Extraction and Processing of NIRSpec Spectra with the NIPPLS

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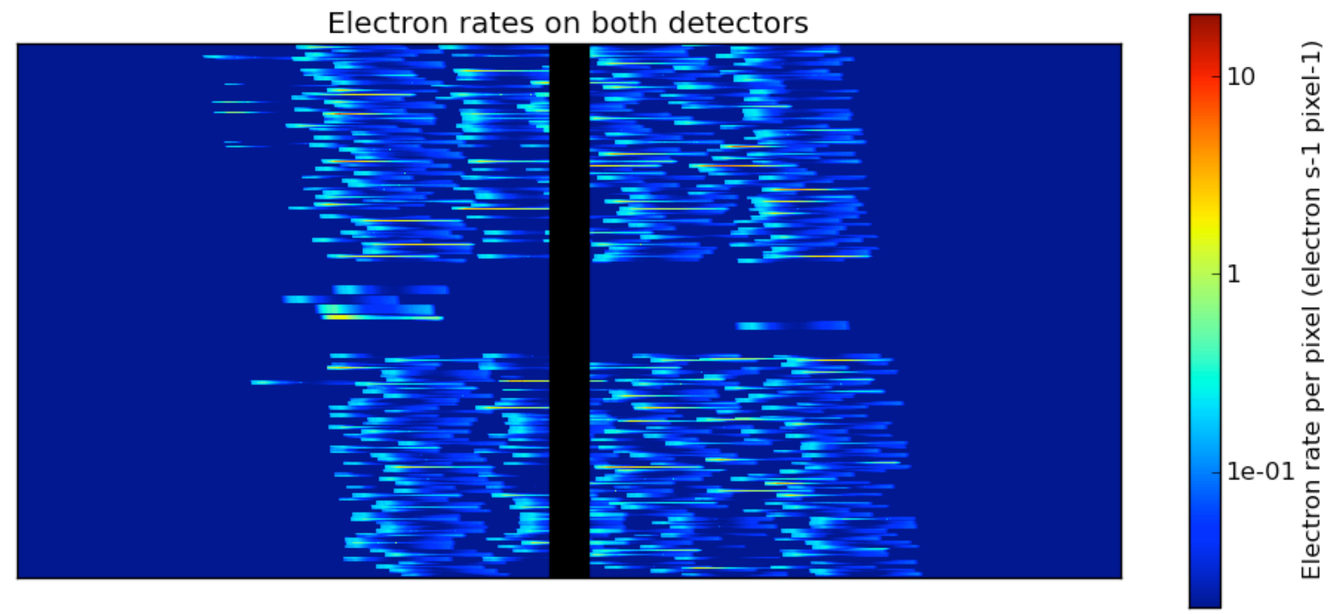
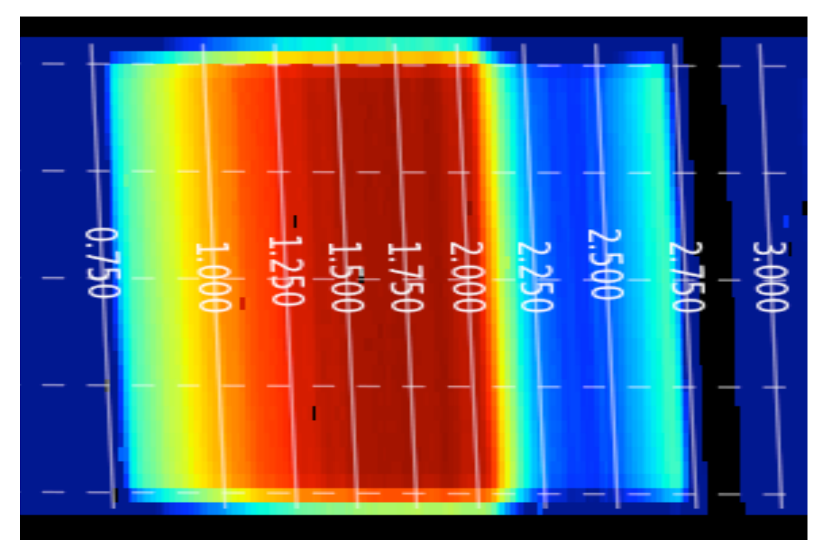
Why another software?

- After Stephan's intervention: pixel-based counts/error/ quality information



- MOS design: different FOV positions can land on same pixel
- Variable dispersion, distortion, slit tilt etc.

