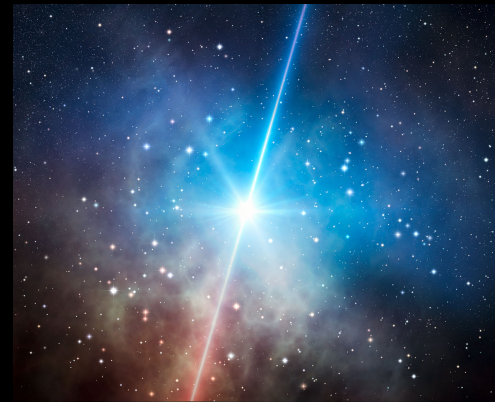




International
Centre for
Radio
Astronomy
Research

Rapid-response Triggering with Radio Telescopes



ESO

Gemma Anderson

ICRAR-Curtin University

Accretion Physics Group

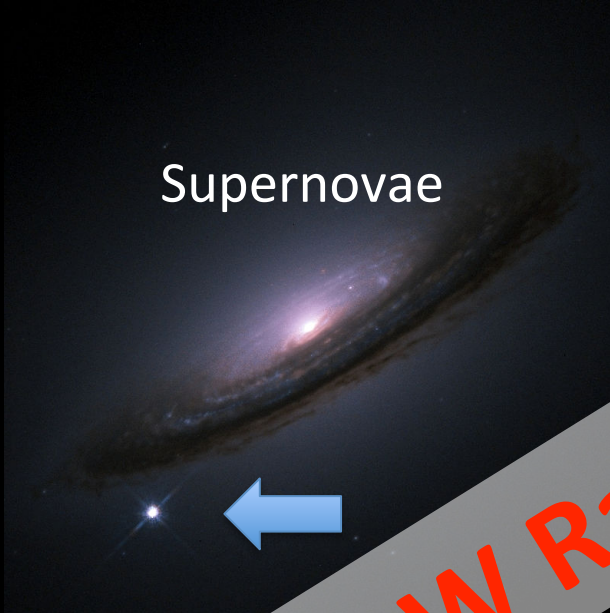
26 Sept 2017

gemma.anderson@curtin.edu.au

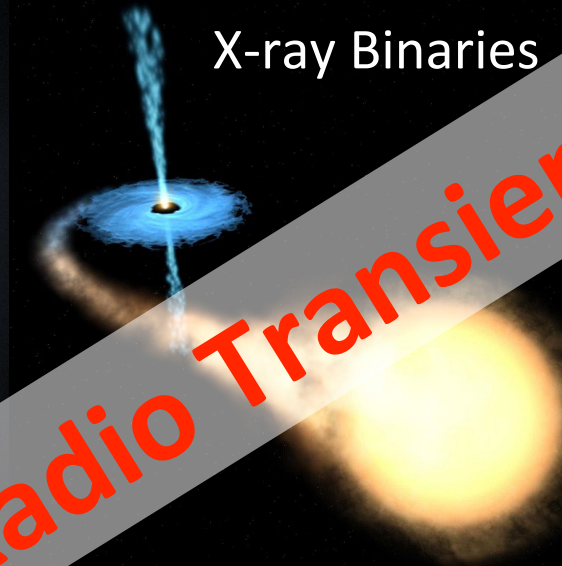


Radio Transients

Supernovae



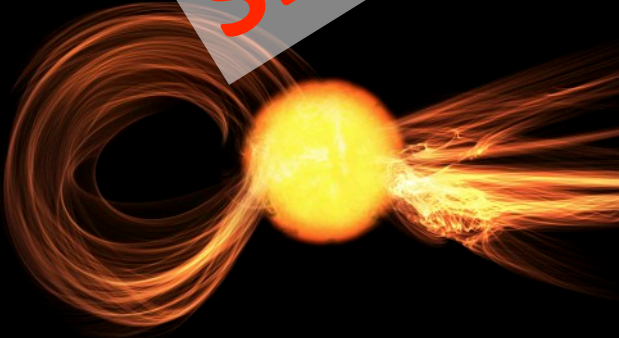
X-ray Binaries



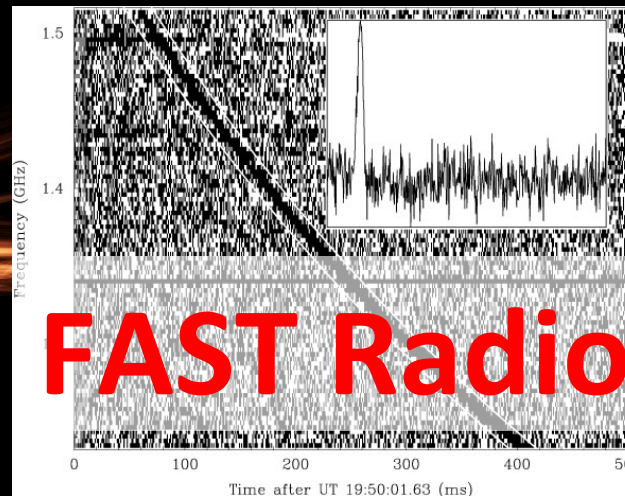
Gamma-ray Bursts



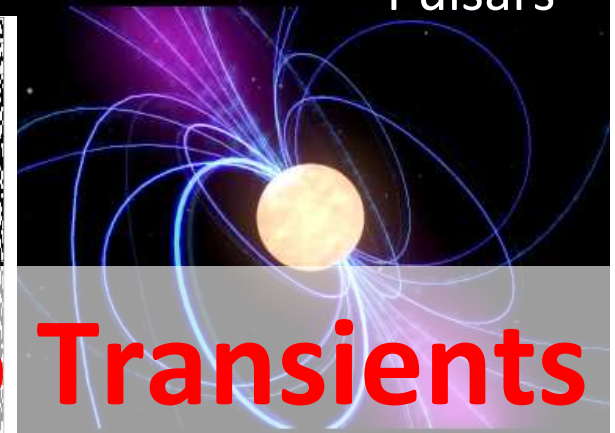
Flare Stars



Fast Radio Bursts (FRBs)



Pulsars



SLOW Radio Transients

FAST Radio Transients



Radio Transient Discovery

Blind Surveys:

- Archival
- Dedicated

Complications:

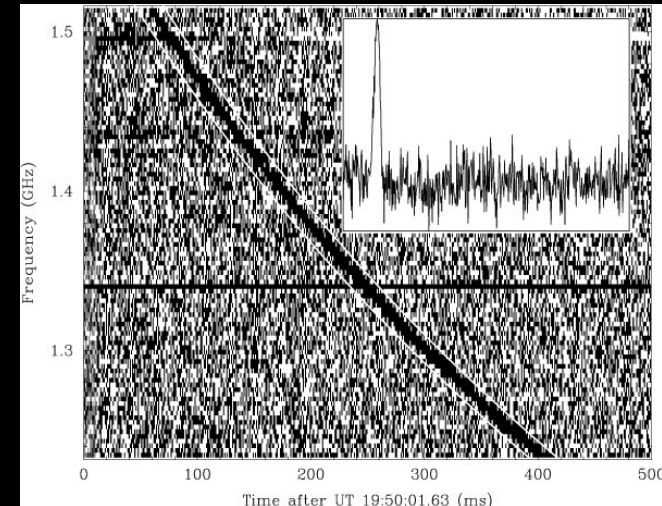
- Evolve rapidly (ms – a few days)
- Radio transients are FAINT (mJy)

