

Shapelet weak lensing analysis of the W1 field

Joel Bergé (CEA/Sap)

With

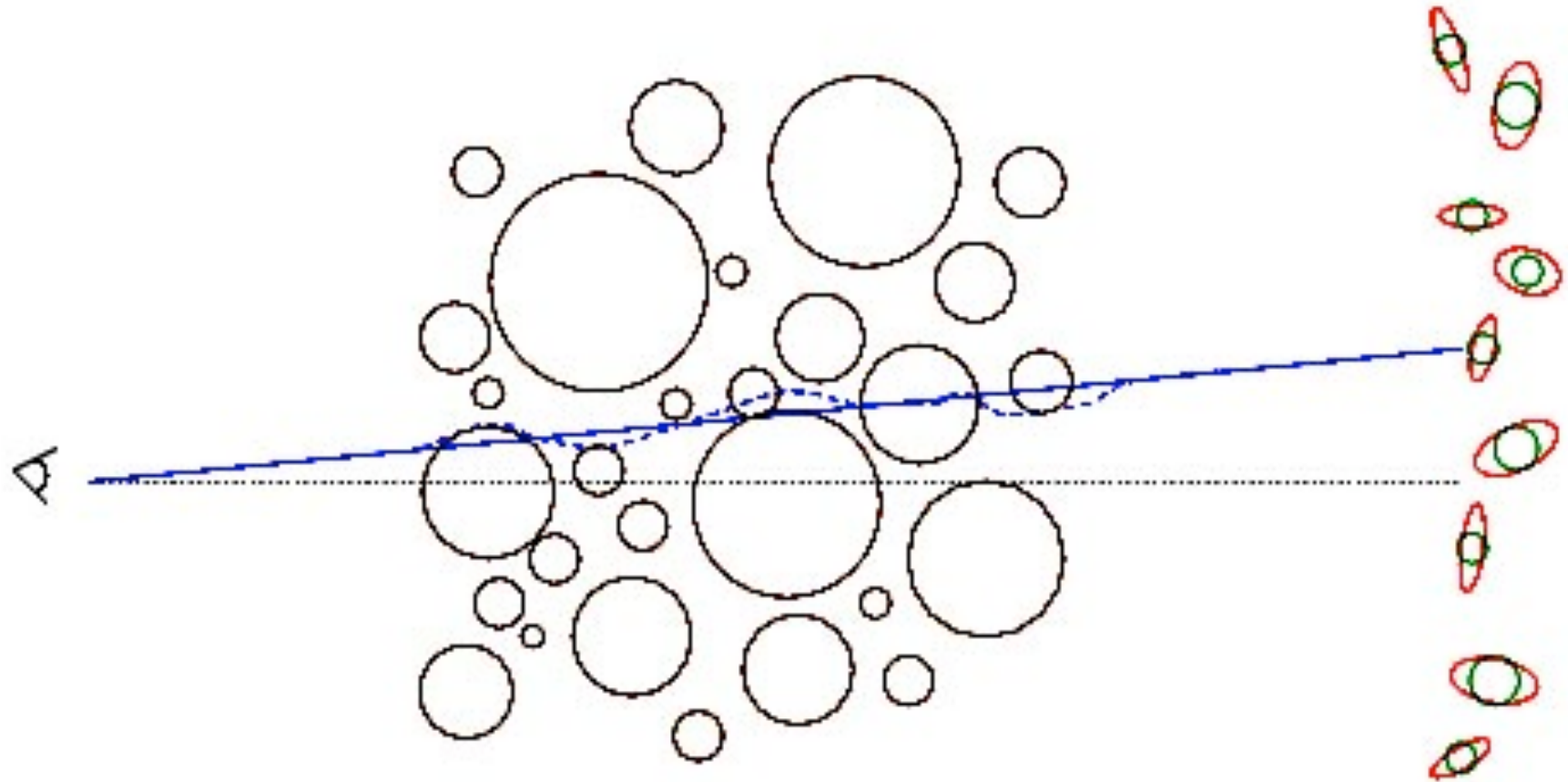
Alexandre Refregier (CEA/Sap)

Richard Massey (Caltech)

Stéphane Paulin-Henriksson (Catania)

Yannick Mellier (IAP)

Weak gravitational lensing



Shapelets

Refregier 2003, Refregier & Bacon 2003,
Massey & Refregier 2005

Complete orthogonal basis
functions

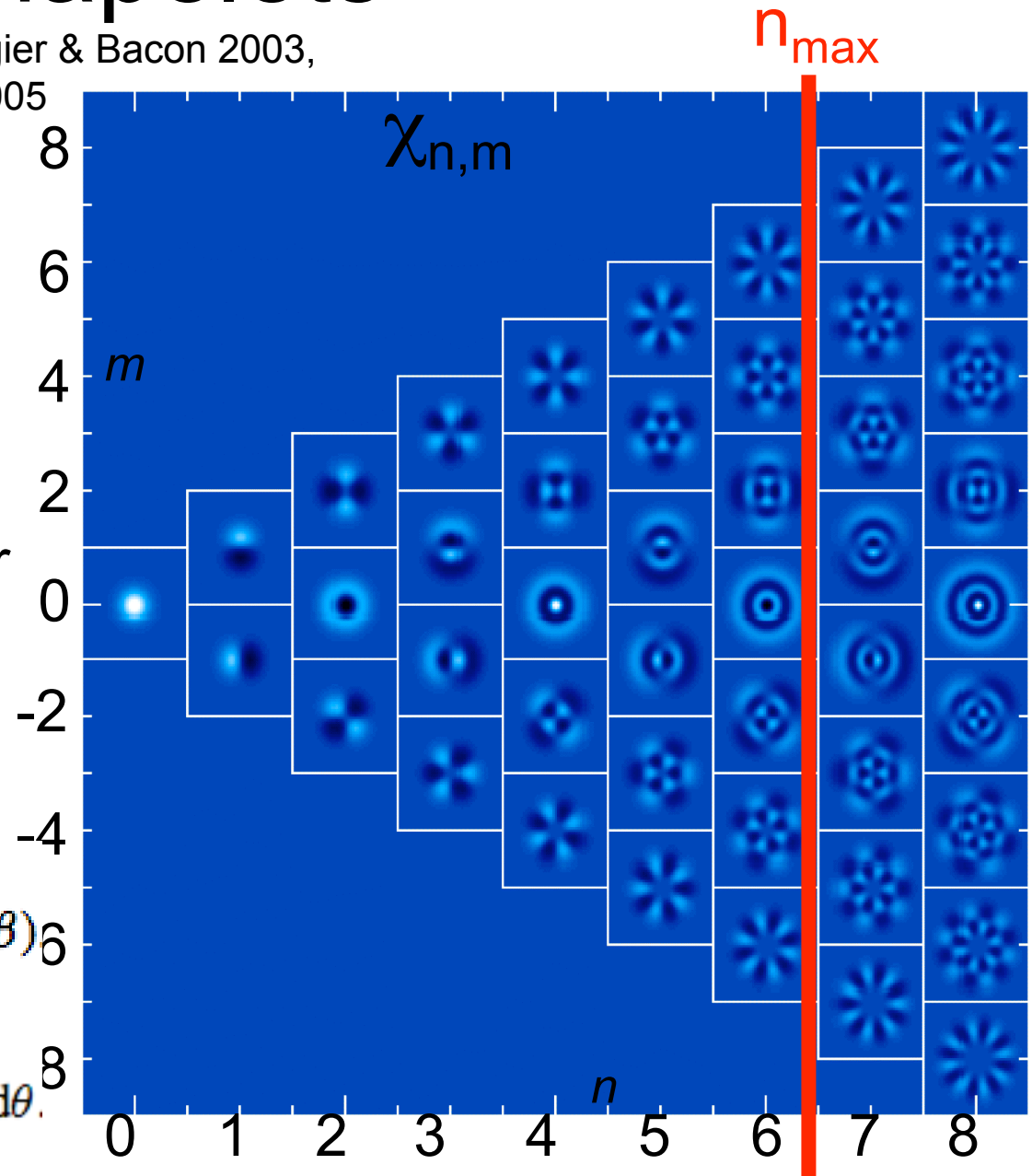
Capture all shape
information of an object

