

Redmonster: Redshift Measurement and Spectral Classification with SSPs

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Motivation

- Primarily eBOSS + DESI driven, but (mostly) survey agnostic
- Robustness in low S/N regime
- PCA-based fitting -> confusion between physical and non-physical models
 - Replace PCA with “archetype-based” templates -> higher redshift success?
- Maximize end-user customization (i.e., hard code as little as possible)
- Map χ^2 surfaces over physical parameter space

Inputs

- Template suite(s) - included with package or user-supplied
 - Resolution \geq data
 - Need not be physically motivated, but can (should) be!
 - Conforms to “ndArch” standard (contains short list of required items)
- Wavelength-calibrated, sky-subtracted, and co-added spectra, rebinned onto uniform baseline of constant $\log(\lambda)$
- Statistical error-estimate vectors for each spectrum, expressed as inverse variance

Ex.: Galaxy templates

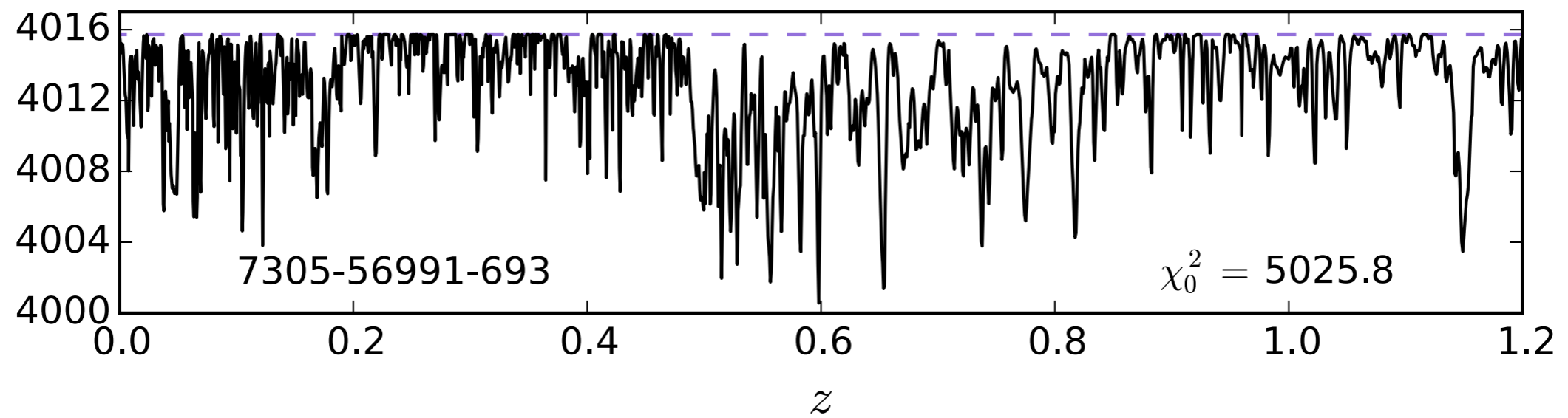
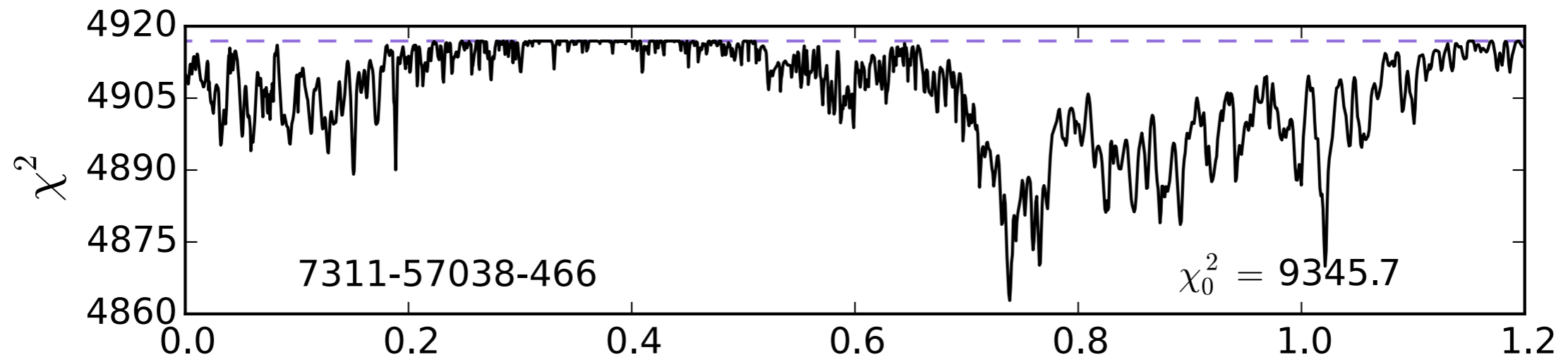
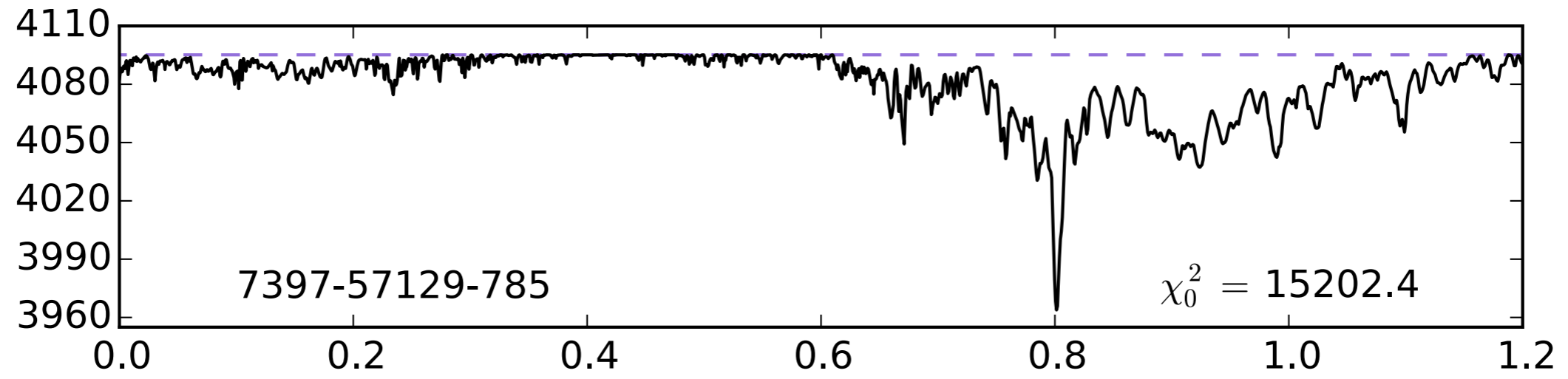
Parameter	Range	$N_{samples}$
$\log_{10}(\text{Age})$	[-2.5, 1]	15
$\log_{10} \sigma_{vel}$	[2, 2.6]	4
H α EW	[0, 100]	5

