Search for NS mergers

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Motivation

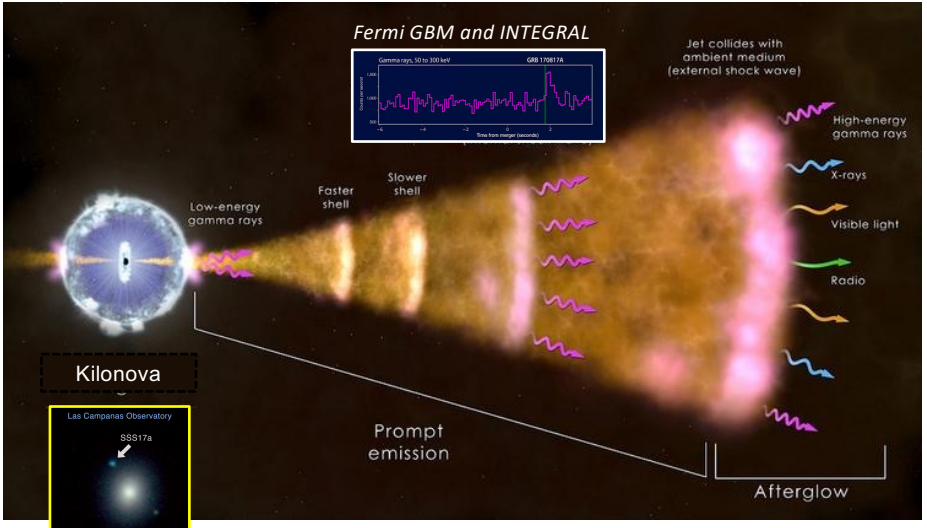
GRB170817A appears different from cosmological short GRBs

- Sub-luminous gamma-ray emission
- Luminous kilonova peaking in the optical at ~12 hrs
- Delayed and sub-luminous afterglow

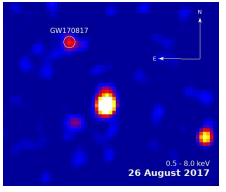
- GW170817/GRB170817A: what did we learn about NS mergers?

