NASA ExEP Resources Available for TDEM PIs

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Pre-Proposal TDEM-17 Briefing Telecon
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ExEP Resources for TDEM PIs

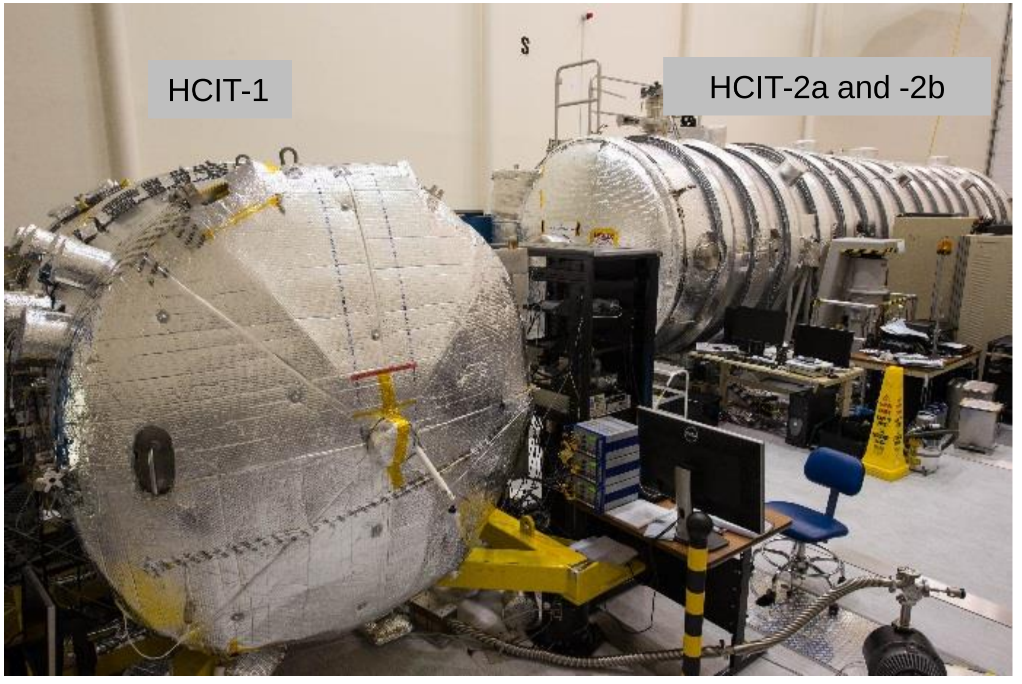
- **This presentation provides an overview of the ExEP resources located at JPL available to support a TDEM-17 proposal.**
- **The available resources, if appropriate for your needs, may help you more efficiently meet your milestone goals and reduce your proposal costs and schedule.**

Unavailable Resources

- HCIT-1 (dedicated to WFIRST)

Available Resources

- HCIT-2a (Decadal Survey Testbed)
  - Obscured, segmented apertures only
- HCIT-2b
- Vacuum Surface Gauge
- Microdevices Laboratory (MDL)



Gaining Access to the ExEP Resources at JPL

How to Request Use of ExEP Resources at JPL

- **Submit preliminary Statement of Work (SOW) for use of ExEP resources to Brendan Crill no later than March 5, 2018.**
  - Follow SOW questionnaire on next page.

- **Schedule telecon with Brendan Crill between March 5 – 12, 2018 to discuss use of the resources of interest and to obtain costing guidelines.**
  - We will evaluate with the PI workforce, labor, and infrastructure access required across all received SOWs.

- **Brendan Crill will supply the proposal PI a Letter of Commitment for use of any ExEP resources.**
  - PIs are to include both the SOW and the Letter of Commitment in their proposal.
  - HCIT will provide workforce cost to set up testbeds; additional labor and unique procurements must be costed within the proposal.

