

# Transient SWG Summary

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NRC-Herzberg Astrophysics  
SKA KSP Workshop, 24-27 August 2015**



# Key Science Projects

- Looking back in time: fast radio bursts  
...single-pulse searches “all the time”
- The power of gravity: accretion-powered explosions  
...multi-wavelength light curves of explosive events
- Exploring the fourth dimension: the variable radio sky  
...surveys optimized to find variable sources

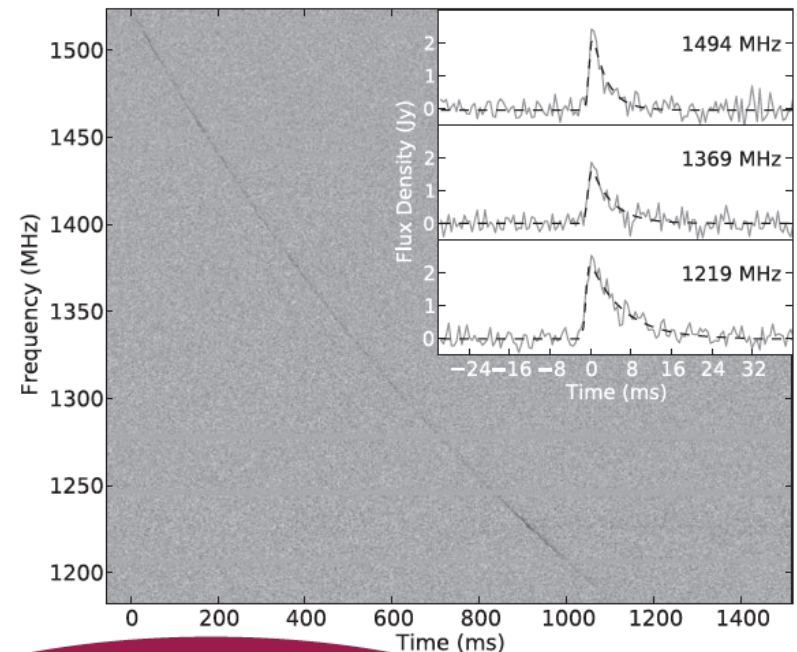
## General points

- **Naturally commensal with almost everyone**
- **Variability database**: light curves for all variables and expected variables
- **Strongly support free & open access** to data & to observing schedules
- **Subarrays** are a game-changer for transient science
- **Low-power mode** for single-pulse searches
- Assign **urgency** as well as priority
- Should establish **formal SKAO-level connections** with other observatories & experiments
  - Possibility of **synchronized telescopes** shadowing SKA1

# *Fast Radio Bursts*

# Looking back in time: fast radio bursts

- Understand the nature of FRBs – extreme physics
- Trace parent population(s) (e.g., star formation)
- Shine a light through the distant universe
  - Dispersion measures
  - Scattering
  - Absorption
  - etc.



# Finding FRBs

- Fast (milliseconds) transients
  - found via **single-pulse searches** using pulsar search beams
- Isotropic, with more at high latitudes
  - **Commensal with almost everything**
  - Some preference for high latitudes
- Rare; unknown spectra
  - **wide-area surveys** & **low frequencies** (LOW, MID B1-B2)
  - Search single pulses **during ALL other observations** – **low-power mode for pulsar search?**
  - Dig down into the noise: **store statistics of +/- pulse candidates**, not just clear detections

# Enabling FRB science

- Good positions essential (to identify counterparts/hosts)
  - Sub-arcsecond  $\rightarrow 62 \text{ km} / \text{freq\_GHz}$  – would like at least **some long baselines, in same subarray** as pulsar search beams
    - $\rightarrow$  Trigger dump of **transient buffer** (station/antenna data) covering full burst
    - $\rightarrow$  Store **time series of images** covering the tied-array beam
- Simultaneous observations very useful (afterglows)
  - $\rightarrow$  **synchronized O/IR/X-ray** (cf. MeerLicht, Desert Transient P...)
  - $\rightarrow$  **publicly-accessible SKA schedules**

