

ASGARD:

A Large Survey for Galactic Radio Transients

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Radio Astronomy in the LSST Era • 2013 May 7



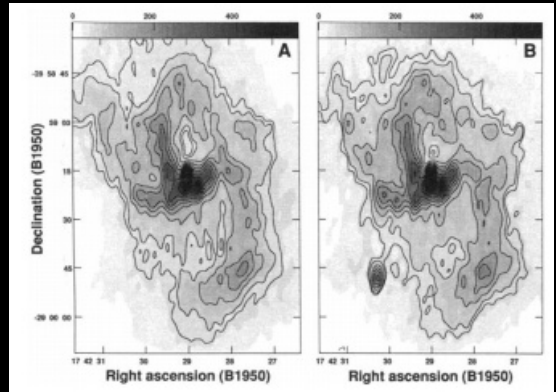
Geoff Bower; Keaton Burns, *Steve Croft*, Rick Forster, Garrett Keating, Colby Gutiérrez-Kraybill, Chat Hull, *Casey Law*, David Whyson, Melvyn Wright

Conclusions

- Galactic RT populations have elusiveness comparable to XG
- ... but, unsurprisingly, more inhomogeneities to worry about
- Technical challenges of working in the GP are surmountable
- Future time-domain work in this area will be *relatively* un-dominated by LSST: extinction, confusion
- Next-gen facilities can provide next-gen results, but details will depend strongly on science driver
- ASGARD aims to provide the current-gen results needed to guide planning

The Galactic Radio-Variable Population

- Stellar components already discussed: generally nearby enough to be \sim isotropic.
- There's a history of unidentified Galactic (Center) RTs: A1742-28, GCT, Burper, other Hyman sources.



The GCT: Zhao+ 1992

- X-ray binaries: Goldilocks class for ASGARD-style approach.
- Scintillation of background sources: cf. Becker+ 2010, Ofek+ 2011.

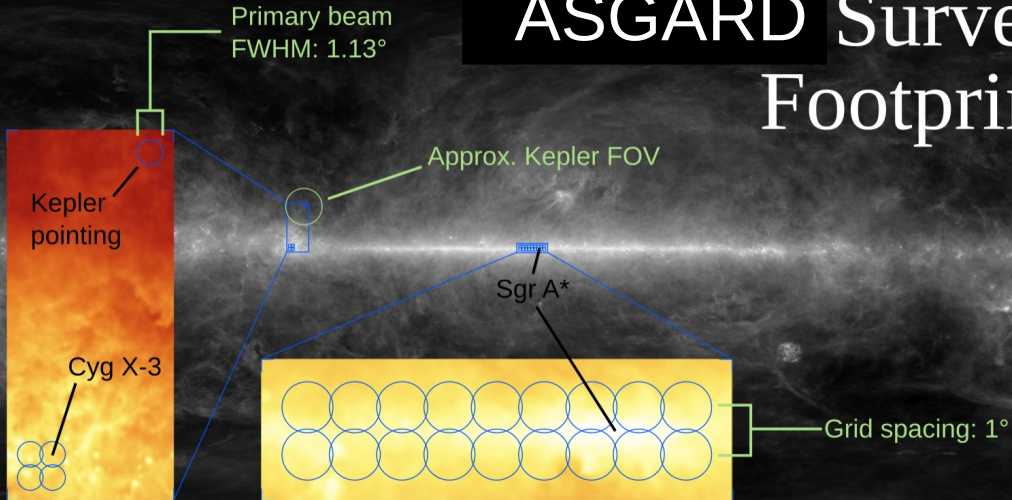
The Allen Telescope Array



- Forty-two 6.1m dishes
- Compact cfg.
- Continuous freq. coverage, 0.5–11 GHz
- BW: 2×100 MHz
- FOV $\sim 1 \text{ deg}^2$ @ 3 GHz

- Initially UCB RAL / SETI partnership
- Brief hibernation but currently on the air
- Now SETI / SRI Inc.
- ~ 50 TB of science data at UCB

ASGARD Survey Footprint



Images: IRAS 100 μm (Davis, Finkbeiner, Schlegel)

