Radio Astronomy

the Challenge for Science and Technology

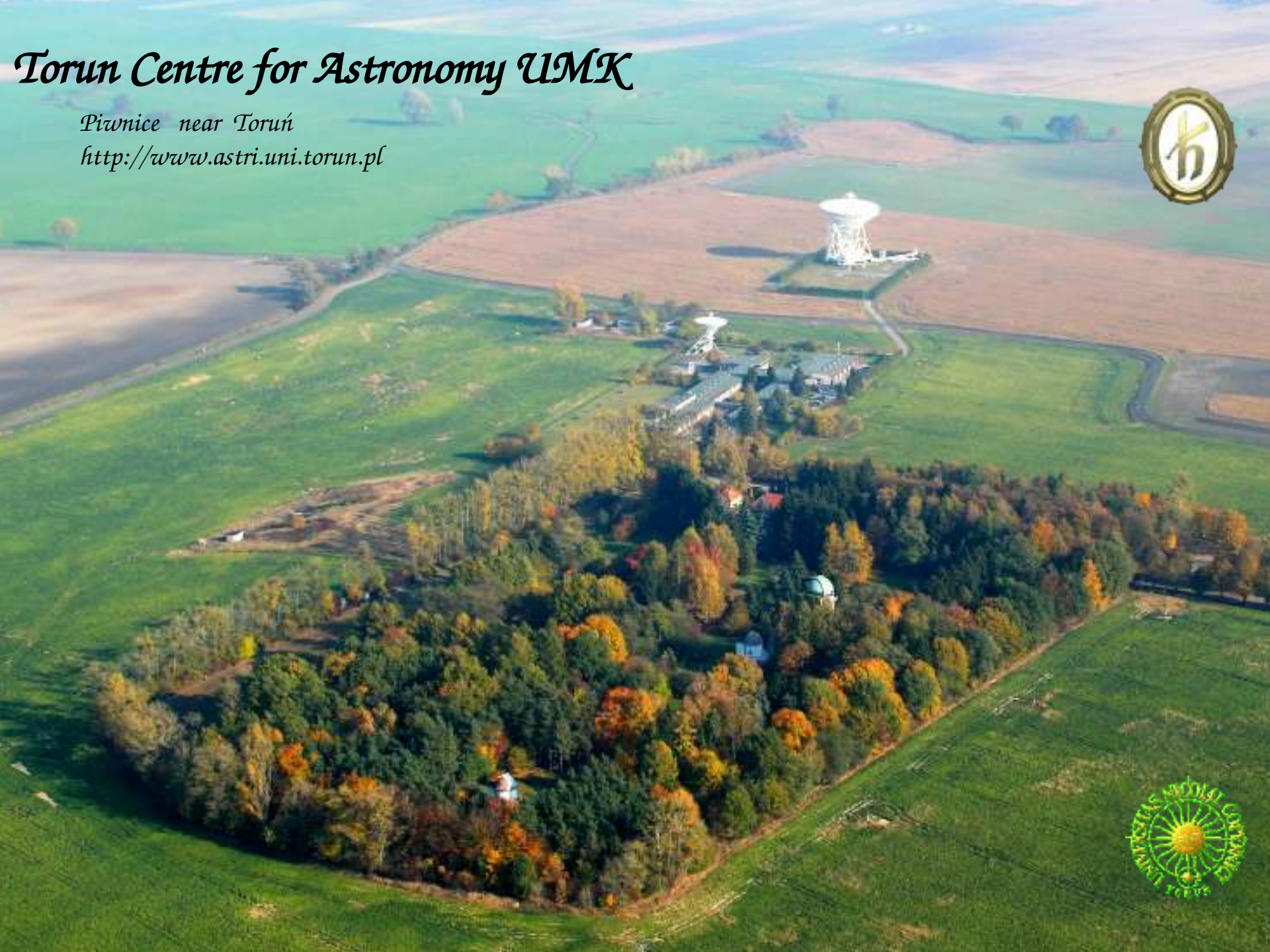
Place and Role for Poland

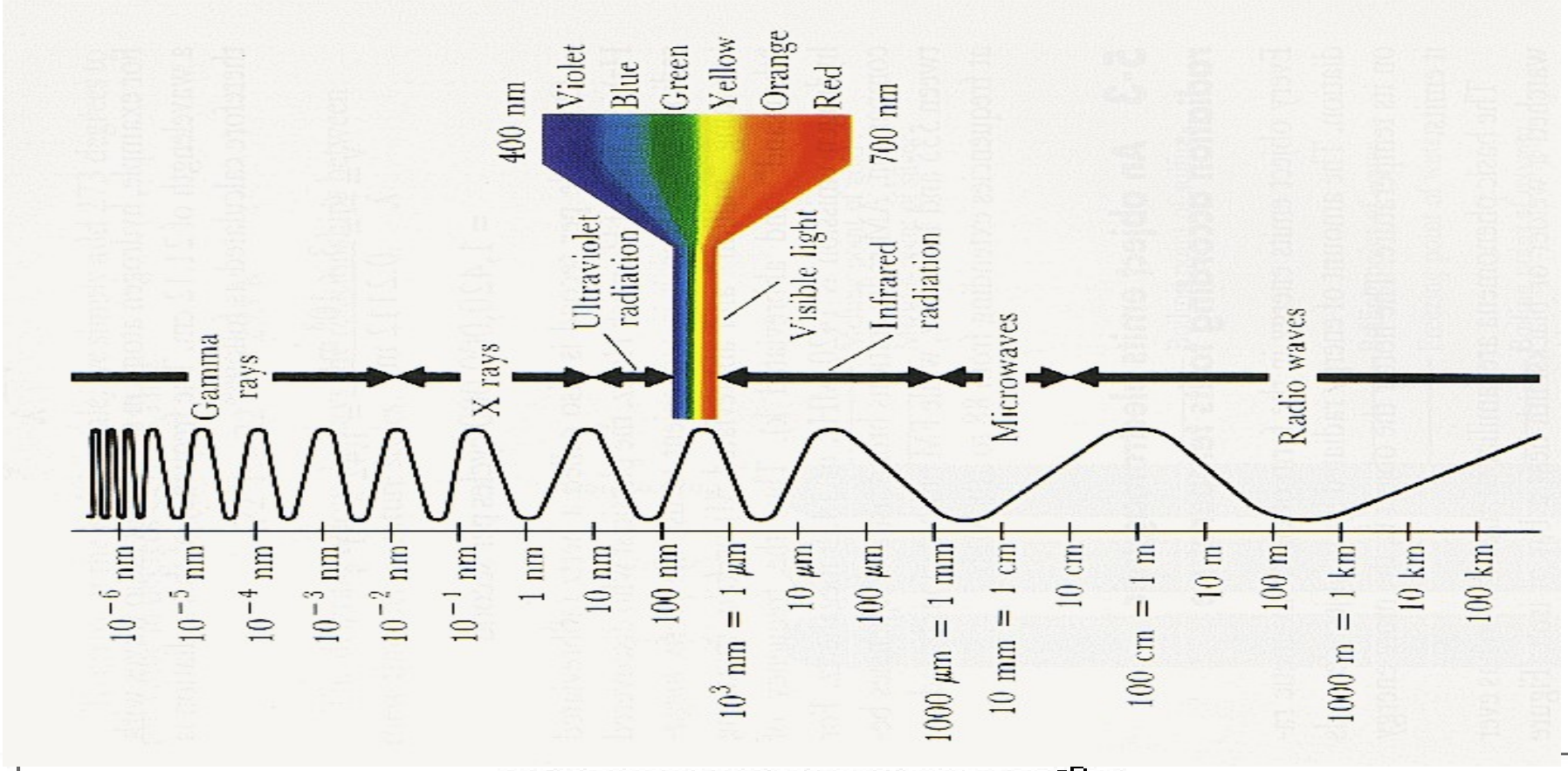
Andrzej Kus, Torun Centre for Astronomy, NCU

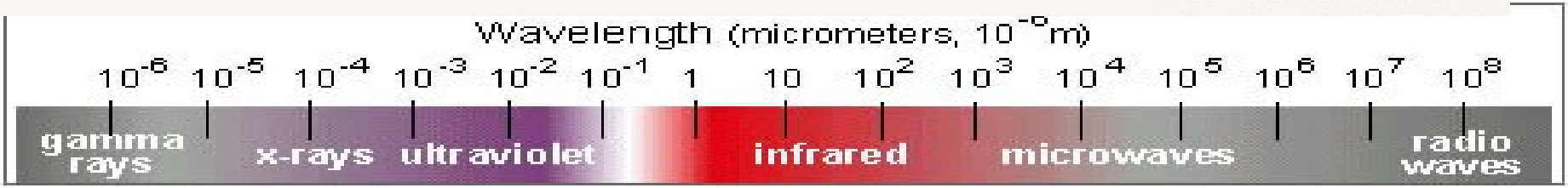
Torun Centre for Astronomy UMK

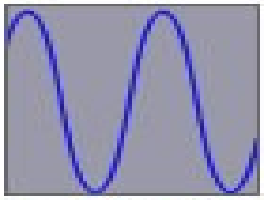
Piwnice near Toruń

http://www.astri.uni.torun.pl

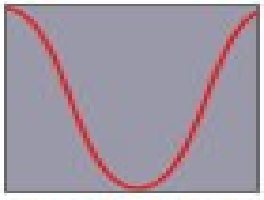




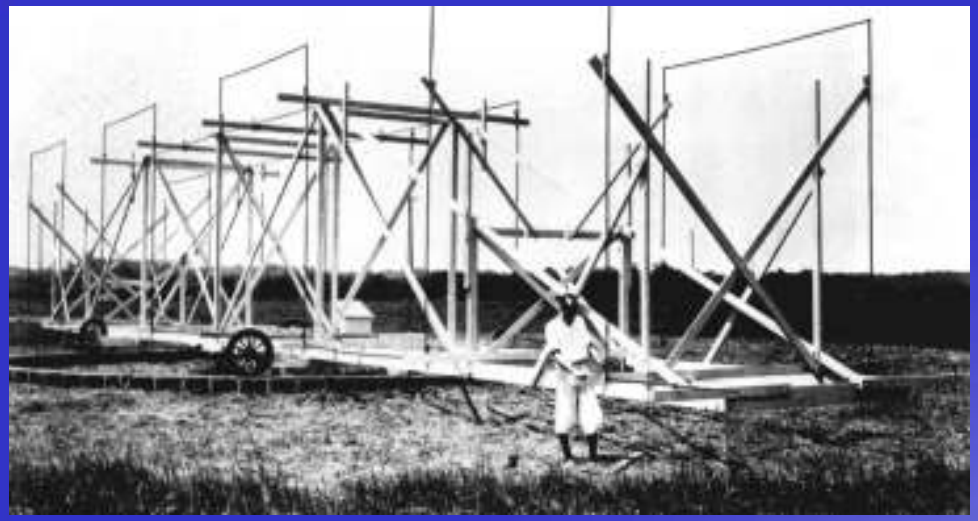




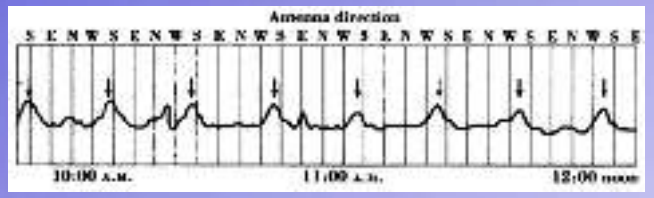
Short wavelength
High frequency
High energy



Long wavelength
Low frequency
Low energy

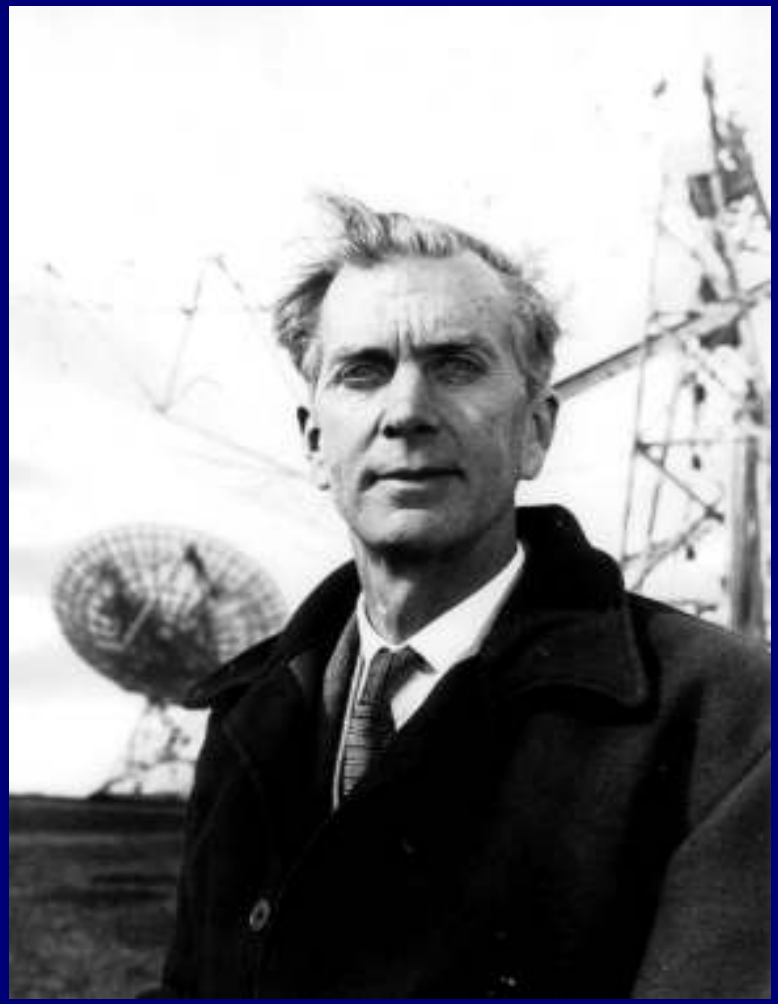


Karl Jansky (1901-1984)



Pioneers of Radio Astronomy

Grote Reber (1905-2007



Sir Martin Ryle

Sir Anthony Hewish

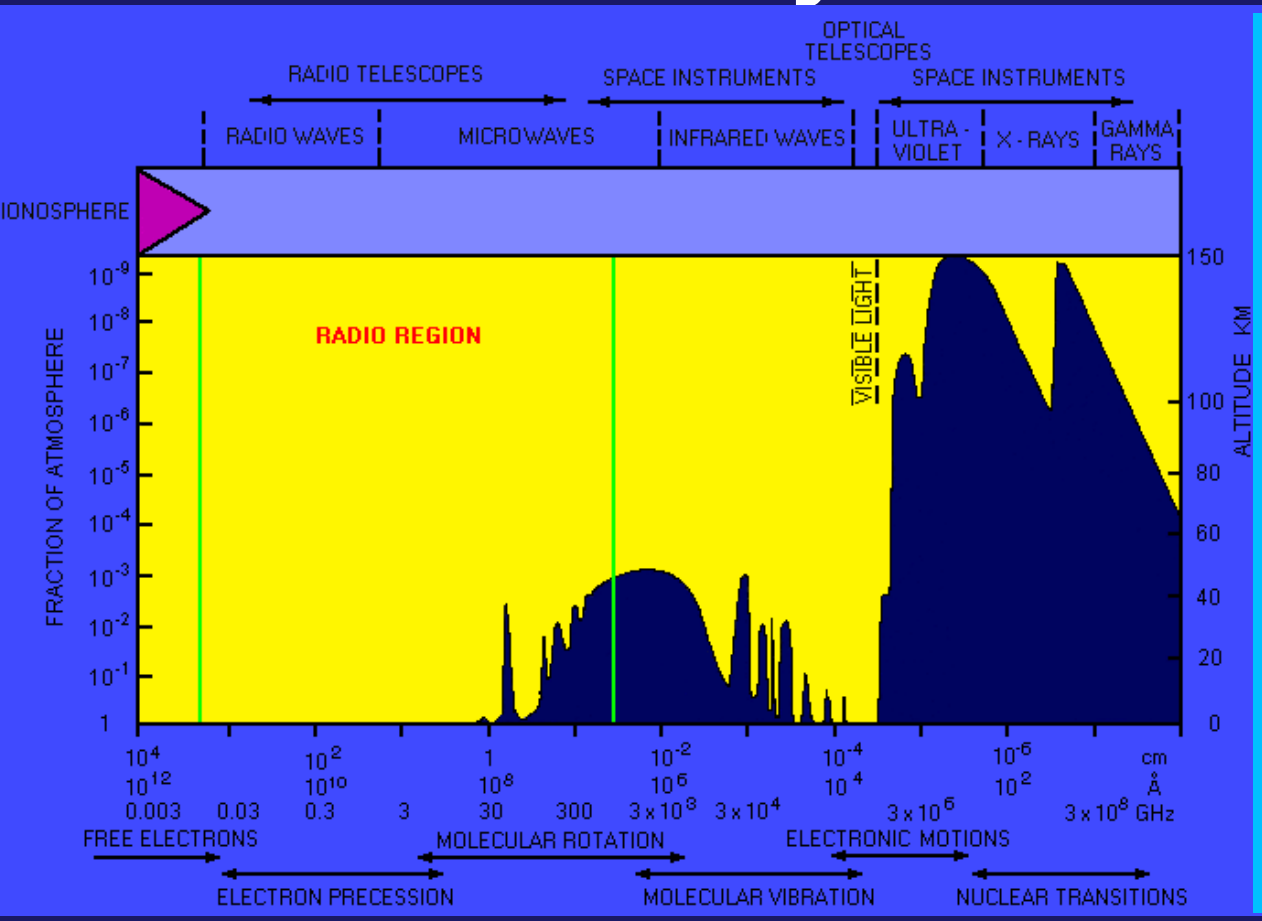
Mullard Radio Astronomy Observatory, Cambridge University, England

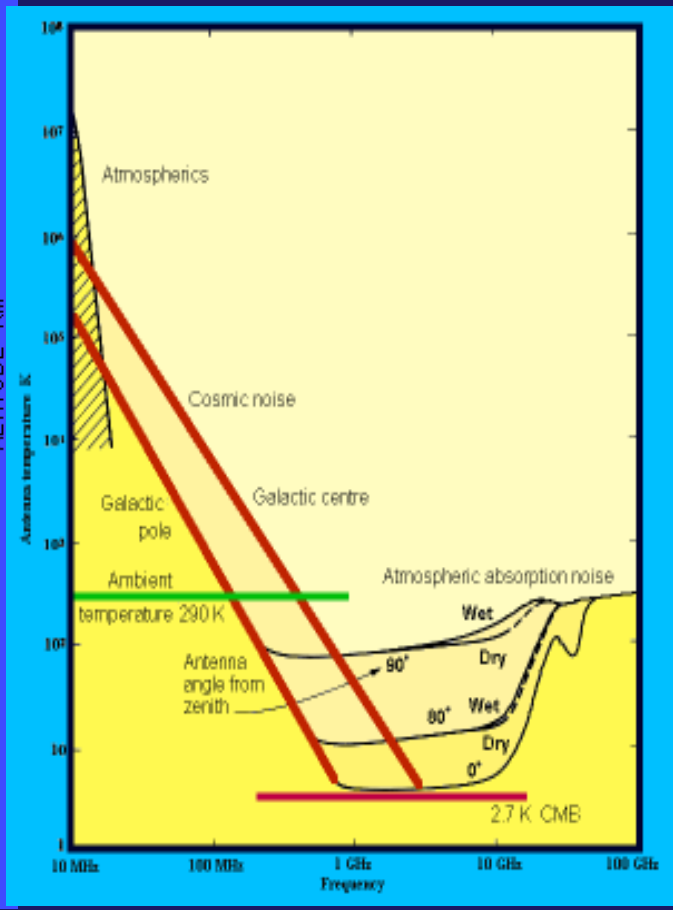
Prof. Wilhelmina Iwanowska
(1905 – 1999)

Prof. Stanisław Gorgolewski
(1926 -2011)

Radio Astronomy

- spectrum
- limitations

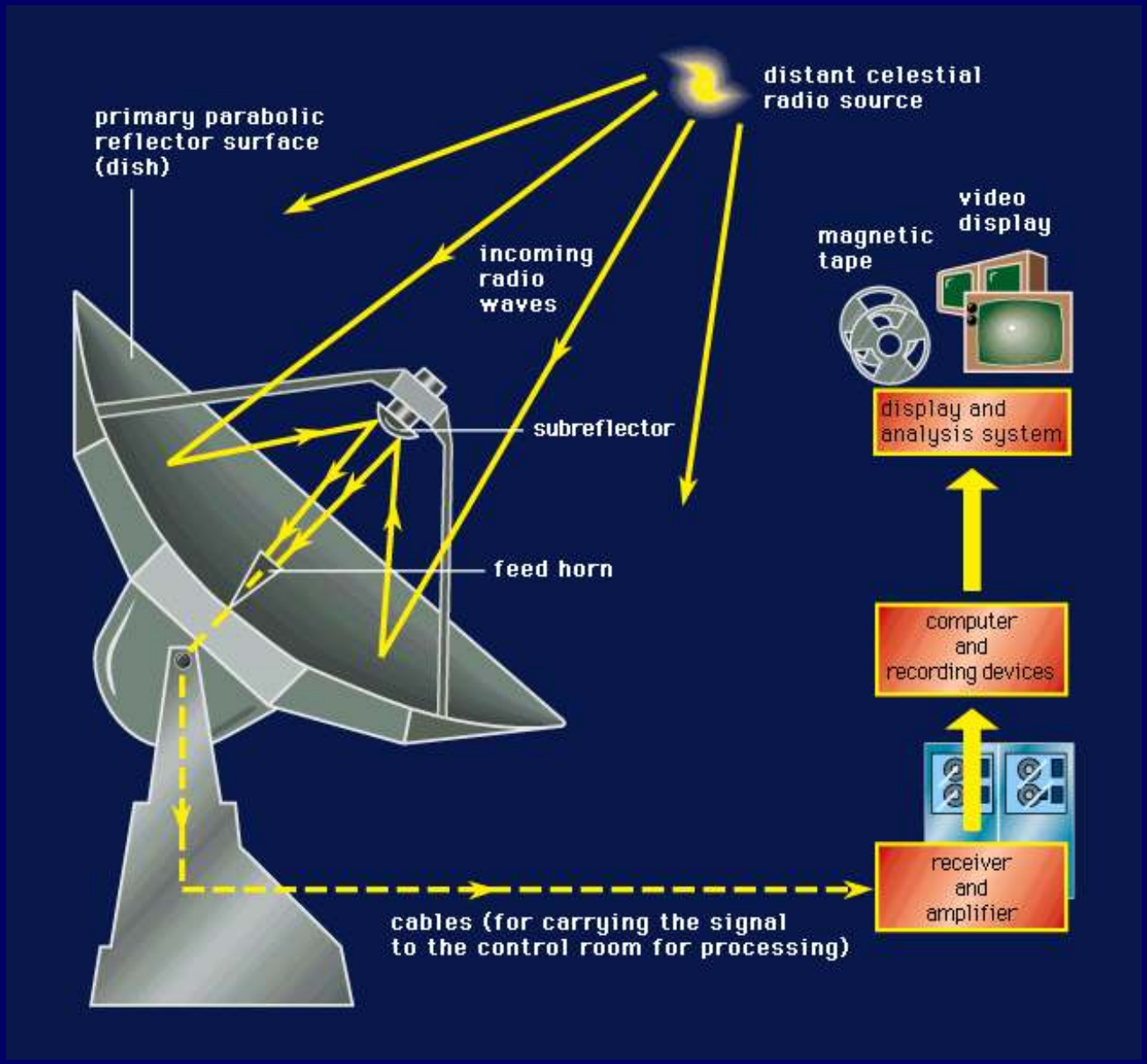


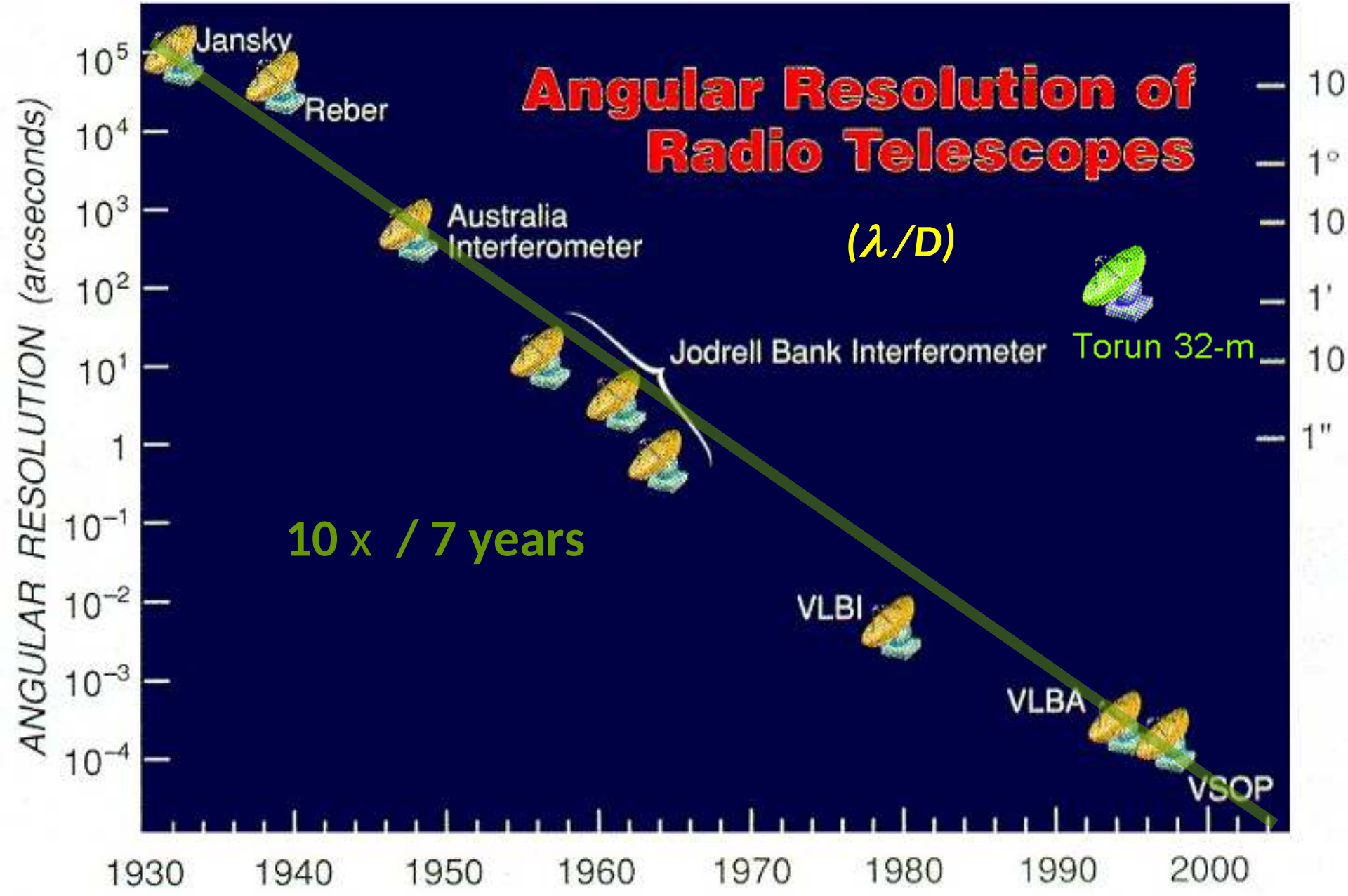


Angular resolution ~1/D

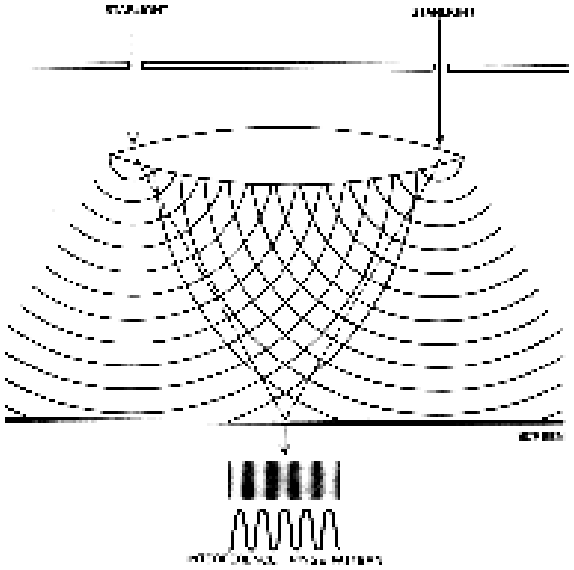
Sensitivity ~D^2

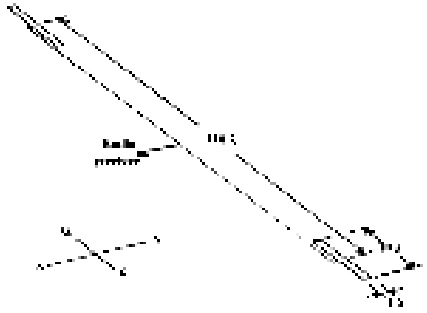
A radio astronomy system

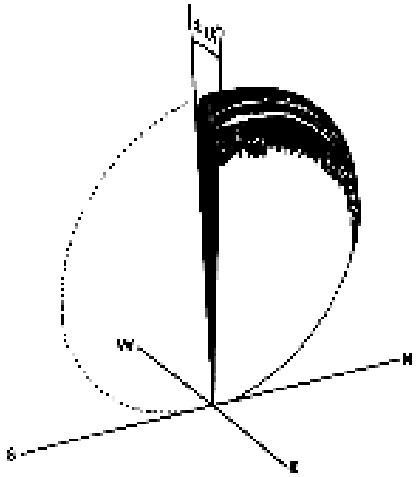


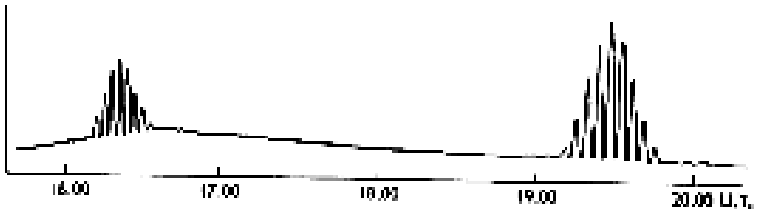

Angular Resolution of Radio Telescopes
(λ/D)
ANGULAR RESOLUTION (arcseconds)
Jansky
Reber
Australia Interferometer
Jodrell Bank Interferometer
Torun 32-m
VLBI
VLBA
VSOP
10 x / 7 years
10^5
10^4
10^3
10^2
10^1
1
10^-1
10^-2
10^-3
10^-4
10
1°
10
1'
10
1"
1930
1940
1950
1960
1970
1980
1990
2000

