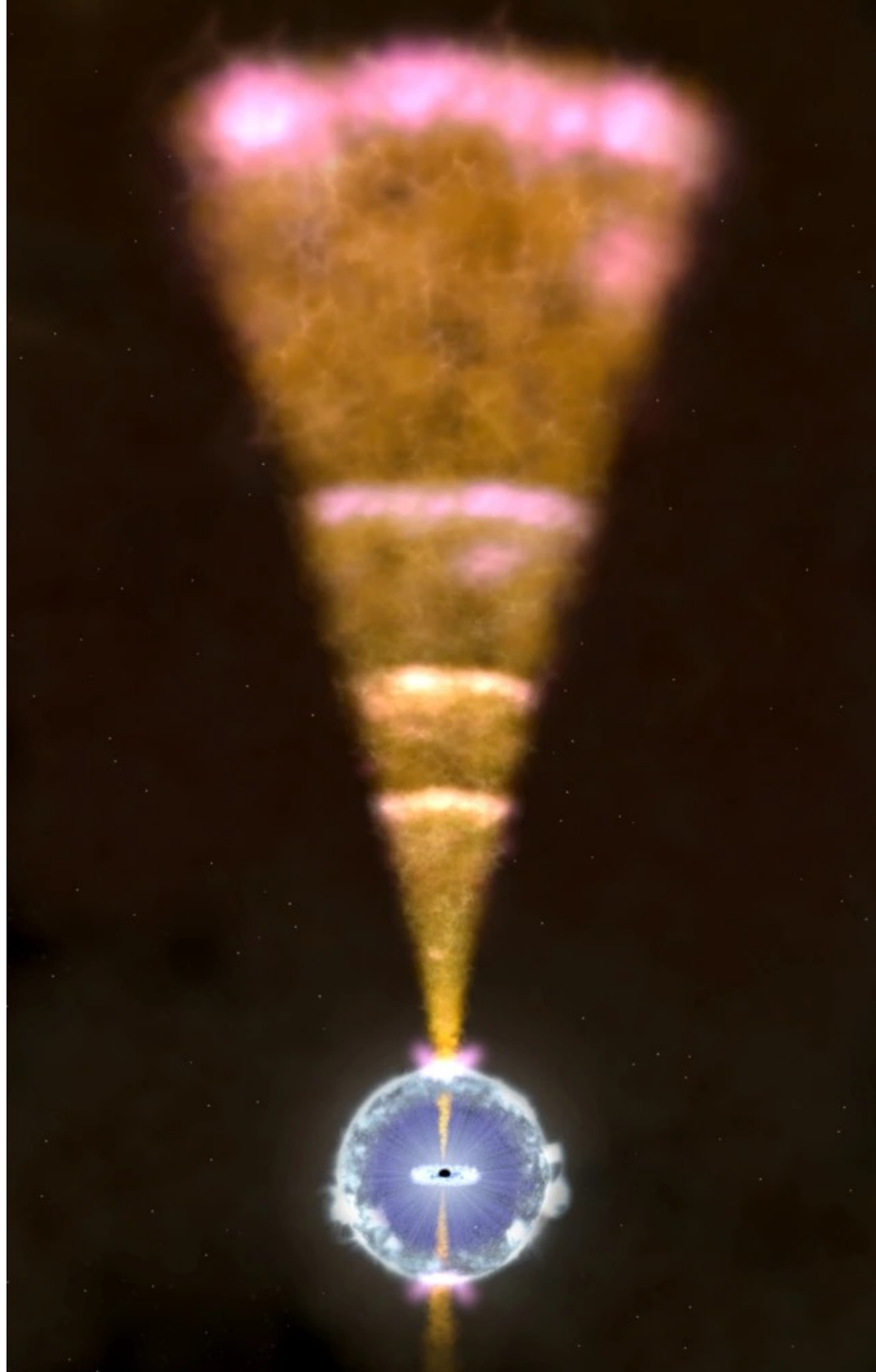
GRB science @ INAF

Lara Nava
INAF-OAB

Giornate INAF RSN4 - Napoli 2026



SCIENCE and METHODS

- **Central engine, jet launching, jet structure**
  - numerical simulations
  - semi-analytic modelling

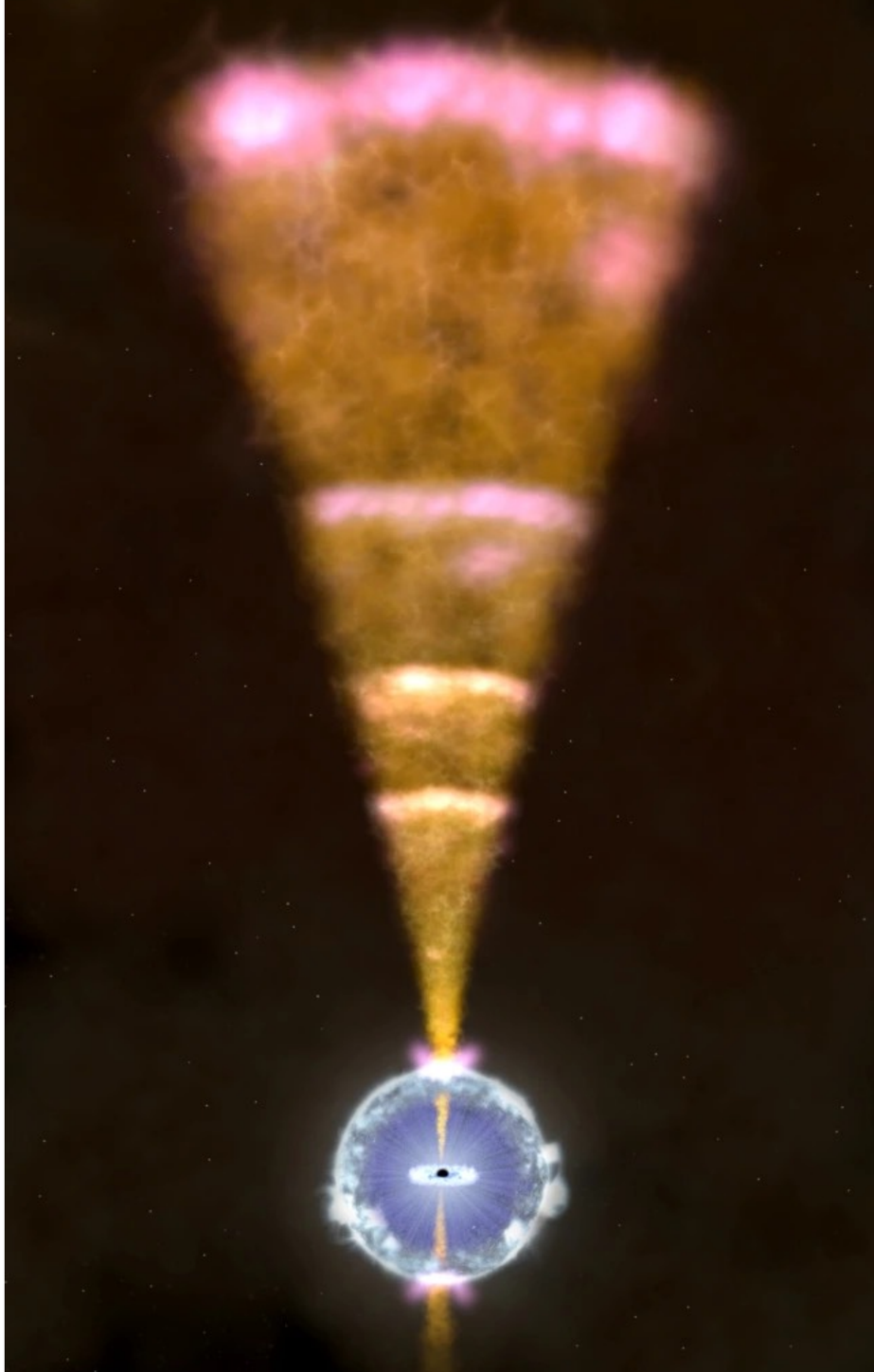
- **Prompt emission**
  - trigger (Swift, AGILE, INTEGRAL, EP, SVOM)
  - modelling and interpretation (semi-analytical code, derivation of physical parameters)

- **Afterglow emission**
  - follow-up (from radio to TeV)
  - modelling and interpretation (semi-analytical code, derivation of physical parameters, jet properties, surrounding medium, particle accelerations)
  - SN/KN associated to GRBs

- **GRB populations**
  - codes for population synthesis (z-distribution, connection with SFR)
  - applications to future facilities (CTAO, ASTRI, THESEUS, HERMES,…)

