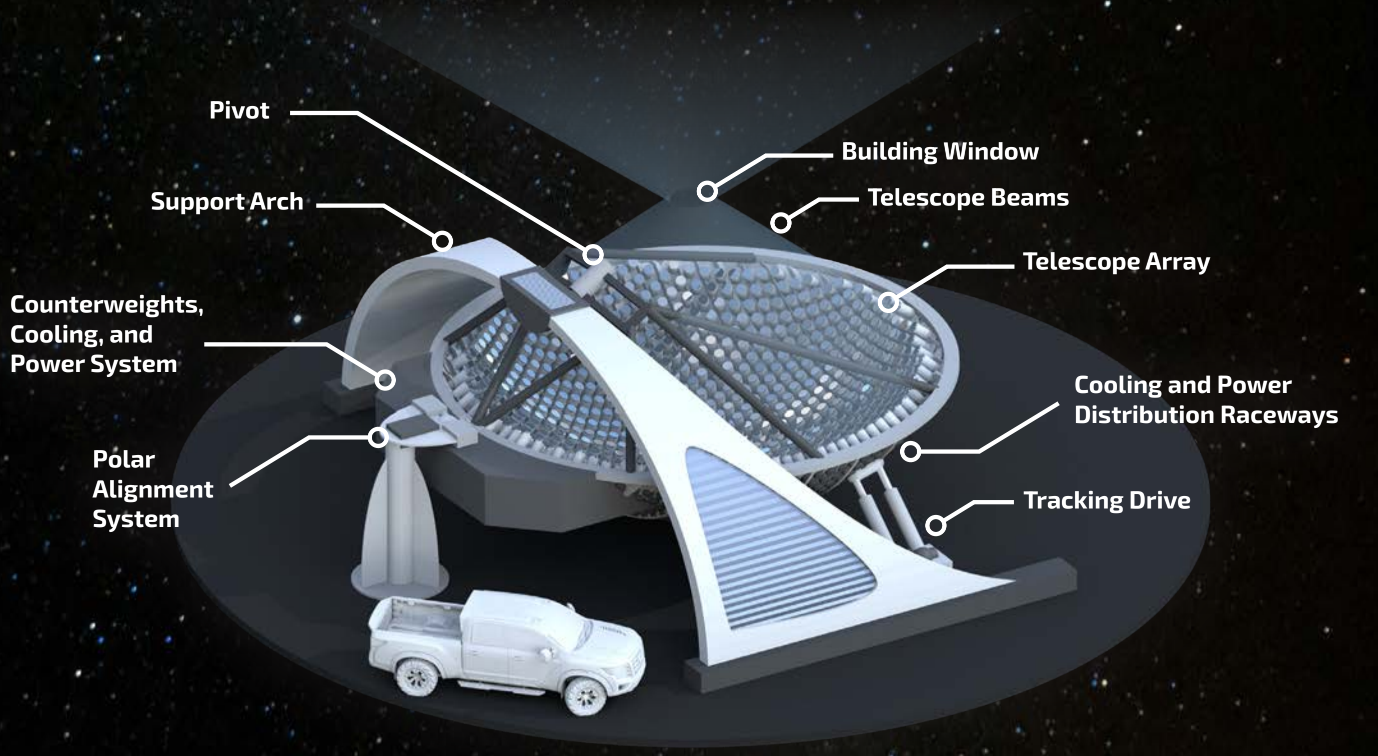
Argus Array

A 55 Gigapixel Telescope, Surveying 20% of the Entire Sky Every Second.

The Argus Optical Array will be an all-sky, arcsecond-resolution, 5-meter telescope which builds a simultaneously high-cadence and deep survey by observing the entire accessible sky all night. The 55 gigapixel, 900-telescope array will cover 8,000 sq. deg. in every exposure, with modern CMOS image sensors enabling sub-second cadences.



Project Overview

The Argus Optical Array will observe the entire accessible sky for 6-12 hours per night. The Array will achieve a limiting magnitude of 24 in 5 days of exposure under typical observing conditions.