Simple and analytic form for
convolution and shear

Adapted to cosmic shear

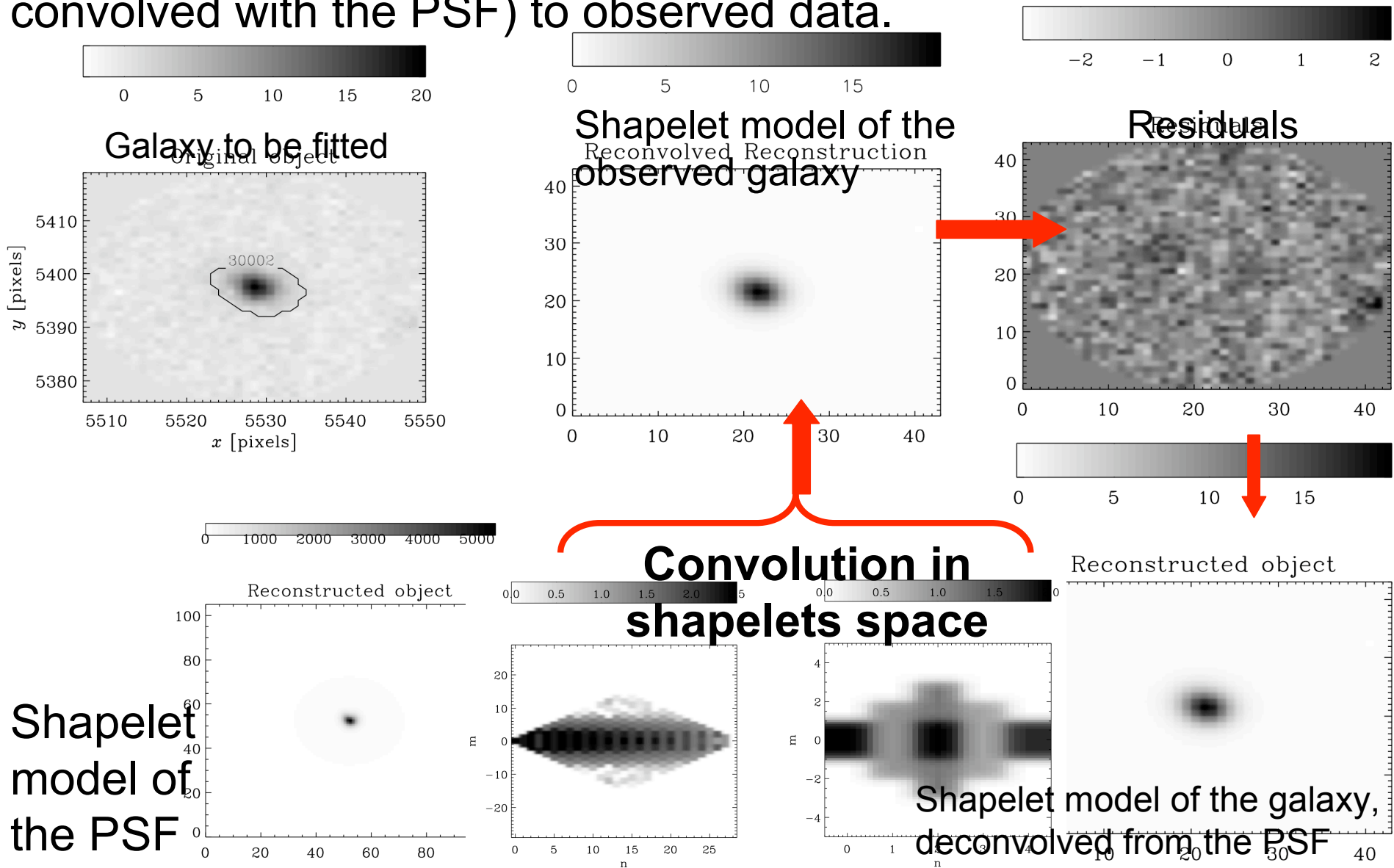
$$f(r, \theta) = \sum_{n=0}^{\infty} \sum_{m=-n}^n f_{n,m} \chi_{n,m}(r, \theta; \beta)$$

$$f_{n,m} = \iint_{\mathbb{R}} f(r, \theta) \chi_{n,m}(r, \theta; \beta) r dr d\theta.$$



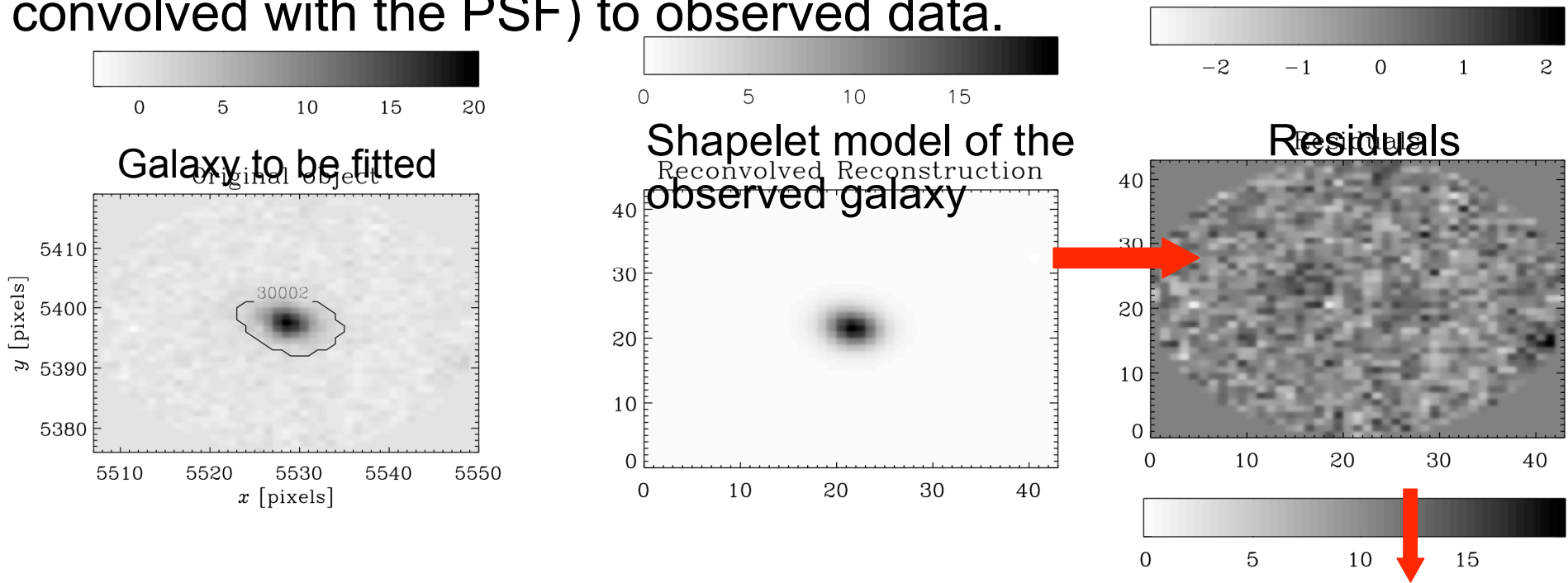
Shapelets decomposition pipeline

Least-square fitting of an analytical model (pixellised and convolved with the PSF) to observed data.

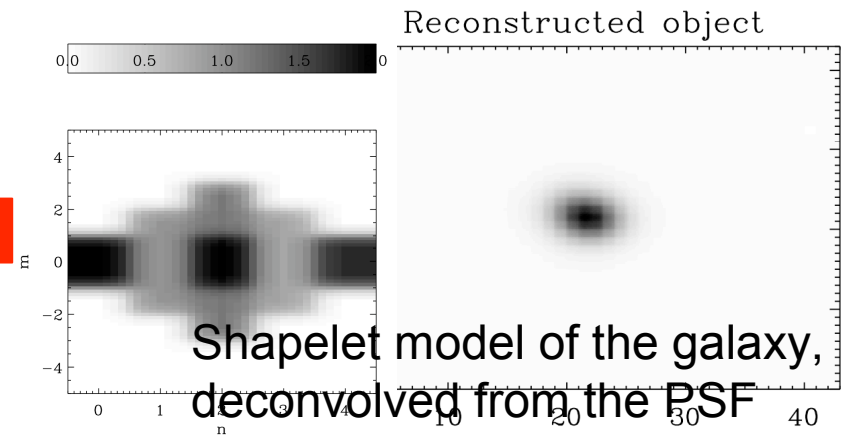


Shapelets decomposition pipeline

Least-square fitting of an analytical model (pixellised and convolved with the PSF) to observed data.