SOW Questionnaire for Use of ExEP Resources

1. **Brief description of the proposed TDEM**
2. **What resources are requested?**
3. **Milestone (s) to be accomplished and performance goals**
4. **Brief description of how the work will be conducted**
5. **Period(s) and preferred dates, if any, over which the resource is requested, stating whether in vacuum or air for testbeds. Include any time required for preparatory work.**
6. **A list of the personnel, expertise, and level of effort (if any) who will assist in the use of the resource.**
7. **Any anticipated changes to the resource needed to accommodate your demonstrations.**
8. **List of items needed for all testbed modifications. Identify items you will be procuring within your proposal's budget and provide approximate cost of needed items.**
    a. Otherwise, state that no additional procurements will be necessary for the use of the infrastructure under consideration.
9. **Provide any other relevant information or constraints.**

ExEP Technology Resources POC

For questions concerning use of ExEP technology resources or requests for more detail contact:

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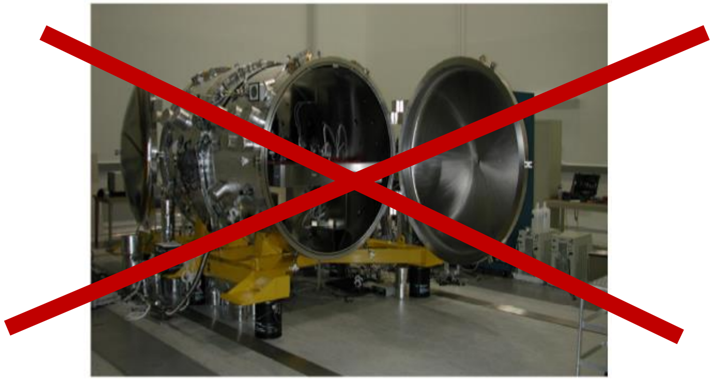
Additional Slides

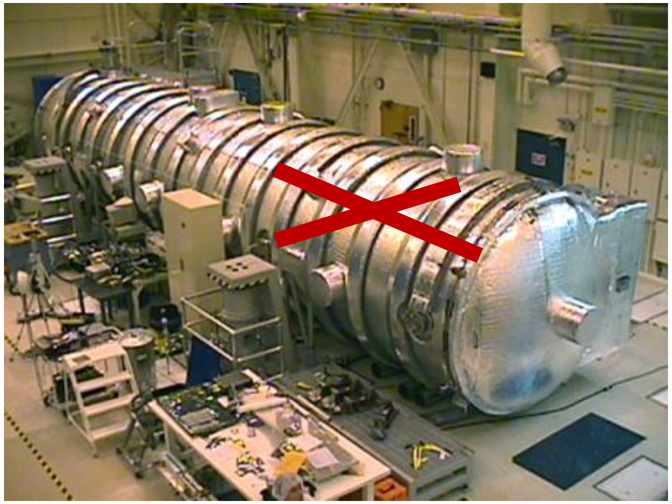
High Contrast Imaging Testbeds (HCITs)

Test Facility

- Two vacuum chambers with 1 mTorr capability
- Seismically isolated, temperature-stabilized ~ 10 mK at RT.
- Narrow or broad band coronagraph system demos
  - Achieved 3×10^{-10} contrast (narrowband)
- Fiber/Pinhole "Star" Illumination
  - Monochromatic: 635, 785, 809, and 835 nm wavelengths
  - 2, 10, and 20% BW around 800 nm center
  - Medium and high power super-continuum sources
- CCD camera ($5e^-$), 13 μm pixels
- Complete computer control with data acquisition and storage
- Coronagraph model validation & error budget sensitivities
- Remote access through FTP site



HCIT-1
Single-testbed capacity (5'x8')

