

Supernova Host Galaxy Identification in DES

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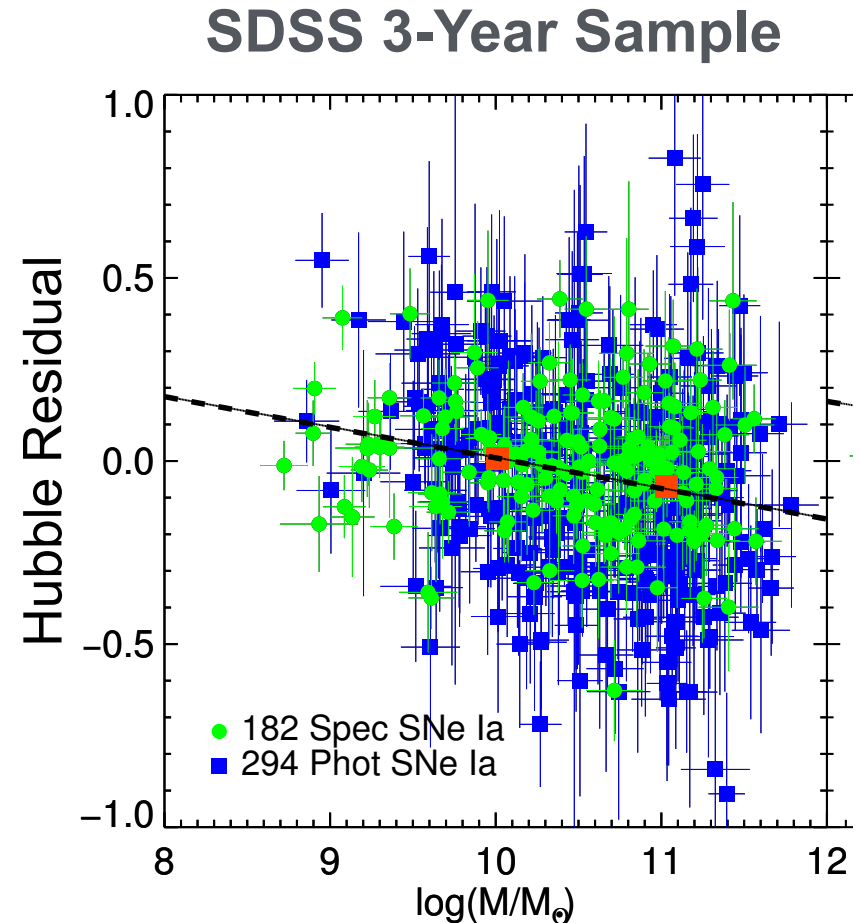
DES Chicagoland Workshop

9 December 2014

Argonne National Lab

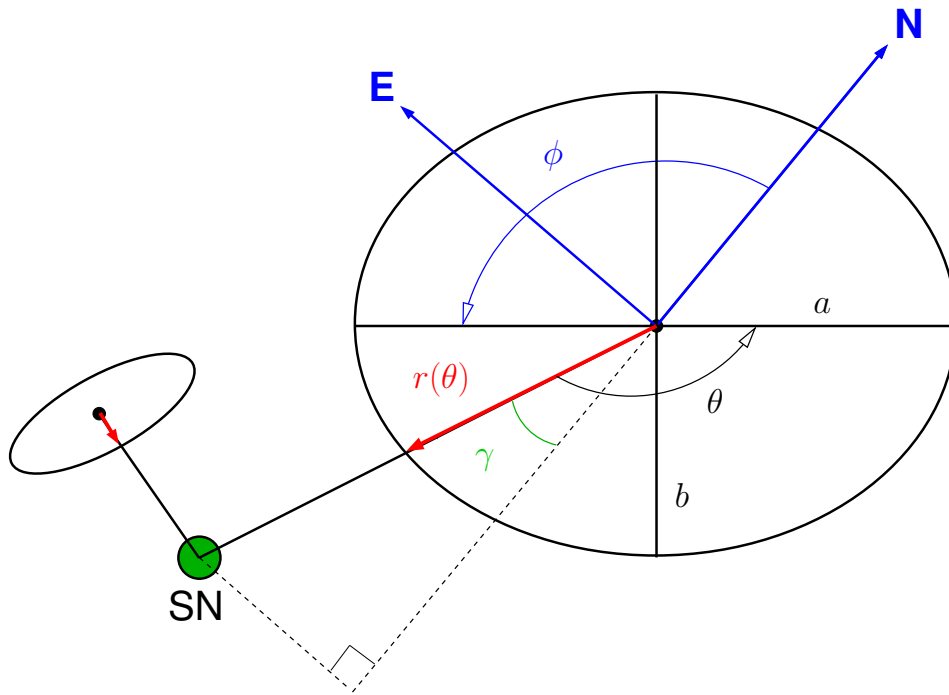
Why host matching matters

- ▶ Current & future surveys (DES, LSST) rely mainly on **host galaxy spectra** to obtain redshifts:
 - ▶ to use as a prior when photometrically typing a SN
 - ▶ to place the SN on a Hubble Diagram (x-coordinate)
- ▶ SN luminosities are known to correlate with host galaxy properties, so reliable identification of host galaxies is essential for cosmology and SN science

