

History of Radio Astronomy Research at Nicolaus Copernicus University (UMK)

Department of Radio Astronomy, Centre for Astronomy UMK /
Institute of Astronomy



Personal view by Prof. Andrzej J. Kus

Toruń, August 2024

Photo: AJK

Origins of the University and the Observatory

15 July 1945 astronomers from Stefan Batory University (USB) arrive in Toruń as part of a group of 200 academic, administrative and technical staff.

24 July **1945** UMK is established in Toruń (government resolution) WH, WM-P, WSzP
UMK - Uniwersytet Mikołaja Kopernika, **NCU** - Nicolaus Copernicus University

UMK Astronomical Observatory established, **1945**,
with two departments: Astronomy (W.Dziewulski) and Astrophysics (W.Iwanowska)

on 4th December 1945 first astronomy lecture given by WI

June 1947 the Draper astrograph arrives in Piwnice
the first sky photographs with it are taken on 24 July 1949

1950 first astronomy graduate at UMK

Institute of Astronomy established from 1952

New Observatory building commissioned, 1954
TSC 60/90 commissioned, 1962





(1878 - 1962)

Prof. Dr Władysław Dziewulski
astronomer

Rector of Stefan Batory University in Vilnius
1936–1939

**(USB was the second-oldest Polish university)
1578/79**

Astronomical Observatory established in 1753

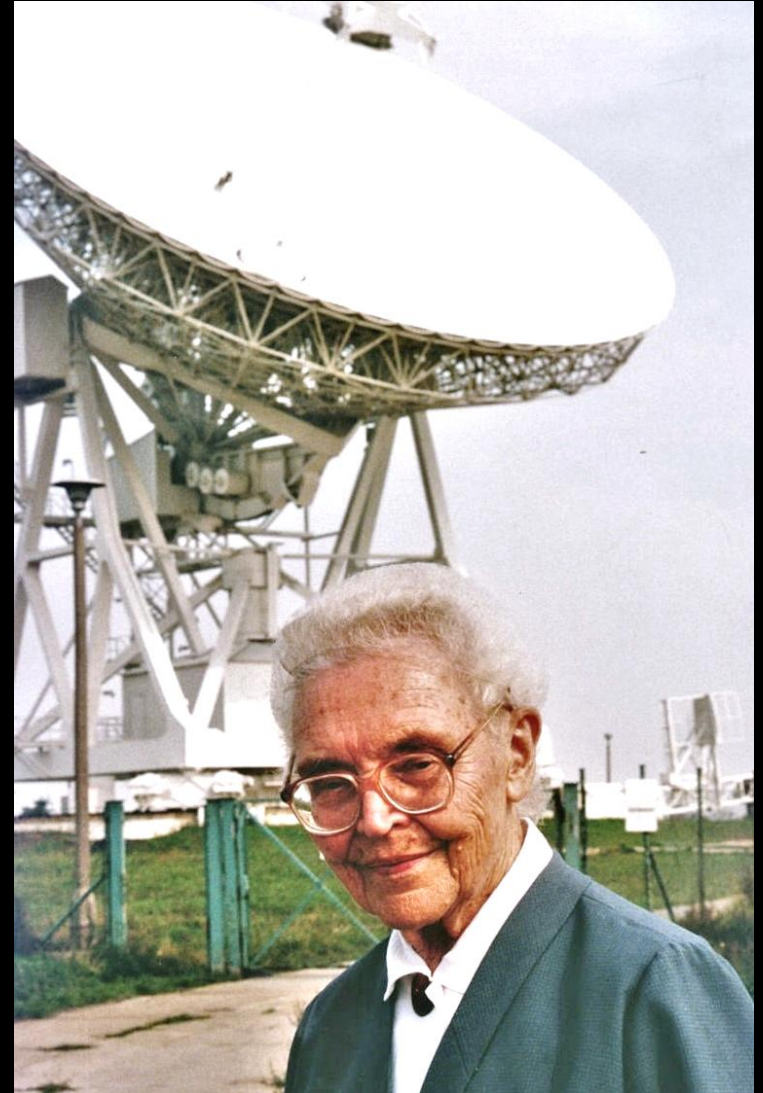
One of the founders of
the Nicolaus Copernicus University in Toruń
Vice-Rector for the Organisation

Head of the UMK Astronomical Observatory
1945–1952

Building UMK on the foundations of USB created an enormous opportunity for the development of the city of Toruń and the whole Pomeranian region.

Doc. Dr. W.Iwanowska and Prof. Dr. W.Dziewulski in 1949 at the Draper astrograph and in 1995 Prof. W.Iwanowska at the 32m radio telescope

Co-founders of the Nicolaus Copernicus University and the NCU Astronomical Observatory



Beginnings of radio astronomy in Toruń (UMK)

Started with lectures given by Prof. W. Iwanowska, her interest in radio astronomy, seminars, she organised a team to build a solar radio telescope (**1956**):

MSc **S. Gorgolewski** (physicist), from 1957, PhD 1960, habilitation 1965,

MSc Eng. **K. Grzesiak** (electronics engineer, physicist) **until end of 1958**

MSc H. Iwaniszewski (astronomer) **until 1962**, PhD 1962

Plus technicians, including Kozierkiewicz, Kowalewski, Kalinowski, Markowski, ...

Scientific objective: systematic monitoring of solar radio activity.

Involving Toruń in the scientific activities of the International Geophysical Year
1957/1958.

Connections with phenomena in the Earth's magnetosphere – space weather

Start of RT-1 construction, challenges / difficulties and problems (1956–1959), RT-1b

Contacts with Warsaw University of Technology and PIT:

Prof. J. Groszkowski and Prof. S. Ryżko.

Important consultations on radio techniques and on the construction and tuning of antennas, and radio receivers

1965 – doctoral dissertation
by Zygmunt Turło,
INTERFEROMETRIC STUDIES OF SOLAR RADIO
ACTIVITY CENTRES

The team was joined by:

Zygmunt Turło, physics student from 1958, MSc 1959, PhD 1965, employed at PAN

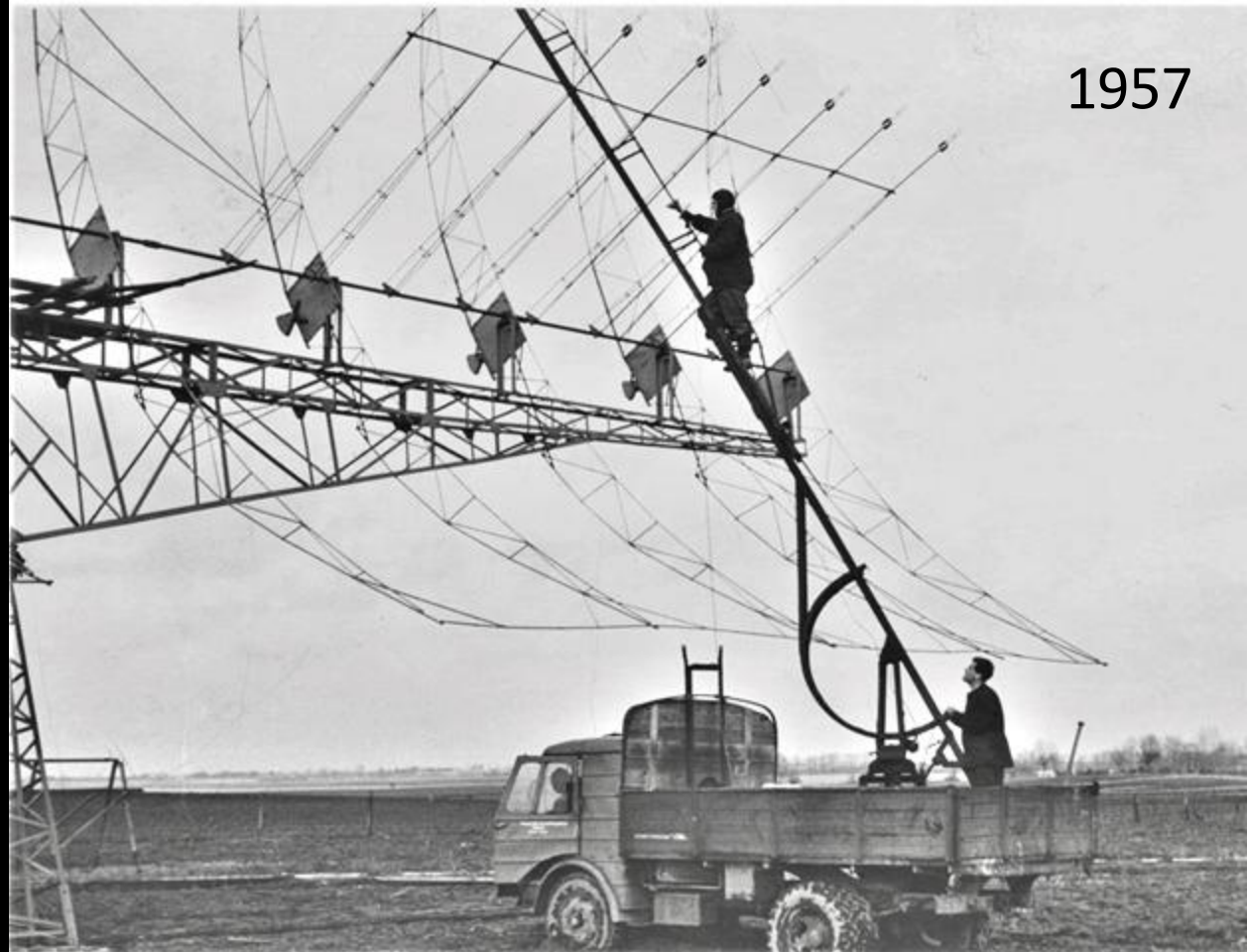
MSc Jan Hanasz, from 1959, PhD 1963, employed at PAN

MSc Bernard Krygier from 1965, PhD 1973, employed at UMK

1957



S.Gorgolewski



Construction of RT-1 took place in 1956–1958

Design and construction was supervised by:

MSc Eng. Kazimierz Grzesiak - receivers

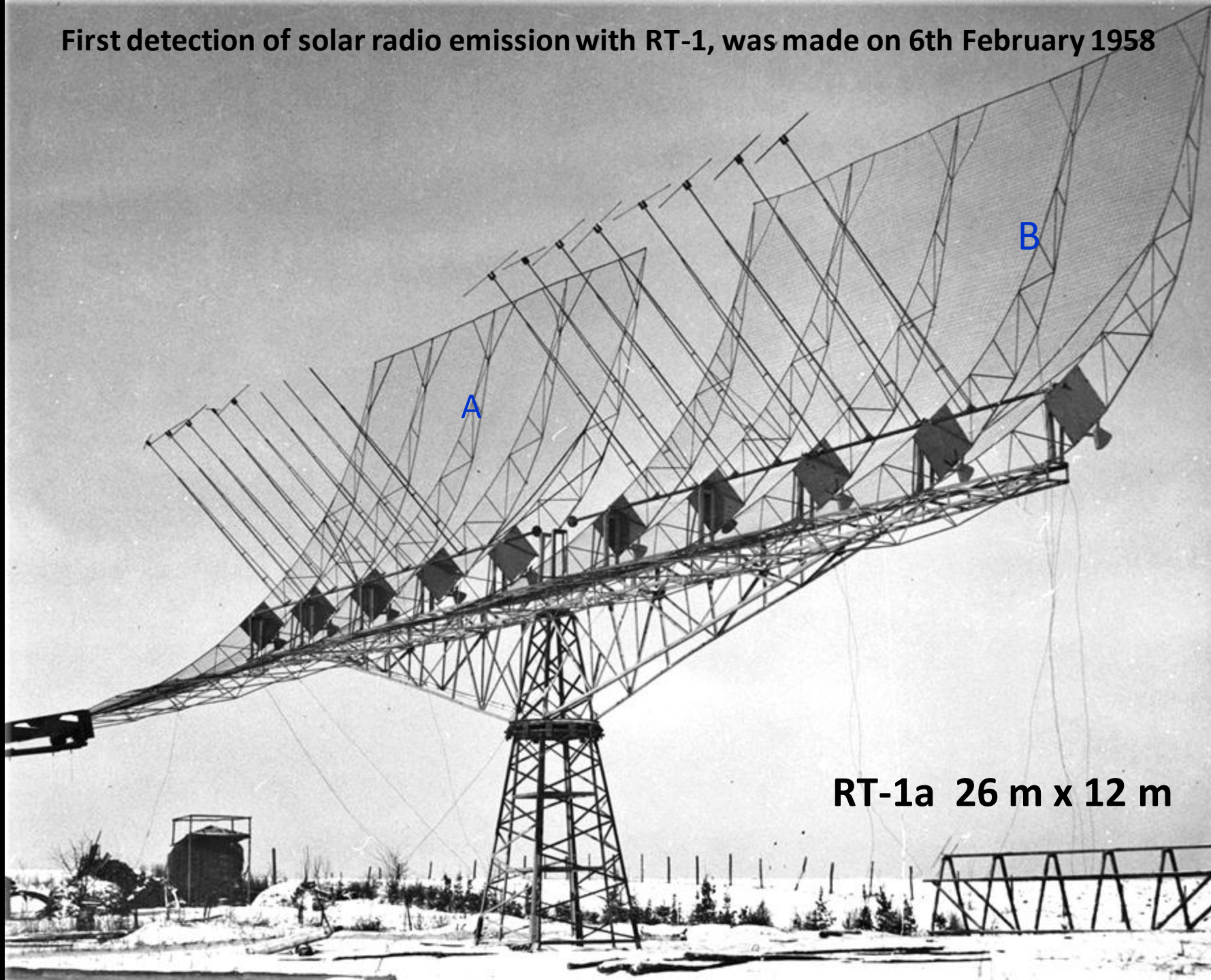
MSc Henryk Iwaniszewski - antenna

MSc S. Gorgolewski - receivers

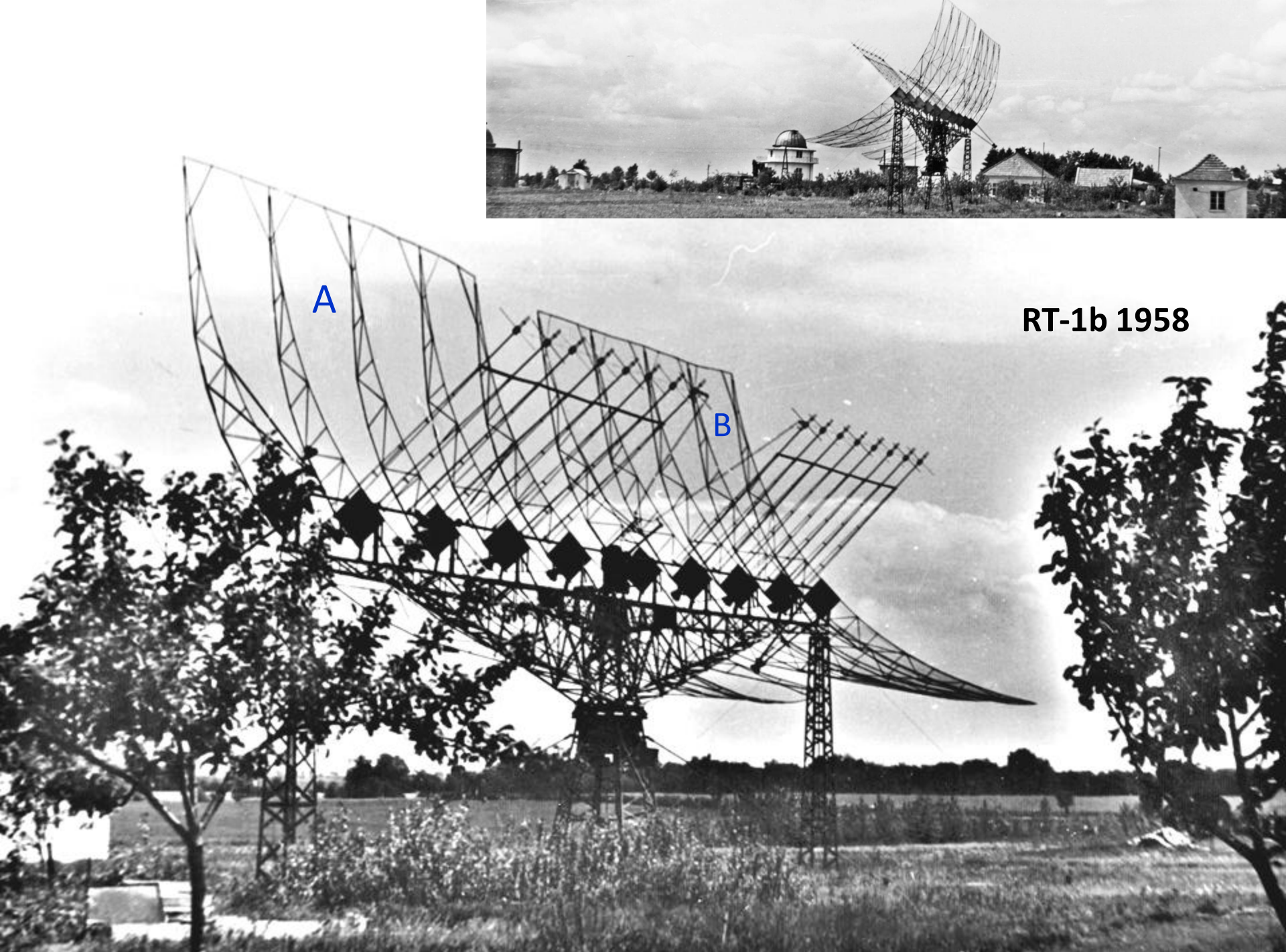
Elements of the construction were built at the Physics Department, the Observatory workshops, the steel structure was fabricated at ZNSM Toruń.



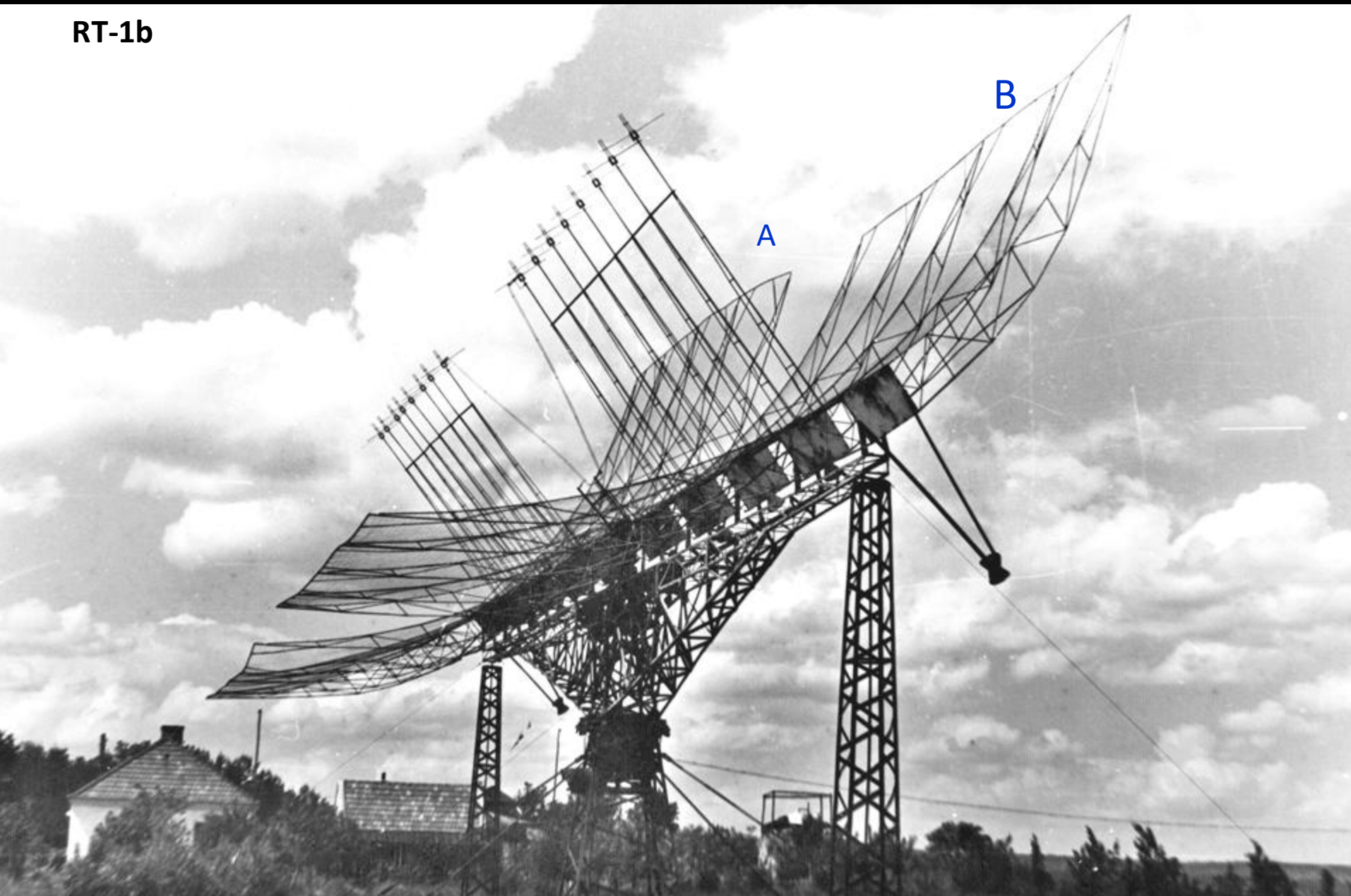
First detection of solar radio emission with RT-1, was made on 6th February 1958



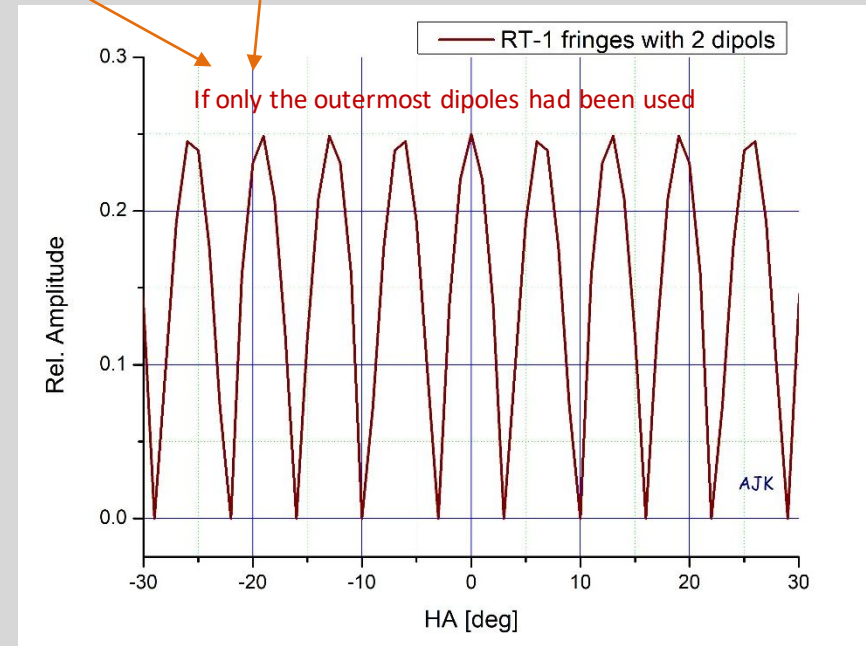
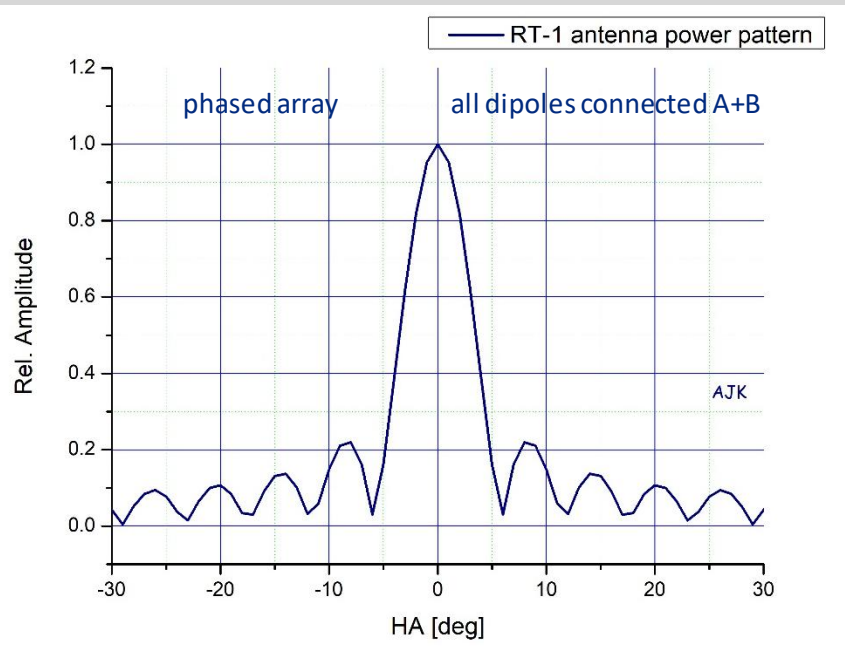
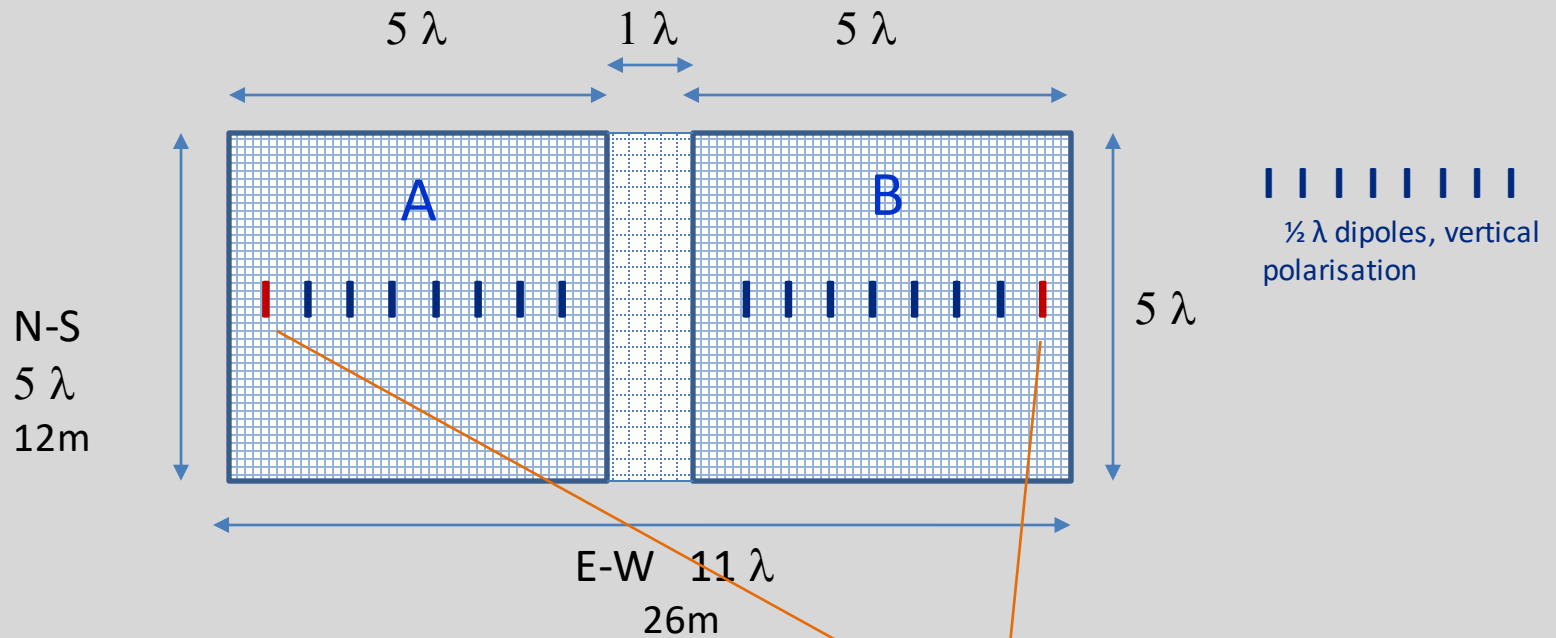
RT-1a 26 m x 12 m



RT-1b



RT-1 26 m × 12 m 127 MHz $\lambda = 2.36$ m



3D power pattern of the RT-1 antenna

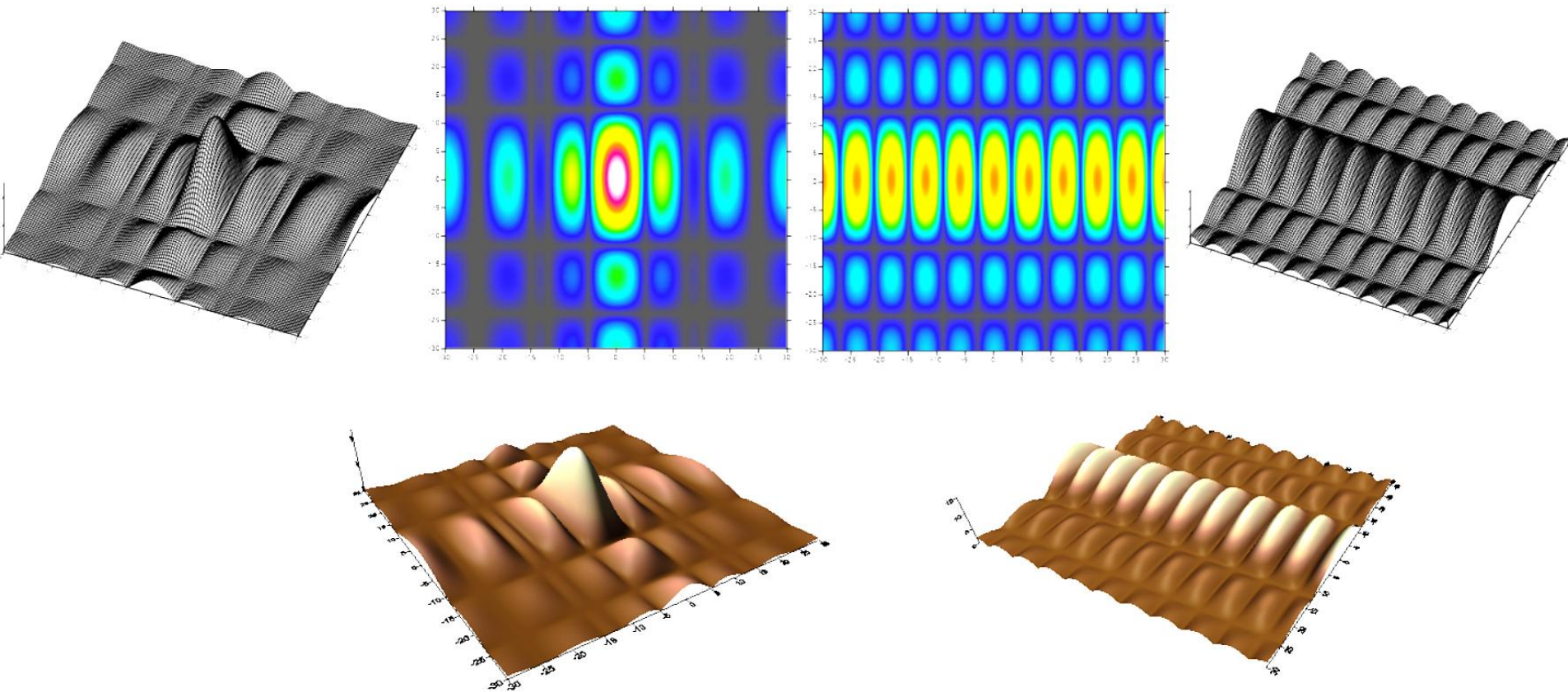
power radiation pattern

RT-1 configured as

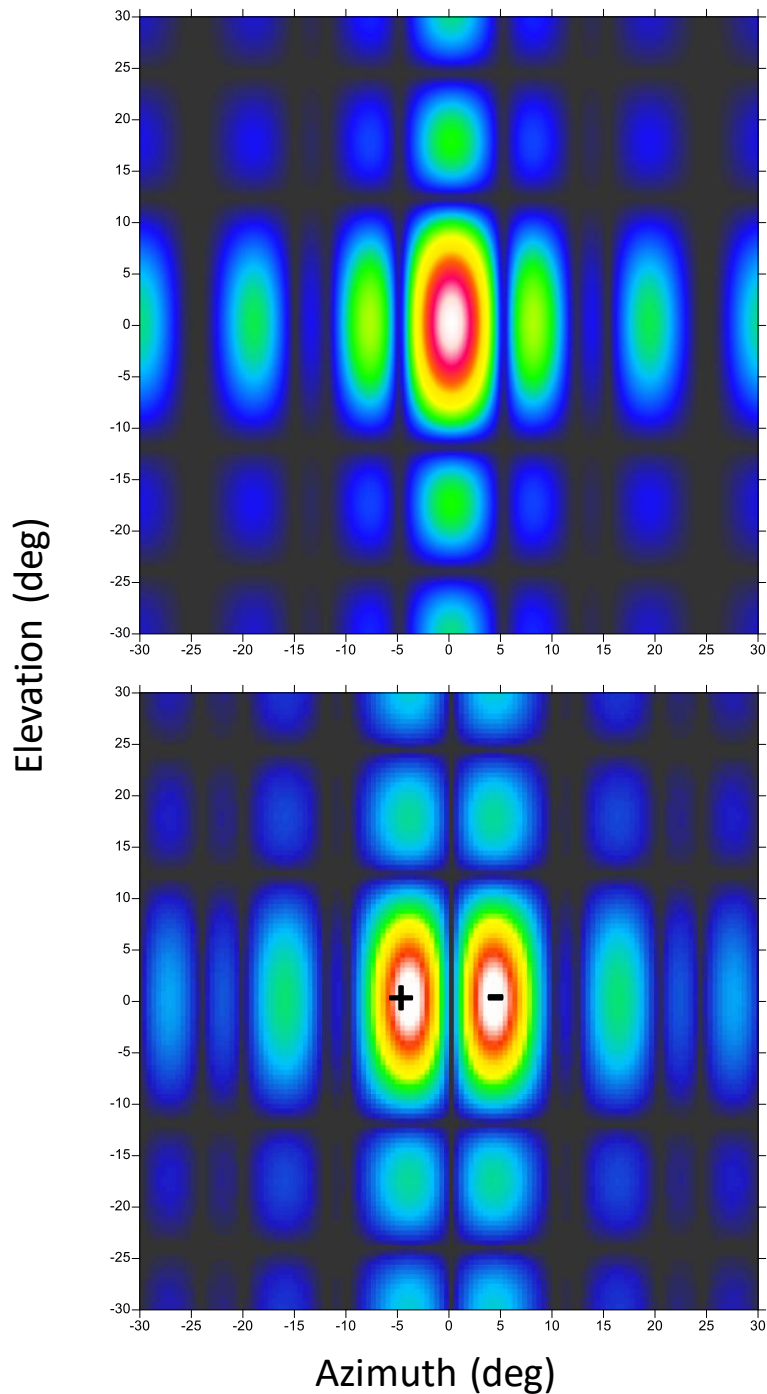
phased array
A+B

and

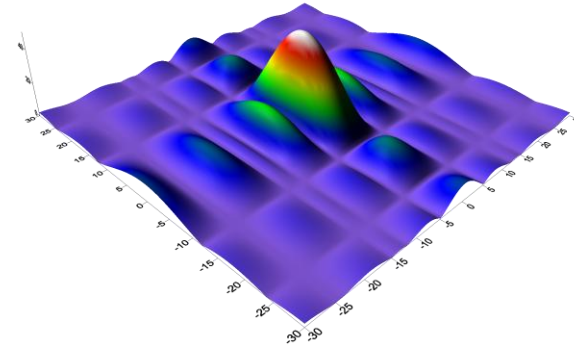
the simplest interferometer
with two outermost dipoles (**never tested**)



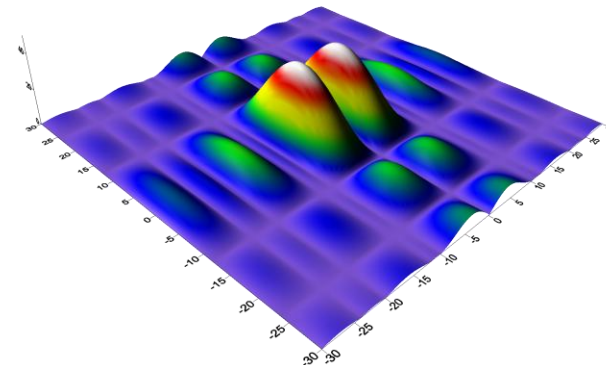
Computed by AJK, January 2026



Phased array: A plus B

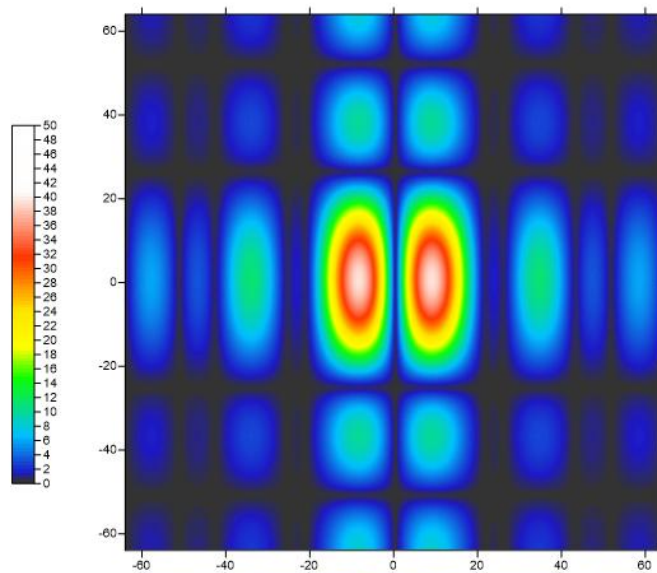


3D radiation / receiving power pattern
RT-1 directional pattern (AJK)

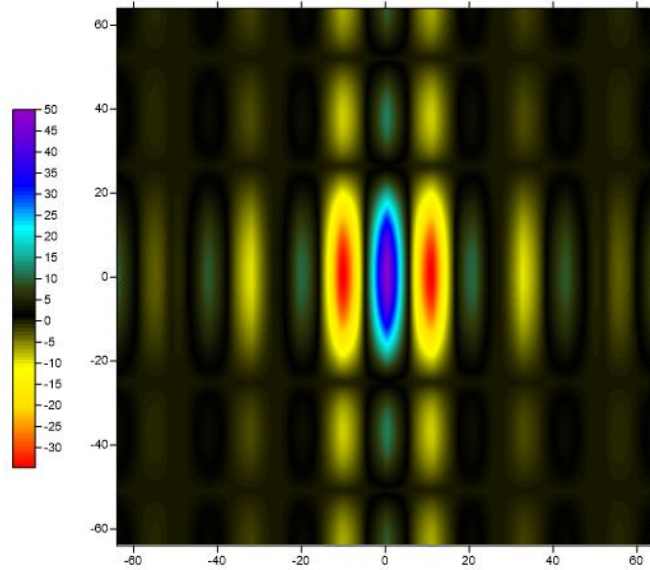
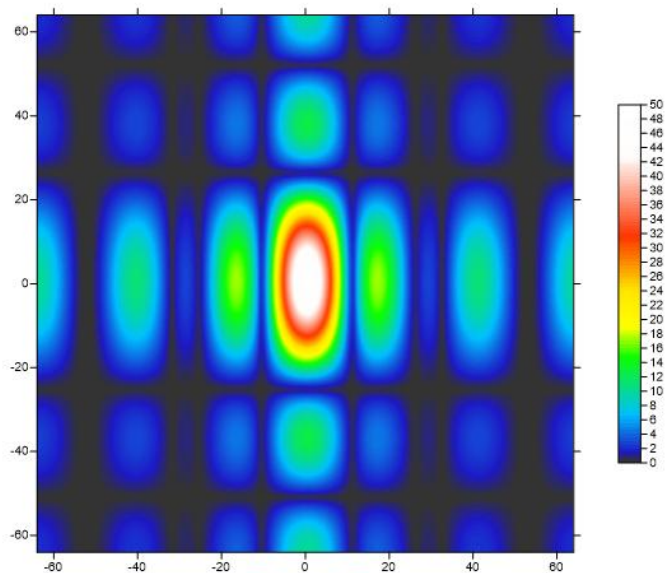


A minus B (B section 180° out of phase)
A Ryle $\lambda/2$ switch used here would alternate
the power pattern – i.e. switch between
upper and lower diagrams (AJK)

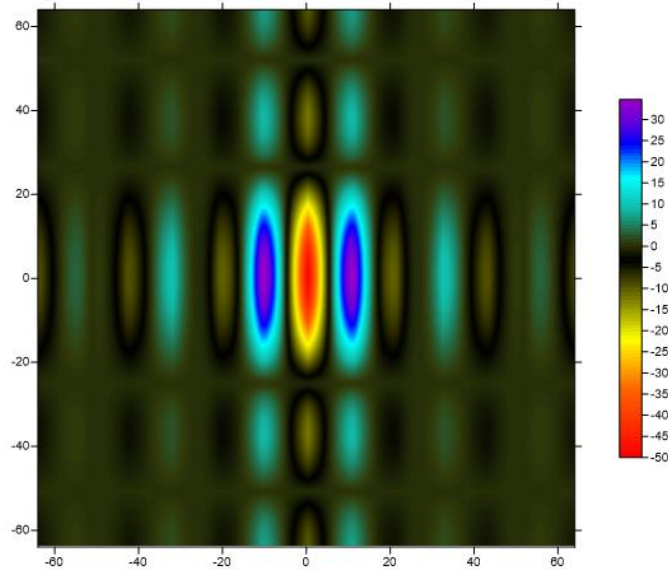
$A - B$



$A + B$



$(A - B) - (A + B)$



$(A + B) - (A - B)$

Beginnings of radio astronomy in Toruń (UMK), cont.

**Detection of solar radio emission with RT-1a, 6 February 1958;
Construction failure due to a night storm on 2/3 March 1958, rebuilt to RT-1b.**

Construction of RT-2: 12 m parabolic antenna, $f=127$ MHz, $\lambda=2.36$ m in 1958.
Offered easier operation and greater resistance to the weather condition.

Daily measurements of the level of solar radio emission began on RT-2 in 1959.

The antenna was repositioned every hour, giving 7 to 9 solar transits through the instrument beam each day. Observations were made at 127 MHz.
Calibration used the radio sources Cassiopeia A and Cygnus A, whose flux densities were well known.

The team of scientists working with RT-2 joined the international research programme known as the International Geophysical Year 1957/1958.

Further RA team members joined only about ten years later

RT-2 12 m radio telescope

construction, summer 1958

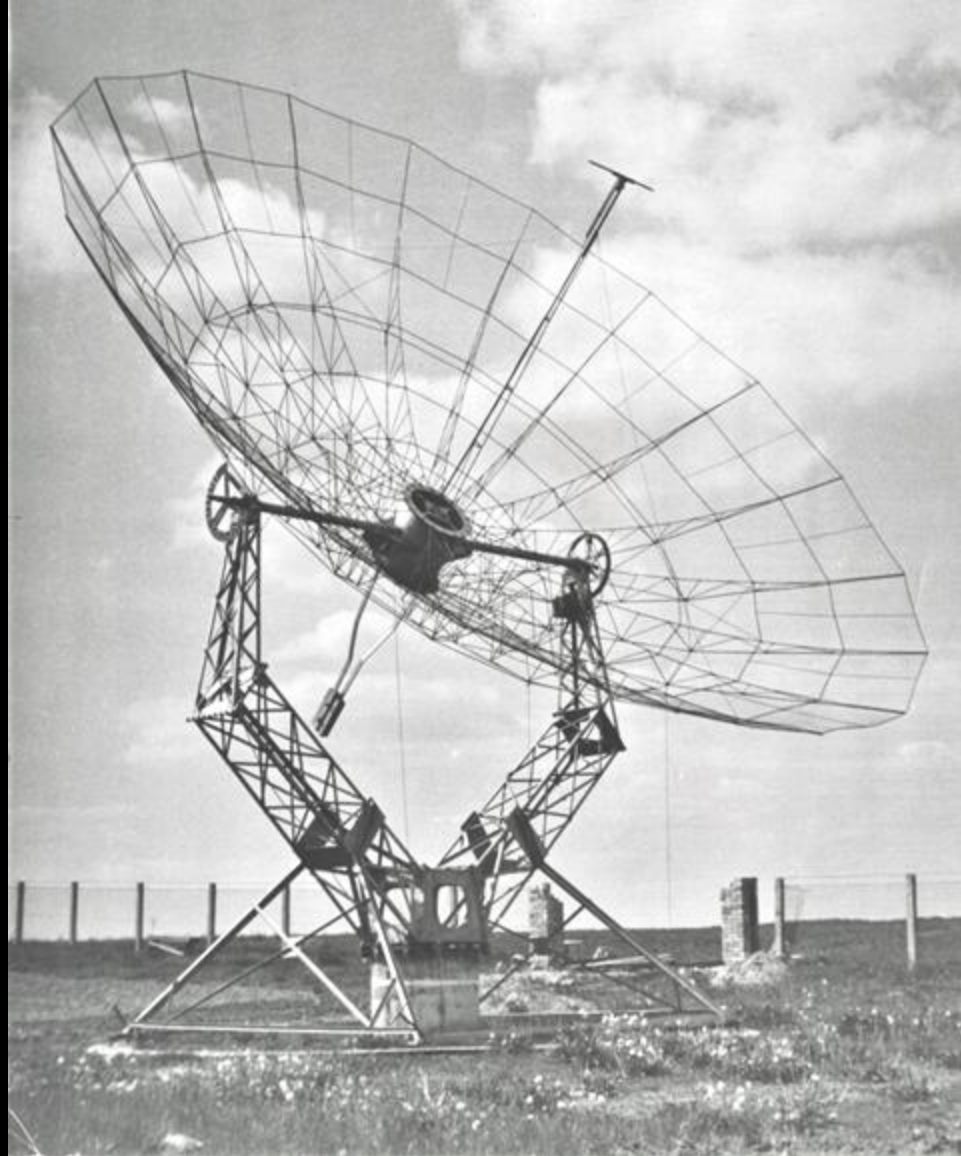
Concept, design and construction supervision:
By Henryk Iwaniszewski

Large steel structural elements were fabricated
at the Toruń Land-Reclamation Equipment Repair Works





RT-2 "in the field outside the observatory fence", autumn 1958



RT-2 at the Observatory, with in a new fence built in 1959.

Electric drives on both axes were commissioned in September 1960;
position read-out and a remote control were commissioned in 1961.

1960

RT-2

RT-1



• Monitoring solar activity, 1958–60

OBSERWACJE RADIOWE SŁOŃCA NA CZĘSTOTLIWOŚCI 127 Mc/s W ROKU 1959

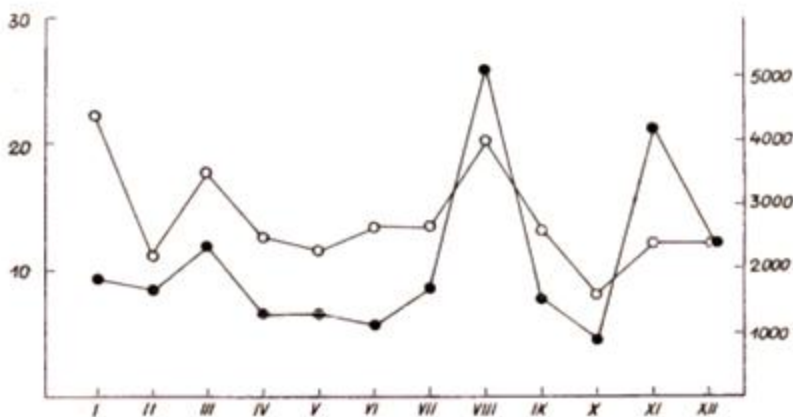
S. GORGOLEWSKI, J. HANASZ, H. IWANISZEWSKI, Z. TURLO

Na Zjeździe Referatowym PTA w czerwcu 1959 roku donoszono, że w Obserwatorium Astronomicznym UMK w Toruniu prowadzi się obserwacje radiowe Słońca na częstotliwości 127 Mc/s. W roku 1959 urządzenie służące do radiowych obserwacji Słońca składało się z reflektora parabolicznego o średnicy 12 metrów oraz z nieprzelącanego odbiornika o poziomie szumowej 11 db z wstęgą 0,5 Mc/s. Wyniki obserwacji są publikowane w postaci tablic „Dziennych Danych” i „Zjawisk Niezwykłych” [1] i służą za podstawę do opracowań.

