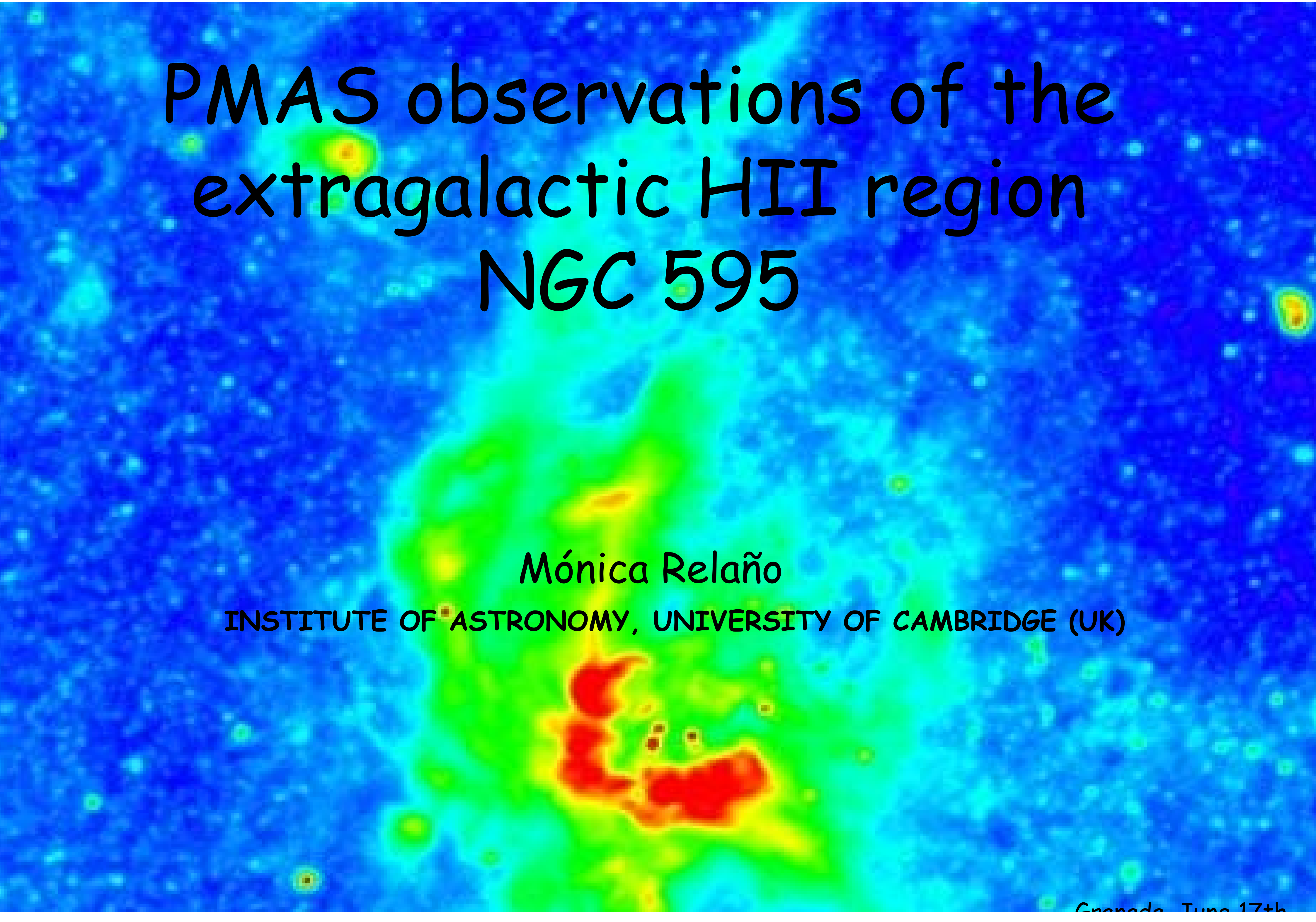


PMAS observations of the extragalactic HII region NGC 595

Mónica Relaño
INSTITUTE OF ASTRONOMY, UNIVERSITY OF CAMBRIDGE (UK)

Granada, June 17th

MOTIVATION

- STUDY THE EMISSION DISTRIBUTION OF THE DIFFERENT COMPONENTS OF THE HII REGIONS: STARS, GAS AND DUST.

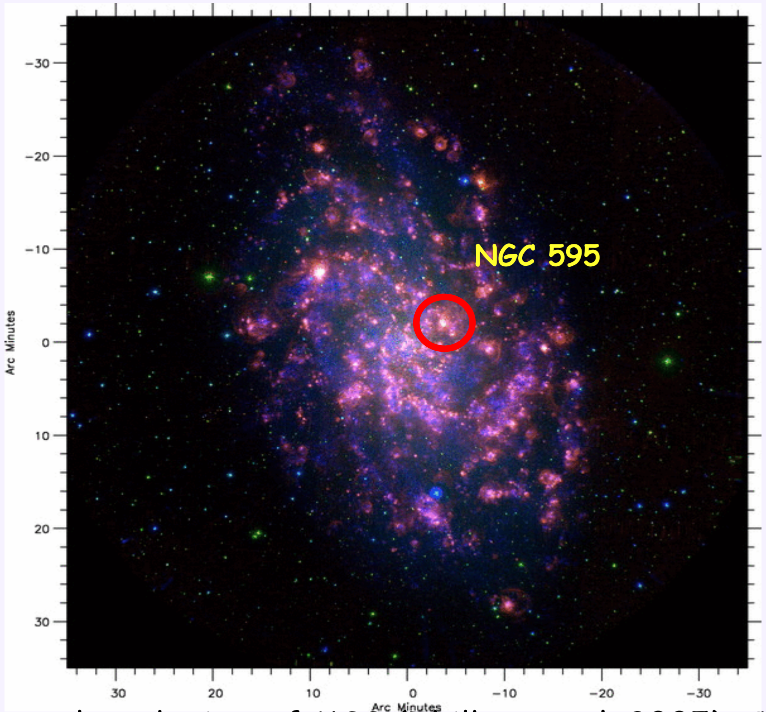
- HIGH RESOLUTION OBSERVATIONS AT DIFFERENT WAVELENGHTS: FROM UV GALEX DATA TO IR SPITZER DATA.

