The effect of wavelength variation of the PSF on weak lensing measurements

Michael Seiffert

Jet Propulsion Laboratory, Caltech

With help from Gary, Jason …

Basic Issue

PSF size is a function of wavelength

PSF shape is a function of wavelength

SED of each galaxy is different

SED of each galaxy is imperfectly known

Therefore, the *effective* psf size and shape will vary with each galaxy.

When determining galaxy shapes, we must use the right psf for each galaxy.

Each galaxy's psf will be different from the stars normally used to calibrate the psf.

How large is this effect?

How can we mitigate it?

Toy model to assess impact – how large is this effect?

Consider only circular, gaussian PSF – ignore anisotropies

Assume linear PSF size vs wavelength

Model galaxy shape as elliptical gaussian

Use SED templates from CFHTLS

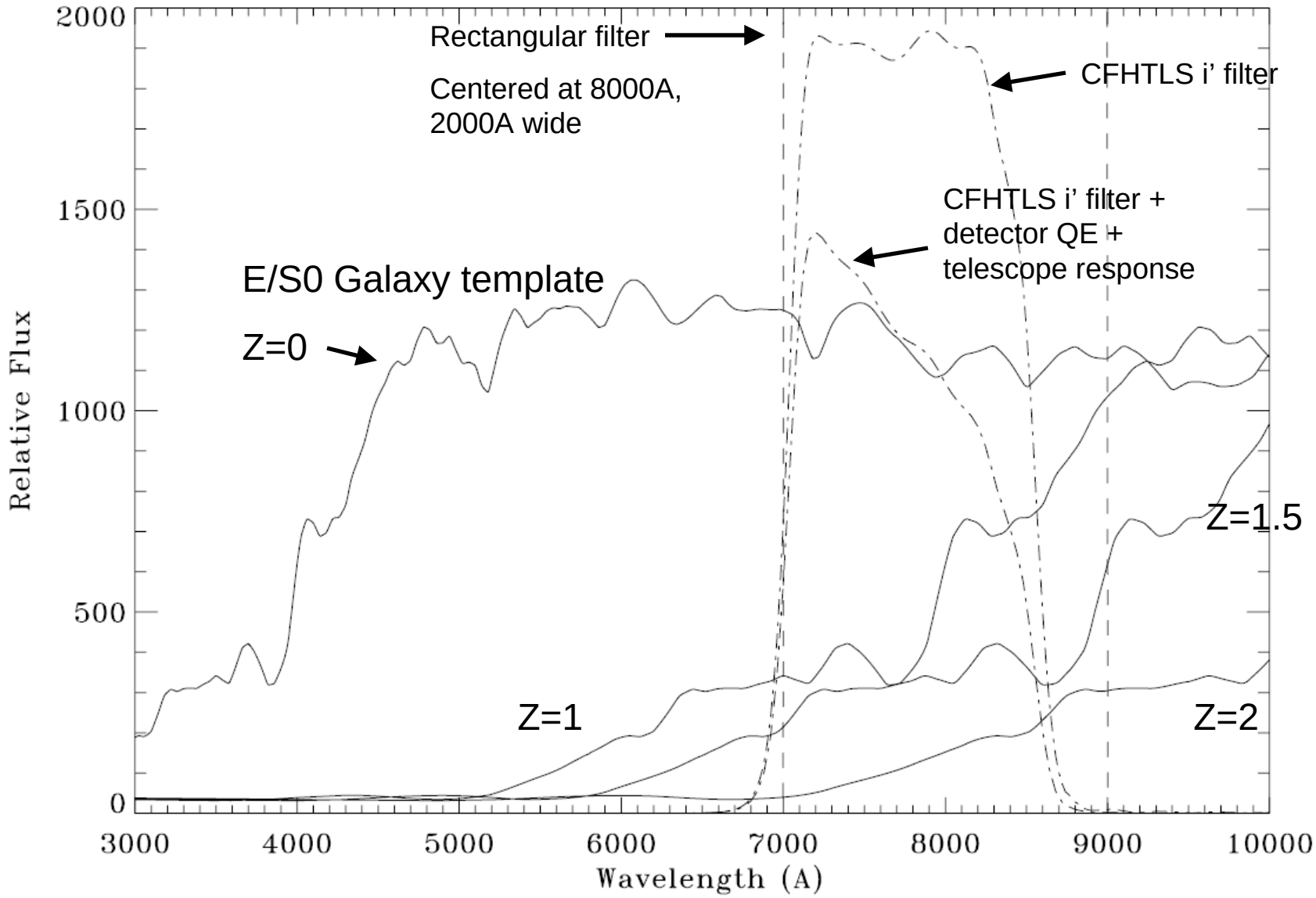
Try a few different filter shapes and sizes