- **Environment**
  - codes for photoionization

- **GRB impact on planet habitability, Machine learning/AI,…**



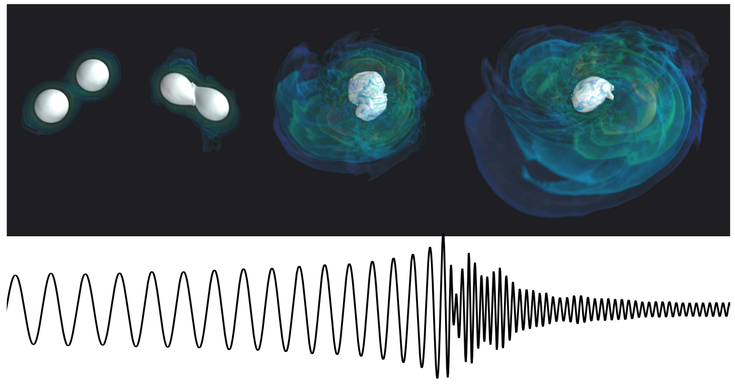
Riccardo Ciolfi @OAPd

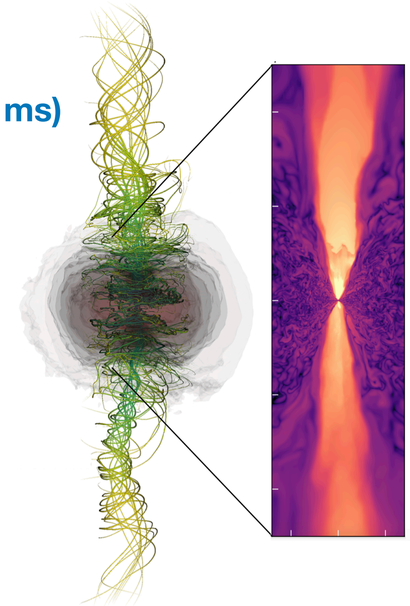
GRB jets from BNS mergers

end-to-end modeling from inspiral to jet afterglow emission

building the first self-consistent description directly combining simulations at different scales

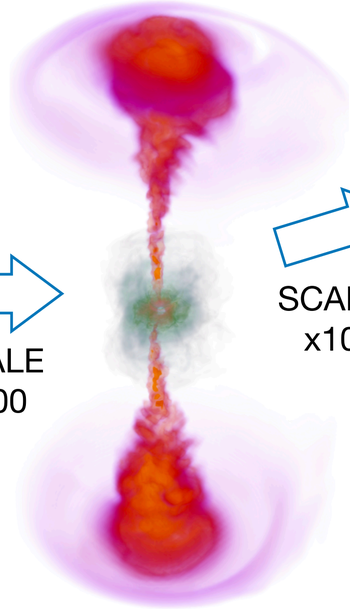
MERGER, COLLAPSE, JET FORMATION (~100 ms)
[GRMHD/Spritz code]





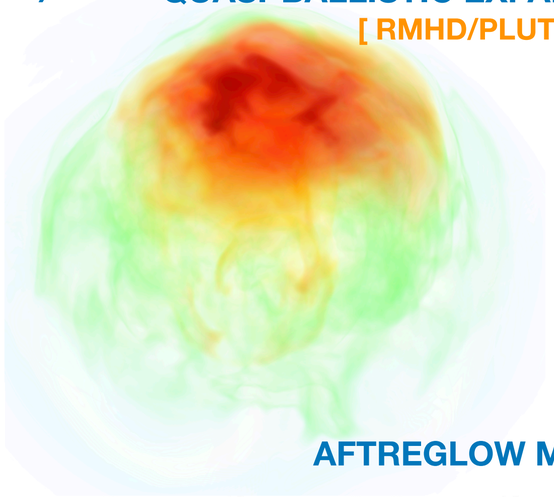
JET BREAKOUT AND PROPAGATION (~1 s)
[RMHD/PLUTO code]

SCALE x600

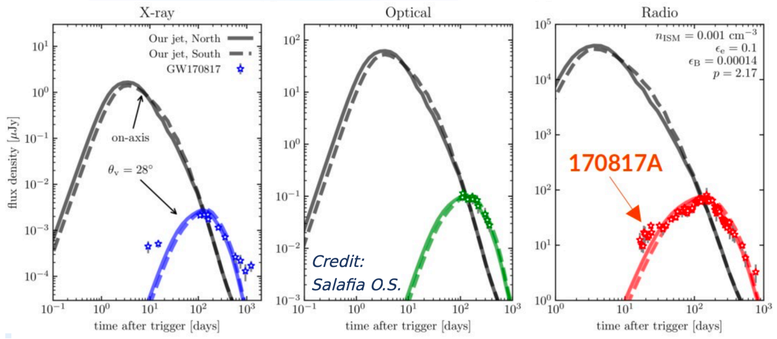


SCALE x10

QUASI-BALLISTIC EXPANSION (~10 s)
[RMHD/PLUTO code]



