

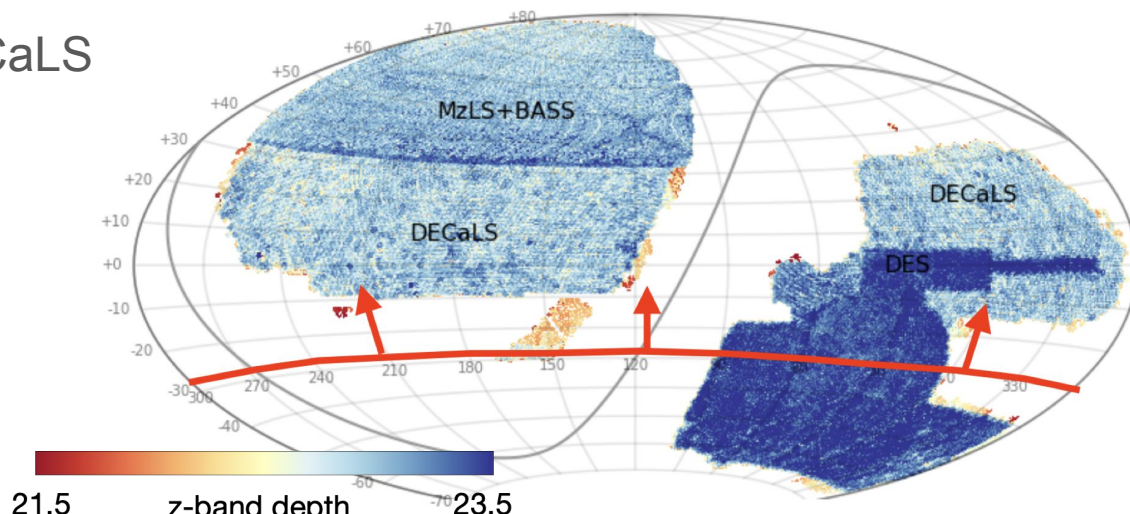
DESI Legacy Imaging Surveys

Dustin Lang
Perimeter Institute
DELVE Workshop
2022-09-16



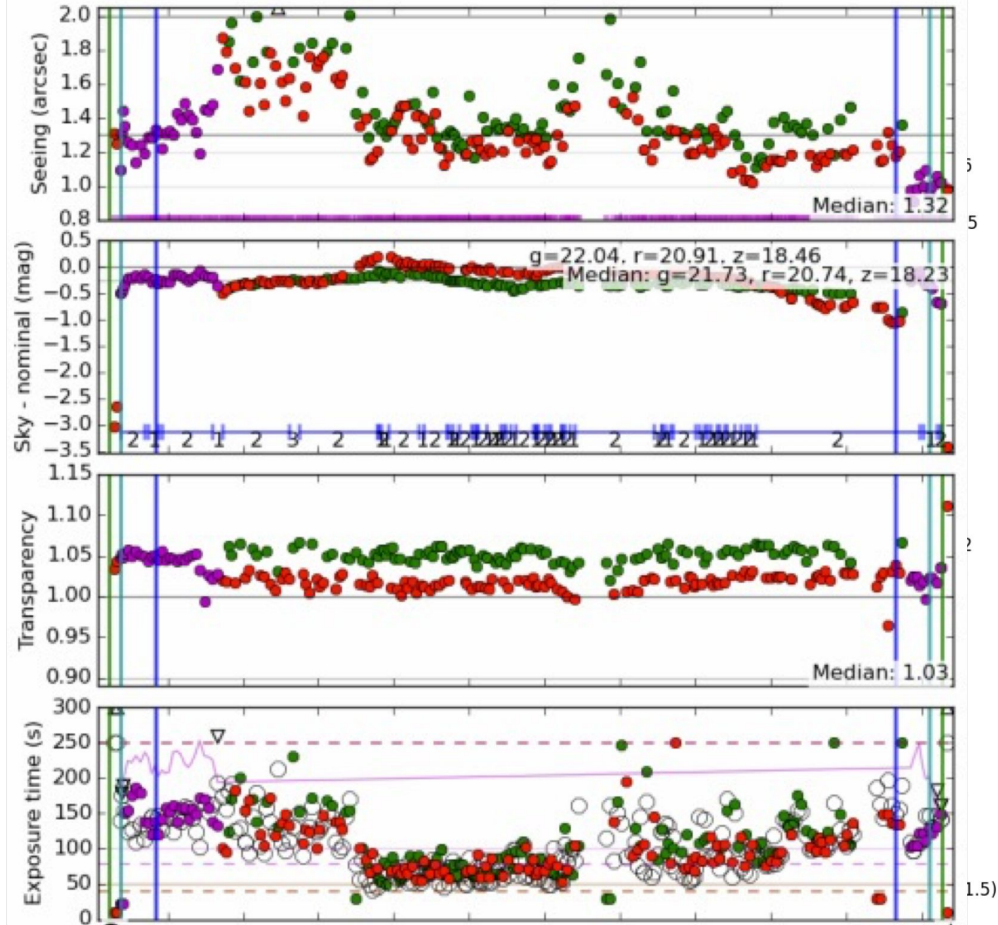
DESI Legacy Imaging Surveys (“Legacy Surveys”)

