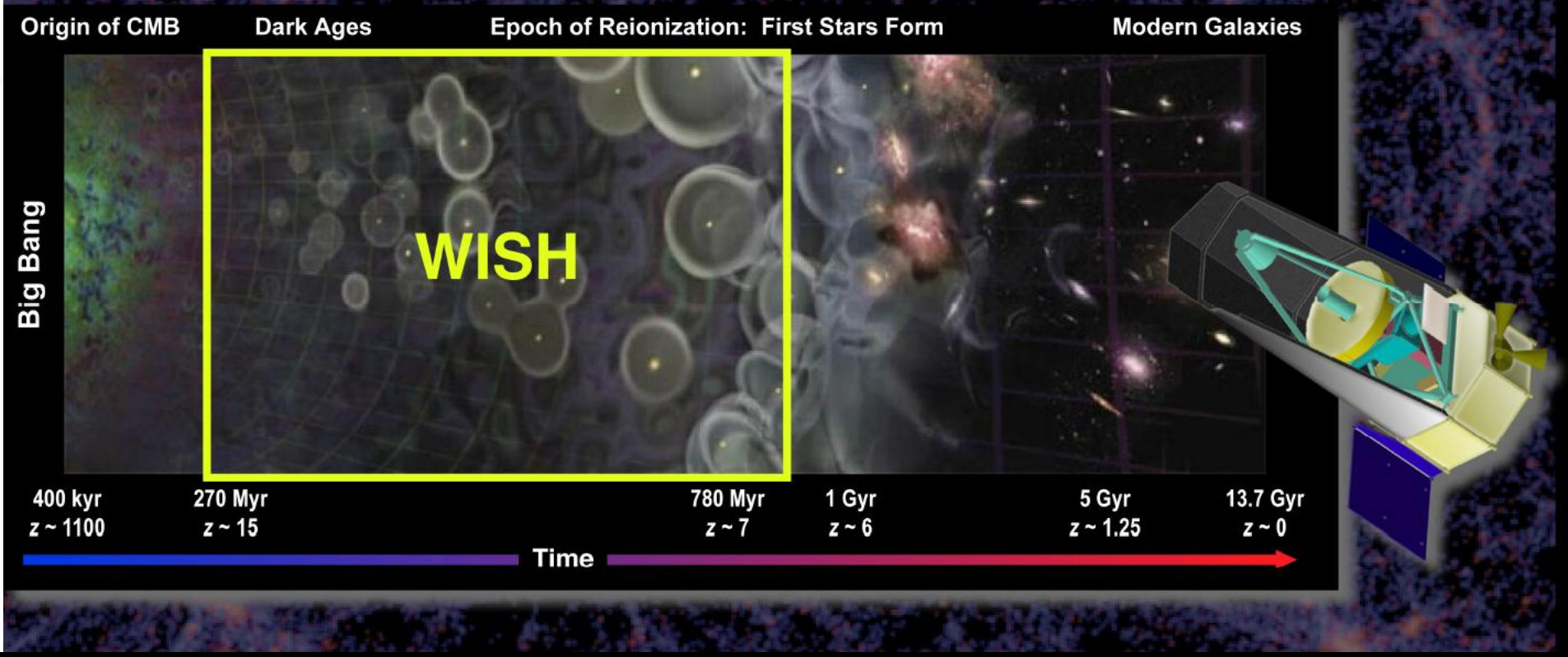
Participation in the JAXA/ISAS Mission WISH: Wide-field Imaging Surveyor for High-redshifts



Matt Ashby
Joe Hora

Smithsonian Astrophysical Observatory has proposed to NASA to team with the JAXA/ISAS WISH project to

- perform groundbreaking surveys of the Cosmic Dawn
- supply the WISH focal plane consisting of 32 H2RG HgCdTe (0.9 – 5.0 μm) arrays
- Operate the U.S. WISH Data Center

