Supernovae and the IFU

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WFIRST-AFTA White Paper

$R \approx 100$ IFU Spectrograph
$0.6 \leq \lambda \leq 2$ μm

7 Epochs of IFU Spectroscopy at S/N = 3
1 Epoch Near Max at S/N = 10
1 Epoch at Late Times at S/N = 6
5-day cadence
4.2 Months for Spectroscopy

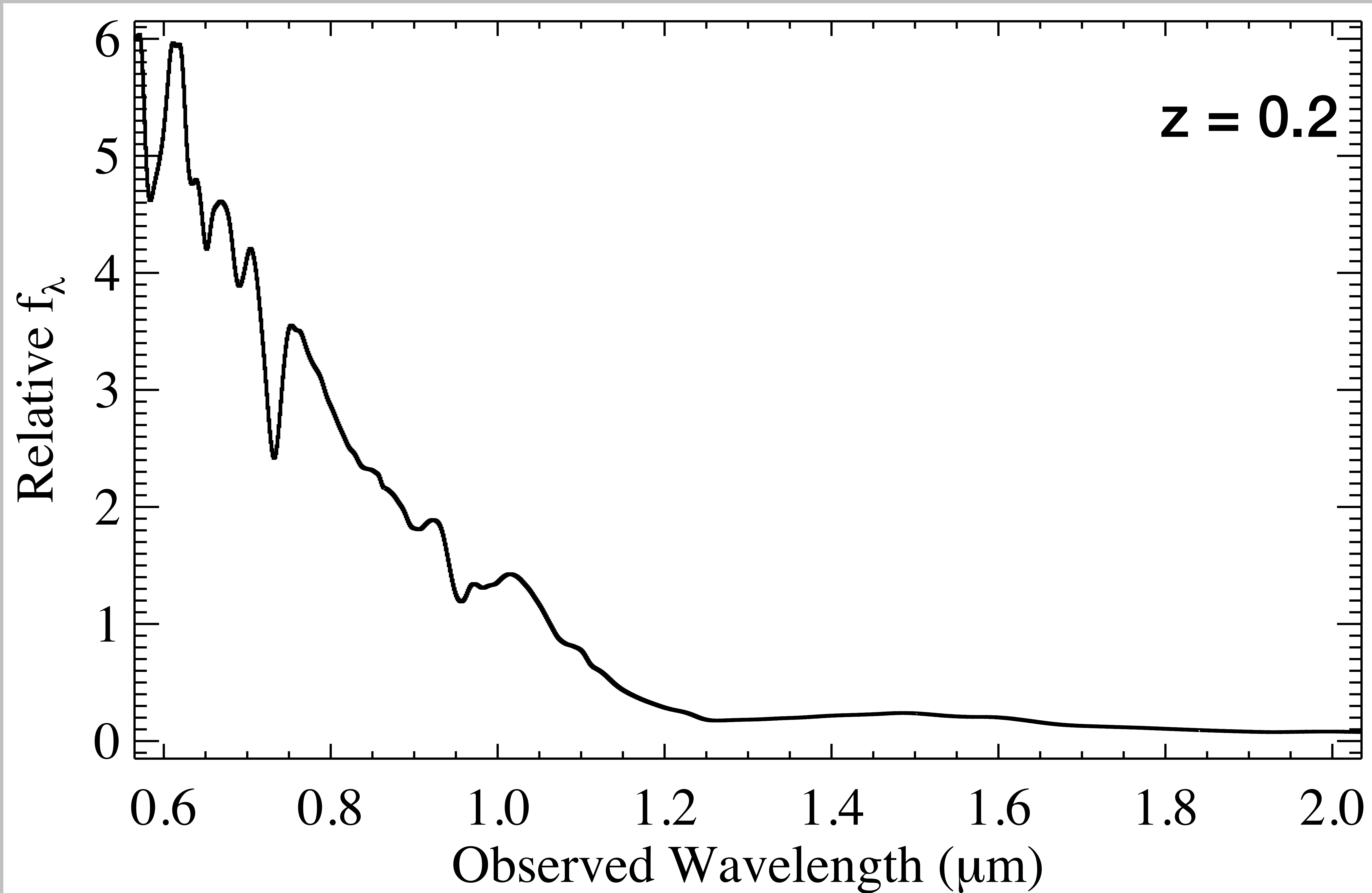
No mention of selection, false positives, or if S/N is peak/median/other

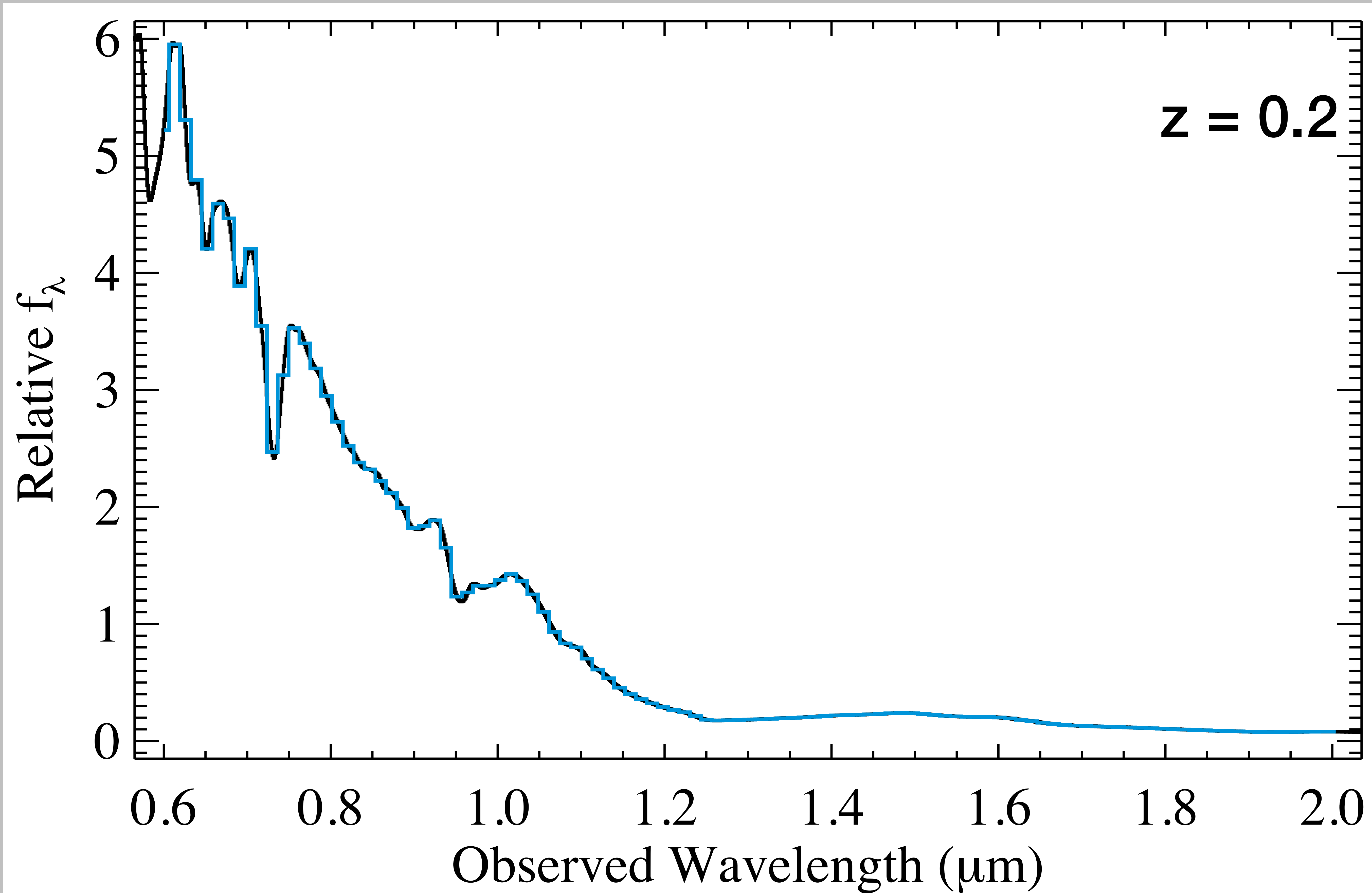
Our Simulations

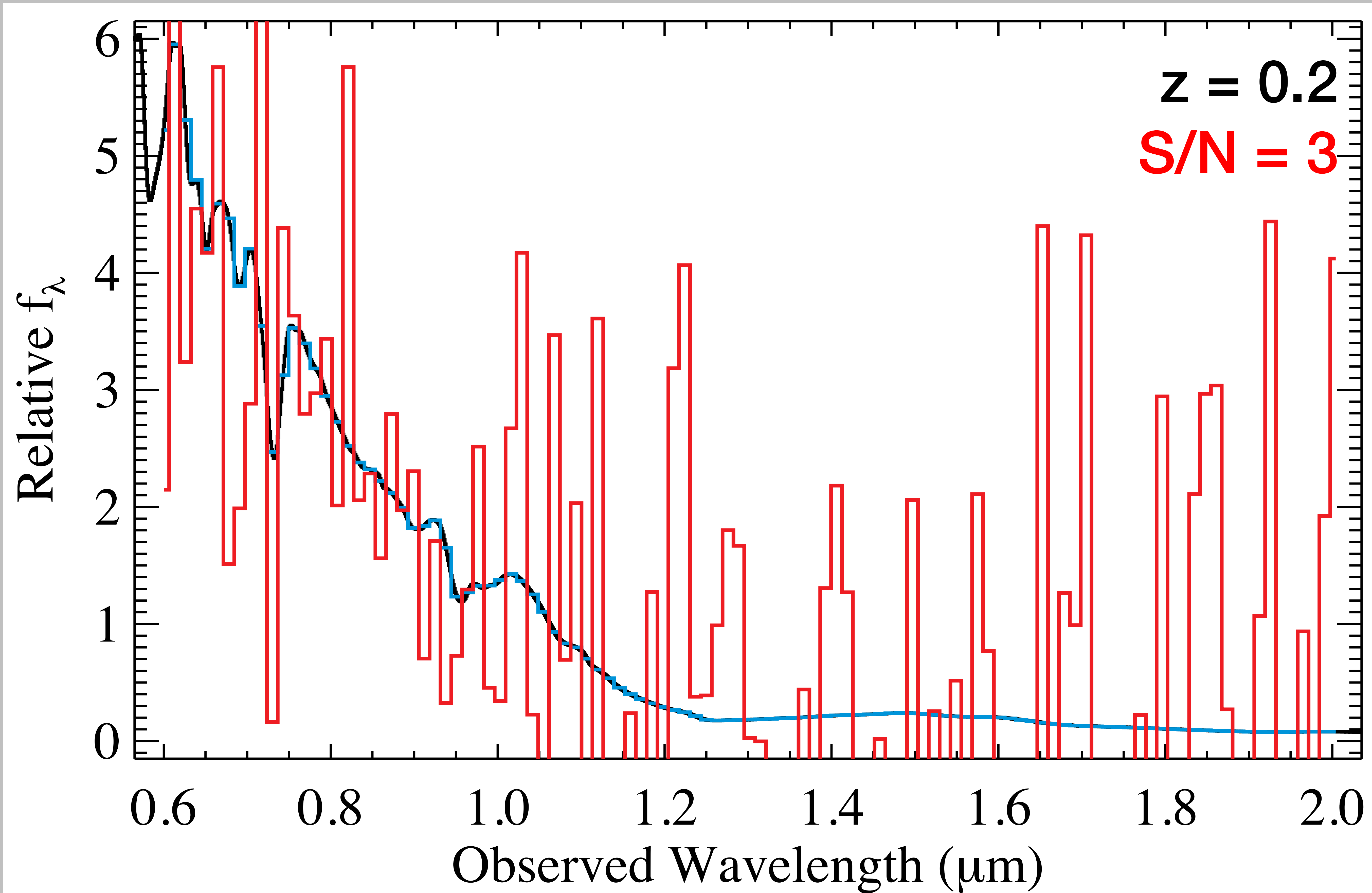
Start with WFC3 IR Grism for Sensitivity
Scale To Match Total Time in White Paper