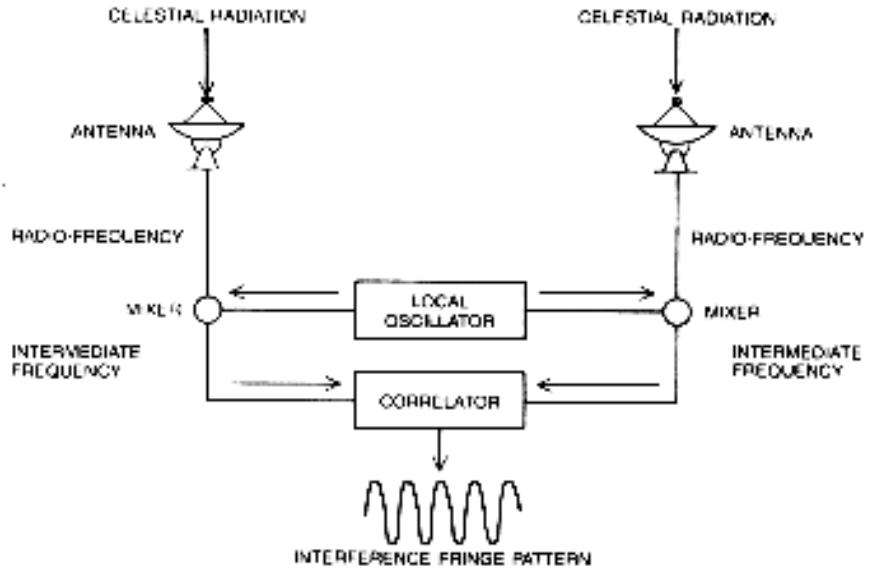
Principle of interferometry

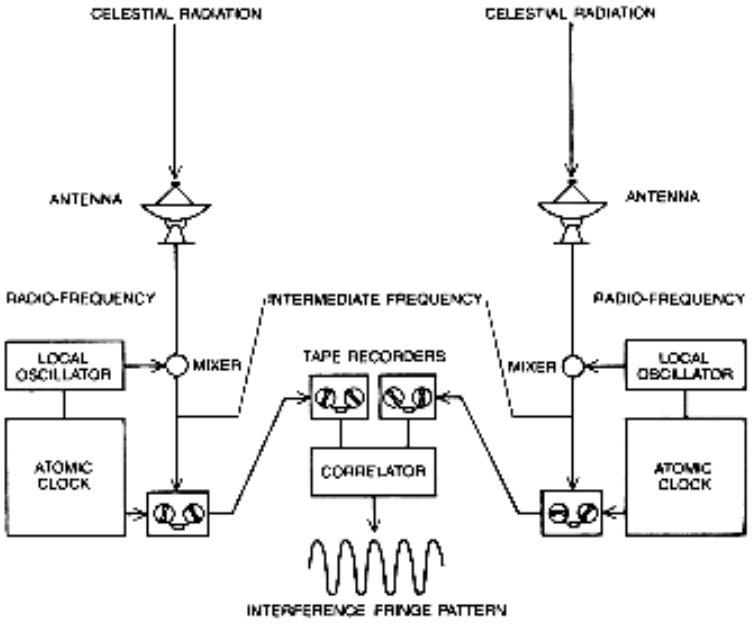




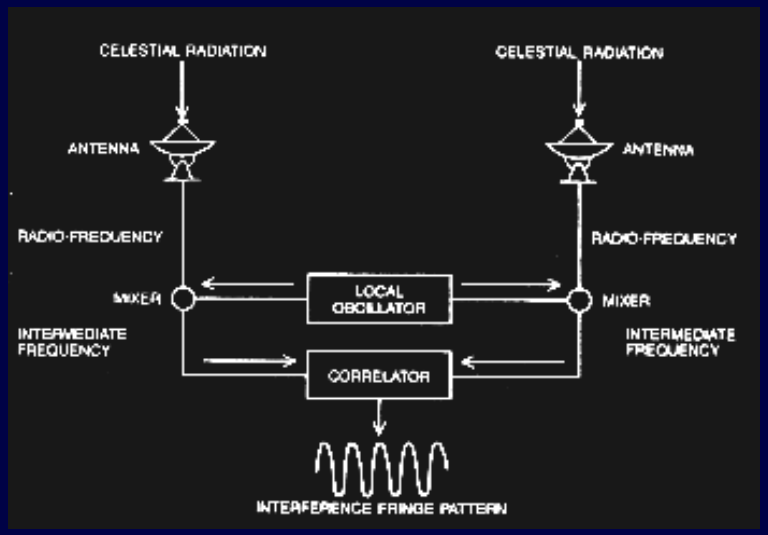


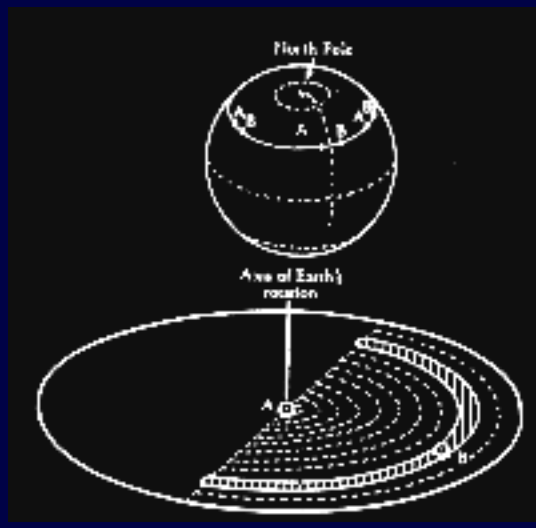






WSRT





Interferometers and Aperture Synthesis

VLA

Very Large Array
NRAO, Socorro, USA

Nobeyama Observatory, Japan *solar interferometer*

A. R. Thompson, J. M. Moran,
G. W. Swenson Jr.

WILEY-VCH

Interferometry and Synthesis in Radio Astronomy

Second Edition

Van Cittert–Zernike Theorem

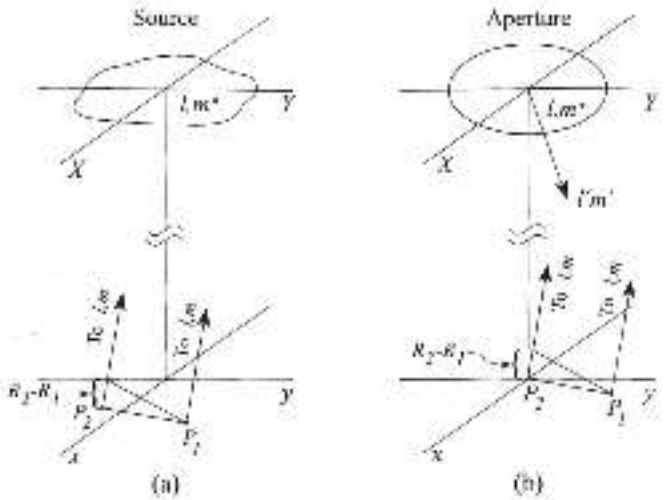
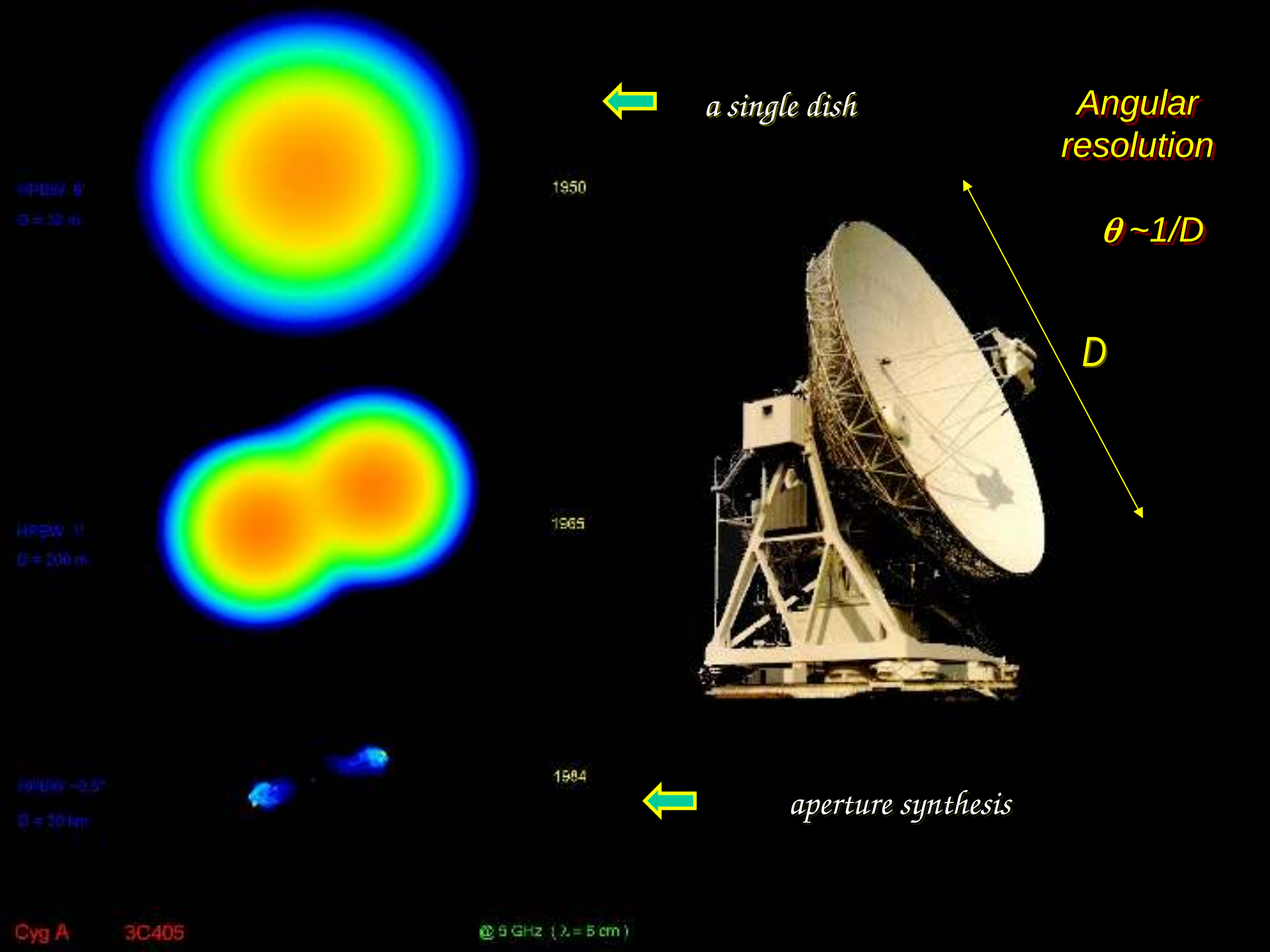
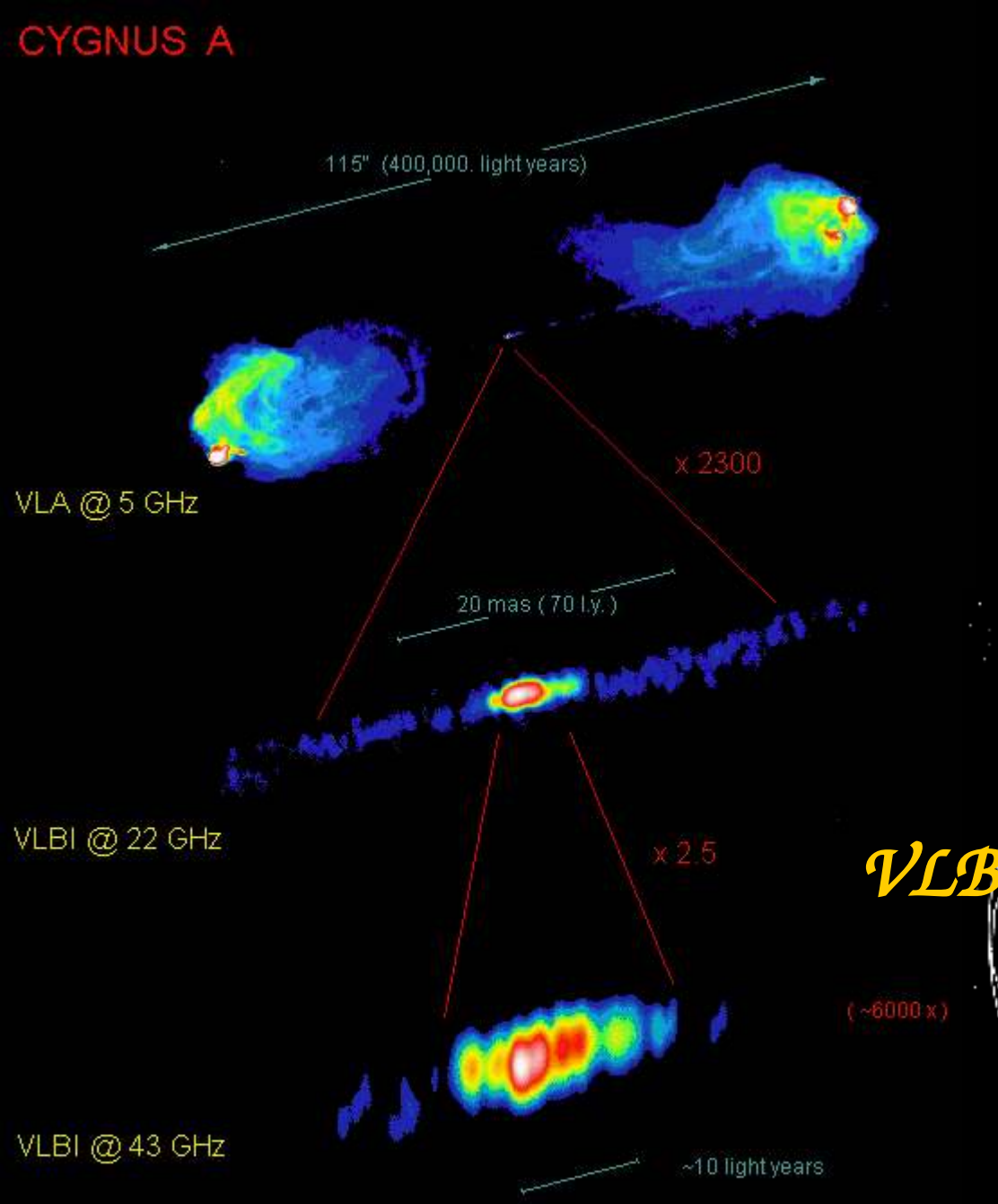


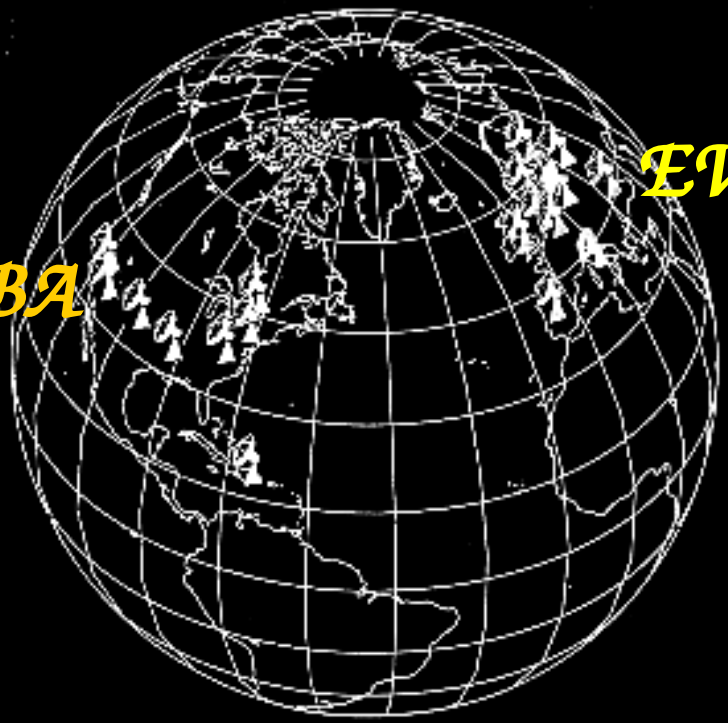
Figure 14.1 (a) Geometry of a distant spatially incoherent source and the points P_1 and P_2 at which the mutual coherence of the radiation is measured. The source plane (X, Y) is parallel to the measurement plane (x, y) but at a large distance from it. (b) Similar geometry for measurement of the radiation field from an aperture in the (X, Y) plane that is illuminated from above by a coherent wavefront. The radiated field has a maximum at the point P_0. Direction cosines (l, m) are defined with respect to the (x, y) axes in the measurement plane, and (l', m') with respect to the (X, Y) axes in the plane of the aperture.

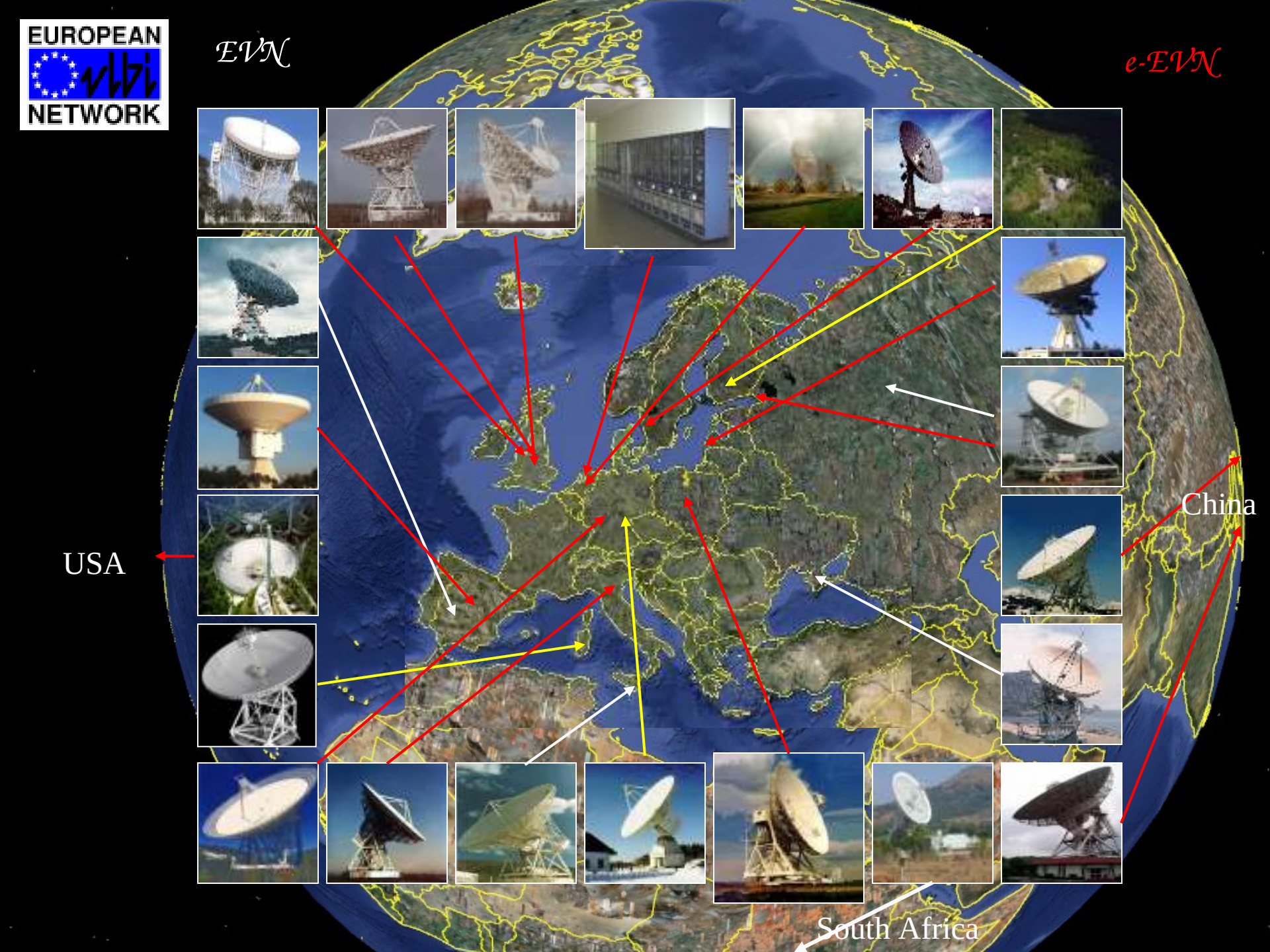

a single dish
Angular resolution
θ ~1/D
D
1950
1965
1994
aperture synthesis
Cyg A
3C405
@ 5 GHz (λ = 6 cm)



Images from Perley et al. 1984, Krichbaum et al. 1998

Very Long Baseline Interferometry



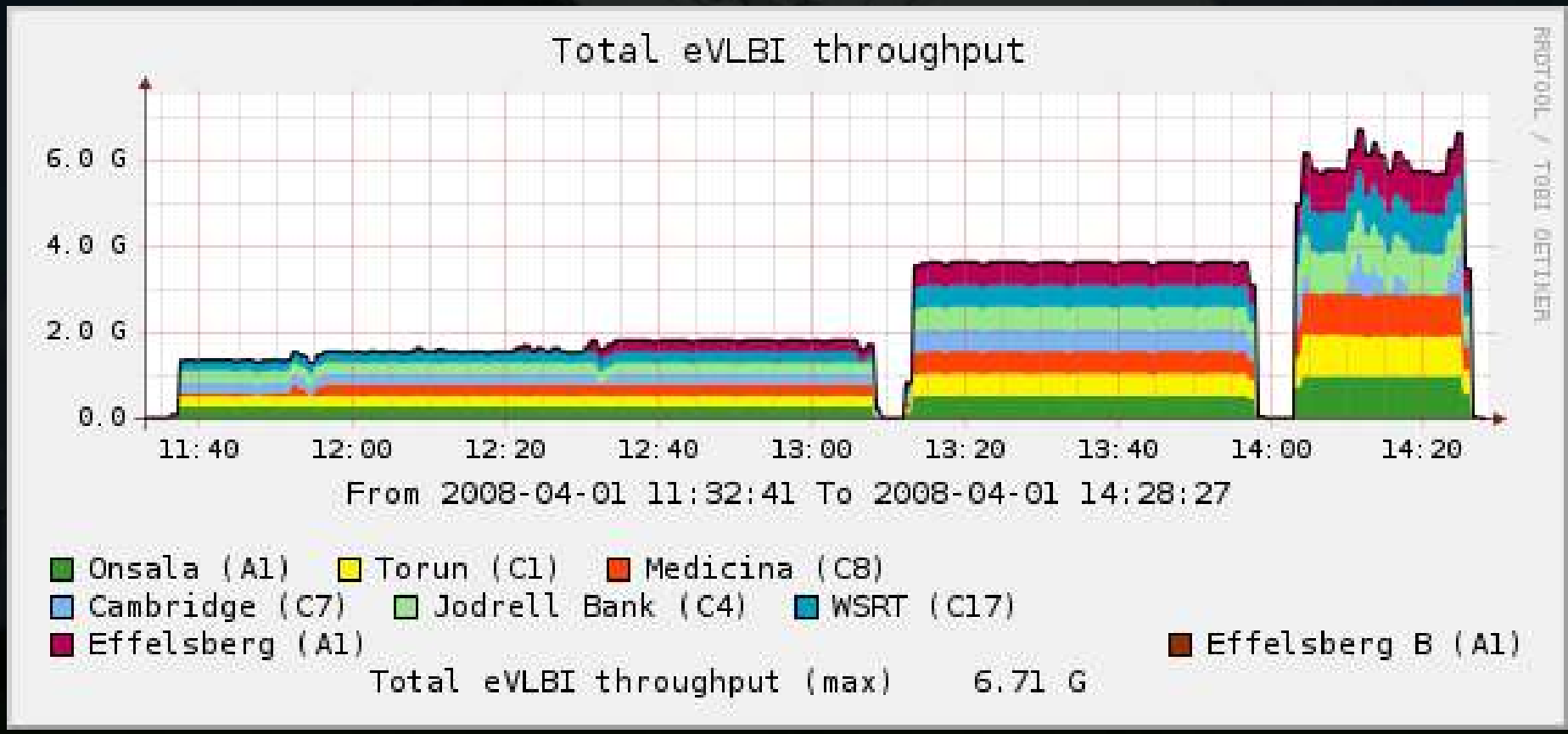

EVN
e-EVN
USA
China
South Africa

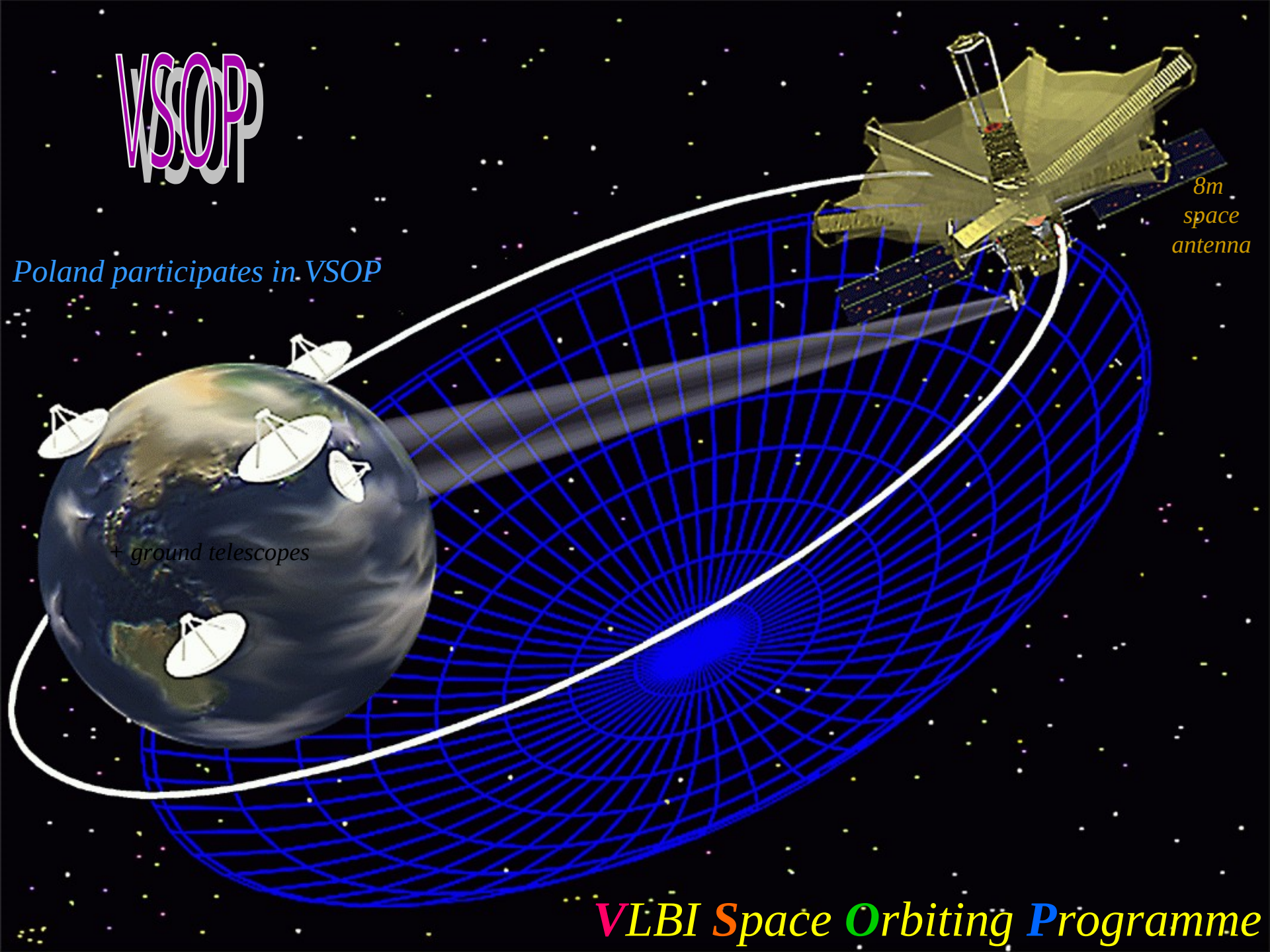
European VLBI Network

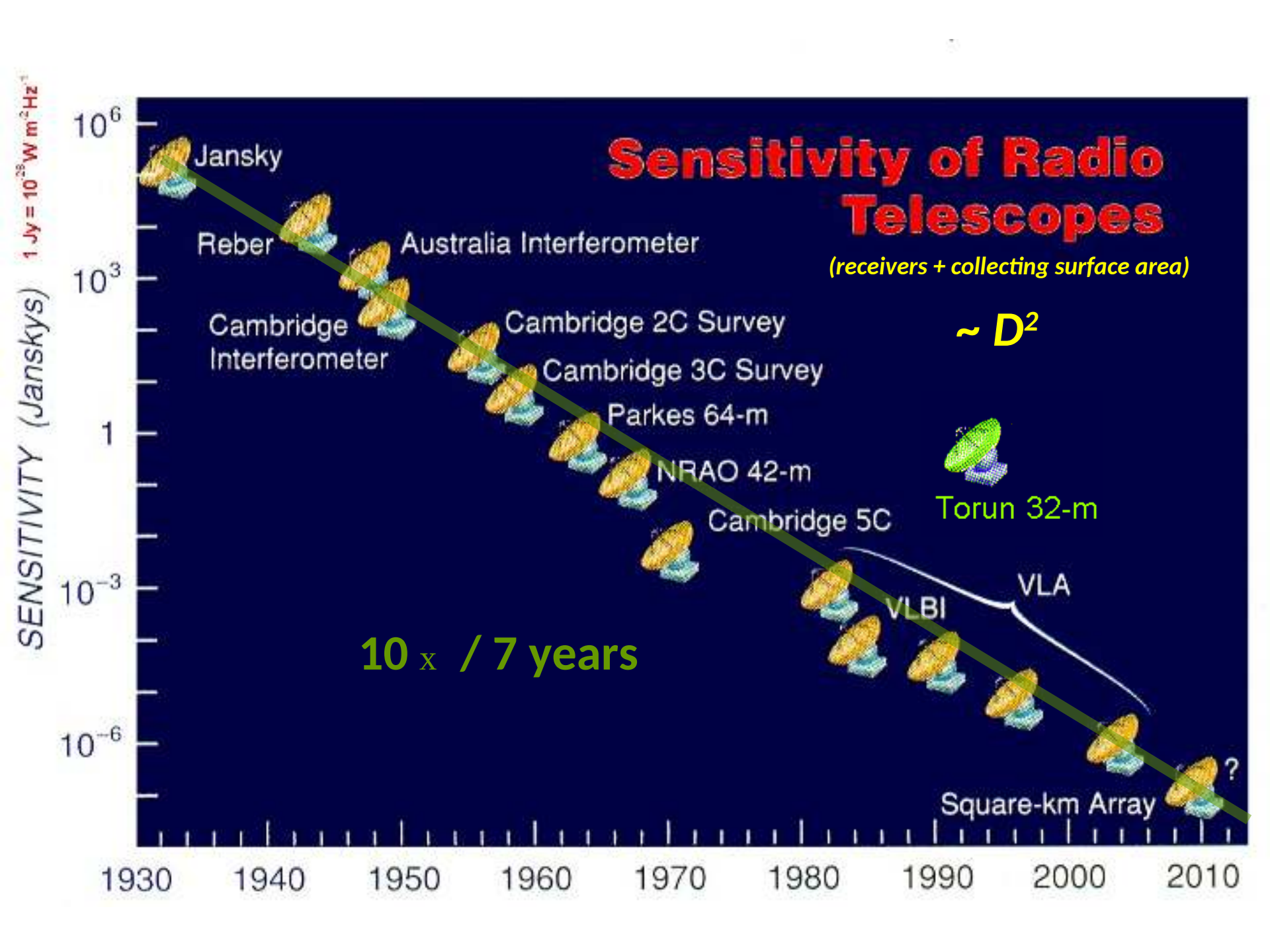
- Poland from 1982 (32m RT4 1986)

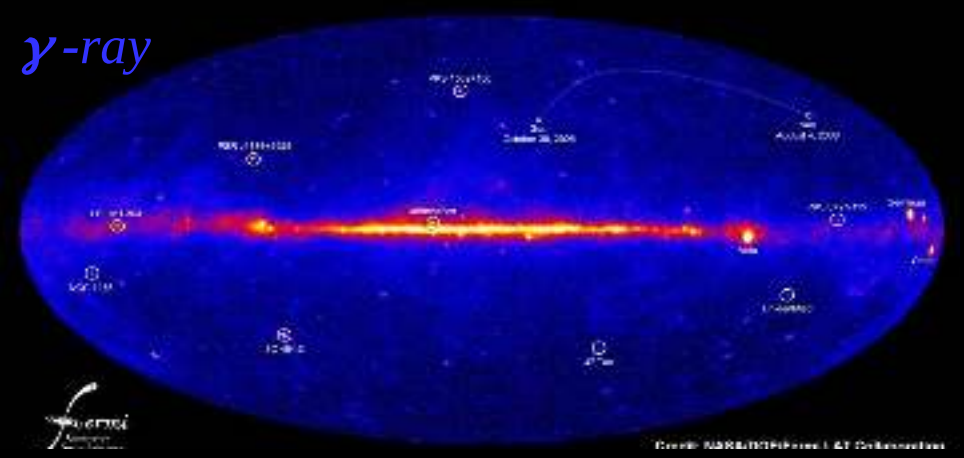
studies of AGNs & Masers

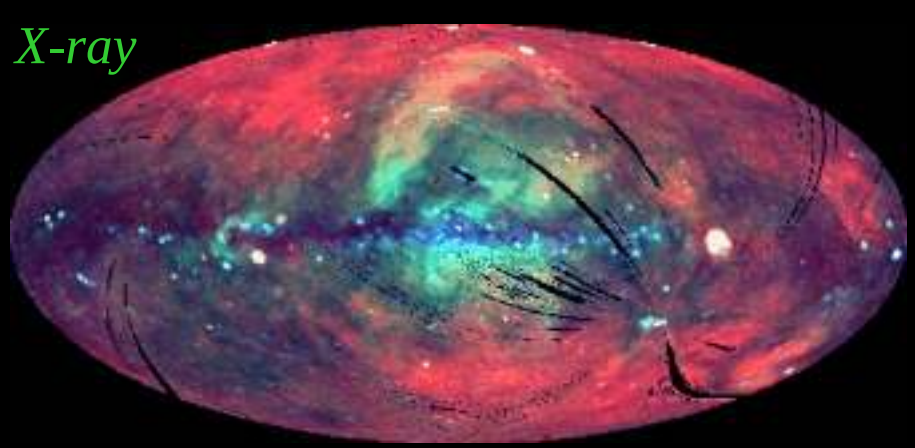
- e-EVN from 2004




VSOP
Poland participates in VSOP
8m
space
antenna
+ ground telescopes
VLBI Space Orbiting Programme

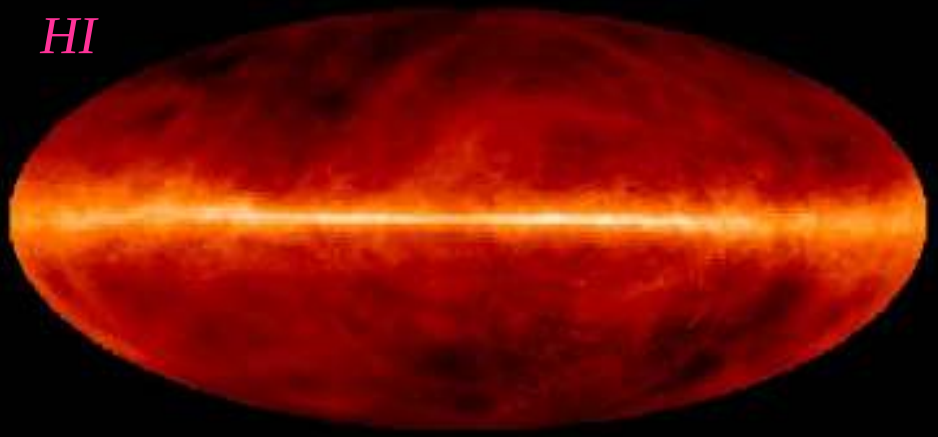

Sensitivity of Radio Telescopes
(receivers + collecting surface area)
~ D²
SENSITIVITY (Janskys)
1 Jy = 10⁻²⁶ W m⁻² Hz⁻¹
10⁶
10³
1
10⁻³
10⁻⁶
Jansky
Reber
Australia Interferometer
Cambridge Interferometer
Cambridge 2C Survey
Cambridge 3C Survey
Parkes 64-m
NRAO 42-m
Cambridge 5C
Torun 32-m
VLA
VLBI
10 x / 7 years
Square-km Array
?
1930
1940
1950
1960
1970
1980
1990
2000
2010


