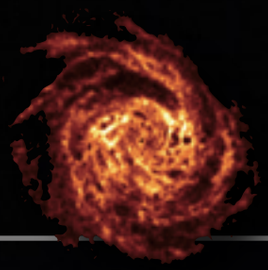


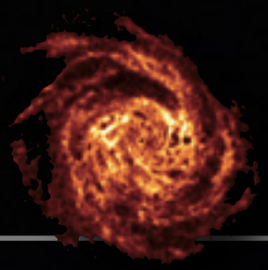
Challenges for characterization and visualisation of 3D data

Thijs van der Hulst
Kapteyn Astronomical Institute

university of groningen / Kapteyn Astronomical Institute

APERTIF

erc



Challenges for characterization and visualisation of 3D data

Thijs van der Hulst
Kapteyn Astronomical Institute

- Signature of HI in galaxies
- Forthcoming HI surveys
- Source characterisation challenges
- Visualisation challenges

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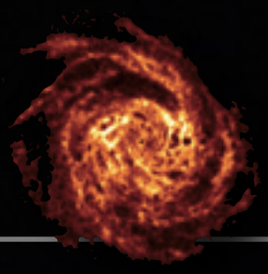
APERTIF

erc



HI spectral-line aperture synthesis imaging

- *HI disks are excellent probes of galaxy structure & kinematics*
  spiral arms, warps, rotation curves, streaming motions, triaxiality, …

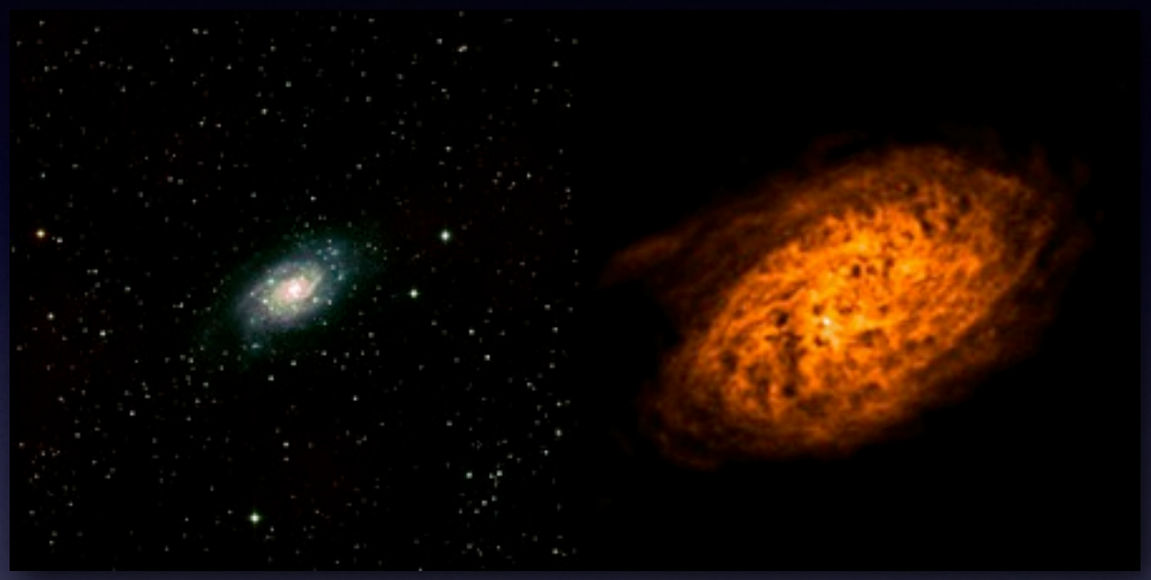
- *HI reveals physical processes not/hardly seen otherwise*
  tidal interactions, accretion/inflows, tidal/ram-pressure stripping, Galactic fountain, …

- *future HI surveys (ASKAP, APERTIF) will detect more than 100 objects every day*

- *automated methods of finding the HI objects and characterising their structure are mandatory for producing scientifically useful catalogues*

HI disks reach far into the Dark Matter halos

NGC 2403



Fraternali et al (2001)

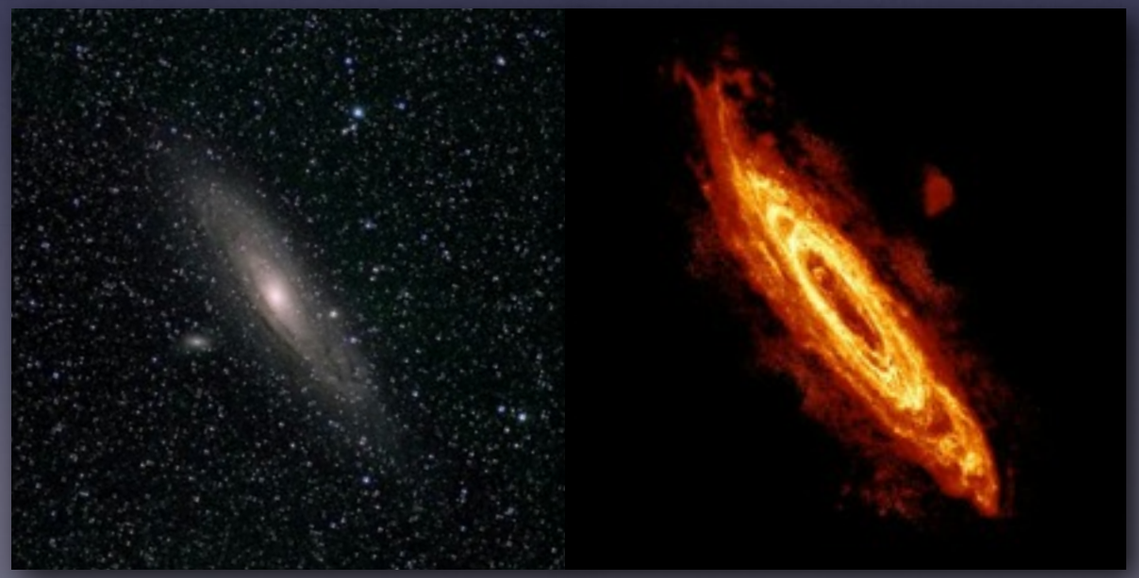
NGC 6946

Boomsma (2007)

NGC 5055

Battaglia et al (2005)

