Combining Weak and Strong Cluster Lensing cont.

July 18, 2008

The Method

We combine weak and strong galaxy cluster lensing in the following way:

- Reconstruction quantity is the lensing potential ψ
- Maximum-likelihood approach

$$\chi^2(\psi) = \chi^2_w(\psi) + \chi^2_s(\psi)$$

- Fully non-parametric
- Grid-based
- Weak lensing input: ellipticity catalogue
- Strong lensing input: critical curve or arc position

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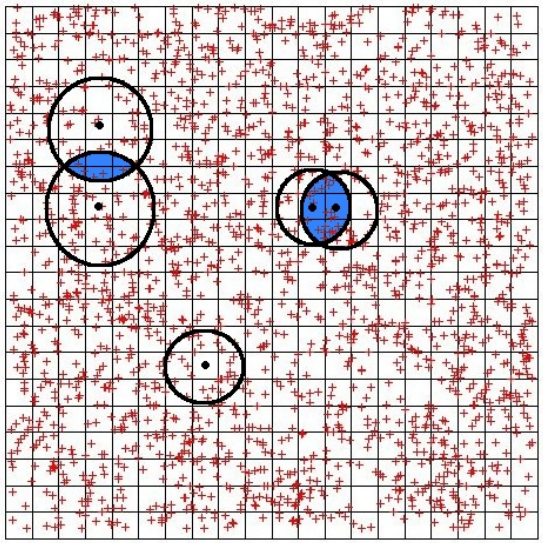
Weak Lensing

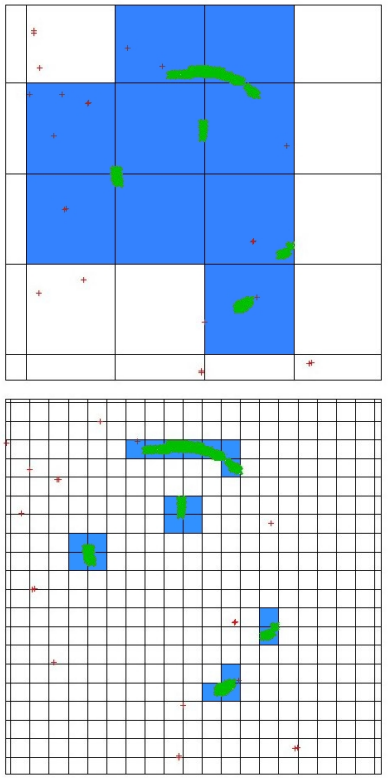
- State-of-the-art observations allow only for a ($\sim$ 10x10) pixel reconstruction grid
- Furthermore galaxies are not distributed homogeneously over the field
- Solution: Adaptive-averaging-process
  Problem:
  Grid points become correlated



$$\chi^2_w(\psi) = \sum_{i,j} \left(\varepsilon - \frac{Z(z)\gamma(\psi)}{1 - Z(z)\kappa(\psi)} \right)_i \mathcal{C}_{ij}^{-1} \left(\varepsilon - \frac{Z(z)\gamma(\psi)}{1 - Z(z)\kappa(\psi)} \right)_j$$

Strong Lensing

- The exact position of the critical curve is not observable
- Position of arcs is a very good approximation for the location of the critical curve
- Arc positions are known with high accuracy
- Using weak lensing grid resolutions would result in information loss



$$\chi_s^2(\psi) = \sum_i \frac{|\det A(\psi)|_i^2}{\sigma_i^2} = \sum_i \frac{|(1 - Z(z)\kappa(\psi))^2 - |Z(z)\gamma(\psi)|^2|}{\sigma_i^2}$$

Cluster Gallery

So far we did reconstructions of:

- Purely synthetic simulations
  Feed real calculated cluster values into the code together with full critical curve
- Realistic simulations by using Massimo's simulator code
  Ray-tracing lensing simulation including realistic noise (background galaxy shape, PSF, seeing, foregrounds)
- One reconstruction of a real galaxy cluster
  MS 2137 using VLT and HST images

