

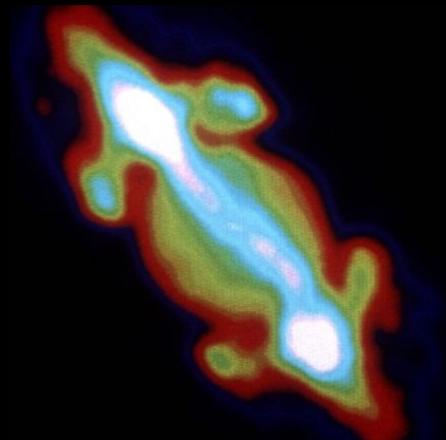
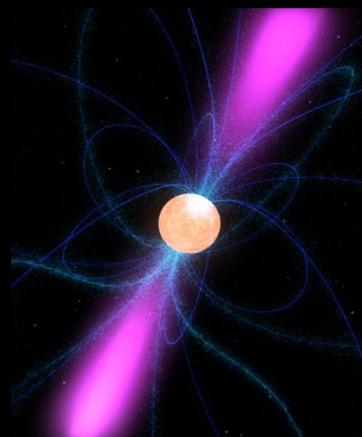
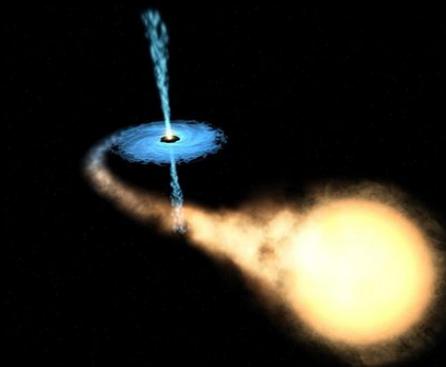
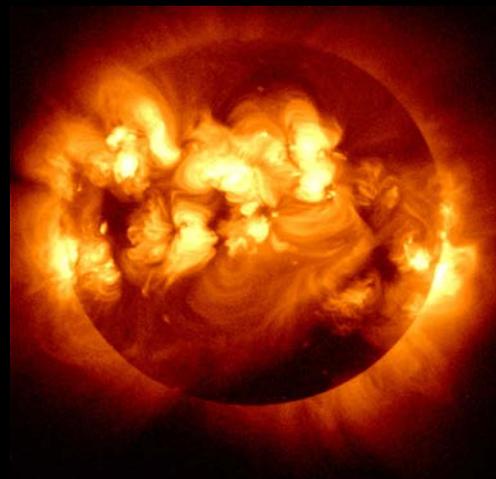
Pioneering Observations with the Murchison Widefield Array: *Searching for Radio Transients*



Greg McGlynn
MIT Haystack Observatory REU
August 6, 2009

Astrophysical Radio Transients

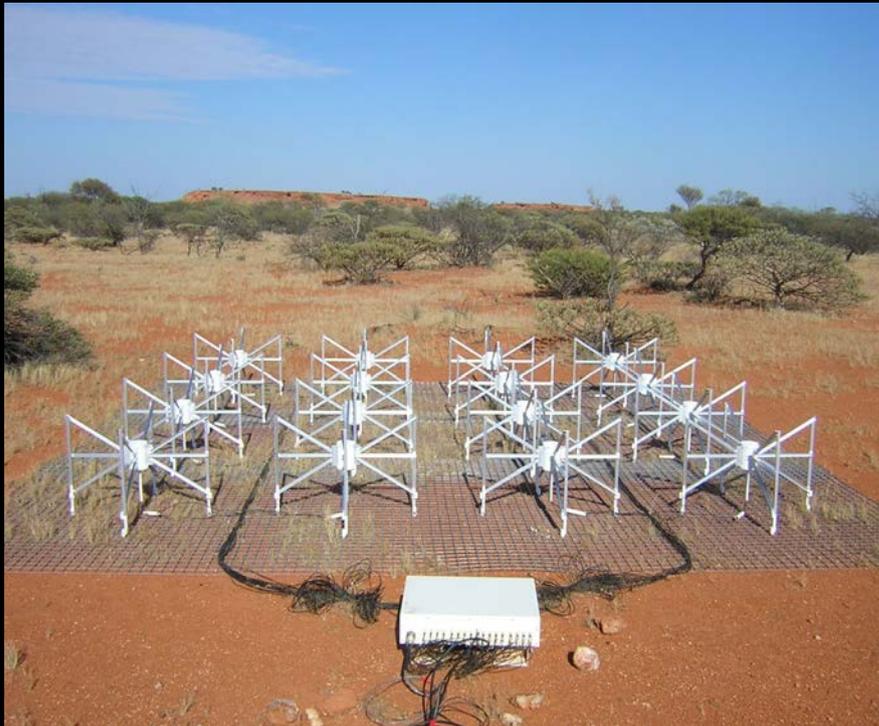
- Flaring stars
- X-ray binaries
- Pulsar giant pulses
- Exoplanets
- Active galactic nuclei
- Maser flares



Cordes et al. "The Dynamic Radio Sky." *New Astronomy Reviews*, 2004.

Transients and the MWA

- Wide field of view: 10s of degrees
- Relatively unexplored frequency range (80-300Mhz)

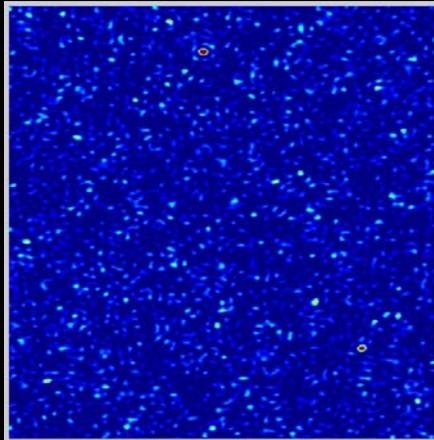


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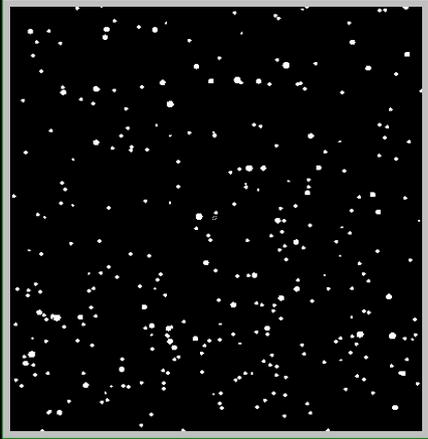
The All-Sky Monitor

