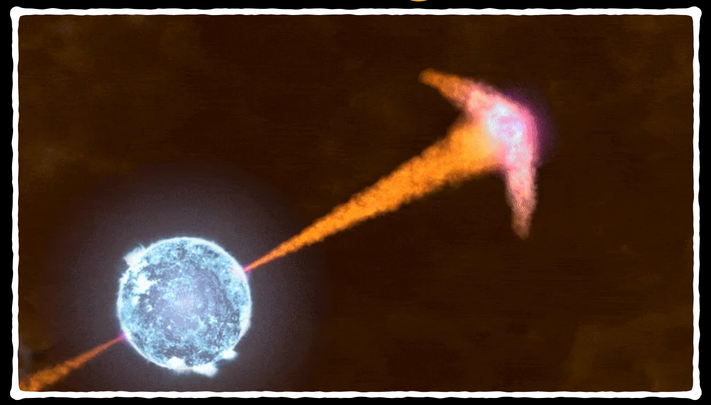
INAF
ISTITUTO NAZIONALE
DI ASTROFISICA

Measuring the expansion of GRB afterglows

with the (fundamental) help of
O. S. Salafia, B. Marcote, M. Giroletti, G. Ghirlanda, L. Nava,
T. Venturi[2], T. An[4], X. Wu and many more...

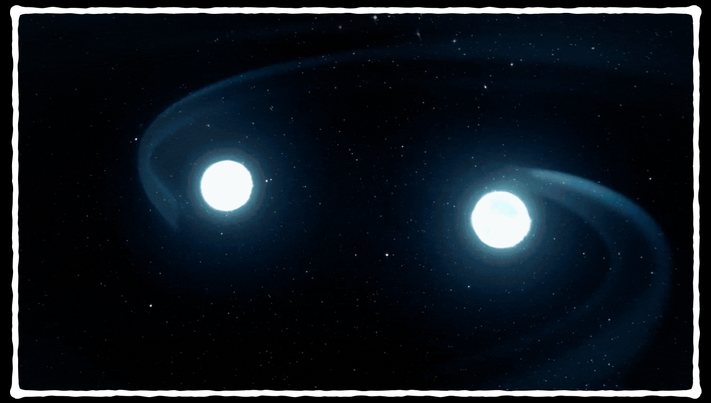
Gamma-Ray Bursts

Long

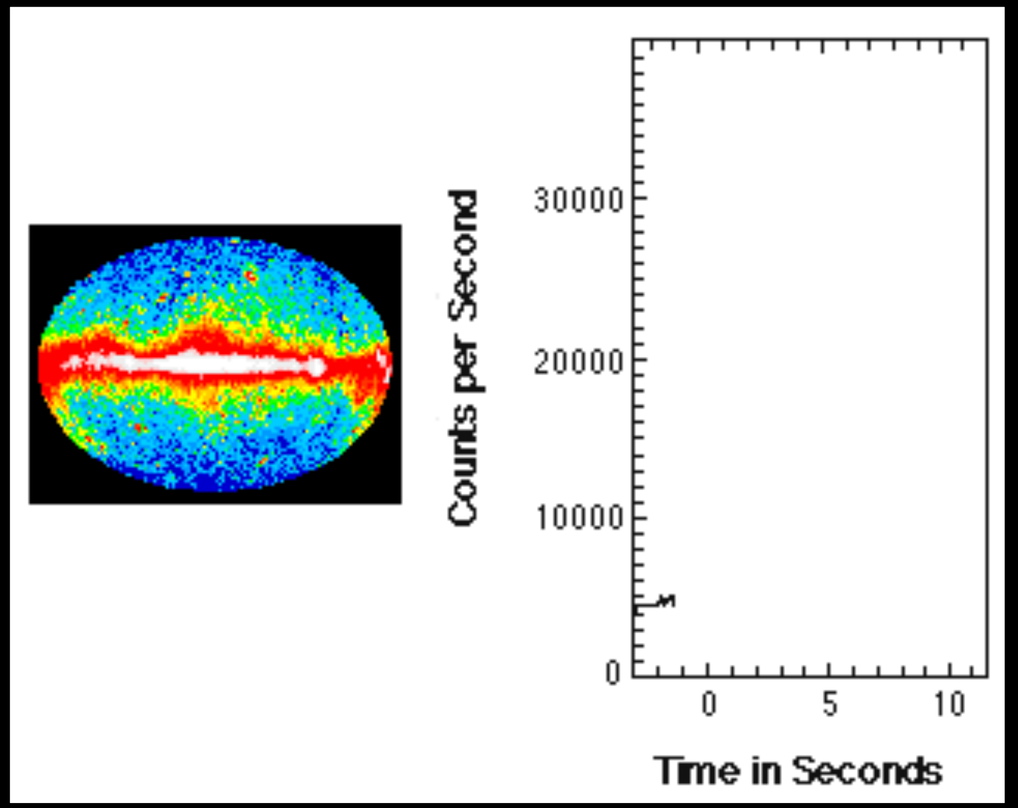


Credits: NASA's Goddard Space Flight Center

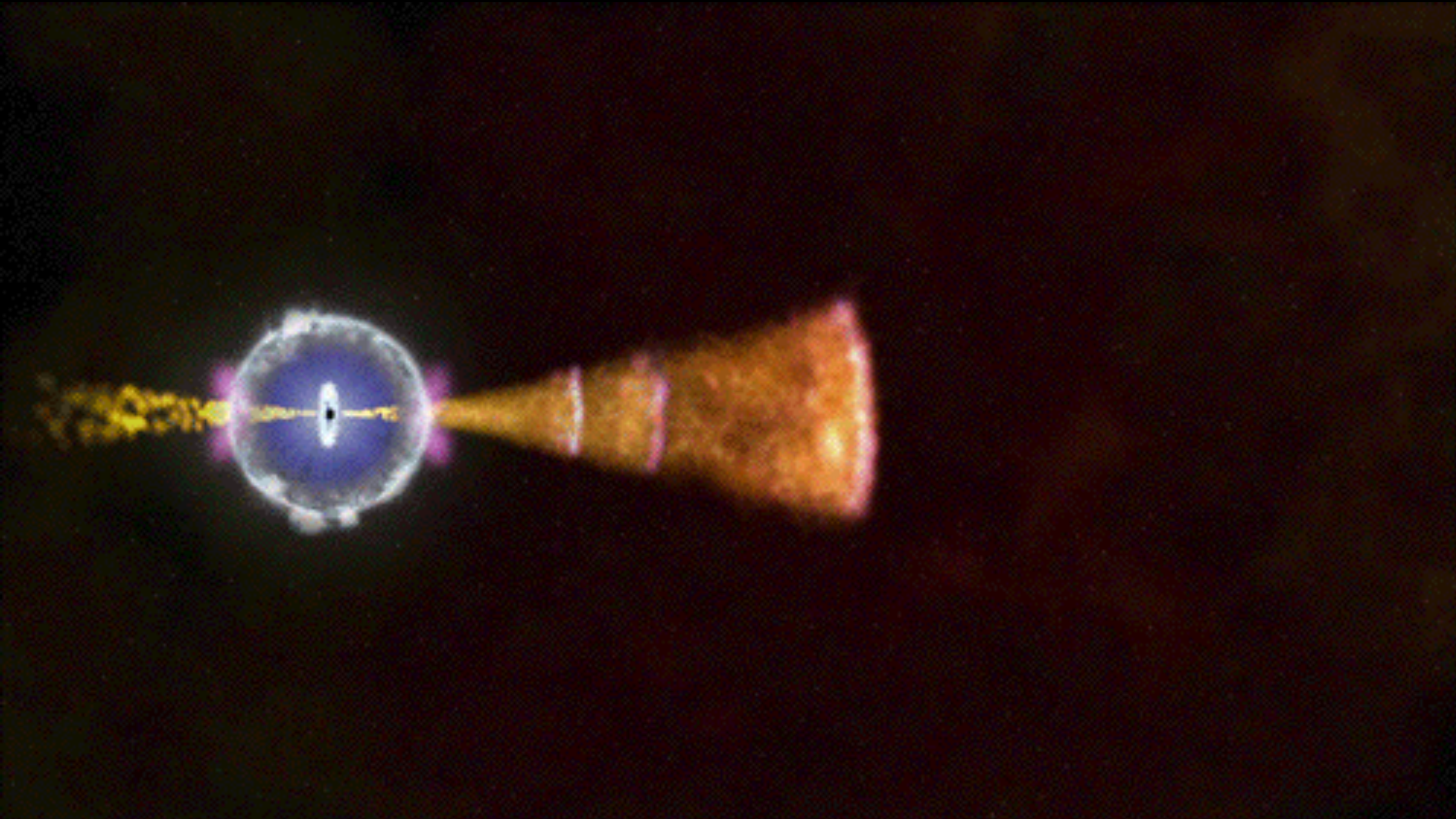
Short



Credits: NASA's Goddard Space Flight Center/CI Lab



A GRB detected by *BATSE* on-board the Compton Gamma-Ray Observatory

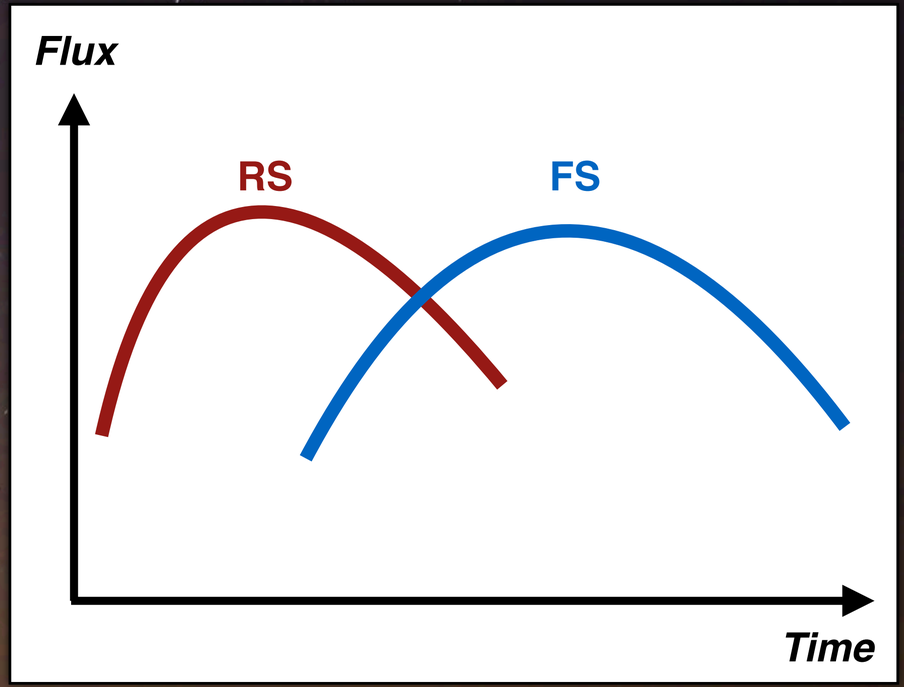


Credits: Sergio Poppi (Inaf Cagliari)

GRBs in Radio

Emission mechanism

Forward vs Reverse shocks



Credits: Sergio Poppi (Inaf Cagliari)