## Knock-on benefits

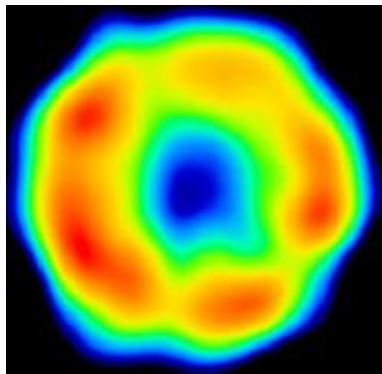
- Some long baselines during pulsar search
  - Instant positions for bright pulsars
  - Needed for LOW self-cal???
- Triggered dump of transient buffer
  - Instant positions for other fast transients – RRATs, giant pulses, etc.
- Simultaneous O/IR observations covering many square degrees
  - Nice for all variables
- Publicly (automatically) accessible SKA schedules
  - Helpful for all multi-wavelength observations



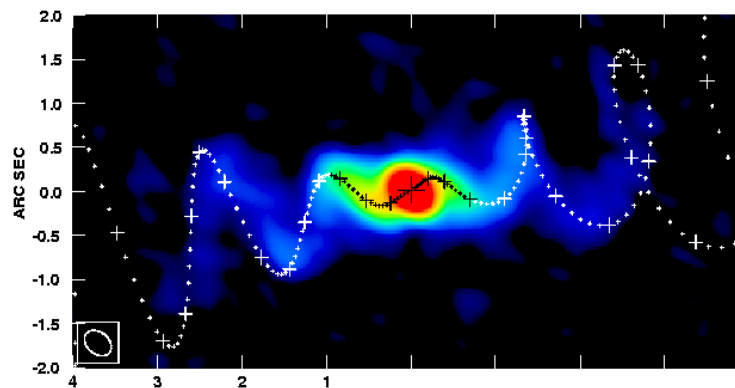
# Accretion-powered explosions

# The power of gravity: accretion-powered explosions

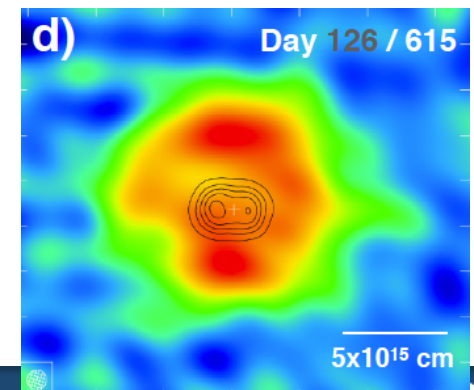
- CVs, novae, NS/BH binaries, supernovae, TDEs, AGNs, GRBs
- Physics of accretion/outflow
  - Explore  $M$ ,  $\dot{M}$ , angular momentum, accretion mode [wind/disk], magnetic field, nature of compact object, ...
- Extreme physics
  - relativity, gravity, pressure, neutron star eq'n of state, ...
- Physics of shocks & particle acceleration
  - Synchrotron, gamma-ray prod'n, interactions with CSM/ISM, ...



Bietenholz et al.



Mioduszewski et al.



Chomiuk et al.

# Explosive observations

- Targeted observations
- External or internal triggers (from any wavelength)
  - VOevents
  - Rapid response: **over-rides**
  - **Separate urgency from priority**
  - **Faster response (<10s) for LOW**
- Properly sampled, complete radio light curves
  - **Observer-specified cadence**, with +/- allowed
  - **Automated schedule block generation**
  - Separate urgency from priority
  - **Automated response** based on past, current, predicted behavior

# Explosive observations

- **Subarrays are a game-changer for transient science**
  - : Multiple simultaneous observing bands (MID-B5 the workhorse)
  - : Efficient, commensal: fully-sampled and complete-life light curves
  - : We want the long baselines many others dislike
  - : Continuous light curves (within a SB)