Dla badania związku między zjawiskami słonecznymi i geofizycznymi wzięto pod uwagę:

- 1) statystykę zjawisk niezwykłych radiowych i rozrysków chromosferycznych,
- 2) zależność promieniowania radiowego od powierzchni plam,
- 3) koincydencje pomiędzy burzami słonecznymi w pasmie metrowym a burzami geomagnetycznymi.

1. W ciągu całego roku zanotowano 212 zjawisk niezwykłych różnych typów na częstotliwości 127 Mc/s. Dla tych zjawisk poszukiwano odpowiedników na innych częstotliwościach a także wśród rozrysków chromosferycznych. Wybrano tylko te zjawiska, które wyprzedzały zjawiska na częstotliwości 127 Mc/s o 10 min a opóźniały się najwyżej o 3 min. Fakt takiego wyboru zjawisk na innych częstotliwościach oraz rozrysków chromosferycznych do statystyki tłumaczy się tym, że zjawiska na częstotliwości 127 Mc/s występują wysoko w koronie Słońca, natomiast wybrane do statystyki zjawiska na innych częstotliwościach oraz rozryski chromosferyczne występują bliżej fotosfery. Czas przelotu cząstek wywołujących promieniowanie radiowe na różnych częstotliwościach przez koronę słoneczną odpowiada w przybliżeniu wybranemu zapóźnieniu. W biu-



Rys. 1. Zmiany średniej miesięcznej powierzchni plam (kółka) i średniej miesięcznej promienności radiowej 127 Mc/s (kropki)

• Solar eclipse, 1961

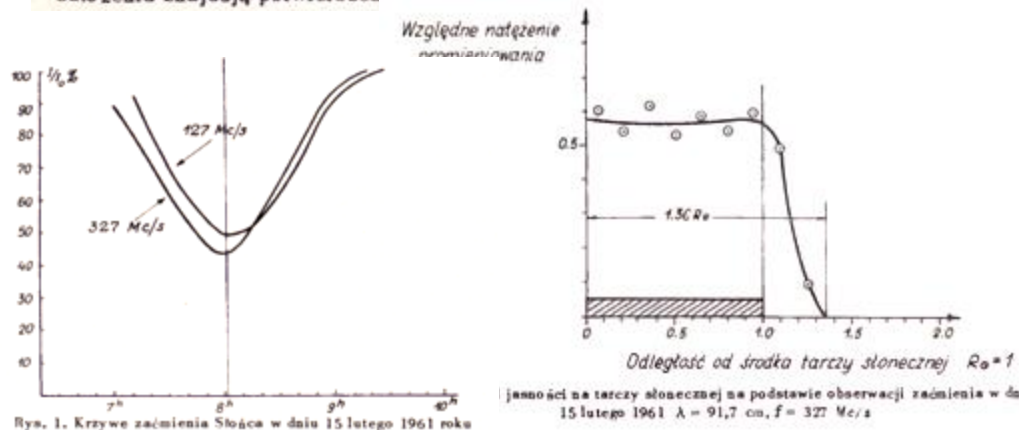
RADIOWE OBSERWACJE ZACIEMIENIA SŁOŃCA W DNIU 15 LUTEGO 1961 R. NA FALACH O DŁUGOŚCI 236 cm I 91,7 cm S. GORGOLEWSKI, J. HANASZ, H. IWANISZEWSKI, Z. TURLO

W czasie zaciemnienia Słońca w dniu 15 lutego 1961 roku dokonano pomiarów radiowego promieniowania Słońca, na falach o długości 236 cm i 91,7 cm. Do obserwacji została użyta 12-metrowa antena paraboliczna Obserwatorium Astronomicznego UMK w Piwnicach. W czasie trwania zaciemnienia antena była prowadzona za Słońcem według przygotowanego uprzednio programu. Promieniowanie rejestrowano przy pomocy dwóch niezależnych odbiorników połączonych z dwoma niezależnymi systemami antenowymi znajdującymi się w ognisku parabolidu. Parametry zastosowanych odbiorników były następujące: $f_1 = 127,15 \text{ Mc/s}$, $\Delta f_1 = 50 \text{ kc/s}$, $T_1 = 800^\circ \text{K}$, oraz $f_2 = 327 \text{ Mc/s}$, $\Delta f_2 = 4 \text{ Mc/s}$, $T_2 = 3000^\circ \text{K}$. Metoda odbioru polegała na szybkim przełączaniu wejścia odbiornika pomiędzy anteną a wzorcowe źródło szumów.

Przy analizie uzyskanych wyników uwzględniono efekt wywołany nieliniowością odbiorników, przyczynę wywołany promieniowaniem Galaktyki oszacowano na podstawie obserwacji tła w pobliżu Słońca, ponadto dla krzywej zaciemnienia na 327 Mc/s z uwagi na stosunkowo wąską charakterystykę anteny wzięto pod uwagę również błędy wynikające z braku ciągłego prowadzenia anteny za ruchem Słońca. Na podstawie stałych obserwacji Słońca na częstotliwościach 127 Mc/s i 327 Mc/s prowadzonych w Obserwatorium Astronomicznym UMK przyjęto, że zmiany strumienia Słońca w czasie zaciemnienia są wywołane jedynie zakrywaniem Słońca przez Księżyc.

Zaciemnienie na częstotliwości 327 Mc/s miało przebieg symetryczny względem maksymalnej fazy optycznej. Minimalny zarejestrowany strumień wynosił 43,3% strumienia całkowitego. Na 127 Mc/s moment maksymalnej fazy nastąpił $4^m 40^s$ po maksimum optycznym. Minimalny strumień wynosił 49,2% strumienia całkowitego. Maksymalna faza zaciemnienia optycznego wynosiła $0,89 (8^m 00^s 11^s \text{ UT.})$ (rys. 1).

Na podstawie uzyskanych krzywych zaciemnienia dokonano próby wyznaczenia rozkładu jasności na dysku Słońca. Została przyjęta metoda polegająca na poczynieniu ogólnych upraszczających założeń co do rozkładu jasności a następnie sprawdzeniu, czy przyjęte założenia znajdują potwierdzenie obserwacyjne.

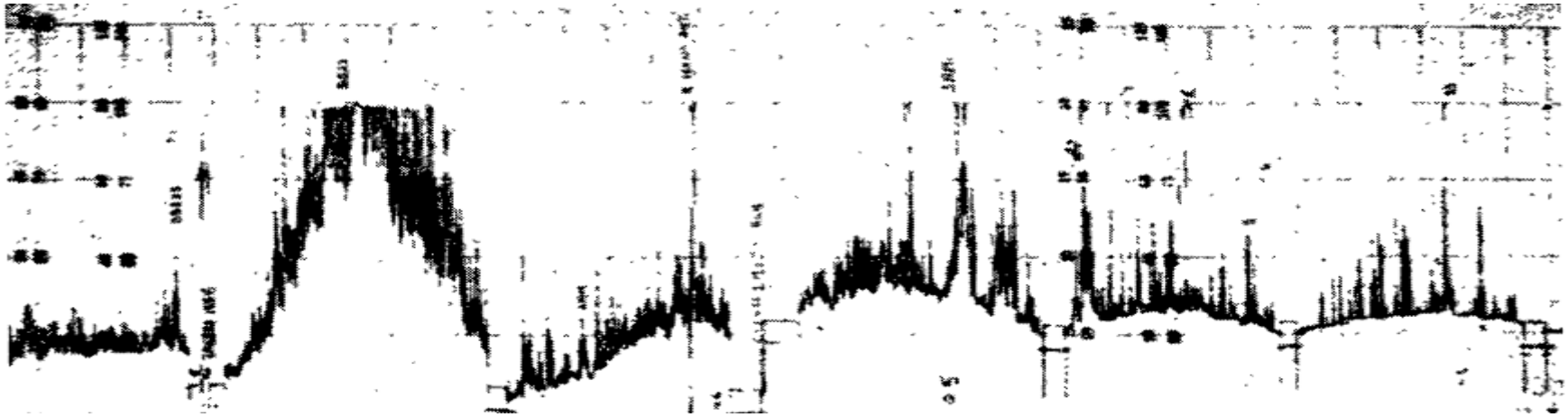


Rys. 1. Krzywe zaciemnienia Słońca w dniu 15 lutego 1961 roku

Monitoring solar radio emission at 127 MHz $\lambda=2.36$ m

RT-2, D=12 m (5λ), beam = 12° , transit through the beam approx. 1 hour

Detection of quiet-Sun radio emission, 17 November 1958

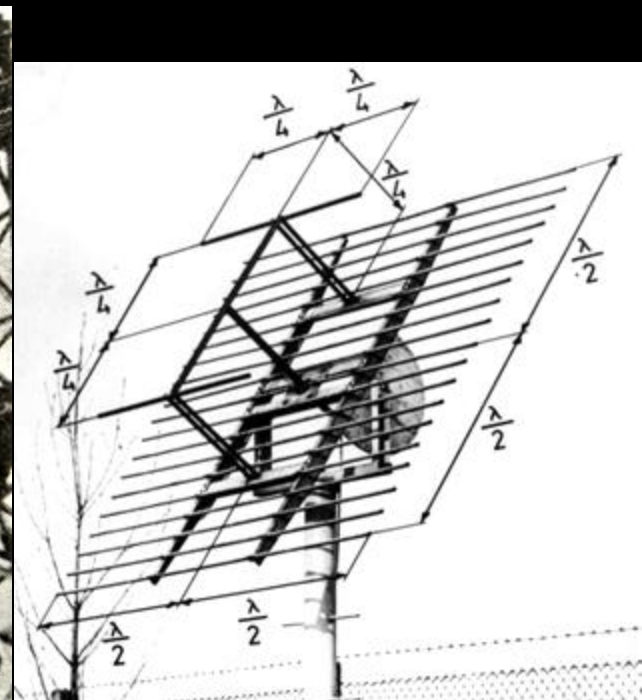
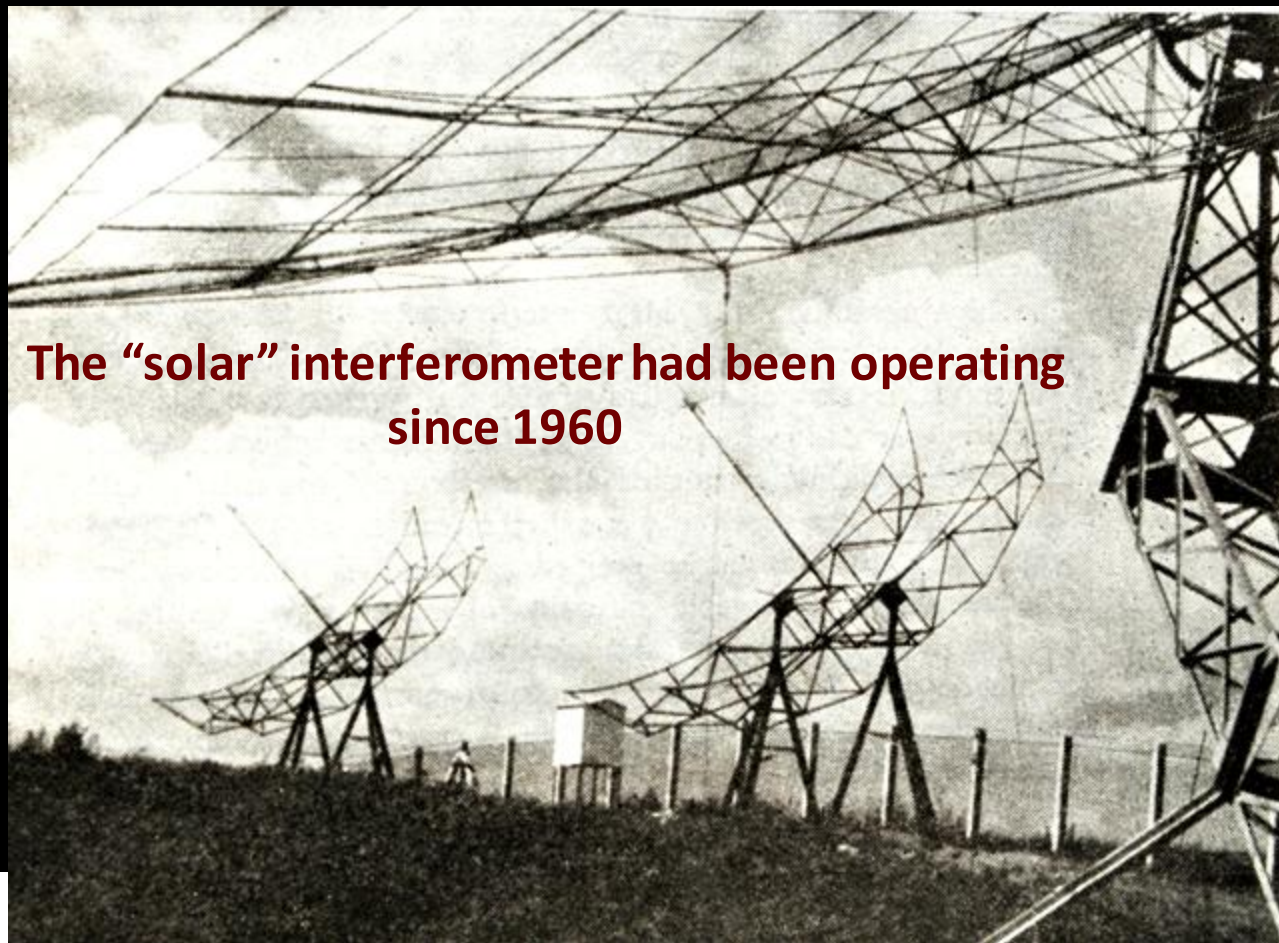


Gorgolewki, Iwaniszewski, Hanasz, Turło, *Acta Astronomica*, Vol. 12, p.75, 1962

https://www.urania.edu.pl/pliki/archiwum/postepy_astronomii_1962.pdf

Monthly reports from the daily measurements were published from 1962 in the *Quarterly Bulletin on Solar Activity (QBSA)*

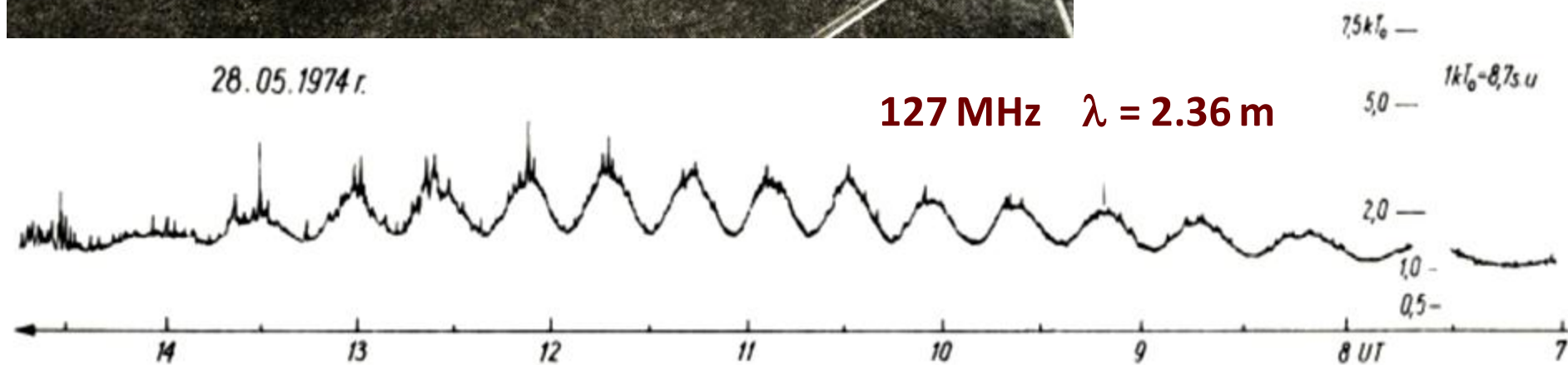
Significant improvements of the data quality and reliability of the monitoring programme was made by a new solar interferometer.



New antennas from 1969

28.05.1974 r.

127 MHz $\lambda = 2.36$ m

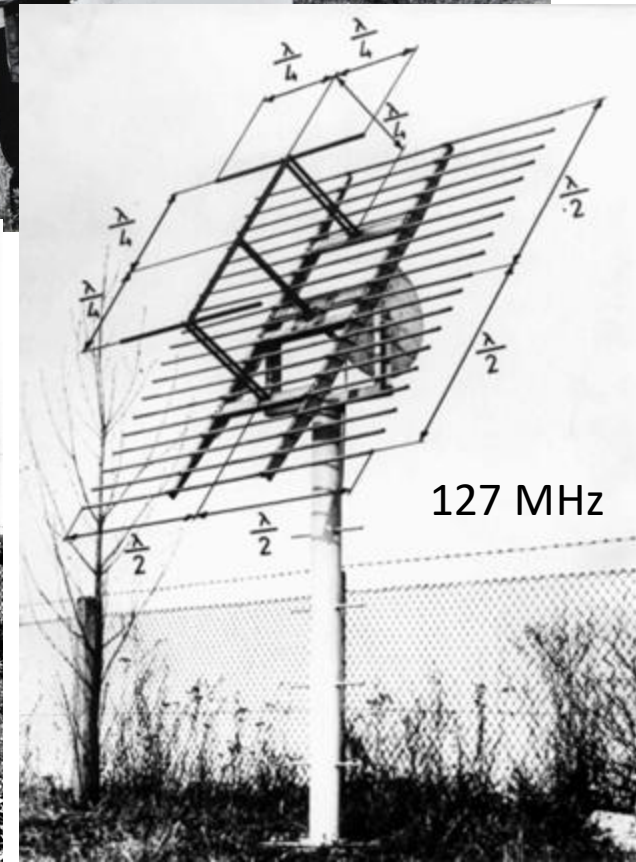
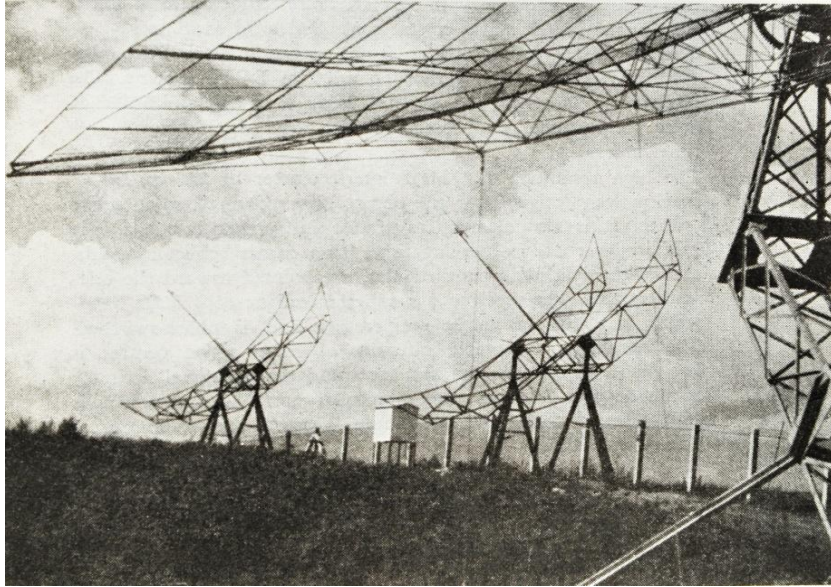


En example of daily record

Receiver systems for monitoring solar activity

Modernisation of the receiver and interferometer antennas (AJK, 1969)

Later, new receivers: Borkowski, Usowicz, Gorgolewski, 1980; K. Borkowski PhD, 1979



Major advances in the quality of research methods, 1960-1970

British Council fellowship for S. Gorgolewski at MRAO, he worked under supervision of Prof. Martin Ryle in collaboration with Prof. Anthony Hewish.

Cambridge observations were used to prepare and to present by S. Gorgolewski the PhD thesis: "Occultations of the radio source Taurus A by the solar corona at wavelengths of 7.9 m and 1.68 m", defended at UMK in 1960. This was the first PhD thesis in radio astronomy in Poland.

From Britain, Sgo. (1958/1959) sent several crates of equipment bought from military surplus with his own money saved from the fellowship stipend.

These included RF amplifiers, converters, switches, radio valves, etc., also used at MRAO.

The components and the experience gained brought a fundamental breakthrough in the quality of the measuring equipment being built. Higher stability, sensitivity and reliability were achieved.

In 1960 construction began on a large three-antenna interferometer for the 32 MHz band

This research lead to habilitation of Dr S. Gorgolewski, 1963,
"Radio observations of the solar supercorona in 1961, 1962 and 1963"

Radio Astronomy Division of the Institute of Astronomy, had been established in 1965

Head of the **Division**: Assoc. Prof. S. Gorgolewski.

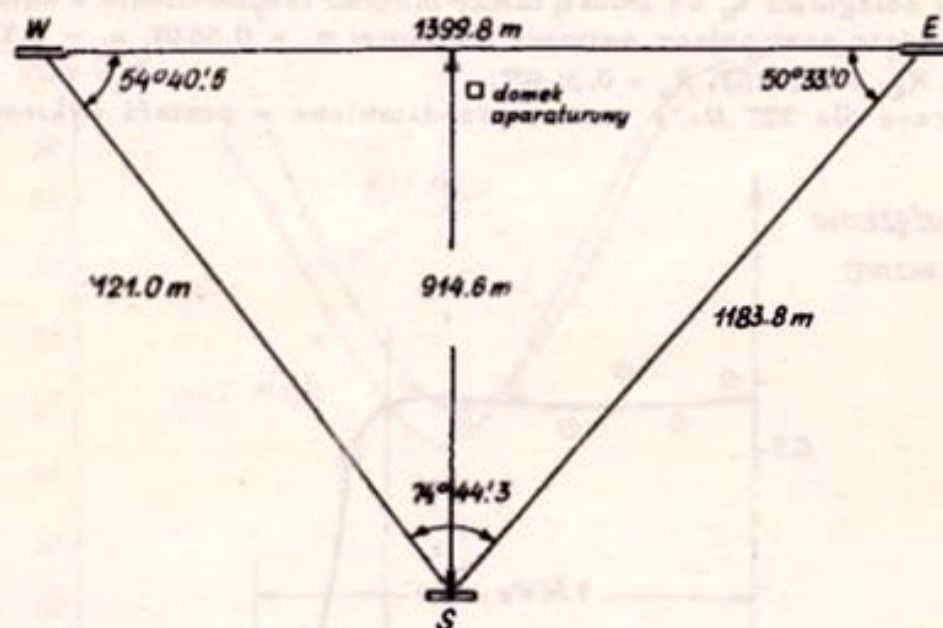


S.Go.

TRÓJANTENOWY SYSTEM INTERFERENCYJNY OBSERWATORIUM ASTRONOMICZNEGO UMK NA FAŁĘ O DŁUGOŚCI 9,32 M

S. GORGOLEWSKI, J. HANASZ, H. IWANISZEWSKI, Z. TURŁO

Dla obserwacji radioźródeł na falach rzędu 9 metrów, został zbudowany w Piwnicach duży system interferencyjny. System ten składa się z 3-ch anten, środki których stanowią wierzchołki trójkąta o podstawie 1399,8 m w kierunku Wschód–Zachód i wysokości 914,6 m w kierunku południowym. Anteny te tworzą potrójny interferometr o następujących bazach: 1) baza E–W 1399,8 m, 2) baza E–S 1183,8 m, 3) baza W–S 1121,0 m (rys. 1). Każda



Rys. 1. Plan sytuacyjny trójanetenowego systemu interferencyjnego

z anten potrójnego interferometru składa się z zespołu 8 dipoli o długości $0,75 \lambda$ każdy, oddległych od siebie o λ . Dipole te umieszczone są wzdłuż linii dwusiecznej kąta reflektora narożnikowego o kącie rozwarcia 90° . Sznur dipoli podwieszony jest na odległości $0,35 \lambda$ od linii przecięcia się płaszczyzn reflektora (rys. 2). Wymiary reflektora każdej anteny wynoszą $80 \times 7 \times 6$ m. Powierzchnie odbijające wykonane ze stalowych cynko-

Interferometer $f=32.3$ MHz, $\lambda=9.2$ m – Tau-A occultations, 4–50 R $\odot$

Studies of the solar corona:

Gorgolewski, Hanasz, Iwaniszewski, Turło

Ref.: AcA, Vol. 12, p. 251; AcA, Vol. 15, p. 26

B.Krygier, <https://adsabs.harvard.edu/full/1970AcA...20..149K>

The interferometer operated from May 1961 for over 10 years

1963 habilitation of Dr S. Gorgolewski, 1972 B. Krygier PhD

80m x 7m x 6m

1399m ($\sim 150 \lambda$)

914m

Obserwatorium
Astronomiczne w...

Różankowo

Piwnice

Google

Normalised amplitude of interference fringes (fringe visibility function) for this interferometer, $d=100-150 \lambda$

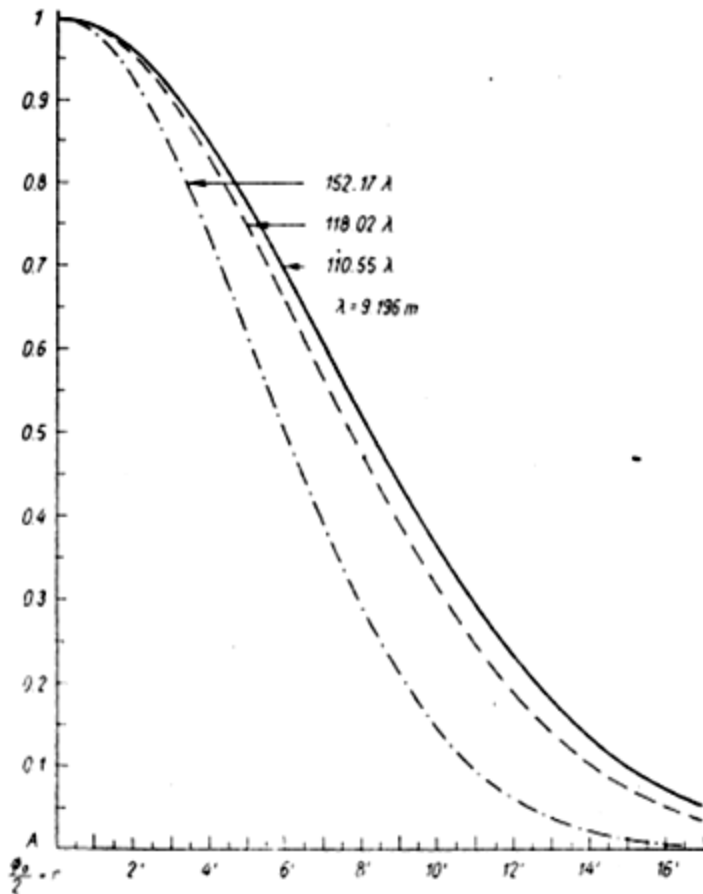
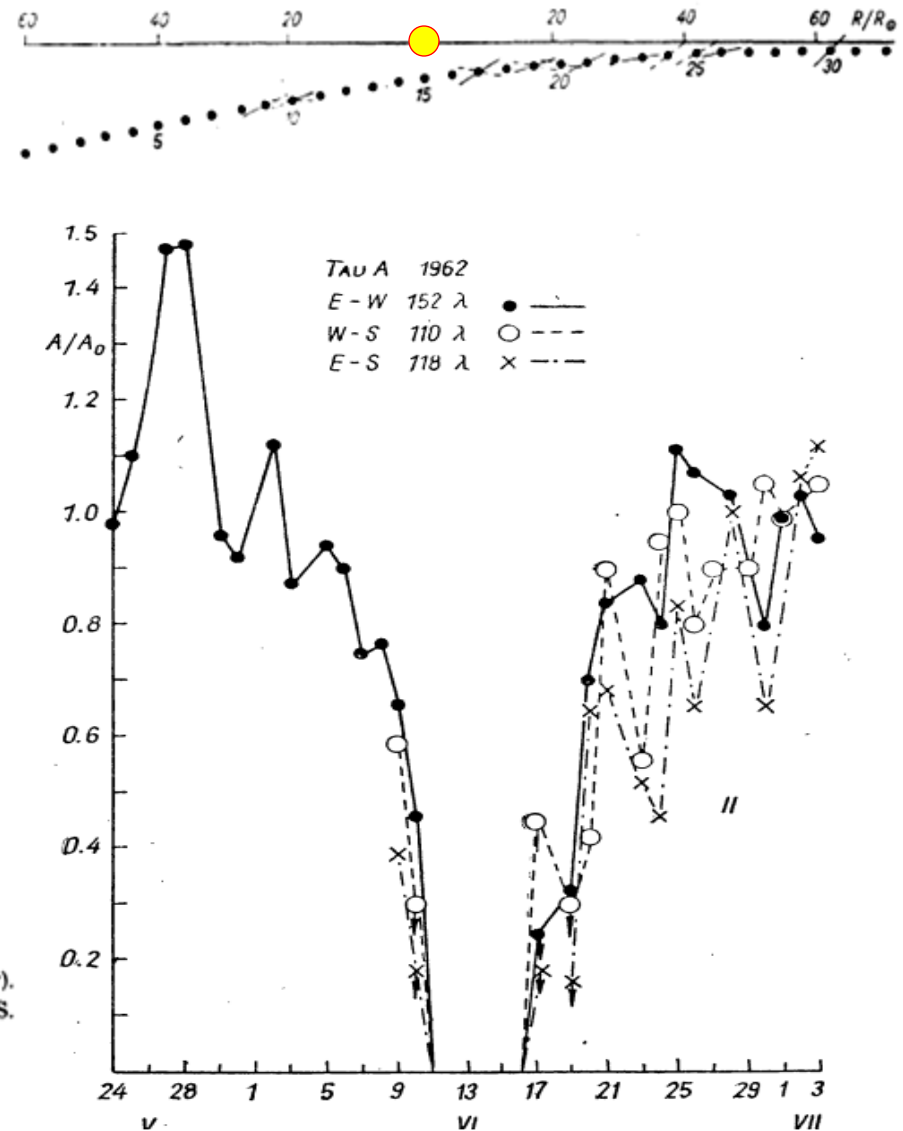


Fig. 2. The dependence of fringe amplitudes (A) on the scattered radius of Tau A (r). The observations of 1962, spacings; 152.17λ E—W, 118.02λ E—S, 110.55λ W—S.



History of radio astronomy at UMK 1967-1975

Projects and plans for the 500th anniversary of the birth of Nicolaus Copernicus (UMK, PAN):

1) 1965 UMK / PAN Radio Astronomy Centre - concept and construction.

Large interferometer: 5×25 m or 3×30 m, $B_{\max} \sim 1500$ m.

2) In 1968, a proposal from the USSR Academy of Sciences to PAN - a space programme.

Assoc. Prof. S. Gorgolewski presents a radio spectrograph project for 0.6-6 MHz, to be installed on an INTERKOSMOS satellite.

Built by the Institute of Aviation; funded by PAN; coordinated by Dr J. Hanasz

Launched into orbit on 19 April 1973; operated for 6 months

Interkosmos – Copernicus 500. In the late 1960s, astronomers from the USSR proposed that Polish astronomers build and place in orbit a special satellite dedicated to the 500th anniversary of the birth of Nicolaus Copernicus.

Assoc. Prof. S. Grzędzielski of PAN approached the head of the Radio Astronomy Division, Assoc. Prof. Gorgolewski, with a proposal for collaboration. Assoc. Prof. Gorgolewski proposed an experiment called the **“Solar Radio Spectrograph”** to study the solar corona. The proposal was accepted, and the UMK Radio Astronomy Division team led by SGo and the PAN First Laboratory team led by Dr Jan Hanasz began work on the project together.

The experiment was funded entirely by the Polish Academy of Sciences (PAN). Dr J. Hanasz was the principal coordinator. Prototype components were made in Piwnice; the “flight” version was built at the Institute of Aviation in Warsaw under the supervision of the PAN and UMK teams.

The spectrograph was launched into orbit in the USSR aboard the “Interkosmos 9 – Copernicus 500” satellite on 19 April 1973.

The instrument operated for several (6+) months, returning unique results to Earth.

For many years it remained the first and most significant space project carried out by Polish astronomers.



Spare unit of the Copernicus-500 radio spectrograph

Stored in the Radio Astronomy building in Piwnice

Copernican Anniversary 1973 continued

UMK–PAN Radio Astronomy Centre

1965 The original concept for the Radio Astronomy Division building in Piwnice evolved by the end of 1965 into the concept of a **UMK–PAN Radio Astronomy Centre**, with a substantial building complex and modern radio telescopes.

Visits by the Director of the Investment Department of the Ministry of Higher Education, and later by PAN President Prof. J. Groszkowski, proved fruitful and encouraging. **They expressed full support for the idea of the Centre as an important scientific undertaking within the Copernican anniversary celebrations.**

June 1967. The UMK Rector (Prof. Dr h.c. Witold Łukaszewicz) appoints a team to prepare **a preliminary concept for the UMK–PAN Radio Astronomy Centre as a major investment** connected with the 500th anniversary of the birth of the University's patron.

The team comprised Assoc. Prof. S. Gorgolewski, Dr J. Hanasz, Dr Z. Turło and MSc Eng. M. Kaczmarek (Director of UMK Administration).

The team was led by SGo; after his departure for the USA, Dr Z. Turło led for one year.

1968 The concept prepared by the UMK Rector's team was presented by Rector Łukaszewicz at a meeting of the Planning Commission of the Council of Ministers on 10 May 1968 and was approved for implementation.

The Ministry's Scientific Council issued a favourable opinion in December 1968.

In January 1969 the UMK Senate approved the construction decision and added it to UMK's investment programme.

Early 1969: Assoc. Prof. Gorgolewski and Dr Z. Turło visited Leiden and Dwingeloo in the Netherlands with engineers from BIPROHUT, specialists in antenna structures (including Eng. Śledziwski and Eng. Bujakowski), control systems and receiver equipment.

Meetings and consultations with Prof. J. H. Oort and engineers designing WSRT 25 m antennas. Full cooperation and openness was experienced, including access to detailed technical documentation. **These consultations led to preparation of updated concept for the Torun's Radio Astronomy Centre.** The new concept was approved by the Ministry's Planning Commission as early as April 1969.

In 1970 SGo was appointed associate professor.

At the end of 1970, unfavourable decisions were taken by PAN, which withdrew its offer to co-finance the construction of the Centre.

This made it necessary to amend the earlier government resolutions.

The ambitious plan to build the UMK–PAN Centre was postponed “until the future”, but a limited programme of building works was adopted as the first stage,
to meet the needs of the Radio Astronomy Division.

On 2 July 1971 the government resolution on preparations for the 500th anniversary of the birth of Nicolaus Copernicus was updated, giving the green light for construction **of a complete building complex for the Radio Astronomy Division, with completion scheduled** for 31 August 1973.

1972–73. Design work (PW Urban Planning Studio) and coordination of the investment by UMK (Investment Department) allowed construction crews to start work on 15 August 1972.

The building work (TPBO) was completed on schedule in the record time of one year. Exactly in time for the IAU Extraordinary General Assembly (symposia in Kraków–Toruń–Warsaw).

History of radio astronomy at UMK, cont. 1967-1975

Recruitment of new Radio Astronomy Division staff - mainly astronomy graduates:

A. Kus (1967), A. Wolszczan (1969), Leszek Nowakowski (1970), Eng. Jerzy Usowicz (1972), Kazimierz Borkowski (1972),

A. Kępa, Andrzej Marecki, Marian Szymczak, Eng. Janusz Mazurek, Eugeniusz Pazderski, Grażyna Gawrońska (1973-1975)

Important studies at leading research centres of radio astronomy :

A. Wolszczan leaves for a fellowship at MPIfR, 1972-1974

A. Kus leaves for the British Council Copernicus 500 fellowship in Cambridge, 1973/74

Ref.: B. Krygier, "25 Years of Radio Astronomy in Toruń", NHiT, no. 3-4/1985

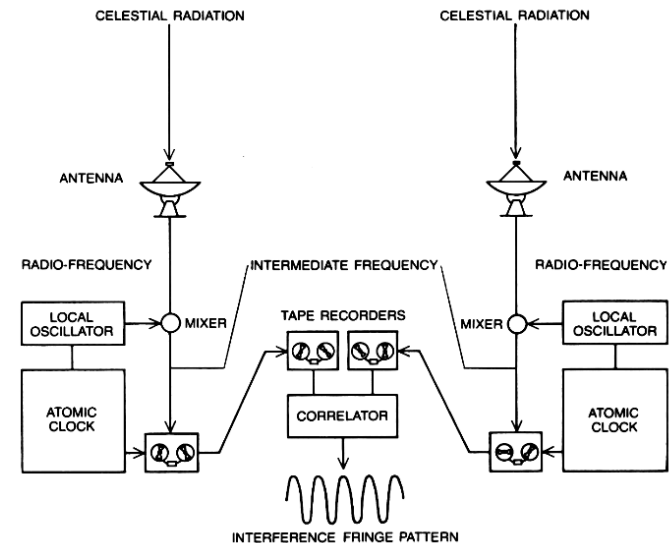
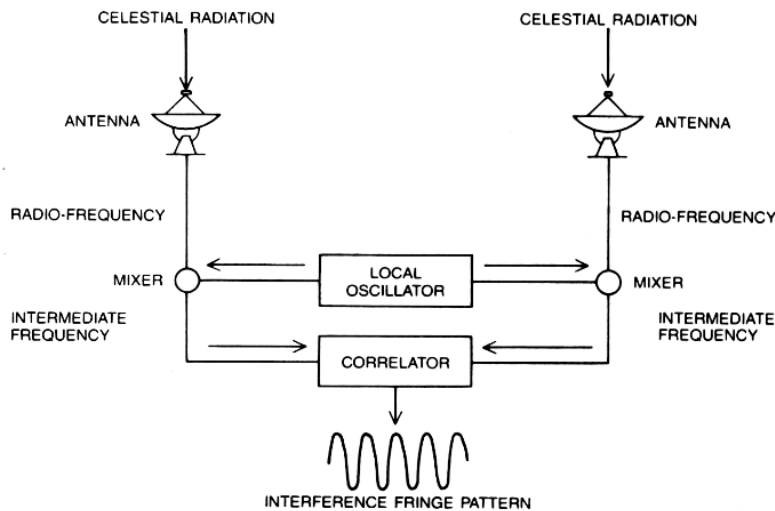
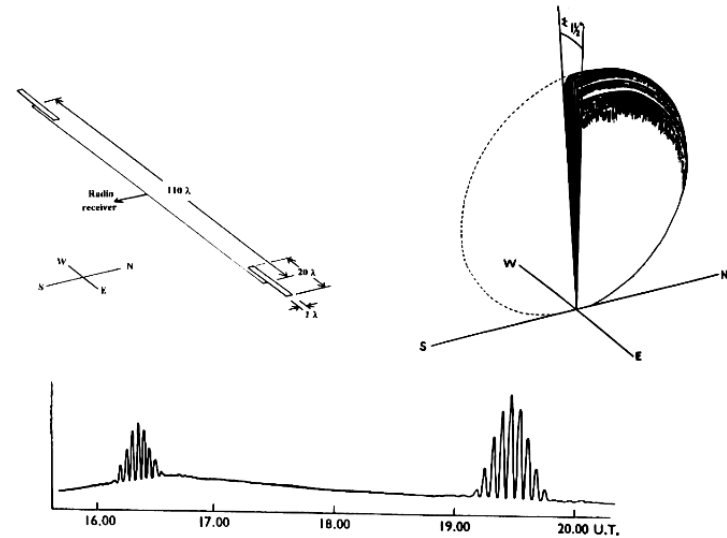
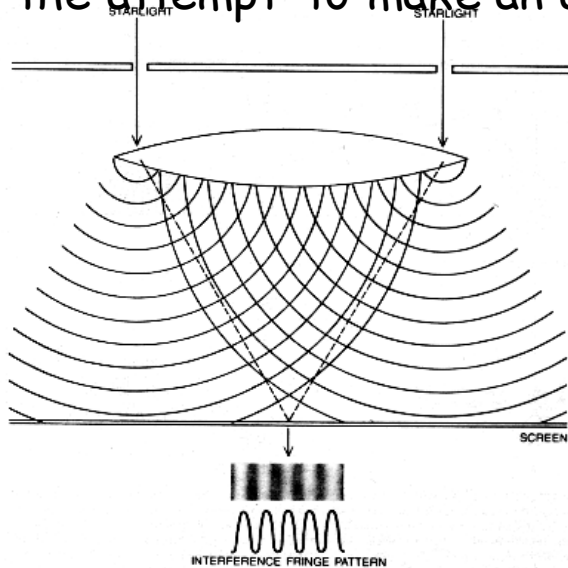
UMK / PAN Radio Astronomy Centre, construction of the centre 1971–1973

Centre concept 04.1969; Council of Ministers resolution 2 July 1971 – “Radio Astronomy Division”
documentation completed in spring 1972; building construction and fit-out 15.08.1972–31.08.1973

June 1973



Fundamentals of radio interferometry were studied at Torun aimed towards the proposed 5x25m antennae interferometer, the attempt to make an aperture synthesis LF system at 45 MHz.



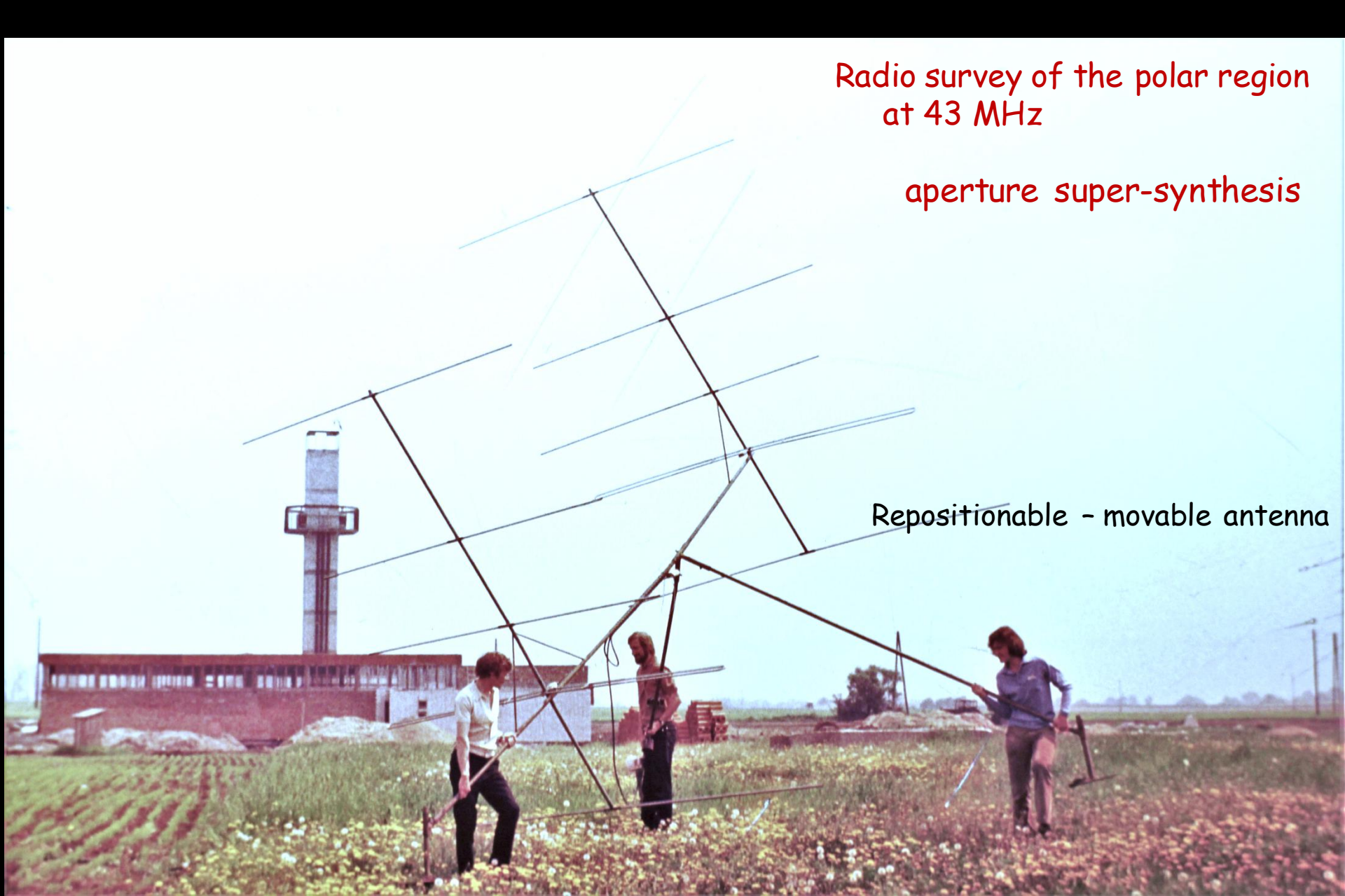


43 MHz
fixed antenna

Radio survey of the polar region
at 43 MHz

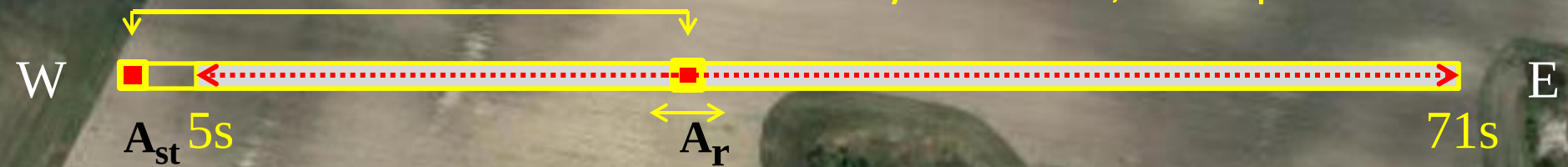
aperture super-synthesis

Repositionable - movable antenna



$$f=43.1 \text{ MHz} \Rightarrow \lambda = 6.97 \text{ m}$$

Interferometer baseline length varied from 50 m to 690 m,
every 24 hours, in steps of $s=10 \text{ m}$



66 positions of the movable antenna
(and the same number of independent interferometers), step (s) every 1.35λ

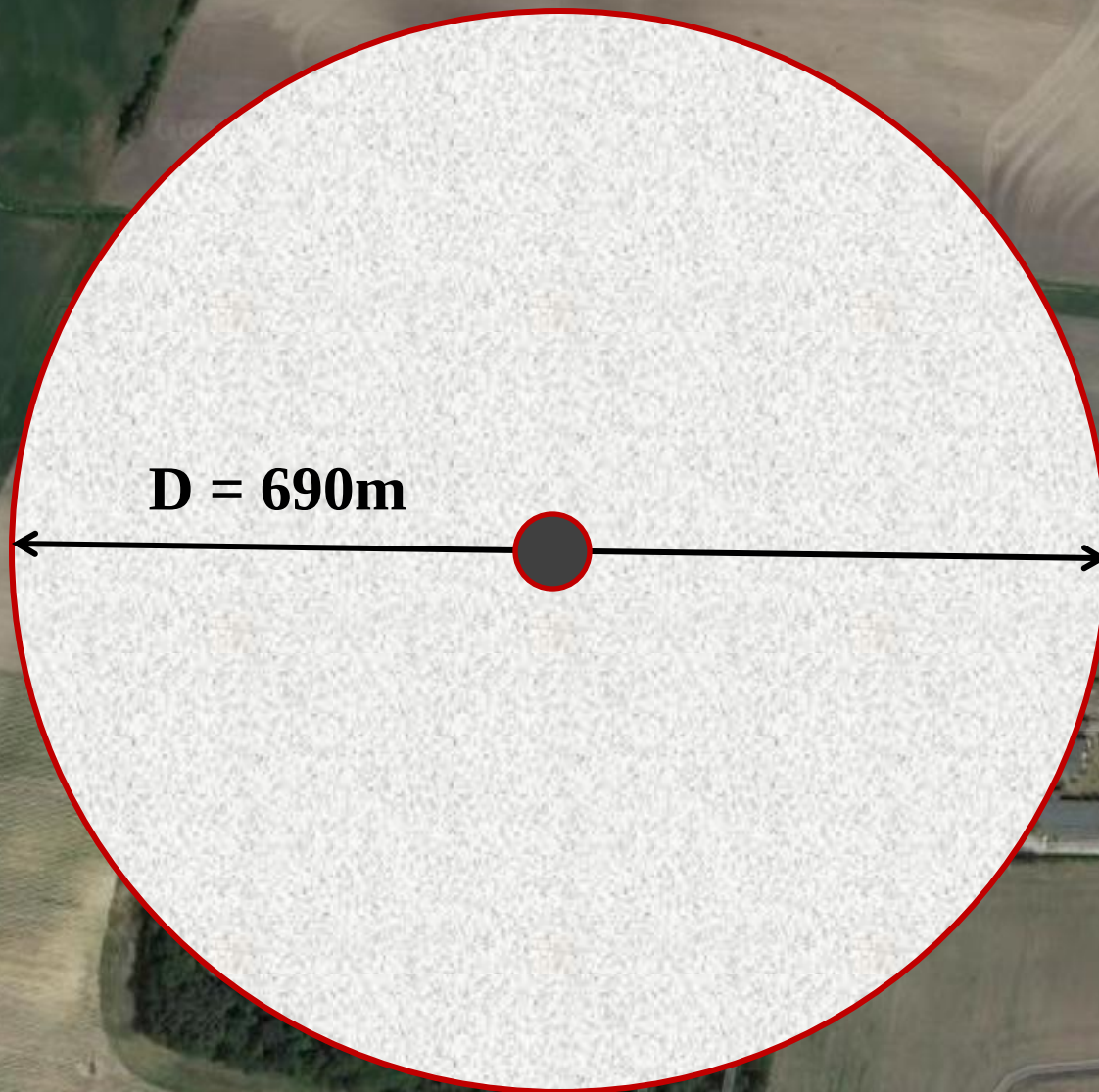
90 observing nights from January to the end of May 1973
+ 20 repeated observations



D = 690m

Obserwatorium
Astronomiczne w...