- A new perspective on short GRBs: search for analogues in the *Swift* database

The aftermath of a NS merger



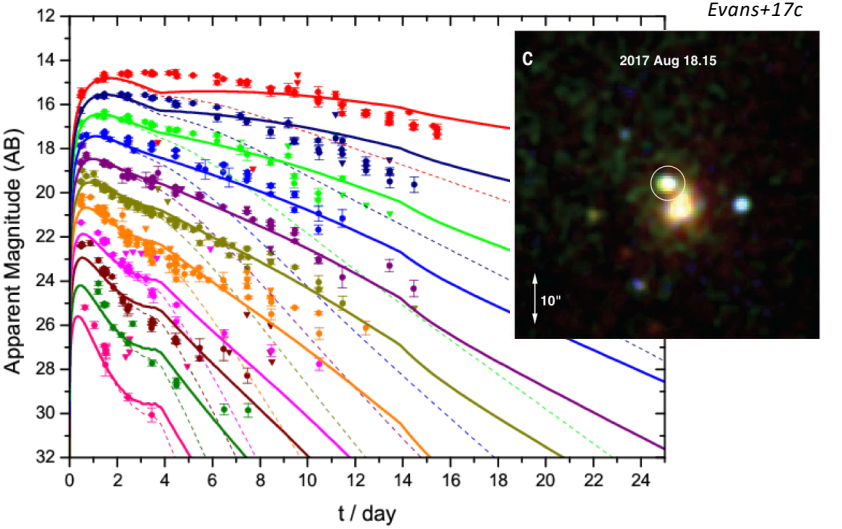
Coulter+17



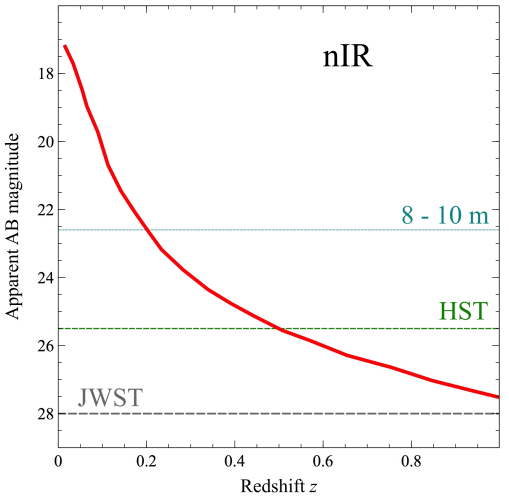
Troja+17

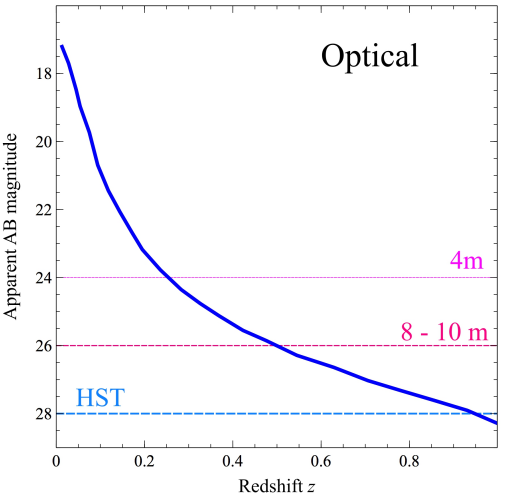
GW170817/GRB170817A: Kilonova

Coulter+17
Drout+17
Pian+17
Arcavi+17
Smartt+17
Tanvir+17
Troja+17
Kasen+17
Kasliwal+17
and many others