AFTREGLOW MODELING

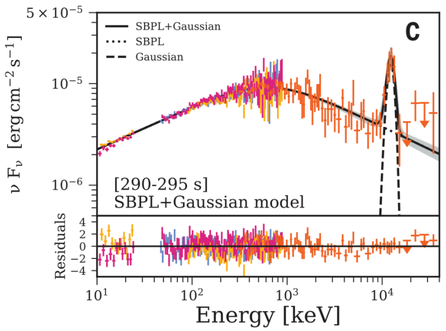


Dreas, Pavan, Ciolfi, Celotti, 2026, submitted, arXiv2601.08714

Pavan, Ciolfi, Dreas et al 2025, MNRAS, 540, 1345

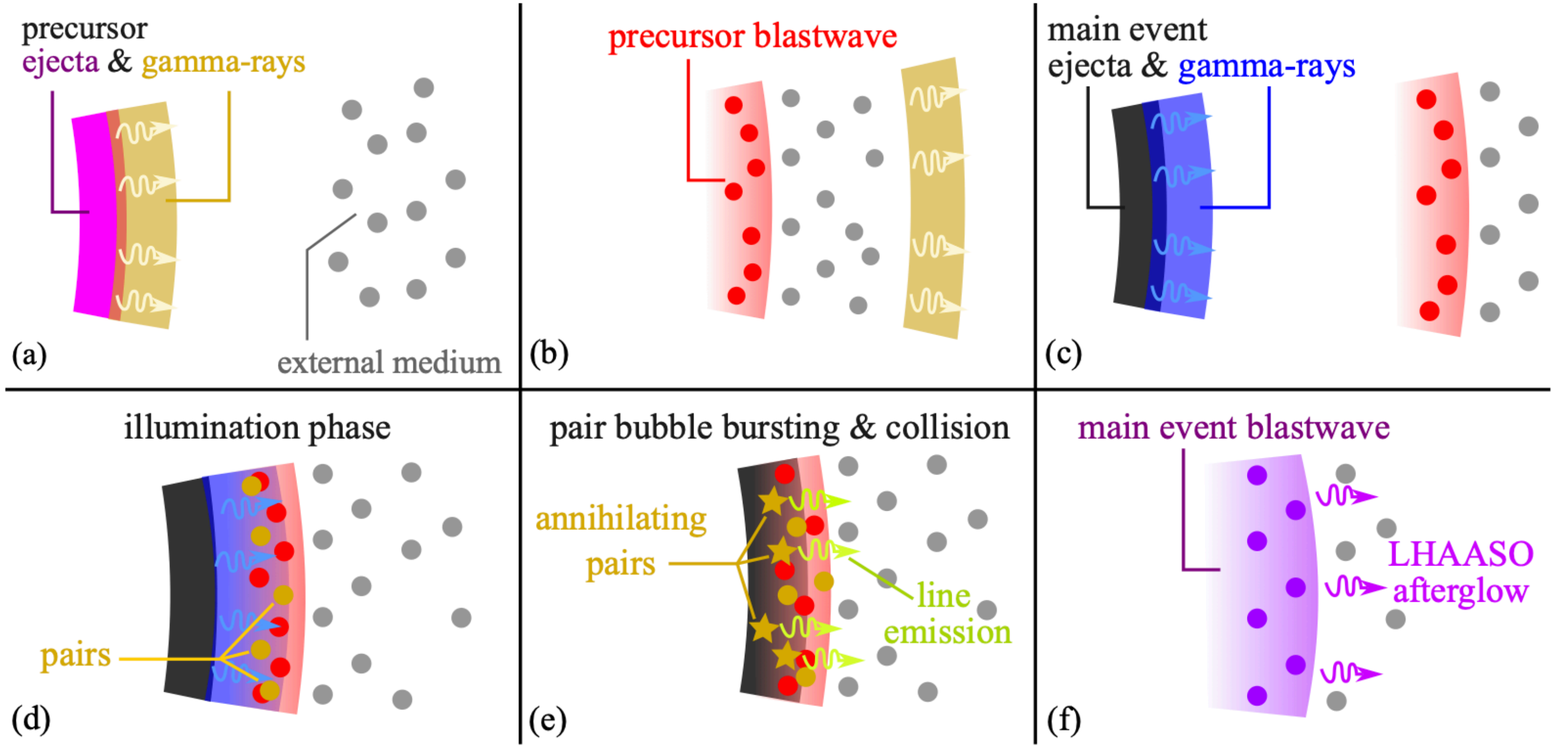
in collab. with O. S. Salafia@OAB

O. S. Salafia and collaborators @OAB



Prompt emission

emission line at around 10 MeV in GRB 221009A



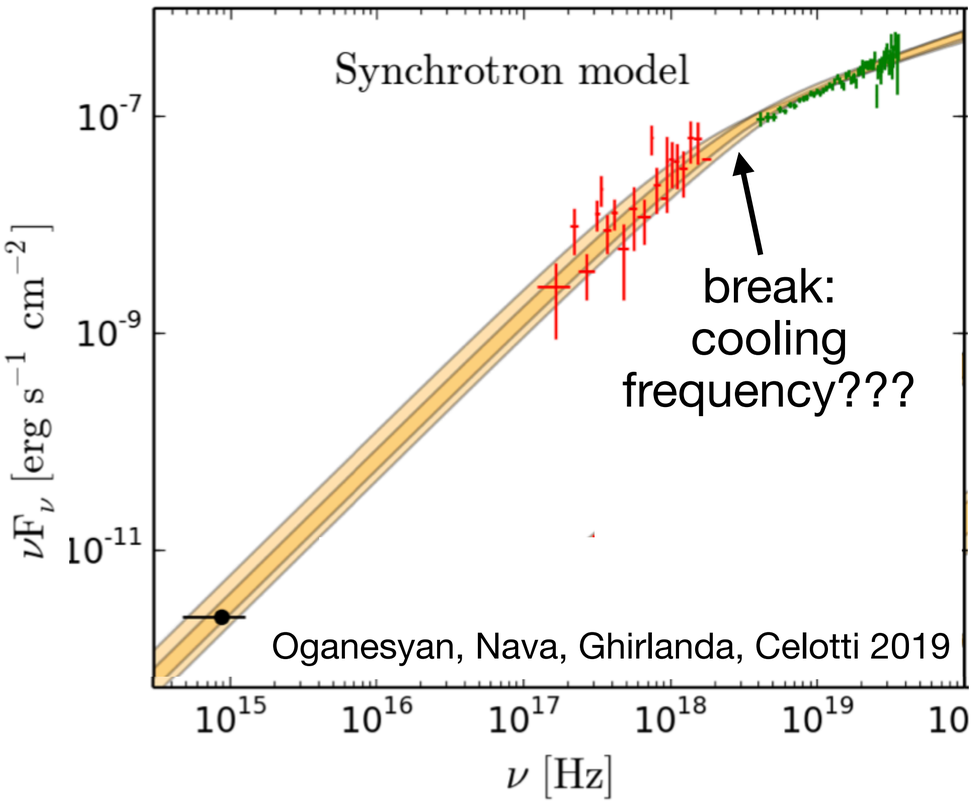
Salafia et al., 2026, submitted, arXiv2601.14257

@OAB

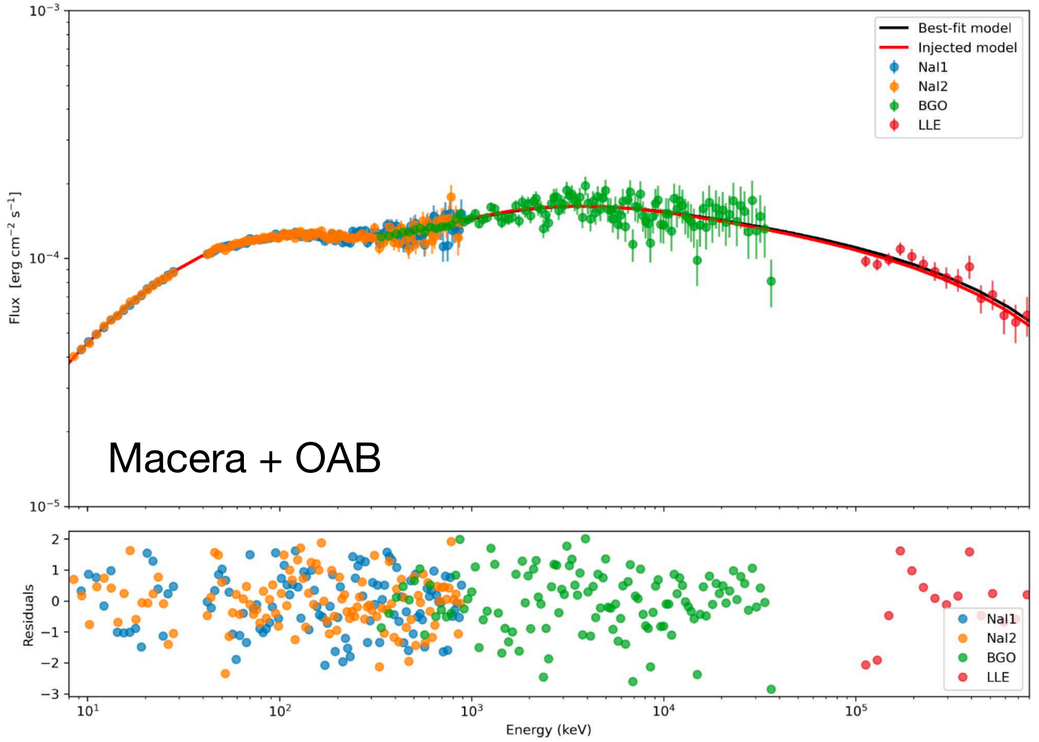
Prompt emission

Acceleration mechanism and radiative process

Low-energy (~keV) break in prompt spectra: testing internal shocks scenario



Presence of thermal relativistic particles accelerated in internal dissipation

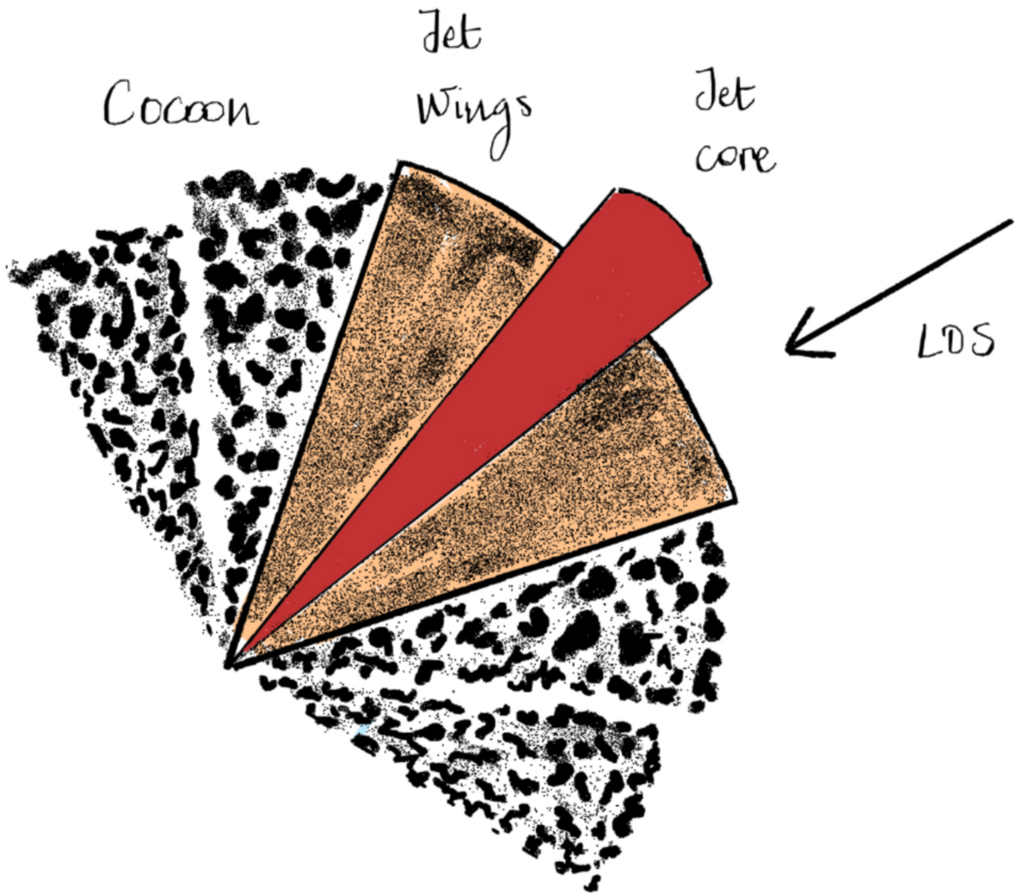


X-ray FLASHES

and their connection to GRBs

@IAPS

EP241021a: follow-up in radio band of fast X-ray transients detected by Einstein Probe



Modelling of their properties, based on the leading models like off-axis GRBs or dirty fireballs.

