



8th International e-VLBI Workshop,
22-26 June 2009 - Madrid, Spain



Is an AGN at the center of the disk galaxy IC 2497 responsible for Hanny's Voorwerp?

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Tom Muxlow (Jodrell Bank) & Zsolt Paragi (JIVE)



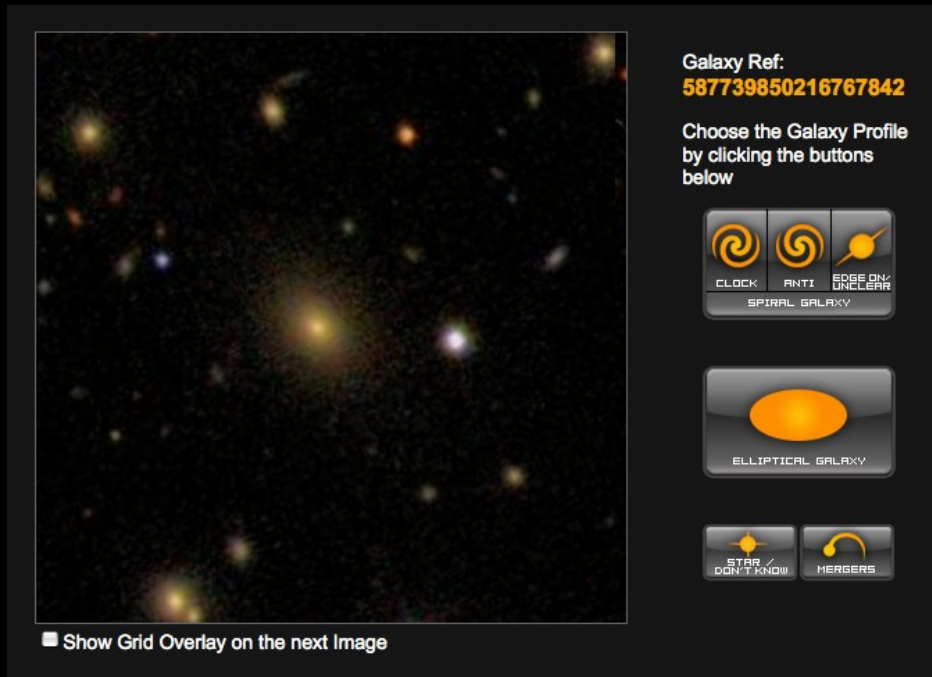
Outline

- Introduction
- Radio Observations (I) – e-VLBI (I) & WSRT
- Results (I)
- Conclusions (I)
- Radio Observations (II) – MERLIN & e-VLBI (II)
- Results (II)
- Discussion
- Conclusions

“Hanny's Voorwerp” (SDSSJ094103.80+344334.2)

Introduction

Galaxy Zoo Interface



Hanny van Arkel

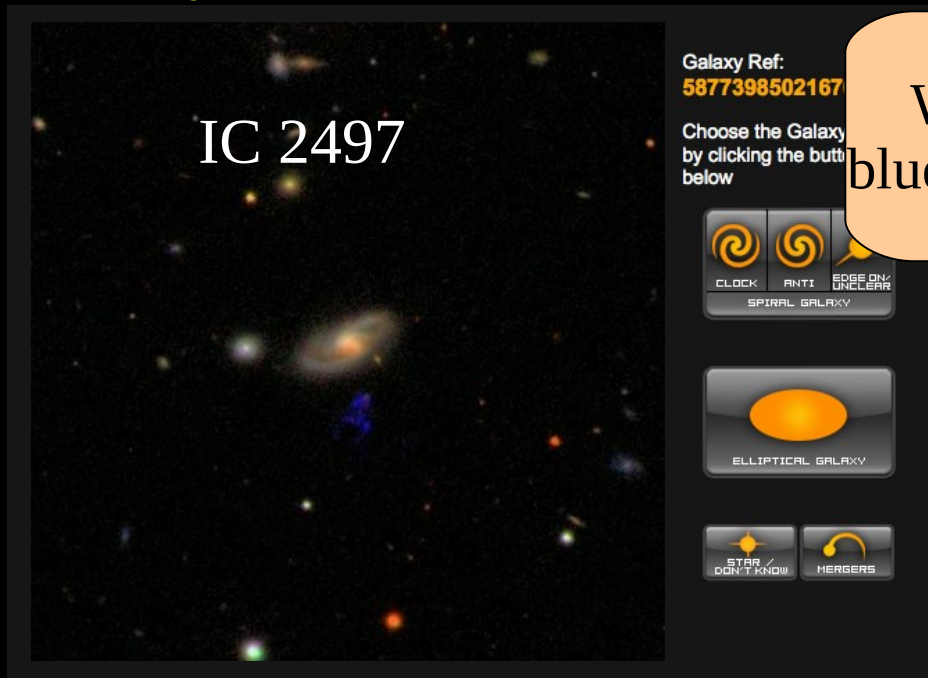


Hanny van Arkel took part in the “Galaxy Zoo” (www.galaxyzoo.org) project, classifying > 20000 objects

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What is the
blue stuff below?



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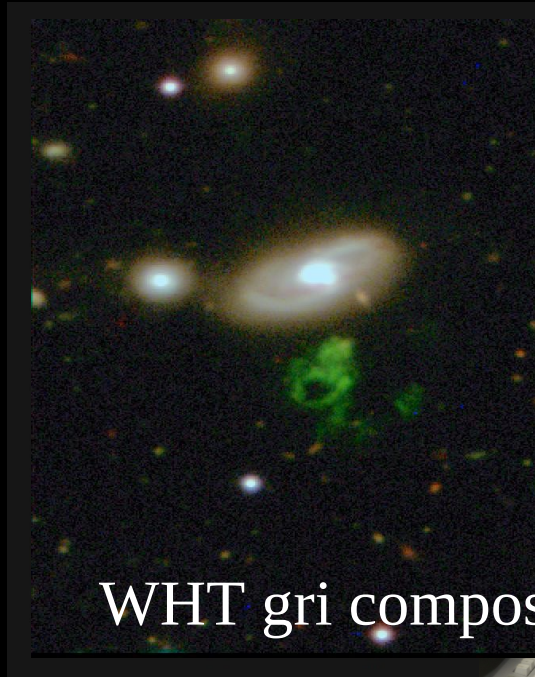
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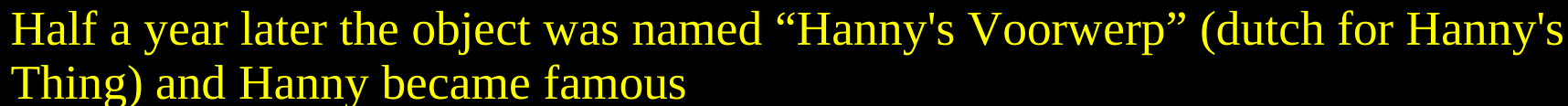
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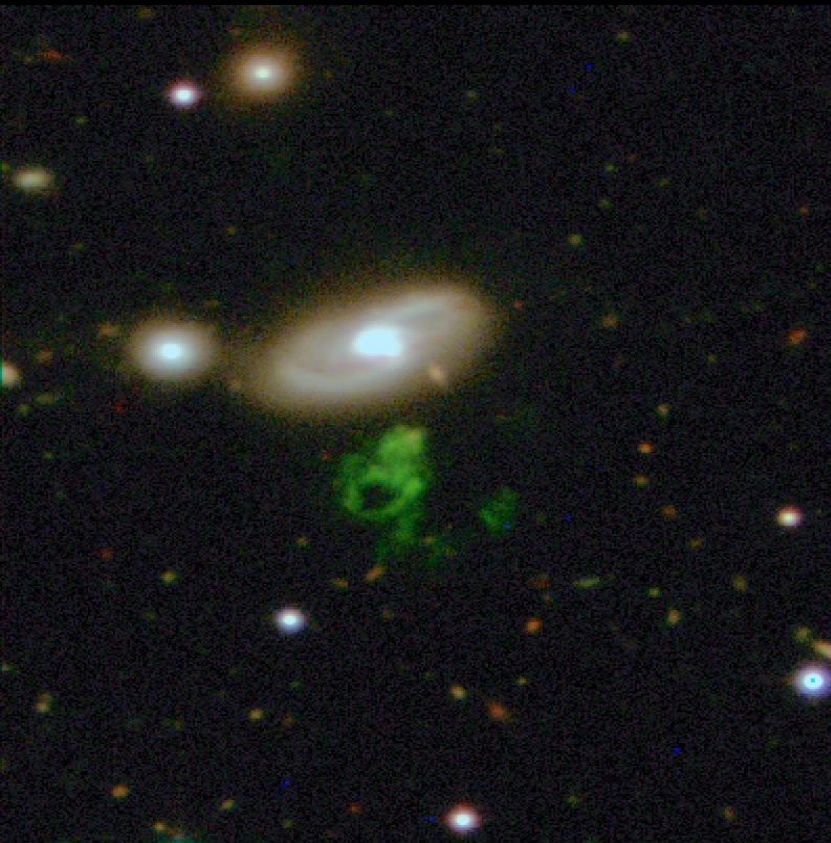
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Introduction



