

# **Bright star mask for S19A (ver. 20200303)**

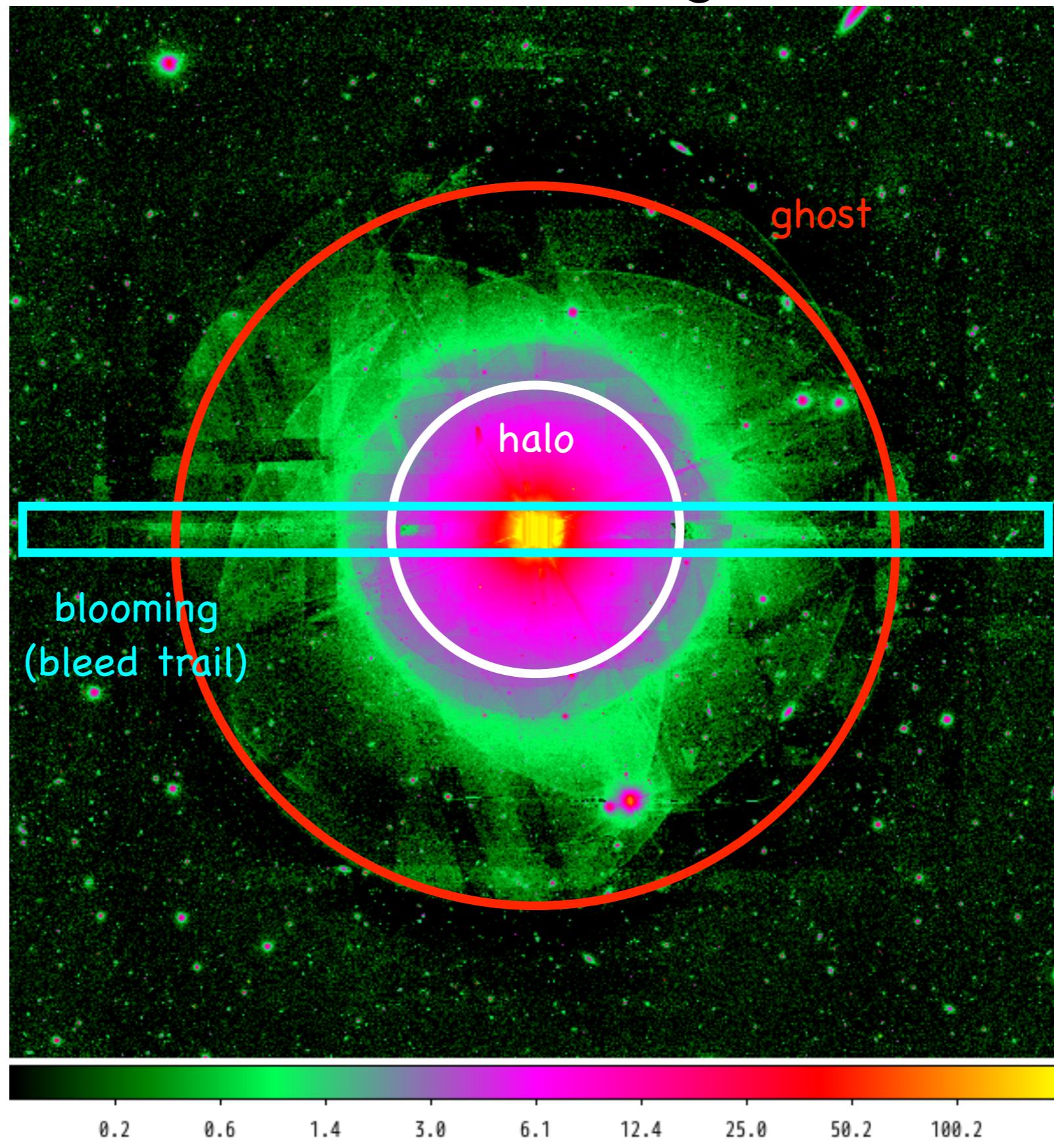
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Update: 20200526

# Introduction

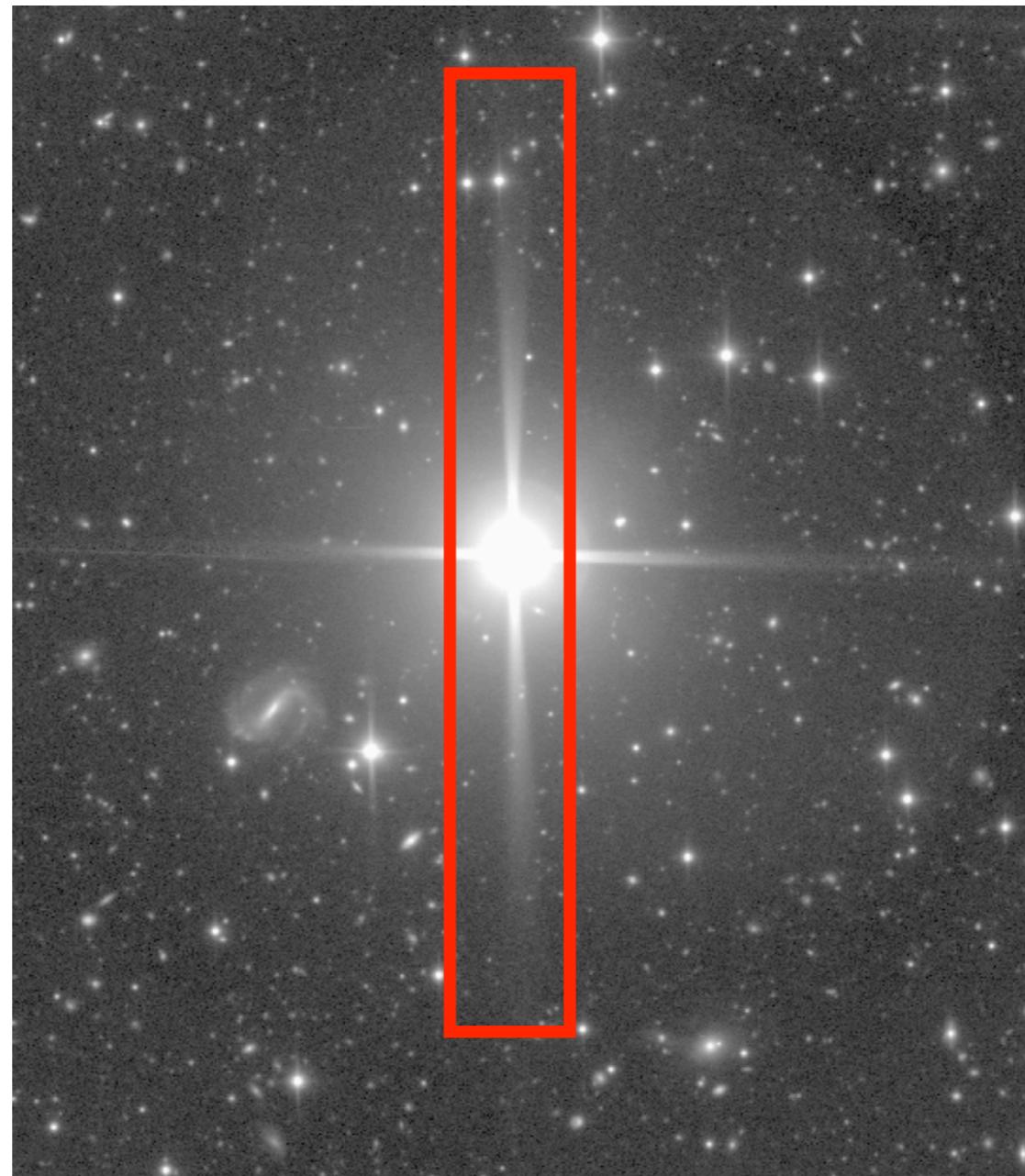
- There are some artifacts around bright star.
  - These artifacts will cause arise of fake sources and under/over estimate of flux densities for real sources.
  - These affected sources should be masked.
- Previous masks
  - hscPipe (<v7) used the Arcturus (see Coupon+2018).
    - No Arcturus masks for S19A.
  - Andy's new masks: served via CAS for the S18A and S19A data.
- Problems
  - There are many changes on hscPipe since v6.
    - Especially, (local) background subtraction are the big change.
  - Andy's masks are too large?
- We need new masks for the S19A data.