Assume Peak S/N
Add Appropriate Noise

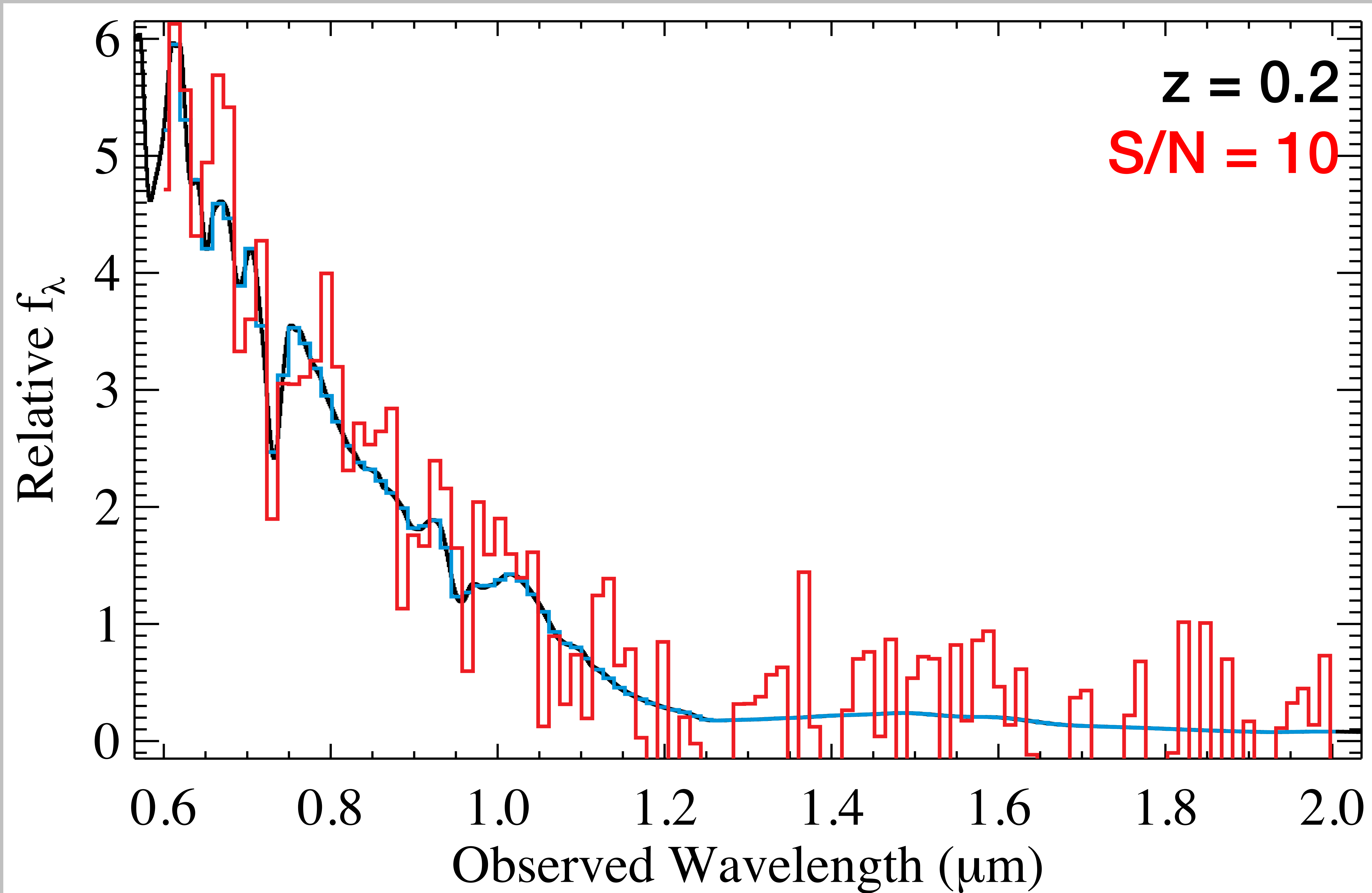
Determine Recovery Rate
($\Delta z < 0.05$, >80% SN Ia Match, Best Match)

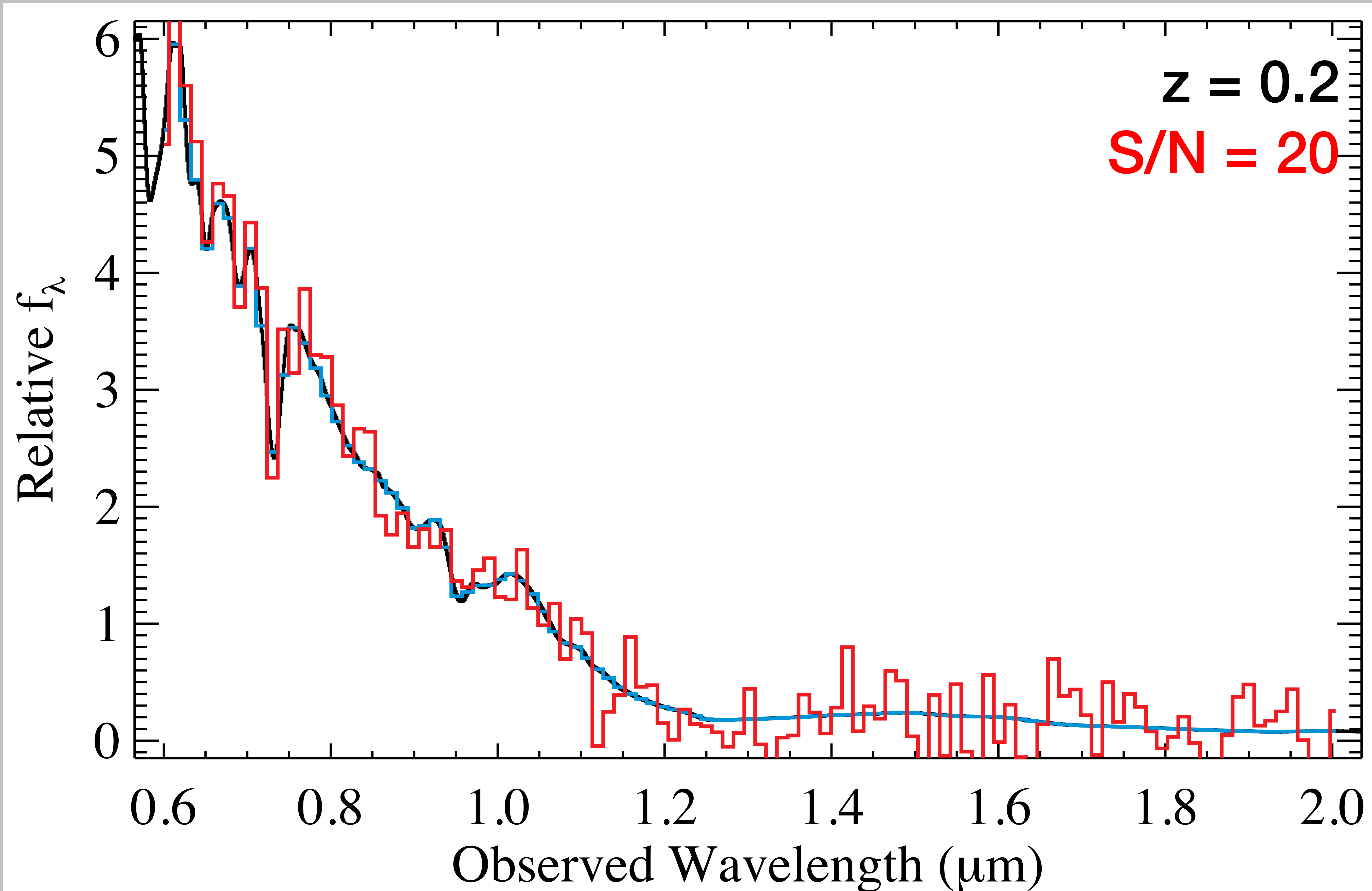

z = 0.2
Relative f_λ
Observed Wavelength (μm)
0
1
2
3
4
5
6
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0

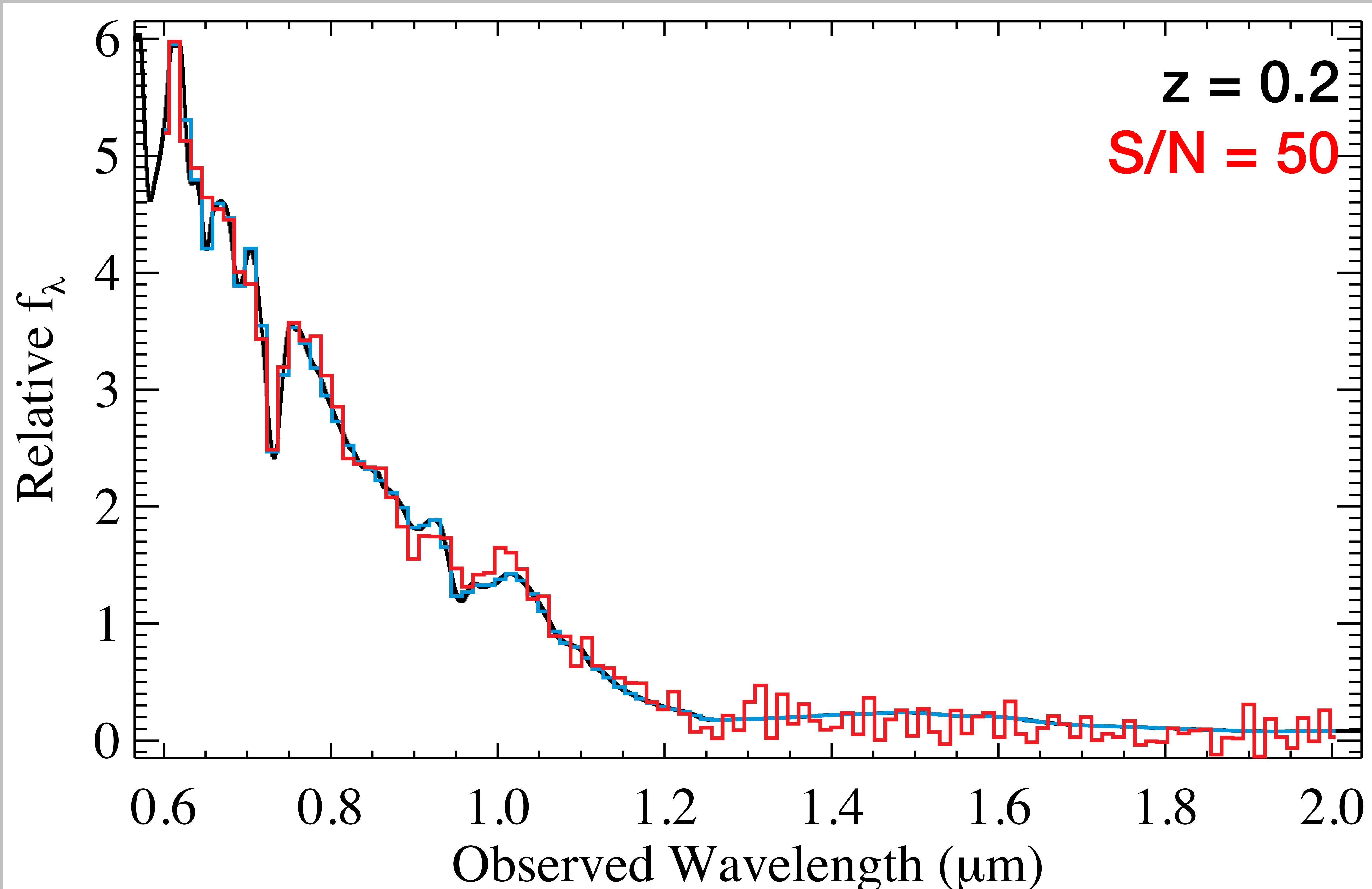

z = 0.2
Relative f_λ
Observed Wavelength (μm)
0
1
2
3
4
5
6
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0



