NIRCam Overview

- NIRCam is the near-infrared imager on JWST, which covers the wavelength range from 0.6 to 5 μm, and figures prominently in most planned science programs for JWST.
- The instrument was selected in the spring. The winning concept is led by Marcia Rieke (University of Arizona), and will be built by Lockheed. The Canadian Space Agency is also involved.
- The University of Arizona NIRCam can image a 2.3'x4.6' FOV in two broad band filters simultaneously via dichroics, with critical sampling at 2 and 4 μm.
- NIRCam includes 7 broad-band filters with R=4 and 8 medium-band filters that cover features of ices and T dwarfs.
- NIRCam also has two special features: two tunable filters with R~100, and coronographic apertures in all instruments.
- NIRCam is currently undergoing a Phase A study (due February 2003) to establish the detailed design.
- General information can be found at http://ircamera.as.arizona.edu/nircam.
# NIRCam Features at a Glance

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<th>Feature</th>
<th>Description</th>
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<td><strong>Wavelength Range</strong></td>
<td>0.6–5.0μm</td>
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<td><strong>Spectral Resolutions</strong></td>
<td>Selection of R<del>4 and R</del>10 discrete filters, R~100 using 2 tunable filters</td>
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<td><strong>Fields of View</strong></td>
<td>Imaging: 2.3' x 4.6' at two wavelengths simultaneously</td>
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<td>R=100 Imaging: Two 2.3’x2.3’ fields (one &lt; 2.5μm, one &gt; 2.5 μm)</td>
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<tr>
<td><strong>Spatial Resolution</strong></td>
<td>Imaging: 0.034”/pixel &lt; 2.5μm</td>
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<td>0.068”/pixel l&lt;2.5μm</td>
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<td>R = 100: 0.068”/pixel</td>
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<tr>
<td><strong>Coronagraphy</strong></td>
<td>Choice of coronagraphic spots and pupils in all instrument sections</td>
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</tbody>
</table>
Approximate size and placement of NIRCam within the ISIM

The camera is very compact and consists of two blocks

The left has the short and long-wavelength tunable filters

The right has the normal imaging elements
One of two NIRCam normal imaging modules

The dichroic splits the light at 2.3 μm into short and long wavelength components, imaged with different f ratios.

Each detector covers 2.3’x2.3’. Pixel sizes are optimized for Nyquist sampling at 2 and 4 μm; the short λ detector is 4k, the long λ is 2k.

Filter wheels include pupils for wavefront sensing.

The tunable filter modules are similar, without dichroic or wavefront sensing.
Focal Plane Arrangement

Schematic arrangement of the focal plane covered by NIRCam, as seen from the sky

Top: the two tunable filters, each covering 2.3'x2.3'

Bottom: the two fields imaged in broad band.

Both fields on the bottom are imaged simultaneously in short and long wavelength (< and > 2.4 mm), with an instantaneous field of view of 2.3'x4.6', or 10 square arcmin, in each
NIRCam Detectors

The focal plane arrangement of NIRCam, as seen from the detectors:

The detectors (Figer presentation) will be sensitive in the range 0.7 to 5 μm. NIRCam uses 12 2k x 2k arrays, for a total of 48 Mpixel.

Detectors and focal-plane electronics will be procured by GSFC.

Note that the short-wave and long-wave arrays cover the same region of sky.
NIRCam’s filters were chosen for:
- photometric redshift estimation
- ability to distinguish ices and other solid state features
- photometric properties -- ability to calibrate into physical units without detailed knowledge of input source spectrum

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### Filter Selection

<table>
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<th>Number of Filters</th>
<th>Performance of adopted filter set</th>
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<tr>
<td>4</td>
<td>R=3 Filters</td>
</tr>
<tr>
<td>5</td>
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<tr>
<td>6</td>
<td>R=4 Filters</td>
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<td>7</td>
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<tr>
<td>8</td>
<td>R=5 Filters</td>
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</table>

### Performance of adopted filter set

![Diagram showing filter performance with redshift ranges](image)

