SWIFT Data Reduction with IRAF

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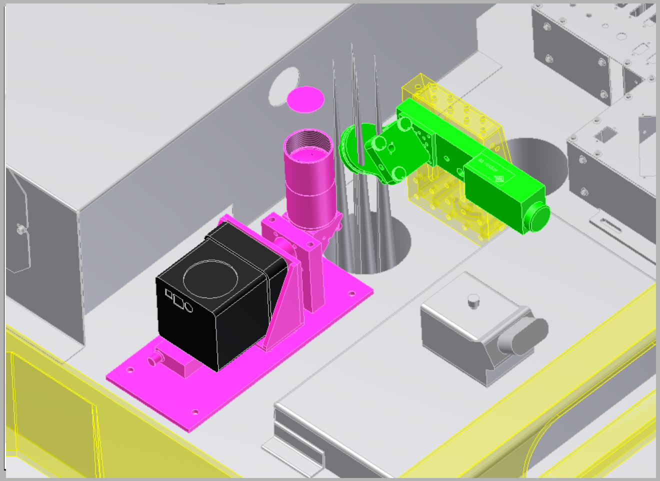
Outline

- The SWIFT Instrument
- IFU slicer principals
- Data reduction principles/steps
  - Raw frames
  - Prepping
  - VL
  - ARC
  - FLAT/ILLUM
  - Bad pixels & cosmic rays
  - Cube creation
- Post-processing
  - Telluric correction
  - Flux calibration
  - Aligning & coadding

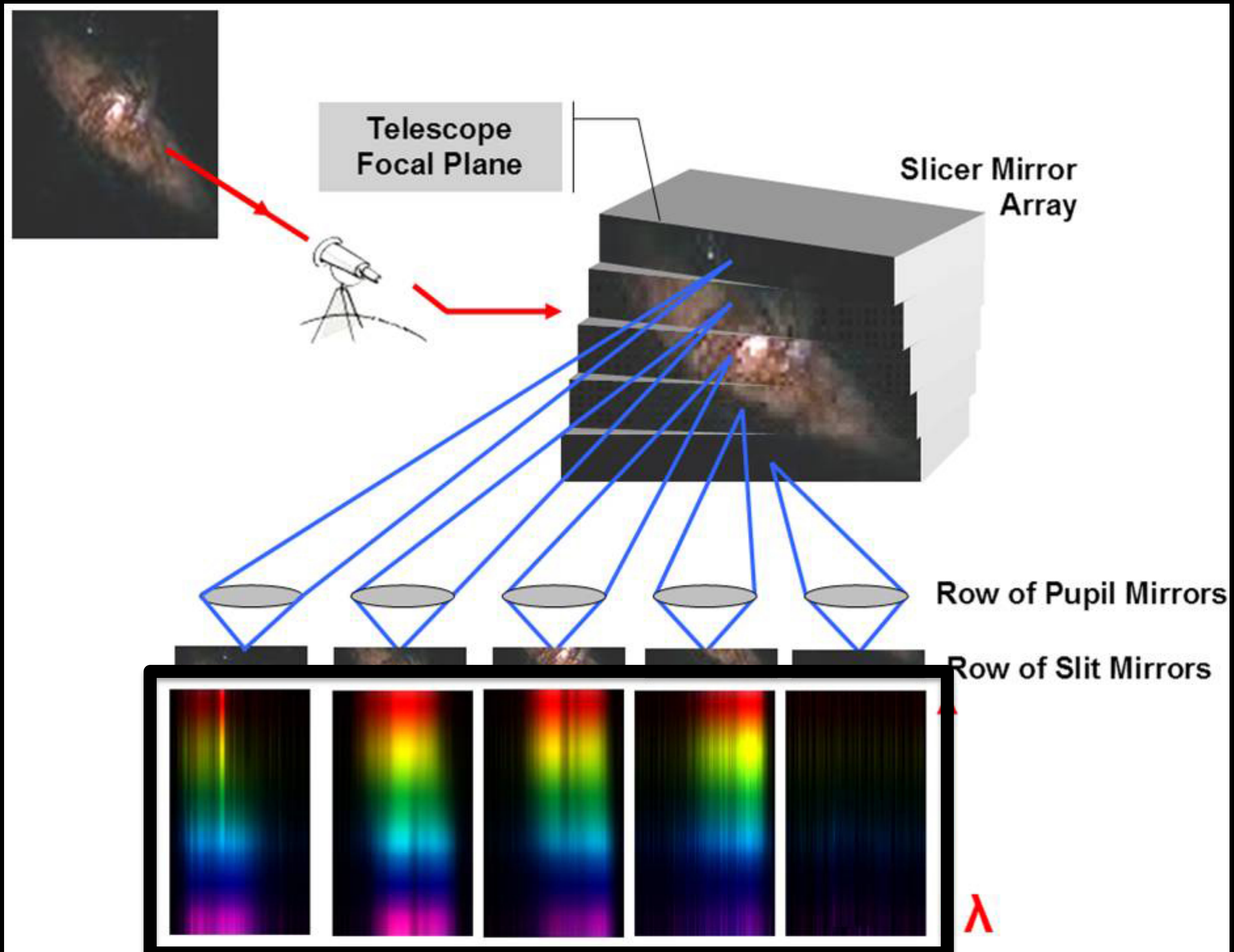
SWIFT

- Short Wavelength Integral Field specTograph
- 0.63um – 1.04um
  - 20"x10" FoV with 0.235" spaxels (seeing mode)
  - 7x3.5" FoV with 0.080" spaxels (80mas AO mode)
  - 2"x1" FoV with 0.016" spaxels (16mas XAO mode)
- Dual 4k × 2k LBNL CCDs
  - 250 µm thick, fully depleted
  - enhanced red quantum efficiency
  - negligible fringing