The All-Sky Monitor

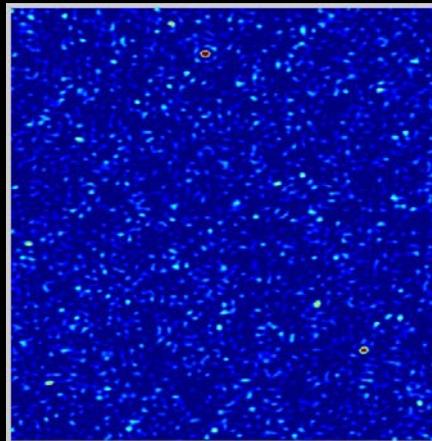


Observed image

The All-Sky Monitor

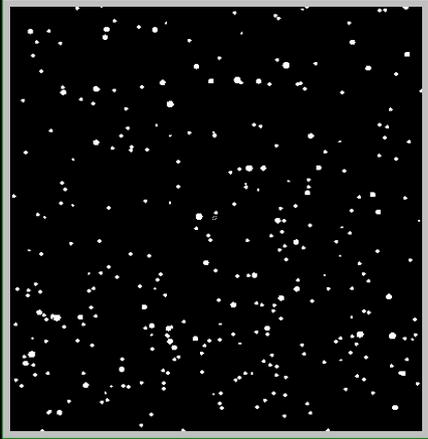


Reference sky

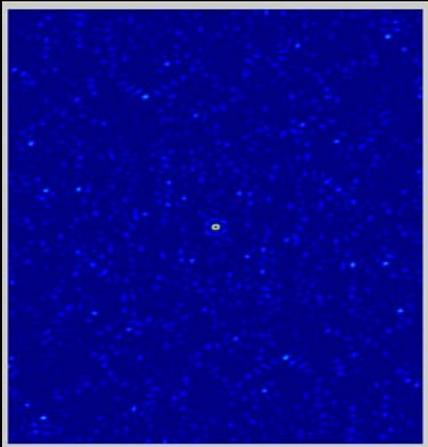


Observed image

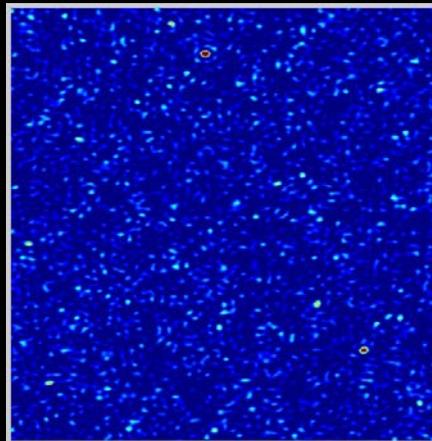
The All-Sky Monitor



Reference sky

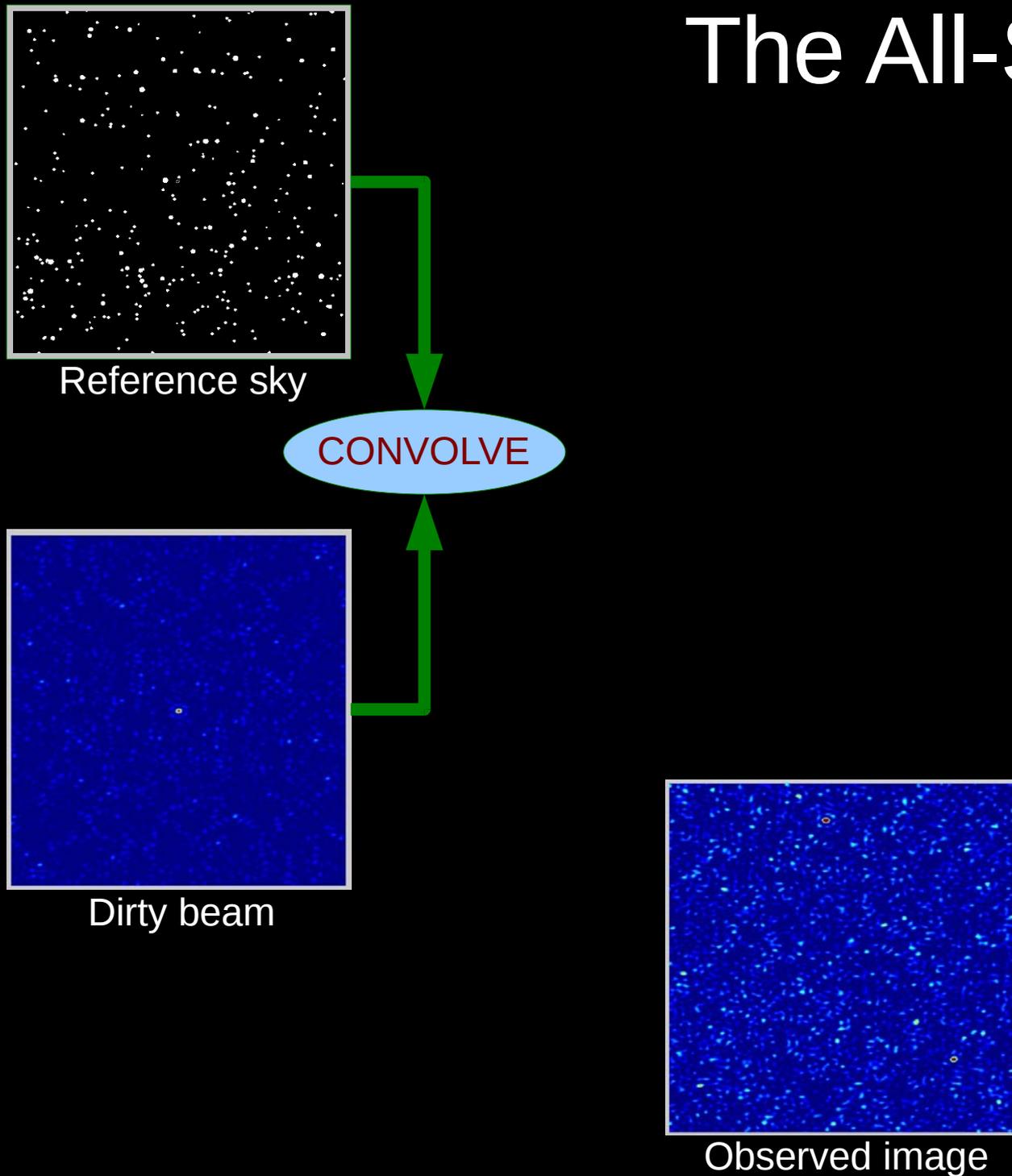


Dirty beam

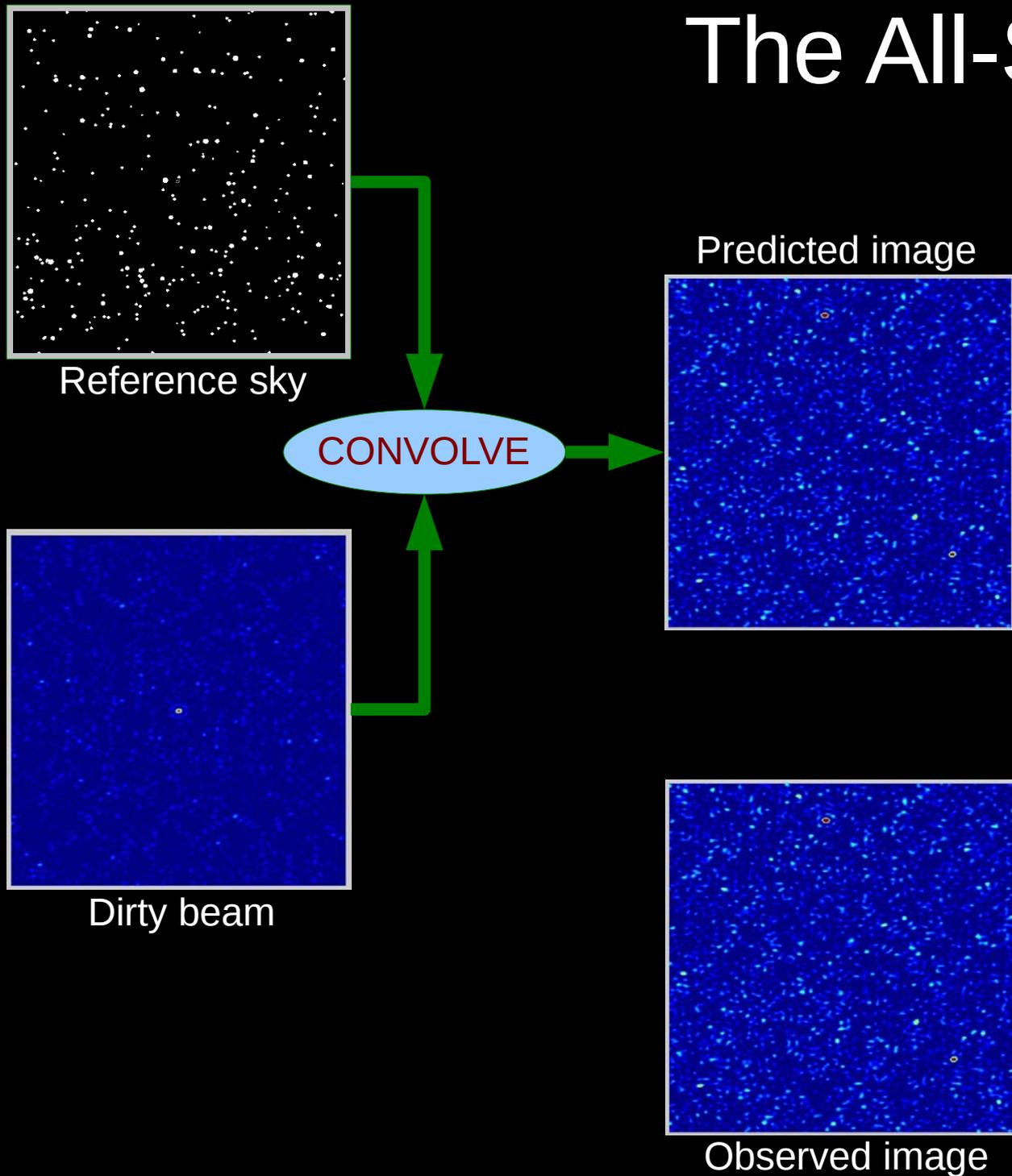


Observed image

