3D datacube reconstruction using *Roman* slitless prism spectra

Tri L. Astraatmadja[1], Andrew S. Fruchter[1], Susana E. Deustua[1,2], Helen Qu[3], and Masao Sako[3]
for the Perlmutter Supernova Science Investigation Team

[1] Space Telescope Science Institute, Baltimore, MD
[2] National Institute of Standards and Technology, Gaithersburg, MD
[3] Department of Physics and Astronomy, University of Pennsylvania, Philadelphia, PA

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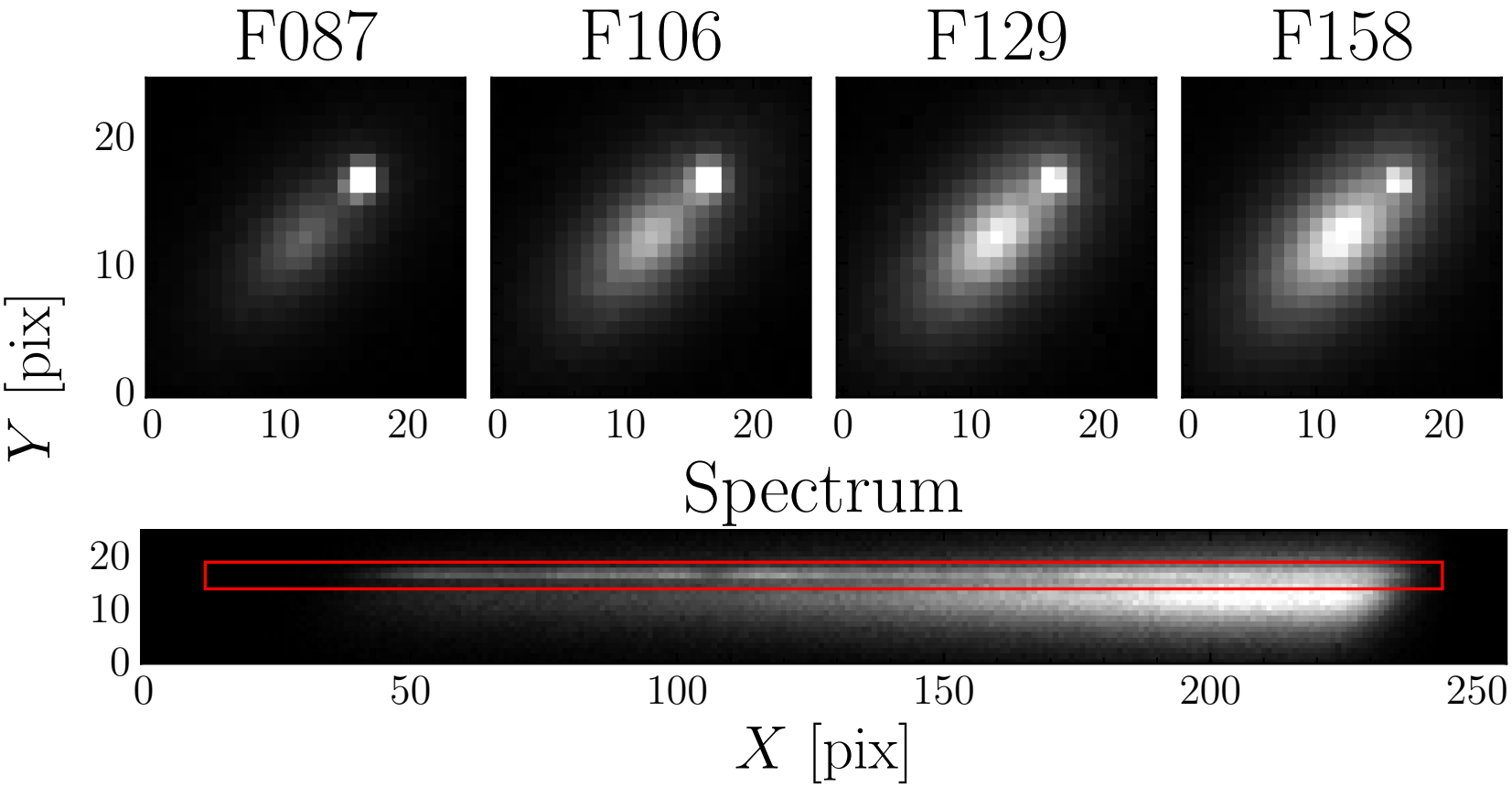
Datacube reconstruction for host galaxy subtraction

- One of *Roman*'s objectives is to study Dark Energy using Type Ia Supernovae (SNe Ia).
- However, when observed using slitless spectroscopy, the spectra of SNe Ia will be contaminated by their host galaxies.



