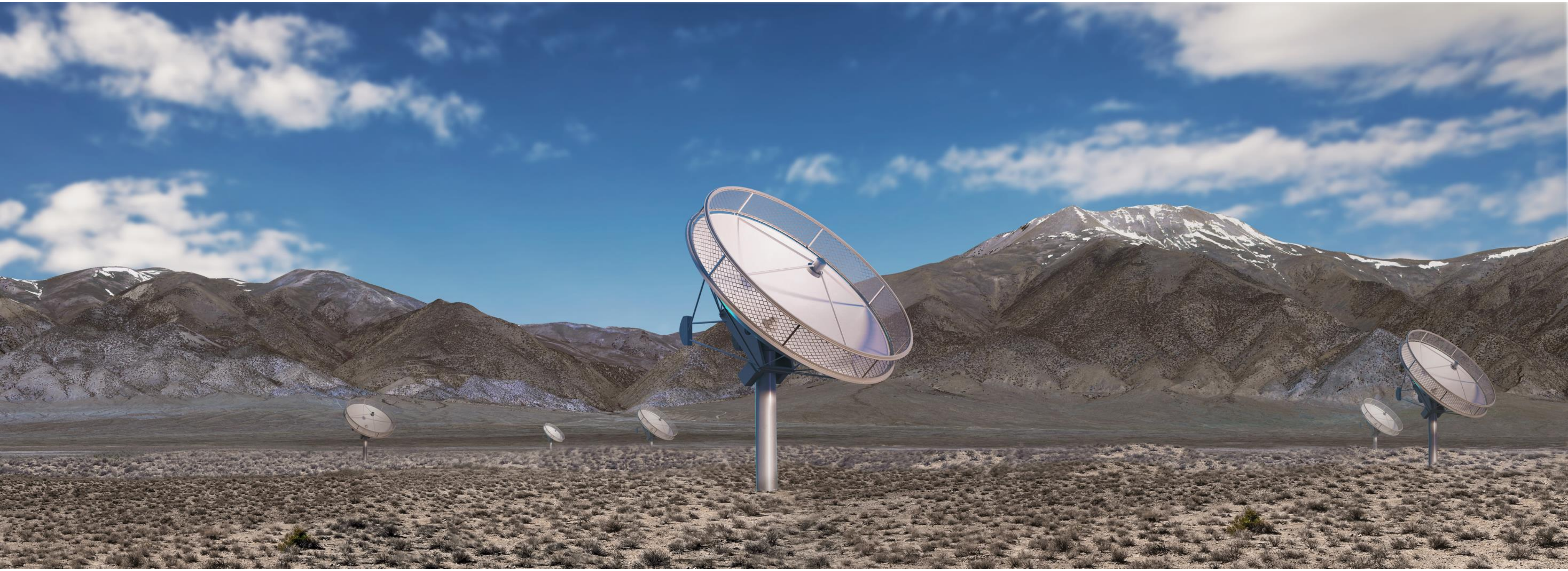
DSA-2000 Overview/Status

Gregg Hallinan, Caltech



Schmidt Sciences

DSA-2000

Caltech

Gregg Hallinan (PI)

Vikram Ravi (Co-PI)

Fabian Walter
(Project Scientist)

Katie Jameson
(Project Manager)

Francois Kapp
(Project Engineer)

A world-leading radio survey telescope and multi-messenger discovery engine

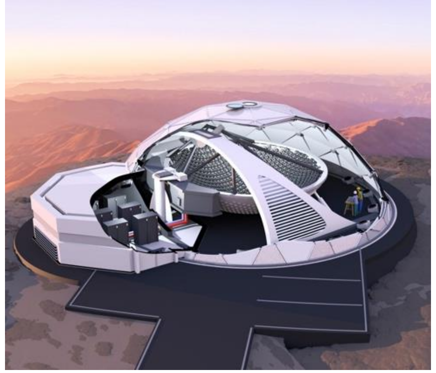
- ~2000 x 5m dishes (19 x 15 km)
- Spring Valley, Nevada
- Frequency: 0.7 - 2 GHz band
- Spatial resolution: 3.3 arcseconds
- **Highly optimized for surveys**