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A Synthetic Example

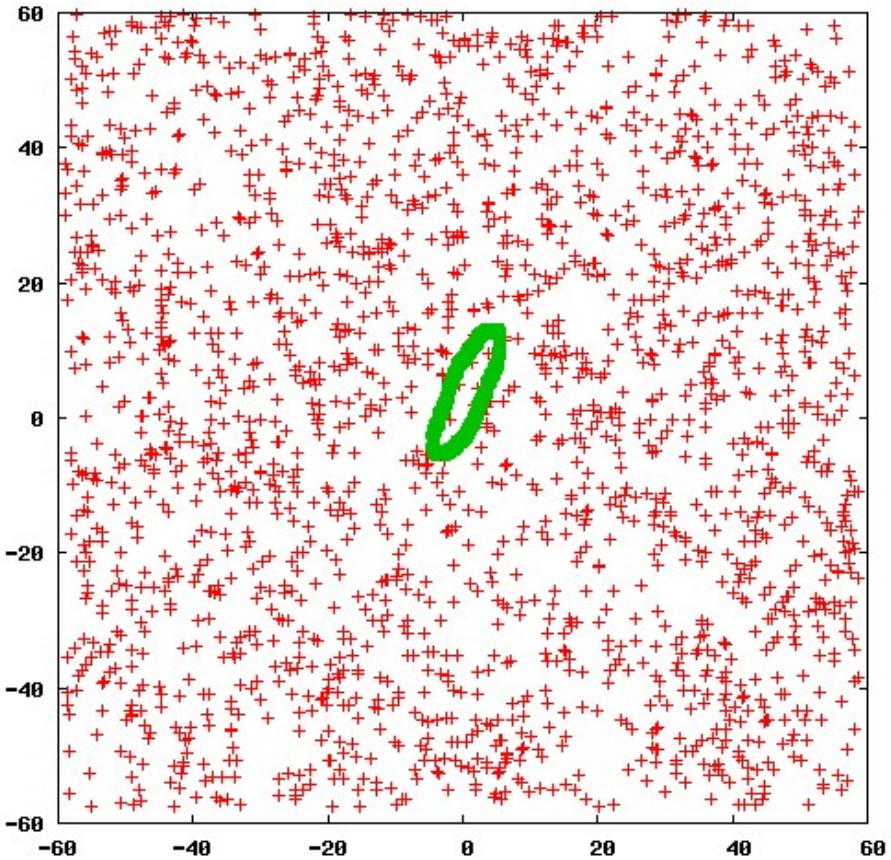

Figure: Fieldsize: 120"x120"; 2000 background galaxies, full critical curve