Gianfagna, Piro, Bruni, Thakur et al., 2025, A&A, 703, 92

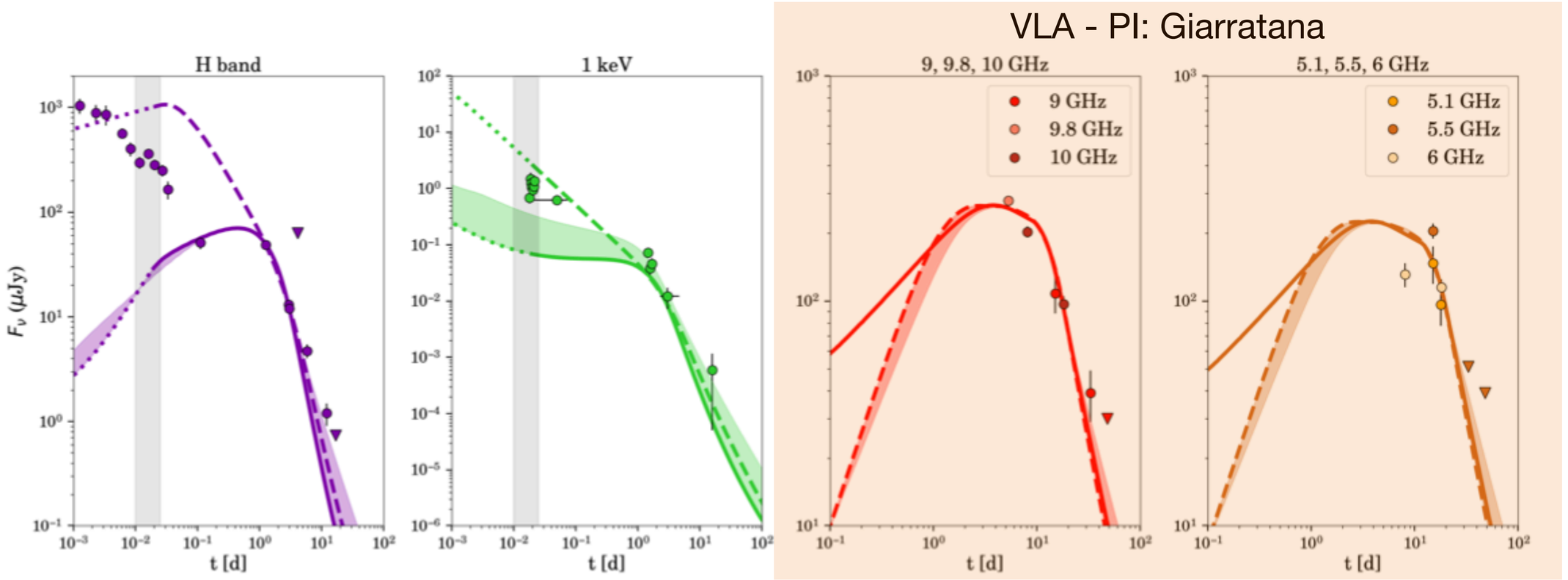
@OAB & IAPS

High-redshift GRBs

MW (and radio) follow-up

Radio follow-up of GRBs at z ≥ 6, afterglow modelling and comparison with low-z GRBs (@OAB,IAPS,OAS)

GRB 240218A at z=6.782



Brivio, Campana, Covino et. al, 2025, A&A, 695, 239

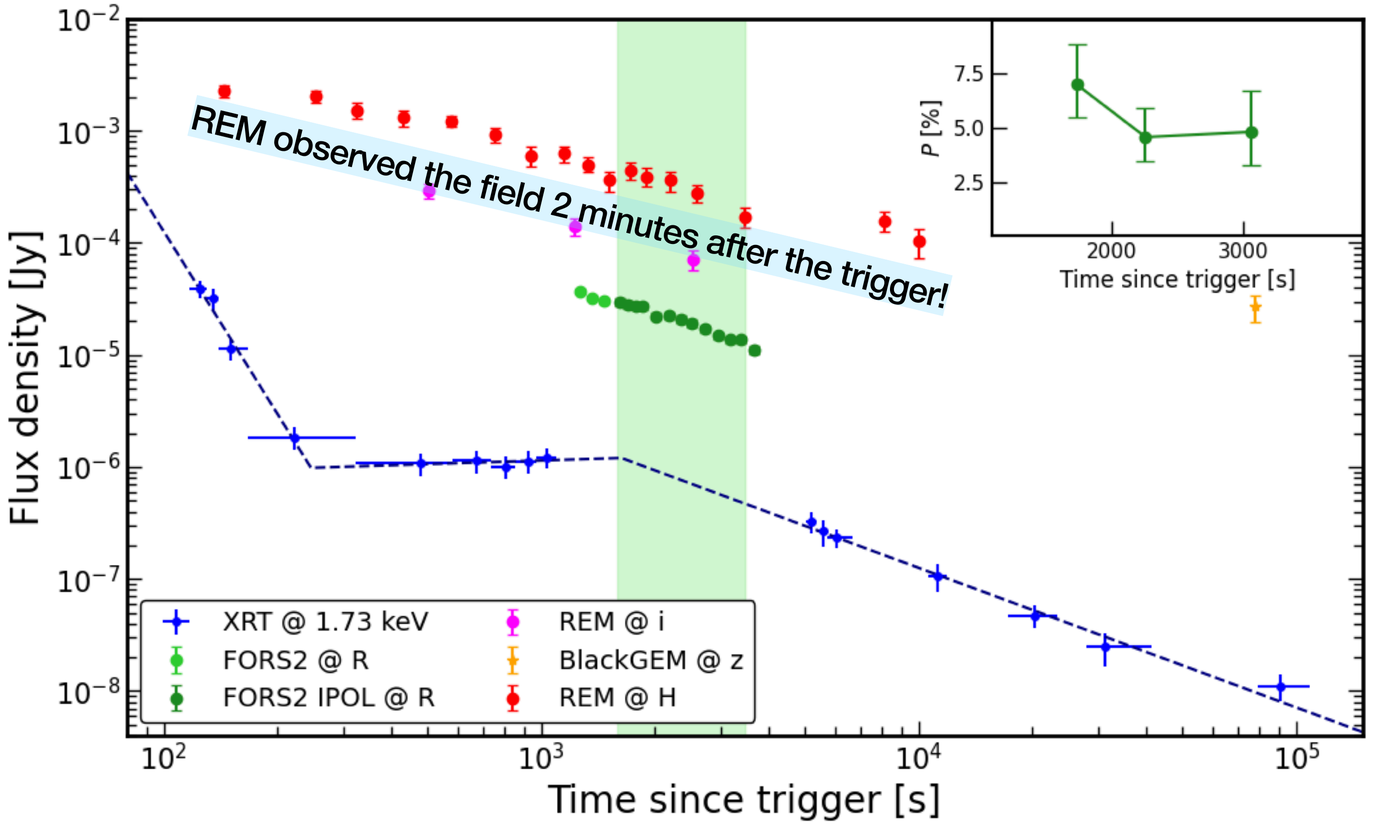
@OAB (et al.)

