Fast radio followup of GRBs

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four π sky

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SKA-KAT Offices, Capetown, November 2012

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COLLABORATORS

- **Southampton:** Rene Breton, Rob Fender, et al.
- **Cambridge:** David Titterington, Keith Grainge, Guy Pooley.
- **Amsterdam:** John Swinbank, Alexander van der Horst, Antonia Rowlinson.
- **Capetown:** Richard Armstrong et al.

Outline

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A LITTLE BACKGROUND

A few major producers of transient alerts dominate:

- **NASA** (*Swift, Fermi, Integral, . . .*) — Gamma-ray, X-ray

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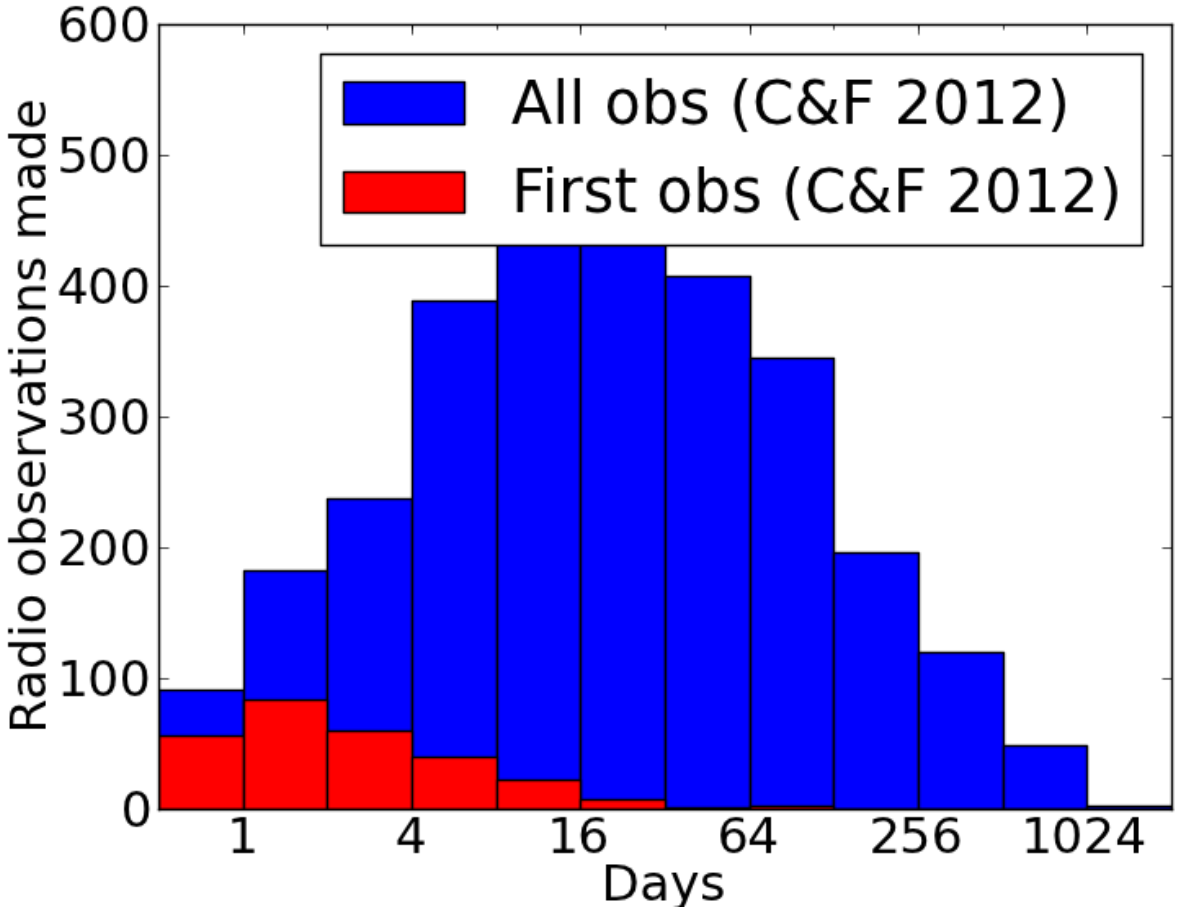
- **Catalina Real-Time Transient Survey (CRTS)** — Optical (1 / 2 colours)
- **Palomar Transient Factory (PTF)** — Optical (1 / 2 colours, spectroscopic followup)

MANUAL RADIO FOLLOW UP OF GRBS



Data from Chanda and Frail, 2012. $\sim$ 8GHz.

4 PI SKY

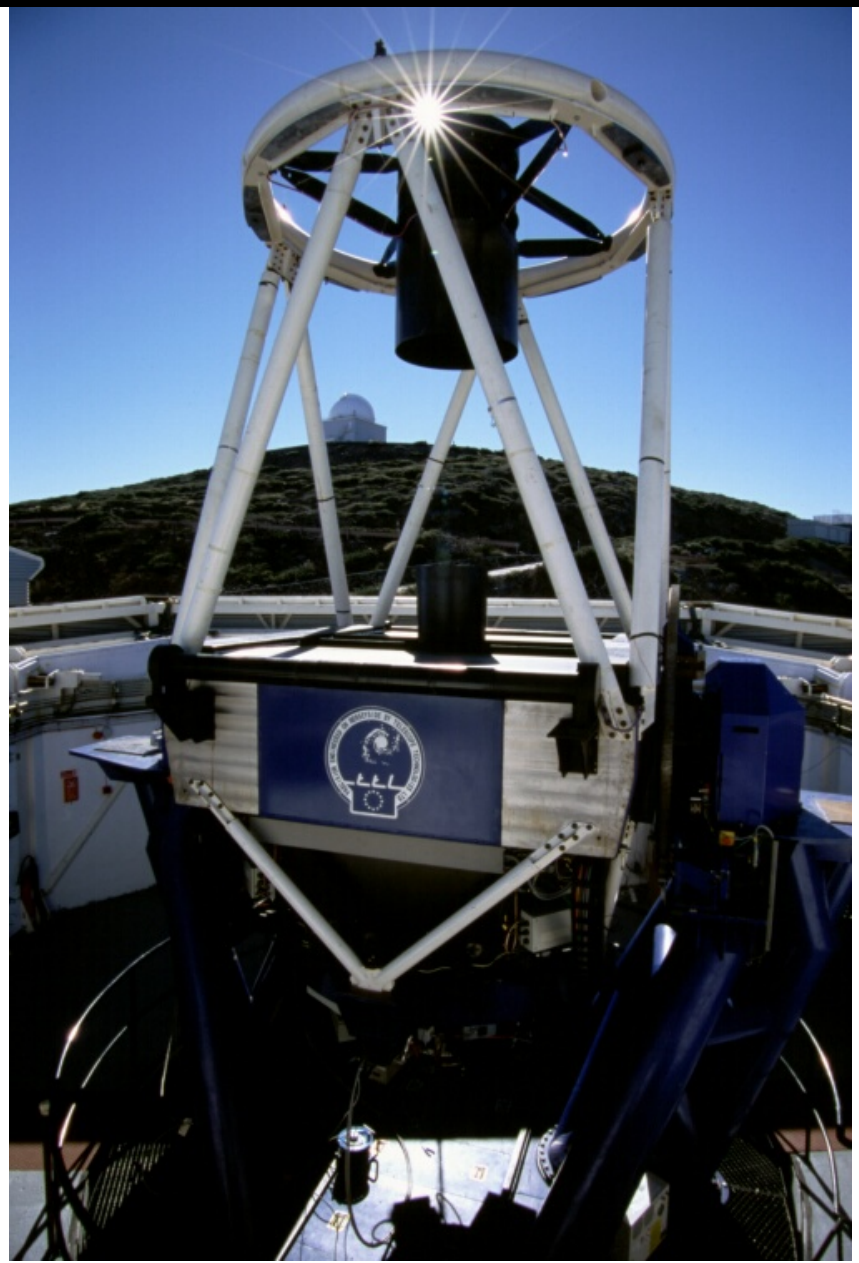
- 4 Pi Sky is a collaborative project aimed at radio transient science.
- (Or to put it another way: you build the telescopes, we'll build the network.)
- Developing **discovery** and **follow up** tools.

LOFAR (Netherlands)

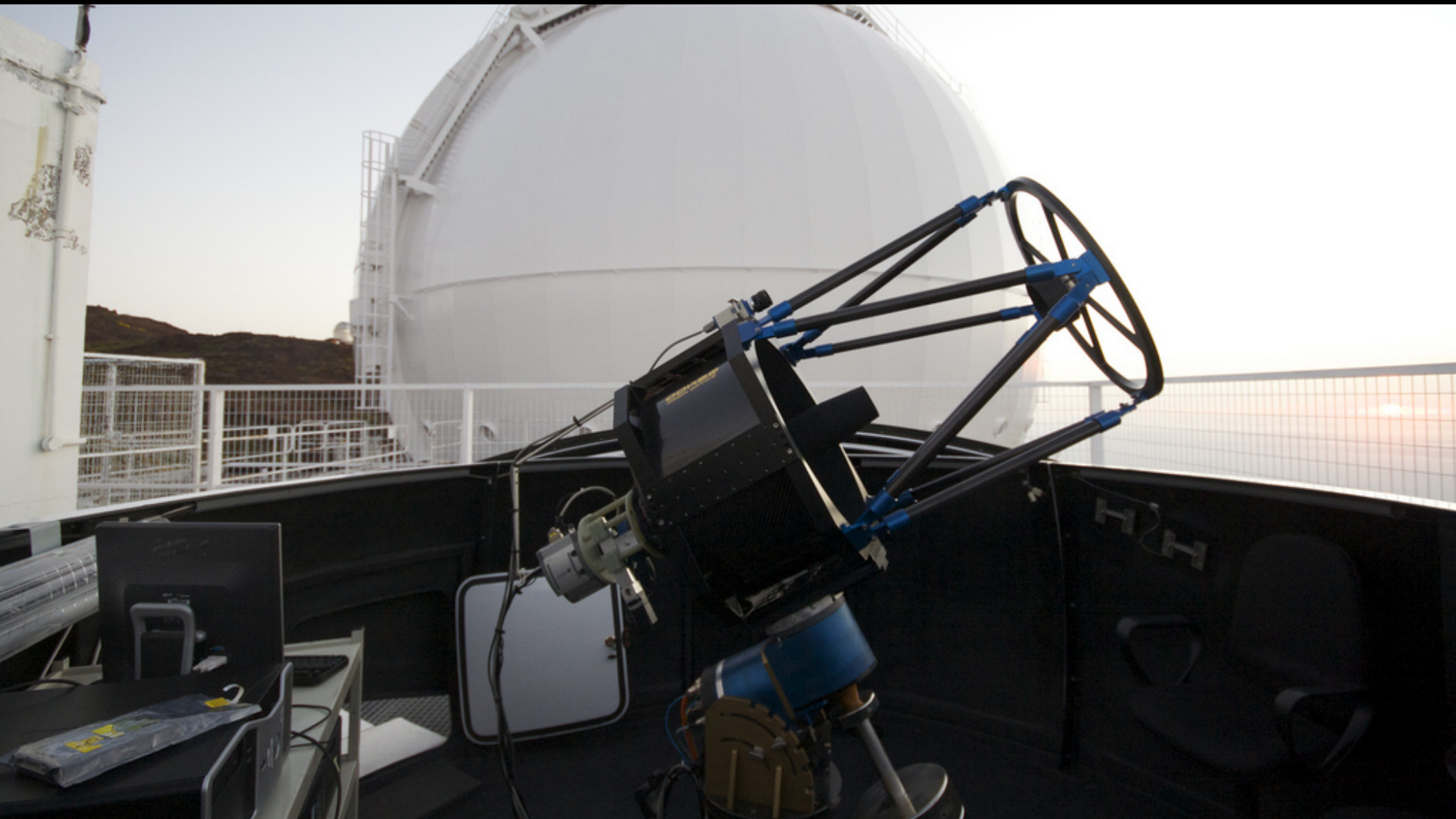
KAT7 / MeerKat (South Africa)

