THE STAR-FORMING DWARF GALAXY POPULATION IN THE LOCAL UNIVERSE AND BEYOND:

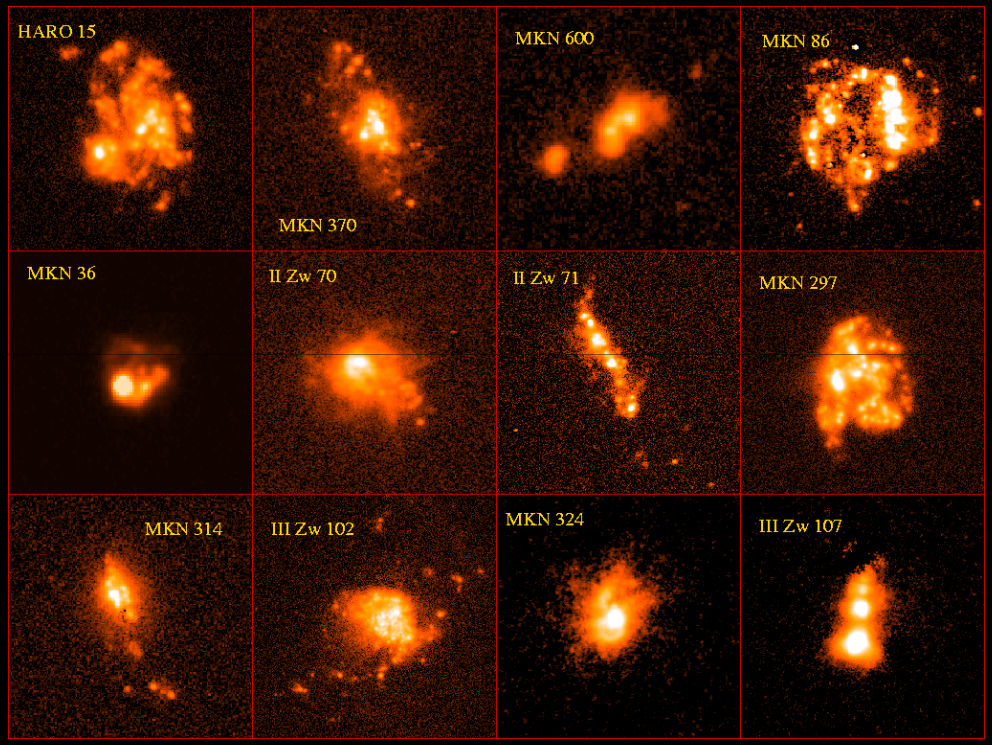
The first 3D Spectroscopic study of a sample of nearby Star-Forming Dwarfs



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STAR-FORMING DWARF GALAXIES



- Starbursts
- Low luminosity ($M_B > -18$)
- Optical H_{II} regions spectra
- Gas-rich objects
- Metal-deficient ($Z_\odot/50 < Z < Z_\odot/3$)
- Star-forming rates: 0.1-10 $M_\odot$/yr
- Blue Compact Dwarfs / H_{II} galaxies / Amorphous galaxies

OPEN QUESTIONS

1. What is their evolutionary status? Are all of them old or do young galaxies exist?
2. What are their star-forming histories?
3. What is their dust content and distribution?
4. Are there evolutionary connections between SFDs and other types of dwarfs?
5. What mechanisms trigger the starburst? Are interactions and mergers playing a role ?

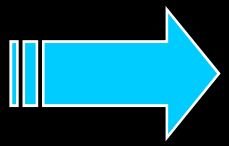
INTEGRAL FIELD SPECTROSCOPY

SCIENTIFIC BACKGROUND

• **90s- ...** Surface brightness photometric studies in the optical and in the NIR of large samples

Papaderos et al. 1996ab; Doublier et al 1997,99; Telles 1997; Marlowe et al. 1997, 1999; Ostlin 1998; Noeske et al. 2003, 2005; Bergvall & Ostlin 2002; Cairós et al 2000, 2001ab, 2003, 2005; Gil de Paz et al. 2003, 2005; Caon et al. 2005; Amorin et al. 2007.

Structural properties of the host: exponential or Sersic ? ; 1D vs 2D modelling



SPECTROPHOTOMETRIC ANALYSES ARE ESSENTIAL

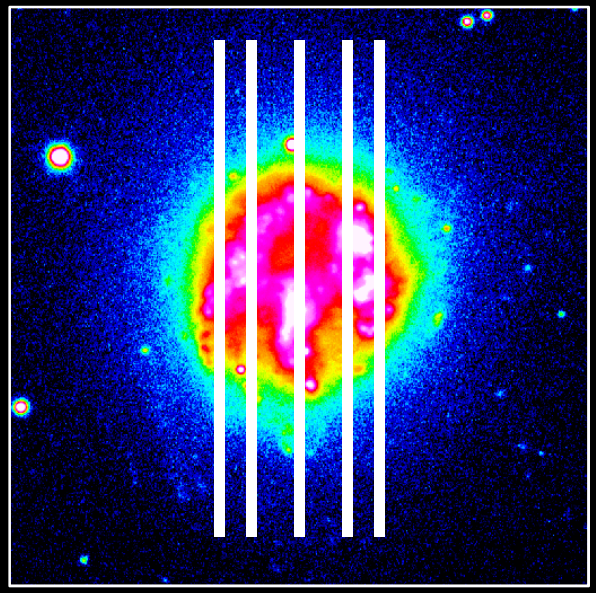
- Characterize the young stars (Hα, WR features ...)
- Gaseous emission (Cairós et al. 2002, 07)
- Dust (Hunt et al. 2001, Cairós et al. 2003, Johnson et al. 2004, Vanzi & Sauvage 2004)
- Absorption features tracing the old stars

Méndez et al. 1999: IIZw33; Gil de Paz et al. 2000: Mrk86; Papaderos et al. 1988: SBS 0335-052; Cairós et al. 2002: Mrk370; Cairós et al. 2007: Mrk35

