Automatic multi-band arc detection

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collaborators:

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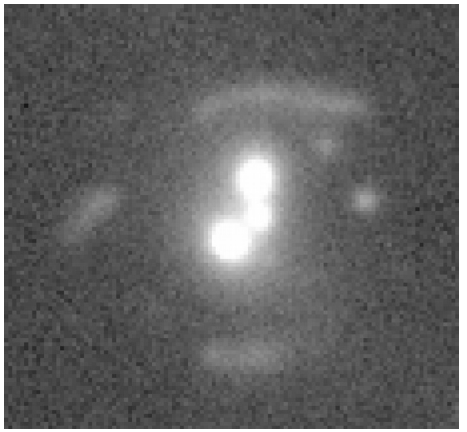
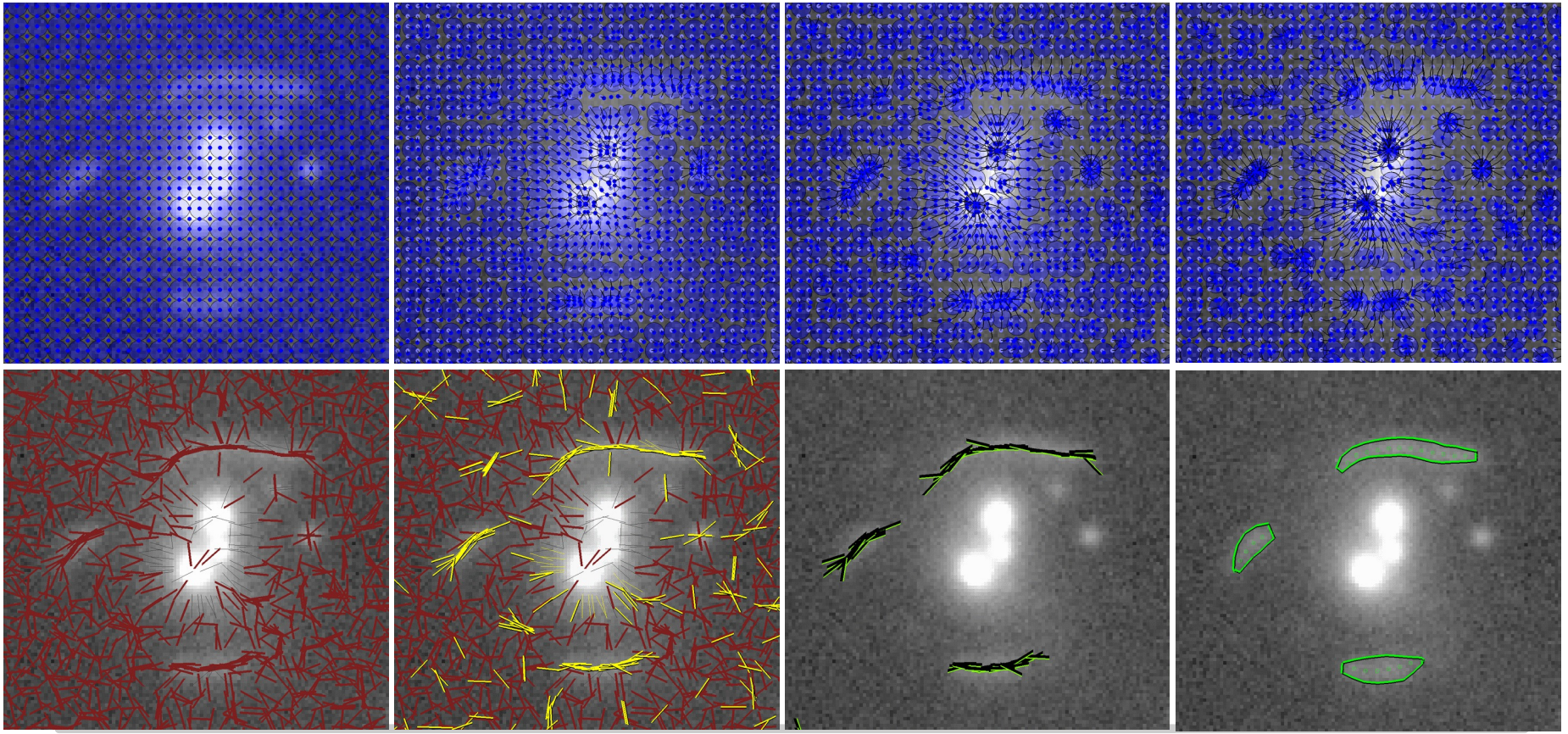
Finding arcs in 1 band

- plain CARS image
- initial cell displacement
- coherent feature detection and segmentation





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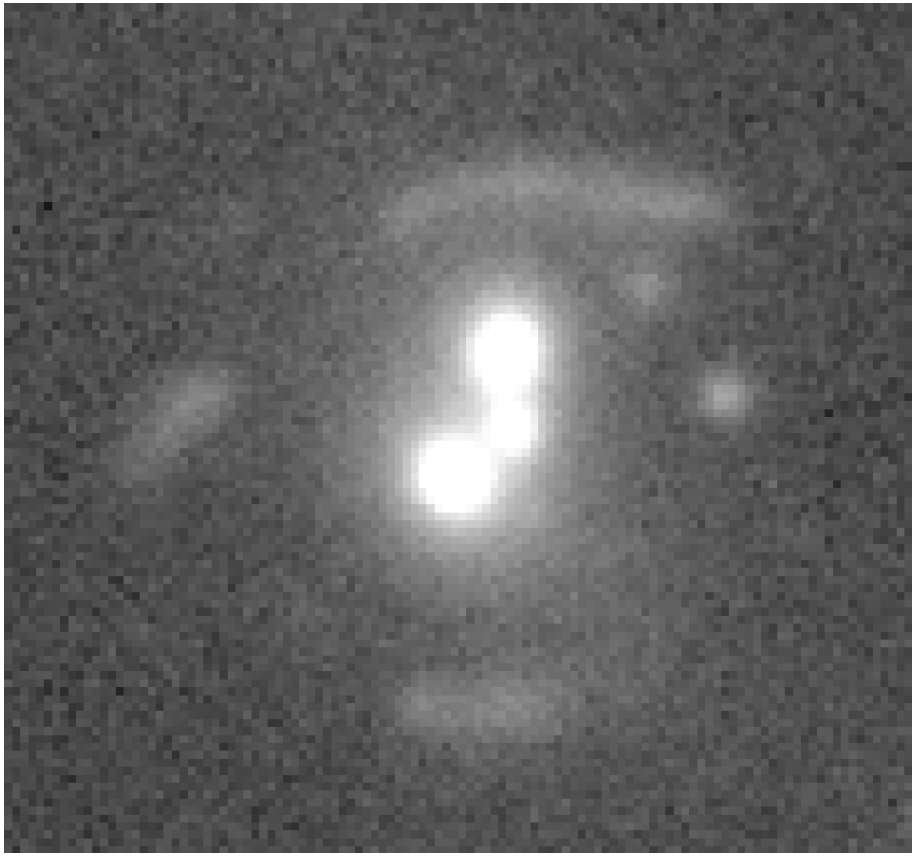

