A HISTORY OF THE EVN

30 YEARS OF FRINGES

Richard Porcas

MPIfR Bonn

1967 **First VLBI Experiments in USA and Canada**
(see Table 3 in Moran, 1998)

1980 **First Observations organized by the EVN**

2010 **10th EVN Symposium in Manchester**

MINUTES
of the meeting of directors of European radio-astronomy observatories on VLBI, held at the MPIfR, Bonn, March 5, 1980

Jodrell Bank
Leiden/Dwingeloo
Onsala
Geod. Inst. Bonn Uni.
Lab. di Radioastronomia, Bologna
MPIfR, Bonn

The draft agreement on setting up the European VLBI network and Programme Committee would be circulated to the observatories for formal approval. An announcement of observing opportunity would then be issued by the Programme Committee.

1980: March – The EVN is called into being

Announcement: Formation of a European VLBI Programme Committee

A European VLBI programme committee has been formed to review proposals and assign observing time within designated 'network' periods. Four observatories, operating the Effelsberg, Westerbork/Dwingeloo, Jodrell Bank and Onsala telescopes have agreed, with certain provisos, to provide observing time for VLBI at intervals of two months. The Bologna antenna, when available, will also participate. The observing sessions will generally follow those of the US VLBI network. Observers who wish to use US, as well as European network telescopes will have to make 'ad hoc' arrangements with the US observatories.

Deadlines for proposals will generally be the same as for the US network, i.e.

Oct	1	for the sessions in early	Feb, April
Feb	1	for the sessions in	June, August
June	1	for the sessions in	Oct, December.

As an exception, the deadline for the October and December sessions this year will be May 15. The observing wavelengths for these two sessions will be 6 cm and 21 cm, respectively.

1980: First EVN Call for Proposals: deadline 15 May

No PCs (computer mainframes only)

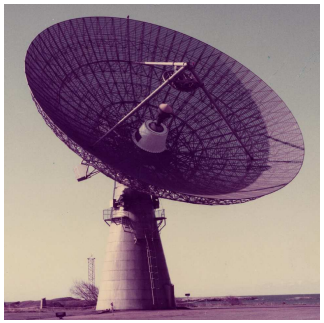
No Internet or email

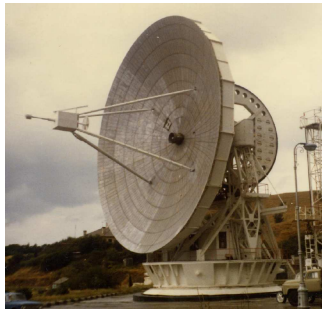
No FAX machines

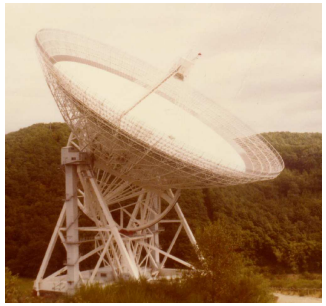
Moore's Law: $\mathbf{2}^{30yr/1.5yr} \approx \mathbf{10}^{6}$ less computer power

FIRST VLBI EXPERIMENTS AT EUROPEAN OBSERVATORIES

Year	Date of Obs.	TELESCOPE (year built)	Partner Telescopes	Frequency
1968	Jan 27–Feb 3	ONSALA (1963–4)	Greenbank, (Haystack)	5 & 1.6 GHz
1968	Jun 27–29	JODRELL MK I (1957)	Algonquin, Penticton	408 MHz
1969	Sep–Oct	SIMEIZ (1966)	Greenbank	5 & 10.7 GHz
1969	Nov–Dec	Jodrell MK I (JB SYSTEM)	Arecibo	610 MHz
1972	Nov	CHILBOLTON (1967)	Algonquin	10.7 GHz
1973	Jun 18–21	EFFELSBERG (1971)	Greenbank, Goldstone	2.3 GHz







VLBI DEVELOPMENTS IN THE US

1971 Announcement of discovery of "Superluminal Motion" (Whitney at al,)
Using model-fitting analysis

1971 NRAO introduces MK2 recording system
2 MHz bandwidth, TV recorders

1975 Formation of US VLBI Network (NUG)

1976 Start of 6 NUG sessions per year
Green Bank–140', OVRO–130', Haystack, Iowa, Fort Davis,...

1977 "An Intercontinental VLB Array" – NRAO

1978 NRAO introduces "absentee observing"
No longer need collaborator at each telescope

1979 Haystack introduces MKIII recording system
28–56–112 MHz bandwidth (up to 224 Mbps)

INTERFEROMETRY GROWTH: 1970–1980

1970 Westerbork starts up

1971 Cambridge 5 km starts up

1974 CLEAN algorithm (Hogbom)

1974 Reintroduction of "closure phase" in VLBI context (Rogers et al.)

1977 Closure phase incorporated in synthesis imaging (Wilkinson et al.)

1978– VLA (partial) starts up

1980 MERLIN starts up

EUROPEAN VLBI BEFORE 1980

1975 April 7th: Legendary MPIfR Cafeteria discussions
on forming a European VLBI Network
Pauliny-Toth, Preuss, Booth, Miley; no minutes !

Various European telescopes take part with US Network
Effelsberg joins the US Network
VLBI experiments named after participating telescopes
E-G-O H-O-G-F-A-C-E

1976 First all-European VLBI experiment

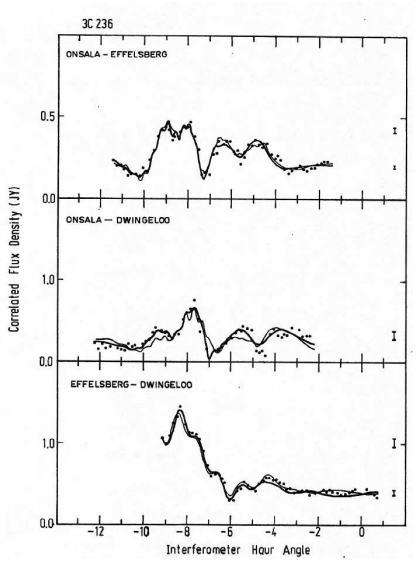
1977 4th European VLBI meeting at Jodrell Bank

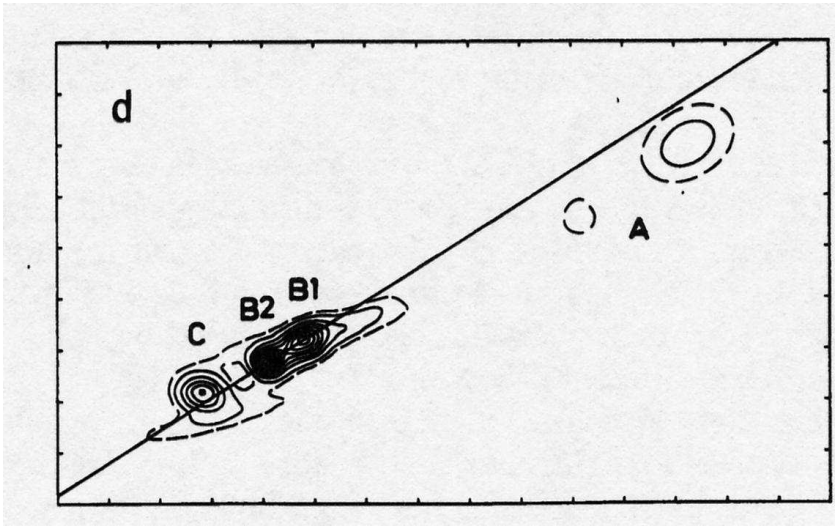
1978 Construction of MkII correlator at MPIfR completed

1978 J-O-D-E observations in January, correlated in Bonn
A polarisation VLBI experiment using polarization switching !

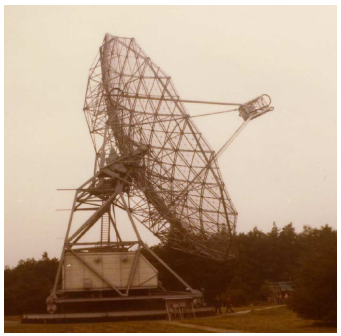
1978 April: first use of WSRT as a phased array for VLBI

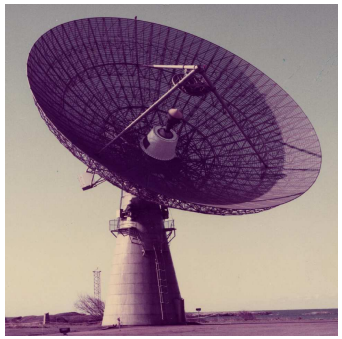
1978 International VLBI Conference in Heidelberg (no proceedings !)

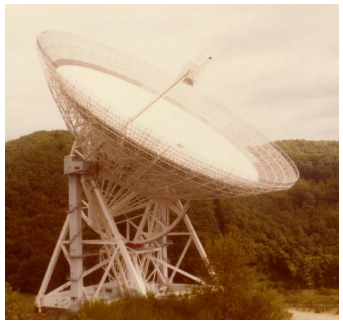




1976: October 2 - 1.6 GHz European VLBI observations of 3C236 (Schilizzi et al. 1979)