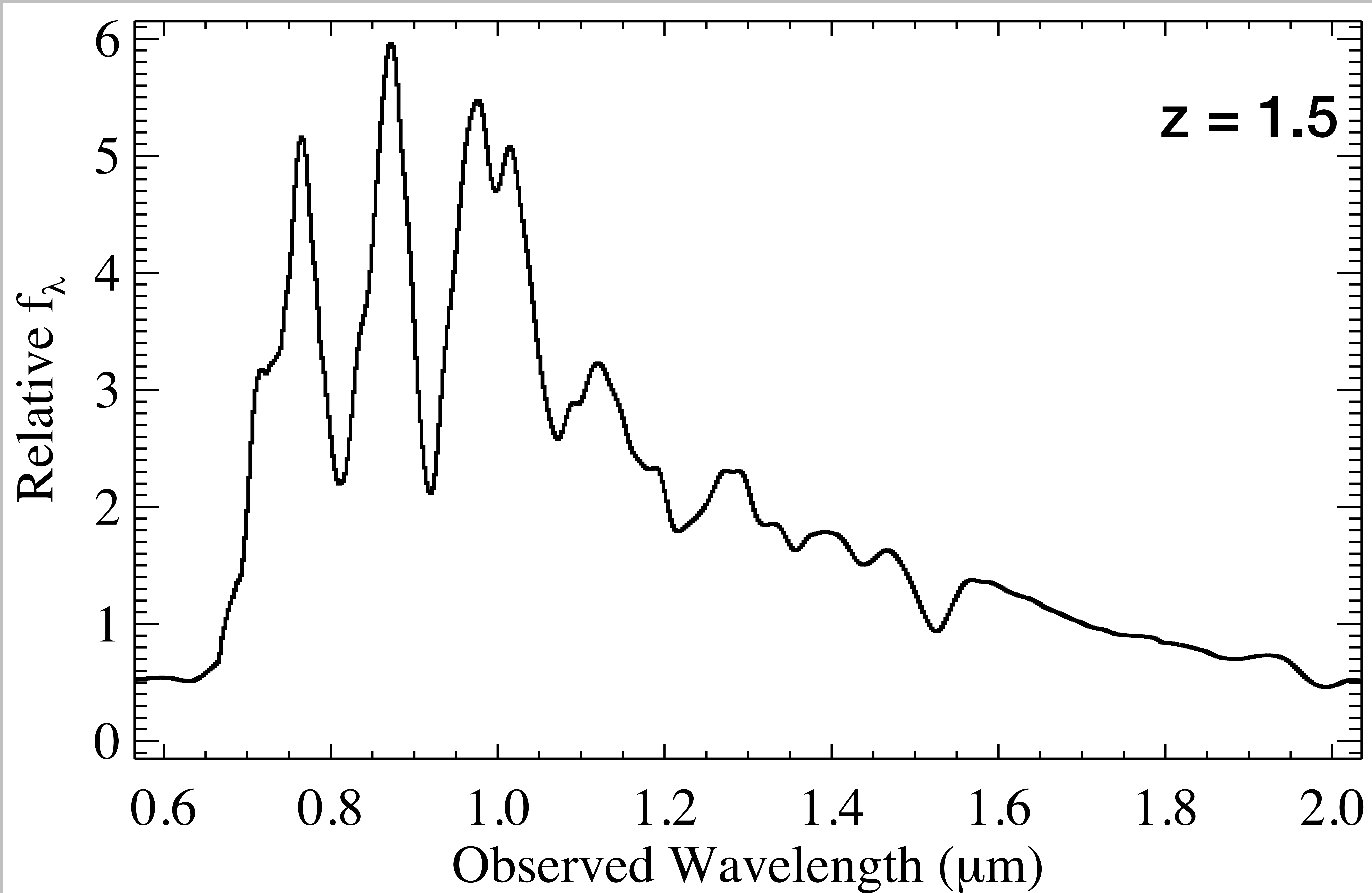
z = 0.2
S/N = 3
Relative f_λ
Observed Wavelength (μm)
0
1
2
3
4
5
6
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0


z = 0.2
S/N = 10
Relative f_λ
Observed Wavelength (μm)
0
1
2
3
4
5
6
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0

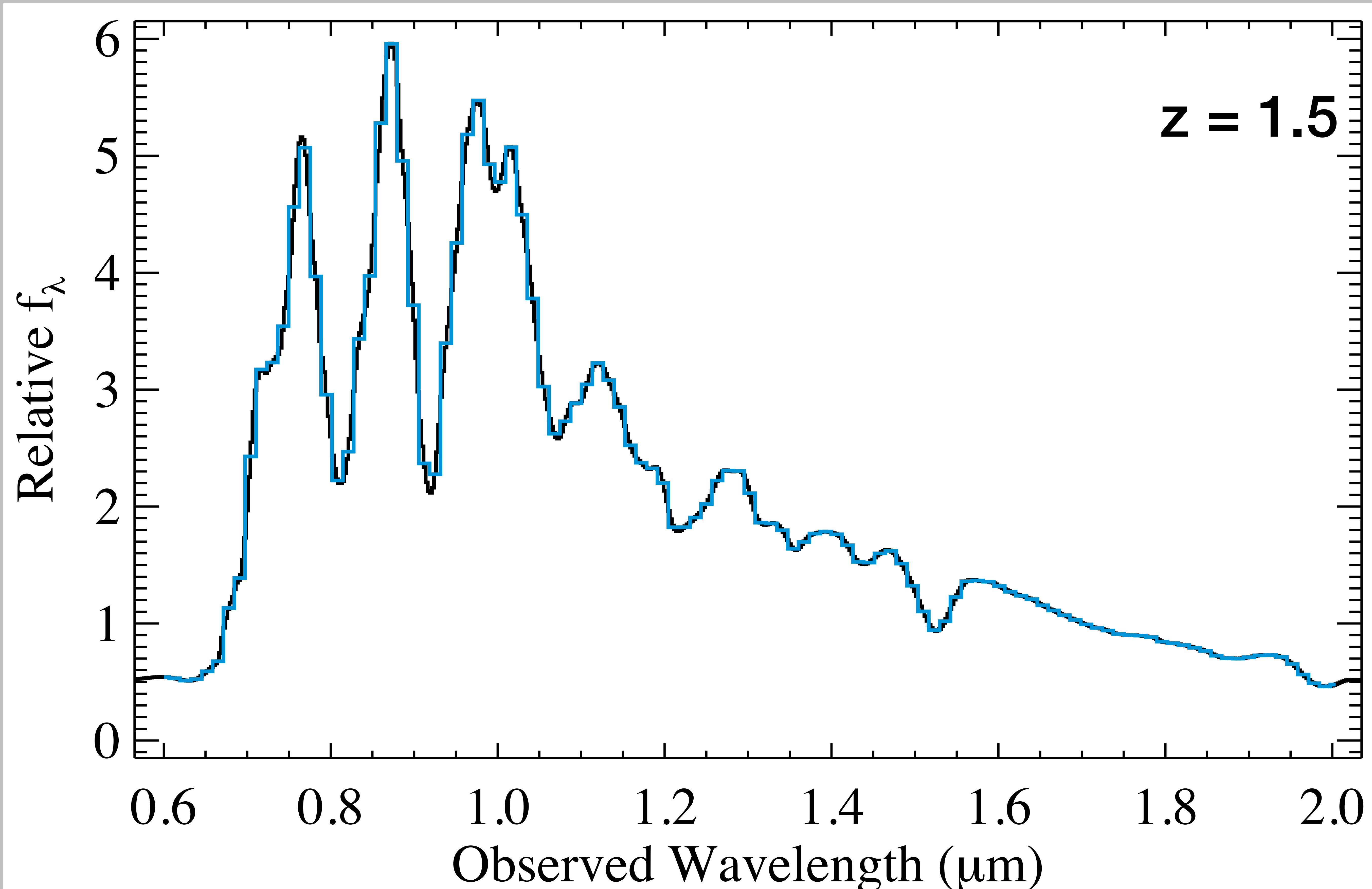

z = 0.2
S/N = 20
Relative f_λ
Observed Wavelength (μm)
0
1
2
3
4
5
6
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0

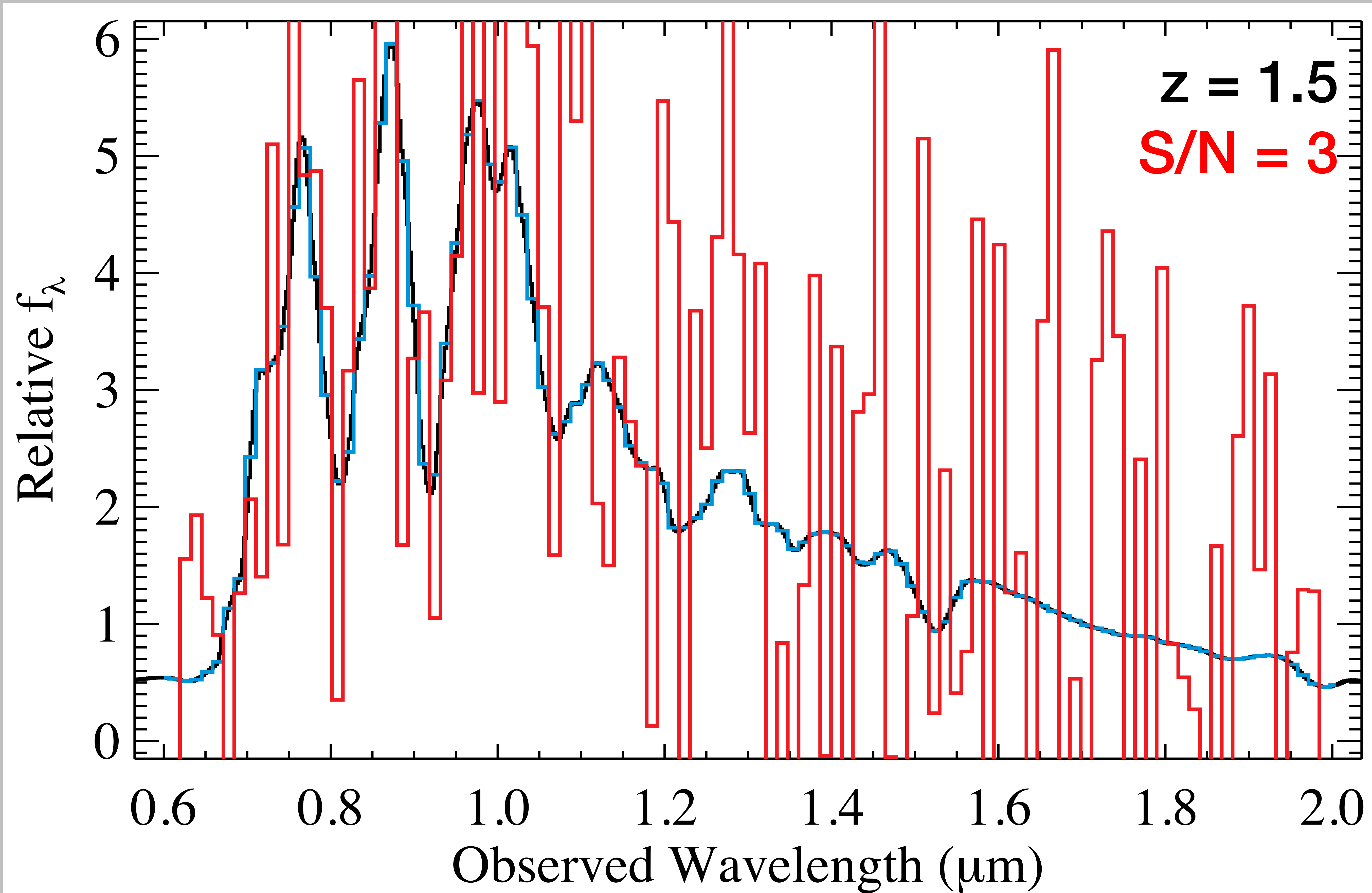


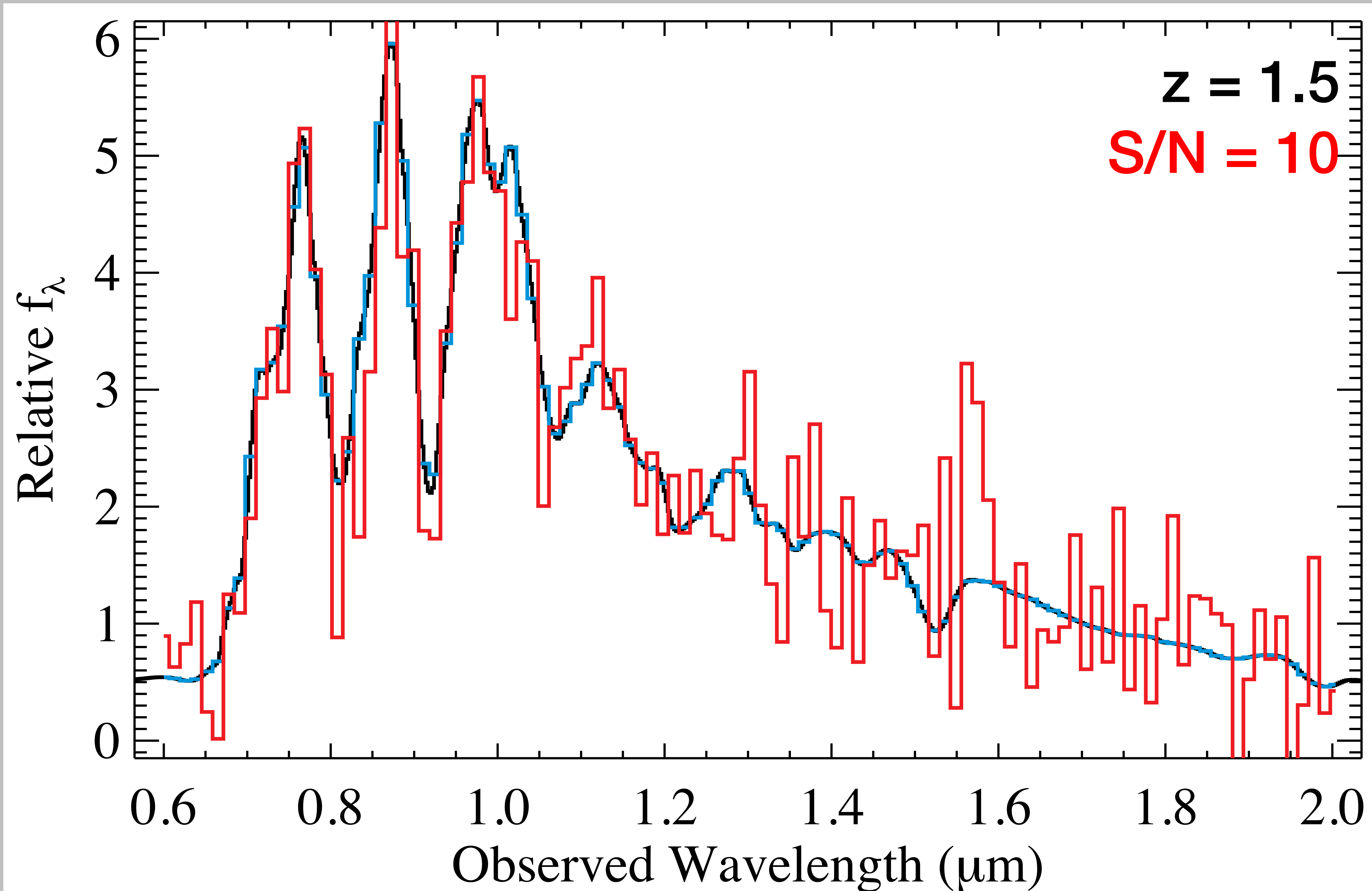
z = 0.2
S/N = 50
Relative f_λ
0
1
2
3
4
5
6
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Observed Wavelength (μm)