3.1 GHz, ~ 2 mJy rms

215 hr on-source

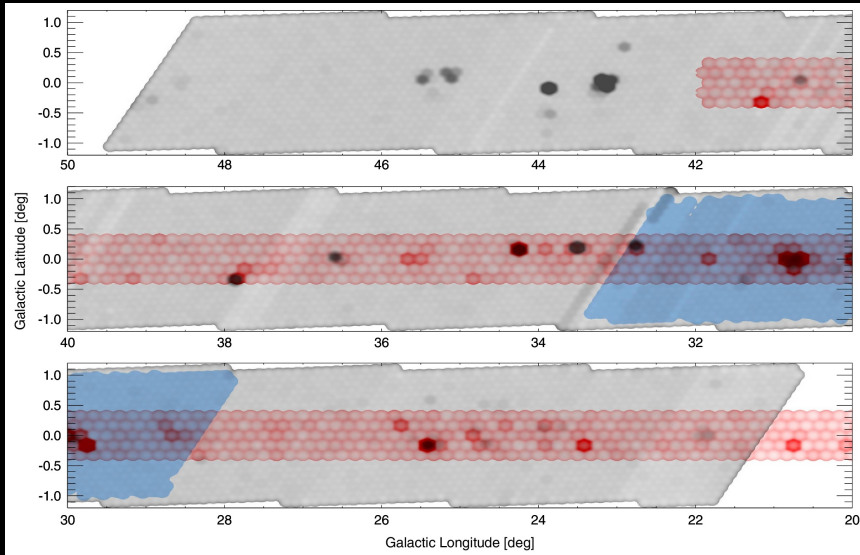
Commensal with SETI

3–7 day cadence

273 epochs, 1.2 years

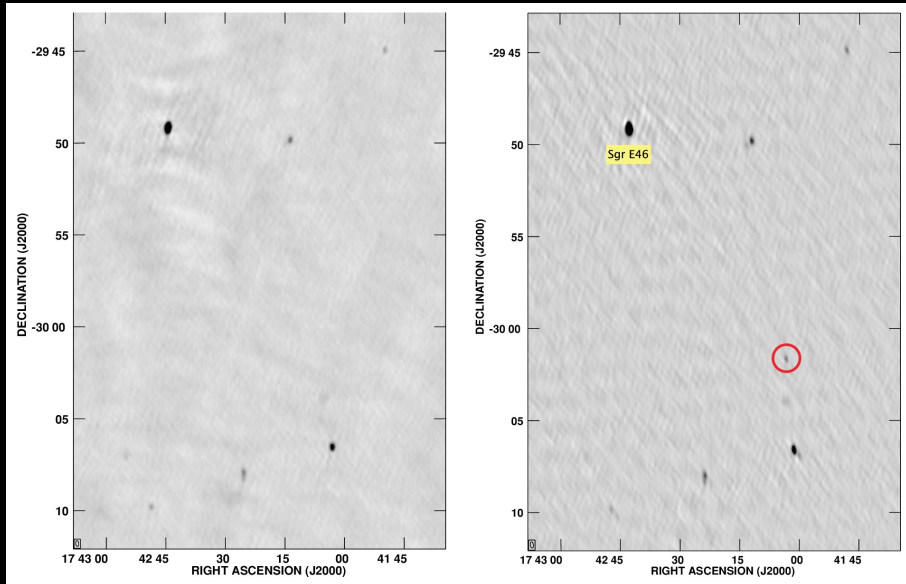
5.4 TB of data

Comparable Work: Becker+ 2010



$\sigma \sim 0.1$ mJy, CORNISH/GPS overlap: 3 epochs,
23.2 deg²; thirty-nine >50% variables

Comparable Work: Hyman+ 200X



$\sigma \sim 5$ mJy; $\Omega \sim 3$ deg²; several genuine transients

Comparable Work: Ofek+ 2011

A VERY LARGE ARRAY SEARCH FOR 5 GHz RADIO TRANSIENTS AND VARIABLES
AT LOW GALACTIC LATITUDES

E. O. OFEK^{1,7}, D. A. FRAIL², B. BRESLAUER^{2,3}, S. R. KULKARNI¹, P. CHANDRA⁴, A. GAL-YAM⁵,
M. M. KASLIWAL¹, AND N. GEHRELS⁶