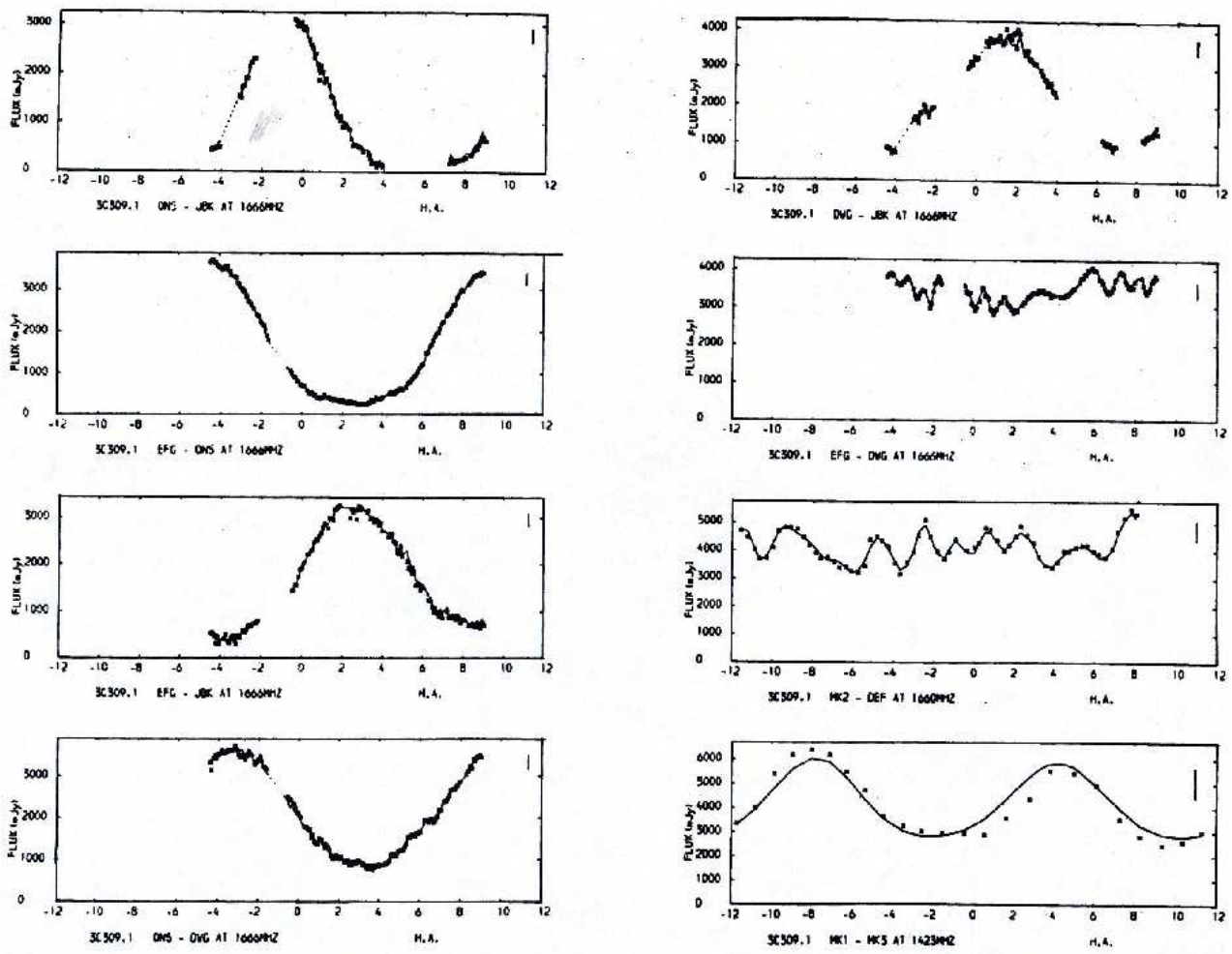




Dwingeloo (1956) – Onsala – Effelsberg **Correlation at NRAO**

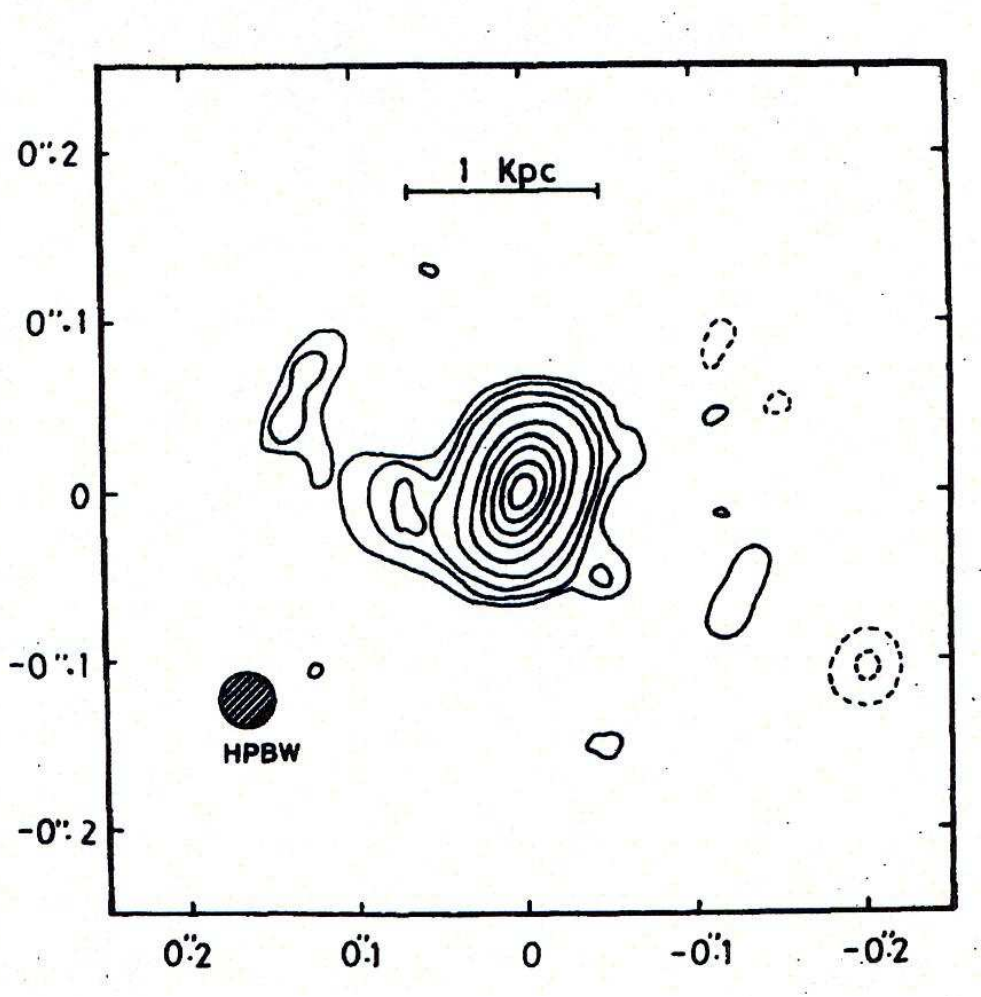
1977: 4th European VLBI Meeting at Jodrell Bank

1978: Horst Blaschke at the Bonn MK2 Correlator



1978: J-O-D-E 18 cm observations of 3C309.1 (Kus et al. 1981)

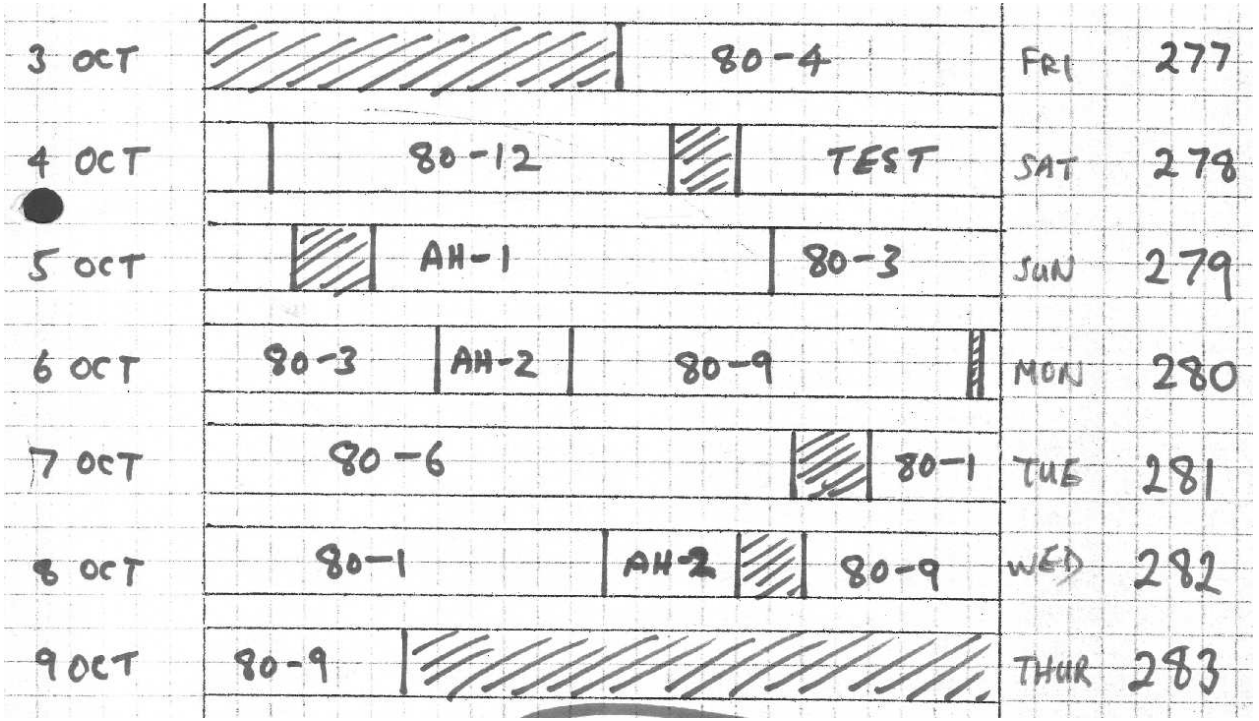
First observation correlated at Bonn MK2 correlator

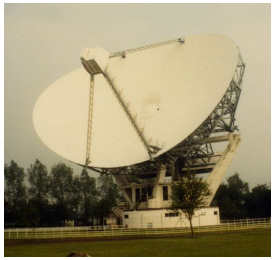


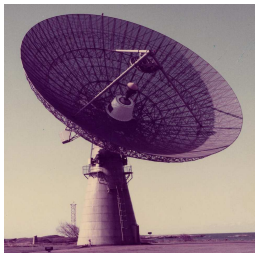
1978: Image of 3C309.1 from J-O-D-E (Kus et al. 1981)

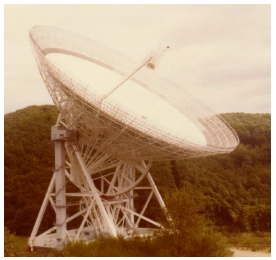
1978: Heidelberg VLBI Conference

THE FIRST EVN OBSERVING SESSION – OCTOBER 1980 (6 cm)









1980: Bonn MK2 correlator

Note 3 generations of MK2 recorders and Moscow 1980 Olympics bear !

Table 1: Observations of SS433.

Epoch (JD)	Date	Telescopes*	Wavelength (cm)
2444248	Jan. 80	E, W, K	6
393	June 80	E, W, C	6
517	Oct. 80	E, W	6
589	Dec. 80	E, W, J	21
651	Feb. 81	O, E, J	18
705	Apr. 81	O, E, W, J	6
750	May 81	O, E, W	6
756	June 81	O, E, W	6

* C: Chilbolton, E: Effelsberg, J: Jodrell Bank, K: Knockin (UK), O: Onsala, W: Westerbork.