SAO-WISH Science Team

- Giovanni Fazio – SAO WISH P. I.
- Gary Melnick – SAO WISH Deputy P. I.
  - will assist Dr. Fazio in leading the SAO science team,
  - develop the survey observing plans
- Matthew Ashby
  - US lead for source extraction, bandmerging, catalog construction, and identification of high-redshift sources in the WISH surveys.
  - Help establish the US-WDC
  - FPA testing
- Joseph Hora
  - lead FPA test effort at SAO
  - support the science survey planning
  - data reduction and analysis techniques
  - Galactic science programs.
- Howard Smith
  - science and data programs
  - direct the US-WDC.
- Volker Tolls
  - FPA testing, develop on-ground science tests
  - on-orbit check-out and performance monitoring
  - Galactic science programs.
- Zhong Wang
  - Participate in FPA testing
  - oversee the science data pipeline design and implementation
  - statistical analysis of the faintest galaxy population.
- Steven Willner
  - participate in FPA testing
  - Observing program design, and
  - science analysis of distant galaxies and active galactic nuclei.
- Daniel Eisenstein
  - study of intermediate and high-redshift galaxies with WISH, focusing on the impact of large-scale structure.
- Lars Hernquist
  - participate in the interpretation of the observations
  - perform cosmological simulations of galaxy and structure formation.
- Avi Loeb
  - will develop state-of-the-art models of high-redshift galaxies in the WISH wavelength range.

SAO Proposal Status

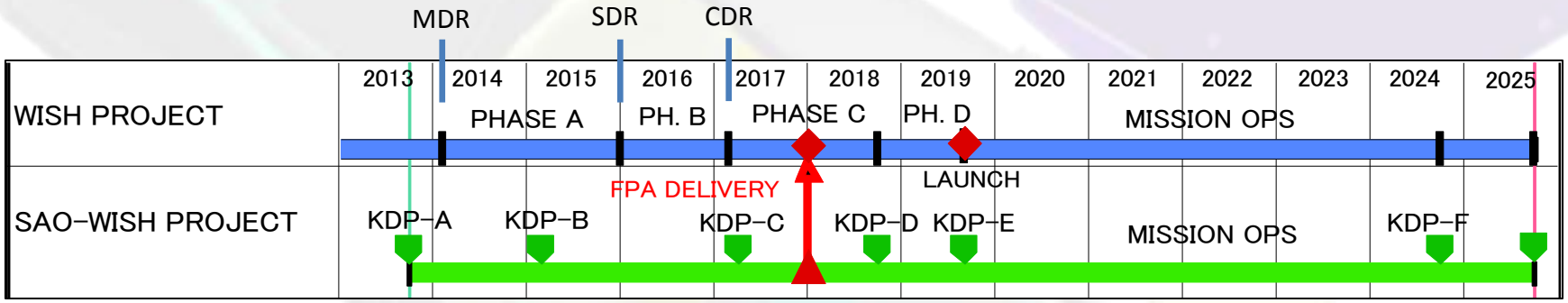
- Proposal to NASA prepared in Fall 2012
  - Second Stand Alone Missions of Opportunity Notice (SALMON-2) Astrophysics Mission of Opportunity (MO) science investigations through the Explorer Program
  - Rough Order of Magnitude (ROM) price estimate obtained from Teledyne ~ $35M
  - Science case and Management Plan written, level of effort at SAO determined for FPA testing and science participation
  - Proposal submitted in December 2012, total $59.5M including ~25% reserves
- Decision expected in mid-2013

