National Aeronautics and Space Administration

APD Technology Development / Small Mission Balance

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NASA's Astrophysics Division

Outline

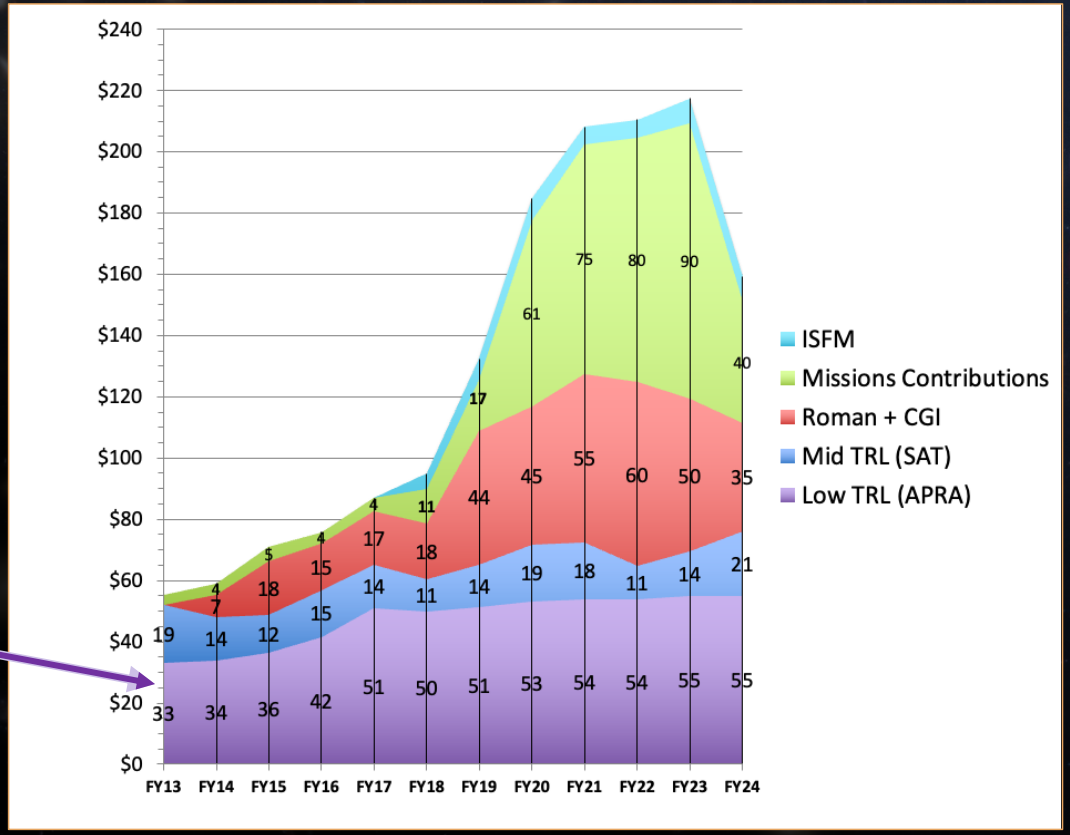
- Technology Funding
- Balance
- Suborbital Projects
- Orbital Projects
- Policy Issues

