SWATS: Serendipitous Westerbork APERTIF Transients Study - *Proposed*

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Supporting collaborations

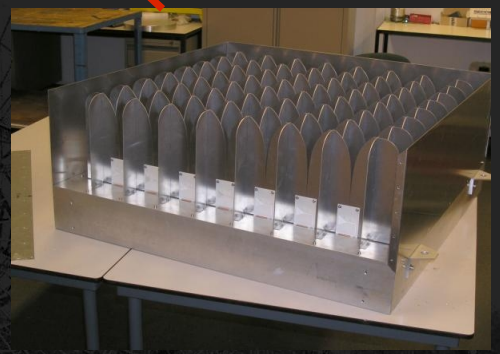
* LOFAR Transients Key Science Project
* MeerKAT 'ThunderKAT' Transients Key Science Project
* Transients programs at the Allen Telescope Array (ATA)
* ASKAP 'VAST' Variable and Slow Transient KSP (PI – T. Murphy)

APERTIF (APERture Tiles In Focus)

* FOV increase: ~0.3 deg^2 to 8 deg^2
* 13x13/sin(δ) $arcsec^2$
* Operational freq: 1 to 1.7 GHz
* Continuum noise (12hours): ~10μJy

* 18 proposed key science project:
  HI, polarisation, deep continuum and pulsars.

* Time line:
  2011 (spring): Full survey proposals
  2011 – 2012 : Preparation of surveys
  2013 : Commissioning
  2014 – 2017 : Operations



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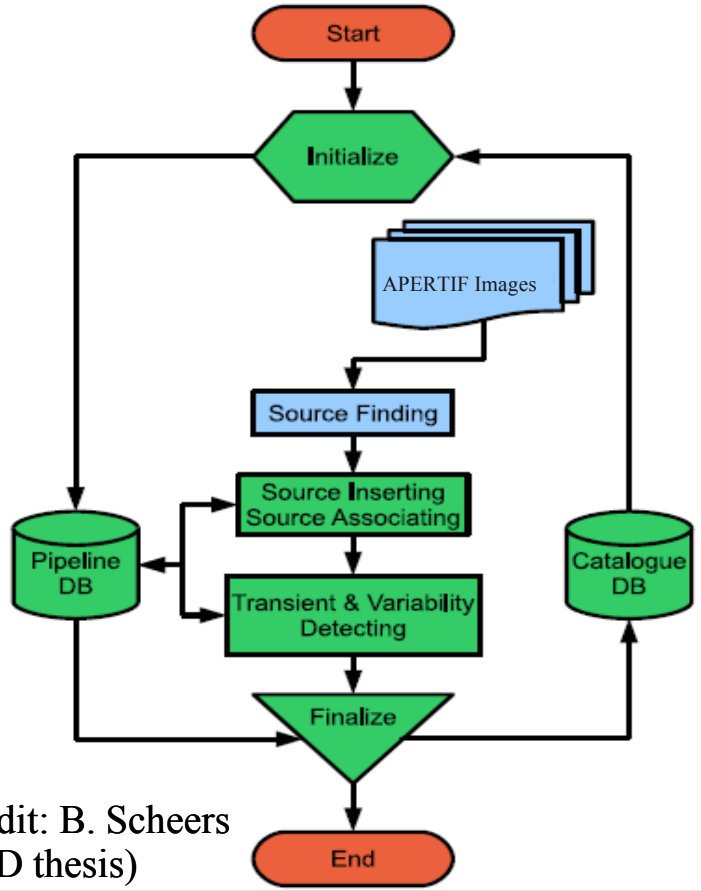
Observing configuration

* 100% commensal on ALL continuum observations.
* No strong preference for frequency.
* Preference for multi-epoch (12 hour) revisit of the same field (either extra-Galactic or Galactic).
* Cadence:
    (I) Days, weeks, months and years to characterise different time-scales of transient and variable behaviour.
    (II) or monthly to sample e.g. GRB afterglow population and to characterise sub-mJy variability of persistent radio sources.
* Filler:
    - Re-observe the same pointing (e.g. ~2 hour integration).
    - Build up an adequate model of the field.
    - Then subtract model and search for transients.
*Visibility searches