RRG formalism

Ignore:

- Real galaxy shape
- Noise
- Pixels
- Change in PSF shape with wavelength
- Variation in SED over galaxy (ouch!)

Relatively flat SED at z=0, but big slope across the filter band
at z=1 as the rest frame 4000A break moves through the filter



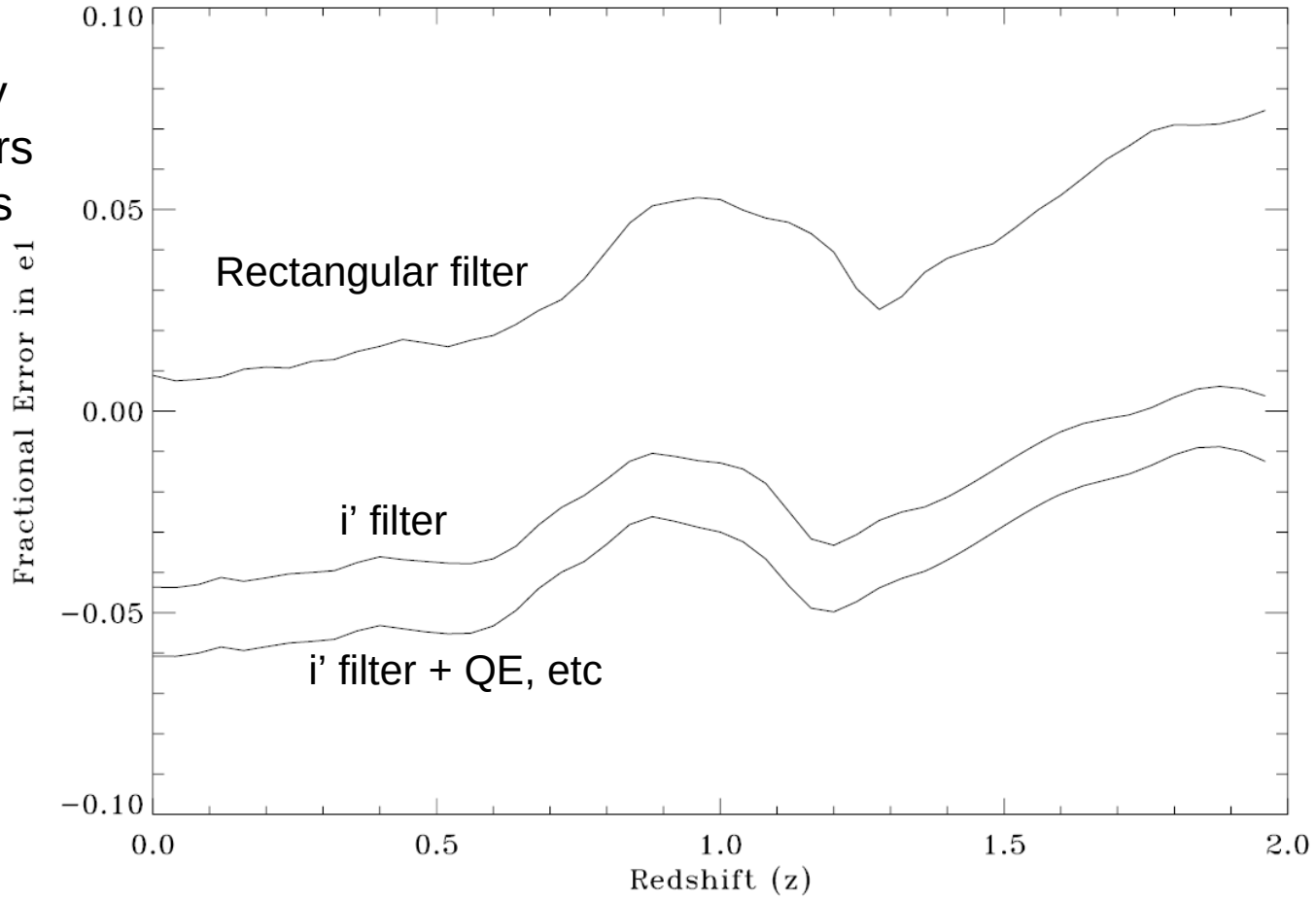
Plot of fractional ellipticity error vs redshift for galaxy template and filters shown in previous graph

