

TECHNIQUES: SEARCHING FOR RADIO TRANSIENTS (WITH A FOCUS ON MWA)

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UC Berkeley

with David Kaplan (UW-Milwaukee)
Tara Murphy, Martin Bell, James Miller-Jones, and the MWA collaboration



BLIND TRANSIENT SEARCHES

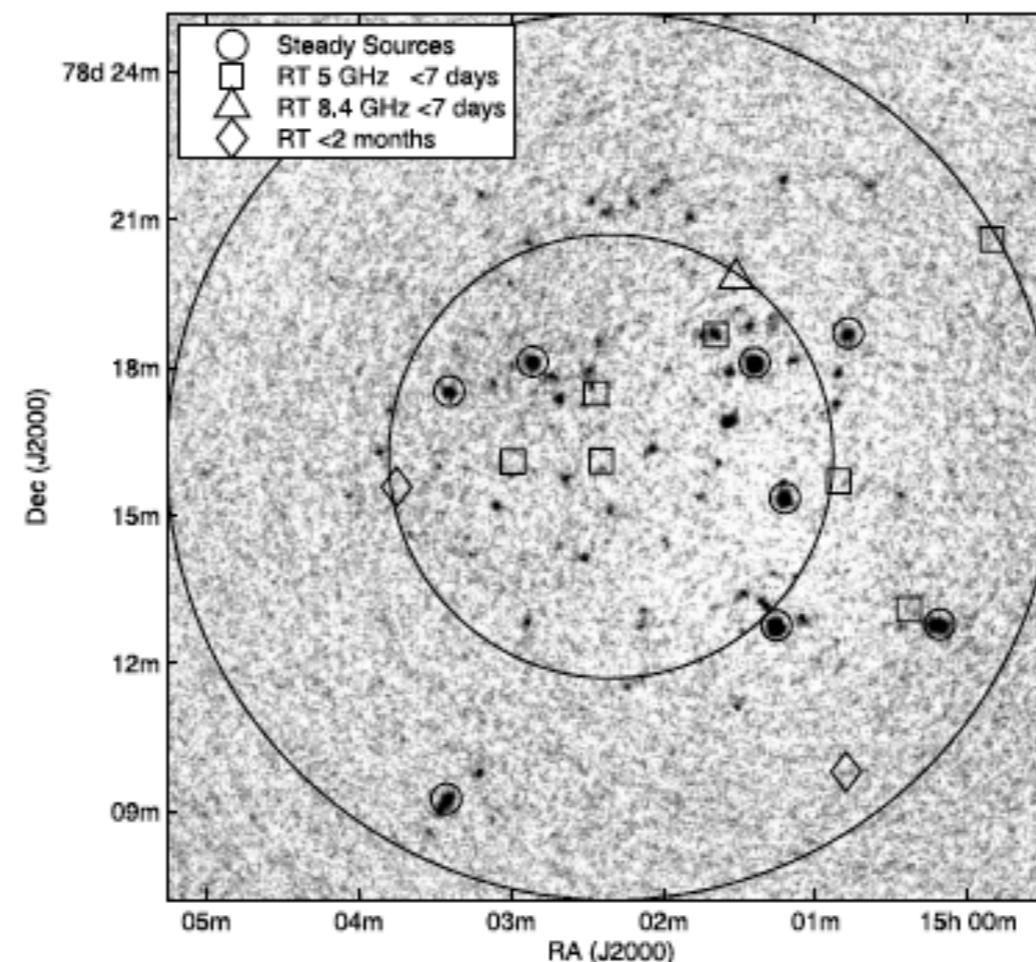
PI

Grad
student



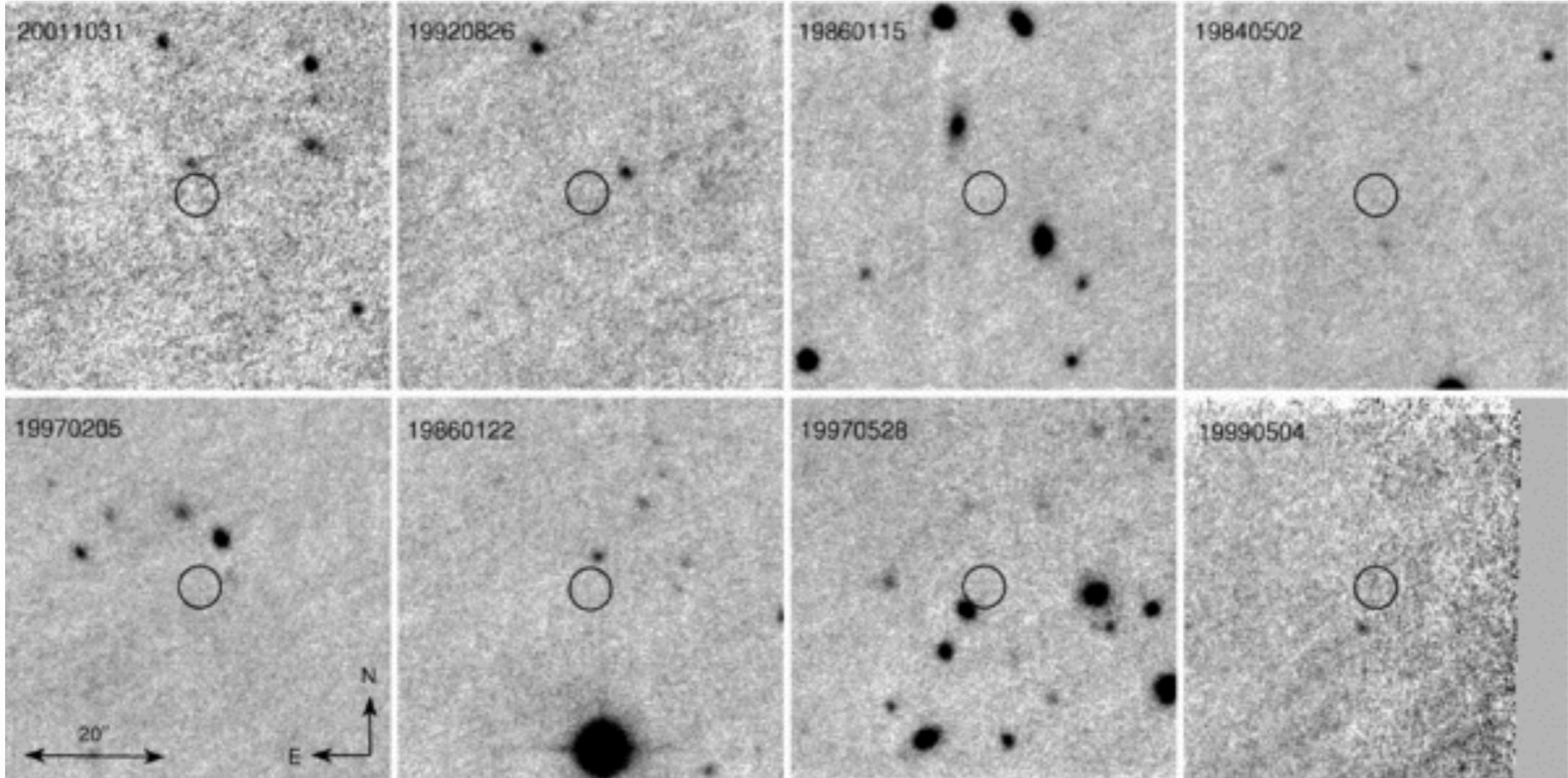
BLIND TRANSIENT SEARCHES

Bower et al. (2007) VLA archival observations at 5 and 8.4 GHz



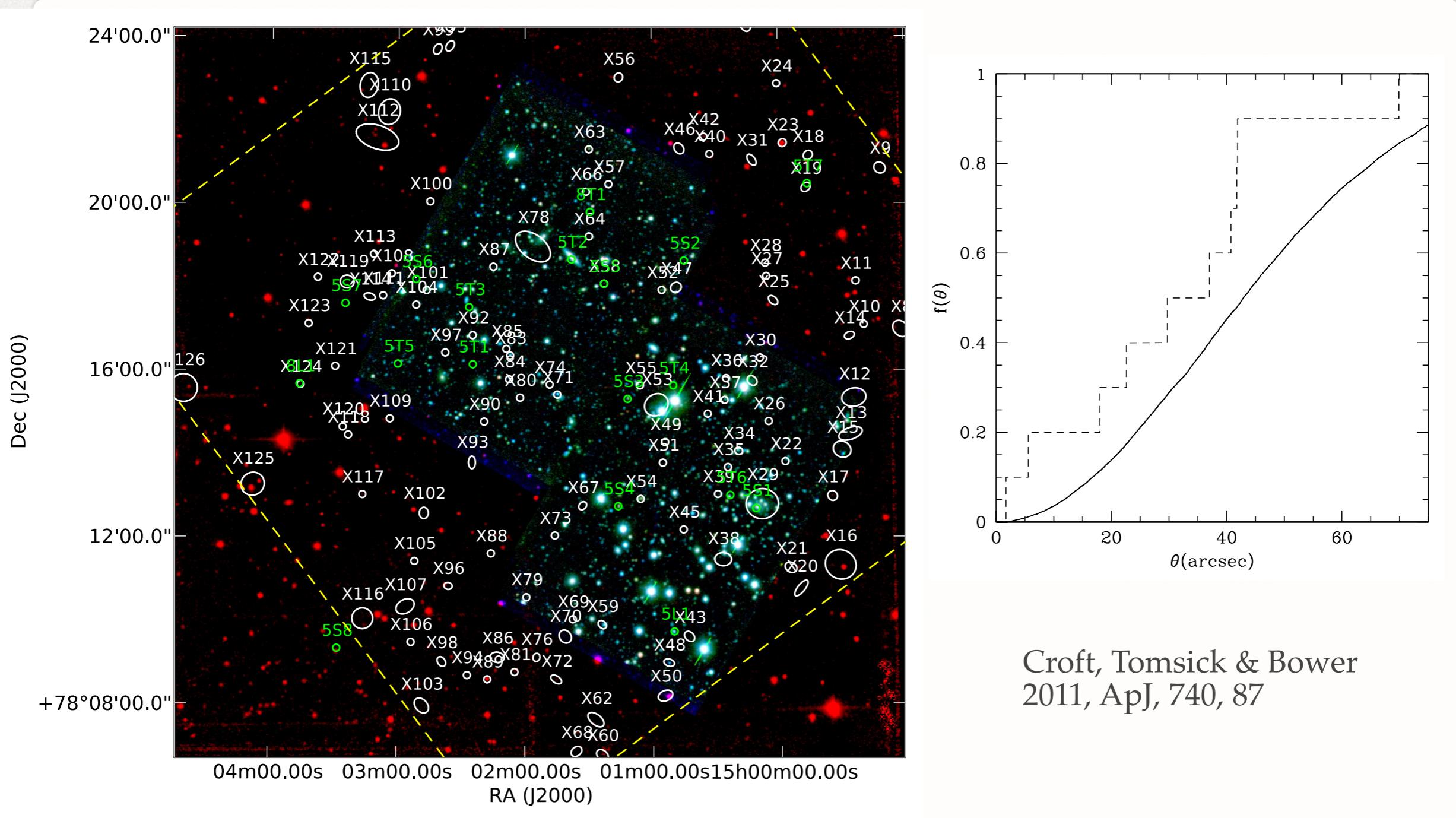
944 epochs, 10 transient candidates ≤ 2 mJy

ARE THEY IN GALAXIES?