TRIGGERED:

- 100% automated response to transient alert
- Rapid-response (s - mins)

TRANSIENTS:

- Swift & Fermi: GRBs, flare stars, XRBs, TDEs
- FRBs, intermittent PSRs, internal events
- Multi-messenger: GW events, cosmic rays, neutrinos



Lorimer et al. (2007)



Radio Transient Discovery

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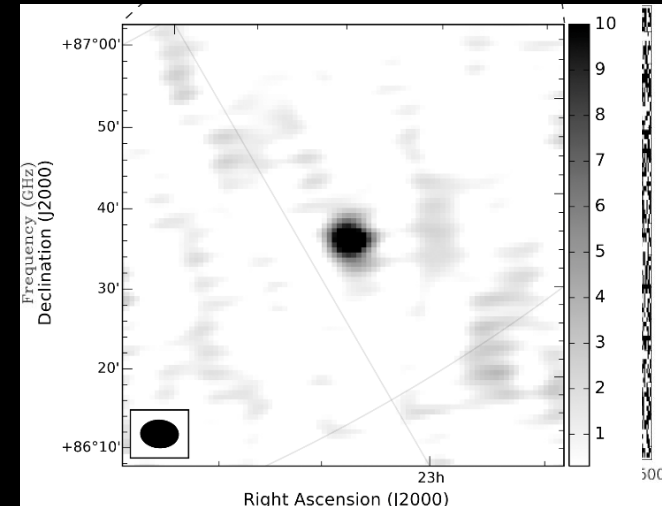
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Stewart et al. (2016)



TRIGGERING History

Gamma-ray Bursts (GRBs)

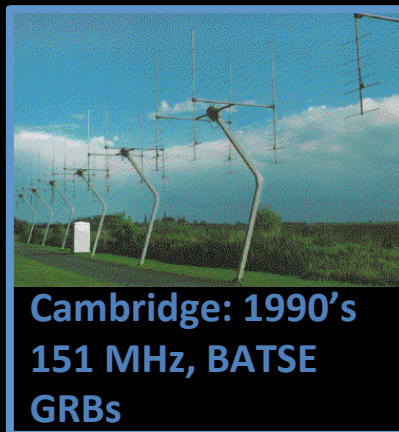
Long GRB:
Core collapse SNe



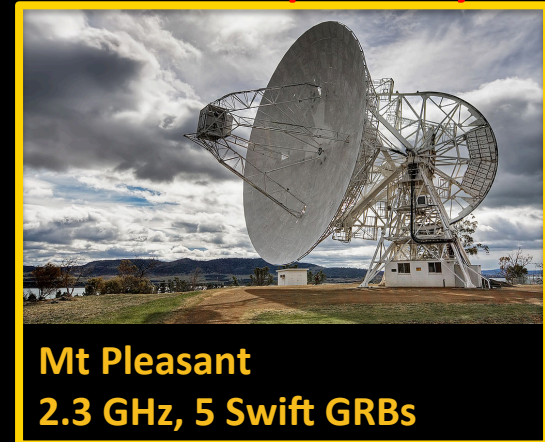
Short GRB: NS-NS merger



Prompt/pulsed coherent radio emission – Low frequency



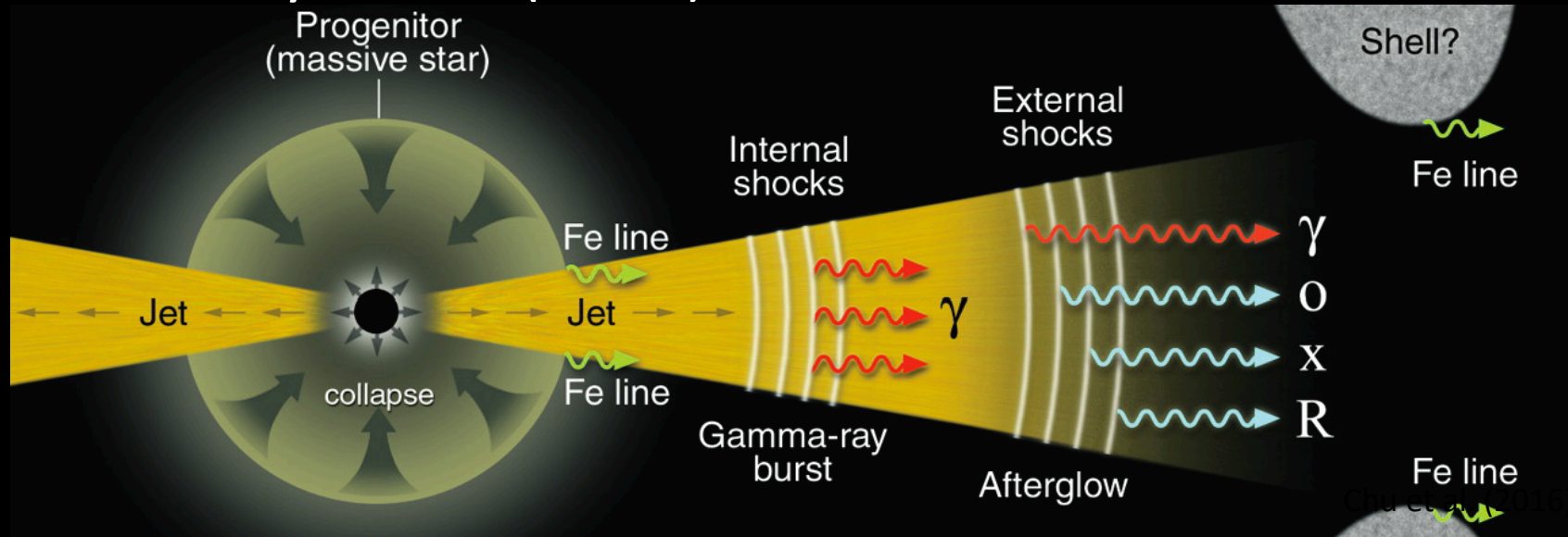
Parkes
12m dish
1.4 GHz
9 Swift
GRBs



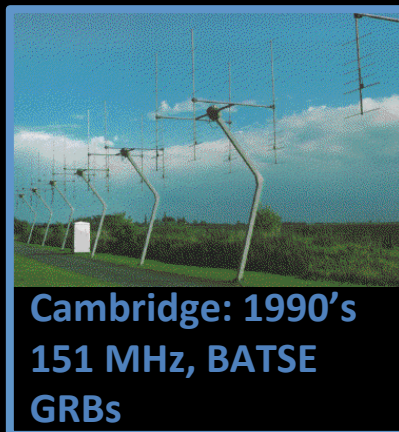


TRIGGERING History

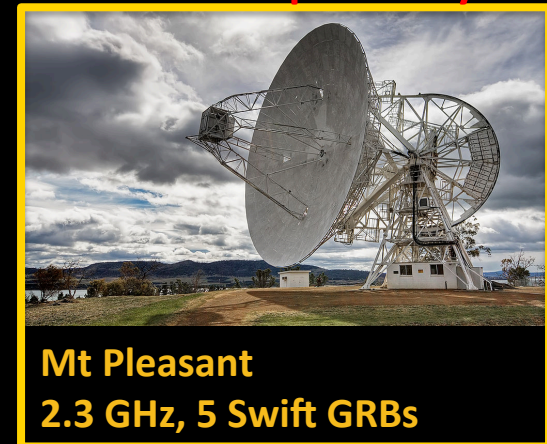
Gamma-ray Bursts (GRBs)