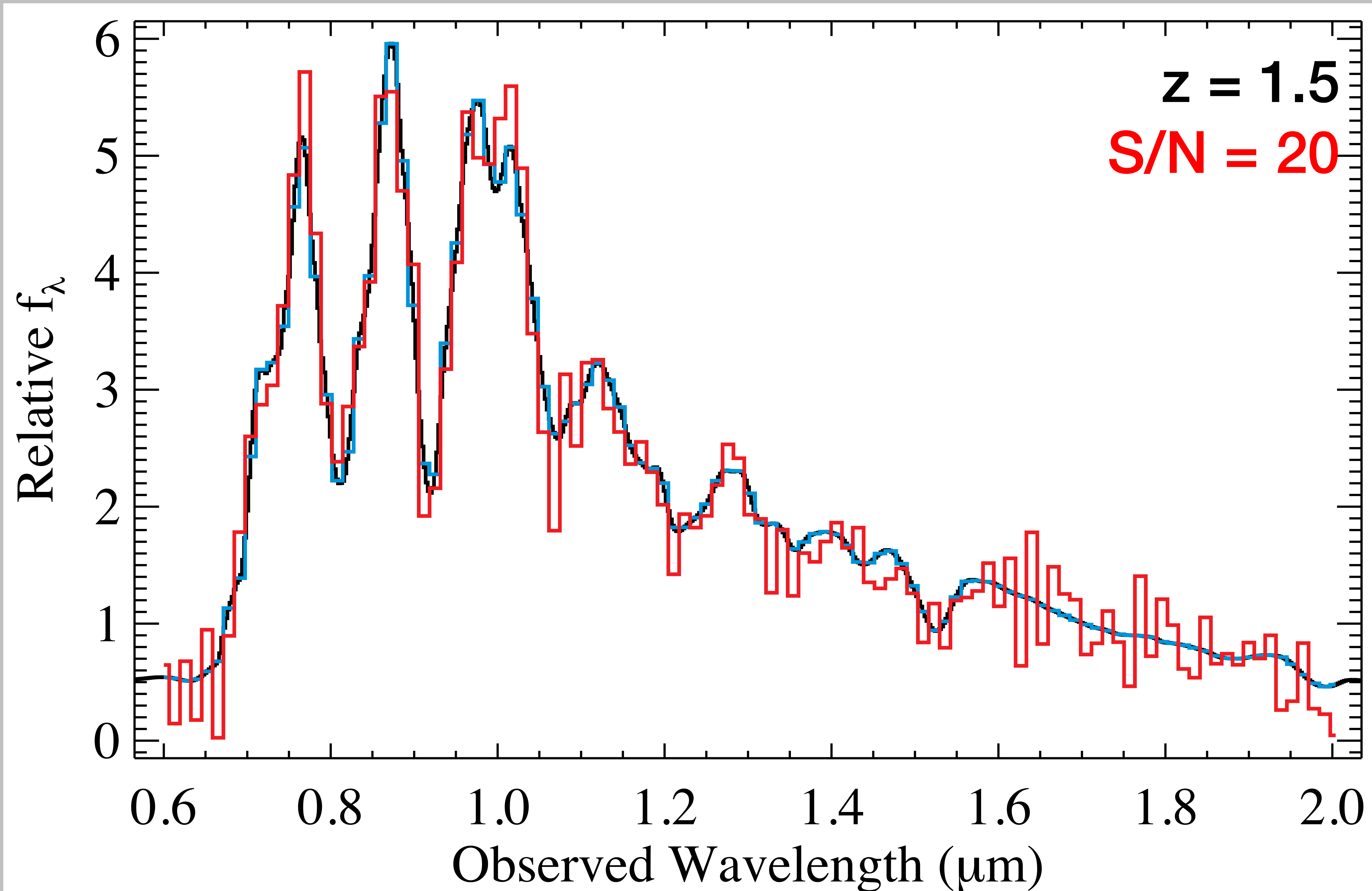


z = 1.5
Relative f_λ
Observed Wavelength (μm)
0
1
2
3
4
5
6
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0

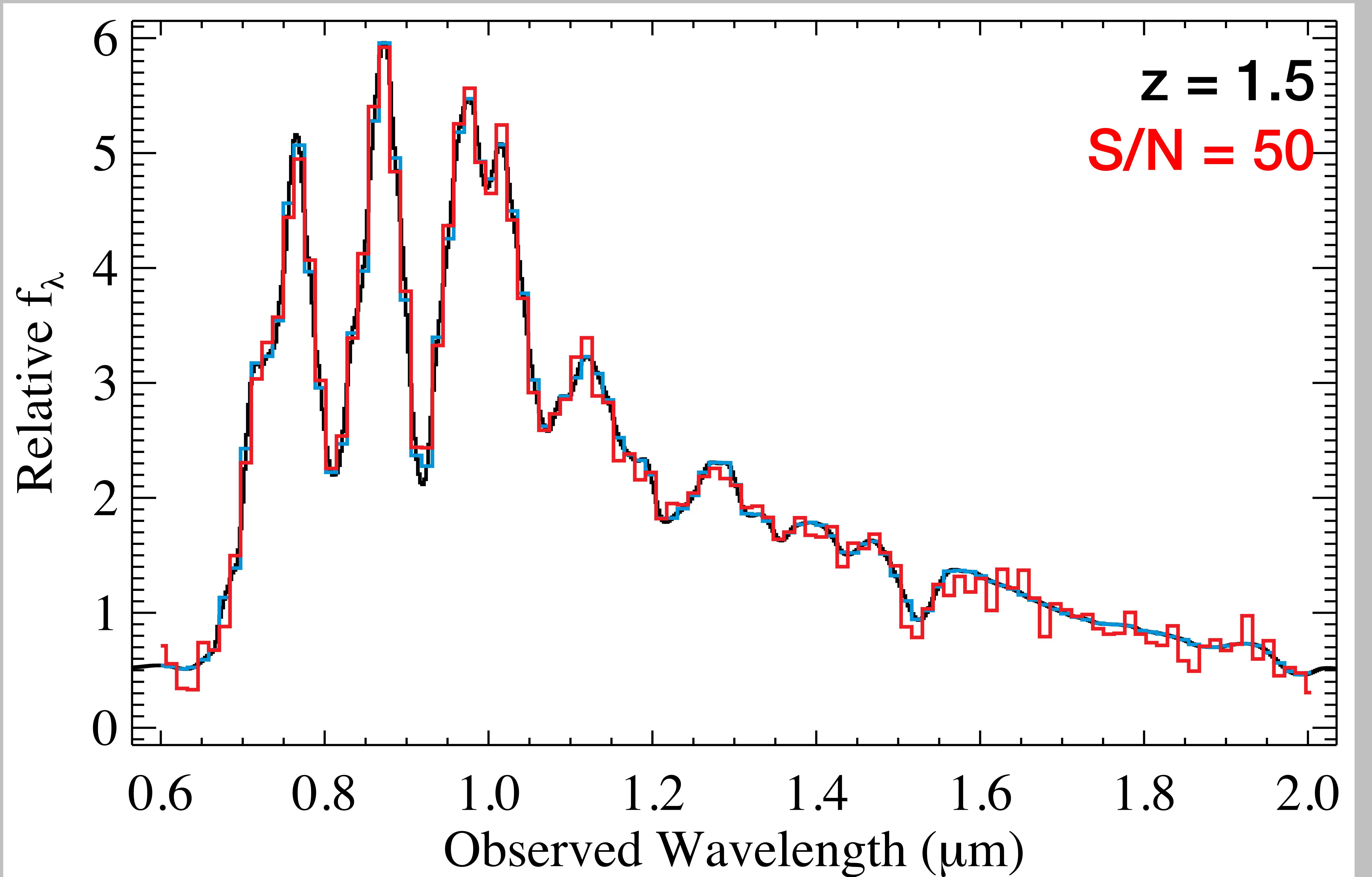

z = 1.5
Relative f_λ
Observed Wavelength (μm)
0
1
2
3
4
5
6
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0


z = 1.5
S/N = 3
Relative f_λ
0
1
2
3
4
5
6
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Observed Wavelength (μm)


z = 1.5
S/N = 10
Relative f_λ
0
1
2
3
4
5
6
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Observed Wavelength (μm)

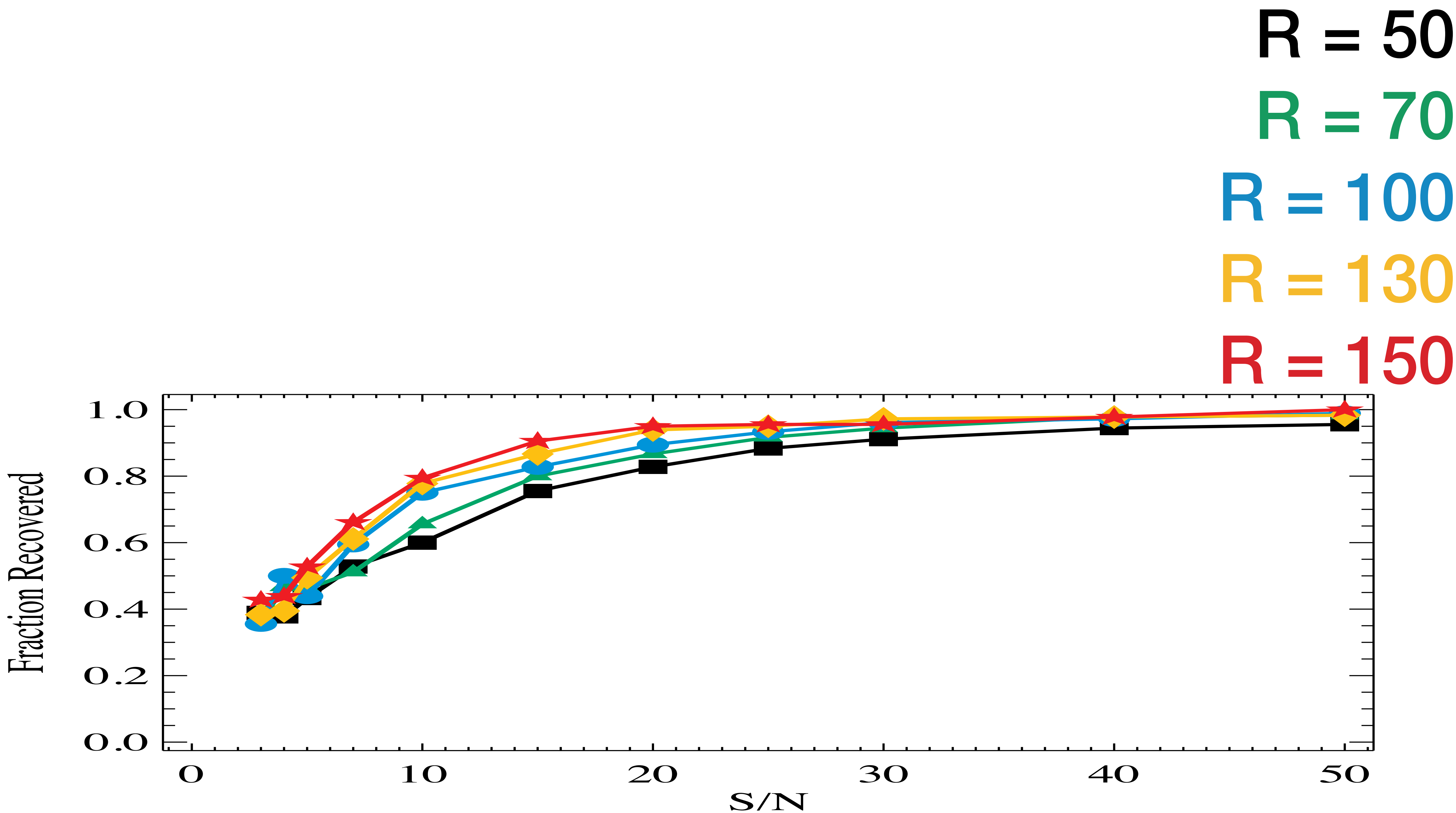


z = 1.5
S/N = 20
Relative f_λ
0
1
2
3
4
5
6
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Observed Wavelength (μm)

