Verification and science with the JWST/NIRSpec Instrument Performance Simulator

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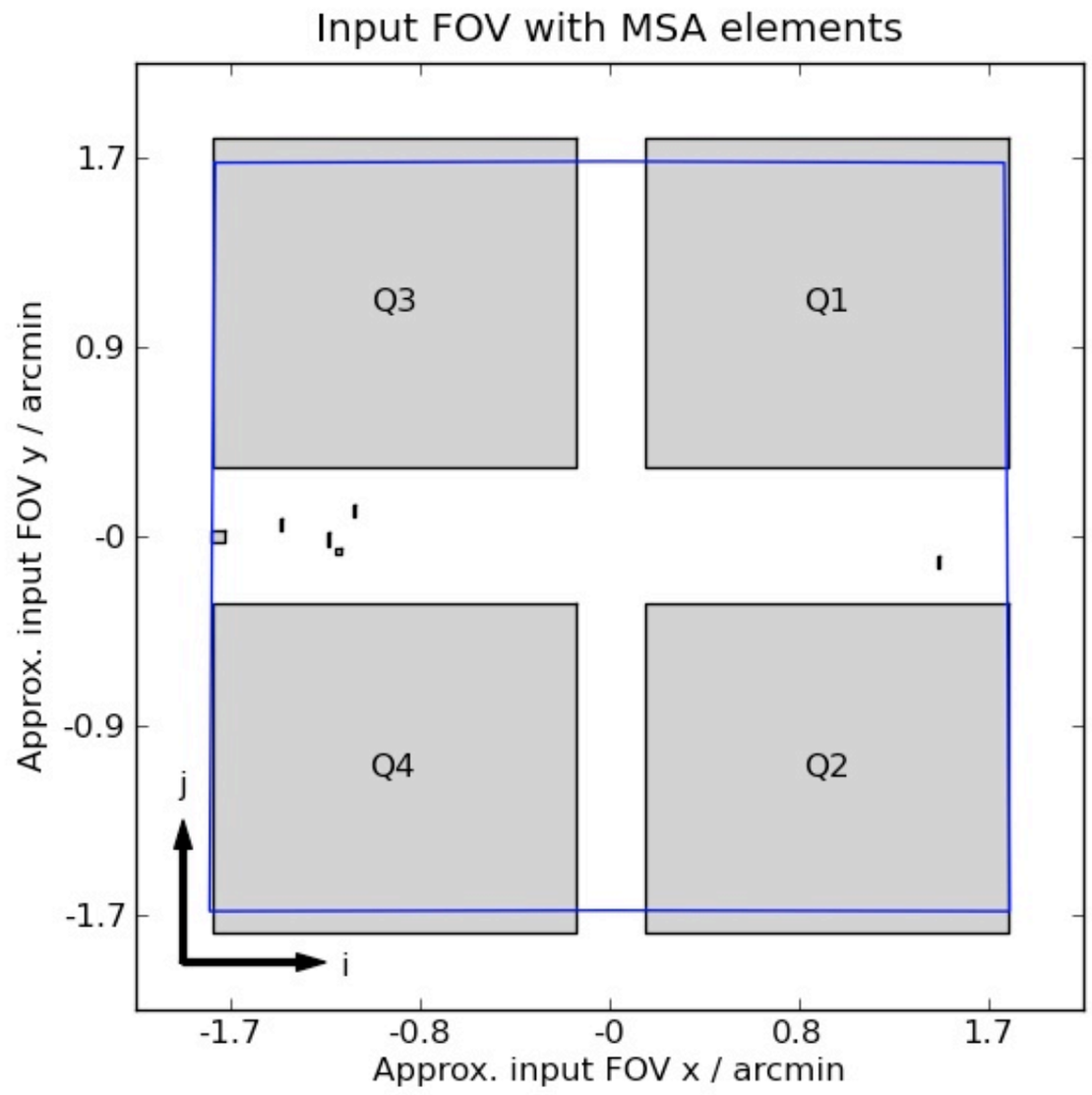
My thesis: It's all abut the IPS...

- Verify simulator algorithms and models
  - Compare with theoretical results
  - Compare with NIRSpec calibration measurements
- Simulate future observations
- Additional developments:
  - Science data input interface
  - Data reduction pipeline

Sky input interface

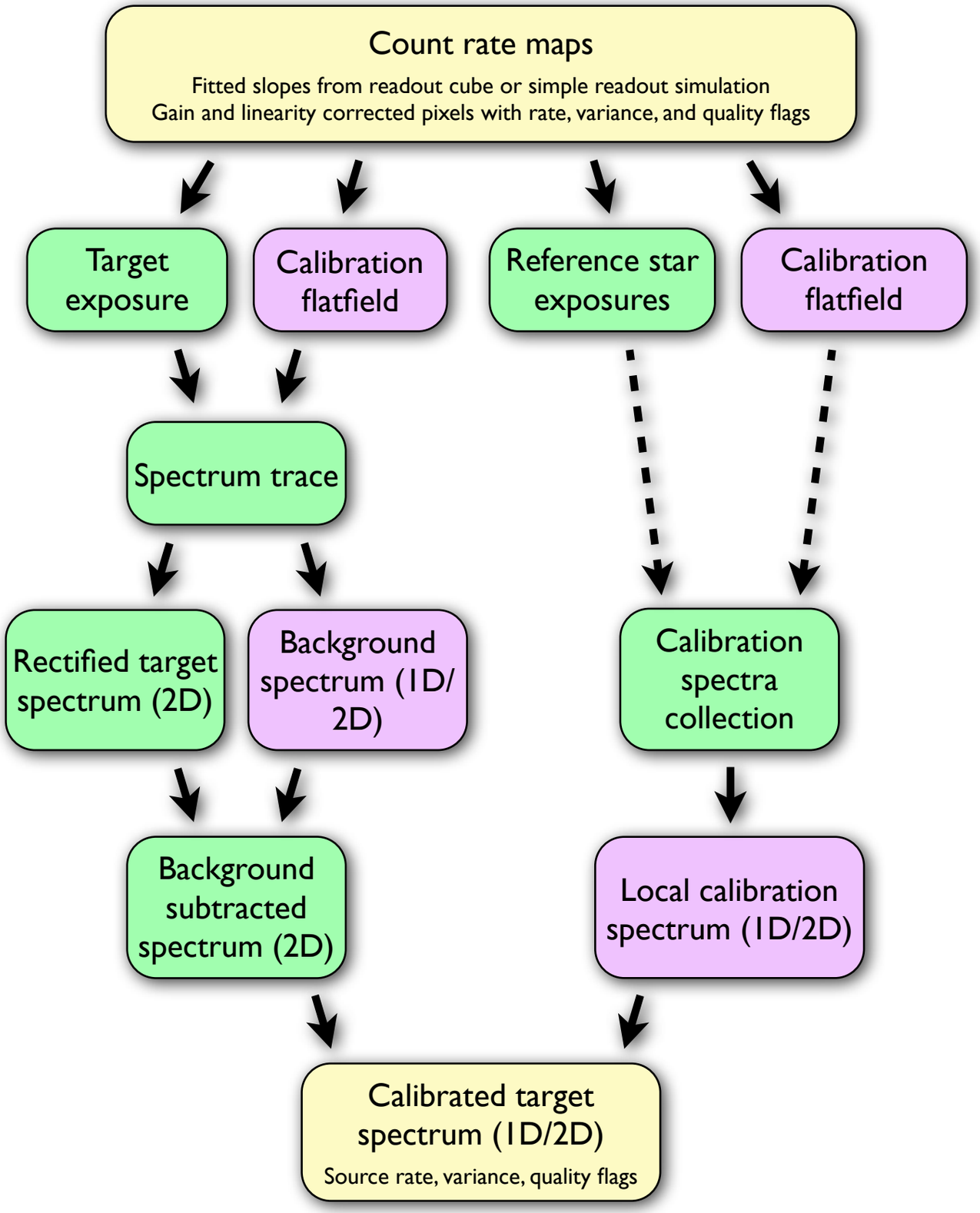
- Direct placement in shutters, slits + IFU slices
- Standard file types (spectrum, image & spectrum, cube)
- IDL and python libraries
- Use short scripts to create scenes
- Needs instrument model for final file creation



