Benford - CGI Info Session

What the **Coronagraph** is for

✦ *and* ✦

How **you** can be involved

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What the Coronagraph is For

Technology Demonstration
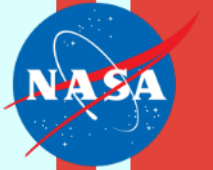
- NASA wants to learn how to build and operate a coronagraph for exoplanet characterization by building and operating a coronagraph to characterize exoplanetary systems.

- Performance for *Roman's* coronagraph instrument (CGI) is still >order of magnitude away from what is needed for future

- Learn throughout: design, model, build, test, use

- Falling below performance expectations, if we learn why, is still valuable

Requirements on the Coronagraph

- "As a technology demonstrator, the CGI has objectives
  - Each includes a statement defining the operational goals of the coronagraph
  - Accomplishing [CGI] objectives… not tied to the success of *Roman*."

- "In order to … address the technology demonstration objectives … the following threshold technical requirements (TTRs) must be satisfied." (Also data requirements)

- We designed the coronagraph to achieve the objectives, but even if we fall short, value lies in what we learn about *why*.

CGI Objectives

Objective
Demonstrate active wavefront control
Demonstrate key coronagraph elements
Demonstrate advanced coronagraph algorithms
Conduct high-contrast performance characterization
Advance high-contrast data processing

CGI Objectives & Goals

Objective	Operational Goal
Demonstrate active wavefront control	Detect a companion object to a star, on at least two stars
Demonstrate key coronagraph elements	Use coronagraph masks, low-order wavefront sensors, deformable mirrors, and low noise detectors
Demonstrate advanced coronagraph algorithms	Demonstrate modifying the wavefront sensing and control algorithms
Conduct high-contrast performance characterization	Characterize the integrated performance of the coronagraph and observatory as a function of time, wavelength, and polarization; use includes a revisit of the target and a repointing maneuver
Advance high-contrast data processing	Produce photometric, astrometric, and spectrographic measurements of at least one point source & at least one extended object.

CGI Objectives ⬌ Requirement

Demonstrate active wavefront control

Demonstrate key coronagraph elements

Demonstrate advanced coronagraph algorithms

Conduct high-contrast performance characterization

Advance high-contrast data processing

TTR5: *Roman* shall be able to measure the brightness of an astrophysical point source w/ SNR ⩾ 5 located 6 - 9 λ/D from an adjacent star with V_{AB} ⩽ 5, flux ratio ⩾ 10^{-7}; bandpass shall have a central wavelength ⩽ 600 nm and a bandwidth ⩾ 10%.

Coronagraph Points to the Future

Parameter	CGI vs. Future Missions (FM) with unobscured apertures: HabEx & LUVOIR B
10σ Flux Ratio Detectable at 3 λ/D	10^{-8} vs 10^{-10} Roman Space telescope Pupil is challenging
Wavefront error sources	Comparable Phase & "new physics" (amplitude and polarization)
Pointing Jitter Control	Comparable CGI lab: ~ 0.35 mas rms V=5 star, CBE = 0.49 mas rms FM: 0.3mas NTE*
Low-order Control	~ 100x better than required for HabEx better than LUVOIR needs Complex Roman Space Telescope pupil: trading low-order sensitivity for overall throughput
High-order drift	Comparable (~5pm) CGI: 1σ prediction** FM: NTE*
# of DMs	Same (2)
DM Stroke Resolution	~4X worse (7.5pm vs 2pm) Engineering problem, not physics problem
DM Actuator Count	48x48 vs 64x64
EMCCD	Comparable at V-band Bit better: dark current, clock-induced charge Bit worse: QE at UV/red at 5 years (rad hard)

CGI Flux Ratio Noise far from HabEx/LUVOIR (telescope not well suited)

…but CGI components and subsystems are highly comparable!

Figure from Mennesson et al. 2020

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CGI Operations

Current planning apportionment is 3 months for tech demo within first 18 months of operations (anticipated for 2027-2028)

Actual apportionment of time will be decided in operations; deliberately held flexible in order to maximize the overall science outcomes while meeting tech demo needs: project has the remit to 'do the right thing' for all stakeholders

Plans for coronagraph shall show meeting tech demo needs in 3 months of time, using worst case performance. This is the simple one-band imaging reflected in TTR5. Expecting a healthy portion of the time focused on the full set of goals/capabilities.

What's Missing?

Imaging Spectroscopy

→ still have a spectrometer; slit-prism design

Extended Source Imaging

Polarimetry

→ still have wide-field shaped pupil mask + polarizers

What's Missing? ⇔ Who's Missing?

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Extended Source Imaging

Polarimetry

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Community Participation Program – solicitation out this year to bring on a small number of small groups to work with the CGI team to capitalize on whatever capability exists and push our understanding of high contrast imaging and spectroscopy as far as CGI (and funding) allows

What's Missing? ⇔ Who's Missing?

Imaging Spectroscopy

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> If the coronagraph works well, NASA wants the option to make it available for science use after tech demo phase is completed.
>
> This is not something that will be decided until well after launch.
>
> However, some activities/modes (e.g., for calibration) may be worked on so as not to preclude a science phase.

team to capitalize on whatever capability exists and push our understanding of high contrast imaging and spectroscopy as far as CGI (and funding) allows

How **You** can be Involved

Roman Opportunity in 2021

NASA issued a call for proposals in 2021 providing opportunities for the community to begin the major work leading towards Roman's observations.

Not the only opportunity, merely the first, but for coronagraphy it is the only one currently planned.

Broad community announcement in February, with full solicitation coming soon.
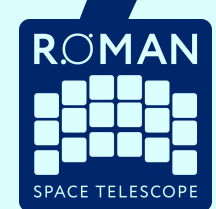
Community Participation Program

Team that will use *Roman*'s Coronagraph Instrument to meet its objectives associated with an in-space technology demonstration of a high-contrast coronagraph.

Opportunity for proposers to work with the coronagraph instrument team to plan and execute its technology demonstration observations.

Proposals accepted only from small groups. PI of each selected investigation, plus coronagraph project & international partner representatives, form the Community Participation Program Team.

Certain focus areas will be identified in the solicitation (things like target/observation prep work; simulations; operation preparation; data analysis tools). Proposers can choose from the list, and can include other areas.

Roman is for *You*

- *All* Roman observing time is available through open processes

- The Coronagraph Community Participation Program Team will be competed soon

- Part of the purpose of "community participation" is to provide a connection between the wider exoplanet community and the coronagraph technology demonstration

- All data will be available to the community with *no period of limited access*

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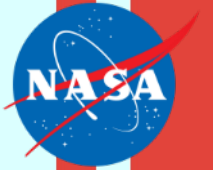
Questions?

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