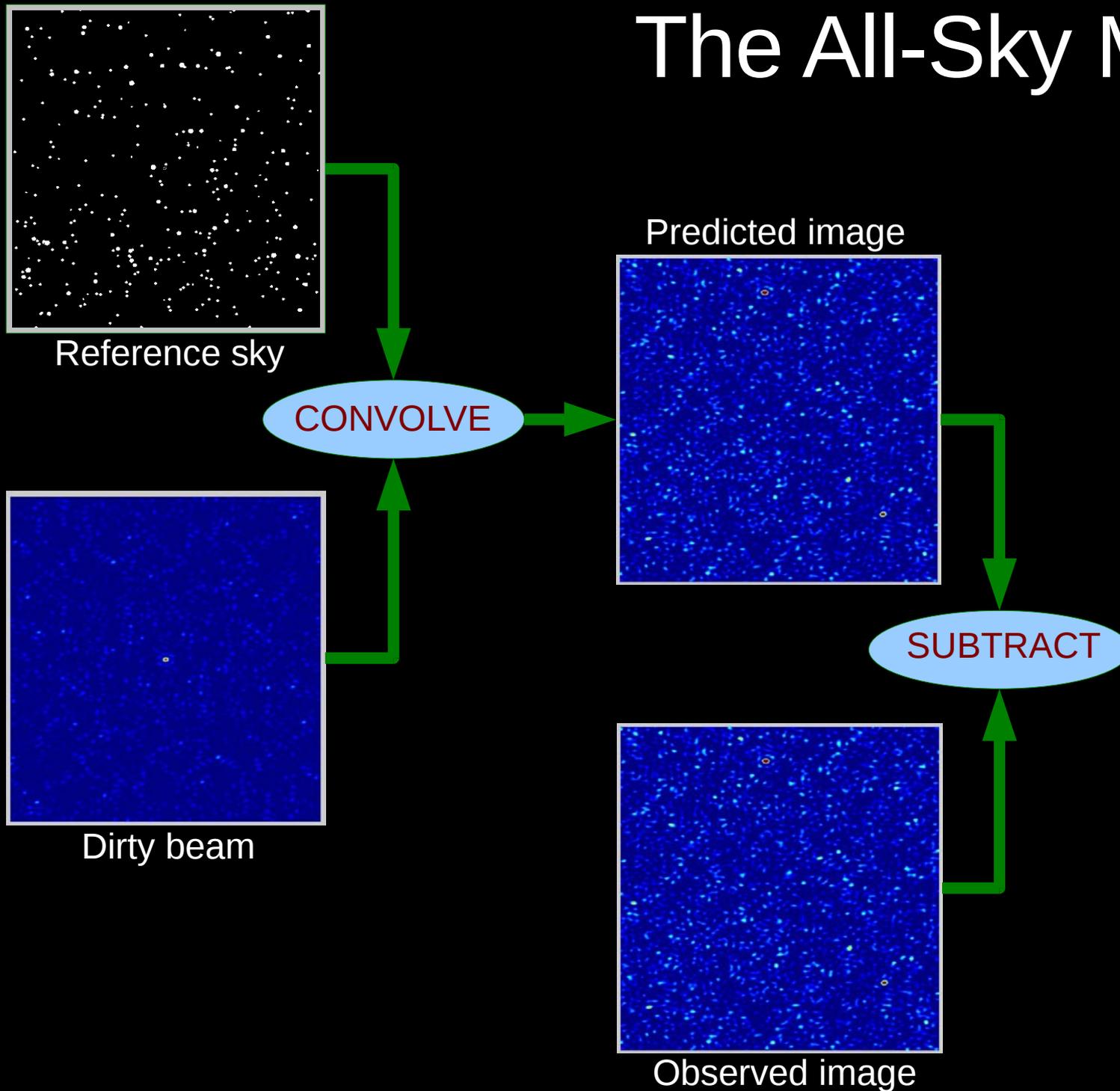
The All-Sky Monitor



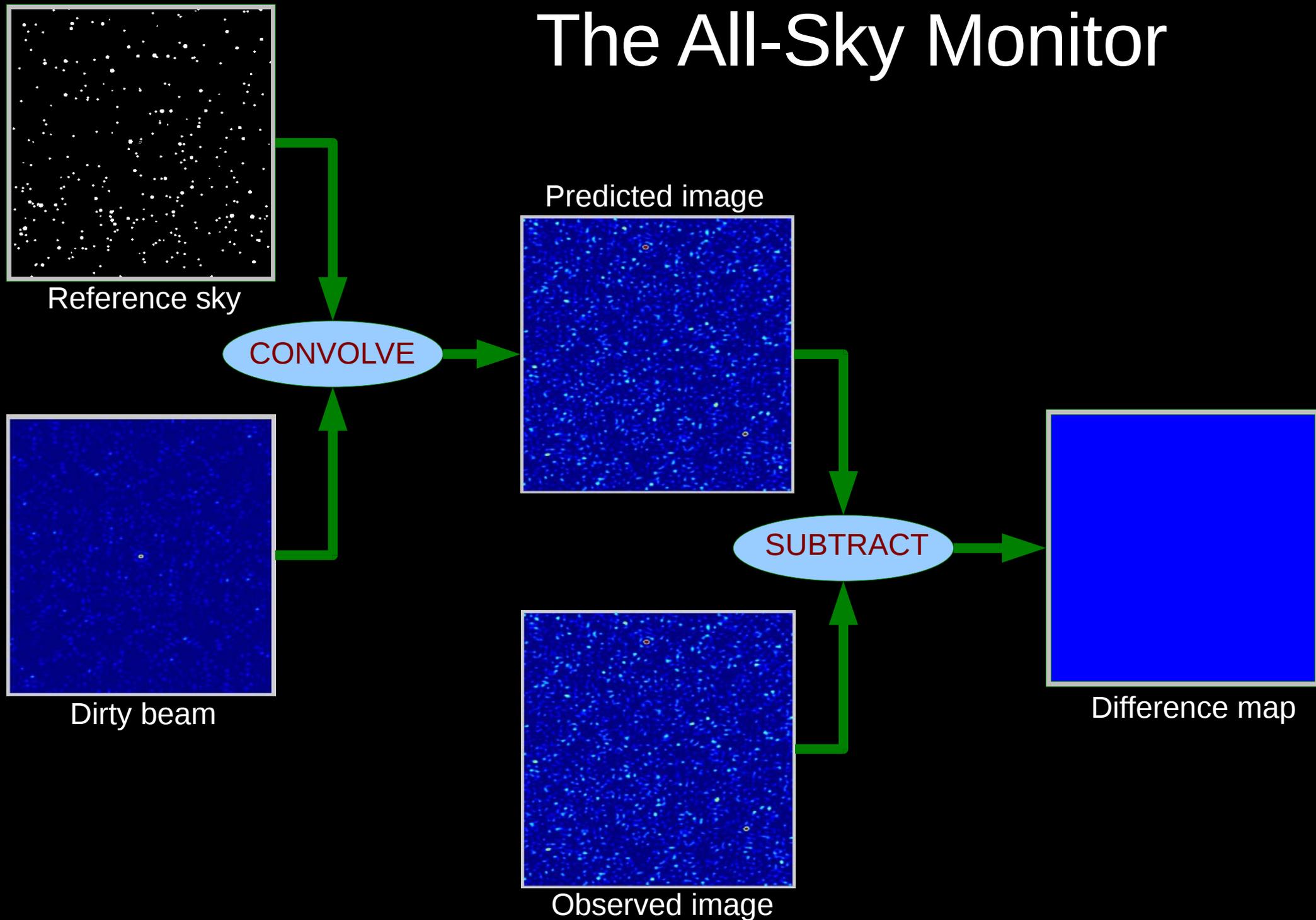
The All-Sky Monitor



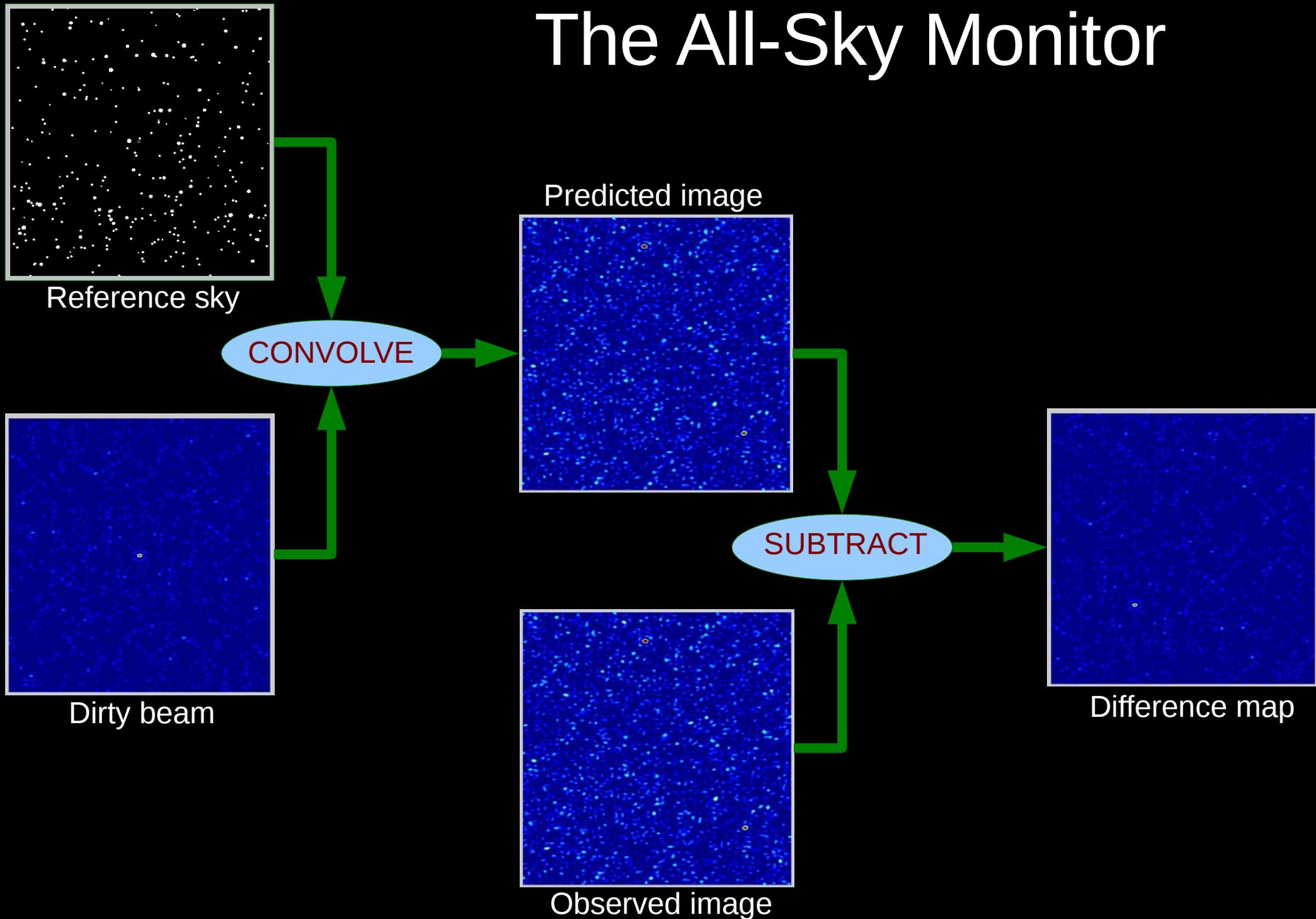
The All-Sky Monitor



The All-Sky Monitor



The All-Sky Monitor



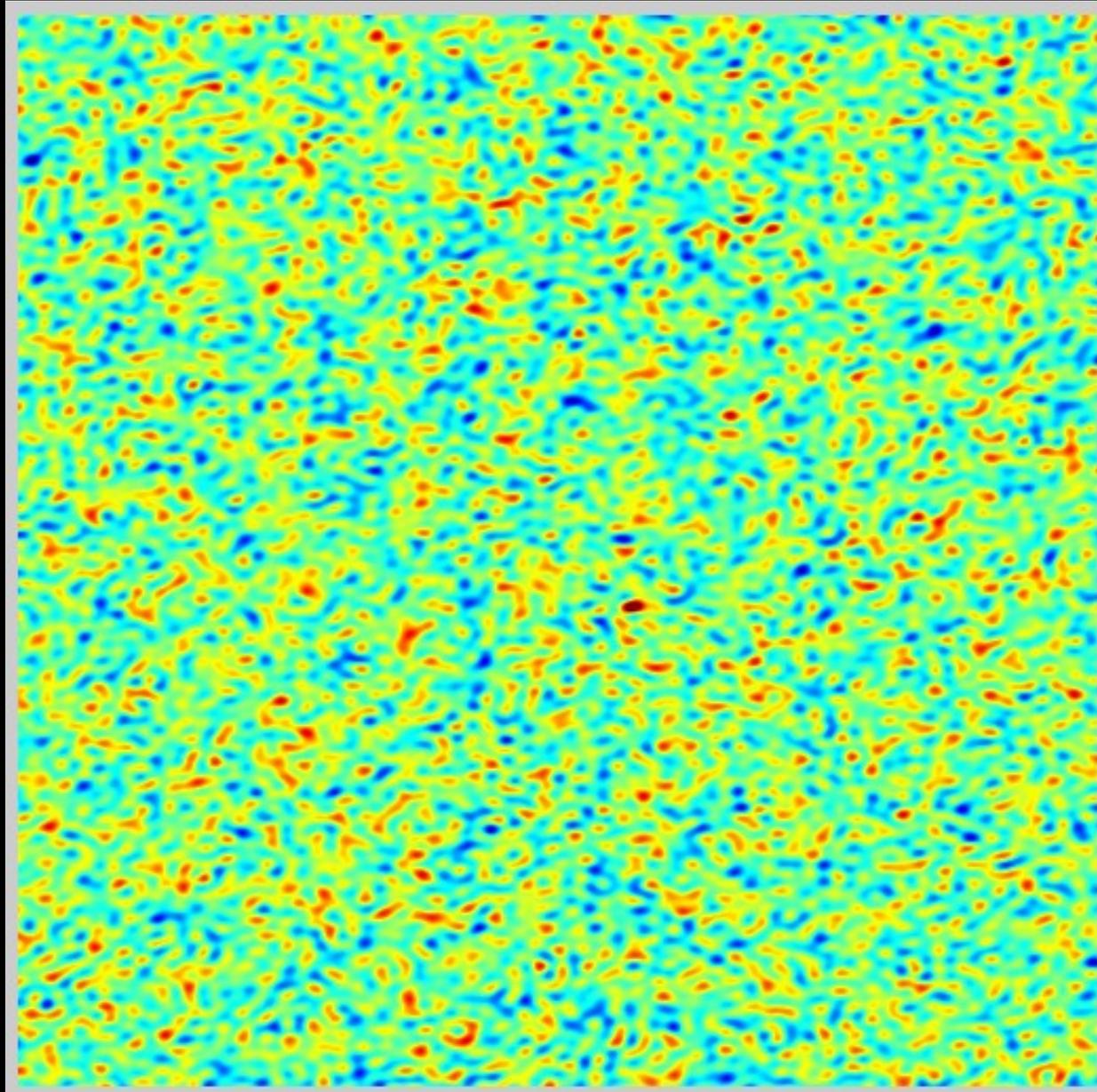
Transient Sensitivity

- For a transient to be detected, its signal must rise above the noise in an image
- Sources of noise:
 - Thermal noise
 - Reference sky inaccuracy

