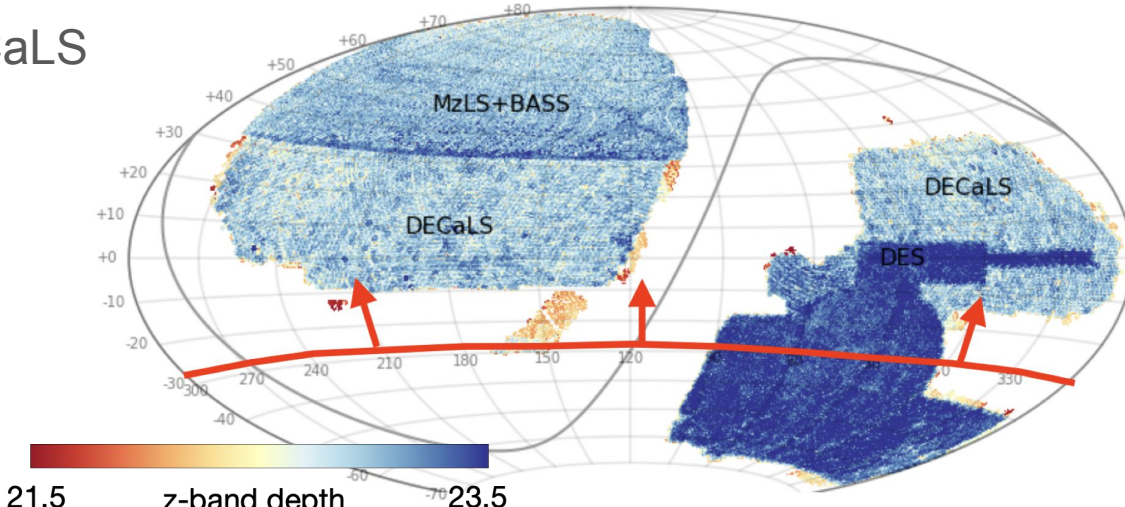
DESI Legacy Imaging Surveys

Dustin Lang
Perimeter Institute
DELVE Workshop
2022-09-16

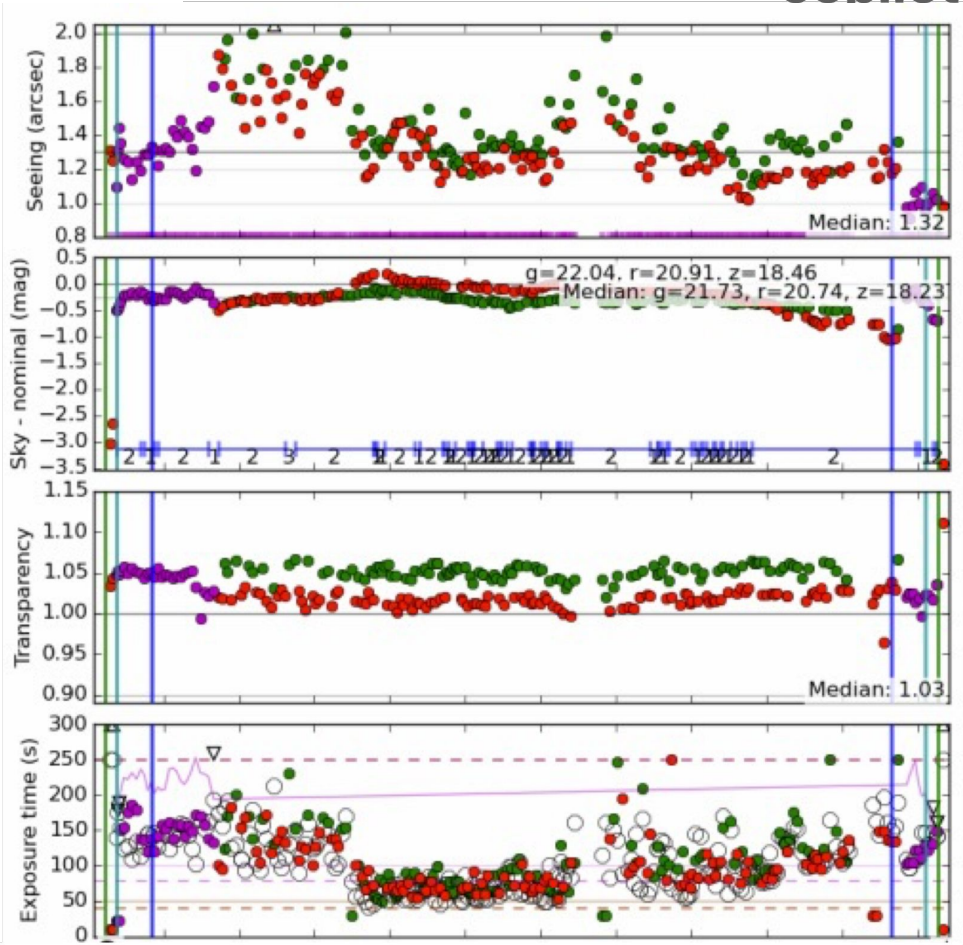
DESI Legacy Imaging Surveys (“Legacy Surveys”)

