Gaseous Halos of Spiral Galaxies; The HALOGAS Survey

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Outline

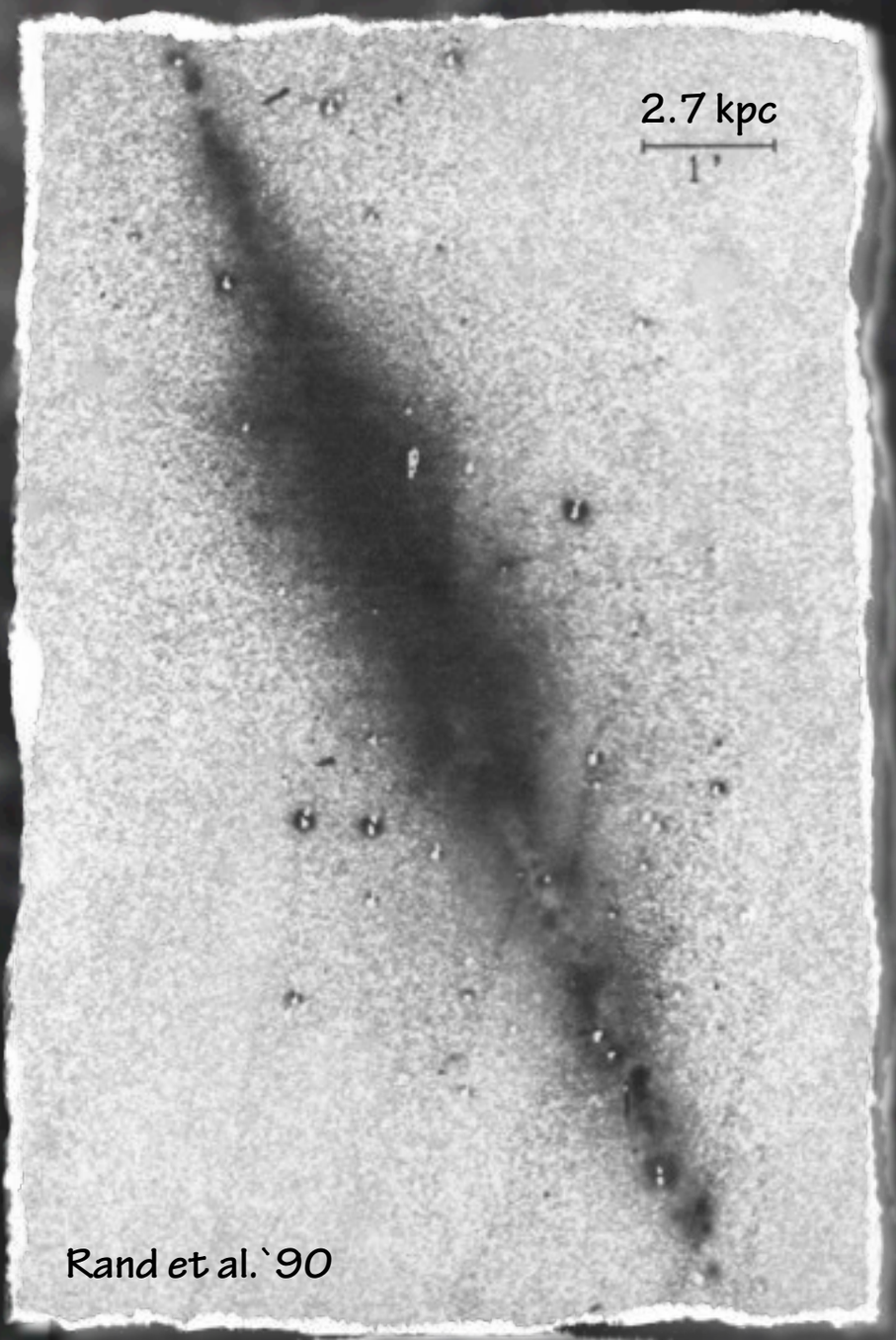
- Introduction
- Westerbork Hydrogen Accretion in LOcal GAlaxieS (HALOGAS) survey
- A single example: NGC 5023
- The Future

Introduction

- Gaseous Halos;
  - What are they?
  - Why are they important?
- The Classical example. NGC 891

