Comparison of HI and optical redshifts of galaxies -
The impact of redshift uncertainties on spectral line stacking

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Comparison of H I and optical redshifts of galaxies - The impact of redshift uncertainties on spectral line stacking

Natasha Maddox*[1], Kelley M. Hess[1], S.-L. Blyth[1], M. J. Jarvis[2,3]

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28 March 2013 arXiv:1305.6154, MNRAS, in press

Natasha Maddox
SKA Postdoctoral Fellow, UCT
with Kelley Hess, Sarah Blyth, Matt Jarvis

Motivation

- Surveys of unprecedented depth and area using new telescopes and instrumentation (CHILES with JVLA, LADUMA with MeerKAT, DINGO with ASKAP, among others)
- Limited observing time allows direct detections of the most HI-bright galaxies, others stay undetected in the noise
- Use all information available to fully exploit existing and upcoming deep HI datasets → HI Spectral stacking
- Use information from optical imaging (position) and optical spectroscopy (redshift) to extract the fainter, more distant galaxies

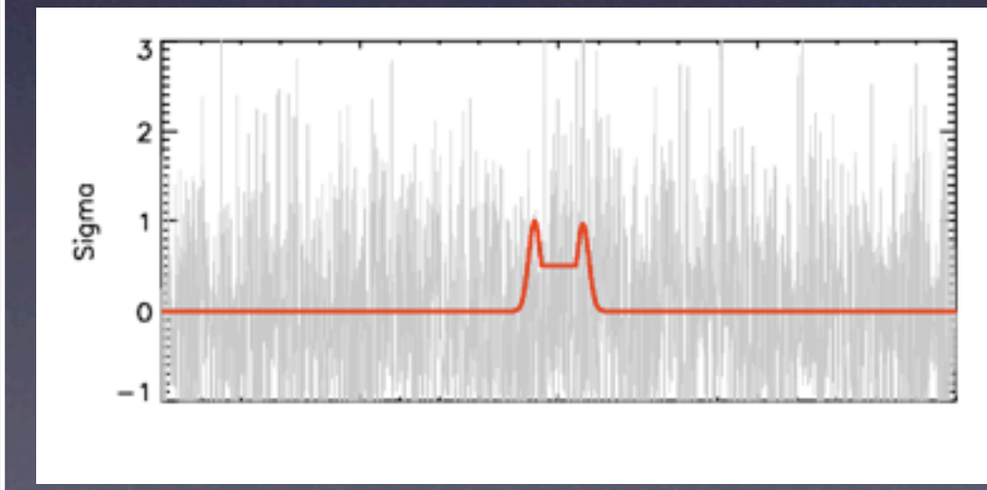
Optical

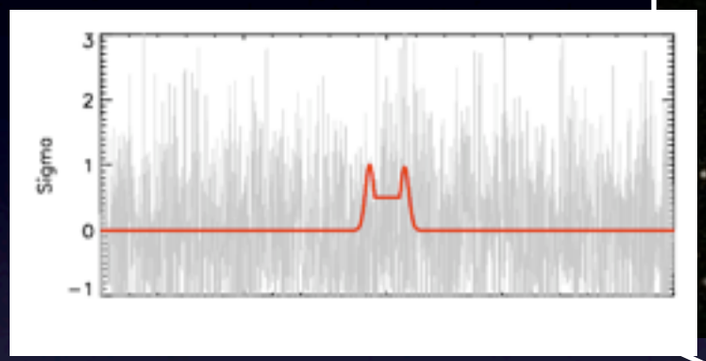
Radio

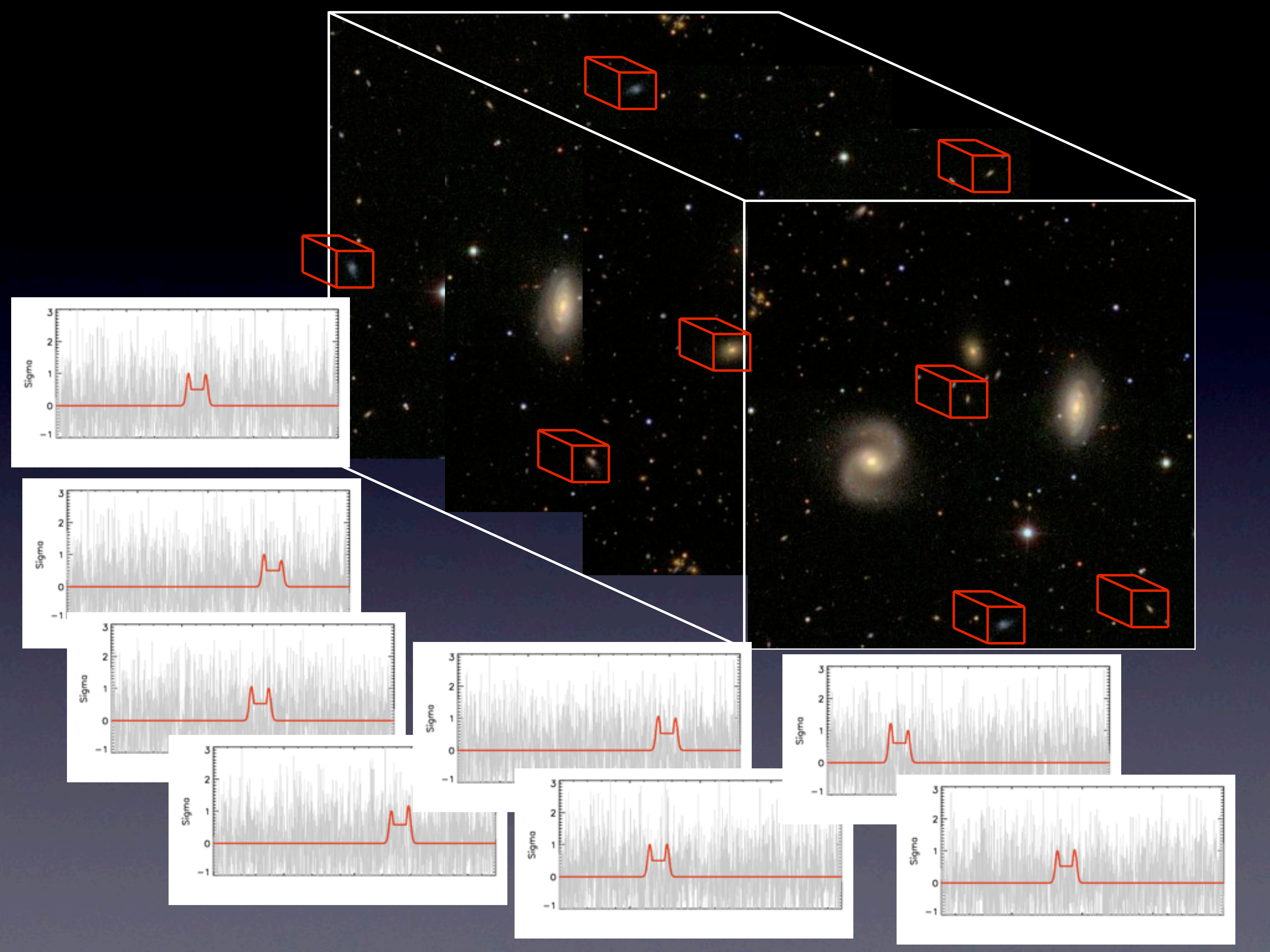
- From optical imaging, get ra, dec (x and y) coordinates
- From optical spectroscopy, get z
- Search radio cube for corresponding x, y, z

Optical

Radio

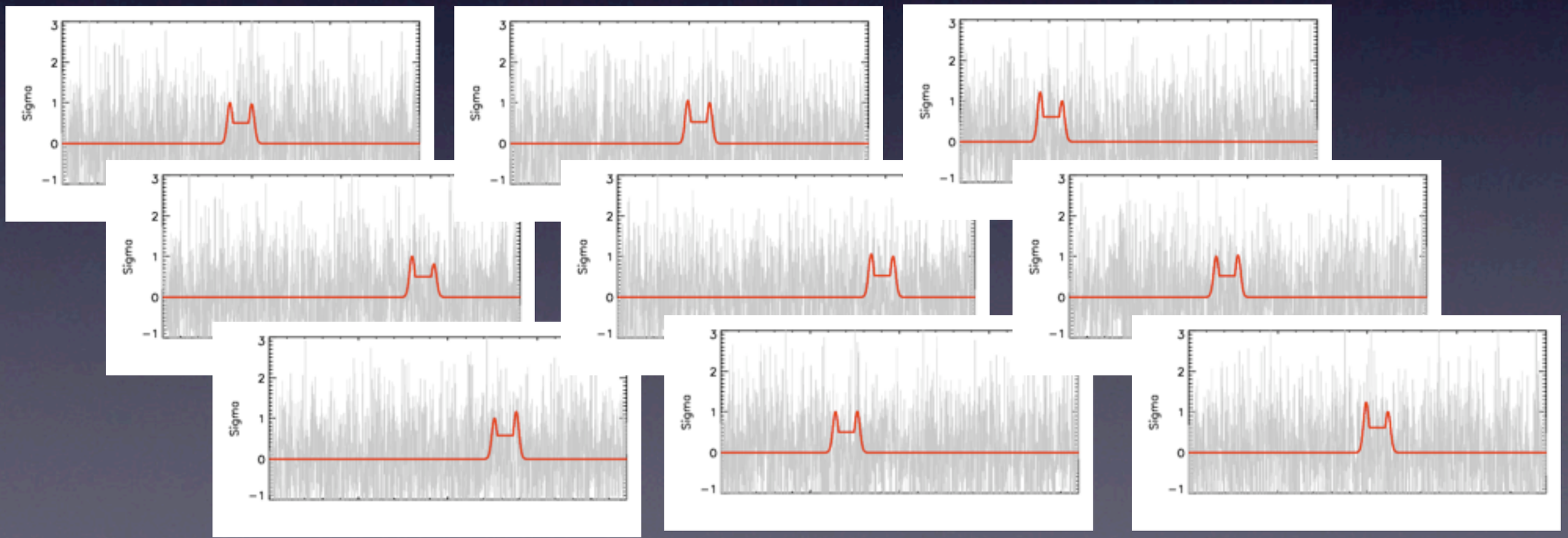



3
2
1
0
−1
Sigma


Sigma
3
2
1
0
−1

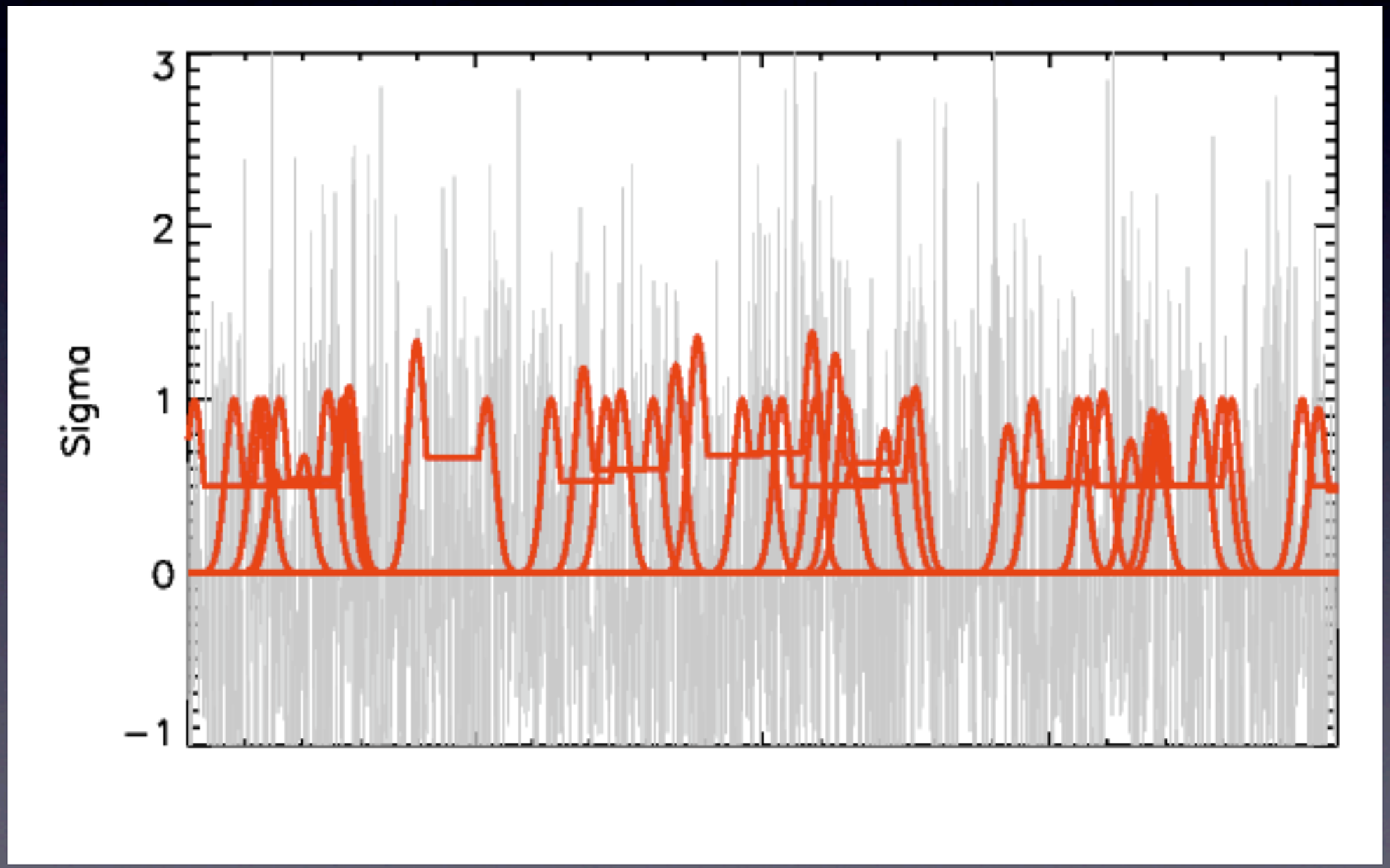
HI Spectral Stacking:

- Collect many of these to stack the radio non-detections
- Stacked signal will give average HI properties of the individual contributing galaxies
- Assumes optical redshift and HI redshift are the same



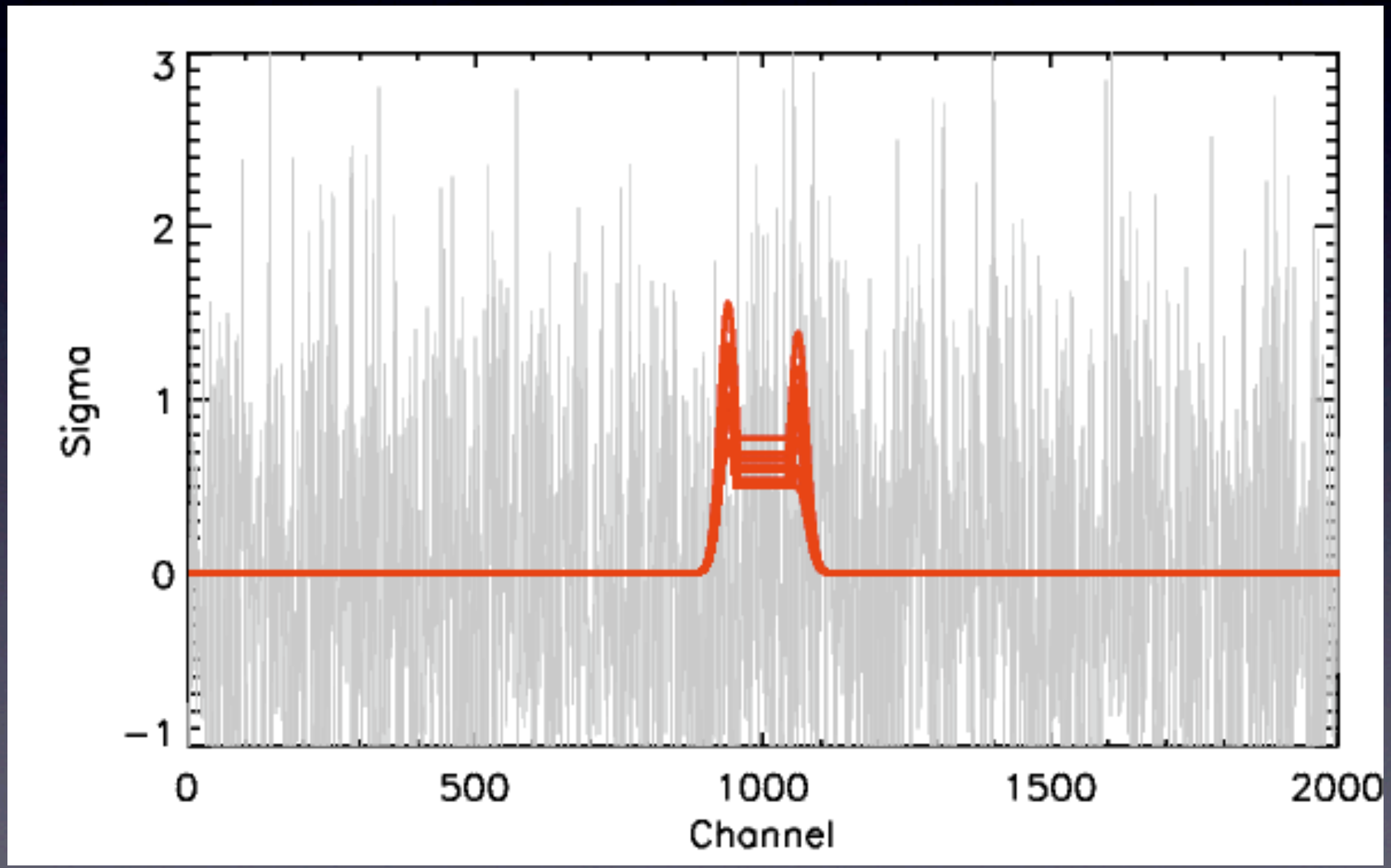
HI Spectral Stacking:

- Have several HI non-detections at various redshifts



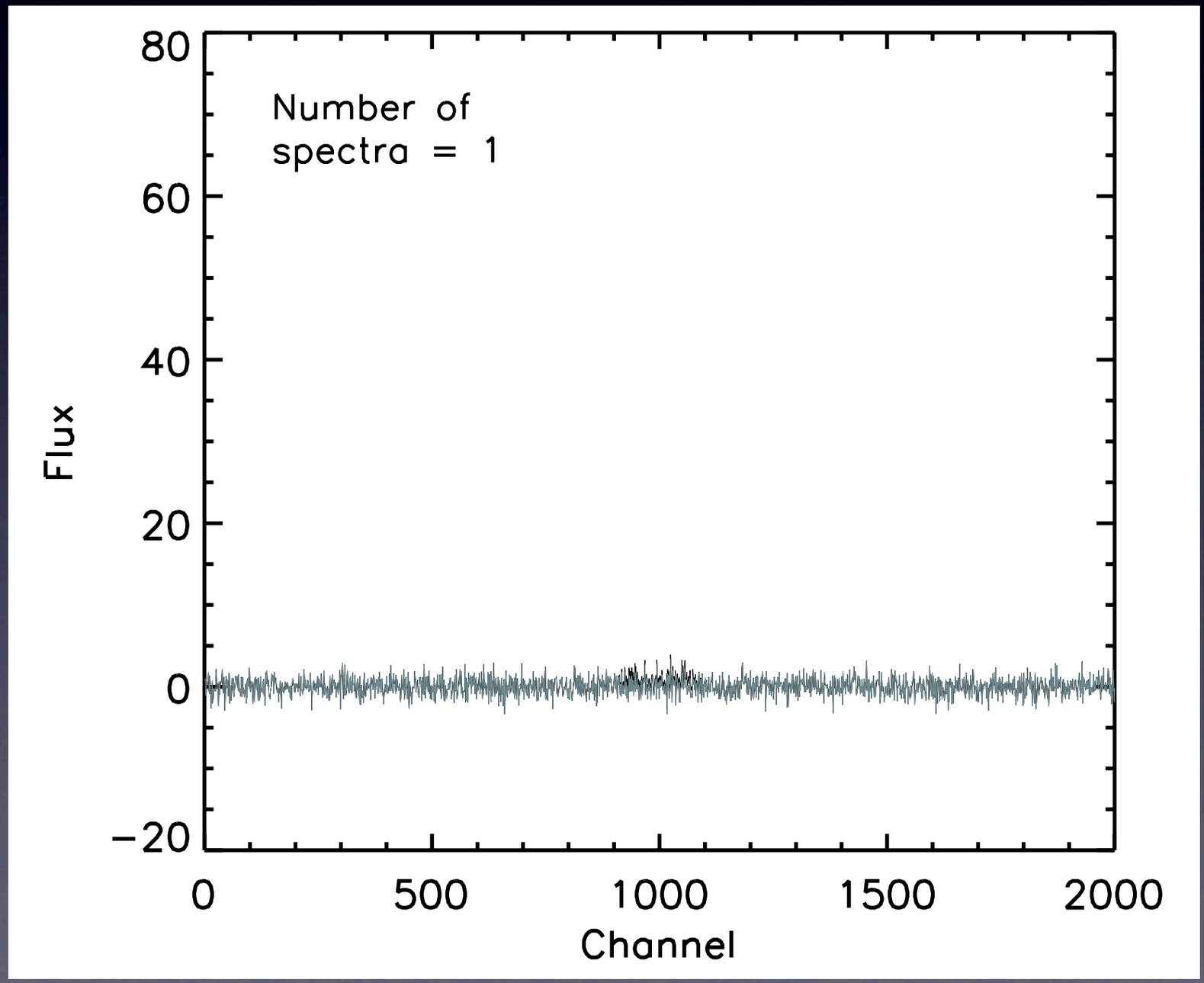
HI Spectral Stacking:

- Shift them all to the same ‘redshift’



HI Spectral Stacking:

- Stack them together
- Signal grows linearly, noise grows as $\sqrt{N_{spectra}}$



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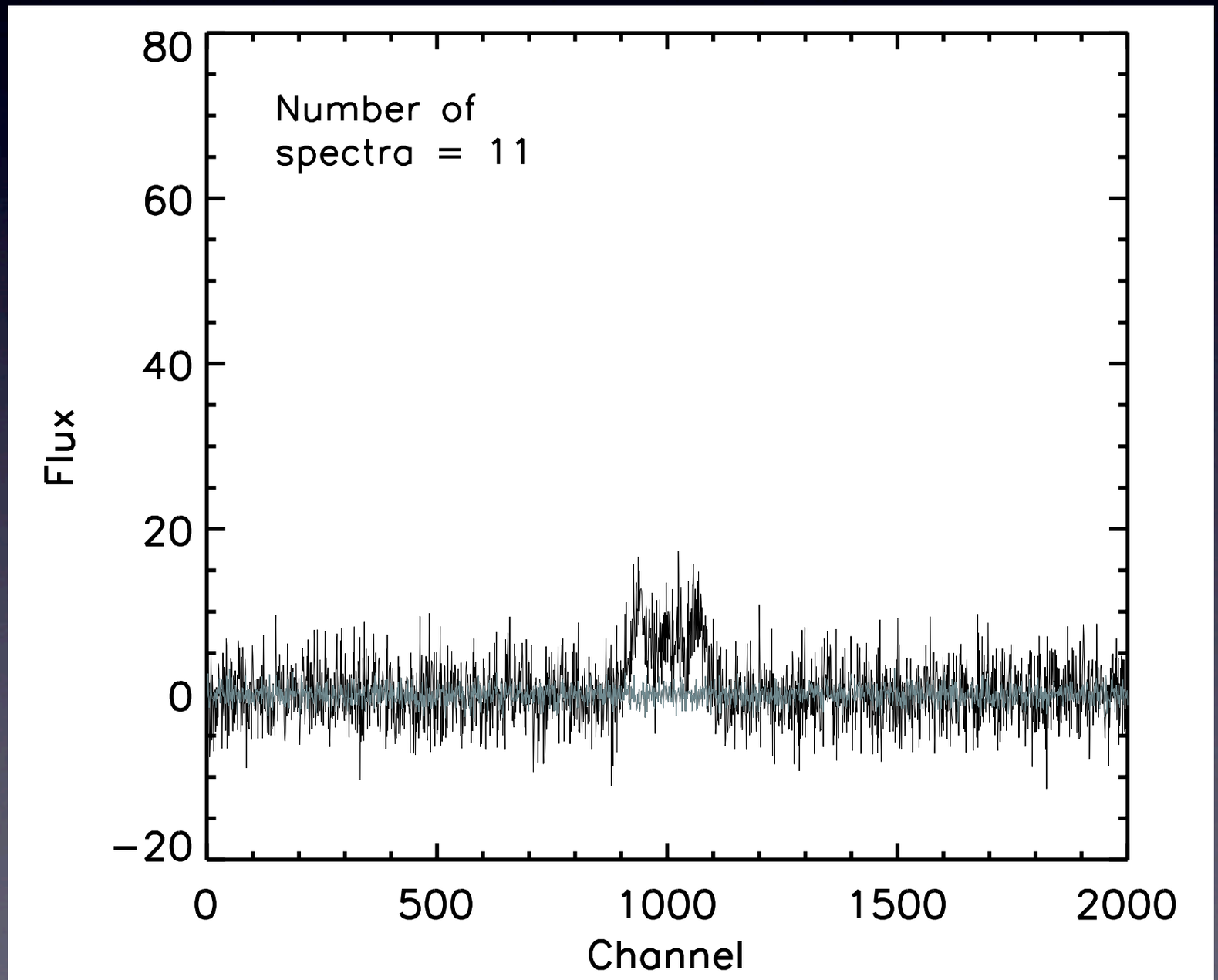

