ASTRON
Netherlands Institute for Radio Astronomy

JIVE
Joint Institute for VLBI ERIC

History of the Westerbork Synthesis Radio Telescope (WSRT)

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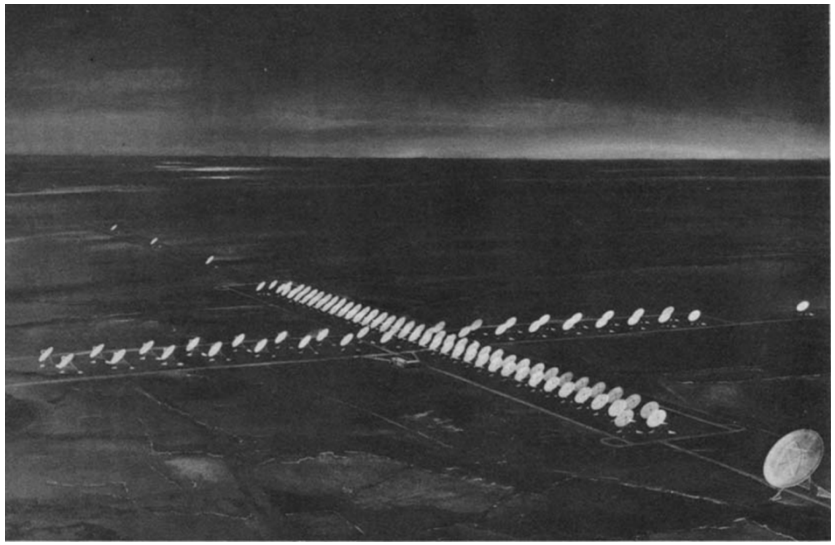
The need for radio telescopes of very large dimensions is so obvious that it does not require an introduction! – Jan Oort (1961)

- WSRT developed from Dwingeloo 25 m dish, and a proposed ≈5 km baseline, ≈100 element cross antenna (with Belgium)
- From the start, one of Oort's concerns was angular resolution (optical: ≤ 1″ arc)
- For Oort, discrepancy of ≈ 2000× between optical & radio resolution: serious limitation
- A key goal: cosmology by source counts

Benelux Cross Antenna Project (BCAP) evolved over some years, became an EW synthesis array

- The first BCAP design was by Seeger (1958)
- Several cross designs followed (Christiansen involved from 1960)
- After Belgium left the project (1964), it had to be de-scoped
- Ryle's OMT played an indirect role
- J Högbom role critical



W.N. Christiansen & C.L. Seeger

The mixed blessings (and politics) of international collaboration

- The involvement of Belgium (& Luxemburg) probably seemed a good idea in the 1950s
- The Benelux countries formed an early union after the Second World War
- However, radio astronomy did not have a high profile among Belgian astronomers
- By 1964, Belgian astronomy had to decide between the BCAP and ESO (funds were limited). Oort (& A. Blaauw) decided Belgium was more important to the European Southern Observatory

Original Westerbork Telescope

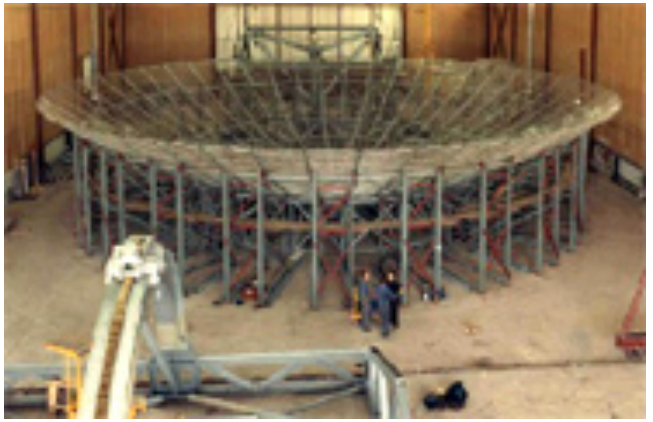
- Built 1967-70
- Project included:
  - Telescopes (12 × 25 m).
  - Buildings, access roads.
  - Cables.
  - Electronics & feeds (all Stokes).
  - Computer hard- and software.
- (White hangar is dish assembly hall.)
- Conservative approach
- Total cost: *fl*. 25 M (about € 50 M today)

Dishes assembled on template in 'bouwhal'

Each telescope has its own control building

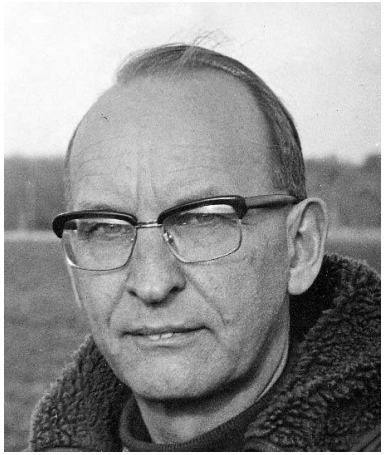
Controlled environment seen as vital for precision assembly.

Epoxy glue used to fix mesh to frames – innovative (no welding)



WSRT 25 m equatorial dishes: light weight & elegant

Project led by Muller & Hooghoudt



- Both had graduated from the Delft Technical University.
- C.A. (Lex) Muller designed the receiver system
- B.G. (Ben) Hooghoudt was responsible for the mechanical aspects, including the dishes
- (Hooghoudt was a consultant to many big antenna projects.)

Ten fixed and two movable 25 m dishes

Dishes all have same geometry and 8 mm mesh surface.
Only prime focus usable.

