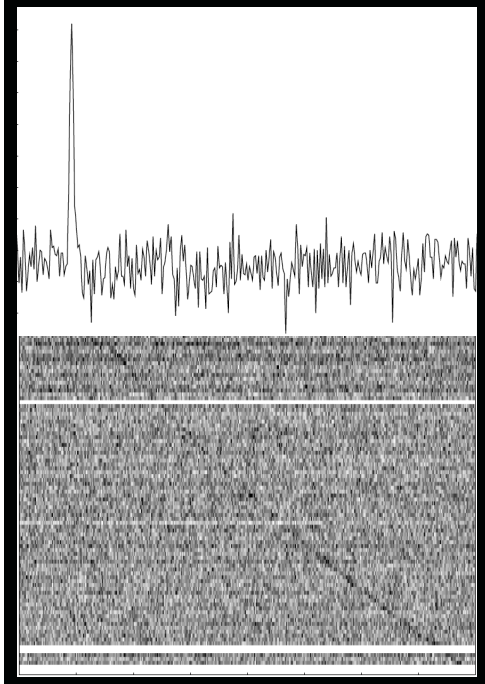
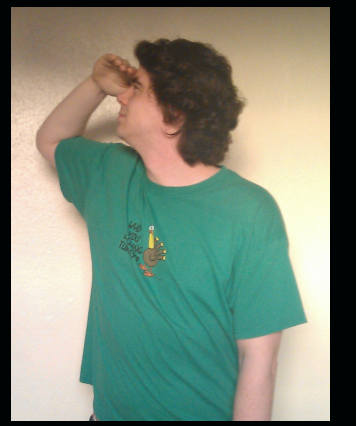
Detecting FRBs w. TNG radio telescopes



Evan Keane
@evanocathain
Swinburne

TEUwWLFA (!) Meeting
12th November 2013,
Perth, Australia.



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Fast Radio Transients

- Why? How?
- A famous burst and its friends
- Rate estimates
- Ideas/questions for discussion this week

Radio Transients

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- Why study transient radio phenomena? 2 main reasons.
  1. Enables study of interesting physical environments.
  2. You can't avoid them!

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- e.g. Pulse of 1 Jy lasting 1 ms from 1 kpc at obs freq. of 1 GHz (all very typical numbers!)
  -> Causality gives size < 300 km
  -> Brightness Temp >= 10^{23} K
  -> Compact objects + non-thermal coherent emission
  -> extreme astrophysical environments.

Radio Transients

- Why study transient radio phenomena? 2 main reasons.
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- e.g. Pulse of 1 Jy lasting 1 ms with DM_{IGM}~1000 $cm^{-3}pc$

  -> z~1! -> D hundreds of Mpc
  -> Causality gives size < 300 km
  -> Brightness Temp >= 10^{35} K
  -> Energy = (1 Jy)(1ms)4π(500 Mpc)^2(10 GHz) = 10^{39} ergs
  -> Peak Luminosity = Energy/(1ms) = 10^{42} ergs/s
  -> These numbers are high (for radio), but << E_{SN}

Radio Transients

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Radio Transients

- Why study transient radio phenomena? 2 main reasons.
  1. Enables study of interesting physical environments.
  2. You can't avoid them!
- Detected in abundance by TNG radio instruments (LOFAR, LWA, MWA, Molonglo 2.0, ASKAP, MeerKAT, FAST, ..., SKA).
  -> would be nice to know what they are!