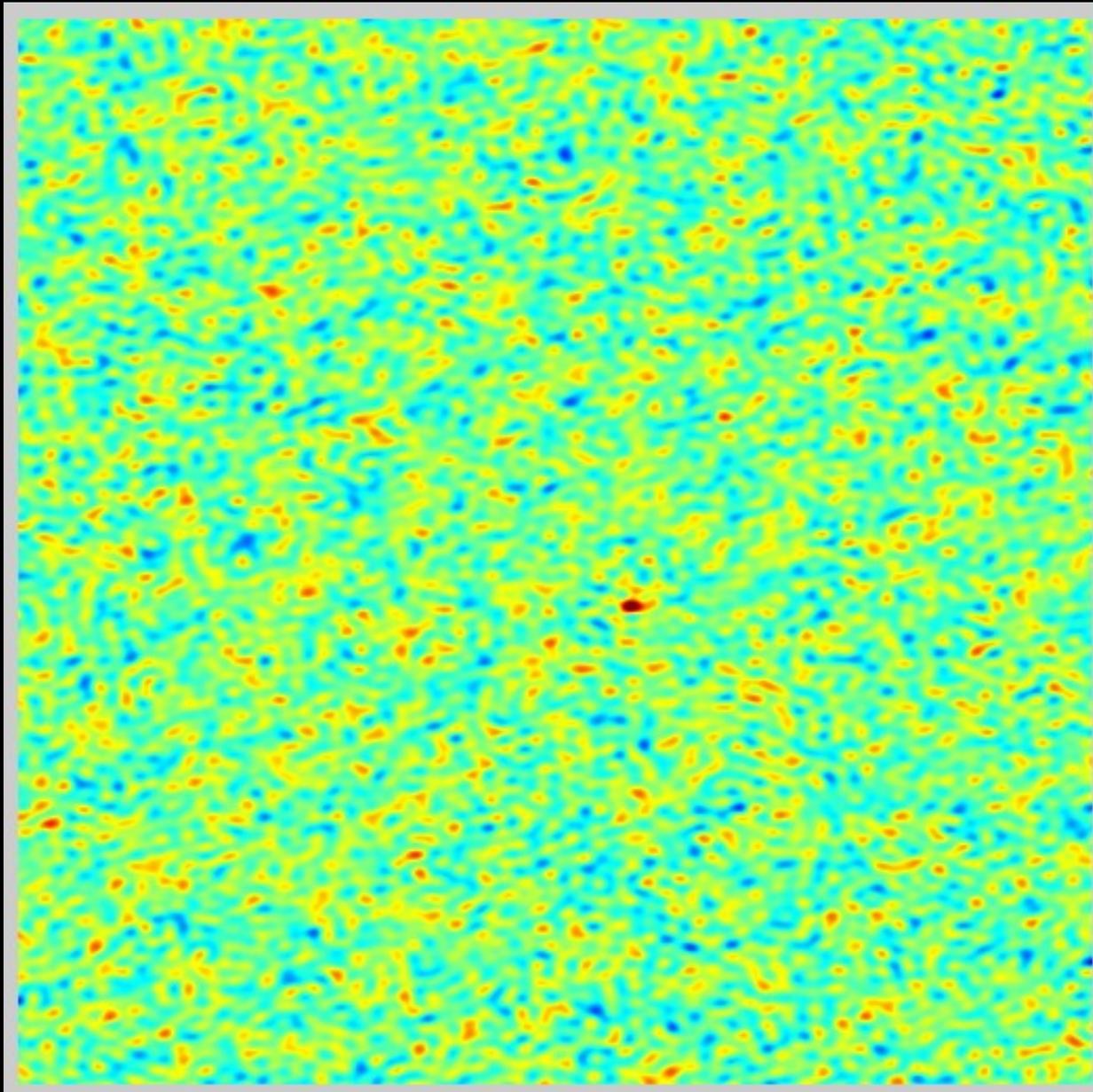
Thermal Noise

- Caused by random errors in visibility measurements
- In the image plane, this results in a bunch of fringe patterns superimposed on each other.
- Averages well over time: goes down with square root of time

