Overview of WFIRST-AFTA
Mission Capabilities

Neil Gehrels
WFIRST Project Scientist
(NASA-GSFC)

AAS
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WFIRST Observatory

- Outer Barrel Assembly (OBA)
- Aft Metering Structure (AMS)
- Coronagraph Instrument
- Instrument Carrier (IC)
- Wide Field Instrument
- High Gain Antenna (2X)
- 2.4m telescope
- Solar Array / Sunshield
- Spacecraft Module
Observatory Capabilities

Spacecraft

Telescope:
- 2.4m primary, 0.6m secondary
- 3rd mirror in WF instrument for TMA

Field of Regard:
- 54° - 126° w.r.t. sun
- 64% of sky

Downlink:
- Continuous 150 Mbps
- Ka-band to Ground Station

GEO orbit

Dry mass: 3900 kg

Wide Field Instrument

Imaging 0.8 – 2.0 microns
- 0.28 FoV 0.11" pixel scale
- 6 filters
- grism: 1.35 – 1.95 microns R~600

IFU (in WFI)

- 0.6 – 2.0 microns
- 3" FoV 0.075" pixel scale R~100

Coronagraph

- 0.4 – 1.0 microns
- 2.5" FoV 0.017" pixel scale

IFS (in coronagraph)

- 0.6 – 1.0 microns R~70
TMA Telescope

- Three Mirror Anastigmatic
- Three powered (curved) mirrors
- 9 degrees of freedom from mirrors (curvature, conic constant, position for each)
- Allows control of 9 parameters (focal length, magnification of each mirror, astigmatism, coma, spherical aberration, field curvature)
- Much wider field than Ritchey-Chrétien
- Better image quality than Schmidt
## Observatory Capabilities

### Spacecraft

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### Wide Field Instrument

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Payload Optical Block Diagram

**Telescope**
- **270 K 2.4 m Telescope:**
  - T1: 2.4 m aperture
  - T2: 30% linear obscuration from baffle
  - 6 struts with realignment capability; outer barrel with recloseable doors

**Wide Field Instrument**
- M3: Cold Pupil Mask
  - Temperature 170 K
  - Guiding performed using guiding functions contained in the 6x3 science SCAs
  - 8 positions (6 filters, GRS grism, blank)
  - Grism R = 550-800 (2 pixel)
  - Ea. square is a 4kx4k, 10µm pixel size SCA; 302 Mpix; 120K; 0.76-2.0µm bandpass
  - 0.28 deg² active area
- Element Wheel
- 110 mas/pix f/7.9

**Wide Field Science Channel**
- Relay
- Slicer Assembly
- Prism Spectrograph
  - R = ~100 (2 pixel)
  - 75 mas/pix; f/21
  - 12kx2k, 18µm pixel size SCA; 4 Mpix; <115K; 0.6-2.0µm bandpass;
  - FOV 3.00x3.15 arcsec

**Integral Field Unit Spectrograph Channel**

**Coronagraph Instrument**
- Relay w/ FSM
- 2 Fixed DMs
- Pupil & Focal Plane Masks
- LOWFS
- Flip Mirror
  - 1kx1k, Si low noise FPA; 150K;
  - IWA 0.25/λ arcsec, λ (400-1000 nm)
  - OWA 2.5 arcsec
- Filter Wheel
- Imaging Detector
- IFS
- IFS Detector
  - 1kx1k, Si low noise FPA, 150K;
  - 600-980 nm bandpass;
  - R~70, 17 masec sampling

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**Abbreviations:**
- GRS = Galaxy Redshift Survey
- SCA = Sensor Chip Assembly
- DM = Deformable Mirror
- FSM = Fast Steering Mirror
- LOWFS = Low Order Wavefront Sensor
- IFS = Integral Field Spectrograph
- IWA = Inner Working Angle
- OWA = Outer Working Angle

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**H4RG 300 Mpix**
Microlensing Capabilities

**Desires**
- Monitor dense star field
- Adequate continuous time
- Long time baseline, astrometry
- Many exoplanet lensed events

