

# DSA Radio Telescope

Design for High-throughput Data Processing

Martin Pokorny, Caltech

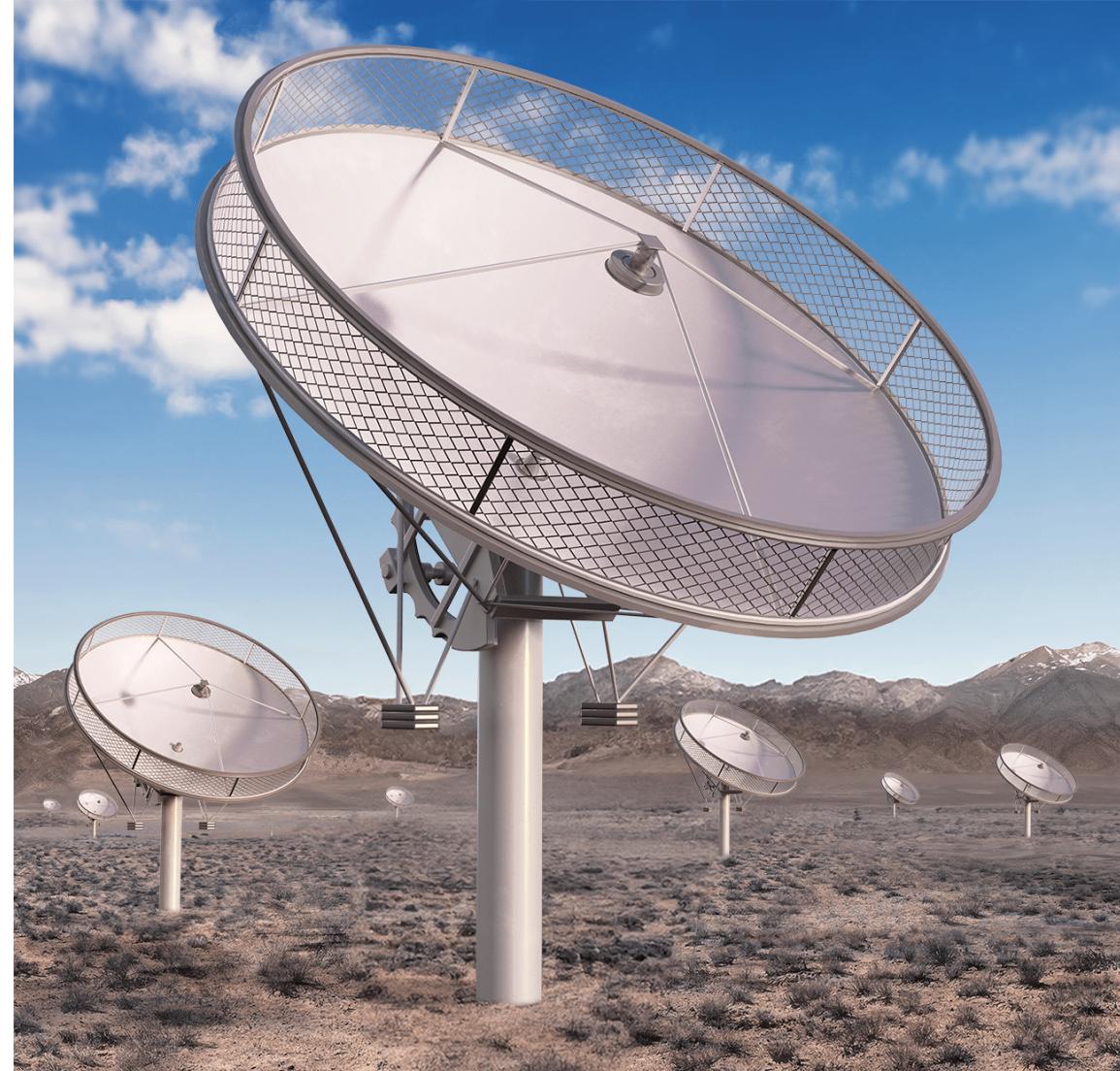
# DSA

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

- 1650 x 6.15m dishes (20 x 16 km)
- Spring Valley, Nevada
- Frequency: 0.7 - 2 GHz band
- Spatial resolution: 3.3 arcseconds
- *Highly optimized for surveys*

Enabled by two breakthrough technologies:

- The first “radio camera”
- An uncooled antenna/receiver



DSA-2000



**DSA-2000**

# 2020s is the decade of surveys

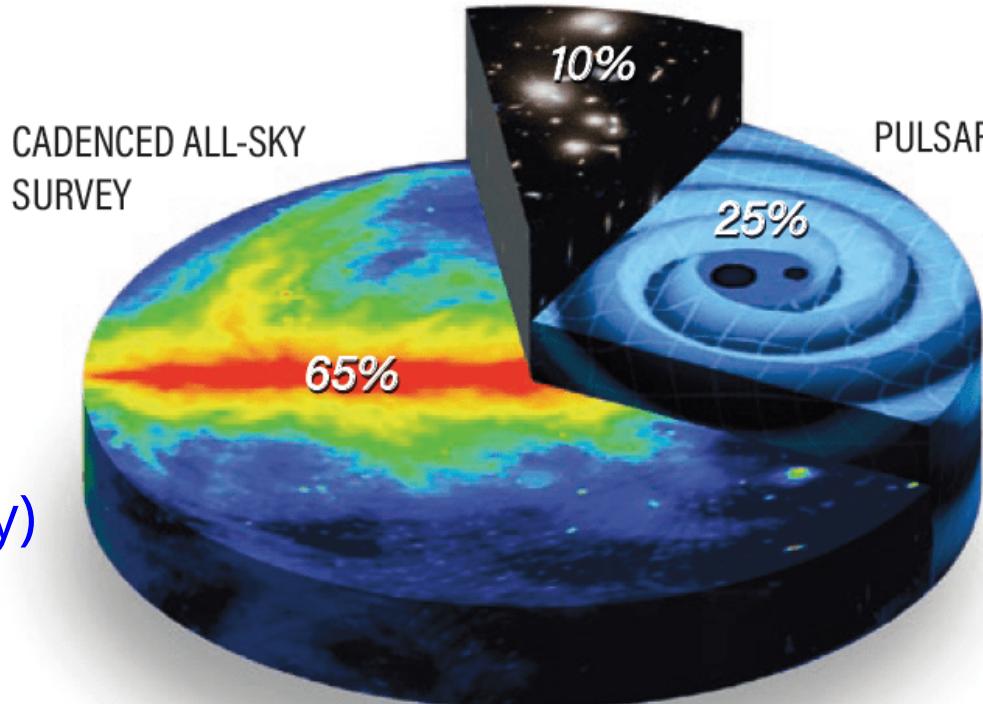


**DSA-2000**

# 5 Year Survey

GW (Triggered)  
and DDT

GRAVITATIONAL WAVE FOLLOW-UP



31,000 deg<sup>2</sup>

Variable depth (~500 nJy)

