VERY LARGE ARRAY SKY SURVEY

What NVSS sources does FIRST miss due to resolution effects?

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Galactic Center (Survey) Multiwavelength Image
Credit: X-ray: NASA/UMass/D.Wang et al., Radio: NRAO/AUI/NSF/NRL/N.Kassim, Mid-Infrared: MSX

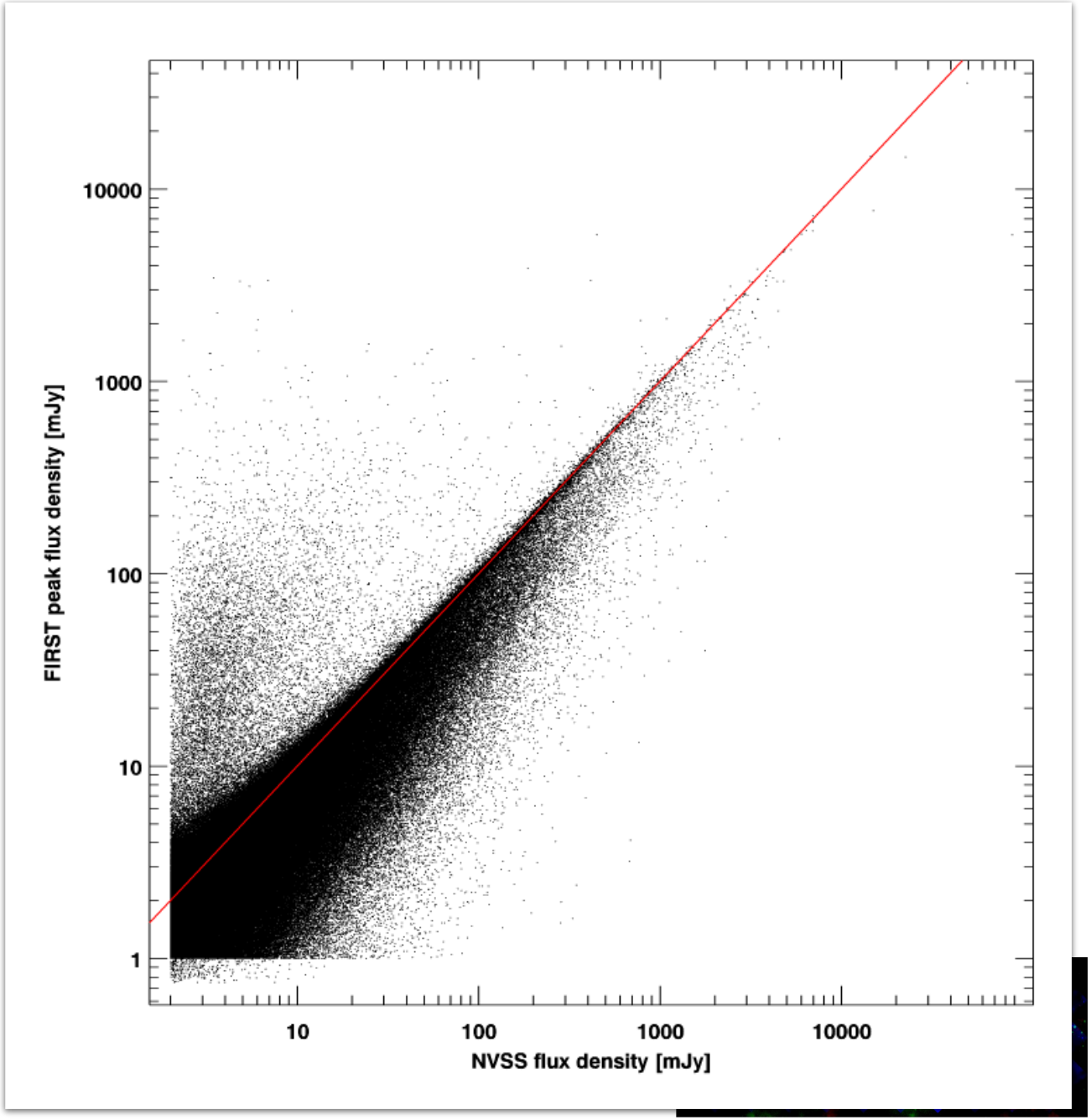
A question from the panel

5. What have we learned in retrospect from the comparison of 5.4” FIRST and 42” NVSS resolution mapping in the (SDSS) area of overlap? How much flux do isolated 2 - 10mJy FIRST sources miss compared to NVSS, and what does this loss imply for the optimal set of baselines chosen for VLASS?

