The Westerbork Synthesis Radio Telescope (WSRT)

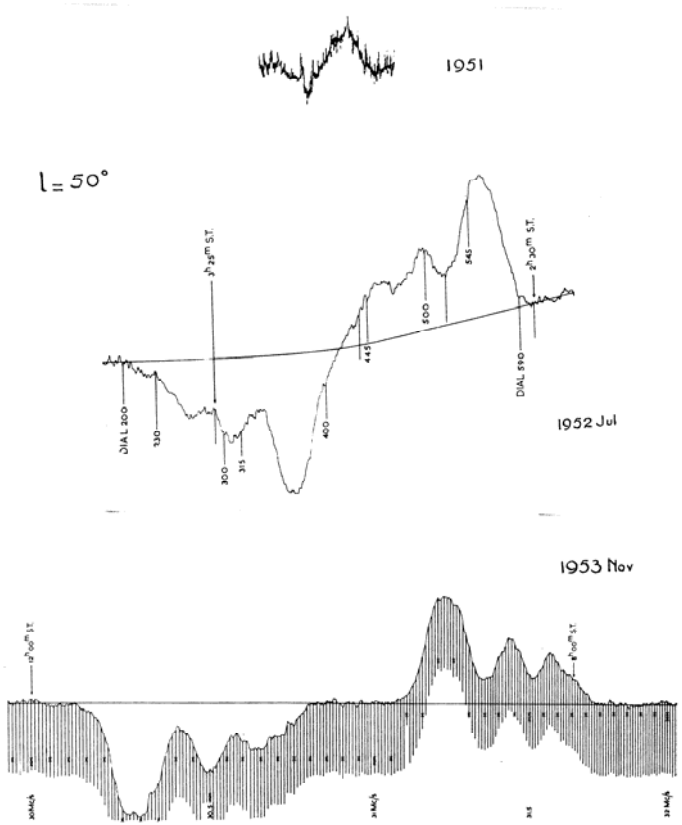
Richard Strom
ASTRON &
University of Amsterdam

The WSRT is operated by ASTRON

It originally began as the Stichting Radiostraling Zon en Melkweg (SRZM)

- (or the Netherlands Foundation for Radio Astronomy, NFRA)
- Founded by Jan Oort, Henk van de Hulst, Marcel Minnaert and others in 1949
- Purpose: study radio emission from the Sun and Milky Way

