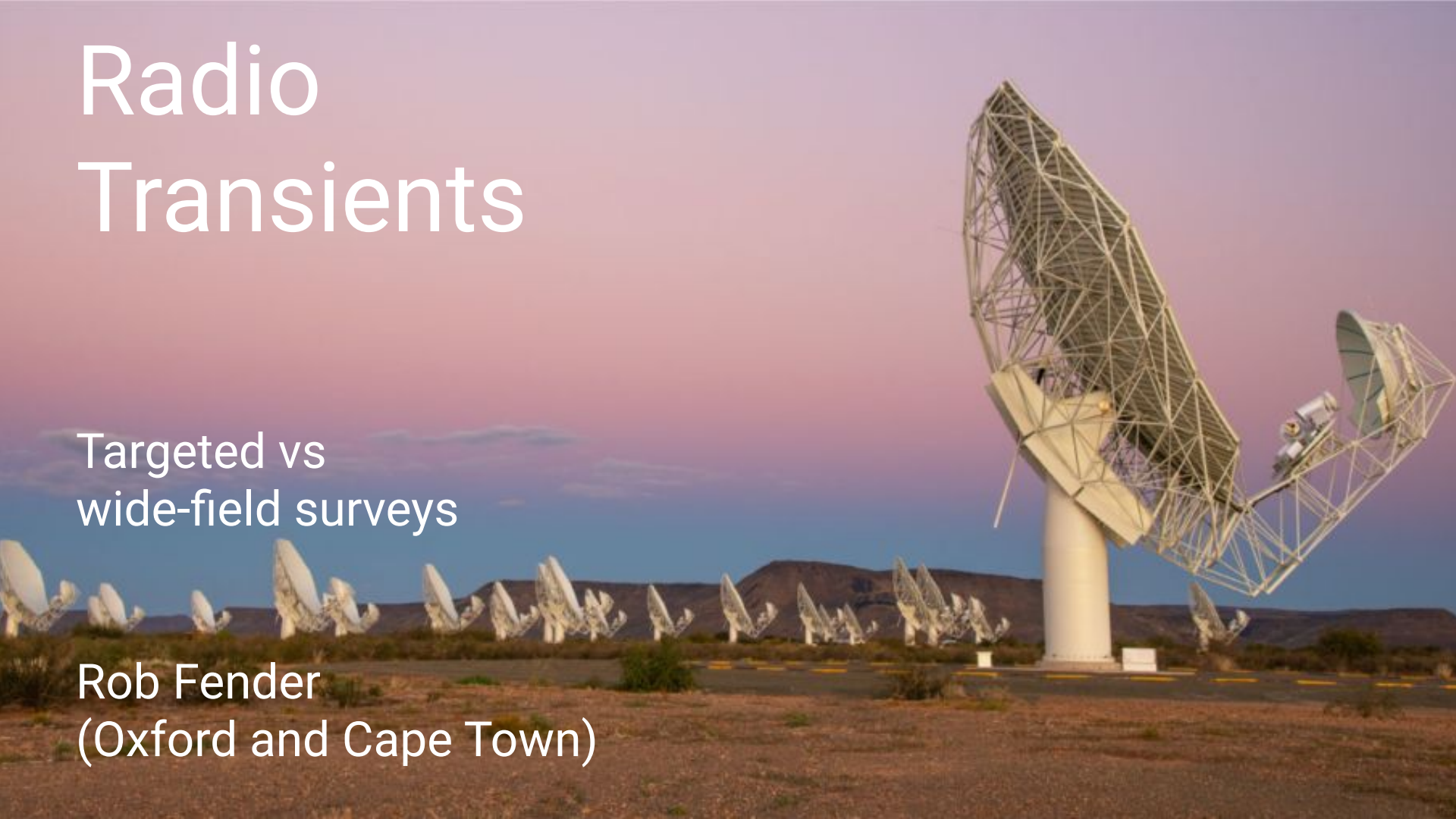
Radio Transients



Targeted vs
wide-field surveys

Rob Fender
(Oxford and Cape Town)