- COMPARISON OF DUST EMISSION AND EXTINCTION DISTRIBUTION WITHIN THE HII REGIONS.

- STUDY THE VARIATIONS OF THE PHYSICAL PROPERTIES WITHIN THE HII REGIONS.

WHY NGC 595 ? (I)

- The second most luminous HII region in M33: log L(Hα) = 39.10 (erg s^{-1})
- Large linear scale (d ~200 pc) that allows the study of the interior of the region
- Stellar content well studied: ~250 OB stars, ~13 WR stars (Malumuth et al. 1996).
- Previous long-slit observations located at the most intense knots (Esteban et al. 2009; Vílchez et al. 1988)
- Hα shell morphology: stellar winds are probably affecting the distribution of the gas and dust within the region.



Multiwavelength view of M33 (Thilker et al. 2005): Color channels Hα + continuum (*red*), continuum (*green*) and *GALEX* NUV (*blue*).

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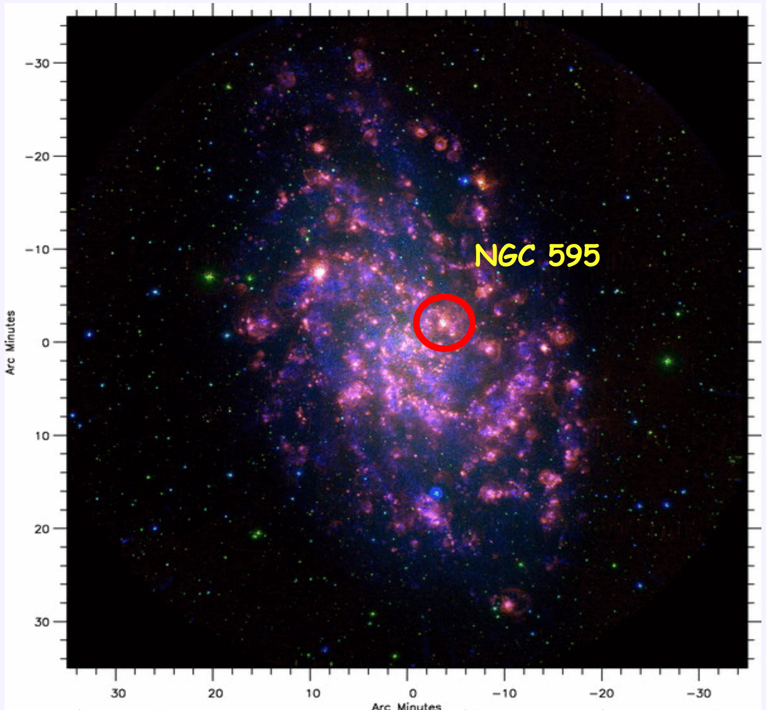
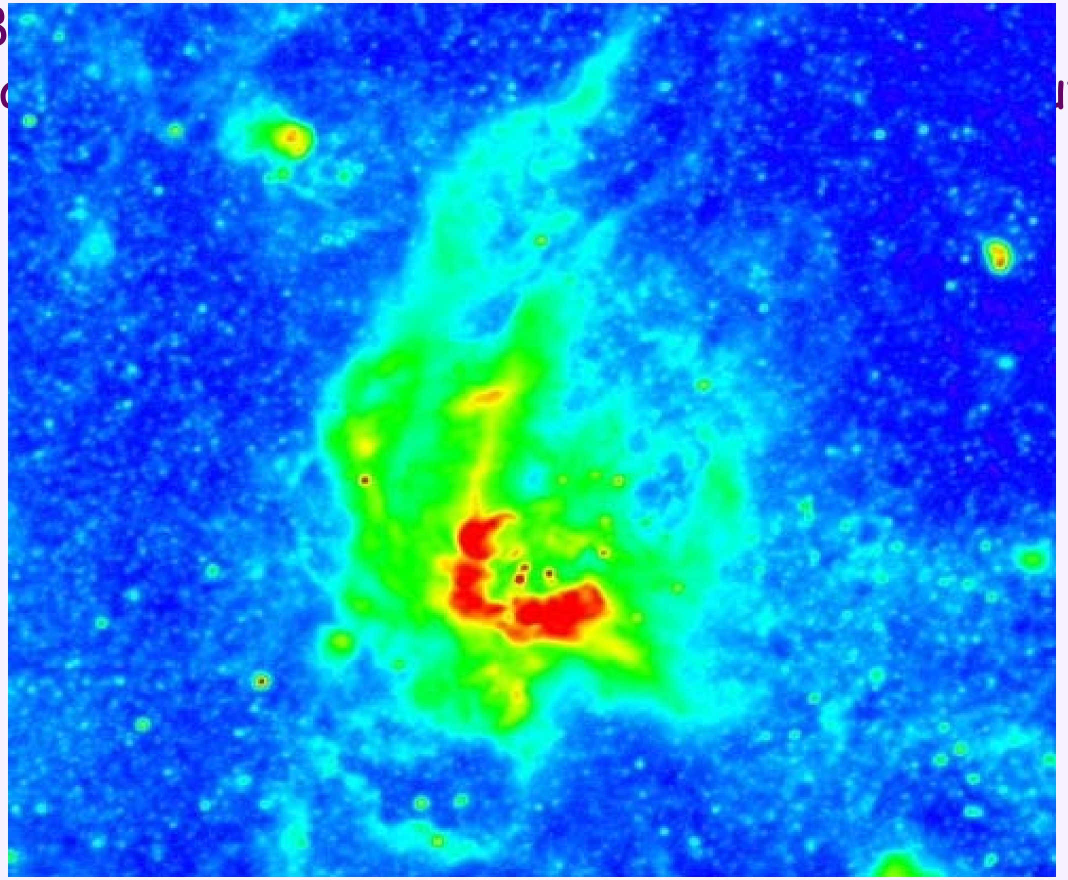