SRZM's first instrument was a 7.5 m radar dish borrowed from the PTT



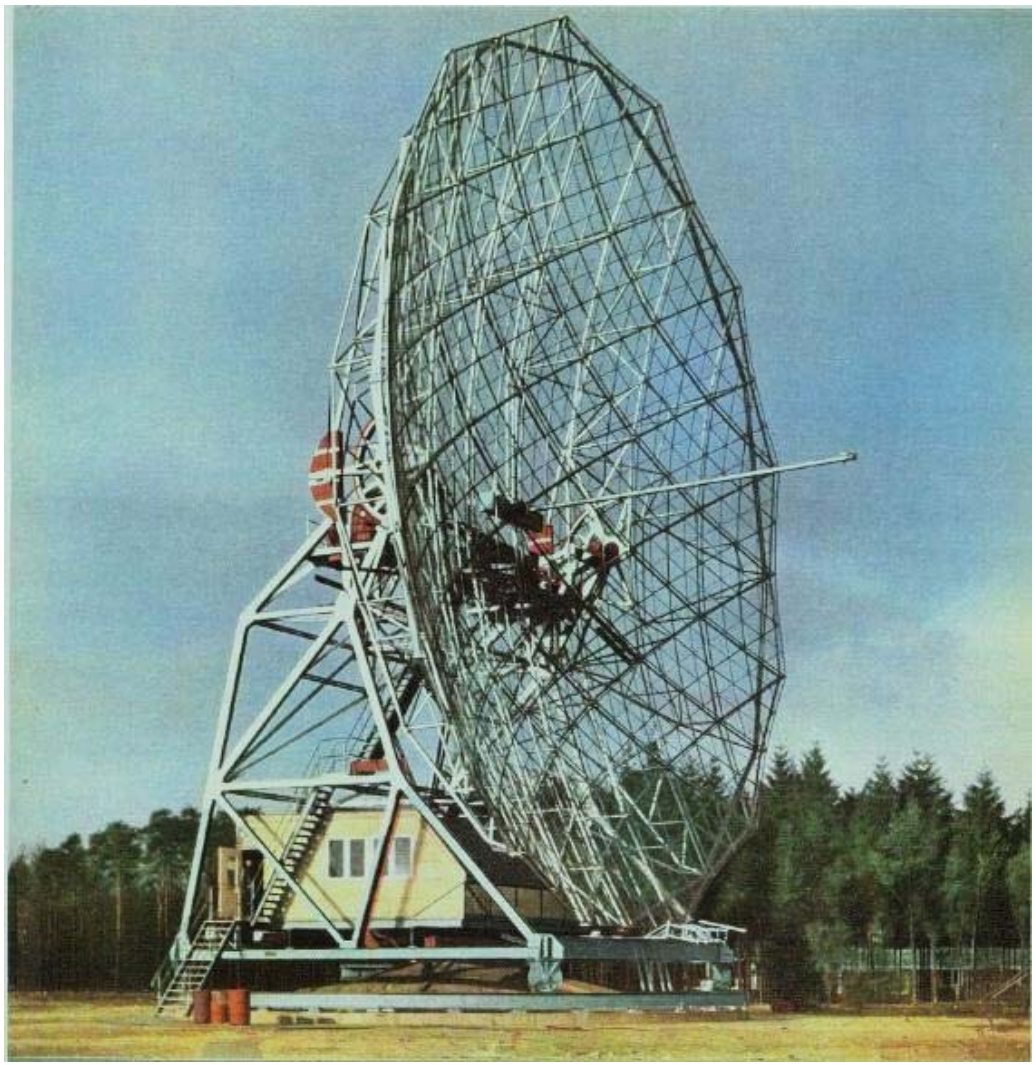
DE WERKELIJK WAARGENOMEN GRAFIEK

Figuur 4. In de drie hier afgebeelde gevallen was de Kootwijkse telescoop gericht op het zelfde punt van de hemel, een punt in het sterrenbeeld Zwaan.
Boven: de grafiek waargenomen met de eerste, verre van volmaakte ontvanger. In dit en de beide andere gevallen bracht de wijze van afstemming mee dat de grafiek zowel op zijn kop als rechtopstaand werd getekend, dus twee maal dezelfde grafiek.
Midden: De ontvanger is zodanig verbeterd dat de kromme minder zigzags vertoont. De ontvanger is nog niet voldoende stabiel: de nul-lijn verloopt tijdens de waarneming.
Onder: De grafiek is aanzienlijk gaver en de ontvanger is zo stabiel dat de nul-lijn recht is. Het gordijn van verticale strepen geeft de frequentie aan in stapjes van 0,01 MHz: deze verdeling vergemakkelijkt het aflezen van de grafiek.

7.5 m Würzberg was at Kootwijk (⊕), the "new" 25 m dish at Dwingeloo (X)

- Kootwijk was the PTT station for long distance radio communication, which began in the 1920s
- It soon became clear that this was not the best location for a radio telescope!
- Hence the move in 1955 to Dwingeloo

Opened in 1956, the first 25 m radio astronomy antenna



The Joint Institute for VLBI in Europe is also in Dwingeloo

The WSRT is an east-west array for earth-rotation aperture synthesis

- Elements: 14 × 25 m parabolic reflectors
- 10 fixed elements on 1296 m baseline
- 2 elements on 300 m rail track at east end
- 2 elements on 180 m rail track 1.3 km further east
- Basic spacing $n \times 72$ m

25 m dishes have 8 mm mesh surface, lightweight construction

- Equatorial mount
- HA range -90.5° to +90.5°
- Dec range: horizon to $\delta = +90°$
- Slew rate: 18°/min
- *f/D* = 0.35, prime focus operation

Observing bands and interferometer properties

Wavelength (cm)	Aperture efficiency	Field of view (°arc)	Synth. beam (″arc)
LFFE 260-170	0.30	8-5	160-104
UHF_{lo} 120-65	0.39	3.1-2	72-39
92	0.59	2.6	55
49	0.59	1.4	30
UHF_{hi} 40-25	0.39	1.11-0.83	26-15
L-band 27-17	0.54	0.8-0.5	15-11
13	0.54	0.37	7.8
6	0.48	0.17	3.7
3.6	0.35	0.1	2.2

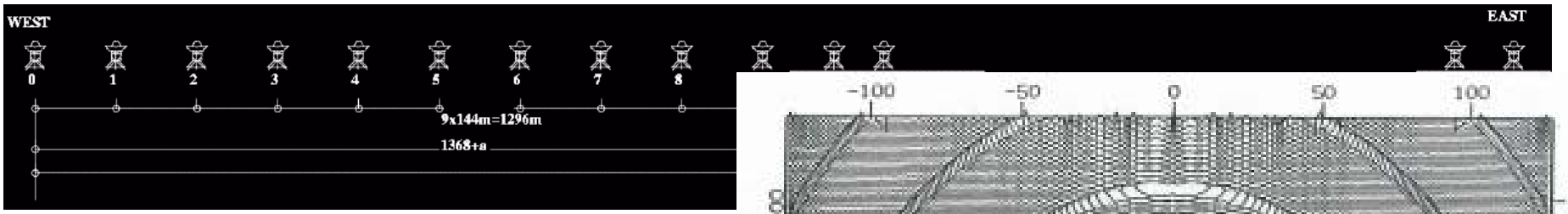
Sensitivities of the bands

Wavelength (cm)	Freq. range (MHz)	System Temp. (K)	r.m.s. in 12^h (mJy/beam)
LFFE 260-170	117-175	700-400	5-3
UHF_{lo} 120-65	250-460	250-120	≈ 0.5
92	310-390	125	≈ 0.25
49	(560-610)	75	≈ 0.15
UHF_{hi} 40-25	750-1200	180-120	0.085
L-band 27-17	1150-1750	27-31	0.012
13	2215-2375	60	0.021
6	4770-5020	65	0.023
3.6	8150-8650	110	0.042