γ-ray

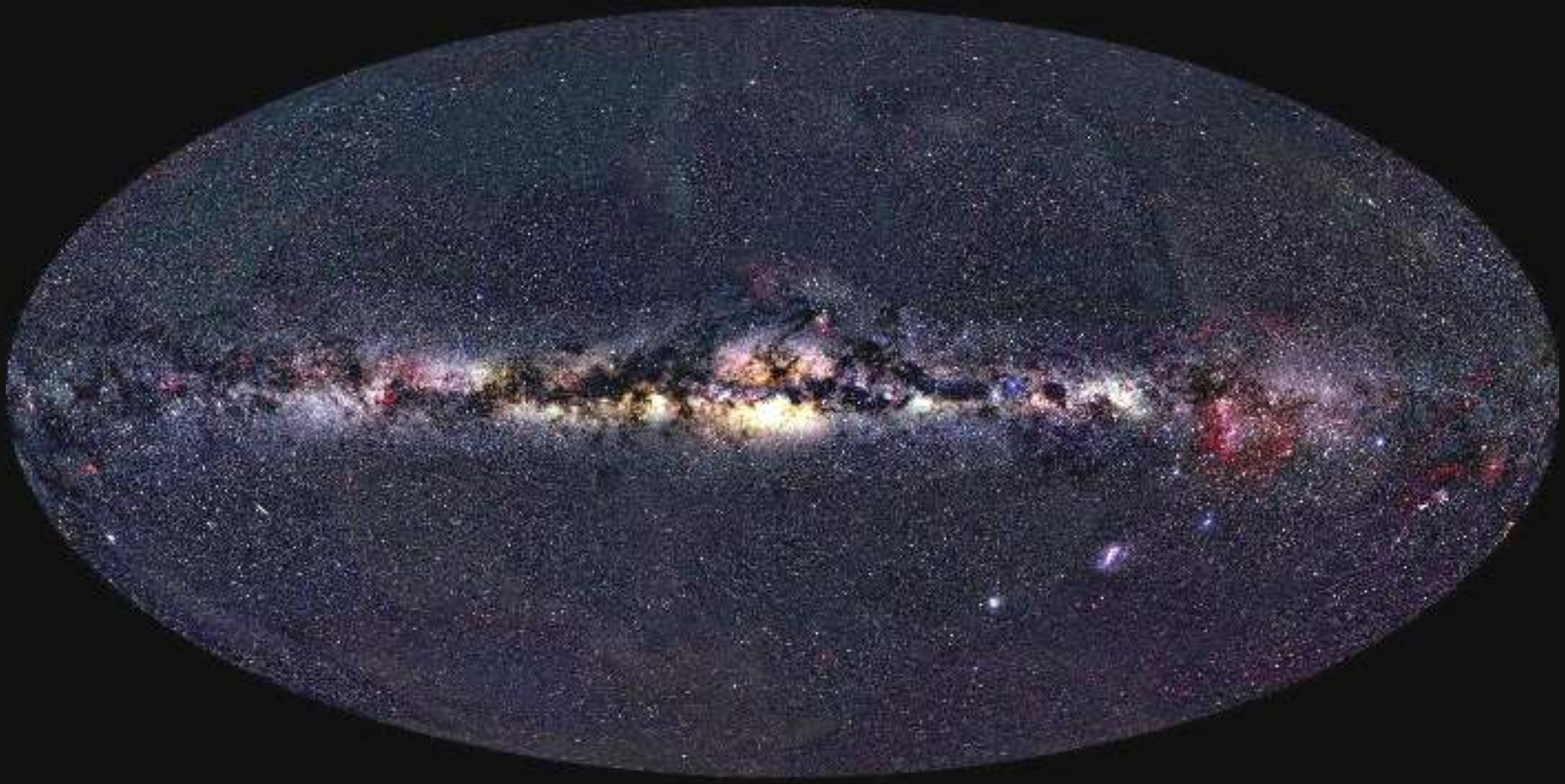

X-ray

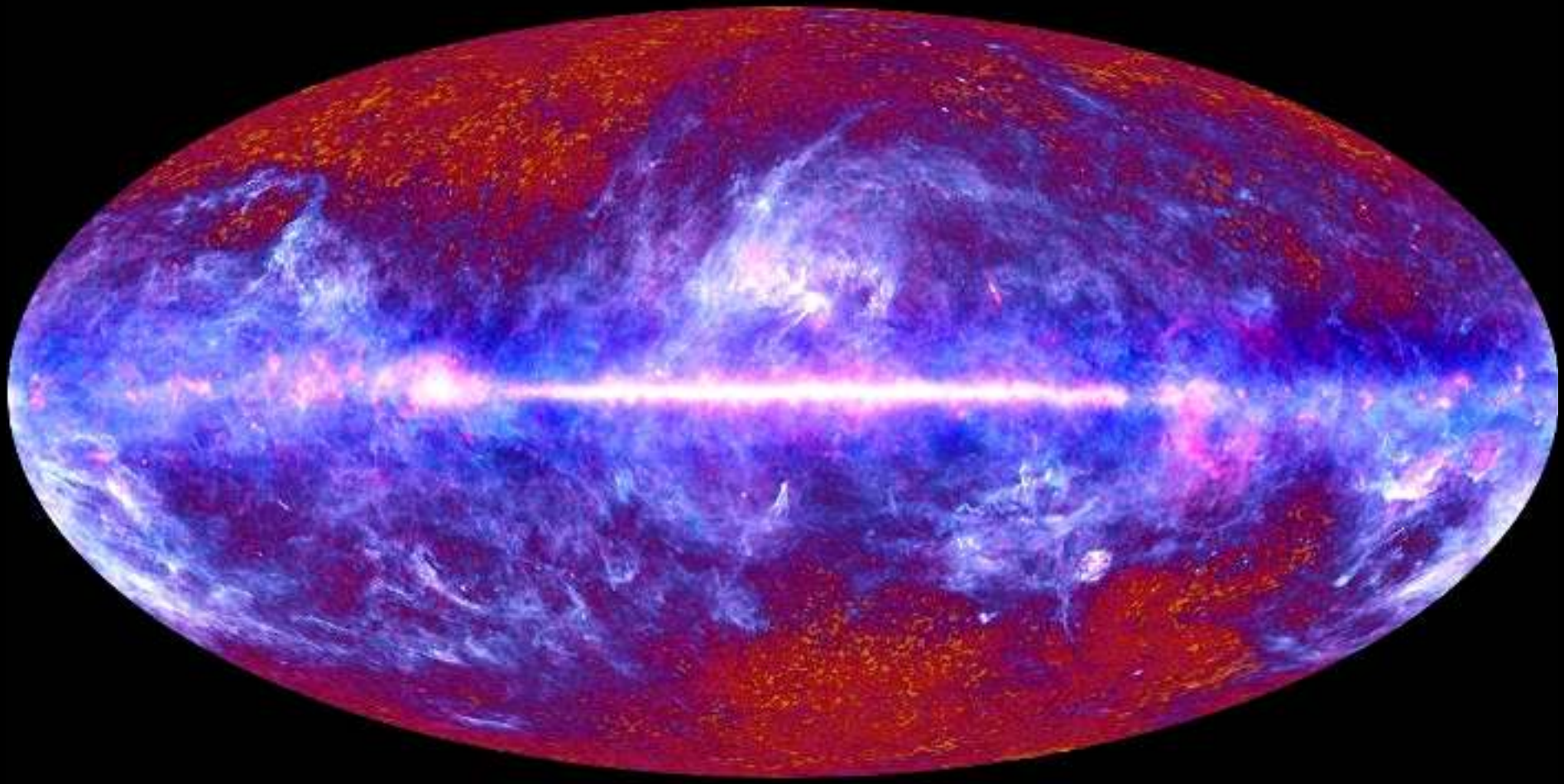

Visible light


IR

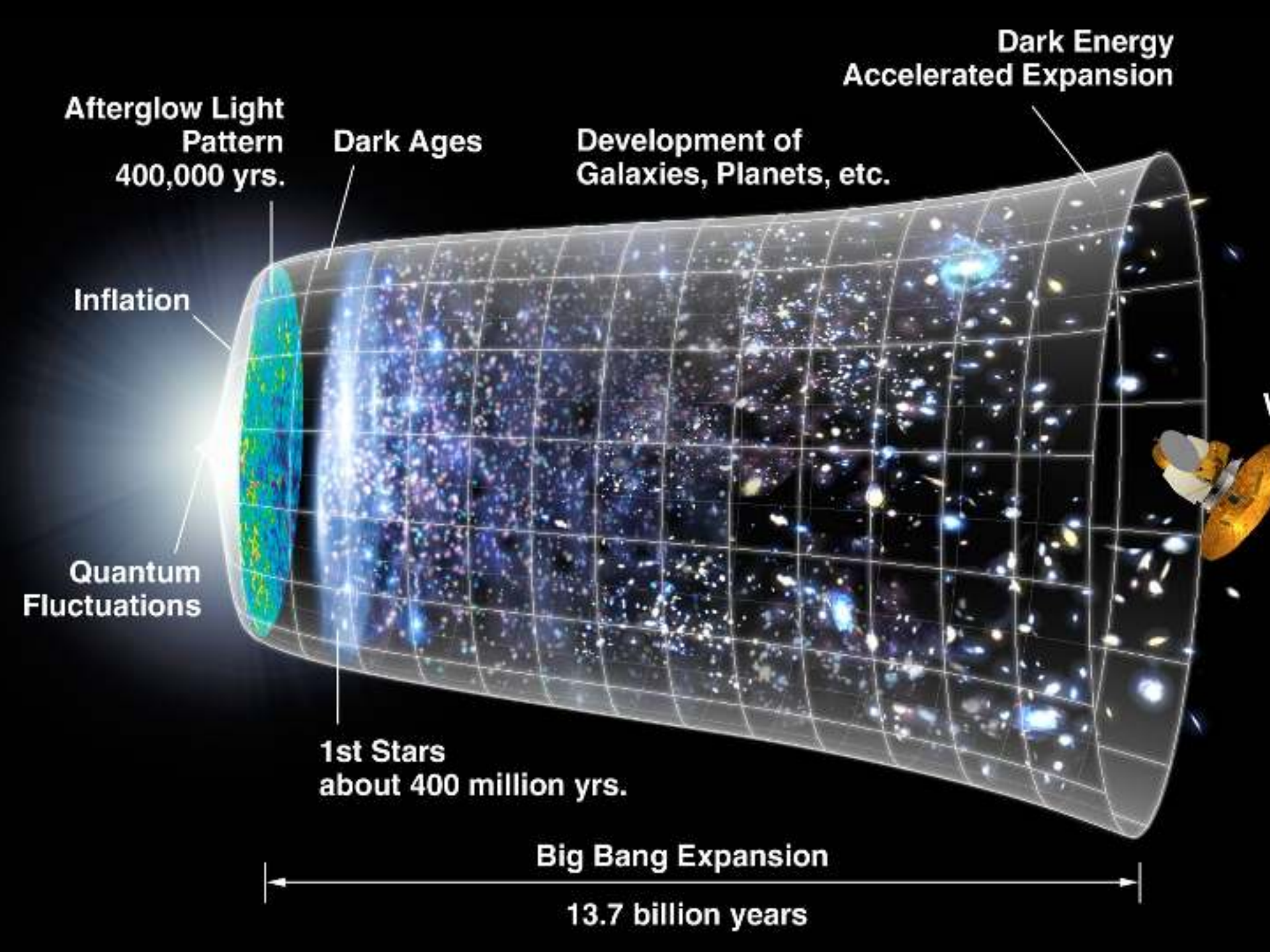

HI

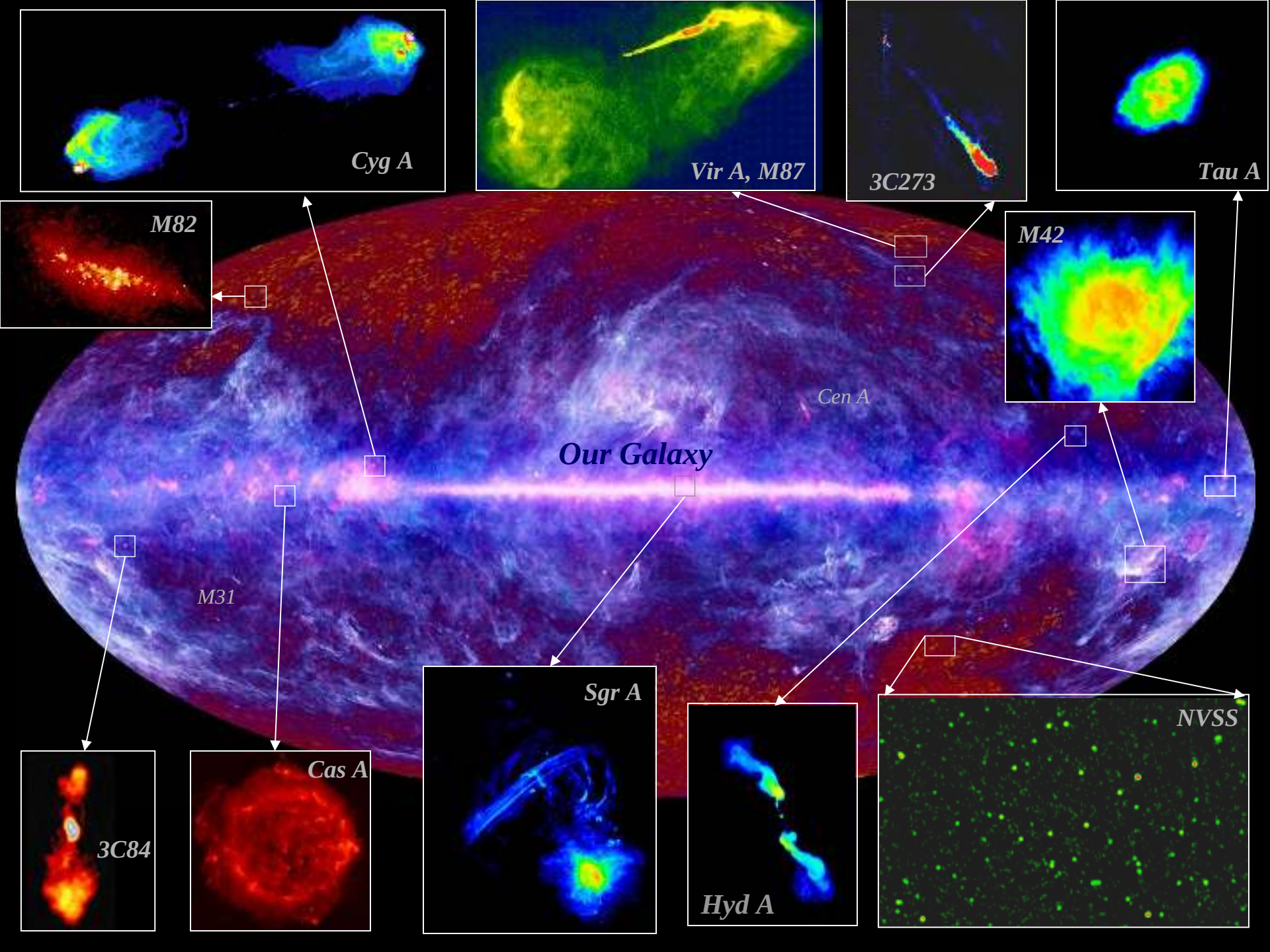

Radio

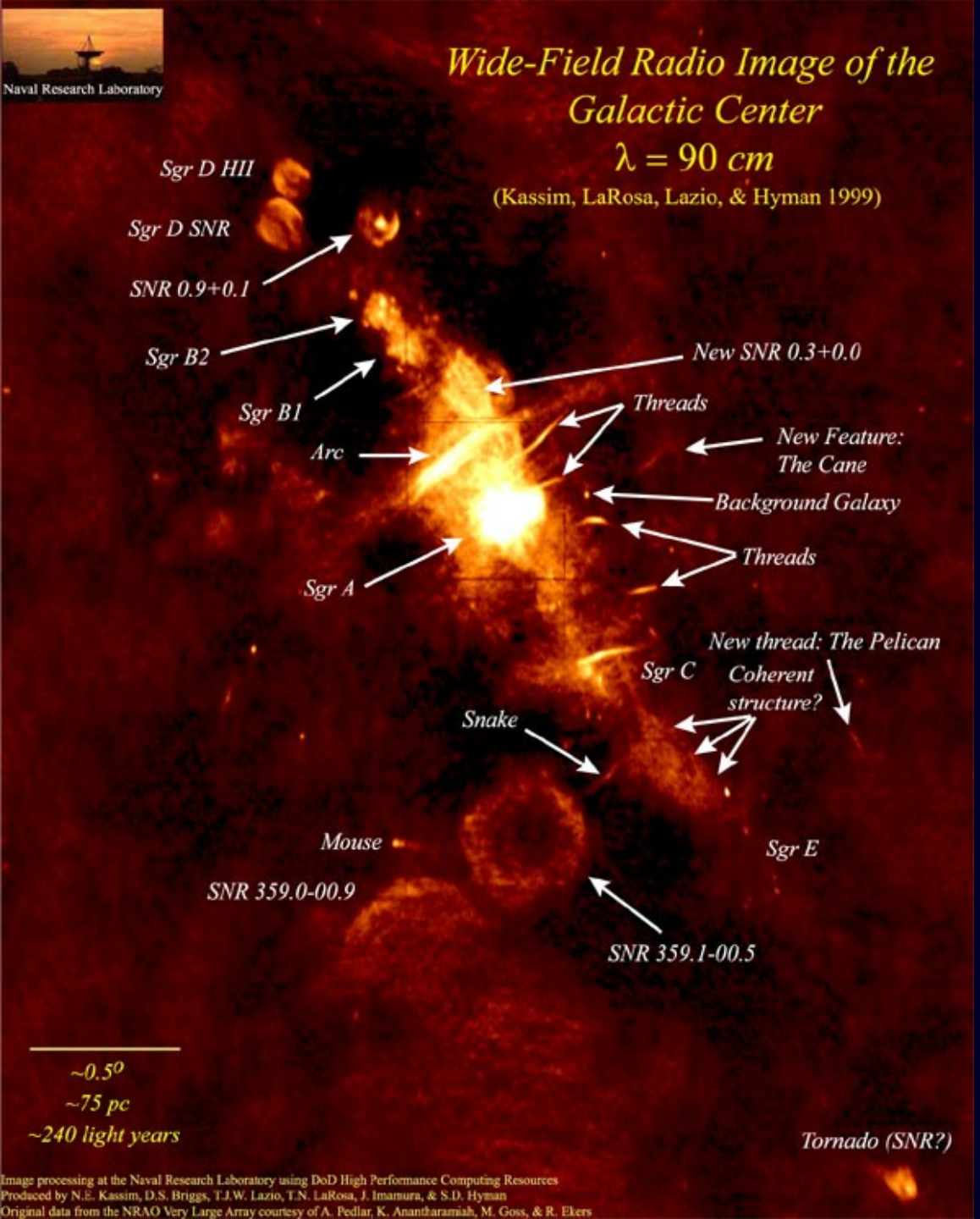

© 2000, Axel Mellinger

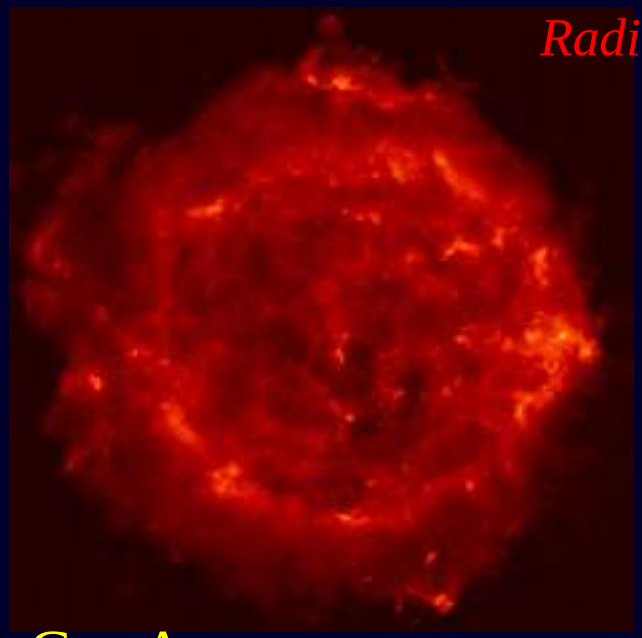


Planck Mission Satellite - all sky map2010, The Galaxy and the CMB

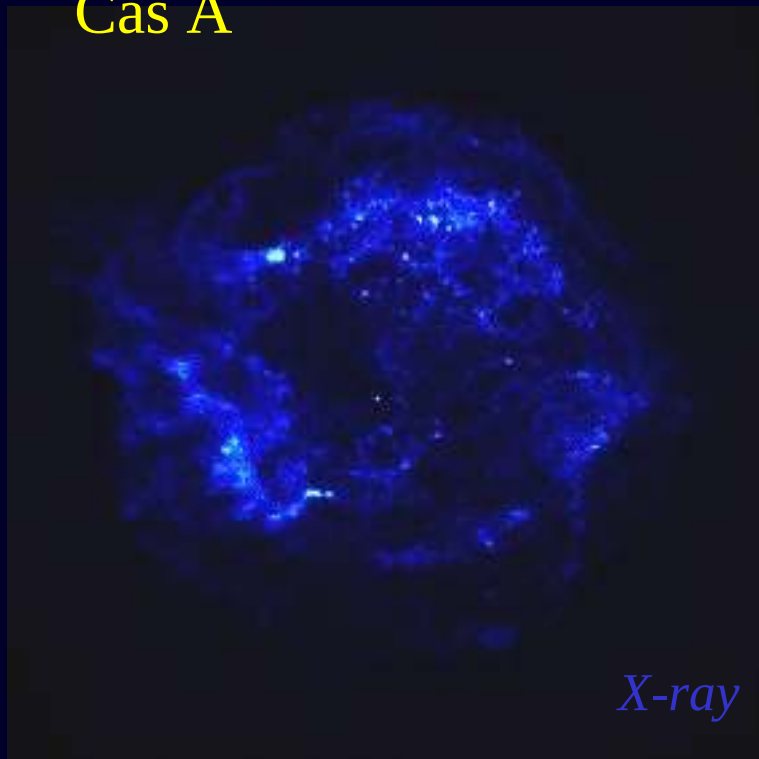

Dark Energy
Accelerated Expansion
Afterglow Light
Pattern
400,000 yrs.
Dark Ages
Development of
Galaxies, Planets, etc.
Inflation
Quantum
Fluctuations
1st Stars
about 400 million yrs.
Big Bang Expansion
13.7 billion years

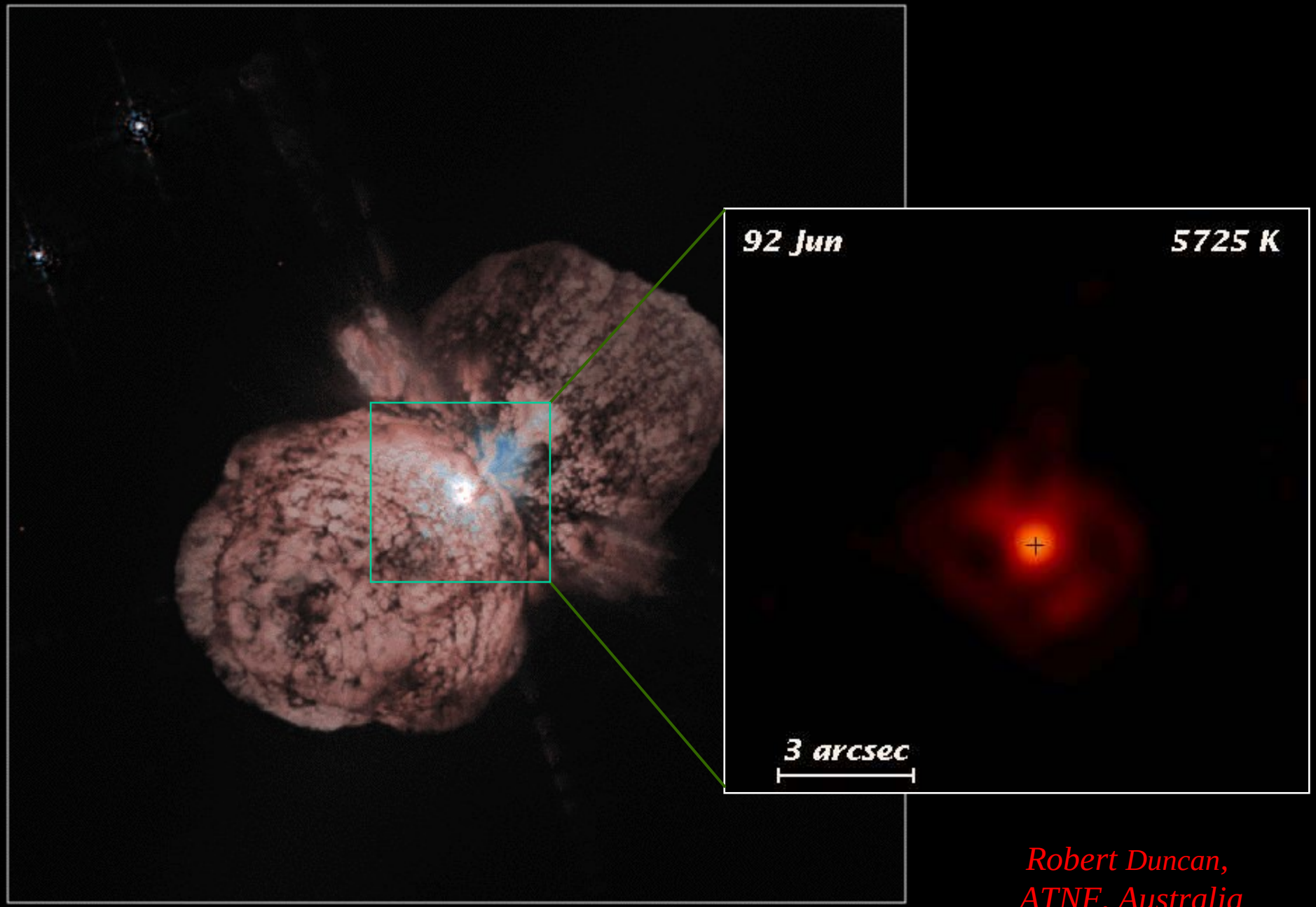

Cyg A
Vir A, M87
3C273
Tau A
M82
M42
Cen A
Our Galaxy
M31
Sgr A
3C84
Cas A
Hyd A
NVSS


Naval Research Laboratory
Wide-Field Radio Image of the Galactic Center
λ = 90 cm
(Kassim, LaRosa, Lazio, & Hyman 1999)
Sgr D HII
Sgr D SNR
SNR 0.9+0.1
Sgr B2
Sgr B1
Arc
New SNR 0.3+0.0
Threads
New Feature: The Cane
Background Galaxy
Threads
Sgr A
New thread: The Pelican
Sgr C
Coherent structure?
Snake
Mouse
Sgr E
SNR 359.0-00.9
SNR 359.1-00.5
~0.5º
~75 pc
~240 light years
Tornado (SNR?)
Image processing at the Naval Research Laboratory using DoD High Performance Computing Resources
Produced by N.E. Kassim, D.S. Briggs, T.J.W. Lazio, T.N. LaRosa, J. Imamura, & S.D. Hyman
Original data from the NRAO Very Large Array courtesy of A. Pedlar, K. Anantharamiah, M. Goss, & R. Ekers


Radio

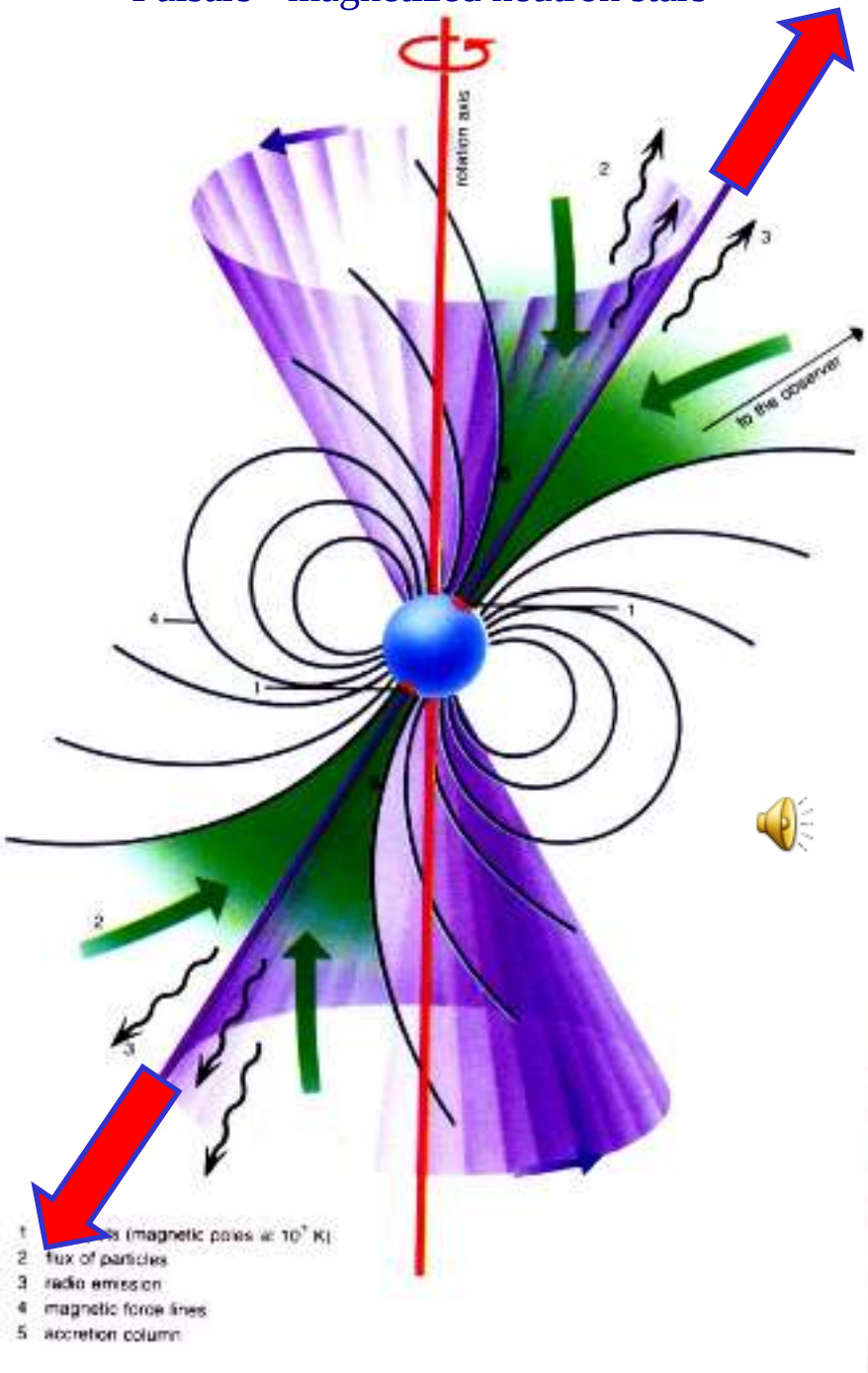
Cas A

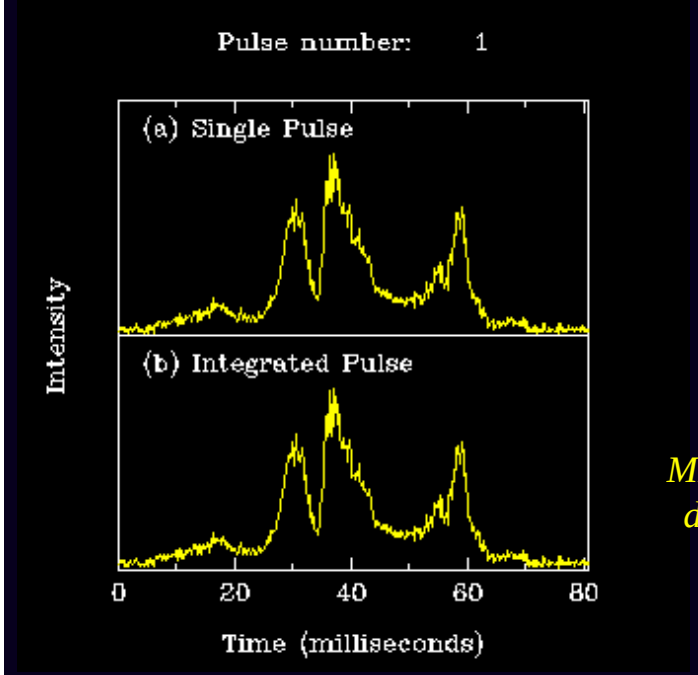

X-ray



Robert Duncan,
ATNF, Australia

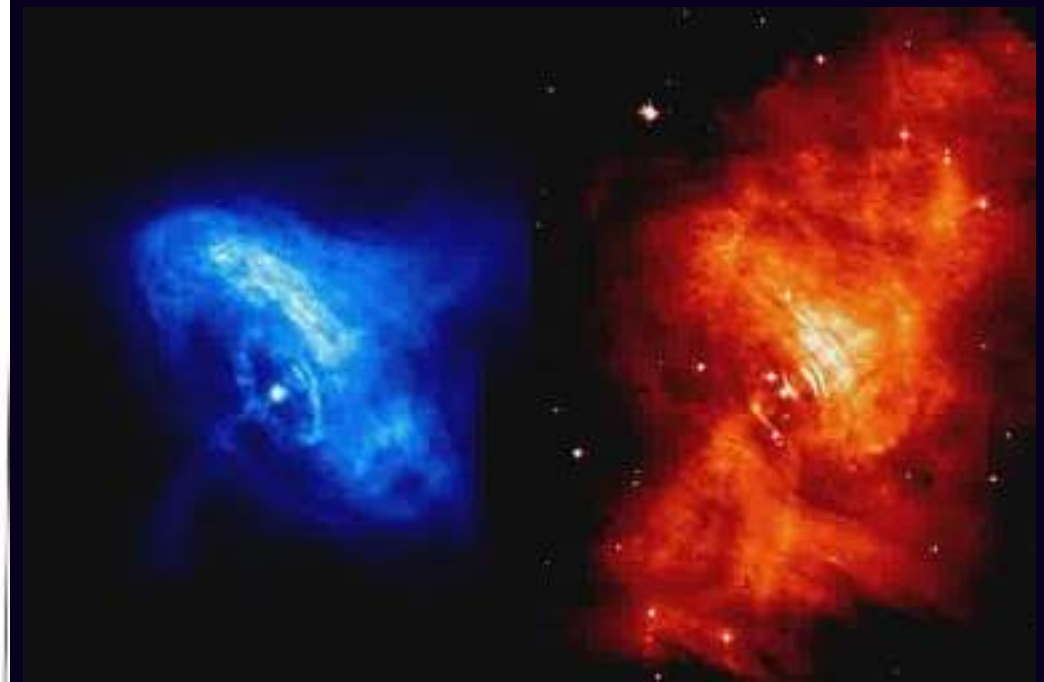
Pulsars - magnetized neutron stars



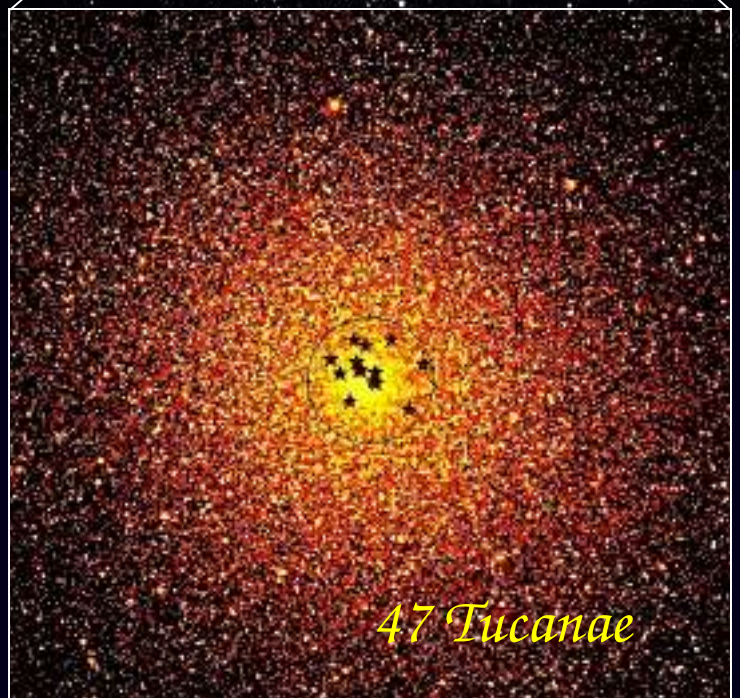


MPIfR data

X-ray image of Crab pulsar envelope

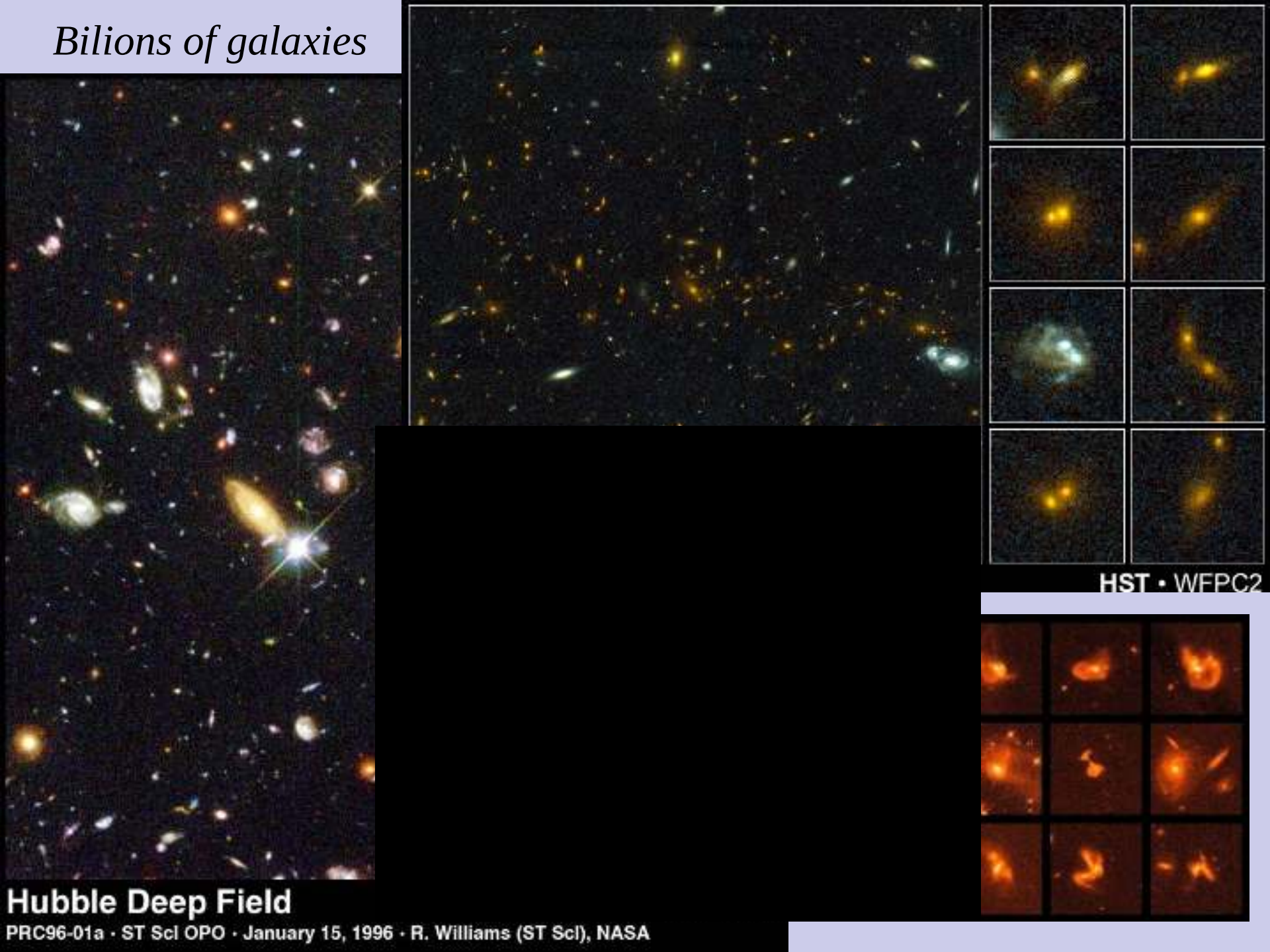


Millisecond pulsars are the most precise astronomical clocks

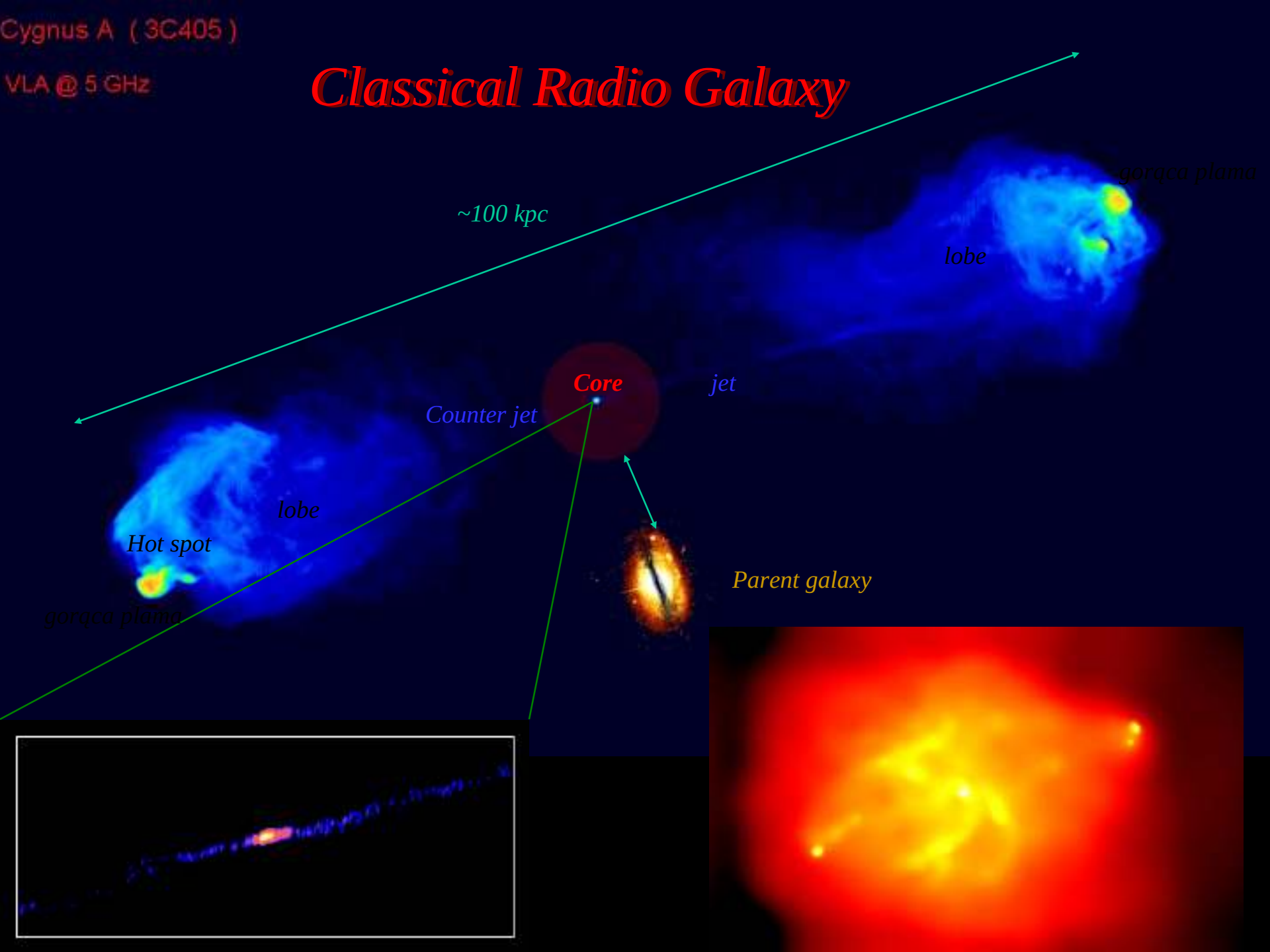


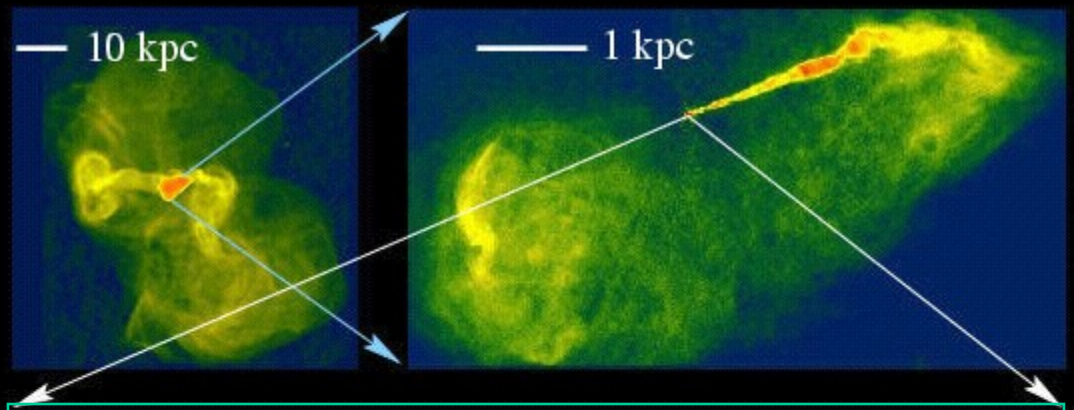
47 Tucanae

Bilions of galaxies



Classical Radio Galaxy

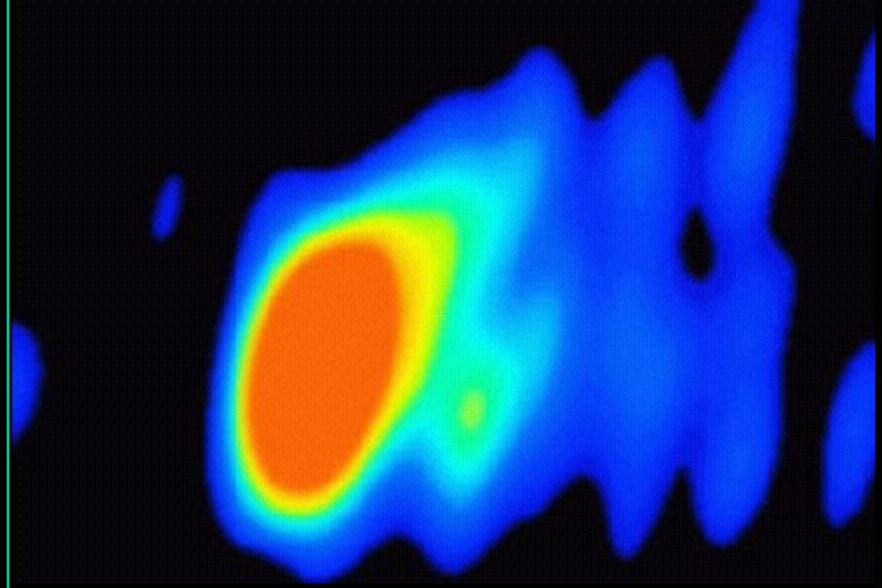




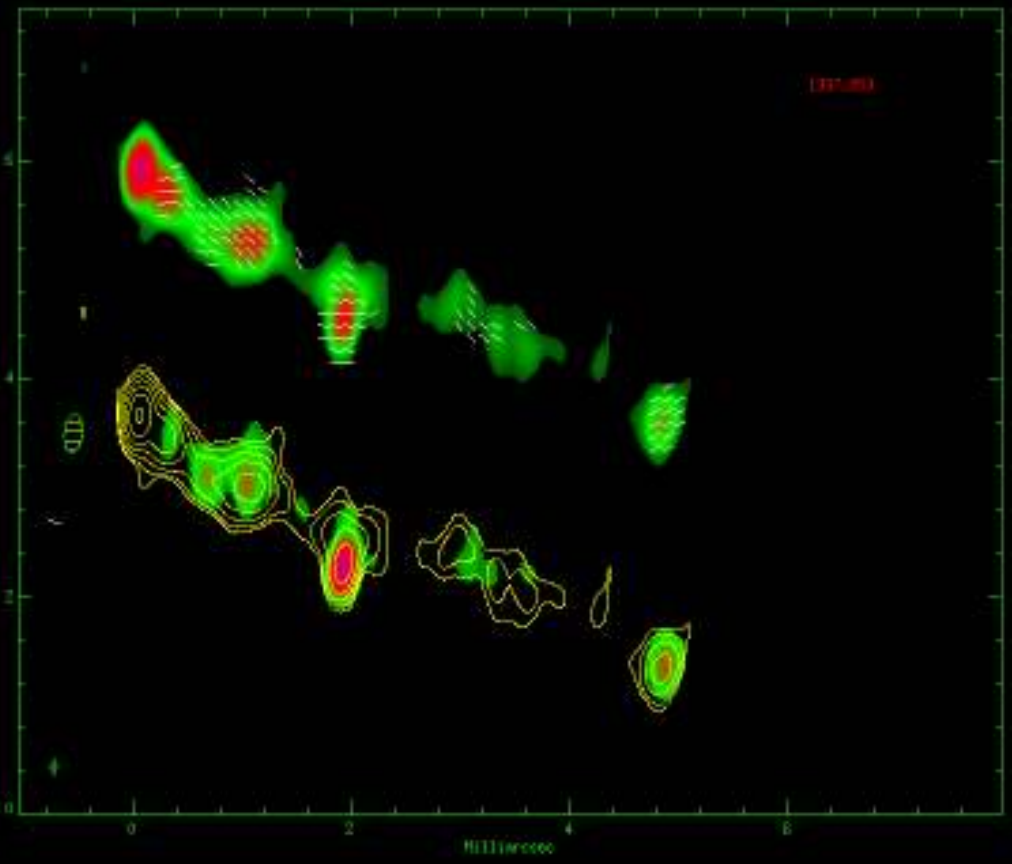
VLBA 22 GHz Observations of 3C120

José–Luis Gómez — IAA (Spain)
Alan P. Marscher — BU (USA)
Antonio Alberdi — IAA (Spain)
Svetlana Marchenko–Jorstad — BU (USA)
Cristina García–Miró — IAA (Spain)