The Array is designed to provide the first deep and extremely-high-cadence imaging of the entire Northern sky, meeting Astro2020 Decadal Survey recommendations for mid-scale time-domain astronomy and matching the sky coverage and timescales of the new wave of all-sky gravitational-wave, neutrino, radio, and x-ray observatories.

Over five years, the Array will build a five-million-epoch movie of the northern sky, enabling some of the most sensitive searches yet for high-speed transients, fast radio burst counterparts, gravitational wave counterparts, exoplanet microlensing events, occultations by distant solar system bodies, and a host of other phenomena.

Timeline

2021
Argus Technology Demonstrator constructed and tested on sky

Summer 2022
Argus Pathfinder, a 38-telescope survey prototype, will begin imaging the entire northern sky each night

The Future of Argus:
Argus Optical Array will be deployed with 900 telescopes observing the entire northern sky simultaneously

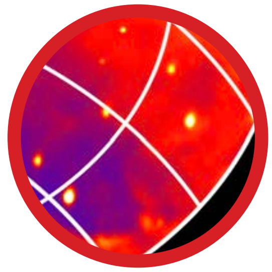
argus.astro.unc.edu

THE UNIVERSITY of NORTH CAROLINA at CHAPEL HILL

Science Cases

The Argus Optical Array is designed for the priority areas identified by the Astro2020 Decadal Survey

Worlds and Suns in Context



New Messengers and New Physics

New Midscale Time-Domain Astrophysics Surveys

Multimessenger Time-Domain Astronomy

• How do kilonova GW-counterpart sources evolve in the minutes
following the gravitational wave emission?
•By how much can the LIGO significant-detection event rate, and resultant astrophysical leverage, be increased with high-cadence optical monitoring of the entire sky for simultaneous optical counterparts?
•Do non-repeating fast radio bursts (FRBs) have optical counterparts? *
•Will simultaneous entire-sky high-cadence monitoring reveal new counterparts to neutrino, gamma-ray, radio and other sources from non-optical all-sky surveys?

Exoplanets

• What is the population of low-mass icy worlds around nearby stars, revealed by the first deep, all-sky high-cadence microlensing survey? *
• What is the population of circumbinary planets, revealed by monitoring the timing variations of 10^7 eclipsing binaries at minute cadence for years?
• What is the population of white-dwarf exoplanet-debris disks, revealed by high-cadence monitoring of 125,000 white dwarfs, an order of magnitude more than any previous survey? *
• With a deep high-cadence survey of all accessible young stars simultaneously, can we identify transient events associated with planetary collisions around young stars? *
• What are the long-term stellar activity effects for the habitability of planets around nearby brown dwarfs?
• Can long-term, high-precision, high-cadence monitoring of all active stars identify light echoes from planets being impacted by the largest and rarest stellar flares? *
• Can star-planet interactions drive periodic stellar activity, and even be used to detect exoplanets?

Stellar Astrophysics

• Is our theoretical understanding of the stellar mass-radius relation (especially at the low-mass end) matched by long-term, high-cadence photometric observations of 10^7 eclipsing binaries?
• How do flare rates correlate with the long-term activity cycles of nearby exoplanet host stars, and what are the implications for habitability of the planets around them?
• Can we characterize the population of ancient galactic transients via long-term light-echo searches?

Stellar Astrophysics (Cont.)

• What are the rotation rates and RV-false-positive implications for slowly-rotating stars (exoplanet hosts or other important sources) that cannot be measured with shorter-term surveys?
• What is the rate of faint galactic stellar mergers due in-spiraling eclipsing binaries like V1309 Sco? Can we find and predict these events before they happen and use them to constrain stellar interior models?
• What are the rates and general properties of dust-disk drop-out events across 10^8 stars?
• How common are the most massive, potentially civilization-ending stellar flares, among stars like our Sun? *