High-redshift GRBs

MW follow-up and polarization

GRB 240419A at z=5.178: the farthest optically polarised afterglow

Swift/BAT + early time follow-up from the ground and polarimetry observations



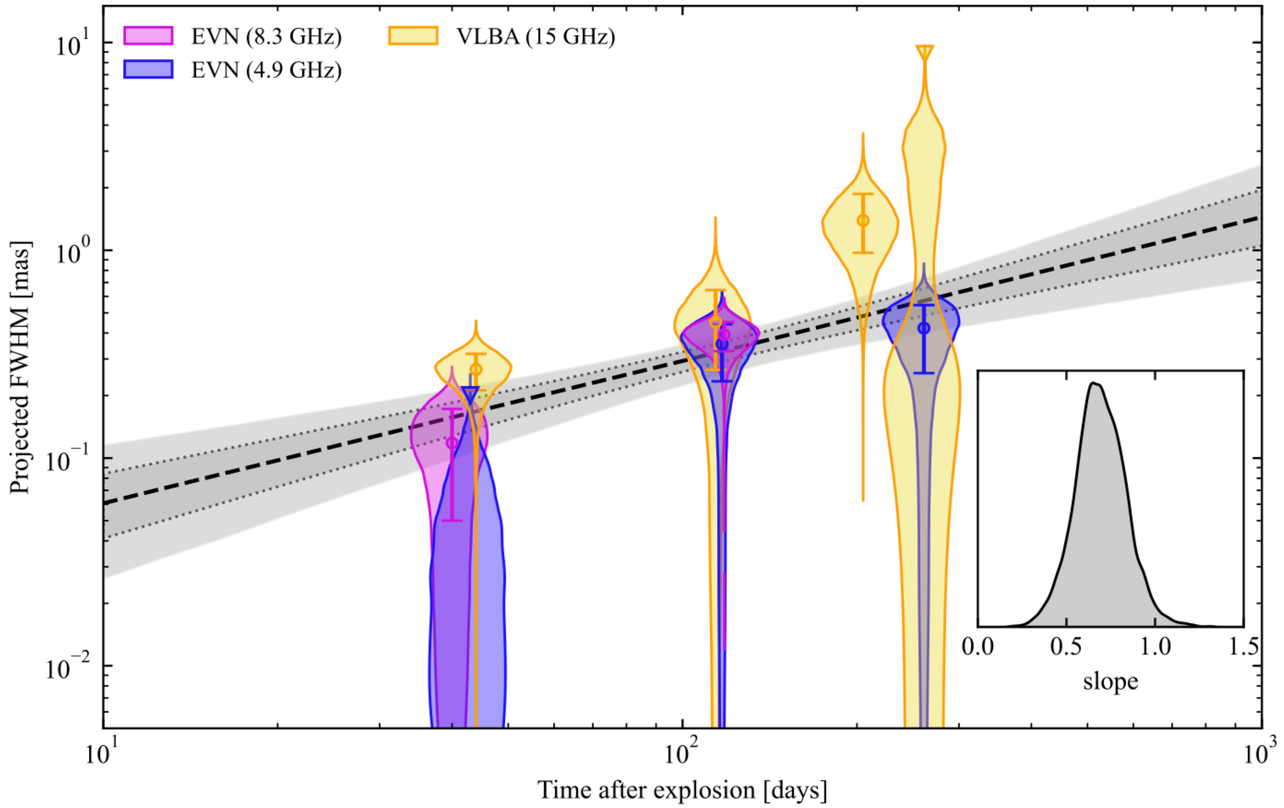
Brivio, Covino, Ferro et. al, 2025, A&A, 703, 49

@OAB & OAS

Radio follow-up

constraining the size and the expansion rate of the blastwave of GRB 221009A

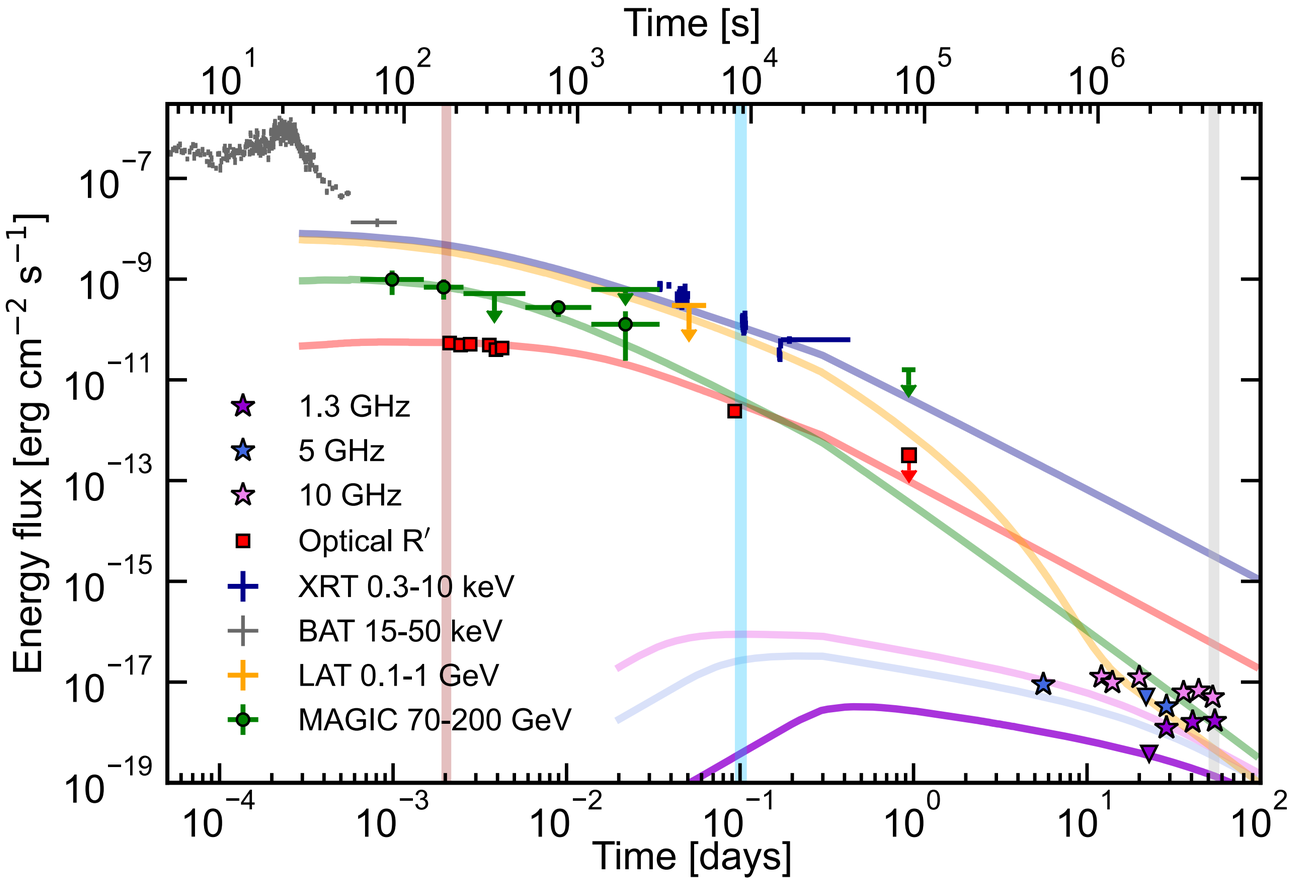
VLBI observations from 40 to 262 days, measure of the projected size



Giarratana, Salafia, Giroletti et al., 2024, A&A, 690, 74

Very-high energy afterglow emission

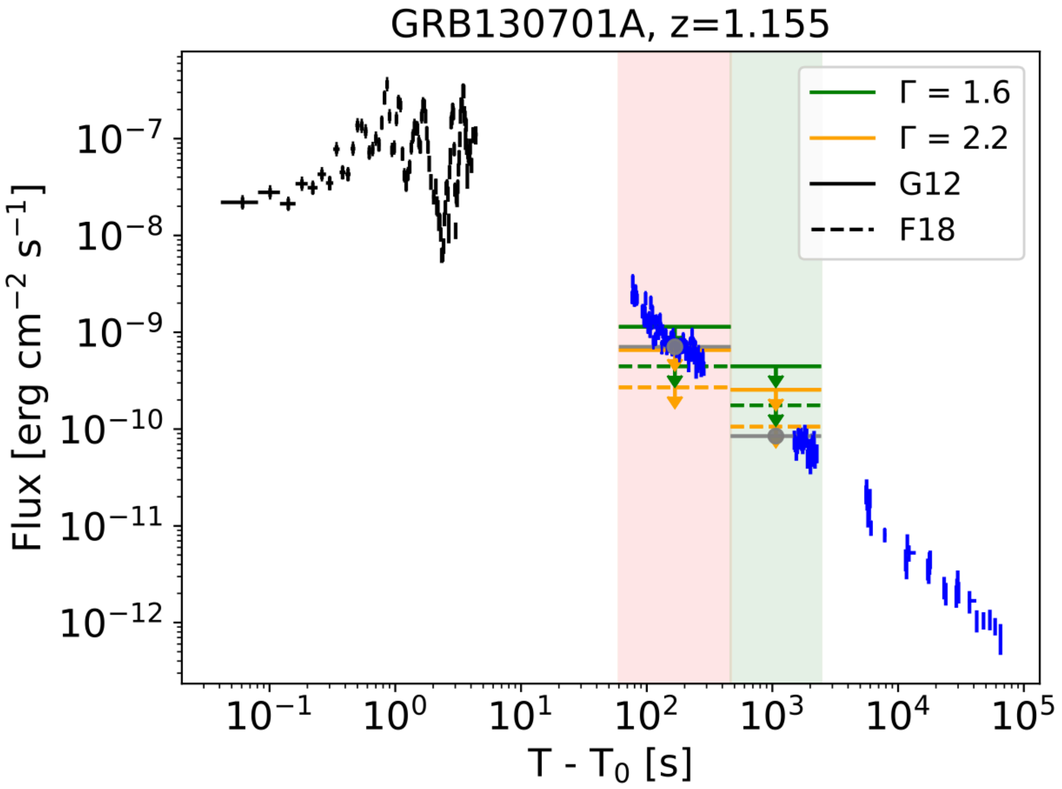
MAGIC detection of GRB 201216C at z = 1.1