SPECTROPHOTOMETRIC ANALYSIS OF SFDs

- Broad-band imaging: UBVRI + NIR
- Narrow-band frames
- long slit spectroscopy

  + evolutionary synthesis models

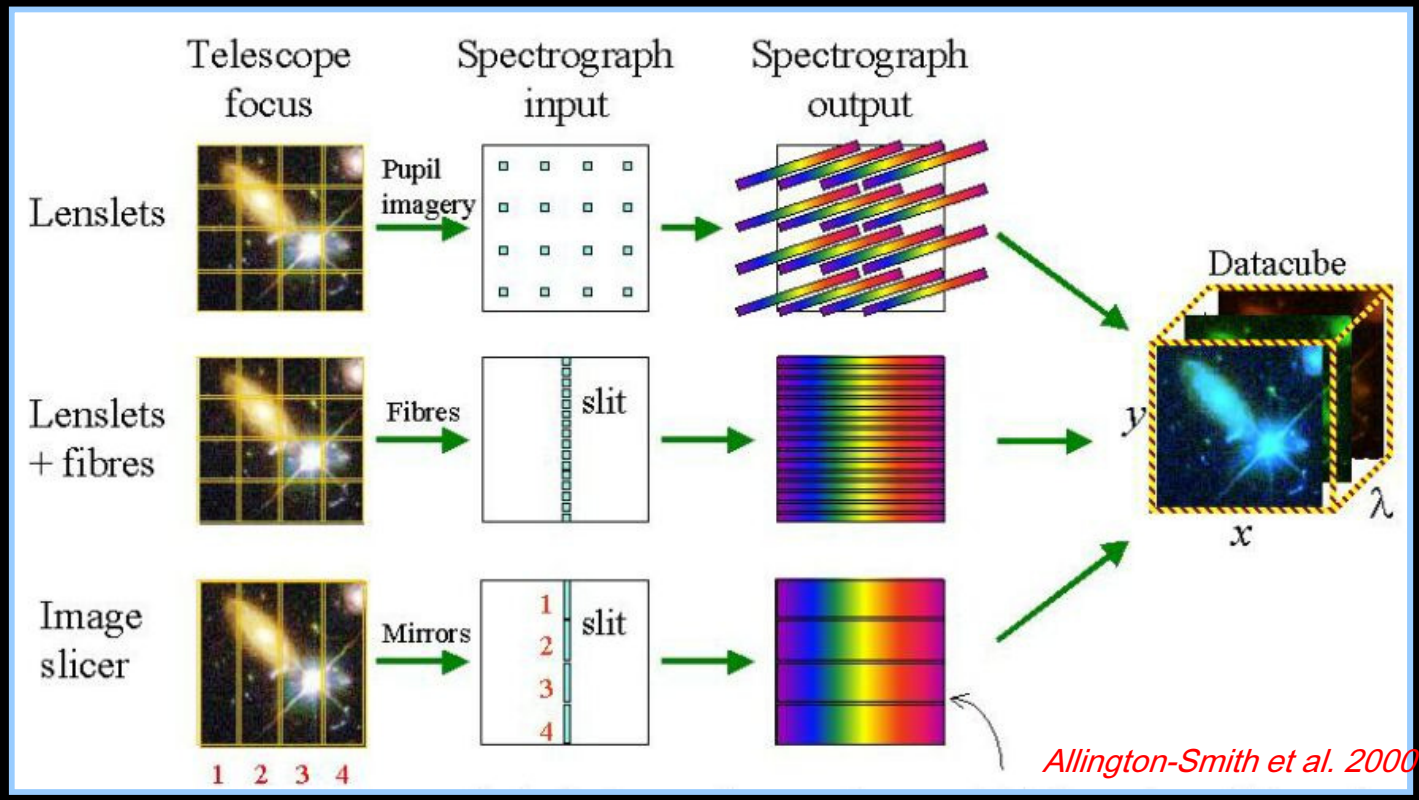


DRAWBACKS

- Prohibitive exposure times: 2-3 nights per object = individual objects
- Long-slit spectroscopy: Sequentiality + Accuracy of the slit position
- Non-homogeneity of the whole data collection

SPECTROPHOTOMETRIC ANALAYSIS OF STATISTICALLY MEANINGFUL SAMPLES ARE NOT FEASIBLE

INTEGRAL FIELD SPECTROSCOPY



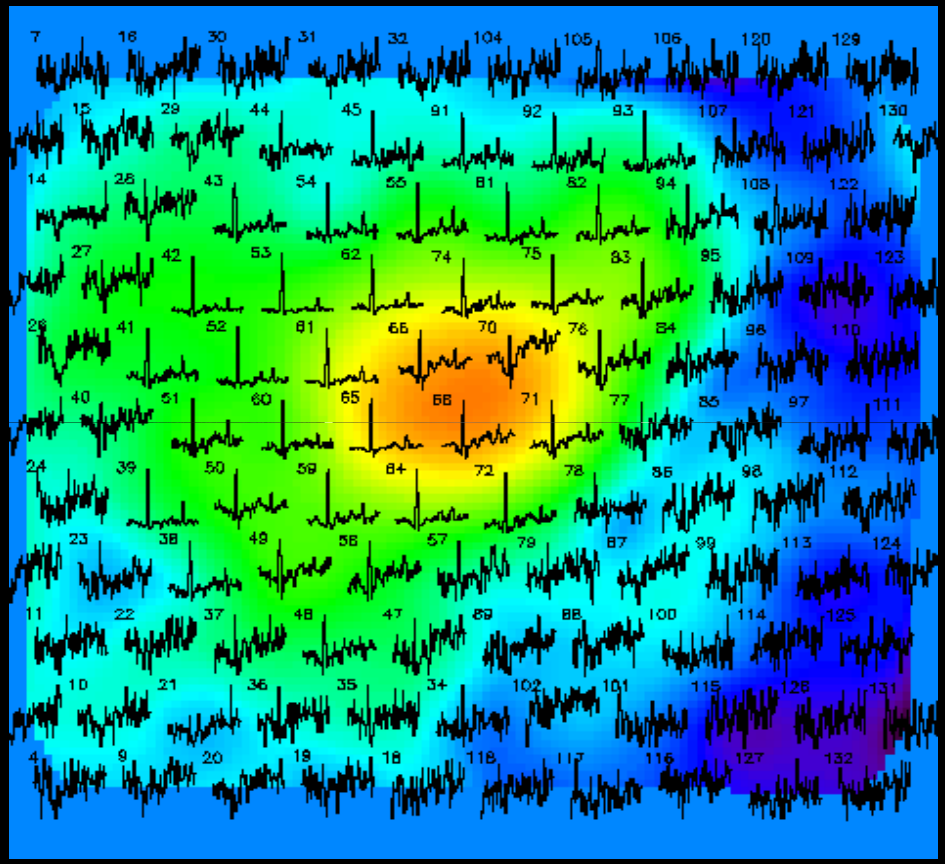
Record simultaneously three variables (α, δ and λ) in two dimensions (x and y)