FIRST F(peak) versus NVSS F(int)

FIRST sources fall below the line because many NVSS sources are resolved in FIRST

When multiple FIRST components match, the brightest peak value is used

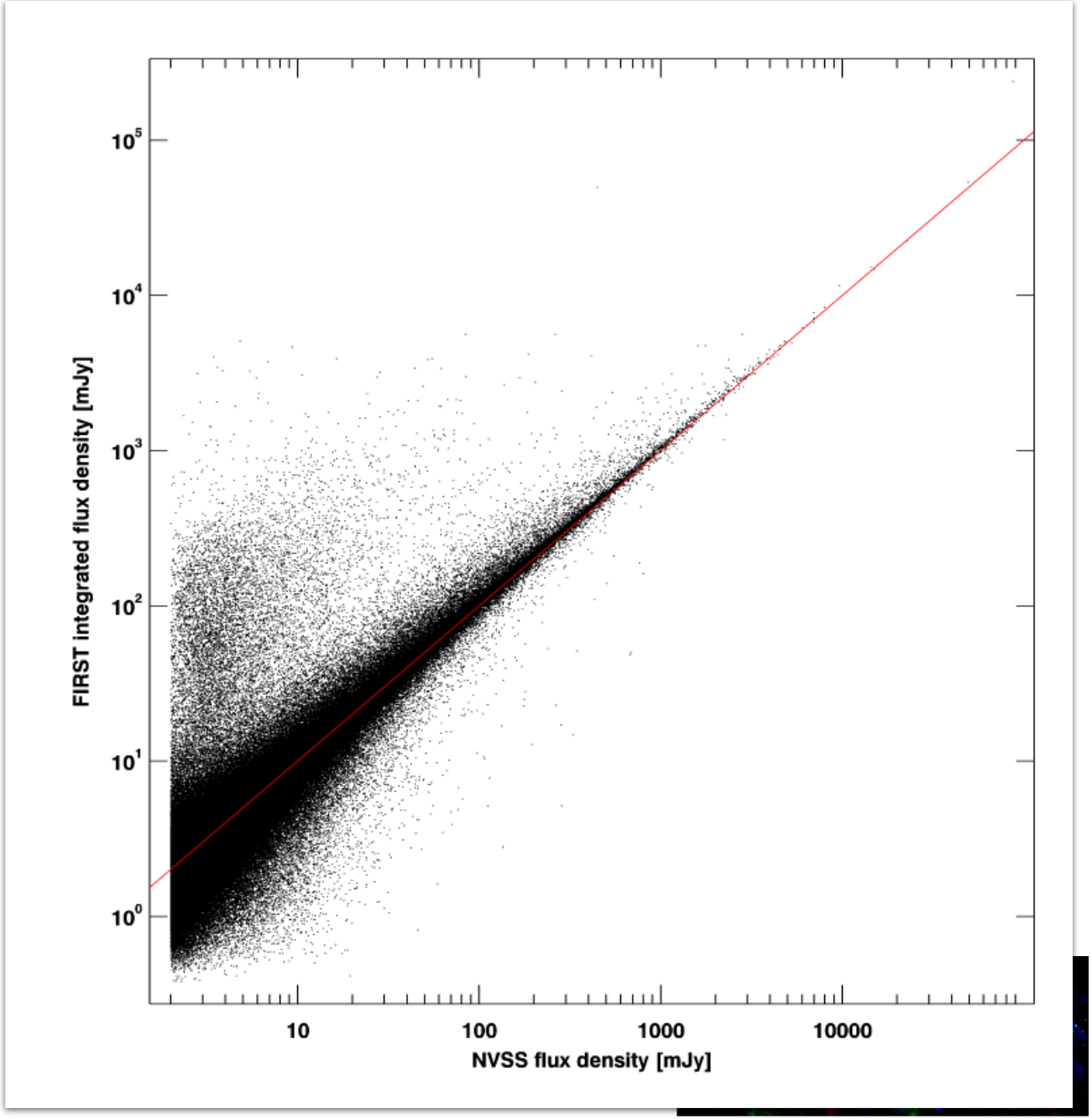


FIRST F(int) versus NVSS F(int)