NIRSpec IPS Pipeline Software (NIPPLS)

- Python software framework for analysis of NIRSpec data
- Extract and process spectra
- Uses instrument model in pipeline
- Initially for IPS data, but also used for measurements (still the only tool to get spectra)
- Modular and flexible for custom processing

NIPPLS standard slit workflow

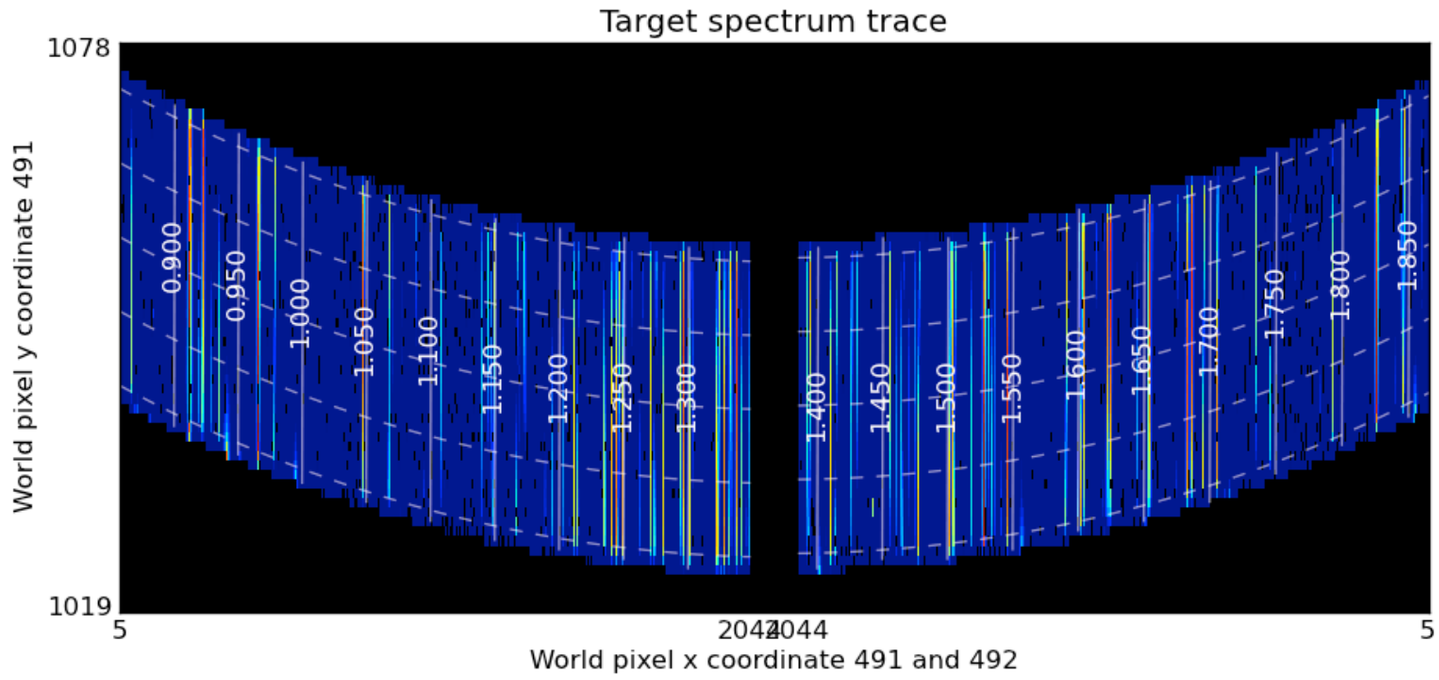


Verification: software and model

- Simulation approach (IPS functionality is tested before delivery)
- Coordinate transforms (geometry, dispersers): spectra, images
- Throughput: Calibrated sources, relative comparisons

Coordinate transforms: Adjustment

- First cryo data from Feb 2011
- Processing with NIPPLS
- Flatfield and emission line spectra: Match in spatial and spectral direction
- Optimize key model parameters



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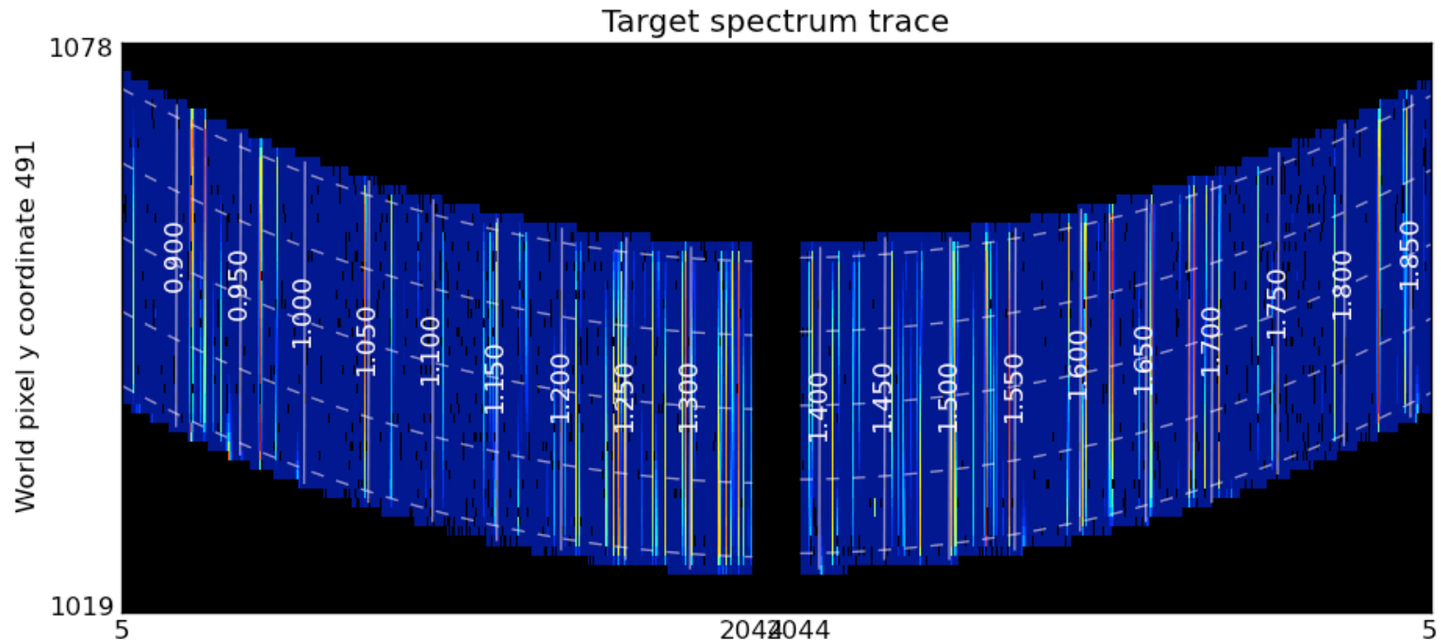