Why and How We Invest

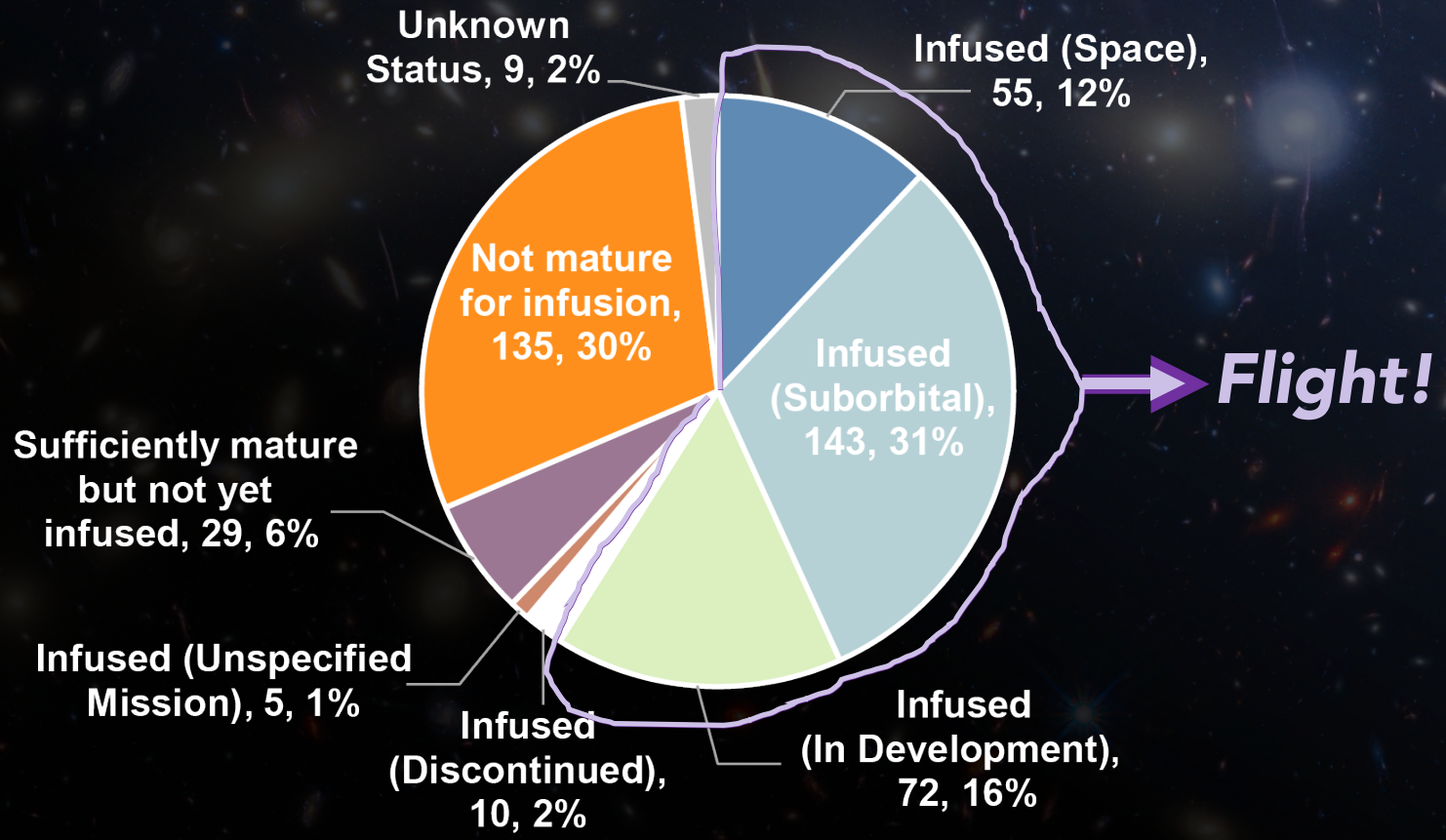
- Astrophysics Division supports a wide range of technologies; everything that is unique to an astrophysics mission need should be fundable somewhere in our portfolio
- Mix both for specific, identified missions (ex: Habitable Worlds Observatory) and those yet to be identified (Explorers)
- Mix of selection mechanisms: primarily via open proposal opportunities but also via directed funding
- Mix of both low-Technology Readiness Level (TRL1-3) and maturation for space flight readiness (TRL4-6)

Astrophysics Technology Investments

- At top: mission-driven
- At bottom: proposal-driven
- Small missions here



Infusion Status, 2010-2020



From Technology Maturation to Infusion

January 2009 - December 2023

		Space	Rocket	Balloon	Airborne	Ground	Total
Infused	Implemented [1]	19	25	11	3	43	**101**
	Upcoming [2]	31	13	8	1	6	**59**
Infused Subtotal		**50**	**38**	**19**	**4**	**49**	**160**
Potential	Concepts [3]	62	-	-	-	-	**62**
	Ready [4]	3	-	-	-	-	**3**
Potential Subtotal		**65**	**-**	**-**	**-**	**-**	**65**
Infused/Infusable Total		**115**	**38**	**19**	**4**	**49**	**225**