- 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

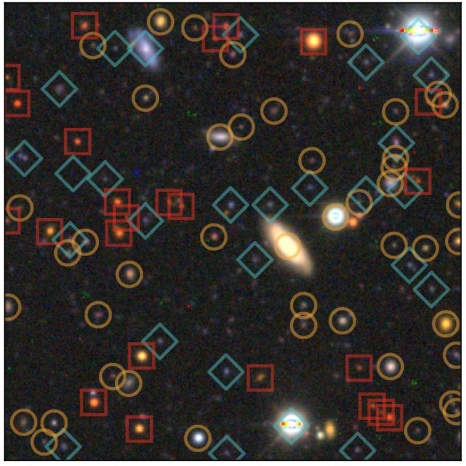
- DECam Community Pipeline at NOIRLab (Frank Valdes)
- legacyzpts:
  - psf (PsfEx)
  - sky background (“splinesky”)
  - photometric zeropoint (PS1 + “ubercal” (internal cross-calibration) - Eddie Schlafly)
  - astrometric offsets (to Gaia DR3)
- sky templates, fringing, and stellar halos (Rongpu Zhou)

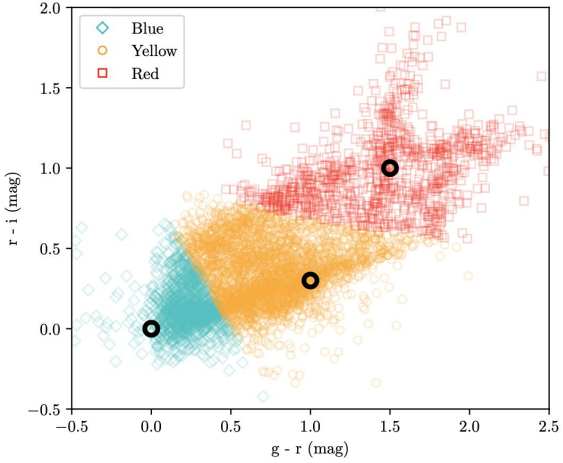
legacypipe

- 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

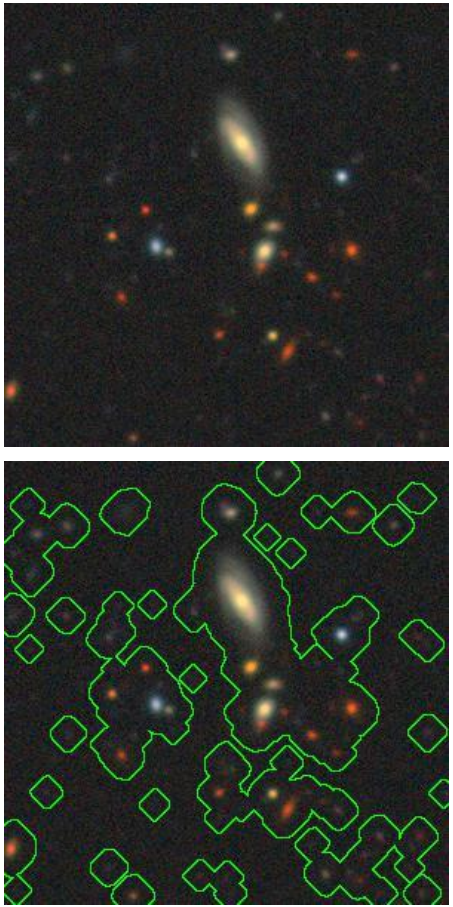
- Source detection is per arxiv:2012.15836
  ("Principled point-source detection in collections of astronomical images", Lang & Hogg)
- Matched filter (PSF-convolve) each image, coadd within each band
- Then do "SED-matched filter" to coadd between bands (we don't go Bayesian)
- Have to assume a set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