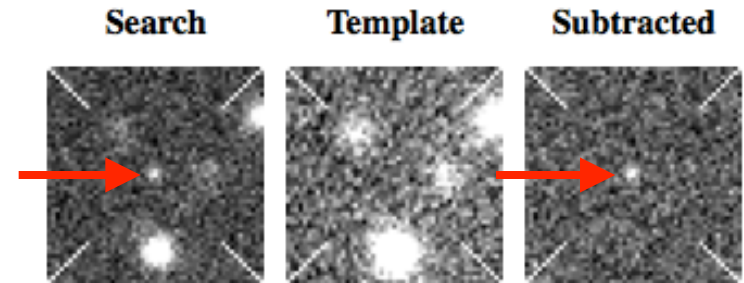


R. C. Wolf et al. (in prep)

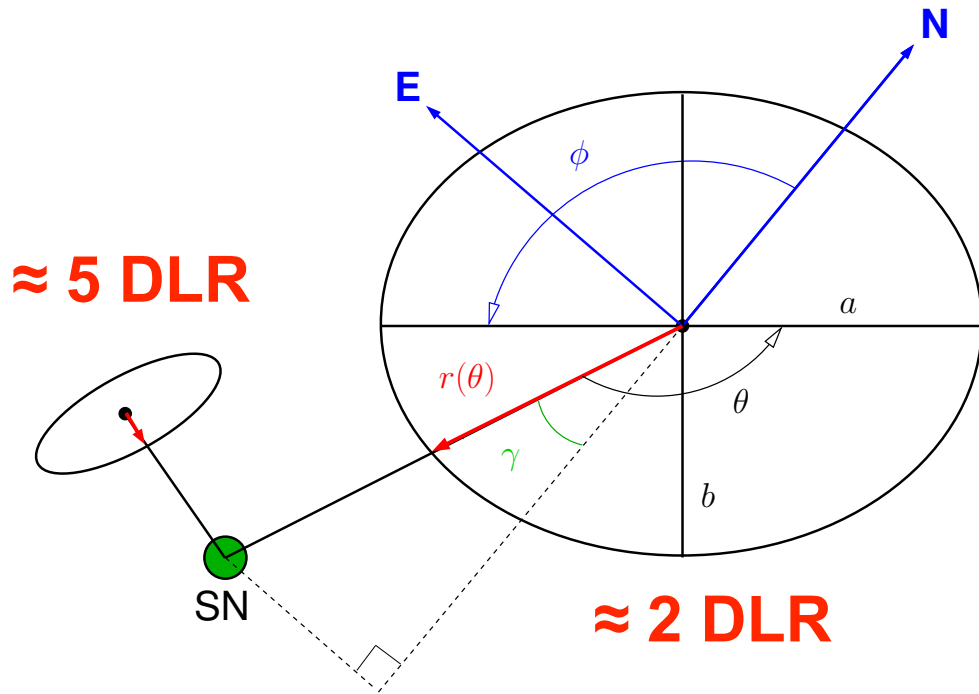
Why host matching isn't always easy



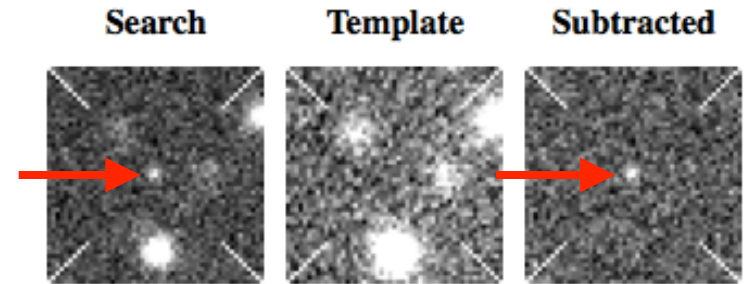
DES13C2ryh



Why host matching isn't always easy



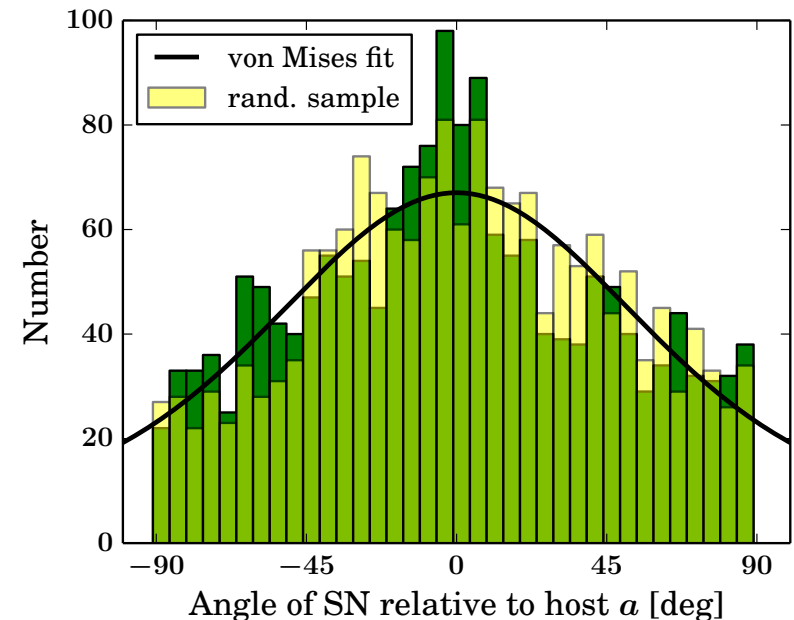
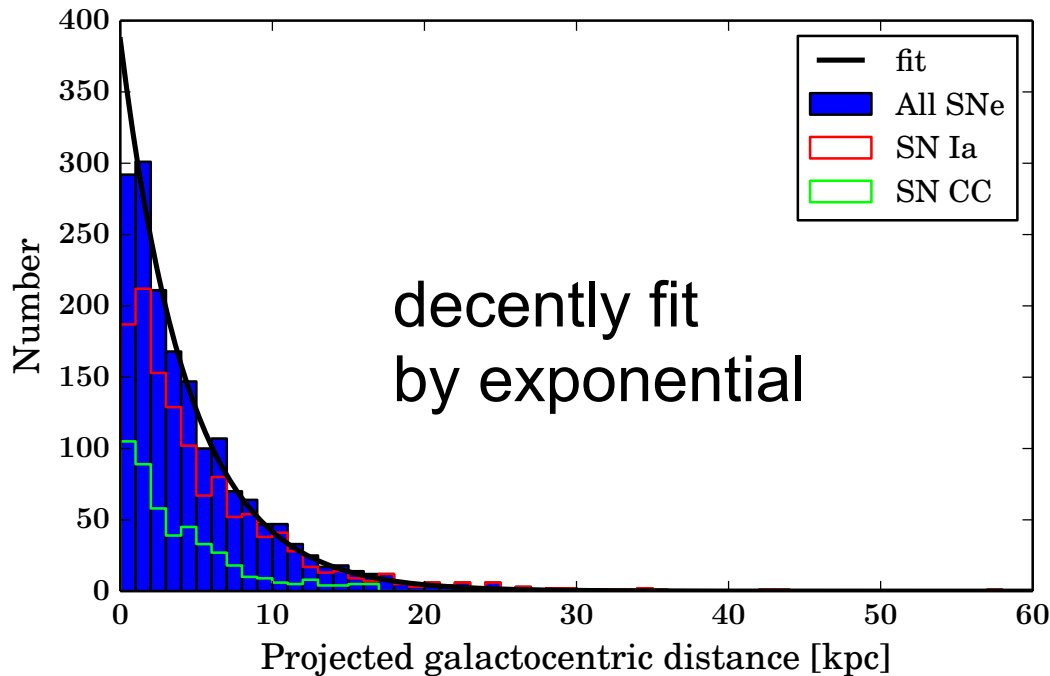
DES13C2ryh



- Use apparent size of nearby galaxies in addition to angular separation to determine host
- **directional light radius (DLR)** = separation of SN from galaxy in units of galaxy's apparent size

