

ExoPAG 7 Introduction and Motivation.

ExoPAG 7 Meeting
Long Beach, CA
January 5+6, 2012
Scott Gaudi

Charter, revisited.

In June 2009, NASA formed the *Exoplanet Exploration Program Analysis Group* (ExoPAG), responsible for soliciting and coordinating community input into the development and execution of NASA's Exoplanet Exploration Program (ExEP). The ExoPAG serves as a community-based, interdisciplinary forum for analysis in support of activity prioritization and for future exploration.

- Articulate the key scientific drivers for exoplanet research.
- Evaluate the expected capabilities of potential ExEP missions for achieving the science goals of the program.
- Evaluate ExEP goals, objectives, investigations, and required measurements on the basis of the widest possible community outreach.
- Articulate focus areas for needed mission technologies.
- Identify related activities that enhance the ExEP mission portfolio such as ground-based observing, theory and modeling programs, and community engagement.

Past Activities.

- EC chaired by Jim Kasting up until June 2012.
- The ExoPAG has had 6 meetings and one joint CoPAG/ExoPAG meeting since January 2010.
- The primary (but not only!) topic of discussion has been planning for a future flagship-class direct imaging mission.
 - Technology development for the New Worlds program was the highest medium-class priority listed in the NWNH report.
 - Joint meetings/discussions with **COPAG** about a large optical/UV space telescope.

New Direction.

- In response to exoplanet community input, and new budget realities, the ExoPAG EC has revised its focus.
- Current and future ExoPAG EC activities aim to:
 - Expand the inclusiveness of NASA's Exoplanet Exploration Program to the wider exoplanet community, beyond the past focus on future flagship missions in space.
 - Consider novel ways in which NASA can address and advance exoplanet research in the short term.
 - This includes ground-based research *in support* of current or future missions.
 - Do this in time for mid-decadal review!
- Does *not* mean we should lose sight of the eventual goal of a flagship direct imaging mission.
 - Progress toward this goal must remain a priority!

New EC Membership.

- As of June 2012: new EC members.

Scott Gaudi (<i>Chair</i>)	Ohio State
Aki Roberge	NASA Goddard
Tom Greene	NASA Ames
Charley Noecker	JPL
Lisa Kaltenegger	MPIA
Alycia Weinberger	Carnegie Institute
Dave Latham	Harvard Smithsonian
Peter Plavchan	Caltech/NexSci
Remi Soummer	Space Telescope Sci. Inst.
Jonathan Fortney	U.C. Santa Cruz
Wes Traub (<i>Ex officio</i>)	JPL
Doug Hudgins (<i>Ex officio</i>)	Headquarters
James Kasting (<i>Ex officio</i>)	Penn State

Science of Exoplanets.

- Finding and characterizing a ‘pale blue dot’ remains a long-term goal.
- But there are many other exoplanet science questions that NASA can and should address in the interim.
- Many of these will likely bear directly on our understanding of habitable worlds.
- Let’s take a step back: what are the ‘big’ science questions in exoplanets?

**Secular evolution
Water delivery
Instability
Impacts**

Physics of Planet Formation and Evolution

Physics, Frequency, Evolution of Habitability

Physics of Planetary Atmospheres and Interiors

Protoplanetary and Debris Disk Observations

Theory

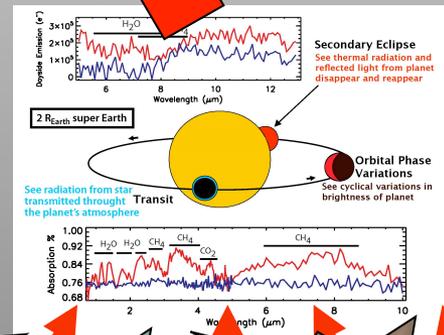
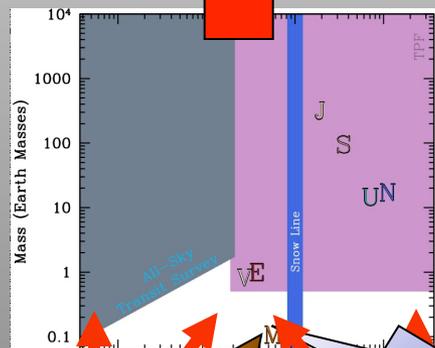
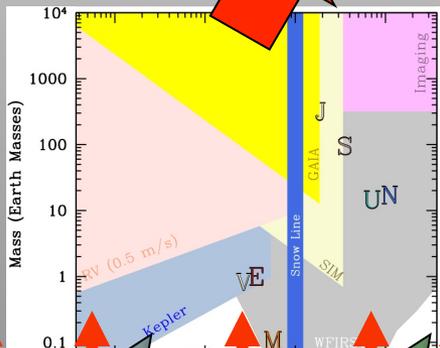
Demographics