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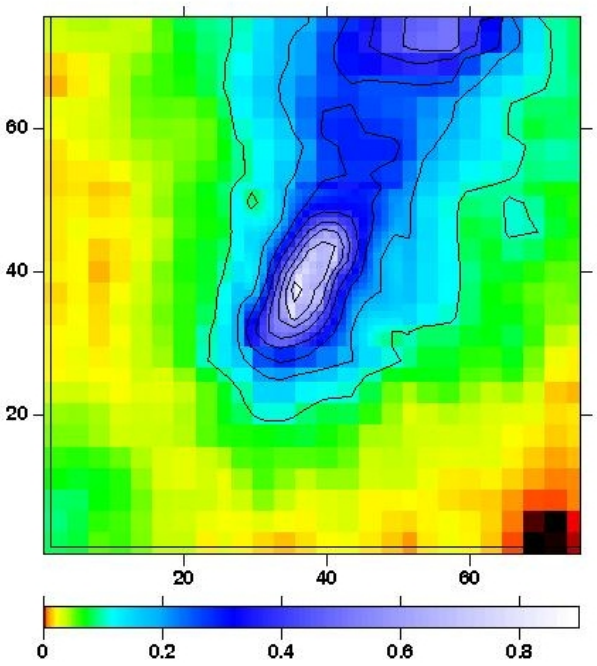
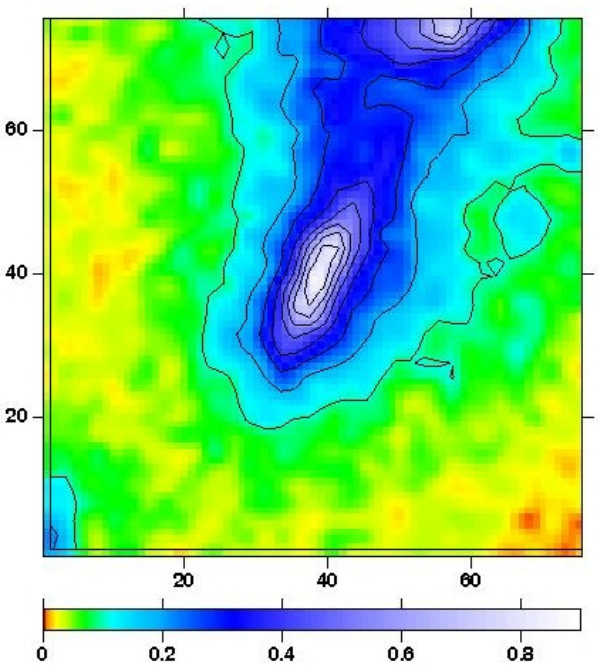
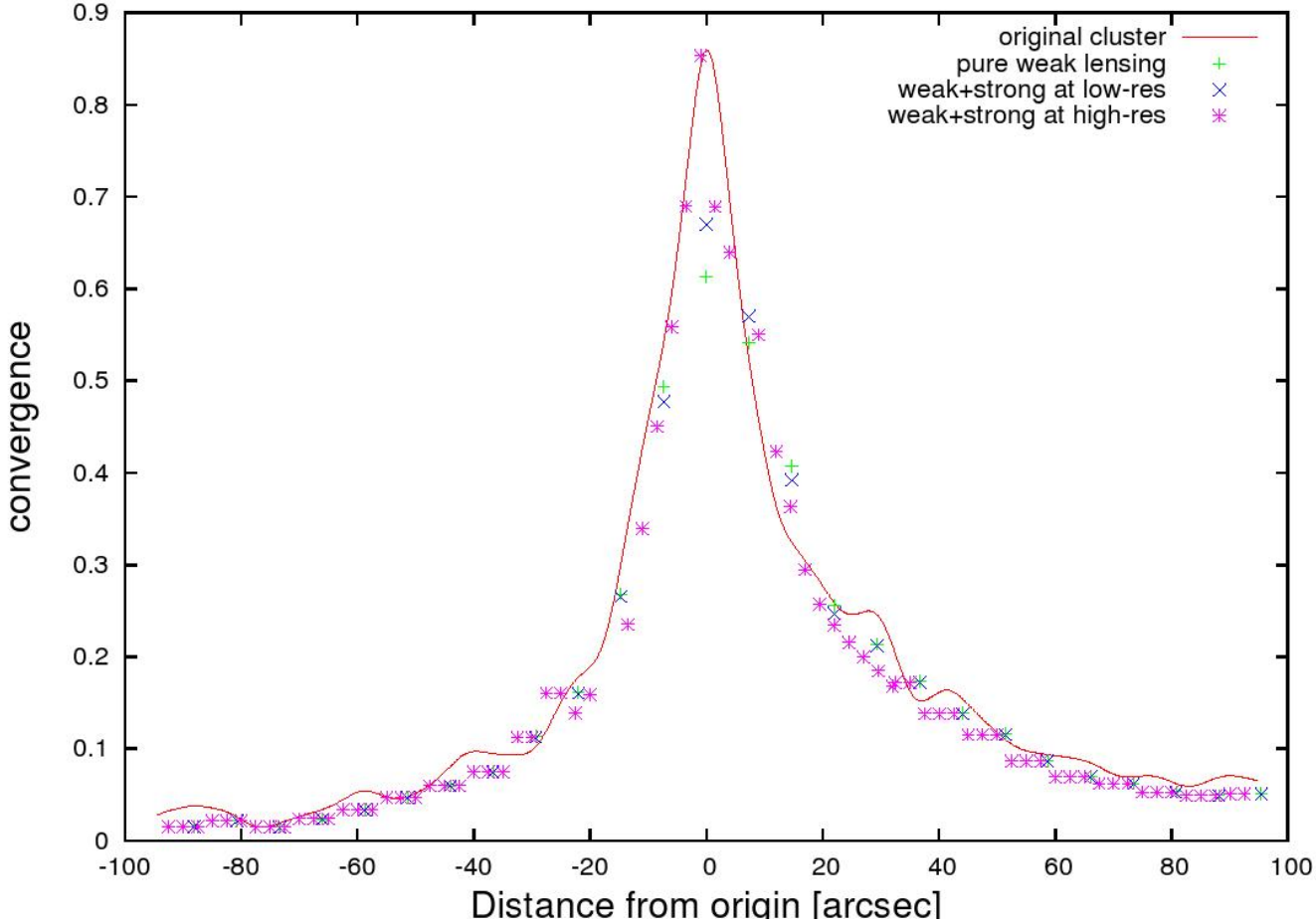




