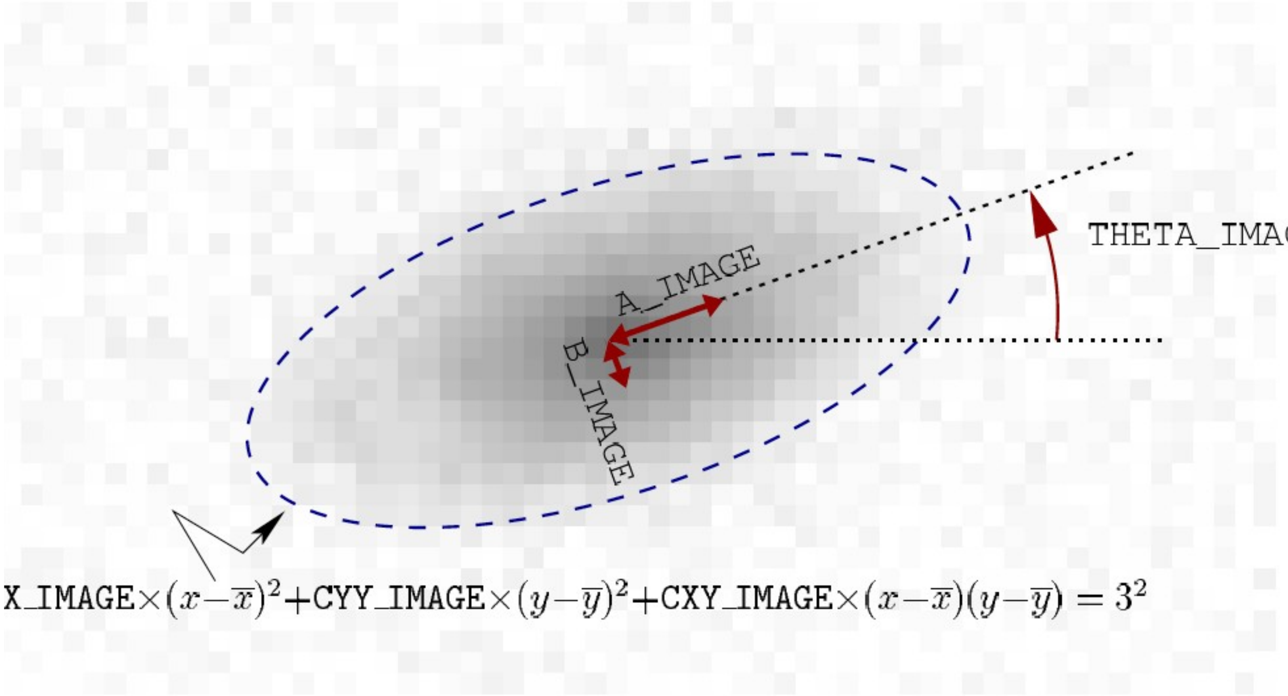
From 2-D to Catalogs

2-D Images

- Viewing 2-D images with ds9
  - Pixel coordinates and world coordinates
  - Stars and galaxies
  - Cosmic rays and defects
  - Satellite trails
- Generating Catalogs with SEXTARCTOR
- Finding Transient Candidates

Catalog

- What should be included in a catalog?
  - Position of the objects
  - Pixel coordinates
  - World coordinates
  - Shape of the objects
  - FWHM
  - Barycenter – first moments
  - Variance along X, Y – axis – second moments
  - Co-variance between X, Y – second moments



A_IMAGE – Profile RMS along major axis
B_IMAGE – Profile RMS along minor axis
THETA_IMAGE – Position algle (CCW/x)
A_WORLD
B_WORLD
THETA_WORLD (CCW/x)
THETA_J2000 Position angle (east of north) (J2000)