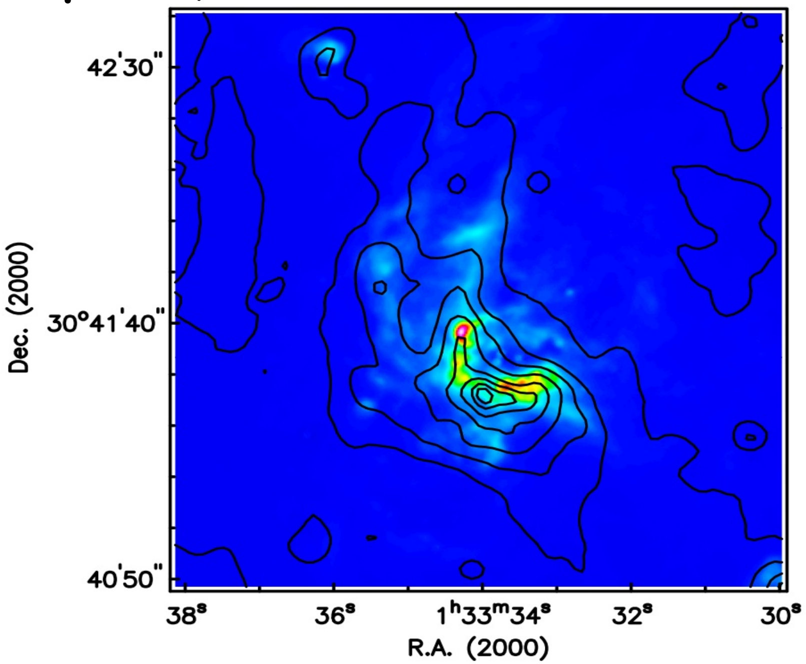
Multiwavelength view of M33 (Thilker et al. 2005): Color channels Hα + continuum (*red*), continuum (*green*) and *GALEX* NUV (*blue*).

NGC 595 (II)

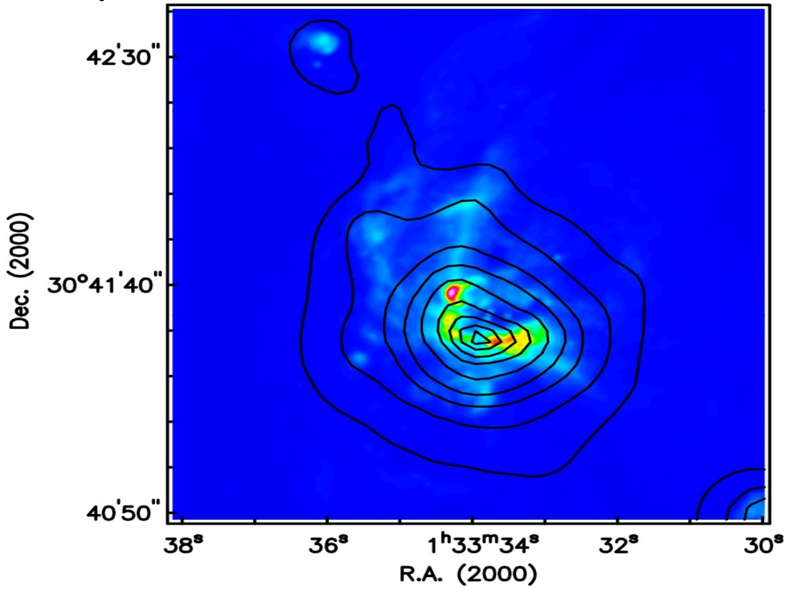
- Dust emission distribution

Good spatial correlation between 24μm and Hα emissions: there should be dust mixed with the ionized gas within the region.

Hα plus 8μm



Hα plus 24μm



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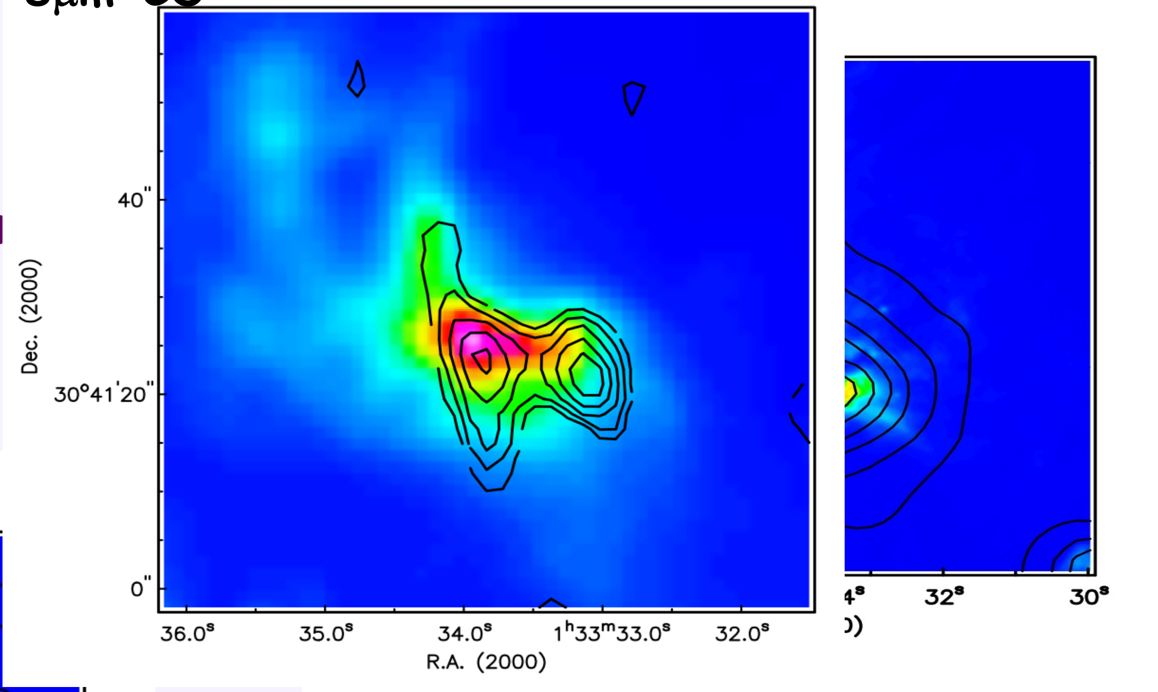
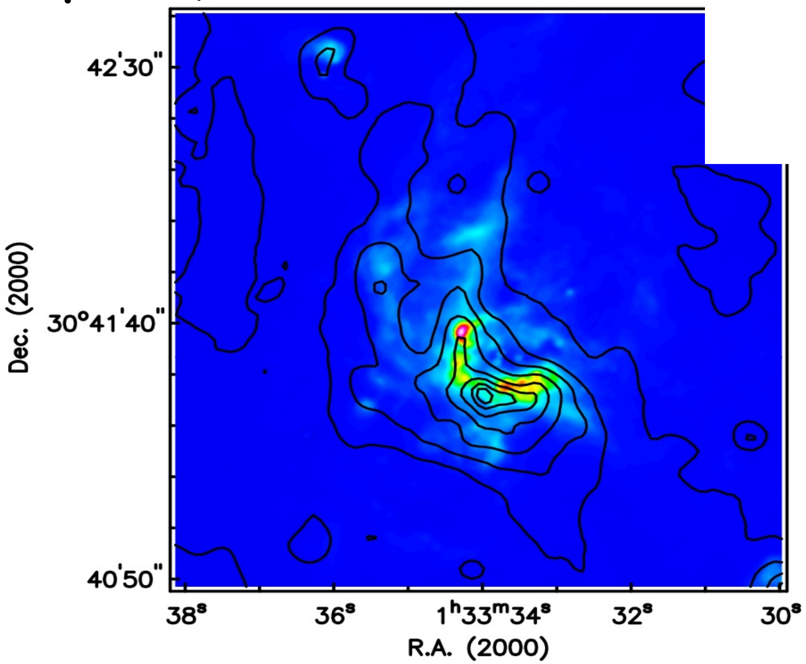
8μm+CO