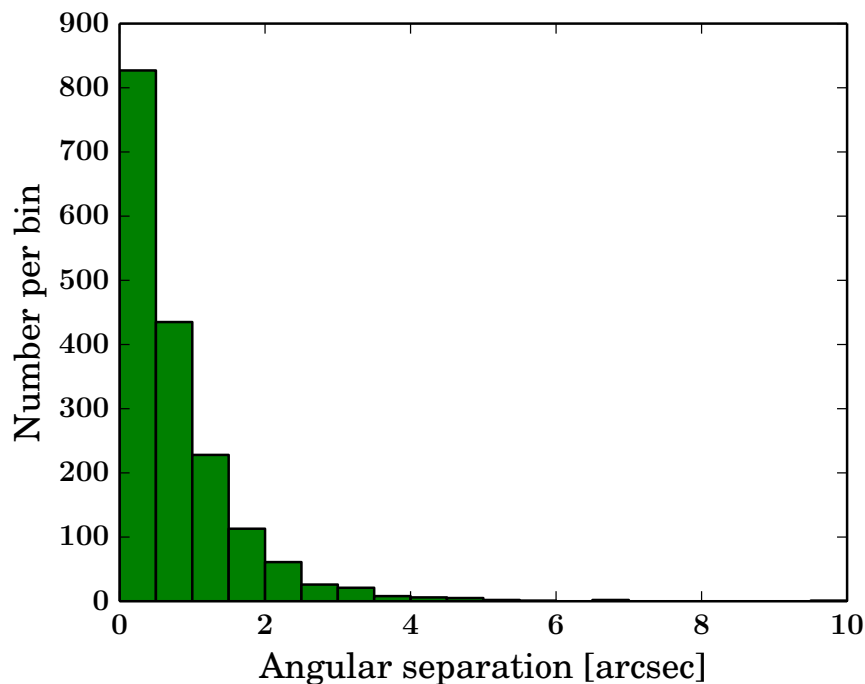
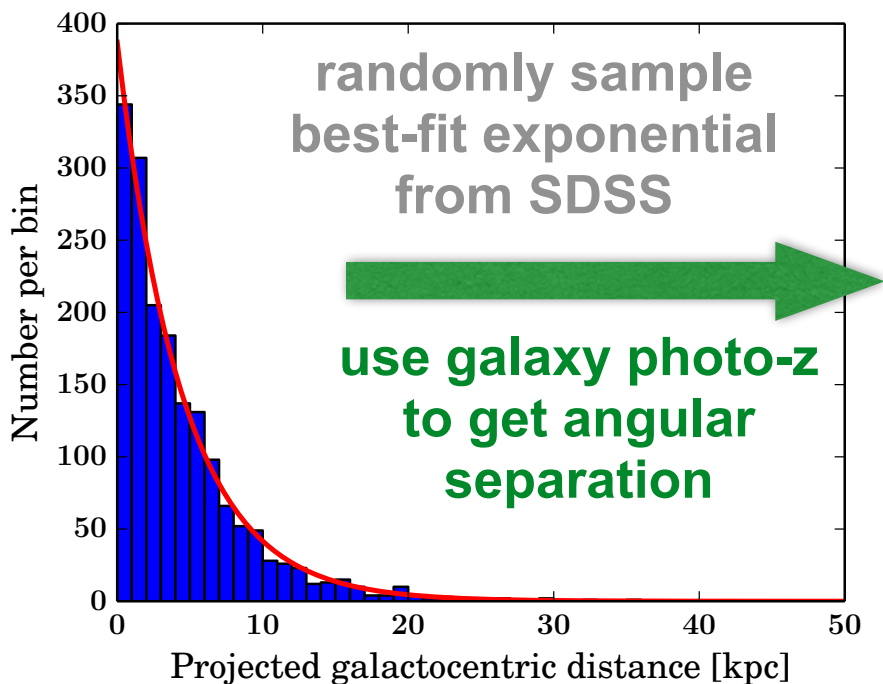
Starting Point: SDSS Supernovae

- ▶ SDSS Data Release: Compile 1736 SNe (of all types, with redshifts)
 - ▶ Construct SN-host physical distance using z and assumed (Λ CDM) cosmology
 - ▶ Construct distribution of SN orientation w.r.t host axis
- ▶ Use these as assumed distributions for placing DES SNe locations



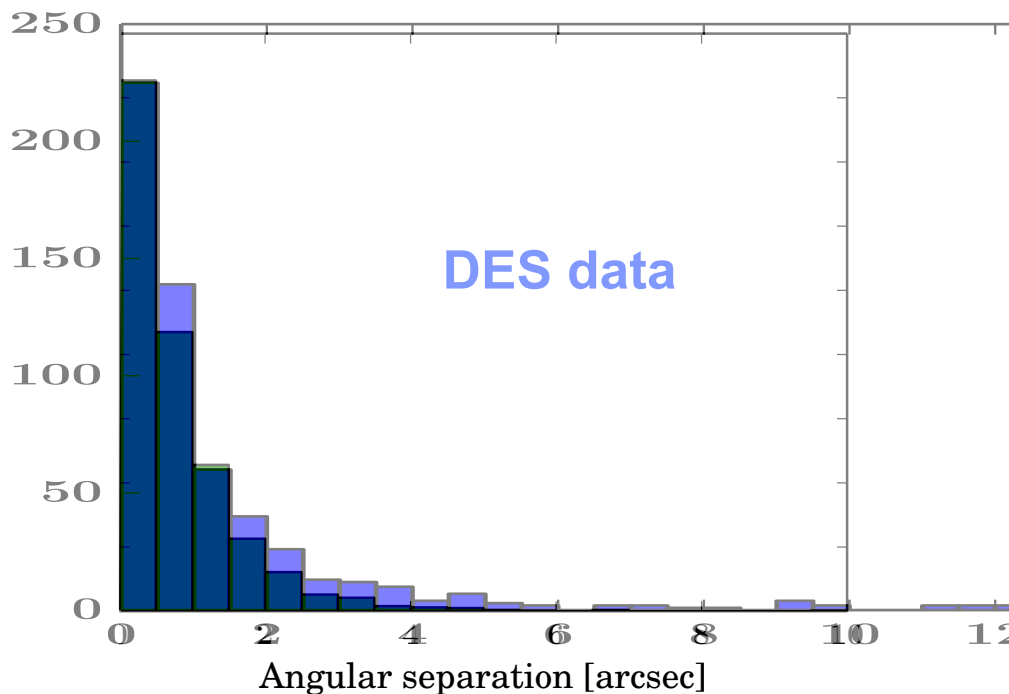
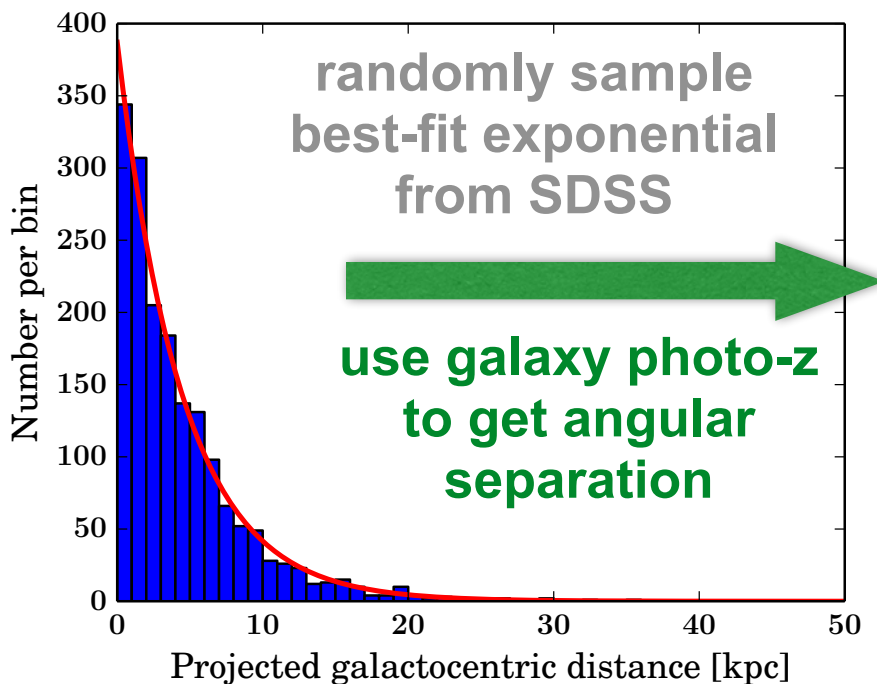
Use DES SVA1_COADD catalog to place “SNe”