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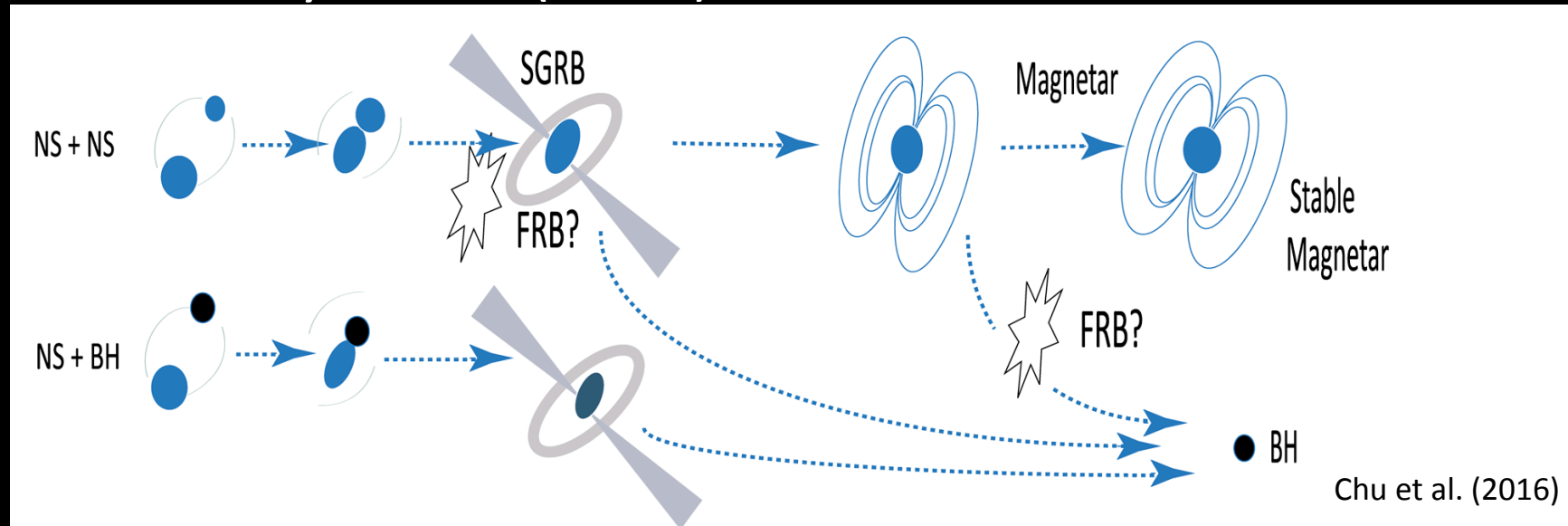
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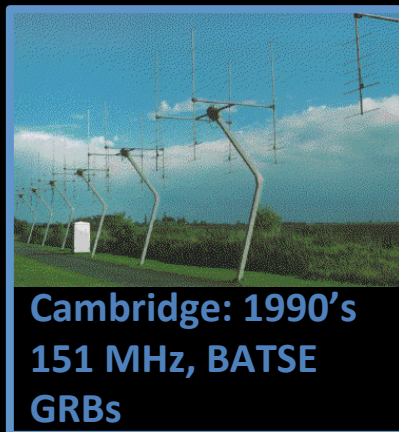


TRIGGERING History

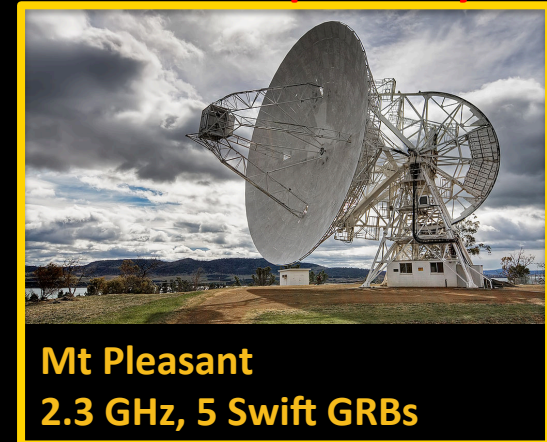
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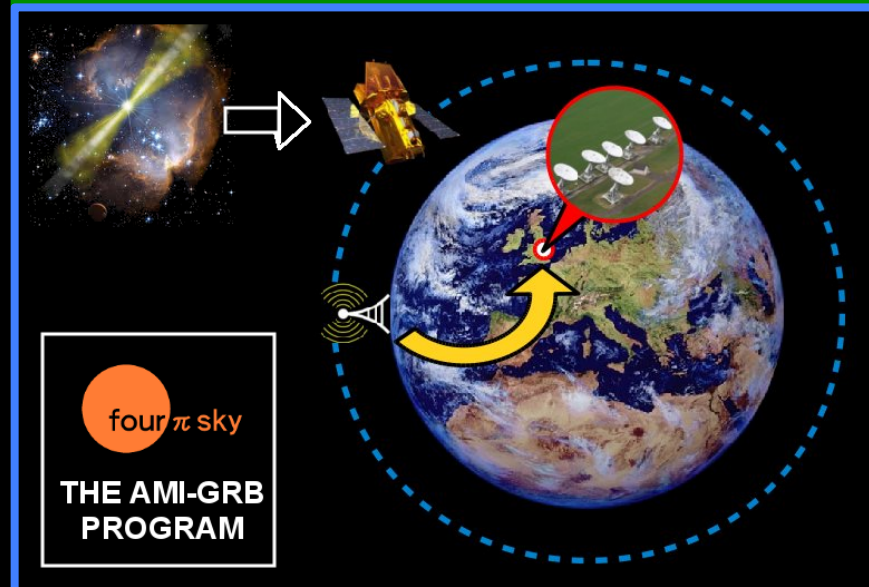
TRIGGERING

Incoherent radio emission –
high radio frequencies

Fireball Model (Synchrotron)

Arcminute Microkelvin Imager
(AMI):

- AMI Large Array Rapid Response Mode (ALARRM)
- 15.7 GHz, 5' PB, ~30'' res
- On-target <2 min
- Updates schedule
- 4 Pi Sky VOEvent broker (NASA-GCN, GAIA, ASASSN)
- Rapid-response: ~200 Swift GRBs since 2012
- Flare stars
- X-ray binaries
- Magnetars....



