Non-parametric estimation of lopsidedness in galaxies

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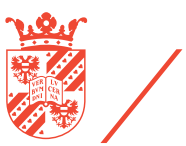

kapteyn astronomical institute

ASTRON

European Research Council

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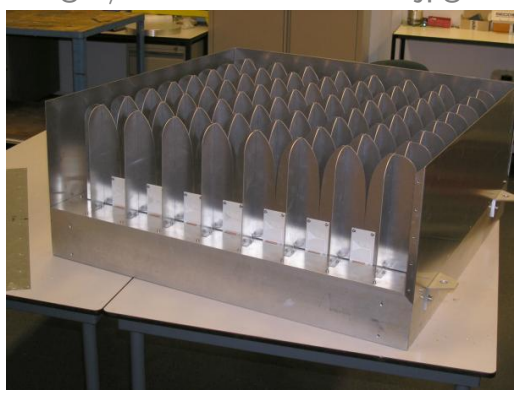
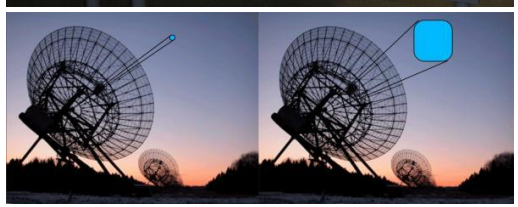
Overview - The problem

- Large blind surveys ⇒ unbiased samples to study galaxy evolution
- Evolutionary processes manifest as lopsidedness in gas morphology and kinematics
- Detailed model fitting (e.g. with TiRiFiC) is time consuming and needs good resolution ⇒ suitable for nearby objects
- Duffy et al. (2012):

	WALLABY	WNSHS
>1 beam [N_{gal} (per cent)]	542 706 (87.5)	327 454 (62.4)
>3 beams [N_{gal} (per cent)]	30 859 (5.0)	11 557 (2.2)
>5 beams [N_{gal} (per cent)]	6205 (1.0)	2416 (0.5)
>10 beams [N_{gal} (per cent)]	699 (0.1)	271 (0.05)
>20 beams [N_{gal} (per cent)]	74 (0.01)	37 (0.01)

http://www.ska.gov.au/PublishingImages/ASKAP_wPAF_web.jpg

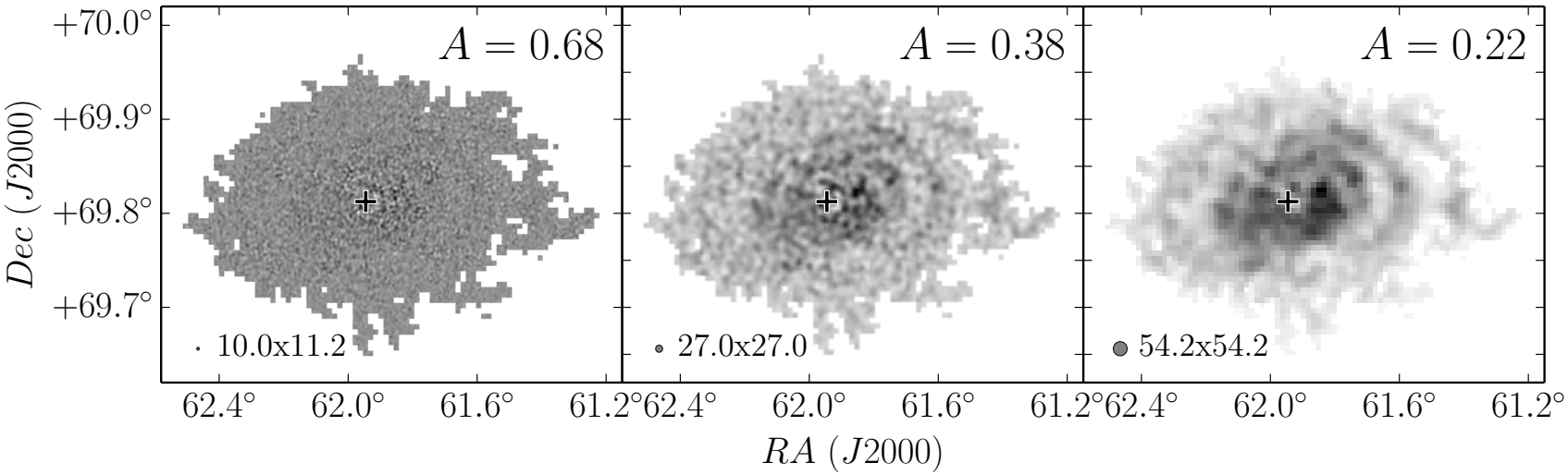




http://www.astron.nl/general/apertif/apertif

Overview - A possible solution?

$\Rightarrow$ Use non-parametric methods for objects at lower resolution to find asymmetric galaxies



S/N	0.34	1.66	4.38

Asymmetry parameter:

$$A = \frac{\sum_{i,j} |I(i,j) - I_{180}(i,j)|}{2 \sum_{i,j} |I(i,j)|}$$

Conselice, Bershady, & Jangren 2000 (optical), Holwerda et al. 2011 (HI)