IC2497:

RA (J2000): 09^h41^m4^s

Dec (J2000): +34° 43′ 58″

V_{sys} : 15056 ± 40 km/s

D_{3K} : 210 ± 15 Mpc

L_B : $63 \pm 7 \cdot 10^9 L_{\odot}$

L_I : $39 \pm 3 \cdot 10^9 L_{\odot}$

WENSS, $S_{325 \text{ MHz}} = 51 \pm 4.9$ mJy

$S_{\text{FIRST}} = 16.8 \pm 0.9$ mJy

FIR-Radio correlation, $q = 2.16$.

“Hanny's Voorwerp”

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Introduction

- Lintott et al 2009 (submitted) – Optical, UV and X-ray
- Dominated in optical by [O III]
- WHT spectrum => very strong emission, with high-ionisation lines (He II, [Ne V])
- Highly ionized gas => shock ionization or photoionization by an AGN
- No evidence for ionization source => very low continuum in spectra
- No X-ray emission from IC2497, detected (yet)

“Hanny's Voorwerp”

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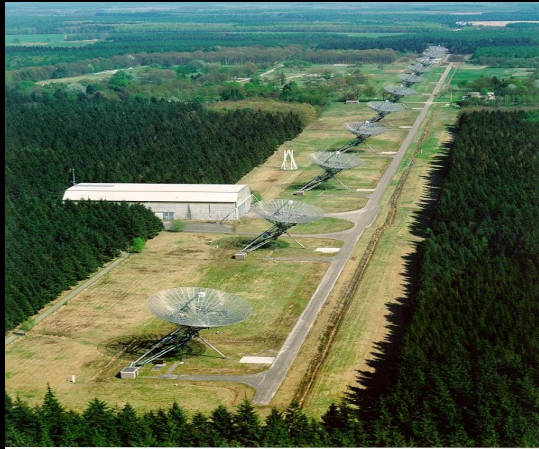
Introduction

What is (creating) the Voorwerp?

- Voorwerp is a light echo? (suggested by Lintott et al)
- Quasar event, that turned off?
- Obscured AGN in IC2497 to us, but not towards the Voorwerp?

“Hanny's Voorwerp” (SDSSJ094103.80+344334.2)

Radio Observations (I)



6x15' WSRT 6cm (September 2008)

8x70' WSRT 21cm (September 2008)

2x12h WSRT HI (October 2008)

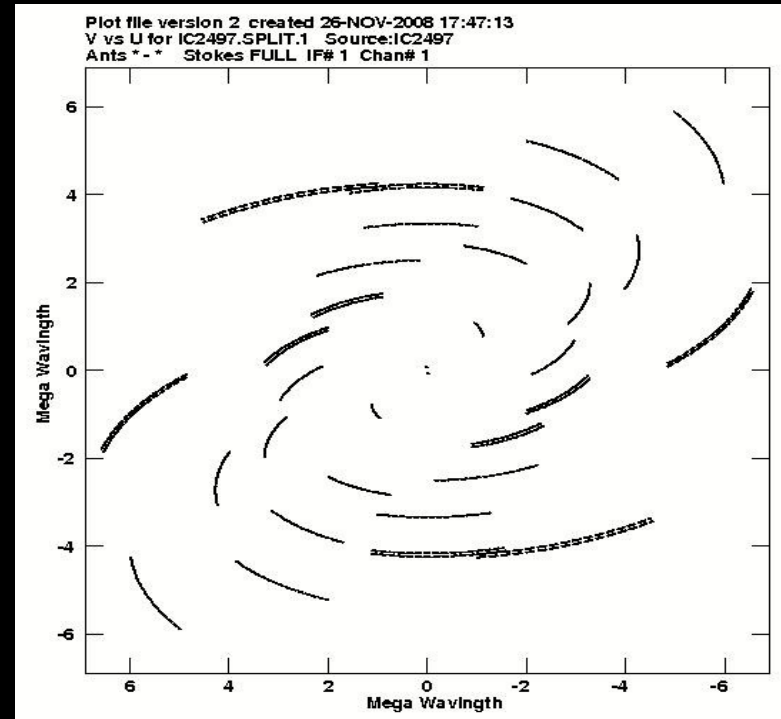
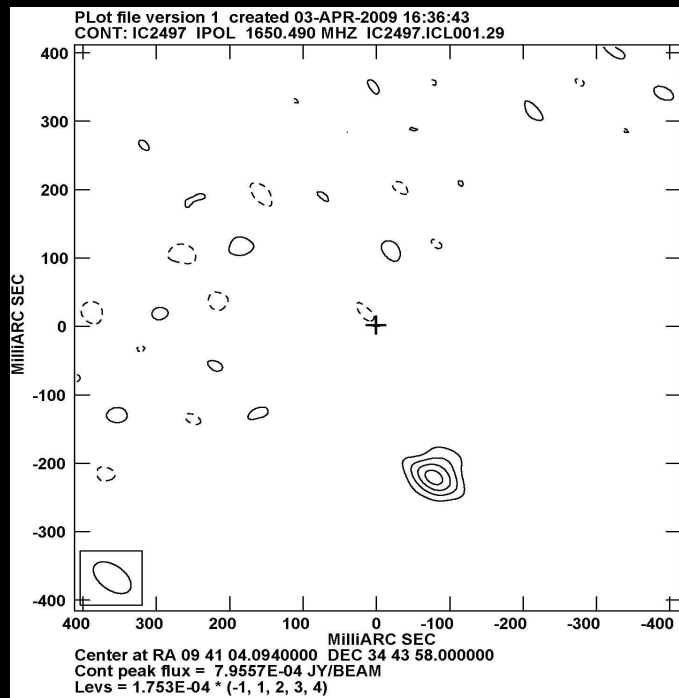
2hr e-VLBI 18cm (September 2008) - Wb, Mc, On, Tr, Ef, JBMkII & Dh

Jozsa et al 2009, accepted A&A

H.R. (JIVE & Leiden)

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e-VLBI 1



Clear detection at the centre of IC 2497 (identification with FIRST source)