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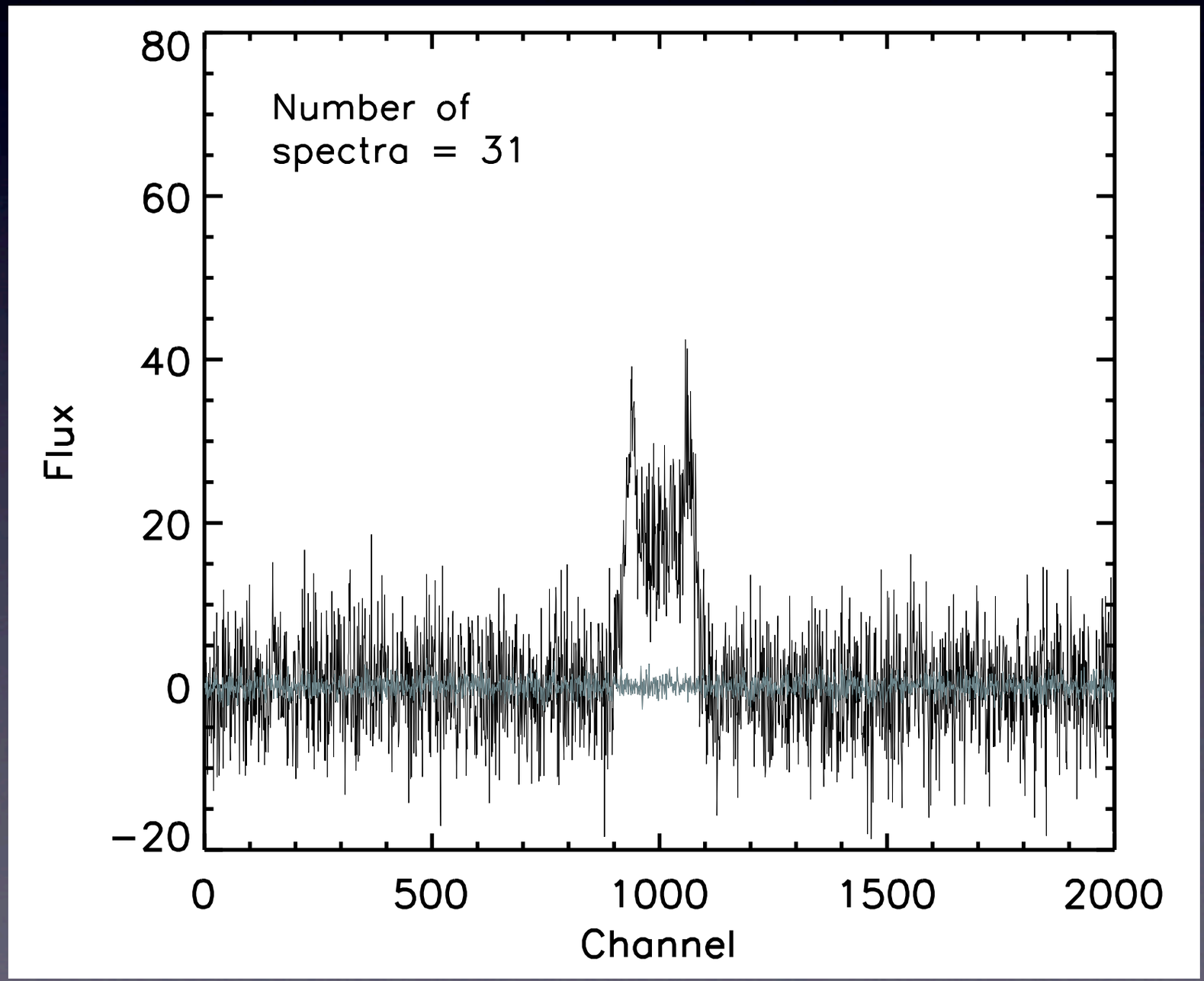

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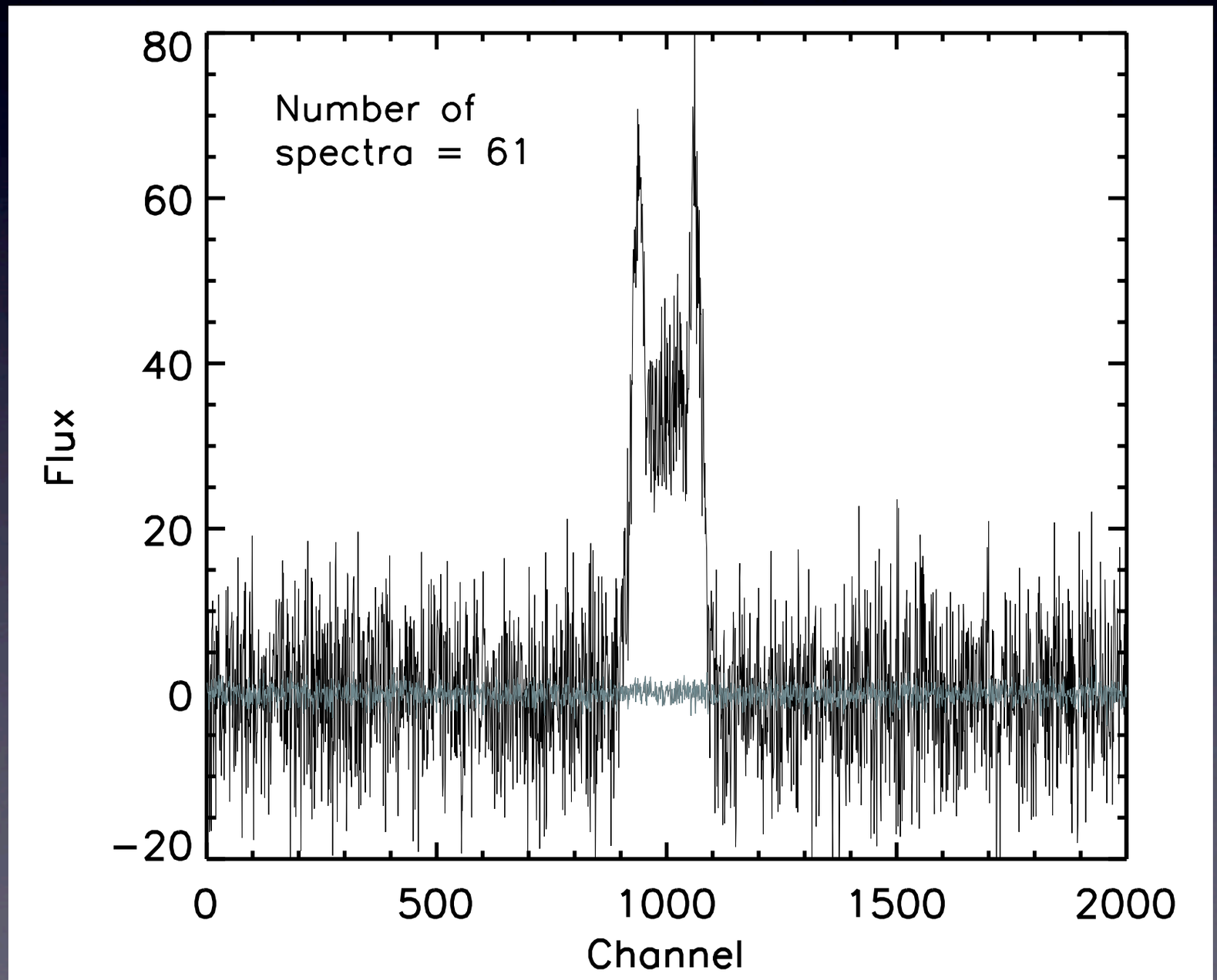

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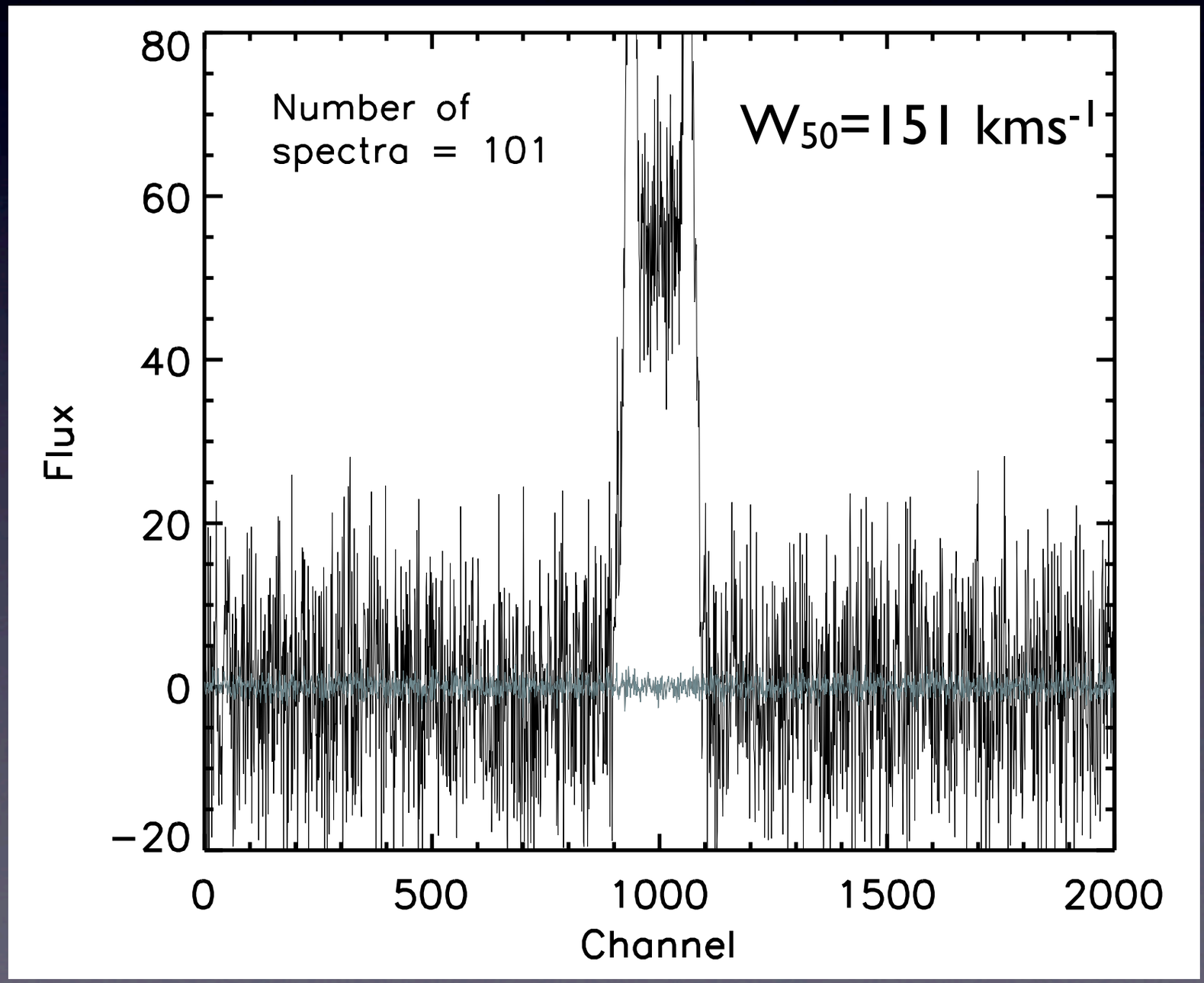
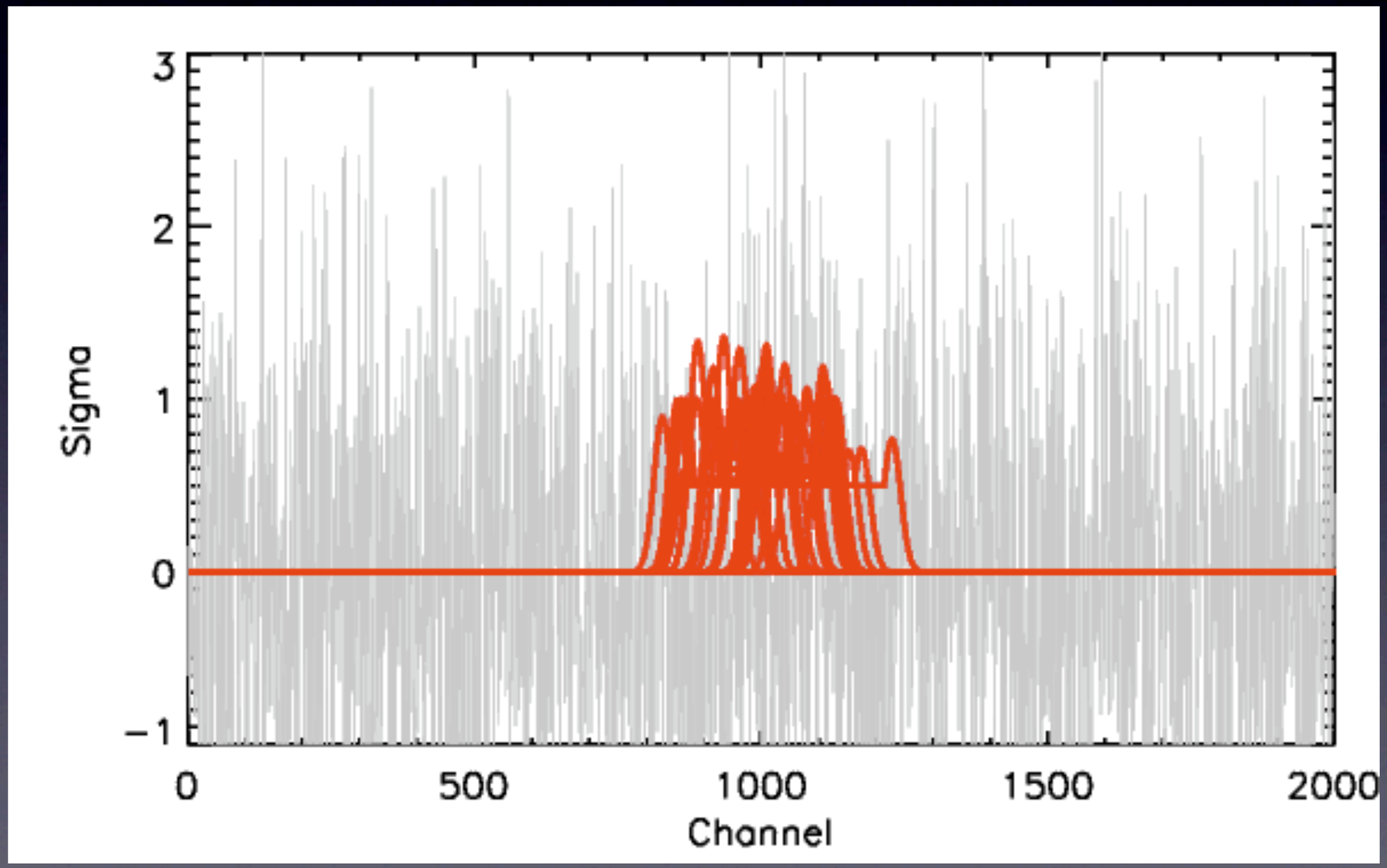


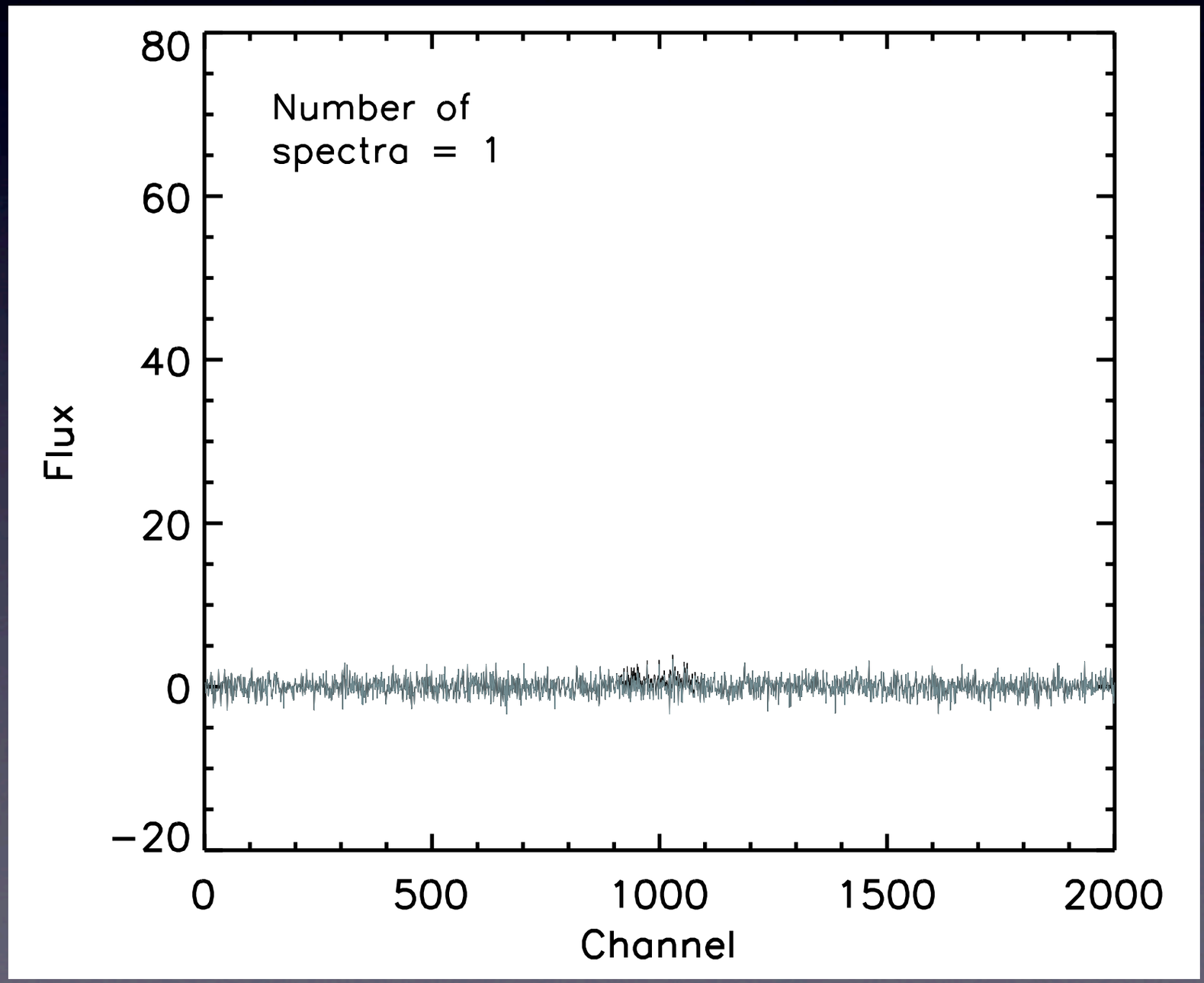
HI Spectral Stacking:

- If your optical redshifts are a bit off



HI Spectral Stacking:

- Stack them together
- Profile doesn't grow as fast, double horn profile is lost



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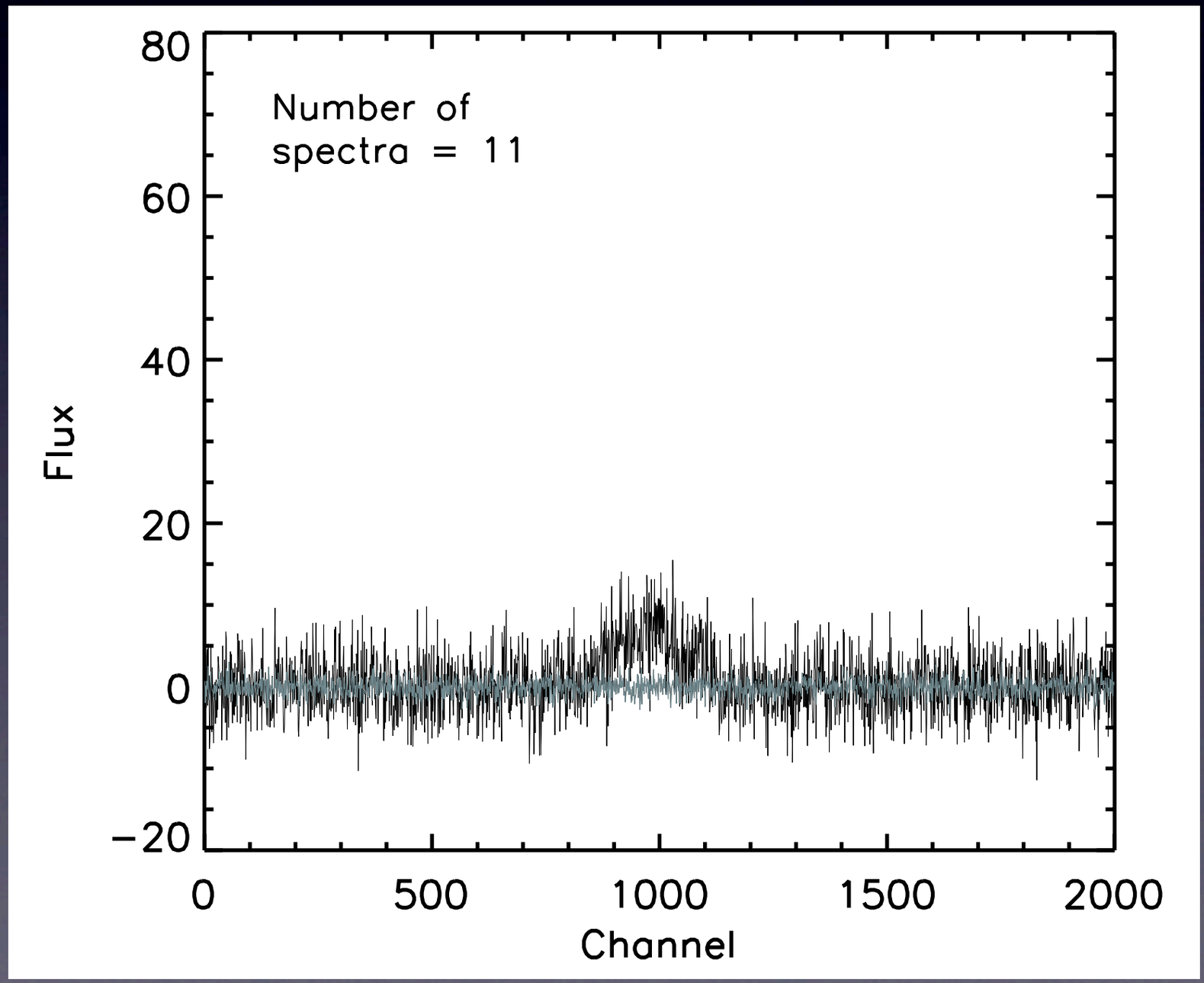

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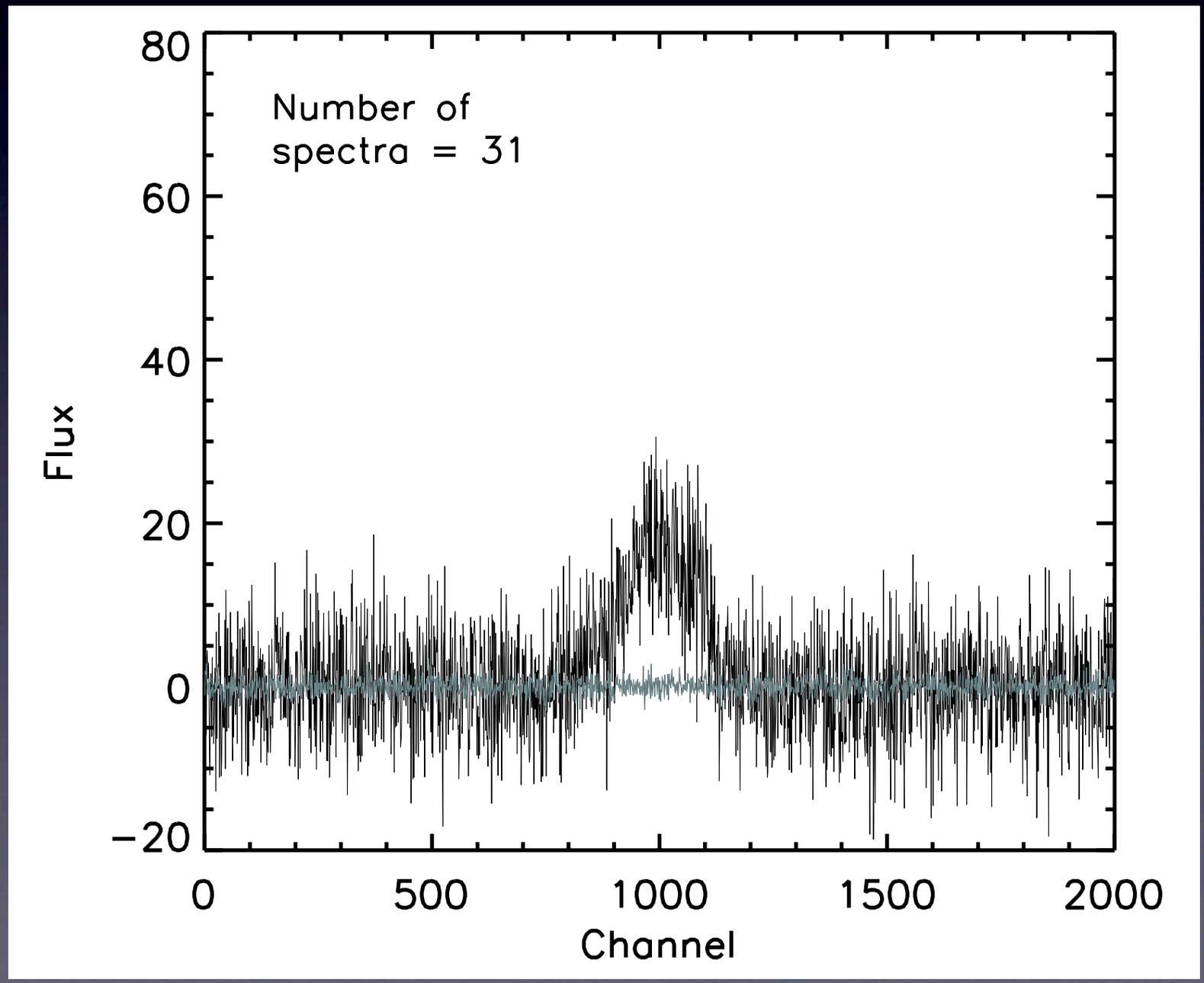

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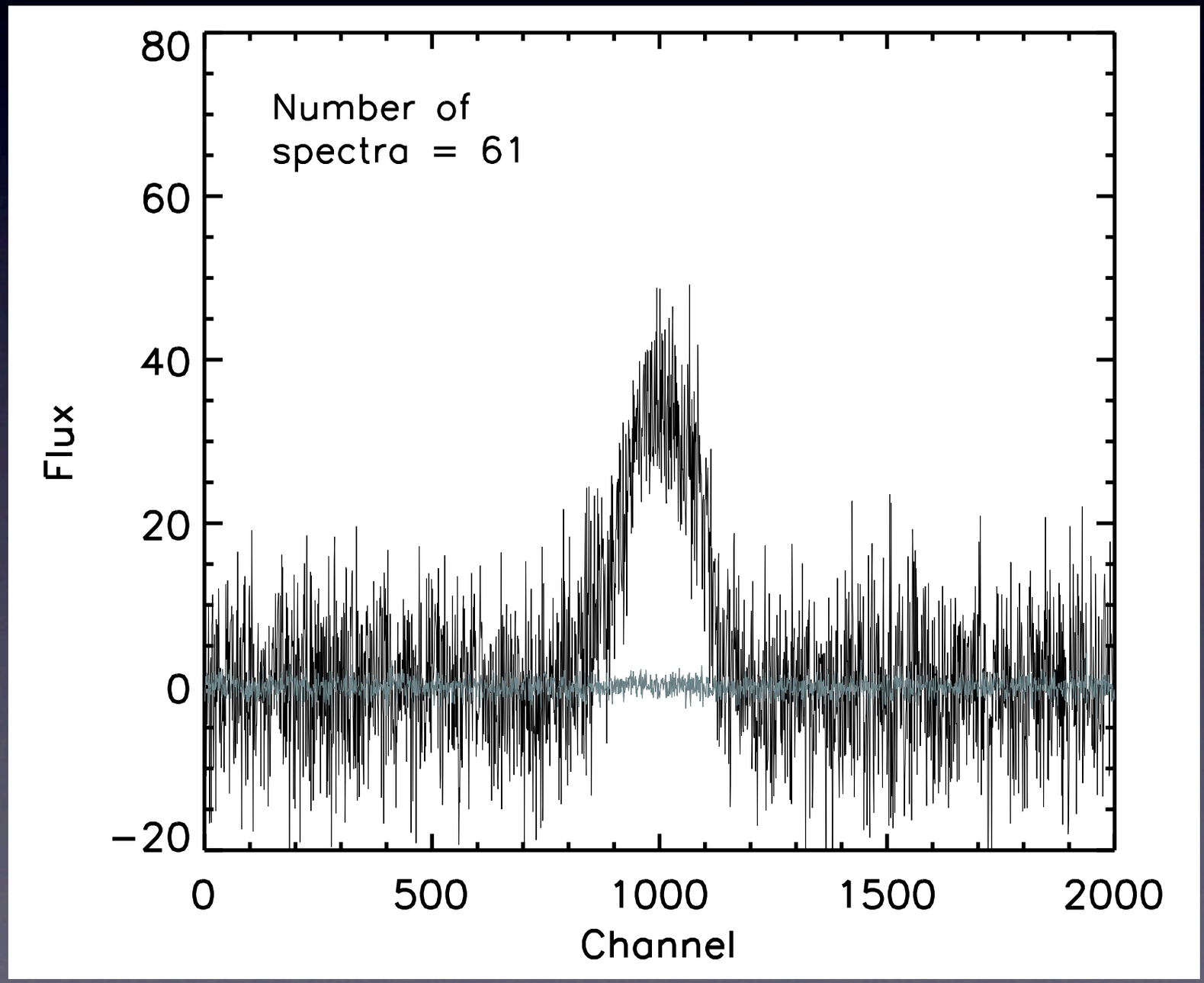

