The expected diversity of afterglows in future neutron star merger events

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Introduction – Objectives

One event: GW 170817/GRB 170817A with full display: γ, AG, KN

D=40 Mpc ; θ_v=20-25°

We were lucky ! What do we loose if we increase D, θ_v ?

	GRB	AG	KN
D_{max} (Mpc)	50	100	$\sim$ 500
$\theta_{v,max}$	?	30-35°	$\sim$ isotr.

T Study of radio AG visibility and distribution of parameters in future GW BNS events

- fraction of GW events to be detected in radio as a function of $D_{H,grav}$
- distribution in distance, viewing angle, flux, …

Assumptions and methods

- Peak of the radio AG: delayed contribution of the central jet as in GRB 170817A

  jets in SHBs are mostly successful (Beniamini et al., 2018)

  $\dot{e}(\theta)$ decrease sufficiently rapidly outside the jet (cocoon below jet contribution at peak)

- Parametrized jet model: $F_{\max}$, $t_{\max}$ [$E_{\rm iso}$, θ_j , n , ε_e , ε_B , p , θ_v , D]

  $F_{\max}$ (but not $t_{\max}$) only weakly depends on the assumption about angular spreading

$$F_{max} \propto \frac{E_{iso}}{D^2} \epsilon_e^{p-1} \epsilon_B^{\frac{p+1}{4}} n^{\frac{p+1}{4}} \theta_j^2 \theta_v^{-2p} \propto \frac{E_{iso}}{D^2} \varepsilon_B^{0.8} n^{0.8} \theta_v^{-4.4}$$ (with ε_e=0.1 ; θ_j=0.1 ; p=2.2)

- Detection threshold at 3 GHz: 10 μJy

- Distribution of parameters: D, θ_v, $E_{\rm iso}$, n, ε_B

  [D, θ_v] : fix $D_{\max}$: horizon in GW (θ_v=0)

  Draw: a distance within $D_{\max}$ (uniform density distr.)

  a viewing angle (random line of sight)

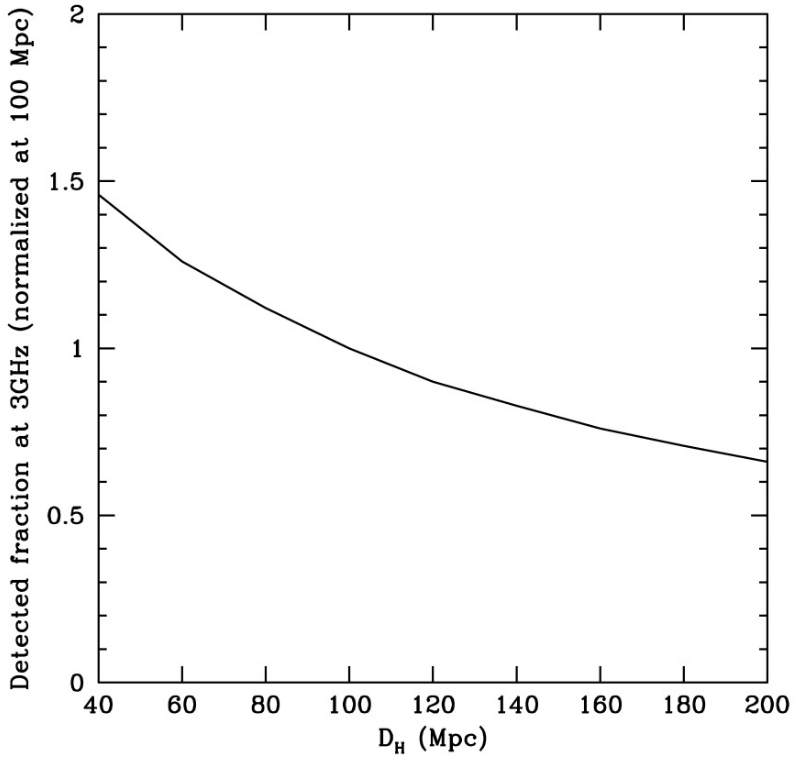
  ⇒ keep if detected in GW ⇒ $f_{grav} \sim 0.3$