Variable cadence



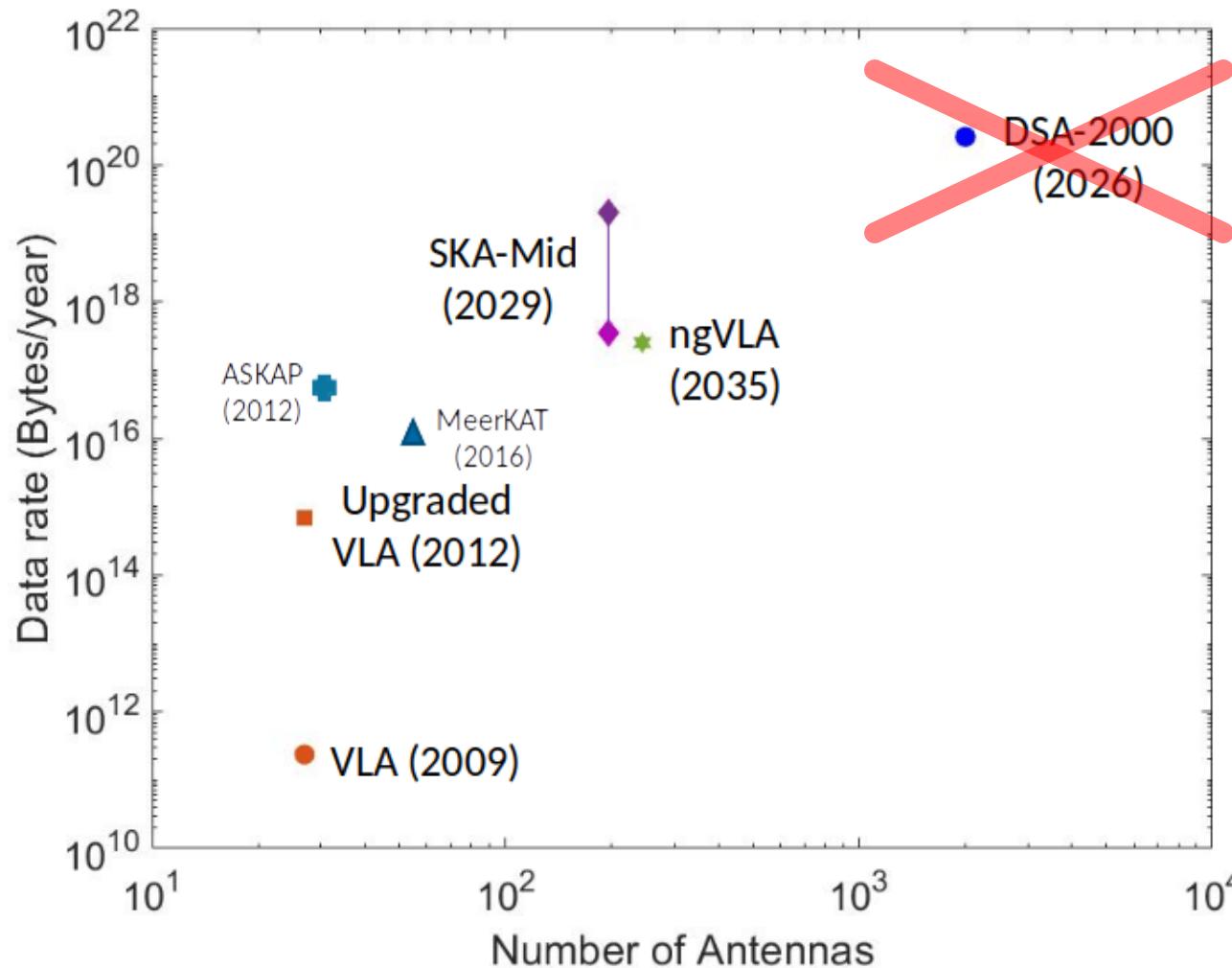
~200 fields

Variable cadence

# Radio Camera

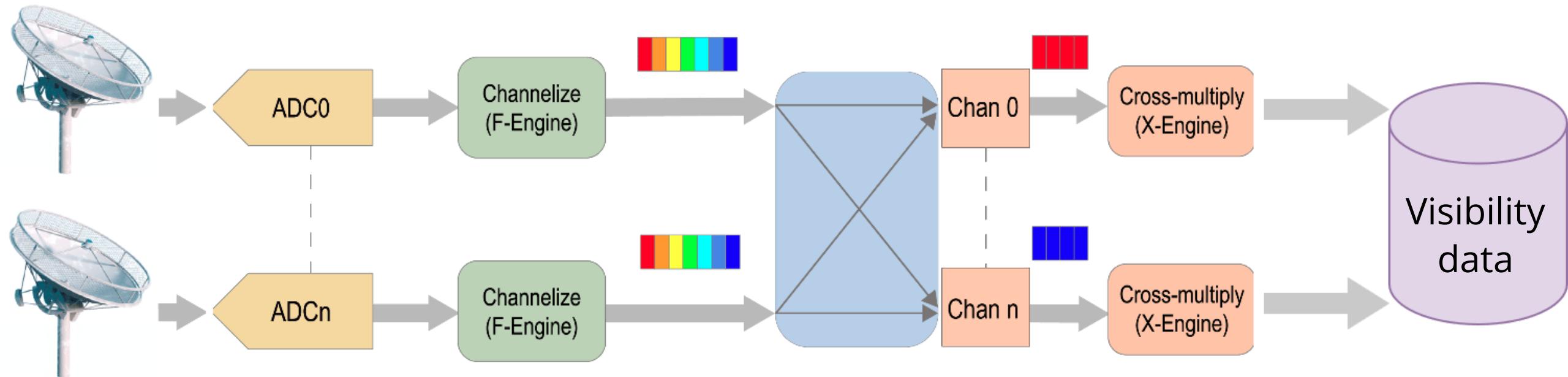
DSA-2000

# Big Data in Radio Astronomy

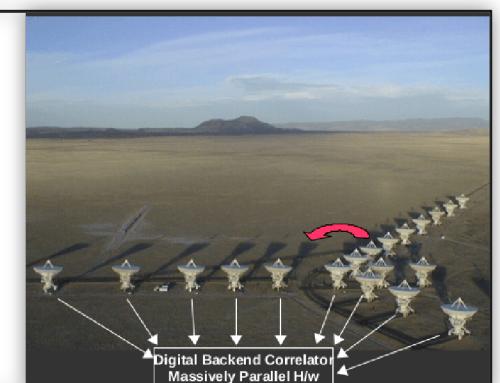
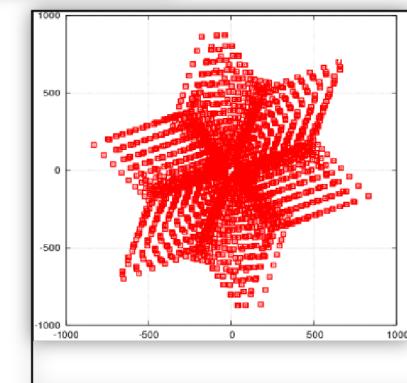
