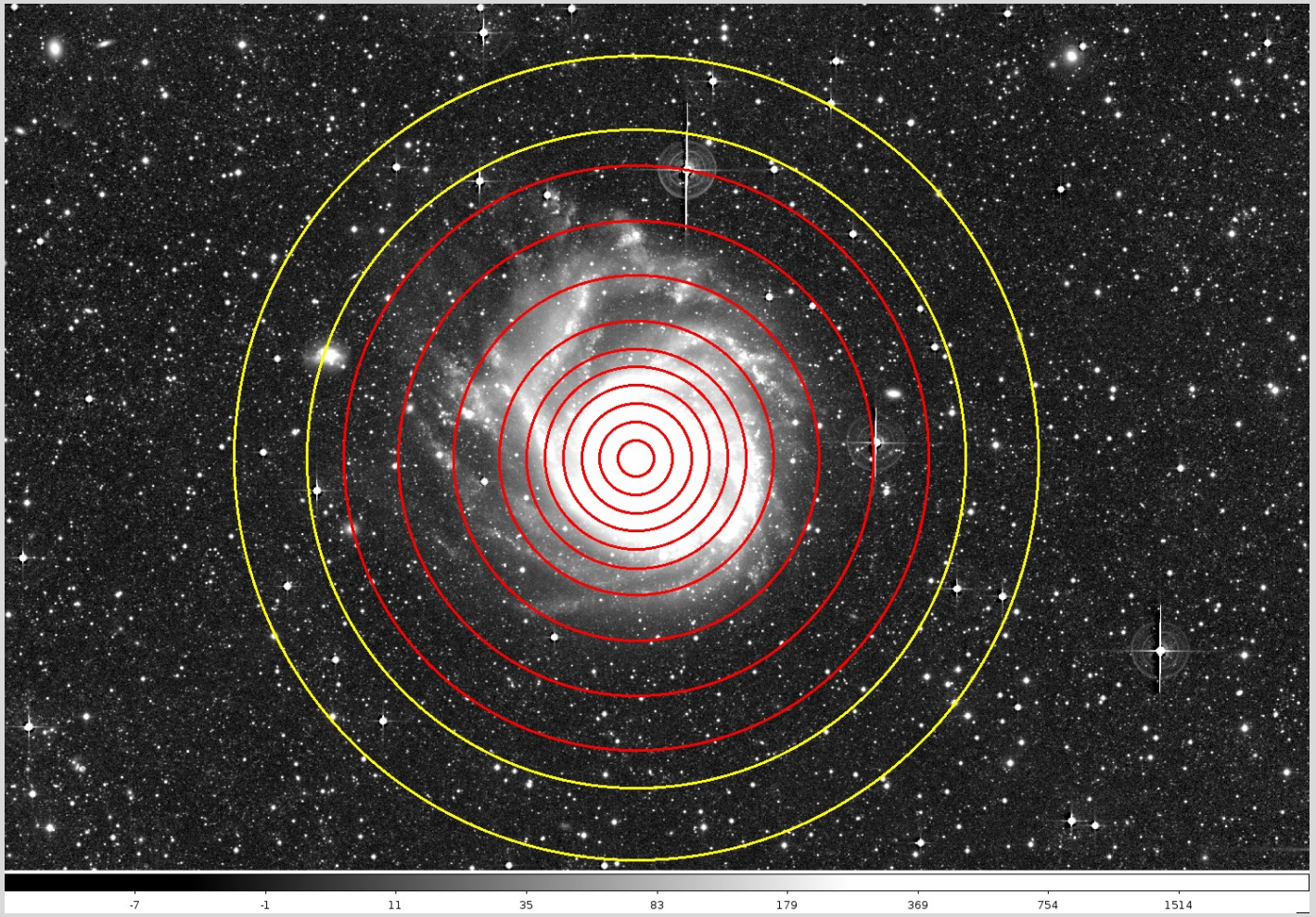
Surface Photometry *(measuring flux per area on the sky)*

M101

Surface Photometry *(measuring flux per area on the sky)* M101

Galaxy annuli and Sky annuli – *accurate sky estimate is critical!*



Beware of contamination: foreground stars, background galaxies, detector artifacts should be masked!