Hα plus 8μm



The emission at 8μm looks more filamantery, with the maximum slightly outwards shifted.

The 8μm emission is more related to the CO molecular gas (PDR?).

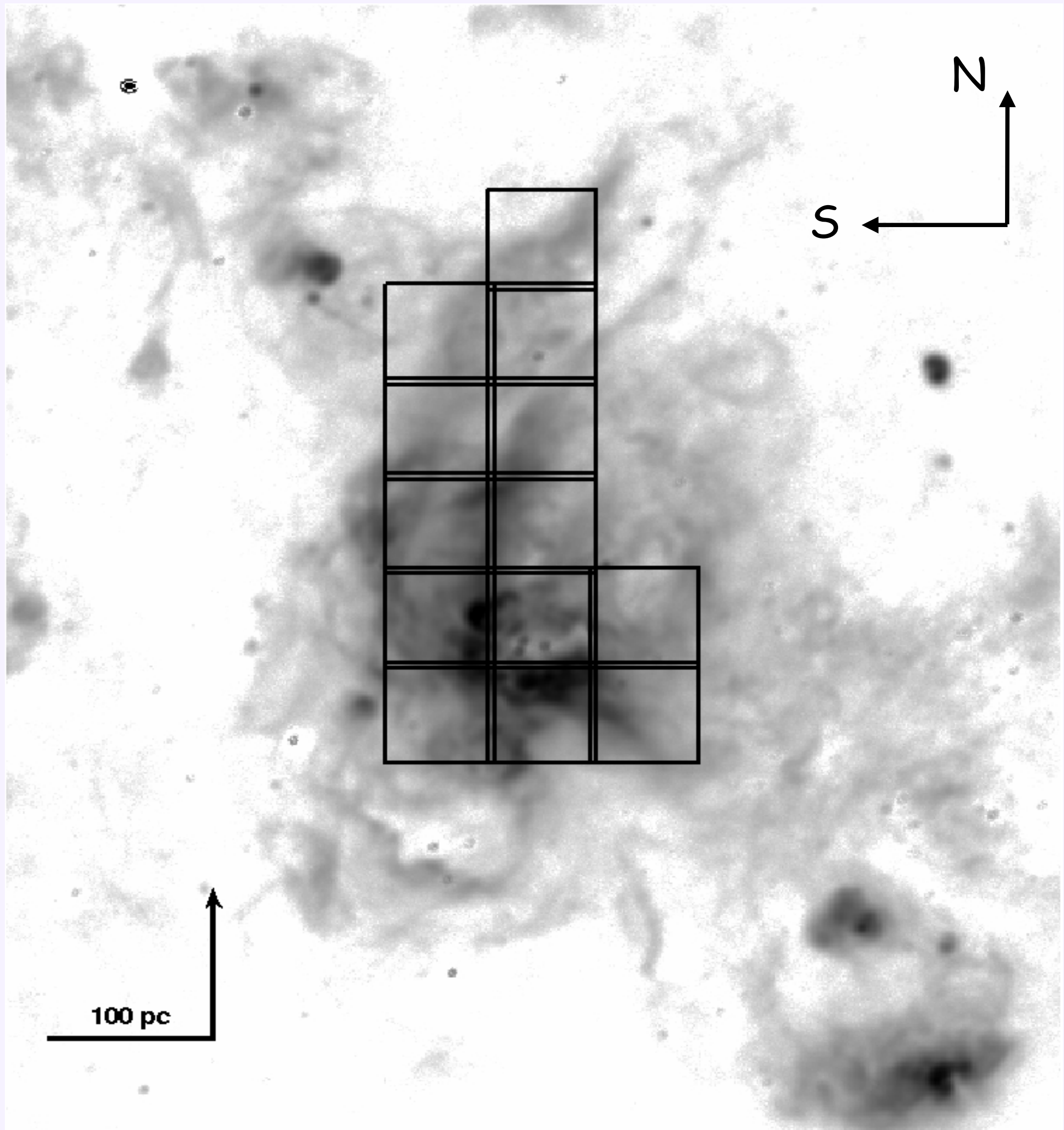
PMAS OBSERVATIONS

- Advantage of PMAS observations:
  - -Slit spectroscopy covers only a portion of the region (interpolation of observational parameters is needed) and it requires high observation time to map the complete surface of the region
  - -Integral Field Spectroscopy overcomes these limitations: spectroscopic information at different positions across a continous field of view.

- Aims:
  - - Study the variation of the physical properties within the HII region NGC 595
  - - Extinction map: allow the study of the dust extinction distribution and the comparison with the emission of the dust.