Introduction

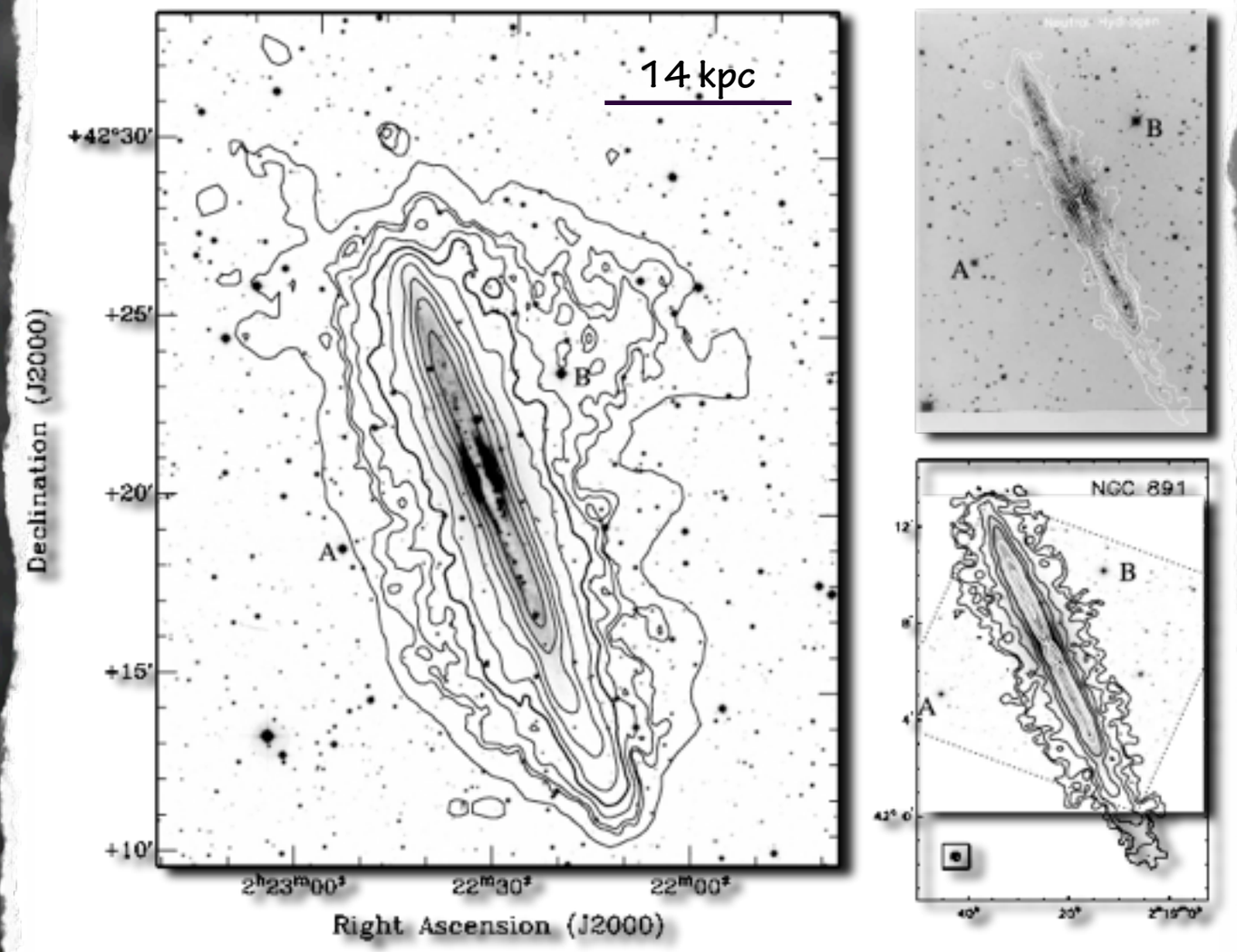
- The vertical distribution of the ionized gas is extensive.
  (Dettmar `90, Rand et al. `90)
- Dust up to 2 kpc
  (Howk & Savage '00,
  Kamphuis et al. '07)



Rand et al.`90

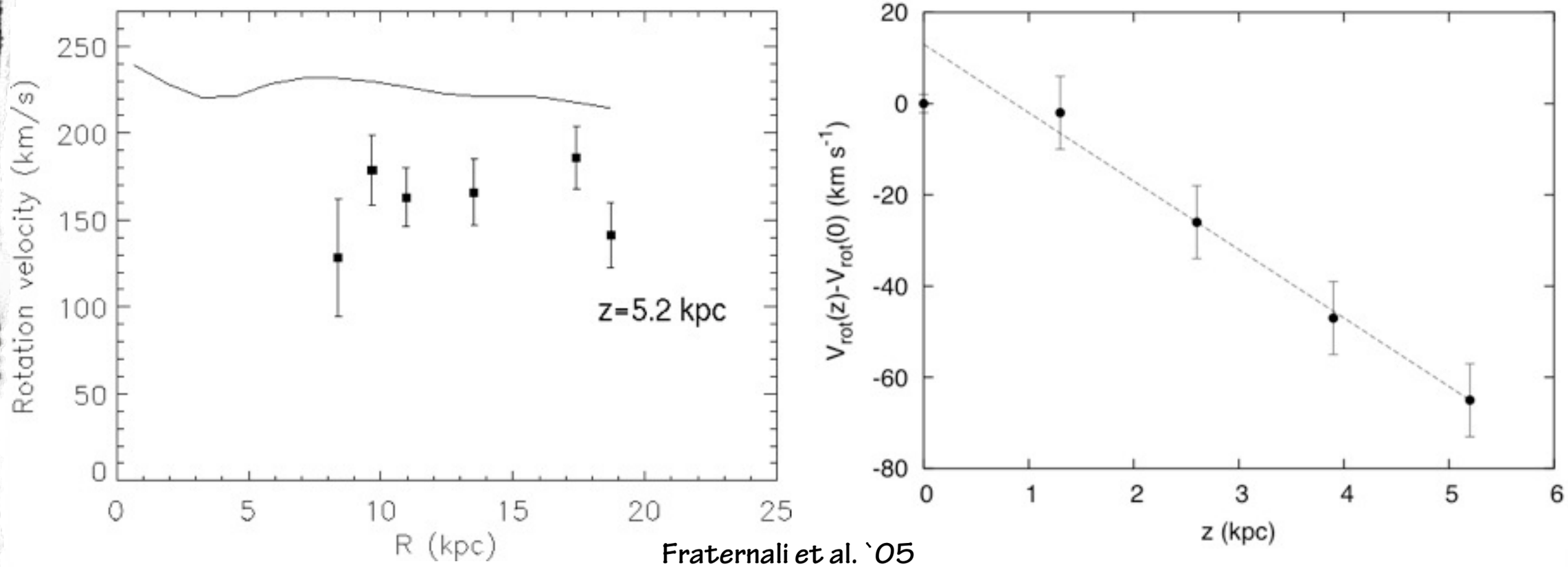
Introduction

- With increased sensitivity, only more HI in the vertical direction.
- 30 % of its HI in the halo. (Oosterloo `07).