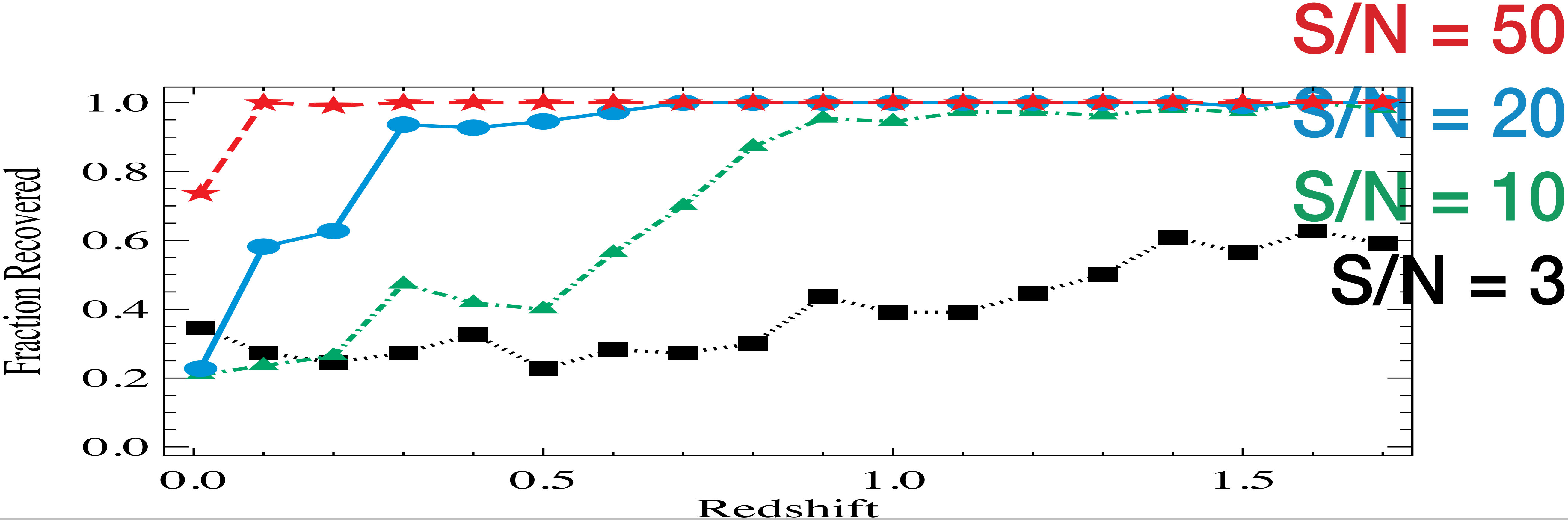


z = 1.5
S/N = 50
Relative f_λ
0
1
2
3
4
5
6
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
Observed Wavelength (μm)