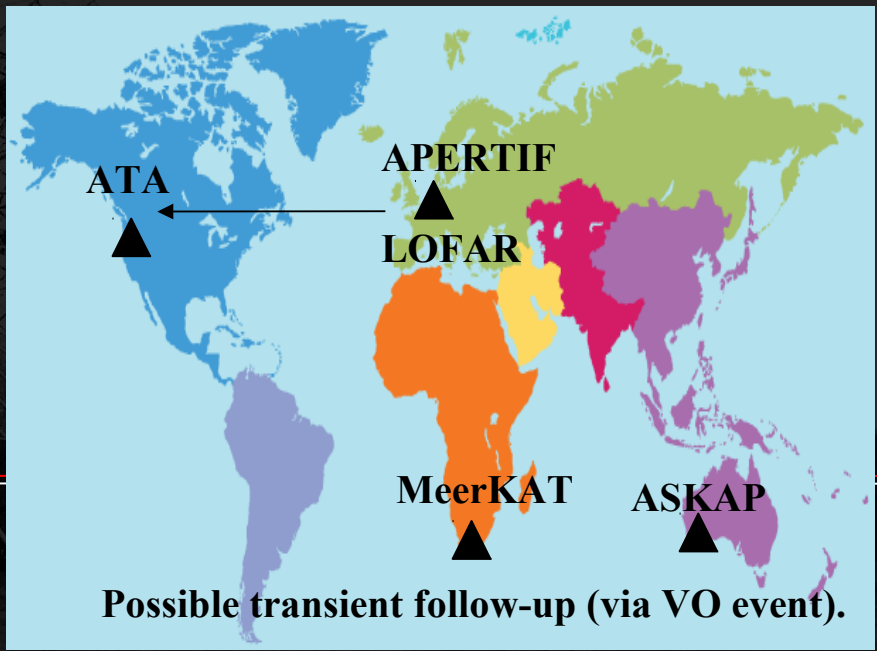
Logistics

* Source extraction, databasing and cataloguing (based on LOFAR transient detection algorithms) needed for transient detection.
* Database will include all major radio catalogues NVSS, FIRST etc.
* Infrastructure can be used by other survey Groups.



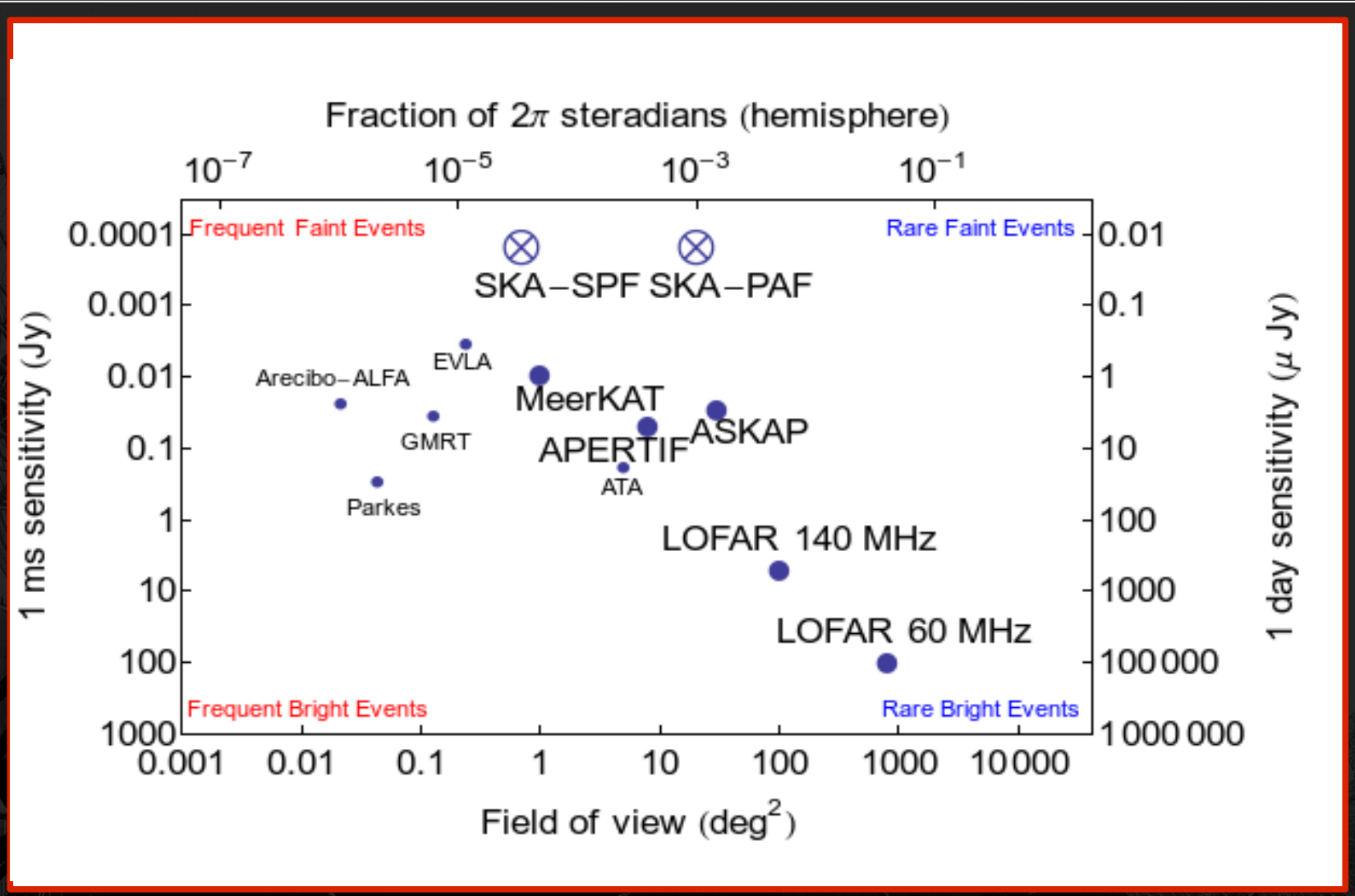
Credit: B. Scheers (PhD thesis)

* Follow-up
  - VO event alerts (within 24 hours?)
  - Allen Telescope Array (ATA)
  - also EVLA, eMerlin, LOFAR and EVN
  - Optical + multi-wavelength.