Surface Photometry

1. Measure average counts in background region: $\langle I_{sky} \rangle$

2. Bin all pixels by radius (annuli).

3. Calculate average (or median) counts ***per pixel*** in annuli:

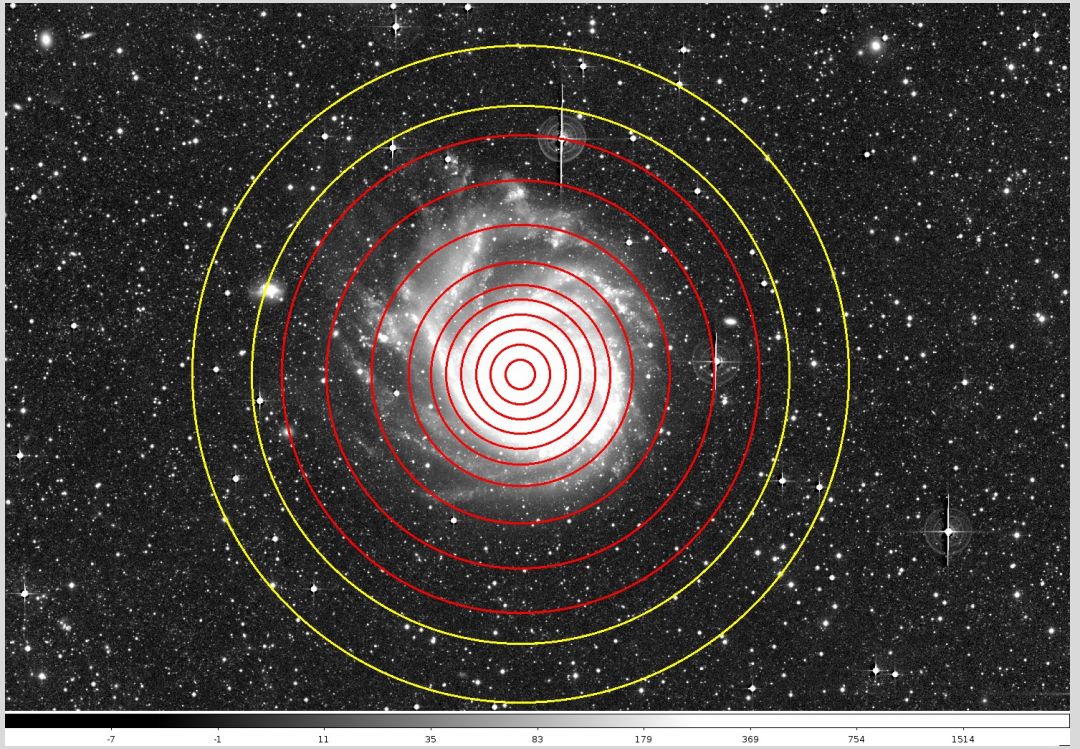
$$I_{pix} = \langle I_{raw} \rangle - \langle I_{sky} \rangle$$

4. Average (or median) surface brightness in annulus:

$$\mu = \underbrace{-2.5 \log(I_{pix}) + (\text{calibration terms})}_{\text{magnitude of a typical pixel}} + 2.5 \log(\text{area of 1 pixel})$$

$$\underbrace{\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad\qquad}_{\text{surface brightness of a typical pixel}}$$

If you are doing averages, this gives **exactly the same** answer as summing all flux in an annulus and dividing by the total area of the annulus.



Remember, observationally surface brightness is a logarithmic measure of flux per angular area on the sky:

$$\mu = m + 2.5 \log(Area)$$

5. Measure surface brightness in two filters (say B and V), then calculate colors by:

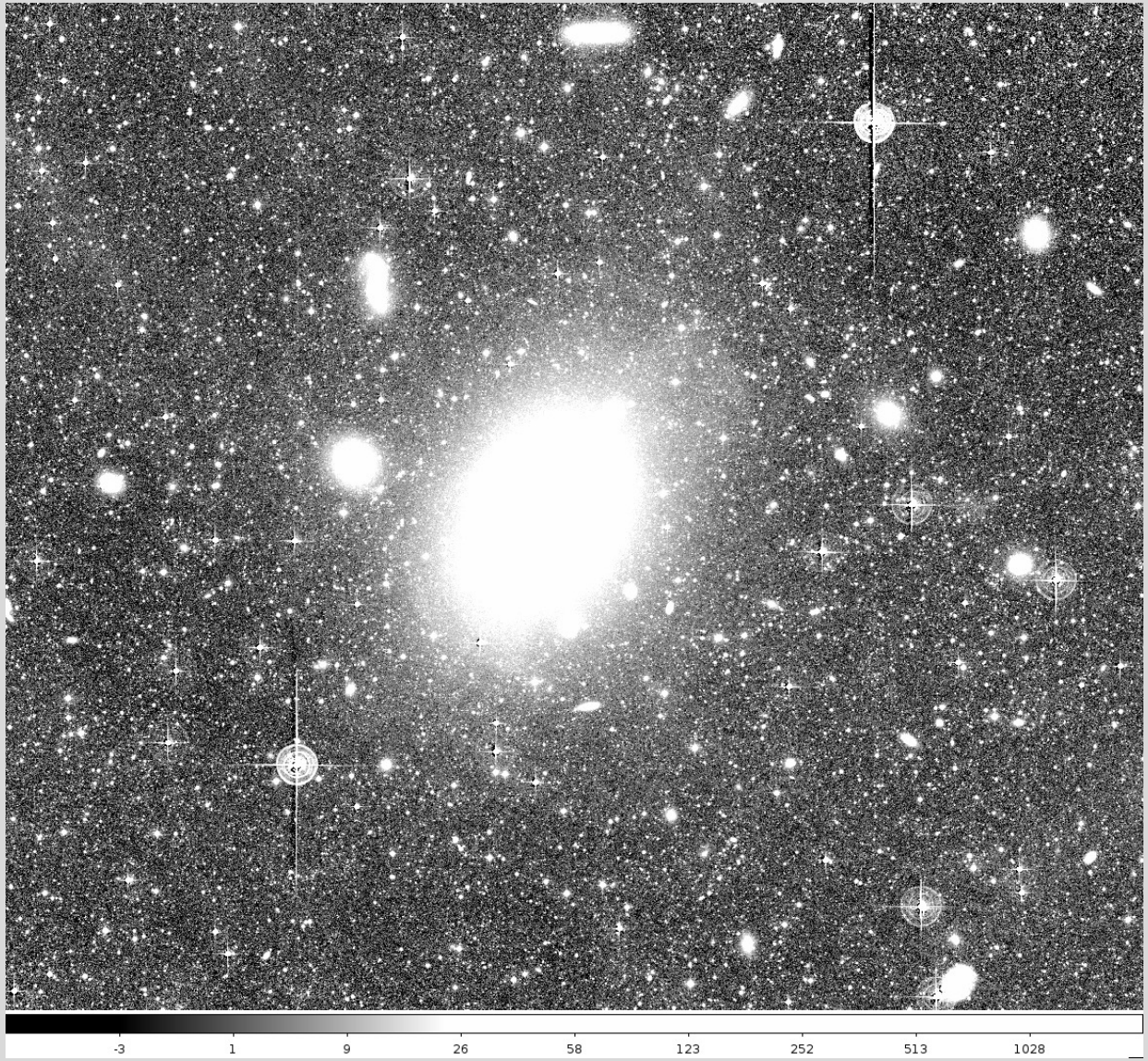
$$B - V = \mu_B - \mu_V$$

Surface Photometry *(measuring flux per area on the sky)*

M49

Easy to generalize into elliptical annuli with axis ratios a and b.

"Radius" typically then refers to semi-major axis of the ellipse (a) or geometric radius ($\sqrt{ab}$).