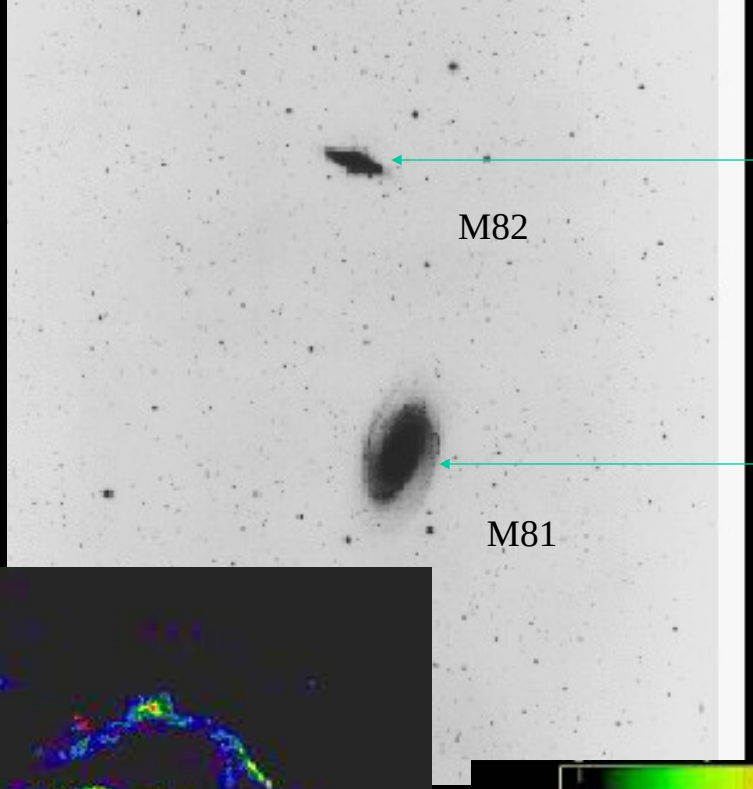
M87 - 3C274

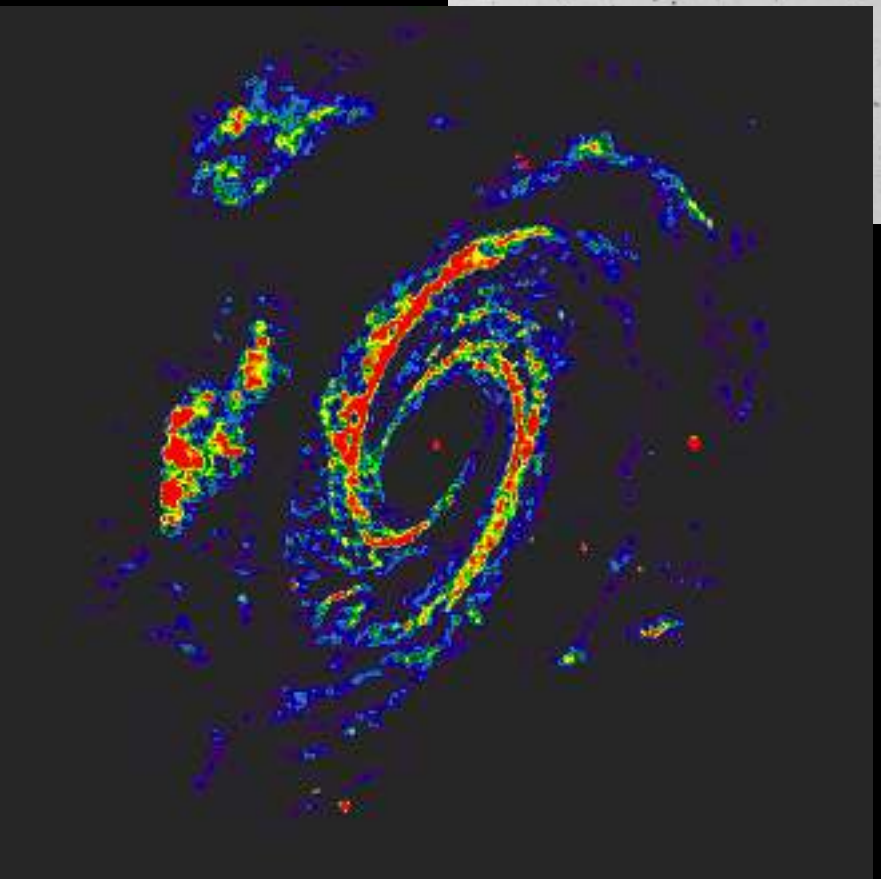


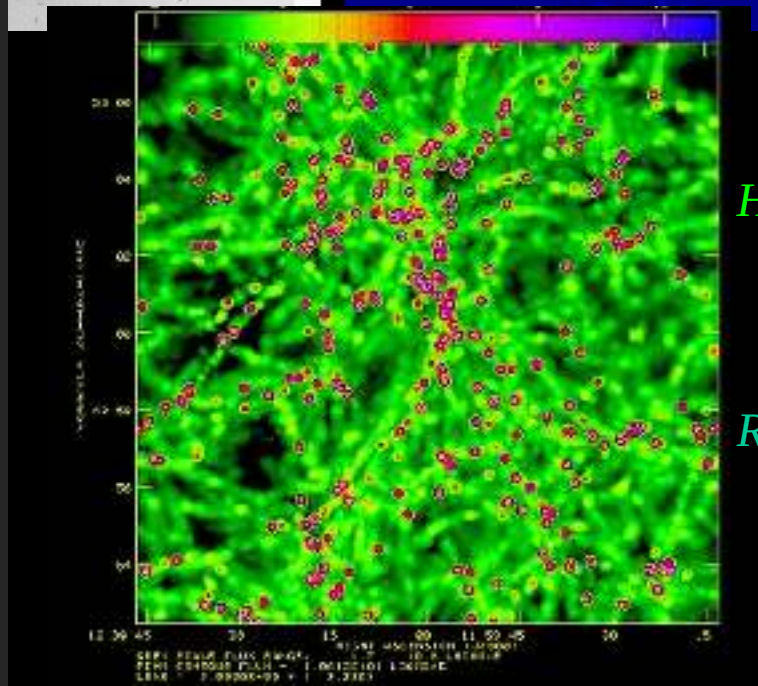
M87 radio jet – VLBI image



Neutral Hydrogen M81 & M82

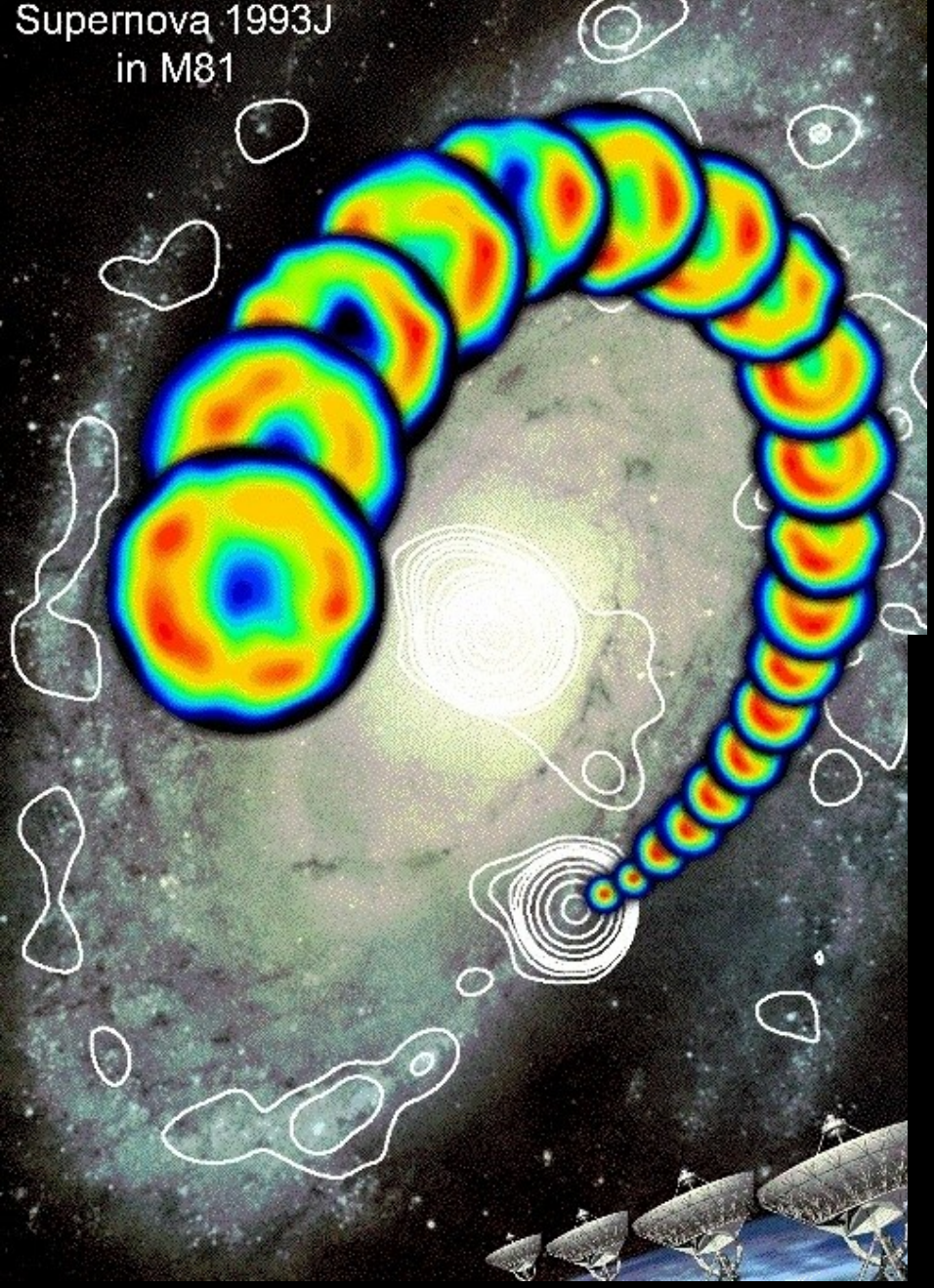




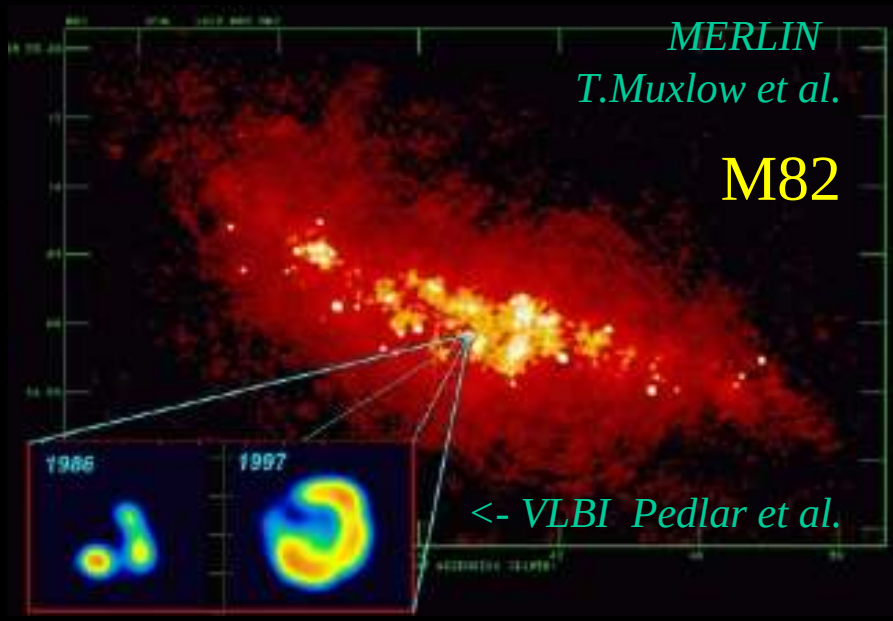


HI distribution simulation for z = 2

Robert Braun NFRA



SN 1993j, Michael Rupen et al.



MERLIN
T.Muxlow et al.

M82

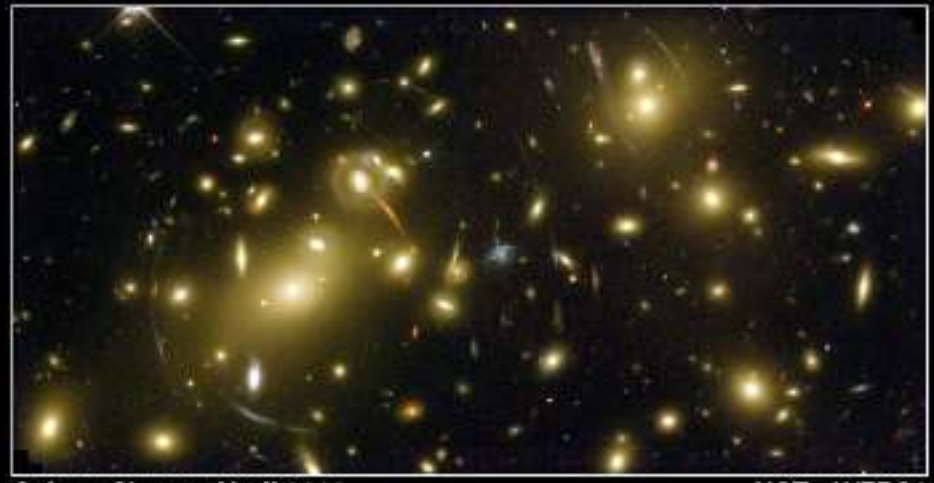
<- VLBI Pedlar et al.

SN1993J in M81

VLBI Observations

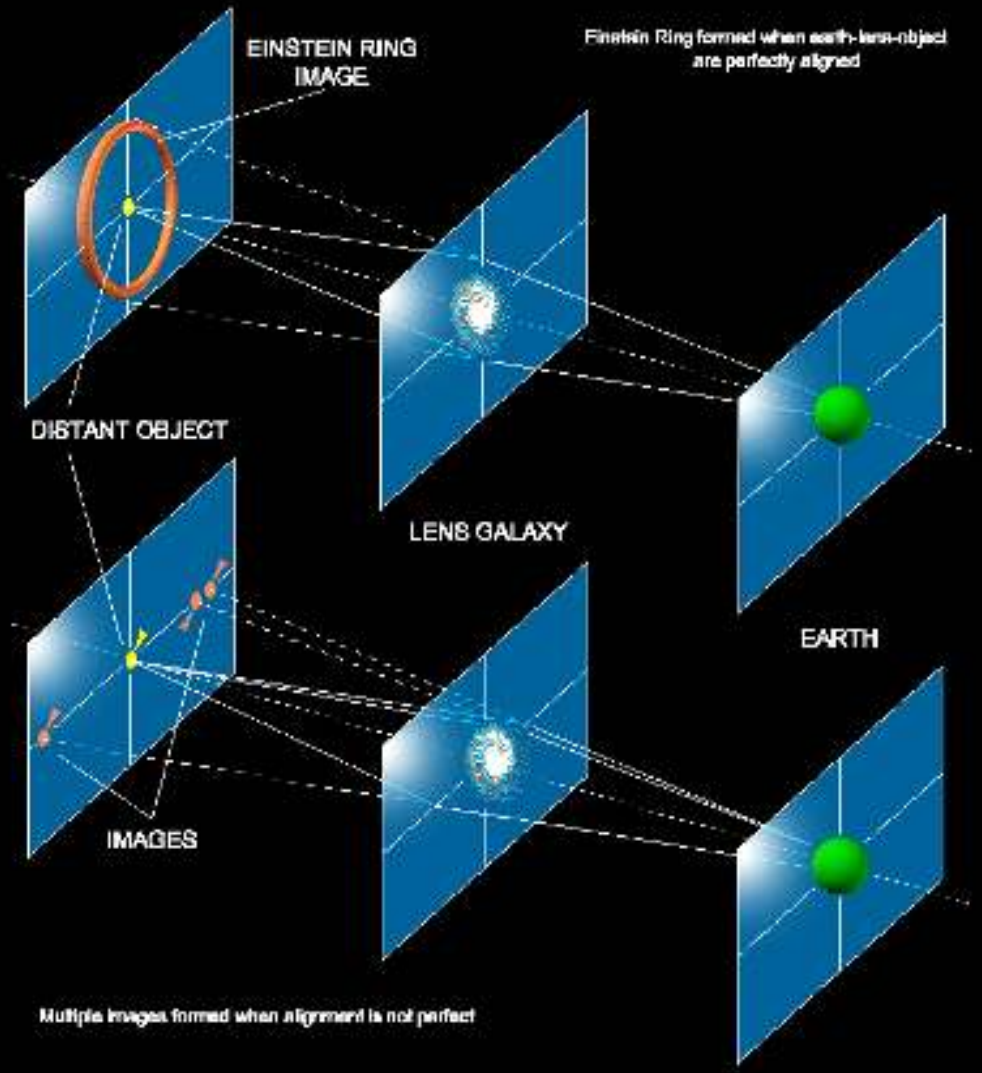
J.M. Marcaide, A. Alberdi, E. Ros,
et al.

Gravitational lensing

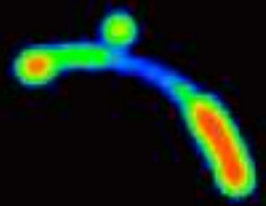


Galaxy Cluster Abell 2218 HST • WFPC2

NASA, A. Fruchter and the ERO Team (STScI, ST-ECF) • STScI-PRC00-08



Optical image

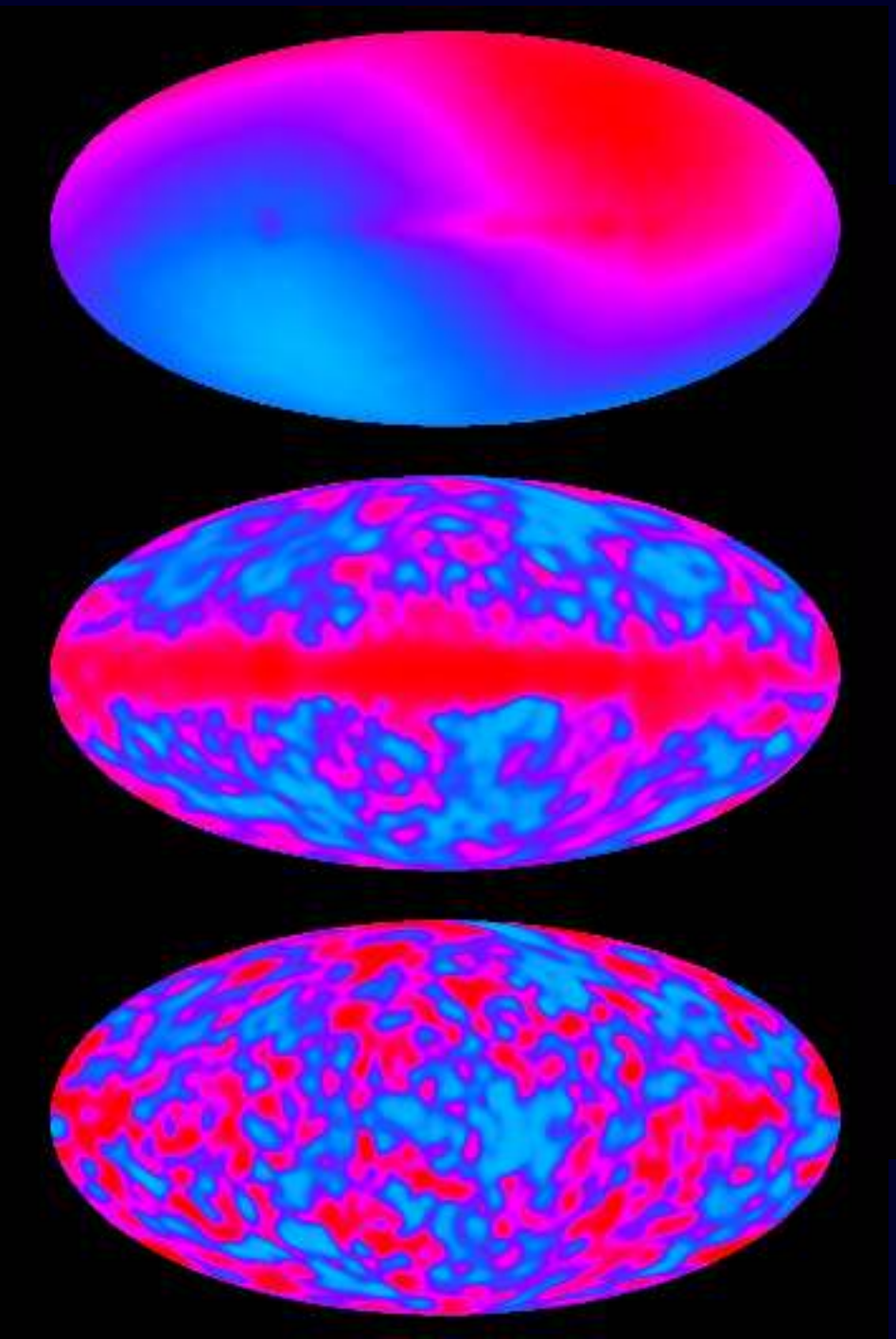


1938+666
Einstein ring

Radio image from MERLIN

Winkilson and Browne of Jodrell Bank


HORN ANTENNA
NATIONAL HISTORIC LANDMARK

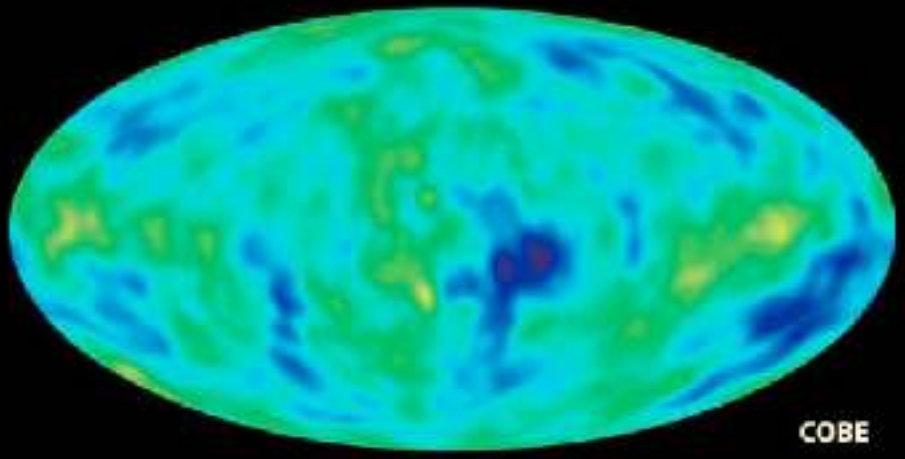


2.7 K CMB

Big Bang !!!

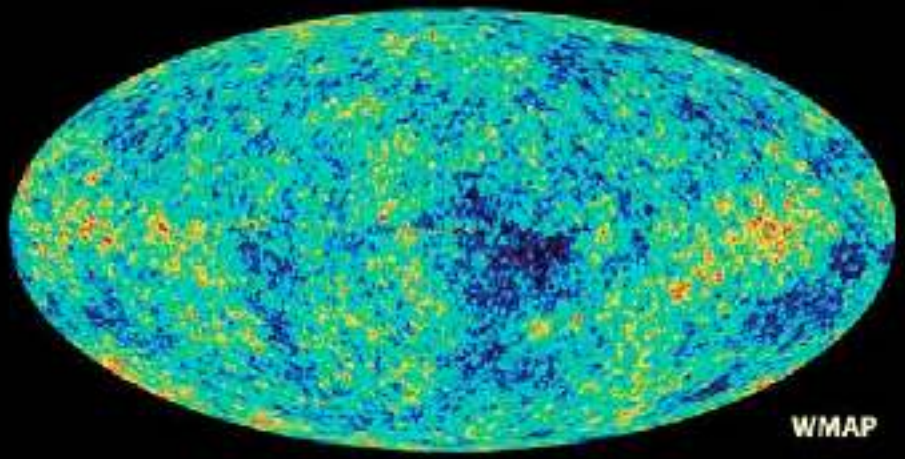
and formation of galaxies

Measuring anisotropies on different scales



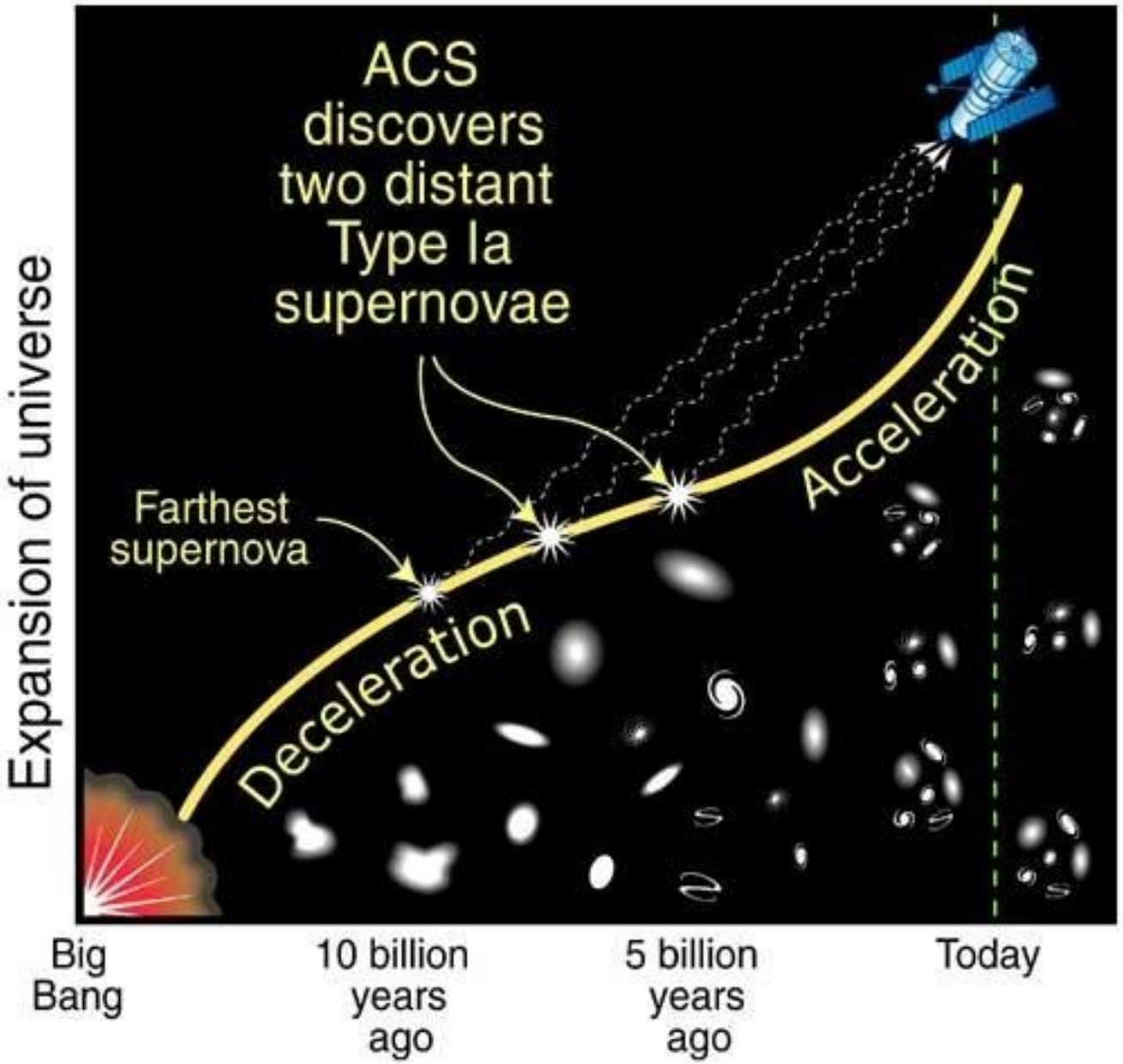
COBE

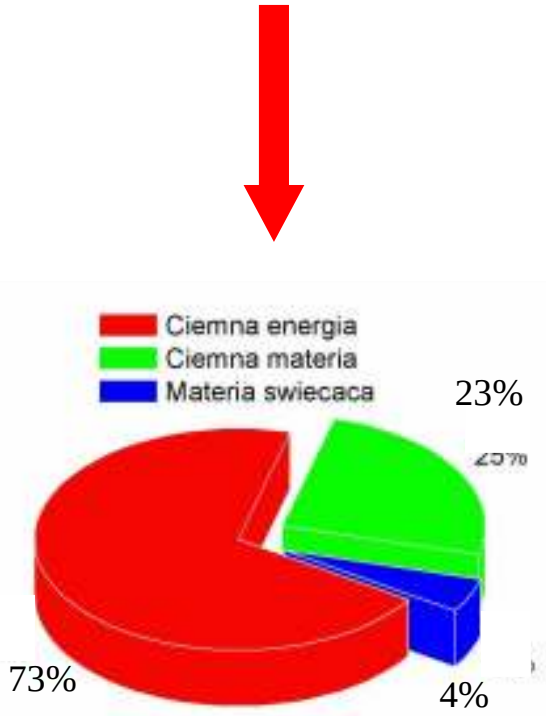
COBE was sensitive to angular scales in the range 10 - 90 degrees

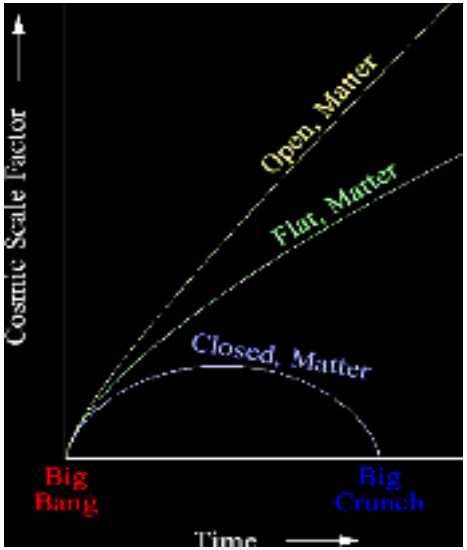


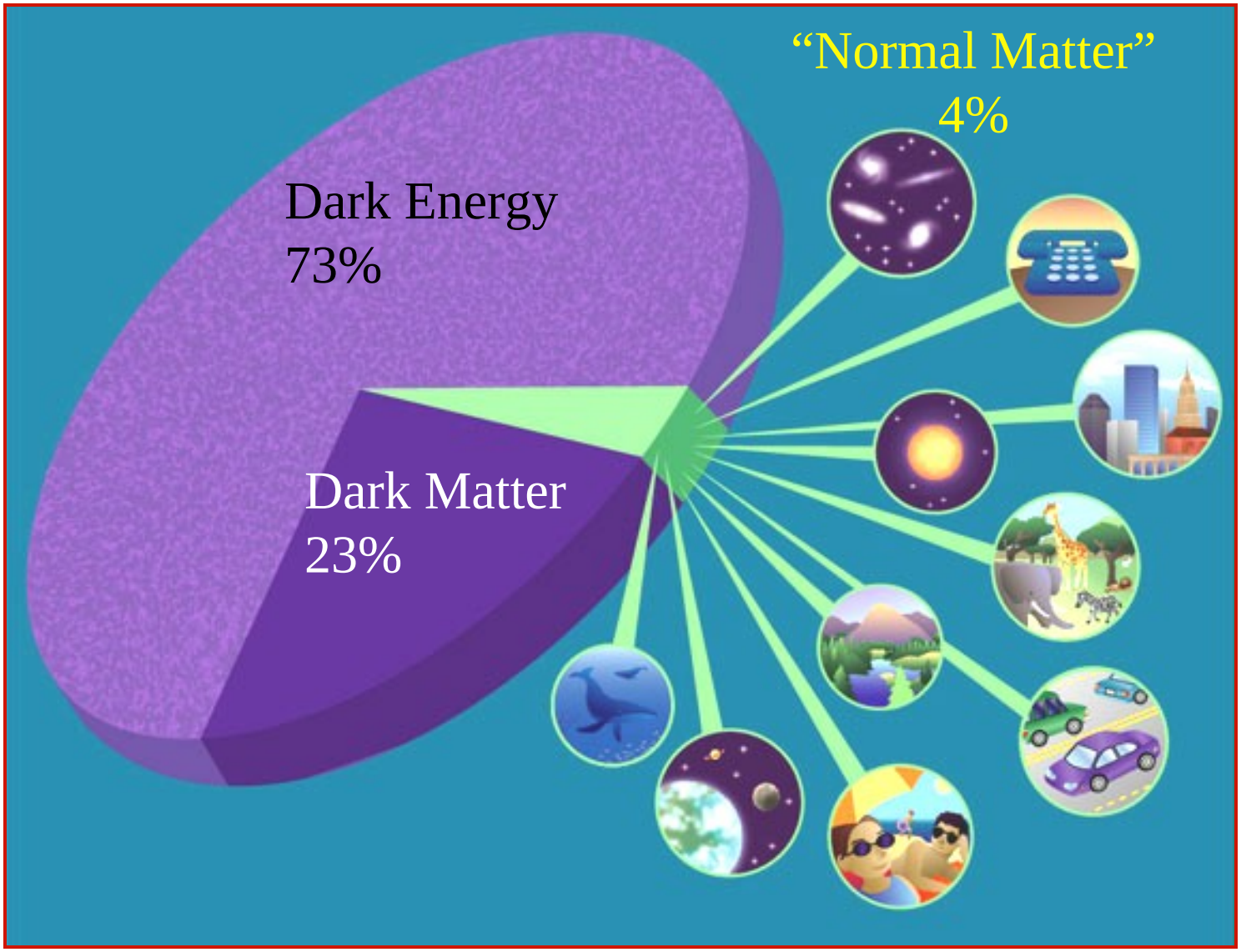
WMAP

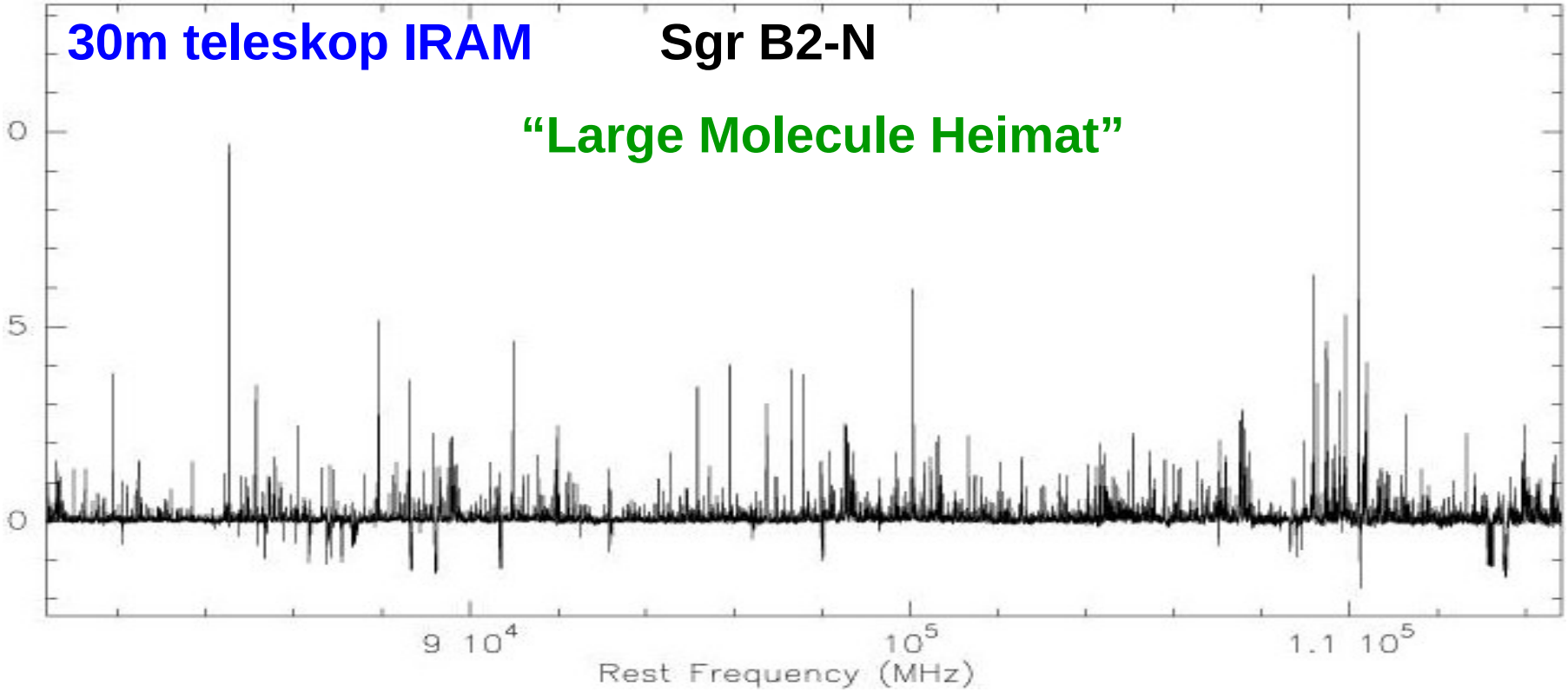
WMAP probed scales as small as 0.3 degrees


ACS
discovers
two distant
Type Ia
supernovae
Farthest
supernova
Deceleration
Acceleration
Expansion of universe
Big
Bang
10 billion
years
ago
5 billion
years
ago
Today


Ciemna energia
Ciemna materia
Materia swiecaca
23%
73%
4%


Cosmic Scale Factor
Open, Matter
Flat, Matter
Closed, Matter
Big
Bang
Big
Crunch
Time


"Normal Matter"
4%
Dark Energy
73%
Dark Matter
23%



In the band of 3 mm (70 – 116 GHz) within 500 MHz there are 2000 – 3000 lines !!!!