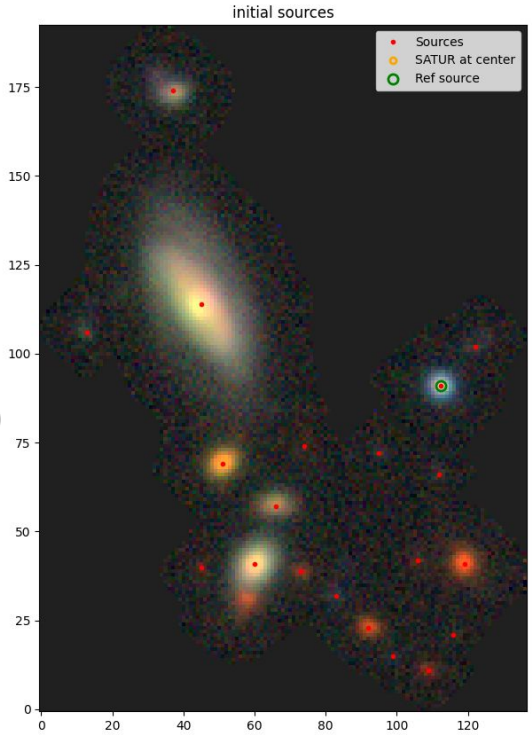
legacypipe - source fitting

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



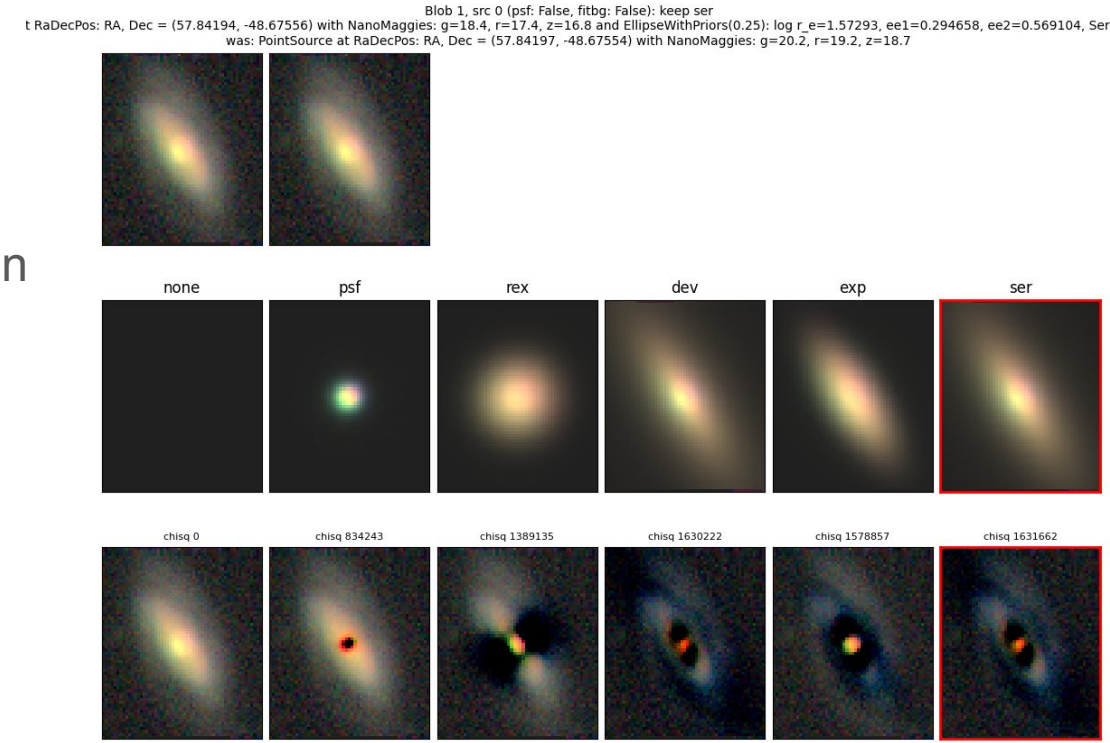
legacypipe - blob processing

- 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)