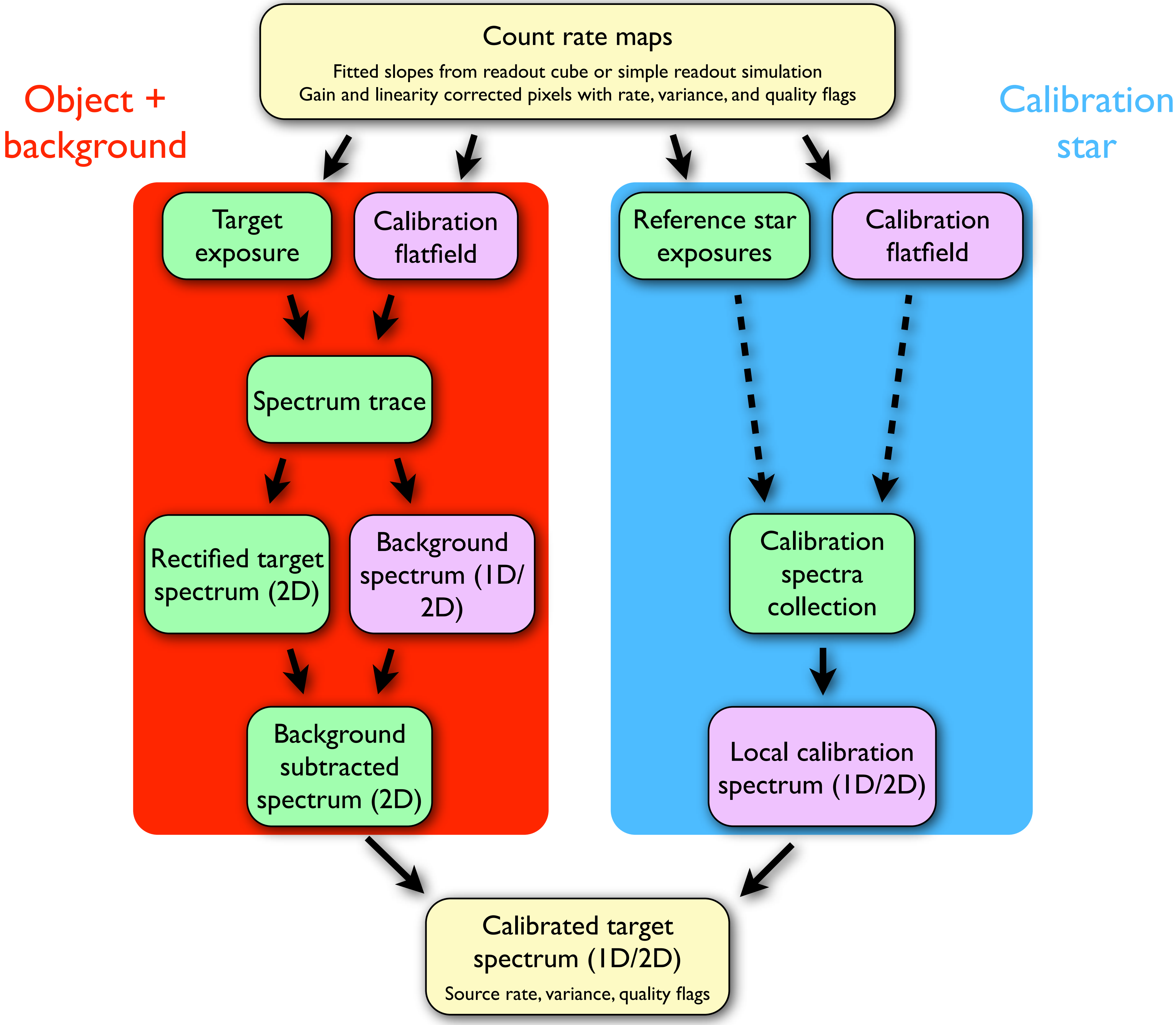


- WANTED: regularly sampled spectra
- Needed for analysis and verification of IPS data