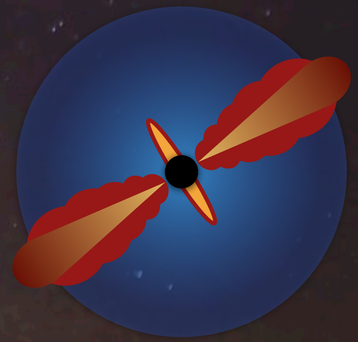
GRBs in Radio

Geometry

Viewing angle

Collimation angle

Size and structure

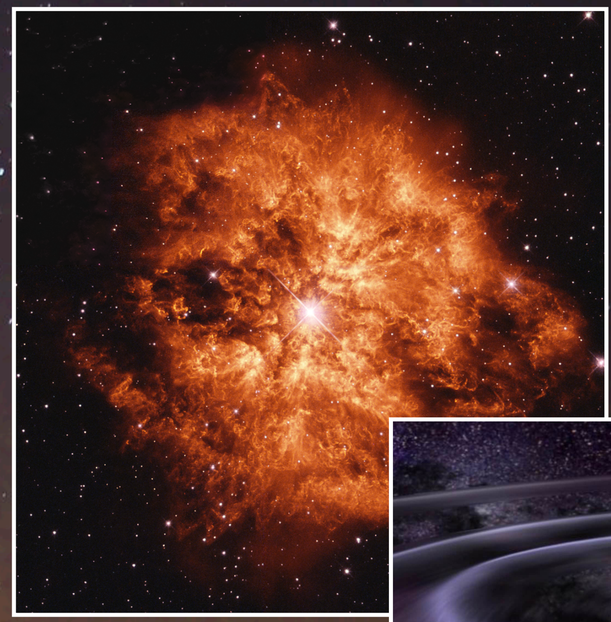


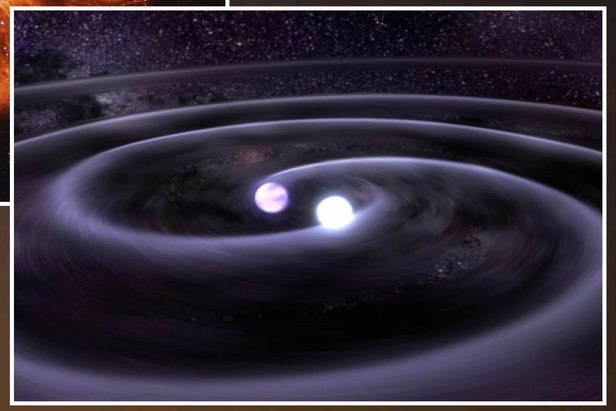
Credits: Sergio Poppi (Inaf Cagliari)