1980: October - Results from First EVN Session (Schilizzi et al. 1982)

II. Observations, Reductions and Results

Short VLBI observations at a wavelength of 6cm, with left circular polarization, were made at different epochs from June 1980 to April 1981 of a sample of spiral and irregular galaxies and two S0 galaxies. The telescopes involved at each epoch and their characteristics are given in Table 1.

TABLE 1

Telescope	Diameter(m)	Clock	Epoch
Onsala(O)	25.6	H Maser	Oct. 6,8 1980
			April.9 1981
Effelsberg(E)	100	H Maser	June 2 1980
			Oct.6,8 1980
			Apr. 9 1981
Westerbork(W)	93	Rb	June 2 1980
			Oct.6,8 1980
			Apr. 9 1981
Jodrell Bank(J)	25	Rb	April 9 1981

GROWTH OF EVN 1980 – 1990

1980 Formation of the EVN Program Committee
Making sure the best science is done on the EVN

1982 Formation of the Technical Working Group (TWG)
(later becomes Technical and Operations Group (TOG) in 1998)

1982 December: MPIfR Bonn acquires a MKIII correlator

1983 New telescopes built for VLBI in Europe
Wettzell(1983) Medicina (1984) Noto(1989)

1984 First 4-station EVN MKIII observations B-S-W-J

1984 EVN Directors form the "EVN Consortium for VLBI"
Main aim to find funding for large correlator centre

1987 Jodrell Bank MK II telescope upgraded to work at 1.3 cm

1990 Expansion of Bonn MKIII correlator to 5 stations

THE EVNPC AND SCIENCE

Initial 8 members (5 observatory, 3 others)

3 meetings per year (>90 to date !)

Review "EVN-only" and "Global" (EVN + US-Network)

4 – 6 telescopes, high sens., intermediate resolution, λ 21/18, 6 cm

8 – 9 telescopes, Global baselines, λ 18, 6, 2.8, 1.3 cm

Organize 4 sessions per year, overlap with US Network sessions

Operations section of the agenda for 5 obs. members

EVNPC Chair also EVN Scheduler until 1990

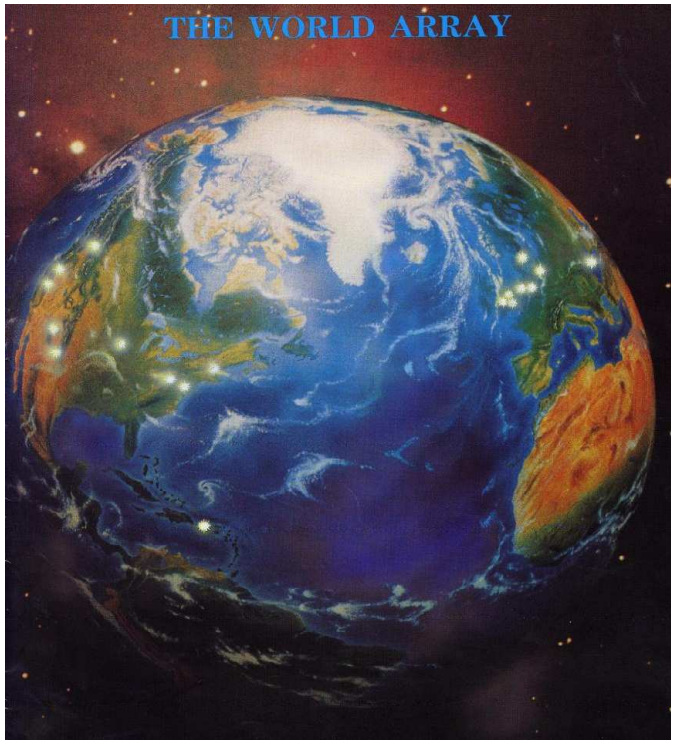
The present members of the Programme Committee are:

I. Pauliny-Toth (MPIfR), P. Biermann (MPIfR),
R. Schilizzi (Dwingeloo),
J. Kuijpers (Utrecht),
R. Booth (Jodrell Bank),
B. Rönnäng (Onsala),
J. Wall (Royal Greenwich Observatory) and
R. Fanti (Bologna).

1980: First EVNPC Members

1984: EVNPC meeting in Herstmonceaux Castle

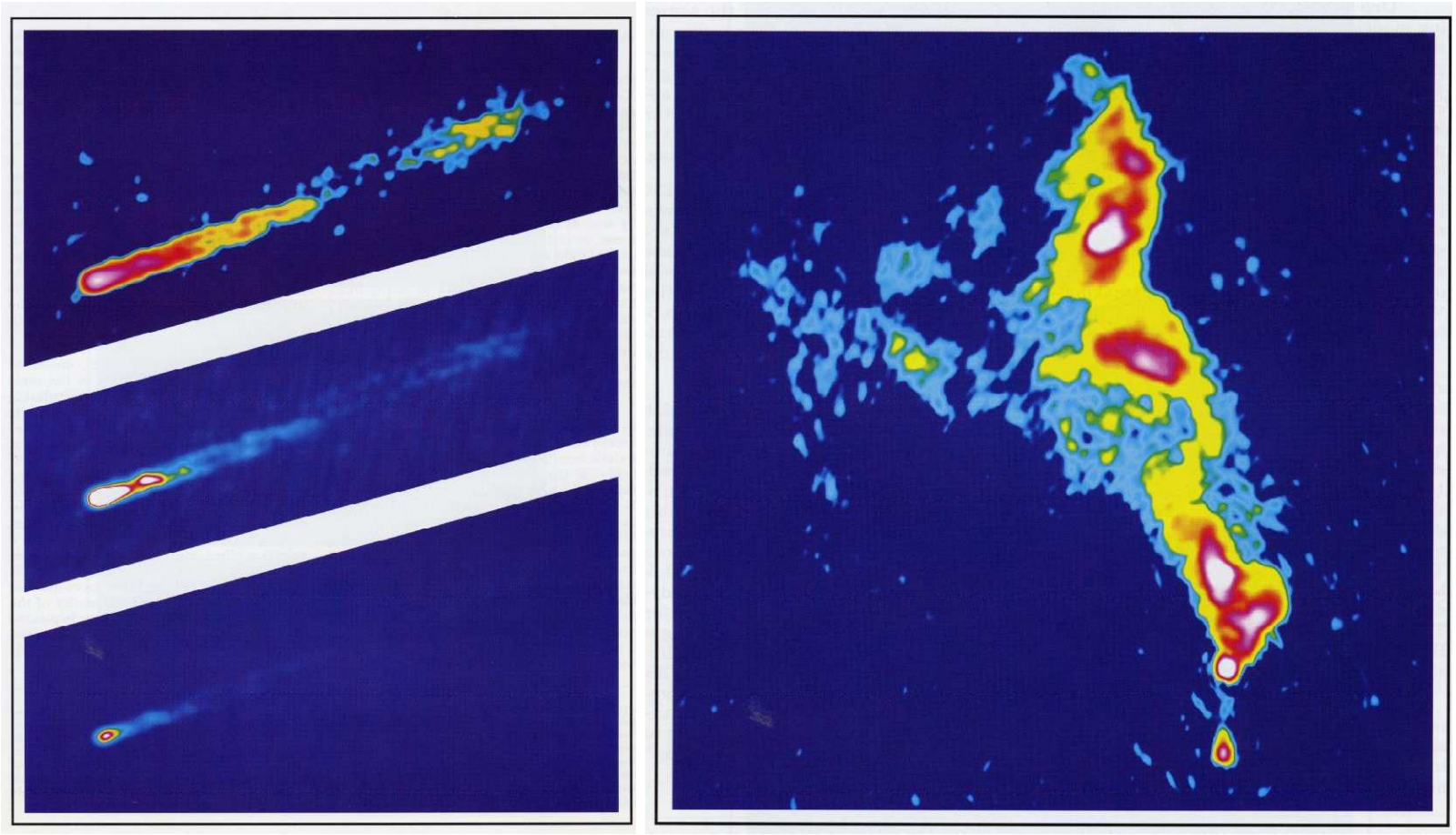
1983: Bologna IAU Symposium



Telescope	Location	Diameter (m)	$\left[\frac{2kT_{sys}}{A_{eff}}\right]^a$ (Jy)
Crimea	Simiez, USSR	22	2000
Torun	Torun, Poland	15	2000
Onsala	Onsala, Sweden	26	410
MPIfR	Effelsberg, FRG	100	34
WSRT	Westerbork, NL	25[b]	730
Cambridge	Cambridge, UK	18	1900
Jodrell (MkII)	Jodrell Bank, UK	26	390
Defford	Worcestershire, UK	25	680
Arecibo	Puerto Rico	300	4
Haystack	Massachusetts, USA	36	1100
NRL	Maryland, USA	26	770
NRAO	West Virginia, USA	43	82
N. Liberty	Iowa, USA	18	1400
GRAS	Texas, USA	26	620
VLA	New Mexico, USA	25[c]	13
OVRO	California, USA	40	220
HCRK	California, USA	25	500
DRAO	Penticton, Canada	26	910

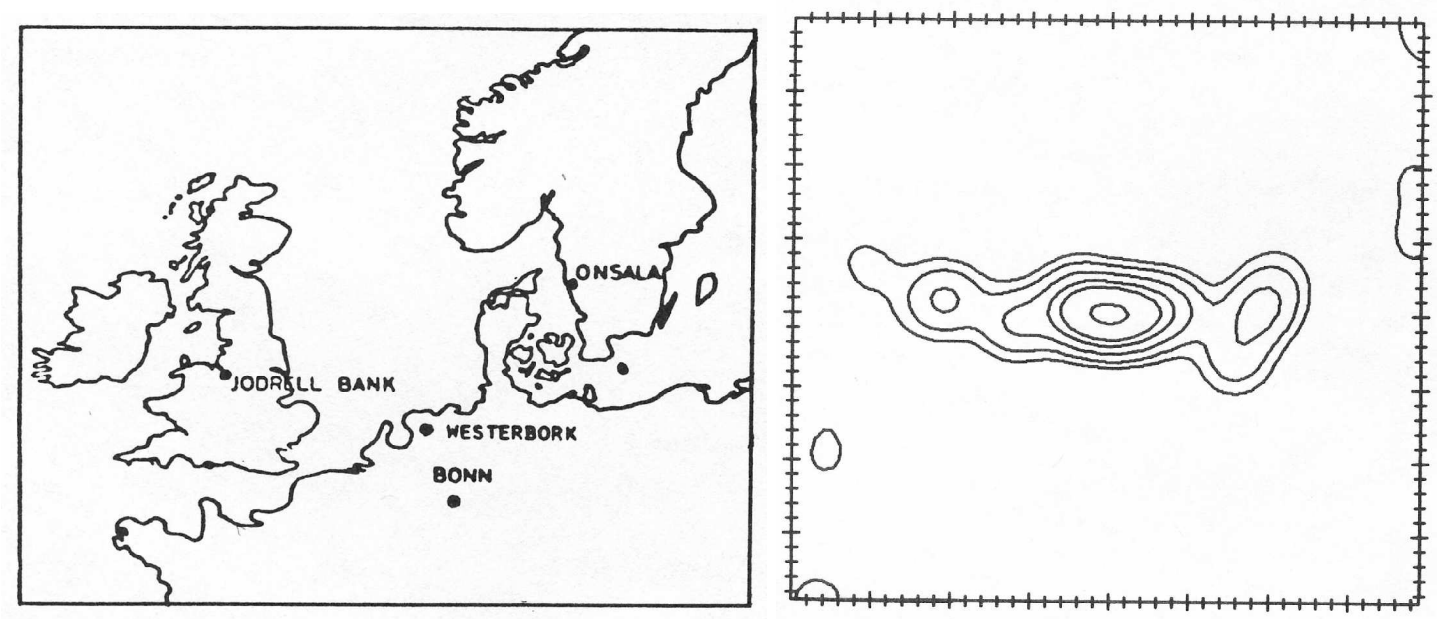
1984: April – "World Array" at 1.6 GHz (18 stations)