AMI-LA (UK)

OPTICAL FOLLOWUP: LT AND PT5M



Optical followup: LT and pt5m (La Palma)



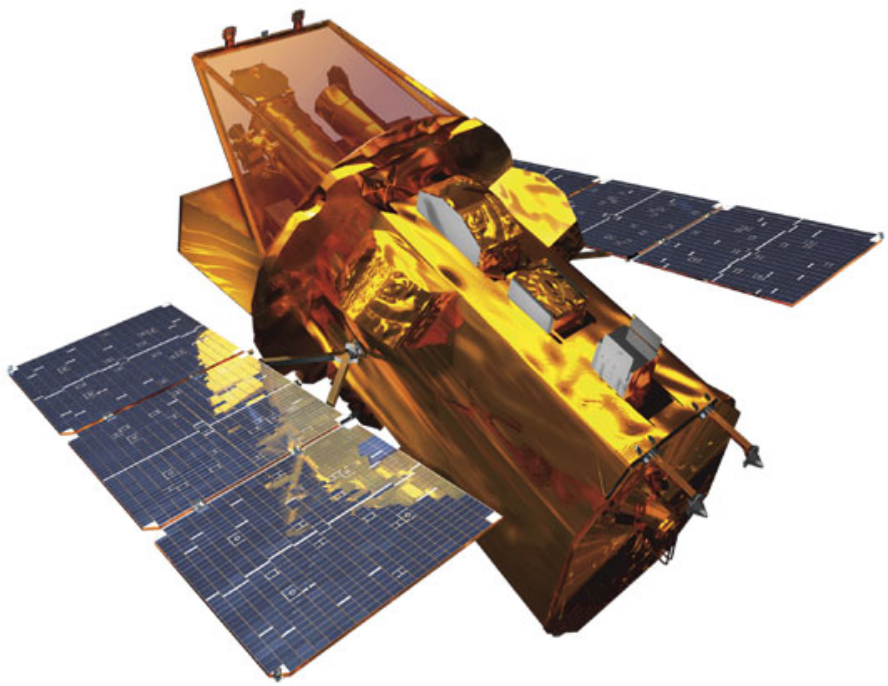
A prototype project: Swift-AMI

A PROTOTYPE PROJECT: SWIFT-AMI

- 15 GHz central frequency, 4.5 GHz bandwidth
- 5.5 arcmin ($\sim 0.1^\circ$) primary beam (FoV)
- 30 arcsec synthesised beam (PSF FWHM)
- $\approx$ 0.1mJy noise level, 1 hr image
- Looking for a new role.

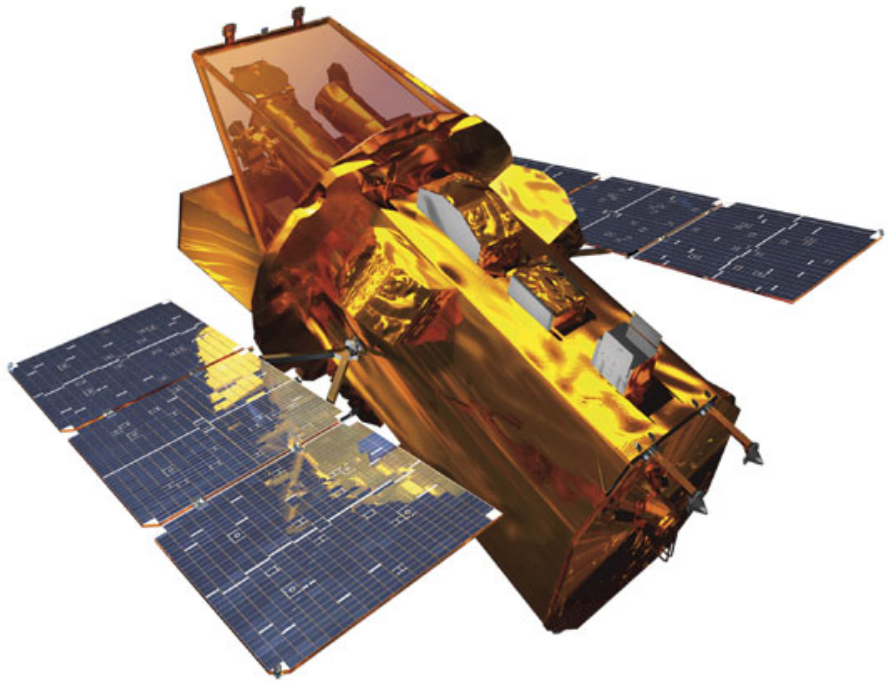
GRBS FROM SWIFT BAT

- Good targets for AMI: $\approx$ 3 arcminute initial localization.



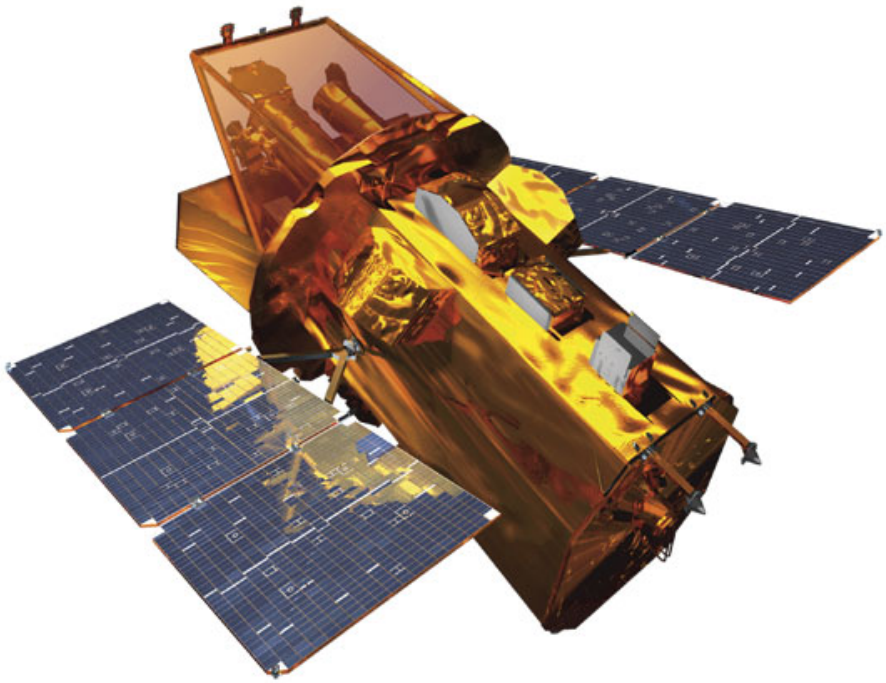
GRBS FROM SWIFT BAT

- Good targets for AMI: $\approx$ 3 arcminute initial localization.
- Once every 3 days or so.
- Now publishing as VOEvents.



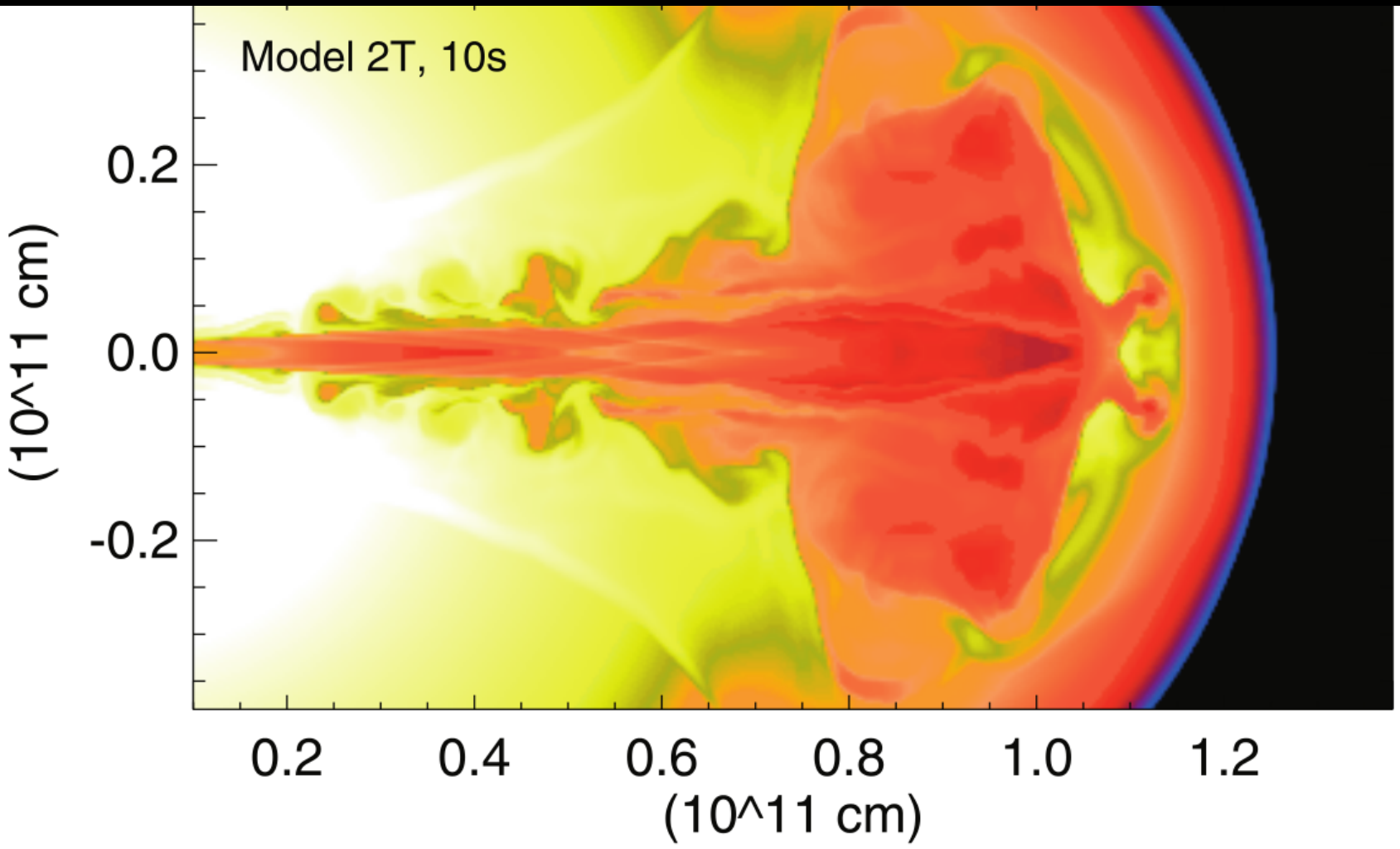
GRBS FROM SWIFT BAT

- Good targets for AMI: $\approx$ 3 arcminute initial localization.
- Once every 3 days or so.
- Now publishing as VOEvents.
- GRBs are interesting!



