D.3 ASTROPHYSICS RESEARCH AND ANALYSIS PROGRAM

NOTICE: Clarified on December 11, 2015. This program element now explicitly states that it does not solicit for 'astro-combs' under supporting technology (see Section 1.2.3), it highlights the timeliness of Laboratory Astrophysics proposals pertaining to JWST and ASTRO-H (see Section 1.2.4), and updates the point of contact for Laboratory Astrophysics (See Section 3). New text is in bold.

In a previous clarification the Points of Contact for Infrared, Submillimeter, and Radio Astrophysics was updated. See Section 3.

1. Scope of Program

1.1 Overview

The Astrophysics Research and Analysis Program (APRA) program solicits basic research proposals for investigations that are relevant to NASA's programs in astronomy and astrophysics and includes research over the entire range of photons, gravitational waves, and particle astrophysics. Awards may be for up to four years' duration (up to five years for suborbital investigations), but shorter-term proposals are typical; four-year or five-year proposals must be well justified. Proposals for suborbital investigations are particularly encouraged. APRA investigations may advance technologies anywhere along the full line of readiness levels, from Technology Readiness Level1 (TRL1) through TRL9. The emphasis of this solicitation is on technologies and investigations that advance NASA astrophysics missions and goals.

1.2 Categories of Proposals

The APRA program seeks to support research that addresses the best possible (i) state-of-the-art detector technology development for instruments that may be proposed as candidate experiments for future space flight opportunities; (ii) science and/or technology investigations that can be carried out with instruments flown on suborbital sounding rockets, stratospheric balloons, or other platforms; and (iii) supporting technology, laboratory research, and/or (with restrictions) ground-based observations that are directly applicable to space astrophysics missions. To meet these goals, proposals are solicited in the following five broad categories:

- Suborbital/Suborbital-class Investigations
- Detector Development
- Supporting Technology
- Laboratory Astrophysics
- Ground-Based Observations.

Specific Considerations and Exclusions:

- Investigators proposing stand-alone detector development should propose to the Detector Development category, whereas proposals for which detector development is integrated

into a suborbital/suborbital-class program should be submitted to the Suborbital Investigations category.

- The Laboratory Astrophysics category of this program element includes theoretical investigations in the area of Atomic and Molecular Astrophysics. However, all other theoretical investigations are solicited separately under the Astrophysics Theory Program described in Appendix D.4 of this NRA.
- The Ground-Based Observations category of APRA will consider proposals only from observers who are ineligible for such support from the National Science Foundation (e.g.. scientists employed by NASA or another Federal Agency). In addition:
  - The program element is not intended to support ground-based observational studies of extrasolar planets. Such proposals should instead be submitted to Appendix E.3 of this NRA. Testing and validation observations conducted at a ground-based facility as part of an exoplanet technology research program are, however, acceptable.
  - Proposals for any ground-based gamma-ray burst investigations are no longer eligible for support within the APRA program and should be submitted to the relevant mission Guest Investigator program(s).
  - Ground-based particle astrophysics observations are not supported by this program element. Such investigations in support of a NASA Astrophysics mission should be directed to the relevant mission Guest Investigator program(s).
- In the Fundamental Physics discipline area, this program element solicits proposals: 1) to test fundamental laws of physics or 2) to develop experimental concepts and/or related technologies to test fundamental laws of physics. Proposals submitted to this program element should be space-related (suborbital, orbital, etc.). This program is not intended to support applied physics or laboratory experiments. Investigations predominantly theoretical in nature should be directed to the Astrophysics Theory Program or to other Federal agencies, as appropriate.
- Projects directed mainly toward the analysis of archival data are solicited under the Astrophysics Data Analysis Program described in Appendix D.2 of this NRA.
- If a proposal is offered as a direct successor to a previous NASA award, it should include a description of the predecessor effort, including any significant findings, and describe how the proposed work extends the previous accomplishments. See Section 1.5 of the *NASA Guidebook for Proposers* for more details.
- The Principal Investigator (PI) institution is expected to fund participating Co-Investigator(s) (Co-I(s)) via subawards, except where the Co-I is at a Government laboratory, including the Jet Propulsion Laboratory (JPL). The only exception is for Suborbital/Suborbital-class Investigations, see Section 1.2.1.3 below. However, note in this case that the PI proposal must include, within the Budget Justification section, a table showing the summed cost per year for the entire investigation.
- Projects devoted to technology development efforts that do not generate data need not provide data management plans but must note on the NSPIRES cover page that they do not need to provide a data management plan because they are in the Detector Development or Supporting Technology category.

1.2.1 *Suborbital/Suborbital-class Investigations*

This APRA category supports science investigations and/or technology development utilizing payloads flown on sounding rockets, balloons, commercial reusable suborbital rockets, or similar-class payloads flown as flights of opportunity. Suborbital payloads may be recovered, refurbished, and reflown in order to complete an investigation.

