

Radio Astronomy in Kraków

Marek Jamrozy
Marian Soida, Krzysztof Chyży
and radio astronomers from Kraków

Astronomical Observatory
Jagiellonian University

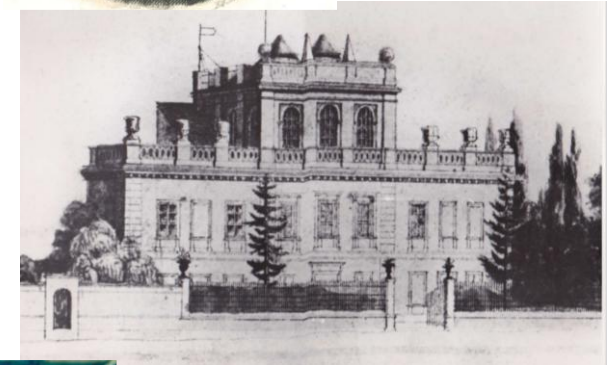
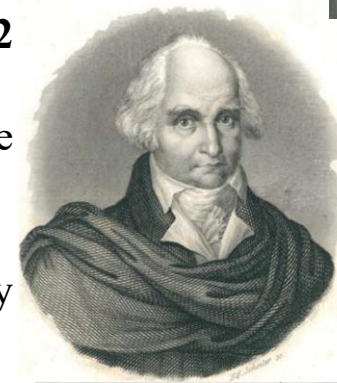
URSI-GASS Kraków 2026



Origins: Solar Patrols at Fort Skala

Where and how did this happen?

- Jagiellonian **University** 1364
- Nicholas **Copernicus** studied in Cracow **1491-95**
 - his instruments - Collegium Maius Museum
- **Astr. Observatory** was founded at the Jagiellonian Univ. in **1792** by Jan Śniadecki (mathematician and astronomer)
- Original Jesuit collegium building was adapted into the Astronomical Observatory (now botanical garden, Kopernika str.)
- XVIII century – Poland lost its independence (stagnation)
- In 1918, Poland became a free country, but it was severely devastated
- Prof. **Tadeusz Banachiewicz** – director 1919-39, 1945-54;
 - libration of the Moon, variable stars – measuring light curve minima, publishing ephemeris, celestial mechanics - trajectories of comets (Banachiewicz-Olbers method), solar occultations, discovering comets: C/1925 Orkisz comet
- After WWII Polish astronomy had to rebuild itself



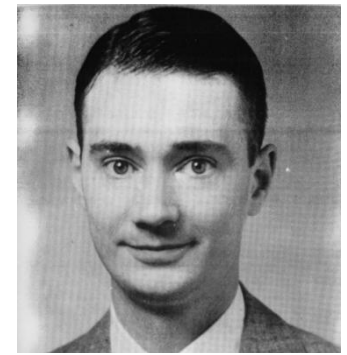
The trigger: Grote Reber's paper and a decision to try radio astronomy

In the early 1950s Tadeusz Banachiewicz gave Adam Strzałkowski a paper by Grote Reber (1940).

It stimulated discussions at the university and led **Adam Strzałkowski**, **Oleg Czyżewski** and **Jerzy de Mezer** to begin building a radio telescope (1950s).



Prof. Tadeusz Banachiewicz
1882-1954



Grote Reber (1911-2002)



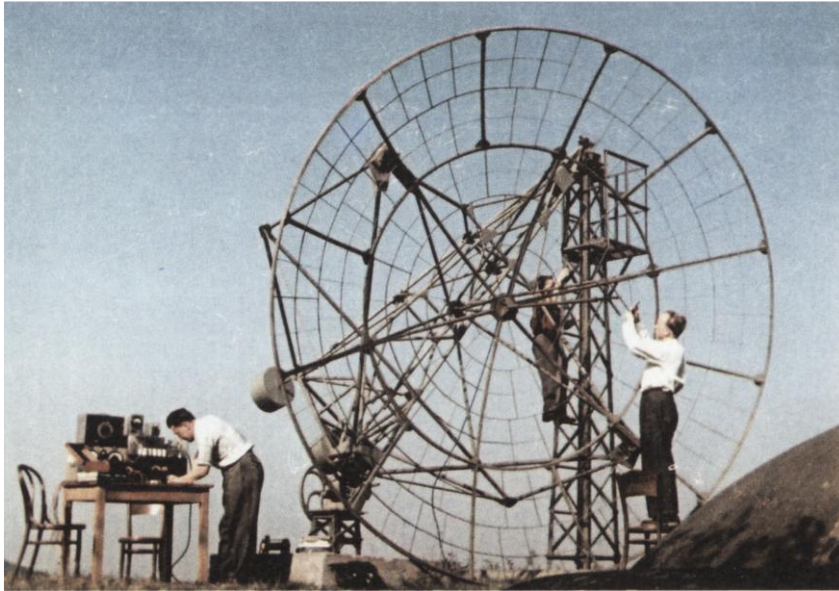
A single paper
helped open a new
observational
window in Kraków



Fort Skala: an old military fort, a relic from the days of the Austrian Empire, becomes a radio observatory