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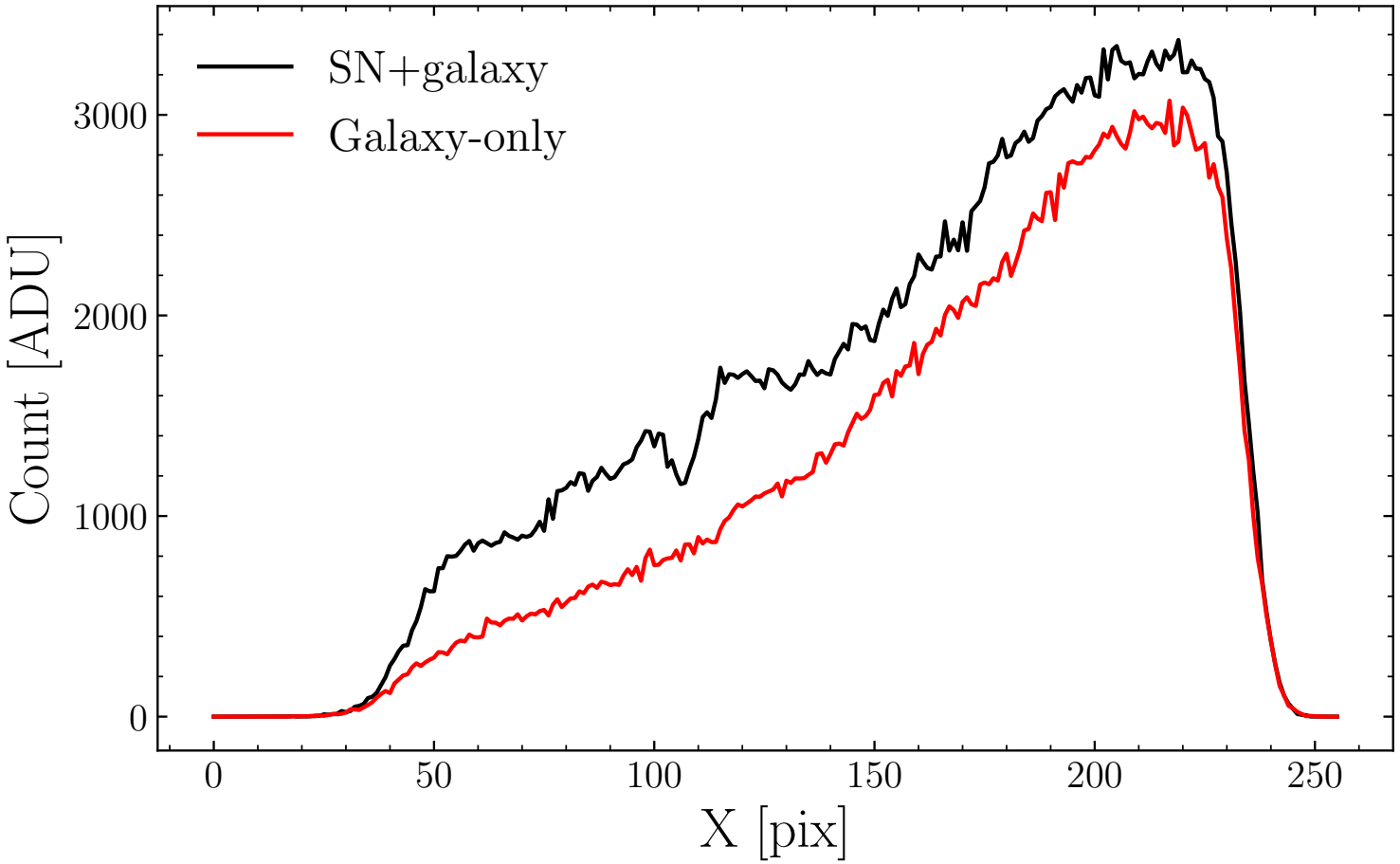
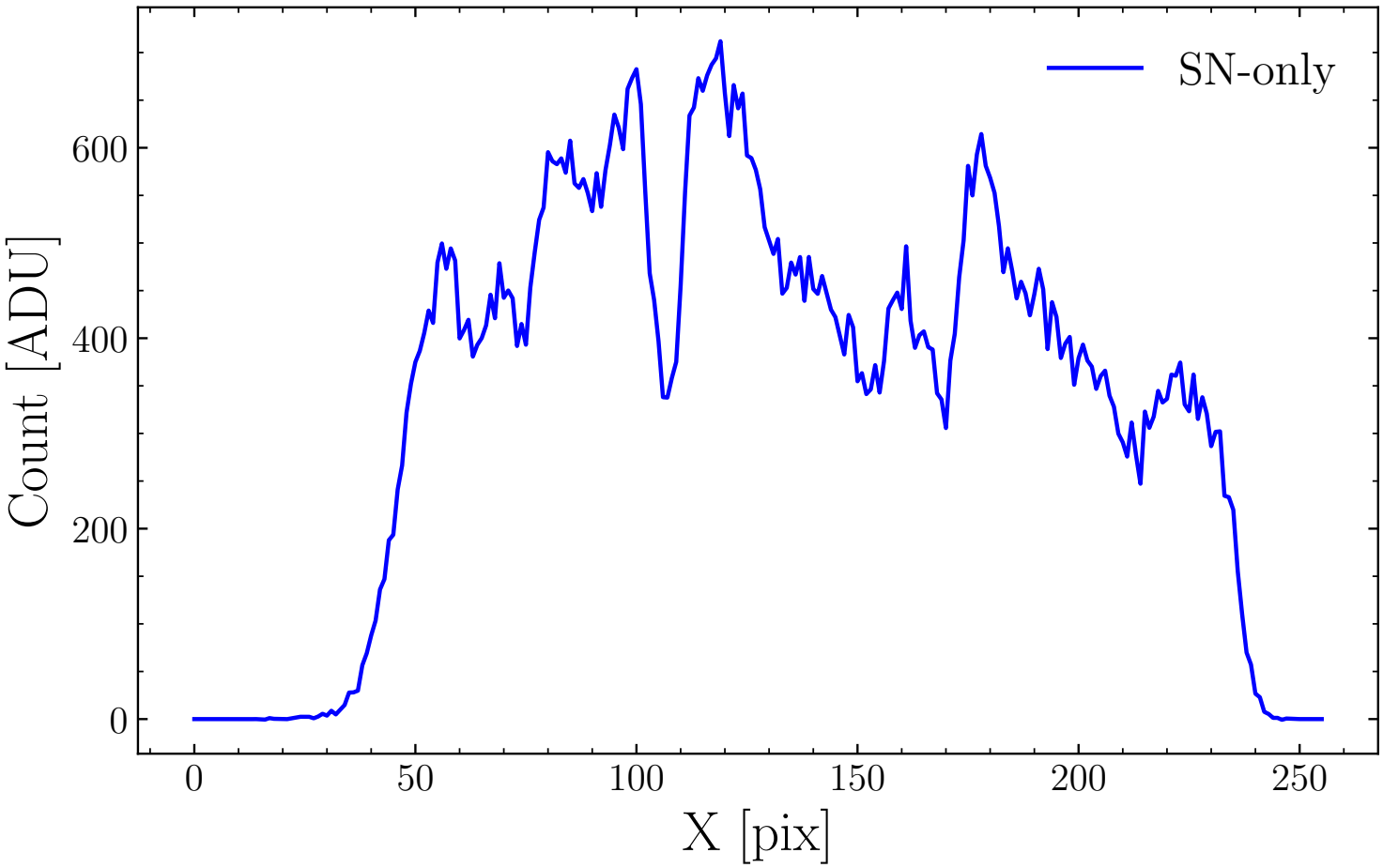