Radio Bursts

4/8; 8192x4096 pixels; 32-bit; 1GB

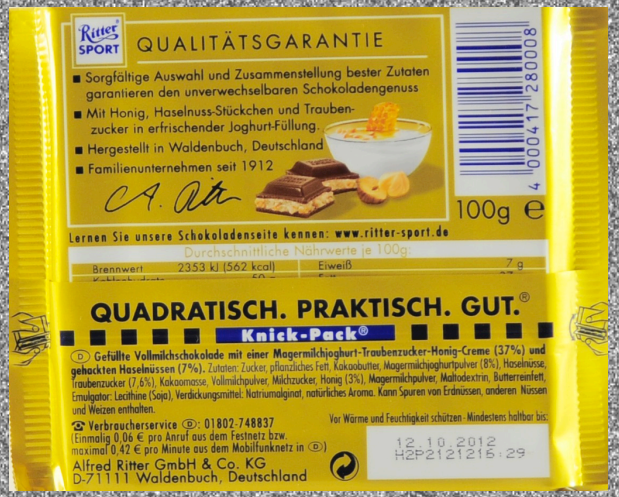
Obs Freq

Time

Arrival time delay

$t_{delay} = 4.150 \text{ ms } (DM/f_{GHz}^2)$

$DM = \int n_e \, dl$



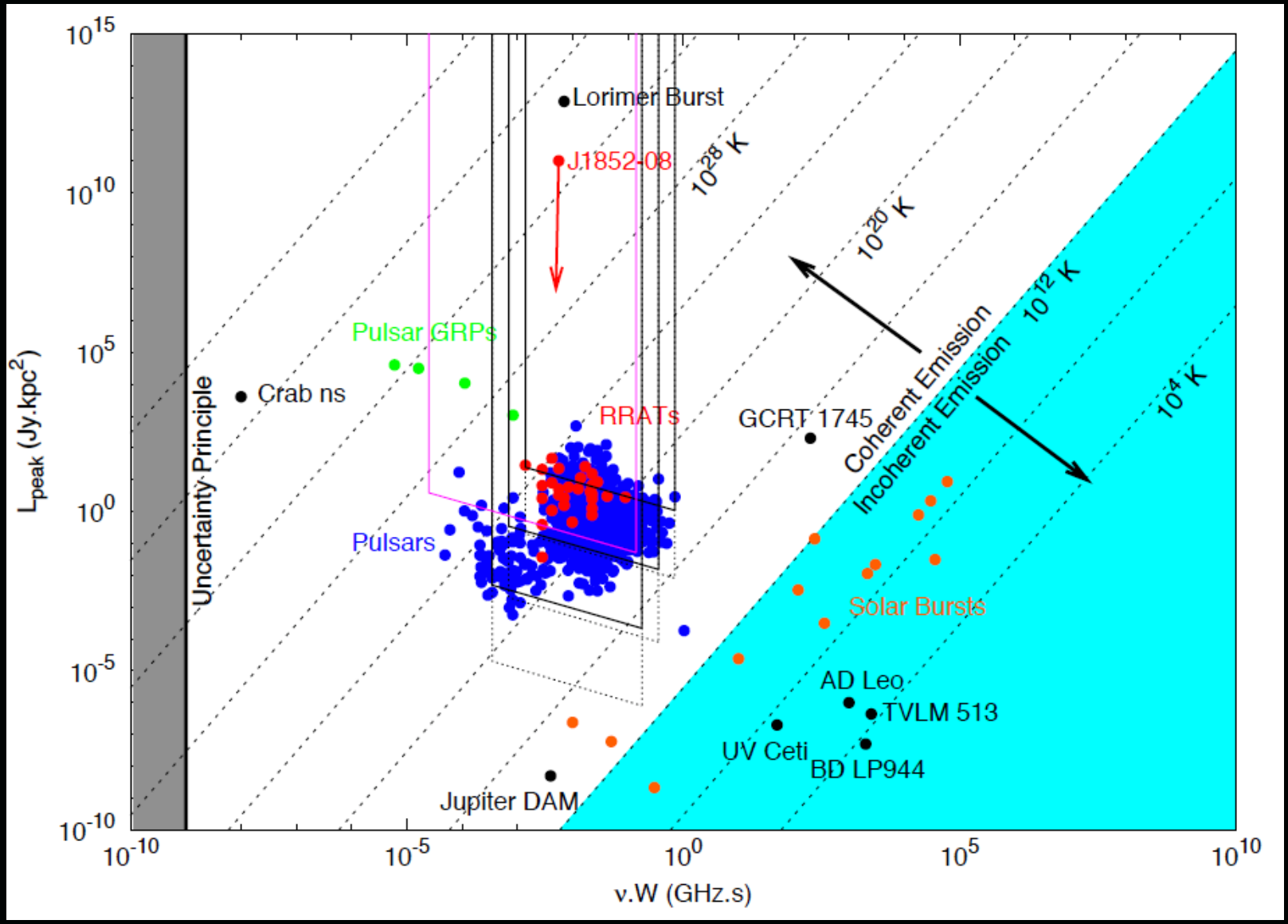
Burst Searches

- Burst searches are basically …

  foreach DM (`make_a_dmlist`)
    dedisp -dm $DM filterbank > timeseries
    thresh_search timeseries -width=range_widths

- This is also the best way to find many PSRs
  (~30% at 1.4 GHz)

Transient Parameter Space



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- McLaughlin -> "let's find PSRs in SP searches again"
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- Lorimer -> "I'll search the SMC survey for bursts"
  -> didn't realise there were off-SMC pointings so went to DM 500 for all pointings -> good idea

In Case You're New

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- Typical PSR survey of SMC & surroundings
  - in Australia
  - observed at L-band (1.4 GHz)
  - BW of few 100 MHz
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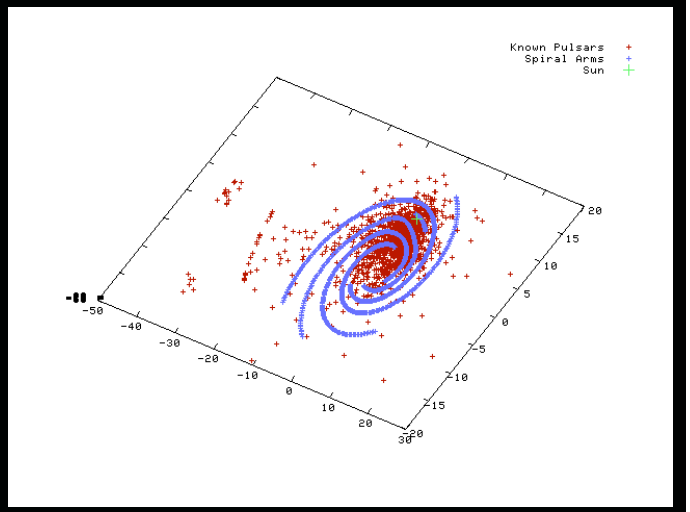

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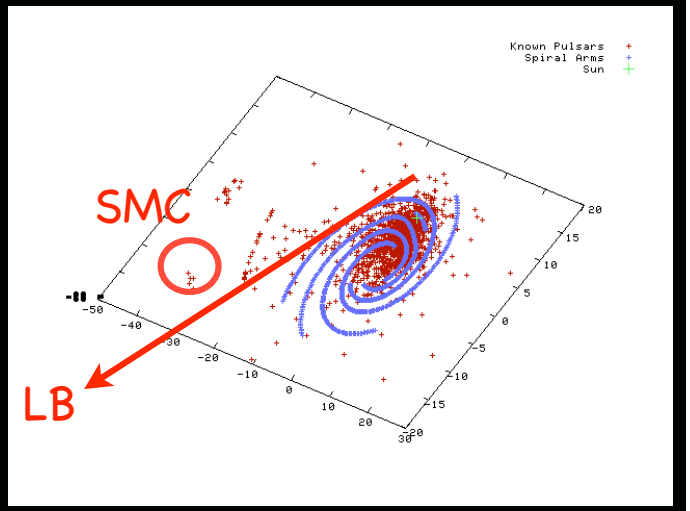