Messier 31

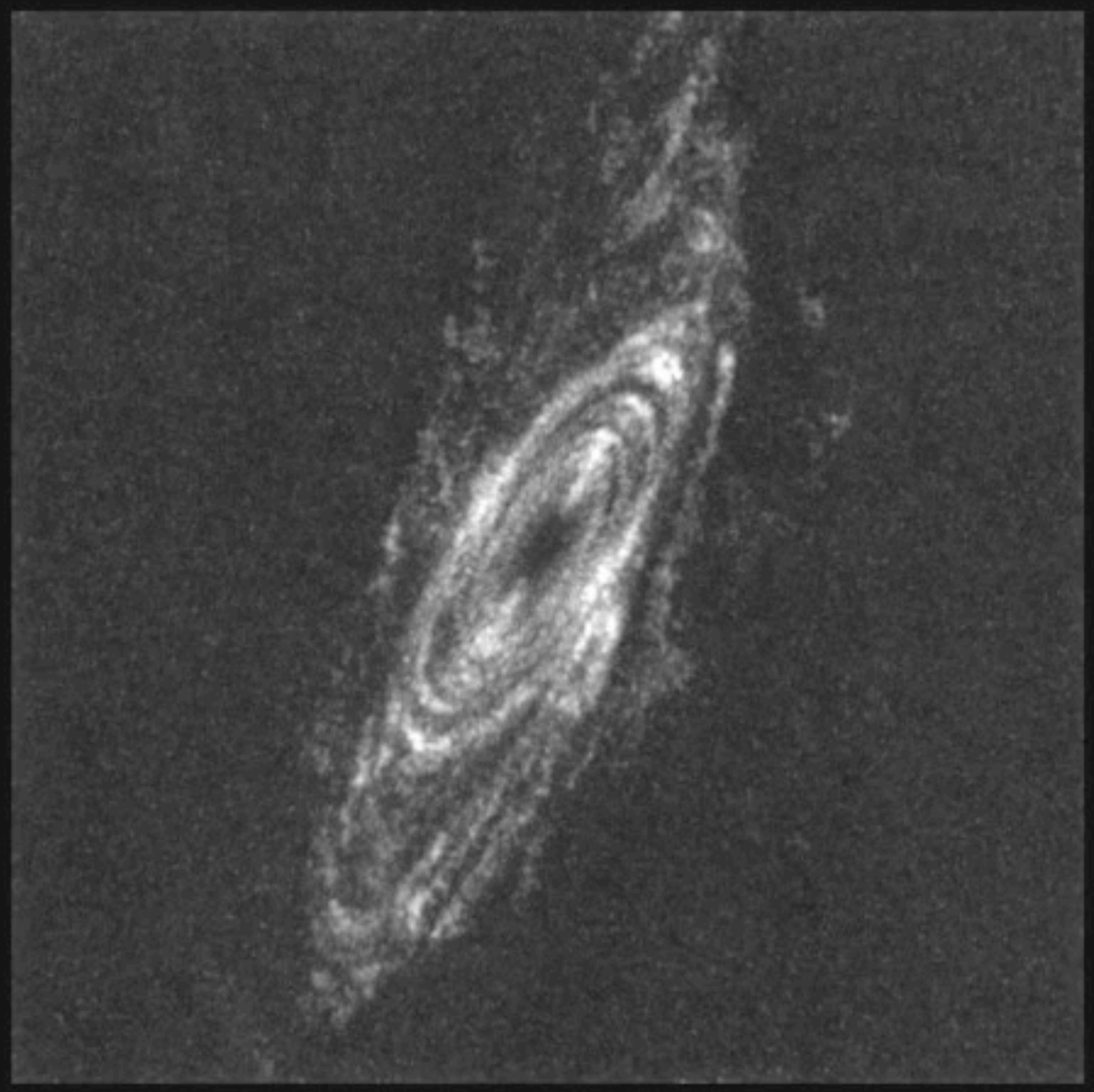


Braun et al

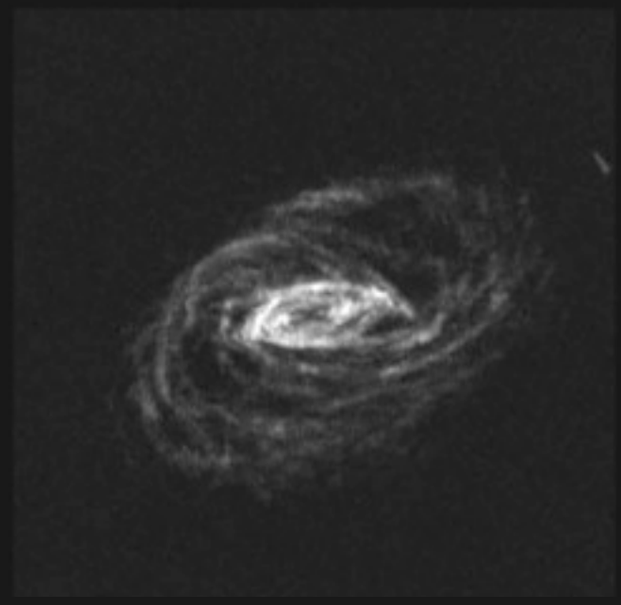
HI data from Westerbork

Rendering of detailed HI data cubes

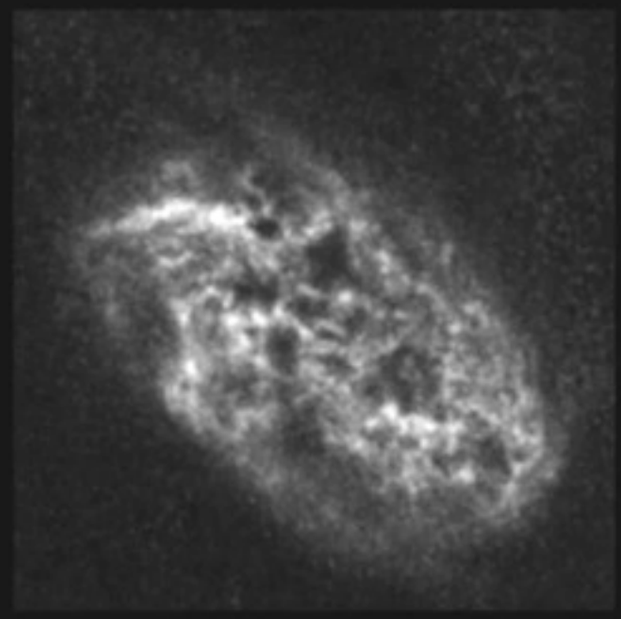
NGC 2841



NGC 5055



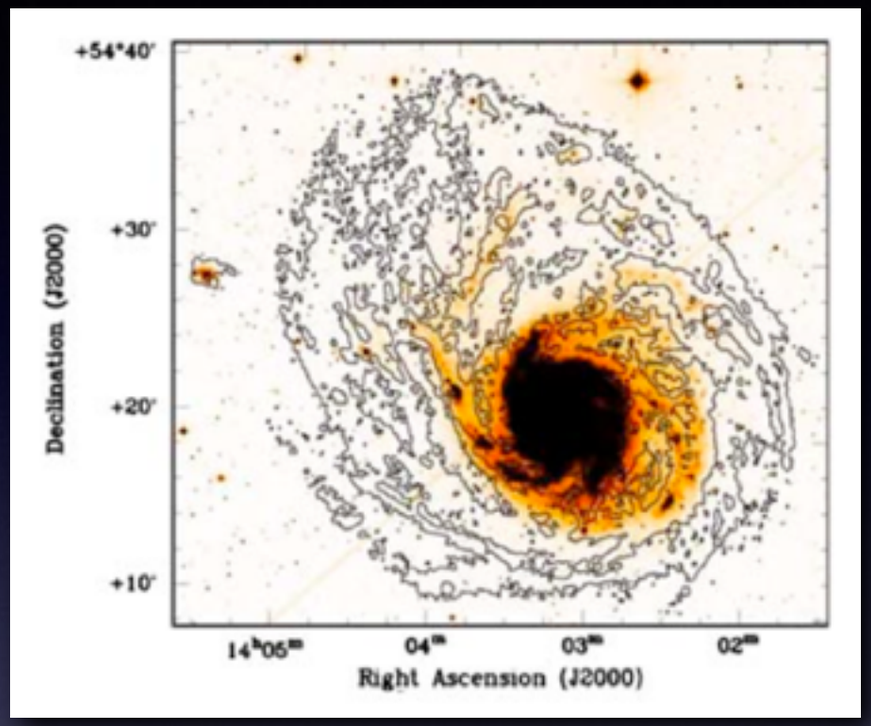
DDO 81



data from THINGS survey
visualization: Davide Punzo, Kapteyn Institute

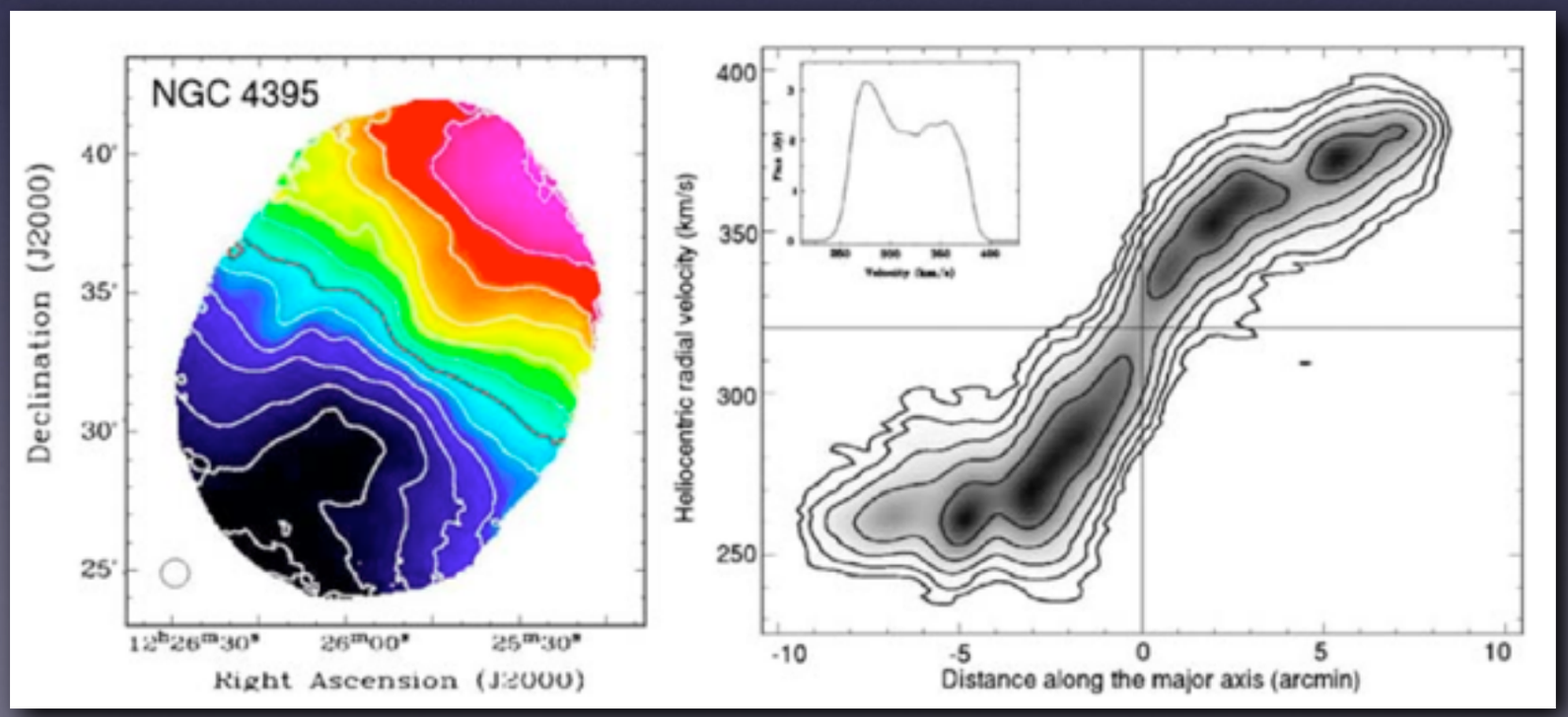
Features: Lopsidedness

M101



Morphological lopsidedness

Kamphuis 1993



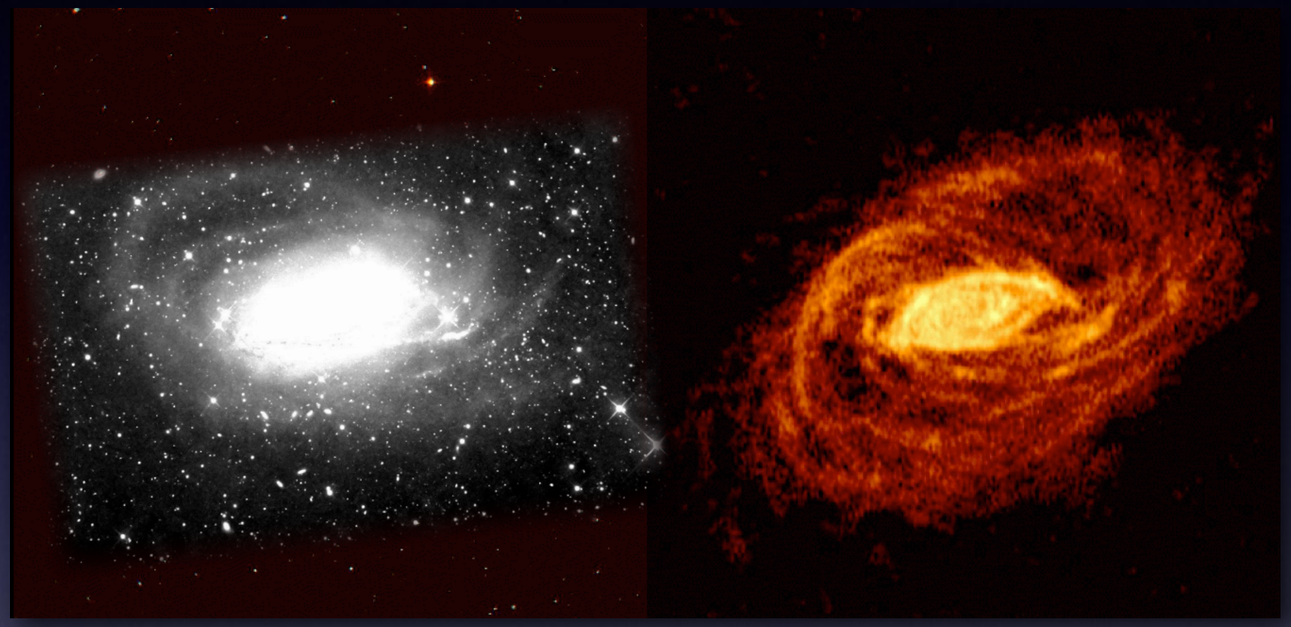
Kinematical lopsidedness

Heald & Oosterloo 2008

Features: Warps and stellar streams

No gas associated with the streams.

NGC 5055



R. Jay GaBany

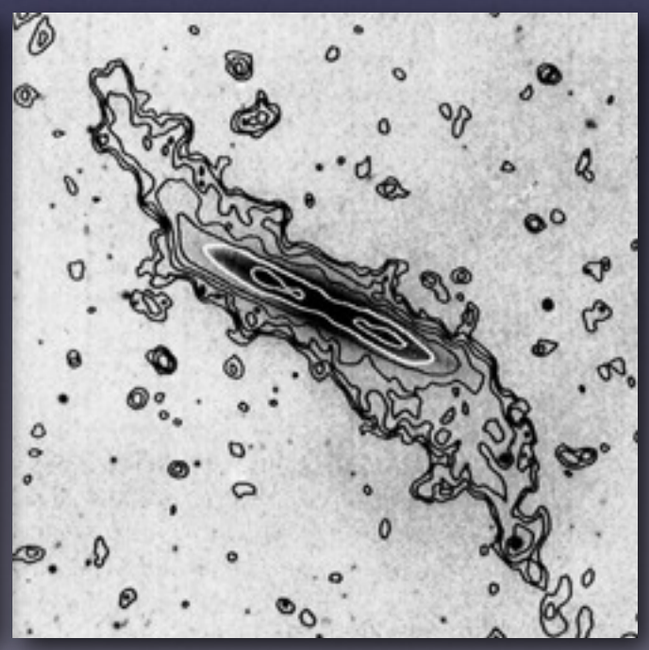
Battaglia+ 05

NGC 5907

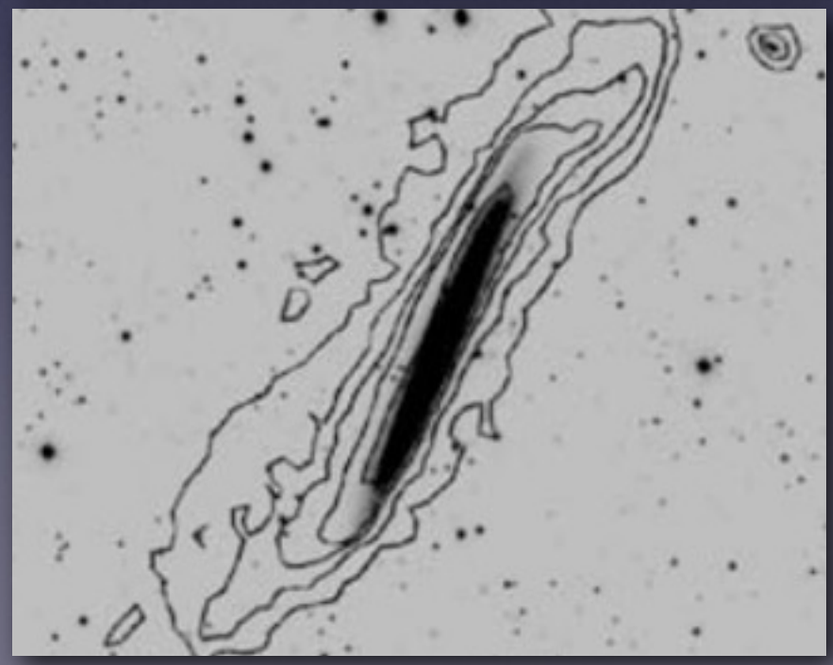
R. Jay GaBany

NGC 4013

R. Jay GaBany

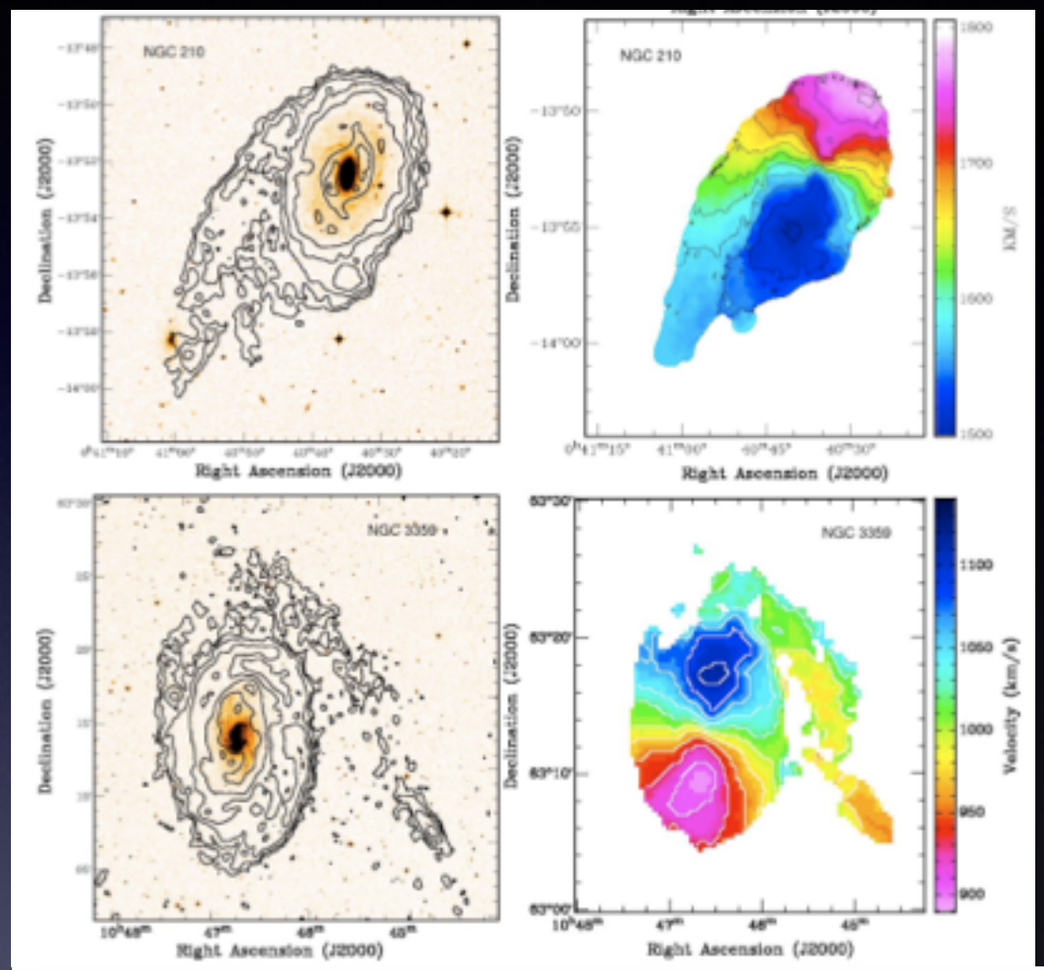


Bottema 95



Shang+ 98

Features: evidence for cold accretion?