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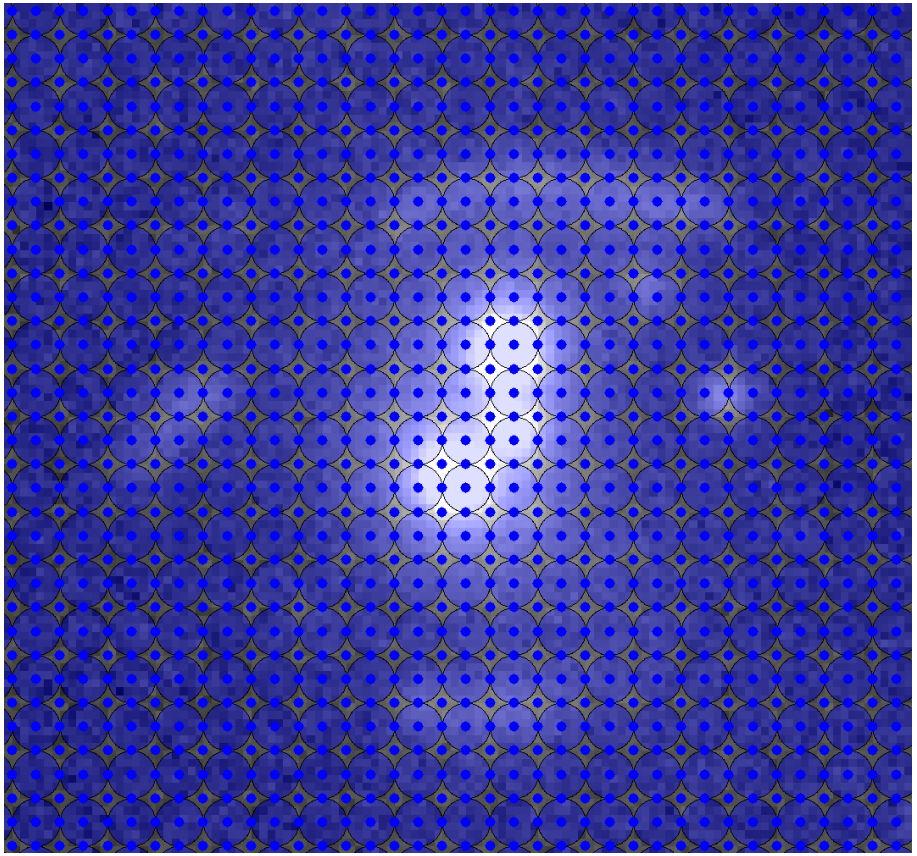

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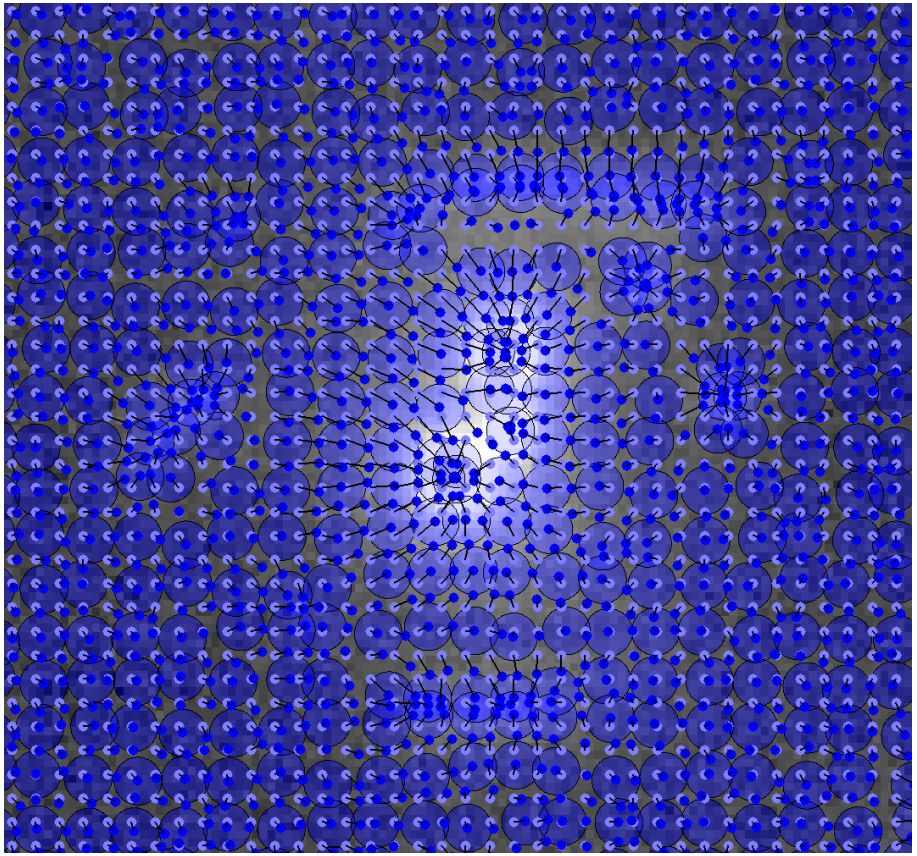