- Imaging surveys to select targets for observation with DESI
- Galactic caps, Dec > -30
- Requirement: 14,000 sq deg, $g > 24$, $r > 23.4$, $z > 22.5$ for a galaxy
- Northern NGC: used the Bok/90prime (g,r) and Mayall/Mosaic3 (z) cameras
- Southern NGC and SGC:
Blanco/DECam (g,r,z) – DECaLS



DECaLS observing

- Dynamic exposure times (automated) for constant depth
- Tiling pattern: 3 passes, with CCD-sized offsets to fill chip gaps
- Total of 203 scheduled nights, 2014 Aug to 2019 March



Calibration & preprocessing

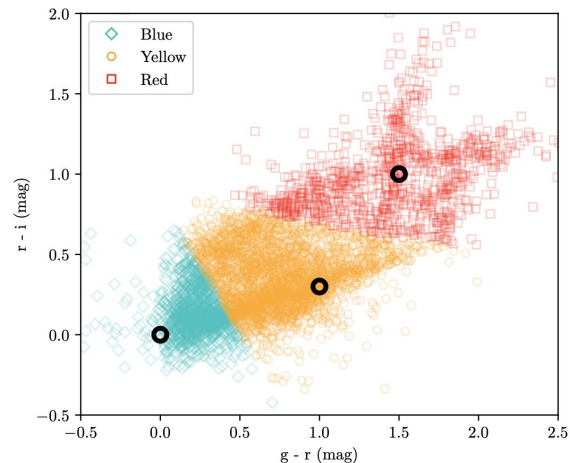
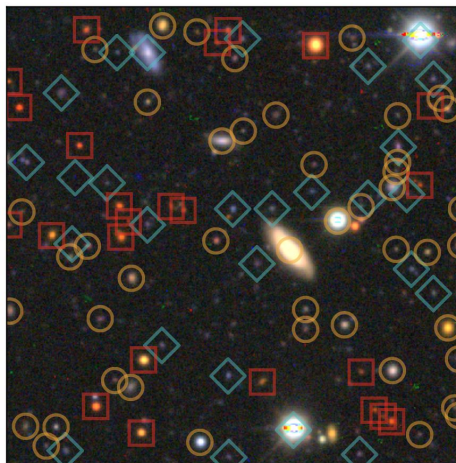
- DECam Community Pipeline at NOIRLab (Frank Valdes)
- legacyzpts:
 - psf (PsfEx)
 - sky background (“splinesky”)
 - photometric zeropoint (PS1 + “ubercal” (internal cross-calibration) - Eddie Schlafly)
 - astrometric offsets (to Gaia DR3)
- sky templates, fringing, and stellar halos (Rongpu Zhou)

legacypipe

- Process the sky in “bricks” of 0.25 x 0.25 degrees (3600 x 3600 DECam pix)
- Find all DECam CCDs that overlap
- (Find Gaia stars and Siena Galaxy Atlas (SGA) galaxies nearby)
- Outlier masking (asteroids, cosmic rays, etc)
- Source detection
- Source fitting (forward modeling with the Tractor)
- Forced photometry on the WISE images
- Coadds & catalogs