The first Polish scientific radio observations

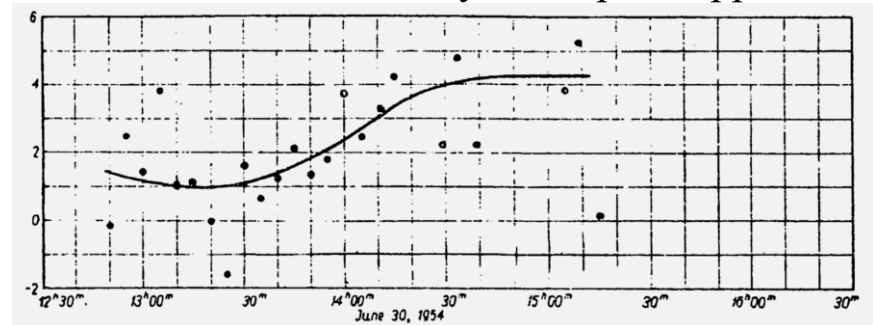
30 June 1954, (total) solar eclipse



From left Czyżewski, Strzałkowski and de Mezer – they start up the apparatus

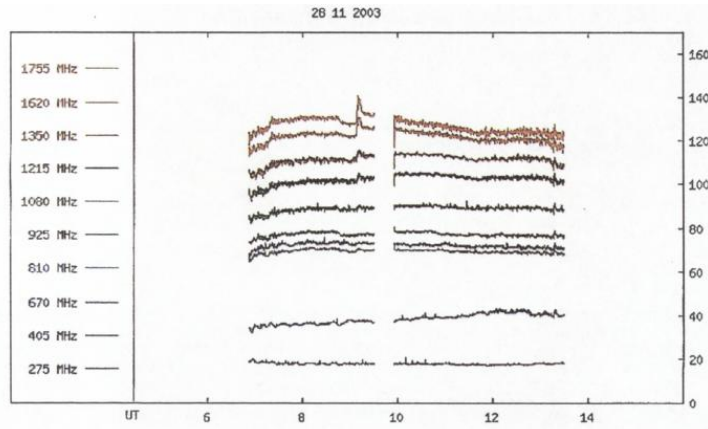


30 June 1954

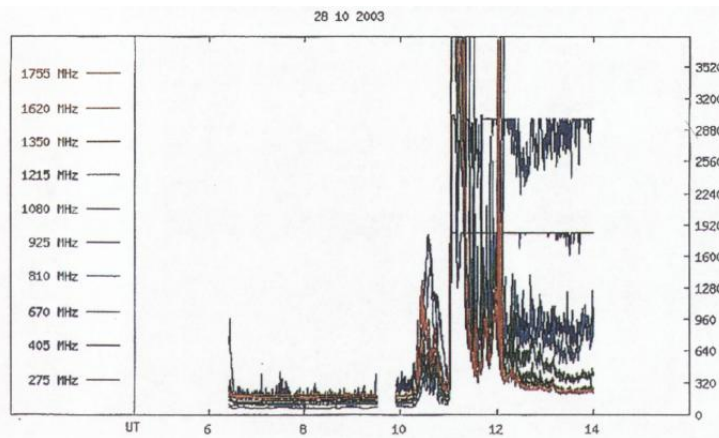


These were the first radio-astronomical observations (332 MHz) made in Poland using equipment specifically designed for that purpose!

Solar patrol: from 5m to 8m, from 1 to 10 frequencies



A recording of the radiation pattern of the quiet Sun on November 28, 2003, at multiple frequencies

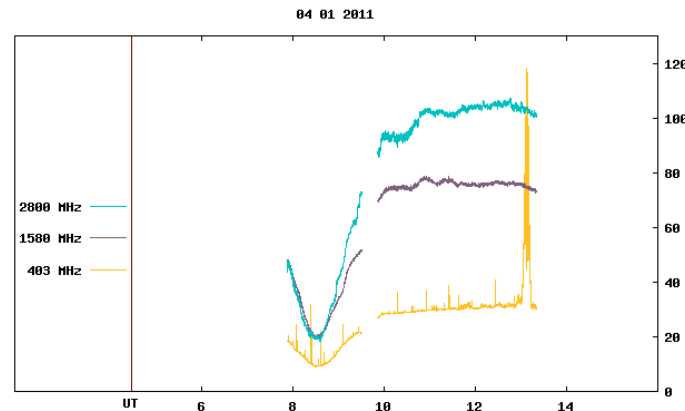


The Sun's eruption, October 28, 2003, featuring the strongest radio burst in the history of observations

Statistical analysis of variations of the basic component of solar radio emission and broad band solar radio bursts – series of papers 1959 (e.g. Acta Astronomica, Monthly Report on Solar Radio Emission)



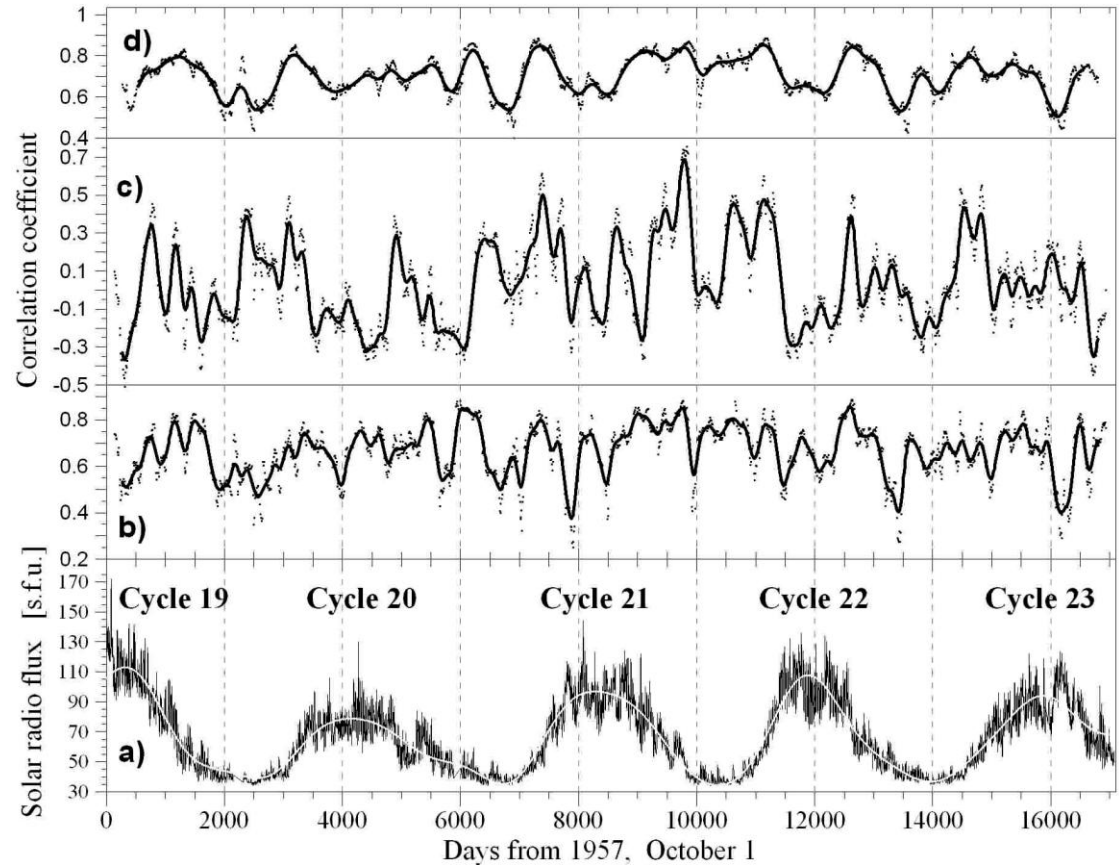
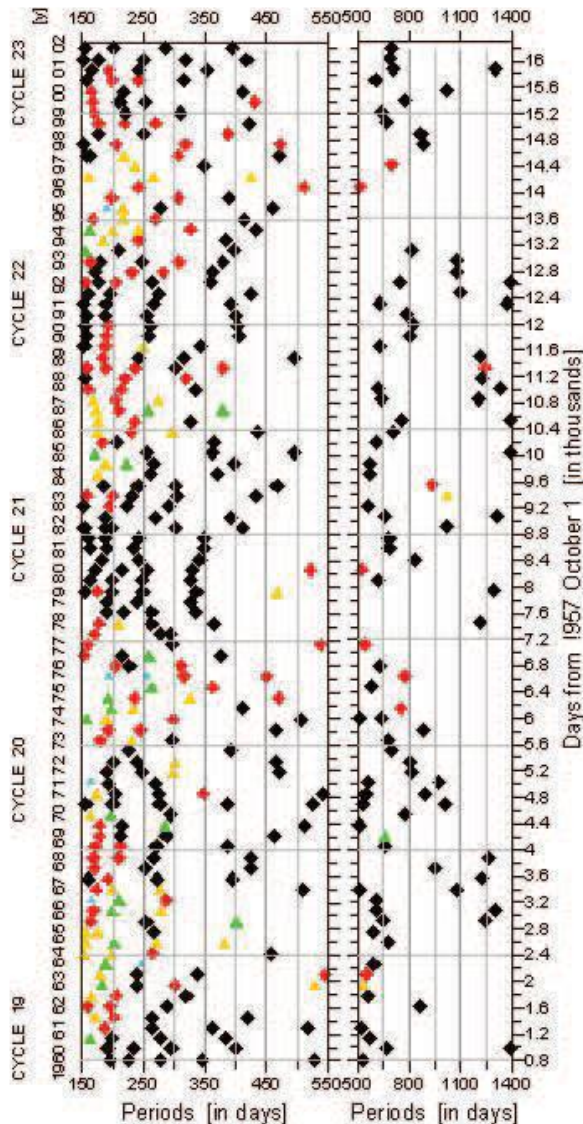
In 1995, a new solar radio telescope (8m) was established.