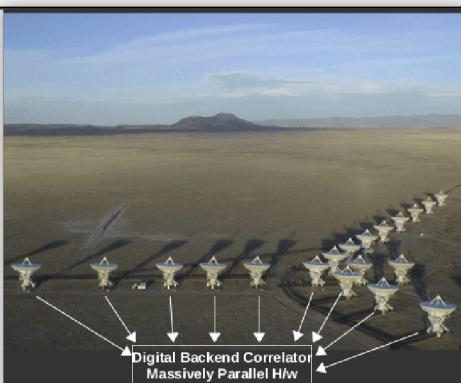
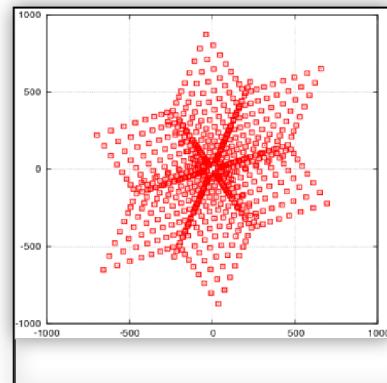
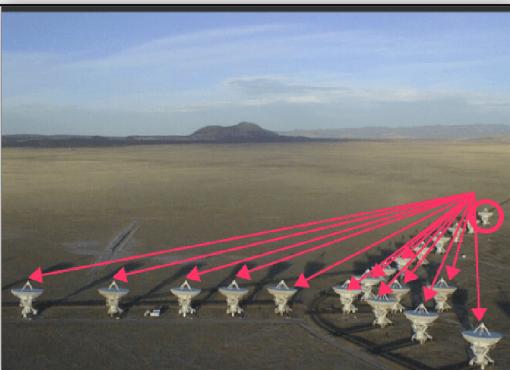
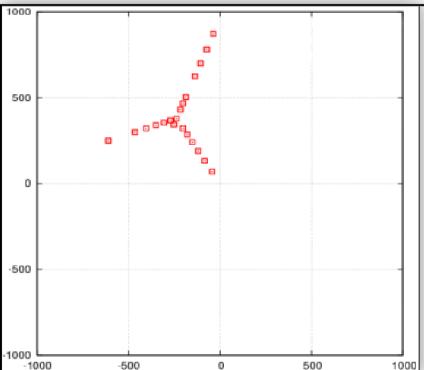


**DSA-2000**

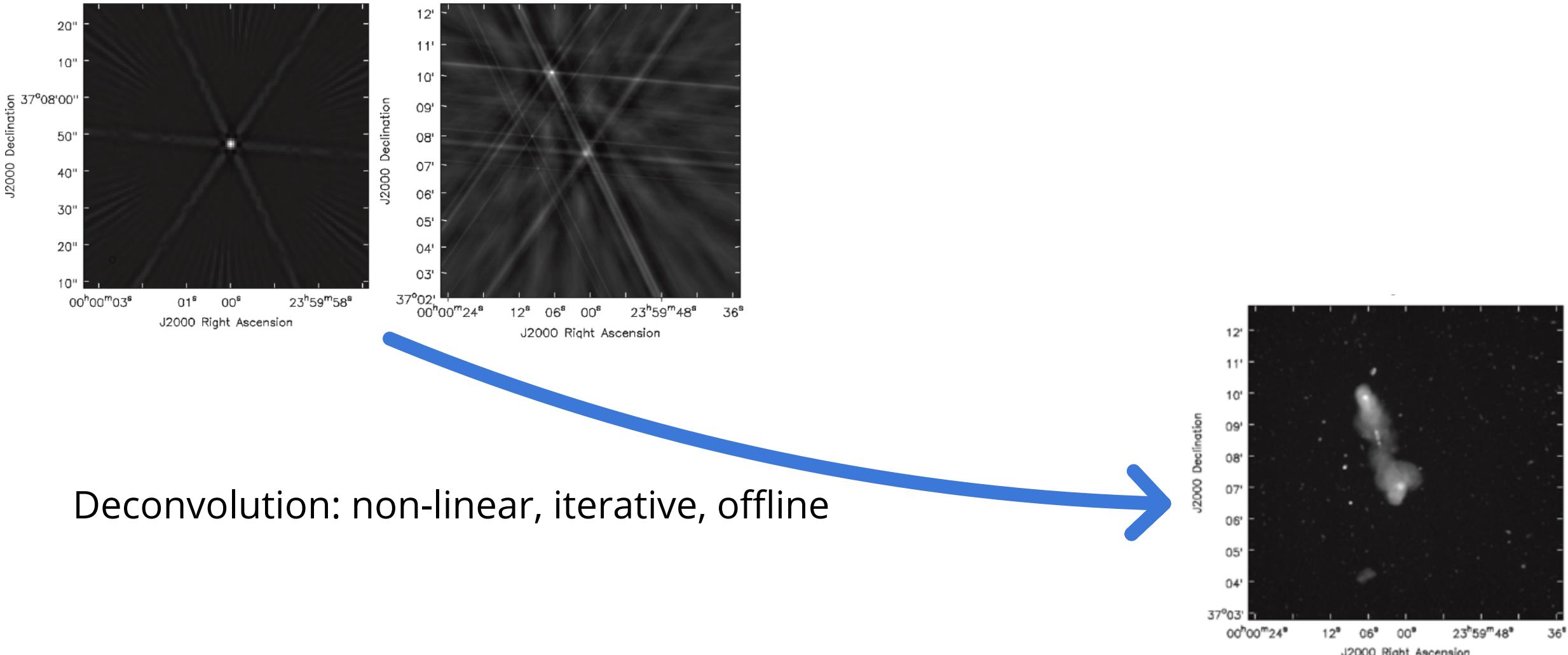
# Radio interferometer array data processing