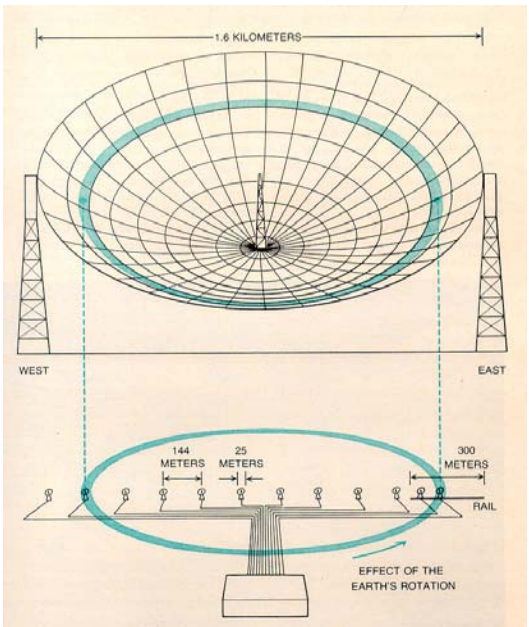
Strong points of the WSRT

- Wide frequency range, from 0.12-8.6 GHz
- Nearly continuous coverage, 0.12-1.7 GHz
- Rapid switching (≤ 1 min) between bands
- HI mapping, $0 \leq z \leq 0.25$
- Highly flexible spectrometric capability, up to 8×20 MHz instantaneous bandwidth
- Wide-field imaging, mosiacing
- Polarization synthesis mapping
- Pulsar backend, tied array capability