Sancisi+ 2008

sustaining star formation

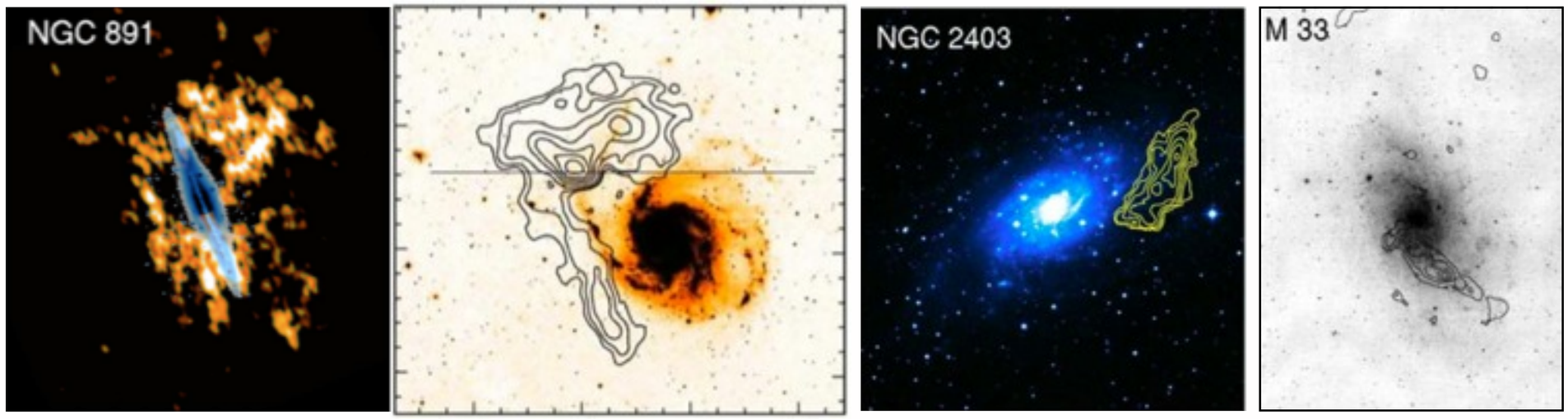
-

building up stellar mass

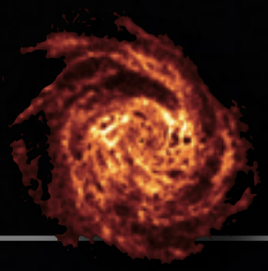
Evidence for cold accretion

or

Galactic Fountain / Fallback?



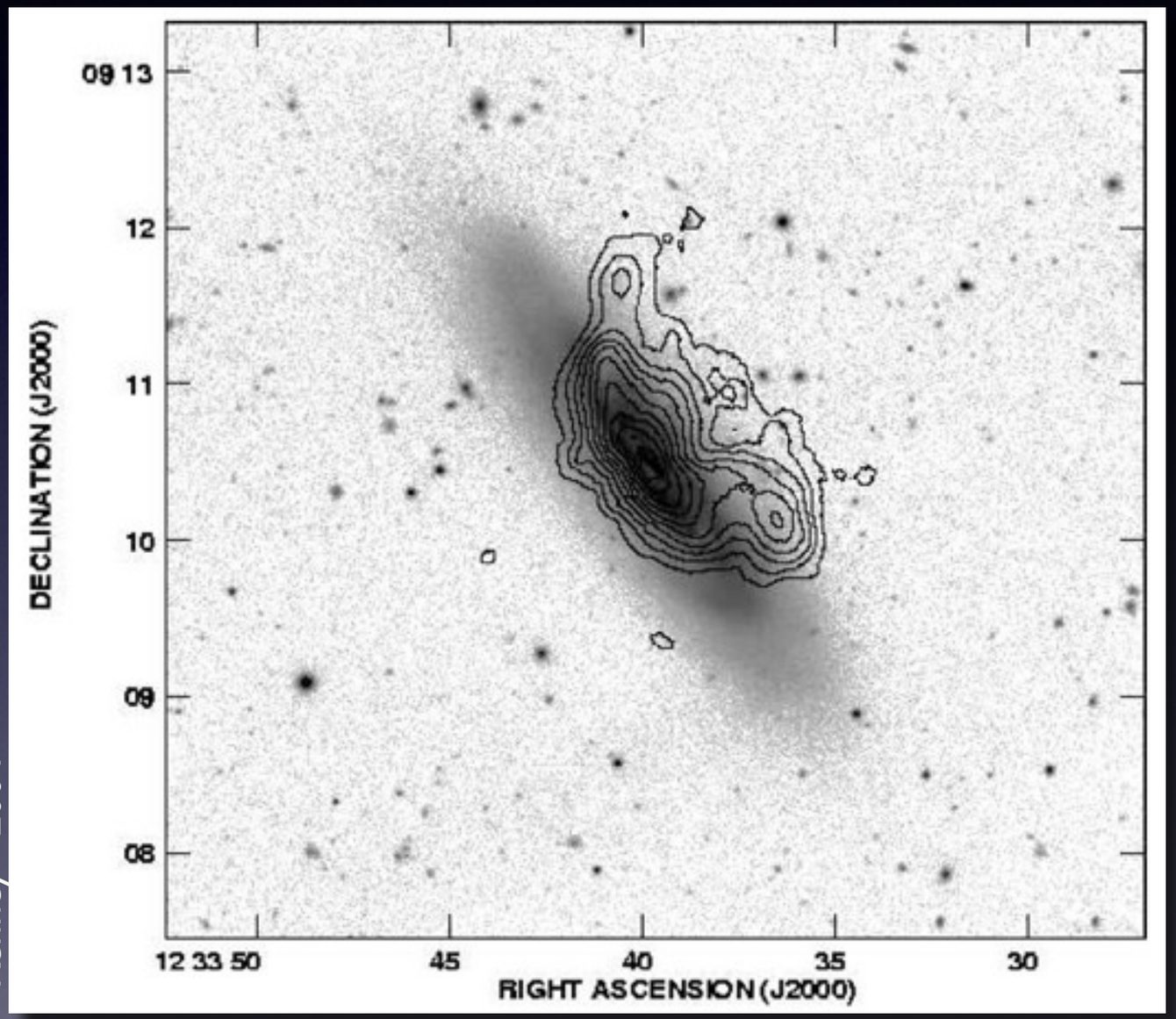
Oosterloo+ 2007



Features: tails and major distortions

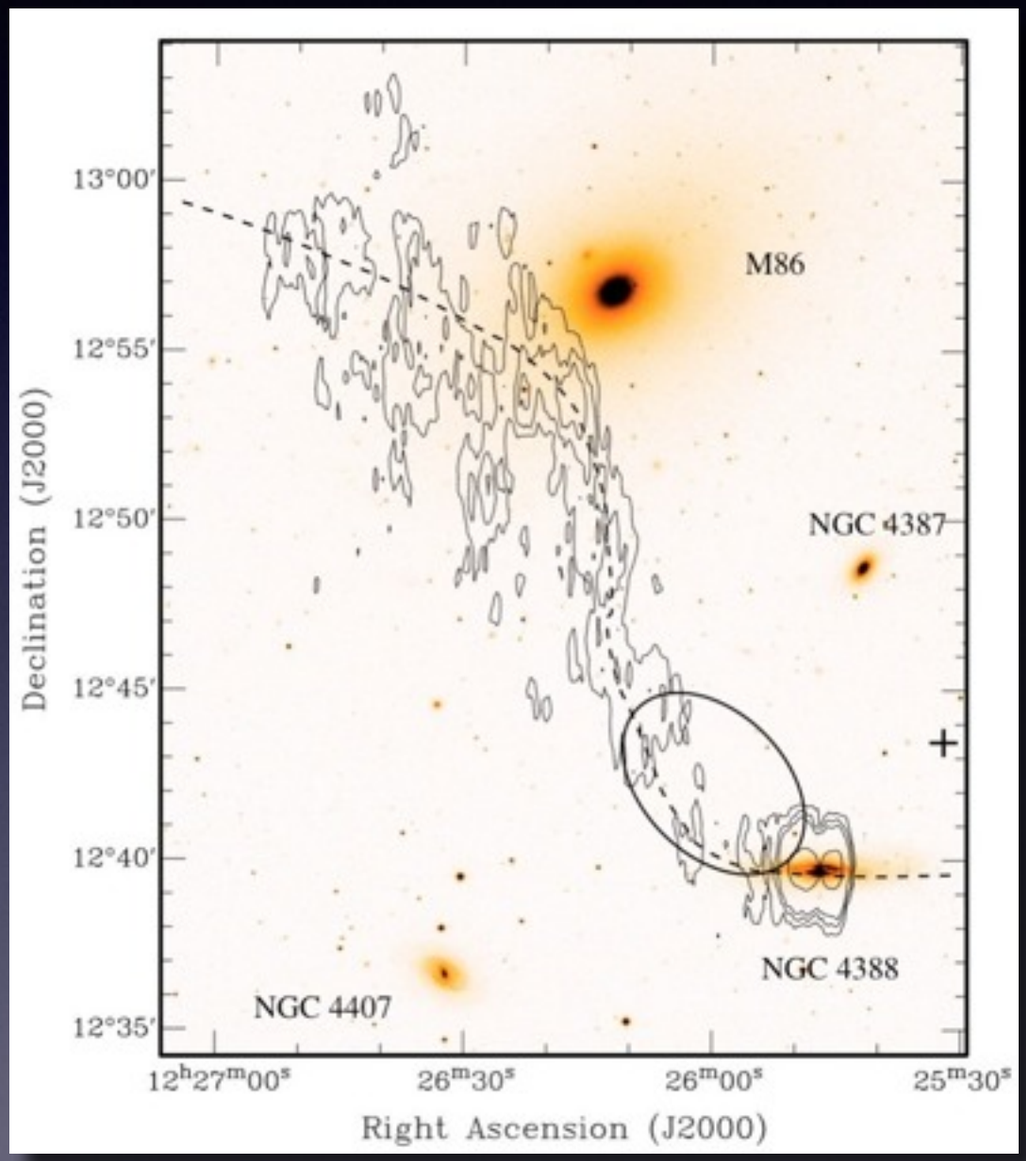
Ram Pressure Stripping in the VIRGO Cluster