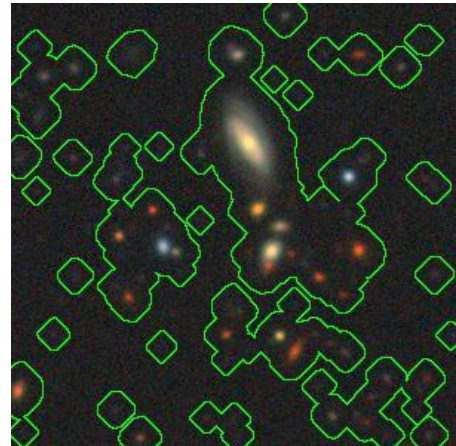
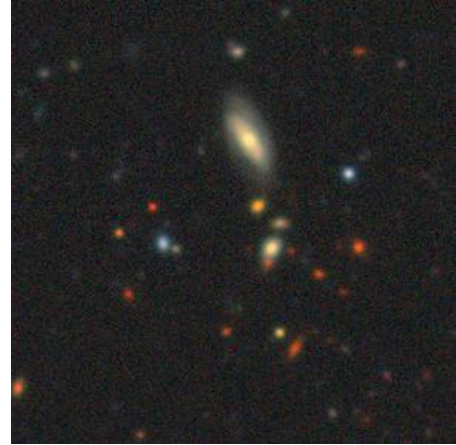
legacypipe - source detection

- Source detection is per [arxiv:2012.15836](https://arxiv.org/abs/2012.15836)
("Principled point-source detection in collections of astronomical images", Lang & Hogg)
- Matched filter (PSF-convolve) each image, coadd within each band
- Then do "SED-matched filter" to coadd between bands (we don't go Bayesian)
- Have to assume a set of SEDs. We use:
 - single-band filters
 - "Red" SED ($g-r = 1$, $r-i = r-z = 0.5$)
 - "Flat" SED ($g = r = i = z$)



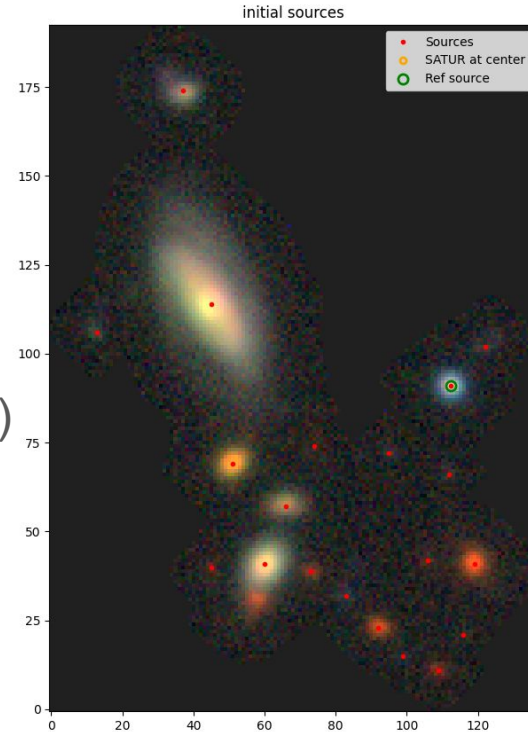
legacypipe - source fitting

- source detection gives us a set of peaks
- and connected “blobs” of significant pixels
- process each blob independently



legacypipe - blob processing

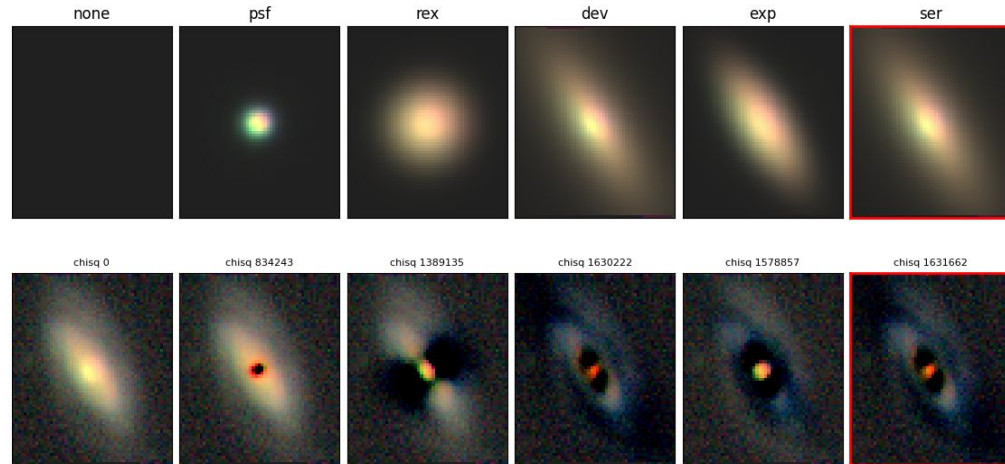
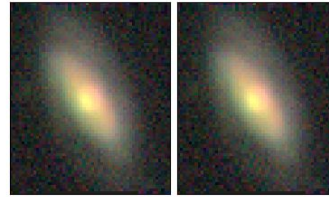
- forward modeling - source models that “explain” or “predict” pixel values
- models get convolved by each image’s PSF
- adjust model parameters to best match all images collectively (sum of chi-squared)



