

National Aeronautics and
Space Administration



EXPLORE SOLAR SYSTEM & BEYOND

NASA Astrophysics SmallSats

Michael Garcia, APD SmallSats Lead Program Scientist

Edwin Griego, APD SmallSat Lead Program Executive

SmallSats 2020, Aug 3, 2020, virtually at Logan, UT

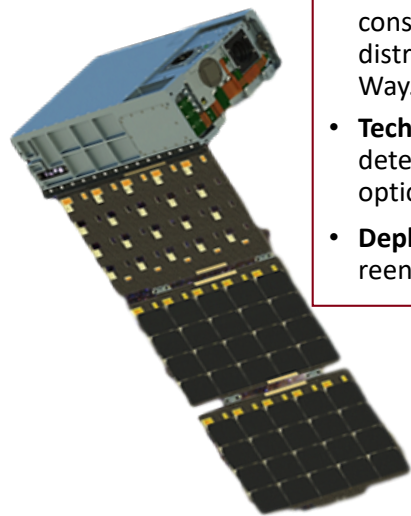
Astrophysics SmallSats – Recent History



- 2012 CubeSats first offered in ROSES/APRA
- 2016 NASEM Study: *Achieving Science with CubeSats: Thinking Inside the Box*
- 2018 CubeSat initiative in ROSES/APRA
- 2018 SMD establishes RideShare Policy
- 2018 SmallSat mission concept studies offered in ROSES/AS³
- 2019 SmallSat Missions of Opportunity offered in Astrophysics Explorers MO AO
- 2019 SmallSat mission concept studies offered in ROSES/AS³
- 2020 Astrophysics Pioneers initiative

NASA Astrophysics CubeSats

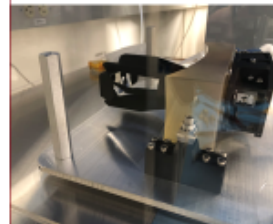
The Astrophysics Division is investing approximately \$5M per year in a CubeSat initiative.



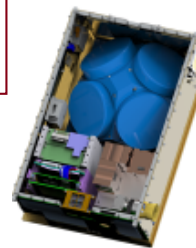
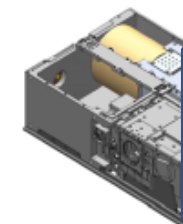
- **HaloSat**, PI: Phil Kaaret, U. Iowa
- **Science Objectives:** HaloSat is mapping soft X-ray oxygen line emission across the sky in order to constrain the mass and spatial distribution of hot gas in the Milky Way.
- **Technologies:** BCT S/C, COTS detectors, collimators with no optics.
- **Deployed:** Jul 13, 2018, from ISS, reentry ~November 2020

Five Astrophysics CubeSats in Development

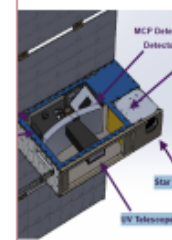
- **CUTE**, PI: Kevin France, CU
- **Science Objectives:** The Colorado Ultraviolet Transit Experiment (CUTE) will take medium resolution UV spectra of 14 hot Jupiters during transit, in order to measure atmosphere being ablated away.
- **Technologies:** BCT S/C, COTS telescope and camera.
- **Launch:** Dec 20 on LandSat-9



- **SPARCS**, PI: Eygenya Shkolnik, ASU
- **Science Objectives:** Determine rate, strength and 2-band color of bright UV flares from 25 M dwarfs, effect on habitability?
- **Technologies:** BCT S/C, doped CCD, UV dichroic.
- **Launch:** September 2021



- **BurstCube**, PI: Jeremy Perkins (GSFC)
- **Science Objectives:** Rapid localizations for LIGO/Virgo detections with short GRBs; Search of g-ray transients.
- **Technologies:** Dillinger derived bus, Fermi-GBM like detectors.
- **Launch:** Fall 2021