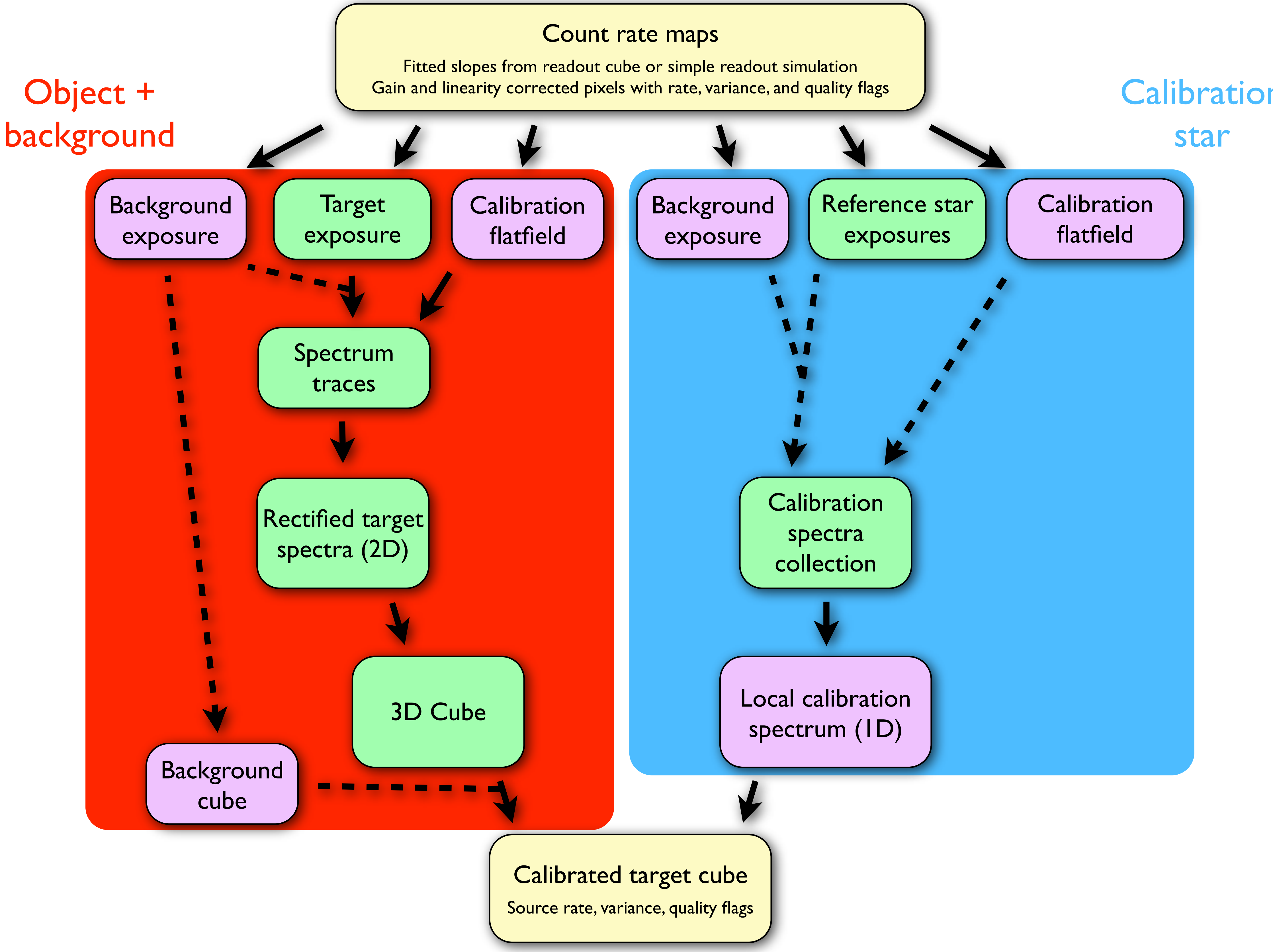
NIRSpec IPS Pipeline Software (NIPPLS)

- Python software framework for analysis of NIRSpec/IPS data
- Uses instrument model in pipeline
- Modular and flexible for custom processing
- Also used for measurements (still the only tool to get spectra)