AREA

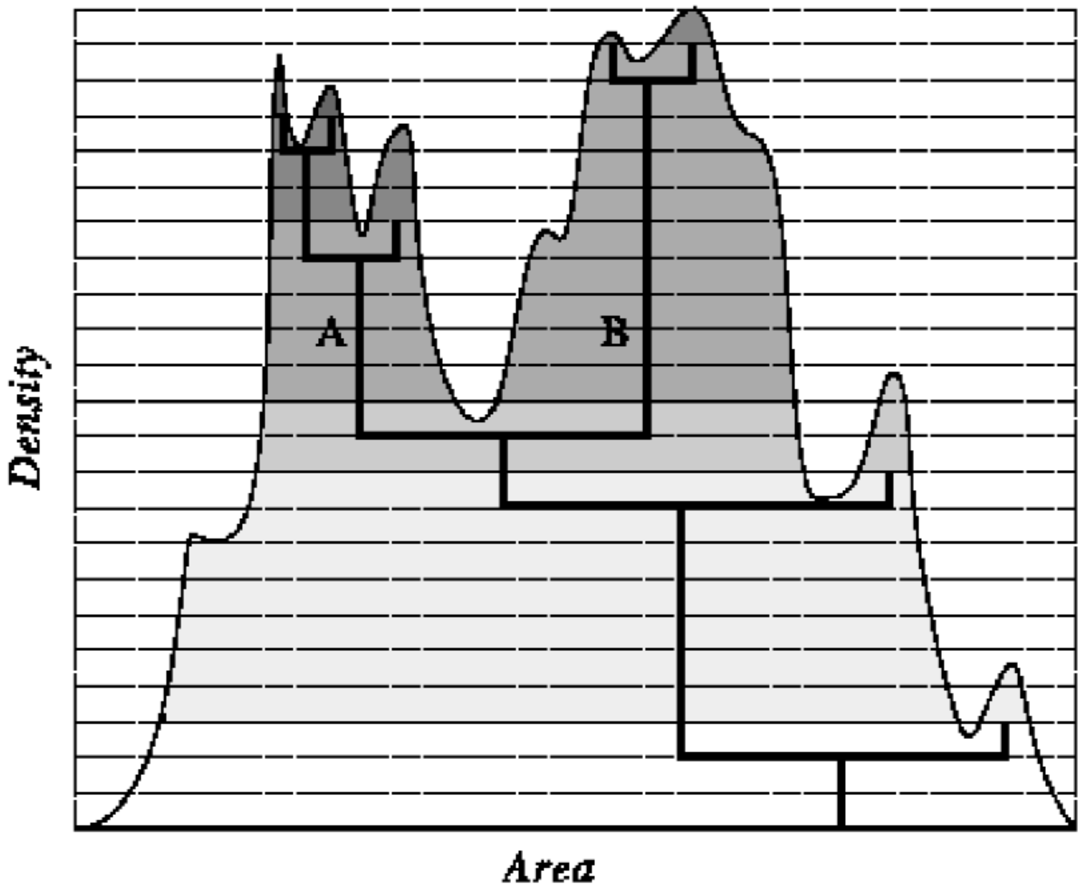
- ISOAREA_WORLD
  - ISO0 – Isophotal area at level 0
  - ISO1 - Isophotal area at level 1
  - ISO2 - Isophotal area at level 2
  - …
  - ISO7 - Isophotal area at level 7

- These parameters are fed to the neural network for deciding whether the object is a star or a galaxy

FWHM

- FWHM_WORLD
- FWHM_IMAGE

Deblending



A branch is considered a different object provided:

1. The number of counts in the branch (A in the figure) is above a certain fraction of the total count in the entire ’island’.
2. There is at least one other branch (yep B!) above the same level that is also above this fraction.

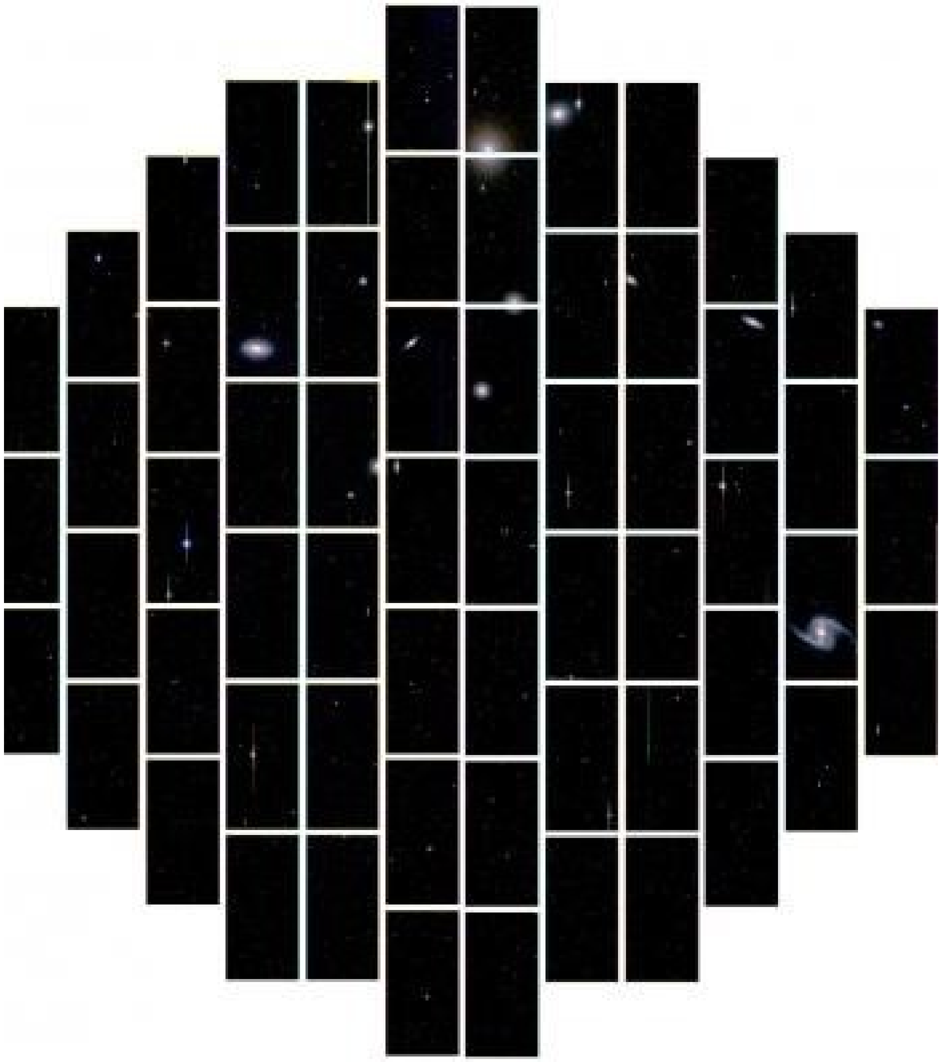
First it defines a number of levels between the threshold and the maximum count in the object. This is set by the DEBLEND NTHRESH parameter. The