Note use of MERLIN Defford telescope.
EVN+MERLIN observations would become an EVN feature from 1988

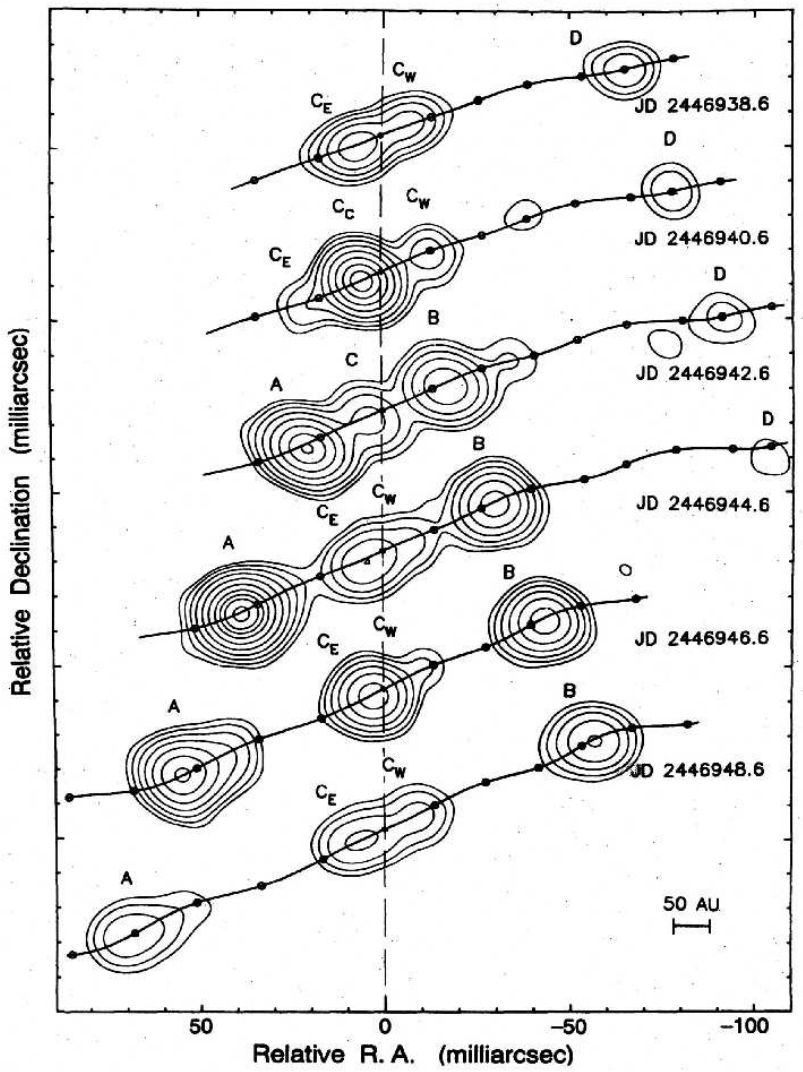


(Left): M87 at 4 mas resolution – 3 "exposures" (Reid et al. 1989)

(Right): 3C 48 at ∼8 mas resolution (Wilkinson et al)

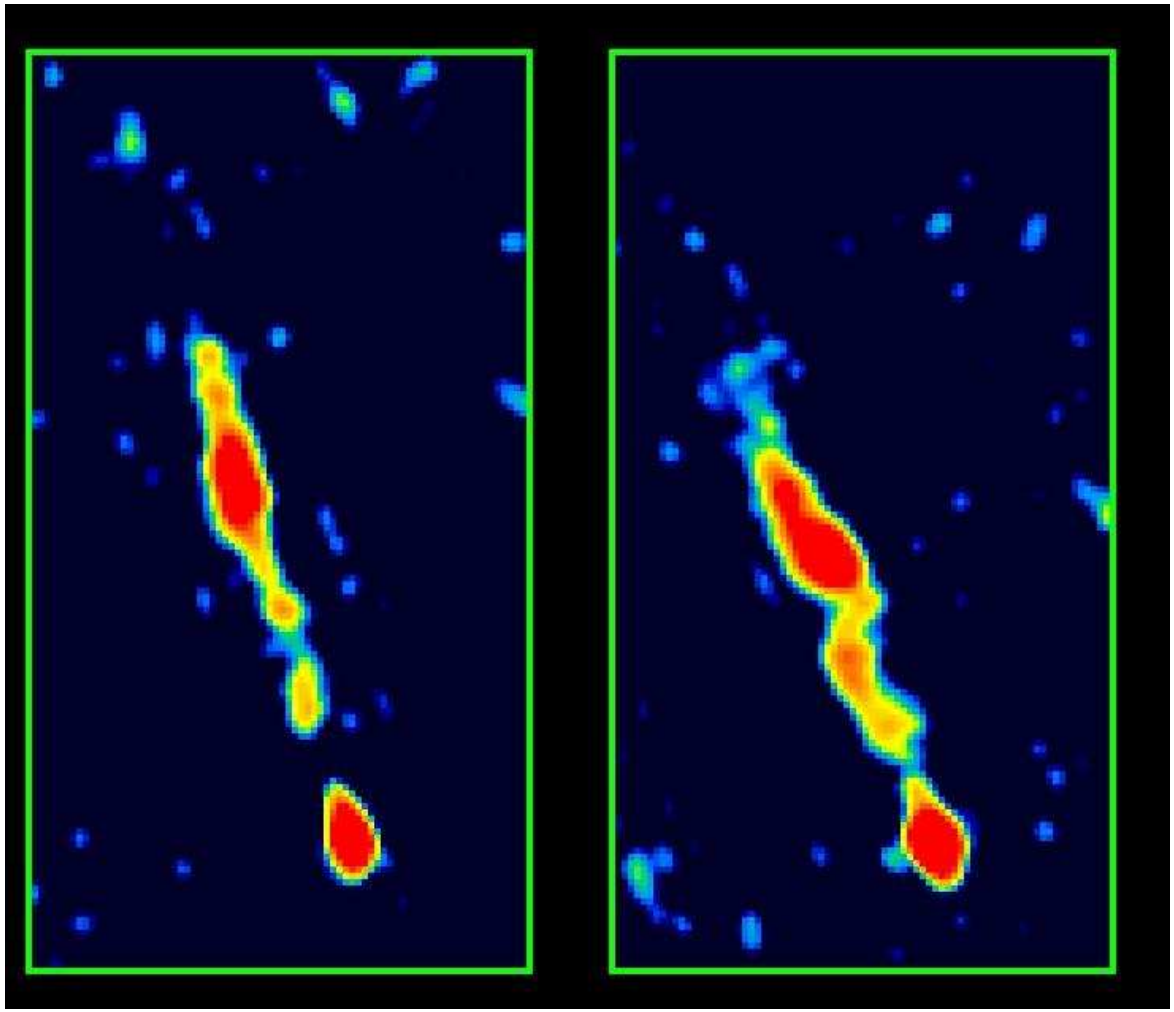


1985: EVN 1.6 GHz MK3 observations of RS Ophiuchi 77 days after outburst
Tick interval 10 mas: resolution 35 mas (Porcas et al. 1986)

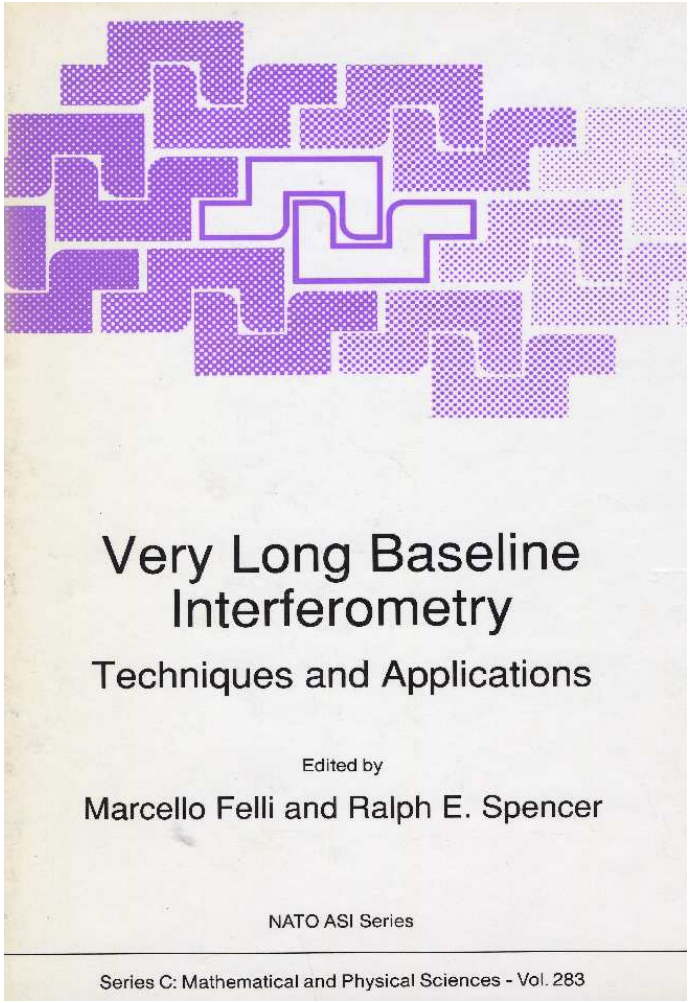


1987: May–June EVN 6 cm MK3 Observations of SS433 (Vermeulen et al. 1993)