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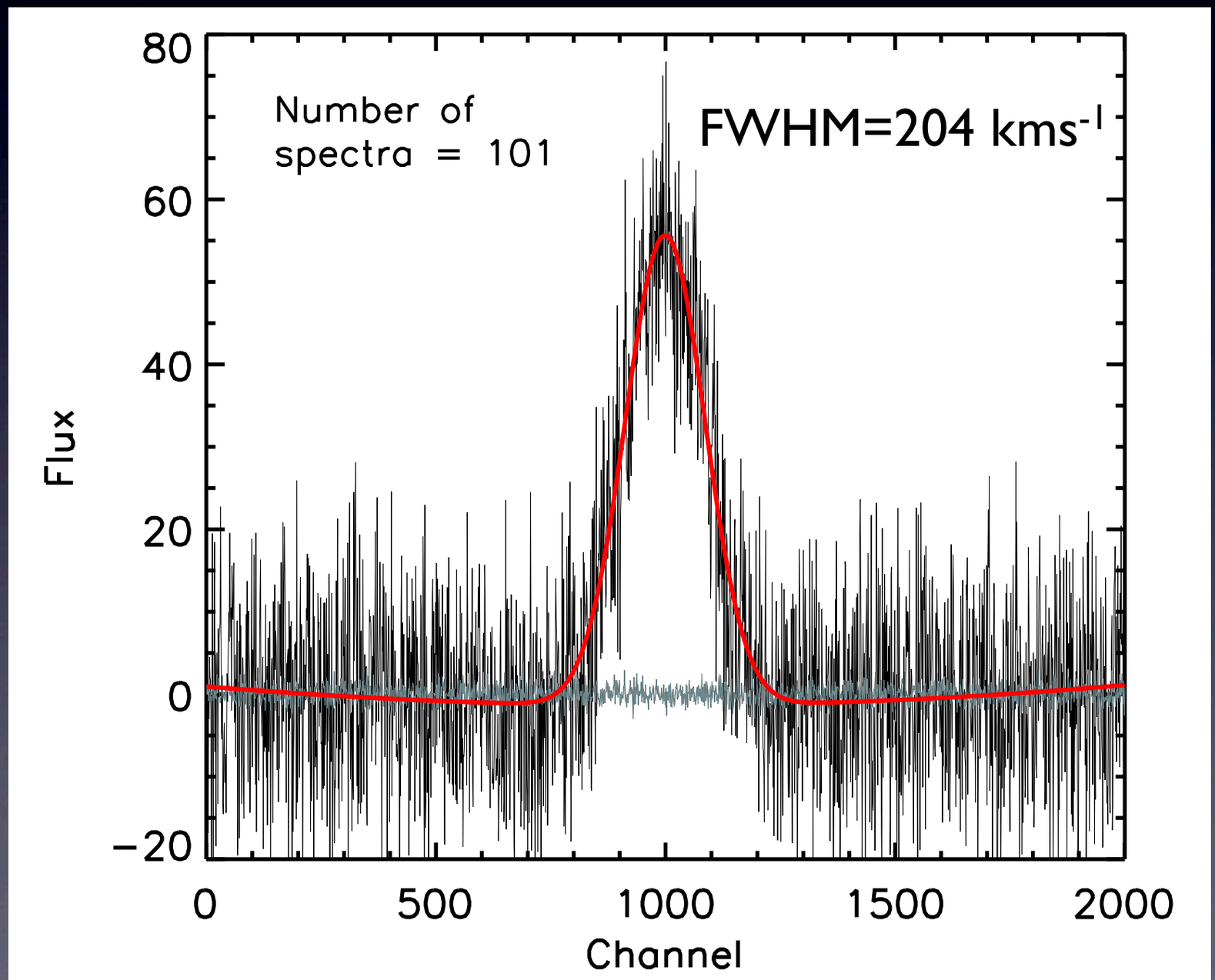

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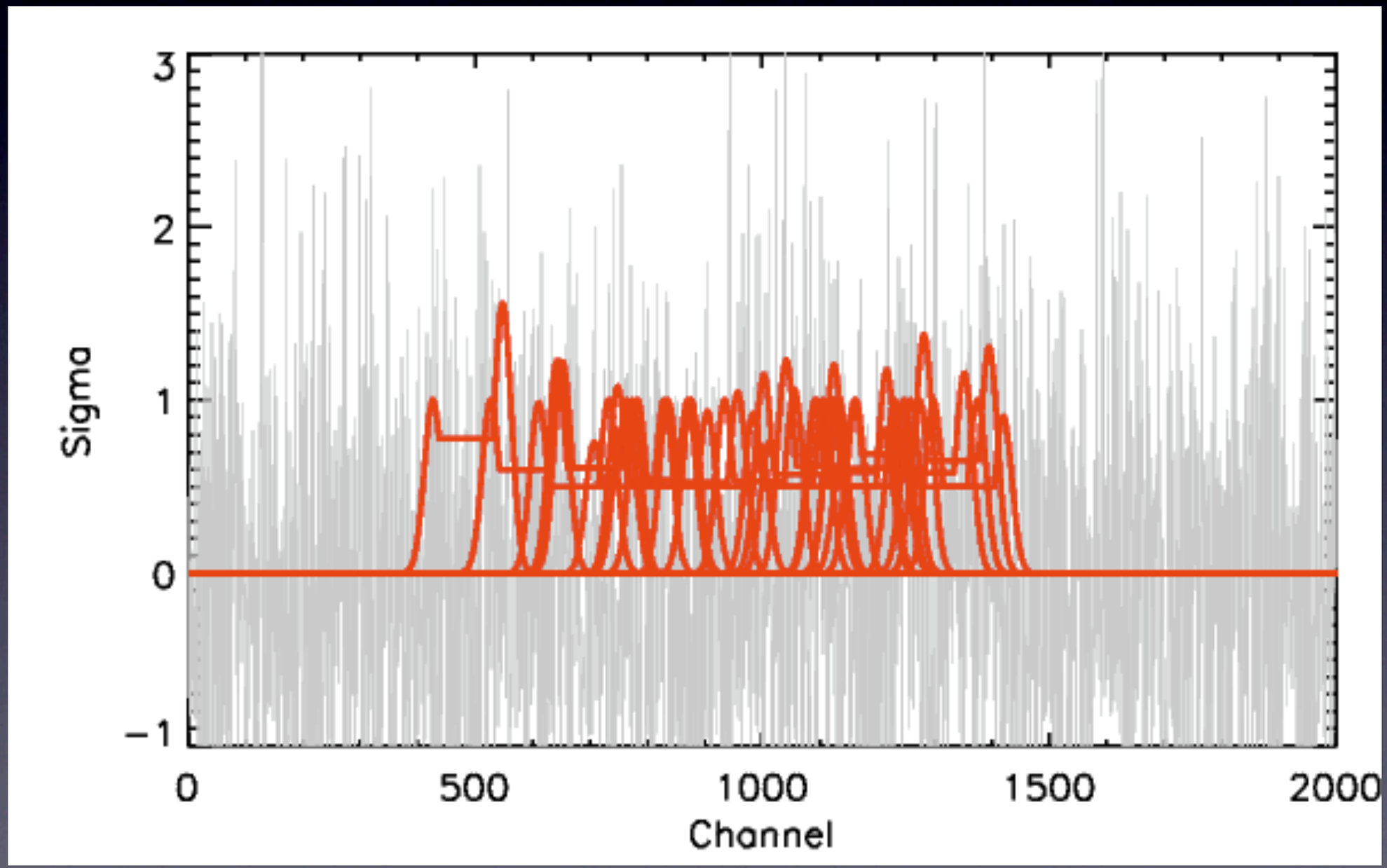

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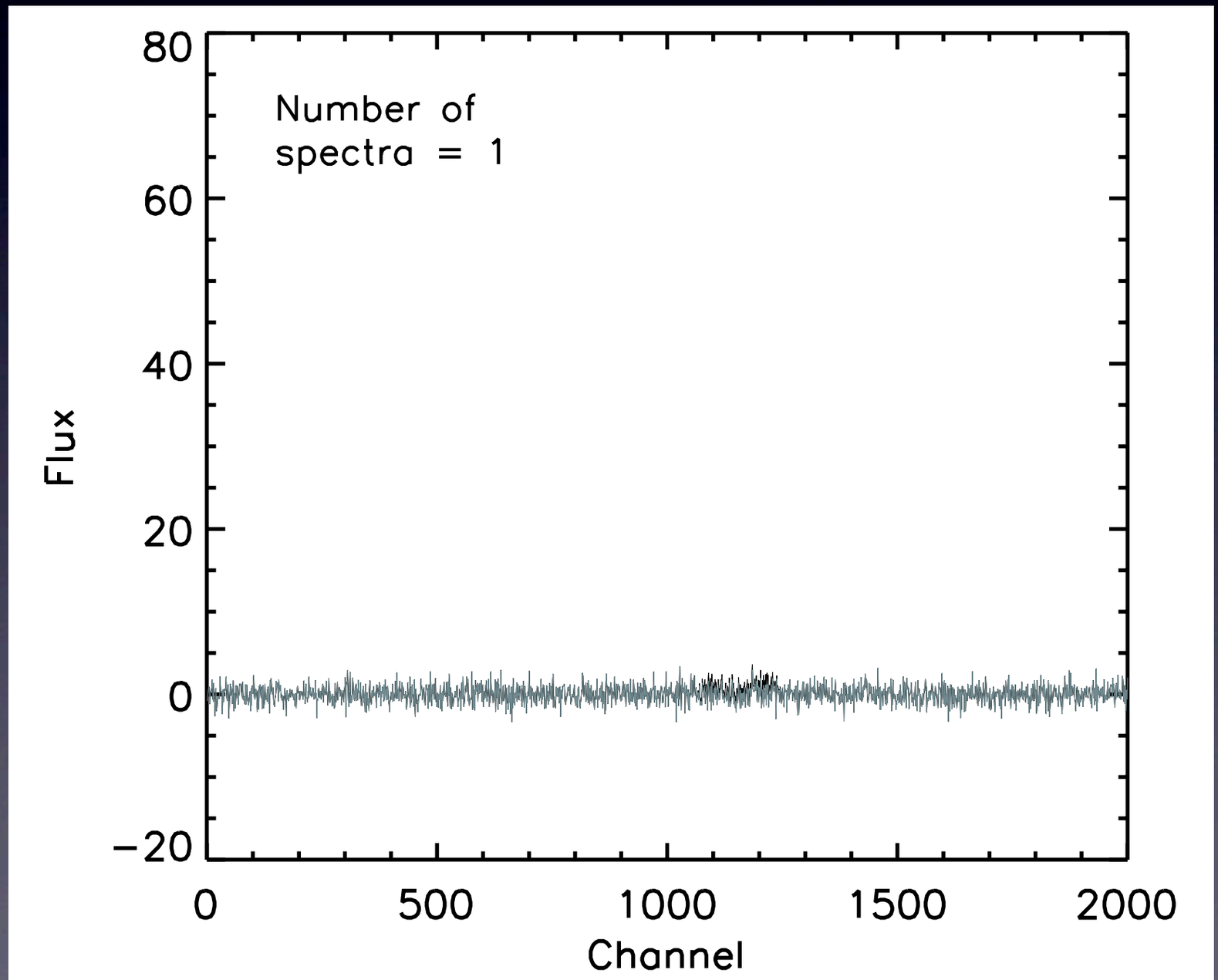

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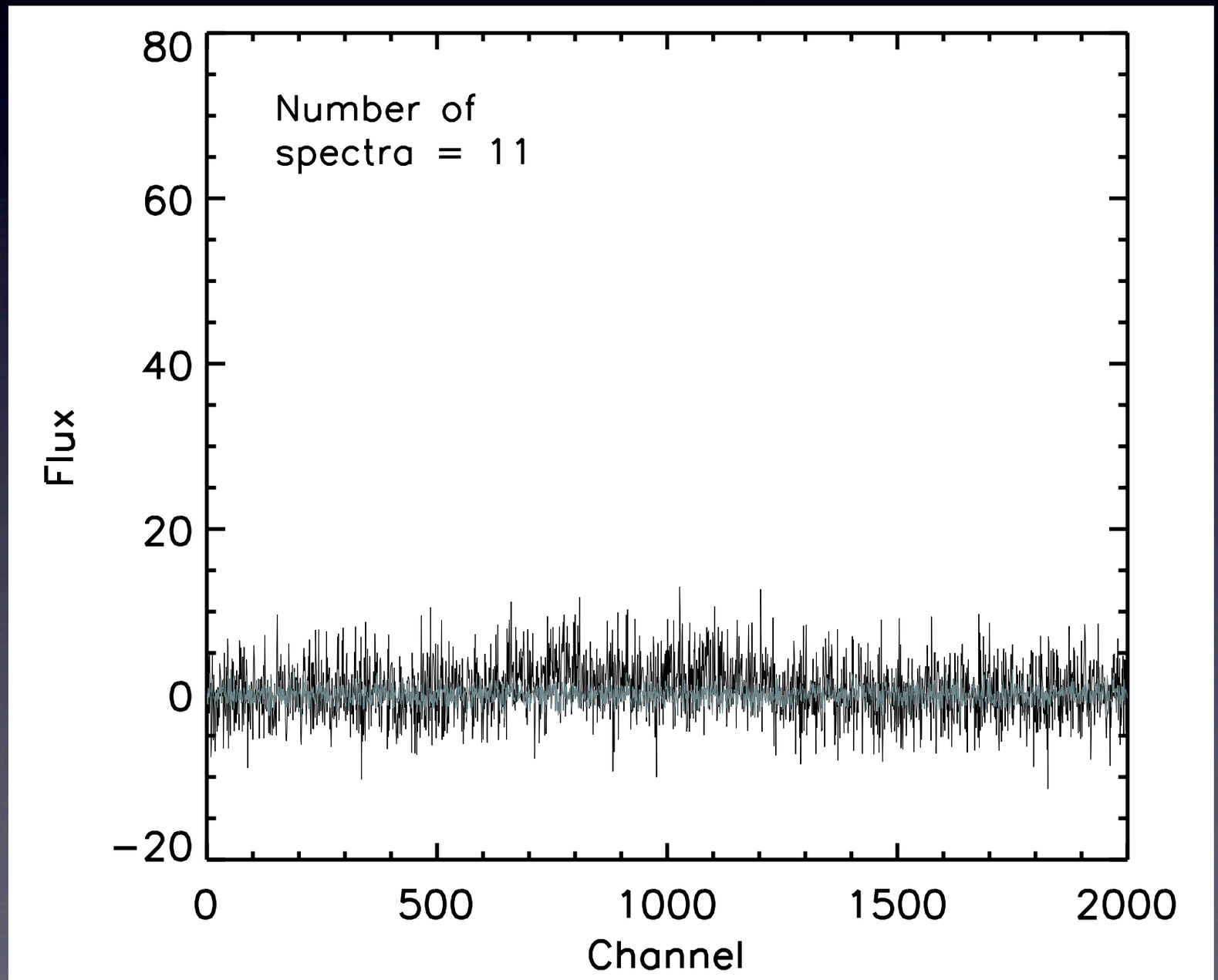

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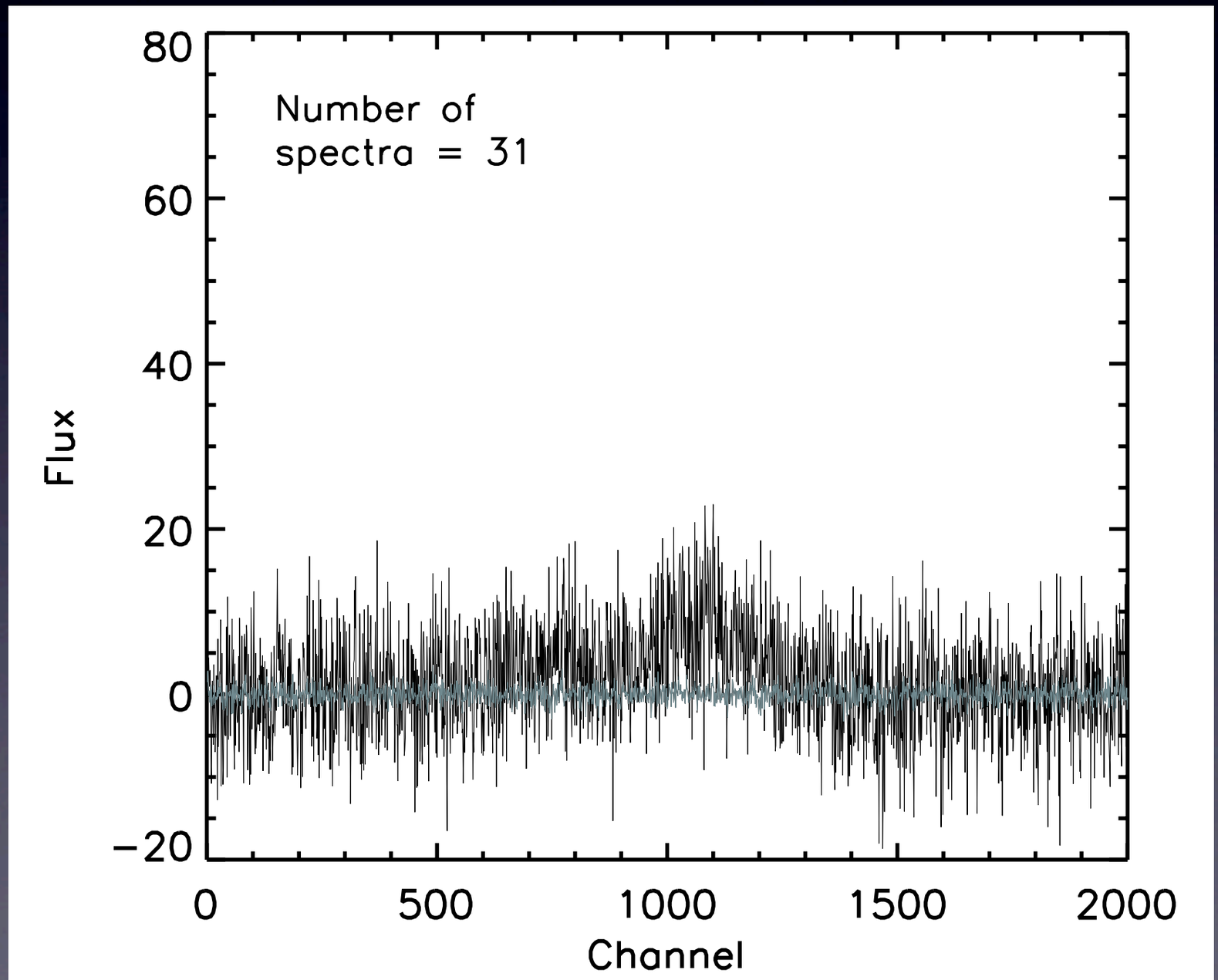

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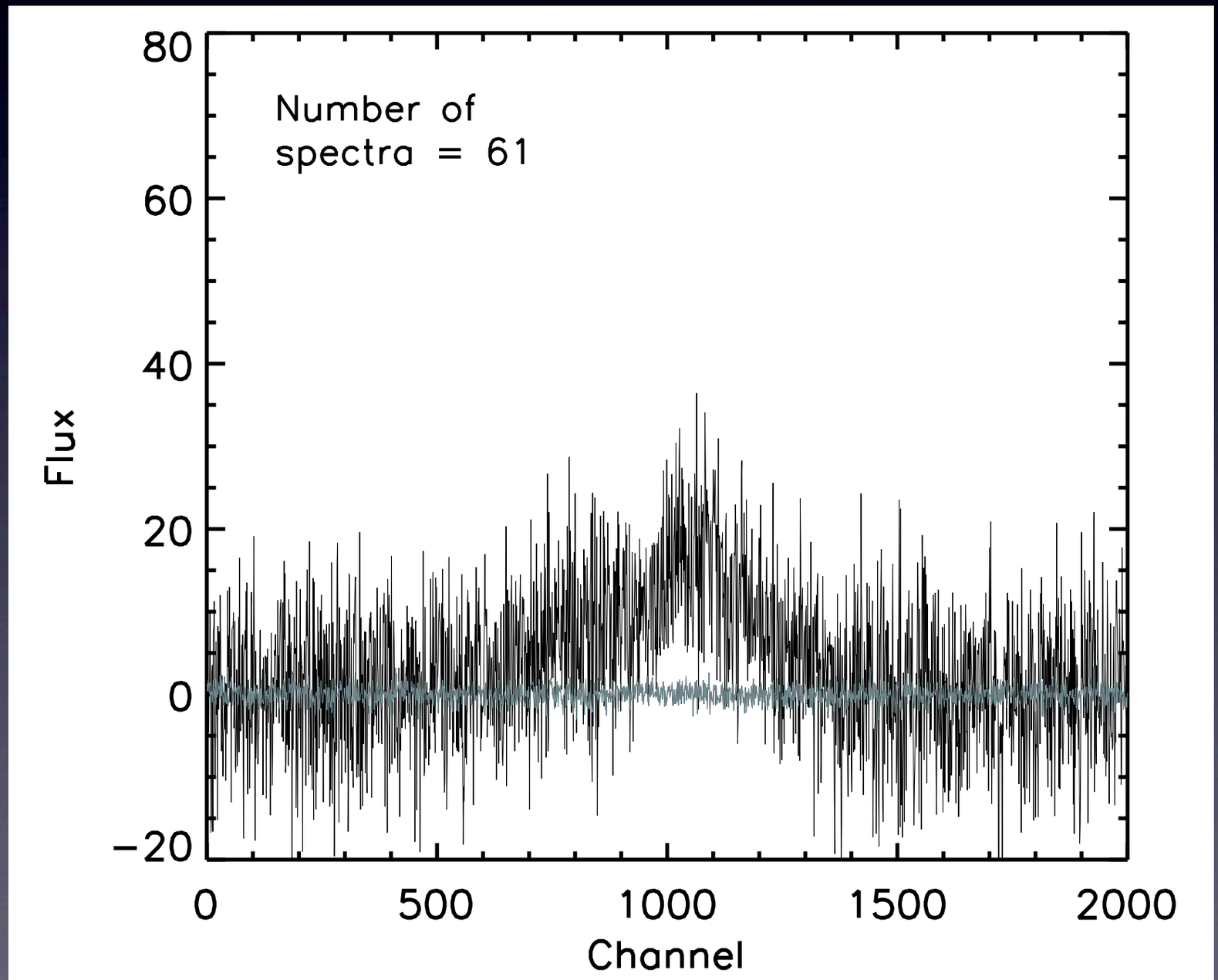

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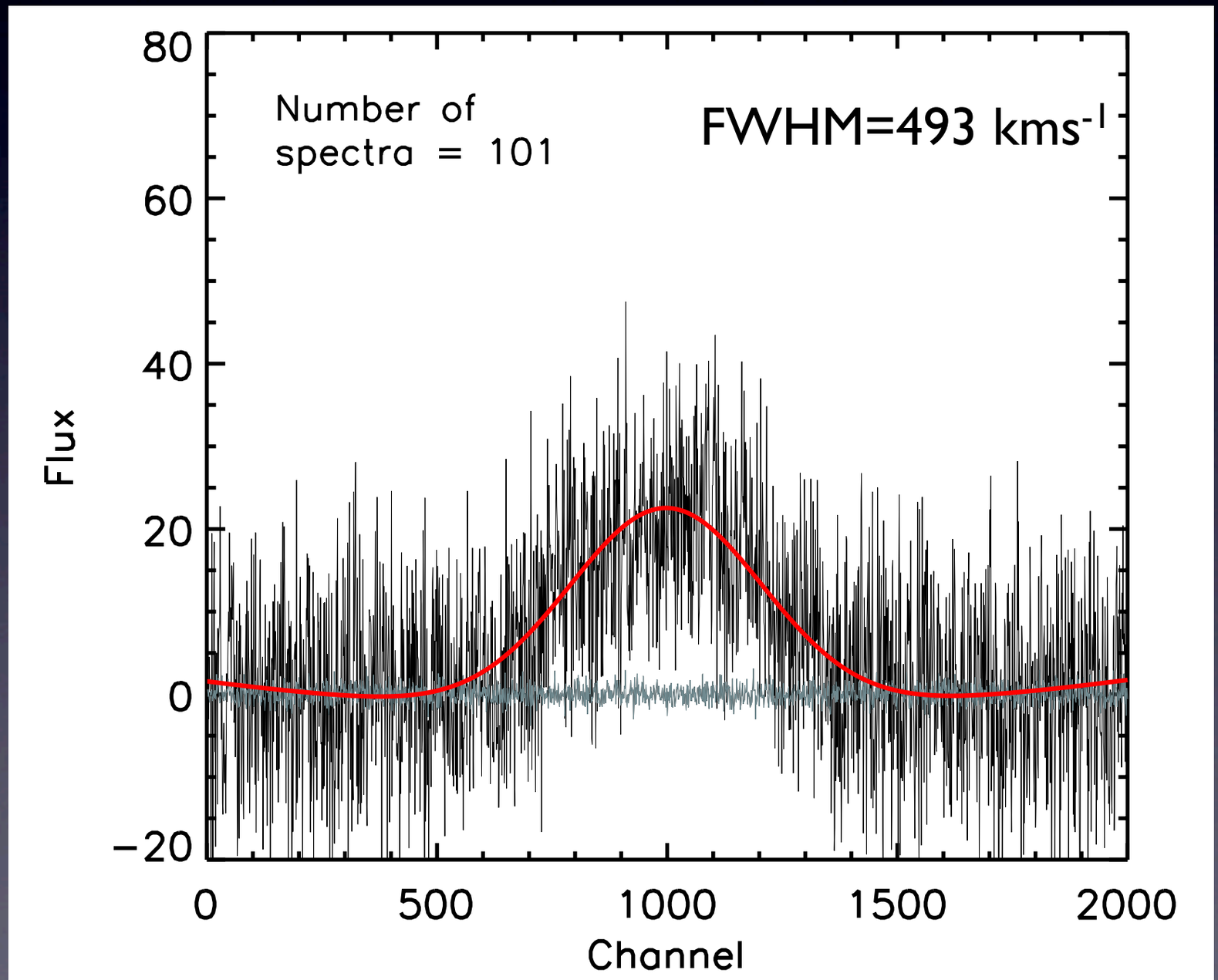