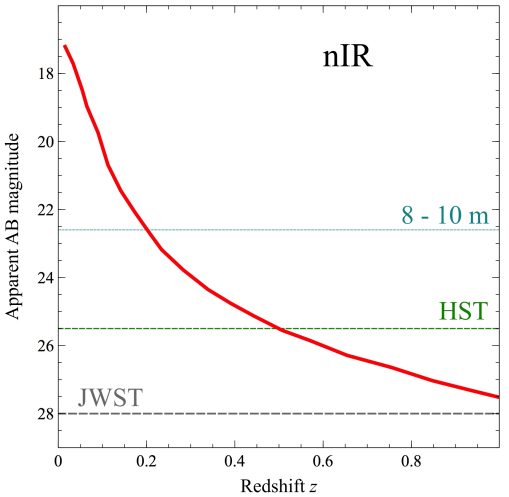


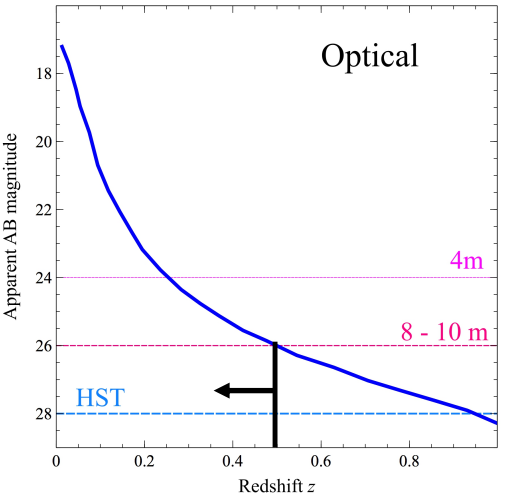
Kilonova Detectability





Kilonova Detectability

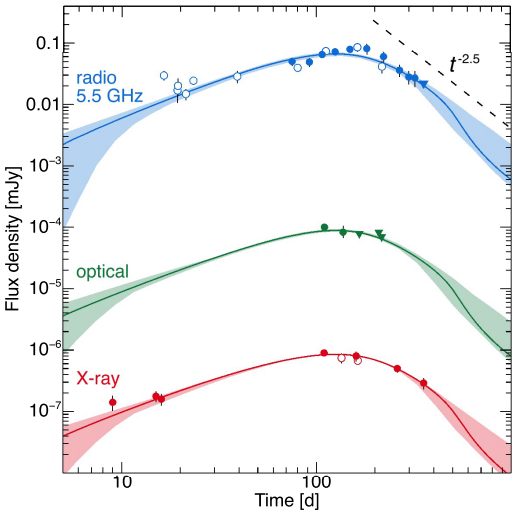


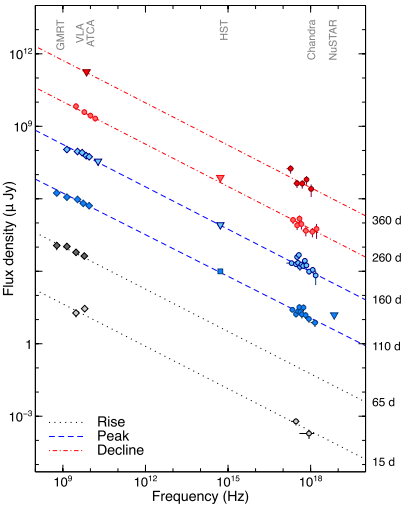


GW170817/GRB170817A: Afterglow

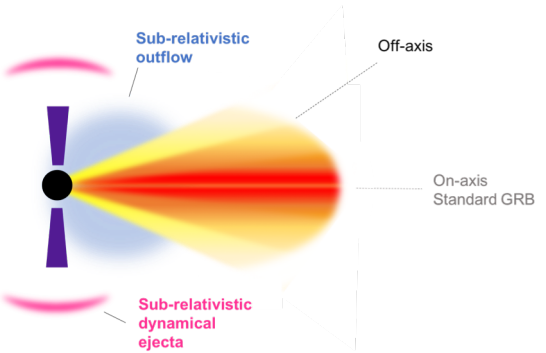
Troja+17
Troja+18
Piro+19
Troja+19
Hallinan+17
Mooley+17
Mooley+18
Lyman+18
D'Avanzo+18
Ghirlanda+18

