Photometric accuracy of QUVIK mission from artificial pictures

An interactive workshop

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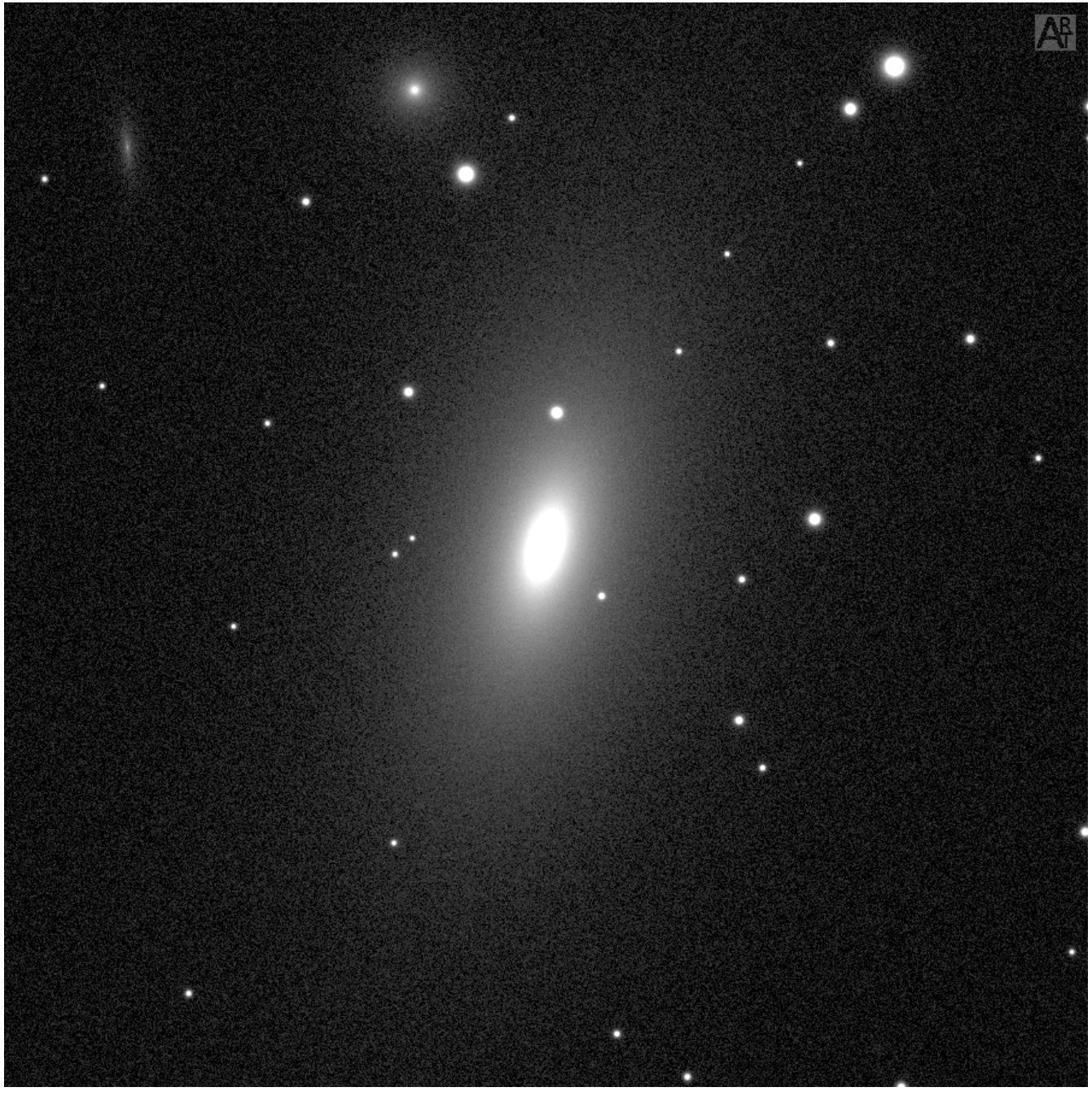
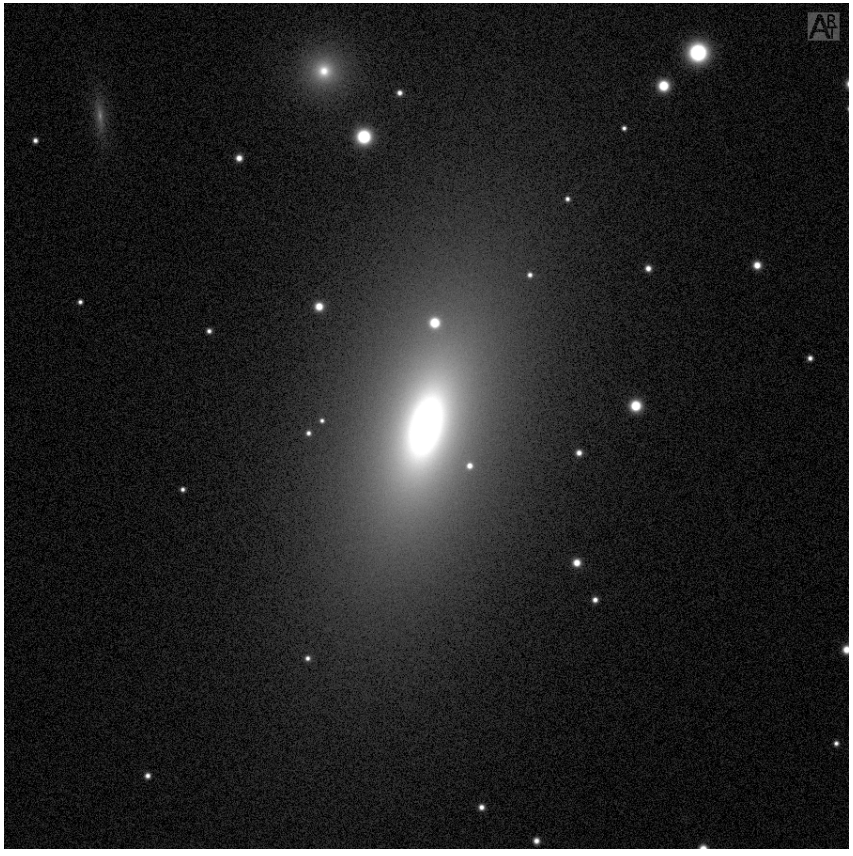
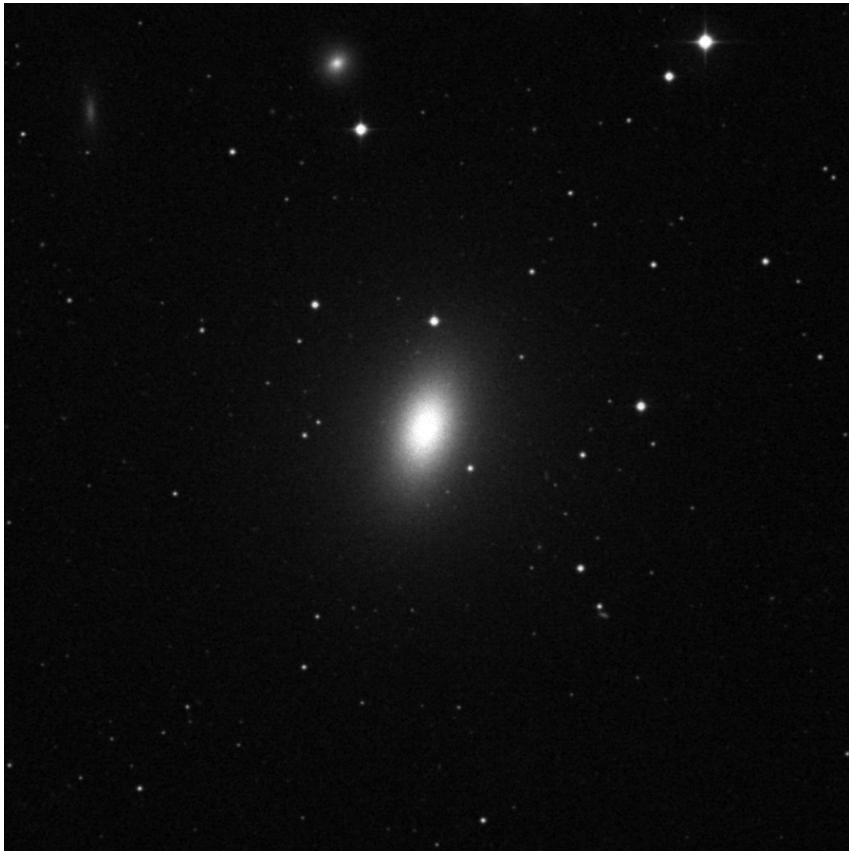