Possible transient follow-up (via VO event).

FOV vs. Sensitivity



Proposed Surveys

	Int Time per pointing	No of pointings
* WODAN – Westerbork Observations of the Deep APERTIF Sky. > Comparable to EMU with ASKAP	12 hours	1250
* WASGOED (Very deep)	6000	1
* WNSHS (HI all-sky + medium deep HI)	12 & 120	1250&125
* FRIGG (Polarisation)	144	5
* Dash (Deep HI)	1200	5
* Pulsars	12	1250

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Summary:

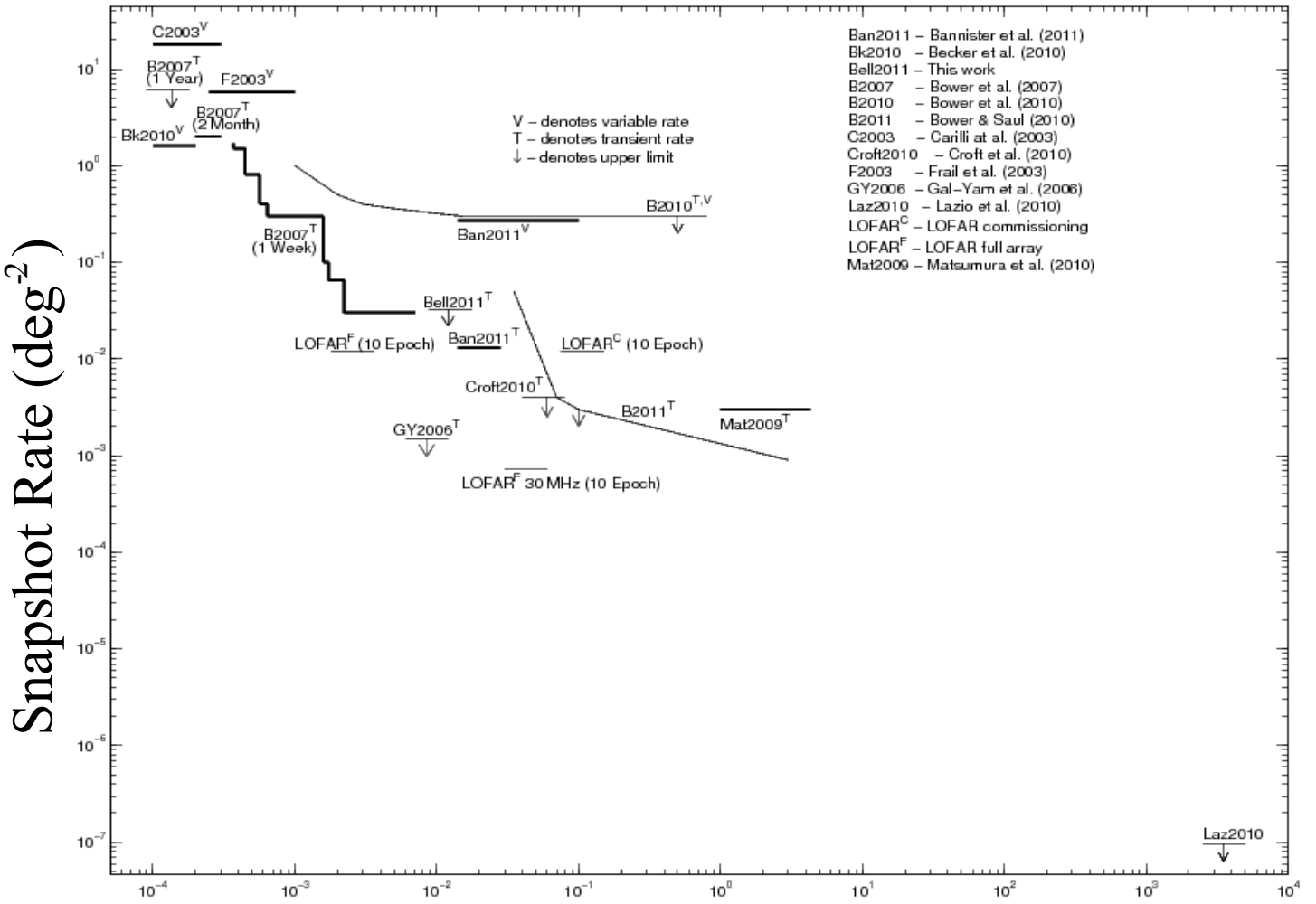
*One all sky survey to ~ 10μJy (NVSS/FIRST transient search)

*Medium (deep) ~ (10x12 hours) x 125 fields
~ (12x12 hours) x 5 fields
} = 1000 deg^2 revisited ~10 times