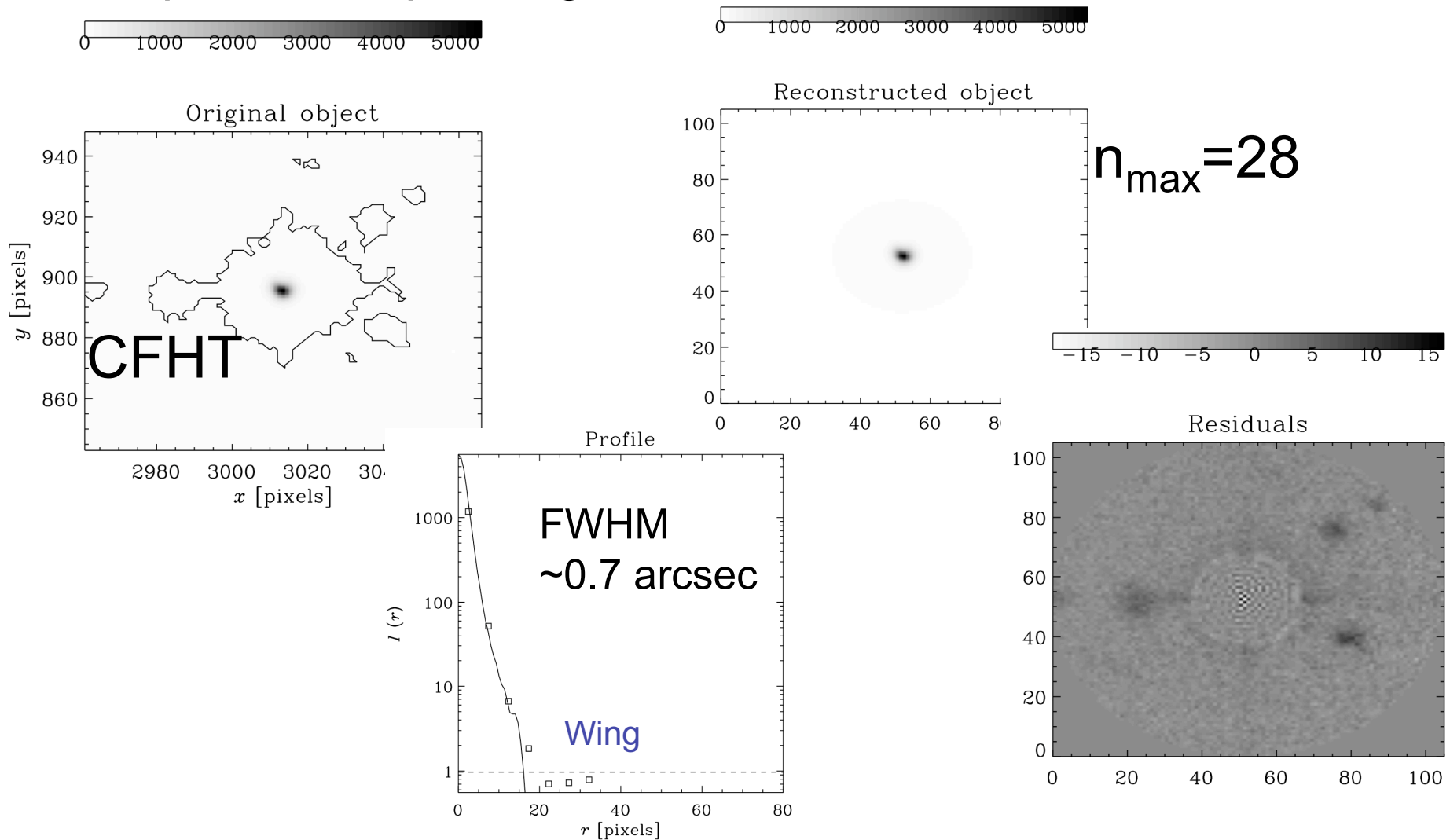


Shear estimator(s)



PSF model

- ◆ Stars selected then decomposed into shapelets, the order of decomposition depending on data



PSF spatial variations

- Polynomial interpolation of each shapelet coefficients of stars
- Possibility to characterize spatial variations of PSF shape information

Coefficients f_{nm}

Flux $F \equiv \iint_{\mathbb{R}} f(\mathbf{x}) d^2x = (4\pi)^{1/2} \beta \sum_n^{\text{even}} f_{n0}$

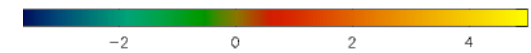
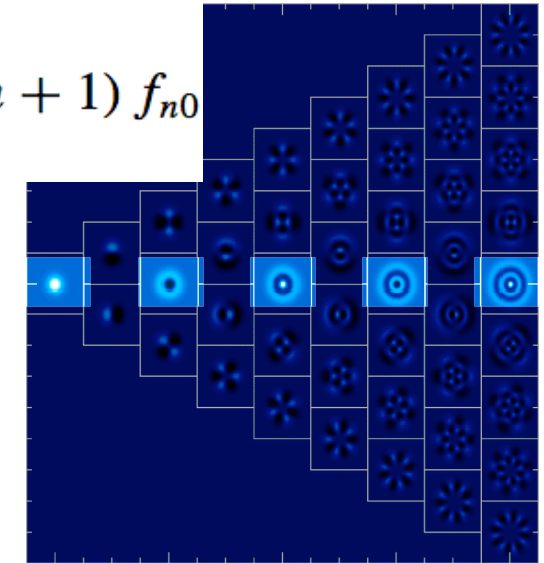
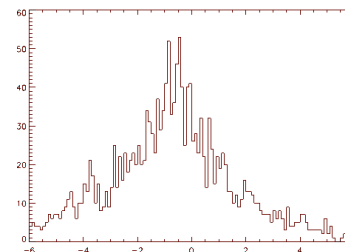
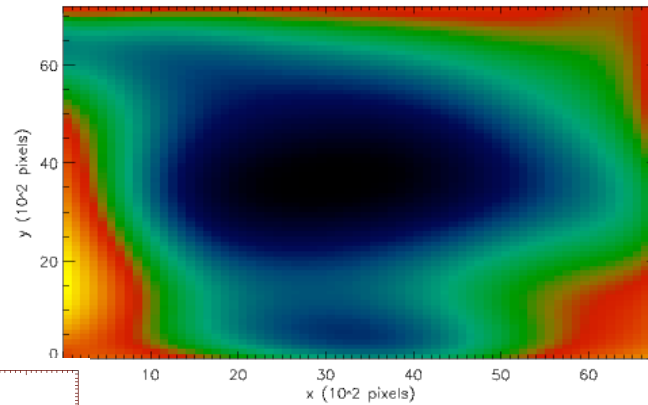
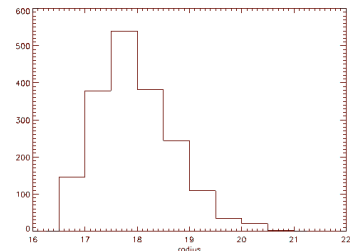
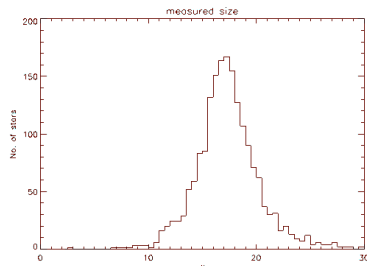
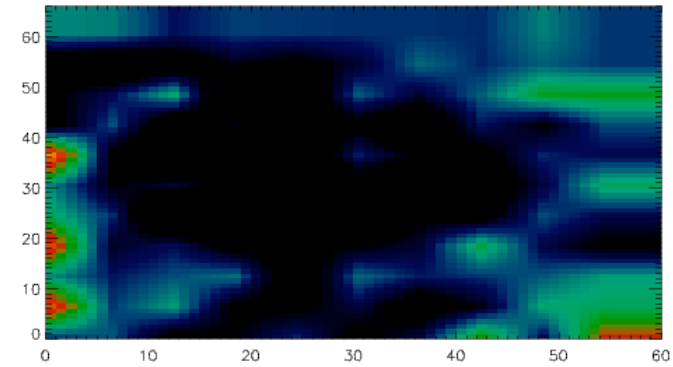
Size $R^2 = \frac{(16\pi)^{1/2} \beta^3}{F} \sum_n^{\text{even}} (n+1) f_{n0}$