Surface Photometry *(measuring flux per area on the sky)*

M49

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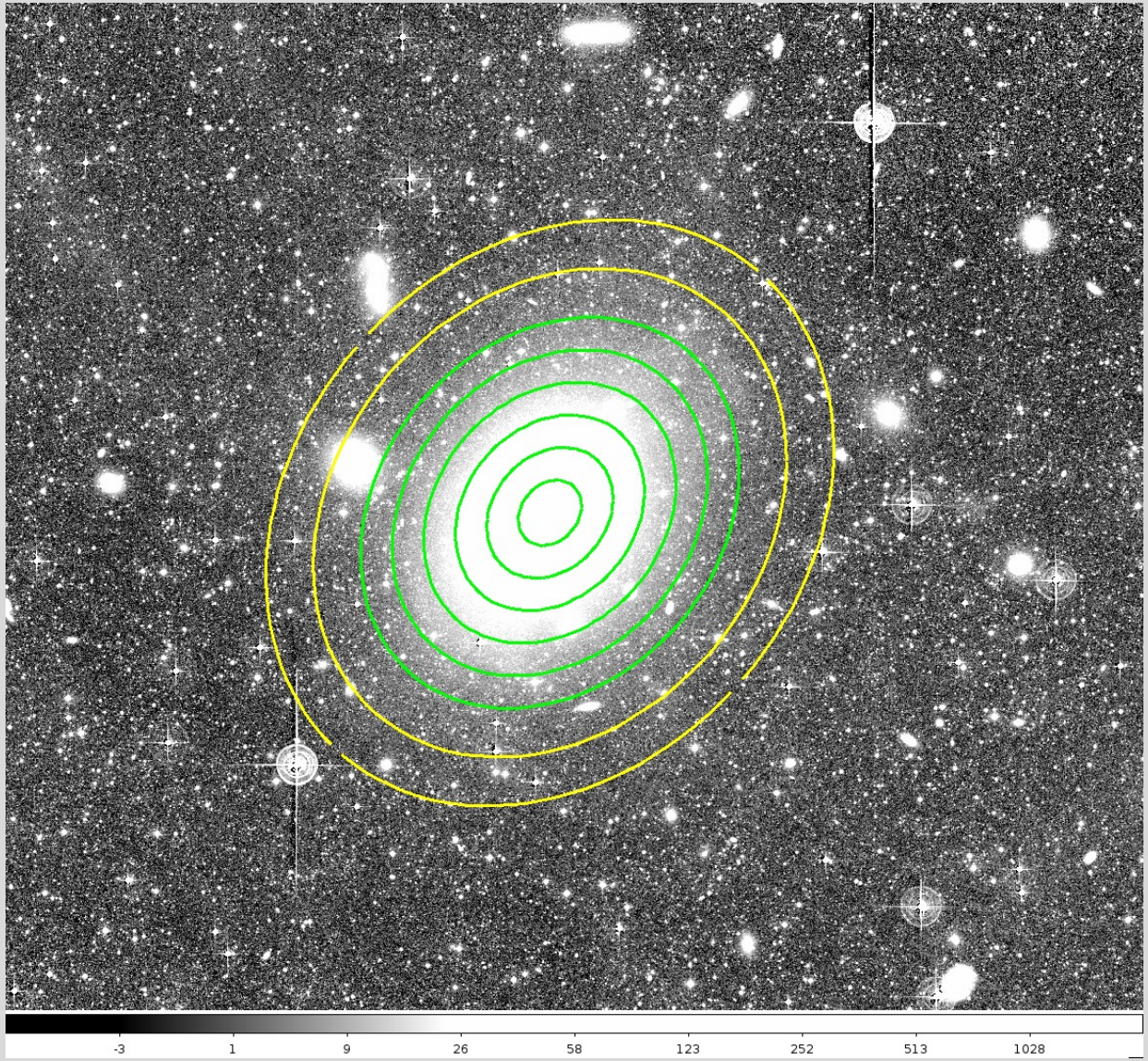