Synchrotron (incoherent) transients are associated with **particle acceleration and kinetic feedback** from explosive events

In most cases they are the **only** way to estimate the power from the event going into the kinetic energy (outflow) channel

Radio telescopes offer a **unique combination** of **very wide fields of view** and **high angular resolution**

However, for most astrophysical transients they are still effectively less sensitive than optical or X-ray telescopes

Interpretation and modelling

The (X-ray) binary community have largely drawn on the AGN community

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Jets -
Collimation -
Connection to accretion
flow
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The GRB/GW community have drawn (more) on the SNe field

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Explosions -
Extended phases of
particle acceleration -
Effect of environment
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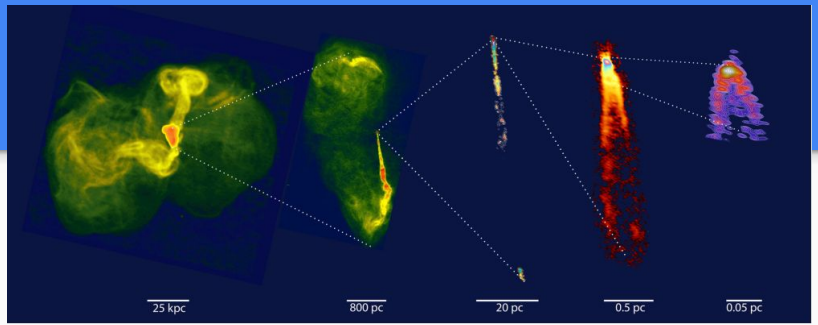
The underlying physics is - of course - the same, but interpretations of complex light curves are strongly influenced by the literature in the field (e.g. interpretation of radio flare from TDE as symmetric interaction with ISM)



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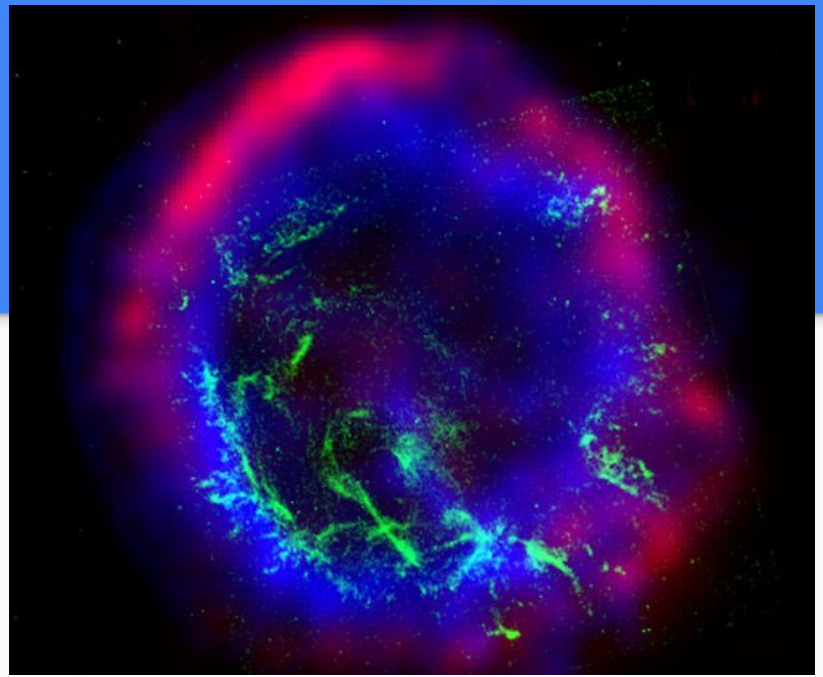


Explosions -
Extended phases of particle acceleration -
Effect of environment

The past 50 years in 5 minutes

1960s-2000: targeted exploration

Pulsars

Variable radio emission associated with accretion state changes in black hole and neutron star binaries