- ▶ Test case: SN-C1 shallow field
- ▶ Sculpt photo-z distribution of galaxies to roughly match expected SN Ia z distribution
- ▶ Placed ~2000 DES “SN locations” (coordinates) on galaxies, according to assumed SDSS distributions.



Use DES SVA1_COADD catalog to place “SNe”

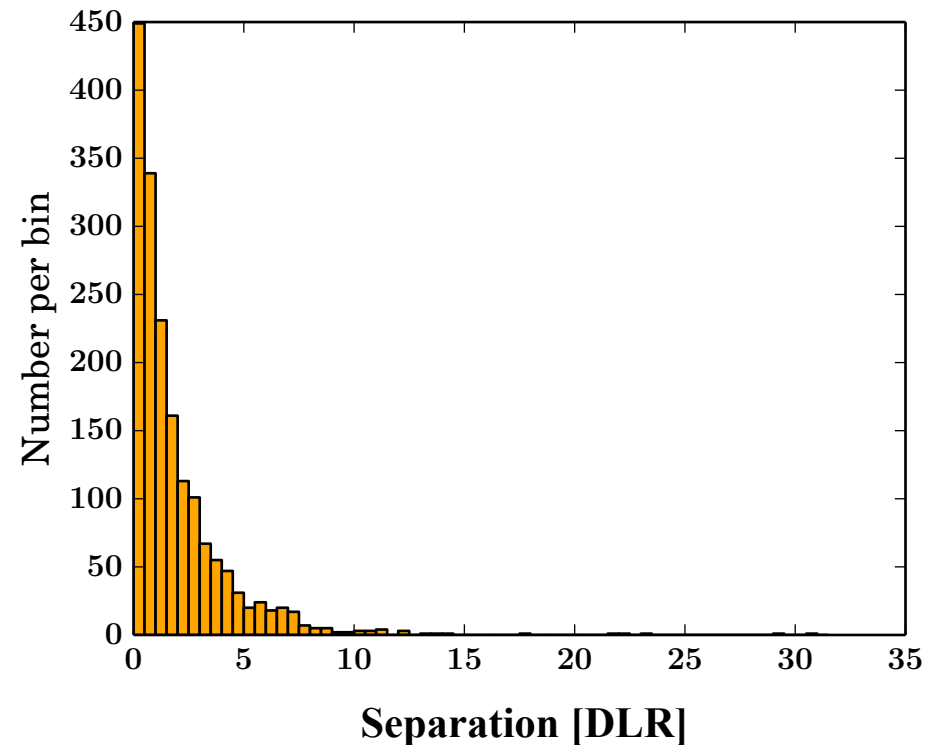
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Necessary DES catalog parameters for placement

- ▶ Host galaxy position angle
- ▶ Host galaxy axis ratio, a/b
- ▶ Host galaxy size

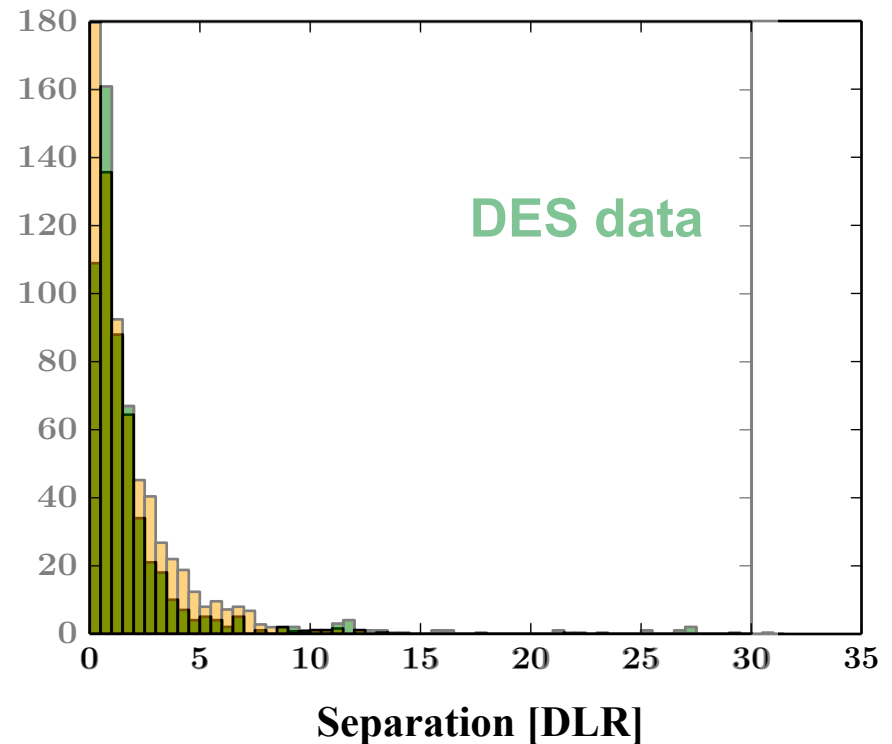
Each “SN” has a known true host with true separation (in arcsec and DLR)