Beams and grating lobes

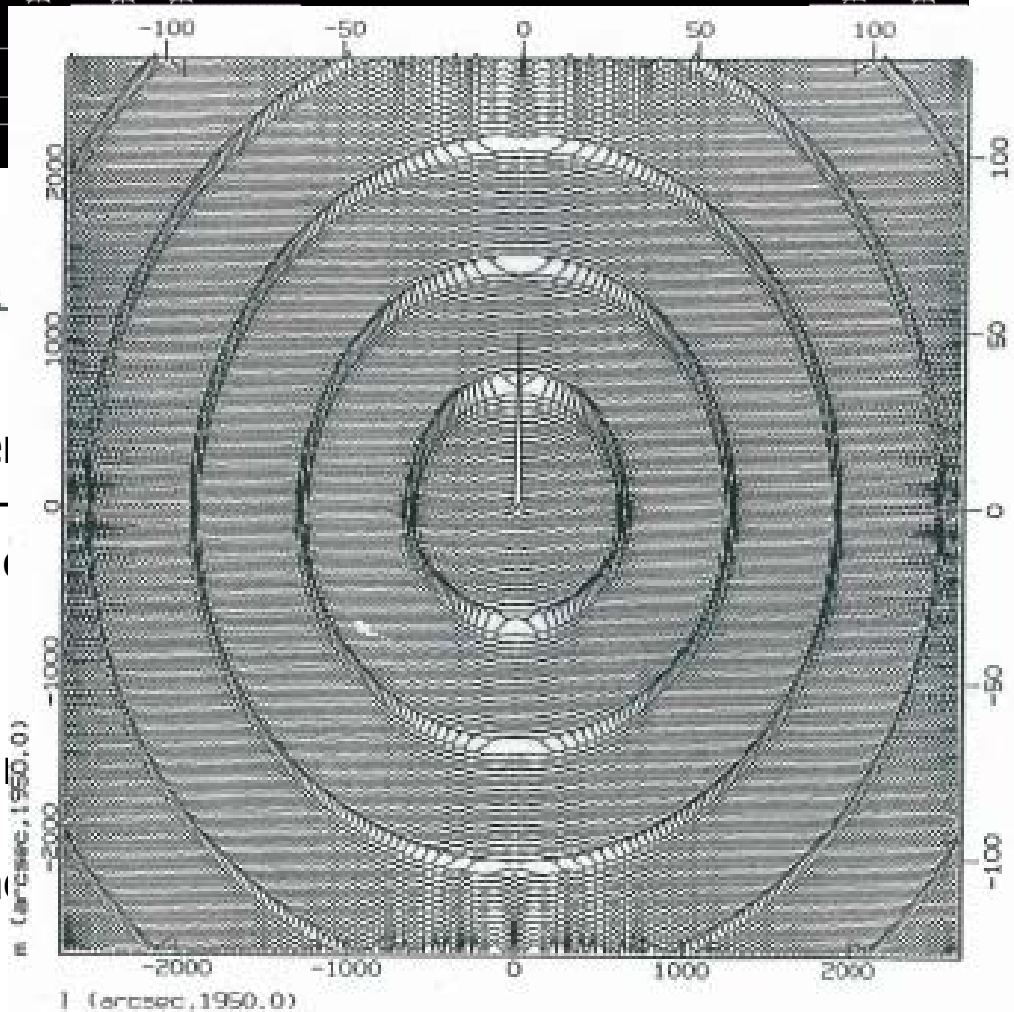


1-D response: series of grating lobes

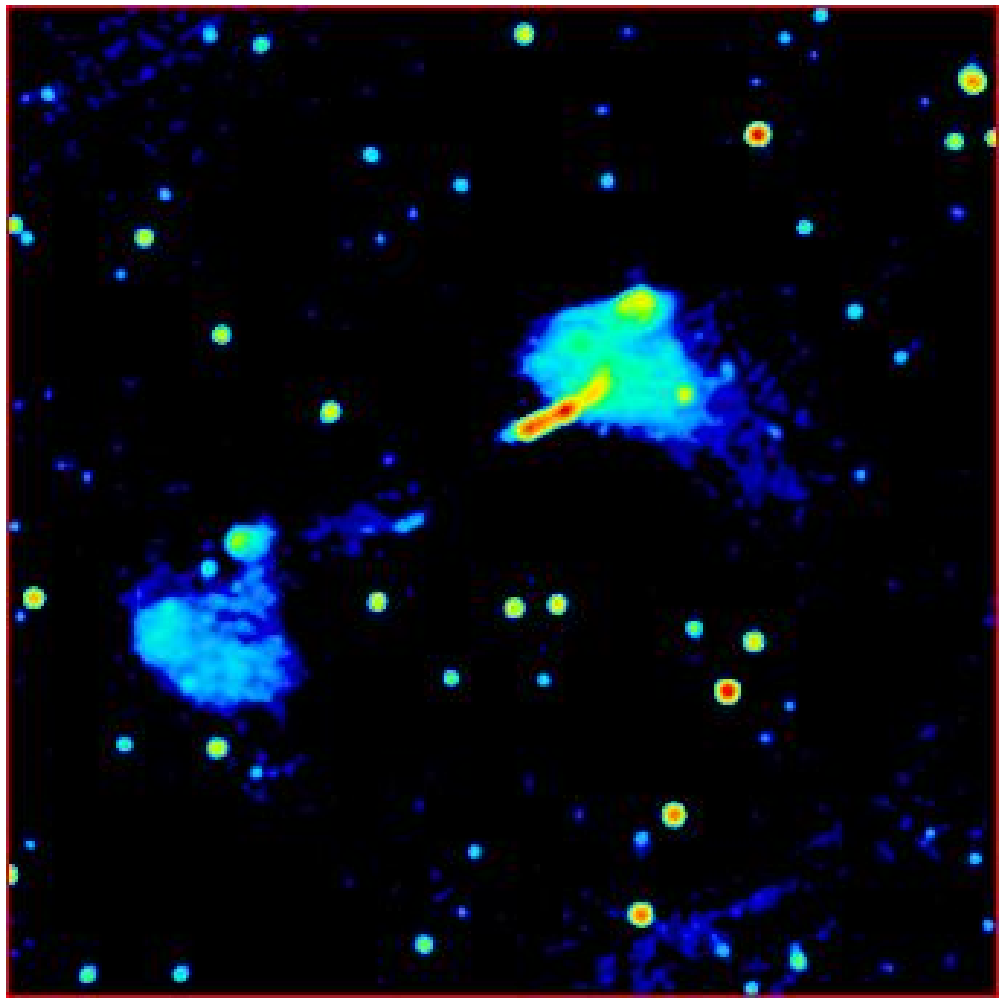


WSRT interfe
generate 38+
u,v -ellipses,

The antenna
produces is a
lobe with con
rings



Cleaned map of extended source, with some residual artefacts