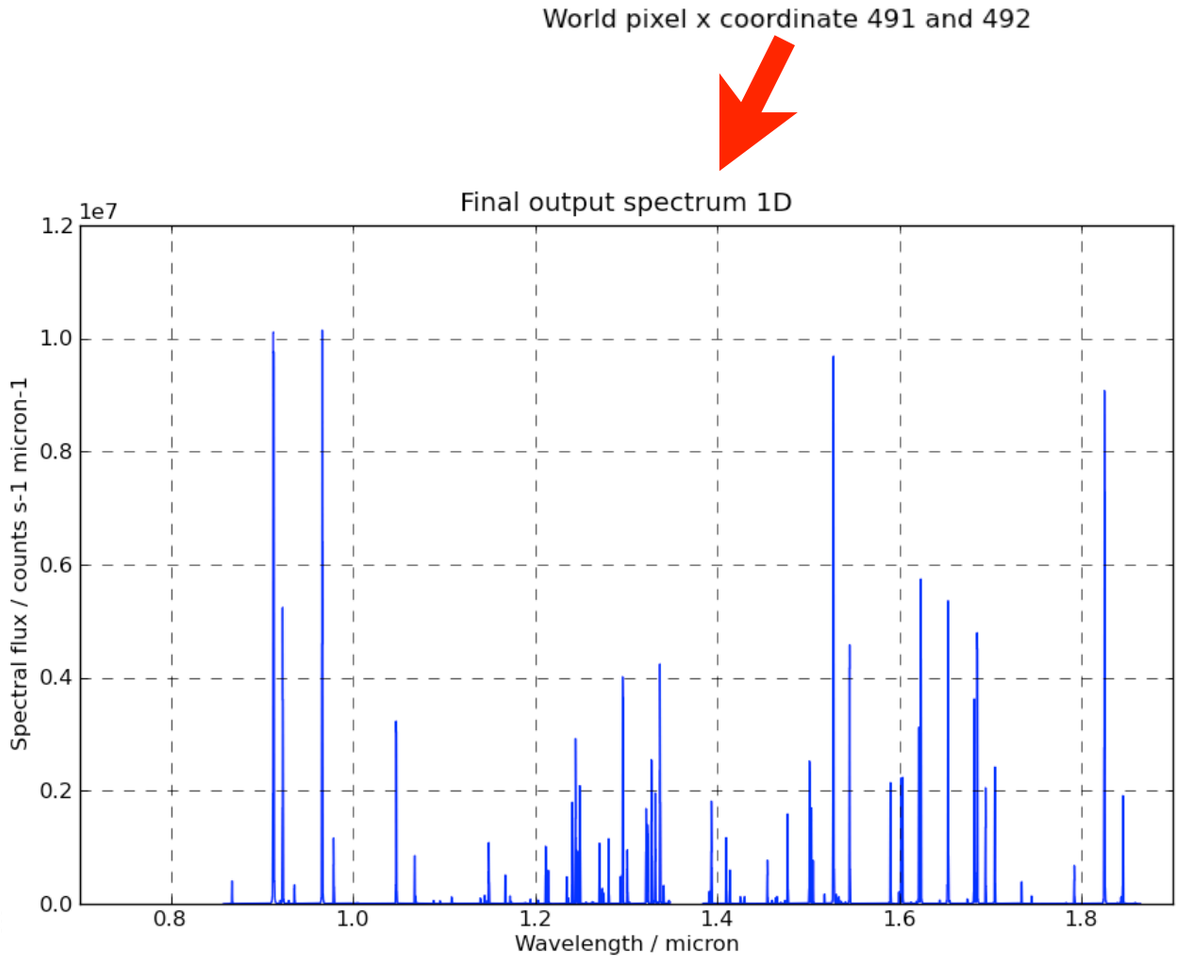

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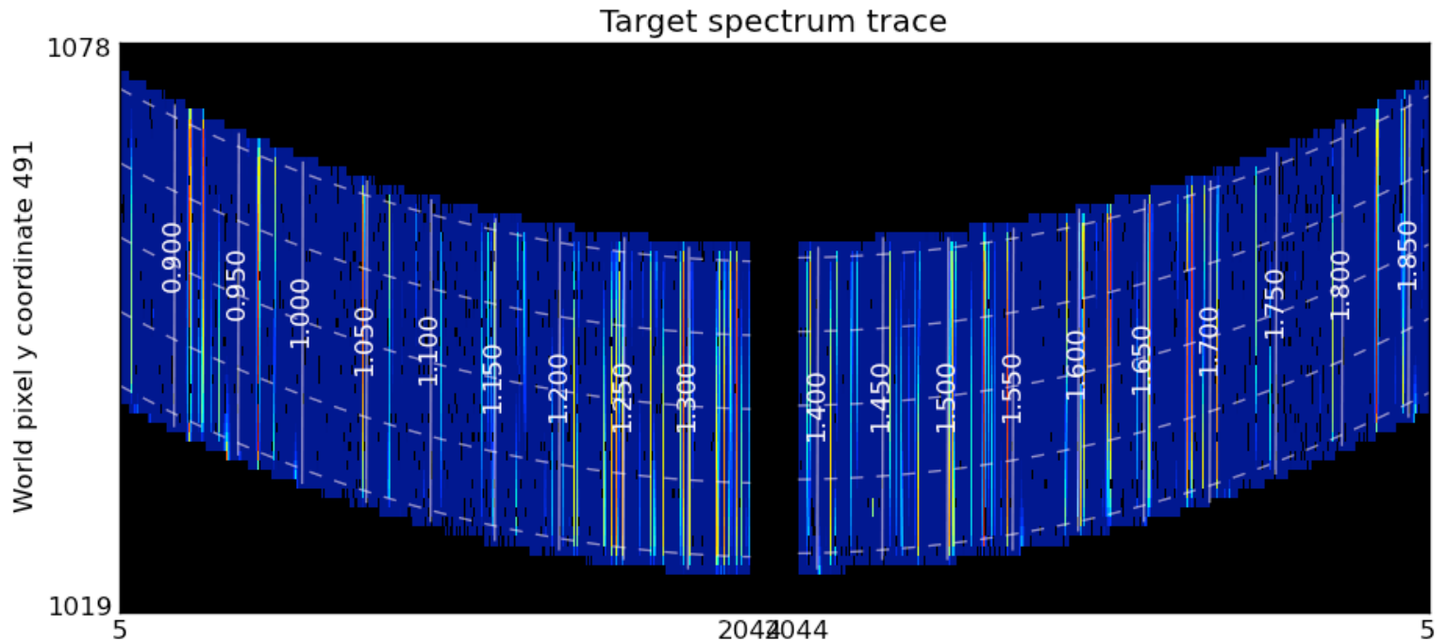
