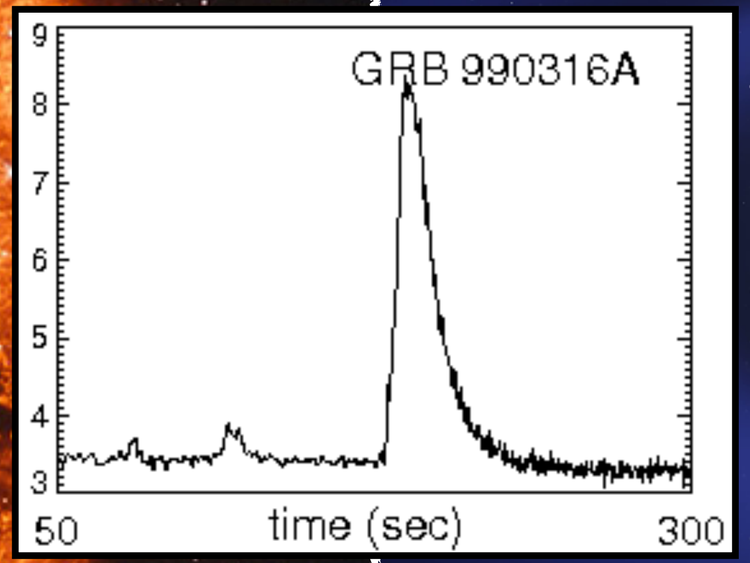
INAF
ISTITUTO NAZIONALE
DI ASTROFISICA

GRBs in the radio sky

the role of the SKA+VLBI

GRBs

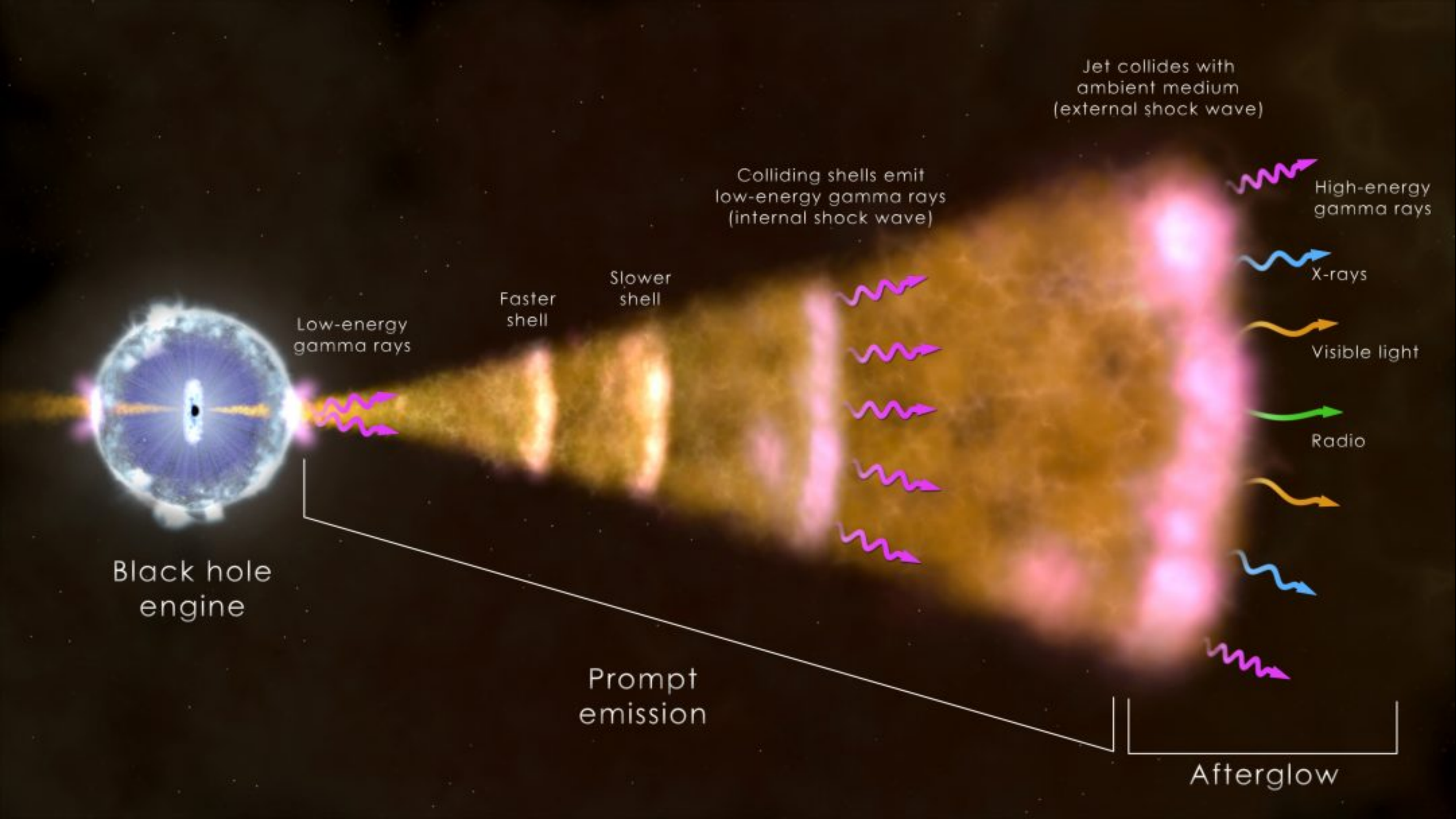


Long

Credits: Judy Schmidt

Credits: ESA

Short


Jet collides with ambient medium (external shock wave)
Colliding shells emit low-energy gamma rays (internal shock wave)
High-energy gamma rays
X-rays
Visible light
Radio
Slower shell
Faster shell
Low-energy gamma rays
Black hole engine
Prompt emission
Afterglow

Credits: Sergio Poppi (Inaf Cagliari)