# Artifacts around bright object



# Other artifacts (1)

for HSC-Y & NB1010

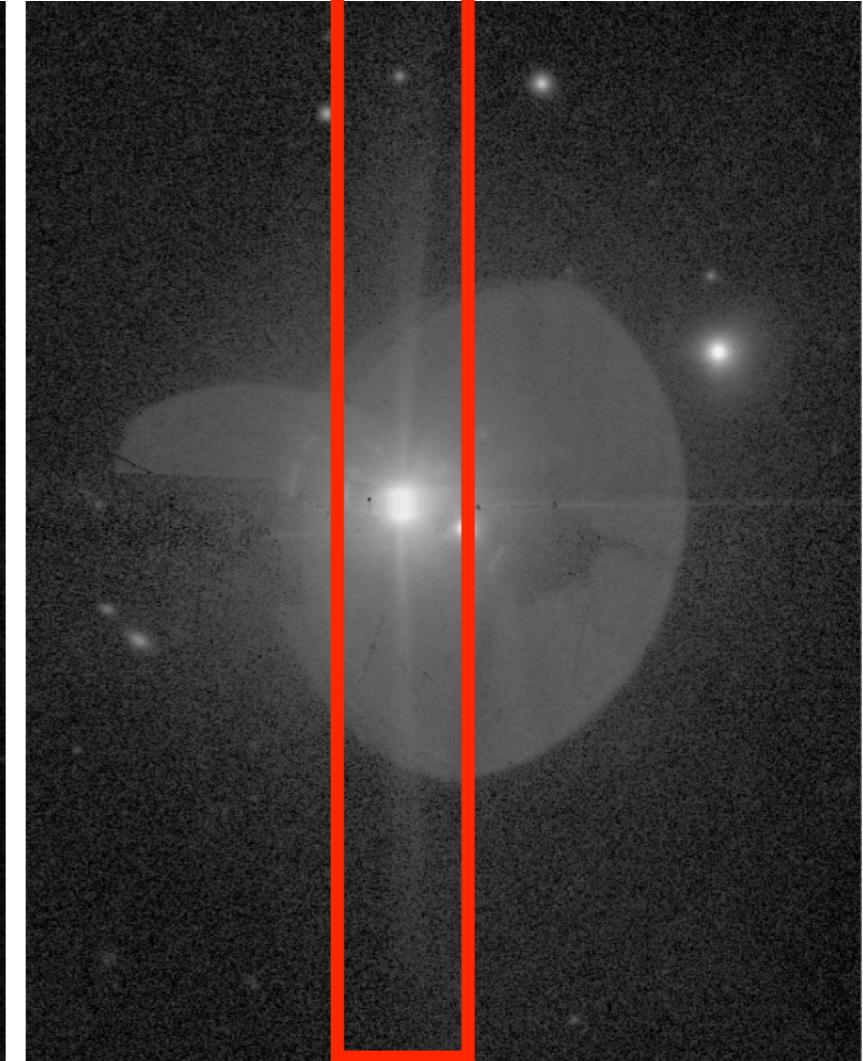
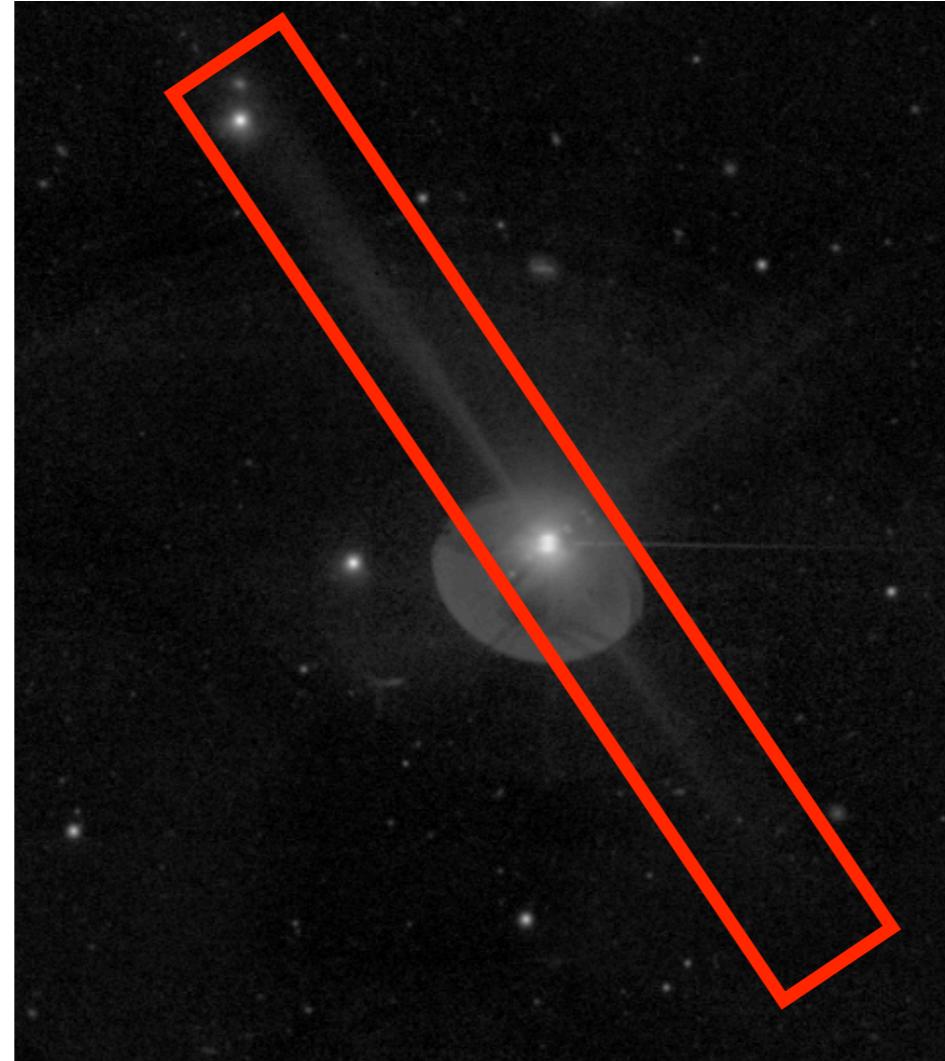
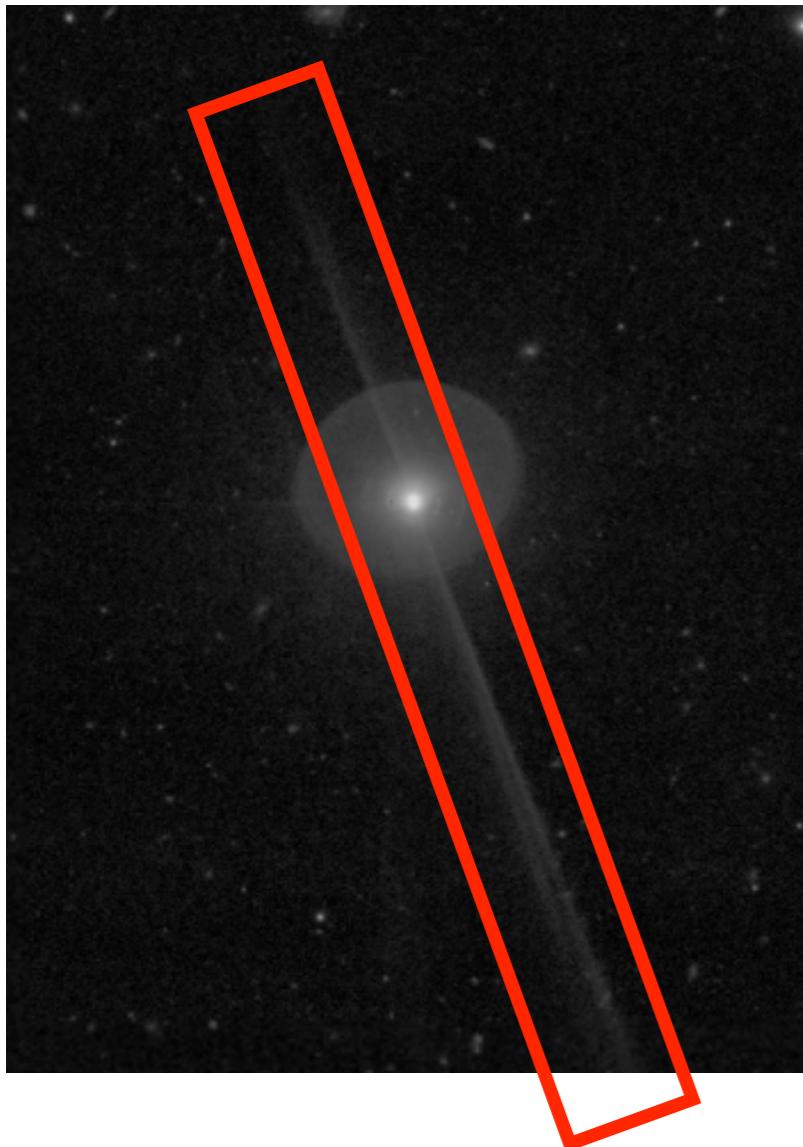


Hereafter, we call "y-scratch"

Kawanomoto-san's guess: long wavelength photons could interact with the wiring backside of the CCD.

## Other artifacts (2)

only for NB387



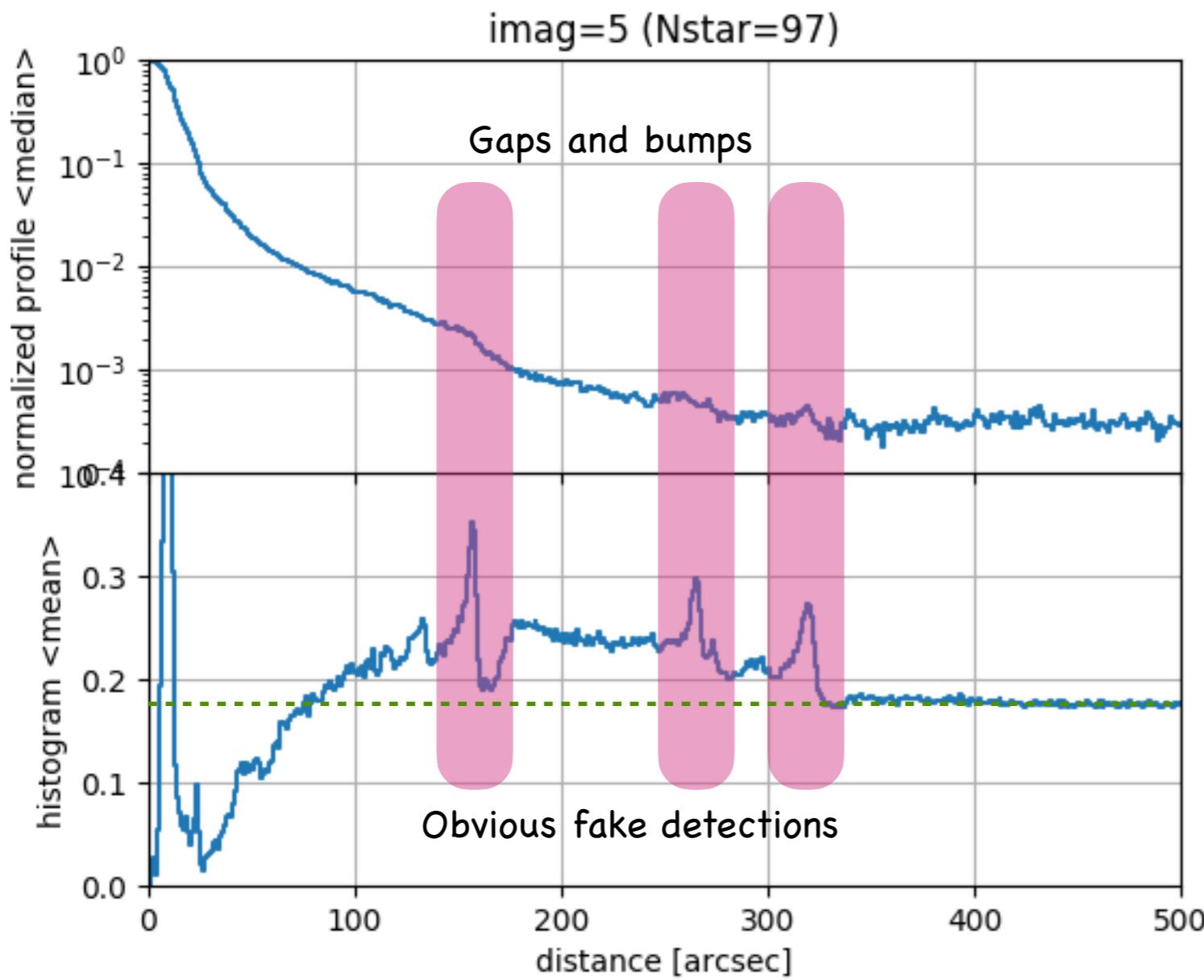
Unknown: various inclination

Need more investigation (i.e., no masks so far)

# Investigation of the affected region

- Input target sources
  - GAIA DR2 with good photometric data
    - selection criteria $\text{phot\_g\_mean\_flux\_over\_error} > 50$   
 $\text{AND } \text{phot\_bp\_mean\_flux\_over\_error} > 20$   
 $\text{AND } \text{phot\_rp\_mean\_flux\_over\_error} > 20$   
 $\text{AND } \text{phot\_bp\_rp\_excess\_factor} < 1.3 + 0.06 * \text{power}(\text{phot\_bp\_mean\_mag} - \text{phot\_rp\_mean\_mag}, 2)$   
 $\text{AND } \text{phot\_bp\_rp\_excess\_factor} > 1.0 + 0.015 * \text{power}(\text{phot\_bp\_mean\_mag} - \text{phot\_rp\_mean\_mag}, 2)$
    - GAIA magnitudes were converted to HSC magnitudes
- Target region
  - for brighter side ( $< 11$  mag): the Equator regions in Wide layer.
  - for fainter side ( $\geq 11$  mag): dud-cosmos, sxds, and deep2 regions.