Partial solar eclipse, January 4, 2011

Harmonic analysis of time variations observed in the solar radio flux measured at 810 MHz from 1957 to 2004

S. Zięba, J. Masłowski, A. Michalec, G. Michałek, and A. Kułak, 2006, ApJ 653, 1517



- Correlation coefficients between the radio emission at 810 MHz and sunspot numbers depend on the solar cycle phase.
- Detected various harmonics which form “impulses of solar activity”

Expansion: Galaxies, Magnetic Fields and International Collaborations

New instrument: 15m radio telescope

- 1964 - 600th anniversary of the founding of Jagiellonian University – Oleg Czyżewski – **let's build a telescope!**
- Prof. Masłowski played a key role in equipping of the 15-meter radio telescope, **installed in 1968**
- It used the receiver with a parametric amplifier at 1300 MHz
- Marks transitions from solar patrols to broader radio astronomy
- Now used by students



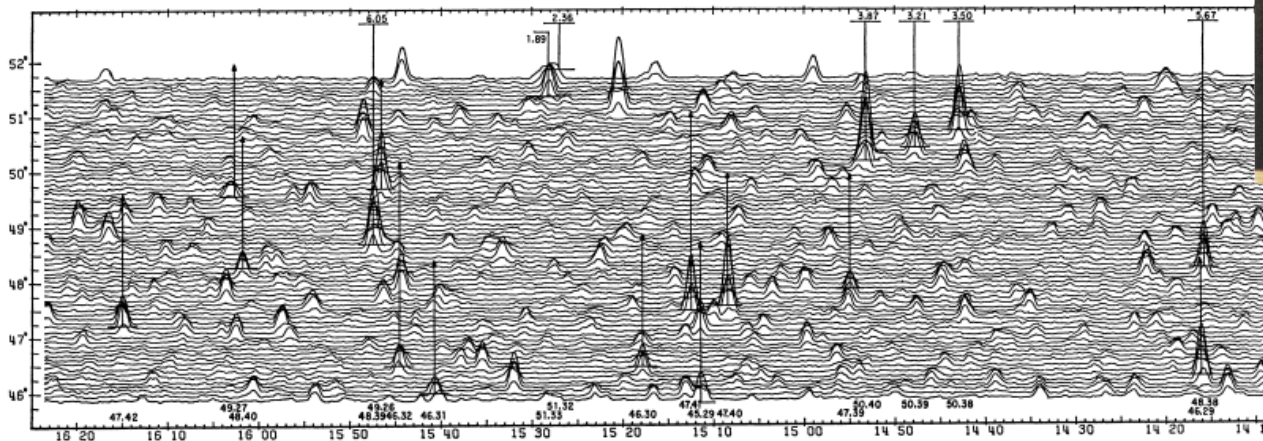
The 15-m dish with its Cassegrain focus

Józef Masłowski and international opening

1971/72 - 15 month stay of Józef Masłowski at the NRAO, Green Bank Observatory (invitation from the Director of NRAO, David S. Heeschen)

- The first major radio survey RA $7^{\text{h}}19^{\text{m}}$ - $16^{\text{h}}24^{\text{m}}$, Dec 45.7° - 51.6° (J2000.0; 521 sq degr) the sky with the NRAO 300-foot radio telescope at the frequency of 1.4 GHz with a beam of $10.3' \times 11.1'$ (the GB, GB2, and GB3 surveys) to detect faint radio sources and to obtain complete samples for statistical studies and investigations of their cosmological evolution.
- 1086 sources above 90 mJy and among them 821 sources were previously uncatalogued
- The counting showed anisotropic distribution of radio sources
- in space – now called the 'cosmic web'
- Kraków radio astronomy begins using the world's leading instruments

GB survey at 1.3 GHz (series of papers (Masłowski, 1971-1974)



Professor Józef Masłowski
(1931–2020), Director of
the Observatory 1979–
1984 and 1989–1999



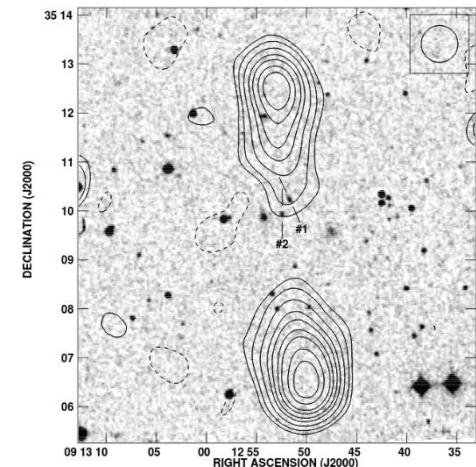
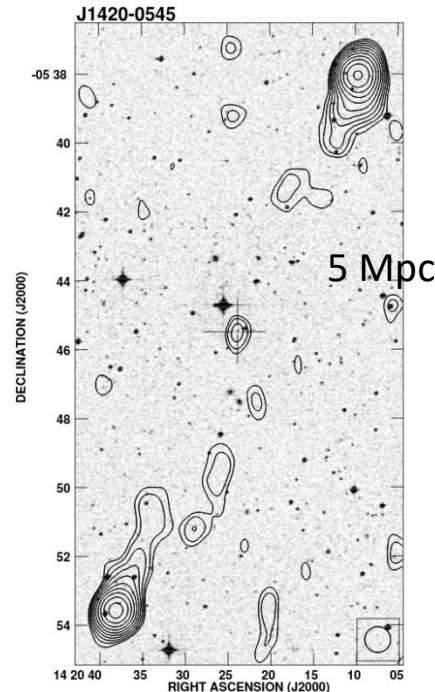
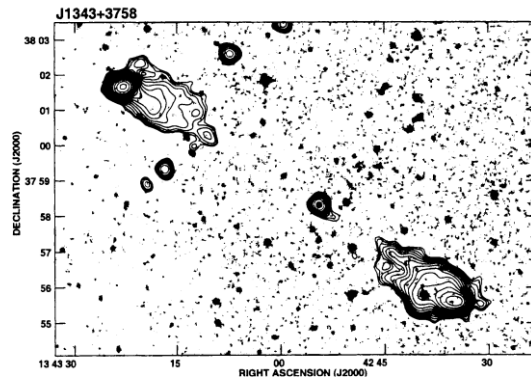
New surveys and new directions

New surveys were defined by **Jerzy Machalski** (**GB2** (1978) and **GB3** (Ryś and Machalski 1987) and observed with 300-foot telescope

The Very Large Array (VLA) was used to map the structures of radio sources: Machalski and Condon in the GB, GB2, and 5C6 regions (1982, 83, 85, 86, 90)

- Studies of variability of sources in complete samples (Ryś and Machalski 1987)
- Cosmological evolution of sources (with J Condon, 1999; and W. Godłowski, 2000)

Research on giant radio sources has become one of the main areas of research in Kraków (Machalski, Jamroz, et al.)