Credit: Opher Ganel & PhysCOS-COR technologists

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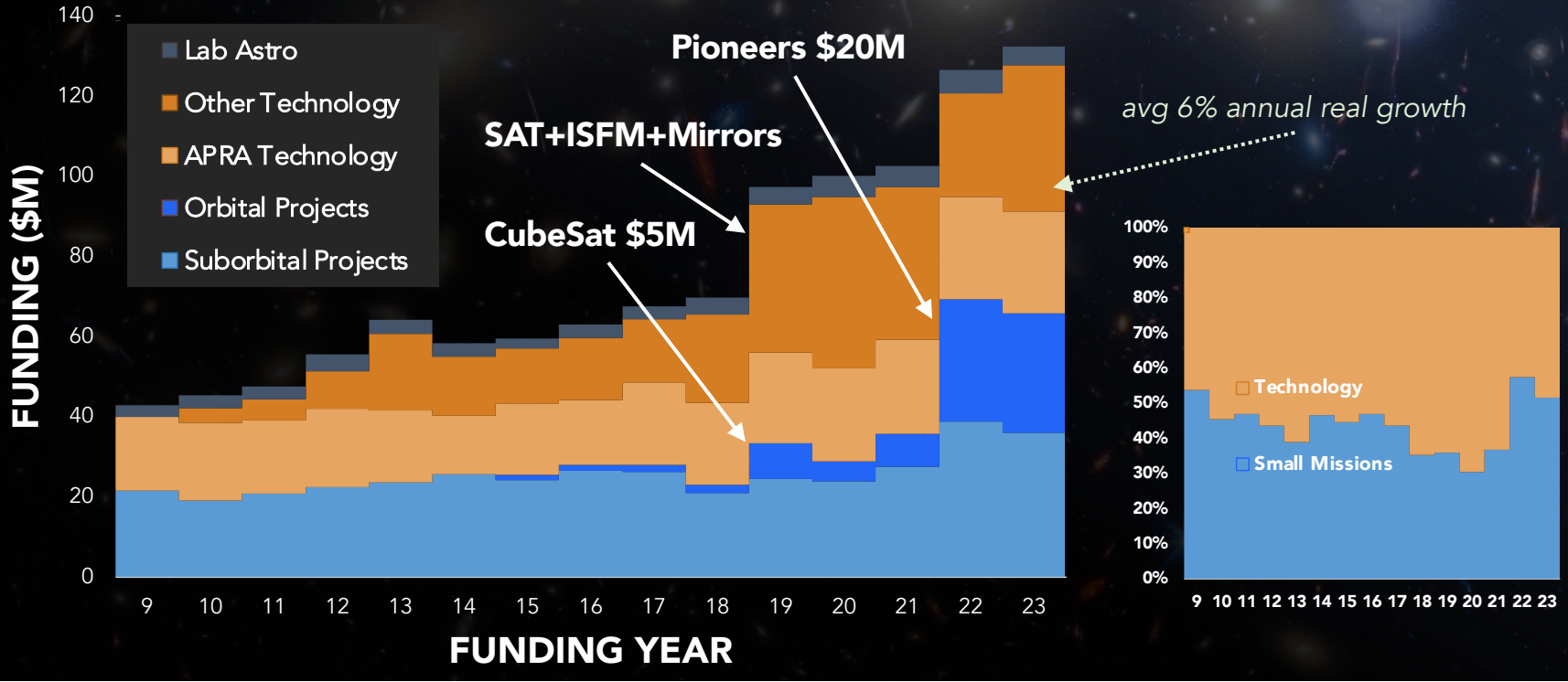
APRA+SAT Proposal Statistics

Year	Submitted		Funded	
	APRA	SAT	APRA	SAT
2015	151	29	60 (40%)	7 (24%)
2016	141	30	54 (38%)	8 (27%)
2017	169	25	52 (31%)	11 (44%)
2018	164	30	58 (35%)	12 (40%)
2020	170	–	45 (26%)	–
2021	155	40	57 (30%$)	16 (40%)
2022	147	37	38 (28%$)	13 (35%)
2023	163	41	36 (20%$)	12 (29%)

Selection rate decline

Small Mission Balance

- **APRA** (tech, lab astro, suborbital-class, CubeSats) **+ Pioneers + SAT, RTF, ISFM, Mirrors**



Outline

- Technology Funding
- Balance
- **Suborbital Projects**
- Orbital Projects
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Suborbital Projects

Balloons:

PICTURE – launched from Ft. Sumner 2022, in data analysis
Spider – launched from McMurdo 22/23 season, in data analysis
SuperBIT – launched from Wanaka 2023, in data analysis
HELIX – launched from Sweden 2024, in data analysis
FIREBALL2 – launch from Ft. Sumner 2024
THAI-SPICE – launch from Ft. Sumner 2024
EXCITE – launch from Ft. Sumner 2024
EXCLAIM – first launch 2024
ASTHROS – launch from McMurdo 24/25 season
GAPS – launch from McMurdo 24/25 season
TIM – launch from Ft. Sumner 2025
ADAPT – launch from McMurdo 25/26 season
GRAMS – first launch 2026
PBR – launch from Wanaka 2027
TAURUS – launch from Wanaka 2027

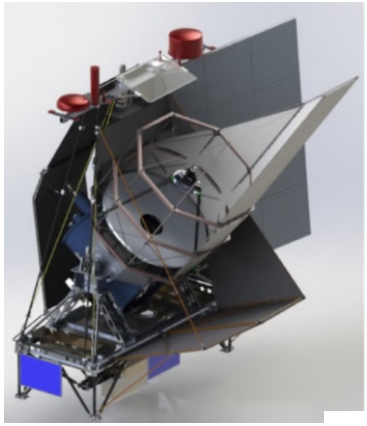
Sounding Rockets:

CHESS/SISTINE – launched from Northern Territories 2022, in data analysis
DEUCE/INFUSE – launched from White Sands 2023, in data analysis
FORTIS – launched from White Sands 2023, in data analysis
CIBER – launched from White Sands 2024, in data analysis
SHIMCO – launch 2026

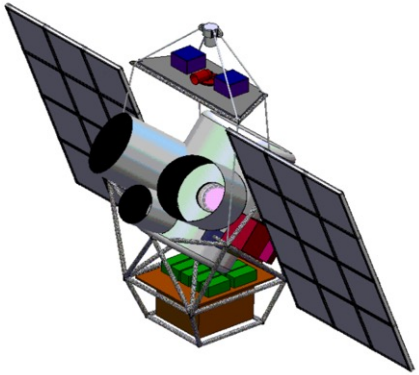
APRA IR Balloons

ASTHROS: PI Jorge Pineda, JPL, Launch 24/25 McMurdo mapping MW star forming regions with [NII] 122um (2.675 THz) and 205um (1.461 THz).

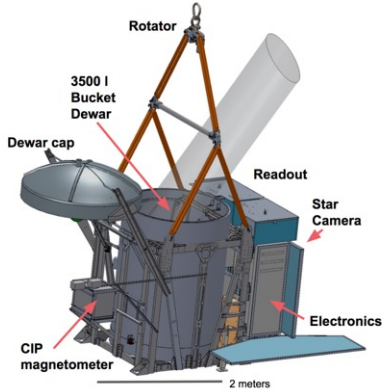
TIM (Terahertz Intensity Mapper): PI Joaquin Vieira. U Illinois, Ft Sumner 24/25, McMurdo 26/27



SPIDER: PI Jeff Filippini, U Illinois, CMB B-mode probe with 94 and 150 GHZ (McMurdo 13/14) 280 GHZ (McMurdo 22/23).



TAURUS: PI Steven Benton, Princeton, SPB Dust Polarization Experiment. Launch Wanaka FY27.



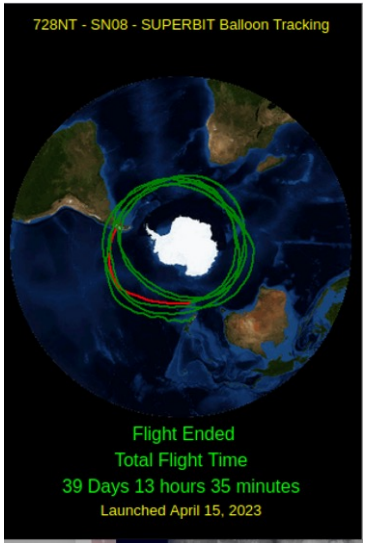
EXCLAIM: PI Eric Switzer, GSFC, mapping CO in star forming $0 < z < 3.5$). First launch Ft Sumner CY24

APRA UV/VIS Balloons

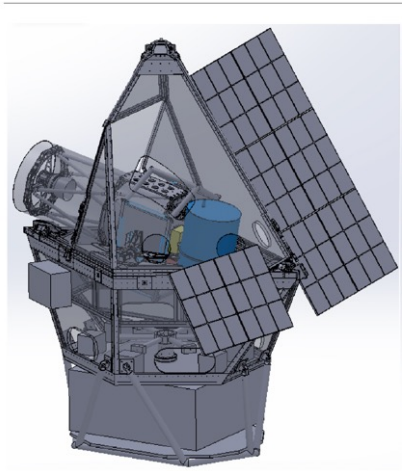
FireBall: PI Chris Martin Cal Tech, Launch 9/2018, 9/2024 Ft Sumner, UV MOS, d-doped EMCCD, French gondola, galaxy evolution, ICM/GCM emission

PICTURE: PI Supriya Chakrabarti / Chris Mendillo, Launch 9/2020,9/2022 Ft Sumner, VV/EMCCD coronagraph testbed, eps Eri

SuperBIT: PI Bill Jones, Princeton, Launch 3x 2016-2019, April 2023 NZ. Optical diffraction limited imaging with 0.5m -> 1.5m telescope. Omega Nebula 2018



- **THAI-SPICE,** PI Eliot Young, SWRI CO, Launch ¼ scale 9/2019, Full Scale 9/2024, Ft Sumner, **T**estbed for **H**igh-**A**cuity Imaging, **S**table **P**hotometry and **I**mage-motion Compensation **E**xperiment