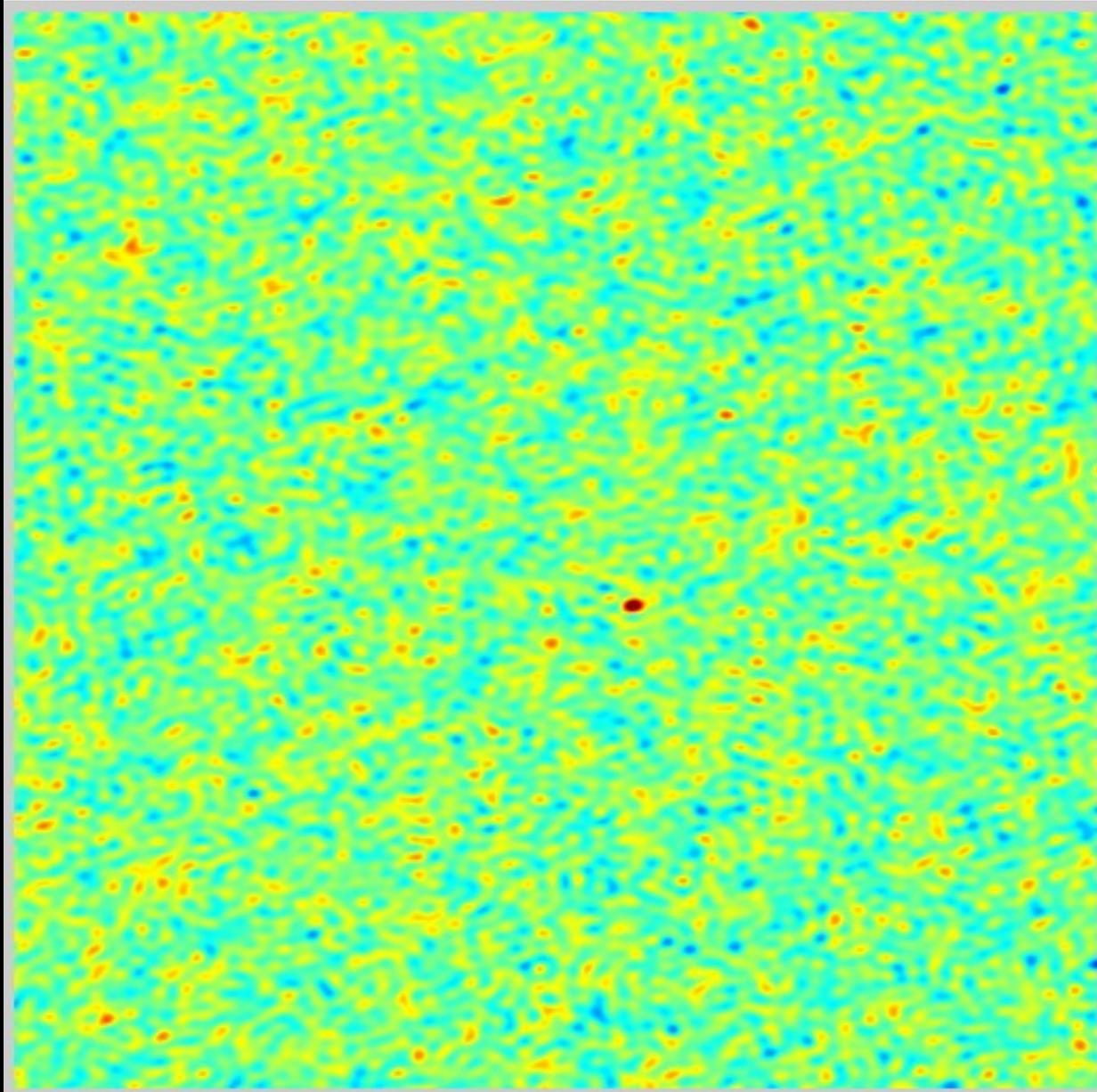
Thermal noise



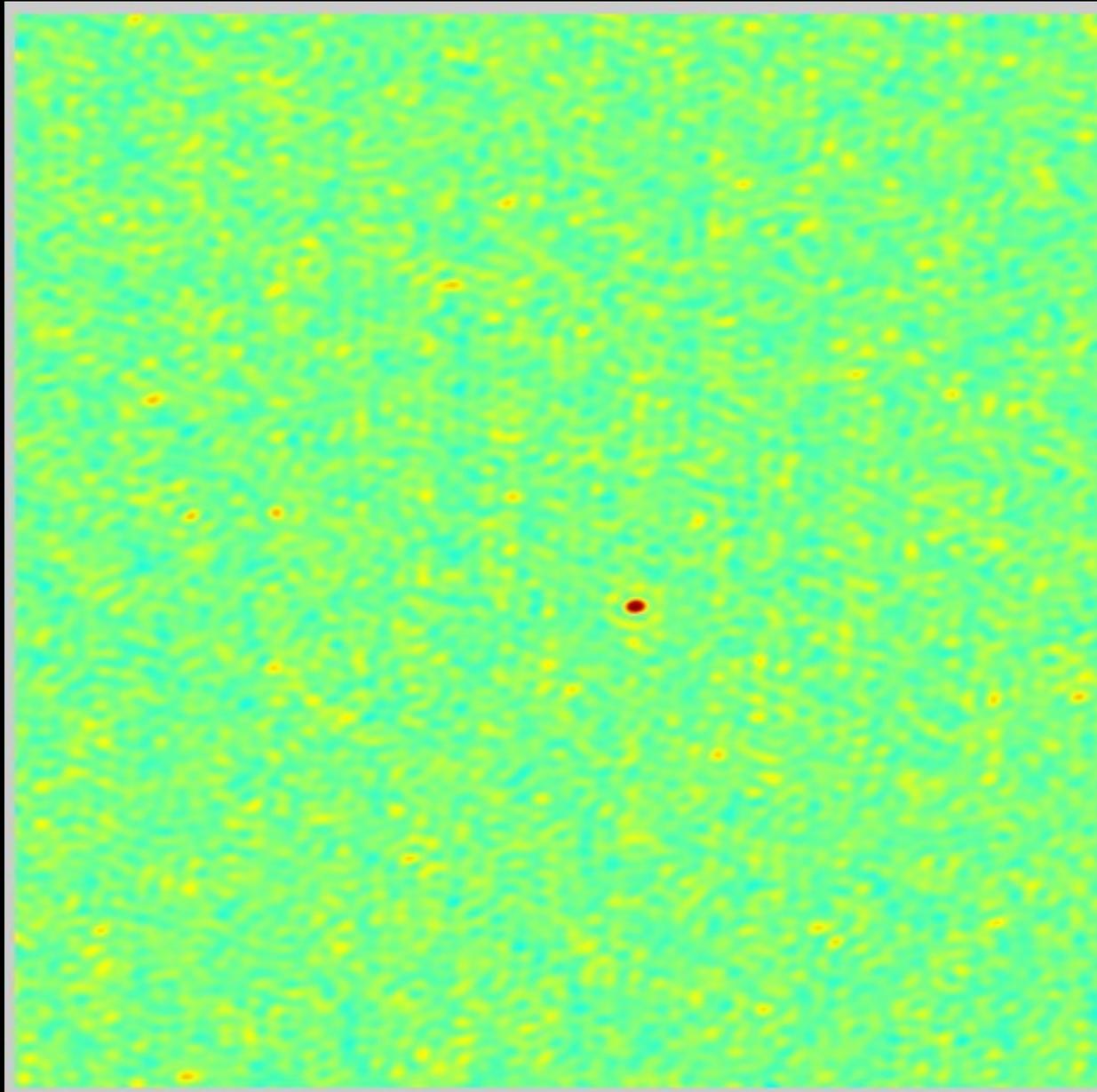
Thermal noise



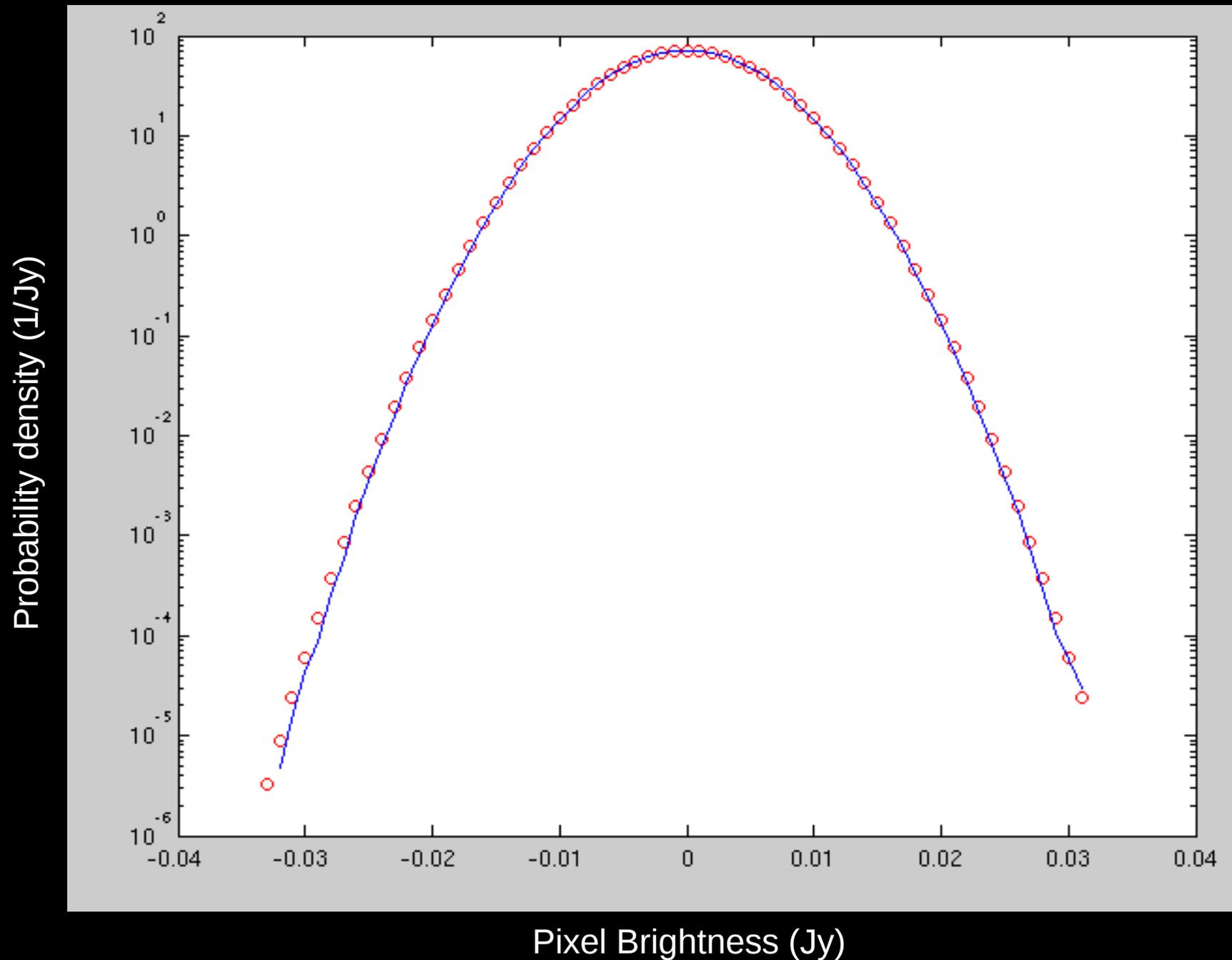
Thermal noise



Thermal noise



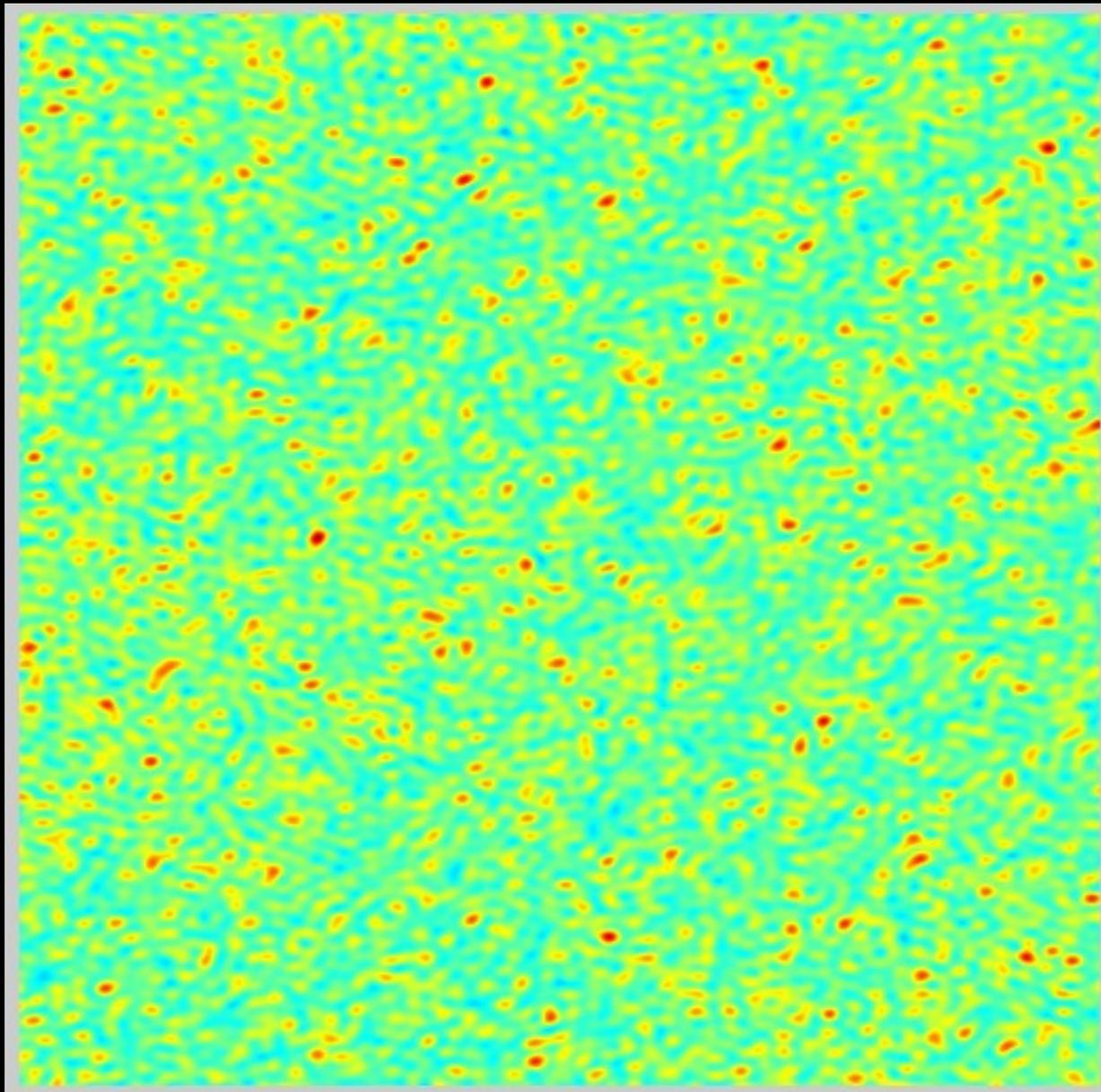
Thermal Noise – Pixel Brightness Distribution



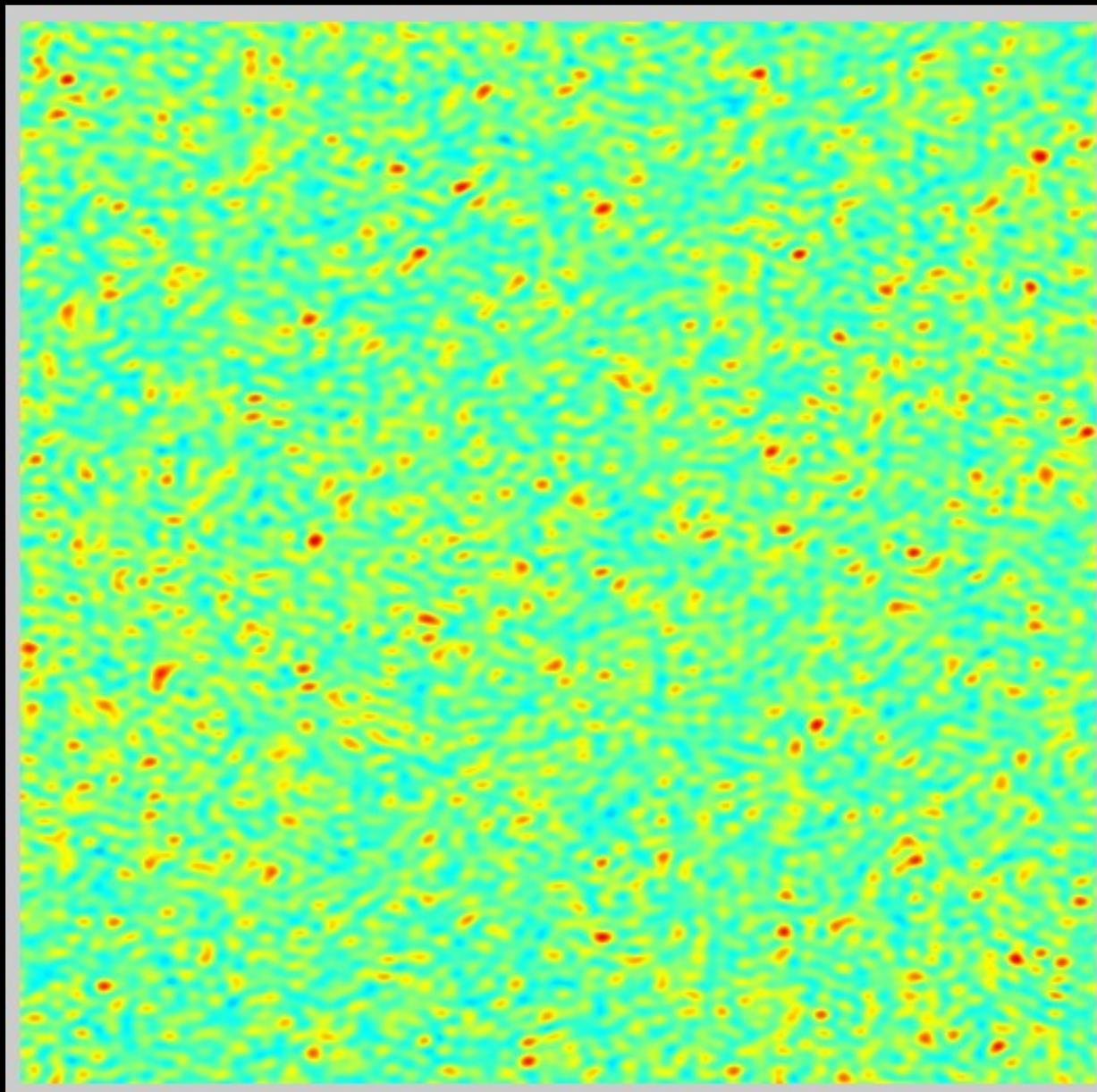
Reference Sky Inaccuracy

- If the reference sky is not perfectly accurate, then flux from real sources in the sky will not be properly subtracted from images
- The residual flux will obscure transients
- Much bigger effect than thermal noise
- Averages poorly over time, as errors are strongly correlated in time