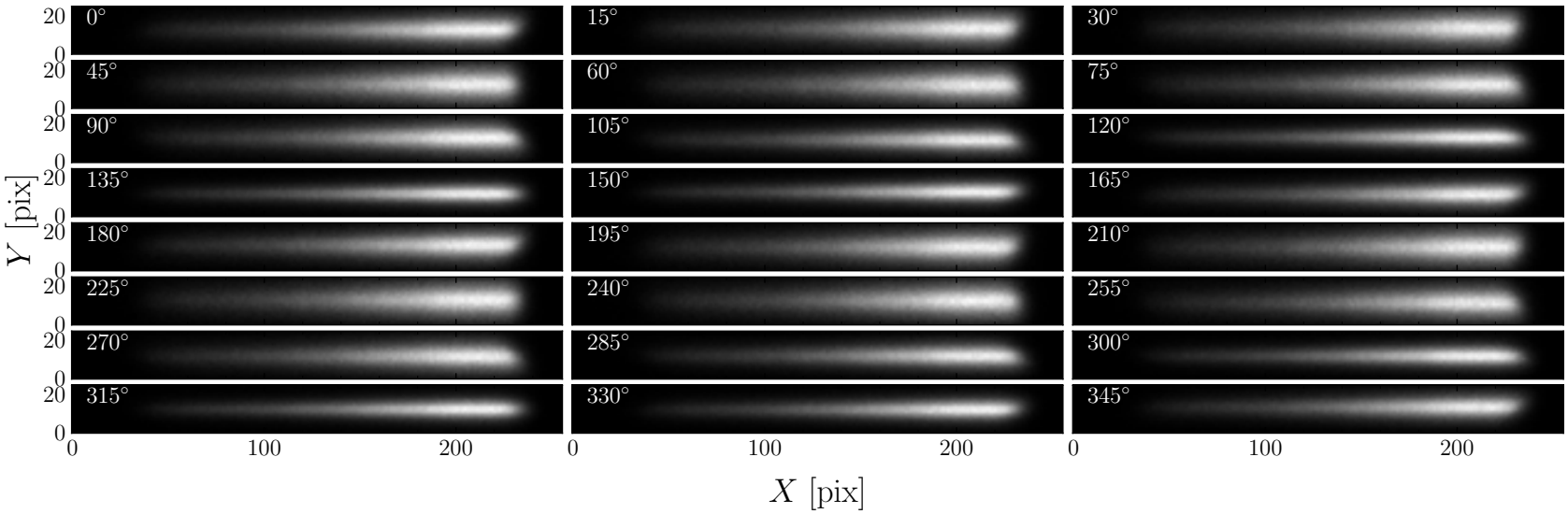
Datacube reconstruction for host galaxy subtraction

- Obtaining clean, uncontaminated SN Ia spectra allows us to accurately determines their luminosity distances and intrinsic brightnesses.



