Cosmic Origins Program Analysis Group (COPAG)

Astrophysics Subcommittee Meeting

March 17, 2015

Kenneth Sembach

Current COPAG Executive Committee Membership

Name	Institution	Term Expiration
Daniela Calzetti	U. Mass. Amherst	Jan 2017
Dennis Ebbets	Ball Aerospace (retired)	Jan 2017
James Green	U. Colorado	Jan 2017
Matthew Greenhouse	NASA GSFC	Jan 2018
James Lowenthal	Smith College	Rotating off Mar 2015
Sally Heap	NASA GSFC	Jan 2017
Lynne Hillenbrand	Caltech	Oct 2015
Mary Beth Kaiser	Johns Hopkins U.	Oct 2017
Joseph Lazio	NASA JPL	Oct 2017
Pamela Marcum	NASA ARC	Oct 2017
Ken Sembach - Chair	STScI	Mar 2016

10 members + ex-officio (S. Neff & D. Padgett in COR office, M. Perez & M. Garcia at HQ)

Active Science Analysis Groups

- SAG #8: Cosmic Origins Science Enabled by the WFIRST-AFTA Data Archive
  - COPAG Lead: Sally Heap
  - Work in progress, report expected at October 2015 meeting
  - Summary here, more details in Backup Slides (slides 20-34)
- SAG #9: Science Enabled by Spitzer Observations Prior to JWST
  - COPAG Lead: Daniela Calzetti
  - Excellent progress, draft report completed
  - Final report expected at the July 2015 meeting
  - Summary here, more details in Backup Slides (slides 36-47)

SAG #8 Update (1/3): Cosmic Origins Science Enabled by the WFIRST-AFTA Data Archive

How do you find what *you* want?
The answer is here … somewhere

WFIRST-AFTA deep field reaches >1,000,000 galaxies in each image

SAG #8 Update (2/3): Cosmic Origins Science Enabled by the WFIRST-AFTA Data Archive

- Collecting input and use cases from the community
- Organizing that input into queries (similar to SDSS)
  - Ex: Find all stars brighter than J~25 whose WFIRST+WISE colors are consistent with an L or T brown dwarf
  - Ex: Find all galaxies in clusters at z~0.5-1.5 in which >0.5-mag flux variations were detected
  - Ex: Find all elliptical z>1 galaxies whose spectra show an anomalous emission line
- Common themes are being identified and findings drafted

SAG #8 Update (3/3): Cosmic Origins Science Enabled by the WFIRST-AFTA Data Archive

- To accommodate Cosmic Origins users, the WFIRST data processing system must include Levels 1, 2, *and* 3
  - Level 1: data capture, error checking, formatting, etc.
  - Level 2: data reduction, flux and wavelength calibration, etc.
  - Level 3: object classification (Galaxy, Star, QSO, KBO, variables, etc.), measurements (mag, colors, morphology, redshifts, sizes, shapes, morphological parameters, environmental parameters)
- NASA Astrophysics Division has traditionally supported Level 1 and 2 data processing, but not level 3
- The usefulness of the WFIRST Archives for Cosmic Origins science would be increased greatly with access to Level-3 science products

SAG #9 Update (1/2): Science Enabled by Spitzer Observations Prior to JWST

- Activities and input have been grouped by science topic
  - Galaxy Evolution and Cosmology
  - Nearby Galaxies
  - Milky Way (incl. Evolved Stars, etc.)
  - Extra-solar Planets
  - Solar System
- Leads for each science topic are assigned and active
- Good cross-section of participants, including Spitzer and JWST personnel
- Key questions/topics identified for each science area

SAG #9 Update (2/2): Science Enabled by Spitzer Observations Prior to JWST

- Community inputs are being solicited in a variety of ways
  - Mail exploders (COPAG, Spitzer Users, DPS members, and the Planetary Exploration Newsletter)
  - Presentations at science meetings (Winter 2015 AAS Meeting, January 4th, 2015; SBAG winter meeting, January 6th, 2015)
  - General input through email (copag.sag9@gmail.com)
  - Community members have been encouraged to contact individual SAG #9 members.

Active Science Interest Groups

- SIG #1: Far-Infrared Cosmic Origins Science and Technology Development
  - COPAG Lead: Pamela Marcum (EC member)
  - External Leads: David Leisawitz / Paul Goldsmith
  - Status report here

- SIG #2: Ultraviolet-Visible Cosmic Origins Space-Based Science and Technology Development
  - External Lead: Paul Scowen (former EC member)
  - Status report here

SIG #1 Update (1/2): Far-Infrared Cosmic Origins Science and Technology Development

- The SIG met on January 4, 2015 in Seattle, and focused on preparing the community to respond to the newly released HQ white paper calling for input on large missions. Eight presentations were given (next slide).
- Planning is underway for the next far-IR community workshop
  - *Objective is to reach consensus and present a coordinated response to the COPAG regarding the "Far-IR Surveyor" mission*
  - 3 – 5 June 2015, on the Caltech campus
  - The workshop has been widely advertised
  - Core group of 9 organizers, recently invited additional co-organizers
- Mini-studies of alternative far-IR mission concepts are underway at GSFC and JPL, building on past studies of SPIRIT (interferometer) and CALISTO (cold single aperture telescope) in preparation for discussion at the workshop. A warm telescope heterodyne-only mission is also under study at JPL.

SIG #1 Update (2/2): Far-Infrared Cosmic Origins Science and Technology Development

Seattle SIG Meeting Presentations (http://cor.gsfc.nasa.gov/copag/aas_jan2015/)

- Dave Leisawitz (NASA GSFC) – The "FIR Surveyor" in NASA's Astrophysics Roadmap, May 2014 community workshop summary and followup study
- Paul Goldsmith (Caltech JPL) – Single-aperture Far-IR Telescopes: Measurement Capabilities and Trade Space
- Dave Leisawitz (NASA GSFC) – Far-IR Interferometers: Measurement Capabilities and Trade Space
- Maxime Rizzo (Univ. of Maryland) – The Balloon Experimental Twin Telescope for Infrared Interferometry (BETTII)
- Matt Bradford (Caltech JPL) – Status and plans for the Space Infrared Telescope for Cosmology and Astrophysics (SPICA) mission
- Erick Young (USRA) – The upGREAT instrument on SOFIA
- Imran Mehdi (Caltech JPL) – Advanced Technologies for Future Heterodyne Missions
- Chris Walker (Univ. Arizona) – The Stratospheric Terahertz Observatory (STO) and the Galactic / Extragalactic ULDB Spectroscopic / Stratospheric Terahertz Observatory (GUSTO)

SIG #2 Update (1/3): UV/Visible Cosmic Origins Space-Based Science and Technology Development