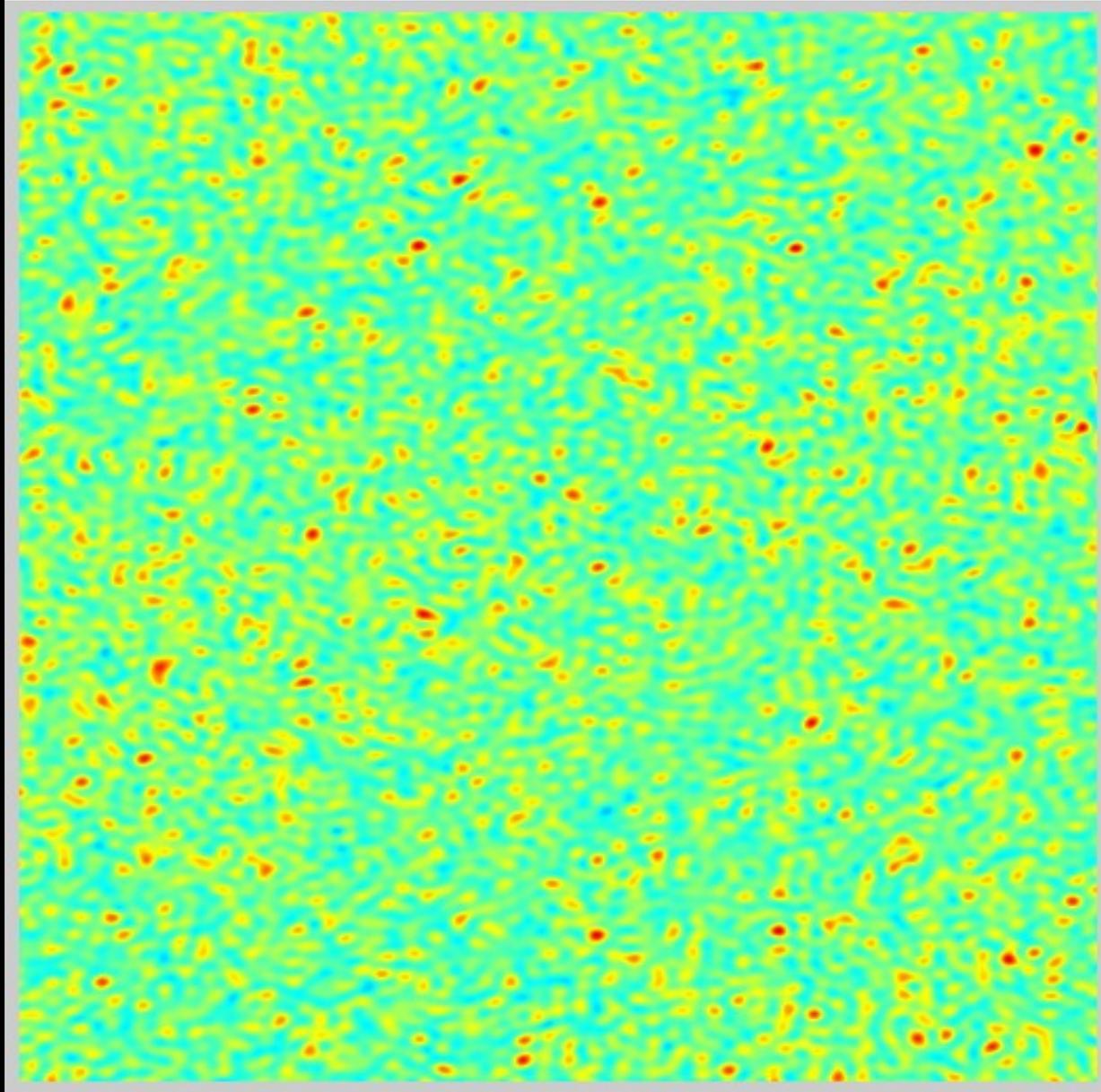
Reference Sky Inaccuracy



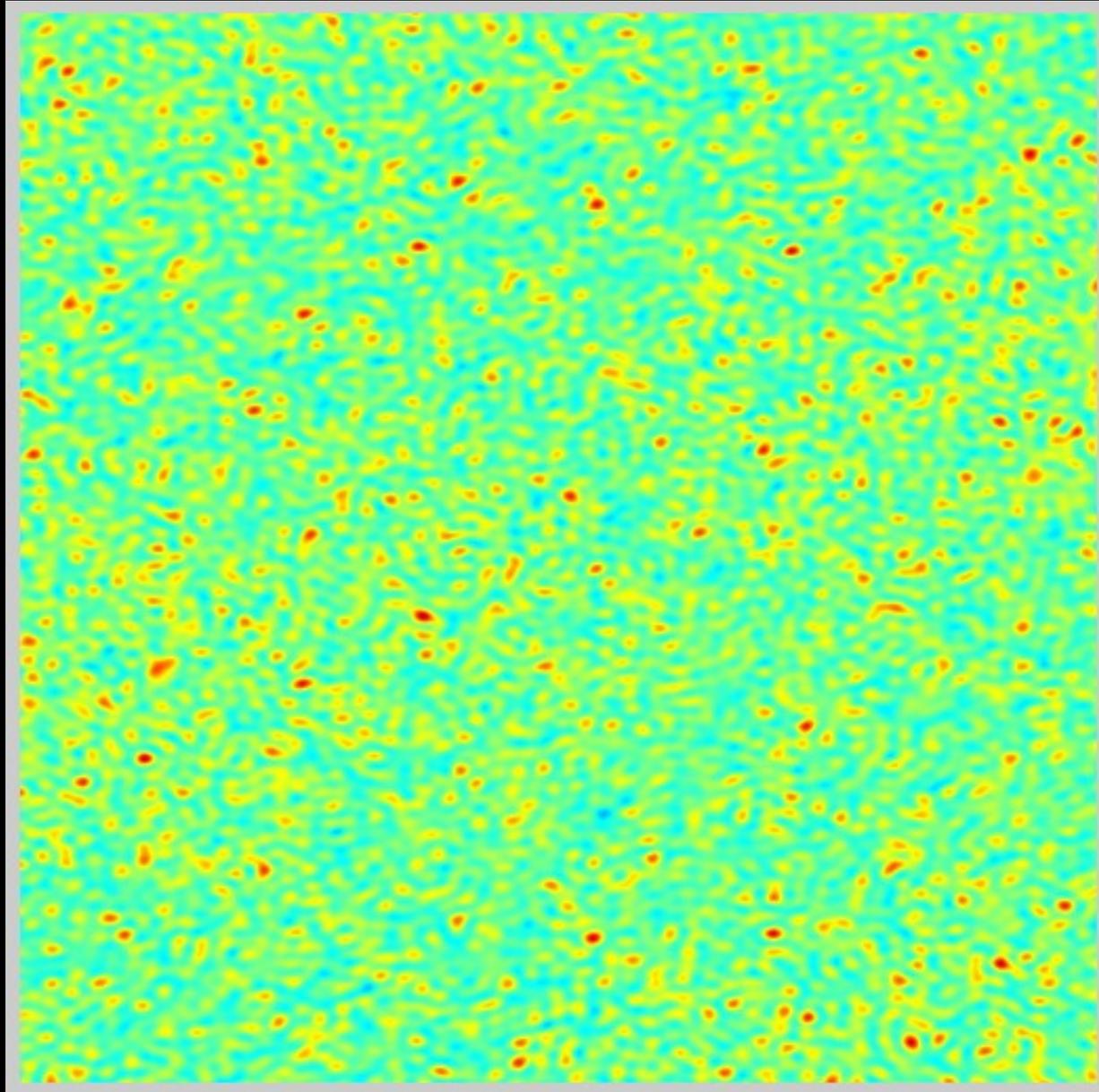
Reference Sky Inaccuracy



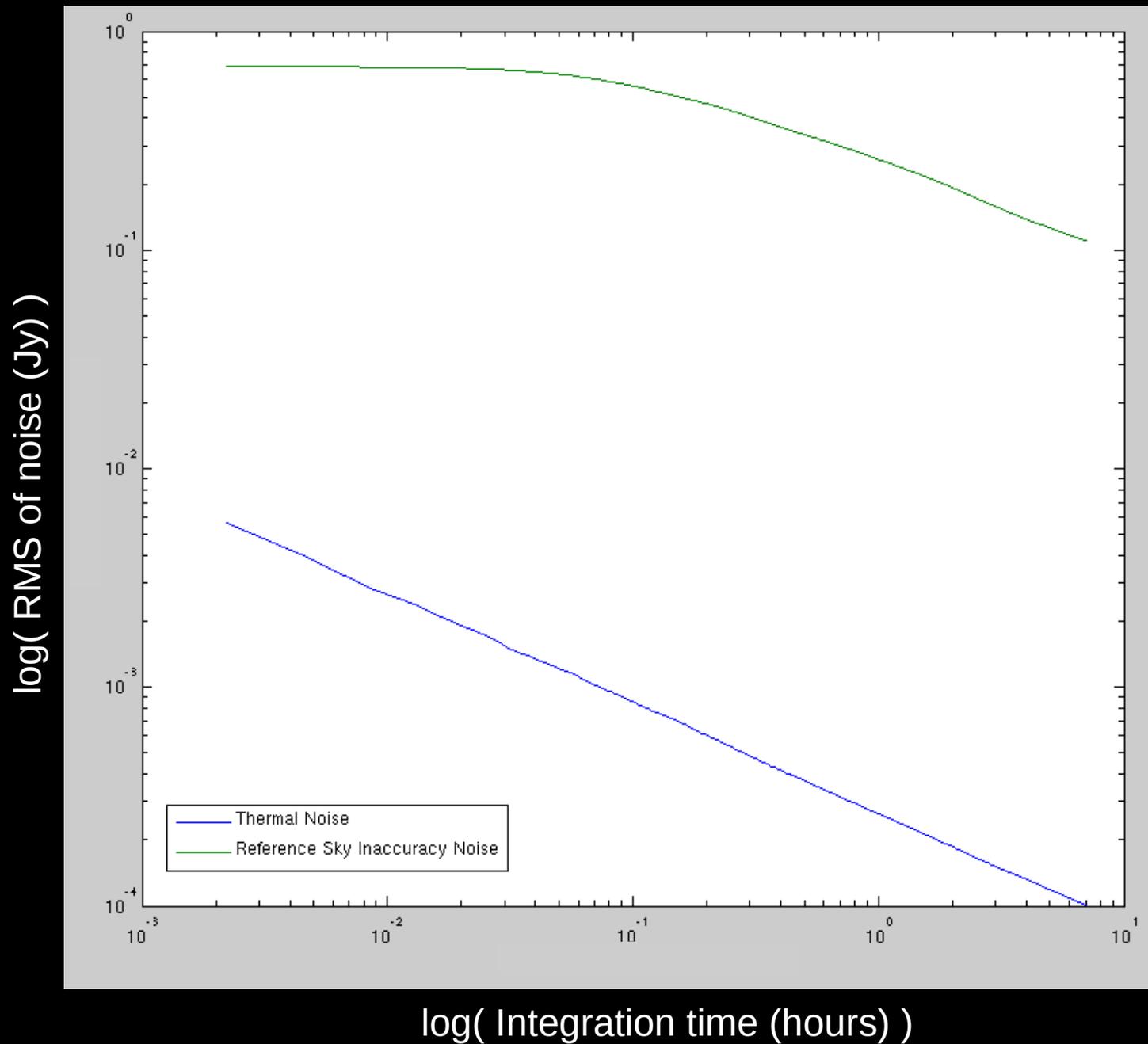
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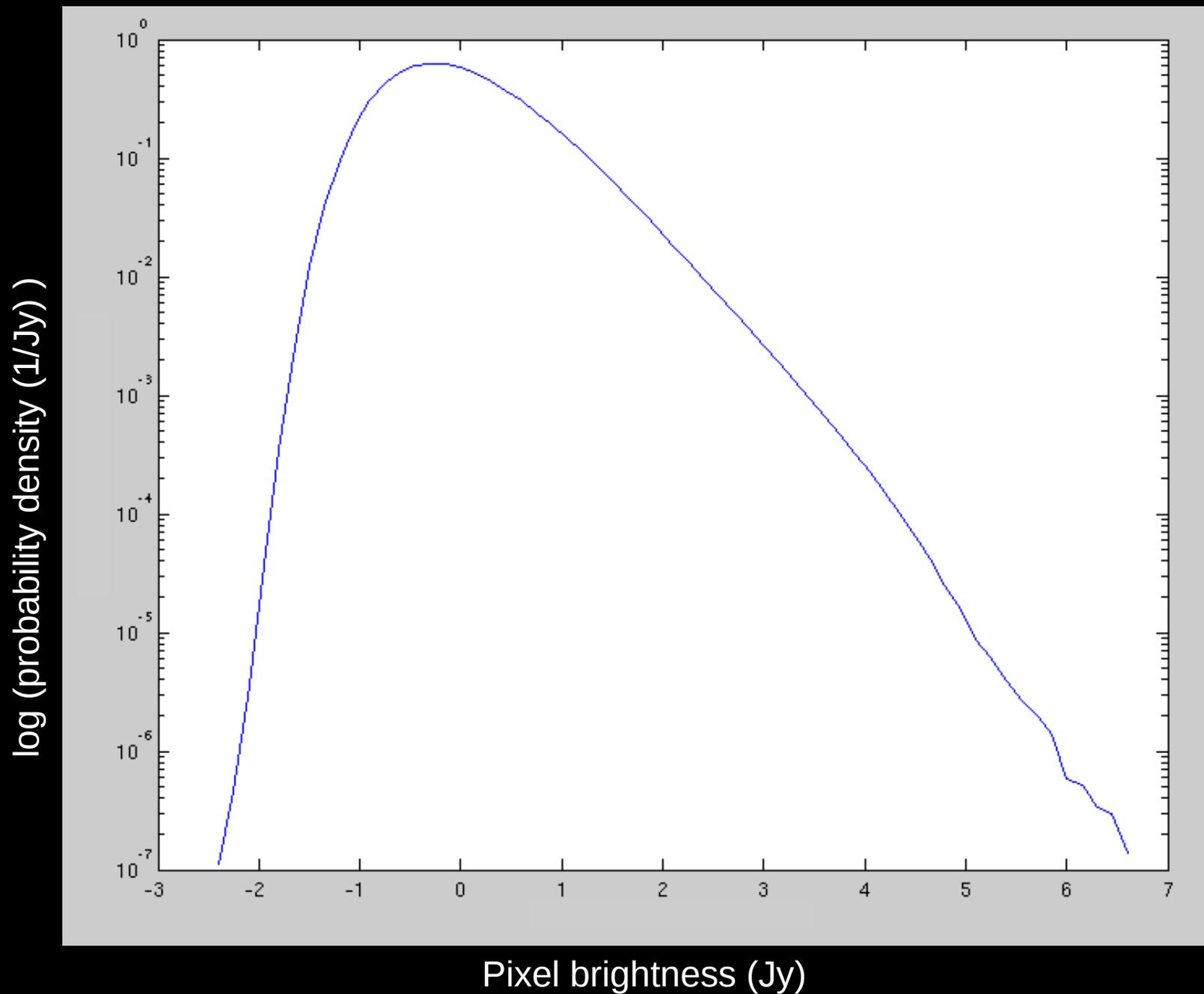
Reference Sky Inaccuracy



Noise in time average of difference maps



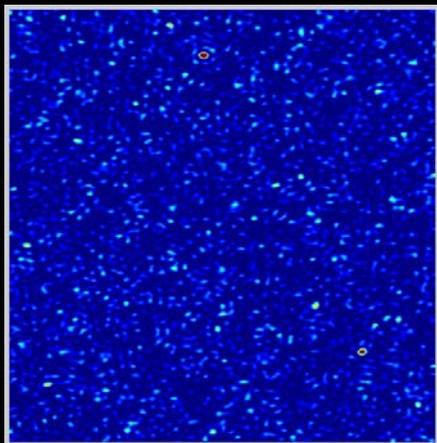
Reference Sky Inaccuracy Noise – Pixel Brightness Distribution