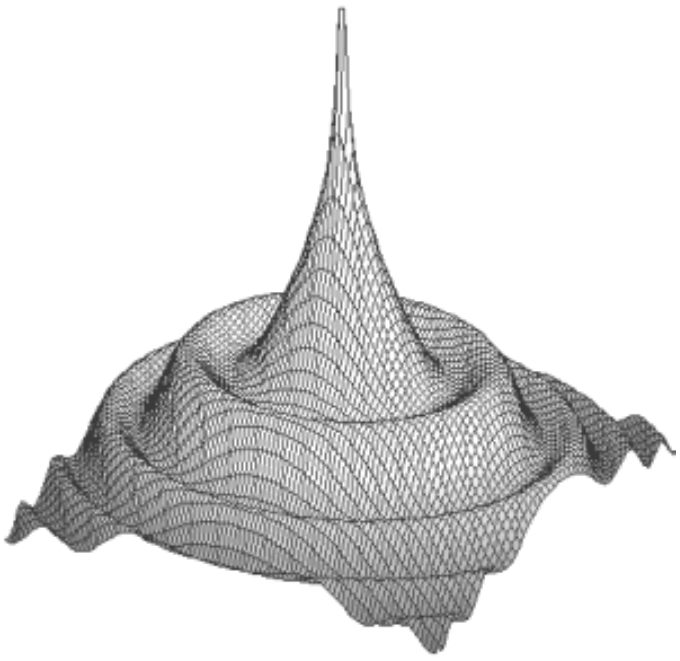
Artificial



Palomar Sky Survey



How to generate the artificial sky?