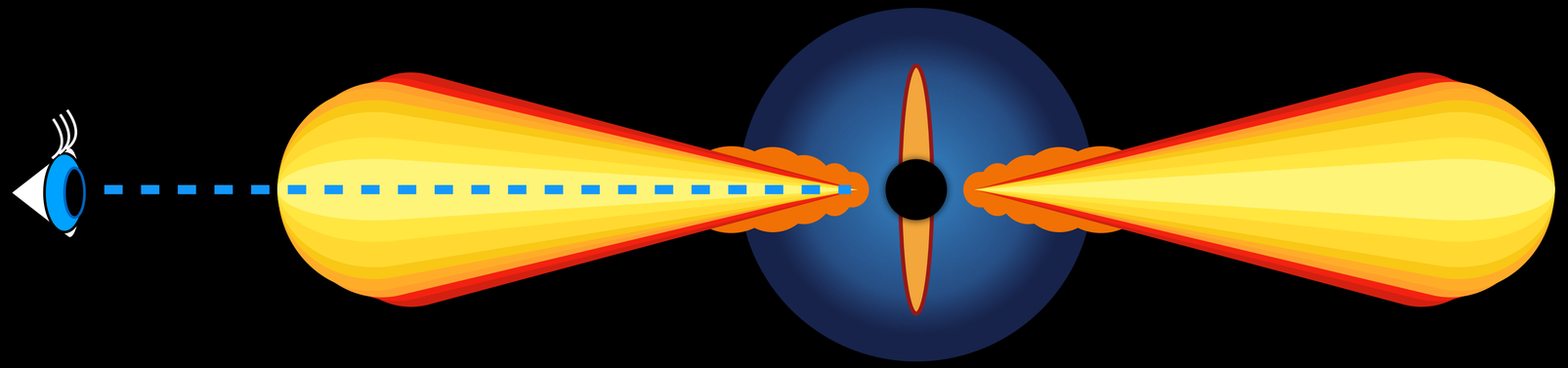
VLBI for GRBs

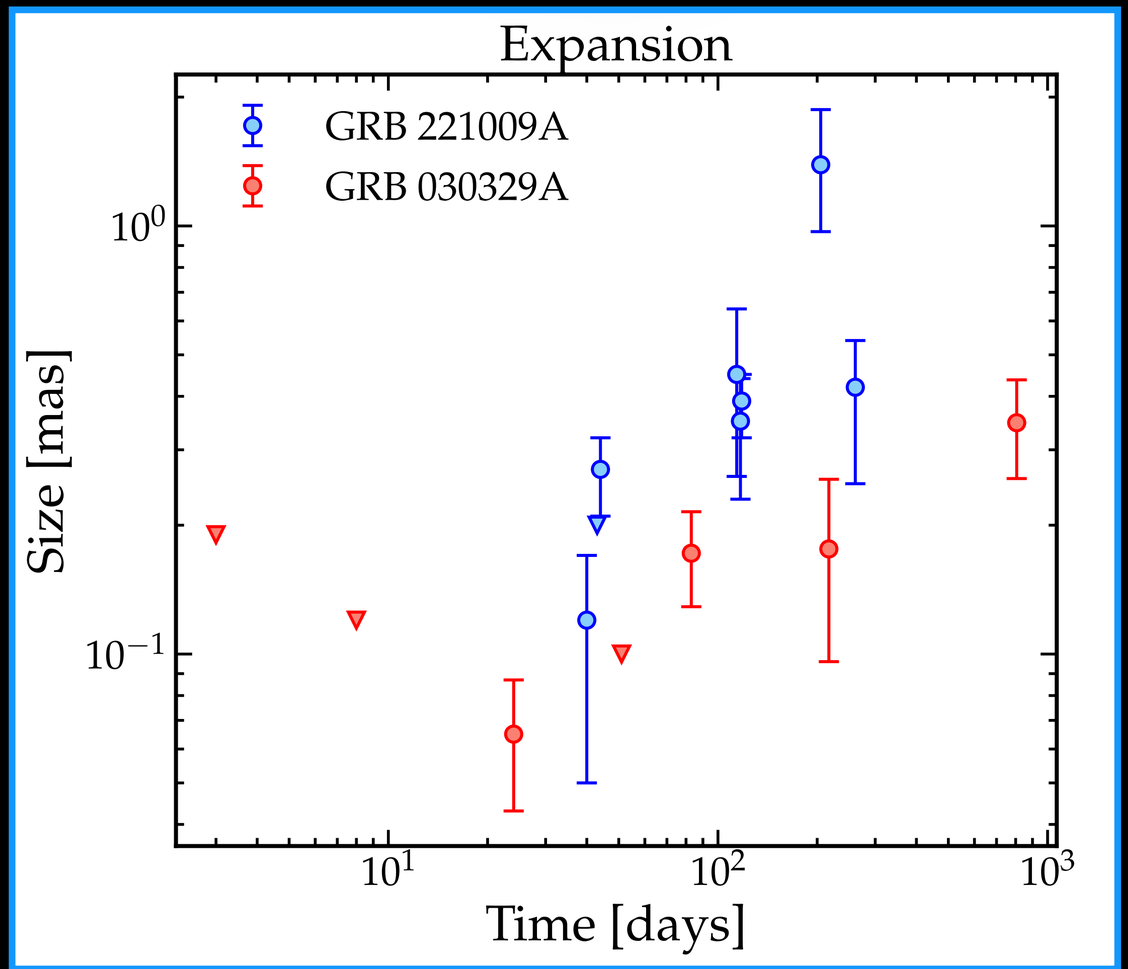
Geometry

Viewing angle

Collimation angle

Size and structure