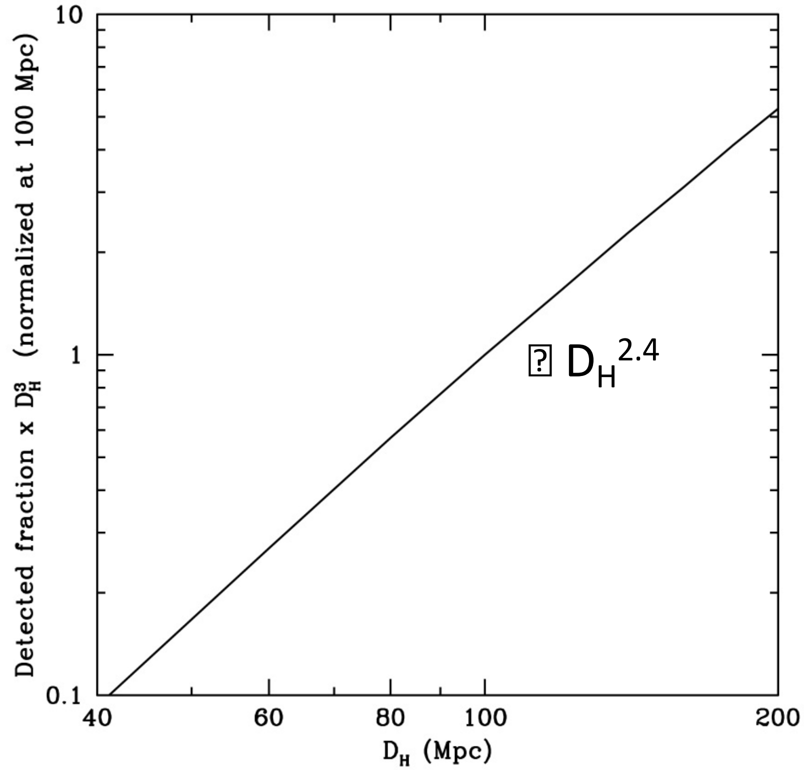
  [$E_{\rm iso}$] : broken power-law : $E_{\min}=10^{51}$ erg ; $E_{\max}=10^{53}$ erg ; $E_{tr}=2\ 10^{52}$ erg ; α_1=-0.7 ; α_2=-2