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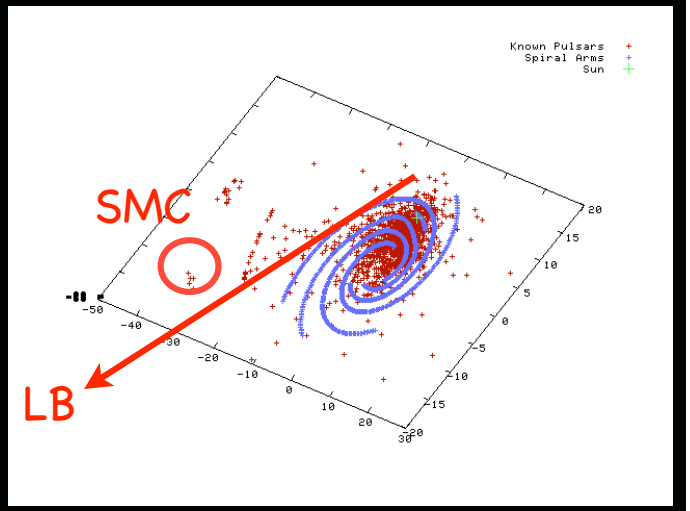

A bright millisecond radio burst of extragalactic origin

D. R. Lorimer,[1,2*] M. Bailes,[3] M. A. McLaughlin,[1,2]
D. J. Narkevic,[1] F. Crawford[4]

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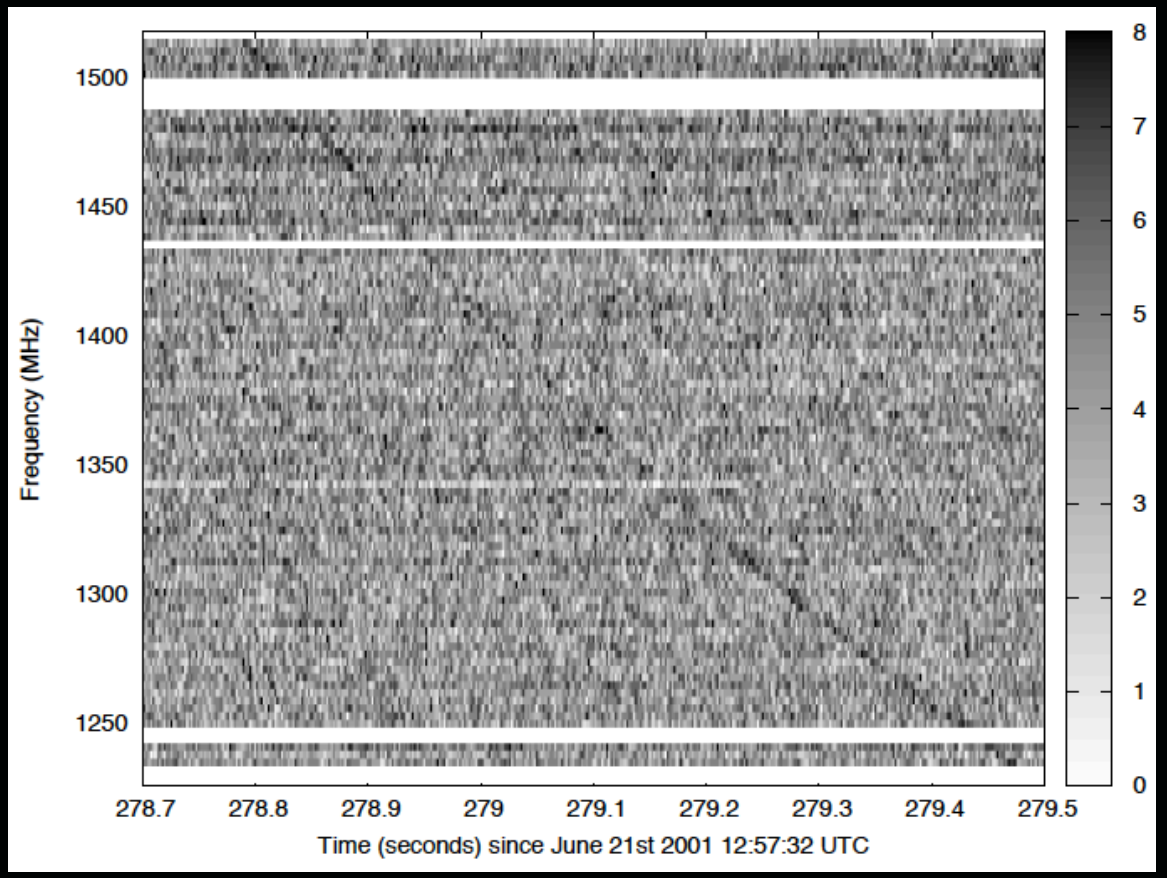
- EK: "In defence of Dunc"