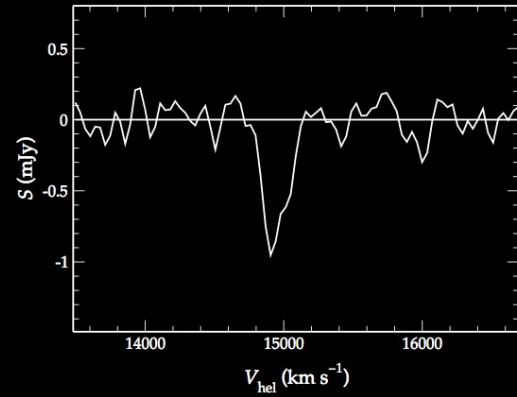
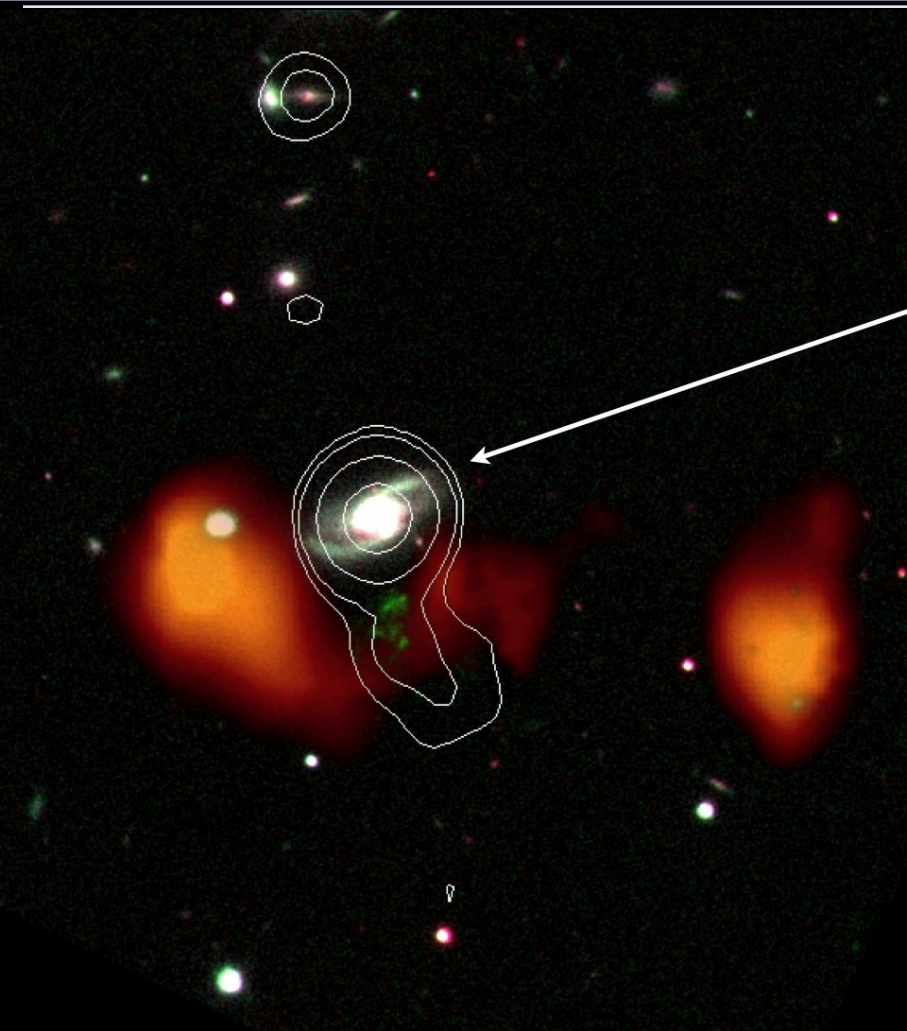
Compact source (size < 60 milliarcsec, HPBW ~ 40 milliarcsec)

$T_B \geq 4 \cdot 10^5 \text{ K} \rightarrow \text{AGN activity}$

H.R. (JIVE & Leiden)

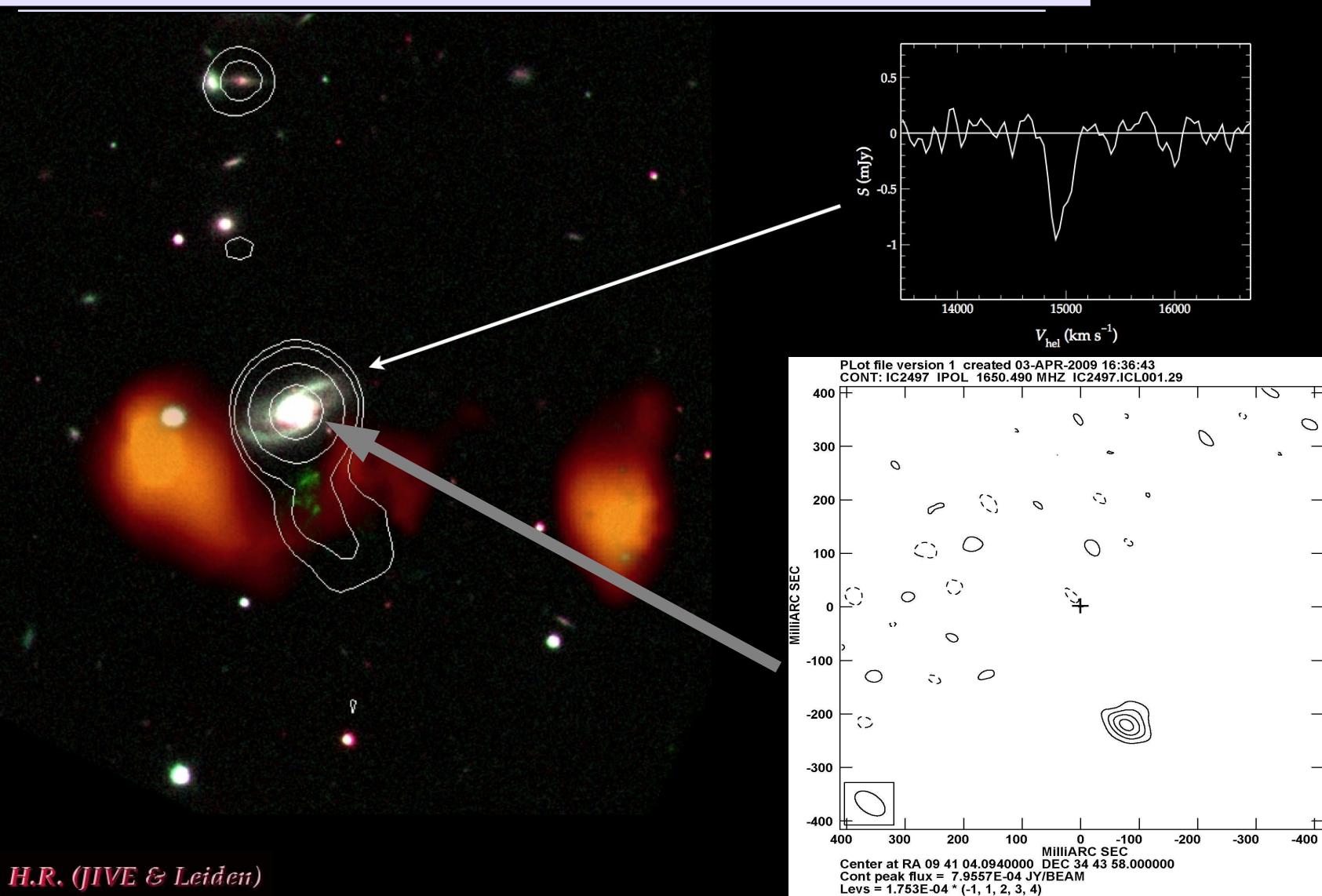
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WSRT



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WSRT



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Results (I)

- WSRT continuum obs @ 1.4GHz and 4.9GHz, reveals the presence of extended emission originating at the centre of IC2497, pointing towards The Voorwerp."
- On mas scale (e-VLBI 1.65GHz observations) a central compact source at the core of IC 2497 is detected -> AGN.
- WSRT, detected a large reservoir of neutral hydrogen in the proximity of IC 2497 and Hanny's Voorwerp.

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Conclusions 1

Hanny's Voorwerp is being ionised by an AGN in the centre of IC 2497.