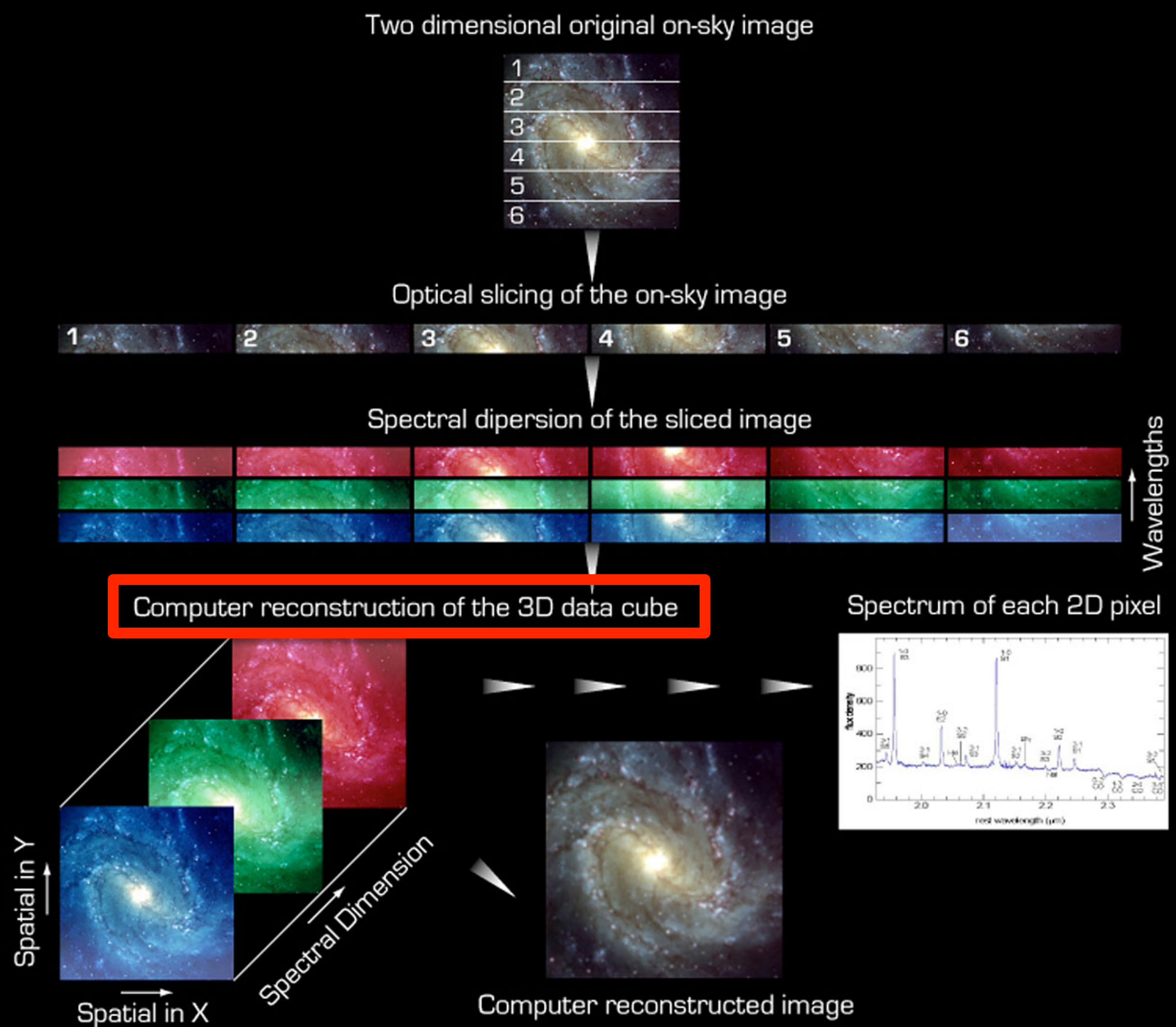
NEW GUIDER!!!



IFU slicer principals

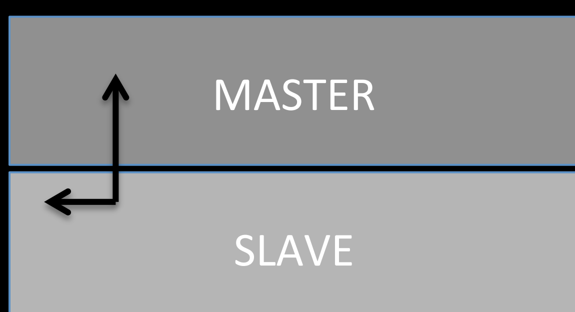


IFU slicer principles

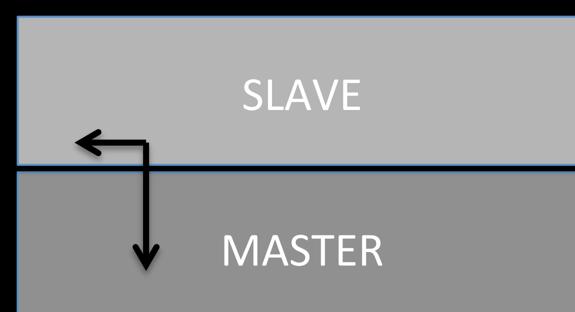


Basic Principles: Raw frames

- SWIFT has two detectors:
  - Master
  - Slave
- You need to reduce them both!
- Each detector takes a different half of the field