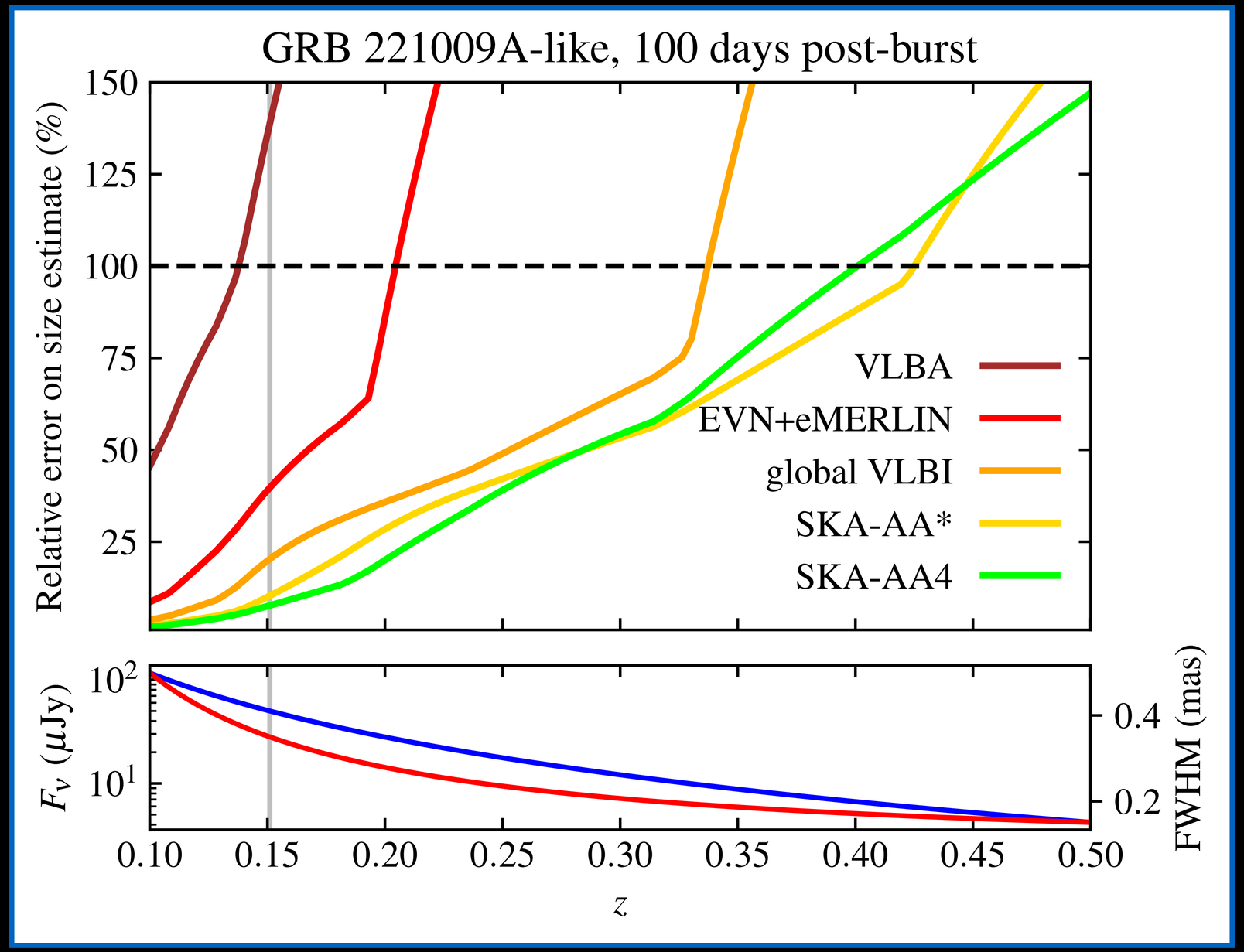


First direct proof of (apparent) superluminal expansion

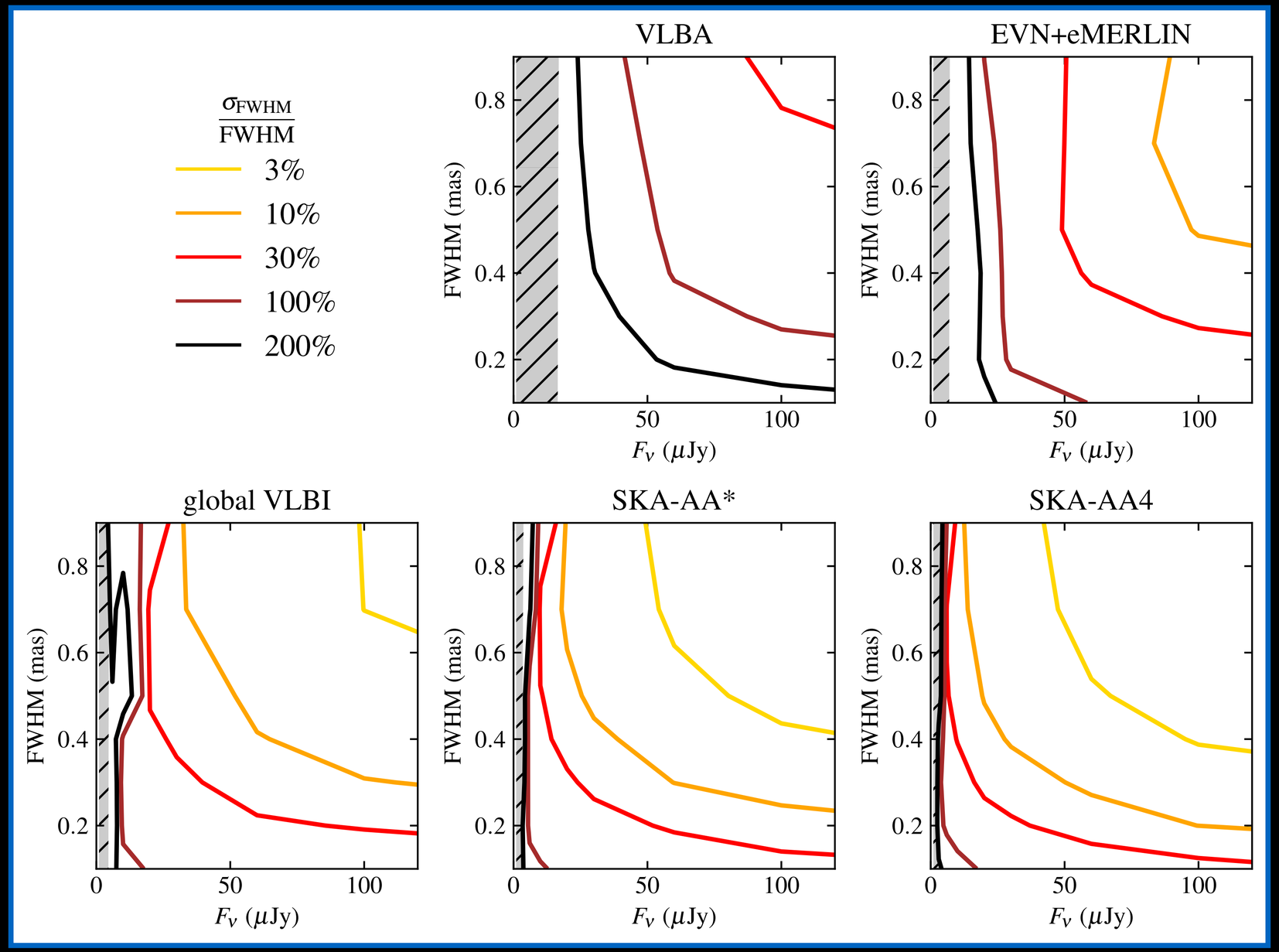
The impact of the SKA: size measurements

