Large Synoptic Survey Telescope

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Strong Lenses with LSST: Simulated 10-year Movies of Multiply-Imaged Quasars

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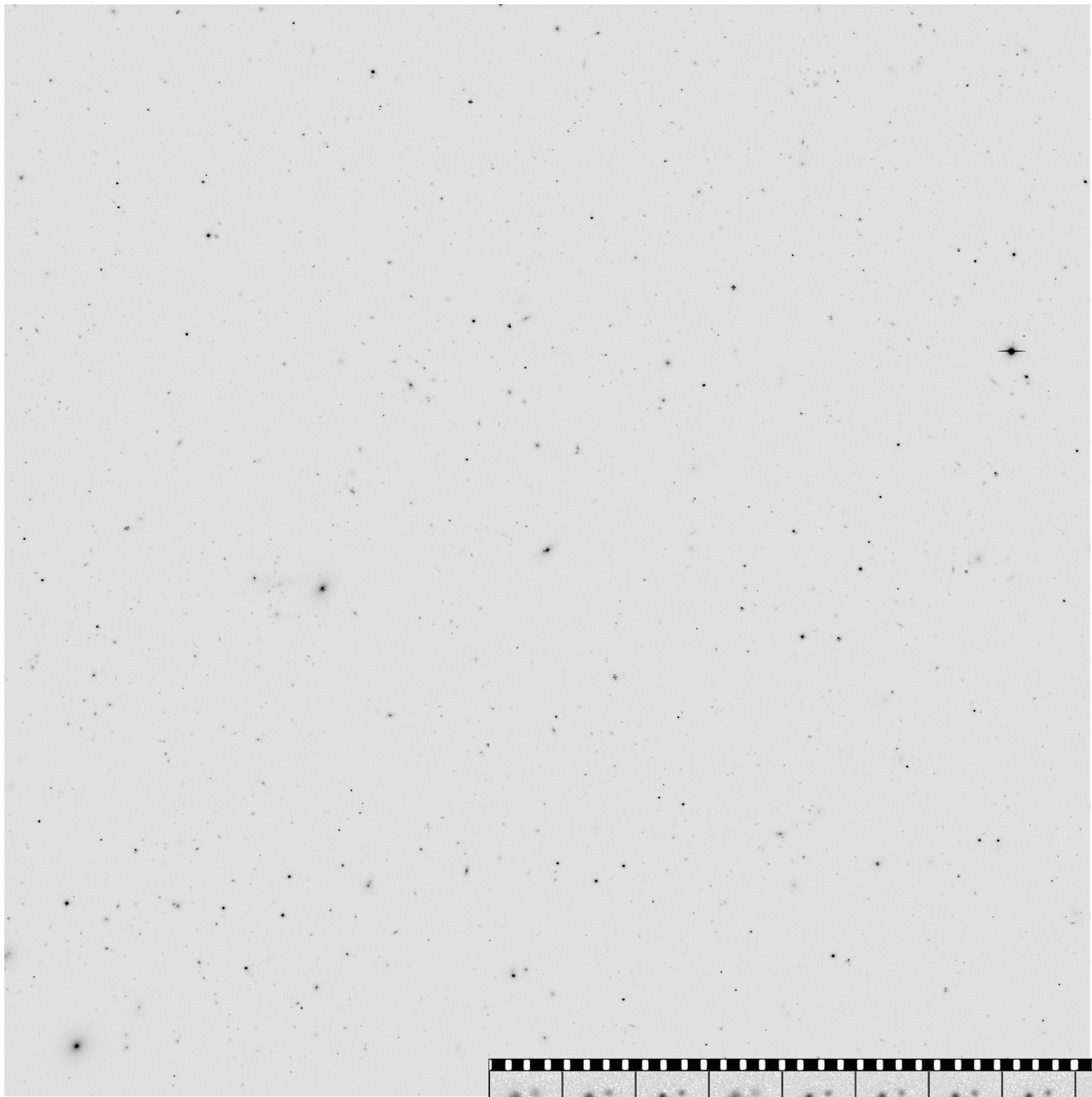
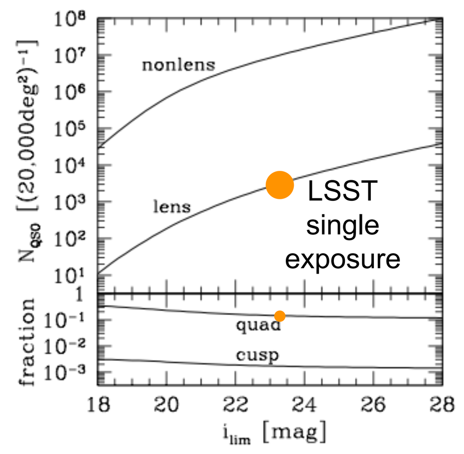
We use the LSST image simulator to generate realistic example datasets for a sample of strong galaxy-scale gravitational lenses expected to be measurable with the universal survey data. The 20 mock i-band images have sky brightness and atmospheric seeing drawn from plausible distributions for the Cerro Pachon site, and we use plausibly varying telescope optics and detector response to fully represent the expected image quality. Passing the simulated images through a standard astronomical object detection pipeline gives us our first view of what these rare and valuable objects will look like in the LSST database. We explore a very basic morphological selection algorithm, and find that even this achieves 50% completeness. The seeing and lens galaxy obscuration can reduce the survey yield by comparable amounts, highlighting the need for good object deblending.