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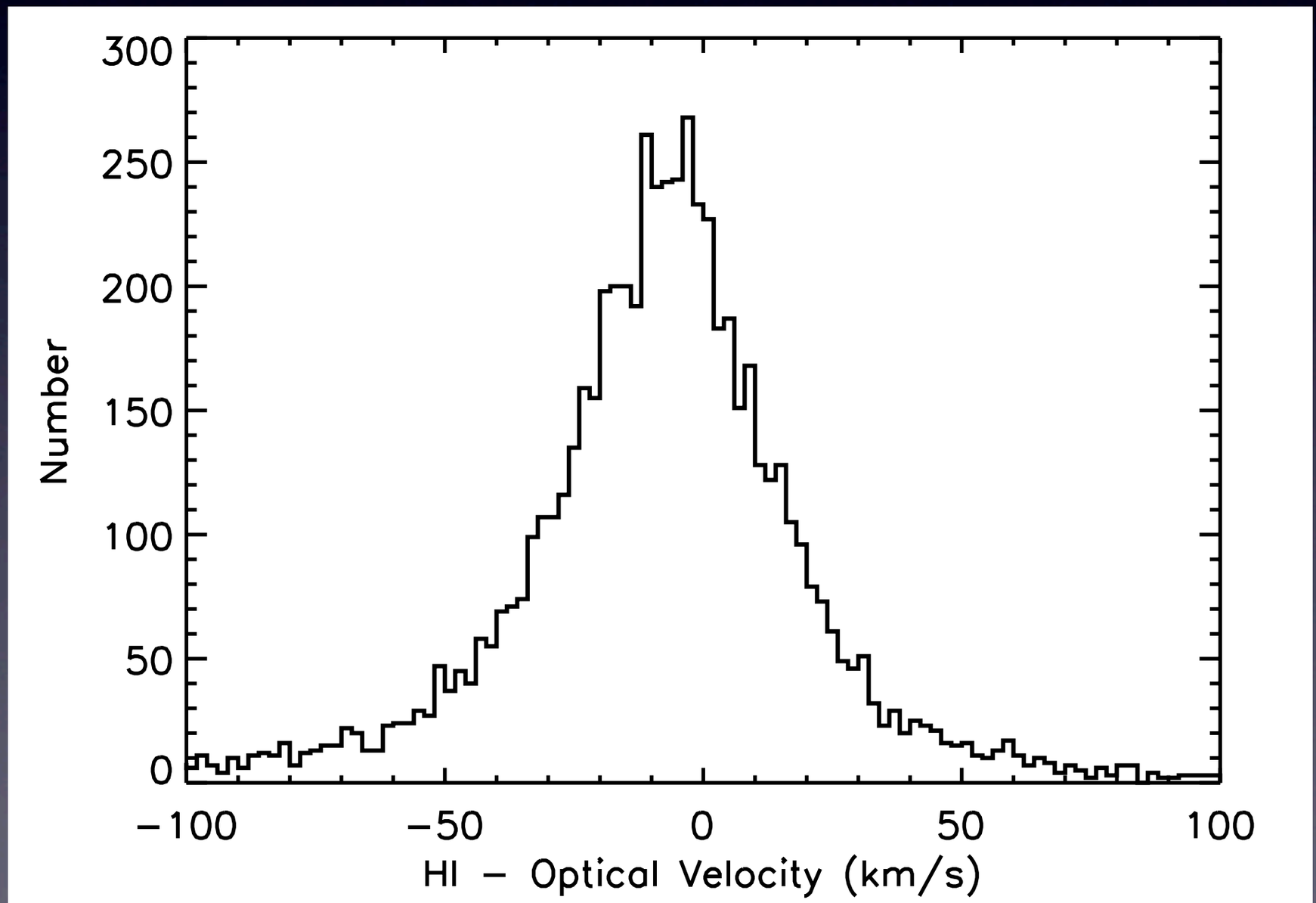

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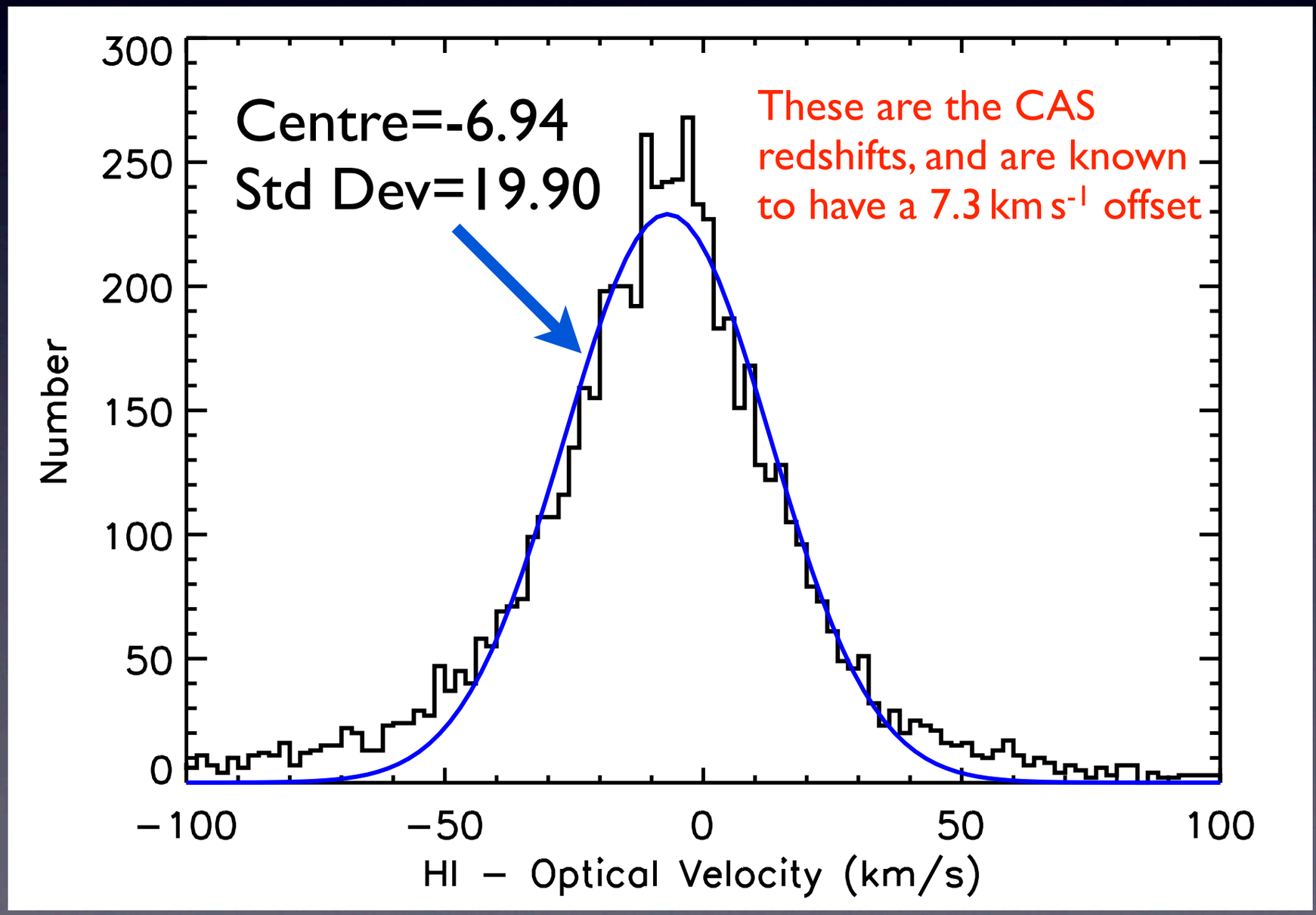

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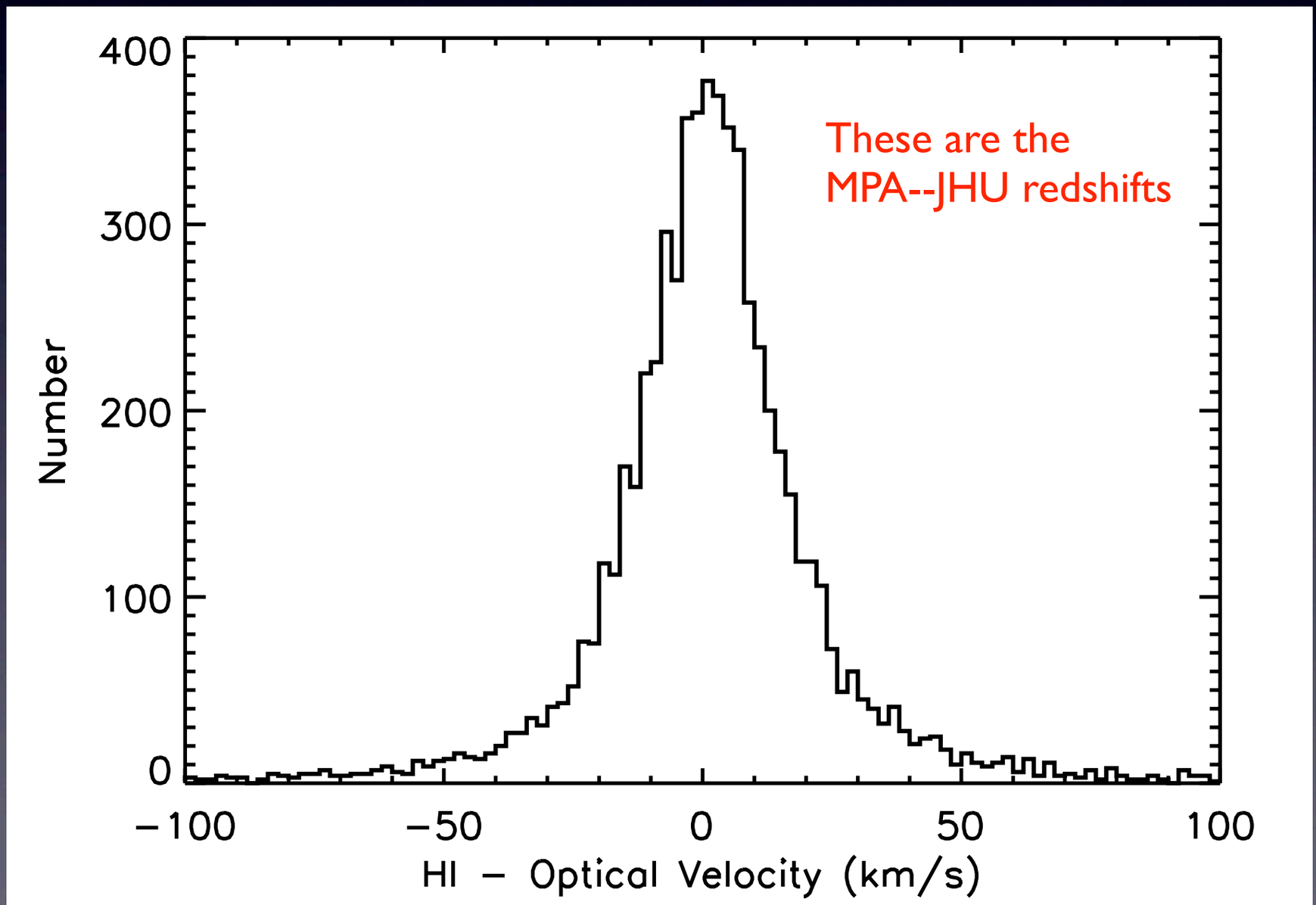

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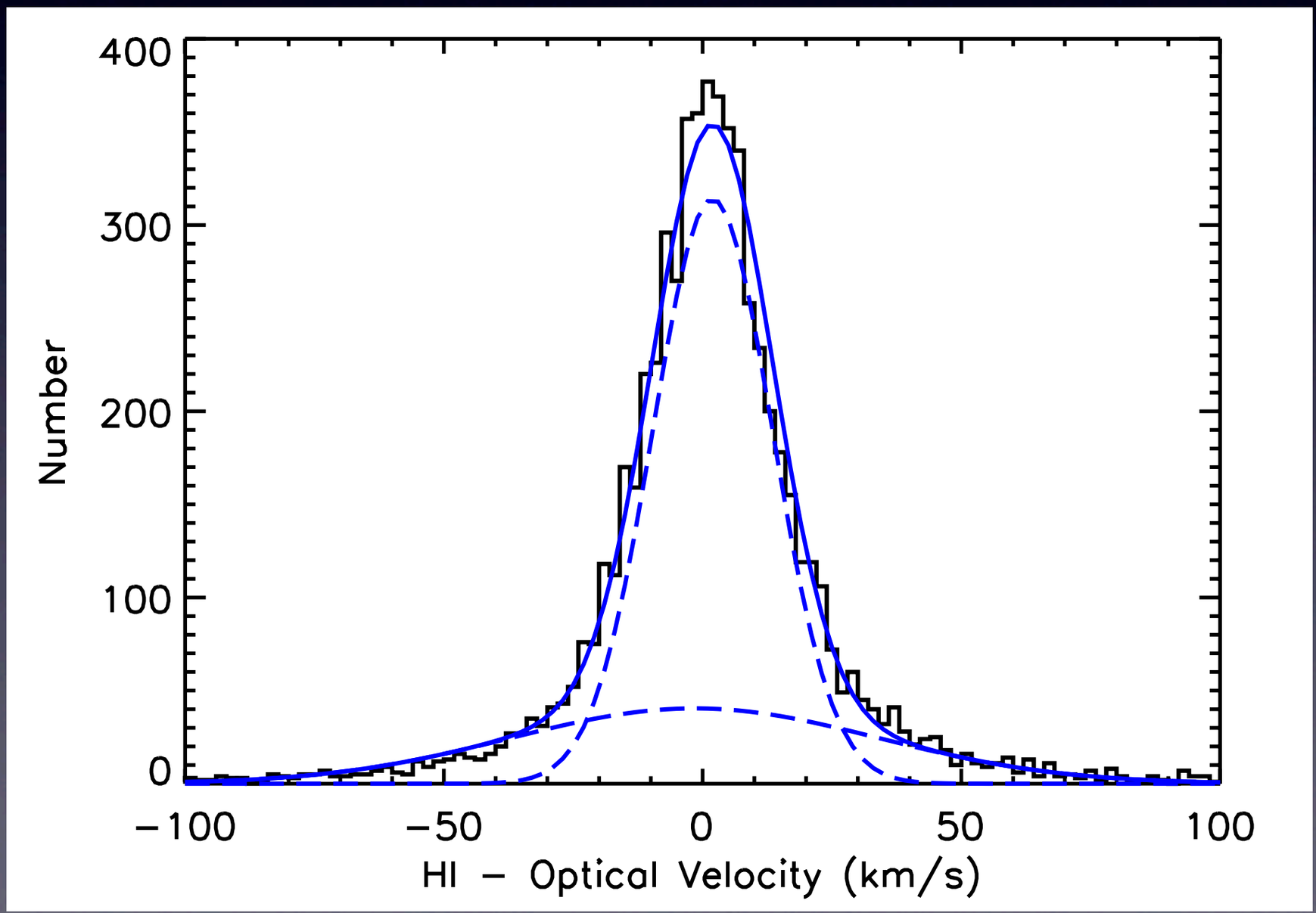

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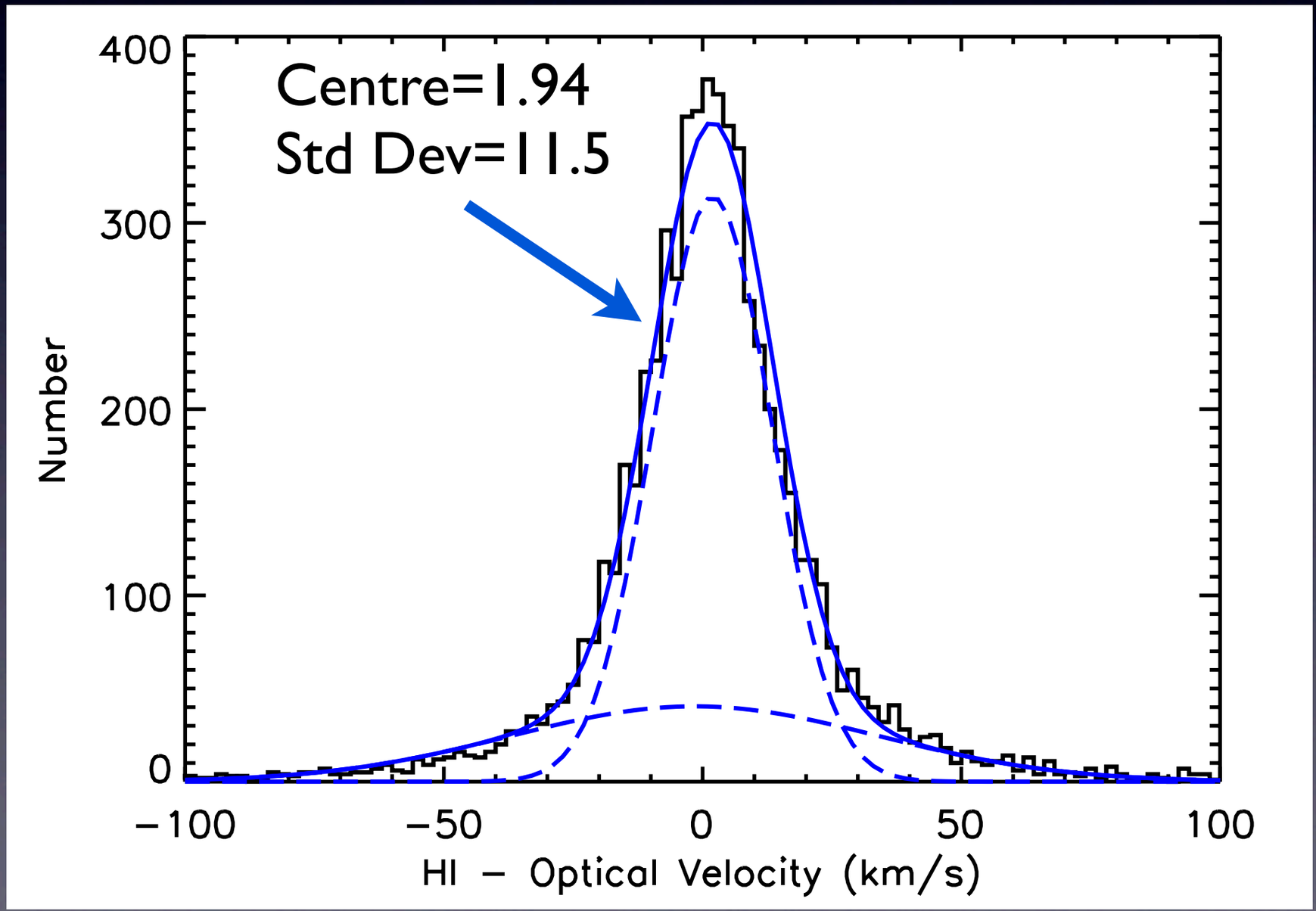

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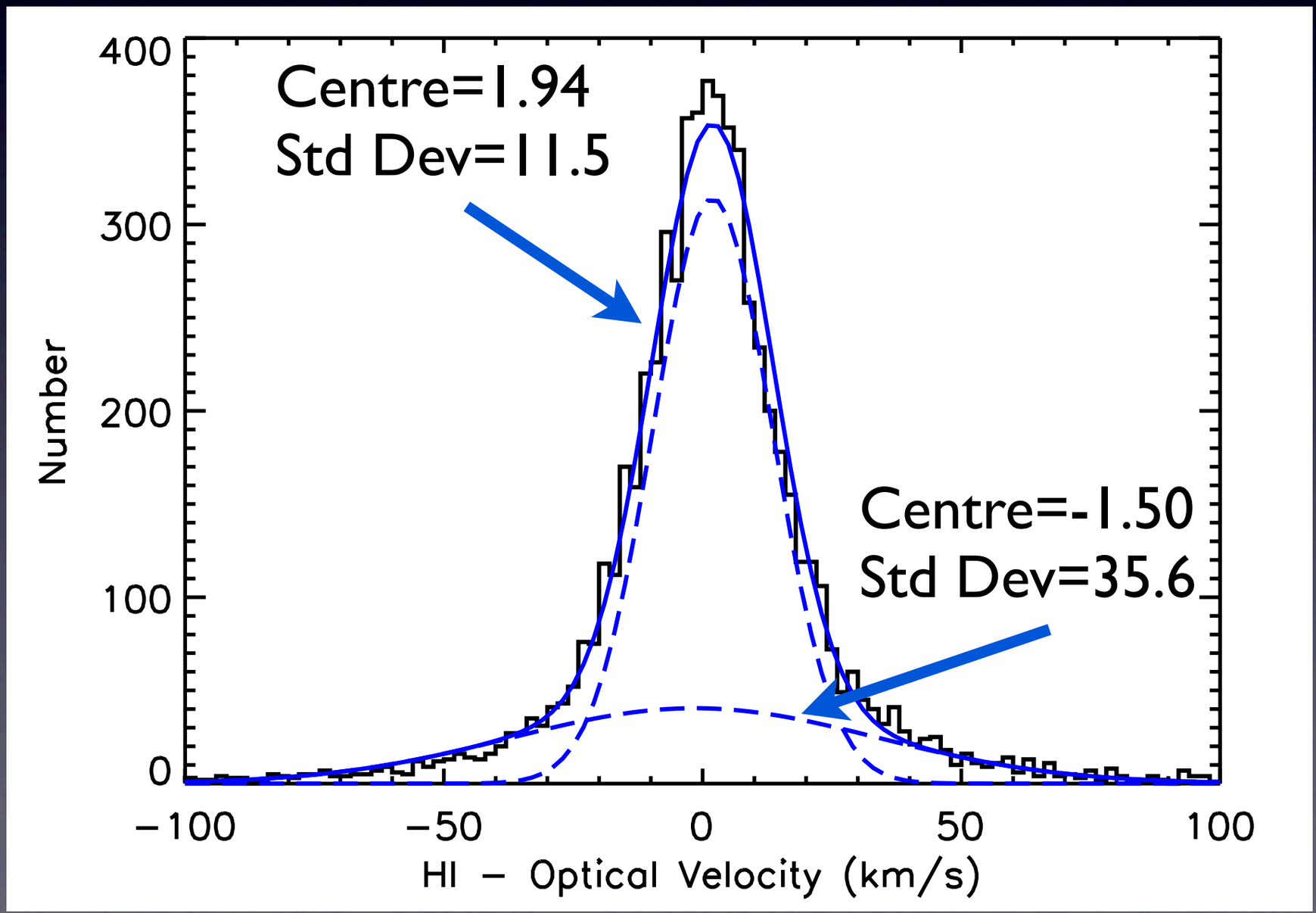
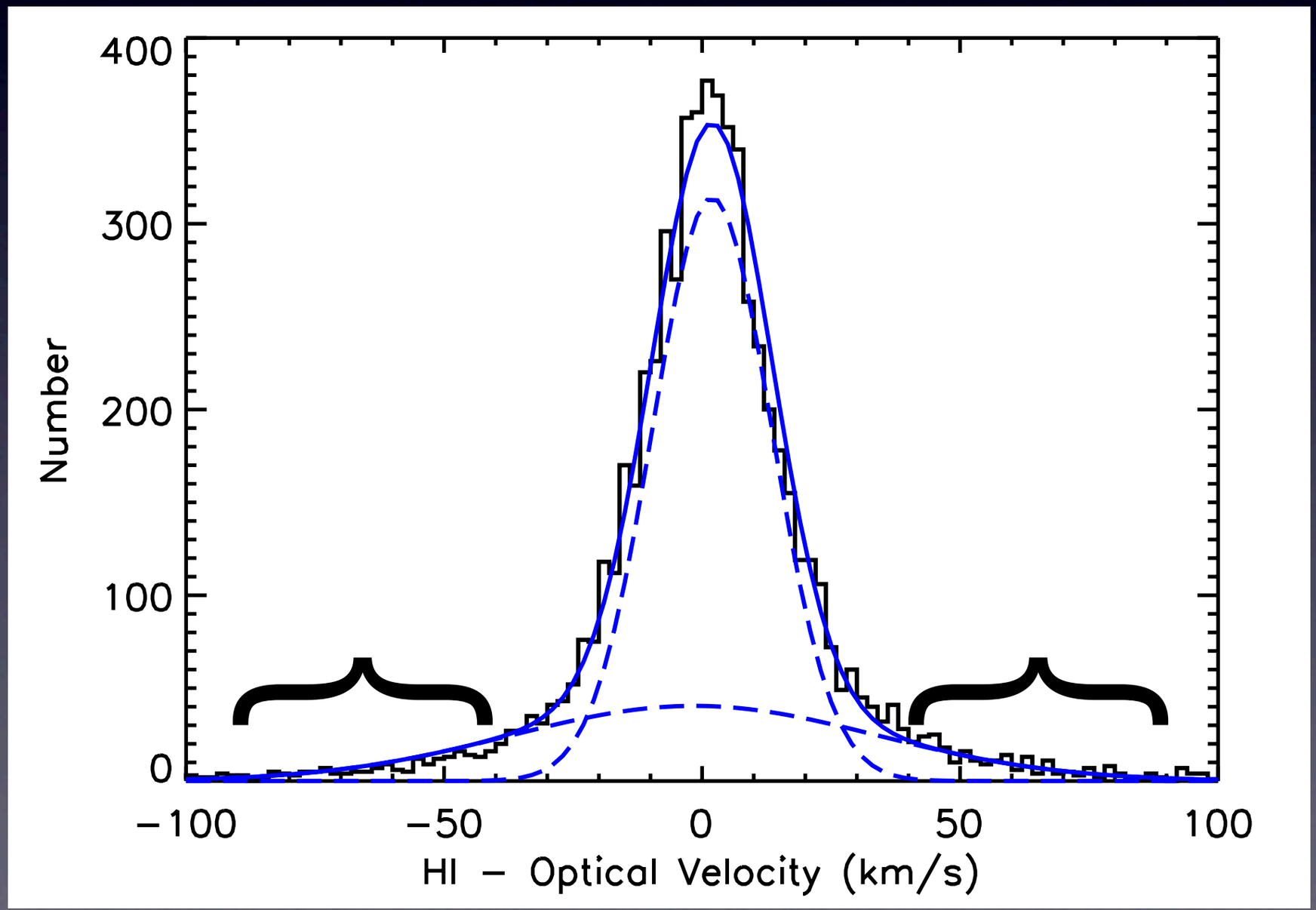


What are the outliers?