Reminder: Surface Brightness Profiles for galaxies

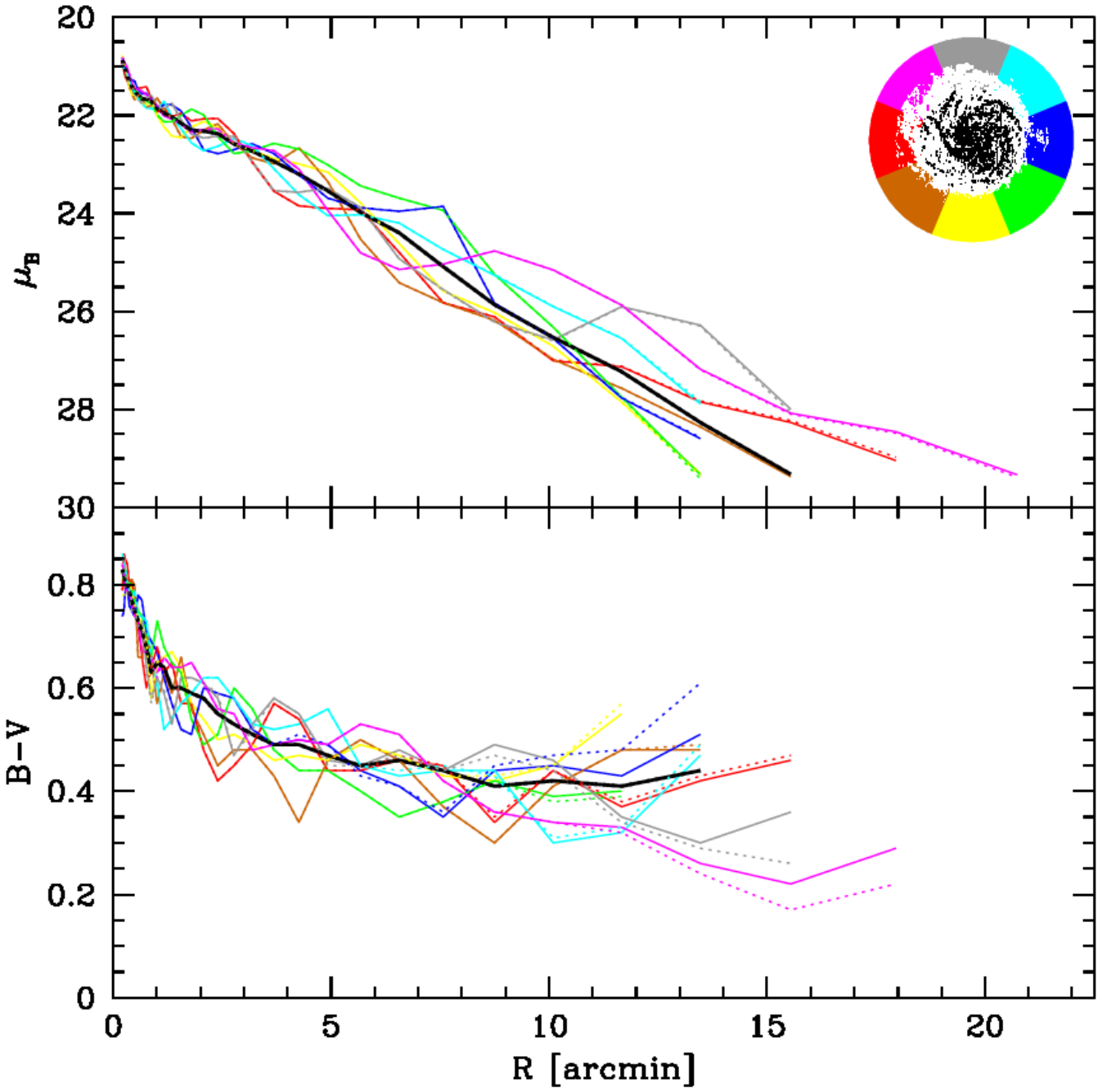
Spiral galaxies (M101)

Exponential disks: $I(r) = I_0 e^{-r/h}$

In surface brightness:

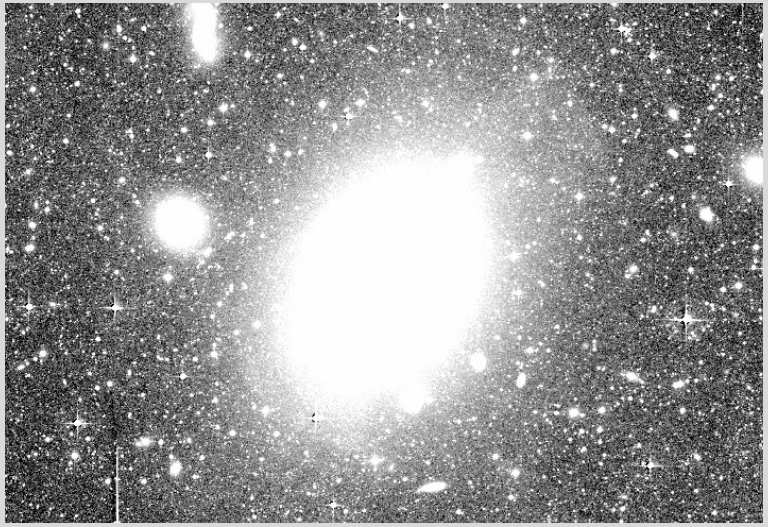
$$\mu(r) = -2.5 \log\big(I(r)\big) = \mu_0 + \frac{2.5}{h \ln 10} r$$

This is a straight line when plotting μ vs r



Reminder: Surface Brightness Profiles for galaxies

Elliptical galaxies (M49)



