

ExoPAG 6 Introduction and Motivation.

ExoPAG 6 Meeting
October 13, 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 5 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 EC Membership.

- As of June 2012: new EC members.

Scott Gaudi (*Chair*)

Aki Roberge

Tom Greene

Charley Noecker

Lisa Kaltenegger

Alycia Weinberger

Dave Latham

Peter Plavchan

Remi Soummer

Jonathan Fortney

Wes Traub (*Ex officio*)

Doug Hudgins (*Ex officio*)

James Kasting (*Ex officio*)

Ohio State

NASA Goddard

NASA Ames

JPL

MPIA

Carnegie Institute

Harvard Smithsonian

Caltech/NexSci

Space Telescope Sci. Inst.

U.C. Santa Cruz

JPL

Headquarters

Penn State

New Direction.

- In response to exoplanet community input, and new budget realities, the ExoPAG EC will revise its focus.
- Future ExoPAG EC activities will 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 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.

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?

General Inquiry Areas.

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

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

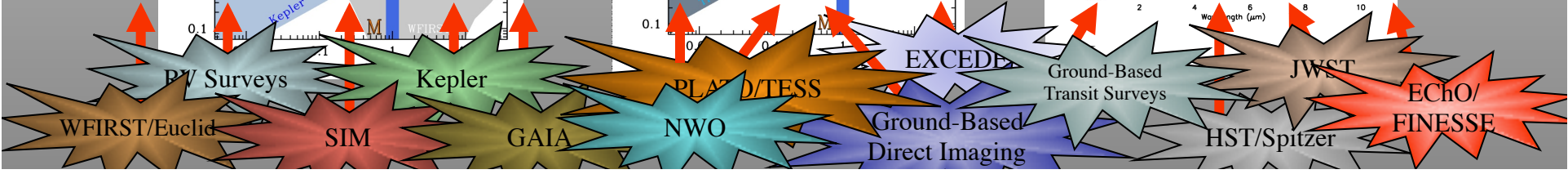
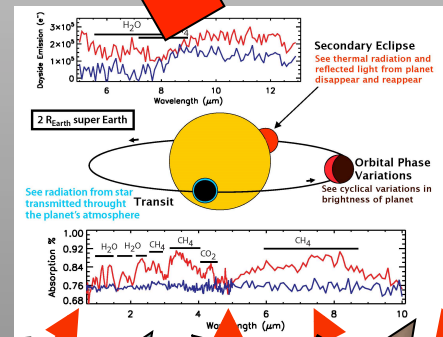
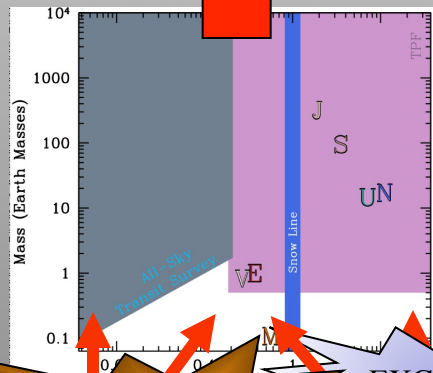
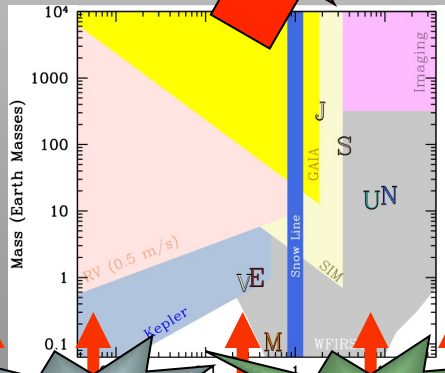
Demographics

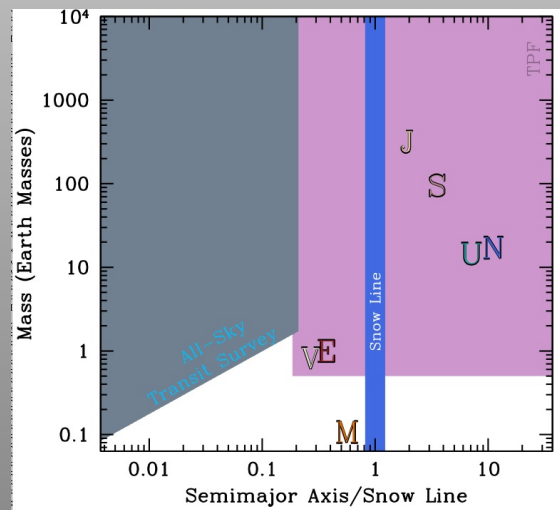
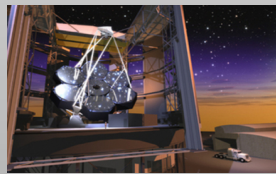
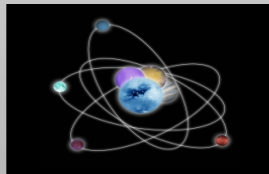
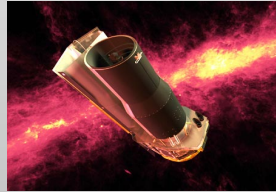
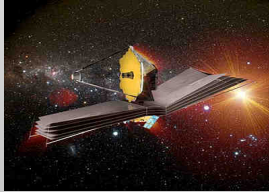
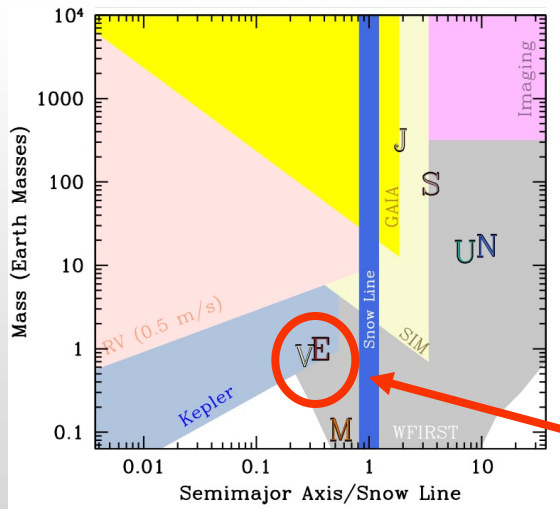
Characteristics

Coupled Demographics and Characteristics

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	

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





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
...	EXCEDE
	Direct Imaging Mission

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?	RV? Astrometry? ↓? Direct Imaging Mission?	TESS PLATO?	MEarth TESS PLATO? ↓ JWST NGELTs?



“Pale Blue Dot”



“Small Black Shadow”

“The Question.”

- 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. (arXiv:1204.0025)
 - Exoplanet Characterization – Kaltenegger
 - Flagship mission requirements – Noecker, Greene
 - Precision RV: requirements, resources – Latham, Plavchan
- Future SAGs?
 - “Medium scale” mission science goals
 - Requirements for host star properties
 - Others?

Goals of ExoPAG 6.

- Address the questions:
 - What is the landscape of current and future missions?
 - What do we need to characterize exoplanets?
 - What is the current and future role of precision RV for exoplanet detection?
 - In particular, what is needed to support NASA goals?
- Determine what additional questions we should be addressing.
- Agenda suggestions for ExoPAG 7 & 8 are requested!

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 \rightarrow 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?