Radio-VO developments of AMIGA within the context ALMA

L. Verdes-Montenegro
Instituto de Astrofísica de Andalucía - CSIC (Granada, SPAIN)

NGC 7217 (CIG 947), WHT

Analysis of the interstellar Medium of Isolated GAlaxies

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OUTLINE

- Context & Motivation
- Archiving
- High-level analysis tools for ALMA
- Expected outcome

CONTEXT & MOTIVATIONS

AMIGA Starts in 2003 @IAA with funding from PNAYA

Need for a reference sample of isolated galaxies

Since 2006 Coordinated project (PI: L. Verdes-M)

IAA-group + IRAM-30m @ Granada (+ recently CAHA)

(+ Univ. of Granada)

Core team: 3 PhDs, 4 Postdocs, 3 Staff, 2 Software engineers

International collaboration:

Obs. Marseille, Obs. Paris, CfA, ASIAA-Taiwan, MPIfA (Bonn), UMASS, Mc Donald Obs., Arcetri, UNAM, IAC, Kapteyn Institute, Pune University, ATNF, ESO (Munich)

January 2009: **AMIGA^3** starts

CONTEXT & MOTIVATIONS

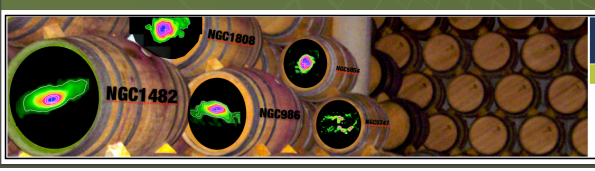
Multiλ statistical study of ISM ~1000 galaxies

Build & analyse the catalog (ISM – dynamics - SF - AGN - bars)

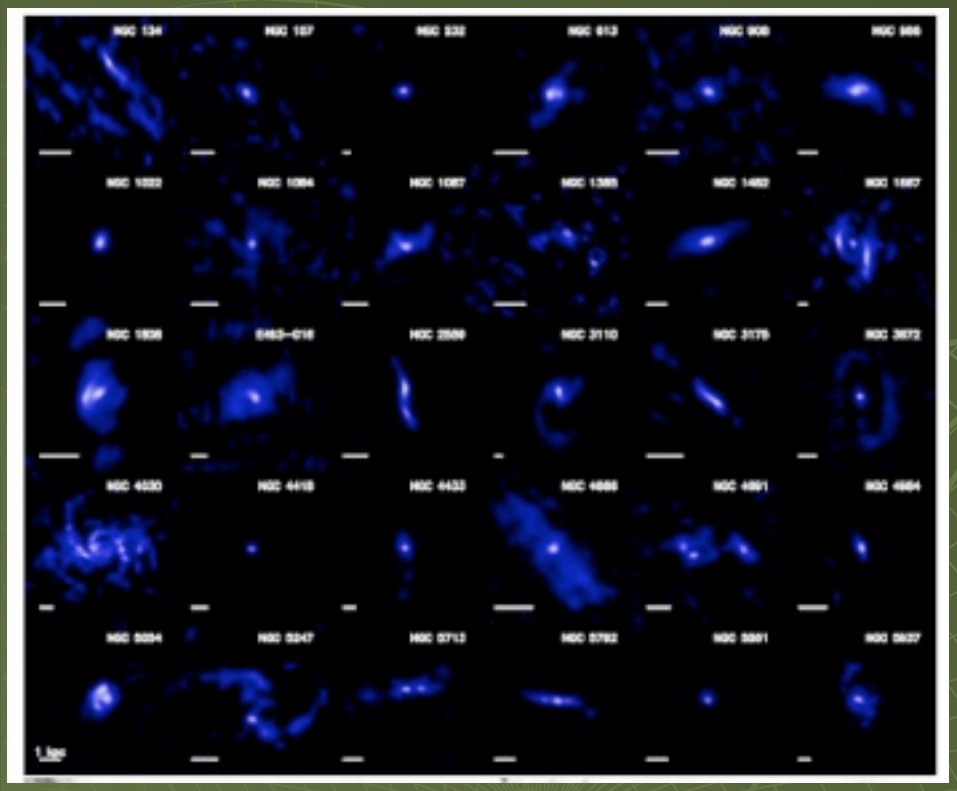
Make it public: VO interface with search utiliies