Radio emission from novae and supernovae

Radio flaring from blazars

Radio afterglows from gamma ray bursts

2000-2015: first radio transient surveys

Change in focus from solely targeted radio observations to surveys for transients

LOFAR Transients Key Science Project: explores parameter space, develops new methods and software (TraP), but ultimately yield is low

Similarly low yield from surveys with other telescopes (e.g. VLA)

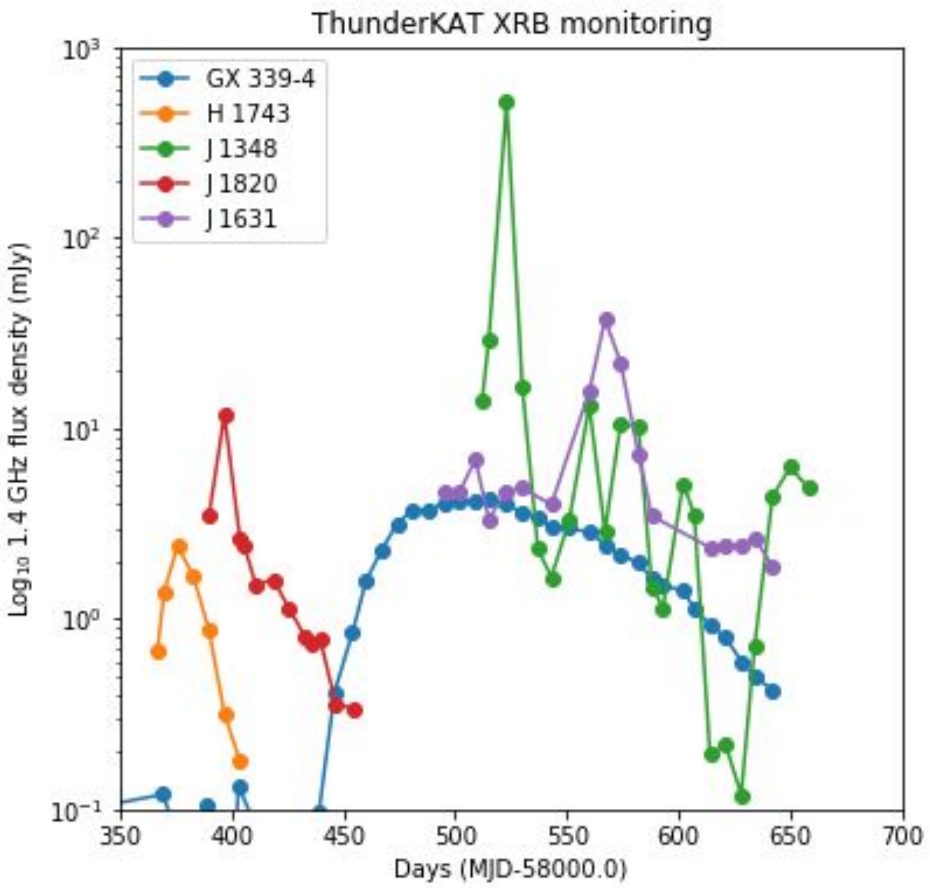
2015-2020: an adjustment: high cadence targeted, serendipitous wide-field surveys

Focus has returned to targeted programmes

Very high cadence programmes (e.g. AMI-LA, over 30% of all observing time dedicated to transients and variables) → do we need the SKA auxiliary telescope?