Necessary DES catalog parameters for placement

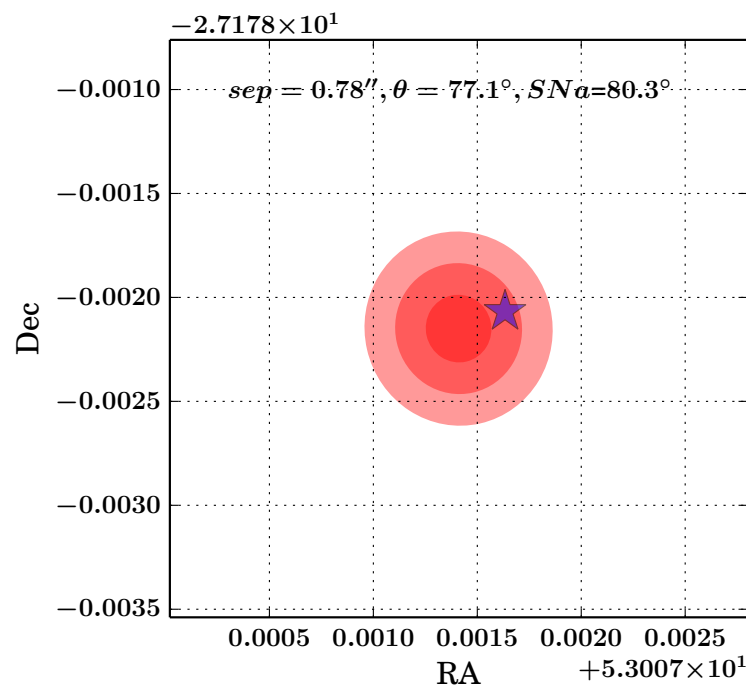
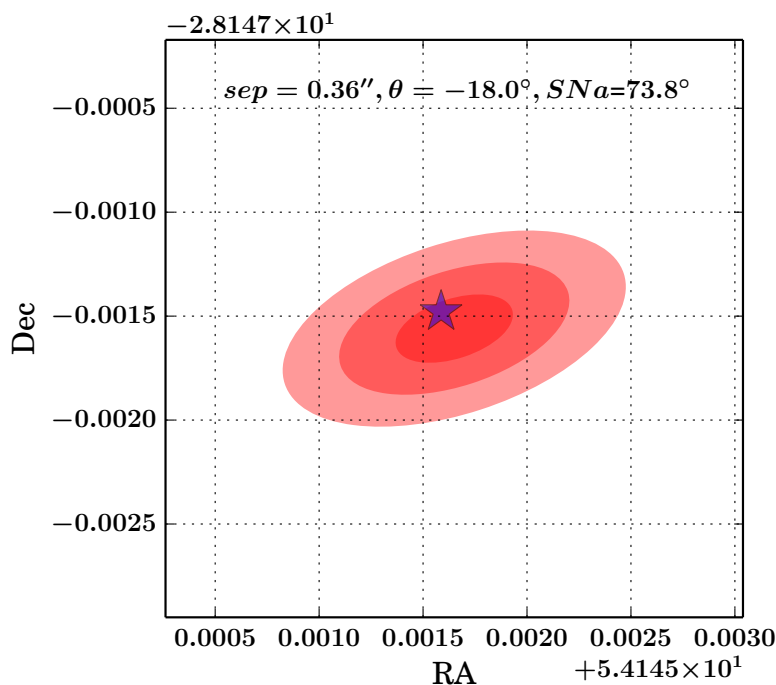
- ▶ Host galaxy position angle `THETA_IMAGE`
- ▶ Host galaxy axis ratio, a/b `A_IMAGE/B_IMAGE`
- ▶ Host galaxy size `A_IMAGE`

Each “SN” has a known true host with true separation (in arcsec and DLR)



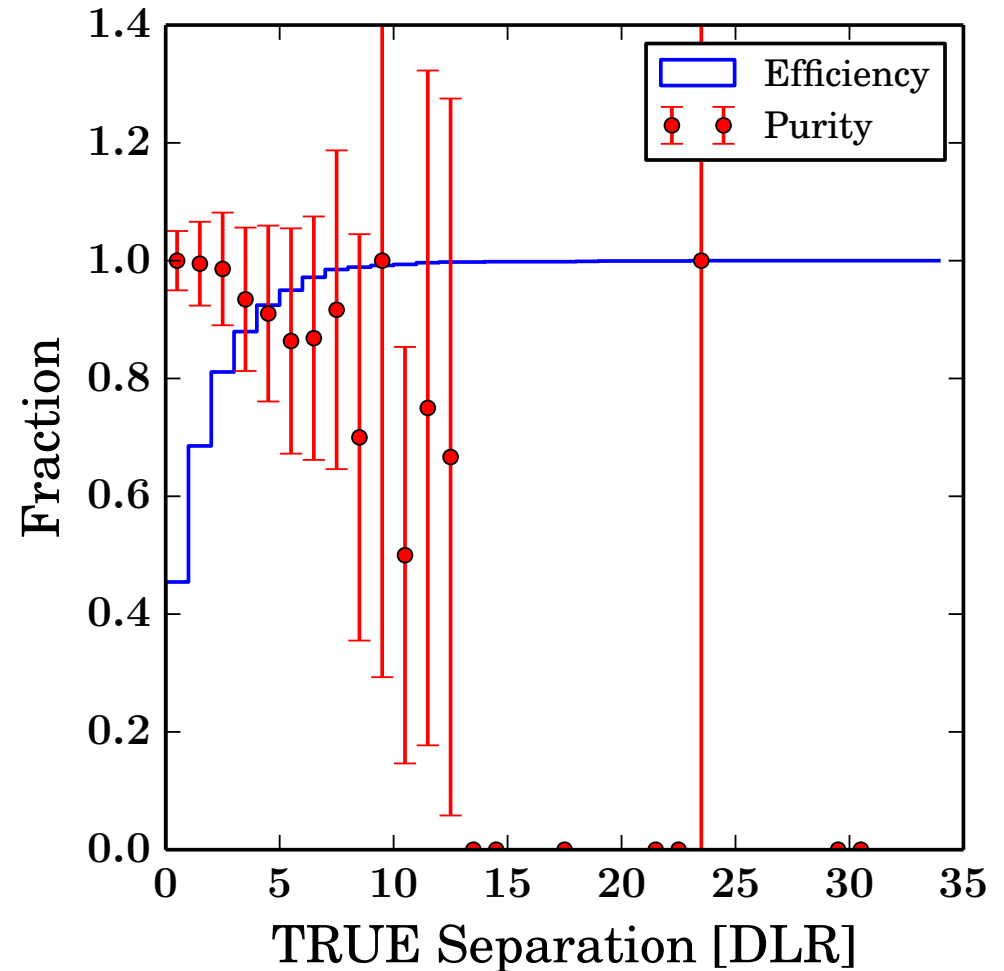
Visually check placement of SN locations

- ▶ Hosts are real DES galaxies (positions, photo-z's, A_IMAGE, B_IMAGE, THETA_IMAGE)
- ▶ SN separation, angle w.r.t host dictated by assumed SDSS distributions
- ▶ Ran current DES SN host matching algorithm on SN
- ▶ Correctly recovered 97% of the ~2000 hosts