WSRT data reduction, and some limitations of the instrument

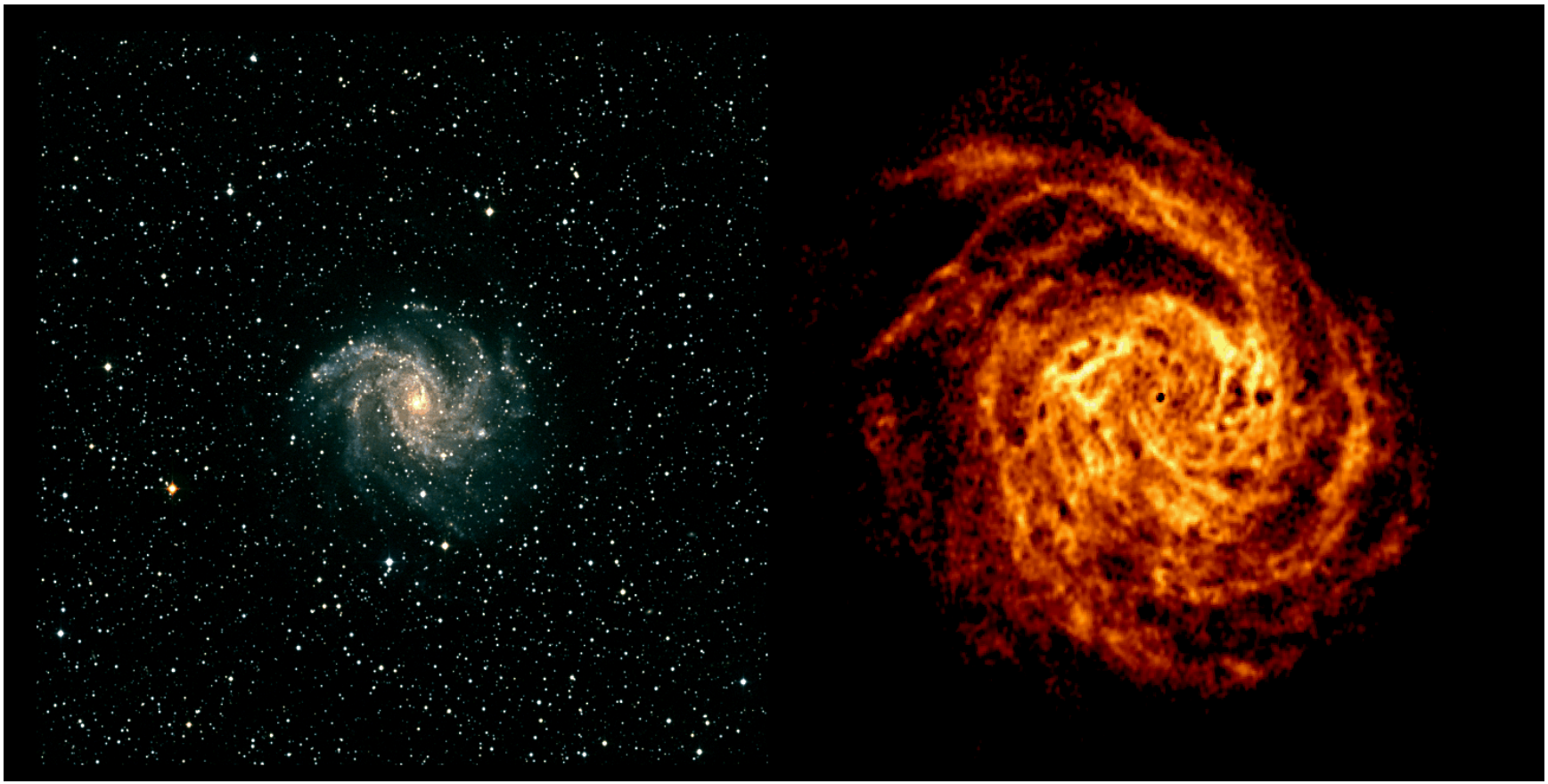
Data reduction packages:

- NEWSTAR (WSRT-specific features)
- AIPS; AIPS++; MIRIAD – via UVFITS

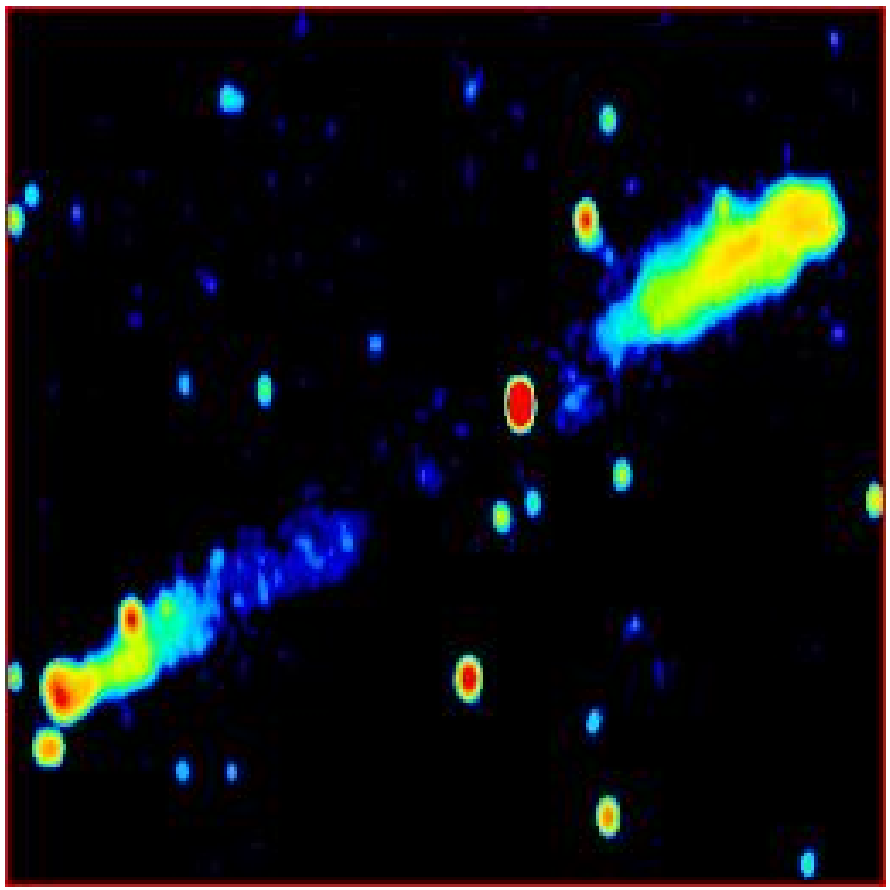
WSRT limitations:

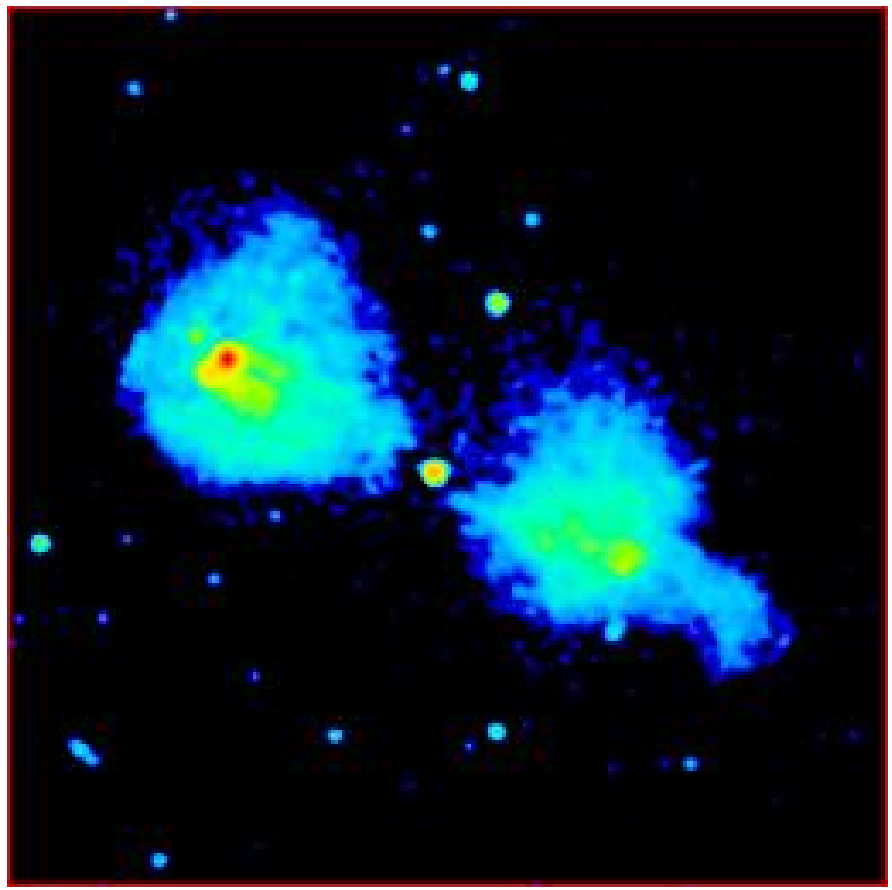
- No ‘snapshots’ (one-dimensional array)
- Beam elongated N-S, $\propto 1/\sin\delta$ (E-W array)
- Poor 2-d imaging for $\delta < 0°$ (cannot measure large ‘wedge’ in *u*,*v*-plane)