Limitations

(Józsa et al. 2007)
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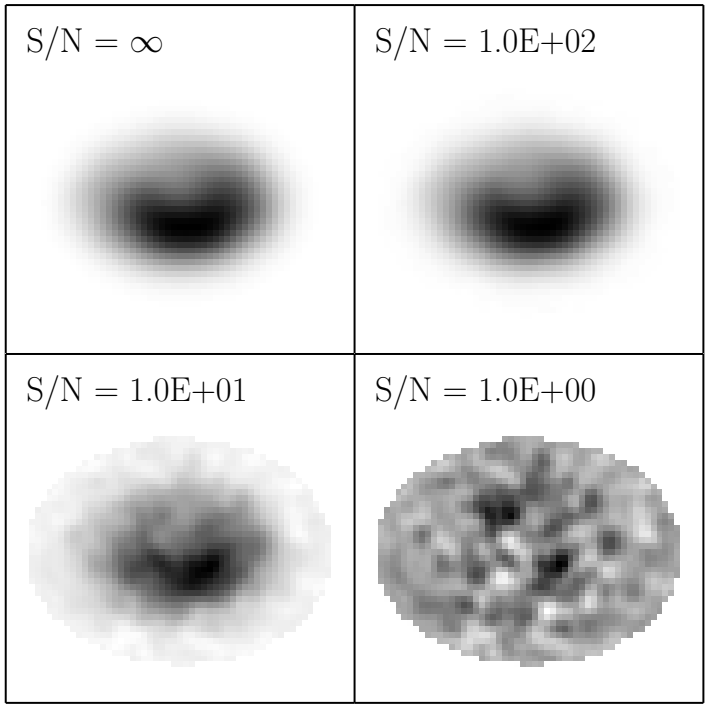
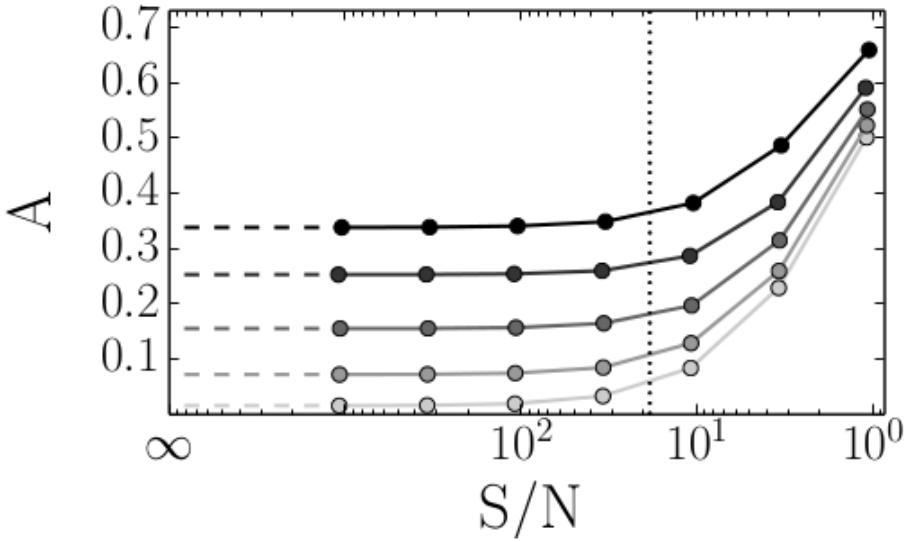
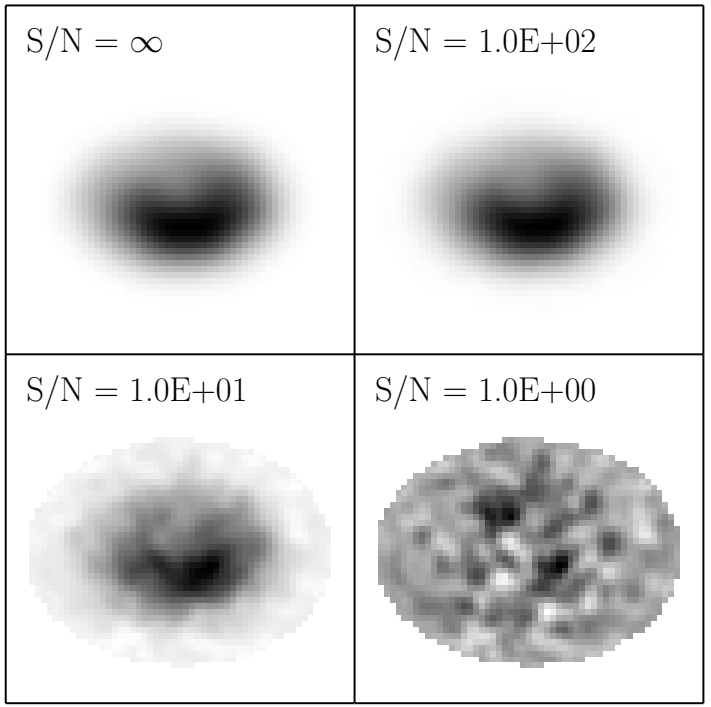


Limitations

Signal to noise





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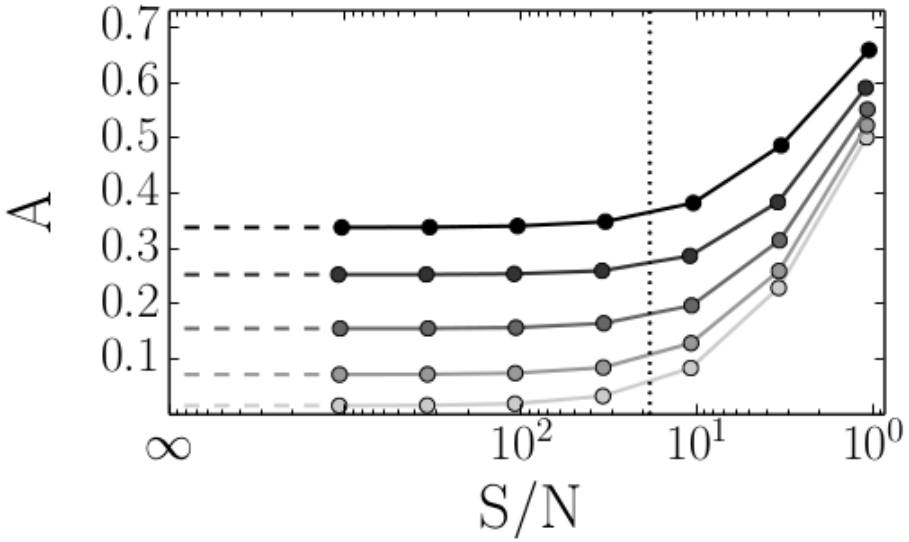
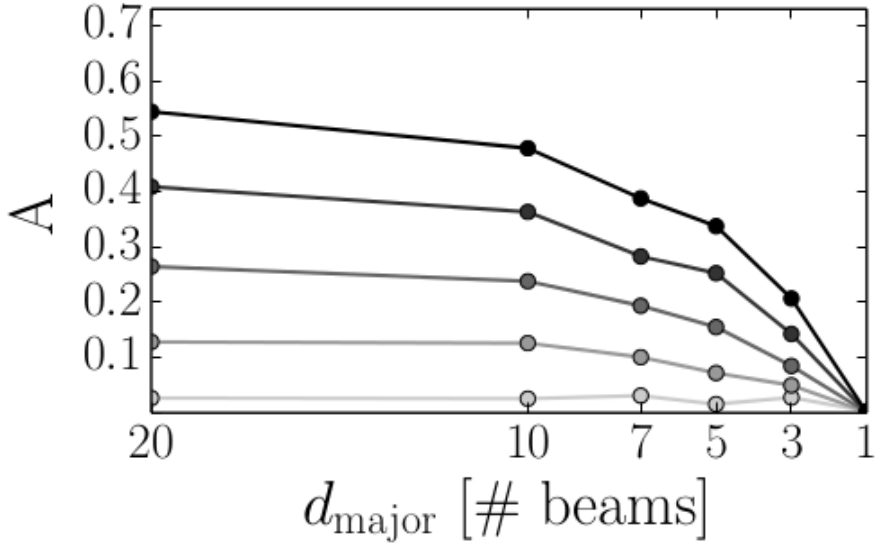