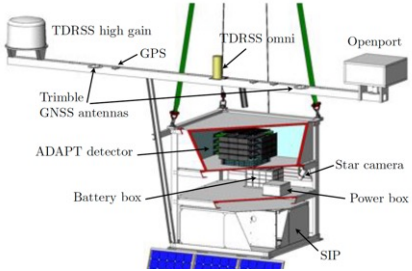


EXCITE: PI Peter Nagler GSFC, 0.5m telescope, Launch 9/2024 Ft Sumner, then NZ 1-4m spectra of hot Jupiters over full orbit

APRA PA Balloons

GAPS (General Antiparticle Spectrometer):
PI Chuck Hailey, Columbia,
Launch 24/25 McMurdo
Search for Antimatter via annelation x-ray emission.

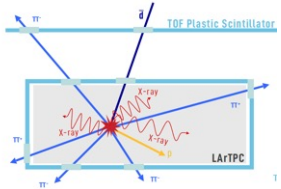
ADAPT (Antarctic Demonstrator for the Advanced Particle-Astrophysics Telescope):
PI James Buckley, WUSTL
Launch McMurdo 25/26



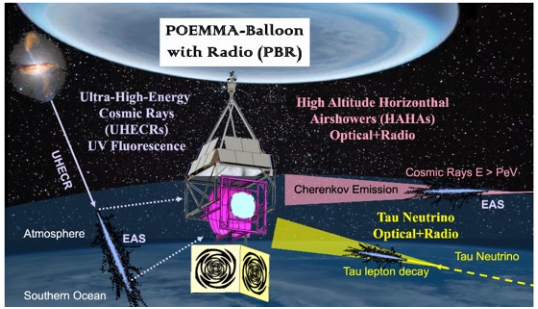
HELIX (High Energy Light Isotope eXperiment):
PI Scott Wakely, U Chicago
Cosmic Ray light element/isotopic composition with super conducing magnetic rigidity spectrometer.
Launched FY24 Sweden

PUEO: PI Abby Vieregg, U Chicago started as an APRA PA award before successfully transitioning to the Pioneer Program.

GRAMS
PI Tsuguo Aramaki, Northeast U
Launch FY26, first commercial balloon launch in ROSES
Liquid Argon detector for antimatter and HE search.



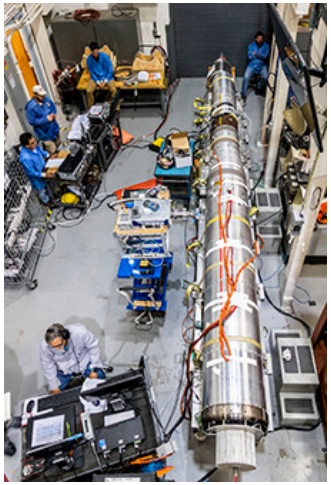
POEMMA-Balloon with Radio (PBR)
PI Angela Olinto, Columbia U
Detection of UHECR through extensive air-showers (EASs) fluorescence and radio
Launch 26/27 Wanaka



APRA U/VIS Sounding Rockets

Australia launch July 2022:
SISTINE, DEUCE, and DLX,
ELA launch, Northern Territories

DEUCE/INFUSE: PI Brian Fleming CU, B-star EUV flux cal and next gen EUV spectrograph, launch, WSMR 12/2018, WSMR 10/2020, ELA 6/2022, WSMR 10/2023

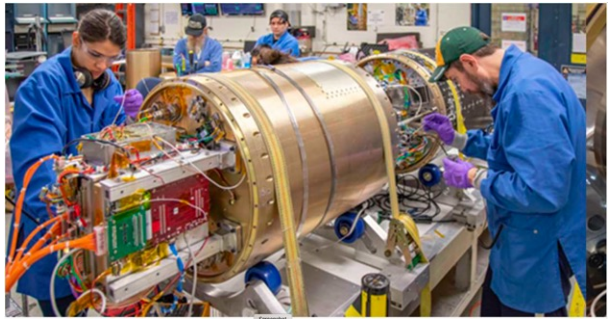


FORTIS: PI McCandliss JHU, Far-UV Off Rowland-circle Telescope for Imaging and Spectroscopy. Launch WSMR 10/2019, 2/2024

CHESS/SISTINE: PI K. France CU, next gen UV coatings/gratings/MCP, launch Kwajalein Atoll April 2018, WSMR Nov 2021, ELA July 2022

CIBER: PI Michael Zemcov RIT, Cosmic IR BG Experiment, Launch 2013 WFF, WSMR 2021/2023/2024

SHIMCO: PI: Corliss, U of AZ, high R spectroscopy of H2 in Orion molecular cloud, LRD early 2026



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Lots of launches coming up!