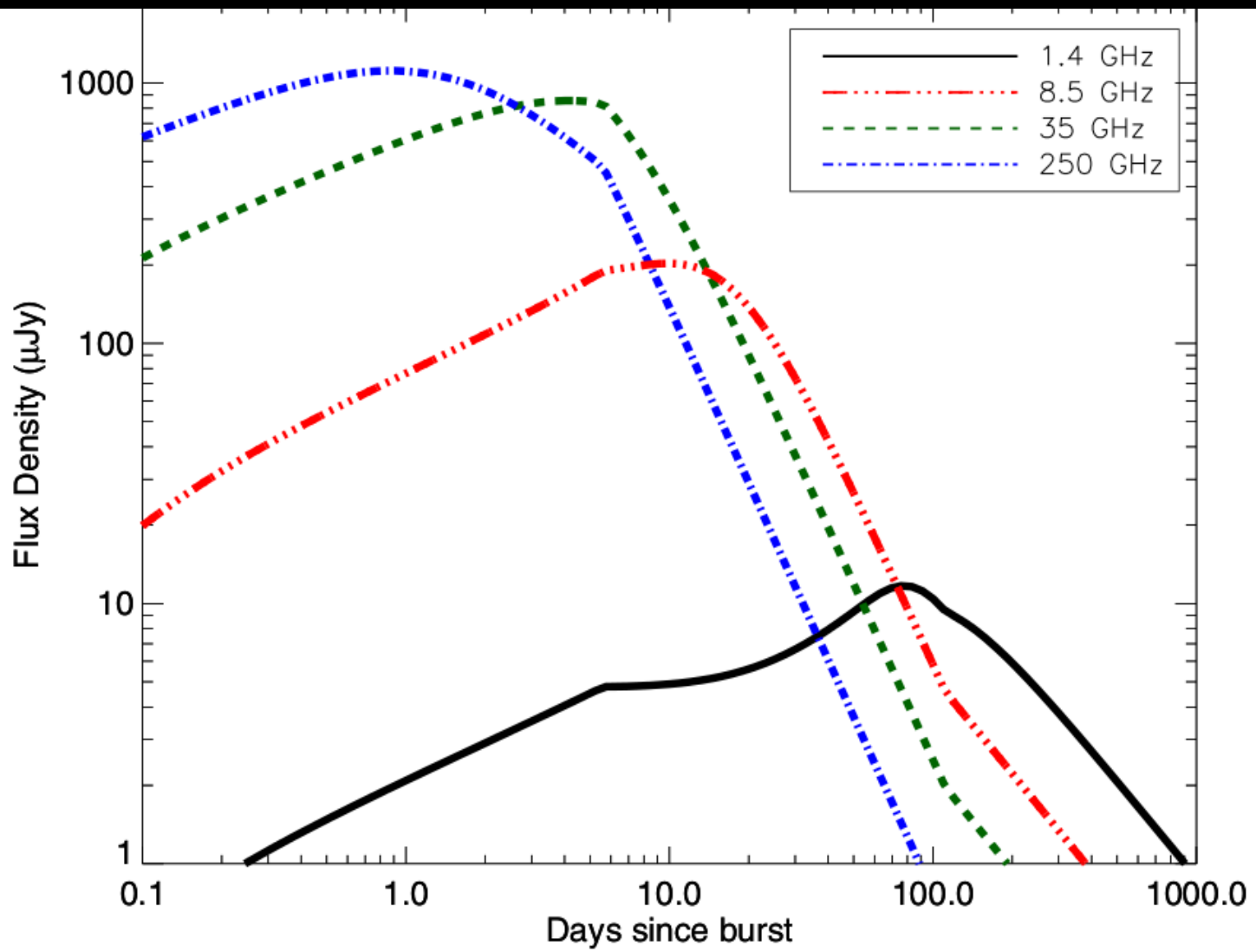
Outline

THE RELATIVISTIC FIREBALL MODEL



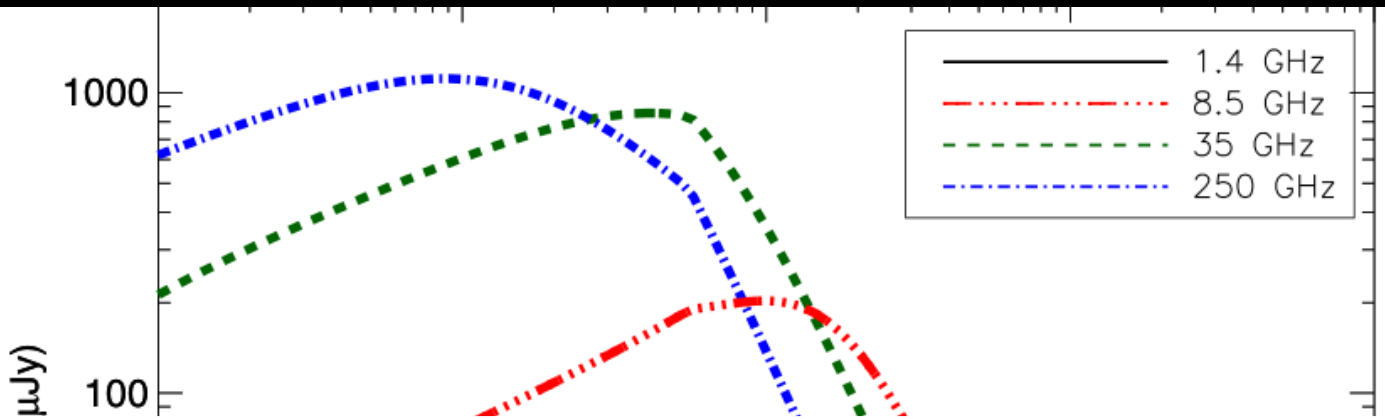
M. Rees and P. Meszaros, 1992; W. Zhang and S. Woosley, 2004.

SYNCHROTRON AFTERGLOW

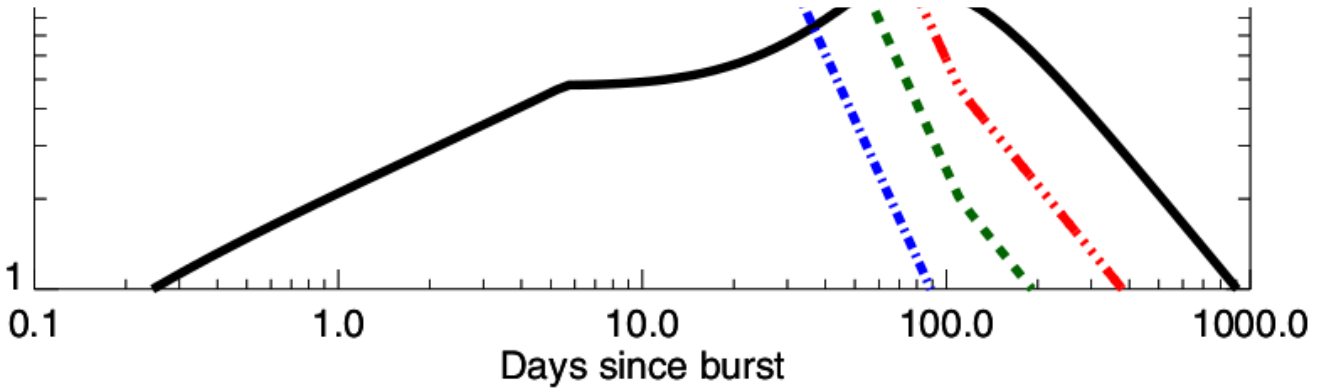


Chandra and Frail, 2012.

SYNCHROTRON AFTERGLOW



Modelling allows us to estimate the energy released, and place constraints on the density of the circumstellar medium.



Chandra and Frail, 2012.

GAMMA RAY BURST FLAVOURS

- 'Gamma Ray Burst' is a purely observational term — says nothing about the progenitor.
- **But** we tend to refer to the two most common progenitor classes as 'GRBs' out of convenience.