and many others

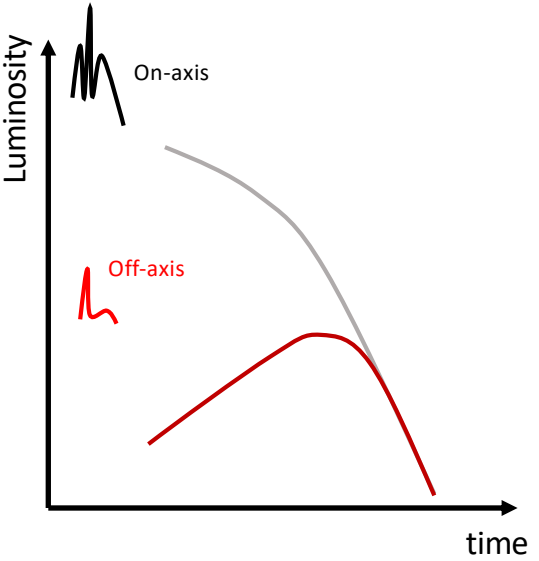




A relativistic structured jet seen off-axis

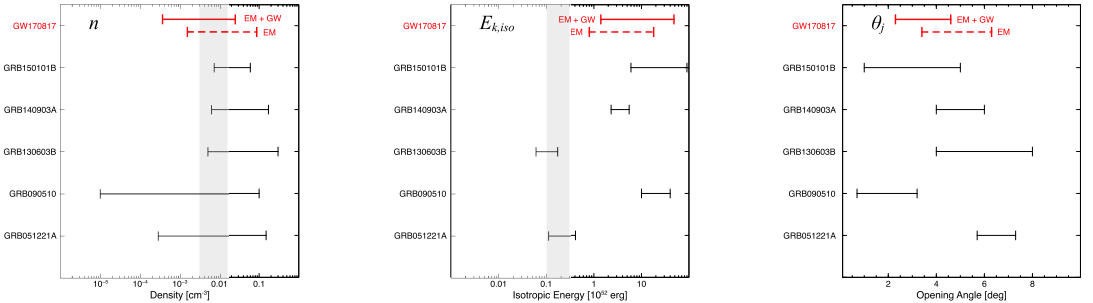


Zhang+02, Rossi+03, Aloy+05, Kathirmagaraju+18, Lazzati+18 and many others



Comparison to short GRBs

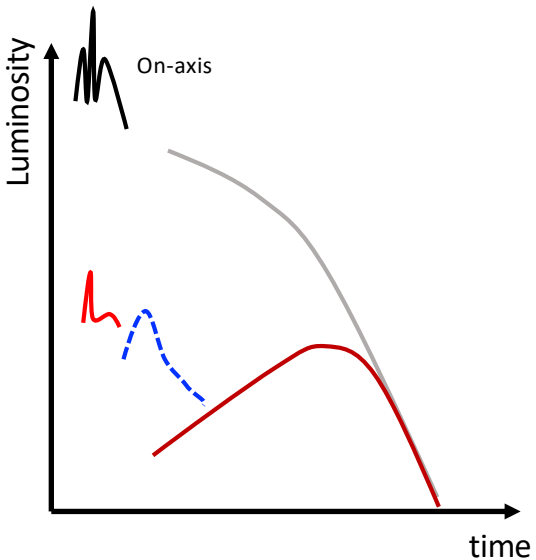
Troja, van Eerten et al. 2019



Explosion properties similar to cosmological short GRBs

A standard GRB explosion seen from an angle of ~20-25 degrees

Signatures of off-axis GRBs



Weak or no gamma-ray emission

Luminous optical/nIR counterpart,
less dependent on viewing angle

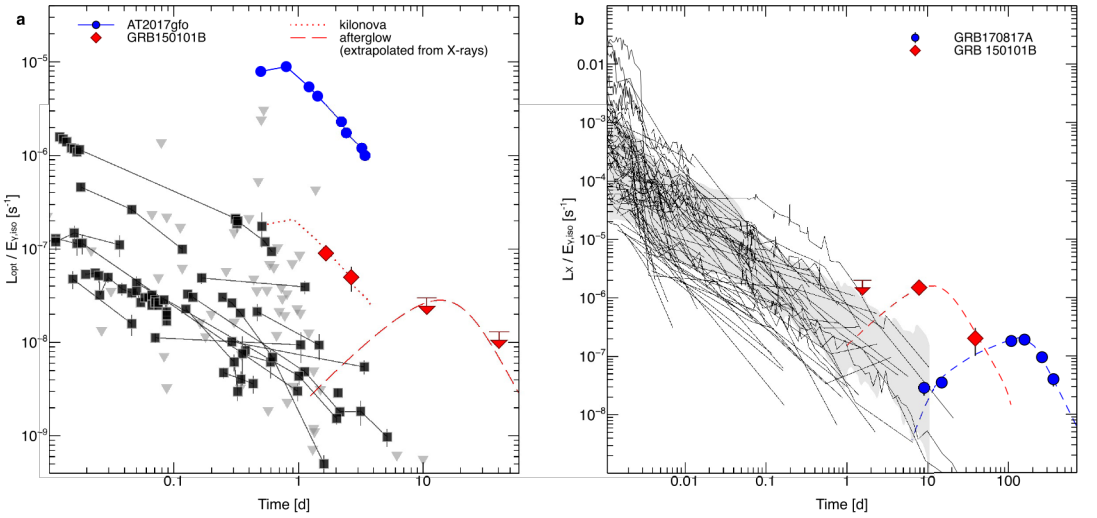
- High optical/γ-ray ratio

Slowly rising afterglow,