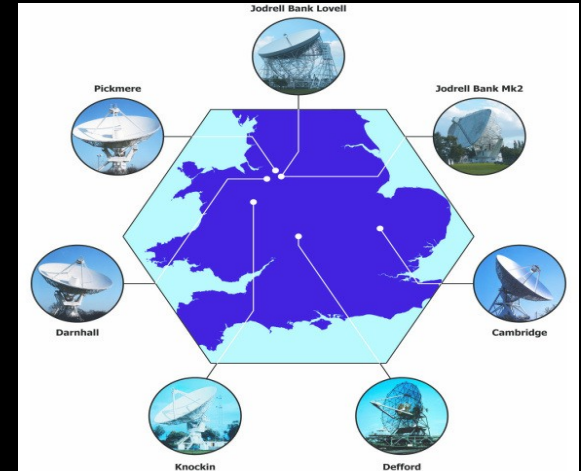
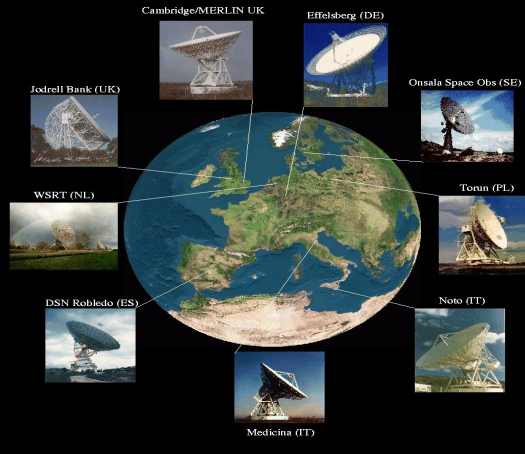
A plasma jet associated with the AGN clears a path through the ISM/IGM in the direction of the Voorwerp

Hanny's Voorwerp is part of a large (neutral) cloud complex

Jozsa et al 2009, accepted A&A

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Radio Observations (II)



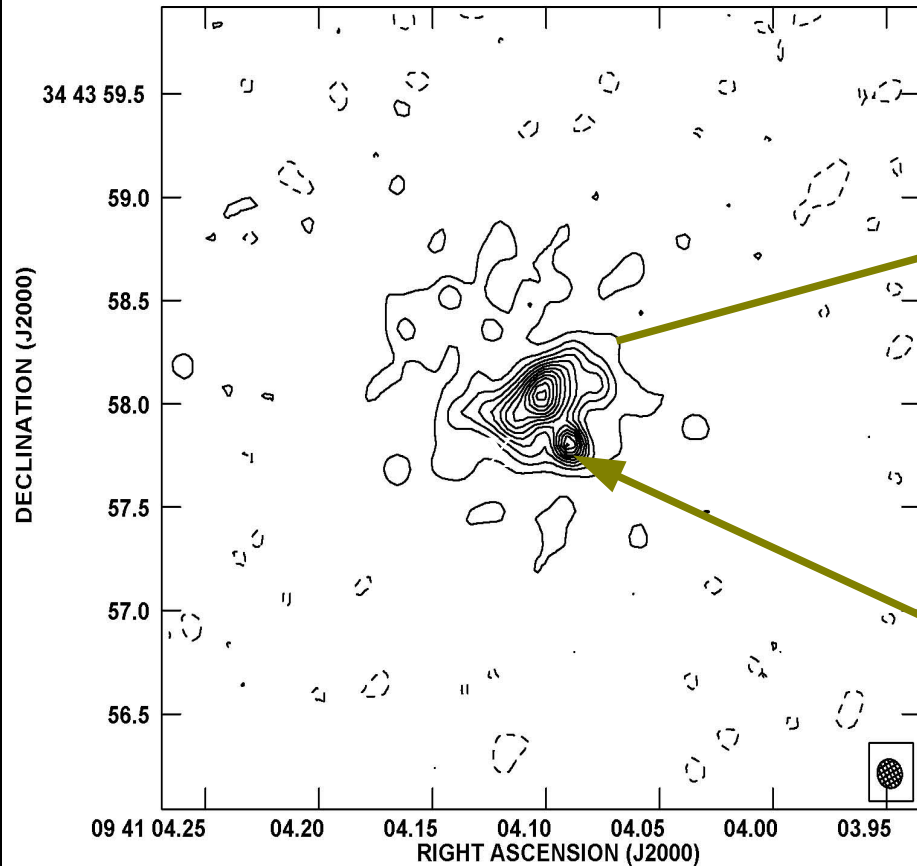
15hr MERLIN 18cm (February 2009)

10.5 hr e-VLBI 18cm (May 2009) - Ef, Mc, On, Tr, Wb, Cm, Jb, Da, De, Kn, Ta, & Sh

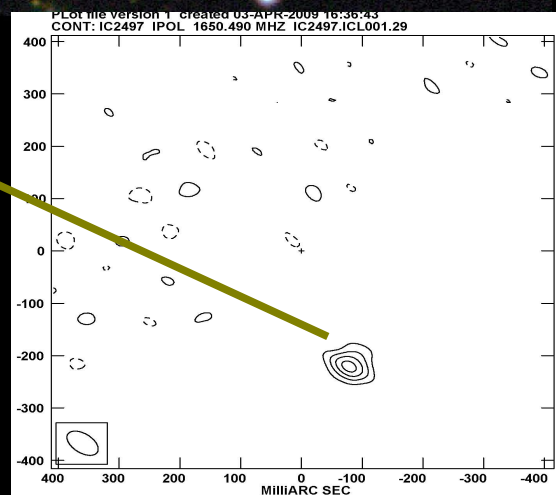
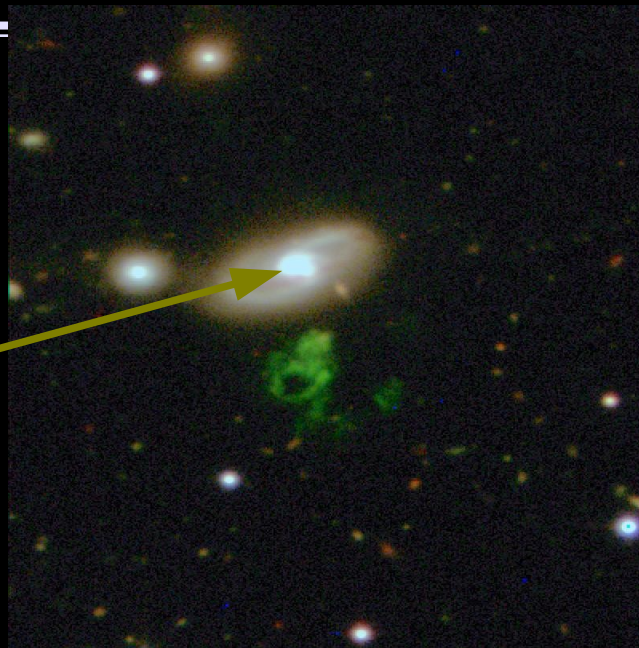
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MERLIN

Plot file version 2 created 12-MAR-2009 07:38:35
CONT: IC2497 IPOL 1658.000 MHZ IC2497.ICL001.14