* Deep ~ (100x12 hours) x 5 fields } = 40 deg^2 revisited 100 times

~ (500x12 hours) x 1 field } = 8 deg^2 revisited 500 times

Current parameter space



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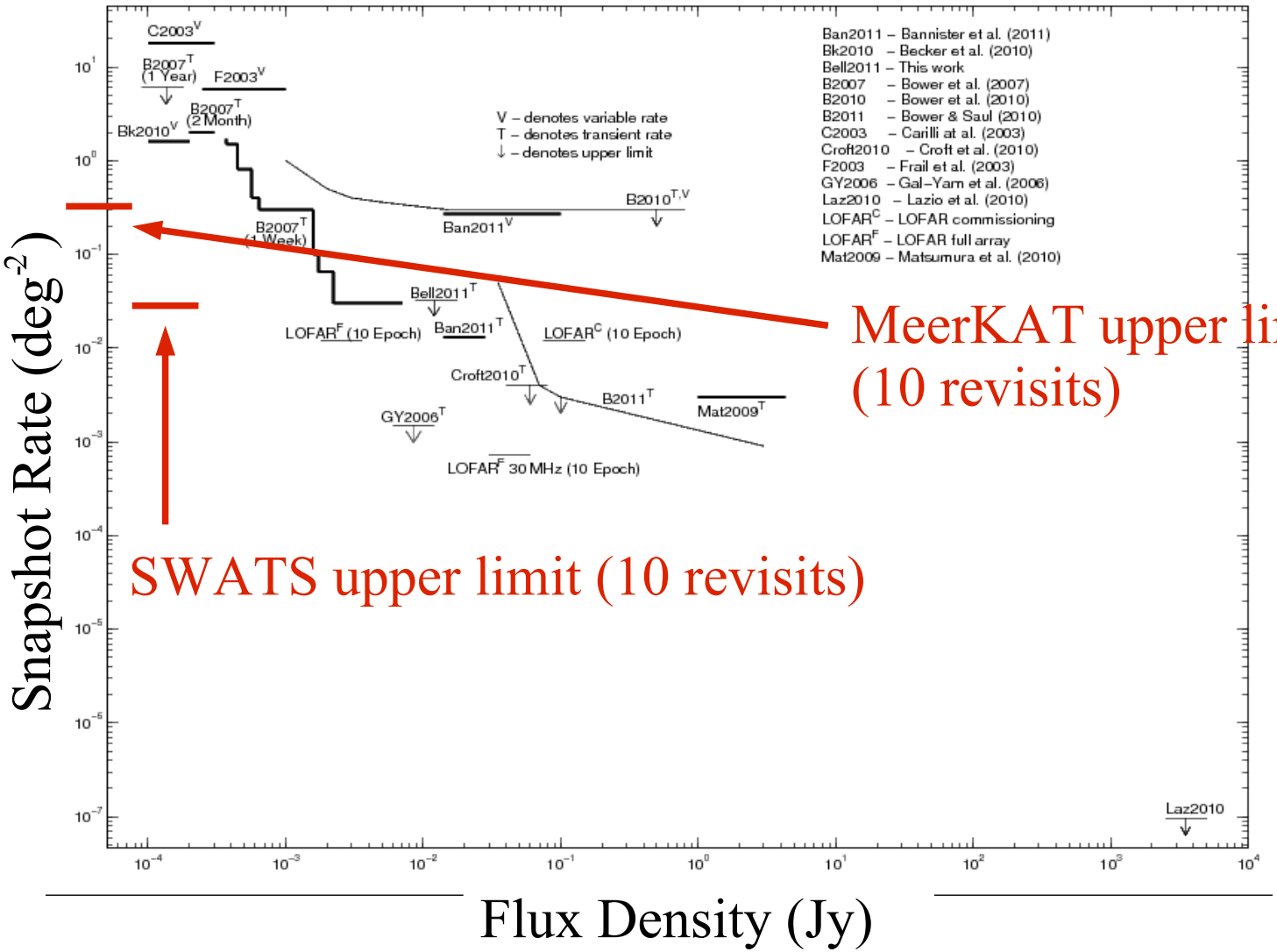