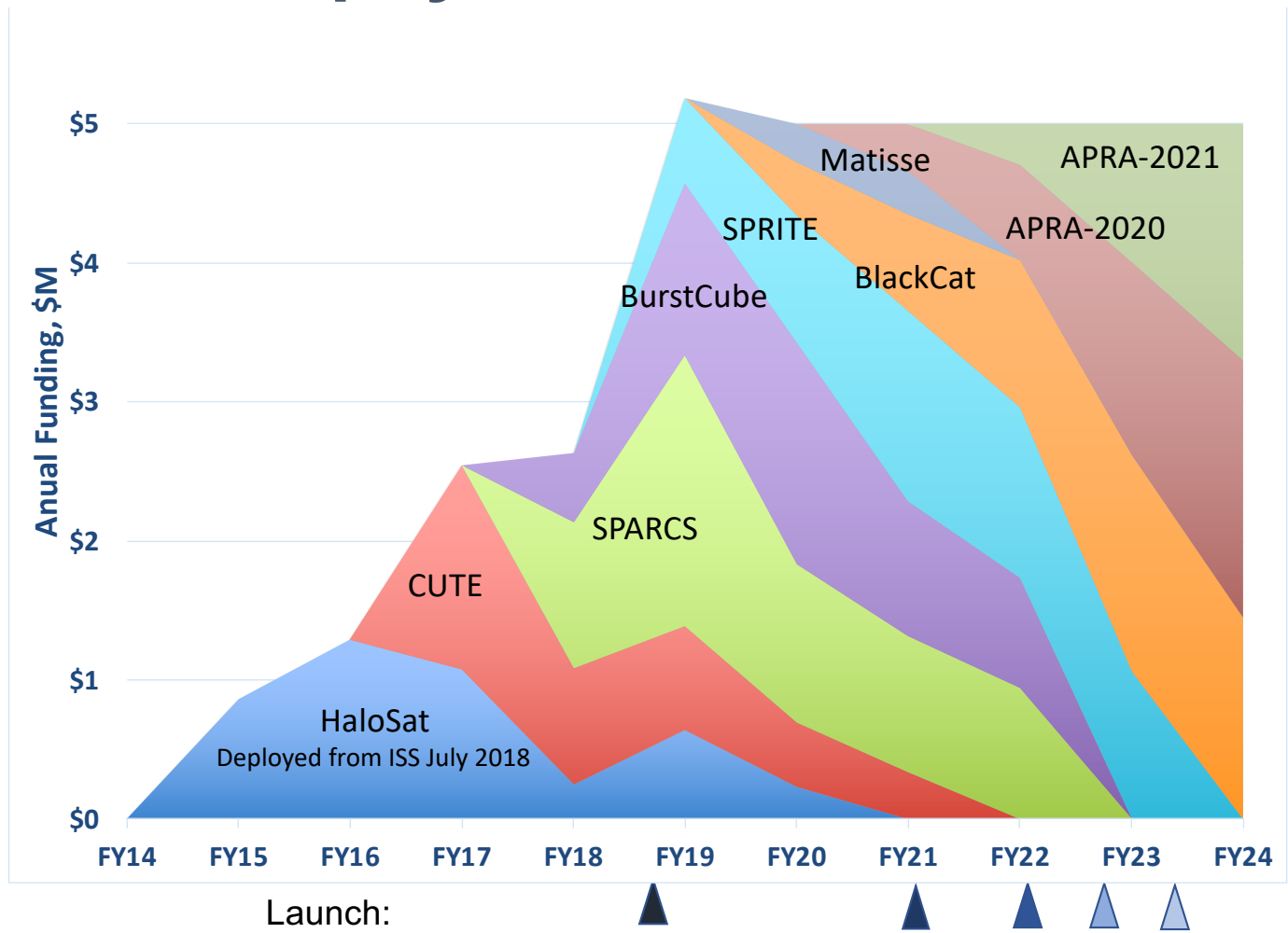


- **SPRITE**, PI: Brian Fleming, CU
- **Science Objectives:** Determine ionization rate of IGM from galaxies and AGN, trace feedback within galaxies driven by star-forming regions, using low-resolution imaging UV spectrograph.
- **Technologies:** in house S/C, UV coatings, next-gen MCP.
- **Launch:** Fall 2022

- **BlackCat**, PI: Abe Falcone, Penn St.
- **Science Objectives:** GRB/Transient detection in 0.2-20keV with coded mask.
- **Technologies:** CMOS x-ray CCD
- **Launch:** FY2024