Planet mass/radius/spin	Stellar environment
Semimajor axis, period, eccentricity, alignments	Rare & unique systems
Host star mass, luminosity, abundances, age	Free floating planets
Host star binarity	System multiplicity, coplanarity, architecture
Giants, subdwarfs, remnants	

Characteristics

Mass/Radii	Emission/Transmission Spectra
Phase Curves	Variability
Rotation rates	Magnetic Fields
Internal Structure	Atmospheric Velocities
Satellites/Rings	Atmospheric escape

Coupled Demographics and Characteristics

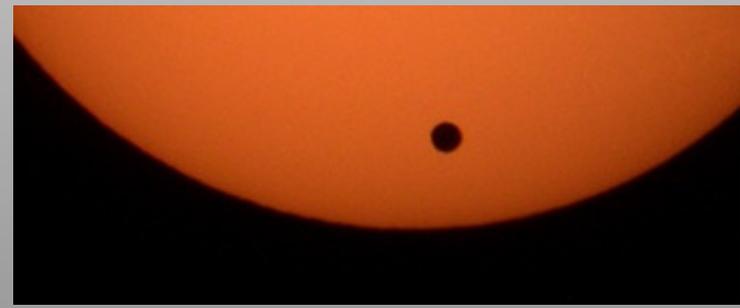


Habitable Planets

	High Mass ($>0.5M_{\text{Sun}}$) ★s		Low Mass ($<0.5M_{\text{Sun}}$) ★s	
	Frequency	Habitability	Frequency	Habitability
Current	Kepler	-	RV MEarth	-
Future	RV? WFIRST/AFTA?	RV? Astrometry? ↓? Direct Imaging Mission?	TESS PLATO?	MEarth TESS PLATO? ↓ JWST NGELTs?



“Pale Blue Dot”



“Small Black Shadow”

A Short Term Strategy.

- So what can NASA do to advance these exoplanet science goals in the next ~10-15 years, given constraints?
- Constraints:
 - JWST
 - No new large starts until JWST is launched.
 - Explorer program going forward.
- Given these, how can NASA make progress on:
 - Demographics?
 - Characterization?
 - Nearby habitable planets?

Future of the ExoPAG.

- Goal: develop a short term strategy with community involvement.
- Developing a coherent, unified strategy within the exoplanet community is an imperative (IMHO).
- Study analysis groups (SAGs):
 - Exozodiacal Dust – Roberge et al. 2012, PASP, 124, 799.
 - Exoplanet Characterization - Kaltenegger.
 - Flagship mission requirements – Noecker, Greene.
 - Precision RV: requirements, resources – Plavchan, Latham.
 - “Medium scale” mission science goals – Noecker, Greene.
- Future SAGs
 - Requirements for host star properties?
 - Others?

ExoPAG 6.

- October 13+14, Reno, NV
 - Coincident with the 44th DPS Meeting.
- First meeting with this broader focus in mind.
- Questions addressed:
 - What is the landscape of current and future missions?
 - Kepler, JWST, WFIRST, NRO, medium-scale direct imaging.
 - What do we need to characterize exoplanets?
 - Mini-workshop on exoplanet characterization.
 - What is the current and future role of precision RV for exoplanet detection?
 - Mini-workshop on the future of PRV.
- Talks available online:

<http://exep.jpl.nasa.gov/exopag/exopag6/agenda/>

Goals of ExoPAG 7.

- Second meeting with this broader focus in mind.
 - Continue to gather broad community input.
- Address the questions:
 - What is the landscape of current and future instruments and missions?
 - What do we need to characterize host stars?
 - What is the future role of precision RV for exoplanet detection?
 - What are the priorities for the next decade in exoplanets?
 - In particular, what is needed to support NASA goals?
- What additional questions we should be addressing?
- Agenda suggestions for ExoPAG 8 are requested!