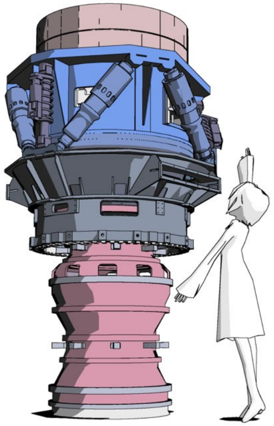
SE then constructs a ’tree’ of the objects, branching every time there are pixels above a threshold

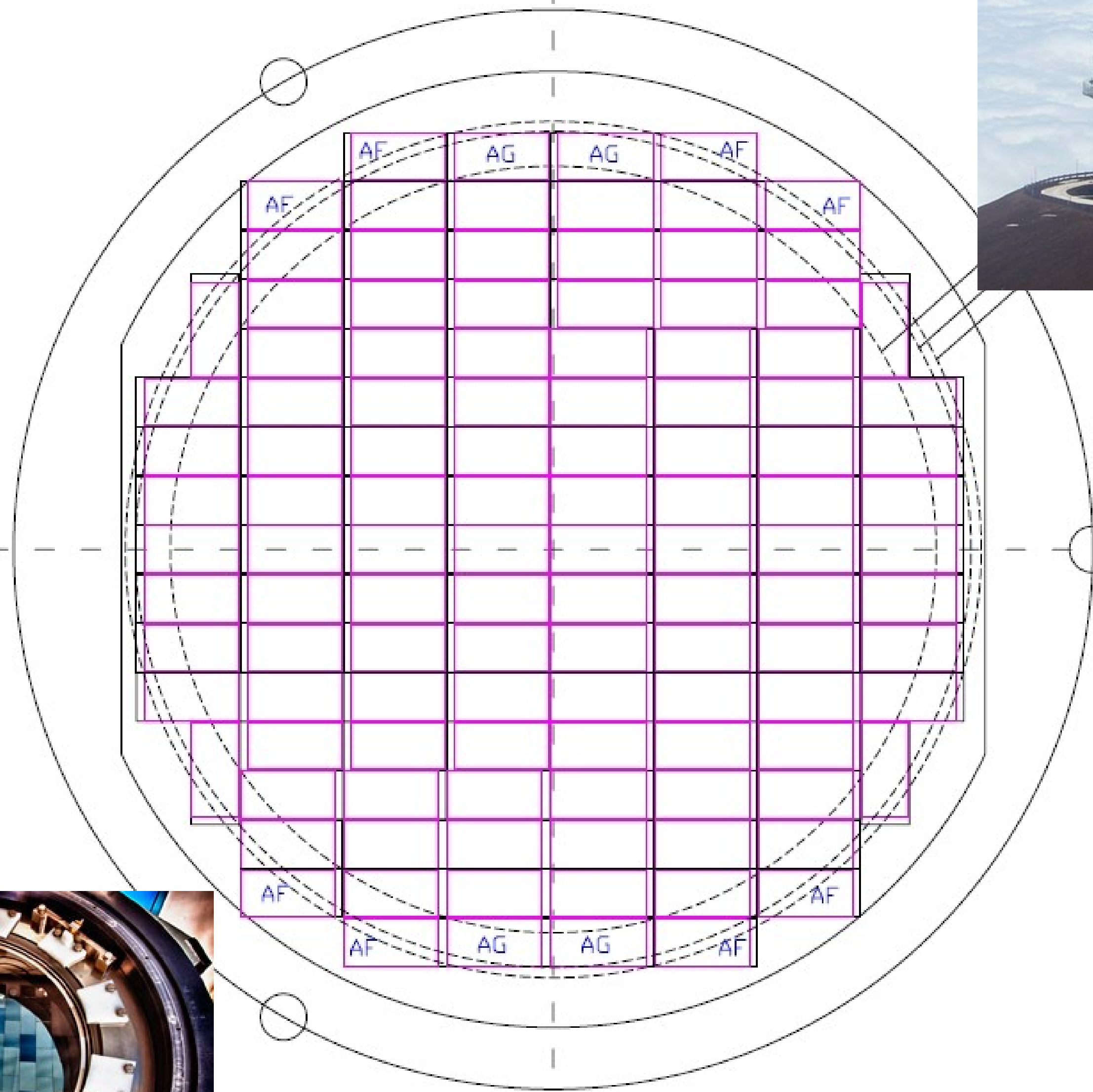
Classification – CLASS_STAR

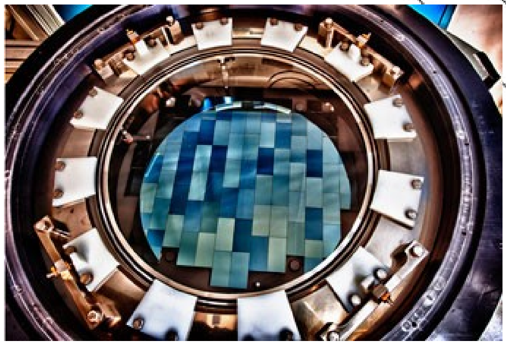
- Input
- PIXEL_SCALE (Pixel size in arcsec)
- Seeing_FWHM (FWHM of stellar images in arcsec)
- BACK_SIZE (Defines the background mesh, width, height)
- THRESH_TYPE
  - RELATIVE scaling factor to the background RMS
  - ABSOLUTE level in ADUs or in surface brightness
- ANALYZE_THRESH Threshold at which CLASSSTAR and FWHM operate
  - 1 arg: relative to background RMS
  - 2 args: mu(mag arcsec-2, zero-point (mag)

DECAM









CCD配置図
窓側(主鏡側)から見た図

Subaru SN Search for Very Early SNe

The outer part of SNe Ia ejecta is still very interesting. We need UV data a few days after explosion.