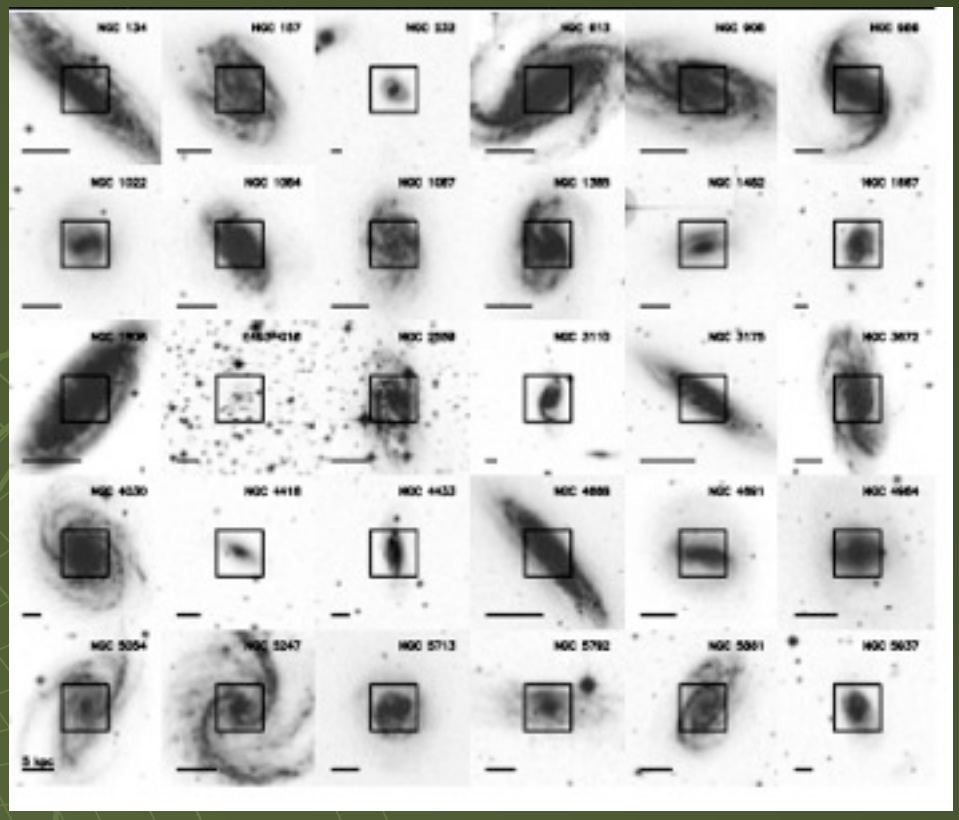
SMA CO(2-1) B0DEGA Legacy project

- B0DEGA = Below 0 DEgree GAlaxies.
  High-res study of molecular gas properties in circumnuclear regions of a statistically significant sample (>100) of IR-bright southern galaxies (mostly interacting galaxies)
- Collaboration CfA / IAA / ASIAA
- PI: D. Espada (CfA/IAA). S. Martin (CfA), P. T.P. Ho (ASIAA/CfA), S. Matsushita, P.Y. Hsieh (ASIAA), L. Verdes-Montenegro, J. Sabater, V. Espigares (IAA), S. Verley (Univ. Granada), M. Krips (IRAM).

