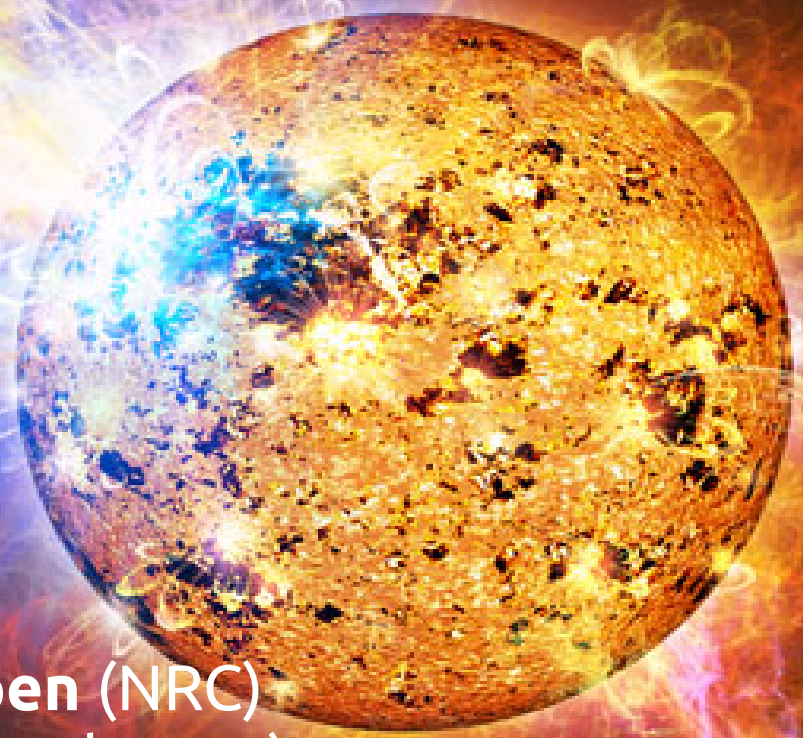
Transients SWG
cost control considerations

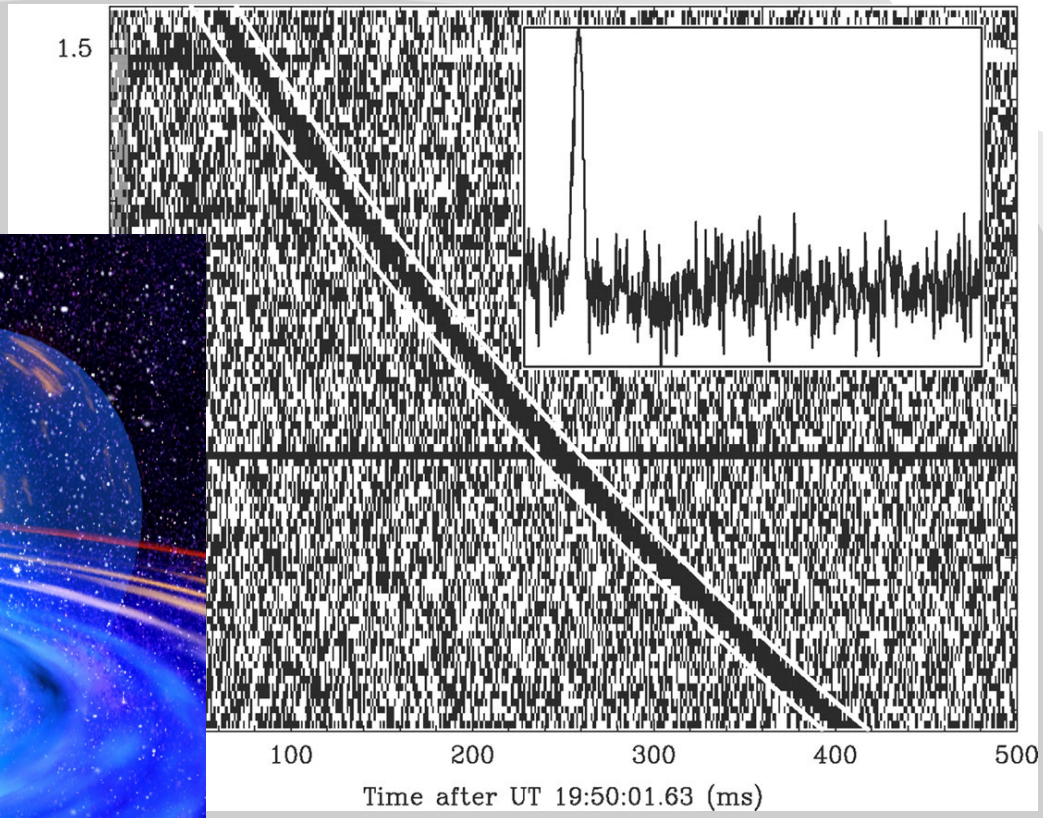


Rob Fender (Oxford)