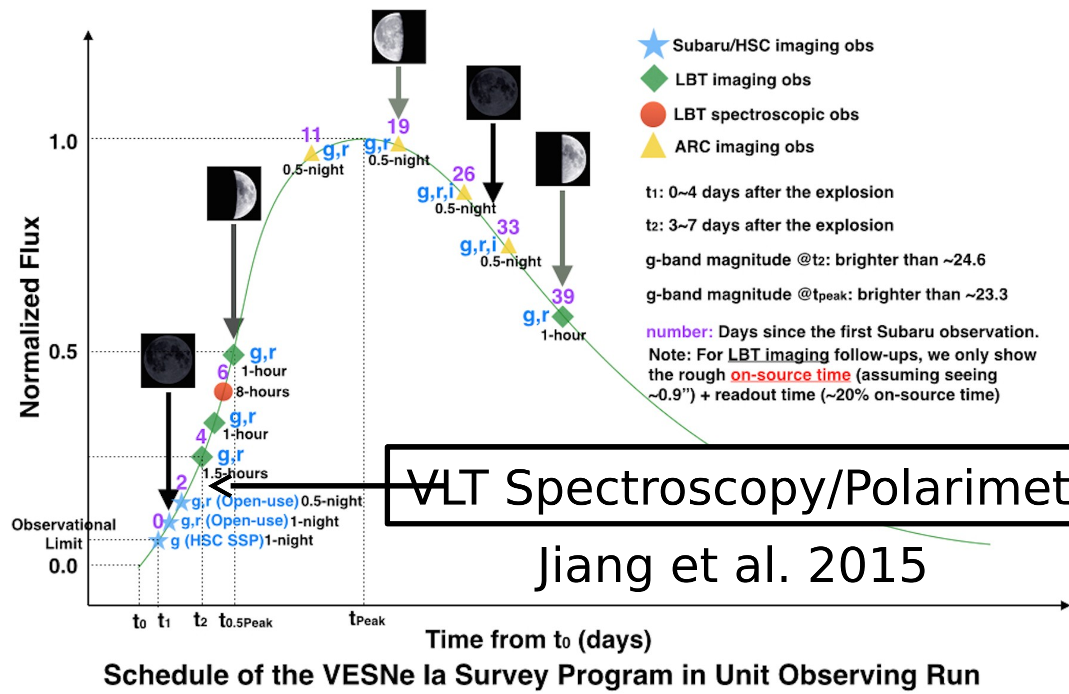
Nearby search: ASAS, iPTF

Bright SNe at low redshift

Swift UV photometry and spectroscopy

Very early polarimetry with VLT

Need ToO

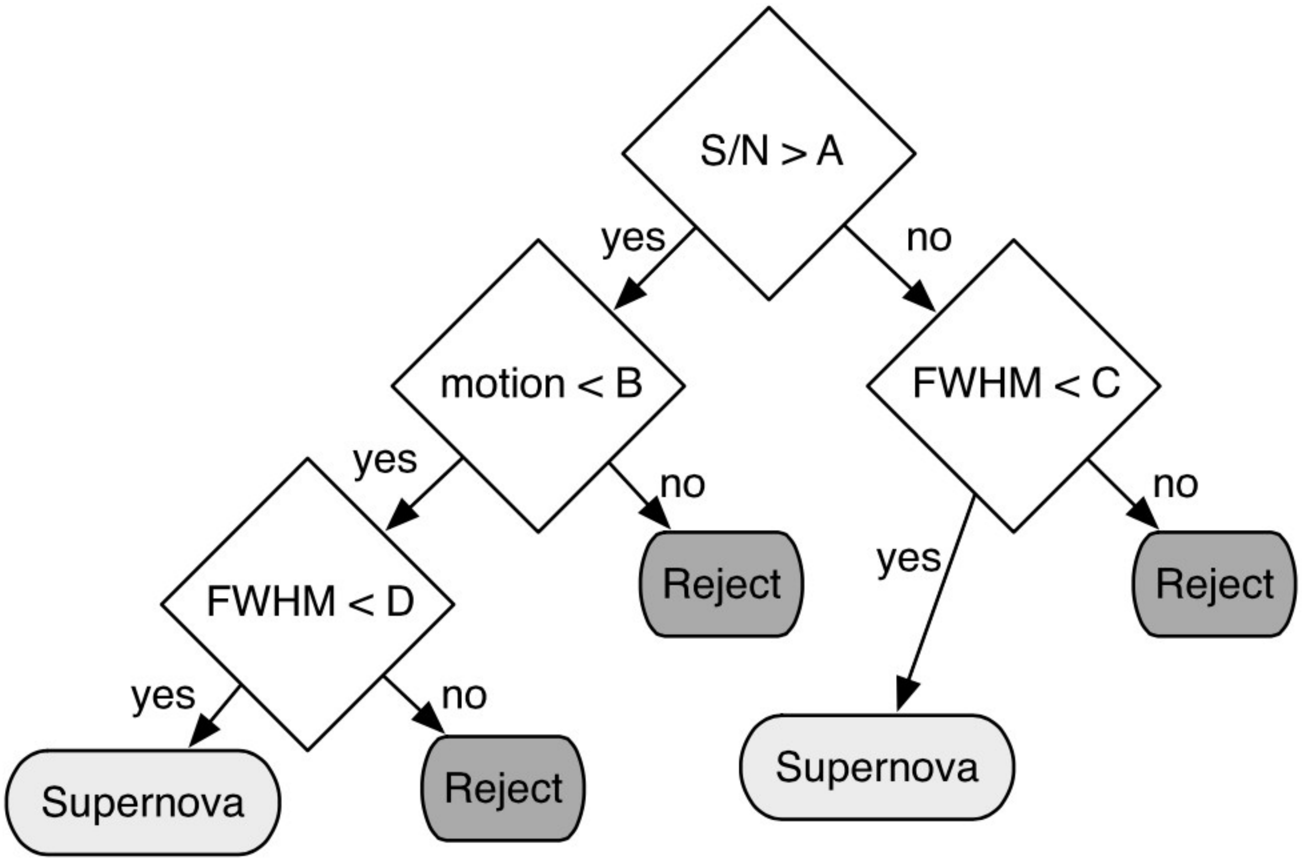


VLT Spectroscopy/Polarimetry

Jiang et al. 2015

Deep Transient Search to routinely discover SNe within 3 day after explosion, followed up with scheduled observations