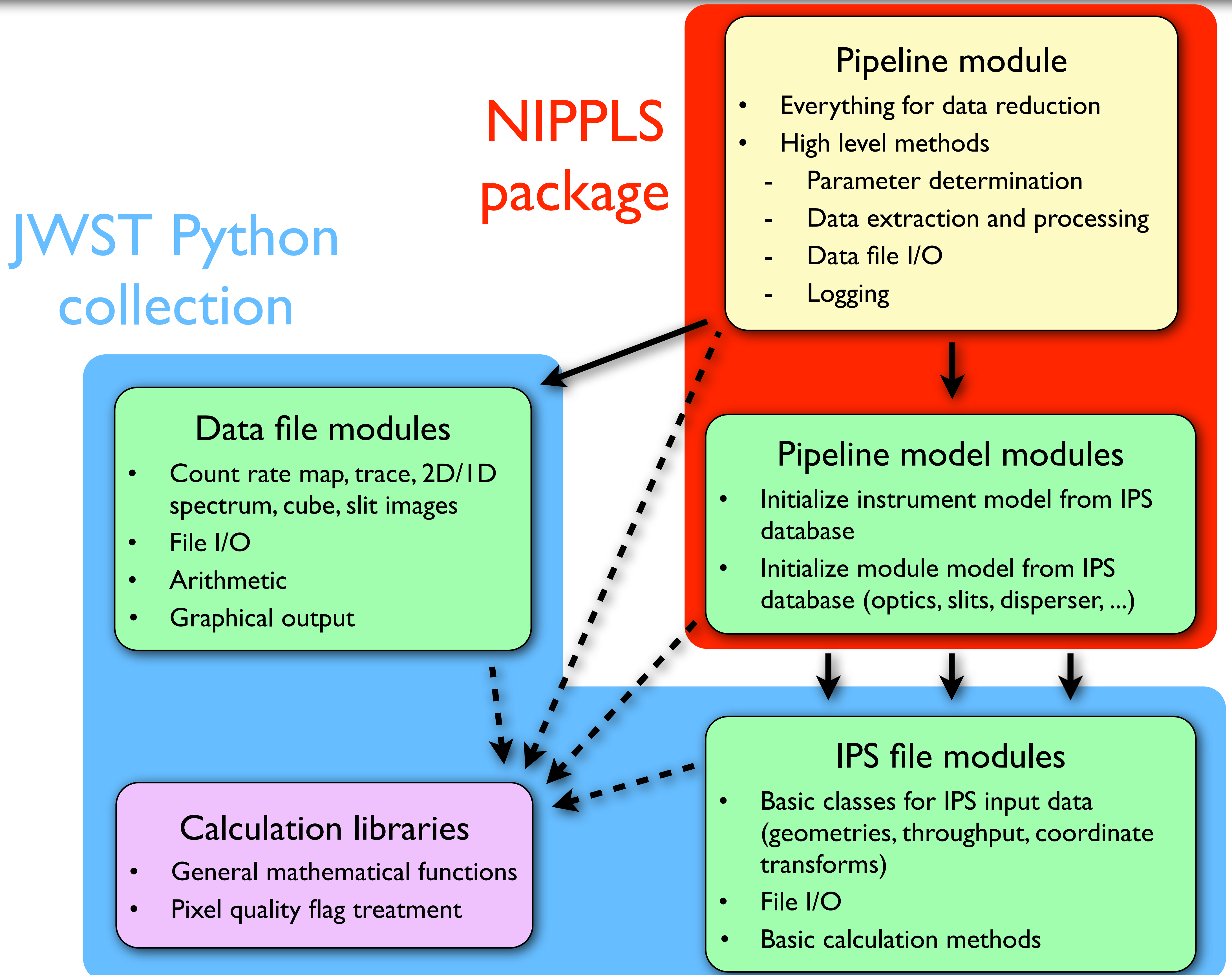
NIPPLS standard workflow



NIPPLS IFU workflow



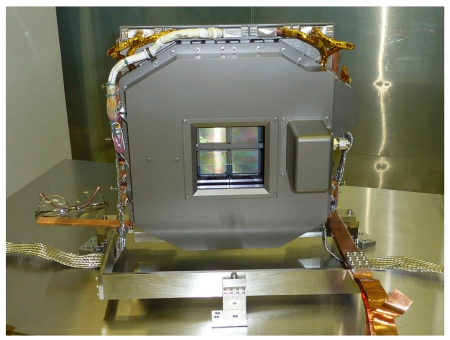
Software structure



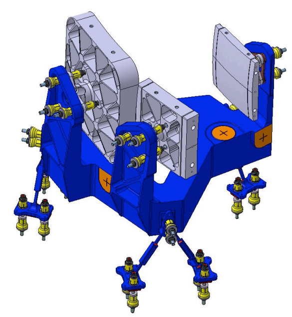
Instrument model usage

- Model data available from simulation: Perfectly calibrated virtual instrument
- Module geometries
  - Focal plane elements
  - Optics and distortion
  - Dispersers
- Example: Calculate coordinates from plane to plane