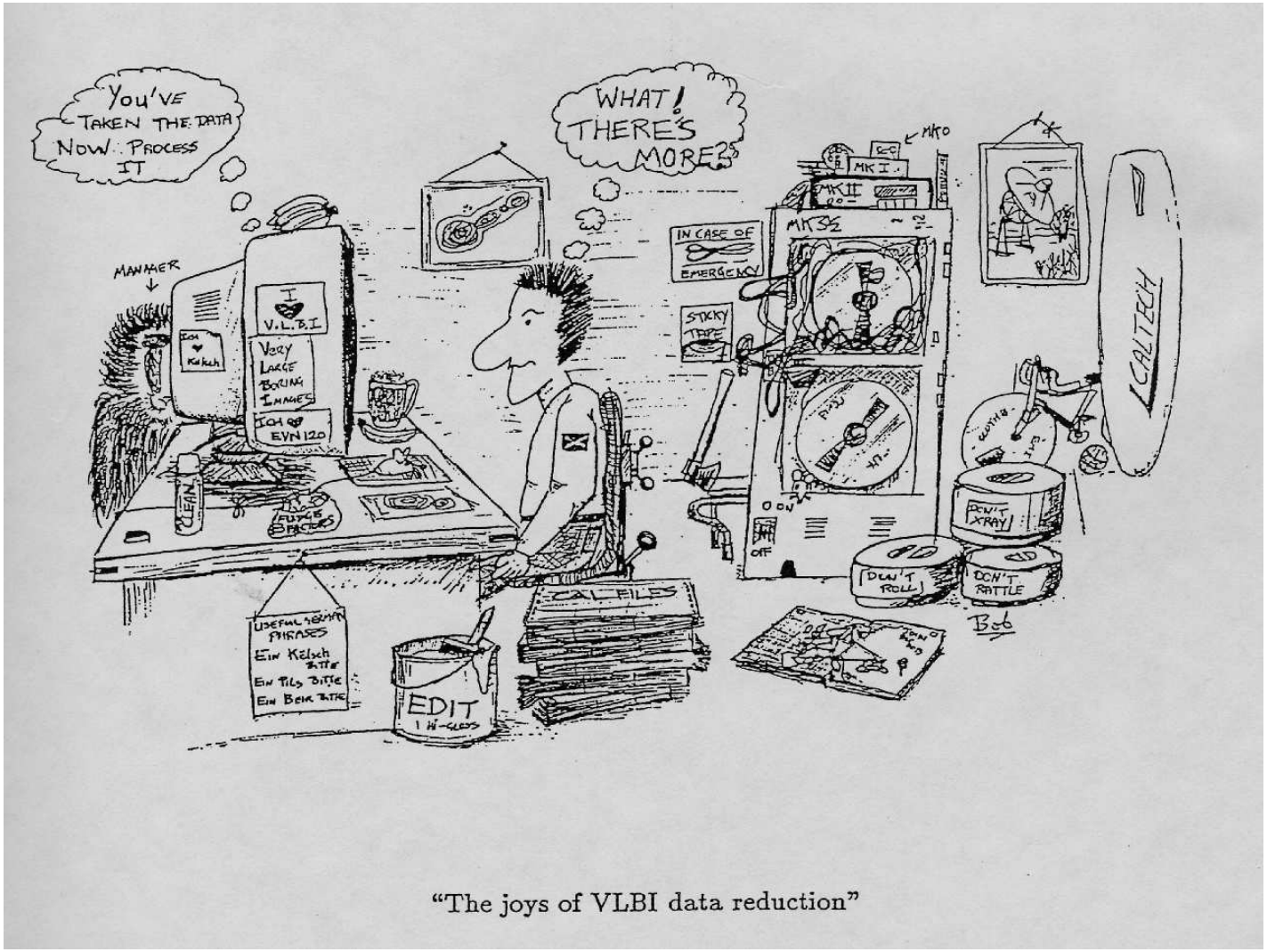
6 epochs, spacing 2 days, most of the EVN MK3 tape supply !



1989: November - Global 1.6 GHz Observations of Gravitational Lens 0957+561A,B
9 telescopes, MK3: images B (left) and A (right) (Garrett et al, 1994)



1988: First EVN VLBI School, Castel S. Pietro Terme, Italy



"The joys of VLBI data reduction"

1989: Guide to Processing in Bonn (Garrett)

No absentee correlation yet..!!

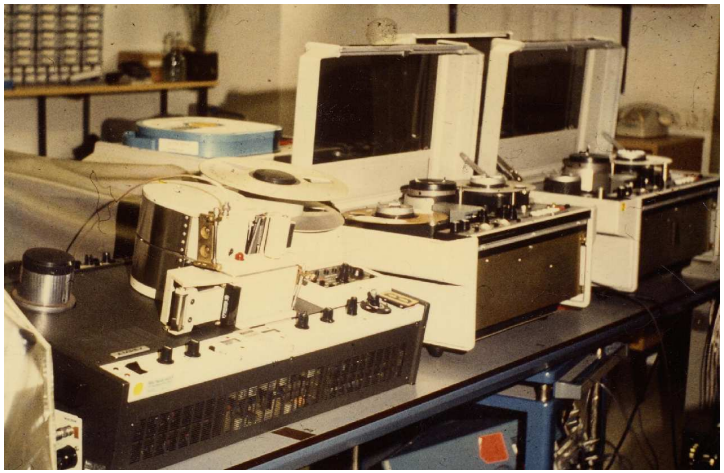
MKII RECORDING AND CORRELATION

1980 MPIfR Bonn MKII 2–3 stations correlator

1980 – Domestic VCRs and cassettes make things cheap and easy

But: global (EVN + US-Network) experiments need many "passes"

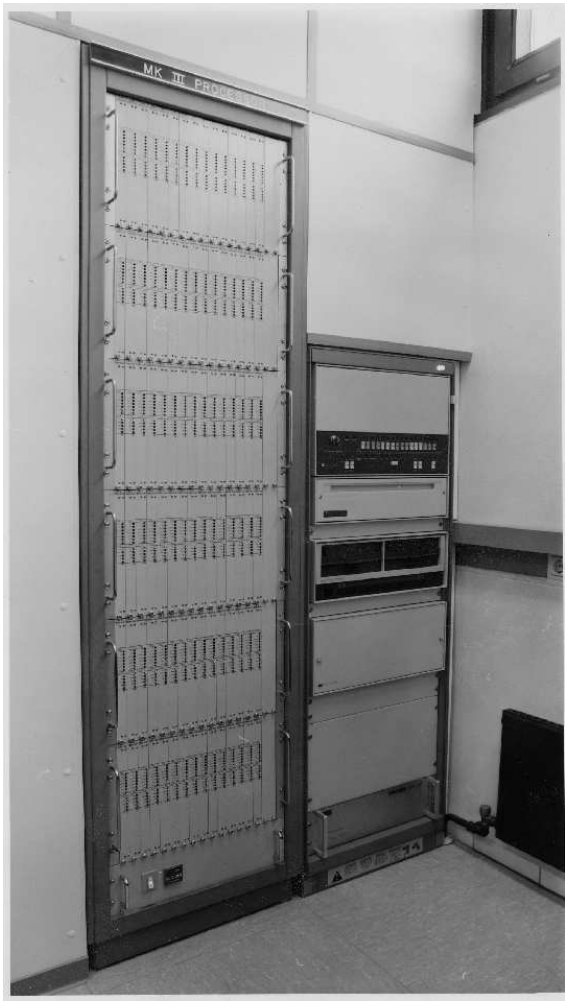
1985 – Caltech Block-II correlator becomes correlator of choice for continuum observations



No more Ampex or IVC please !

Caltech Block-II correlator

MKIII RECORDING AND CORRELATION



1982: December - Bonn MK3 correlator (3-stations)

MK II MK III COMPARISON

	MARK II	MARK III
Cost of record terminal	a few 1000 $	a few 100,000 $
Cost of tape or cassette	a few $	several 100 $
Playing time	4 hours	13 minutes
BANDWIDTH:	2 MHz	56 MHz

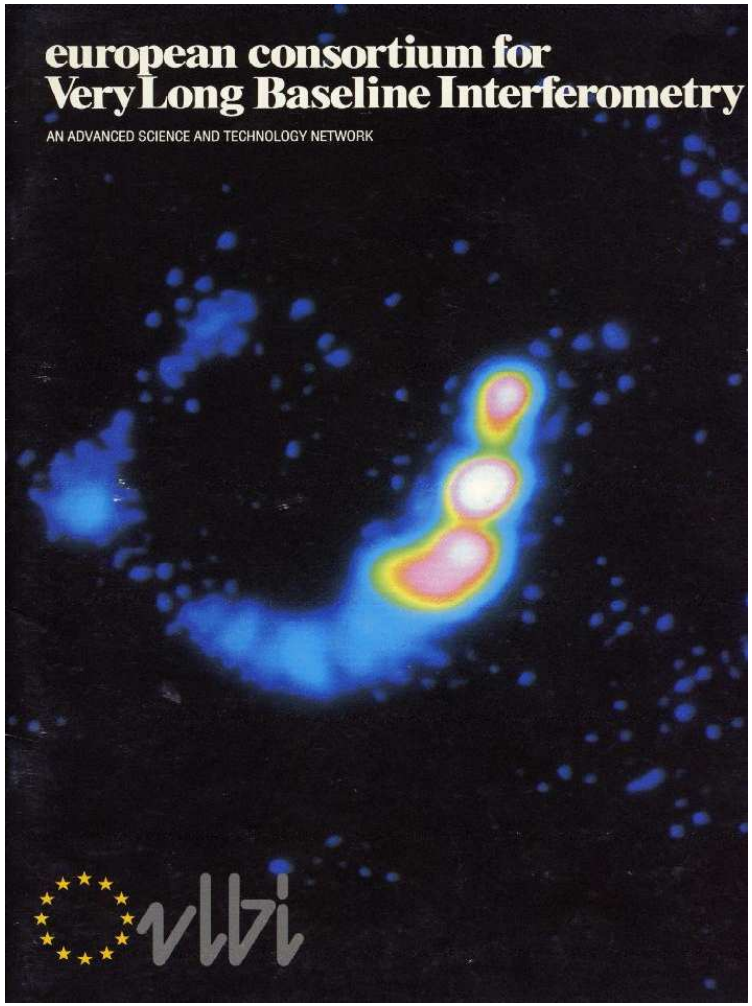
THE PRIZE: A FACTOR OF 5.5 INCREASE IN SENSITIVITY !