NGC 4522

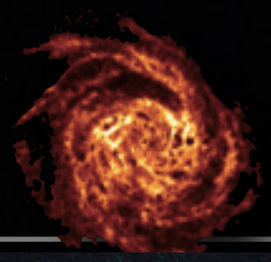


Kenney+ 2004

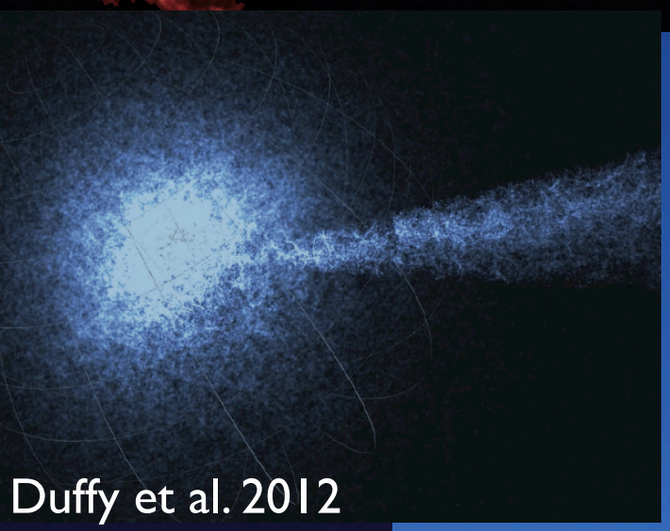
NGC 4388



Oosterloo & van Gorkom, 2005

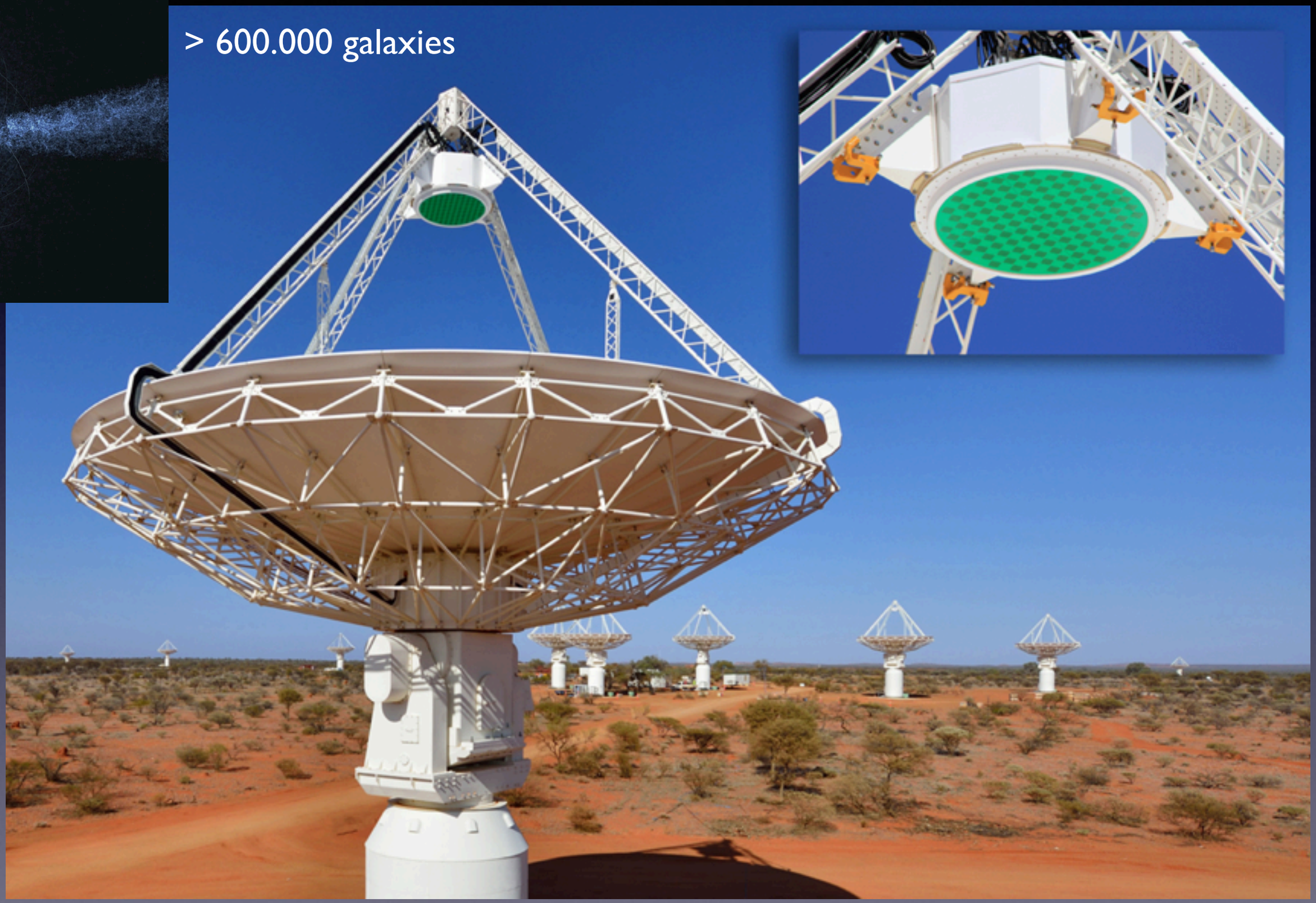


ASKAP: WALLABY and DINGO



Duffy et al. 2012
MNRAS 426, 3385

> 600.000 galaxies

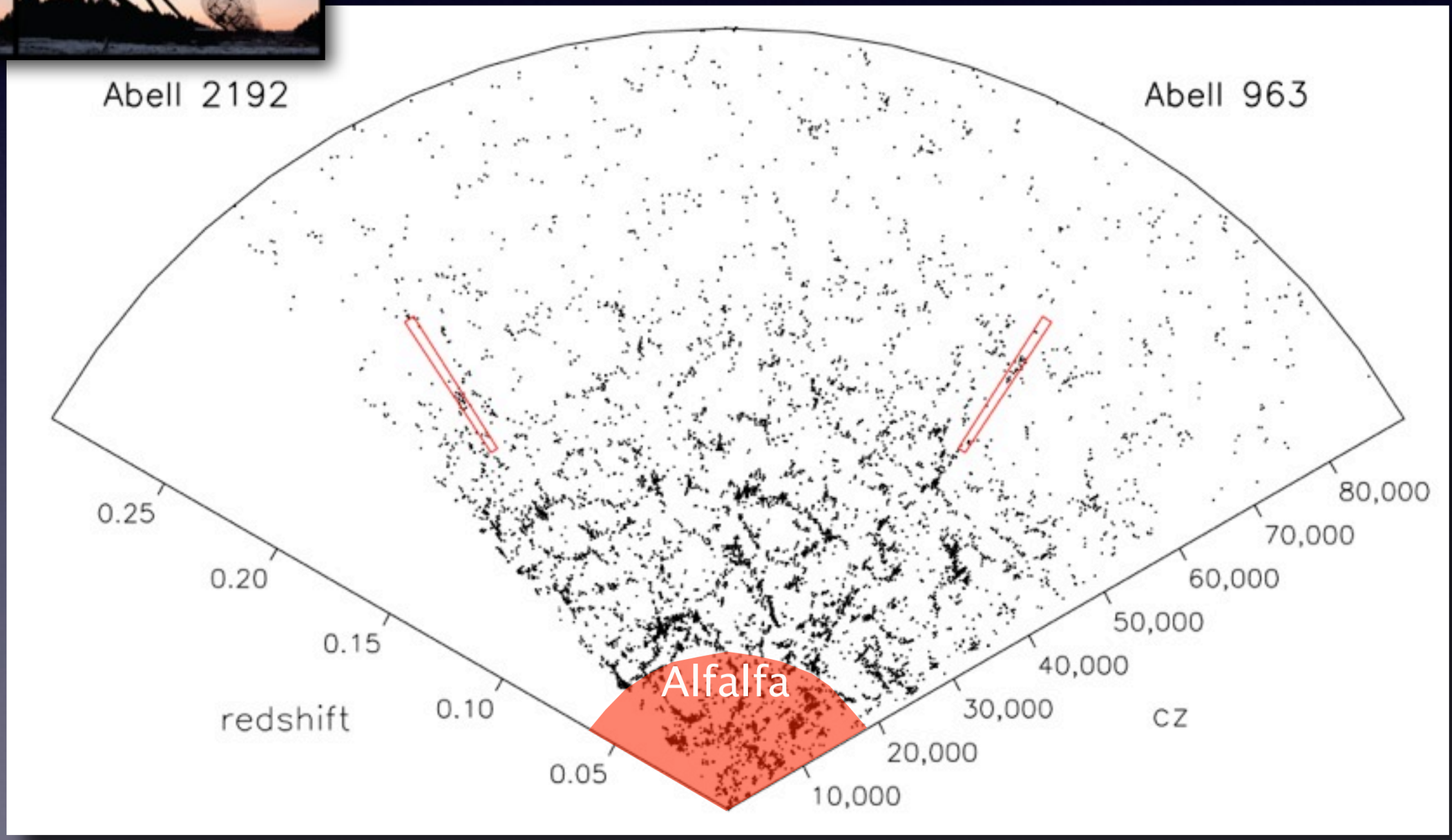


36 12-m dishes with Phased Array Feeds

The promise of Apertif

A Phases Array Feed 'camera' for the WSRT

10^5 detections, 10^4 resolved disks



The promise of Apertif

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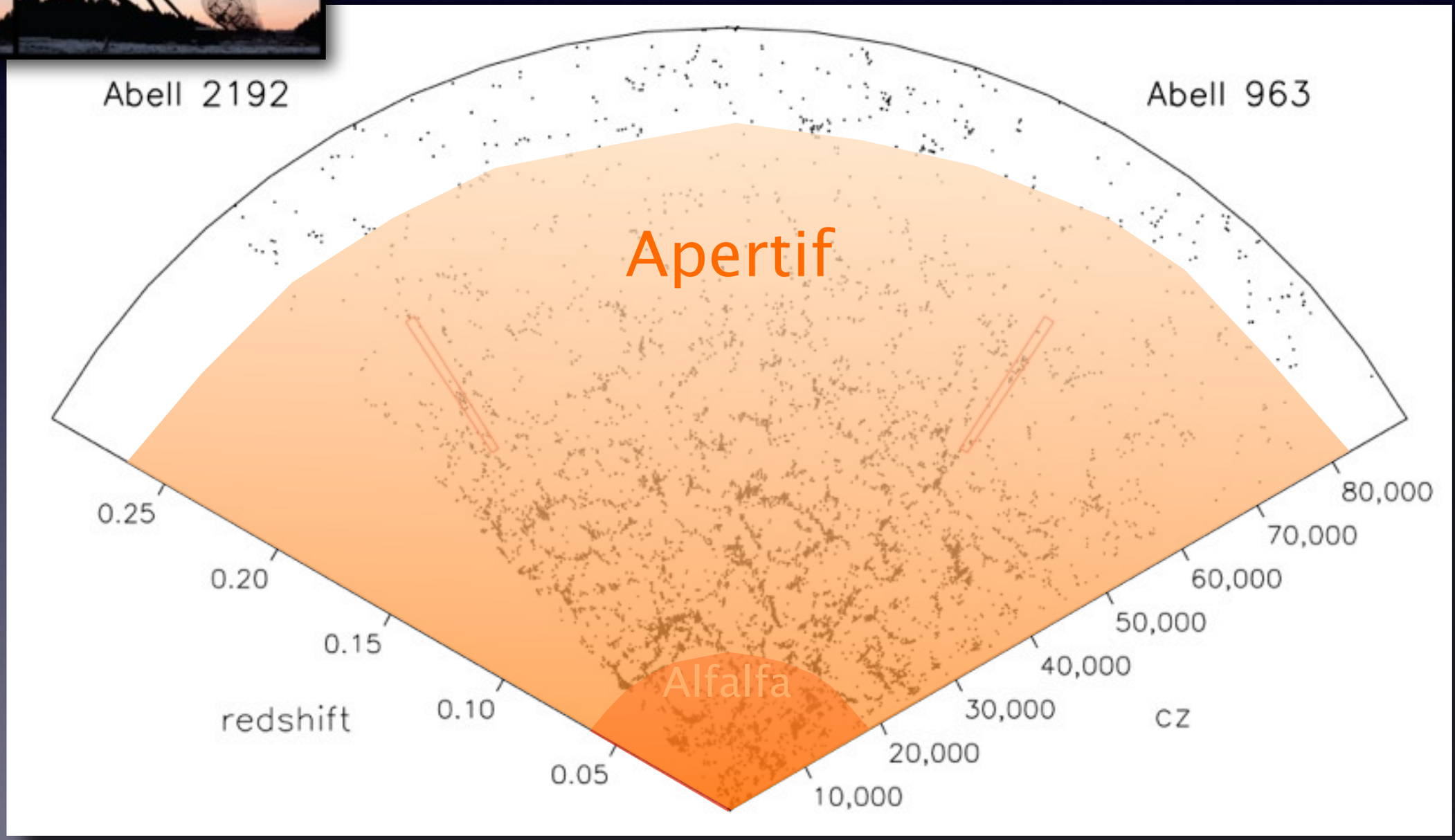
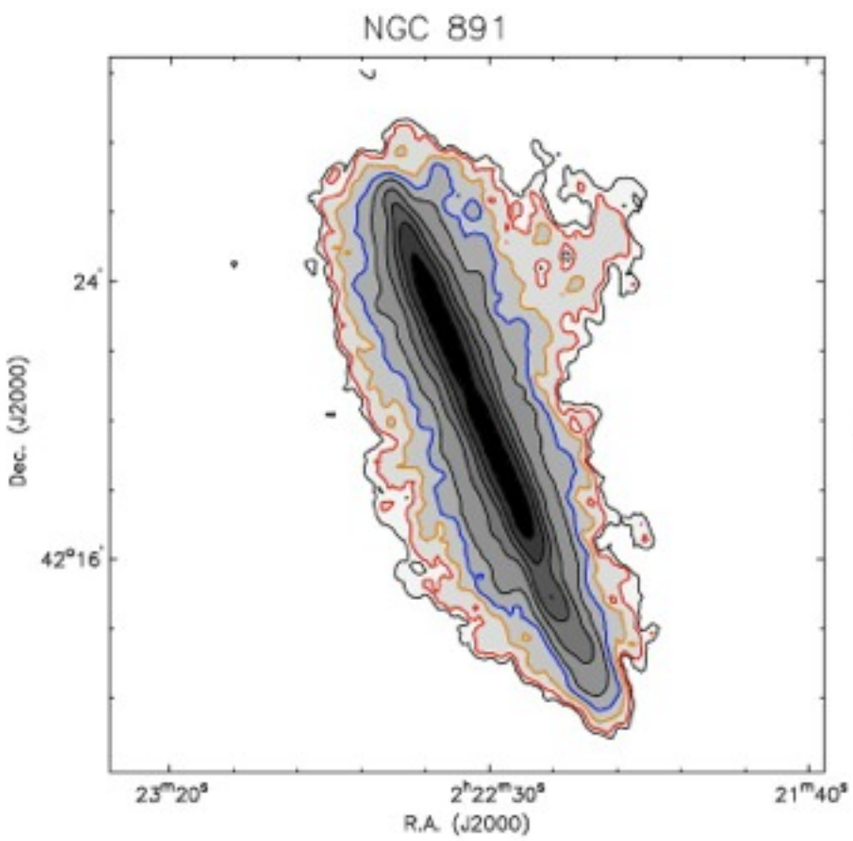