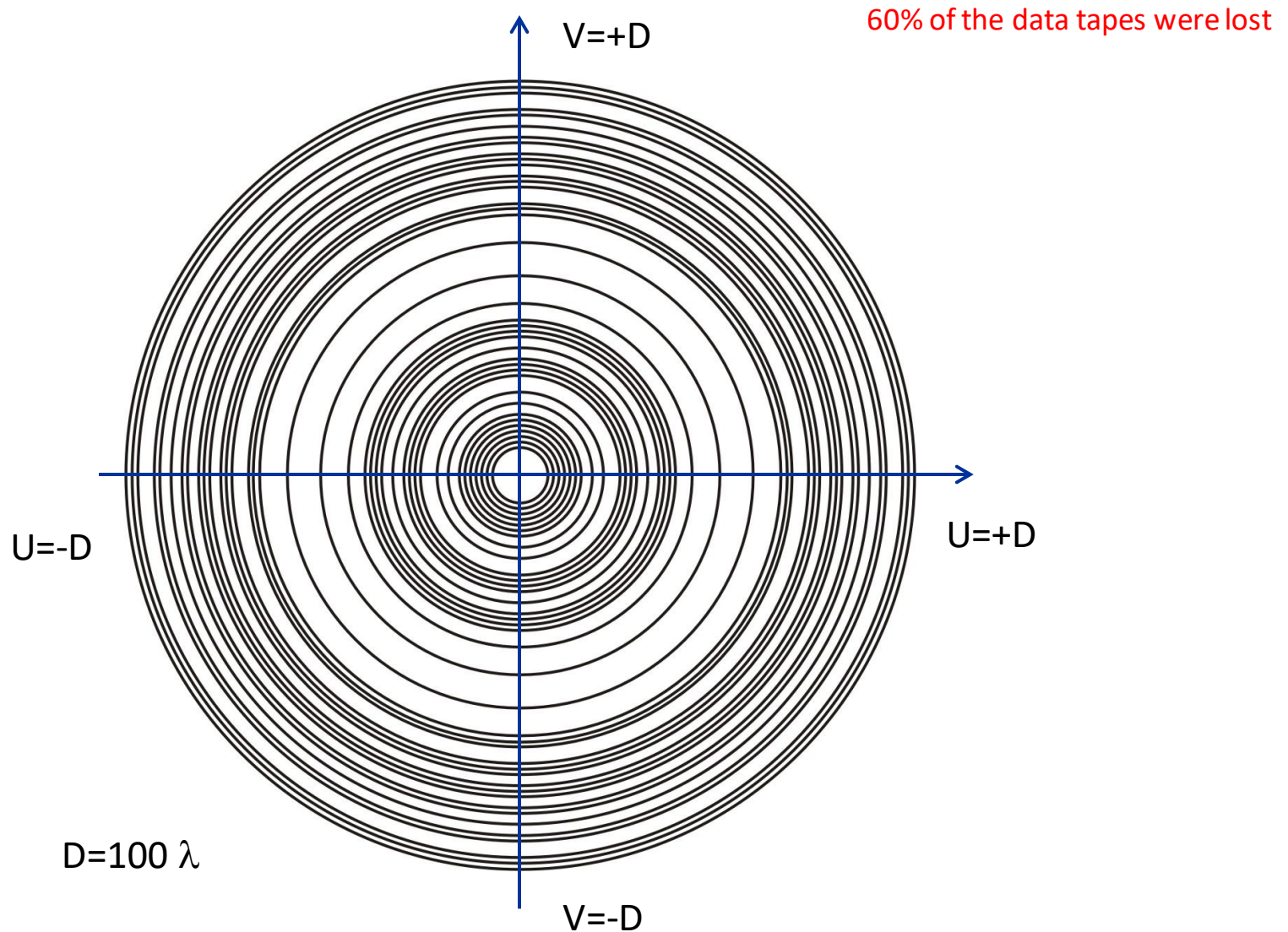
Google

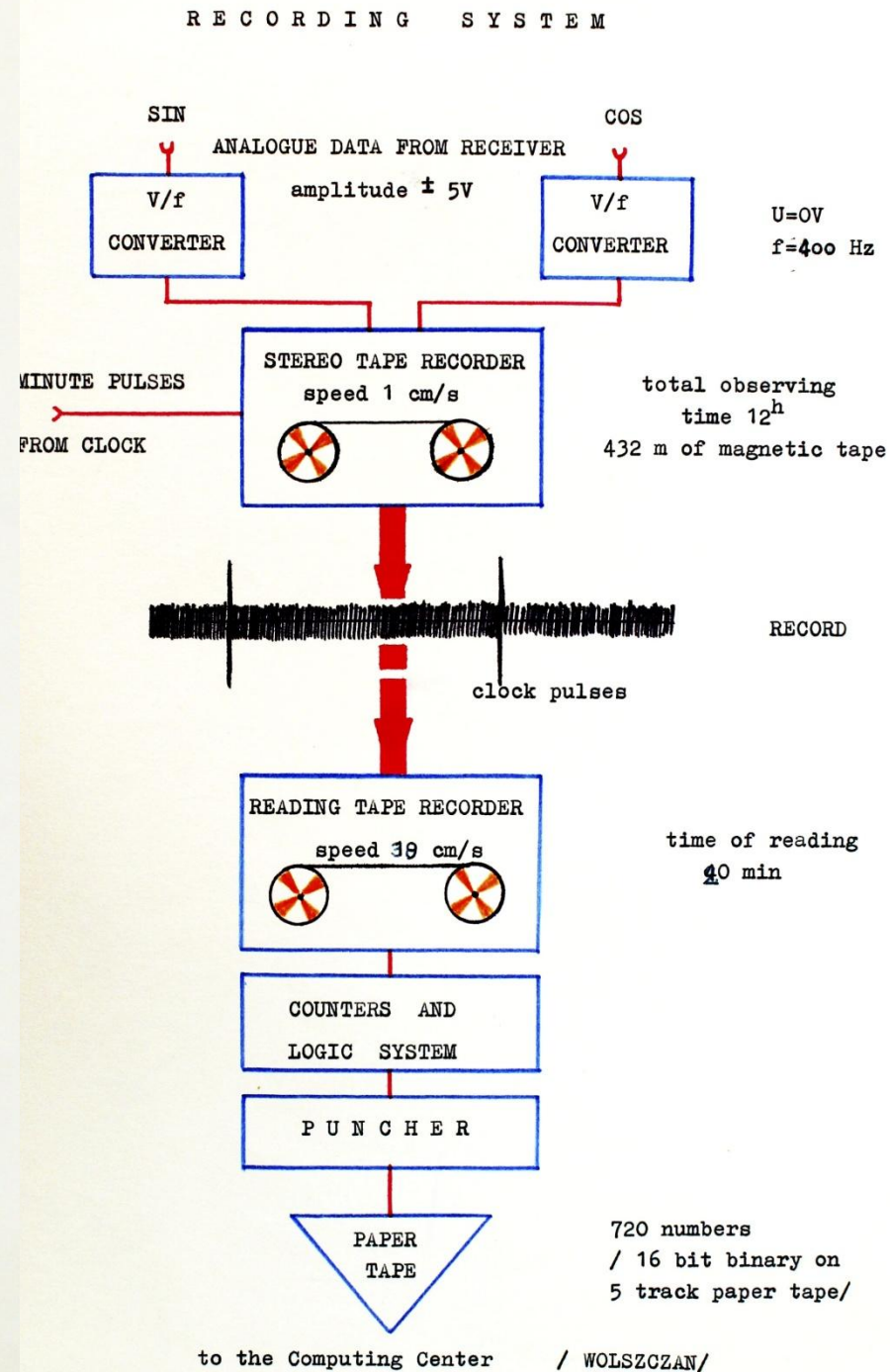
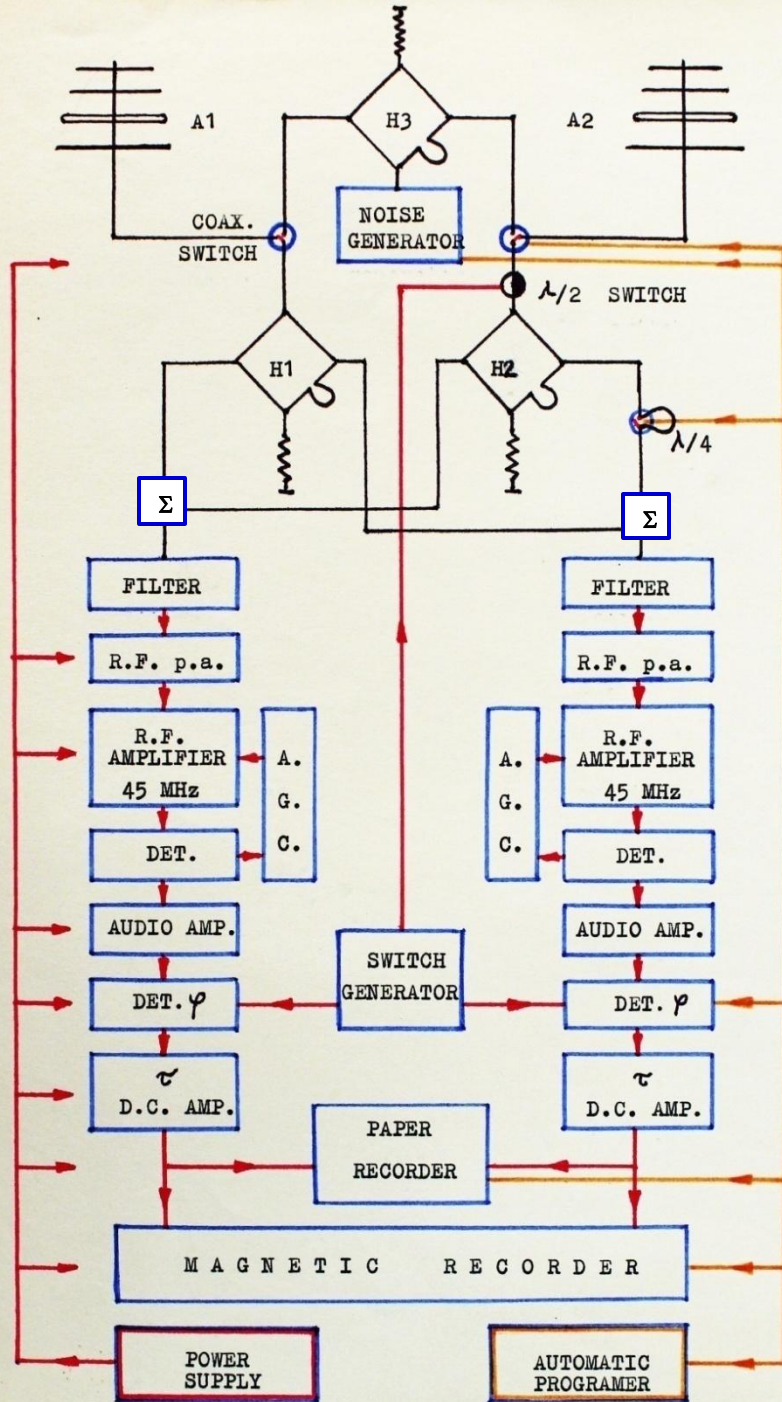


Obserwatorium
Astronomiczne w...

Google

Current data UV-plane coverage
(archival data recovered in 2024 from observations made in 1973, ~40%)





Data recorded on audio magnetic tape in two channels: "cos and sin"

Tape speed during recording: 1 cm/s

- Voltage-to-frequency converters (analogue => digital)
- Signal integration in one-minute intervals 16 bit values

Read-out on a ZK 140 tape recorder at 19 cm/s

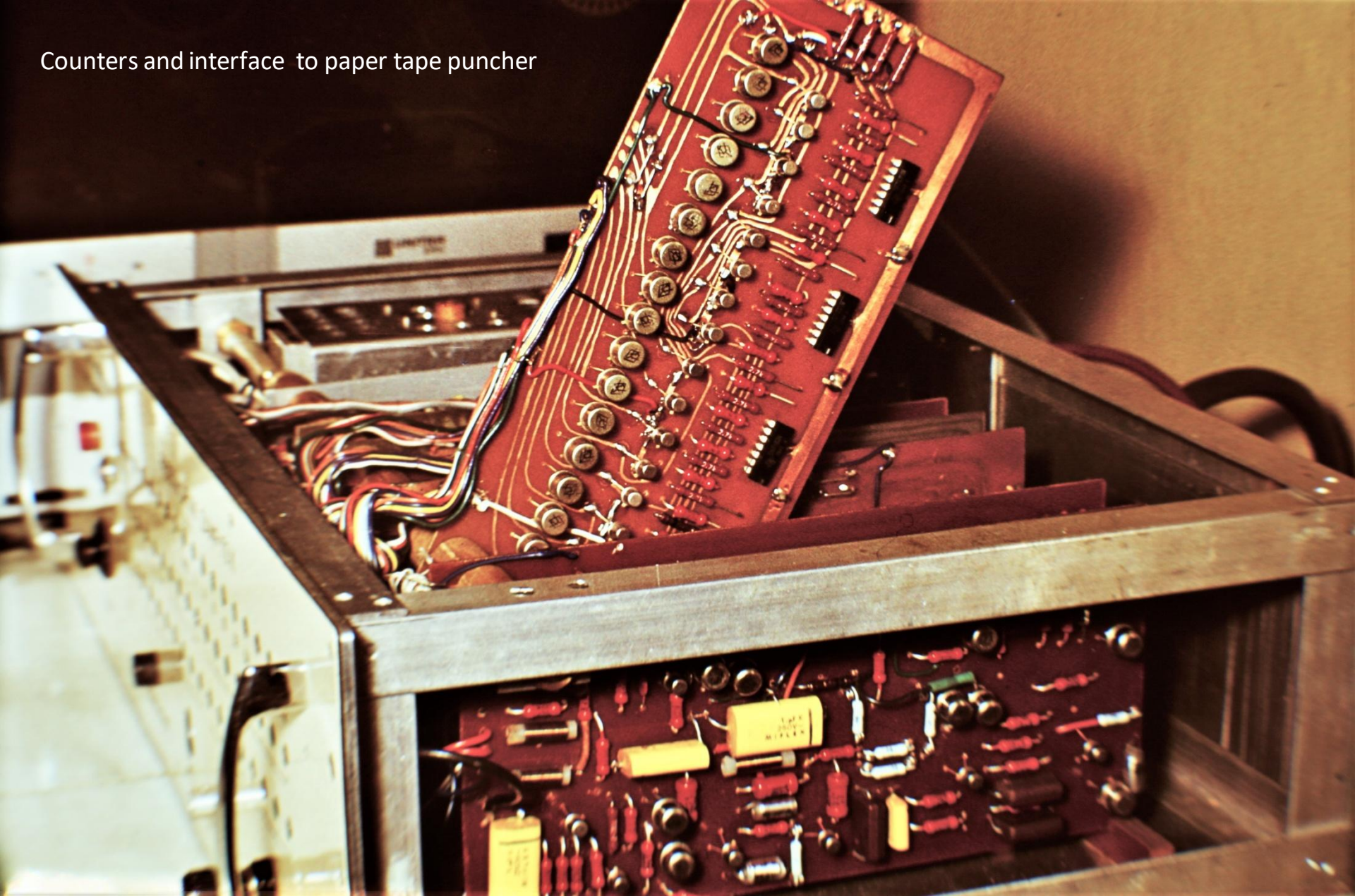
ZAMP-72K converter - a set of counters
and an interface to a paper-tape puncher,

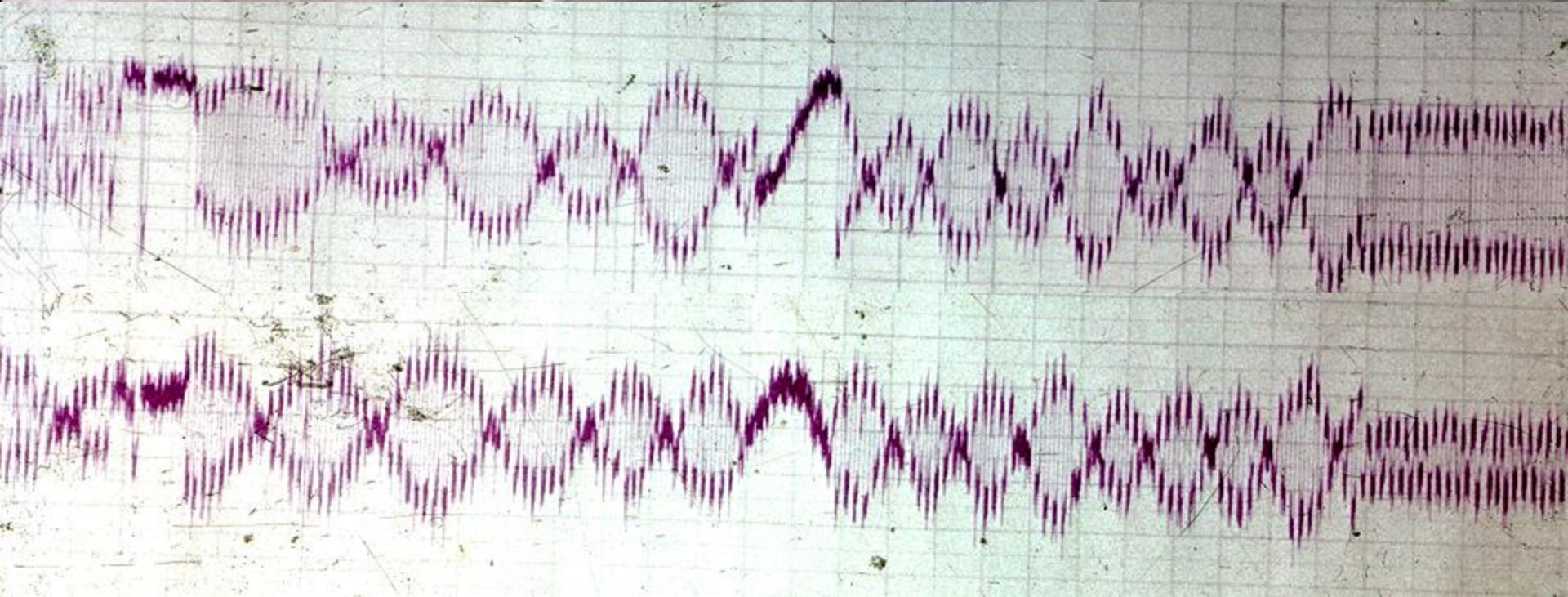
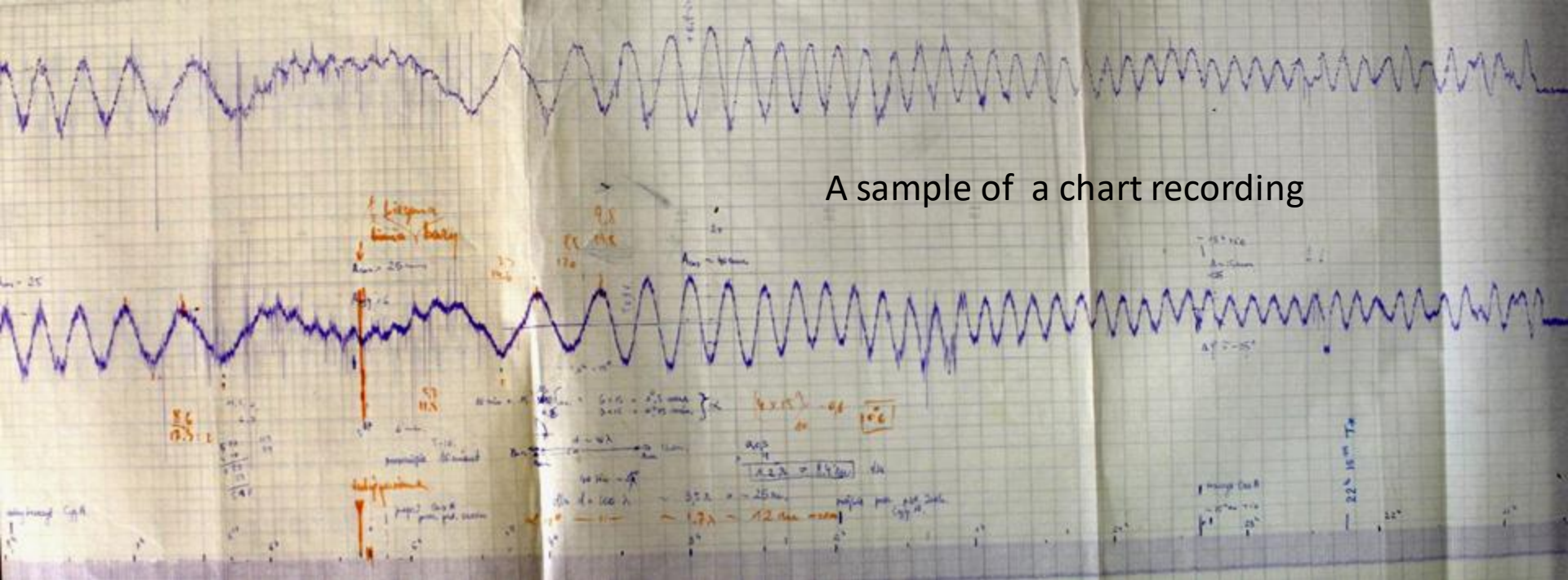
All electronic's equipment: analogue and digital designed and built by A.Kus 1990-1993
work supervised by Prof. S.Gorgolewski

Observation data were collected from January till June 1973 every night

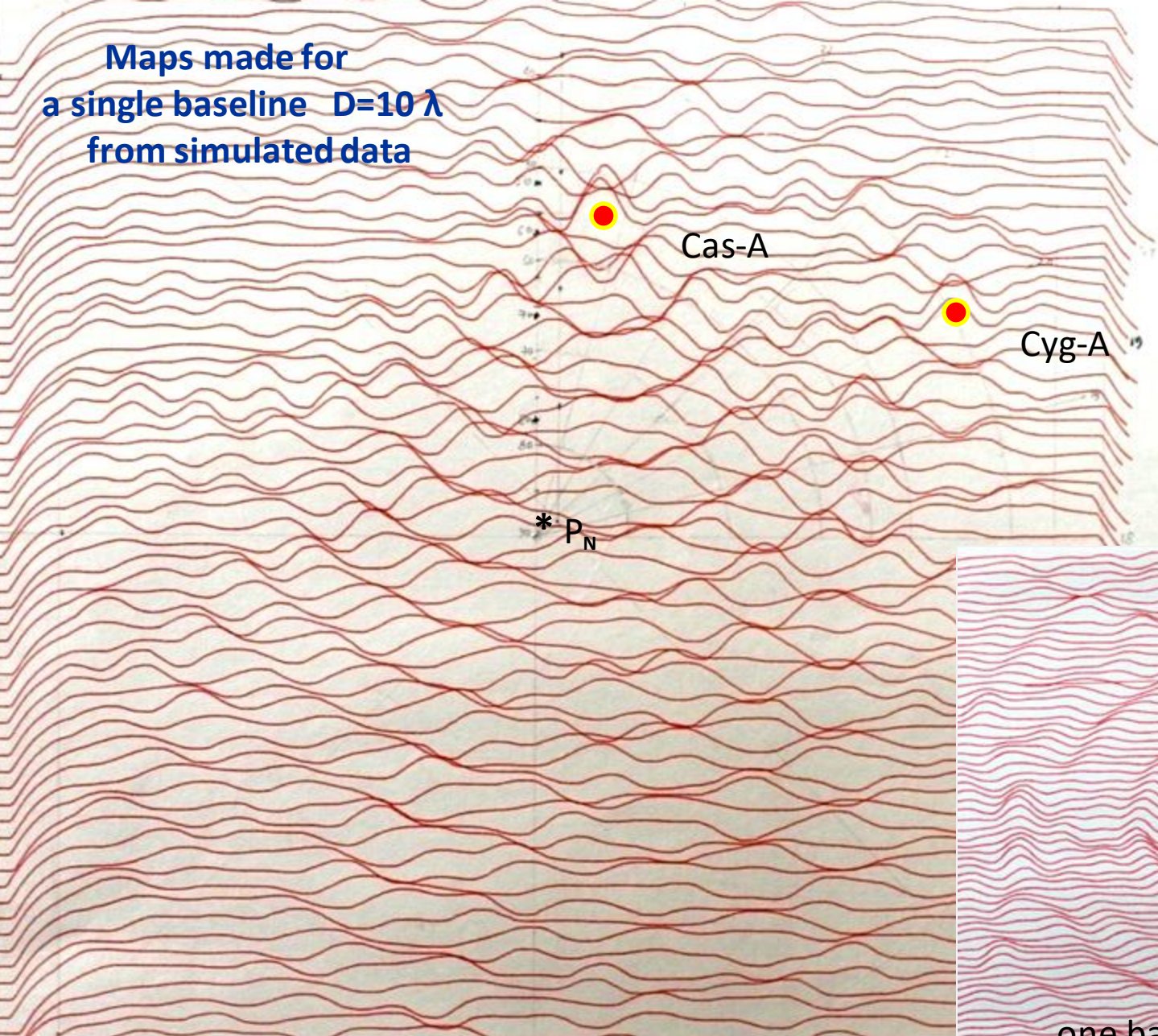


Counters and interface to paper tape puncher





Maps made for
a single baseline $D=10\lambda$
from simulated data



Cas A, Cyg A
artificially generated.
 $N=1$; $\frac{D}{\lambda}=10$

Plotted:

spw: 1

sm: 15

d.-a. conv: 1

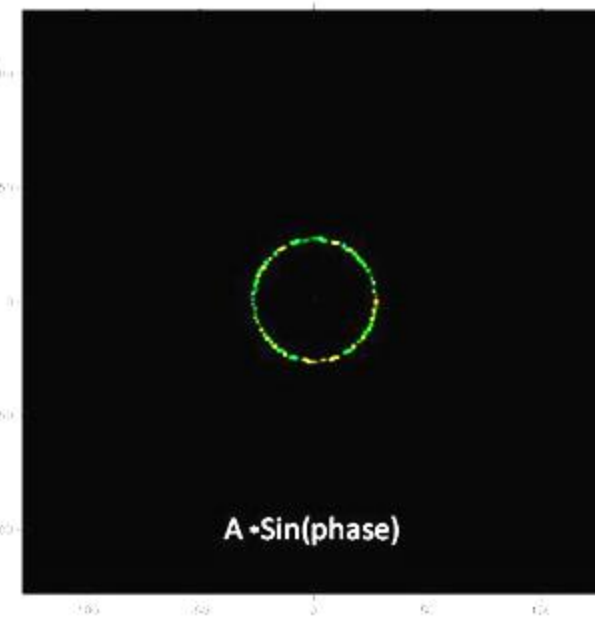
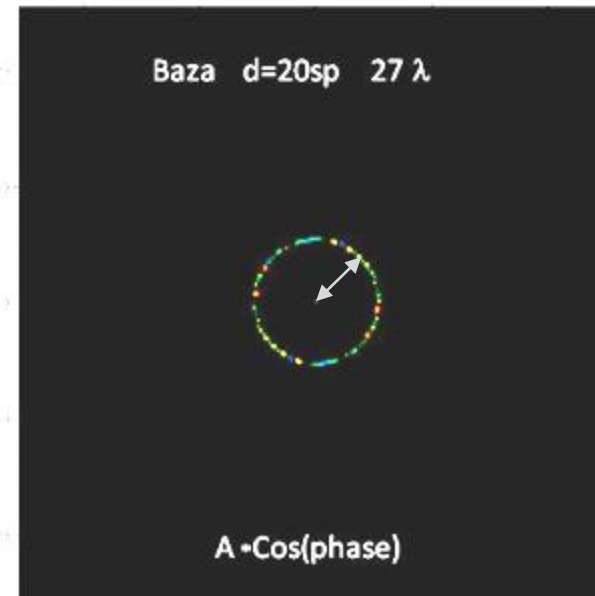
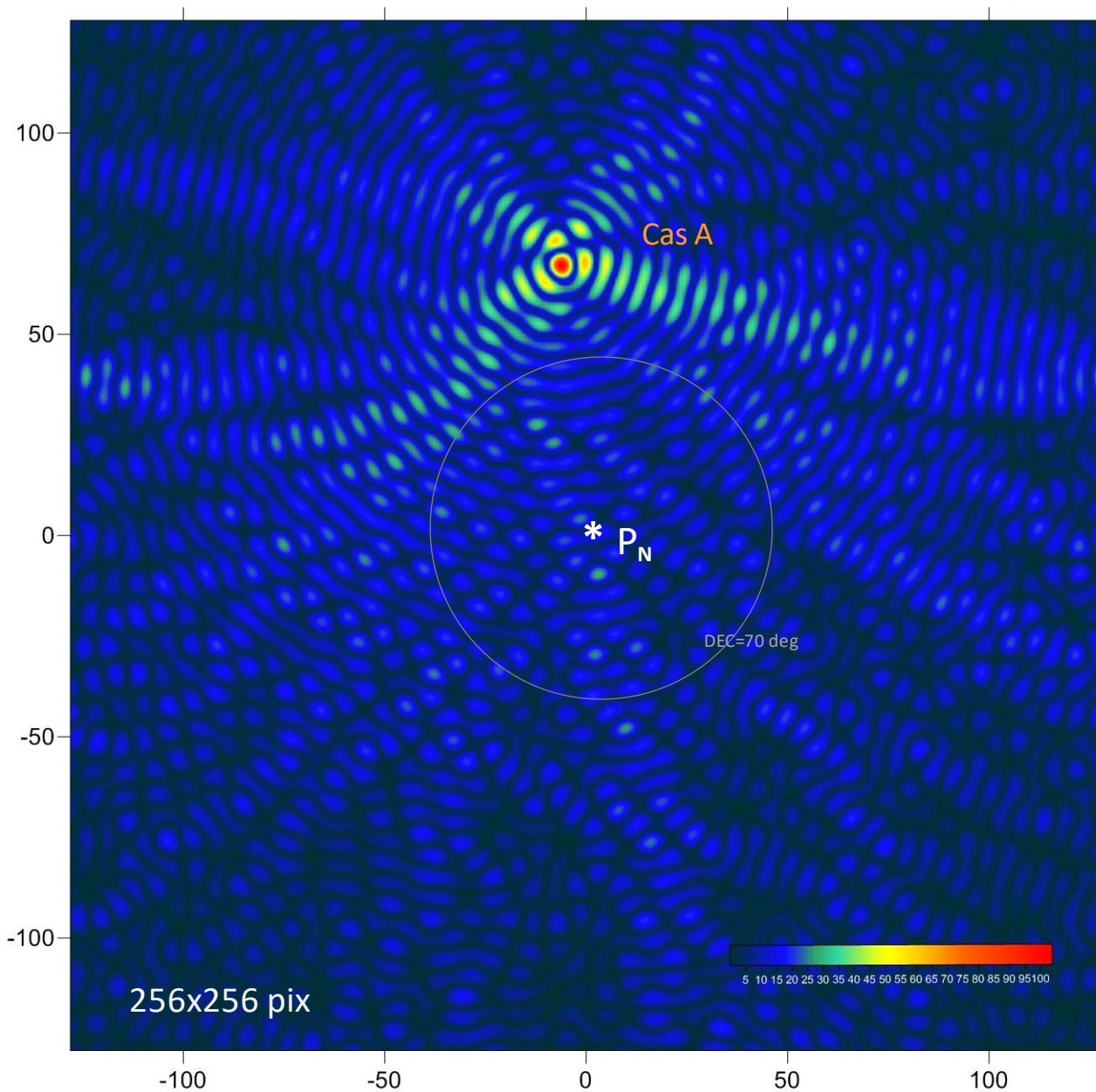
40 + 160 ms

	α	δ
Cas A	$23^h 21^m 11^s$	$+58^\circ 33'$
Cyg A	$19^h 57^m 45^s$	$+46^\circ 36'$

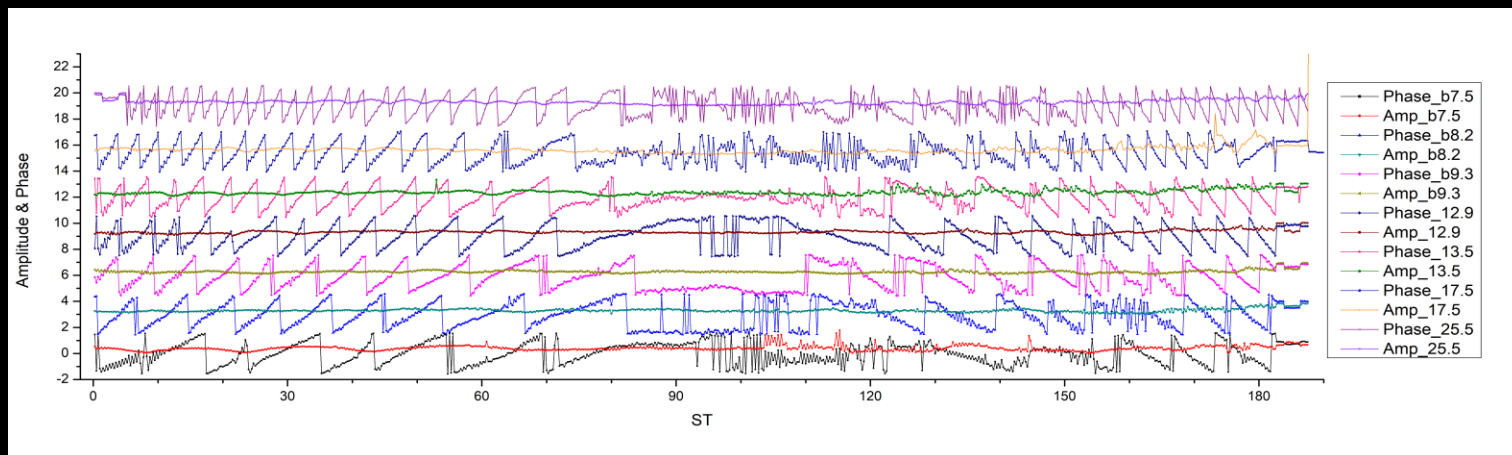
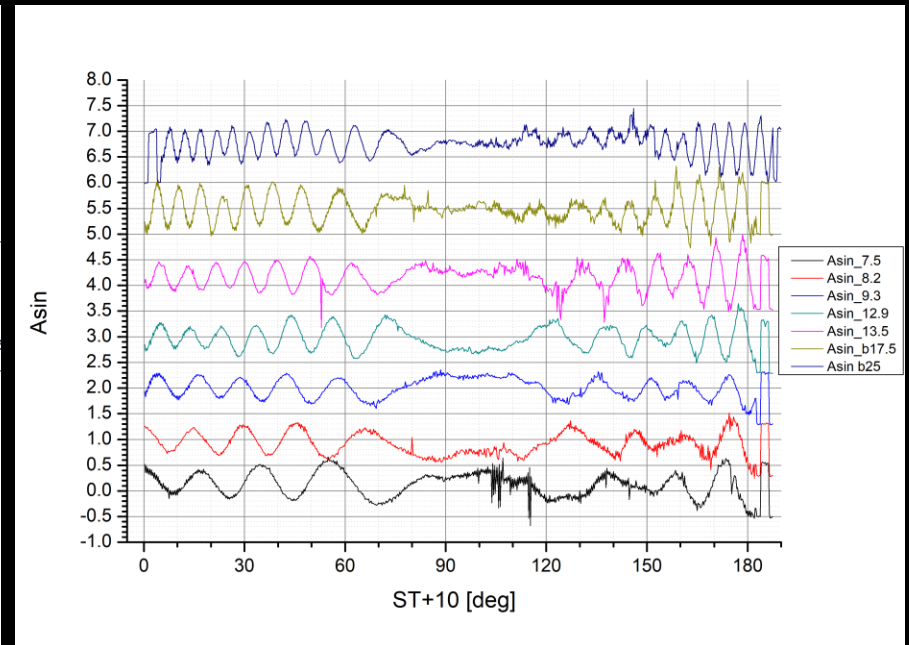
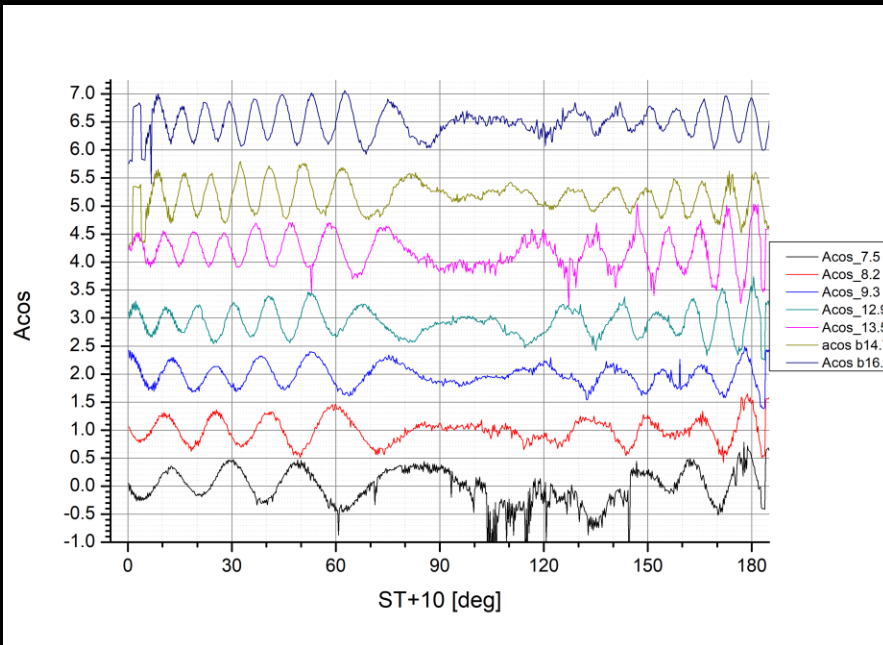


Early software developed by A. Wolszczan and L. Nowakowski

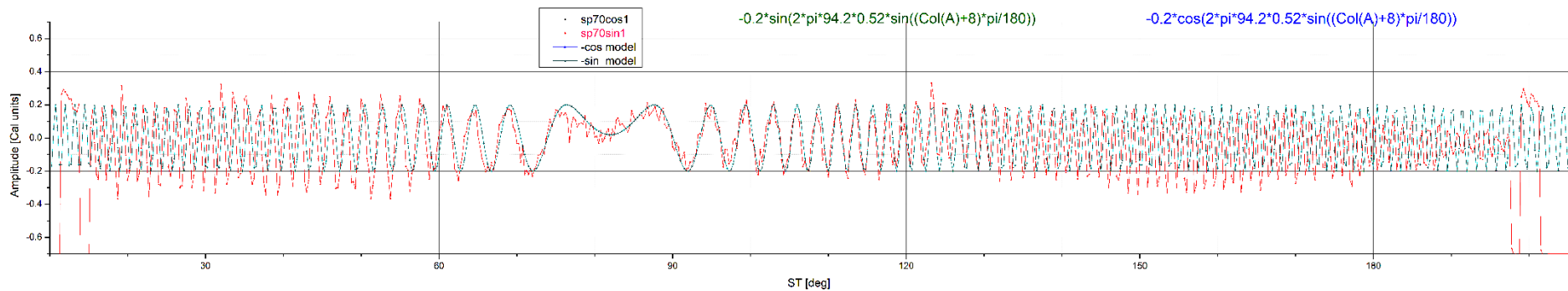
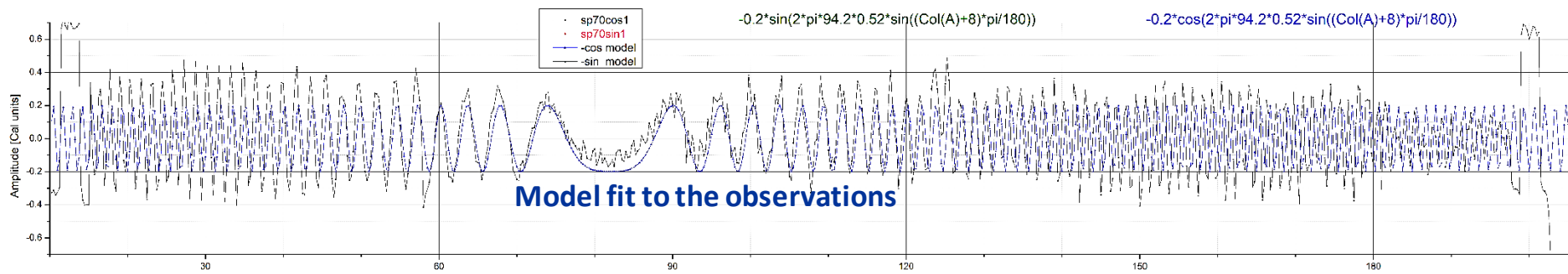
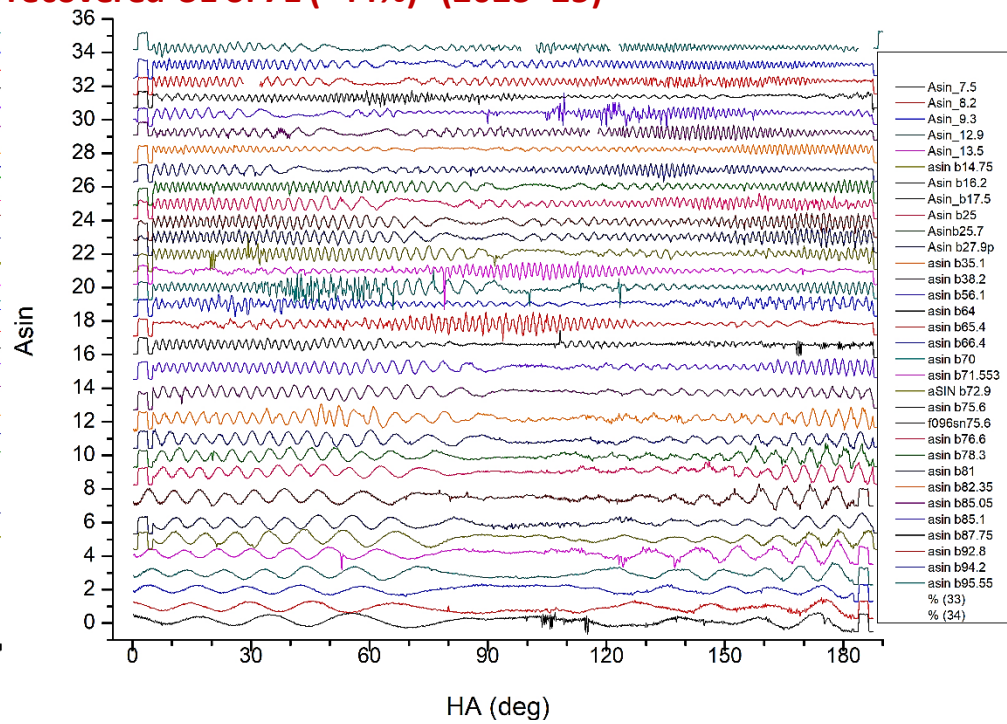
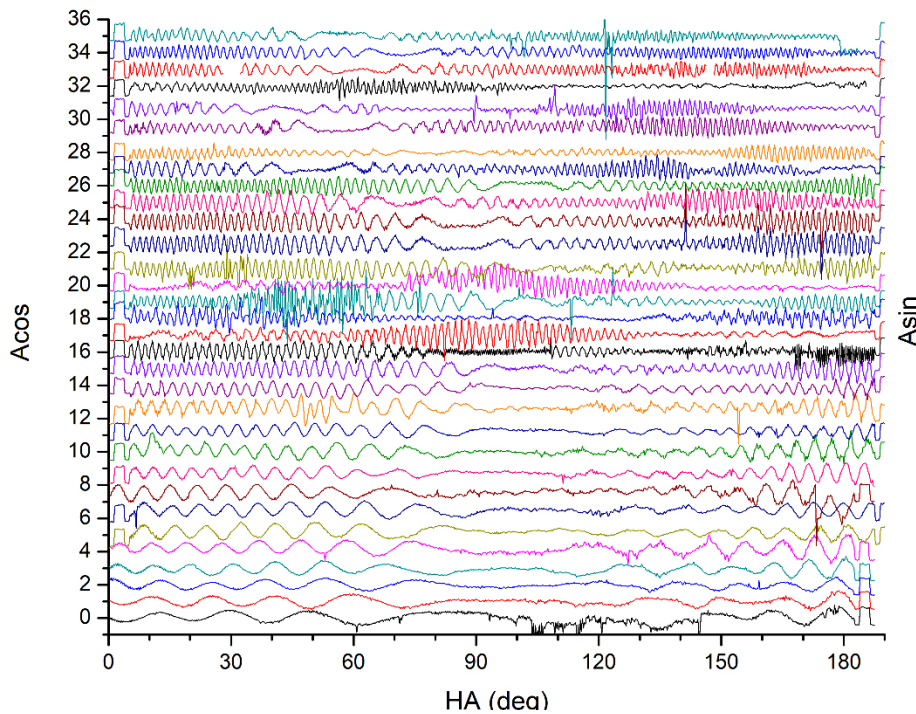
2024-11-10 FIRST MAP made from real data, one baseline



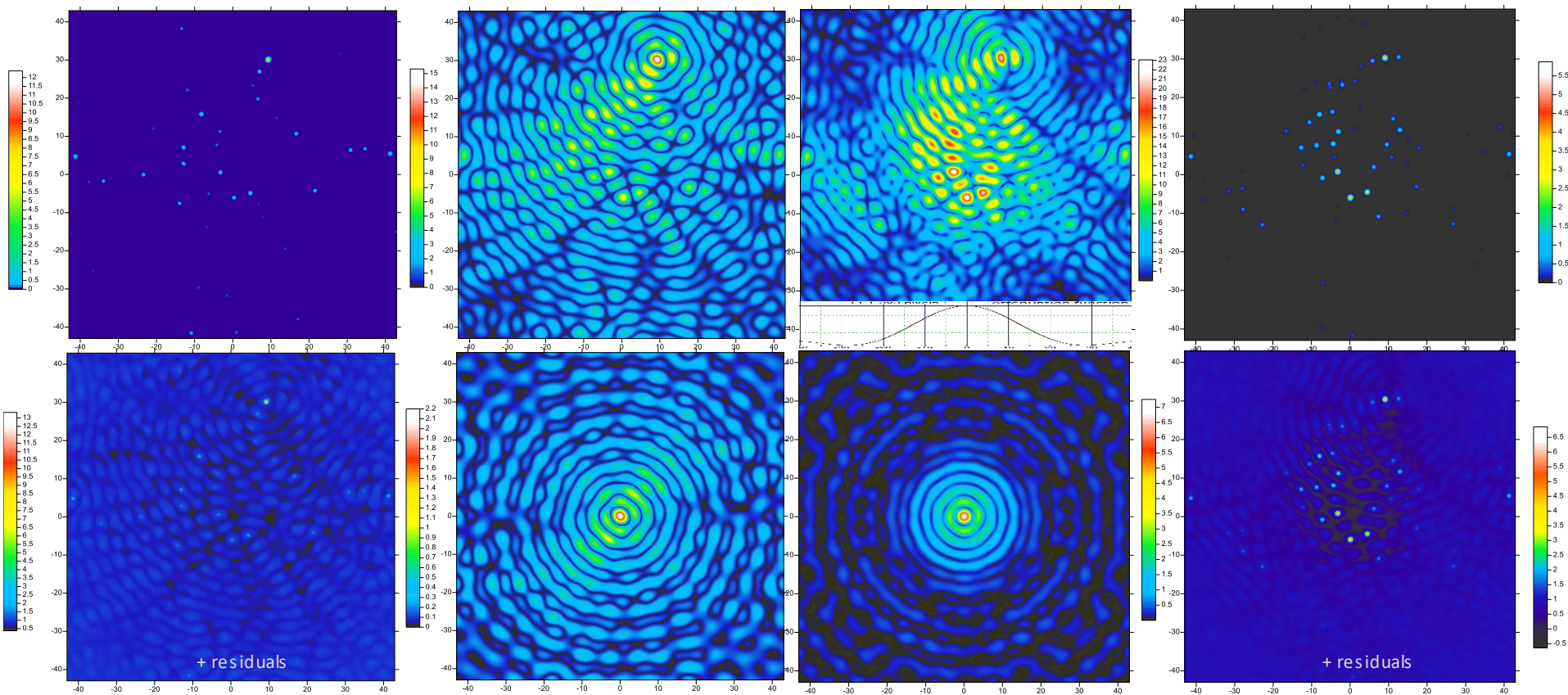
Examples of raw data after use of EDIT and Origin8 programs, 2024.