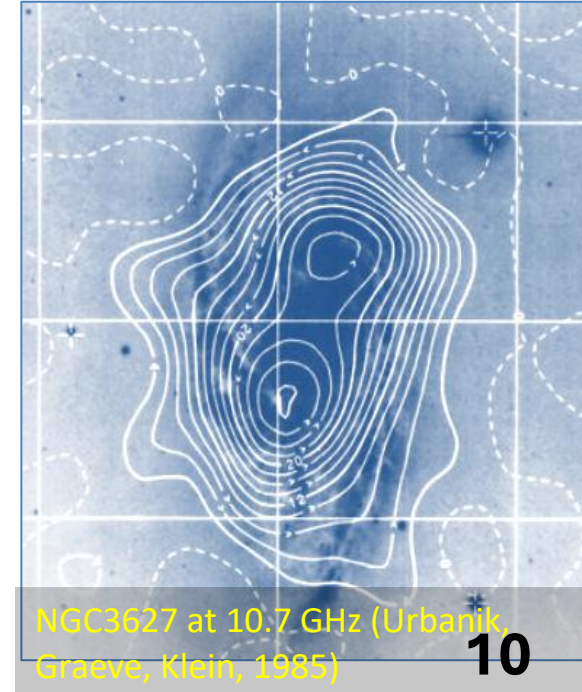
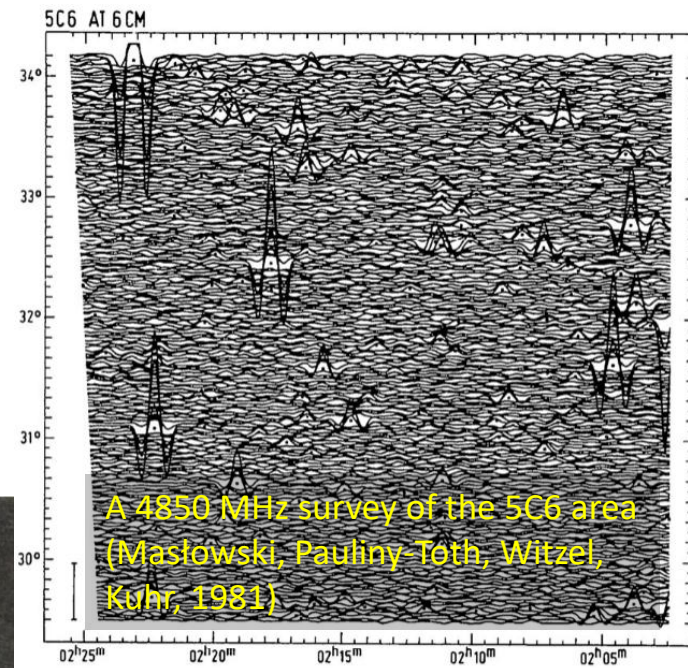
100m telescope – new collaborations

The world's largest, fully movable radio telescope in Effelsberg was used by Józef Masłowski in 1976 and 1978 to map GB, GB2 and some 5C sources at 4.8 GHz for spectral properties and cosmological studies.



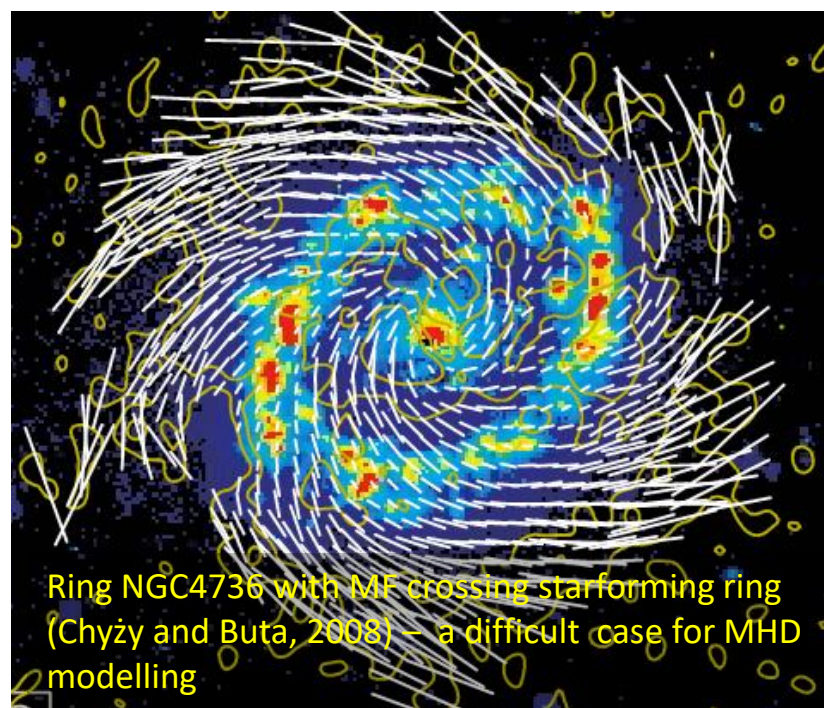
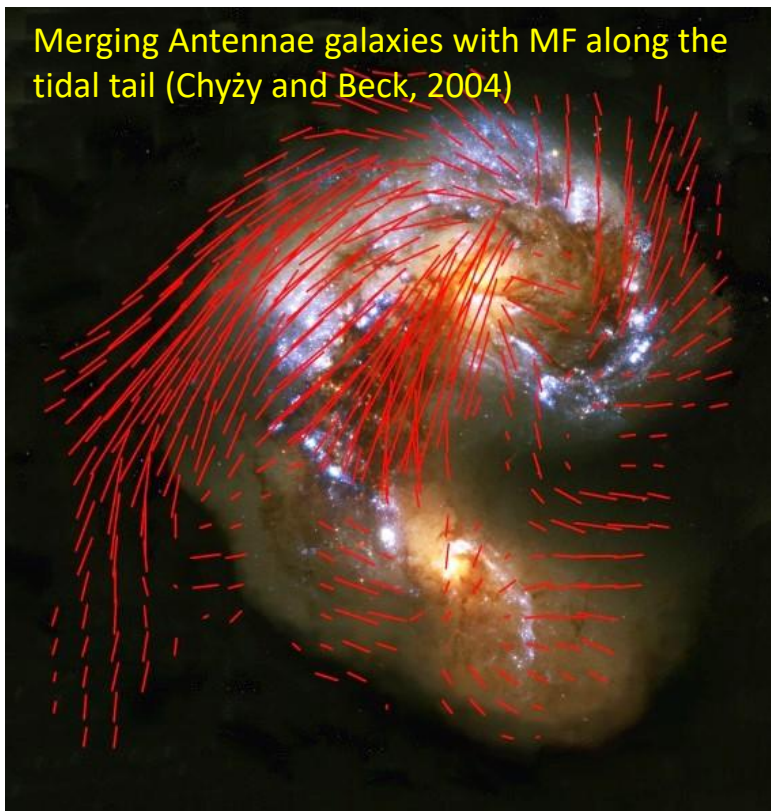
This radio telescope was also used by **Marek Urbanik** since 1980 (invitation from prof. **Richard Wielebinski**)