Homogeneity

Shorter exposure times

THE POWER OF IFU SPECTROSCOPY

One exposure = imaging and spectra over a wide wavelength range.



IFU observations are one order of magnitude more efficient than traditional techniques

Now, for the first time, spectro-photometric studies of large samples of SFDs are feasible

THE FIRST 3D SPECTROPHOTOMETRIC MAPPING OF A LARGE SAMPLE OF STAR FORMING DWARFs

THE SAMPLE:

- 60 Galaxies
- Luminosity range: MB = -14.10 to **–20.50**
- Metallicity: 0.05 – **0.85 $Z_{\odot}$**
- All morphological subclasses (Cairós et al. 2001b)
- Additional deep imaging in at least two bands

IMMEDIATE AIMS

Build flux and equivalent width maps of emission lines: Hγ, Hβ, Hα, [OIII] or the shock-heated [SII], [OII]

Age, SFR, trigger of SF

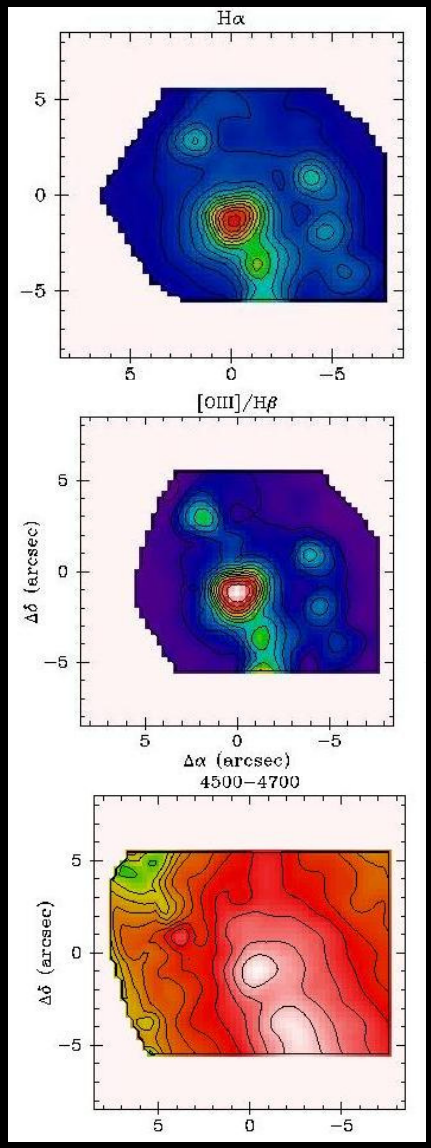
Build maps of the most interesting line ratios: [OIII]/ Hβ or [NII]/ Hα

Ionization mechanism

Build continuum maps (lines free passband or interpolating across emission lines)

Morphology and stellar content

Mrk314



IMMEDIATE AIMS

Map the reddening

Dust content and distribution

Map WR features, 4650-4690 Å

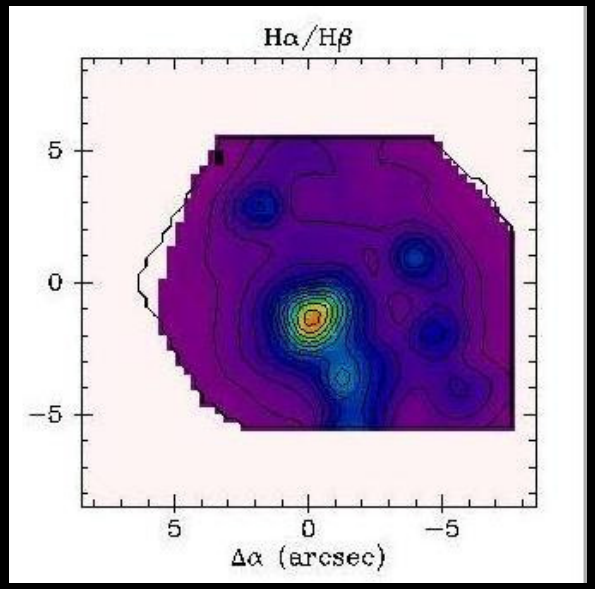
Ages and IMF parameters

Map the physical parameters of the gas (Te,Ne)

Chemical abundances

Search for absorption features tracing the cooler stars: Mg 5167, 5184 Å, Fe 5270, 5335 Å , Na 5890, 5896 Å, CaT