Munipack

- Artificial framework
- The test tool for photometry

`https://munipack.physics.muni.cz/artific.html`

The star profile

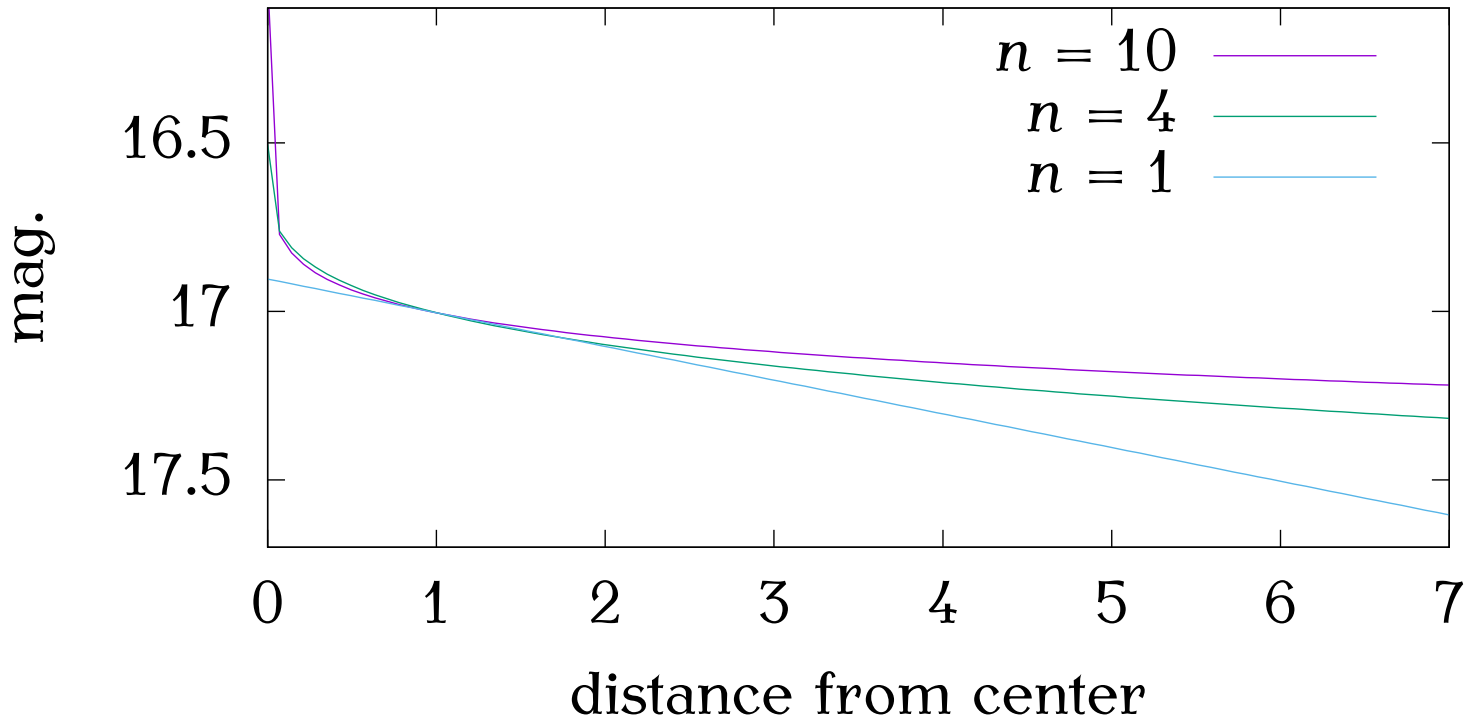
Point spread function (PSF)

https://en.wikipedia.org/wiki/Astronomical_seeing

- Convolution
- Diffraction

Sérsic profile for elliptical galaxies

$$I(R) = I_e \exp\left\{-b\left[\left(\frac{R}{R_e}\right)^{1/n} - 1\right]\right\}$$



https://en.wikipedia.org/wiki/S%C3%A9rsic_profile

Photon counts from fluxes

A logarithmic scale in magnitudes m to fluxes F (energy rate) in a filter

$$F = F_0 10^{-0.4m}.$$

Fluxes to counts, an approximation error better than 5%:

$$C = t \cdot AT \cdot \frac{F}{hc/\lambda_0}$$

C detected counts, t transitivity, A area, T exposure time, F_V flux in a filter centred on λ_0, hc/λ_V is an energy of photon

The recipe

- Stars by a catalogue,
- image specifications (width, ...),
- exposures (duration, frequency, times, ...),
- telescope parameters,
- atmosphere parameters (extinction, seeing, ...),
- wave-band specification,
- ...and a bunch of the noise.

