

## Fifty WSRT highlights

---

**Richard Strom**

ASTRON

Oude Hoogeveensedijk 4, 7991 PD Dwingeloo, The Netherlands

E-mail: [strom@astron.nl](mailto:strom@astron.nl)

**Thijs van der Hulst**

Kapteyn Astronomical Institute, University of Groningen, Landleven 12, 9747AD Groningen,

The Netherlands

E-mail: [j.m.van.der.hulst@rug.nl](mailto:j.m.van.der.hulst@rug.nl)

**Arnold van Ardenne**

ASTRON

Oude Hoogeveensedijk 4, 7991 PD Dwingeloo, The Netherlands

E-mail: [ardenne@astron.nl](mailto:ardenne@astron.nl)

*50 Years Westerbork Radio Observatory, A Continuing Journey to Discoveries and Innovations*  
Richard Strom, Arnold van Ardenne, Steve Torchinsky (eds)

## Chapter 18 Fifty WSRT highlights

Richard Strom<sup>1</sup>, Thijs van der Hulst<sup>2</sup>, Arnold van Ardenne<sup>3</sup>

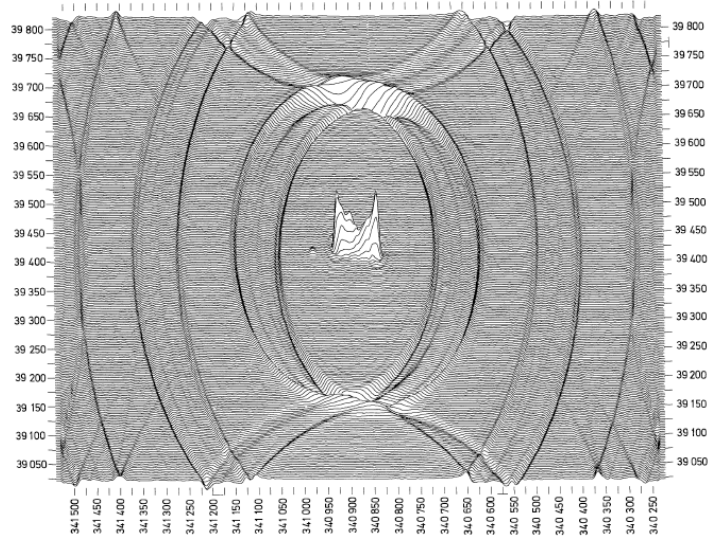
Ger de Bruyn felt that a leading telescope should produce about one outstanding result each year. He maintained a list of exciting science coming out of the WSRT, and when last updated it numbered 50 noteworthy results, about one per year with the 50th anniversary of the telescope soon upon us. Largely based on that with a few additions and modifications, the following pages represent WSRT milestones most of which are represented by an image as published by those who did the research. Most of the highlights concern astronomical results, though 10% fall in the categories of hard-/software development. Each highlight is presented with a minimum of descriptive text: the pictures should speak for themselves. Enjoy the almost abstract shapes, shades and colors which rolled out of the WSRT (a search of the Astrophysics Data System (ADS) will help satisfy the curious) – relish these WSRT highlights!

<sup>1</sup> ASTRON, University of Amsterdam, The Netherlands

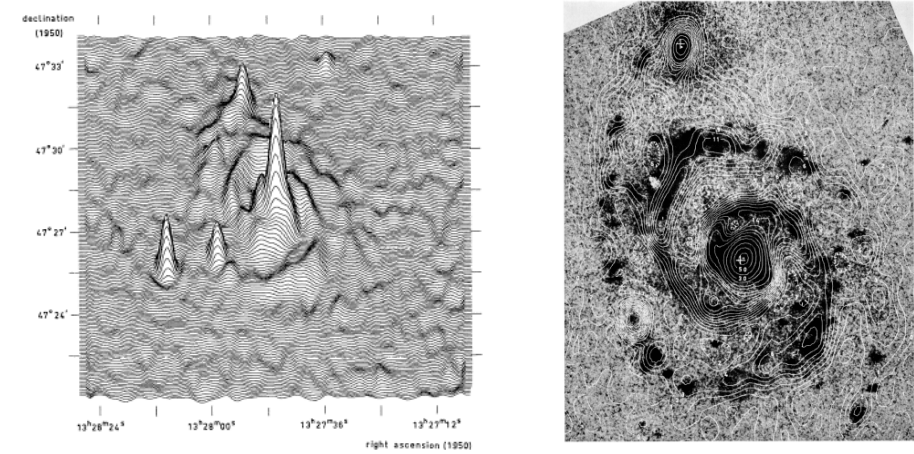
<sup>2</sup> University of Groningen, The Netherlands

<sup>3</sup> ASTRON, The Netherlands

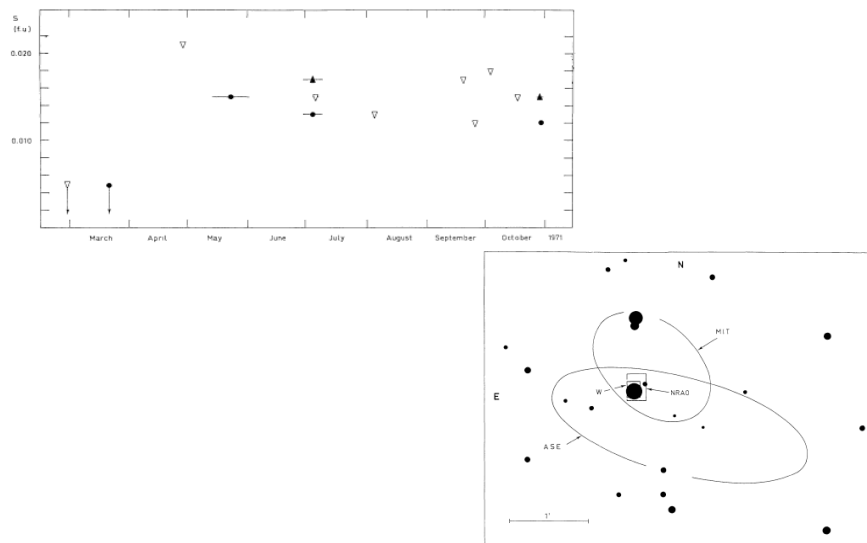
### Software (mapping, display), 1970



### M51 radio spiral arms, 1972



### Cyg X-1 radio flares & identification, 1971



### NGC 4258 radio spiral arms, 1972



- 1970
- 1971
- 1972
- 1973
- 1974
- 1975
- 1976
- 1977
- 1978
- 1979
- 1980
- 1981
- 1982
- 1983
- 1984
- 1985
- 1986
- 1987
- 1988
- 1989
- 1990
- 1991
- 1992
- 1993
- 1994
- 1995
- 1996
- 1997
- 1998
- 1999
- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011
- 2012
- 2013
- 2014
- 2015

## Head-tail radio galaxies, 1973

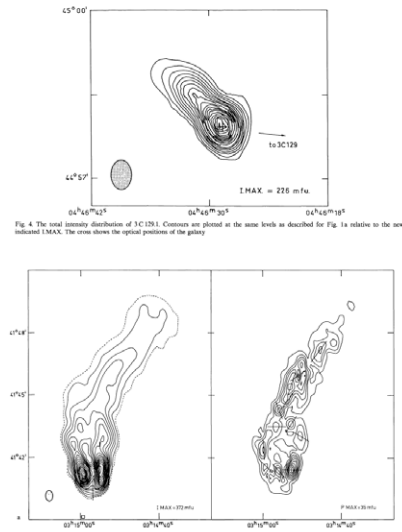
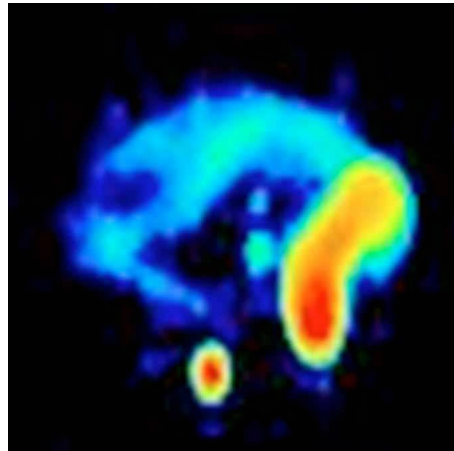
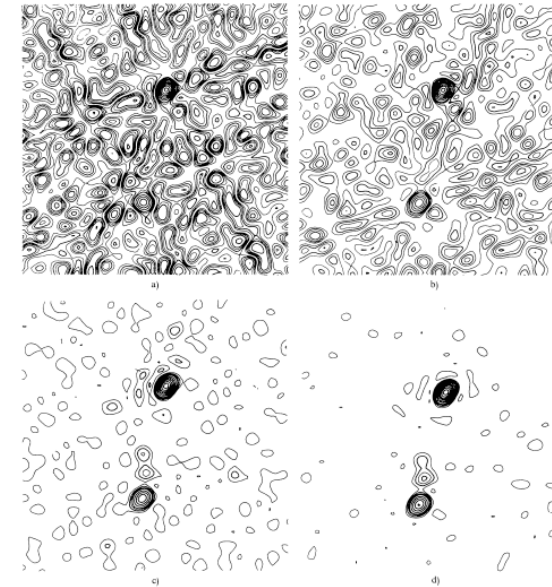
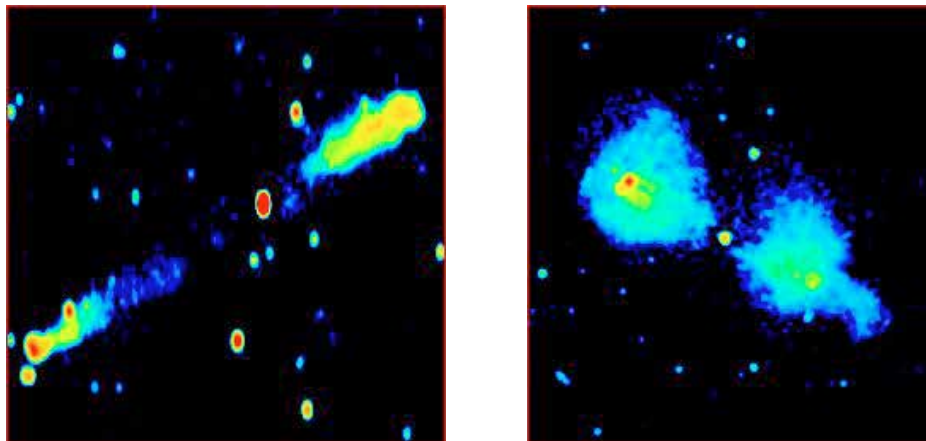


Fig. 4 The total intensity distribution of 3C129.1. Contours are plotted at the same levels as described for Fig. 1a relative to the now indicated I MAX. The cross shows the optical position of the galaxy.