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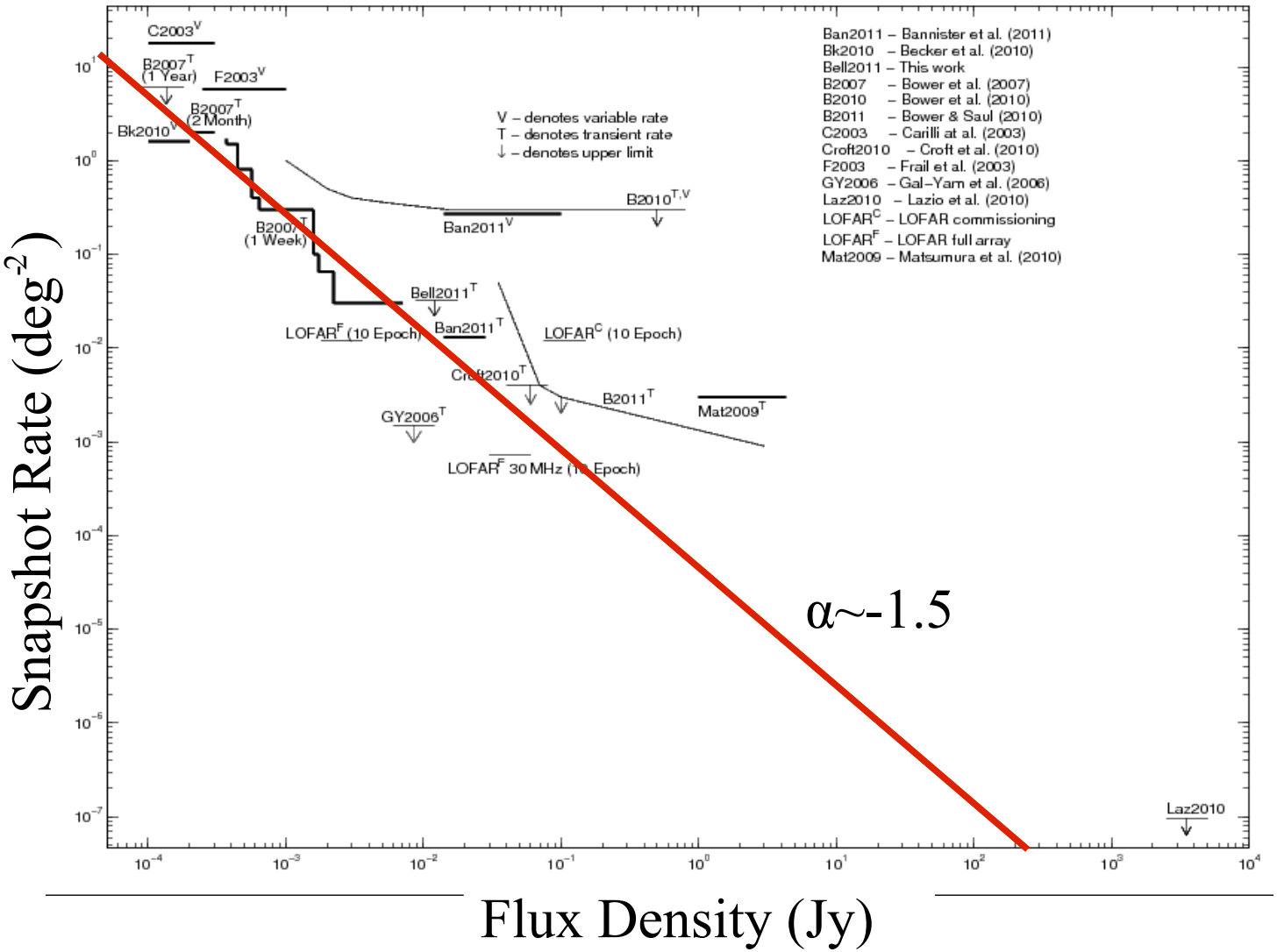