OBSERVATIONAL CONFIGURATION

- PMAS observations at 3.5m Telescope in Calar Alto (Almería)
- LARR: f.o.v.: 16″ x 16″ with spaxels of 1″
- Grating: V300, 3.40 Å/pix and λ=(3650-6990) Å
- Mosaics: 13 tiles (2″ over.) to cover the whole HII region
- 3-4 exposure of 400s
- Seeing: 1.2-1.8″
- Result of the Data Reduction: a data cube with spaxels of 1″x1″ each one having the corresponding spectrum in λ=(3650-6990) Å.



Utilized mosaic to map NGC 595 overplot onto a continuum subtracted Hα image from NOAO Science Archive (Massey et al. 2007)

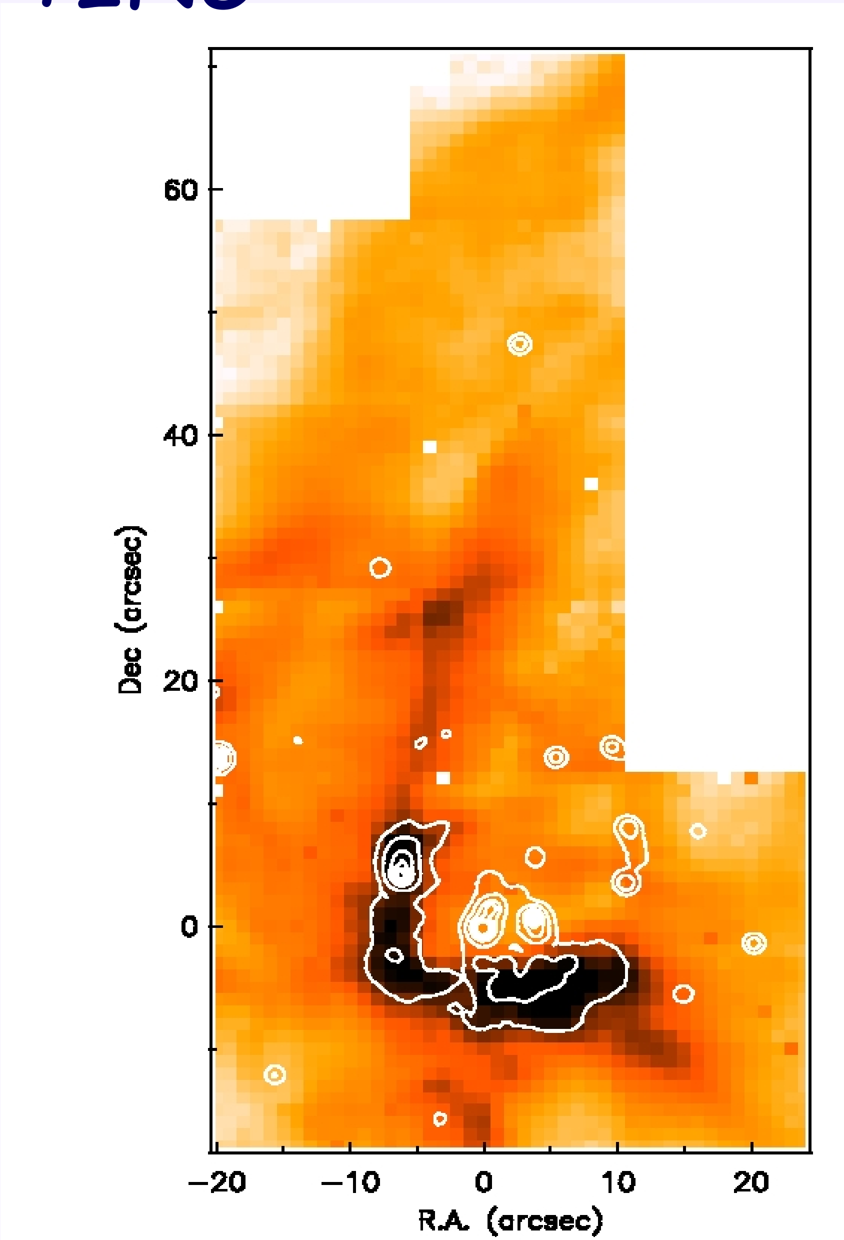
PROFILE FITTING

- At each spaxel and wavelength required we fit the profile with one or several Gaussian components and 1-degree polynomial fucntion for the continuum subtraction.

- Rejection of the fits with S/N < 5 (noise: Stddev of the continuum close to the line)

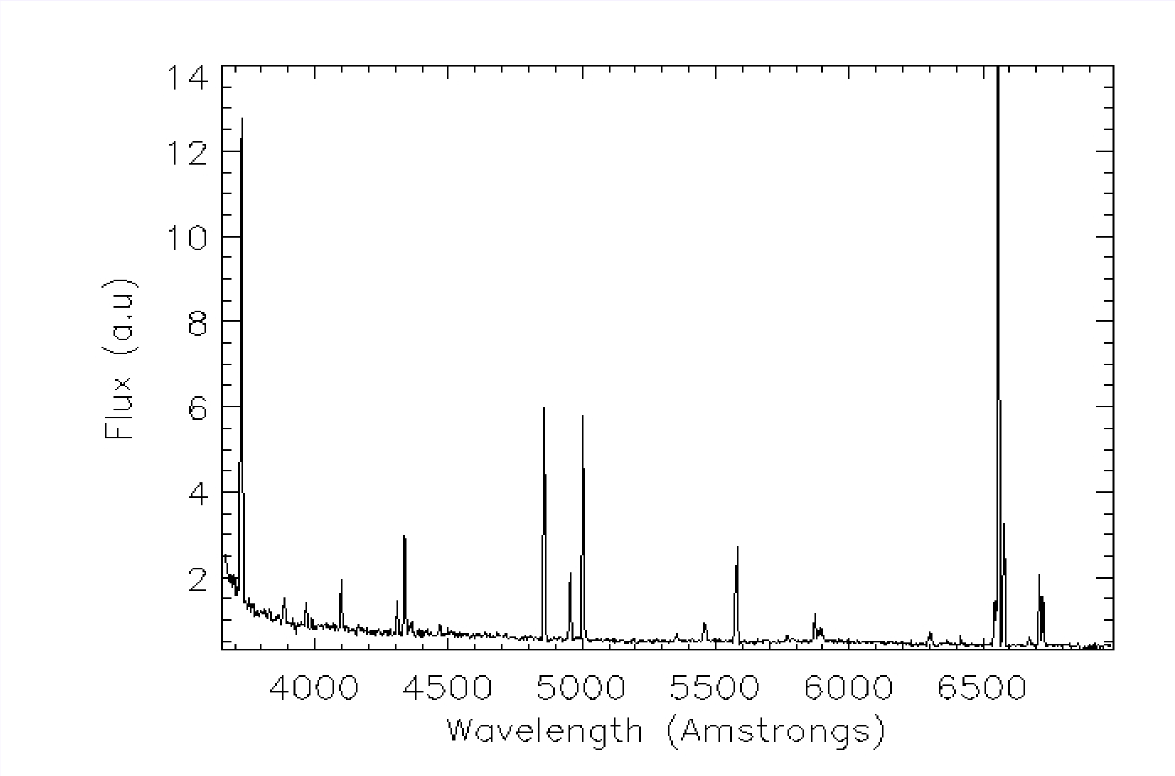
- Flux= Area within the best fitted component.