Resolution



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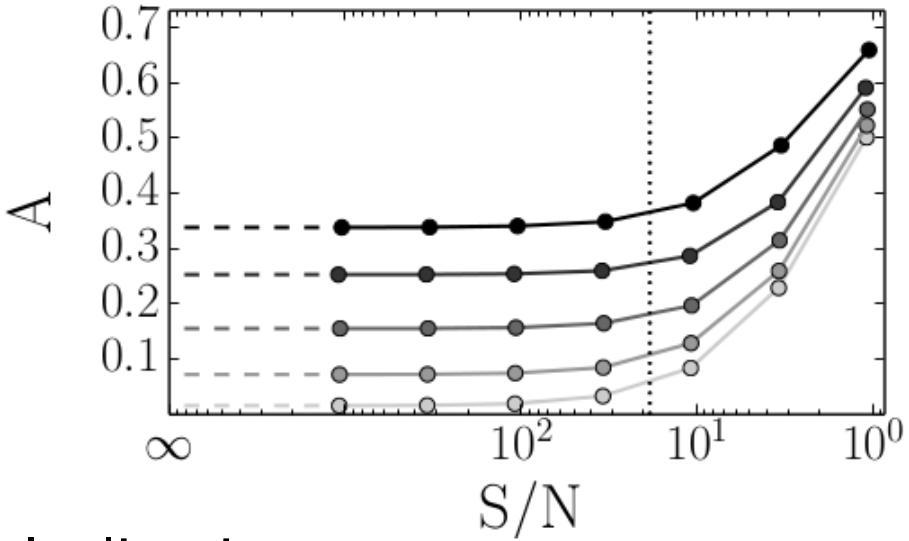

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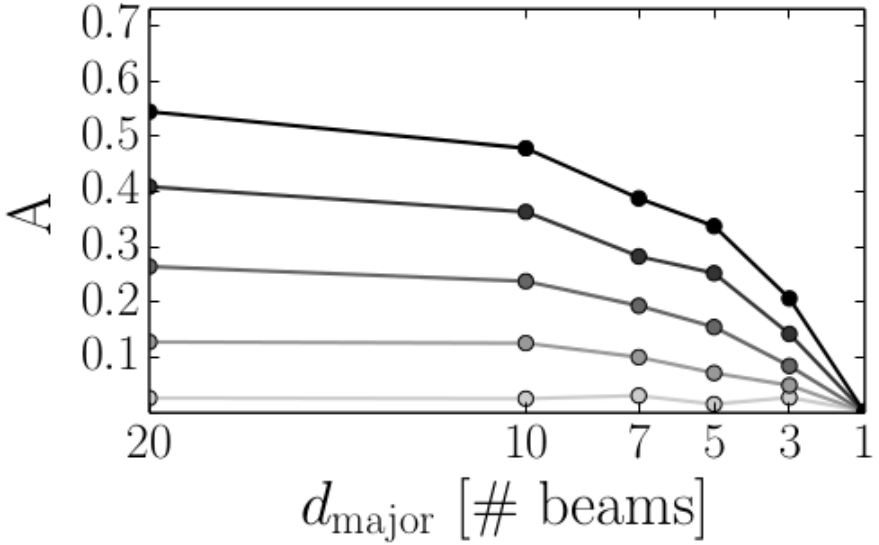
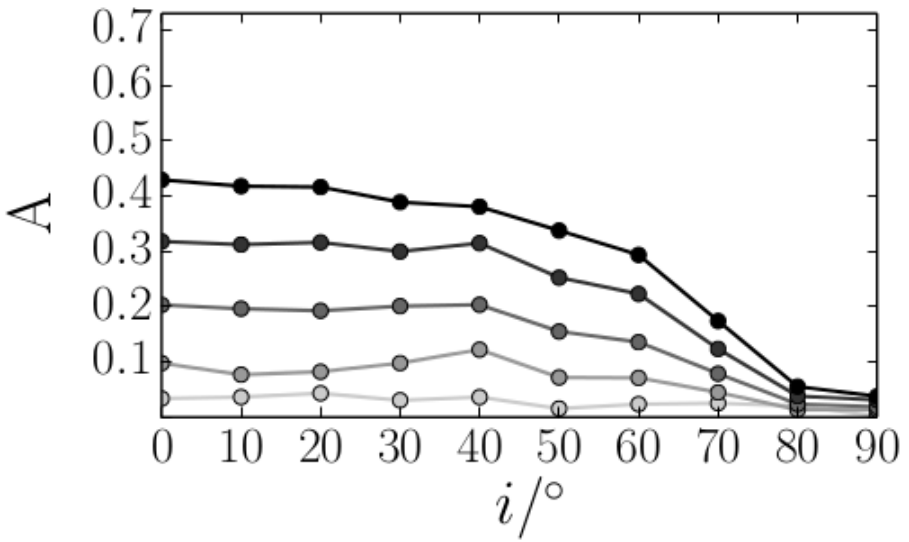