Fraternali et al. `05

Introduction

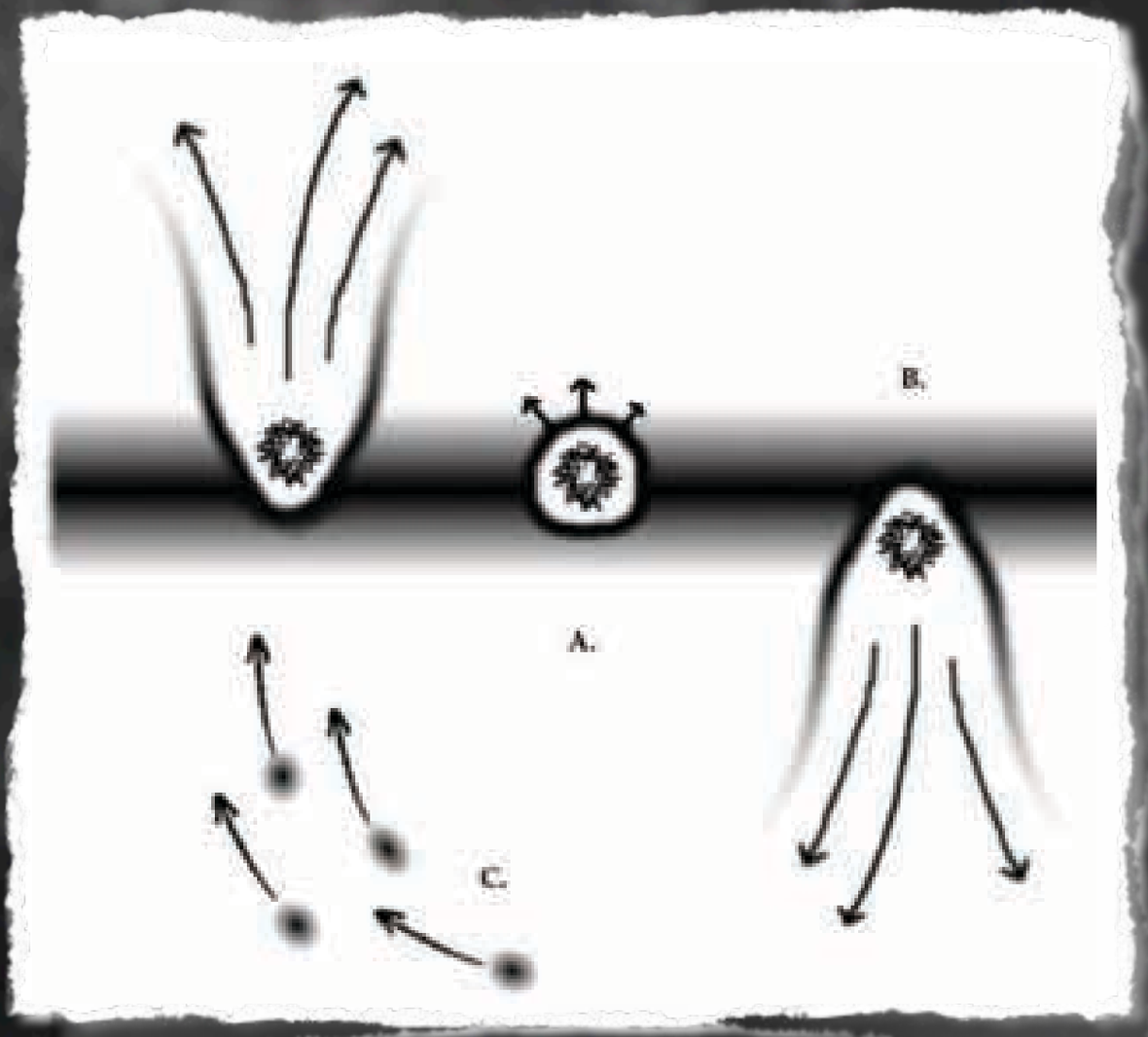


Fraternali et al. `05

In HI (Fraternali et al. `05) and in Hα (Rand `97; Heald et al. `06, Kamphuis `07) a deviation from co-rotation was measured above the plane.

Introduction

- Chimney/Galactic fountain model?
  (Norman & Ikeuchi `89,Shapiro & Field `76)
- Accretion (Sancisi et al `08)
- Stationary Models (Benjamin `02, Barnabe et al. `06)



HALOGAS
Survey Setup

- Team from U.S, Germany, the Netherlands, Italy, Belgium (PI: G.H. Heald)
- 22 edge-on and moderately inclined galaxies
- Each galaxy 10 x 12 hrs WSRT observations
- Typical limiting column density (3σ) NHI~1019 cm-2
- Neutral sample that covers a range of morphology (Sa-Sd), mass, star formation rates.
- Multiwavelength Extensions:
  - Optical: HALOSTARS (INT R-band imaging) (Minor Mergers)
  - UV: deep GALEX Imaging (SF, scattered light)
  - Hα: APO multislit spectroscopy (DIG kinematics)
  - X-Rays: XMM-Newton (Halo Structure)