For sources that are detected in FIRST, the integrated flux density is usually recovered accurately

When there are multiple matches, this shows the sum of all F(int)

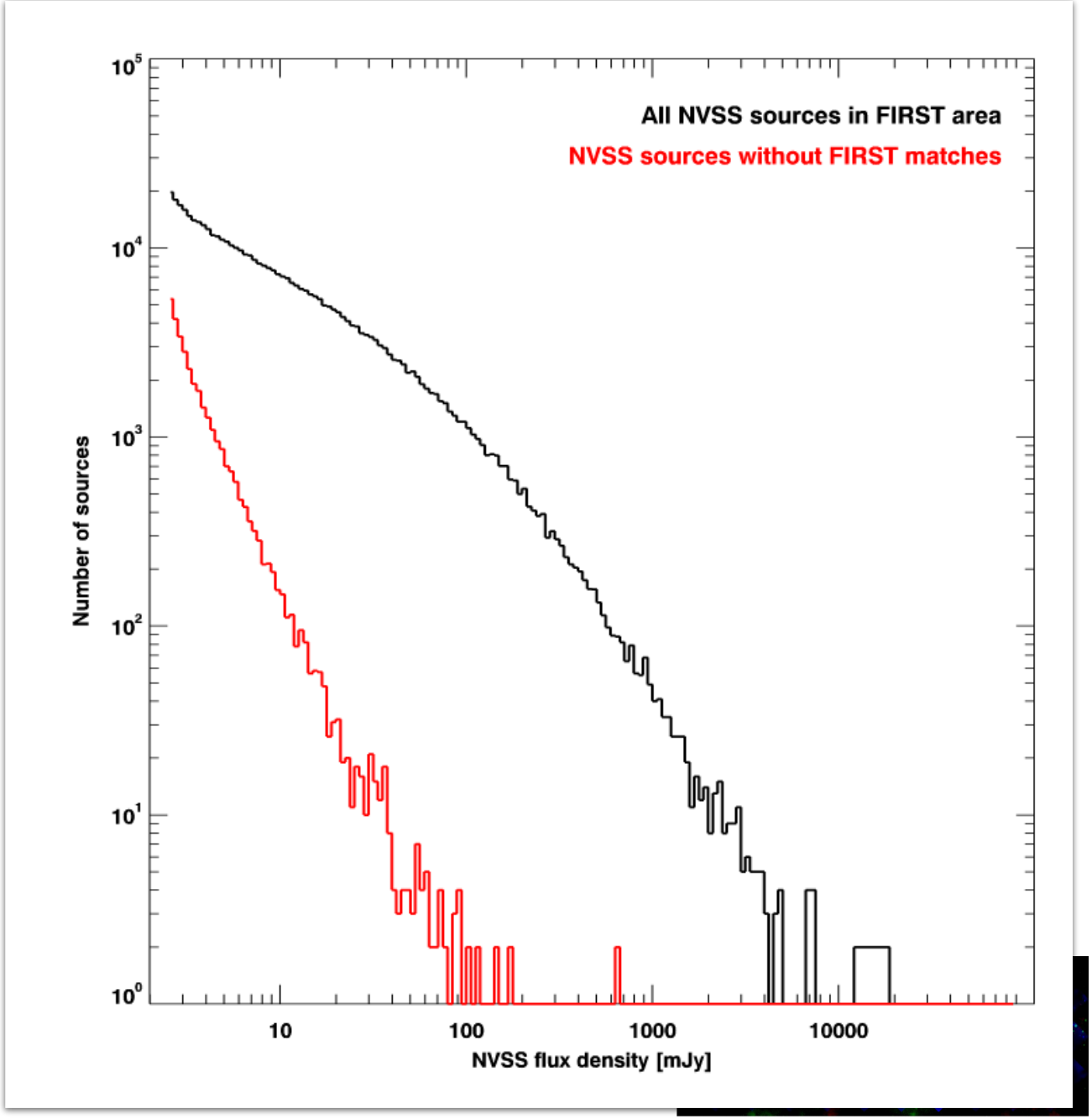
The rare objects where FIRST is much brighter are probably mis-matches, but some might be variables



