Gaussian Aperture and PSF (GAaP) photometry

Matched-aperture photometry:
colours for photo-z

Colours for Photo-z

- Two requirements:
  - Good S/N
  - No biases
- Problem
  - galaxies are noisy, small
  - Seeing, PSF changes

Colours do NOT need to be based on total magnitudes!

As long as all points on the SED refer to the same parts of the galaxy

Optimal S/N
⇒ aperture function matches galaxy image

Matched apertures

- Total magnitudes: hard, noisy

- Aperture magnitudes:
  - affected by PSF
  - colour gradients may bias result further
- Want <u>same</u> part of the galaxy contributing to each band
  - (in fact, can favour central red parts of galaxies for which photo-z are a little easier)

Gaussian Aperture and PSF (GAaP)

- Relate aperture photometry on pre- and post-seeing images:
  - **I(x)** is pre-seeing image, **P(x)** is the PSF
  - **∫dy I(y) P(x-y)** is post-seeing image
  - **∫dx ∫dy I(y) P(x-y) W(x)** is aperture photometry with weight **W**

$$= \int dy\, I(y) \underbrace{\int dx\, P(x-y)\, W(x)}$$

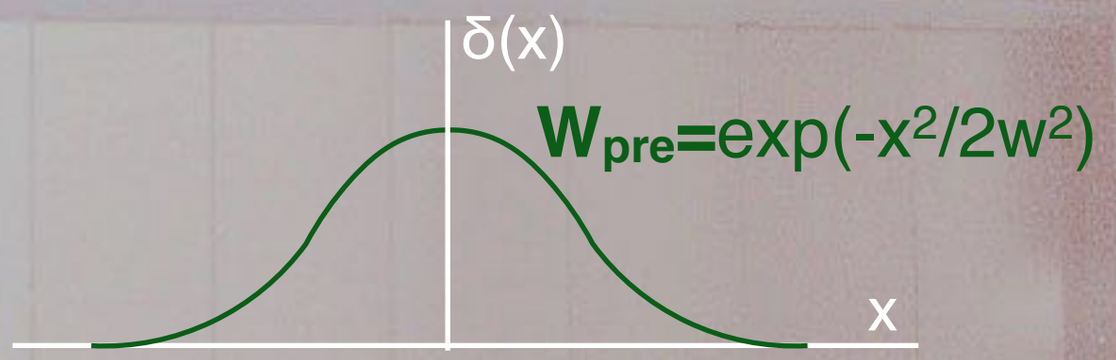
= modified aperture $\mathbf{W_{pre}}$ on pre-seeing image **I(y)**.

As long as $\mathbf{W_{pre}}$ is the same in all bands our SED is unbiased

- In GAaP, **P** and **W** are Gaussians, so all integrals analytic
- Choose $\mathbf{W_{pre}}$: then given **P** calculate **W** (deconvolve by **P**)