Ages and metallicity of the old stars

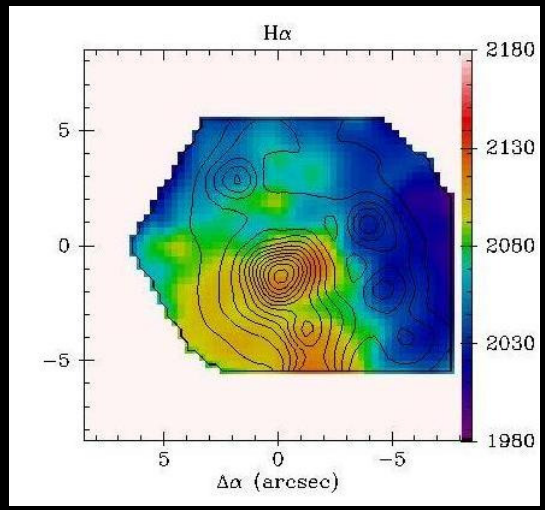


IMMEDIATE AIMS

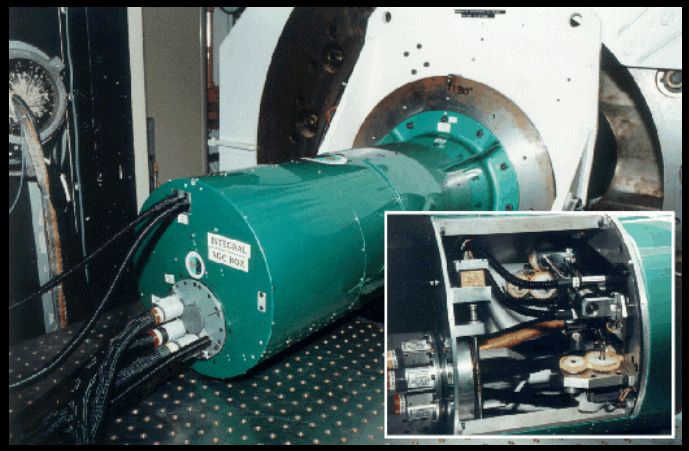
Gas velocity fields
+
Stars velocity fields

- Mechamism that trigger the SF, interactions?

Starburst99 GALEV



OBSERVATIONS - INSTRUMENTATION



INTEGRAL, 4.2m WHT, ORM

FOV rectangular

STD/SB2 0.9´´ FOV: 16.0 x 12.3

Number of fibers: 219 (189 + 30)

STD/SB3 2.7´´ FOV: 33.6 x 29.4

Number of fibers: 135 (115 + 20)

Spectral range: 4300 – 7304

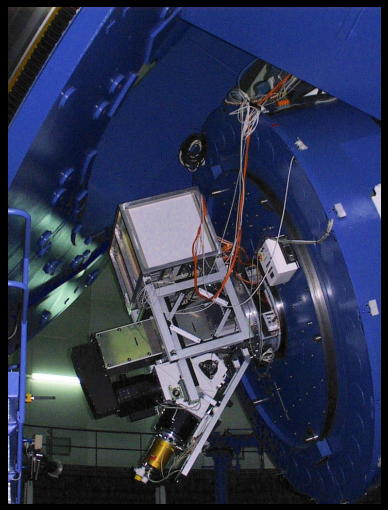
3700 –6900

Linear dispersion: 3 A/pix

Typical exposure times: 2 hours

- Mrk297, IIIZw102, Mrk314, Mrk370, Mrk35
- Mrk33, Mrk140, UM462, Mrk131, Mrk36, Mrk35

OBSERVATIONS - INSTRUMENTATION



PMAS 3.5m CAHA

PMAS/Lens array	PPAK IFU
FOV rectangular	FOV hexagonal
1.0´´/lens FOV: 16.0 x 16.0	2.7´´ FOV: 74.0 x 65.0
Number of fibers: 256	Number of fibers: 331 + 36+15

Spectral range: 3600 – 7000

Linear dispersion: 3A/pix

Typical exposure times: 2 hours

5 nights allocated in March 07

10-12 objects

- Mrk32, Mrk177, Mrk475, Izw123, Mrk209, Mrk450, Mrk747
- Mrk5, Haro33, Mrk170
- IIZw71, Mrk149, Mrk157, Mrk186

OBSERVATIONS - INSTRUMENTATION



FOV hexagonal

4.10´´ FOV: 112 x 112

Spectral range ~ 3400-5650

Linear dispersion: 1.2 A/pix

Number of fibers: 247

Typical exposure times: 3-4 hours

VIRUS-P, 2.7 Harlan J. Smith, McDonald Observatory, Texas

On-going program during the instrument commissioning:

Larger objects as IIZw33, IIIZw102, Mrk153, Mrk401 …

OBSERVATIONS - INSTRUMENTATION



FOV rectangular

0.67´´ FOV: 27.0 x 27.0

Spectral range ~ 4200 – 7400

Linear dispersion: 3A/pix

Number of fibers: 6400

Typical exposure times: 1-2.5 hours

VIMOS, 8.2m VLT, ESO

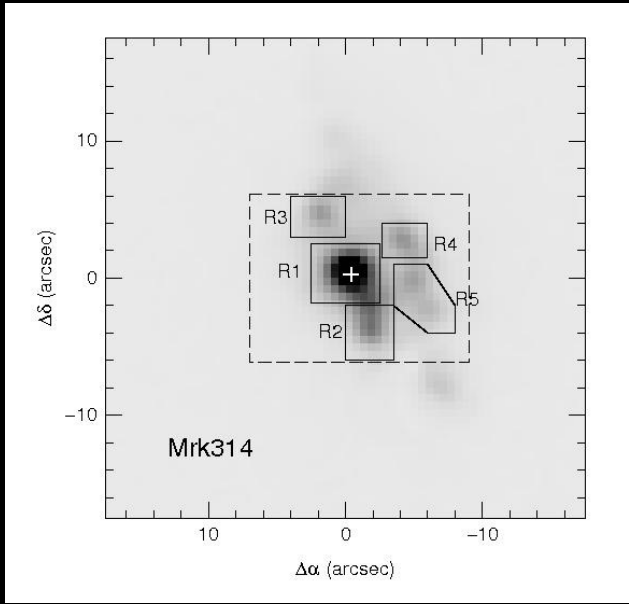
Allocated 3 nights, August:

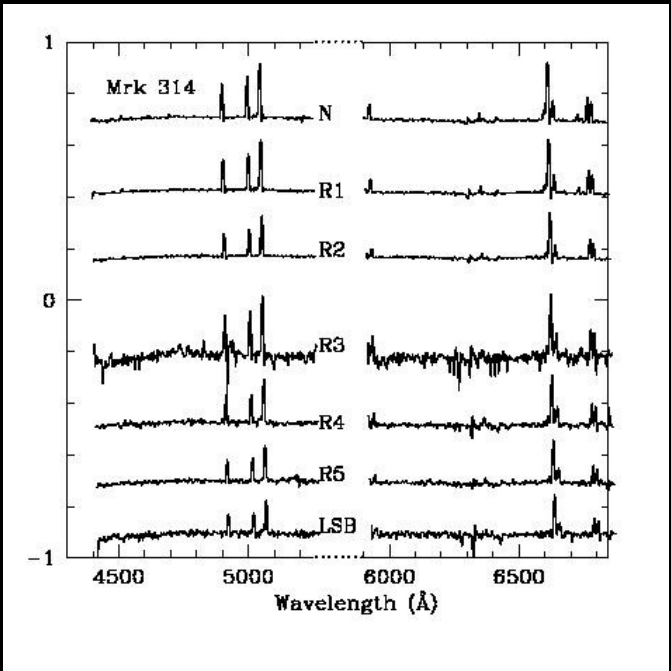
high signal to noise observations

Tololo 197-423, Mrk900, Mrk1131, Haro14, Haro15, Tololo0127-397

ANALYSIS AND FIRST RESULTS

1. We study the properties of selected regions: flux, eqw, line ratios …

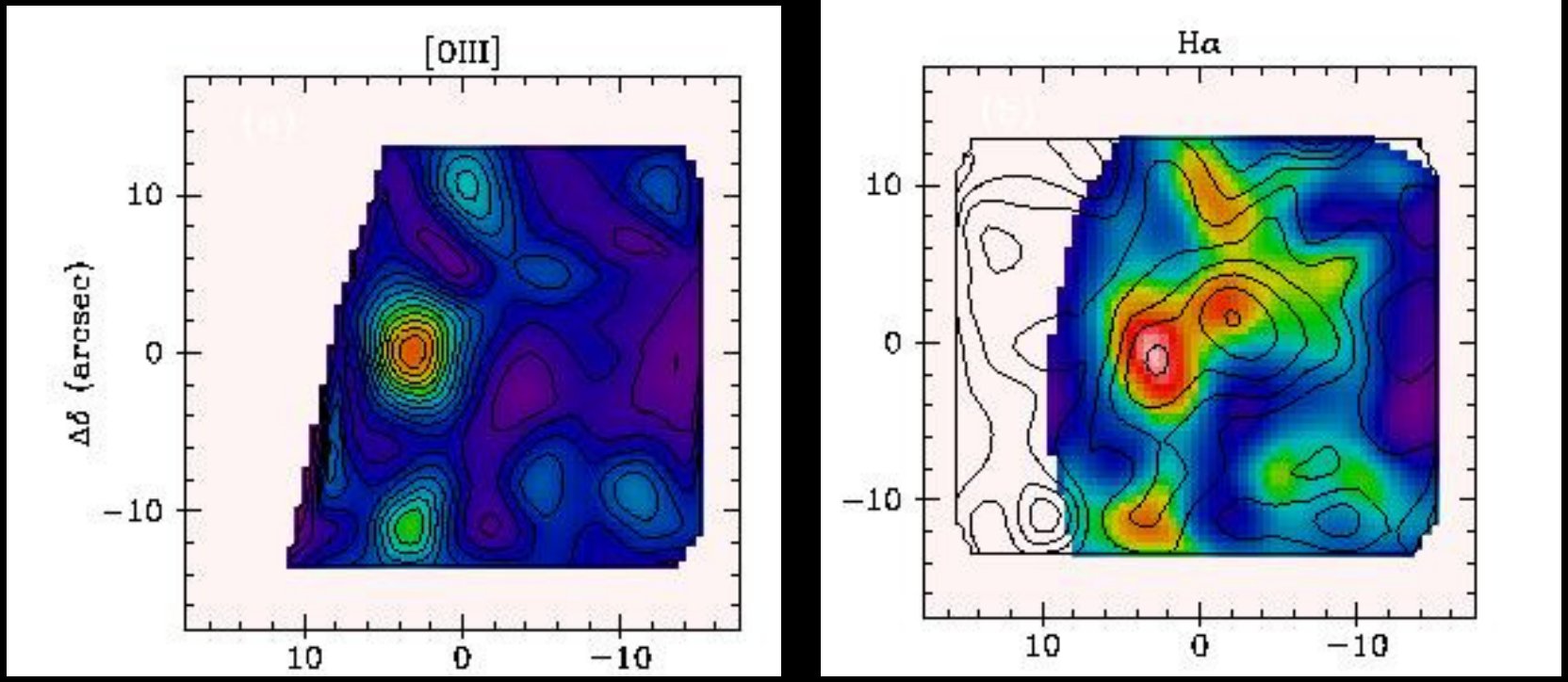




Densities, ionization mechanism, abundances

FIRST RESULTS

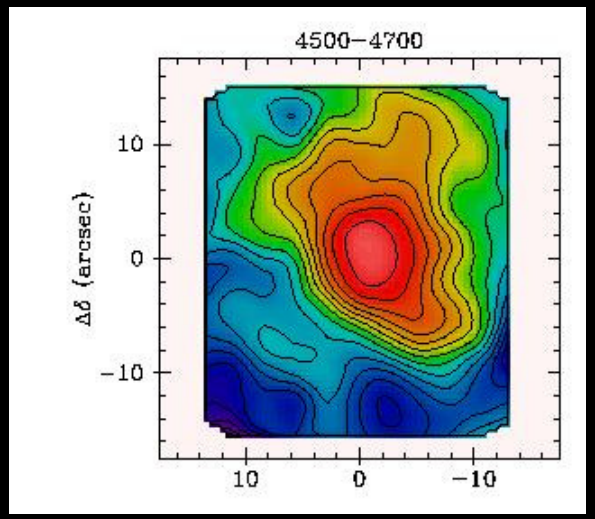
1. Maps of ionized gas

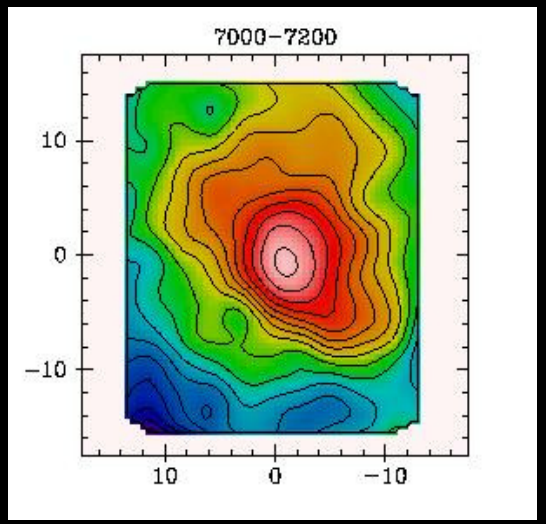


Mrk 297: [OIII] + Hα

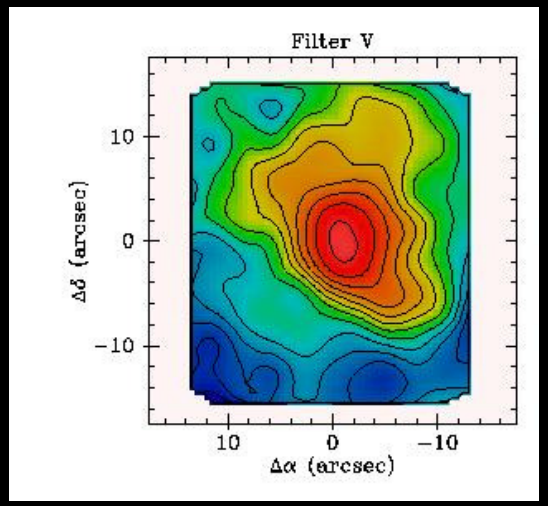
FIRST RESULTS

2. Continuum maps





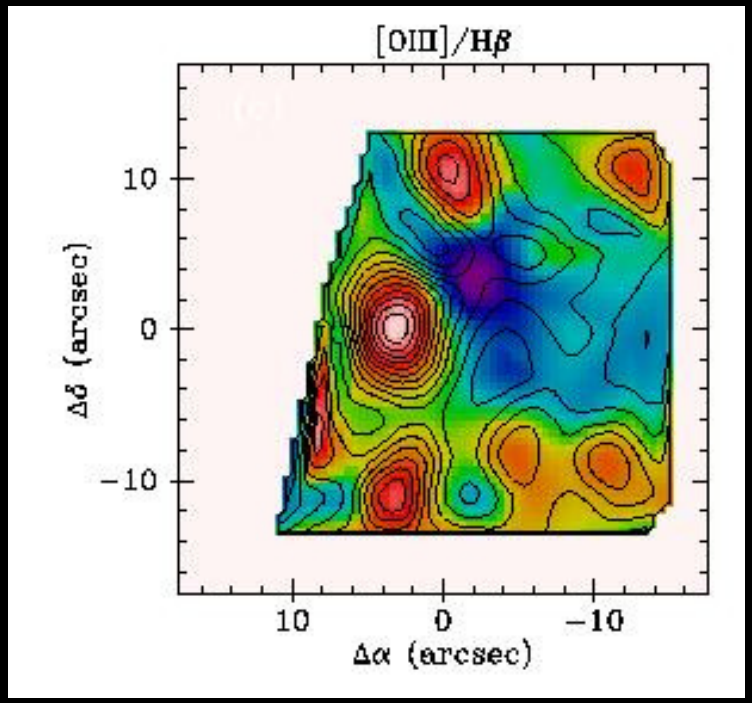
IIIZw102: ``pure continuum´´´maps