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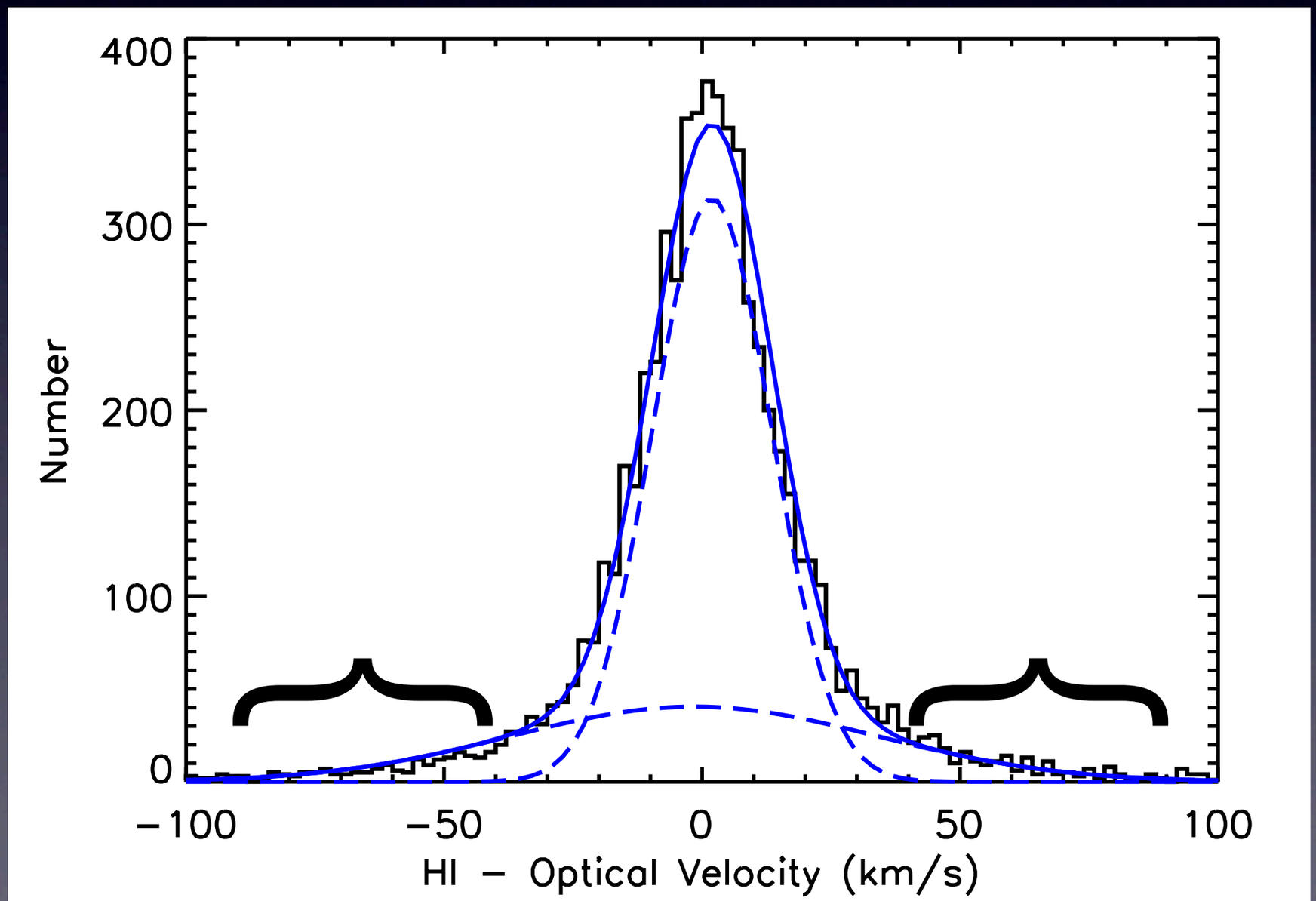
- Galaxies with large ($|\Delta v|$>40km/s) velocity offsets are usually:



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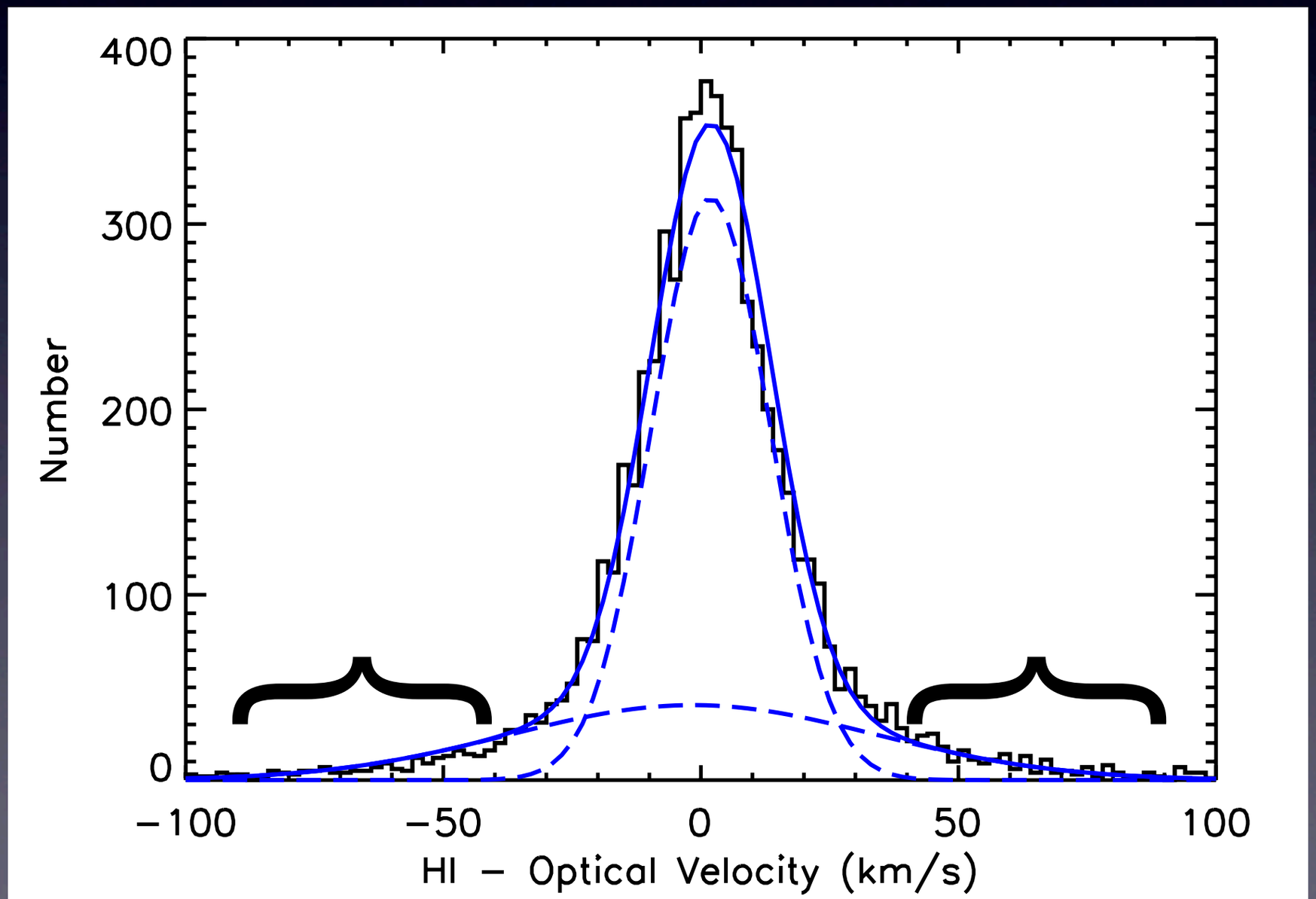

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- Galaxies with large ($|\Delta v|$>40km/s) velocity offsets are usually:
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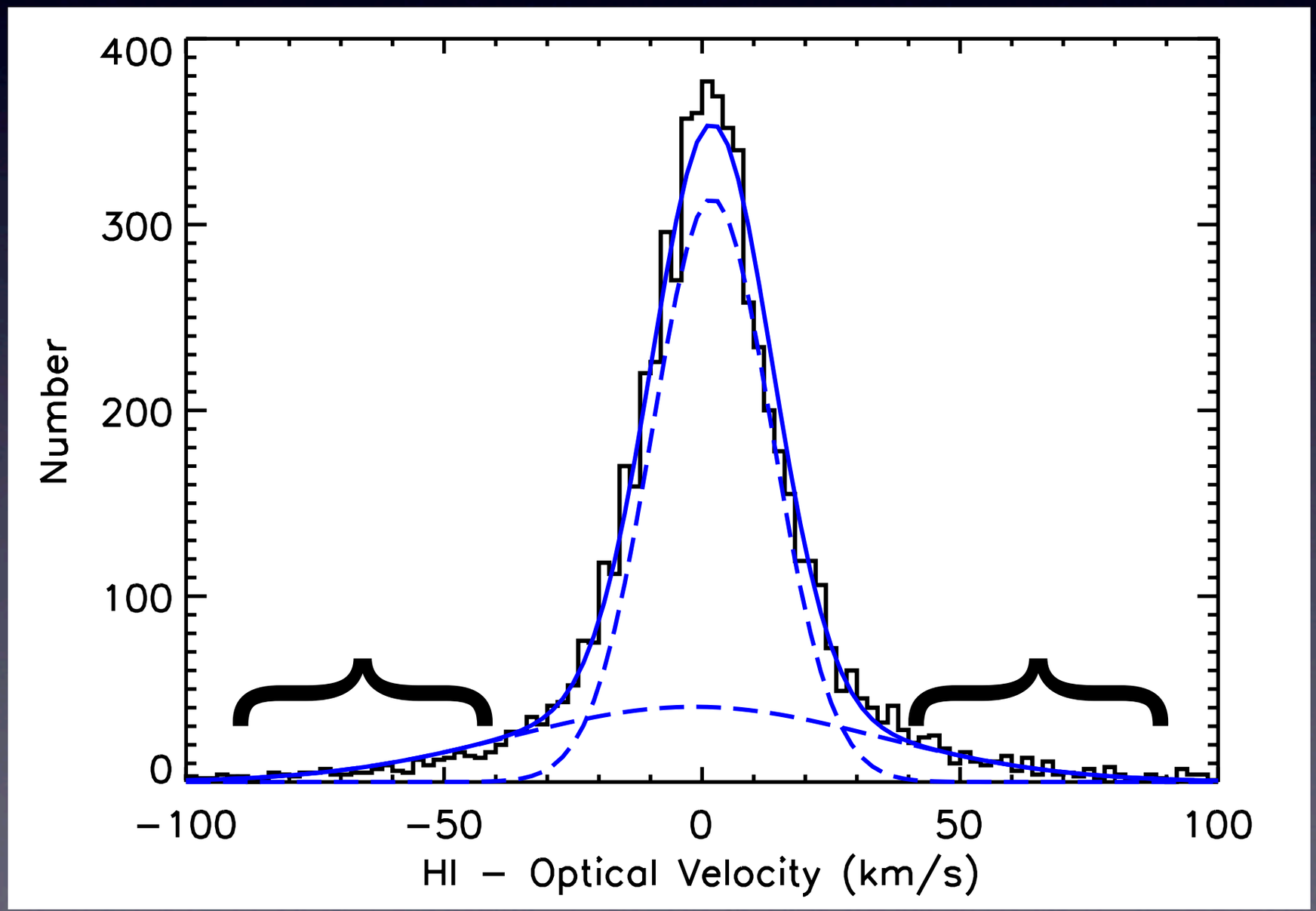
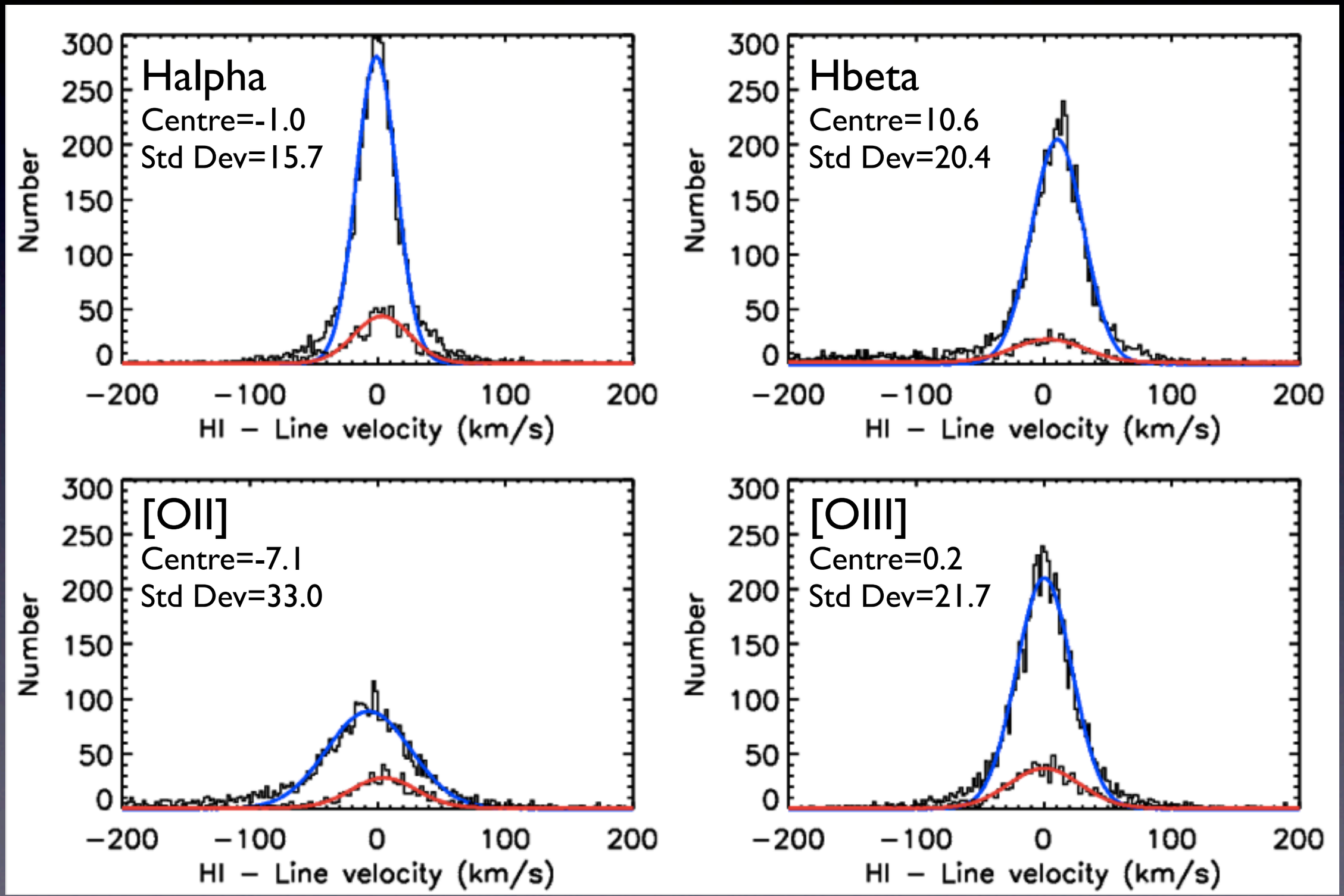
  - ➡ Interacting galaxies (systemic velocity poorly defined*)



What if you only have one spectral line?

- At low redshift, Hα is the most prominent emission line
- At higher redshift, only [OII] will be visible



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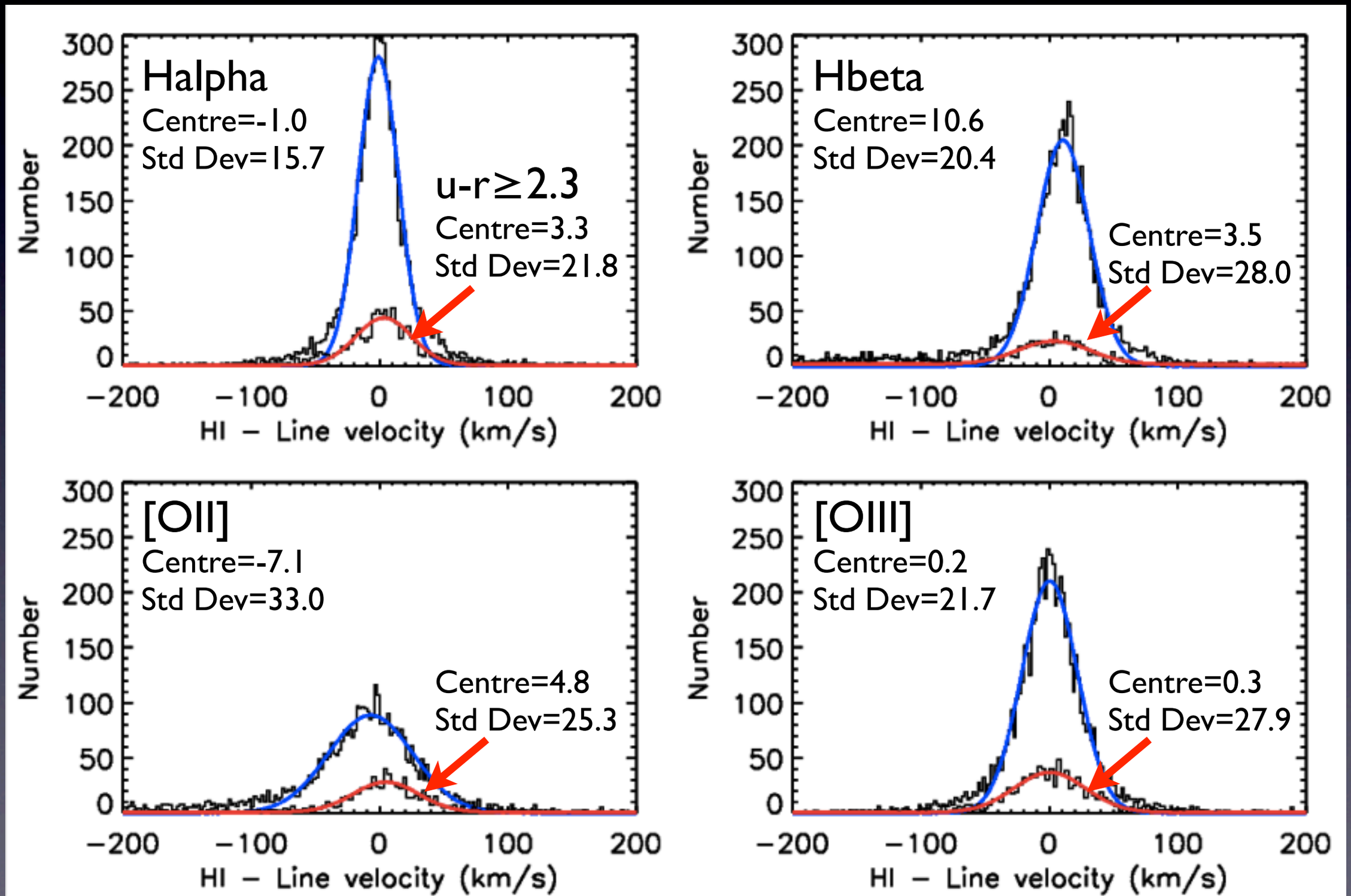

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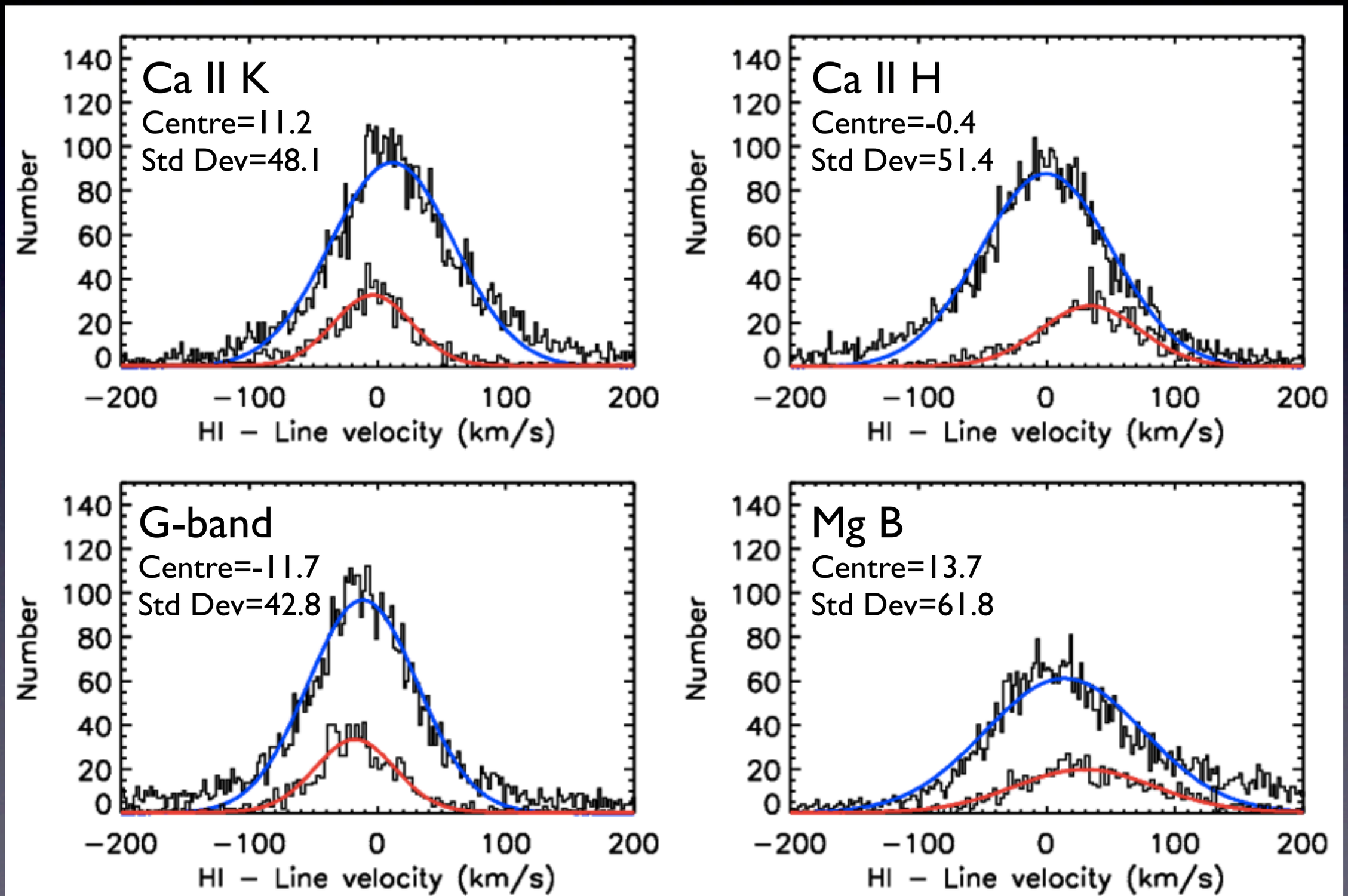