J-P Macquart (Curtin), **Michael Rupen** (NRC)
Evan Keane (SKA), Ben Stappers (Manchester),
Aris Karastergiou (Oxford), Jess Broderick (ASTRON)

Transients: extreme astrophysics

Most extreme astrophysics since the big bang



Searchlights shining over cosmological distances

Two flavours of radio transients

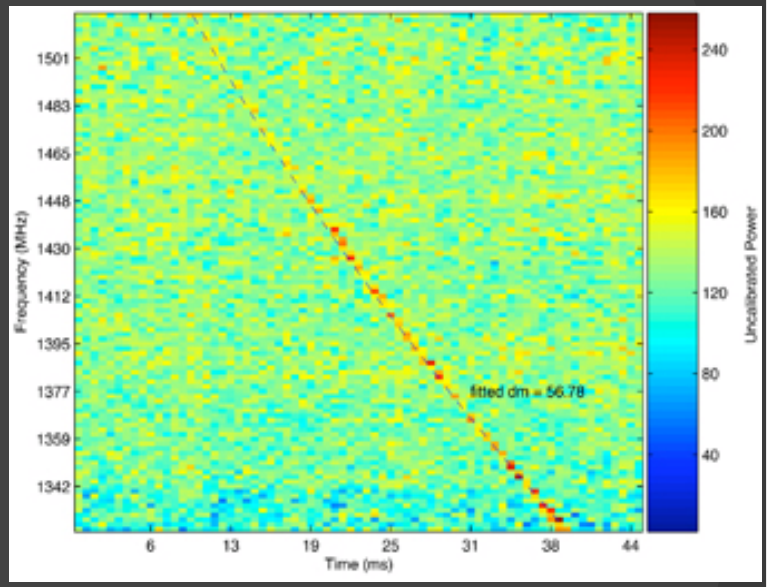
Incoherent synchrotron and bremsstrahlung emission

Relatively slow variability
Brightness temperature limited
Associated with all explosive events