## Högbom CLEAN, 1974



## Giant radio galaxies, 1974



## Hydrogen (HI) in galaxy M81, 1975

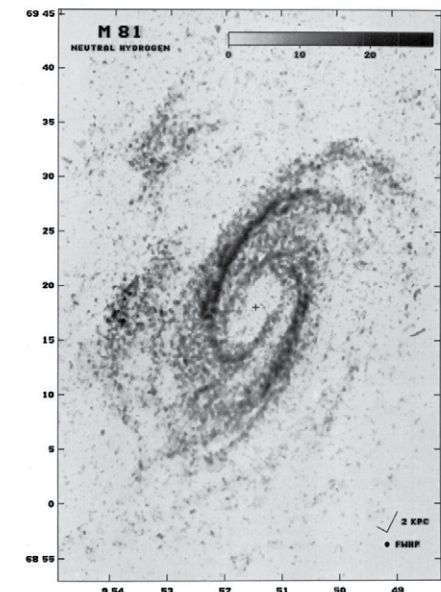
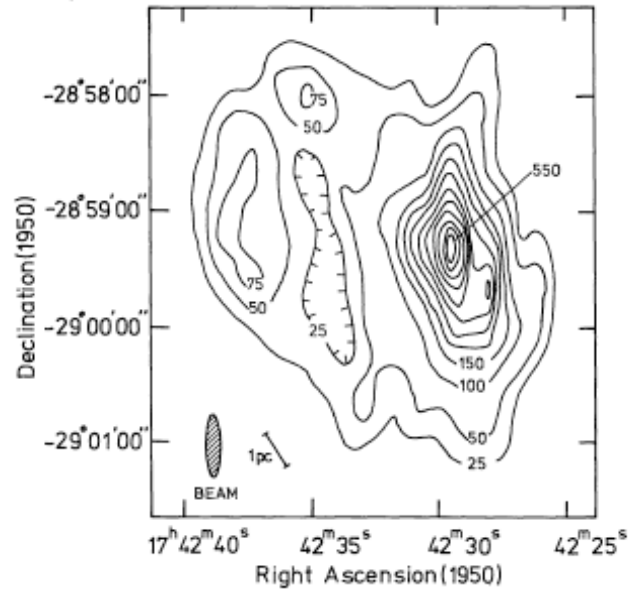


Fig. 5 Radiograph of the density distribution of HI in M81. The half power beamwidth (HPBW) is shown in the lower right hand corner which also contains an indication of the linear scale in the plane of the galaxy. 0.1" corresponds to 1 kpc. The coordinates are right ascension and declination (1950). The gray scale is labeled in units of  $10^{20}$  atom/cm<sup>2</sup>. (Photo prepared using the N.R.A.O. Image Recording System)

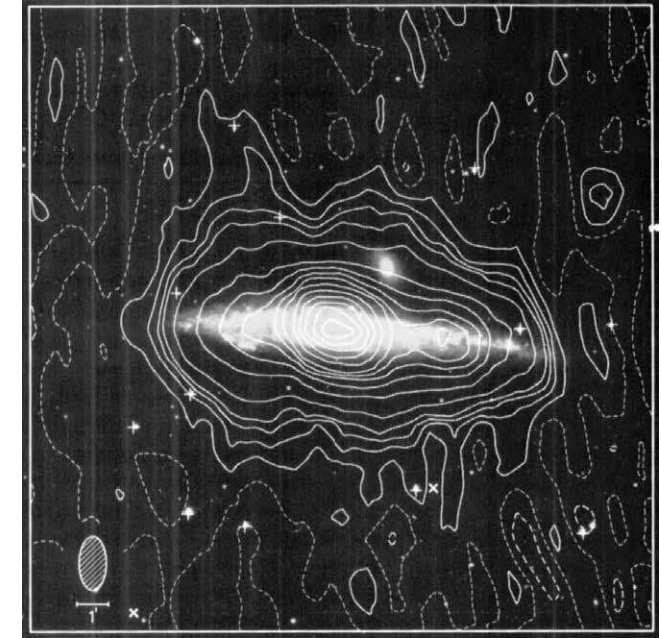
© European Southern Observatory • Provided by the NASA Astrophysics Data System