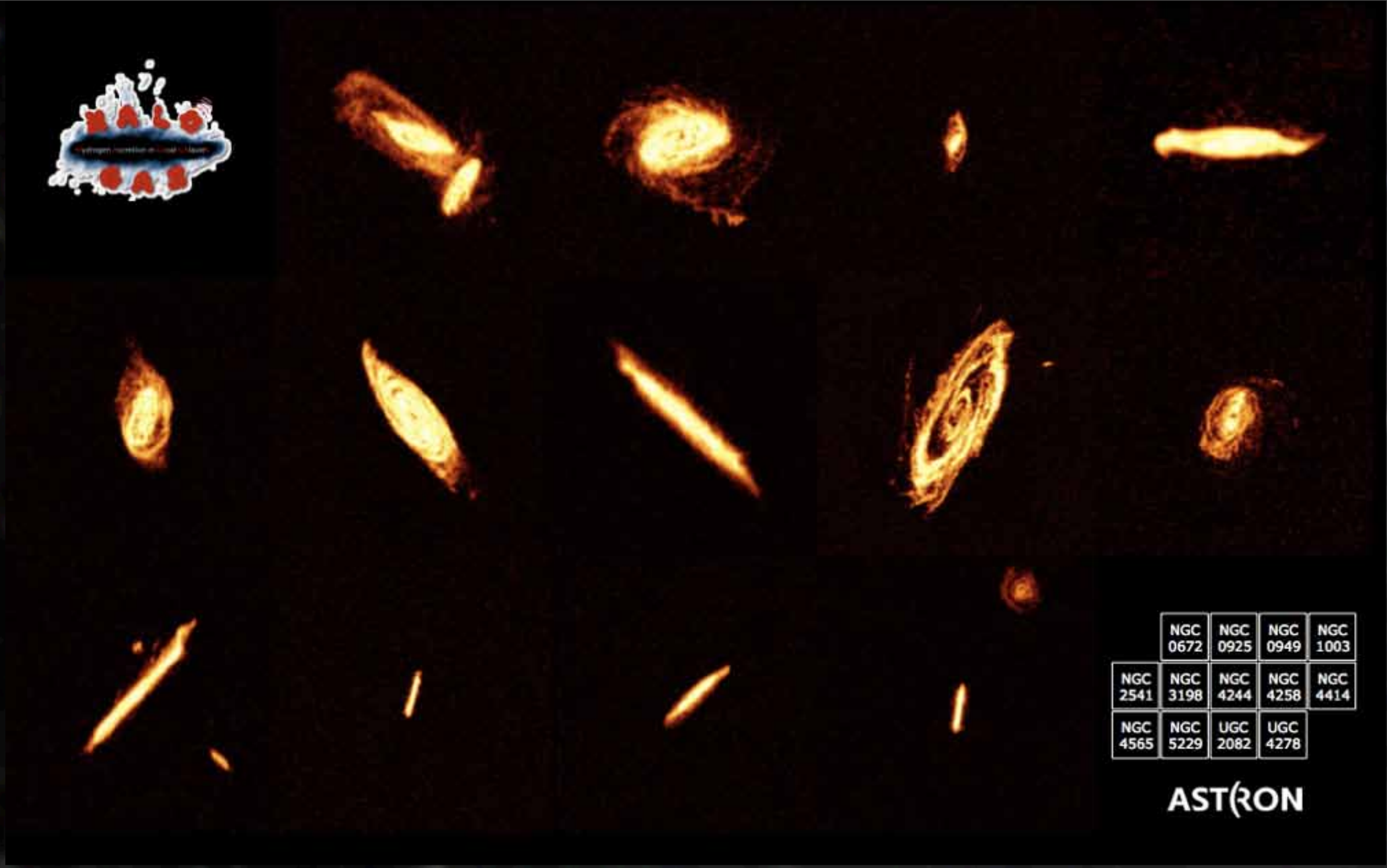
Team Members

George Heald (PI)	ASTRON
Tom Oosterloo	ASTRON
Renzo Sancisi	Osservatorio Astronomico di Bologna
Filippo Fraternali	Bologna University
Rich Rand	University of New Mexico
Gianfranco Gentile	Universiteit Gent
Gyula Jozsa	ASTRON
Paolo Serra	ASTRON
Eva Juette	Ruhr-Universität Bochum
Rene Walterbos	New Mexico State University
Laura Zschaechner	University of New Mexico
Björn Adebahr	Ruhr-Universität Bochum
Maria Patterson	New Mexico State University
Cat Wu	New Mexico State University
Peter Kamphuis	Ruhr-Universität Bochum
Ralf-Jürgen Dettmar	Ruhr-Universität Bochum
Bob Benjamin	University of Wisconsin - Whitewater