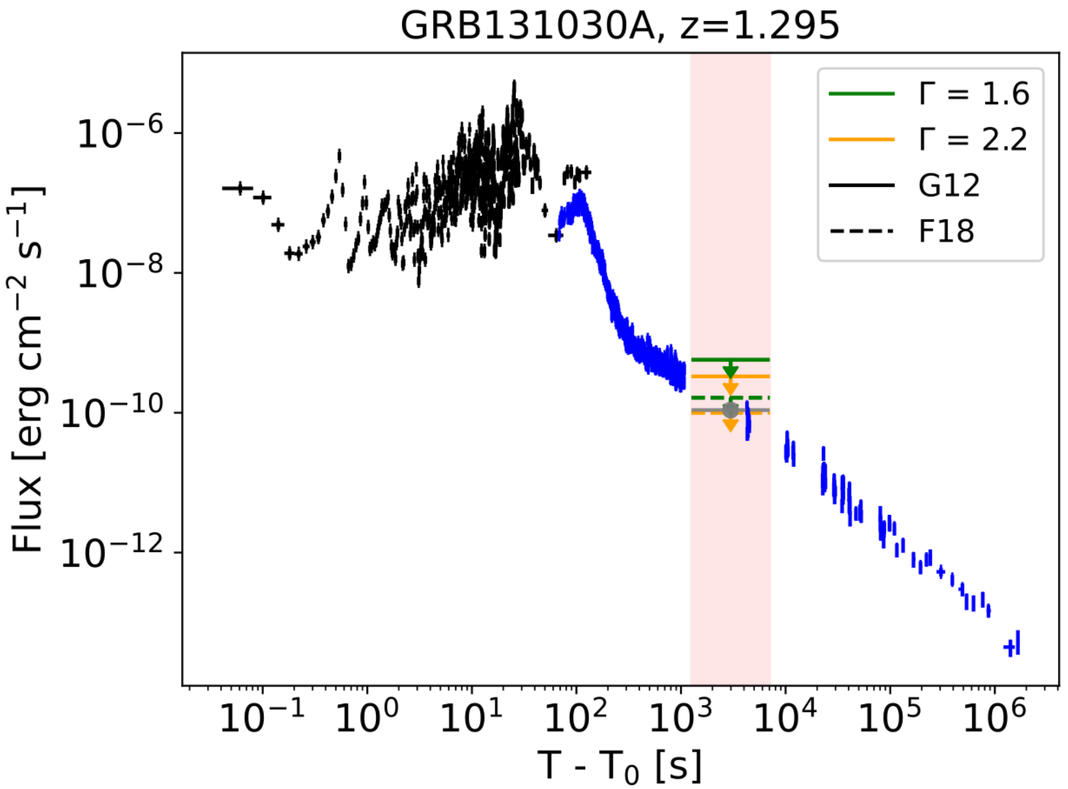


MAGIC Collaboration, 2024, MNRAS, 527, 5856

Very-high energy afterglow emission

MAGIC upper limits

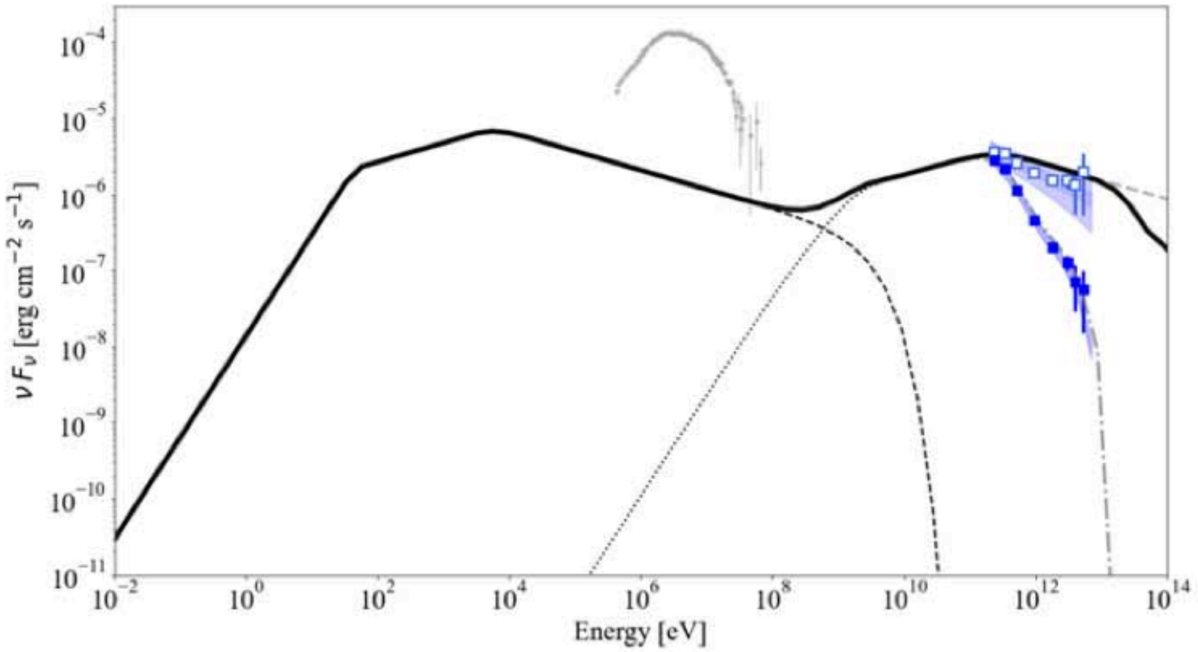


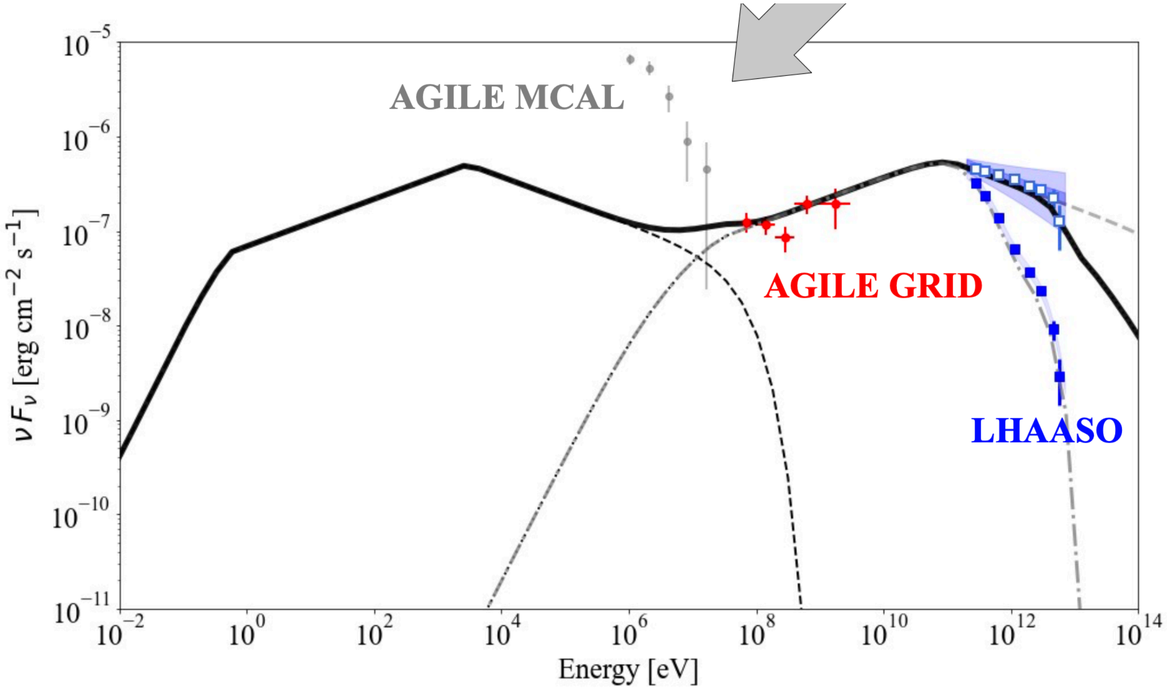


MAGIC Collaboration 2025, A&A, 700, 96

Very-high energy emission with AGILE

transition from **prompt** to **afterglow:** coexistence of MeV and GeV-TeV emissions