NVSS sources missed by FIRST

Black histogram shows the flux histogram for all NVSS sources in the FIRST area

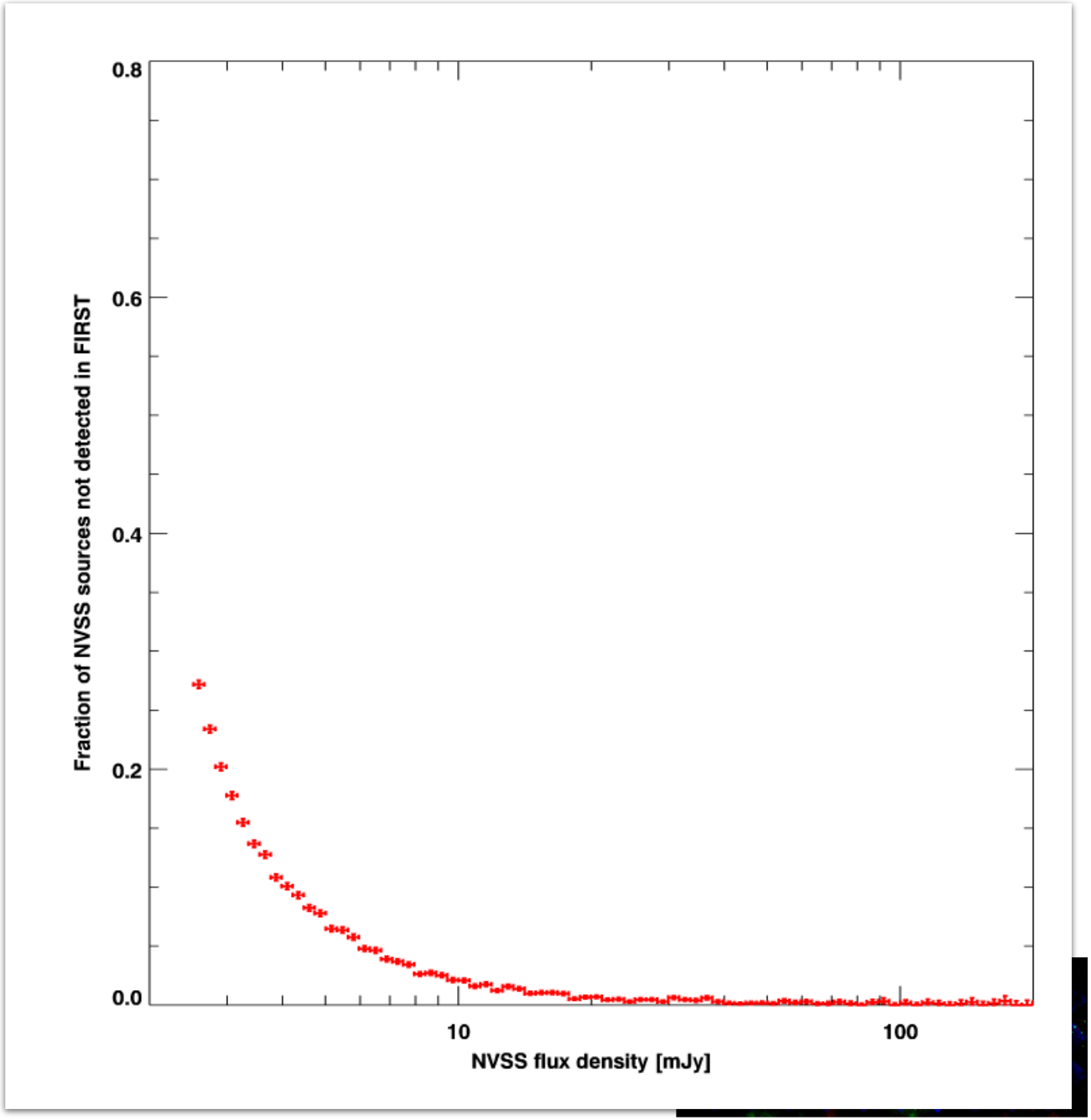
The red histogram is for NVSS sources that do not have a FIRST match