1st moments

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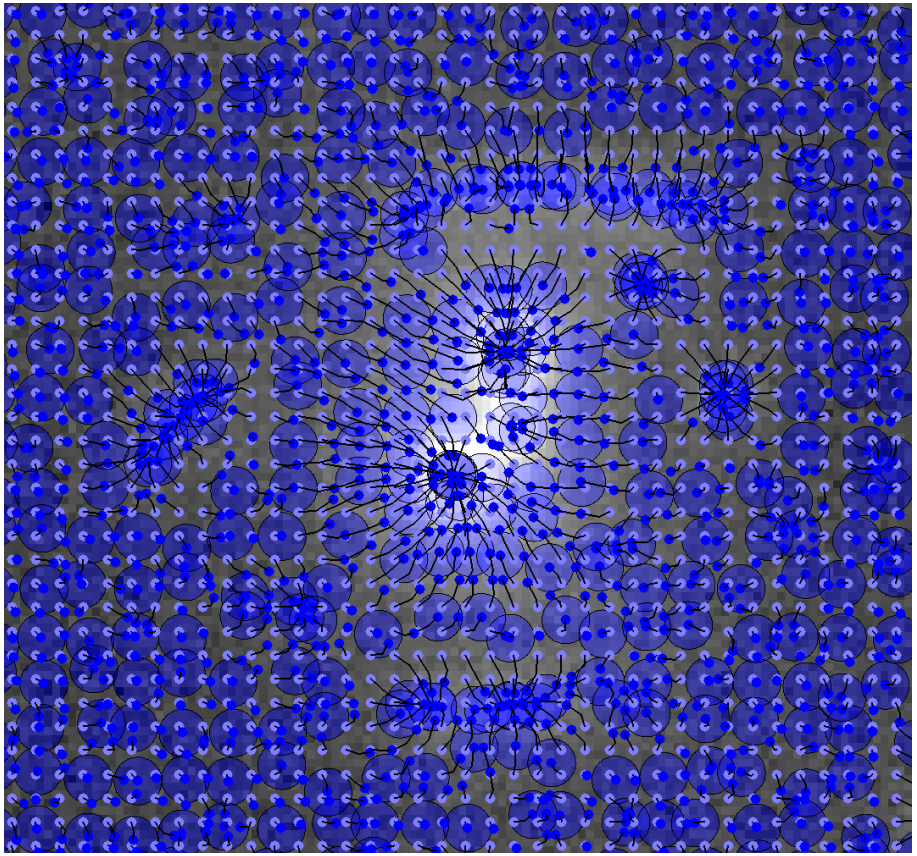

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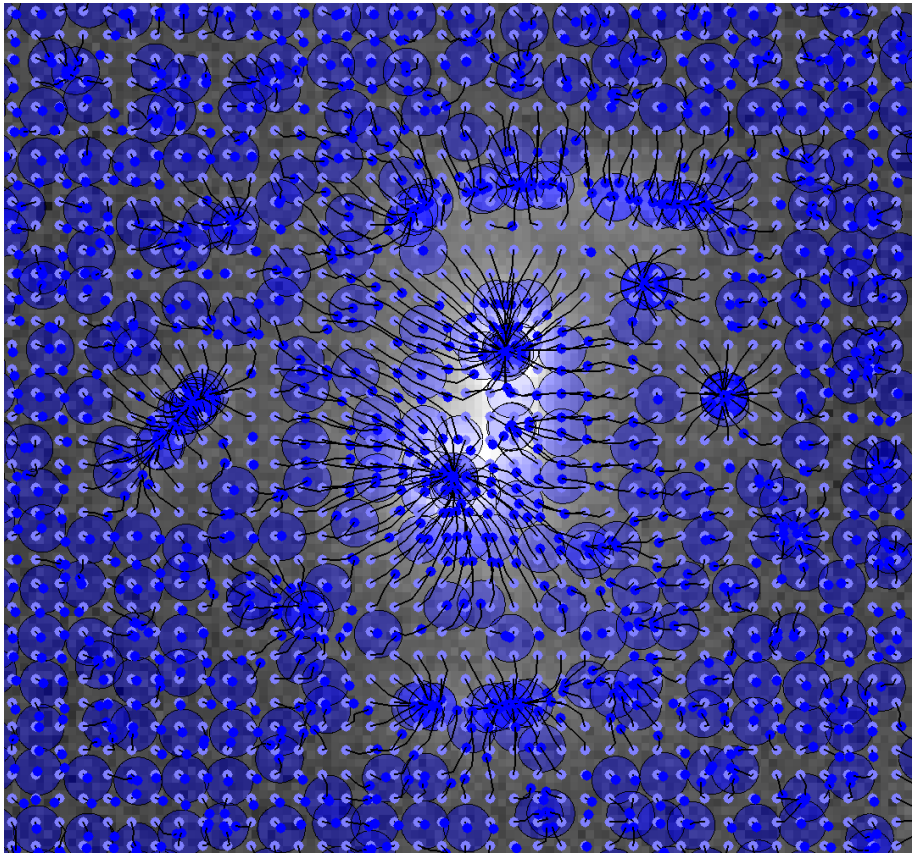

1st moments

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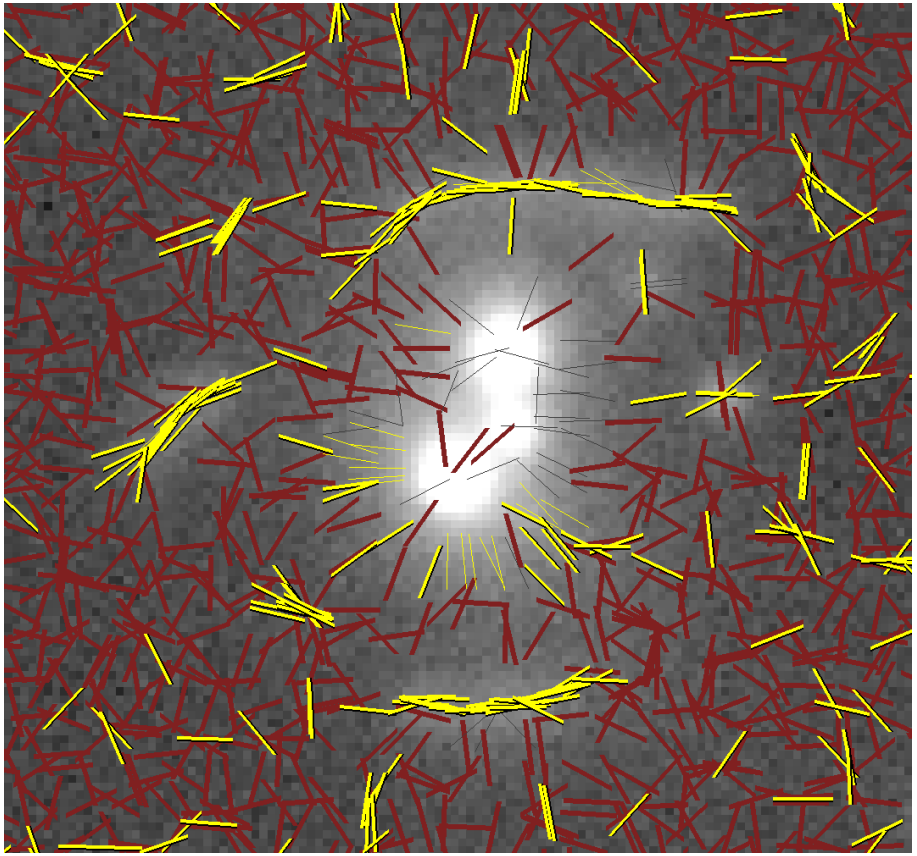
cell coherency:

$$c^{kl} = e^k e^l \, max\left(0, 1 - \frac{\left|\left(x^k - x^l\right) \times e^k\right|}{d}\right)$$