# Investigation of the affected region



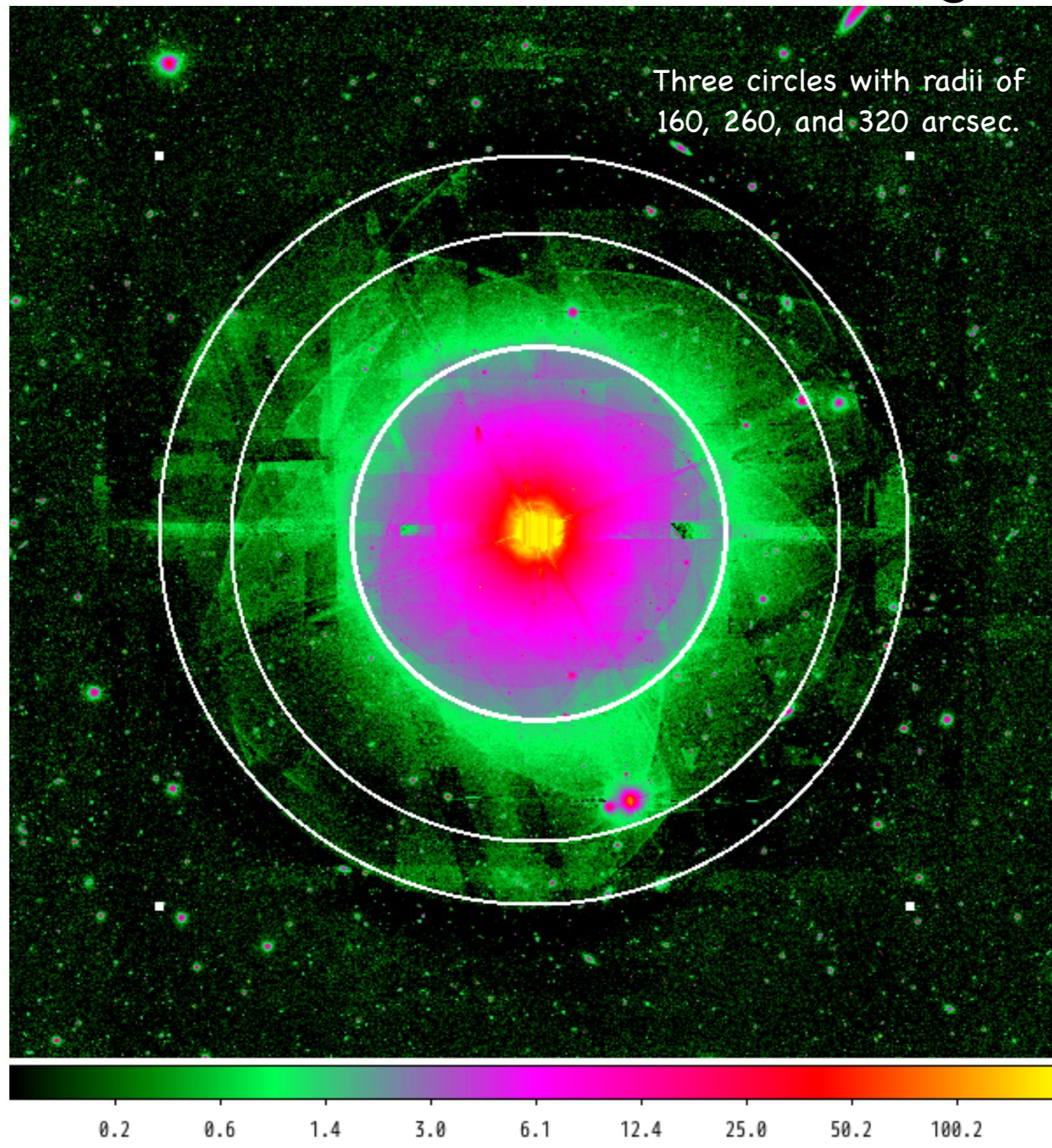
top: Normalized radial profile around bright stars.  
Median values of 97 sources with i-band magnitudes of 5.0--5.9

bottom: The histogram ( $dN/dr$ ) of SSP-detected sources around bright stars.  
Mean values of 97 sources.

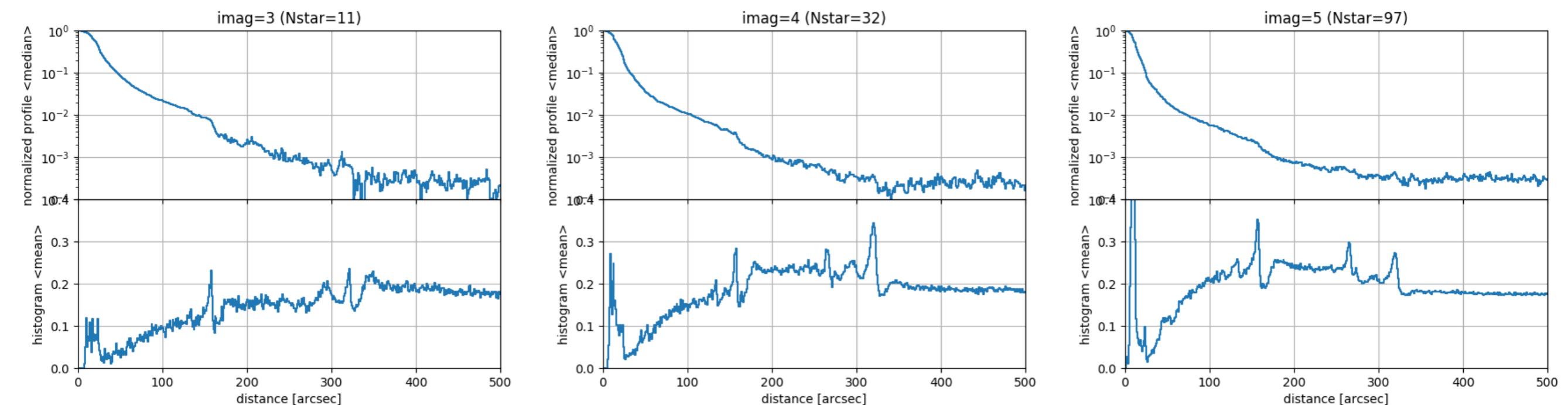
Three features at 160, 260, and 320 arcsec can be seen in both the profile and histogram.

Histogram value of  $\sim 0.2$  is thought to be the sky.

# Three features on coadd image

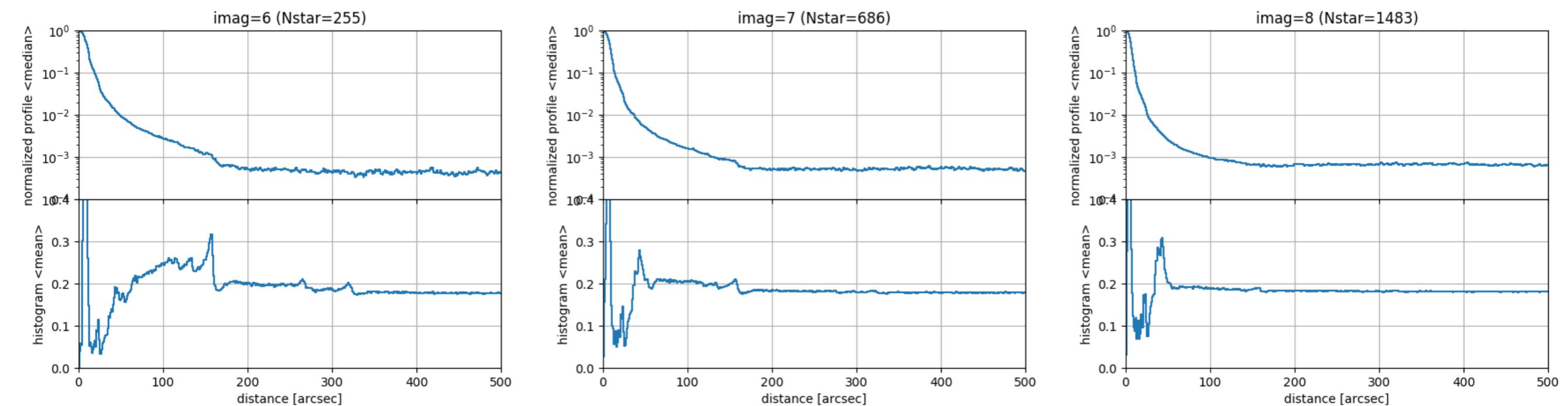


# Plots for various brightness



Three features are still on 160, 260, and 320 arcsec.  
The distances are fixed and independent from brightness -> optical ghost

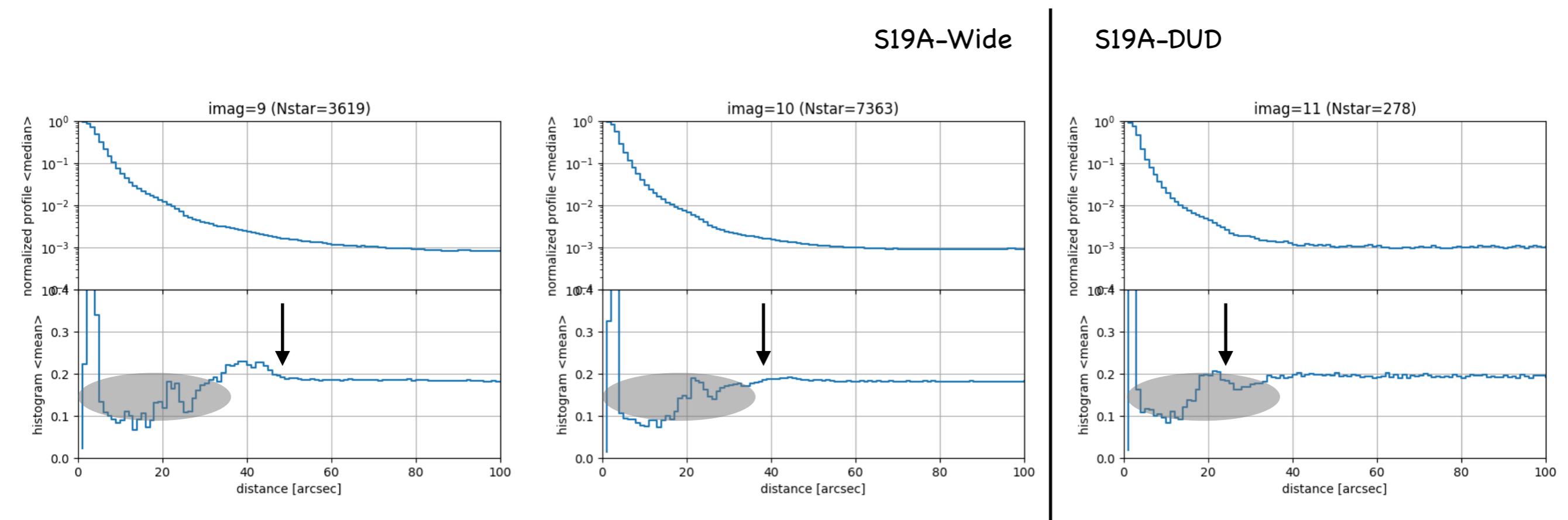
# Plots for various brightness



For magnitude of 7, it is hard to recognize the 260 and 320 arcsec features.  
For magnitude of 8, the 160 arcsec feature still remains, but is almost disappeared.

# Plots for various brightness

Closer look (distance of < 100 arcsec)