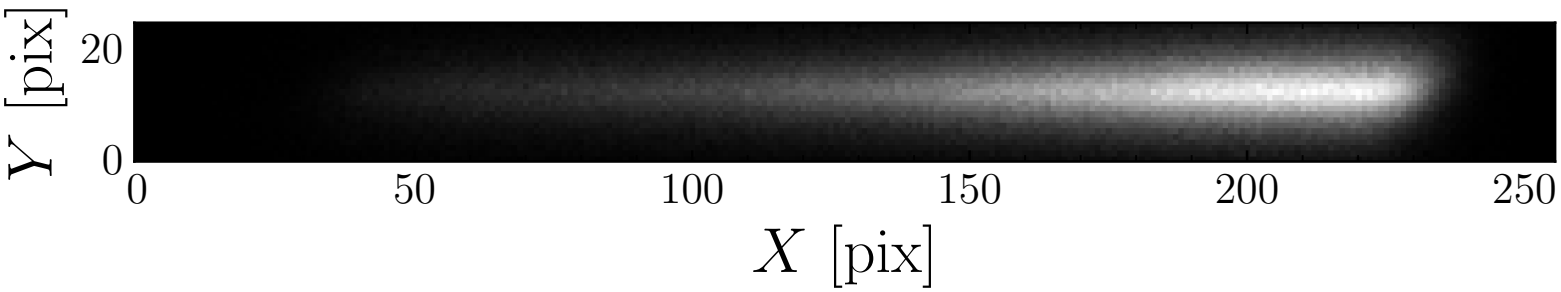
Datacube reconstruction for host galaxy subtraction

- Our approach is to develop a datacube reconstruction algorithm that uses the host galaxy spectra observed at various roll angles and dithers:



- The reconstructed datacube can then be used to predict what a galaxy spectrum would look like when a supernova occurs.

Regularized regression and the projection model

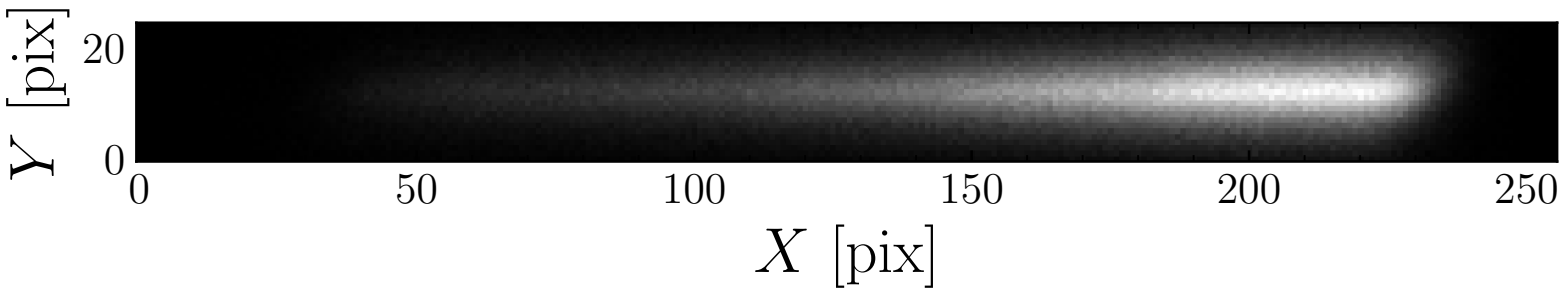


- We infer the fluxes in the datacube using Ridge regression:

$$\min_f ||\phi f - I||^2 + \alpha ||f||^2, \tag{1}$$

  with the regularization parameter α found by cross-validation.
- A slitless 2d-spectrum is a projection of not only wavelength but also position. We can construct the projection model.

Regularized regression and the projection model



- A measured count I_{ij} in pixel coordinates (i, j) is a summation of fluxes f in the datacube:

$$I_{ij} = \sum_{l=l_{\min}(j)}^{l=l_{\max}(j)} A_{\text{eff}}(l)\Delta\lambda(l)\left[h(l) \star f(l)\right], \tag{2}$$