# Synthesis imaging

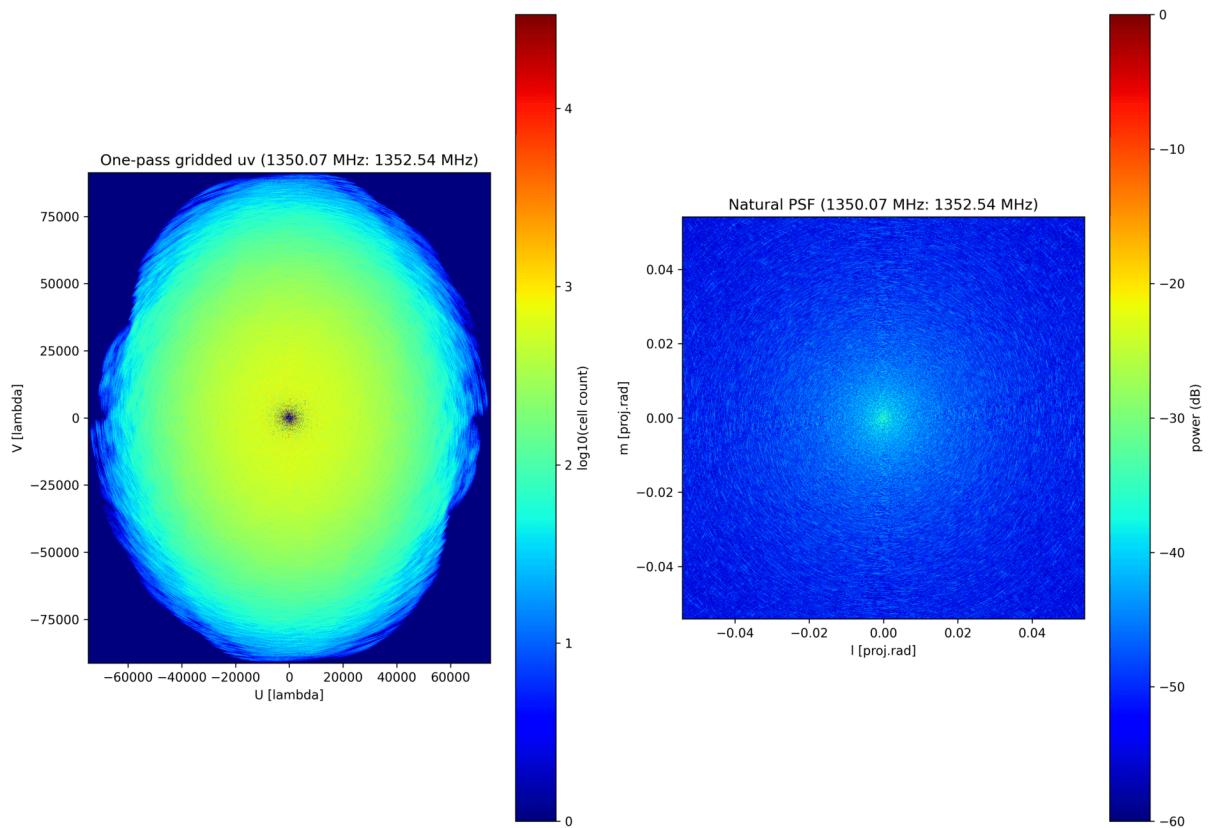


# Role of deconvolution

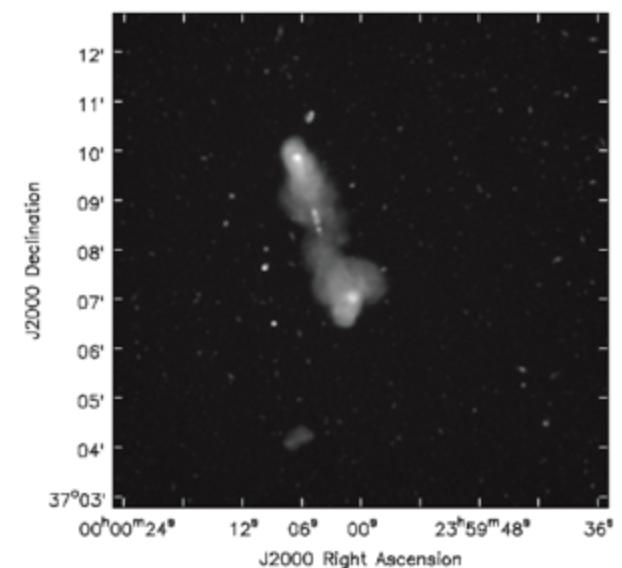


Deconvolution: non-linear, iterative, offline

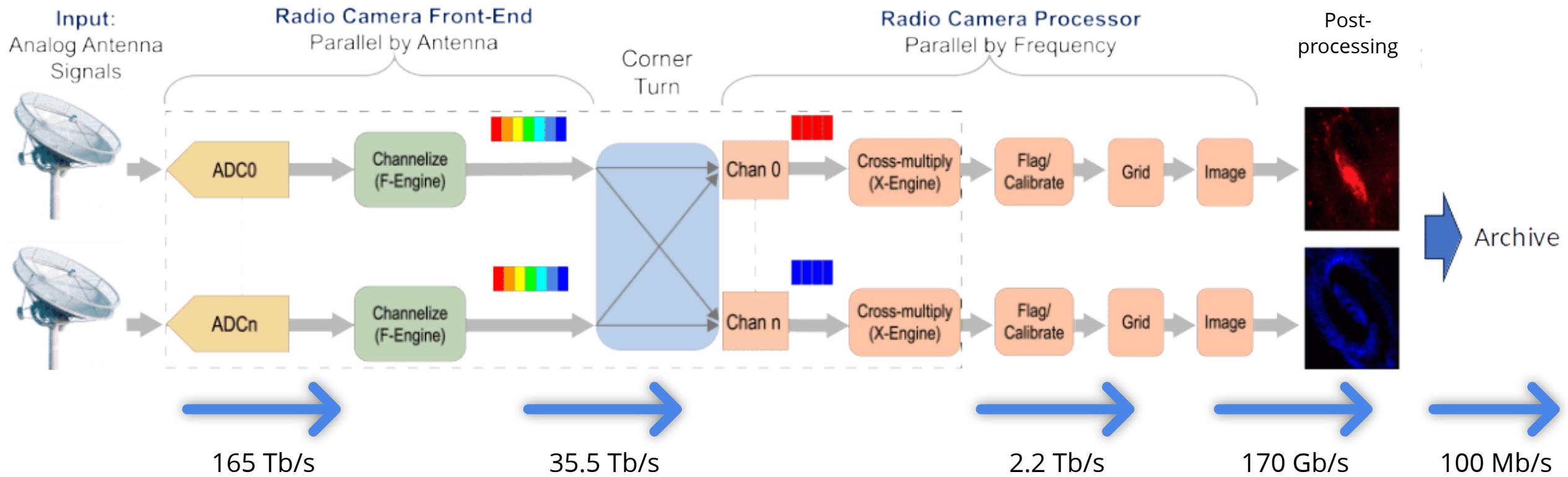