More baseline data recovered 31 of 71 (~44%) (2023-25)

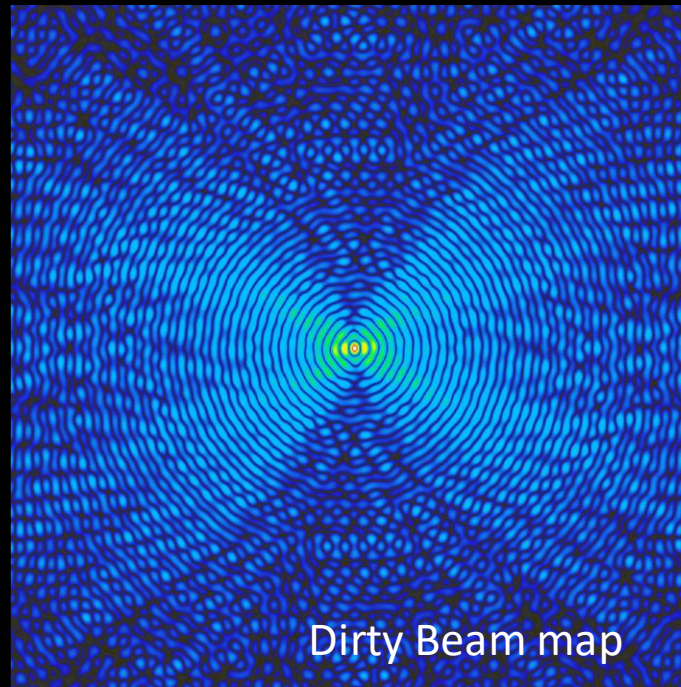
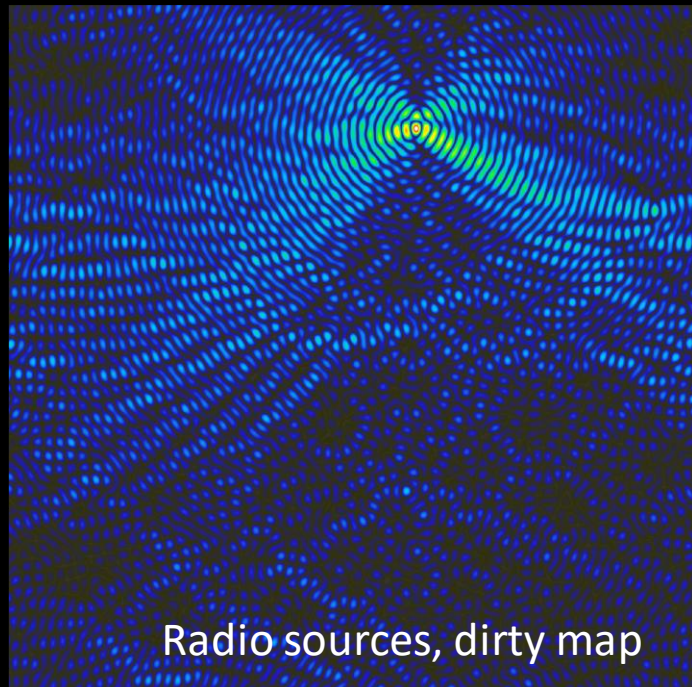


Baseline $d=9.45 \lambda$ (66 m) processed recently - on March 2026



----- maps without UV-pixel averaging -----

----- averaged over 3x3 UV pixels -----

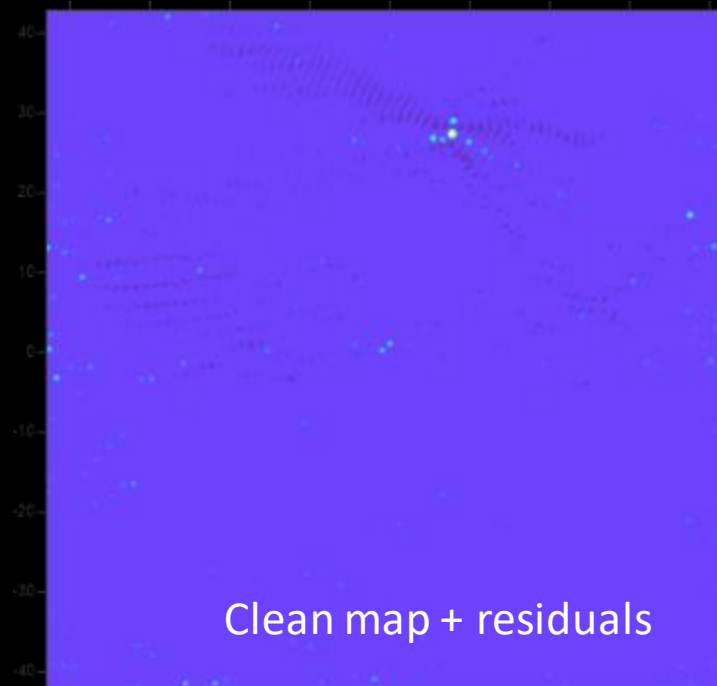
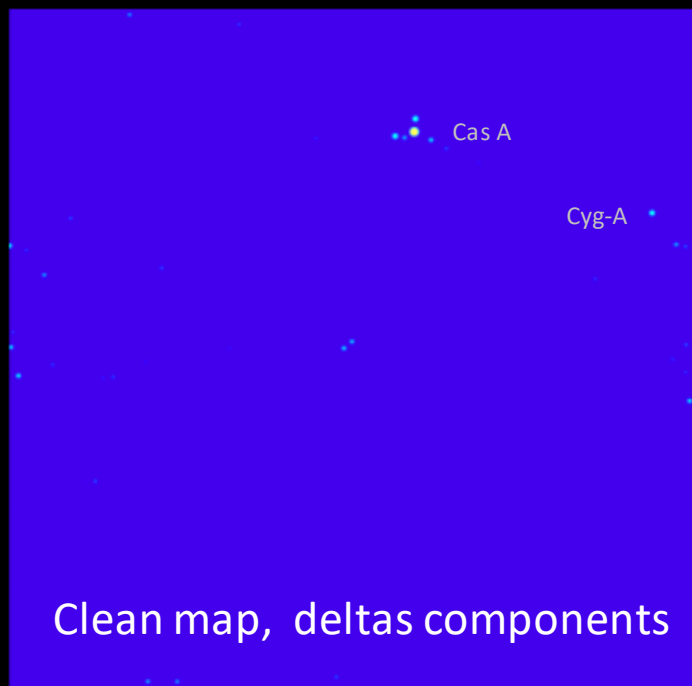


Single baseline maps

$D = 27 \lambda$

2048 x 2048 pix
90 x 90 deg

Software
for editing,
processing
and presenting
observational
data



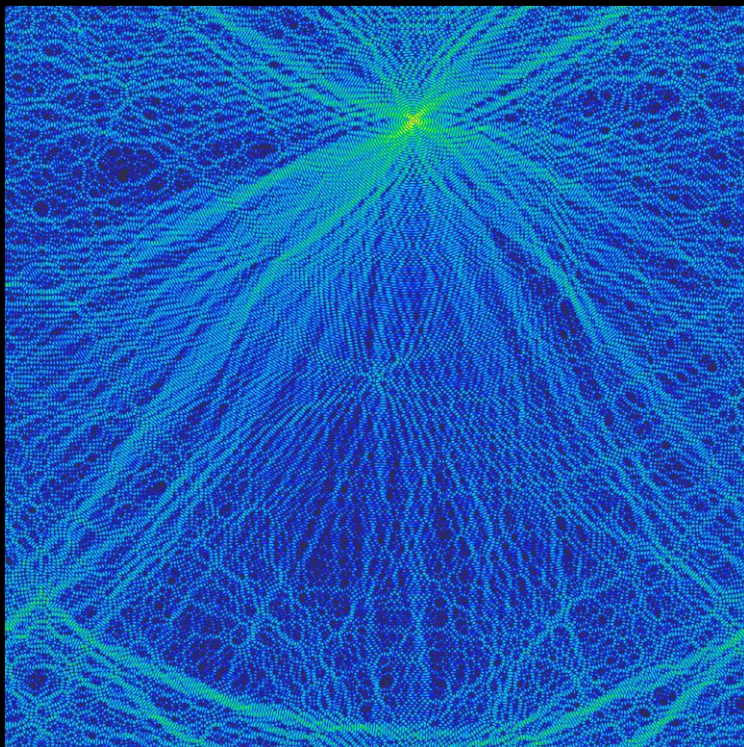
made by AJK

W11 + Debian
Fortran 77 code

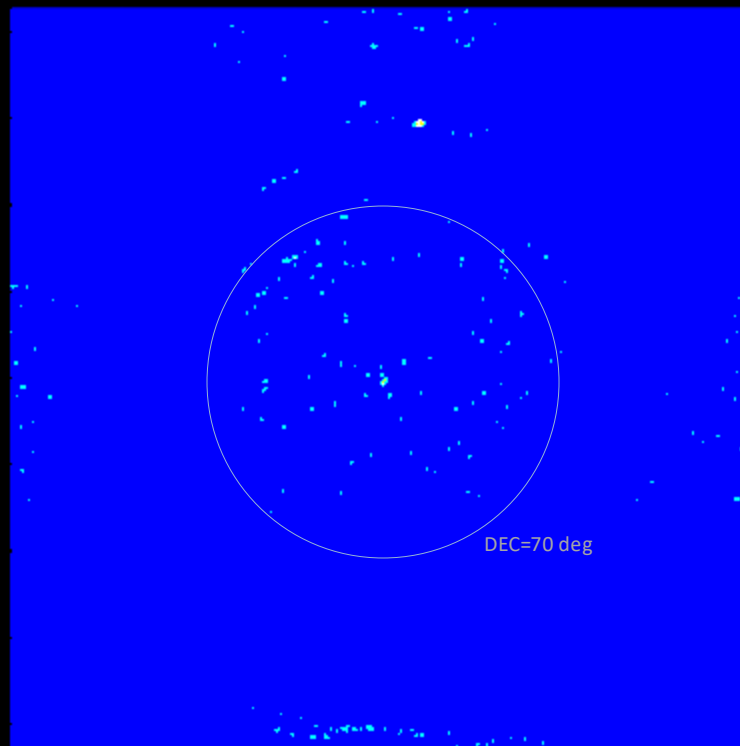
Support

Origin 8, OriginLab
Surfer, Golden Software

Processed on March 2026



Dirty map, single baseline $d=94 \lambda$



Map made of delta components obtained by the CLEAN process

Project currently in progress; final maps made from all available data
will probably be available in late summer 2026.

The current stage (March 2026) is the production of single-baseline maps,
their common calibration, and correction of observing times and actual baseline lengths,
which will be possible through cross-comparison of the single-baseline maps.

AJK visit to MRAO, Cambridge University: a special 12-month British Council fellowship funded for the Copernican anniversary, 1973-1974.

Observations and data processing for the 5C7 radio sky survey with the One-Mile Telescope, and collaboration with Prof. J. Baldwin on construction of a new 151 MHz radio telescope being prepared for the 6C sky survey.

The stay in Cambridge provided important experience and contacts. At the time, it was the world's leading centre for radio astronomy.

Documentation for Phase Switch *G* and IF amplifiers was brought back. This made it possible to introduce major changes to the receiver equipment already in use and being built for RT-3.

After returning, the doctoral dissertation "5C7 - a radio sky survey carried out by aperture synthesis" was written and defended in June 1975.

Cavendish Laboratory



Physics Research Students

Cambridge 1974



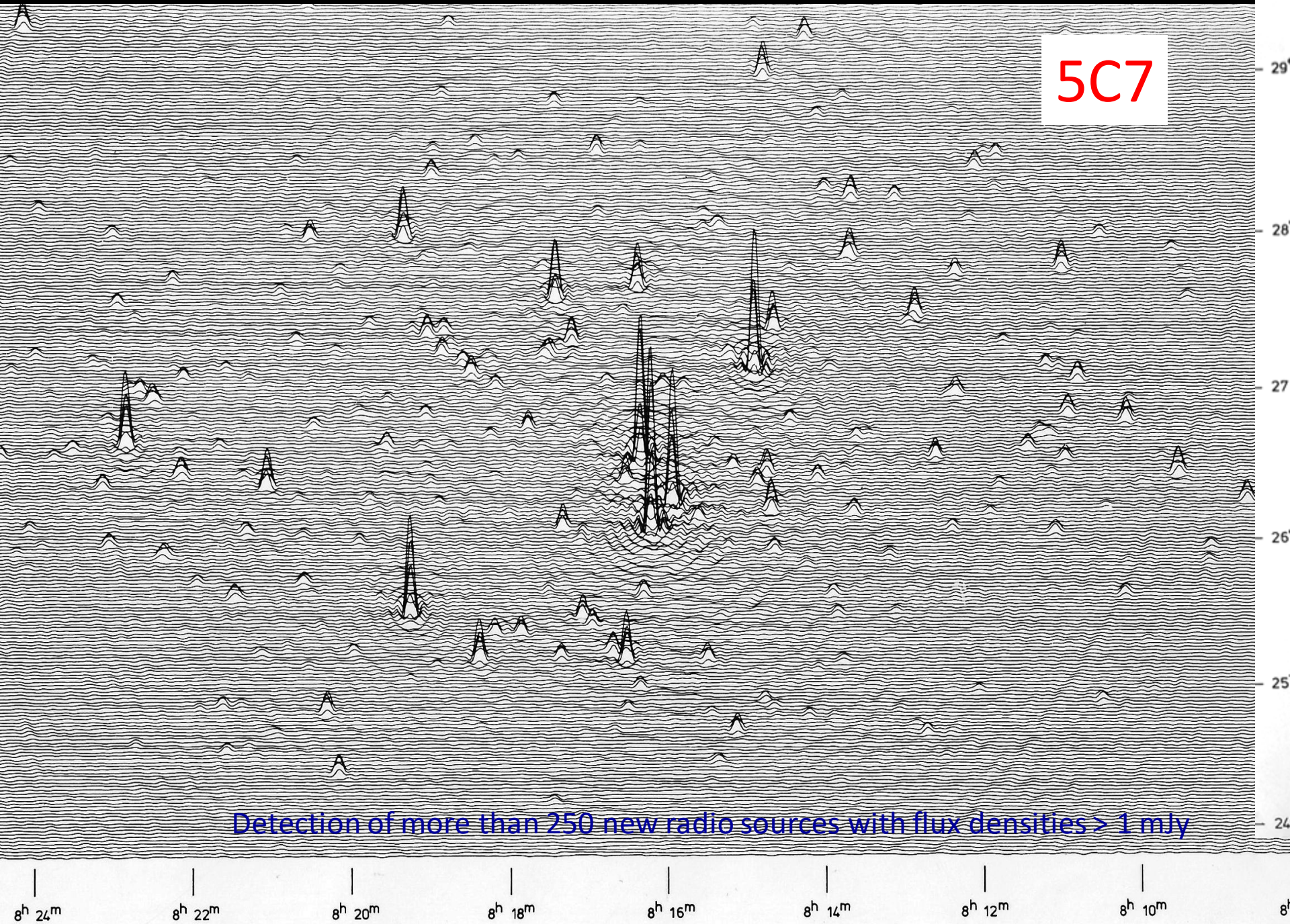
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Dr P.H.	Giess.	Griffiths.	Scott.	Hannay.	Eve.	Winter.	McEllin.	Maslin.	Shaw.	Smith.	Crozier.
R.D.	P.J.	B.D.	M.S.E.	D.M.	K.J.E.	D.T.	P.J.	J.M.	A.B.	A.	
Gaskell.	Leapman.	Duffett-Smith.	Turland.	Shafik.	Odell.	Northover.	Emerson.	Hargrave.	Riley.	Harris.	Hooley.
A.	G.A.	I.P.	S.M.	C.S.M.W.	†J.	I.M.	Dr M.S.	Dr C.G.	Dr A.S.	Dr D.J.	L.J.
Slingo.	Cottrell.	Williamson.	Goodman.	Harris.	Pearson.	McHardy.	Longair.	Wynn-Williams.	Webster.	D.R.	Munday.
Dr R.E.	D.W.J.	A.J.	P.J.	Dr M.A.	Dr J.C.	C.J.	Dr P.A.	J.	G.	E.A.C.	R.J.
Hills.	Bly.	Kus.	Warner.	Pelling.	Mumford.	Elliott.	Elcombe.	Halliday.	Ioannidis.	Crouch.	Barlow.
											Webber.
B.	Dr J.G.	Dr A.A.	Dr J.E.	Dr V.E.	Prof	Prof O.R.	Prof A.H.	Dr K.G.	Dr E.A.G.	Dr S.	
Elmore.	Rushbrooke.	Townsend.	Baldwin.	Cosslett.	Sir Martin.	Ryle.	Frisch.	Hewish.	Cook.	Budden.	Scheuer.
											Kenderdine

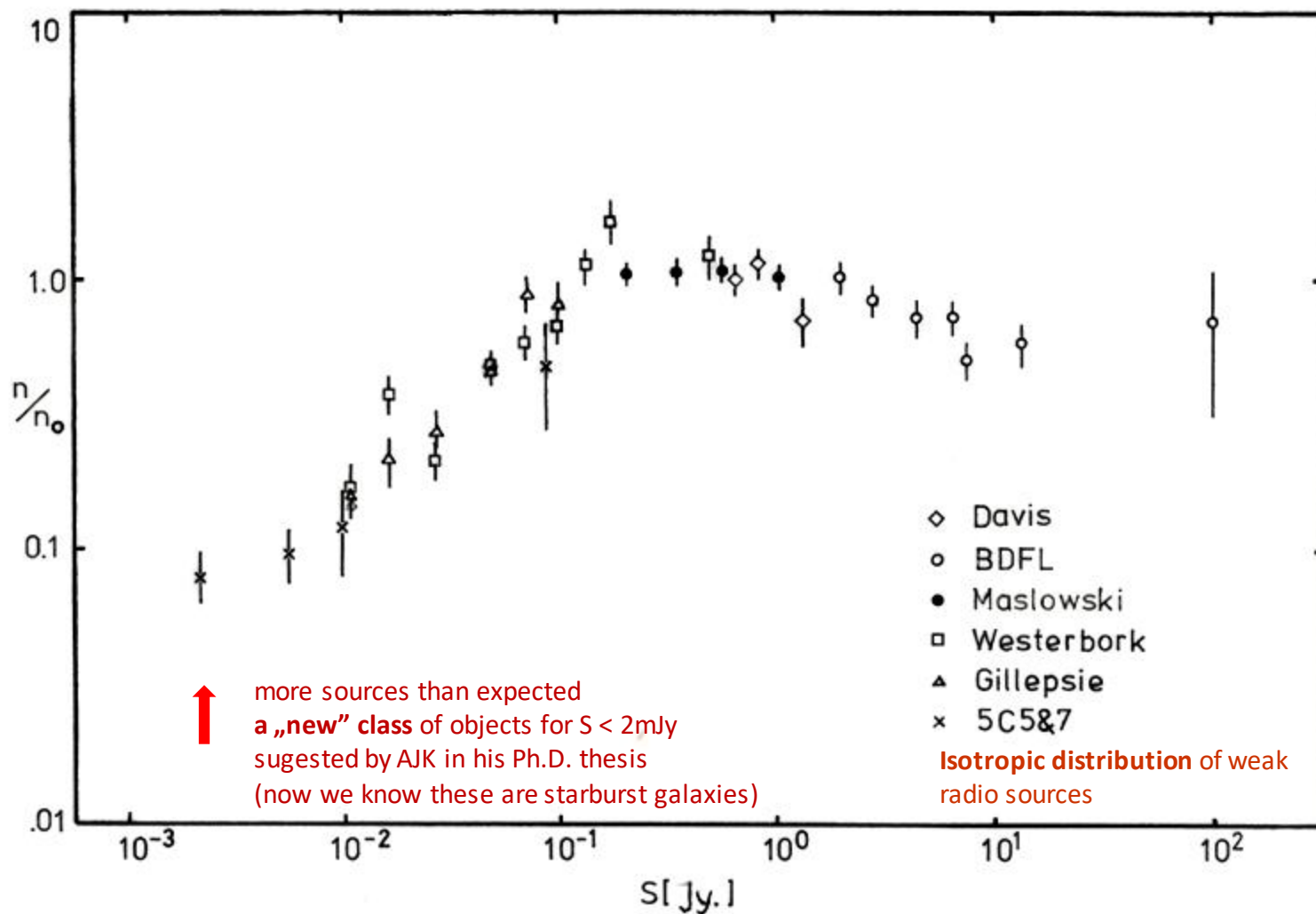
Edward Long 1117 74

Cambridge

One of the two deepest sky surveys carried out in the 1970s (5C6 and 5C7)

5C7





Rys.32 Zestawienie większości danych z przeglądów w pobliżu 1400 MHz. Zliczenia znormalizowano dla $N_0 = 200 \text{ sr}^{-1}$ i $S = 1 \text{ f.u.}$

Two visits by Prof. S. Gorgolewski to the USA, Caltech Pasadena, in 1967 and 1975

In 1967 he spent a year as a visiting professor at OVRO, California Institute of Technology, Pasadena, USA, where he conducted, among other work, radio studies of Jupiter's moons.

He discovered radio emission from Callisto, 1970.

For this work he used, what was then the world's best, two-antenna interferometer (90-ft antennas) at 960 MHz.

He also carried out a series of observations of occultations of several radio sources by the solar corona. The aim was to investigate changes in the size and shape of the corona over a longer period.

The data, brought back on magnetic tape, were analysed in Toruń by the PhD student MSc Jacek Stryczyński.

Insufficient computing power and a lack of specialised software prevented completion of this interesting project.

A new idea for interferometry in Toruń emerged – the VLBI.

Full documentation for the Mark IIc VLBI formatter and converter was obtained, together with permission to build a copy of the terminal in the Radio Astronomy Department workshop.

Purchasing of the components needed to build the terminal, along with the formation of a team of collaborators who would be employed in the Radio Astronomy Division began in subsequent years.

RT-3

The technical design was prepared by the BIPROHUT team under Eng. Śledziewski and Eng. Bujakowski, December 1974.

Voluntary work for the Copernican anniversary.

Construction in 1974–1977

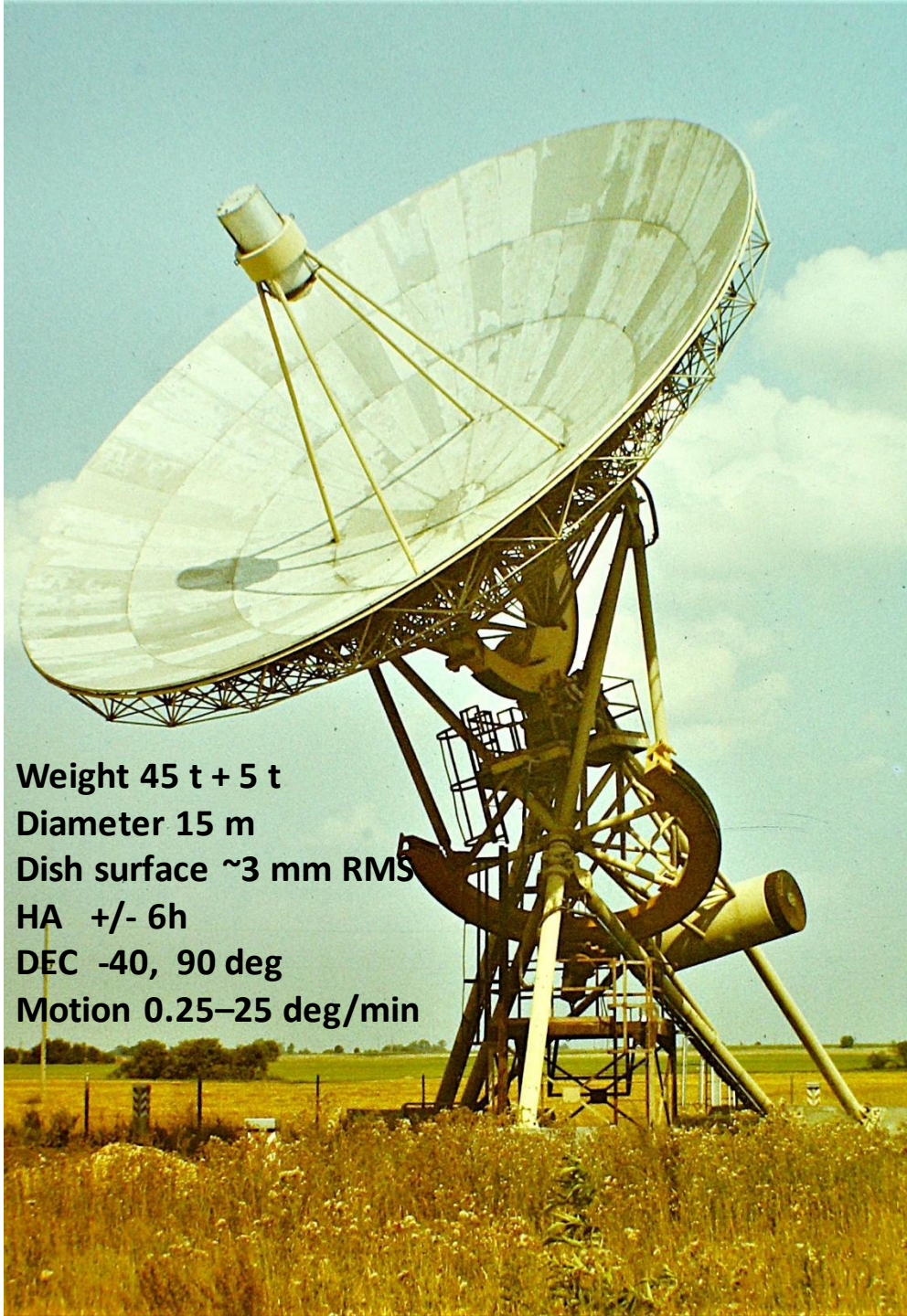
Contractors: MOSTOSTAL + 7 companies.

Coordination: Dr Z. Turło + support from the UMK Investment Department

Instrumentation assembled in 1977–1980

- Receivers: 408 MHz, 609 MHz, 1420 MHz, 1660 MHz, 5 GHz, 10.7 GHz
- VLBI Mk IIc terminal
- Autocorrelation spectrograph
- Computer control: Momik 8b, M400, SM1420

**Important support received from:
ASTRON, MPIfR, and JBO**



Weight 45 t + 5 t
Diameter 15 m
Dish surface ~3 mm RMS
HA +/- 6h
DEC -40, 90 deg
Motion 0.25–25 deg/min

Radio Astronomy Division of the IA, 1960-1974

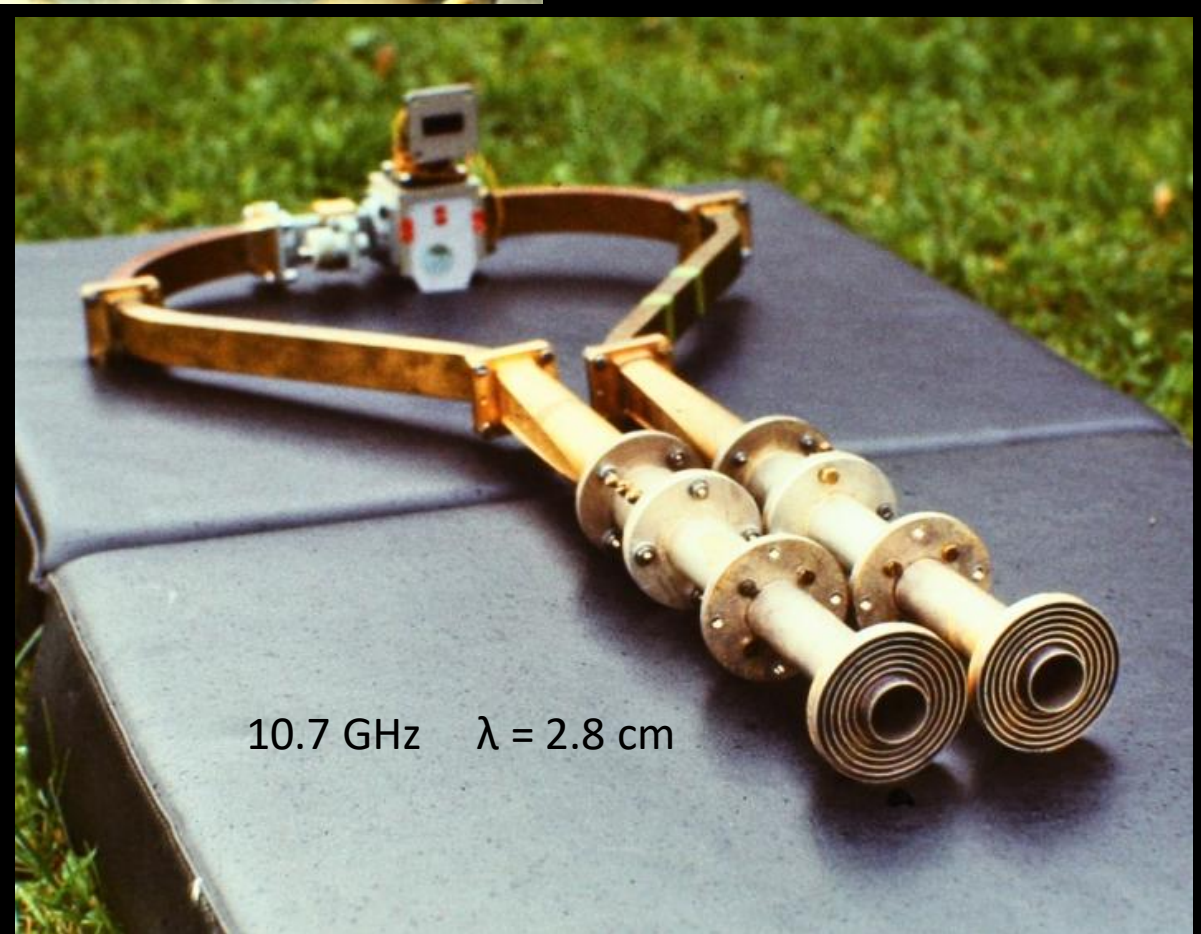
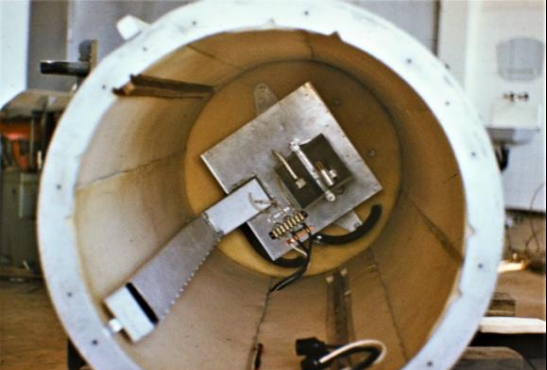
Department of Radio Astronomy, 1975-1979

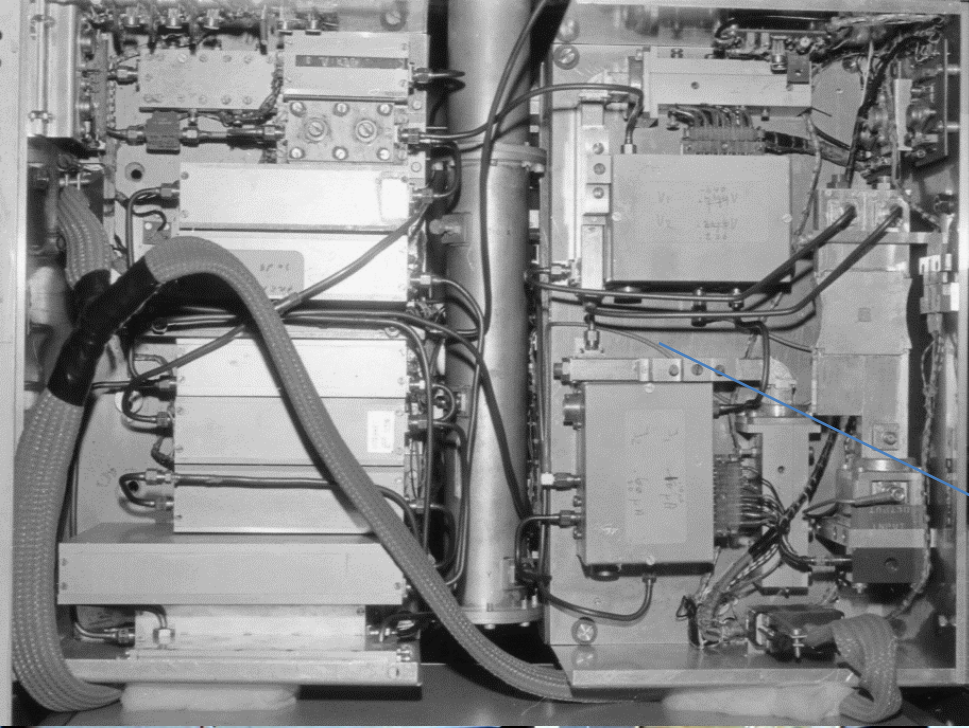
- Preparation of receiver systems for RT3
407 MHz, 12 GHz (later MPIfR parametric amplifier), back-ends,
1420 MHz, 1650 MHz, and 609 MHz and 5 GHz (receivers from NFRA,
Dwingeloo, Netherlands).
- Visits to ASTRON (610/4995 MHz receivers) and MPIfR (10.7 GHz
parametric amplifier, VCR).
- Commissioning of the first observations with RT3
Pulsars, spectroscopy, measurements of calibration sources
- VLBI terminal for RT3 - VLBI converter / complete
equipment

September 1978 "first light", calibration sources Tau A, Cas A

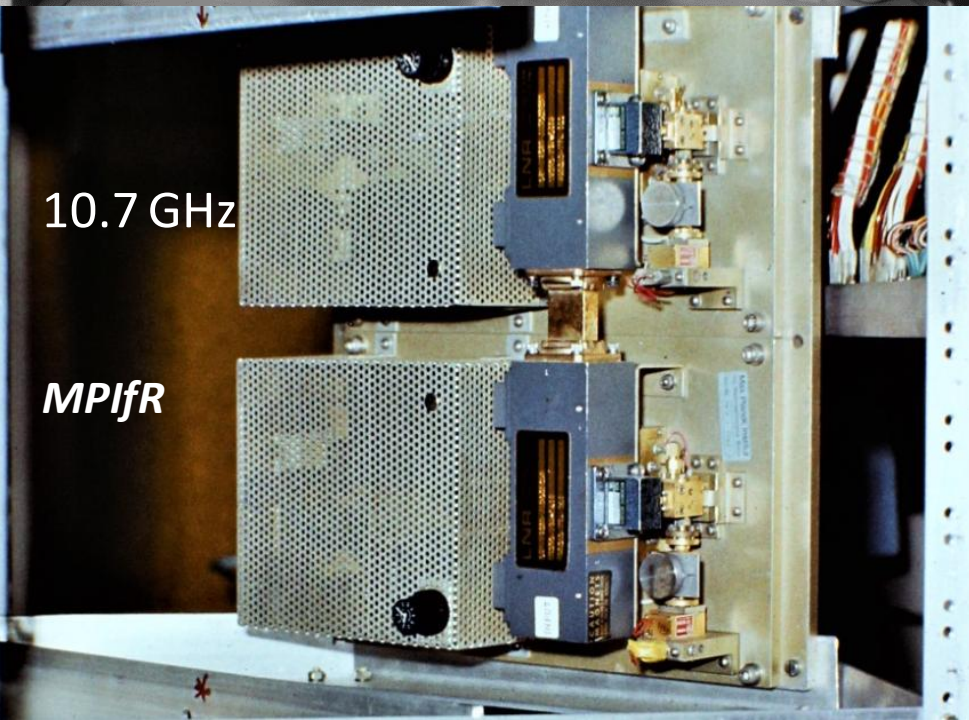
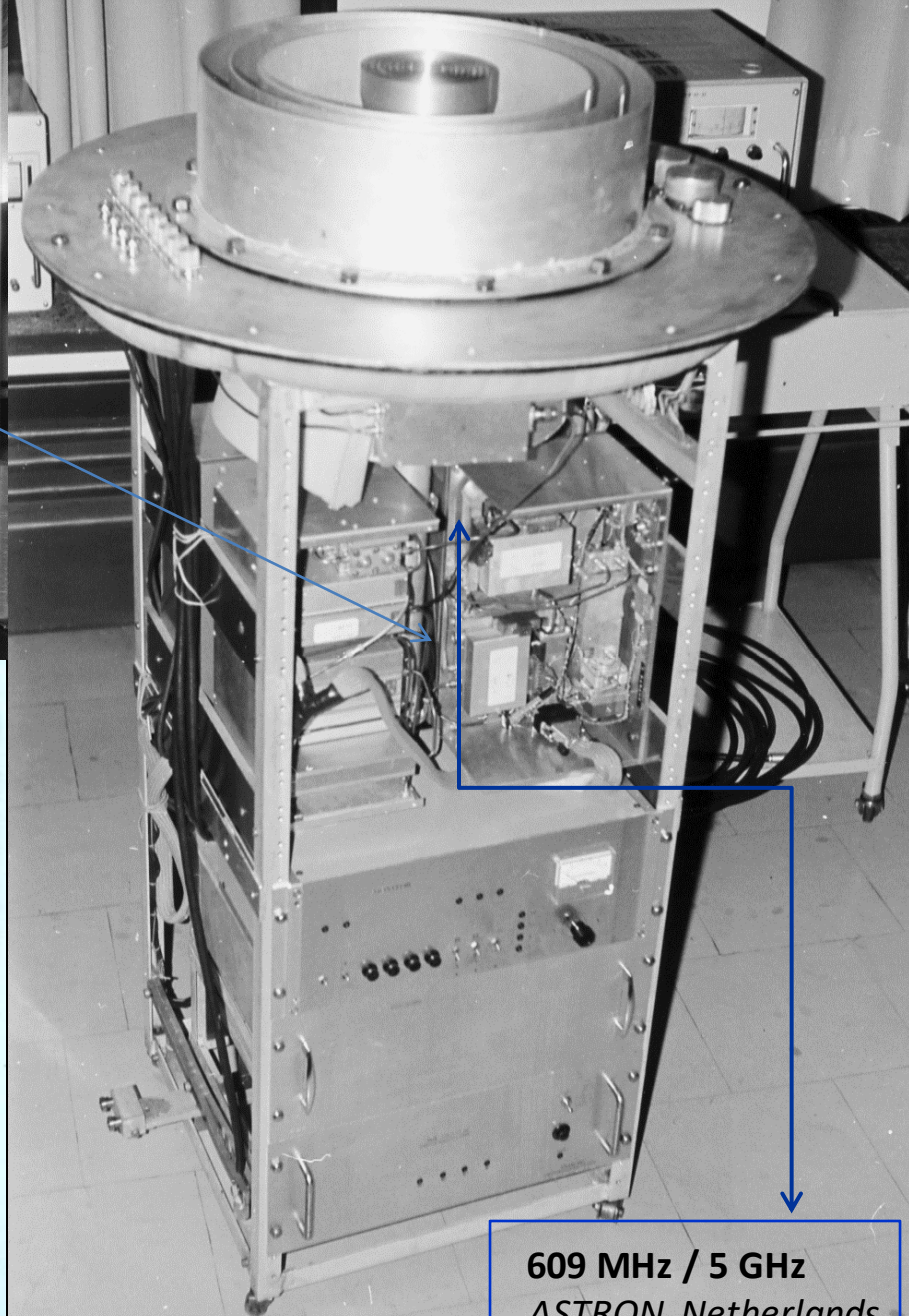
Installation of the focal cabin
with 408 MHz and 10.7 GHz receiver
equipment







1978/79



10.7 GHz

MPIfR

609 MHz / 5 GHz
ASTRON, Netherlands



RT3 control room, 1977

1976: Prof. W. Iwanowska retires.

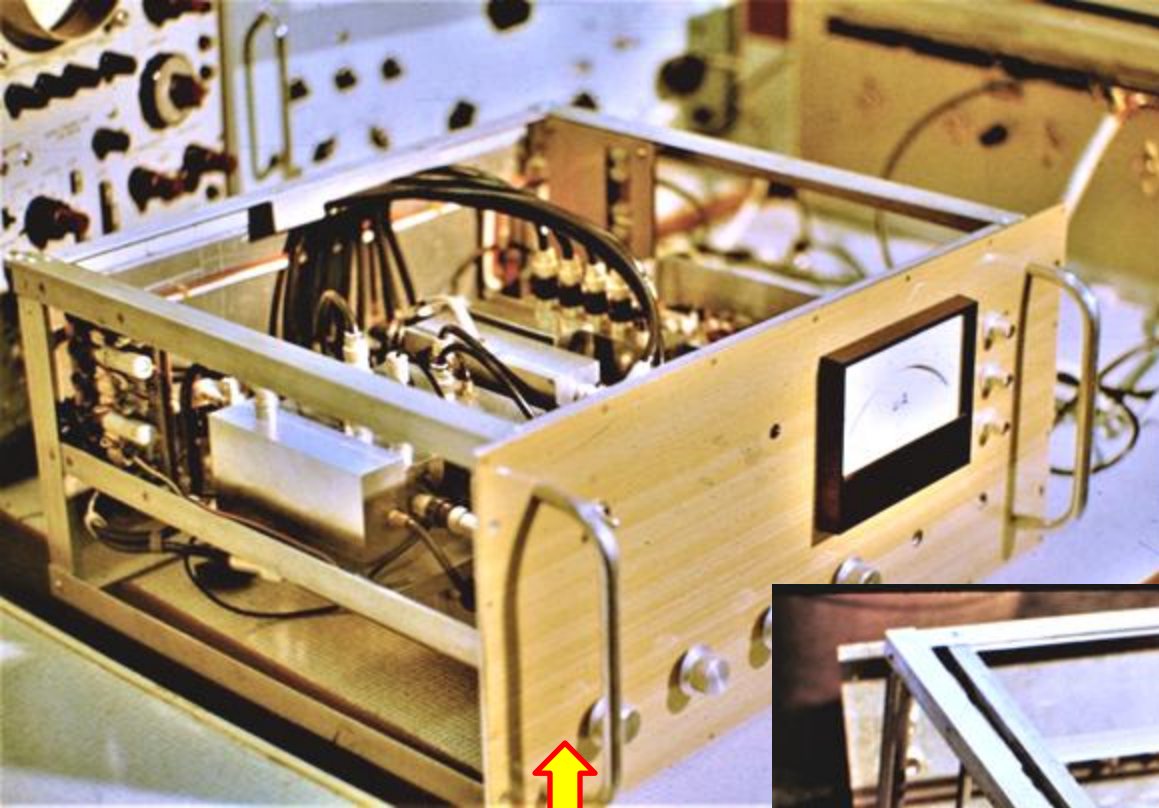
Prof. S. Gorgolewski is appointed as the new Director of the Institute;
Assoc. Prof. S. Grudzińska serves as his deputy until 1979.

A serious illness and complicated operation keep Prof. Gorgolewski
away from active work for several months.

Prof. Gorgolewski campaigns to restore the independence of the Radio Astronomy Division.
Intervention with the Ministry and state authorities leads to a ministerial decision
by M.Sz.W.N.iT to transform the Radio Astronomy Division of the Institute of Astronomy
into an independent faculty-level unit – the Department of Radio Astronomy at
the UMK Faculty of Mathematics, Physics and Chemistry.

1 October 1979 the Torun Radio Astronomy Observatory - TRAO was formally established.

In this new structure, the Department existed until 1996, then a new entity:
the UMK Centre for Astronomy was created.



VLBI signal converter



- Frequency conversion
- Phase locking of the local oscillator to a rubidium frequency standard
- Single-sideband filter with step-selectable bandwidth (0.125–4 MHz)
- Video amplifiers

A.Kus, E.Pazderski, S.Gorgolewski

Digital formatter for the Mark IIc VLBI signal

- Digital samplers
- Signal formatting
- Recording time information
- Interface to a VHS video recorder

S.Gorgolewski, A.Kępa, J.Mazurek



For this work a team award by Minister of Science and Higher Education was received, 1985.

A.J.Kus postdoc at Jodrell Bank Observatory, Manchester University, 1979-1980+

1. CSS QSOs, VLBI data and observing techniques
2. 3C309.1 study of mas (kpc) structure
3. Participation in MERLIN data processing
4. Image reconstruction from interferometers in the spectral domain
5. OH/IR 127.8-0.0
6. Preparation of Toruń VLBI observations, test sessions
7. Data processing at MPIfR Bonn and Caltech; our RT3 VLBI observations at 609 MHz and 1665 MHz.