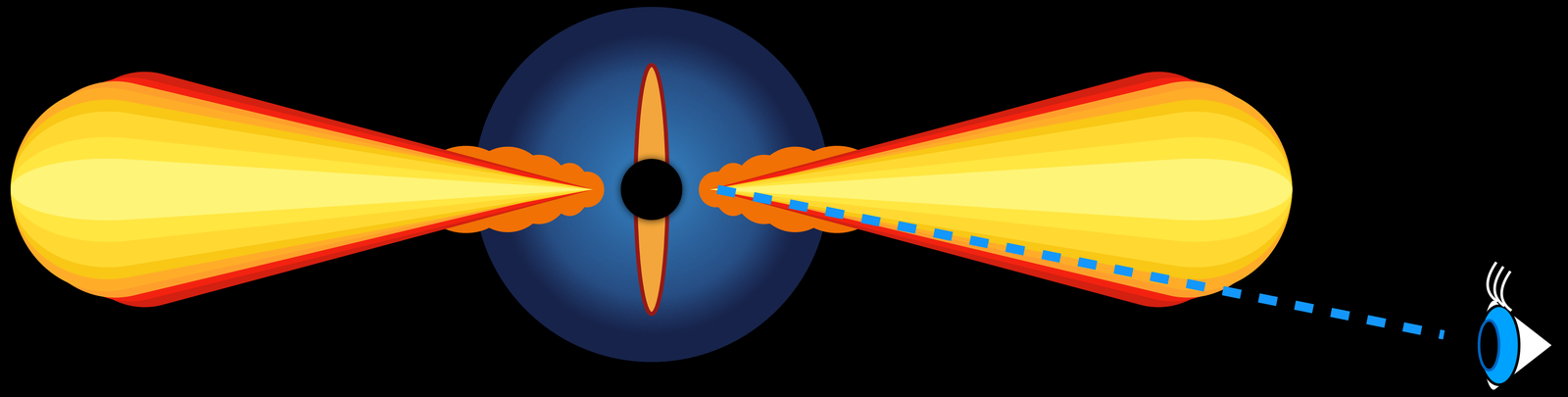
From
$z \simeq 0.16$
to
$z \simeq 0.25$

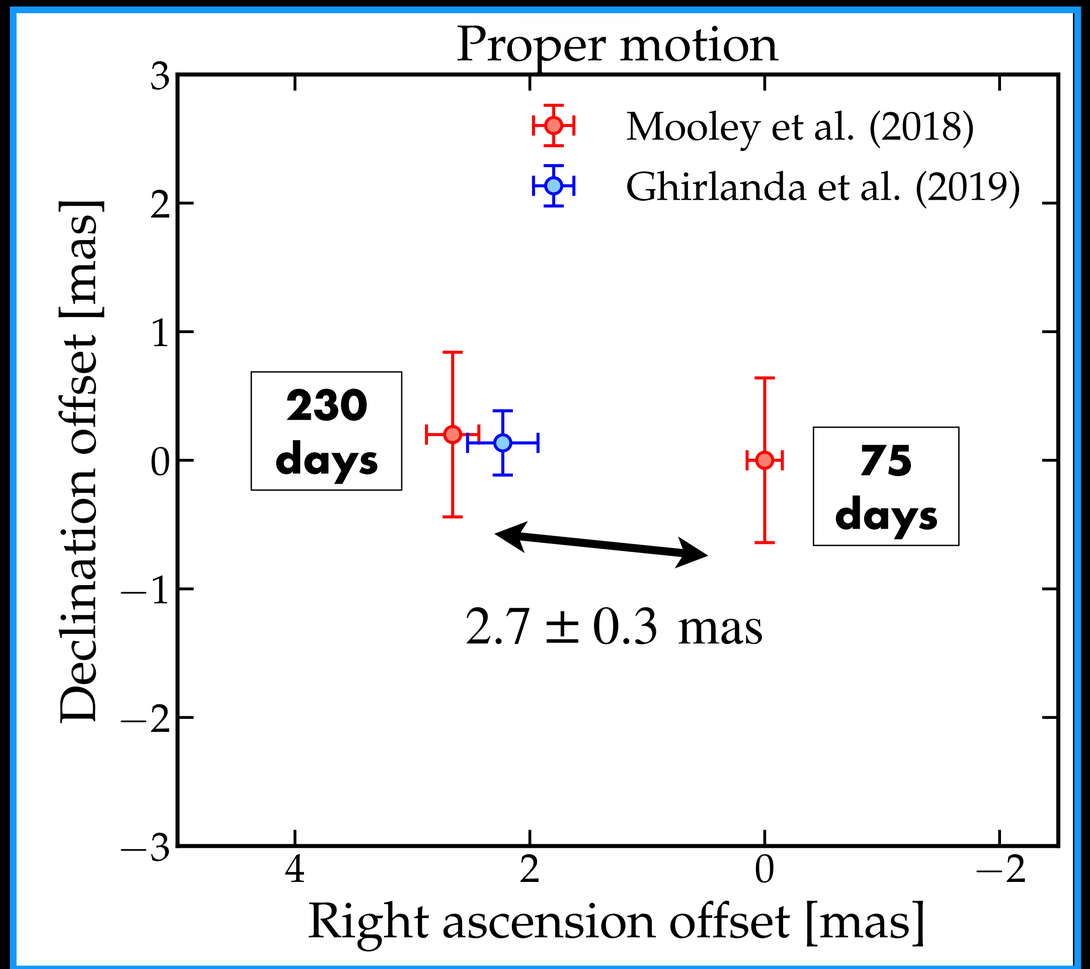
Constraining the size 2 times better



The impact of the SKA: resolving powers

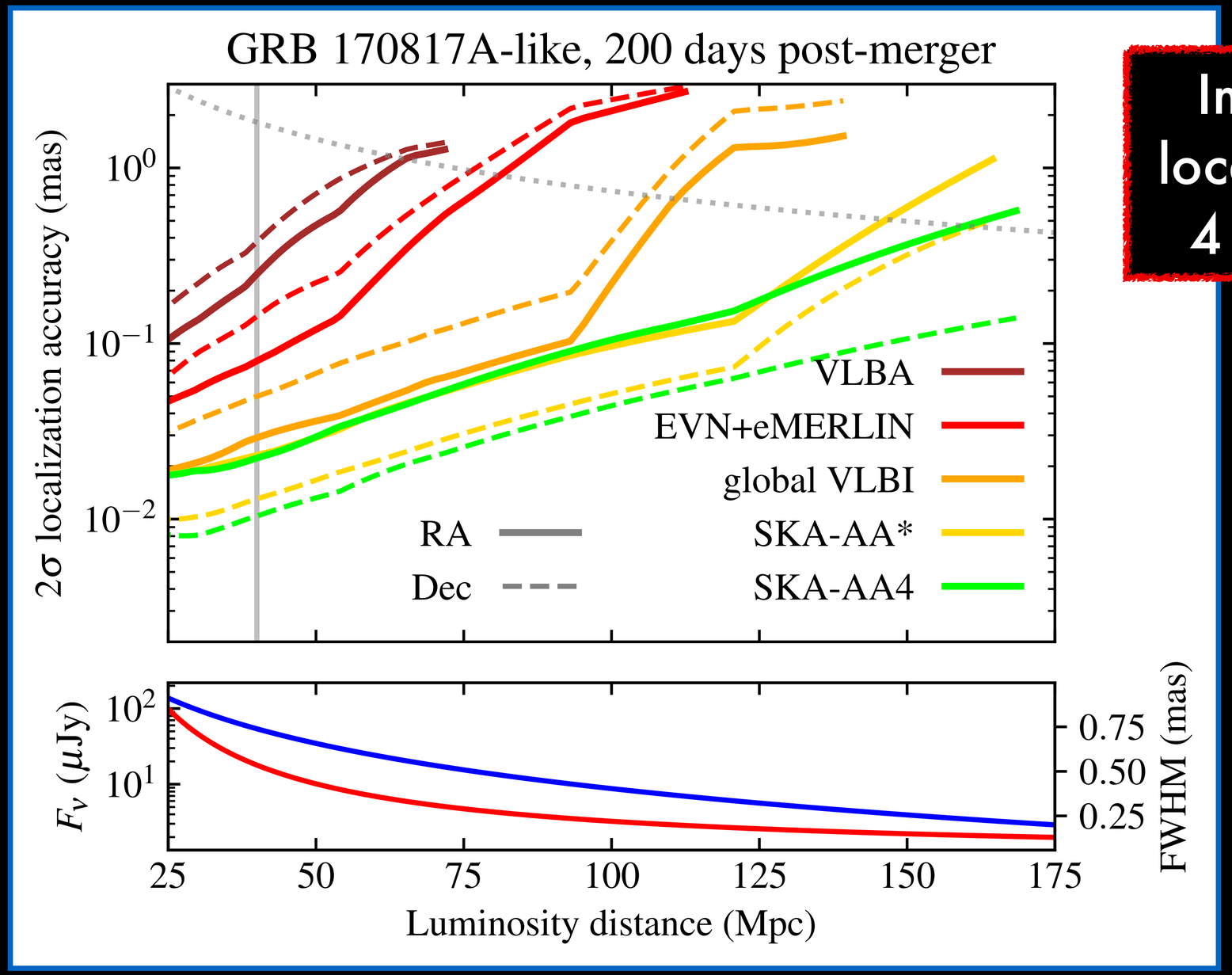






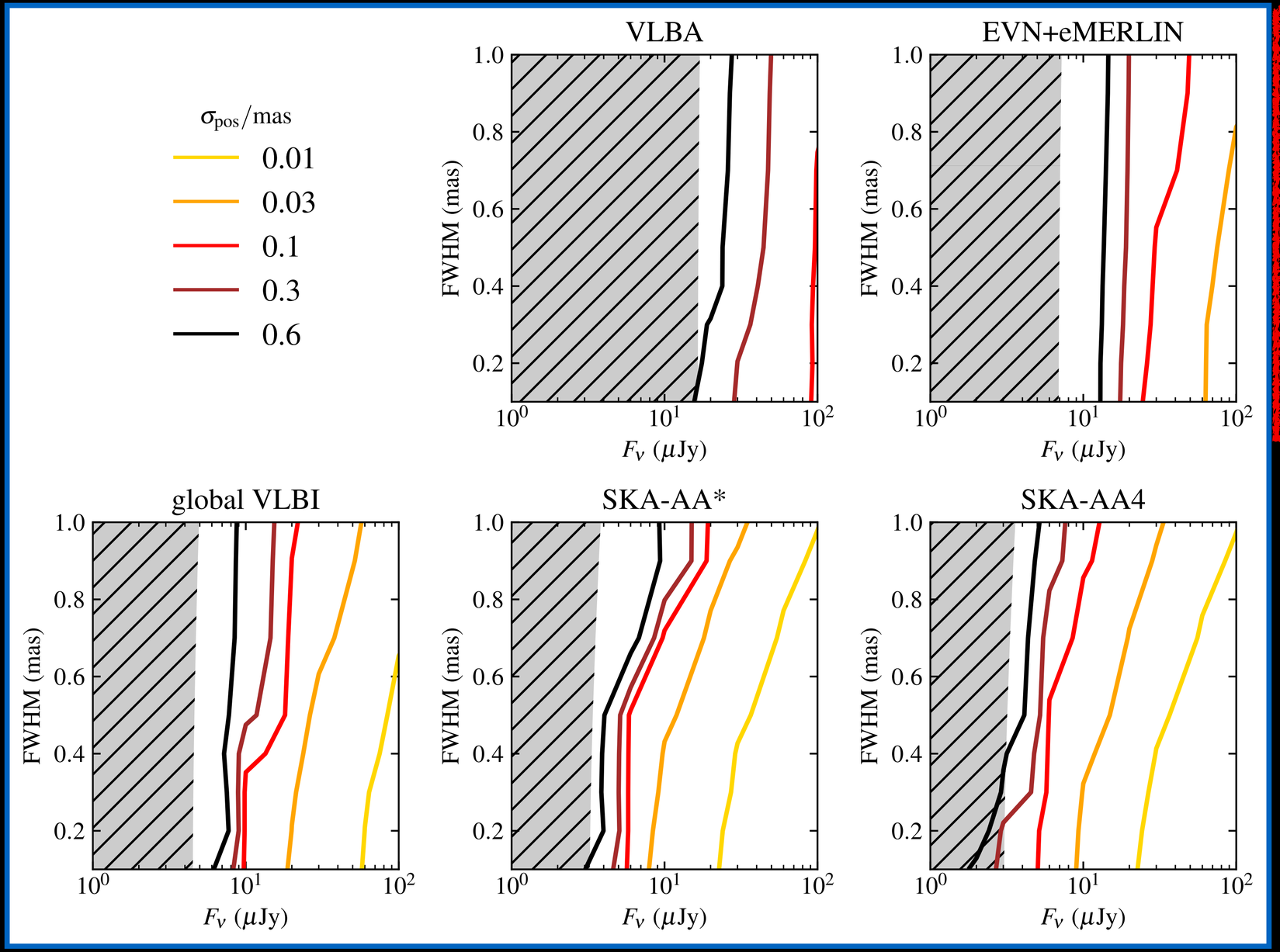
First proof of successful jet from a BNS merger