GRBs in Radio

Progenitors

Circum-burst density profile





Very Long Baseline Interferometry

The European VLBI Network


Lovell


eMERLIN


WSRT


Onsala


Metsahovi


Irbene


Torun


Effelsberg


Yebes


SRT


Noto

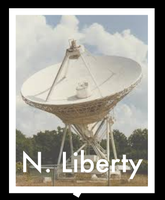

Medicina

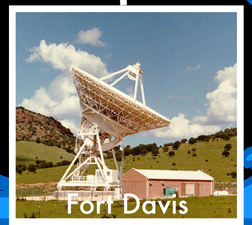

Hart


Urumqi

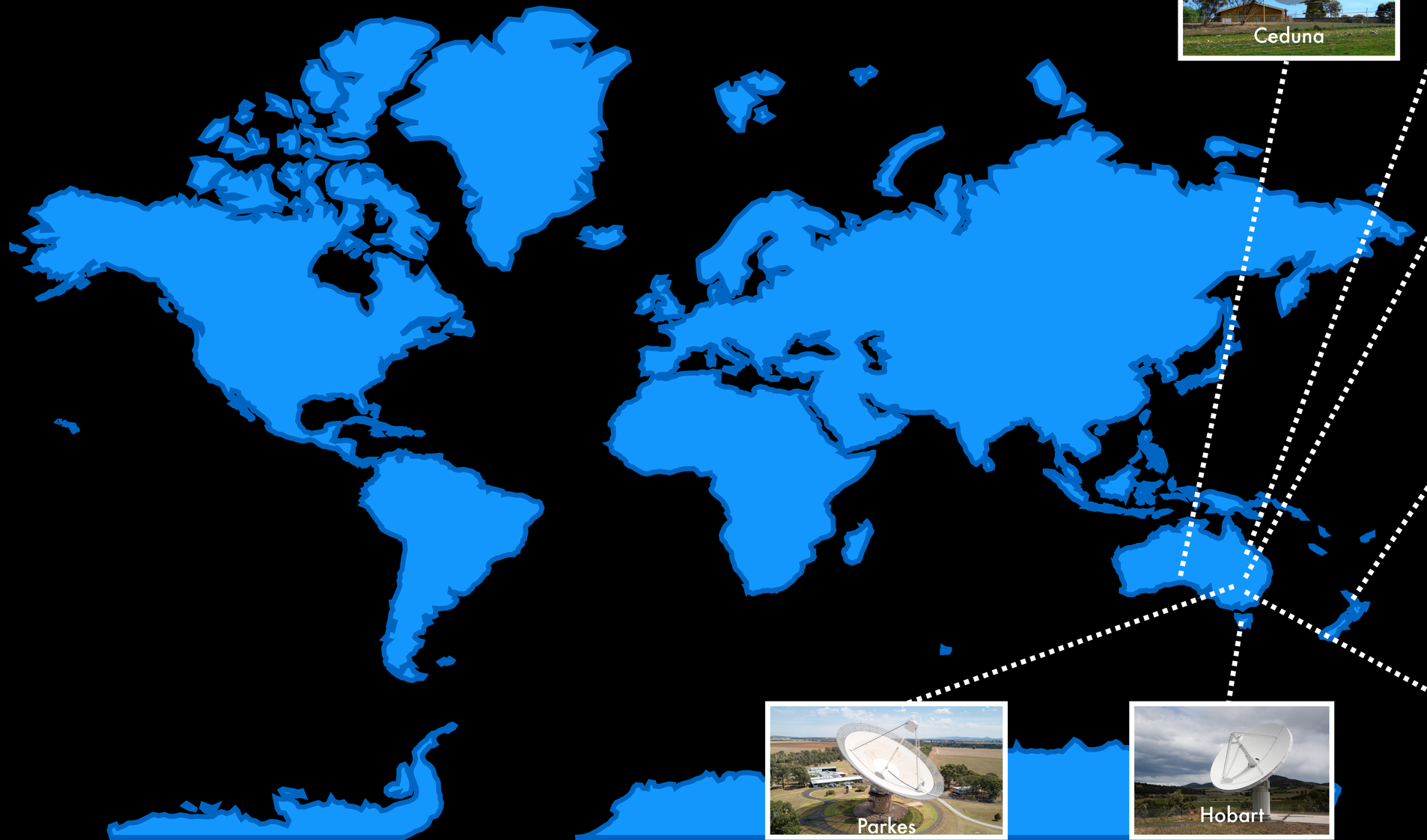

Tianma

The Very Long Baseline Array



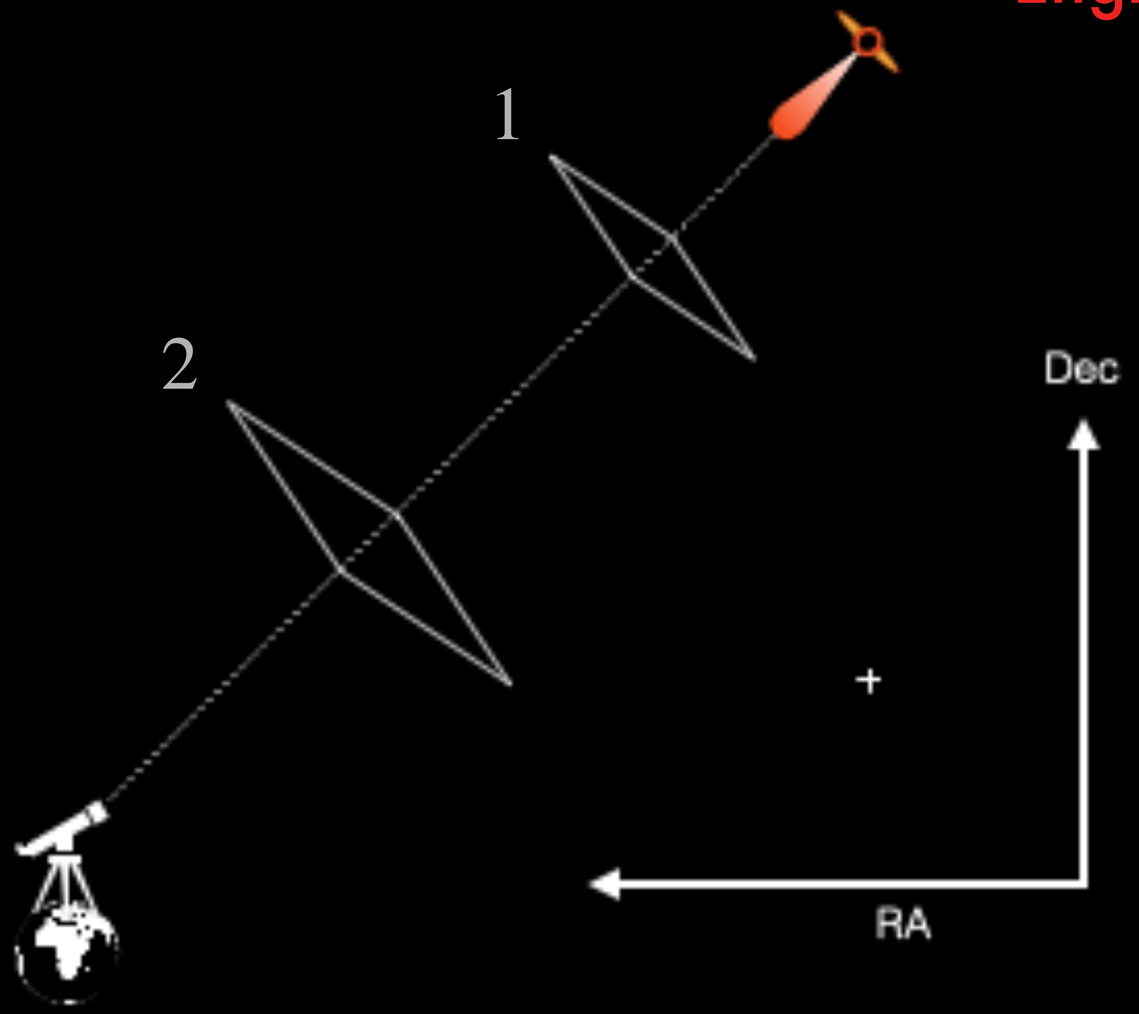


The Long Baseline Array



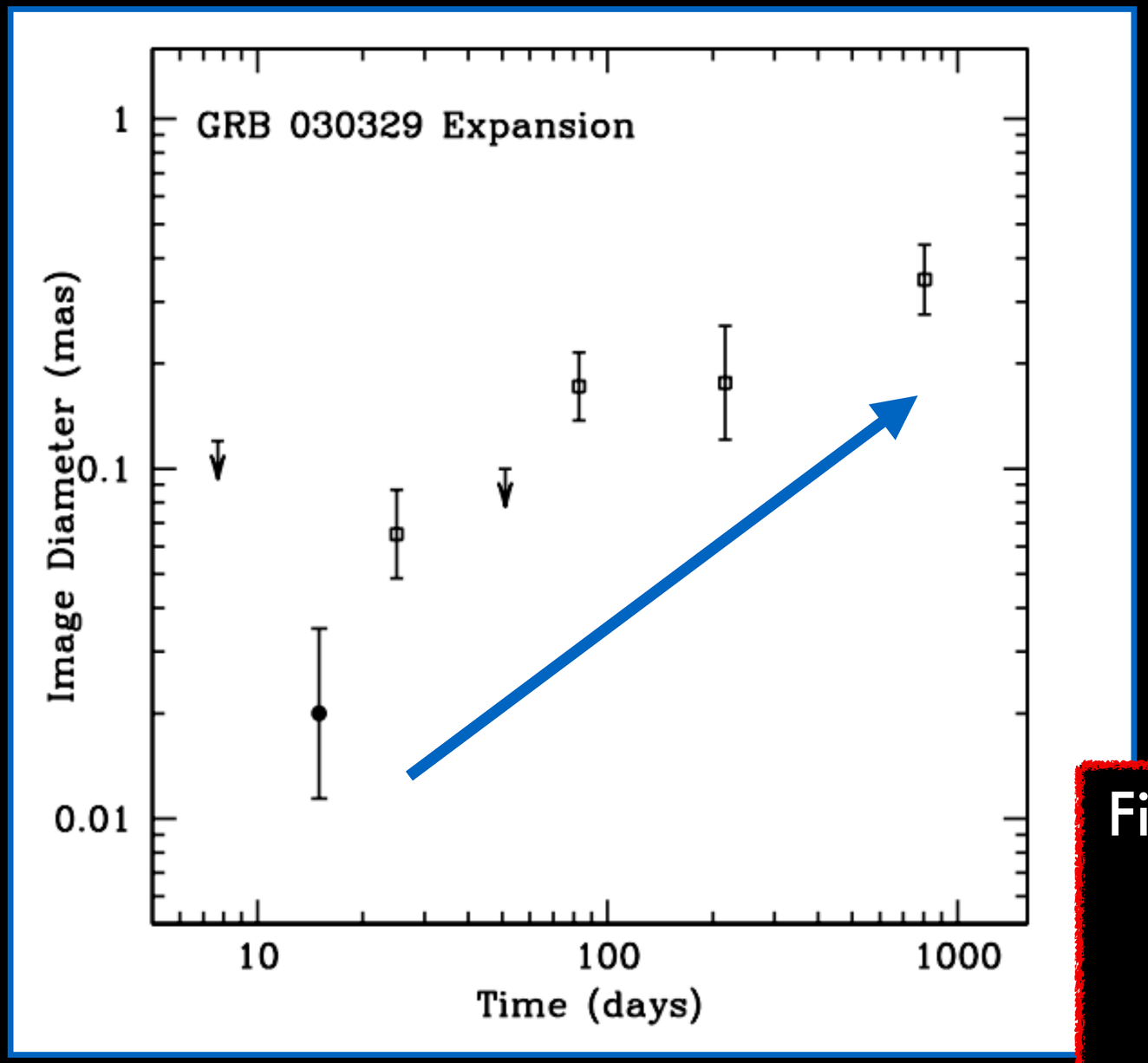
On-axis GRBs

Central Engine



Observer

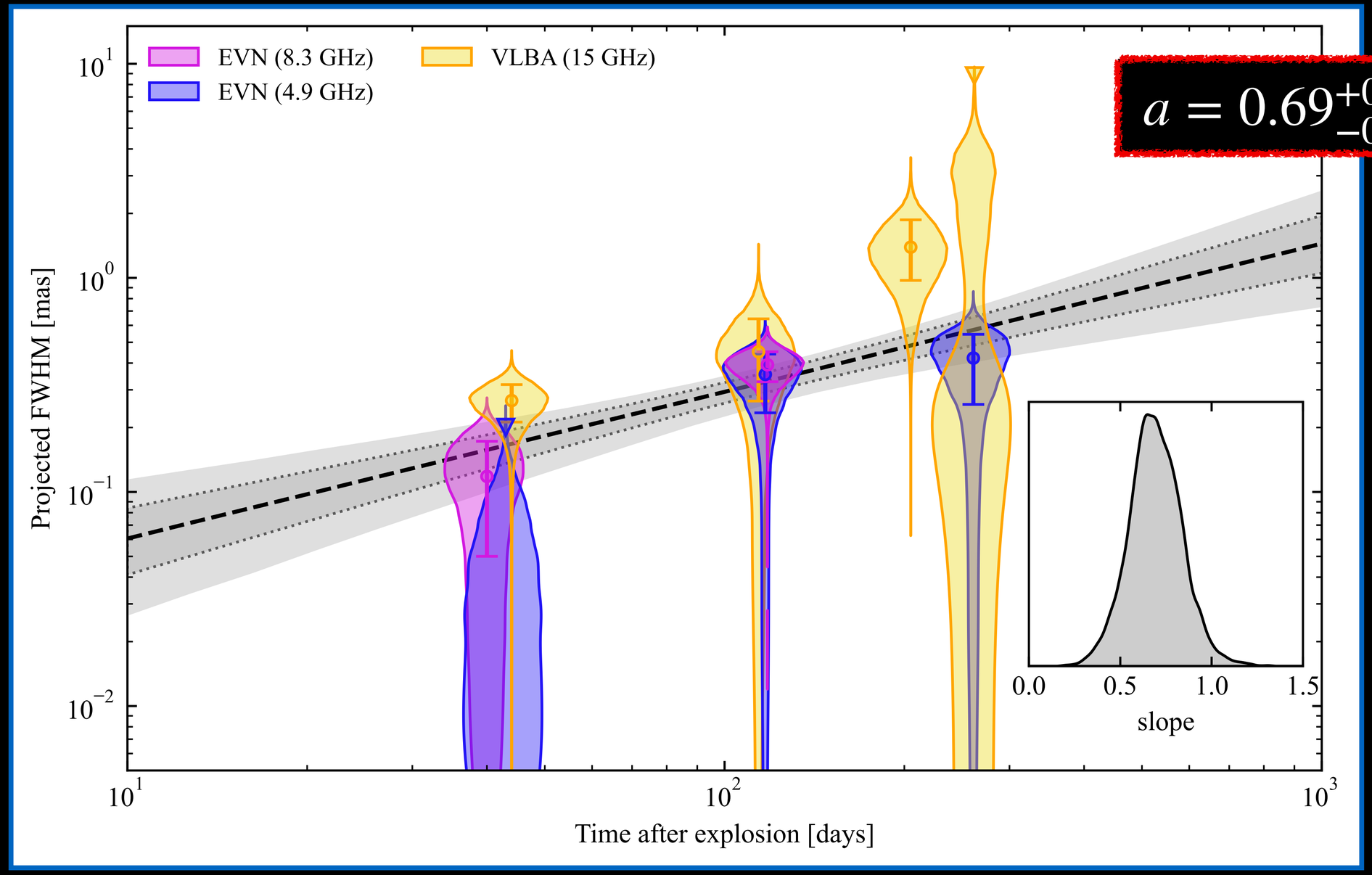
GRB 030329



From *Pihlström et al. (2007)*

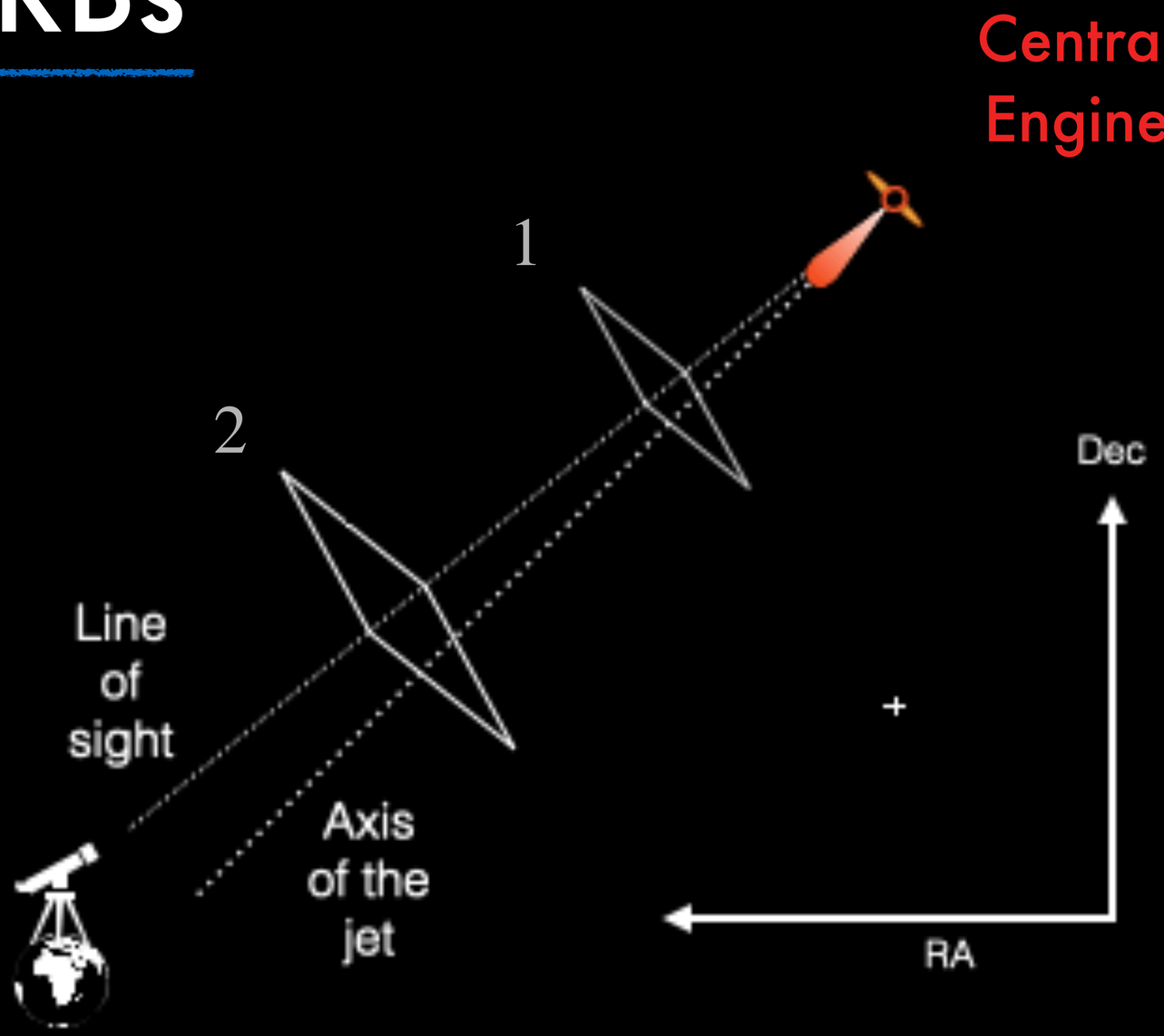
First direct proof of (apparent) superluminal expansion