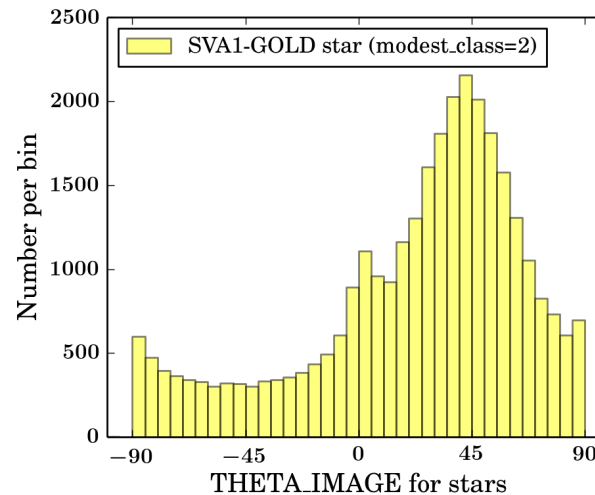
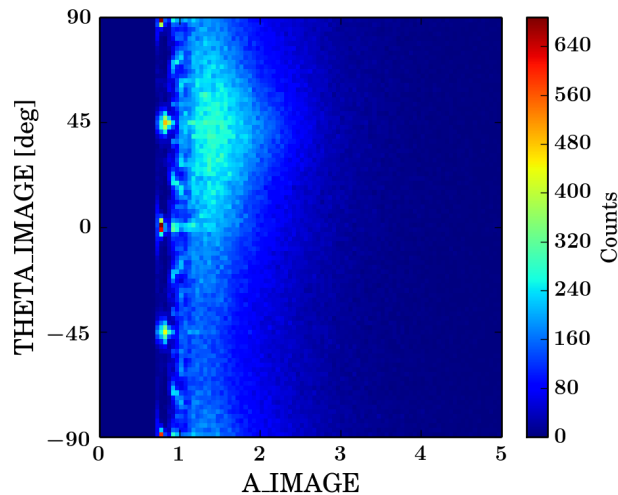
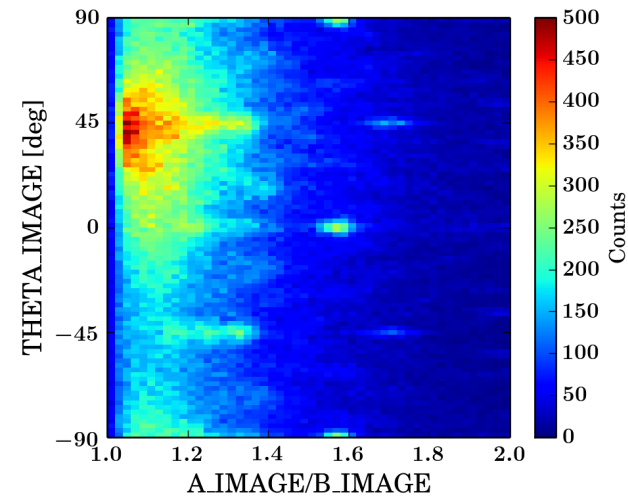
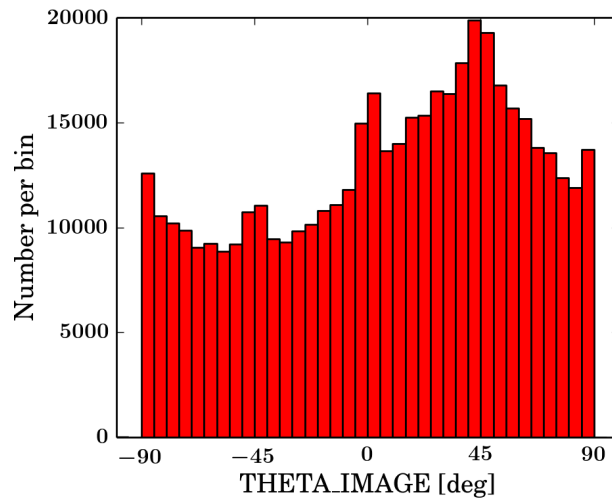
Purity & Efficiency of host matching for test case

- ▶ **Efficiency** = cumulative sum (normalized) of the DLR distribution
- ▶ **Purity** = in each bin, # of correct matches / total # in bin



In search of better SVA1_COADD parameters

Problem 1: The *_IMAGE parameters are raw measurements, not corrected for PSF.



In search of better SVA1_COADD parameters

Problem 2: The MODEL_WORLD parameters for A, B, THETA are absent from the database.

Workaround: Try to use what exists to get better (PSF-corrected) parameters I need.

Position angle

$$\text{ELLIP1MODEL_WORLD_}[GRIZY] = e_1 = |e| \cos(2\theta)$$

$$\text{ELLIP2MODEL_WORLD_}[GRIZY] = e_2 = |e| \sin(2\theta)$$



$$\theta = 0.5 * \text{atan2}(e_2, e_1) * 180/\pi$$

THETAMODEL_WORLD
in deg (E of N? N of W?)

Axis ratio

$$e_1^2 + e_2^2 = |e|^2$$



$$|e| = \frac{a - b}{a + b}$$

?

or

$$|e| = \frac{a^2 - b^2}{a^2 + b^2}$$

?

Size (r_{eff})

$$\text{MAG_MODEL_}[GRIZY] =$$

mag from model-fitting

$$\text{MU_EFF_MODEL_}[GRIZY] =$$

SB above bkg (mag/arcsec²)