141 VLA pointings, $|b| \sim 6\text{--}8^\circ$; $\Omega = 2.66 \text{ deg}^2$

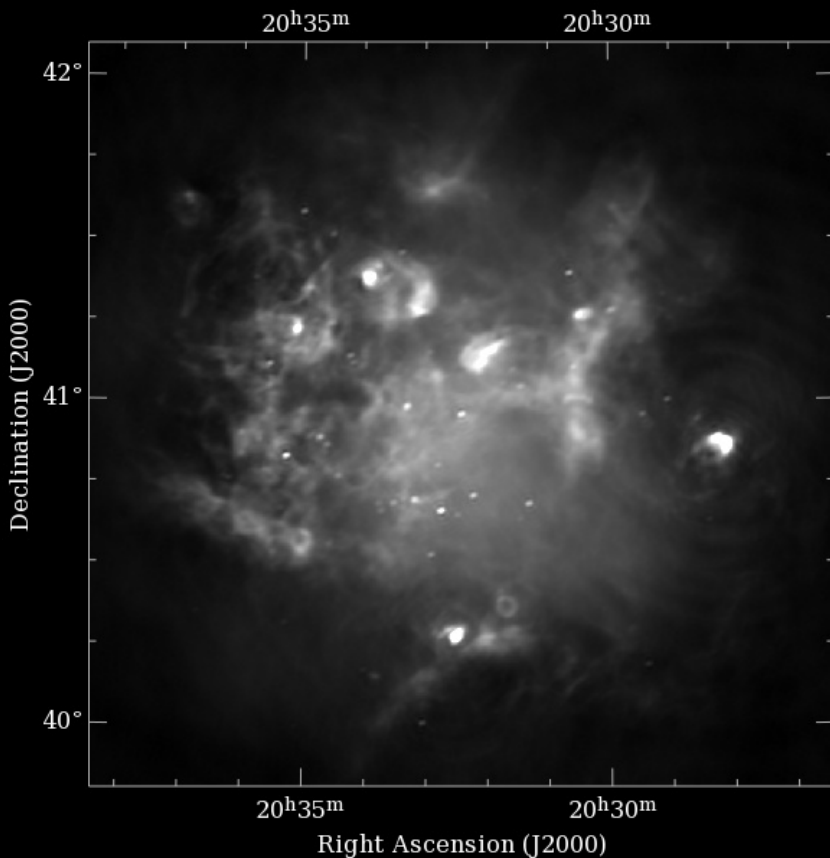
16 visits, real-time followup

$\sigma \sim 0.1 \text{ mJy}$

one potential transient

ASGARD Paper I

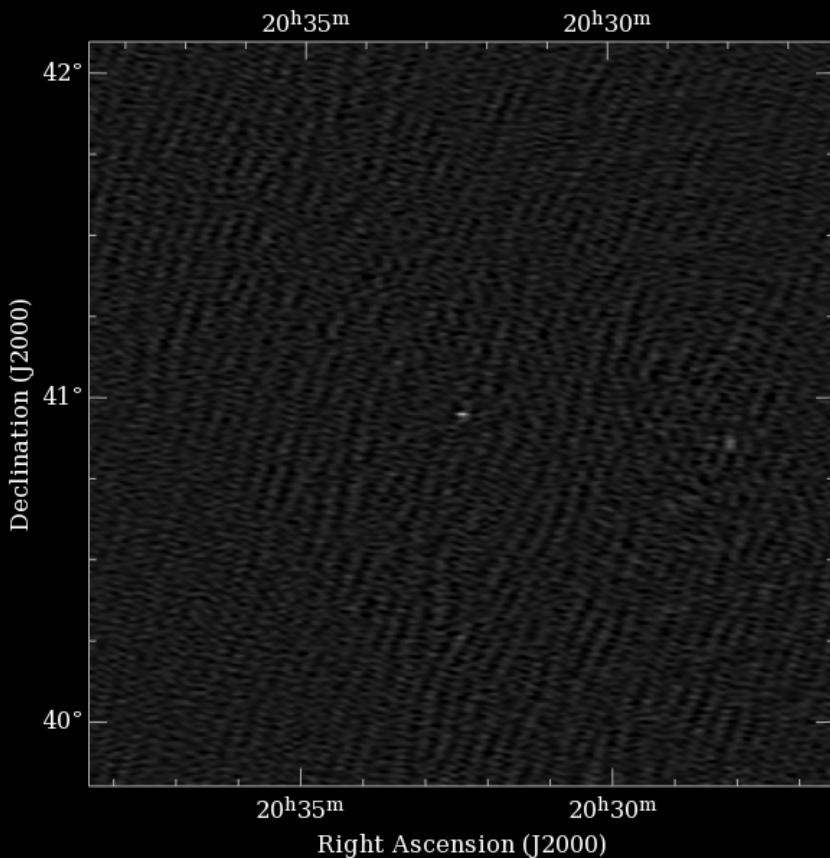
- Williams+ 2013:
 - 2013ApJ...762...85W
 - 1211.1042
 - 10.1088/0004-637X/762/2/85
- Comprehensive survey characteristics
- Techniques in *excruciating* detail
- Analysis of 10% of dataset: Kepler and Cyg X-3 pointings
- No transients; first rate limits



Cyg X-3 Pointing

Dynamic
range of
A/V
system
totally
fails to do
this
justice.