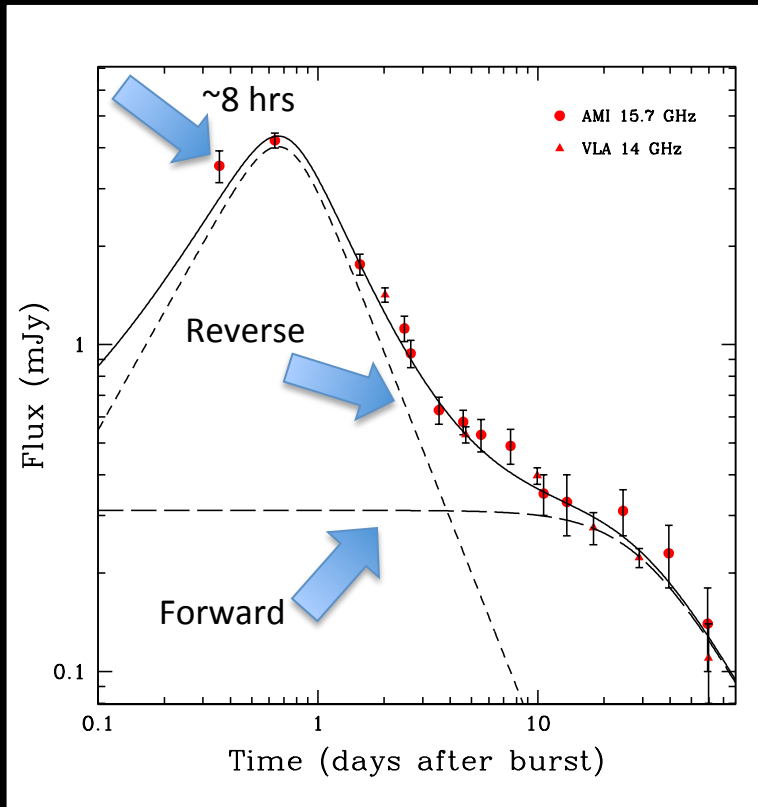
Rob Fender, Tim Staley, Four π Sky (Oxford), Antonia Rowlinson,

Ralph Wijers (UvA), Alexander van der Horst (GWU) Gemma Anderson, Rapid-response transient triggering (26 Sept 2017)