Ellipticity,
order by order $\varepsilon = \frac{F_{11} - F_{22} + 2iF_{12}}{F_{11} + F_{22}} = \sum_n^{\text{even}} \varepsilon_n$

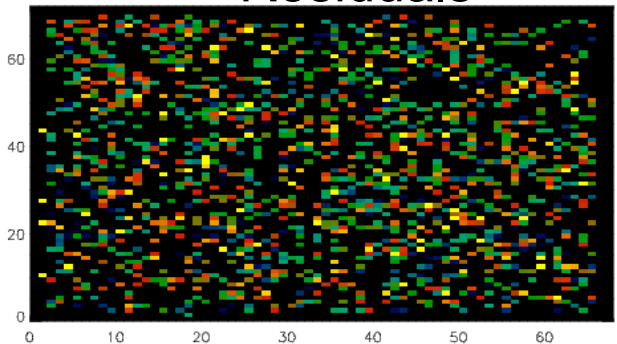
$$\varepsilon_n = \frac{(16\pi)^{1/2} \beta^3}{FR^2} [n(n+2)]^{1/2} f_{n2}$$

Size

$$R^2 = \frac{(16\pi)^{1/2} \beta^3}{F} \sum_n^{\text{even}} (n+1) f_{n0}$$



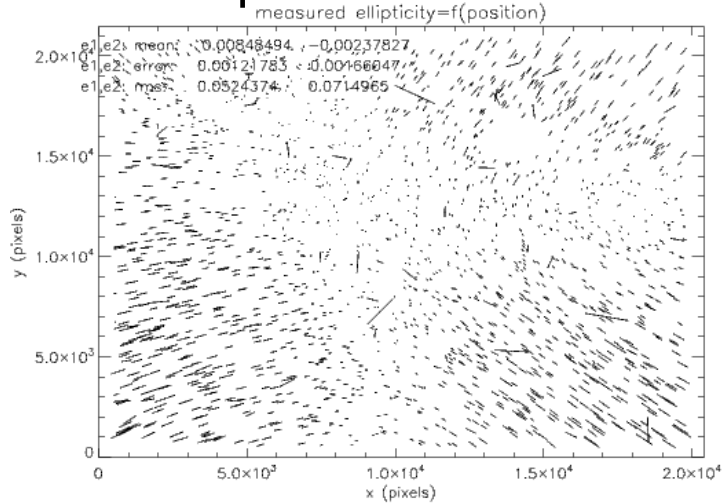
Residuals



20% variation of the size across the image

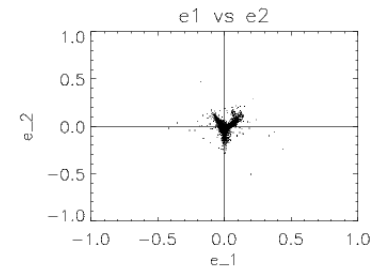
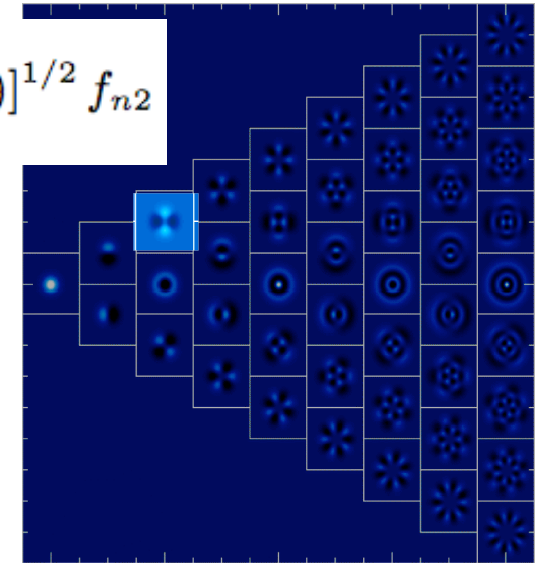
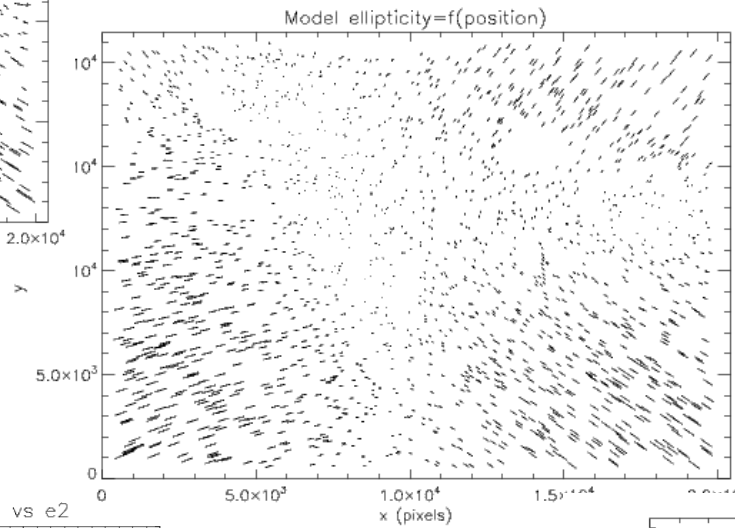
Ellipticity n=2

Shapelet measure



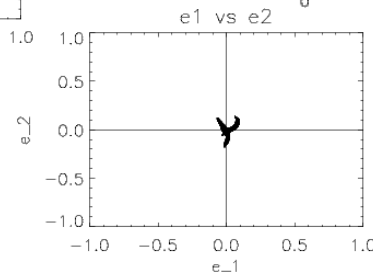
$$\epsilon_n = \frac{(16\pi)^{1/2} \beta^3}{FR^2} [n(n+2)]^{1/2} f_{n2}$$