The verification

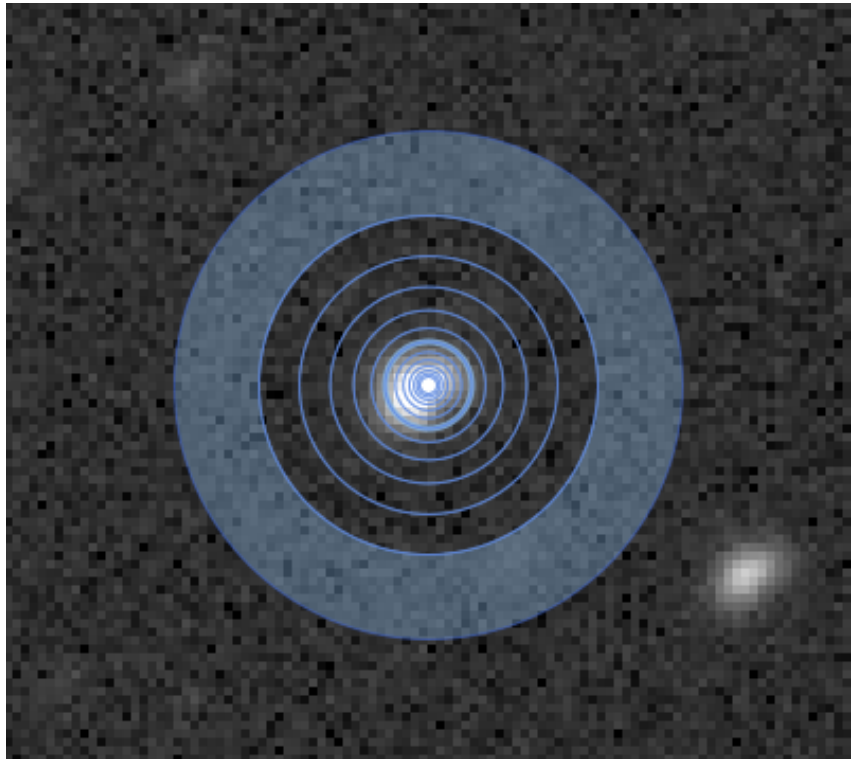
Aperture photometry

$$C = \sum_i (c_i - B) \in \mathcal{N}(C, \sigma_c),$$

$$\sigma^2 = C + \sum_i \sigma_i^2$$

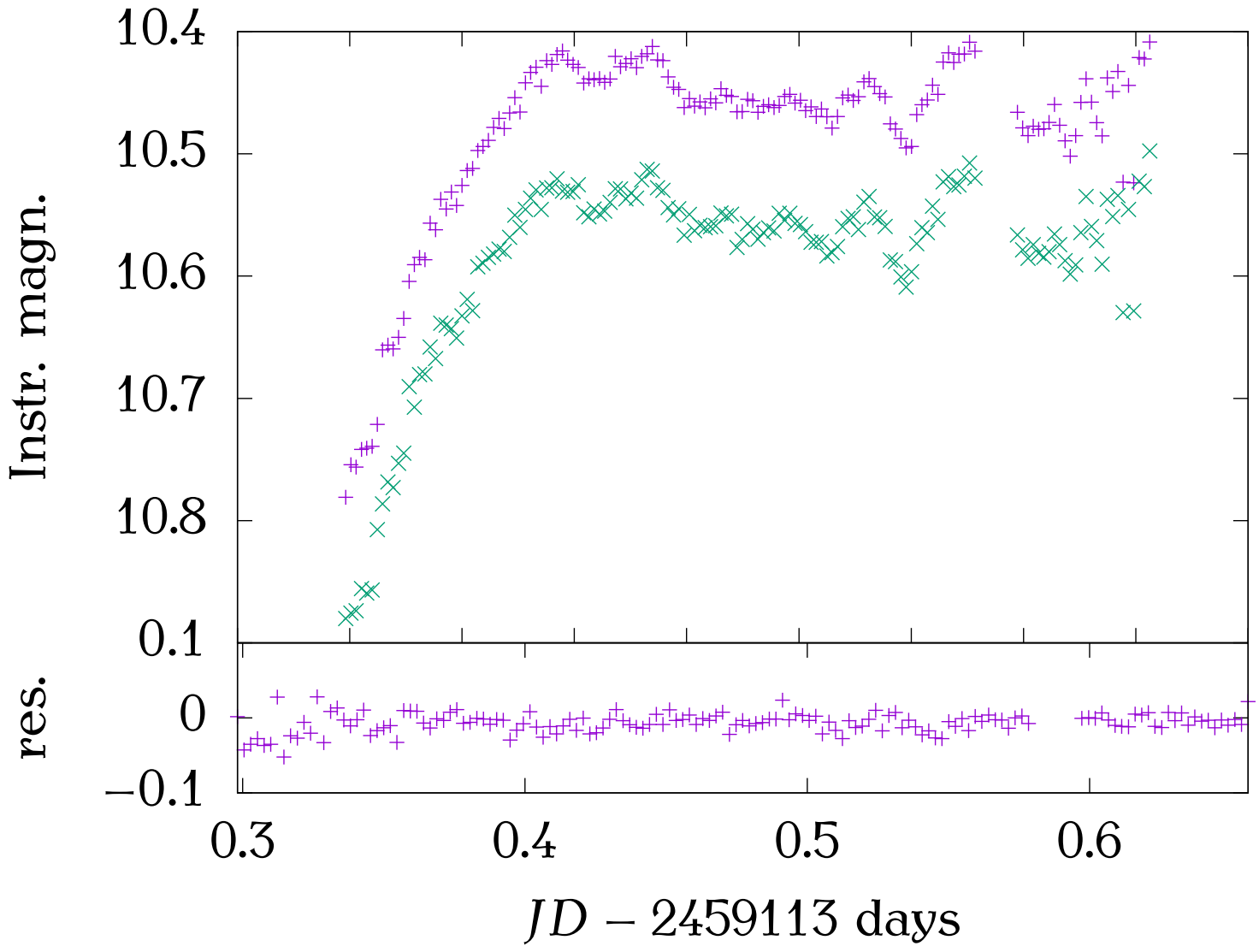
(Poisson noise + bias + ...)
Relative error (in magnitudes)