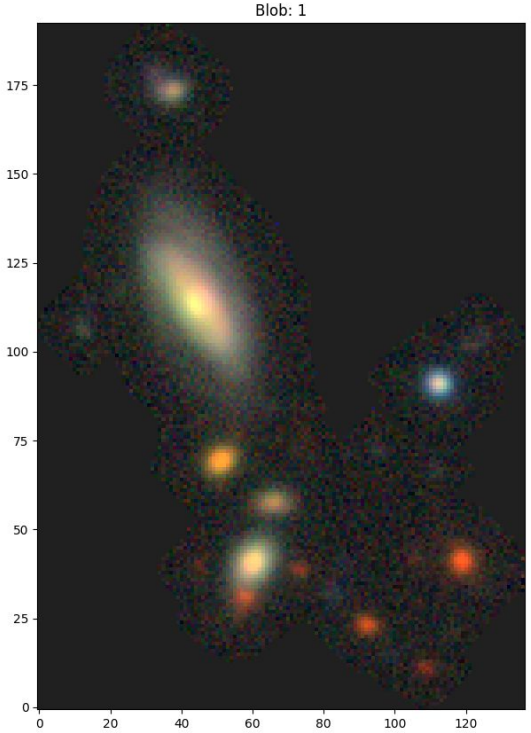


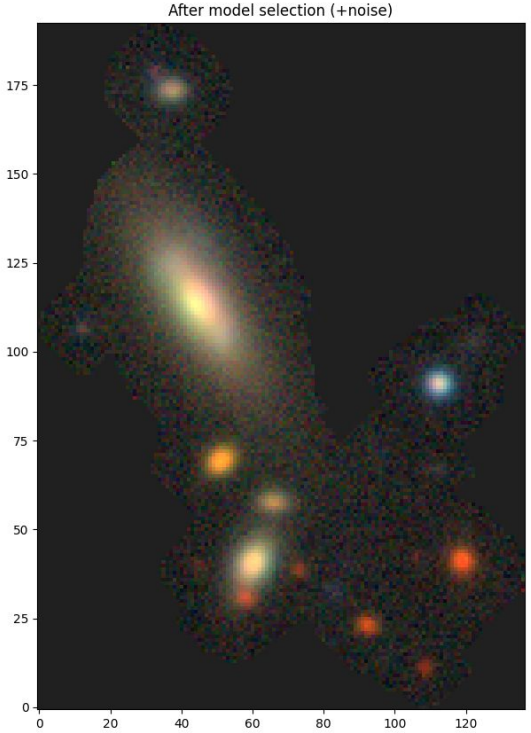
legacy pipe - model selection

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



legacypipe - model fitting



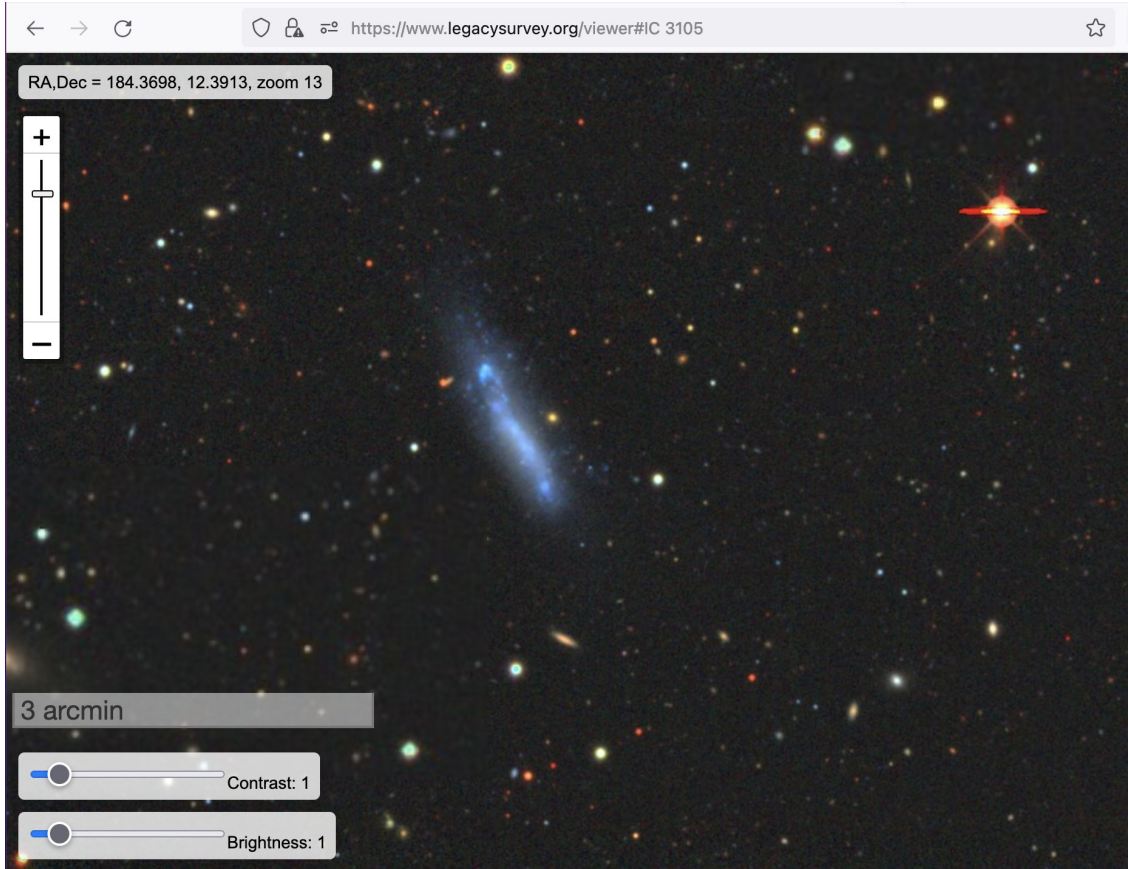