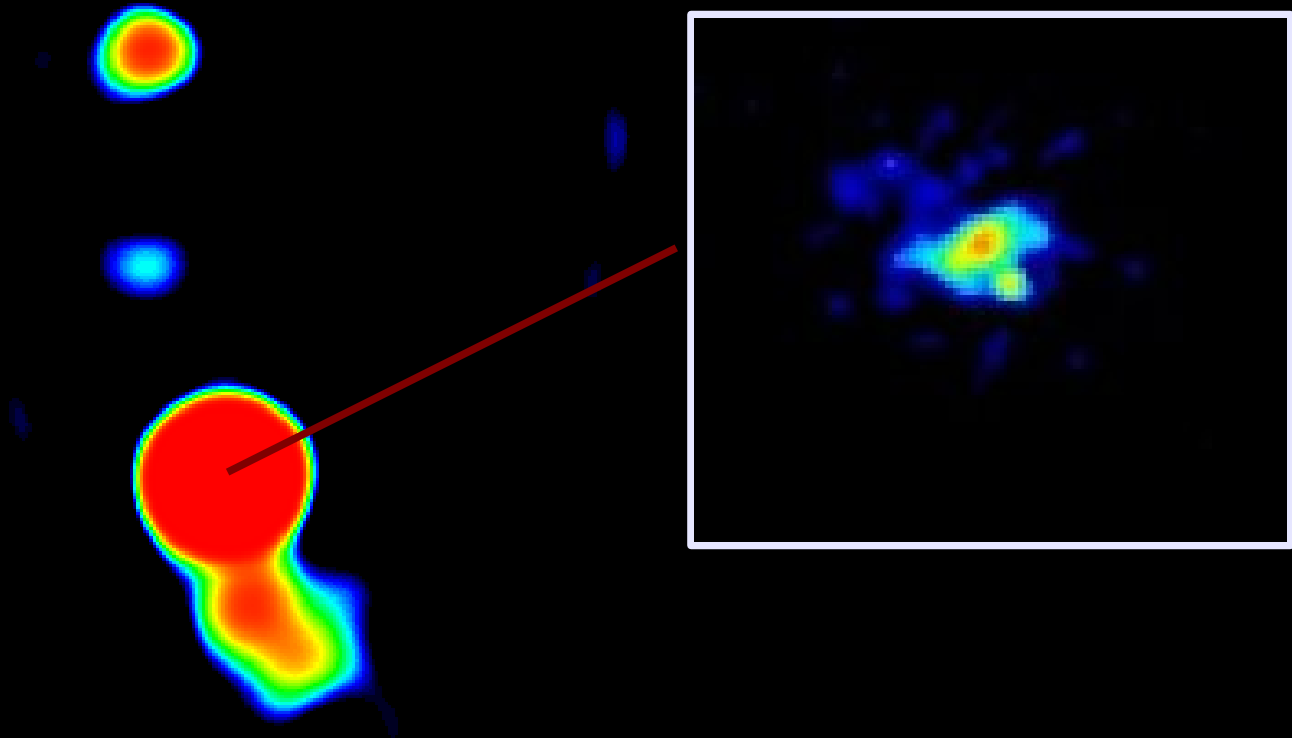


Cont peak flux = 1.1290×10^{-3} JY/BEAM
Levs = $9.167 \times 10^{-5} * (-1, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15)$



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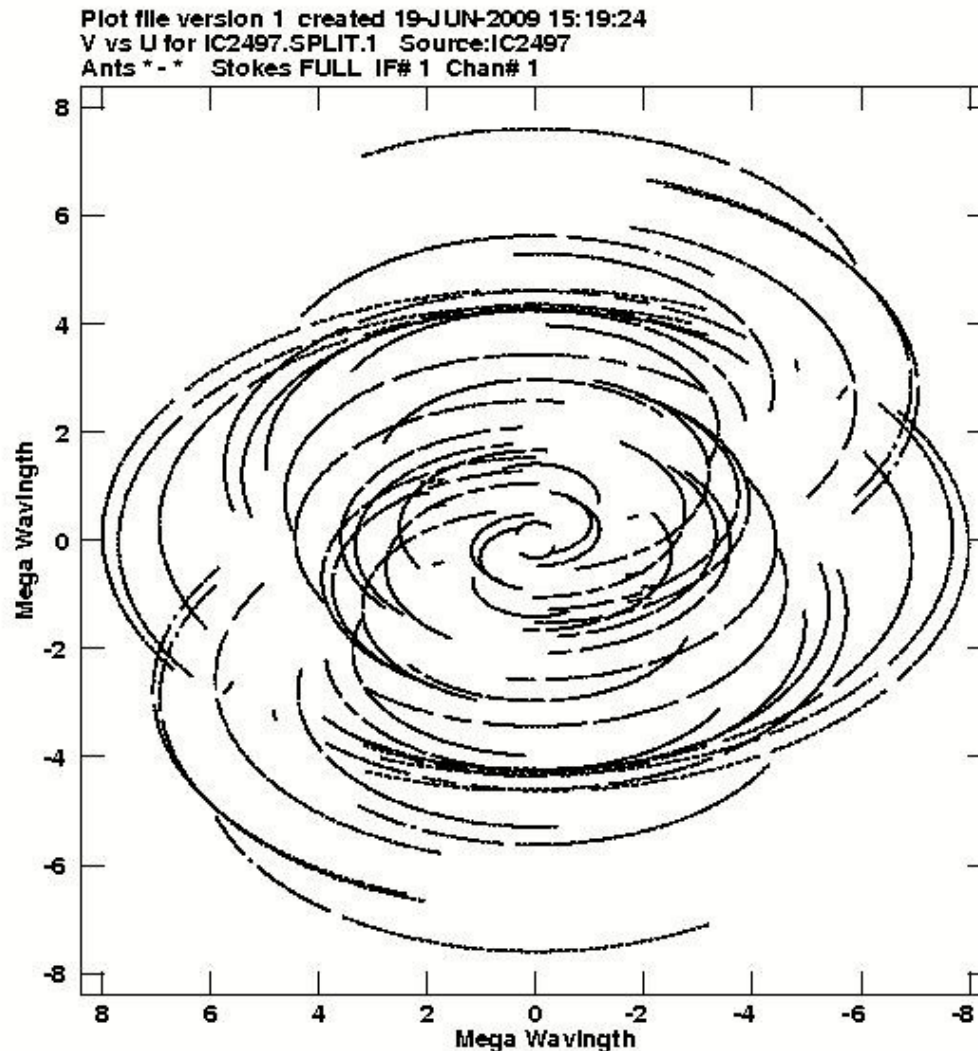
MERLIN