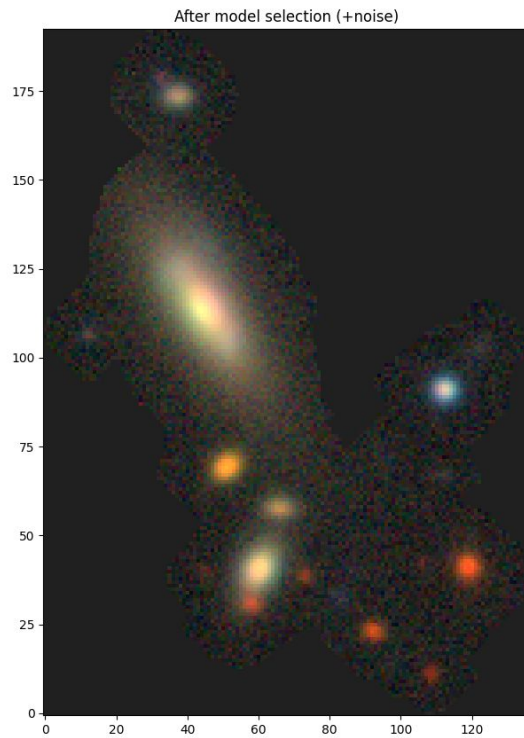
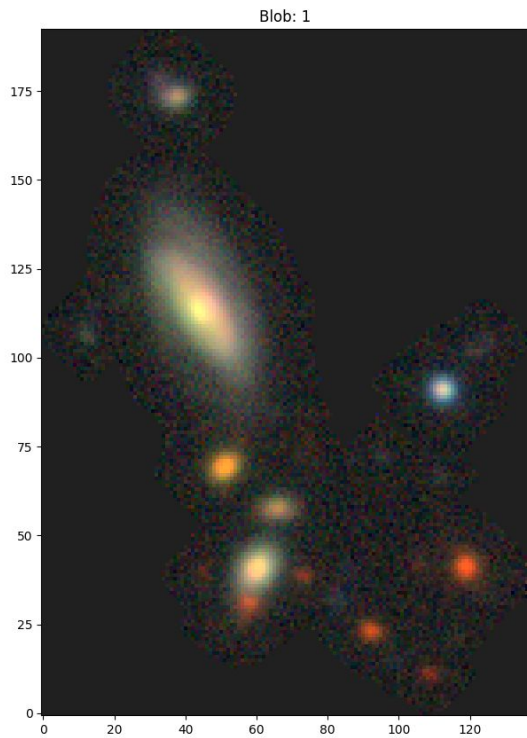
legacy pipe - model selection

- for each source, choose between PSF and different galaxy models
- penalized chi-squared decision

Blob 1, src 0 (psf: False, fitbg: False): keep ser
t RaDecPos: RA, Dec = (57.84194, -48.67556) with NanoMaggies: g=18.4, r=17.4, z=16.8 and EllipseWithPriors(0.25): log r_e=1.57293, ee1=0.294658, ee2=0.569104, Ser was: PointSource at RaDecPos: RA, Dec = (57.84197, -48.67554) with NanoMaggies: g=20.2, r=19.2, z=18.7