Polynomial model



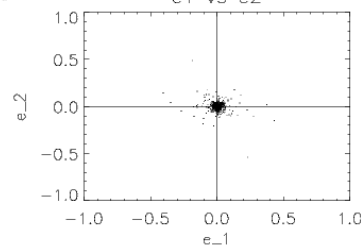
$$\langle e_1 \rangle = 0.00848$$

$$\langle e_2 \rangle = -0.00237$$

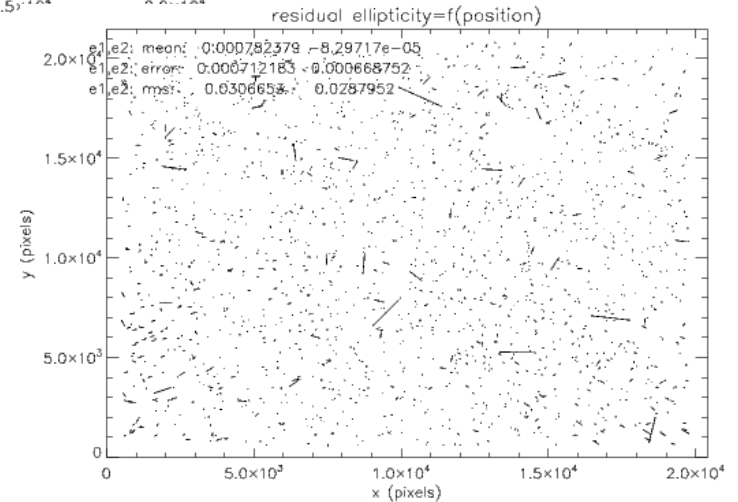


$$\langle e_1 \rangle = 0.00078$$

$$\langle e_2 \rangle = -8.3 \cdot 10^{-5}$$

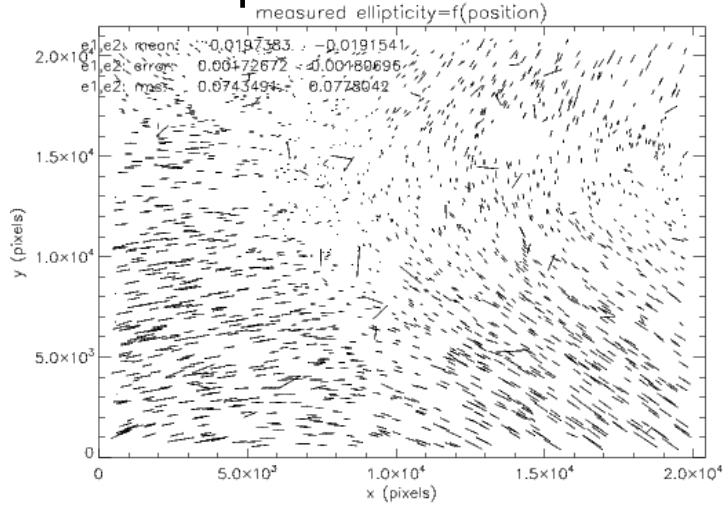


Residuals



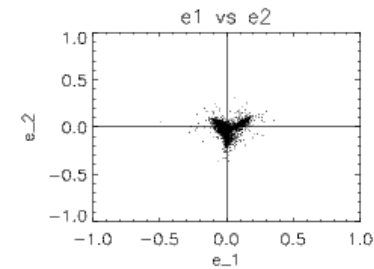
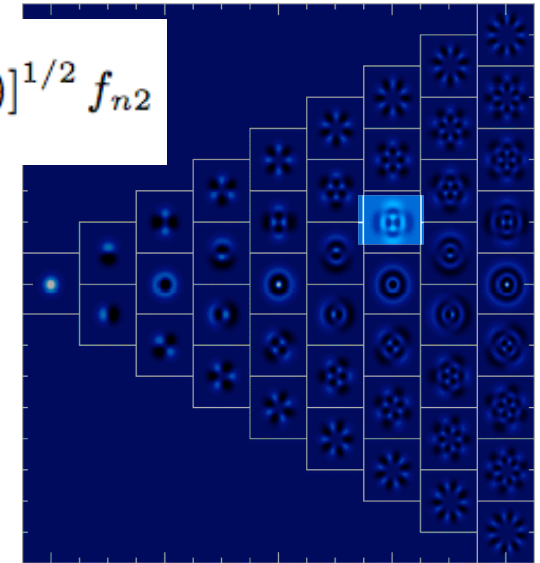
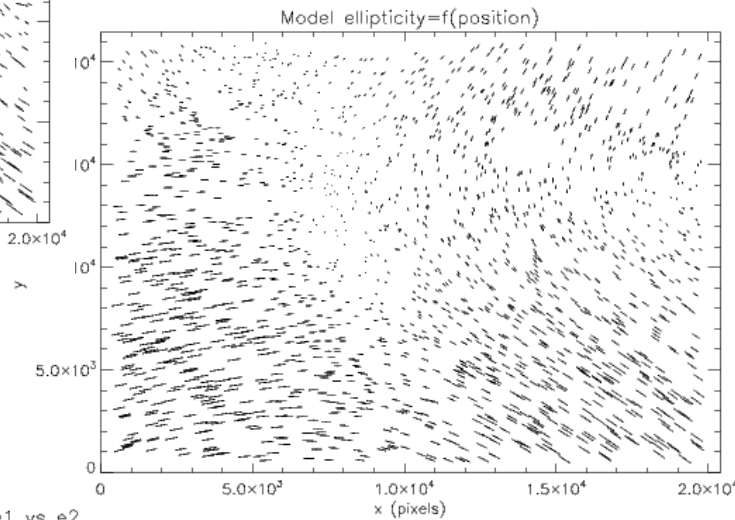
Ellipticity n=6

Shapelet measure



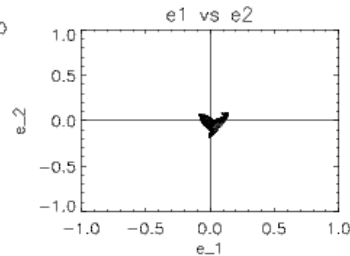
$$\epsilon_n = \frac{(16\pi)^{1/2} \beta^3}{FR^2} [n(n+2)]^{1/2} f_{n2}$$

Polynomial model



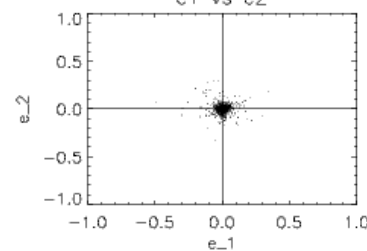
$$\langle e_1 \rangle = 0.0197$$

$$\langle e_2 \rangle = -0.0192$$

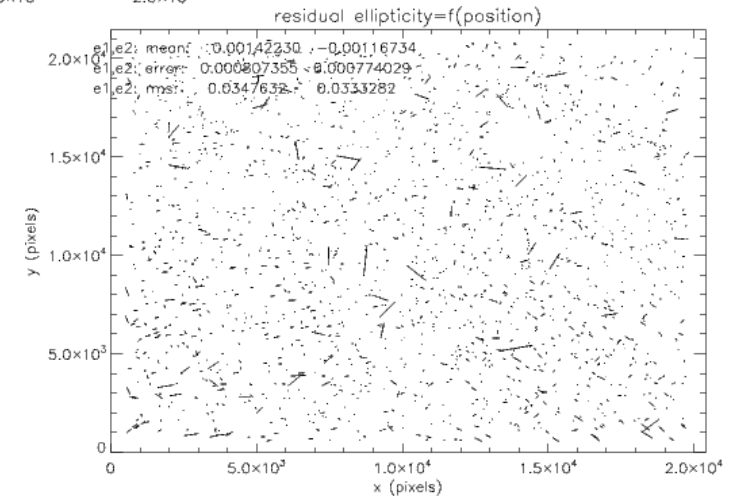


$$\langle e_1 \rangle = 0.0014$$

$$\langle e_2 \rangle = -0.0011$$

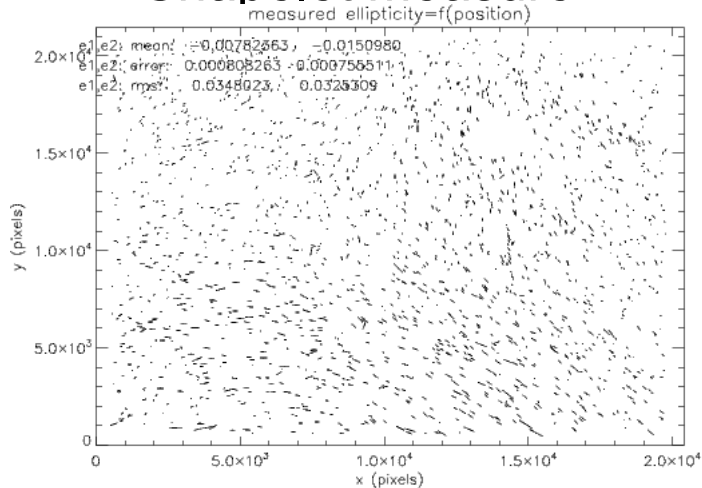


Residuals



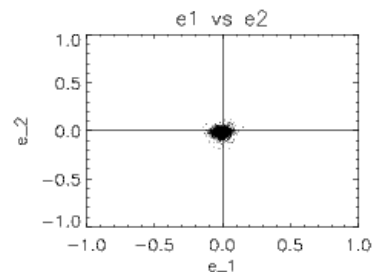
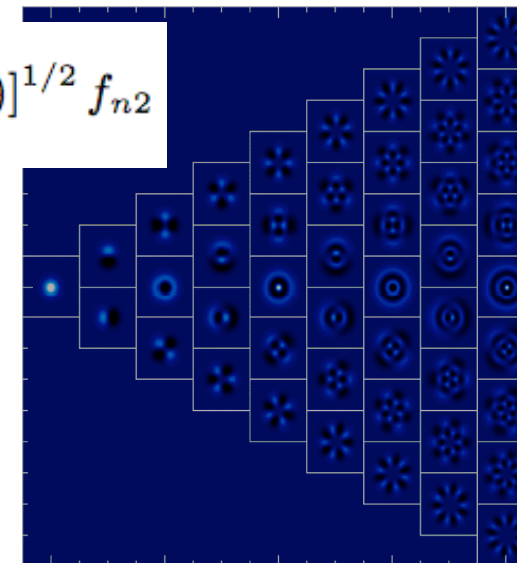
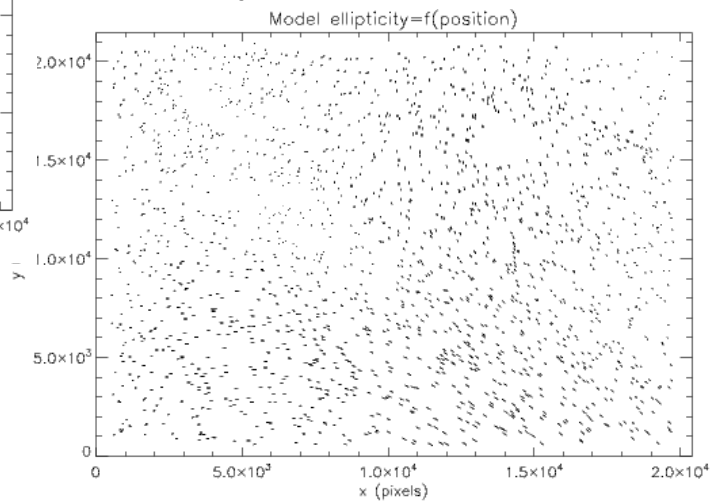
Ellipticity n=18