WSRT continuum

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e-VLBI 2

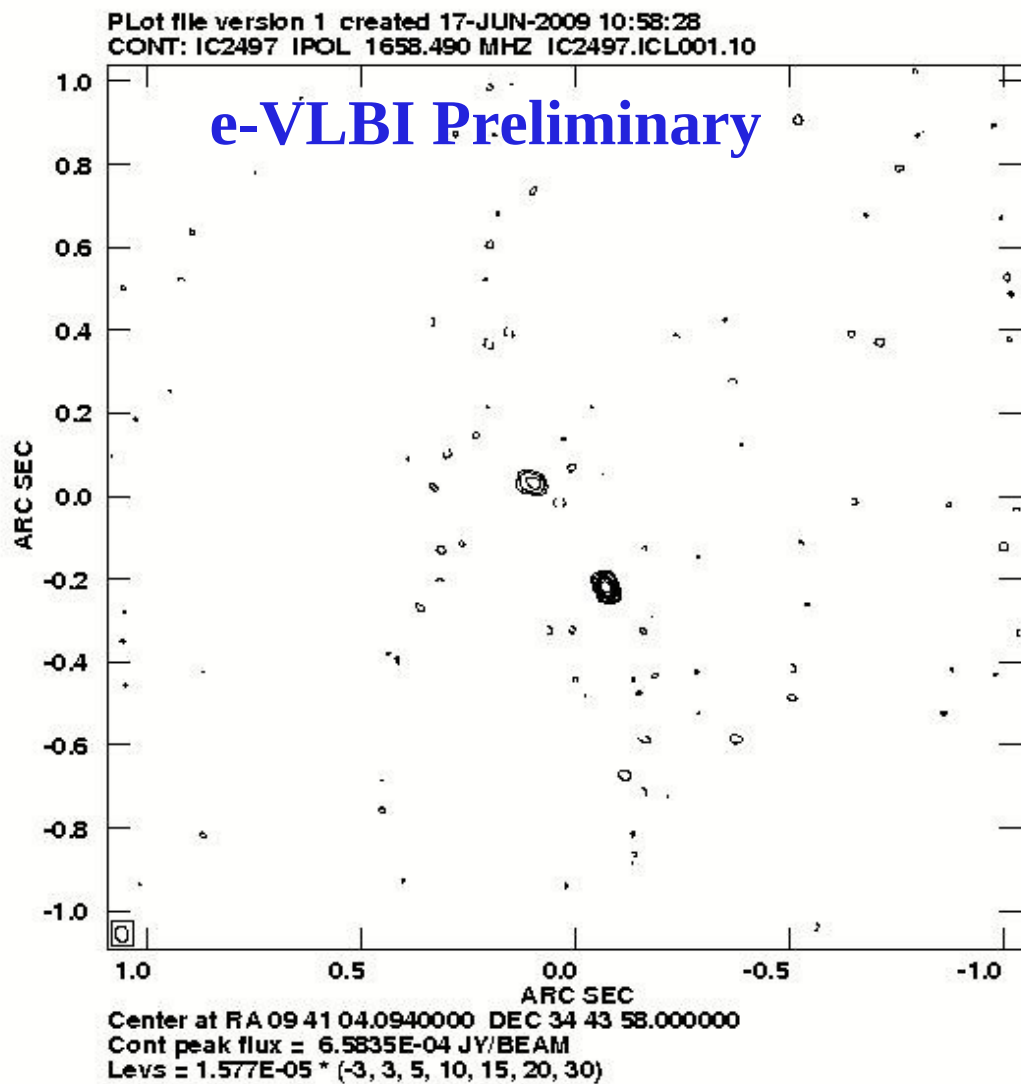


x 8 IFS
x 32 Channels

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e-VLBI 2

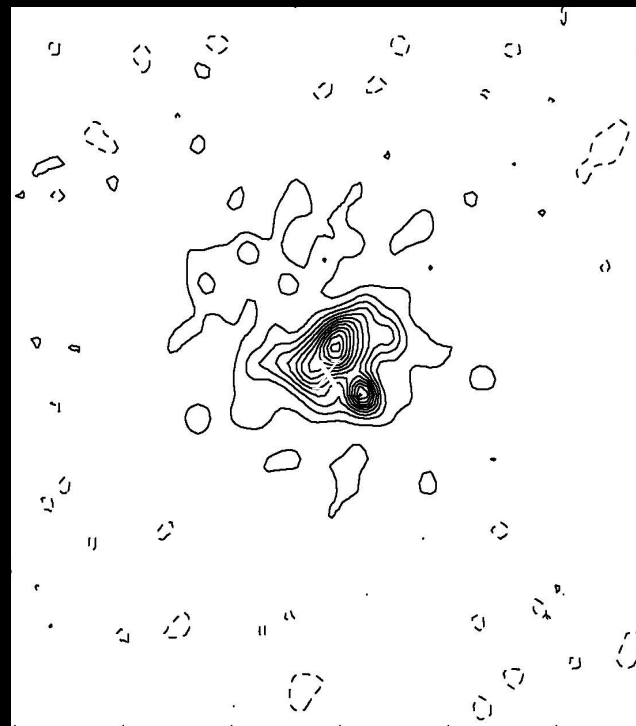
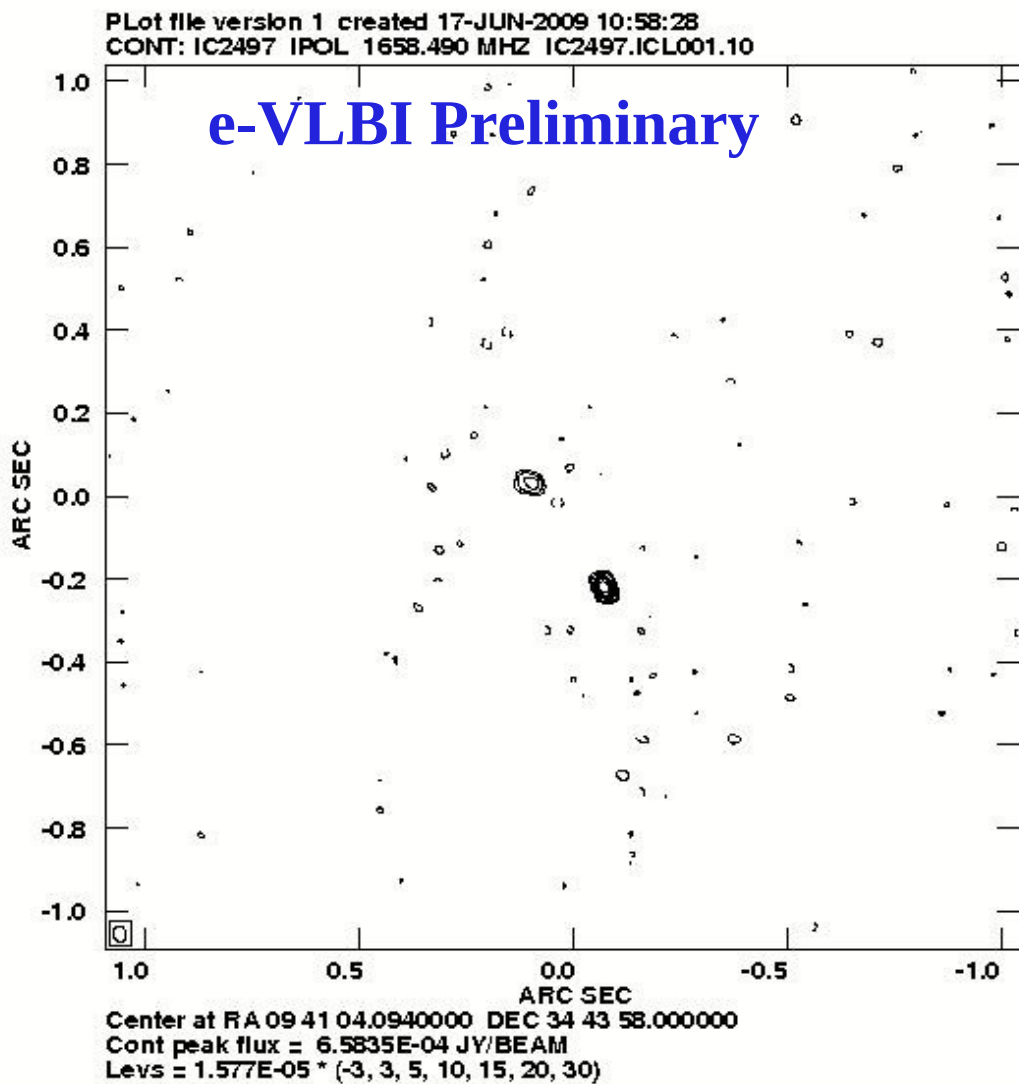
e-VLBI Preliminary