The radio structure of 3C 309.1 determined by multi-baseline interferometry

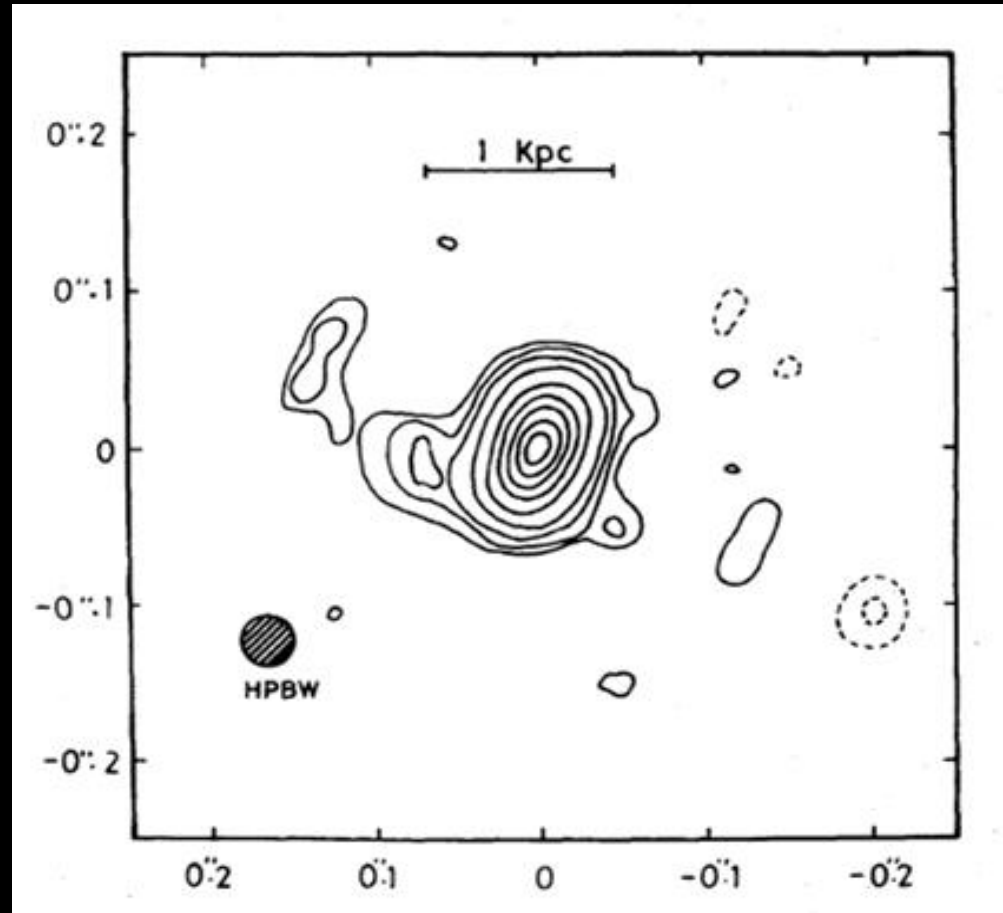
A. J. Kus[★], P. N. Wilkinson and R. S. Booth

The University of Manchester, Nuffield Radio Astronomy Laboratories, Jodrell Bank, Macclesfield, Cheshire SK11 9DL



Results from the first VLBI experiment of European stations, January 1978, for 3C309.1

Hybrid map without phase information



The radio structure of 3C 309.1 determined by multi-baseline interferometry

A. J. Kus[★], P. N. Wilkinson and R. S. Booth

The University of Manchester, Nuffield Radio Astronomy Laboratories, Jodrell Macclesfield, Cheshire SK11 9DL

First published results from
a test observing session
(1978) of the European VLBI network

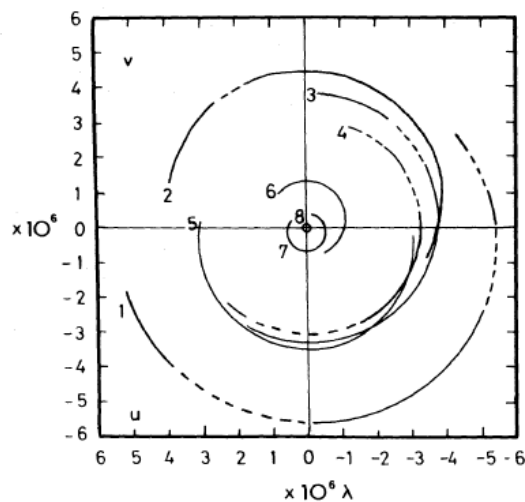


Figure 1. The $u-v$ coverage for 3C 309.1. The solid lines represent the regions covered by the observations. The VLBI baselines are 1. Jodrell Bank–Onsala, 2. Effelsberg–Onsala, 3. Effelsberg–Jodrell Bank, 4. Onsala–Dwingeloo, 5. Dwingeloo–Jodrell Bank, 6. Effelsberg–Dwingeloo. The Jodrell Bank baselines are: 7. Mk II–Defford, 8. Mk I–Mk III.

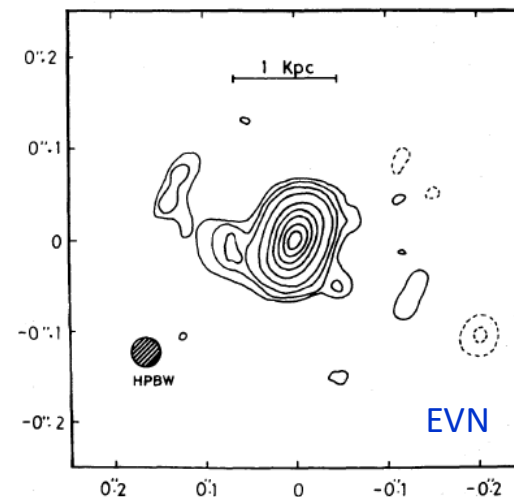
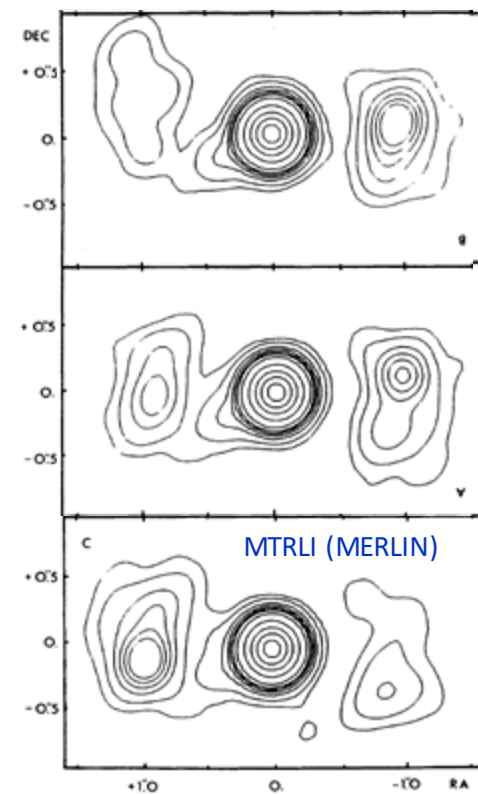


Figure 2. The hybrid map of the central component with a resolution of 30 milliarcsec. The contour intervals are: $\pm 0.5, 1, 2, 5, 15, 30, 50, 70$ and 90 per cent of the peak value which corresponds to 2330 mJy per beam area. There is a 180° uncertainty in the orientation of this map.



First ever 3D tomography of the stellar envelope

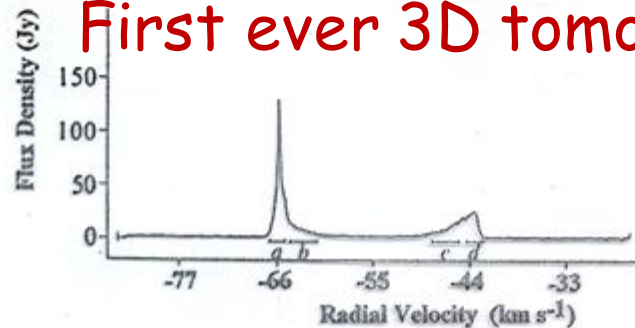


Fig. 11.8. MERLIN maps of OH masers around the star OH 127.8. Four velocity intervals have been selected from the spectrum (above) and separately mapped (Booth *et al.*,

Observations of a circumstellar shell around the OH/IR star OH127.8-0.0

R. S. Booth, A. J. Kus*, R. P. Norris & N. D. Porter

University of Manchester, Nuffield Radio Astronomy Laboratories, Jodrell Bank, Macclesfield, Cheshire SK11 9DL, UK

The 1,612 MHz OH maser emission associated with cool long-period variable stars is generally characterized by two main regions of emission separated in velocity by $\sim 10\text{--}50\text{ km s}^{-1}$. This has been taken to indicate that the OH lies in an expanding shell surrounding the star, the main peaks originating at the near or far sides of the shell along the line of sight where the maser column lengths may be greatest. Here we present the first high-angular resolution measurements of the OH emission from such a source which demonstrates dramatically that this picture is correct.

The 1,612-MHz OH maser source, OH127.8-0.0 (hereinafter called OH127.8) was discovered in a survey by 'Jodrell Bank'. Like many other sources found in such surveys^{1,2}, it shows the OH characteristics of the long period variable stars but has no optical identification although it is probably coincident with an IR star³. These objects have been designated Type II OH/IR stars and are assumed to be long period variable stars which are either at too large a distance for optical identifications or have circumstellar shells which are too thick for the visible radiation to penetrate (their properties are discussed elsewhere^{4,5}).

Observations of the OH maser radiation from OH127.8 were made between late 1978 and early 1980 with three single baseline interferometers of the Jodrell Bank telescope network, before the completion of the new Multi Telescope Radio Linked Interferometer (MTRLI)⁶ and as a prelude to its use as a line instrument.

These observations of OH maser radiation form part of a larger programme of observations of several such objects using the Mk1A-Knockin, the Mk1A-Defford and the Mk1A-Mk111 interferometers respectively⁶. On each occasion the usual radio link technique was used and the data were cross-correlated in the 1,024-channel digital spectrometer to give a 512 point cross-correlation spectrum in the manner described by Norris and Booth⁷.

The autocorrelation spectrum of OH127.8 is shown in Fig. 1. The special feature of this source is that the narrow spectral component at -65.7 km s^{-1} was virtually unresolved on all baselines and could therefore be used as phase reference not only to correct the phase on all the other channels of the cross-correlation spectrum but also to combine the three sets of interferometer data. After combination and normalization the new data set was split into velocity intervals and a series of maps produced, each corresponding to a particular range of velocities in the masing gas. The procedure, described fully elsewhere⁸ consisted essentially of Fourier inversion and cleaning⁹.

Four of the maps are reproduced in Fig. 2a-d—they represent the spatial distribution of the masing gas in the velocity intervals a, b, c and d indicated in Fig. 1. Figure 2a is a map of the distribution of the OH gas with velocities close to the reference feature and in the range -65 to -66.5 km s^{-1} (region a in Fig. 1). It shows that the material within this velocity interval is concentrated in a small region of angular extent ~ 0.4 arc s and is dominated by the -65.7 km s^{-1} component. Figure 2d shows the distribution of OH in the corresponding redshifted velocity interval (-43 to -43.7 km s^{-1}) and is clearly similar in extent although slightly offset in position.

Figure 2b, c shows maps of the weaker OH emission in

Fig. 1. The 1,612 MHz OH spectrum of OH127.8. The bracketed velocity intervals a, b, c and d represent those ranges of velocity for which the spatial distribution of the maser emission has been determined (see Fig. 2).

velocity regions closer to the stellar velocity (-62.2 to -64.7 km s^{-1} and -45.2 to -47.5 km s^{-1} respectively). Both have a similar annular form with angular diameter ~ 2 arc s. The map centres are the same in each case and correspond to the position of the reference feature.

The distributions found are exactly those expected of a uniformly expanding circumstellar shell¹⁰ of OH. The strongest maser components have small angular diameters and are situated close to the line of sight through the centre of the shell along which the gain paths are largest, and the weaker emission delineates those portions of the shell where constant velocity path lengths along the line of sight will be shorter, giving lower maser gain. At the edges of the shell the velocity gradient is such that the line of sight emission is reduced to zero.

Note that the spectrum of the source varied slightly in intensity between observations thus we could not be sure of the relative amplitudes to better than 10%. However, as the fits to the data were good, we believe that our normalization was correct; as an example, in Fig. 3 we show a plot of the data and corresponding points produced by Fourier inverting the map of Fig. 2b. As an extra check on this effect, we varied the amplitudes by 10% on each baseline and repeated the fitting procedures. In all cases, although the detailed distribution changed, the overall shell pattern remained, it being strongly dependent

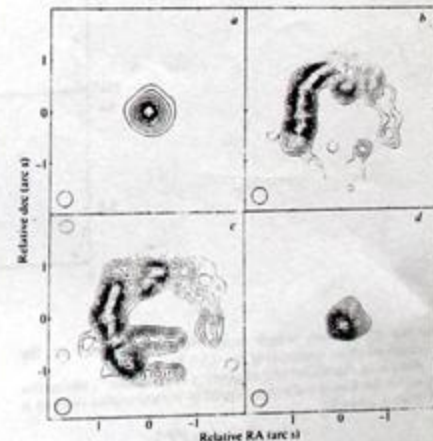


Fig. 2. a-d, Maps of the spatial distribution of the integrated OH emission in the velocity intervals marked a to d respectively in Fig. 1. In each map the contour interval is 5% of the peak integrated emission in that velocity interval and the lowest contour is $\sim 10\%$.

VLBI in Toruń - the only participating site in Eastern Europe

What was needed: preparations 1980/81

1. Radio telescope (15 m RT-3)
2. Receiver systems (LO synthesiser from JBO)
3. Control systems
4. Mark IIc VLBI terminal + VCR (borrowed from MPIfR)
5. Atomic frequency / time standard (HP Rubidium Clock)
6. Skills, commitment and mutual trust
7. Enthusiasm.

29 June 1981 First successful VLBI observations (3C286)

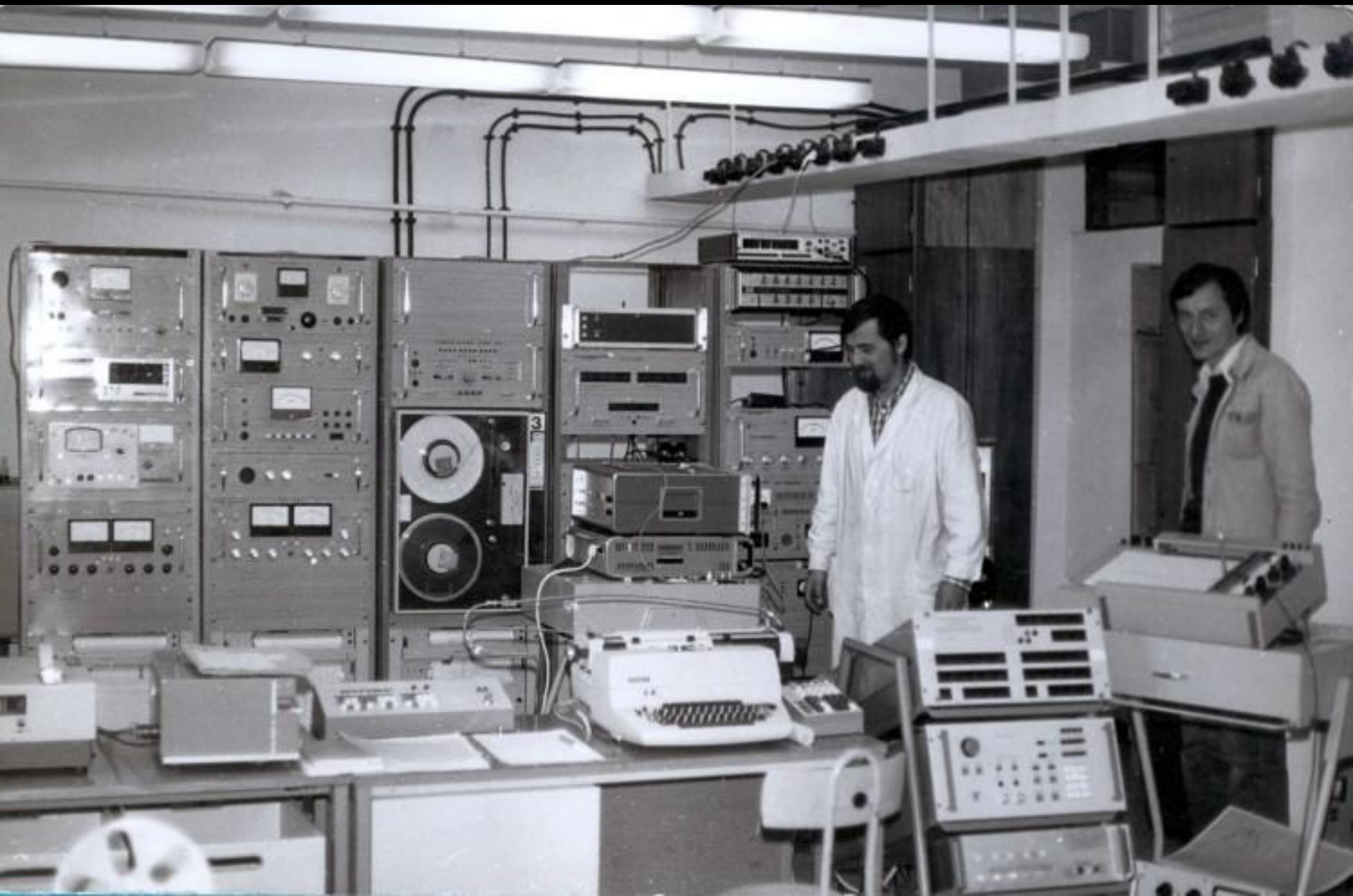
RT-3 was used in the VLBI network until about 1992

1984



VLBI in Toruń was the result of many years of work by a team led by Prof. Gorgolewski
Participants: A. Kus, B. Krygier, A. Marecki, K. Borkowski, A. Kępa, E. Pazderski, J. Usowicz, J. Mazurek, R. Feiler, ...

VLBI tests 1980/1981



29 June 1981 First successful VLBI observations (Mk IIc terminal)



KRa computers: M400, SM 1420 (PDP-11), 1979-1990

Convex C120, Piwnice, 1990. Then Sun workstations / PCs



AIPS NRAO software for VLBI image processing available from 1990

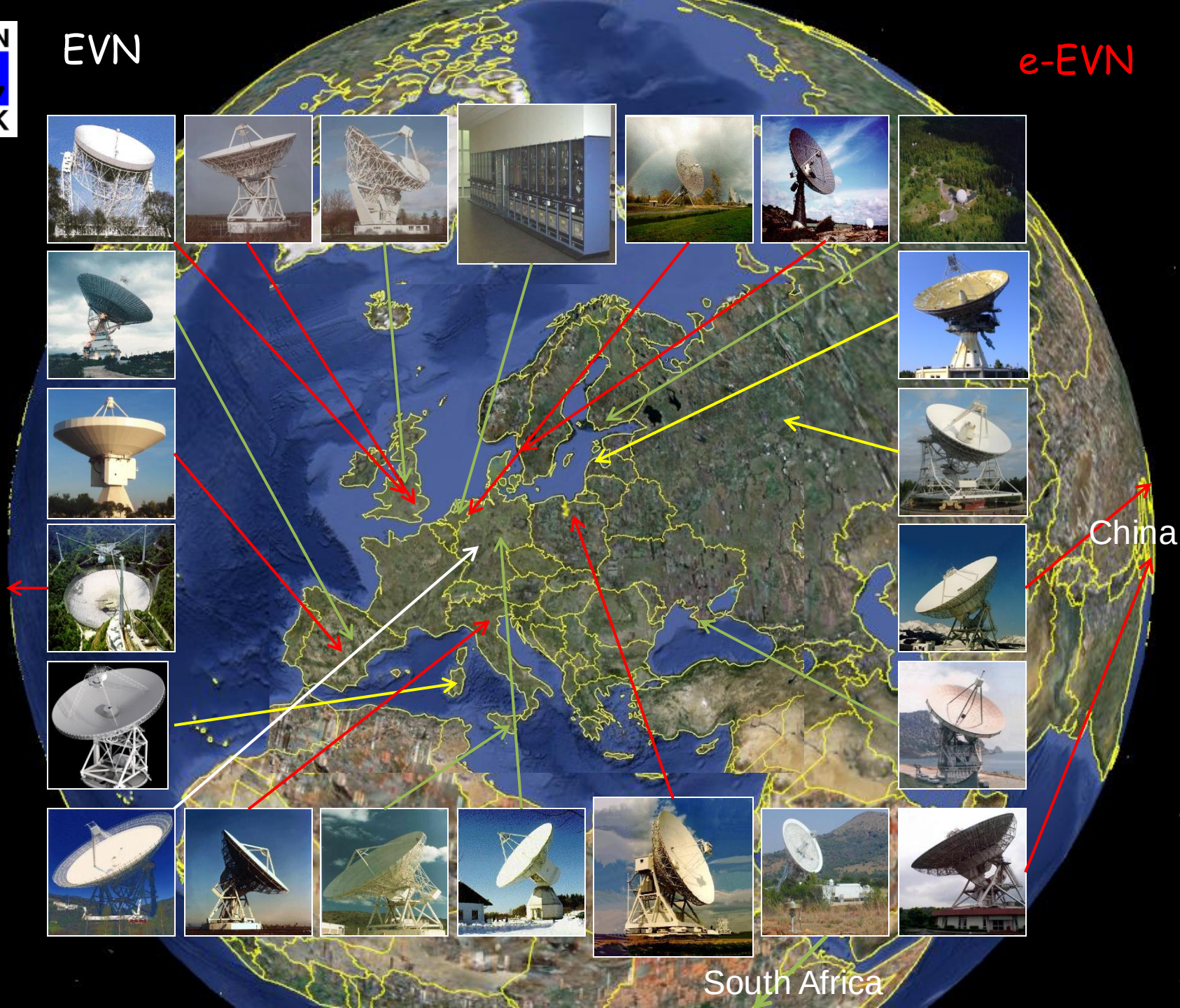
EVN

e-EVN

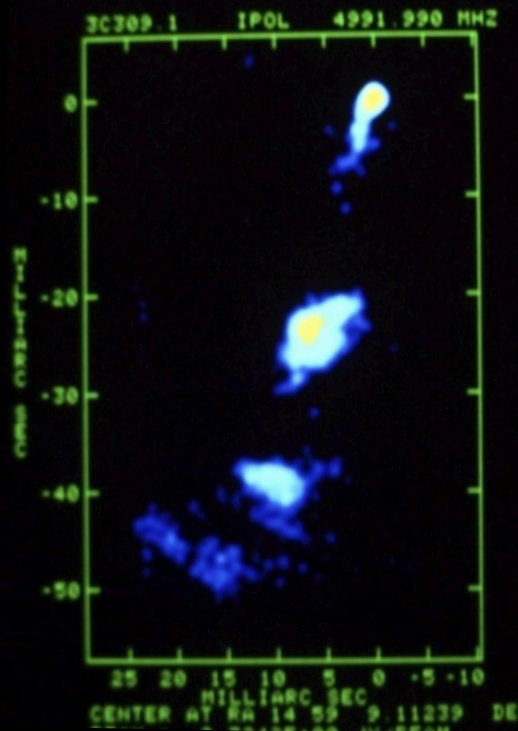
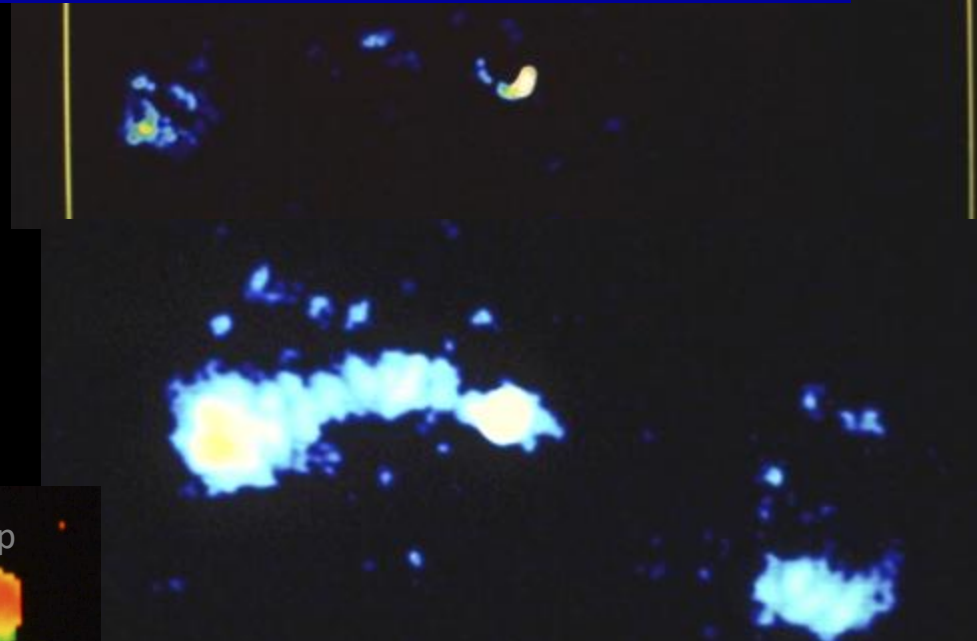
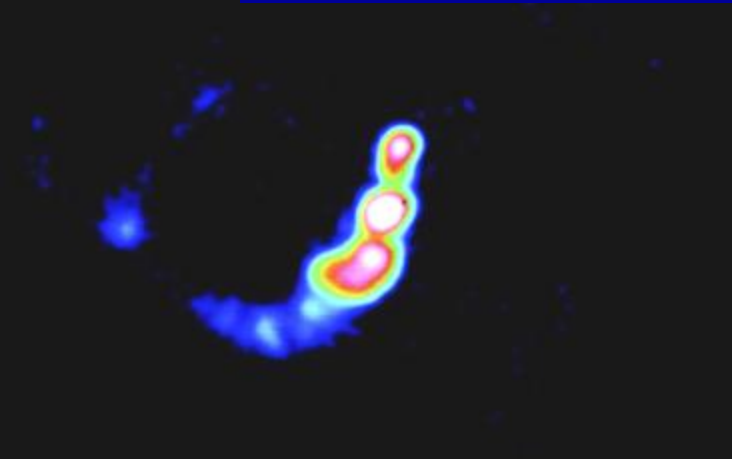
USA

China

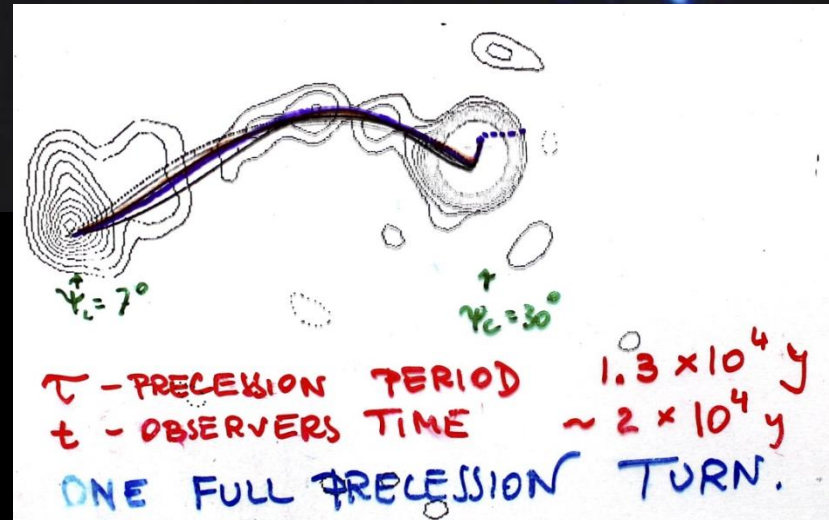
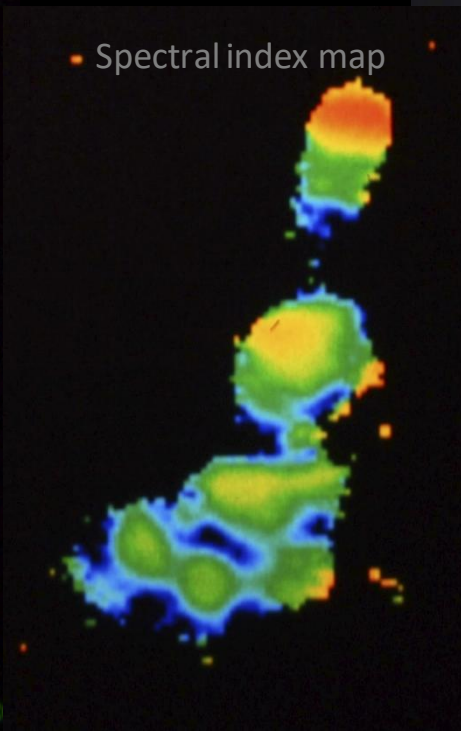
South Africa



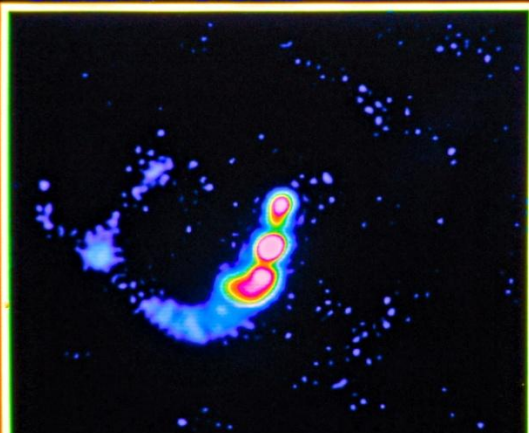
Radio studies of the SSC quasar 3C309.1 (AJK) an example of early Torun's VLBI studies



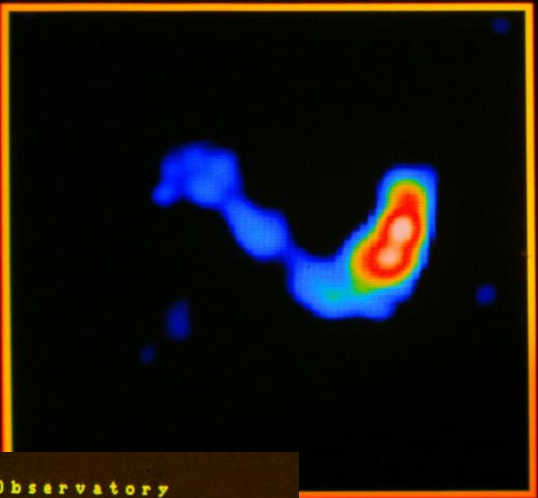
Spectral index map



3C309.1 1.6GHZ BEAM 6MAS

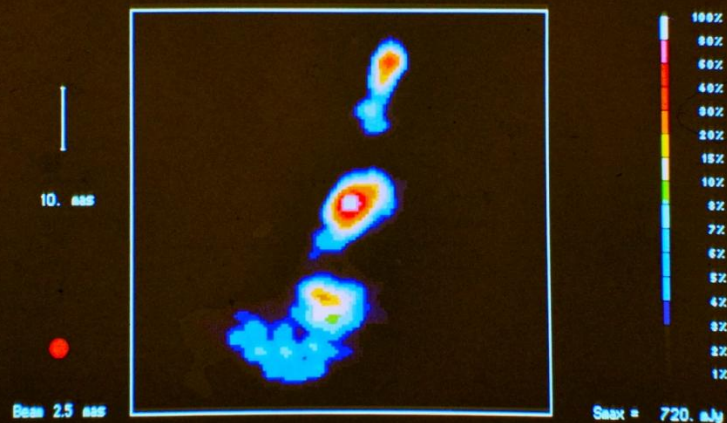


3C309.1 93cm VLBI beam=15mas

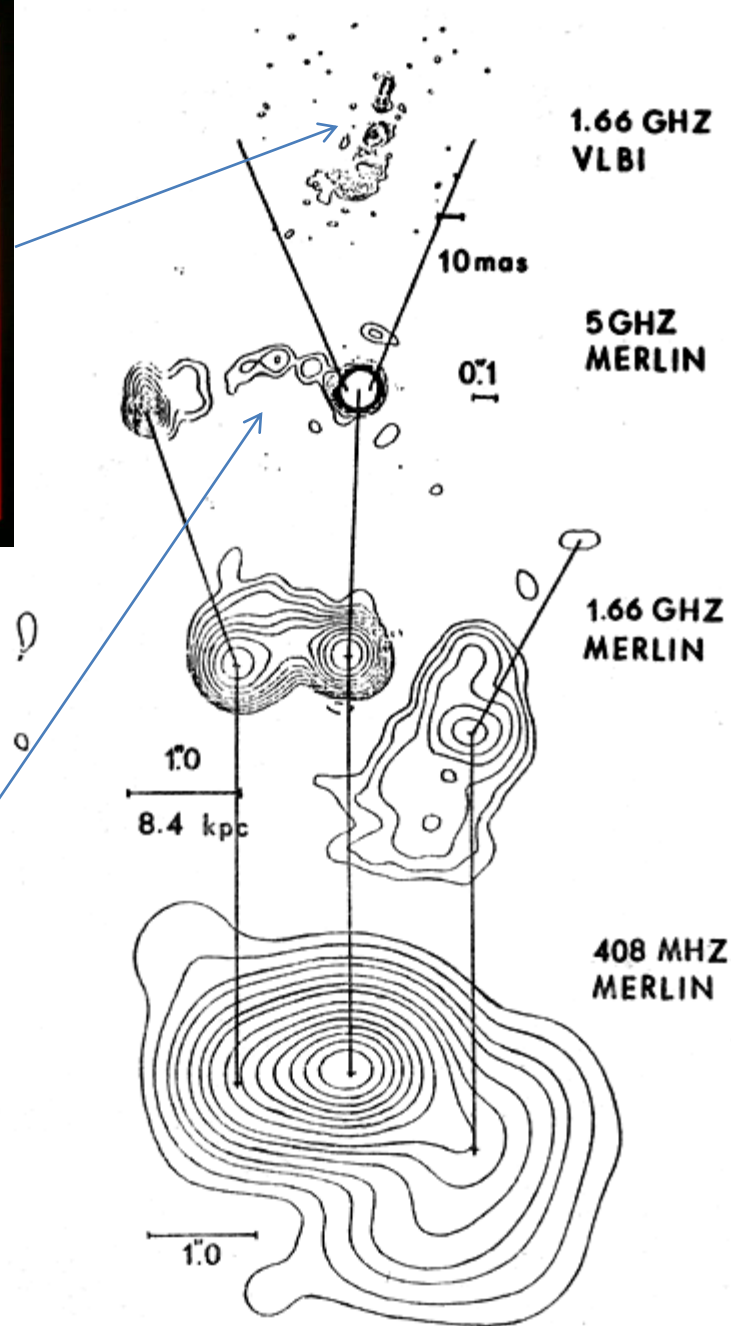
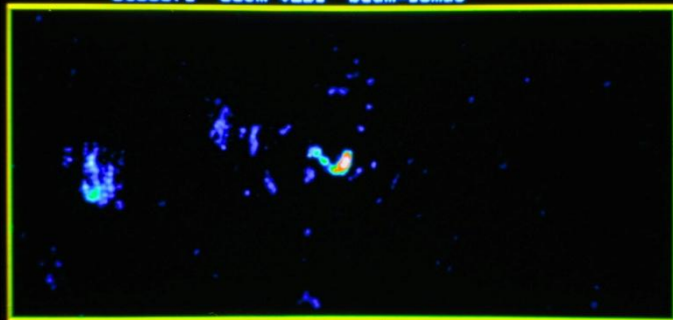


Torun Radio Astronomy Observatory

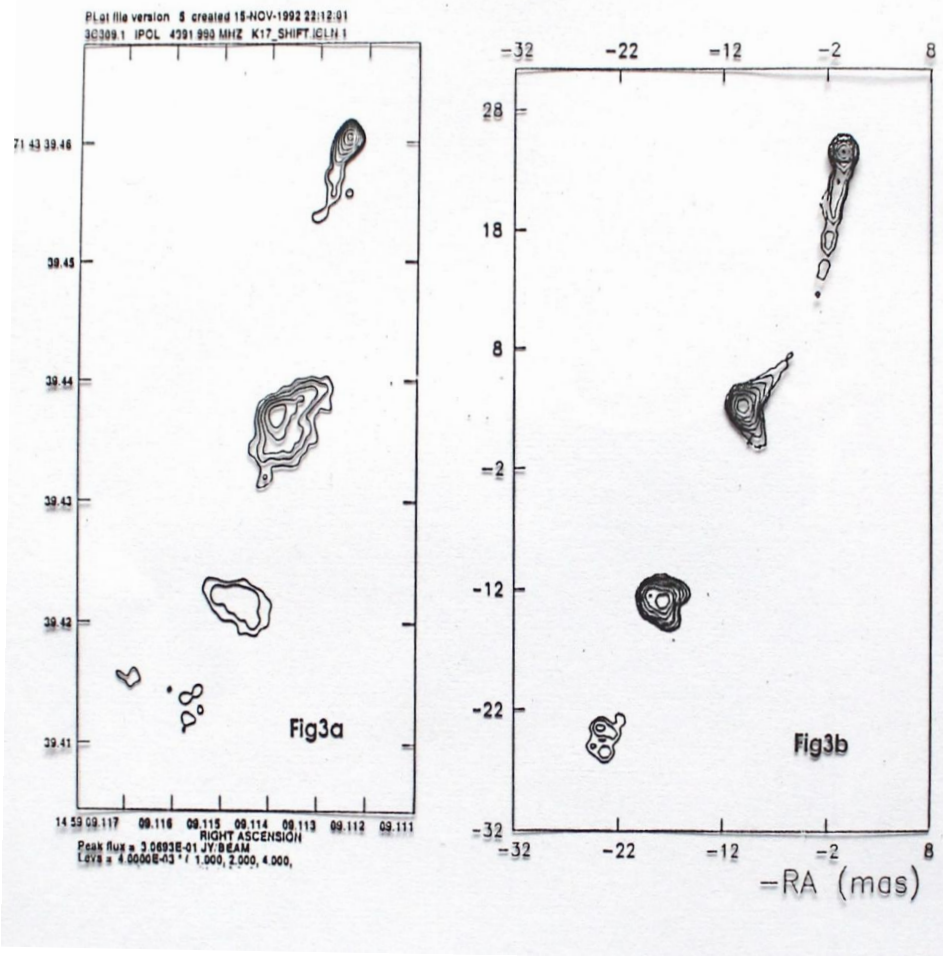
Source name : 3C309.1 Freq. : 1662 MHz Glob. VLBI 1982.9



3C309.1 93cm VLBI beam=15mas



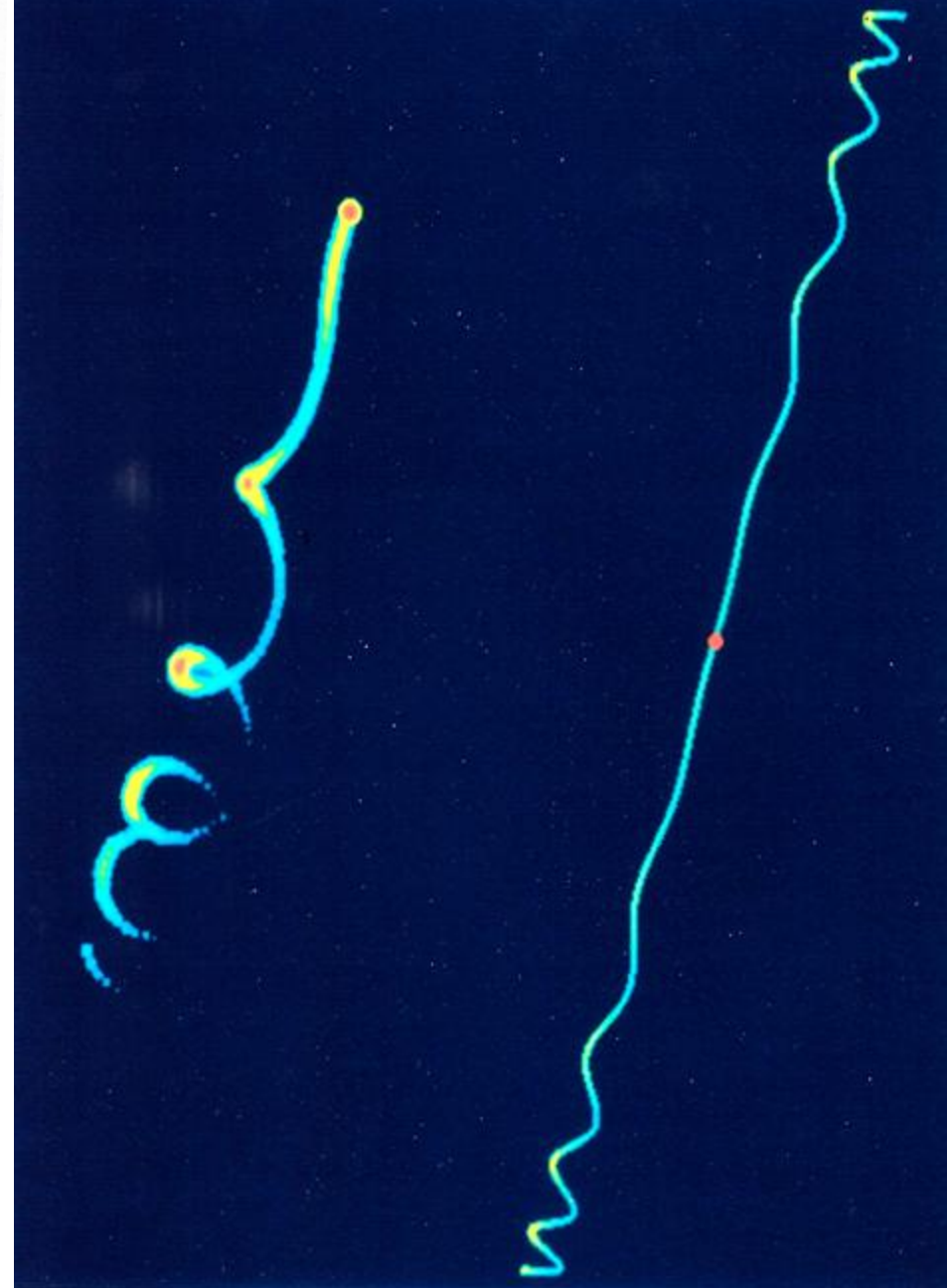
Struktura kwazara 3C 309.1 obserwowana w różnych skalach (A. Kus, *Radiowe badania kwazara*. Wyd. UMK, Toruń 1985)



Helical relativistic jet models (AJK)

here the real and model structure of 3C309.1 CSO

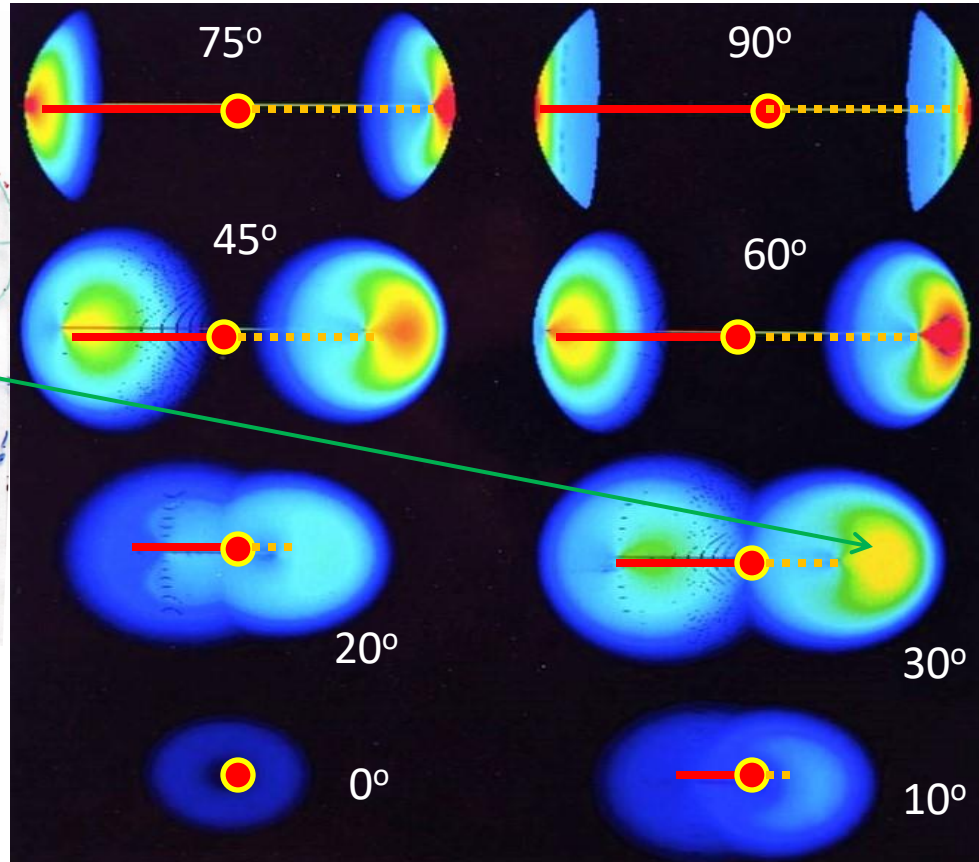
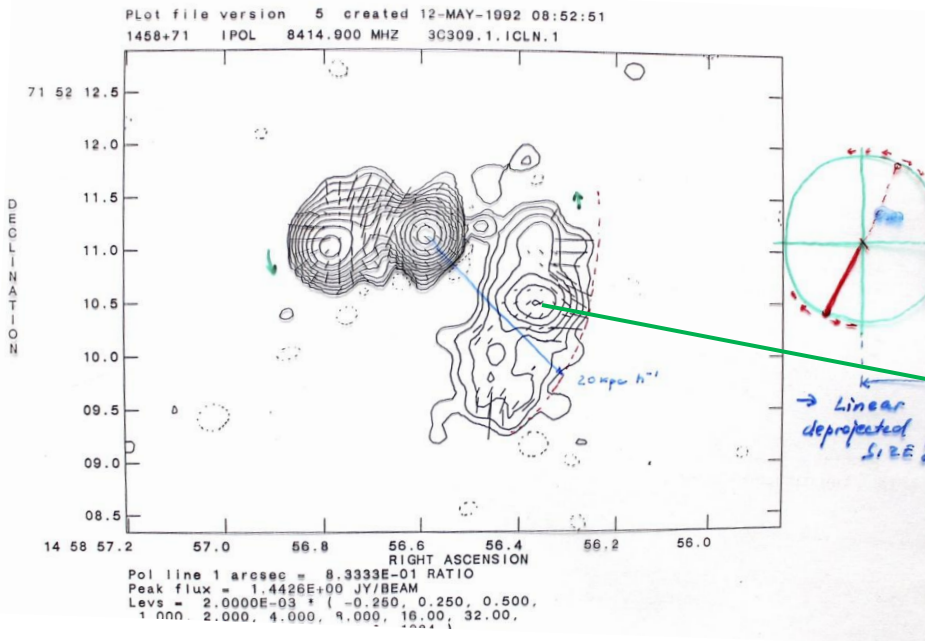
jet axis to LoS



20°

and

90°

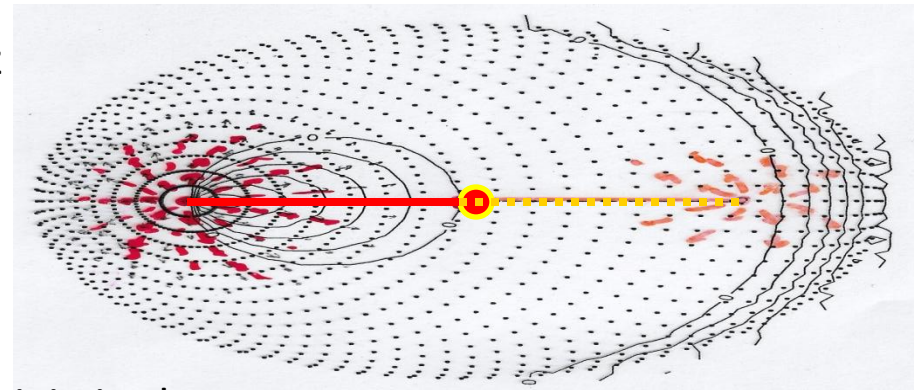


AJK habilitation, 1992

“Radio studies of the CSS quasar 3C309.1”

VLBI observations at 0.6 GHz, 1.6 GHz and 5 GHz
+ MERLIN observations, X-band data
Data processing – images of the source
at different epochs (stages of evolution)

Physical parameters, Lorentz factor – gamma,
magnetic fields, electron energies, speed of relativistic plasma,
core – $T > 10^{12}$ K, jet trajectory.



Relativistic back-flow

Other important VLBI research results obtained by the VLBI team using the Mk IIc system, and later Mk III and Mk IV with RT4

Iza Owsianik – CSO (Compact Symmetrical Object) radio sources, their properties and evolution

Andrzej Marecki – observations of the CSS quasar 3C286 with the global VLBI array, and other sources in the CSS and CSO/GPS groups

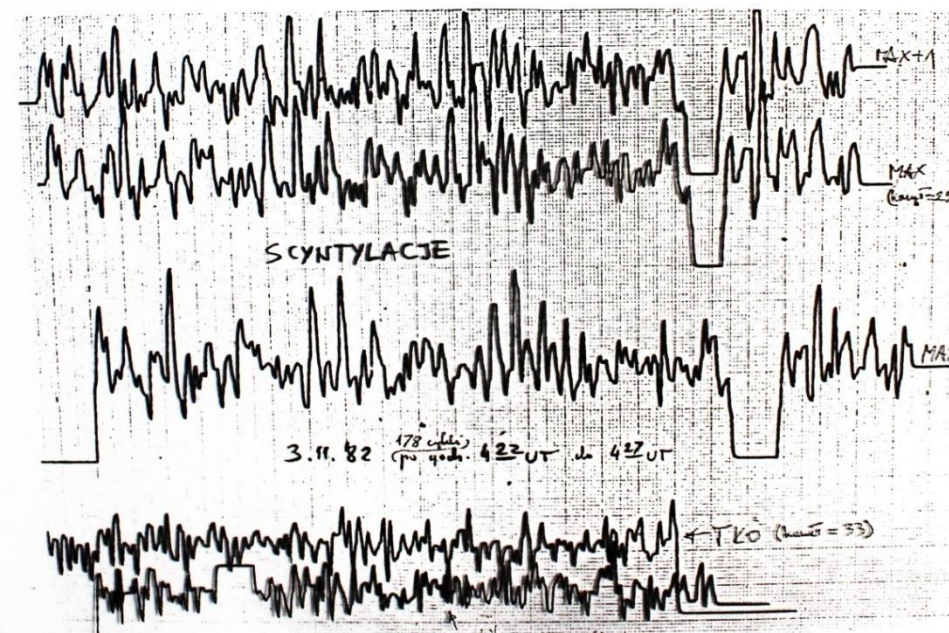
Magda Kunert-Bajraszewska – recurrent AGN activity; CSS and CSO sources.