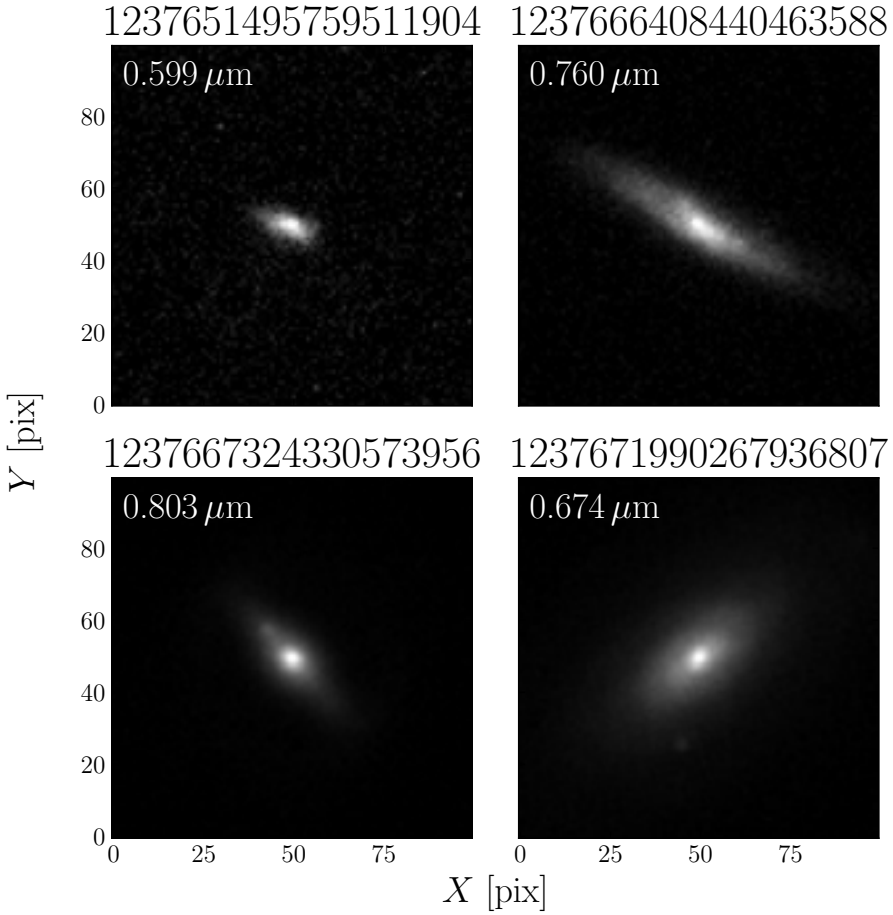
- The flux I_{ij} is in principle a linear summation of fluxes in spatial coordinates (due to convolution) and wavelength (due to dispersion):

$$I_{ij} = \sum_{r} \phi(\boldsymbol{x}) f_r, \tag{3}$$

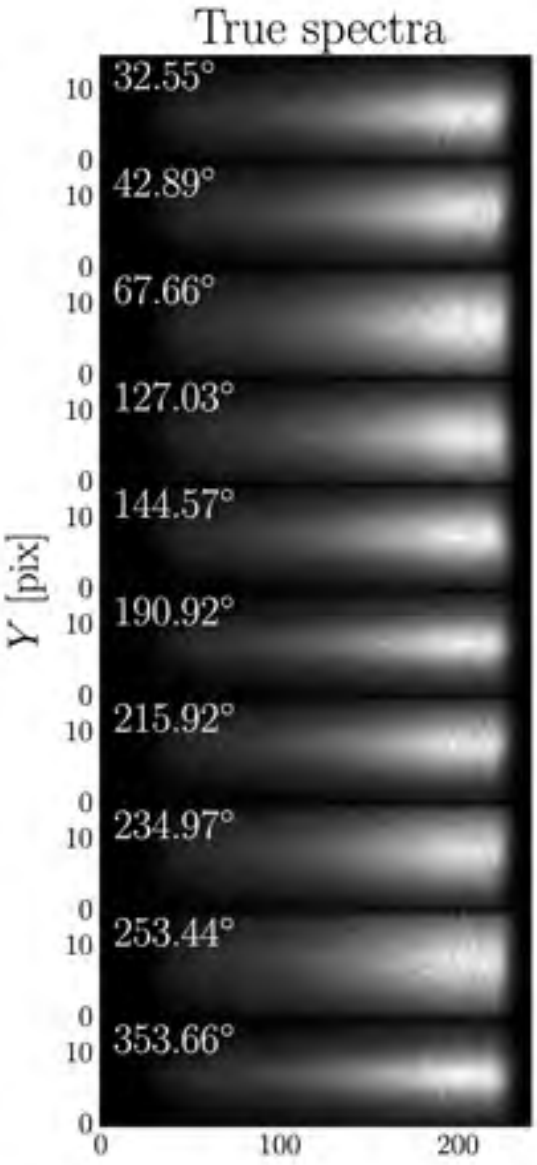
here $\phi(\boldsymbol{x})$ is the basis function at scene coordinate $\boldsymbol{x}$.

Constructing galaxy datacubes

- Galaxy datacubes are constructed using SDSS images as templates.
- To construct spectrum at each point in the galaxy, we use redshift-dependent star formation models.