~10 minutes integratiion/spectrum → confusion limit

(Belloche, Comito, Hieret, Leurini, Menten, Schilke)

ALMA the new way to observe molecular clouds, protoplanets, chemical evolution of the Universe, origin of life

Table 1: Molecules in space

Detected cosmic molecules in interstellar and circumstellar environments (adapted from Wootten 2001).

Diatomic	Triatomic	4 atoms	5 atoms	6 atoms	7 atoms	8 atoms	9 atoms	10 atoms	11 atoms	13 atoms
H_2	C_3	c-C_3H	C_5	C_5H	C_6H	CH_3C_3N	CH_3C_4H	CH_3C_5N	HC_9N	$HC_{11}N$
AlF	C_2H	l-C_3H	C_4H	l-H_2C_4	CH_2CHCN	$HCOOCH_3$	CH_3CH_2CN	$(CH_3)_2CO$		
AlCl	C_2O	C_3N	C_4Si	C_2H_4	CH_3C_2H	CH_3COOH	$(CH_3)_2O$	NH_2CH_2COOH		
C_2	C_2S	C_3O	l-C_3H_2	CH_3CN	HC_5N	C_7H	CH_3CH_2OH			
CH	CH_2	C_3S	c-C_3H_2	CH_3NC	$HCOCH_3$	CH_2OHCHO	HC_7N			
CH^+	HCN	C_2H_2	CH_2CN	CH_3OH	NH_2CH_3		C_8H			
CN	HCO	CH_2D^+	CH_4	CH_3SH	c-C_2H_4O					
CO	HCO^+	HCCN	HC_3N	HC_3NH^+	CH_2CHOH					
CO^+	HCS^+	$HCNH^+$	HC_2NC	HC_2CHO						
CP	HOC^+	HNCO	HCOOH	NH_2CHO						
CSi	H_2O	HNCS	H_2CHN	C_5N						
HCl	H_2S	$HOCO^+$	H_2C_2O							
KCl	HNC	H_2CO	H_2NCN							
NH	HNO	H_2CN	HNC_3							
NO	MgCN	H_2CS	SiH_4							
NS	MgNC	H_3O^+	H_2COH^+							
NaCl	N_2H^+	NH_3								
OH	N_2O	SiC_3								
PN	NaCN									
SO	OCS									
SO^+	SO_2									
SiN	c-SiC_2									
SiO	CO_2									
SiS	NH_2									
CS	H_3^+									
HF	SiCN									
SH										

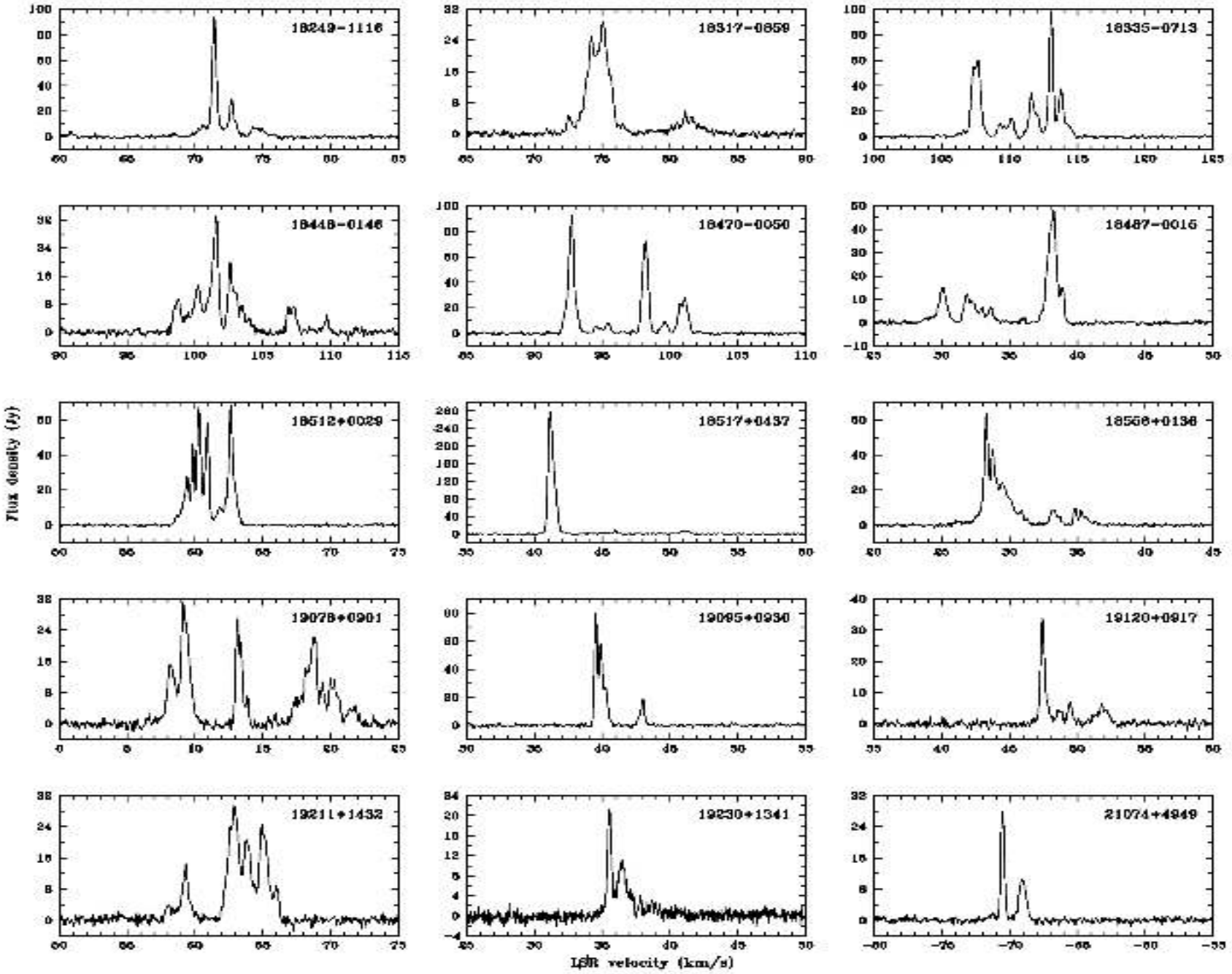
Cosmic Masers

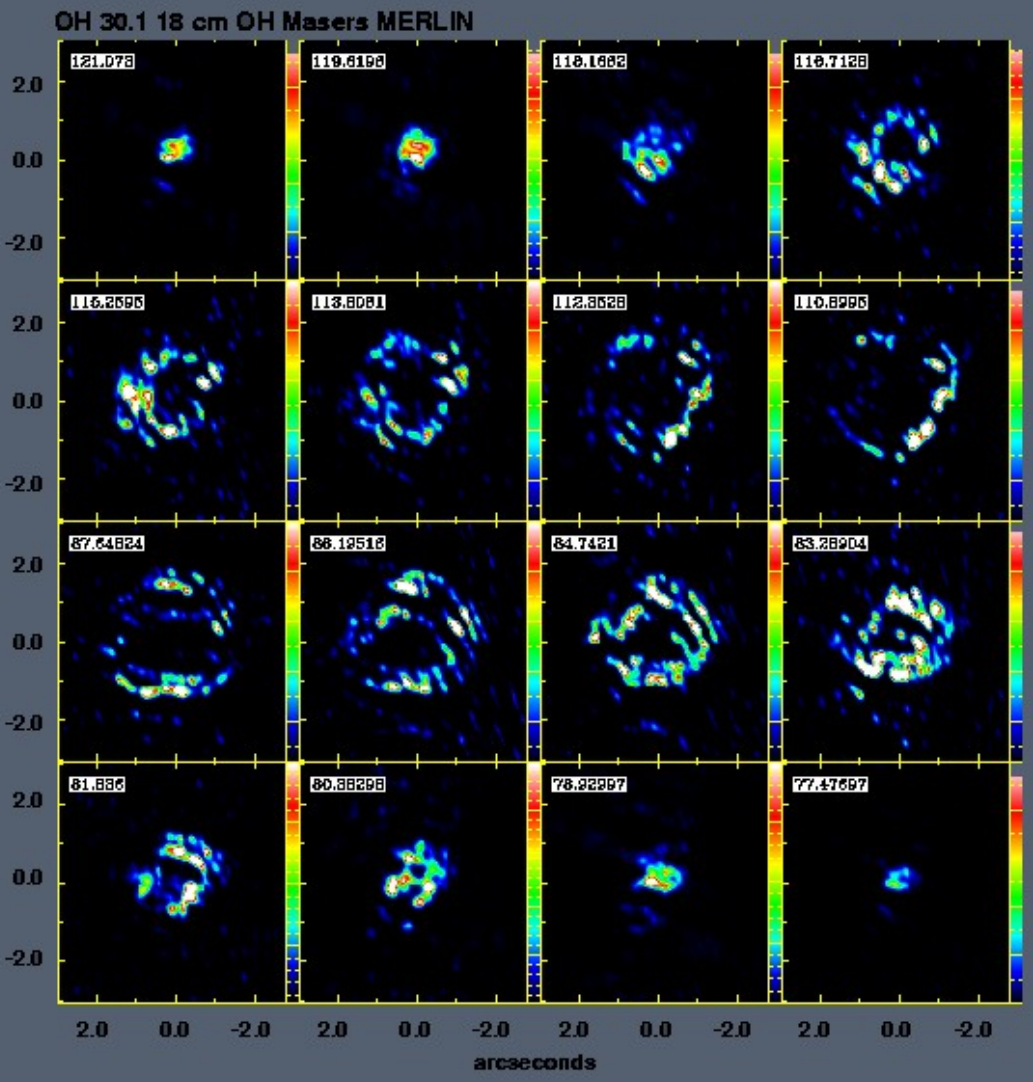
OH

H_2O

SiO

CH3OH


18249-1116
18317-0859
18335-0713
18448-0146
18470-0050
18487-0015
18512+0029
18517+0437
18556+0136
19078+0901
19095+0930
19120+0917
19211+1432
19230+1341
21074+4949
Flux density (Jy)
LSR velocity (km/s)

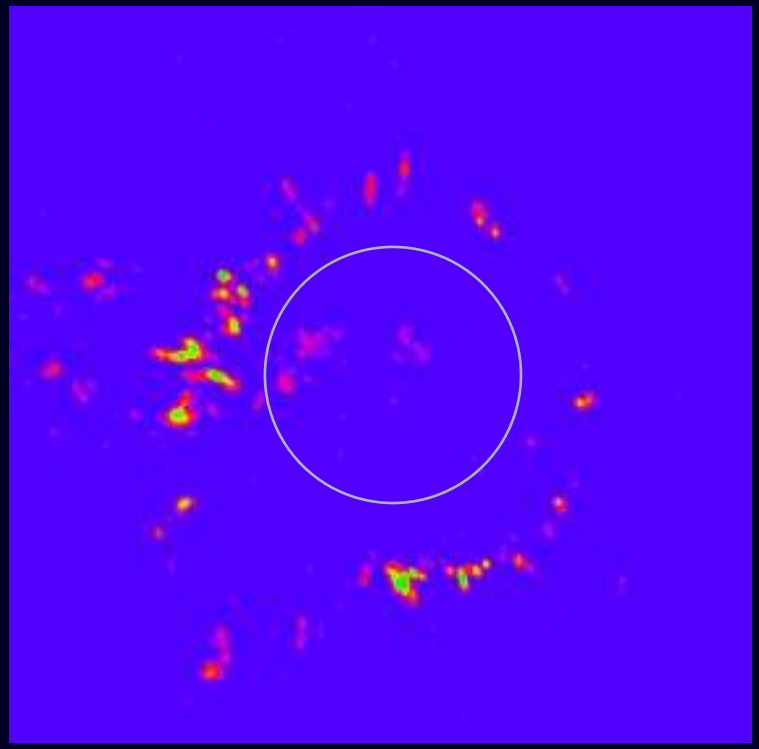


Images made by Chapman (ATNF) at Jodrell Bank with MERLIN telescopes

OH

3D tomography of stellar atmospheres

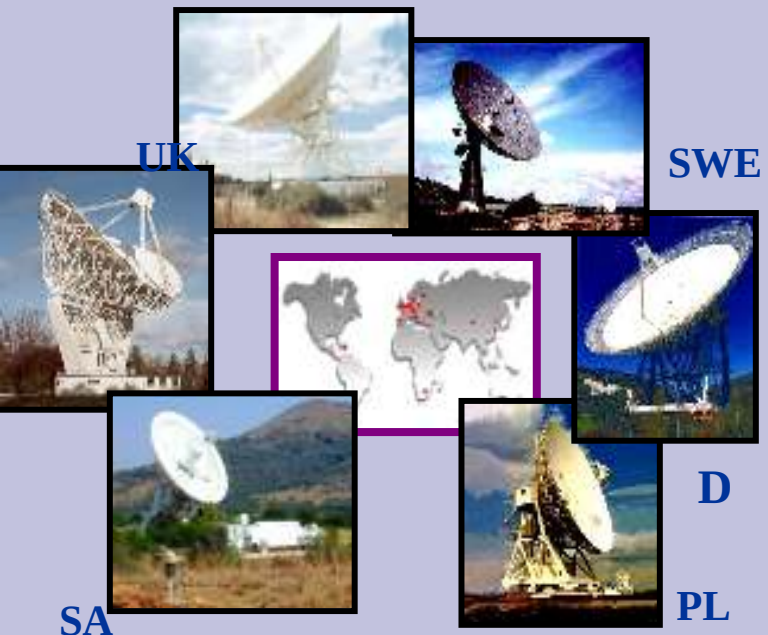
stellar disk

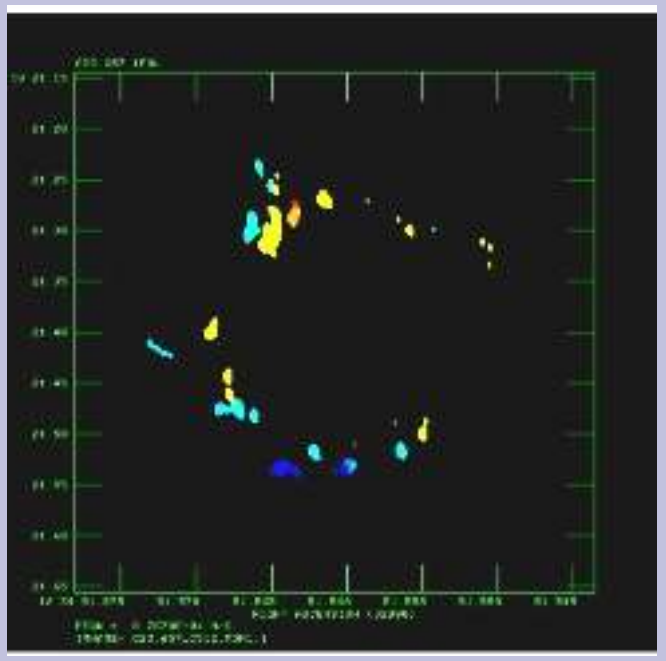


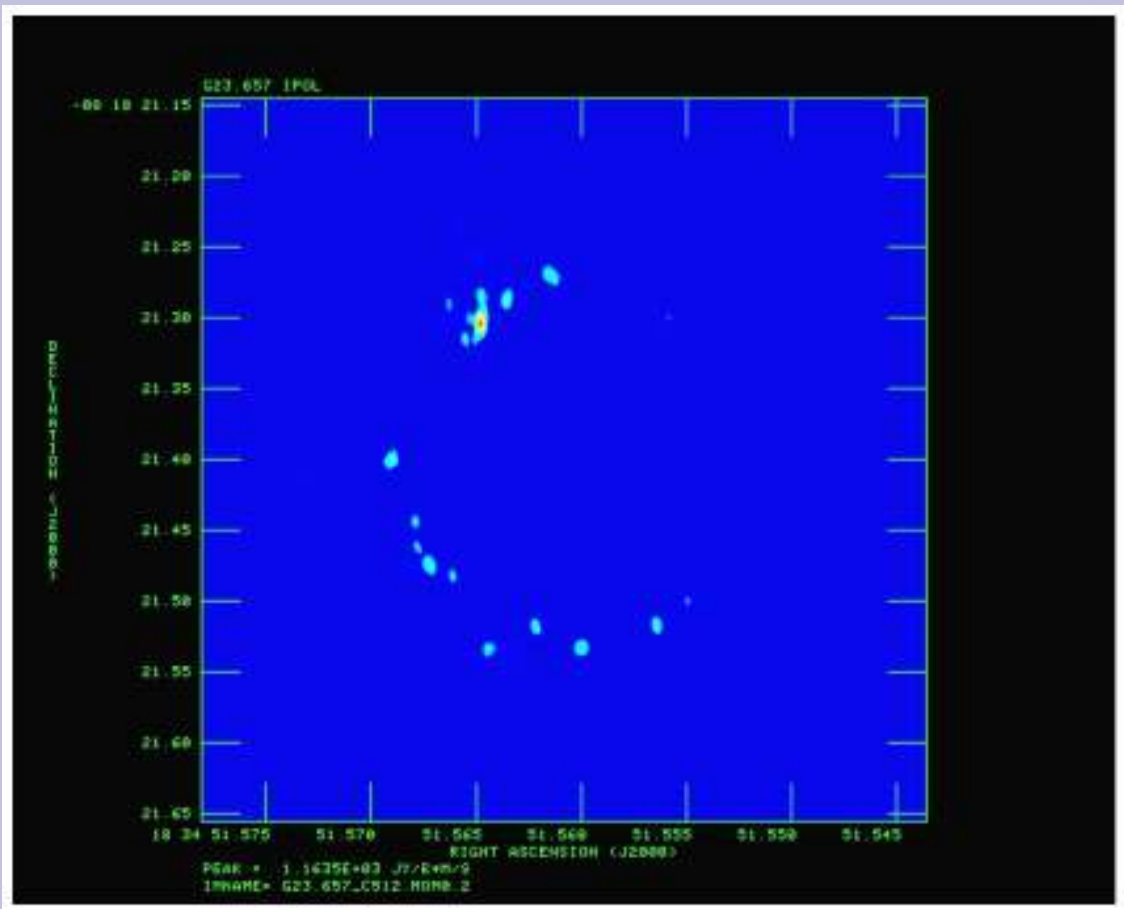
Evolution of SiO masers in TX Cam Diamond and Kambal

SiO

H_2O





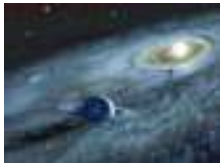


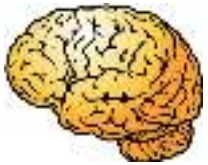
G23.657 methanol maser

Drake Equation

Frank Drake





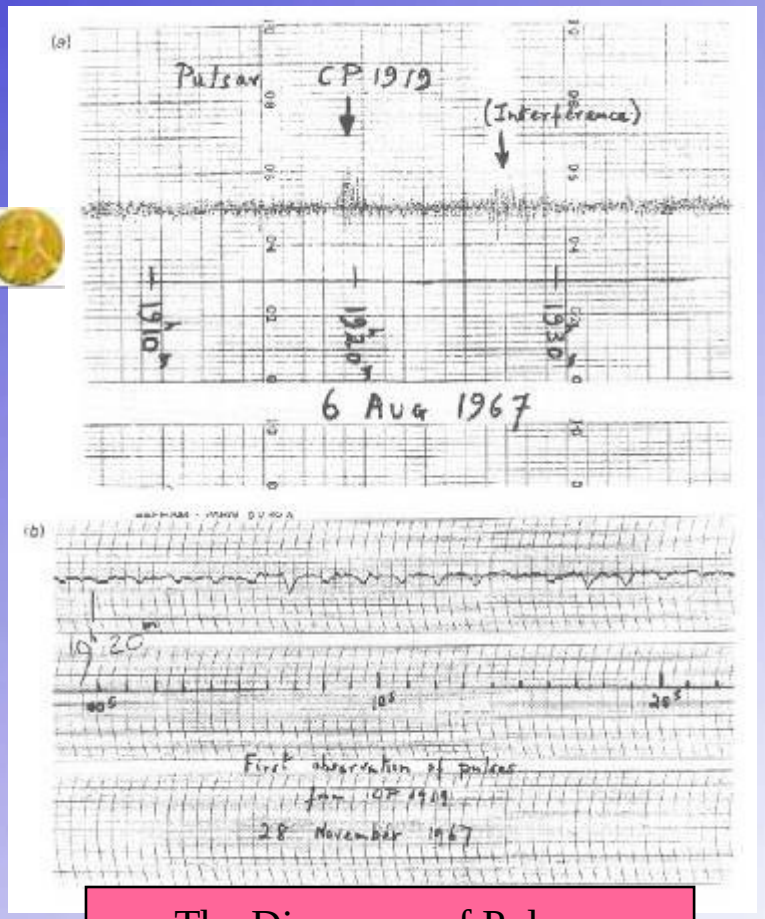



$$N = R_* \times f_p \times n_e \times f_l \times f_i \times f_c \times L$$

# of advanced civilizations we can contact	Rate of formation of Sun-like stars	Fraction of stars with planets	# of Earthlike planets per system	Fraction on which life arises	Fraction that evolve intelligence	Fraction that commun-icate	Lifetime of advanced civilizations

It has a rich history of discovery

- ***Over the past 50yr***
  - ***Pulsars***
  - ***Microwave Background***
  - *Cosmic Evolution*
  - *Dark Matter in galaxies*
  - *Quasars*
  - *Jets + Superluminal motion*
  - ***Gravitational Radiation***
  - *Aperture Synthesis*
  - ***First exoplanets*** *(AW)*



The Discovery of Pulsars

The Nobel Prizes

- *1974 M.Ryle, A.Hewish*
- *1978 A.Penzias, R.Wilson*
- *1983 S.Chandrasekhar, W.Fowler*
- *1993 R.Hulse, J.Taylor*
- *2002 R.Giacconi*
- *2006 J.Mather, G.Smoot*
- *2011 S.Perlmutter, B.Schmidt, A.Riess*
- *2013 (?)*

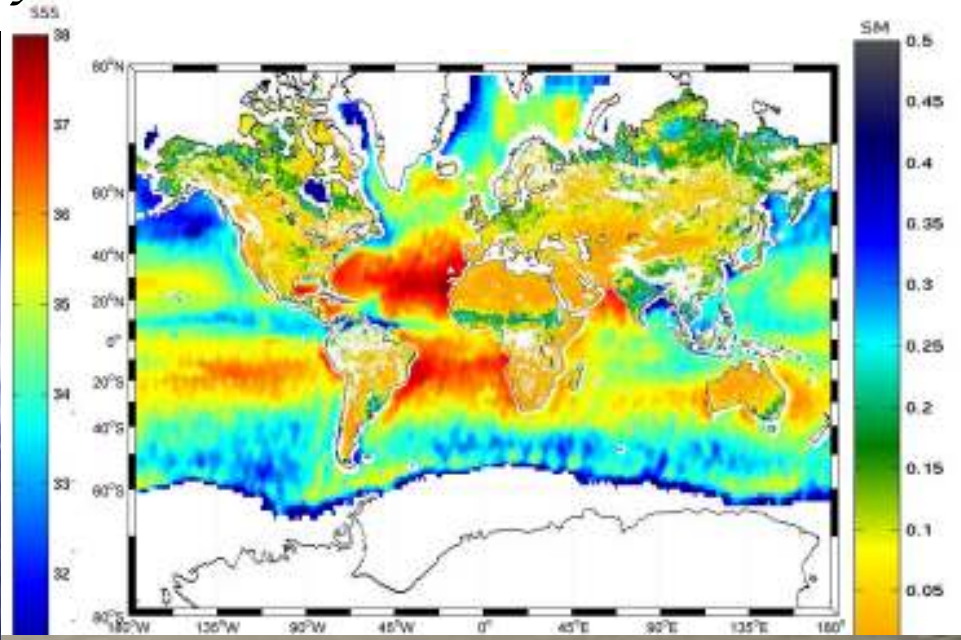
Radio Astronomy (8) Astrophysics, X-ray (6)

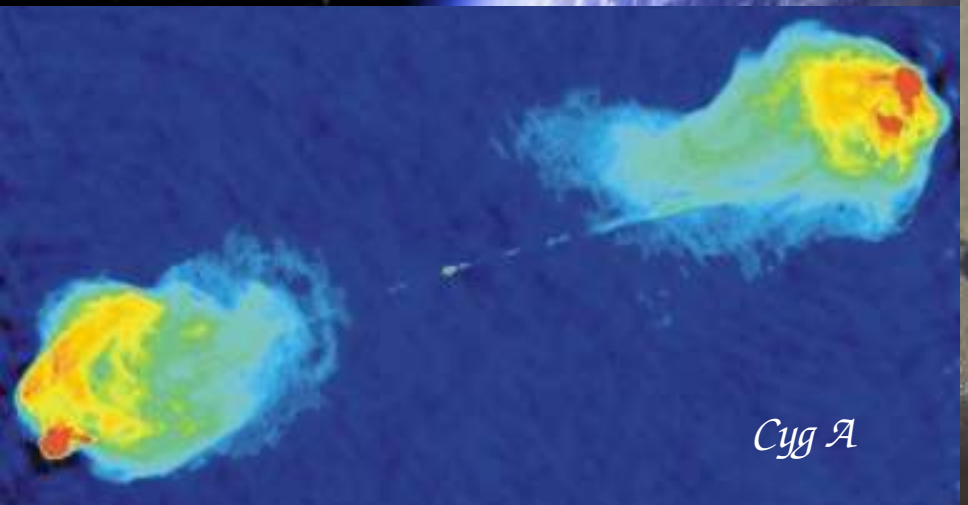
Technology Advances

- Antenna techniques
- Ultra low noise receivers
- Radiometry
- Remote sensing
- Interferometry IVS (geodesy)
- Navigation (Earth and Space)
- GPS
- Satellite TV brodcast
- Data processing, new methods

Practcal applications of radio astronomy technique

ESA **SMOS**



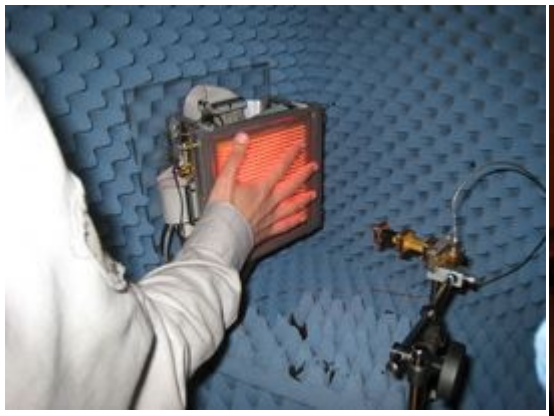


Cyg A

VLA USA

Practical applications of radio astronomy techniques

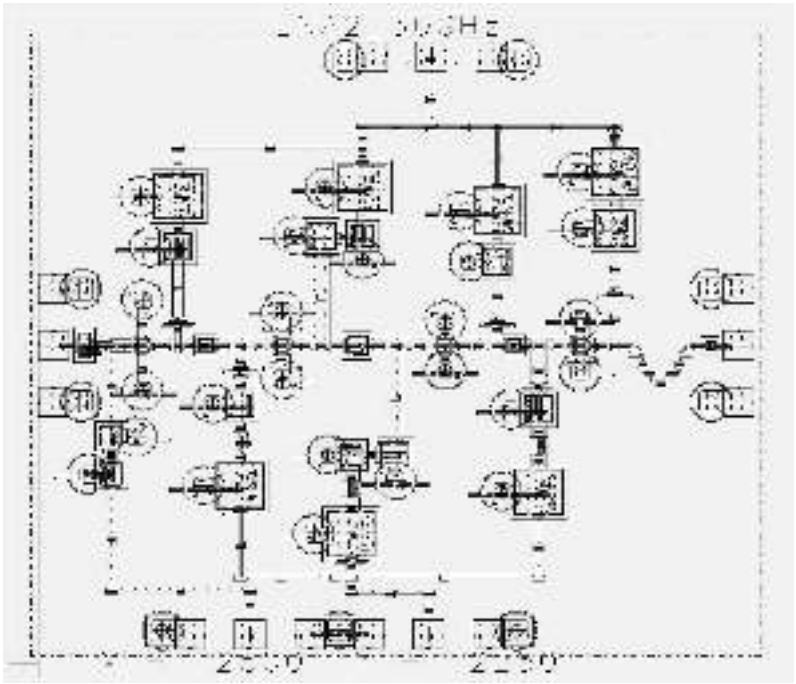
Microwave cameras, skanners, radiometry, Telecommunication, TV-sat

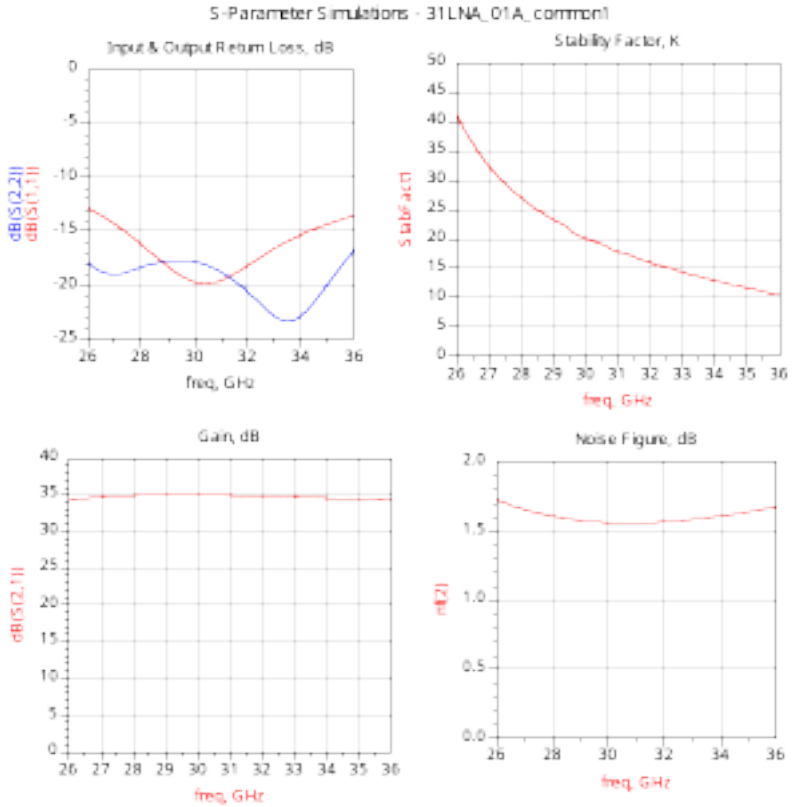


OCRA-f cryostat

Chip designs for 2nd wafer run.

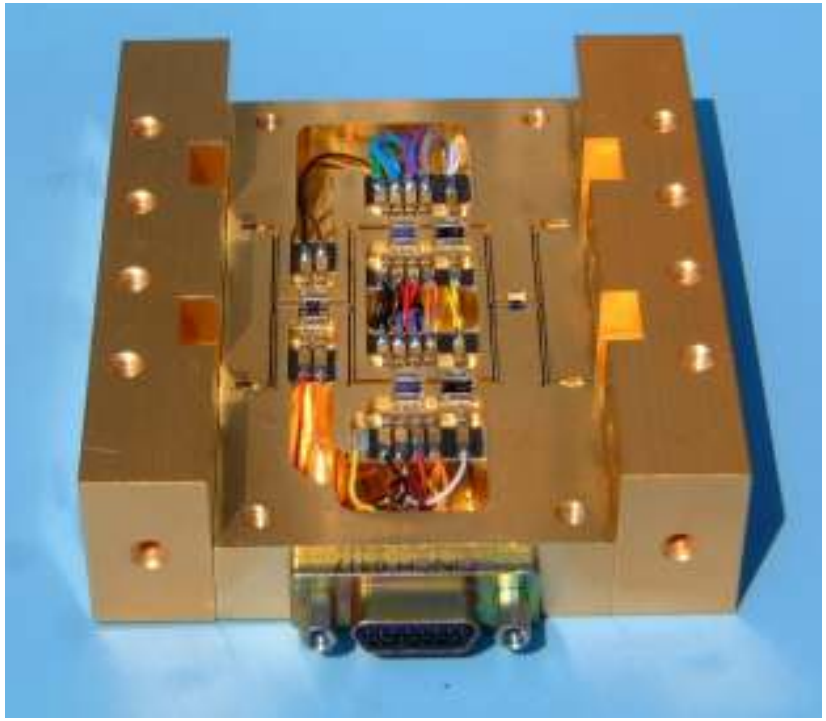
30 GHz LNA common bias

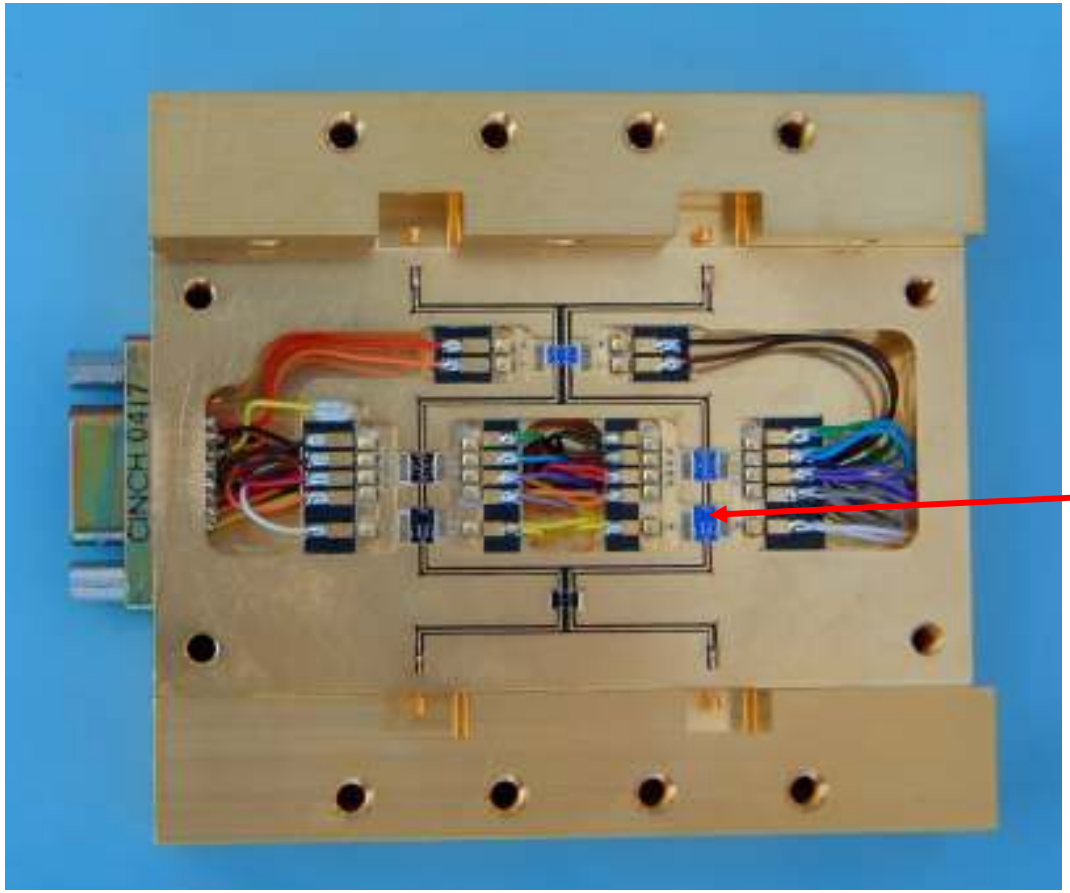




Prototypowy

front-end-module



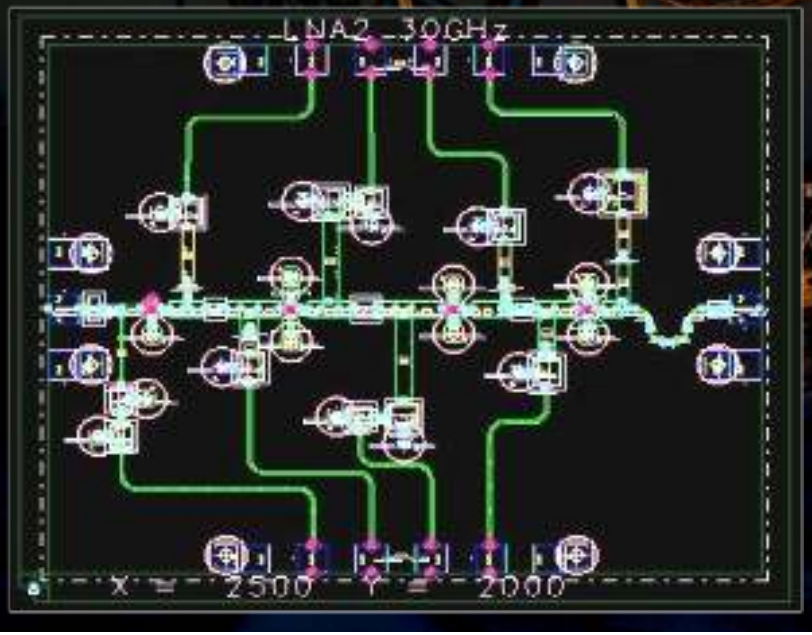


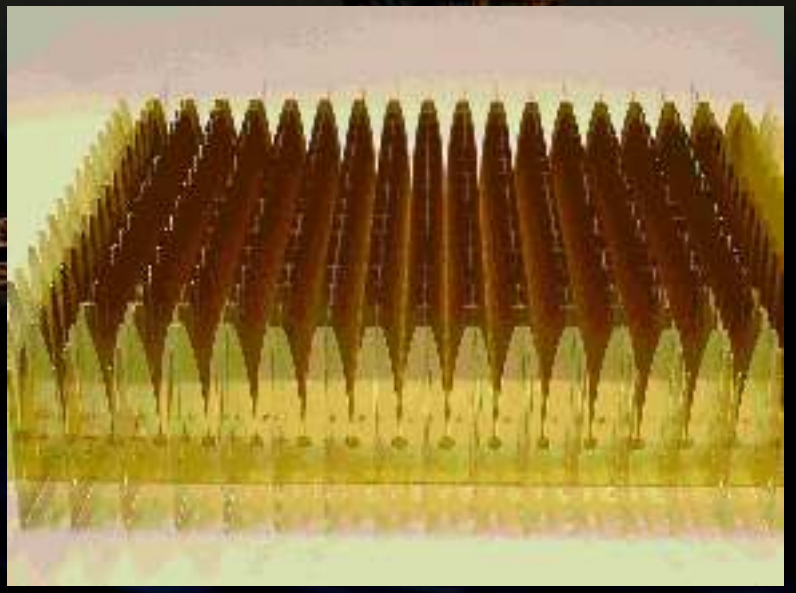
MMIC

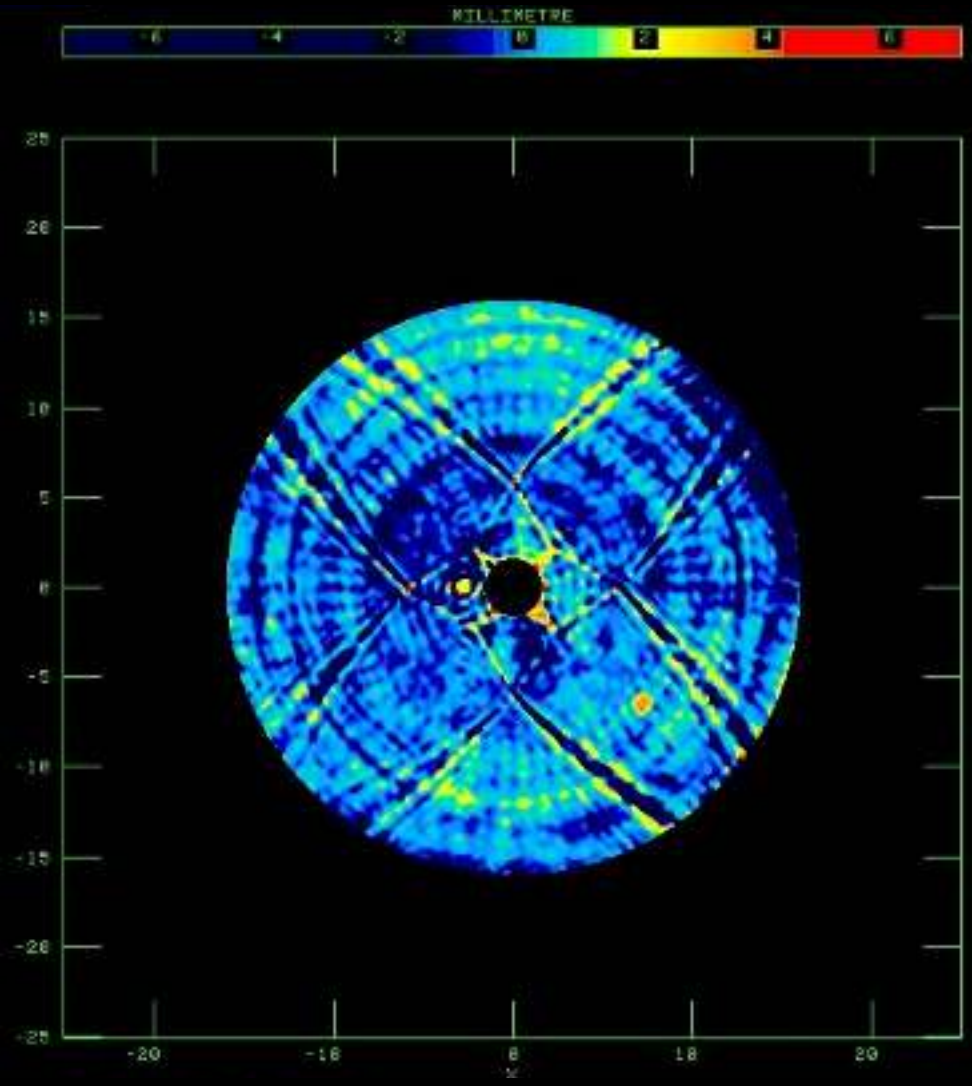
PHased Arrays for Reflector Observing Systems