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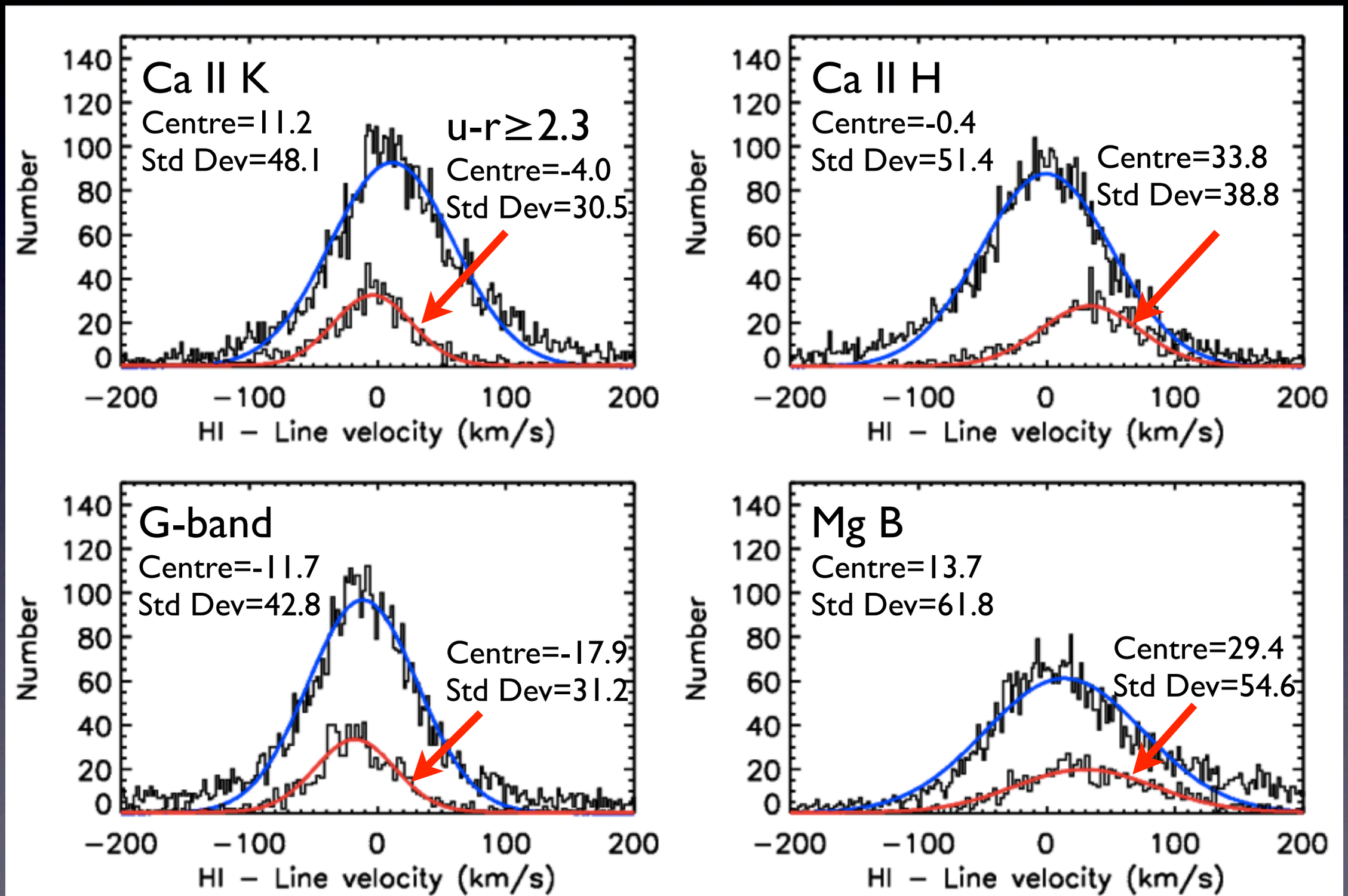
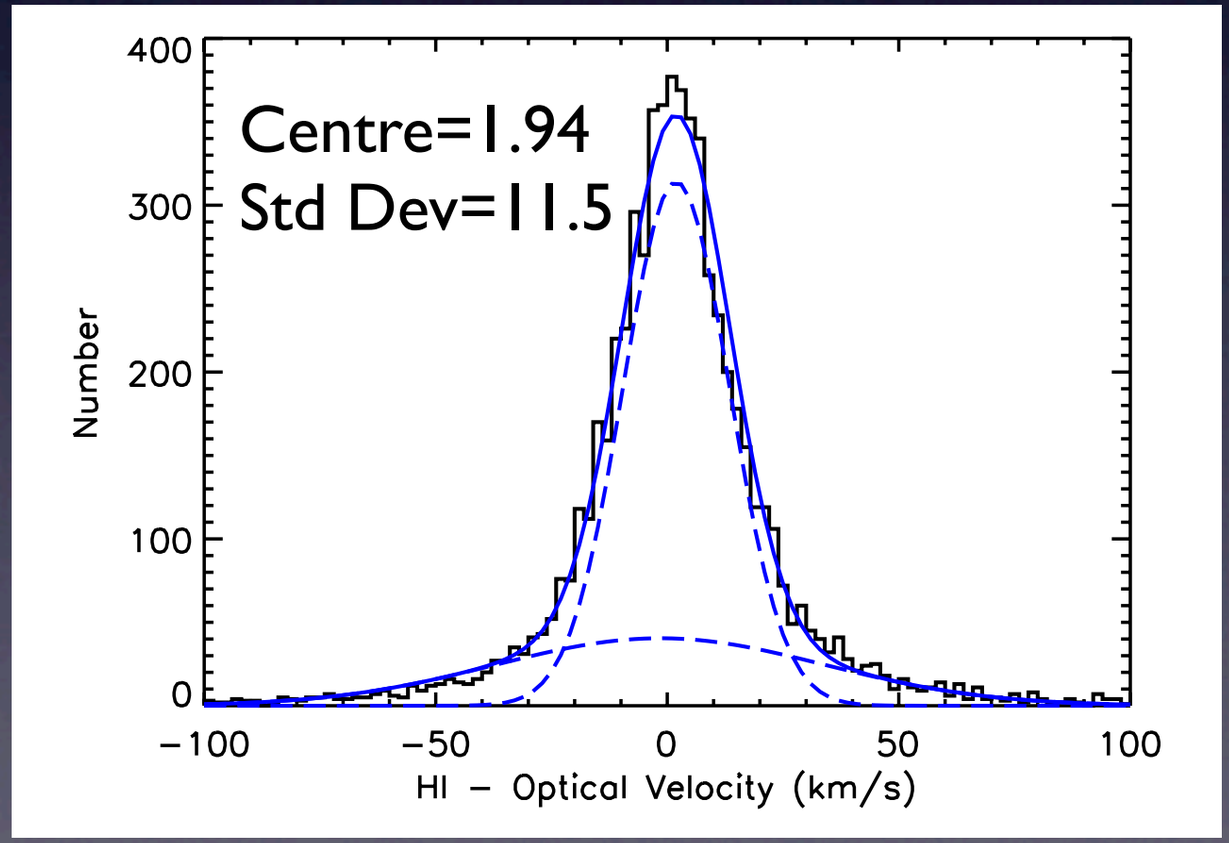
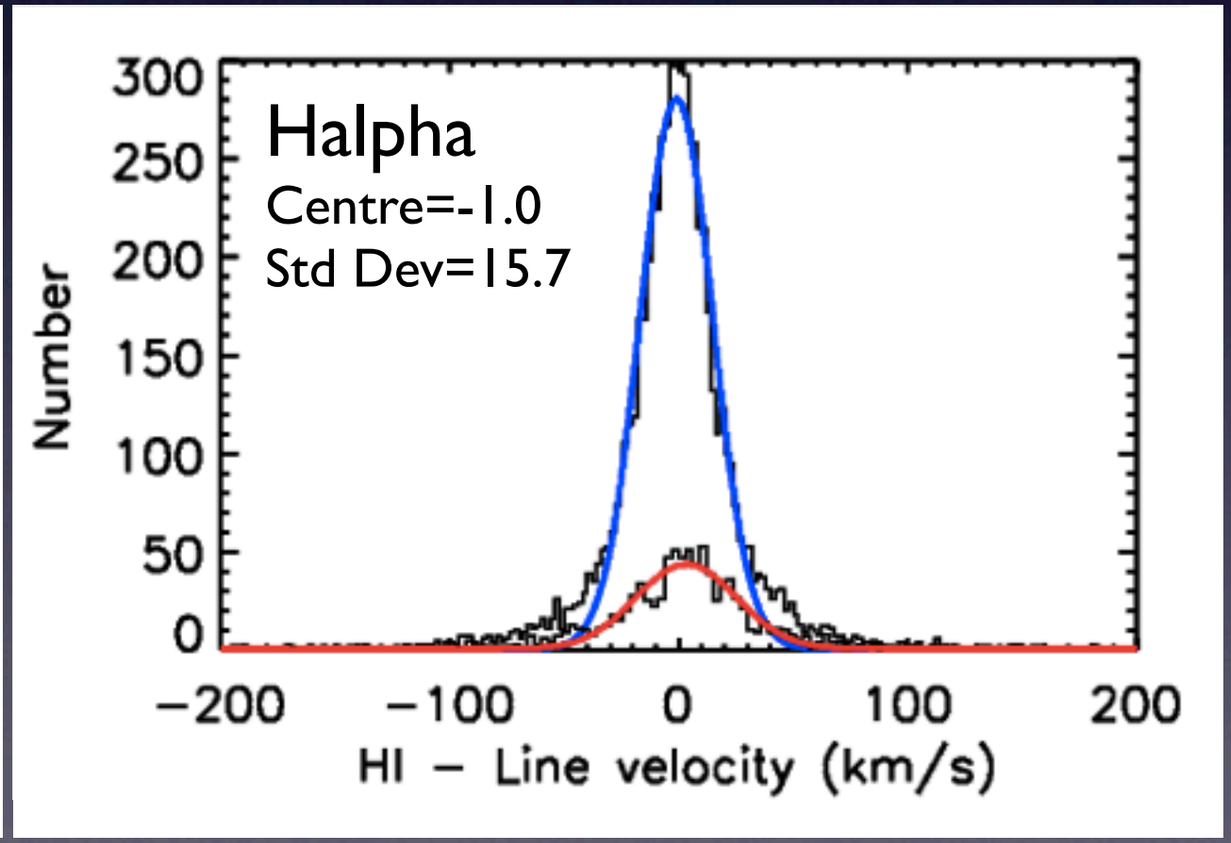


Preliminary summary:

- Best redshifts are derived from many spectral features
- Hα is the best emission line to use, but [OII] is all that is left at z>0.7
- Absorption lines are not as accurate as emission lines





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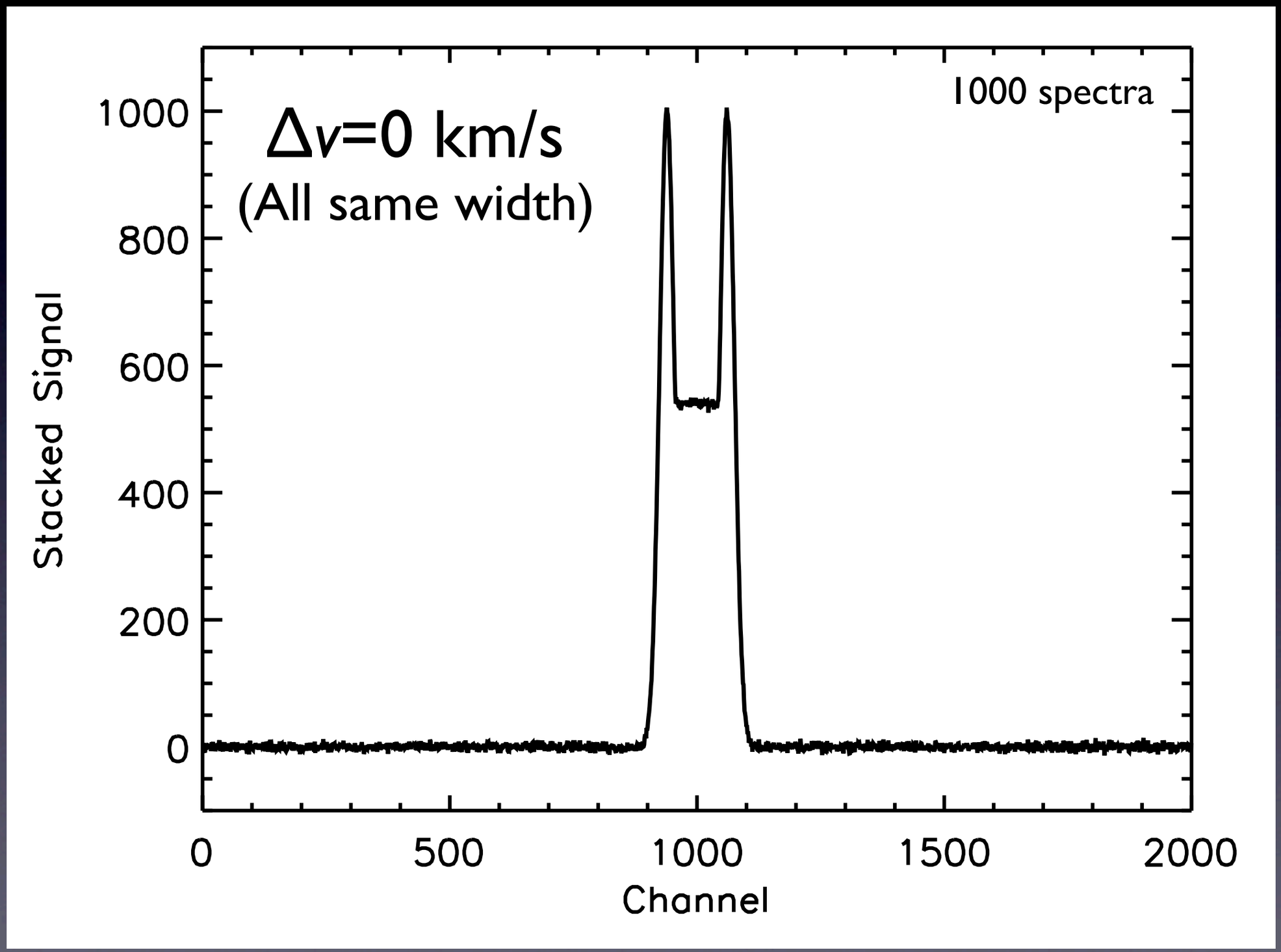
- Include observed distribution of galaxy widths (W_{50}) from ALFALFA

Velocity widths altering the stacked profile



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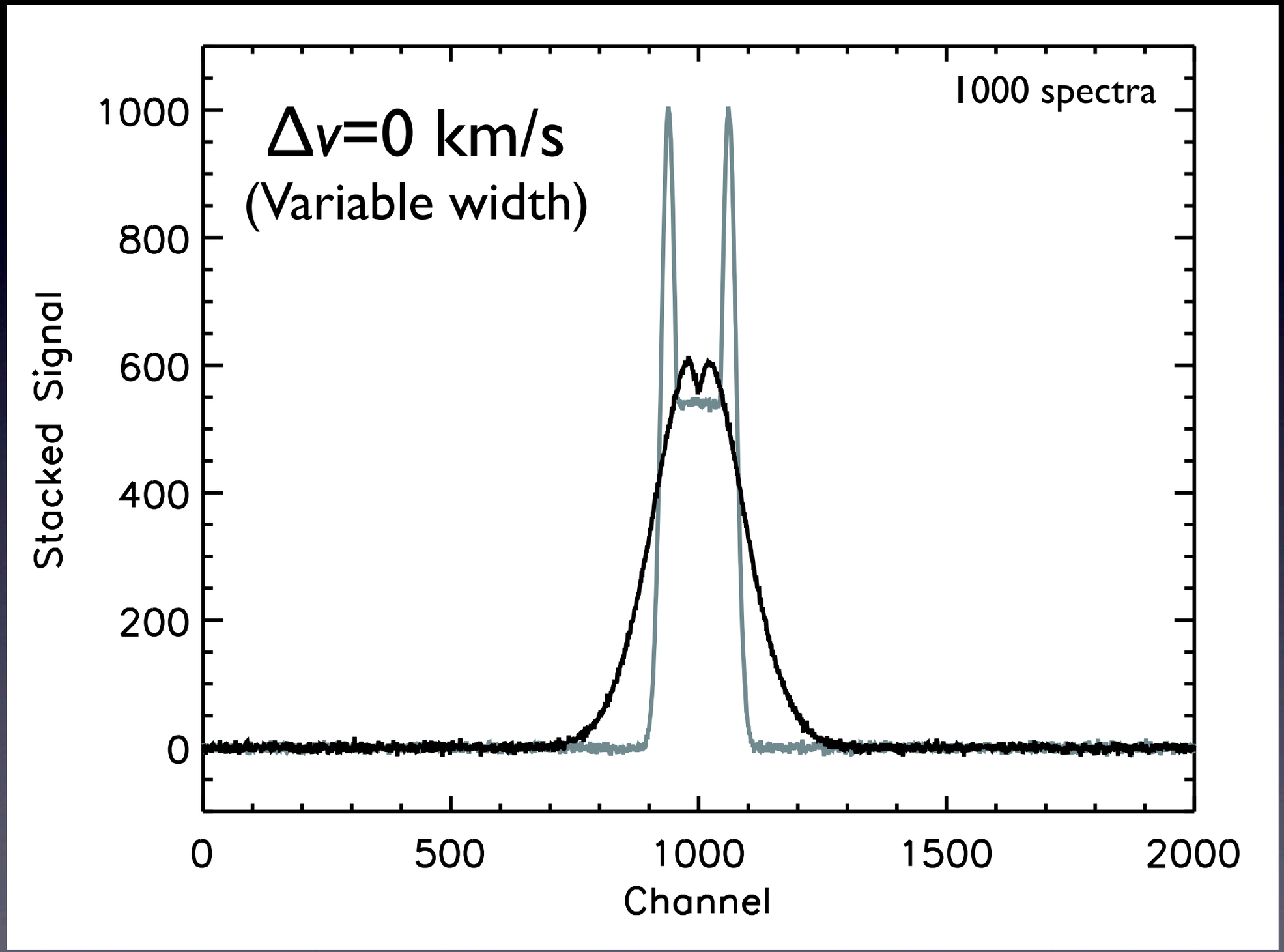

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- Stack 1000 individual spectra

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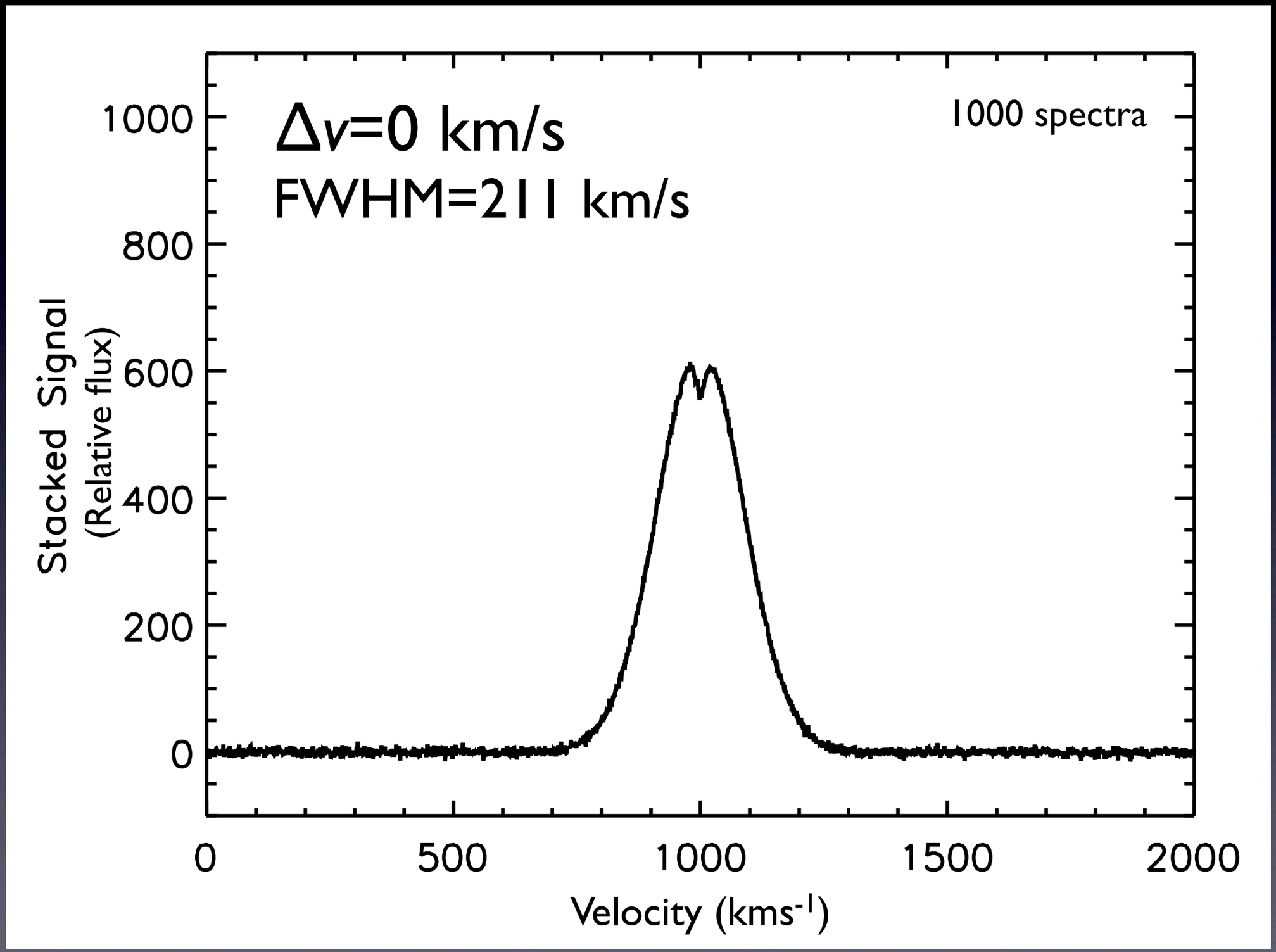
- Construct toy simulation to stack many spectra and create a stacked profile
- NOTE: no complications from observations, measurement, calibration, RFI, etc, are included here
- Include velocity offsets from ALFALFA--SDSS comparison, as well as other distributions
- Include observed distribution of galaxy widths (W_{50}) from ALFALFA
- Stack 1000 individual spectra
- Investigate the effect of velocity offsets on the stacked signal

Velocity offsets altering the stacked profile



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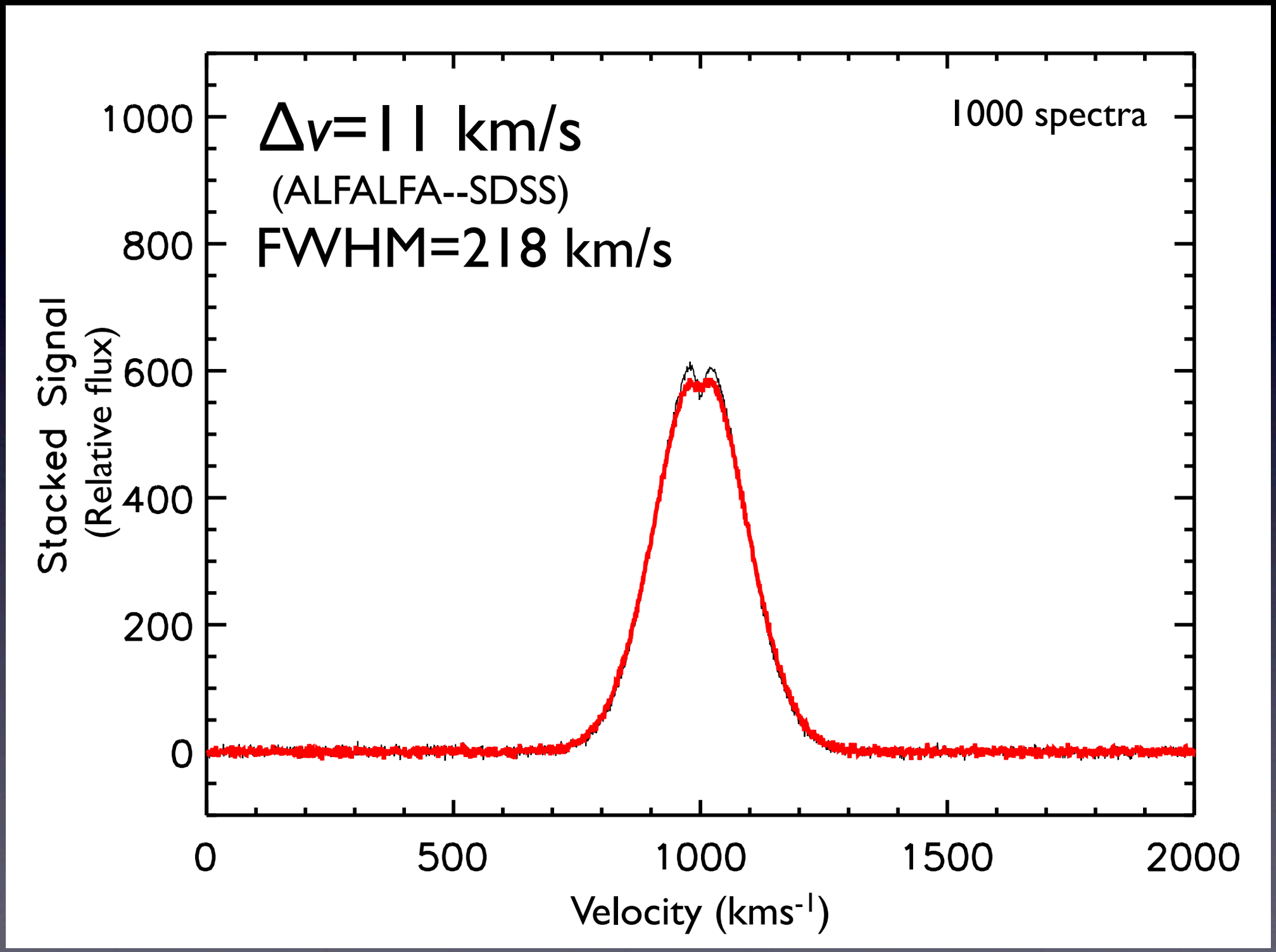

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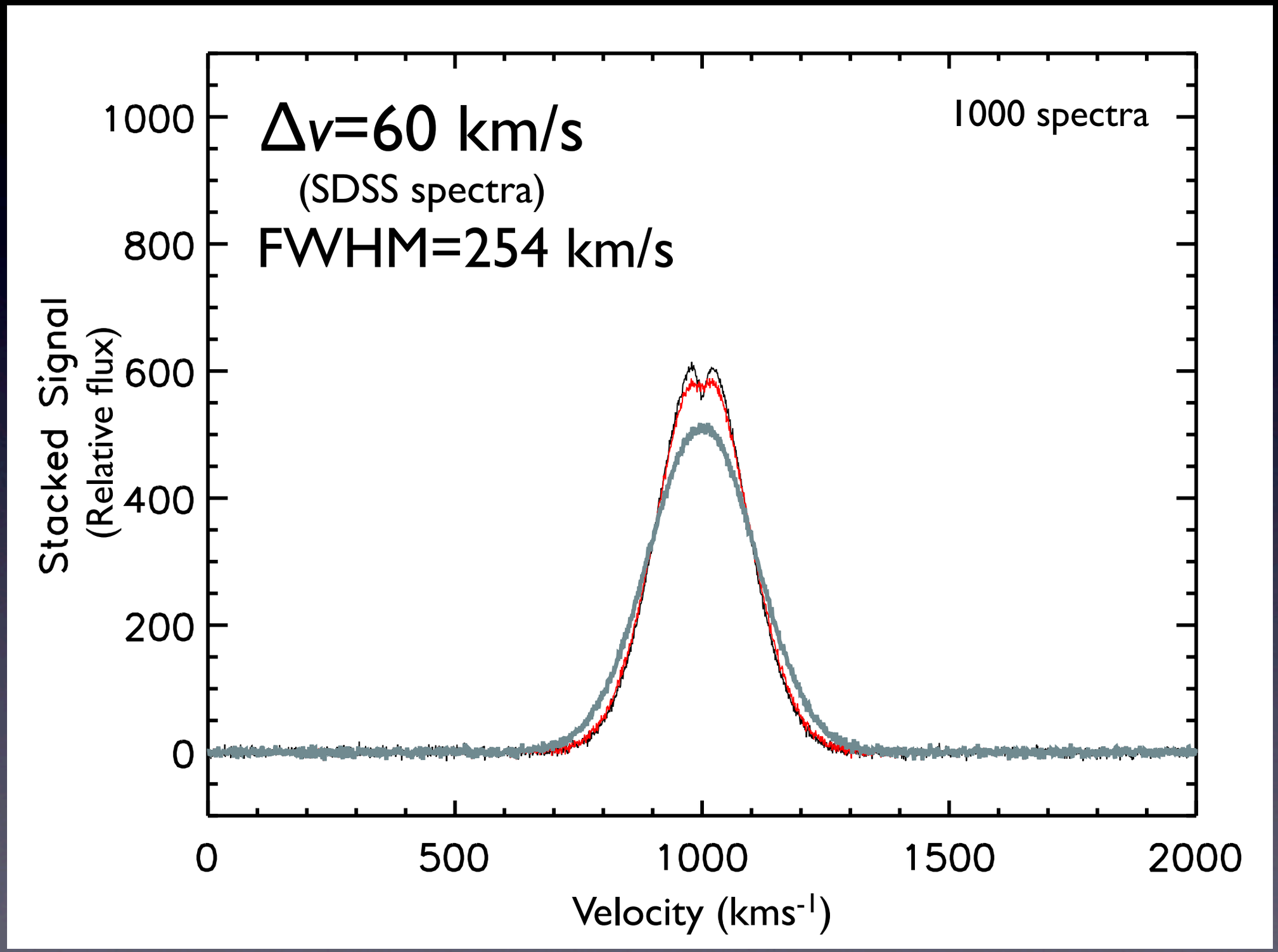
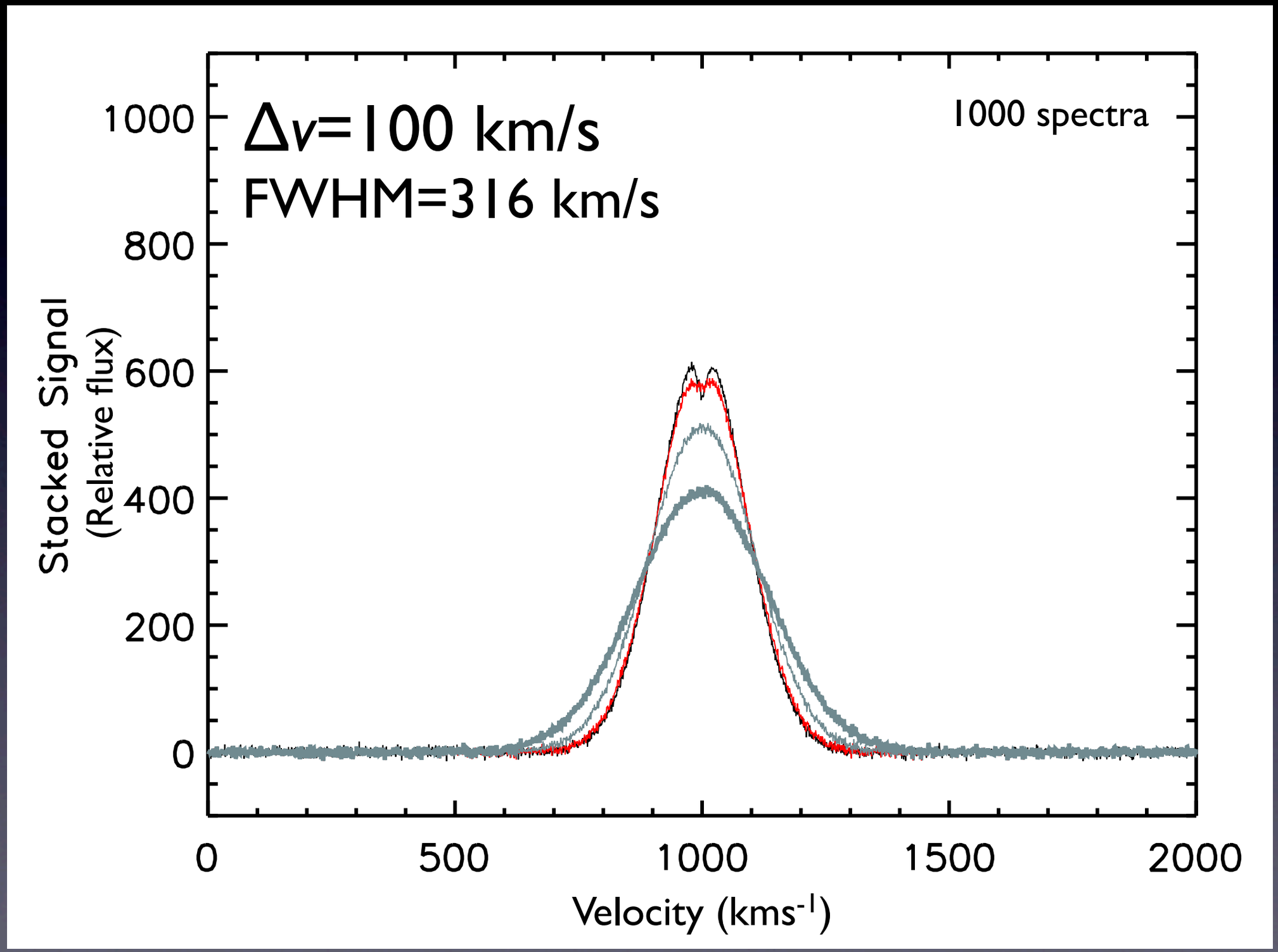