C: BurstCube, Space-X ISS resupply, 3/21/2024 Launched; , 4/18/2024 Deployed

C: SPARCS, March 2025, launch not yet identified

C: SPRITE, Space-X rideshare with ESD, April 2025

C: BlackCat, July 2025, launch not yet identified.

P: Pandora, LRD 9/2025

P: ASPERA, LRD 2/2026

P: TIGERISS, LRD 10/2026

P: PUEO, LRD 12/2026

P: StarBurst, LRD 1/2027

P: Landolt, launch NET 2027

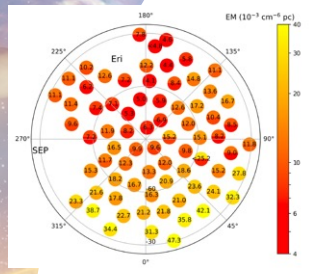
C: MANTIS, launch NET 2028

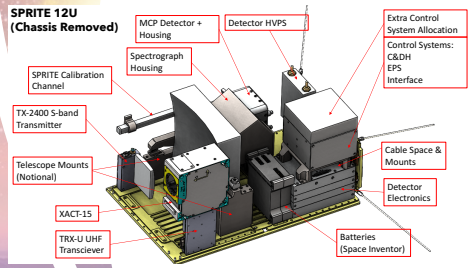
P: POEMM, launch NET 2029

C: CubeSat ***P: Pioneer***

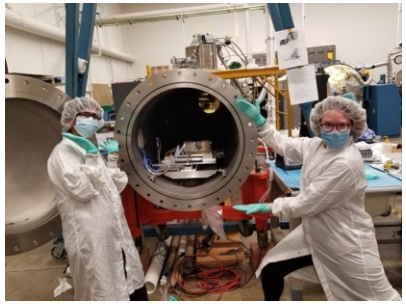
APRA CubeSats

HaloSat: PI Phil Karret U of Iowa, Launch 5/2018, reentry 2/2021, OIV line in Galaxy Halo, found unexpected structure of Halo

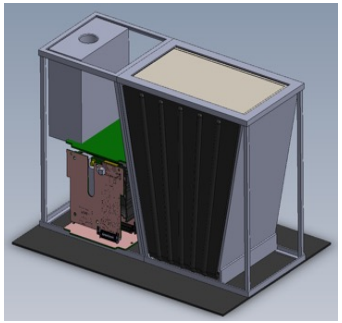




SPRITE: PI Brian Fleming U CO, First APD 12U, UV spectra of ionizing radiation from star forming galaxies, Bus in house, launch 4/25, Space-X Transporter



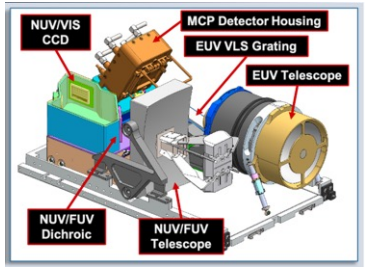
CUTE: PI Kevin France U CO, launch 9/2021
In operation
UV Imaging of Hot Jupiter ablation,BCT bus, Arika Egan & Ambily Suresh in lab



BlackCat: PI Abe Falcone Penn St., Launch NET 7/2025, 2-20 KeV wide FOV localization of X-ray Transients, real-time 'cell phone' downlink, NanoAvionics bus

BurstCube: PI Jeremy Perkins GSFC, launch 3/2024, **in commissioning**, GRB monitor w/ TDRSS link, GSFC Bus

SPARCS: PI Evgenya Shkolnik ASU, Launch NET 3/2025,Two UV band monitoring of M-star flares to investigate planetary habitability effects, BCT bus



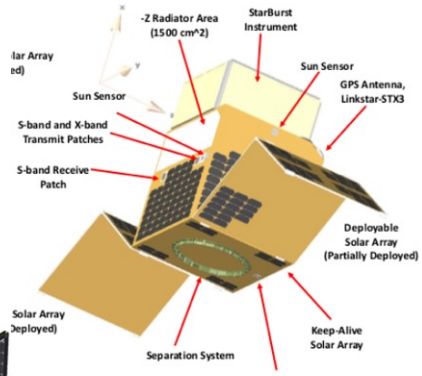
MANTIS: PI Briana Indahl, U CO, Launch NET 2028, EUV-NUV stellar flux on ExoPlanet Habitability, Bus in house

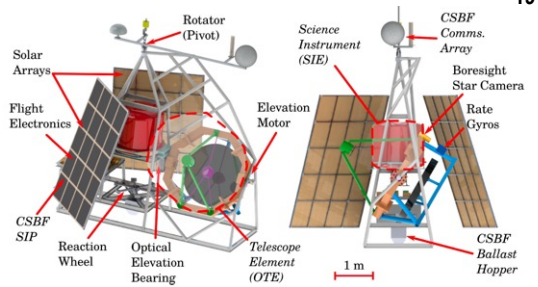
CANDLE:
PI Susana Deustra NIST, three-year build of EDU, goal is 0.1% absolute calibration of 0.4u-2.5u flux scale for astronomy

Pioneers SmallSats

Figure 10: A rendering of the PUEO payload, including a design for the low-frequency drop-down instrument.