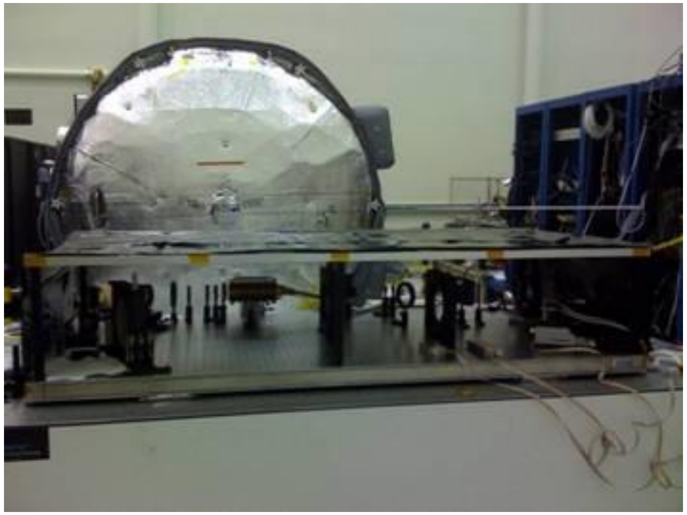


HCIT-2
Two-testbed capacity (6'x10')

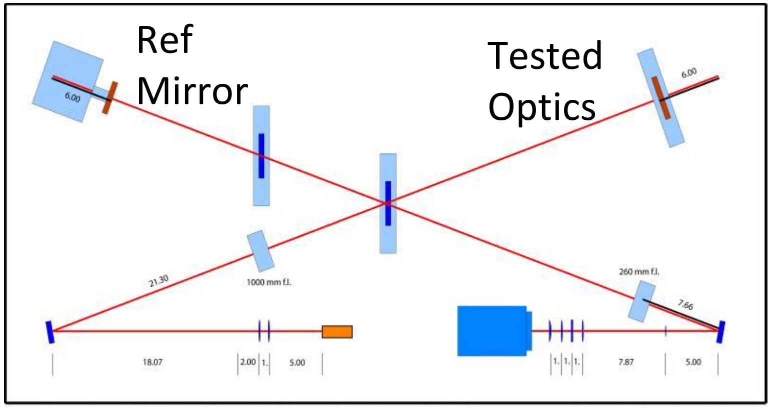
Vacuum Surface Gauge

Purpose: Accurate surface error measurement and deformable mirror calibration.

- **Demonstrated optical surface measurement accuracy: ≤ 100 pm rms**
- **Customized Michelson interferometer set-up**
  - ➢ Reference mirror w/ absolute position feedback
  - ➢ Frequency stabilized laser source
- **Dedicated algorithms for wavefront extraction over > 10^6 pixels**



Vacuum Surface Gauge testbed



End-points of axes are [4.5,6.5] inches from table corners. Beam height = center of beamsplitter = 4.405 inches. Top of b.s. mount = 8.810. Lens cell dia = 3.480. Top of lens cell = 6.147 inches.

Surface Gauge optical layout

MicroDevices Laboratory (MDL)

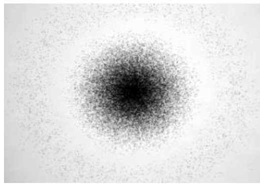


Figure 1. Microscope image (above) and AFM profile (below) of a micro dot patterned mask for JWST NIRCam coronagraph

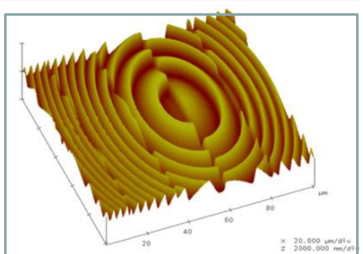
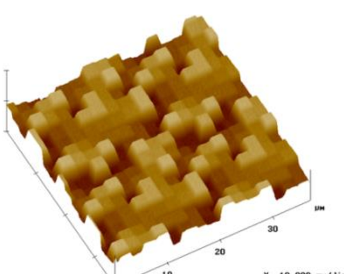


Figure 2. Diffractive optical devices



Purpose: Precision sub-micron materials fabrication and characterization

Advanced fabrication and characterization techniques

- Electron Beam Lithography
- Deep Reactive Ion Etching
- ICP Cryo Etching of Black Silicon microstructures

- Scanning Electron Microscopy
- Precision Optical Microscopy
- Atomic Force Microscopy
- 2D and 3D profilometry

Light suppression mask fabrication processes developed for:

- Micro dot patterned mask for JWST (Fig 1)
- Diffractive optical structures for spectrometer gratings and other computer generated holograms (Fig 2)
- Shaped pupil masks with fine structures and slits for transmission geometry (Fig 3)
- Shaped Pupil masks with black silicon structures in reflective aluminum background (Fig 4)
- LOWFS masks (Fig 5) incorporating a black silicon region (Fig 6) as well as shaped aperture through a silicon wafer
- Achromatic focal plane masks with deep diffractive structures (Fig 7)
- PIAACMC mask (Fig 8)
- Hybrid Lyot mask for WFIRST(Fig 9)
- Starshade mask for Princeton testbed (Fig 10)

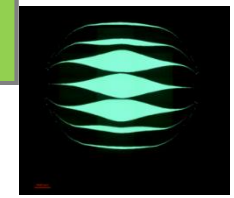


Figure 3. Transmissive slit SP mask

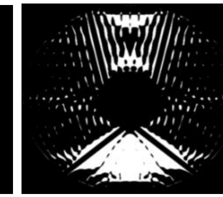


Figure 4. Reflective and absorptive SP mask

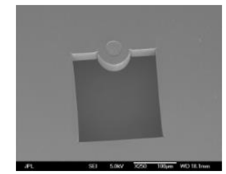


Figure 5. LOWFS mask

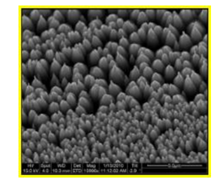


Figure 6. Black Si Microstructure

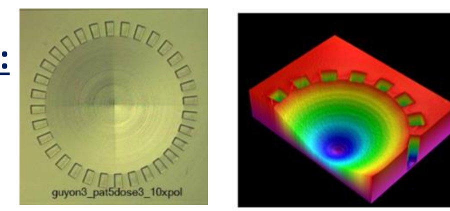


Figure 7 . Achromatic Focal Plane Masks (AFPM)

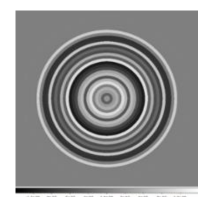


Figure 8 . PIAACMC mask

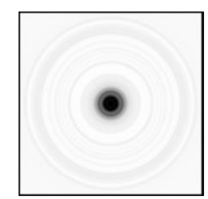


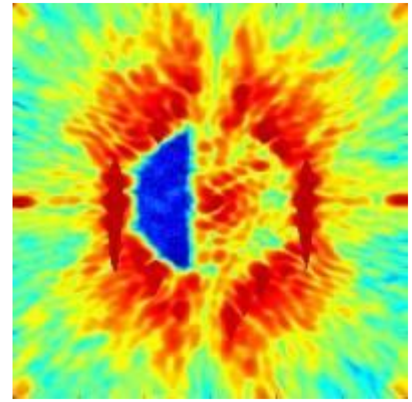
Figure 9 . Hybrid Lyot mask

Figure 10 . Starshade mask

Wavefront Sensing & Control

Nulling Algorithms

- Electric Field Conjugations (EFC) algorithms exist for single and dual DM control
- Demonstrated to < 10^{-9} contrast and 20% bandwidth
- Coupled to HCIT coronagraph models and DM calibration data for optimal efficiency



Best Results to Date

***Band-Limited Coronagraph*:**
6 e-10, @ 3 λ/D with 10% BW
2 e-9, @ 3 λ/D with 20% BW

***Shaped-Pupil Coronagraph*:**
1.2 e-9, @ 4 λ/D with 2% BW
2.4 e-9, @ 4 λ/D with 10% BW

***PIAA Coronagraph*:**
<1e-9, @ 2 λ/d with 0% BW

***Vector Vortex Coronagraph*:**
<1e-9, @ 3 λ/d with 0% BW

EFC Nulling and current performance

Deformable Mirrors

- **Wavefront control and speckle nulling available with Xinetics PMN deformable mirrors.**
  - Format sizes: 32x32mm, 48x48, and 64x64 mm with 1 mm pitch and 500 nm stroke size.
  - Continuous fuse silica facesheet polished to λ/100 rms
  - Two-DM configurations available

Xinetics DM