Ofek et al. (2010)

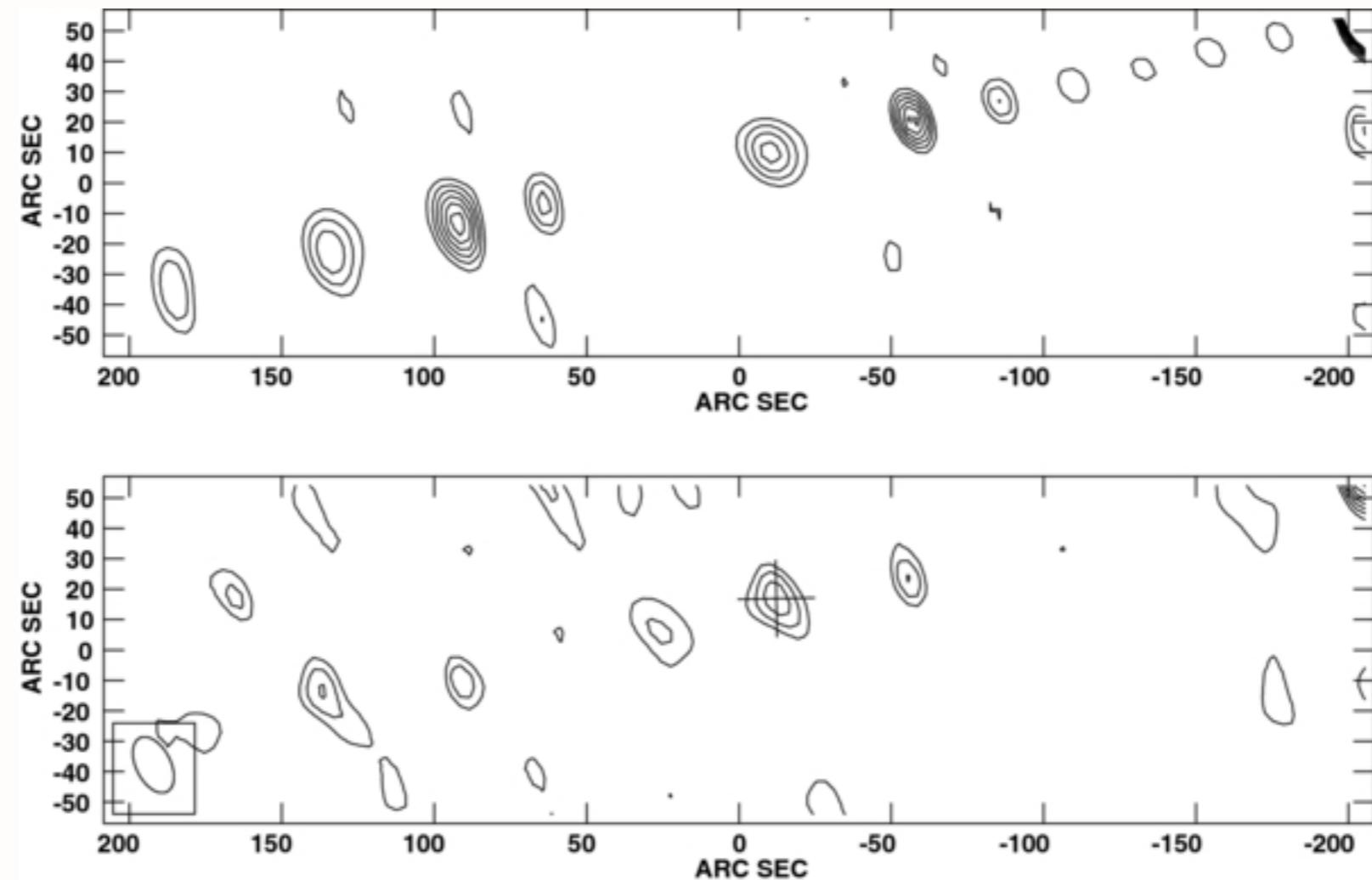
IS THERE X-RAY EMISSION?



Steve Croft, UC Berkeley - FenderFest, Oxford, 2015 Sep 14

BLIND SEARCHES ARE HARD

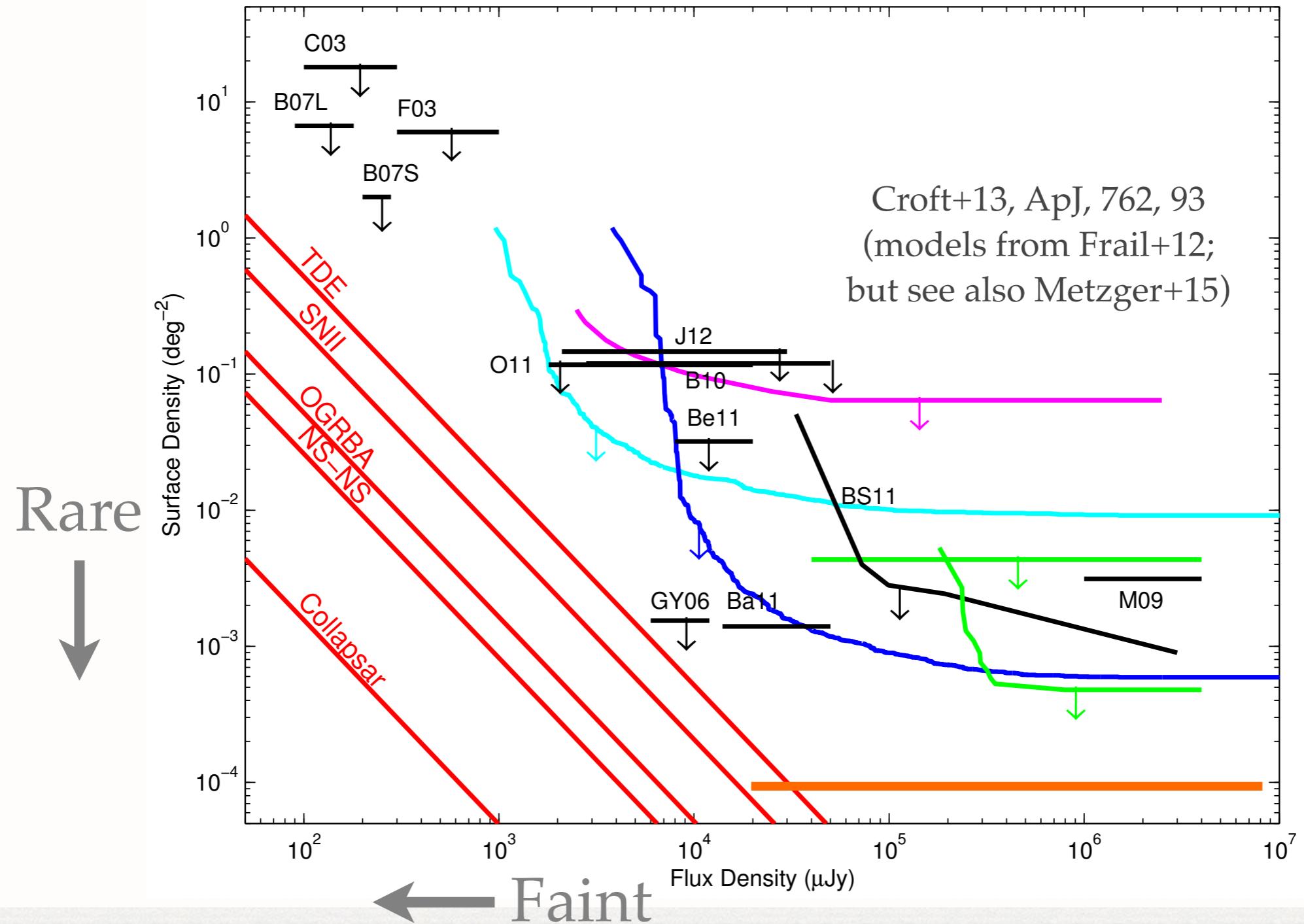
Frail et al. (2012)