Predicting Galaxy-only spectra at random roll angles



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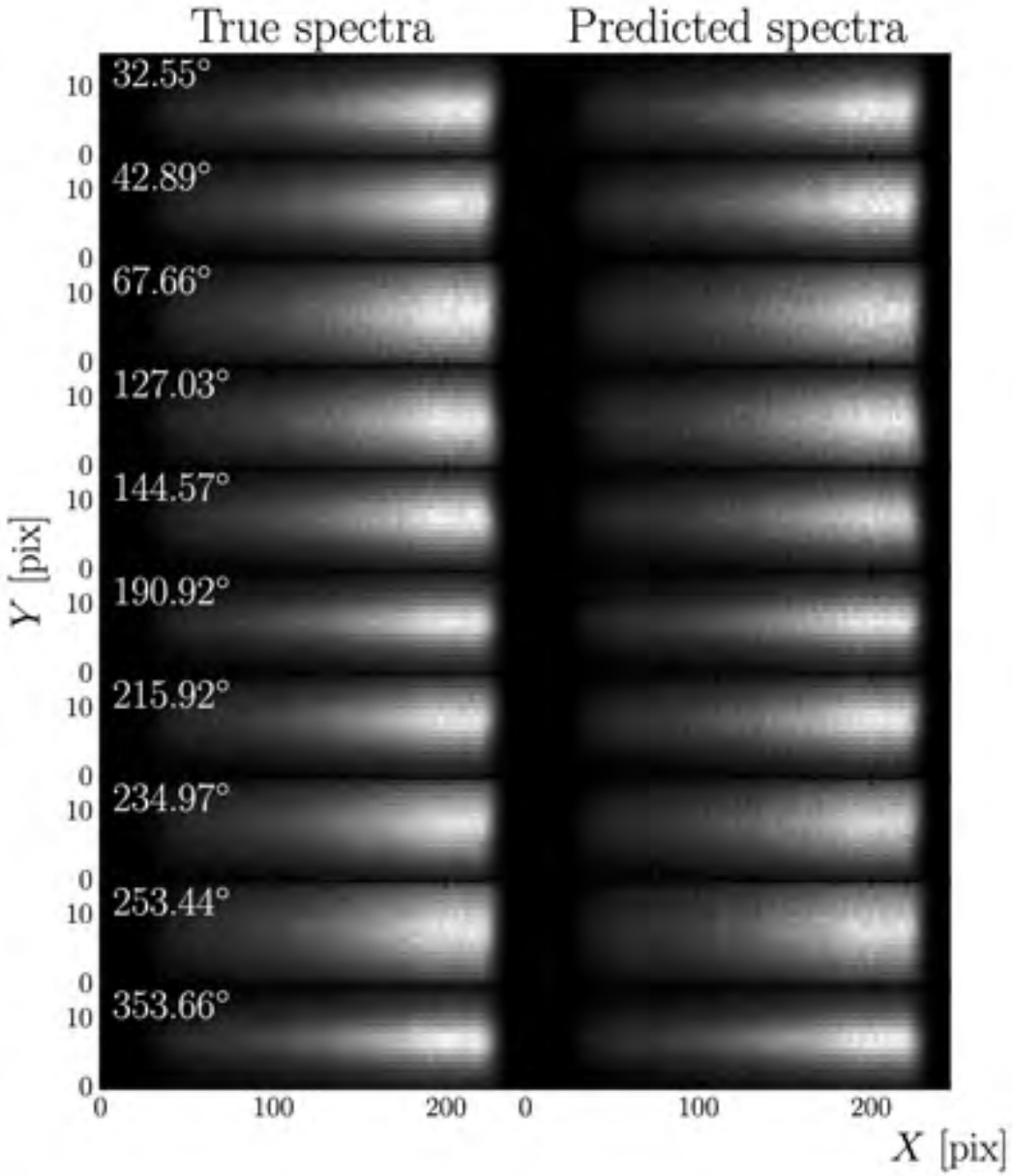