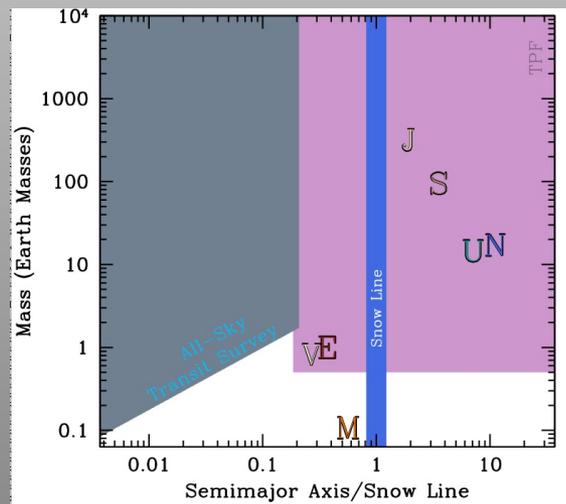
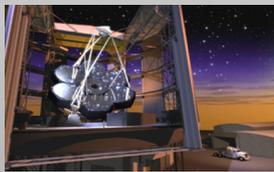
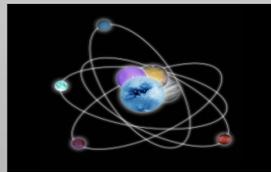
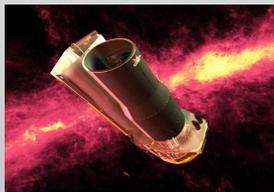
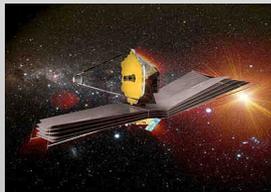
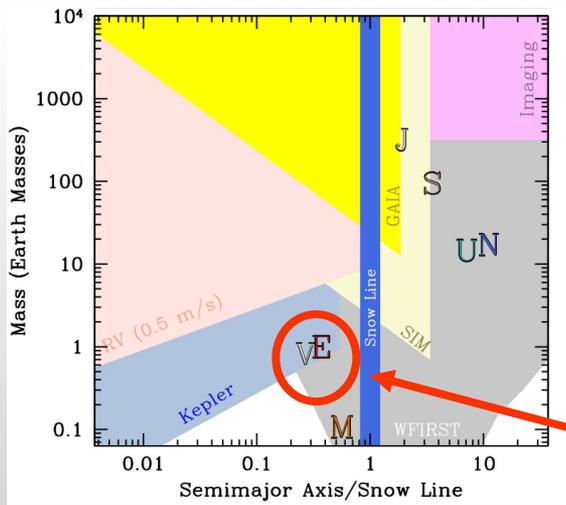
Welcome, and
thanks!

Demographics+Characterization

- Demographics:
 - Need to understand what's out there!
 - Kepler (only half of the story)
 - Euclid?
 - WFIRST/NRO?
- Characterization (bright stars)
 - Need to understand the stars themselves
 - Disks, ages, distances, abundances, etc.
 - Precision RV
 - Outer planets
 - Pushing to <10 cm/s – technology development
 - Near-IR RV
 - Ground based (current LTs -> NGELTs)
 - Direct imaging
 - Characterization
 - Explorer-class characterization mission (e.g., FINESSE)

Habitable Planets

- Nearby habitable planets
 - Remains the ultimate goal
 - But a flagship mission is a ways off
- Make progress where we can!
 - Now: MEarth/near-IR RV
 - Soon: TESS/PLATO? + JWST
- Be prepared
 - Technology development
- “Medium-class” mission?
 - Technology demonstration
 - Science yield
 - NRO coronagraph?



Demographics

Current	Future
RV Surveys	Ultra-Precise RV Surveys?
Ground-based μ lensing	GAIA
Kepler	Precision astrometry?
...	WFIRST

Potentially Habitable Planets
nadir of detection sensitivity

Characteristics

Current	Future
Ground-based Transit Surveys	NGELTs
Ground-based Follow-Up	JWST
Spitzer	ECHO/FINESSE
HST	...

Demographics + Characteristics

Current	Future
Ground-Based Direct Imaging	PLATO/TESS
...	JWST/EXCEDE
	Direct Imaging Missions

General Inquiry Areas.

- Physics of Planet Formation and Evolution.
- Physics of Planetary Atmospheres and Interiors.
- Physics, Frequency, and Evolution of Habitability.