FRBs Everywhere



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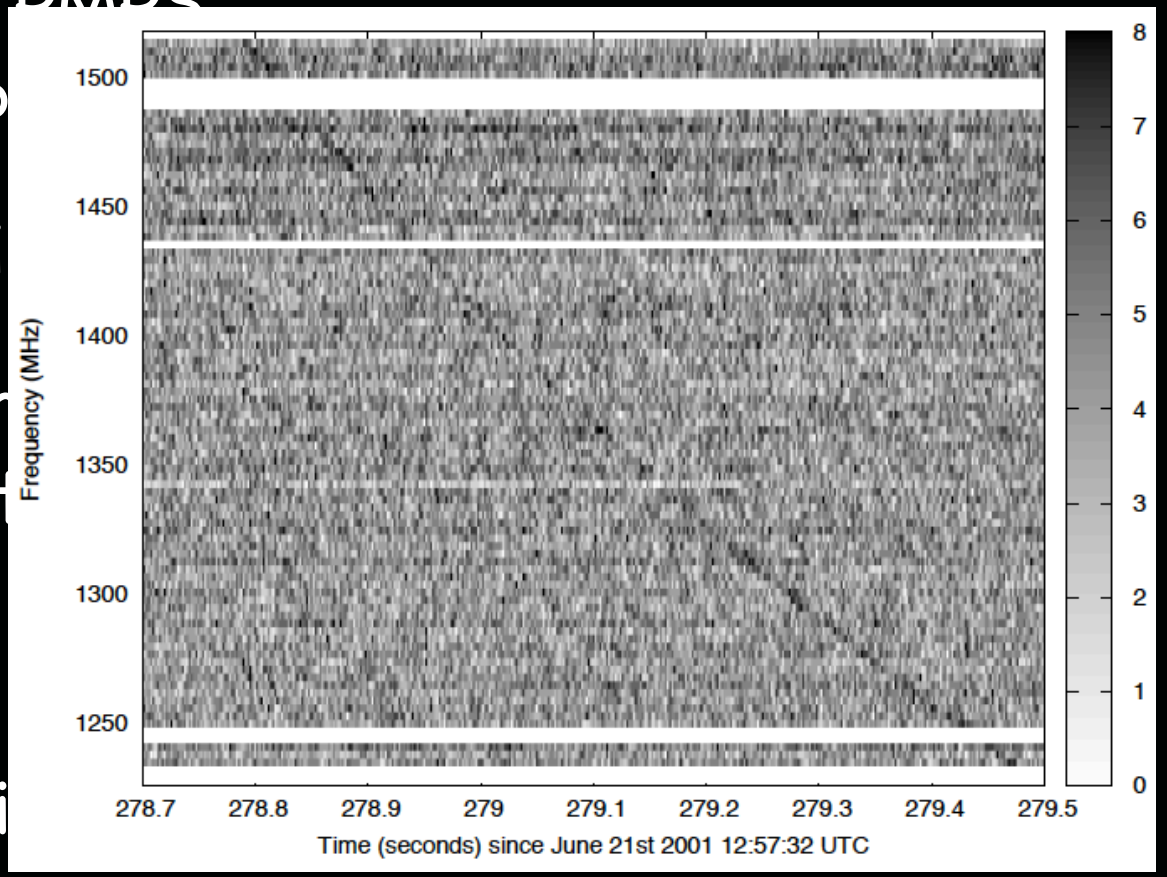

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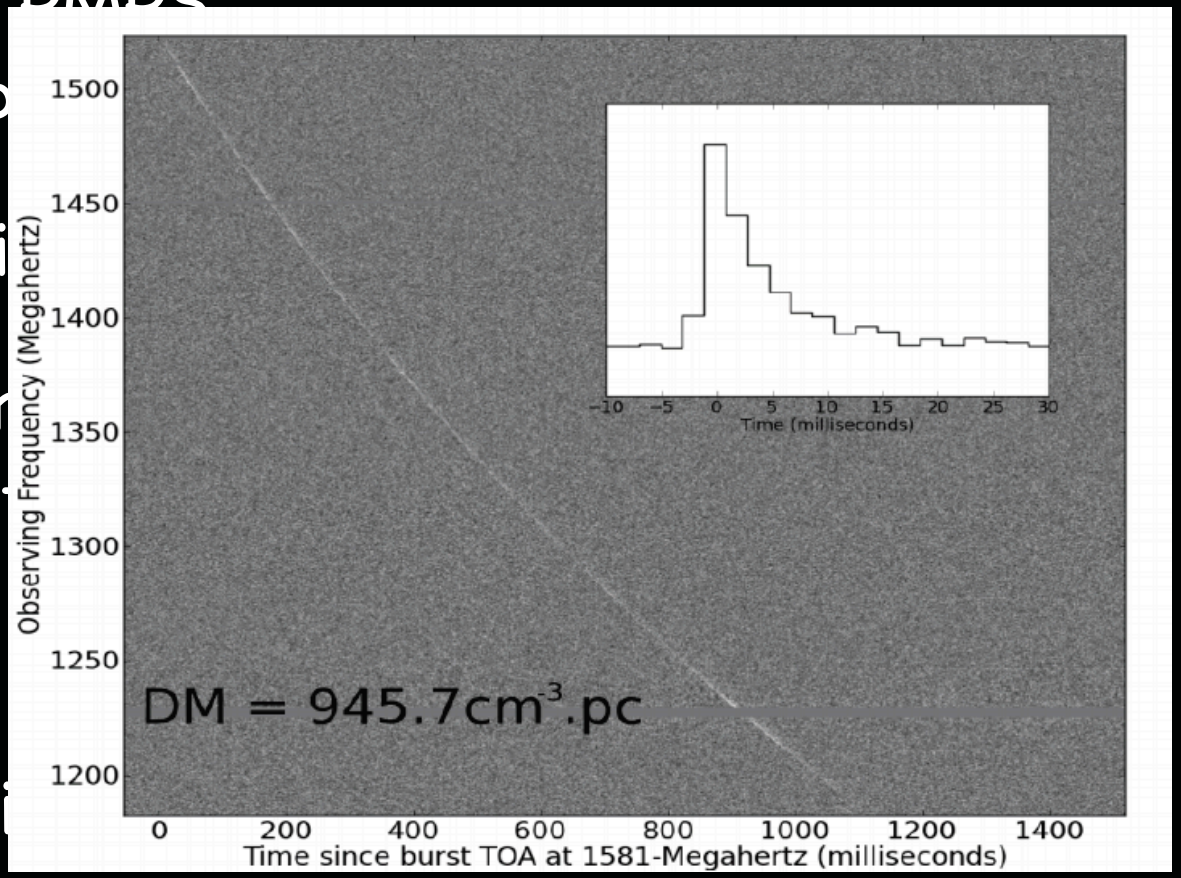