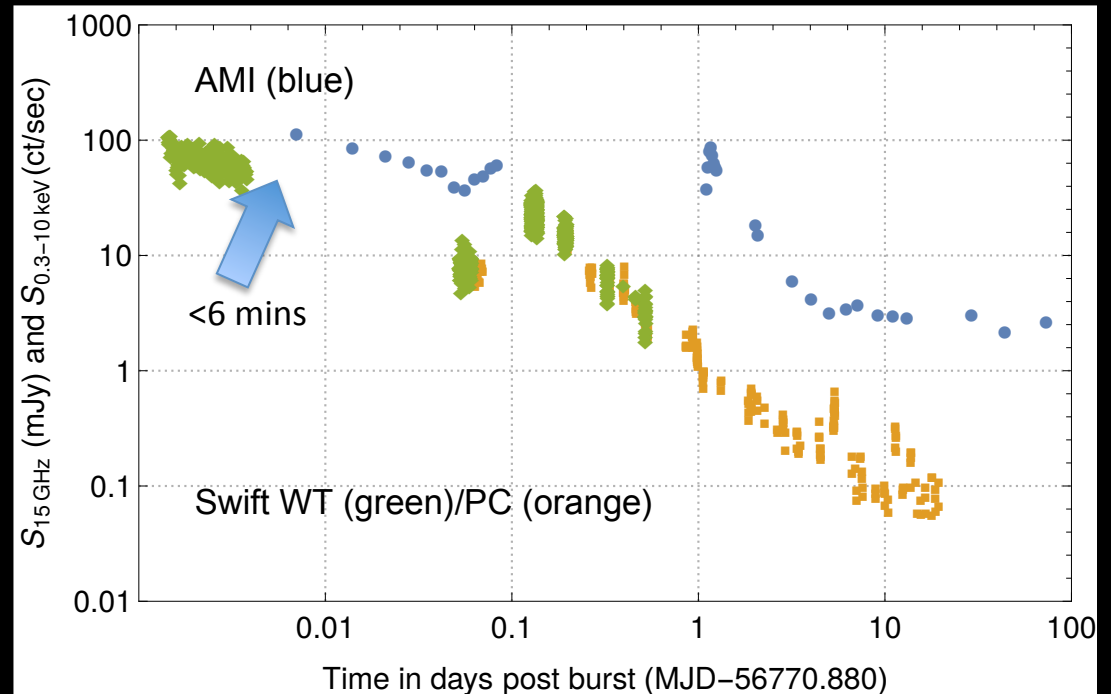
TRIGGERING: AMI results

GRB 130427A: Radio REVERSE SHOCK detection



Anderson et al. (2014), MNRAS, 440, 2059

DG CVn (rapidly-rotation M dwarf):
Associated radio flare with γ -ray superflare

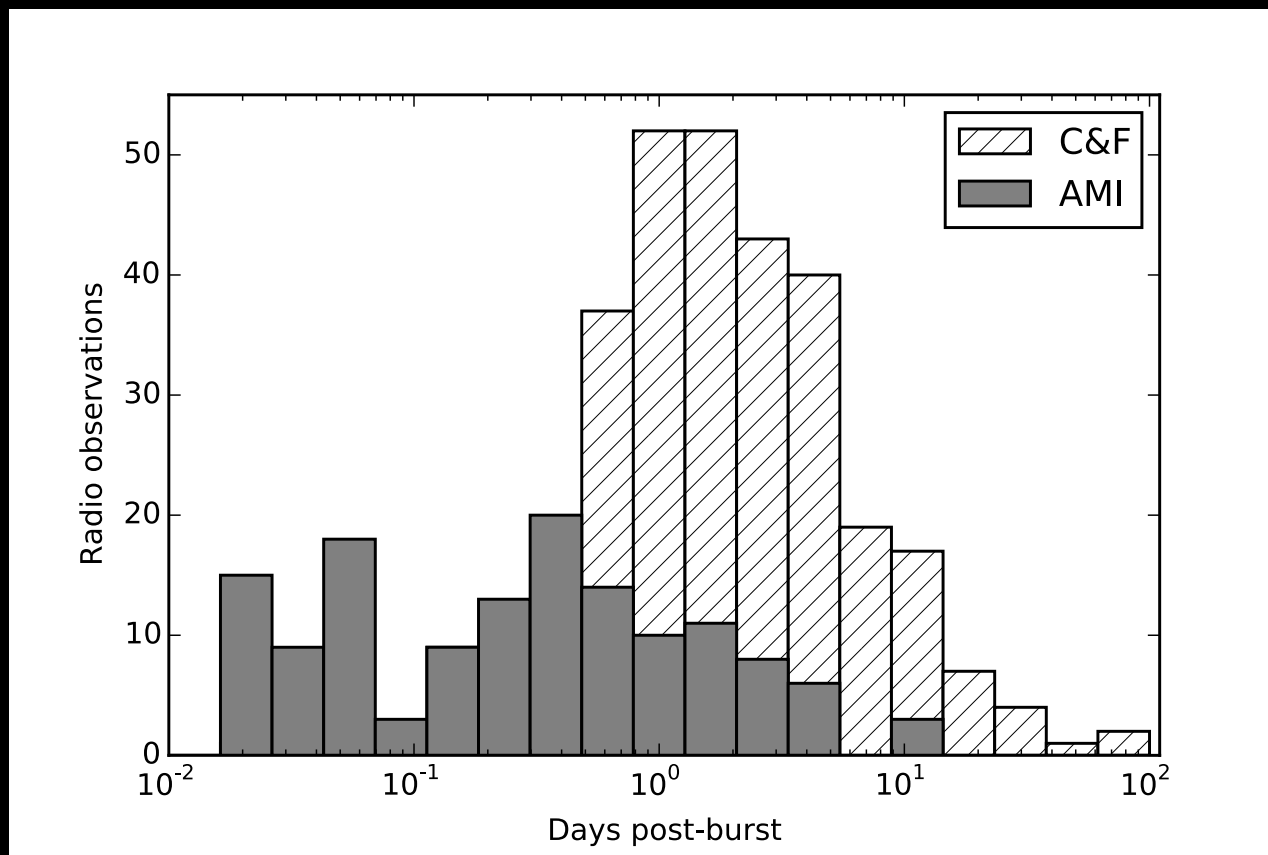


Fender, Anderson et al. (2015), MNRAS, 446, L66



Earliest GRB Radio Observations

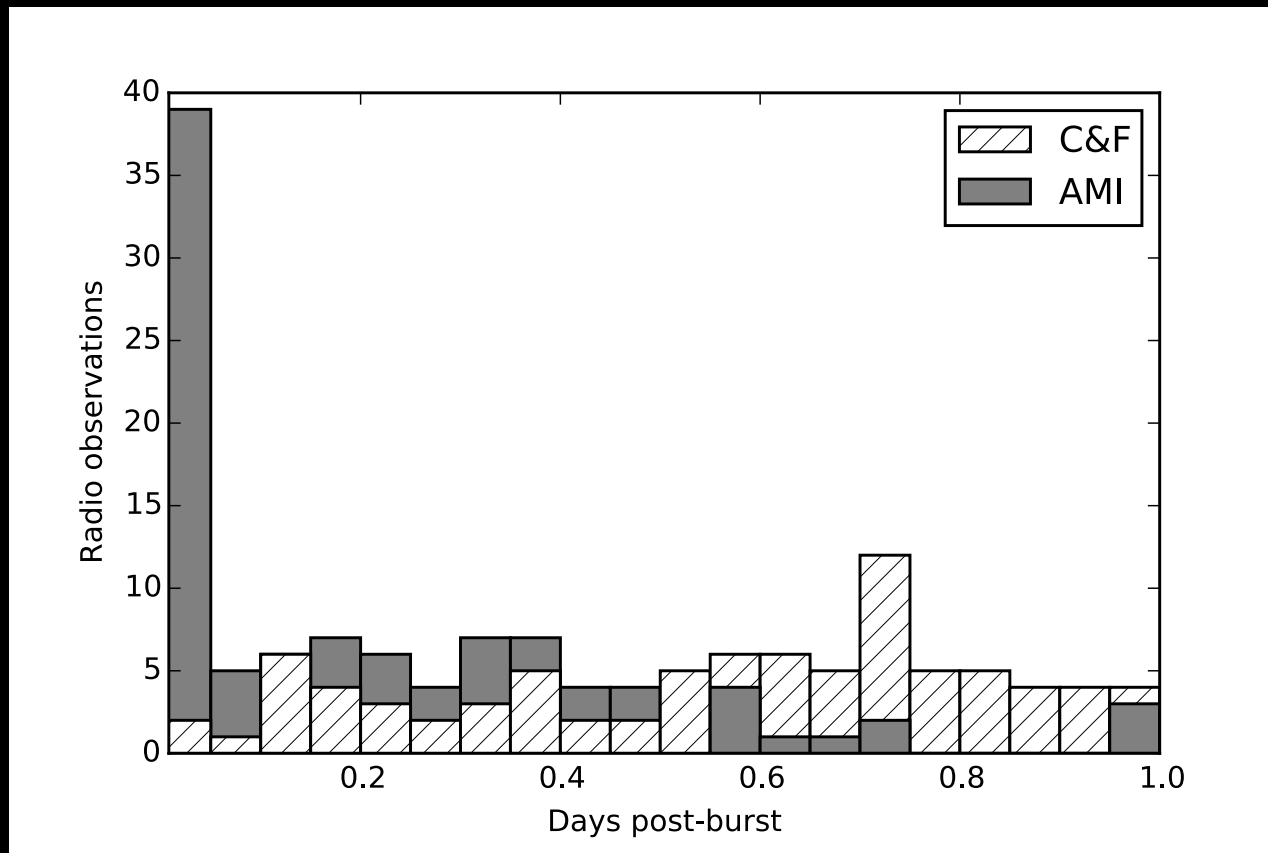
- First 15 years: Chandra & Frail (2012)
 - 2995 flux densities and limits, 0.026-1339 days post-burst
 - 30% radio GRBs - Sensitivity, not intrinsic
 - Radio follow-up of GRBs is biased!
- AMI GRB Catalogue (2012-2015), 139 GRBs