- We create maps for each observed emission line.



Map of the observed Ha flux derived from the fit overplot with R-Band contours (NOAO Sc. Archive, Massey et al 2006). Maxima correspond to the most intense stellar clusters within the region. The distances are relative to the position of one of the central stellar clusters.

BRIEFLY: INTEGRATED PROPERTIES



Integrated spectrum of NGC 595 obtained adding the signal of ~3000 spaxels in the field of view. It shows the principal emission lines observed in the region.

PROPERTIES

C(Hβ)=0.211+-0.009

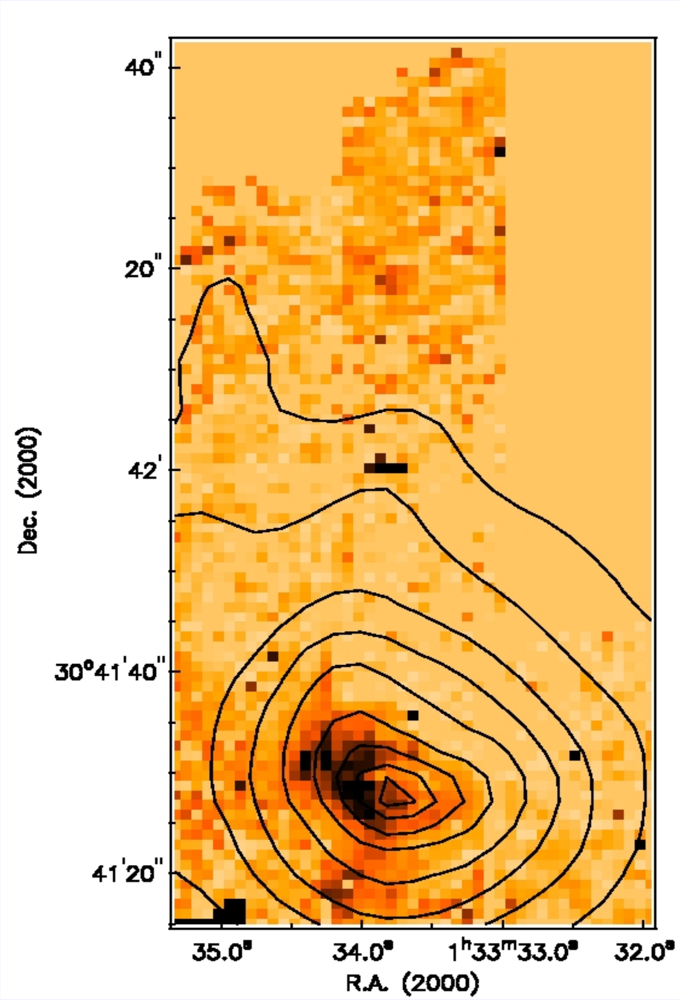
n_e= < 100 (cm^{-3}) (from [SII]λ6717/6731)

T_e= (7670+-116) K (from the literature, we are not able to detect [OIII] λ4363)

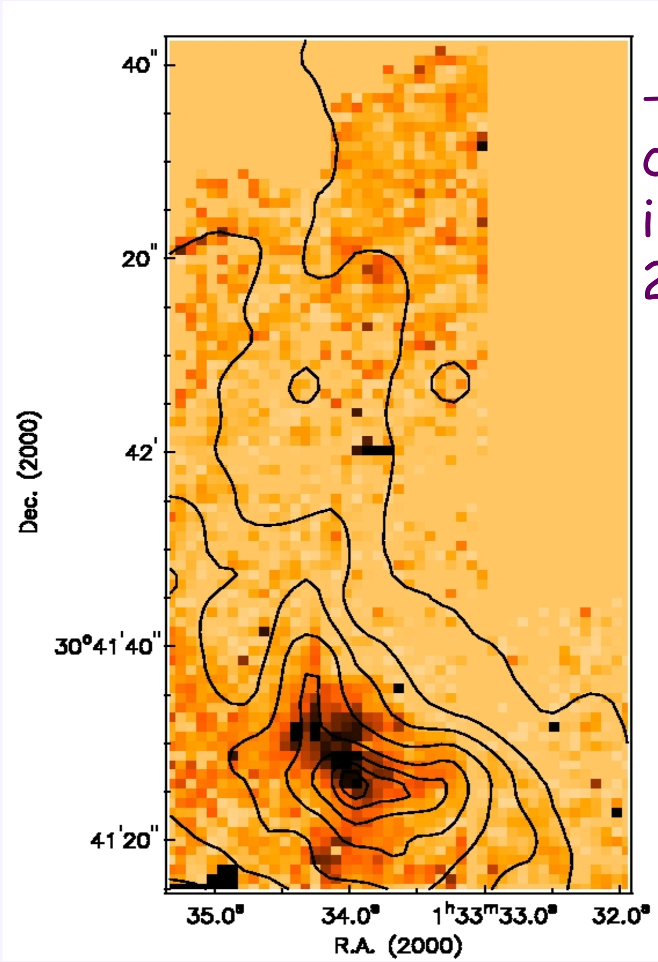
12+log[O/H]=8.813+-0.004 (from R23 calibrations of Kewley & Dopita (2002) and Kobulnicky et al. 1999)

Extinction map

- Observed Hα/Hβ ratio: map of reddening coefficient.
- Only spaxels with relative errors < 30% are taken into account
- Reddening coefficient map shows a central concentrated distribution.