HALOGAS

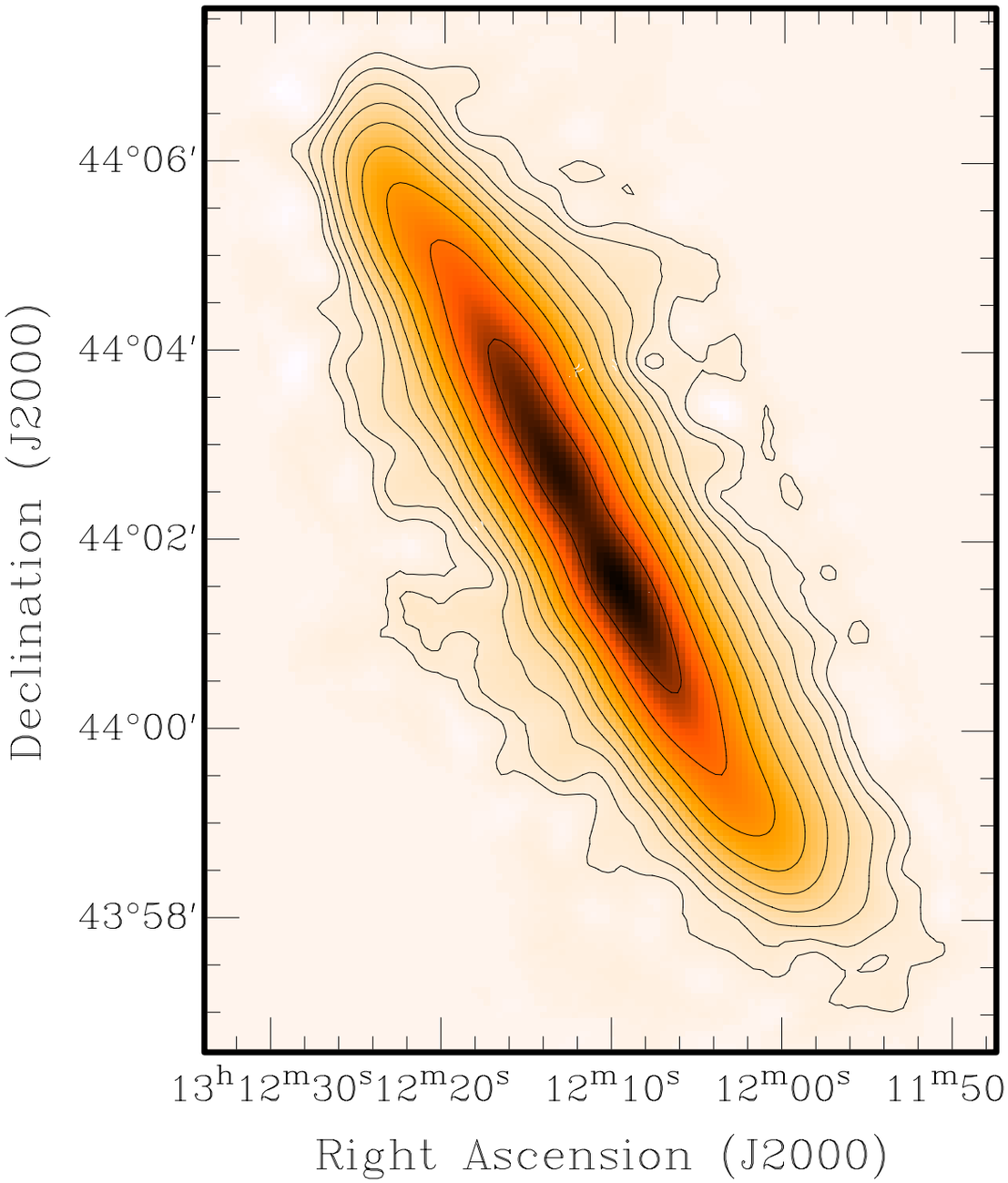
Main Goals & Current Status

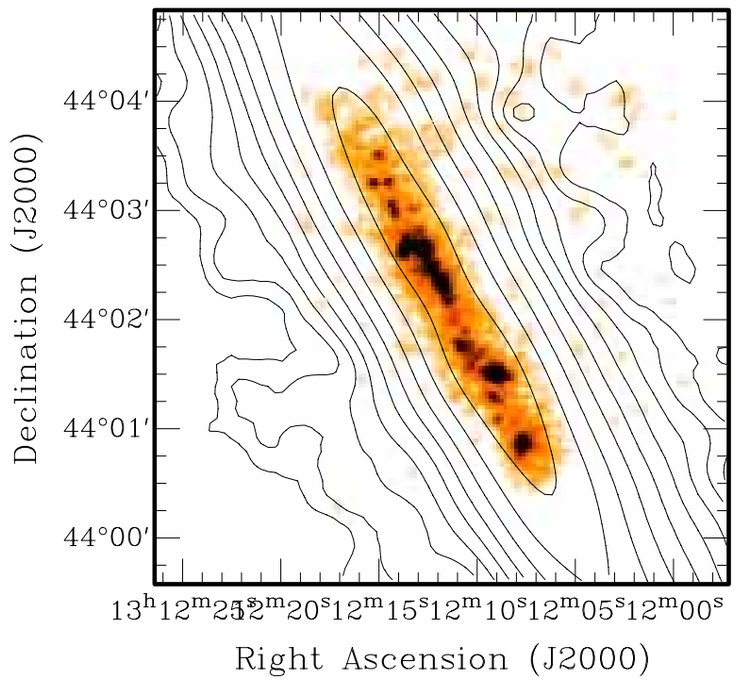
- Provide a census of the amount and manner of cold gas accretion in local spiral galaxies.
- How common are HI Halos?
  - (Preliminary: NGC 891 is special)
- Ongoing analysis, detailed tilted-ring fitting for all galaxies.
  - Pilot Paper (Heald et al. 2011 A&A, 526, 118)
  - First individual galaxy paper published (NGC 4244, Zschaechner et al. ApJ 2011). No Halo, Lag ~9 km/s/kpc.
  - http://www.astron.nl/halogas



First 13 of 22 galaxies, all galaxies are fully observed in HI as of June 2011.