legacypipe - model fitting

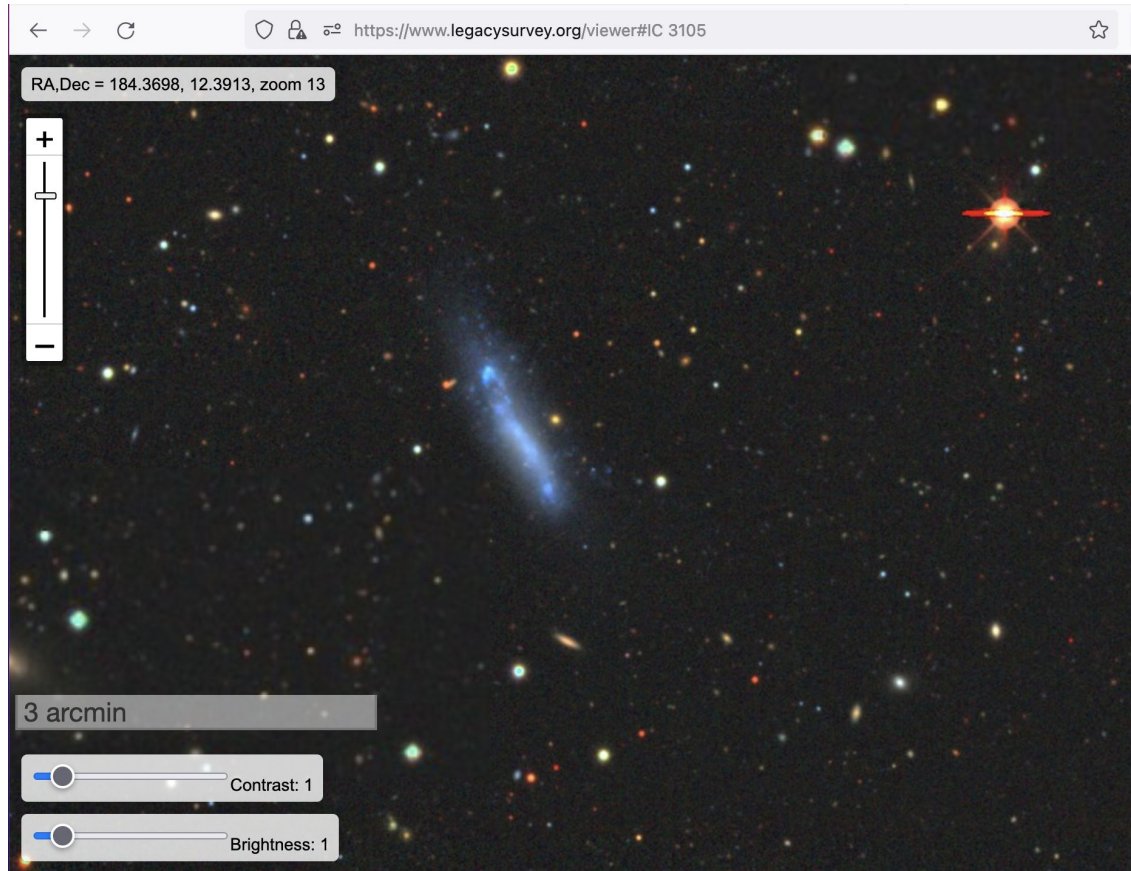


legacypipe - catalog contents

- TYPE (PSF or different galaxy types REX, DEV, EXP, SER)
- RA, Dec
- fluxes (g,r,i,z)
- galaxies: elliptical shapes SHAPE_R, SHAPE_E1, SHAPE_E2
- forced-photometry fluxes for WISE W1/W2/W3/W4
- “maskbits” for near a bright Gaia star or SGA galaxy, etc
- aperture fluxes (on the coadds)
- uncertainties, depth estimates, effective PSF size, “fiberflux”, ...

Legacy Surveys Sky Viewer

- Initially built for our own exploration of the data
 - Really fun!
- <https://www.legacysurvey.org/viewer>



Legacy Surveys Sky Viewer - tidbits

- DECam footprint
- “Link Here”
- Custom catalogs
- Fly to location

RA,Dec 186.7923 , 12.9831 , zoom 9

Go Cancel

Duration: 5 Fly

30 arcmin

Contrast: 1

Brightness: 1

Jump to object:

Custom catalog upload (FITS or CSV; RA,Dec,[name,color,radius]):
Browse... No file selected. Upload

- Images

- Legacy Surveys DR10-early
- Legacy Surveys DR10-early (grz)
- + Legacy Surveys DR9 images
- + Older Legacy Surveys
- + unWISE W1/W2 NE07
- + More surveys

- Overlays

- Boundaries

- DECam Footprint
- Legacy Surveys Bricks
- Legacy Surveys DR9 CCDs
- Legacy Surveys DR9-north CCDs
- Legacy Surveys DR9-south CCDs
- Legacy Surveys DR9-south Exposures
- All masks (LS-DR9)
- + Legacy Surveys DR8 CCDs
- + DECaLS DR7 CCDs
- SDSS CCDs
- unWISE tiles