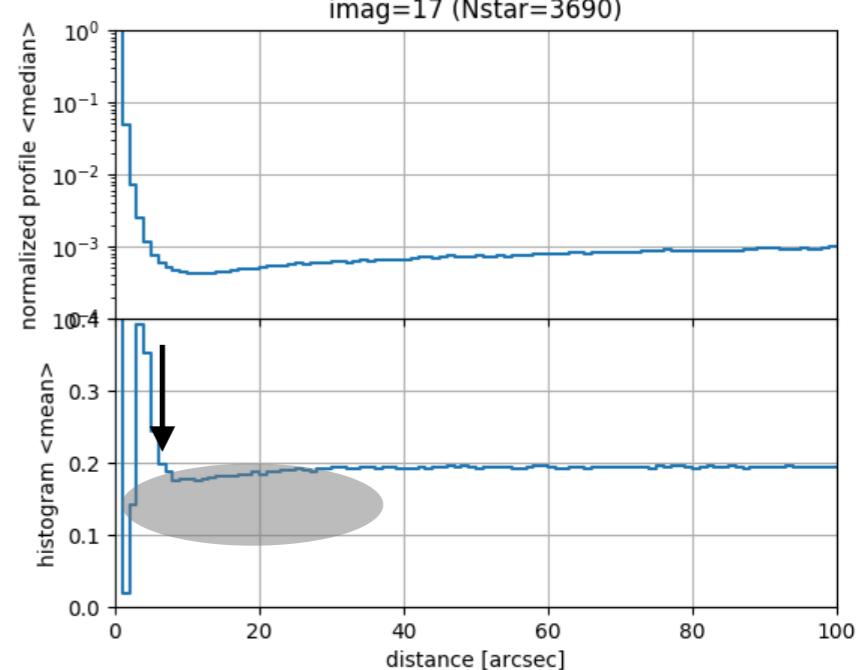
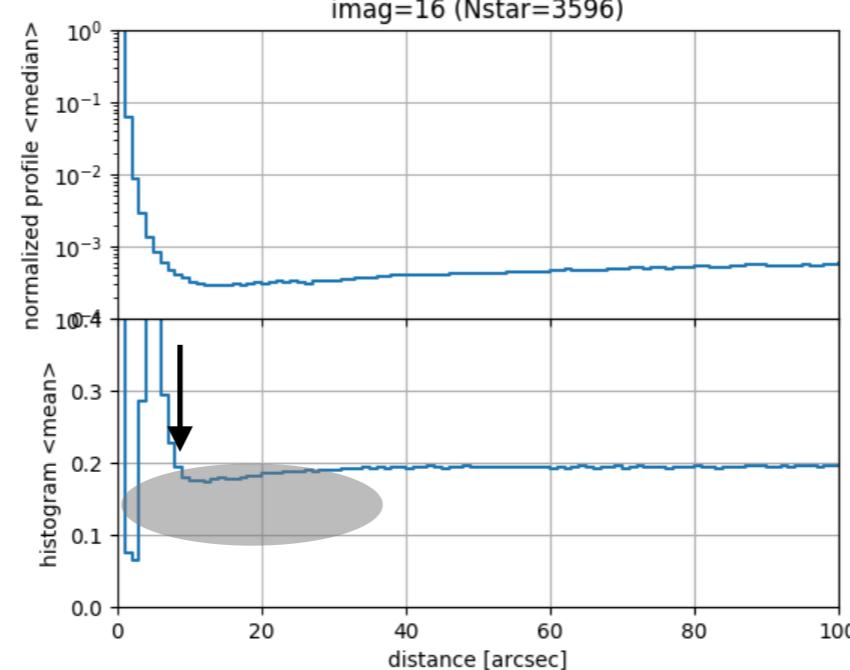
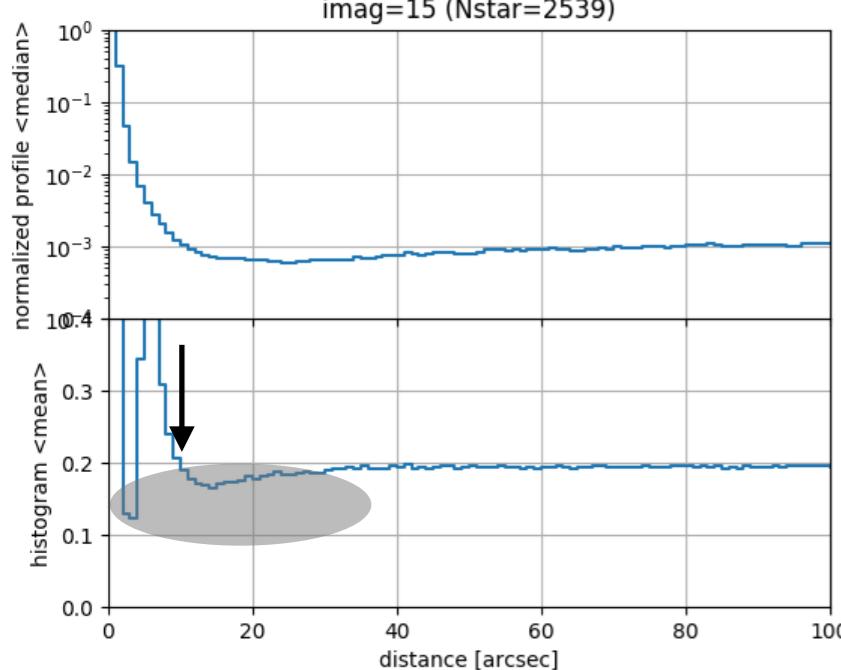
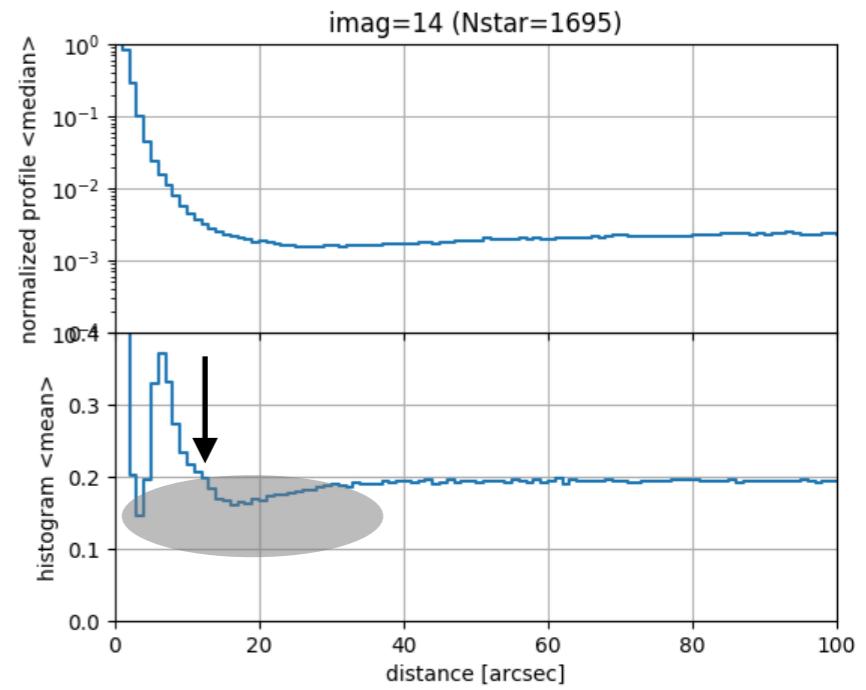
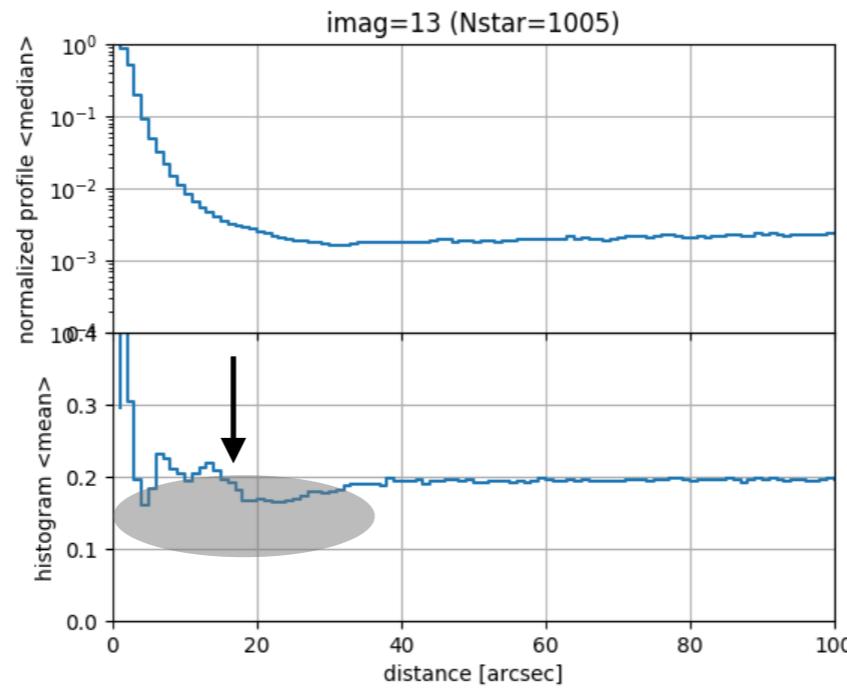
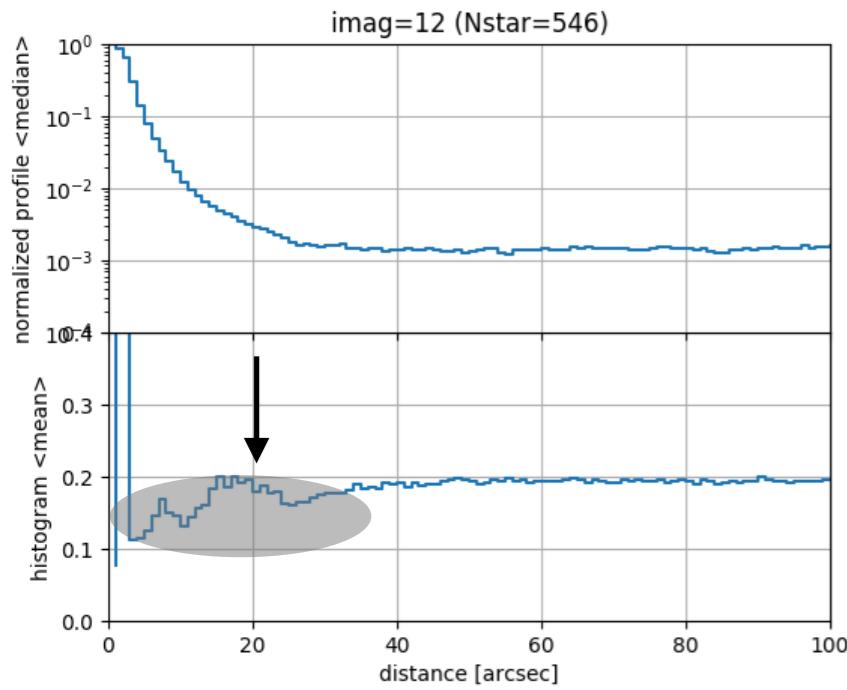


From histogram, the settle distance to the sky value of ~0.2 is closer with fainter sources.  
(The sky values are different between Wide and D/UD)

There are dips with distances of 5--40 arcsec.  
They may be caused by local sky subtraction of 128 pix (~20 arcsec) smoothing.

# Plots for various brightness

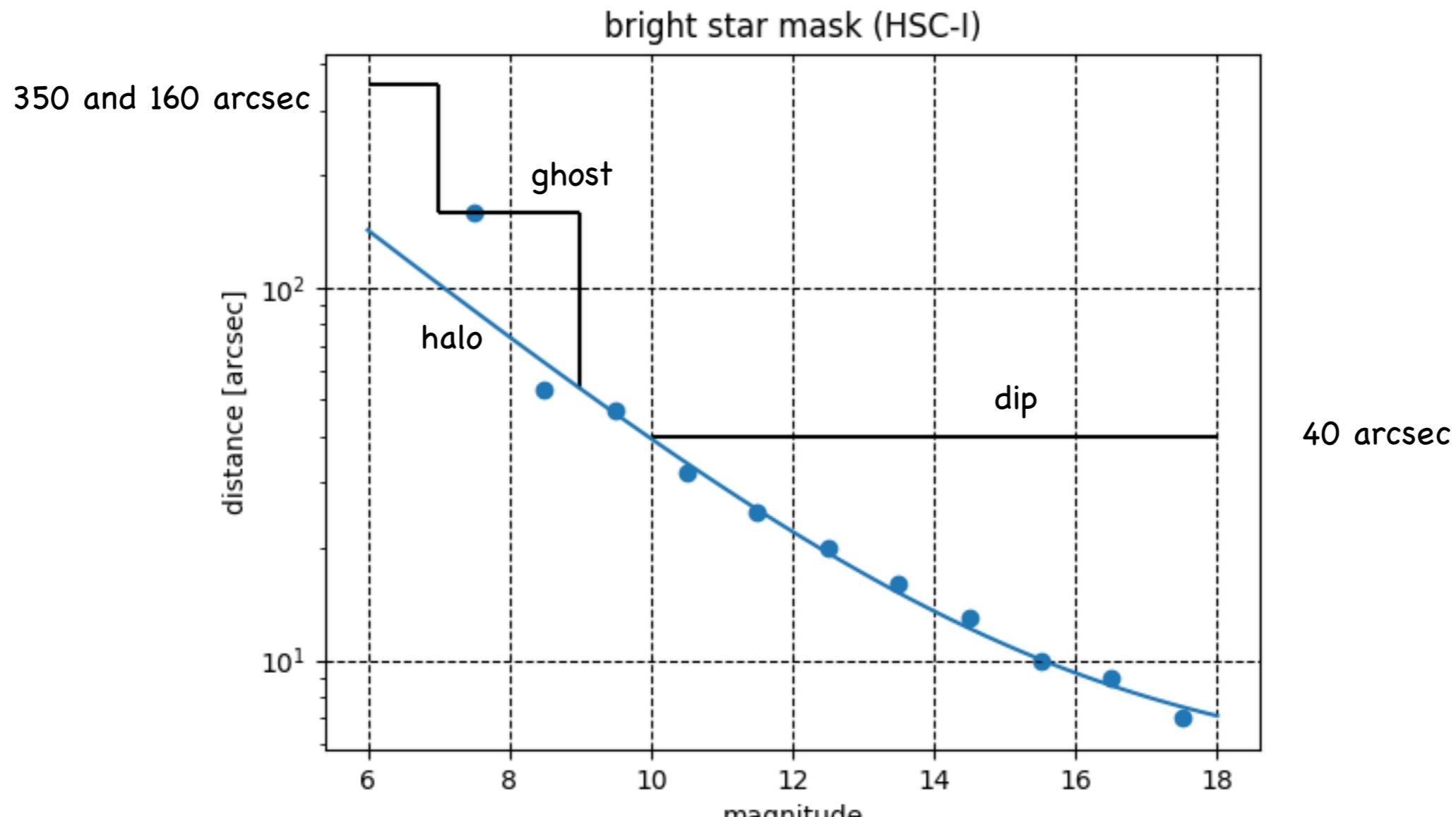
Closer look (distance of < 100 arcsec)



# Mask sizes

- The histograms settle to sky value of ~0.2 at large distance.
  - The settle distance is closer with fainter sources.
  - This distance will be the mask size.
- Bright (< 9 mag) sources have a feature at 160 arcsec, for both the histogram and radial profile.
- Much brighter (< 7 mag) sources have additional features at 260 and 320 arcsec.
  - The distances of these features are fixed and do not depend on the source brightness, i.e., they are thought to be caused by optical ghost.
  - For bright sources, we should make "ghost" mask with 350 arcsec radius at maximum.
- The "dip" might affect photometry/shape measurement (from weaklens team).
  - The distance of ~40 arcsec is thought to be related to the mesh size of local sky subtraction of 128 pix (~20 arcsec).