The only 1D profile-plot I will show!



Realistic Simulation

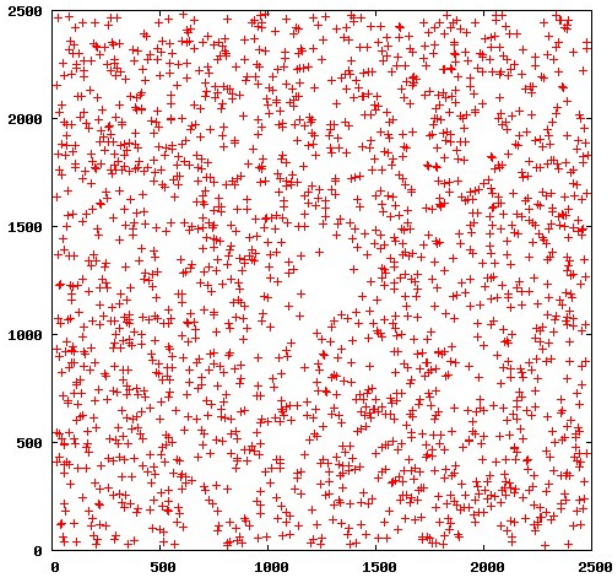


Figure: Fieldsize 400"x400"; 1826 background galaxies

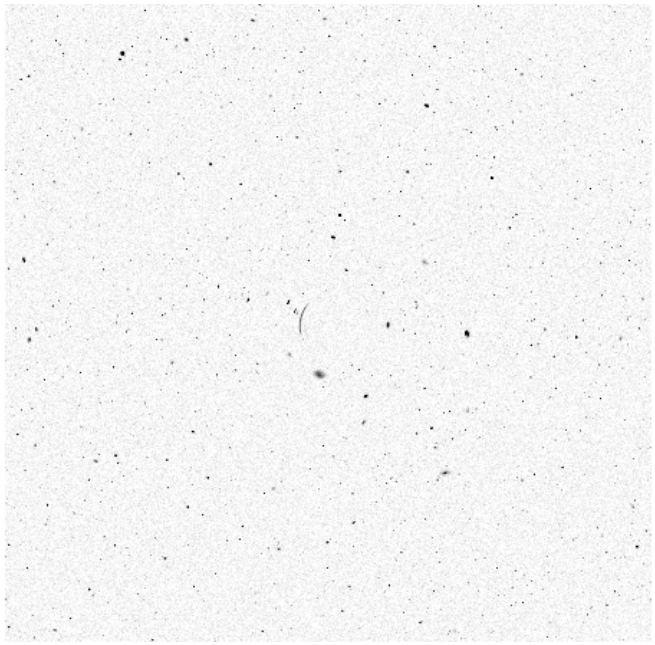
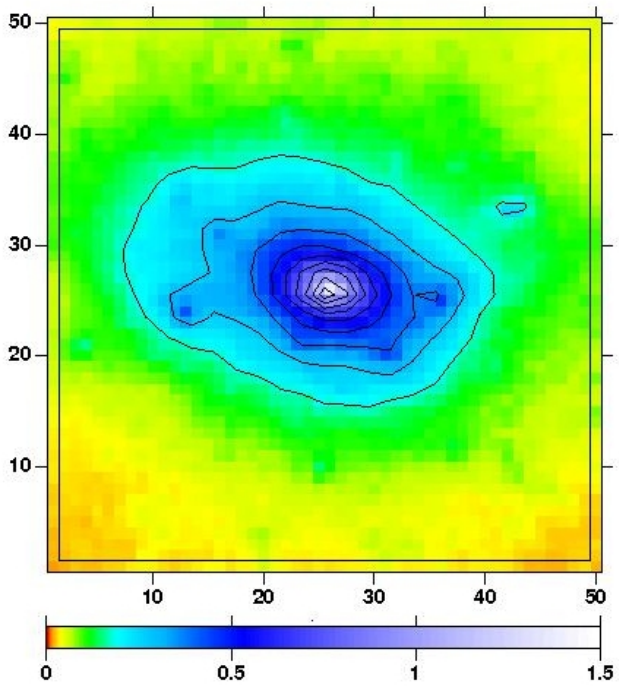
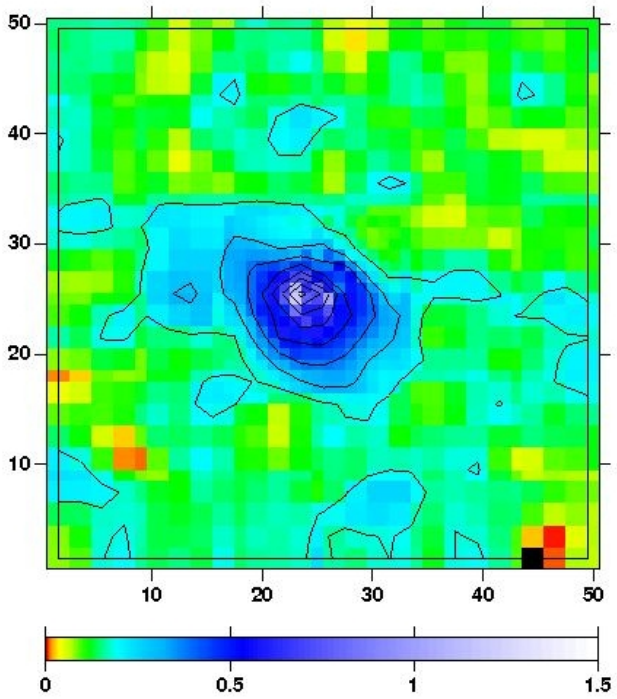