SKA top science priorities include both classes of object

Coherent emission

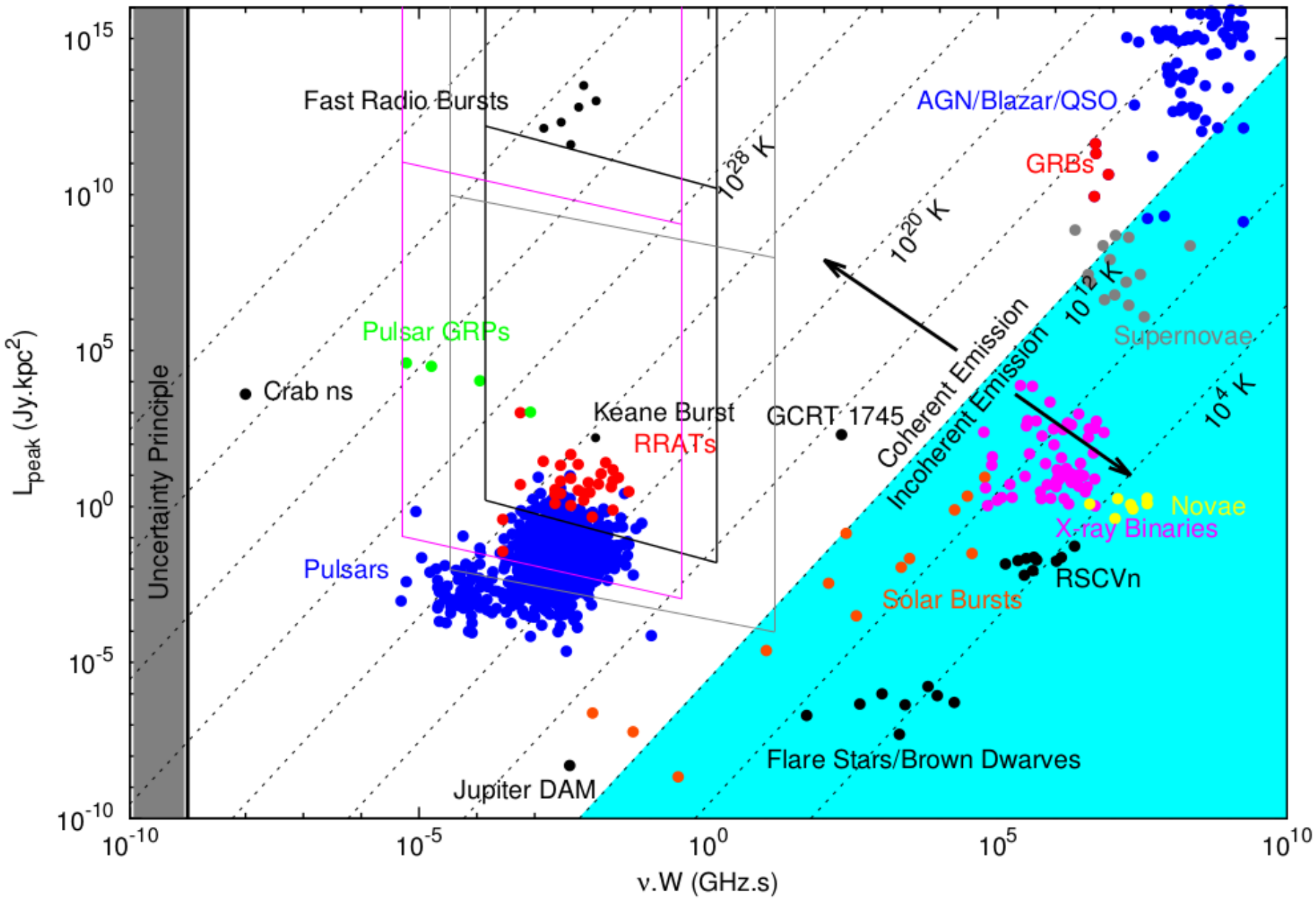
Relatively fast variability
High brightness temperature
Often highly polarised
Sometimes very steep spectra



Find these (mostly) in images

Find these (mostly) in time series

Beamformed / custom fast-imaging | 'standard' imaging



Pietka, Fender & Keane (2015)

SWG response: summary

Transients science can be affected by loss of *sensitivity, angular resolution* or *accessible parameter space*

The cost-control proposals potentially affect four areas of science:

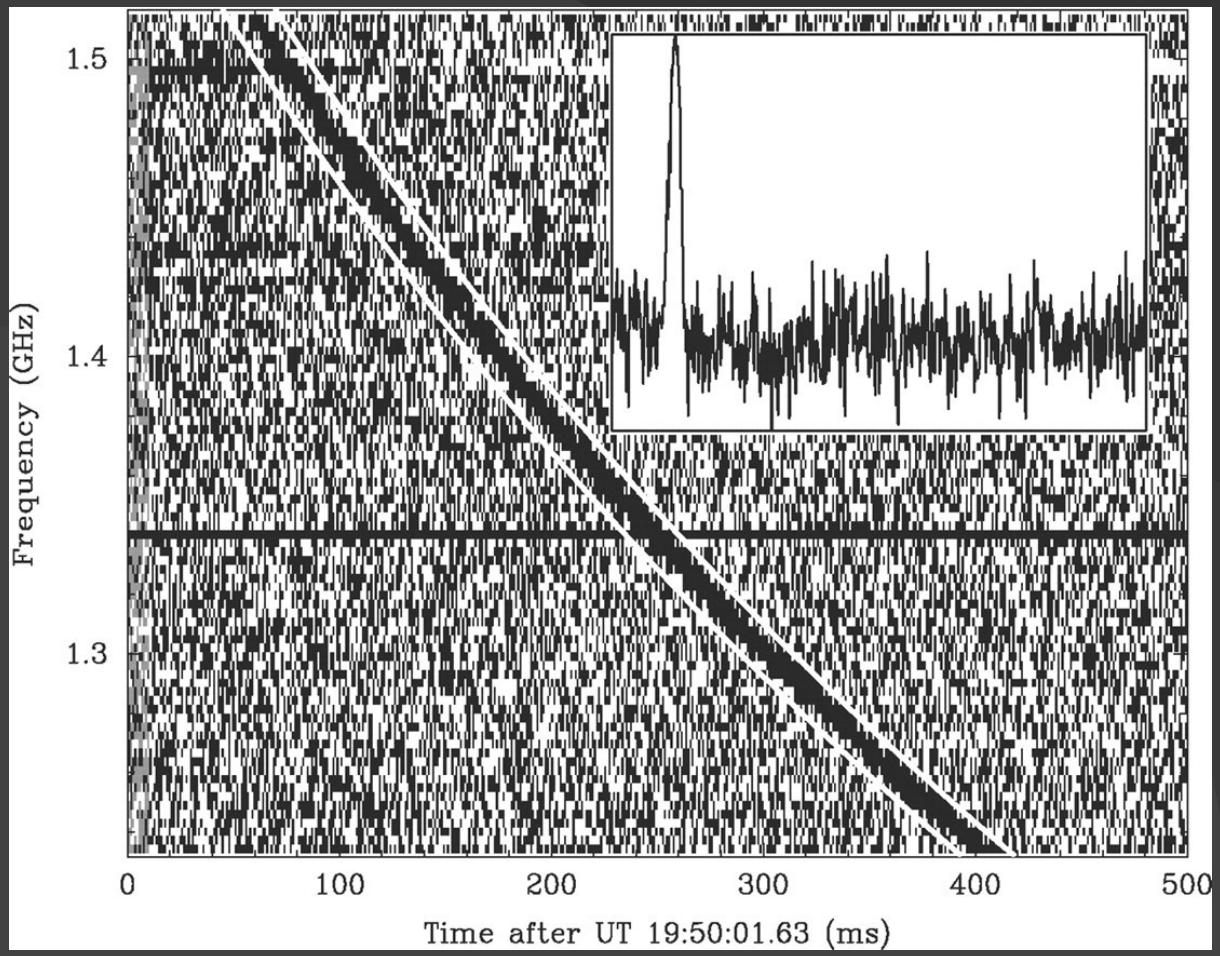
– Fast Radio Bursts (high science priority objective for SKA)

– Targeted studies of transients and variables

– Searches for explosive synchrotron and thermal transients

– Applications requiring fast imaging

Fast radio bursts



>>20 FRBs now detected

Strong support for the cosmological distances originally inferred from excess dispersion measure

→ possibilities to do unique science using FRBs as probes

Repeating FRB 121102 localised in host galaxy, has faint steady radio counterpart.

New physics, high priority SKA science case

Fast radio bursts II

Loss of sensitivity will result in a reduced rate by a factor which depends upon the (poorly-known) population flux and spectral index distributions

$$N\left(F > S_\nu\right) \propto S^{-\alpha}$$

where best estimates of α for FRBs are close to the Euclidean -3/2

A reduction in sensitivity by 20% reduces the FRB detection rate by 30%.

Cosmology with FRBs requires large numbers of events (>>1000)

Fast radio bursts III

SKA1-Mid: removal of band-1 and reduced maximum baselines

Removal of SKA1-Mid band-1, resulting in searches being performed primarily in band-2, would (almost certainly) result in a reduced rate of FRB detection due to reduced field of view.

Localisation to an arcsec or better is required for host galaxy identification

SKA1-Low:

The impact of cost-control measures for SKA1-Low is less clear, since no FRBs have been detected to date at SKA1-Low frequencies.

Fast radio bursts IV

SKA1-Mid: reduced beams / capabilities of PSS (pulsar search machine)

The number of FRBs detected will depend both on the number of beams deployed and the capability of the PSS to explore parameter space.

Beams: the number of FRBs will drop linearly with the number of beams

PSS restrictions: an inability to perform acceleration searches would not directly affect FRB searches (in all likelihood…).