General Transient Events

• What is the very-early-time evolution of supernovae? What does the shock-breakout regime look like for the likely-to-be best-studied supernova events?
• What is the chemical makeup of stellar winds just before supernova explosions?
• How common are stellar outbursts just before supernova events?
• What is the early-time behavior of nearby SN-1a events used for supernova cosmology?
• Are there short-timescale extragalactic transient events rejected as asteroids in longer-cadence surveys? *

Solar System Science

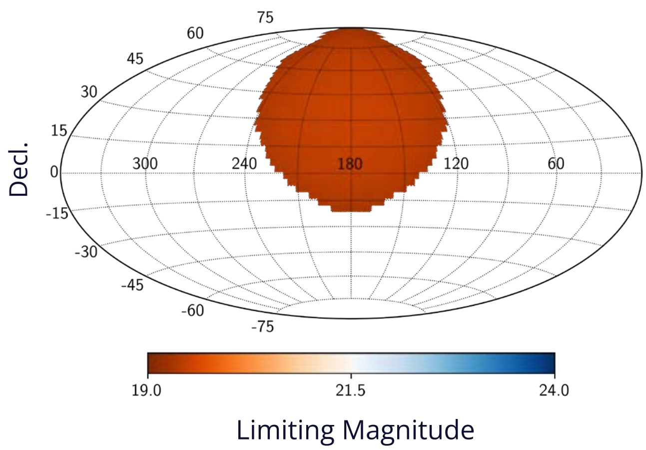
• What is the comprehensive distribution of shapes, rotation rates and thus strengths of main-belt and Kuiper-belt objects, as determined from 10^5-10^6 epoch multicolor light curves?
• What is the (upper-limit-to-the) population of large bodies in the Oort cloud, as determined by a years-long occultation survey of 10^8 stars? *
• How many main-belt objects and KBOs have eclipsing moons, and what are their mass distributions?
• Are outbursts the source of anomalous acceleration for interstellar asteroids?
• What are the detailed shapes, rotation rates and strengths of interstellar asteroids?
• How much do the surfaces of interstellar asteroids vary, spatially and during their solar system passages?

***** *Argus Pathfinder Prototype science areas*

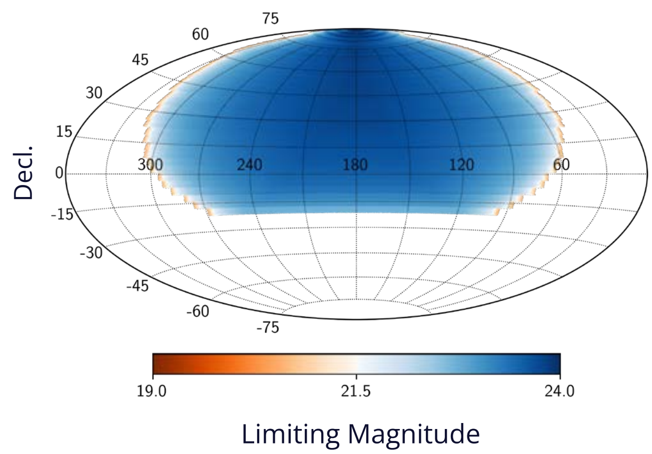
Sky Coverage

Sky coverage and depth of the Argus Optical Array. Limiting magnitudes represent a 5-σ signal-to-noise ratio, under median conditions, including both moon phase and weather effects.