The promise of Apertif

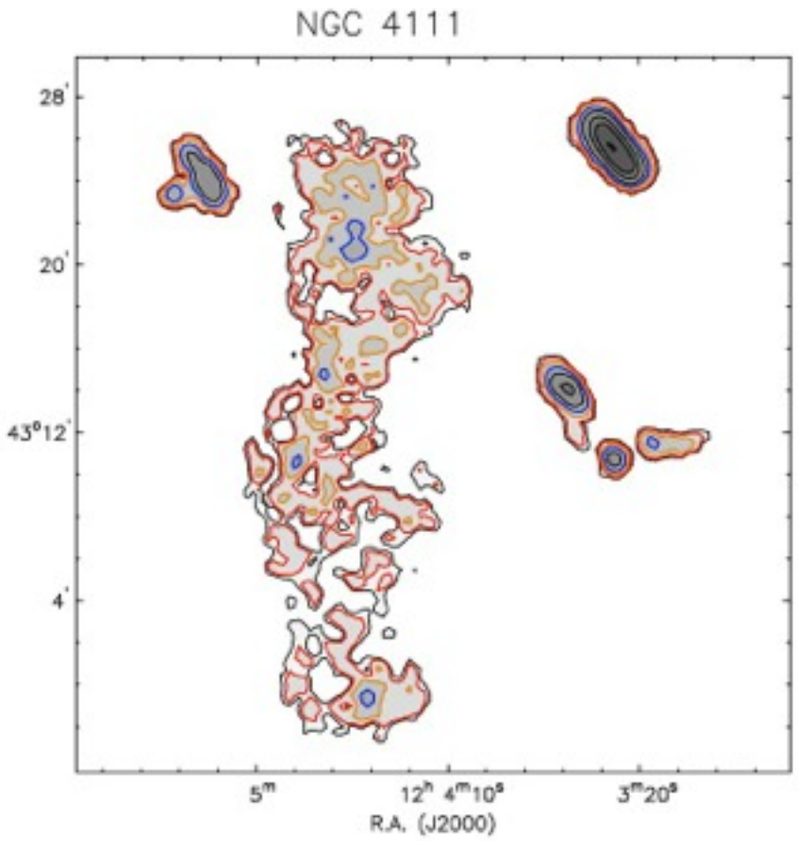
A Phases Array Feed 'camera' for the WSRT

10^5 detections, 10^4 resolved disks

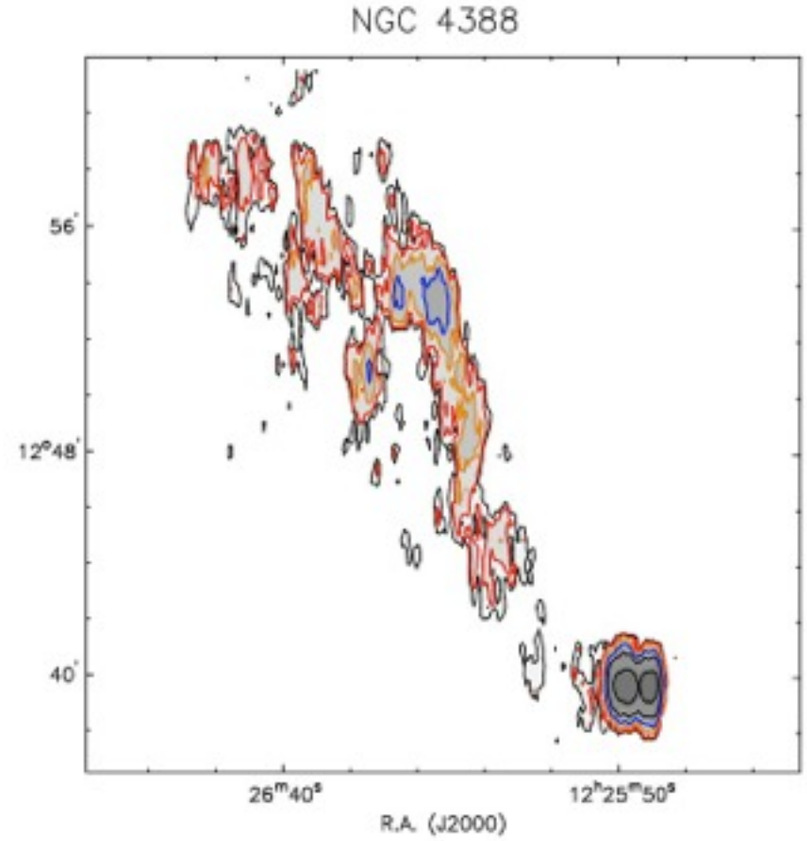
extraplanar gas

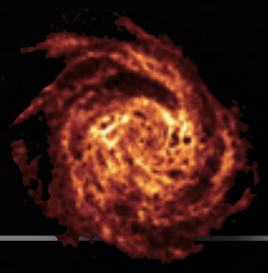


tidal filaments



ram-pressure tails



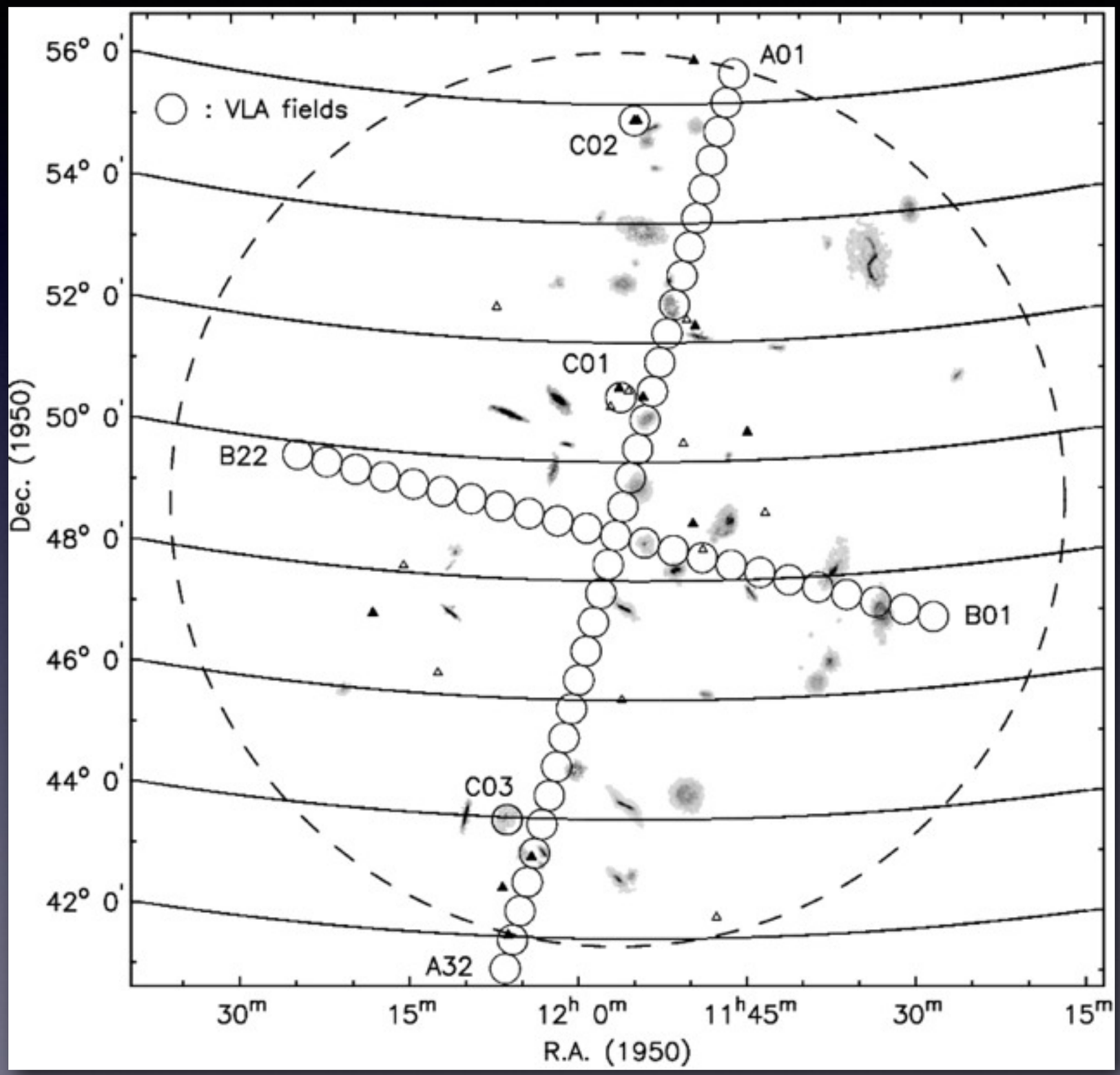


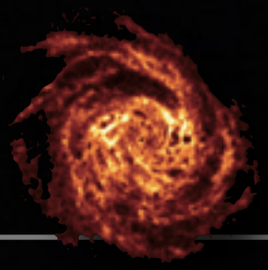
A preview of one day worth of data

A blind survey of Ursa Major

VLA-D
54 pointings

Verheijen+





A preview of one day worth of data

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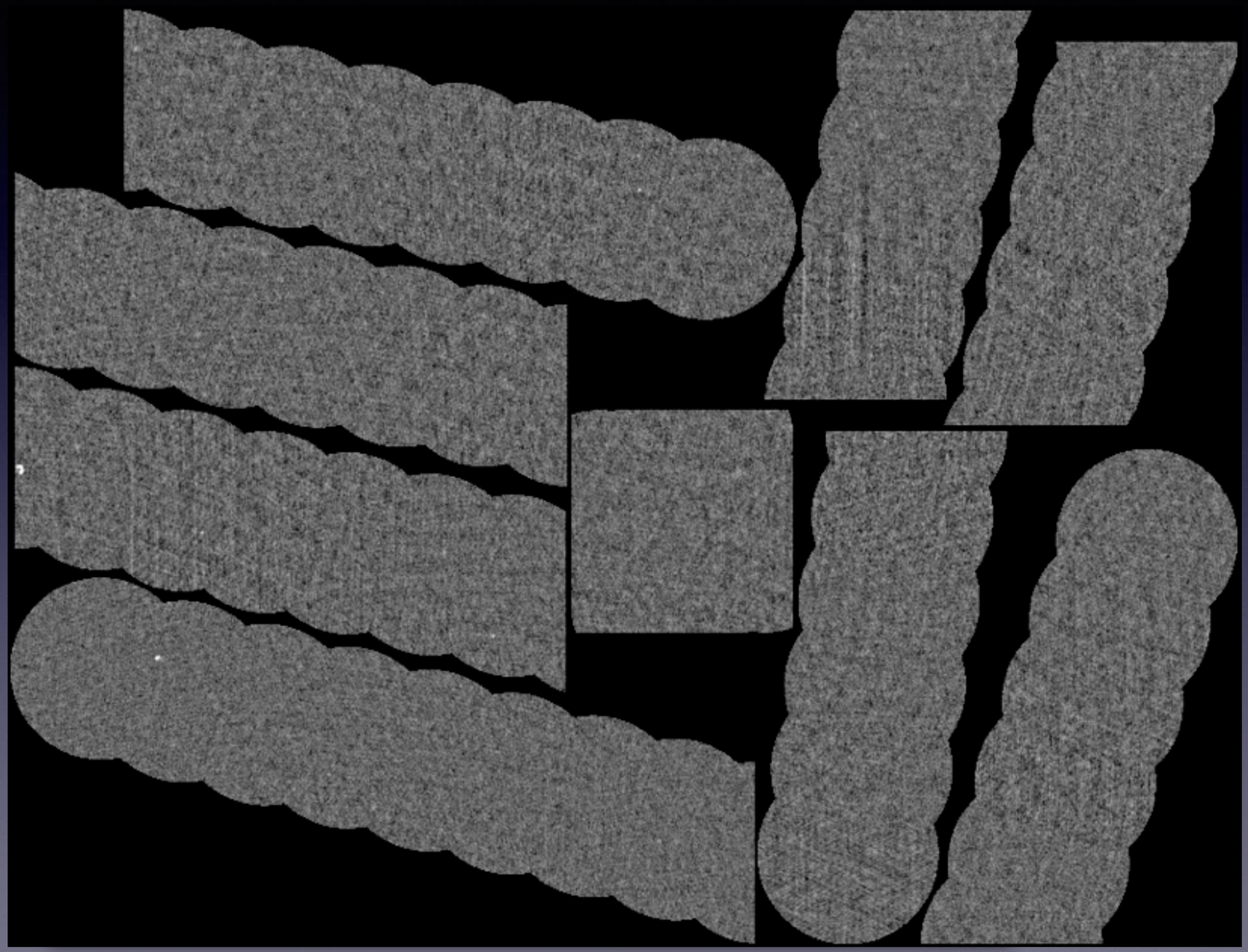
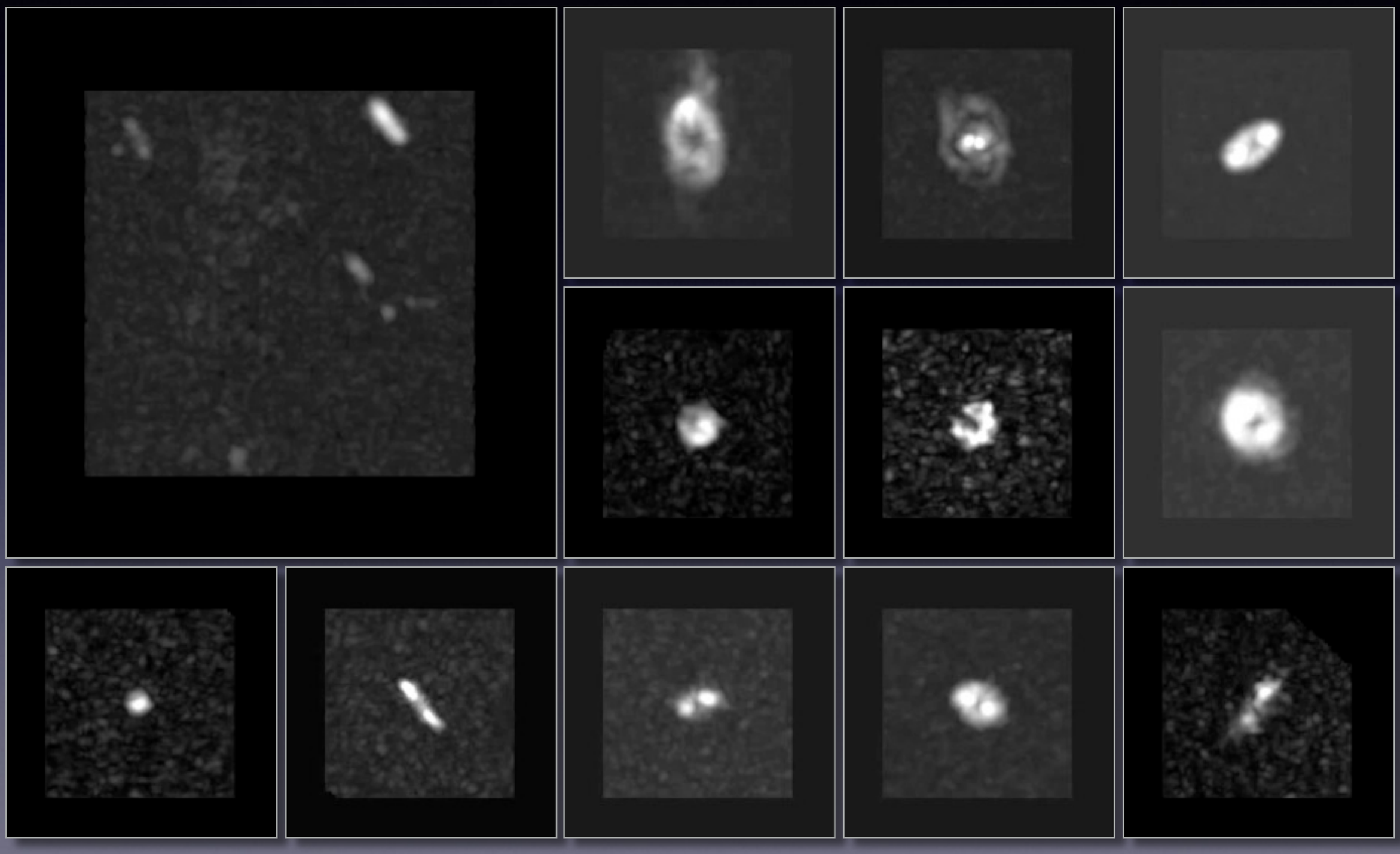