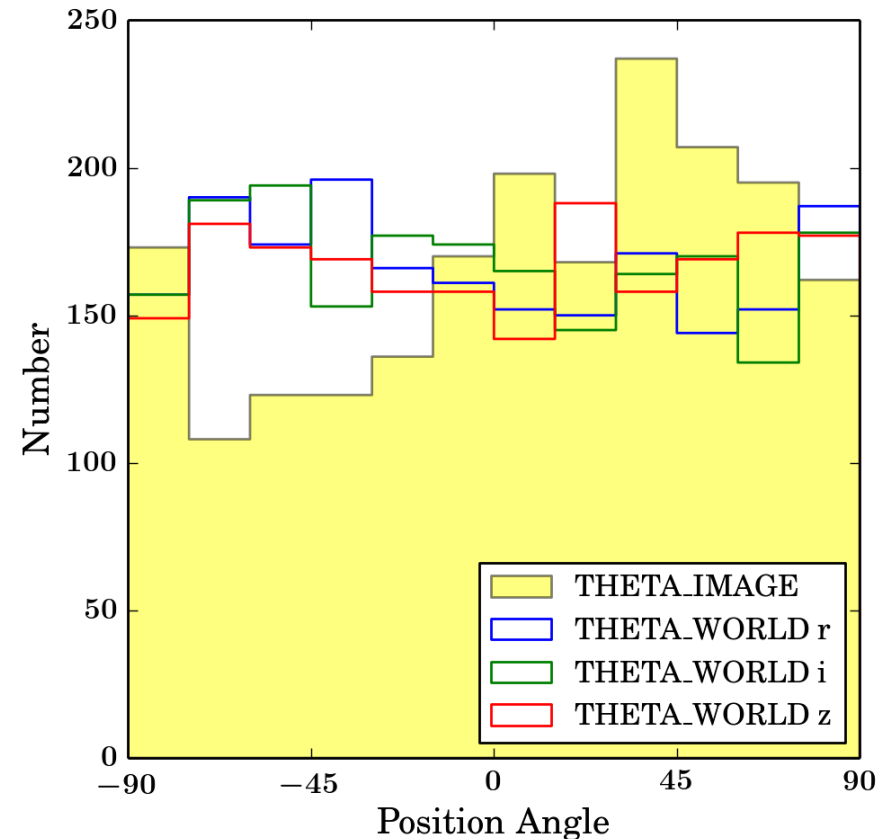
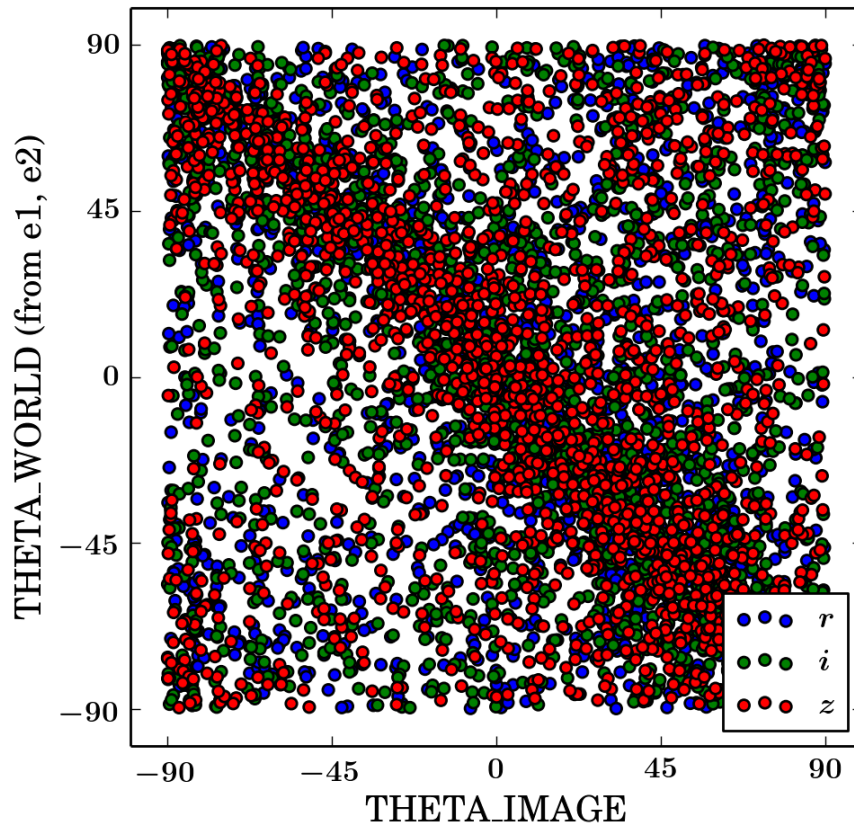
$$\text{Flux} = (\text{Flux/Area}) \times \text{Area}$$

$$10^{-\text{MAG_MODEL}/2.5} = 10^{-\text{MU_EFF_MODEL}/2.5} \times \pi r_{\text{eff}}^2$$

$$\text{(arcsec)} \quad r_{\text{eff}} = \sqrt{\frac{10^{-\text{MAG_MODEL}/2.5}}{\pi 10^{-\text{MU_EFF_MODEL}/2.5}}}$$

In search of better SVA1_COADD parameters

Position Angle

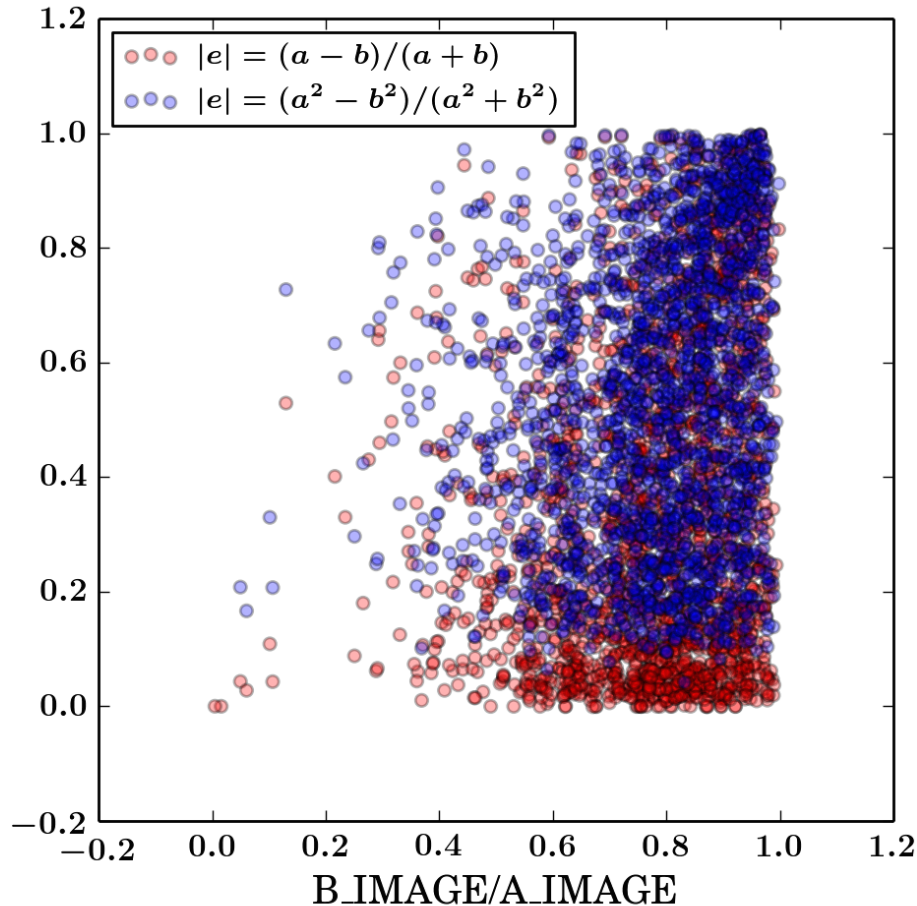


THETA_IMAGE measured CCW from +X (N of W)

THETA_WORLD measured CCW from WORLD X (WORLD X = ?)