GRB 221009A

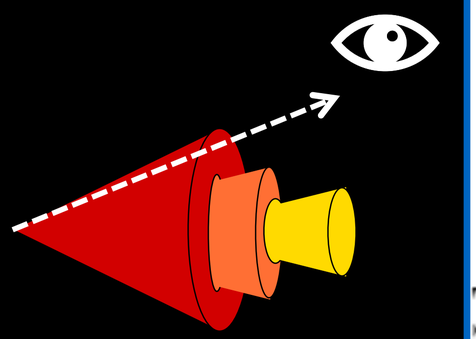


From *Giarratana et al. (2024)*

Off-axis GRBs

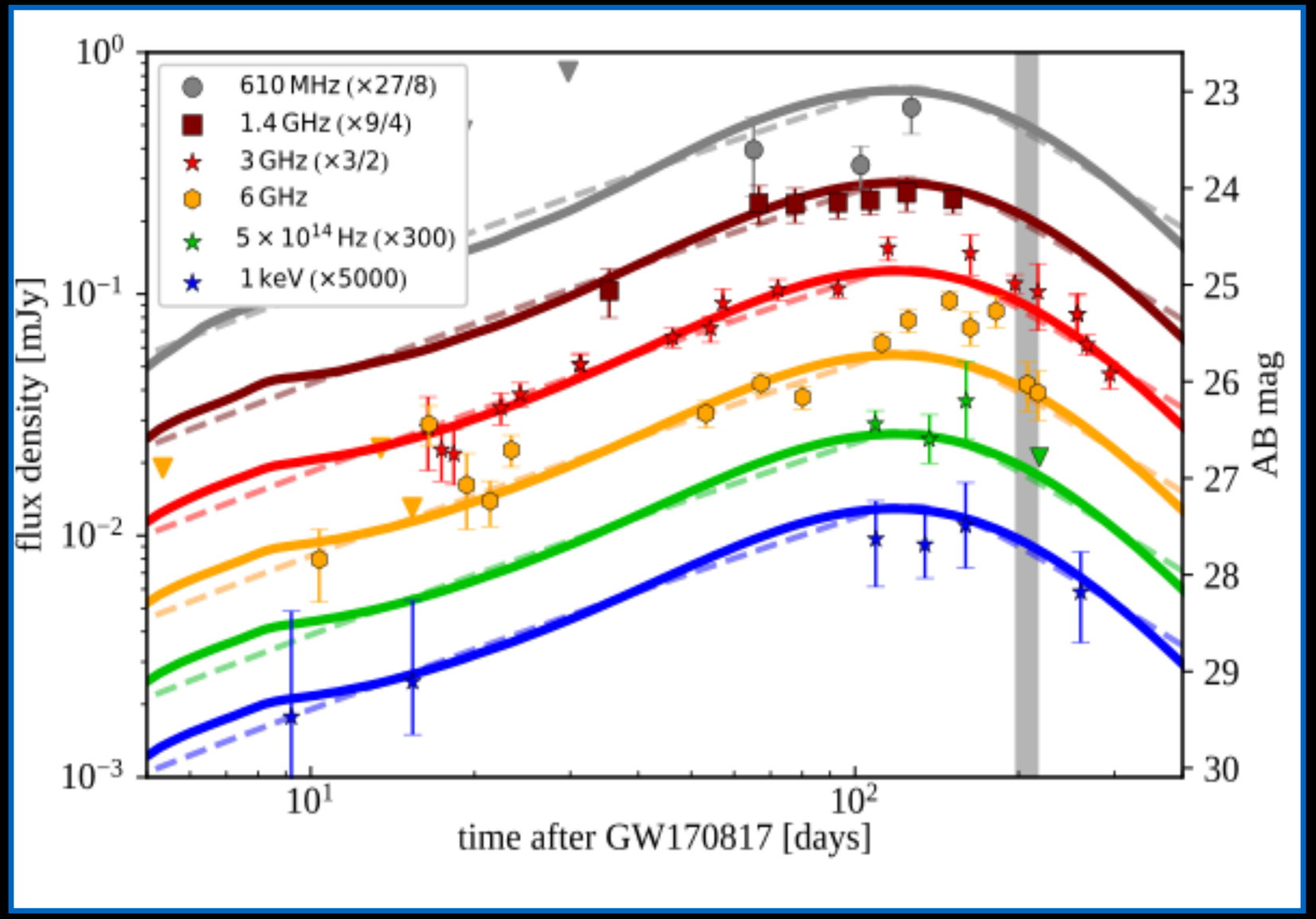


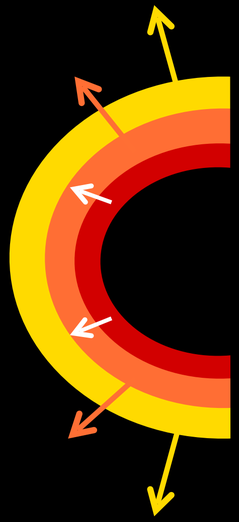
GRB 170817A



$\Gamma_1 < \Gamma_2 < \Gamma_3$

$E_1 < E_2 < E_3$



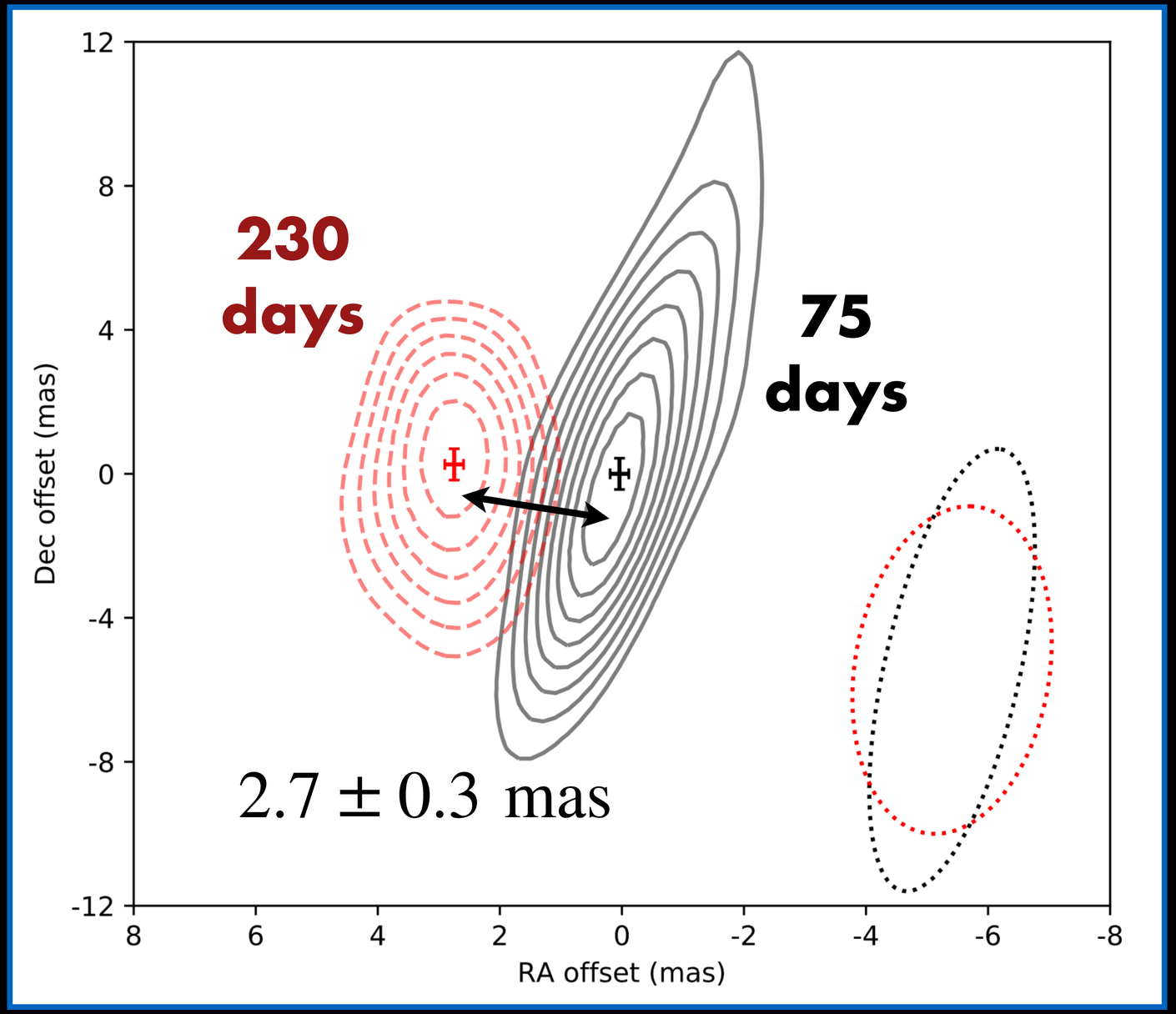


$\Gamma_1 < \Gamma_2 < \Gamma_3$

$E_1 > E_2 > E_3$

From *Ghirlanda et al. (2019)*

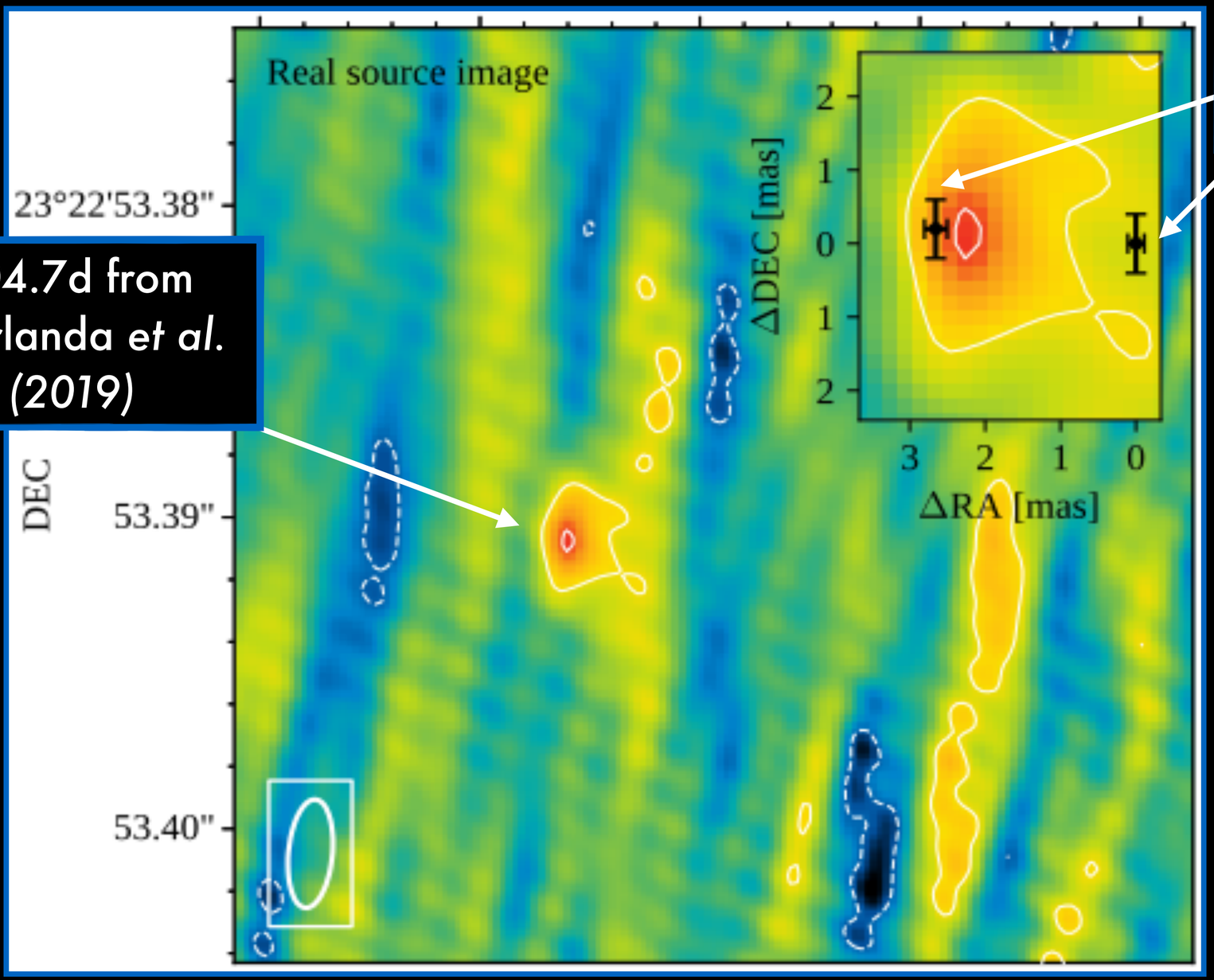
GRB 170817A



A (slightly) off-axis GRB

From *Mooley et al. (2018)*

GRB 170817A



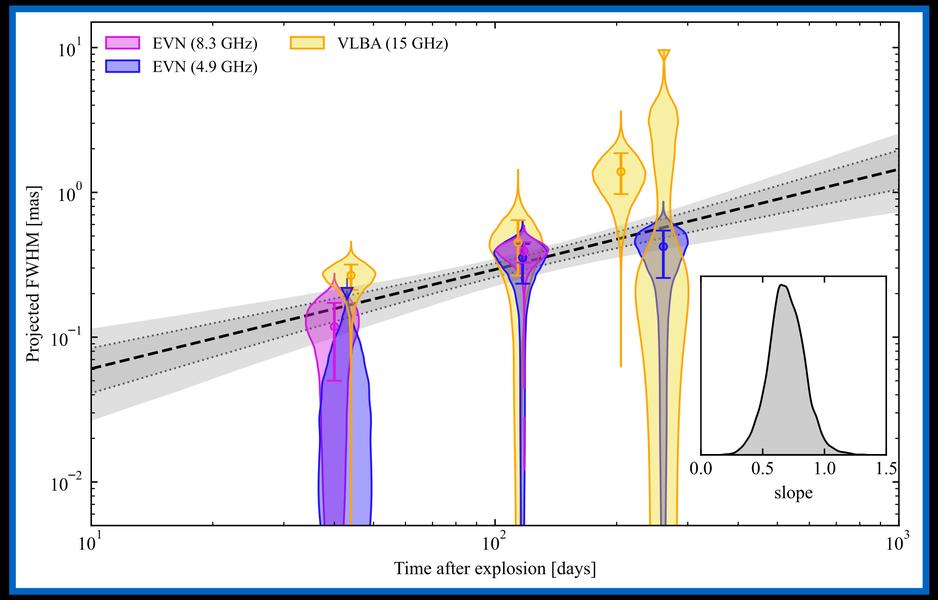
204.7d from Ghirlanda *et al.* (2019)

75d & 230d from Mooley *et al.* (2018)

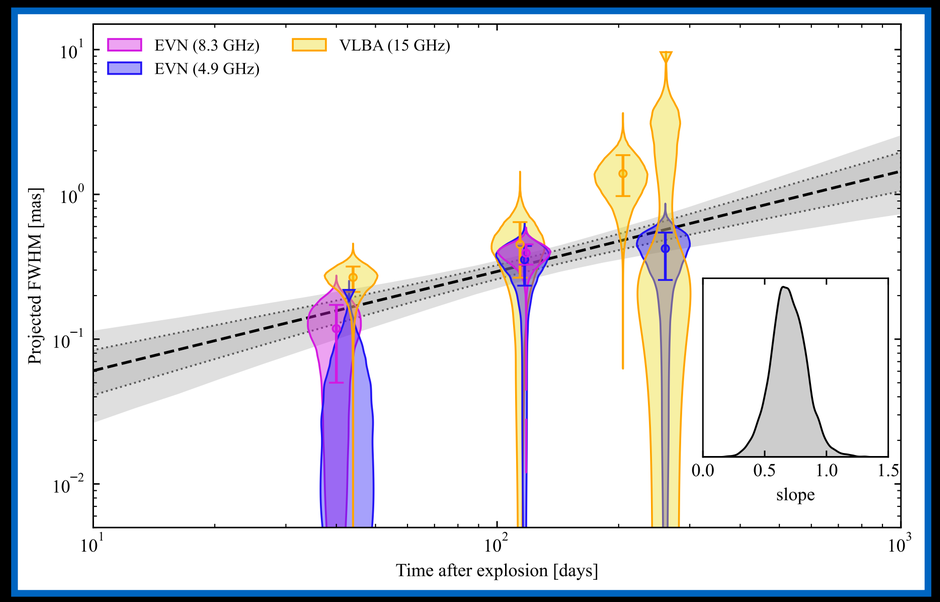
First proof of successful jet from a BNS merger