legacypipe - catalog contents

- 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”, …

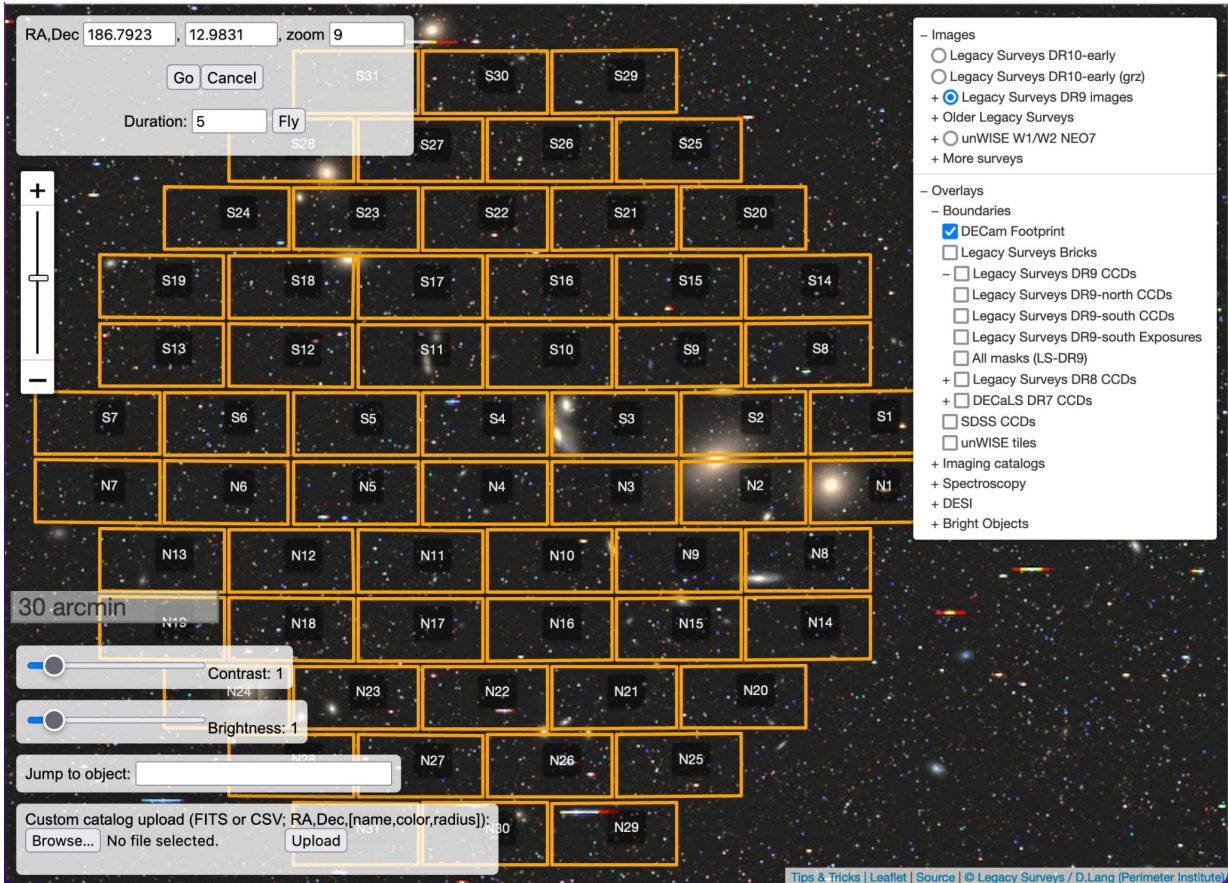
Legacy Surveys Sky Viewer

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