In search of better SVA1_COADD parameters

Axis Ratio



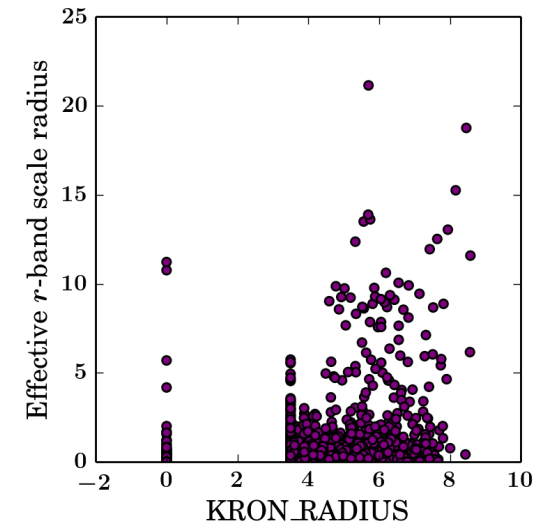
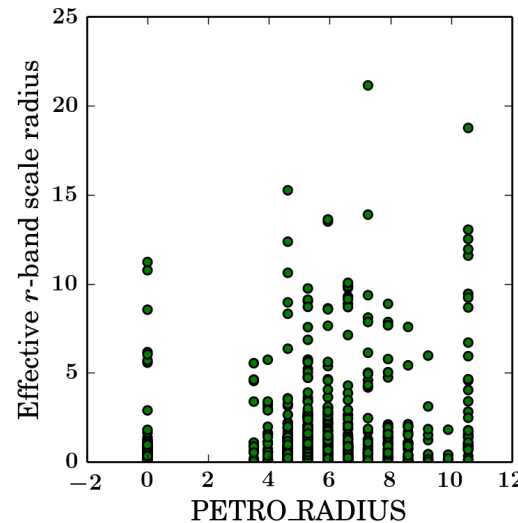
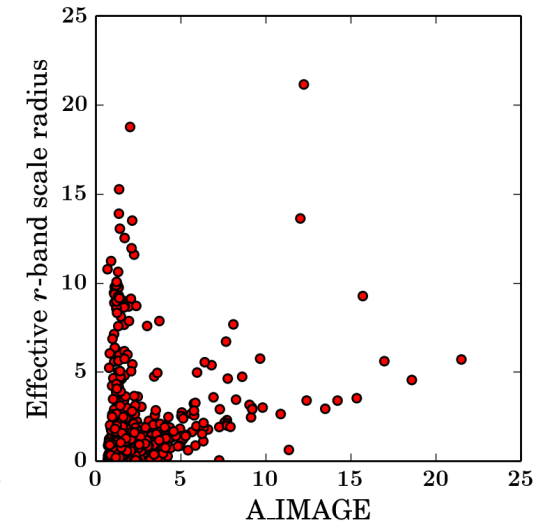
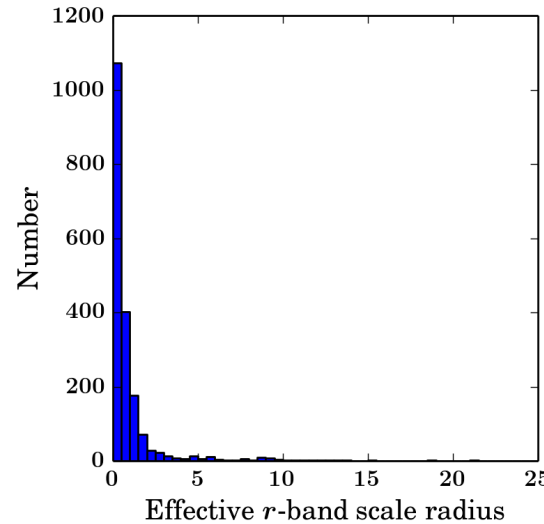
I believe $|e| = \frac{a^2 - b^2}{a^2 + b^2}$

is the correct relation, as it gives physical values in the expected range (someone please confirm!)

In search of better SVA1_COADD parameters

Size (r_{eff})

- ▶ Is this estimate of size reasonable?
- ▶ r_{eff} does not seem to correlate with other measures of size in the table
- ▶ Is there a better parameter that could be used?



Extra Slides



Parametrizing Host Confusion

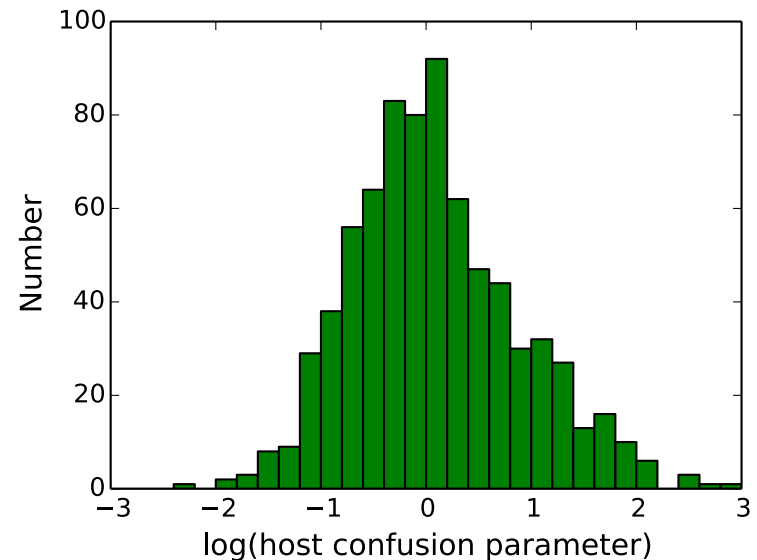
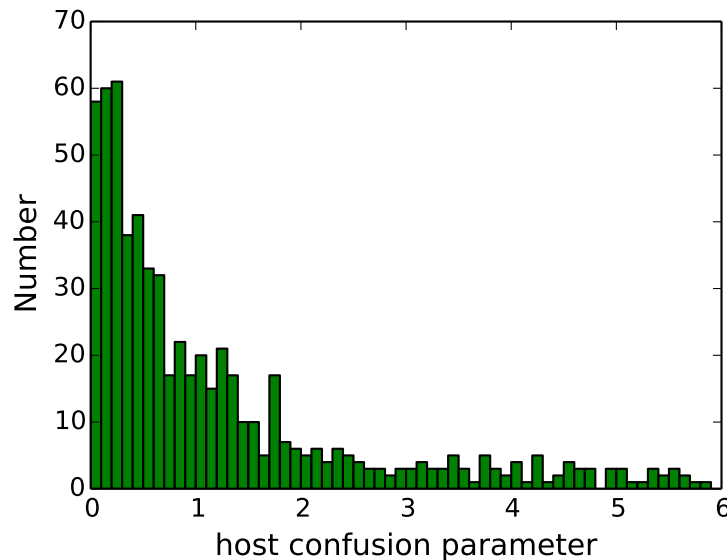
S_i = separation distance of i th host (arcseconds)

$$\Delta S_{ij} = S_i - S_j$$

D_i = separation distance of i th host (DLR)

$$\Delta D_{ij} = D_i - D_j$$

$$HC = \begin{cases} 0 & \text{if } N = 1 \\ \left(\sum_{\text{pairs } i,j} \frac{\min(S)}{|\Delta S_{ij}|} \right) + \left(\sum_{\text{pairs } i,j} \frac{\min(D)}{|\Delta D_{ij}|} \right) & \text{if } N > 1 \end{cases}$$



Investigating incorrect host matches