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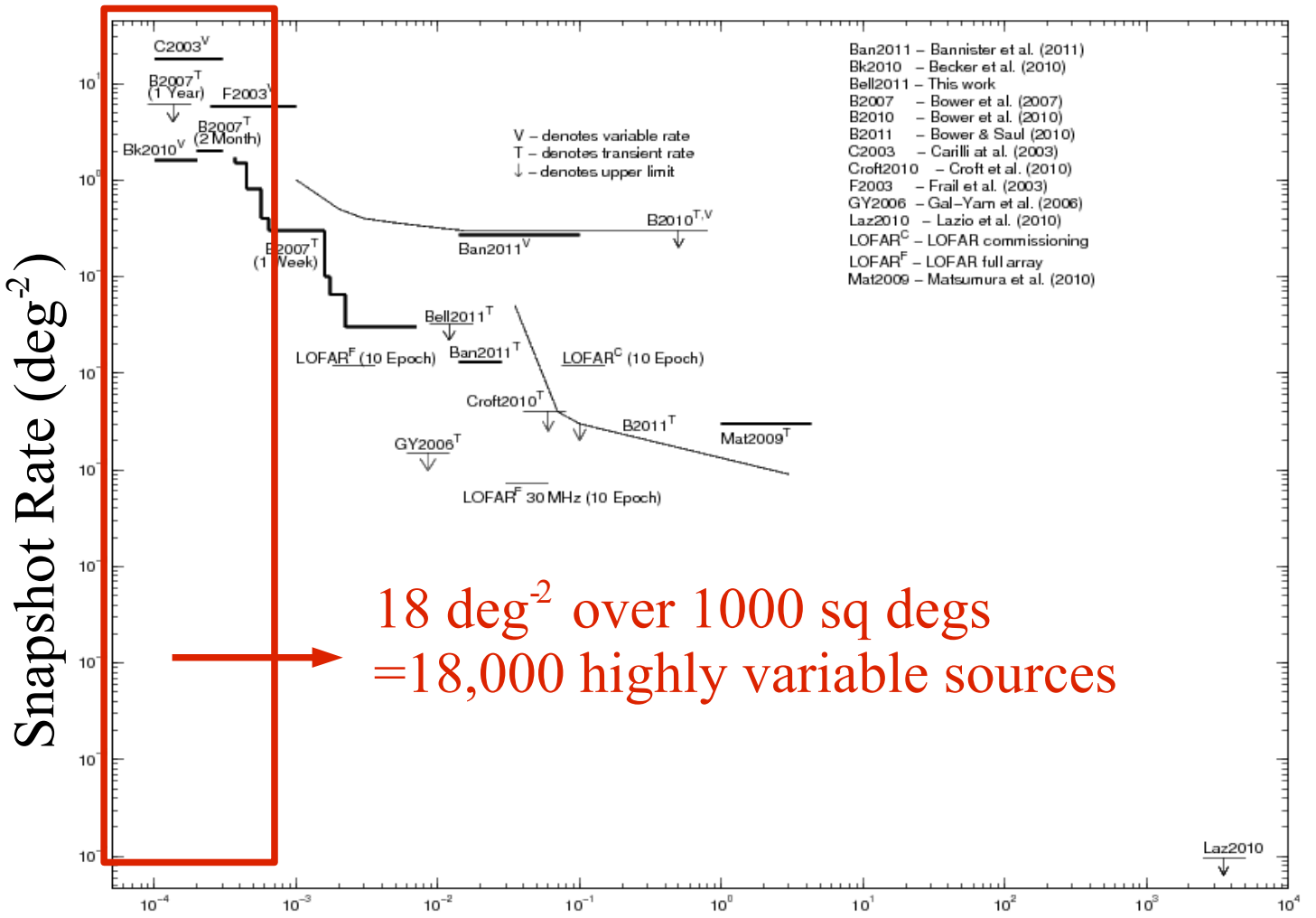