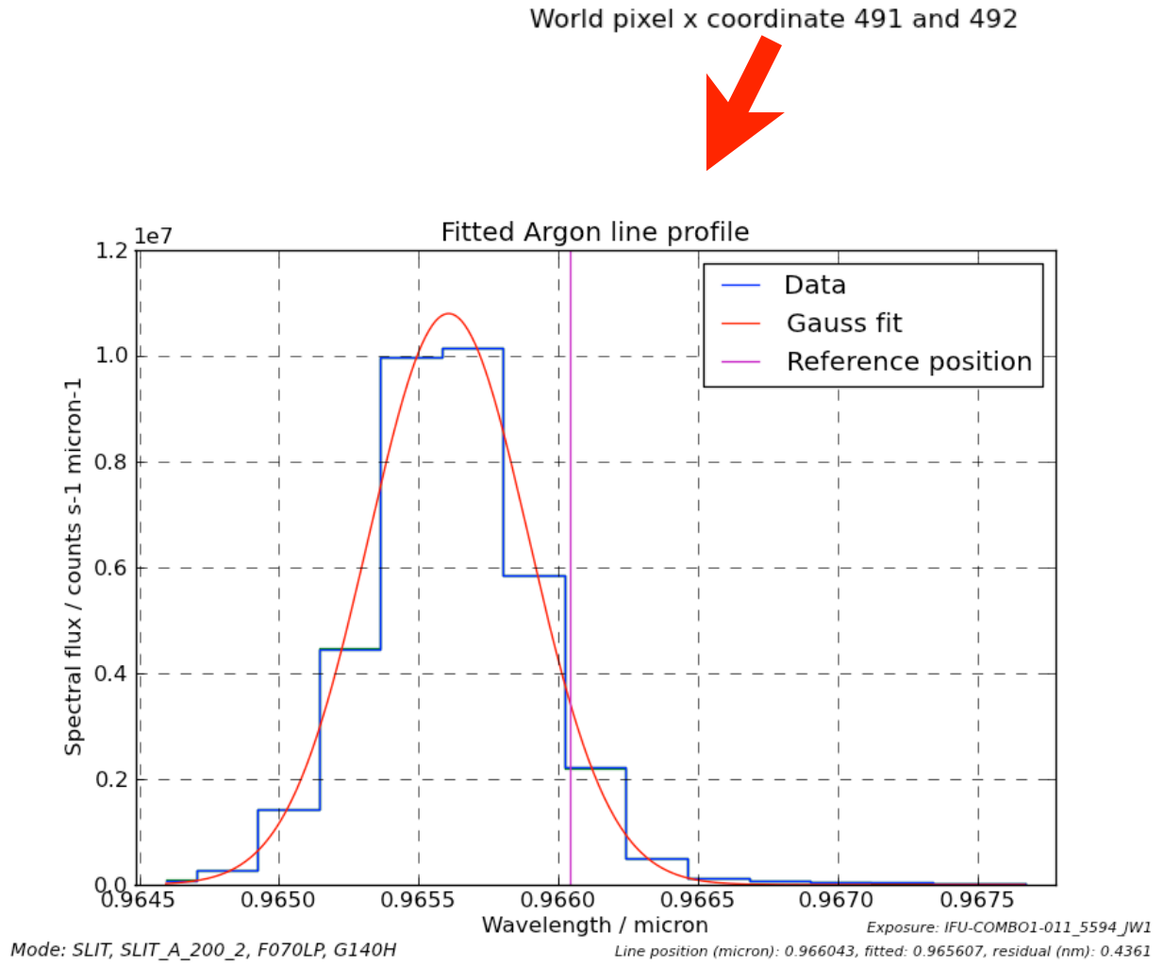
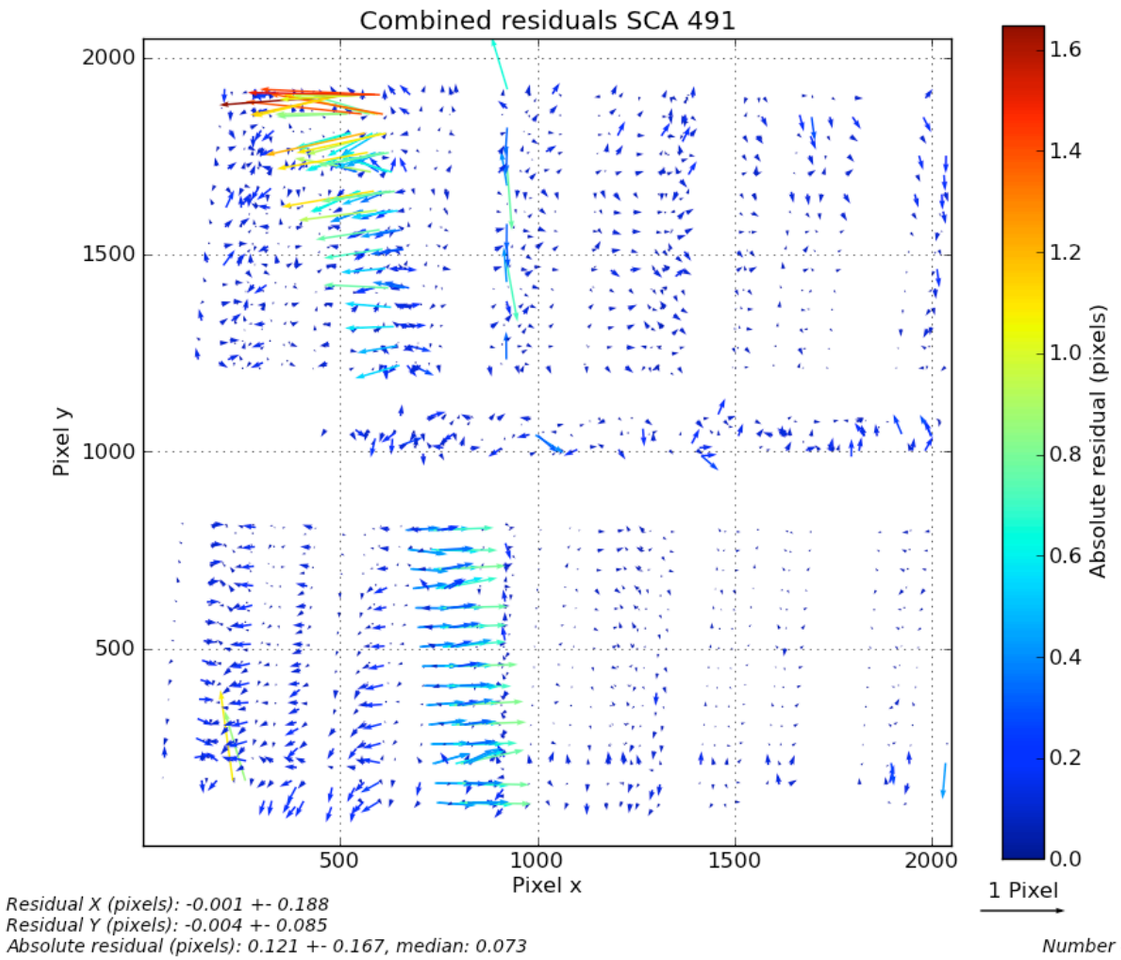
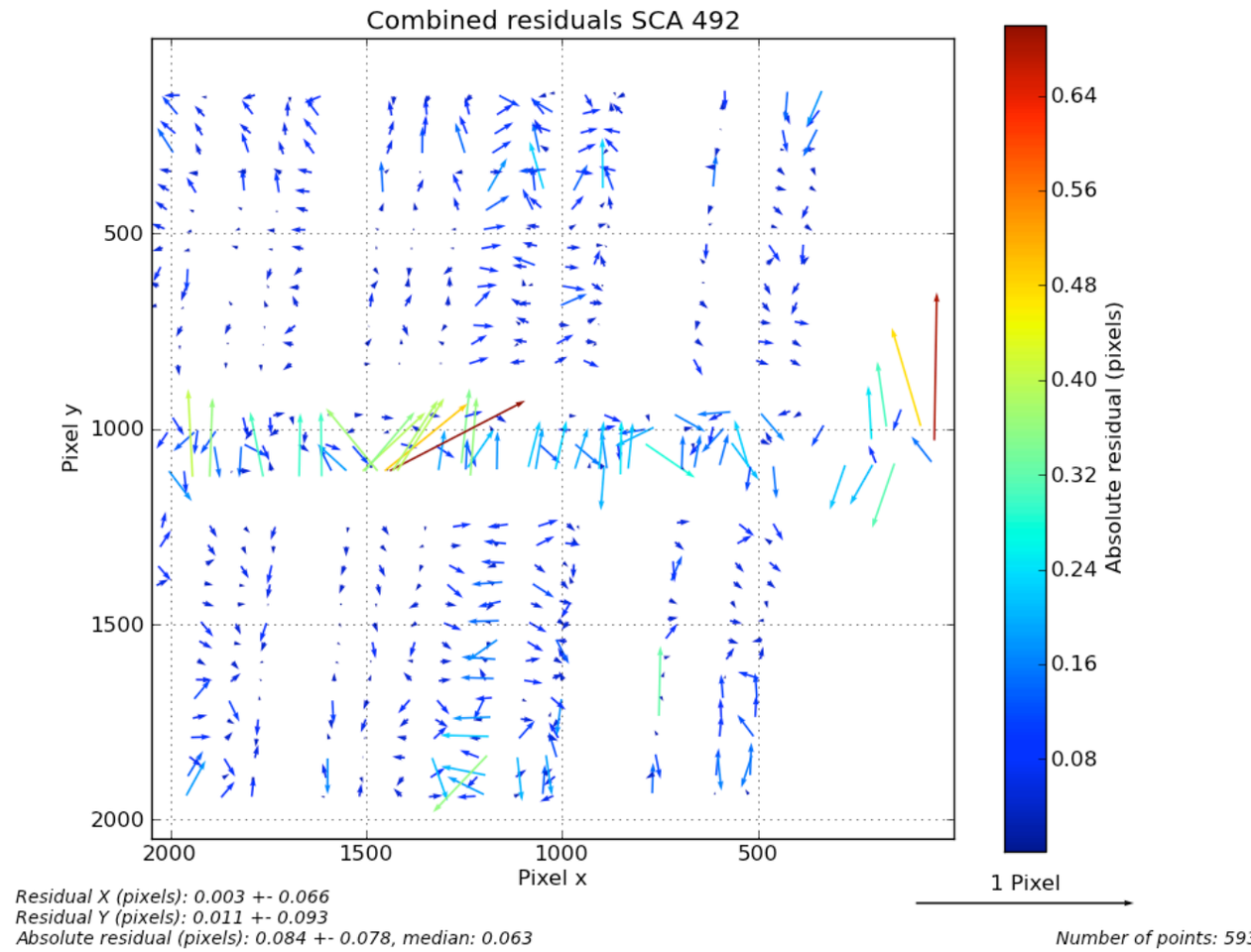