- Initial call to community went out December 4, 2014
- Targeted participants:
  - Authors and co-authors who responded to the COPAG RFI issued in 2012 on the future of UV-visible science
  - Technologists who contributed UV-visible technology and science-driven development at the 2014 SPIE Astronomical Technology meeting in Montreal
  - COPAG membership through a call from the COR office
- Recruited 79 scientists and 40 technologists from this process, from about a dozen countries, academia, and government labs

SIG #2 Update (2/3): UV/Visible Cosmic Origins Space-Based Science and Technology Development

- Initial face-to-face meeting at the AAS Seattle on Jan. 4, 2015
- Very well attended in person (full room) and by phone
- Conducted summary discussions of both current science interests and technology development in the UV-visible to bring each side of the SIG "up to speed"
- One focus of the SIG is to better interface the science and technology worlds to enable better science and direct technological development

SIG #2 Update (3/3): UV/Visible Cosmic Origins Space-Based Science and Technology Development

- Action items from the first meeting included:
  - Analysis of what a possible Flagship UVOIR mission could mean for the field – which dovetails with Paul Hertz's charge to the PAGs
  - Consideration of what range of science can be done from a spectrum of smaller missions that can be done on a shorter development timeframe
  - Study of the interplay and prioritization between Cosmic Origins and Exoplanet science drivers for possible Flagship mission definition
  - The need for coherent technology development roadmaps with an inclusive focus on workforce development and efforts to avoid losing national capabilities
  - Definition of a science portfolio for the UV-visible that would attract community participation and foster support for future large-scale investments
- Subcommittees are being formed to address all these issues
- The Flagship analysis is being fast-tracked to respond to Paul Hertz's call before the summer – a possible virtual workshop may happen soon

Request to start SIG #3: Cosmic Dawn Science

- Provide a community forum for discussion of Cosmic Dawn science
- Identify a compelling suite of science cases to provide programmatic focal points that would justify investments in next generation space-based missions or facilities
- Consider what is needed for a long-term technology roadmap, which has not yet been discussed widely within the community
- SIG activities are expected to occur over an extended period of time
  - Results reported at periodic intervals (quarterly or semi-annually) to the COPAG Executive Committee and the Astrophysics Subcommittee
  - Similar activities being done with the Far-IR and UV/Optical SIGs
  - Chaired by Joe Lazio (COPAG EC member)
  - SIG charter is given in Backup Slides (slide 49)

Recent Community Meetings

- January 2015 AAS meeting in Seattle
  - SAG and SIG splinter sessions followed by joint PAG session (Sunday, January 4)
  - COPAG lunch with Paul Hertz (Sunday, January 4)
  - PAG special session (Wednesday , January 7)

- November 2014 WFIRST science workshop in Pasadena
  - SAG #6 (coronagraph) - Dennis Ebbets
  - SAG #8 (archive) - Sally Heap

Responding to the Charge: Preparing for the 2020 Decadal Survey

- Bi-weekly COPAG telecons
- Joint PAG Executive Committee telecon on February 24
  - Began cross-PAG discussions of approach to responses, cooperation
- COPAG call for white papers released on March 2
- COPAG virtual town hall on March 10
  - Outlined charge from Paul Hertz and COPAG call for white papers
  - Explained what COPAG will / will not do in response to charge
  - Questions / clarifications
  - 60-70 attendees via webex, 40-50 attendees on the phone
  - Charts are appended in Backup Slides (slides 51-62)
  - A second VTH is planned for May 2015 to discuss community inputs
- Joint PAG Executive Committee meeting at STScI on March 19
  - Agenda topics on next page
  - Webex available for offsite EC / Program Office / HQ personnel

Agenda topics for Joint PAG EC Meeting on March 19

- PAG Activity Updates
  - Status of PAG responses to charge
  - Suggestions/rationale for additional missions

- Discussion Session 1
  - Science / technology synergies for missions under consideration
  - Identification of joint PAG activities
  - Sharing of information (inputs, white papers, etc)
  - Meetings (HEAD, ExoPAG 12, Far-IR Workshop, others?)
  - IAU plans

- Discussion Session 2
  - Schedule for final report(s) to ApS
  - Sharing of draft reports
  - Scope of (what to include in) final report(s) for ApS
  - What to do (if anything) about probe-scale missions
  - Structure of recommendations

Backup Slides
SAG #8 Report
(Slide set from January 2015 AAS)

SAG#8: Cosmic Origins Science Enabled by the WFIRST-AFTA Data Archive

Sally Heap & the SAG#8 Team

SAG#8 Charter

How will the WFIRST-AFTA data archive be used for Cosmic Origins science?

- Cross-section of COR science investigations
- High-level science data products
- Catalogs
- Archive interface design
- Calibration requirements
- Data accessibility & distribution
- Computing resources
- Archive operations

What are the data requirements needed to conduct COR science?

How to maximize the return via coordination with other astronomical archives?

Partial Inventory of Objects to be Observed by WFIRST

High Latitude Surveys

- 400M galaxies with measured shapes
- 30M galaxies in redshift survey
- 20M Hα galaxies at z=1-2
- 2M [O III] galaxies at z=2-3
- 10^5 galaxies at z≥7.5 brighter than 26 mag
- 40K massive galaxy clusters
- 2700 SN Ia at z=0.1-1.7