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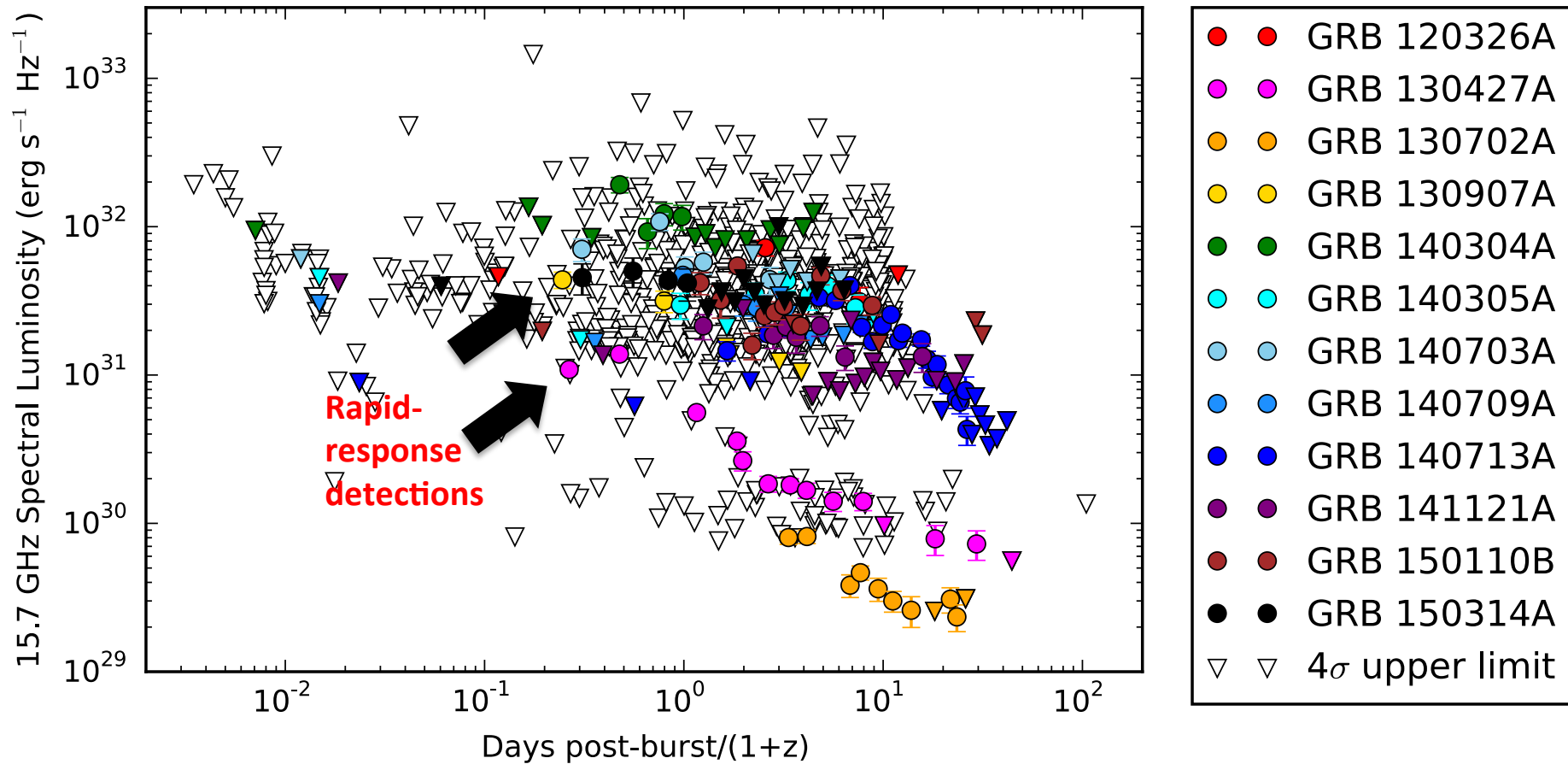
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TRIGGERING: AMI GRB Catalogue

- 13 (12 Swift) radio GRBs
- 5 AMI discovered GRBs!
- Increased radio GRBs 50% in 18 months
- AMI detection rate: 15% (~ 0.1 - 0.2 mJy)
- Scaled C&F12: ~ 44 - 56% (~ 0.1 - 0.15 mJy)
- UNBIASED: AMI rapid-response





MWA Triggering on GRB 150424A

- 80-300 MHz (150 MHz)
- FoV $\sim 600 \text{ deg}^2$
- Swift *short* GRB ($< 1/\text{yr}$ for MWA $> 45^\circ$)
- GW counterparts
- Search prompt emission
- GRB 150424A
- 23s – 30 mins
- Limits 4s, 2, 30 min timescales
- 3 Jy limit (3σ) 4s timescales

(Kaplan et al. 2015)