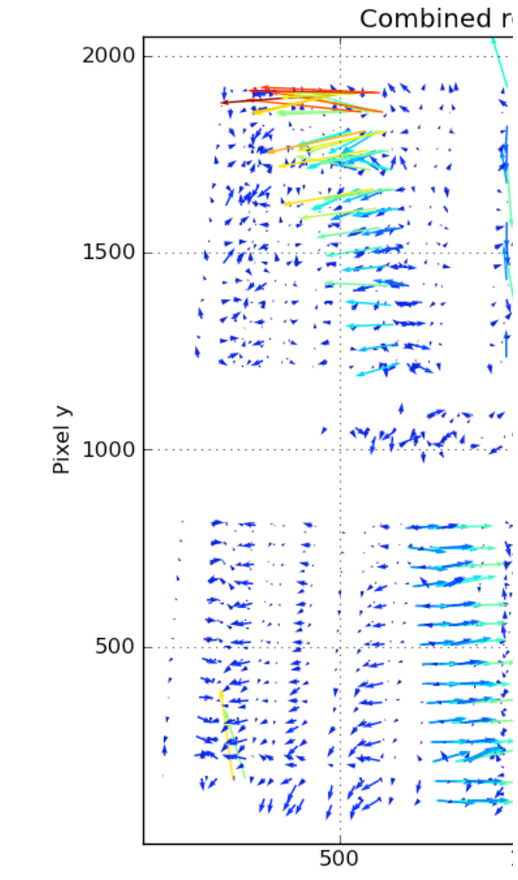
Coordinate transforms: Residuals



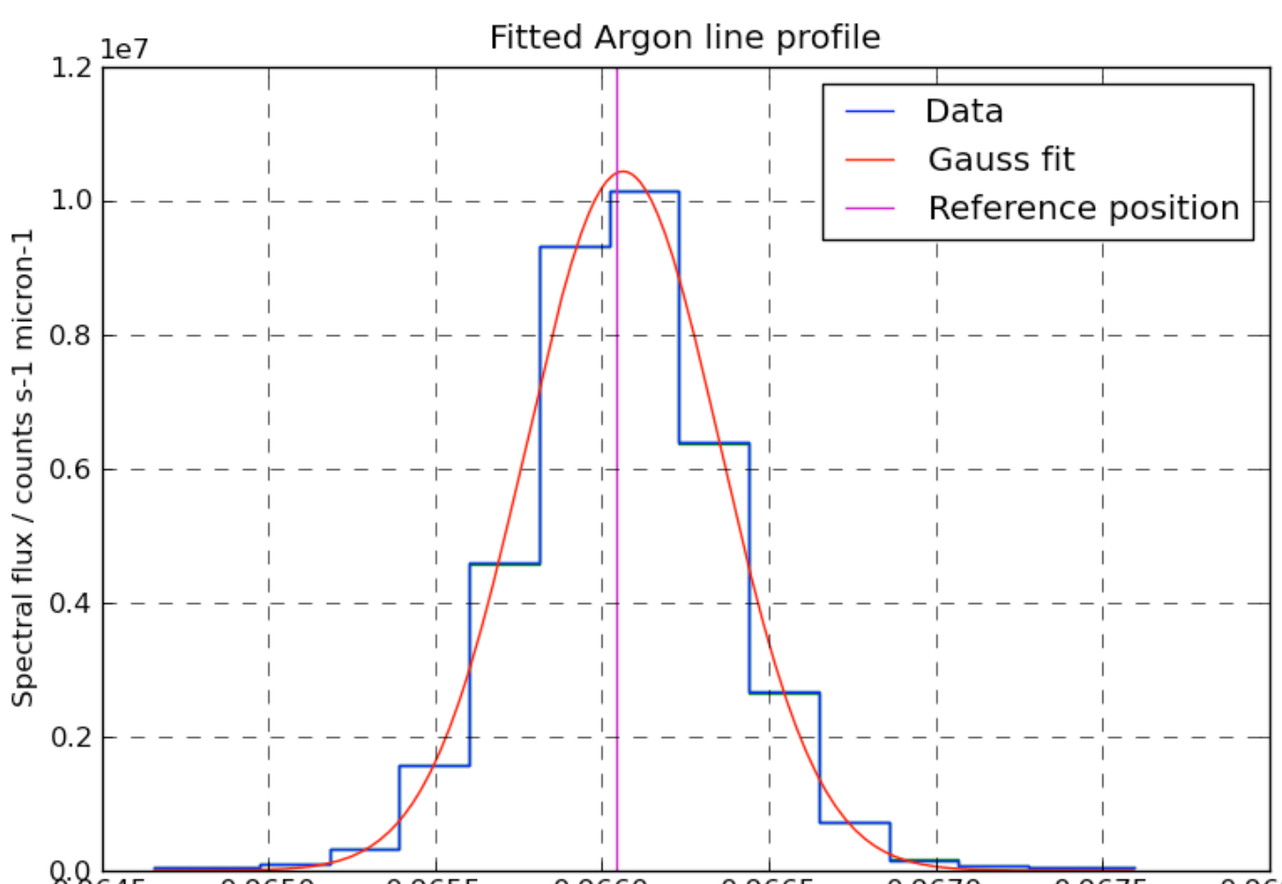


Overall residuals: about 1/15 px

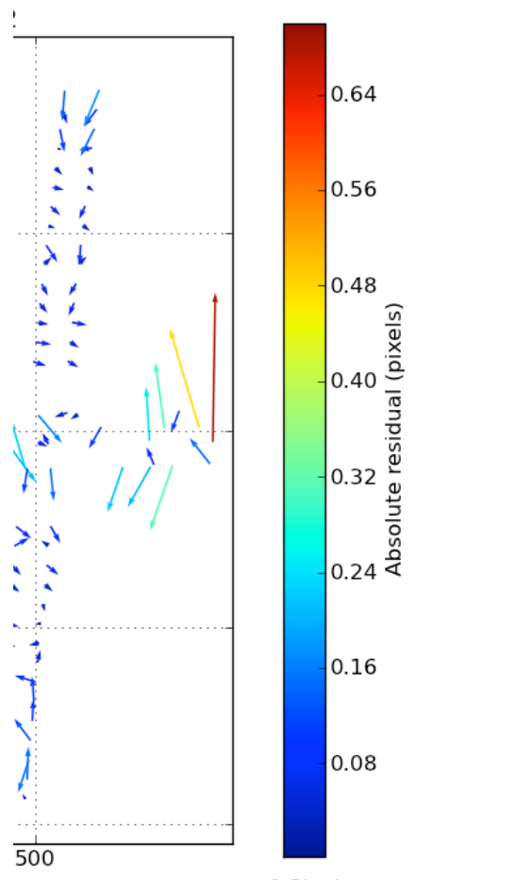
Coordinate transforms: Residuals



Residual X (pixels): -0.001 +- 0.188
Residual Y (pixels): -0.004 +- 0.085
Absolute residual (pixels): 0.121 +- 0.167, median: 0.07



Mode: SLIT, SLIT_A_200_2, F070LP, G140H
Exposure: IFU-COMBO1-011_5594_JW1
Line position (micron): 0.966043, fitted: 0.966063, residual (nm): -0.02023