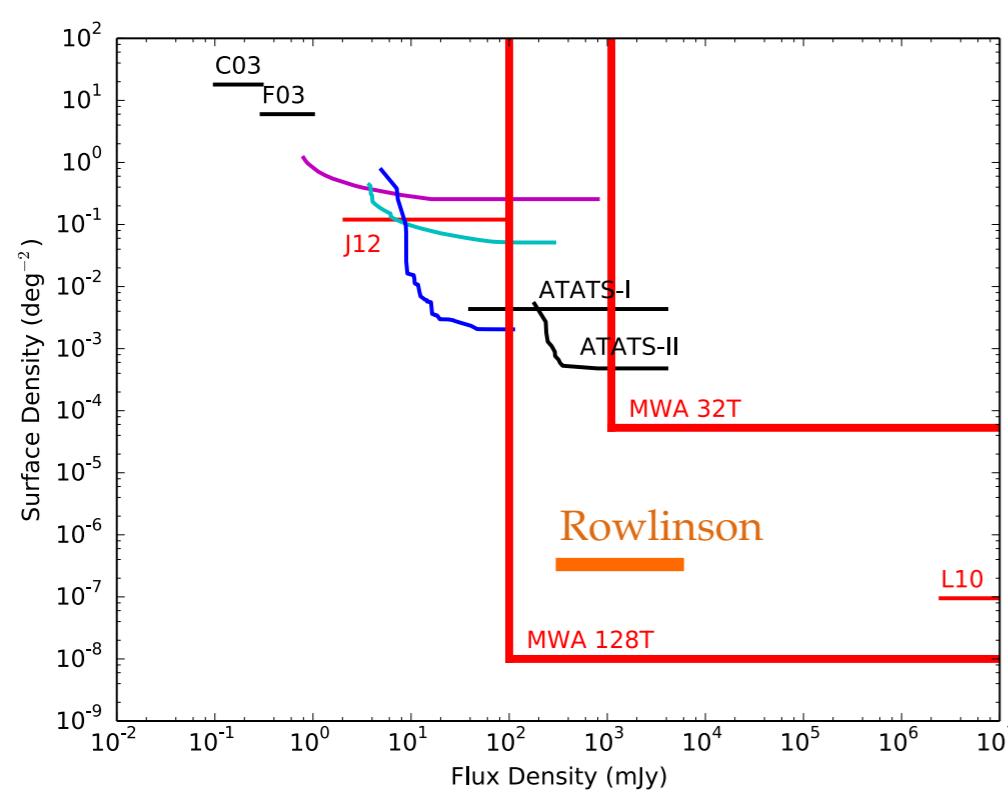
BLIND TRANSIENT SEARCHES



PUSHING SENSITIVITY AND AREA

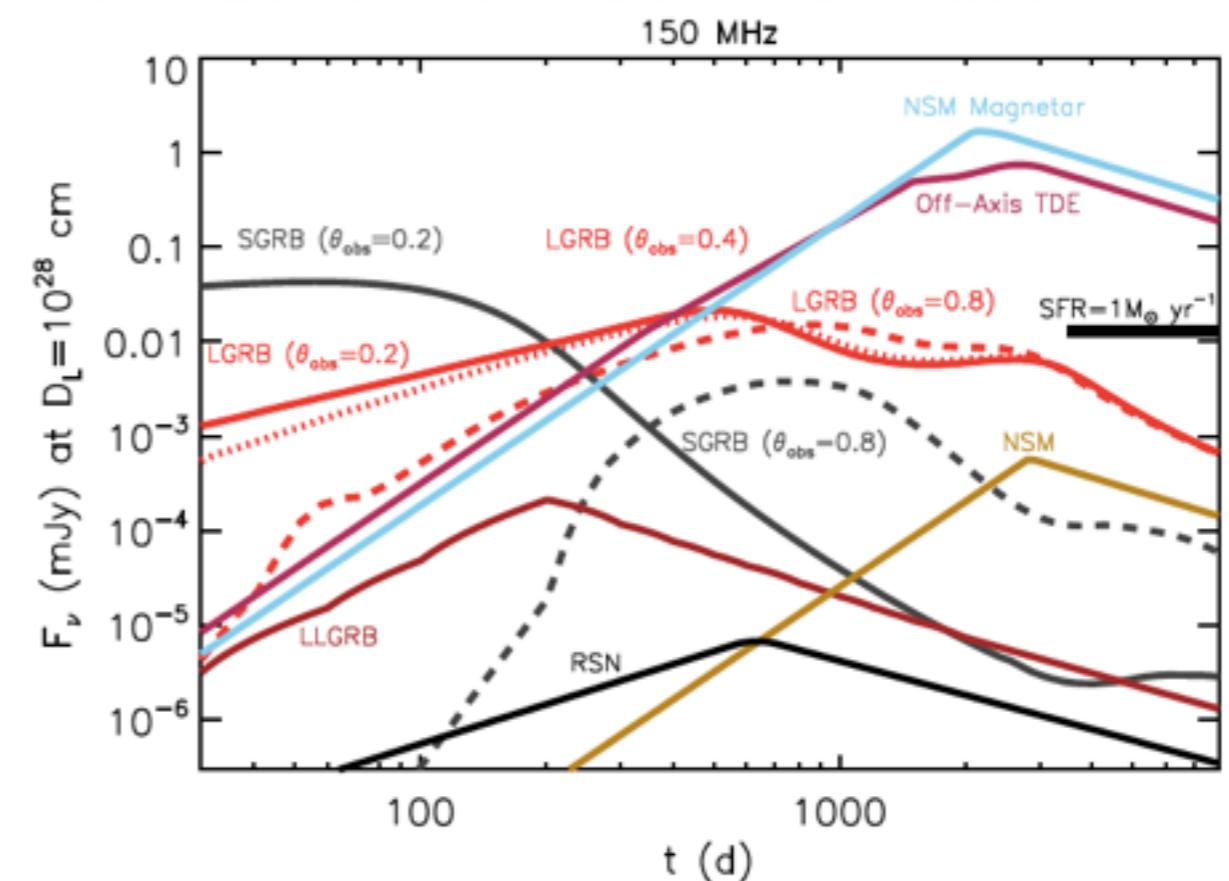


MWA



MWA32T Bell+14

MWA128T example 1000 h commensal survey



Metzger+15

SEPARATING THE WHEAT FROM THE CHAFF



HOW TO FIND THE GOOD STUFF

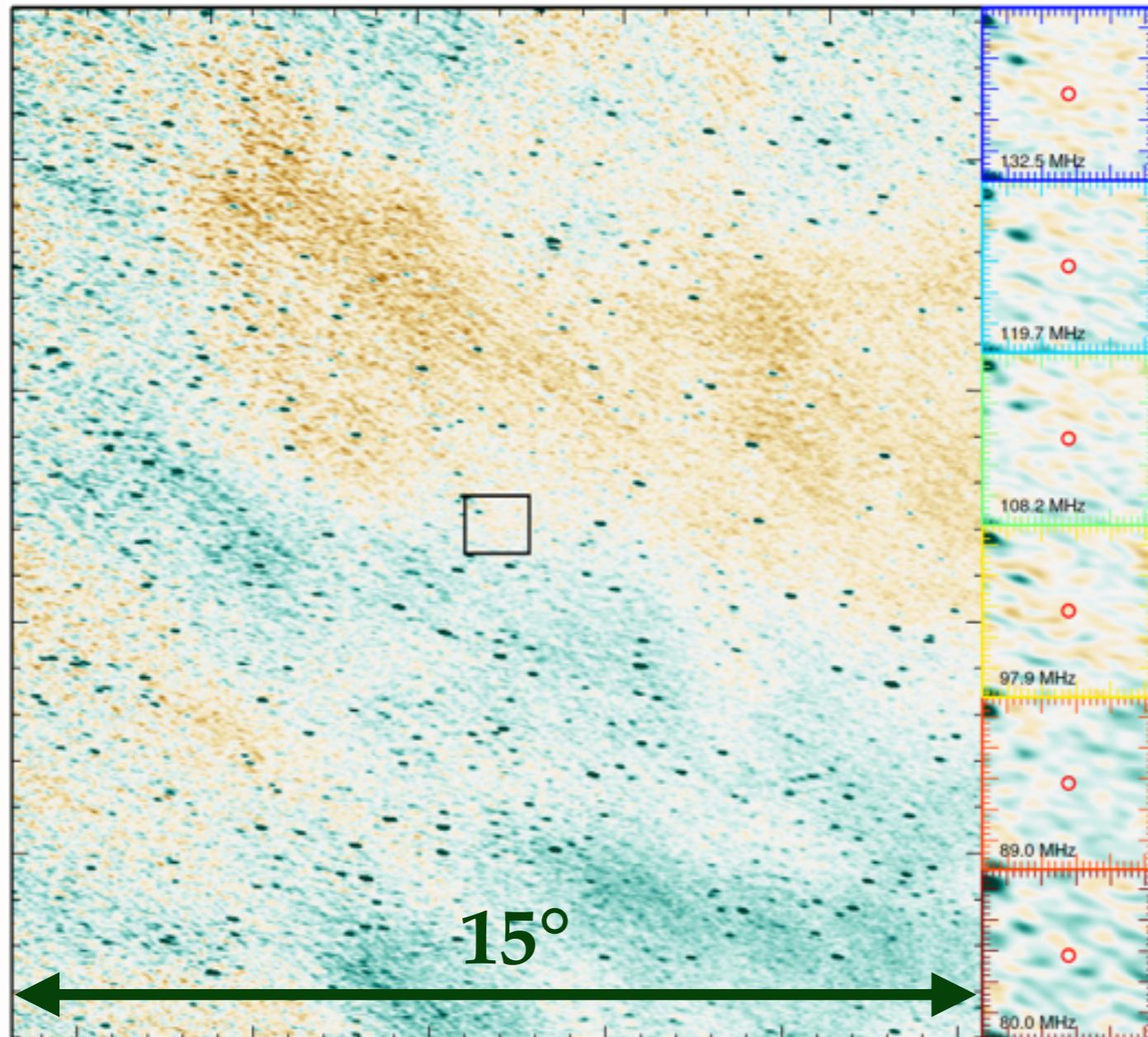




A Calvin and Hobbes Collection by Bill Watterson

- Sources with known positions that may flare (e.g. pulsars, flare stars, blazars)
- Transients detected at other wavelengths (commensal / triggered) or with other methods (e.g. GRBs, GW and neutrino sources)
- Multi-epoch with cadence matched to sources of interest (e.g. TDEs)

RAPID RESPONSE



Kaplan+15 in prep.
23 s - 30 min after SGRB
Fainter than 3 Jy on a
timescale of 4 s
Can be used to provide
constraints on GRB
models