2nd moments, ellipticity

$$\chi = \frac{Q_{11} - Q_{22} + 2\,i Q_{12}}{Q_{11} + Q_{22}}$$

Finding arcs in 1 band

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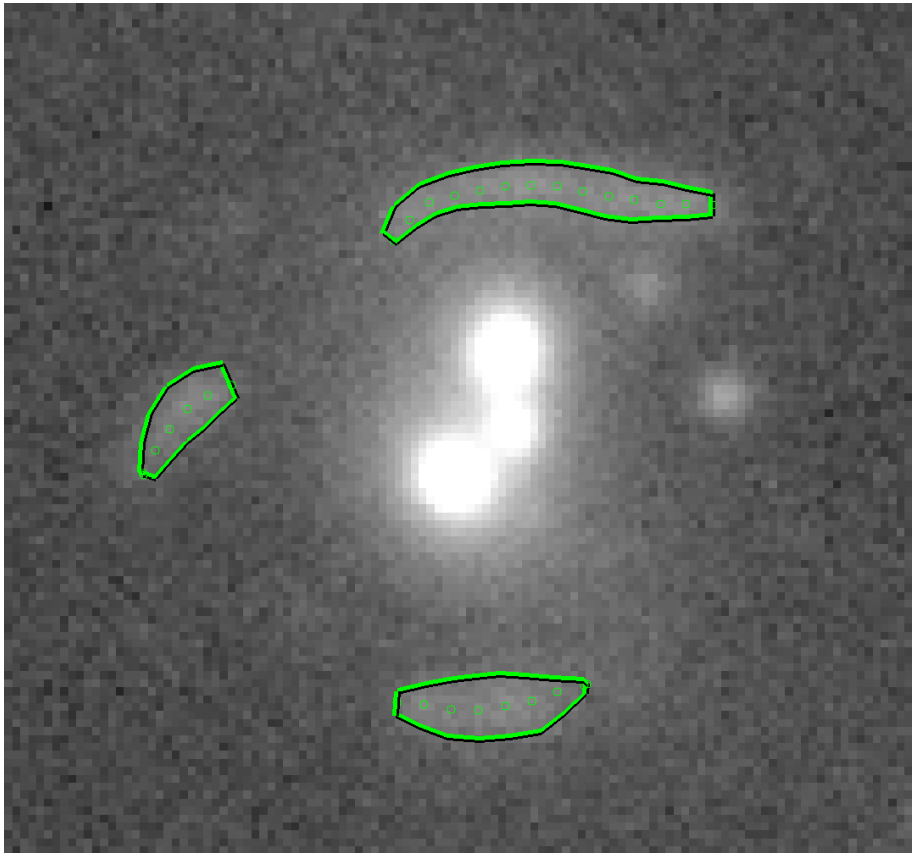
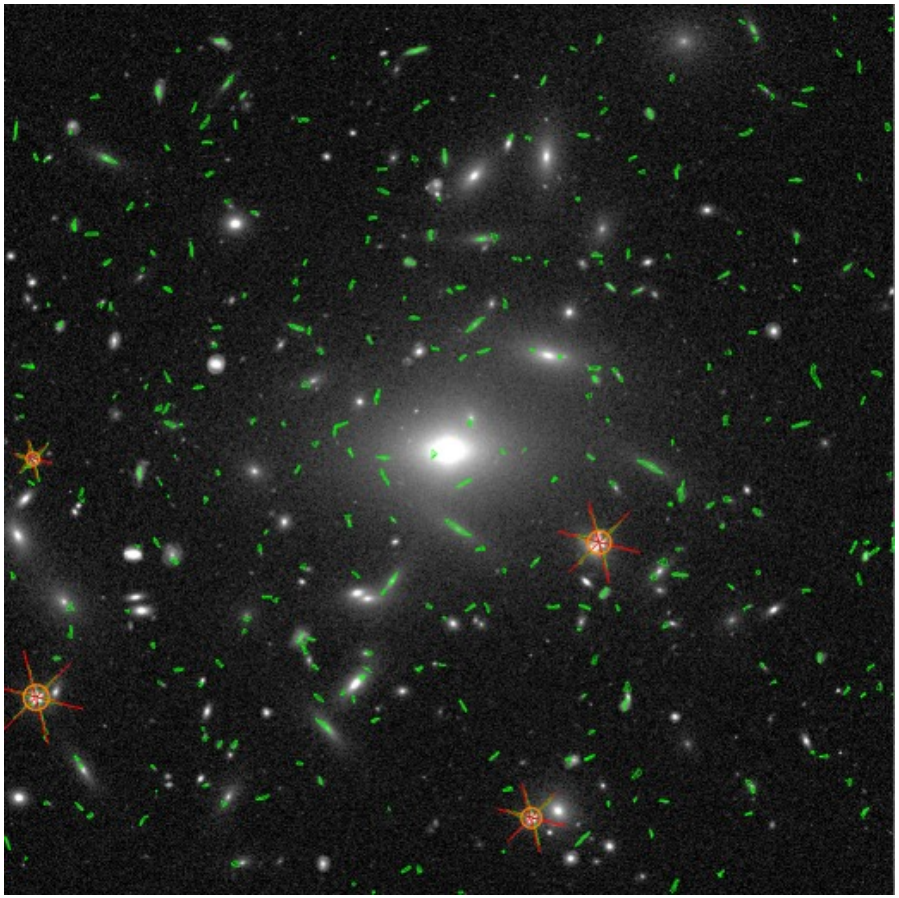
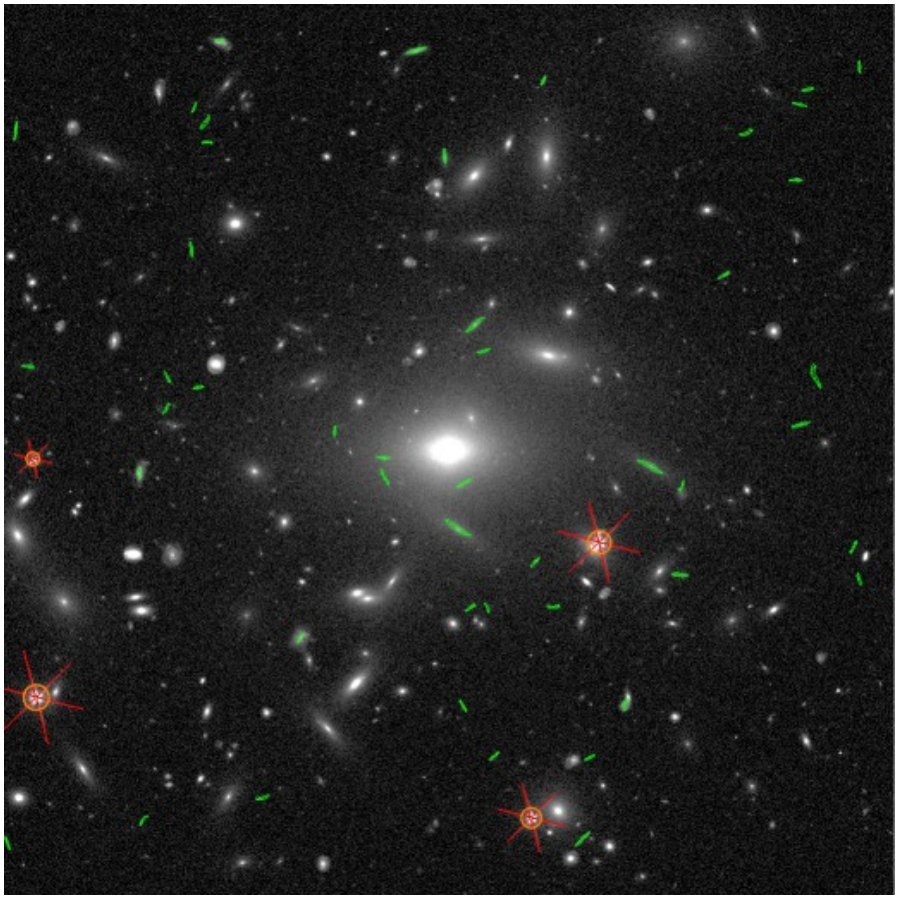