Number of points: 593

Overall residuals: about 1/15 px

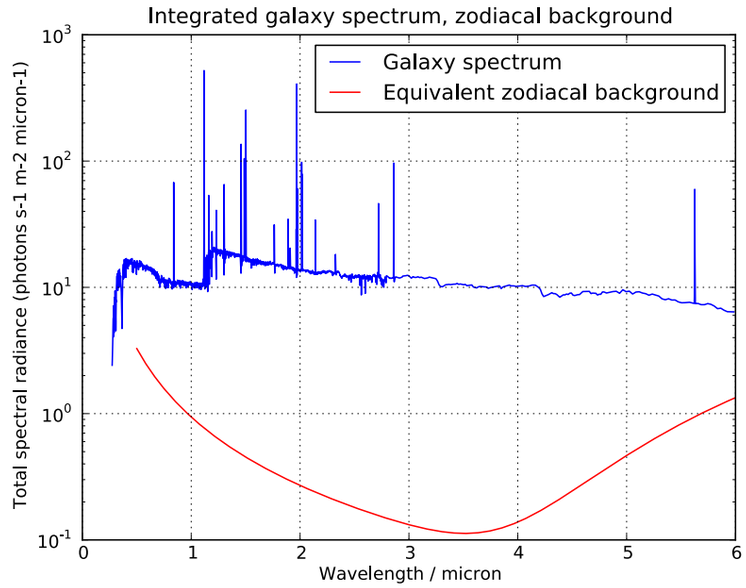
ELIXIR meeting Madrid 05/10/2011

Science simulations

- Multi-object spectroscopy (Camilla, Peter, Stéphane)
  - High-redshift galaxies (z=1...8) in UDF with model spectra
- Integral field spectroscopy (Enrica, Santiago)
  - Ultra-luminous infrared galaxies
- Planetary transits (Jeff Valenti)
  - Capabilities for exoplanet characterization

Realistic multi-object scenes

- Hubble UDF: Objects with band photometry and redshift
- Model galaxy spectra from simulations



- Select observable objects in shutter grid
- Find matching spectra to UDF objects
- Construct mock sky scene

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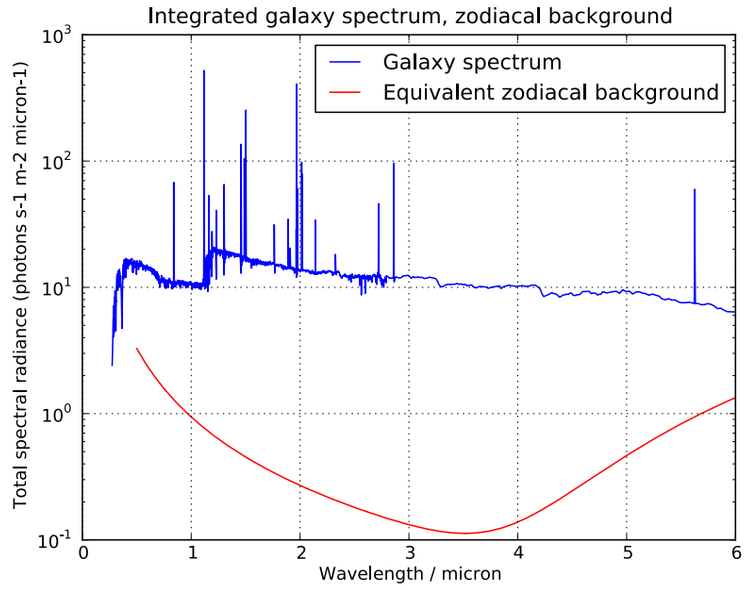

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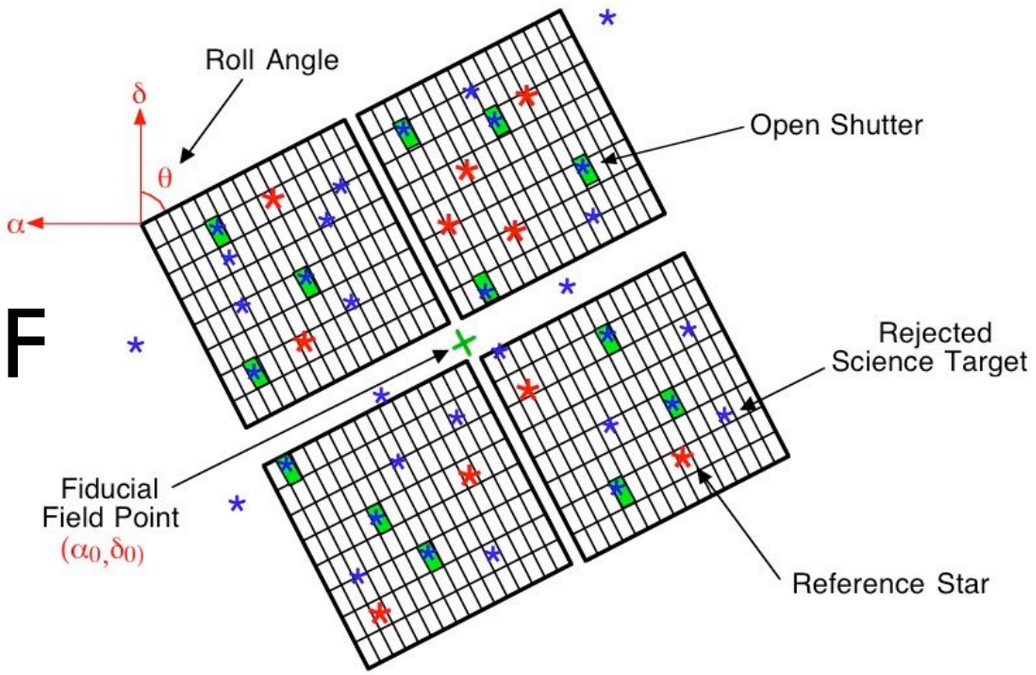
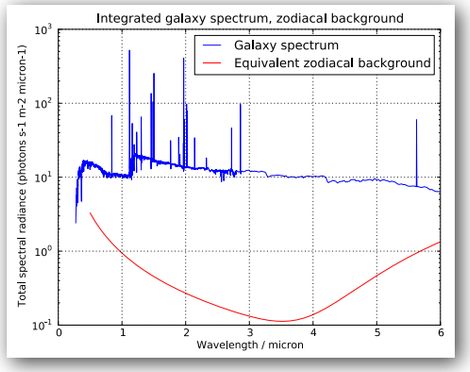
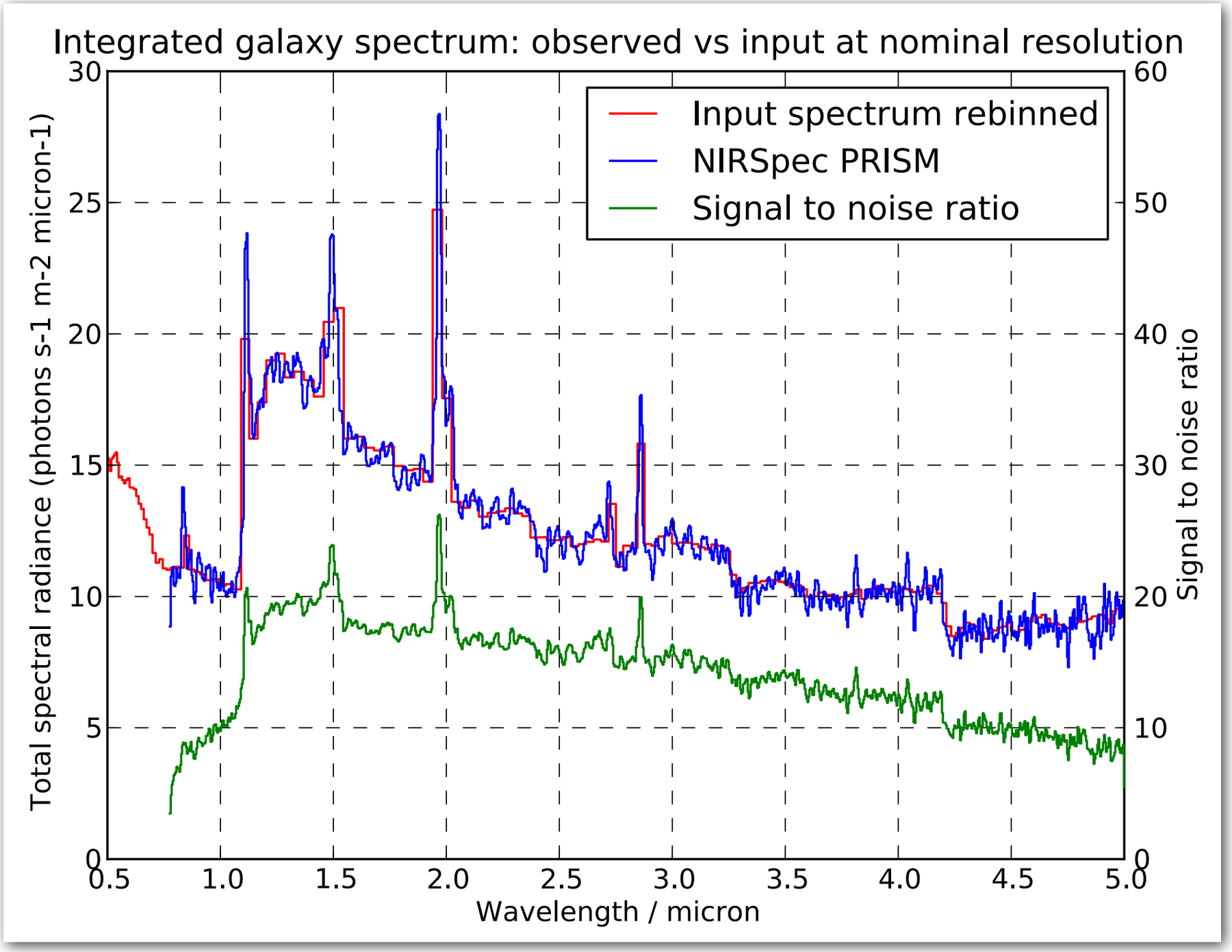