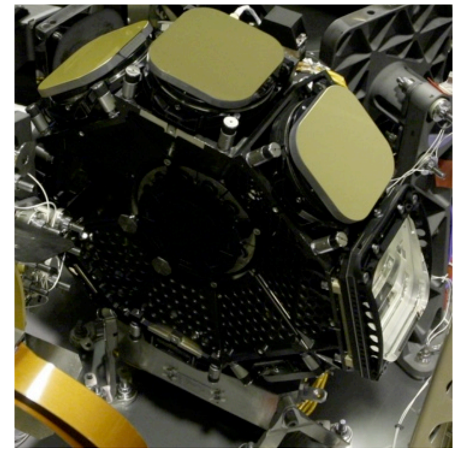
Howto: Spectrograph transform



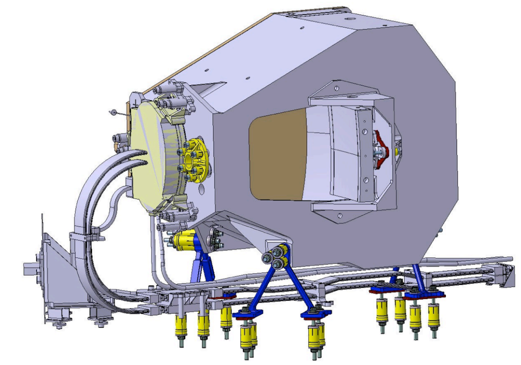
Slits



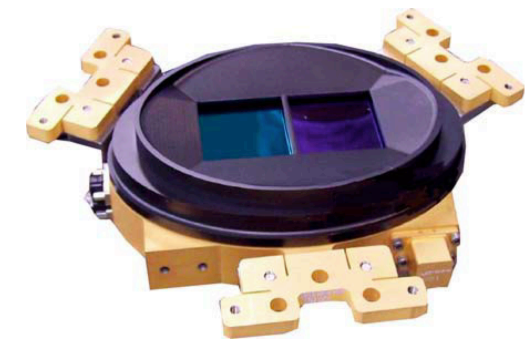
COL



GWA



CAM



FPA

$MSA_{x,y}(SlitID, Offset_{x,y})$

$GWAin_{x,y}(MSA_{x,y})$

Paraxial + polynomial

...and also backwards

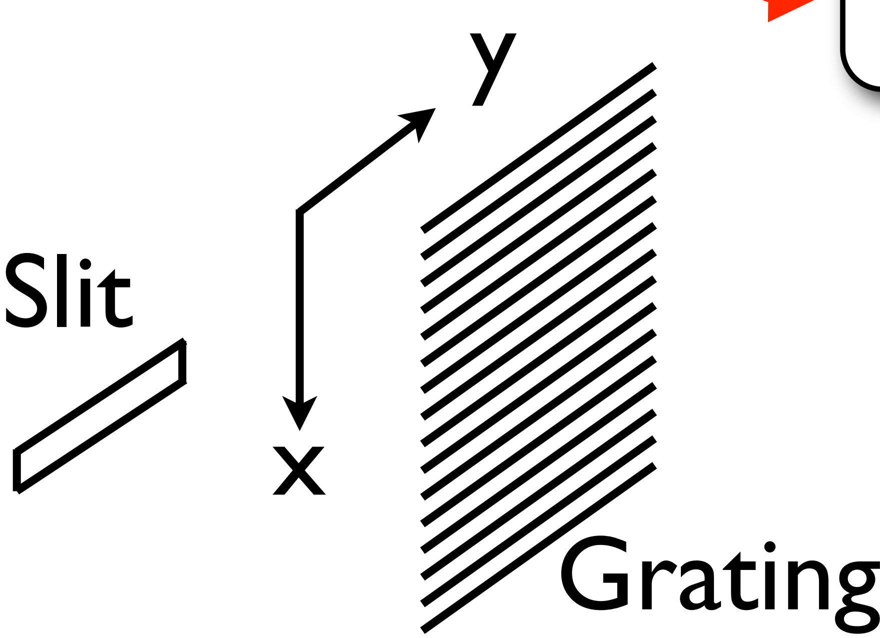
$GWAout_{x,y}(GWAin_{x,y}, \lambda)$

Disperser

$FPA_{x,y}(GWAout_{x,y})$

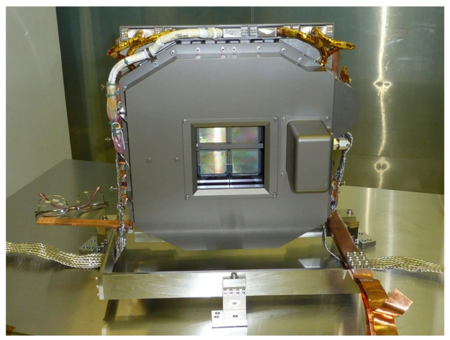
Paraxial + polynomial

$((Pixel_{i,j}, SCA)(FPA_{x,y})$

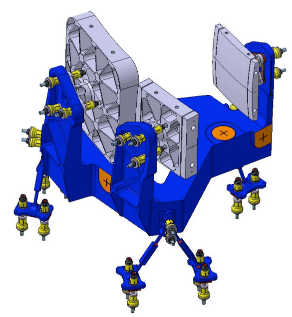


5 coordinates, constrained by 3

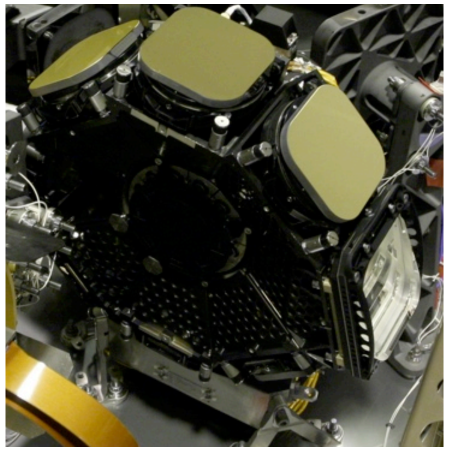
Howto: Spectral coordinates of pixels



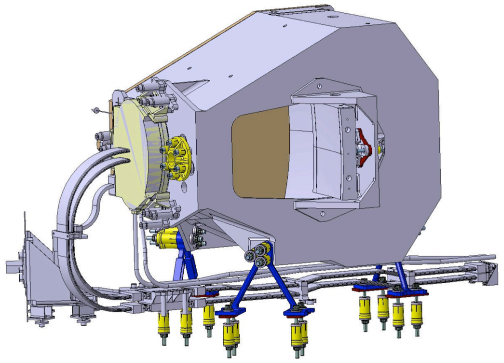