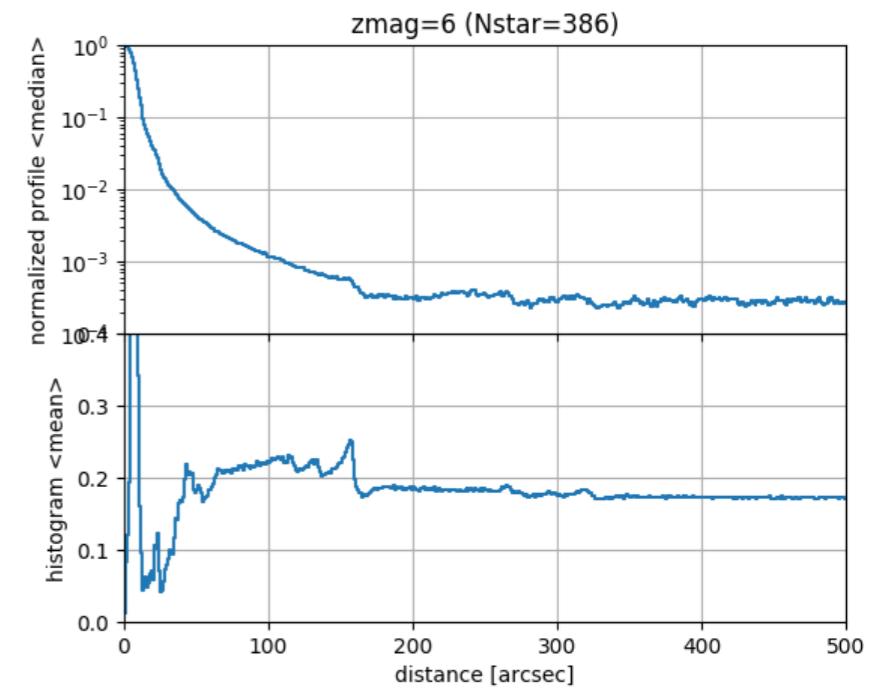
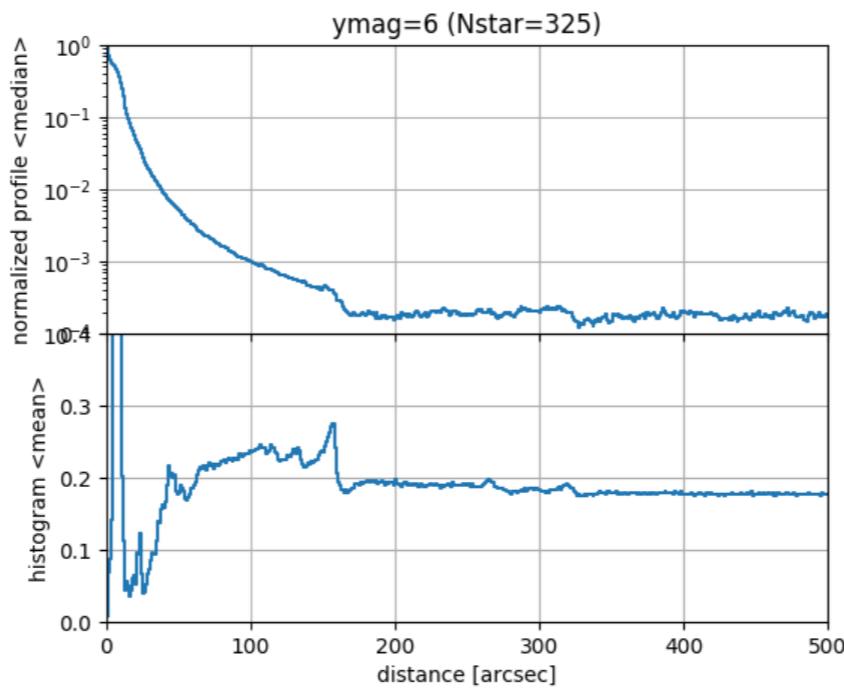
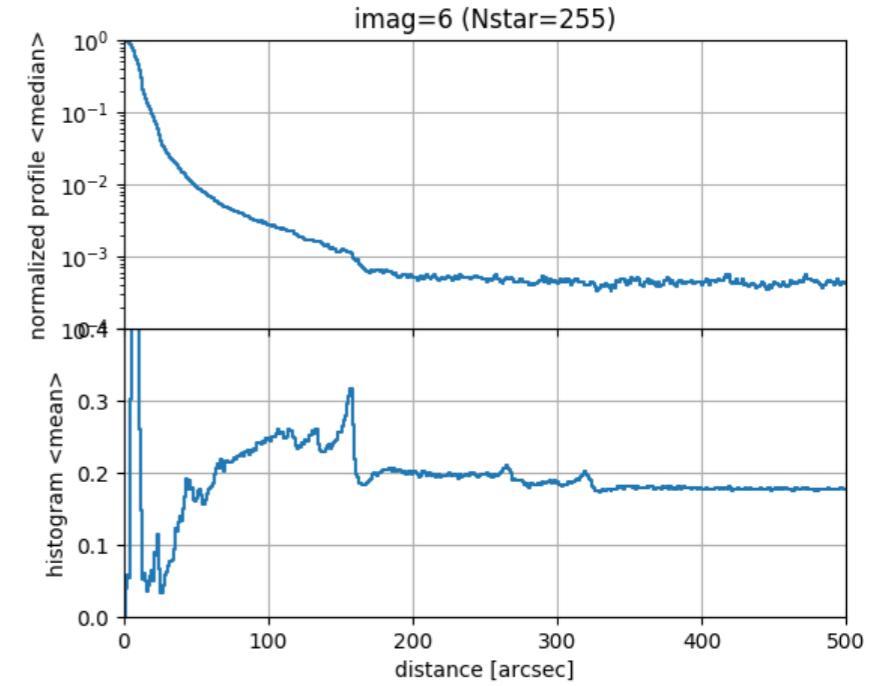
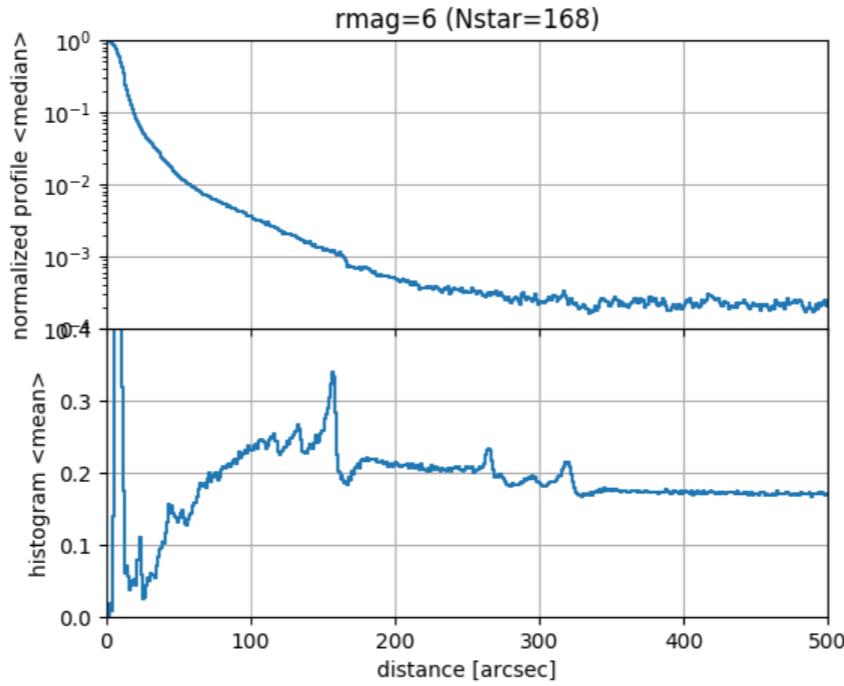
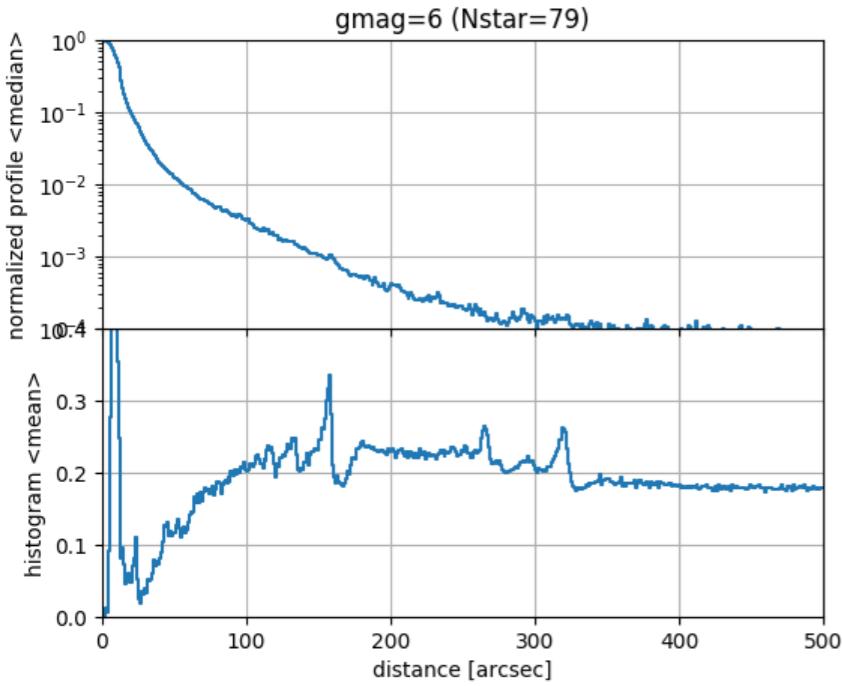
# Mask sizes



The size of the halo mask is defined as

$$y = A * \exp(-B * x) + C$$

# Band dependency



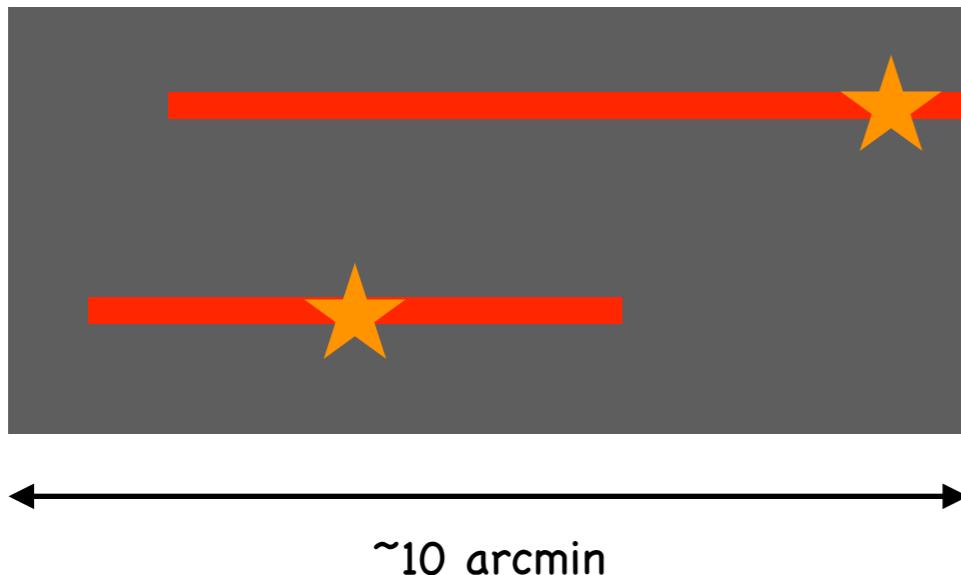
No significant differences on the distances of the feature.  
-> Same mask parameters for each bands.