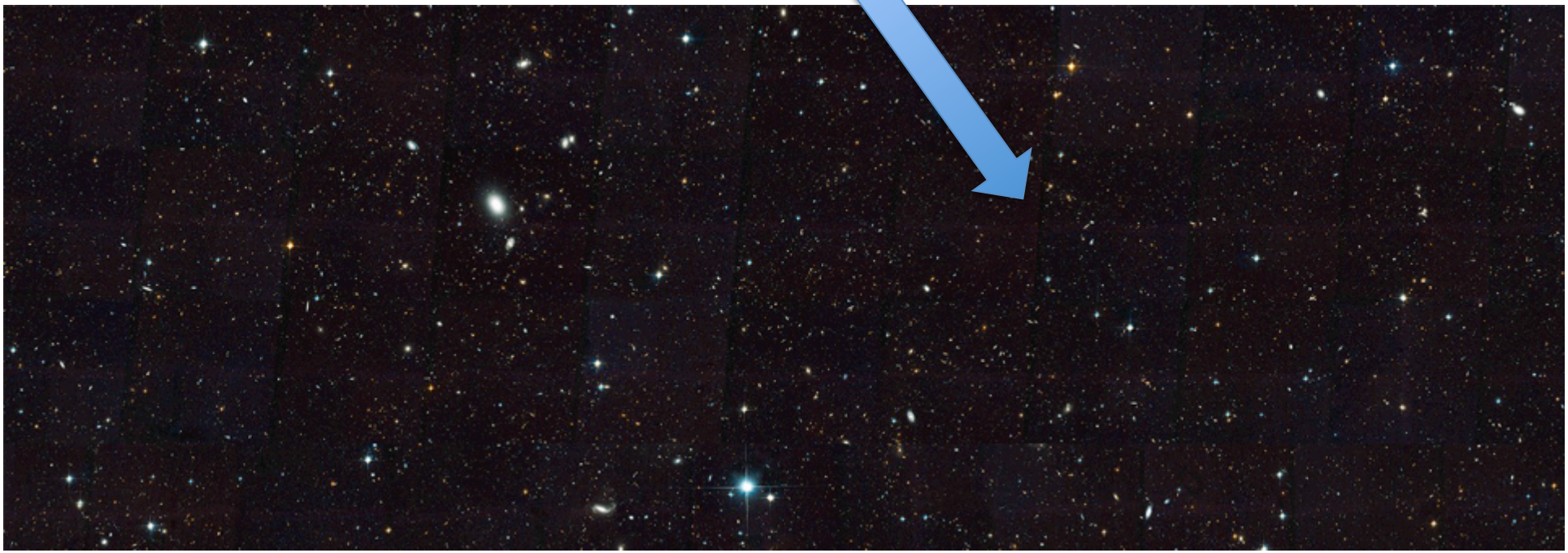
Microlensing Survey

- $2x10^8$ stars in galactic bulge (~40,000 obs. per star)
- 3000 planets; 300 with $M \leq M_{\oplus}$
- 10^5 transiting planets
- 5000 KBO's down to 10 km with orbits

WFIRST-AFTA SDT Interim Report, April 2014

The answer is here …somewhere

WFIRST-AFTA SDT Interim Report, p. 16



WFIRST-AFTA Deep Field reaches >1,000,000 galaxies in each image

How to find what *you* want?

Developing Query System to the WFIRST Archives

WFIRST SDT Reports + 1-Page Science Ideas

WFIRST-AFTA SDT Final Report, May 24, 2013 including Appendix A: 1-page science ideas

WFIRST-AFTA SDT Interim Report, Apr 30, 2014

\+ Typical Queries of the SDSS Archive

Designing & Mining Multi-TB Ast. Archives: SDSS Szalay et al. (2000) Proc. ACM SIGMOD 2000, p. 451

= Typical Queries of the WFIRST Archive

Cosmic Origins scientists have told us how they want to use the WFIRST archives

WFIRST Sample Queries*

- Microlensing Field (Z087, W149) – COPAG queries

- *ML1: Find all microlensing events of stars in the galactic bulge in which the apparent position of the lens shifted by a measurable amount during the microlensing event. (Sahu, A-18).* This is a search for neutron stars and stellar-mass black holes in the Galaxy.
- *ML2: Provide a complete database of the fluxes, positions, proper motions and parallaxes of all bulge and disk stars (~10^8 stars) in microlensing survey of the galactic bulge. (Gaudi, A-19)*
- *ML3: Provide a list of all bulge stars showing evidence of having a transiting planet(s). (IR-53,57)*
- *ML4: Find all KBO's (Gould 2014, IR-57)*
- *ML5: Find all objects whose absolute magnitudes and colors are consistent with blue stragglers /red giants / white dwarfs / <keyword>. (31Oct14 WFIRST SDT telecon)*

- All queries inspired by references; not direct quotes
- References: author of 1-page science idea; Appendix A, page #

WFIRST Sample Queries*

- High latitude imaging (~R, Y, J, H, F184)

Find all stars brighter than J~25 whose WFIRST+WISE colors are consistent with an L or T brown dwarf (Tanner, A-12)

Find all galaxies showing double nuclei (Conselice, A-32)

Find all galaxies whose LSST + WFIRST SED's indicate a $z_{phot}>7$

WFIRST Sample Queries

- High-latitude spectra (1.35-1.95 μm)

Find all elliptical z>1 galaxies whose spectra show an anomalous emission line (Szalay, Q11)

Find all z>1 galaxies observed by both WFIRST and Euclid (0.9-2.0 μm) having Hα and [O III] emission lines (Scarlata, A-47).

- Supernovae

Find all galaxies in clusters at z~0.5-1.5 in which >0.5-mag flux variations were detected

The 20 Queries around which the SDSS SkyServer was built

Q1: Find all galaxies without unsaturated pixels within 1' of a given point of ra=75.327, dec=21.023

Q2: Find all galaxies with blue surface brightness between and 23 and 25 mag per square arcseconds, and -10<super galactic latitude (sgb) <10, and declination less than zero.

Q3: Find all galaxies brighter than magnitude 22, where the local extinction is >0.75.

Q4: Find galaxies with an isophotal surface brightness (SB) larger than 24 in the red band, with an ellipticity>0.5, and with the major axis of the ellipse having a declination of between 30" and 60"arc seconds.

Q5: Find all galaxies with a deVaucouleours profile ($r^{¼}$ falloff of intensity on disk) and the photometric colors consistent with an elliptical galaxy. The deVaucouleours profile

Q6: Find galaxies that are blended with a star, output the deblended galaxy magnitudes.

Q7: Provide a list of star-like objects that are 1% rare.

Q8: Find all objects with unclassified spectra.

Q9: Find quasars with a line width >2000 km/s and 2.5<redshift<2.7.

Q10: Find galaxies with spectra that have an equivalent width in Ha >40Å (Ha is the main hydrogen spectral line.)

Q11: Find all elliptical galaxies with spectra that have an anomalous emission line.

Q12: Create a grided count of galaxies with u-g>1 and r<21.5 over 60<declination<70, and 200<right ascension<210, on a grid of 2', and create a map of masks over the same grid.

Q13: Create a count of galaxies for each of the HTM triangles which satisfy a certain color cut, like 0.7u-0.5g-0.2i<1.25 && r<21.75, output it in a form adequate for visualization.

Q14: Find stars with multiple measurements and have magnitude variations >0.1. Scan for stars that have a secondary object (observed at a different time) and compare their magnitudes.

Q15: Provide a list of moving objects consistent with an asteroid.

Q16: Find all objects similar to the colors of a quasar at 5.5<redshift<6.5.

Q17: Find binary stars where at least one of them has the colors of a white dwarf.

Q18: Find all objects within 30 arcseconds of one another that have very similar colors: that is where the color ratios u-g, g-r, r-I are less than 0.05m.

Q19: Find quasars with a broad absorption line in their spectra and at least one galaxy within 10 arcseconds. Return both the quasars and the galaxies.

Q20: For each galaxy in the BCG data set (brightest color galaxy), in 160<right ascension<170, -25<declination<35 count of galaxies within 30"of it that have a photoz within 0.05 of that galaxy.

Szalay's 20 questions were implemented as SQL queries of the SDSS archive

http://cas.sdss.org/dr4/en/help/docs/realquery.asp

"Click on the name of the query from the list below to go directly to that sample query. The queries are roughly in order of increasing complexity. You can cut and paste queries from here into your favorite search tool".