- **First light: 2027**
- **Key surveys: 2028 – 2033**

Schmidt Sciences

DSA-2000

The 2020s is the Decade of Surveys



GROUND

Rubin: 2025

DSA-2000: 2028

Argus Array

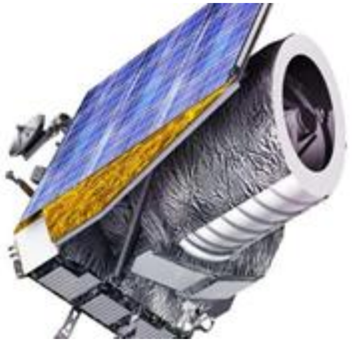
Cryoscope

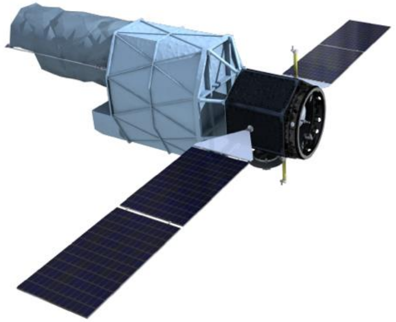
SPACE

Euclid: 2023

Sphere-X: 2025

UVEX: 2029

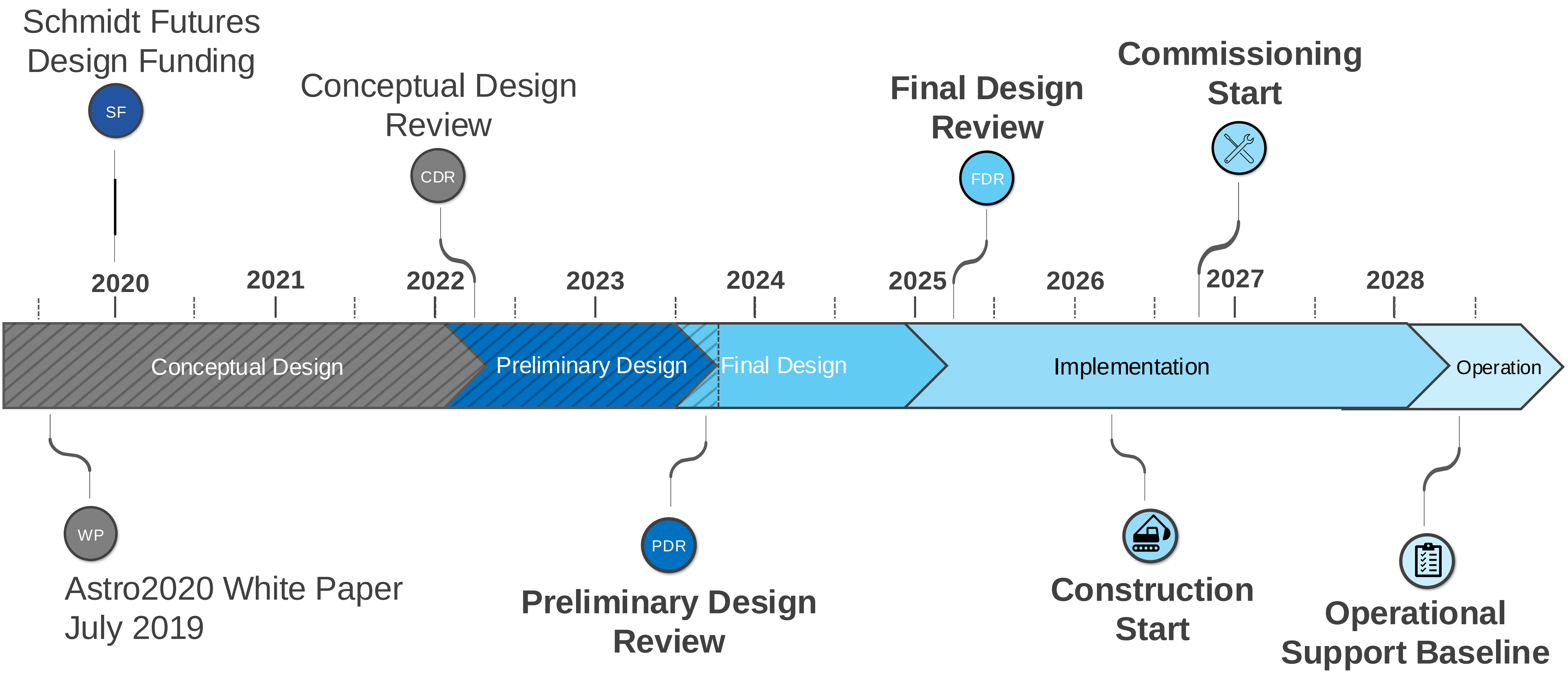




DSA-2000


DSA-2000
Spring Valley, NV
Google Earth
Landsat / Copernicus, Data SIO, NOAA

Timeline



DSA-2000

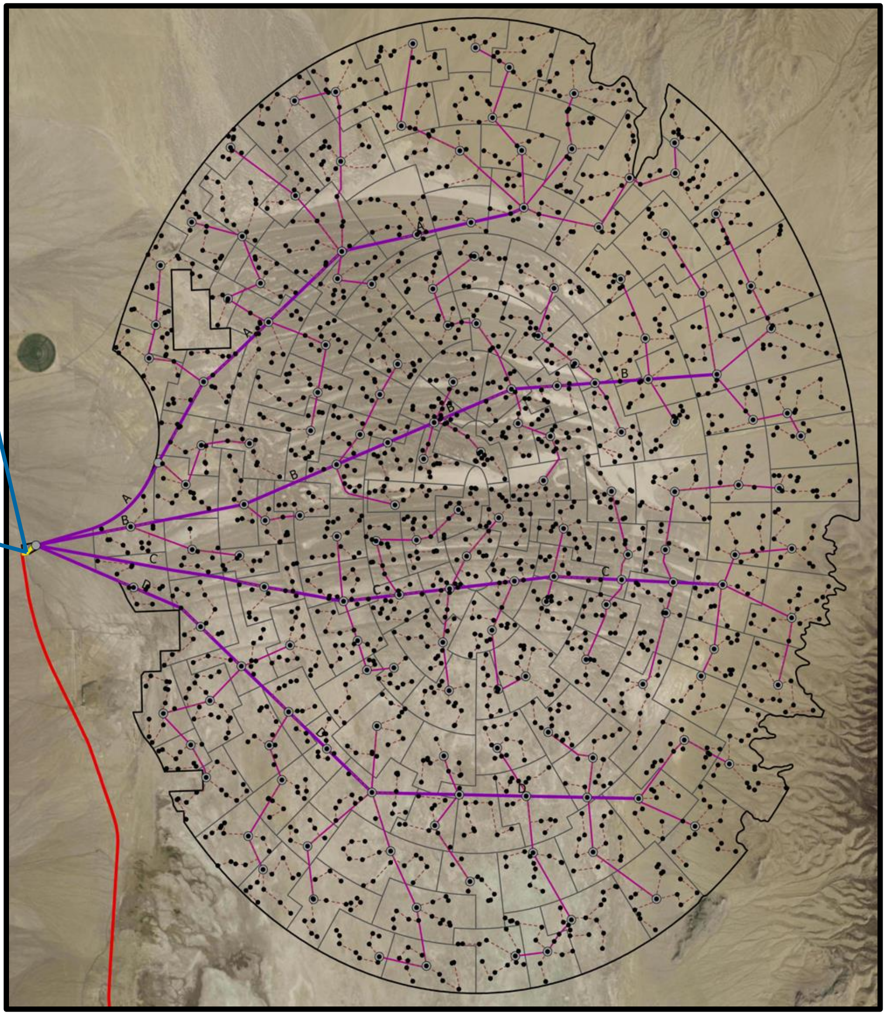
Spring Valley, Nevada

2023: submitted ap

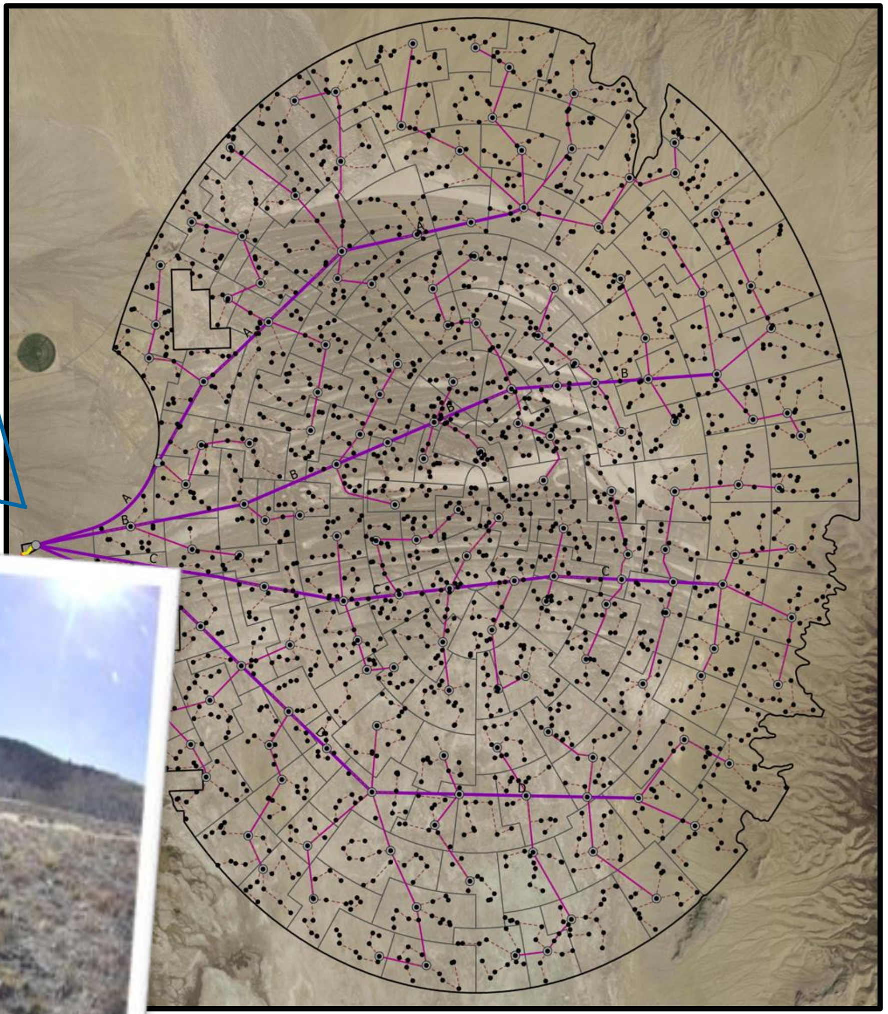