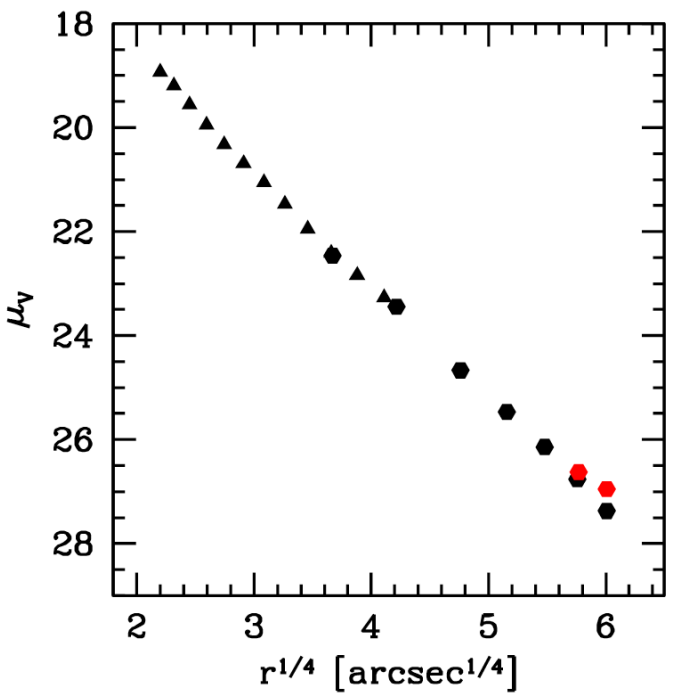
Sersic profiles: $I(r) = I_e e^{-b_n[(r/r_e)^{1/n}-1]}$
Typically $n \sim 4$ (i.e. "r$^{1/4}$ law")

In surface brightness:

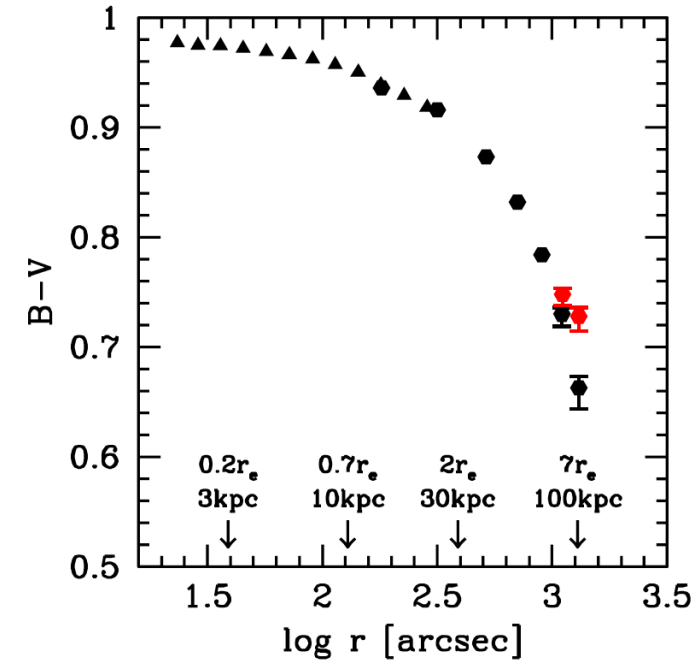
$$\mu(r) = -2.5\log\big(I(r)\big) = \mu_e + \frac{2.5 b_n}{\ln 10}\left[(r/r_e)^{1/n} - 1\right]$$

(For n=4) This is a straight line when plotting μ vs $r^{1/4}$

V-band Surface brightness as a function of r$^{1/4}$



B–V color as a function of log(r)