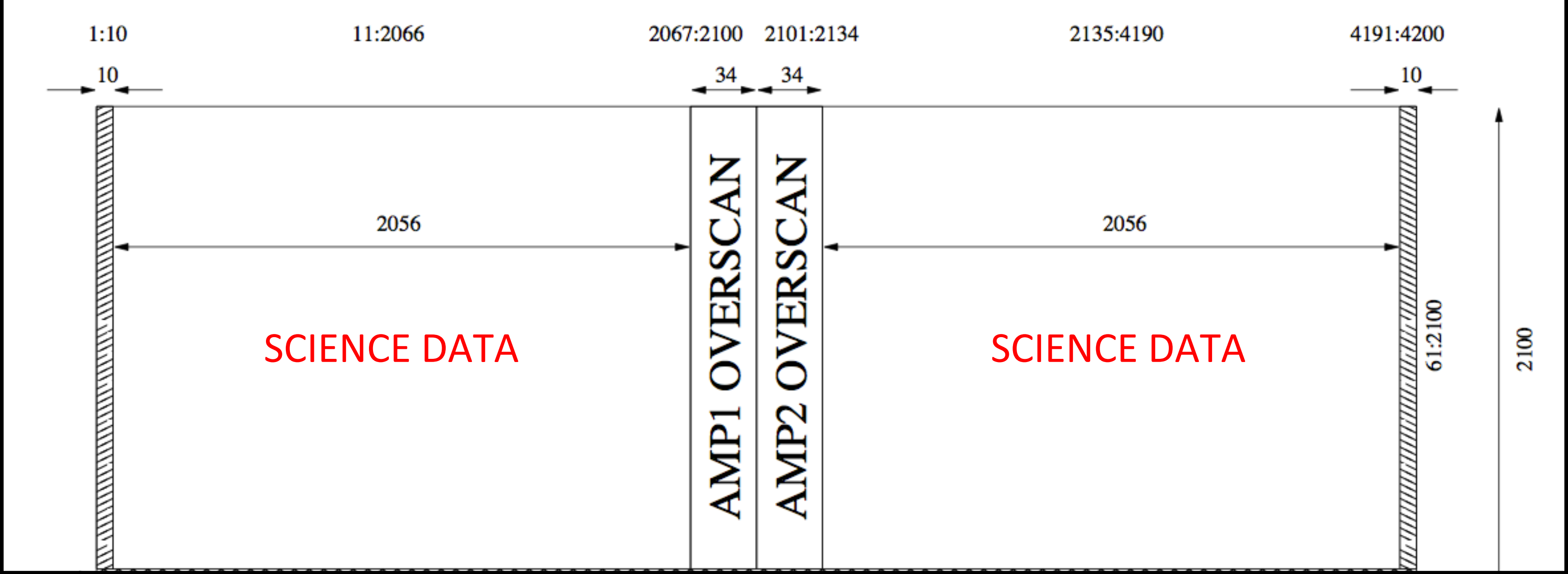


On sky

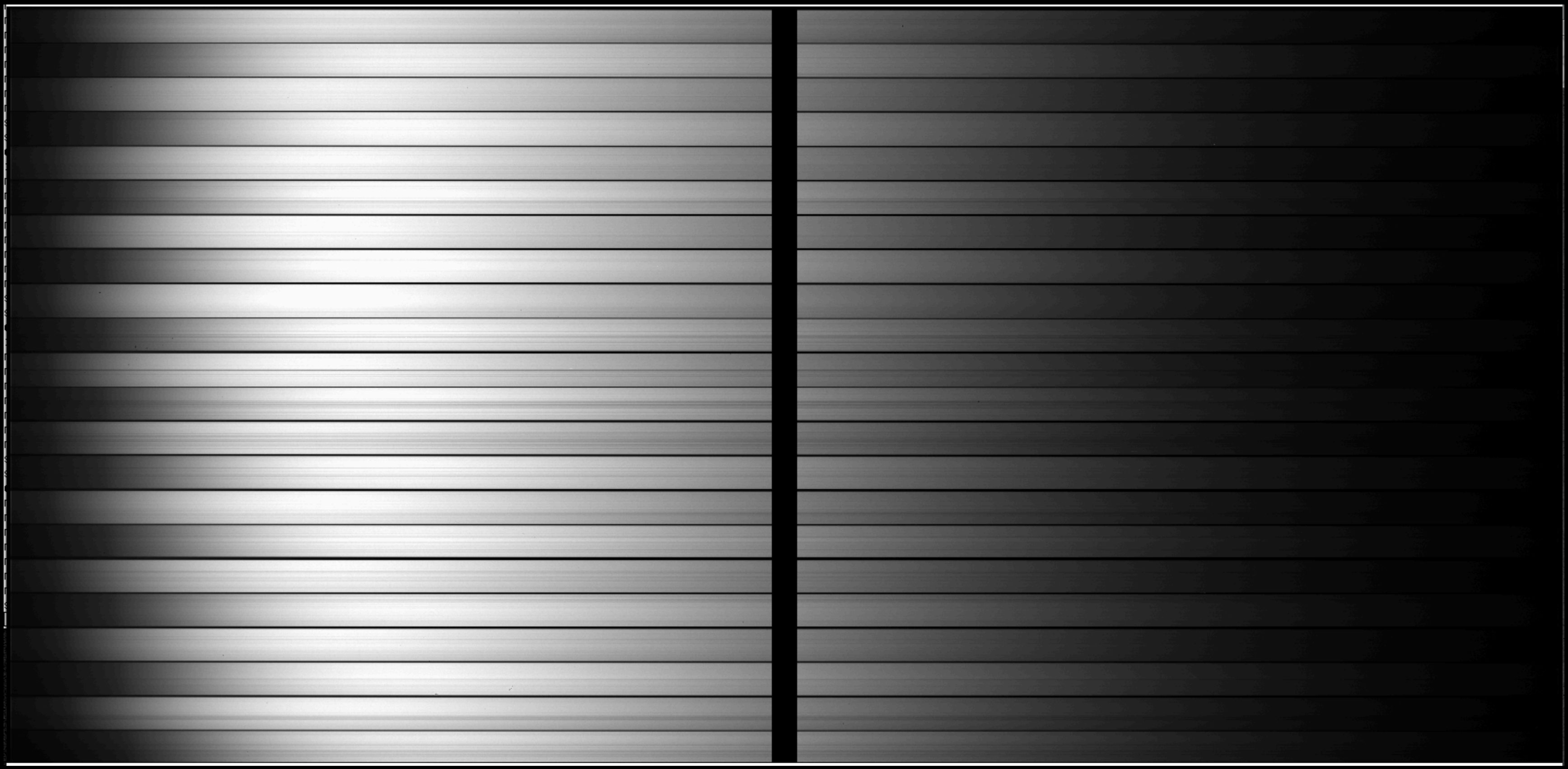


On RTD

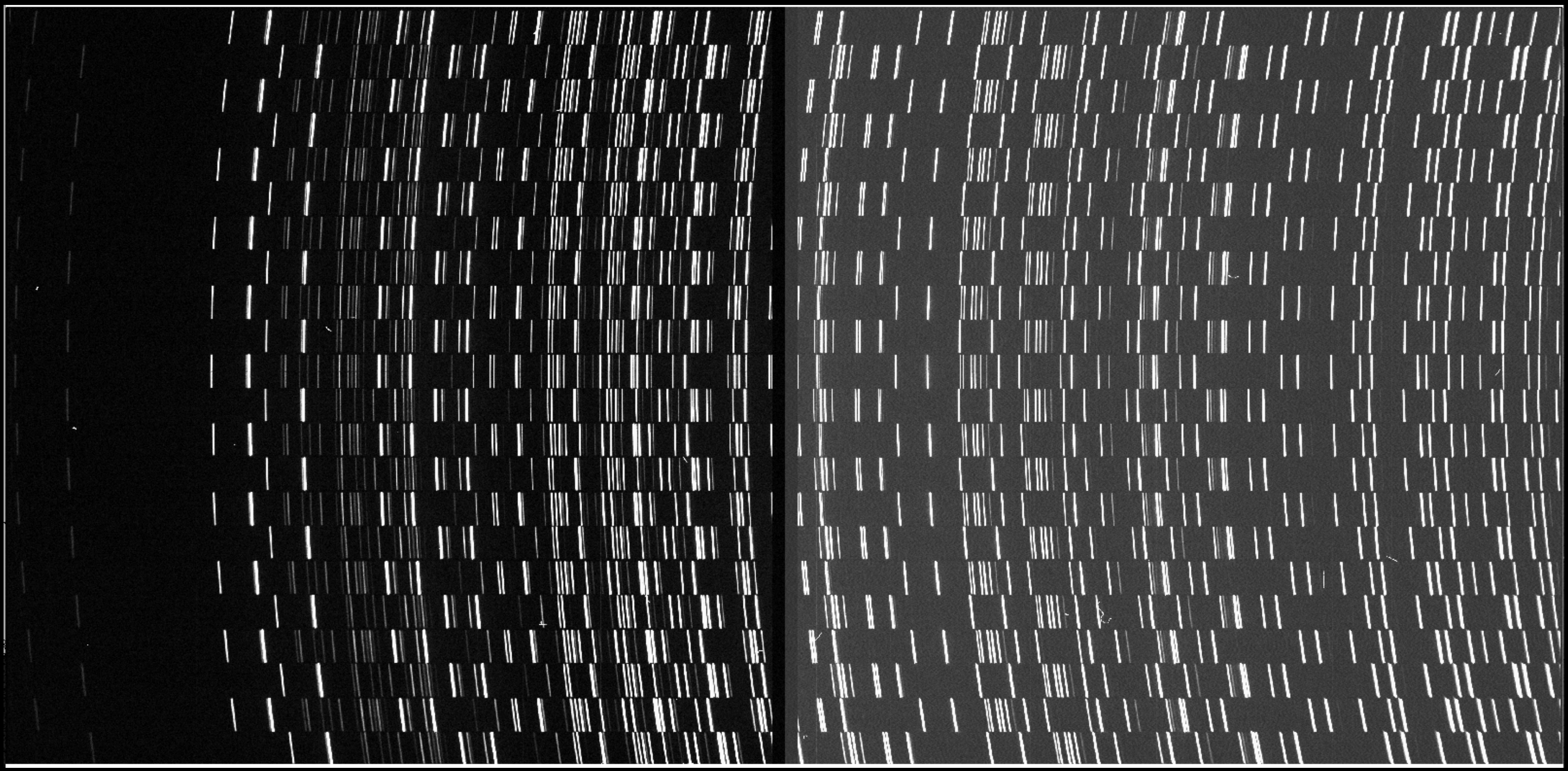
Basic Principles: (single) raw frame



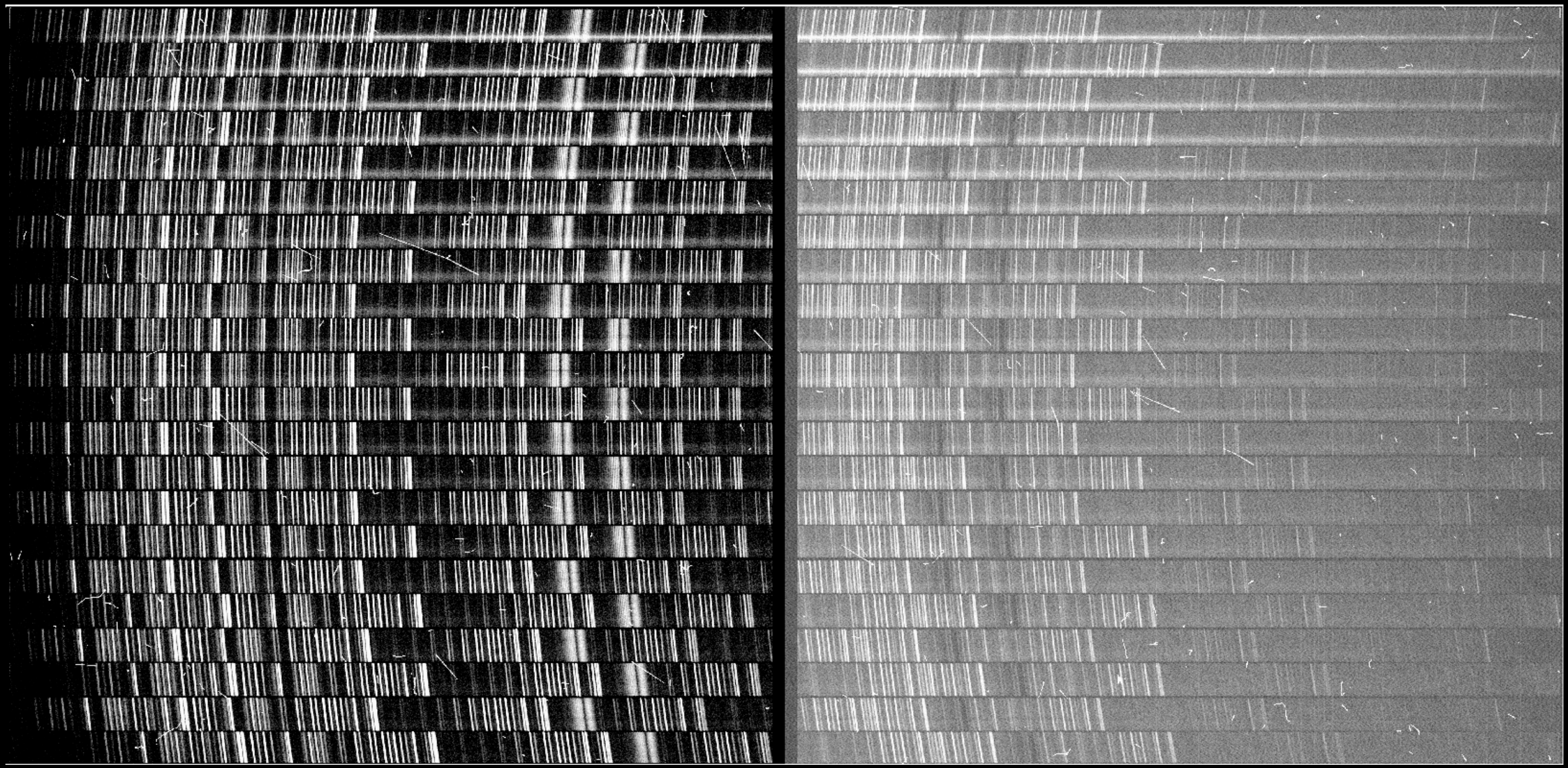