2024-2025: Key sur

2026: Completion o

Detailed Construction Planning

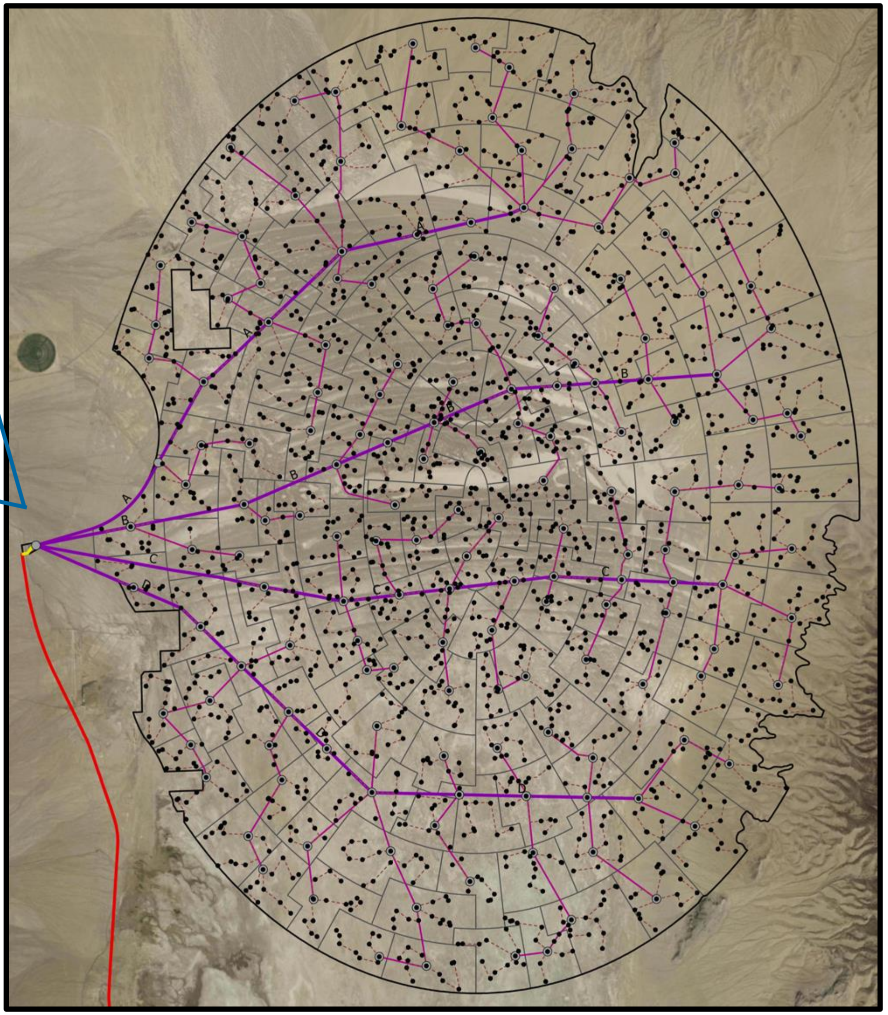


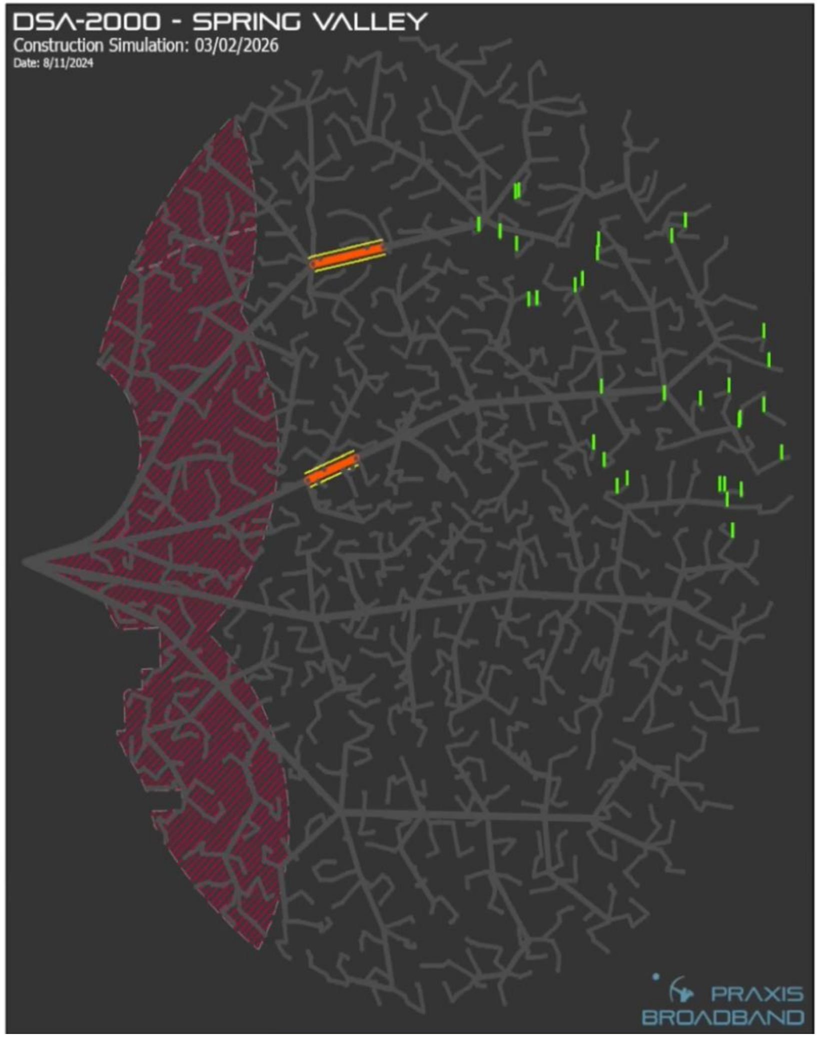
Detailed Construction Planning



DSA-2000

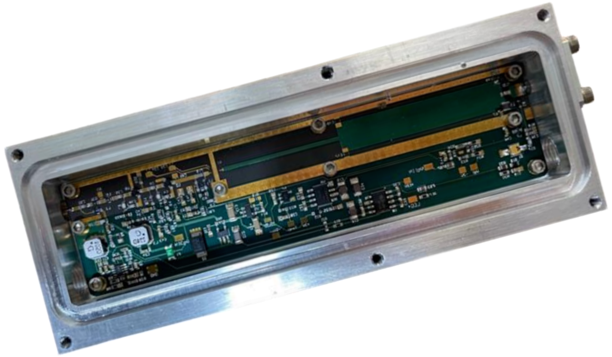
Detailed Construction Planning