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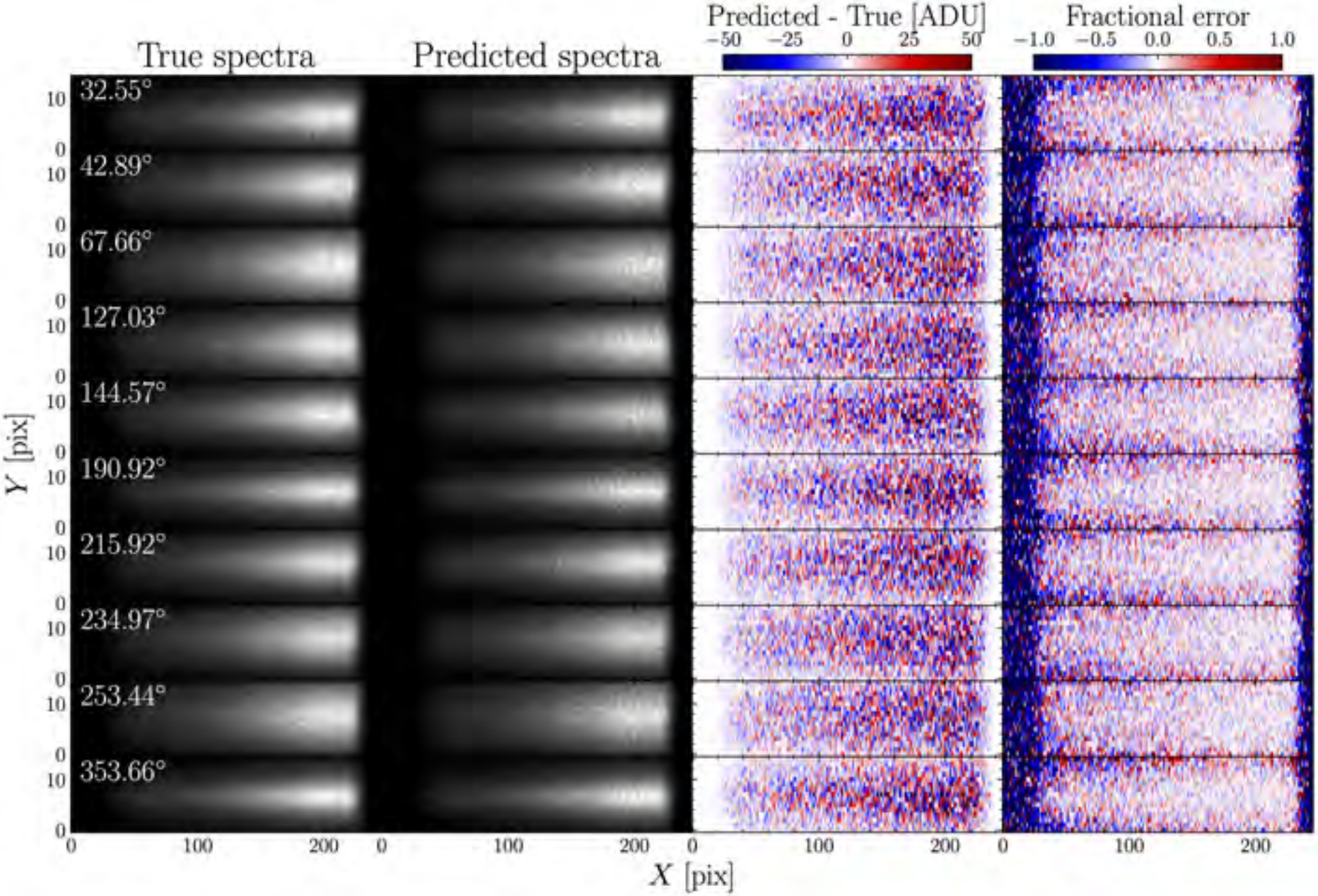
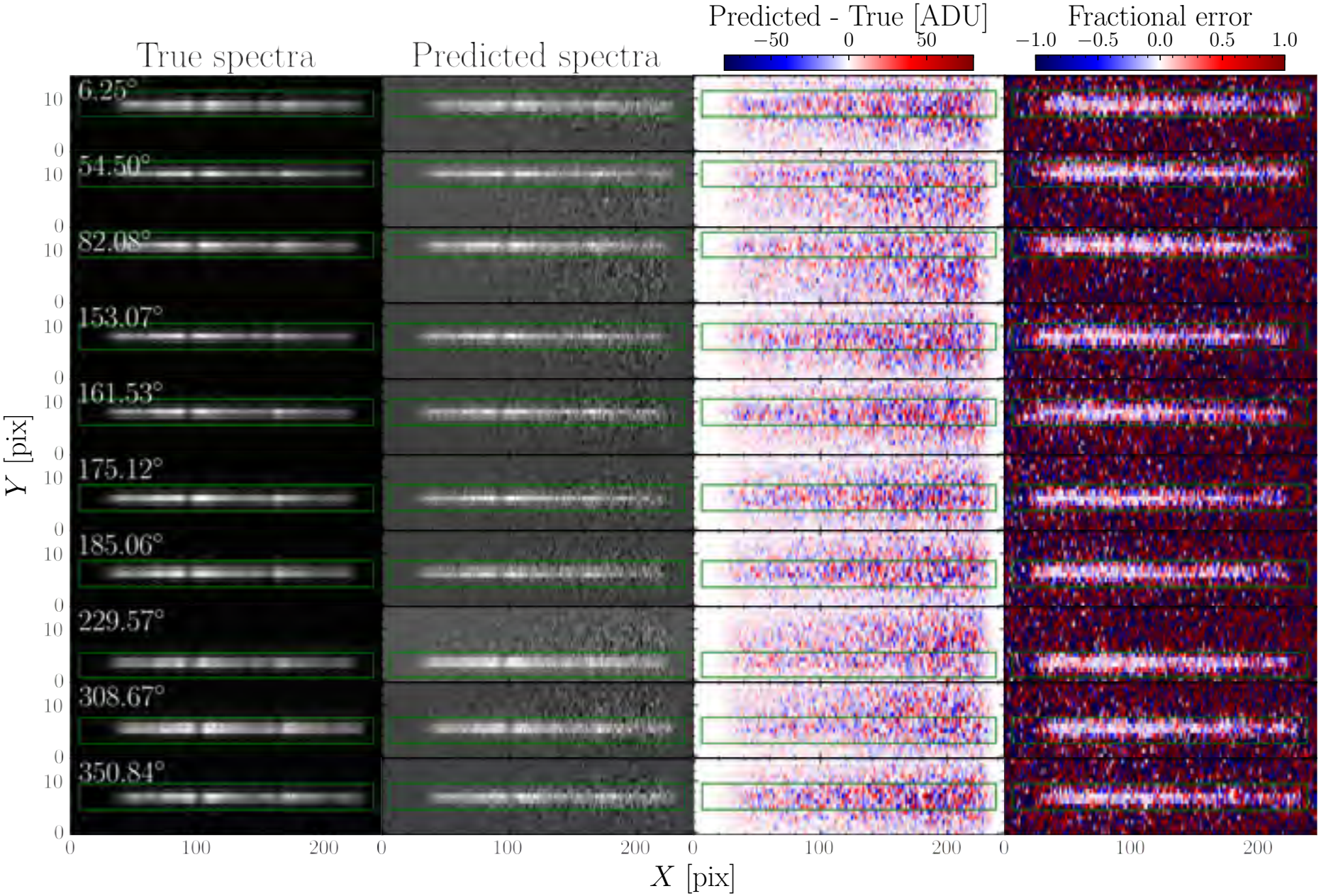