COORDINATED



GP survey

iPTF 45 nights, Jul 1 - Aug 15

MWA 18 epochs x 1 hour (14 x 4 min snapshots) every ~2 days

118, 154, 185 MHz, $|b| < 20^\circ$, $15^\circ < l < 50^\circ$

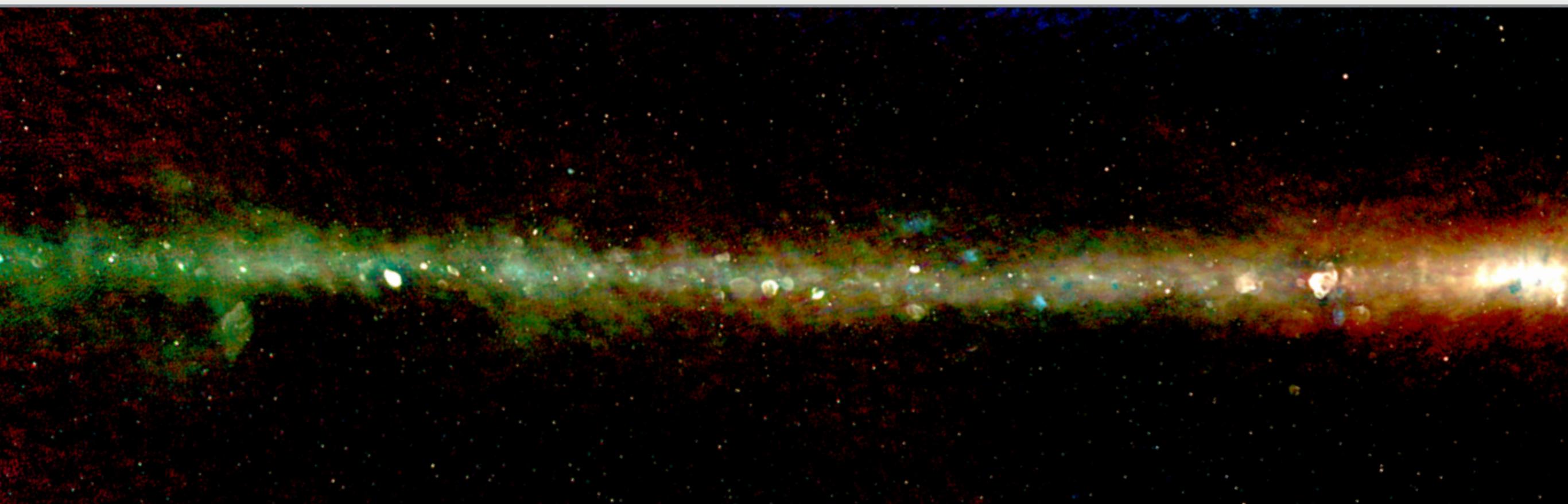
LATEST RESULTS FROM MWA IPTF OBSERVATIONS

```
6. scroft@mwa-process02: ~ (ssh)
scroft@mwa-process02: ~ (...) scroft@mwa-process02: ~ (...) bash
# 2015-09-11 17:47:46,067 INFO:preprocess: Downloading 1122477536_20150801151841_gpubox18_00.fits
# 2015-09-11 17:48:01,356 INFO:preprocess: 1122477536_20150801151841_gpubox05_00.fits complete [17 of 25]
# 2015-09-11 17:48:02,085 INFO:preprocess: Downloading 1122477536_20150801151841_gpubox16_00.fits
# 2015-09-11 17:48:03,608 INFO:preprocess: 1122477536_20150801151841_gpubox04_00.fits complete [18 of 25]
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# 2015-09-11 17:48:16,101 INFO:preprocess: Downloading 1122477536_20150801151841_gpubox03_00.fits
# 2015-09-11 17:48:19,891 INFO:preprocess: 1122477536_20150801151841_gpubox10_00.fits complete [20 of 25]
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# 2015-09-11 17:48:50,529 INFO:preprocess: 1122477536_20150801151841_gpubox15_00.fits complete [23 of 25]