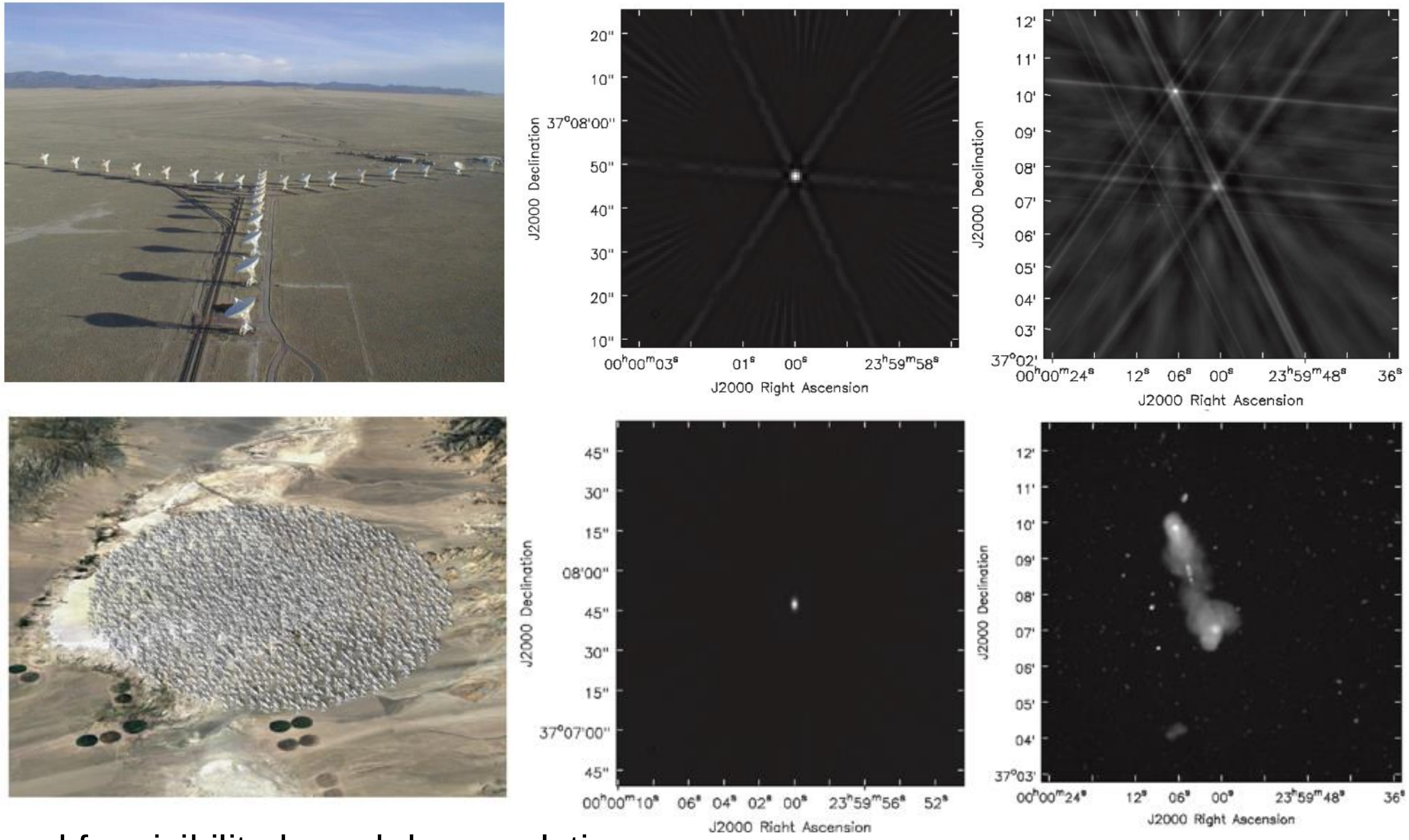
DSA-2000

Key Technology: Uncooled Antenna/Receiver



DSA-2000

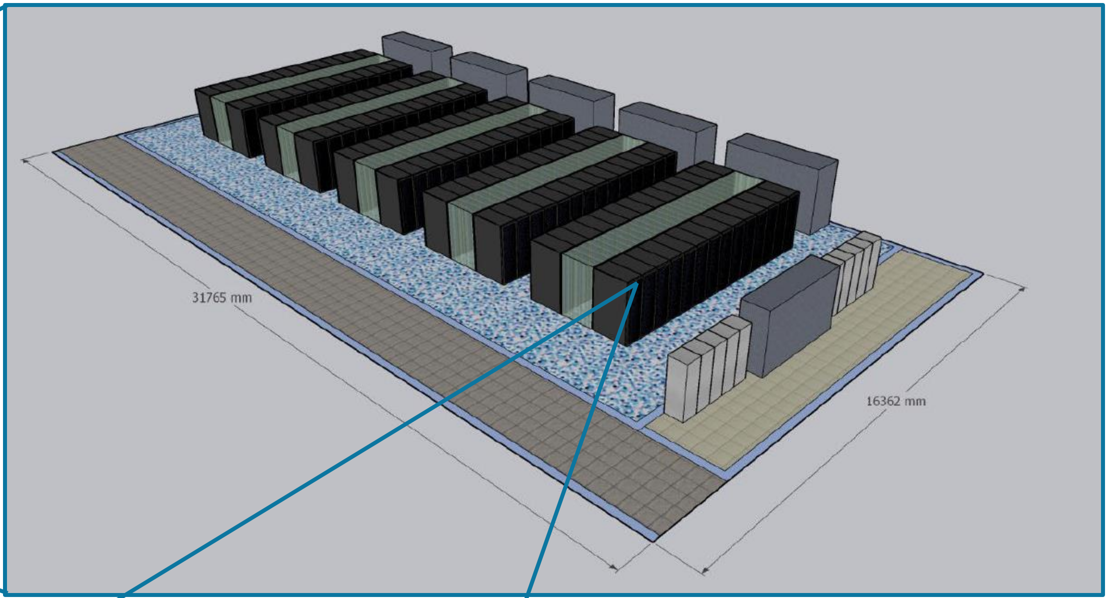
Key Technology: A Radio Camera



- No need for visibility-based deconvolution
- Enables a deterministic stream processing pipeline that creates images