### Wavelength vs. Signal (linear units)

**Wavelength (µm)**

- B2
- B3
- B4
- B5
- B6
- B7

**Signal (linear units)**

- CO ice
- H2O ice
- CO2 ice
- N2 ice
- CH4 ice
- NH3 ice
- Pholus
- WR106
- PAH
- EL 18
- L-dwarf
- T-dwarf
- W33A

**Legend:**
- CO ice
- H2O ice
- CO2 ice
- N2 ice
- CH4 ice
- NH3 ice
- Pholus
- WR106
- PAH
- EL 18
- L-dwarf
- T-dwarf
- W33A

*(M. Rieke / SWG meeting / 9/24/2002)*
### Complete Filter and Pupil List

<table>
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<th>Imaging Module, long λ arm(2)</th>
<th>Tunable Filter Modules (2)</th>
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<td><strong>Filter wheel</strong></td>
<td><strong>Pupil wheel</strong></td>
<td><strong>Filter wheel</strong></td>
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<tr>
<td>B1 0.7 μm</td>
<td>Imaging pupil</td>
<td>Order blocker 1</td>
</tr>
<tr>
<td>B2 1.1 μm</td>
<td>Flat field source</td>
<td>Order blocker 2</td>
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<tr>
<td>B3 1.5 μm</td>
<td>Outward pinholes</td>
<td>Order blocker 3</td>
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<tr>
<td>B4 2.0 μm</td>
<td>Coronagraph pupil 1 with wedge</td>
<td>Order blocker 4</td>
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<tr>
<td>1.55-1.7 μm</td>
<td>Coronagraph pupil 2 with wedge</td>
<td>Order blocker 5</td>
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<tr>
<td>1.7-1.95 μm</td>
<td>Hel 1.08 μm</td>
<td>Order blocker 6</td>
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<tr>
<td>2.0-2.22 μm</td>
<td>Reserved for wavefront sensing (6 positions)</td>
<td>TF calibration pattern 1</td>
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<tr>
<td>0.8-1.0 μm</td>
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<td>Order blocker 7</td>
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<tr>
<td>Hα 0.656 μm</td>
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<td>Order blocker 8</td>
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<tr>
<td>[Fell] 1.64 μm</td>
<td></td>
<td>Order blocker 9</td>
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<tr>
<td>Pα 1.875 μm</td>
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<td>Narrow filter (1 %) 1</td>
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<tr>
<td>H2 2.12 μm</td>
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<td>Narrow filter (1 %) 2</td>
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<td>TBD</td>
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- **TBD** indicates that the value is to be determined or is pending.
NIRCam Tunable Filters and Coronographs

Tunable filter modules
- The two tunable filter modules will cover 1.2 to 2.3 and 2.5 to 4.5 mm respectively.
- They have a scale of 0.068”/pixel (2.3’ x 2.3’) and a spectral resolution of 1%.
- Each wavelength to be observed requires a separate exposure, but the full FOB is observed at the same time.
- The two modules cover different areas of the sky.

Coronographic capabilities
- All NIRCam modules have coronographic spots in the telescope focal plane
- The pupil wheels include coronographic masks
- The coronographic spots in the tunable filter modules allow low-resolution spectra to be obtained for faint objects near bright stars (e.g., planets)
The NIRCam Team

Science Team:

Marcia Rieke (UAz)  
David Crampton (HIA/DAO)  
Tom Greene (NASA Ames)  
Doug Johnstone (HIA/DAO)  
Don McCarthy (UAz)  
Tom Roellig (NASA Ames)  
Erick Young (UAz)  
Stefi Baum (STScI)  
René Doyon (UMontreal)  
Klaus Hodapp (UHawaii)  
Simon Lilly (ETH)  
Michael Meyer (UAz)  
John Stauffer (SSC)  
Chas Beichman (JPL)  
Daniel Eisenstein (UAz)  
Scott Horner (LMATC)  
Peter Martin (UToronto)  
George Rieke (UAz)  
John Trauger (JPL)