Basic SQL:
Basic SELECT-FROM-WHERE
Basic position search
Using PhotoTag
Search for a Range of Values
Rectangular position search
More than one table: JOIN...ON
Photometry & spectroscopy
Counting by type or category
Using flags

SQL Jujitsu:
Data subsample
Objects in close pairs
Selected neighbors in run
Object counts and logic
Repeated high-z objects
Splitting 64-bit values
Using LEFT OUTER JOIN
Using Nested Queries

Quasars:
QSOs by spectroscopy
QSOs by colors
FIRST matches for quasars

General Astronomy:
Only stars or galaxies
Clean photometry
Using Field MJD
Objects by spectral lines
Spectra by classification
Moving asteroids
Plates with repeat spectra
Galaxies blended with stars
Counts by type and program
Checking SDSS footprint

Stars:
Clean photometry - Stars
CVs using colors
Binary stars colors
Using sppLines table
Using sppParams table
Proper motions

Miscellaneous:
Photometric Redshifts
Spectra in Other Programs - I
Spectra in Other Programs - II
Using WISE Cross-Match

Galaxies:
Clean photometry - Galaxies
Galaxies with blue centers
Diameter limited sample
LRG sample selection
Galaxy counts on HTM grid
Classifications from Galaxy Zoo
BOSS target selection
BOSS Stellar Masses
BOSS Stellar Vel. Disps.

Varaibility Queries:
Stars multiply measured
Multiple Detections and Time Series

APOGEE:
All APOGEE Plate Visits
ASPCAP Parameters and Errors
APOGEE Stars No BAD Flags
ASPCAP Params for Cluster Mbrs
APOGEE Proper Motions
APOGEE Stars Near Cluster Ctr
RVs for Individual APOGEE Visits
APOGEE and SEGUE Spectra
SDSS photometry for APOGEE Stars

Sample Query

Query written
In SQL

Query contributed
by user

Galaxies with blue centers Top

```
-- Galaxies with bluer centers, by Michael Strauss. For all galaxies with r_Petro < 18,
-- not saturated, not bright, and not edge, give me those with centers appreciably bluer
-- than their outer parts, i.e., define the center color as: u_psf - g_psf and define
-- the outer color as: u_model - g_model; give me all objs which have
--     (u_model - g_model) - (u_psf - g_psf) < -0.4
--
-- Another flags-based query.
-- NOTE: This query takes a long time to run without the "TOP 1000".

SELECT
colc_u, colc_g, objID
FROM Galaxy
WHERE
( flags & (dbo.fPhotoFlags('SATURATED') +
dbo.fPhotoFlags('BRIGHT') +
dbo.fPhotoFlags('EDGE')) ) = 0
and petroRad_r < 18
and ((colc_u - colc_g) - (psfMag_u - psfMag_g)) < -0.4
```

Q19: Find quasars with a broad absorption line in their spectra and at least one galaxy within 10 arcseconds. Return both the quasars and the galaxies.

QSO broadlines near galaxy

Top

```
-- Find quasars with a broad absorption line and a nearby galaxy within 10arcsec.
-- Return both the quasars and the galaxies.

SELECT Q.BestObjID as Quasar_candidate_ID , G.ObjID as Galaxy_ID, N.distance
FROM SpecObj as Q, -- Q is the specObj of the quasar candidate
     Neighbors as N, -- N is the Neighbors list of Q
     Galaxy as G, -- G is the nearby galaxy
     SpecClass as SC, -- Spec Class
     SpecLine as L, -- L is the broad line we are looking for
     SpecLineNames as LN -- Line Name
WHERE Q.SpecClass =SC.value -- Q is a QSO
     and SC.name in ('QSO', 'HIZ_QSO') -- Spectrum says "QSO"
     and Q.SpecObjID = L.SpecObjID -- L is a spectral line of Q.
     and L.LineID = LN.value -- line found and
     and LN.Name != 'UNKNOWN' -- not not identified
     and L.ew < -10 -- but its a prominent absorption line
     and Q.BestObjID = N.ObjID -- N is a neighbor record
     and G.ObjID = N.NeighborObjID -- G is a neighbor of Q
     and N.distance < 10.0/60 -- and it is within 10 arcseconds of the Q.
```

Conclusions & Recommendations

To accommodate Cosmic Origins users, the WFIRST data processing system must include Levels 1, 2, *and* 3

- Level 1 ~ data capture, error checking, formatting, etc.
- Level 2 ~ data reduction and flux & wavelength calibration, etc.
- Level 3 ~ object classification (Gal, Star, QSO, KBO, variables, etc), & measurements (mag, colors, morphology, redshifts, sizes, shapes, morphological parameters, environmental parameters, etc.)

NASA Astrophysics Division has traditionally supported Level 1 and 2 data processing, but not level 3

The usefulness of the WFIRST Archives to Cosmic Origins scientists depends on having access to Level-3 data

Make it better

Get the full list of 40+ queries for WFIRST archives

Send suggestions and criticisms to:

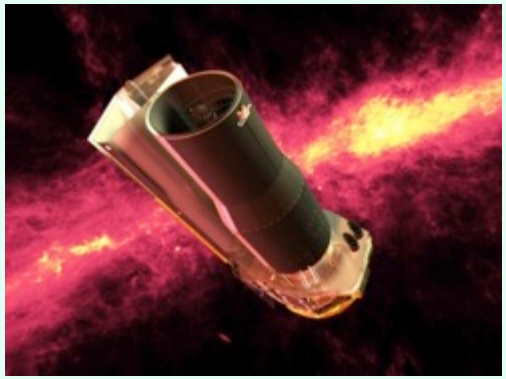
Sally.Heap@NASA.gov

Better yet, join the COPAG and participate in the Science Analysis Group #8

We need your help

Backup Slides
SAG #9 Report
(Prepared for the ApS)

COPAG/SAG 9:
Science Enabled by Spitzer Observations Prior to JWST Launch
- Progress Report -



Presentation to the Astrophysics Subcommittee, March 2015

Picture credits (for entire presentation): ESA and NASA

Charter of SAG 9

- Much of the science conducted with JWST will build off of existing Spitzer data and science results.
- Spitzer has now entered the 6th year of its Warm Mission, and its capabilities still offer unique science opportunities for JWST precursor observations and science.
- Identify compelling science to be done with JWST, that is enabled by or that benefits from large blocks of Spitzer observing time prior to JWST launch.
- Document its findings in a report to the Astrophysics Subcommittee (currently in draft form).