DSA-2000

Key Technology: A Radio Camera



<u>Radio Camera Frontend</u>

2000x ADCs

2000x iWave ZU11
System-on-module

Data throughput
~200 Tb/s

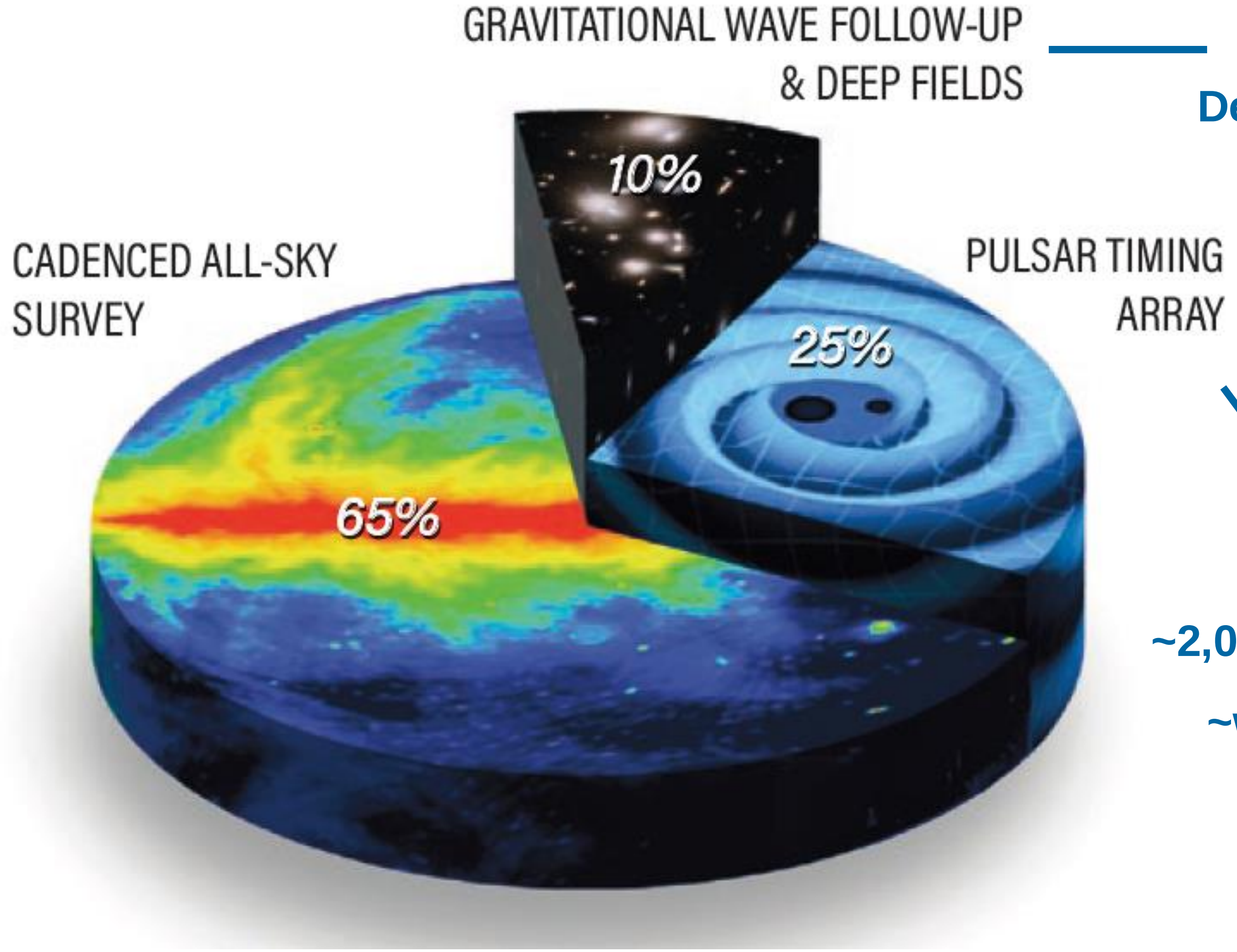
<u>Radio Camera Processor</u>

528 servers
4960 RTX 4000 GPUs
27,000 CPU cores
500 TB RAM

Data throughput
~43 Tb/s

DSA-2000

5-Year Survey



31,000 deg^2 to 500 nJy

Deep reference epoch

12 additional epochs

logarithmic cadence

GW (Triggered)

Deep: 30 deg^2 to 50 nJy

(or confusion limit)

~2,000 deg^2 to 200 nJy

~weekly cadence

NANOGrav Physics Frontiers Center

Public Archive: IPAC

31,000 deg^2 to 500 nJy (AB: 24.7)

>1 billion radio sources (IQUV)