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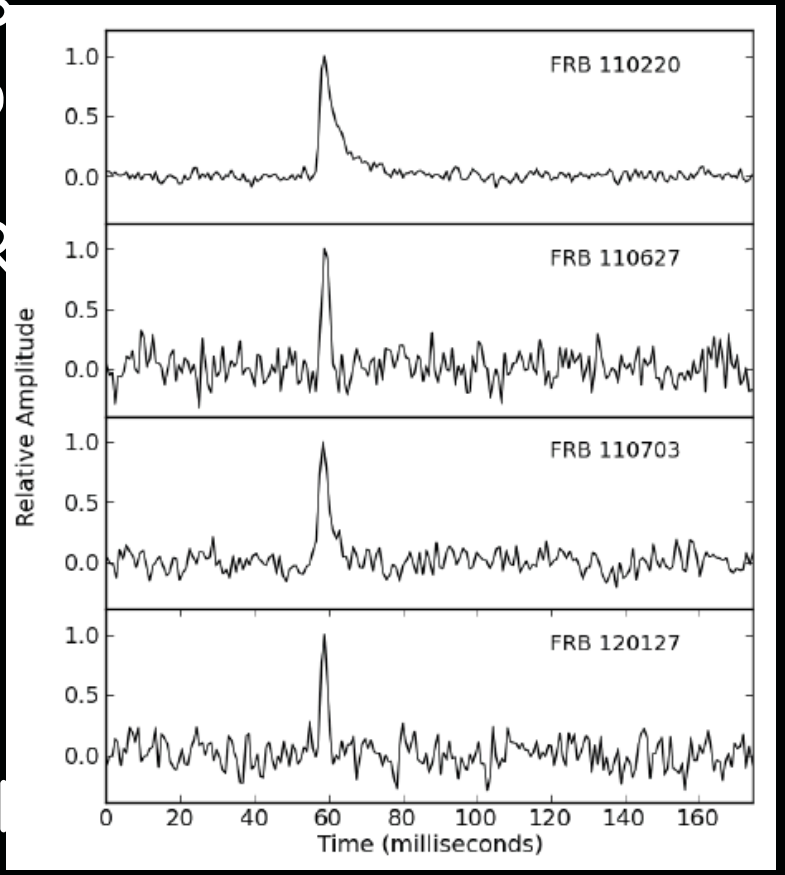

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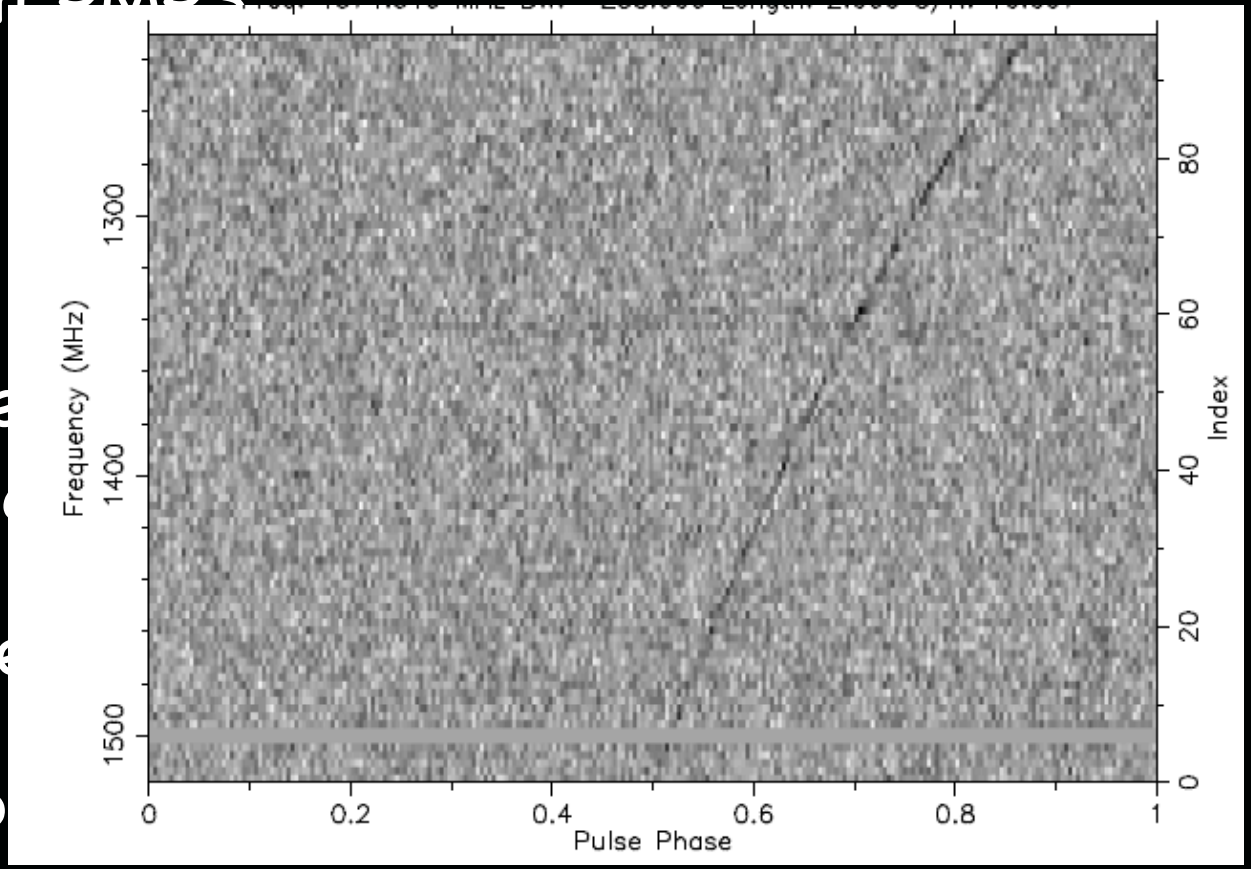

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Remind re: dates!