Fraction of NVSS sources with no match

Computed from the histograms in the previous plot

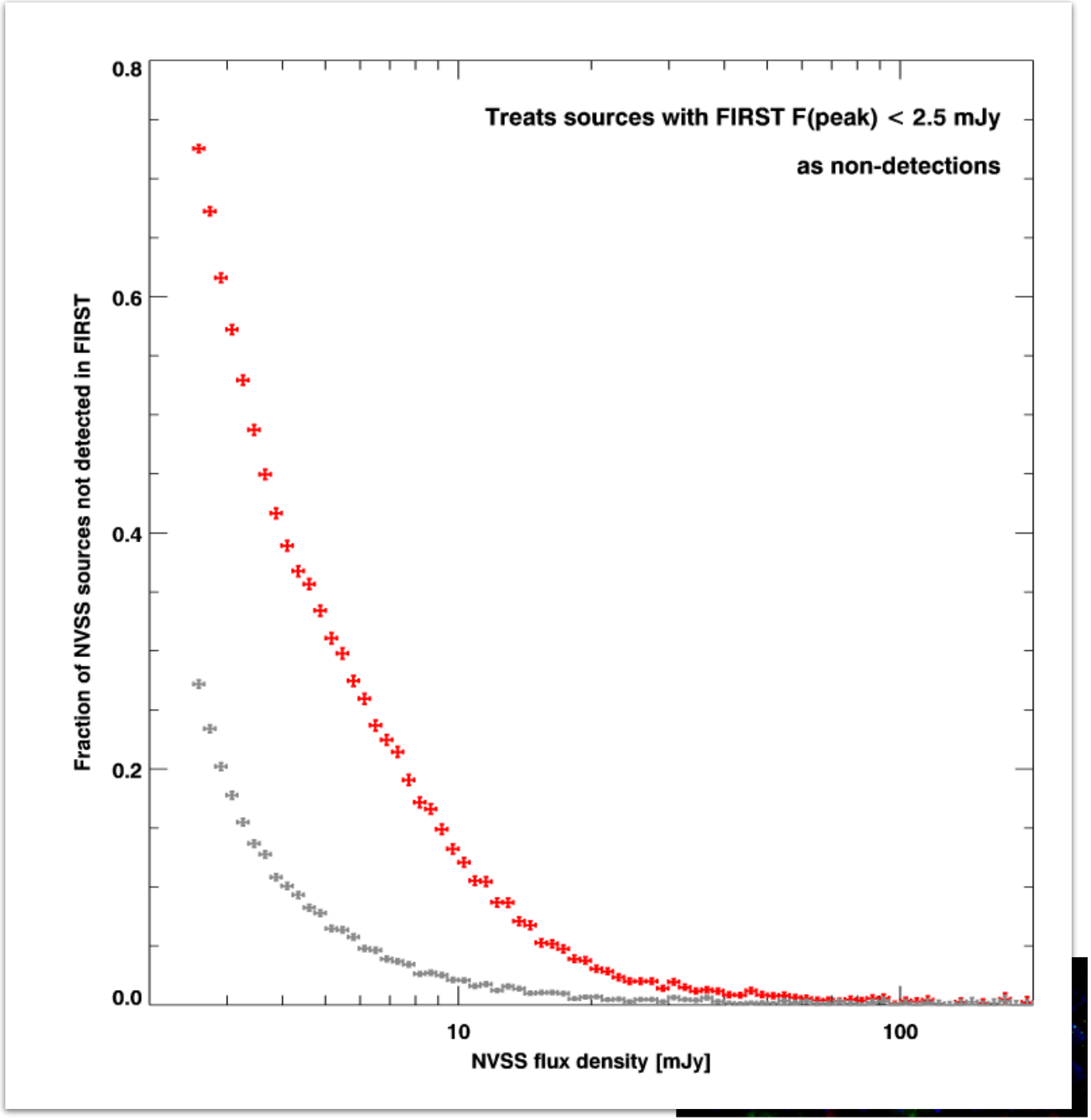
Error bars are noise estimates using binomial statistics



Non-detection fraction for equal sensitivity

FIRST is deeper than NVSS, so it is not a fair comparison to include all FIRST detections

This version also counts as non-detections FIRST sources with peak flux densities less than the NVSS detection limit of 2.5 mJy