- Survey of galaxies at 10.7 GHz (with Uli Klein, Rolf Greave, 1981-1985)
- Detection of helical MF in several spirals (1994)
- Attempts to determine the structure of their magnetic field from polarized emission (e.g. NGC253, with R. Wielebinski, R. Beck, 1984)
- Then, **Marian Soida** and **Krzysztof Chyży** were invited (1999) to continue the collaboration
- **Jacek Knapik**, **Marek Jamrozy**, **Marek Weżgowiec**, **Błażej Nikiel Wroczyński** also used the Effelsberg telescope in the near future



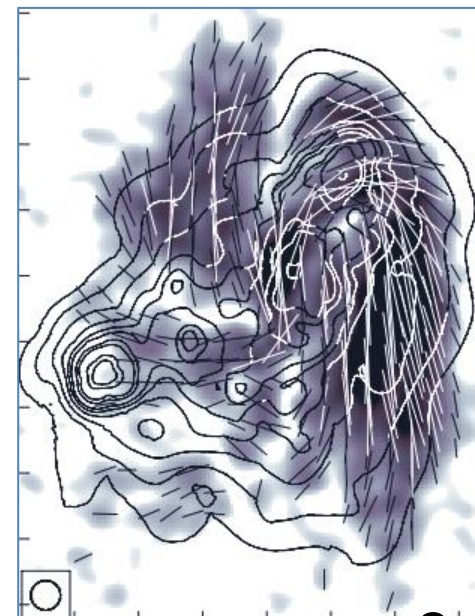
Revealing magnetic field structures in perturbed galaxies

Merging Antennae galaxies with MF along the tidal tail (Chyży and Beck, 2004)



Ring NGC4736 with MF crossing starforming ring (Chyży and Buta, 2008) – a difficult case for MHD modelling

XMM-Newton X-ray observations of NGC 3627 with polarized radio emission in the Leo Triplet galaxy group to explain peculiar features visible in the polarized radio maps (Marek Weżgowiec, Marian Soida and Dominik Bomans, 2012)



NGC3627 X-rays and polarized ridge

Discovering regular magnetic fields in a dwarf irregular galaxy NGC4449

NGC4449 - nearby irregular, 5x smaller, 8x less massive than the MW

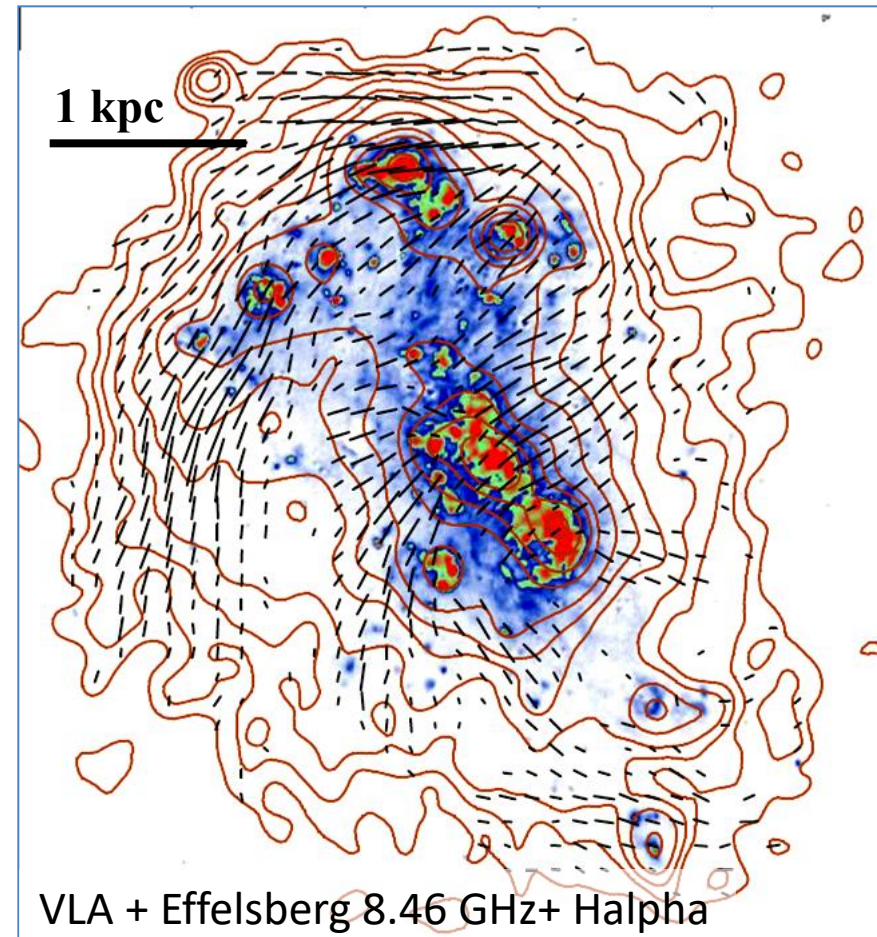
Despite the slow and chaotic rotation, unfavourable for classical dynamo-induced magnetic fields, it possesses strong **regular, galaxy-scale fields**.

$$B_{\text{tot}} = 14 \mu\text{G}!$$

$$B_{\text{reg}} = 7 \mu\text{G}!$$

Partly spiral with magnetic fans in the centre

Fast dynamo, driven by e.g. cosmic rays is needed!



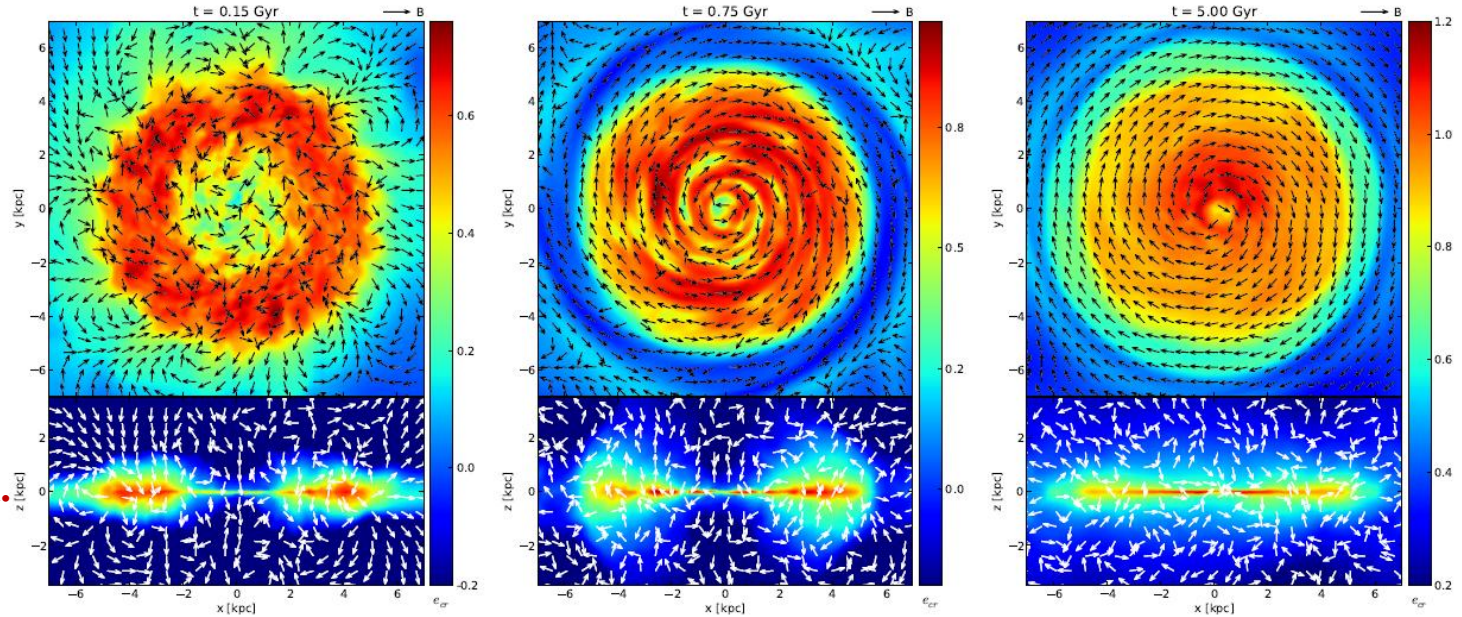
Krzysztof Chyży, Marek Urbanik in collaboration with Rainer Beck (MPIfR, Bonn), and Uli Klein (Bonn Univ.), 2002