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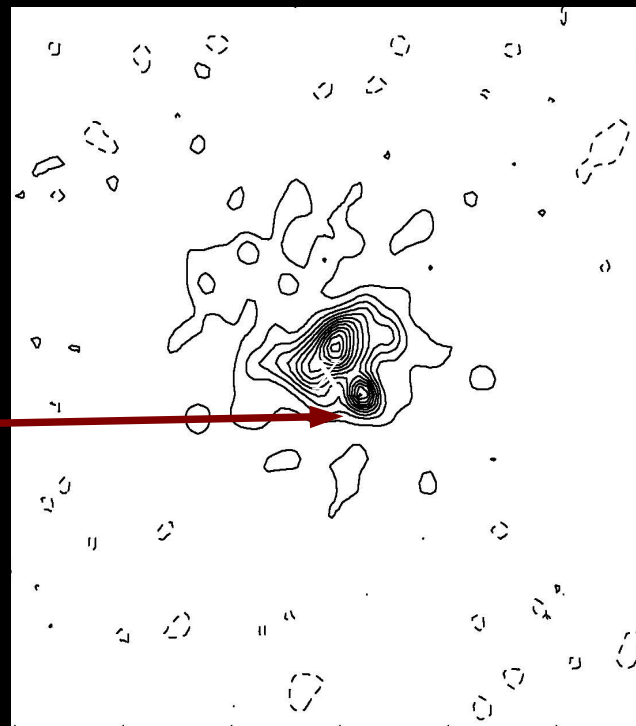
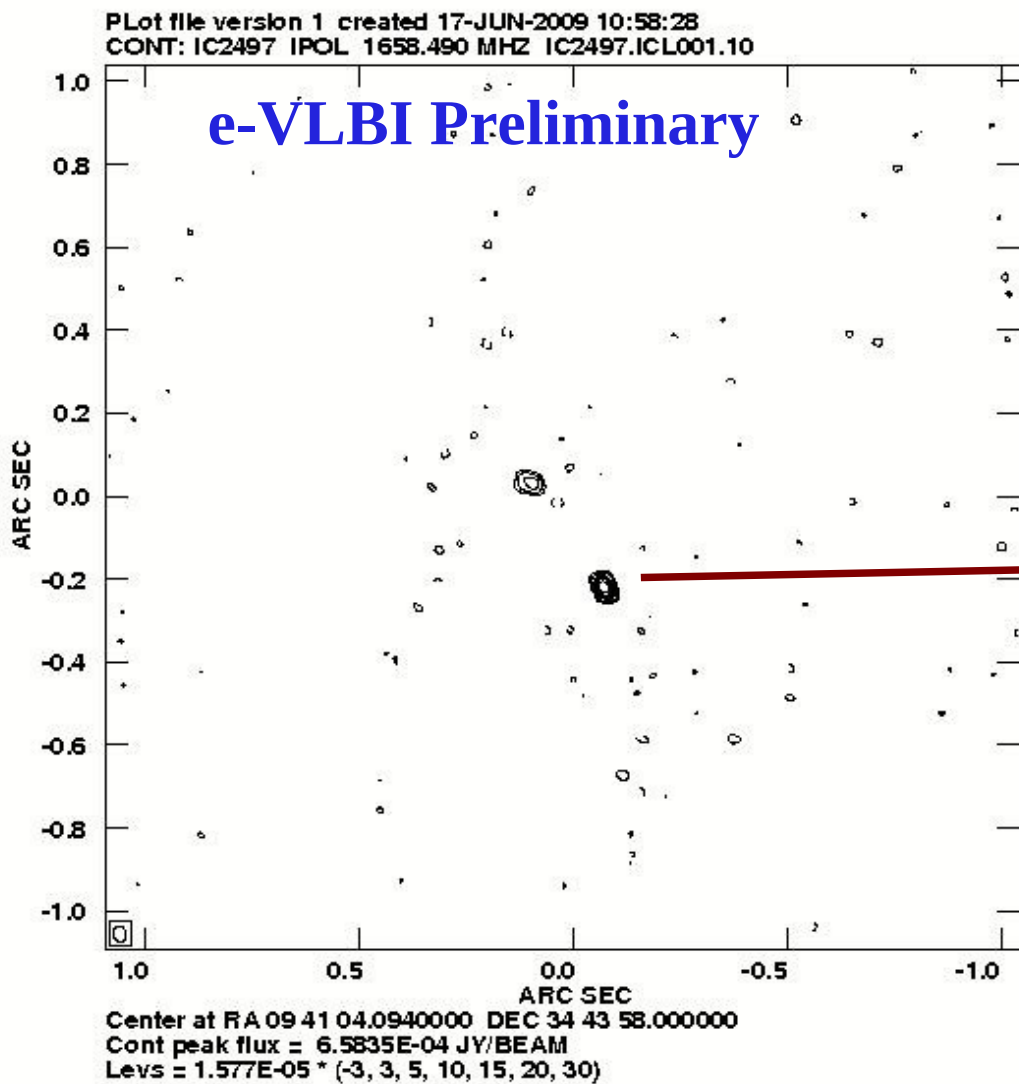
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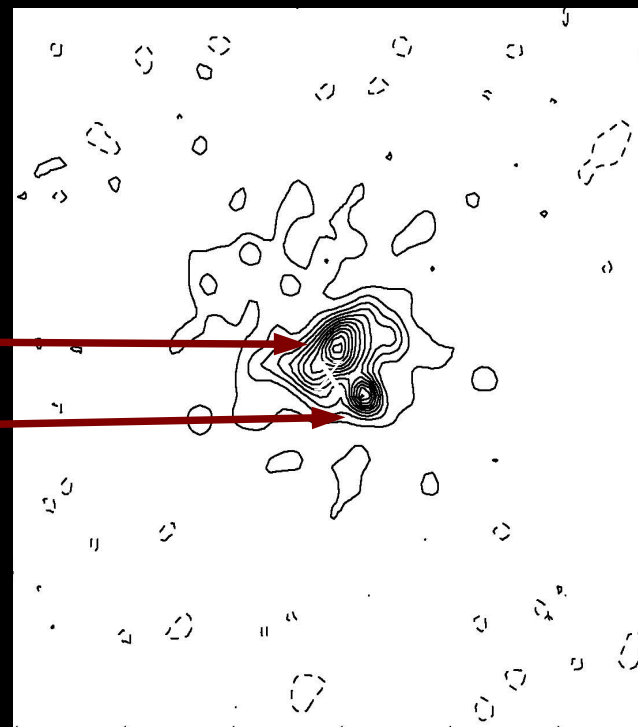
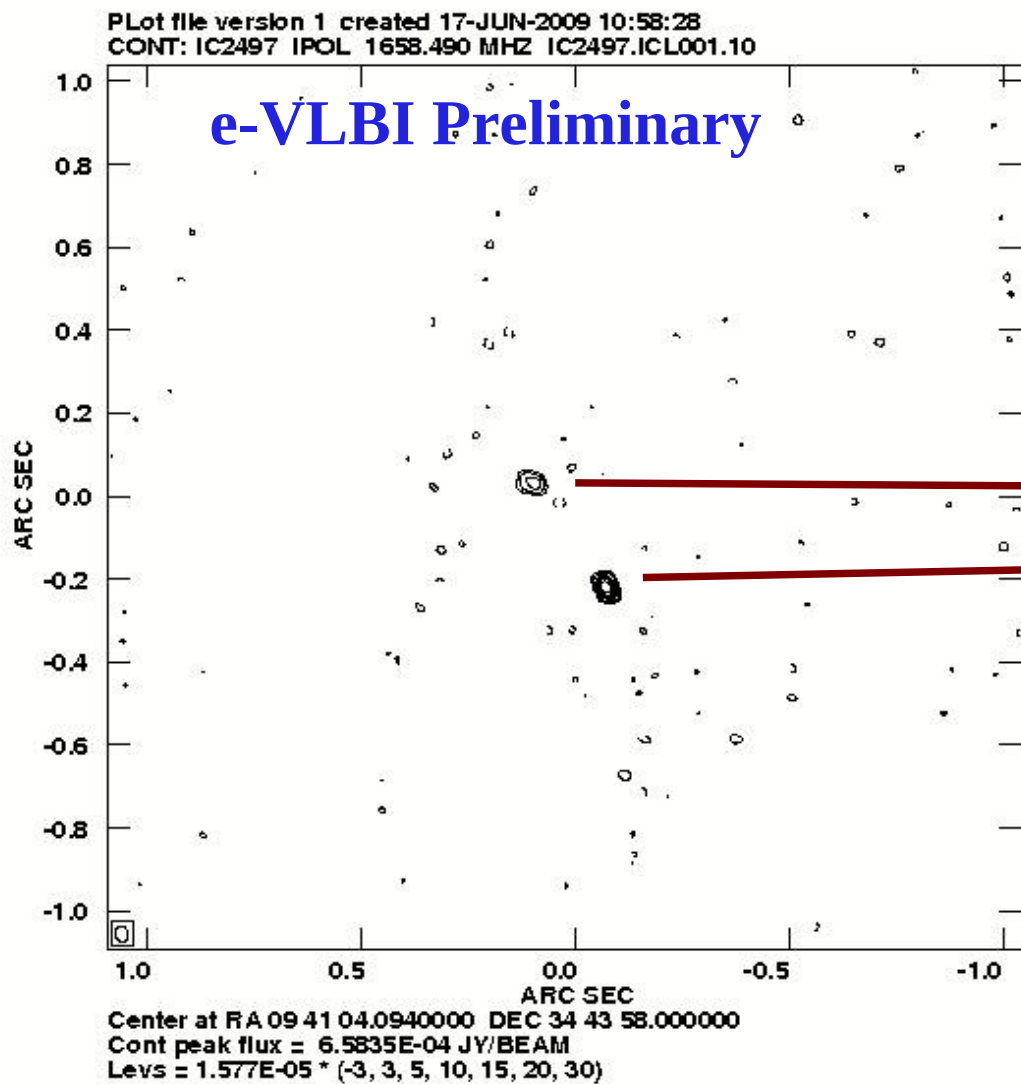
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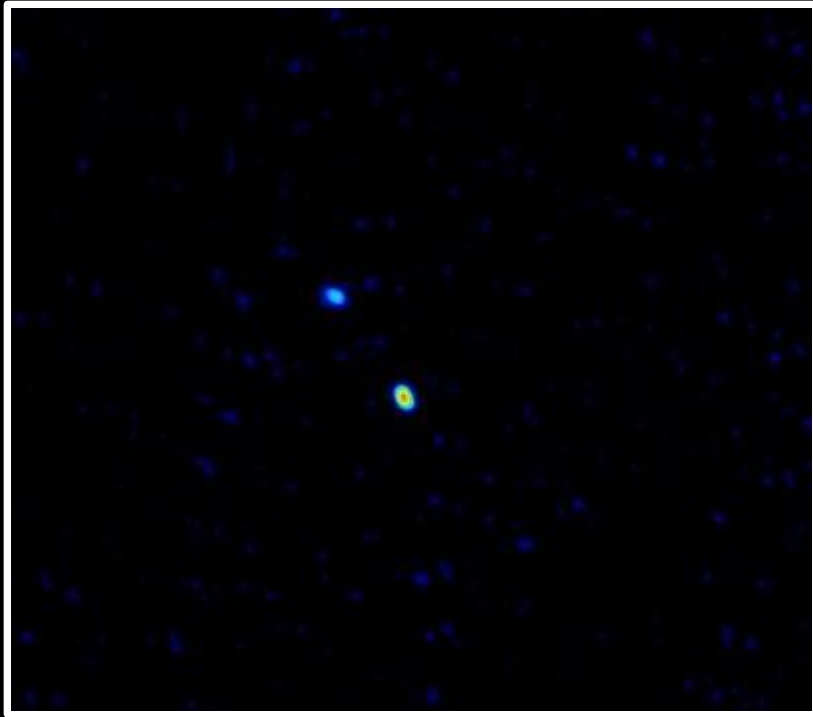
e-VLBI 2