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The Future

- These bursts are now pouring in …
- Real time detection system now in place at PKS (2 'live' detections with ~minute lag) with alerts etc. Similar systems in place/in prep. at many other observatories.
- Looking at wider FOVs (LOFAR, MWA, Molonglo …)
- What are expectations for the future?

FRB Rates

- The rate is (ignoring redshift evolution):

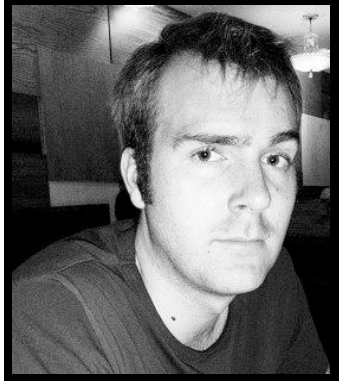
$$R = (1/4\pi) \int_{V1}^{V2} \int_{L1}^{L2} \rho(L)\, dL\, dV \quad \text{FRBs/hour/sr}$$

$$\rightarrow R_{obs} = \int_{D1}^{D2} \int_{L_{min,em}(D)}^{L2} \rho(L)\, dL\, D^2\, dD = N_{obs}/(\Omega_{obs} T_{obs} (4/3)\pi D^3)$$

- Need to know 4 things: $S_{min}(D)$, $\rho(L)$, $W(D)$ & D-DM-z

FRB Rates

- $S_{min}(D)$ known for any given telescope/survey
- $\rho(L)$ -> standard candle -> easy
  -> !standard candle -> need more sources
- W(D) depends (mostly) on scattering in IGM
  -> tactic to examine 2 extremes
- Standard candles:
  -> R_{obs} = const $[\max(D_2, D_{sc})^3 - D_1^3]$ FRBs/hour/sr
- Get const from known bursts, scale by FOV for predictions for your favourite telescope



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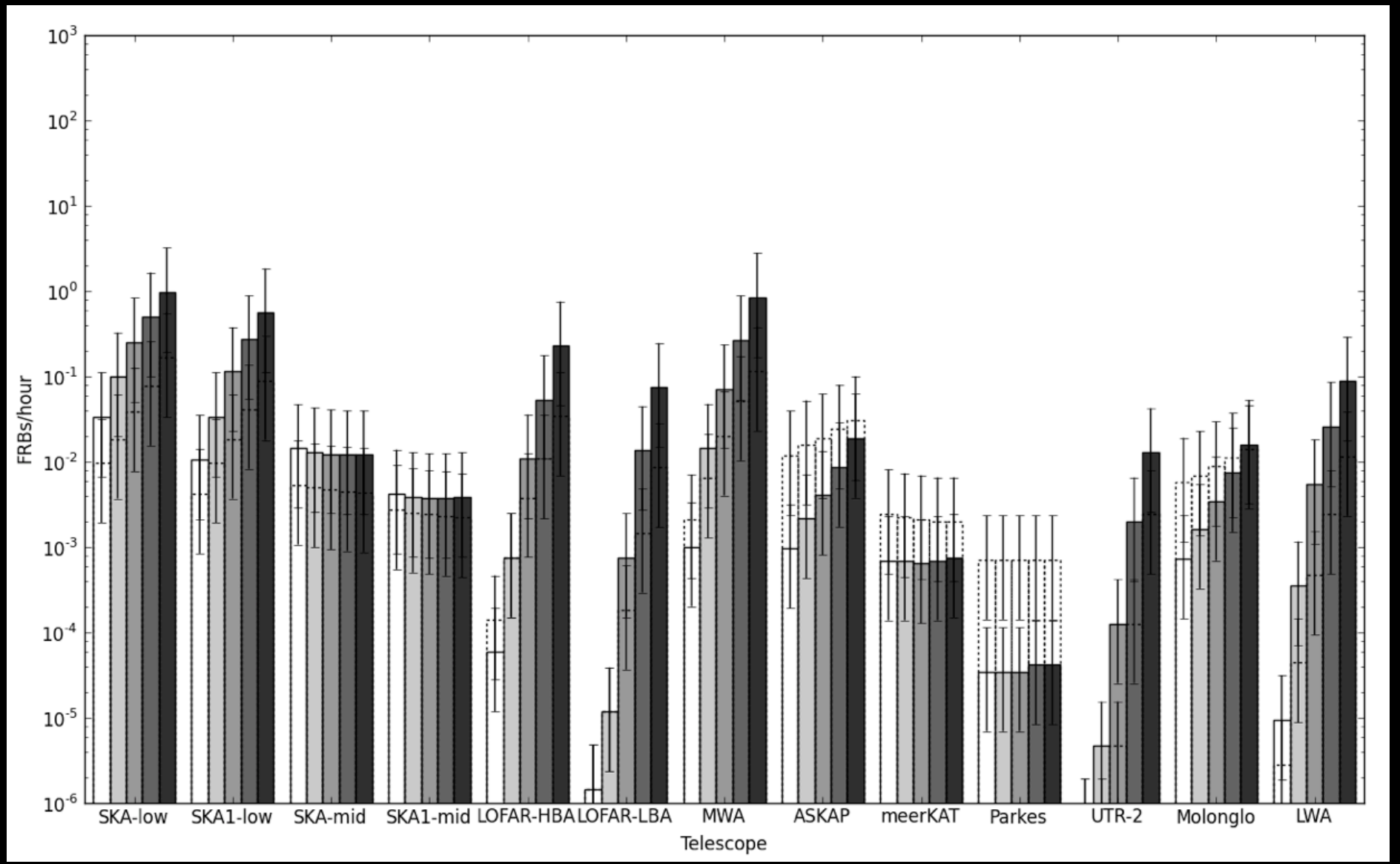
FRBs/hour
10^{3}
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
SKA-low
SKA1-low
SKA-mid
SKA1-mid
LOFAR-HBA
LOFAR-LBA
MWA
ASKAP
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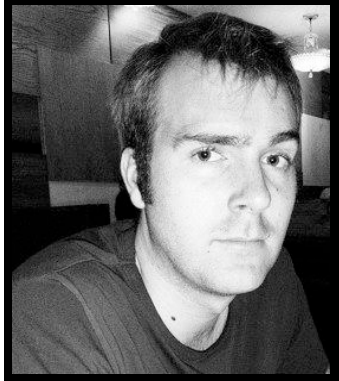
Parkes
UTR-2
Molonglo
LWA
Telescope