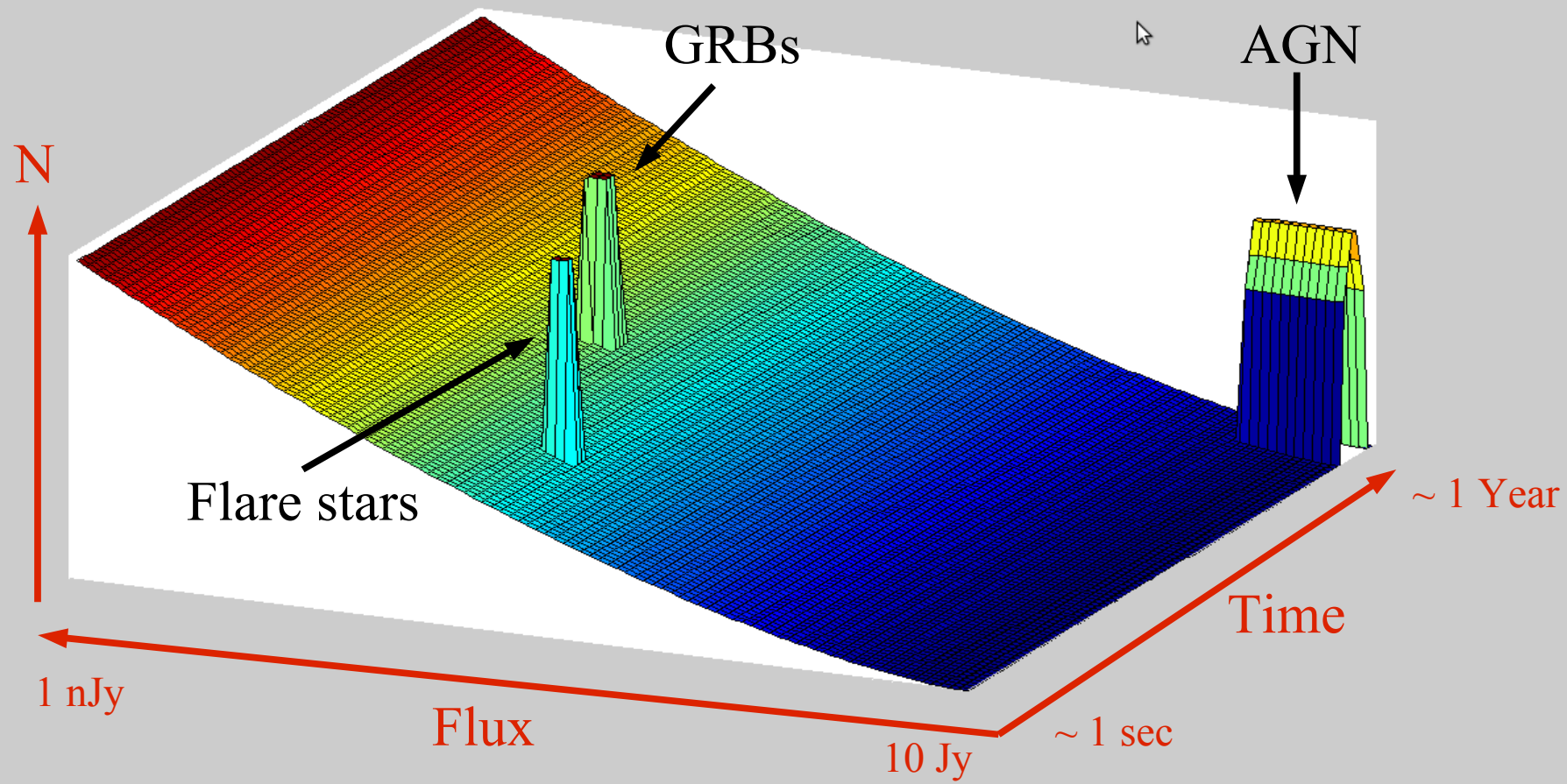
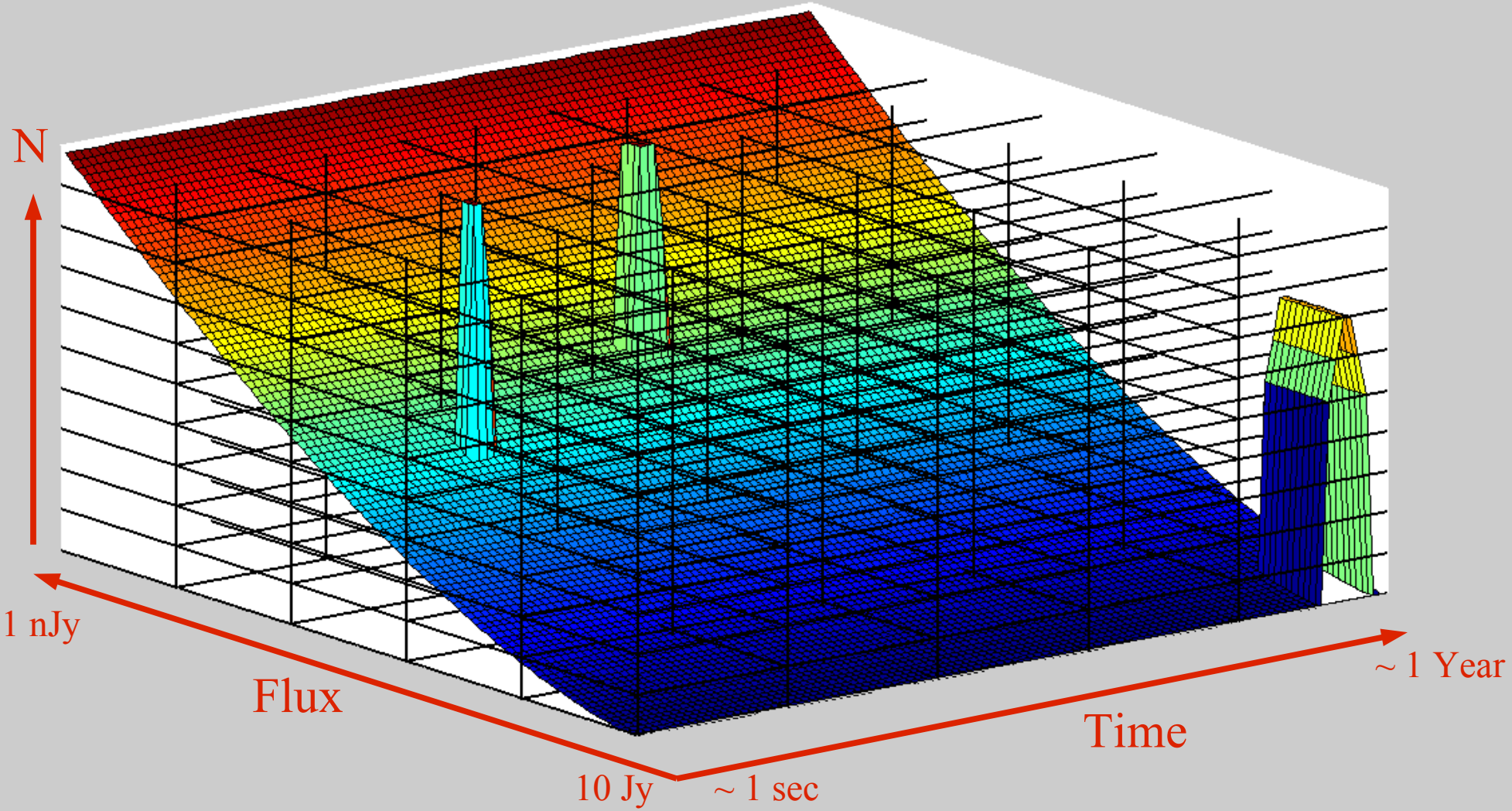