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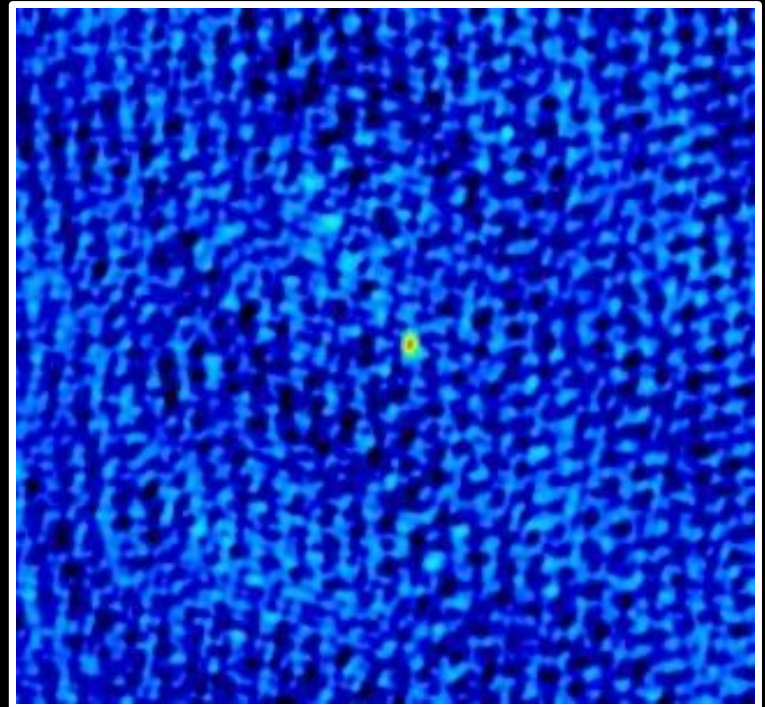


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Importance of a 100m telescope ...



with Effelsberg



without Effelsberg

“Hanny's Voorwerp”

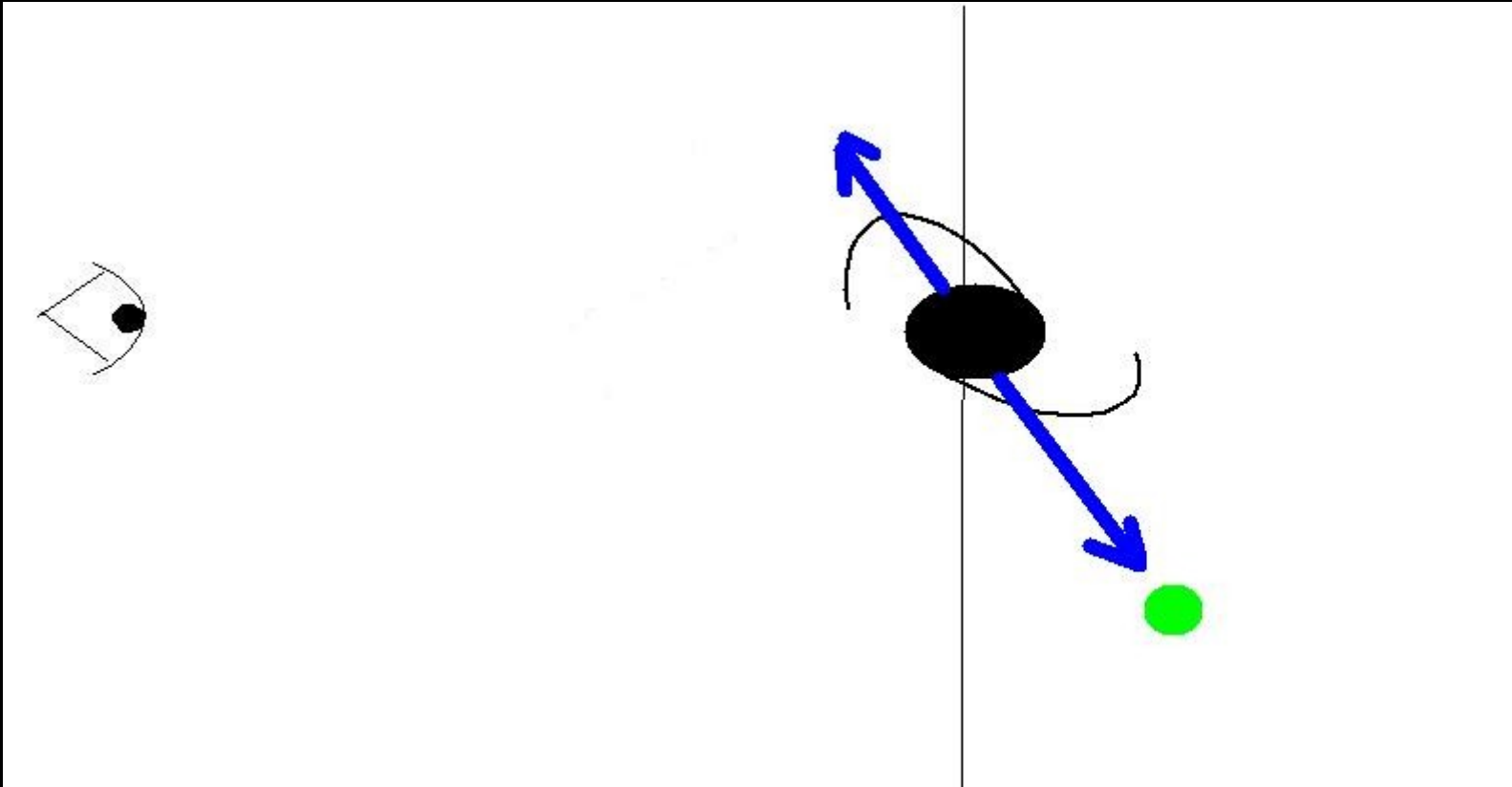
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What's Going on?

- 230-310 km/s blueshifted with respect to IC2497 (reported by Lintott et al)
 - could be peculiar velocity wrt IC2497
 - cannot say with certainty the location of the Voorwerp wrt IC2497
- On kpc scales a jet towards the Voorwerp (WSRT)
- On pc scales a jet in the “opposite direction” ? (MERLIN & e-VLBI)

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An Idea ...



Conclusions, Questions & Future

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- Have a good look at the new eVLBI obs.
- Observations on VLA scales.