Suborbital launch vehicle services include those provided by the NASA Sounding Rocket Program Office (SRPO) and the NASA Balloon Program Office (BPO) and commercial suborbital reusable launch vehicle services through the Flight Opportunities Program of NASA's Office of the Chief Technologist (OCT). The Science Mission Directorate also provides for CubeSats and International Space Station (ISS) payloads. These are described in Section V of the *ROSES Summary of Solicitation*. Investigators are strongly urged to discuss their proposed payload with the contact person(s) for the appropriate Program, as given in that section. Please pay particular attention to the additional requirements for proposals for the ISS that are described in that section. ISS payloads will be subject to oversight beyond that of a typical sounding rocket or balloon payload.

A discussion of the plans for management and for reduction and analysis of the data should be given. Although most awards are for three or four years' duration, a five-year proposal may be accepted to develop a completely new, highly meritorious investigation through its first flight. Because of the anticipated greater degree of complexity, the Scientific/Technical/Management section of proposals for these investigations may be 20 pages long, instead of the default 15 pages specified in the *NASA Guidebook for Proposers.*

Budgets are expected to cover complete investigations, including payload development and construction, instrument calibration, launch, and data analysis. The number of investigations that can be supported is limited and heavily dependent on the funds available to this program. Note that NASA does not carry reserves to accommodate any cost overrun incurred by a particular investigation, including the loss of the payload owing to a rocket or balloon system failure. Therefore, failure to achieve the proposed goals within the proposed time and budget could require either descoping the initially proposed investigation, delaying it, canceling a particular launch date opportunity, or canceling the investigation altogether.

Suborbital and suborbital-class investigations provide unique opportunities, not only for executing intrinsically meritorious science investigations, but also for advancing the technology readiness levels of future space flight detectors and supporting technologies and preparing future leaders of NASA space flight missions, such as early-career researchers and graduate students. For these proposals, specific factors that will be considered when evaluating a proposal's intrinsic merit are the scientific merit, the degree to which it advances the technology readiness level of a detector or supporting technology, and the degree to which it advances the readiness of early-career researchers or graduate students to assume leadership roles on future NASA space flight missions.

1.2.1.1 *Sounding Rocket Payloads*

Investigators proposing payloads to be flown on sounding rockets should answer the program-specific questions on the APRA proposal cover pages. For planning purposes, the Sounding Rocket Program Office uses this information to generate a rough order-of-magnitude cost estimate for the operational requirements associated with a proposed investigation. The required information includes the envisioned vehicle type, payload mass, trajectory requirements, launch site, telemetry requirements, attitude control, or pointing requirements, and any plans for payload recovery and reuse.

The Sounding Rocket Program is currently planning to provide launches from Woomera, Australia, in September of 2016 and again in April-June of 2018, subject to the availability of funds. Investigators responding to this APRA solicitation may propose sounding rocket flights launched from this southern hemisphere site for either opportunity. Normal payload recovery is anticipated for flights using either the Black Brant IX or Black Brant XI launch vehicles.

1.2.1.2 *Balloon Payloads*

The Balloon Program is planning to provide a shared platform capable of carrying multiple, independent, piggyback-like instruments in order to offer suborbital flight opportunities to more users. The intent is to support more small instruments for science investigations, technology development, and/or training of early-career scientists and engineers. Investigators should identify, on the proposal cover page, which of these three categories is the main focus of the proposal. The following table summarizes the standard services and anticipated constraints for a flight supporting about six instruments:

Balloon Altitude:	Flight Duration:	Per instrument Weight/Size:	Data Rate/Power:	Launch location:
30-37 km	6-24 hours	136 kg; 0.4 cubic meters; Standard interface	> 50 kbs LOS; 50-100 watts, regulated 28 V battery nominal	Ft. Sumner (Spring or Fall) Palestine (Summer)

Projects, including a flight from Antarctica or needing unique engineering and/or technical support services and/or vehicles and/or the Wallops Arc-Second Pointing System (WASP), should contact the Balloon Program Office directly for an estimate of the Government Furnished Equipment (GFE) cost of the desired support.

1.2.1.3 *Special Instructions for Multiple-Institution Proposals for Suborbital/Suborbital-class Investigations: Co-Investigator Proposals*

Proposals for suborbital and suborbital-class investigations often involve the development of payloads that require major hardware collaborations among several organizations. In such cases, the lead Principal Investigator (PI) may propose a direct subcontracting arrangement between his/her organization and the Co-Investigator (Co-I) organization(s) other than U.S. Government organizations, in which case all the nominal instructions in the *NASA Guidebook for Proposers*

(see further below) apply. As described in Section 2.3.10.c (ii), the activities of Co-Is at U.S. Government organizations, such as NASA centers, are always funded directly. If the PI is from a U.S. Government organization, Co-Is will be funded by awards from that organization. NASA centers apply no overhead cost to the budgets for Co-I organizations.

