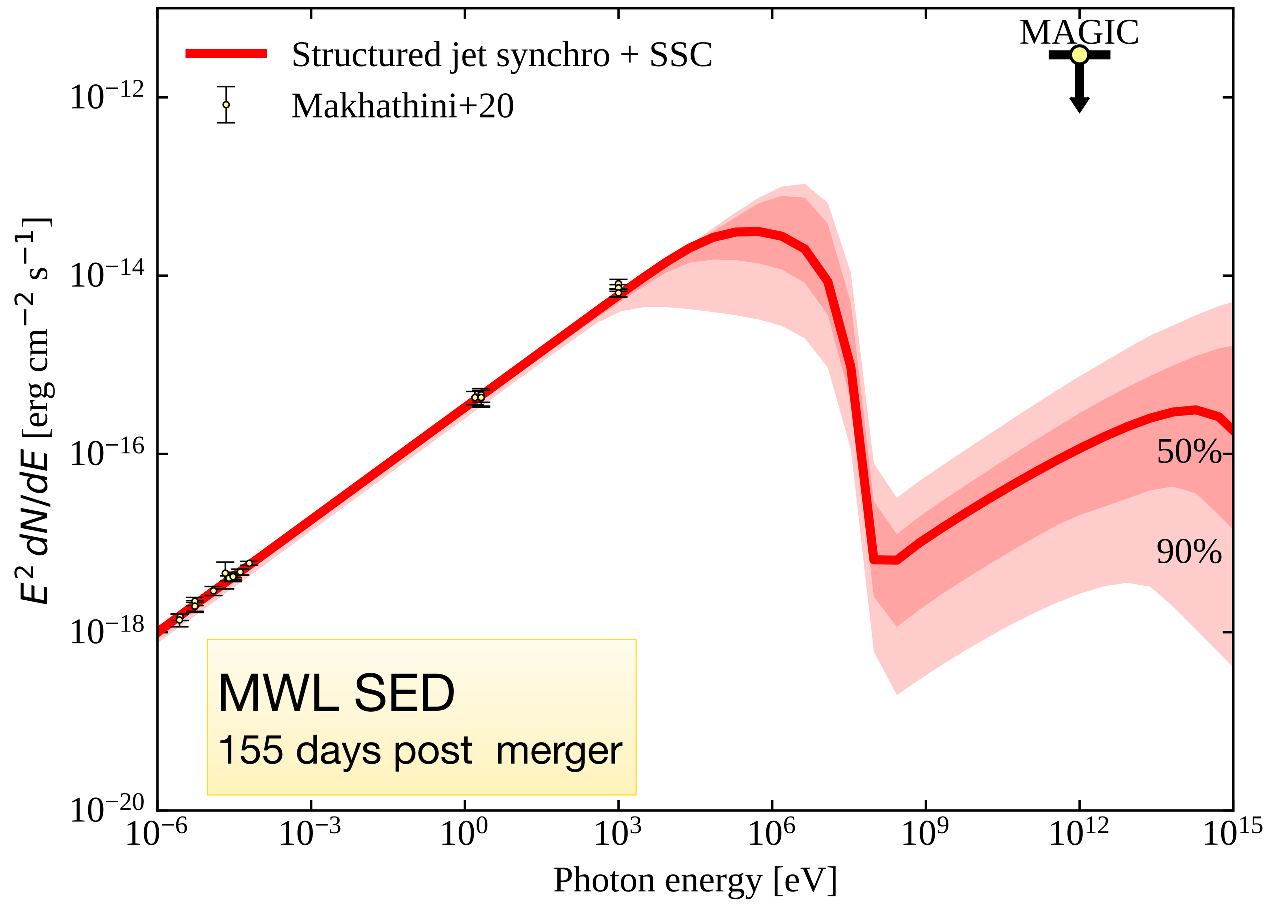


SSC modeling of late afterglow emission

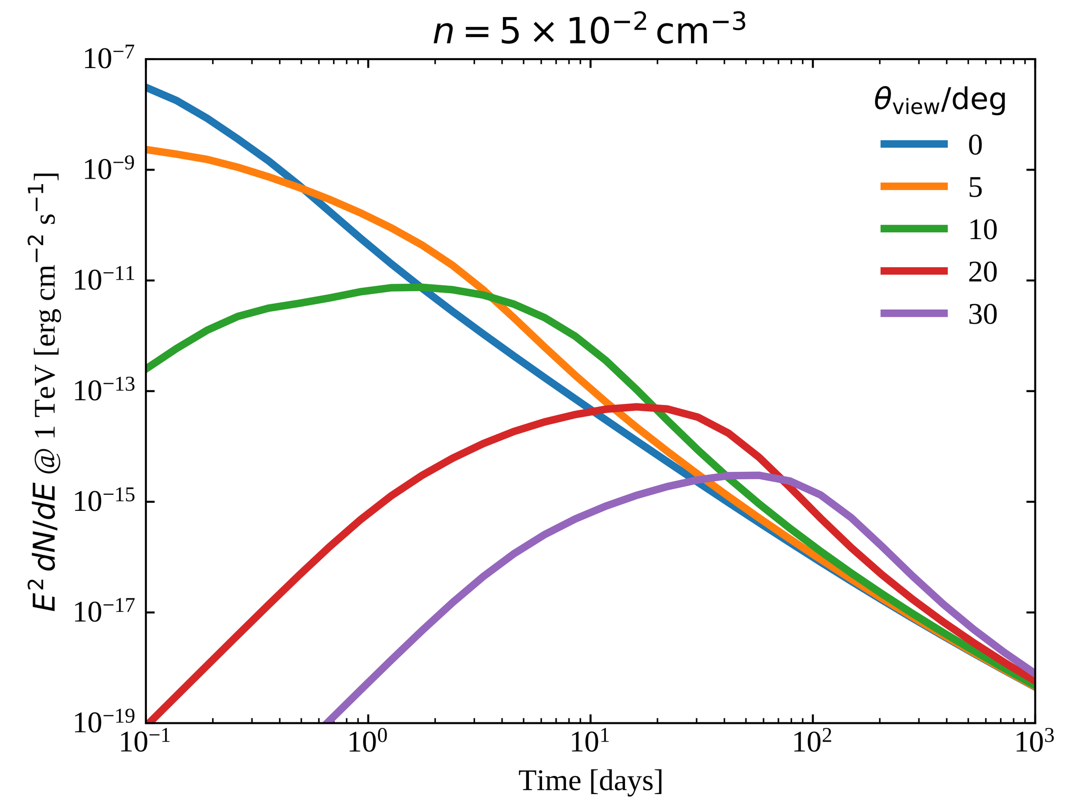


- The emission is computed from the shock that arises as the structured jet sweeps the interstellar medium (ISM).
- Relativistic electrons are assumed to be injected in the shock downstream with a power law energy distribution.
- Electron cooling is computed accounting for synchrotron and self-Compton losses
  - the best fit parameters obtained in [2] by fitting the model to the multi-wavelength data, with the constraints from the measurement of the radio VLBI centroid
  - The total emission is integrated over equal-arrival-time surfaces, accounting for relativistic beaming and for the off-axis viewing angle θ_v.
- The predicted SED at 155 days post-merger is computed.

Results: Multifrequency SED and SSC model



Results: expected light curves at different viewing angles with higher ISM density



Take home messages

- MAGIC observed GW 170817 during the peak of its late non-thermal emission.
- SSC model from a structured jet shows that TeV emission from short-GRBs seen off-axis (with angles >10-20 deg) is challenging for the present generation of Cherenkov telescopes
- The detection of an energetic component from GW and BNS counterparts by Cherenkov telescopes is expected with either fsmaller off-axis angle <~10 deg and denser interstellar medium density, or an additional emission component.

References

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[2] Ghirlanda, G. et al. 2019, Science, 363, 968
[3] MAGIC collaboration 2019, Nature, 575, 455-458
[4] MAGIC collaboration, et al. 2019, Nature, 575, 459
[5] Abdalla, H. et al. 2019, Nature, 575, 464
[6] H.E.S.S. Collaboration et al. 2021, Science 372, 1081
[7] Makhathini S., et al. 2020, arXiv:2006.02382