Method

- χ^2 minimization problem through cross-correlating spectra with “templates” at known redshift
- Fit linear combination of template + polynomial, giving χ^2 at each trial redshift for each point in parameter space of templates
- Reject non-physical (i.e., negative template coefficient) fits
- Marginalize over template-parameter dimensions
- Fit $\chi^2(z)$ curve with B-spline and identify local minima
- Fit each local minimum with quadratic and adopt analytic minimum as candidate redshift, estimate errors based on fit

Method (cont.)

- Ignore minima separated by $<$ some threshold (1000 km/s by default)
- Assess statistical confidence based on $\Delta \chi^2$ threshold
- Compare across template suites (if multiple suites used)



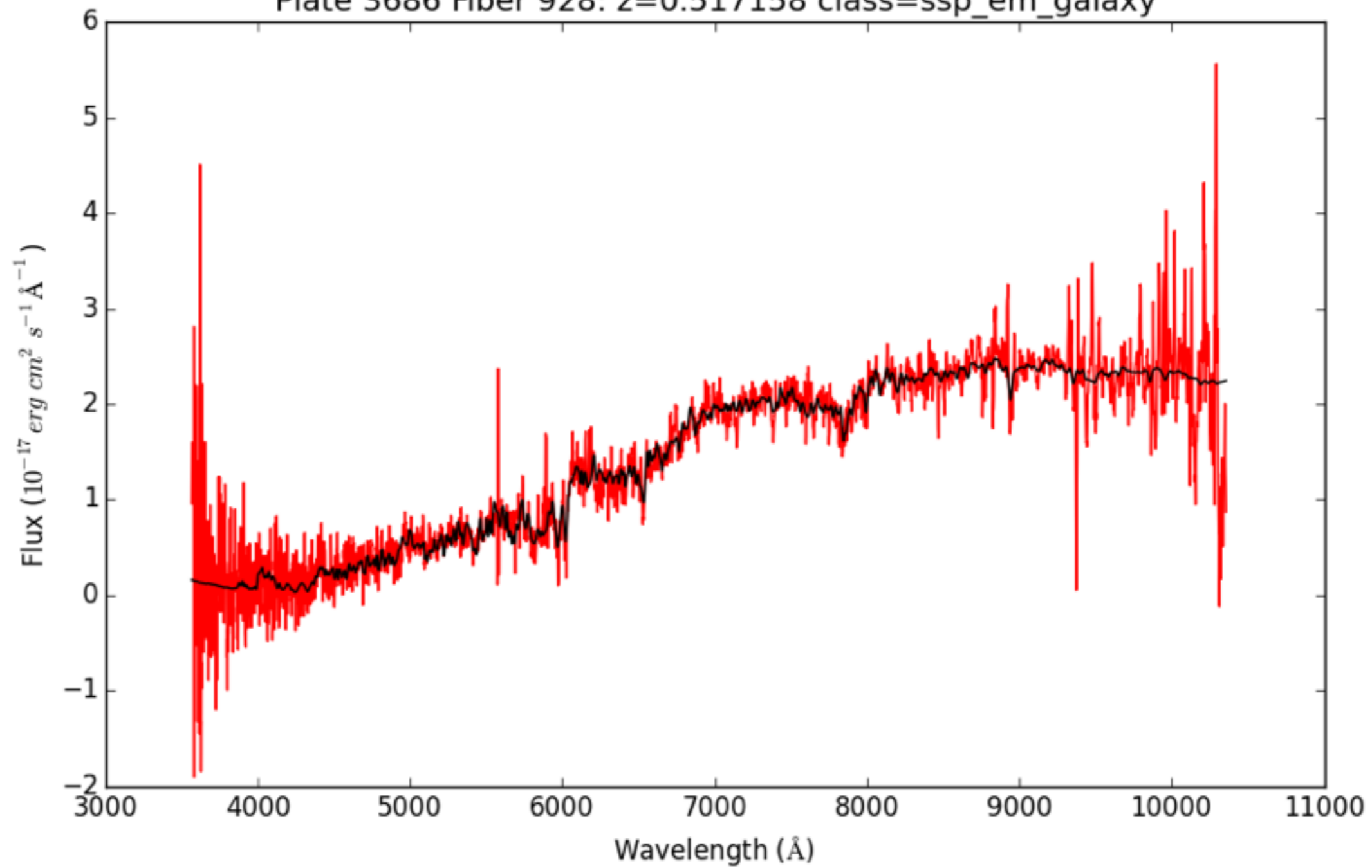
Outputs

- N best redshifts (with N set by end-user) and associated error estimates
- Object type classification (from templates) for each
- Reduced χ^2 for each
- Difference in χ^2 between best and second-best fit
- χ^2 of polynomial-only fit
- $(S/N)^2$ of each spectrum
- Relative contribution to fit of template and each polynomial degree