Relative sizes:

PSF size =1

Galaxy = 1.2 x 1.4

Weight fnc = 1.3



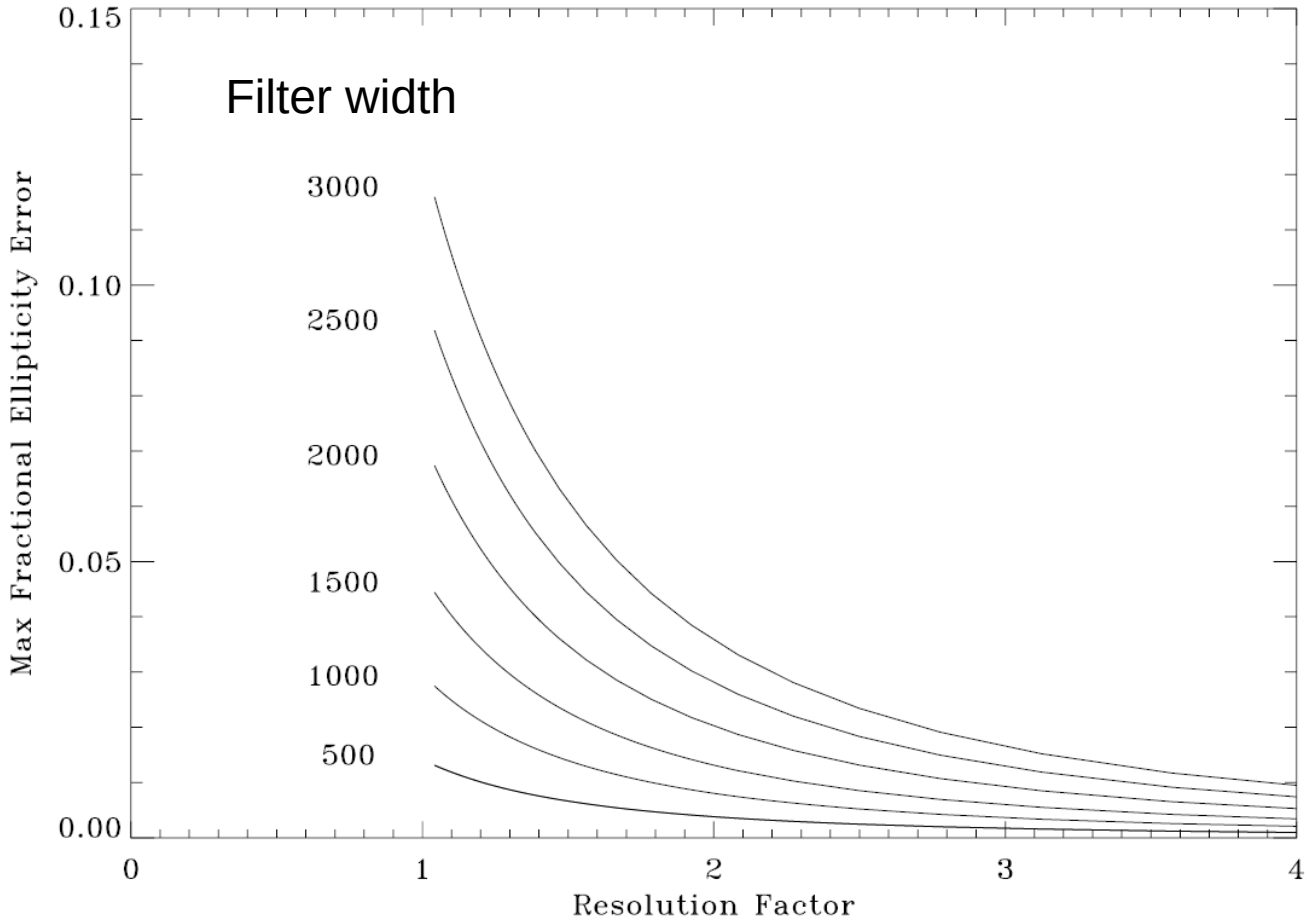
- For each ellipticity measurement, assumed psf was determined at 8000A perfectly
- Offsets of these curves reflect the center of the band differs slightly from 8000A
- The real concern is that the ellipticity error is of order 4% between z=0 and z=1
- Some slight variation amongst filters, but main effect is the overall width of filter