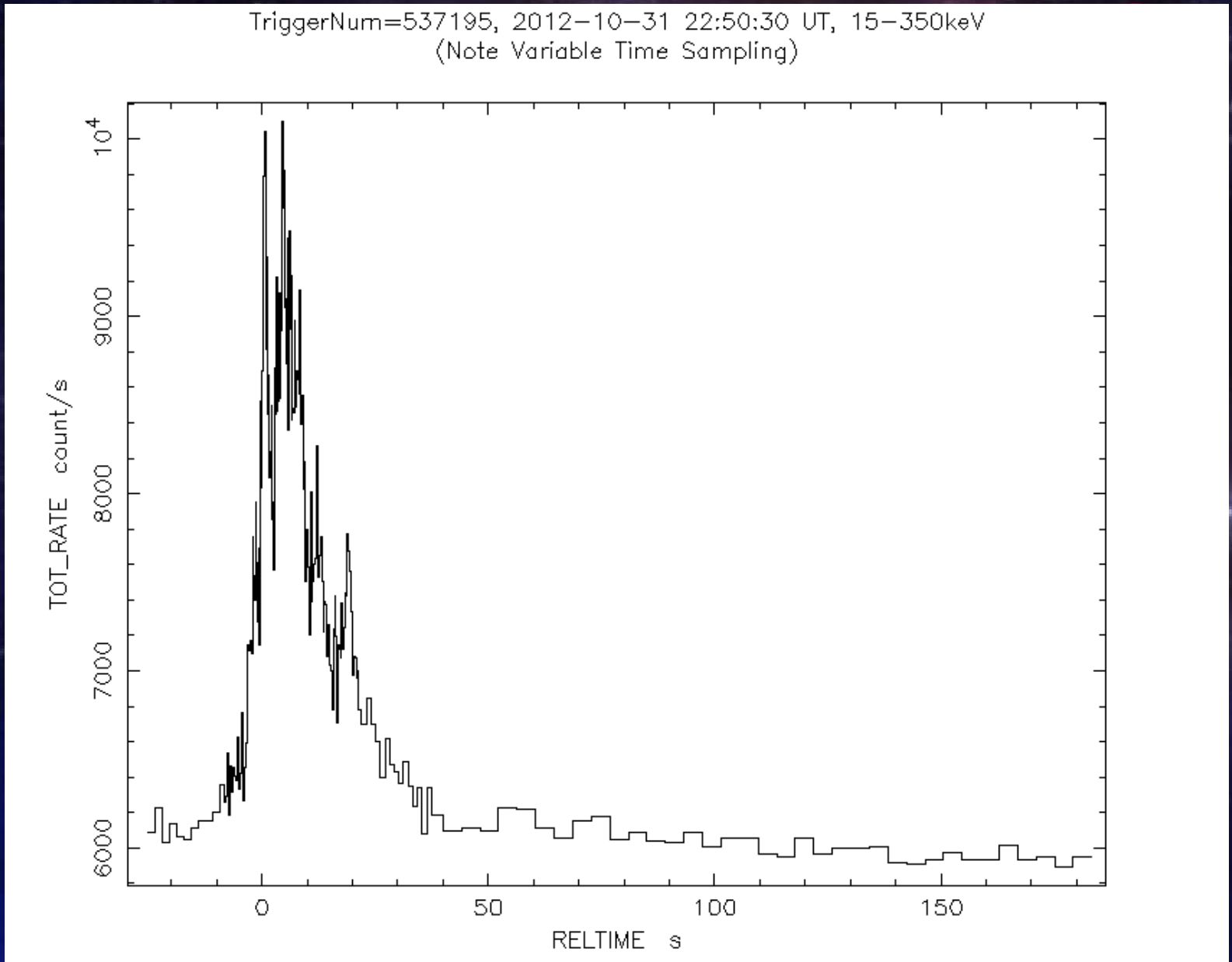
COMMON OR GARDEN LONG GRBS

Image credit: D. Berry

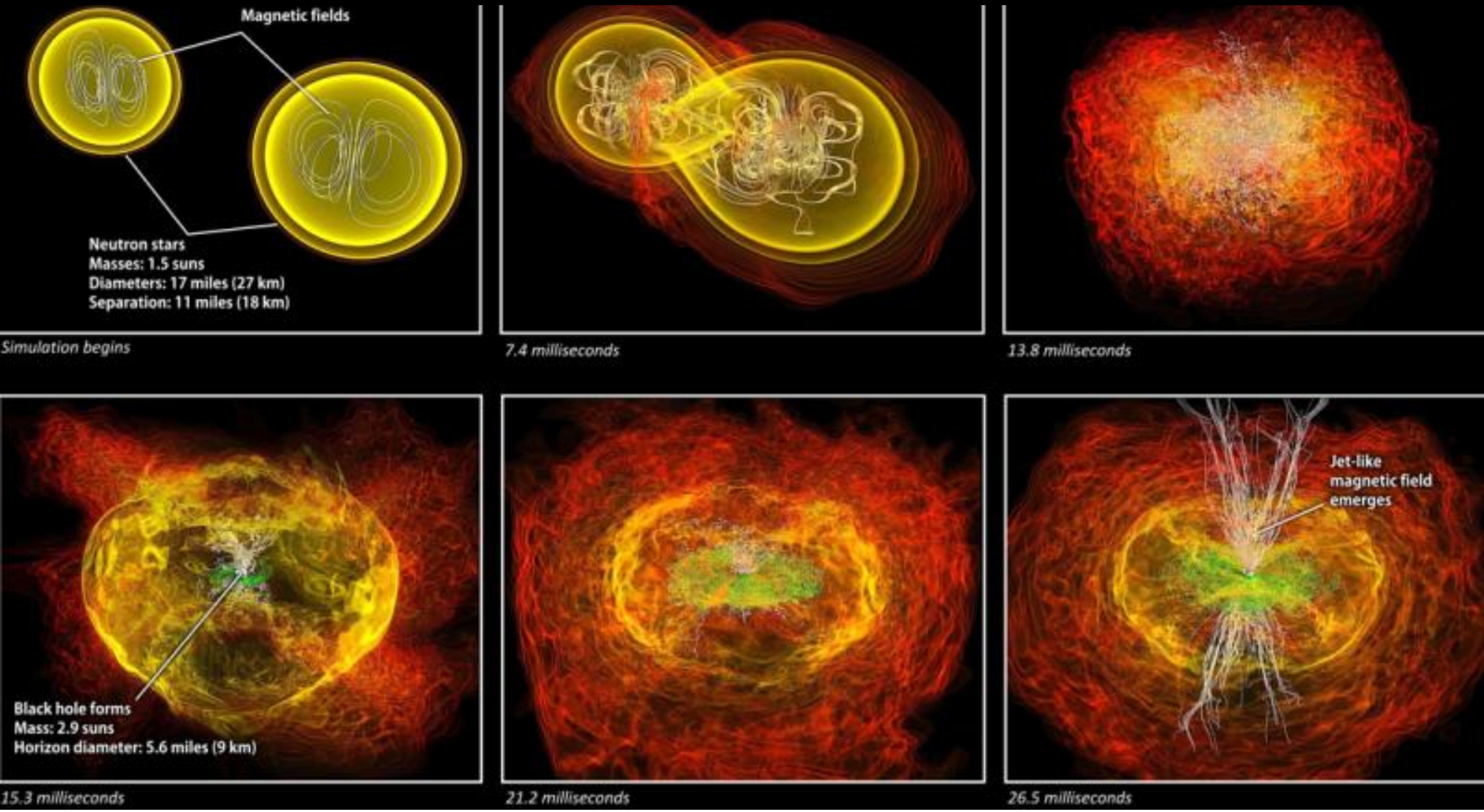
COMMON OR GARDEN LONG GRBS

- $T_{90} > 2$ seconds.
- $E \sim 10^{51}$ ergs.
- $\sim 90\%$ of GRBs.
- Sometimes observe a supernova in days after the GRB — progenitors thought to be giant stars.