The movable dishes can be driven along 300 m long E-W rails

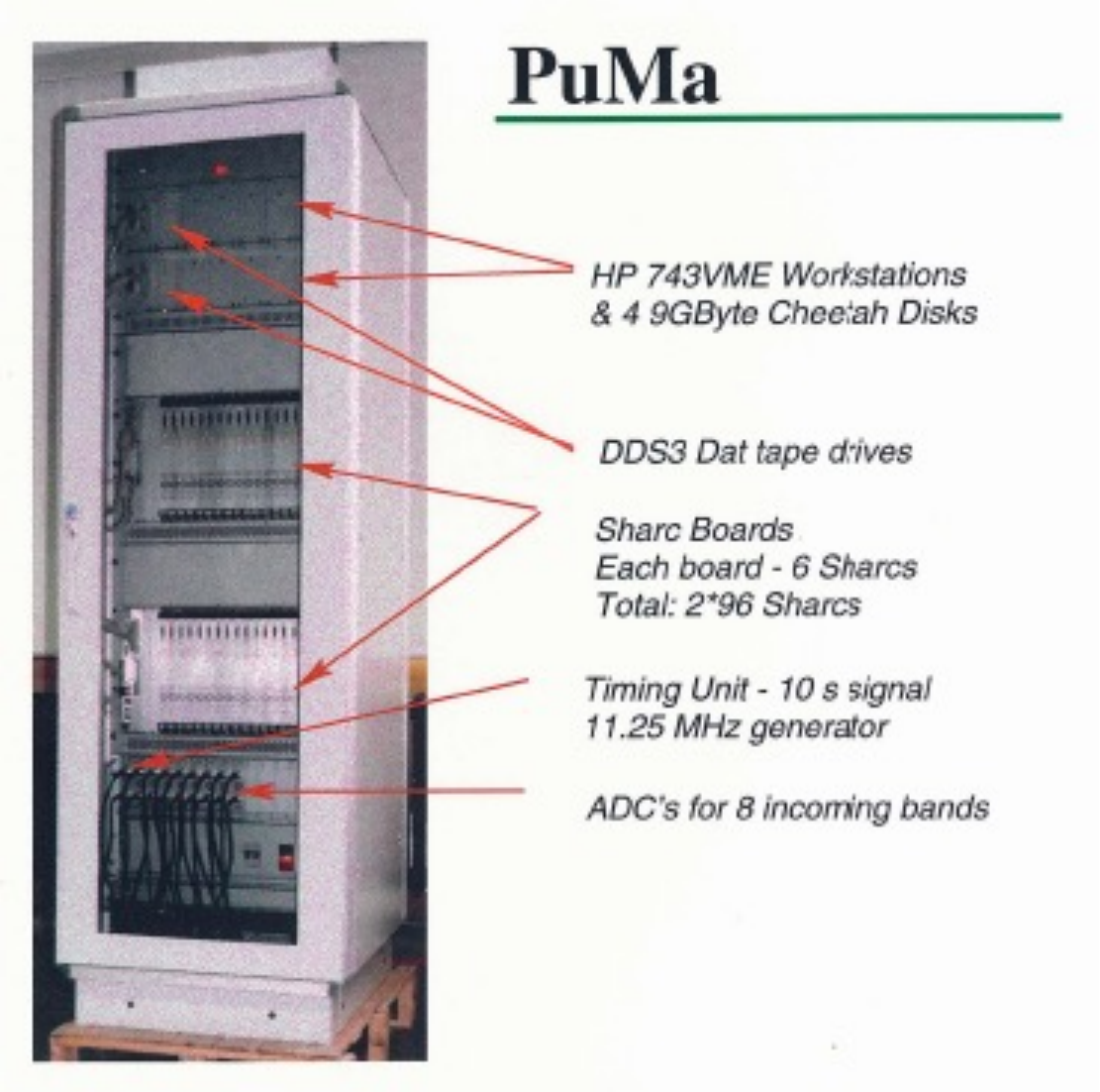
Early upgrades: lower T_s, wider band, two additional movable dishes, longer baseline

- Two new dishes built, first placed on original track (halved the time for synthesis)
- These telescopes (C & D) moved (1976-80) to new rail track 1.3 km east of original rails
- This improved angular resolution by factor of 2

Major upgrades over the years

- 12 → 14 × 25 m dishes; 1.4 →2.7 km baseline
- Bandwidth: 4 MHz→10 MHz→8 × 10→8 × 20 MHz
- T_s (L-band): 240 K→ 30 K
- From L-band 1 channel (continuum only) → multi-channel filter-bank (analog) spectrometer → series of flexibly configurable digital backends
- The L-band (18-22 cm) frontend later joined by receivers at wavelengths of 3.6, 6, 13, 30, 49, 90 cm & 2 m; most bands incorporated in MFFEs
- Tied array system for VLBI & pulsar observing

The pulsar machine PuMa



WSRT telescopes are equatorially mounted; only cover -90°< HA < +90°

- Limited HA kept costs down
- 12 h coverage suffices for a full synthesis: this limitation made sense
- But it can be annoying for anyone observing circumpolar sources
- And an important limitation for VLBI observing

Technical experience

- One of the innovations at the beginning was to use epoxy glue to secure the mesh surface panels to the backing structure
- Unfortunately, by the mid-1970s, it became obvious that the mesh was pulling loose
- A campaign was organized to use self-tapping bolts (each with its own lead drill) to (re)attach the mesh (with 180,000 bolts)
- Innovation can have its down side

Concluding remarks

- Technical developments vastly enhanced WSRT capability (sensitivity, bands, etc.)
- Going from a collective management to a Director General was of benefit to WSRT
- ASTRON has generally enjoyed support of ministers, members of parliament, civil servants. Provincial support (including local pride in the WSRT) has been a basis for the observatory nationally

Thank you!