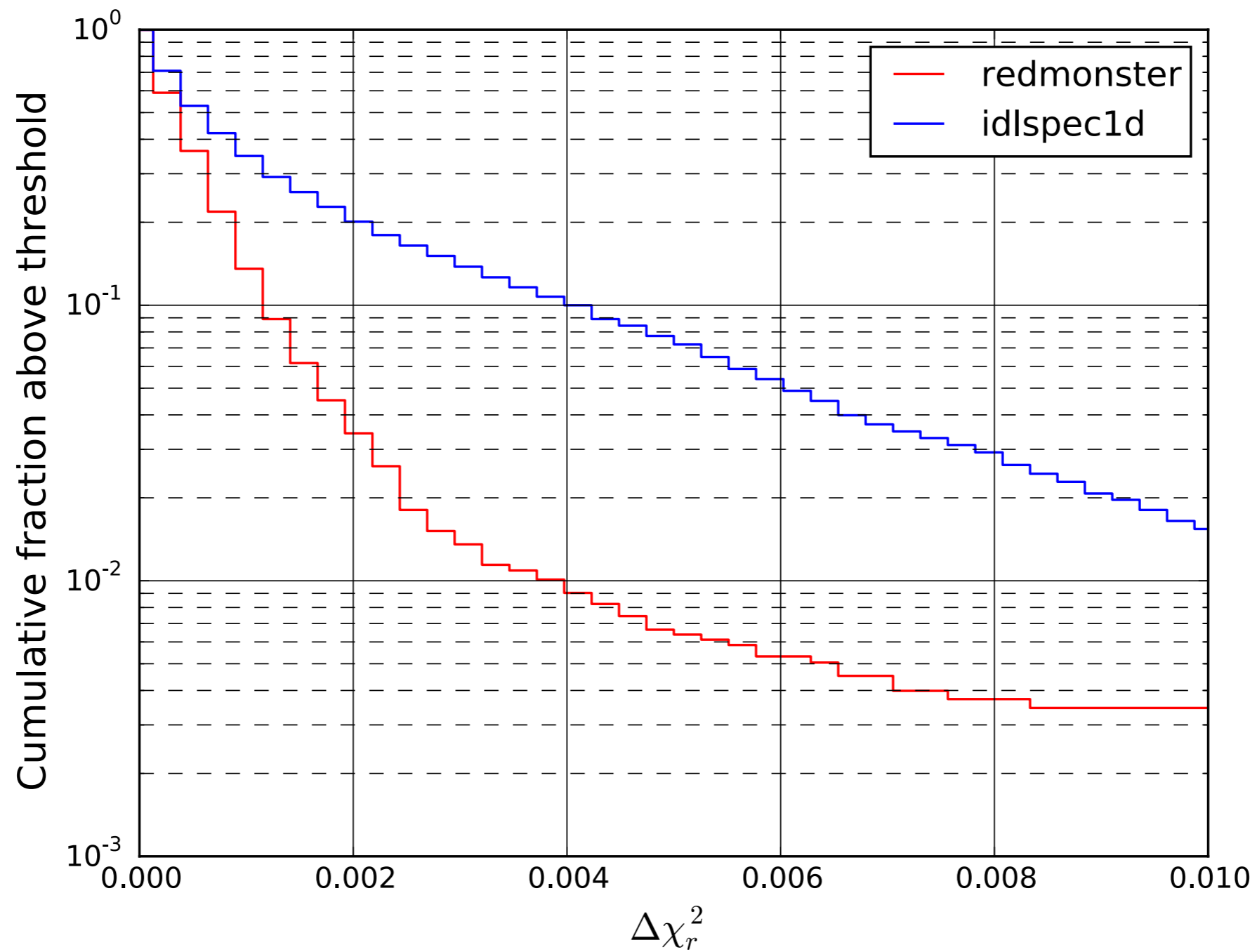
Outputs (cont.)

