GPI 2.0



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GPI 2.0 – A Facility-Class High Contrast Imaging System in the North for the 2020s



- ~\$7 Million upgrade project funded by NSF MRI, Heising-Simons Foundation, and NRC
 - PIs Jeff Chilcote (Notre Dame) and Quinn Konopacky (UCSD, also Project Scientist)
 - Co-Is Bruce Macintosh (Stanford) and Dmitry Savransky (Cornell)
 - CAL 2.0 upgrade on a slightly different schedule, led by Christian Marois (NRC-HAA)
- Timeline of baseline upgrade
 - Design work is nearly finalized
 - GPI will be shipped to North America this fall
 - Procurement is mostly finalized, waiting on delivery (COVID delays)
 - Hardware work Fall 2021-2022
 - Back on-sky 2023 at Gemini North





The upgrades of GPI 2.0 are driven by the lessons learned in GPI 1.0 and enabling additional science.









Lesson from GPI 1.0 and other surveys: get closer and fainter to see more planets.



MOST JUPITERS HERE

VERY FEW JUPITERS HERE







Detecting more "cold start" (core accretion formed) planets will required +2 magnitudes of contrast.

Separation (")



ο

1.0

20 0.1 <u>UC San Diego</u>

5

10

15

Contrast





- GPI 2.0 will have the ability to probe very young targets (~1-3 Myr) to search for forming Jupiters and image transition disk structure
- Taurus (~140 pc away) is challenging from the southern hemisphere
- Improved limiting magnitude unlocks >50 targets in Taurus, including ~2 dozen transition disk hosts
- UC San Diego



Additional sensitivity will provide access to new sources, such as nearby AGN

NGC 1068



Gratadour et al. 2015 (SPHERE Polarimetry)

- AO-assisted near-IR
 polarimetry is a potentially
 powerful tool for
 resolving dusty torus,
 outflow structures
- Ability to perform this measurement on an R-mag 14 (or H-mag 12) source will open up 10s of
 potential candidates













New pyramid wavefront sensor design leverages decades of R&D on TMT NFIRAOS.





New pyramid wavefront sensor (PyWFS) design leverages decades of R&D on TMT NFIRAOS.







Carefully designed PyWFS fits in a narrow space envelope on existing GPI AO bench.









Carefully designed PyWFS fits in a narrow space envelope on existing GPI AO bench.











Performance modeling indicates that GPI 2.0 will be able to guide down to I=14.



Of concern is the Gemini North M2 print through, which can significantly lower our contrast





New apodized pupil lyot coronagraphs based on design work done in the last 10 years for space-based platforms.



N'Diaye et al. 2015



New apodized pupil lyot coronagraphs based on design work done in the last 10 years for space-based platforms.





L. Pueyo, M. Nguyen

1.75



2.00

Optimizer design Transmission: 76%



-2

We will add a "low-res" mode – single shot YJHK – which is ideal for enhancing sensitivity.





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GPI Spectral Mode Parameters

Band	Cut-on/-off (μm)	Length (pixels)	$R=\lambda/\Delta\lambda$
y-band	0.95 - 1.07	18.3	76.9
J-band	1.13 - 1.34	19.4	57.0
H-band	1.498 - 1.796	16.8	46.5
K-band	2.00 - 2.40	20.0	55.1
1-2.4 mode	0.97 - 2.4	20.0	11.8





Major software updates are part of the upgrade.



- Real time controller HEART algorithm from HAA
 - Also being used for GNAO, so will offer the opportunity for uniform tools at the observatory
- "One button" operations
 - Software upgrades, updates, and fixes to enable easy operation for any observer
 - This will increase the execution of GPI queue programs





CAL 2.0 Upgrade

Vibrations prevent the current HOWFS from working.

Replace the dual-arm interferometer (HOWFS) by a common-path interferometer (a.k.a. Self-Coherence Camera) more robust to vibration. This requires a new Focal Plane Mask (FPM).

Expected star/planet contrast gain up to 100x

Pupil Pupil Apodizer / Apodizer FPM (APLC) FPM (TG) Light Light from LOWFS from OWFS GPI AO GPI AO (only for old APLC) Lyot Stop + Pinhole HOWFS Sci arm Sci arm Lyot Stop Lyot Stop SCC Ref arm #S *S LOWFE GPI CAL1.0 GPI CAL2.0

CAL2 will use a FAST SCC FPM (see Gerard 2019 and related papers)

PI: Christian Marois, NRC, Canada

Coll: NRC, UVic, OMP, UofT, UCSC, Cornell, Laval, Gemini & GPI team









Original GPI CAL system

NRC GPI CAL2 upgrade





WiP CAL2 optical design

- CAL2 narrowband images could be used for science.
- Kickoff meeting mid October 2021, @Gemini North late 2024.









- GPI has been a scientifically productive instrument on Gemini South that has revealed fundamental properties of planet formation and evolution
- With GPI 2.0 on Gemini North, new, transformative scientific potential will be realized
- GPI 2.0 will offer a technology testbed for the next generation of high contrast imagers being planned for the ELTs