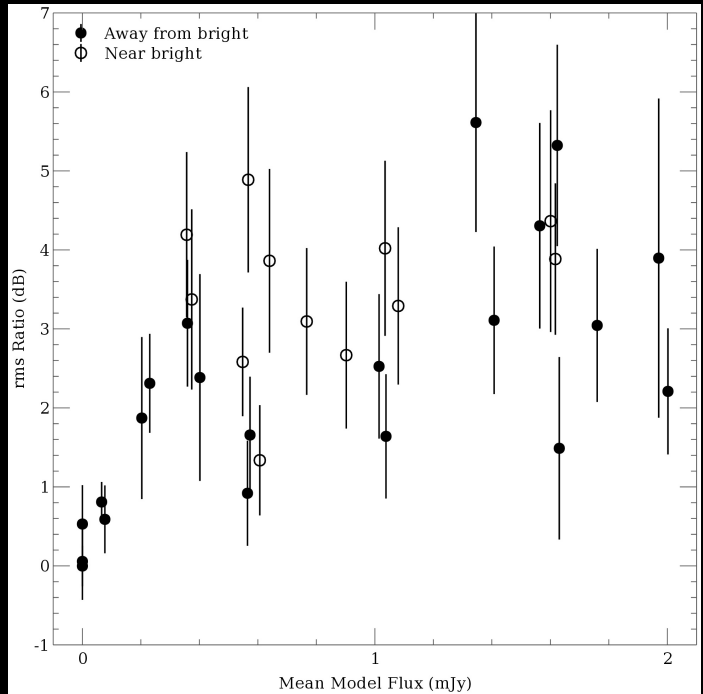
Cyg X-3 Pointing

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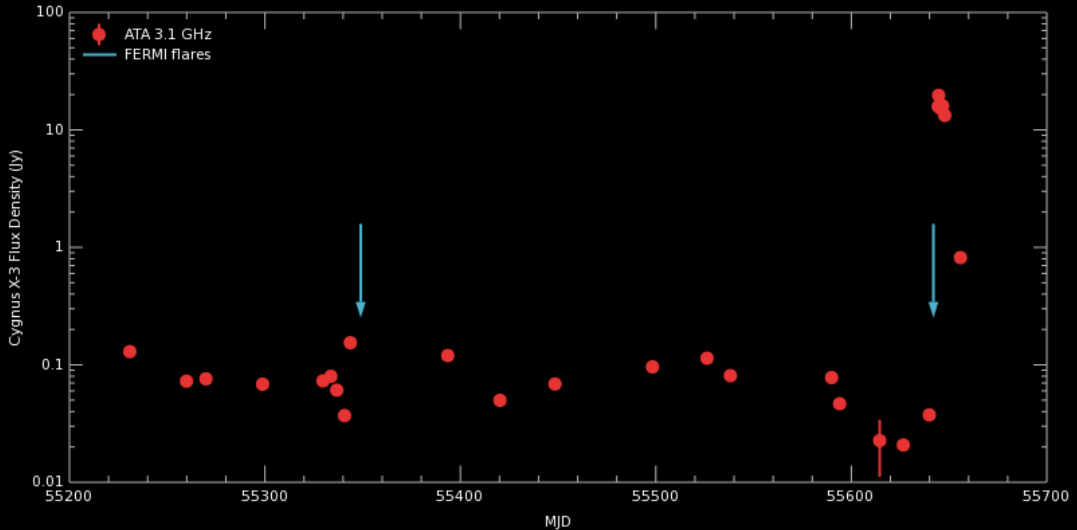
Assessing LSS Subtraction Quality

Noise residuals
show that LSS
subtraction works
well.

Residuals do not
increase with
brightness of LSS.