1-Minute Exposure

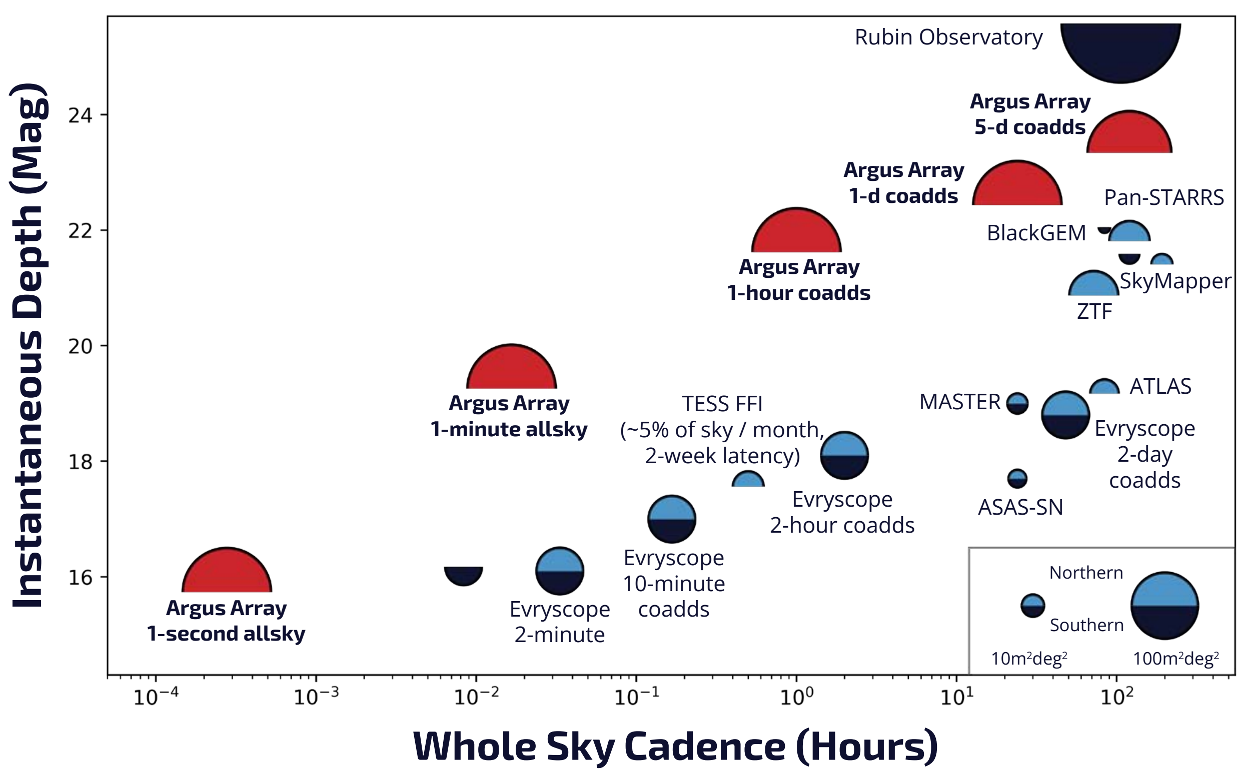


5-Night Coadd



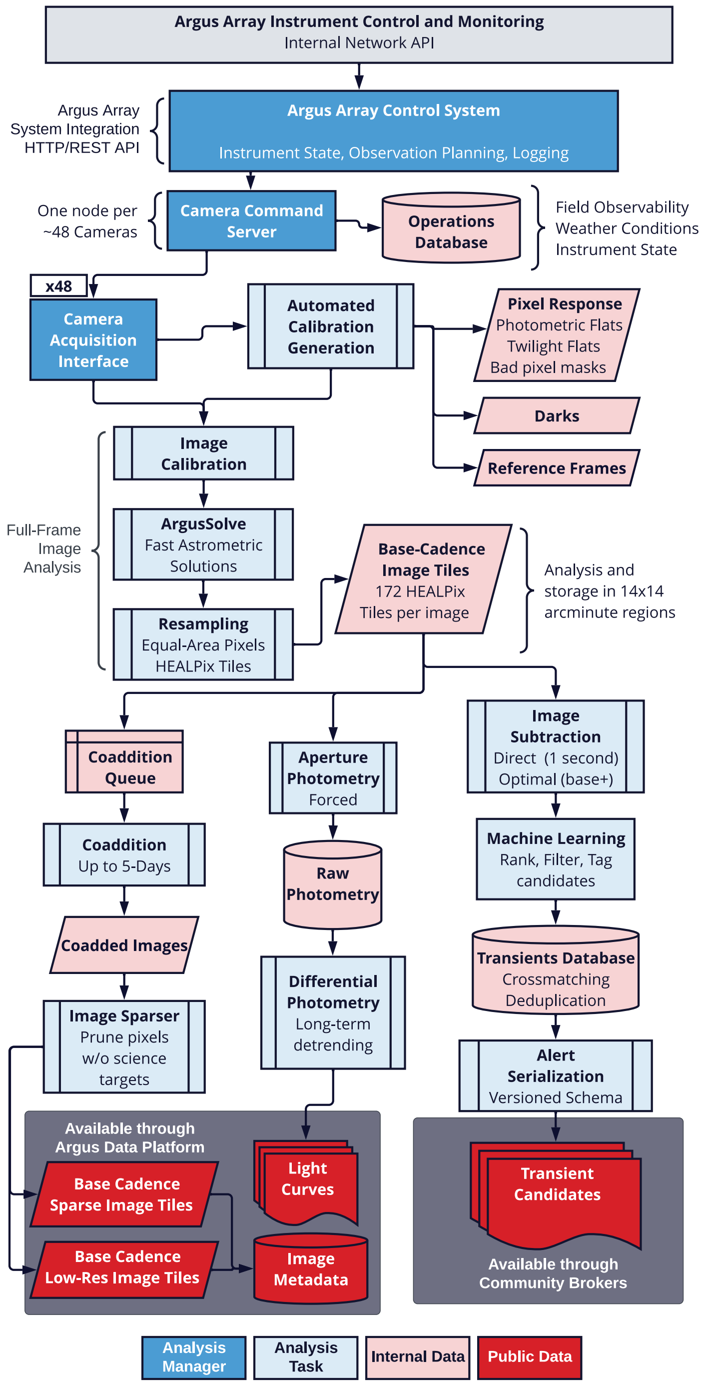
Discovery Space

Operating and planned all-sky surveys with rapid transient detection capabilities. The position of each survey is a function of mirror, étendue, cadence and survey design. The shape and size of the points show site location and étendue, respectively. Where telescopes operate multiple surveys, we have selected the survey with the fastest rate of all-sky coverage, and (where available in the literature) we compare dark-sky, 5-σ detection limiting magnitudes. The Argus concept builds depth by all-night coaddition of short exposures on each part of the sky, producing a hybrid fast and deep survey.



Argus Pipeline

A high-speed pipeline processes incoming data and produces reduced data products in real-time. 15-minute-cadence coadded images are stored, along with base-cadence image segments around pre-selected science targets and transient candidates. Image subtraction is performed at both the base cadence and in deep coadds, producing low-latency alerts to be distributed to the astronomical community.