+ Imaging catalogs

+ Spectroscopy

+ DESI

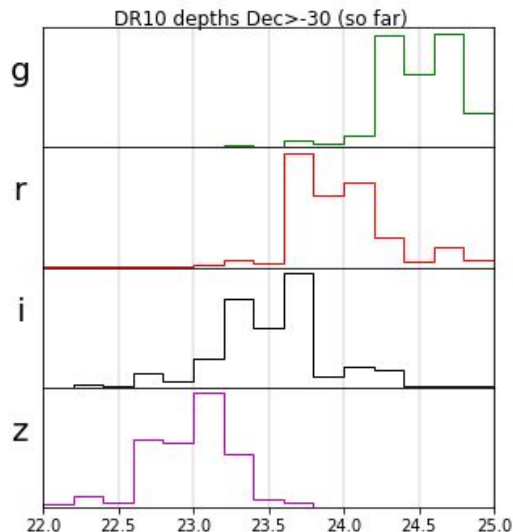
+ Bright Objects

Tips & Tricks | Leaflet | Source | © Legacy Surveys / D.Lang (Perimeter Institute)

Legacy Surveys status

- Legacy Surveys DR9 is used for DESI targeting
- Legacy Surveys DR10 is 99.9% done (the last 0.1% of the sky is stubborn!!)
 - In collaboration with eROSITA team members
 - Adds i band (now griz)
 - Adds new area (DeROSITAS, DELVE)
 - Adds one more year of WISE data

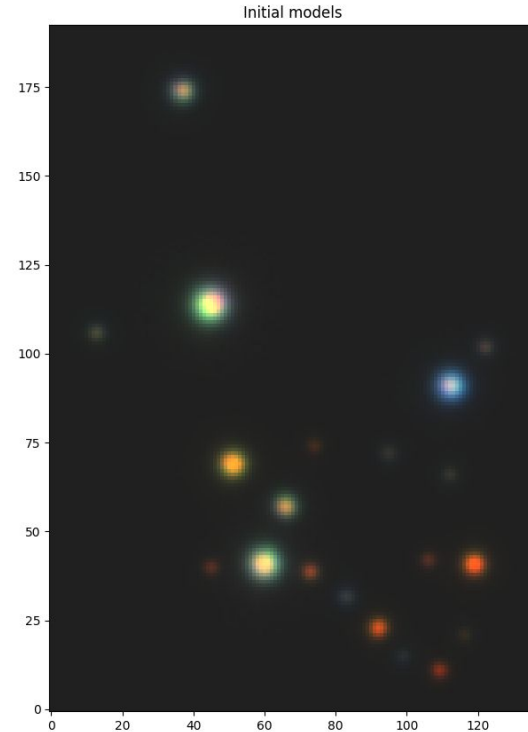
Thanks!!



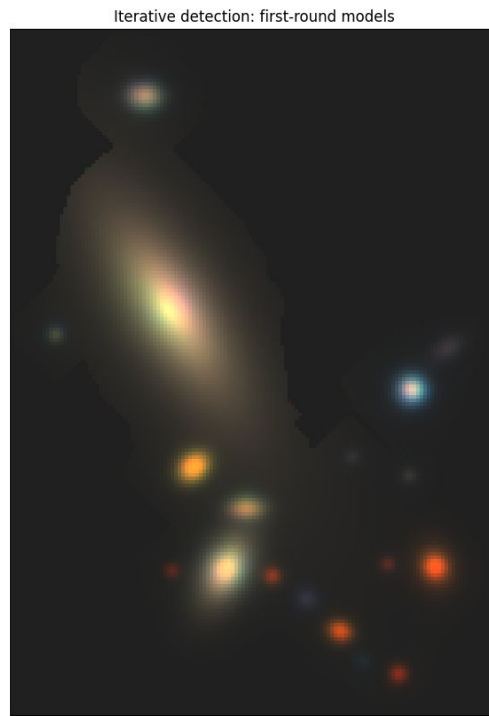
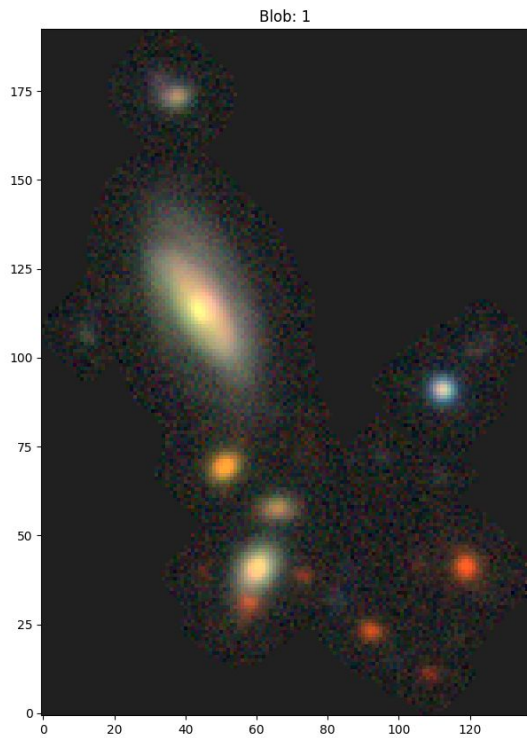
BONUS SLIDES