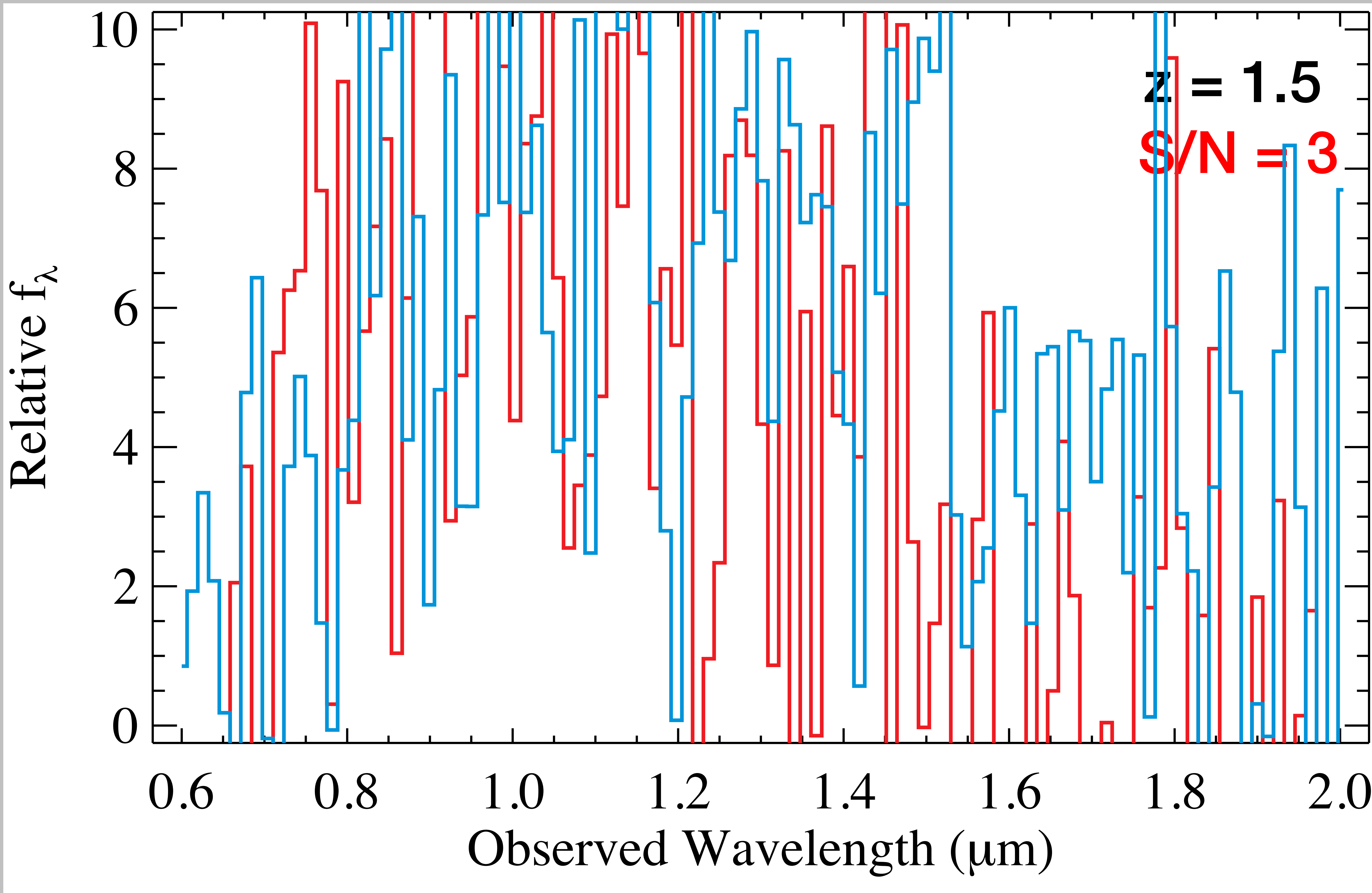
Resolution Matters for Classification



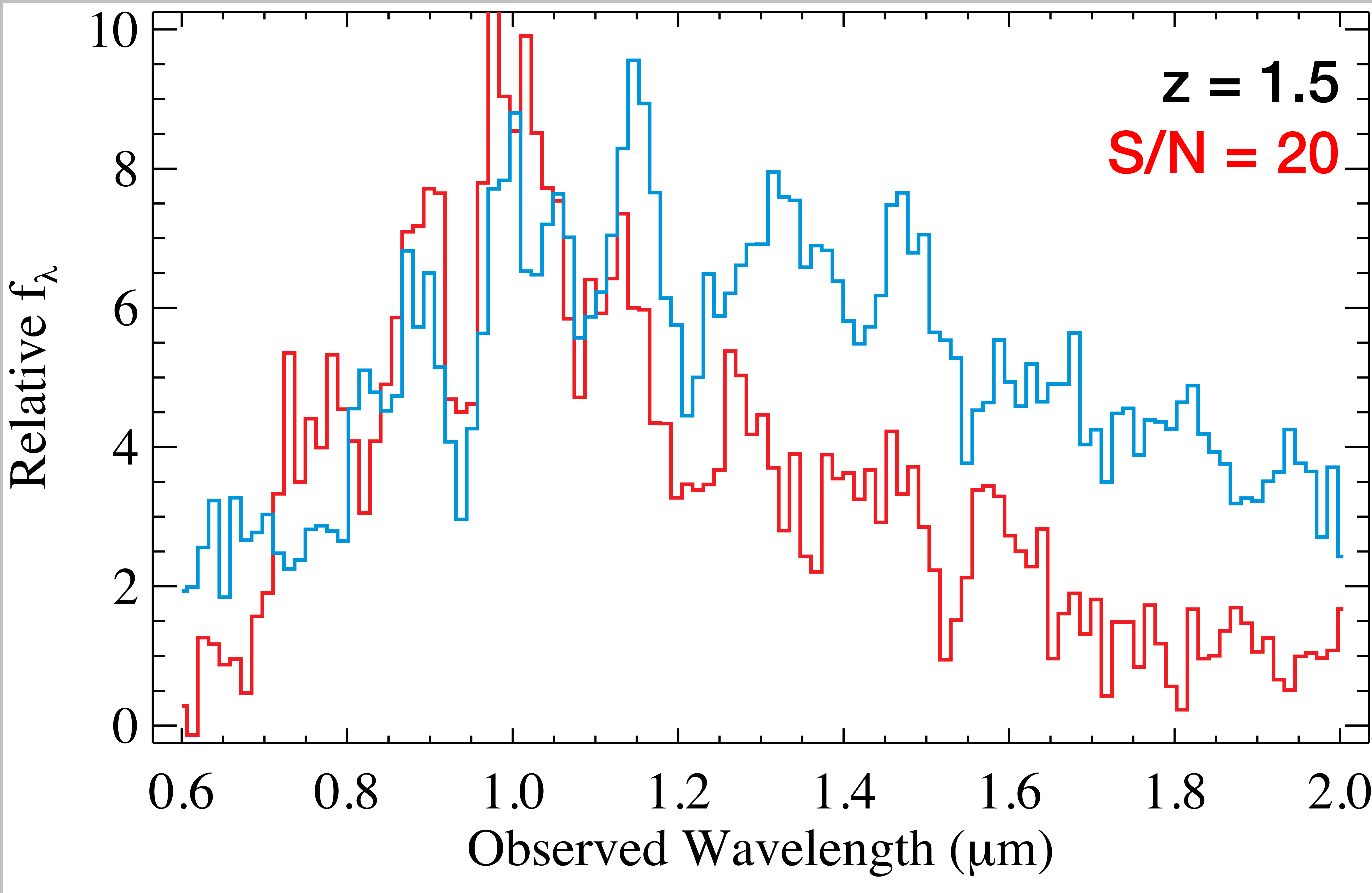
S/N REALLY Matters for Classification



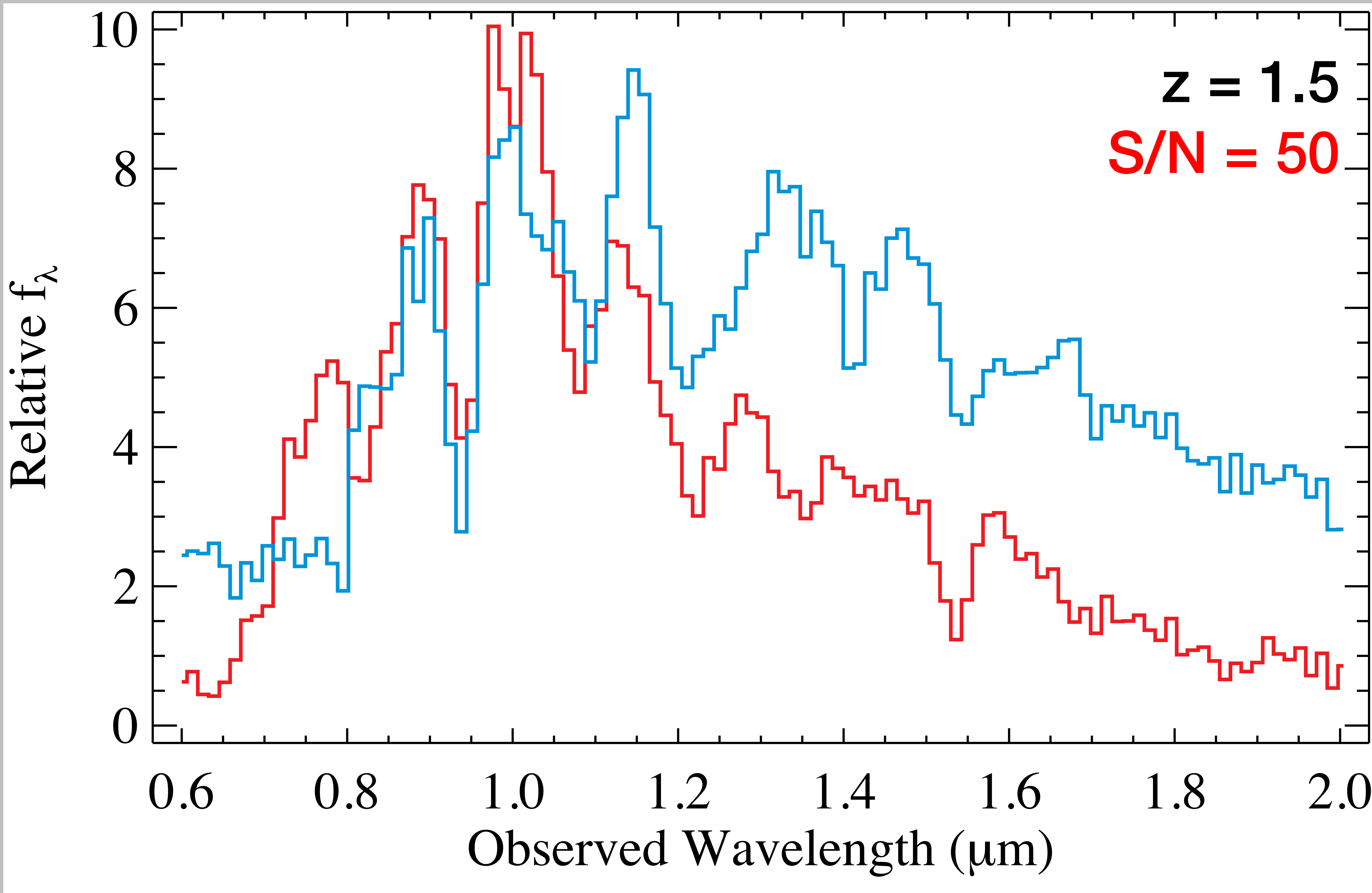
Contamination Potentially High



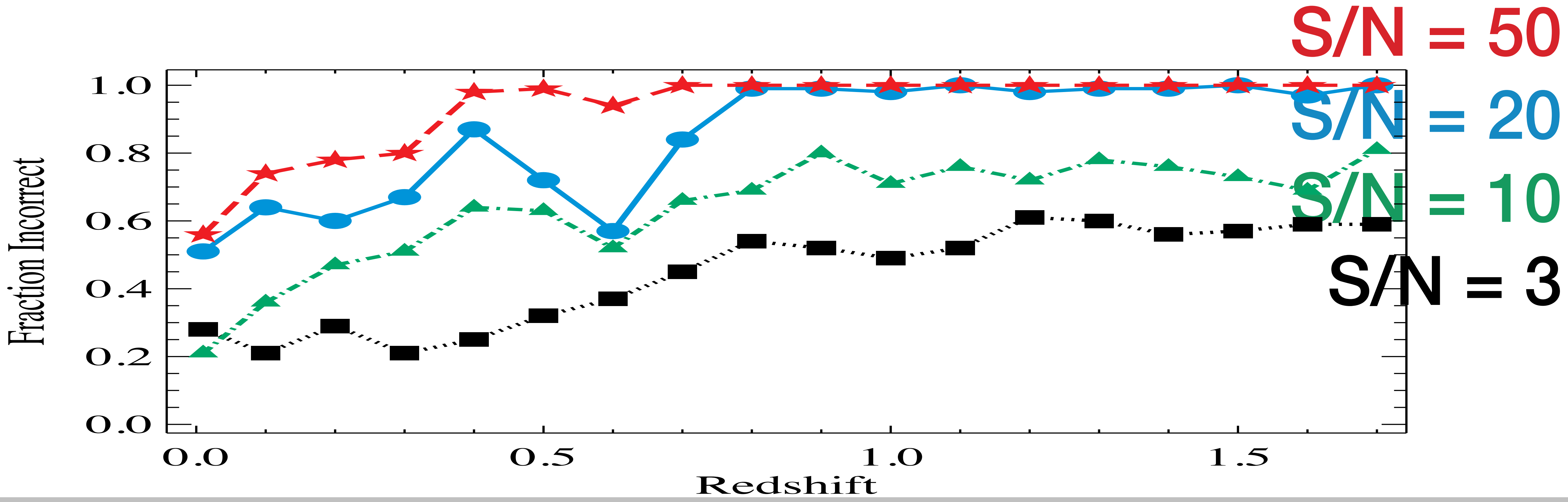
Contamination Potentially High



Contamination Potentially High

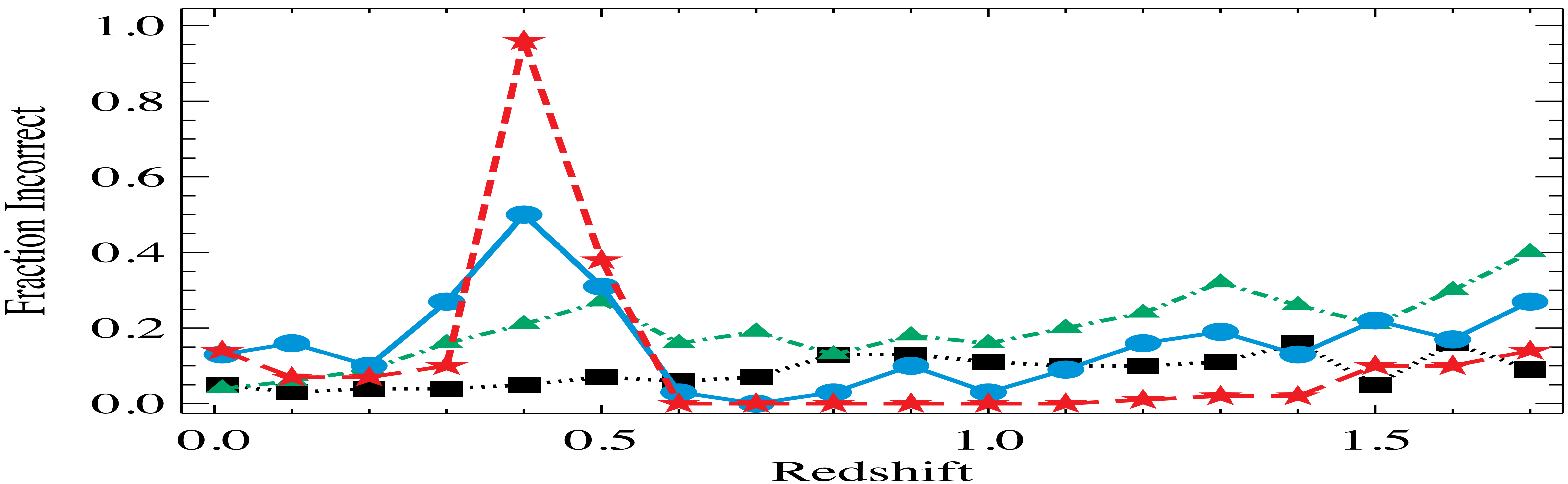


S/N Matters for MISclassification

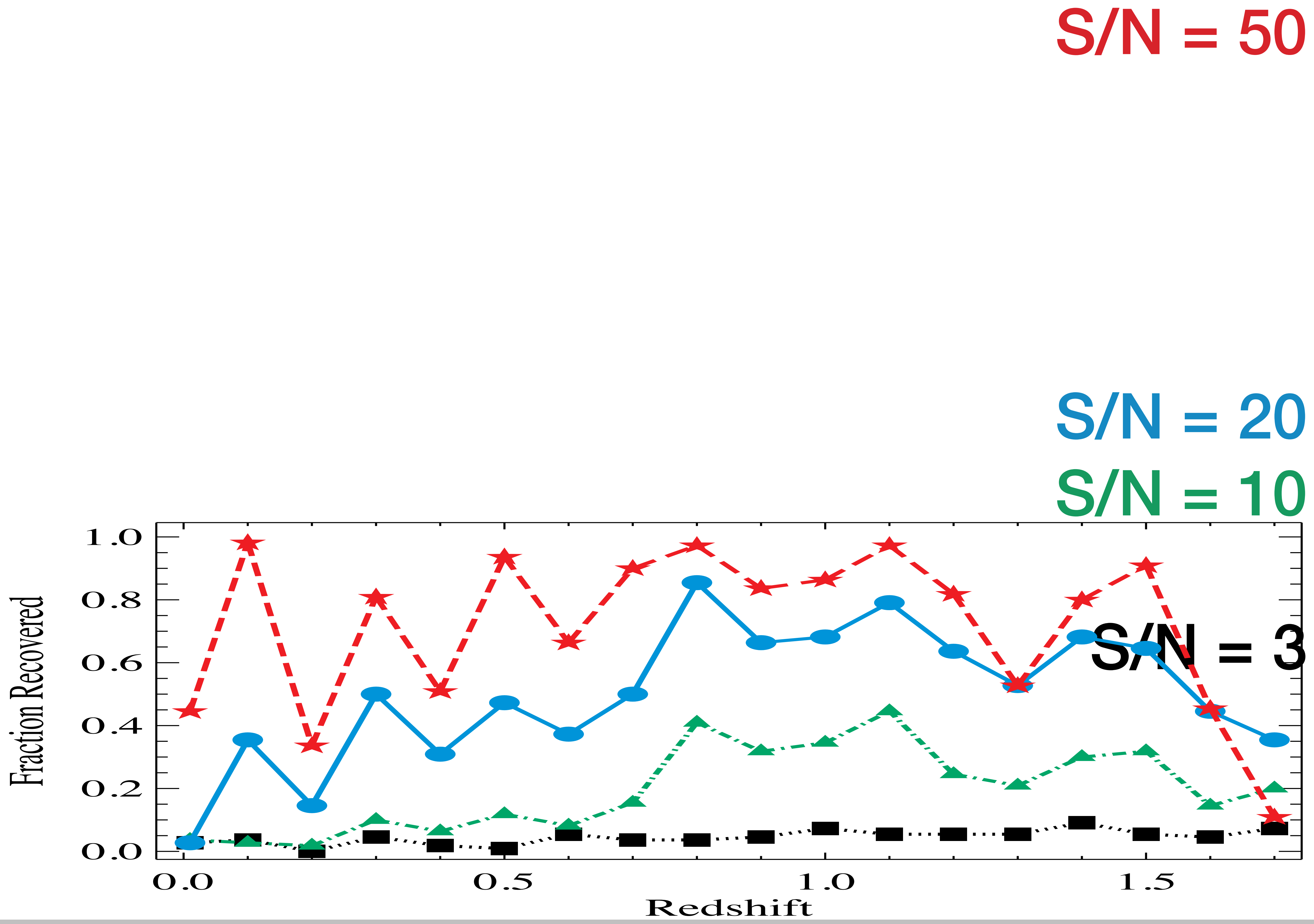


S/N Matters for MISclassification

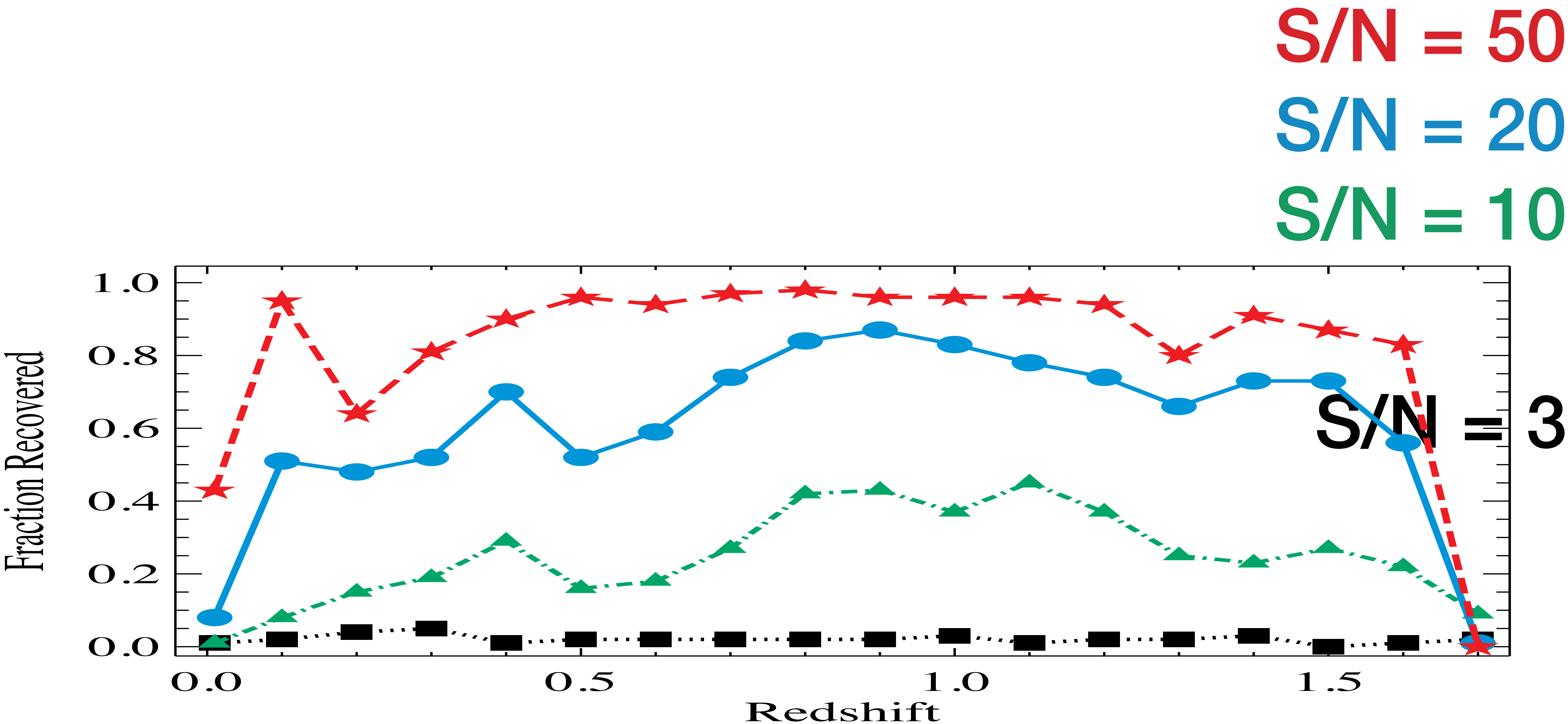
S/N = 50
S/N = 20
S/N = 10
S/N = 3



S/N REALLY Matters for Classification