18 deg^{-2} over 1000 sq degs
=18,000 highly variable sources

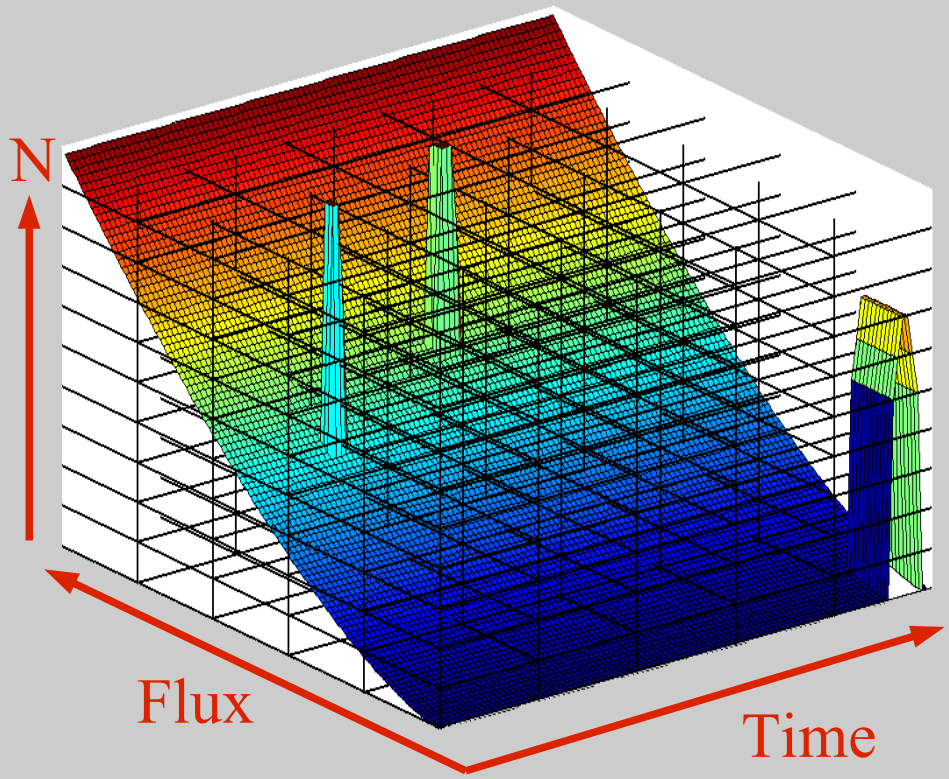
Log N – Log S – Log T



Variability Map..



Variability Map.



*Define complete flux and time limited sample.

→ Calculate variability of known sources within sample using *standard* metric.

→ Search for transients.

→ Define variability and transient upper limits/detections as a function of red-shift?

→ Repeat for different freq's and Galactic/extra-Galactic.

*Sensitive to GRB science.

*Useful for planning for SKA science i.e. will all nJy sources scintillate?

Will we achieve all of this with SWATS (if accepted)?

Can *we* – transients and surveys - co-exist.

Does re-visiting the same field over yearly time-scales effect the calibration of survey fields?

Table 1: A selection of variable source statistics taken from the literature. ρ gives the snapshot rate of sources (deg^{-2}). t_{char} gives the characteristic timescale that the variability was sampled on. $\frac{\Delta S}{S}$ gives the fractional change in flux (please refere to individual publications for further details).

Study	Flux (mJy)	ρ (deg^{-2})	t_{char}	ν (GHz)	$\frac{\Delta S}{S}$
[Bannister et al.(2011)]	>14	0.268	days - years	0.843	$\geq$50%
[Carilli et al.(2003)]	>0.1	<18	19 days and 17 months	1.4	$\geq$50%
[Becker et al.(2010)]	>0.1	1.6	$\sim$ 15 years	4.8	$\geq$50% (d)
[Frail et al.(2003)]	>0.25	5.8	$\sim$ 1 day	5 and 8.5	$\geq$50%
[Gaensler & Hunstead(2000)]	> 2500	-	days - years	0.843	<20% (d)
[Condon & Backer(1975)]	$\sim$ 1000 to 25000	-	days	2.695 and 8.085	0.5% and 0.98% (a)
[Dennison et al.(1981)]	$\sim$ 500 to 33000	-	5 to 10 years	0.318	8 to 100%
[Simonetti & Cordes(1990)]	400 to 12000	-	days	0.820 and 1.41	4.1% and 3.5% (b)
[Ryle et al.(1978)]	200 to 2000	-	months	2.7 to 15.4	10% to 50% (c) and (d)
[Taylor & Gregory(1983)]	18 to 1200	-	days to months	5	10% to 400% (c) and (d)

(a) *0.5% at 2.695 GHz and 0.98% at 8.085 GHz. Values are derived from the average (daily) fractional change in 16 sources.*
(b) *4.1% at 0.820 GHz and 3.5% at 1.41 GHz. Values are derived from the average modulation index (rms/mean) in 13 flat spectrum sources.*
(c) *also see [Rickett(1986)]*
(d) *Observations in the direction of Galactic plane.*

Conclusion and open questions.

*Will we achieve a coherent probe of variability with SWATS ...do we need ***all*** pathfinder instruments.

*Do we need to standardise our metrics of variability and transient behaviour.

*Are certain instruments better placed to explore given volumes of parameter space.

*What if we repeat experiments i.e Northern/Southern hemisphere.

*APERTIF is the widest field Northen hemisphere GHz instrument with extremely competitive sensitivity

*Commensal surveys can provide a lot of data – for free!