Comparison of WISH, Euclid, WFIRST, JWST

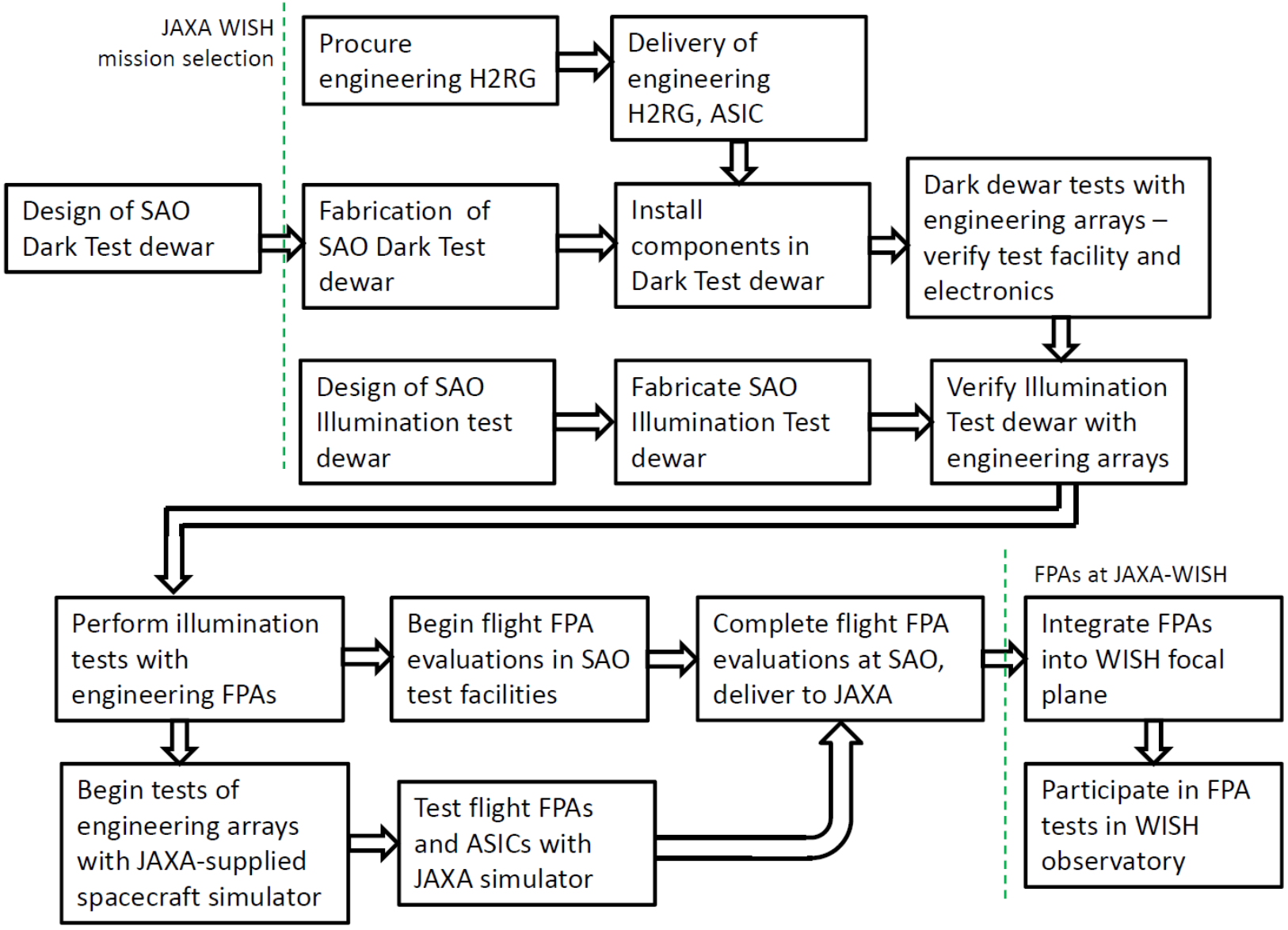
	Euclid[a]	**WFIRST** (DRM1)[b]	**WFIRST** (NRO)[c]	**JWST**	**WISH**
Mirror	1.2m	1.3m	2.4m	6.5 m	1.5m
FOV	0.55 deg^2	0.375 deg^2	0.375 deg^2	0.0026 deg^2	0.24 deg^2
Visible Imager	0.55 – 0.90 μm	——	——	0.6 – 2.3 μm	——
NIR Imager	0.92 – 2.0 μm	0.73 – 2.4 μm	0.92 – 2.0 μm	2.4 – 5 μm	0.90 – 5.0 μm
Lim. Mag. (5σ)	24 AB	26 AB	27.5 AB	29.1 AB[d]	28 AB[e]
Survey Area	15,000 deg^2	3,400 deg^2	~ 3,400 deg^2	0.044 deg^2[d]	100 deg^2[e]
NIR Spectroscopy	1.1 – 2.0 μm	——	Grism 1.3 – 2.0 μm	Grism 2.4 – 5.0 μm	Grism Option 1 – 5 μm
Primary Science	Dark Energy, Dark Matter	Dark Energy, Exoplanets, Deep NIR Surveys	Dark Energy, Exoplanets, Deep NIR Surveys	First Galaxies	First Galaxies, Reionization, Galactic Science

[a] [27]; [b] Green et al. [35]; [c] Dressler et al. [22]; [d] JWST NIRCam Mosaic of the Chandra Deep Field South [44]; [e] WISH Ultra-Deep Survey; the WISH Extreme Survey reaches 29.5 AB mag within 0.24 deg^2.