Inclination



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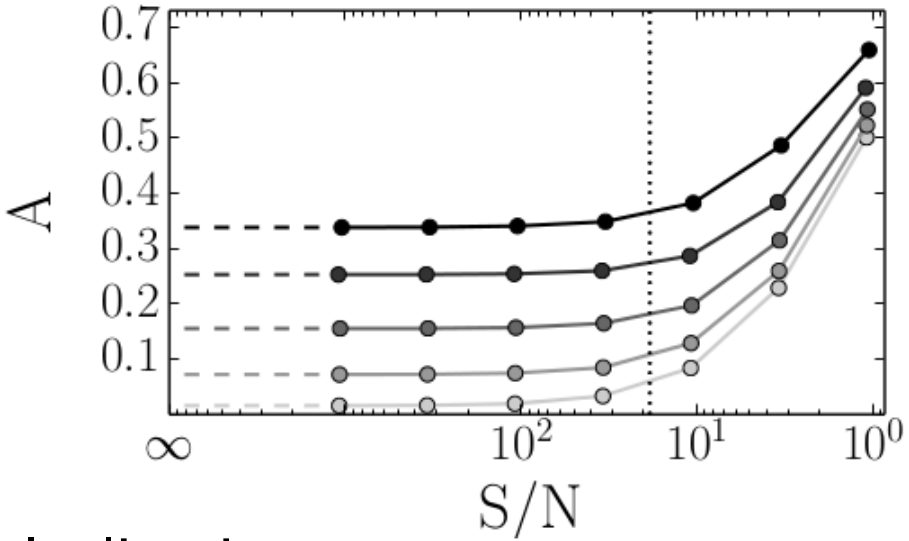

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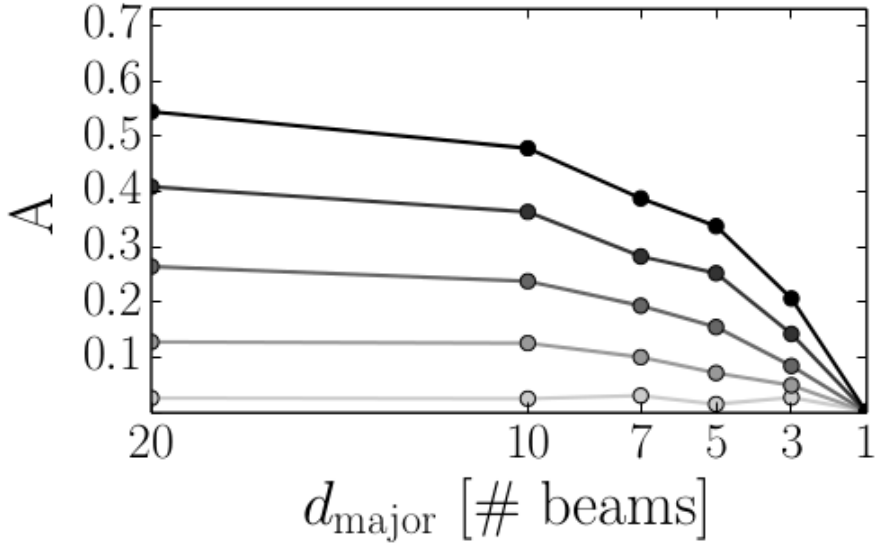

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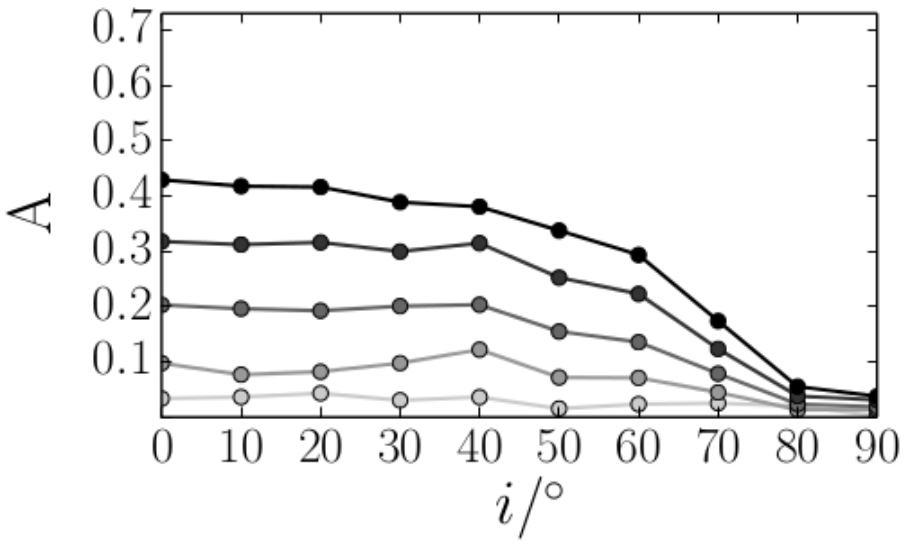
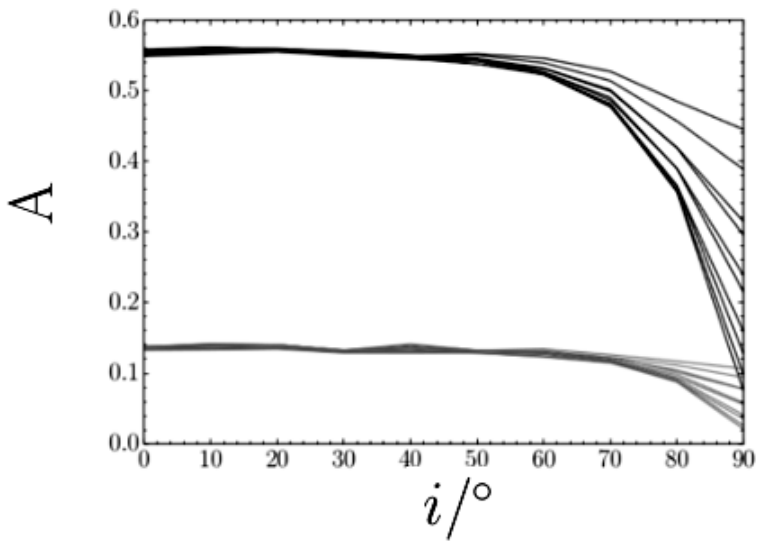
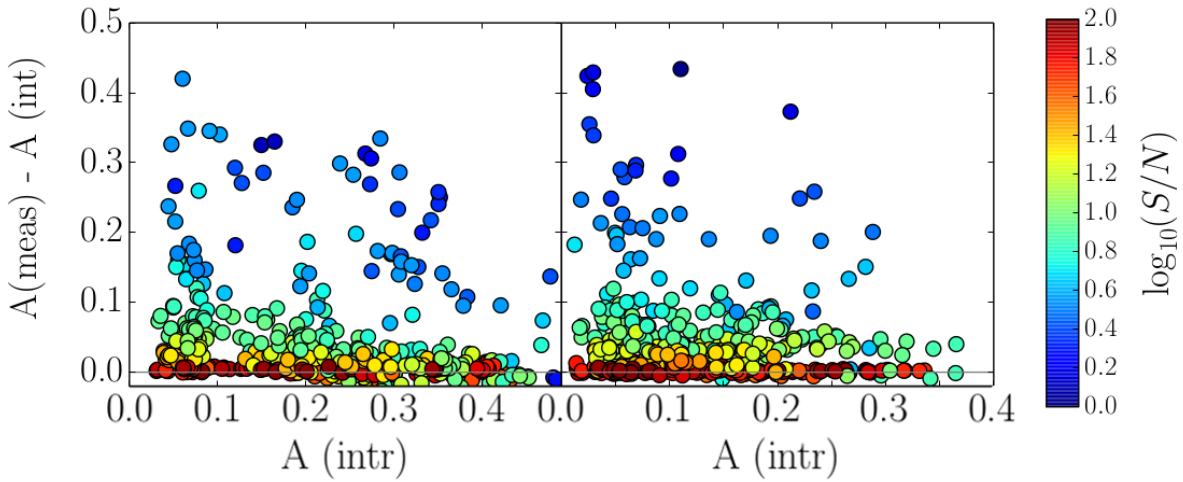


