PAN-CHROMATIC ASTRONOMY IN THE 2020S: A STRAWMAN AFFORDABLE PROGRAM.

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Introduction: For two and more decades astronomy has enjoyed ready contemporaneous access to matched facilities across the entire electromagnetic spectrum. There is a danger that this capability will be lost in the 2020s. Many of us believe that this pan-chromatic coverage is an essential part of 21st century astrophysics. The problem is the cost of maintaining a set of Great Observatories.

When planning the future program for space astrophysics there is a tendency to assume that ambitious missions must be expensive flagships. This idea leads to the potential 2020s crisis of coverage, since we cannot fit a set of flagships into the budget. It is not necessarily true, however, but is a technology-dependent statement.

By good fortune we are at a point at which new technologies enable order-of-magnitude advances in almost every waveband. The result is that a prudent choice of missions can create a powerful pan-chromatic program for the 2020s.

A Strawman Program: In order to see whether an affordable pan-chromatic program is possible in the 2020s, the set of Probe white papers submitted to NASA[1] and the ESA M-class proposals were studied. Table 1 presents a sub-set of these proposals chosen to span the electromagnetic spectrum.

To demonstrate that such a program need not exclude flagships altogether, Lynx is included. In addition a notional UV-only mission was included, and Gamma-ray Explorer (an MeV SMEX, based on the COSI balloon experiment) was added. AMEGO and Gamma-ray Explorer can be combined into a single gamma-ray observatory.

Column 3 shows the ballpark gain in performance over the predecessor mission listed in column 4. Values range from 10 to 800. The total cost is $6.3 B.

Discussion: A pan-chromatic astronomy program with ambitious order(s)-of-magnitude advances in all bands is possible, as Table 1 shows. The mission costs span from Explorer to flagship class, with most falling in the Probe range.

Of course all these costs are nominal and subject to increases. However, it will be easier for NASA to exert cost control when there are half a dozen missions in the program rather than one “too big to fail” flagship. If NASA were to deliberately over-select and plan on a down-select based on cost control before competing proposals were submitted, this too might encourage realistic costing.

The Astro2020 Decadal could put a pan-chromatic program as its top priority, ensuring that this goal is treated as a whole. The second place ranking of the Explorer program in the 2010 Decadal is a good precedent for this approach.

References: [1] Swinyard, B. and Nakagawa, T., 2009, Exp Astron (2009) 23:193. [2] Hamden, E.T., et al., 2017, arXiv:1701.02733. [3] Fleming, B.T., et al., 2016, Proc. SPIE, 9905, eds. J.-W.A. den Herder, T. Takahashi, M. Bautz. [4] Gaskin, J.A. et al., 2015, in: “UV, X-Ray, and Gamma-Ray Space Instrumentation for Astronomy XIX”, Proc.of SPIE. No.9601, Art. No. 96010J. ISBN 978-1-62841-767-8. [5] Harrison, F., et al., 2016, https://pcos.gsfc.nasa.gov/physpag/probe/probewp.php, 2017 Feb 7. [6] Zoglauer, A., et al., https://asd.gsfc.nasa.gov/conferences/future_gamma_obs/program/COSI_final.pdf. [7] McEnery, J., et al., 2016,https://pcos.gsfc.nasa.gov/physpag/probe/probewp.php, 2017 Feb 7. [8] Tatischeff et al. (2016), Proc SPIE vol.9905, 99052N.

Table 1: A Strawman Affordable Pan-Chromatic Astronomy Program for the 2020s

Band	Example New Mission	Factor gain	Predecessor	ROM Cost estimate	Technical Advance	Ref.
Far-IR	SPICA/ESA-M5	×100	Herschel	~$0.8 B	Cold primary mirror	1
UV/FUV	Probe	×10	FUSE, HST-COS	~$1 B	High efficiency coatings, detectors	2,3
X-ray	Lynx	×50-800	Chandra	~$3 B	Novel X-ray Optics	4
Hard X-ray	HEXP	×50	NuSTAR	~$0.5 B	Improved angular resolution, area	5
MeV#	Gamma-ray Exp	×100	COMPTEL	~$0.3 B	Detection efficiency	6
GeV#	AMEGO	×10	Fermi LAT	~$0.7 B	Higher mass c/o cheap launchers,	7,8

Refs: 1. Swinyard and Nakagawa (2009); 2. Hamden et al. (2017); 3. Fleming et al. (2016); 4. Gaskin et al. (2015); 5. Harrison et al. (2016); 6. Kierans, et al. (2017)arXiv:1701.05558; 7. McEnery et al. (2016), 8. Tatischeff et al. (2016).