So, how do we deal with this effect?

Three methods of dealing with this come to mind:

1. Use narrower filters. Will help, but will increase observing time requirement
2. Use only well resolved galaxies so that PSF error doesn't hurt much. Will help, but will reduce the number of effective galaxies available for weak lensing measurement.
3. Estimate the *effective* PSF for each galaxy, and use that, rather than just one PSF for everybody.

approximate impact of methods 1 & 2 :



Ratio of galaxy size to PSF size

Shown is the max difference in ellipticity error between z=0 and z=1 as a function of filter width and resolution factor.

Using well resolved galaxies with narrow filter helps, but the price is high!

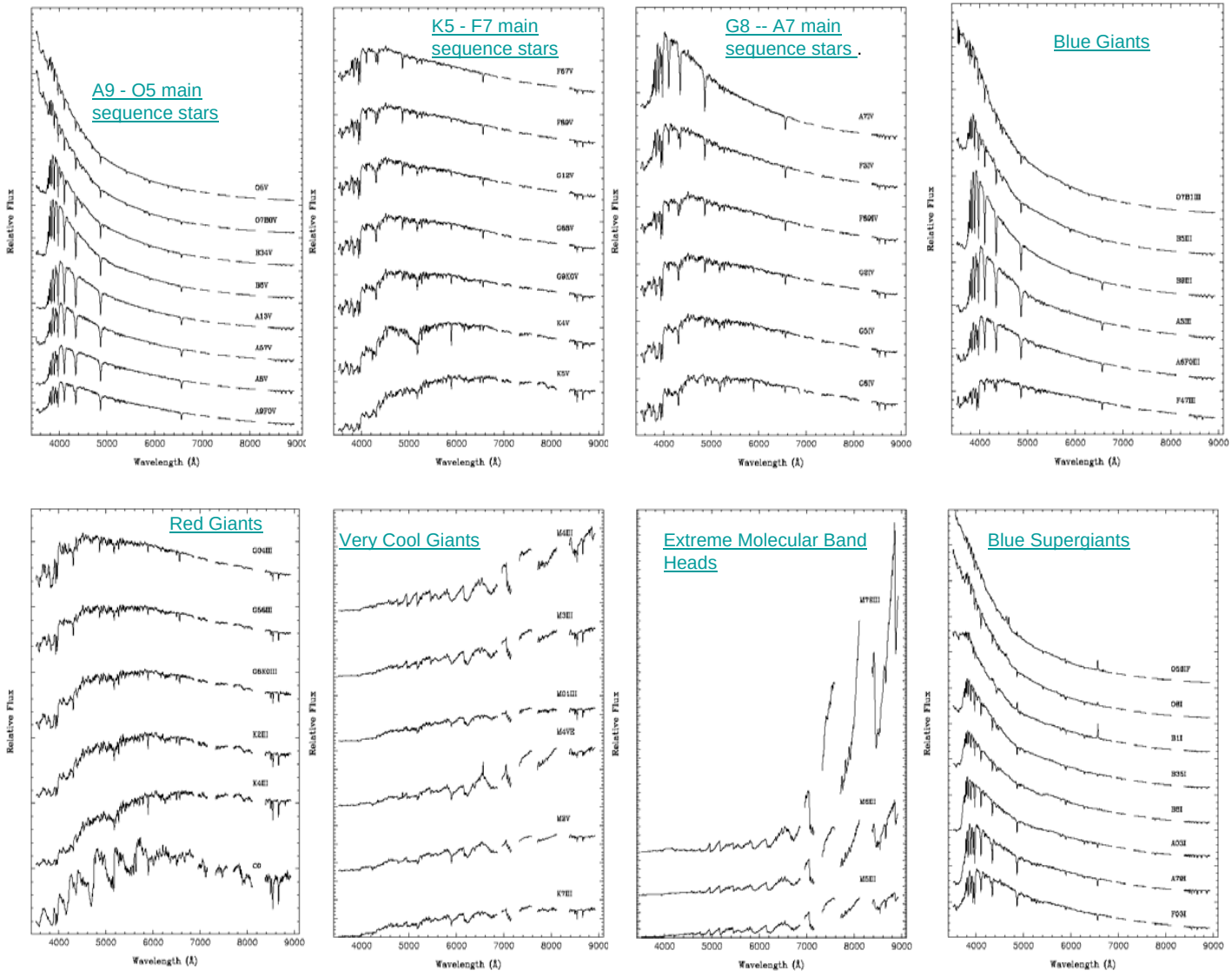
Let’s turn to method 3: estimating the *effective* PSF for each galaxy

Several potential methods for estimating the effective PSF:

- Determine PSF from several classes of stars. Match the star color to the galaxy color (*following pages*)
- Use a polynomial fit to the photometry in several bands for each galaxy to get a crude estimate of galaxy spectrum across the band of interest (*in progress)*
- Use template fitting based on several filters for each galaxy (*untried as yet*)
- Use relative photometry in several bands to try to avoid the band(s) where the spectrum is changing rapidly. Only use other bands for shape determination (*untried as yet*)

One idea:

Determine the psf from stars that match the broad band color of the galaxy that we are trying to measure the shape of.