Cyg X-3 Paper I Lightcurve



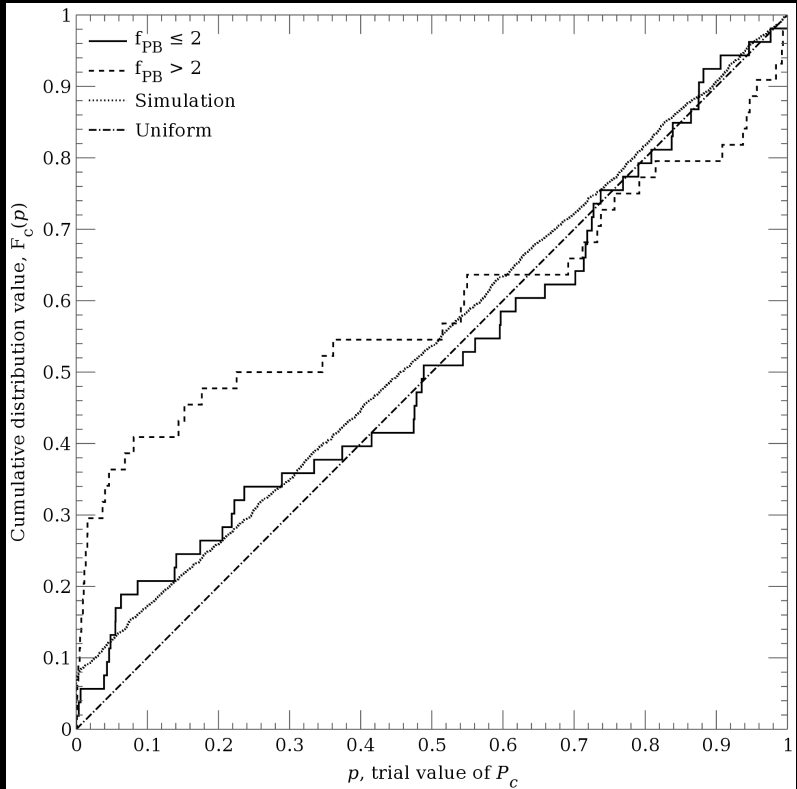
Williams+ 2011, Williams+ 2013

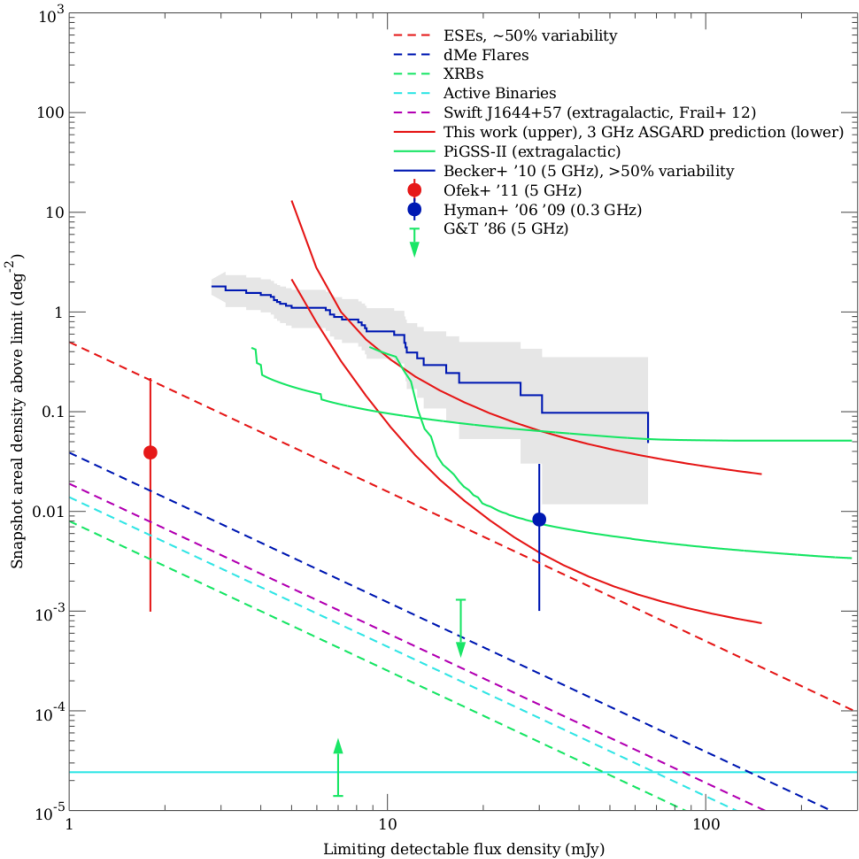
~20% of observations

The "P_c" Statistic

CDF can be used to diagnose correctness of uncertainty model.

Things are well-behaved inside half-power point.





Density Limits From Paper I

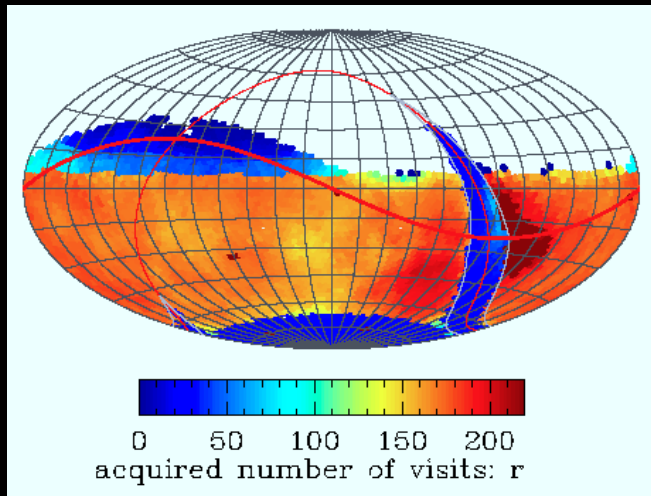
And projection for full survey

Looking Forward

Nearer: complete ASGARD search; static maps; followup as appropriate. Focus on Kepler FOV.