Predicted SN-only spectra at random roll angles



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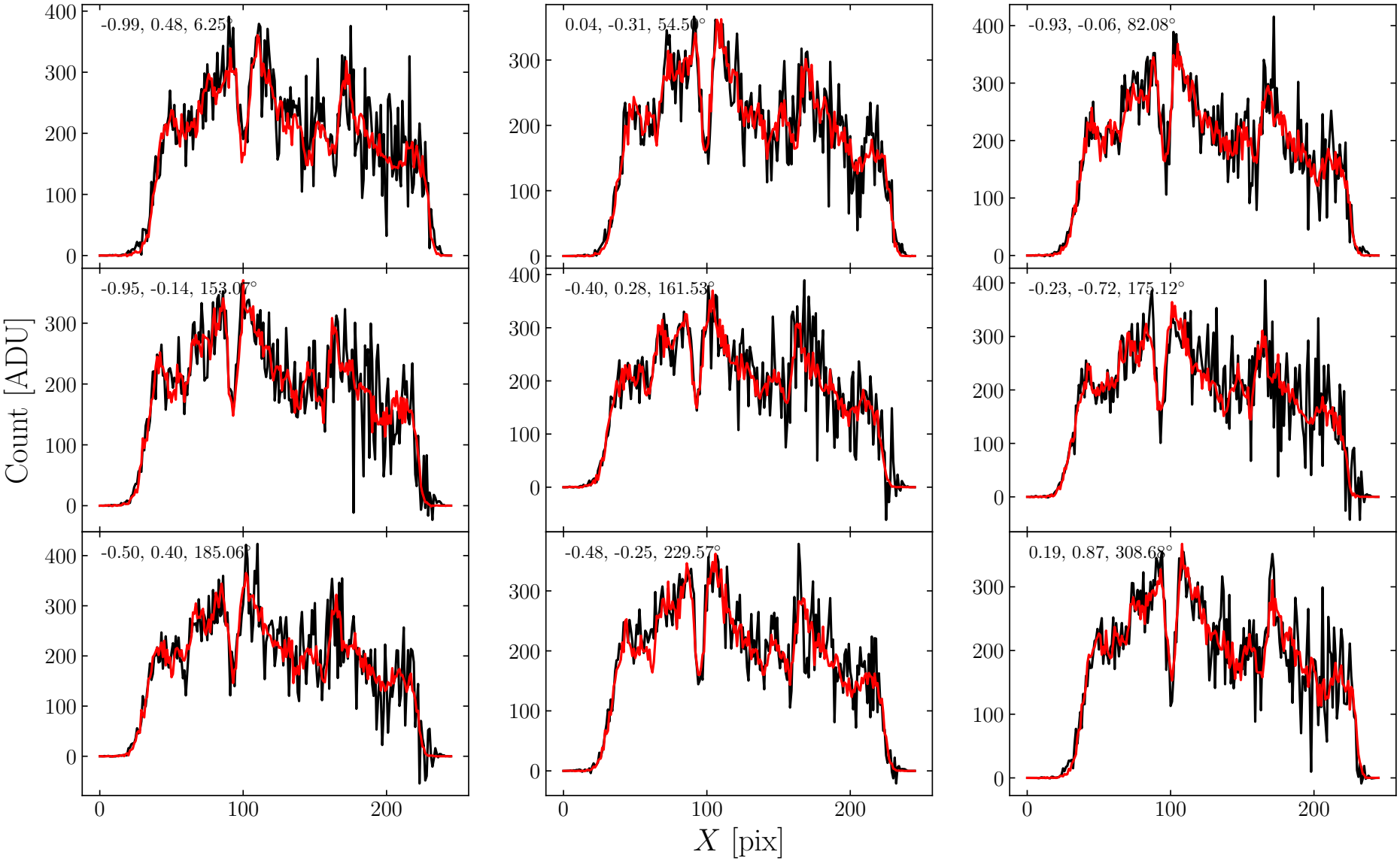

Summary and conclusions

- We address the problem of obtaining clean SN Ia spectra by reconstructing the host galaxy datacube from a set of spectra observed at various roll angles and dithers. Using the reconstructed datacube, we can predict what the host galaxy spectrum would look like when a supernova occurs.
- Because there are more parameters (fluxes in 2d space and wavelengths) than there are data (pixels), datacube reconstruction is an ill-posed problem. Some form of regularization is essential.

Next steps

- We are trying to reduce this uncertainties further by constructing datacube priors from set of images taken in conjunction with the spectroscopic survey.
- We will study various cases that might occur during the course of the SN survey:
  - Galaxies at various redshifts.
  - Various SN models.
  - Various SN positions in the host galaxies.