Marcin Gawroński – **superluminal motion of 3C309.1 core components**, hybrid morphology of radio sources, CSS sources.

Krzysztof Katarzyński – advanced theoretical models of jet evolution in AGNs

Kazimierz Borkowski – (1992) the first determination in Poland of the RT-3 position relative to the Onsala reference station from geodetic VLBI measurements, with the highest precision achieved up to that time: 0.19 m (X); 0.54 m (Y); 1.66 m (Z) (1σ)

A high-quality VLBI system enabled other / test observations



One-bit sampling,
total bandwidth 4 MHz,
32 boards, each with 16 channels
a total of 3424 ICs + approx. 200
interfaced with the SM1420
computer

Designed and built by:
MSc Andrzej Kępa + JMz +
workshop

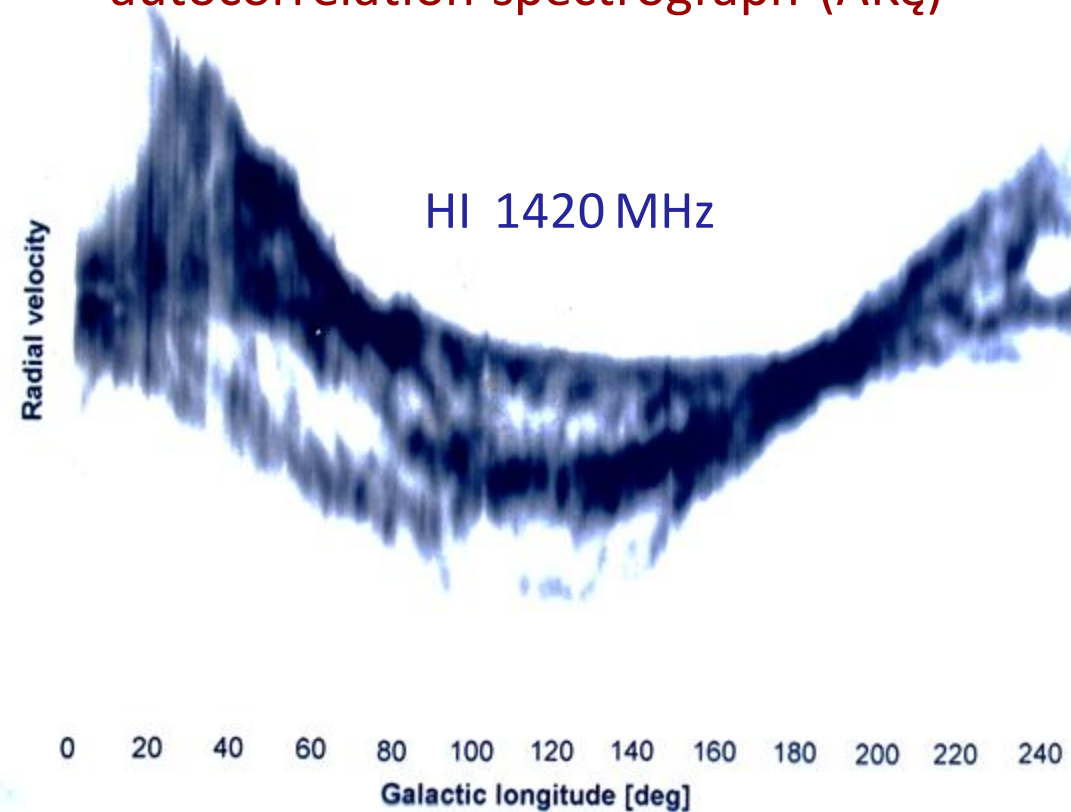
Inspired by Prof. S. Gorgolewski

Autocorrelation spectrograph, 1985



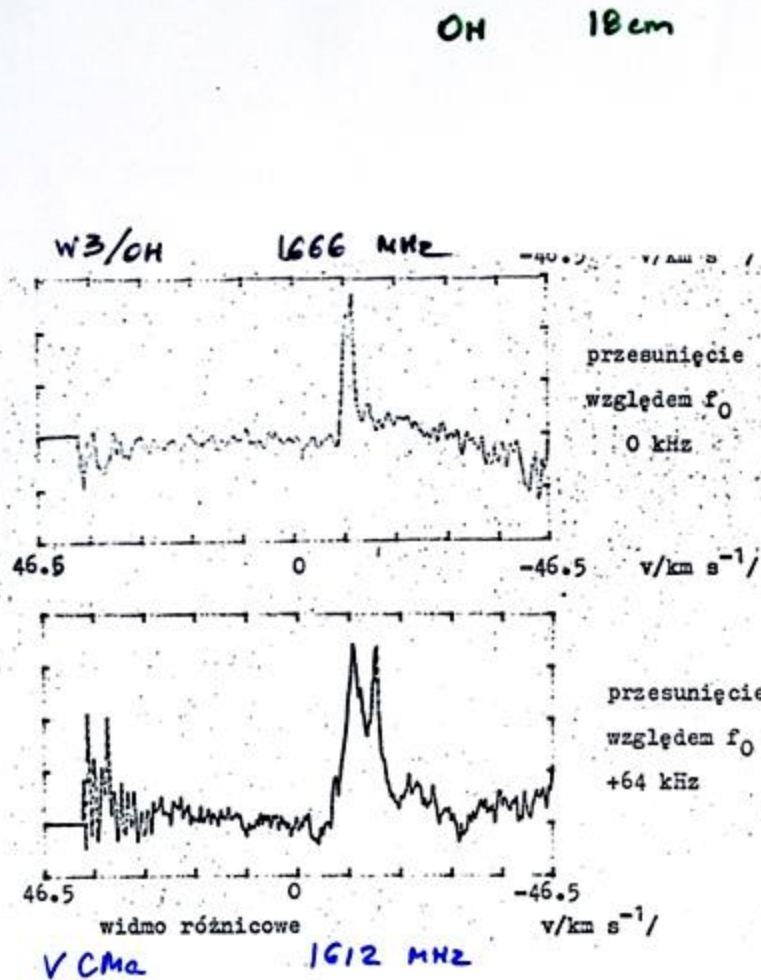
RT-3, L-band receiver 1420 ± 2 MHz

VLBI IF converter, 512-channel
autocorrelation spectrograph (AKę)



First radio-spectroscopic observations in
Poland

R.Feiler, A.Kępa, A.Kus, E.Pazderski,
K.Borkowski, J.Mazurek, 1985



History of RT-4 1983 In spring, several meetings of KRa UMK staff with Eng. Z. Bujakowski gave rise to the concept of building a 32 m parabolic antenna for KRa in Poland.

In June the Radio Astronomy Department commissioned the Centre for Experts and Organisational and Technological Progress (ZORPOT) in Katowice to prepare the design brief for the antenna's preliminary design. The commission and resulting work were funded from KRa's modest internal research funds managed by Prof. S. Gorgolewski.

The preliminary design brief was completed extremely quickly, by October 1983.

Further efforts were made to secure funding for the next preparatory stages.

1983/84 An important visit by Prof. R. Wielebiński and Prof. S. Gorgolewski to the Minister of NiSzW to seek funding for construction of the 32 m radio telescope.

1984 Prof. Graham Smith, Director of Jodrell Bank Observatory, Manchester University, submits a formal request for quotation to the Ministry of Industry for construction of **a 32 m antenna for Jodrell Bank Observatory.**

The document prompted an assessment of the feasibility of fulfilling such an order by Polish industry and an estimate of costs. Serious interest in producing

a larger number of 32 m antennas in Poland, together with the opinion of MPIfR Director Prof. Wielebiński, led the Ministry to approve substantial funding for the project

“Construction of a new VLBI station” with a 32 m antenna as a prototype antenna for possible export sales.

A delegation of engineers from JBO, Manchester University, visited the Ministry of Industry to negotiate the terms of an antenna purchase agreement.

1984 Through the PAN Astronomy Committee, MNiSzW allocates funding for the 32 m

1985 antenna and, at the same time, to ease negative sentiment in the optical-astronomy

1986 community, for two 60 cm optical telescopes at Suhora and Piwnice.

Project coordination was assigned to the UMK Rector, then Prof. S. Łęgowski.

1986–1990 Implementation of the project:

UMK (Rector, coordinator); Prof. S. Gorgolewski (KRa), project leader and later senior construction supervisor; Dr Bernard Krygier, RT32 construction coordinator and representative Of the UMK Rector; Eng. Z. Bujakowski, designer's supervision of the work.

Nearly 60 Polish companies produced structural components, mechanisms and foundations, and carried out construction work, painting, the necessary calculations and software development.

1990 Most RT-4 structural components have been made and brought to Piwnice; the foundations are ready, but the formal project deadline has been reached and the funding is exhausted!!!

The University applies to the Minister of Education and to KBN for funds to complete the project. **A critically important decision is taken by the Minister (R. Głębocki) to provide additional funding** to bring the construction to a successful conclusion (the first large KBN project). On we go – hurra

1992 Dr hab. A. Kus, Prof. UMK, becomes Head of the Department of Radio Astronomy.

1994 Completion and commissioning of RT-4; opening ceremony for the radio telescope, EVN Directors' Meeting, EVN Users' Meeting and VLBI Science Meeting, October 1994.

First light: April 1995, 5 GHz, Tau A.

1995 Rector Prof. A. Jamiołkowski, with the support of the UMK Senate, decides to co-finance equipment purchases from UMK's own funds; UMK's application **to KBN for an additional equipment fund is approved (PLN 10 billion in total)**. These funds are used to purchase a hydrogen frequency standard – a hydrogen maser – **from the University of Neuchâtel (UniNE), Switzerland**. Stability 10^{-15} s/s. Dr Jerzy Usowicz organises its transport and formally takes responsibility for the standard.

A permanent time service based on the hydrogen maser is established by J. Usowicz, K. Borkowski, A. Kępa and J. Mazurek, a key element of the Mk III VLBI system.

History of RT-4 construction

- 1983 Preliminary concept for a 30 m parabolic antenna (Z. Bujakowski)
- 1986-1988 Work on the preliminary and final design of the 32 m antenna and the start of fabrication and construction work



16 October 1991 Start of assembly of the 32 m antenna



April–May 1993





1993



22 October 1994 completion and commissioning of the 32 m antenna

+ EVN Directors' Meeting,
EVN User's Meeting,
VLBI Science Meeting,
foreign and Polish guests.



RT4



Basic information

- Designed and built in Poland*
- Homologous structure*
- Built in 1994, operational since 1996*

- Diameter 32 m*
- Cassegrain with a 3.2 m subreflector*
- Surface accuracy 0.4 mm RMS*
- Pointing and tracking ~ 5 arcsec*
- Total weight 600 tonnes*
- Az and El motion up to 30 deg/min*
- Full computer control*

- Receives radio waves in the range
1400–30000 MHz (20 cm–1 cm)*

*Chief designer: Eng. Z. Bujakowski
Contractors: 60 Polish companies
Construction: 1985–1994.*



Designer of the 32 m radio telescope
MSc, Eng. Zygmunt Bujakowski

Dr B.Krygier Prof. S.Gorgolewski



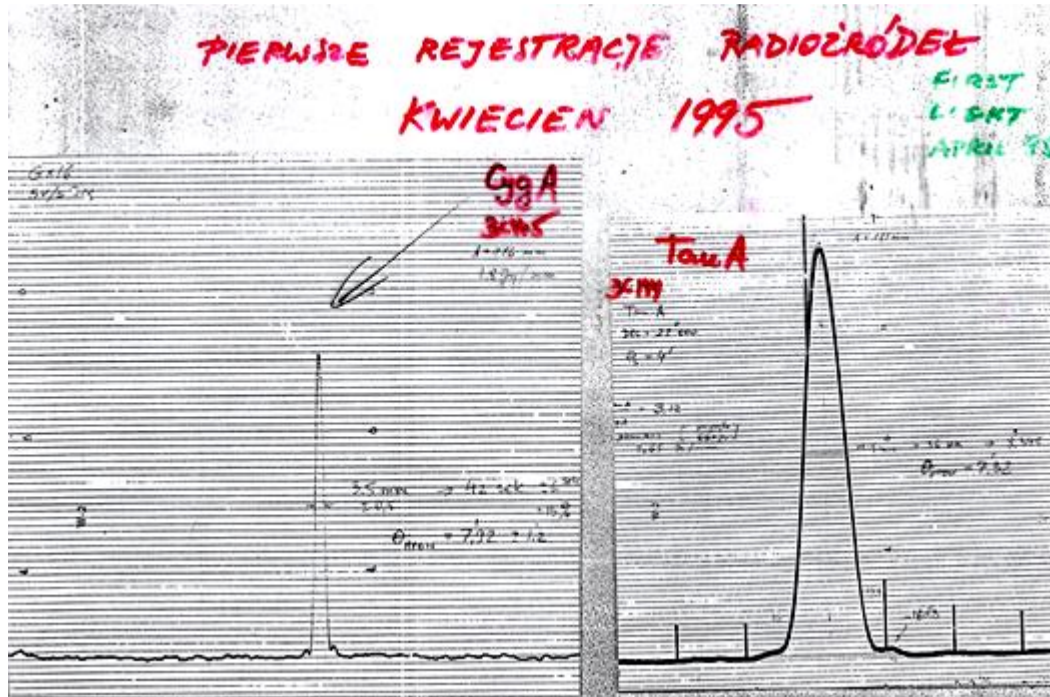
Construction supervision

Project initiator and
project leader until 1991

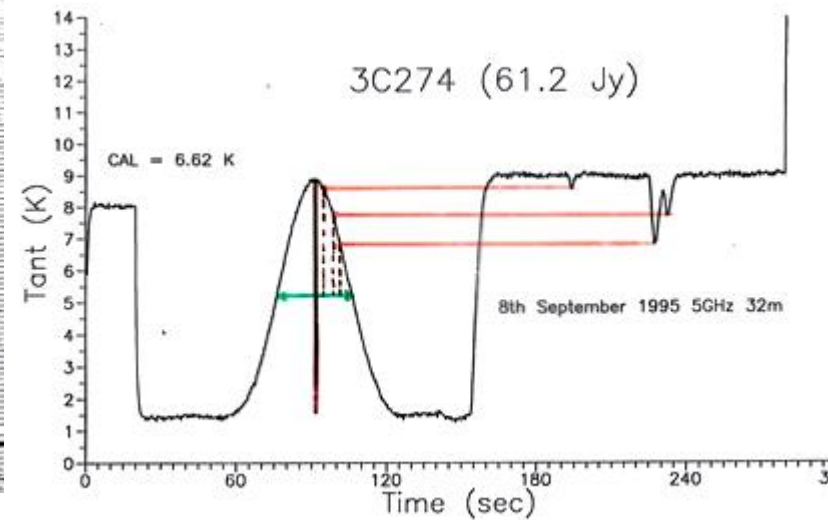
1992-2000 investment work coordinated by Dr A. Kus

April 1995
at 5 GHz

First observations with the 32 m antenna



September 1995



May 1996

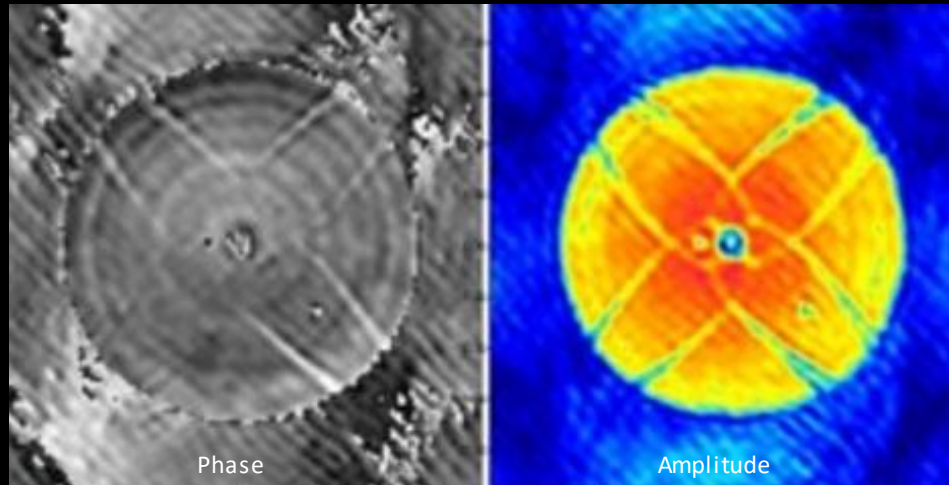
RT4 fully commissioned for scientific work



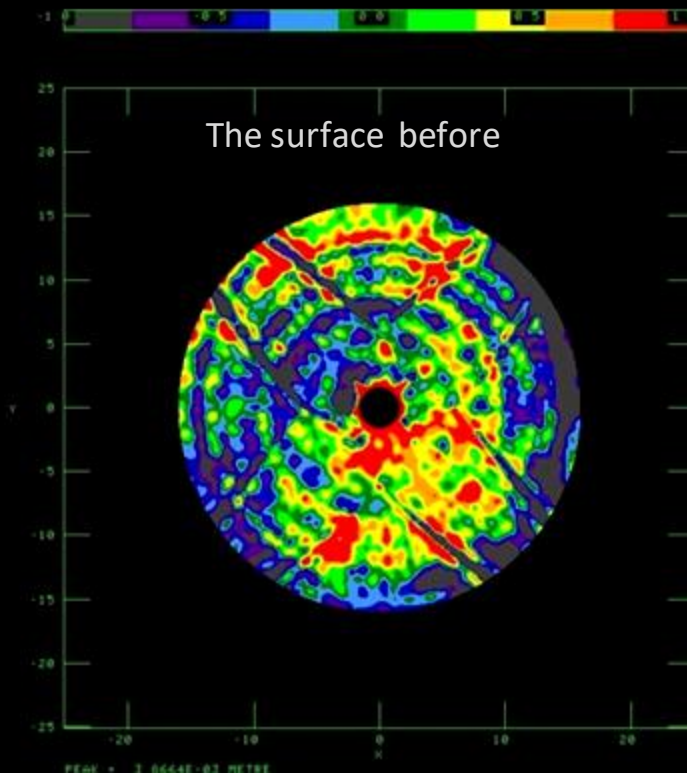
RT4 control room

Alignment of the RT4 dish panels - antenna holography

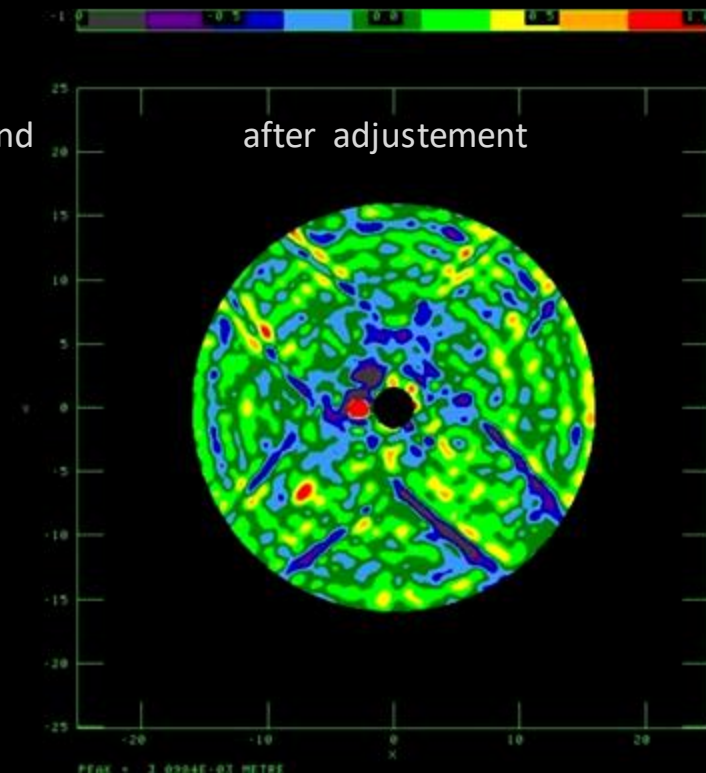
Holography equipment
designed by E.Pazderski



Software
and data
processing by
A. Kus



and



Construction and purchase of essential measurement equipment for VLBI and other projects carried out with RT4

- Atomic clock - hydrogen maser (MNiSzW equipment fund)
- New-generation broadband VLBI terminal (European funding)
- Receivers cooled to 15 K (support from NRAO, MPIfR, ASTRON, JBO)
- High-speed communication with JIVE, broadband Internet (PCKS)
- Observation logistics and automation
- Dispatch and receipt of magnetic tapes (purchases for the shared resource pool)
- Direct fibre-optic links to JIVE, 1 Gb/s to 4 Gb/s (PIONIER)
- Real-time e-VLBI since 2006

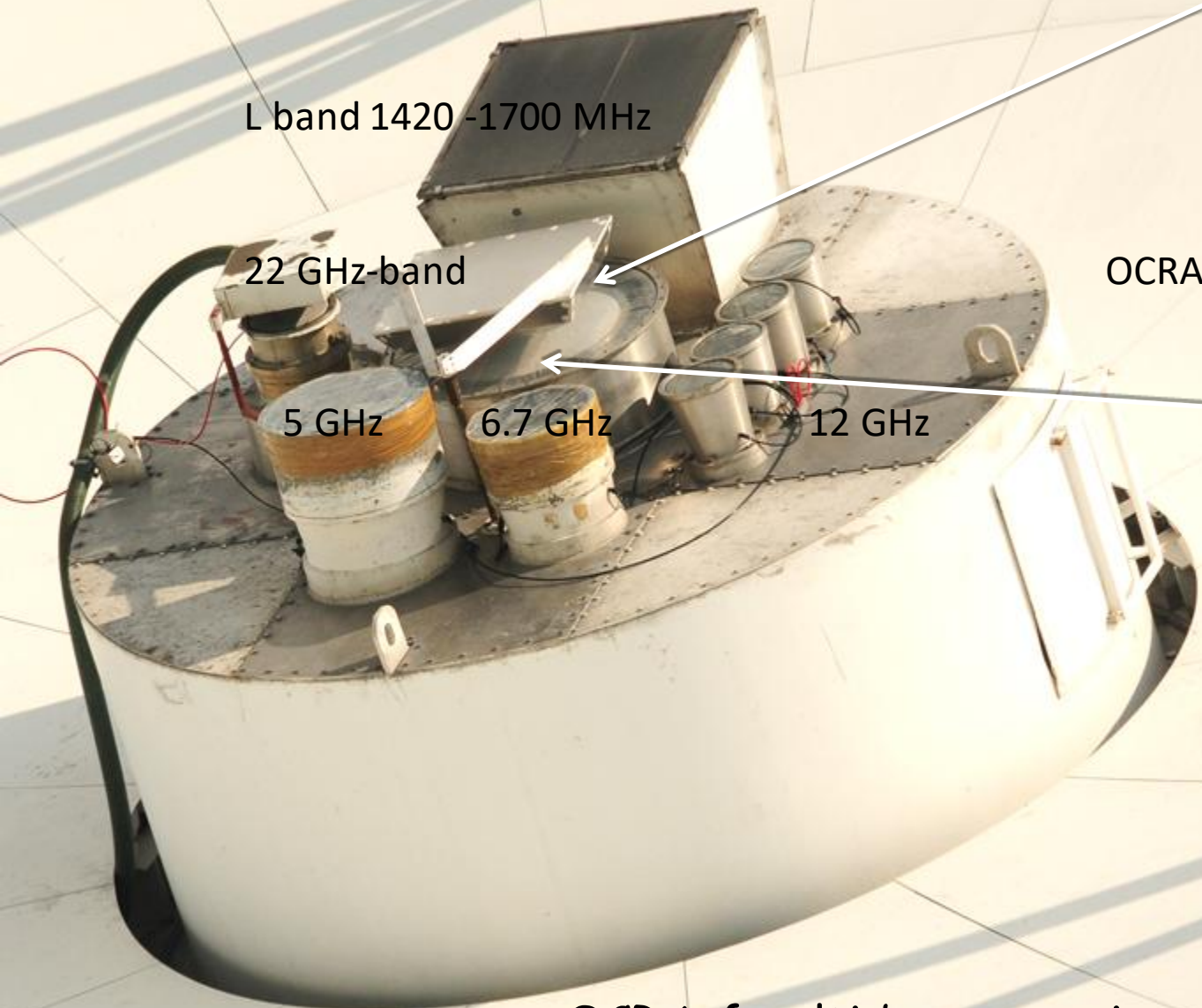
- Keeping the telescope and equipment fully operational (specialist team)

- Observations for other projects as a guarantee of VLBI reliability

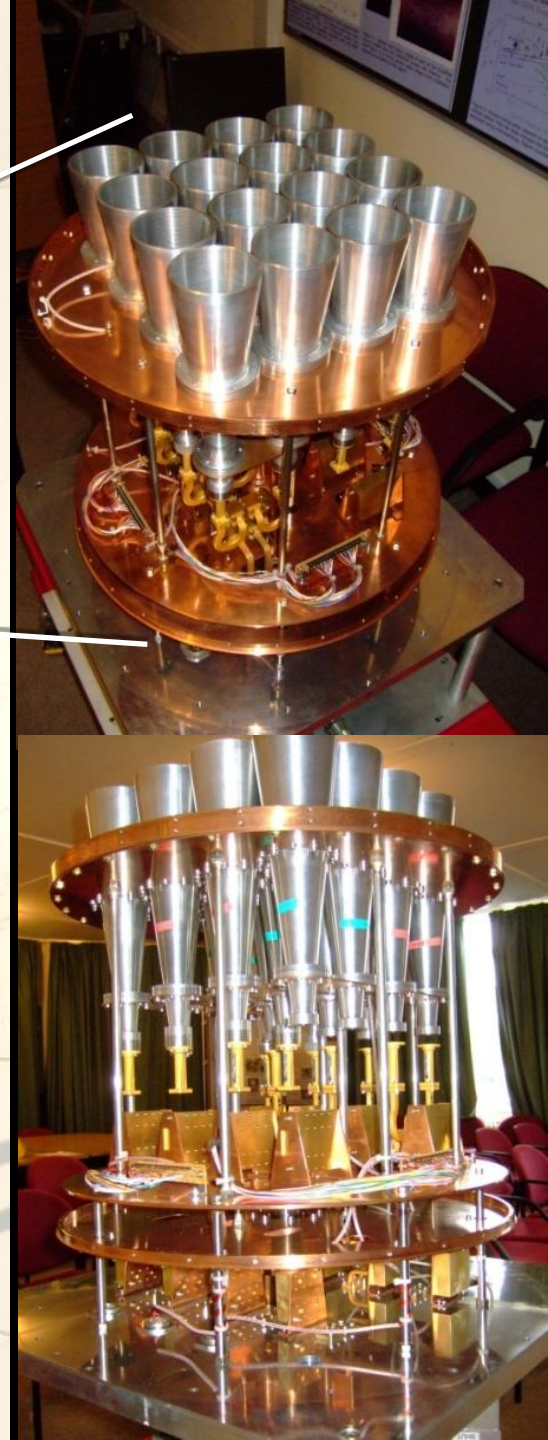
- RT4 was used for observations for approx. 85% of the year;
the telescope operated 24 hours a day, with a team of operators / observers

TCfA with the RT32 became a key element of the EVN and a reliable partner in European scientific cooperation structures (1996-2010)

Receivers System



OCRA-f multi-beam receiver
on the RT32 m, @ 30 GHz



Receiving systems

1995–2000. Construction of cryogenic receivers for the 5 GHz and 1400–1800 MHz bands;

detailed construction documentation for the “front ends” was obtained from NRAO, USA (Prof. M. Pospieszalski); all components were made in the UMK Centre for Astronomy workshops.

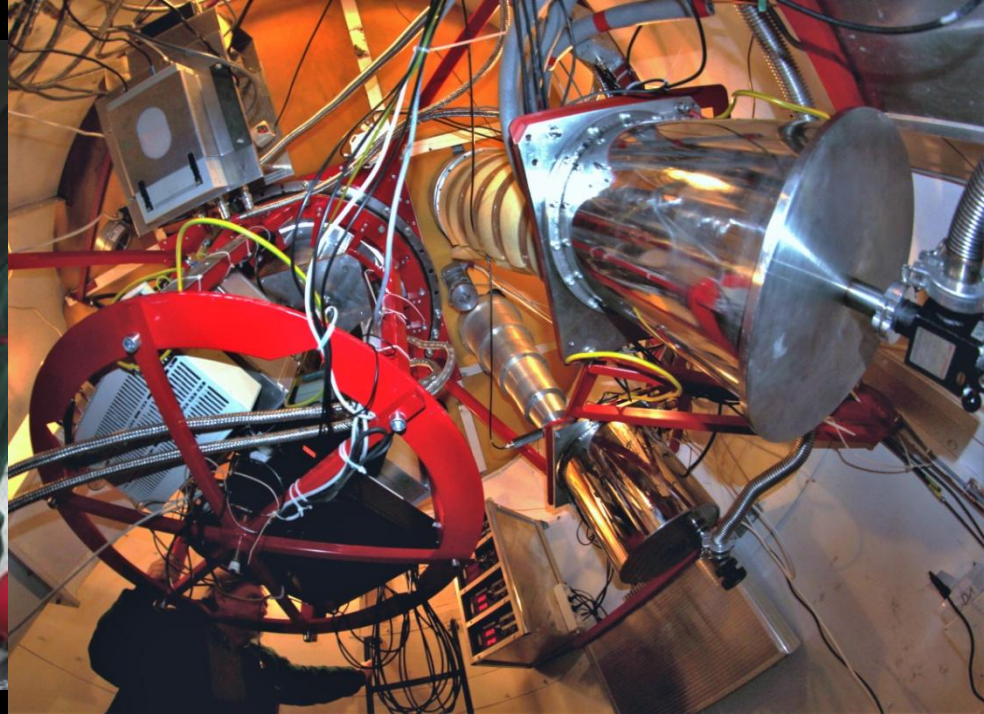
Low-noise preamplifiers were made by **E. Pazderski** while working at MPIfR, Germany (2 months) and at ASTRON, Netherlands (several weeks).

Assembly and commissioning of the cryogenic front ends:

E. Pazderski, A. Kępa, S. Jakubowicz, W. Szymański, J. Król, J. Jopczyński and many others from the RA team.

Uncooled receiver components – successive stages of amplification and frequency conversion – were designed and built by E. Pazderski and S. Jakubowicz; housings and assembly were made with the help of the Centre’s mechanical workshop.

The quality of our receivers matched that of receiver systems at leading radio astronomy centres: MPIfR, JBO and Dwingeloo.

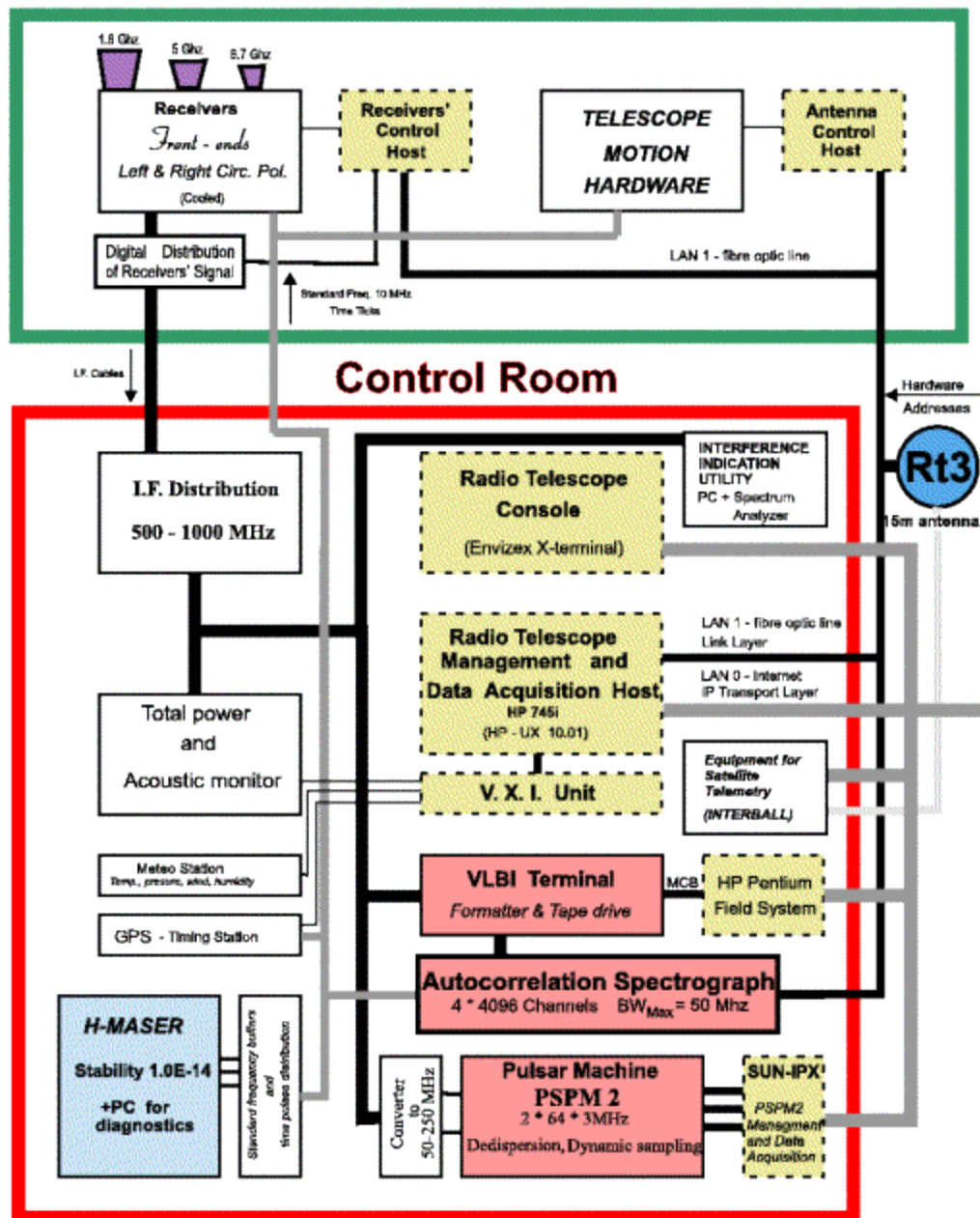


An outstanding
contribution
to the development of
RT4 instrumentation

was made by

MSc
Eugeniusz Pazderski

32 Meter Antenna - RT4



32 m radioteleskop

Handbook



Opis techniczny i podręcznik obserwatora

Wersja 5.2 (sierpień 2003 r.)
w trakcie redagowania

Redakcja: K.M. Borkowski, A.J. Kus

Centrum Astronomii UMK w Toruniu
Katedra Radioastronomii
Piwnice 2003



Hydrogen maser purchased with KBN funds



Mark III (VLBA) VLBI terminal European grant



EVN

e-EVN

USA

China

The global VLBI radio telescope still remains as the largest and most technologically advanced instrument for radio astronomy research



Postbus 2, 7990 AA Dwingeloo,
the Netherlands
Oude Hoogeveensedijk 4,
7991 PD Dwingeloo
Tel: +31 (0)521 595100

FAX MESSAGE	
TO:	Prof. A. Kus
FROM:	JIVE
DATE:	960503
NR. OF PAGES:	1
FAX NR. JIVE:	+31 521 597332

2 May 1996

Dear Andrzej,

Congratulations to you and your team
on first fringes to the 32 m telescope
at Torun!

From all of us at JIVE,

Richard Scholten

Hardy's Sanyal
Jim Ulvestad
K. S.

Maric Rijja

Olike Juntt.

Joel Butten

Hynd
Fy Snel
Jean-Claude

From p062gra@mpifr-bonn.mpg.de Thu May 2 17:00:41 1996
Received: from [134.104.14.56] by copernicus.astro.uni.torun.pl
(5.64/AMr-1.0)

id AA08481; Thu, 2 May 96 16:59:44 +0200

From: David Graham <p062gra@mpifr-bonn.mpg.de>
Subject: Champagne !

To: ajk@astro.uni.torun.pl (Andrzej Kus)

Date: Thu, 2 May 1996 16:56:28 +0100 (MESZ)

Cc: alef@fsl.mpi-fr-bonn.mpg.de, porcas@fsl.mpi-fr-bonn.mpg.de

Andrzej,

We put in the 100microsec and **found fringes**. Correlation coefficient is about 77/10000 (Usual MkIII units). This is corrected for 1-bit losses. If one assumes average Tsys in Jy for the two systems (Medi + Torun) this means 4Jy, about correct for DA193. The sidebands are reversed as expected. Clock is within 1microsec of the value you gave. Clock rate corresponds to about -0.6 microsec/day, assuming Medicina rate is low. Polarisation seems OK. The formatter errors are there about 20-30% of the time, same errors on all tracks. Walter is writing a better account of the whole QASP run which will be out in a few days.

>

The metal reels
have been changed, i.e. the front part of the reel has
been unscrewed and put on the back, and back on the front.
This seems unnecessary to me.

> We checked the quality of recordings while doing SAT
> and found various results depending of used tapes. So I
> assume that the forward tracks are worse due to the tape.

However this tape tracks OK on a Honeywell drive. Perhaps
P&G is just a little more sensitive. This tape cannot be read
at all on our P&G playback drive.

>

UMK Centre for Astronomy

established by order of the UMK Rector on 29 October 1996
a faculty-level unit of WFAiIS, UMK

Organisational units within the UMK Centre for Astronomy:

- Department of Astronomy and Astrophysics
- Department of Radio Astronomy
- Centre for Astronomy Library
- Administration and Facilities Department

tasks:

- Scientific research
- Teaching
- Public outreach in astronomy



TCfA Torun Centre for Astronomy

1996-2020

Centre for Astronomy

Status at year 2009 (KAA+KRA)

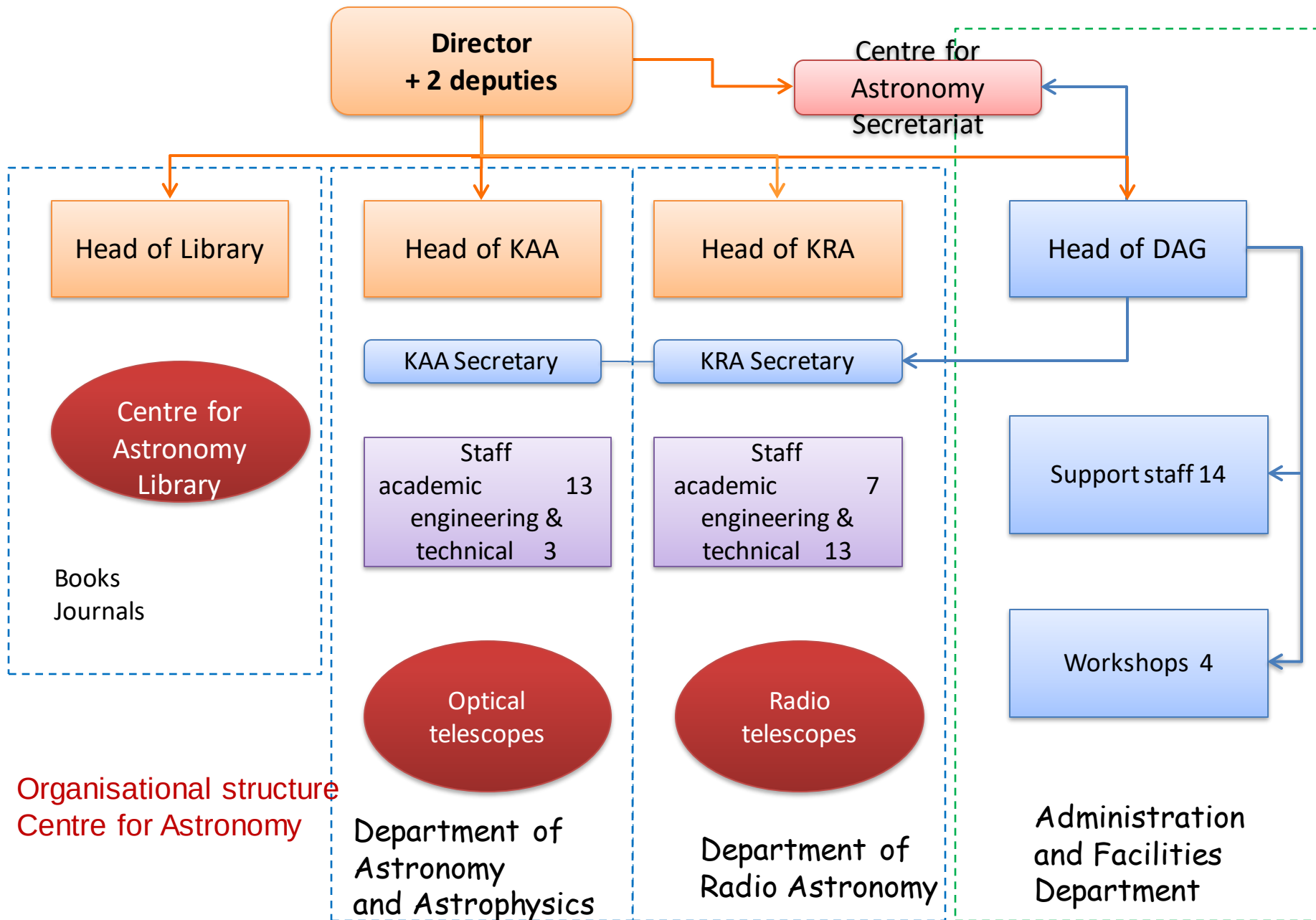


- Academic staff 12+7 FTE
- Research/engineering/technical staff 3+11.5 FTE
- Administrative staff 4 FTE
- Library 1 FTE
- Support staff 17 FTE

TOTAL 55.5 FTE

- Students 88 (17, 11, 15, 12, 11)
- Doctoral students 16+8

- Category I MNiSW (KBN)
- Centre for Astronomy assets million ~ PLN 150-200



TCfA Torun Centre for Astronomy

Radio Astronomy Department



~ 2005

At KRa, the RT 32 m, equipped with modern instrumentation, enabled research in many areas of contemporary radio astrophysics

Radio spectroscopy (masers: OH, CH₃OH, H₂O)

Neutron stars - pulsars

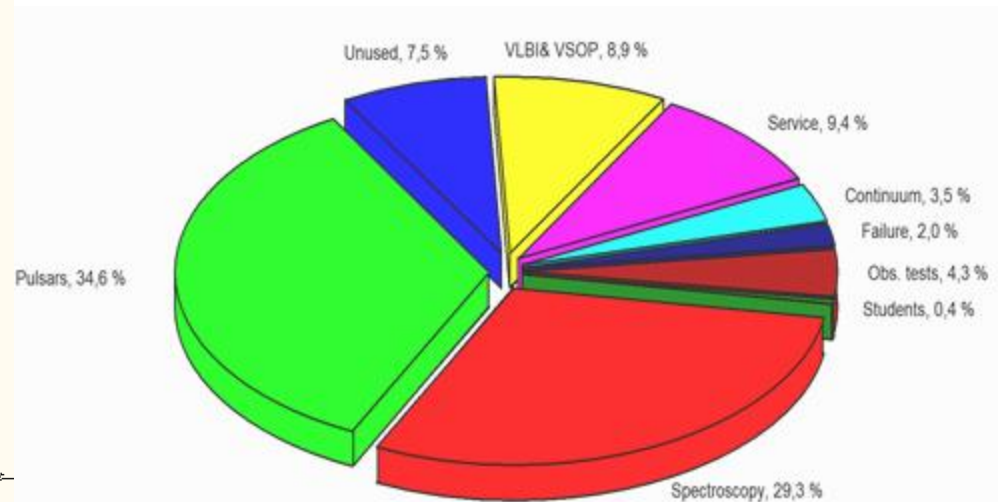
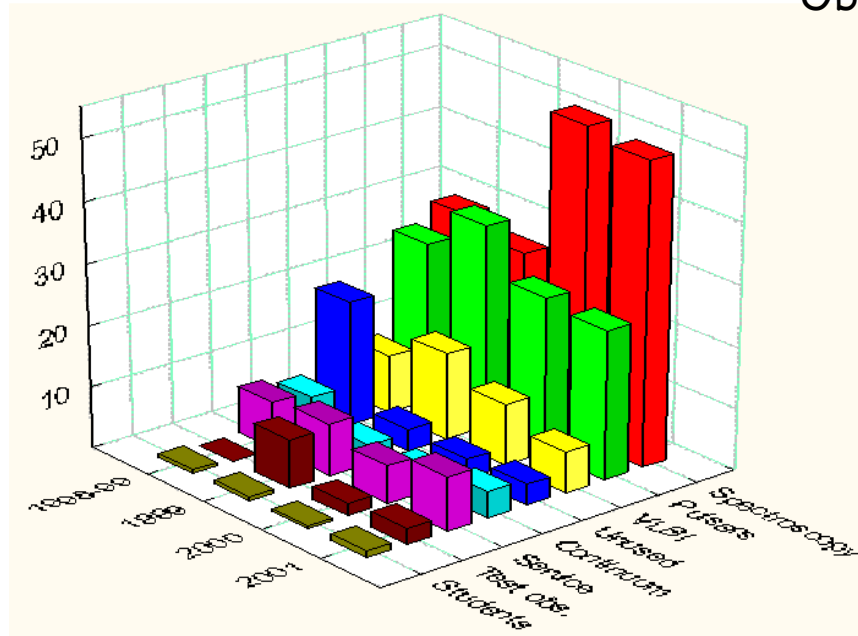
VLBI (AGN, SSO, CSO, CSO, ...)