Farther: a niche relatively un-dominated by LSST?

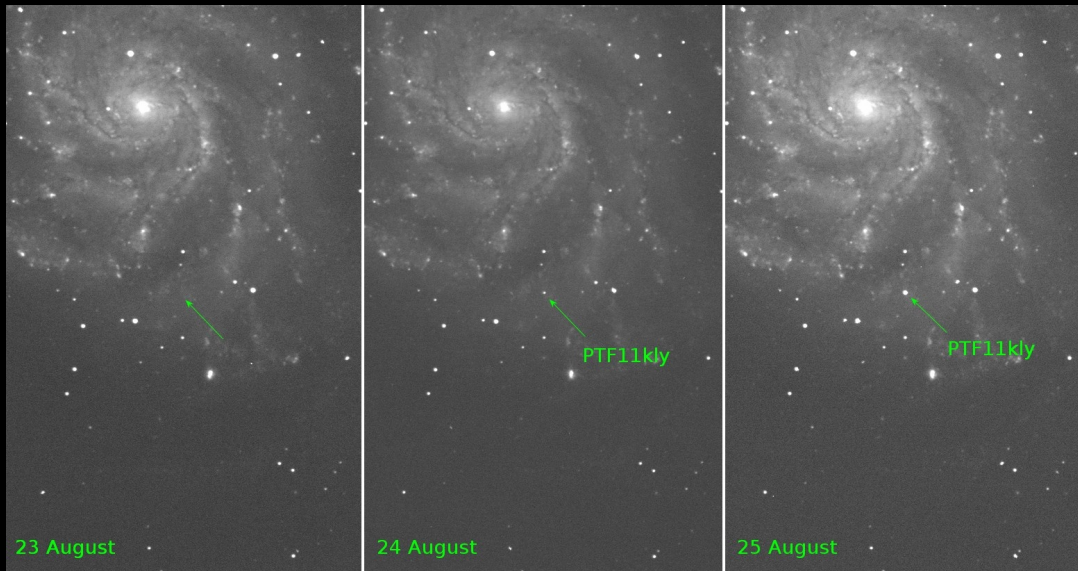
- Extinction
- Lesser coverage (due to confusion)



Conclusions

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SN 2011fe (ptf11kly)

