on behalf of 7 billion current Earthlings, ~10,000 future observers, ~1000 engineers and technicians, ~100 scientists worldwide, 3 space agencies
Planning your **Solar System Observations with the James Webb Space Telescope**

- Provide, via the JWST Project members:
  - current instrument specifications and observing modes
  - observatory capabilities (brightness limits, moving targets, tracking, and others)
  - preliminary case studies from JWST SO-DRM

**Goal:** fully engage Solar System community and provide tools they need to begin planning their observations with JWST

14 October 2012, Reno, Nevada
AAS Division for Planetary Sciences Meeting
JWST Vital Stats

- General Observatory: 5 years required; 10 years goal
- Diameter of primary mirror: 21.3 feet (6.5 meters)
- Number of primary mirror segments: 18
- Sunshield: 5 layer, 69.5 feet by 46.5 feet (21.2 meters by 14.2 meters)
- Orbit: 930,000 miles (1.5 million kilometers) from Earth
- Operating temperature: Below 50 Kelvin (−370° Fahrenheit)
- Four Science Instruments covering 0.6–28.8 microns
  - Filtered Imaging
  - Spectroscopy – Slit, Integral Field, Grism/Prism
  - Coronagraphy – Traditional Lyot + Four Quadrant Phase Masks
  - Aperture Mask Interferometry – Non-Redundant Mask (NRM)
## JWST Instrumentation

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Science Requirement</th>
<th>Capability</th>
</tr>
</thead>
</table>
| **NIRCam**      | Wide field, deep imaging
• 0.6 μm - 2.3 μm (SW)
• 2.4 μm - 5.0 μm (LW) | Two 2.2’ x 2.2’ SW
Two 2.2’ x 2.2’ LW
Coronagraph
Dual filter wheel |
| **NIRSpec**     | Multi-object spectroscopy
• 0.6 μm - 5.0 μm | 9.7 Sq arcmin Ω + IFU + slits
100 selectable targets: MSA
R=100, 1000, 3000 |
| **MIRI**        | Mid-infrared imaging
• 5 μm - 27 μm
Mid-infrared spectroscopy
• 4.9 μm - 28.8 μm | 1.9’ x1.4’ with coronagraph
Filter wheel
3.7”x3.7” – 7.1”x7.7” IFU
R=3000 - 2250 |
| **FGS/NIRISS**  | Fine Guidance Sensor
0.8 μm - 5.0 μm
Near IR Imaging Slitless Spectrometer,
• 1.6 μm - 4.9 μm | Two 2.3’ x 2.3’
2.2’ x 2.2’
R=150, 700 with coronagraph |
## JWST Imaging Modes

<table>
<thead>
<tr>
<th>Mode</th>
<th>Instrument</th>
<th>Wavelength (microns)</th>
<th>Pixel Scale (arcsec)</th>
<th>Full-Array* Field of View</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Imaging</strong></td>
<td>NIRCam*</td>
<td>0.6 – 2.3</td>
<td>0.032</td>
<td>2.2 x 2.2'</td>
</tr>
<tr>
<td></td>
<td>NIRCam*</td>
<td>2.4 – 5.0</td>
<td>0.065</td>
<td>2.2 x 2.2'</td>
</tr>
<tr>
<td></td>
<td>NIRISS</td>
<td>0.9 – 5.0</td>
<td>0.065</td>
<td>2.2 x 2.2'</td>
</tr>
<tr>
<td></td>
<td>MIRI*</td>
<td>5.0 – 28</td>
<td>0.11</td>
<td>1.23 x 1.88'</td>
</tr>
<tr>
<td><strong>Aperture Mask Interferometry</strong></td>
<td>NIRISS</td>
<td>3.8 – 4.8</td>
<td>0.065</td>
<td>-----</td>
</tr>
<tr>
<td></td>
<td>NIRCam</td>
<td>0.6 – 2.3</td>
<td>0.032</td>
<td>20 x 20''</td>
</tr>
<tr>
<td></td>
<td>NIRCam</td>
<td>2.4 – 5.0</td>
<td>0.065</td>
<td>20 x 20''</td>
</tr>
<tr>
<td><strong>Coronography</strong></td>
<td>MIRI</td>
<td>10.65</td>
<td>0.11</td>
<td>24 x 24''</td>
</tr>
<tr>
<td></td>
<td>MIRI</td>
<td>11.4</td>
<td>0.11</td>
<td>24 x 24''</td>
</tr>
<tr>
<td></td>
<td>MIRI</td>
<td>15.5</td>
<td>0.11</td>
<td>24 x 24''</td>
</tr>
<tr>
<td></td>
<td>MIRI</td>
<td>23</td>
<td>0.11</td>
<td>30 x 30''</td>
</tr>
</tbody>
</table>
## JWST Spectroscopy Modes