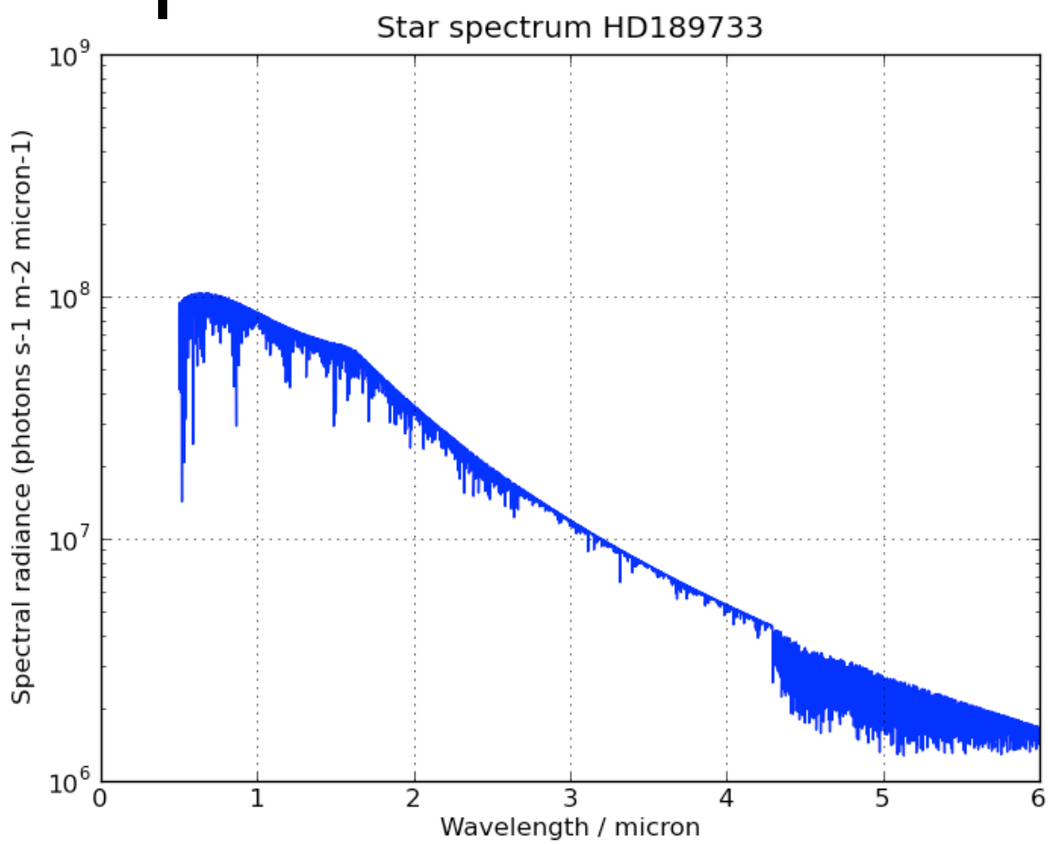
Data reduction: NIPPLS with flatfield + calibration





Simulation example: Planet host star

- HD 189733
  - G5, 0.81 M_{Sun}
  - 2MASS K_S = 5.541
  - Kurucz synthetic spectrum