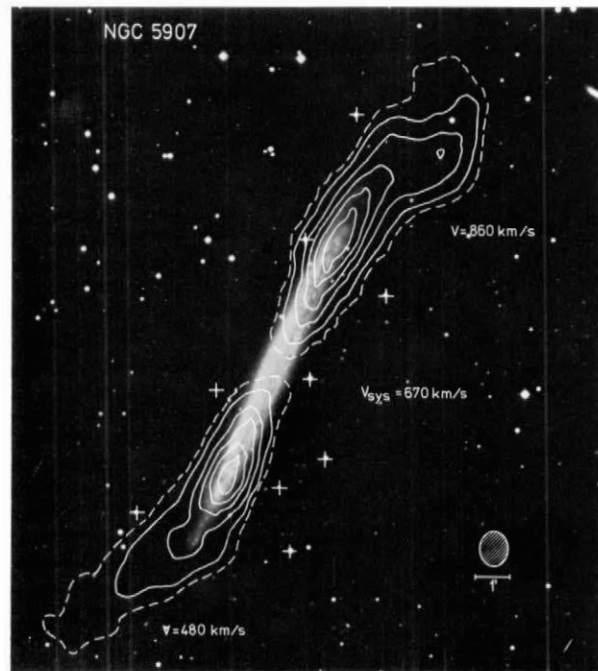
### Nucleus of the Milky Way, 1975



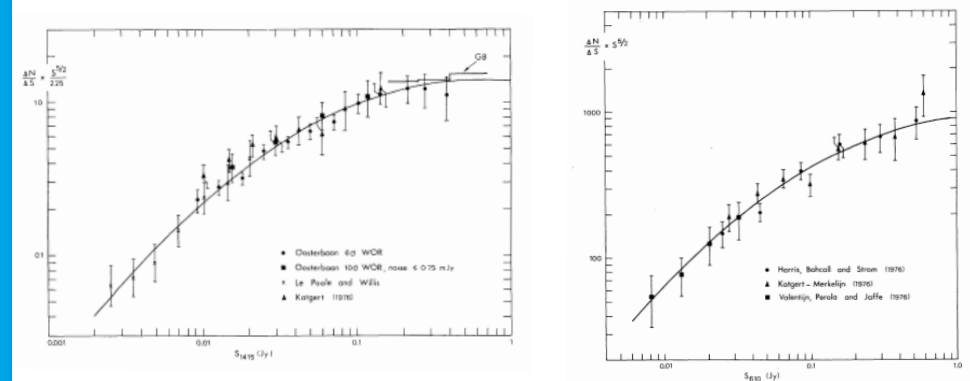
### NGC 4631 – radio halo, 1976



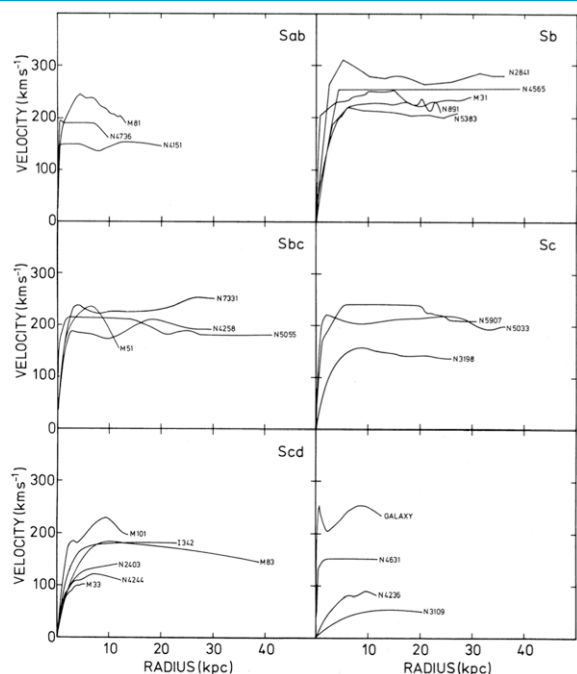
### “Warps” in spiral galaxies, 1976



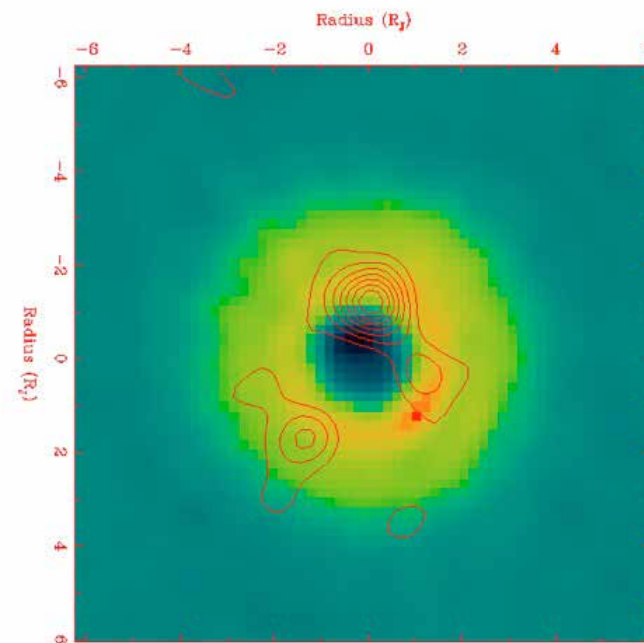
### Deep source counts, 1977



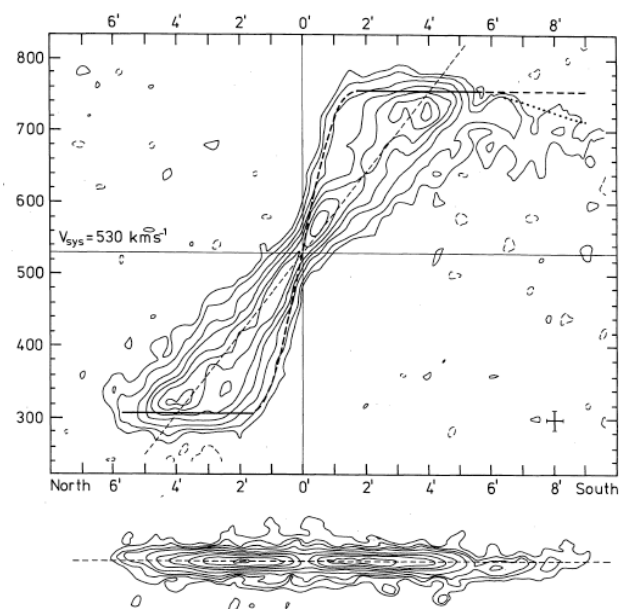
## Dark matter in spirals, 1978



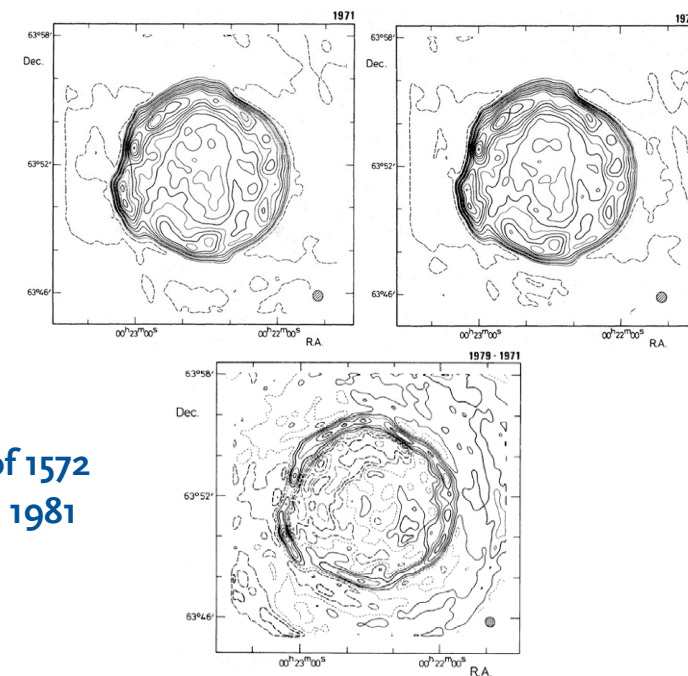
## Radiation belts of Jupiter, 1980



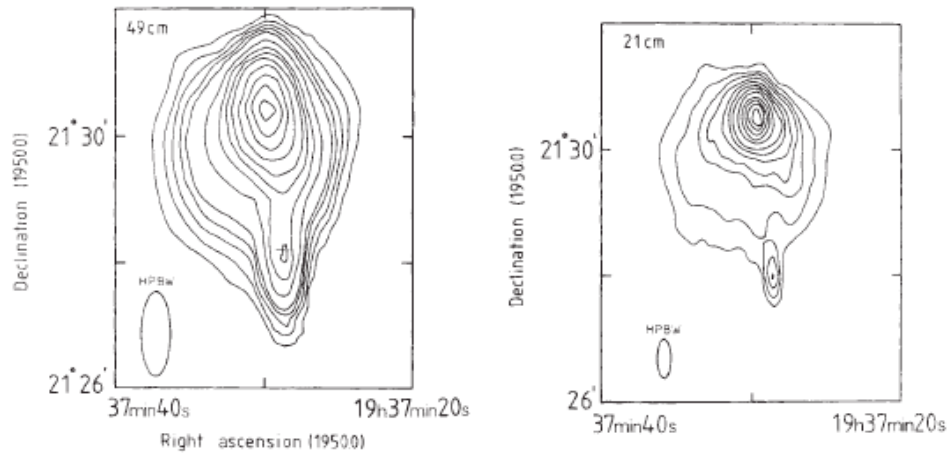
## NGC 891 HI, a milky way edge-on, 1979



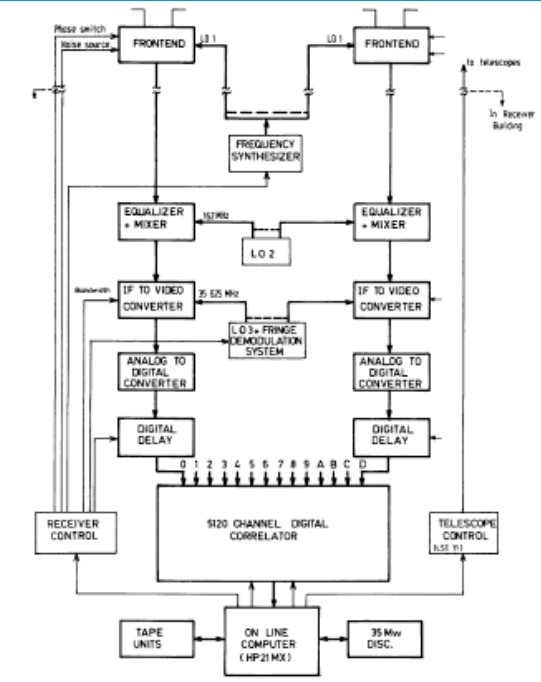
## Expansion of 1572 supernova, 1981



ms pulsar PSR 1937+214 in 4C21.53, 1982

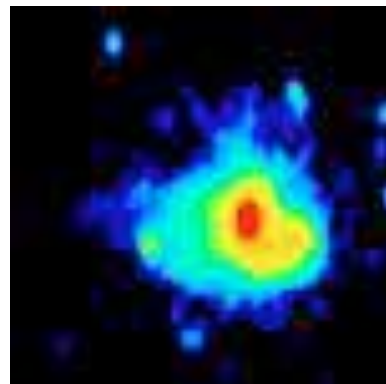
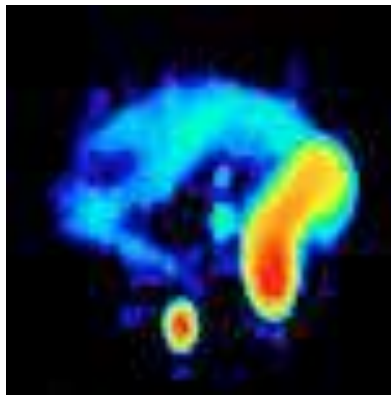


WSRT digital spectrometer, 1983

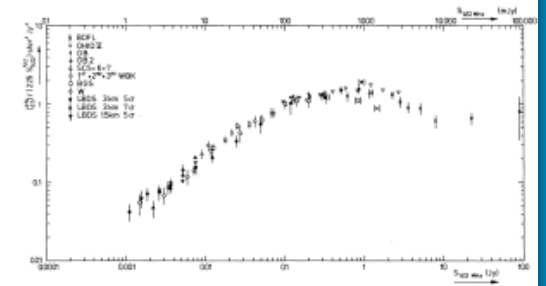
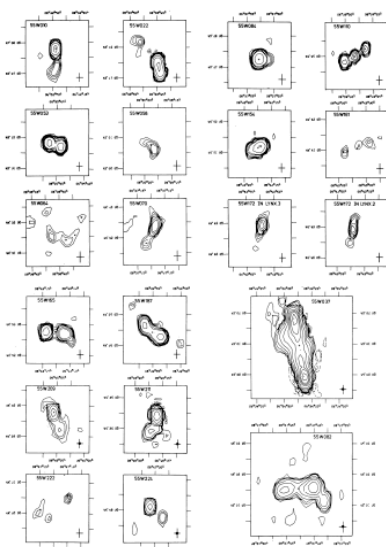


1970  
1971  
1972  
1973  
1974  
1975  
1976  
1977  
1978  
1979  
1980  
1981  
1982  
1983  
1984  
1985  
1986  
1987  
1988  
1989  
1990  
1991  
1992  
1993  
1994  
1995  
1996  
1997  
1998  
1999  
2000  
2001  
2002  
2003  
2004  
2005  
2006  
2007  
2008  
2009  
2010  
2011  
2012  
2013  
2014  
2015

Redundancy: High Dynamic Range imaging of the Perseus cluster, 1982

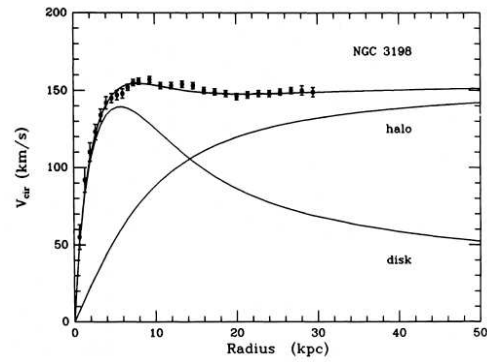
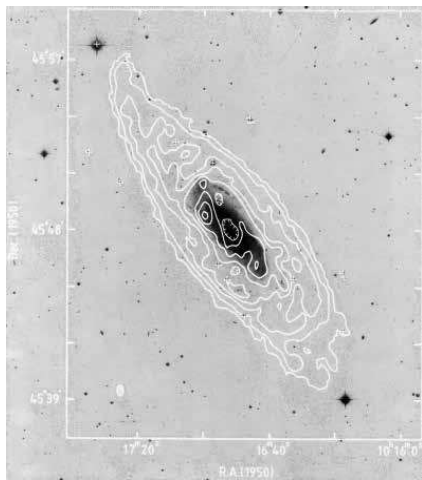