Azimuthal position



Correction for noise effects

- Correction method from Conselice, Bershady, & Jangren (2000):
  - Estimate bias from noise areas around the galaxy
  - Correction experiment: two TiRiFiC model sets with varying inclination, resolution, degree and kind of lopsidedness...



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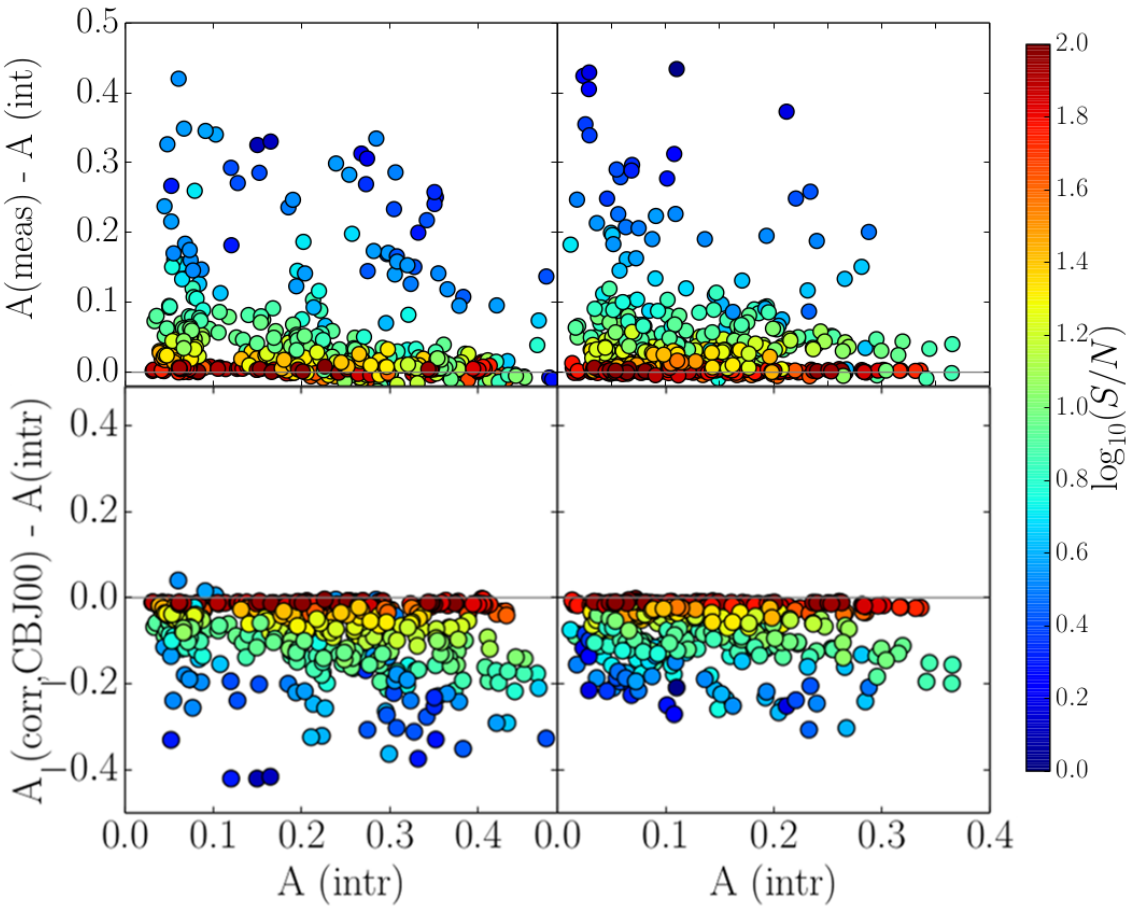