Basic Principles: Raw frames



Basic Principles: Raw frames

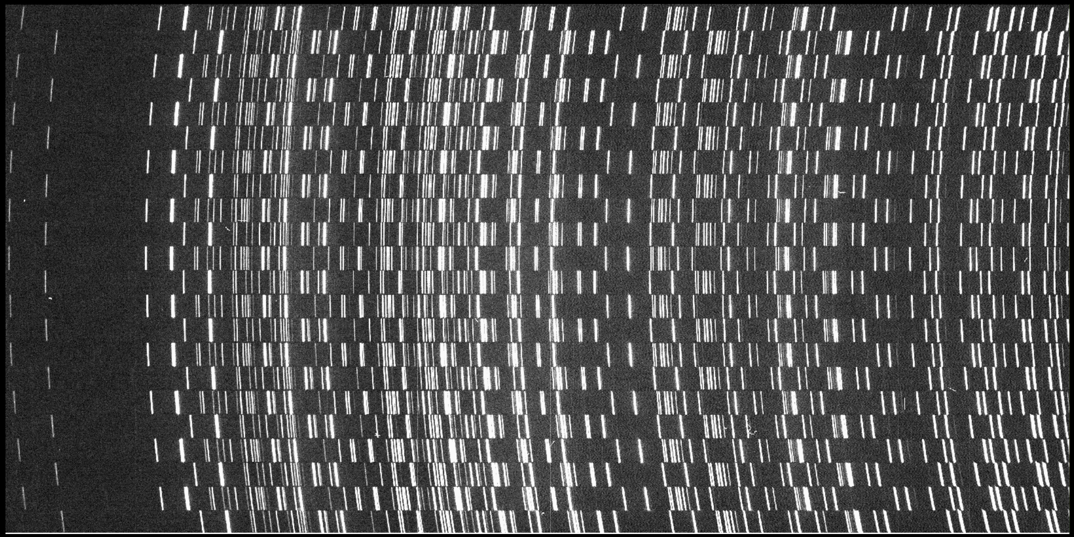


Basic Principles: Raw frames



Basic Principles: Prepping

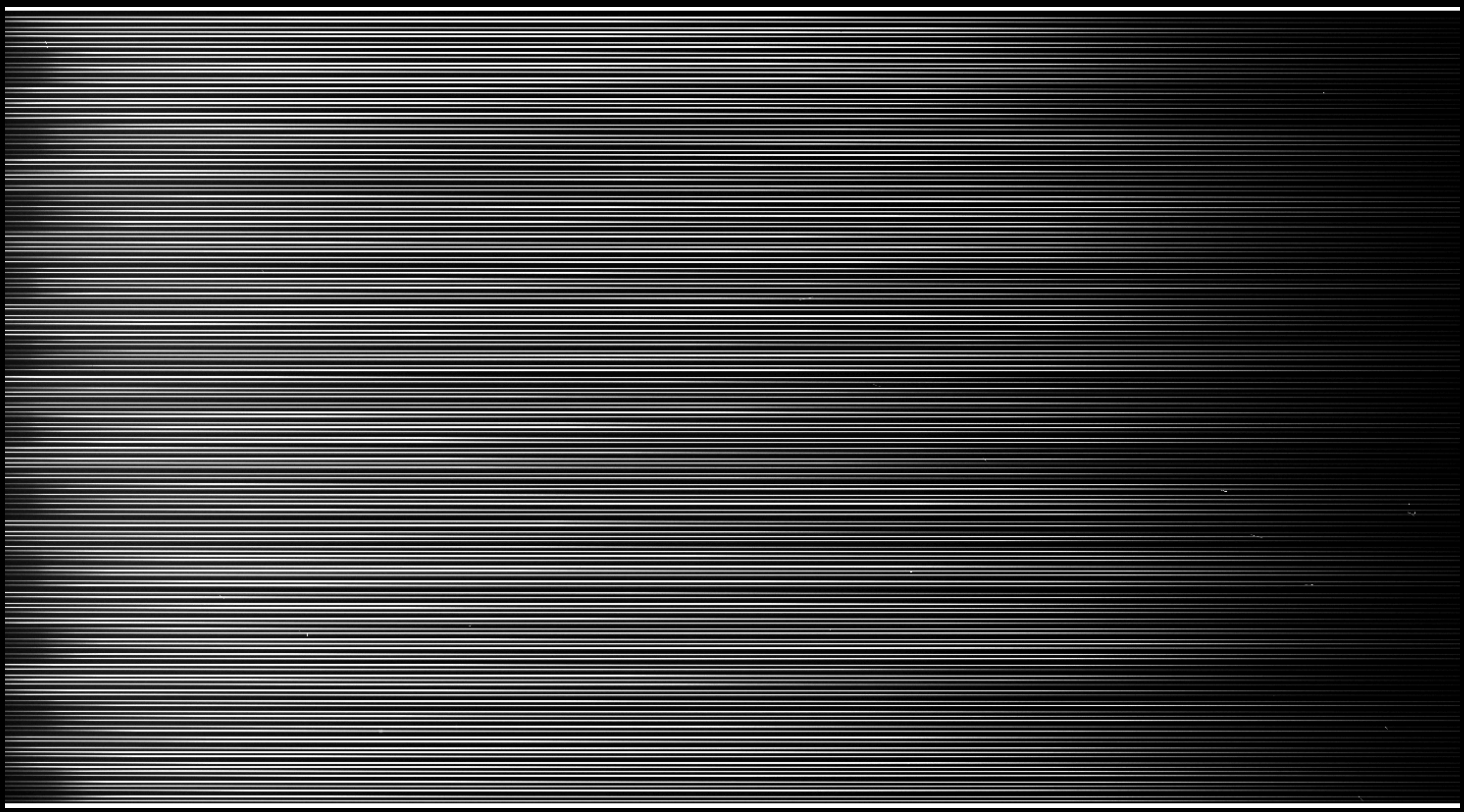
- Subtracts bias from individual amplifiers
- Cuts out regions exposed to light (real pixels)
- Stiches regions together to make contiguous field (detector plane)
- Plus: Sneaky static bad pixel correction