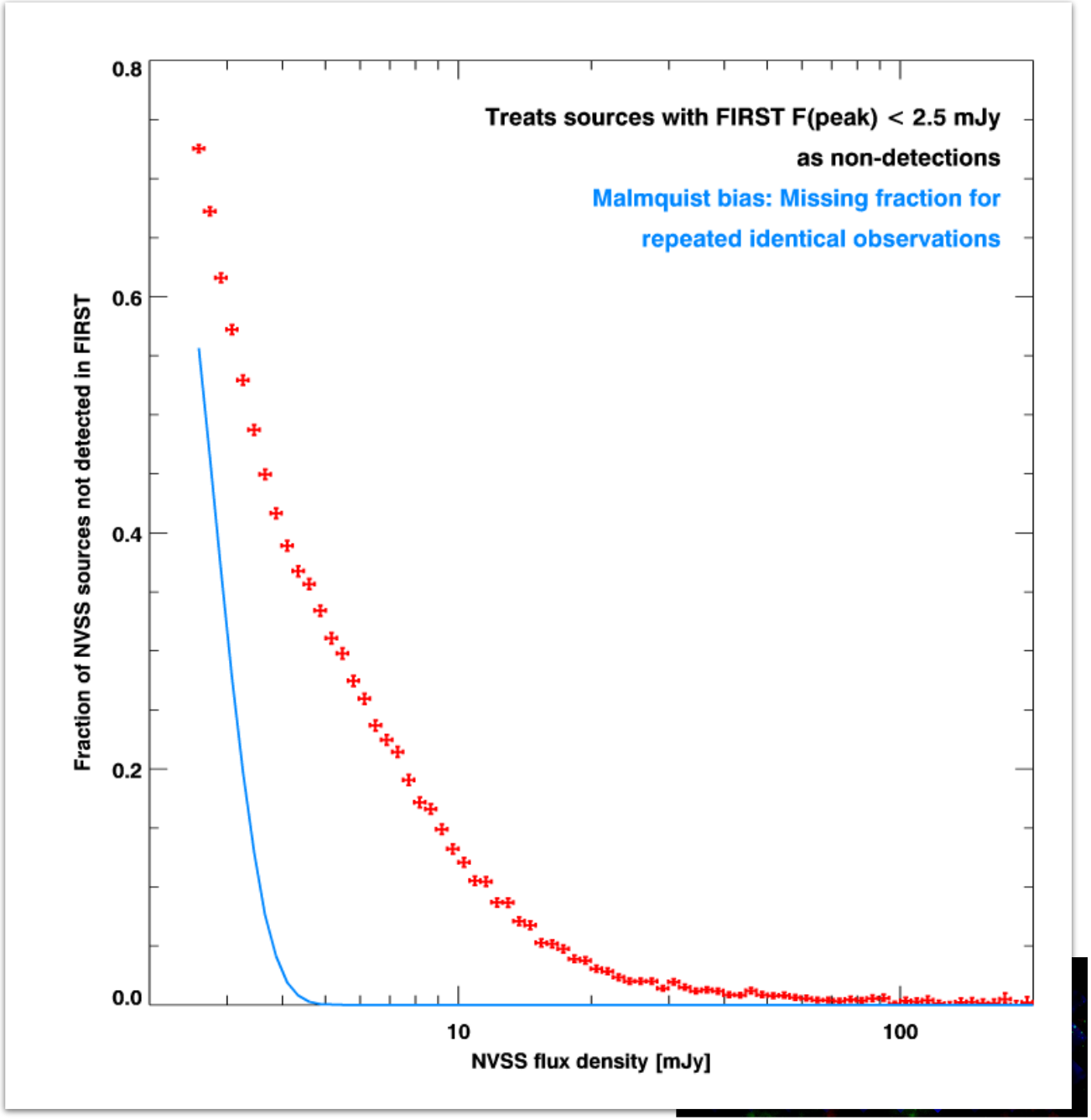


Malmquist bias at the detection threshold

But even repeated observations using exactly the same configuration will not detect all the sources.

The blue line shows the fraction of sources that will be missing in a repeated observation as a result of Malmquist bias.

