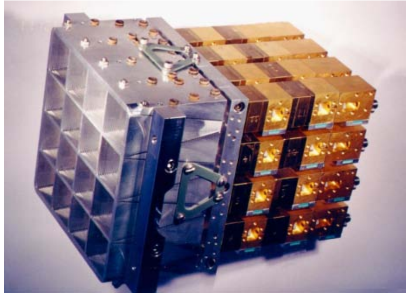
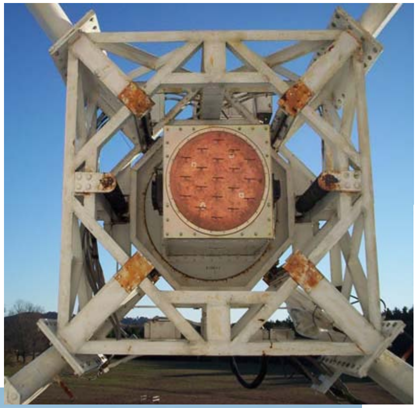
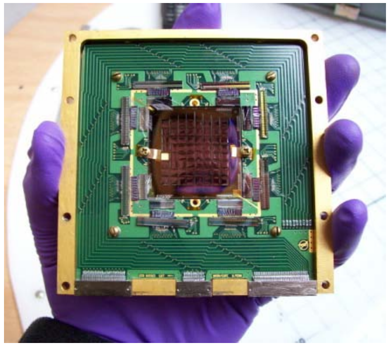
The Future of Radio Astronomy



Karen O'Neil





The Present

Arecibo Telescope

305m diameter dish

0.4 -10 GHz

7-pixel FPA (1.2-1.5 GHz)

$-01^{o} < \delta < 38^{o}$

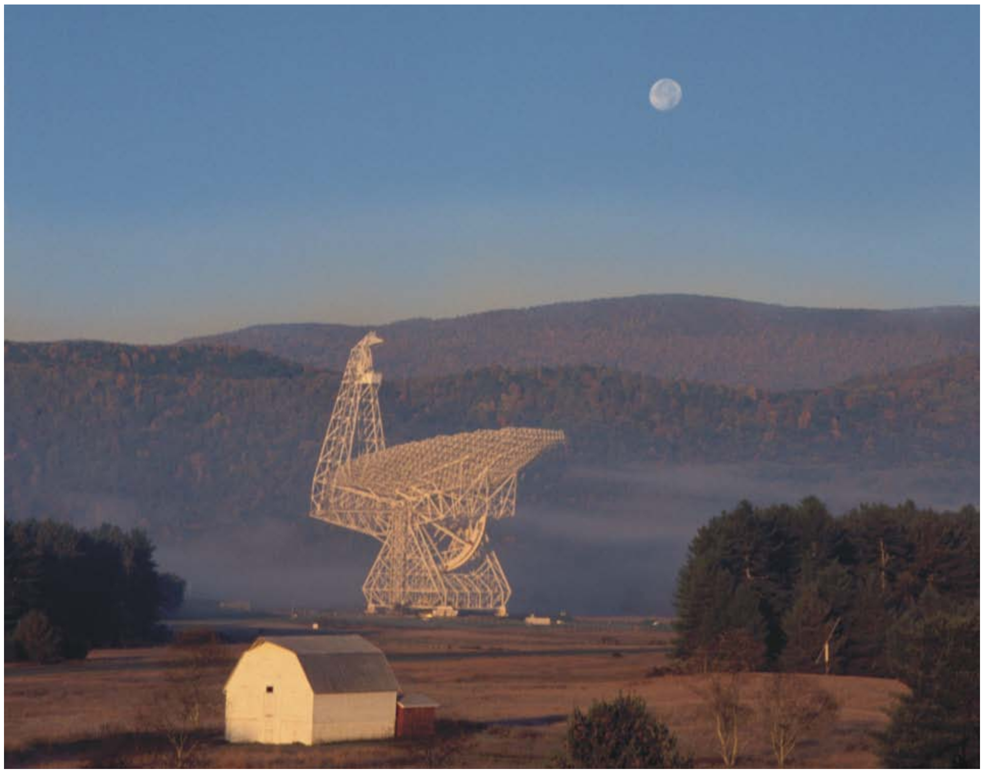
Resolution :