Example of HI mapping

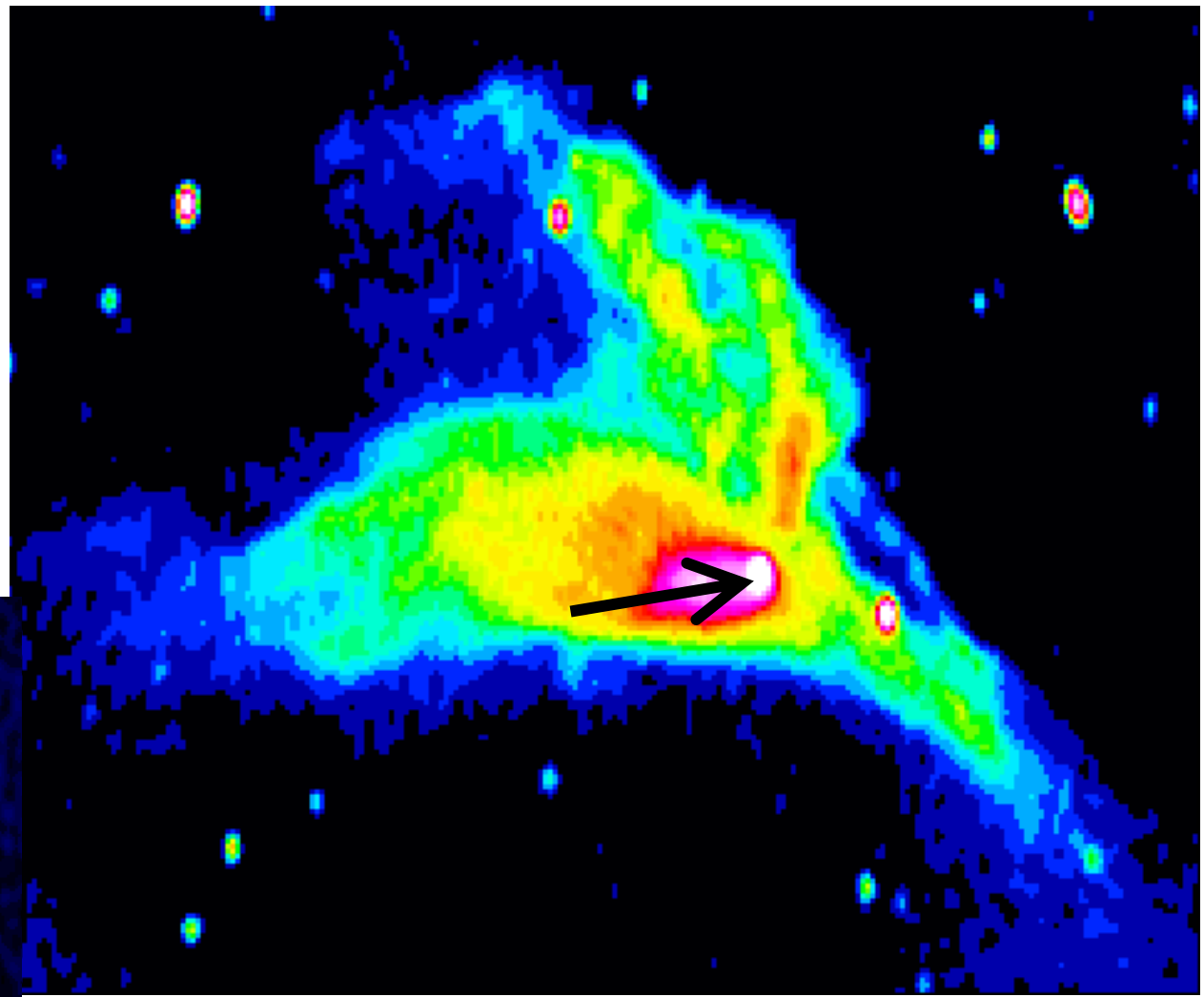


Very extended radio galaxies like 3C 236 and DA 240

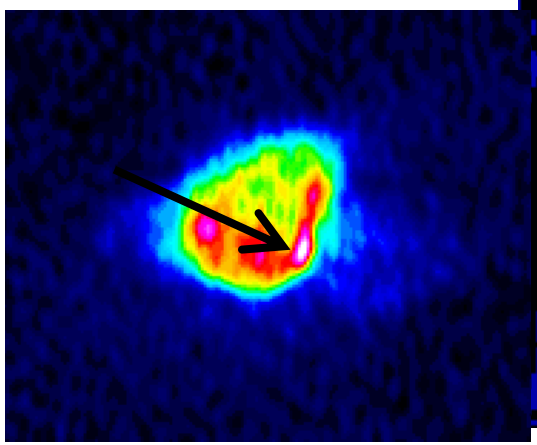




The presumed supernova remnant CTB80 at λ49 & 3.6 cm

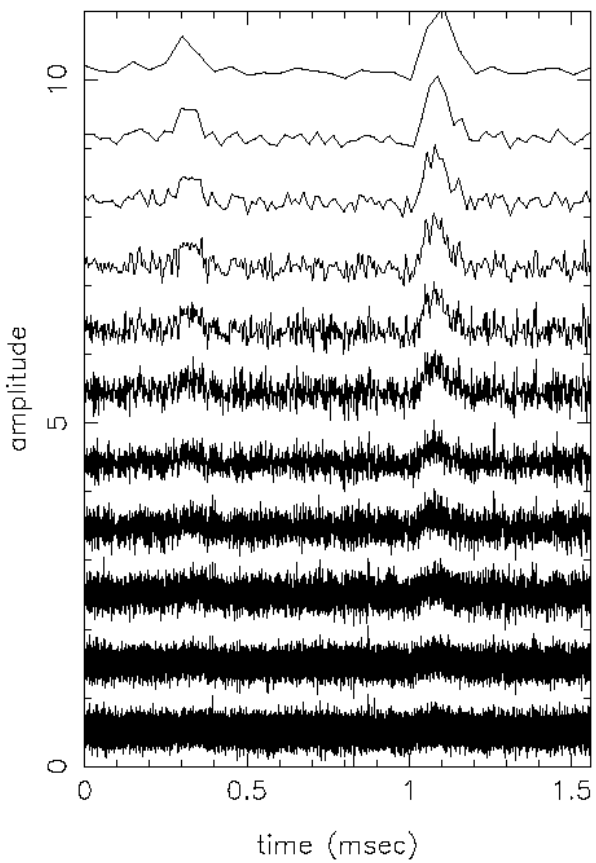


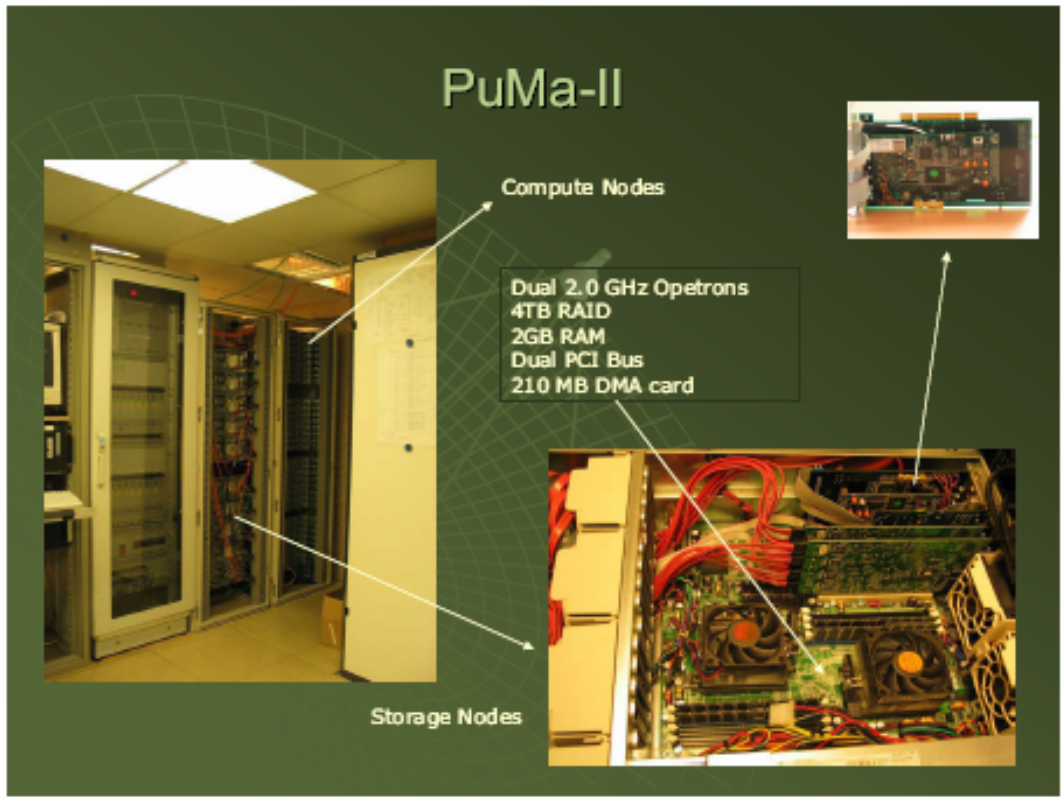
This flat spectrum PWN contains a 40 ms pulsar



Pulsar observing is done with the PuMa backend

PSR 1937+21, P=1.6 ms



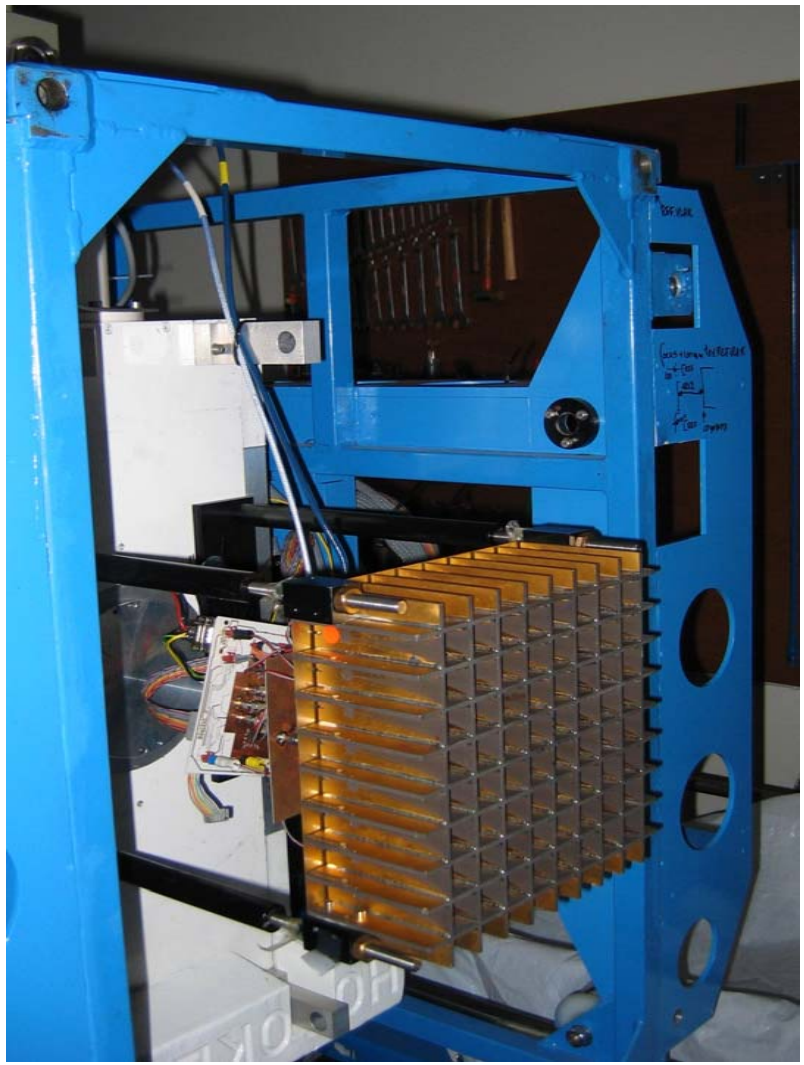


In tied array mode (pulsars, VLBI) the WSRT has collecting area of 94 m dish

Things to keep in mind when the WSRT is used as a VLBI element:

- Equatorial mount, not alt-az
- Allowed HA range (-6^h – $+6^h$) means any source can only be observed for 12 h
- The tied-array response is a fan-beam, ~12” arc wide at L-band. It can be broadened by dropping elements, with some loss of sensitivity

New project to produce multiple beams in each WSRT element for survey work



Thanks!