Deep continuum surveys, 1984

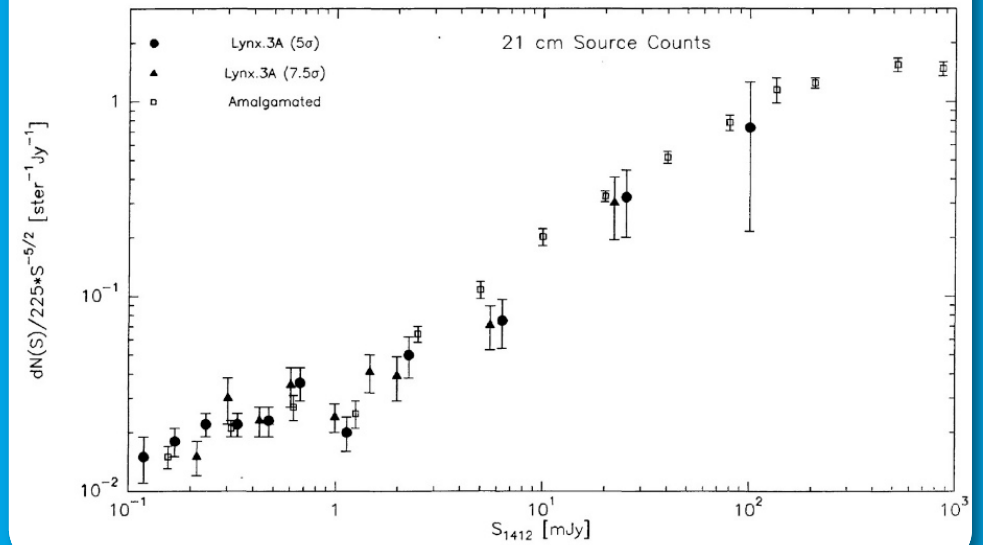




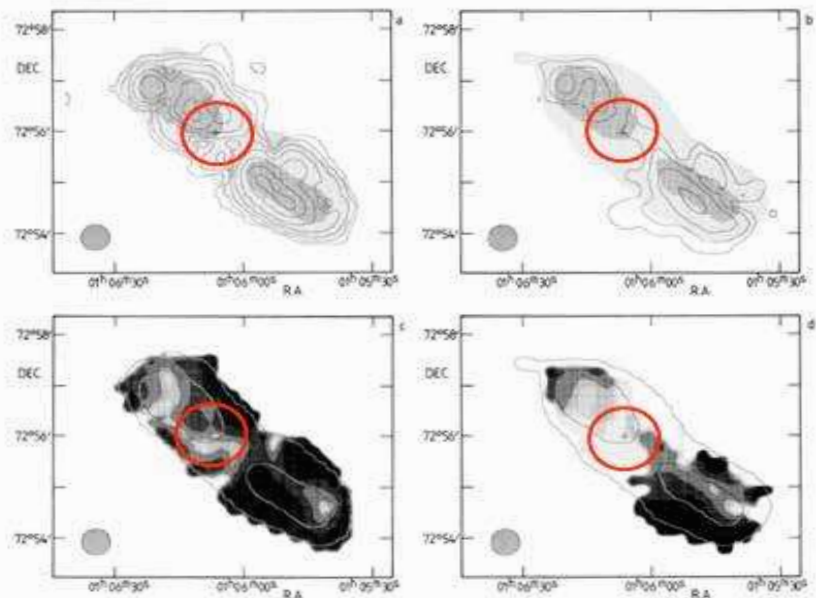
### Rotation of galaxy NGC 3198, 1985



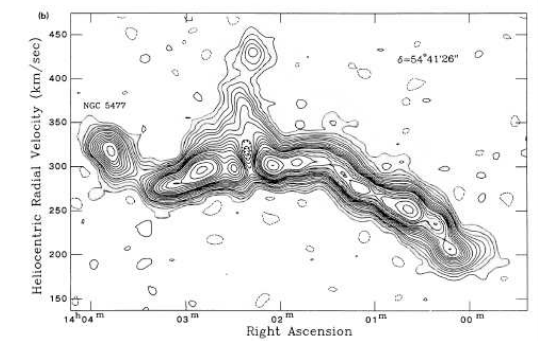
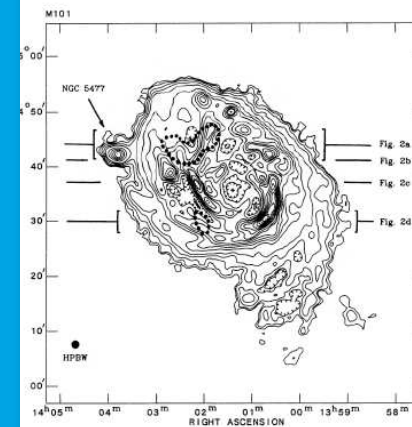
### Deep Source Counts, 1987



### Radio galaxy polarization, 1986



### High velocity clouds – M101, 1988

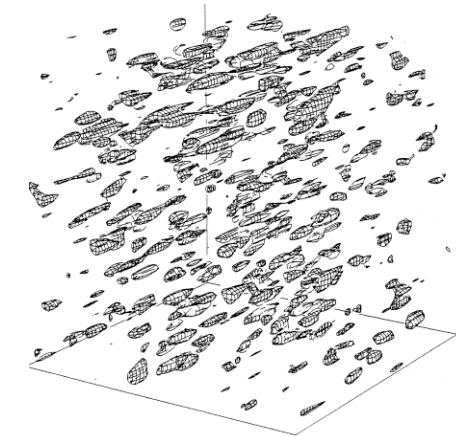
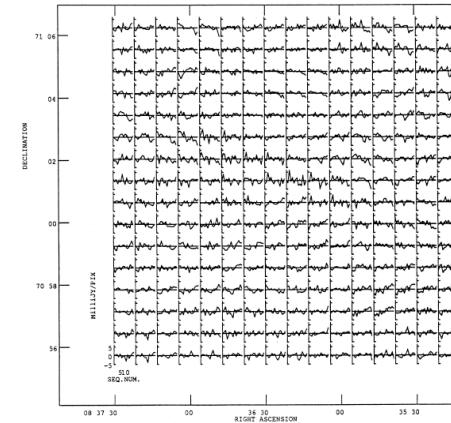