COMMON OR GARDEN LONG GRBS



SHORT GRBS



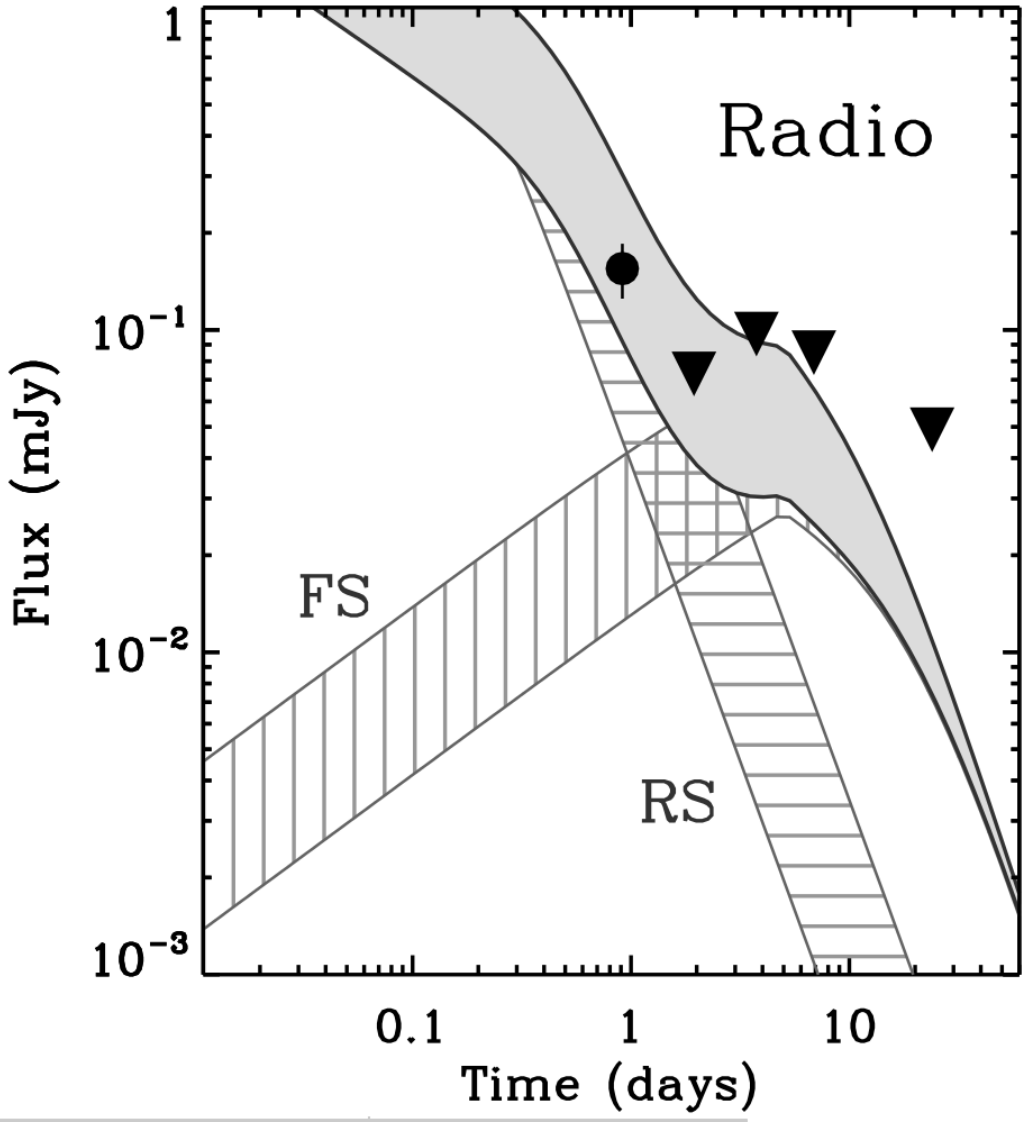
L. Rezzolla et al 2011

OTHER GRB TRIGGERS

- Soft Gamma Repeaters / Magnetars
- Flare stars
- AGN flares

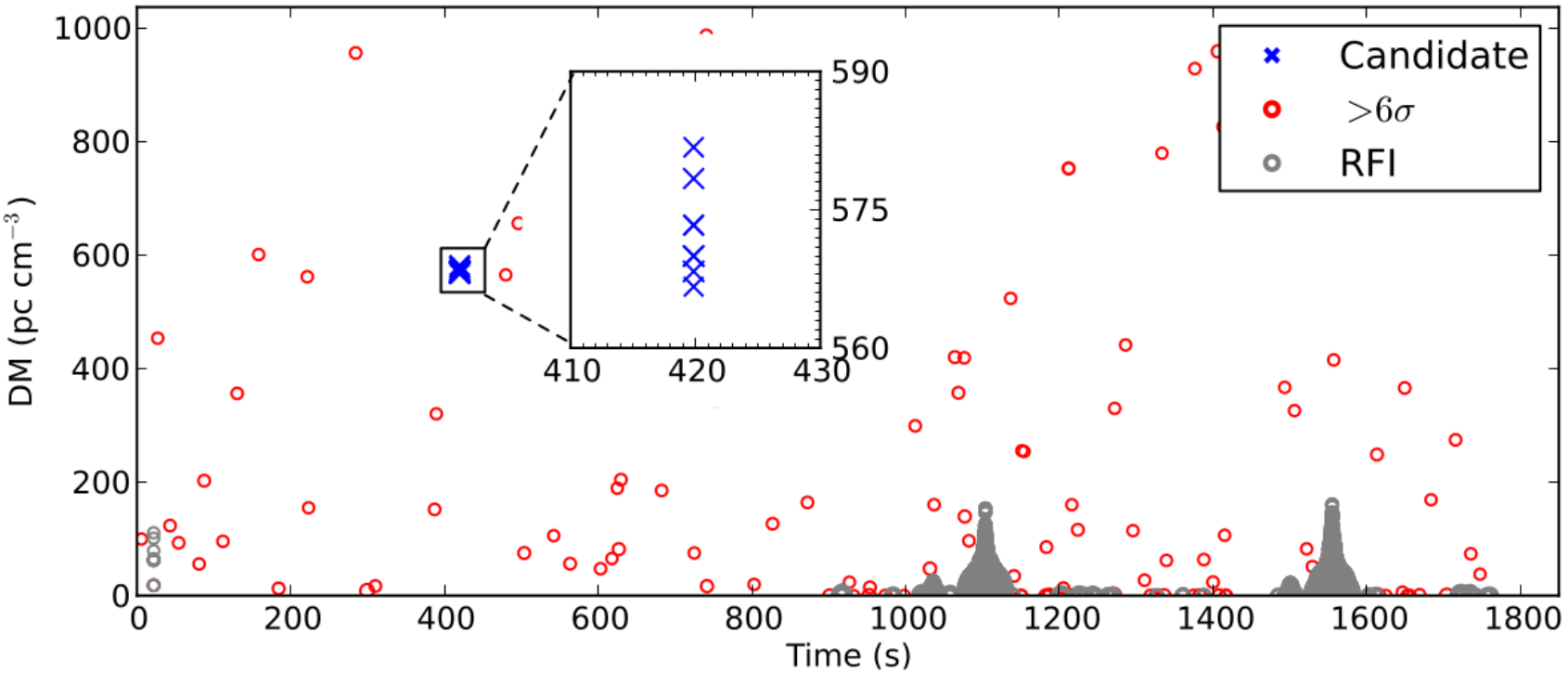
(Generally not referred to as 'GRBs')

EARLY RADIO EMISSION?



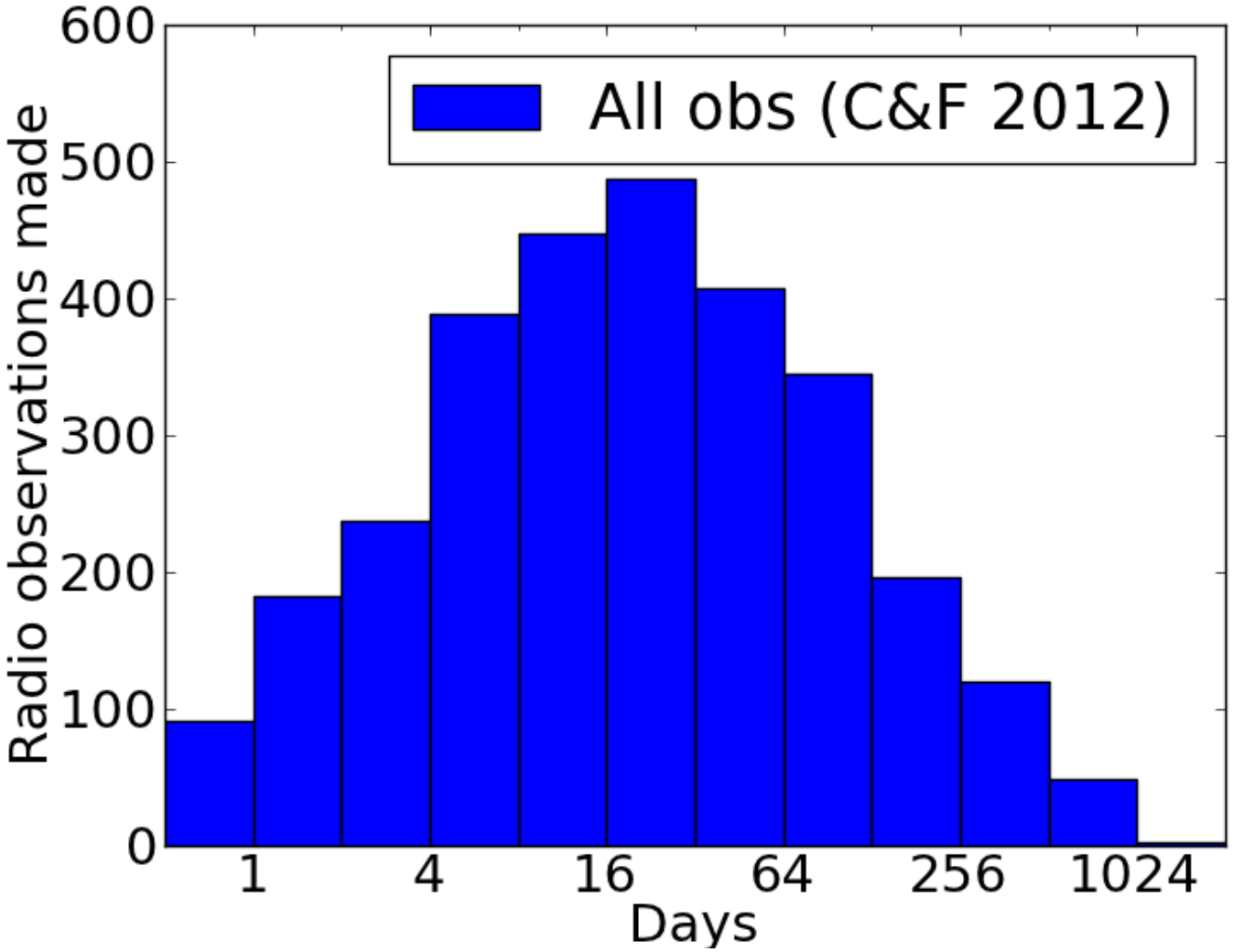
(Soderberg 2006)

EARLY RADIO EMISSION?



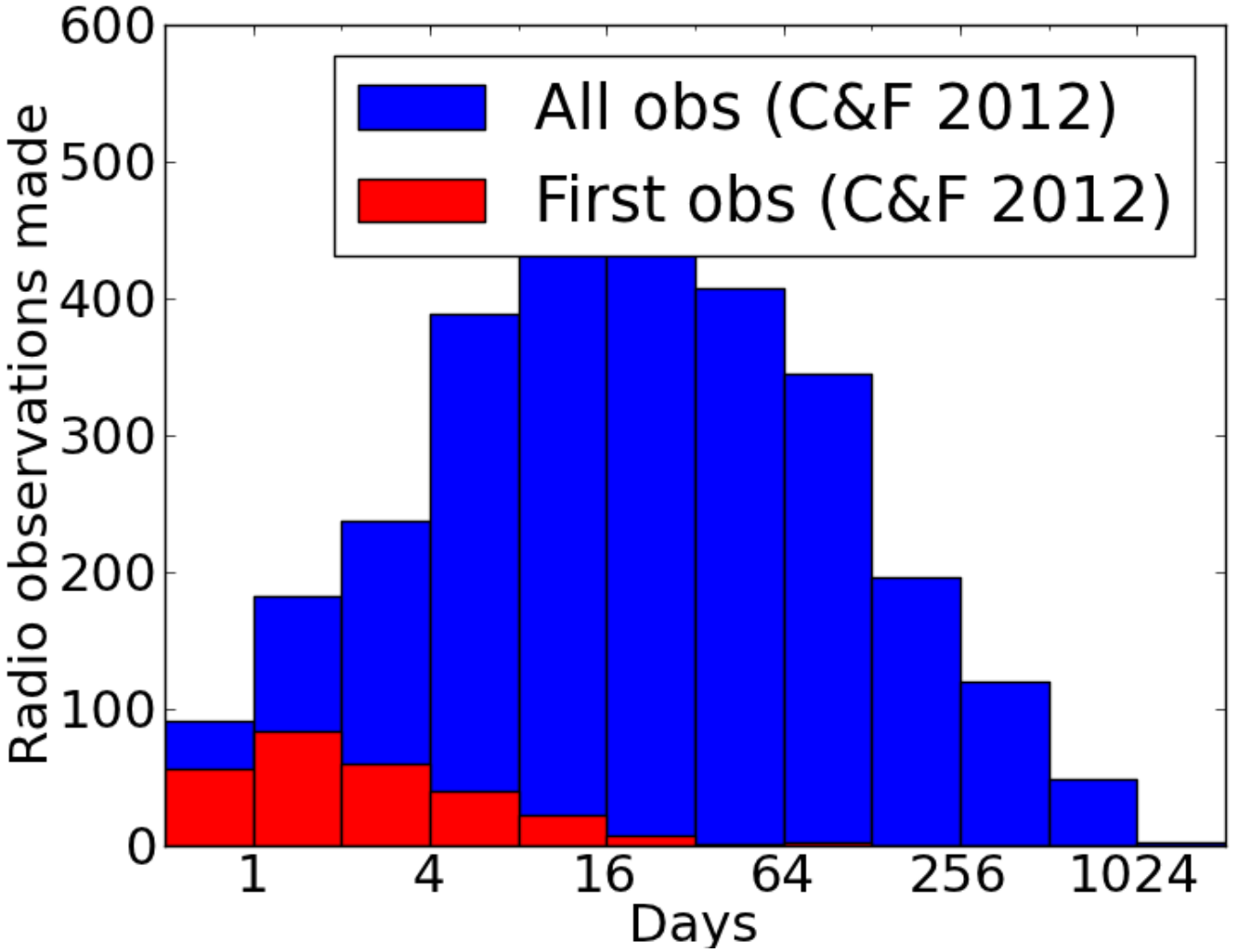
(Bannister 2012)

PRIOR RADIO OBSERVATIONS



Data from Chanda and Frail, 2012. $\sim$ 8GHz.