Figure: Simulated CCD-image with Subaru characteristics

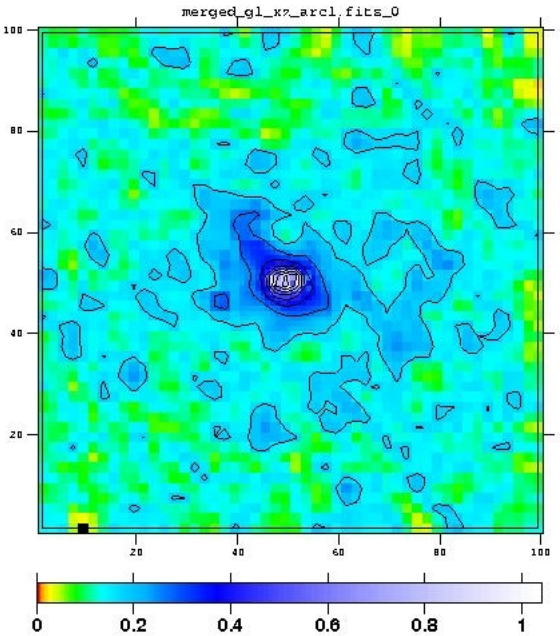
Realistic Simulation

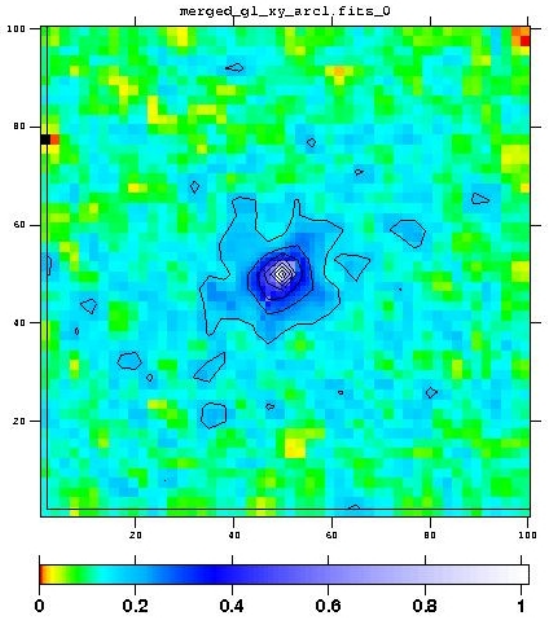


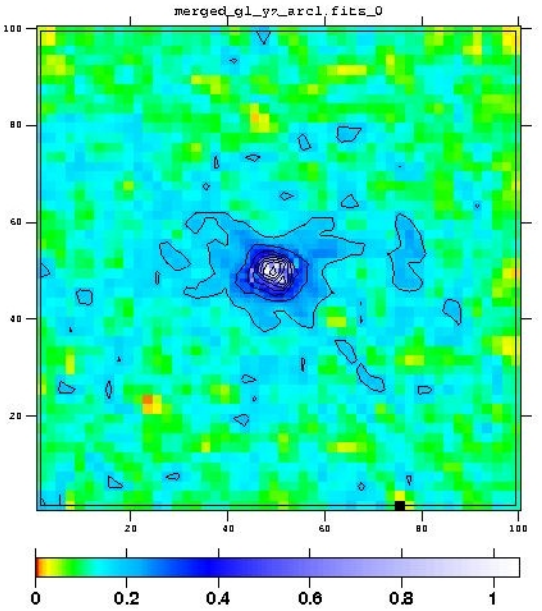


Realistic Simulations cont. / g1

Name:	g1
Fieldsize:	1280"x1280"
Weak lensing:	13797 galaxies
Strong lensing:	Full critical curve