similar to on-axis afterglow
at late times

- High X-ray/γ-ray ratio

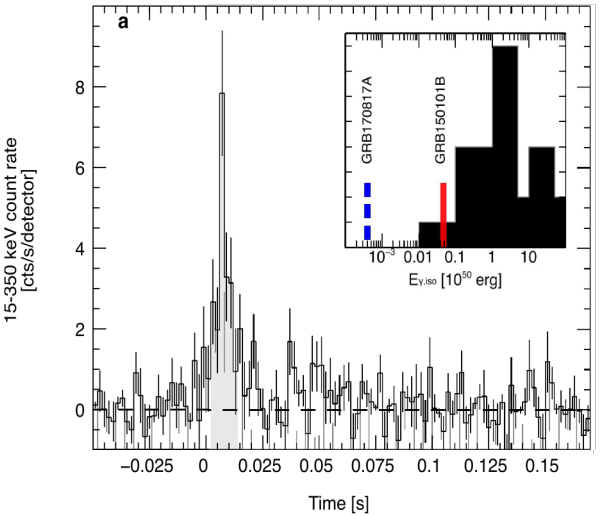
Archival search

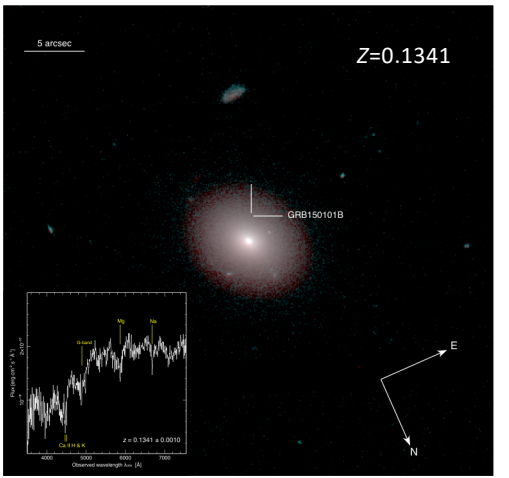
Troja, Ryan, et al., Nature Communications, 2018



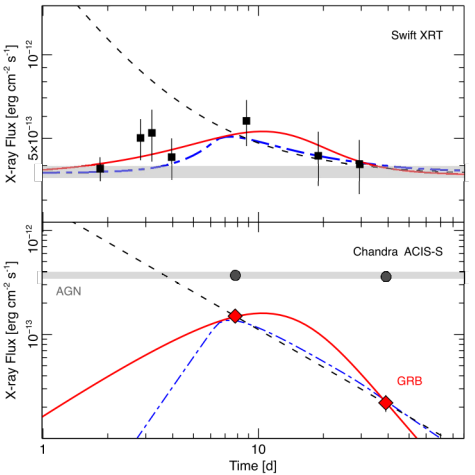
GRB 150101B

Troja, Ryan, et al., Nature Communications, 2018





Afterglow: evidence for an off-axis jet



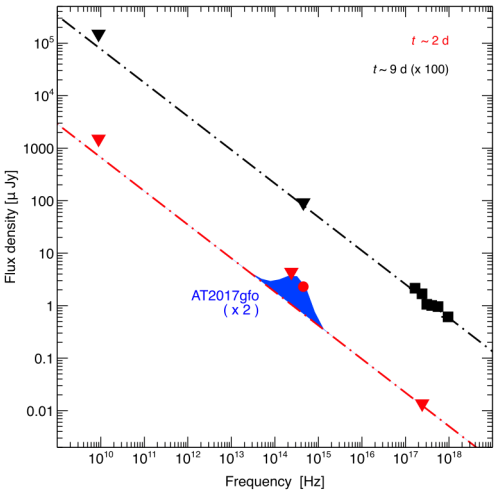
Troja, Ryan, et al., Nature Communications, 2018

Swift observations rule out a standard fading afterglow

Swift and *Chandra* observations can be explained by an off-axis jet model

Standard GRB properties and viewing angle ~13 degrees

Another blue kilonova ?