PRIOR RADIO OBSERVATIONS



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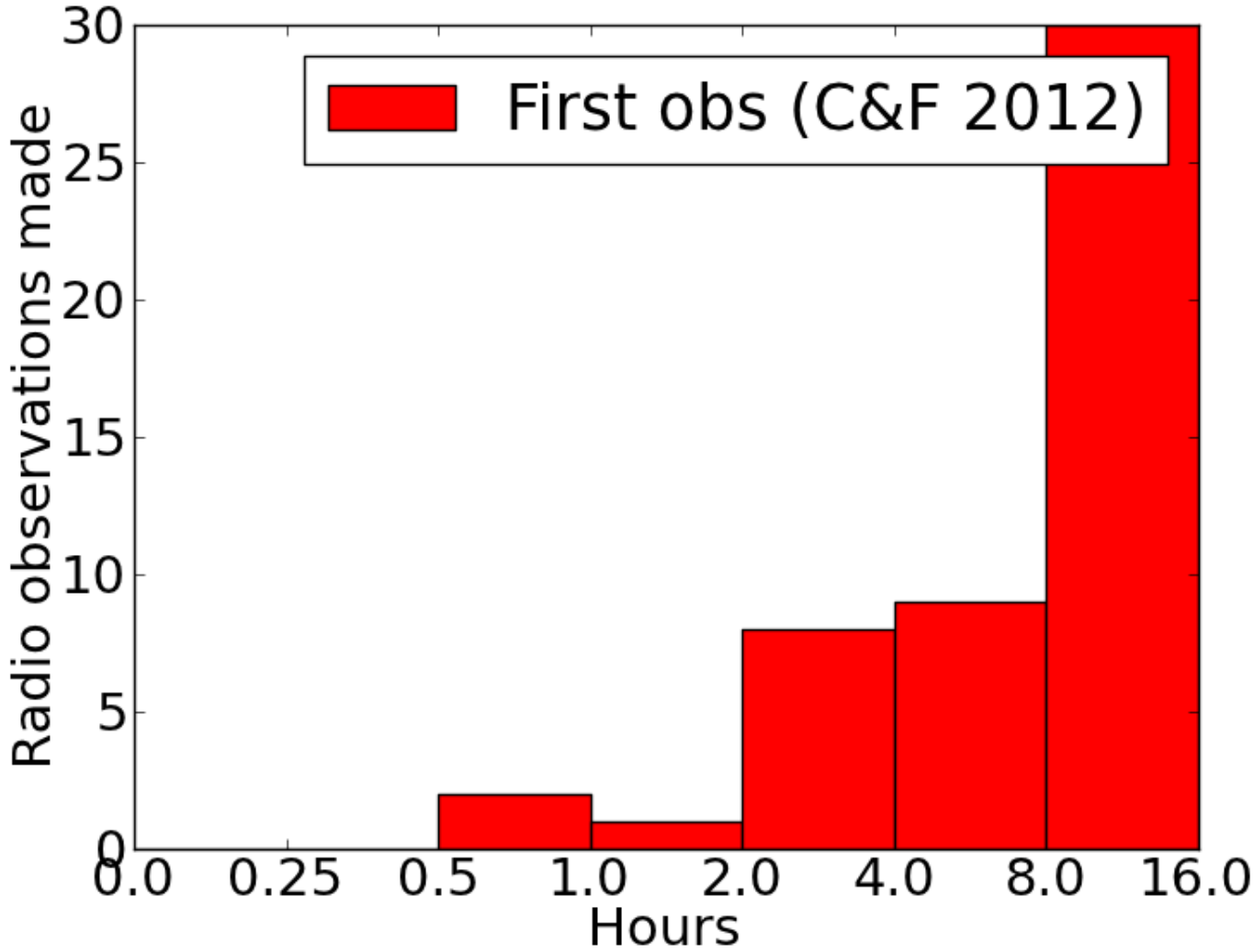
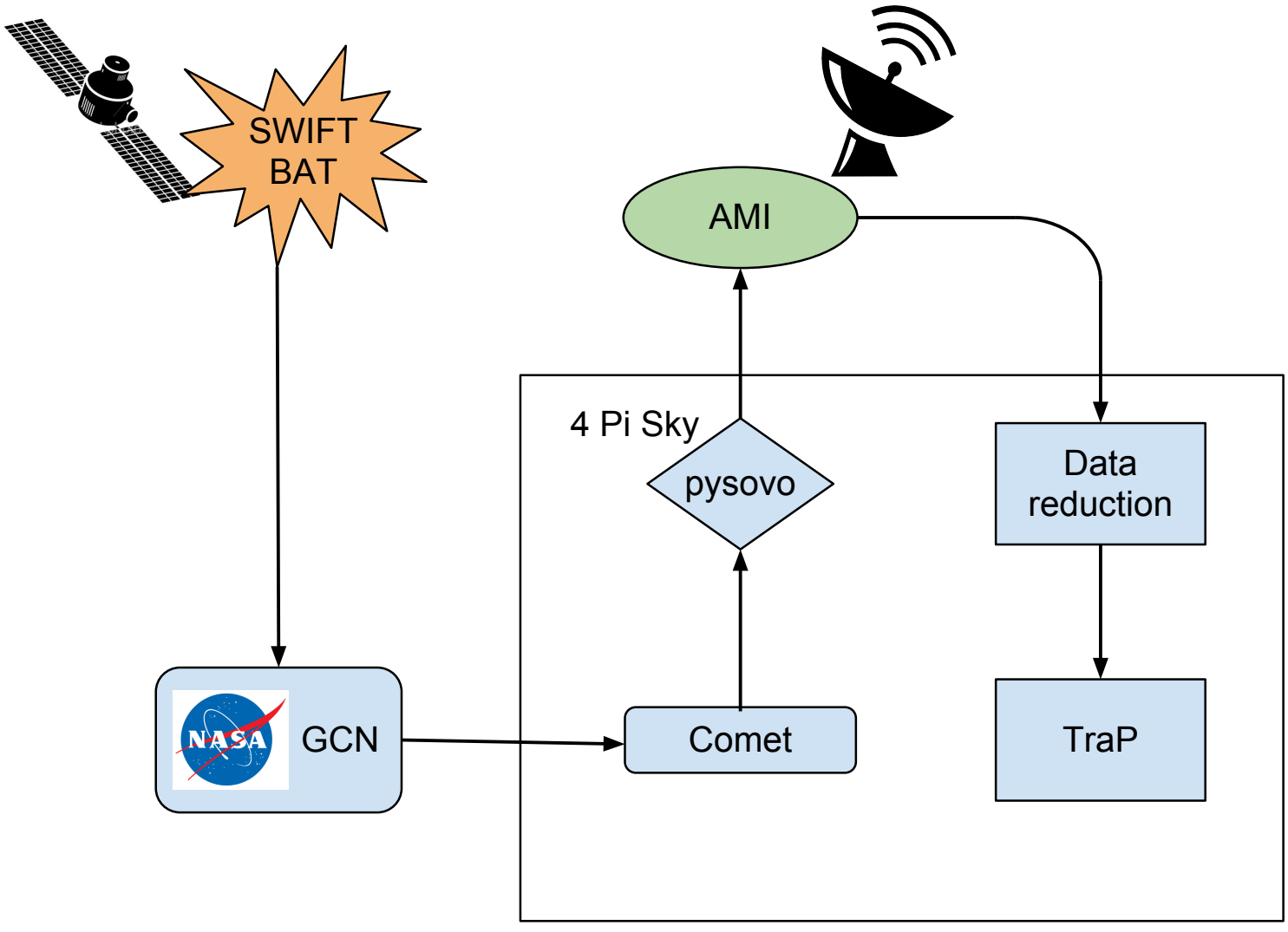


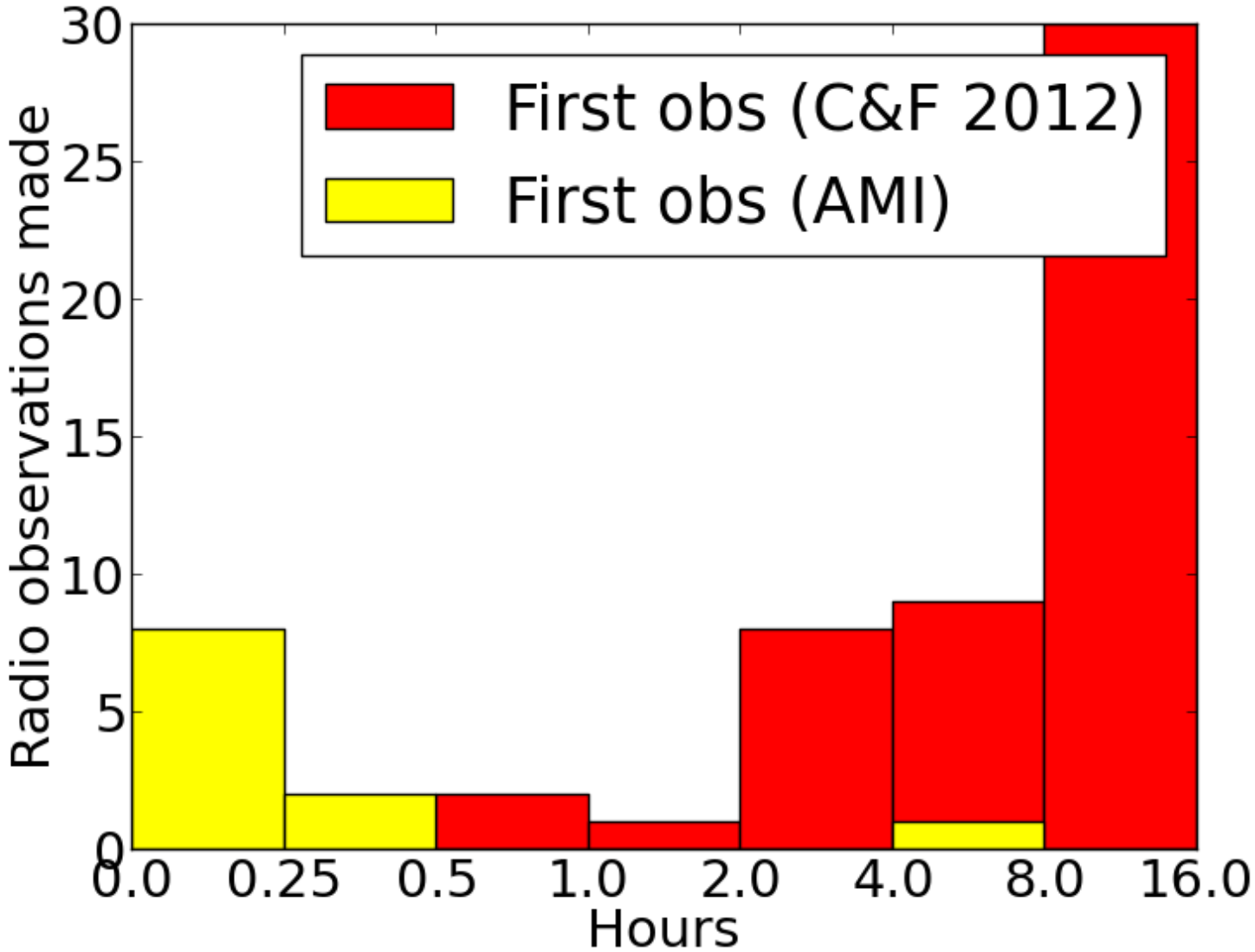
(Excluding Dave Green et al. 1995)