PHAROS (FARADAY)

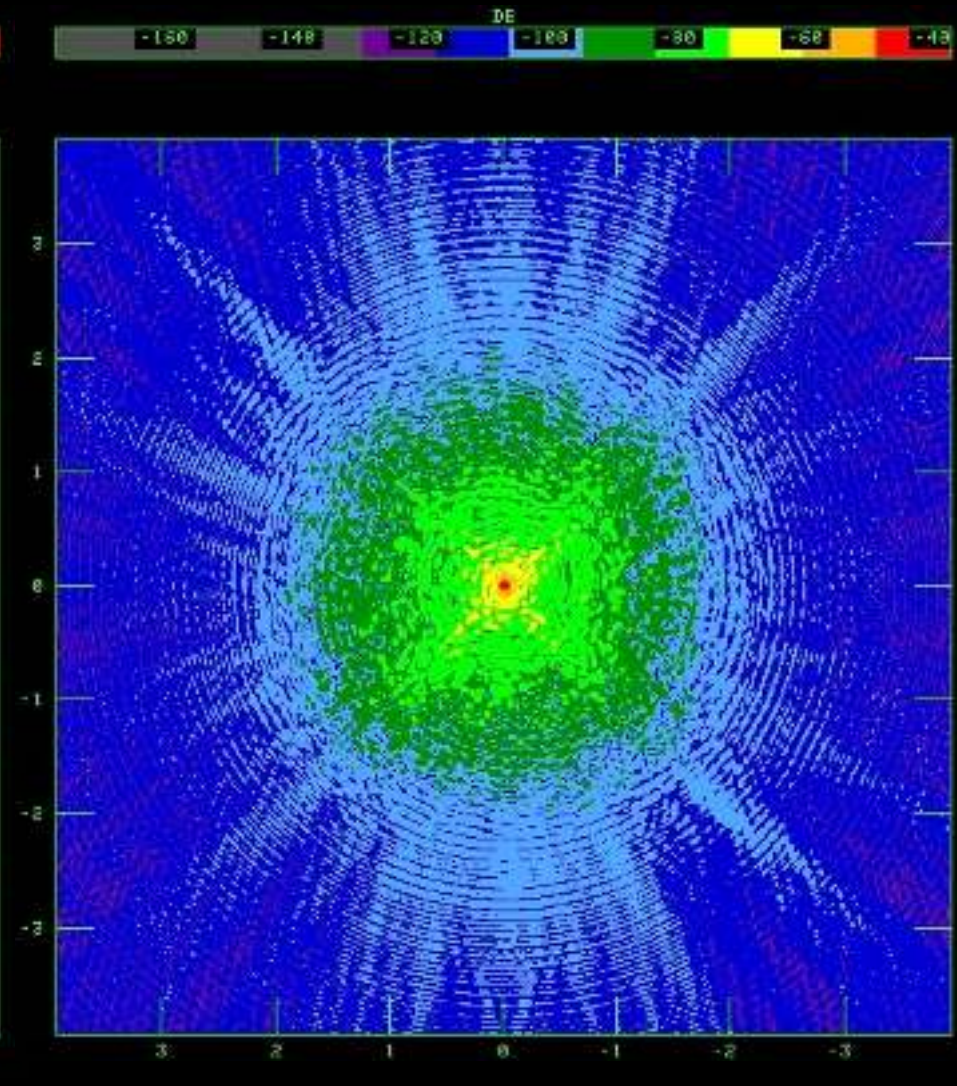
VI PR EU







Surface errors [mm]



Point source PSF

Significant progress in modern astronomy is being made by dramatic improvements of instrumental performance

- sensitivity, - angular resolution, - spectral resolution,
- time resolution ***these are of fundamental merit****.*

In observational astrophysics we still need :

- *large apertures (but then small field of view, can only study individual objects)*

- *telescopes for surveys with large field of view (statistical s.)*

- *telescopes in new spectral domains, + gravitational waves, cosmic rays and more (?)*

in RADIO progress possible if we get :

– higher sensitivity -> SKA

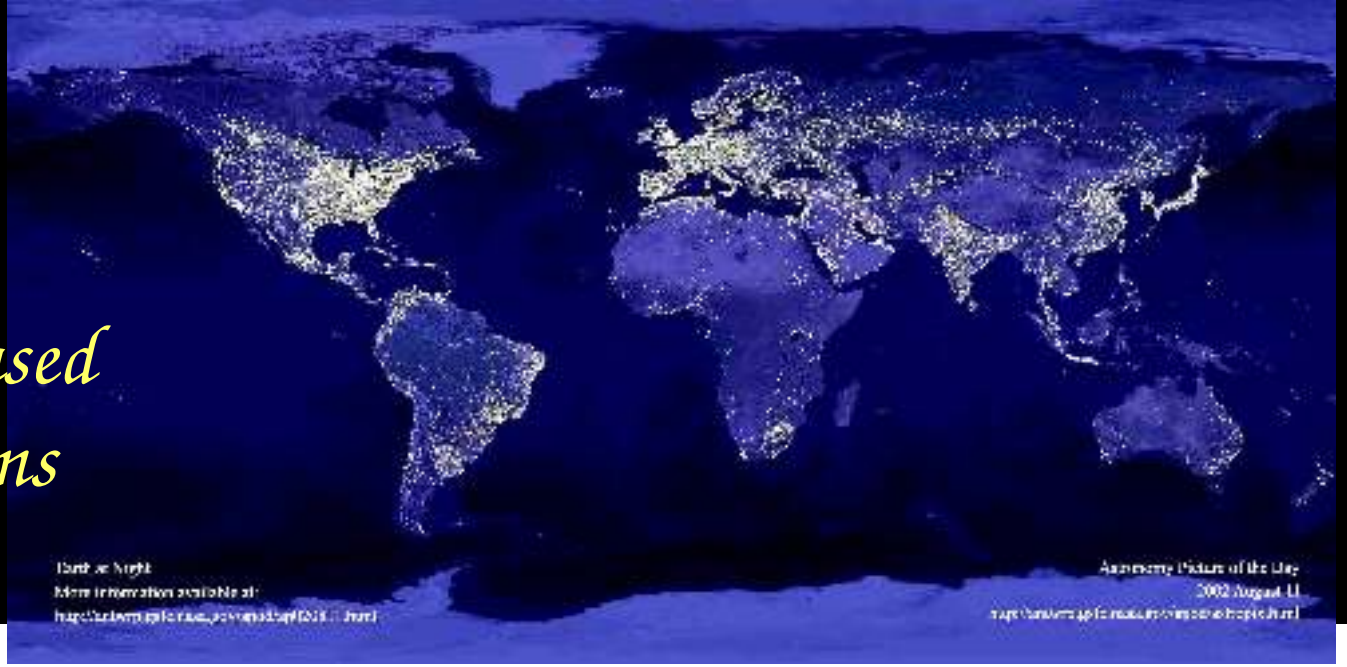
– higher angular resolution - VLBI (interferometry)

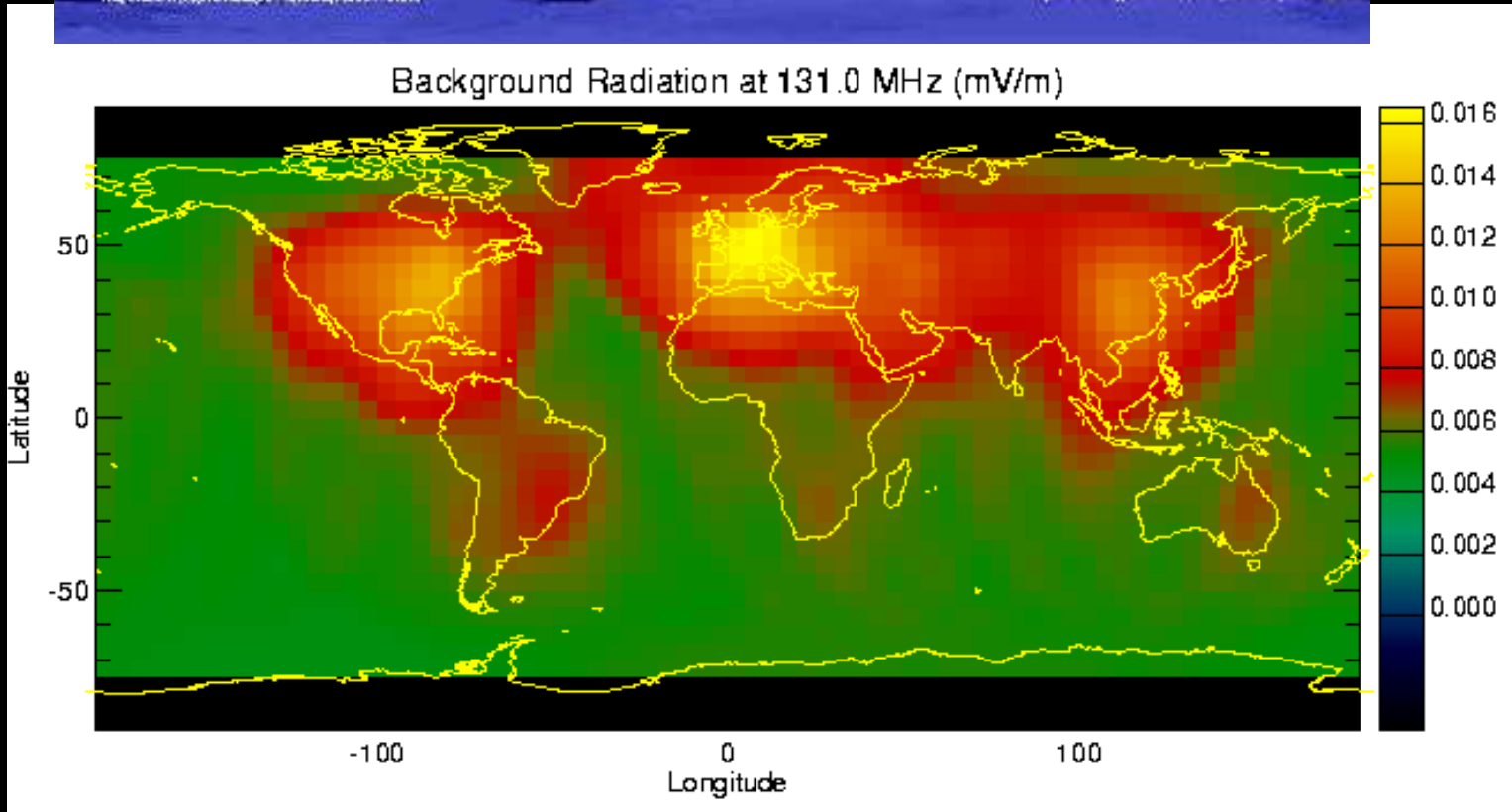
- new radio bands (mm - submm) -> ALMA

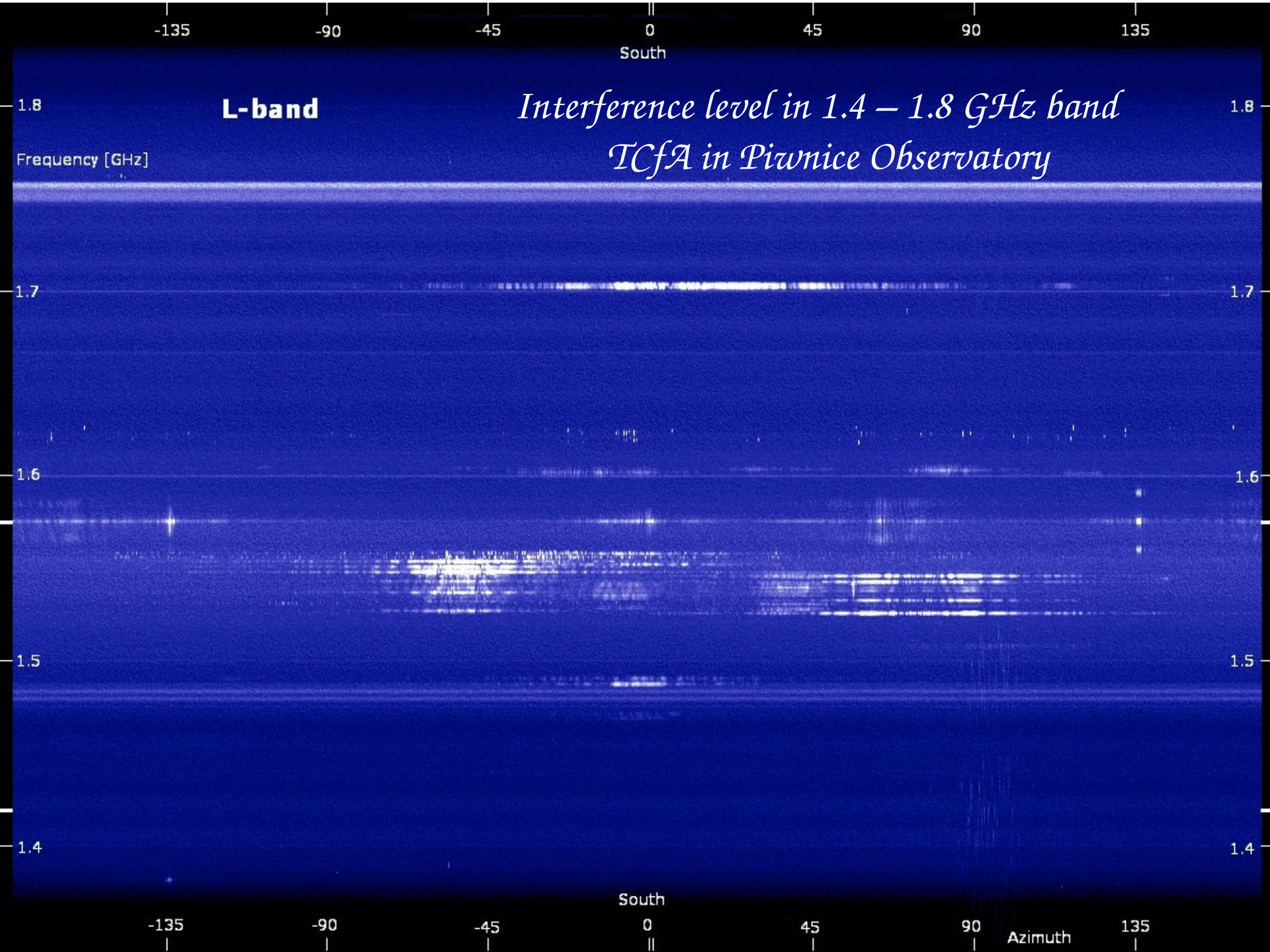
- new astronomical targets (yet unknown !)

But .... rising level of radio / light pollution !!!

Ground based observations






-135
-90
-45
0
45
90
135
South
L-band
Interference level in 1.4 – 1.8 GHz band
TCfA in Piwnice Observatory
1.8
Frequency [GHz]
1.7
1.6
1.5
1.4
South
Azimuth

Beginnings of Radio Astronomy in Poland

Cracow Observatory

- 1954 first observations

of solar radio emission O.Czyżewski, A.Strzałkowski J.Demezer, Kozieł, Masłowski

5m antenna at λ 90 cm

- 1970 15m antenna
- Solar Radio Emission
- Extragalactic polarization studies

2014 LOFAR

Torun Observatory

-1958 first successful solar observations, 12m antenna

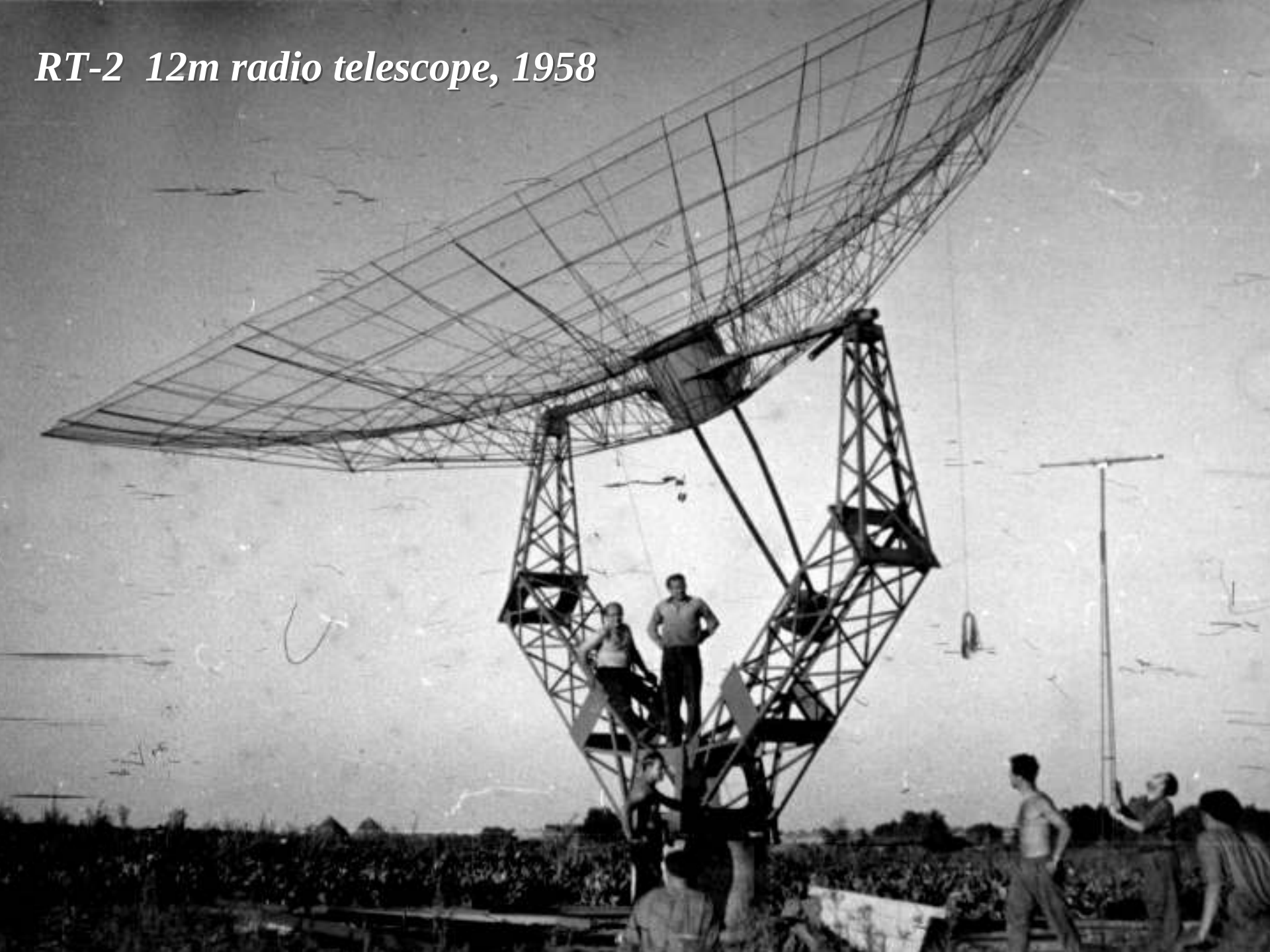
S.Gorgolewski, A.Manczalski, J.Groszkowski,

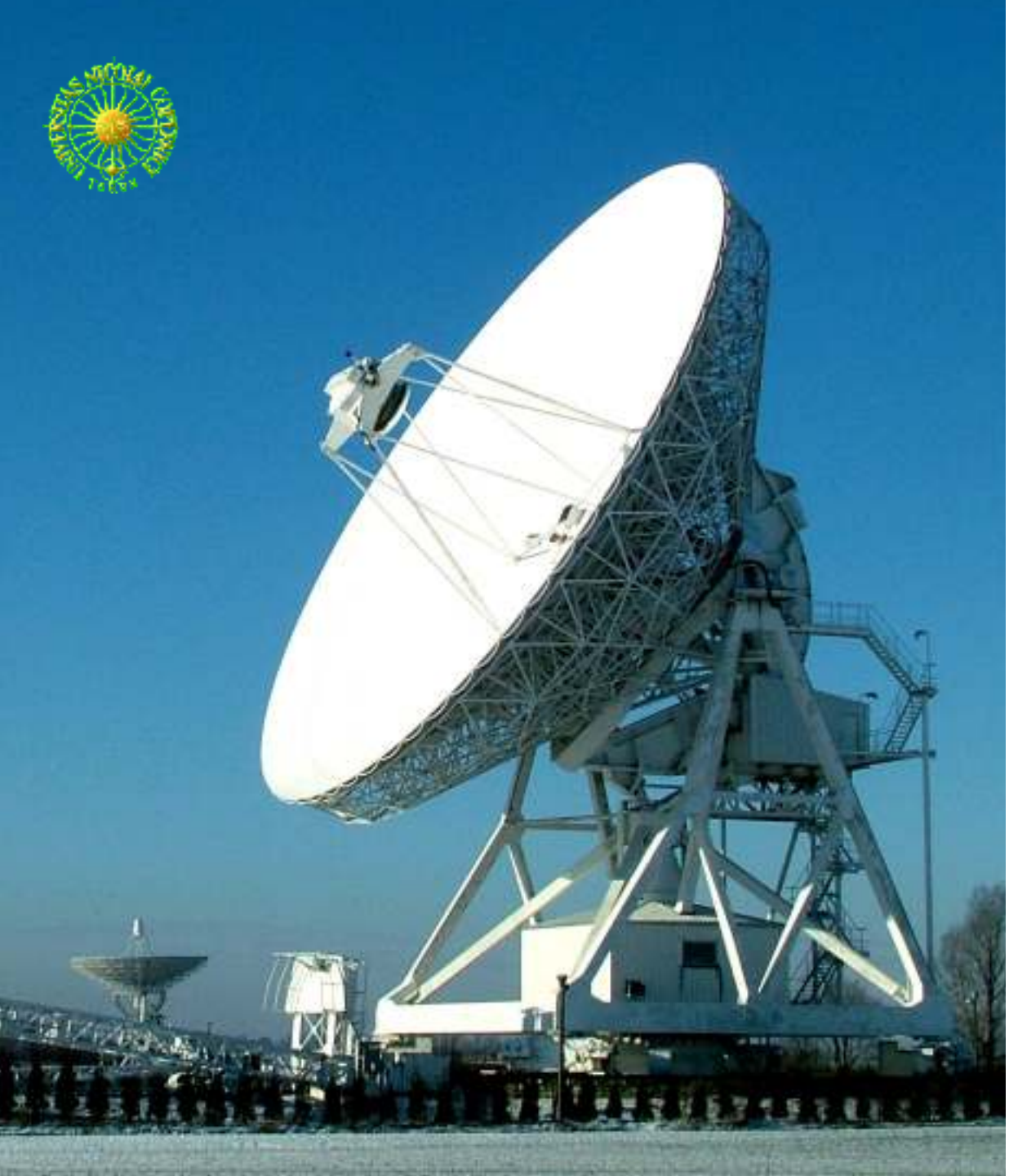
- 1977 15m antenna
- 1994 32m antenna

VLBI, pulsars, spectroscopy, polarimetry

2014 ~90m antenna

RT-1 30x12m
and its crew


RT-2 12m radio telescope, 1958



Basic information on RT4

- Designed and built in Poland
- Homology design – „self correcting”
- Completed in ’94, operation since ’96

- Diameter 32m
- Cassegrain with 3.2m secondary
- Surface accuracy 0.4 mm RMS
- Pointing and tracking ~10 arcsec
- Total weight 600 Mg
- Motors in Az and El up to 30 deg/min
- Control fully computerized

- Radio receivers cover

750-1100 MHz	*(30cm)*
1400-1800 MHz	*(20cm)*
4400-5100 MHz	*(6cm)*
6100-7000 MHz	*(5cm)*
26000-34000 MHz	*(1cm)*

- VLBI terminal (MkIV => MkVa)
- Pulsar machine
- Autocorrelation spectrometr
- Polarymeter
- Hydrogen maser frequency standard
- OCRA – multi beam system

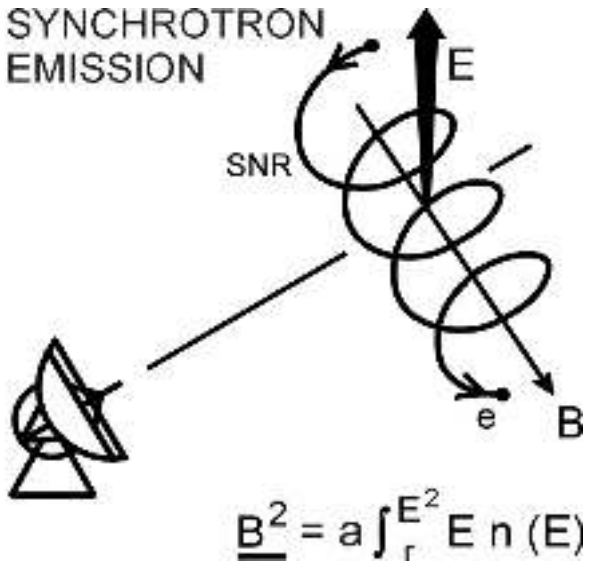
Current projects on RT4

- *EVN*
- *Pulsars*
- *Radio spectroscopy*
- *Polarymetry*
- *OCRA – radio camera*
- *education*

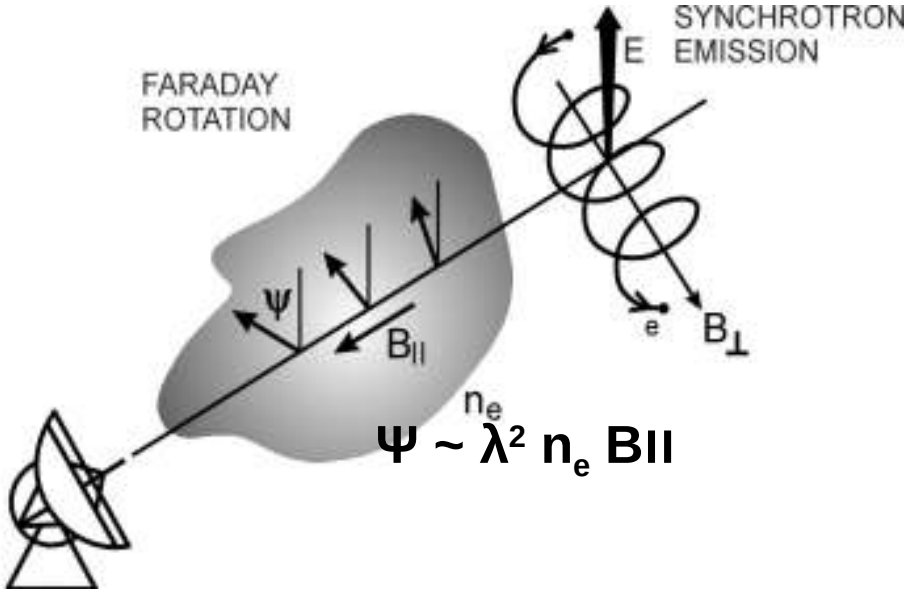
Cracow Astronomical Observatory

Jagiellonian University

Radio polarimetry – a method of measuring cosmic magnetic fields

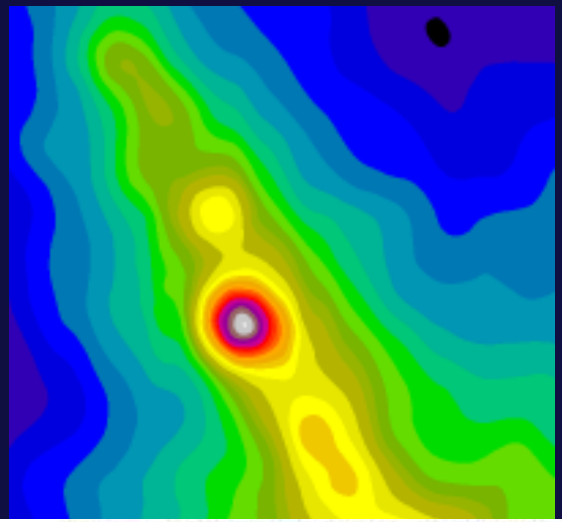


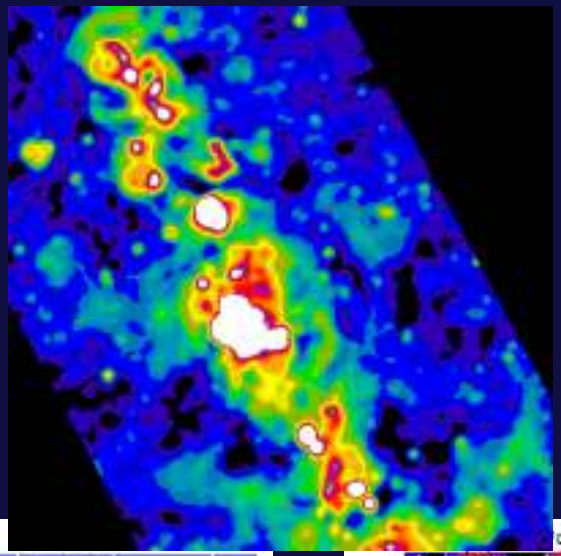
Radio waves emerge polarized from magnetic field regions

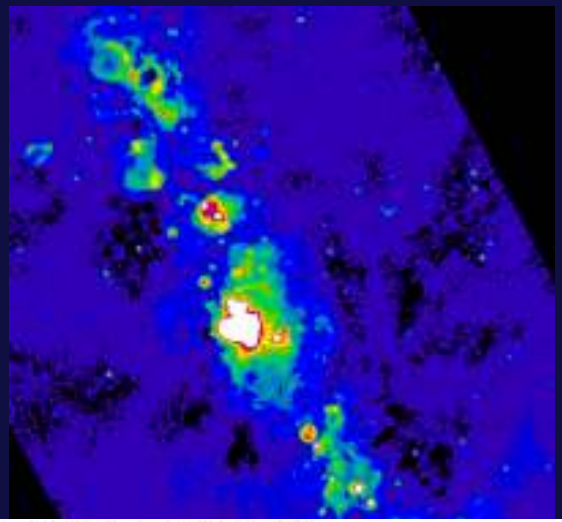


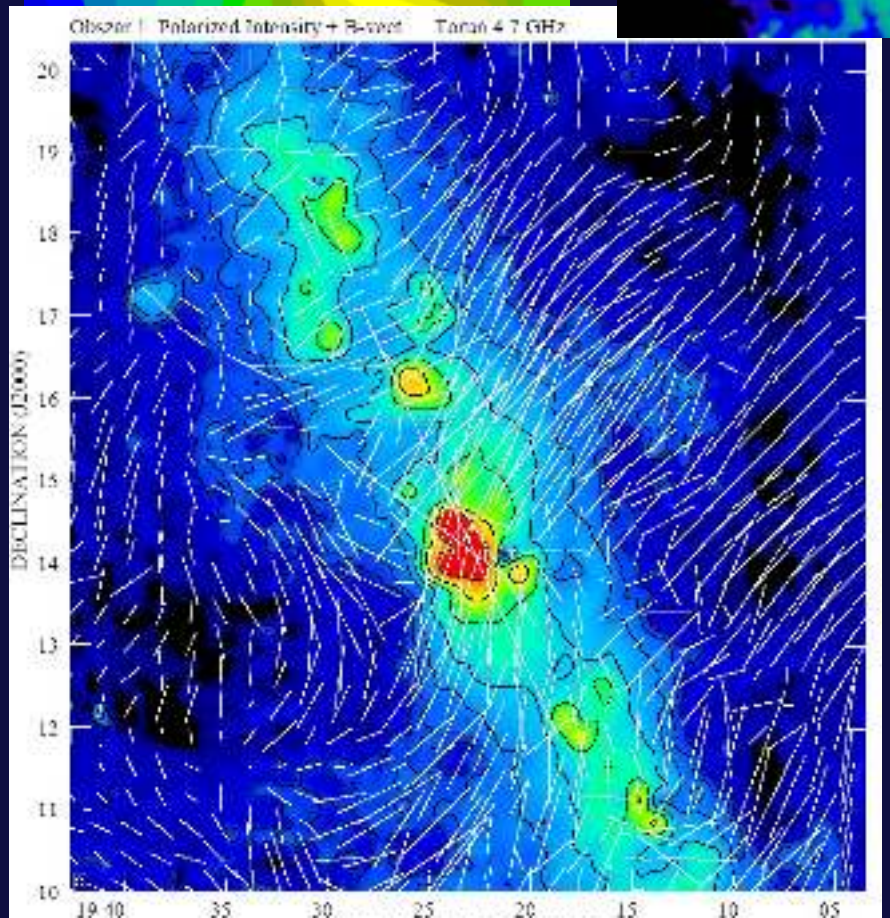
Radio waves suffer rotation In the interstellar medium

The measurement of polarization gives us information about the cosmic magnetic fields