  [n] , [e_B] : both log-normal centered at -3

Results

Fraction of GW events detected in radio as a function of GW horizon distance



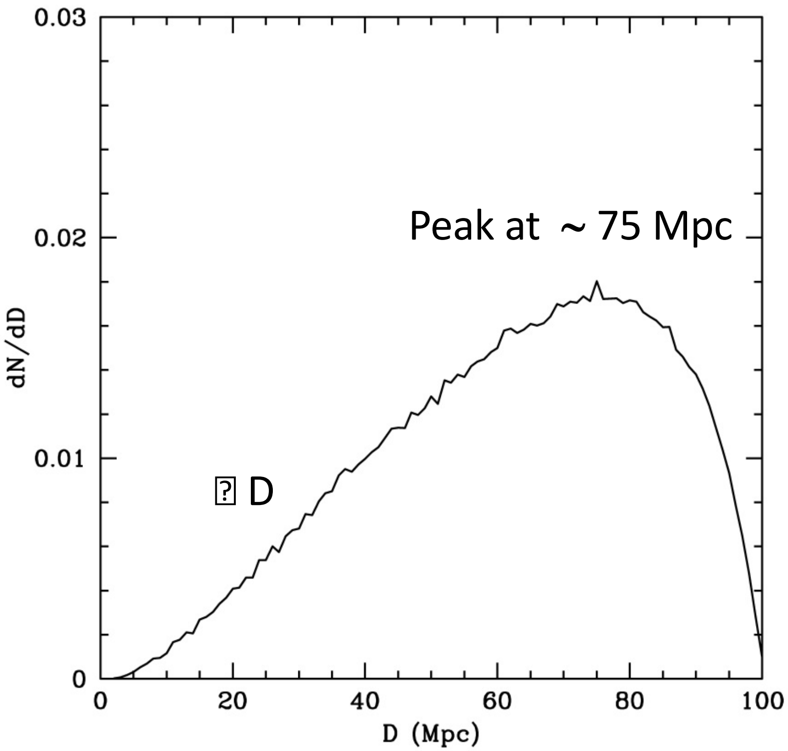


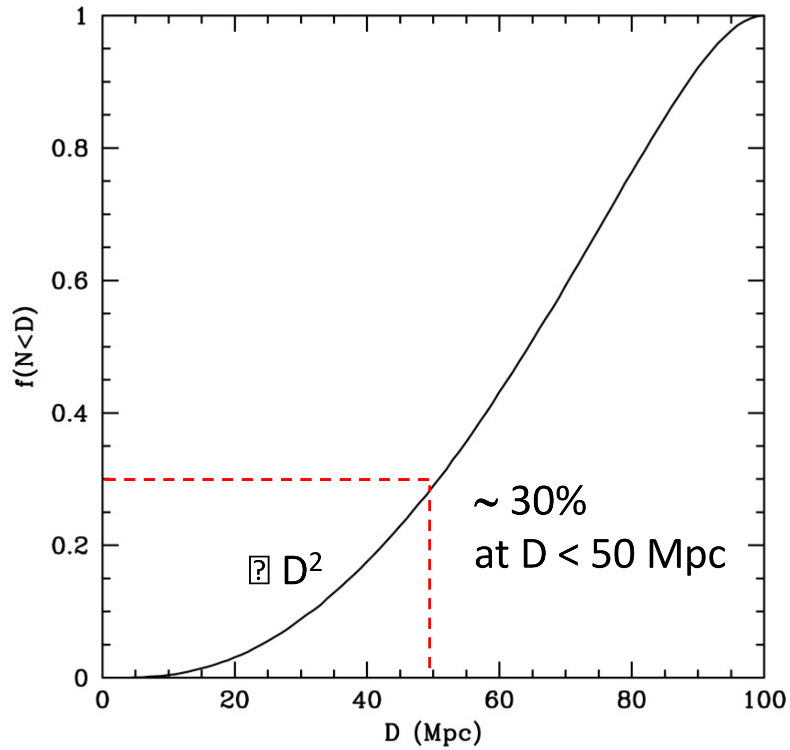
Normalized fraction only weakly depends on the distributions of $E_{\rm iso}$, n, ε_B