legacypipe - blob processing

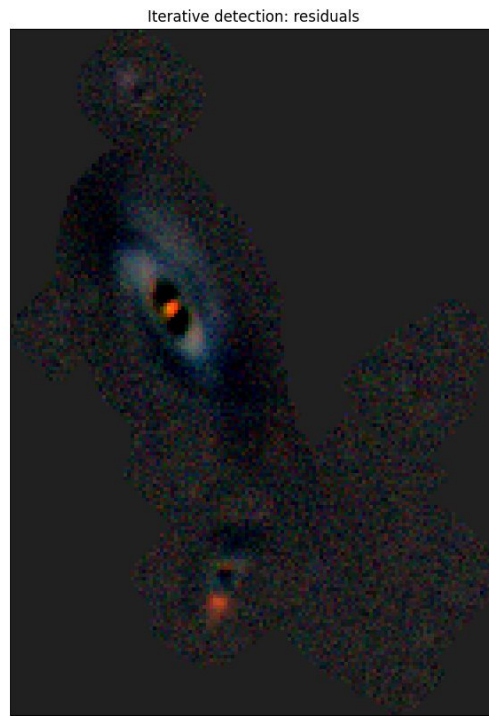
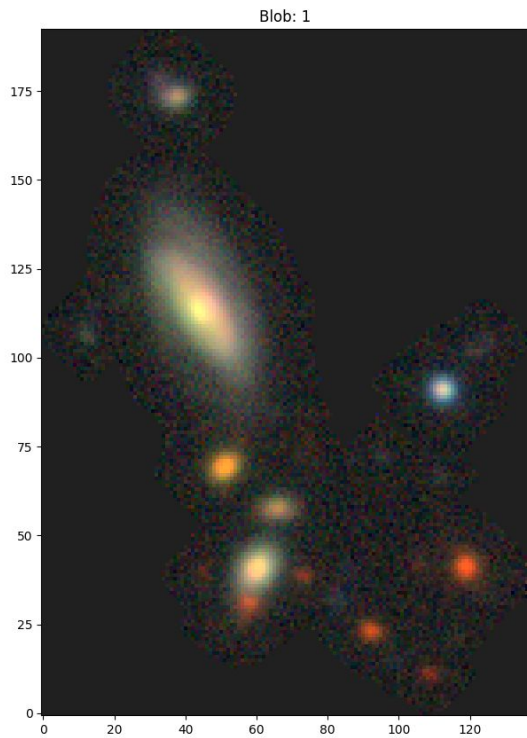
- forward modeling - source models that “explain” or “predict” pixel values
- models get convolved by each image’s PSF
- adjust model parameters to best match all images collectively
- fit sources one at a time, subtracting out current best model of everything else
- start out as point sources, then do model selection