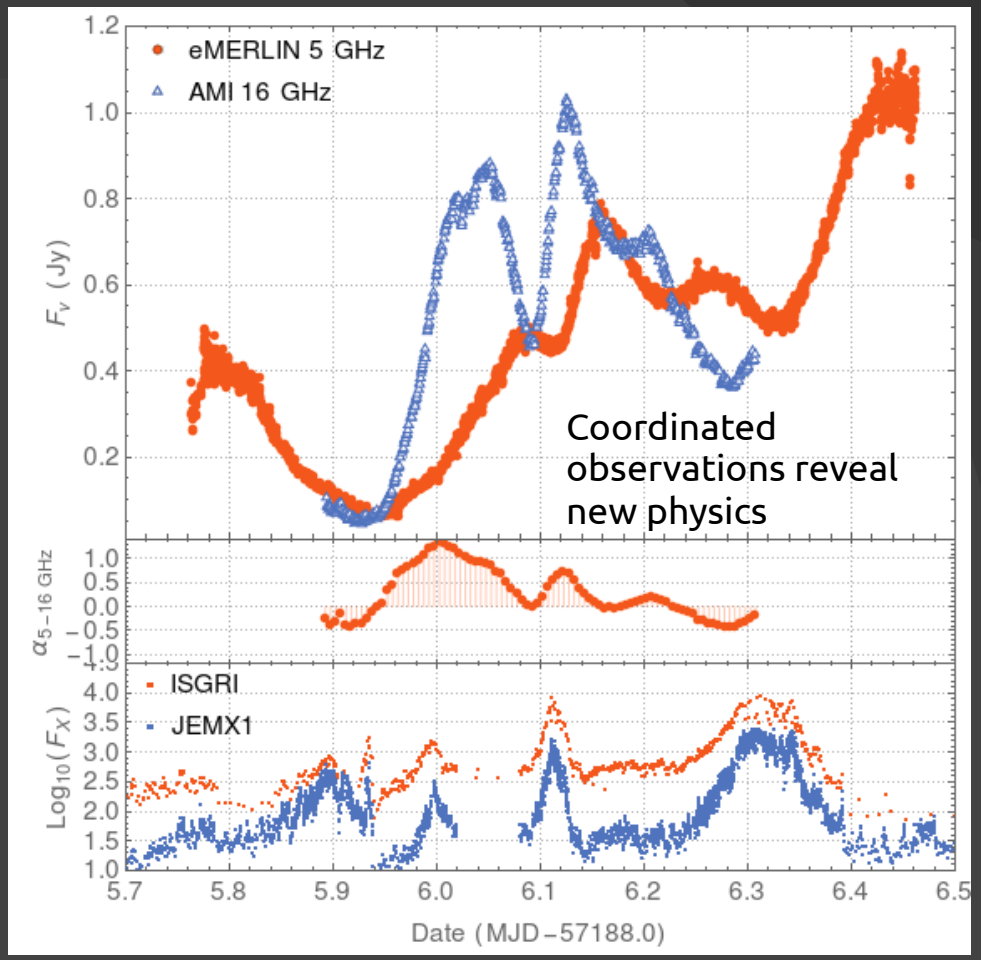
A reduced capability to perform de-dispersion, e.g. with a restricted range or coarser sampling of DM parameter space, would reduce the number of FRBs found, although the scaling is less clear.

Targeted follow-up of explosive transients

Much follow-up science is based on multi-frequency observations to determine e.g. emission mechanism, optical depth