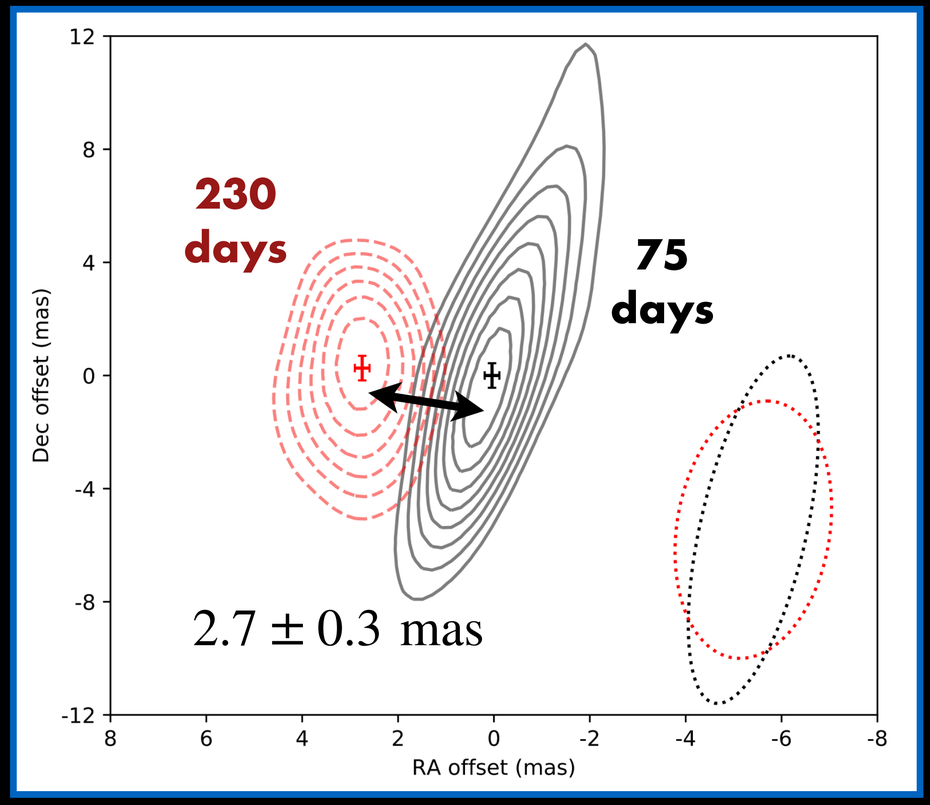
From *Ghirlanda et al. (2019)*

(some) Conclusions

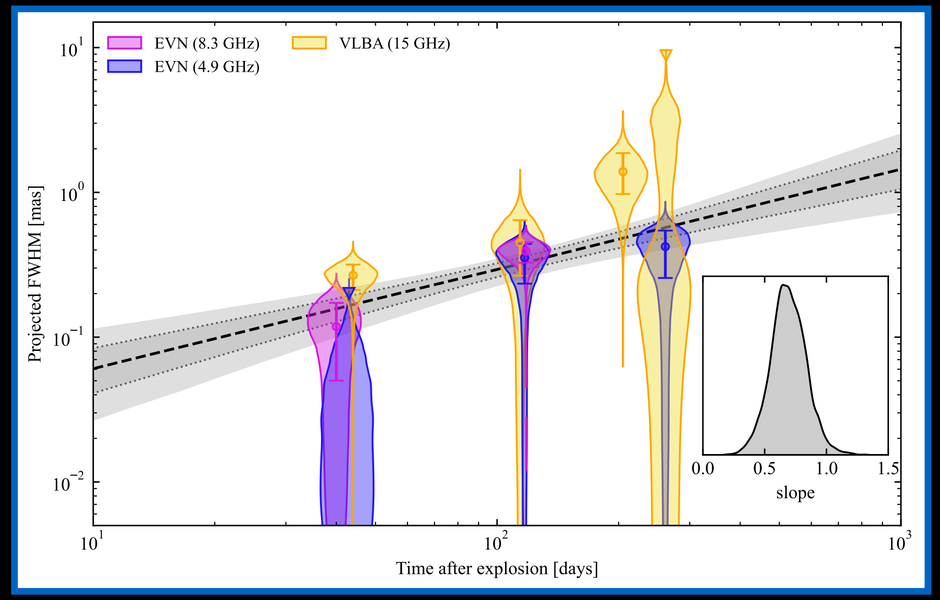


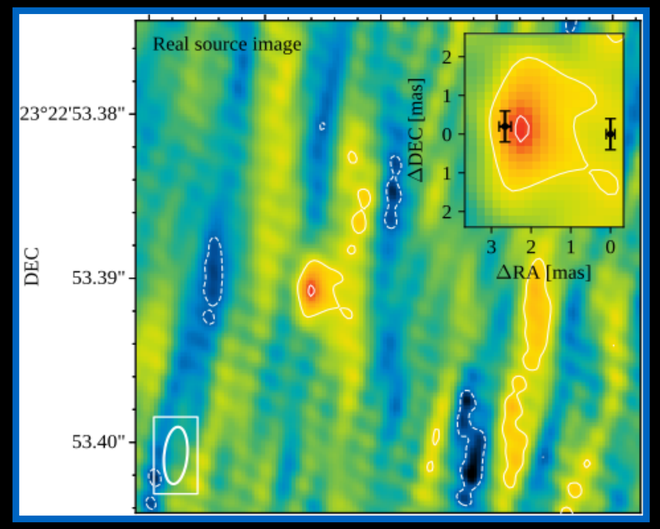
(some) Conclusions

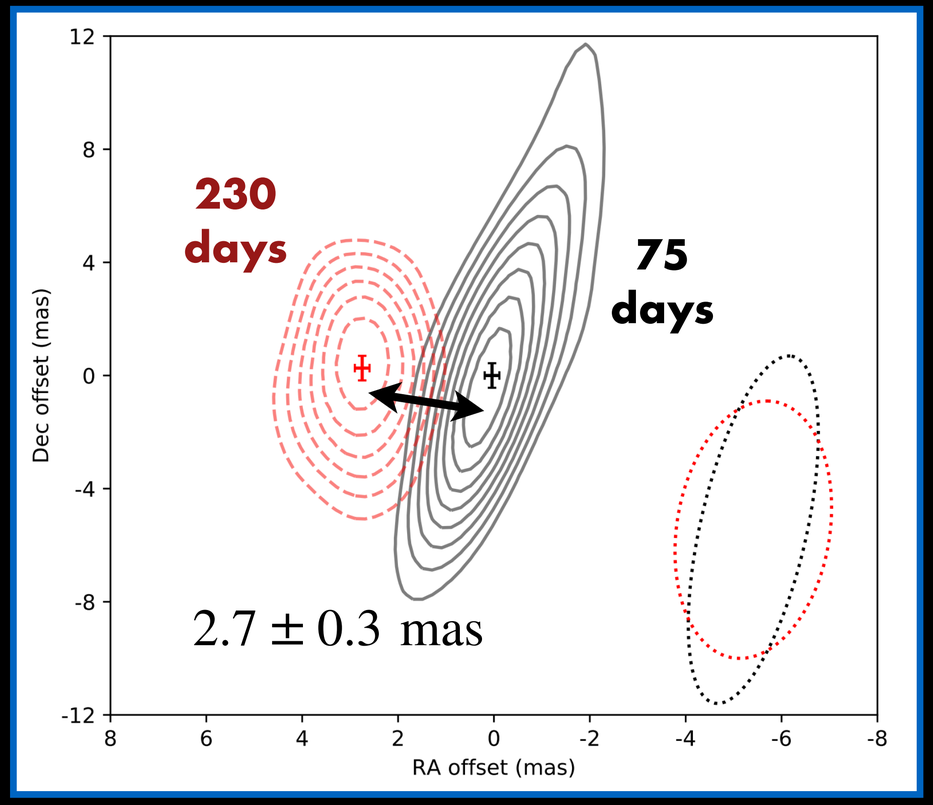




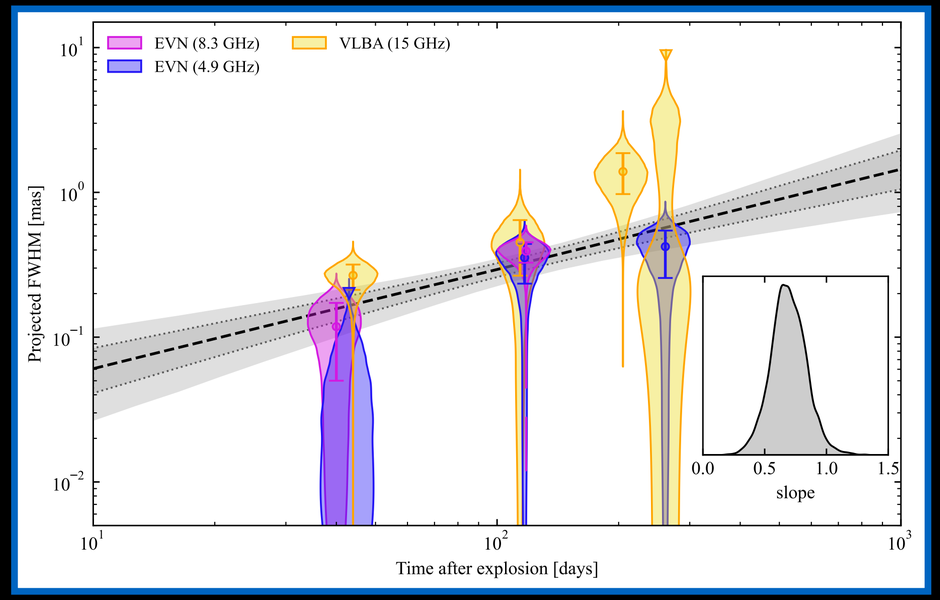
(some) Conclusions

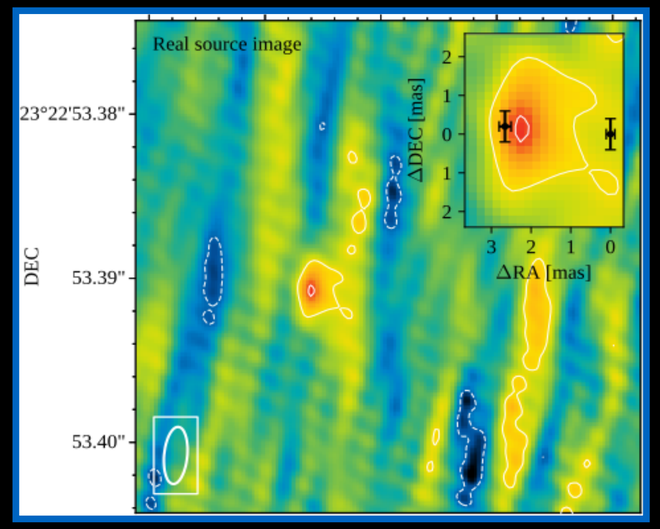