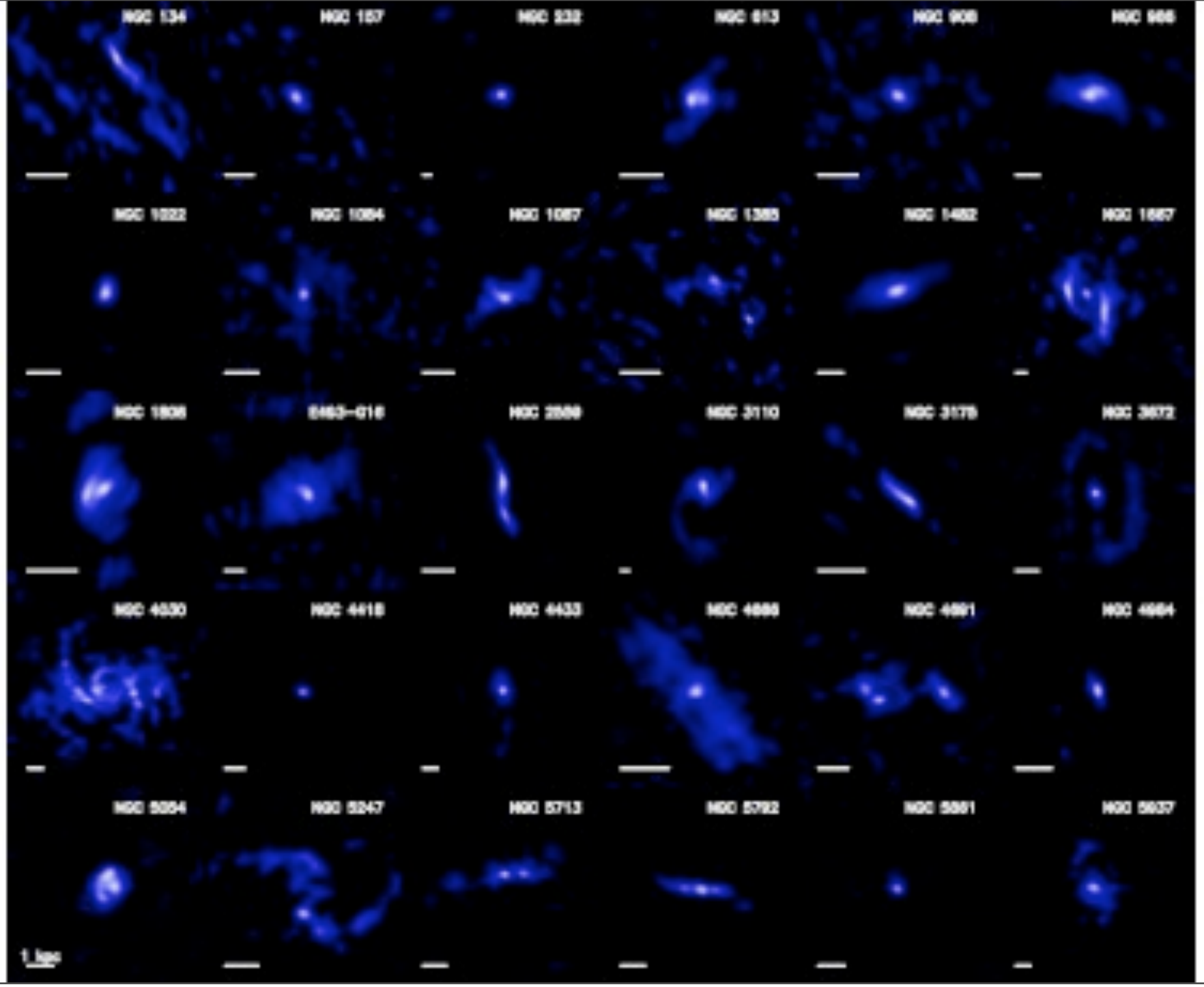


CONTEXT & MOTIVATIONS





- CO(2{1) maps (F.O.V. = 10) for the 1st 30 galaxies observed in our sample.
- Morphologies: arms (NGC 3110), nuclear spirals (NGC 613), rings (NGC 134), and circumnuclear rotating features in almost every source.
- Optical DSS images (F.O.V. = 30.5)


NGC 134
NGC 157
NGC 232
NGC 613
NGC 908
NGC 986
NGC 1022
NGC 1084
NGC 1087
NGC 1385
NGC 1482
NGC 1667
NGC 1808
0463-016
NGC 2559
NGC 3110
NGC 3175
NGC 3672
NGC 4030
NGC 4418
NGC 4433
NGC 4666
NGC 4691
NGC 4984
NGC 5054
NGC 5247
NGC 5713
NGC 5792
NGC 5991
NGC 6037
1 kpc

CONTEXT & MOTIVATIONS

AMIGA + B0DEGA extent are based on

multi-λ astronomy, with emphasis at radio (mm/submm)λ

- Collaboration on submm phase calibration

  Phase transfer:

  - Calibration of high-freq (690 GHz) data with low freq (230 GHz)
  - Fast switching

Daniel Espada joined ALMA CSV

CONTEXT & MOTIVATIONS

AMIGA + B0DEGA extent are based on

multi-λ astronomy, with emphasis at radio (mm/submm)λ

intensive analysis of 3D data

- Few radio data available in archives (even less in VO)
- Optical/IR data more often available, but too diverse queries
- VO:

  essential for multi-λ astronomy

  uniform access to the data
- Need for powerful soft package for datacube analysis

Actions: radio-VO

Access Exploitation

Archiving Tools

ARCHIVING

RADAMS:

Radio Astronomy DAta Model for Single-dish telescopes

1st VO data model for single dish

- VO-compliant: based on existing IVOA data models + development of new specific standards
- Extensible: additional metadata can be provided for different instruments, observing modes, switching modes…

- Conceived for DSS-63 Robledo antenna (+LAEFF-INTA)
- Revised, extended and implemented for IRAM-30m

ARCHIVING

AMIGA^3: Collaboration with ESO-Archive team (G. Raffi, A. Wicenec) for **integration of ALMA archive in the VO**

Characterization of the ALMA Archive:

Mapping between the ALMA data model, the database implementation, and the VO data models

Development of a suitable IVOA data model for radio-astronomical data cubes

Implementation of VO spectral and image services

TOOLS

- Existing VO-enabled analysis tools are mostly optical
- Existing radio astronomy tools not VO-aware

Need for VO-enabled radio oriented analysis tools

Solution: INTEROP

Not producing new soft but adding VO functionalities

Intercommunication in the least intrusive way

TOOLS

MOVOIR Development (J. D. Santander, PhD)

MOdular Virtual Observatory Interface for Radio-astronomy

Tools: MASSA/MADCUBA (Herschel packages for HIFI, usable with 30m data developed by J. M. Pintado's group)

Data services:

Access to standard FITS imported by the MOVOIR from VO

SDSS, HST, MAST, FUSE, IUE, ISO, XMM-Newton, VizieR, AMIGA*, IRAM 30m*, Robledo*…

Applications

Aladin, Topcat, VOPlot, VOspec…

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TOOLS FOR ALMA

Why?: Key to the success of ALMA:

data accessible to the community at large, not only domain of experienced radio astronomers.

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data accessible to the community at large, not only domain of experienced radio astronomers.

This requires access to:

- well documented+intuitive tools to inspect+analyse 3D data
- existing VO tools widely accepted by the community (e.g. Aladin, VOSpec, Topcat, etc)
- complementary data sets at same or different wavelengths

TOOLS FOR ALMA

What is now foreseen for ALMA

- Automatic processing: fully calibrated science products
- Data reduction: CASA (AIPS++ evol for ALMA; Python)

  Transformation UV-image

  Spectral line analysis, fitting, catalogs

  Fundamental image structure: cubes

  Processing of cubes (integration, rotation, filtering, clipping)

  Visualization + specific tools for SS objects and pulsars

All this can be achieved by

TOOLS FOR ALMA

AMIGA^3 developments:

High-level analysis tools for 3D data

Starting from:

GIPSY (Groningen Image Processing System)

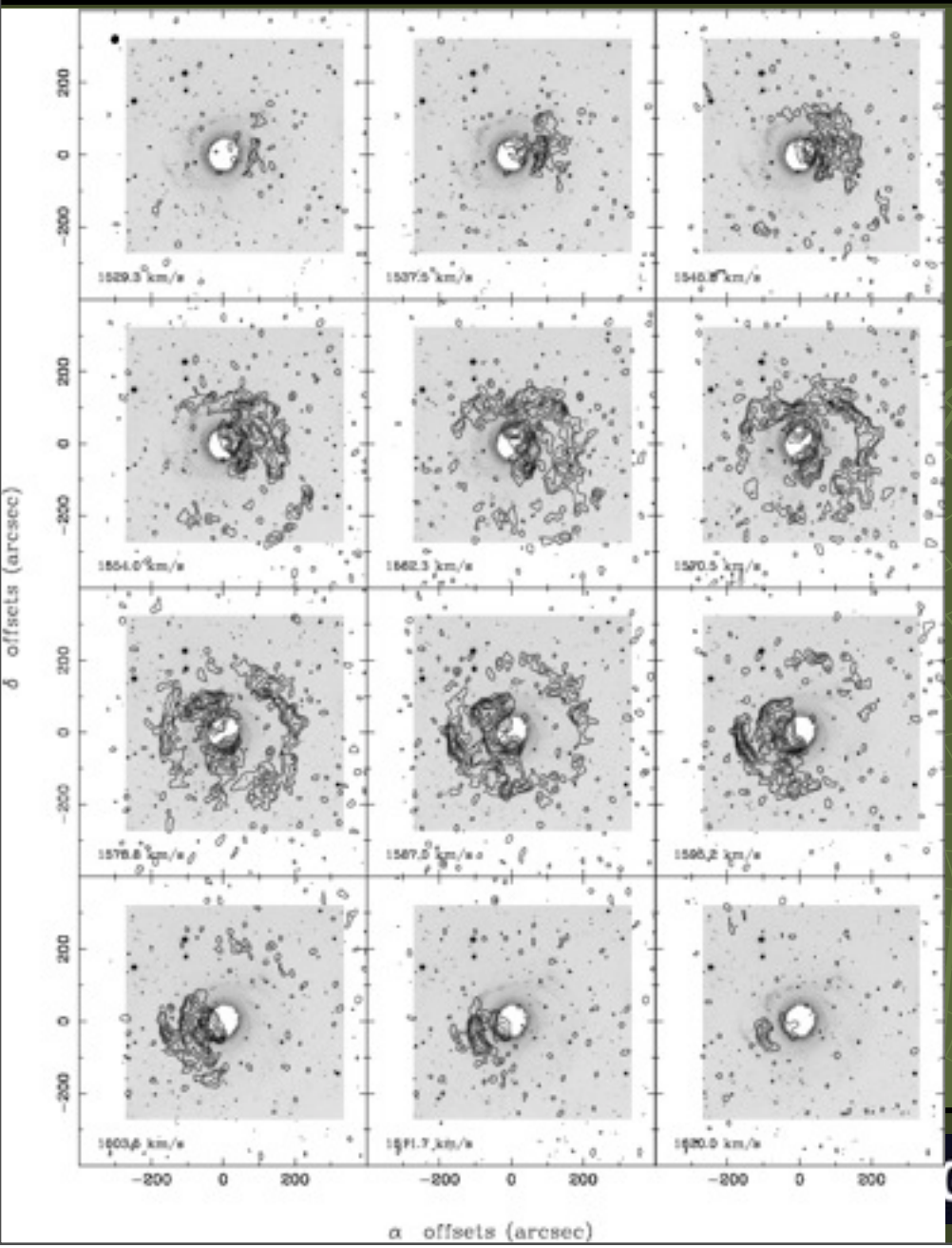
One of oldest + most powerful packages available to visualize and analyze multiD data