SAG 9 Membership

Daniela Calzetti (co-Chair)		- calzetti@astro.umass.edu
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Ned Wright	- UCLA	- wright@astro.ucla.edu

Observers:

Pierre Ferruit	- ESA	- Pierre.Ferruit@cosmos.esa.int

Community Involvement

- Community inputs solicited through a number of channels:
  - Mail exploders (COPAG, Spitzer Users, DPS members, and the Planetary Exploration Newsletter)
  - Presentations at science meetings (Winter 2015 AAS Meeting, January 4th, 2015; SBAG winter meeting, January 6th, 2015)
  - Advertisement via the above channels of a general email address (copag.sag9@gmail.com), set-up to facilitate inputs from the community
  - Community members also encouraged to contact individual SAG9 members.
  - In response to solicitations, several members of the community have provided inputs.

Current (Warm) Spitzer Capabilities

[courtesy of Sean Carey (SSC-IPAC)]

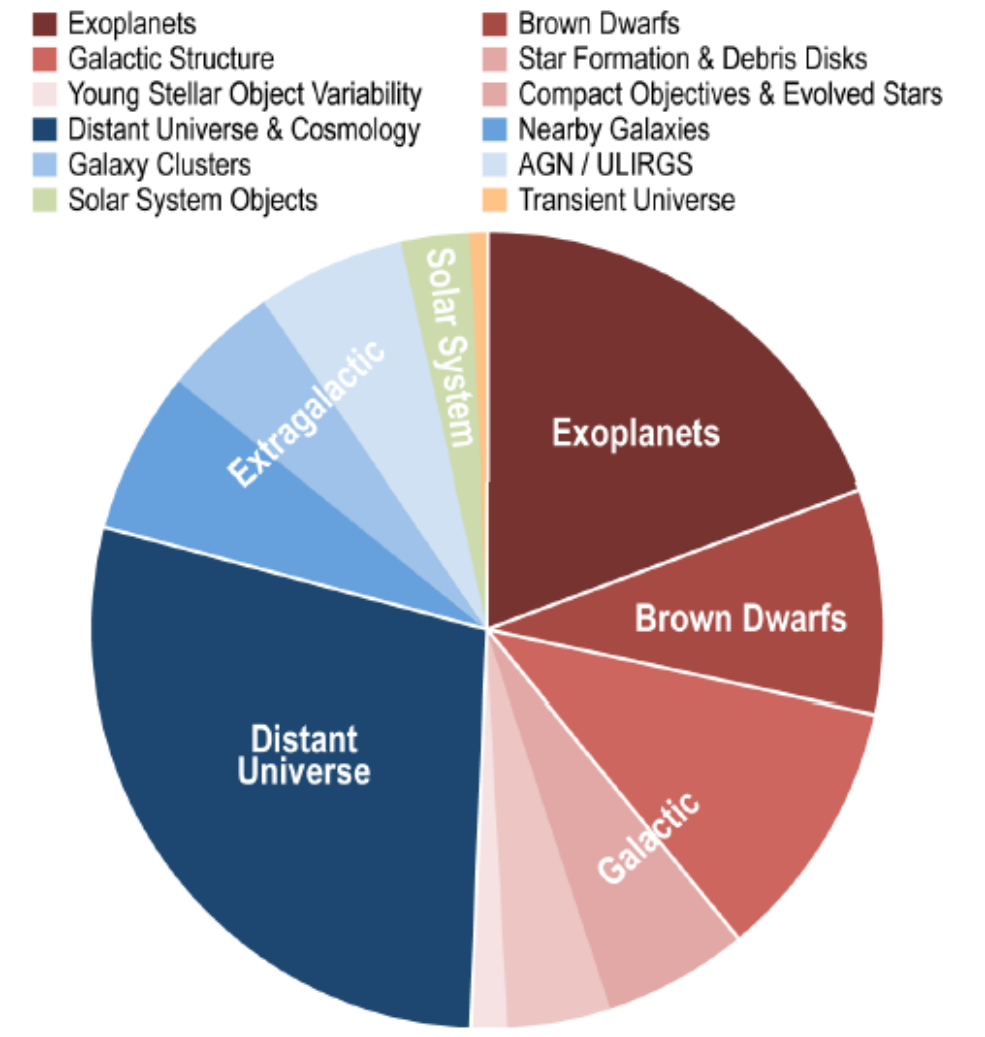
- Two IRAC Cameras at 3.6 and 4.5 μm, with ~1.7" resolution; 2% absolute calibration accuracy.

Channel	λ_0	$\lambda/\Delta\lambda$	FOV	1σ in 1hr integration	Mapping speed[A]
	μm		arcminutes	μJy	hours
3.6	3.550	4.7	5.2 x 5.2	0.14	3.3
4.5	4.493	4.4	5.2 x 5.2	0.21	3.3

[A]To confusion limit ([3.6], [4.5]~17 Vega magnitudes, 49 & 28 uJy, respectively) in Galactic plane at $l = 60°$, $b = 0°$ for 1 square degree in hours.

- Deep Imaging: Demonstrated depth of 81 nJy (3 σ) in 34 hours for unconfused sources. SB limit ~0.5 kJy/sr. SNR increases as $t^{0.4}$ for total integration times above 10 hours.
- Exoplanets: near Poisson limited precisions for relative photometry at both 3.6 and 4.5 μm. The best precision obtained with IRAC for an eclipse is 28 ppm from four epochs of observations of 55 Cnc e.
- Solar System: Track moving targets at 0.1 milliarcsec/sec to 1 arcsec/sec rates. Demanding result: detection of 2011 MD with a flux density of 0.6 μJy and rate of 0.14 arcsec/sec detected in a 19.3 hour observation with IRAC.
- Zodi Light: absolute measurements possible for a range of solar elongations 82.5° to 120° with an accuracy of <2% if the IRAC shutter is used to remove the instrumental bias pattern.
- Orbital Stability+Uninterrupted Viewing: Monitoring 20+ days of M dwarfs for Earth-size companions; monitoring 20+ hrs of Sgr A for variability (in sync with Chandra)

Warm Spitzer Observing Time Distribution



Excerpted from Senior Review Report 2014

Science Areas of SAG 9

- Galaxy Evolution and Cosmology
  - Ranga-Ram Chary (Lead), Lee Armus, Pierre Ferruit, Adam Stanford, Massimo Stiavelli, Rogier Windhorst
- Nearby Galaxies
  - Daniel Dale (Lead), Kathleen Kraemer, Massimo Stiavelli, Mike Werner
- Milky Way (incl. Evolved Stars, etc.)
  - Kathleen Kraemer (Lead), Rachel Osten, John Stauffer, Mike Werner
- Extra-solar Planets
  - Avi Mandell (Lead), Sean Carey, Drake Deming, Pierre Ferruit, Rachel Osten, John Stauffer
- Solar System
  - Stefanie Milam (Lead), Sean Carey, Josh Emery

