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° < δ < 38°

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
\(-45^\circ < \delta < 90^\circ\)

Resolution:
\(13' \ (0.1 \text{ GHz}) - 6'' \ (100 \text{ GHz})\)

35% efficiency at 90 GHz
The Present

The EVLA

27 antennas, 25m diameter dishes
1 - 50 GHz
-45° < δ < 90°

Resolution: 13’ (74 MHz, D-config) - 0.05” (45 GHz, A-config)
The Present
Other Telescopes
(an incomplete list)

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

Very Large Array
(Socorro, New Mexico)
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