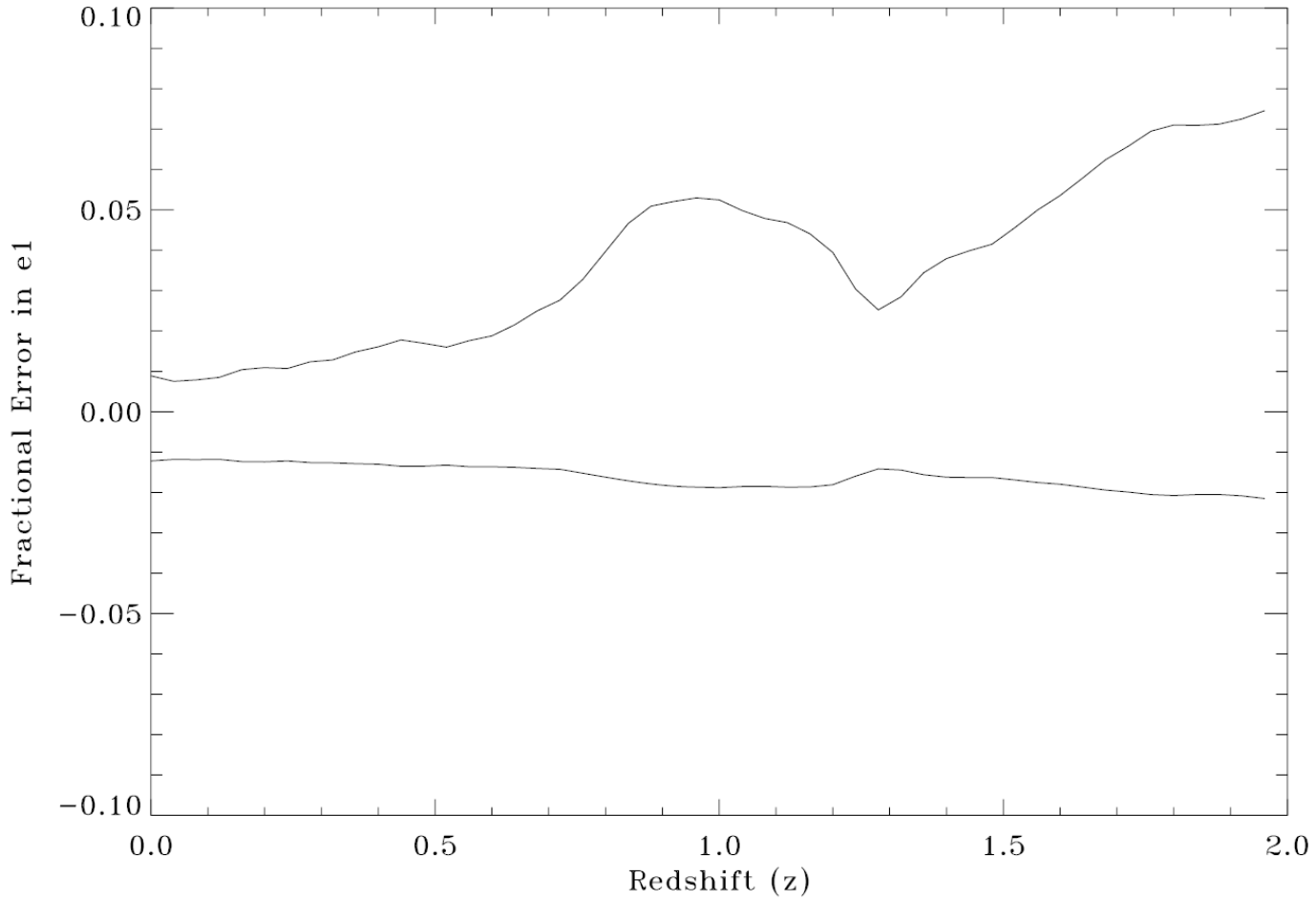


Hard to find stars that are as red as a z~1 galaxy

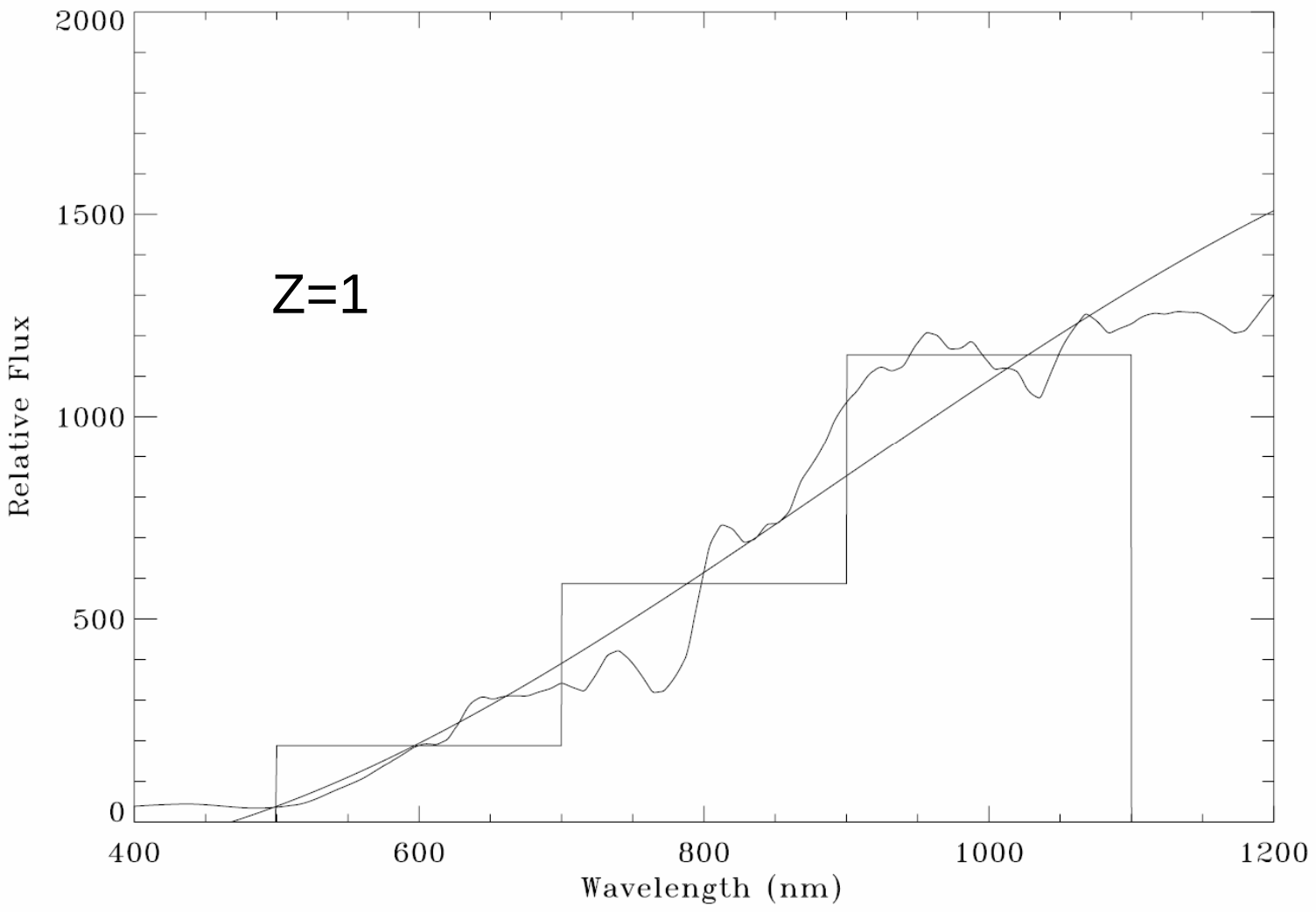
Those that generally have molecular bands and are unsuitable

First thing to check: how well can we do if we know the galaxy sed exactly?

For the psf size, use the second moment of the image of a point source with the same sed as the galaxy of interest.