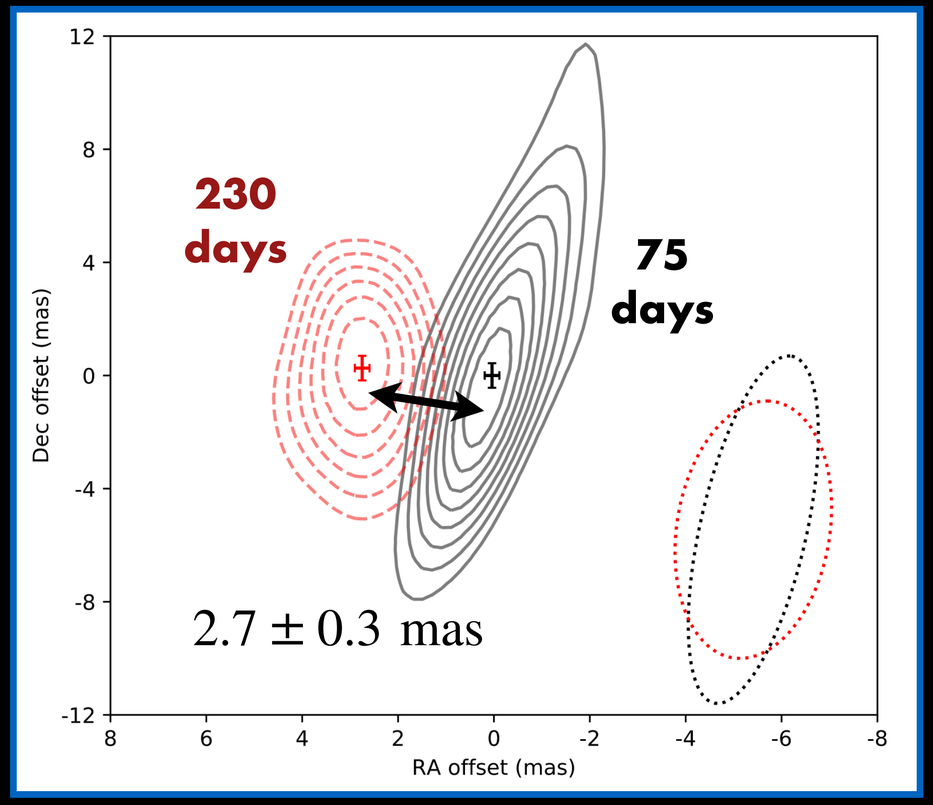




(some) Conclusions







Thank you!

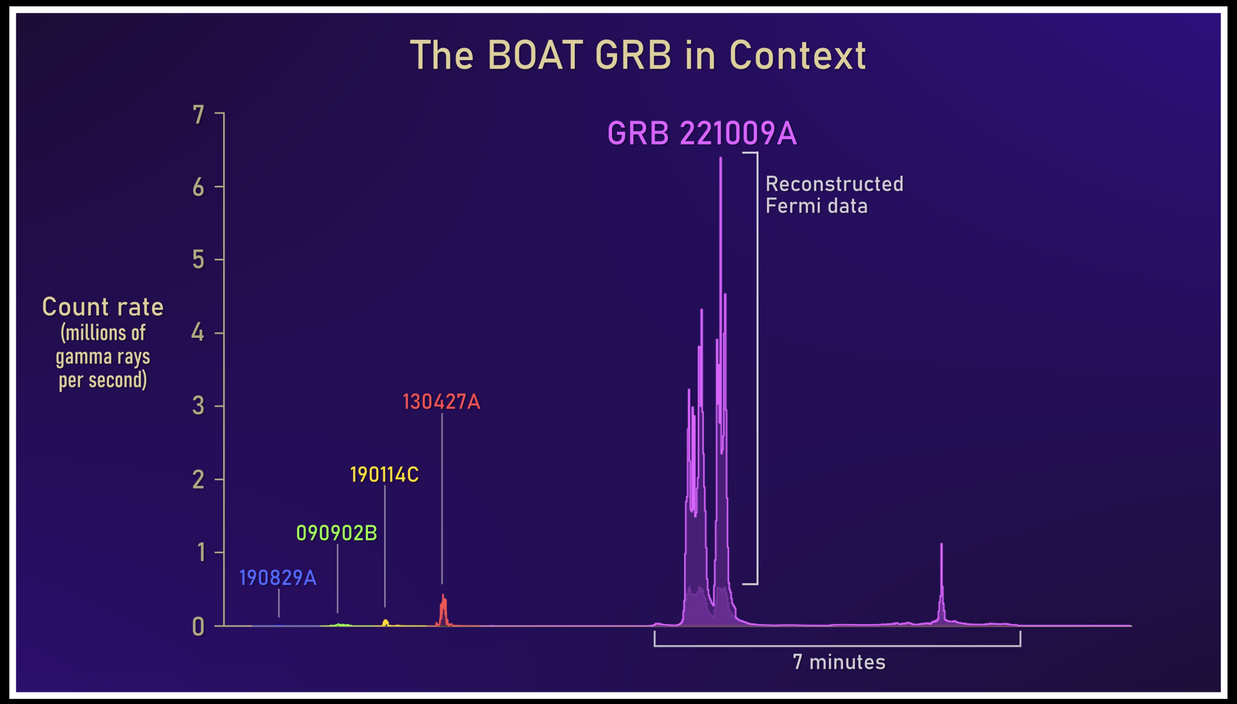
Backup Slides

GRB 221009A

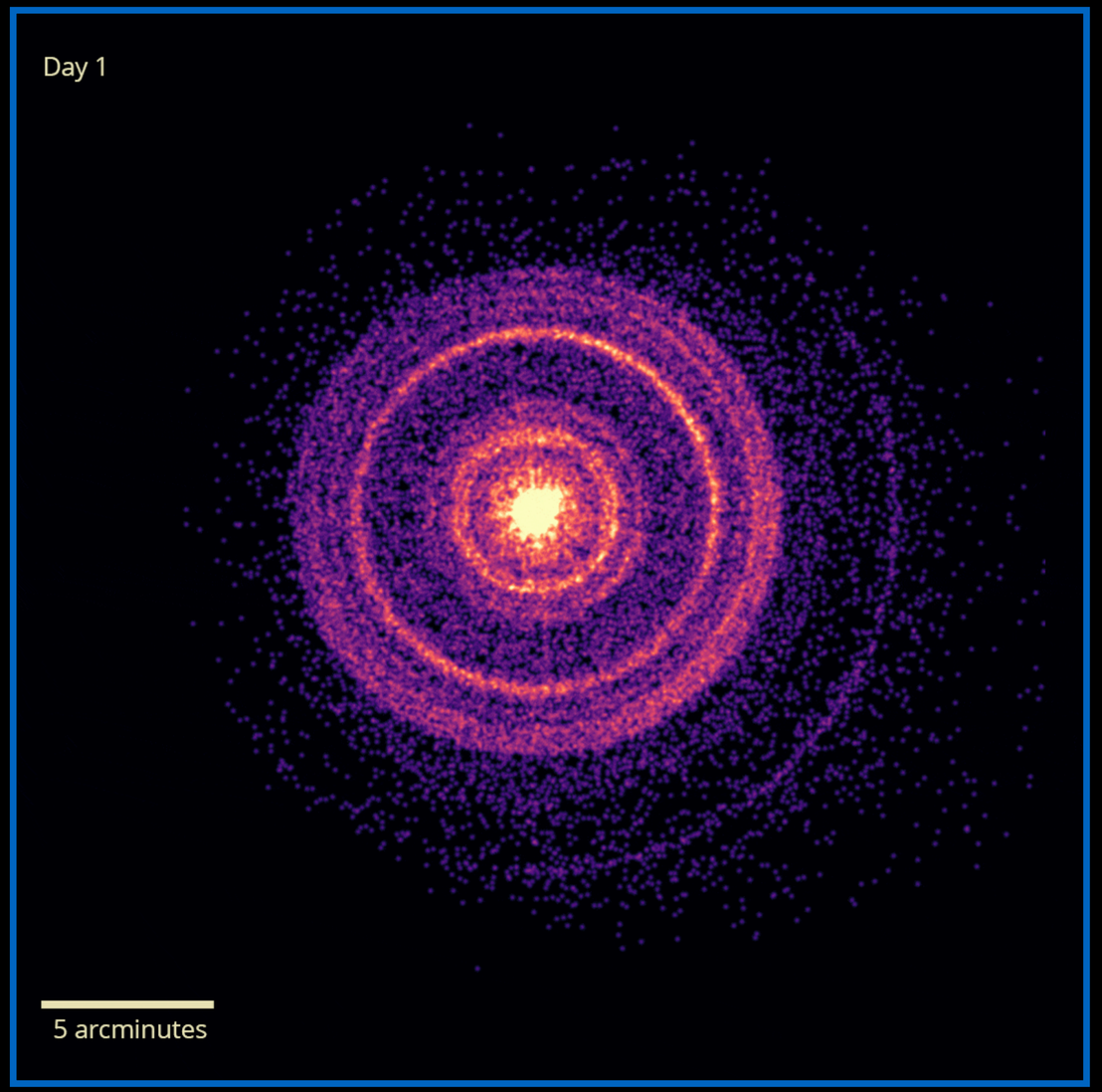
$E_{iso} \simeq 3 \times 10^{54}$ erg

$z = 0.151$

$R = 1/10000\, yr^{-1}$



Credit: NASA's Goddard Space Flight Center and Adam Goldstein (USRA)



