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# HUBBLE LEGACY TELESCOPES for the INTERNATIONAL SPACE STATION

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# ISS "MAST-TOP" VIEW



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HUBBLE LEGACY  
TELESCOPES for  
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# CONCEPT IS A MULTI PHASE PROGRAM

- 1) ATTACHED 0.5 to 1 m TELESCOPE TO CONFIRM THE ISS IS THE PREMIER LOW EARTH ORBIT SITE FOR 0.4  $\mu\text{m}$  to 1.4  $\mu\text{m}$  OBSERVATIONS.
- 2) SIMILAR CRYO TELESCOPE EXTENDS TO NIR – TO 5  $\mu\text{m}$  FOR LOW ENOUGH TEMP.
- SINGLE WAVE-BAND (1.2–1.4 & 2.0–2.4  $\mu\text{m}$ ?).
- ATTACHED, TETHERED OR FREE FLYING?.
- 3) SCALE BOTH TELESCOPES TO LARGEST ISS APERTURE – HUBBLE 2.4 m IS GOAL.
- 4) AUGMENT SPECTRAL COVERAGE BY ADDING “CLONE” TELESCOPES.

# BROAD PROGRAM OBJECTIVES

- PHASES 1 & 2 PROVIDE SCIENTIFIC AND ENGINEERING RESULTS BY 2015.
- PHASES 3 & 4 RESULT IN A “GREAT OBSERVATORY” IN 2016 - 2020.
- THOUSAND-FOLD IMPROVEMENT IN DISCOVERY EFFICIENCY OVER HUBBLE!
- DEMONSTRATE KEY TECHNOLOGIES FOR ASSEMBLING, VERIFYING AND OPERATING A MAJOR RESEARCH FACILITY FROM ISS.
- TRANSFERS HUBBLE’S EXCITEMENT, EDUCATIONAL ATTRACTION AND PUBLIC OUTREACH APPEAL TO THE ISS.

# PROGRAM SCIENCE DRIVER

- SMA-4 DEMONSTRATED THE VALUE OF MANNED SERVICING IN LOE
- THE 1 Mpxl WFC3 IR SENSOR SMA-4 DEPLOYED ACHIEVED 40 TIMES THE DISCOVERY EFFICIENCY OF NICMOS.
- Gpxl MOSAICS NOW FEASIBLE OFFER A FURTHER GAIN OF A THOUSAND!
- THERE IS NO PATH APPARENT TO IMPLEMENT THIS ON HUBBLE.