Resolution: 10000

- HD 189733b
  - R = 1.14 R_{Jup}
  - Msin i = 1.14 M_{Jup}
  - a = 0.031 AU

- Depth: 2.41%
- Transit time: 60 min

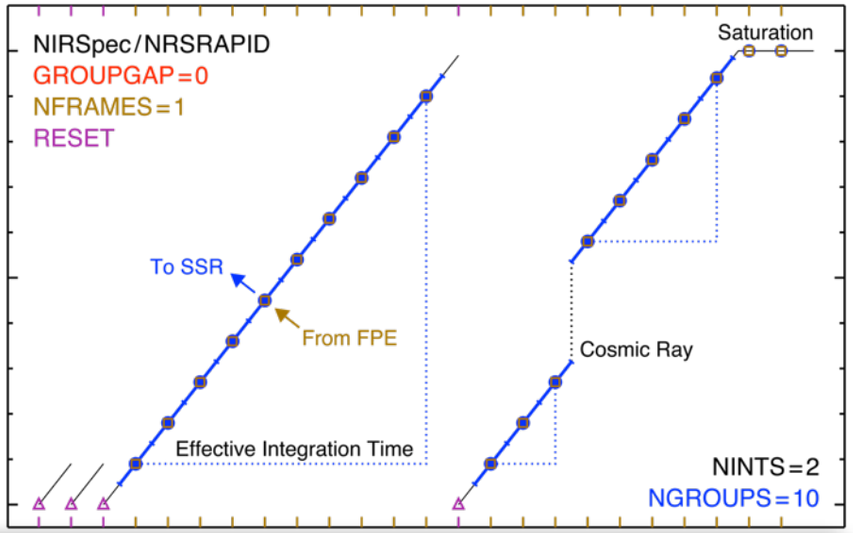
Observability and exposure times

HD189733

- G5, 19.45 pc

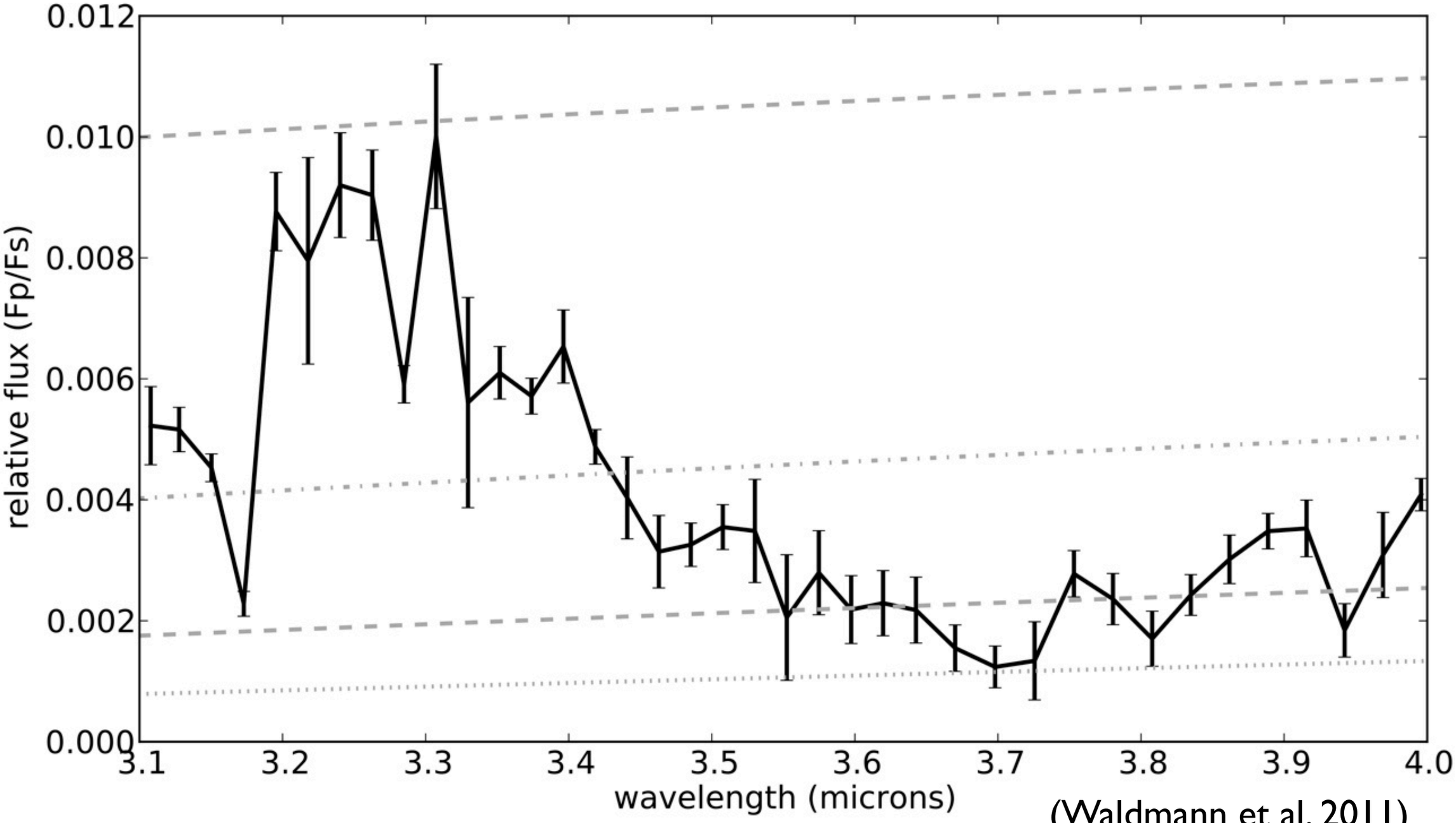
GJ1214

- M4.5V, 12.95 pc



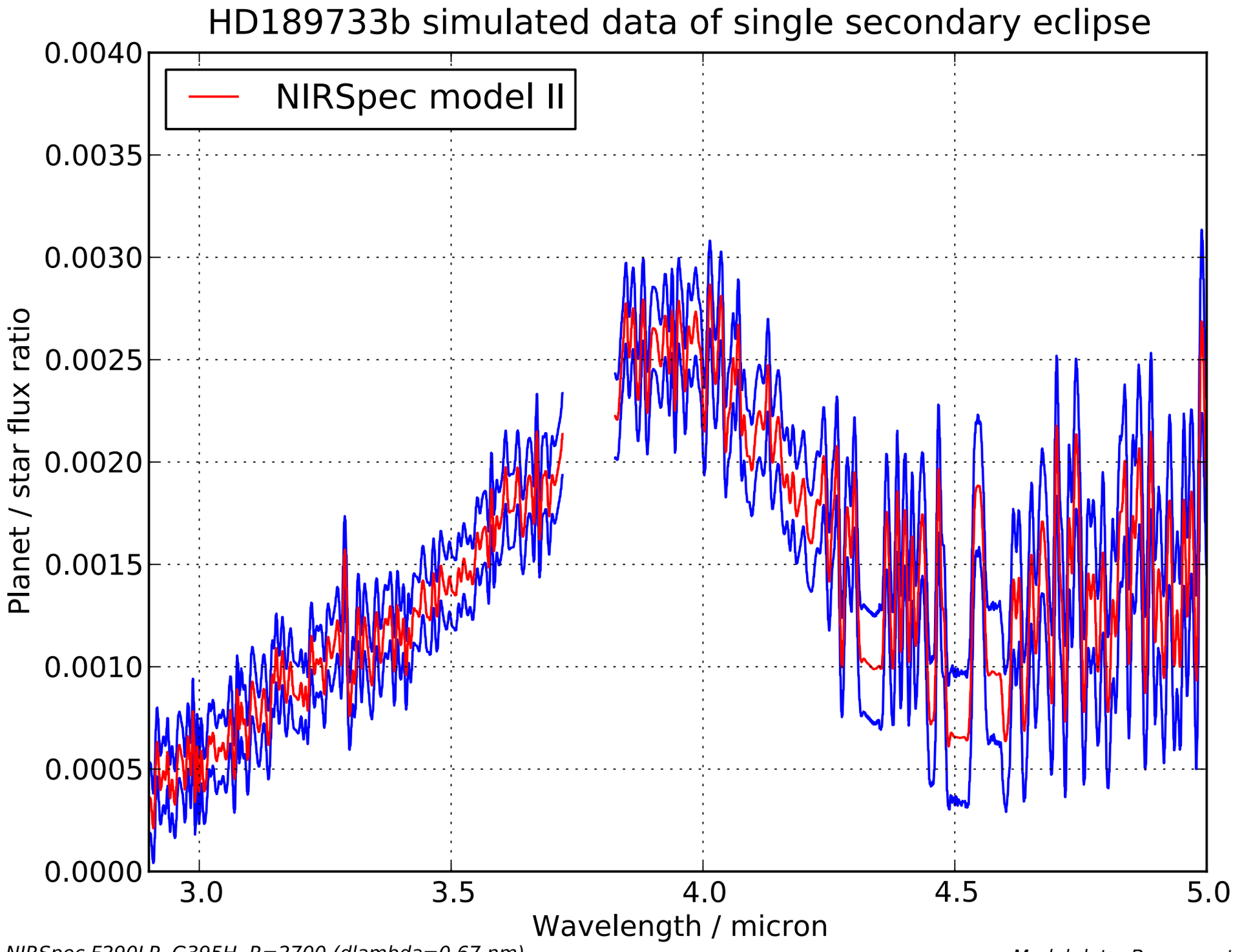
Planet	NIRSpec mode	Maximum frame number n_f	Duration T_{trans} / sec	Effective exposure time t_{eff} / sec
HD189733b (eclipse)	R2700 band III	2	3456 (Knutson et al. 2007)	1145
HD189733b (transit)	R2700 band III	2	3600 (Winn et al. 2007)	1199
GJ1214b	R2700 band I	20	2406 (Berta et al. 2010)	2056
GJ1214b	R2700 band II	20	2406	2056
GJ1214b	R2700 band III	38	2406	2001
GJ1214b	R1000 band I	7	2406	1785
GJ1214b	R1000 band II	7	2406	1785
GJ1214b	R1000 band III	14	2406	1992

HD189733b: eclipse today



(Waldmann et al. 2011)

HD189733b: eclipse with NIRSpec



NIRSpec F290LP, G395H, R=2700 (dlambda=0.67 nm)

Model data: Burrows et al. 2008

Conclusion

- IPS and NIPPLS are very useful tools for NIRSpec verification and science preparation
- Instrument model in completion and verification
- Starting final simulations in cooperation with network partners
- End of thesis: envisaged April 2012