Absolute fraction for the adopted distributions: $f_{det} \sim 50\%$

Distribution in distance for events detected in radio

Assuming a conservative GW horizon distance D_H=100 Mpc

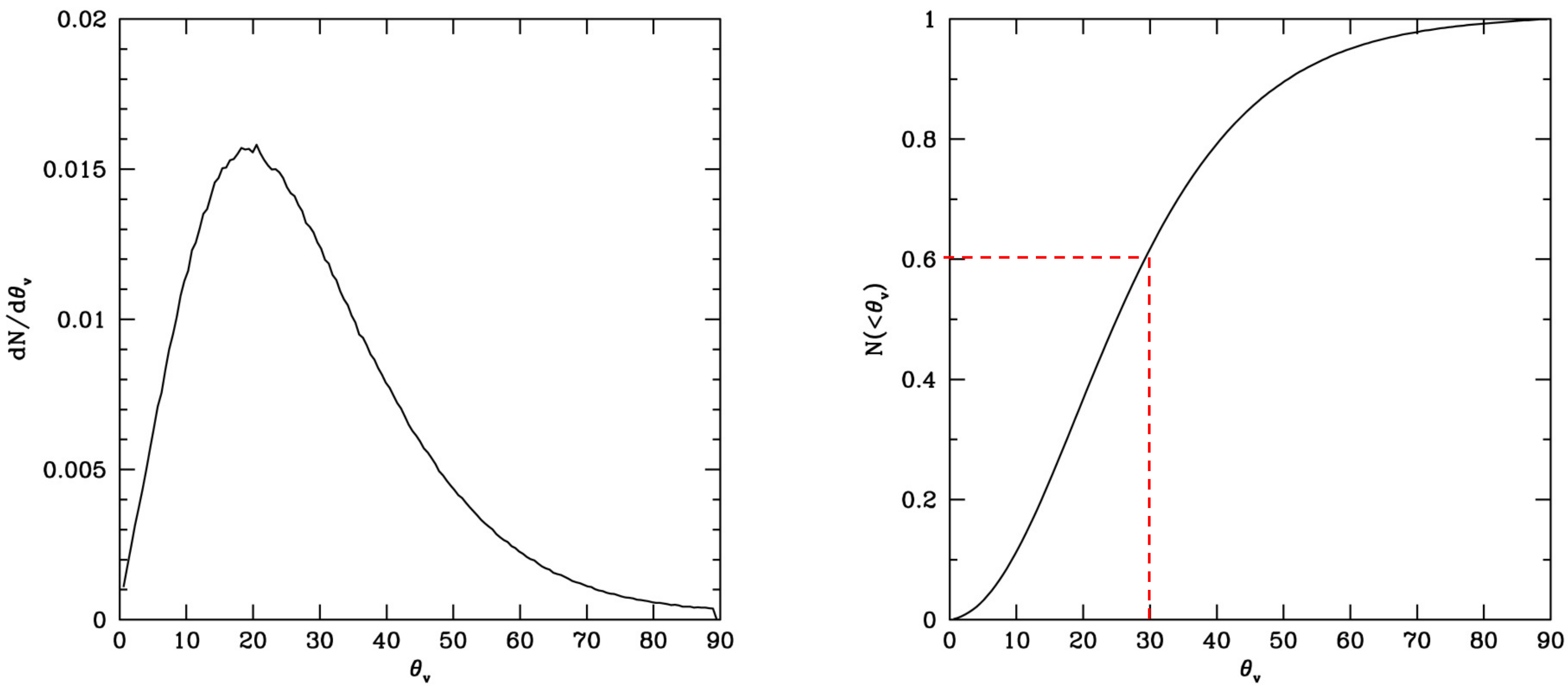




dN/dD $\propto$ D and f(<D) $\propto$ D^2

As the distance increases, source with large viewing angles are lost ($F_{max} \propto \theta_v^{-4.4}$)