Credit: NASA/Swift/A. Beardmore (Univ of Leicester)

GRB 221009A: ISM vs wind-like?*

ISM

Post jet-break:
$a = 1/4$

Lateral spreading:
$a \sim 0.7$

No jet break:
$a = 0.625$

Structured jet

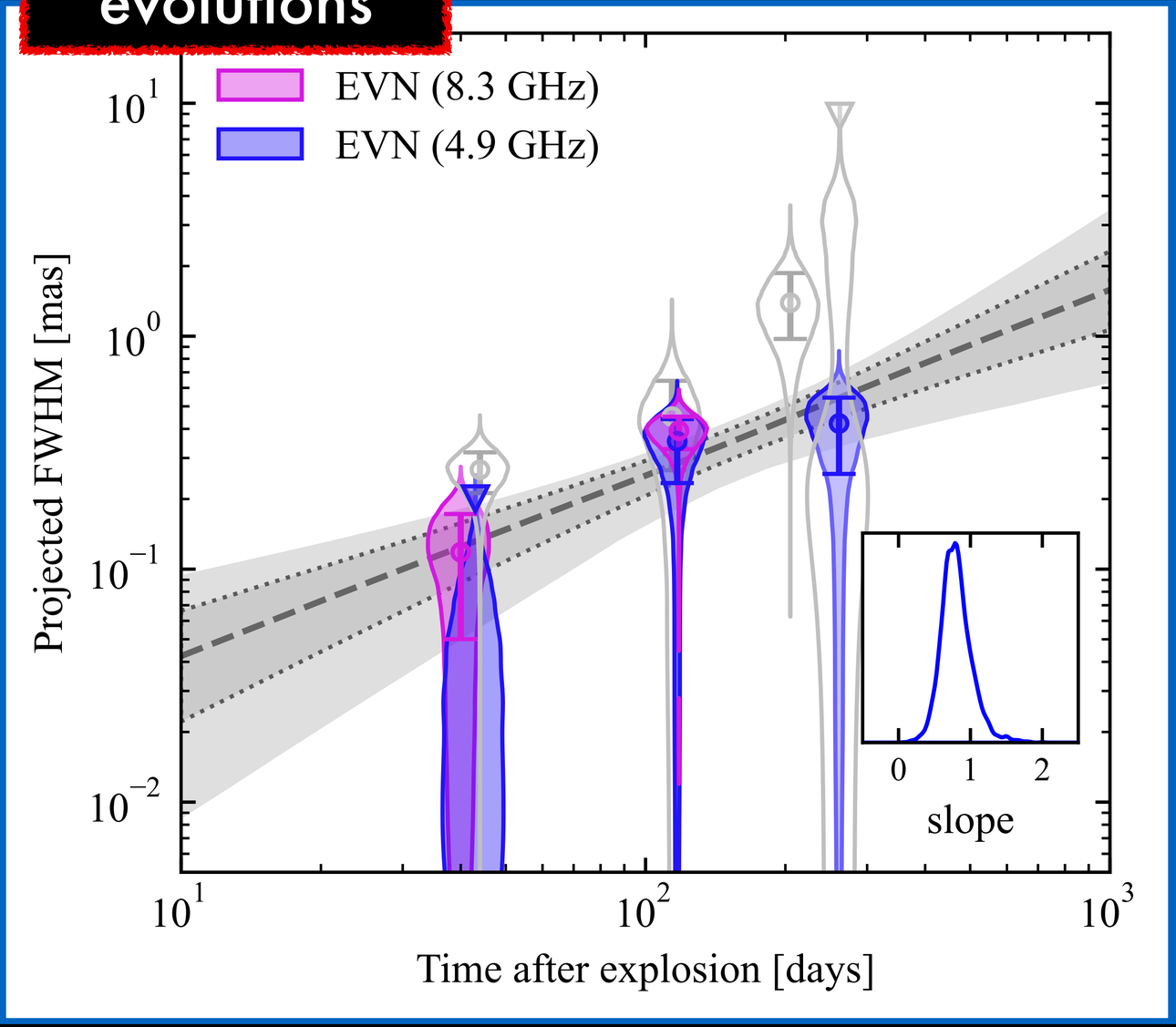
Wind

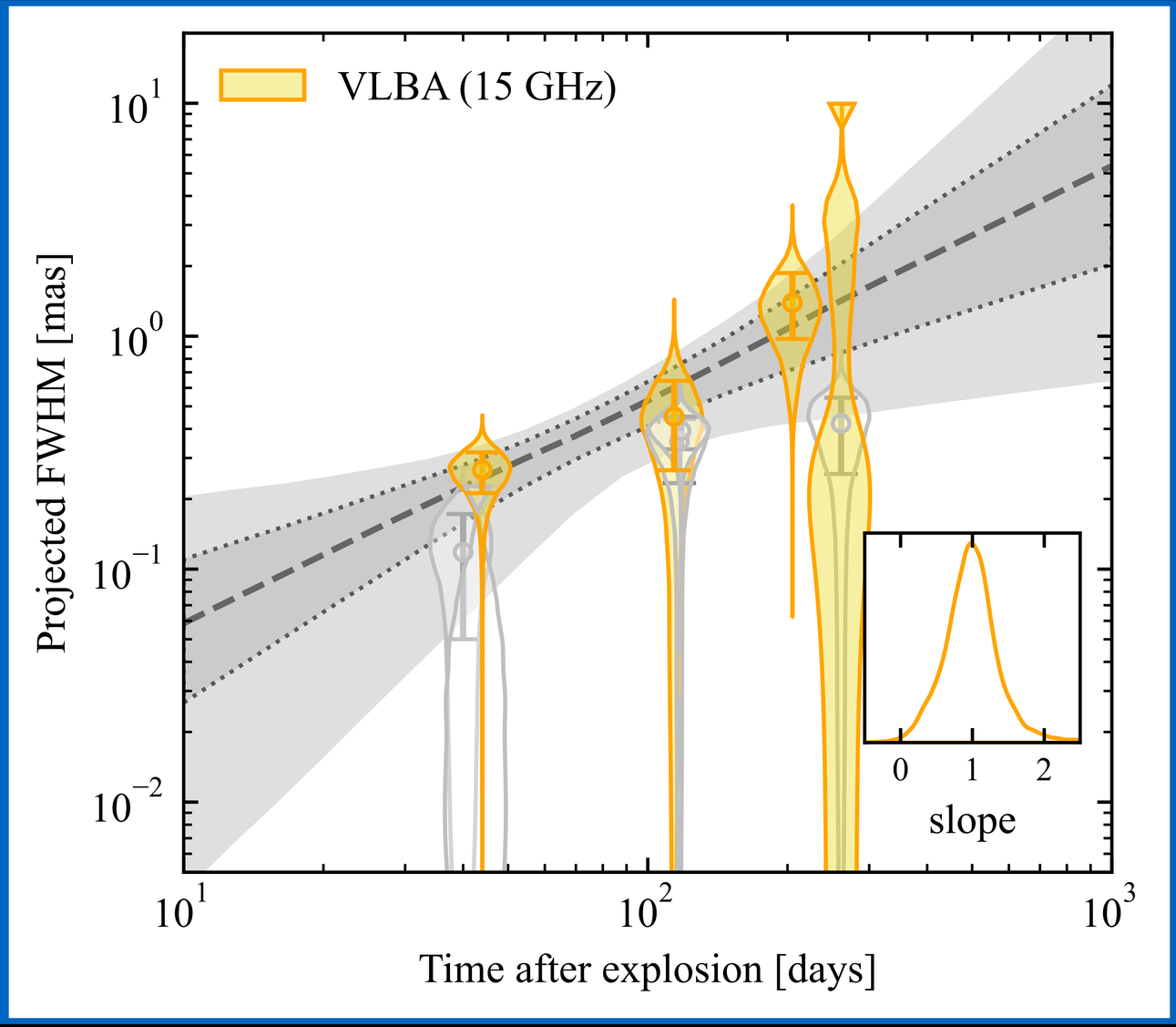
Post jet-break:
$a = 1/2$

* *Blandford & McKee (1976)* blastwave

Forward vs Reverse shocks?

Hint for different size evolutions

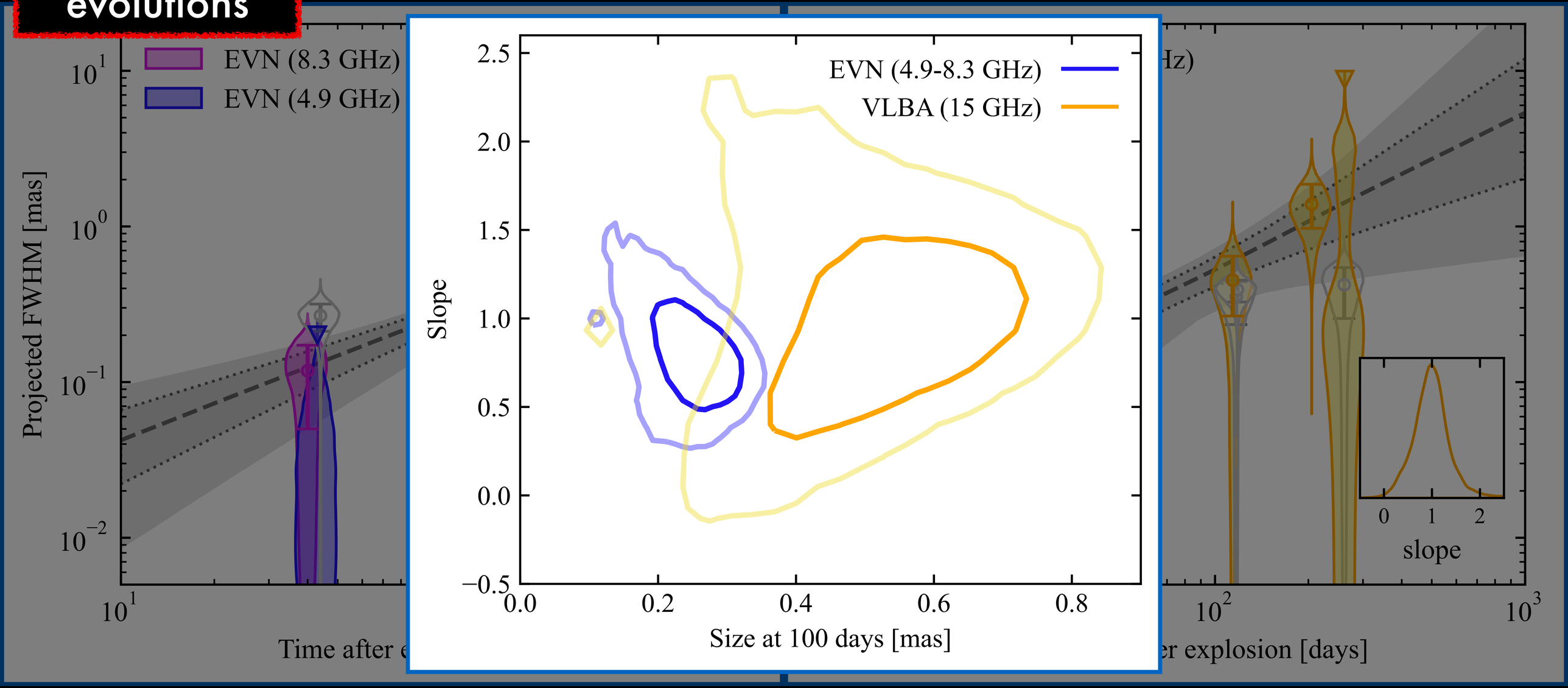




From *Giarratana et al. (2024)*

Forward vs Reverse shocks?