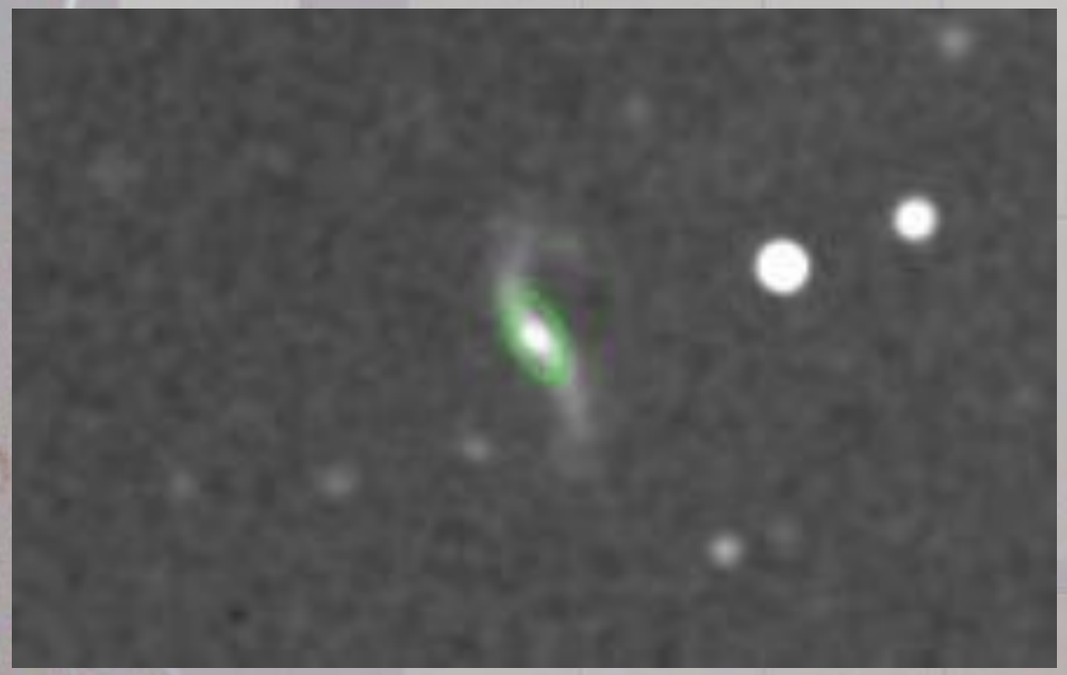
Advantages

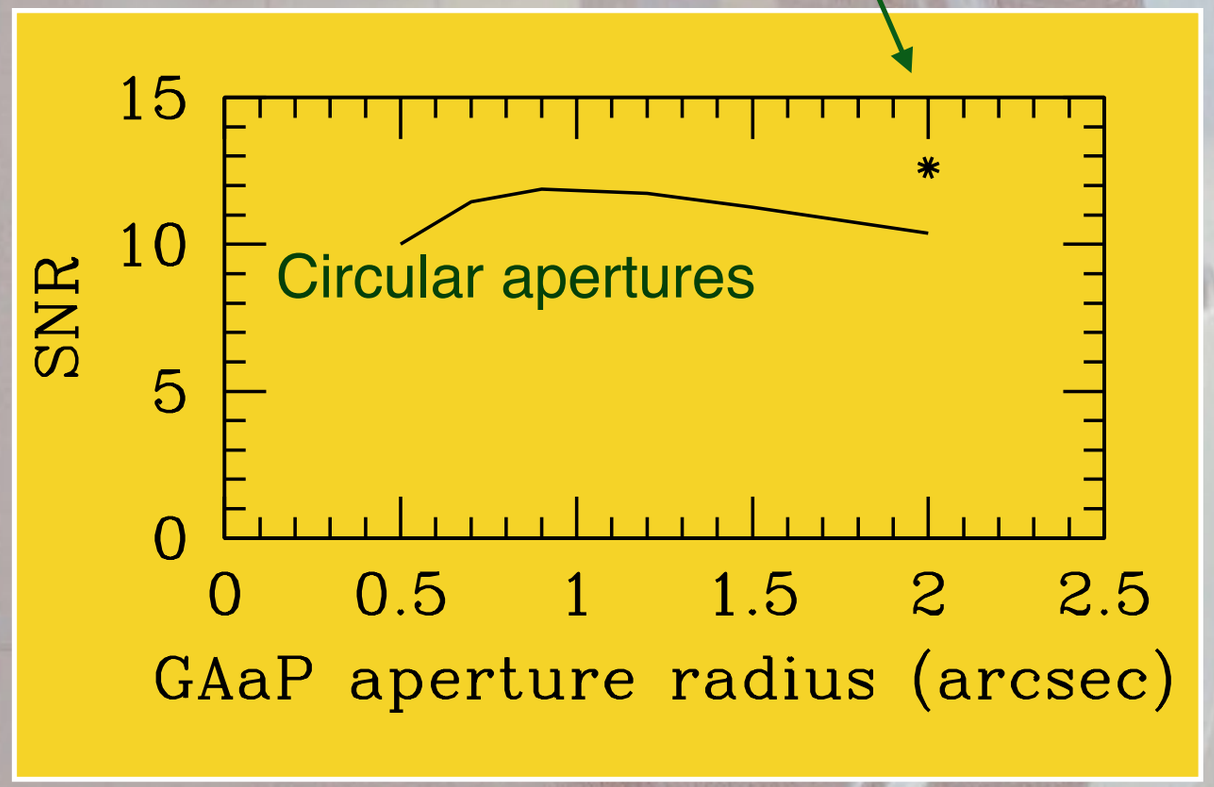
- Flexible, only requirement is that W_{pre} is fatter than P
- Can use different pixel scales, image orientations
- Generalize to elliptical Gaussian weight fns.
- Linear, propagate noise covariance. Real error bars!
- compact apertures, NOT total flux! Choose these to optimize S/N



- For stars GAaP flux IS total flux. Use this to discriminate stars/galaxies (pre-seeing curve-of-growth)

Broad SNR maximum





Kuijken et al 2015, MNRAS 454, 3500

Gaussianizing the PSF

- GAaP requires images with Gaussian PSF
- Convolve square-degree tiles with Gaussianization kernel
- Parametrize kernel as sum of shapelets + ‘wing terms’
  - shapelet = Gaussian x polynomial
    - Fourier transform analytic so easy convolutions
  - least-squares fit kernel coefficients to give target PSF
  - fit coefficients’ variation across image with polynomials

Conclusion

- GAaP photometry combines high S/N aperture photometry with accurate correction for PSF effects.
- Forced photometry: easy to add new bands to data set
- Flexible in terms of pixel size and image orientation
- PSF Gaussianization most expensive step
  - Take advantage of shapelets formalism
- For details see Kuijken et al 2015, MNRAS 454, 3500