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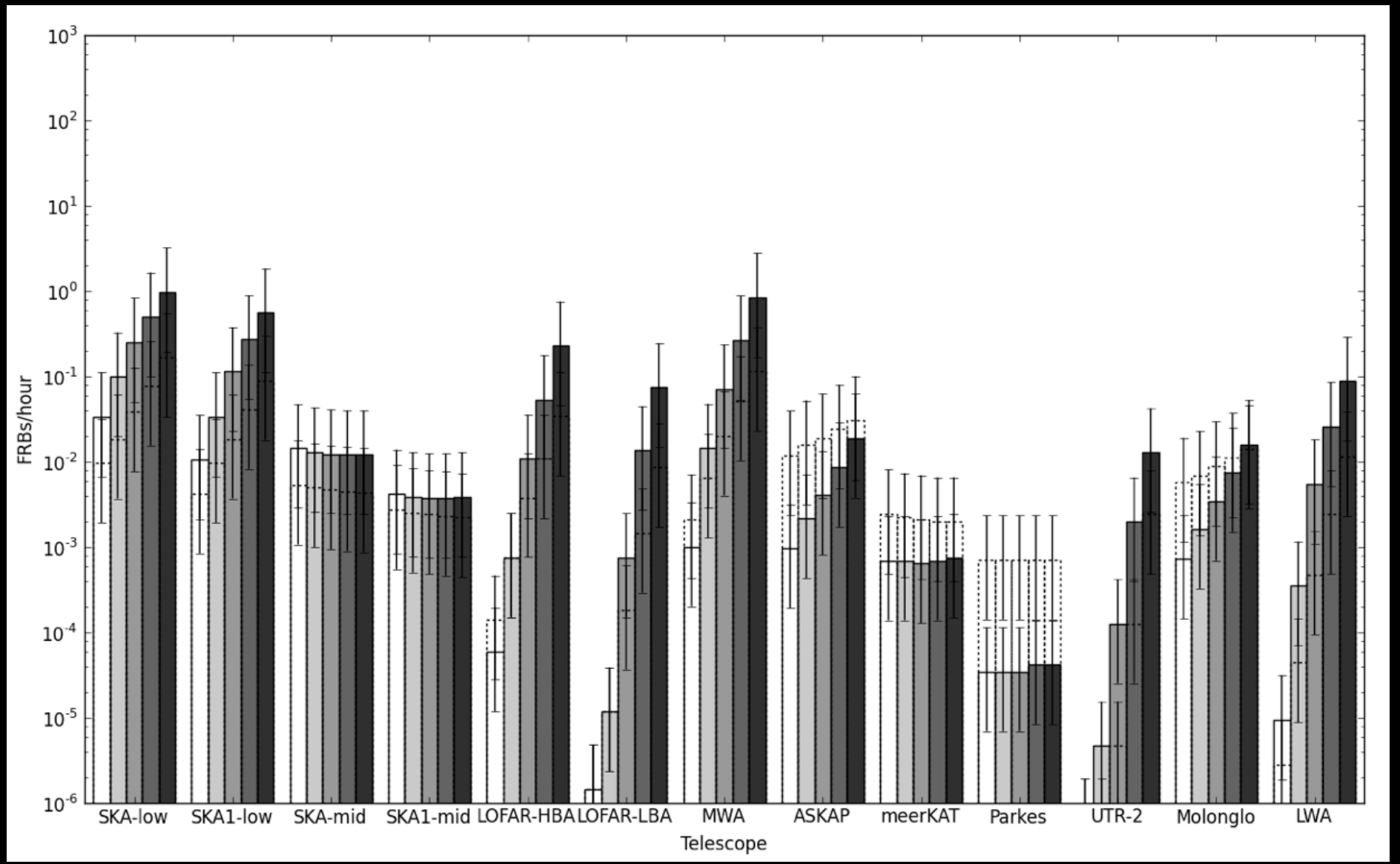
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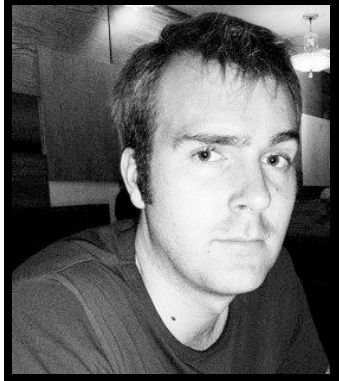