Shapelet measure



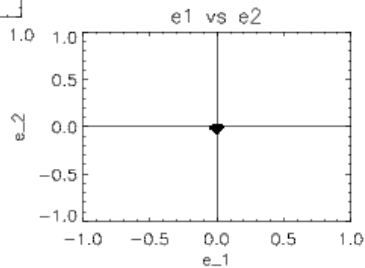
$$\epsilon_n = \frac{(16\pi)^{1/2} \beta^3}{FR^2} [n(n+2)]^{1/2} f_{n2}$$

Polynomial model



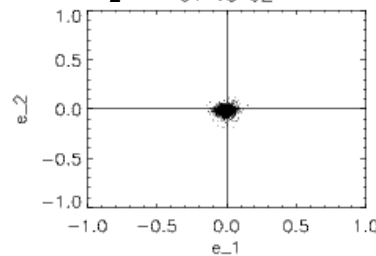
$\langle e_1 \rangle = 0.00728$

$\langle e_2 \rangle = -0.00151$

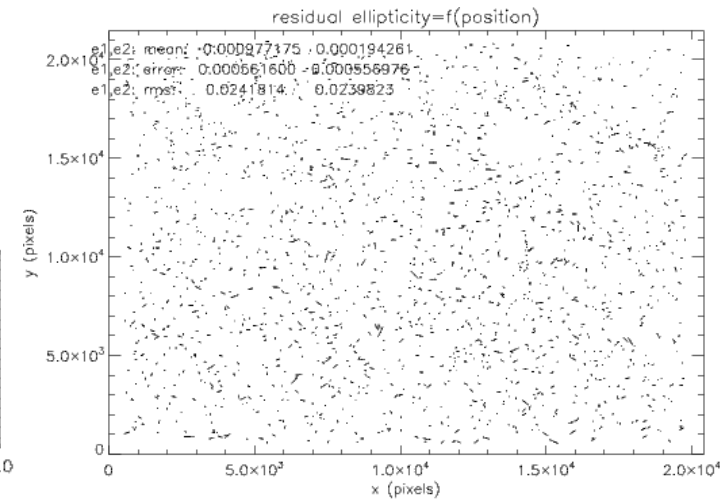


$\langle e_1 \rangle = 0.00097$

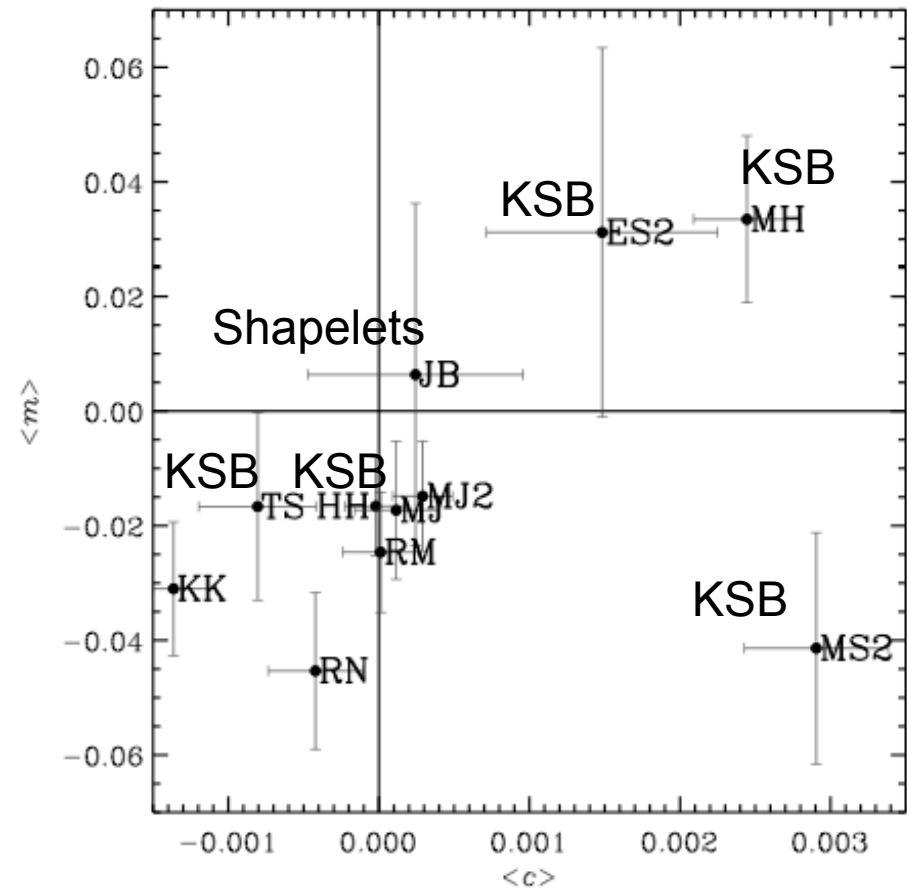
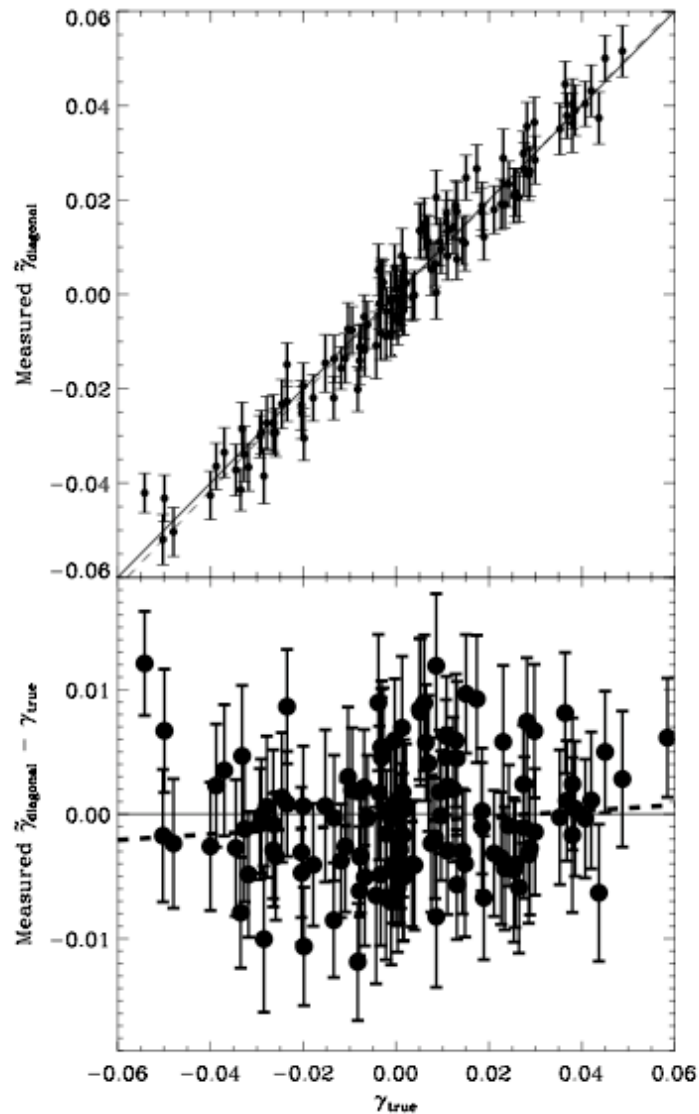
$\langle e_2 \rangle = 0.00019$