Outline

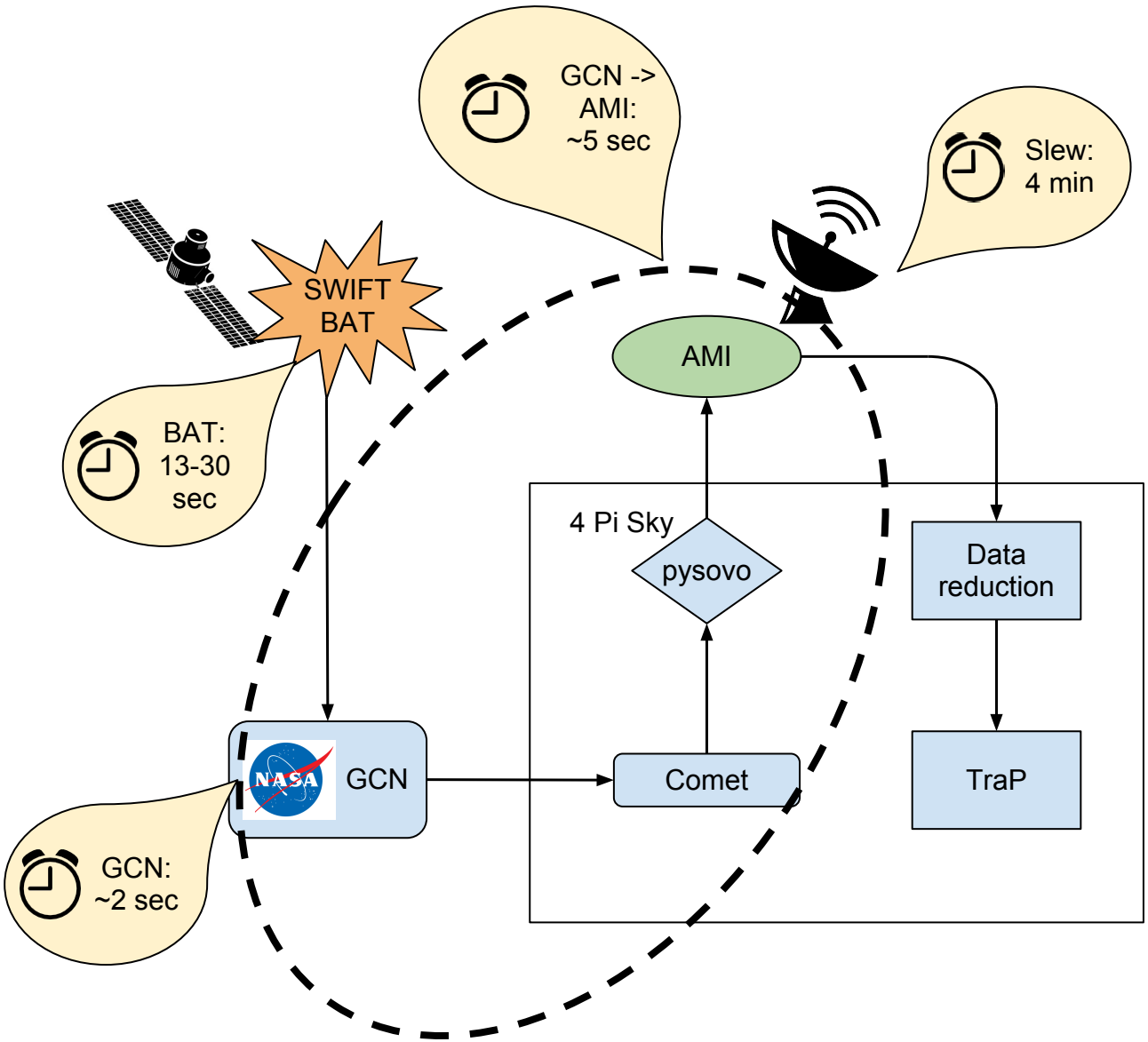
SYSTEM COMPONENTS



FASTER RESPONSE TIMES



SYSTEM TIMESCALES BREAKDOWN

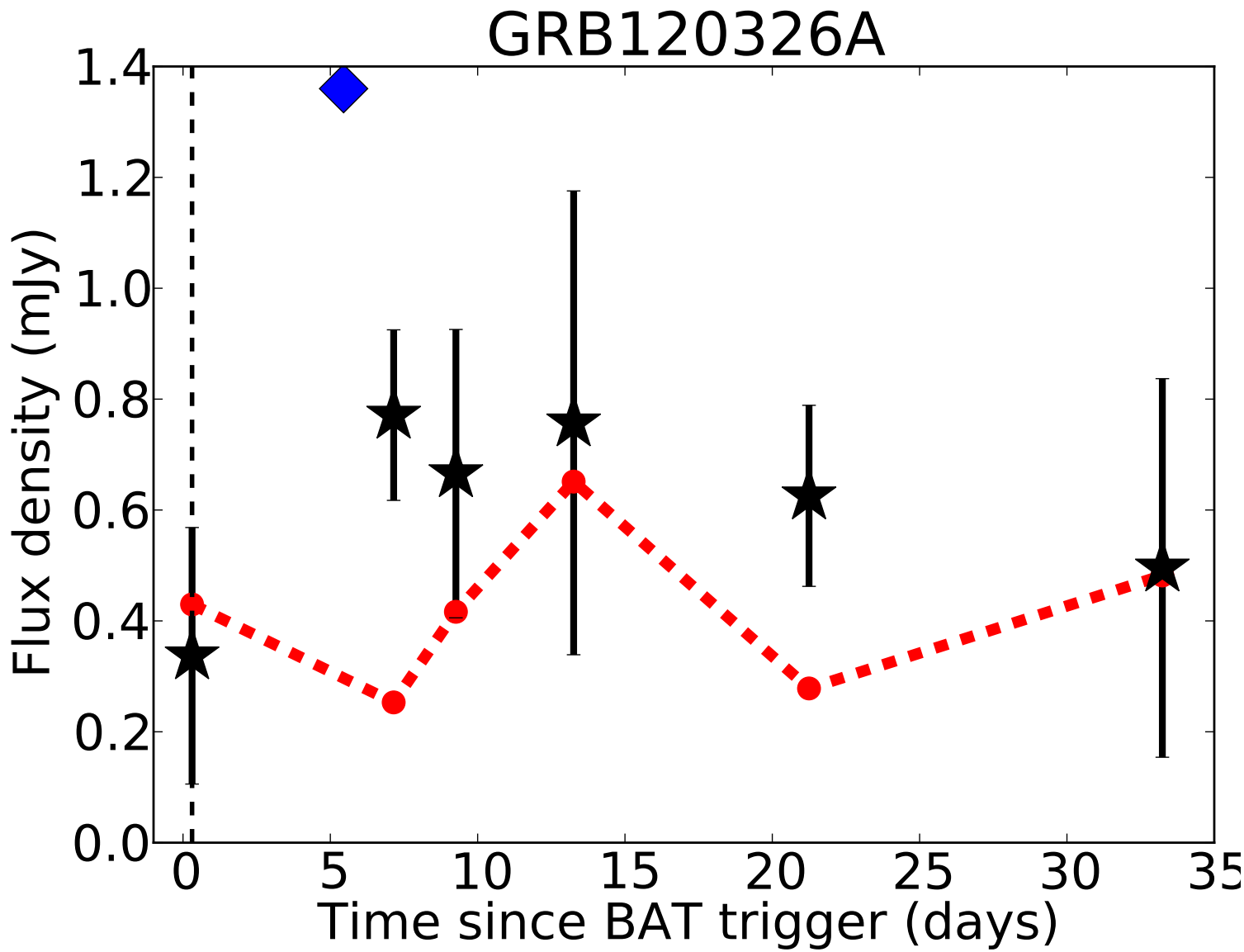


Outline

EARLY CONSTRAINTS

GRB ID	Hours since burst	3σ upper limit (mJy)
GRB120305A	0.07	0.316
GRB120308A	0.08	0.164
GRB120311A	0.07	0.230
GRB120320A	14.32	0.196
GRB120324A	0.07	0.218
GRB120326A	7.37	0.430
GRB120403A	7.48	0.238
GRB120404A	11.32	0.223
GRB120422A	6.41	0.616
GRB120514A	50.91	0.211
GRB120521C	0.24	0.302

GRB120326A LIGHTCURVE



SOFTWARE TOOLS DEVELOPED

- **Comet**: A VOEvent node. (John Swinbank)
- **Pysovo**: VOEvent handling / triggering tools (TS).
- **AMI-casapy-reduce**: Meta-pipeline for automated imaging of AMI data (TS).
- **TraP**: Transients detection and classification pipeline (LOFAR-TKP).