15’(0.3 GHz) – 0.4’(10 GHz)

60% of astronomy time is being used for surveys (ALFA)

The Present

The GBT



100m diameter dish

0.1 -100 GHz

7-pixel FPA (18 - 26 GHz)

64-pixel bolometer array

$-45^{o} < \delta < 90^{o}$

Resolution:

13' (0.1 GHz) – 6'' (100 GHz)

35% efficiency at 90 GHz

The Present

The EVLA

27 antennas, 25m diameter dishes

1 - 50 GHz

$-45^o < \delta < 90^o$

Resolution: 13’ (74 MHz, D-config) - 0.05” (45 GHz, A-config)

The Present

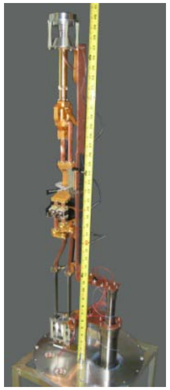
Other Telescopes

(an incomplete list)

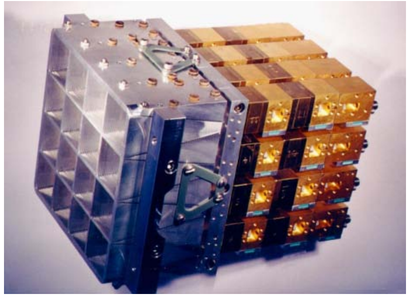
Telescope	Diameter	Freq Range	
Efflesburg	100m	0.4-90 GHz	Efflesburg, Germany
Nançay	20m-40m (10 panels)	1-3.5 GHz	Nançay, France
Lovell	76m	0.15 – 26 GHz	Jodrell Bank, England
Parkes	64m	0.4-23 GHz	New South Wales, Australia
Nobeyama	45m	20-150 GHz	Nobeyama, Japan
GMRT	30 x 45m	0.05 – 1.4 GHz	Pune, India
IRAM 30m	30m	80-280 GHz	Pico Velata, Spain
Westerbork	14 x 25m	0.25- 9 GHz	Westerbork, Netherlands
ATCA	6 x 22m	1.2-106 GHz	New South Wales, Australia
Plateu de Bure	6 x 15m	80-280 GHz	Plateau de Bure, France
Nobeyama Array	6 x 10m	80-230 GHz	Nobeyama, Japan

The Future

Camera Development

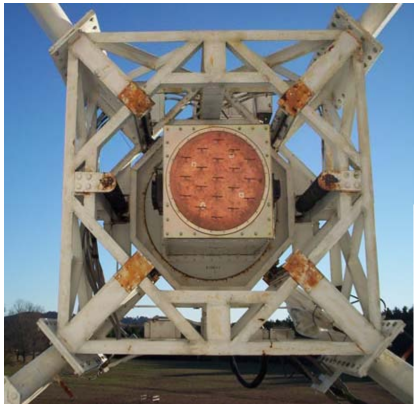


- Traditional Feed Horn Arrays
  - Integrated feed designs will allow for 100s of pixels with wide bandwidth
  - Cooled designs will be competitive with existing receivers
  - Challenges:
    - Hardware integration vs. access to components
    - Signal processing (A/D converters & backend processing costs)
    - Data issues - processing costs, visualization, archiving
  - Requires generational improvement over existing systems

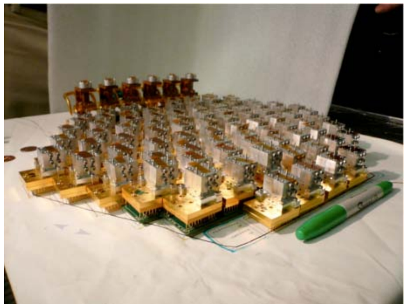


The Future

Camera Development

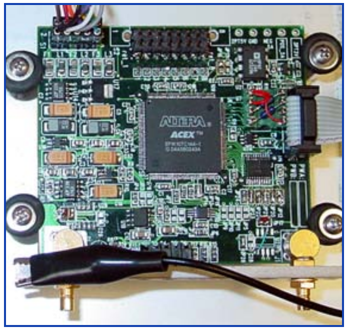


- Phased Array Feeds
  - Potential for many 100s pixels on the sky
  - Could allowed for steered beams, improved RFI excision
  - Cooled designs will be competitive with existing receivers
  - Can potentially pack many more beams onto telescope
  - Challenges:
    - First cooled PAF not yet in operation*
    - Signal processing costs will limit bandwidth and beams
    - Data issues - processing costs, visualization, archiving
  - First cooled PAFs should be here soon!