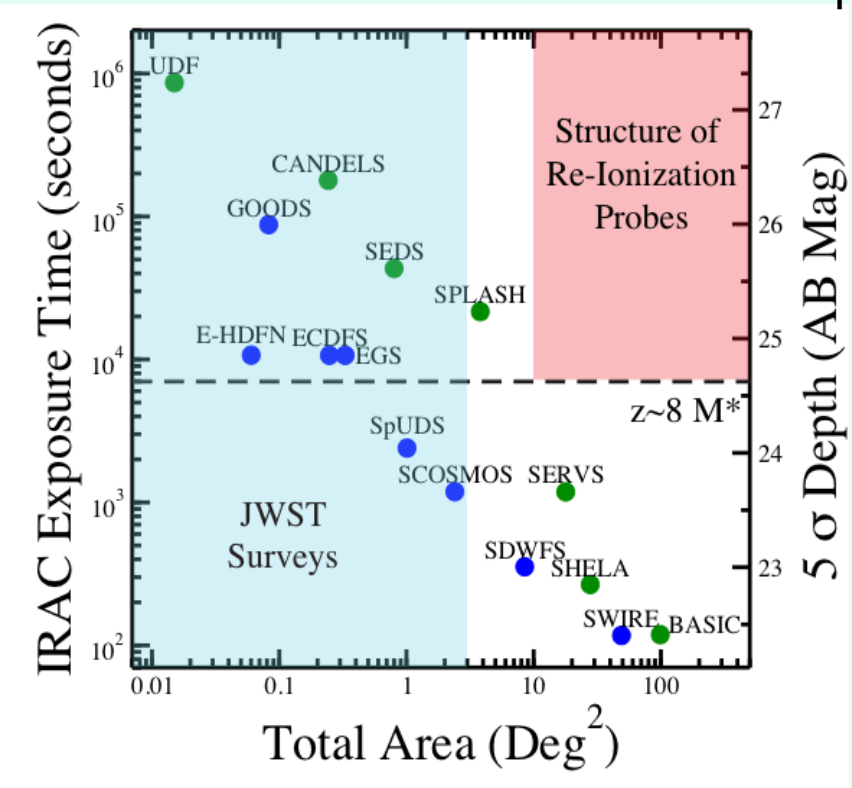
Galaxy Evolution and Cosmology

From P. Capak

A number of surveys already in existence. See Figure: blue points for cryogenic and green points for warm Spitzer. 1σ depth of 26.2 – 27.4 AB in 50 hours. Light-blue area is practical region for JWST.

Recently approved observations push into confusion noise (~200 hrs per pixel), and require use of priors, e.g., from HST.

Pink area accessible with Spitzer with >1 year observing time.



- Key questions/observations:
  - Characterize Zodiacal Light, for stray-light model of JWST and for accuracy improvement of cosmic infrared background (integrated galaxy starlight, reionization sources, …)
  - Wide fields for rare and/or lensed sources (z<2 clusters, galaxy-galaxy lenses, z>7 QSO candidates)
  - Deep Fields: surveys of 0.5<z<1 clusters for lensed, first-light galaxy candidates

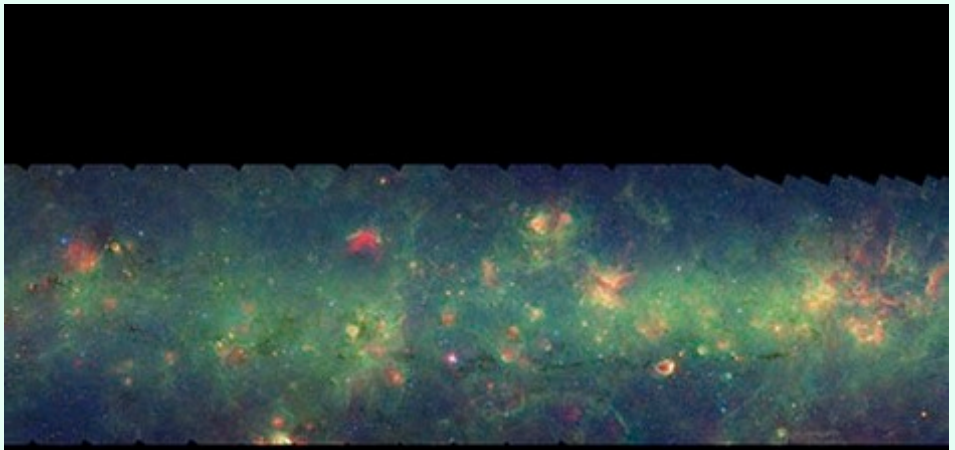
Nearby Galaxies

Many surveys of the local Universe in the archive, both with cryogenic (e.g., SINGS, LVL, SAGE, …, see Figure) and warm Spitzer (e.g., S4G, EDGES, etc.)
Programs have focused on both inner and outer disk regions, including subregions (e.g., HII regions, nuclear and circumnuclear regions, etc.).

- Key questions/observations:
  - IRAC characterization of ultrafaint dwarf galaxies around the Milky Way (the missing dwarf galaxy companions problem), for JWST follow-up
  - Extended stellar emission in galaxies outskirts, to test models of galaxy assembly, as precursor science
  - Time-domain science (e.g., IR transients) may benefit if Spitzer and JWST can operate simultaneously (unclear whether possible)

The Milky Way

The Milky Way has been extensively mapped with both the cryogenic and the warm Spitzer missions. Extended areas as well as regions of interest have been targeted (GLIMPSE+extensions, MIPSGAL, c2d, SMOG, …).
Both the plane and the outer regions, as well as the far side of the Galaxy have been imaged.



Milky Way: 3.6, 8, 24 μm (GLIMPSE-MIPSGAL; detail)

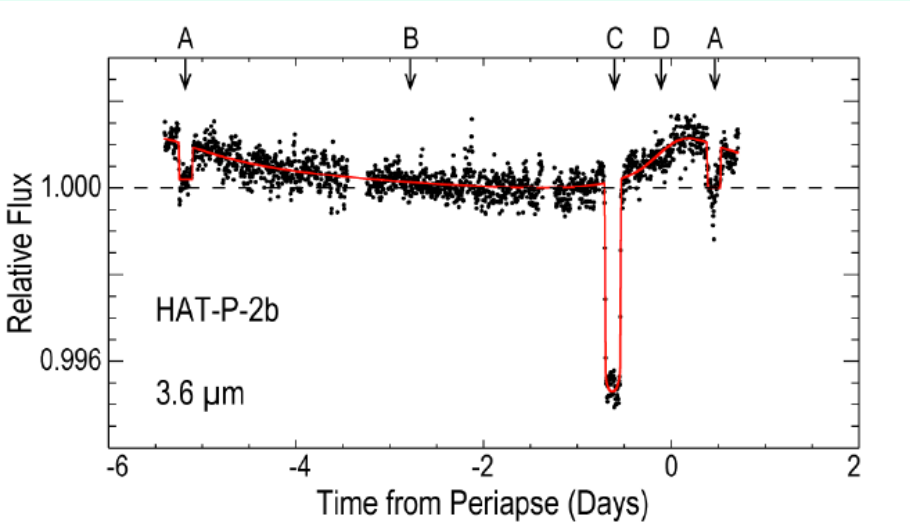
- Key questions/observations:
  - Expand samples of externally-polluted White Dwarfs for bulk composition comparison of extra-solar minor planets observed with JWST
  - IRAC Photometry for GAIA RR Lyr & Cepheid Variables for new cosmic distance ladder, to be extended with JWST
  - Galaxy structure via IRAC Photometry of Bulge Microlensing Fields
  - Outer Galaxy star forming regions and Disk Warp characterization

Exoplanets

Key capability: photometric precision to better than 30 ppm over several hours.