$$\frac{\sigma}{C} = \frac{\sqrt{C + \sum_i \sigma_i^2}}{C}$$



Observed light curve

20200920, SA 23, 150 snapshots, V filter, 60s, 0.5m Vyškov

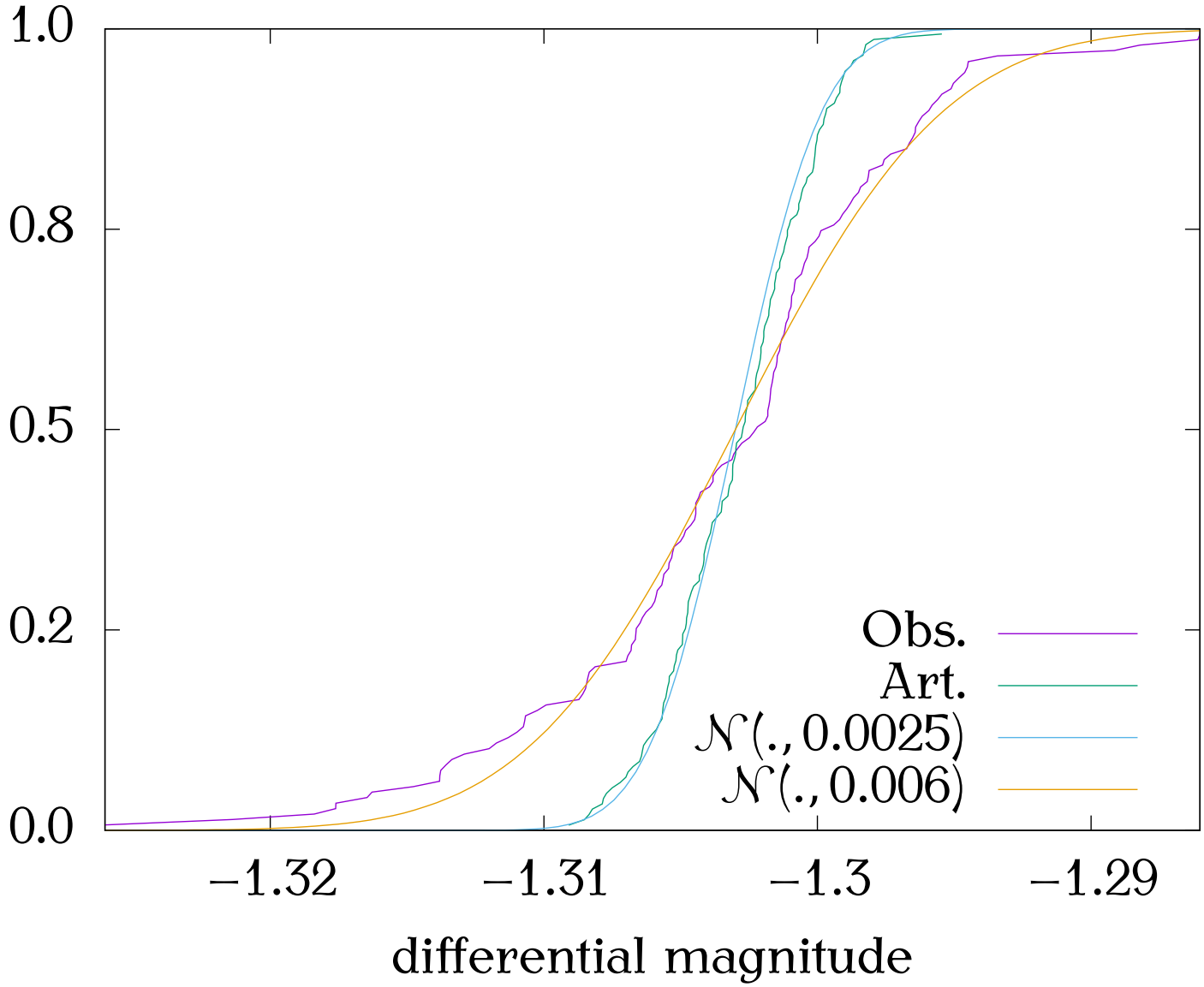


Artificial light curve

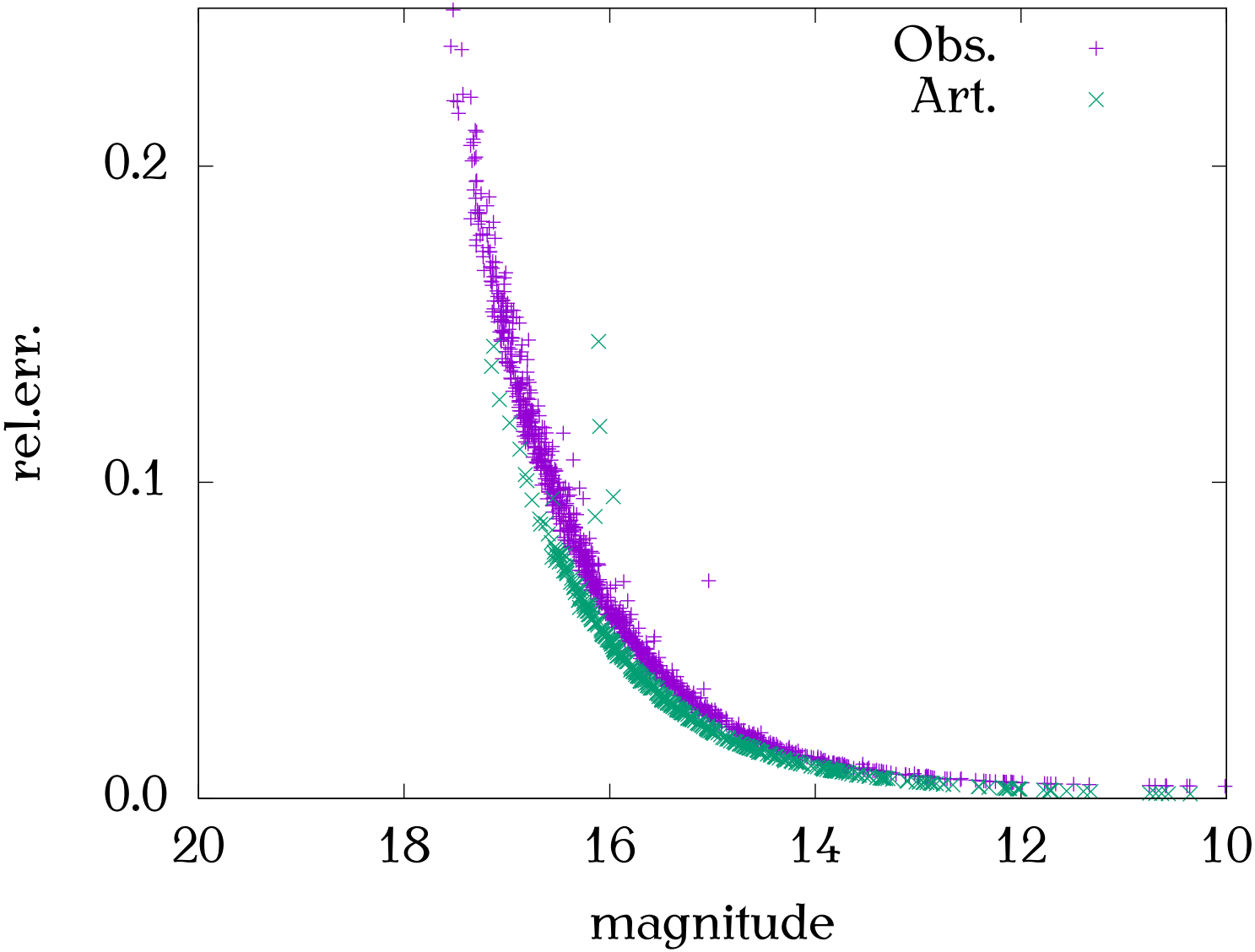
- Stars on SA 23
- Similar scale, centre
- Similar telescope, efficiency
- Same date, time, exposures
- Seeing extinction, and sky background