# 2015-09-11 17:48:56,009 INFO:preprocess: 1122477536_20150801151841_gpubox01_00.fits complete [24 of 25]
# 2015-09-11 17:48:58,468 INFO:preprocess: 1122477536_20150801151841_gpubox07_00.fits complete [25 of 25]
# 2015-09-11 17:48:58,509 INFO:preprocess: File Transfer Complete
# 2015-09-11 17:48:58,509 INFO:preprocess: File Transfer Success
# 2015-09-11 17:48:59,100 INFO:preprocess: Metafits written to /transdata/scroft/1122477536/1122477536.metafits
# 2015-09-11 17:48:59,127 INFO:preprocess: Expect compression of 2 in time and 2 in frequency
# 2015-09-11 17:48:59,127 INFO:preprocess: Unzipping flags from 1122477536_flags.zip
# 2015-09-11 17:48:59,175 INFO:preprocess: Will run:
cotter -j 4 -m /transdata/scroft/1122477536/1122477536.metafits -timeres 4.0 -freqres 40 -o 1122477536.ms -flagfiles 1122477536_90%.ms
waf -allowmissing *.fits
# 2015-09-11 17:53:28,854 INFO:preprocess: M5file 1122477536.ms was created with size 9289954070 bytes
# 2015-09-11 17:53:32,895 INFO:preprocess: Will run:
rsync -aruvP 1122477536.ms scroft@nano.phys.umn.edu:/mnt/astrodata/MWA/iptf/raw/20150801/
# 2015-09-11 18:17:59,262 INFO:preprocess: 1122477536.ms copied to scroft@nano.phys.umn.edu:/mnt/astrodata/MWA/iptf/raw/20150801
# 2015-09-11 18:17:59,262 INFO:preprocess: Will run:
rsync -aruvP /transdata/scroft/1122477536/1122477536.metafits scroft@nano.phys.umn.edu:/mnt/astrodata/MWA/iptf/raw/20150801/