Legacy Surveys Sky Viewer - tidbits

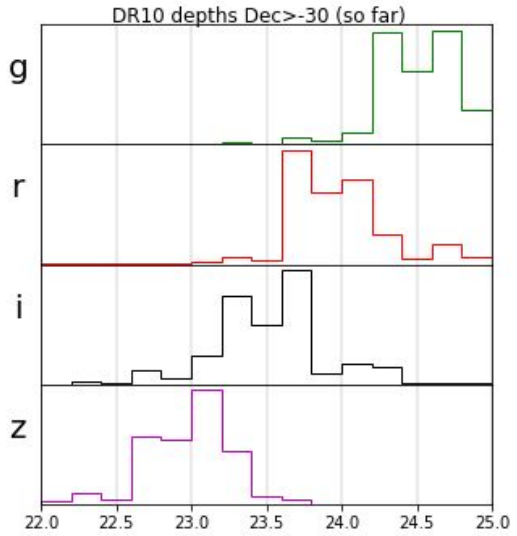
- DECam footprint
- “Link Here”
- Custom catalogs
- Fly to location



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

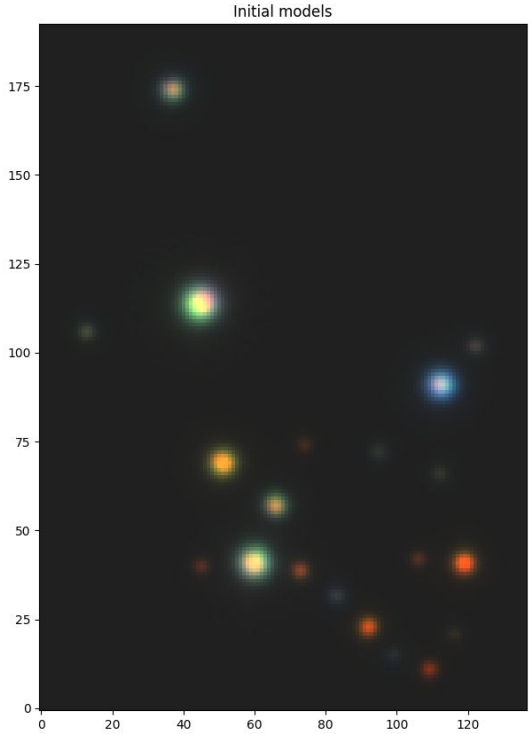
Thanks!!