Statistical error analysis

by Empirical cumulative distribution function

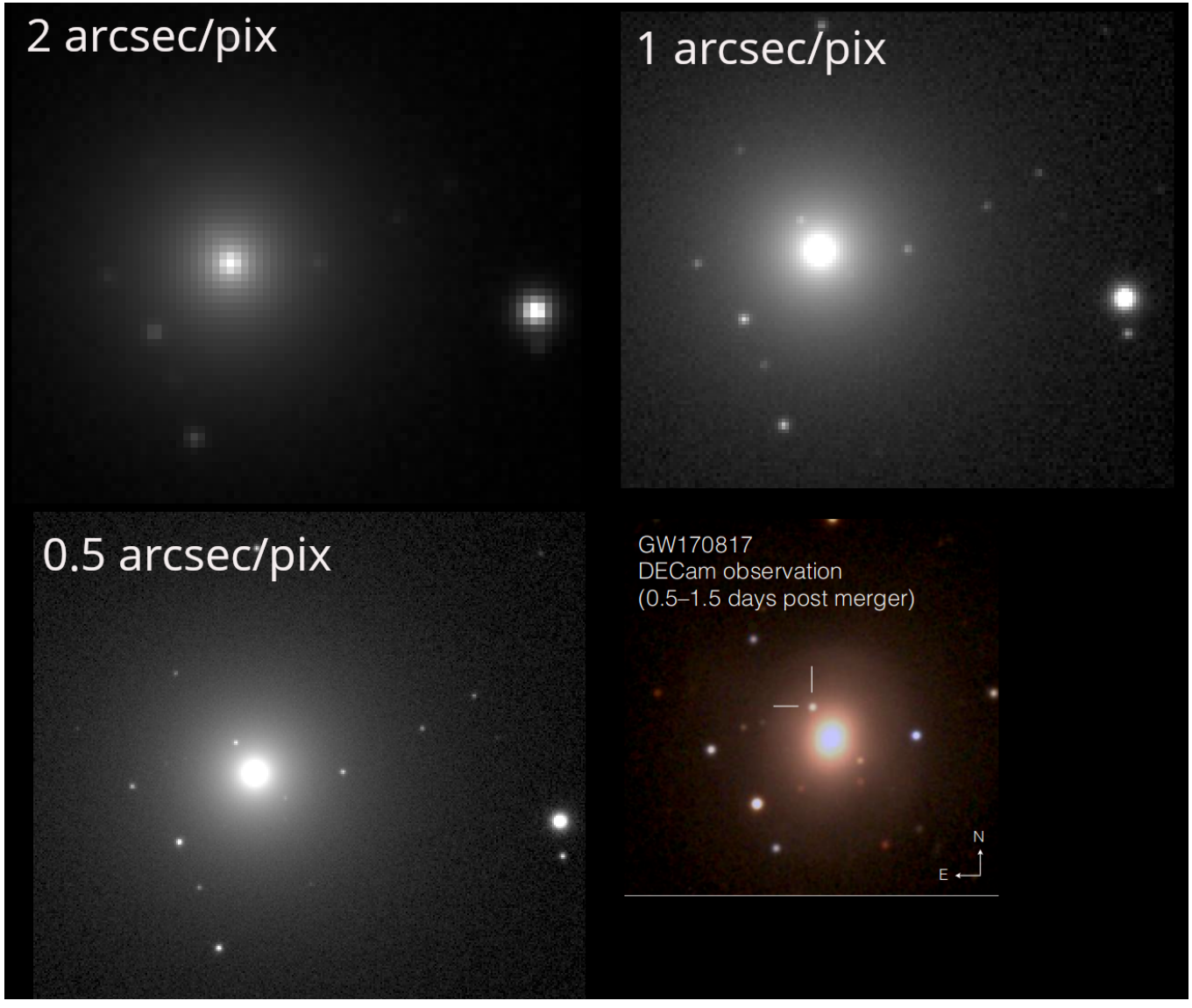


Relative errors on magnitude dependence



QUVIK

QUVIK and kilo-novae



QUVIK models

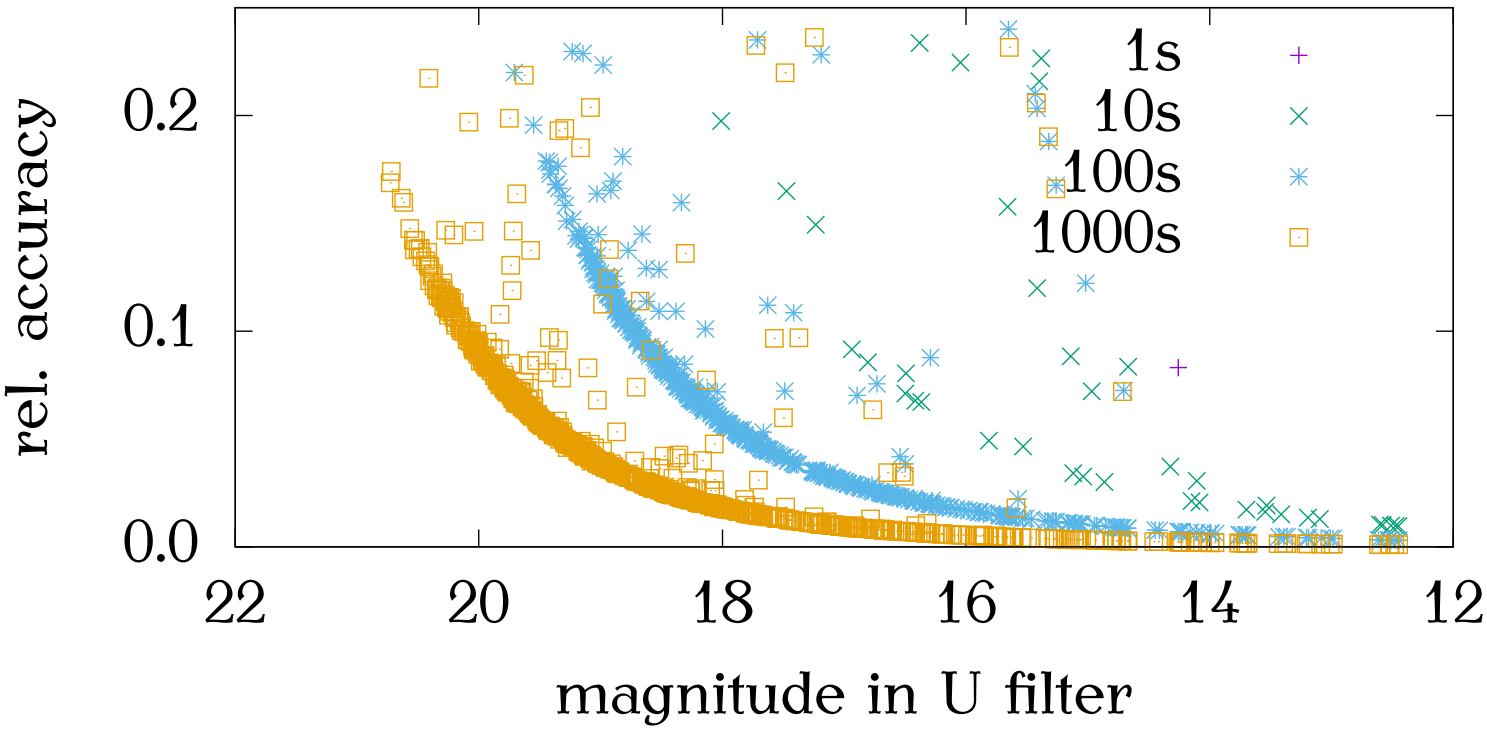
On thin ice

Key questions:

- extrapolation to UV,
- spread of PSF,
- *pointing accuracy*,
- background(s),
- choice of filter.

Precision of photometry I.

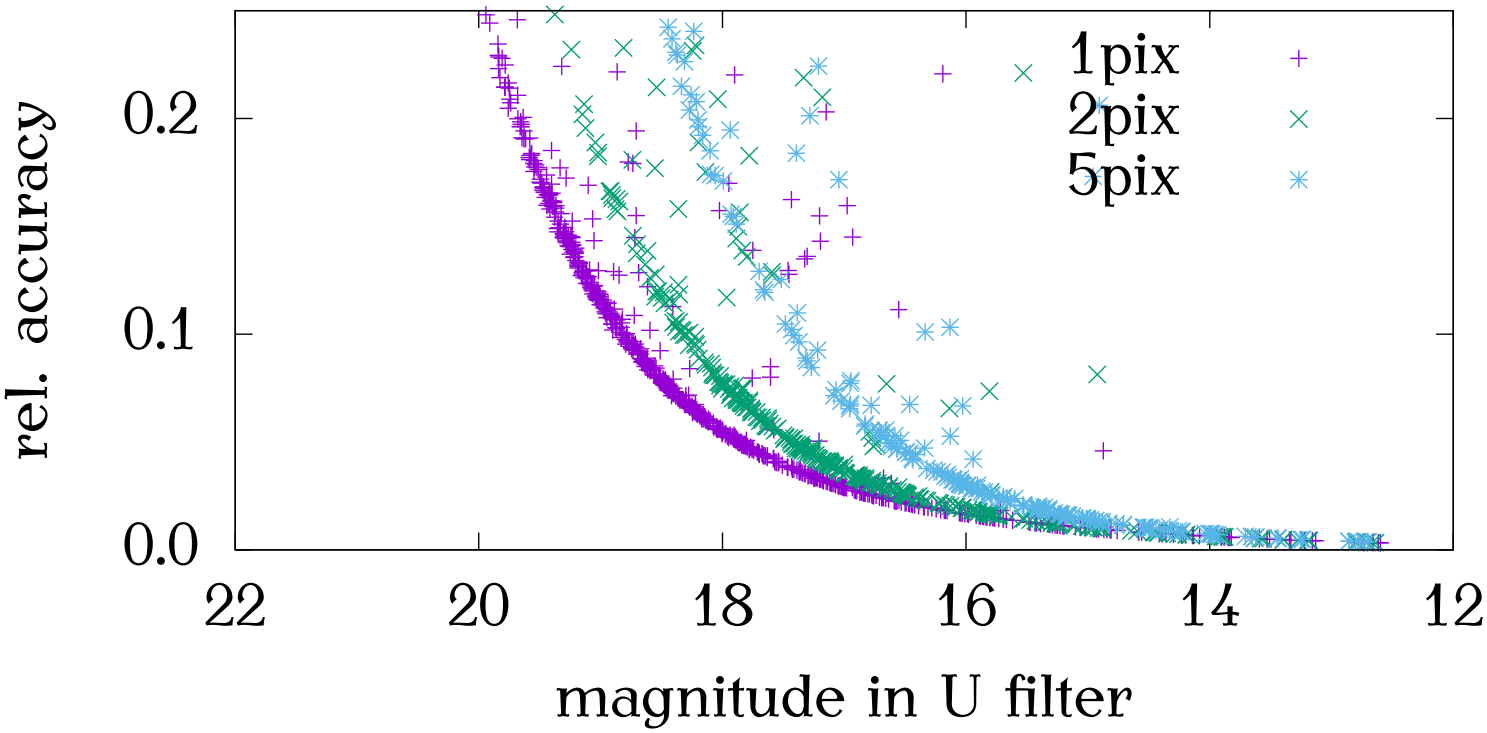
Exposure time



$\eta = 25\%, A = 0.05\mathrm{m}^2$, sky 21 mag, seeing 1 pix

Precision of photometry II.