# 2015-09-11 18:18:05,362 INFO:preprocess: /transdata/scroft/1122477536/1122477536.metafits copied to scroft@nano.phys.umn.edu:/mnt/astrodat
a/MWA/iptf/raw/20150801
# 2015-09-11 18:18:05,382 INFO:preprocess: #####
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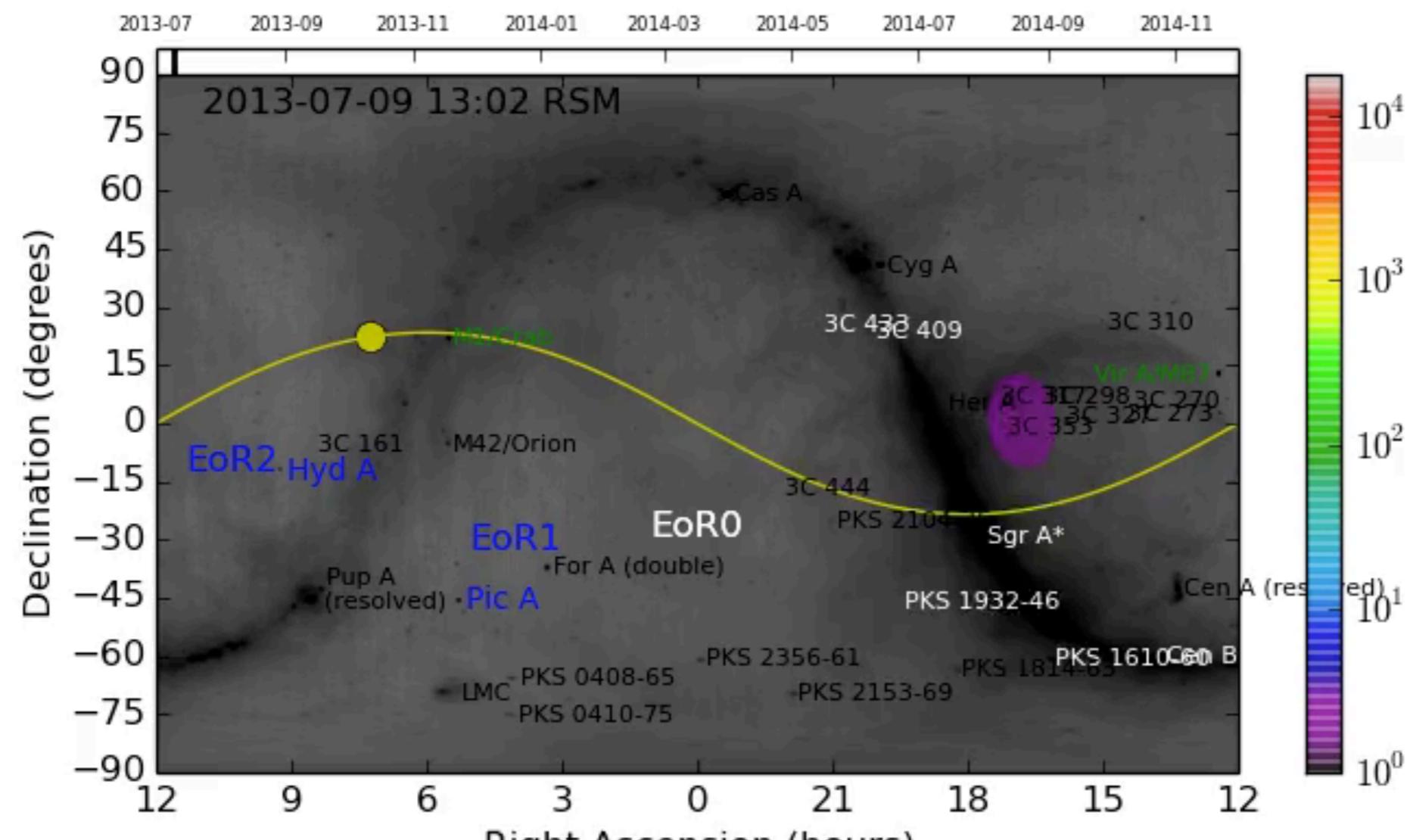
# 2015-09-11 18:18:05,586 WARNING:preprocess: Deleting downloaded FITS files 1122477536_20150801151841_gpubox14_00.fits,1122477536_201508011
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# 2015-09-11 18:18:10,911 WARNING:preprocess: Deleting M5 file 1122477536.ms
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```

IPTF EPOCH 1

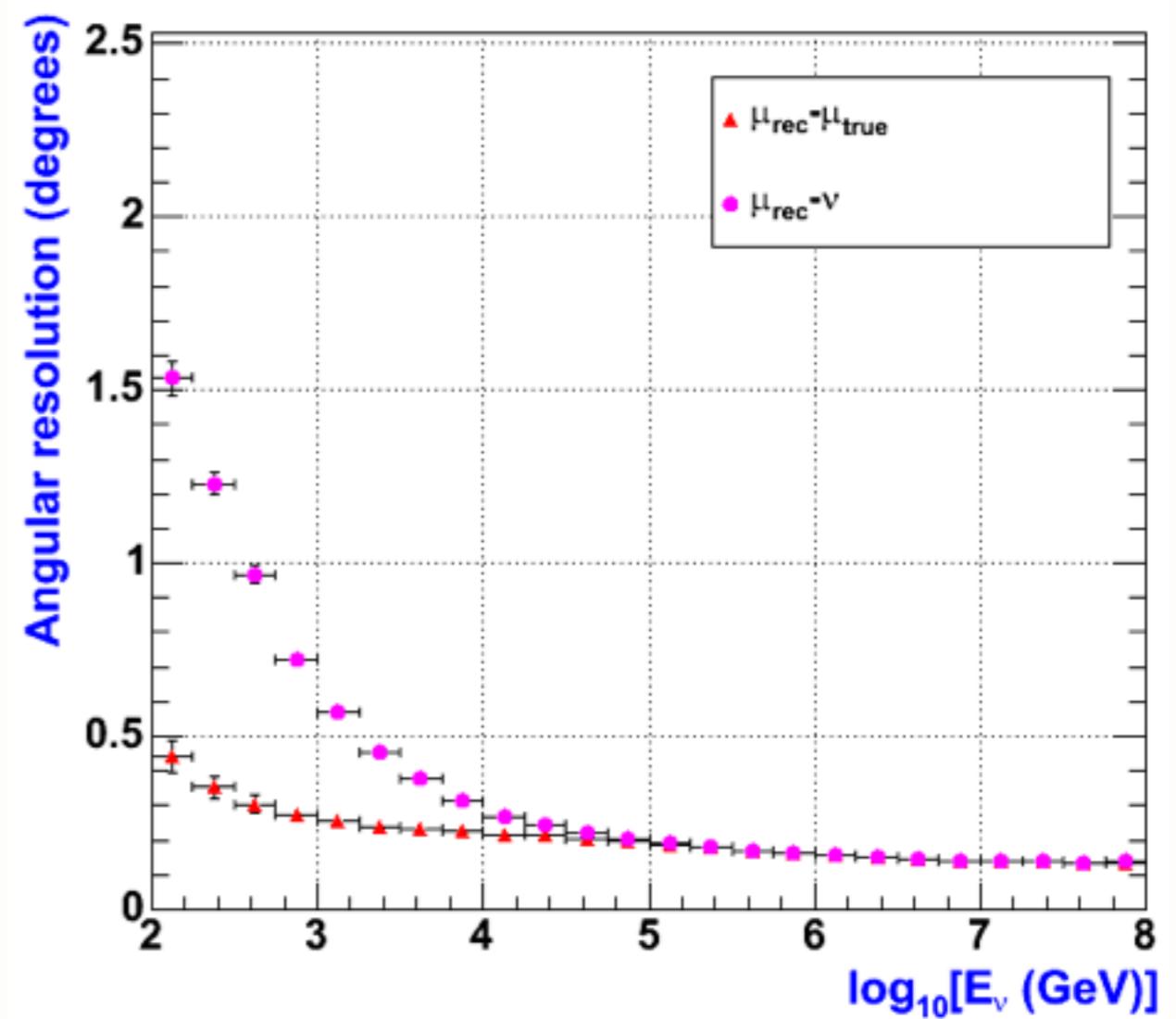
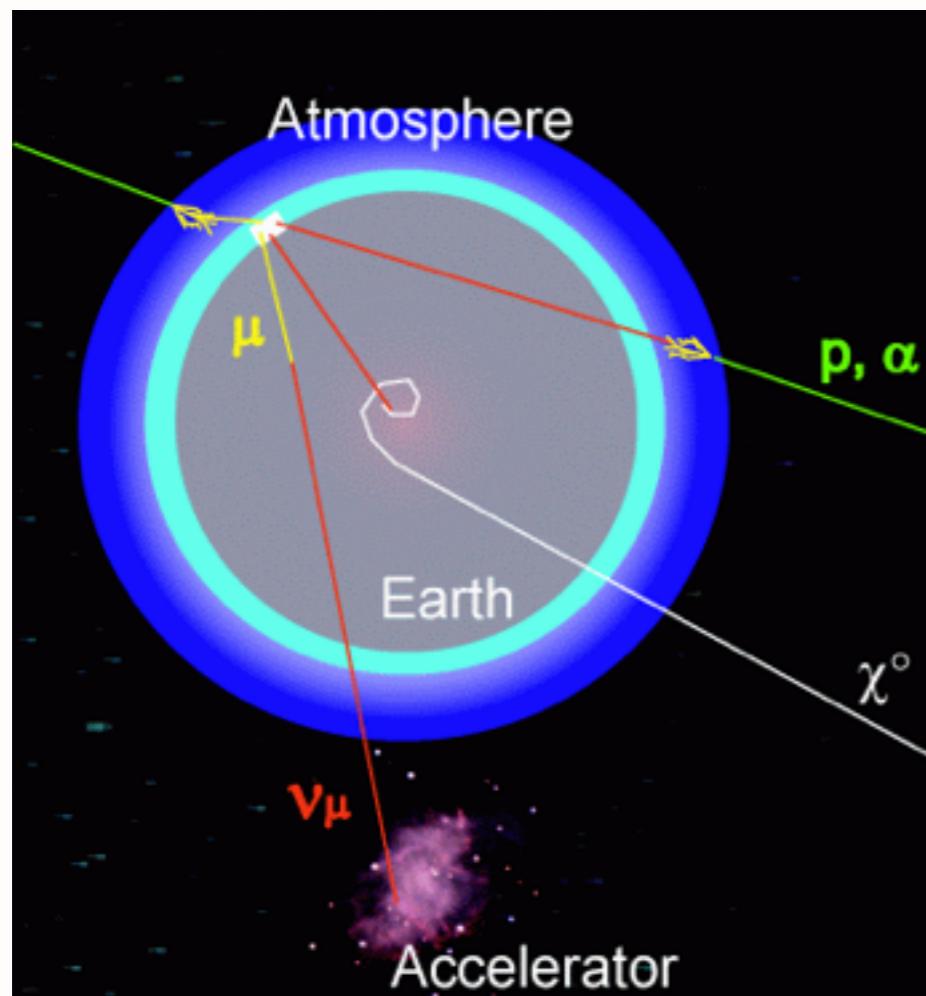


ARCHIVAL

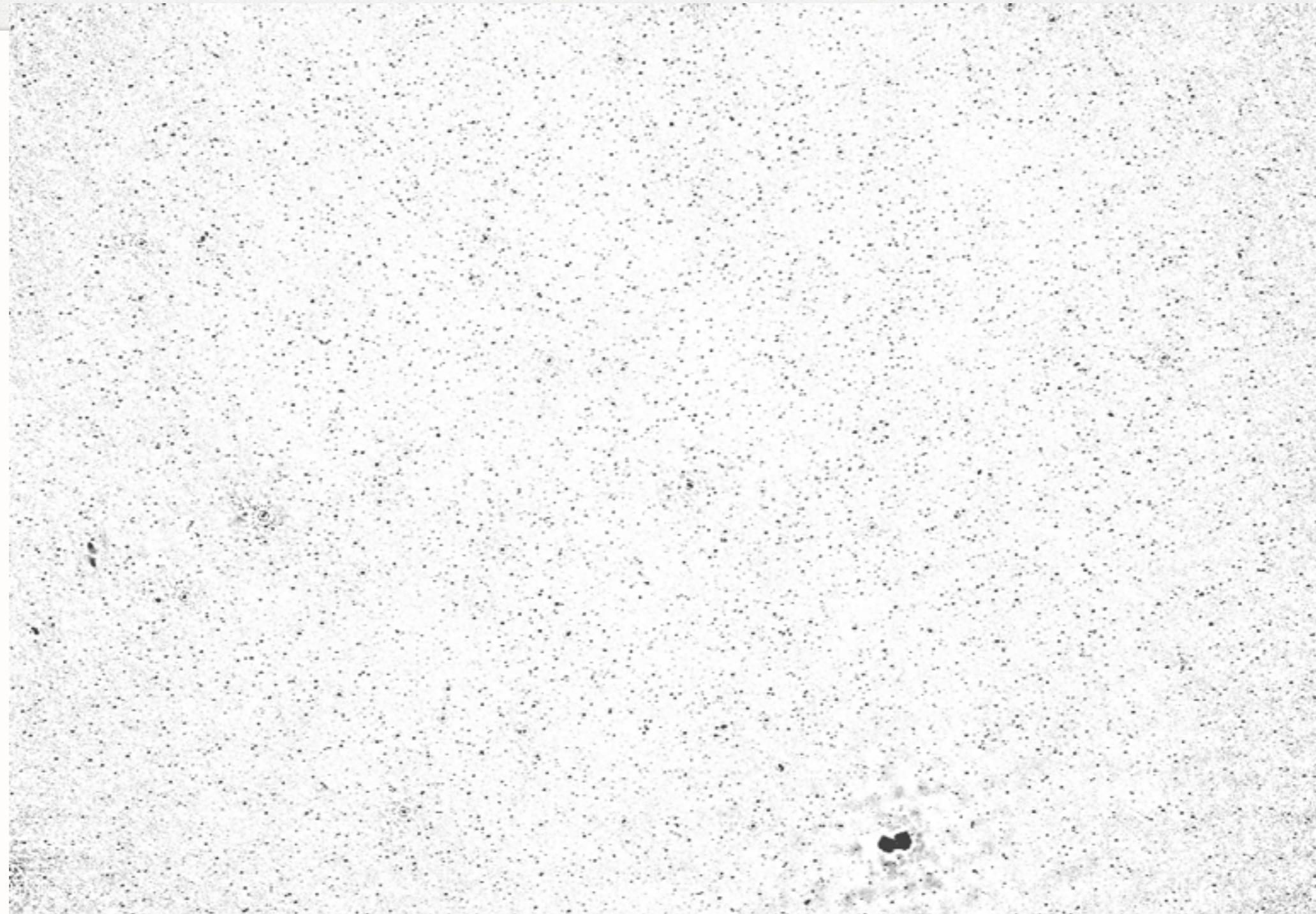


Kaplan

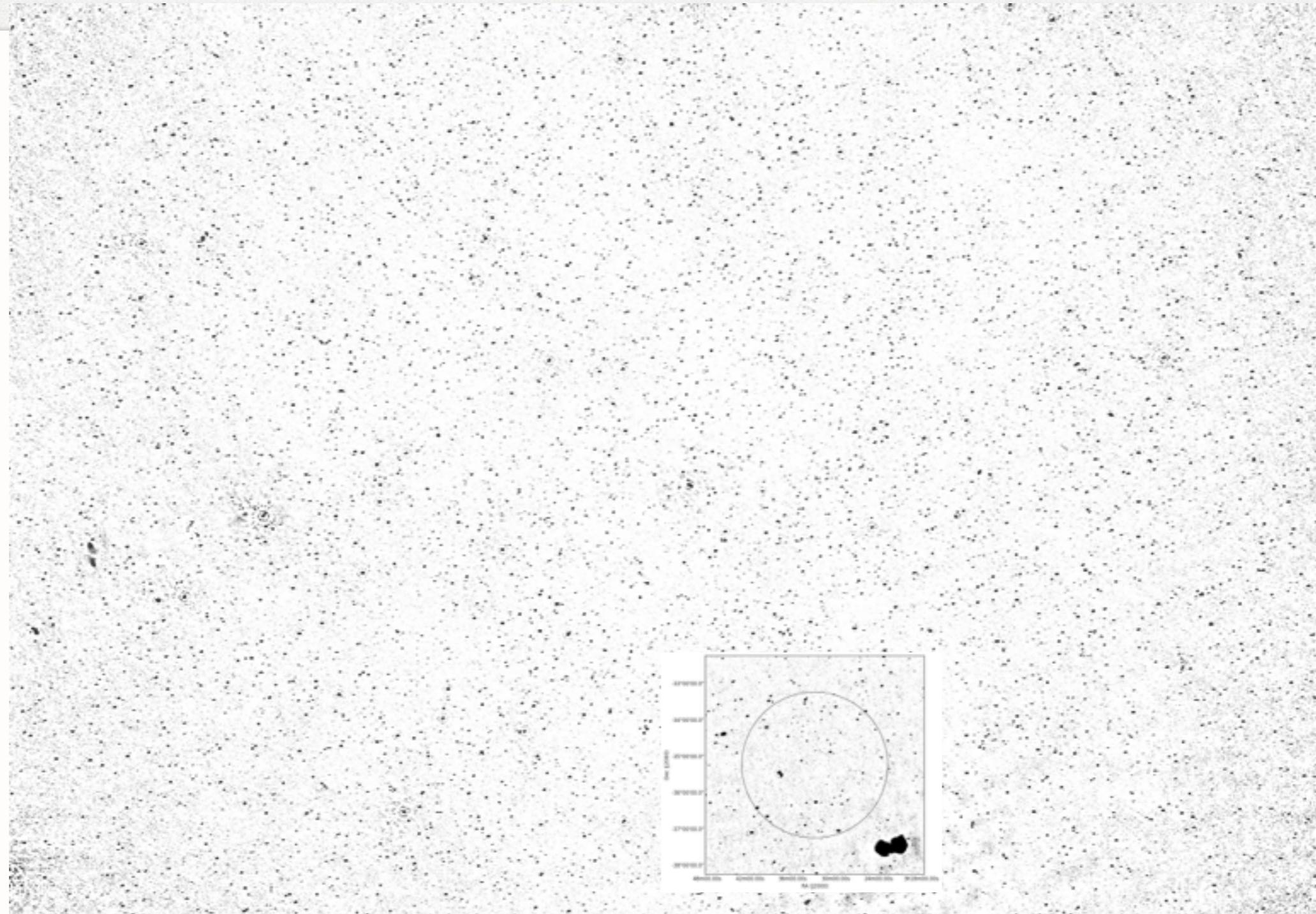
ANTARES



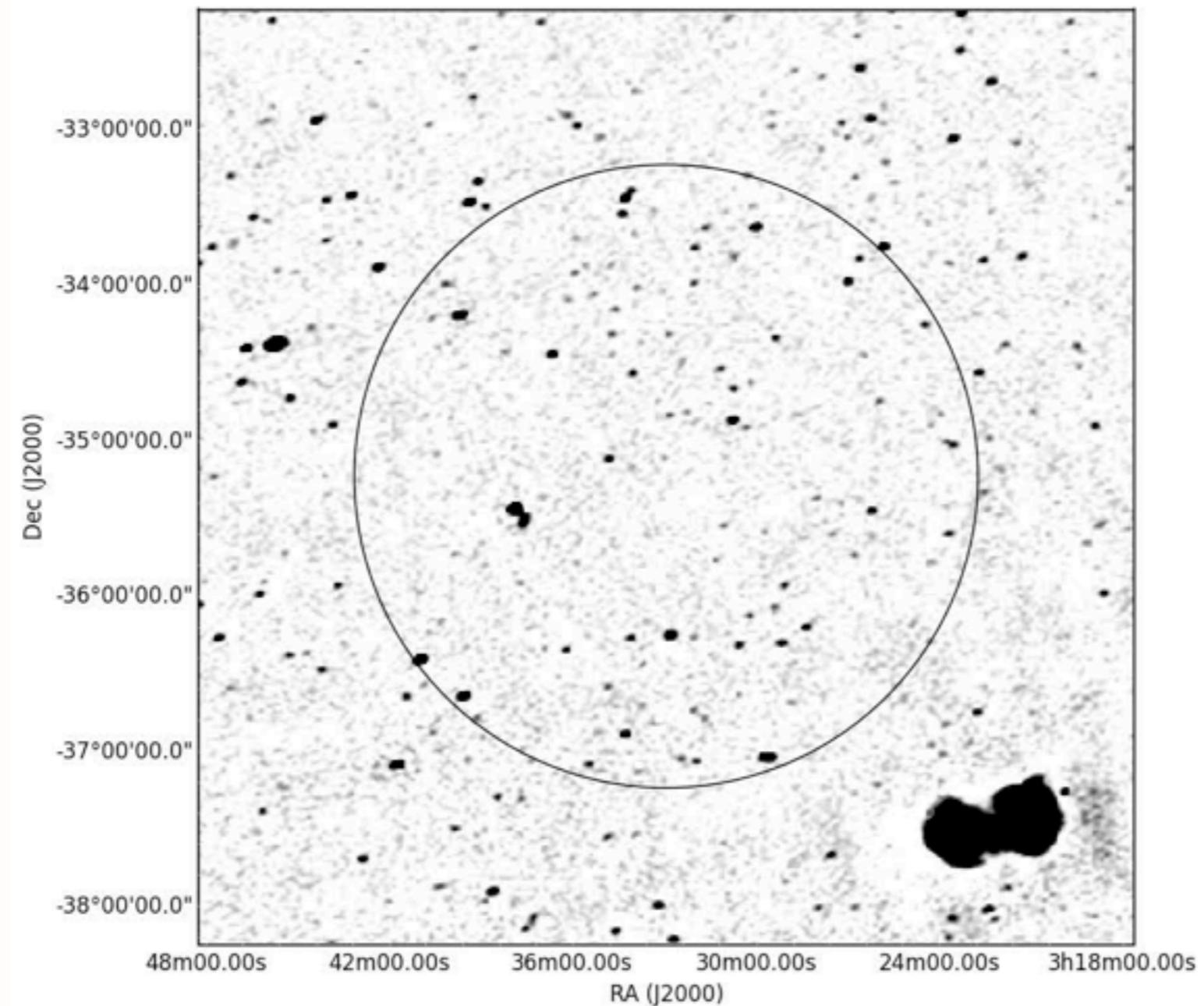
ANTARES FOLLOWUP



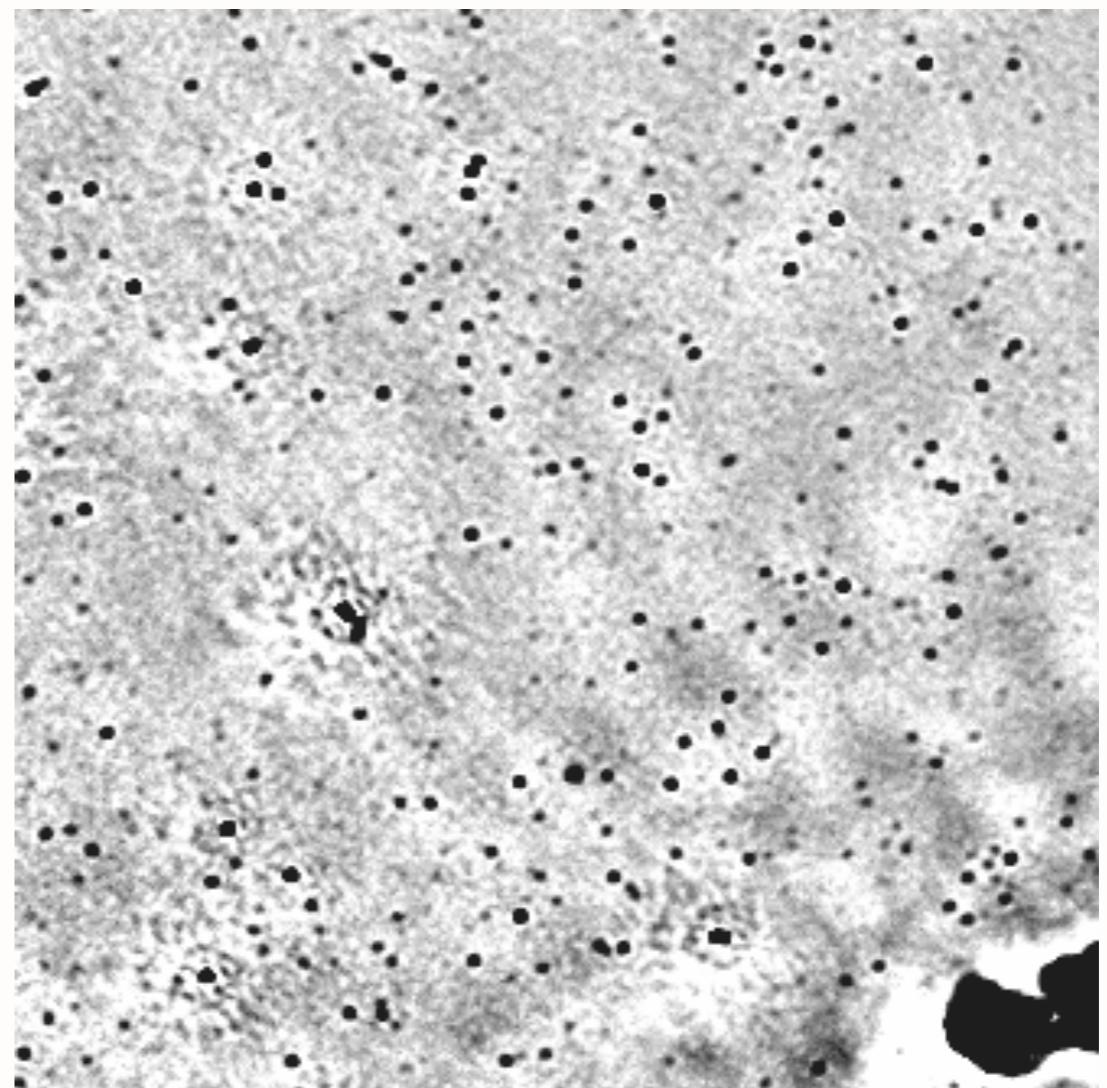
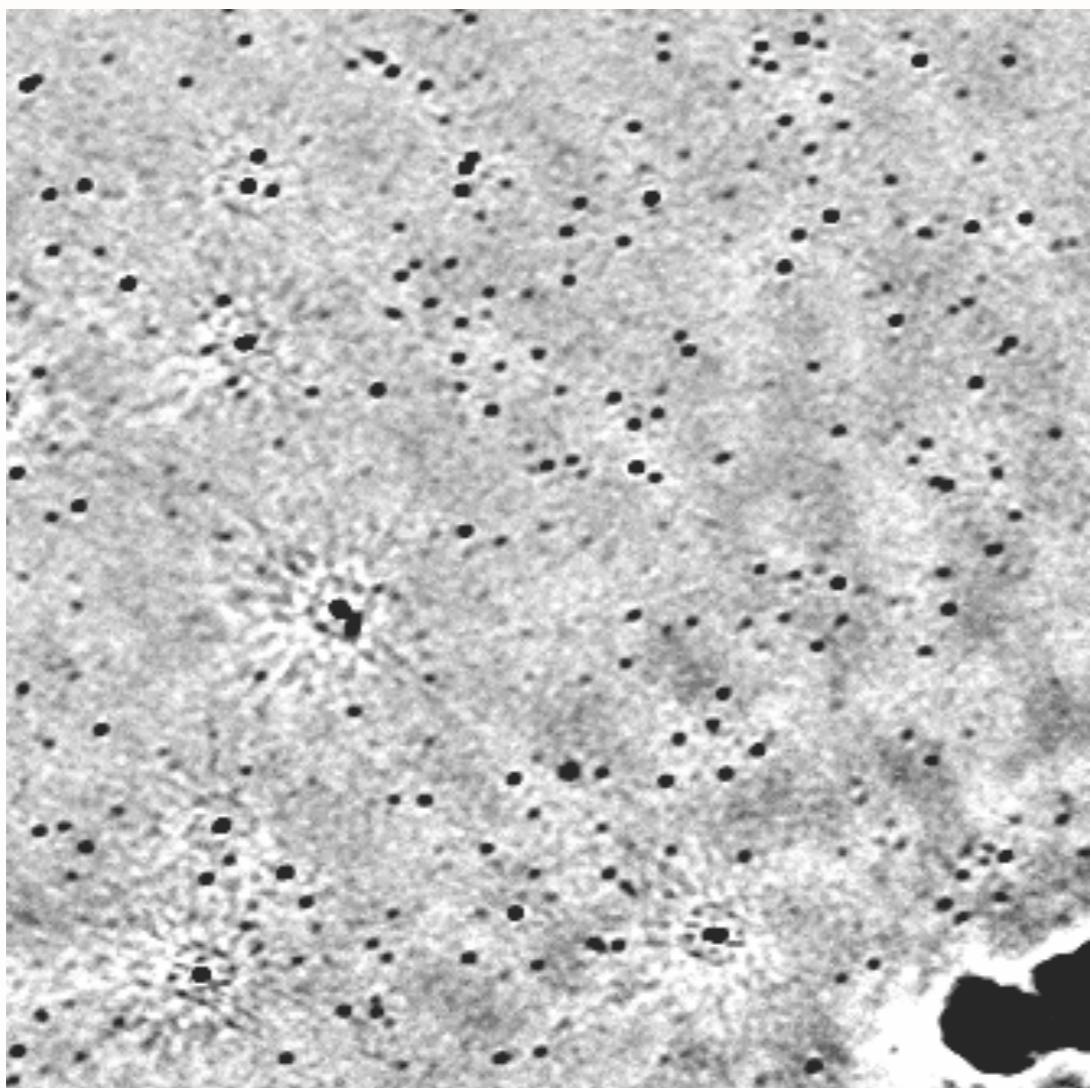
ANTARES FOLLOWUP



ANTARES FOLLOWUP



ANTARES FOLLOWUP

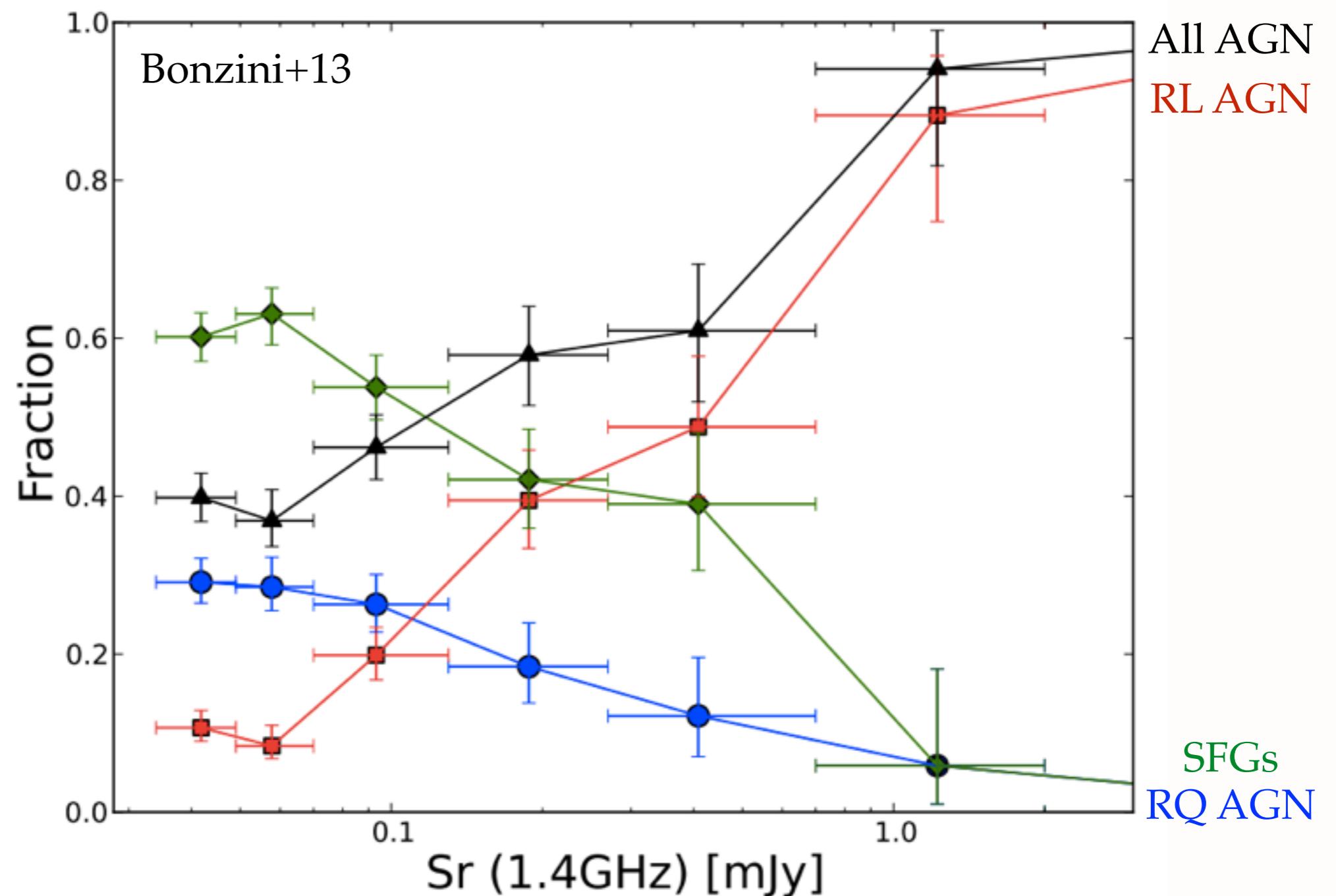


PLAYING WITH THE TOYS WE HAVE