Verheijen+

detecting & characterizing 3D structures



Characterisation from 2D data: by eye

The Westerbork HI survey of spiral and irregular galaxies

I. HI imaging of late-type dwarf galaxies

R. A. Swaters[1,2,3], T. S. van Albada[1], J. M. van der Hulst[1], and R. Sancisi[4,1]

*A&A **390**, 829–861 (2002)*

The Westerbork HI survey of spiral and irregular galaxies

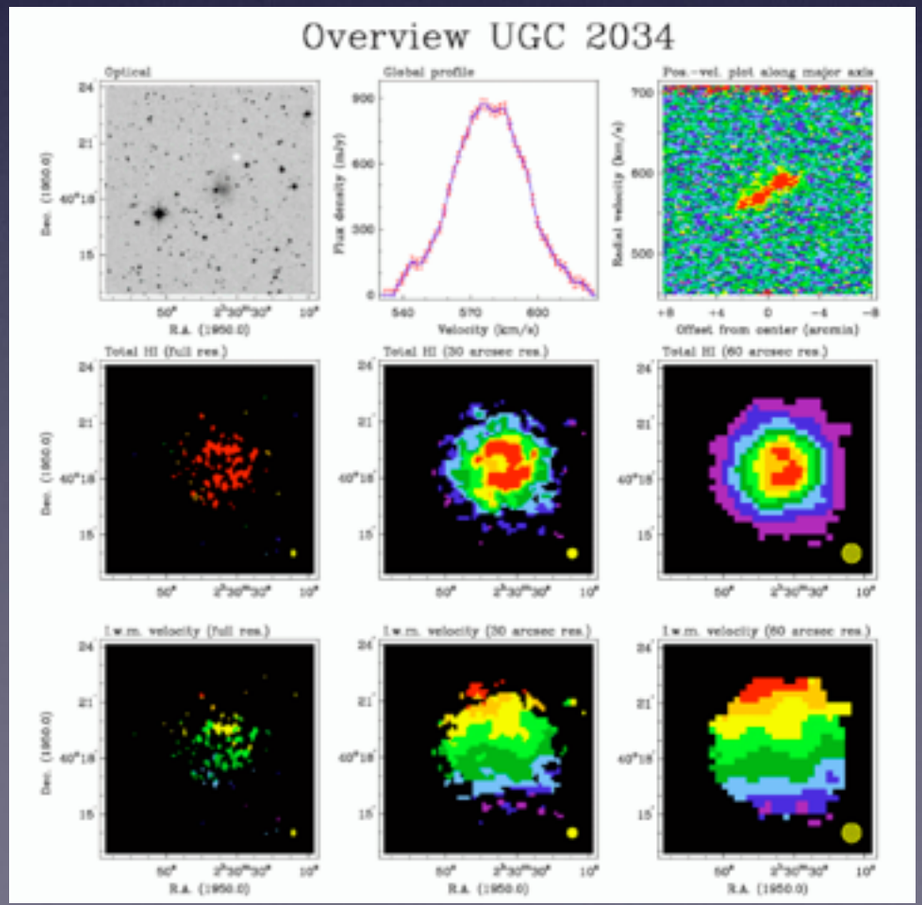
III. HI observations of early-type disk galaxies⋆

E. Noordermeer[1], J. M. van der Hulst[1], R. Sancisi[1,2], R. A. Swaters[3], and T. S. van Albada[1]

*A&A **442**, 137–157 (2005)*

Asymmetries examined by eye from:

HI distributions
velocity fields
rotation curves
global HI profiles



Characterisation from 2D data: automated

Lopsidedness in WHISP galaxies

I. Rotation curves and kinematic lopsidedness*

J. van Eymeren[1], E. Jütte[2], C. J. Jog[3], Y. Stein[2], and R.-J. Dettmar[2]

A&A ***530****,A29 (2011)*

Lopsidedness in WHISP galaxies

II. Morphological lopsidedness*

J. van Eymeren[1], E. Jütte[2], C. J. Jog[3], Y. Stein[2], and R.-J. Dettmar[2]

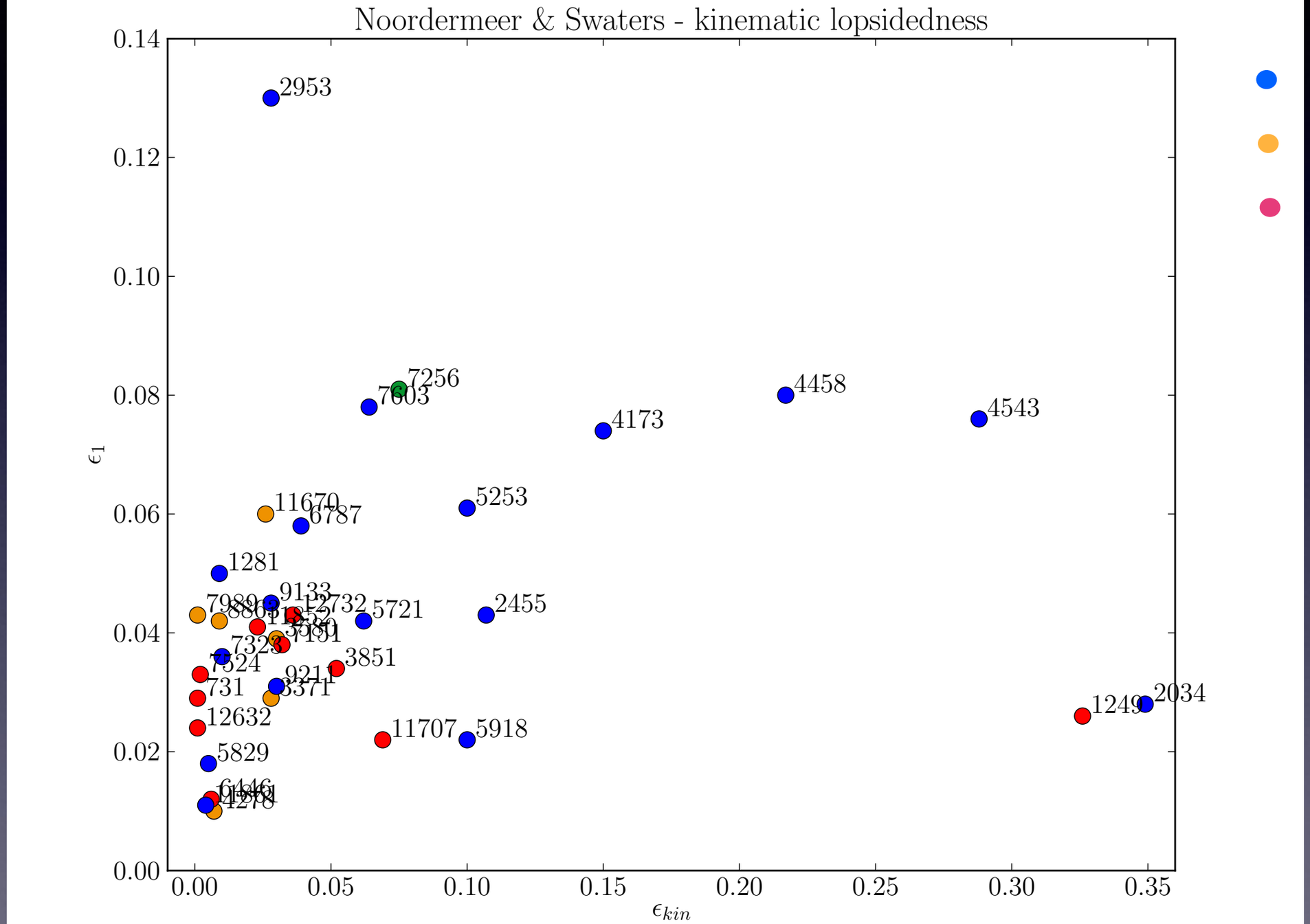
A&A ***530****,A30 (2011)*

Quantified H I morphology – II. Lopsidedness and interaction in WHISP column density maps

B. W. Holwerda,[1,2*] N. Pirzkal,[3] W. J. G. de Blok,[2] A. Bouchard,[4] S.-L. Blyth,[2]
K. J. van der Heyden[2] and E. C. Elson[2]