DECLINATION (J2000)
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19
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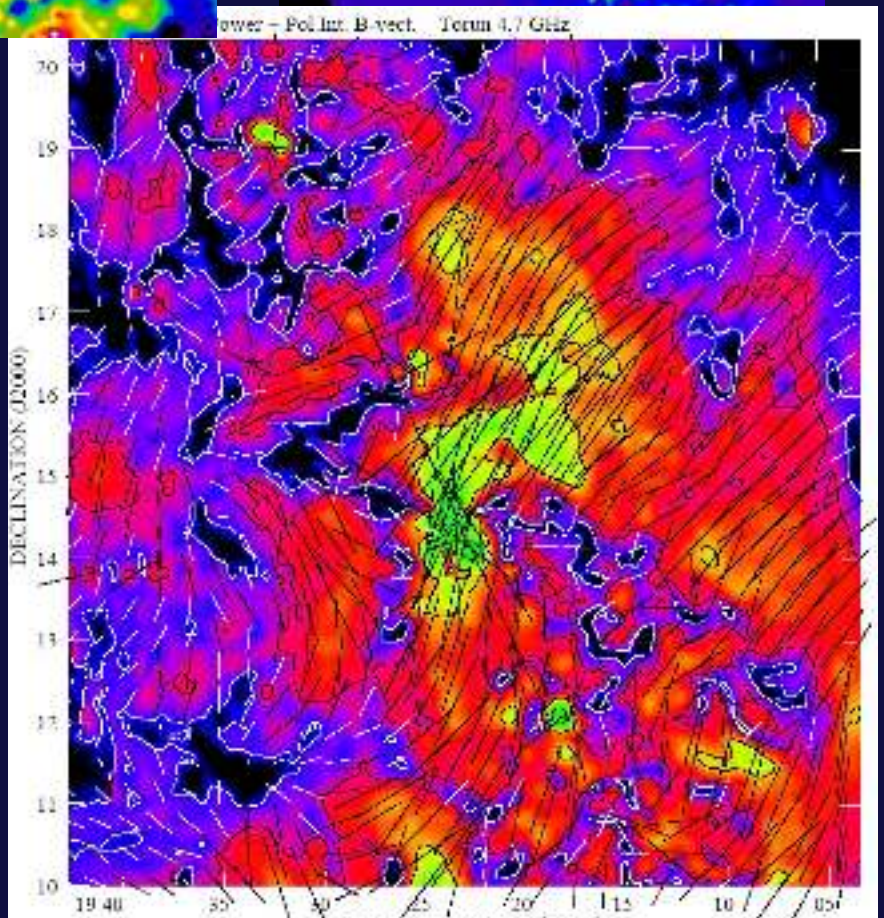
DECLINATION (J2000)
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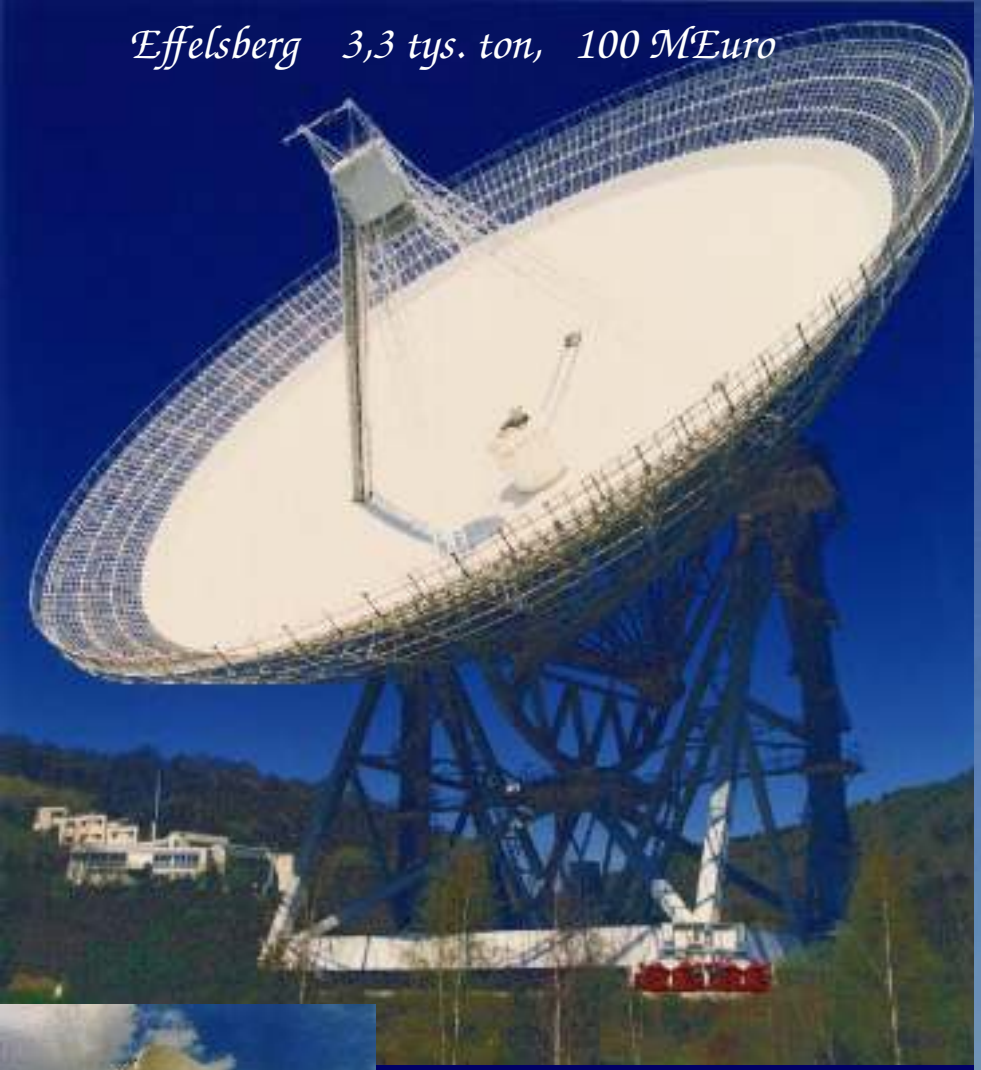
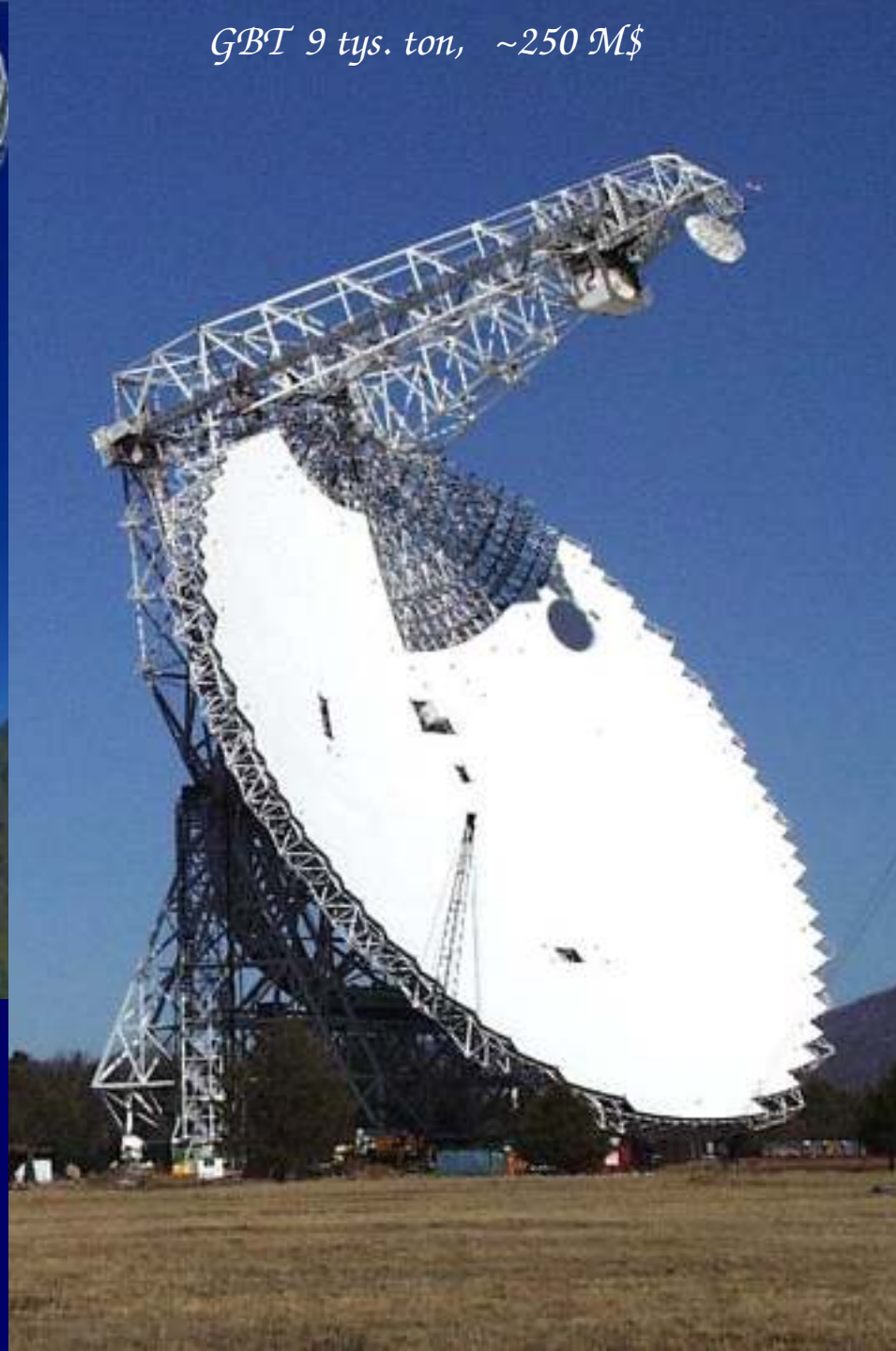
Effelsberg 3,3 tys. ton, 100 MEuro

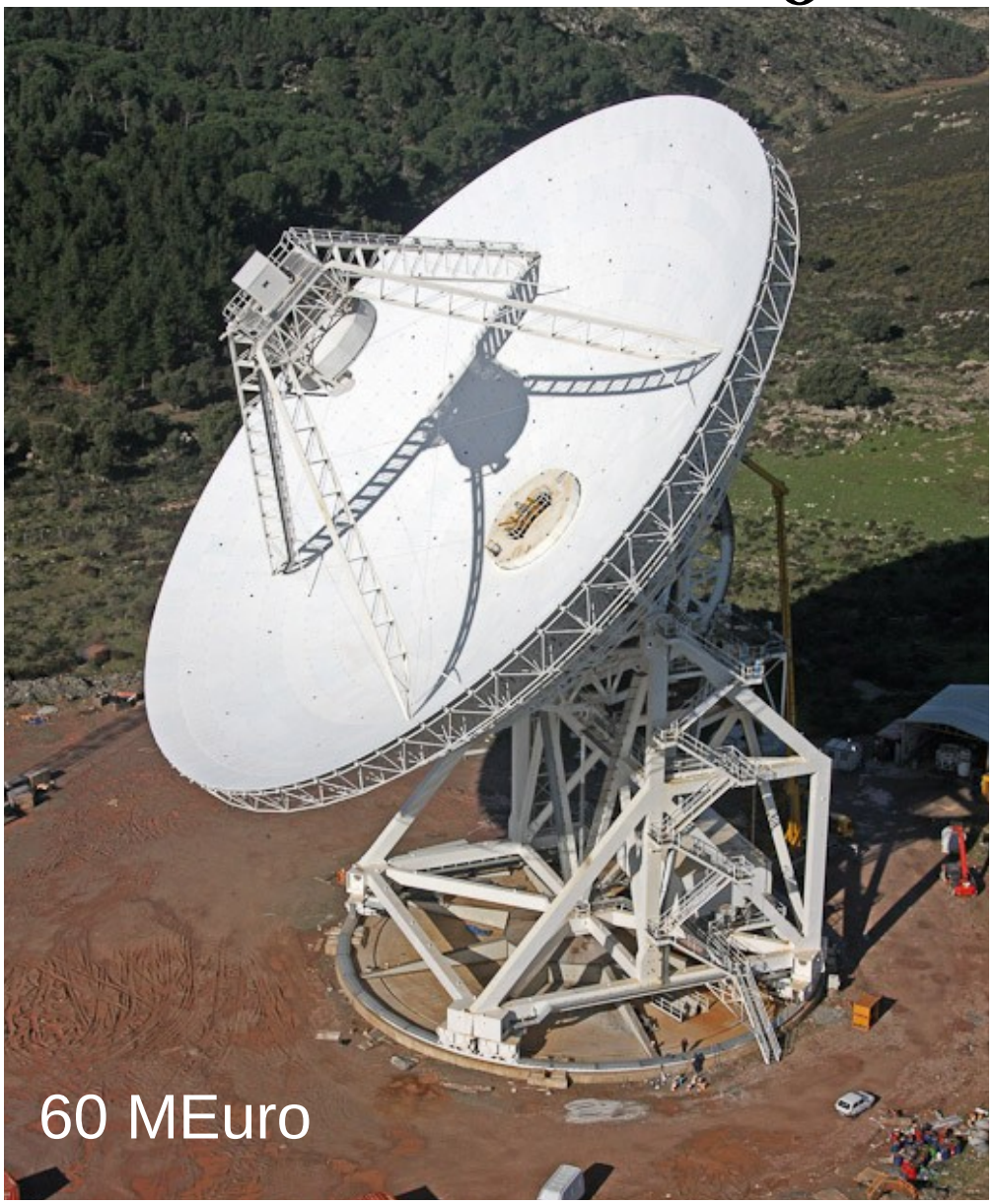


RT4, weight 600 ton
cost ~8 MEuro

GBT 9 tys. ton, ~250 M$



Sardinia Radio Telescope (2012)



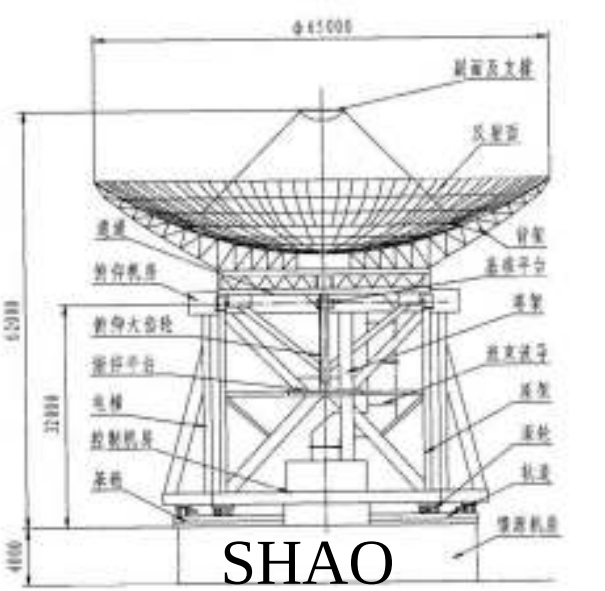
New large radio telescopes

Yebes Spain 40m

64 m SRT

frequency cover up to 100 GHz

Miyun
50m



SHAO

Urumqi, Shanghai, NAOC

China Radio Telescopes

50m 65m 80, 120m

Urumqi 80+m

Five hundred meter Aperture Spherical Telescope

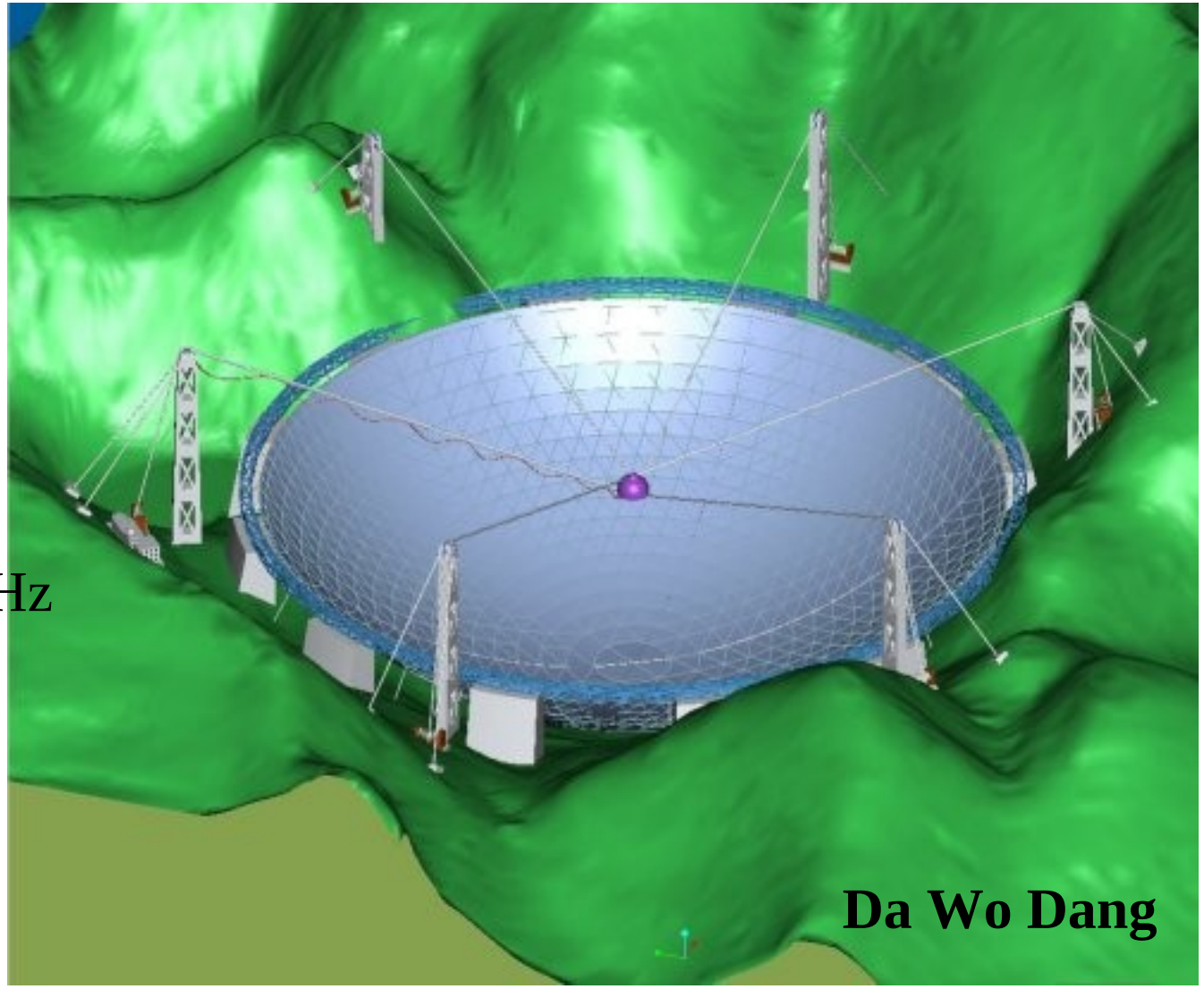
FAST in China (2015)

- 2x Arecibo
- 5x larger field-of-view than Arecibo

500 m diameter
300 m active surface
+/- 30^{o} sky coverage
130 MHz – 2(8.8) GHz
4” pointing

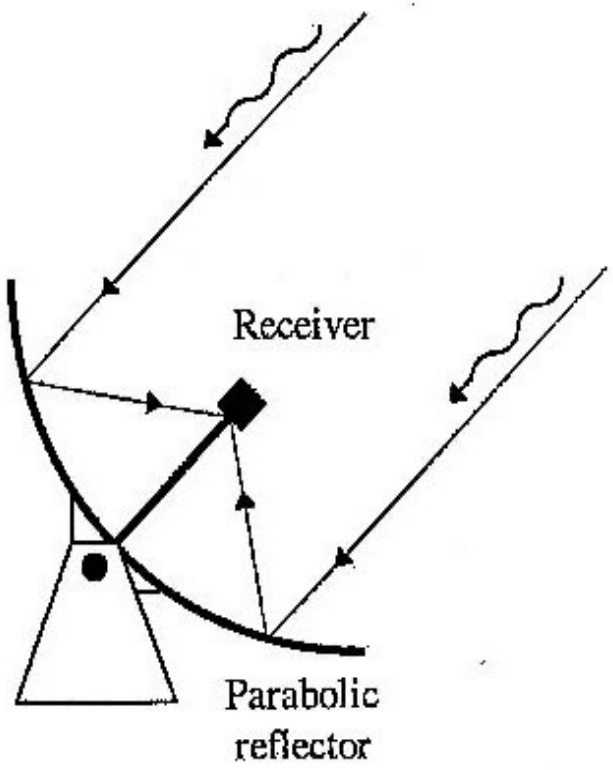
4x FAST => SKA

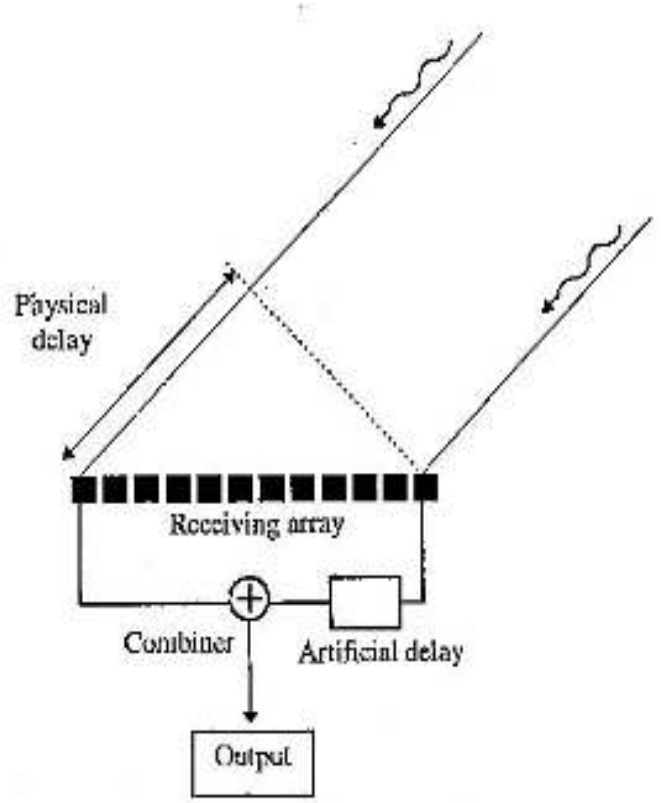
Cost ~100 M $



Phased array concept

Basic idea: replace mechanical pointing & beam forming by electronic means






VLA/e-VLA 2012
Very Large Array
NRAO, Socorro,
USA
Built in 1972-1980
78 millions $ (1975)

ALMA - Atacama Large Millimeter Array

International project (ESO, USA, Japan)

~50 antennae, each ~ 12m diameter

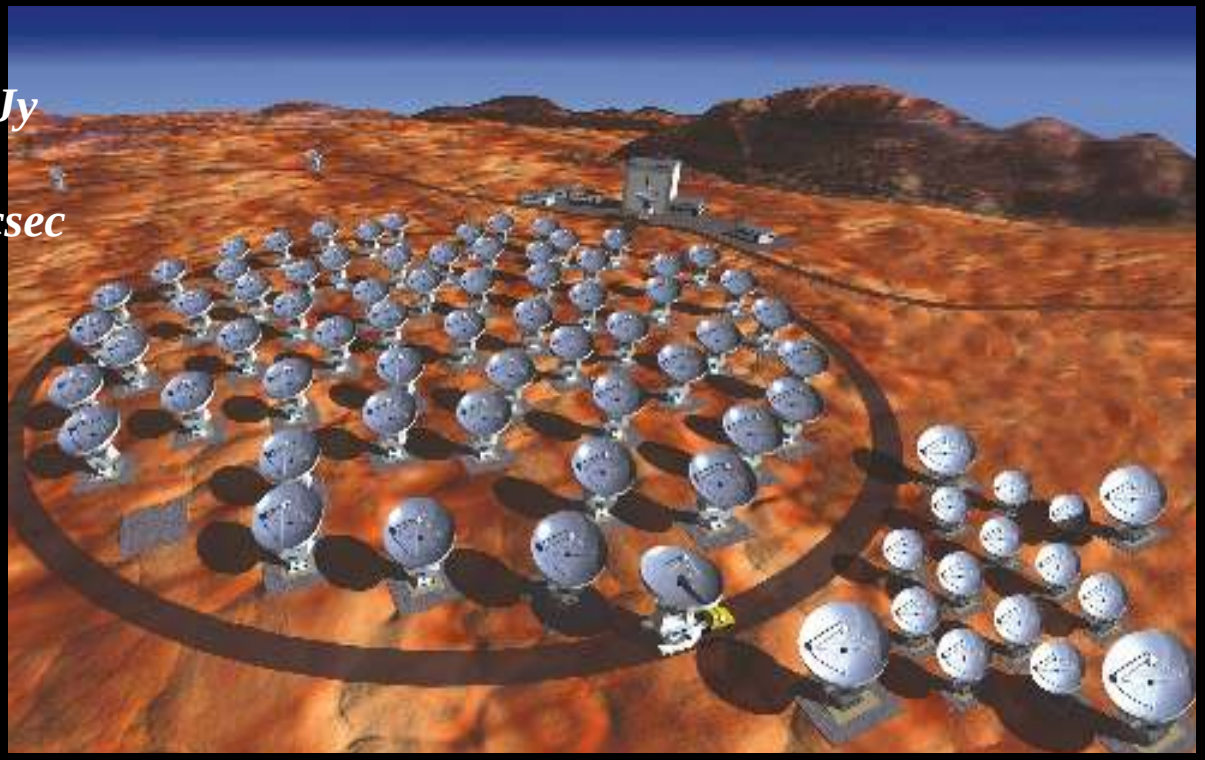
Configuration 0.15-10 km

Wave length 10-0.35 mm

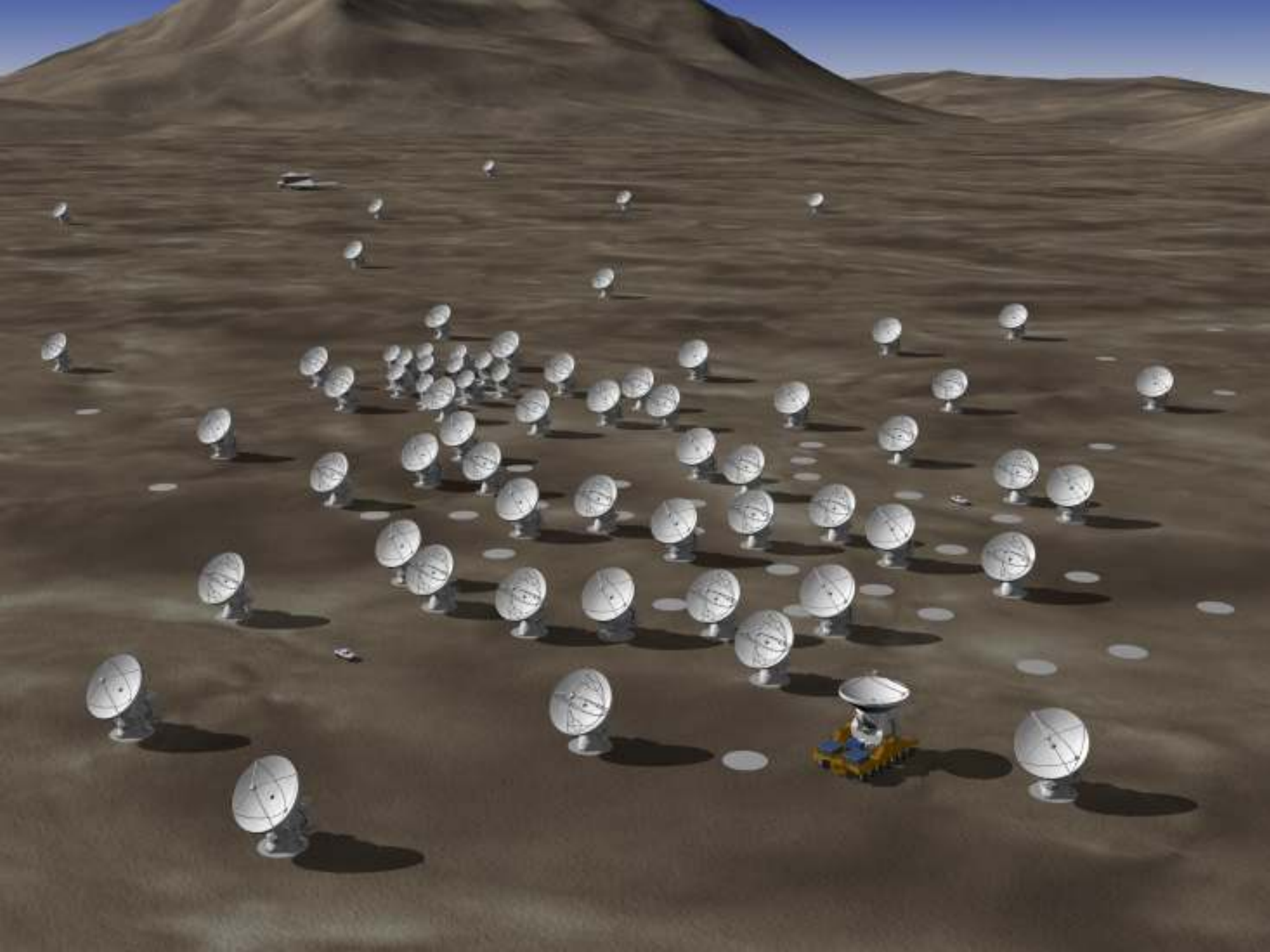
Sensitivity 15 microJy – 100 mJy

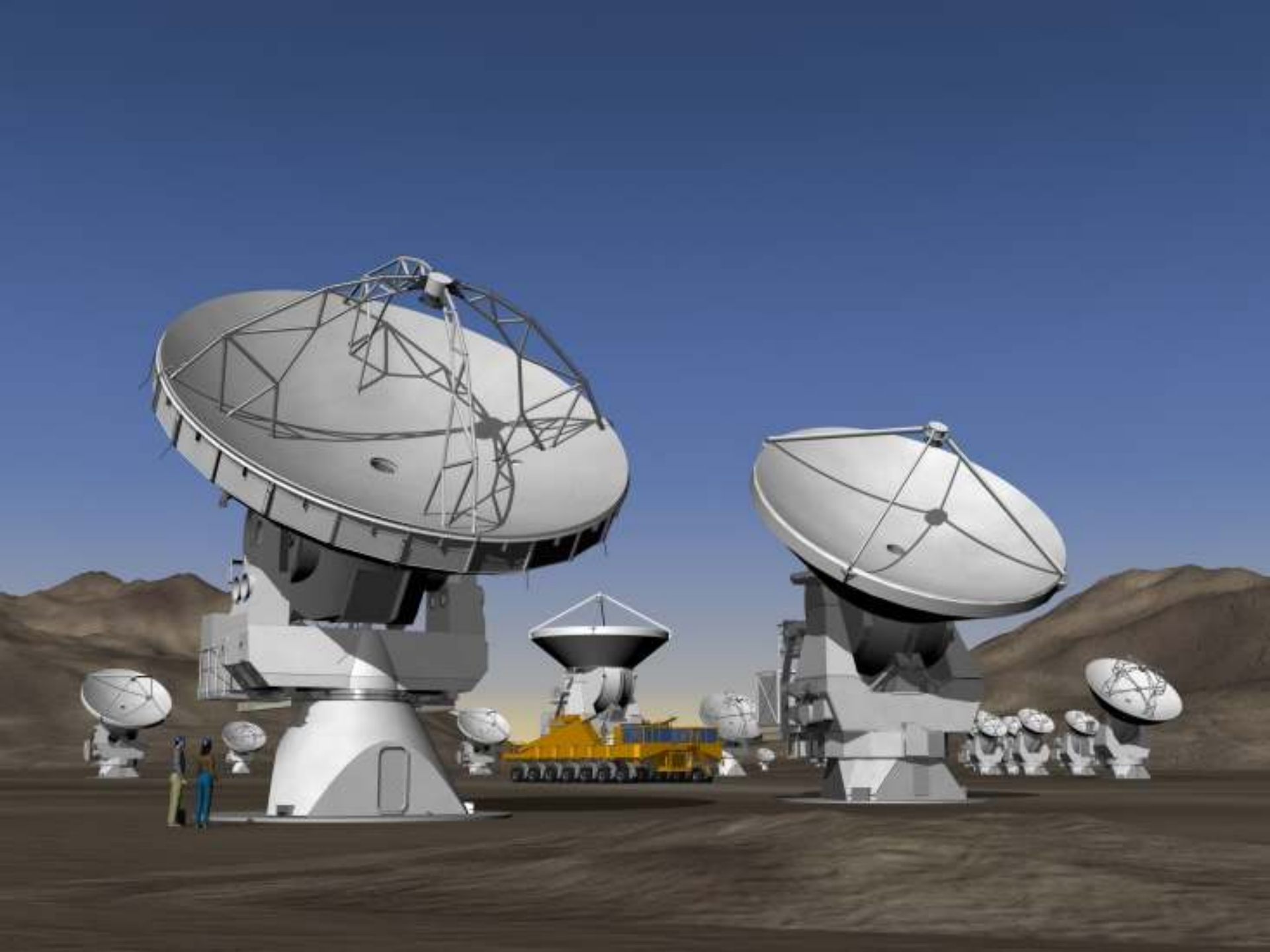
Angular resolution 10 milli arcsec

Operation from 2012



Cost ~> 1 G Euro !

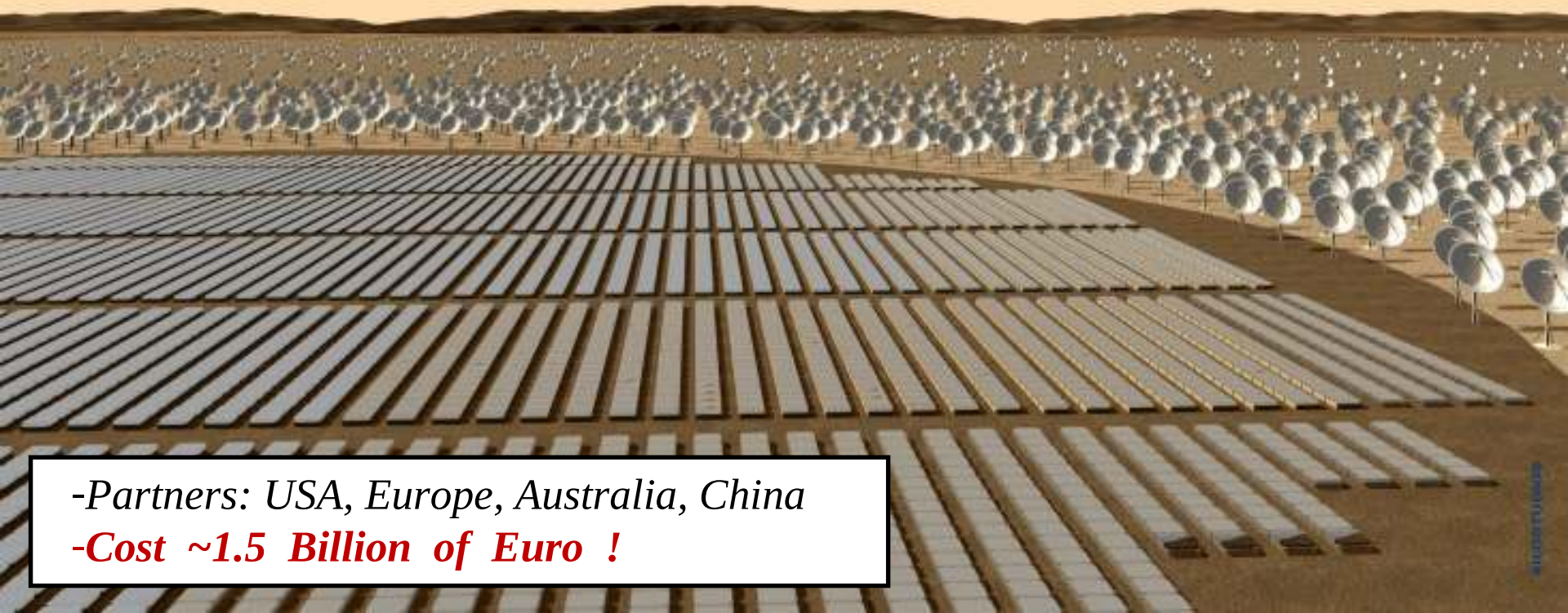




The Square Kilometre Array (2025)

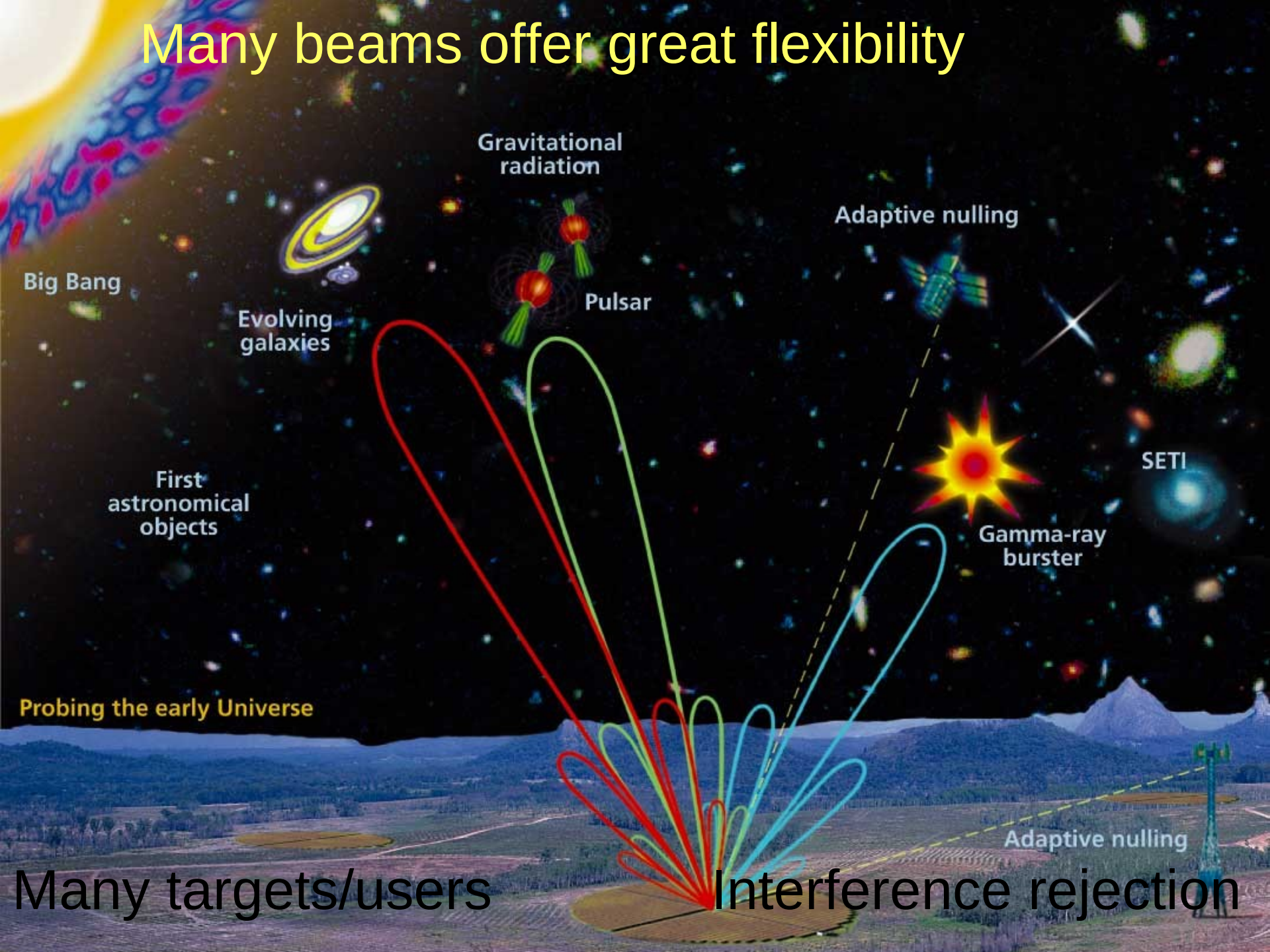
Up to 1500 dishes each of 15m diameter, in central 5km core plus another 1500 in groups at distance of 5 km to 3000+ km

+ aperture arrays – initially for all-sky monitor
connected to a massive data processor by an optical fibre network



-Partners: USA, Europe, Australia, China
-Cost ~1.5 Billion of Euro !