OCRA (young AGNs, S-Z, PN)

Polarimetry (N. Galaxy and AGN)

Observing time for individual projects

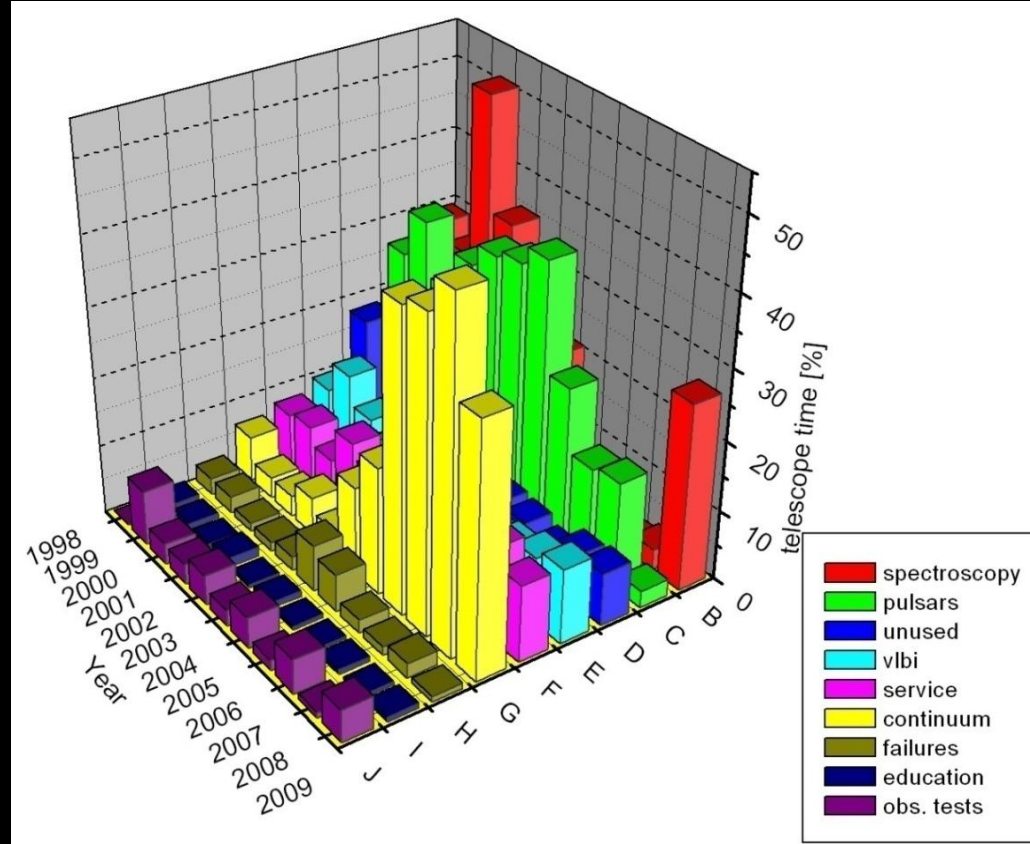
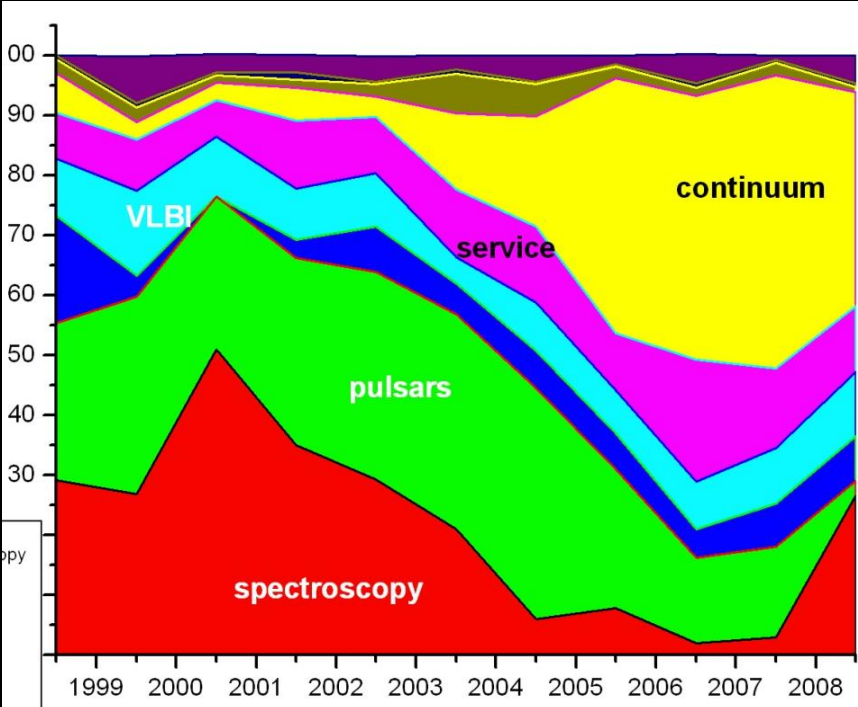
year 2000



Use of the RT-4 radio telescope

RT4: 85% of the time was used for observations

Years 1998-2009



Pulsars on RT-4 - 30% of observing time (1996-2000)

Prof. A. Wolszczan + team



Pulsars on RT-4 - 30% of observing time (1996-2000)

Timing of approx. 100 pulsars
searches for and studies of exoplanets

Prof. A. Wolszczan + doctoral students:

W.Lewandowski, B.Jacoby, M.Konacki,
M.Redmerska, G.Feiler, +
A.Maciejewski, A.Niedzielski ESP

L band: 1700 MHz

Cryogenic receiver

Two circular-polarisation channels



PSPM-2

Parameters:

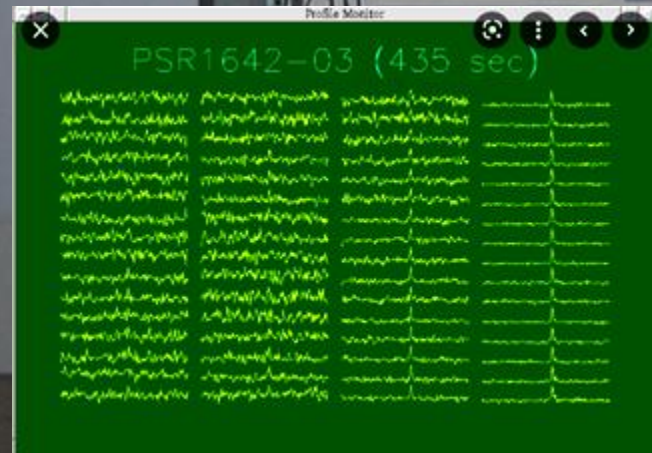
Two circular-polarisation channels,

Bandwidth $64 \times 3 = 192$ MHz,

Sun workstation,

PSU software,

Synchronous accumulation,



Pulsars on RT-4 (1996-2000)

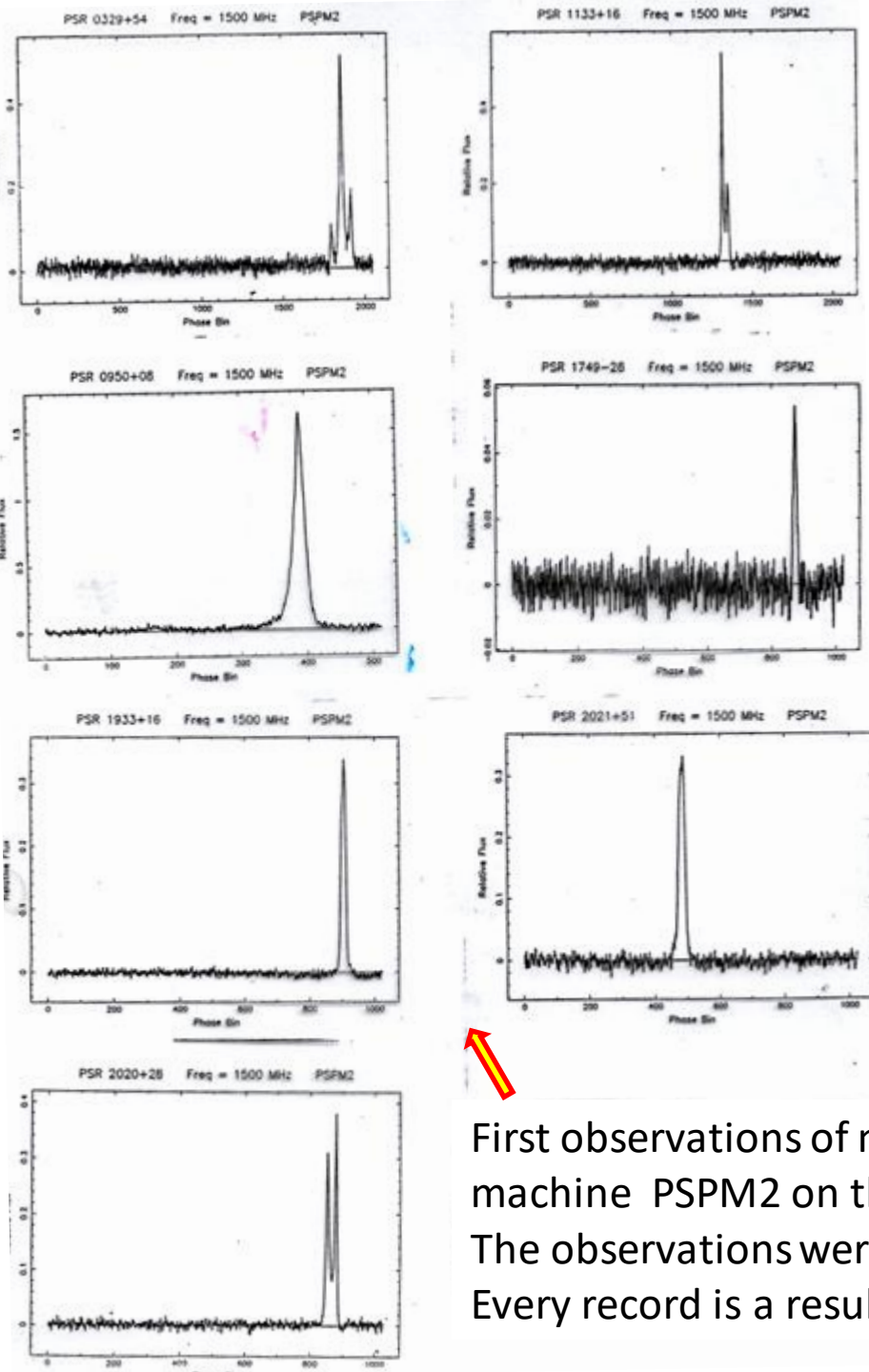
Pulsar timing

Prof. A. Wolszczan + doctoral students:

All pulsars on the list were observed at least once a week,
Integration time: 60 to 240 minutes.

This powerful homogeneous data set was used to study the stability of the periods of selected pulsars.
The aim was to search for periodicities caused by internal phenomena or by planets orbiting the pulsar.

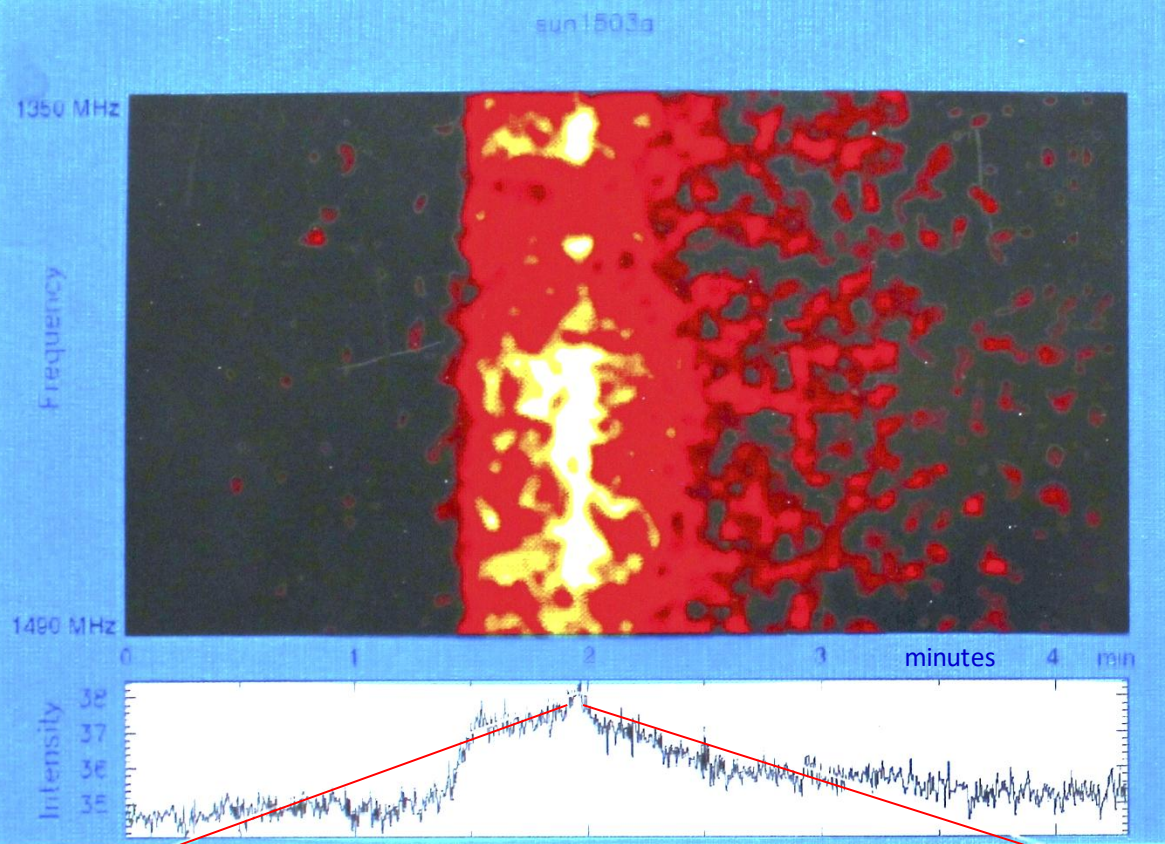
First observations of neutron stars using pulsar machine PSPM2 on the 32m radio telescope.
The observations were carried on from July '96.
Every record is a result of 10 minutes integration.



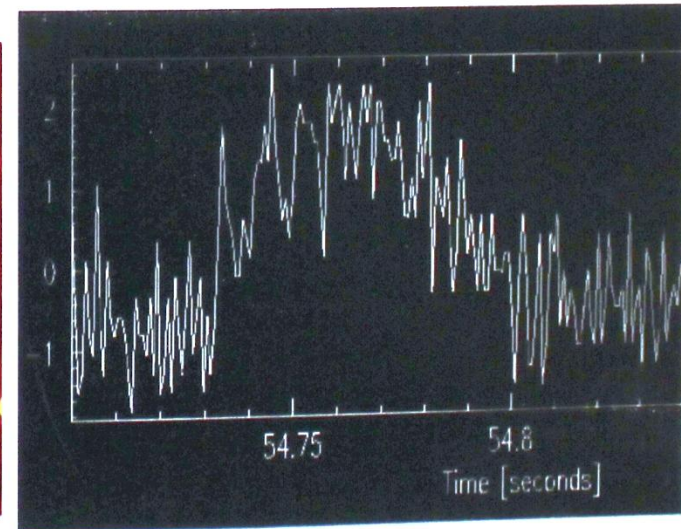
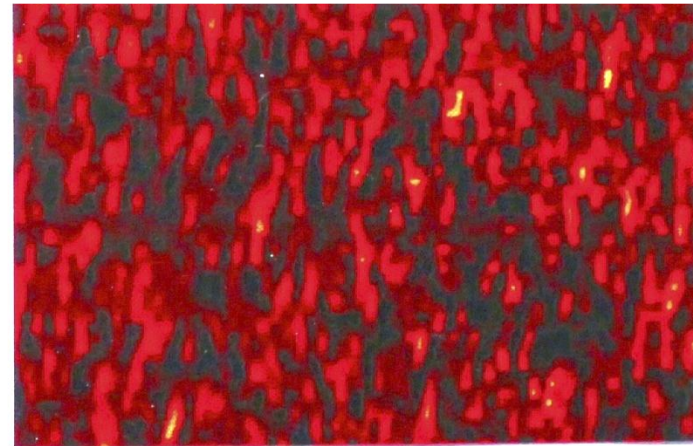
Radio "spikes" in solar flares

RT-3 + PSPM2 @ 1400 MHz

B.Dąbrowski, A.Kus



1 second



Team carrying on various VLBI projects

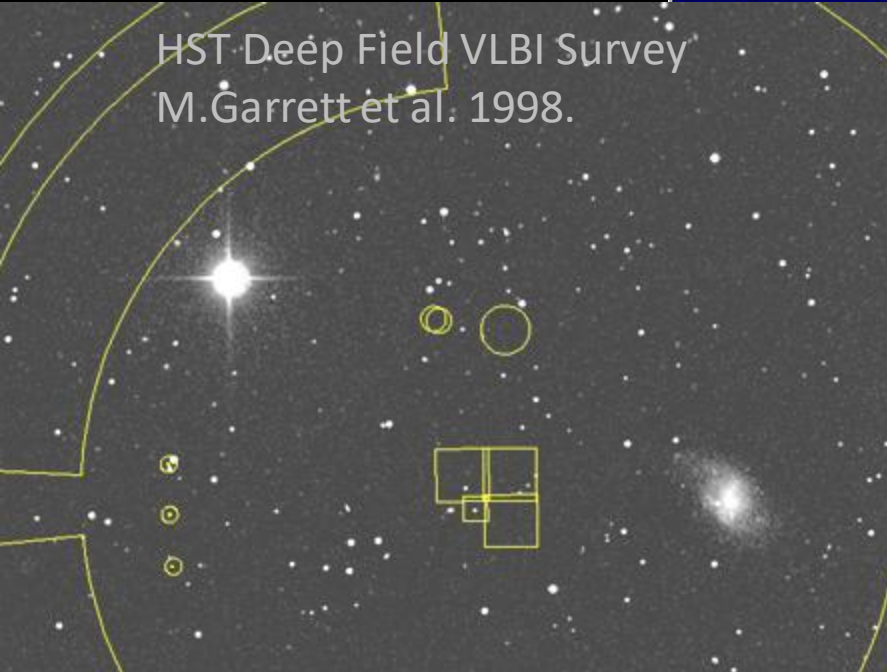
extragalactic research and AGN studies

A.Kus
K.Borkowski
A.Marecki
M.Gawroński
K.Katarzynski
I.Owsianik
M.Kunert Bajraszewska
J.Niezgoda

Supported by the team maintaining and developing the radio telescope instrumentation

E. Pazderski - receivers, radio telescope control, fibre-optic links, remote control of receiver equipment
R. Feiler - field system for terminal operation and telescope control
A. Kępa - VLBI terminal, equipment synchronisation
J. Mazurek - logistics, dispatch and receipt of tapes and disks to and from the JIVE correlator
J. Usowicz - hydrogen frequency standard, CRAF, protection of radio-frequency bands
B. Krygier - administration and management of the Centre for Astronomy workshop
G. Gawrońska - VLBI observations + processing of daily solar-interferometer data until 2017

HST Deep Field VLBI Survey
M. Garrett et al. 1998.



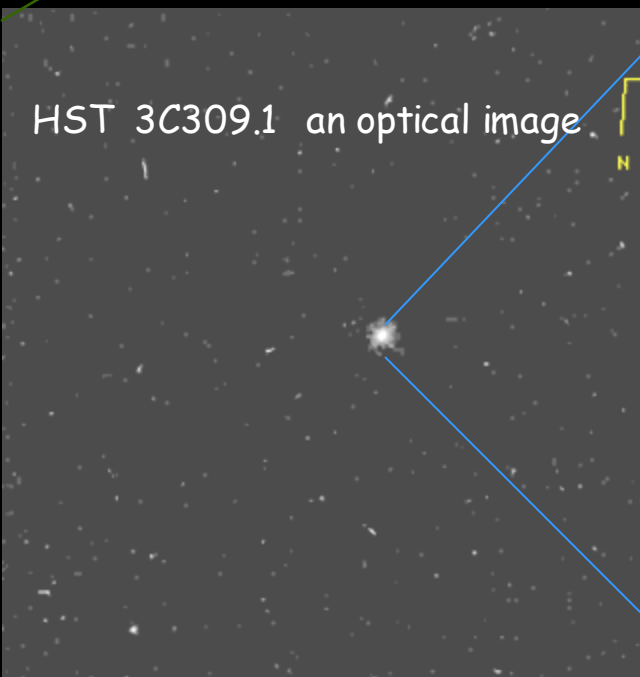
Examples of important VLBI results

1 arc sec

3C309.1 CSS QSO

High resolution radio images

HST 3C309.1 an optical image



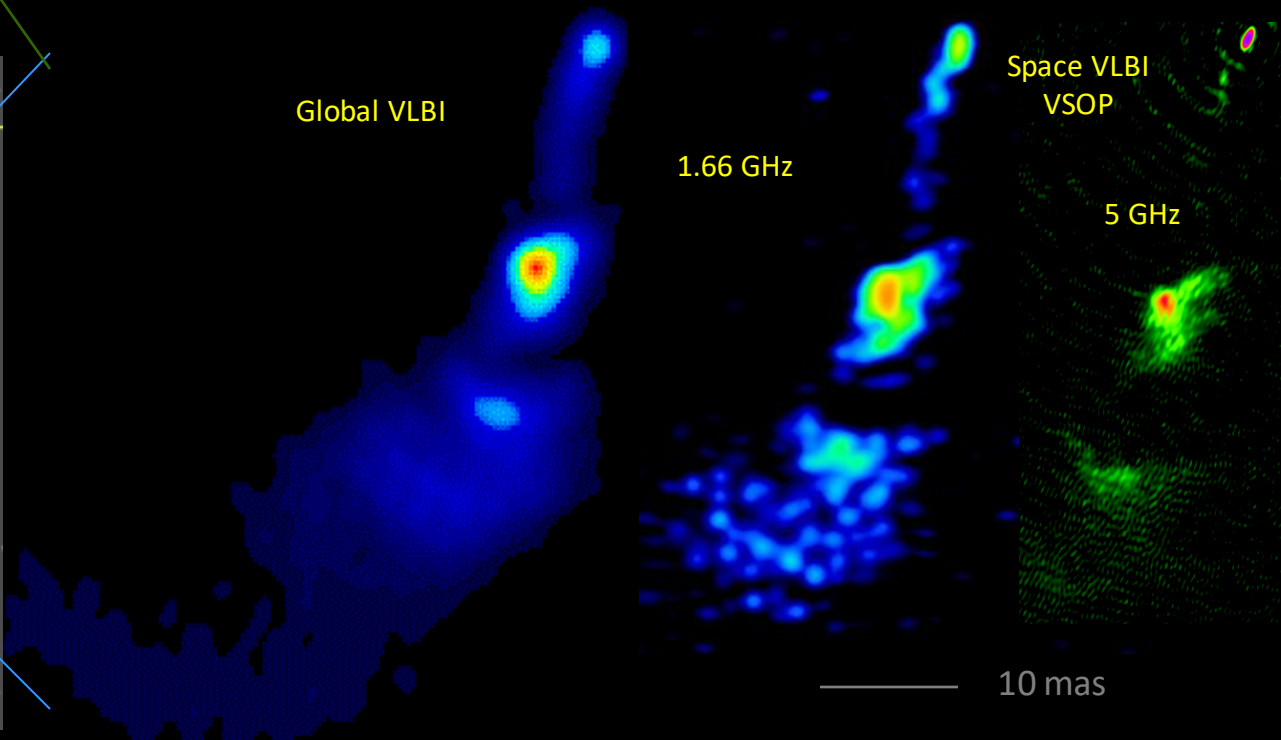
Global VLBI

1.66 GHz

Space VLBI
VSOP

5 GHz

10 mas





Top row: W.Lewandowski, J.Mazurek, K.Katarzynski, A.Wiśniewska, J.Jopczynski, A.Kępa, E.Pazderski, S.Jakubowicz, B.Jacoby, A.Lech,
B.Gertner, R.Feiler, M.Gleba, K.Borkowski, A.Król, W.Szymański,
Bottom row: A.Marecki, S.Krawczyk, B.Krygier, S.Gorgolewski, W.Iwanowska, A.Kus, G.Gawrońska, J.Urowicz, S.Etoka.



ZESPÓŁ KATEDRY RADIOASTRONOMII

siedzą od lewej: Andrzej Marecki, Eugeniusz Pazderski, Stanisław Gorgolewski, Wilhelmina Iwanowska, Aleksander Wolszczan, Andrzej Kus, Grażyna Gawrońska

stoją od lewej: Adam Jacek Król, Bernard Krygier, Andrzej Kępa, Włodzimierz Leszczyński, Anna Wiśniewska, Marek Urbanowski, Marek Gleba, Jerzy Ułowicz, Kazimierz Borkowski, Janusz Filarecki, Wojciech Szymański

nieobecni: Leszek Błaszkiwicz, Roman Feiler, Sławomir Jakubowicz, Jacek Jopczyński, Maciej Kamiński, Andrzej Lech,

1998



EVN - European VLBI Network

EVN Consortium

AJK - Director of the EVN Consortium
2008-2010

VLBI - the leading project for RT4
enabled a wide range of research

The guarantee of reliability and
the highest-quality instrumentation.

eEVN: European VLBI Network

Data processing
centre:
16 Gbps (2005)
1 Tbps (2010)

Russia

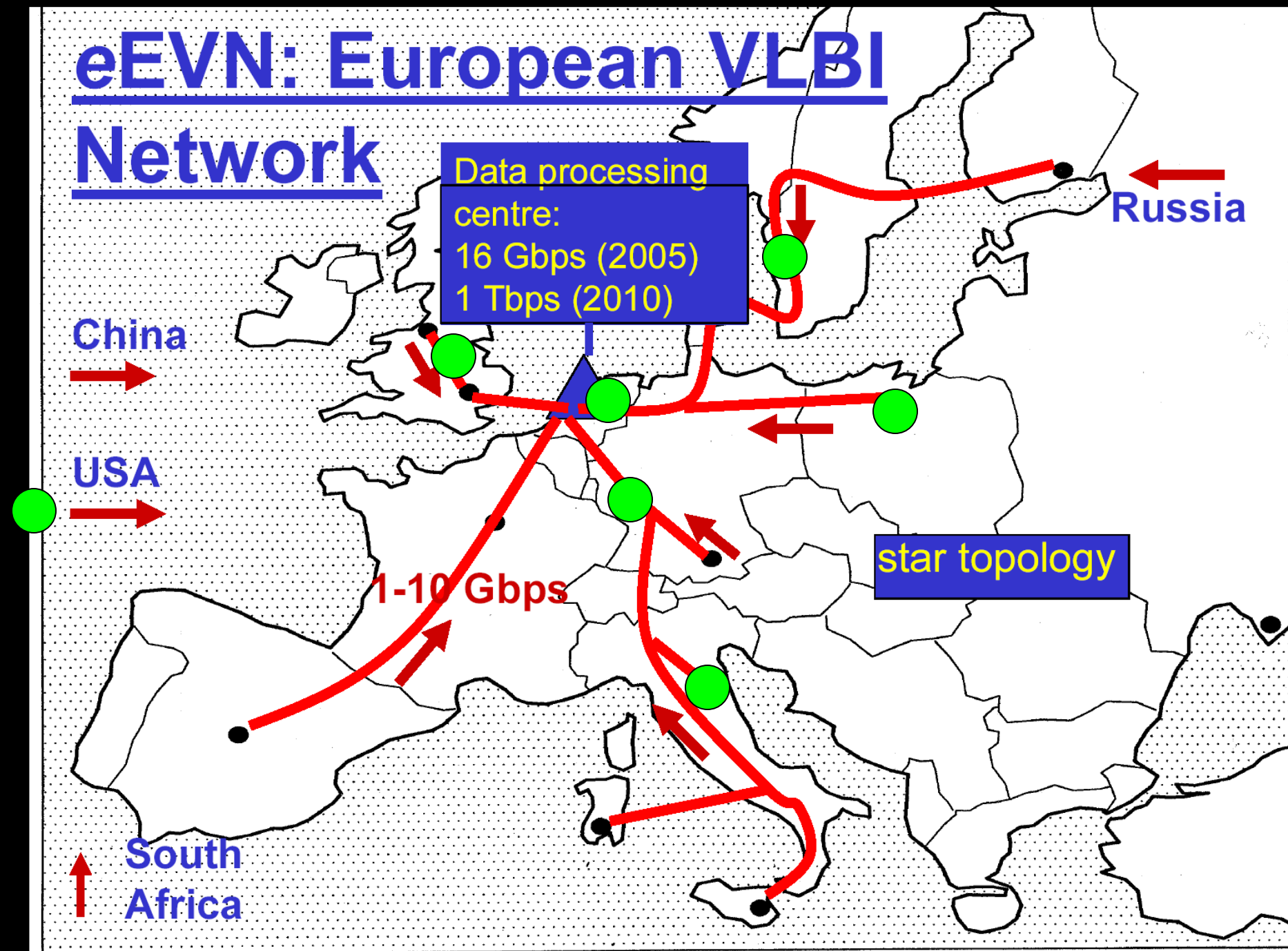
China

USA

star topology

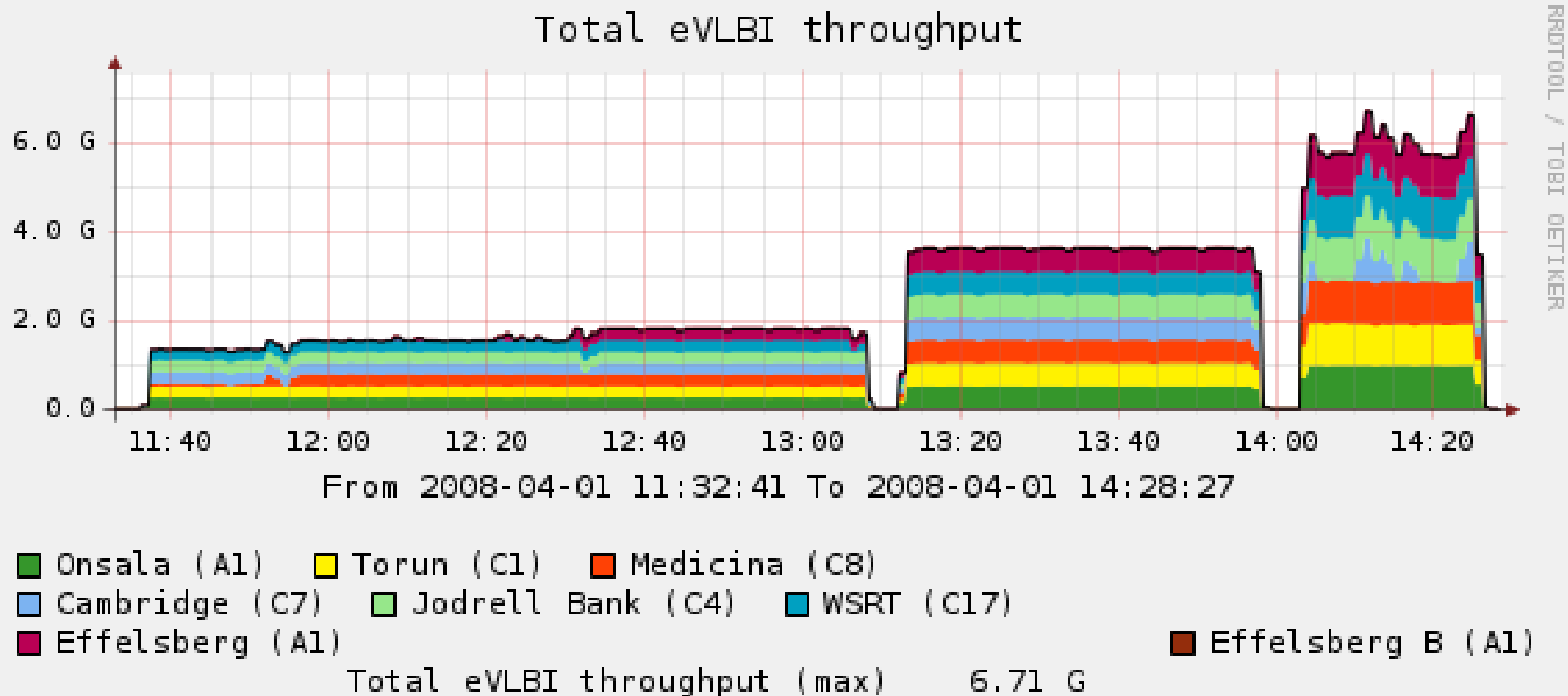
1-10 Gbps

South
Africa



European VLBI Network

- participation since 1982 (32 m RT4: 1986)
studies of AGNs and masers
- e-EVN participation in real-time VLBI since 2005



Methanol spectroscopy, CH₃OH, 6.7 GHz

Team involved in commissioning and implementation of the programme

M. Szymczak – processing of observational results, writing papers, scientific lead

A. Kus – initiation and coordination of the project in its initial phase

L. Błaszkiwicz – observations and processing of observations made at 12 GHz

A. Kępa – autocorrelation spectrograph design, cryogenics

R. Feiler – spectrograph computer software

E. Pazderski – low-noise preamplifiers, RT-4 control systems, software, construction of the 12 GHz receiver, servicing of receiver systems

S. Jakubowicz – construction of the 6.7 GHz receiver

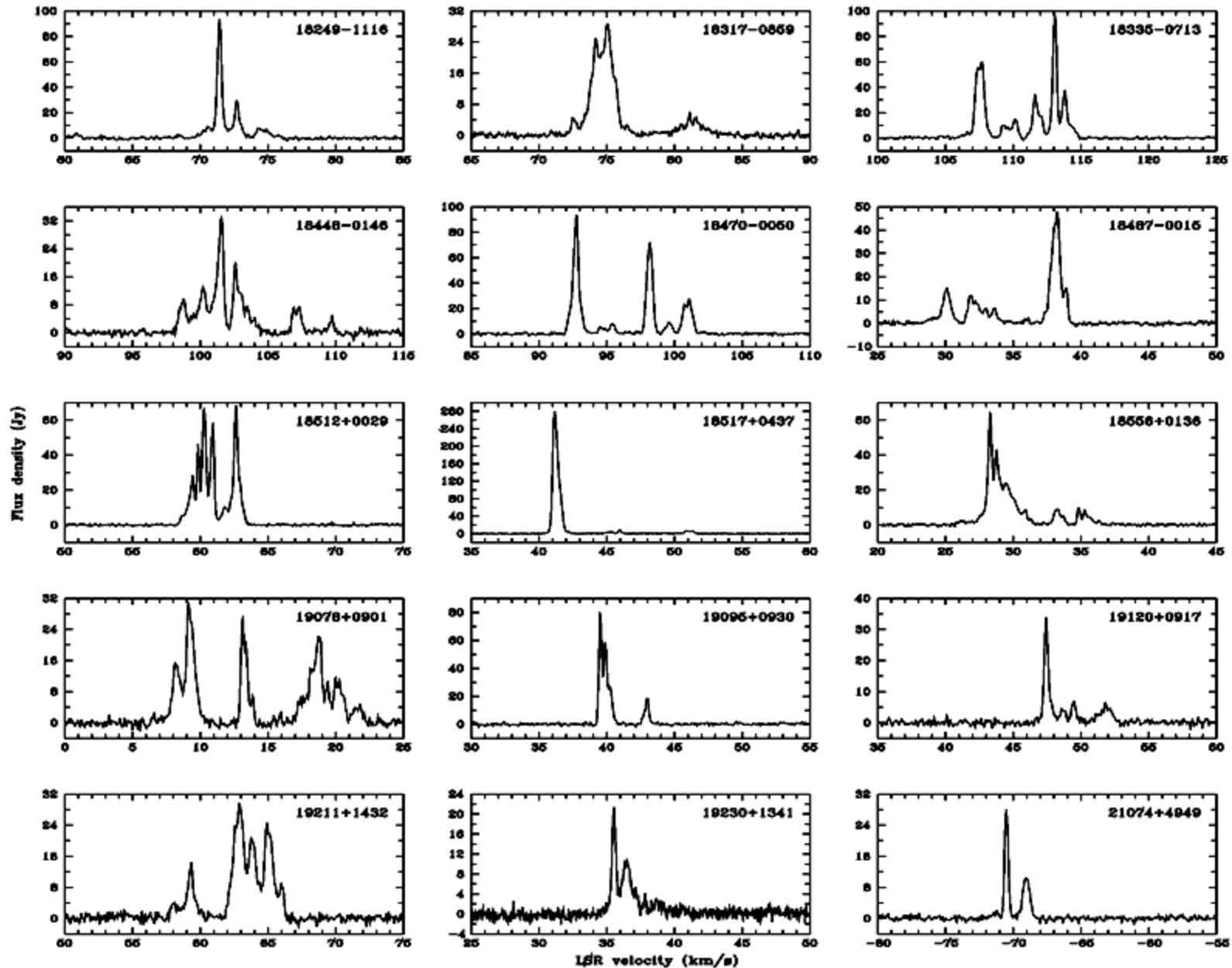
K. Borkowski – RT-4 pointing corrections

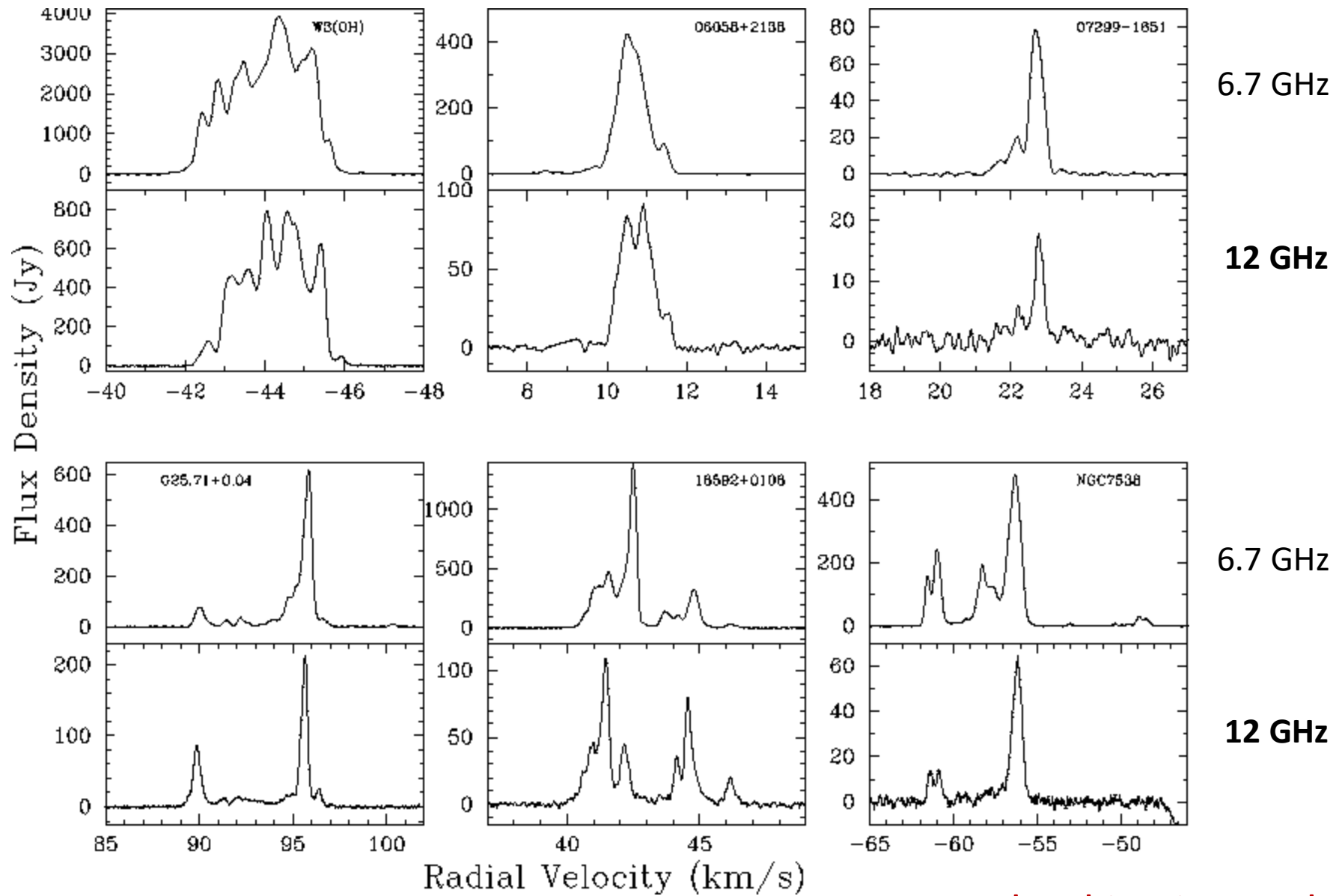
G. Hrynek – logistics and conducting observations

Team Award of the Polish Academy of Arts and Sciences for research activity, Kraków, 2005.

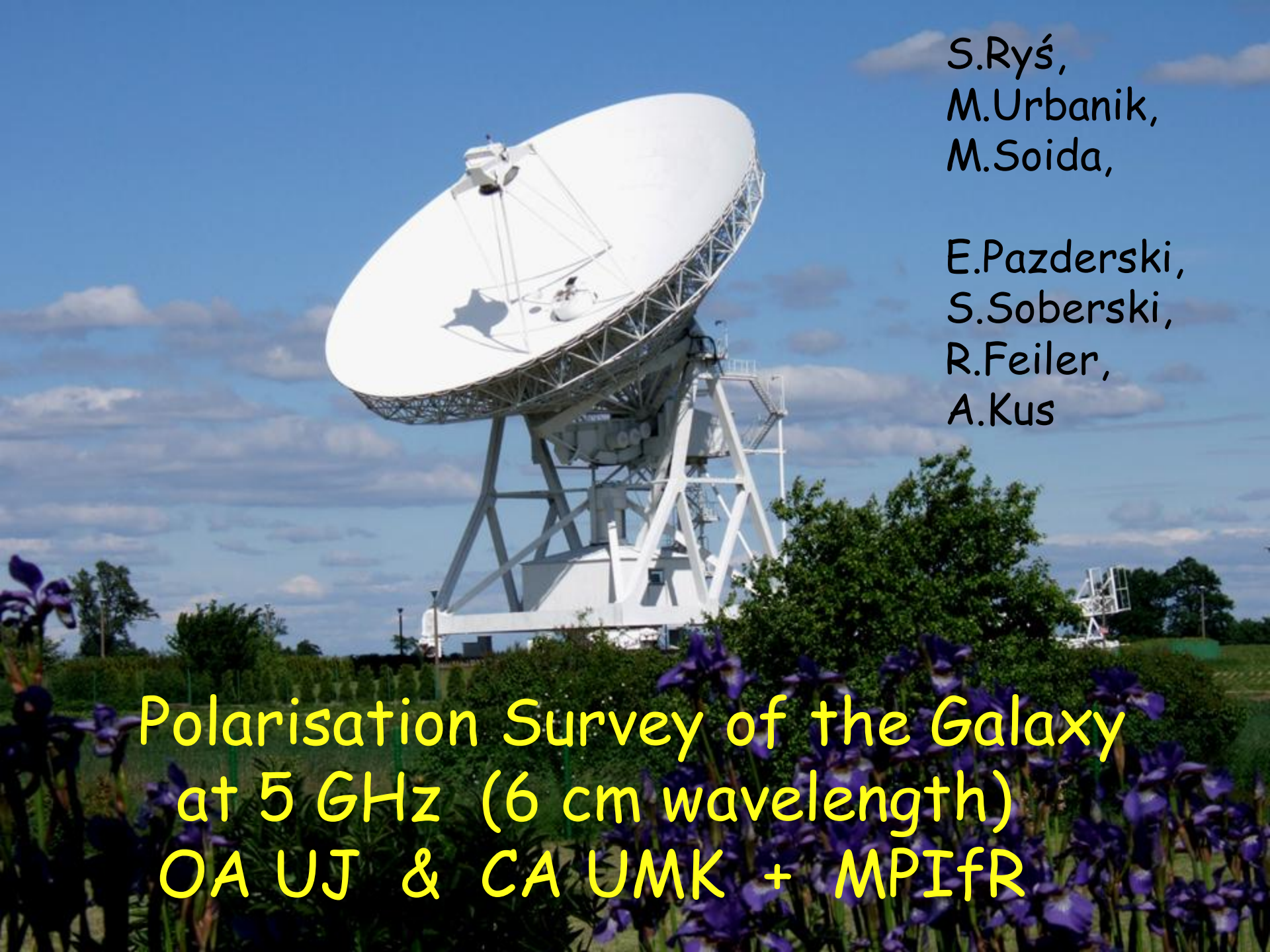
L.Błaszkiwicz, A.Kępa, A.Kus, E.Pazderski, M.Szymczak

Toruń 6.7 GHz methanol survey of the Galactic plane M. Szymczak et al.





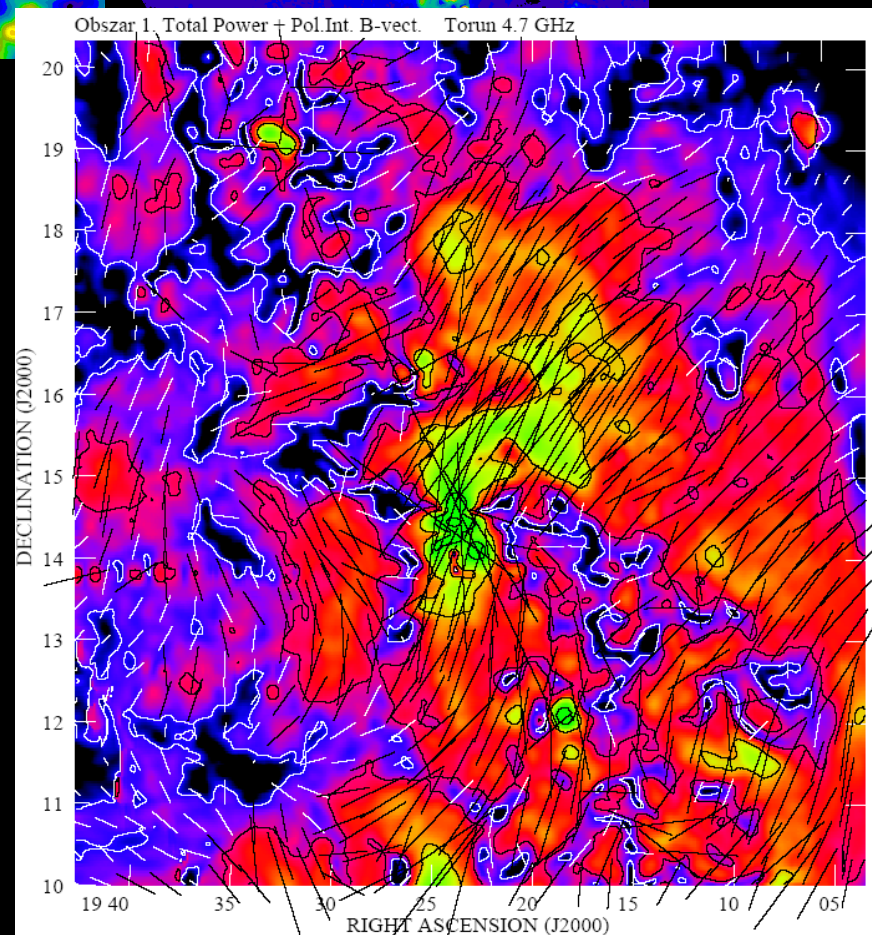
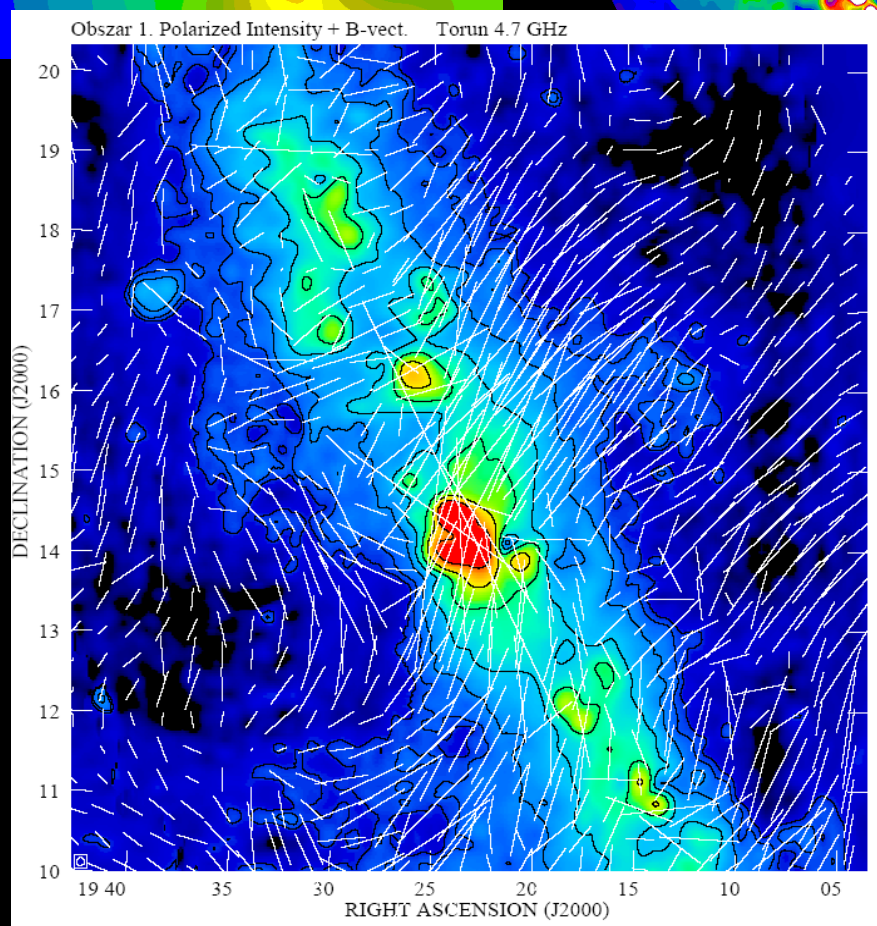
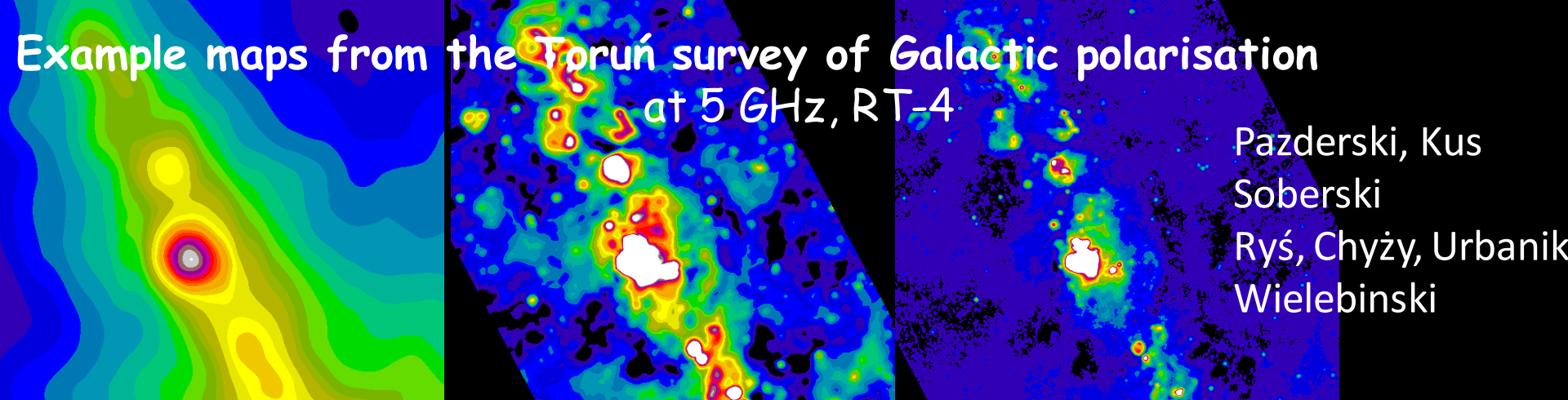
L. Błasziewicz et al.