Distribution in viewing angle

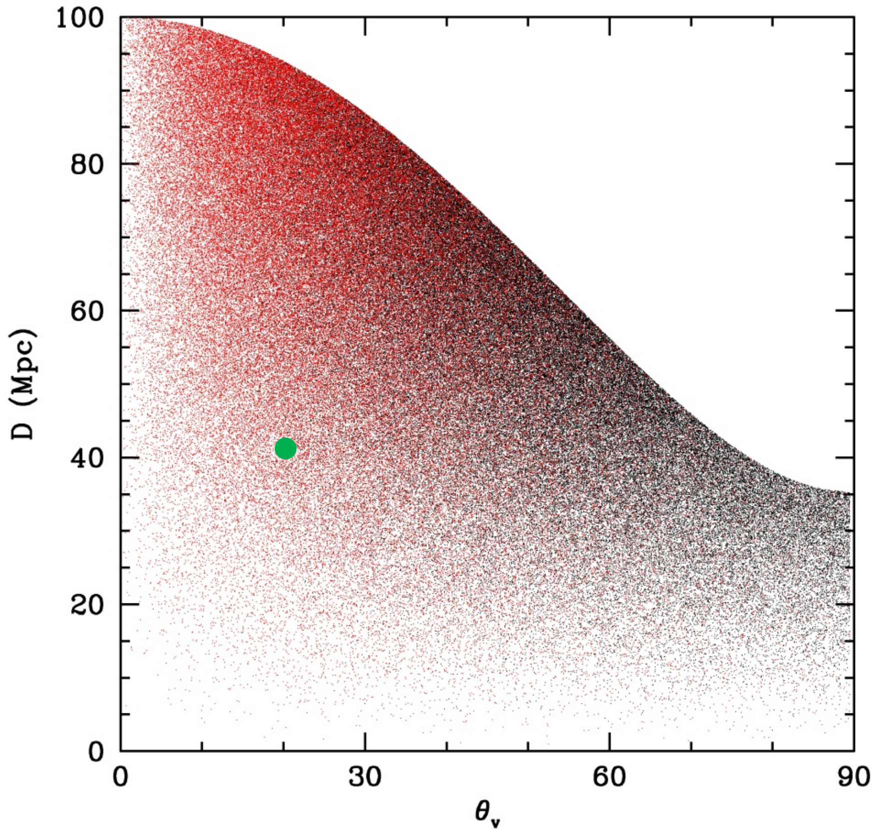


Peak of the distribution in viewing angle at $\theta_v \sim 20°$

60% of events at $\theta_v < 30°$

When D_H increases the peak of the distribution shifted to smaller θ_v

[Viewing angle – Distance] diagram



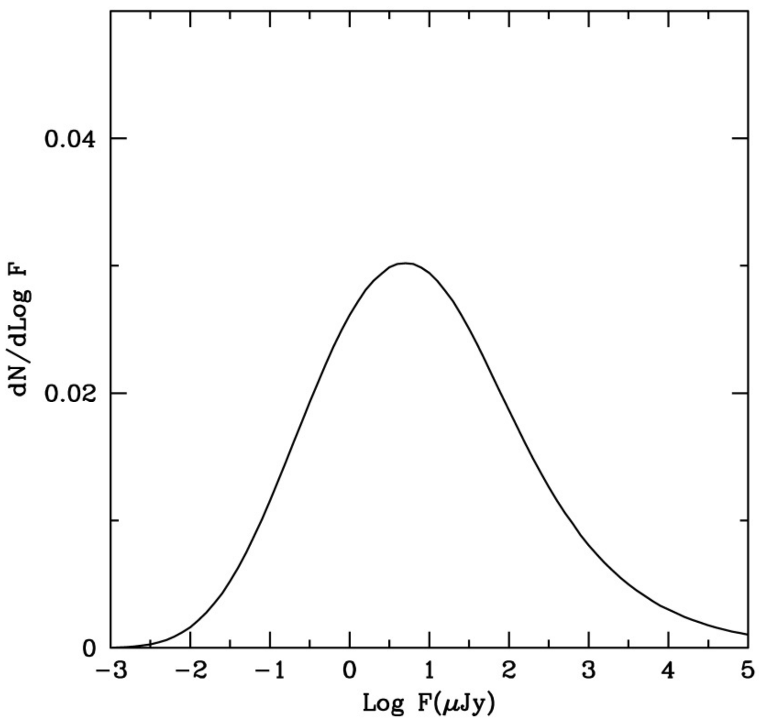
black dots: all sources detected in GW

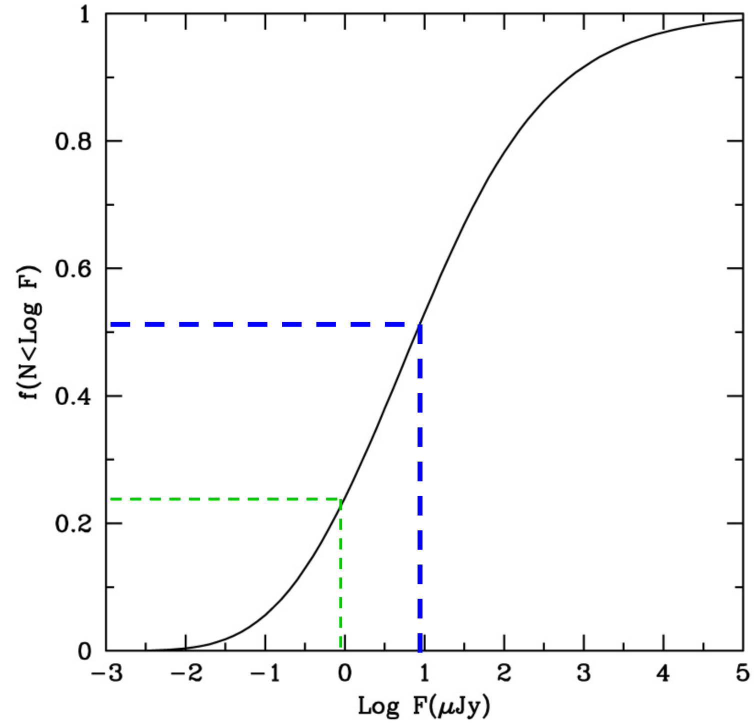
red dots: sources detected in radio

appear concentrated at small viewing angles and large distances

GRB 170817A

Distribution in flux





~ 50% of the sources above VLA detection threshold of 10 μJy

~ 75% with an increase by a factor of 10 in sensitivity

[but depends on the distributions adopted for $E_{\rm iso}$, n, ε_B]

Conclusions

- Assuming that in most cases the peak of the radio AG corresponds to the delayed contribution of a successful central jet we have obtained the distribution of various observables for the radio afterglows: f_{det}, D, θ_v, F

- The time to build up these distributions will depend on the (still uncertain) detection rate of radio afterglows, but could be quite long…

- For a fixed D_H, the distributions of D, θ_v, do not vary much when input parameters (distributions of E_{iso}, n, ε_B) are changed

- The peak of the distribution of viewing angle is about 20° and expected to decrease when D_H increases

- Extension of this work to include the distribution of more observables: peak time, centroid motion…