The impact of the SKA: localisation accuracy



Improving Dec localisation from 4 to 30 times!

The impact of the SKA: astrometry



3x confidence level for apparent proper motion

Conclusions

The impact of the SKA-VLBI:

- Size measurements up to $z \simeq 0.25$
- 2x better constraints on size estimate
- 4x - 30x better precision in Dec
- 3x confidence level for detection of proper motion

Conclusions

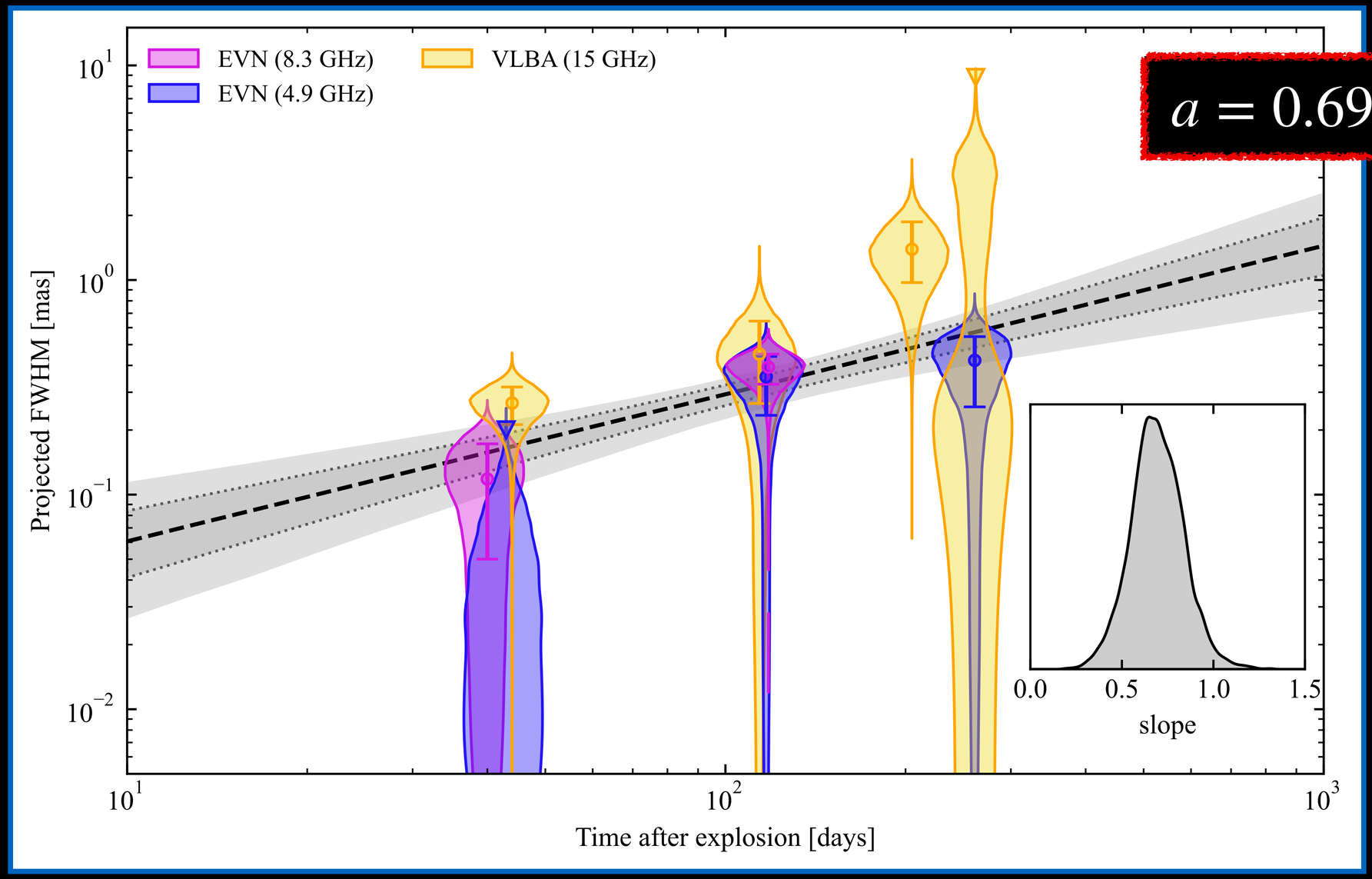
The impact of the SKA-VLBI:

- Size measurements up to $z \simeq 0.25$
- 2x better constraints on size estimate
- 4x - 30x better precision in Dec
- 3x confidence level for detection of proper motion

Thank you!