MHD galaxy modeling with strong collaboration with theorists and observers



(1957–2020)

Dwarf gal.
IC 10

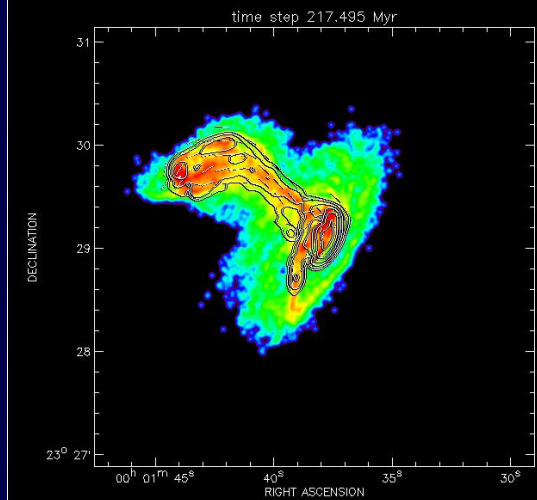
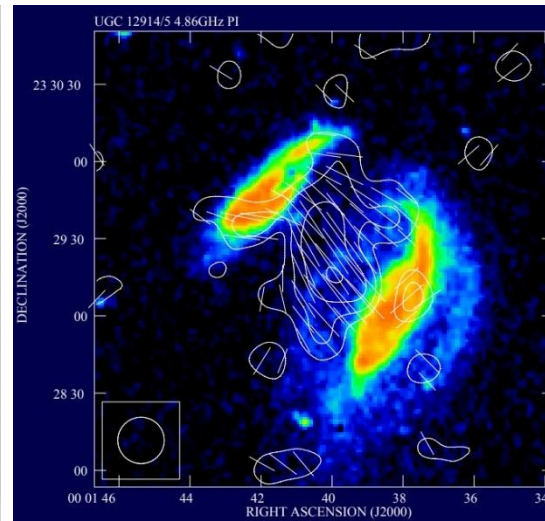
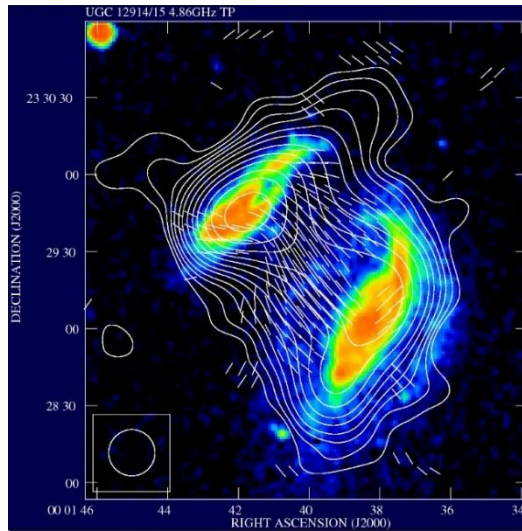


Siejkowski, Otmianowska-Mazur, Soida, Hanasz (2014)

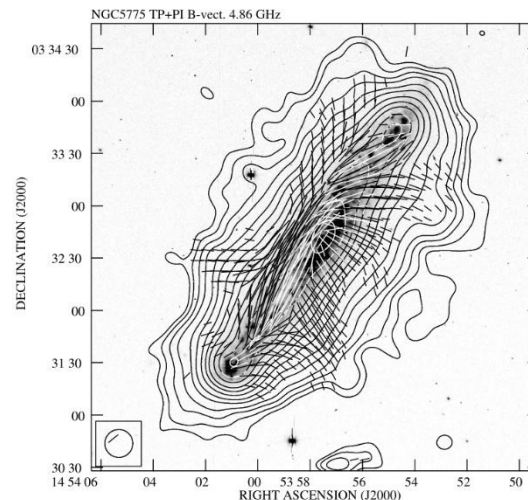
Cosmic-ray-driven dynamo in galactic disks and magnetic reconnection, new MHD models:
Katarzyna Otmianowska-Mazur, Natalia Nowak, Hubert Siejkowski, Marian Soida, in collaboration with Grzegorz Kowal (Sao Paulo), Alex Lazarian (University of Wisconsin), Detlef Elstner (Potsdam Univ.), Michał Hanasz (NC Univ. in Toruń), from 1995

Many joint conferences emerged from this cooperation of theorists and observers

Collaboration with the group at Bochum and Strasbourg



A dynamical model for the **Taffy galaxies UGC 12914/5**
Vollmer, Braine, Soida, 2012, A&A, 547, 39



The large scale
magnetic field
structure of **NGC 5775**
Soida, Krause,
Dettmar, Urbanik
2011

The Network Era: LOFAR, SKA and Beyond

Łazy (Jag. Univ.)



LOFAR and POLFAR: Kraków in the network era

In 2007, K. Otmianowska Mazur, K. Chyży, M. Soida, M. Urbanik, M. Jamroz et al. started efforts to build (together with several other institutes in Poland) LOFAR stations in Poland