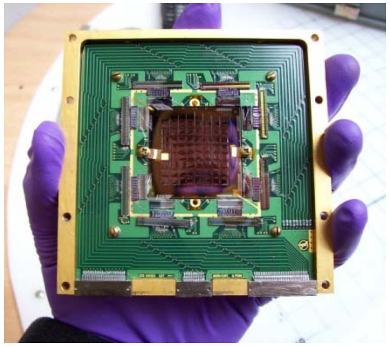


The Future

Camera Development



- Bolometer Arrays
  - Potential for many 1000s pixels on the sky
  - Extremely sensitive technology
  - New designs should ne significantly more sensitive
  - Challenges:
    - Reaching sensitivity limits extremely difficult
    - No system yet exists which consistently meets theory



The Future

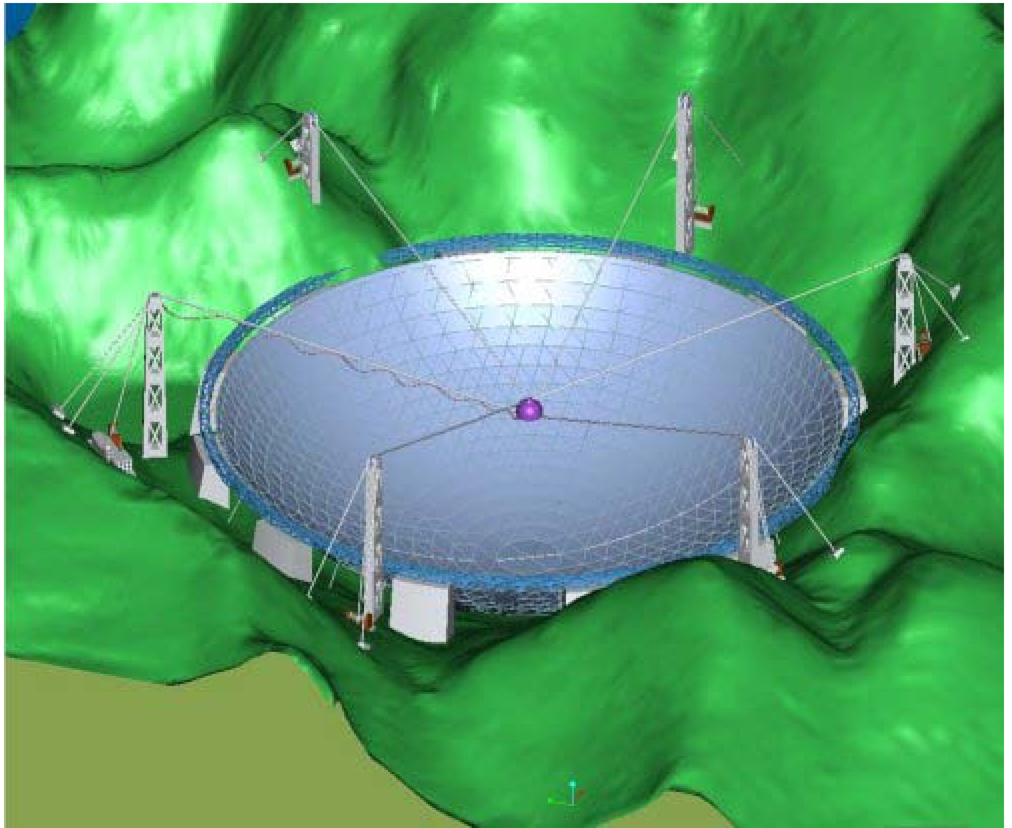
Specialty Instruments

- Wideband receivers
  - Ku receiver for Galactic Center pulsar Search
  - L/S receiver for pulsar search and timing
- Specialty backends
  - FPGA backends for pulsar timing
  - Analog receiver for 14 GHz bandwidth CO search
- Etc