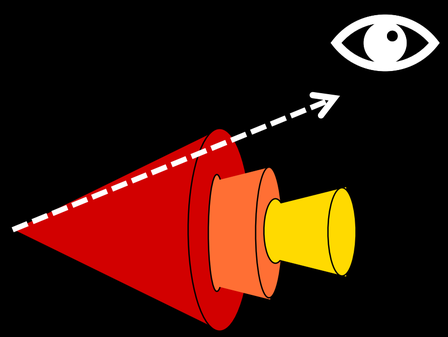
Backup Slides

GRB 221009A



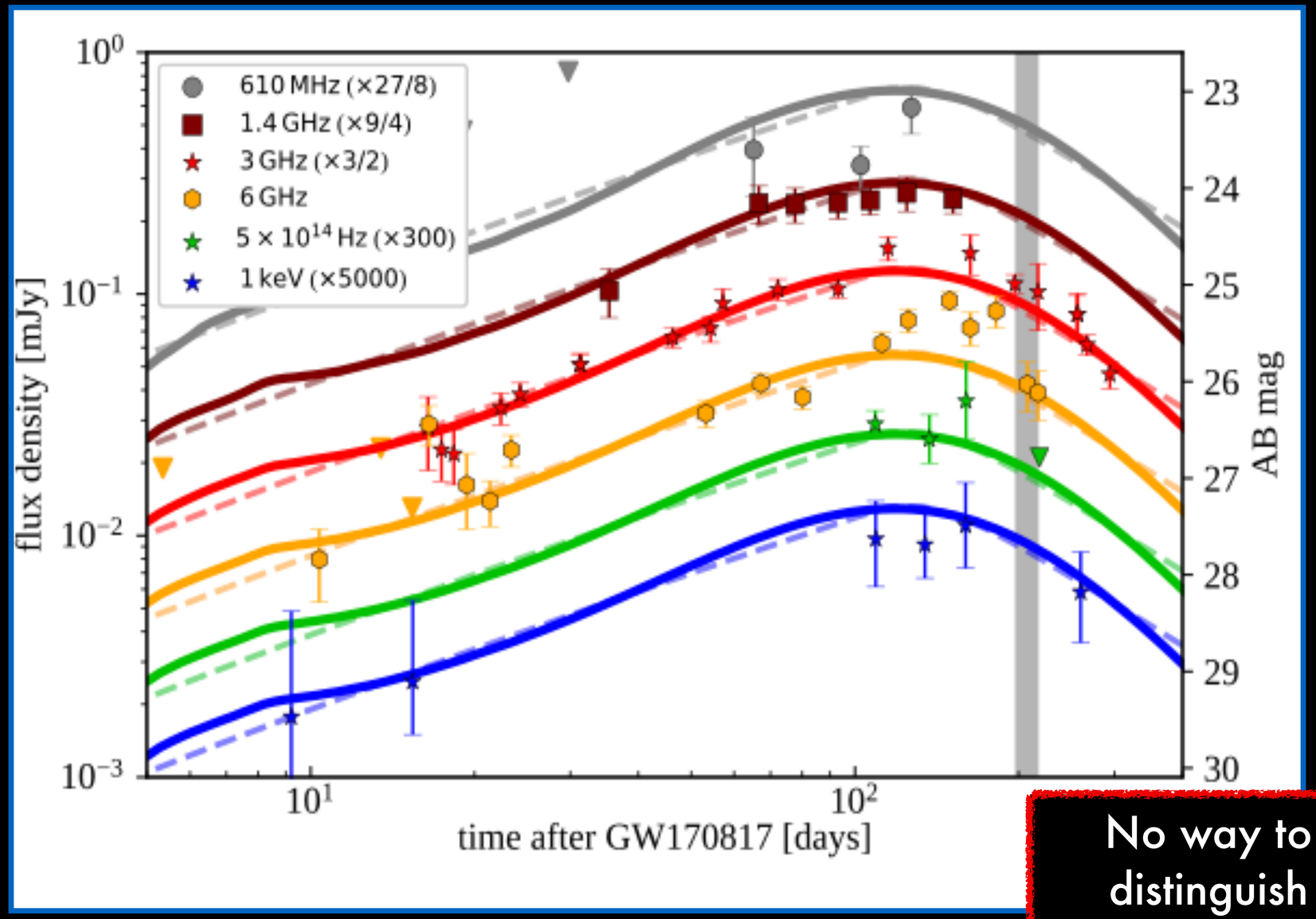
Apparent size evolution.
From *Giarratana et al. (2024)*