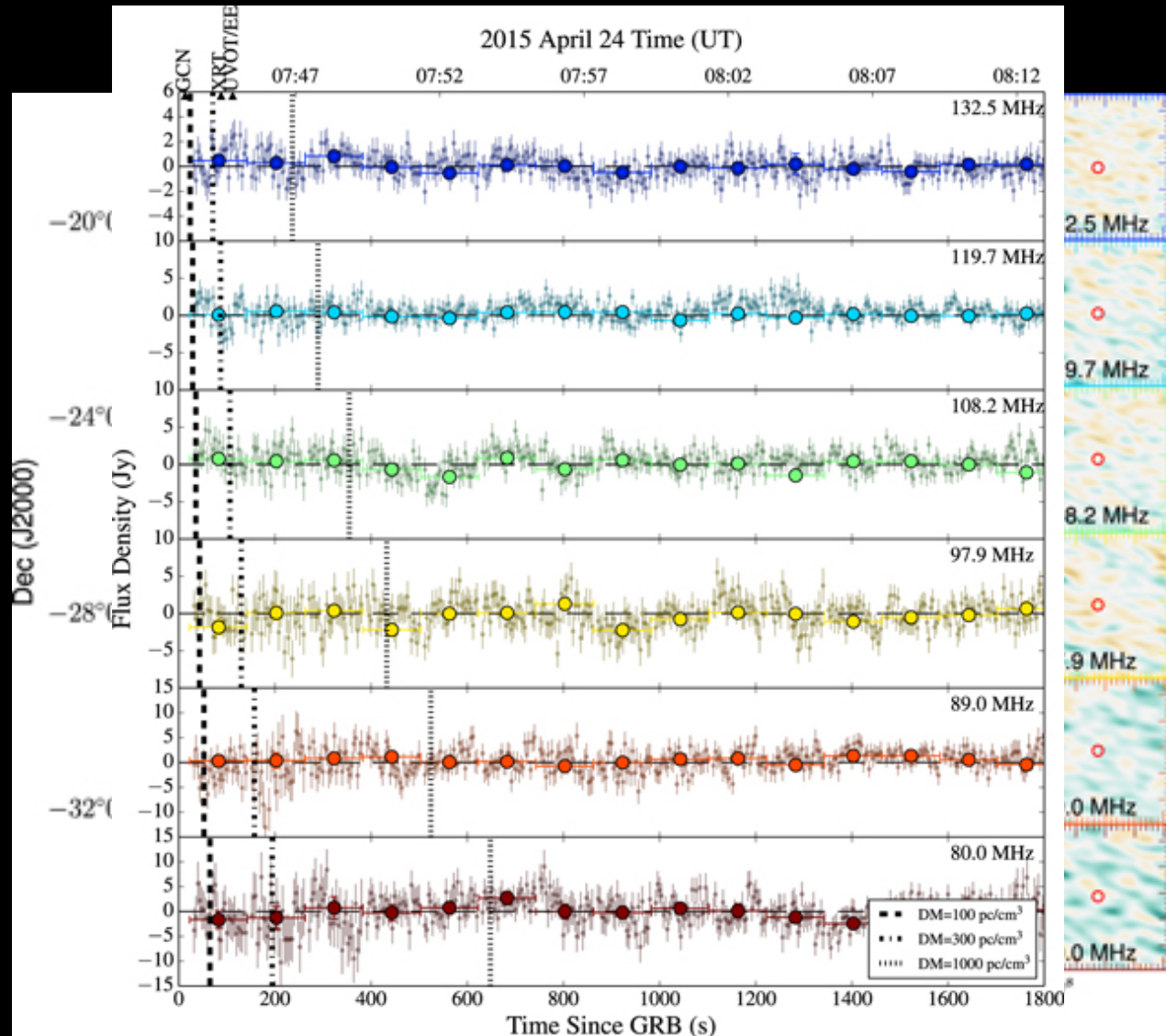


Fig1: 30 min mosaic, 132.5 MHz, $15^\circ \times 15^\circ$



MWA GRB Triggering: GRBs

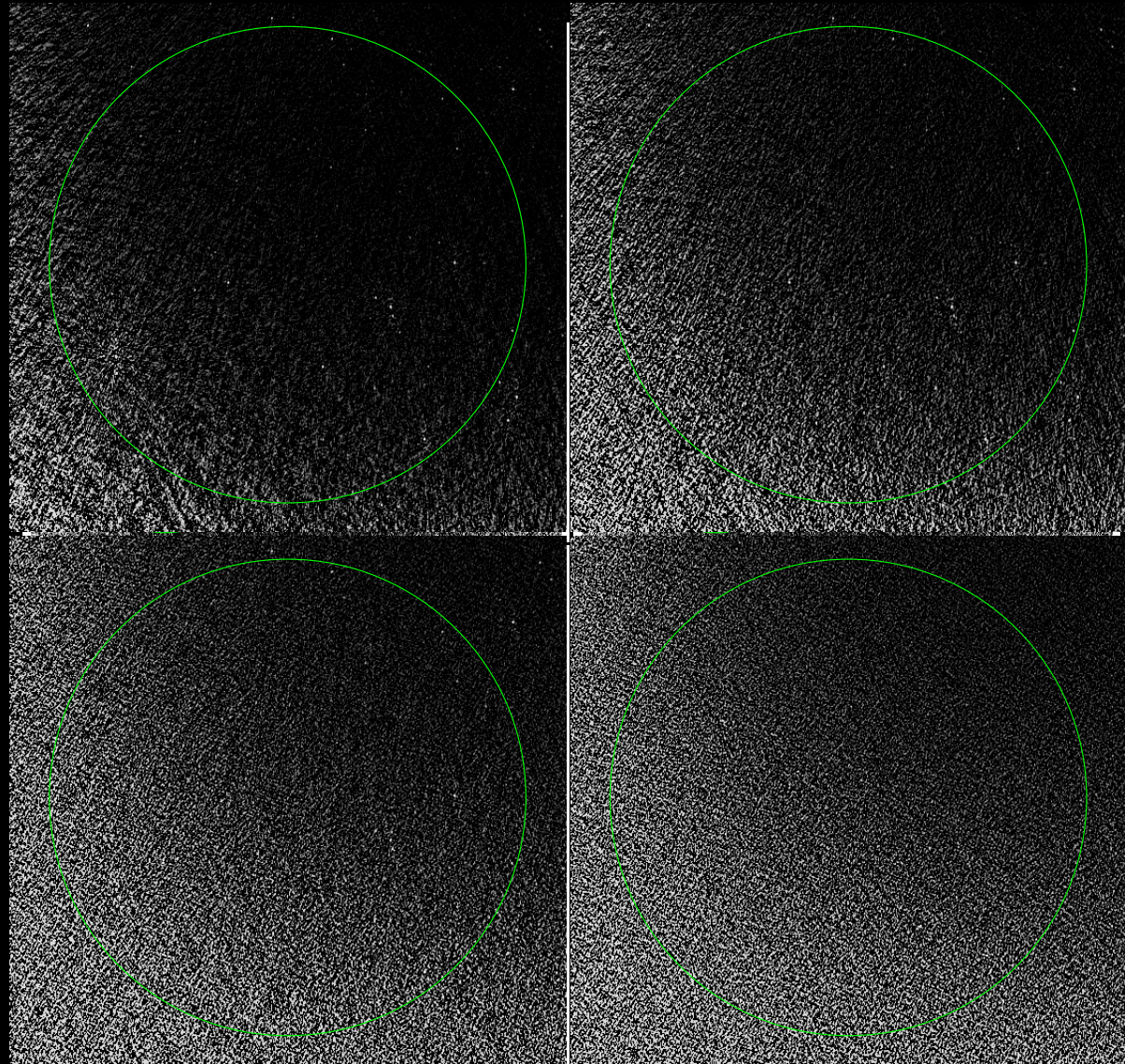
- Swift, Fermi GRBs
- Triggers if source in sky
- 2014 - 2017
- 30 mins, 0.5 s/40 kHz
- 0.5, 28s, 2min imaging

Fermi SGRB 525555489
(27 Aug 2017)
40s start-time delay

Wide fov – covers Fermi

- RMS change factor 10
- Position update
- GBM ground position
 - Swift-BAT position

Anderson, Hancock, Rowlinson
et al. in prep





MWA GRB Triggering: GRBs

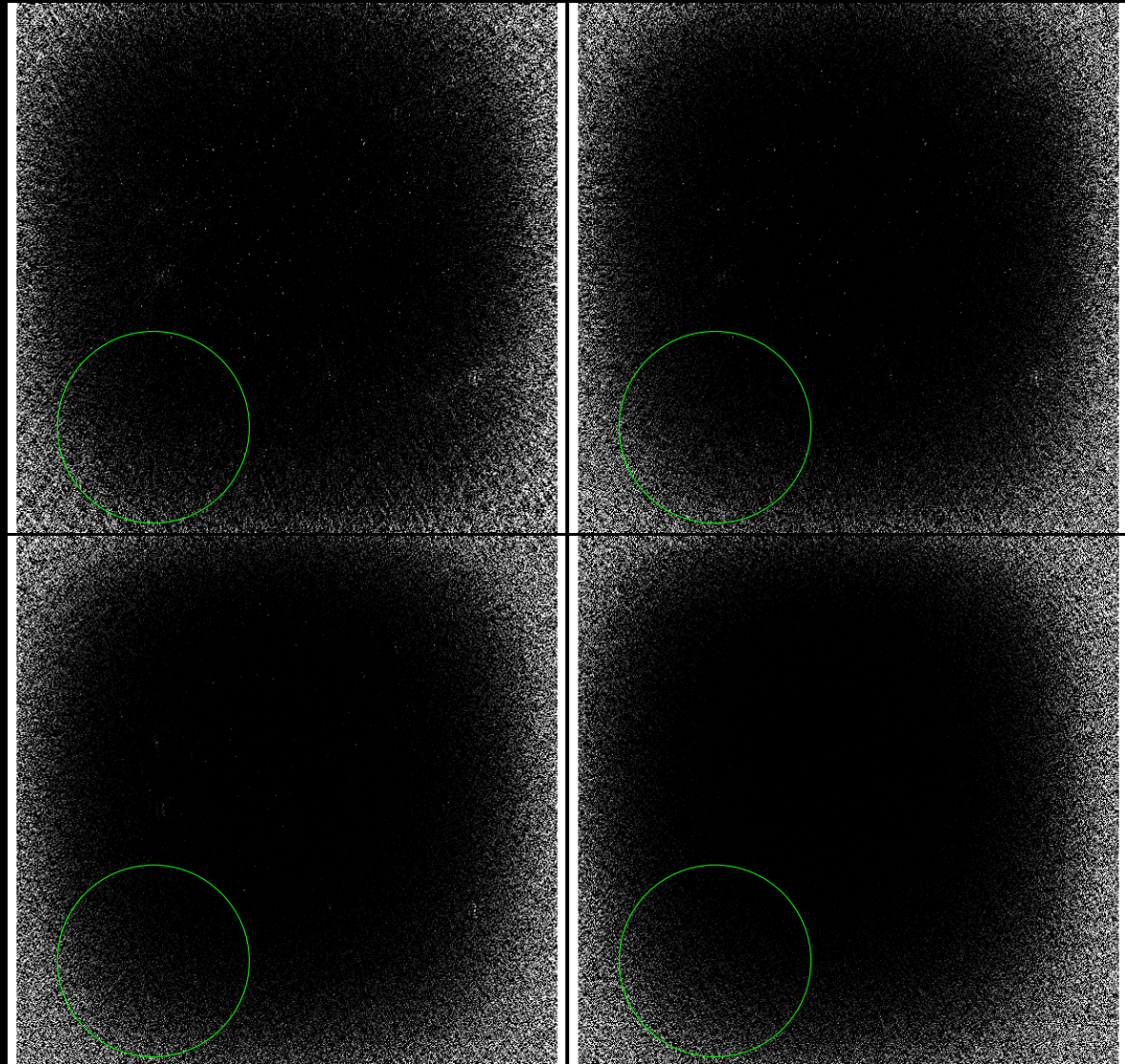
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ATCA triggering Strategy