New Telescopes

Single Dish and Arrays

- FAST:
  - Five hundred metre Astronomical Spherical Telescope
  - Built in southwest China
  - Coming online 2016
  - Up to 5 GHz
  - Innovative design –
    - Inner 300m for observing



New Telescopes
Single Dish and Arrays

- LMT (Large Millimatre Telescope)
  - 32m diameter now; 50m eventually
  - In Puebla, Mexico
  - 75-275 GHz range
  - First proposal call very soon

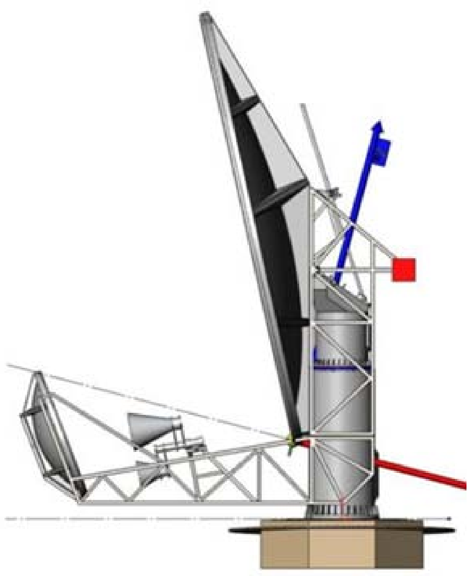
New Telescopes

Single Dish and Arrays

- ALMA (Atacama Large Millimetre Array)
  - 84-720 GHz (eventually)
  - In Atacama Desert, Chile
  - Main Array: 50 x 12m antennas
    - + Total Power Array 4 x 12m
    - + Atacama Compact Array (ACA): smaller array of 12 x 7m antennas
  - Early science call (16 telescopes) out!

New Telescopes
Single Dish and Arrays

- MeerKAT
  - 64, 13.5m telescopes
  - 0.6 – 14.5 GHz
  - In Karoo, South Africa
  - KAT-7 now online and working!
  - Complete by 2018



New Telescopes
Single Dish and Arrays

- ASKAP (Australian Square Kilometre Array Pathfinder)
- 36, 12m antenna
- 0.7-1.8 GHz (eventually to 2.5 GHz)
- Planned completion in 2013
- In Western Australia

New Telescopes

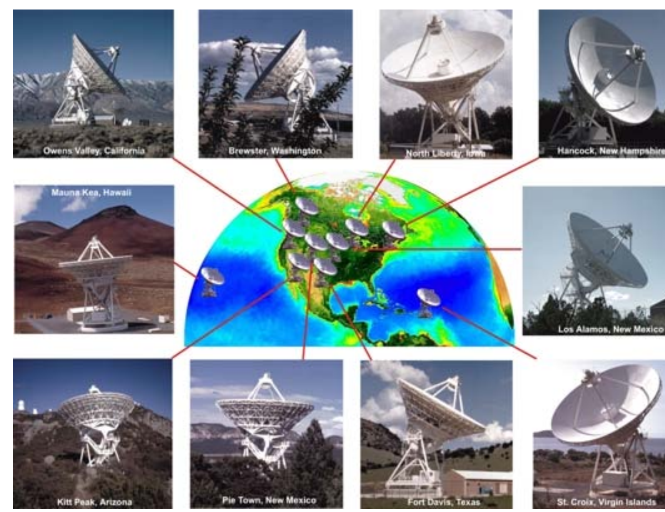
Single Dish and Arrays

- SKA (Square Kilometre Array)
  - International partnership between 67 organisations in 20 countries
  - “3, 000 dish antennas, each about 15 m wide”
    - \+ “two other types of aperture array antennas”
    - \+ “five spiral arms extending to distances of at least 3 000 km from the centre of the array”
  - Construction 2016, full science 2024

New Telescopes

Single Dish and Arrays

- North American Array
  - Combination of existing & new telescopes in the northern hemisphere
  - Works from ~1 – 50+ GHz, filling in frequencies above SKA
  - Will require new/refurbished telescopes and systems
  - Can be started immediately



The Future of Radio Astronomy…

is very bright

- Single dish telescopes with cameras will provide major leap in science research
- Fantastic new arrays being built
- Possibility of SKA →
    - Increased interest, funding for radio astronomy
    - New telescopes and improved instrumentation
    - Possibility of very high resolution and sensitivity telescopes through SKA