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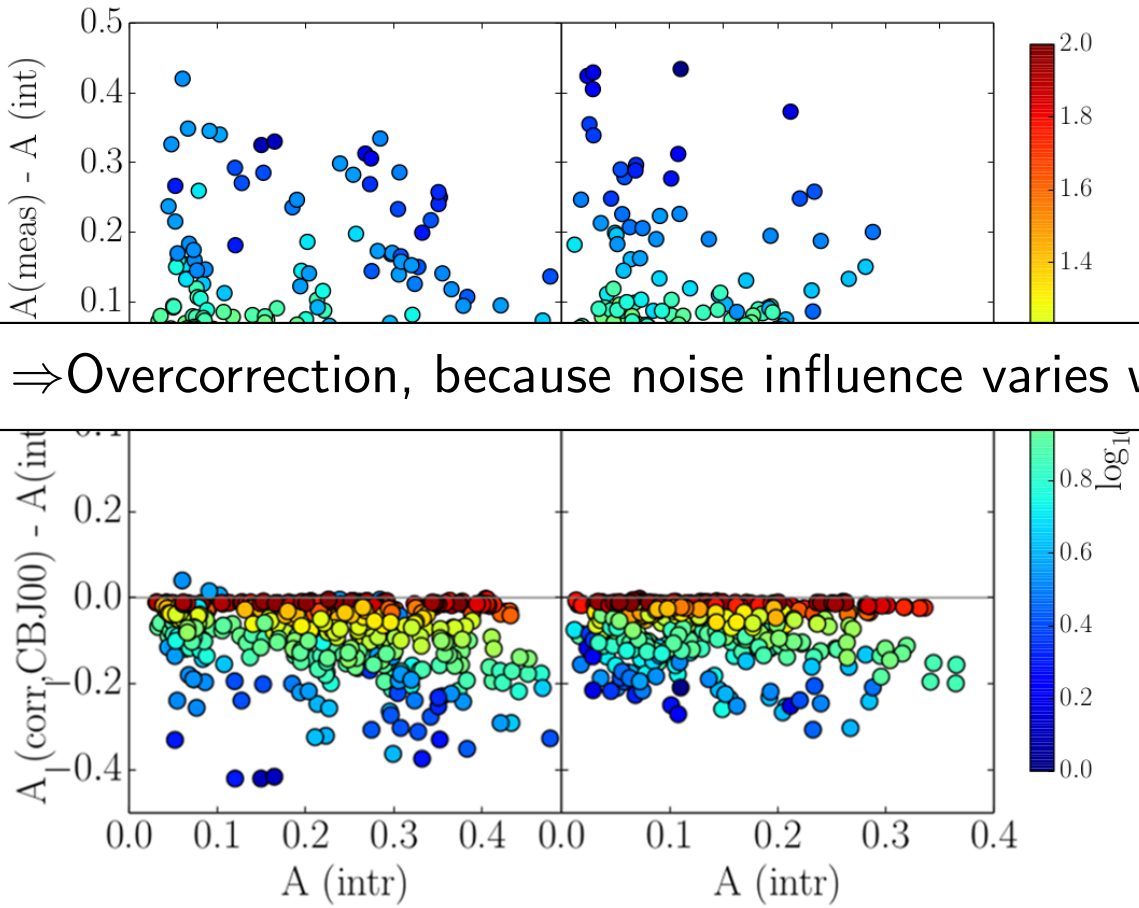


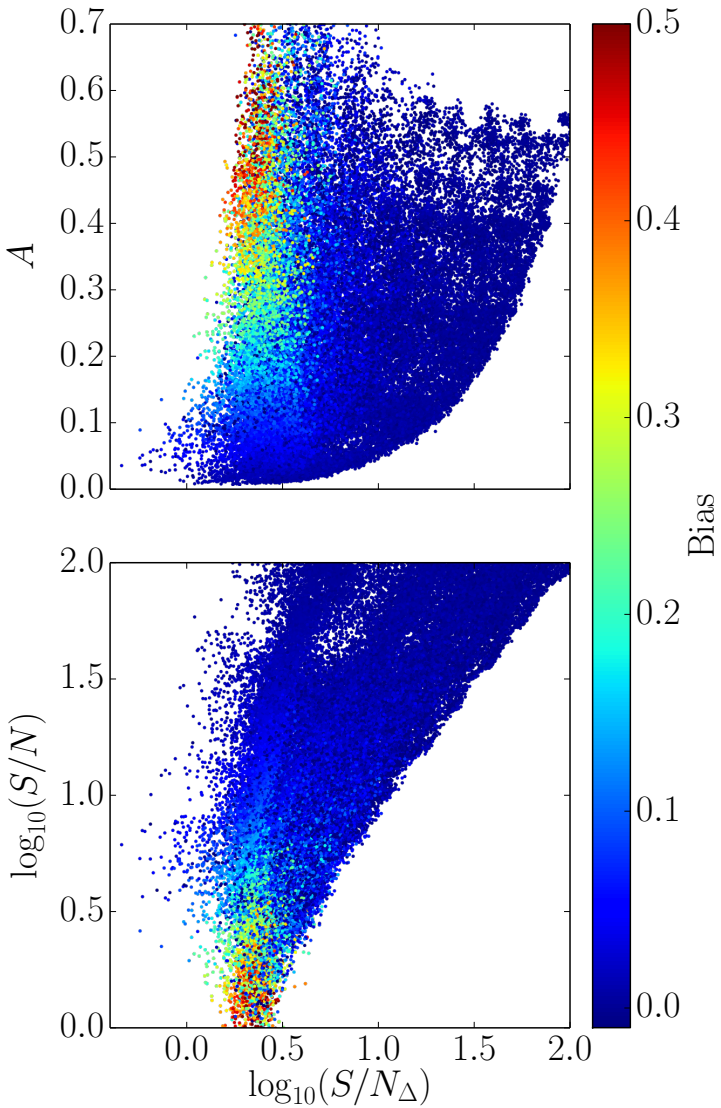
⇒Overcorrection, because noise influence varies with flux

New approach

- Create a model data base that covers the range of properties of test galaxy sets (only 1st order SBR distortions)
- Find A bias trends with various data properties (S/N, A, F_{tot},...)
- Define new parameter that reflects the signal to noise of the difference $|I - I_{180}|$:

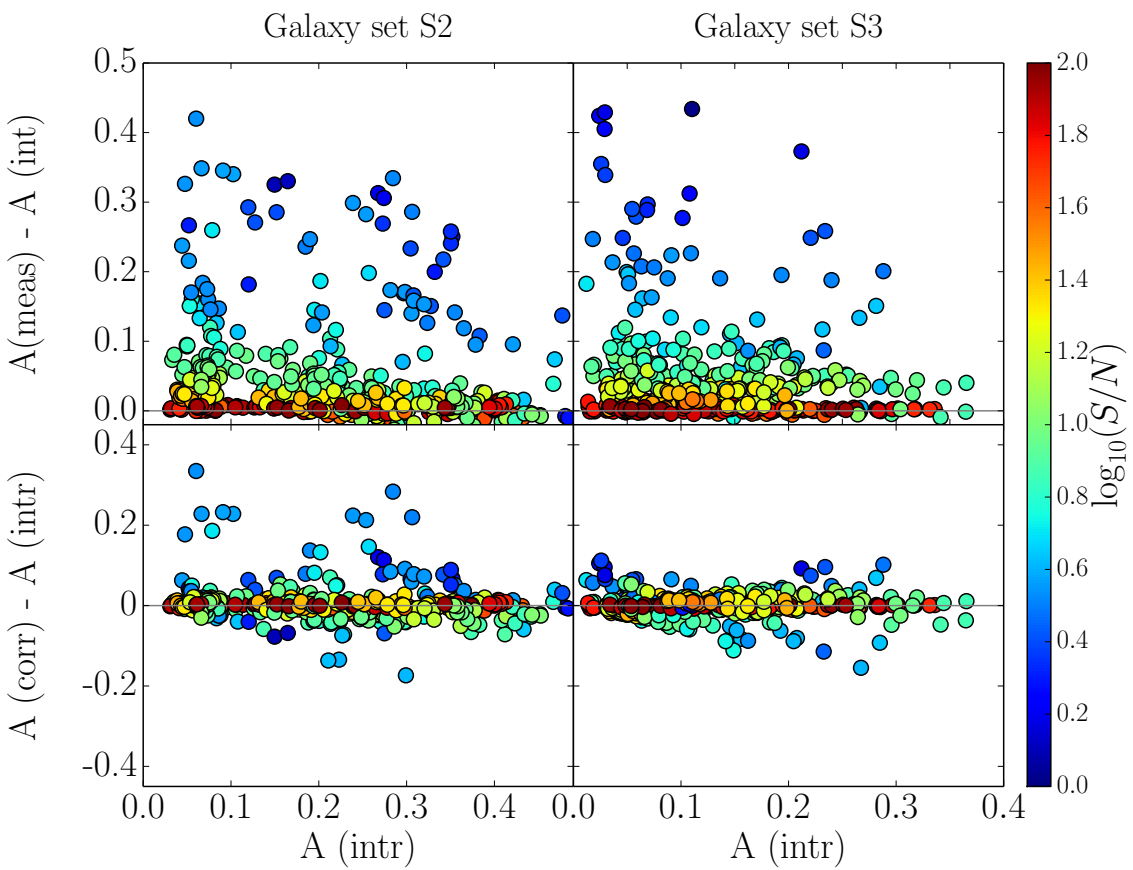
$$S/N_{\Delta} = \left\langle \frac{|I(i,j) - I_{180}(i,j)|}{\sqrt{\frac{1}{2}(N(i,j) + N_{180}(i,j))}\sigma} \right\rangle$$

Best results:



New approach

Use database to approximate bias for the test galaxies and correct them

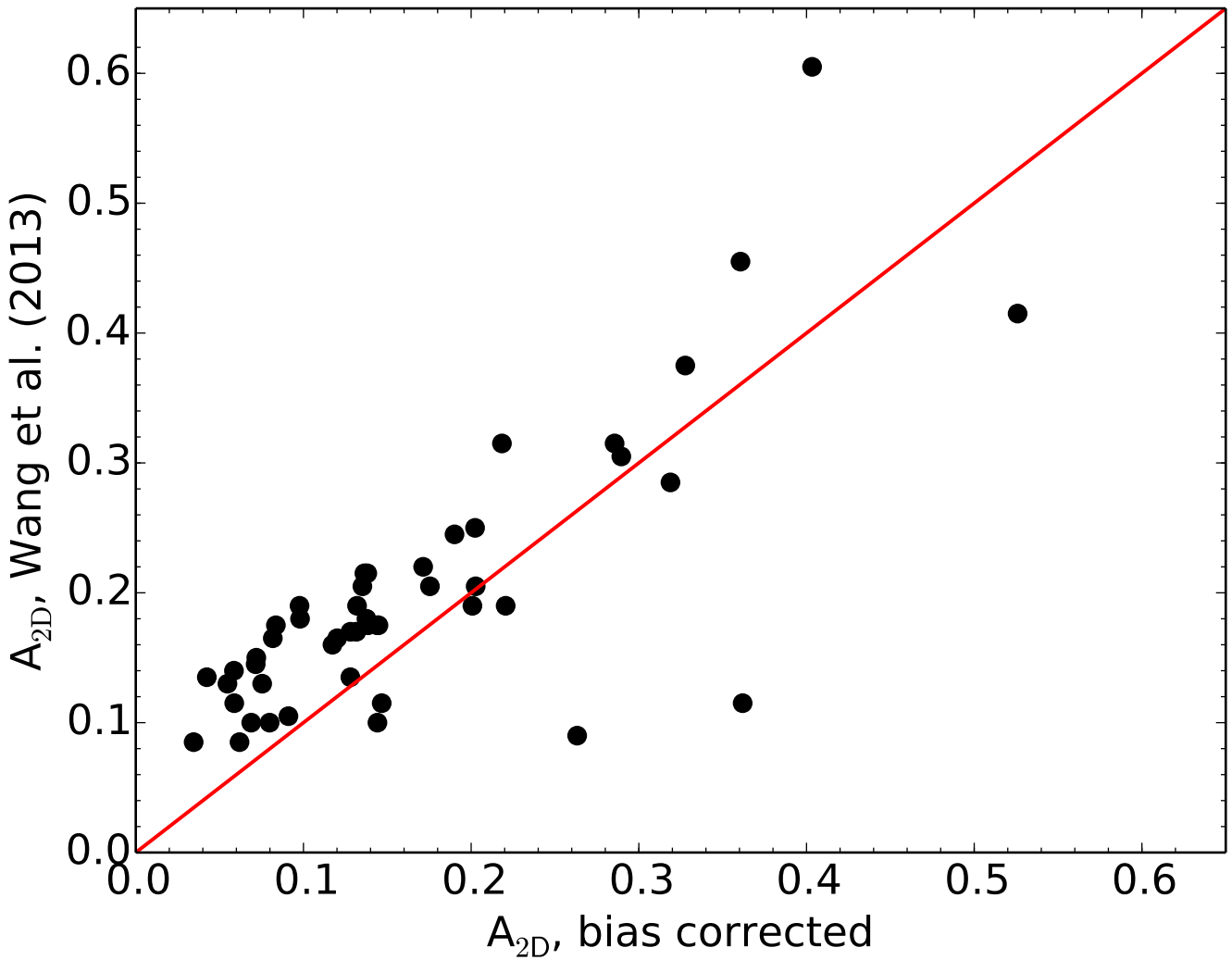


- Majority of objects corrected within $\Delta A = 0.2$ of intrinsic A
- Outliers have low S/N
- Correction also works well on test set with 3rd order SBR distortions

$\Rightarrow$ Possible way for noise bias correction, without choosing clip threshold or making any assumptions about the object

First application and limitations

BLUEDISK sample - Wang et al. (2013)



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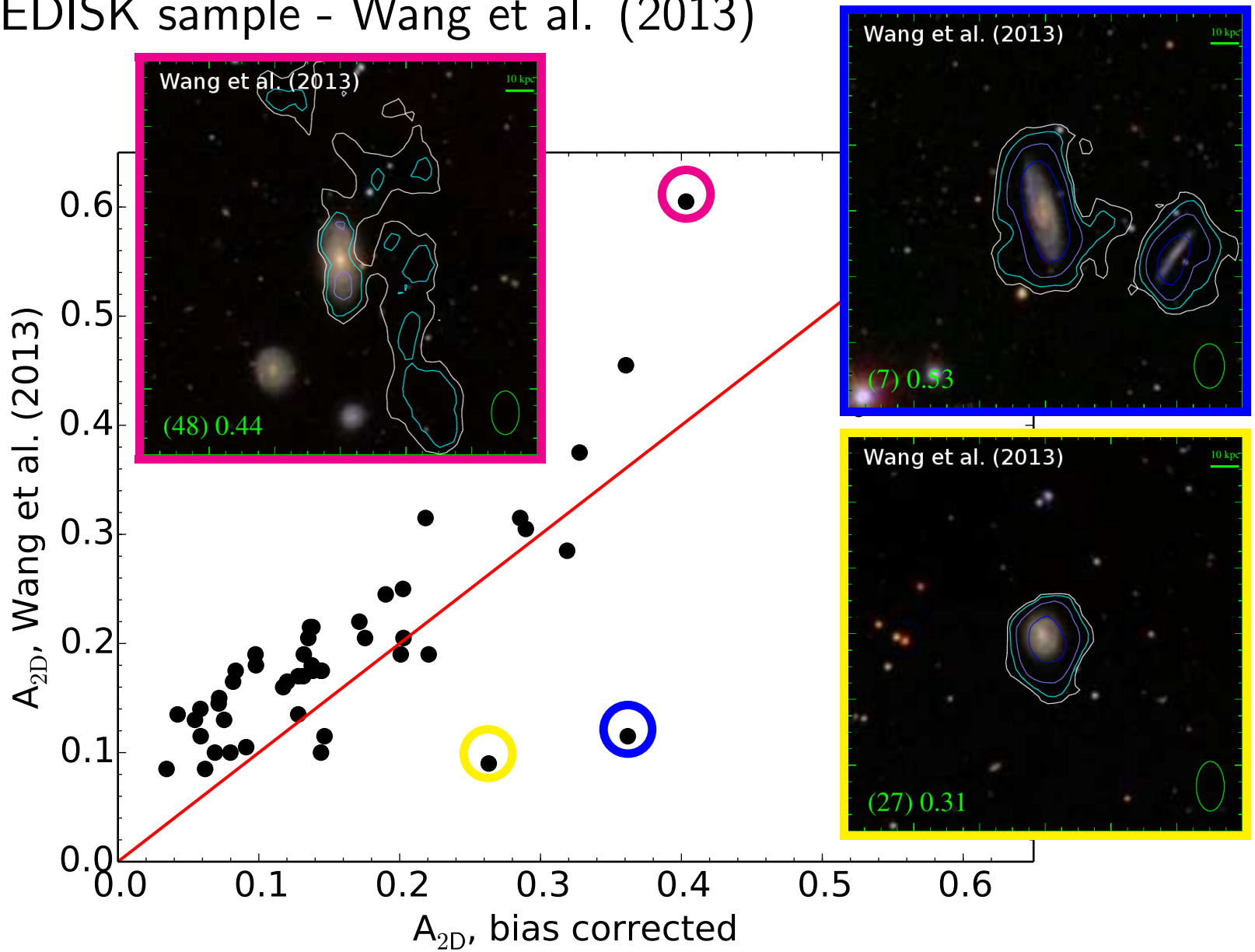

Summary

Conclusions

- Data quality and galaxy properties have significant influence on the estimation of A
  - Galaxies with S/N < 100 need bias correction
  - Resolution and inclination effects show as decrease in A
- S/N bias can be corrected using model galaxies

Outlook

- 2D maps should be divided into inner/outer regions
- Full 3D information should be used for complete image
- Use correction on real galaxies (e.g. WHISP, Atlas3D, BLUEDISK, VIVA) & compare with visual classifications
- Do some interesting science (relation between Asymmetry and environment density)