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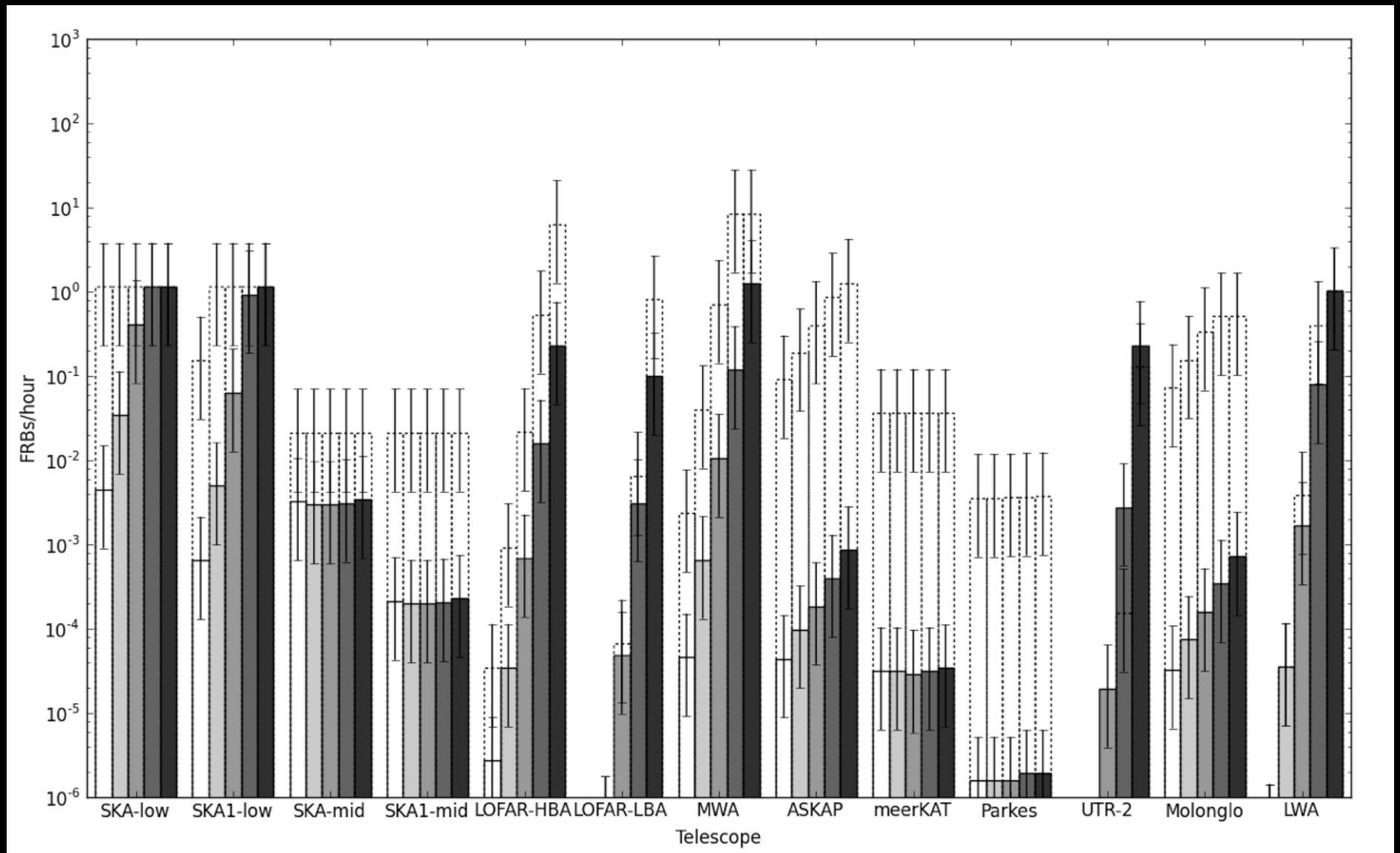
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FRB Rates

- Rates between 1hr/FRB and 1000hr/FRB across the various current & TNG instruments
- For standard candles:
  R_{obs} = const $[\min(D_2, D_{sc})^3 - D_1^3]$ FRBs/hour/sr
  R_{obs} ~ const * $[\min(D_2, D_{sc})]^3$
  where D_{sc} is the DM/distance where the standard candle's smeared out pulse falls below our S_{min}
- Important to make sure we don't stop searching at DM values below this point
  -> worth it searching up to DM of 6000!

Ideas/Questions for Discussions this week

- Are we 'detecting' the missing baryons (low ρ, high T)?? Can we 'weigh' them?
- Do we trust the Ioka D-DM-z relation? What are sensible MW/host DM contributions.
- There are no Parkes FRBs (out of ~10) with |b| < 15. Low-b selection effect(s)? T_{obs}, scintillation, scattering, something else? (cf. Johnston talk)
- What is the actual scattering & scintillation, experienced by FRBs?

Ideas/Questions for Discussions this week

- Published HTRU Rate(> 3 Jy*ms) is wrong & search algorithm !optimal (now correct+faster w. Heimdall)
- Usefulness of RM/polarisation/<B> measurements?
- What cosmology can we do? e.g. if we find more & observed ρ(z) leads to intrinsic ρ(z) & it's consistent with something (const., SFR, ...) then so what?
- WHAT ARE THEY?! Does the blitzar model, or any of the others, hold up? Or make predictions?

Thank You
(questions, comments?)

@evanocathain

Extra Slides

Comparison of Burst Search Codes