- Warning flags
 - Insufficient wavelength coverage
 - Small $\Delta\chi^2$
 - “z_fitlimit”
 - “null fit”
- Full χ^2 surfaces spanning template's parameter space (optional)

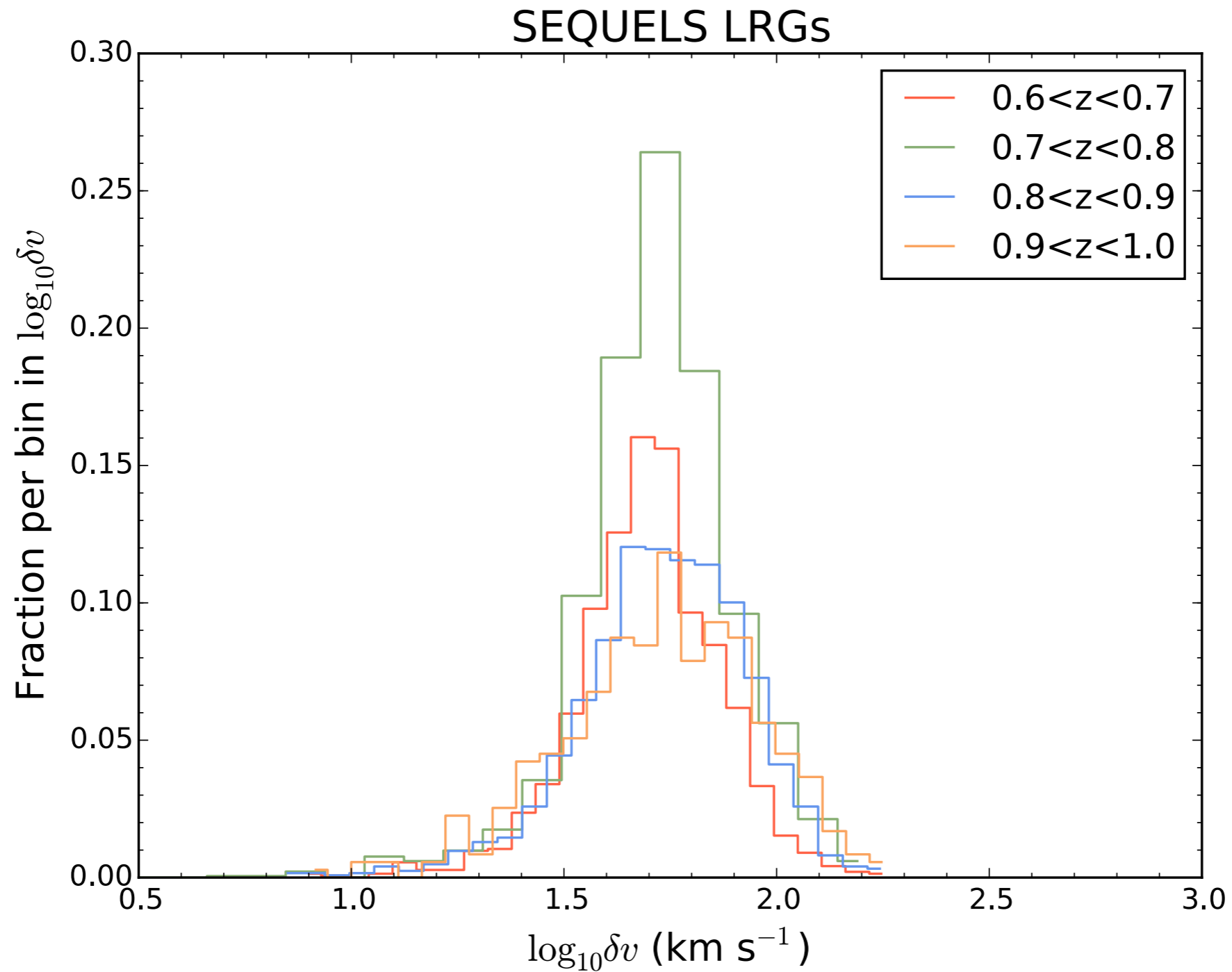
Plate 3686 Fiber 928: z=0.517158 class=ssp_em_galaxy