A large white radio telescope dish is mounted on a white metal structure on a grassy hill. In the foreground, there are purple flowers. The sky is blue with some clouds.

S.Ryś,
M.Urbanik,
M.Soida,

E.Pazderski,
S.Soberski,
R.Feiler,
A.Kus

Polarisation Survey of the Galaxy
at 5 GHz (6 cm wavelength)
OA UJ & CA UMK + MPIfR



OCRA – One Centimetre Receiver Array



TCfA

OCRA collaboration

University of Manchester:

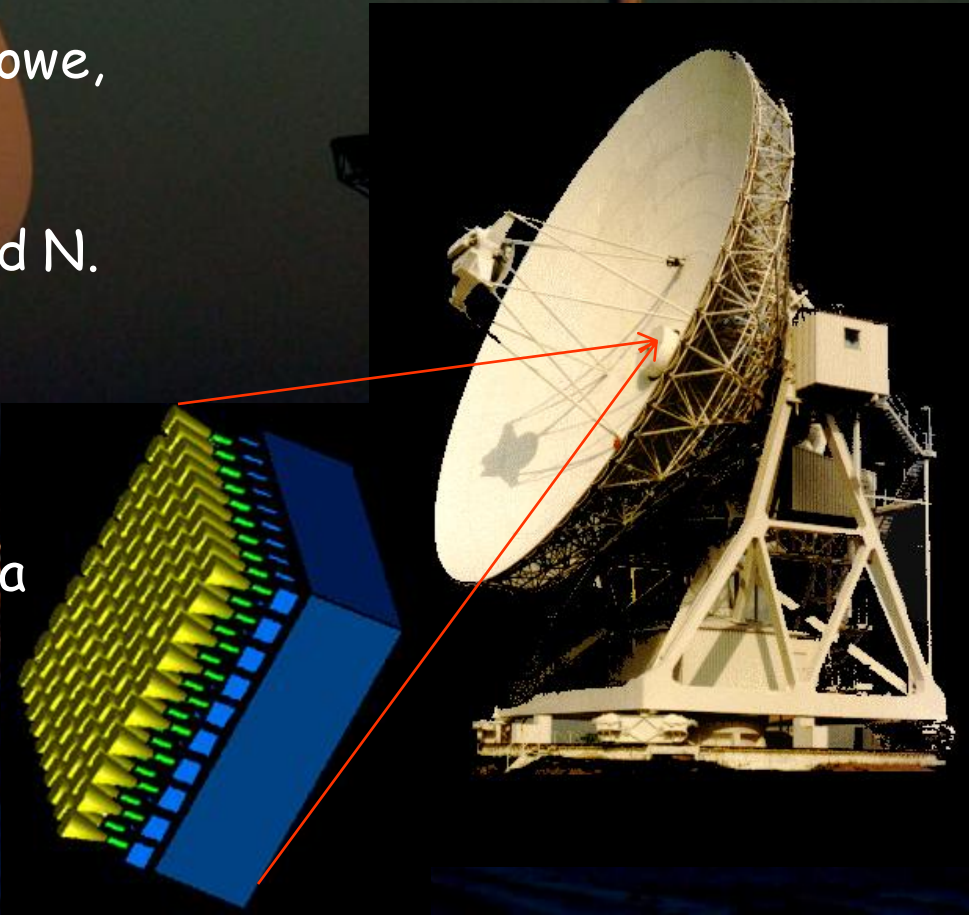
R. Battye, I. Browne, R. Davis, S. Lowe, M. Peel and P. Wilkinson. Also E. Blackhurst, C. Baines, J. Edgley, J. Kitching, D. Lawson, J. Marshall and N. Roddis

Toruń Centre for Astronomy:

R. Feiler, M. Gawronski, A. Kus, B. Pazderska, E. Pazderski, B. Roukema

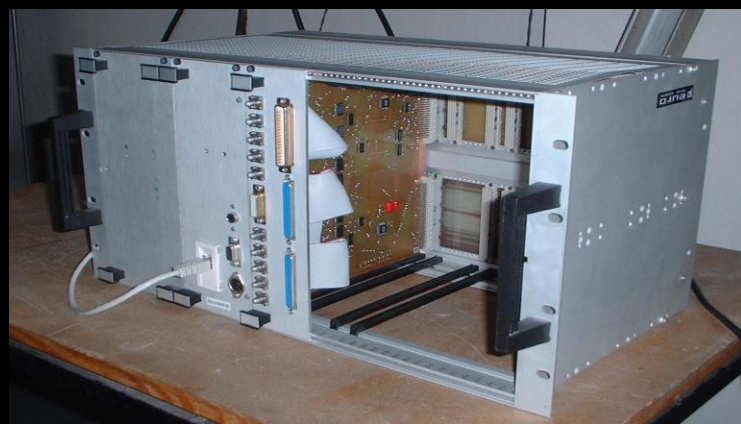
University of Bristol:

A. Azareedh, M. Birkinshaw, K. Lancaster





OCRA-p = OCRA prototype



OCRA-f programme

OCRA-f designed at JBO
Delivered to Torun Centre for
Astronomy in May 2008

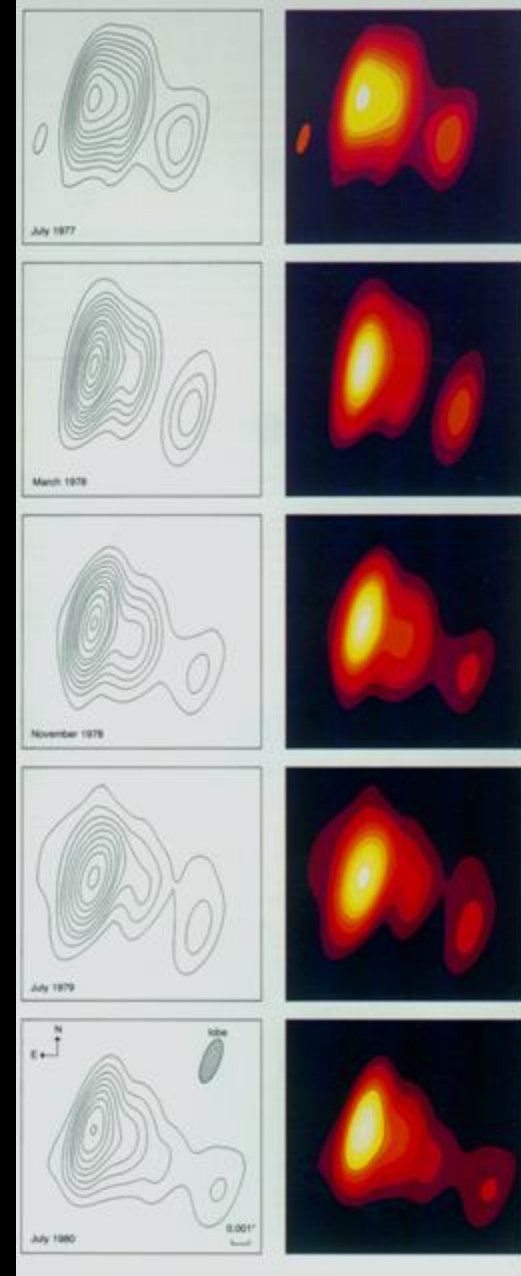
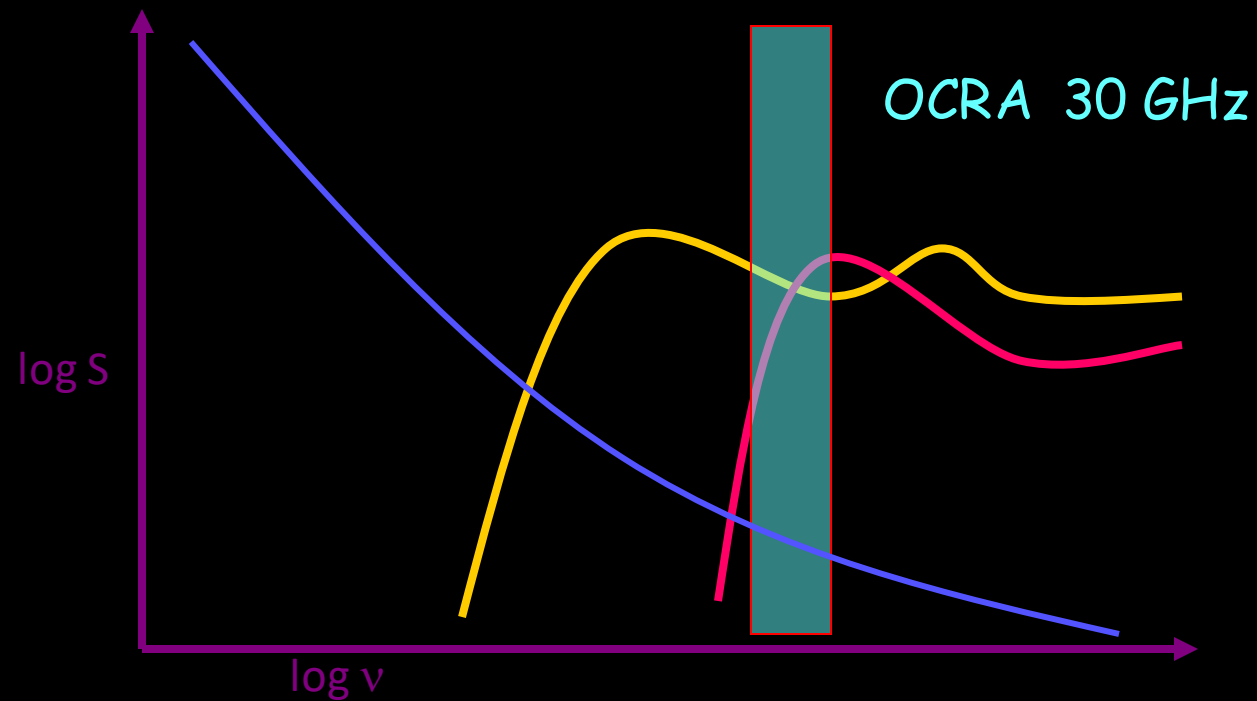
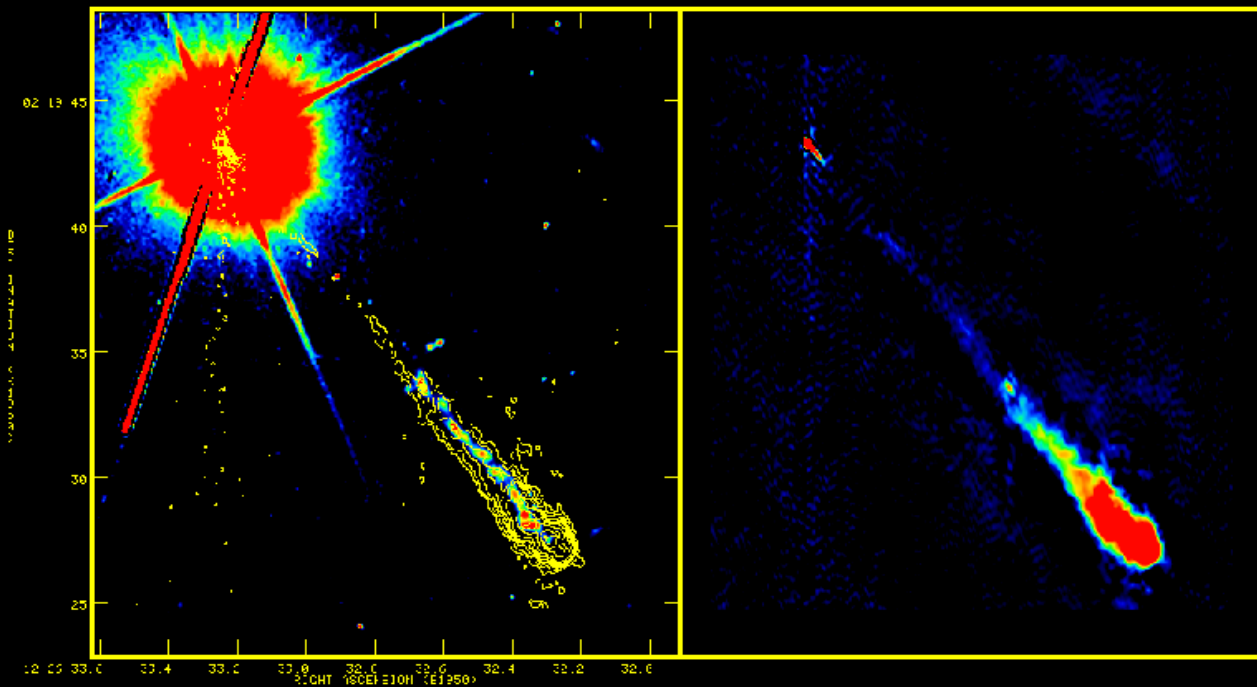


Centre for Astronomy
designs rotator & DAQ system



HST WFPC2 / MERLIN

MERLIN 18cm



Evolution of 3C273
T.Pearson et al. CALTECH



SEST La Silla ESO VLBI

1990 and 1993 (AJK contribution)

**First global VLBI experiments
at millimetre wavelengths (3 mm)**

International project
Sweden, USA, Germany, Japan

Radio telescopes: SEST, Kitt Peak, Hat Creek,
Onsala, Owens Valley, Nobeyama.

Processing: MIT, Haystack Observatory

Results published in Nature and A&A

Several publications, 1989–93

3C273, 3C274, 3C345, OJ287, ...

Resolution 30–50 milliarcsec

Symposia, schools and meetings organised by TCfA

EAS Meeting 1993, Toruń

JIVE school on interferometry 1998

EVN Symposium 2006

YERACs

OCRA

RoboPol

Important for building the Centre's international standing

JIVE school on interferometry 1998

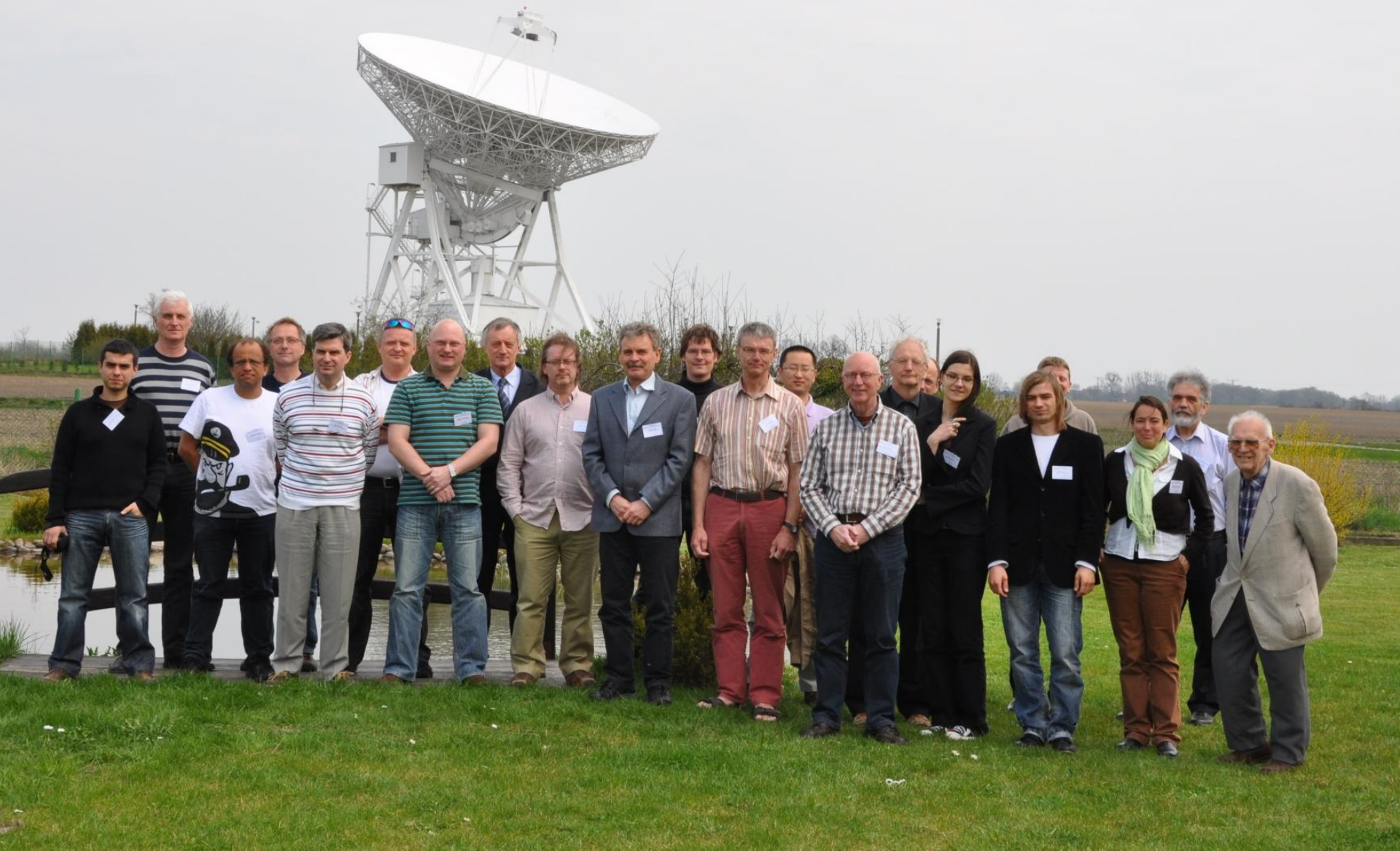


8th EVN Symposium + EVN Directors Meeting + EVN Users Meeting



September 2006

EVN TOG April 2009



RoboPol Annual Meeting in Toruń, 29 July – 1 August 2013





Academic, technical, administrative staff and doctoral students of the UMK Centre for Astronomy.

Seated from left: A. Marecki, T. Tomov, A. Niedzielski, B. Roukema, J. Krełowski, A. Woszczyk, A. Kus, A. Strobel, S. Gorgolewski, M. Mikołajewski, K. Goździewski, S. Krawczyk; standing behind them: A. Kępa, P. Wąż, J. Jopczyński, I. Sworowska, E. Pazderski, K. Borkowski, G. Gawrońska, J. Usowicz;

above, behind the balustrade, standing: K. Słyk, T. Łączkowski, J. Osiwała, A. Nieżurawska, M. Cikała, A. Skowron, A. Pleskacz, S. Frąckowiak, A. Czarny, K. Wojtkowska, M. Gleba, W. Szymanski, M. Gawroński, M. Kunert, E. Nowakowska, R. Feiler, S. Soberski.

Piwnice ~1970



Academic and administrative/technical staff of the UMK Institute of Astronomy and the PAN Astrophysics Laboratory

Seated from left: H. Górski, A. Stawikowski, J. Hanasz, A. Świdzińska, N. Maron, S. Gąska, W. Iwanowska, S. Gorgolewski, C. Iwaniszewska, A.

Woszczyk, J. Strobel, S. Krawczyk, E. Basińska, E. Górka,

Standing behind them from left: H. Sikorski, A. Buchholtz, Z. Turło, M. Wiśniewska, Z. Walczyna, M. Moraczewska, A. Kus, A. Strobel, A. Kaczor, B. Krygier, R. Tylenda, A. Burnicki.

Standing along the balustrade from left: H. Wiśniewski, D. Wrukowska, T. Wrukowska, B. Wikierski, A. Wolszczan, S. Kaspercuk, J. Sikorski, P. Olszewski, L. Dybkowski, A. Raczkowski, J. Smoliński, S. Grudzińska, J. Kretowski, J. Krempeć, H. Wełnowski.



October 2014: formal end of AJK's employment at UMK, continued as professor emeritus

Heads of the Radio Astronomy Division

1. Prof. S. Gorgolewski, 1965-1992
2. Prof. A. Kus, 1992-2005
3. Prof. M. Szymczak, 2006-2010
4. Dr / Dr hab. K. Katarzynski, 2011-2018
5. Dr hab. A. Marecki, Professor at UMK, 2018-2022

Acknowledgements

- UMK Rectors

Prof. W.Łukaszewicz
Prof. S.Dembiński,
Prof. J.Kopcewicz,
Prof. S.Łęgowski
Prof. A.Jamiołkowski,
Prof. A.Radzymiński,
Prof. A.Tretyn.

- Deans of the Faculty of Mathematics, Physics and Chemistry / FAiIS

Prof. K. Karpiński,
Prof. S.Kwiatkowski,
Prof. F.Rozpłoch,
Prof. J.Szudy.

To the entire team of the Department of Radio Astronomy
and the UMK Centre for Astronomy,

with special thanks to:

E.Pazderski, K.Borkowski, R.Feiler, A.Kępa, A.Marecki, M.Szymczak,
G.Gawrońska, J.Mazurek, J.Urowicz, S.Jakubowicz, M.Kamiński
B.Krygier, S.Krawczyk, E.Nowakowska, I.Sworowska.

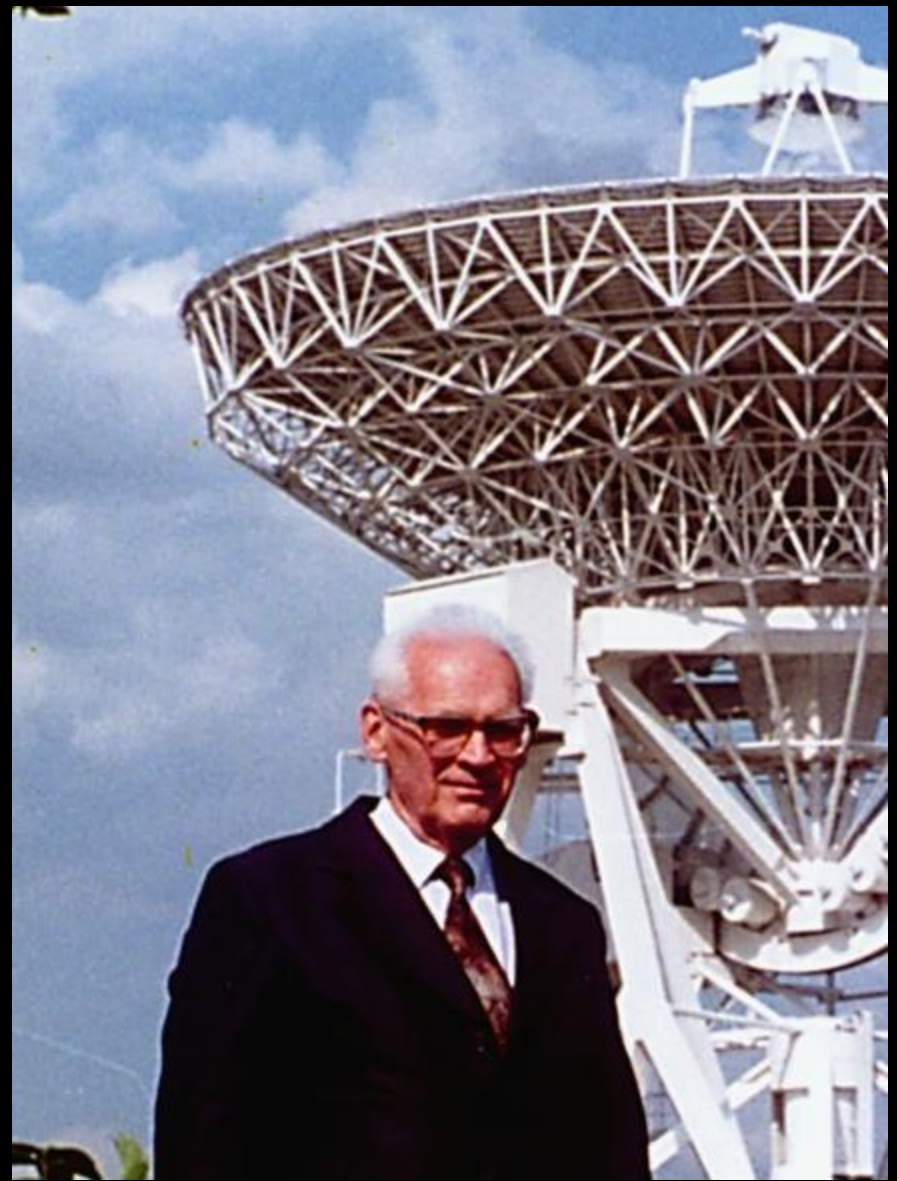


Prof. Wilhelmina Iwanowska

(1905 – 1999)

Founder of modern astrophysics in Poland

Director, Institute of Astronomy 1952–1978



Prof. Stanisław Gorgolewski

(1926 -2011)

Founder of radio astronomy in Toruń

Director, IA 1978–1980, RA Division 1965–1990



Thank you for your attention

References (PL, EN):

Gorgolewski, Hanasz, Iwaniszewski, Turło, *AcA, Vol. 12, p.251, AcA, Vol. 15, p.26*

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J.Szudy, „Rozmowa o Wilnie, Toruniu i Wszechświecie z Wilhelminą Iwanowską”, *Postępy Fizyki, Tom 39, Zeszyt 4, 1988.*

W.Iwanowska, „Mój życiorys naukowy”, *HNiT, R.XXVI-2, PL.ISSN 0023-598, 1981.*

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K.Borkowski, „Radiowa interferometria wielkobazowa (VLBI)”, Toruń UMK, 1993.

A.Plaskacz, „Życie wśród gwiazd Profesor Wilhelminy Iwanowskiej”, TNOiK, Toruń, ISBN 83-86850-39-6, 1997.

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A.Kus, R.Wielebinski, „History of Radio Astronomy in Torun”, *Journal of Astronomical History and Heritage, Vol. 24, No. 4, p. 957-980, 2021.*

K.Borkowski, „System sterowania RT3”, <http://www.astro.uni.torun.pl/~kb/Telescopes/RT15/SystemSterowania.htm>

K.Borkowski, „Początki VLBI na UMK”, <http://www.astro.uni.torun.pl/~kb/Telescopes/RT15/KRaVLBI.htm>

K.Borkowski, A.Kępa, J.Mazurek, A.Kus, "Toruński system do radiowych obserwacji pulsarów", *Postępy Astronomii, 31, 255-277; 1983*

E.Pazderski, „Aparatura radioteleskopów i inne informacje historyczne”, <http://epsrv.astro.uni.torun.pl/>

RT32 Podręcznik obserwatora, <http://www.astro.uni.torun.pl/~kb/HandbRT32/HandbookRT32.htm>

J.Szudy, A.Bielski, „Aleksander Jabłoński, Fizyk, Muzyk, Żołnierz”, Wydawnictwo Naukowe UMK, Toruń, 2010



Proposal for 90 m radio telescope

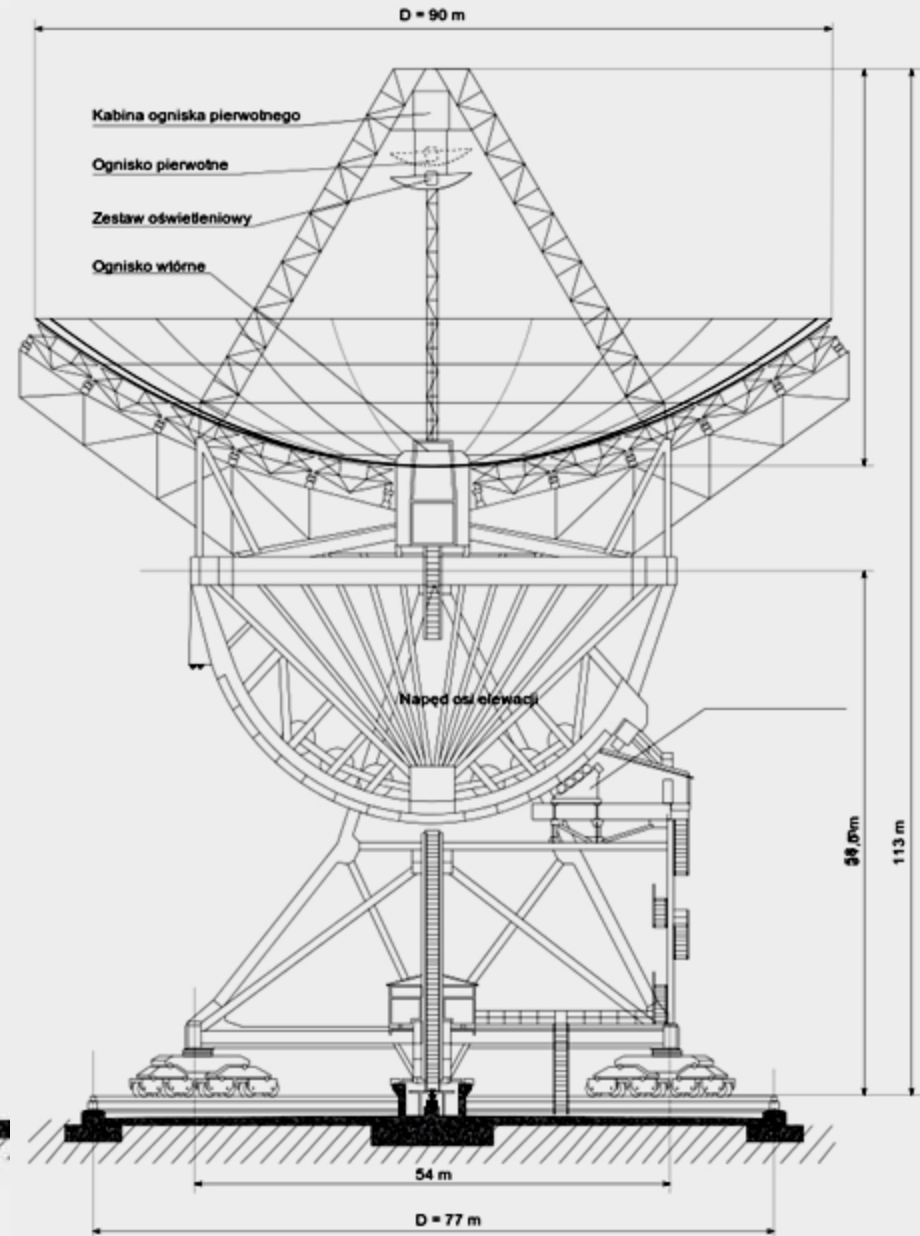
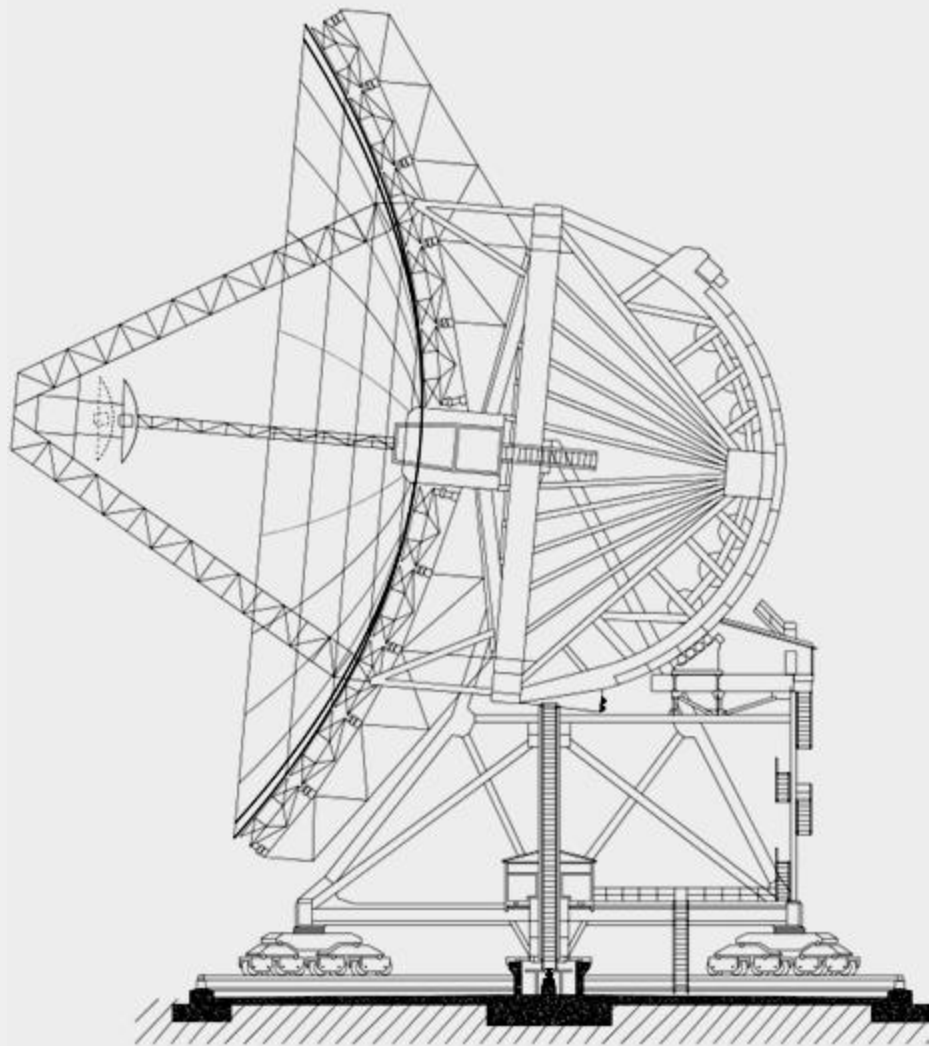
and

National Centre for Radio
Astronomy and
Space Engineering

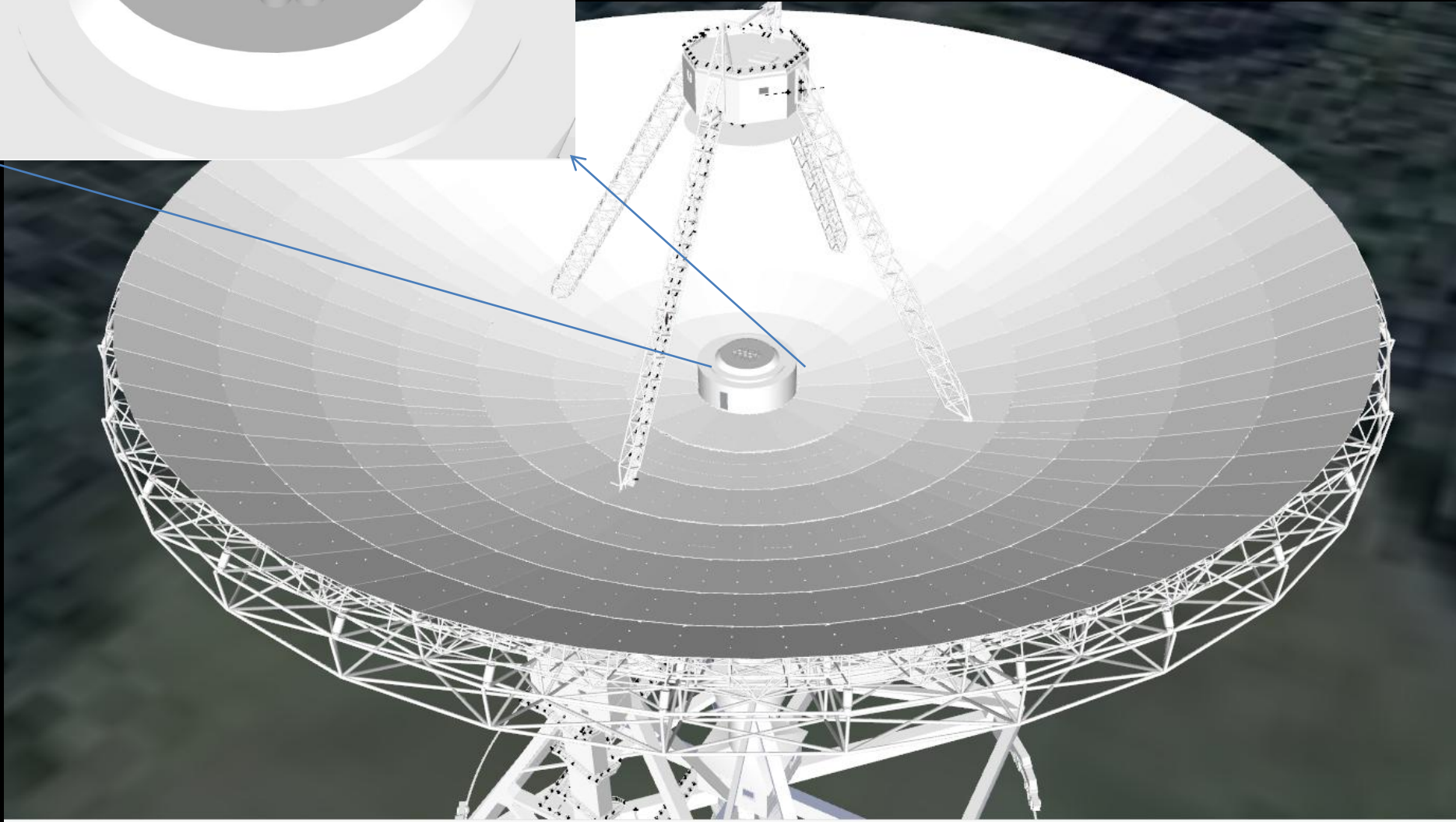
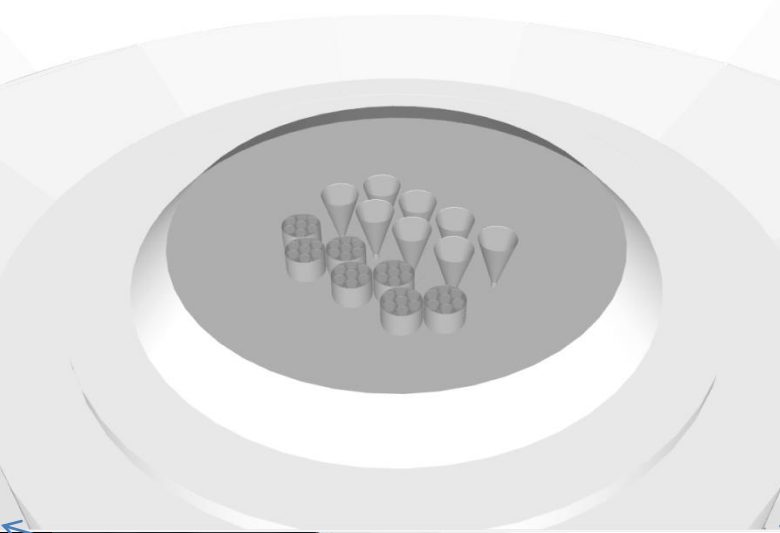
Data: SIO, NOAA, U.S. Navy, NGA, GEBCO
© 2013 Cnes/Spot Image
Image © 2013 DigitalGlobe
Image © 2013 GeoEye

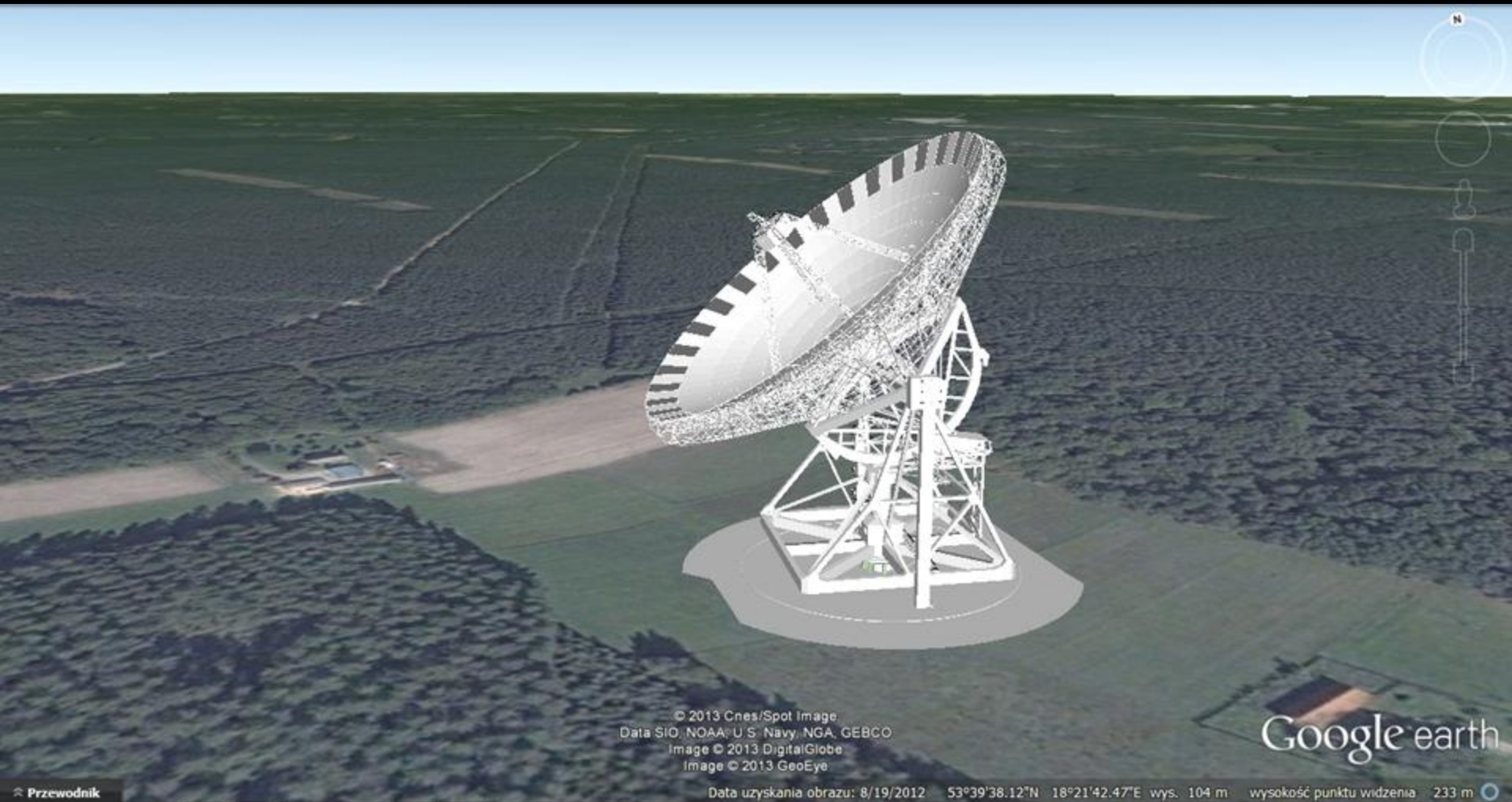
Go

The RT90+ concept is based on the RT70 design
by Eng. Zygmunt Bujakowski



RT90+ R-C type Receiver arrays





RT90+ radio telescope Dębowiec $D = 90 \text{ m}$

The 3D model was created from drawings by MSc Eng. Z. Bujakowski
by MSc Eng. Janusz Mazurek and MSc Roman Feiler of the UMK Centre for Astronomy
using Google SketchUp



Comparison of the size of RT90+ with buildings in central Warsaw

Consortium "National Centre for Radio Astronomy and Space Engineering"

established on 28 August 2012,
ceremonial signing of the consortium agreement on 6 November 2012

partners

1. Nicolaus Copernicus University (lead coordinator)
2. Gdańsk University of Technology (co-coordinator)
3. Military University of Technology - Warsaw
4. Space Research Centre, PAN - Warsaw
5. Jagiellonian University
6. University of Zielona Góra
7. Nicolaus Copernicus Astronomical Centre, PAN - Warsaw
8. Institute of Bioorganic Chemistry, PAN - Poznań (PCSS)
9. University of Technology and Life Sciences - Bydgoszcz

Postanowienia ogólne

1. Strony niniejszej umowy powołują konsorcjum pod roboczą nazwą „**Narodowe Centrum Radioastronomii i Inżynierii Kosmicznej**” (zwane „Konsorcjum” w dalszej części niniejszej umowy), którego podstawowymi narzędziami badawczymi będą: radioteleskop RT90+ (o średnicy czaszy co najmniej 90 metrów i o wstępnej lokalizacji w Gminie Osie), oraz bazy laboratoryjne przy Uniwersytecie Mikołaja Kopernika (Narodowe Centrum Radioastronomii - NCR) i Politechnice Gdańskiej (Krajowe Centrum Inżynierii Kosmicznej - KCIK).

Cele Konsorcjum

Przedmiot działalności Konsorcjum obejmuje:

1. Połączenie potencjału naukowego i technicznego instytucji członkowskich Konsorcjum dla realizacji zadań badawczych, rozwojowych i technologicznych w dziedzinach nauk technicznych, eksploracji kosmosu, transferu i przetwarzania danych oraz radioastronomii.
2. Wspólne pozyskiwanie środków finansowych na realizację przedmiotu działania Konsorcjum.
3. Stworzenie zasad powołania i funkcjonowania NCR i KCIK.
4. Koordynacja prac projektowych i realizacja budowy radioteleskopu RT90+ i obiektów towarzyszących.
5. Zaprojektowanie, budowa i uruchomienie aparatury naukowej stanowiącej wyposażenie radioteleskopu RT90+ (realizacja głównie przez UMK, PG, WAT, CBK).
6. Koordynacja i prowadzenie badań naukowych przy pomocy radioteleskopu RT90+ i bazy laboratoryjnej.
7. Podłączenie radioteleskopu RT90+ do sieci krajowej PIONIER.
8. Badania i analiza wykorzystania zaawansowanych mocy obliczeniowych do wsparcia procesu badań naukowych wykonywanych przez Konsorcjum.
9. Kształcenie i rozwój kadry naukowej.



Consortium Council

1. Professor Andrzej Tretyn, Rector of UMK (Chair)
2. Professor Ryszard Katulski, PG
3. Professor Marek Sarna, Director of CAMK PAN
4. Professor Janusz Gil (+), Vice-Rector of UZ
5. Professor Mariusz Figurski, WAT, Vice-Rector of WAT
6. Professor Dariusz Boroński, UTP, Vice-Rector of UTP
7. Professor Hanna Rothkaehl, CBK
8. Dr habil. Krzysztof Chyży, UJ
9. Dr Maciej Stroiński, PCSS
10. Professor Andrzej Kus - UMK, Consortium Director
11. Professor Zbigniew Sikora (+) - PG,
Deputy Consortium Director



Positive resolutions by:

UMK Centre for Astronomy Council
FAiS Faculty Council
UMK Senate
UMK Strategy
Regional Strategy

The "90 m Radio Telescope" investment
and its location were included in
the Ministry of Regional Development document
"National Spatial Development Concept 2030"

It is included in the "Polish Research Infrastructure Roadmap"

It is included in the "UMK Development Strategy 2011-2020"

It is included in the "Development Strategy of the Kujawsko-Pomorskie Voivodeship"

Finally the RT90+ HAD NOT BEEN FUNDED

2015 Regional European infrastructure funds cut by half

The Ministry had not supported application for funds from Brussels **2016**

Significant loss (+) of key staff involved in the project

Growing lack of support within the UMK astronomy community

Implementation of the RT90 project suspended and postponed “for the future”
far for beyond 2020

<https://www.youtube.com/watch?v=kmmKwVZFsl8>