Developed at Kapteyn Astronomical Institute for WSRT

Oldest, but:

Ha kinematics of the SINGS nearby galaxy survey (Dicaire et al 2009)

TOOLS FOR ALMA



Channel maps

(Verdes-Montenegro et al 2002)

TOOLS FOR ALMA

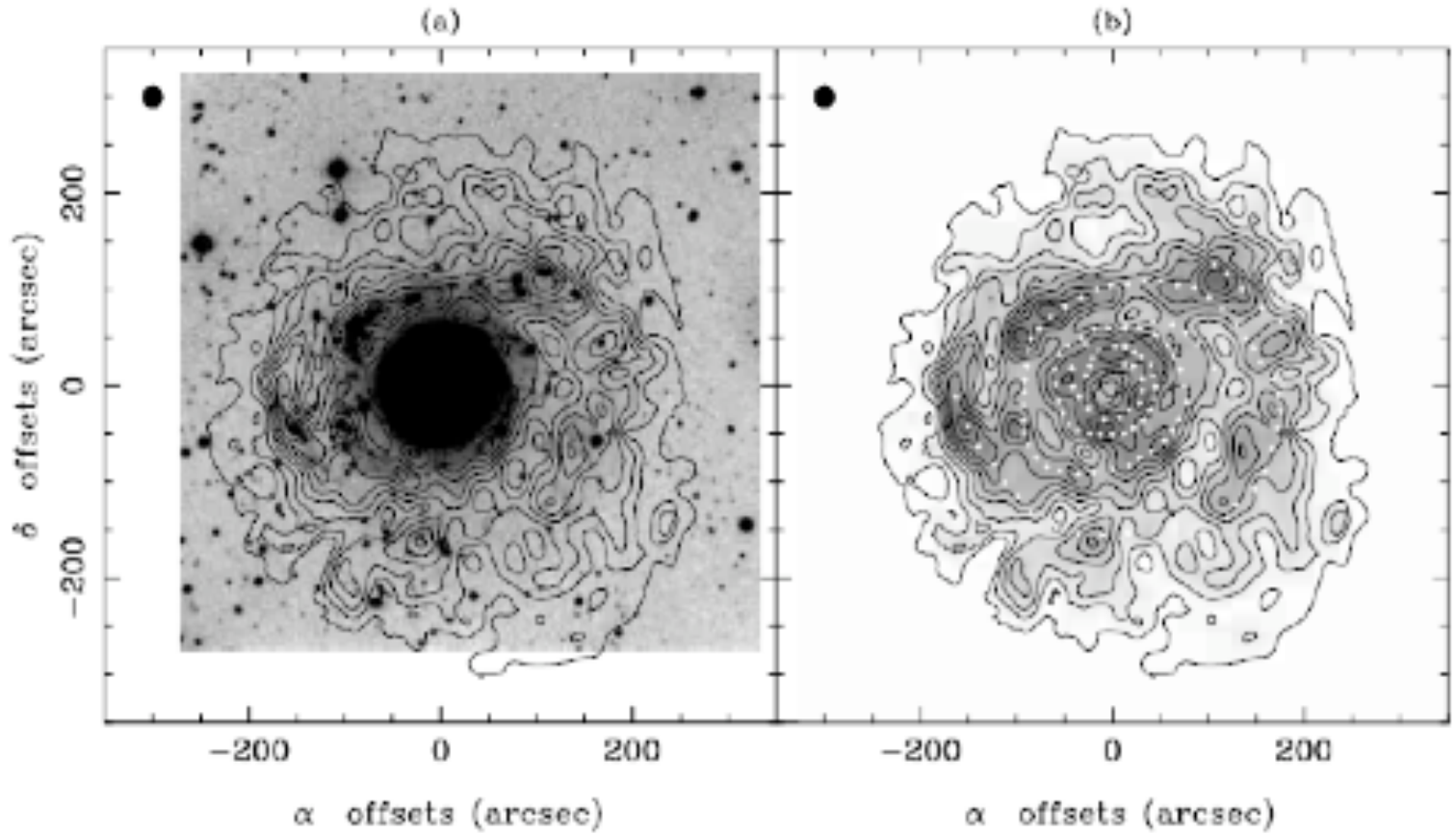


Fig. 6. a) Contour map of the HI column density distribution in NGC 3642 overlapped on the *R* image. The contours are 1.1, 3.4, 5.6, 7.9, 10.2, 12.4, 14.7, 16.9, 19.2 and 21.4×10^{20} atoms cm^{-2}. b) Greyscale map of the HI column density distribution with contours as in a). The main features are marked as dots. The synthesized beam ($21''.4 \times 18''.4 - \alpha \times \delta$) is plotted in the upper left of both panels.