4 Pi Sky VOEvent broker

- VOEvent – transient alert standard
 - NASA-GCN, GAIA, ASASSN...
 - aLIGO, FRBs, Antares...

- Generate schedule file

ATCA Rapid-response mode: Apr 2017

- Source above horizon?
- Can current program be overridden?
- Start-time rescheduled up to 48 hrs

Biggest challenges:

- Override policy – updated Oct 2017
- Filtering Swift events

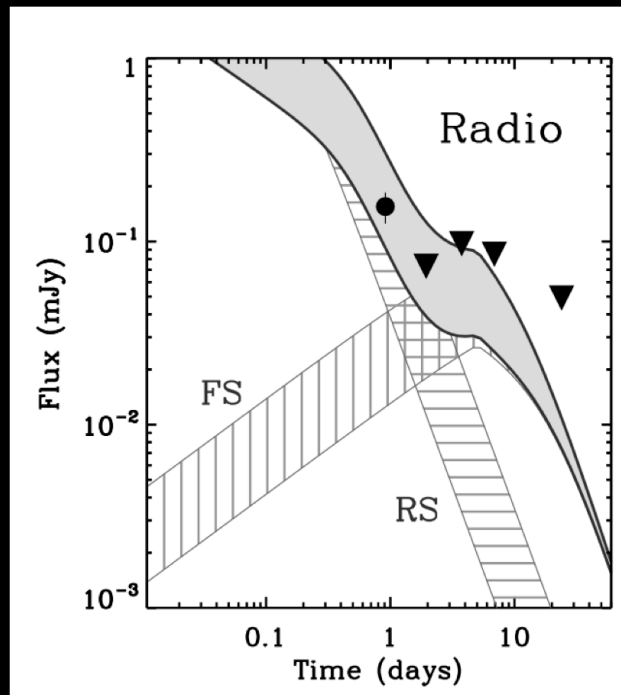




ATCA triggering: SGRBs & flare stars

Short GRBs

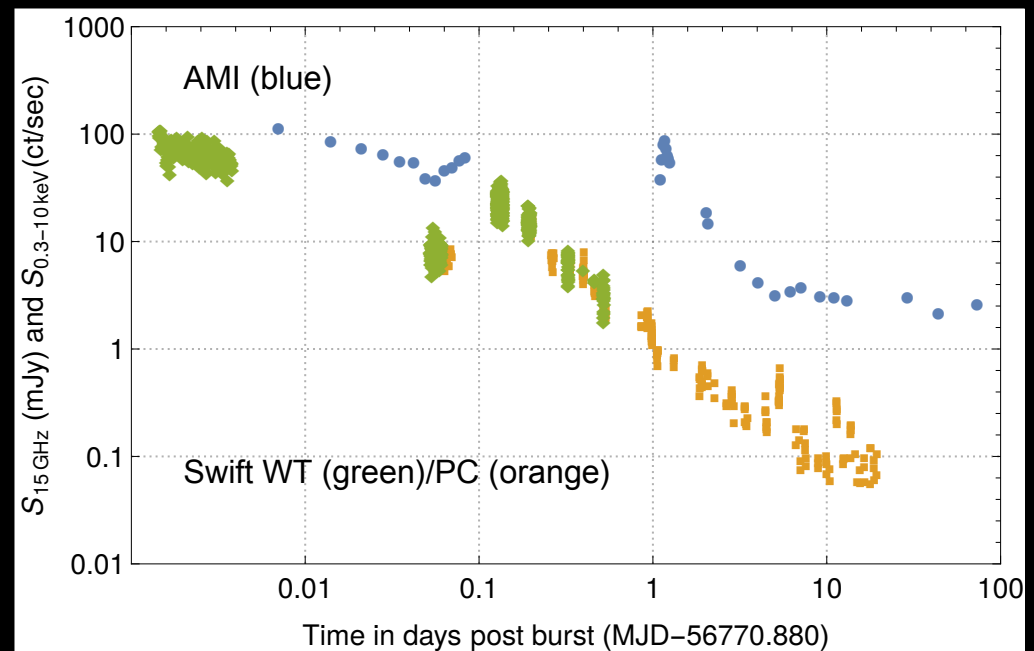
- Swift-BAT trigger: 1-4 arcmin error
- SGRBs: <24 hrs post-burst
- Probe radio reverse shock
- 4 SGRB trigger
- No overrides – Apr 2017



Soderberg et al. (2006)

Flare stars

- Swift: γ -ray superflare
- Giant radio flare (gyrosynchrotron)
- Emission mechanism?
- Associated coherent flares?
- 1 sub-threshold trigger (no overrides)



Fender et al. (2015)



Conclusions

Triggering

- AMI – early-time radio transient detections
- ATCA is triggering! – **Short GRBs, flare stars**: high sensitivity, multiple freq, polarisation
- MWA – **GRBs**, (gravitational wave events, FRBs)
- **Multi-messenger Opportunities!**
 - MWA large fov: Neutrinos, cosmic rays, gravitational waves
 - Sensitive to coherent emission – triggering (and shadowing?)
 - MoUs
- **Look for radio transients where we expect to find them**
- Explore SKA strategies