Wide fields of view on GHz-frequency telescopes (MeerKAT, ASKAP) are allowing **serendipitous wide-field searches as a by-product of targeted programmes**

Today: high cadence, wide fields



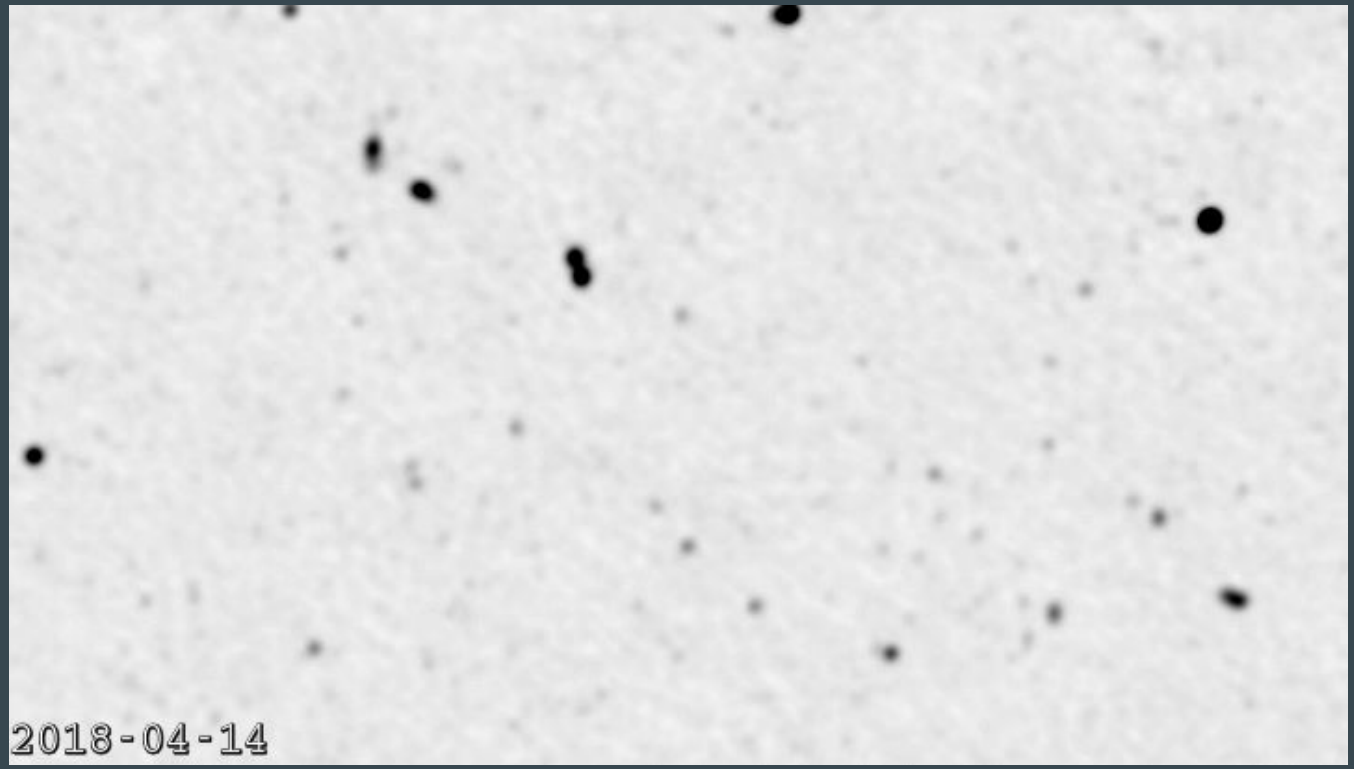
ThunderKAT

Five year programme, weekly monitoring of radio-bright white dwarf, neutron star and black hole binaries (plus targetted programmes on GRBs and SNe)

Provides by-product of repeated relatively deep (~40 μ Jy in 15 minutes) images of the same field

GX 339-4

Black hole binary with high but variable accretion rate



Tremou et al. (2020)