Troja, Ryan, et al., Nature Communications, 2018

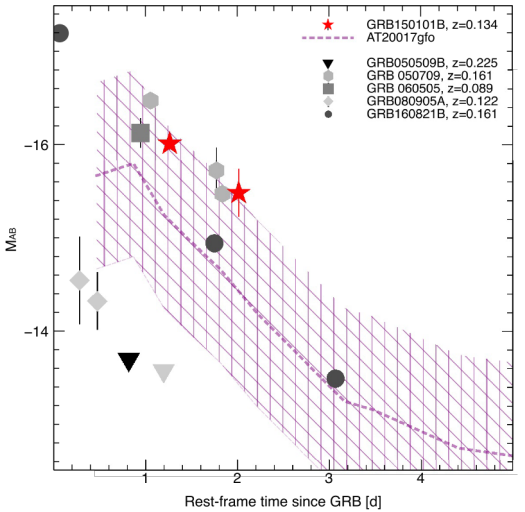
Bright optical fading counterpart

Initially classified as afterglow

More luminous than predicted from X-ray afterglow:

a kilonova excess?

Comparison to AT2017gfo



Troja, Ryan, et al., Nature Communications, 2018c

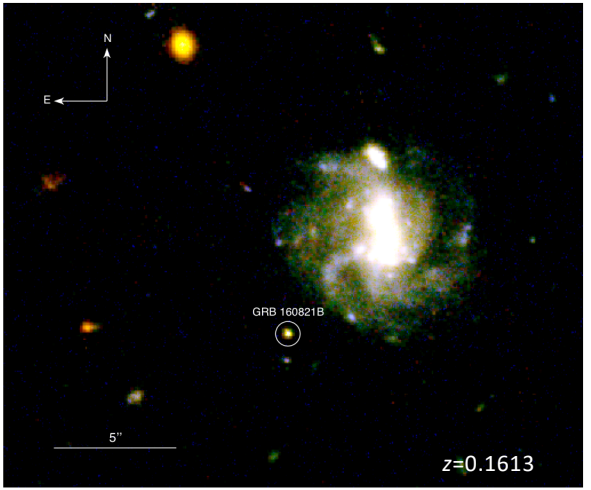
Luminosity and timescales consistent with AT2017gfo

Some cases exclude a kilonova as bright as AT2017gfo

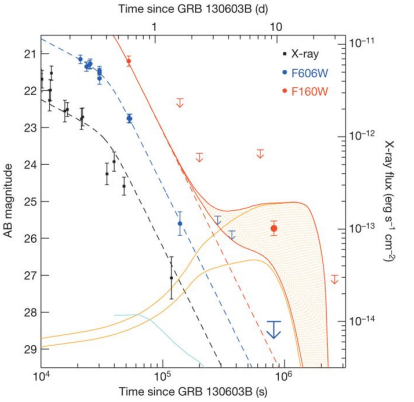
Many other cases are consistent with a similar kilonova

see also Gompertz+18, Rossi+19

A kilonova in GRB 160821B?