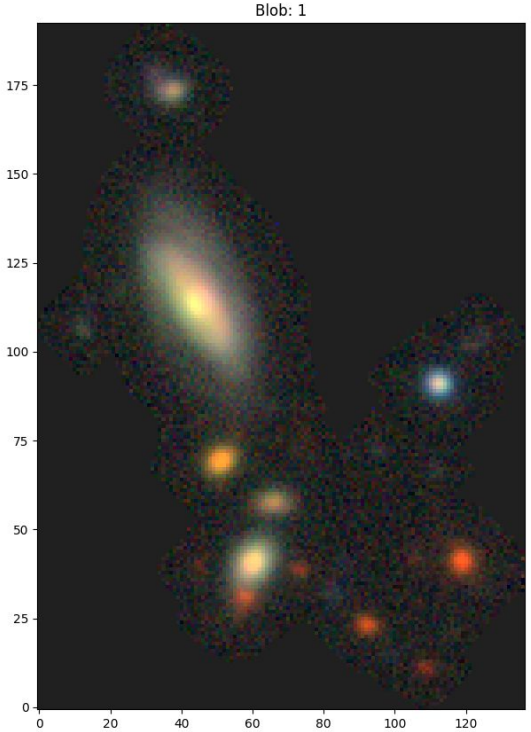
BONUS SLIDES

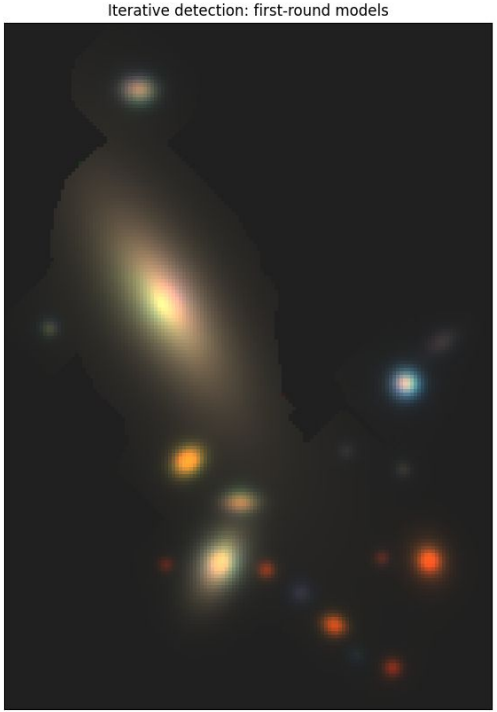
legacypipe - blob processing

- 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

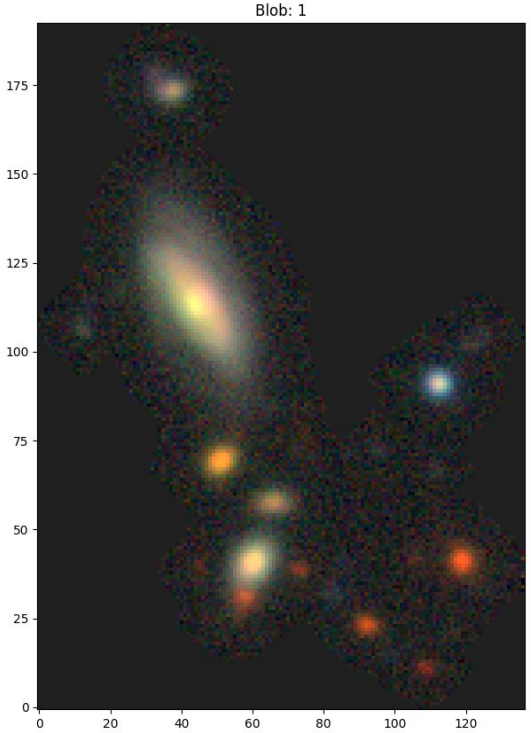


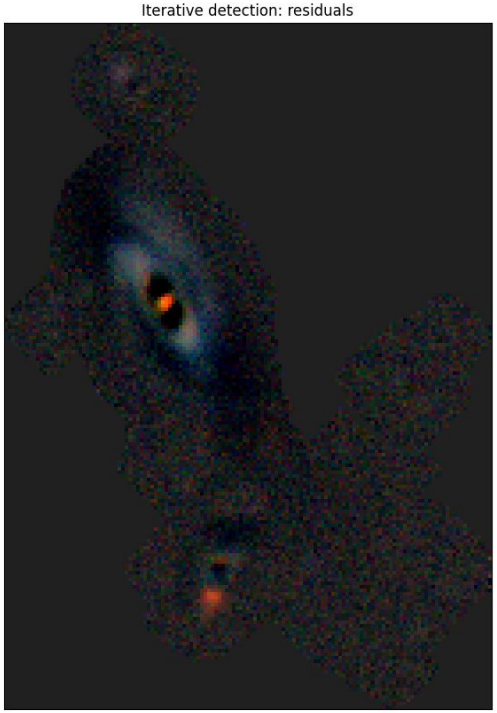
legacypipe - model fitting