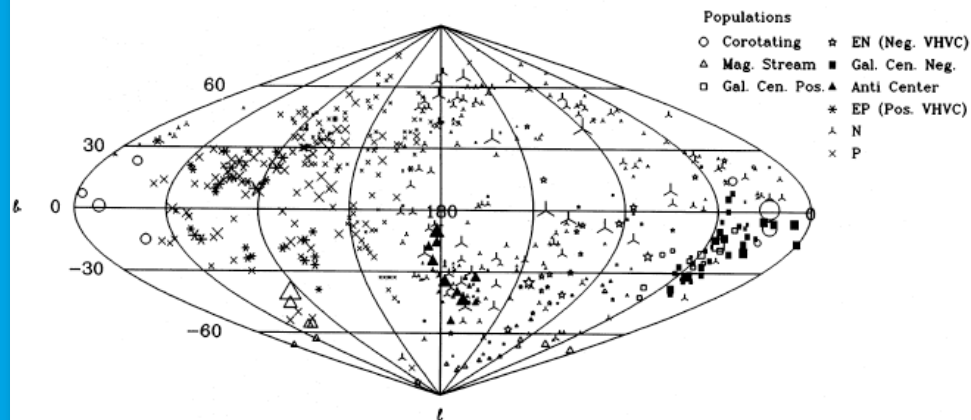
NEWSTAR software package, 1990

# Netherlands East West Synthesis Telescope Array Reduction

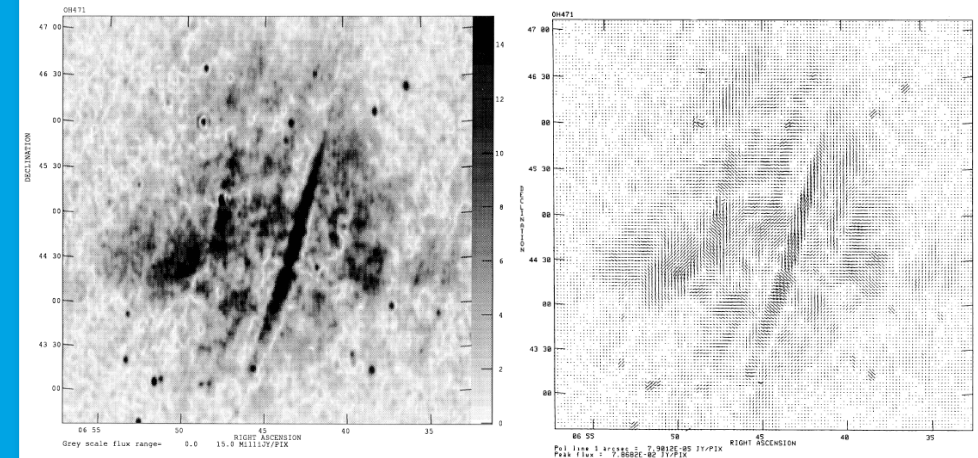
No Hydrogen “pancakes”, 1992



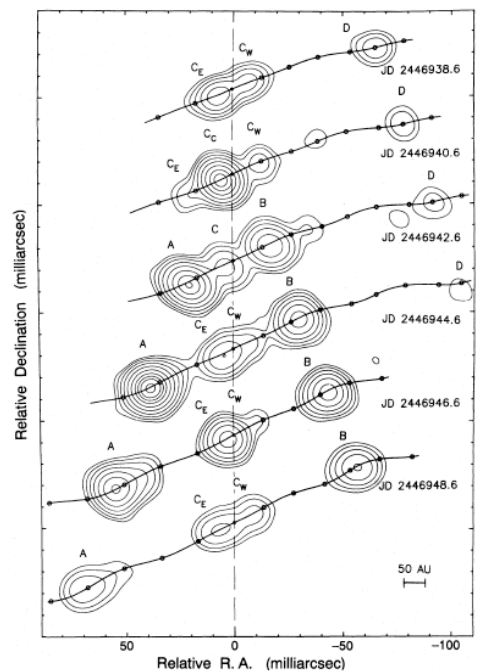
Milky Way high velocity clouds, 1991



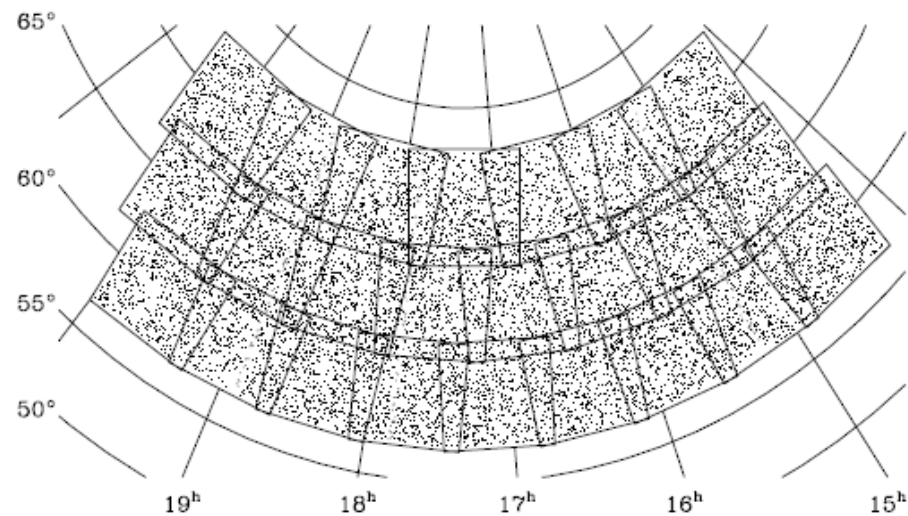
Polarization filaments, 1993



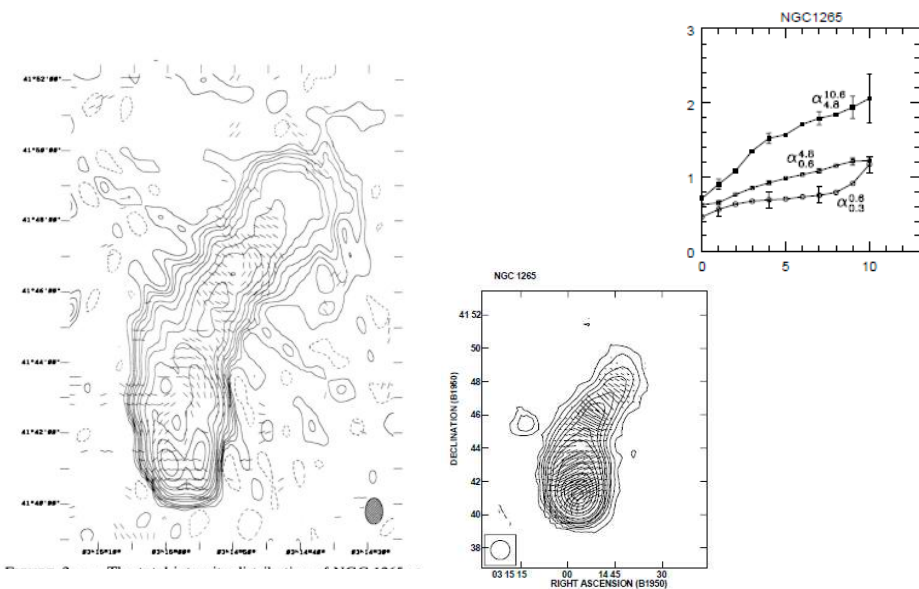
### EVN VLBI images of SS433, 1993



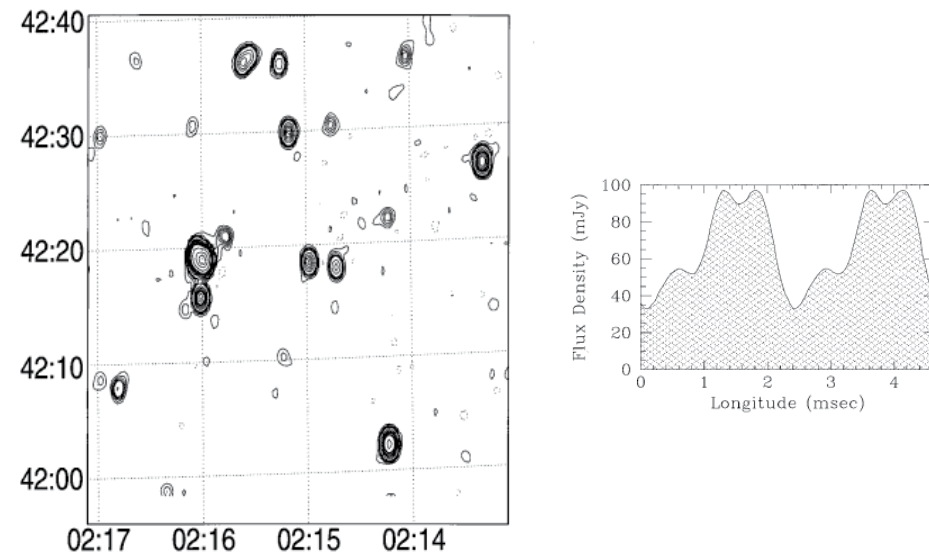
### WENSS survey, 1995



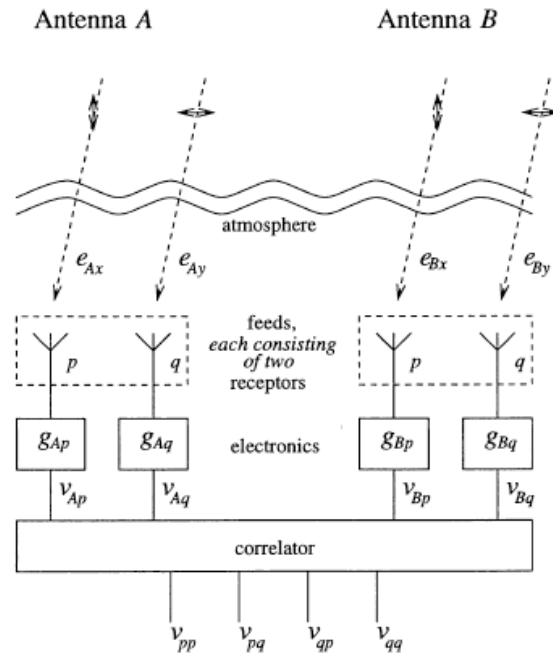
### Perseus galaxy cluster, 1994



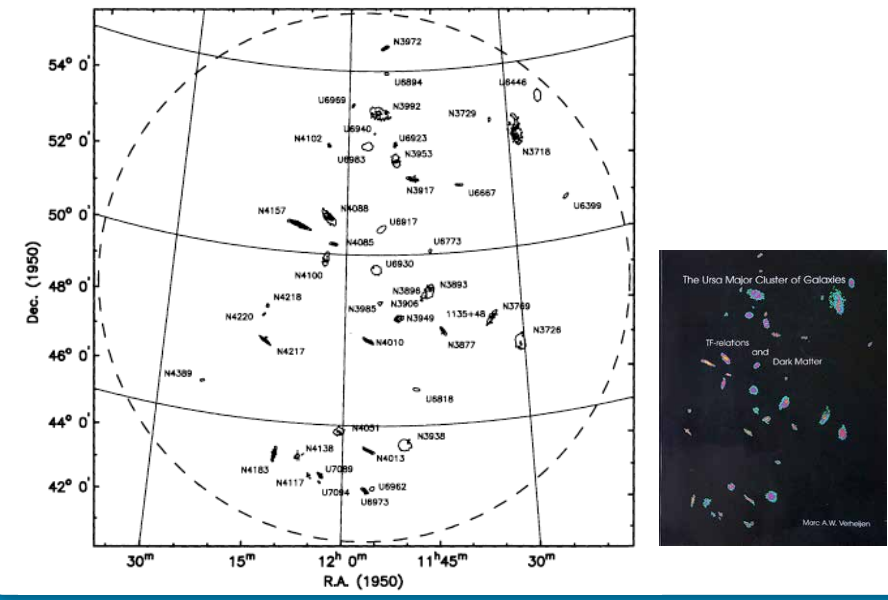