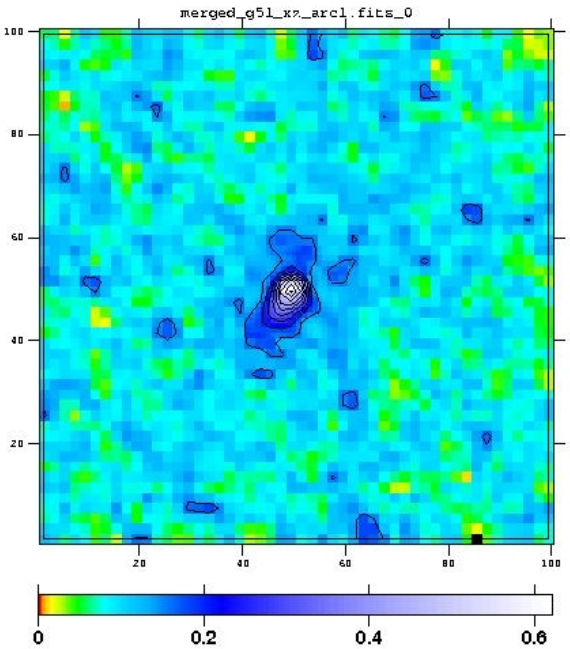


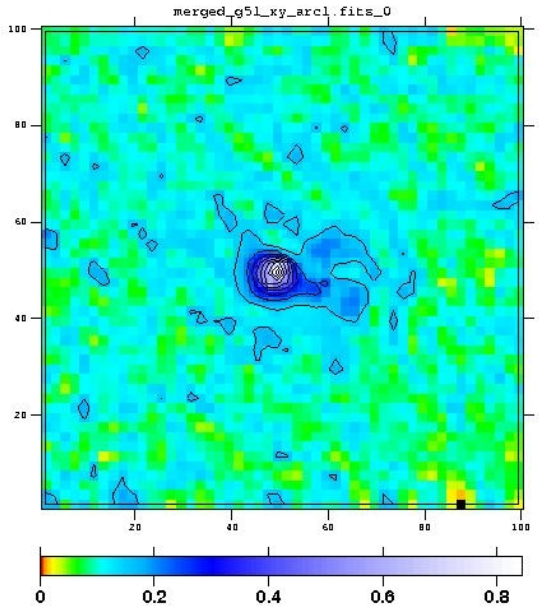


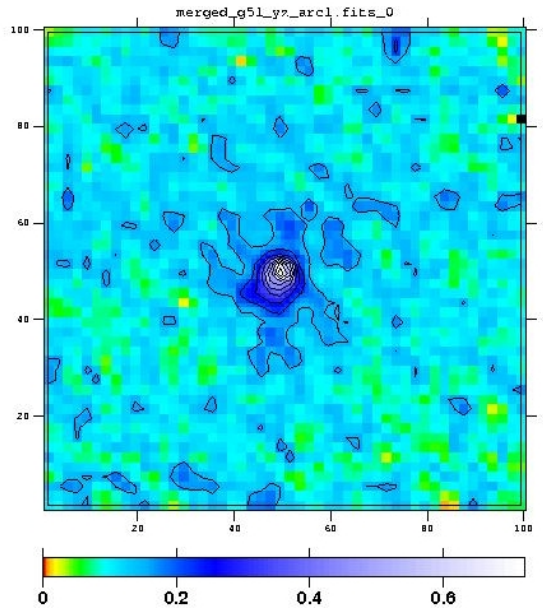


Realistic Simulations cont. / g51

Name:	g51
Fieldsize:	1900"x1900"
Weak lensing:	30839 galaxies
Strong lensing:	Full critical curve