# Explosive science

- Multi-wavelength essential (for both triggers & follow-up)
  - **Public observing schedules**
  - **Local synchronized telescopes**
  - Allow for **fixed-time scheduling**
  - **SKA-level agreements** with other telescopes & experiments
    - simultaneous, contemporaneous, collaborative observations
    - multi-telescope proposals (check boxes)
  - **Dedicated SKA liaison**
- Imaging vital to interpretation
  - **Long baselines**
  - Simultaneous/contemporaneous radio imaging (**VLBI** et al.)
  - Useful to allow for **imaging adjacent to variable & strong sources**

# Explosive science

- **Public access to data** (à la *Swift*)

→ **Public database with light-curves**, including all observations of:

- near real-time updates
- new variables
- classes expected to be variable (e.g., CVs, novae, XRBs, FRBs, ...)
- “trigger criteria” attached to each source (default + proposal-driven)
- access to specific entries could be restricted according to proposals (mostly PI-driven)

...many benefits, including also intelligent triggers based on unusual behavior

→ **No proprietary period** for (most) transients/variables

...reference is to an overview paper, or in acknowledgements

# Explosive science

- **Advance agreement** on “ownership” (if any)/authorship
  - SWGs to negotiate/propose a standard
  - Could be modified by individual KSP or PI proposals
  - ...many examples to consult: *Swift*, *MAXI*, *RXTE*, SDSS, LSST, precursors, etc.
- Lots of commensal opportunities

# Knock-on benefits

- Urgency parameter
  - More efficient use of telescope
- Subarrays
  - Less intrusive, easily commensal
  - More efficient use of telescope
- Automated schedule generation
  - Essential for us, but good for everyone
- Common proposals
  - Makes SKA more accessible → expands SKA user base
  - Top-level agreements make SKA (even) more visible



# Knock-on benefits

- Open-access schedules
  - make simultaneous and contemporaneous observations easy
- Open-access light curves & ancillary data base
  - More efficient use of telescope: choose observing time and cadence based on historical data and current flux density/spectrum
  - Expands SKA user base
  - Very appealing to public (e.g., amateur observers)
  - Great for everyone: source subtraction, calibration, QA, other primary science (brown dwarfs etc.), ...
- **Suitable for early science & commissioning**

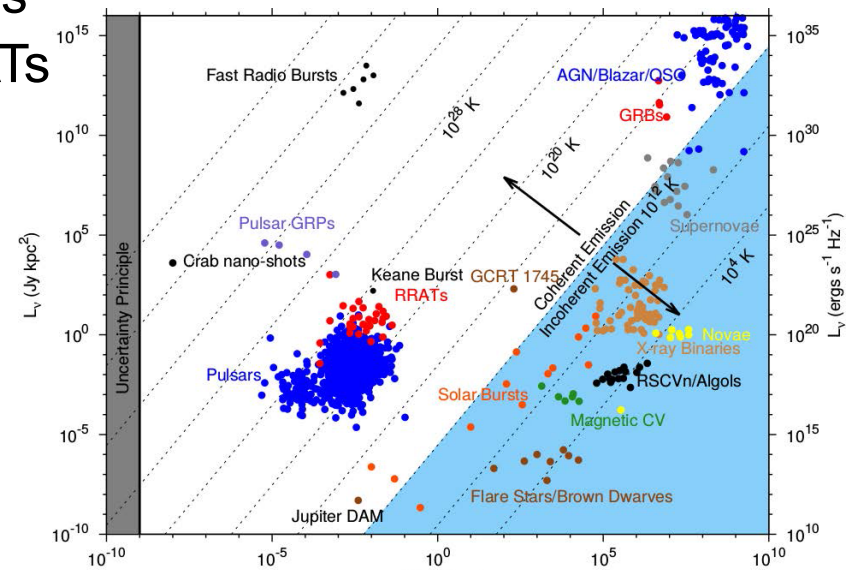
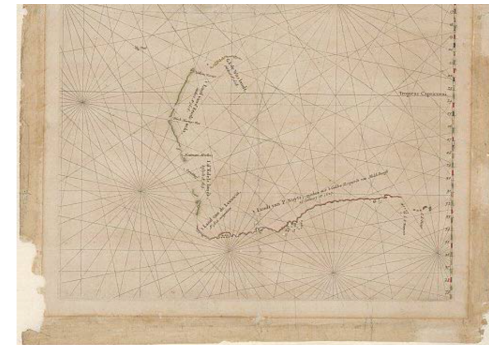
# The Variable Radio Sky