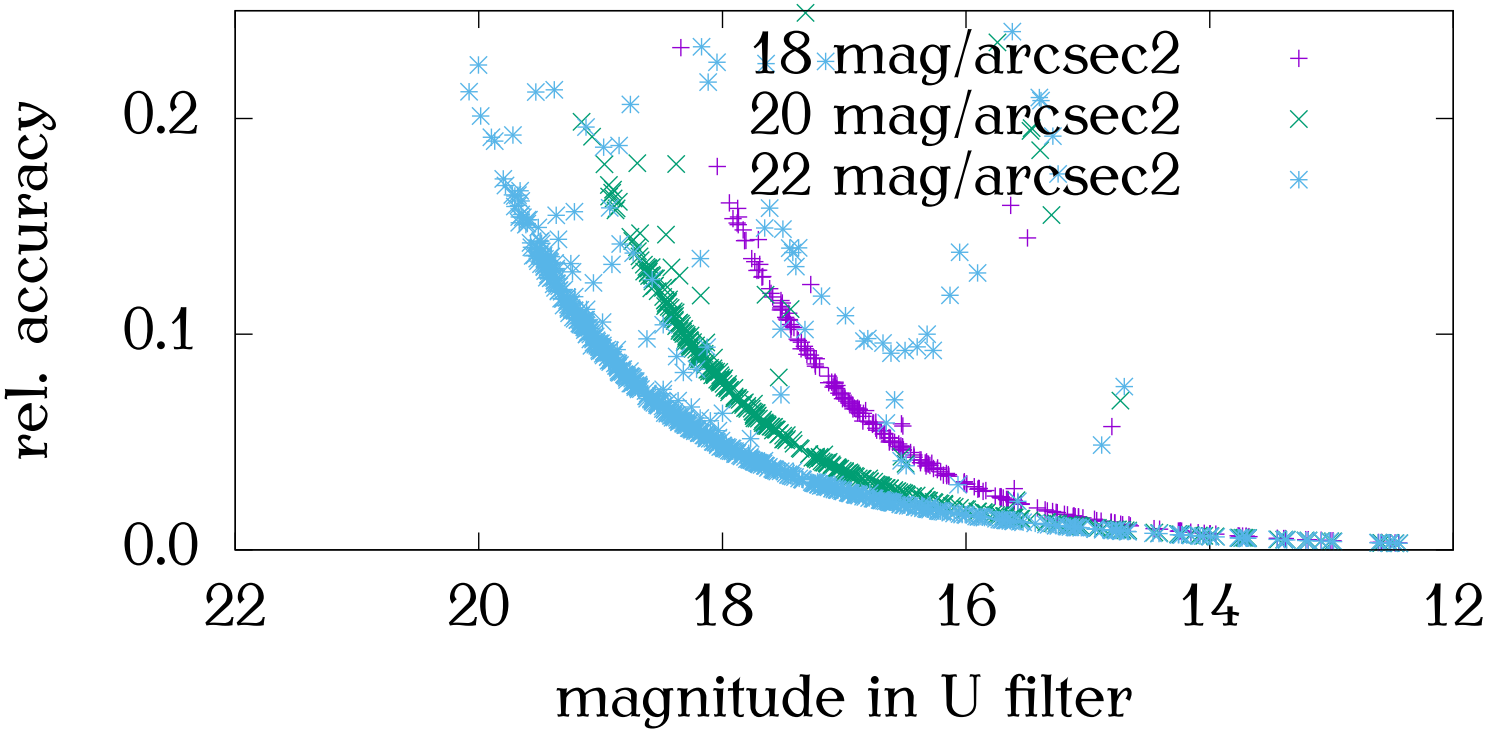
Spread of PSF



$\eta = 25\%, A = 0.05\ \mathrm{m}^2, T = 100\ \mathrm{s}$, sky 21 mag

Precision of photometry III.

Background brightness



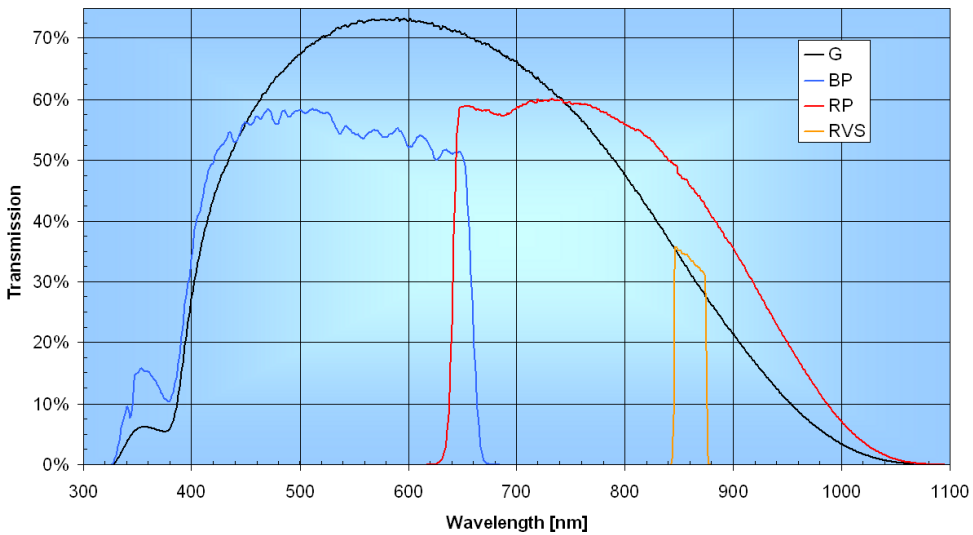
$\eta = 25\%, A = 0.05\ \mathrm{m}^2, T = 100\ \mathrm{s}$, seeing 1 pix

Precision of photometry improving

Wide UV sensitivity

$$F_V = \sqrt{2\pi}\, f_\lambda \Delta\lambda$$

F_V flux in a filter centred on λ_0 with half-width $\Delta\lambda$, f_λ spectral density in energies



- A non-standard filter,
- efficiency,
- $2 \times \Delta\lambda, \Delta m = 0.75$.

`https://www.cosmos.esa.int/web/gaia/transmissionwithoriginal`

Conclusions

- A framework for sky simulations,
- materialised by Munipack,
- gives tool for space missions design.