HI column density distribution

TOOLS FOR ALMA

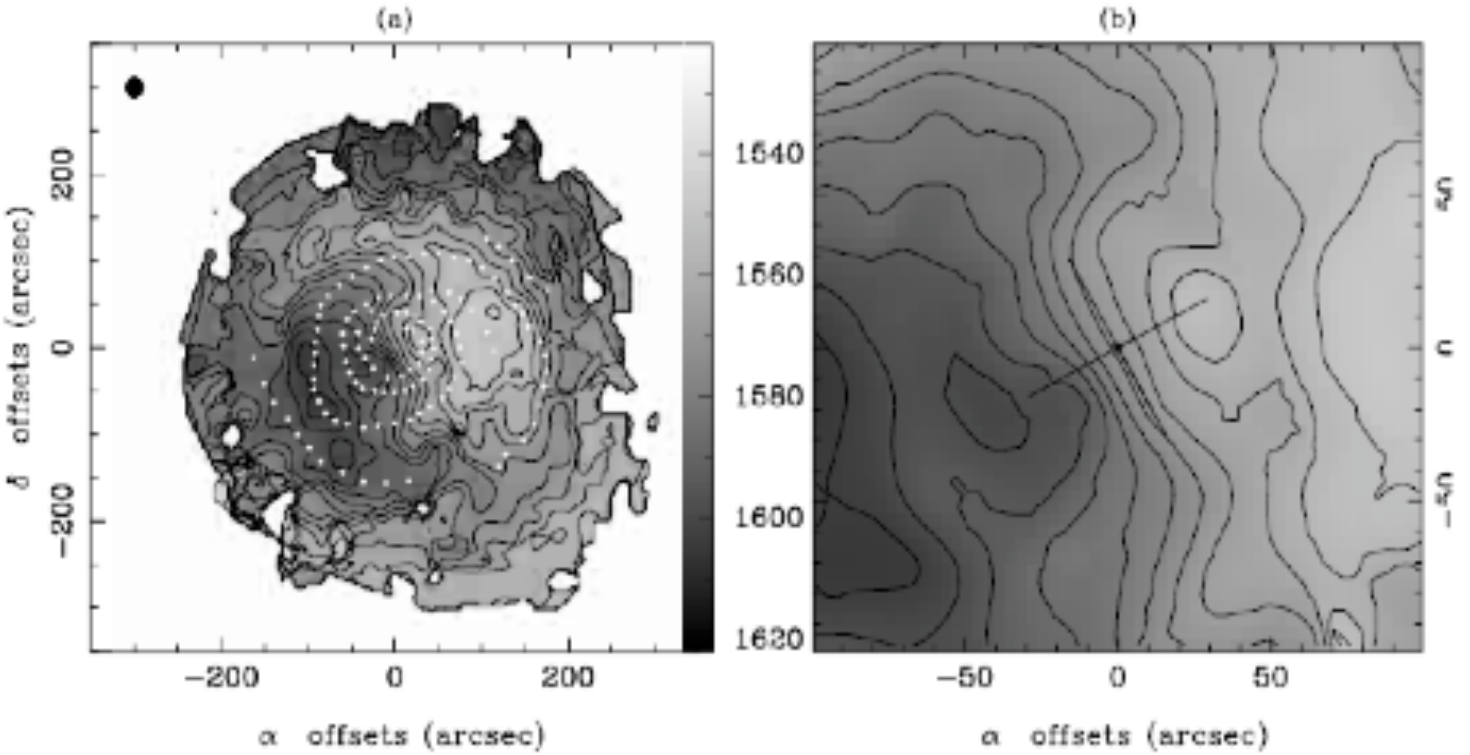


Fig. 7. a) Map of the first–order moment of the radial velocity field where both iso-velocity contours and greyscale are shown for clarity. The scale goes as in the wedge, where the numbers indicate heliocentric velocities in km s^{-1}. The contours go from 1532 to 1602 km s^{-1} with a step of 5 km s^{-1}. The main spiral features are marked as dots. The straight line indicates the direction of the position-velocity cut shown in Fig. 8. The beam size is $21''.4 \times 18''.4$ and is plotted in the upper left. b) Central