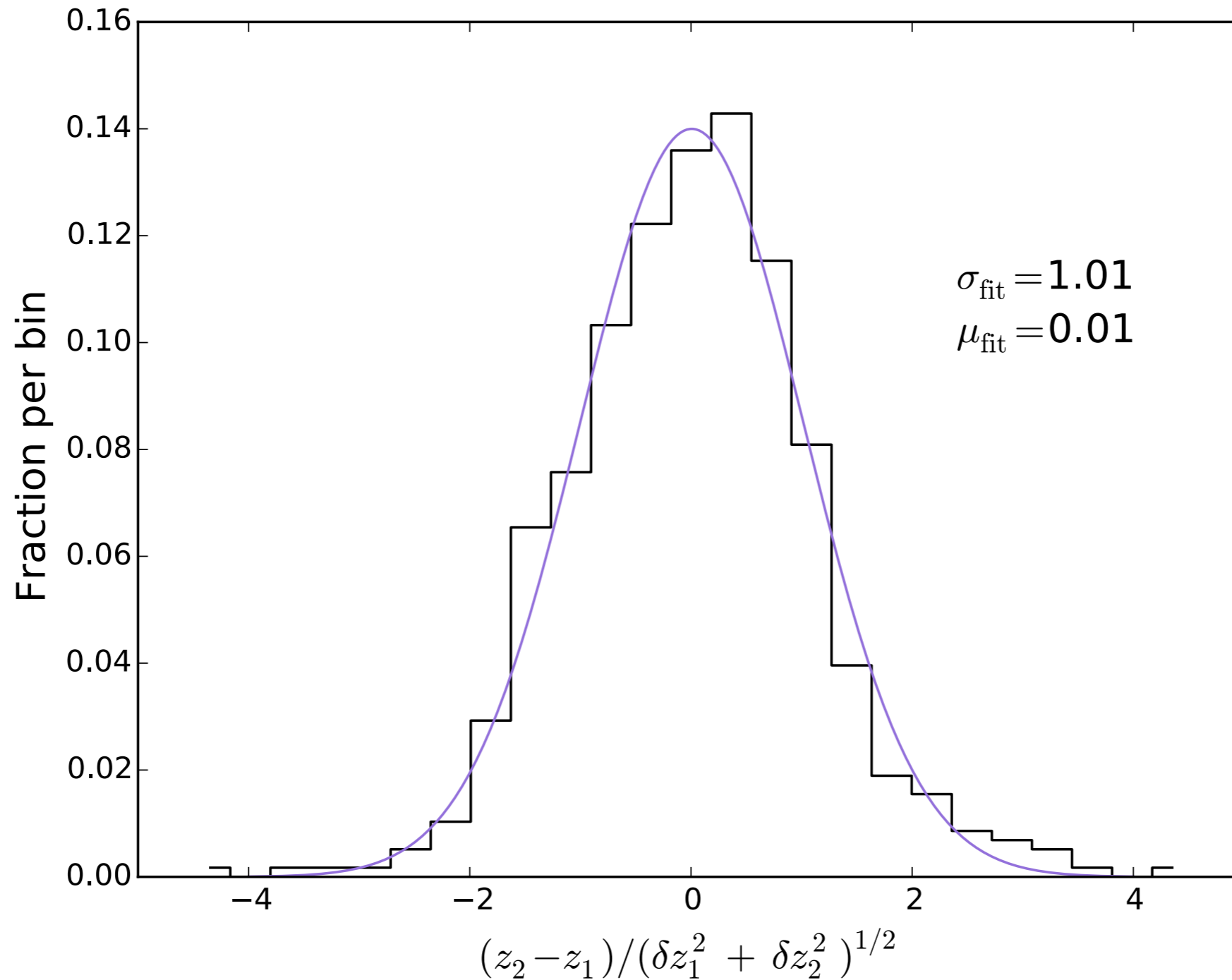
Sky fibers



Redshift errors



Re-observed spectra



Future

- Variable resolution + multi-exposure
- Template superpositions (both more realistic SFHs and lenses)
- Incorporate photometry