### PSR J0218+4232 (2.3 ms), 1995



### Measurement equation, 1996



### HI in Ursa Major cluster, 1998



### Dark matter in dwarf galaxies, 1997

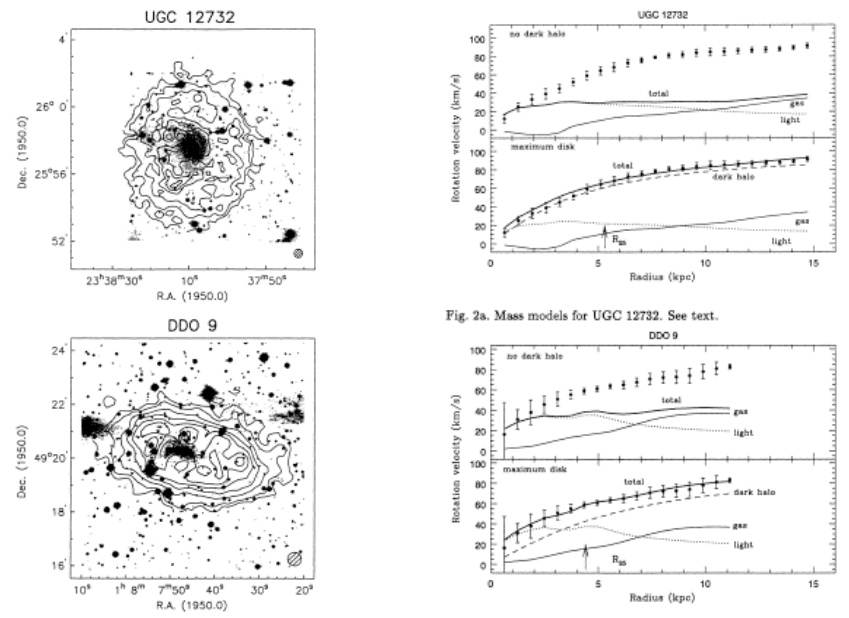
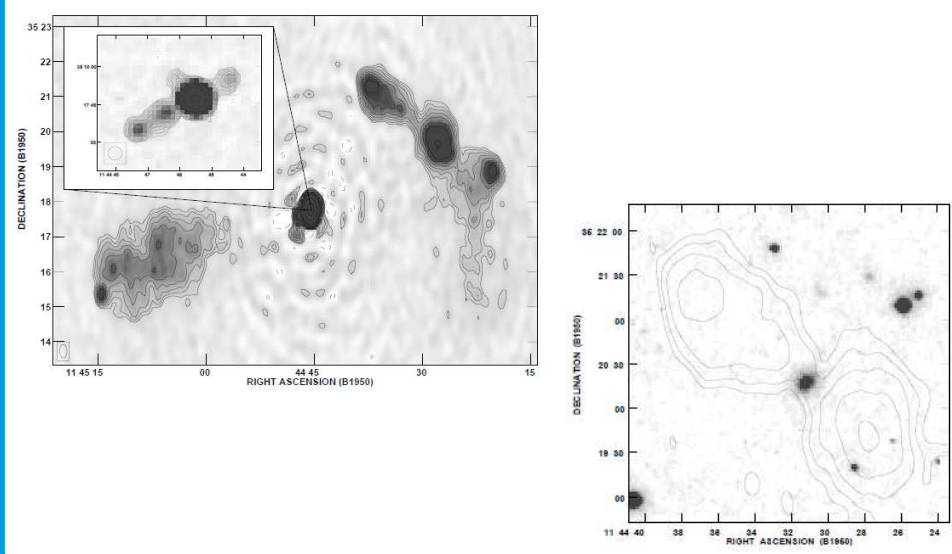


Fig. 2a. Mass models for UGC 12732. See text.

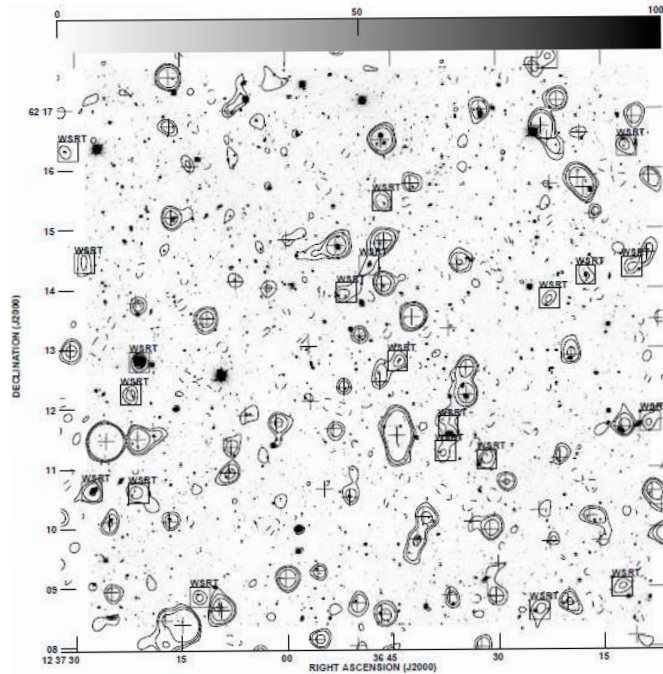
### Giant radio galaxy survey, 1999



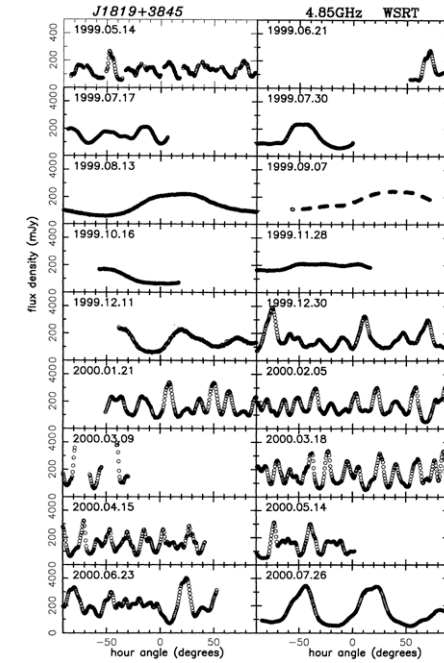
- 1970
- 1971
- 1972
- 1973
- 1974
- 1975
- 1976
- 1977
- 1978
- 1979
- 1980
- 1981
- 1982
- 1983
- 1984
- 1985
- 1986
- 1987
- 1988
- 1989
- 1990
- 1991
- 1992
- 1993
- 1994
- 1995
- 1996
- 1997
- 1998
- 1999
- 2000
- 2001
- 2002
- 2003
- 2004
- 2005
- 2006
- 2007
- 2008
- 2009
- 2010
- 2011
- 2012
- 2013
- 2014
- 2015