<table>
<thead>
<tr>
<th>Mode</th>
<th>Instrument</th>
<th>Wavelength (microns)</th>
<th>Resolving Power ($\lambda/\Delta\lambda$)</th>
<th>Field of View</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Slitless Spectroscopy</strong></td>
<td>NIRISS</td>
<td>1.0 – 2.5</td>
<td>150</td>
<td>2.2’ x 2.2’</td>
</tr>
<tr>
<td></td>
<td>NIRISS</td>
<td>0.6 – 2.5</td>
<td>700</td>
<td>single object</td>
</tr>
<tr>
<td></td>
<td>NIRCam</td>
<td>2.4 – 5.0</td>
<td>2000</td>
<td>2.2’ x 2.2’</td>
</tr>
<tr>
<td><strong>Multi-Object Spectroscopy</strong></td>
<td>NIRSpect</td>
<td>0.6 – 5.0</td>
<td>100, 1000, 2700</td>
<td>3.4’ x 3.4’ with 250k 0.2 x 0.5” microshutters</td>
</tr>
<tr>
<td><strong>Single Slit Spectroscopy</strong></td>
<td>NIRSpect</td>
<td>0.6 – 5.0</td>
<td>100, 1000, 2700</td>
<td>slit widths 0.4” x 3.8” 0.2” x 3.3” 1.6” x 1.6”</td>
</tr>
<tr>
<td></td>
<td>MIRI</td>
<td>5.0 – ~14.0</td>
<td>~100 at 7.5 microns</td>
<td>0.6” x 5.5” slit</td>
</tr>
<tr>
<td><strong>Integral Field Spectroscopy</strong></td>
<td>NIRSpect</td>
<td>0.6 – 5.0</td>
<td>100, 1000, 2700</td>
<td>3.0” x 3.0”</td>
</tr>
<tr>
<td></td>
<td>MIRI</td>
<td>5.0 – 7.7</td>
<td>3500</td>
<td>3.0” x 3.9”</td>
</tr>
<tr>
<td></td>
<td>MIRI</td>
<td>7.7 – 11.9</td>
<td>2800</td>
<td>3.5” x 4.4”</td>
</tr>
<tr>
<td></td>
<td>MIRI</td>
<td>11.9 – 18.3</td>
<td>2700</td>
<td>5.2” x 6.2”</td>
</tr>
<tr>
<td></td>
<td>MIRI</td>
<td>18.3 – 28.8</td>
<td>2200</td>
<td>6.7” x 7.7”</td>
</tr>
</tbody>
</table>
TITAN

JWST/NIRSpec IFU
0.1″ x 0.1″ spaxel grid

10000
1000
100
10
1

0.8″ ~ 5200 km

10σ NEFD; Flux Density (µJy)

JWST/NIRSpec
PSF at 2 microns

Cassini image credit:
NASA/JPL/Space Science Institute

Starsberry, private communication
NIRCam 640 Pixel (40") Subarray Saturation vs. Outer Planets

Sat. Limits
- Jupiter
- Saturn
- Mars (<50 Jy/"m")
- Uranus
- Neptune

Surface Brightness (Jy/"")

Wavelength (um)

J
H
K
L
M

J. Stansberry
Planet (Preliminary) Summary

- Mars: NIRSpec, NIRCam (LW)
- Jupiter: MIRI (MRS <10 micron and FND), NIRCam – new subarray, NIRSpec
- Saturn: MIRI (MRS, imaging with subarray, FND), NIRCam (LW, SW), NIRSpec
- Uranus: MIRI (spectra and imaging), NIRCam (subarray), NIRSpec
- Neptune: MIRI (spectra and imaging), NIRCam (subarray), NIRSpec
JWST solar system capabilities

• HST (or better) angular resolution at longer wavelengths
  – diffraction limited 6.5 telescope at 2 µm
• Zodi background limited imaging sensitivity for λ < 12 µm
  – faint objects like KBO’s, asteroids, satellites of Pluto, planetary rings
• Full coverage from 0.6 to 28 µm with imaging and spectroscopy, \( R = \frac{\lambda}{\Delta \lambda} = 3000 \) (chemistry and physics)
• Follows ephemeris up to at least 0.03 arcsec/sec for moving targets
  – Nonlinear tracking
• Can observe all planets and satellites except Mercury, Venus, Earth, and Moon (from 85 to 135 deg from Sun)
• Subarray readout modes for bright objects
http://www.stsci.edu/jwst/science/solar-system
Panel and Discussion

• Issues identified
  • Moving targets—tracking rates, specifically or workarounds
  • Subarray observations in general and implementing subarrays for NIRISS
  • NIRSpec Microshutter
  • Moons near giant planets—how close can you go...also rings (see stray light)
  • Peak-ups on objects of varying brightness
  • Possibility of interaction on guide stars between observer and ground system
  • Shadow observations—very useful for moving targets
  • Slew time penalty and short-exposure-time science
  • Stray light issues (crucial for rings and fainter objects as well)
  • 24 hour scheduling visit—too large for solar system. Are we penalized?
  • Solar system proposal issues; sociology, panels, overall time
  • Launch is 6 years away, but now is the time to develop realistic, detailed use cases-----beyond SO-DRM.
44th Lunar and Planetary Science Conference
March 18-22, 2013
The Woodlands, Texas

- Peripheral Meeting Request
  - Sunday, March 17 (afternoon)
  - Same format as DPS
  - Targeted Invite List