part of the velocity field shown in a). The major and minor axis directions are indicated, and a cross indicates the optical center position (see Sect. 3.2).

Velocity field

(Verdes-Montenegro et al 2002)

TOOLS FOR ALMA

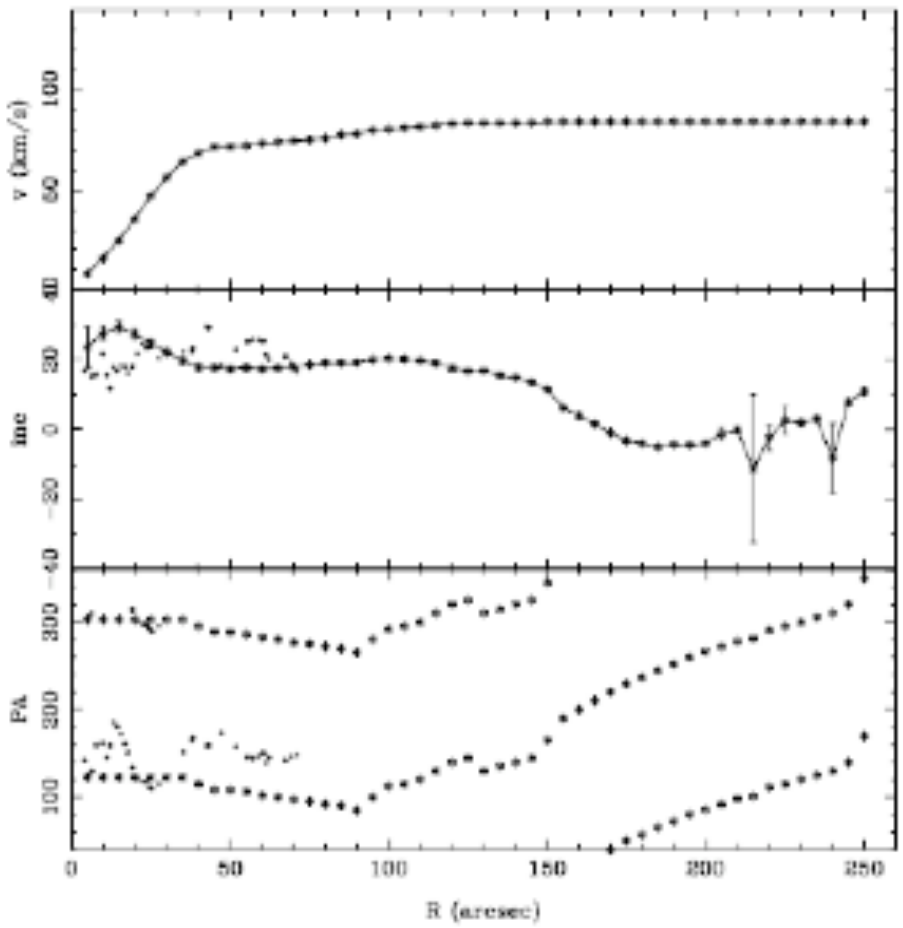


Fig. 9. a) Rotation curve assumed for the modelling of the velocity field. The best fit to this curve and to the observed velocity field is given by the combination of inclination and position angle plotted in b) and c) respectively. Filled dots correspond to the isophotal fitting of the optical R image (Fig. 4). Angles are measured from North to East.

