Supernovae and the IFU

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WFIRST-AFTA White Paper

R ≈ 100 IFU Spectrograph
0.6 ≤ λ ≤ 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)
Observed Wavelength (µm)

Relative $f_\lambda$

$z = 0.2$
Observed Wavelength (µm)

Relative $f_\lambda$

$z = 0.2$
Observed Wavelength (µm)

Relative $f_\lambda$

$z = 0.2$

S/N = 3
Observed Wavelength ($\mu$m)

Relative $f_\lambda$

$z = 0.2$

S/N = 10
Observed Wavelength ($\mu$m)

Relative $f_\lambda$

$z = 0.2$

S/N = 50
Observed Wavelength (µm)

Relative $f_\lambda$

$z = 1.5$
Observed Wavelength (µm)

Relative $f_\lambda$

$z = 1.5$
Observed Wavelength ($\mu$m)

Relative $f_\lambda$

$z = 1.5$

S/N = 3
Observed Wavelength ($\mu$m)

$z = 1.5$

$S/N = 20$
Observed Wavelength (µm)

$z = 1.5$

S/N = 50
Resolution Matters for Classification

- R = 50
- R = 70
- R = 100
- R = 130
- R = 150

Fraction Recovered vs. S/N ratio.
S/N REALLY Matters for Classification

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

Redshift

Fraction Recovered

0.0  0.2  0.4  0.6  0.8  1.0  1.2  1.4  1.6  1.8  2.0
0.0  0.2  0.4  0.6  0.8  1.0  1.2  1.4  1.6  1.8  2.0

0.0  0.5  1.0  1.5
0.0  0.5  1.0  1.5
Contamination Potentially High

![Graph showing observed wavelength (µm) vs. relative $f_\lambda$. The x-axis represents the observed wavelength ranging from 0.6 to 2.0, and the y-axis represents the relative $f_\lambda$ ranging from 0 to 10. The graph indicates potentially high contamination at $z = 1.5$ with a S/N = 3.](image)
Contamination Potentially High

\[ z = 1.5 \]
\[ S/N = 20 \]
Contamination Potentially High

$z = 1.5$

S/N = 50

Relative $f_\lambda$

Observed Wavelength ($\mu m$)
S/N Matters for MISclassification

![Graph showing the fraction of incorrect classifications vs. redshift for different S/N values: S/N = 50, S/N = 20, S/N = 10, S/N = 3. The graph illustrates that the fraction of incorrect classifications increases with decreasing S/N.](image-url)
S/N Matters for MISclassification

![Graph showing the effect of S/N on misclassification](image)

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

**Y-axis:** Fraction Incorrect

**X-axis:** Redshift
S/N REALLY Matters for Classification

S/N = 50

S/N = 20

S/N = 10

S/N = 3

Fraction Recovered vs. Redshift
S/N REALLY Matters for Classification

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

Fraction Recovered vs. Redshift
Convolved with Redshift Distribution

Relaxed
Strict
Samples of SNe Ia have Low $R_V$

Foley & Kasen 2011
Optical Spectrum to Measure Velocity

- **High Velocity**
- **Low Velocity**

Silicon
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

Foley & Kasen 2011

High Velocity

Low Velocity

$R_V = 2.5$

$R_V = 2.2$

$A_V$ (mag)

$E(B-V)$ (mag)
Large Biases from Intrinsic Color

Mandel, Foley, & Kirshner 2014
R \geq 100 \text{ improves recovery rate, gives more precise (less biased) distances, and allows for additional systematic tests}

S/N > 20 \text{ 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?