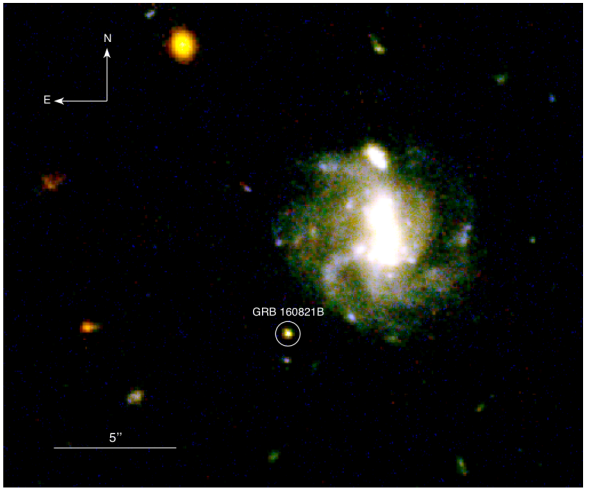


Troja+19

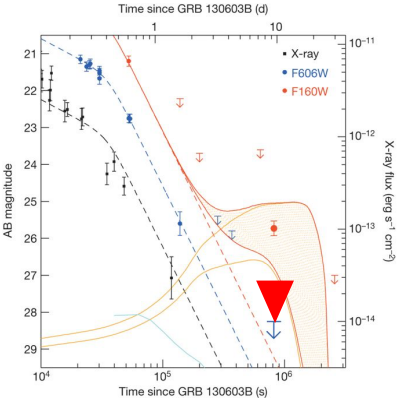


Tanvir+13

A kilonova in GRB 160821B?

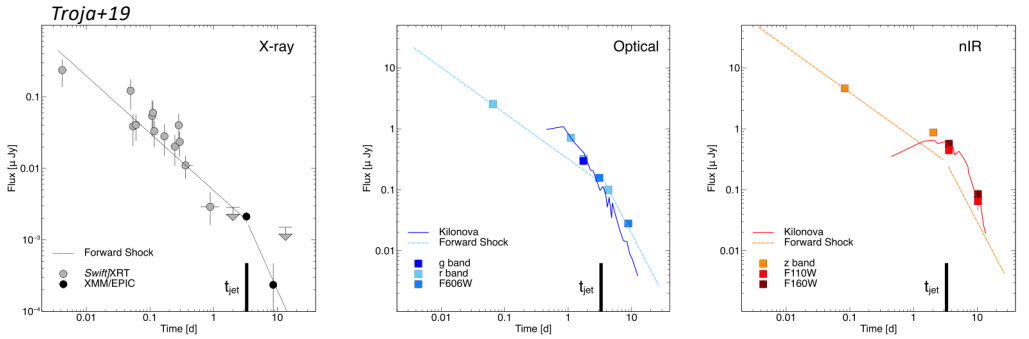


Troja+19



Tanvir+13

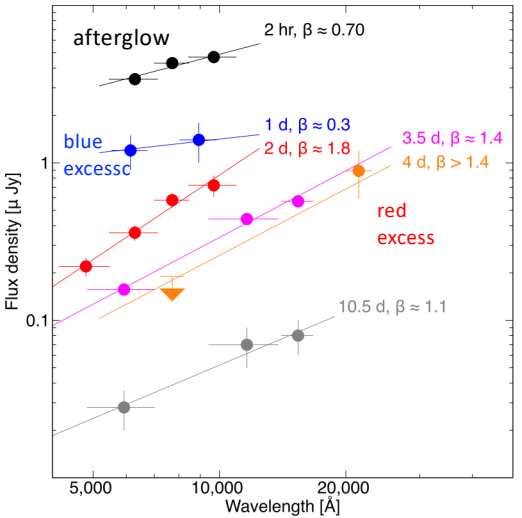
An afterglow + kilonova model



Afterglow is dominant

Luminosity, color and timescales of excess consistent with AT2017gfo

Color Evolution



Troja+19 (in prep), Jin+18, Kasliwal+17

>10 hrs of GTC (10m)
12 HST orbits (focused on IR)
Swift
XMM-Newton
VLA

Detection of kilonovae was possible

but

Identification required a significant investment of observing time and a well thought strategy on different facilities. c

Summary

- GW170817/GRB170817A: consistent with a short GRB seen at an angle of ~25 deg.
- At least another similar event was observed in 2015. GRB150101B is consistent with an short GRB seen at an angle of ~13 deg.
- GRB150101B also shows evidence for kilonova emission in the optical.
- GRB160821B at z=0.161 shows a strong blue to red color evolution, consistent with a kilonova origin
- Kilonovae similar to AT2017gfo are easy to detect for z<0.5 but hard to identify:
  faint + significant afterglow contribution

Thanks!

Back-up

Comparison to afterglows