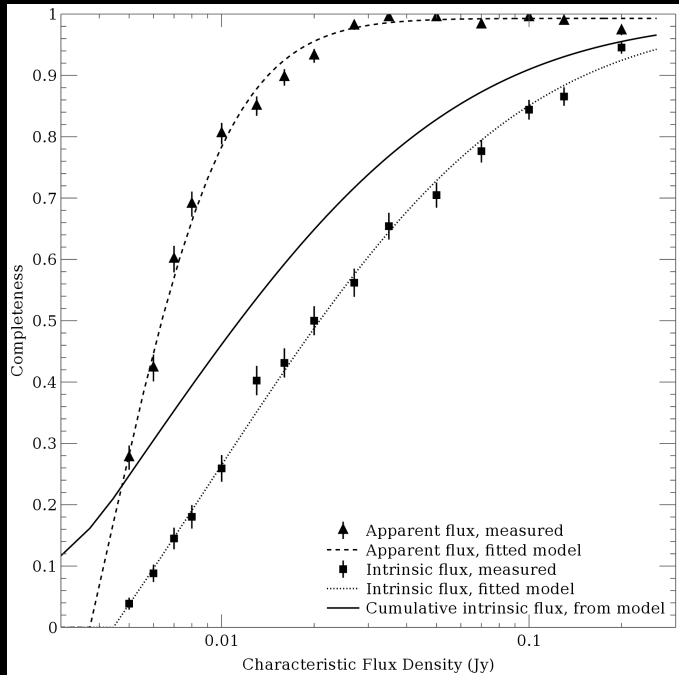


Palomar Transient Factory; Nugent et al 2011

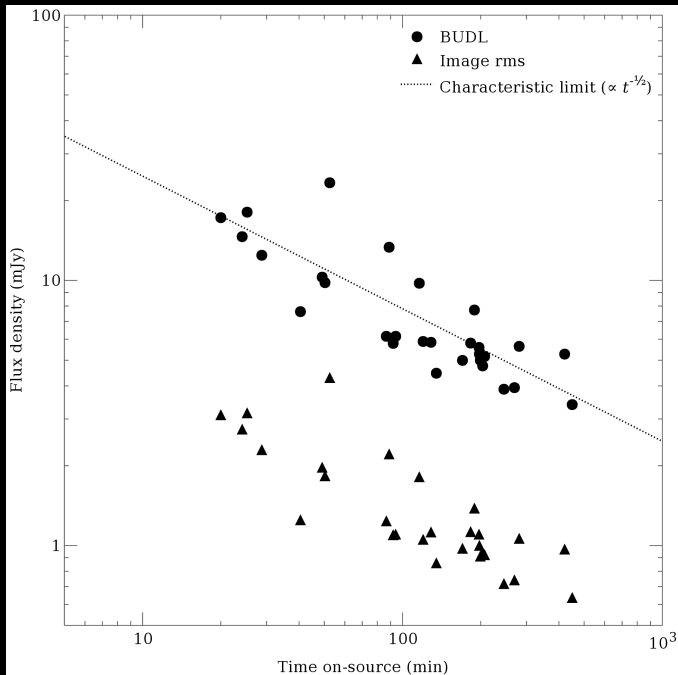
ASGARD: Completeness

Cumulative
completeness
depends on $N(>S)$
model.

Highly complete
above 10σ .



ASGARD: Detection Limits

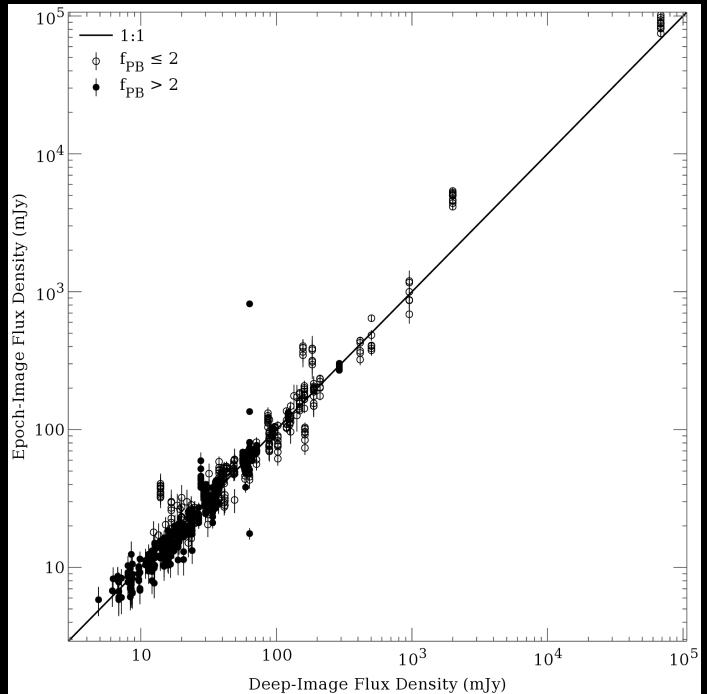


Typical 5σ limit of
10 mJy.

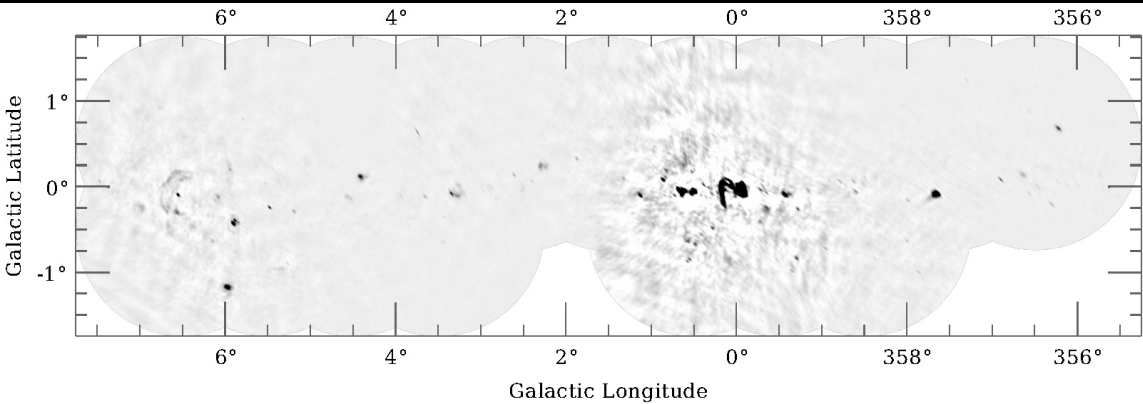
Scales with
integration time as
expected.

ASGARD: Flux-Flux Diagram

Things behave as
you'd expect.