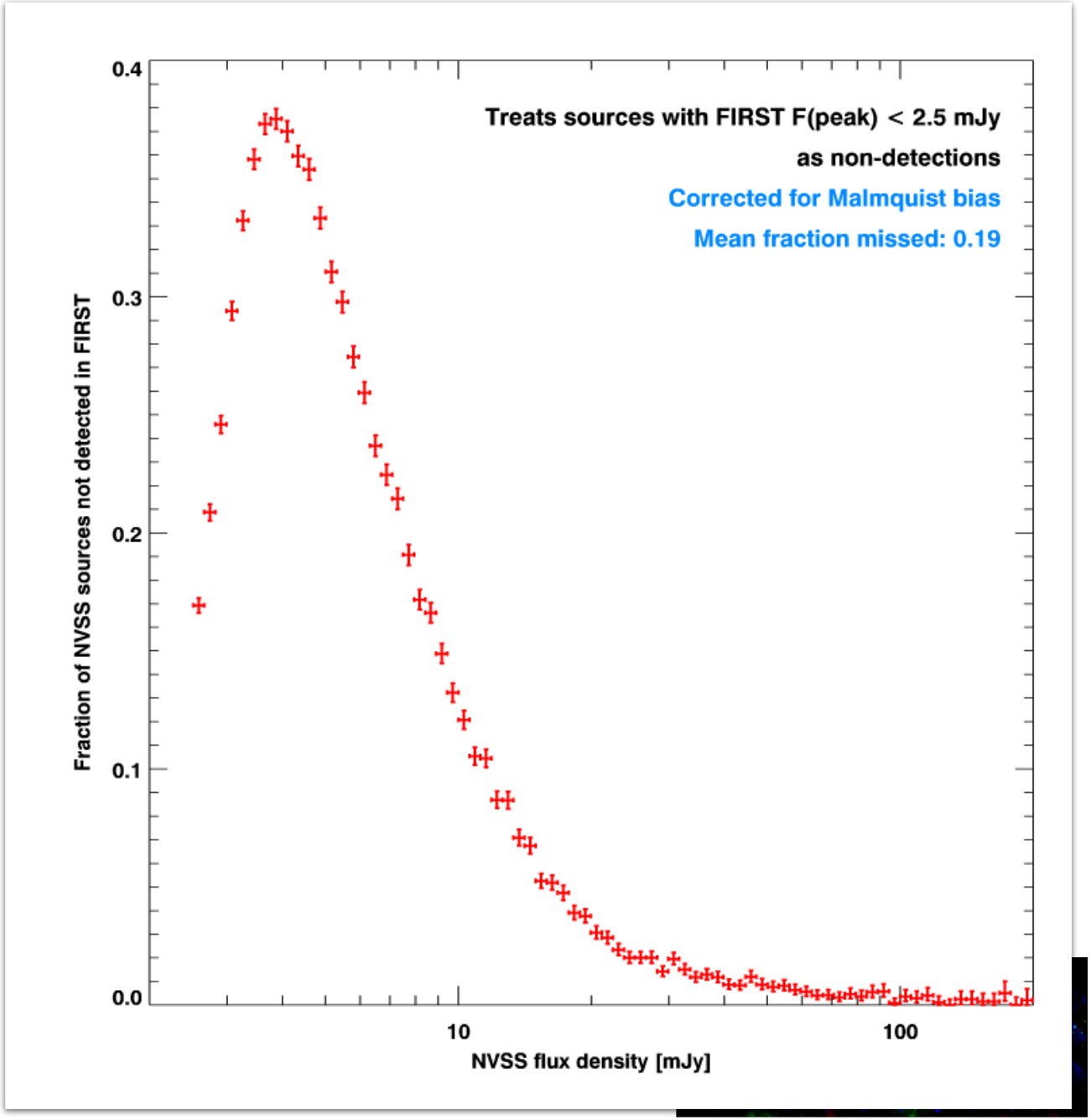
This effect is large at the threshold. It is greater than ½ because of rising number counts below the detection threshold.



Missing fraction after correcting for bias

The fraction of sources missing near the threshold is much reduced when Malmquist bias is corrected.

The missing fraction for the entire catalog is 19%.