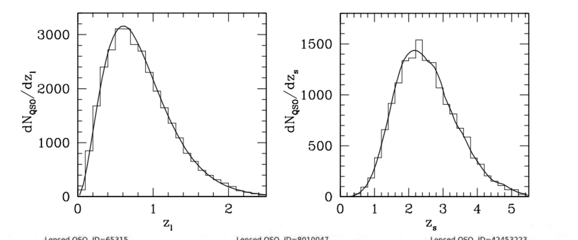


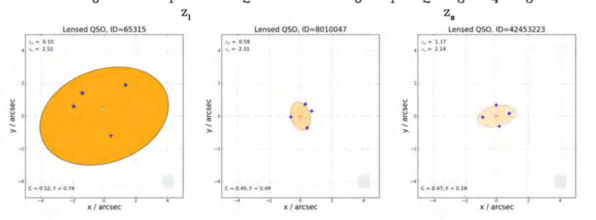
Strong Gravitational Lenses with LSST

We expect to detect nearly ten thousand lensed quasars with LSST (Oguri & Marshall 2010). Focusing on the 4-image systems for their high scientific value, and ensuring measurability at each observing epoch, we generated a sample of around 440 "quads" detected down to an i-band AB magnitude limit of 23.3 (right).

What will they look like in the LSST images?