Existing and on-going work:

- Secondary eclipse measurements of newly discovered hot Jupiters
- Thermal phase curves for new and remaining key targets
- Microlensing parallax measurements
- Transits for Neptunes/Super-Earths to lock down presence of clouds
- Imaging outer planets with precise PSF subtraction – long time baseline for JWST
- Repeating eclipse and transit measurements to search for variability

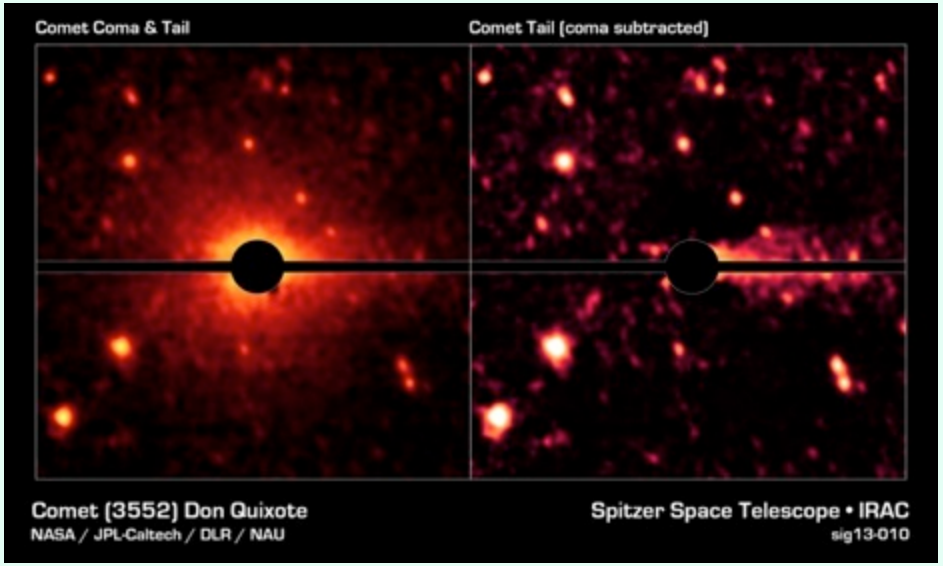


Spitzer's measurement of the phase curve of the transiting planet HAT-P-2b. A: Eclipse— the planet moves behind the star; B: Apoapse; C: Transit—the planet moves in front of the star; D: Periapse. Data from Lewis et al. (2013).

- Key questions/observations (prioritize/optimize targets for JWST):
  - Constraints on thermal profiles of new exotic hot extra-solar planets
  - Characterization of known super-Earths
  - Prioritization of super-Earths and Earth size planets for biological activity tracers with JWST
  - Continue characterization of newly discovered (K2, TESS, etc.) exoplanets

Solar System

The archive contains a robust inventory of observations of solar system objects, including satellites, comets, asteroids, NEOs, etc., in some cases including monitoring (e.g., weather).
Spitzer has the mid-infrared sensitivity and required orbital geometry for many observations.



- Key questions/observations:
  - Secure statistically-significant samples of icy bodies to be followed up with JWST for physical and chemical characterization
  - Prioritization of small bodies (e.g., Near Earth Objects) lists for JWST thermal spectroscopy (size and albedo)

Backup Slides
Proposed SIG #3 Charter

SIG #3: Cosmic Dawn Science

In its first billion years, the Universe underwent two rapid transitions. First, it transitioned from an ionized state to a nearly completely neutral state, an era that has been extensively and productively probed with the cosmic microwave background for multiple decades. The second transition was from the nearly completely neutral state back to a nearly fully ionized state. This second transition, involved the formation of the first stars, the first black holes, and the assembly of the first galaxies. Known as Cosmic Dawn and the Epoch of Reinonization, it is only now beginning to be revealed. A combination of ground- and space-based telescopes is beginning to detect and study youthful galaxies near the end of the Epoch of Reionization. A small number of gamma-ray bursts from early generations of stars have also been detected. These observations constitute only the first steps, however. The *JWST* will identify galaxies much earlier in the Epoch of Reionization, and various space-based missions offer the potential of probing even deeper into the Cosmic Dawn, potentially to the era of the formation of the first stars.

The *New Worlds, New Horizons* Decadal Survey identified "Cosmic Dawn" as one of the three science objectives for this decade, and it will likely continue to be a research focus well into the next decade. In order to realize the potential of probing as deeply into the Cosmic Dawn epoch, new space-based missions will be needed to provide imaging and spectroscopic capabilities, likely across the electromagnetic spectrum and even including multi-messenger approaches. A holistic approach to considering what is needed for a long-term technology roadmap has not yet been discussed widely within the community.

This Cosmic Dawn Science Interest Group [SIG #3] will work with the COPAG to collect community input and define long-term Cosmic Origins science objectives toward Cosmic Dawn that can be addressed by space-based observations. A primary goal for the SIG will be to identify a compelling suite of science cases to provide programmatic focal points that would justify and energize the community to support investment in next generation missions or facilities. Through the SIG, the community will update the existing community-based roadmap for technology development for missions of different scales. The SIG will facilitate communication that will merge the needs and desires of the science community with the achievements and plans of the technology community. The SIG activities are expected to occur over an extended period of time, with results reported at periodic intervals (quarterly or semi-annually) to the COPAG Executive Committee and the Astrophysics Subcommittee. The SIG is open to any interested members of the community, and we welcome any and all input.

Backup Slides
COPAG Virtual Town Hall Slides

COPAG Virtual Town Hall

March 10, 2015

COPAG Webex Session Info

When you join the Webex session, your microphone will be muted automatically. Tony Darnell will be moderating the participants and sending chat messages if there is any relevant information to convey while the meeting is going on. If you have a comment or would like to ask a question, please use the 'Raise Hand' feature to let the moderator know and he will indicate that he's seen that with a chat message. Alternatively, you can send a question via chat to the moderator and he will ask it on your behalf. You will need to remember to unmute your microphone when you begin speaking and mute again when you are done. (Add note on twitter/email for those who attend only by phone)

Cosmic Origins Panel (Meeting number / Access Code: 649 877 380)

Tuesday, March 10, 2015

3:00 pm | Eastern Daylight Time (New York, GMT-04:00) | 1 hr

Join WebEx meeting

https://stsci.webex.com (select “unlisted meeting”, enter meeting number)

Join by phone

1-855-244-8681 Call-in toll-free number (US/Canada)

1-650-479-3207 Call-in toll number (US/Canada)

Preparing for the 2020 Decadal Survey Large Mission Concepts

- The 2020 Decadal Survey will prioritize large space missions to follow JWST and WFIRST.
  - To enable this prioritization, NASA needs to provide information on several candidate large space mission concepts for consideration by the 2020 Decadal Survey Committee.