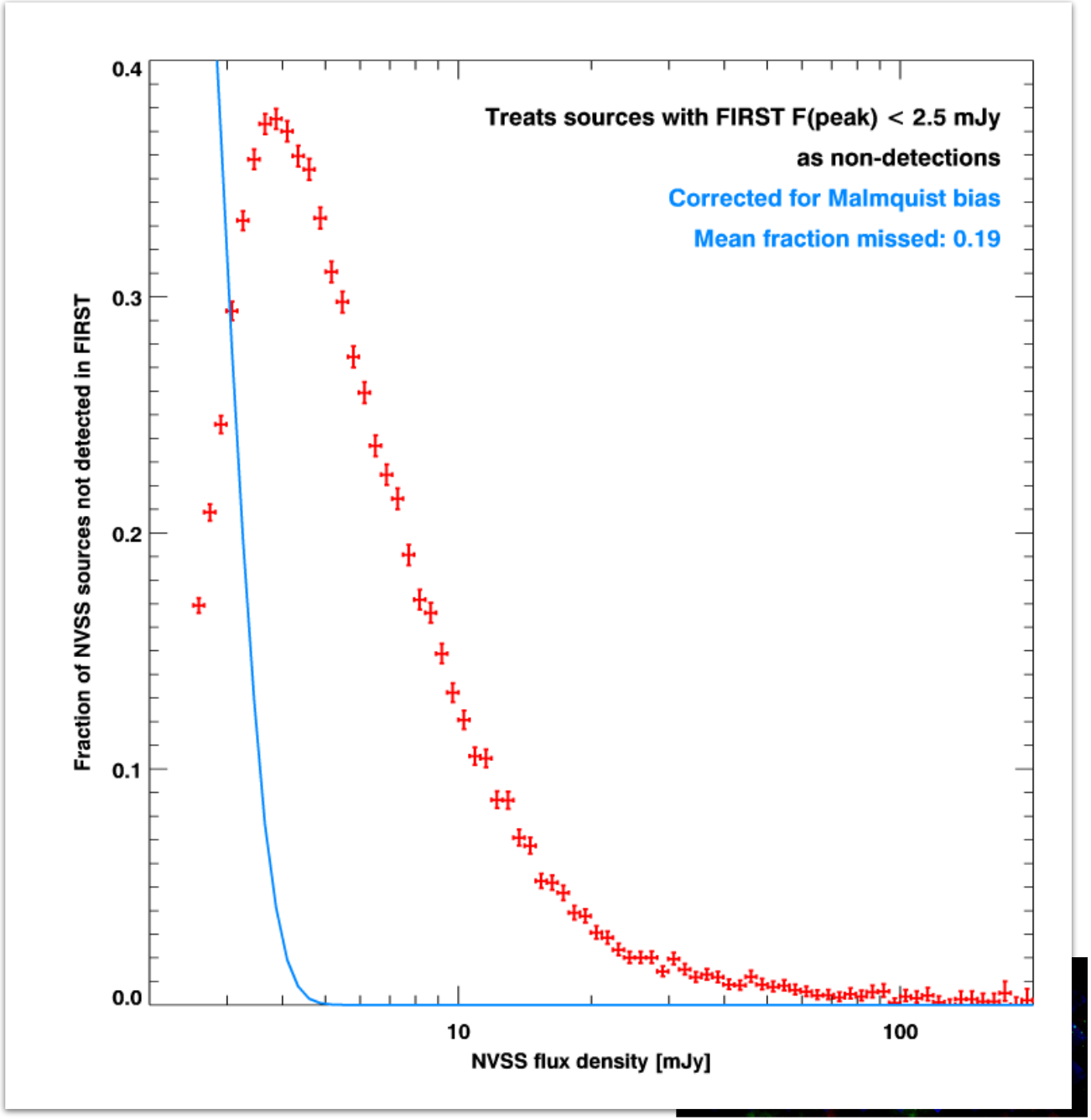


Bias is much larger than resolution at the threshold

The Malmquist bias is much larger at the threshold than the loss of sources due to resolution effects.

Overall 8.5% of sources would be missed in a second epoch of observations.

That is really a lower limit on the bias: NVSS artifacts, regions of higher noise, calibration errors, and source variability will all increase the bias.



Summary

- The fraction of NVSS sources missed by FIRST is more complicated than you think.
- Malmquist (detection) bias leads to a significant fraction of 8.5% of non-detections even in repeated observations using exactly the same configuration.
- After correcting for the bias, 19% of NVSS sources (45” FWHM) are not detected by FIRST (5.4” FWHM).
  - This assumes equal depth surveys – the actual FIRST catalog (without 2.5 mJy flux cut) detects a much higher fraction.
- NVSS & FIRST differ in resolution by a factor of 10, with beam areas a factor of 100 different.
  - Losses will be smaller for, e.g., VLASS vs EMU.
- FIRST accurately recovers the fluxes for the sources that it detects.

Missing fraction after correcting for bias

This missing fraction is an upper limit to the sources that are missing due to resolution effects.

The missing fraction decreases near the detection threshold, indicating that sources become more compact.

Deeper surveys will suffer less from increased resolution. Resolution is needed for identifications and does not severely affect detection efficiency.