One Example
NGC 5023





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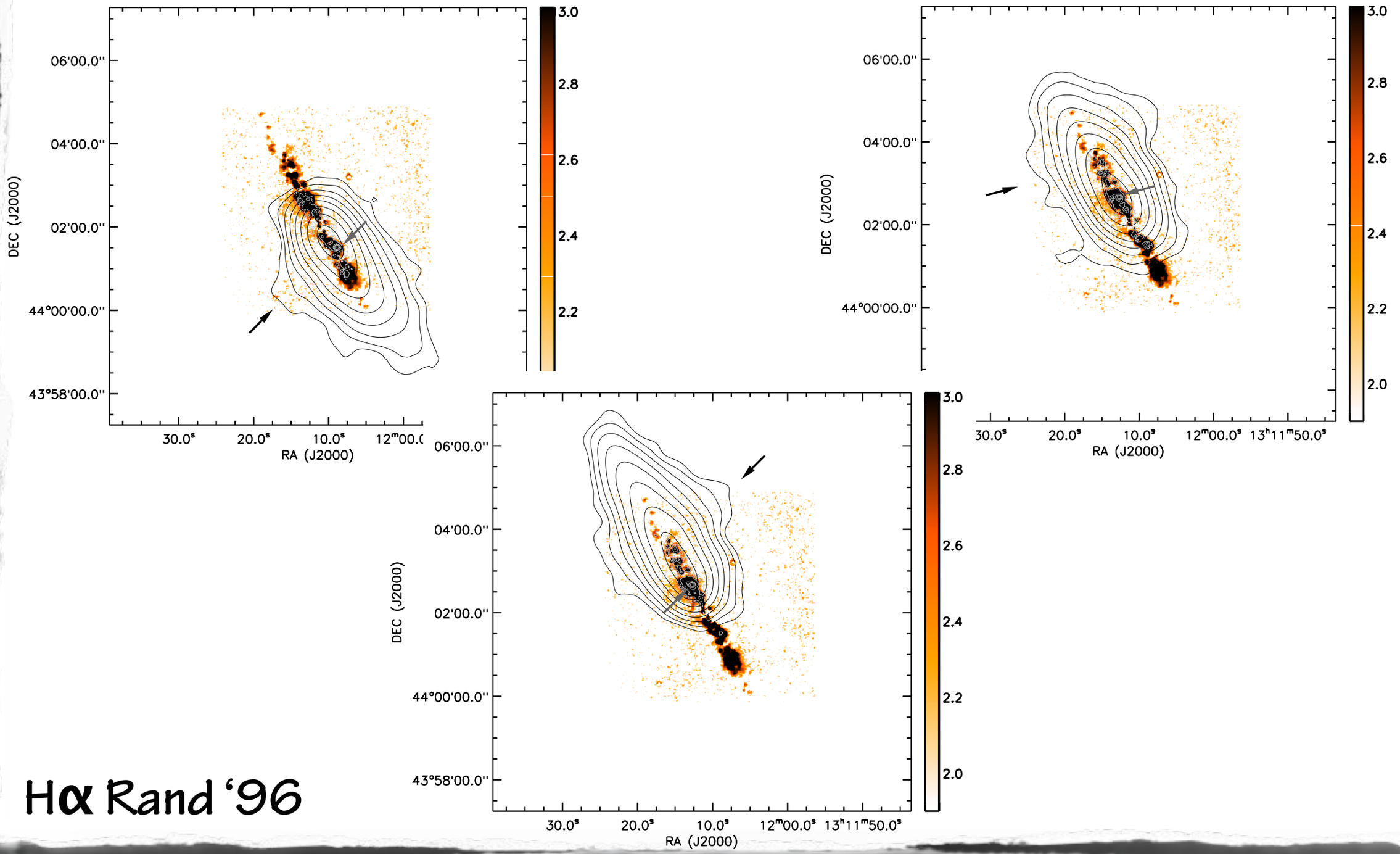
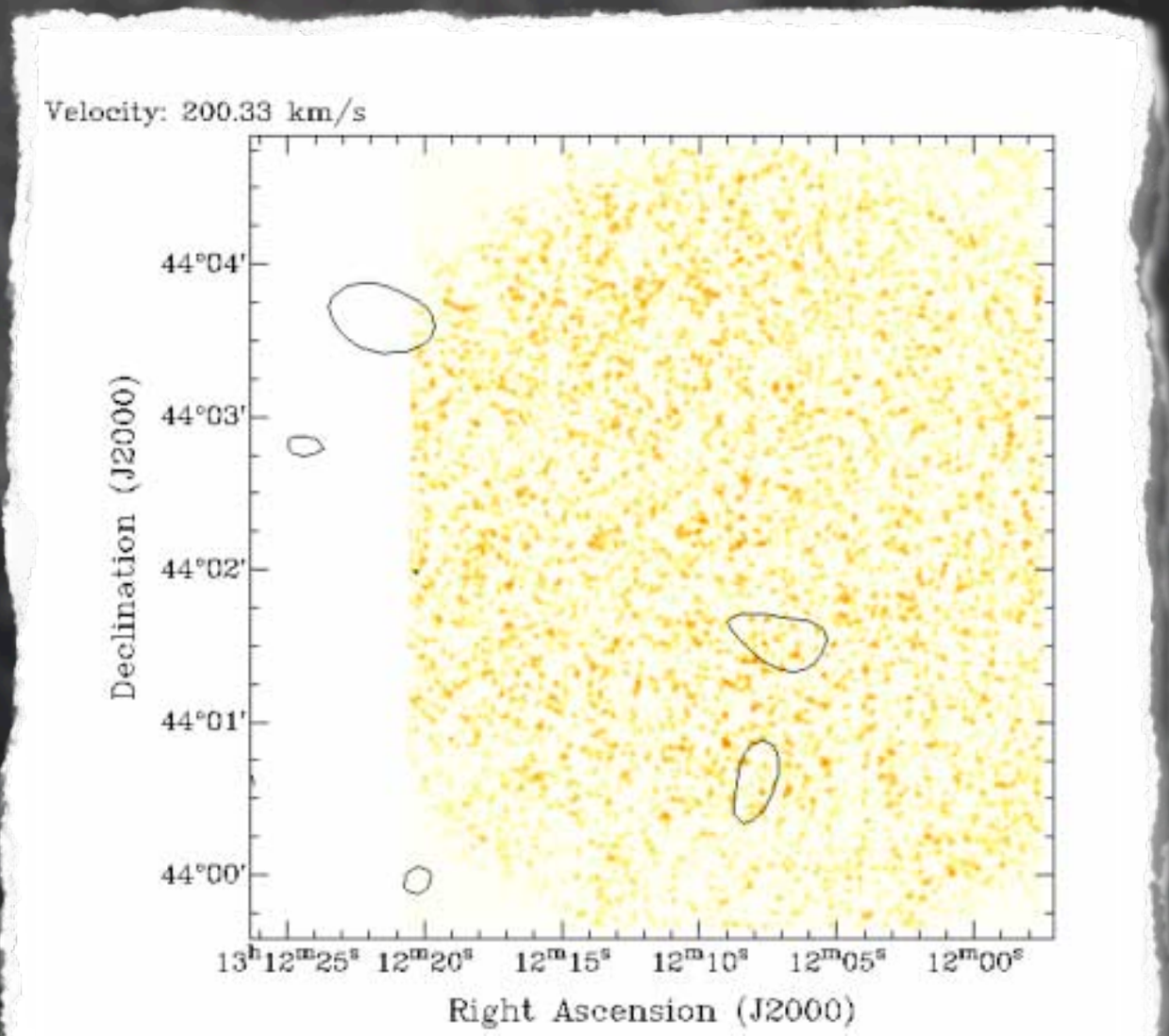