Slits



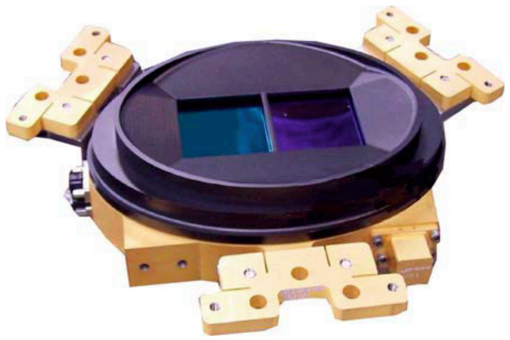
COL



GWA



CAM



FPA

$MSA_{x,y}(SlitID, Offset_y)$

$GWAin_{x,y}(MSA_{x,y})$

$Disperser\ in_y(GWAin_{x,y})$

$FPA_{x,y}(Pixel_{i,j}, SCA)$

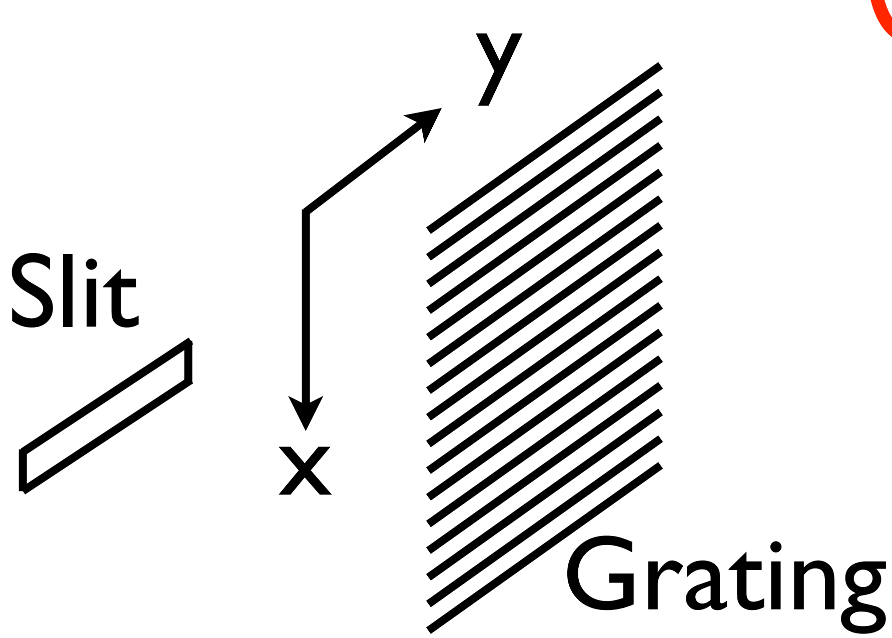
$GWAout_{x,y}(FPA_{x,y})$

$Disperser\ out_{x,y}(GWAout_{x,y})$

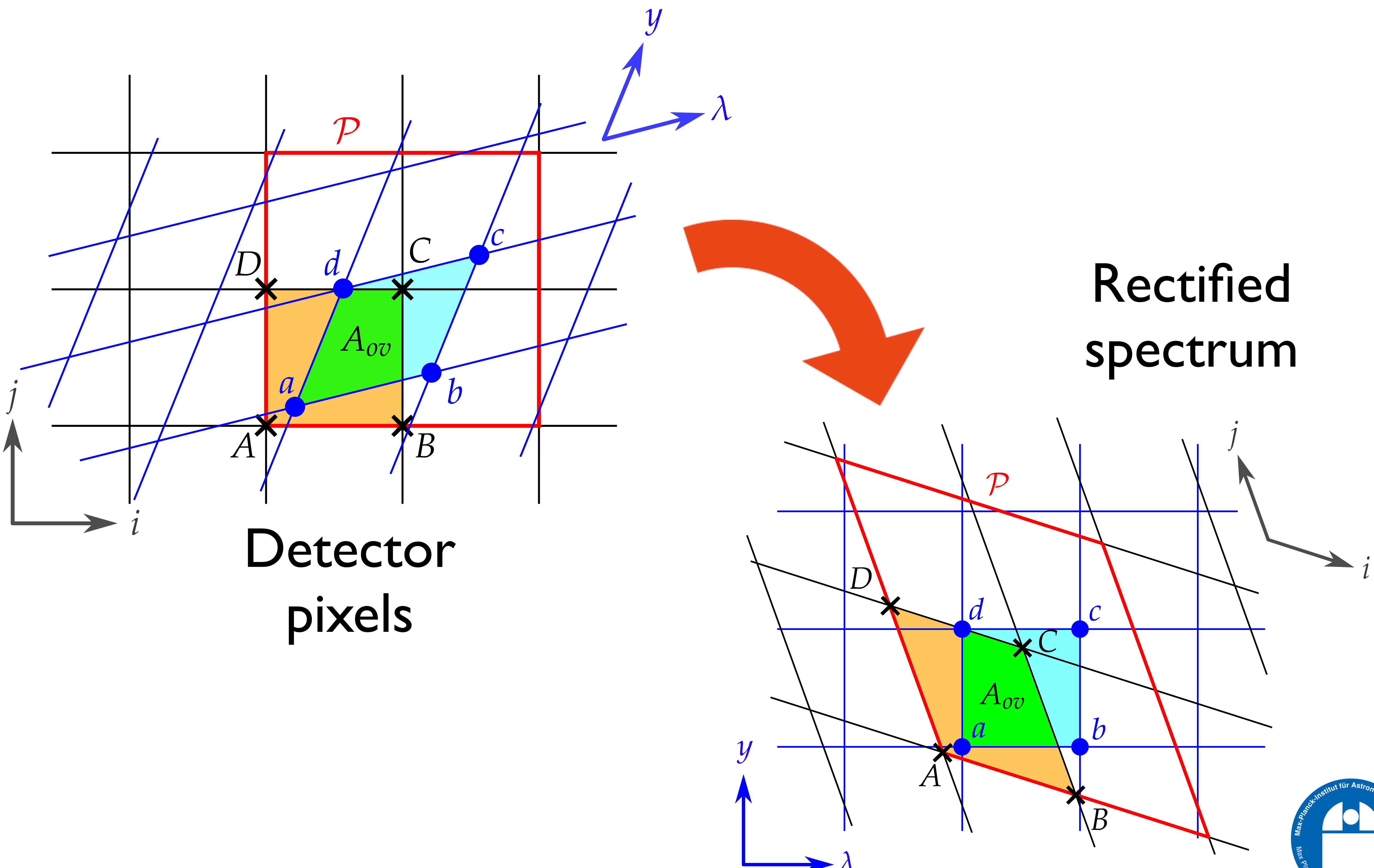
$Offset_y(Disperser_y)$

$Disperser\ in_x(Offset_y)$

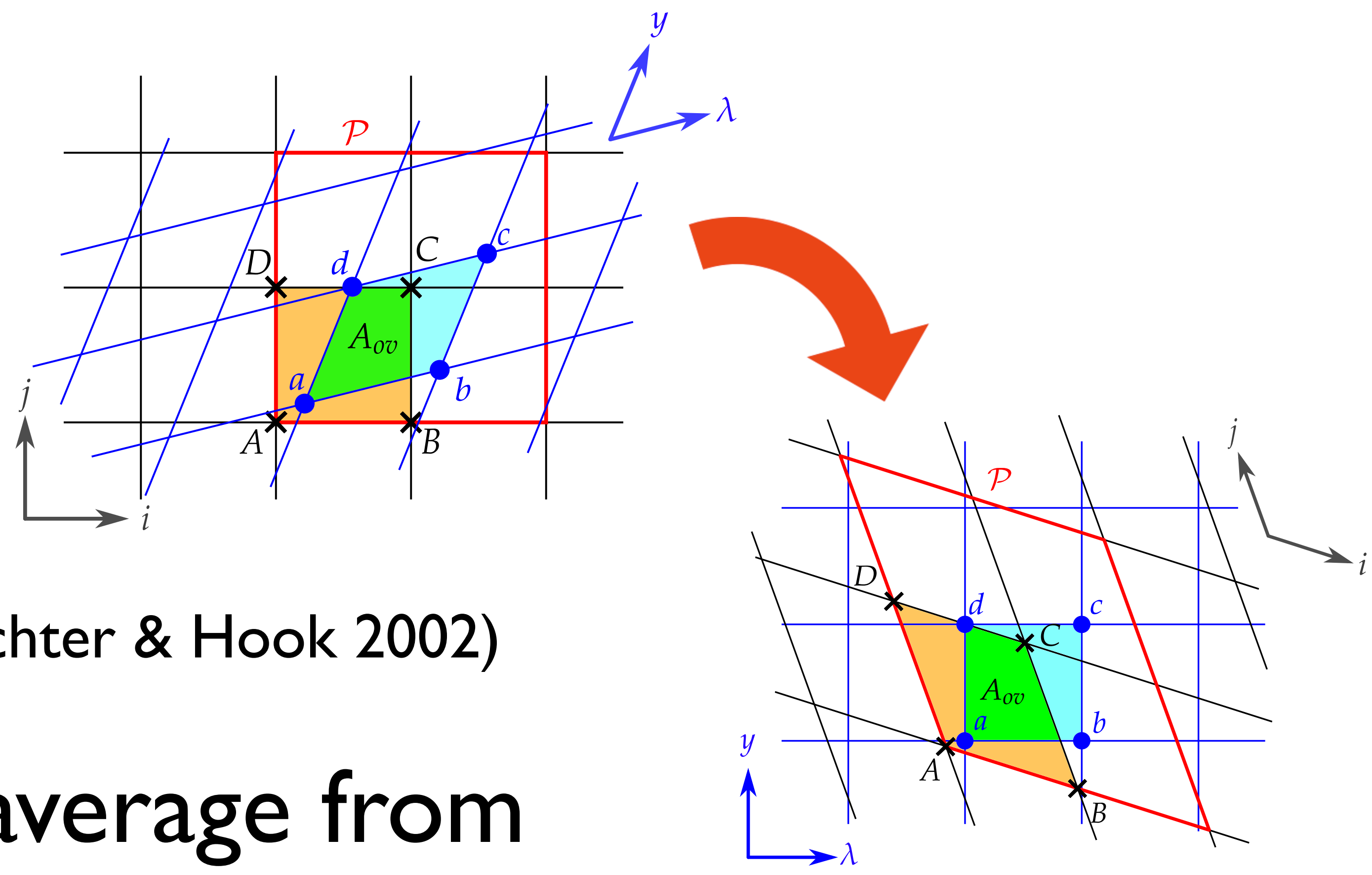
$\lambda(Disperser\ in_x, Disperser\ out_x)$



Spectrum rectification



Spectrum rectification



- Projection into grid
- Similar to Drizzle (Fruchter & Hook 2002)
- Output as weighted average from overlaps
- Preserves spectral surface brightness
- Adjusted variance calculation for large scales

NIPPLS basic parameters

- Required:
  - Paths, exposures and type (instrument mode)
  - Aperture IDs with targets and background
- Optional:
  - Quality flags
  - Extraction intervals and methods
  - Spatial axis type (on sky or in aperture)

Extraction of measured data

- Only on-ground exposures
- Additional parameters needed
  - Instrument model (data file collection)
  - Exposure setup (external/internal lamps)
  - Grating wheel tilt calibration
- Extraction depends on model accuracy

Special features

- Quick data evaluation: irregular spectrum from detector columns
- Use shutter list from simulation scene definition
- Correct chromatic aberration in FORE:
    - Shift in spatial direction in the slit (up to 38 mas)
    - Compensate movement during rectification
    - Spectrum center has constant position on sky

Other use cases

- Quicklook of ground test exposures
- Analyze data from imaging exposures
- Verification of requirements
- Instrument model optimization
- Everything that you want to do with NIRSpec data (extension with throughput model)

Wrap-up

- NIPPLS required for detailed NIRSpec data analysis
- Works with simulations and measurements
- Relies on a physical instrument model
- Proper sky calibration automation still missing (depends on instrument model)
- Fast and easy to use, yet highly customizable for various applications