Bold = Science Theme Leader  
Blue: EPO Leader

Corporate Partners:

Lockheed Martin Advanced Technology Center, Palo Alto, California
EMS Technologies, Ottawa, Ontario
COM DEV, Cambridge, Ontario

Goddard Instrument Manager:  
Doug Campbell

STScI Instrument Scientist:  
Stefano Casertano
The NIRCam Team Science Program and the DRM

<table>
<thead>
<tr>
<th>NIRCam Programs by Number and Title</th>
<th>FOV ≥ 16'</th>
<th>FOV ≤ 4'</th>
<th>Photometric z</th>
<th>Broadband</th>
<th>Intermediate BB</th>
<th>R = 100</th>
<th>Dynamic range</th>
<th>Crngrph R=4-10</th>
<th>Crngrph R=100</th>
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<td>1. Formation and evol. of galaxies I. Imaging</td>
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<td>3. Map dark matter at high z</td>
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<td>5. Cosmology with high z SN</td>
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<td>Massive planets</td>
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* Although NIRCam observations were not specified by the ASWG for DRM#7 and DRM#10, they will make substantial contributions.

(M. Rieke / SWG meeting / 9/24/2002)
NIRCam Team Science Program

Our camera design is driven by the requirements derived from the Design Reference Mission and our team science needs.

Team Science Program:

When Galaxies Were Young:
Discovering the First Galaxies, Reionization, Period of Galaxy Assembly

Making of a Star: Testing the ‘Standard Model:’ Physics of the IMF, Structure of Pre-stellar Cores, Emerging from the Dust Cocoon

Debris Disks and Planetary Systems:
Disks from Birth to Maturity, Survey of KBOs, Planets Around Nearby Stars

(M. Rieke / SWG meeting / 9/24/2002)
Current observations have pushed detections of QSOs to $z \sim 6$. The cosmic background radiation was emitted at $z \sim 1000$. The interval between these $z$’s has been dubbed the “Dark Ages”. It is NGST’s job to discover

• the first light emitting objects
• the epoch when H became reionized
• how galaxies were assembled and how they developed their characteristic shapes we recognize today

Team will use 50,000 sec exposures per filter on two 4.6’x4.6’ regions of sky to probe the “Dark Ages”.

(M. Rieke / SWG meeting / 9/24/2002)
NIRCam’s primary goal - JWST’s primary goal - is the detection of “first light” objects.

Requires:
- Deep imaging, large area
- Photo-z
- Spectroscopy follow-up

Ancillary goals:
- When did H reionize?
- When did galaxies form?
- How did they become like today’s?

Deep images are good…

Simulation by Stockman and Im - 2’x2’ field
The broad outline of star formation is reasonably well understood as the collapse of a cloud. This occurs quickly and in heavily obscured environments. But what controls the initial mass function? How do cloud cores collapse to form protostars? Does mass loss via jets play a crucial role in regulating star formation?

Team will combine surveys of star forming regions and dense clouds with detailed observation of selected protostars and disks to address these questions.

(M. Rieke / SWG meeting / 9/24/2002)
Reconstructing a Spectrum with NIRCam

NIRCam builds up a spectrum by taking a series of images. Consequently spectral information can be obtained without knowing positions ahead of time or in situations where high dynamic range scenes need to be observed.

Debris disk like Vega’s at 60pc with star suppressed by the coronagraph. Vertical arrow = 1”

|M. Rieke / SWG meeting / 9/24/2002|
Many debris disks and planets around other stars have been discovered recently. However, these objects have not been characterized in any detail. How do debris disks form and evolve? How are they related to the Kuiper Belt in the Solar System? How many planets orbit nearby stars? What are the characteristics of these planets?

Team will use the coronagraph to observe the reflected light from disks. A survey for planets around nearby stars will be done with more detailed study of the brighter planets. A sample of Kuiper Belt objects will be surveyed to define their surface properties for comparison with debris disks.

(M. Rieke / SWG meeting / 9/24/2002)