# DSA



NO UV DECONVOLUTION



# Radio camera



# Chronoscope

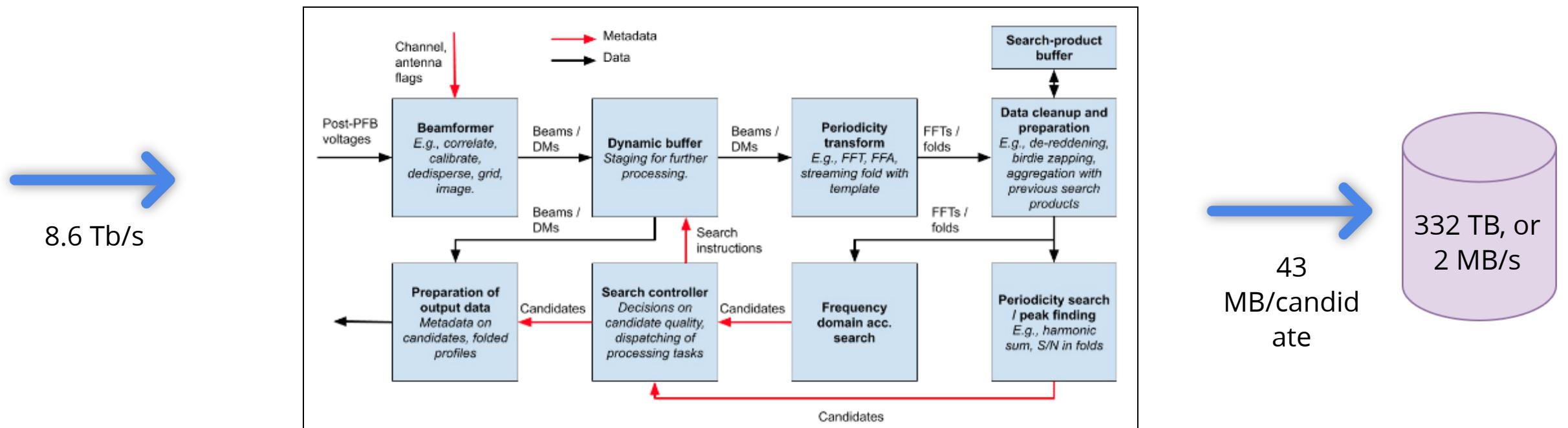
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# Chronoscope Summary