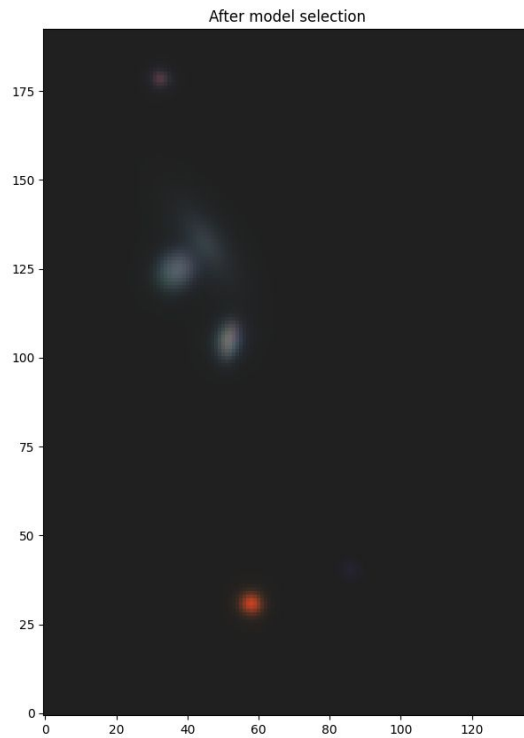
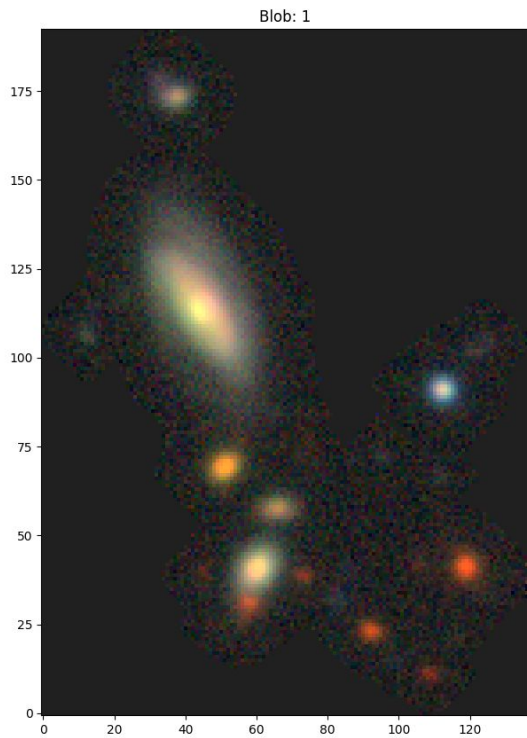
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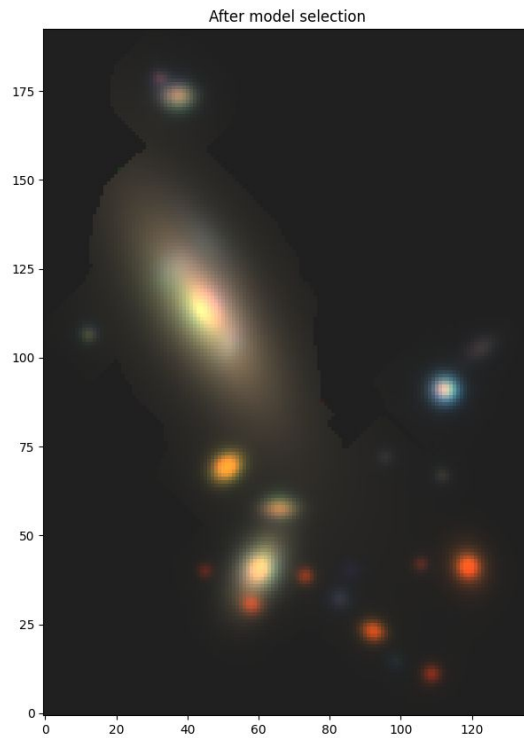
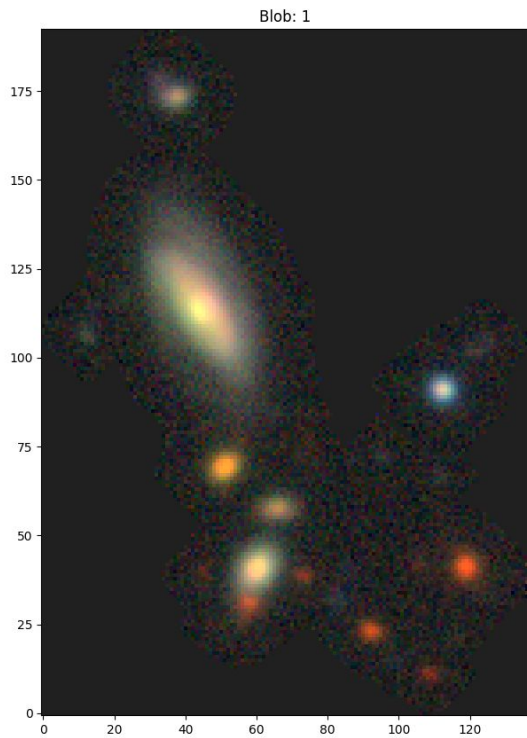
legacypipe - model fitting



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