# Mask for blooming

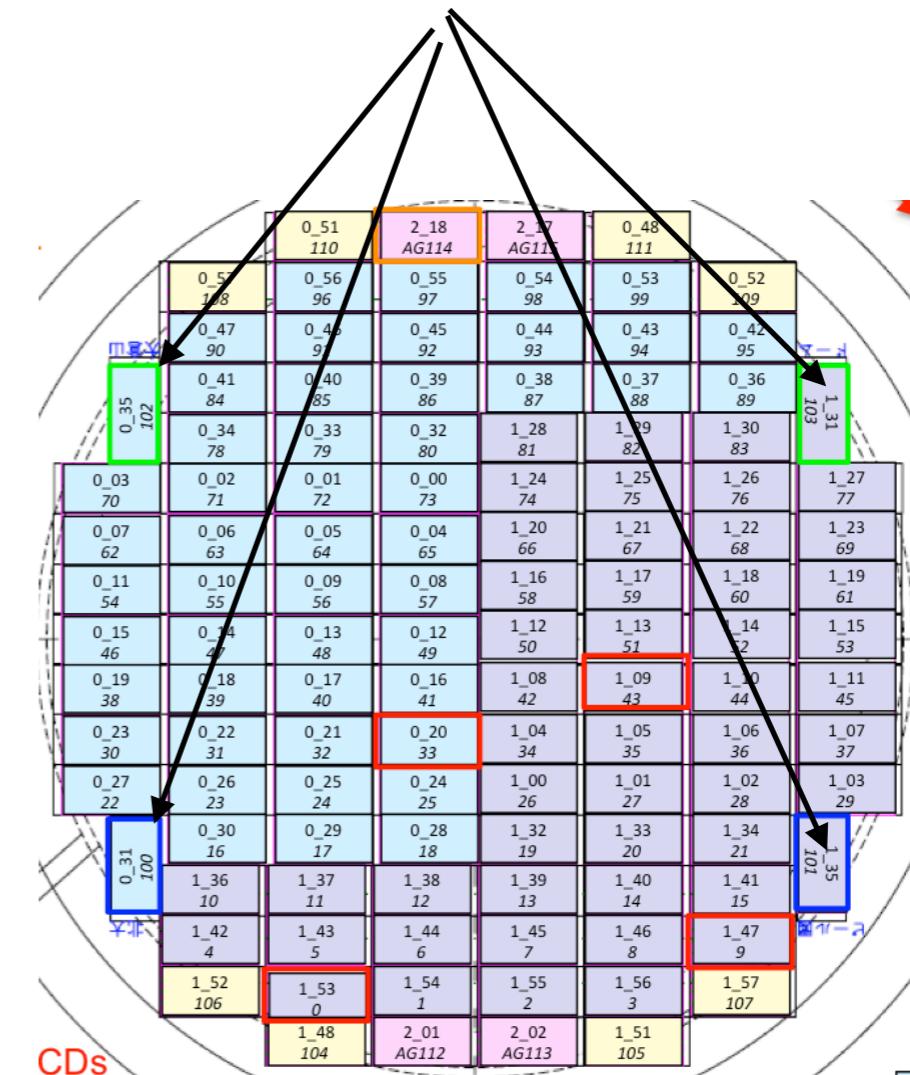
Blooming (or bleed trail) is parallel to the CCD wiring.

The length depends on the source's brightness and positions on the CCD.

The maximum length is about 10 arcmin.



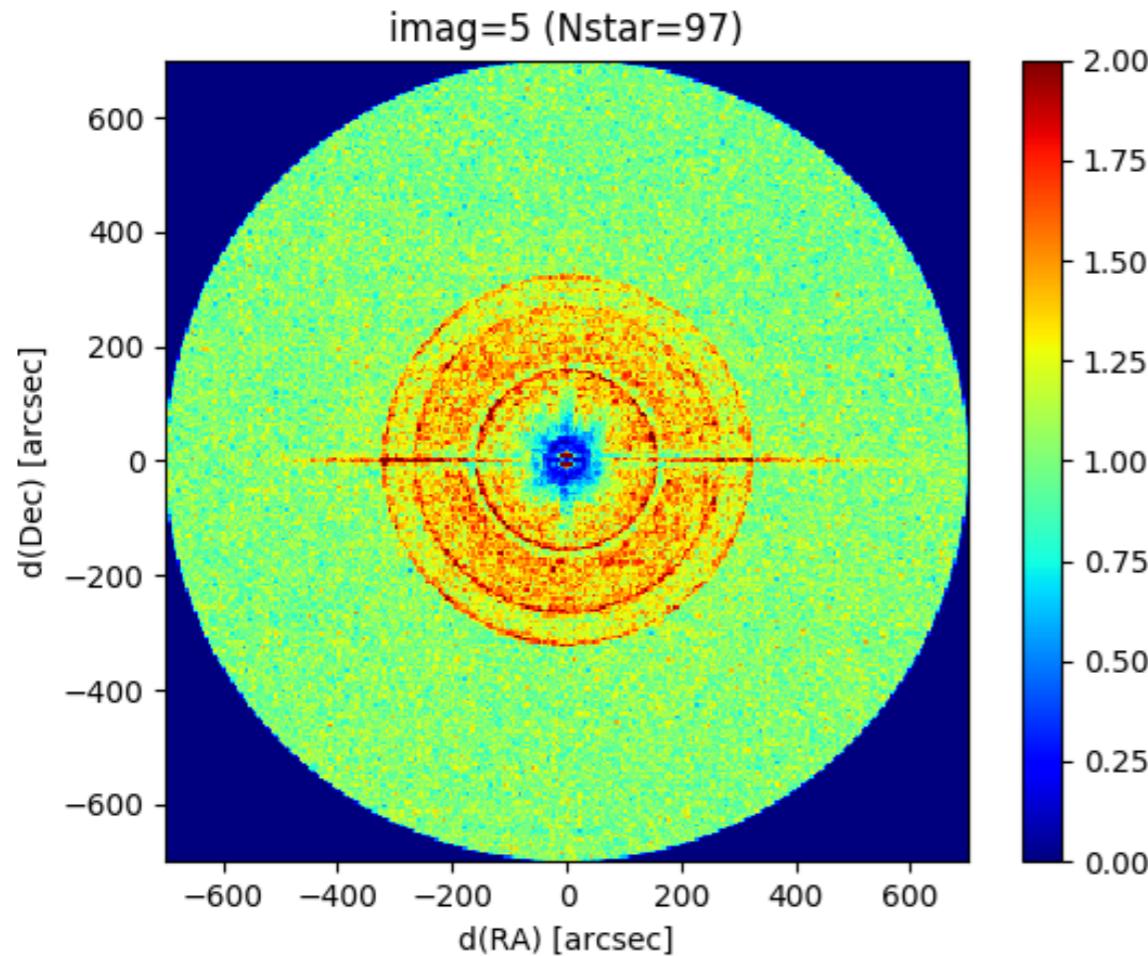
These 4 CCDs are perpendicular to the others.



The distortion is also complication for the outskirts of the FoV.

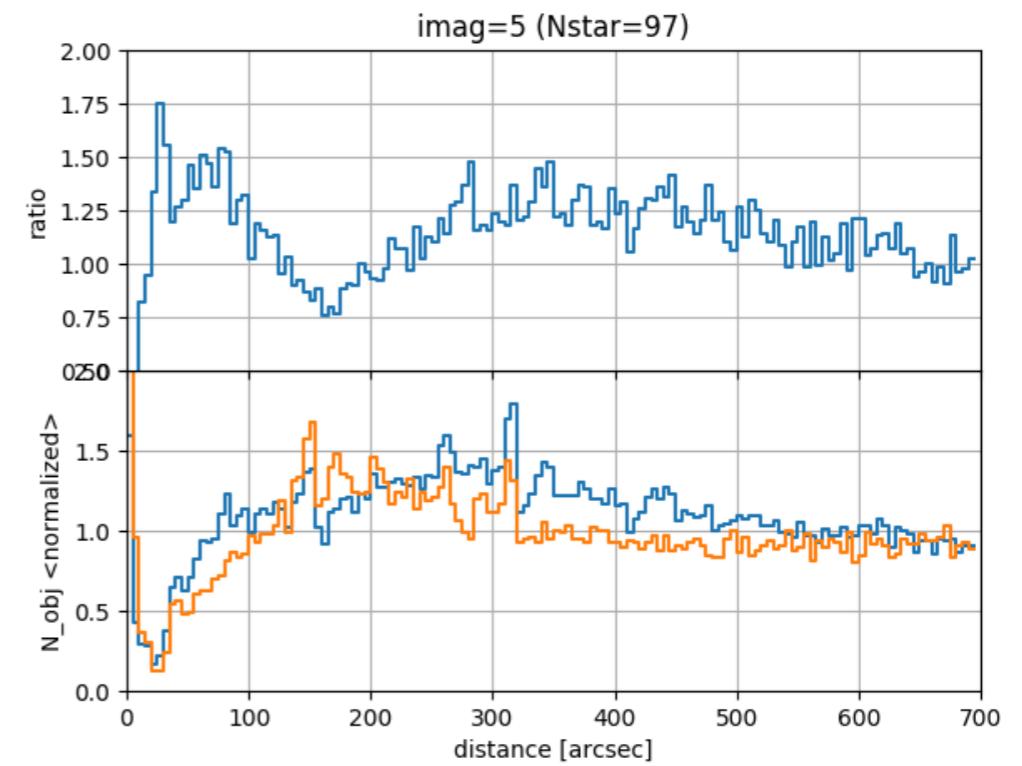
The best practice is put some flags at the CCD analysis stage (i.e. corr image), not on the warp/coadd image.  
We can make "typical" masks from coadd image.

# Range of the blooming effect



The 2-D histogram ( $dN/dr$ ) of SSP-sources around bright stars. Normalized at the sky value. Mean values of 97 sources with i-band magnitudes of 5.0--5.9

Fake detections arise along horizontal.