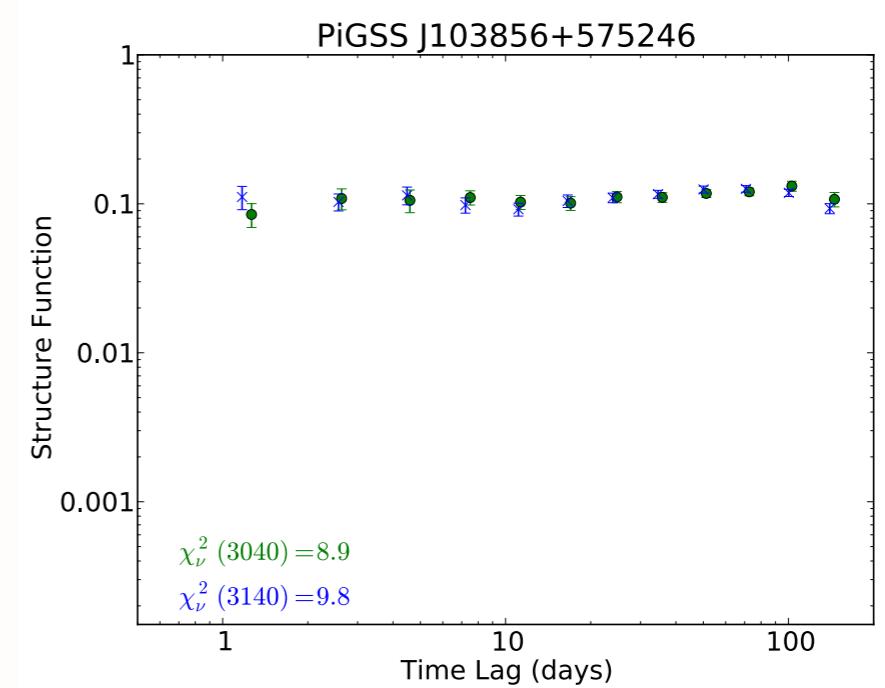
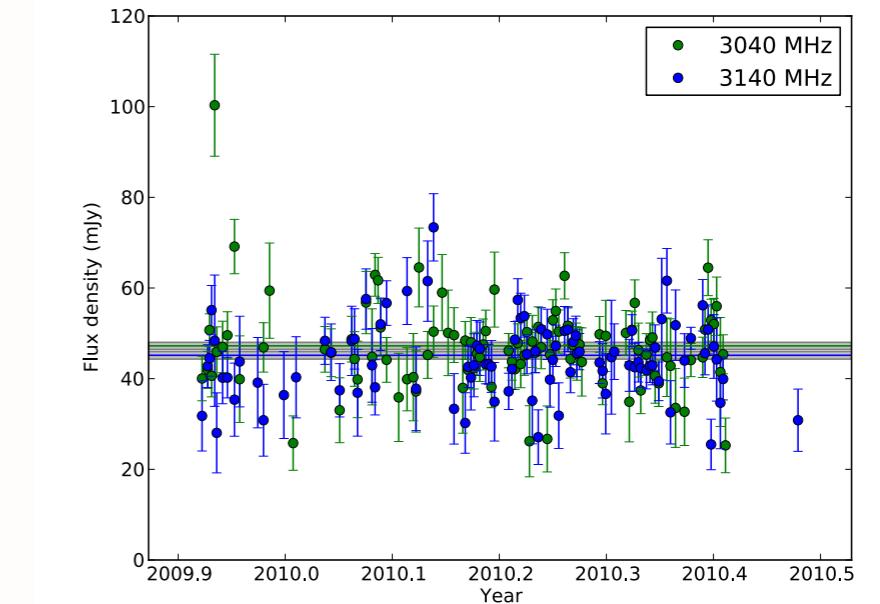
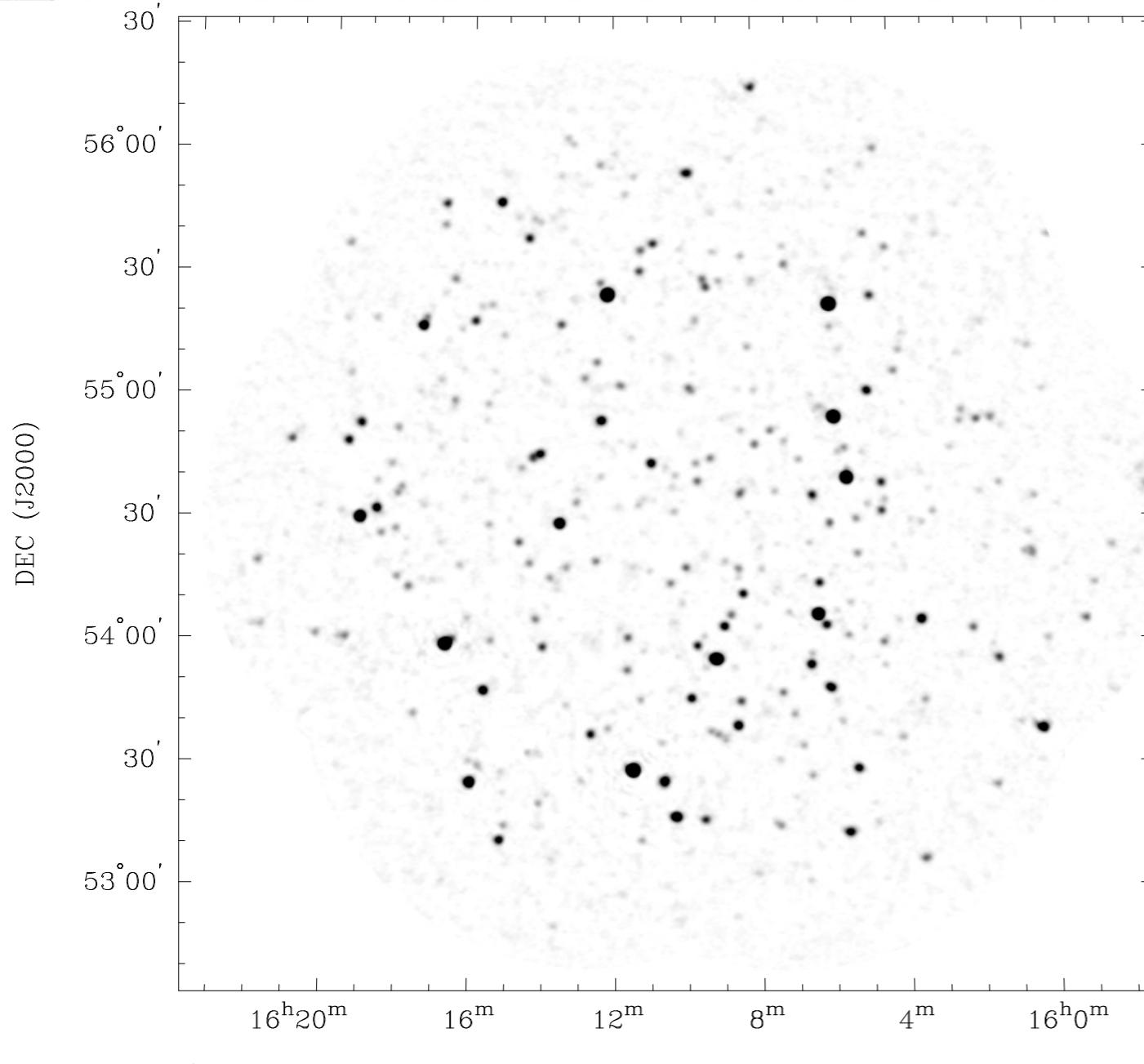
AGN DOMINATE

(even for SKA)



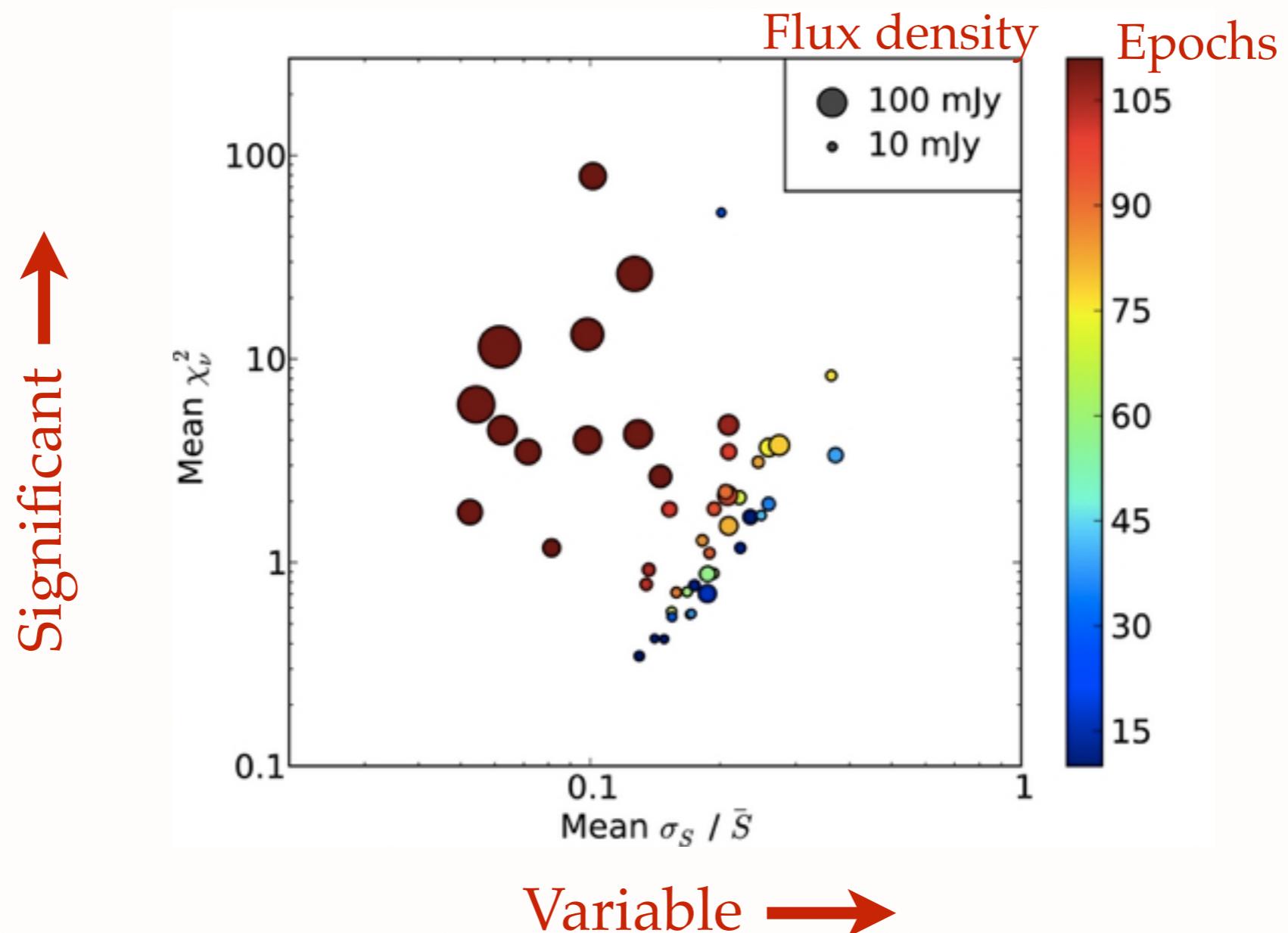


AGN VARIABILITY



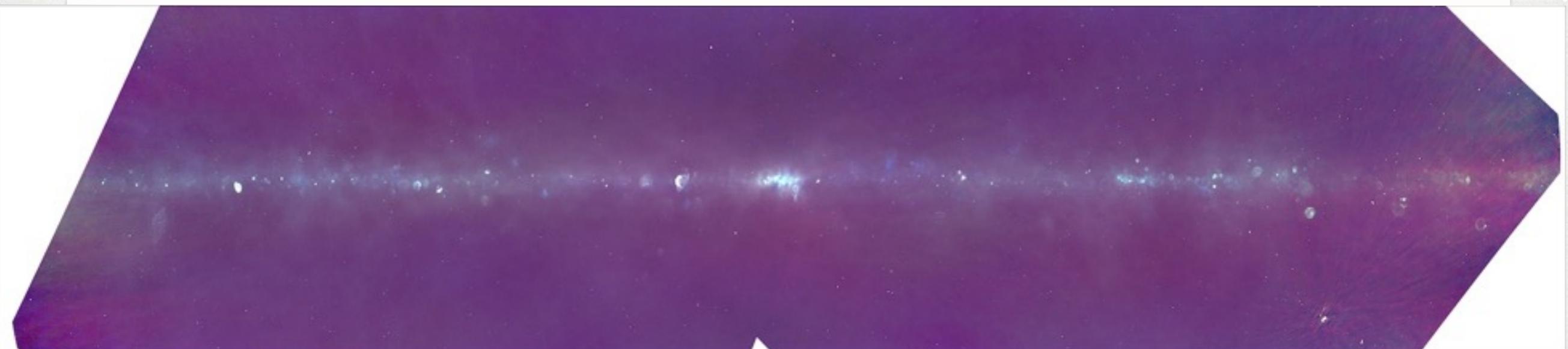
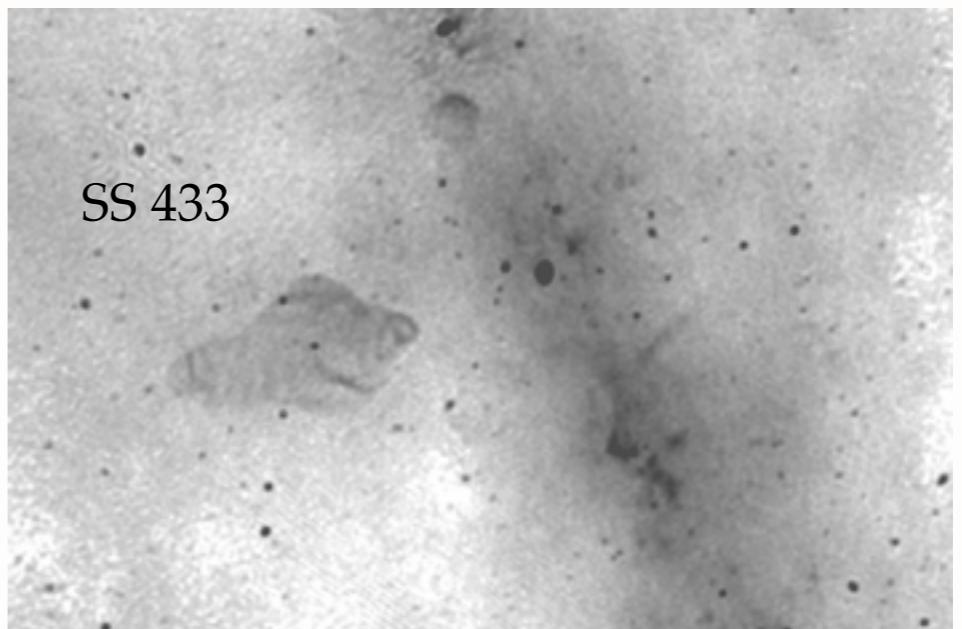
PIGSS AGN VARIABILITY

Croft+13, ApJ, 762, 93



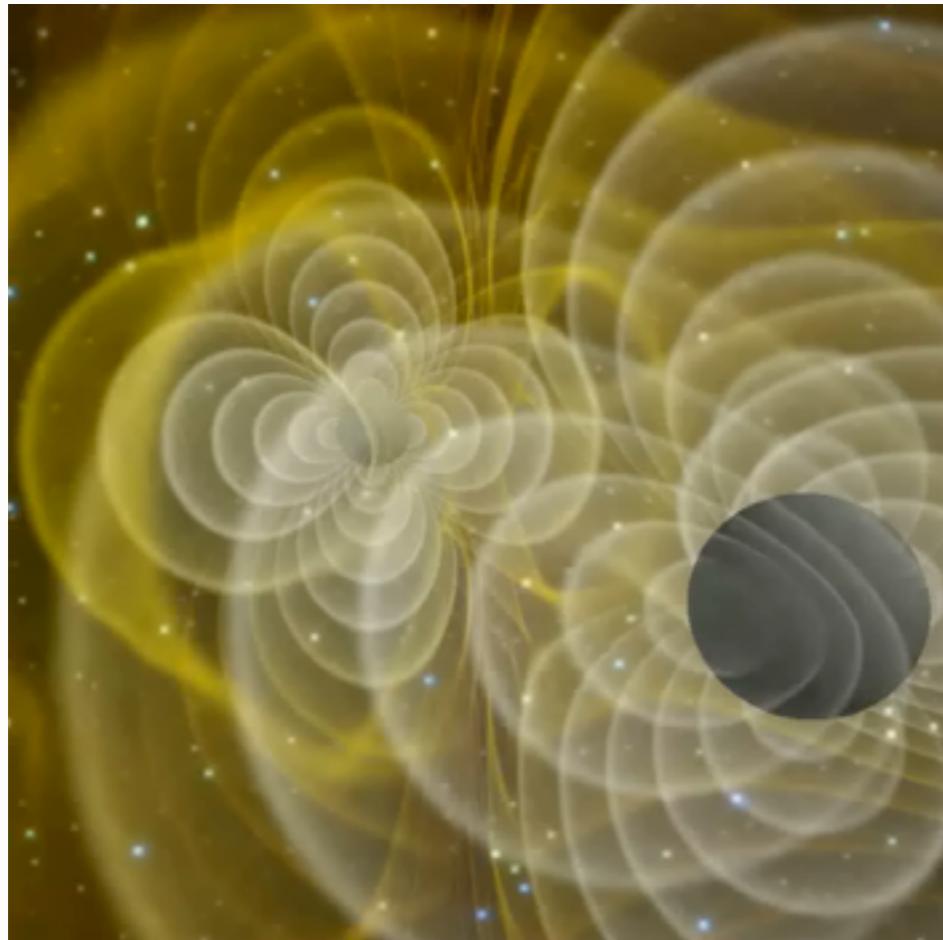
MWA

- FOV 1000 sq. deg
- RMS ~ 20 mJy / beam
- Thousands of AGN in each image
- Hundreds detected at > 10 sigma
- Typical cadence ~1 month
- Also monitoring Galactic sources and searching for transients



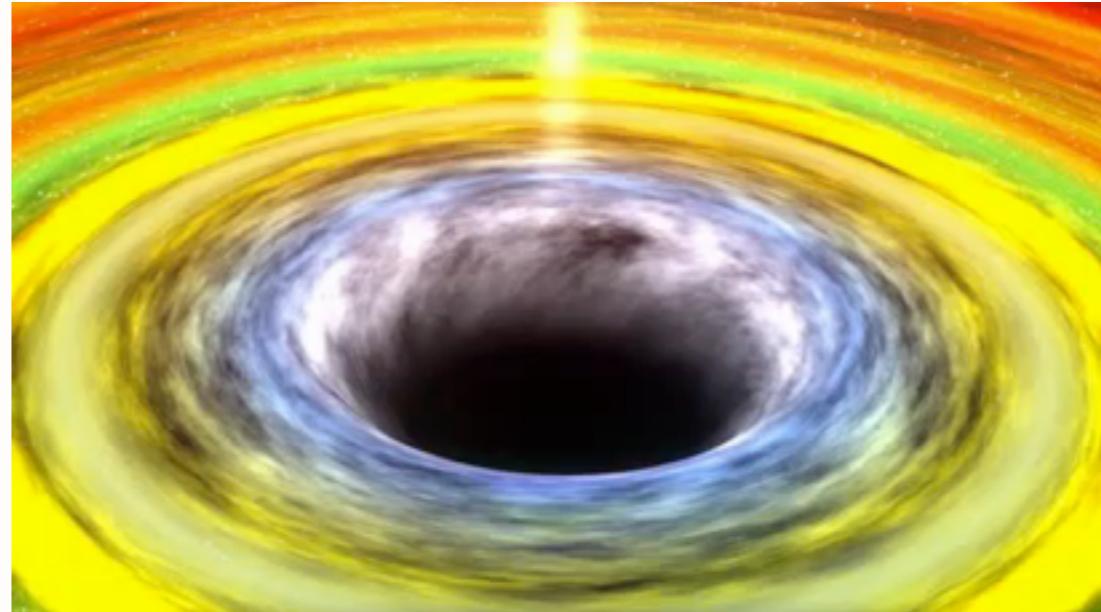
PROBING BH GROWTH

Mergers, steady accretion, and tidal disruptions

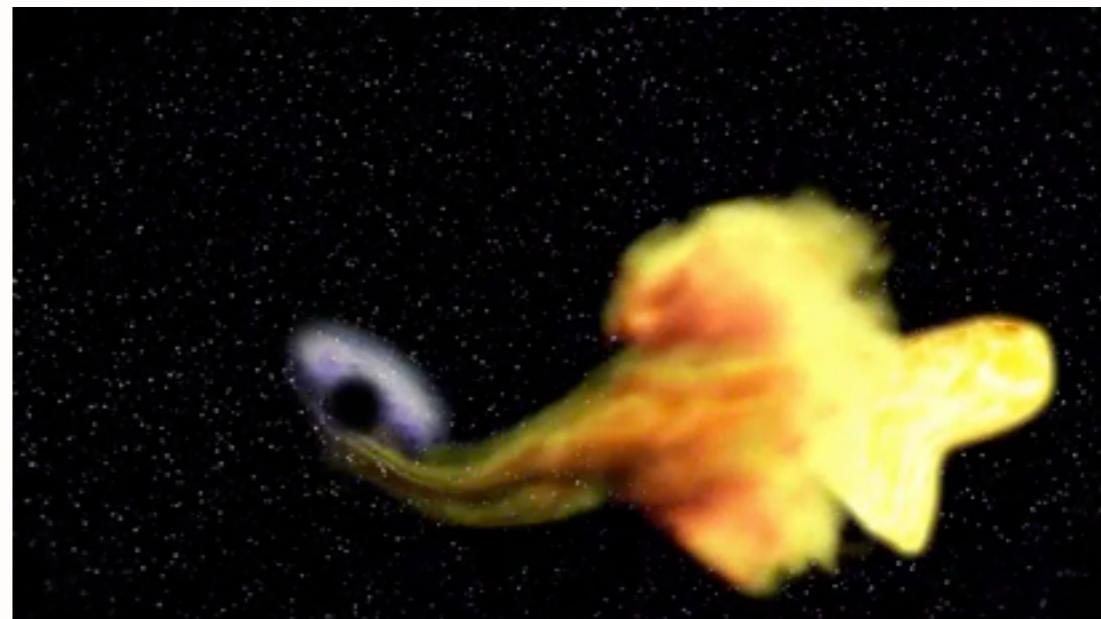


NASA / C. Henze

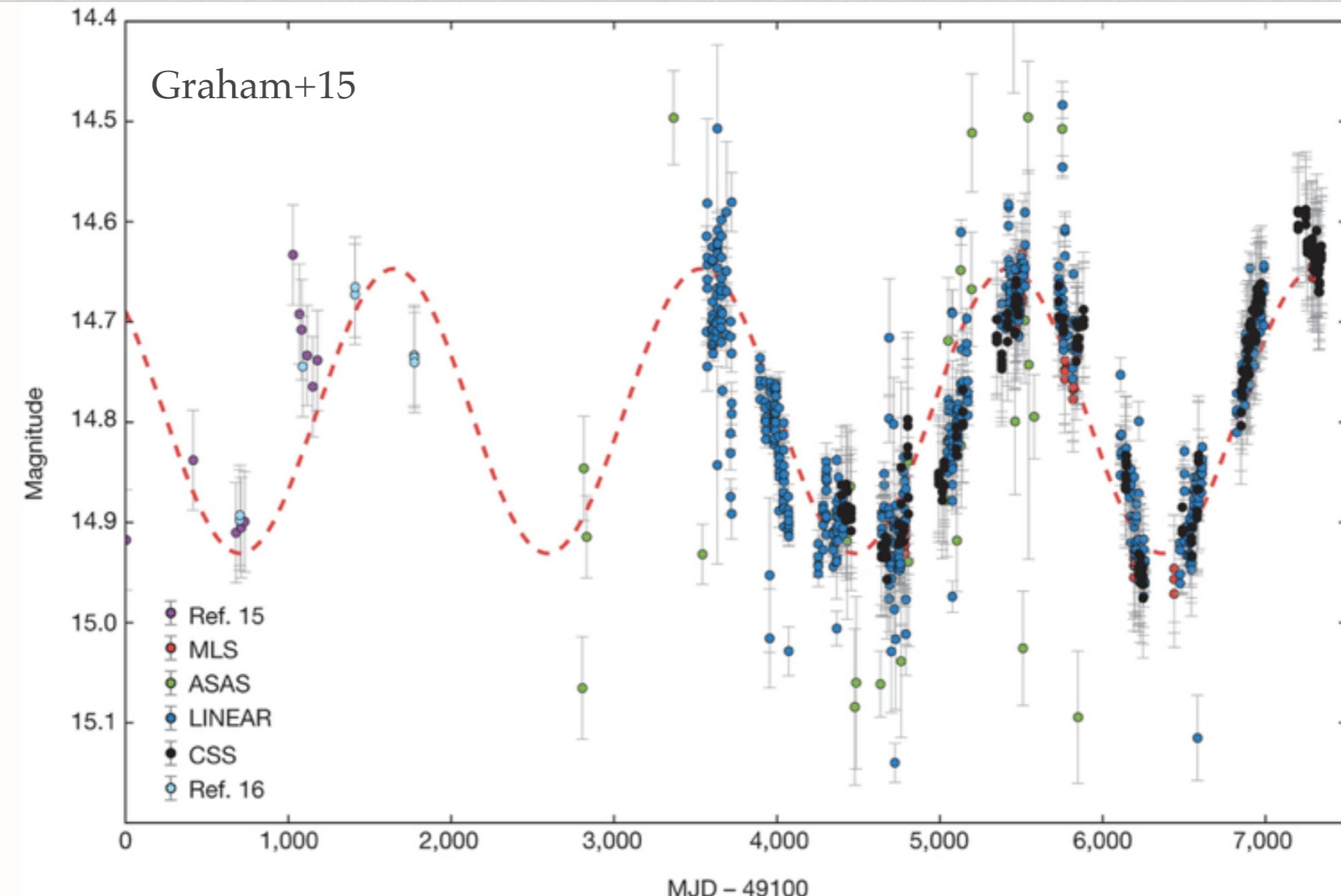
SKA1 Headline Science:
“Strong-field Tests of Gravity
with ... Black Holes”



NASA GSFC

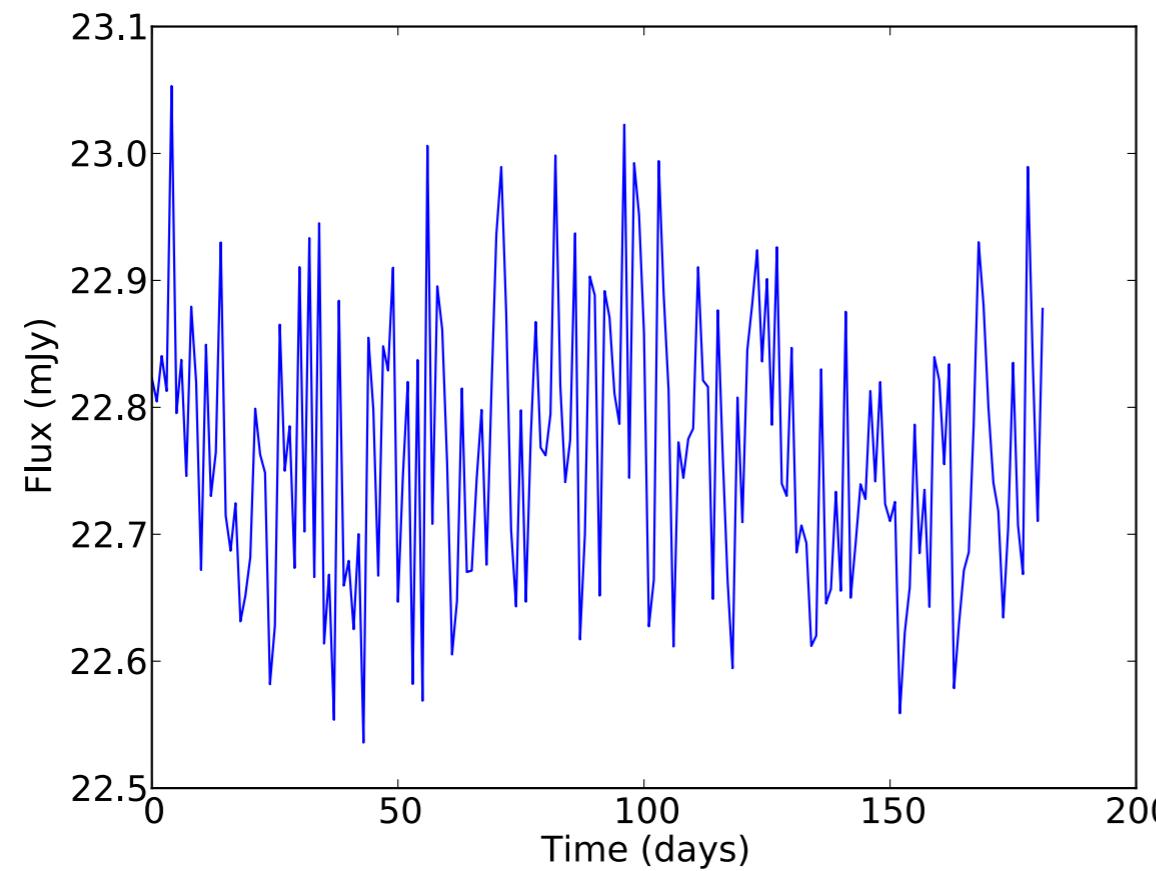


TIME DOMAIN



INSPIRAL SIGNATURES

- Unlikely to catch brief flares hours before merger
- Could maybe see modulation of emission at earlier times



O'Shaughnessy+11
Kaplan+11
Croft, O'Shaughnessy & Kaplan in prep.

KEY AREAS OF INTEREST

- Red and white noise variability and QPOs from variations in accretion rate; flares, turbulence, and shocks in disks and jets; transitions between soft and hard states; and other *processes near the black hole*
- Disk - jet connection
- Constraints on black hole mass (from variability power spectrum break and TDE lightcurves)
- Demographics, radio loudness, and correlation with host properties and environment (can find “buried” sources too)
- Propagation and scattering
- Polarization and frequency-dependent structure of jets with μ as precision (\rightarrow jet mag. field, particle density, pressure, geometry)
- See Bignall, Croft et al. (2015) arxiv:1501.04627

SKA

- Strawman survey with SKA1-sur or SKA1-mid: entire visible sky every day to RMS $\sim 100 \mu\text{Jy}$ / beam
- AGN still dominate in surveys, even for SKA1 (millions monitored daily with $10\sigma \sim \text{mJy}$; cf. NVSS / FIRST)
- 1% should vary at 25% on year timescales at GHz freq (Thyagarajan+11); more at lower levels / fluxes / different timescales
- Band 5 of SKA1-mid along with two lower frequency bands, will provide a powerful discriminant between intrinsic and extrinsic variability (especially in conjunction with LSST and high energy)
- Bignall, Croft et al. (2015) arxiv:1501.04627