Basic Principles: VL

- We need to cut out the slitlets
- Standard Calibration is the vertical line frame
  - Vertical line mask in focal plane illuminated by halogen (flat field) lamp
  - Sometimes called the north-south test
- We need to trace these lines and extract the data
- For both master and slave!

Basic Principles: VL

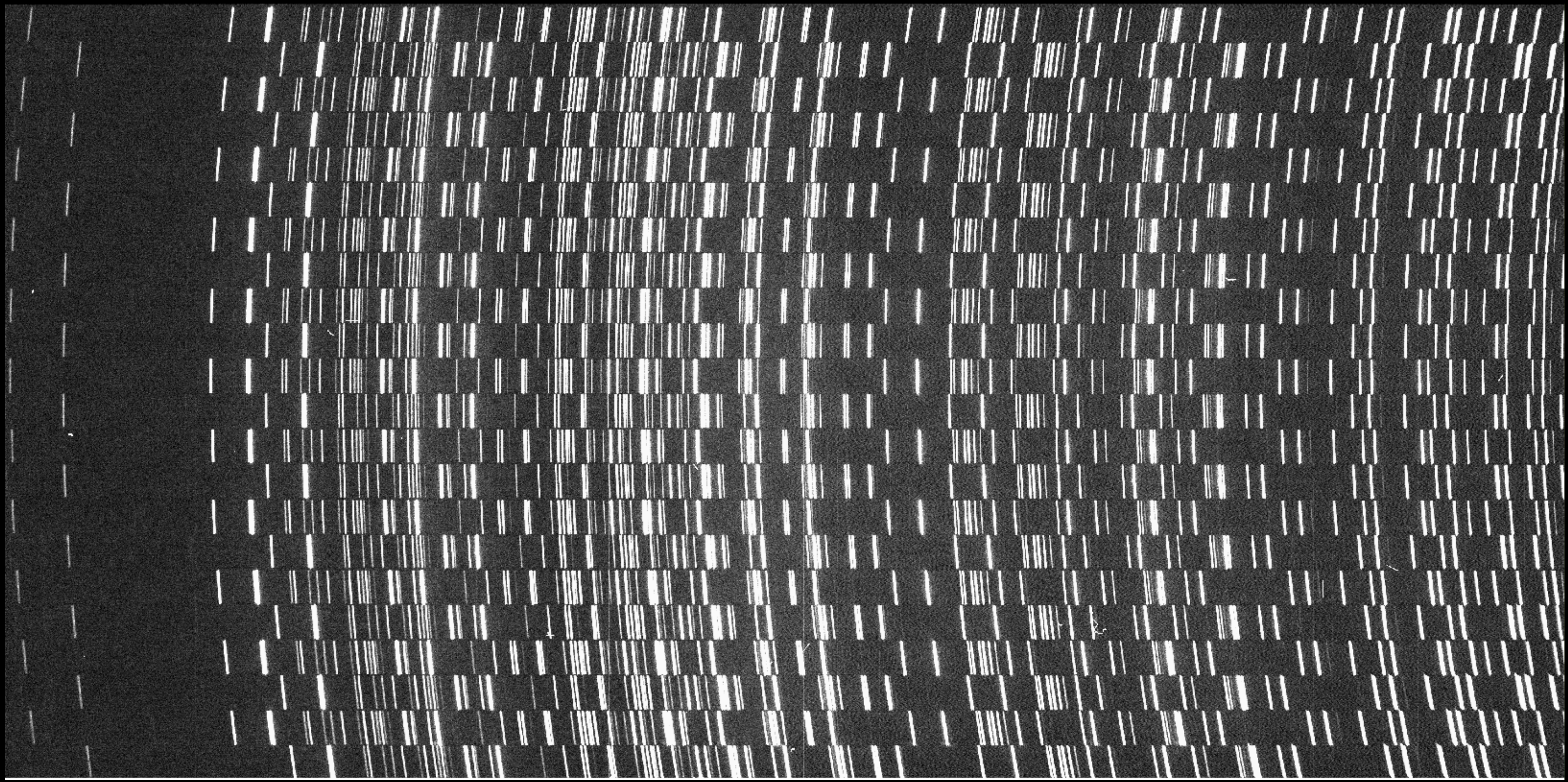


Basic Principles: VL

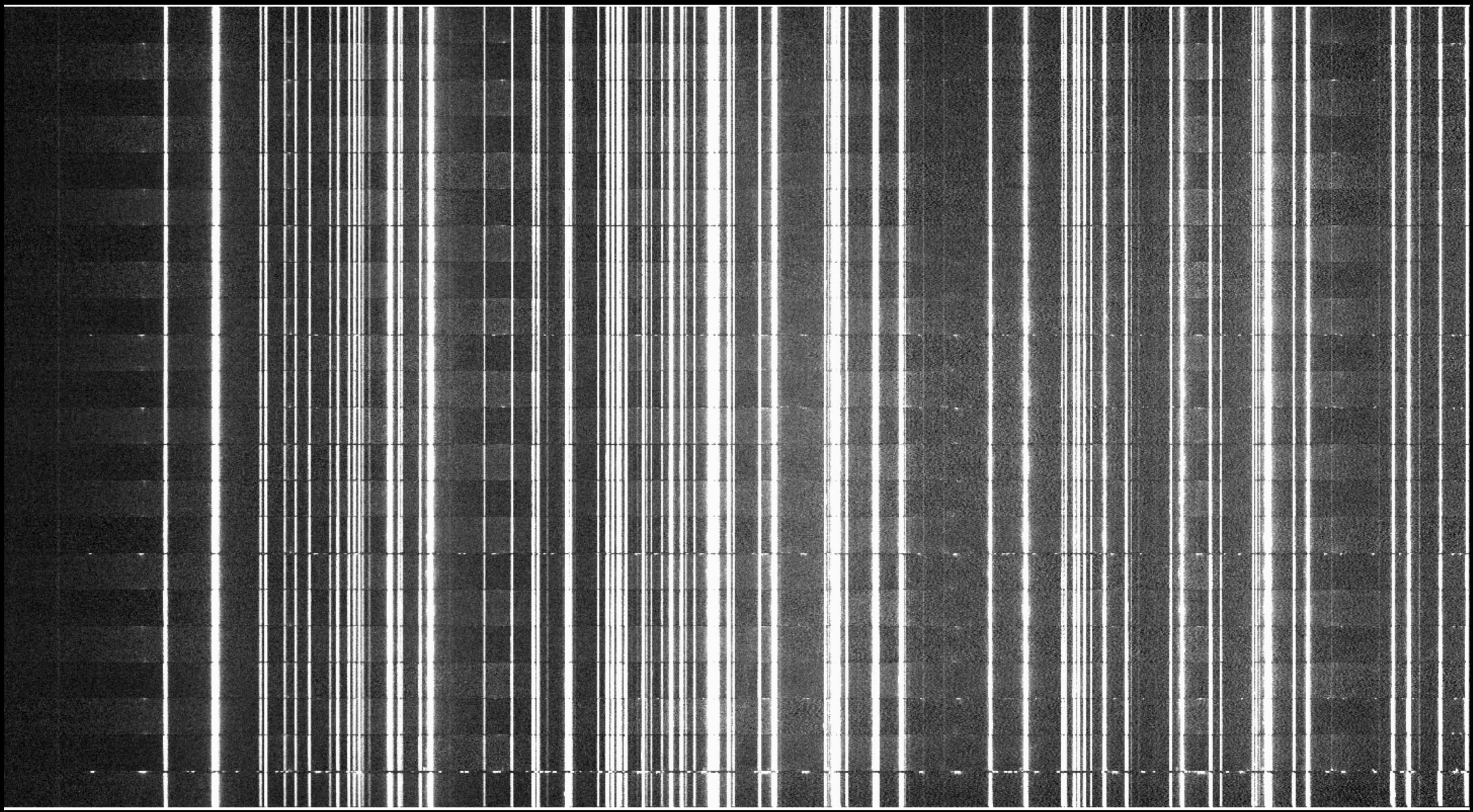
Basic Principles: ARCs

- We need to wavelength calibrate each slitlet
- Standard Calibration is the ARC LAMP frame
  - Detector illuminated with Neon and Argon lamps
- We need to:
  - Identify lines
  - trace lines
  - Fit a (polynomial) surface
  - Resample the data onto a regular (wavelength) grid
- For both master and slave!

Basic Principles: ARCs



Basic Principles: ARCs



Basic Principles: FLATs & ILLUMs

- Definition of flat-field and illumination frames varies
- Need to correct for ***pixel-to-pixel*** quantum efficiency variations
  - Corrected by a FLAT FIELD
- Standard Calibration is the HALOGEN frame
  - Detector illuminated with Halogen lamp