# Exploring the fourth dimension: the variable radio sky

- Surveys optimized to find variable sources
- Explore the unknown, find the unexpected
- Previous examples:
  - Pulsars
  - X-ray binary jets
  - Tidal destruction events
  - Stellar radio emission
- The universe is smarter than we are...

*...we should listen to it!*

- \* Gamma-ray bursts
- \* FRBs
- \* RRATs



Pietka, Fender & Keane 2015

# Anticipating the unexpected

- Returning to a given piece of sky
  - Blind surveys
  - Unique places (e.g., Galactic bulge, nearby galaxies, our neighborhood)
  - **Commensal with virtually all other** deep fields & surveys
- Repeated visits
  - Variability timescales are minutes to years, with recurrence times of hours to millenia
  - **logarithmic cadence with no special start time:** e.g.,  
0.1 – 1 – 1.1 – 5 – 5.1 – 6 – 6.1 -- 10 – 10.1 – 11 – 11.1 - ... days

# Anticipating the unexpected

- **SDP should check for variability on many timescales** (1sec, 5sec, 30sec, 1min, 5min, 10min, 1 hr, 5 hr, 10hr?)
- Produce external or internal triggers
  - SDP should **report variability within N x the variability timescale**, with N 3-10 (TBC)
  - **Alerts**
  - **VOevents**
- Synchrotron, coherent, and thermal sources
  - **MID-Band 5** useful in spanning (and distinguishing between) all three
  - **Other bands** also have advantages (e.g., field-of-view)

# Anticipating the unexpected

- Variability generally implies small & possibly absorbed
  - **Long baselines** most useful
  - May want **high-res'n images** (i.e., toss large-scale structure)
  - Wide frequency range helpful
  - **Separating short and long baseline variability** distinguishes ISP from source variability
- Response to a trigger
  - **Automatic classification & response** based on spatial coincidence, flux density, flux behavior, etc.
  - High-res'n or multi-band follow-up
  - **Subarrays** very useful here

# General Thoughts

# For the SKAO

- Need to move on to concrete numbers
  - Exposure Calculator would be very useful
- Don't change the telescope unless it's essential
- Too early to opt for surveys over KSPs
- Eager to help with design/ConOps questions
  - ...but would like clear feedback and continued discussion, not a one-touch consult or review
- Matrix of KSP & survey parameters would be great
- Strongly encourage inviting non-radio observers & theorists
  - Multi-messenger transients: physics community too



## Commensality with other KSPs/SWGs

- Will develop a (short!) document on “best practice” to allow transient/variable source science
- Main discussions have been:
  - Cadence
  - Use of subarrays (mostly by baseline length)
- Designated ambassadors/**contacts for the other SWGs?**
  - Some SWGs have joint membership
  - Could have transient SWG folks, or just use the chairs – comments?

## Commensality: (important!) technical details

- Lots of interest in zoom + higher-res'n continuum
- Need to sort noise diode question – determines whether pulsar folks can observe with anyone else

## Next steps for Transients SWG

- Report to & discuss with SWG
- Set up wiki
  
- Develop best-practices document
- Use cases
- L1 suggestions
- SDP product definitions
  
- Start in on real numbers for KSPs
- Work with other SWGs on policy on cross-KSP conflict resolution

## General points (reprise)

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