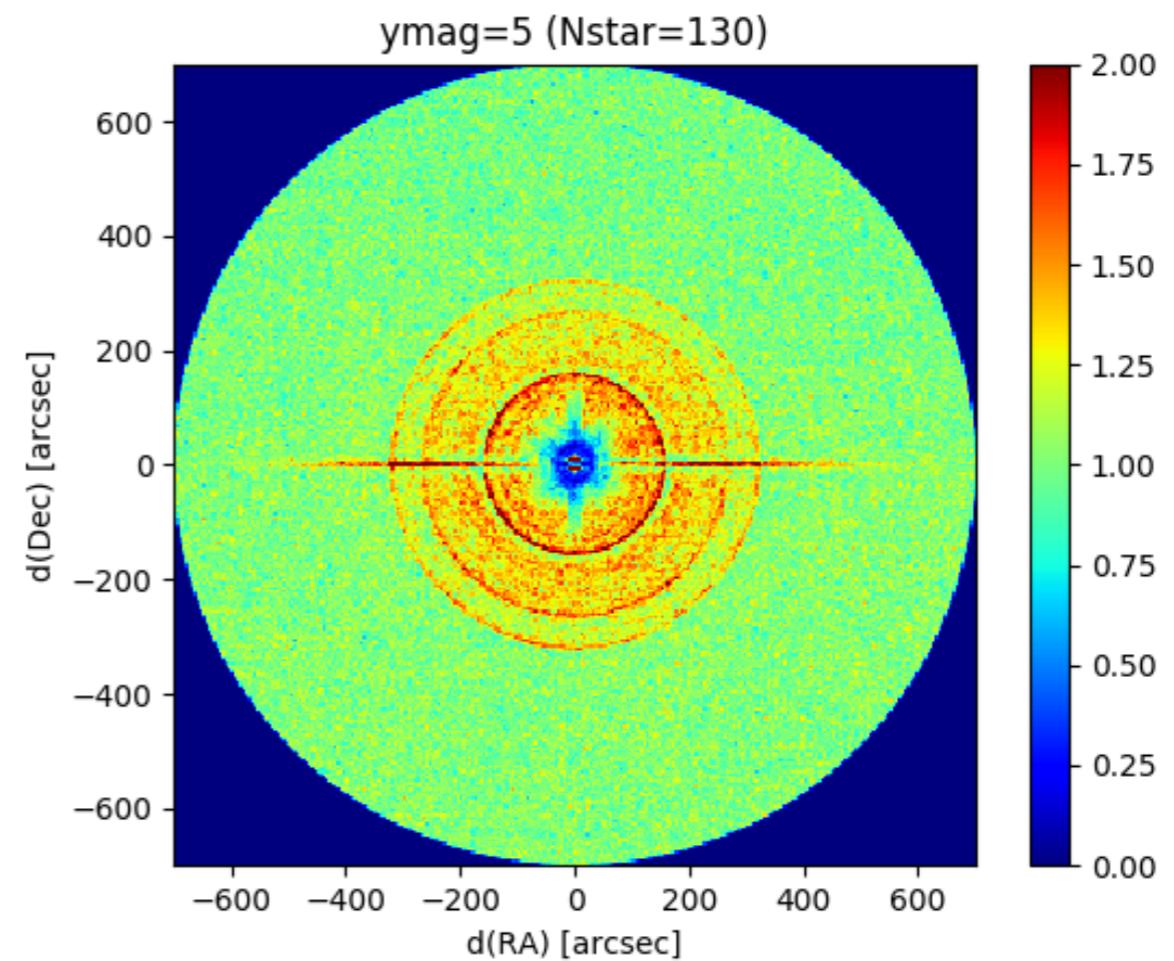
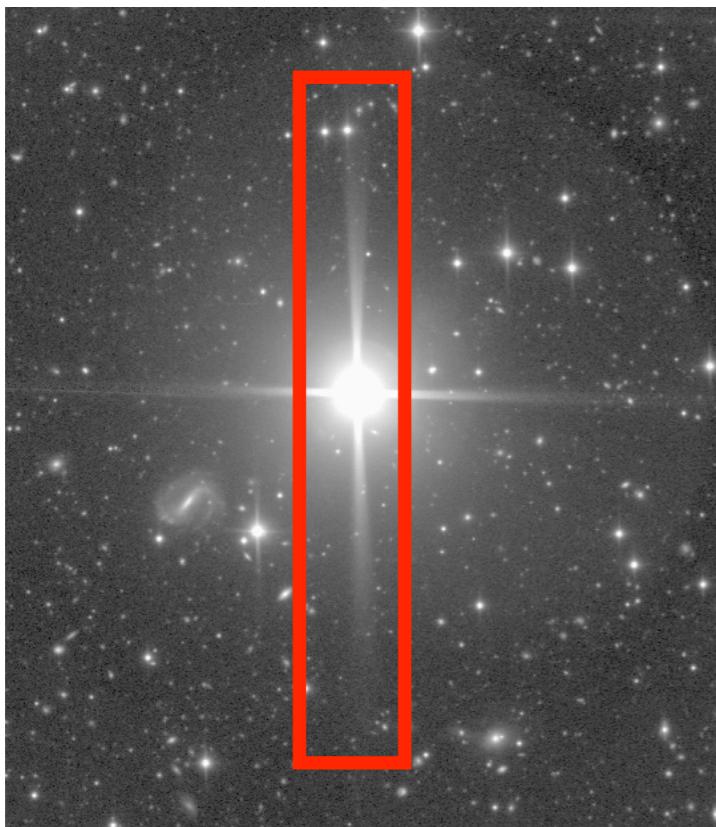


Profiles along horizontal (blue) and vertical (orange) lines of the 2-D histogram (bottom), and their ratio (top).

Length of the blooming effect reaches 600 arcsec for sources with magnitude of 5.

# Scratches on Y-band image

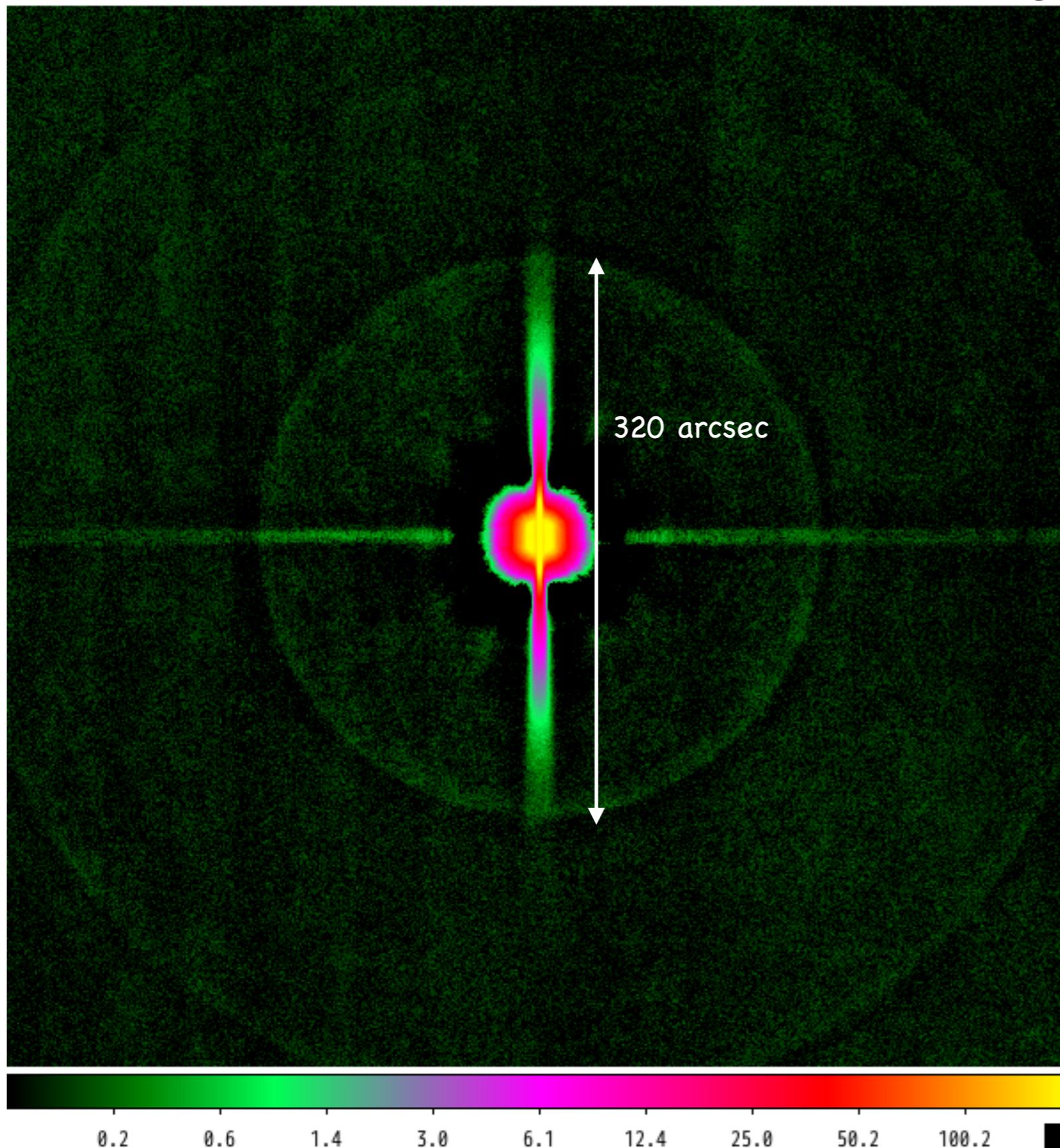
The Y-band scratch is perpendicular to the blooming.



The 2-D histogram of SSP-sources around bright stars.  
Normalized at the sky value.  
Mean values of 130 sources with y-band magnitudes of 5.0--5.9

There is no excess fake sources along the vertical.  
May be affect only for photometry?

# Stacked image



Stacked image of 130 sources  
with y-band magnitudes of 5.0--5.9.

The length of this stray light is  
about 320 arcsec for 5 mag sources.  
This length varies with source's  
brightness, and maximum length  
is about 320 arcsec.

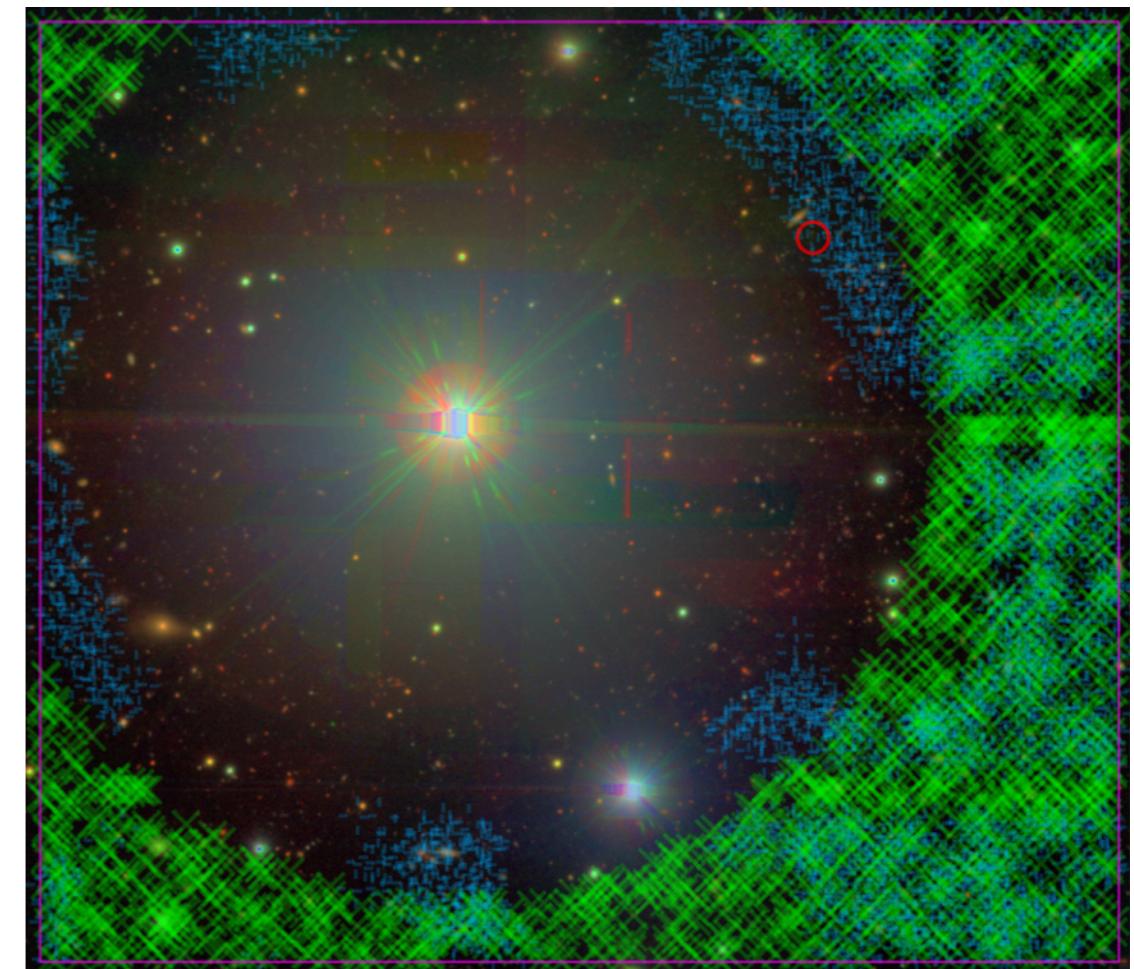
# Summary

- We made bright star masks using the S19A data.
  - Reference catalog was created from GAIA DR2.
  - Bright galaxies were not considered.
- There are halo, dip, ghost, blooming, and y-scratch masks.
  - The halo, dip, and ghost masks will work fine.
  - The blooming masks may also work, but not perfect.
  - Since the y-scratch does not seem to contribute fake sources, this mask is applied only for y-band.
  - The NB387 stray light needs more investigation.
- The new masks will be installed to the database (new table).
  - 4 or 5 columns for each band.
    - i\_mask\_halo, i\_mask\_dip, i\_mask\_ghost, i\_mask\_blooming (for g, r, i, and z-bands)
    - y\_mask\_halo, y\_mask\_dip, y\_mask\_ghost, y\_mask\_blooming, y\_mask\_scratch (for y-band)
  - Additional one summary column.
    - i\_mask\_any (= i\_mask\_halo OR i\_mask\_dip OR i\_mask\_ghost OR i\_mask\_blooming)

# Additional table

UPDATE: 20200526

- There seem some defects in coadd image, due to the small number of CCD data, especially in the WIDE layer.
- They are noticeable around bright sources which cause "optical ghost" (i.e., brighter than 9 mag).
- Those area can not be fully covered by the standard "ghost mask" flag in the current masks table.
  - Here, we add another table (suffix with "\_extra") for covering extended area around these "ghosts" so that users can choose necessary size of masks.
  - In this extra table, the following flags are available.
    - {filter}\_mask\_brightstar\_ghost12: expanded area by 20% from standard ghost mask.
    - {filter}\_mask\_brightstar\_ghost15: expanded area by 50% from standard ghost mask.