- What information needs to be provided to the Decadal Survey committee to enable prioritization of large missions
  - Science case
  - Strawman design reference mission with strawman payload
  - Technology development needs
  - Cost requirements assessment

- NASA needs to initiate technology development for candidate large missions so that technology will be ready when needed.
  - Technology needs to be sufficiently mature when it is time to start the highest priority large mission in the 2020 Decadal Survey.
  - The next large mission after WFIRST could be started when funding becomes available as WFIRST approaches launch in the early or mid-2020s.

Preparing for the 2020 Decadal Survey Large Mission Concepts

Part A – 2015

- Identify a small set of candidate large mission concepts to study
  - Incorporate community input through the three Astrophysics Program Analysis Groups (PAGs)

Part B – 2016-2019

- Initiate studies
  - Includes community-based Science and Technology Definition Teams
- Conduct studies
  - Includes NASA Center-provided engineering teams
- Identify technology requirements to motivate early technology development
  - Enables funding through existing Astrophysics technology programs
- Deliver results to 2020 Decadal Survey committee

Planning for the 2020 Decadal Survey: An Astrophysics Division White Paper
available at http://science.nasa.gov/astrophysics/documents

Preparing for the 2020 Decadal Survey Large Mission Concepts

Part A: Identify a small set (~3-4) of large mission concepts to study

- The community has invested considerable resources in discussing notional classes of mission concepts for consideration as large missions following JWST and WFIRST and in parallel with the ESA-led missions Euclid, Athena, and L3.
  - The 2010 Decadal Survey, *New Worlds New Horizons in Astronomy and Astrophysics*.
  - The 2014 Astrophysics Visionary Roadmap, *Enduring Quests, Daring Visions*.
- NASA has drawn an initial small set of 4 candidate mission concepts from the missions discussed in these strategic documents.
- [Hertz is] charging the Astrophysics PAGs to solicit community input for the purpose of commenting on the small set, including adding or subtracting large mission concepts; each PAG will submit a report regarding the small set of large mission concepts for consideration by the NAC Astrophysics Subcommittee.
- At its Fall 2015 meeting, the NAC Astrophysics Subcommittee will consider the three PAG reports and submit a report to NASA on the small set of large mission concepts for study.
- The Director of the NASA Astrophysics Division will decide which large mission concepts will be studied as input for the 2020 Decadal Survey.

Preparing for the 2020 Decadal Survey Large Mission Concepts

The initial short mission list (alphabetical order):

- **FAR IR Surveyor** – The Astrophysics Visionary Roadmap identifies a Far IR Surveyor as contributing through improvements in sensitivity, spectroscopy, and angular resolution.
- **Habitable-Exoplanet Imaging Mission** – The 2010 Decadal Survey recommends that a habitable-exoplanet imaging mission be studied in time for consideration by the 2020 decadal survey.
- **UV/Optical/IR Surveyor** –The Astrophysics Visionary Roadmap identifies a UV/Optical/IR Surveyor as contributing through improvements in sensitivity, spectroscopy, high contrast imaging, astrometry, angular resolution and/or wavelength coverage. The 2010 Decadal Survey recommends that NASA prepare for a UV mission to be considered by the 2020 Decadal Survey.
- **X-ray Surveyor** – The Astrophysics Visionary Roadmap identifies an X-ray Surveyor as contributing through improvements in sensitivity, spectroscopy, and angular resolution.

Preparing for the 2020 Decadal Survey Large Mission Concepts

Charge to the PAGs (subset):

1. Each PAG, under the leadership of its Executive Committee, shall broadly solicit the astronomy and astrophysics community for input to the report in an open and inclusive manner.
   - To accomplish this, each PAG is empowered to envision and use its own process.

2. Each PAG will consider what set of mission concepts should be studied to advance astrophysics as a whole; there is no desire for mission concepts to be identified as "belonging" to a specific Program or PAG.
   - Each PAG shall keep the number of large mission concepts in the set as small as possible.
   - Each PAG is specifically charged to consider modifications and subtractions from the small set, and not just additions.

3. Each PAG shall produce a report, where it shall comment on all large mission concepts in its small set of large missions, including those in the initial small set and those added or subtracted.
   - The PAGs may choose to work together and submit coordinated or joint reports.

What the COPAG will be Doing in Response to this Charge

- Collecting Cosmic Origins community input for the four missions in NASA's shortlist
  - Science cases
  - Technology needs
  - Comments on the four strawman missions
- Identifying any other large missions having broad community support for Cosmic Origins science
- Summarizing that input for each of these missions for the Astrophysics Subcommittee
- Working with the PhysPAG and ExoPAG in responding to this charge when possible (collecting/sharing input, joint reports)

What the COPAG won't be Doing in Response to this Charge

- Prioritizing these flagship missions
  - This is the work of the Decadal Survey Committee
- Advocating for specific mission concepts
  - Focus on capabilities, science drivers, science synergies, technology tall poles,
- Advocating for smaller missions
  - Only large (>$1B) missions are being considered (i.e., no Probes, Explorers)
  - Other avenues for input are (or will be) available
- Performing Technical Trade Studies
  - This is the work of the STDTs in Part B of Paul Hertz's charge
  - Input collected will inform the STDT studies

Request for White Papers

- The COPAG wants your input
- White paper solicitation
  - http://cor.gsfc.nasa.gov/copag/rfi/Large_missions_white_paper_solicitation-01Mar2015.pdf
  - Length = 1-2 pages
  - Due April 24, 2015
  - PDF, MS Word, or ASCII format
  - All white papers will be posted on the COPAG website: http://cor.gsfc.nasa.gov/copag/rfi/copag-rfi.php
  - Submit papers (or questions) to: COPAG_Contact@bigbang.gsfc.nasa.gov

Next Steps

- COPAG will hold another virtual town hall to discuss the community input it has received
  - Likely to occur in May 2015
  - Date/time and webex details will be posted on the COPAG website
- COPAG will continue to collect input through its two Science Interest Groups
  - SIG#1 (Far-IR, Leads: David Leisawitz / Paul Goldsmith)
  - SIG#2 (UV-Optical, Lead: Paul Scowen)
- COPAG Executive Committee is available for input

Questions / Comments?

Please remember to “raise your hand” via webex.

End Backup Slides