C(Hβ) plus contours of 24μm emission



C(Hβ) plus contours of 8μm emission

-Maximum in extinction corresponds to the maxima in emission of the dust at 24μm and 8μm of the region.

Extincti

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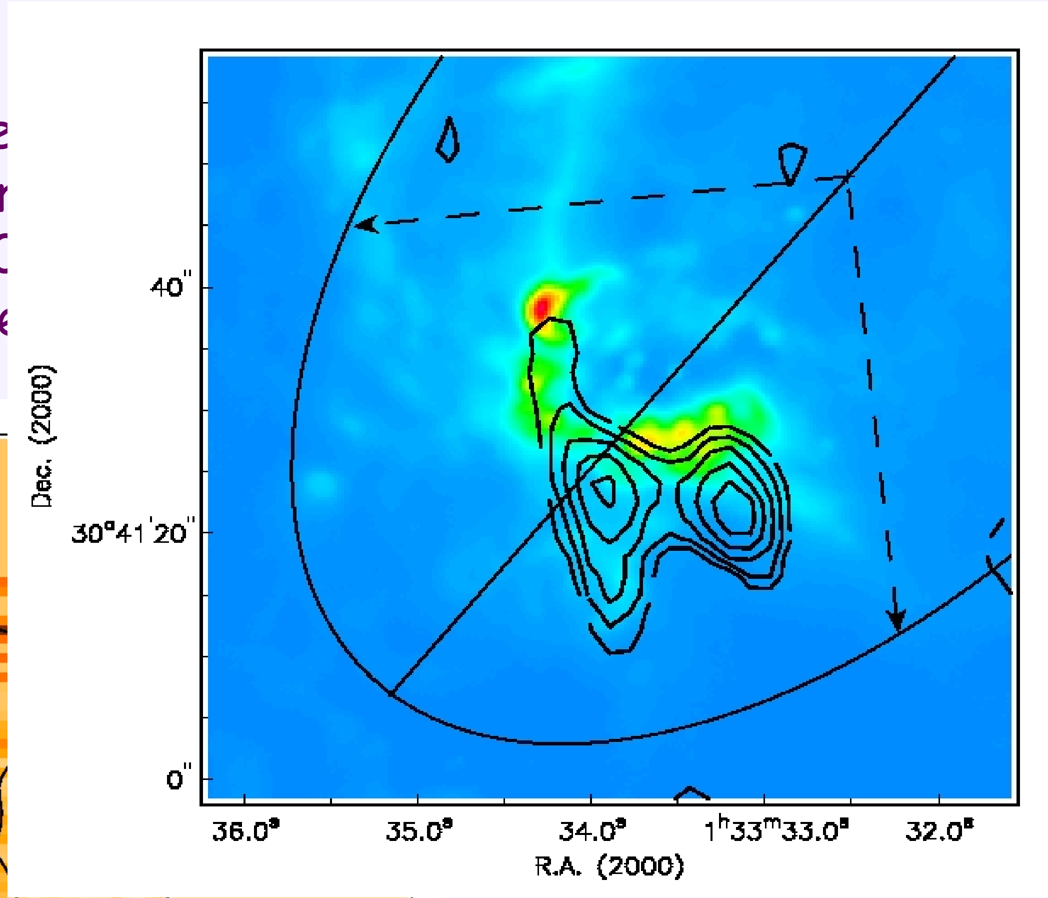
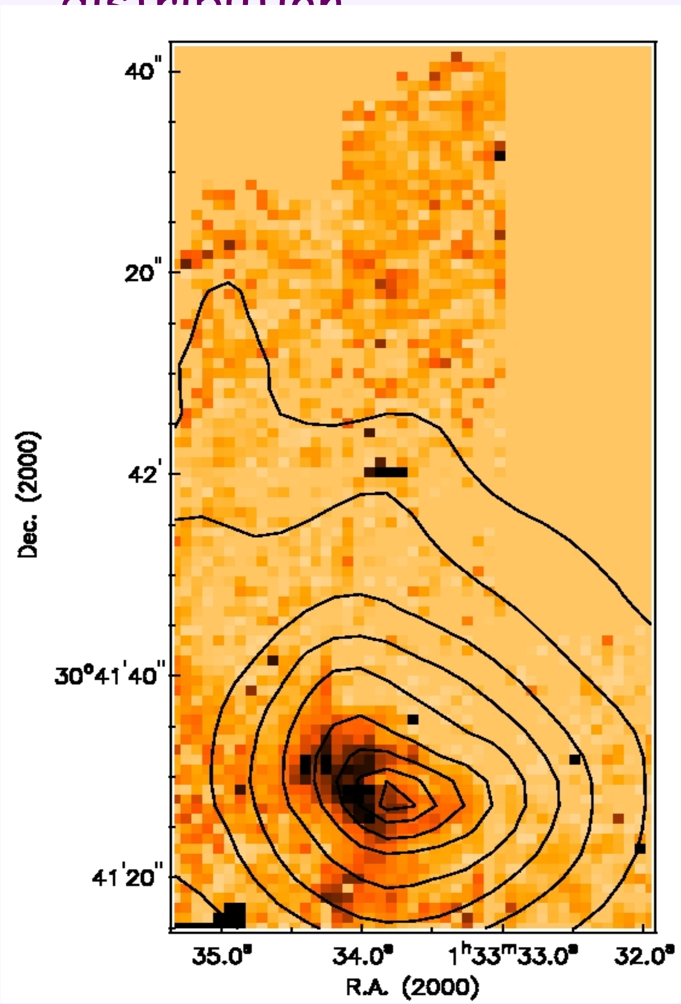
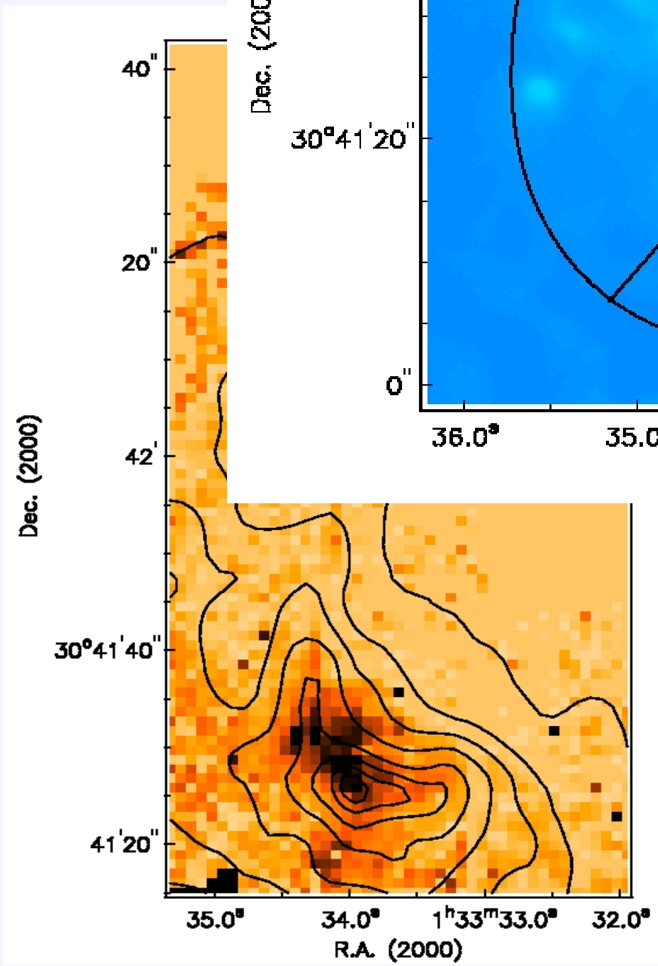