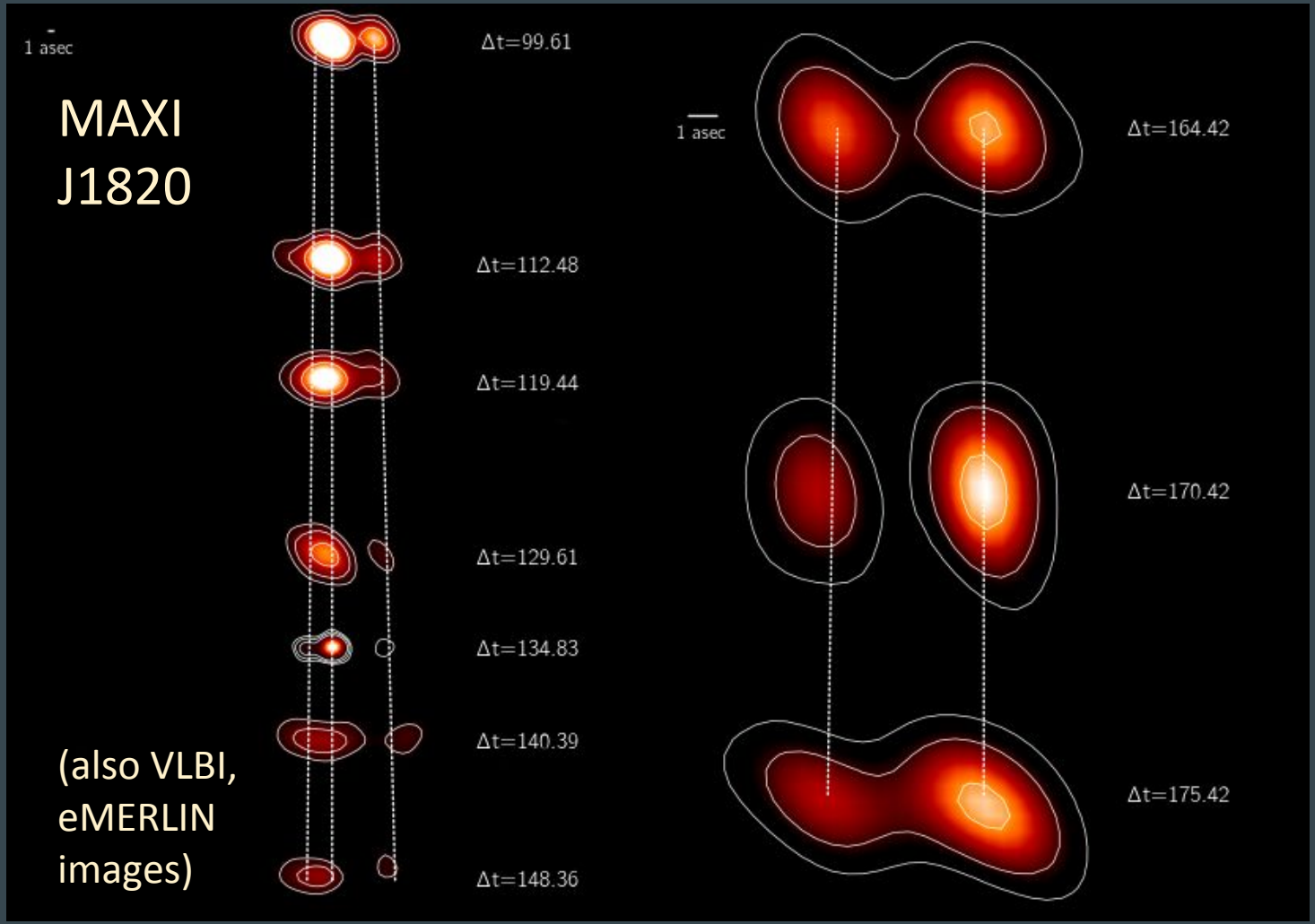
Animation by Ian Heywood

0.3 x 0.17 deg

10-min snapshots

Targeted