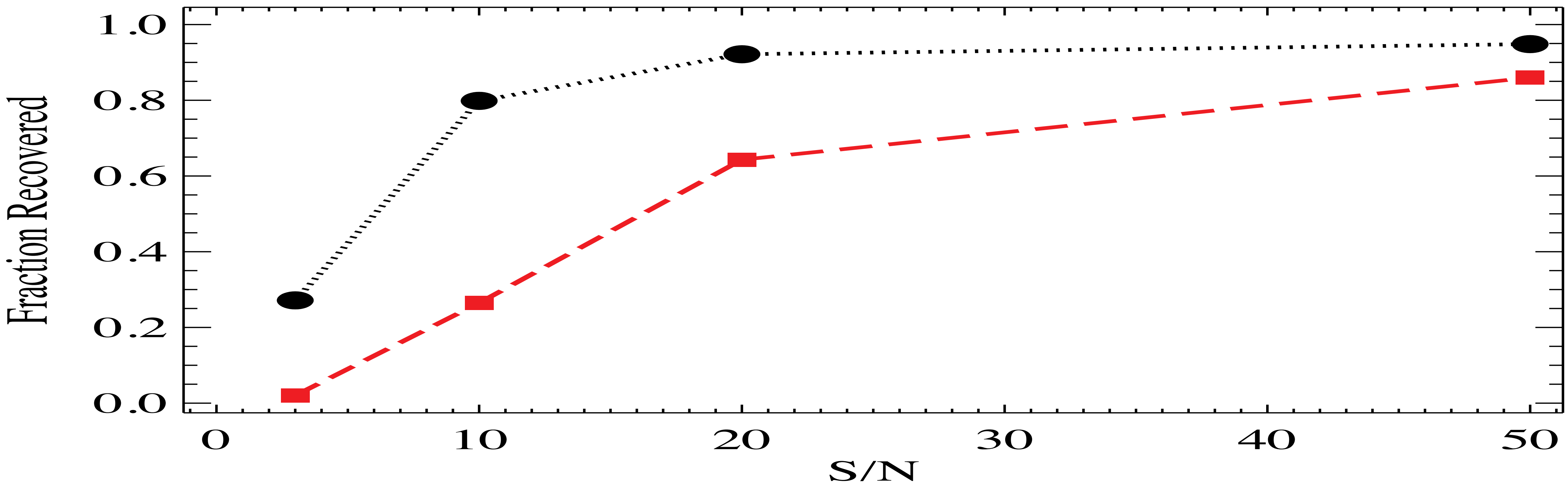
S/N REALLY Matters for Classification



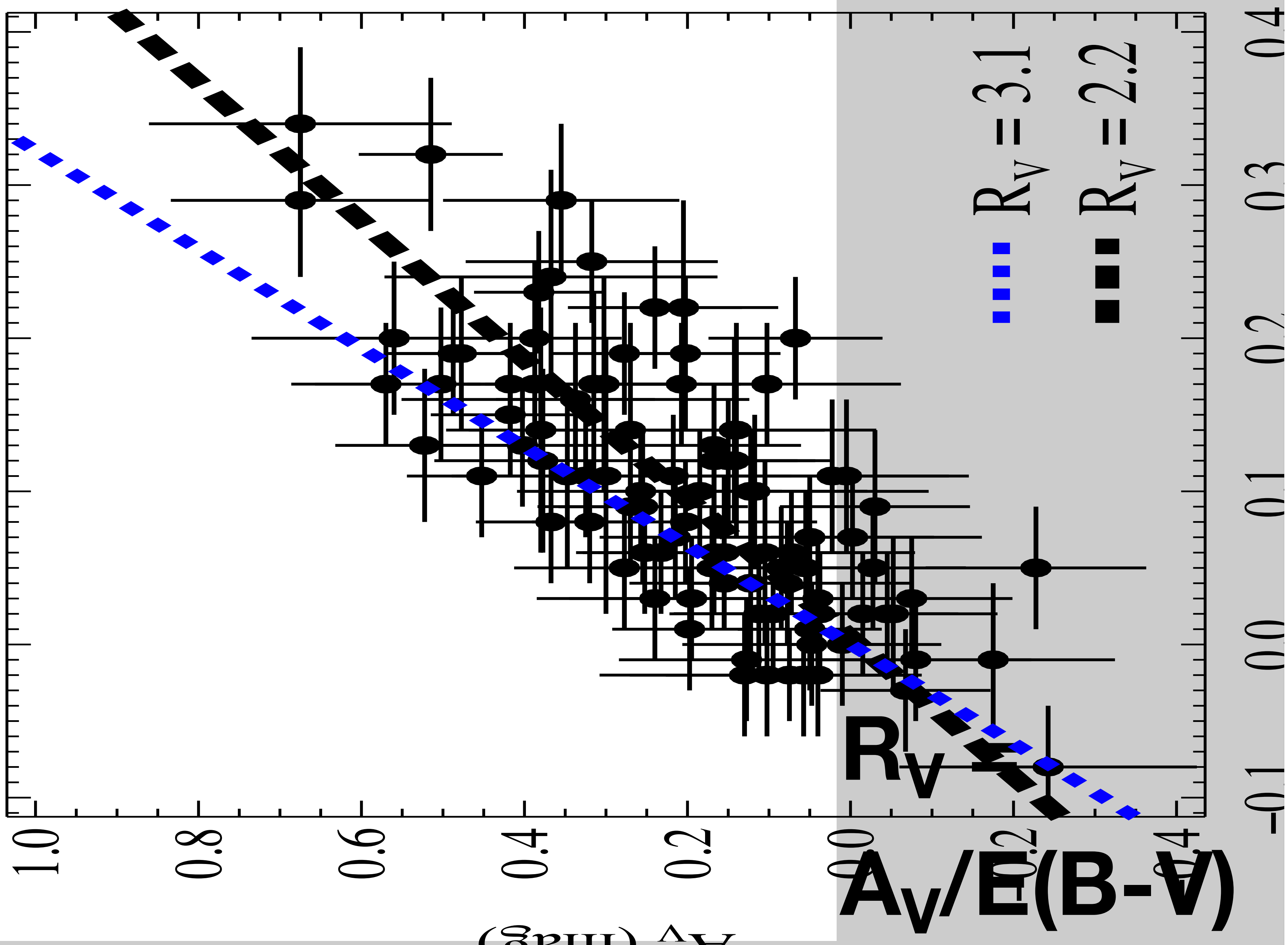
Convolved with Redshift Distribution

Relaxed

Strict

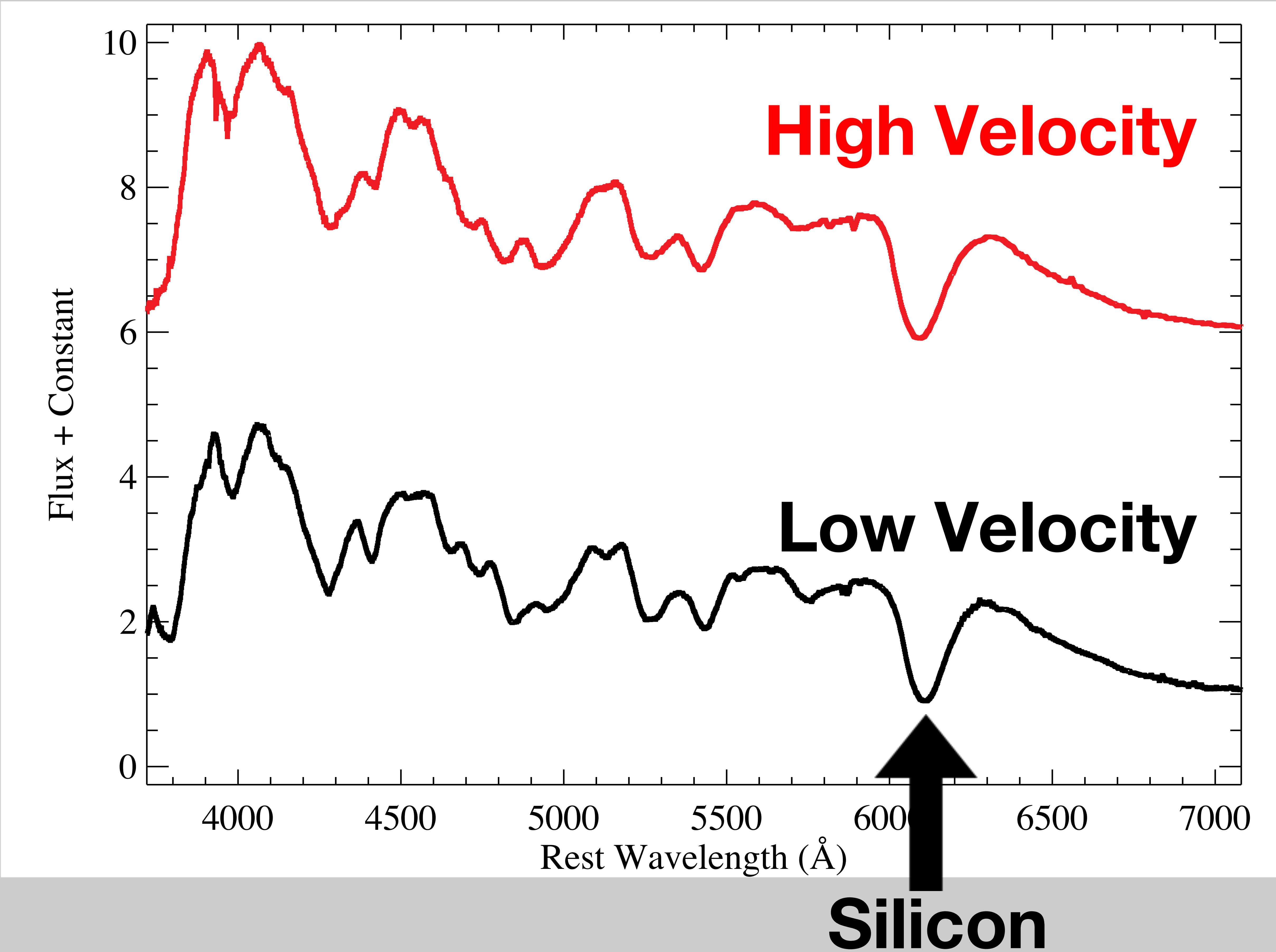


Samples of SNe Ia have Low R_V

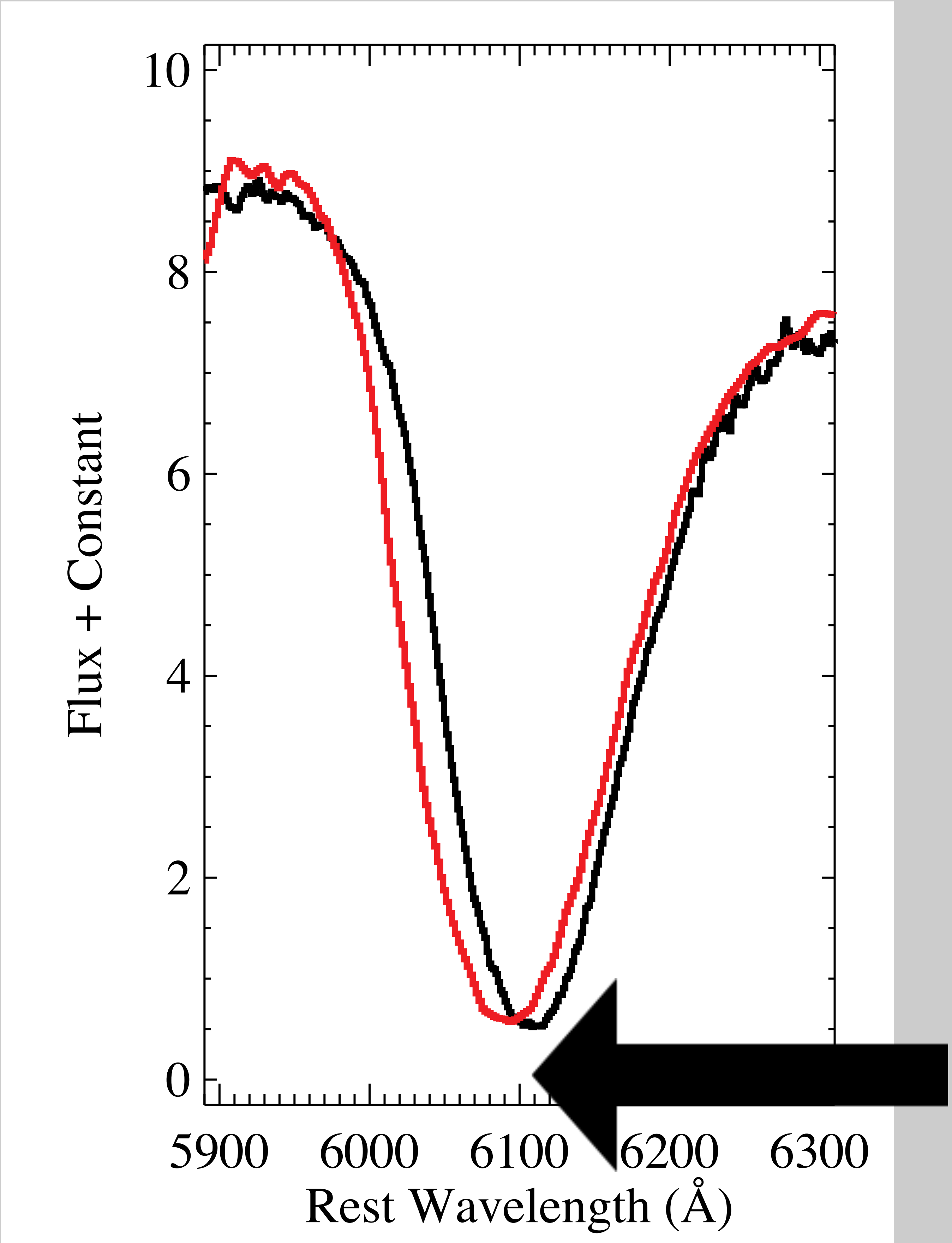


Foley & Kasen 2011

Optical Spectrum to Measure Velocity



Measure Silicon Velocity



High Velocity:

~ -13,000 km s^{-1}

Low Velocity:

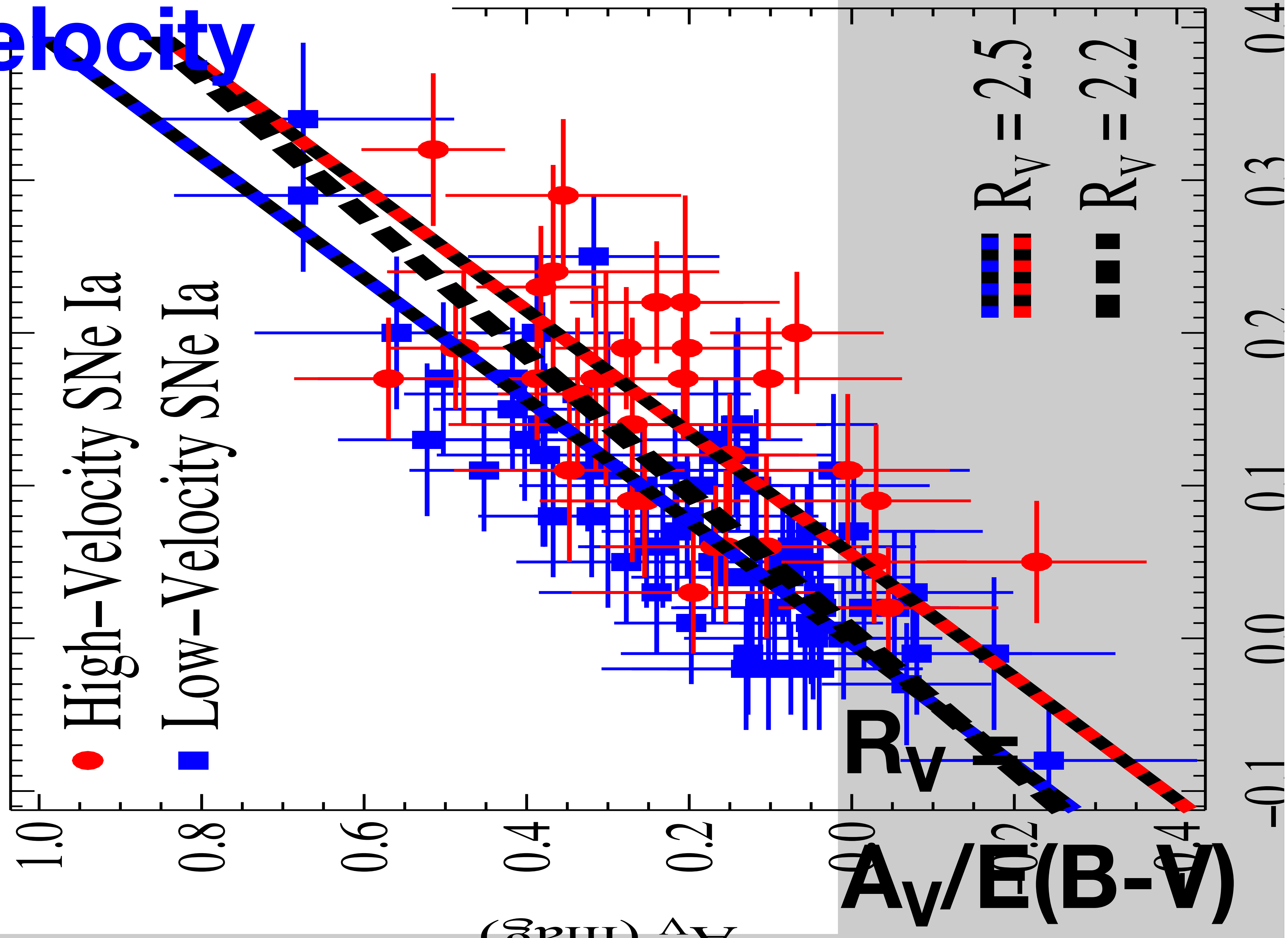
~ -10,000 km s^{-1}

Wider Lines With Higher Velocity

Intrinsic Color Depends on SN Velocity

High Velocity

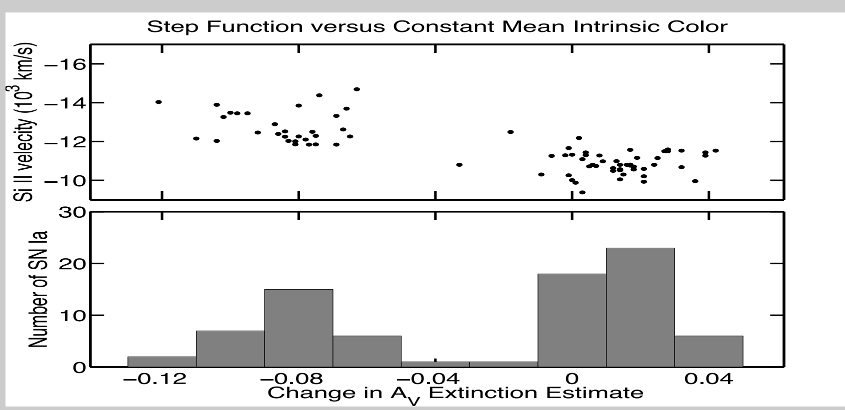