**WFIRST capability**
- Galactic bulge, IR imaging
- 3 sq deg field
- 6 x 72 days = 1.2 years total
- 6 years
- 3000 exoplanets
- 300 Earth-mass
- 100's free floating

**WFIRST Benefits vs Ground**
- Steady uninterrupted view for weeks at a time
- NIR coverage for reddened / obscured bulge region
- High angular resolution (~ 0.1" vs ≥1")
Microlensing Capabilities

Exoplanet Discovery Potential

Mass (Earth masses)

semi-major axis (AU)

Kepler

wide-FOV
ML network

WFIRST

free floating planets

UN

S

M

M

VE
Coronagraph Capabilities

**Desires**
- High contrast, image Jupiter exoplanets
- Small inner working angle
- Spectroscopy to characterize planets
- Polarization to determine geometries

**WFIRST vs Ground & Space**

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Desired Contrast</th>
<th>Inner Working Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>WFIRST</td>
<td>$10^{-9}$</td>
<td>100-200 mas</td>
</tr>
<tr>
<td>HST</td>
<td>$10^{-4}$</td>
<td>200 mas</td>
</tr>
<tr>
<td>GPI</td>
<td>$10^{-6}$</td>
<td>100 mas</td>
</tr>
<tr>
<td>ELT</td>
<td>$10^{-7}$</td>
<td>~50 mas</td>
</tr>
</tbody>
</table>

**WFIRST capability**
- $10^{-9}$ effective contrast
- IWA $\sim$ 100-200 milli-arcsec
- $R\sim70$ (TBD) 600 – 950 nm
- Polarization sensitivity
GO Capabilities

Attributes

Imaging survey

Multi-filter photometry

Slitless spectroscopy

Slit multi-field spectroscopy

Number of SN Ia SNe

Number galaxies with spectra

Number galaxies with shapes

Number of galaxies detected

Number of massive clusters

Time domain astronomy

WFIRST capability

J ~ 27AB over 2400 sq deg

J ~ 29AB over 3 sq deg deep fields

Filters: z, Y, J, H, Ks, W (wide)

0.28 sq deg, R~600

IFU, R~70

2x10^3 to z~1.7

2x10^7

4x10^8

few x 10^9

4x10^5

supernovae – slit spectroscopy in 5 days

lensed exoplanets – few hours to 1 day

transient response in few hours (goal)

*** Coronagraph also available for GO observations
High Redshift Galaxy Luminosity Function

WFIRST’s High Latitude Survey will yield up to 2 orders of magnitude more high redshift galaxies than currently known.
Response to Transients

GRB Optical/NIR Afterglow

NS-NS mergers produce GWs & GRBs

EM afterglows are bright, but short-lived

short GRBs

long GRBs

Corrected $R_e$ magnitude

$t$ (days after burst in the observer frame)

WFIRST-AFTA

LSST

JWST

Kann+ '08
Status

- SDT study underway with project team. Final report due '15
- "New start" in FY16 of FY17.
- Science teams and possibly hardware teams to be selected competitively in about 2 years.
- Use of donated telescope and addition of coronagraph have increased the interest in WFIRST:
  - $66M add by Congress. Used for pre-Phase A risk reduction & schedule advancement
  - Funding ramps up in FY18, capturing the JWST funding "wedge" for astrophysics
- Cost with coronagraph is $2.1 - 2.4B depending on launcher
- Launch date is 2023 to 2024
Conclusions

• WFIRST-AFTA with 2.4m telescope has capabilities that are orders of magnitude better than current instruments

• Microlensing observations
  – NIR from space
  – More sensitive and less confused than ground measurements.
  – 3000 exoplanet detections

• Coronagraph is enabled by larger mirror.
  – Optical measurements in controlled instrument from space
  – $10^{-9}$ contrast and 100-200 mas IWA
  – significant improvement compared to space and ground

• WFIRST-AFTA is gaining momentum in funding and community support. Need to work hard on coronagraph development, keeping it "in the box"