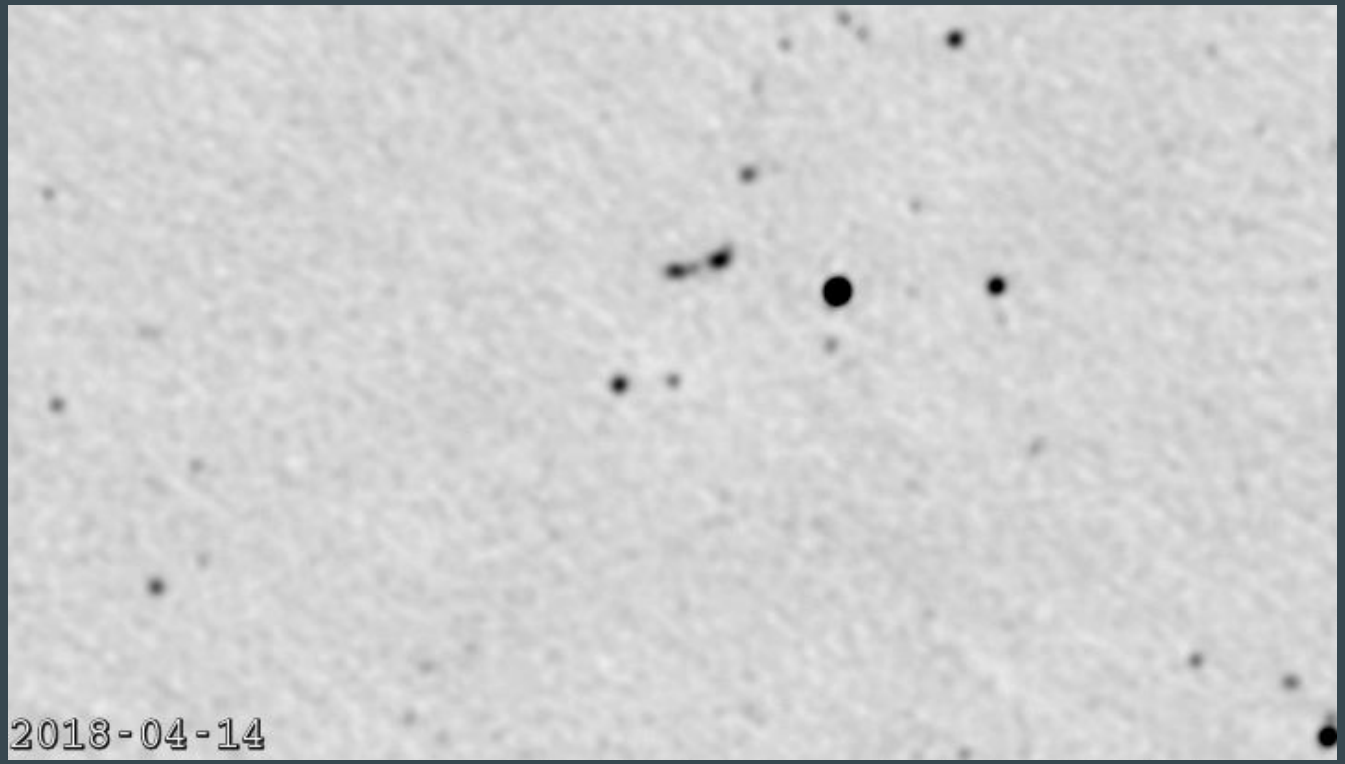
MeerKAT



JVLA

Jets physically tracked from 150 mas to 15 arcsec

Bright et al. (Nature Ast. 2020)