Many beams offer great flexibility



Many targets/users

Interference rejection

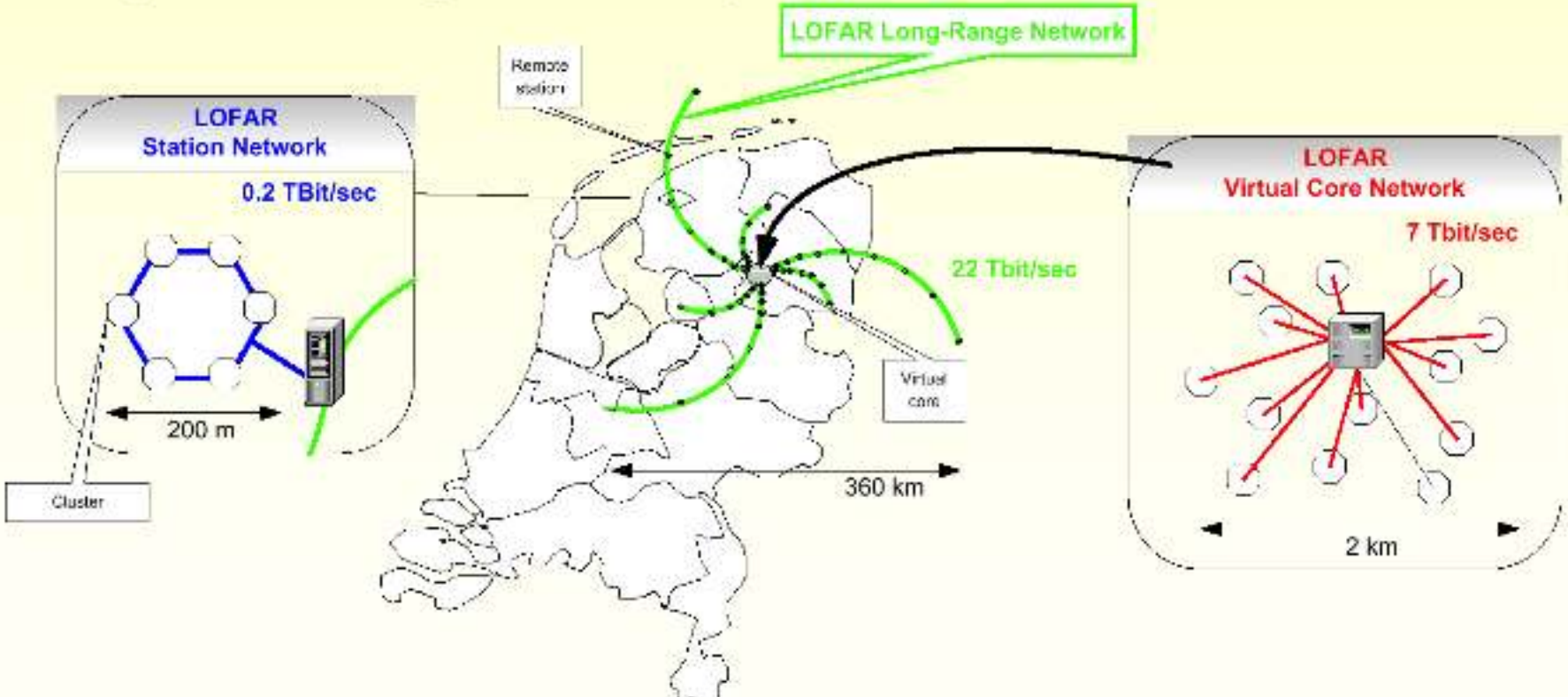
Not a single 1 km square aperture !

a wide range of baselines

The LOFAR instrument

- 13,000 antenna's
- Distributed over 100 stations
- producing ~20 Tbps raw data

30-250 MHz



Polish extension of LOFAR - POLFAR

LBA


UBA

Why is radio astronomy important?

Explores fundamental physics using:

- *the first photons set free in the universe after the "Big Bang"*
- *the basic element, hydrogen – the 21cm line*
- *magnetic fields -- polarisation imaging*
- *the most accurate clocks in the universe – millisecond pulsars*

"Window" on matter in different phases

- *synchrotron radiation*
- *maser emission*
- *bremsstrahlung from thermal gas*

Penetrates dust/gas:

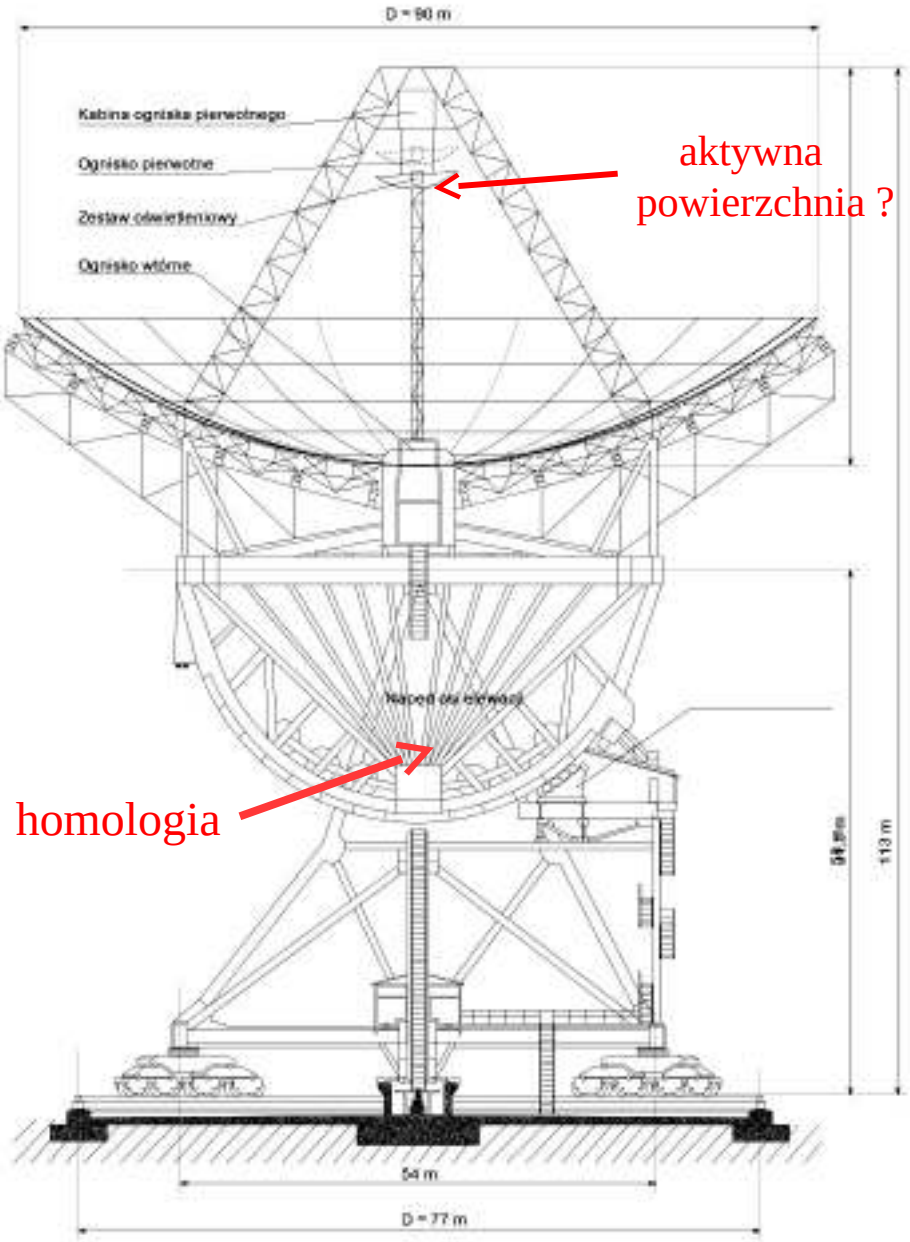
- *absorbs & scatters radiation in most other wavebands*

Provides highest resolution images at any wavelength - VLBI

90m radio telescope

Koncepcja RT90

Koncepcja projektu
Radioteleskopu w Toruniu



Optics: *Cassegrain, Ritchey-Chretien*

Optymalisation for: *large field of view, high sensitivity, low spill-over*

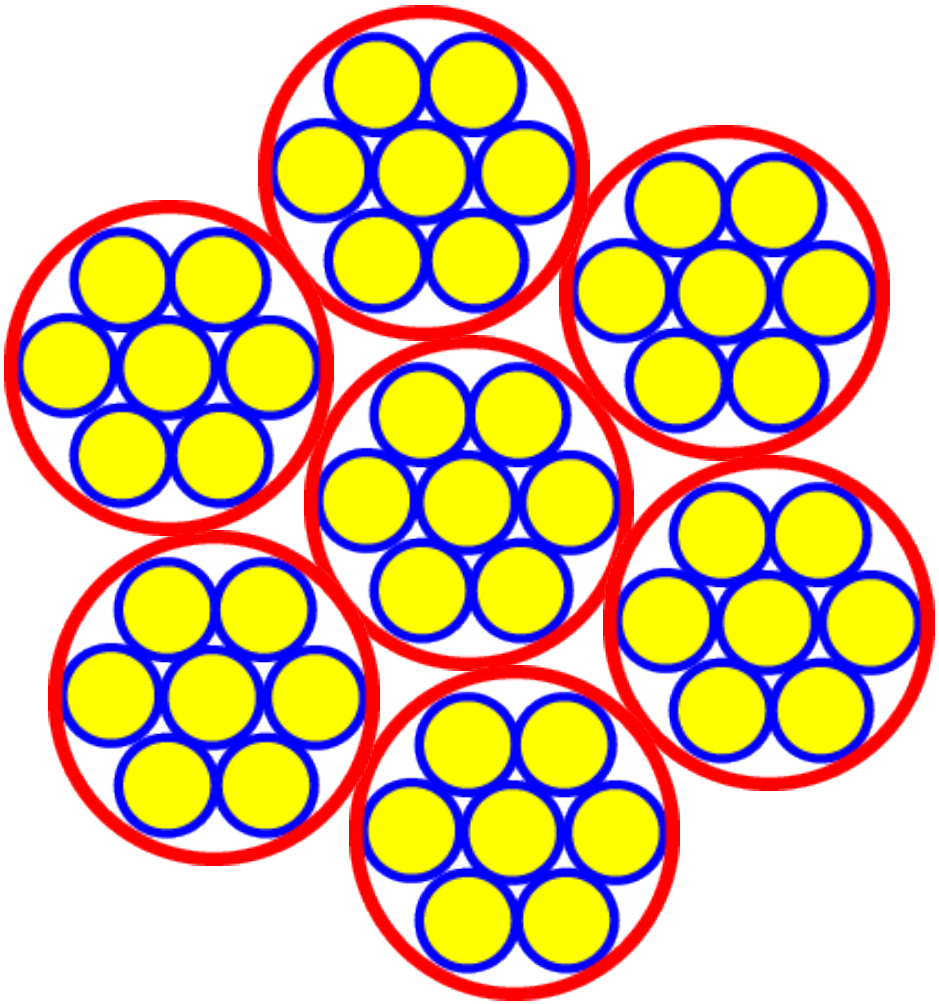
Mount: *Alt-Az (hydraulic drives ?)*

Precision: *surface 0.5 mm RMS, pointing <10"*

Receivers: *ultra broad band, Tsys < 30K,* ***radio camera***

Back-ends: *all digital (4-10 Gb/s)*

Multi beam receiver OCRA
on RT32m, at 30 GHz band



-1,5 m 0 +1,5m

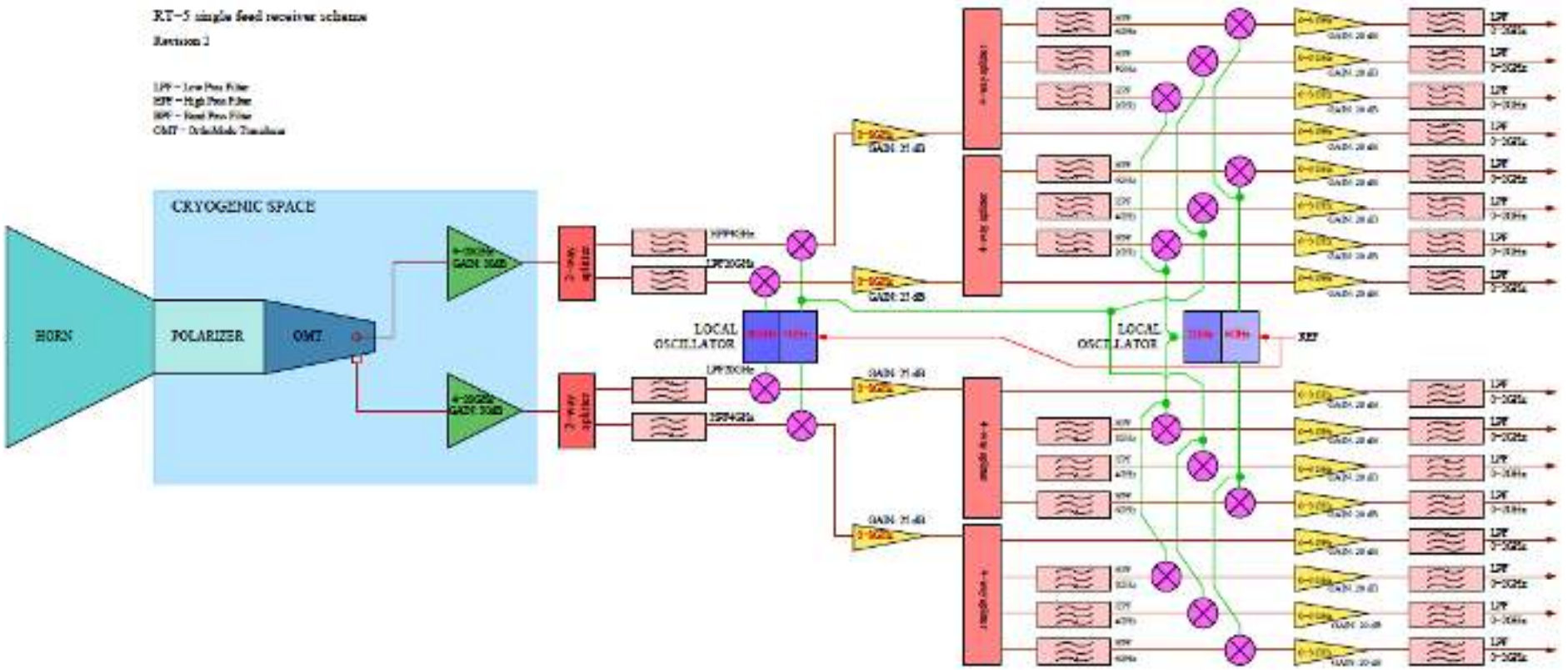
BW 5-21 GHz
POL LHC & RHC
Sub-Bands 2 GHz

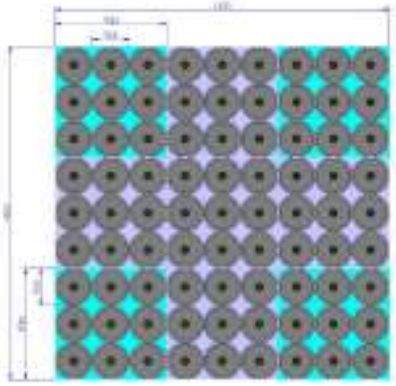
Digital Back-ends FPGA

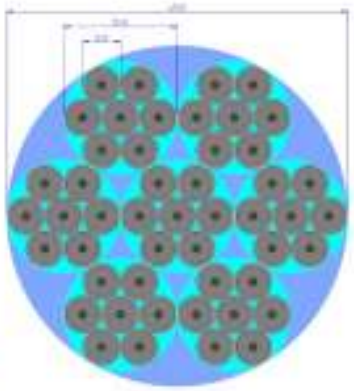
Radiometry
Polarymetry
Spektroscopy
PSR-s
Transients

41 outputs x 2 pol x
16 (1 GHz) sub-bands=>
1312 channels, ~1 kHz spectral resolution
raw data ~5 TB/s

Concept of the reciver system and digital back-ends FPGA





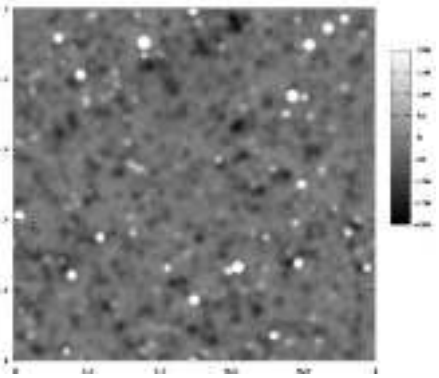


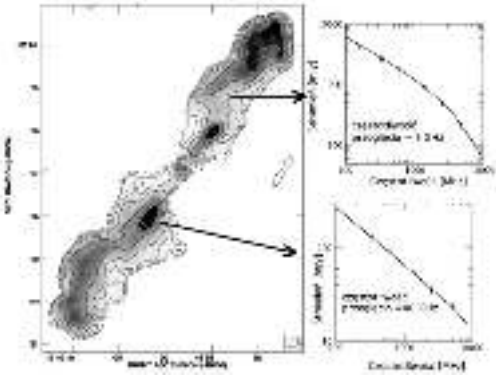
Research Programs

***VLBI** (interferometry EVN)*

Single dish research

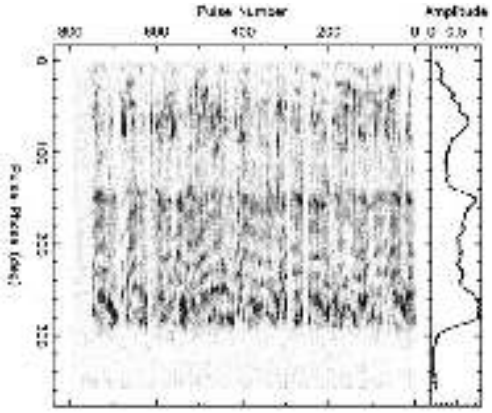
An RTH Legacy project: "2CMS"
the 2-Centimetre Million Source sur

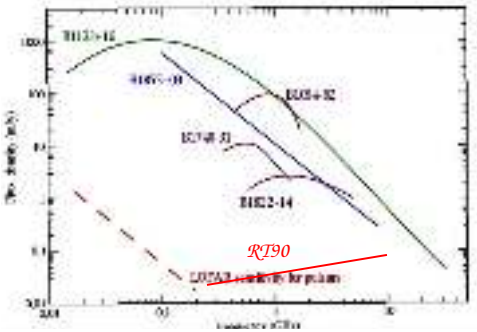




Extragalactic astronomy

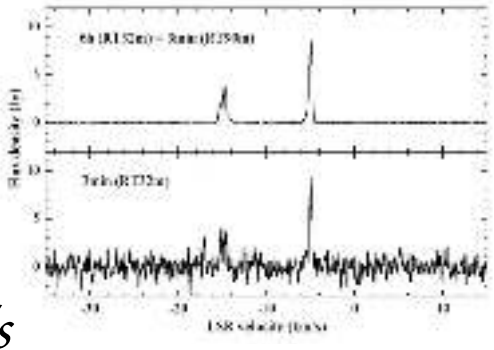
- *Foregrounds*
- *Clusters of galaxies*
- *AGNs*
- *Normal galaxies*
- *IGM*

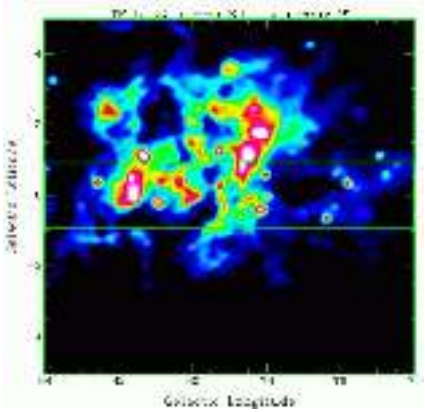


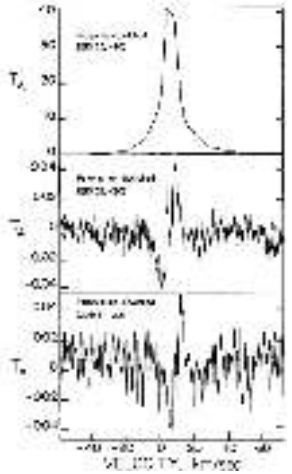


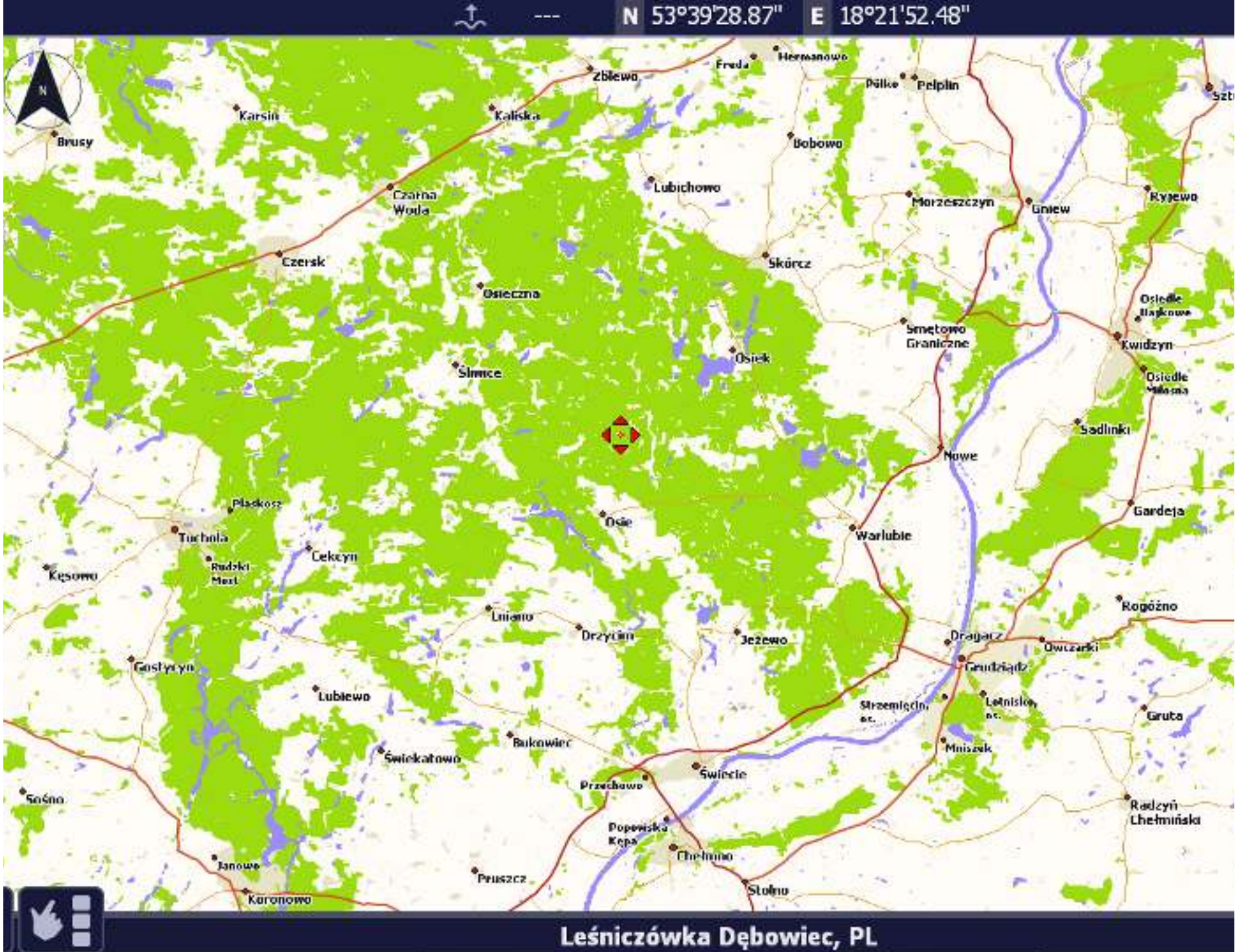
Galactic astronomy

- *Pulsars*
- *Transients*
- *Active stars*
- *Molecules*
- *Magnetic fields*
- *ISM*

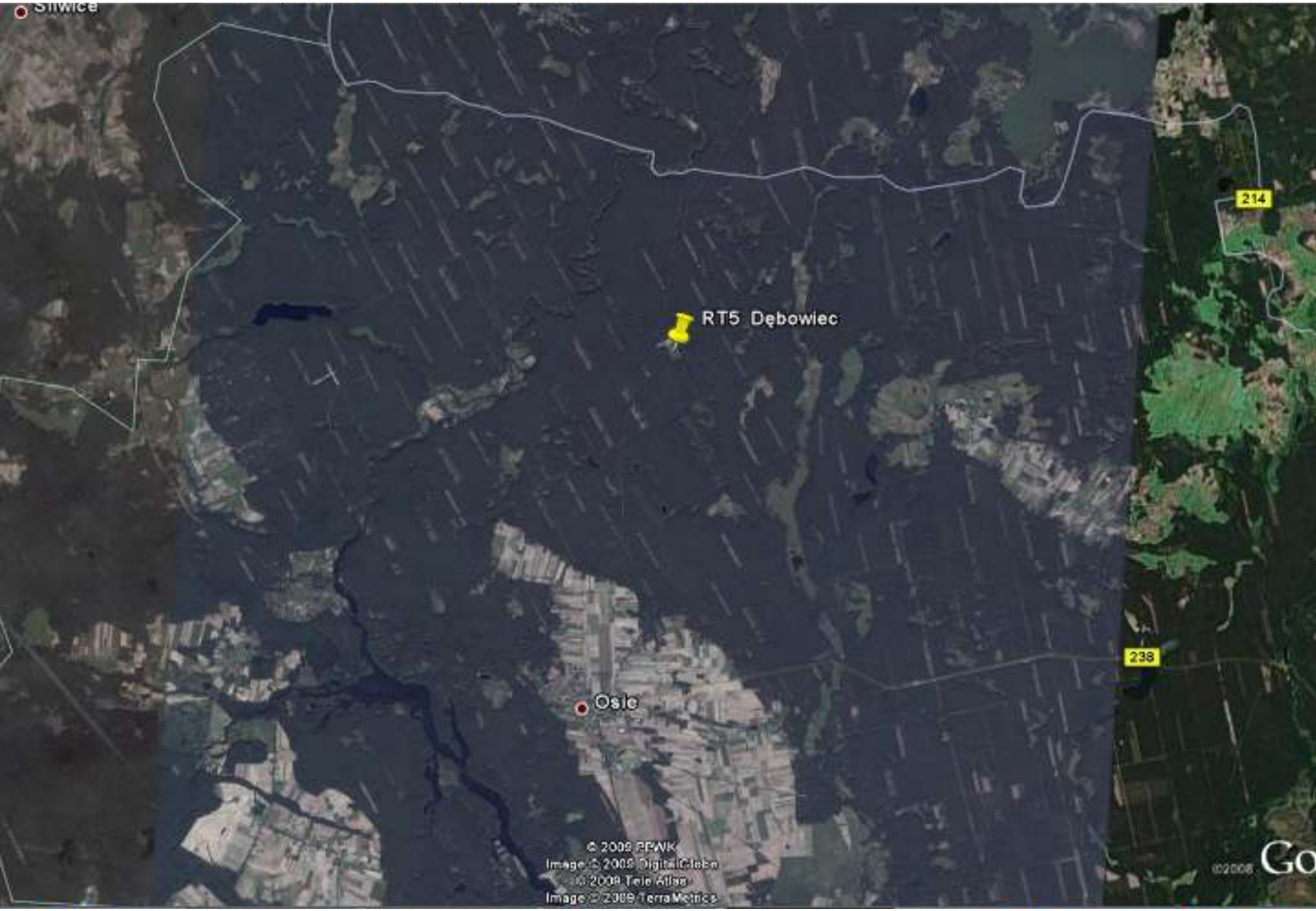








N 53°39'28.87"
E 18°21'52.48"
Brusy
Karsin
Kaliska
Zblewo
Freda
Hermanowo
Pelplin
Bobowo
Lubichowo
Czarna Woda
Czersk
Morzeszczyn
Gniew
Rywo
Skórcz
Osieczna
Smętowo Graniczne
Kwidzyn
Osiek
Ślmice
Sadlinki
Nowe
Warlubie
Gardeja
Osie
Tuchola
Cekcyn
Rudski Most
Kęsowo
Rogóźno
Drzycim
Jeżewo
Owczarki
Grudziądz
Gostycyn
Lubiewo
Strzemięcin
Gruta
Mniszek
Świekatowo
Świecie
Przechowo
Popowska Kępa
Chełmno
Radzyń Chełmiński
Janowo
Pruszcz
Stolno
Koronowo
Leśniczówka Dębowiec, PL


Sławice
RT5 Dębowiec
214
238
Osie
© 2009 PPWK
Image © 2009 DigitalGlobe
© 2009 Tele Atlas
Image © 2009 TerraMetrics


bowiec
© 2009 PPWK
Image © 2009 DigitalGlobe
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Inwestment „90m Radioteleskop”
At the planned site were written into document of
the Polish Infrastructure Ministry known as
„Koncepcja Przestrzennego Zagospodarowania Kraju 2030”

Zatwierdzam

MINISTER
NAUKI I SZKOLNICTWA WYŻSZEGO

prof. Barbara Kudrycka

Warszawa, 23 luty, 2011 r.

Lista projektów umieszczonych na Polskiej Mapie Drogowej Infrastruktury Badawczej

Badania naukowe w coraz większym stopniu będą się skupiać na poszukiwaniu odpowiedzi na globalne, długoterminowe wyzwania, przed którymi stoją społeczeństwa Polski i Europy. Do tych wyzwań należą między innymi: społecznie akceptowalna jakość życia, zmiany demograficzne, zrównoważony rozwój i ochrona środowiska naturalnego i środowiska człowieka, bezpieczeństwo energetyczne i dostęp do surowców oraz rozwój nowych technologii.

Obiekty nowoczesnej infrastruktury badawczej o dużej skali, zdolne skupiać potencjał naukowy danego kraju, regionu a nawet całej Europy stają się coraz ważniejszymi narzędziami służącymi do formułowania tych odpowiedzi. Znaczące zaangażowanie Polski w budowę infrastruktury badawczej jest zatem naszą rozwojową koniecznością.

Poniższa lista przedstawia wybrane w wyniku konkursowej procedury projekty umieszczone na Polskiej Mapie Drogowej Infrastruktury Badawczej, uszeregowane według strategicznych obszarów badań zdefiniowanych pod kątem oczekiwanych społecznie rezultatów. Obszary te dotyczą działań nakierowanych na rozwój nauki, a także nawiązujących do przedstawionych powyżej globalnych wyzwań.

1. Rozwój nauki poprzez badania podstawowe (astronomia, fizyka).

Wnioskodawca / Koordynator	Tytuł projektu	Charakter projektu
Uniwersytet M. Kopernika w Toruniu	90 m Radioteleskop - Narodowe Centrum Radioastronomii	Krajowy ośrodek badawczy (astronomia)
Uniwersytet Jagielloński w Krakowie	CTA – Obserwatorium astronomii gamma TeV	Polski wkład w projekt międzynarodowy z mapy drogowej ESFRI (astrofizyka)
Uniwersytet Jagielloński w Krakowie	FAIR – Ośrodek Badań Antyprotonów i Jonów	Polski wkład w projekt międzynarodowy z mapy drogowej ESFRI (fizyka)
Uniwersytet Warszawski	NLPQT - Narodowe Laboratorium Fotoniki i Technologii Kwantowych	Krajowy ośrodek badawczy (fizyka)

LIST INTENCYJNY
W SPRAWIE WSPÓŁPRACY NAUKOWO - BADAWCZEJ

pomiędzy
Politechniką Gdańską (PG) z siedzibą w Gdańsku, ul. G. Narutowicza 11/12, 80-233 Gdańsk,
którą reprezentuje:
JM Rektor prof. dr hab. inż. Henryk Krawczyk
a
Uniwersytetem Mikołaja Kopernika (UMK) z siedzibą w Toruniu, ul. Gagarina 11, 87-100 Toruń,
który reprezentuje:
JM Rektor prof. dr hab. Andrzej Radzimiński

Preambuła
W dniu 9 maja 2011 roku odbyło się spotkanie zorganizowane przez **Marszałka Województwa Kujawsko-Pomorskiego Piotra Całbeckiego**, w którym udział wzięli:
Mieczysław Struk – Marszałek Województwa Pomorskiego,
Prof. Andrzej Radzimiński – Rektor UMK,
Prof. Jan Godlewski – Prorektor ds. Infrastruktury i Organizacji PG,
dr Jacek Gierliński – Ministerstwo Nauki i Szkolnictwa Wyższego,
Prof. Eligiusz Mieloszyk - PG,
Prof. Zbigniew Sikora - PG,
Prof. Michał Hanasz - UMK,
Prof. Andrzej Kus - UMK,
Prof. Marian Szymczak - UMK
Dr hab. Maciej Mikołajewski – Polskie Towarzystwo Astronomiczne,
Czesław Ficner – Urząd Marszałkowski, Woj. Kujawsko-Pomorskie.

Działając w duchu tego spotkania Politechnika Gdańska i Uniwersytet Mikołaja Kopernika zwane dalej Stronami ustalają co następuje.

§ 1
Strony deklarują chęć nawiązania współpracy mającej na celu wspólną realizację umieszczonego przez Ministerstwo Nauki i Szkolnictwa Wyższego dnia 23 lutego 2011 roku na tzw. Polskiej Mapie Drogowej Infrastruktury Badawczej, projektu pn. „**90m Radioteleskop – Narodowe Centrum Radioastronomii**”, o charakterze krajowego ośrodka badawczego.

§ 2
W dążeniu do powyższego celu, Strony będą zabiegały o utworzenie ośrodka naukowo – badawczego pod roboczą nazwą **Centrum Inżynierii Kosmicznej (CIK)**, którego podstawową bazą będzie radioteleskop z anteną o średnicy co najmniej 90m **(RT Hevelius).** Ośrodek będzie działał na rzecz całego polskiego środowiska naukowego, na podstawie porozumienia konsorcyjnego uzgodnionego pomiędzy zainteresowanymi jednostkami.

§ 3
Strony wyrażają wolę współpracy i koordynacji swoich działań w zakresie:
-przygotowania koncepcji, struktury i organizacji CIK, ze szczególnym uwzględnieniem RT Hevelius i innych obiektów inżynierskich,
- określenia propozycji lokalizacji poszczególnych obiektów,
- ustalenia resortów, do których należy skierować stosowne zapytania oraz określić ich treść,
-wstępnego określenia poziomu zakłóceń radiowych i identyfikacji ich źródeł dla wariantów lokalizacji RT Hevelius,
- zbadania możliwości utworzenia strefy ciszy radiowej dla proponowanych lokalizacji RT Hevelius,
- wyboru lokalizacji optymalnych dla poszczególnych obiektów;
-wstępnego określenia wielkości środków niezbędnych do realizacji przedsięwzięcia i jego utrzymania, oraz źródeł ich pozyskania,

Organisation

1. Radiotelescope 90m (+RT32m) **NCRa** (UMK), **CIK** (PG)
2. Planowanie i realizacja badań naukowych i prac rozwojowych – porozumienie koncorsorcyjne
3. Coordinators– **UMK+PG**
4. European Structure Funds and Central Government
5. MoU and Consortium

Partners (*signed in, declared, negociations/proposed*)

0. EVN, JBCA.uk JIVE.nl MPIfR.d HU.se
1.CA UMK oraz Politechnika Gdańska
2.CBK PAN
3. OA UJ
4. IA UZG
5.Poznańskie Centrum Superkomputerowo-Sieciowe
6.CAMK PAN
7. **WAT**, UWM, UTP

Inne ważne cele inwestycji RT90

PROMOCJA NAUKI i technologii,

nadzwyczajne znaczenie „propagandowe”

popularyzacja nauk ścisłych i techniki

promocja edukacji

Budowa wizerunku i pozycji Polski w Europie i świecie jako kraju nowoczesnego, o znaczącym potencjale gospodarczym, naukowym i technologicznym, kraju ludzi wyedukowanych, otwartych na nowe idee, ludzi kreatywnych.

Summary so far…..

- *Radio technology developing at a great pace*
  - *Several technical revolutions underway*
  - *New large instruments underway*

→ *subject is vibrant*

- *Radio astronomy will continue to make major contributions to fundamental physics and cosmology*


Urbi et Orbi


The End
Thank you for your attention