Residuals



STEP (Shear TEsting Programme)



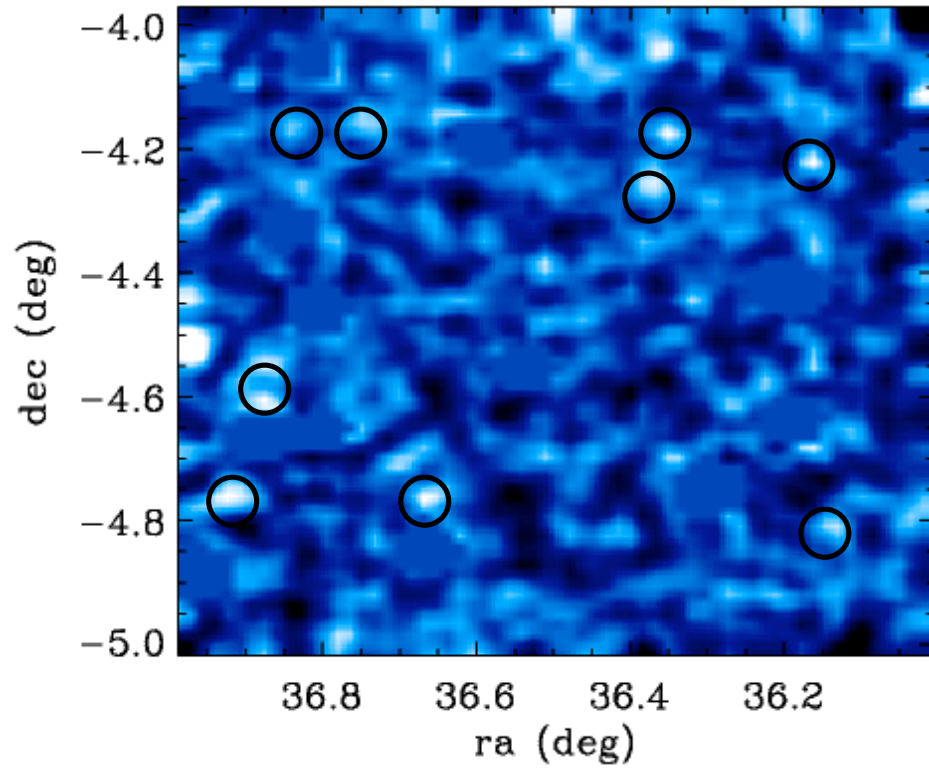
Processed data

- Currently 4 deg² of W1 stack provided by Yannick Mellier
- X-rays data from XMMLSS (Pierre et al 2006, Pacaud et al 2006)
- D1 field in this area (Gavazzi & Soucail 2006)

Mass map : D1



Shapelets

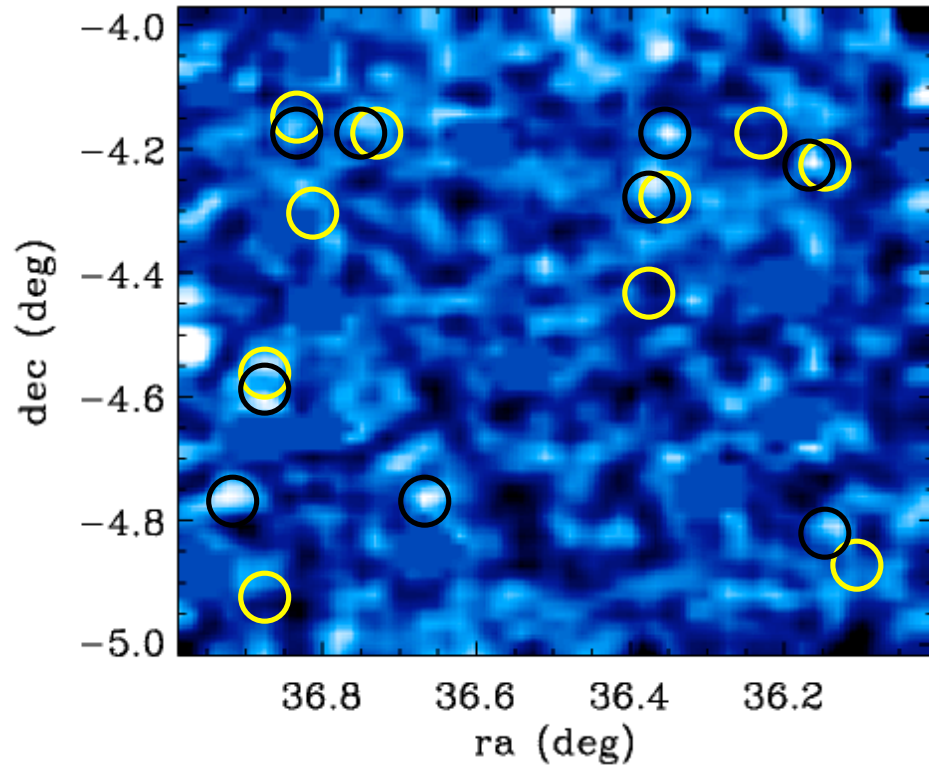


○ Shapelets

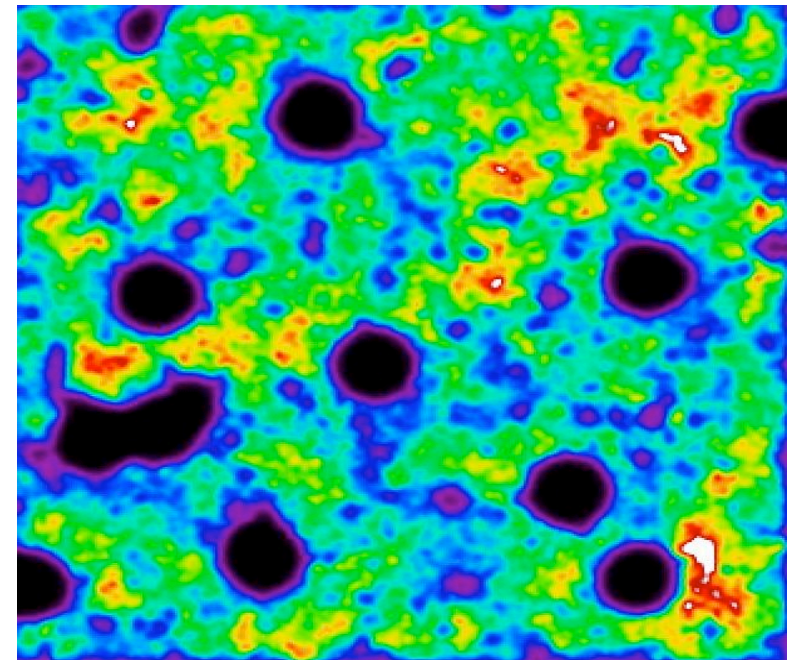
Mass map : D1



Shapelets



Luminosity map
(courtesy Chiara Marmo)



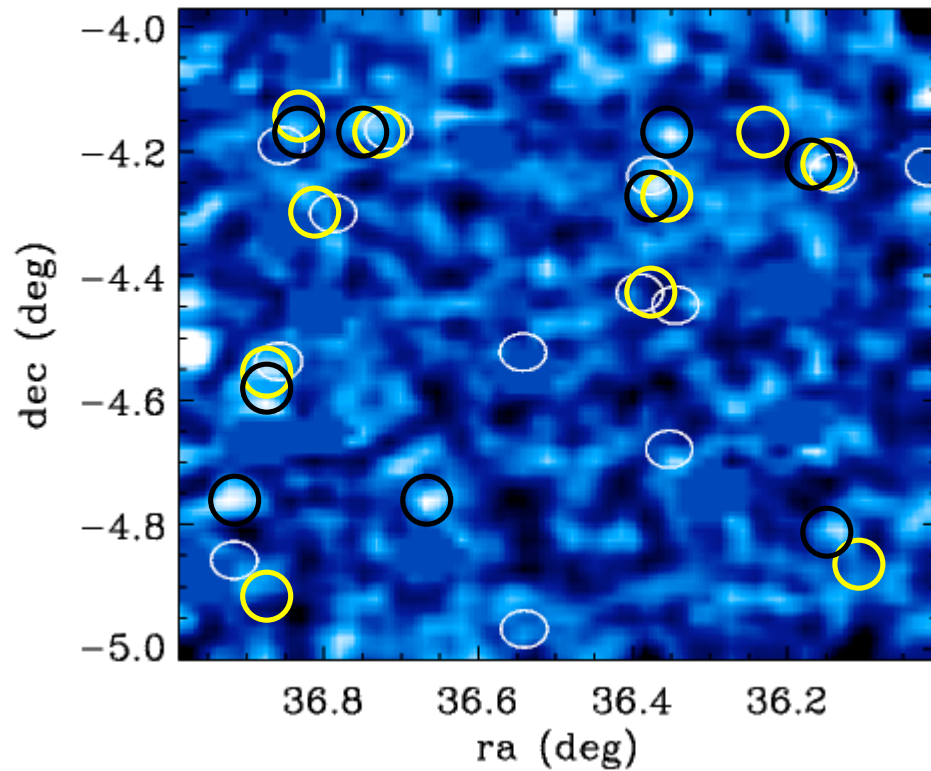
○ Shapelets

○ "Luminosity" (courtesy C. Marmo)