Decision Tree for Transient Search



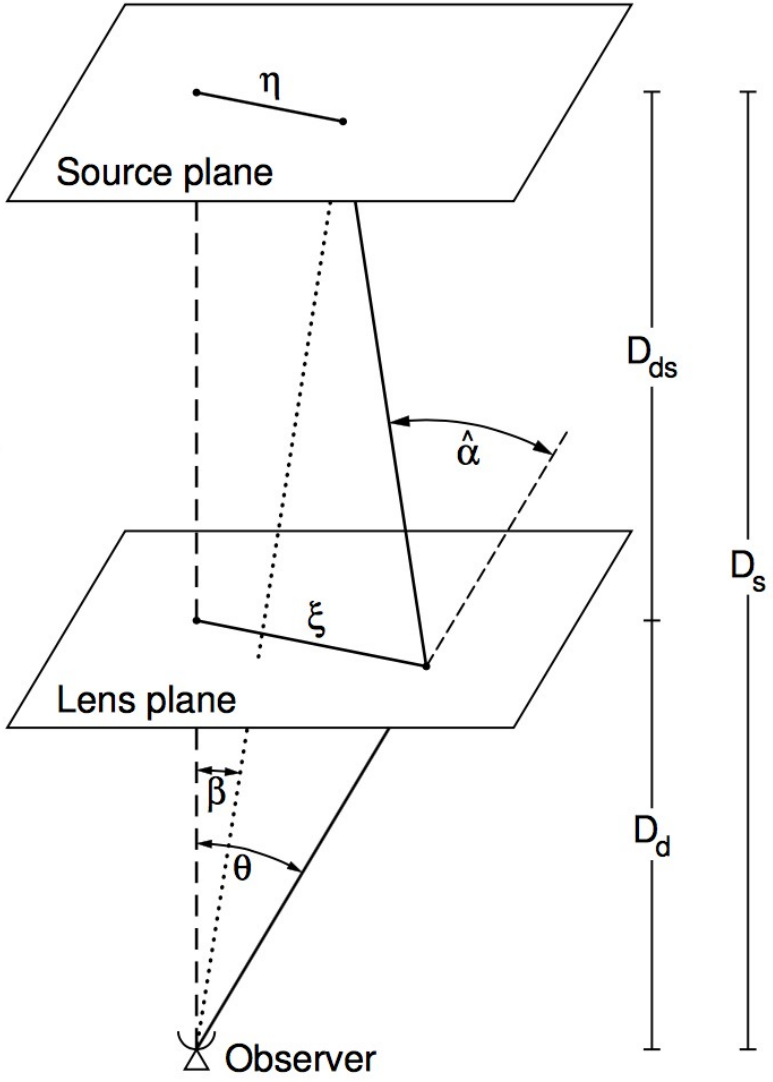
Weak Lensing

- Weak lensing in practise, from galaxy to CCD pixel
- STEP 1
  - Shear measurement accuracy
- STEP 2
  - More complex simulations
- GREAT08 - take part in the challenge!
- Making a shear catalogue: object detection practical