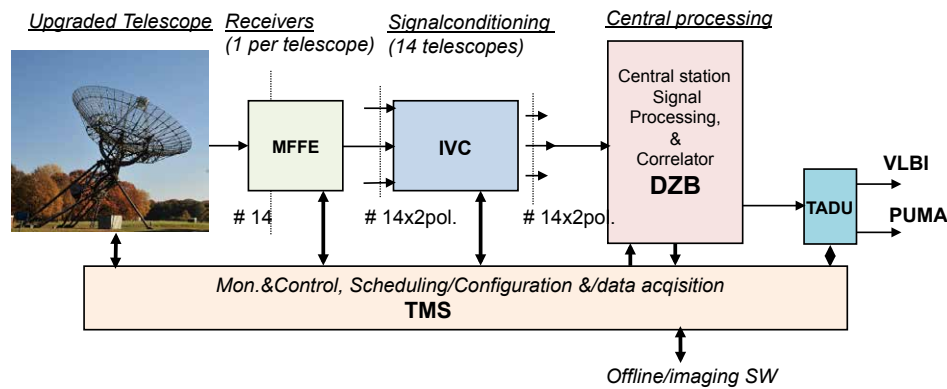
# Hubble deep-field images, 2000



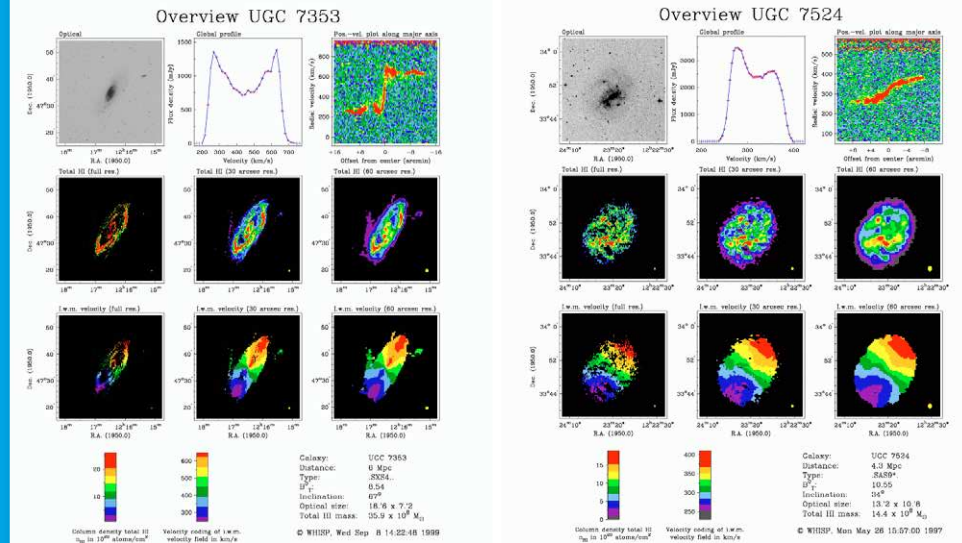
# Variable quasar J1819+3845, 2001



# WESTERBORK 2000 after the system upgrade

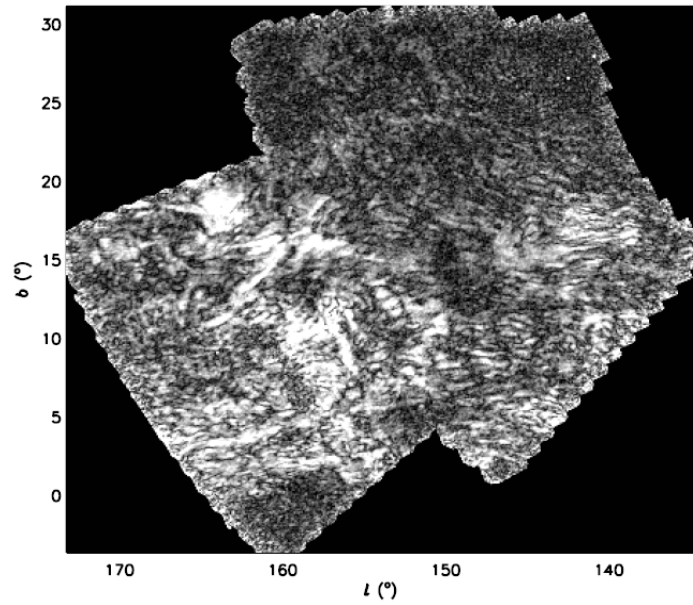


# WHISP HI galaxy survey, 2002

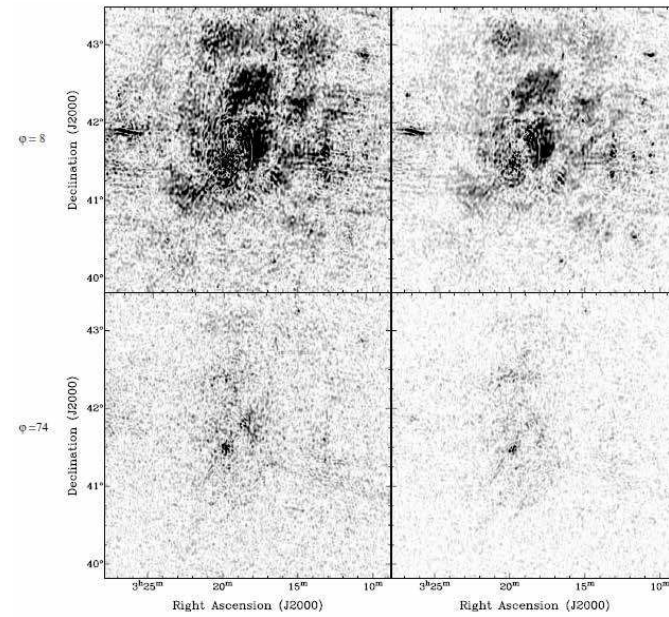


1970  
1971  
1972  
1973  
1974  
1975  
1976  
1977  
1978  
1979  
1980  
1981  
1982  
1983  
1984  
1985  
1986  
1987  
1988  
1989  
1990  
1991  
1992  
1993  
1994  
1995  
1996  
1997  
1998  
1999  
2000  
2001  
2002  
2003  
2004  
2005  
2006  
2007  
2008  
2009  
2010  
2011  
2012  
2013  
2014  
2015