1983 – 1989 Observing limited by lack of MK III tapes

1990 – MK III Track density upgrade
12 tape passes with micro-motion of head
Observing starts to become limited by correlator time

1985: First meeting of the EVN Consortium

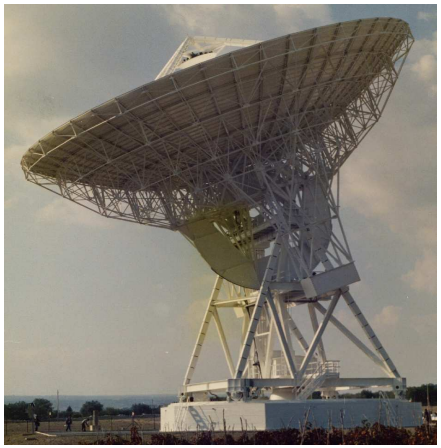
1985: First meeting of the EVN Consortium
(no lap-tops !)



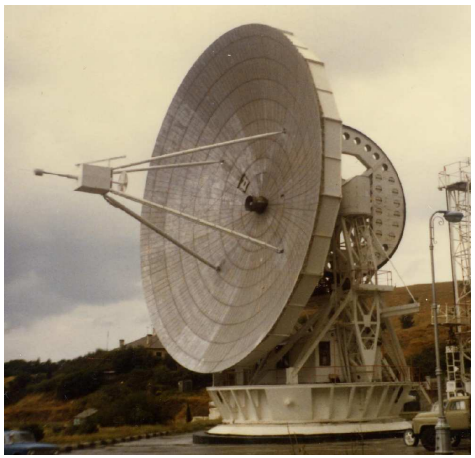
EVN Consortium Brochure

The long quest for a European source of funding begins...





New EVN telescopes: Wettzell Medicina Noto


Taking part in the EVN: Jb-Mk2 (resurfaced) Simiez Torun-15m

EVN 1991 – 2000

1992 – New telescopes join EVN:
Cambridge ∼1992 Seshan (Shanghai) ∼1993 Urumqi ∼1997
Torun-32m 1996 Yebes-14m 1999 Metsaehovi 1999 at 7 mm

1993 JIVE established as a Foundation in the Netherlands

1993 Dedication of the VLBA

1993 First EVN Symposium at Jodrell Bank

1995 1st JIVE/EVN VLBI School

1995 EVN MK IV upgrade (EMU, VIV)

1997 DSN agrees to make Robledo-70m telescope available for some EVN projects

1997 Launch of VSOP satellite HALCA

1997 2nd JIVE/EVN VLBI School

1999 3rd JIVE/EVN VLBI School

The Beginnings of JIVE

1989 First EU funds to support correlator proposal.
Partly used at Thorn-EMI (later Penny and Giles) for European record terminal

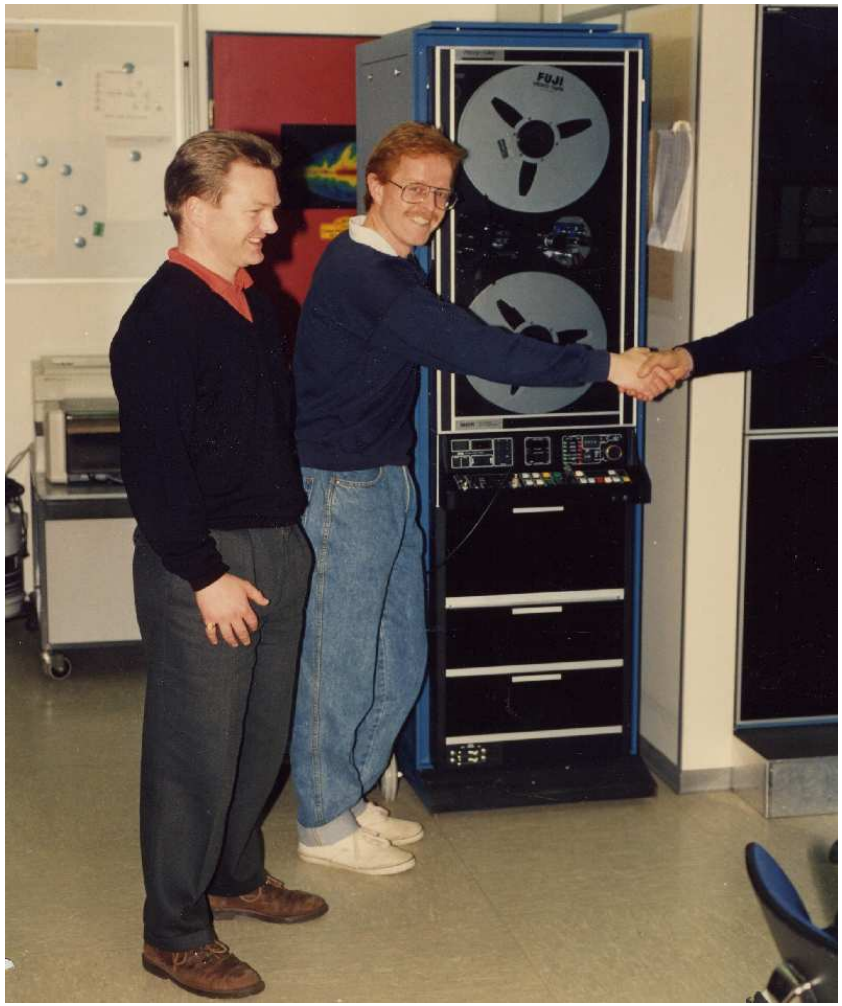
1993 JIVE established as a Foundation in the Netherlands
with funds from various countries to build a correlator

1993 Funds from European Union - " Access to Large Facilities"

1993 Appointment of Support Scientists to assist users:
at Bonn and VLBA correlators, and at some EVN telescopes

1998 Official opening of the EVN 16-station Data Processor at JIVE
at the time of the 4th EVN Symposium

1999 First EVN observations go to JIVE for correlation



1991: Penny and Giles Playback Terminal at Bonn Correlator

Homeless JIVE staff

THE VLBA COMES

VLBA: 10 telescopes + 20-station correlator
VLBA has new recording modes (wider "IF" channels)
But: VLBA antennas can record some MK III modes

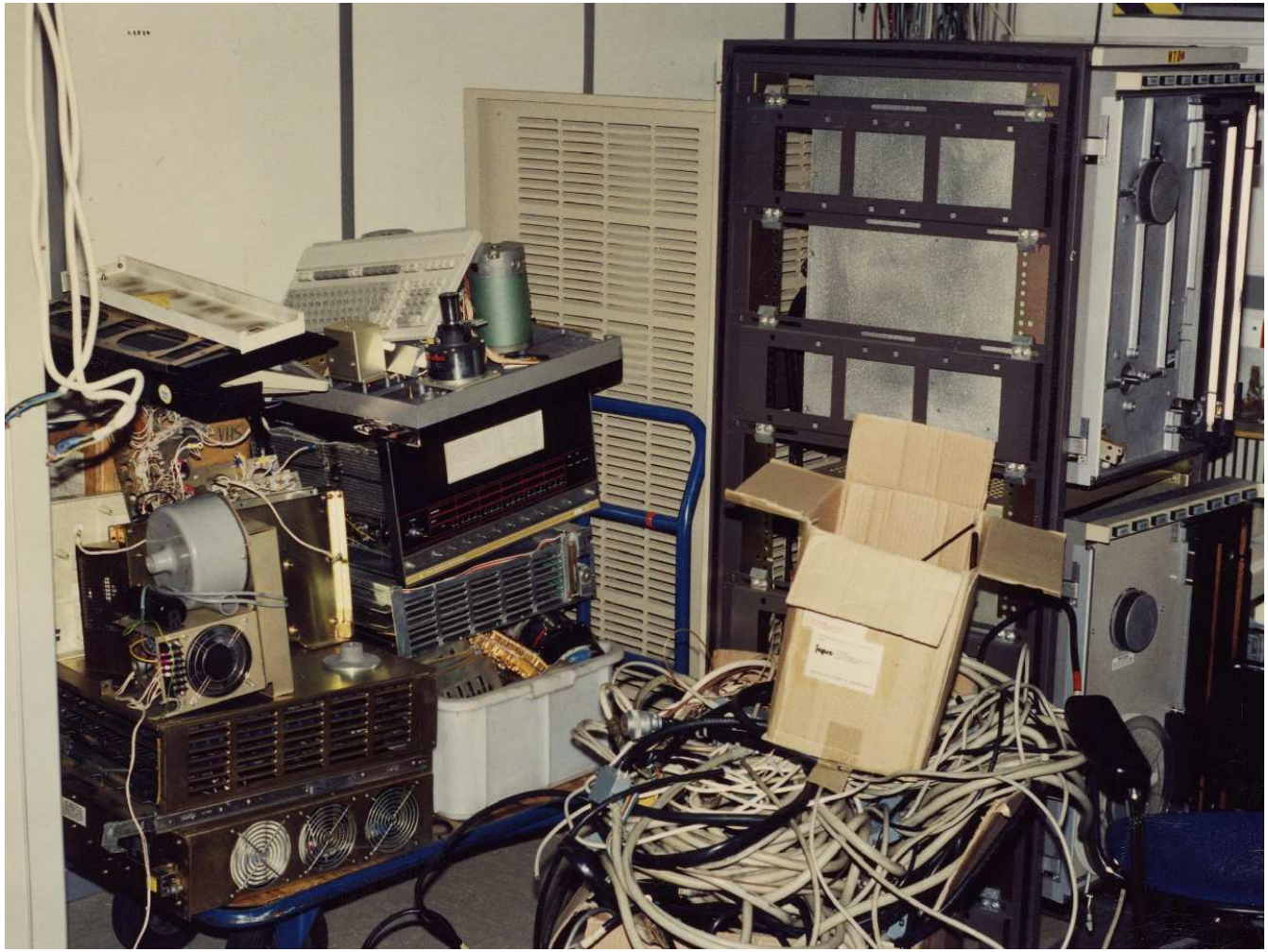
~1992 VLBA takes over from US-Network as EVN partner for Globals
US-Network antennas lose funding as VLBA start up Loss of 2.8 cm !

~1993 Caltech loses NSF grant for running Block II correlator
DEATH OF MK II SYSTEM !!