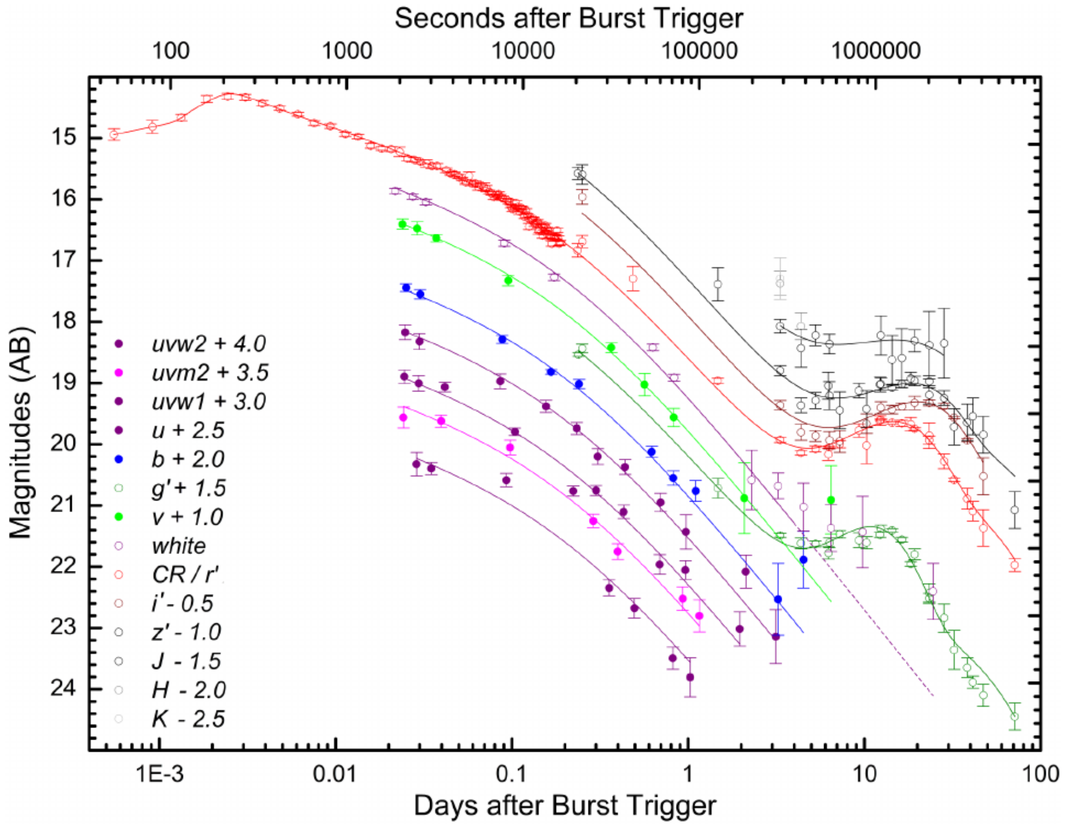


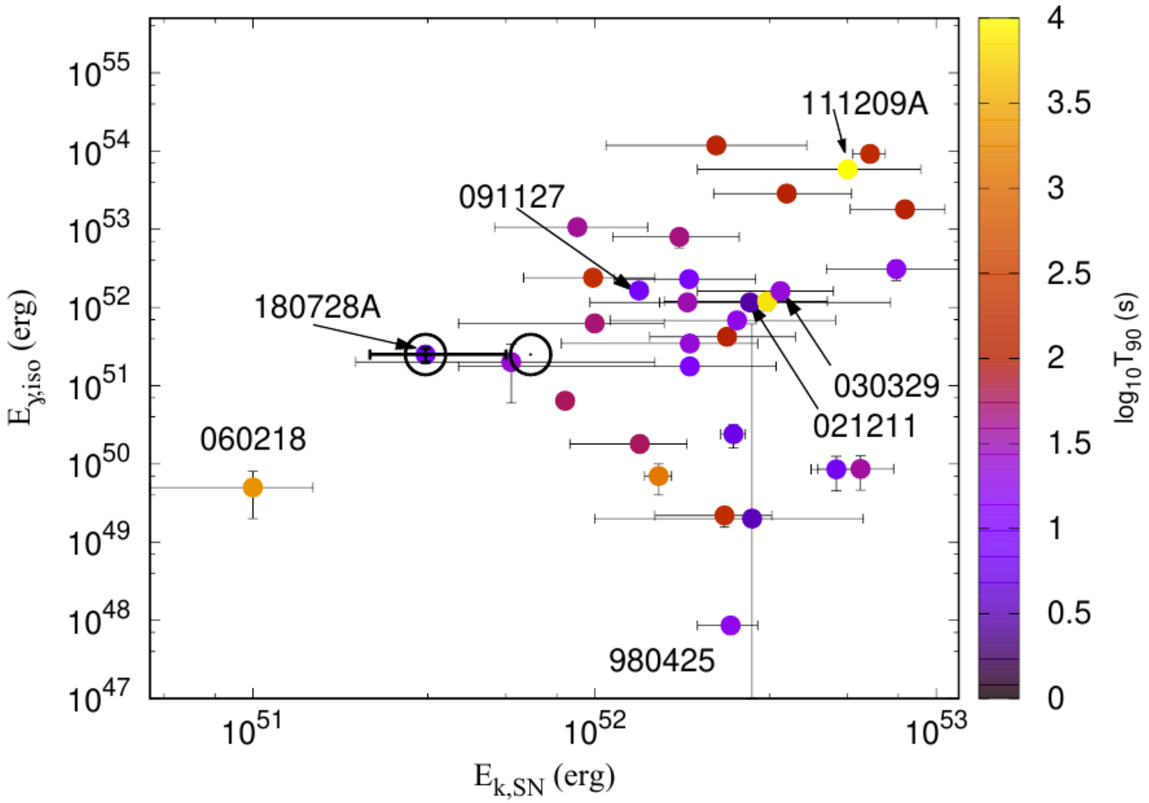


Foffano, Tavani, Piano, 2024, ApJ, 973, 44

GRB/SN connection

GRB 180728A and SN 2018fip at z=0.117



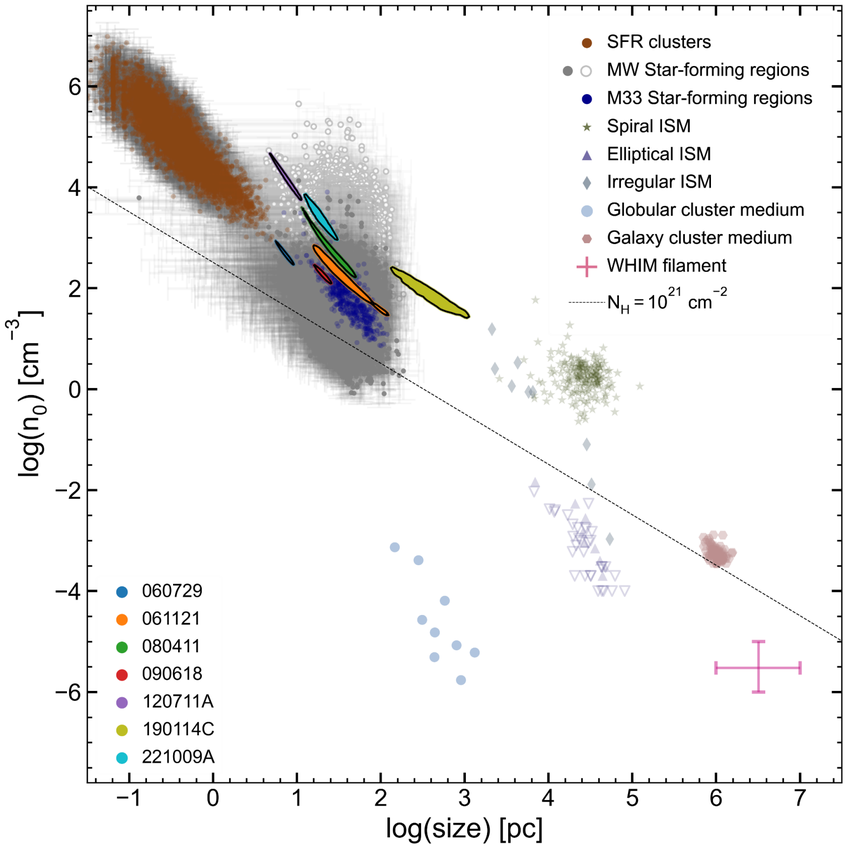


Rossi, Izzo et al., 2026, arXiv2601.04179

@IAPS

GRB environment

X-ray spectroscopy of GRB environments throughout a physically accurate modelling of the photoionisation



Highly variable and large GRB flux into circumburst environment requires proper time dependent modeling (Luminari et al. 2022)