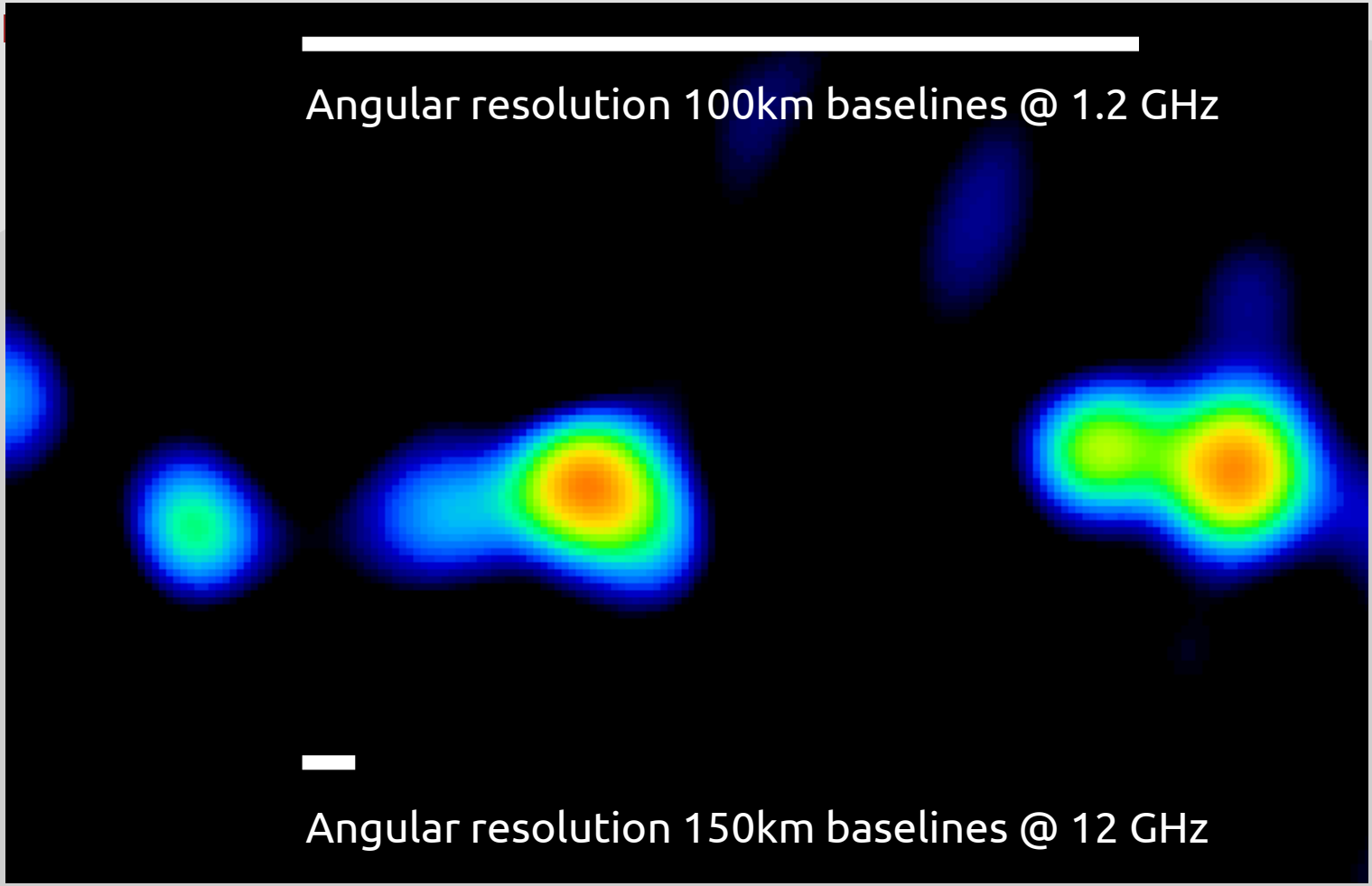
For the most rapid variables we cannot recover sensitivity losses by simply observing longer since the source state will have changed

For both synchrotron and thermal transients (e.g. novae) the loss of band 5 would be a significant issue: physical scales / correlation with accretion processes



$$r \propto \nu^{-1}$$

Targeted follow-up of explosive transients



NB JVLA @ 43 GHz ~ SKA1-Mid @ 12 GHz

Searches for explosive transients / Fast imaging

Blind searches for radio transients at GHz frequencies are expected to discover 1000s of interesting objects (e.g. SNe, off-axis GRBs) as well as providing the most thorough exploration of the unknown.

Sensitivity reductions will affect expected numbers just as for FRBs
→ proposed cost-control measures may reduce yield by 10-30%

Concern that significant cuts in SDP may affect ability to search all data streams (commensally) for transients

Fast imaging modes have been proposed for imaging FRBs and interplanetary scintillation (scattering timescales for FRBs at SKA-Low frequencies can be ~seconds). These modes will be affected by a loss in instantaneous sensitivity which cannot be recovered by observing longer.

Notes on Band 5

We note that for targetted observations of specific objects:

Current baseline spec SKA1 + Band 5 in continuum is ~7 times faster than JVLA

Reduction of number of feeds to 67 *and* a reduction of bandwidth to 1.4 GHz would result in a system which was about a factor of two *slower* than the JVLA

SKA1-Mid still has a wider field of view, better instantaneous *u-v* coverage and longer baselines

Summary

The cost-control options for Transients science are more decramental than catastrophic.

Lost sensitivity will scale to lost numbers of transients roughly as

$$N\left(F > S_{\nu}\right) \propto S^{-3/2}$$

Our largest specific concerns are:

– reduction in PSS capabilities to the point that it cannot do full DM grid searches and so will miss FRBs / loss of SDP capability to make blind searches

– loss of band 1 → reduced number of FRBs

– loss of band 5 → significantly reduced science capabilities for explosive transients