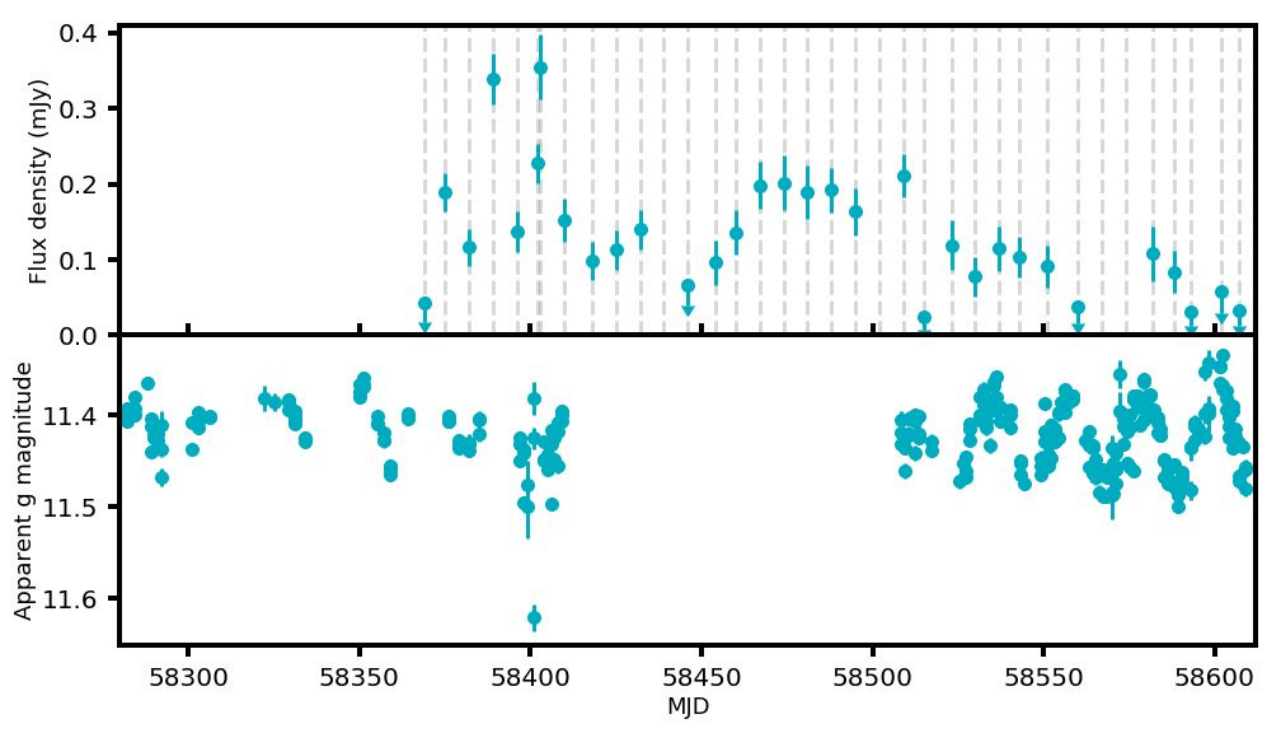
Commensal discovery of unusual flare star TYC8332

… in the first field we checked

(2nd transient now discovered)

Driessen et al. (2020)

Free survey from targeted observations



Commensal discovery of unusual flare star TYC8332

Spectroscopic binary, X-ray active

Nature of radio flaring unclear

Reconnection event associated with starspot formation?

Driessen et al. (2020)