MS 2137

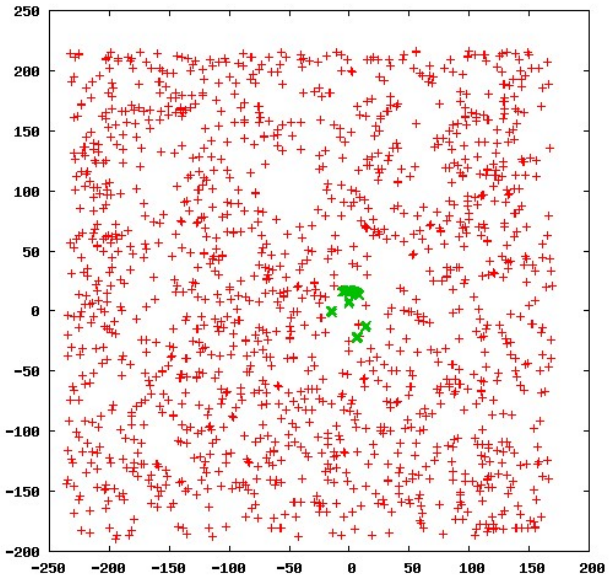


Figure: Fieldsize 405"x405"; 1500 background galaxies, arcs included

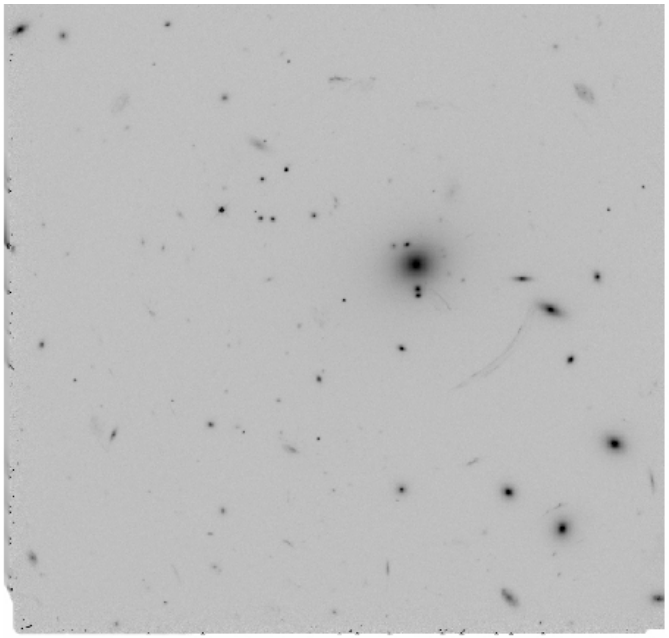


Figure: HST/WFPC2 image, first radial arc to be discovered (Fort et al. 1992)

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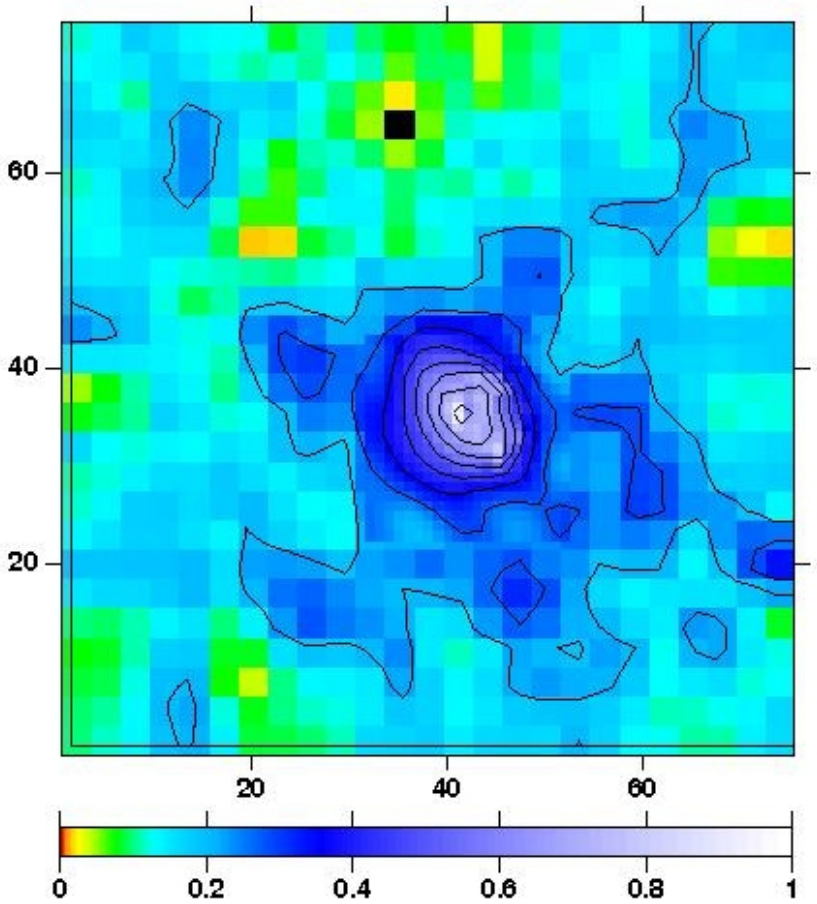

Outlook (large scale)

- Comparison of weak, strong and combined lensing-reconstructions with Massimo.
- Web interface for the lensing simulator and reconstructions of a big simulated cluster sample with Peter and Massimo.
- Application to more real data.

Outlook (small scale): The $\nabla, \triangle, \nabla\triangle$-Project

Flexion

- Flexion finite differences schemes
- Testing their implementation
- Flexion $\chi^2(\psi)$-function
- Fast χ^2-minimisation algorithm
- Testing its implementation
- Reconstructions of synthetic clusters
- Realistic simulations including flexion

Multiple image systems

- ...

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Have a nice semester break!