PUEO: A Long-duration Balloon-borne Instrument for Particle Astrophysics at the Highest Energies, PI Abigail Vieregg, U Ch LRD 12/2026, Antarctic ULDB





POEMM: High resolution tomography in proto-planetary disks, PI Gordon Stacey Cornell, LRD 12/29, New Zealand ULDB

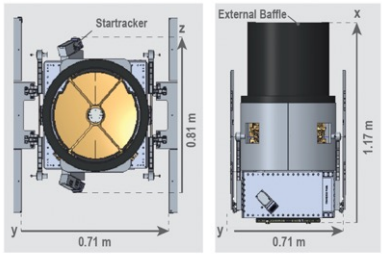


Figure 13: BCT X-SAT-9 is accommodated by an EELV Secondary Payload Adapter (ESPA) Grande 5-m fairing The stowed volume is 1,173.7 mm in X-axis, 809.2 mm in Z-axis, and 709.9 mm in Y-axis. Shown here with arrays deployed (left panel) and stowed (right).

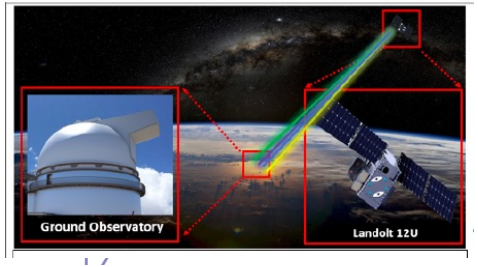
Aspera: IGM Inflow/outflow from galaxies via OVI 10^5K emission line imaging. PI Carlos Vargas, U of A, SFL bus, eLiFl mirror coating. LRD 2/26, 60kg

StarBurst: Gamma-ray ASM, Simultaneous detection of NS/NS mergers with LIGO, PI Daniel Kocevski MSFC, SFL bus, ESPA-G, 0 inclination preferred, LRD 1/27, 300kg

Landolt: Absolute stellar photometry, PI Peter Plavchan GMU, BCT bus, 12U GEO, LRD mid 2027, 16kg

Pandora: Multiwavelength Characterization of Exoplanets and their Host Stars, PI Elisa Quintana, GSFC, BCT Bus, LRD 9/25, 250kg

TIGERISS: measuring ultra-heavy (r-process) cosmic rays on ISS, PI Brian Rauch, Wash U. LRD 10/26, 300kg



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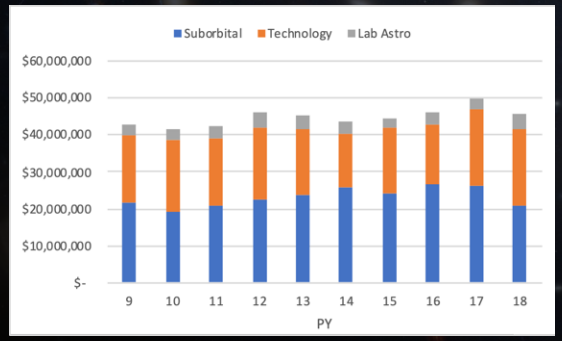
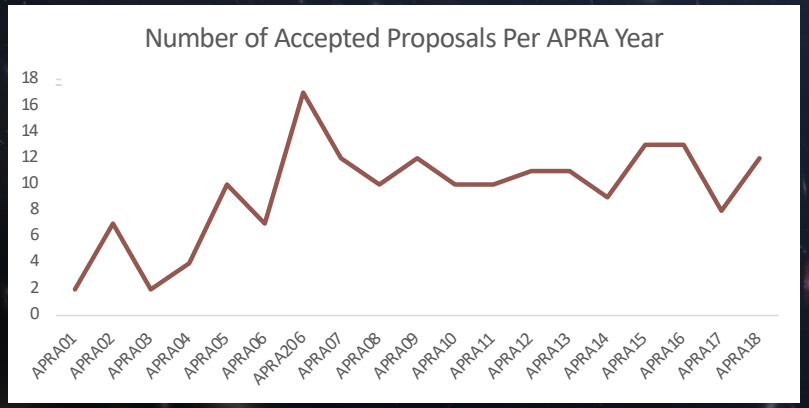
For APAC Consideration

