The MIRI medium resolution spectrometer for the James Webb Space Telescope

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On behalf of the MIRI spectrometer team
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MIRI has four functions:

- Mid-Infrared Imaging from 5 to 27 µm, 0.11” pixels, 1.3’ x 1.7’ field of view
- Coronagraphic Imaging (at 10.65, 11.4, 15.5, 23 µm)
- Low Resolution Slit Spectroscopy R ~100 from 5 to 10 µm
- Medium Resolution Integral Field Spectroscopy, R ~ 3000, from 5 to 28.3 µm
MIRI Optical Module – Key Design Features

- Lightweighted, all aluminium, modular optical system
- Supported by thermally isolating carbon fibre hexapod which attaches to ISIM structure.
- Cooled to ~7K by a dedicated cryo-cooler
- Three 1kx1k SiAs detectors.
- 4 Mechanisms – 3 wheels based on ISO design (filters, dichroics, gratings) and a contamination control cover
- Light enters from the telescope via the pick-off mirror
- The fields of view of the Imager and the Medium Resolution Integral Field Spectrometer are defined and separated in an “Input optics/calibration module”
- Imager optics on one side of primary structure, spectrometer on the other
MIRI spectrometer scientific requirements

- Wavelength range 5 – 28 microns
- Field of view not less than 3.5 x 3.5 arc-seconds squared
- Spatial sampling to match FWHM of JWST PSF
- Spectral resolving power
  - $5 \mu m < \lambda < 10 \mu m \Rightarrow R > 2400$
  - $10 \mu m < \lambda < 15 \mu m \Rightarrow R > 1600$
  - $15 \mu m < \lambda < 28 \mu m \Rightarrow R > 800$
- Image quality: 80% EED @ $8 \mu m < 1.1 \times 80\%$ EED of an unaberrated JWST – translated to an RMS wavefront error specification for the sub-systems
- Detector format: Two 1024 x 1024 SiAs arrays with 25µm pixels
Optical path through MIRI spectrometer
Spectrometer pre-optics (SPO) layout

Key
1 input baffle tube
2 Dichroic wheel A
3 Dichroic wheel B
4 Fold mirror
5 APO

Calibration system
Exit port to SMO collimator
Input/output port to SMO collimator/camera/grating
SPO – layout of dichroic level
SPO – dichroic wheel assembly EQM

CdTe filter

Diamond machined aluminium wheel
SPO – verification model chassis hardware

- Black anodized baffle structure
- Mirror mounting pads
SPO – Anamorphic Pre-Optics (APO)

- Input aperture
- Output fold mirror
- Toroidal mirror
- Aluminium mirror substrate
APO verification model hardware

Toroidal mirror

Output fold mirror

Input aperture
For more details on the mirror arrays, manufactured at Cranfield University, see talk 6273-74, Mon 14:00
Assembly carried out in class 100 clean room
SMO – opto-mechanical layout

- Focal plane module
- Grating assembly
- Input from IFU
- Camera optics
- Collimator mirror
SMO – optical layout of camera optics
SMO – mechanical structure

Short wavelength spectrometer (Channel 1 + 2)

Grating assembly

Long wavelength spectrometer (Channel 3 + 4)
QM is
• Manufactured
• Assembled
• Verified regarded alignment
• Vibration tested
• Verified regarding alignment
SMO – QM Alignment inspection
SMO – QM vibration test

Vibration Test
Modelled performance for channel 2 at 8 µm

Full end to end optical system analysis done using physical optics propagation tool in zemax

Central slice

Reconstructed image meets specifications on FWHM and EED

Specsim - MIRI spectrometer simulator described in Lorente et al. 6274-55
Summary and status

- Opto-mechanical design complete. Both SPO and SMO have completed CDR

- Verification model hardware
  - SPO components have been received
  - SMO CMs are ready
  - SMO M1-1, M1-2 and M3 are ready to be gold-coated
  - SMO VM Gratings on track for a June 2006 delivery

- Most of sub-system testing now complete

- Assembly of Verification Model in progress

- Delivery of spectrometer sub-systems to Rutherford Appleton Laboratory for integration and test into MIRI VM will be later this year
MIRI draws on the expertise of the following organizations:

Ames Research Center, USA; Astron, Netherlands Foundation for Research in Astronomy; CEA Service d'Astrophysique, Saclay, France; Centre Spatial de Liége, Belgium; Consejo Superior de Investigaciones Científicas, Spain; Danish Space Research Institute; Dublin Institute for Advanced Studies, Ireland; EADS Astrium, Ltd. U.K, European Space Agency, Netherlands; Institute d'Astrophysique Spatiale, France; Instituto Nacional de Técnica Aeroespacial, Spain; Institute of Astronomy, Zurich, Switzerland; Jet Propulsion Laboratory, USA; Laboratoire d'Astrophysique de Marseille (LAM), France; Lockheed Advanced Technology Center, USA; Max-Planck-Institut für Astronomie (MPIA), Heidelberg, Germany; Observatoire de Paris, France; Observatory of Geneva, Switzerland; Paul Scherrer Institut, Switzerland; Physikalishes Institut, Bern, Switzerland; Raytheon Vision Systems, USA; Rutherford Appleton Laboratory (RAL), UK; Space Telescope Science Institute, USA; Toegepast-Natuurwetenschappelijk Ondenzoek (TNO-TPD), Netherlands; U.K. Astronomy Technology Centre (UK-ATC); University College, London, UK; Univ. of Amsterdam, Netherlands; Univ. of Arizona, USA; Univ. of Cardiff, UK; Univ. of Cologne, Germany; Univ. of Groningen, Netherlands; Univ. of Leicester, UK; Univ. of Leiden, Netherlands; Univ. of Leuven, Belgium; Univ. of Stockholm, Sweden, Utah State Univ. USA