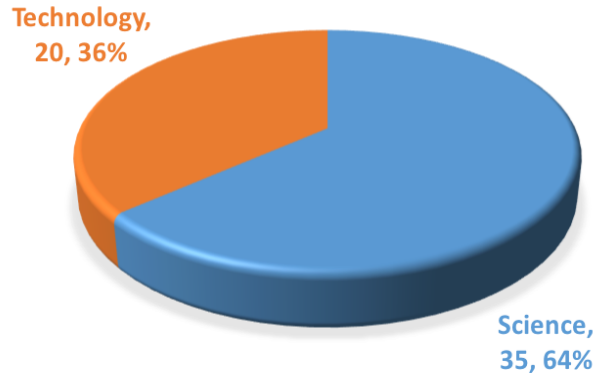


Astrophysics CubeSat Cadence

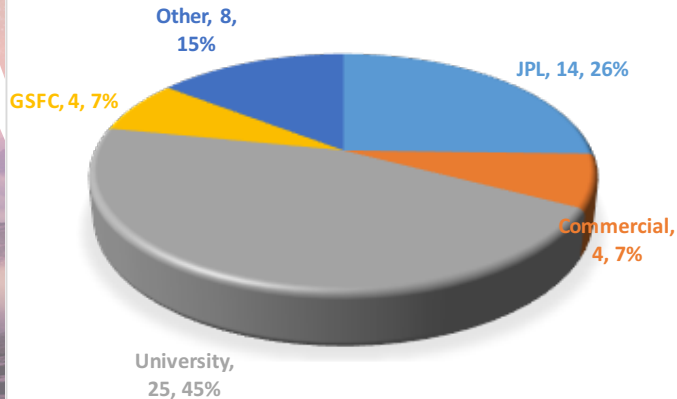


Astrophysics Science SmallSat Studies AS³

RESPONSE TYPE



RESPONDING INSTITUTION TYPE



SMD is interested in exploring ways that CubeSats/SmallSats can do highly valued science for lower price points.

2017 Astrophysics RFI for SmallSats asked for ideas to do high priority Astrophysics science projects at a price point between typical R&A and Explorer MOO projects (\$10M-\$35M).

2018, 2019 Funded Mission Concept Studies for Astrophysics Science SmallSat Studies: Paper studies, ~\$120K, no hardware development. Costing by PI and at NASA Design Centers. Cost point <\$35M.



Astrophysics Science SmallSat Studies AS³ v1, 2018

- AS³ 2018 funded 9, 6 month studies of <\$35M SmallSats

XQSat, (X-ray Quantum Calorimeter Satellite) Philip Kaaret at University of Iowa in Iowa City

DAPPER, (Dark Ages Polarimetry Pathfinder) Jack Burns at University of Colorado in Boulder

GUCI++, (Gravitational-wave Ultraviolet Counterpart Imagers) Stephen Cenko at NASA Goddard Space Flight Center in Greenbelt, Maryland

mDOT, (Miniature Distributed Occulter Telescope), Bruce Macintosh at Stanford University in California

MASS, (MicroArcsecond Small Satellite), Michael Shao at the NASA Jet Propulsion Lab in Pasadena, California

SEEJ, (Smallsat Exploration of the Exospheres of Nearby Hot Jupiters), Scott Wolk at the Smithsonian Astrophysical Observatory in Cambridge, Massachusetts

VTXO, (Virtual Telescope for X-ray Observations), John Krizmanic at the University of Maryland, Baltimore County

HSP, (HREXI SmallSat Pathfinder), Jonathan Grindlay at Harvard College in Cambridge, Massachusetts

ISCEA, (Infrared SmallSat for Cluster Evolution Astrophysics), Yun Wang at the California Institute of Technology in Pasadena, California



Astrophysics Science SmallSat Studies AS³ v2, 2018

- AS³ 2019 funding 8, 1 year studies of <\$35M SmallSats
- 2019 Topics include ExoPlanets, GRB, Massive Stars, SMBH, EBL, Adaptive Optics

GOSoX (Globe Orbiting Soft X-ray Polarimeter), Herman Marshall/MIT

NExtUP (The Normal-incidence Extreme Ultraviolet Photometer) Jeremy Drake/Smithsonian Astrophysical Observatory

MAGIC (The Massive star Asteroseismology Instrument Cubesat) Derek Buzasi/Florida Gulf Coast University