Dense gas within star-forming regions photoionised by embedded GRBs

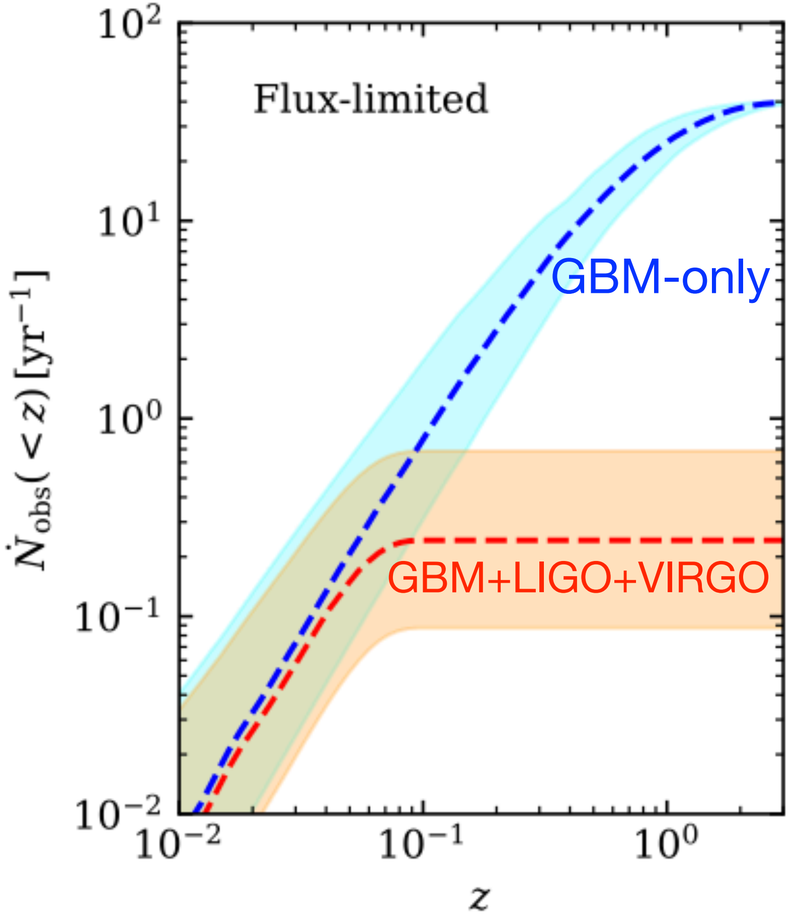
Thakur, Piro, Luminari et al. 2026, Nat Astron (in press)

@OAB, @OAB+IASF

Population synthesis models

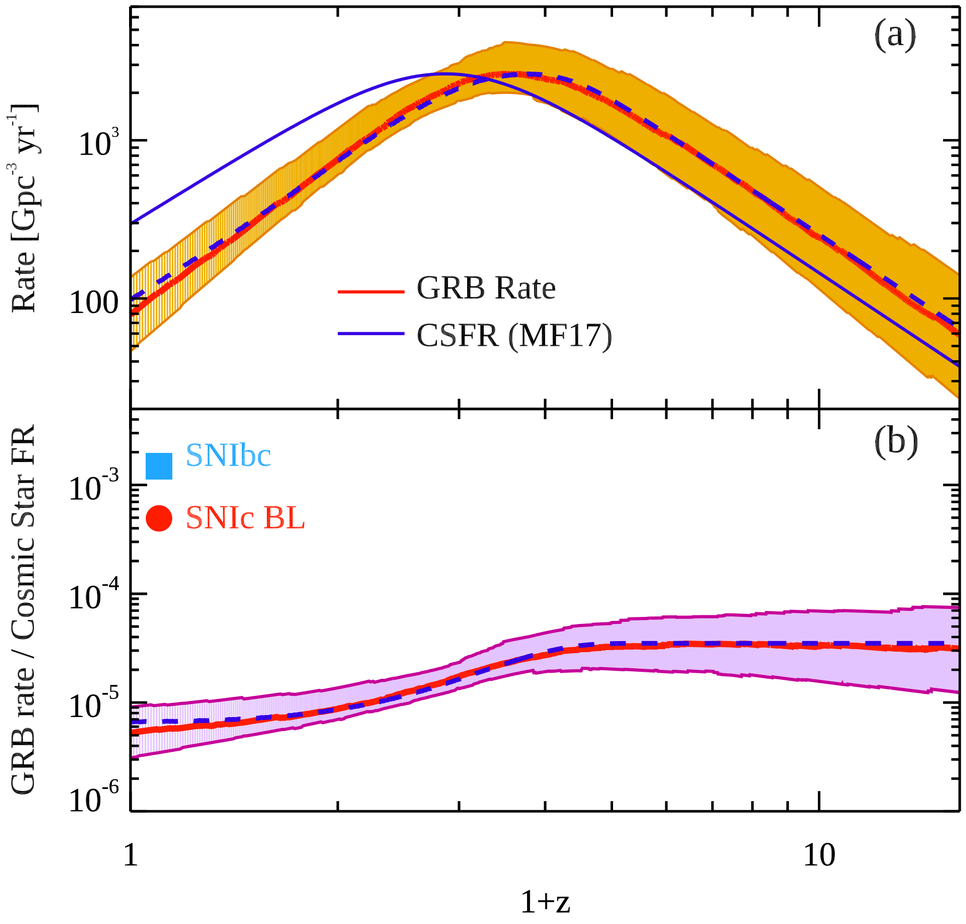
Applications to GW detector and THESEUS, CTAO, ASTRI, HERMES (and COSI in progress)

Short GRBs



Salafia et al., 2023, A&A, 680, 45

Long GRBs



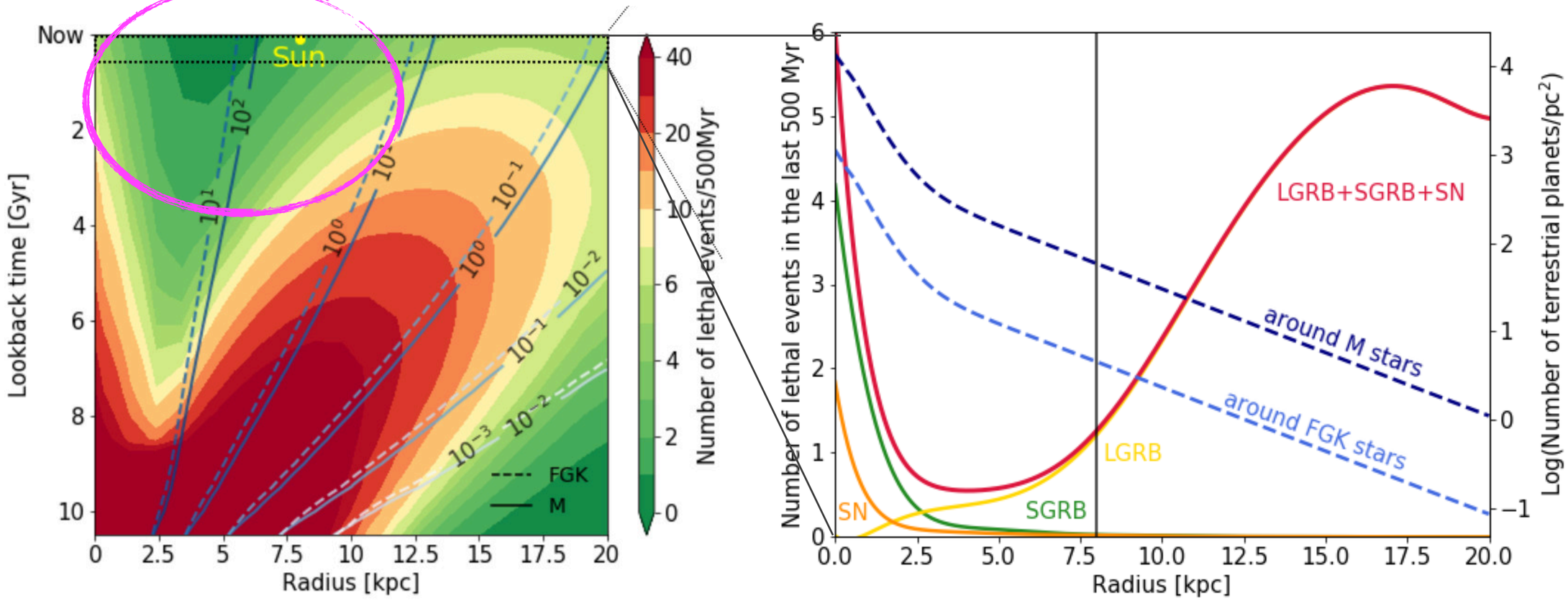
Ghirlanda & Salvaterra 2022, ApJ, 932, 10

@OAB

The Impact of GRBs on Exoplanetary Habitability

Galactic Habitable Zone (GHZ) and its evolution through cosmic times

Latest “green valley”



Spinelli, Ghirlanda et al., 2021, A&A, 647, 41

Review paper: Spinelli & Ghirlanda 2023

Machine Learning and GRBs in AGILE data

Development of AI models based on Deep Learning for GRB detection and localization using AGILE satellite data

- First approach: GRB detection and localization using tracker count maps (Parmiggiani, Bulgarelli, Fioretti et al., 2021, ApJ, 914, 67)
- Recent studies (Parmiggiani et al., 2023, ApJ, 945, 106; Parmiggiani et al., 2024, ApJ, 973, 63):
  - GRB detection from anti-coincidence system light curves
  - Anomaly detection and background estimation driven by satellite orbital parameters

Involvement in international projects

FACILITIES

- Swift
- CTAO
- MAGIC
- ASTRI
- SOX
- LSST
- Einstein Probe
- Einstein Telescope
- COSI
- NewAthena
- THESEUS
- eXTP
- HERMES
- COSI

COLLABORATIONS/PROPOSALS FOR FOLLOW UP

- Stargate
- CIBO
- GRAWITA
- ENGRAVE
- Radio
- VHE

prossimo congresso nazionale?