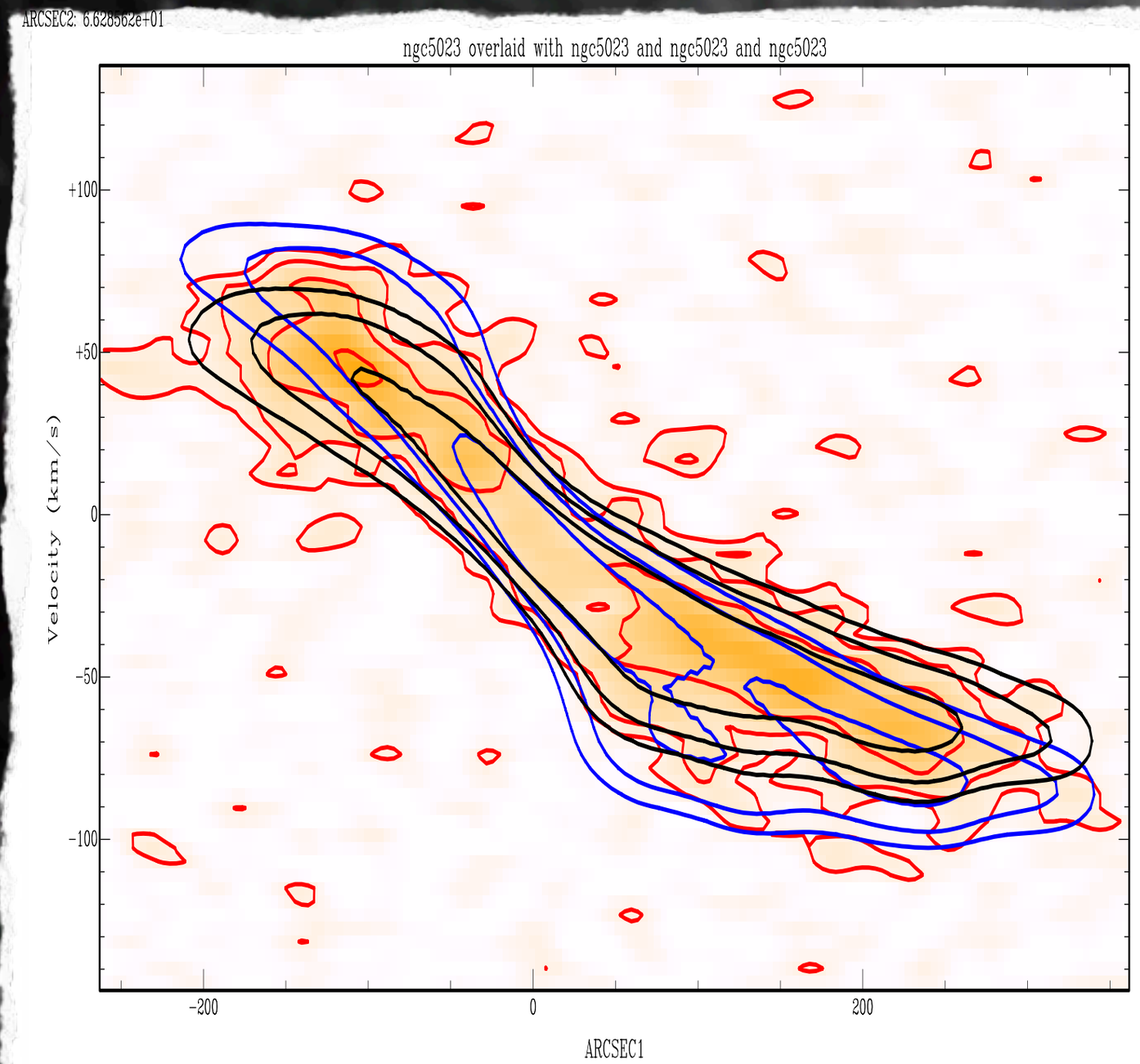
Hα Rand '96

One Example NGC 5023

- NGC 5023
- HI features seem to correlate with underlying HII regions



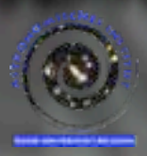
One Example NGC 5023



- PV-diagram 2.1 kpc offset from major axis
- Red Data (2σ x2)
- Blue no-lag
- Black 15.6 km/s/kpc

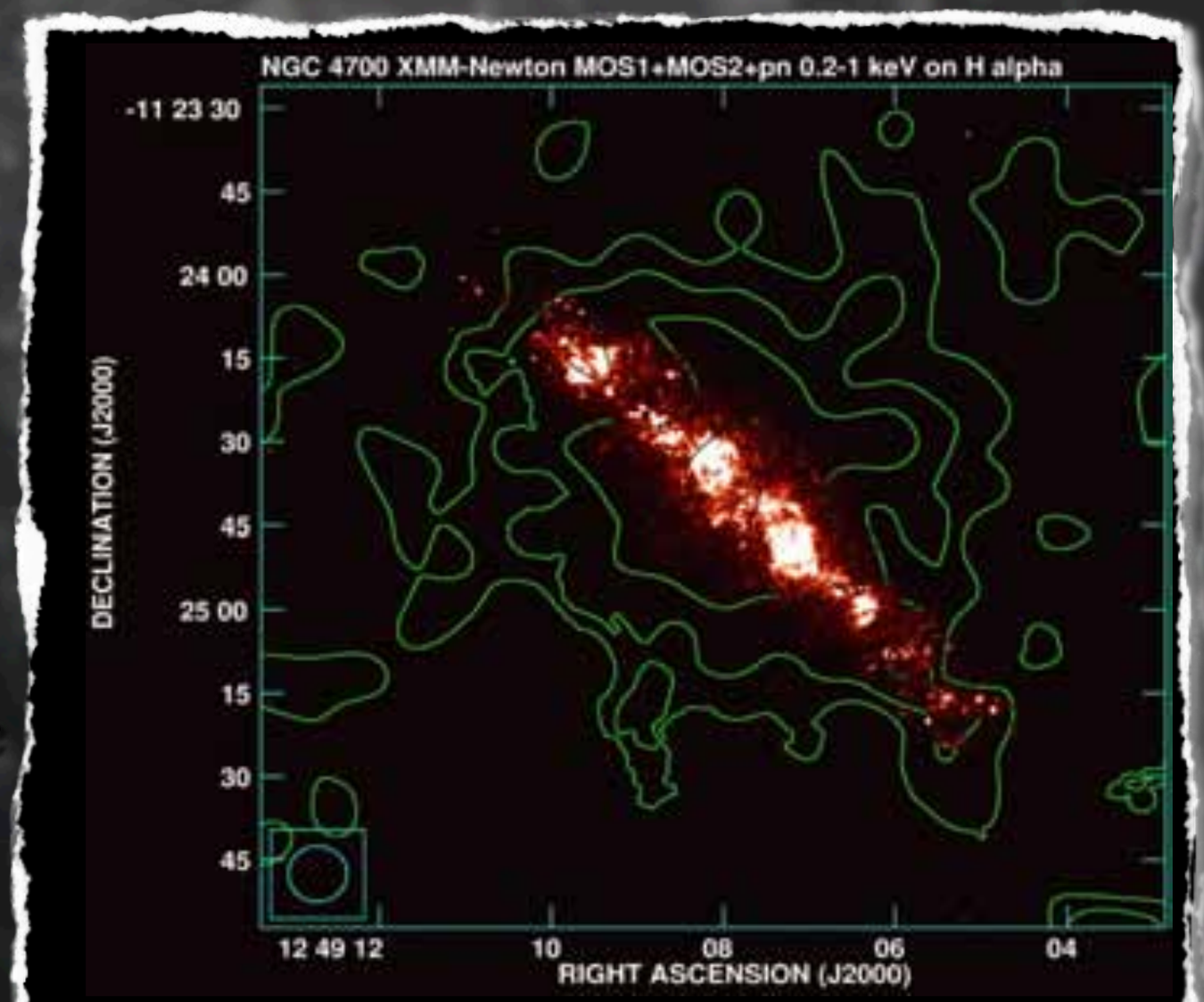
The Future

- Larger telescopes (SKA and pathfinders) are required to observe larger samples in a reasonable amount of time.
- New large surveys will provide proper statistics on cold gas accretion and halo characteristics.
- Larger surveys might be able to separate between different modes of accretion related to morphology or environment.
- Modeling of the lagging halos can be improved by gaining better understanding of the halo through the investigation of other wavelengths, such as the X-rays.



X-Rays and Cosmic Rays

- Often large X-ray halos detected around galaxies.
- Come from the hot gas in the halo.
- Provide additional clues about the structure of the halo.



Wezgowiec & Dettmar in prep.