Alternatively, for some combinations of collaborating organizations, NASA recognizes that there may be advantages to providing separate awards to some of the collaborating organizations in response to "Co-Investigator Proposals." The lead investigator from the Co-I organization serves as the "Institutional PI" for the award to his/her organization (see Section 1.4.2 in the *NASA Guidebook for Proposers*).

For teams wishing to take advantage of such multiple-award flexibility, the following instructions should be followed:

- Only the "lead proposal" for the overall investigation, submitted by a single PI, will be reviewed. This lead proposal must include:
  - A clear statement in the first sentence of the Proposal Summary that identifies the proposal as the lead proposal.
  - The Cover Page/Proposal Summary/Budget Summary of the lead proposal, showing the summary of the budget requested by the lead organization. This should not include the budgets for those organizations submitting Co-I proposals. Support for Co-Is at organizations that do not submit separate Co-I proposals should be included in the budget summary of the lead proposal in the usual way.
  - A work statement and budget justification (narrative and details) covering the items in the budget summary of the lead proposal, appending the Task Statements and the budget justifications (narrative and details) from each of the Co-I proposals (see further below).
  - A table in the budget justification that shows, for the complete period of performance, the yearly cost for the "lead proposal," along with that for each of the Co-I proposals, and also the sum of all proposals, which together must add to the total request for the entire integrated investigation.

- Each organization submitting a Co-I proposal must:
  - Have a Proposal Title that is identical to the title of the lead proposal, except that "[Organization Name] Co-I" is added to the end.
  - Have a Proposal Summary that clearly cross-references the PI of the lead proposal in the first sentence.
  - Complete the Cover Page/Proposal Summary/Budget Summary and include all materials indicated in the *NASA Guidebook for Proposers*.
  - Contain, in lieu of the Scientific/Technical/Management section, a *Task Statement*, not to exceed five pages, that describes the contribution of the Co-I organization and the role of the Co-I(s) to the overall investigation. In the case of multiple Co-Is from the same organization, a single Co-I serving as the "Institutional PI" must be identified.
  - Include a budget justification (narrative and details) covering the Co-I organization's proposed activities.

- Be submitted electronically through the organization's Authorized Organizational Representative (AOR), with the Co-I (Institutional PI) from that organization listed as the PI.

1.2.2 *Detector Development*

This APRA category solicits investigations that either advance our understanding of the fundamental operational aspects of detectors or develop new types of detectors to the point where they can be proposed in response to future announcements of flight opportunities. Either new measurement concepts or methods to improve the performance of existing detectors may be proposed, provided they would be candidates for use in space. Among the characteristics typically desirable in space-quality detection systems are high sensitivity to relevant signals, low mass, low sensitivity to particle radiation, low power consumption, compactness, ability to operate in a vacuum (such that high-voltage arcing is minimized), vibration tolerance, ease and robustness of integration with instrumentation, and ease of remote operation, including reduced transient effects and ease of calibration.

This program does not support development of detectors or instrument subsystems that are intended primarily for ground-based astronomy. However, observing with ground-based facilities may be proposed to verify new detectors or overall system performance, if adequately justified as an integral part of a detector development program.

Proposals for new detectors will be evaluated in the context of currently available space astronomy detector technologies. Proposers are encouraged to identify potential mechanisms that could facilitate transfer of these detector technologies to other users, including Homeland Security and/or the private sector, for possible application beyond the immediate goals of NASA's programs.

1.2.3 *Supporting Technology*

This APRA category supports investigations of technologies not yet ready for incorporation into new detector or space mission systems, but that offer promise of potential breakthroughs that could lead to future advances in instrumentation useful for NASA's space astronomy and astrophysics programs. This program includes small technology efforts for future NASA Astrophysics missions, such as development of optics, mirrors, coatings, or gratings. **Unlike in APRA-2014, proposals for 'astro-combs' are not solicited this year [Clarified December 11, 2015].**

This category also supports proposals for development of new data analysis methods for future space missions. These proposals should be mission enabling or mission enhancing and directly applicable to future space flight missions, in particular (but not necessarily limited to) those that have been considered in the most recent decadal survey or Astrophysics roadmap. Missions already funded (pre-Phase A or beyond) are excluded.

1.2.4 *Laboratory Astrophysics*

The Laboratory Astrophysics category of the APRA program supports the determination of fundamental atomic, molecular, nuclear, and solid-state parameters that are essential for analyzing and interpreting the data from NASA Astrophysics missions. The program supports both experimental and computational efforts to explore the spectroscopic properties of atoms and molecules and particulate matter, as well as their chemical, physical, and dynamical properties under astrophysical conditions. The resulting data products directly impact our understanding of a wide range of astrophysical phenomena spanning the electromagnetic spectrum, and ranging from the epoch of reionization and the evolution of cosmic structure to the formation and evolution of galaxies, stars, and exo-planetary systems in the current epoch.