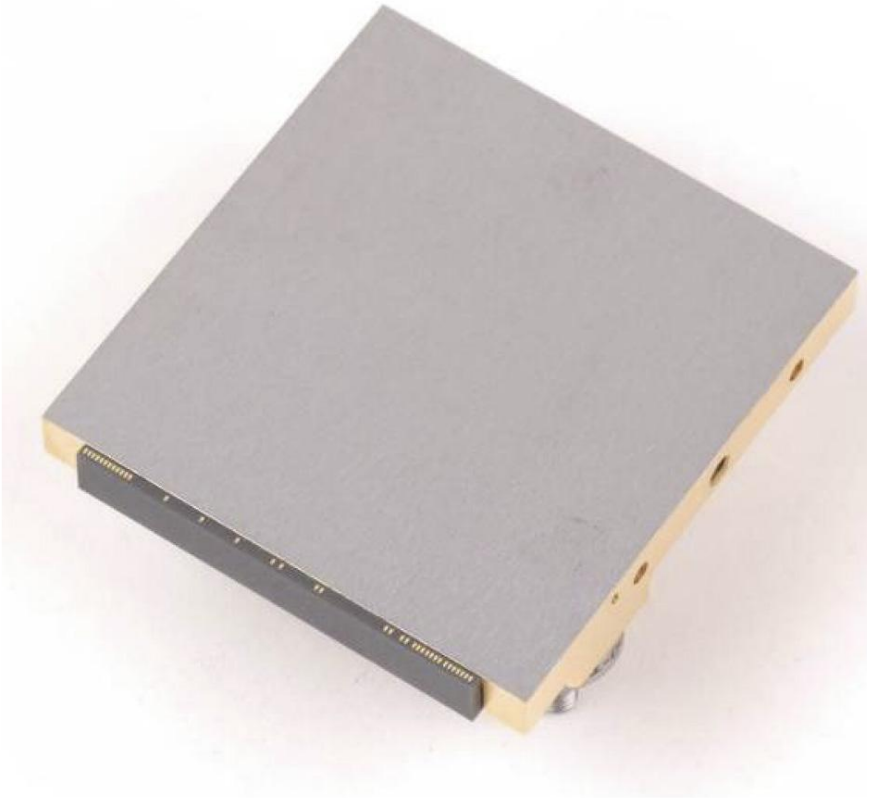
Project Schedule Summary

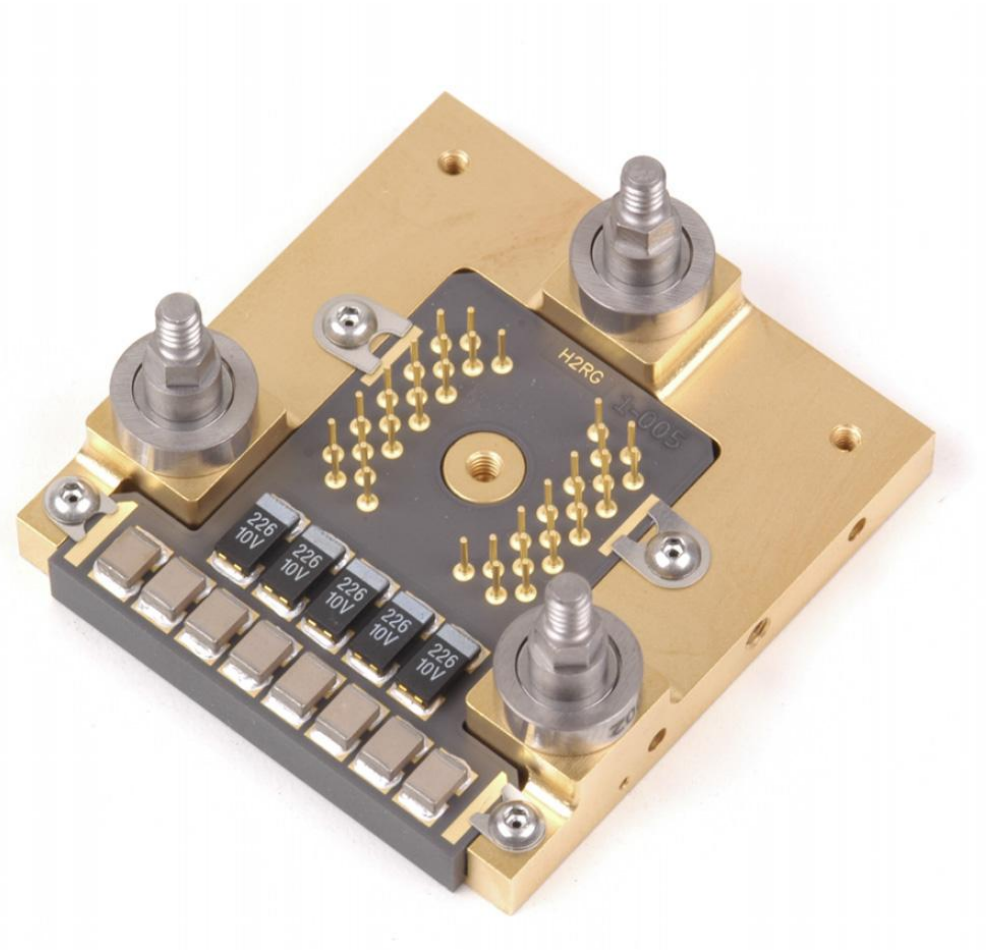


FPA Test Flow

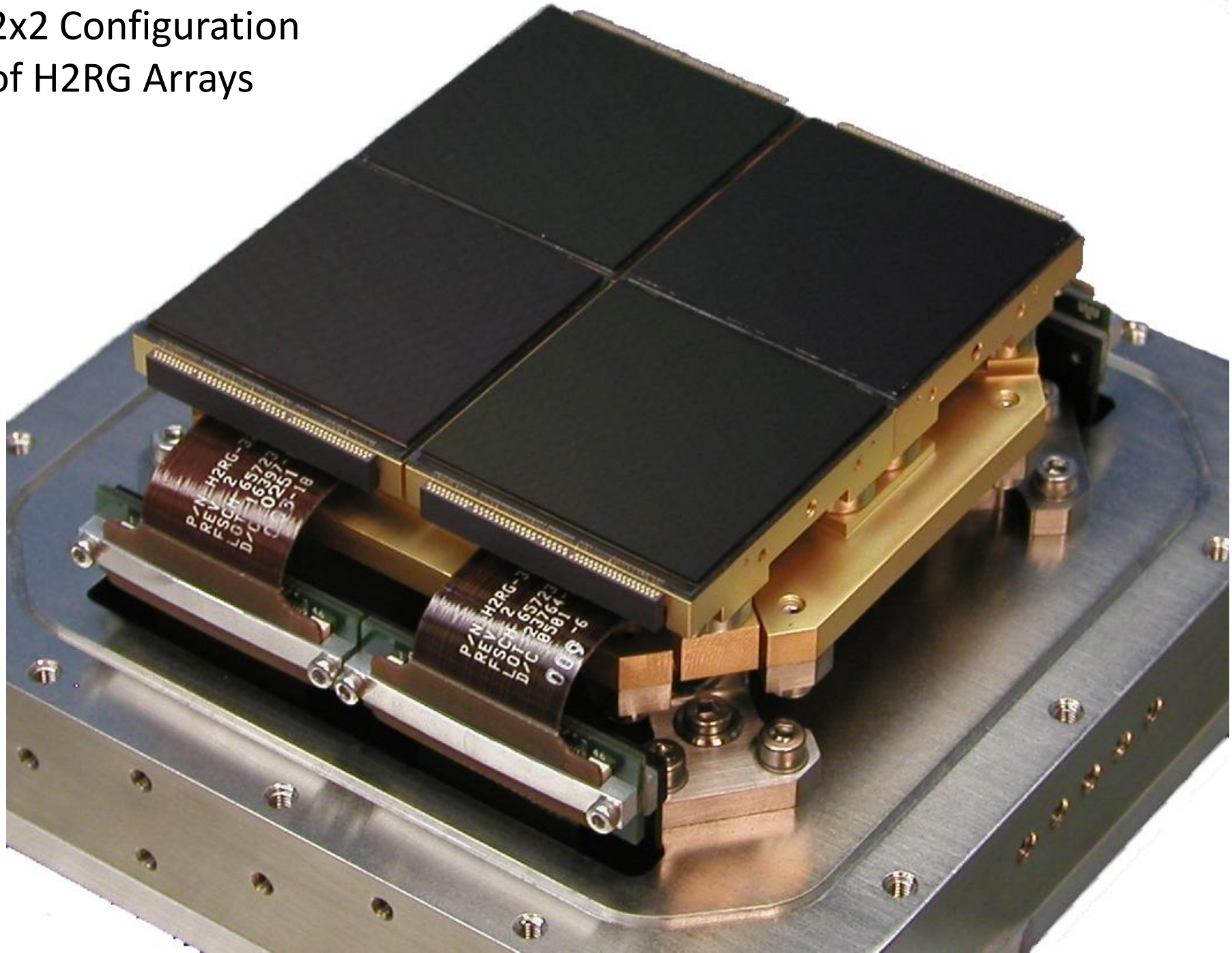


H2RG Flight Packaging





2x2 Configuration of H2RG Arrays



FPA Requirements and Margin

FPA Parameter	Requirement	Expected	% Margin
Median read noise	≤15 e-/sec	≤12 e-/sec	25
Median pixel-pixel crosstalk	≤4 %	≤2%	100
Median quantum efficiency	≥70%	≥80%	14
Median dark current	≤0.05 e-/sec	≤0.01 e-/sec	400
Median well capacity	≥65000	≥85000 e-	30
Inoperable pixels	≤5%	≤1%	400

Time Requirements for Surveys

	Depth (5σ) (AB Mag.)	Area (deg^2)	Center Wavelengths (μm)	Survey Time[a] (years)
Ultra-Deep Survey (UDS)	28	100	1.0, 1.4, 1.8, 2.3, 3.0	3.48
Ultra-Deep Survey, 4μm (UDS-II)	28	10[b]	UDS + 4.0	0.24
Ultra-Wide Survey (UWS)	25	1,000	1.0, 1.4, 1.8, 2.3, 3.0, 4.0	0.24