~few million galaxies in HI

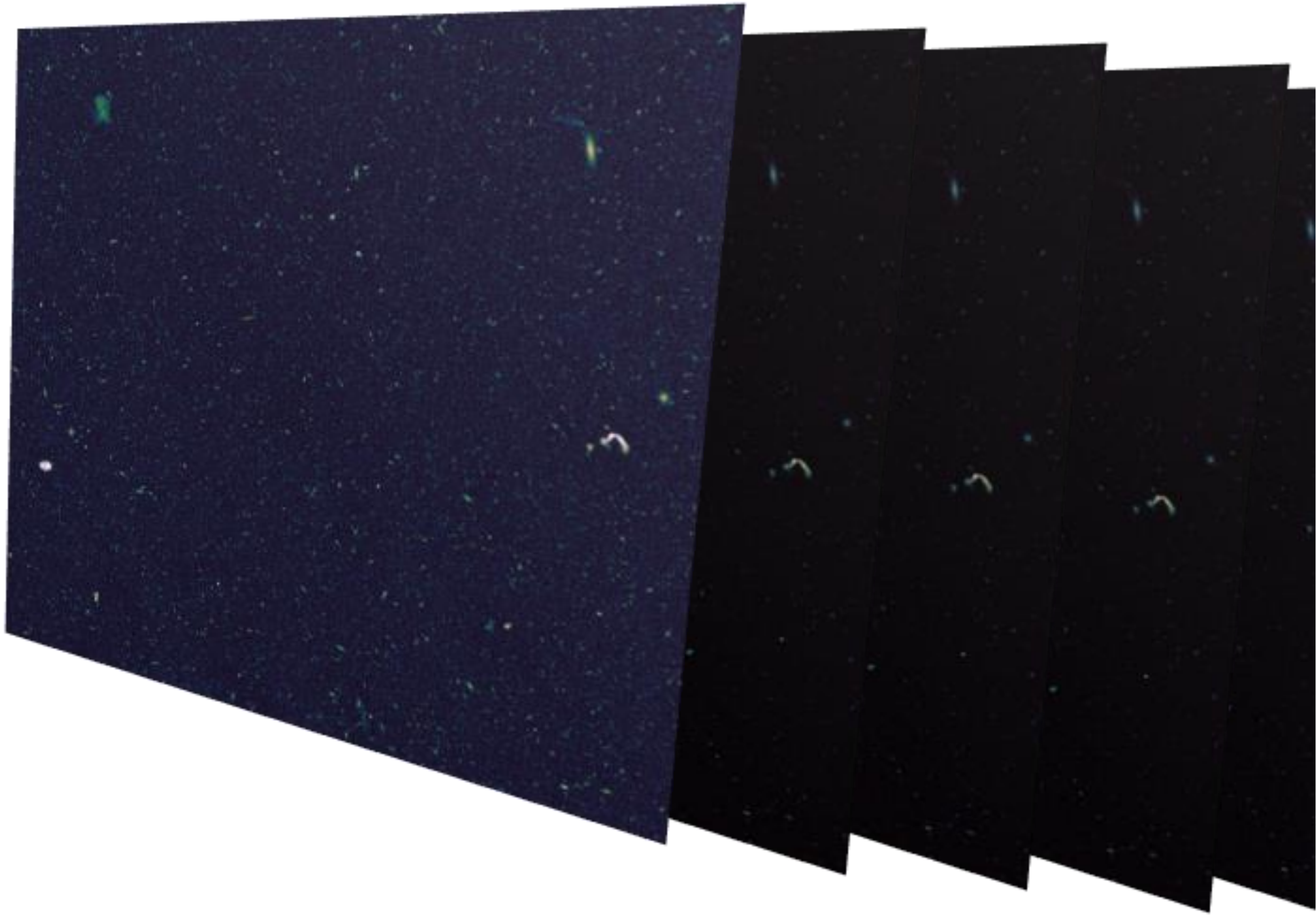
~50,000 FRBs and 20,000 pulsars

~10^6 ‘slow’ transients

No proprietary period

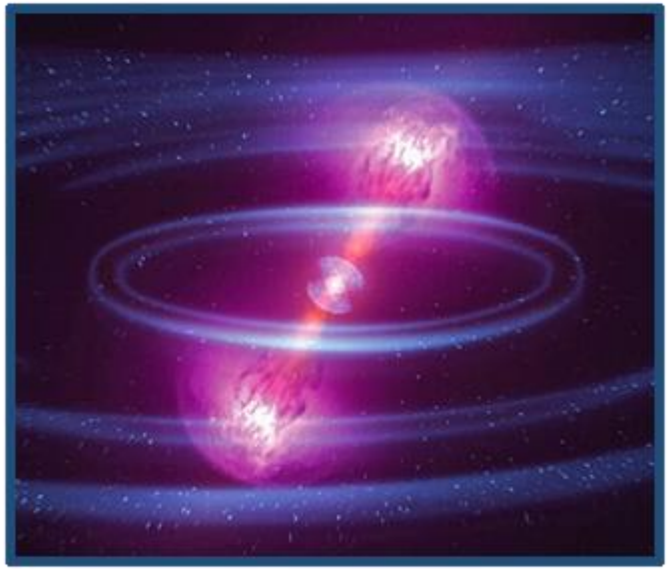
Products include:

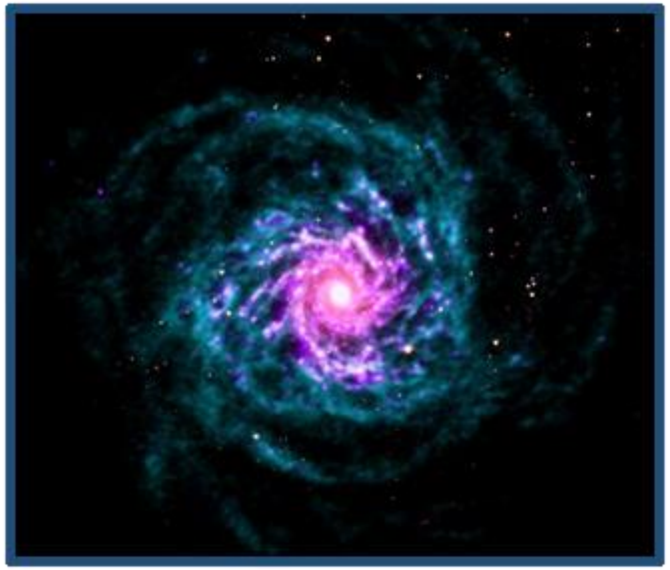
- Continuum data (10 sub-bands)
- Spectral image cubes (HI, OH)
- Polarization (IQUV)
- Photometry
- Spectra and light curve fits