Parameters of the modelled velocity field

(Verdes-Montenegro et al 2002)

TOOLS FOR ALMA

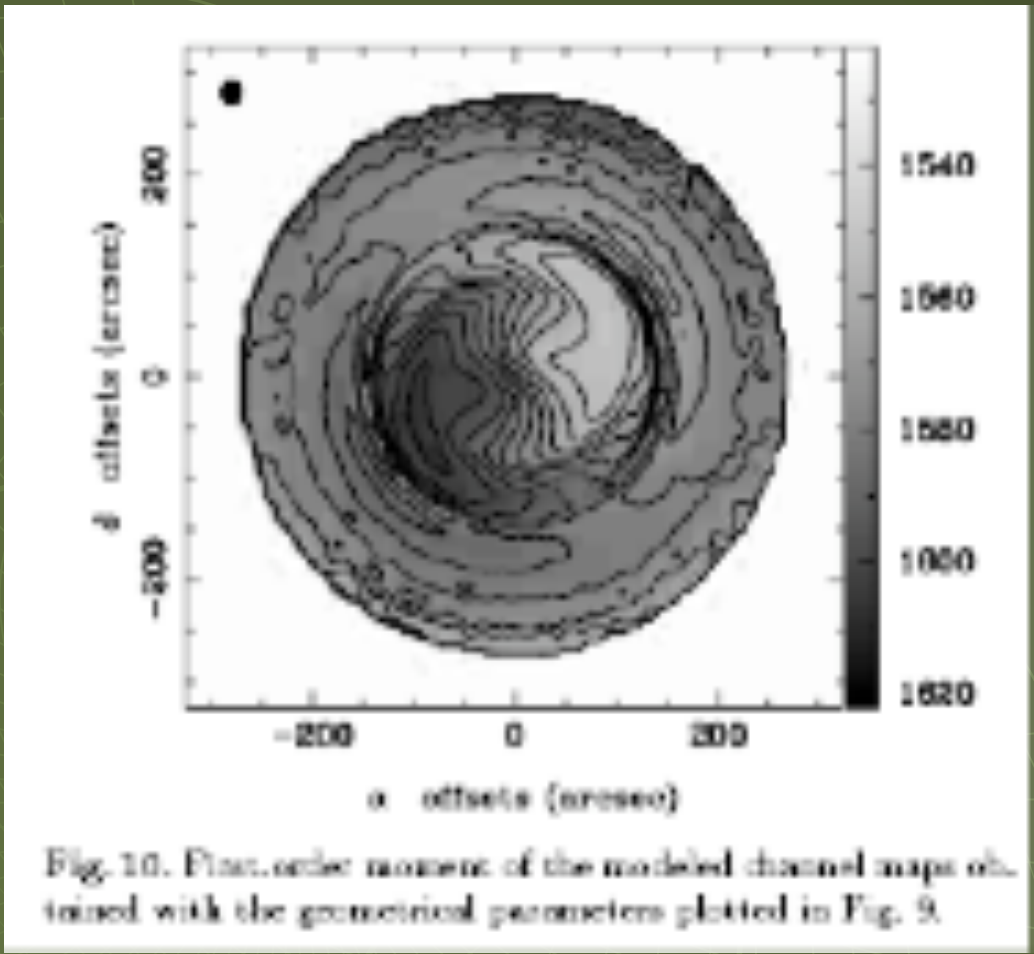


Fig. 10. First-order moment of the modeled channel maps obtained with the geometrical parameters plotted in Fig. 9.

Map of the first-order moment of the modeled channel maps

TOOLS FOR ALMA

AMIGA^3 in collaboration with Kapteyn Institute

GIPSY upgrade

- Documentation, and easily installable and maintainable
- Ensure data compatibility:
  - Integration in the data environment of ALMA + CASA
  - Not only ALMA but other radiointerferometers, FP, IFUs
- Integration in the VO: implementation of VO access + tools
  - Available to a larger scientific user base
  - Enables efficient multiwavelength comparisons

TOOLS FOR ALMA

- Intuitive graphical user interfaces:
  to fully exploit the (wealth) of input parameters in GIPSY
  (e.g: vsys, pa, I, vrot, vexp, center, side, weigth, etc)

- Definition of functional and technical specifications:
  Use cases being elaborated based on scientists inputs via a survey

- Feasibility study for server-side GIPSY deployment:
  In order to supply VO services based on distributed computing analysis (GRID)

2010: workshop on management of cubes in the VO

EXPECTED OUTCOME

- Collaboration with ESO to produce an ALMA VO-compliant archive
- Spanish contribution to (now unenxistent) IVOA standards for cube data models and cube VO access protocols
- Coordinated integration of GIPSY + ALMA archive in VO
- First high-level, friendly, VO-aware analysis package for radio 3D data, applicability to multiλ, fully compatible with ALMA

AMIGA web page