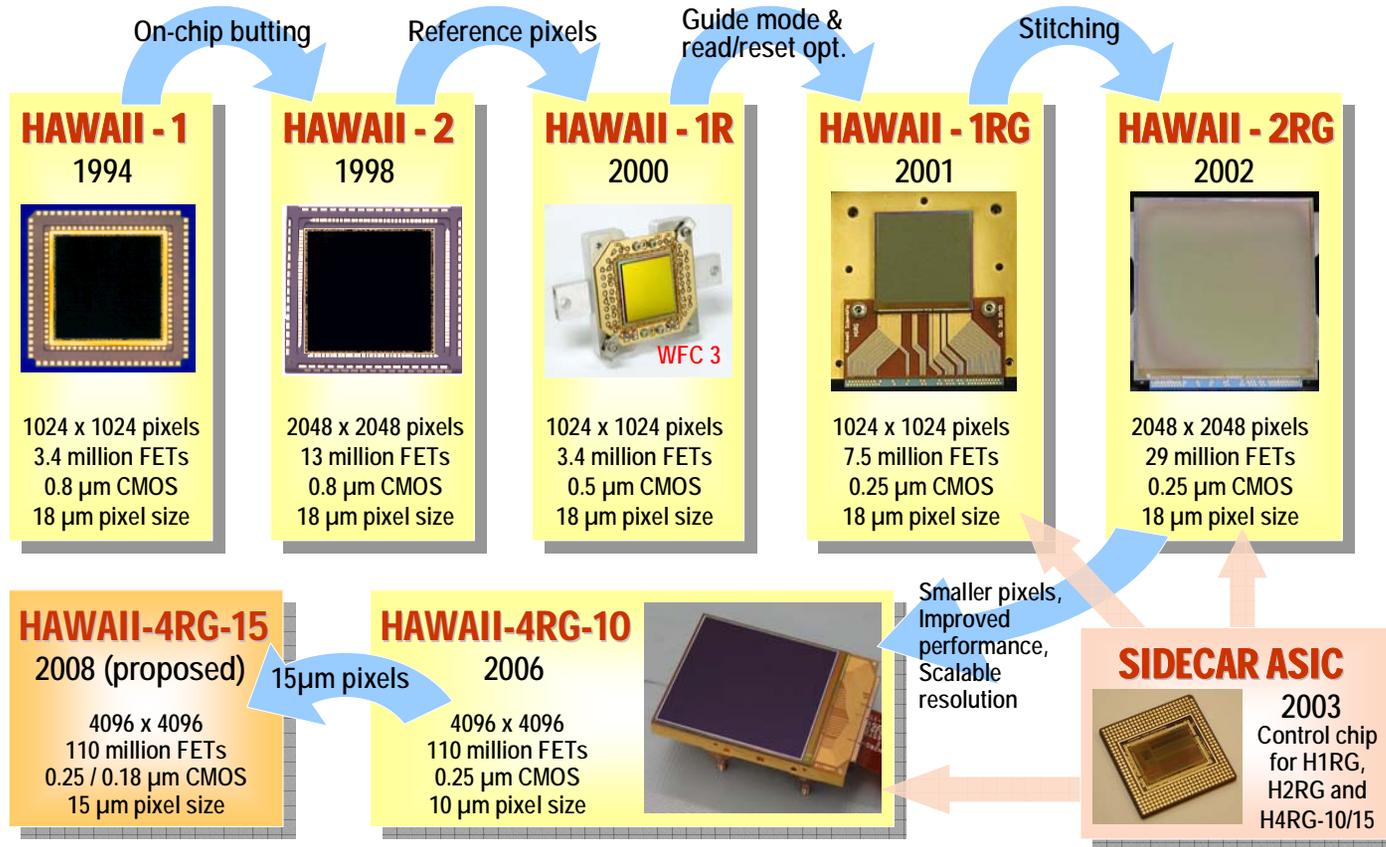


# LARGE FORMAT & PHOTON COUNTING O-NIR ARRAYS

- THE 4 Mpxl HAWAII-2RG AND SIDECAR ASIC WILL FLY ON JWST.
- 16 Mpxl 2x2 MOSAICS FOR NIRCAM.
- THE DEVELOPMENT BY NSF OF THE 16 Mpxl HAWAII-4RG-15 IS UNDERWAY.
- THE PATH TO SPACE QUALIFICATION IS DIRECT.
- EVOLUTION FROM 64 Mpxl (2x2) TO 256 Mpxl (4x4) & 1 Gpxl (8x8) MOSAICS.

# HAWAII-4RG-15 & SIDECAR ASIC HERITAGE

## HAWAII Heritage



# TELESCOPE CONSTRAINTS & OPTIONS

- FOCAL PLANE DIMENSIONS
  - *65.5 Mpxl 8Kx8K is 125x125 mm – 175 mm DIAG*
  - *262 Mpxl 16Kx16K is 250x250 mm – 350 mm DIAG*
  - *1.05 Gpxl 32Kx32K is 500x500 mm – 700 mm DIAG*
- DIFFRACTION LIMITED RESOLUTION REQUIRES f/4 OR SLOWER PRIMARY.
- ONE SPECTRAL BAND PER TELESCOPE?
- SINGLE FILTER DEPOSITED ON SENSOR?
- POINTING & FGS ARE ONLY MECHANISMS.
- ONLY TWO MIRRORS + FIELD FLATTENING LENSES FOR ULTIMATE THROUGHPUT.
- DEVELOP FROM Pan-STARRS & LCGTO.

# COMPLEMENTS OTHER FACILITIES

- 1 Gpxl YIELDS 1,000 TIMES HUBBLE WFC3's IR FIELD WITH OVER TWICE THE THROUGHPUT & IR OUT TO  $\lambda \geq 2.5 \mu\text{m}$ .
- ALSO 400 TIMES JWST NIRCcam SWIR FIELD ALTHOUGH ONLY 40% OF  $2\mu\text{m}$  RESOLUTION
- SUPERB SURVEY TELESCOPE FOR JWST & 8 – 30 METER CLASS GROUND BASED TELESCOPES.
- TRADE-OFF FOR SPECTROSCOPY DEPENDS CRITICALLY ON AVAILABILITY OF PHOTON COUNTING IR ARRAYS.

# CONCERNS FOR ISS IN O-NIR?

- VIBRATION – CHALLENGE TO ISOLATE FROM VERY NOISY ENVIRONMENT.
- EMI – JWST SIDECAR ASIC AVOIDS LOW ANALOG SIGNALS OUTSIDE THE IMMEDIATE FOCAL PLANE.
- CONTAMINATION IN O-NIR – AVOID WITH PROPER SHIELDING; ISS ALLOWS WARM UP FOR EVAPORATION & CLEANING.
- VIEWING ZONE & OTHER CONSTRAINTS – FOR THE BEST POTENTIAL LOCATIONS ON THE ISS, THE TARGET AVAILABILITY IS EXCELLENT

# ADVANTAGES OF ISS FOR TELESCOPE

- FINAL ASSEMBLY, ALIGNMENT & VERIFICATION ON-ORBIT IN ZERO-g.
- ALLOWS LAUNCH IN DISCRETE, ROBUST MODULES.
- ISS INFRASTRUCTURE – e.g. POWER, COMMUNICATIONS, SERVICING
- RAPID RESPONSE MAINTENANCE & REPAIR ROUTINELY AVAILABLE.
- REGULAR OPPORTUNITIES FOR REFURBISHMENT & AUGMENTATION.
- ATTRACTIVE BASELINES FOR INTERFEROMETRY

# BENEFITS OF HLT TO ISS PROGRAM

- **PROVIDES A CREDIBLE, HIGH PROFILE SCIENCE PROGRAM AS THE RATIONALE FOR AN INITIAL DEMONSTRATION WITH THE OPTION OF A MAJOR ISS BASED OBSERVATORY.**
- **COMBINATION OF “SHIRT-SLEEVE” AND EVA ASTRONAUT PARTICIPATION.**
- **WOULD ALLOW EVOLUTION TO SOPHISTICATED ROBOTIC SERVICING.**
- **OPENS SUPERB EDUCATIONAL AND PUBLIC OUTREACH OPPORTUNITIES.**
- **COULD ENDOW THE ISS PROGRAM WITH HUBBLE VISIBILITY AND RECOGNITION.**

# CANDIDATE LOCATIONS ATTACHED TO THE ISS

- VERY PRELIMINARY, FURTHER STUDY
- 1) ABOVE S3, S1, S0, P1 & P3 ASSEMBLY.
- 2) DEDICATED TRUSS ABOVE CENTRIFUGE ACCOMMODATION MODULE.
- 3) EXTENSION OF TRUSS BEYOND S6 & P6 SEGMENTS.
- OPTION 3), OR A COMBINATION, ATTRACTIVE FOR INTERFEROMETRY.
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