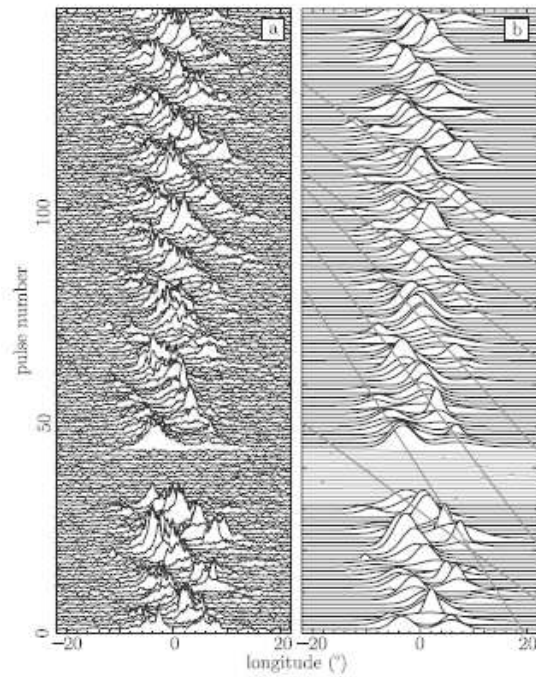
### Polarization in the Galaxy, 2003



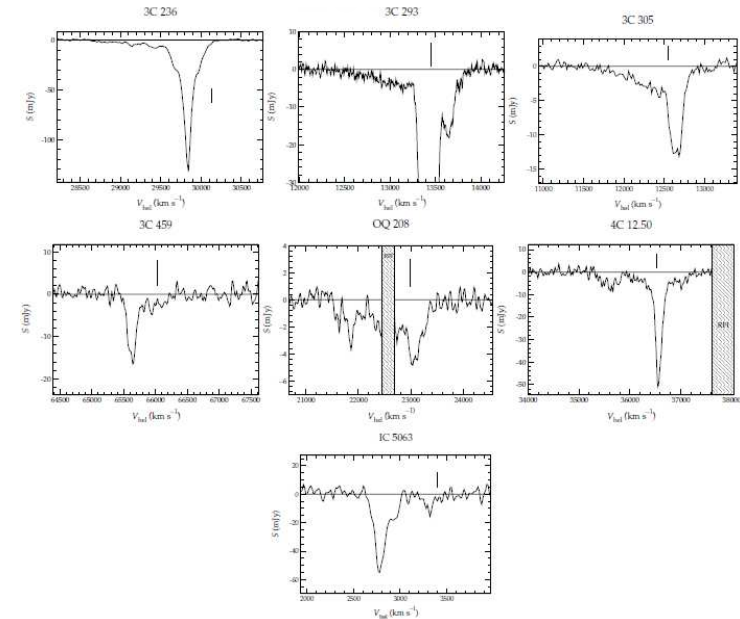
### Rotation-measure synthesis, 2005



### PSR o809+74 drifting sub-pulses, 2004

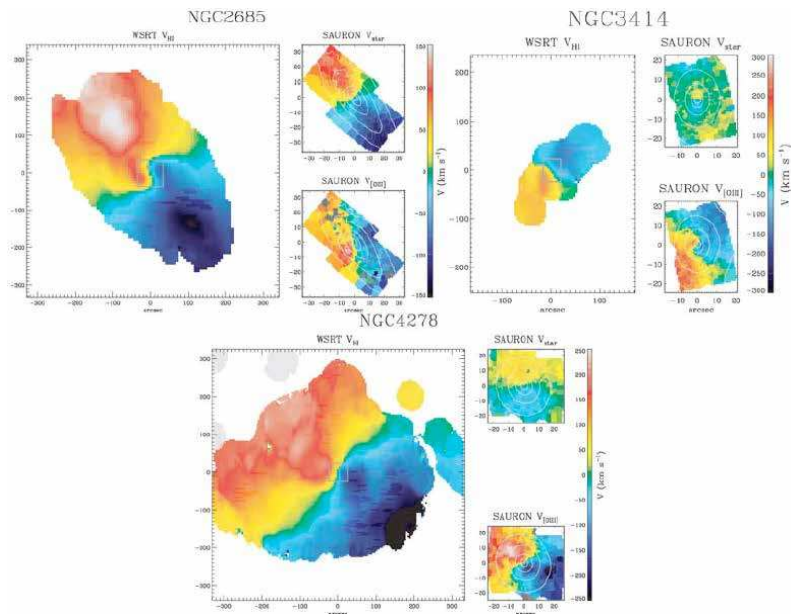


### HI outflow in Active Galaxy Nuclei, 2005

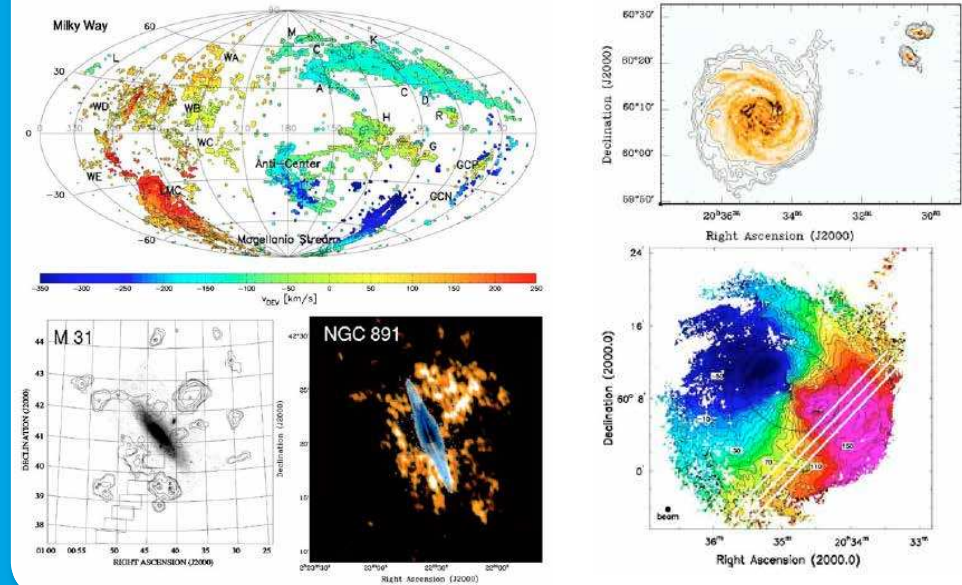




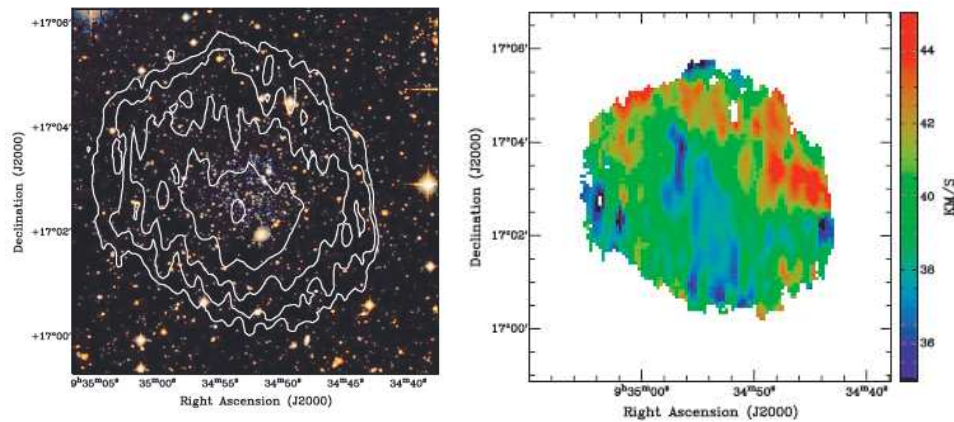
## HI in elliptical galaxies, 2006



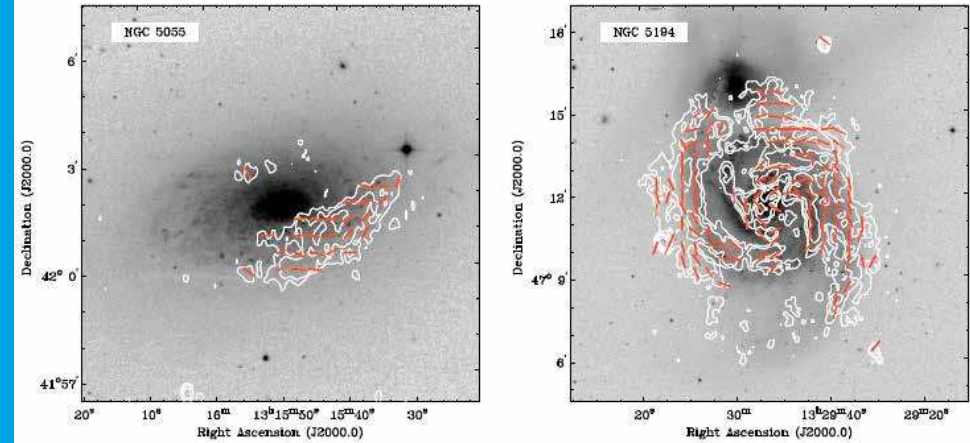
## Accretion of cold gas, 2008



## Leo T dark matter dwarf in HI, 2008

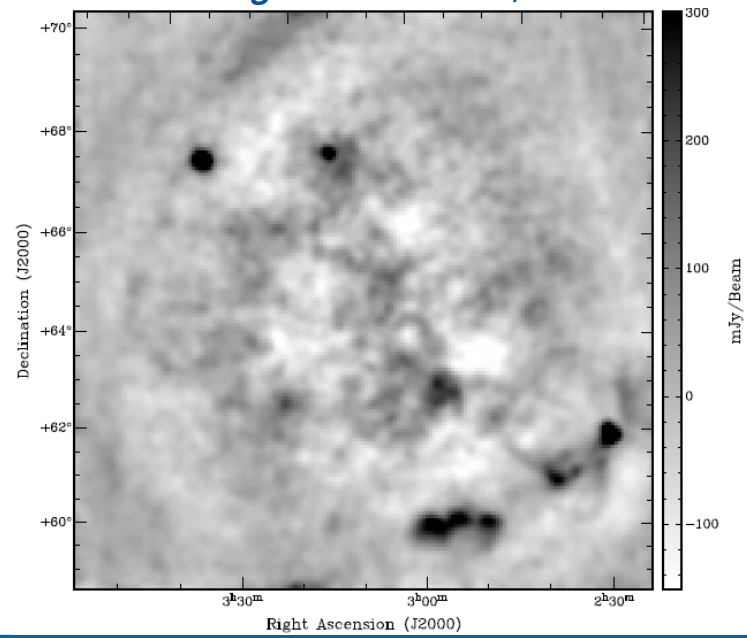


## SINGS polarization atlas, 2009

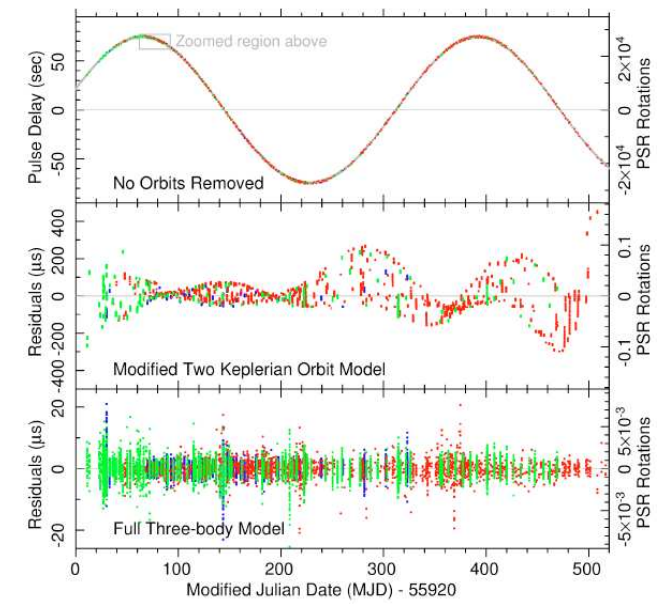




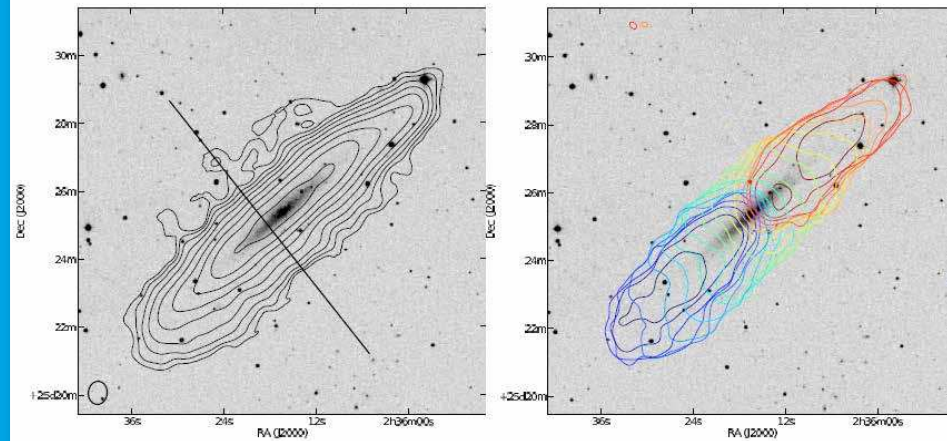
### LFFE foreground emission, 2010



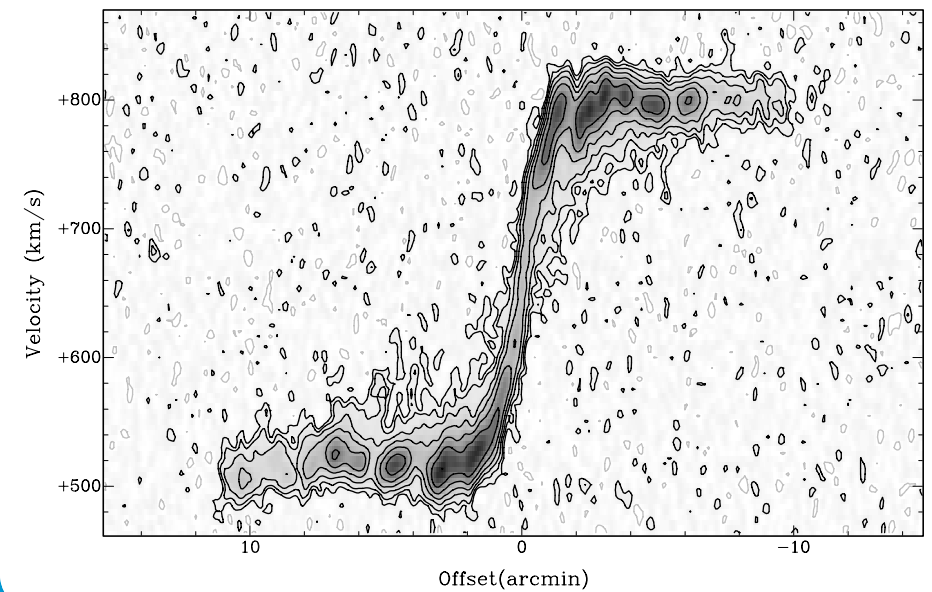
### Pulsar in three-body system, 2013



### HALOGAS survey, 2011

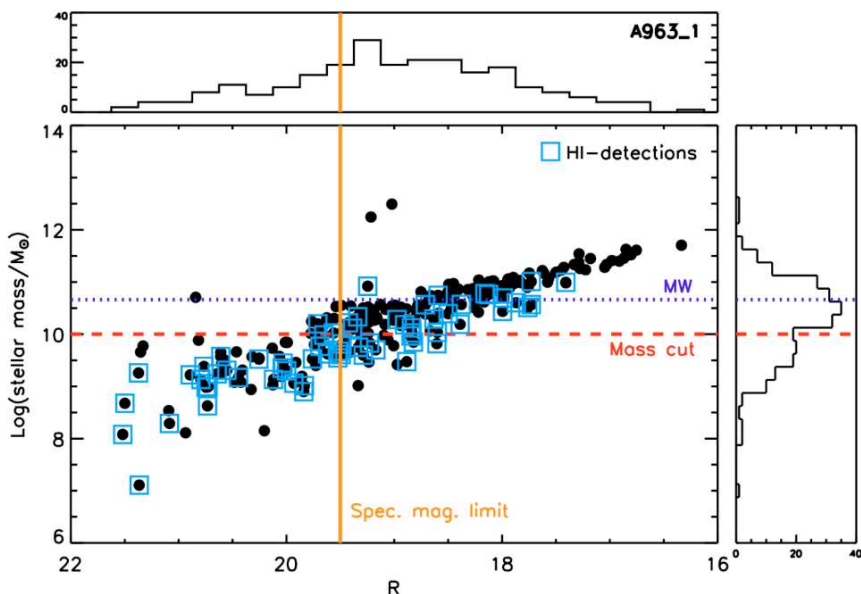


### Extrplanar gas in a galaxy, 2013



1970  
1971  
1972  
1973  
1974  
1975  
1976  
1977  
1978  
1979  
1980  
1981  
1982  
1983  
1984  
1985  
1986  
1987  
1988  
1989  
1990  
1991  
1992  
1993  
1994  
1995  
1996  
1997  
1998  
1999  
2000  
2001  
2002  
2003  
2004  
2005  
2006  
2007  
2008  
2009  
2010  
2011  
2012  
2013  
2014  
2015

## HI stripping in cluster galaxies, 2014



## The HI gas absorption zoo, 2015