Low Velocity



$R_V = A_V/E(B-V)$

Foley & Kasen 2011

Large Biases from Intrinsic Color



Mandel, Foley, & Kirshner 2014

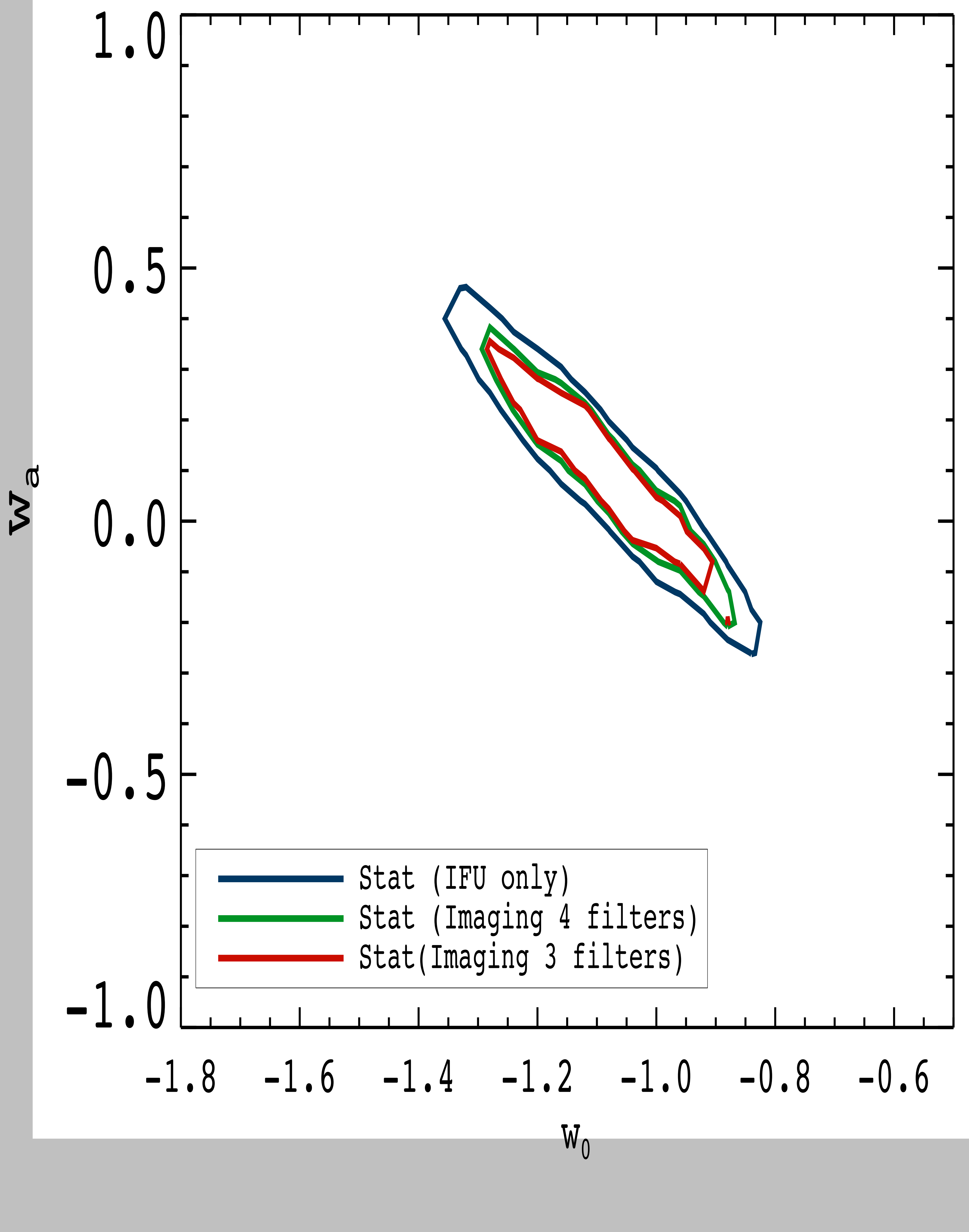
FOR YOUR CONSIDERATION

$R \geq 100$ improves recovery rate, gives more precise (less biased) distances, and allows for additional systematic tests

$S/N > 20$ needed for robust classification

Spectroscopy from Ground?
Could do everything at $z < 1$ with dedicated 8-m telescope

Distances through imaging with single high-S/N spectrum?



Stat (IFU only)
Stat (Imaging 4 filters)
Stat(Imaging 3 filters)
1.0
0.5
0.0
-0.5
-1.0
-1.8
-1.6
-1.4
-1.2
-1.0
-0.8
-0.6
w_a
w_0