Velocity offsets altering the stacked profile



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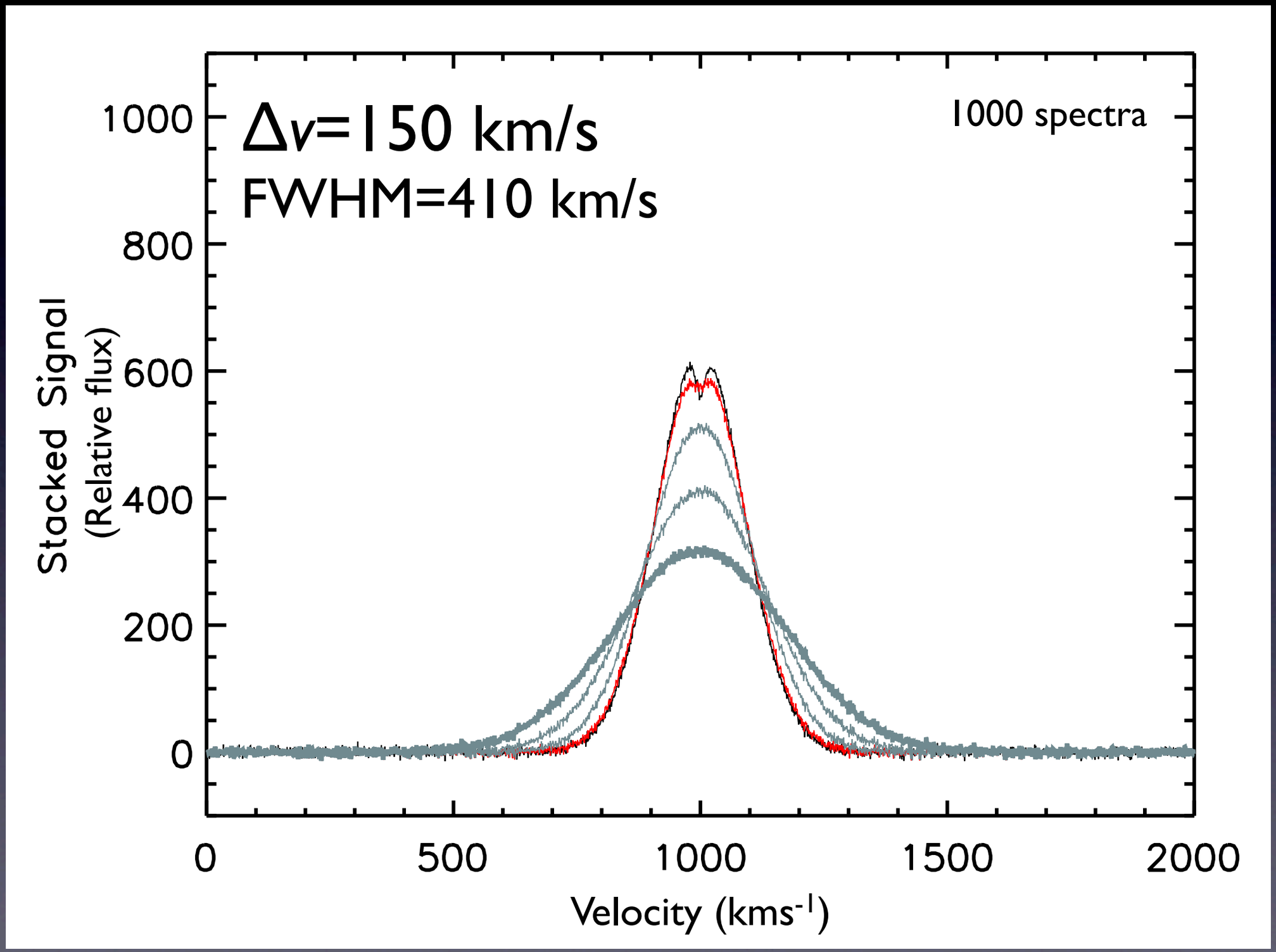

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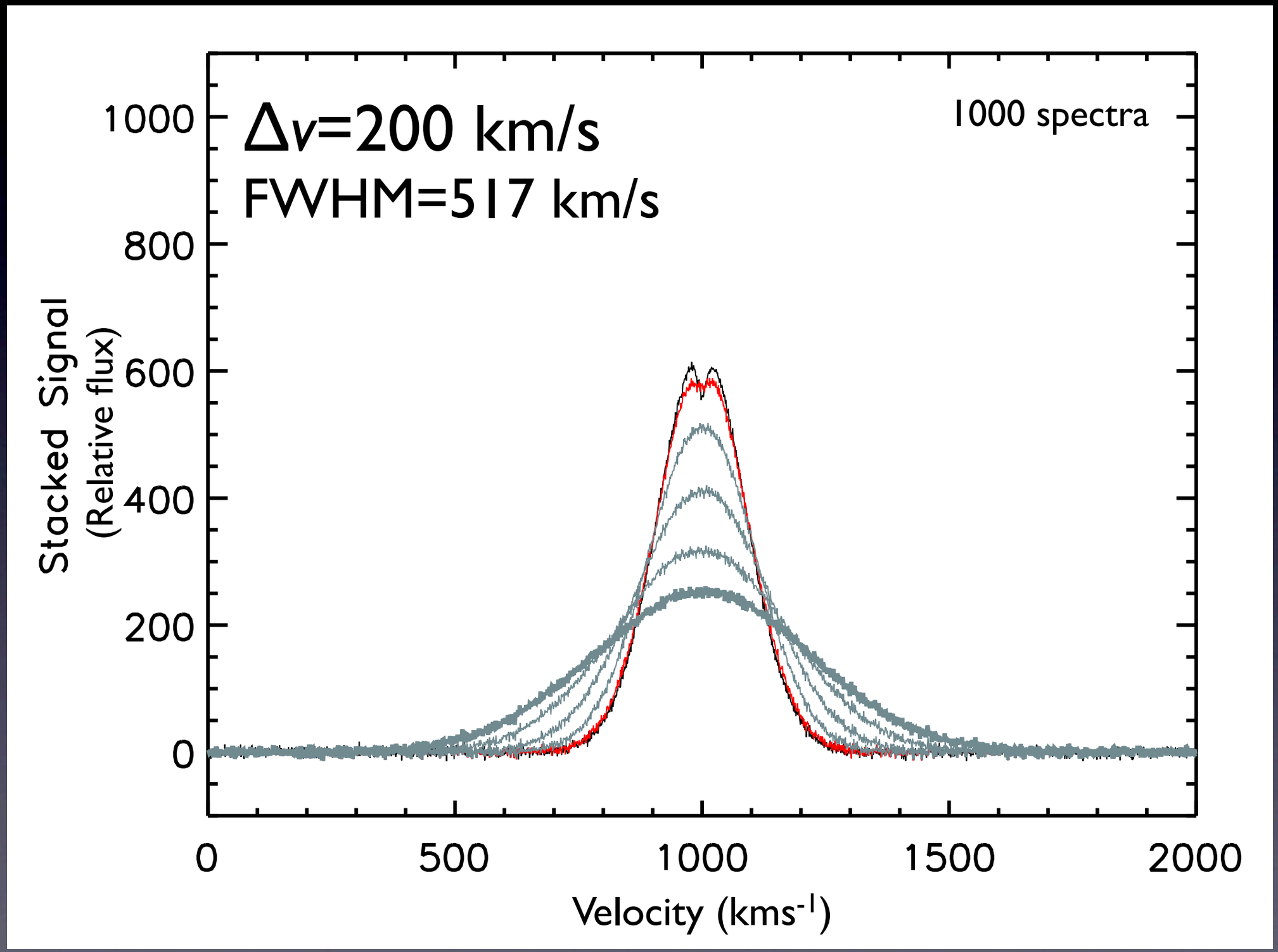

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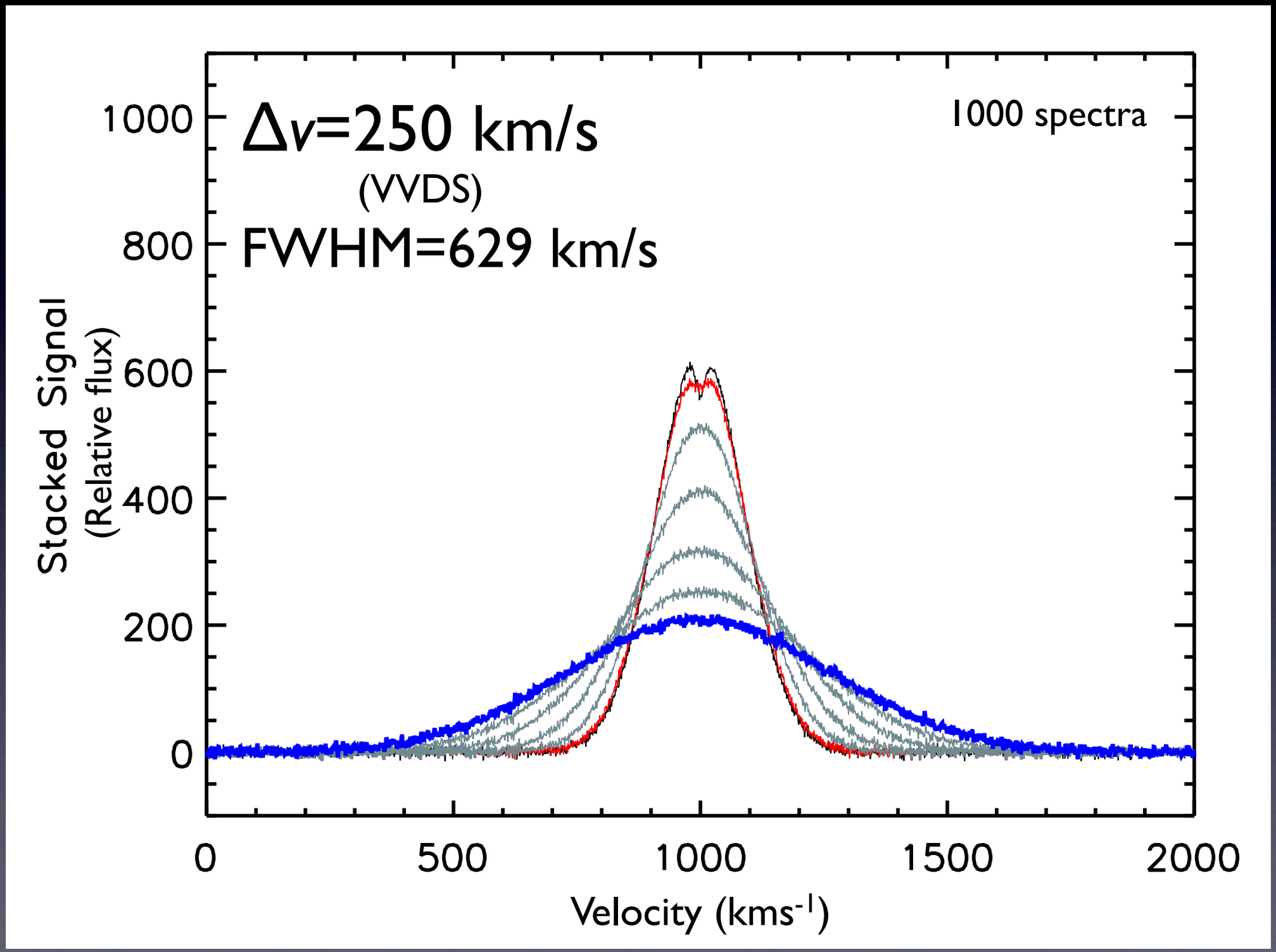

How does this affect the stacked signal?

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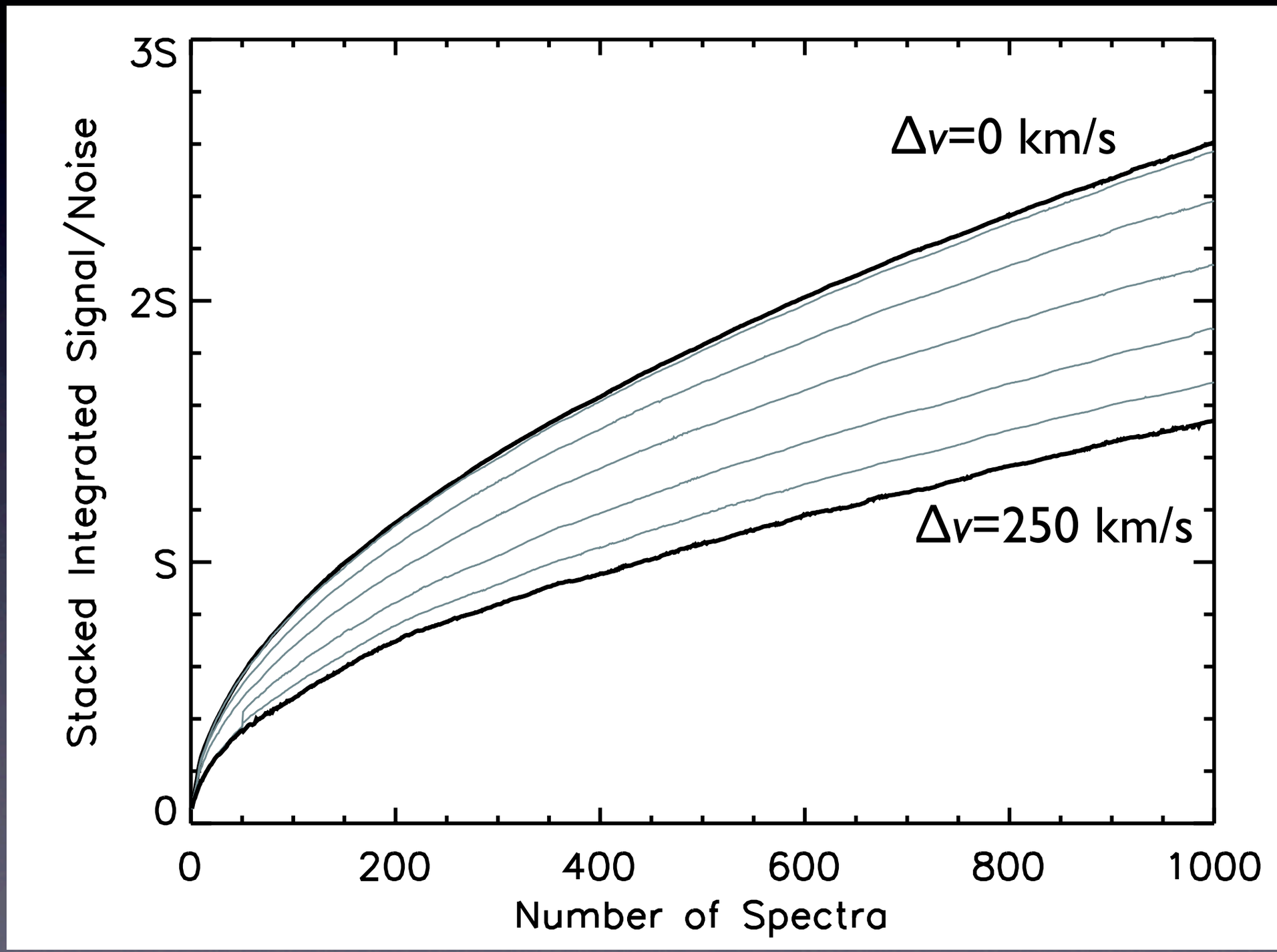

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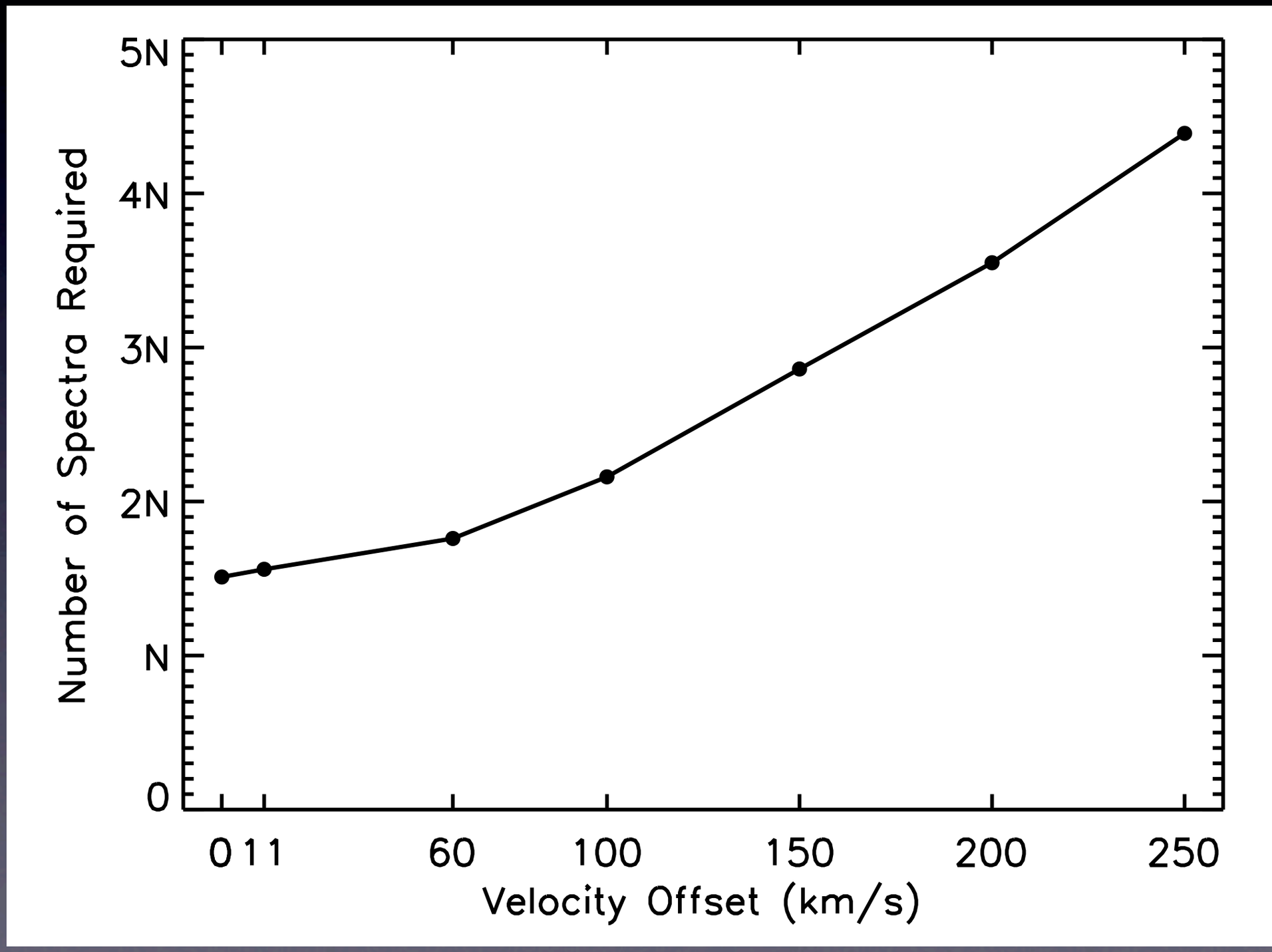

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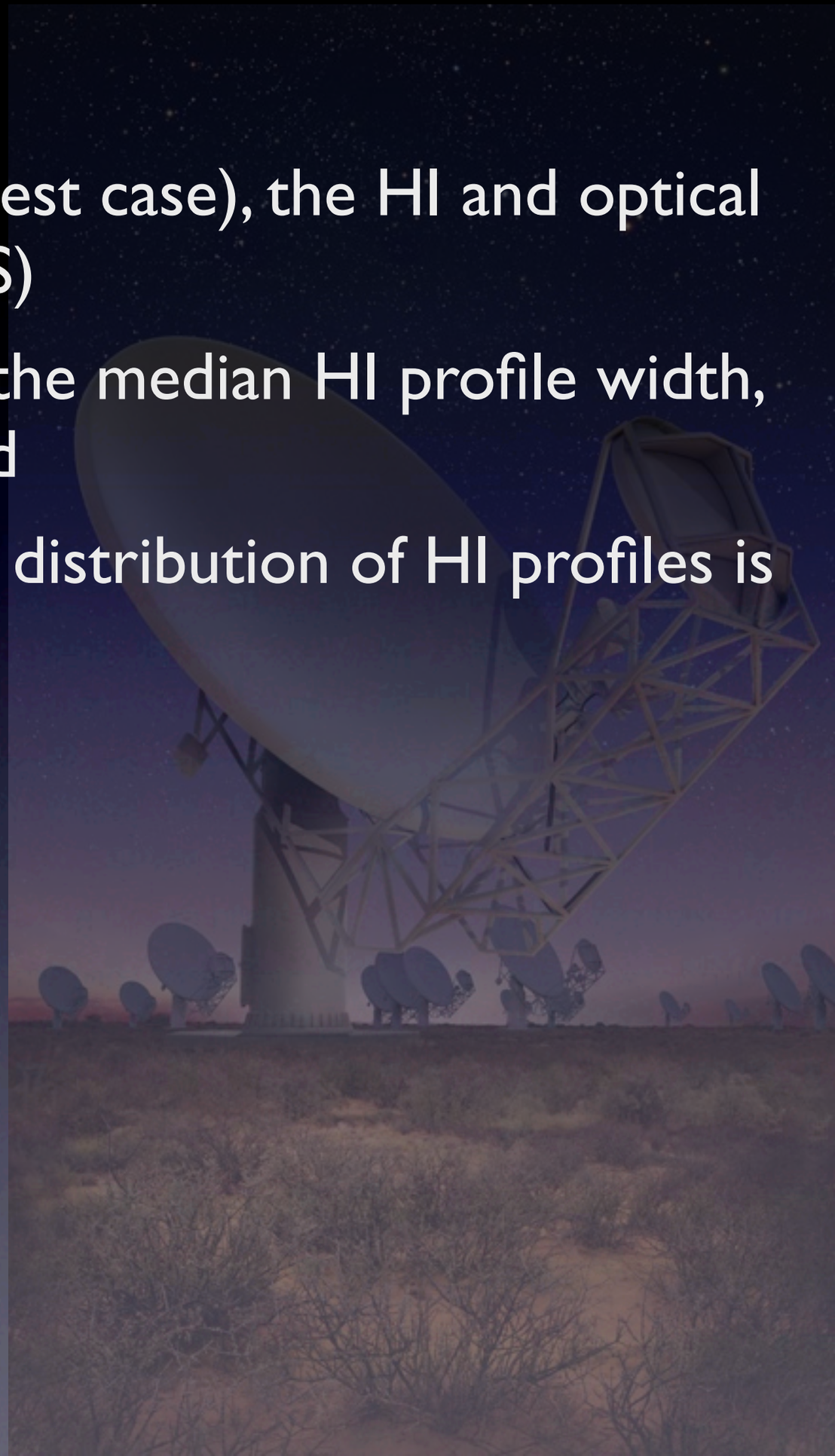

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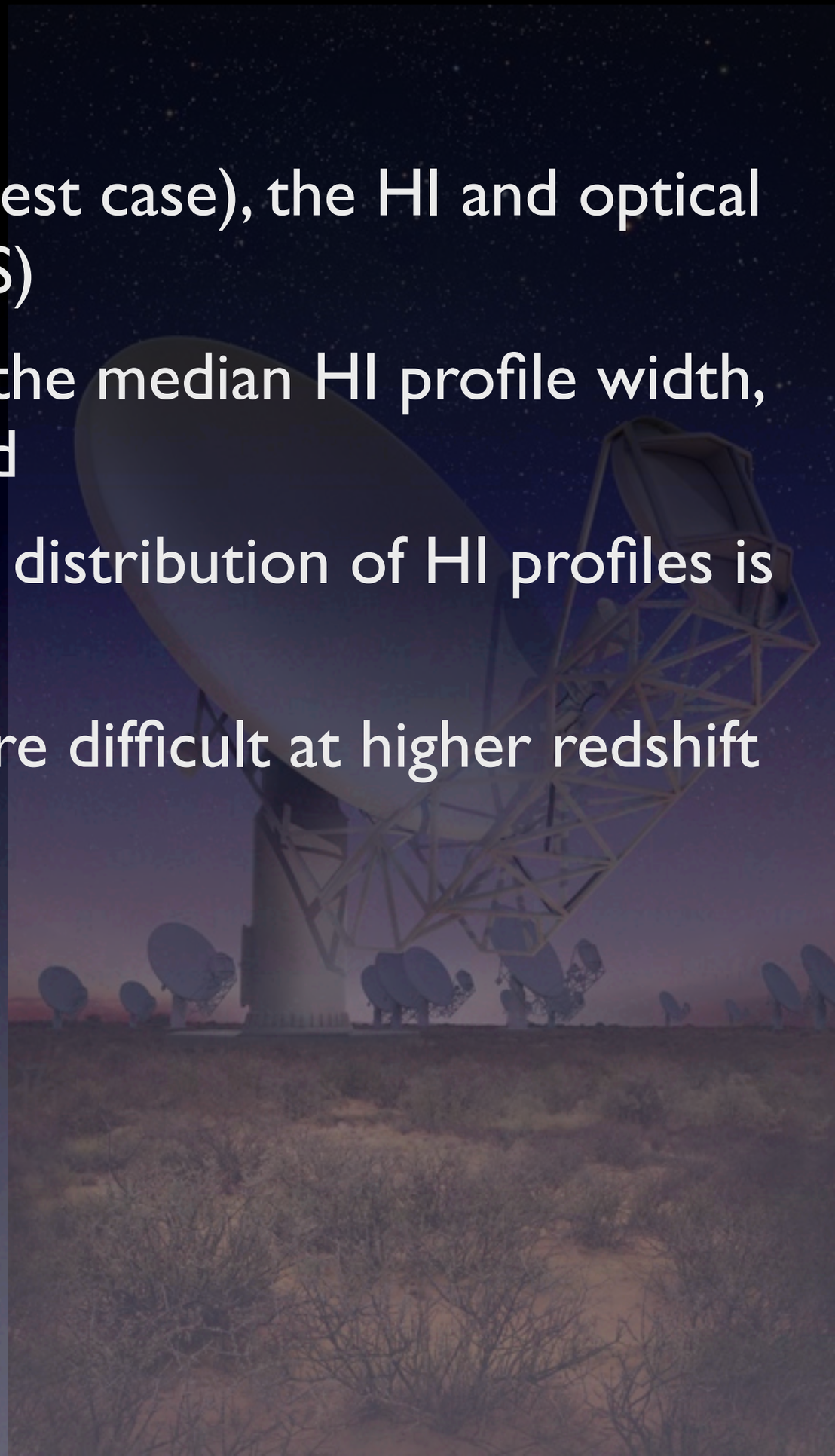