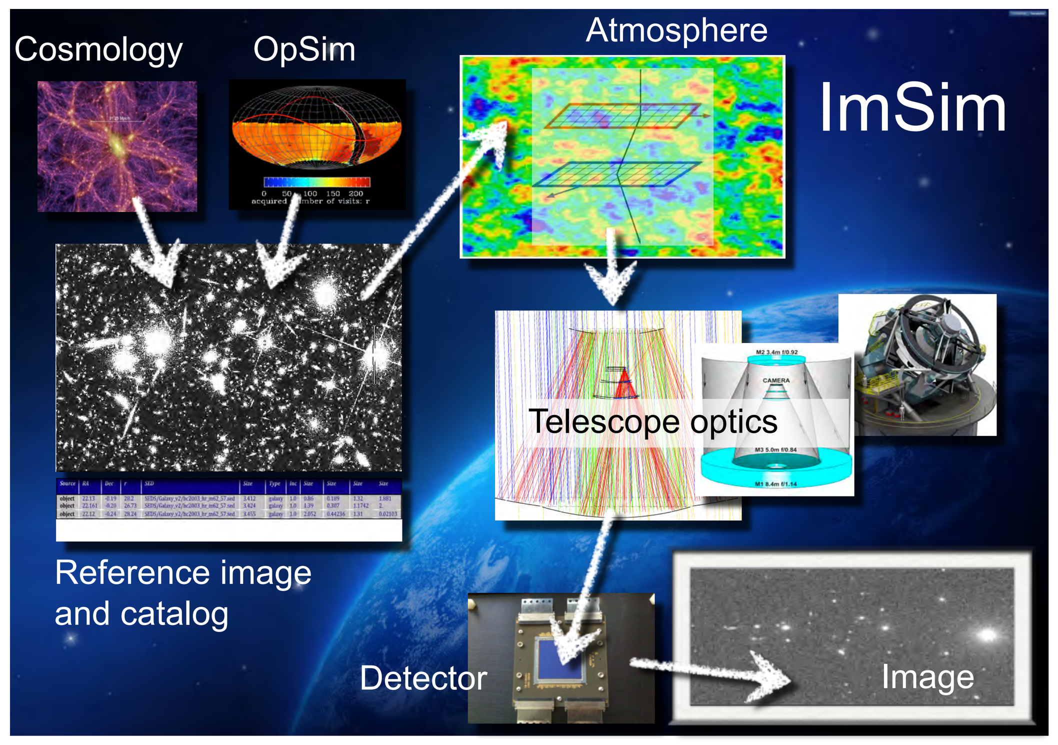


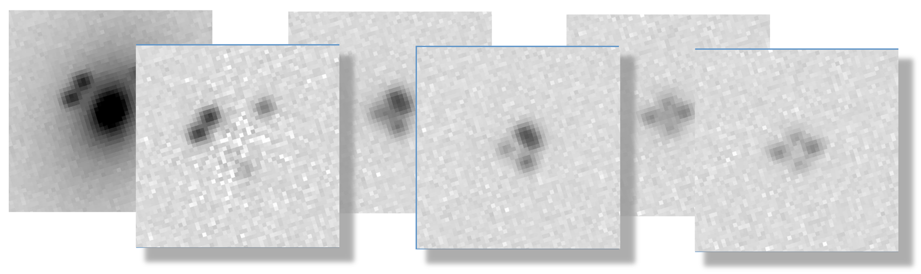
Model lens galaxies and sources are drawn from realistic distributions; image configurations for each system take magnification bias into account.

Simulating the LSST Sky

We used the ImSim ray-tracing code to simulate reduced LSST 15-second exposures. The schematic diagram on the right shows the history of each photon, from astronomical source to counts of electrons in pixels. (See also the ImSim posters by S. Krughoff, S. Marshall, C. Chang and J. Pizagno)

Left: a single simulated, reduced 13.7x13.7 arcmin LSST chip i-band image, containing model stars, galaxies and ~100 quad lenses. Artificially high density simulations like this provide an efficient way of investigating the systematic errors involved in lens detection and measurement. This mock observation is at median sky background with 0.4" atmospheric seeing, and represents a typical "good" image.



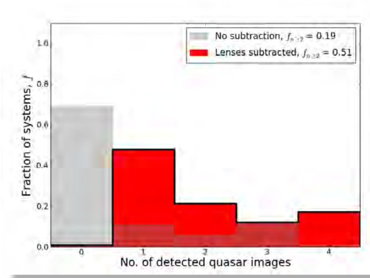


Deblending, Detecting and Measuring

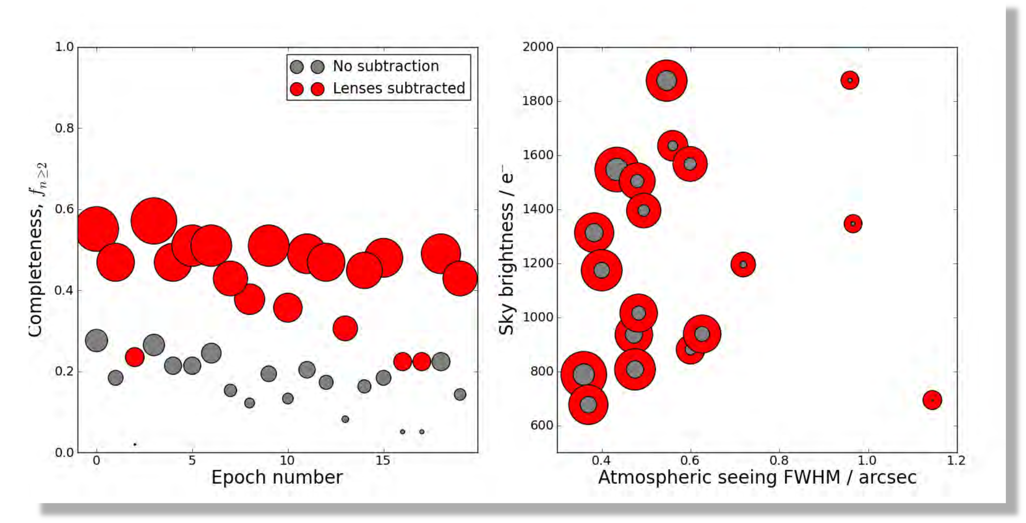
Above we show mock lenses with and without the lens galaxy subtracted: a perfect subtraction increases the number of morphologically-selectable quad lenses by more than a factor of two (right).