Active Contour Segmentation

(Kass et al. 1988)

Select likely arcs by shape & flux



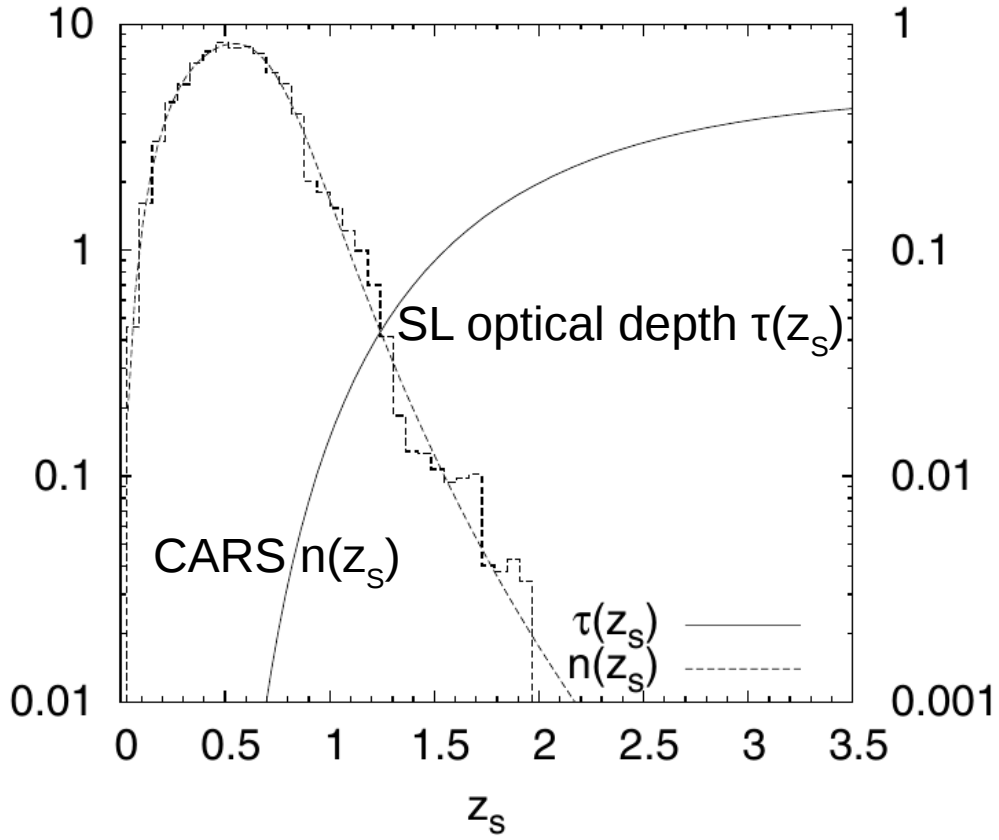


- local brightness distribution, length, length-to-width & brightness filters can remove a large fraction of spurious detections
- COSMOS: depending on initial settings, ~98% less spurious

Select likely arcs by colour

with Matteo Maturi & Sebastian Mizera

Lensing optical depth $$\tau_d(z_s) = \frac{1}{4\pi D_s^2} \int_0^{z_s} \int_0^{\infty} N(m,z)\,\sigma_d(m,z,z_s)\,dz\,dm$$



Lensing cross-section

$$\sigma_d(z_s) = \left(\frac{D_s}{D_l}\theta_0\right)^2 \int_{A_{L/W>d}} \frac{d^2x}{|\mu(x)|}$$