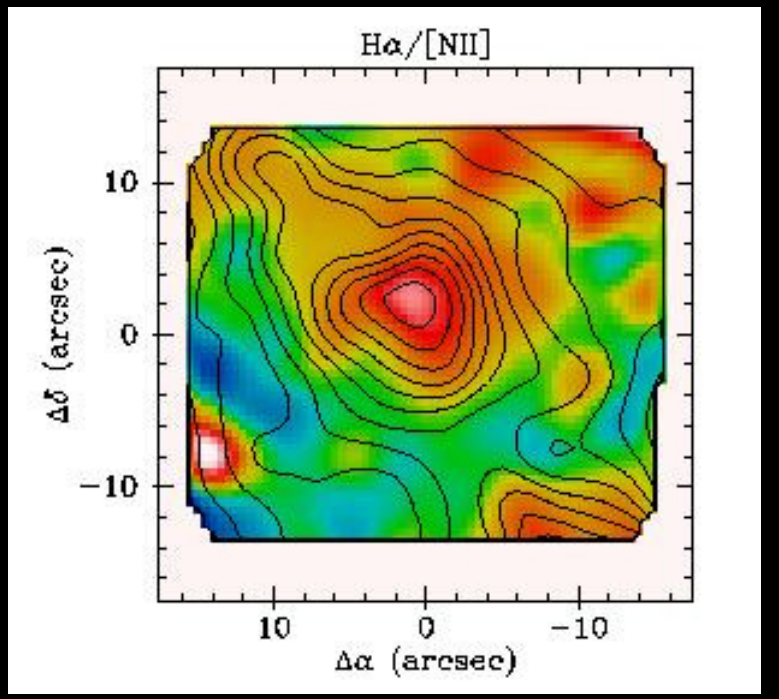
V-band map

FIRST RESULTS

3. Line ratio maps



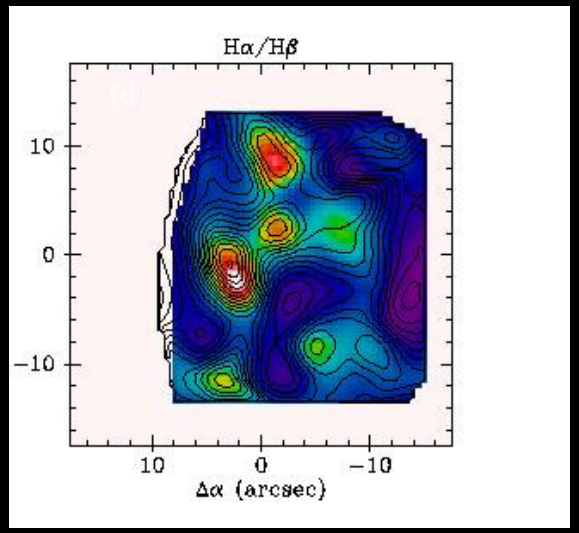
Mrk297



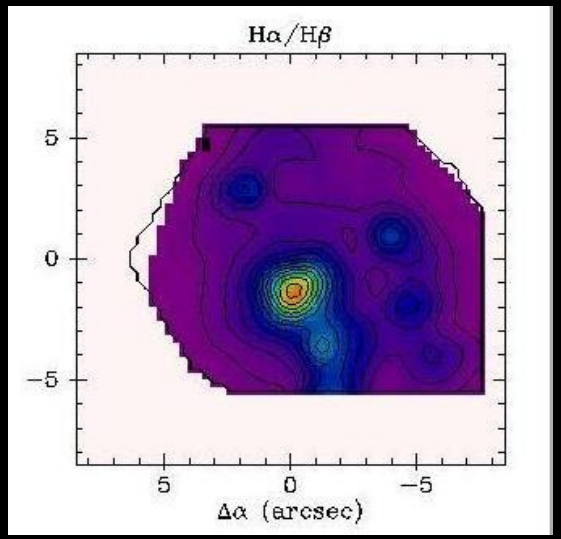
Mrk35

FIRST RESULTS

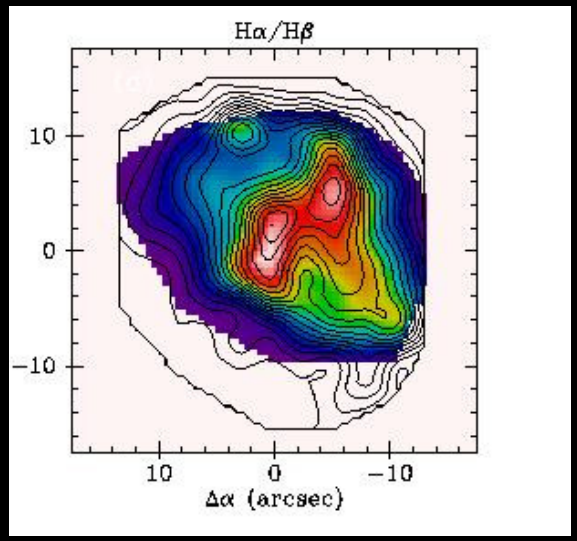
4. Extinction maps



Mrk297



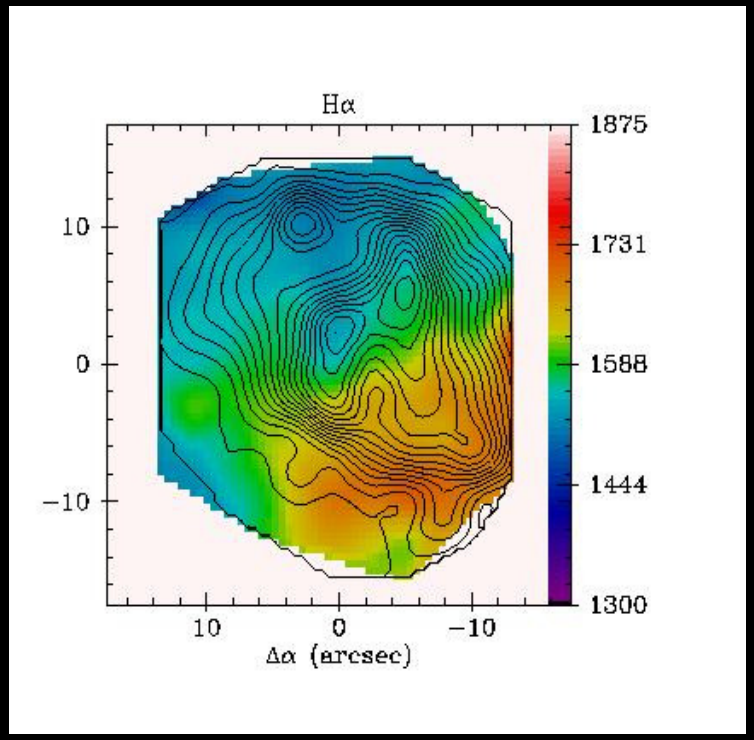
Mrk314



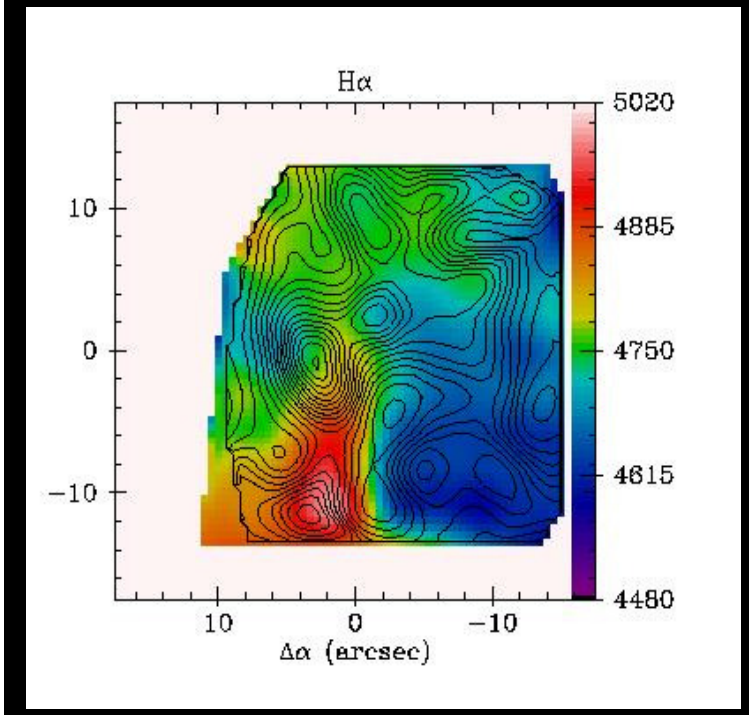
IIIZw102

FIRST RESULTS

5. Ionized gas kinematics



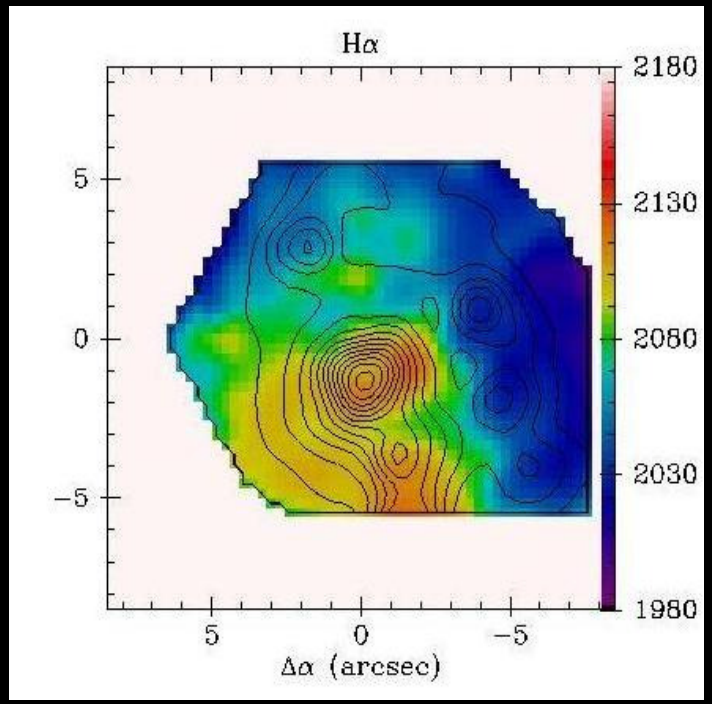
III Zw 102



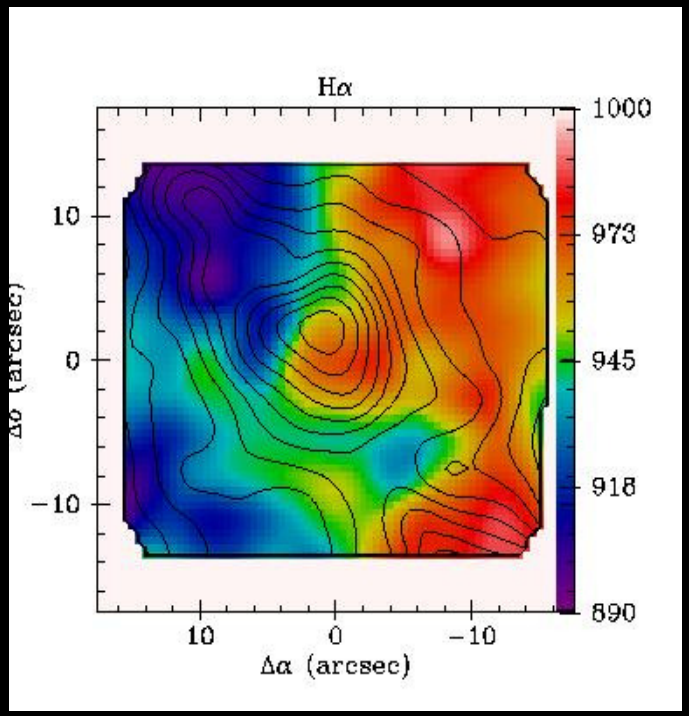
Mrk 297

FIRST RESULTS

5. Ionized gas kinematics



Mrk 314



Mrk 35

Summary: the pilot study of five SFDs

The spectra:

The strength of emission lines and absorption features, as well as the continuum shape or the presence of relevant lines significantly vary across each galaxy:

- The studied regions present HII-like ionization
- Ne variations: 20-400 cm^{-3}
- Oxygen abundances do not change from knot to knot

3D maps:

Continuum and emission lines morphologies are different.

Line ratio maps have structure

All the galaxies present a complex extinction pattern and high values of C(Hβ).

High metallicities: 0.17 to 0.87 Zsolar

Four galaxies have distorted velocity fields.

These galaxies display properties typical of the so-called LBCDs, very different from "normal" BCDs/Hii galaxies.

And a final remark … The relevance of SFDs in a general astrophysical framework

- Star-formation process
- Chemical enrichment of the Inter Galactic Medium
- Cosmology

Galaxy formation and evolution: dwarfs are the building blocks out of which larger galaxies are assembled

Big Bang Nucleosynthesis

but also, the more massive, more metallic SFDS ~ counterpart of the LBCs

Essential template to interpret the results of studies at higher redshifts

The Team

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Alexander von Humboldt Foundation