Hint for different size evolutions

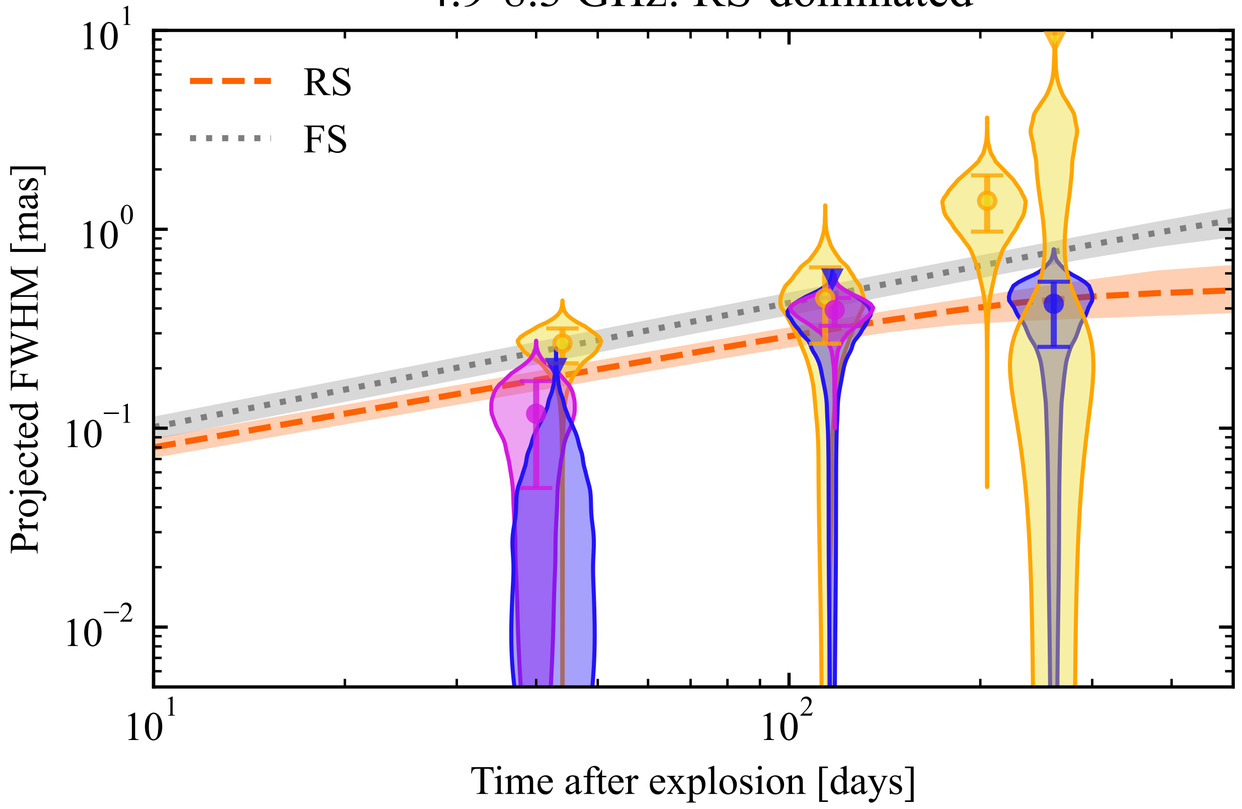


From *Giarratana et al. (2024)*

GRB 221009A

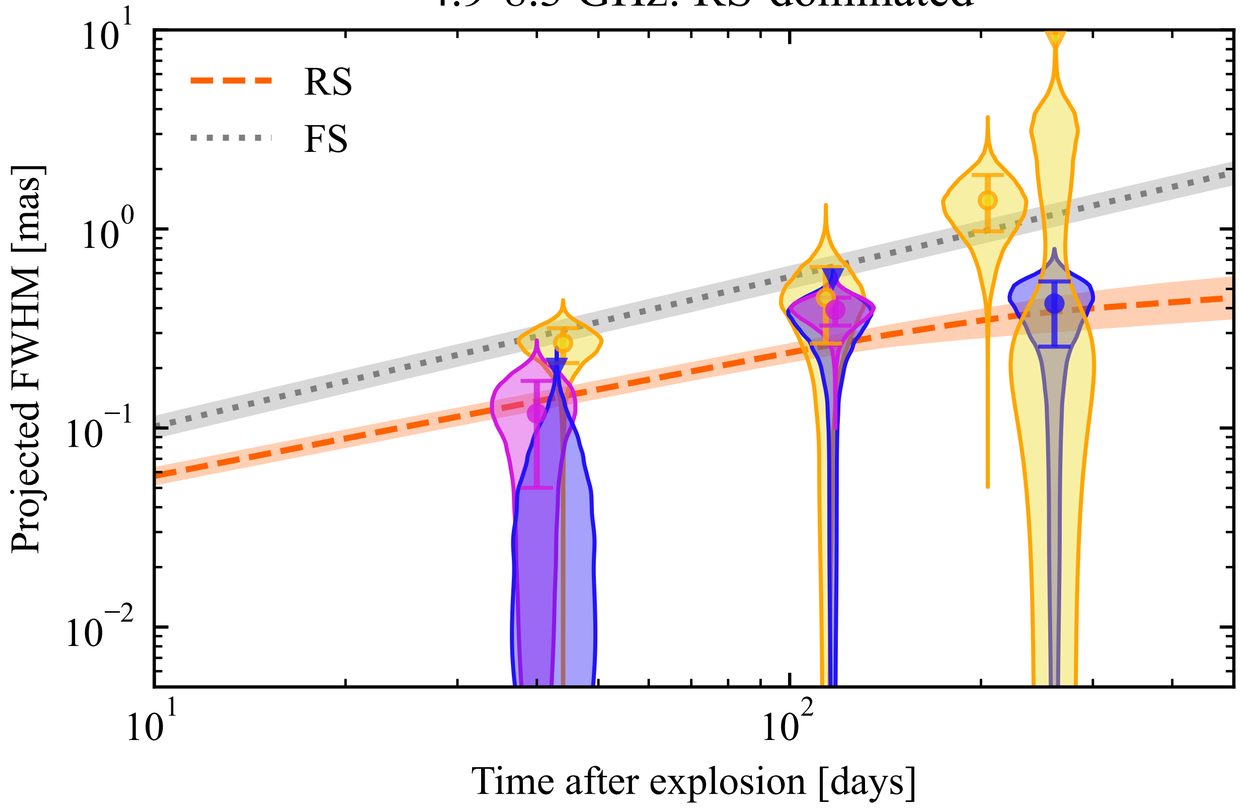
ISM

15 GHz: FS-dominated
4.9-8.3 GHz: RS-dominated



Wind

15 GHz: FS-dominated
4.9-8.3 GHz: RS-dominated

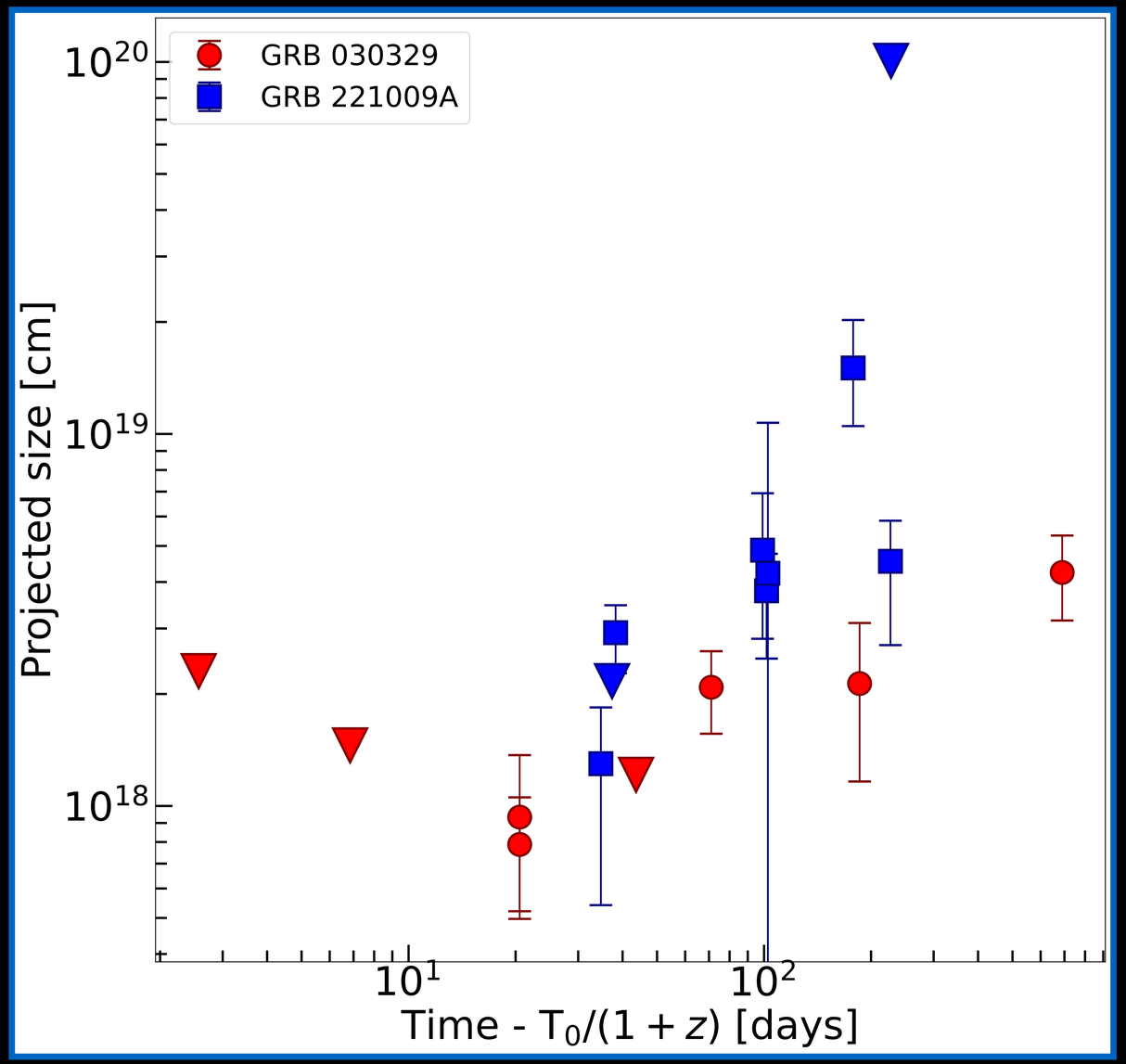


$E/A \simeq 10^{57}$ erg cm^3
$\theta_j \simeq 21^\circ$

Model size evolution in a FS + RS scenario.
From *Giarratana et al. (2024)*

$E/A \simeq 10^{55}$ erg cm^3
$\theta_j \simeq 23^\circ$

GRB 221009A



Size evolution of GRB 221009A and GRB 030329.
From *Giarratana et al. (in press)*