Sheth & Tormen differential mass function

$$N(m,z)$$

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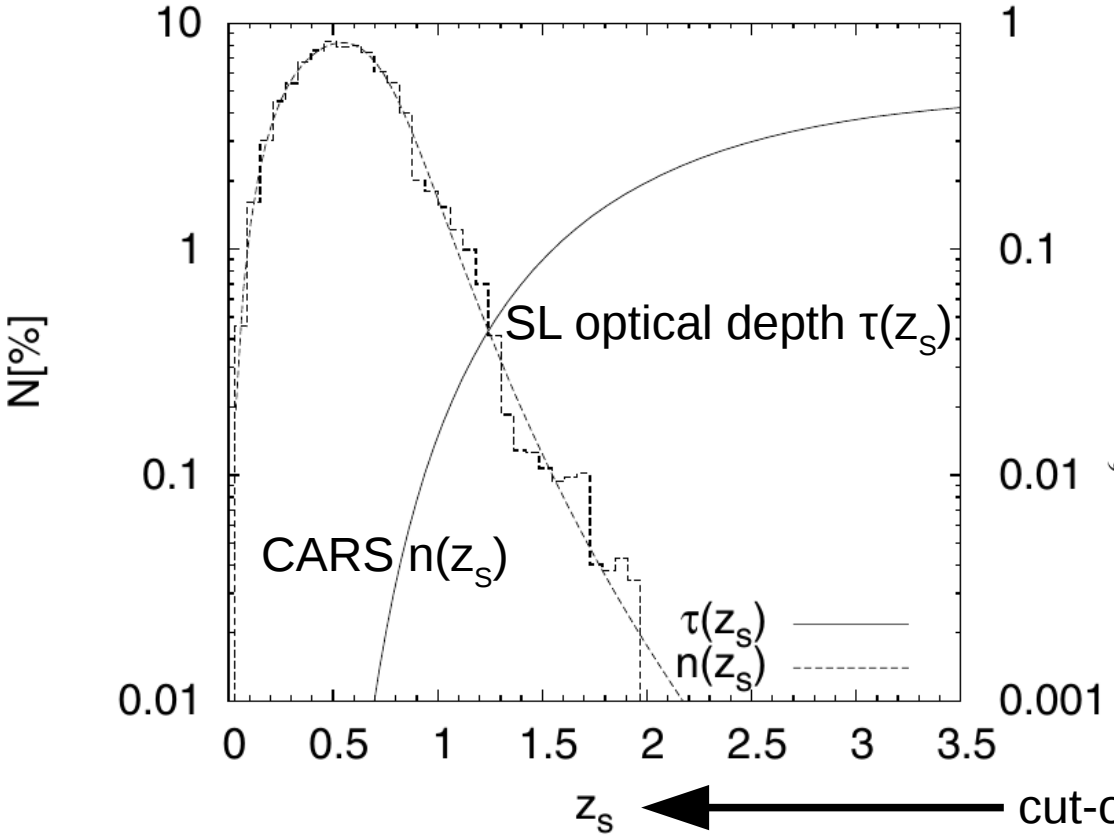
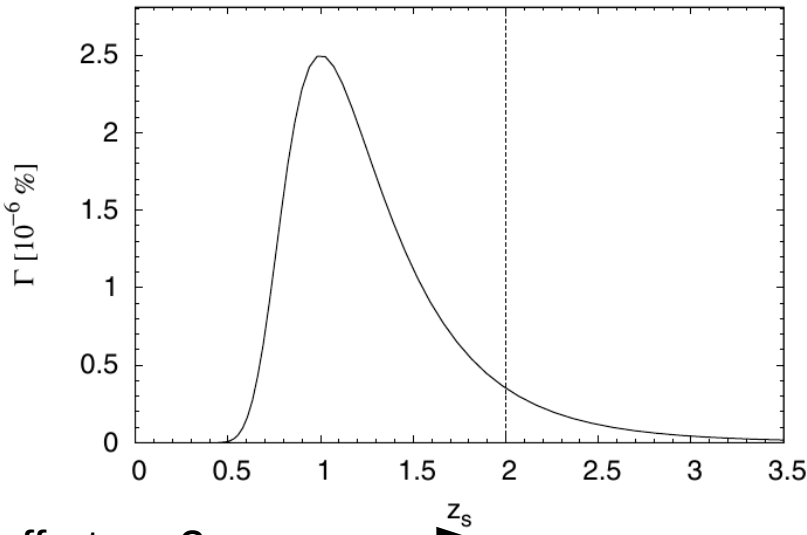


Expected arcs from sources at redshift z_s:

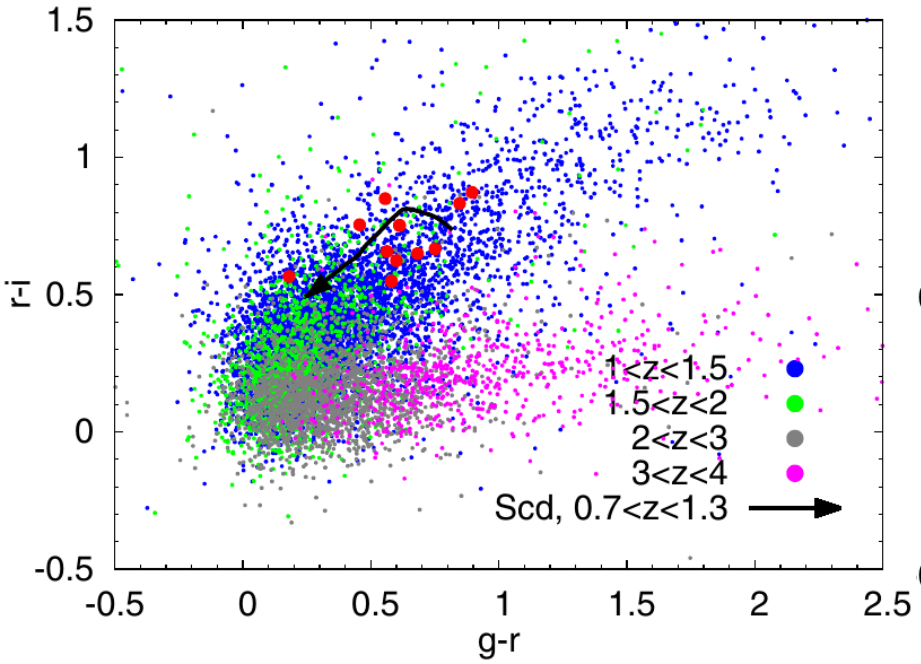
$$\Gamma_d(z_s) = \tau_d(z_s)\,n(z_s)$$



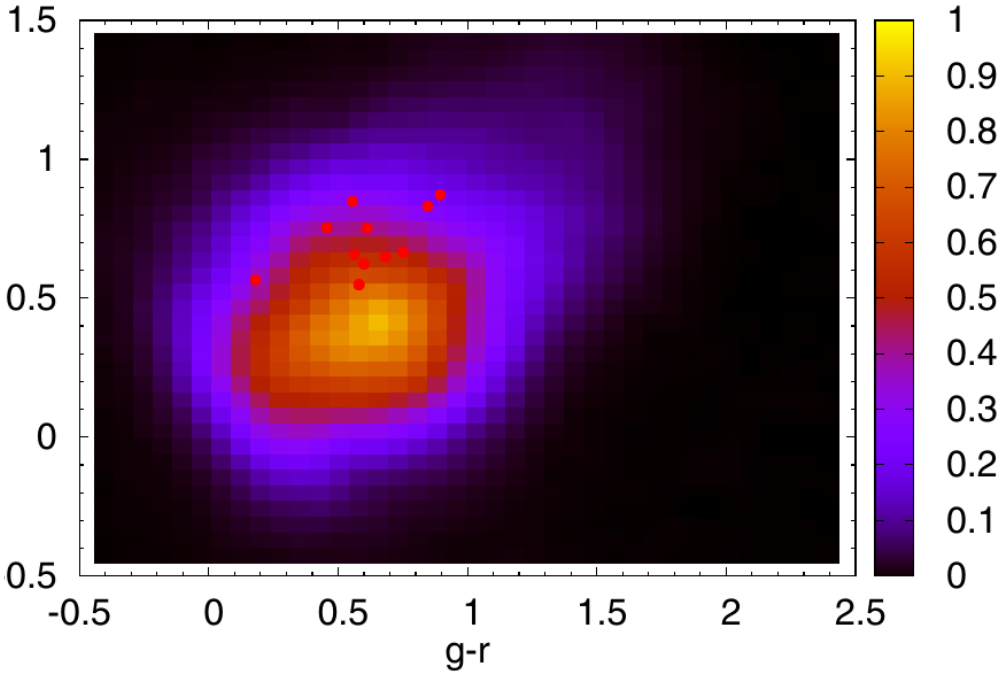
z_s ⟵ cut-off at z ~2 ⟶

Select likely arcs by colour

COSMOS galaxies,
Scd Redshift (arrow),
+known candidates in (r-i,g-r)



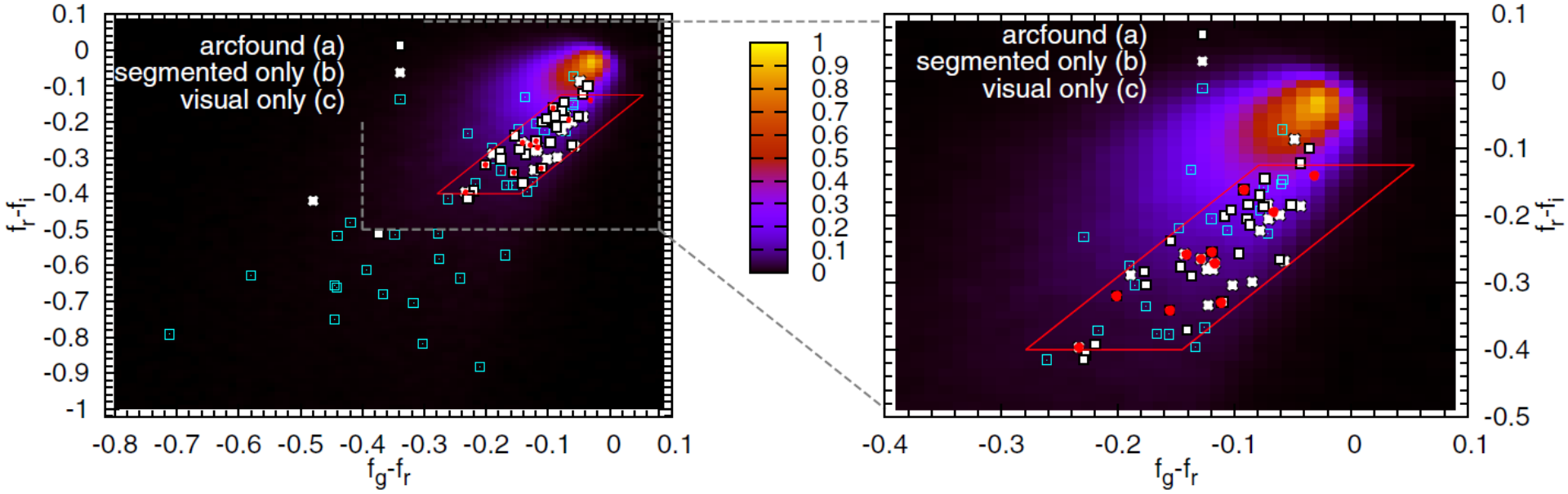
arcfinder detections
+ known candidates in (r-i,g-r)
(A. More 2012, R. Cabanac 2007)



Select likely arcs by colour

arcfinder detections (map) +
known (red) +
arcfinder candidates (white) +
visual candidates (cyan)

(f_r-f_i,f_g-f_r) colour space,
flux instead of magnitudes



- Most spurious detections can be ignored based on colour!

Application to CARS

with Matteo Maturi & Sebastian Mizera (Maturi 2014)

CARS (CFHTLS Archive Research Survey):