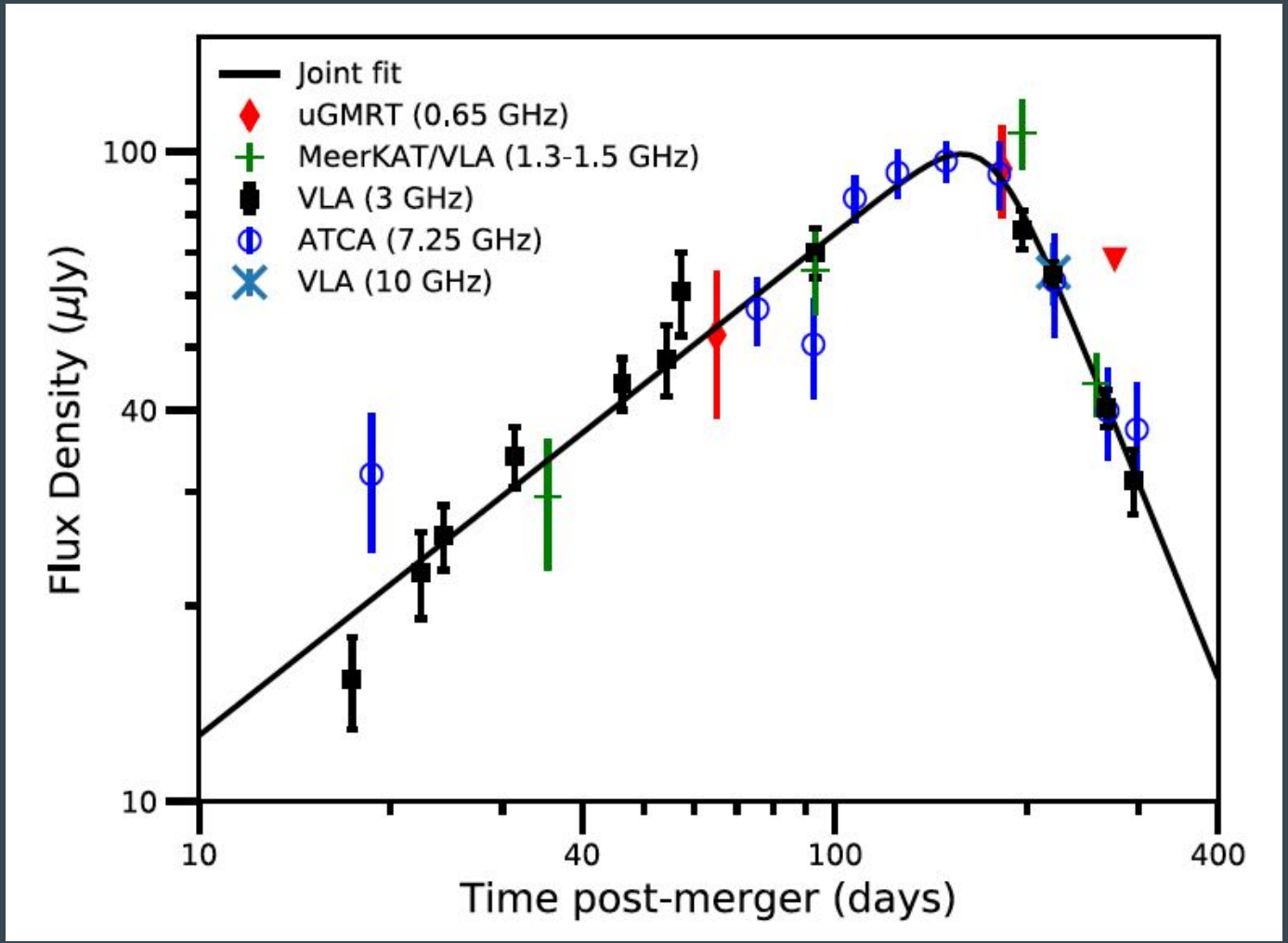
HESS / MAGIC GRBs with AMI-LA

We have observed all three GRBs detected by ground-based Cherenkov detectors

Very high cadence outperforms larger facilities with higher cost / hour

Rhodes et al. (2020)

HESS GRB 190829A



GW 170817

Radio afterglow of NS merger event

Everyone is waiting for the next one!

Mooley et al. (2018)

Makhathini et al. (2020 *in prep*)

Thoughts for the future

Monitoring bright transients in the SKA era

The SKA (+extended VLA or equivalent) will be **the** main facility for radio science in the 2030s

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Conclusions

Radio observations provide a unique window on the astrophysics inaccessible by other means

The serendipitous wide-field surveys are now arriving as a by-product of targeted programs (and are yielding results)

We need to think carefully about how we will follow-up / respond to transients in the era of mega-telescopes like SKA