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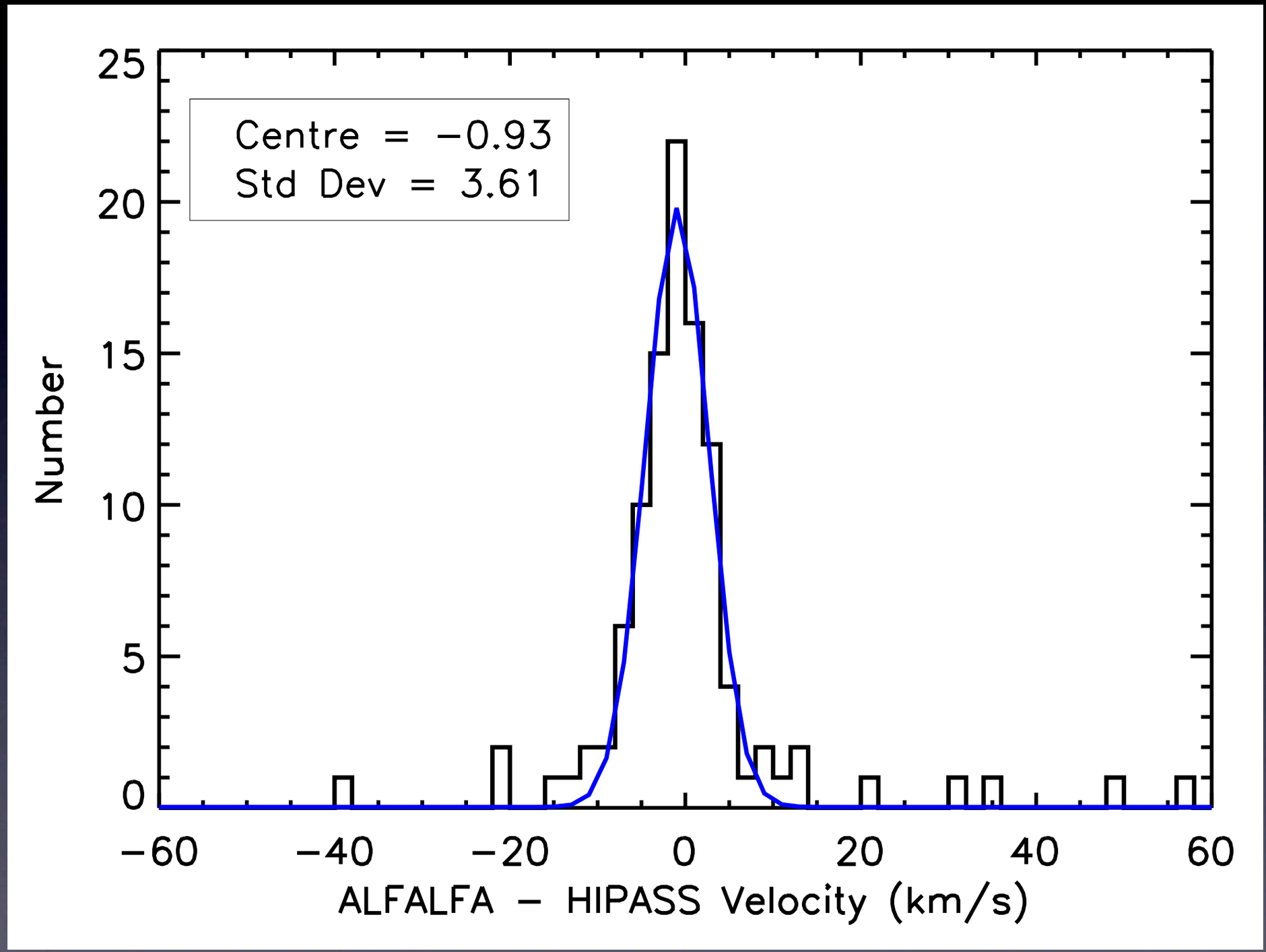
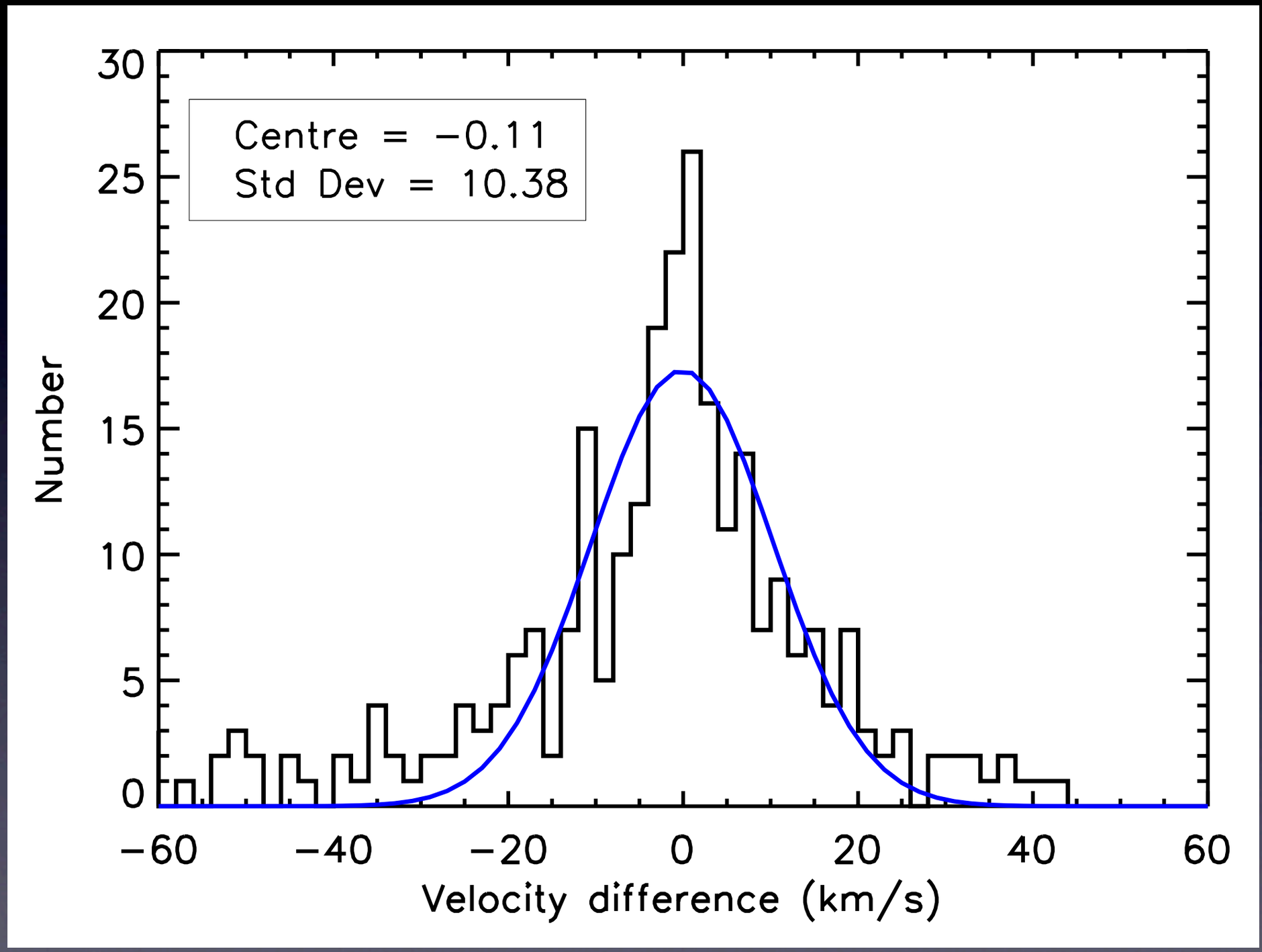
- Can determine how many spectra are required to build a profile with a target S/N, what spectral resolution we need, how well the recovered HI mass corresponds to the input mass, ...

With thanks to SKA AFRICA SQUARE KILOMETRE ARRAY

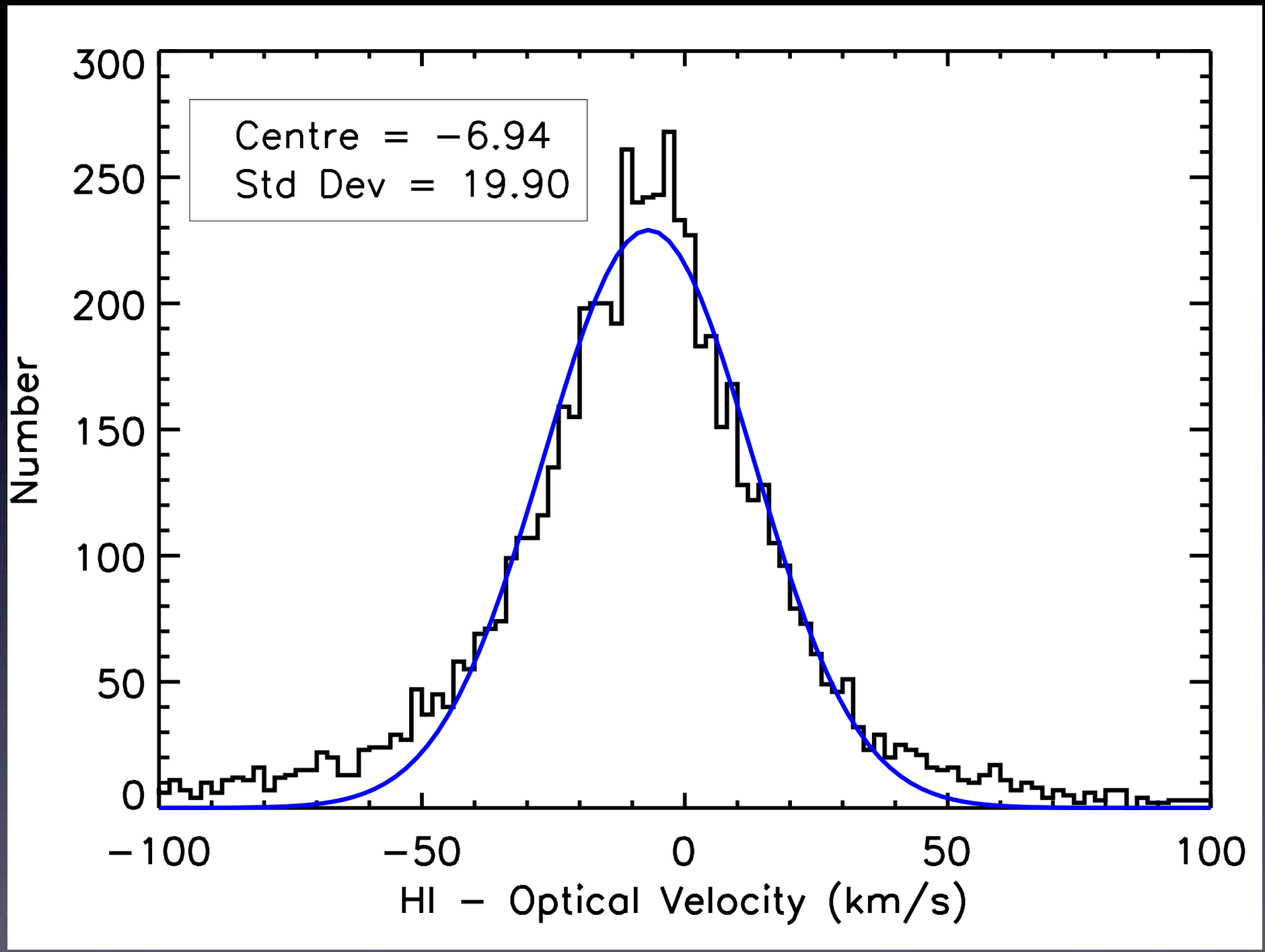
ALFALFA - HIPASS velocities:



SDSS - SDSS velocities:

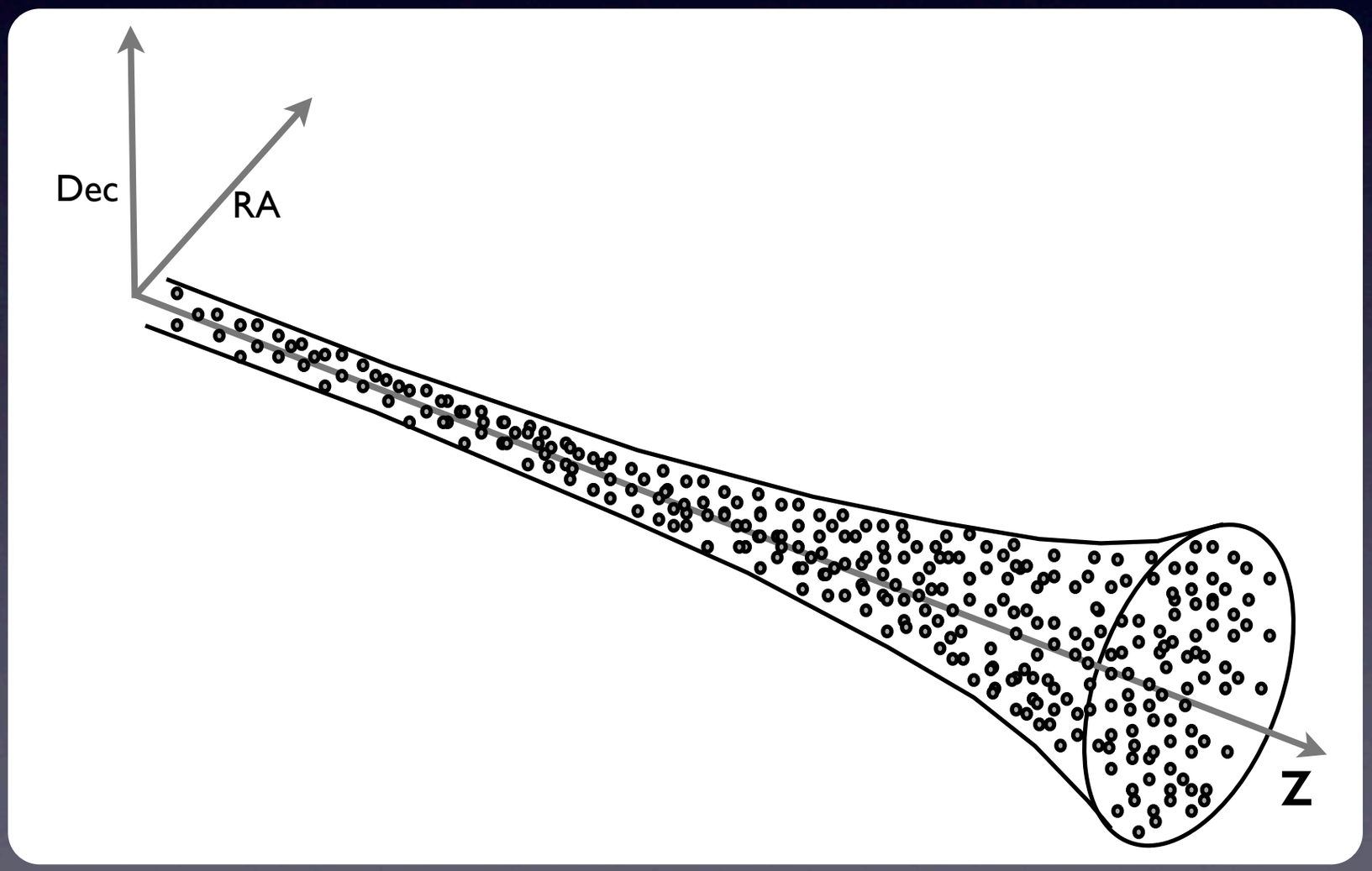


ALFALFA - SDSS CAS velocities:



LADUMA

- Awarded 5000 hours of MeerKAT time for observations of a single pointing
- Direct HI detections $z \leq 0.6$, stacked detections $z \leq 1.4$



The LADUMA Field:

- Single pointing encompassing ECDF-S (dec=-27)
- Significant multi-wavelength data already exist

ECDF-S
0.3deg^2

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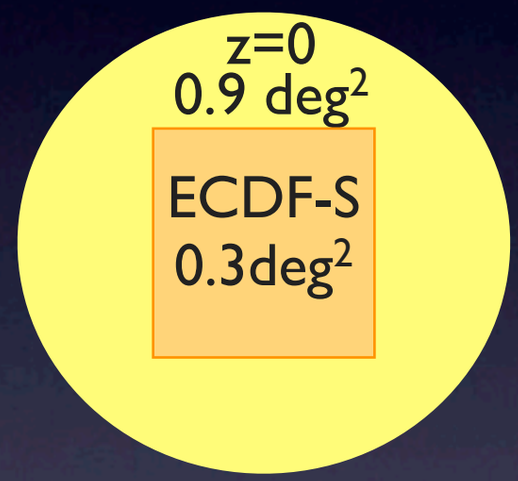

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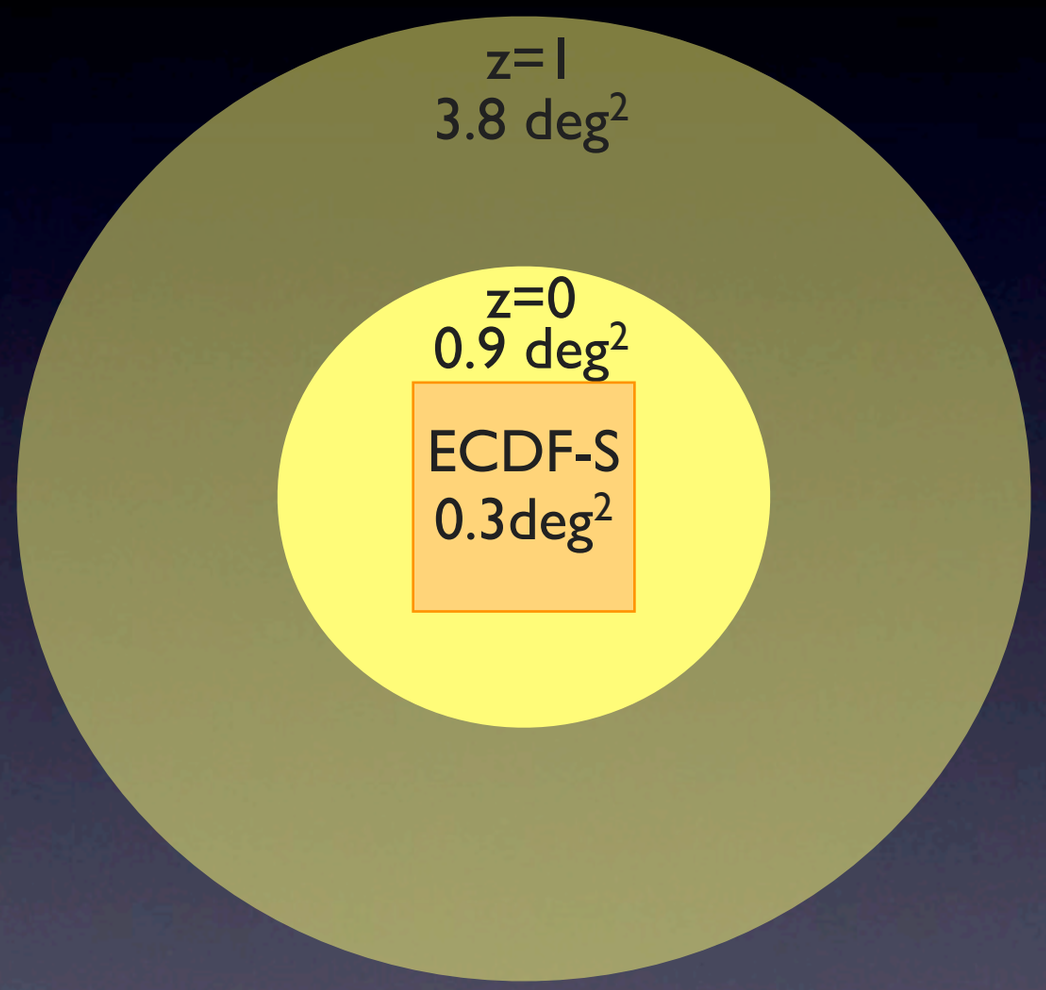

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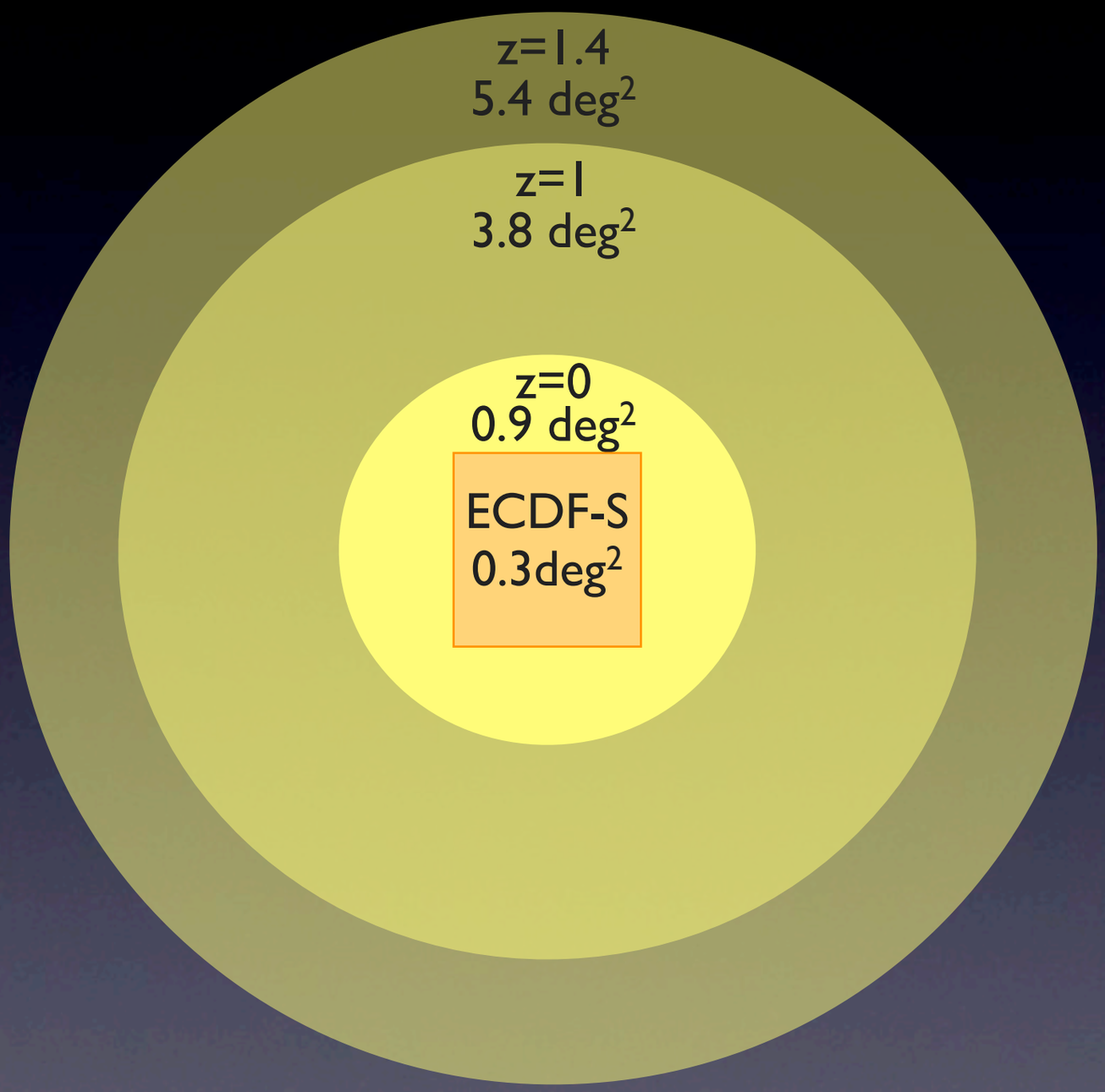

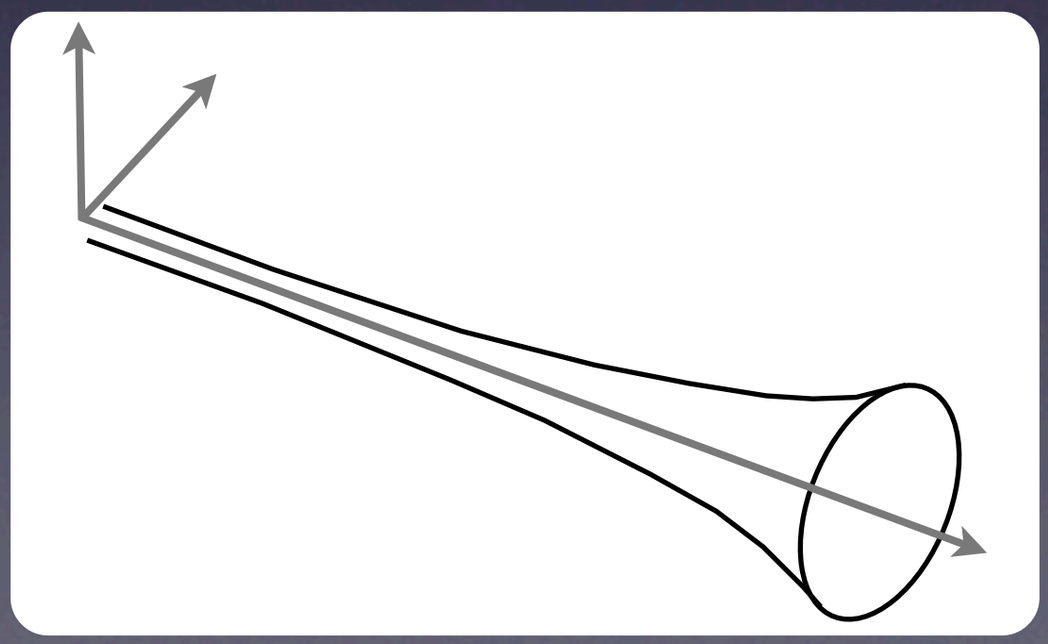

The LADUMA Field:

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- Significant multi-wavelength data already exist
- Would like multi-wavelength data over entire >5 deg^2