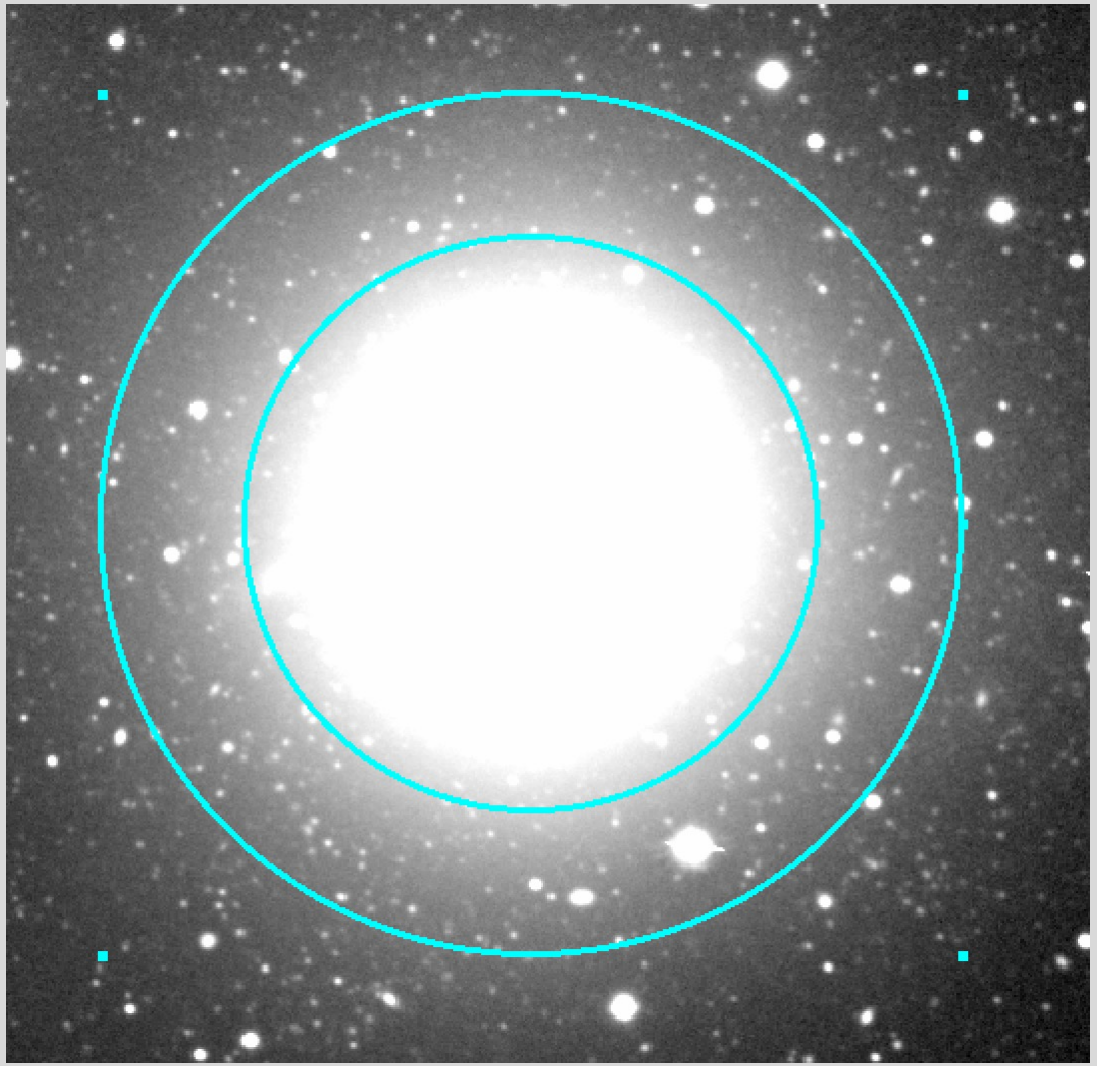
Dealing with Contamination (important for M101 project!)

Background galaxies and foreground stars often litter the image. How do we get rid of them?

Masking: Digitally “zero out” bright compact sources. Mask-designing can be complicated, though, and faint sources are hard to mask.