- We need to:
  - Fit and divide out the continuum
    - With a polynomial
    - For each 'spaxel'
  - Create a fame to correct for this (FLAT)
- For both master and slave!

Basic Principles: FLATs & ILLUMs

- Need to correct for ***differences*** in flux arriving on the detector, caused by the ***instrument***
  - Corrected by an ILLUMINATION frame/cube
- Standard Calibration is the HALOGEN frame
  - Detector illuminated with halogen lamp
- Alternatives: dome flats, twilight flats or moon flats
- We need to:
  - Calculate the average spectrum of the lamp (or twilight sky)
  - Measure the response of each 'spaxel' (the ratio)
  - Create a frame to correct for this (ILLUM)
- For both master and slave!

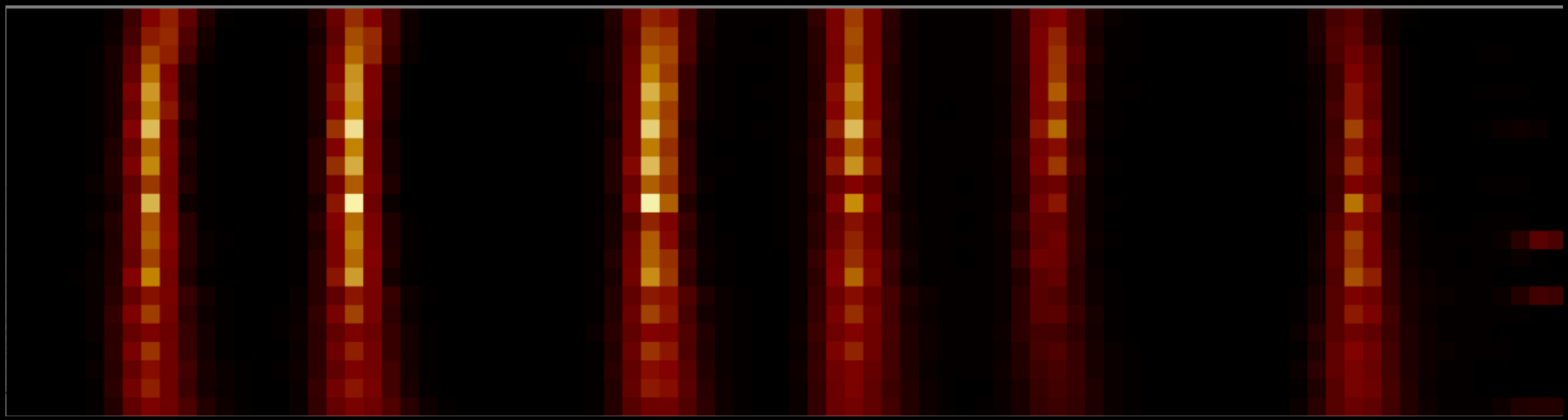
Basic Stages: Bad pixels & cosmics

- Some pixels are bad, or have been struck by cosmic rays
  - Require highlighting
  - Either correct, or no longer use
- We use LACOSMIC (van Dokkum 2001) to find & correct cosmics
  - Also follow how they spread (interpolation)
  - Can choose to ignore those pixels later on