June 2010 – Polish Roadmap for Research Infrastructures

2013 – funding from Ministry of Science and Higher Education

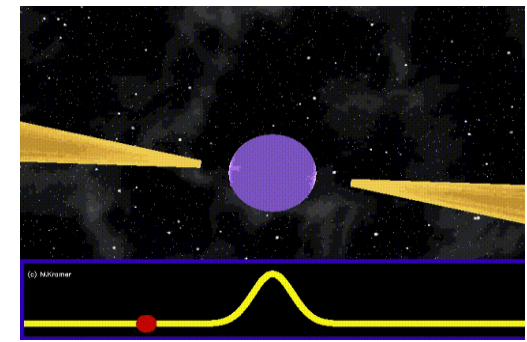


<https://www.oa.uj.edu.pl/lofar>

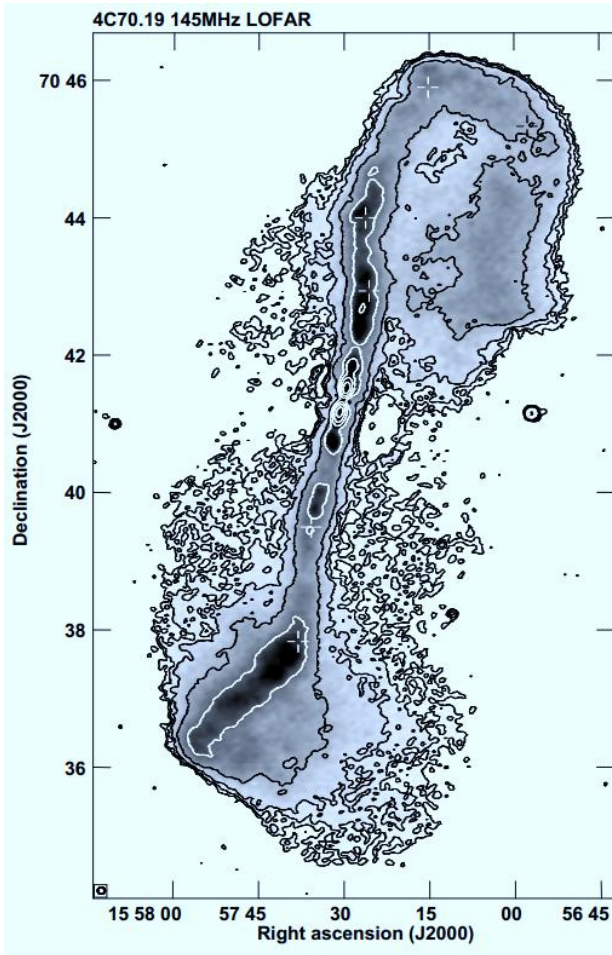
In 2015, we successfully joined International LOFAR Consortium with the Jagiellonian Univ. station in Łazy PL611, now LOFAR ERIC consortium

Modern science with LOFAR

An example of multiwavelength study of an extended **powerful radio galaxy** 4C 70.19 with a "hook" (LOFAR, VLA, Effelsberg) (Marek Weżgowiec et al. 2024)

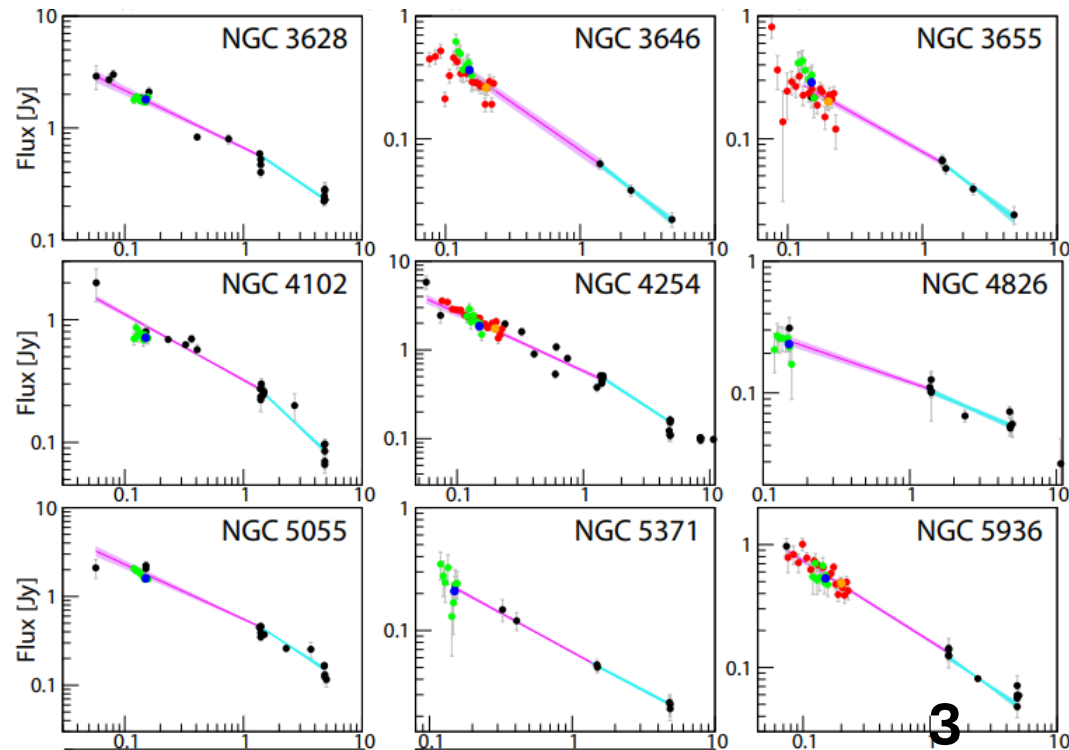


We use **LOFAR station in Łazy** to explore scattering of pulsars in the ISM (PhD student Iga Drogosz, K. Chyży and Wojciech Lewandowski, Univ. of Zielona Góra)



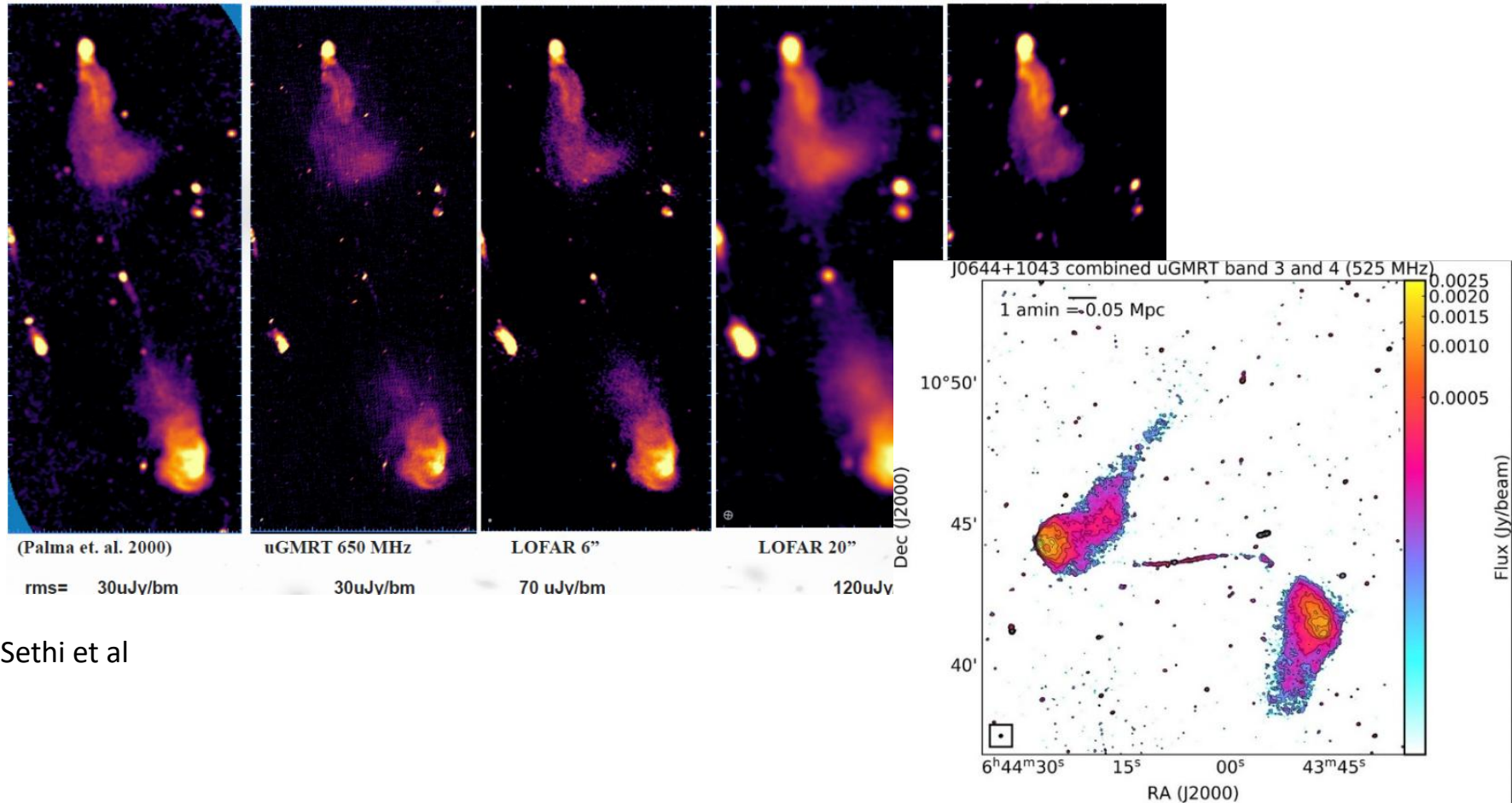
First LOFAR shallow survey of **normal galaxies** with radio spectra, (Chyży, Jurusik, Piotrowska et al. 2018)