VLBA correlator can correlate Global MK III experiments
But: requires special "thin" double-length tape, $ 1000 each

1993 EVN starts "thin tape upgrade" at MK III recorders

1995 EVN starts upgrade to MK IV (very compatible with VLBA modes)
New data formatters reaching 1 Gbps, IF channels up to 16 MHz
Capable of recording "VSOP–mode" 128-2-2



1992: End of Bonn MK2 correlator

SPACE VLBI: VSOP COMES

1990 EVN plays major role in forming Global VLBI Working Group (GVWG)

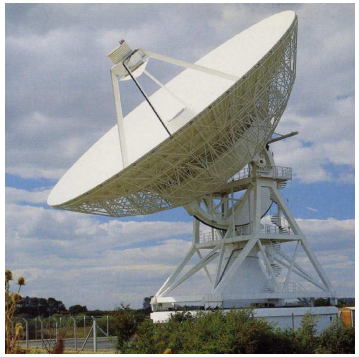
Organize committments of ground radio telescope time to VSOP mission

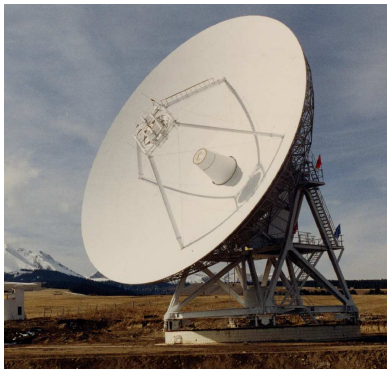
EVN commits observing time to VSOP mission

1997-1999 EVNPC reviews VSOP proposals: EVNPC Chair on VSOP TAC

1997-2001 EVN observes together with HALCA satellite at 6 and 18 cm
Increases from 3 to 4 sessions per year to accomodate projects
Correlation at VLBA correlator

1993: GVWG meeting in Onsala for GRT commitments






New telescopes: Cambridge-32m Seshan Urumqi Torun-32m

INTERCONTINENTAL BASELINES TO CHINA GIVE GLOBAL RESOLUTION


Taking part at 7 mm: Yebes-14m Metsaehovi 14-m

EVN 2001 – 2010

Old telescopes join EVN:

2000 Hartebeesthoek(1961)

2001 Arecibo(1963)

2001 VLBI School at Castel S. Pietro Terme, Italy

2002 First EVN observing at 512 Mbps (on tape !)

2003 Replacing tapes with disk recording: MK5 vs PC-EVN
MK5 adopted by IVS, followed by EVN and VLBA

2004 First EVN observing at 1 Gbps (with MK5)

2006 First EVN e-VLBI session in March

2008 First EVN observations with Yebes-40m ("Ys")

2009 Russian KVAZAR Network joins the EVN
Svetloe-32m Zelenchukskaya-32m Badary-32m
First EVN observations 2010

2010 10th EVN SYMPOSIUM IN MANCHESTER

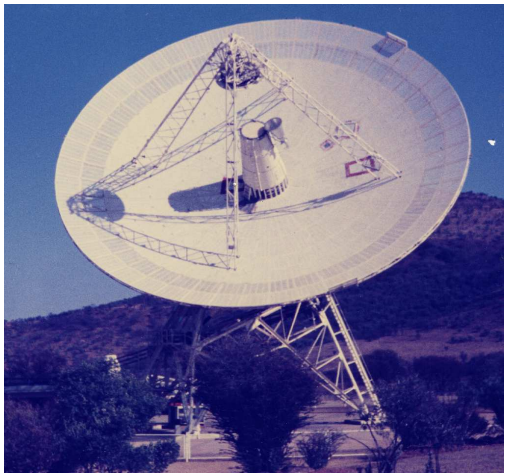
2008: EVN CBD meeting in Arecibo

2004: EVNPC meeting Bordeaux

Single-polarization observations more sensitive than dual-polarization !

2004: EVNPC meeting Bordeaux

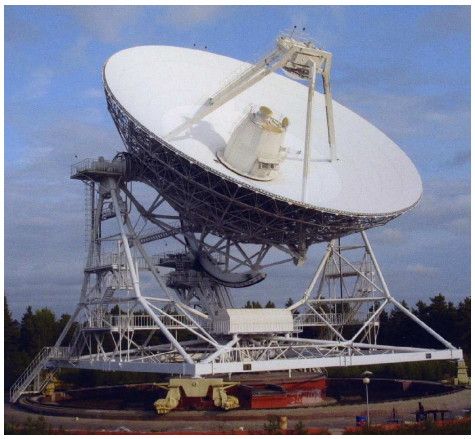
2008: No more tapes please !



