PACS spectroscopy
range scan

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**PACS spectrometer**

Integral field:
- 47”x47”
- 5x5 pixels

Instantaneous spectral coverage:
- ~ 0.15 - 1μm
PACS Spectrometer overview

- Telescope
  - Entrance Optics
    - chopper
    - calibration optics
  - Field splitter
  - Spectrometer
    - To Slicer
    - Image Slicer
    - Grating Spectrometer
    - Anamorphic System
      - Dichroic
      - Filter
      - Filter Wheel
    - Red Photoconductor Array
    - Blue Photoconductor Array

- Bolometer
  - Bolometer Optics
    - Dichroic
    - Filter
    - Filter Wheel
    - Red Bolometer Array
    - Blue Bolometer Array
**Spectral resolution**

\[ \frac{\lambda}{\Delta \lambda} \sim 940 - 5500 \]

\[ c \frac{\Delta \lambda}{\lambda} \sim 55 - 320 \text{ km/s} \]
Parallel blue and red ranges

Different grating orders are observed simultaneously in the red and blue detector

- order 1 + 2
  - 105-210 //
  - 72-105µm

or

- order 1 + 3
  - 105-210 //
  - 55-72µm
Parallel ranges – examples

- Range scan 60-70 μm [order 3]
  - Will yield 'free' range in order 1 : 180-210μm
- Range scan 72-80 μm in [order 2]
  - Will yield 'free' range in order 1 : 144-160μm
- Range scan 120-180 μm [order 1]
  - Can yield 'free' range in order 2 : (60-)72-90 μm
    [order selection filter: cut-off short of 72μm]
  - Can yield 'free' range in order 3 : (40-)55-60 μm
    [cut-off short of 55μm]
Ranges within 1 AOR – limitations

- Maximum 10 different wavelength ranges
- No filter wheel change -> only one combination of
  - order 1 // order 2
  - order 1 // order 3
- If more wavelength ranges or order 2 and 3 needed: concatenate several AORs
Full range scan

- PACS full range scan: 2 concatenated AORs
  - AOR 1: order 1 & 2
    - order 1: 105-210 µm
    - order 2: (52 –) 72 - 105 µm
      [order selection filter: cut-off short of 72µm]
  - AOR 2: order 1 & 3
    - order 1: 165 – 210 µm
    - order 3: 55 – 72 µm
- Full range scans are predefined in HSPOT:
  - SED Blue [order 3]
  - SED Red [order 2]
Two spectral sampling densities

- **Nyquist sampling**
  - Unresolved line FWHM Nyquist sampled
  - Nyquist considering all 16 spectral pixel
  - This sampling is chosen for SED mode (PACS full range AOR)

- **High Sampling**
  - Spectral sampling as in line spectroscopy
  - ~3 samples per FWHM in every detector
Nyquist sampling

- 4 scans in 1 telescope nod cycle
  - 1 up / 1 down wavelength direction
  - Repeated on 2\textsuperscript{nd} nod position
- Duration, e.g. full range
  - 105 - 210 $\mu$m (72-105 for free): $\sim$2050 sec
  - 55 – 72 $\mu$m (extra 165-210 free): $\sim$1300 sec
    [total full PACS range $\sim$ 0.9h]
- Sensitivity (line / continuum)
  - Varies over wavelengths
  - Increase S/N: repeat nod cycle
Nyquist: continuum sensitivity

RMS continuum PACS SED range scan
Nyquist: line sensitivity

line RMS PACS SED range scan

RMS [W/m²]

10⁻¹⁷ 2 × 10⁻¹⁷ 3 × 10⁻¹⁷ 4 × 10⁻¹⁷ 5 × 10⁻¹⁷

Wavelength [um]

60 80 100 120 140 160 180 200
High sampling

• 4 scans in 1 telescope nod cycle
  • 1 up / 1 down wavelength direction
  • Repeated on 2\textsuperscript{nd} nod position

• Duration, e.g. full range
  • 105 - 210 \(\mu\)m (72-105 for free) : \(~18300\) sec
  • 55 – 72 \(\mu\)m (extra 165-210 free): \(~15601\) sec
    [total: \(~9.4\) hours]

• Sensitivity (line / continuum)
  • Varies over wavelengths
  • Increase S/N : repeat nod cycle
High sampling – continuum Sensitivity

RMS continuum PACS full sampling range scan

RMS [Jy]

Wavelength [um]
High Sampling – line sensitivity

line RMS PACS full sampling range scan

RMS [W/m²]

Wavelength [μm]

60 80 100 120 140 160 180 200

3.0 × 10⁻¹⁸ 6.0 × 10⁻¹⁸ 9.0 × 10⁻¹⁸ 1.2 × 10⁻¹⁷ 1.5 × 10⁻¹⁷
Source type and chopping

- Point-like sources: *Pointed*
  - Chopping / nodding
    - Small (1')/ Medium (3')/ Large throw (6')

- Compact, but resolved: *Pointed with dither*
  Goal: eliminate diffraction effects field slicer
  - Chopping / nodding
    - Small (1')/ Medium (3')/ Large throw (6')

- Extended sources: *Mapping*
  - Chopping / nodding (Large throw; 6'): maximum size 6'
  - Off position