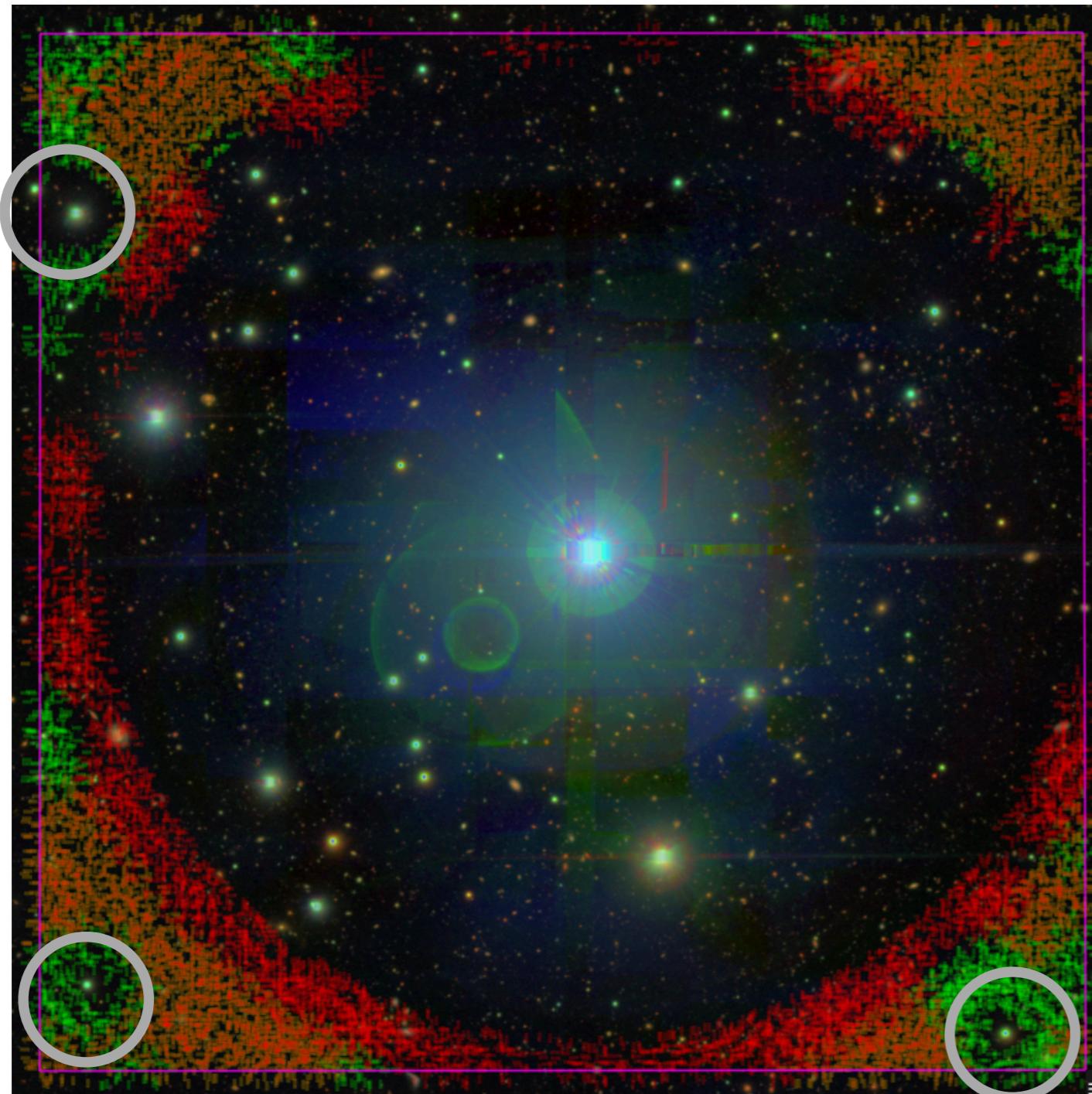


Cyan: i\_mask\_brightstar\_any from masks\_test20200303

(any = halo + dip + ghost + blooming)

Green: i\_mask\_brightstar\_ghost12 from masks\_test20200303\_extra

# Example

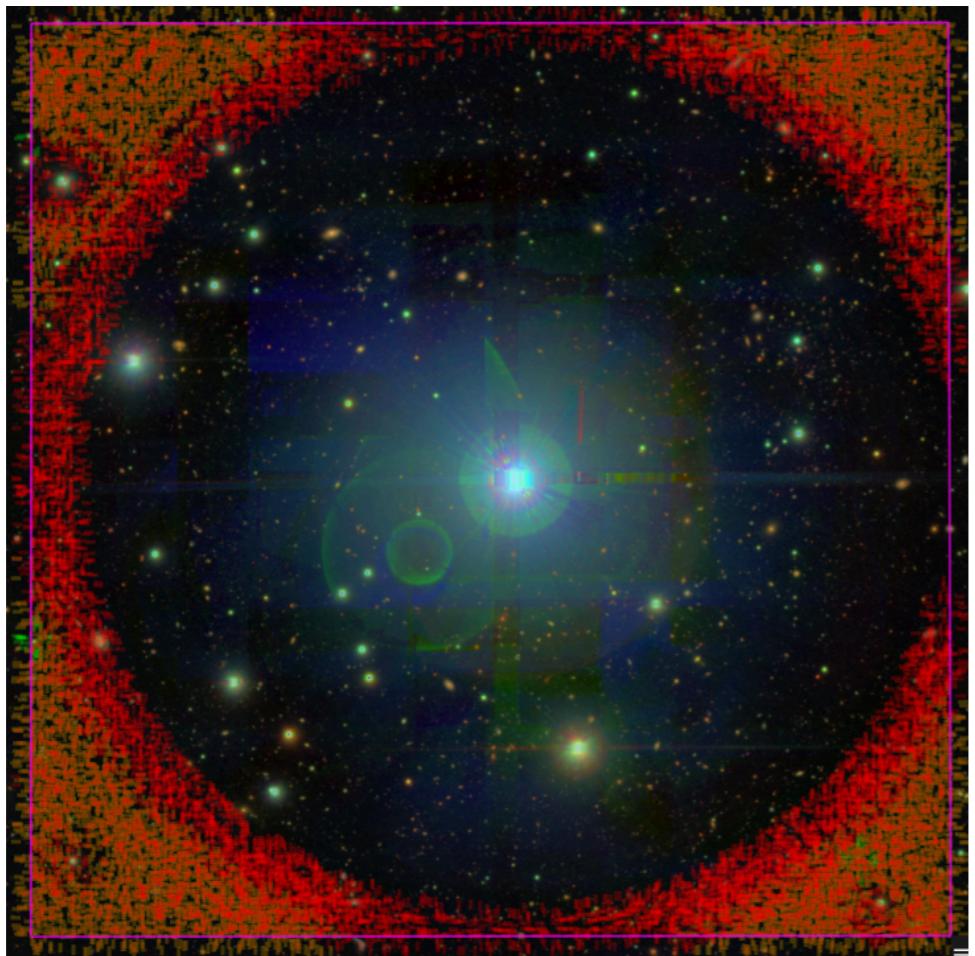


~12 x 12 arcmin data

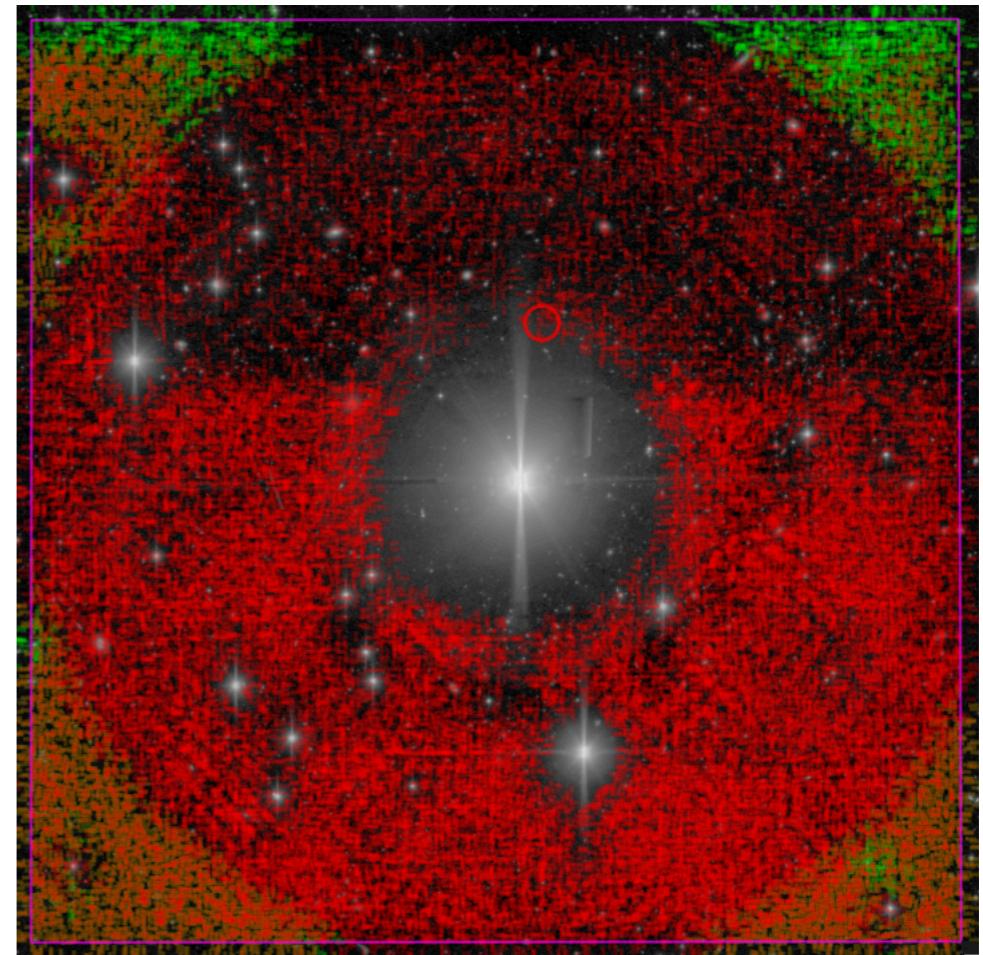
green: Andy's  
NOT i\_mask\_s18a\_bright\_objectcenter

red: this work  
NOT i\_mask\_brightstar\_any

These are "dip" masks



`NOT ( i_mask_brightstar_halo OR i_mask_brightstar_ghost)`



`NOT (y_mask_brightstar_halo OR y_mask_brightstar_scratch)`