Extreme Survey (ES)	29.5	0.24	1.0, 1.4, 1.8, 2.3, 3.0	0.13

Assumes 85% observing efficiency toward the ecliptic pole, detector QE =70%, dark current =0.05 e^-/s, read noise = 15 e^- (for N=1, CDS), throughput of 74%, and Fowler 4 sampling

FPA testing at SAO

- All FPAs will be screened at Teledyne
  - Must meet procurement specs in order to deliver
- Each FPA will be tested at SAO to confirm performance, tune parameters to optimize for individual ASIC operation
- Subset of FPAs will be tested for
  - more extensive exploration of detector characteristics: point source response, bright source effects, etc.
  - development and verification of flight ASIC code
  - interface to WISH electronics

Low Background Tests

- “Dark Dewar” with arrays in 2x2 configuration
- For testing low background operation
  - Read noise
  - Dark current
- Simple flood illumination of detectors to measure
  - Operability
  - Radiometric stability
  - Quantum efficiency
  - Uniformity
  - Linearity
  - Well depth
  - Residual images

Spot Illumination Tests

- Second test facility will provide focused point sources on the arrays, wheel for filters in 1-5 μm range
- Detector parameters to be measured:
  - Quantum efficiency
  - Linearity
  - Well depth
  - Residual images
  - Radiometric stability
  - ASIC readout modes and functionality (e.g. windowing and guide modes)
  - Crosstalk – inter-pixel and between SCAs in the 2×2 configuration

FPA Characterization

- Operate FPAs in flight-like modes – pointing, guiding, science frame readout
- Use flight ASIC code, WISH electronics simulator
  - Effects of guiding windows on science data
  - Crosstalk between arrays
- Perform optimization of biases, operating modes