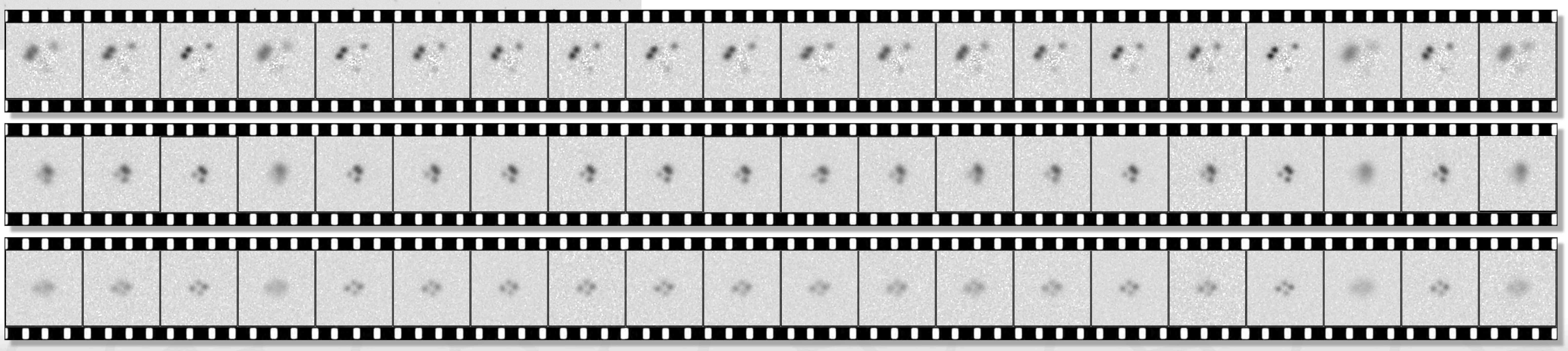
Varying sky brightness and seeing are illustrated in the 20-exposure movie clips below. The seeing ranges from 0.36" to 1.14" FWHM in this representative image subset, and it is this that drives the detection rate.

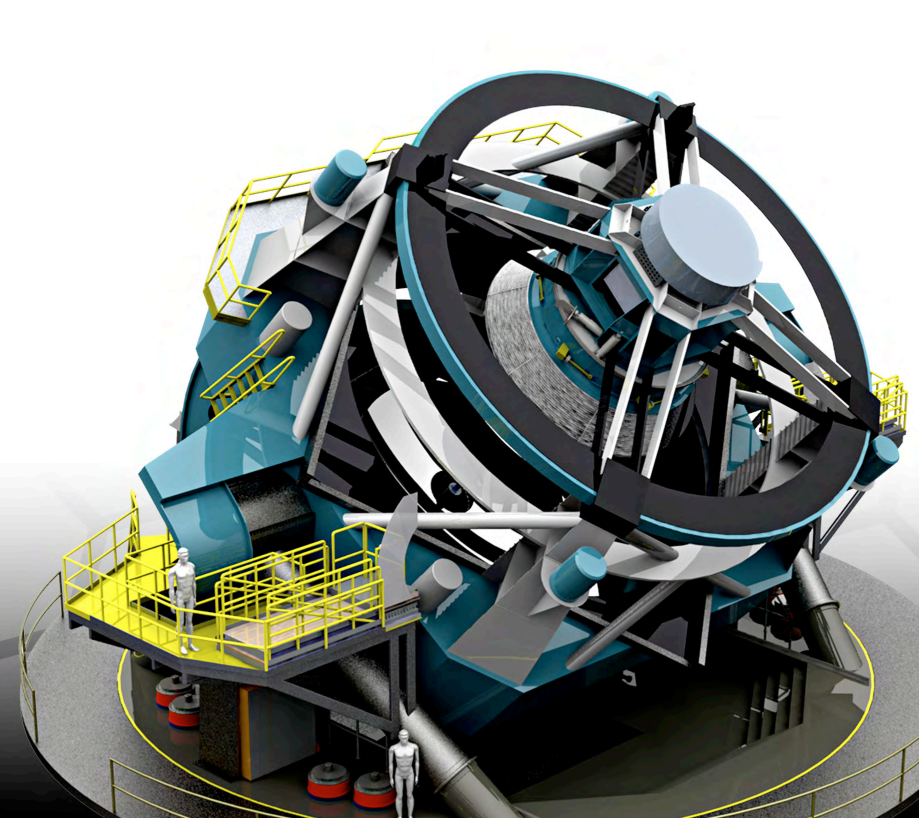
We used SExtractor to deblend the sources in each exposure independently: color and variability selection, and then "MultiFitting," should increase the lens yield.



The number of detected quasar images is a rough indicator of quad identifiability. If we define 2 detected quasar images as the detection threshold for a lens candidate, we find that the completeness $f_{n>2}$ (indicated by the plot symbol radius) increases by more than a factor of two when the lens galaxy is subtracted. Completeness is mostly sensitive to atmospheric seeing FWHM, decreasing by a factor of 2-3 over the range 0.4" to 1.2".







References:
Oguri & Marshall, MNRAS, 405, 2579, (2010)
Bertin & Arnouts, SExtractor (1996)

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