Detection of short-timescale transient signals

- pulsars (periodic)
  - 0.1 ms time resolution
  - search output: intensity vs time, frequency
  - timing output: intensity vs phase
- fast radio bursts (non-periodic)
  - 1 ms time resolution
  - output: intensity and voltages vs time, frequency, position

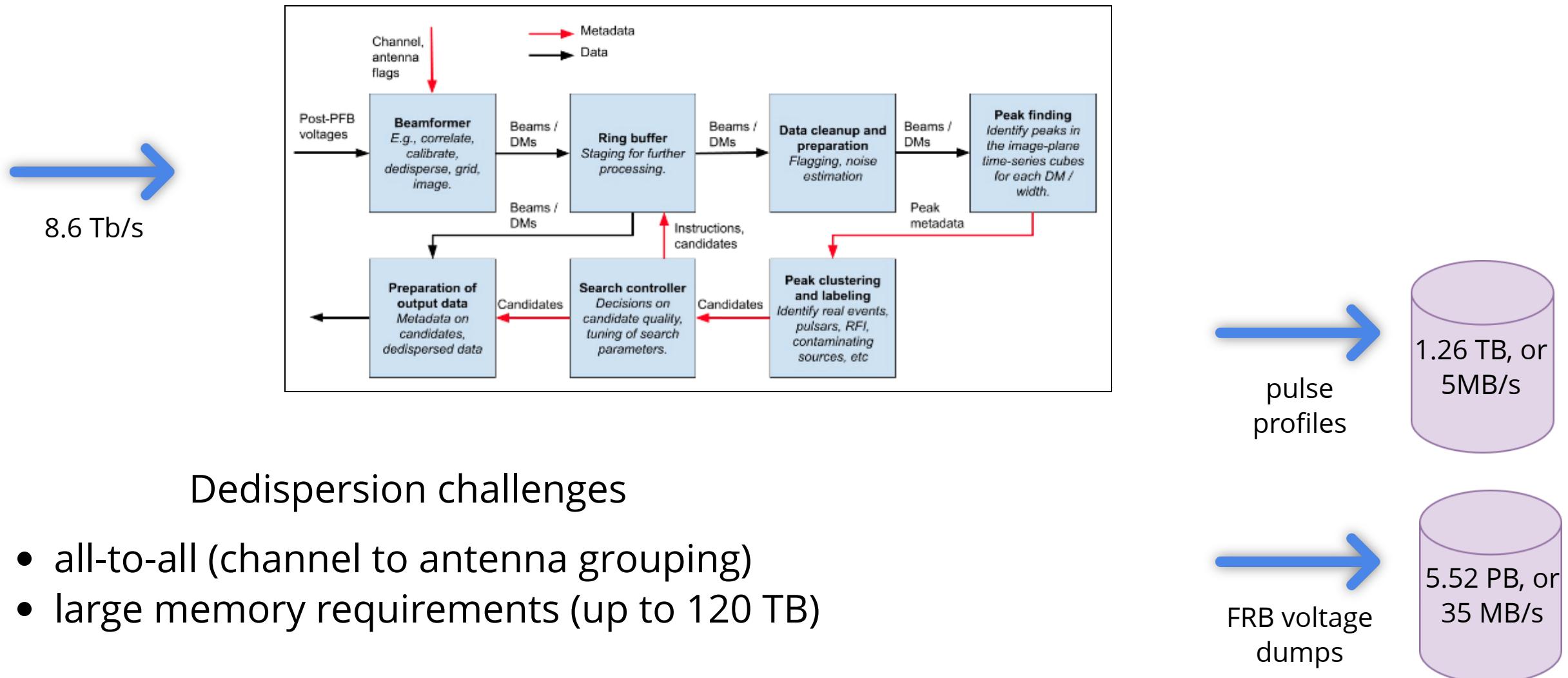
# Pulsar search pipeline



## Dedispersion challenges

- all-to-all (channel to antenna grouping)
- large memory requirements (up to 30 TB)