What happens if we use the approximate sed to try to estimate the effective psf? Approximate the sed with a second order polynomial fit to the flux in three filter bands



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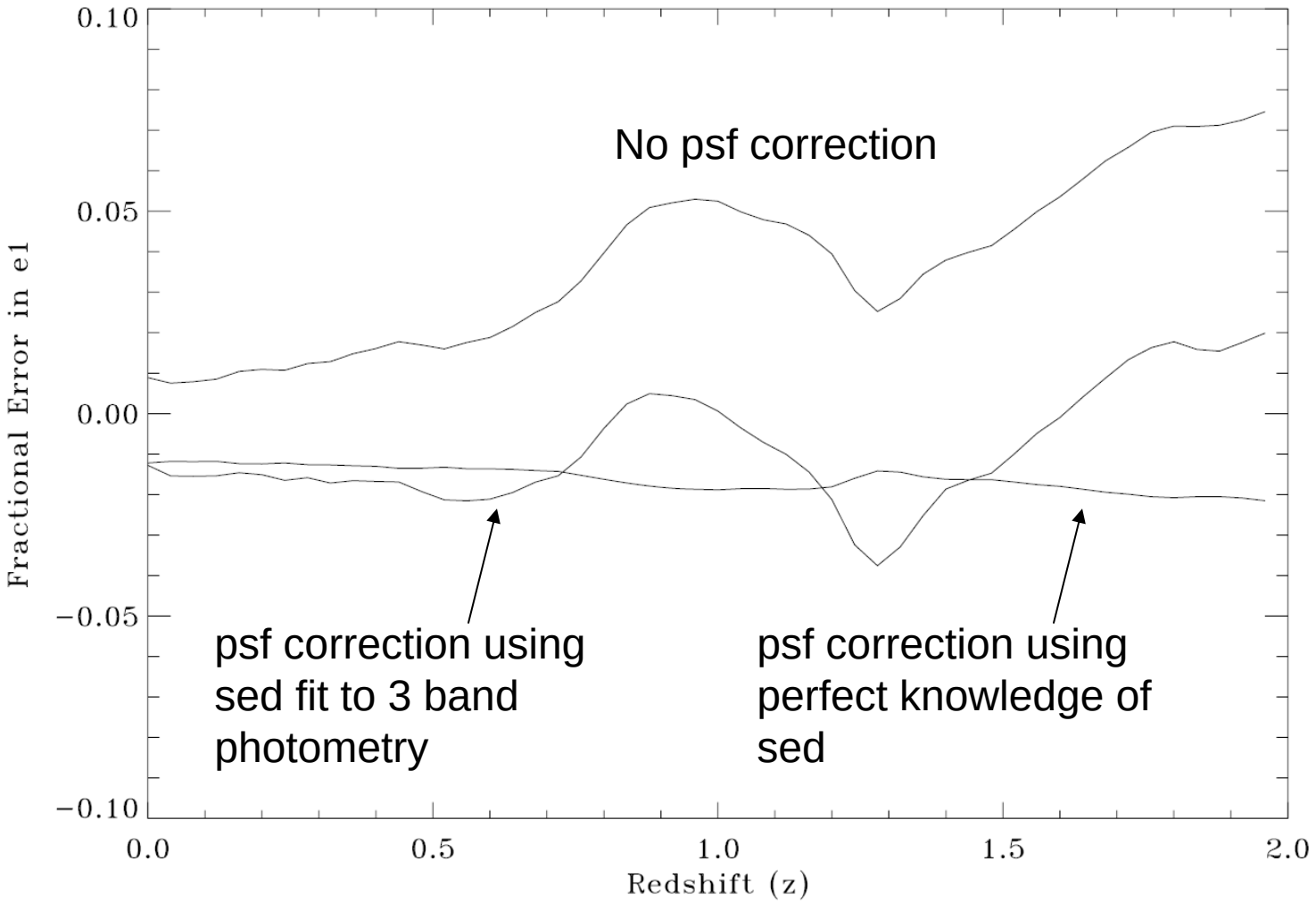

No conclusion, just a to do list:

Effect seems mildly scary for galaxies with a 4000A break. How big is the effect when we average over galaxy types? What is the effect on measuring the shear power spectrum? What error level do we need to achieve?

Improve correction with perfect sed knowledge

Try sed template fitting

More realistic psf, including detector effects?

Move from toy model to more realistic simulation?

How do we deal with SED variation across the image?