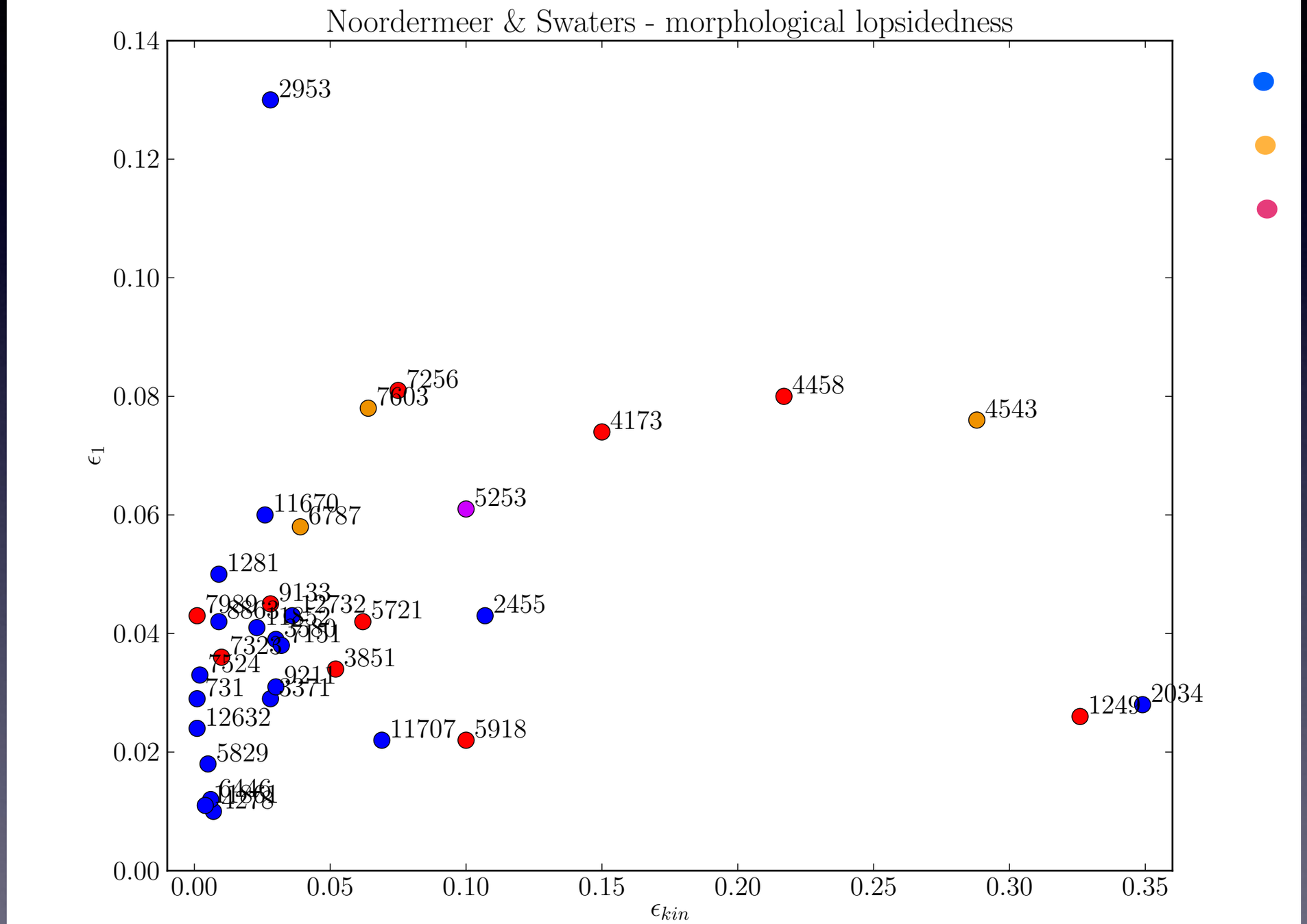
MNRAS ***416,*** *2415–2425 (2011)*

Comparison of Van Eymeren et al. with Noordermeer and Swaters



Coutesy Nadine Giese (*Kapteyn Institute*)

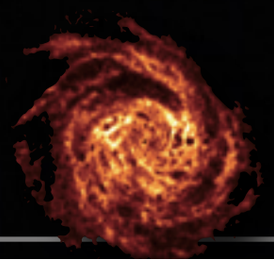
Comparison of Van Eymeren et al. with Noordermeer and Swaters



not
mildly
very

Coutesy Nadine Giese (*Kapteyn Institute*)

Investigate use of full 3D characterisation



kapteyn astronomical institute

Non-parametric characterization of 3D HI data

Nadine Giese[1,2], Thijs van der Hulst[1], Tom Oosterloo[1,2]
[1]Kapteyn Astronomical Institute, University of Groningen, The Netherlands
[2]ASTRON, Dwingeloo, The Netherlands
giese@astro.rug.nl

Blind HI surveys with APERTIF

Kinematic and morphological asymmetries in galaxies are thought to be caused by evolutionary processes, such as interactions, accretion and ram pressure stripping.

Large, blind HI surveys with APERTIF [1] will provide HI data for a large number of galaxies, allowing a statistical analysis of galaxy asymmetries in relation to e.g. the local environment.

The large number of detections calls for fast non-parametric characterization methods to describe galaxy properties.

Existing & new characterization methods

Existing non-parametric HI characterization methods so far focus on estimating parameters from the total HI map. Holwerda et al.[2] use the Concentration, Asymmetry and Smoothness parameters adopted from IR studies. Their morphological asymmetry is defined as

$$A_{\mathrm{morph}} = \sum_{i,j} \frac{|I(i,j) - I_{180}(i,j)|}{2|I(i,j)|},$$

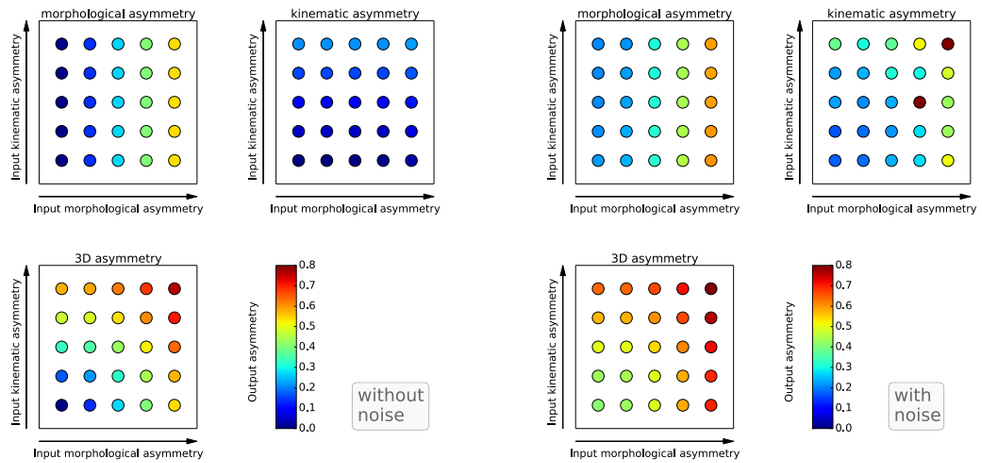
with I being the total HI map and I_{180} its 180 degrees rotated representation. Here, we introduce a kinematic and a 3D asymmetry:

$$A_{\mathrm{kin}} = \sum_{i,j} \frac{|I_v(i,j) + I_{v,180}(i,j)|}{2|I(i,j)|} \qquad A_{\mathrm{3D}} = \sum_{i,j,k} \frac{|I_{\mathrm{3D}}(i,j,k) - I_{\mathrm{3D,inv}}(i,j,k)|}{2|I(i,j,k)|}.$$

Therein, I_v is the velocity field and I_{3D} the full 3D representation of the galaxy. $I_{\mathrm{3D,inv}}$ denotes the 3D galaxy inverted along the RA, Dec and velocity/frequency axes.

3D asymmetry

To compare 2D with 3D asymmetry measurements we modeled galaxies with TiRiFiC [3]. A harmonic surface brightness distortion and harmonic terms in tangential rotation velocity with varying strength were added to introduce morphological and kinematic asymmetry. A second set of test galaxies was generated by adding noise to the models. Each panel shows the 2D morphological asymmetry, the 2D kinematic asymmetry and the 3D asymmetry in color as a function of input morphological and kinematic asymmetry, without and with noise.



Results:

- Morphological asymmetry can be recovered sufficiently in 2D
- Kinematic asymmetry cannot be estimated correctly using the 2D estimate on the velocity field
- The presence of noise increases the asymmetry values in all methods
- The 3D asymmetry estimation appears superior to the 2D methods

Further challenges

- Quantitative estimation of noise influence
- Error estimation
- Connect parameters to physical units

Conclusions

- In some cases the asymmetry of a galaxy cannot be recovered sufficiently using only 2D maps
- The use of the full 3D information enhances the asymmetry measurement
- Noise introduces a considerable bias to asymmetry

References

[1] Verheijen et al. (2008), 2008AIPC.1035..265V [2] Holwerda et al. (2008), 2011MNRAS.416.2415H [3] Józsa et al. (2007), 2007A&A...468..731J

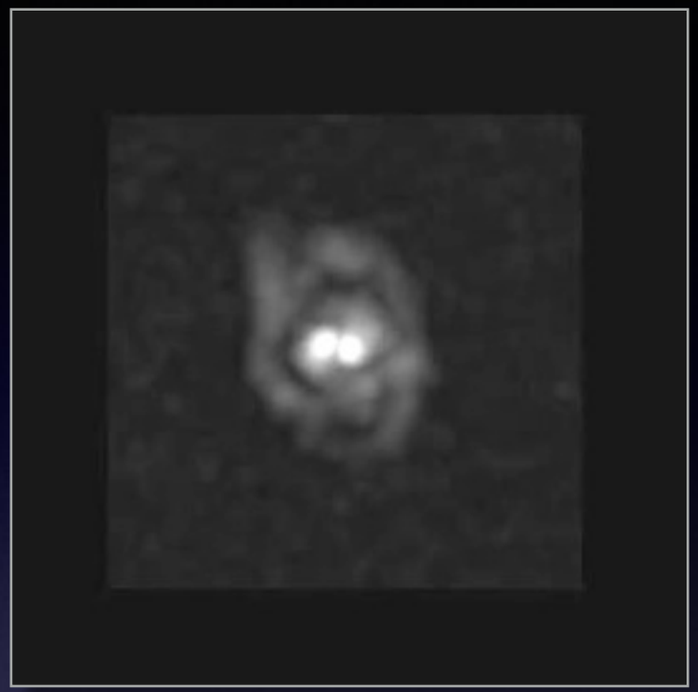
Highlight talk and poster by Nadine Giese

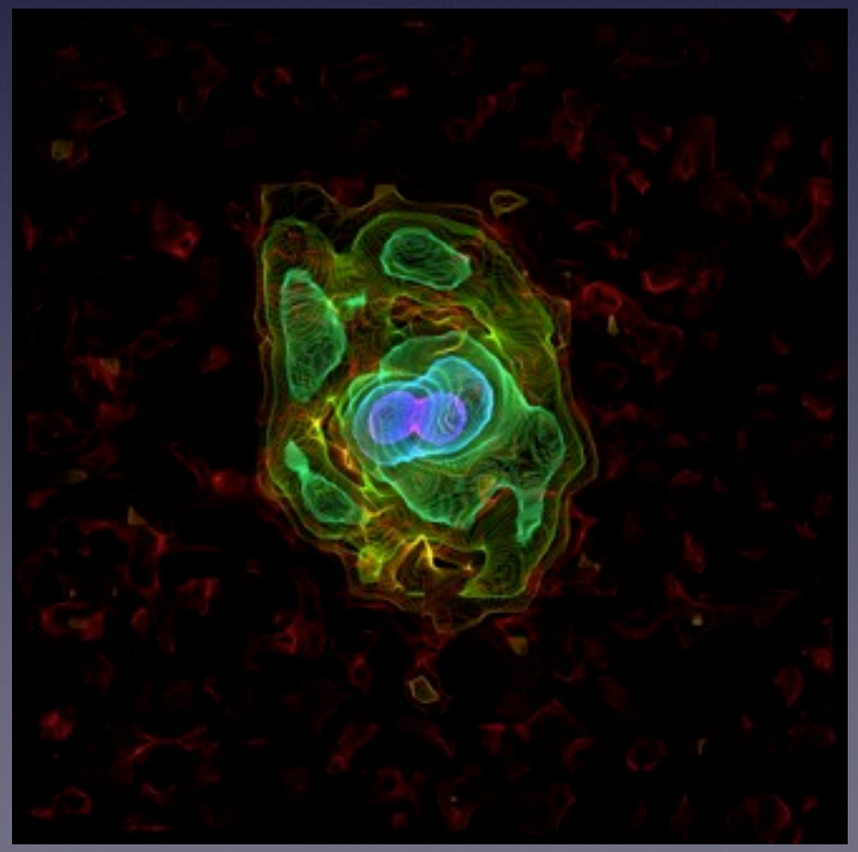
about the promise of full 3D source characterisation