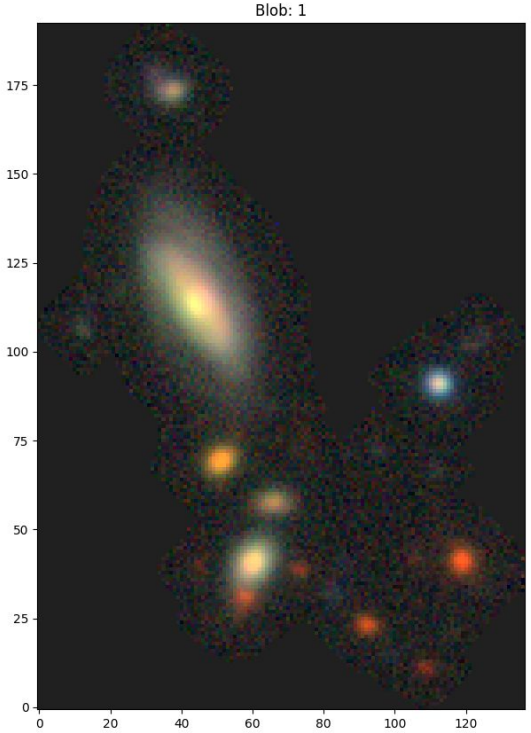


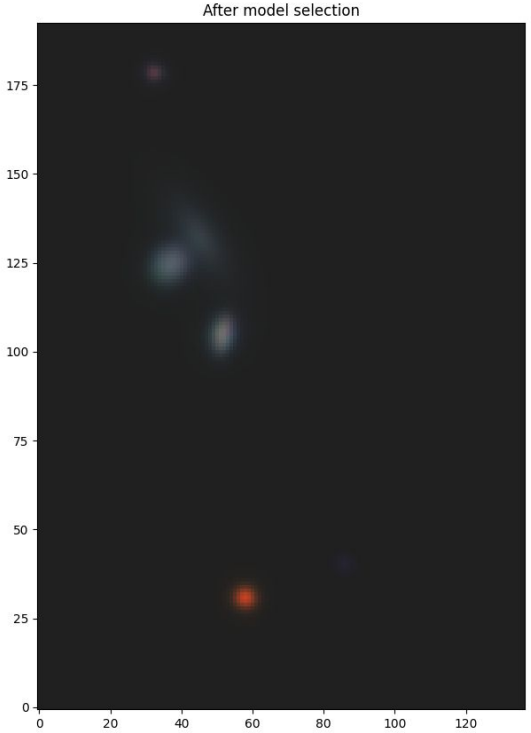
legacypipe - model fitting



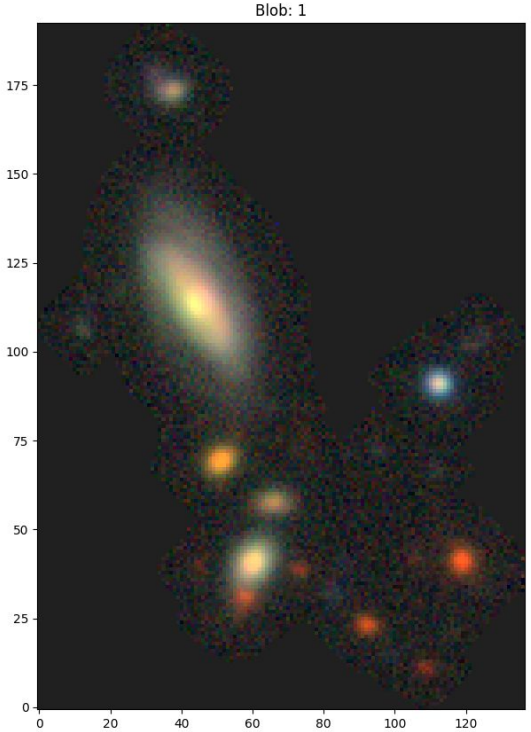


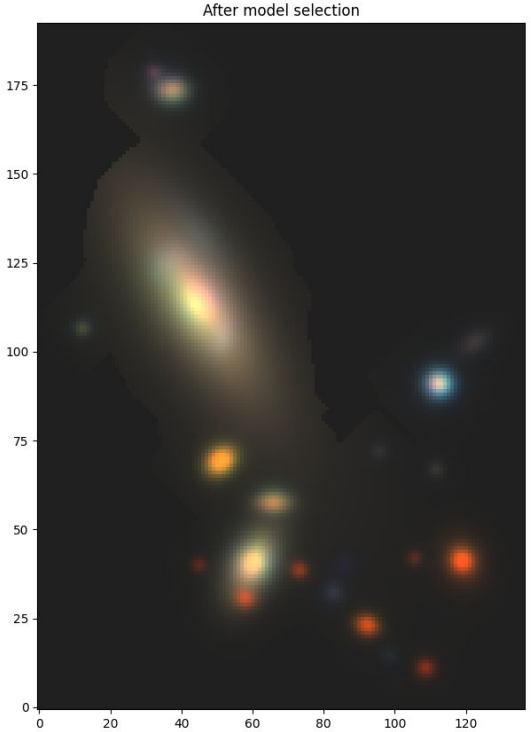
legacypipe - model fitting





legacypipe - model fitting





legacypipe - model fitting