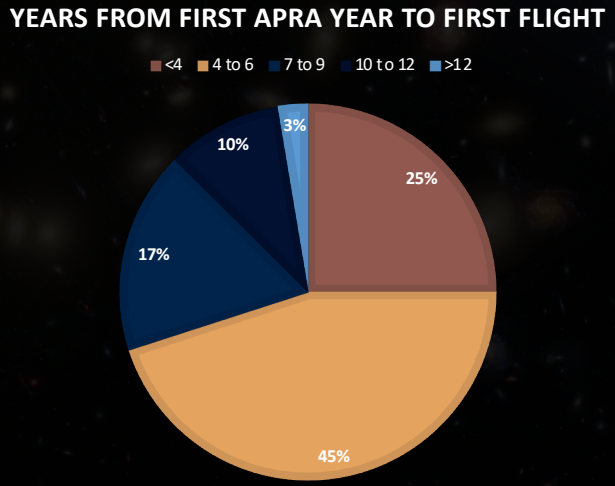
- *How to prioritize "balance" of the investment into 'pure' technology development, mission technology development (SAT, directed), and suborbital/small missions?*
- Balance in use of Suborbital and Small Missions for supporting early career researchers vs. doing science
- Pressure for bigger projects vs. more projects
  - Balloons
  - CubeSats
- Balance in use of small missions for science vs. tech dev

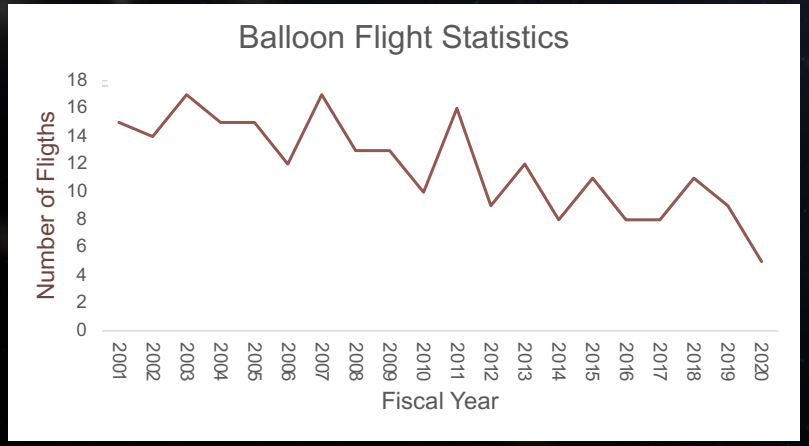
Balloon Flight Rate Decreasing: *better vs. faster?*

- **Selected:**
- **Flown:**









Wiser & Benford, AAS #237 432.04

CubeSat Costs

- **Cost have been increasing, largely due to vendor price increases; also projects are delayed and on-orbit operations continue**
- **We have been advertising/targeting 1 new CubeSat per year.**
- ***This is no longer possible at $5M/year.***
- **We did not select a new CubeSat last year, only an EDU build.**
- **APRA SubO is for early career training; we are providing fewer such opportunities if we decrease the selection rate.**
- ***Sustainability: select <1/yr, lower cap, reallocate funds; which?***

sum of 6	$37.5M
average	$6.2M*
last 4	$27.7M
average	$6.9M**
last 2	$15.7M
average	$7.8M***

Strategic Technology Flight Demonstration

- SAT tech maturation does not currently allow flight projects
- APRA "merit" includes both scientific and technology value
  Pioneers "merit" focus on scientific value (both emphasize early career)
- Opinion: in practice, selected small orbital missions emphasize science over technology demonstration
- SAT *could* allow for CubeSat-class (~$10M) proposals as a pilot project to try out flight technology maturation
- Constant funding → displacing other SAT selections
- If cap set at $10M (~12U CubeSat), displaces ~4 projects
- *Is it beneficial to offer this and let peer review decide?*

For APAC Consideration

- *How to prioritize "balance" of the investment into 'pure' technology development, mission technology development (SAT, directed), and suborbital/small missions?*
  - *Metrics for appropriate balance between tech dev + small missions?*
  - *Should balance depend on strategic missions? Science area / Field?*
- **Balance in use of Suborbital and Small Missions for supporting early career researchers vs. doing science**
- **Pressure for bigger projects vs. more projects**
  - **Balloons:** *bigger vs. faster?*
  - **CubeSats:** *sustainability?*
- **Balance in use of small missions for science vs.** *tech dev?*

Thank You!