The observed flattening is not due to thermal absorption, contradicting the suggestion of Israel & Mahoney (1990)



GMRT array in India

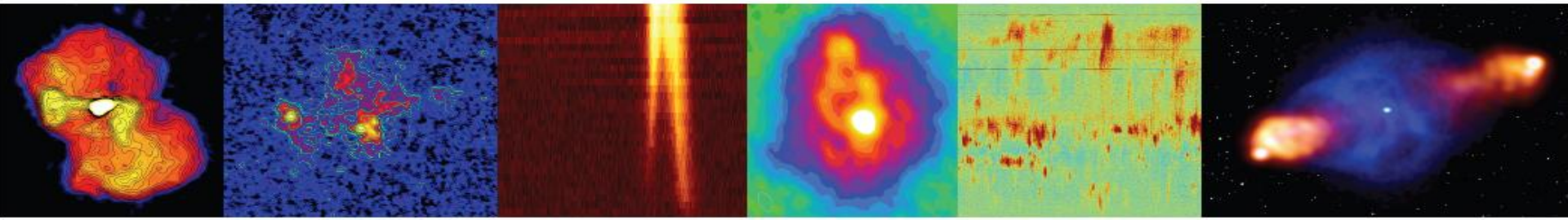
Multi-frequency radio continuum maps of this 2.9 Mpc GRG from our dedicated LOFAR, uGMRT and VLA observations



Sethi et al

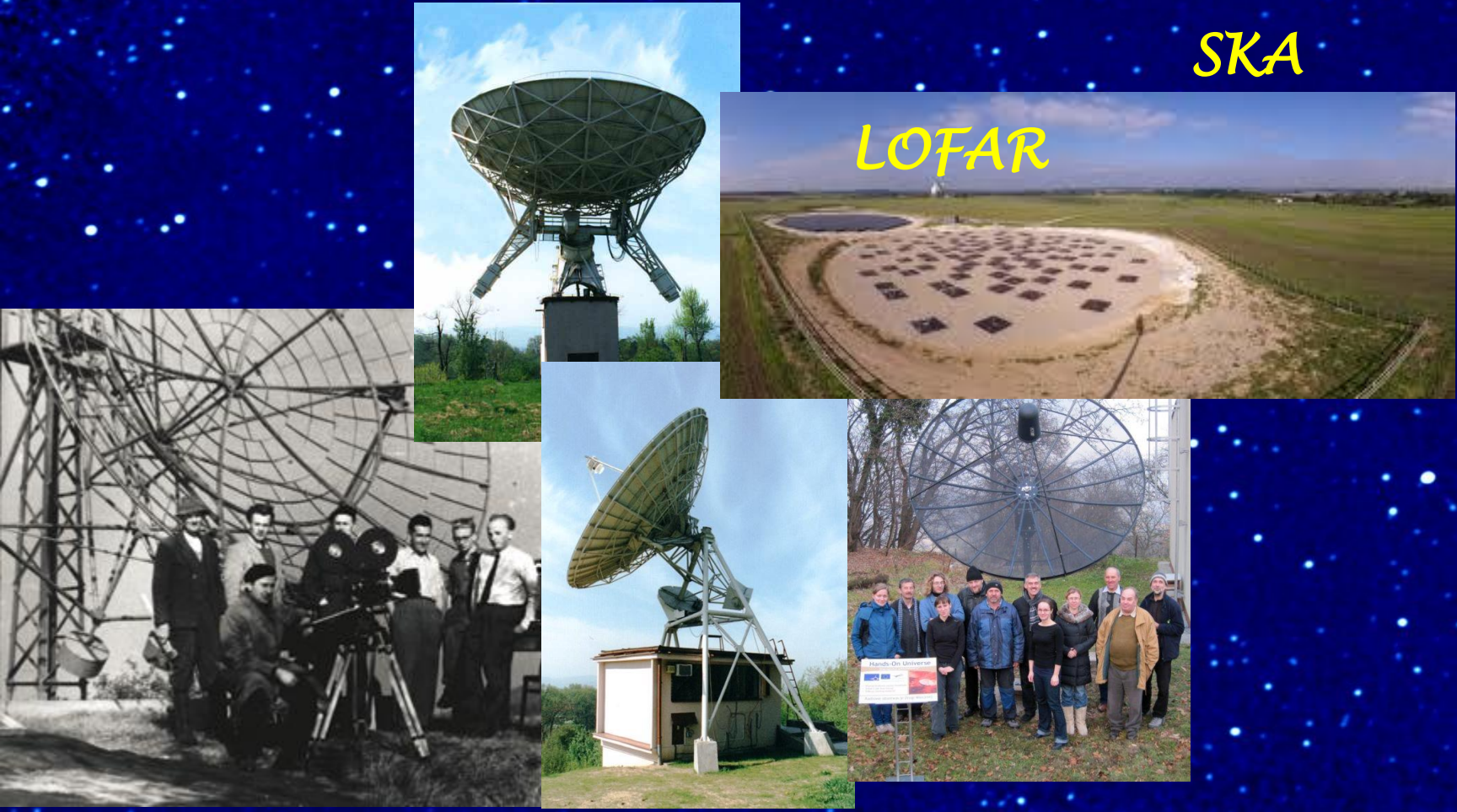
Kraków radio astronomers have been using the GMRT since the early 2000

From Fort Skala to LOFAR and beyond



SKA

LOFAR



We also enjoy promoting radio astronomy

- Connecting classrooms to the Milky Way – by 3m dish – HI observations by Internet, ”looking for dark matter” at school

<https://www.oa.uj.edu.pl/hou/>



- Radio Meteor Station – online on youtube – many satellities and meteors

<https://www.youtube.com/@RadioMeteors>