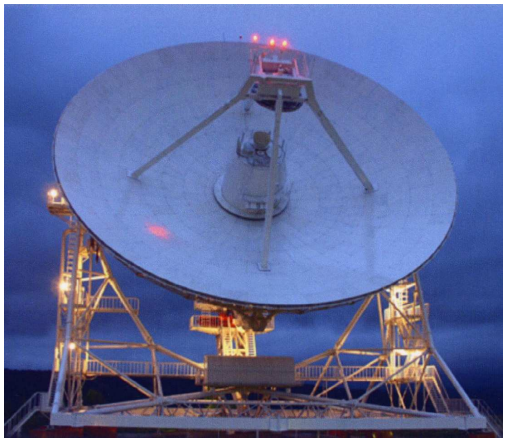
Hartebeesthoek

Arecibo

Yebes-40m

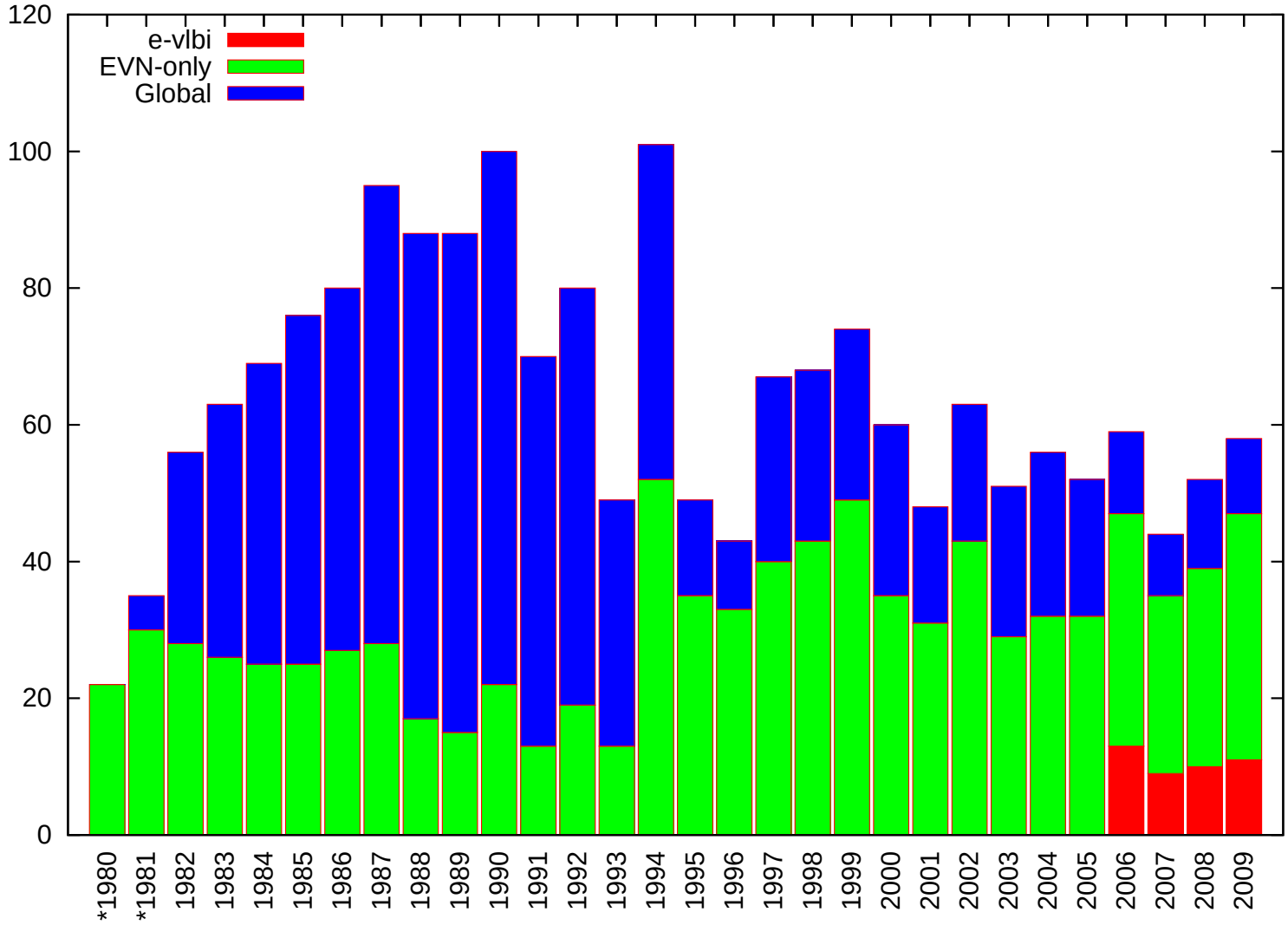


Svetloe

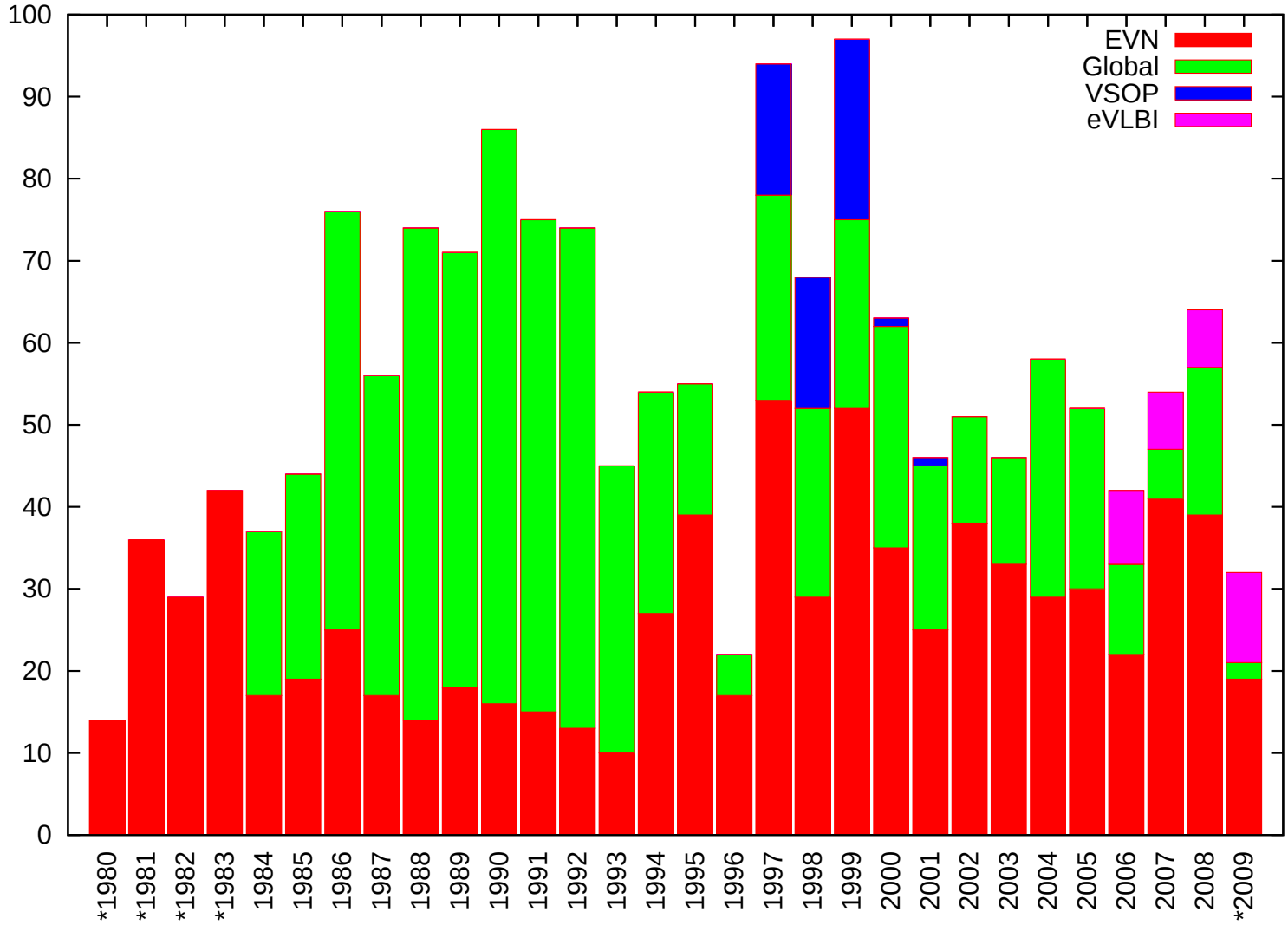


Zelenchukskaya

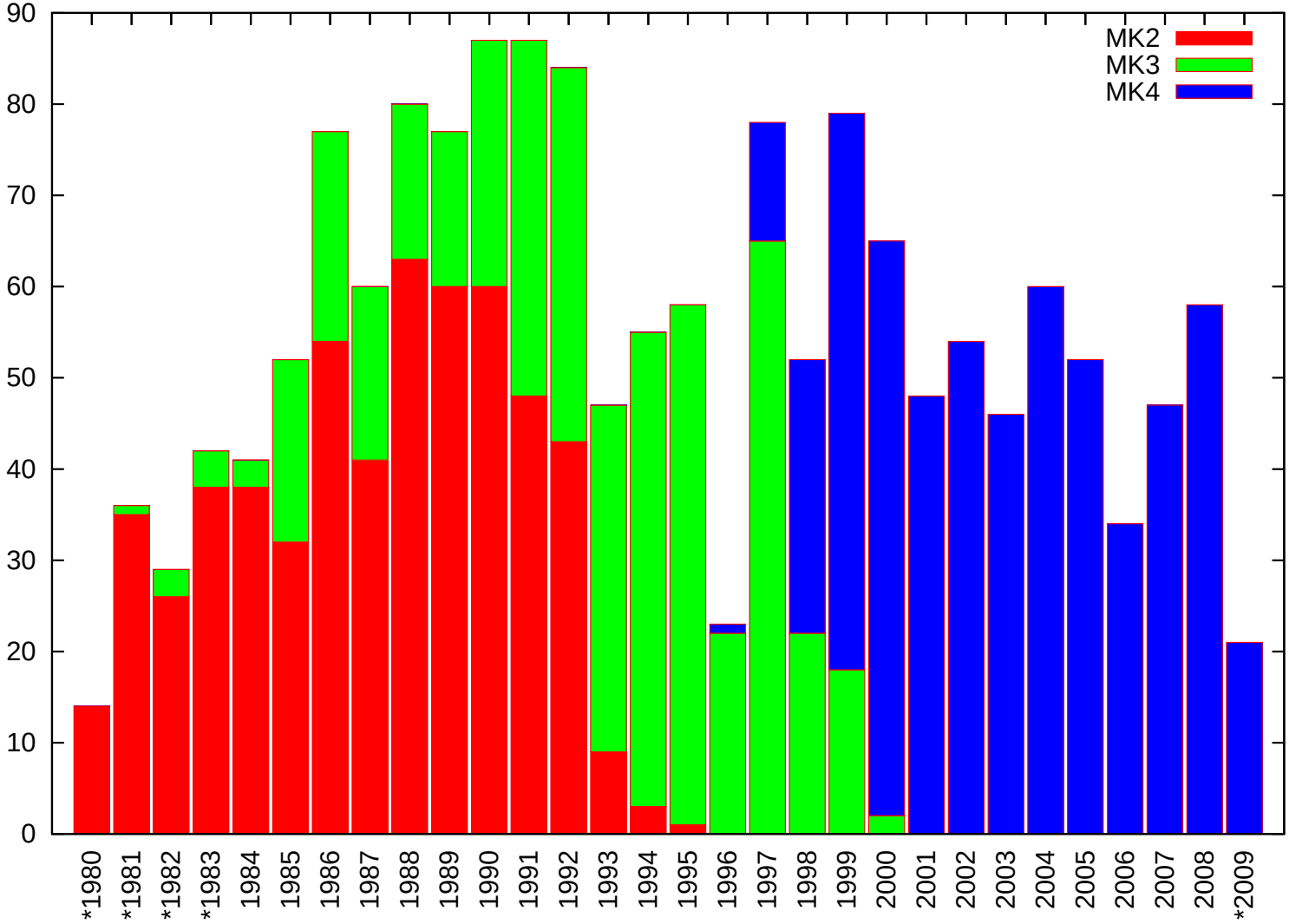
Badary



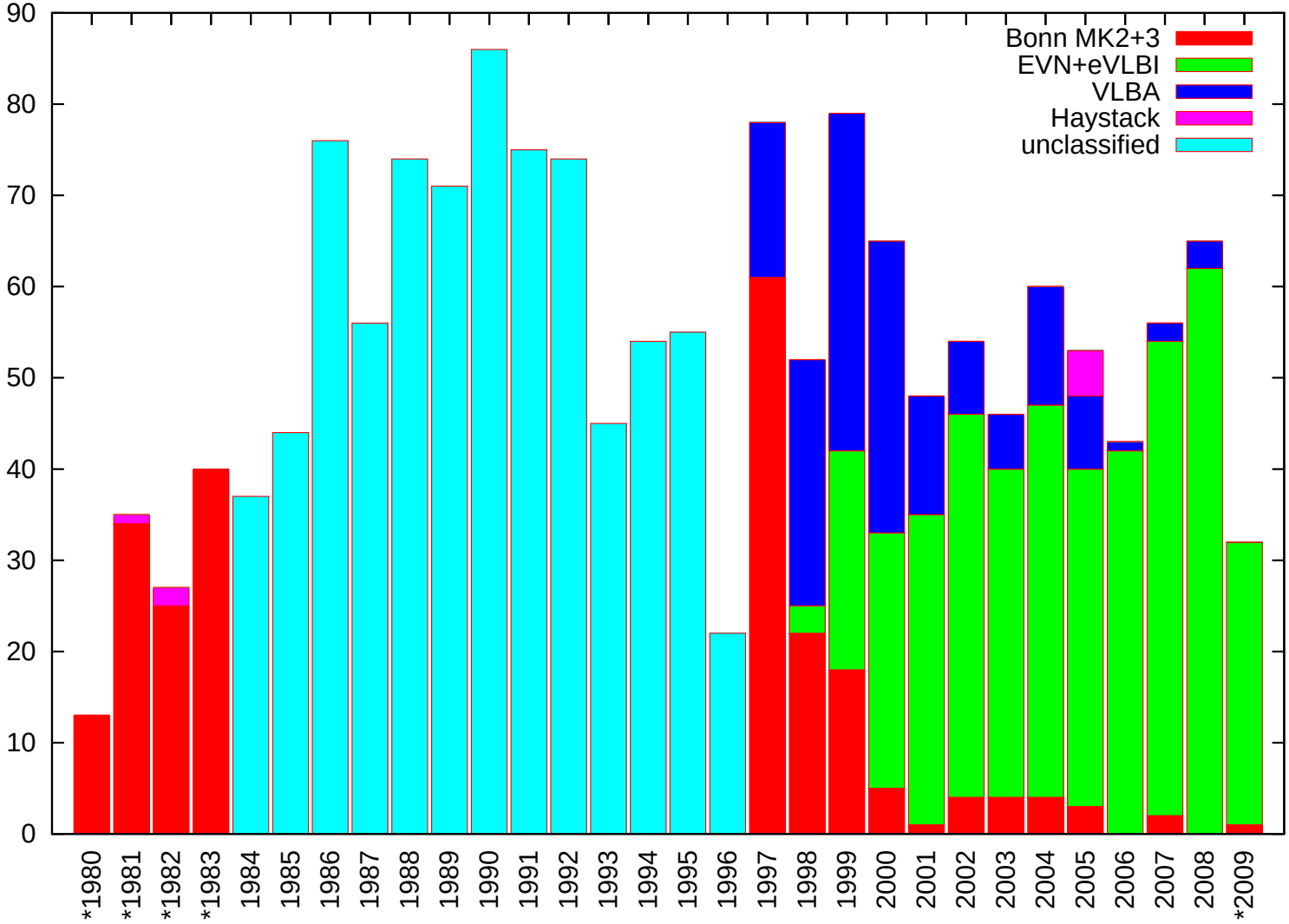
EVN PROPOSALS 1980–2009



EVN OBSERVATIONS 1980–2009



RECORDING MODES OF EVN OBSERVATIONS 1980–2009



CORRELATION OF EVN OBSERVATIONS 1980–2009