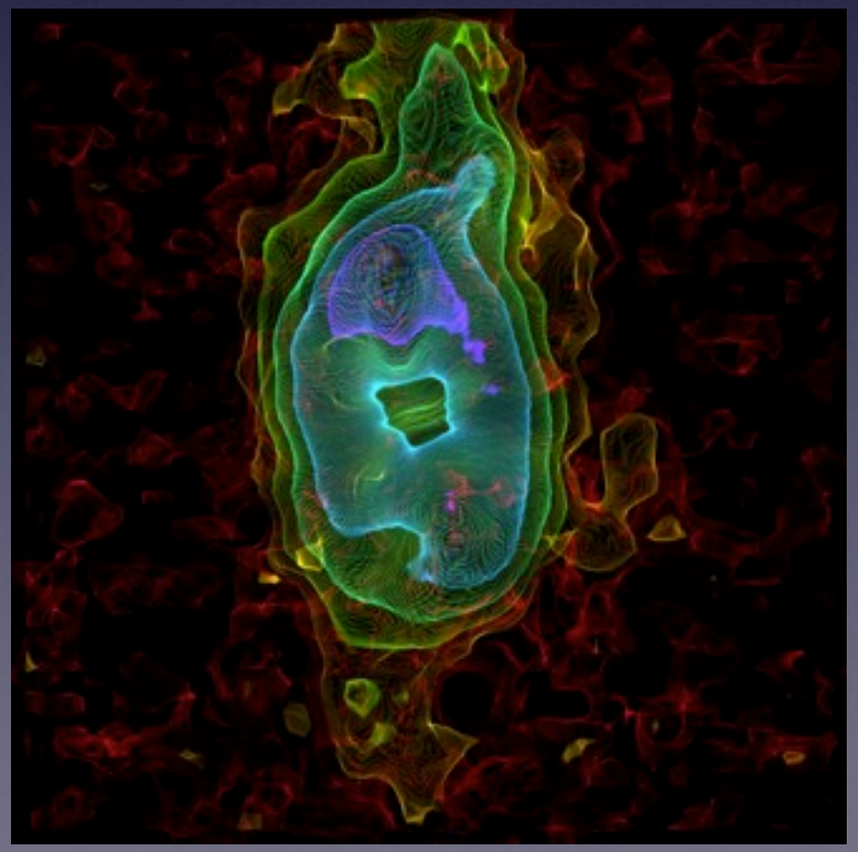
3D2014 ESO 10-14 Dec 2014

Challenge: detecting & characterizing 3D structures

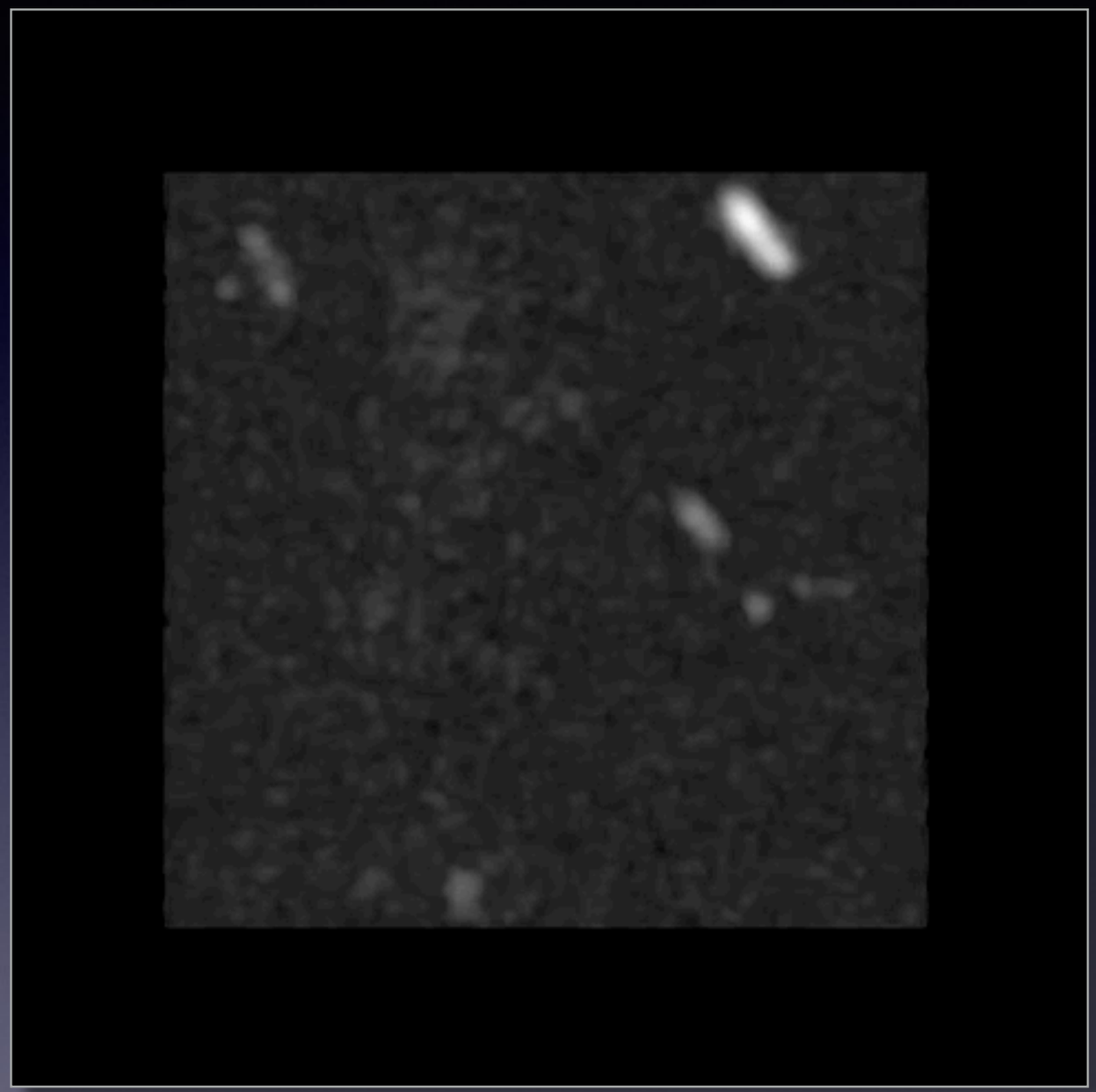
Visualization by
Davide Punzo
Kapteyn Institute

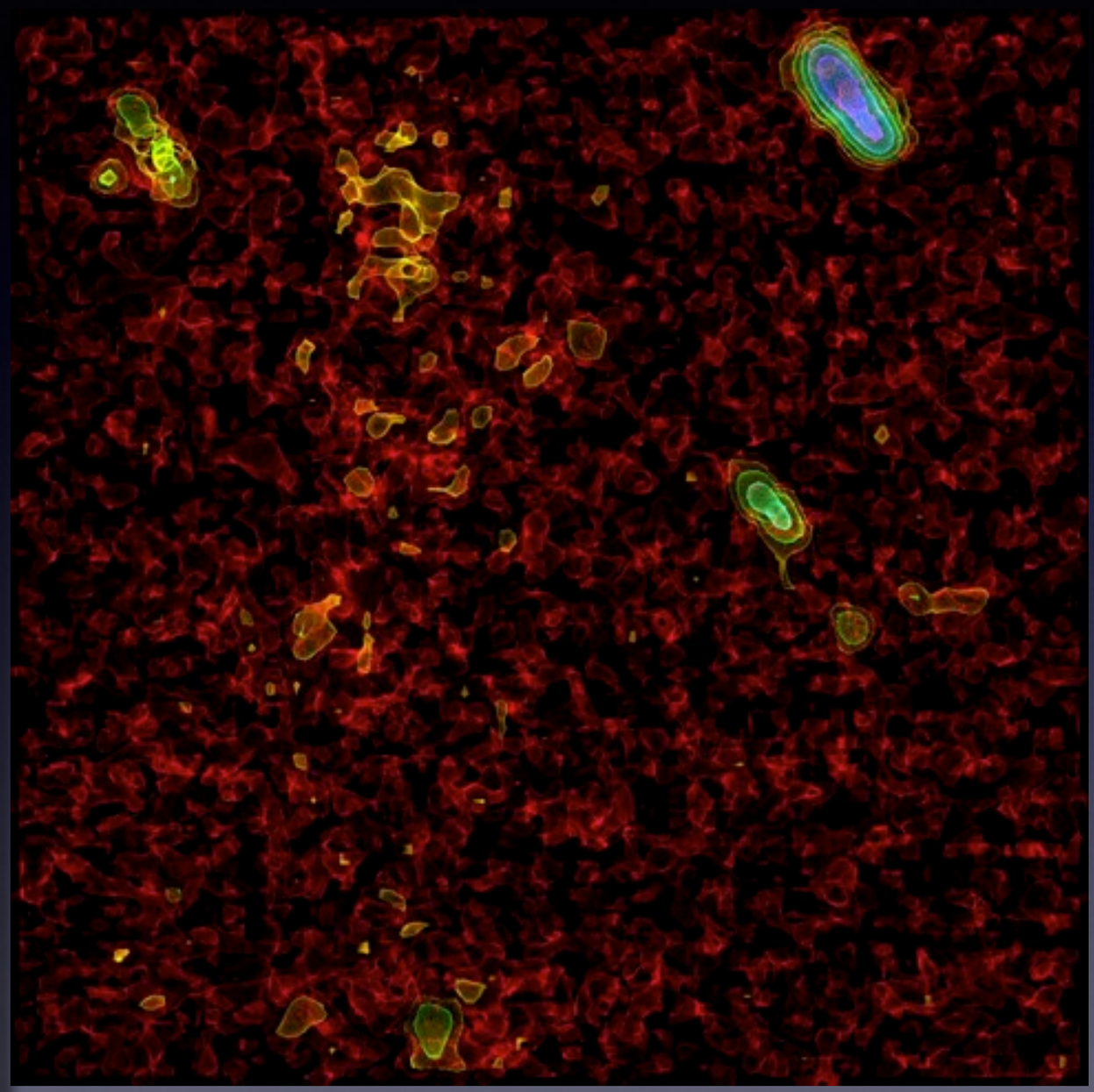






Challenge: detecting & characterizing 3D structures





Visualization by
Davide Punzo
Kapteyn Institute

Challenges for visualisation of 3D data

Challenges for visualization of *HI* in galaxies

Davide Punzo[1]*, J.M. van der Hulst[1], J.B.T.M. Roerdink[2] *D.Punzo@astro.rug.nl
[1] Kapteyn Astronomical Institute, University of Groningen, Landleven 12 Groningen, 9747 AD, Netherlands
[2] Johann Bernoulli Institute, University of Groningen, Nijenborgh 9 Groningen, 9747 AD, Netherlands

Abstract

APERTIF surveys will produce 2048x2048x16384 pixel data cubes covering 3 × 3 degrees over a bandwidth of 300 MHz every day. HI surveys will detect hundreds of well resolved sources, thousands of sources with a limited number of resolution elements and tens of thousands of objects which are at best marginally resolved. The second class of sources contains a wealth of morphological and kinematic information but extracting it quantitatively is difficult due the complexity of the data. Our aim is to develop a fully interactive visualization tool with quantitative and comparative capabilities which will enable flexible and fast interaction with the data. Full 3D visualization, coupled to modeling, provides additional capabilities helping the discovery of subtle structures in the 3D domain.

❑ **Challenge 1**:

Interactive exploration in *full* 3D

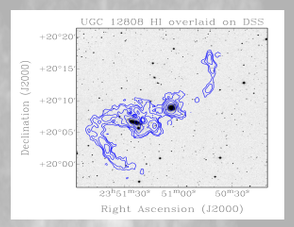
❑ **Challenge 2**:

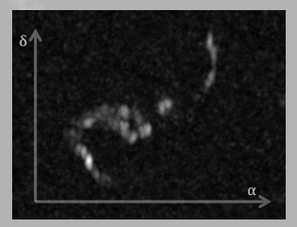
Retrieving quantitative information from selected *volumes*

❑ **Challenge 3**:

Quantitative and interactive comparison with *models*

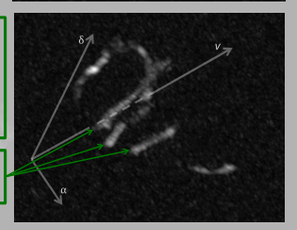
Challenge 1



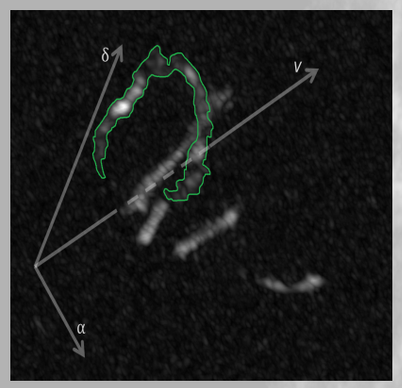


Different view reveals tidal structures much better.

The three streched features are rotating galaxies.

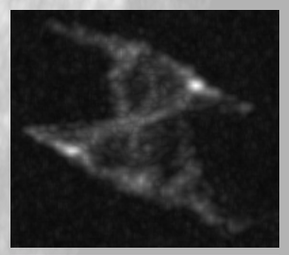


Challenge 2

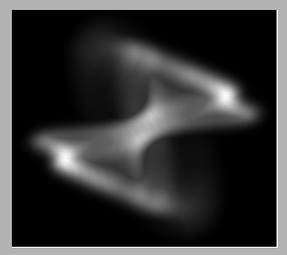


Extract quantitative information from selected volume (HI mass, velocity dispersion and gradient, etc...)

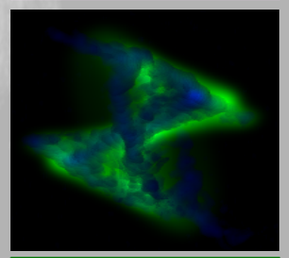
Challenge 3



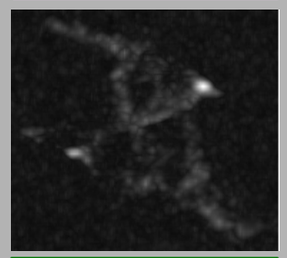
Data



Tilted ring model



Model overlaid on the data



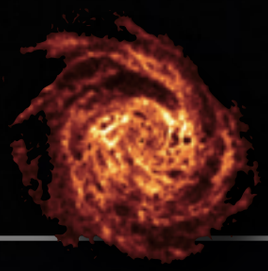
Model subtracted from the data

Our aim: a single interactive tool to meet these challenges.

university of groningen

Highlight talk and poster by Davide Punzo

about the challenges of interactive and quantitative visualisation



Summary

- *HI disks are excellent probes of galaxy structure & kinematics*
  spiral arms, warps, rotation curves, streaming motions, triaxiality, …
- *HI reveals physical processes not/hardly seen otherwise*
  tidal interactions, accretion/inflows, tidal/ram-pressure stripping, Galactic fountain, …

Necessity to deal with the data flood from future HI surveys:

- *Automated 3D shape characterisation*
- *Fully interactive and quantitative visualisation*
- *Coupling to modelling and simulations*