SOFTWARE TOOLS DEVELOPED: TKP-WEB

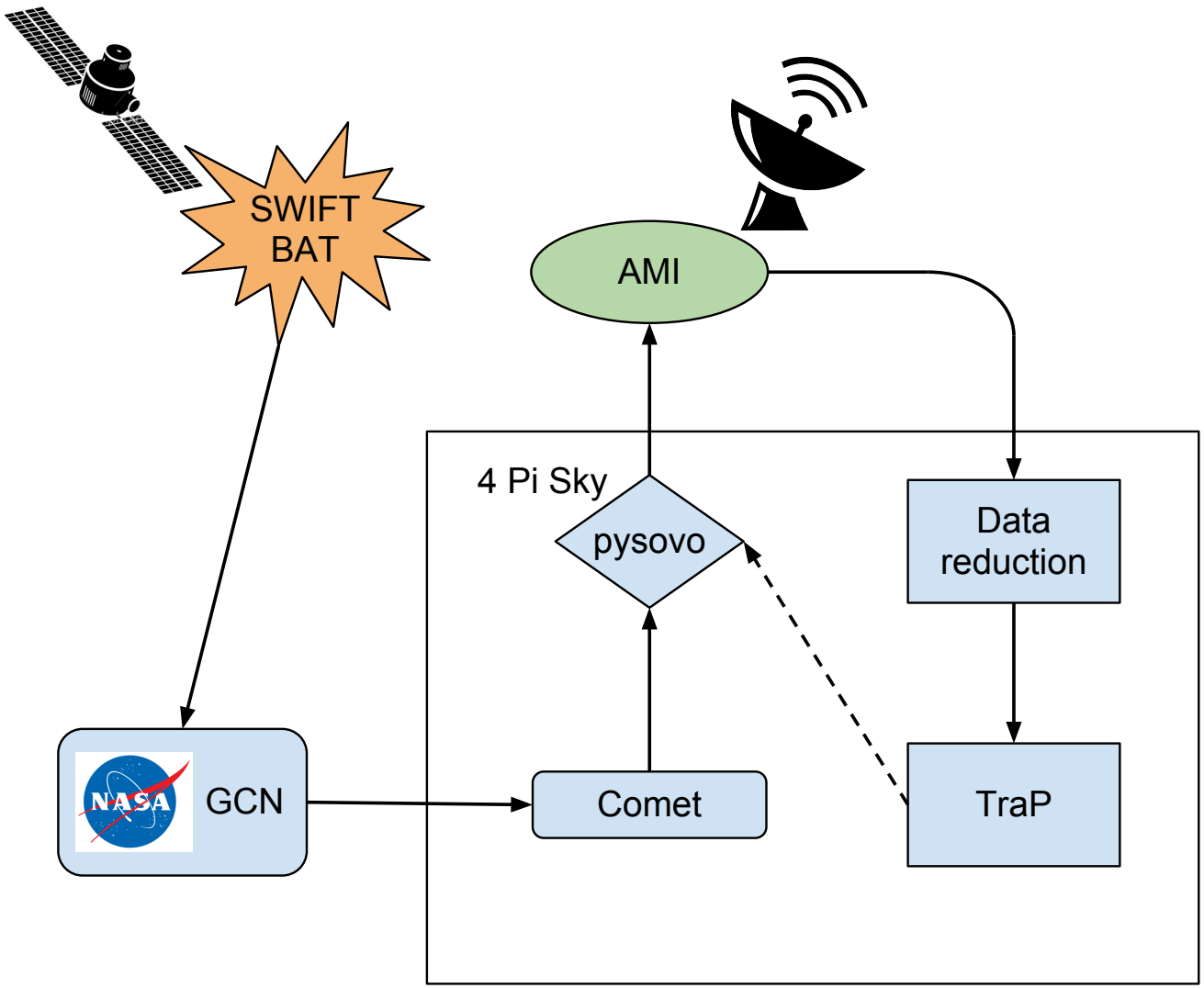
LOFAR transients database

Datasets

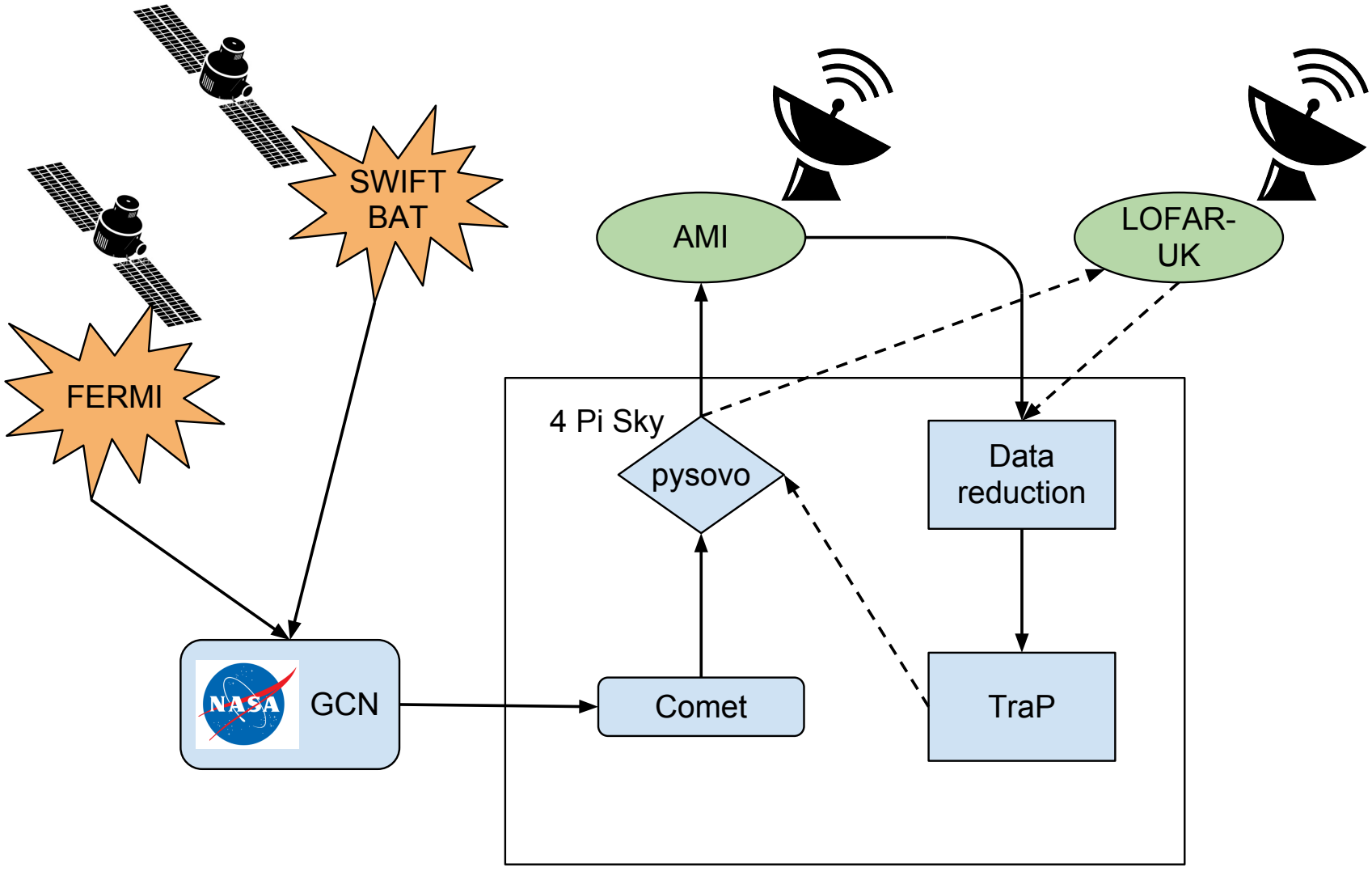
id	description	in name	Reprocessing step #	Processing finished	Number of transients
1	None	GRB120422	0	2012-06-11T13:54:17	0
2	None	GRB120404	0	2012-06-11T13:55:58	0
3	None	GRB120514	0	2012-06-11T13:57:10	0
4	None	GRB120403	0	2012-06-11T13:58:56	0
5	None	GRB120320	0	2012-06-11T13:59:54	0
6	None	GRB120326	0	2012-06-11T14:01:24	1
7	None	GRB120324	0	2012-06-11T14:03:35	0
8	None	GRB120422	1	2012-06-11T14:04:05	0
9	None	GRB120404	1	2012-06-11T14:04:33	0
10	None	GRB120308	0	2012-06-11T14:06:15	0
11	None	GRB120305	0	2012-06-11T14:10:48	0
12	None	GRB120311	0	2012-06-11T14:13:20	0
13	None	GRB120422	2	2012-06-11T15:55:10	0
14	None	GRB120422	2	2012-06-11T15:56:06	0
15	None	GRB120422	3	2012-06-11T15:59:18	0
16	None	GRB120422	4	2012-06-11T16:07:00	0

Outline

FULLY AUTOMATED DATA REDUCTION



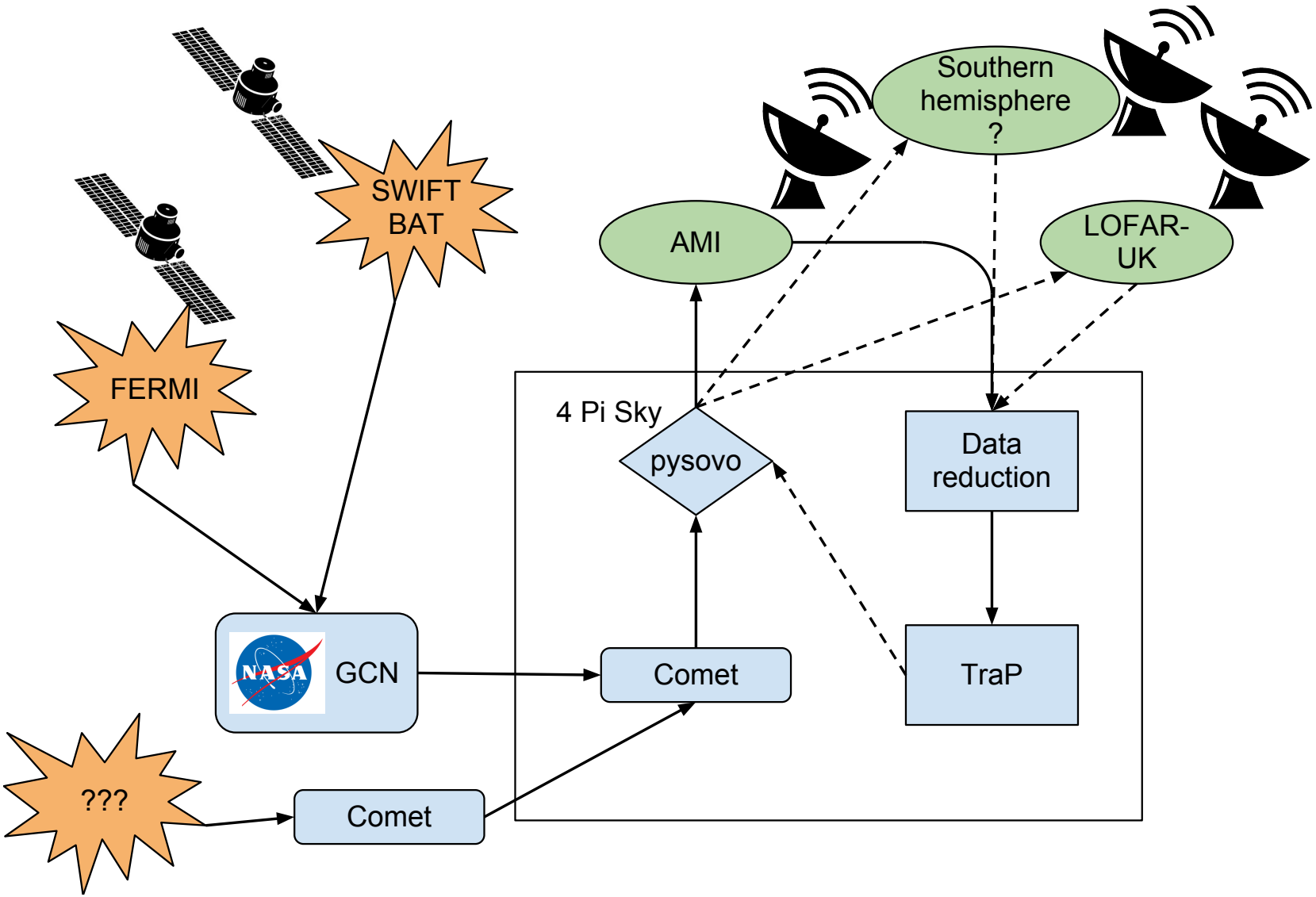
LOFAR-UK: TIME MACHINE



LOFAR-UK: TIME MACHINE

LOFAR stations include 'transient buffer boards', these allow us a 'look-back' functionality akin to BBC nature's rolling buffer cameras, e.g.
`https://www.youtube.com/watch?v=n-t2ayKadD0`

NETWORKING


SWIFT
BAT
FERMI
Southern
hemisphere
?
AMI
LOFAR-
UK
4 Pi Sky
pysovo
Data
reduction
GCN
Comet
TraP
???
Comet

WIDER ADOPTION OF VOEVENTS?

- GRB notices could be easily automated.

WIDER ADOPTION OF VOEVENTS?

- GRB notices could be easily automated.
- We need this for smart automated follow-up of GRBs!

SUMMARY

- It's a great time to be a radio astronomer.
- Doubly so if you're into transients.
- Transient software is out there, talk to us if you're interested!