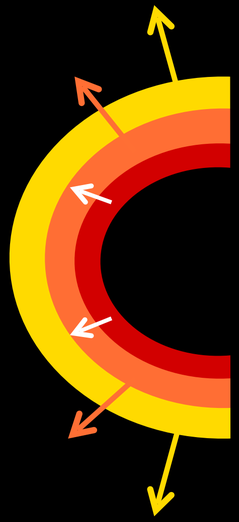
GRB 170817A



$\Gamma_1 < \Gamma_2 < \Gamma_3$

$E_1 < E_2 < E_3$





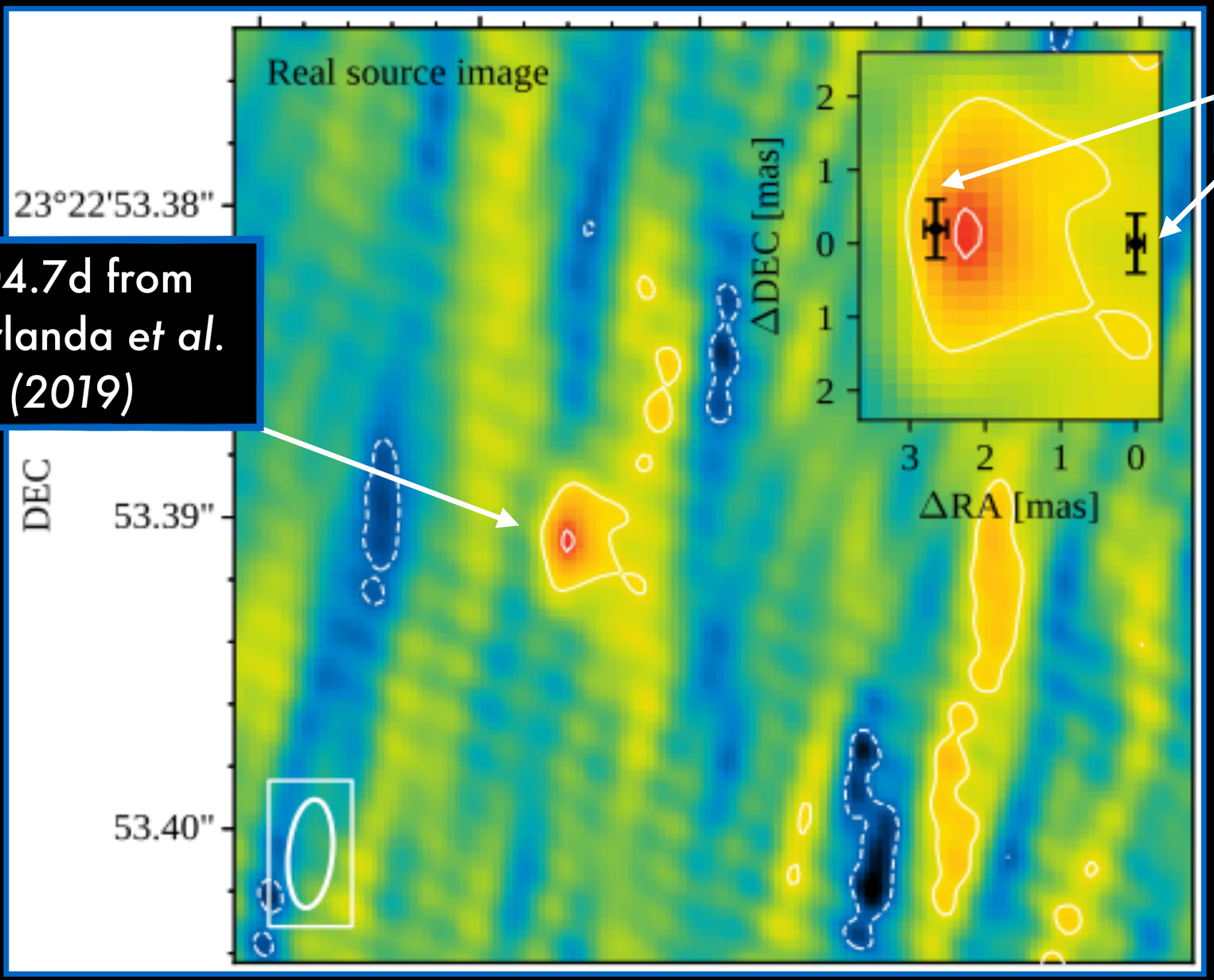
$\Gamma_1 < \Gamma_2 < \Gamma_3$

$E_1 > E_2 > E_3$

No way to distinguish between models!

From *Ghirlanda et al. (2019)*

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)*

The SKA

Milestones	Mid (end-date)	Low (end-date)
AA0.5 • 4 Mid dishes • 4 Low stations	2026 Jan	2024 Dec
AA1 • 8 Mid dishes • 18 Low stations	2026 Aug	2025 Nov
AA2 • 64 Mid dishes • 64 Low stations	2027 Jul	2026 Oct
AA* (staged delivery plan) • 144 Mid dishes • 307 Low stations	2028 May	2028 Jan
Operations Readiness Review	2028 Aug	2028 Apr
Formal end of construction (including schedule contingency)	2029 Mar	
AA4 (design baseline) • 197 Mid dishes • 512 Low stations	TBD	

Telescope	Maximum baseline length		
	AA2	AA*	AA4
Low	39.0 km	73.4 km	73.4 km
Mid	108.0 km (36.0 km, excluding dish SKA008)	108.0 km (36.0 km, excluding dish SKA008)	159.6 km

Timeline and maximum baseline length.

The SKA

SKA1 Telescope Expected Performance – Imaging

Nominal frequency	110 MHz	300 MHz	770 MHz	1.4 GHz	6.7 GHz	12.5 GHz
Range [GHz]	0.05-0.35	0.05-0.35	0.35-1.05	0.95-1.76	4.6-8.5	8.3-15.4
Telescope	Low	Low	Mid	Mid	Mid	Mid
FoV [arcmin]	327	120	109	60	12.5	6.7
Max. resolution [arcsec]	9.7	3.5	0.7	0.3	0.06	0.03
Max. bandwidth [MHz]	300	300	700	810	3900	2 x 2500
Cont. rms, 1hr [μJy/beam] [a]	26	14	4.4	2	1.3	1.2
Line rms, 1hr [μJy/beam] [b]	1850	800	300	140	90	85
Resolution range for cont. & line rms [arcsec] [c]	12-600	6-300	1-145	0.6-78	0.13-17	0.07-9
Channel width (uniform resolution across max. bandwidth) [kHz]	5.4	5.4	13.4	13.4	80.6	80.6
Narrowest bandwidth, zoom mode [MHz]	3.9	3.9	3.1	3.1	3.1	3.1
Finest zoom channel width [Hz]	226	226	210	210	210	210

a. Continuum sensitivity at nominal frequency, assuming fractional bandwidth of $\Delta\nu/\nu = 0.3$

b. Line sensitivity at nominal frequency, assuming fractional bandwidth per channel of $\Delta\nu/\nu = 10^{-4}$ ($>10^{-6}$ will be possible]

c. The sensitivity numbers apply to the range of beam sizes listed

For more details refer to the document "Anticipated SKA1 Science Performance" (SKA-TEL-SKO-0000818 available on astronomers.skatelescope.org and at arxiv.org/abs/1912.12699)

SKA info sheet from the public SKAO website.