# FRB search pipeline



# Pulsar Timing

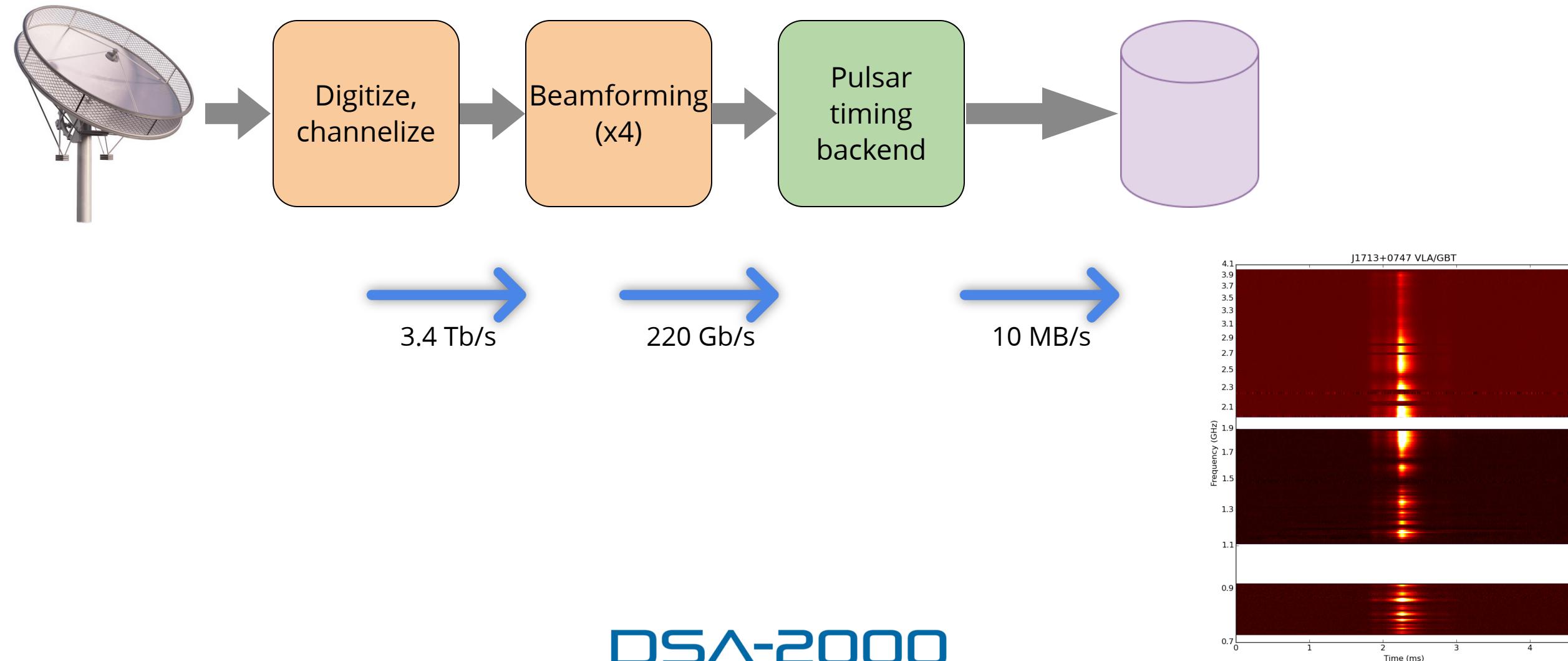
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# Pulsar timing science

- Main science goal is nHz-freq GW detection via pulsar timing array (NANOGrav project).
- DSA provides large sensitivity boost vs current instruments.
- “Secondary” pulsar science (binaries, GR, NS mass, ISM, etc.)
- Main targets for PT are known millisecond pulsars (MSPs).



# Pulsar timing pipeline



# Science data products

- DAT (post-processing)
  - Radio camera (images)
    - ~12,000 raw images every 21 min.
    - frequency channel bandwidths
    - polarization products
    - mosaics
    - co-add over epochs
    - source extraction
    - image cubes
  - Chronoscope
  - Pulsar timing
- Archive (~4 TB/day)

# Doing science with radio frequency data

- Experimental design
  - Instrument design
  - Instrument configuration
  - Instrument operation
  - Instr. data processing
  - Scientific analysis
- 
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- How will DSA ensure validity?
    - design
    - processing
    - performance
  - For streaming data?
  - For an instrument that doesn't yet exist?

# Forward modeling

- Goal: authentic realizations of DSA data products before final design.
- Digital twin  $\Rightarrow$  operate the telescope in silico.
- Use for design discrimination: verify that requirements are feasible with systematic floors.
- simulation of signal path
  - antennas through DAT processing
  - flagging and calibration of streaming data is a challenge
    - need to complete deterministically, and be correct

# Timeline

Schmidt Sciences  
Design Funding