DSA-2000 Key Science

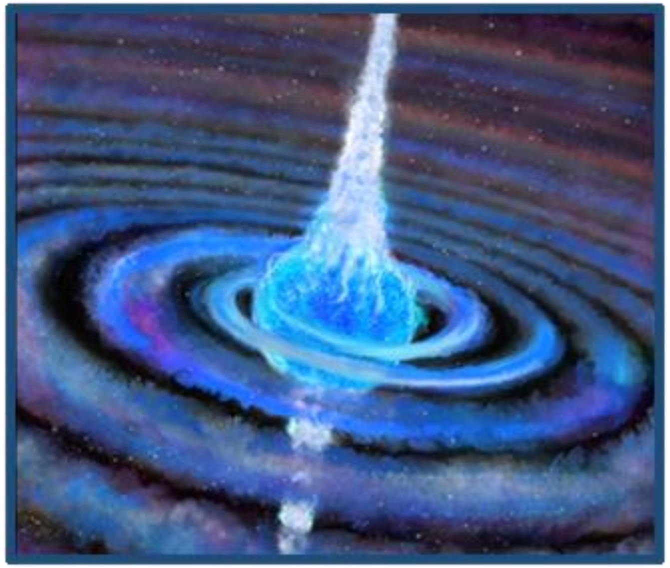
Multi-Messenger Astronomy

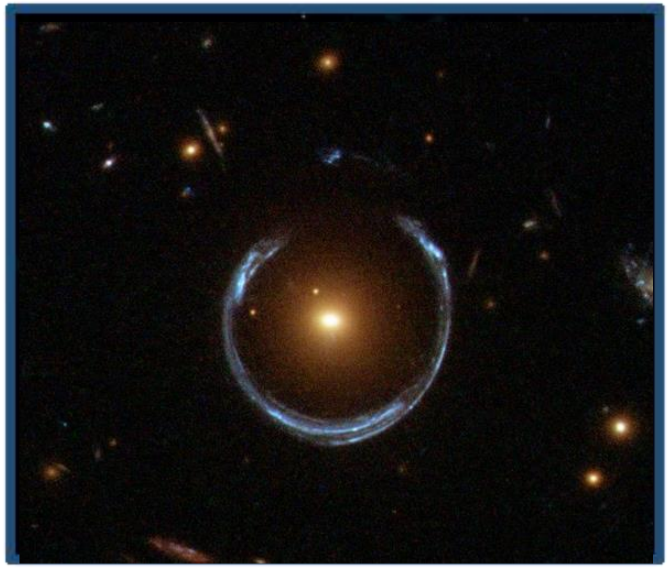




Our Cosmic History

The Dynamic Radio Sky





The Dark Sector and Strong Gravity

DSA-2000 Key Science Goals	Astro 2020 Science Panel Questions	
Multi-Messenger Astronomy	**Q1.** What are the mass and spin distributions of neutron stars and stellar mass black holes?	
KSG1: Characterizing the nanohertz gravitational-wave universe via pulsar timing. **Q4, Q8, Q9**	**Q2.** What powers the diversity of explosive phenomena across the electromagnetic spectrum?	
	Q3. What do some compact objects eject material at nearly-light-speed jets, and what is that material made of?	
KSG2: Discovering the counterparts to compact binary coalescences detected in gravitational waves. **Q1, Q2, Q3, Q8, Q22**	**Q4.** What seeds supermassive black holes and how to they grow?	
	Q5. What set the hot Big Bang in motion?	New Messengers and New Physics
	Q6. What are the properties of dark matter and the dark sector?	
Our Cosmic History	**Q7.** What physics drives the cosmic expansion and the large-scale evolution of the universe?	
KSG3: Neutral hydrogen census through half of the Universe's age. **Q10, Q12, Q17**	**Q8.** How will measurements of gravitational waves reshape our cosmological view?	
KSG4: The cosmic-ray lifecycle: production, propagation and cooling amidst galactic and intergalactic magnetic fields **Q3, Q4, Q9, Q11**	**Q9.** How did the intergalactic medium and the first sources of radiation evolve from cosmic dawn through the epoch of reionization?	
	Q10. How do gas, metals, and dust flow into, through, and out of galaxies?	
The Dynamic Radio Sky	**Q11.** How do supermassive black holes form and how is their growth coupled to the evolution of their host galaxies?	Cosmic Ecosystems
KSG5: Determining the distribution of matter in the circum- and inter-galactic medium with FRBs. **Q2, Q10**	**Q12.** How do the histories of galaxies and their dark matter halos shape their observable properties?	
	Q13. What is the range of planetary system architectures, and is the configuration of the solar system common?	
KSG6: A new window on binary-driven mass loss and relativistic jets in stellar explosions. **Q2, Q3, Q22**	**Q14.** What are the properties of individual planets, and which processes lead to planetary diversity?	
	Q15. How do habitable environments arise and evolve within the context of their planetary systems?	
The Dark Sector and Strong Gravity	**Q16.** How can signs of habitable life be identified and interpreted in the context of their planetary environments?	
KSG7: Physical Characteristics / Fundamental Properties of Dark Matter and Dark Energy. **Q6, Q7, Q12**	**Q17.** How do star-forming structures arise from, and interact with, the diffuse ISM?	
	Q18. What regulates the structures and motions within molecular clouds?	
KSG8: A Galactic census of radio pulsars to test theories of gravity, bulk nuclear matter, and the endpoints of stellar evolution. **Q1, Q2**	**Q19.** How does gas flow from parsec scales down to protostars and disks?	Worlds and Suns in Context
	Q20. Is planet formation fast or slow?	
	Q21. What are the most extreme stars and stellar populations?	
Ancillary Science	**Q22.** How does multiplicity affect the way a star lives and dies?	
Q3, Q7, Q9, Q12, Q14, Q15, Q16, Q21, Q23, Q24	**Q23.** What would stars look like if we view them like we do the Sun?	
	Q24. How do the Sun and other stars create space weather?	

March 2023: Science Workshop

https://www.deepsynoptic.org/2023-conference

~70 contributions to the DSA-2000 Community Science Reference Document

From Minkoski (1972)…

TWENTY YEARS ASTRONOMY WITH THE 48-INCH SCHMIDT TELESCOPE ON PALOMAR MOUNTAIN

R. Minkowski

The main motive for the design and construction of the 200-inch telescope on Palomar Mountain was the desire to extend extragalactic research to fainter galaxies and to larger distances. The need for a companion instrument that could survey the sky to as faint a magnitude as possible was obvious.

Caltech DSA-2000 Schmidt Sciences

- DSA-2000 will be a powerful radio survey telescope and multi-messenger engine

- 5 year surveys: 2028-2033

- Key science tied to four pillars – Multi-messenger astronomy, our cosmic history, the dynamic radio sky, the dark sector and strong gravity

- A finder scope for ngVLA

- All data will be publicly available with no proprietary period

NANOGrav NRAO PRAXIS BROADBAND Real-Time Radio Systems Ltd Mark III Systems NVIDIA mtex | antenna technology MINEX ENGINEERING CORP.