- 37 deg^2, depth r' = 24.36, PSF FWHM <0.75”
- about $7 \cdot 10^6$ galaxies

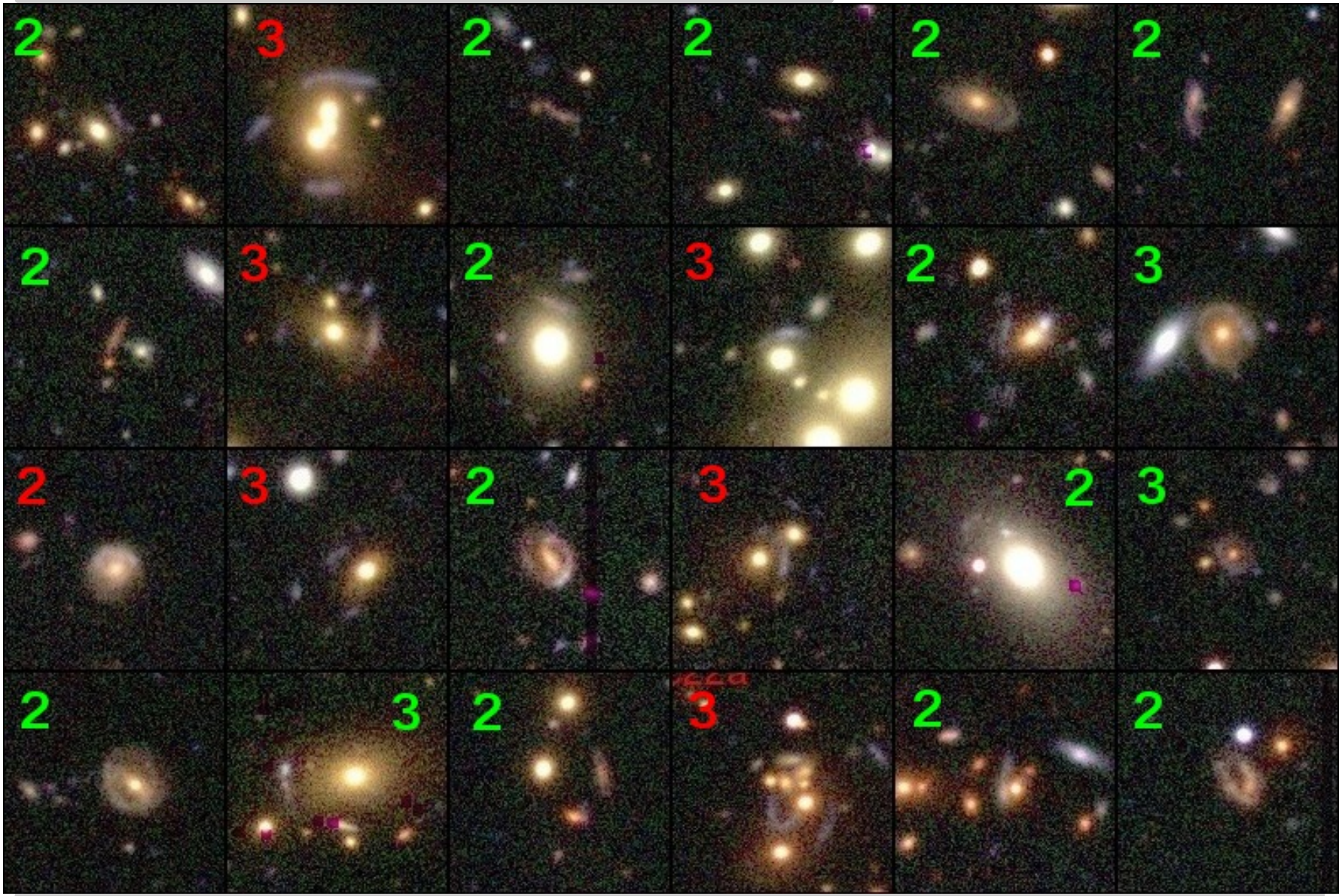
Spurious detections:

- 36026 detections with L>3” & L/W>4
- 5597 survived colour selection => contamination reduced by ~6.4

Arcs:

- 27 known candidates (Cabanac et al. 07, More et al. 12)
- 90 candidates after visual inspection
- classification: 1 (unlikely) to 3 (very likely)
- 49 candidates detected by automatic arcfinder
- 29 (out of 36026) survived length and L/W criteria: L>3” & L/W>4
- 24 (out of 5597) survived colour selection
  => 83% completeness of colour cuts

Application to CARS: 24 candidates



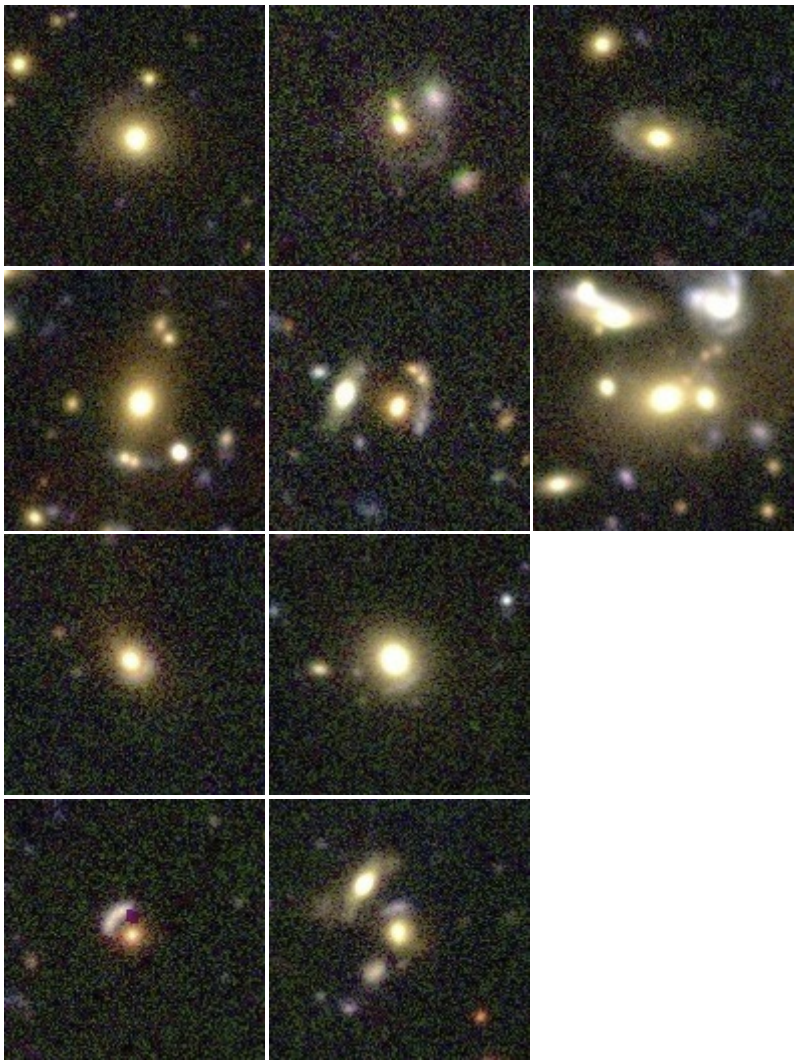
Application to CARS: 5 candidates lost

found and segmented by arcfinder, failed colour cut

~~problems~~ challenges:
colour contamination by background + lens
low signal to noise of colour

Application to CARS: detection failures

visual classification 3
but not detected



dispersed
shallow profile

bright cores

blending

invalid pixels,
scale

Future

- Status:
  no a priori information on lens galaxy used
  => spurious detections in the field
- Goal (done for COSMOS): remove detections using catalogues

- Status:
  algorithm developed for cluster lenses, applied to galaxy lens search
  => difficult to detect blended arcs
  => colour contamination by background lens
- Goal: galaxy subtraction (use colour, subtract PCA modelled lens)

- Status:
  single image detection (stacked g' and r')
  => ignores any colour information for segmentation
- Goal: adapt detection to run simultaneously on multiple bands