Laboratory Astrophysics proposals must be well motivated by a detailed description of the relevance of the proposed investigation to the analysis of measurements from NASA astrophysics missions (past, current, or future). **Such proposals pertaining to JWST or ASTRO-H would be particularly timely. [Clarified December 11, 2015].** Proposals for projects that aim to produce data products for wide use across the astronomical community should explain how those products would be made available to the intended users in a stable fashion.

1.2.5 *Ground-Based Observations*

This APRA category will consider proposals for ground-based observations, but only from observers who are ineligible for such support from the National Science Foundation (e.g., scientists employed by NASA or another Federal Agency). Moreover, this program element is not intended to support ground-based observations for general scientific objectives. Rather, these observations must be an integral part of a technology development or demonstration project for space astrophysics or directly support the planning and design of future NASA space astrophysics missions.

2. Programmatic Information

2.1 General Information

The following table provides the amount of Year -1 funding and the number of investigations that have been selected for the five APRA categories in four recent cycles; note that proposals for APRA-09 (denoted A-09) were due in 2010 and funded in FY 2011, etc. If the budget allows, we expect (but cannot guarantee) that that the selections in the coming year will be similar.

APRA Category	Total allocated to new selections [$M]					Number of New Selections (including Co-I proposals)				
	A-09	A-10	A-11	A-12	A-13	A-09	A-10	A-11	A-12	A-13
Suborbital Investigations	5.6	8.9	5.0	6.1	5.7	10	12	8	15	17

Detector Development	1.9	1.3	2.7	3.1	1.6	6	4	10	7	5
Supporting Technology	4.3	2.8	3.1	1.9	2.3	15	12	13	6	9
Laboratory Astrophysics	1.0	1.8	0.9	0.6	1.1	8	8	8	5	8
Ground-Based Observations	0.03	0.06	0	0	0	1	1	0	0	0

2.2 Student Participation

The participation of graduate students is strongly encouraged, especially if the project can be concluded within the nominal tenure of graduate training. In such cases, brief details of the educational goals and training of the participants should be included in the proposal.

2.3 Request for reviewer names

Proposers are strongly encouraged to provide names and contact information of up to five experts qualified to review their proposal. These experts must not be from the institutions of the PI or Co-Is or stand to benefit financially from the selection (or otherwise) of the proposal. This information should be included in the proposal summary in the Notice of Intent, or E-mailed to the relevant Program Officer listed below.

3. Summary of Key Information

Expected program budget for first year of new awards	See Section 2.1
Number of new awards pending adequate proposals of merit	See Section 2.1
Maximum duration of awards	4 years (5 years for suborbital investigations)
Due date for Notice of Intent to propose (NOI)	See Tables 2 and 3 in the *ROSES Summary of Solicitation*.
Due date for proposals	See Tables 2 and 3 in the *ROSES Summary of Solicitation*.
Planning date for start of investigation	Between 1 January and 31 March after the proposal due date (except that NASA Centers may plan for a start at the beginning of the fiscal year).
Page limit for the central Science-Technical-Management section of proposal	15 pp (20 pp for suborbital proposals); see also Chapter 2 of the *NASA Guidebook for Proposers*
Relevance	This program is relevant to the Astrophysics questions and goals in the NASA Science Plan. Proposals that are relevant to this program are, by definition, relevant to NASA.
General information and overview of this solicitation	See the *ROSES Summary of Solicitation*.

Detailed instructions for the preparation and submission of proposals	See the *NASA Guidebook for Proposers* at http://www.hq.nasa.gov/office/procurement/nraguidebook/.
Submission medium	Electronic proposal submission is required; no hard copy is required or permitted. See also Section IV of the *ROSES Summary of Solicitation* and Chapter 3 of the *NASA Guidebook for Proposers*.
Web site for submission of proposal via NSPIRES	http://nspires.nasaprs.com/ (help desk available at nspires-help@nasaprs.com or (202) 479-9376)
Web site for submission of proposal via Grants.gov	http://grants.gov (help desk available at support@grants.gov or (800) 518-4726)
Funding opportunity number for downloading an application package from Grants.gov	NNH15ZDA001N-APRA
NASA point of contact concerning this program	Michael R. Garcia Astrophysics Division Science Mission Directorate NASA Headquarters Washington, DC 20546-0001 Telephone: (202) 358-1053 E-mail: Michael.R.Garcia@nasa.gov

Questions about the APRA Program should be directed to the point of contact above. Questions about specific discipline areas may be directed to the relevant Program Officers listed below, along with their areas of expertise. If uncertain about whom to contact, please direct your inquiries to the APRA point of contact listed above.

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