Mass map : D1



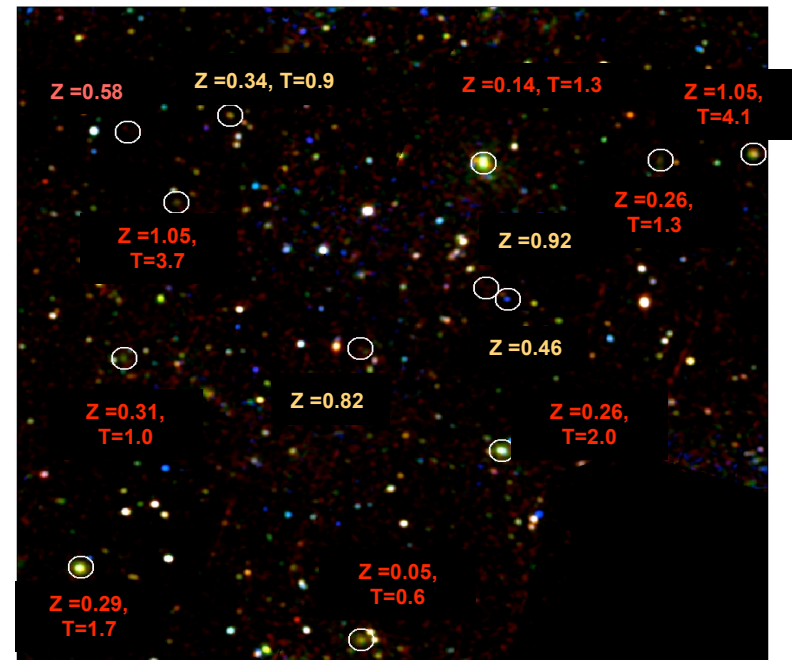
Shapelets



○ Shapelets

○ “Luminosity” (courtesy C. Marmo)

X-ray map (courtesy Florian Pacaud and Marguerite Pierre)

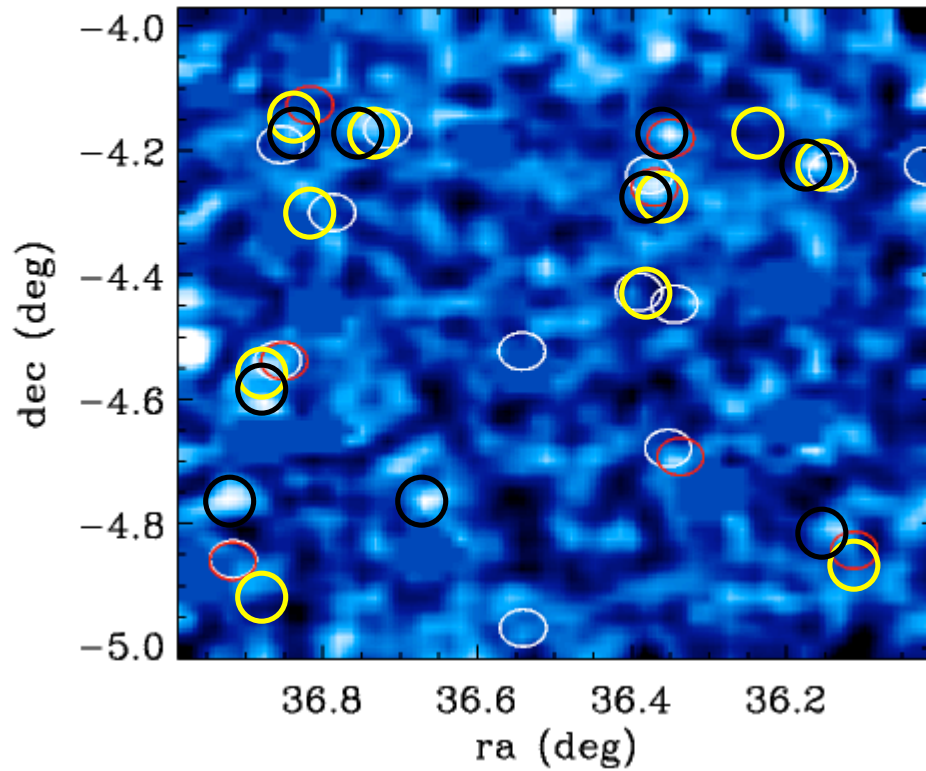


○ XMM-LSS clusters, Pacaud *et al* 2006

Mass map : D1



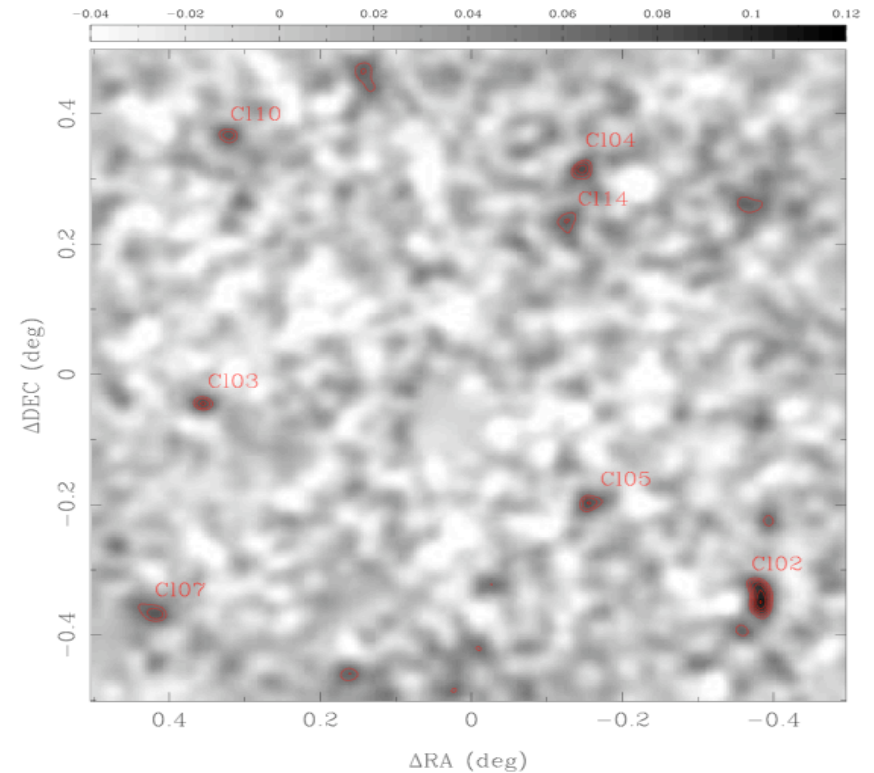
Shapelets



○ Shapelets

○ “Luminosity” (courtesy C. Marmo)

KSB (Gavazzi & Soucail 2006)



○ XMM-LSS clusters, Pacaud *et al* 2006

○ KSB (Gavazzi & Soucail 2006)

Conclusions

- Full model of the PSF
- Mass map / cluster detection
- Comparison with XMM-LSS X-ray detected, and optically detected clusters
- Detailed comparison with Stéphane Paulin-Henriksson's KSB implementation in progress

Software package and documentation

<http://www.astro.caltech.edu/~rjm/shapelets/>

<http://www.astro.caltech.edu/~jberge/shapelets/>