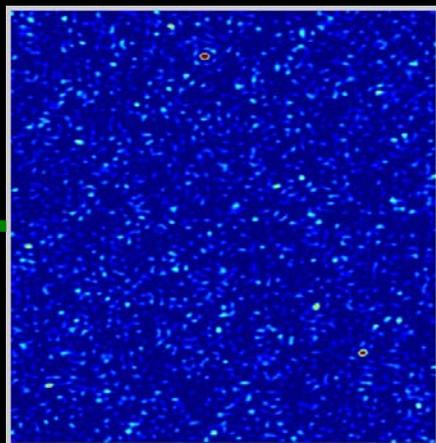
Time differencing

- Can reduce errors from reference sky inaccuracy on short timescales

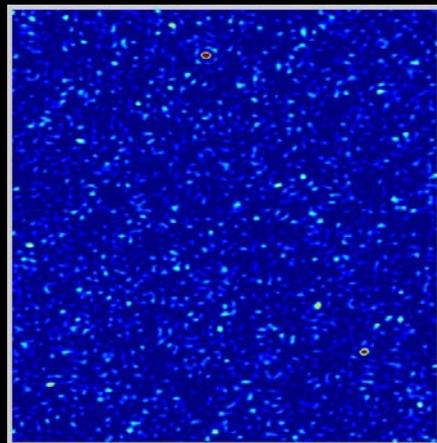
Observed image (t_0)



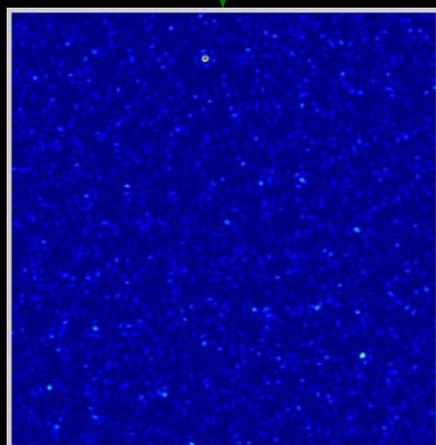
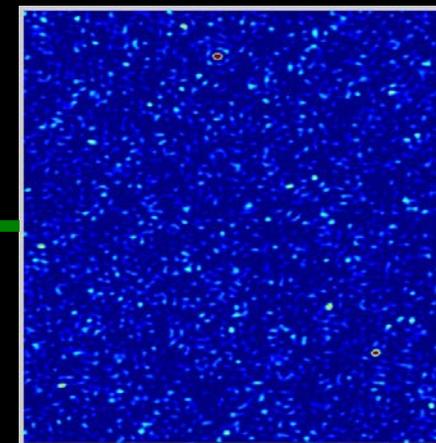
Predicted image (t_0)



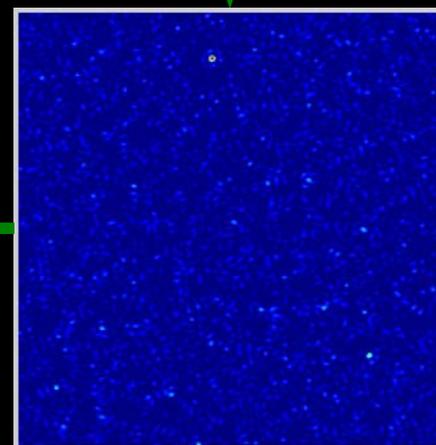
Observed image (t_1)



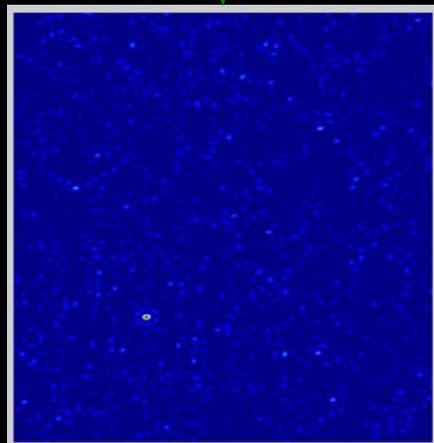
Predicted image (t_1)



Difference map (t_0)