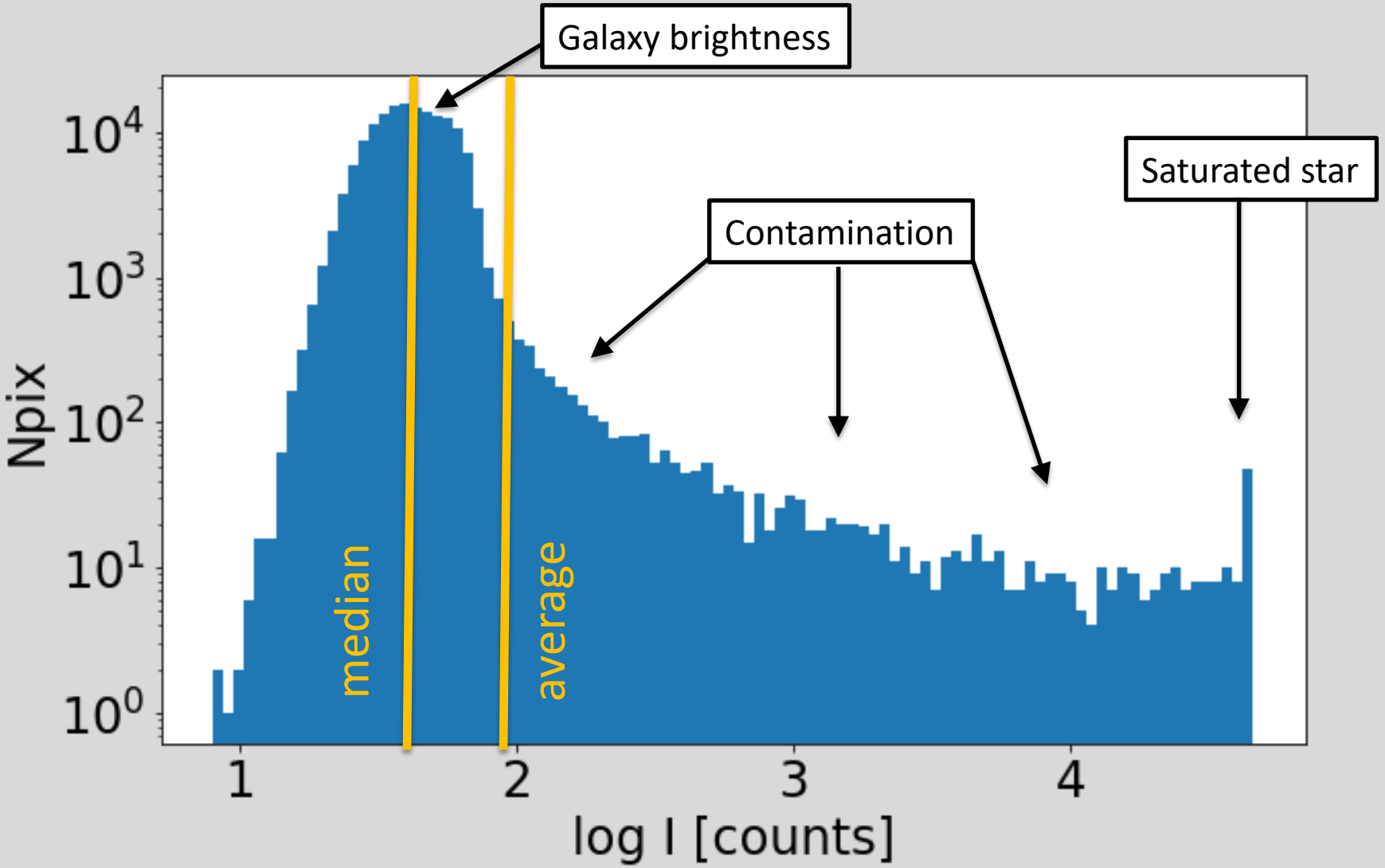
Statistics: Compact sources are bright objects covering only a small number of pixels. Most pixels are fine. Use statistics to ”ignore” bright compact source pixels.

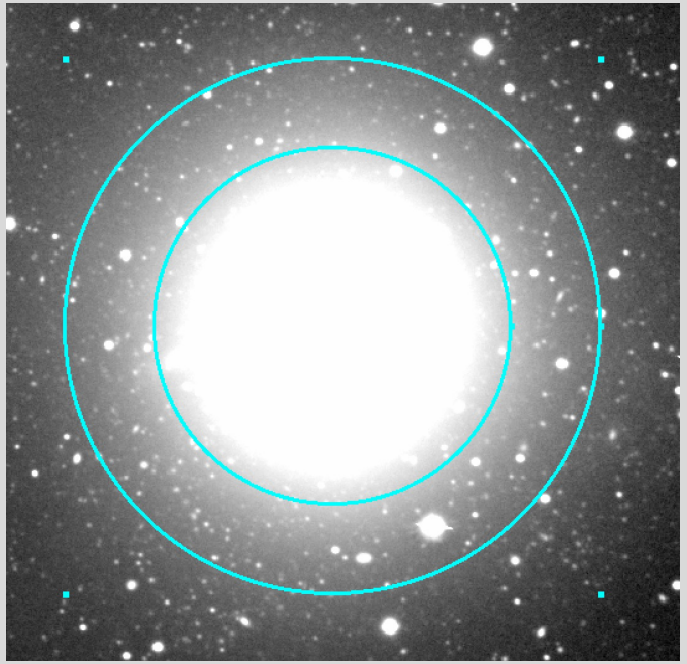
(Best solution is a combination of both….)



Dealing with Contamination: Statistical Approach

Look at histogram of pixel intensity values (I) in that annulus.
Important: this Is a log-log plot!





Average pixel value: strongly affected by the small number of VERY bright pixels. *Not what we want!*

Median pixel value: Less affected by a the small number of superbright pixels. *Much better estimate of the galaxy light!*

Caveat

Be careful: not every compact source is a contaminant!

Spiral galaxies have lots of bright compact star forming regions that shouldn't be ignored.

LIFE AS AN ASTRONOMER IS HARD.