$$A_{ij} = \frac{\delta\beta_i}{\delta\theta_j}$$

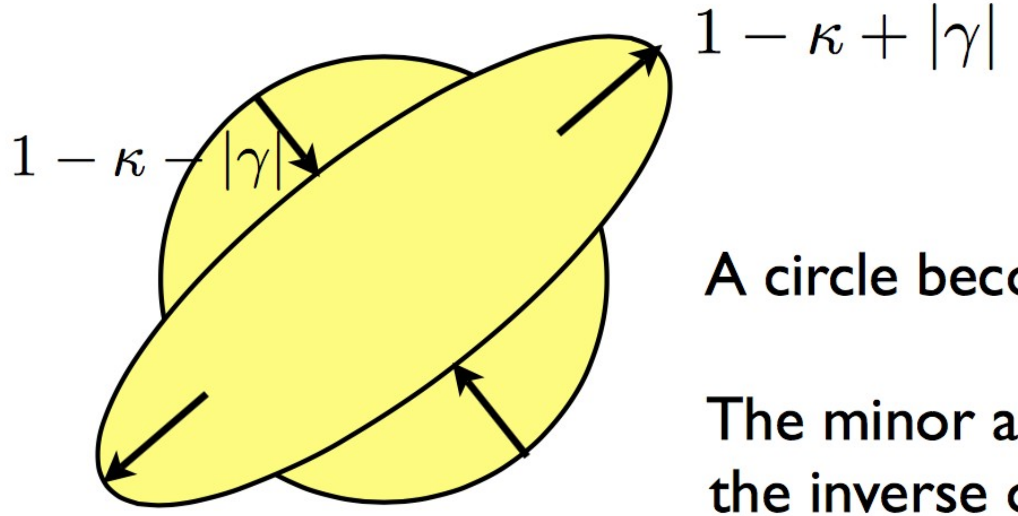
$$A = \begin{pmatrix} 1-\kappa-\gamma_1 & -\gamma_2 \\ -\gamma_2 & 1-\kappa+\gamma_1 \end{pmatrix},$$

- The lensing Jacobian maps the source to the image plane.
- The effect depends on the lensing potential, through the shear and convergence terms
- We want to measure the convergence (mass), but we can only observe the shear.



What happens to a circular source?

$$I(\vec{\theta}) = I^{(s)}\left[\vec{\beta}_0 + \mathcal{A}(\vec{\theta}_0)\cdot(\vec{\theta}-\vec{\theta}_0)\right]$$



A circle becomes an ellipse.

The minor and major axes given by the inverse of the eigenvalues of A.

The orientation is given by the eigenvectors of A

Centroids and Quadrupole Moments

- Lensing changes the shapes of galaxies, so we need a statistic with which to quantify their shape.
- The first moment determines an objects centroid

$$\bar{x} = \int I(x,y)\, x \,\mathrm{d}x\,\mathrm{d}y$$
$$\bar{y} = \int I(x,y)\, y \,\mathrm{d}x\,\mathrm{d}y\ ,$$

- The second moment (or quadrupole moments determines shape)

$$\mathcal{Q}_{xx} = \int I(x,y)\,(x-\bar{x})^2\,\mathrm{d}x\,\mathrm{d}y$$
$$\mathcal{Q}_{xy} = \int I(x,y)\,(x-\bar{x})(y-\bar{y})\,\mathrm{d}x\,\mathrm{d}y$$
$$\mathcal{Q}_{yy} = \int I(x,y)\,(y-\bar{y})^2\,\mathrm{d}x\,\mathrm{d}y.$$

Quadrupoles, ellipticity and shear

$$\epsilon \equiv \epsilon_1 + i\epsilon_2 = \frac{Q_{xx} - Q_{yy} + 2iQ_{xy}}{Q_{xx} + Q_{yy} + 2(Q_{xx}Q_{yy} - Q_{xy}^2)^{1/2}} ,$$

$$\begin{aligned} \epsilon_1 &= \frac{a-b}{a+b}\cos(2\theta) \\ \epsilon_2 &= \frac{a-b}{a+b}\sin(2\theta). \end{aligned}$$