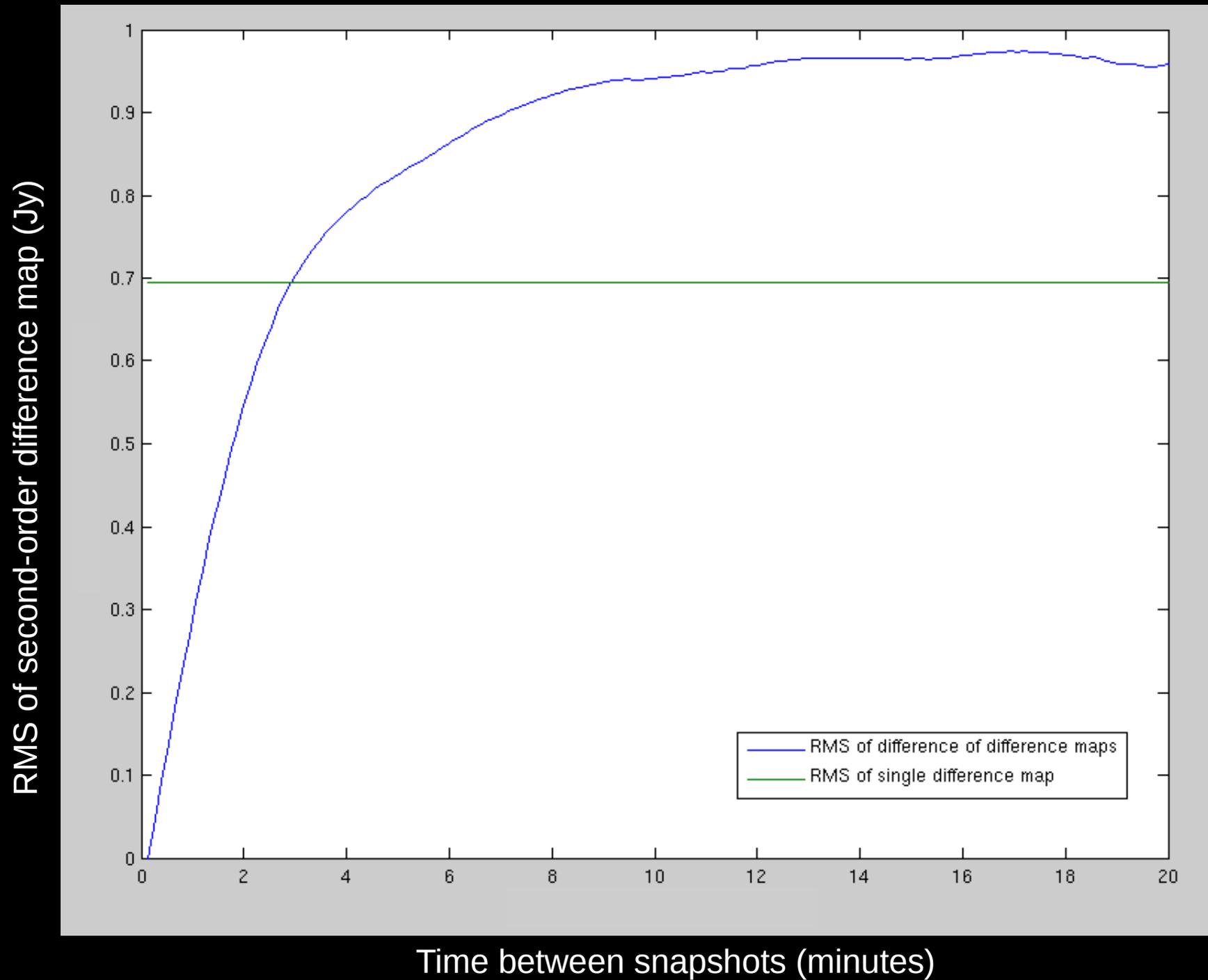


Difference map (t_1)

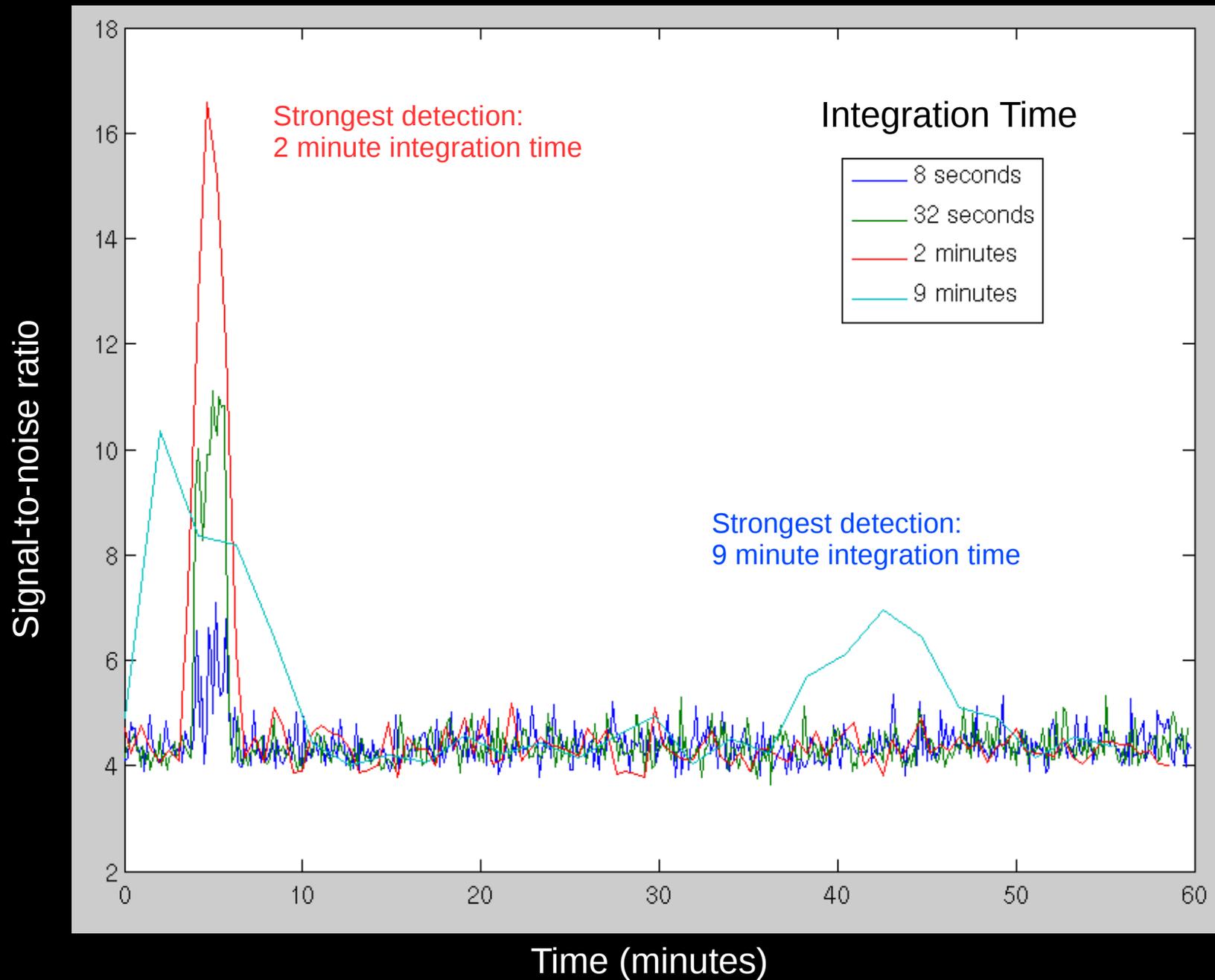


Second order difference map

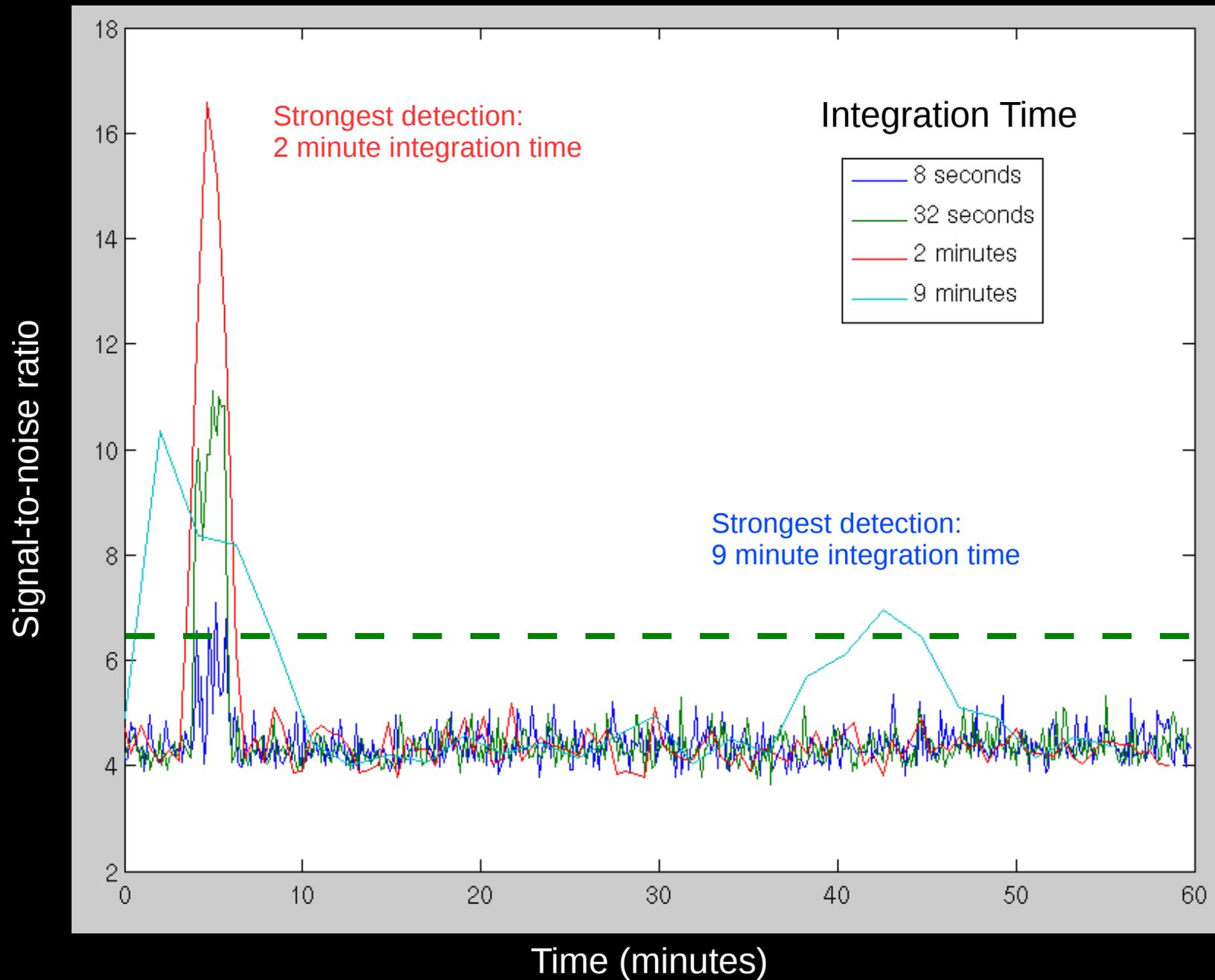
Noise in Second Order Difference Map



Example Transient Detection



Example Transient Detection



Acknowledgements

- My mentor, Roger Cappallo
- Divya Oberoi, Lynn Matthews, and Colin Lonsdale
- Richard Crowley
- Shane Rightley