ORCAS (Orbiting Configurable Artificial Star) Eliad Peretz/NASA

MoonBEAM (A Beyond Earth-orbit Gamma-ray Burst Detector for Multi-Messenger Astronomy) Chiumun Hui/NASA/MSFC

BHAGERA (Black Hole Accretion and Growth Experiment with Reverberation Analysis) Varoujan Gorjian/JPL

MISE (Mid-Infrared Sky Explorer) Asantha Cooray/University of California Irvine

A Constellation of Small Satellites to Search for a Transiting Earth-Size Planet in an Earth-like Orbit about a Bright Sun-Like Star Sara Seager/Massachusetts Institute of Technology



Astrophysics Pioneers

- NASA anticipates that major extended duration balloon payloads, CubeSats larger than 6U, and CREAM-class ISS payloads will be more expensive than ROSES/APRA can accommodate. (~\$10M maximum)
- Pioneers: A new class of small missions offered for first time in ROSES-2020, \$20M maximum PI cost cap

Why is Pioneers a good idea?

- Numerous opportunities for low cost rideshare and s/c bus.
- Superpressure balloon capability just now coming on line
- Incorporate lessons learned from ISS-CREAM, GUSTO, and recent large suborbital payloads

Strengthens our partnership with commercial providers

SpaceX's SmallSat rideshare Program

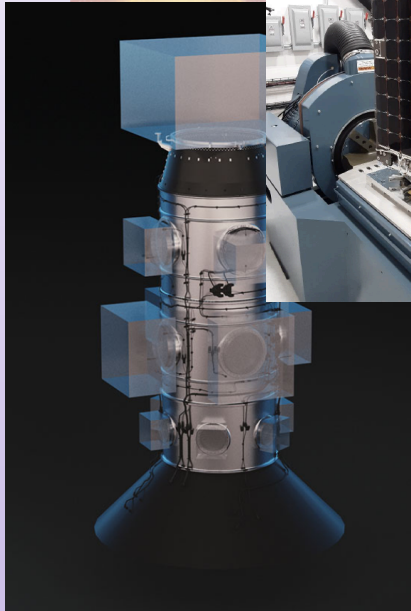
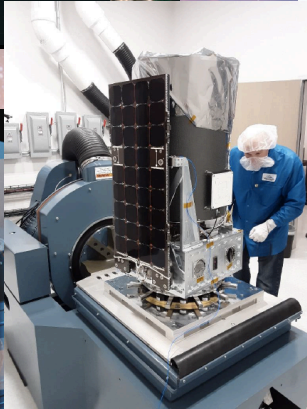
- Monthly rideshare missions starting 3/2020
- ESPA class payloads, 200 kg for "as low as \$1M", to LEO including SSO
- CSLI \$0.9M for 12U CubeSat in last APRA

York Space Systems S-class bus

- 3-axis stabilized (10", 1.5°/s)
- 85kg payload, in operation
- \$1.2M, comparable to CubeSats

BCT 'S5' Bus

- \$2.7M, in Operation
- AFRL ~0.5m telescope





Astrophysics Pioneers

- Astrophysics Pioneers
 - Include SmallSats, CubeSats >6U, major balloon payloads, and modest ISS attached payloads with a \$20M cost cap, not including launch.
 - Fill in the gap between existing ROSES investigations (<\$10M for APRA) and existing Explorers MO investigations (~\$35M for SmallSats)
 - Solicited through ROSES; relieves burden of writing full Explorers MO proposal
 - Managed as Research and Analysis projects with enhanced research project processes with defined gates and light touch management from WFF and HQ, rather than flight project processes appropriate for a SMEX.
- NASA will no longer solicit ISS attached payloads within APRA
- NASA will no longer solicit balloon payloads within Explorers MO



Pioneers Timeline

10 Feb 2020	FY21 President's Budget Request
20 Feb 2020	Community announcement
5-6 Mar 2020	APAC meeting
Spring 2020	Release draft ROSES-2020 amendment
July 2, 2020	Final ROSES-2020 amendment
Aug 13, 2020	Mandatory Notices of Intent due
Oct 1, 2020	Proposals due
Early 2021	Selections announced

Funding starts with FY21

Concept Study Review in 2021/2022

Launch readiness date(s) NLT 2026