$$Q^{(s)} = \mathcal{A}\, Q\, \mathcal{A}^T$$

$$\epsilon_{obs} = \frac{\epsilon^s + g}{1 + g^* \epsilon^s}$$

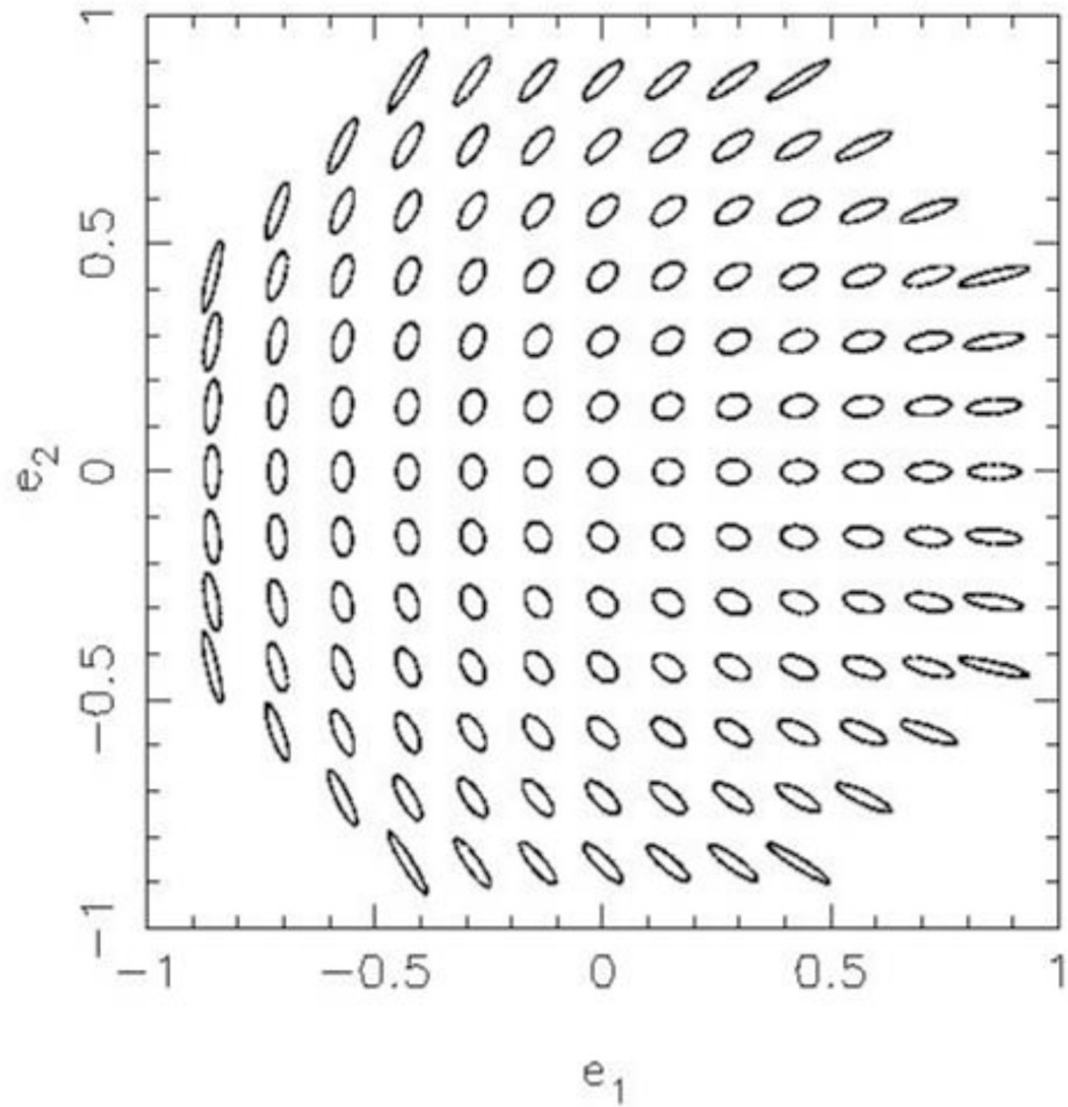
Lensing of an elliptical source

Observables : Galaxy Ellipticity

$$e^{\rm obs} = e^{\rm source} + \gamma$$

$$< e^{\rm source} >= 0$$

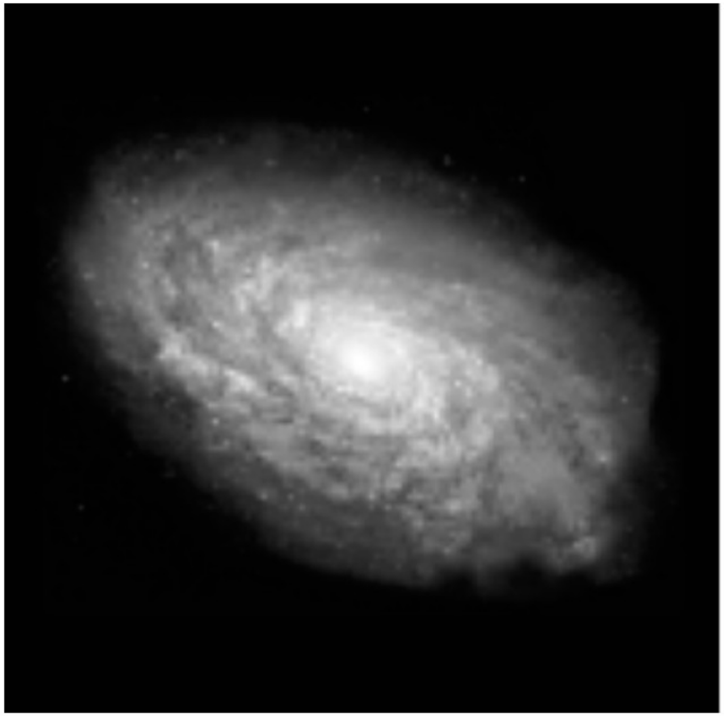
$$\gamma =< e^{\rm obs} >$$



So it's easy! Measure the ellipticity, you have the shear and all knowledge of cosmology?