Basic Principles: cube creation

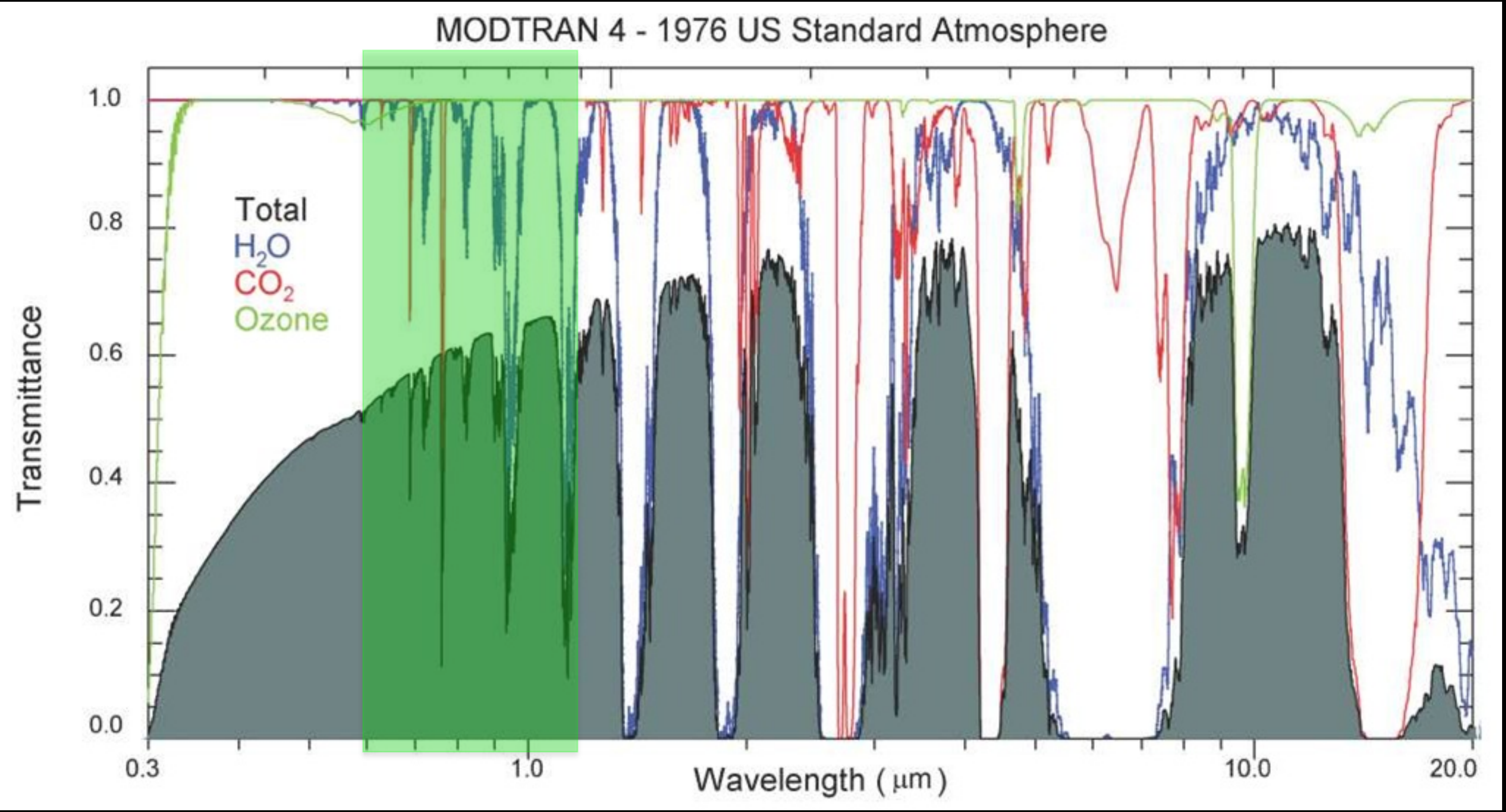
- After
  - vertical line indentification
  - wavelength calibration
- And optionally
  - flat-fielding
  - illumination correction
  - Bad pixel identification / correction
- We use the vertical line calibration to extract slitlets
- Stacking slitlets on top of each other creates a cube

Basic Principles: cube creation



Post-processing: Telluric correction

- Corrects for atmospheric absorption



Post-processing: Telluric correction

- You should have observed a telluric standard during the run!
- There are pipeline routines to extract a spectrum from a cube
- It's you're decision how best to use this
  - I do the following:
    - use the same routine to extract a spectrum of my galaxy
    - use the IRAF telluric routine to match them
    - create a cube of the resulting best fit telluric spectrum
    - Divide my science data through by this cube

Post-processing: Flux calibration

- You should have observed a flux standard during your run!
- There is a pipeline routine to extract a spectrum from a cube, but it uses an aperture
  - You'll need to calculate the aperture correction (as a function of wavelength)
- May be better to fit a Moffat/Gaussian to each wavelength channel to extract a spectrum
- You can then ratio this to the known spectrum of the star

Post-Processing: Aligning & coadding

- If the science object is seen in a single exposure:
  - Fit a Gaussian in QFitsView (median image)
  - Calculate offset
  - Use python script to combine cubes
    - Cannot currently combine cubes at different PA
- If science object not visible
  - Could try using telescope offsets
  - If in seeing mode, the guider offsets may be more accurate