Hardware

System Design	900 telescopes, shared tracking drive Sealed enclosure for long-term stability
Telescopes	203 mm aperture F/2.8
Detectors	61 MPix Sony IMX455 CMOS sensor 1.7 e^- noise @ 0.1 s full-frame readout ≈90% QE @ 500 nm 2×10^4 e^- well capacity
Total Detector Size	54.9 GPix
Field of View	9.04 sq. deg. per telescope 7916 sq. deg. instantaneous total
Sky Coverage Per Night	19,370 sq. deg. (2-10 hours per night)
Sampling	1.38” /pixel
Site	North America
Exposure Times	1 second & 1 minute
Observing Strategy	Track for 15 minutes; reset (48 s) and repeat (“ratchet”)
Wavelengths	15 minutes (1 ratchet) in g-band followed by 15 minutes in wide-band
Data Analysis	Real-time analysis for fast transients Full-data storage for science targets All-sky data at 15-minute cadence

Limiting Magnitude

High Speed	m_g=16.1 in 1 sec.; 20% of entire sky
Normal Operation	m_g=21.9 in 1 hour; 24% of entire sky
Coadding	m_g=21.9 in 1 hour; 24% of entire sky m_g=22.7 in 1 nt.; 47% of entire sky m_g=23.6 in 5 nts.; 48% of entire sky

5σ, median sky conditions

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SCHMIDT FUTURES

MSIP #2034381