Sadly not - instrumental, atmospheric and physical distortions are an order of magnitude larger than the weak lensing signal you want to detect.

Cosmic Lensing



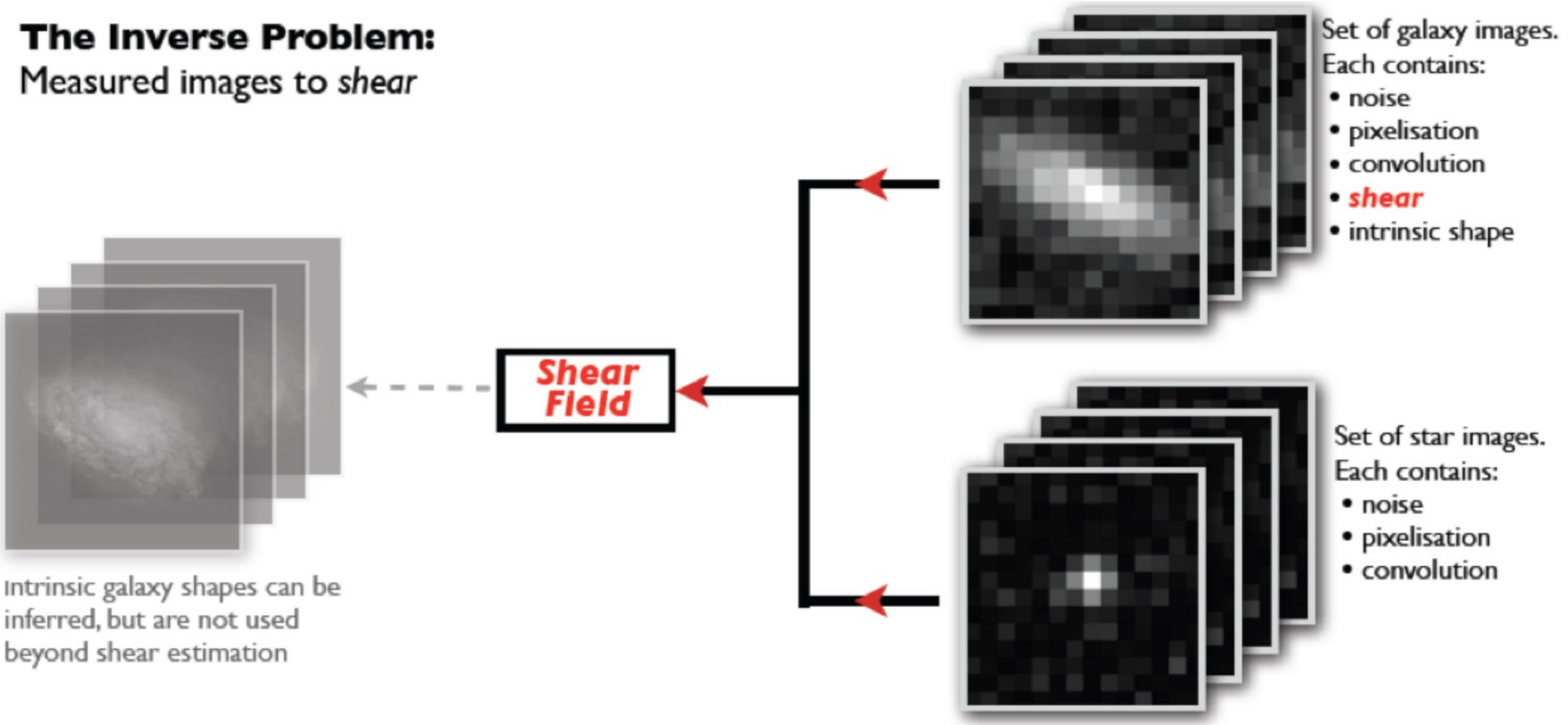
g_i~0.2

$$\begin{pmatrix} x_u \\ y_u \end{pmatrix} = \begin{pmatrix} 1-g_1 & -g_2 \\ -g_2 & 1+g_1 \end{pmatrix} \begin{pmatrix} x_l \\ y_l \end{pmatrix}$$

Real data:
g_i~0.03

Weak lensing analyses reverse this process

The Inverse Problem:
Measured images to *shear*



Intrinsic galaxy shapes can be inferred, but are not used beyond shear estimation