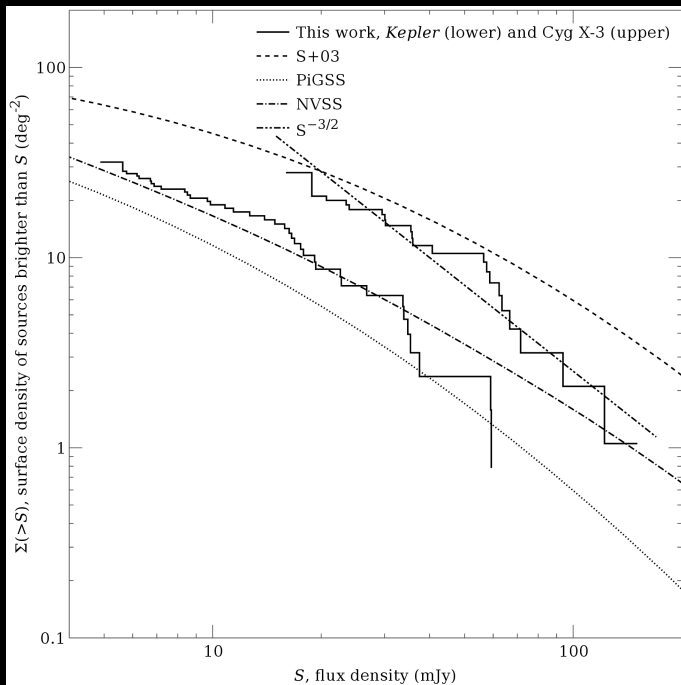


Very Preliminary GP Mosaic



Limited gamut and number of pixels don't do justice; still, much work to be done.

ASGARD: Number Counts



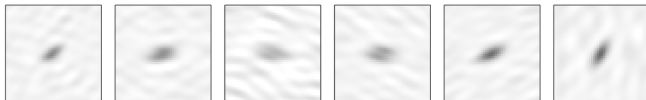
Things behave as you'd expect.

Kepler Pointing Cutouts

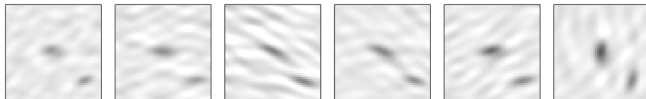
Remaining
variable-
seeming
sources
generally have
close
neighbors.

Photometry
code attempts
to deal with
this, evidently
needs
improvement.

19:20:15.8
+44:03:05
-3 to 60 mJy/bm



19:23:11.0
+43:50:20
-3 to 32 mJy/bm



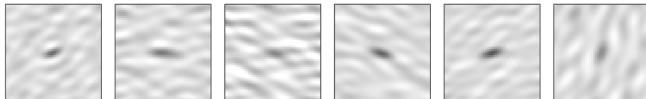
19:24:28.5
+44:17:08
-3 to 43 mJy/bm



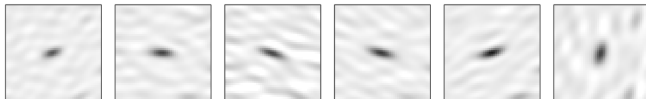
19:23:06.3
+43:42:38
-3 to 38 mJy/bm



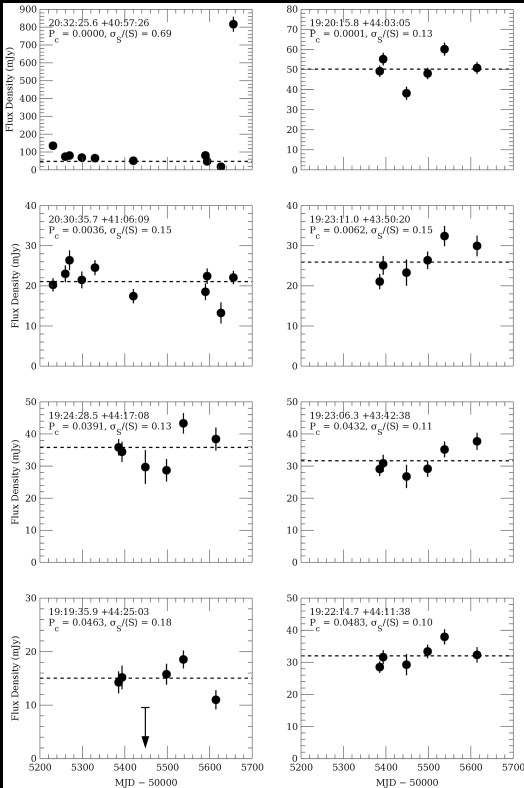
19:19:35.9
+44:25:03
-3 to 18 mJy/bm



19:22:14.7
+44:11:38
-3 to 38 mJy/bm



Cygnus Pointing Lightcurves



No compelling results for sources other than Cyg X-3

Comparison of Variability Metrics

Min/max and σ -based statistics overstate variability in low-SNR regime.