C(Hβ) plus contours of 24μm emission



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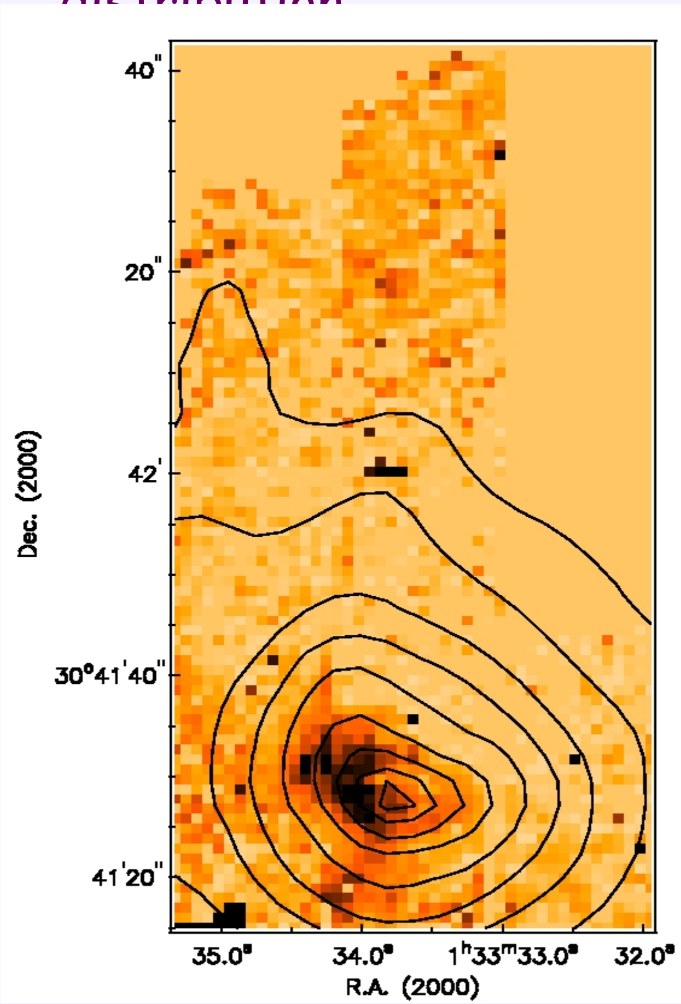

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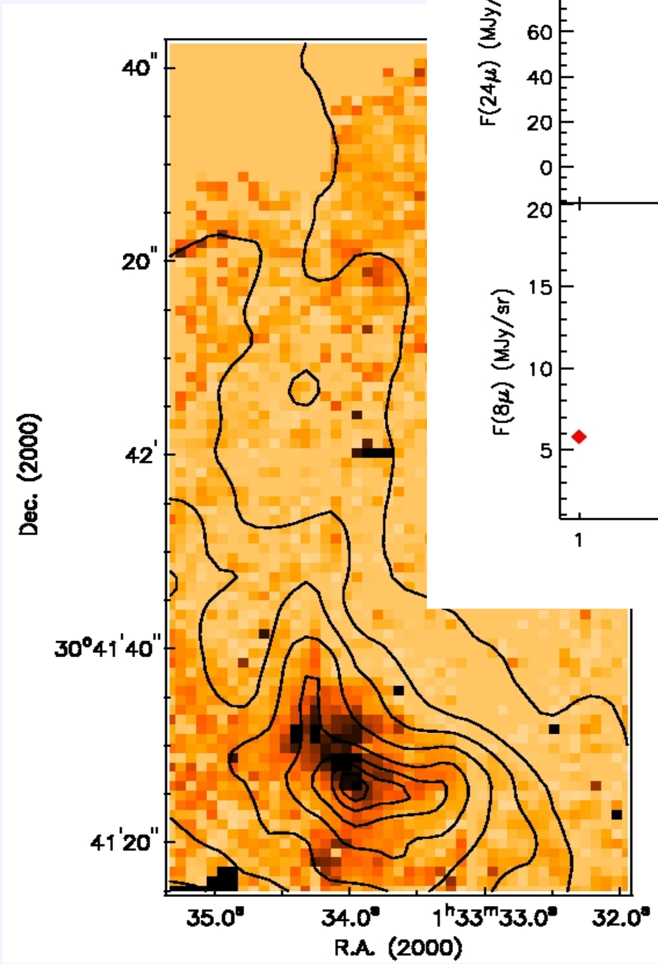

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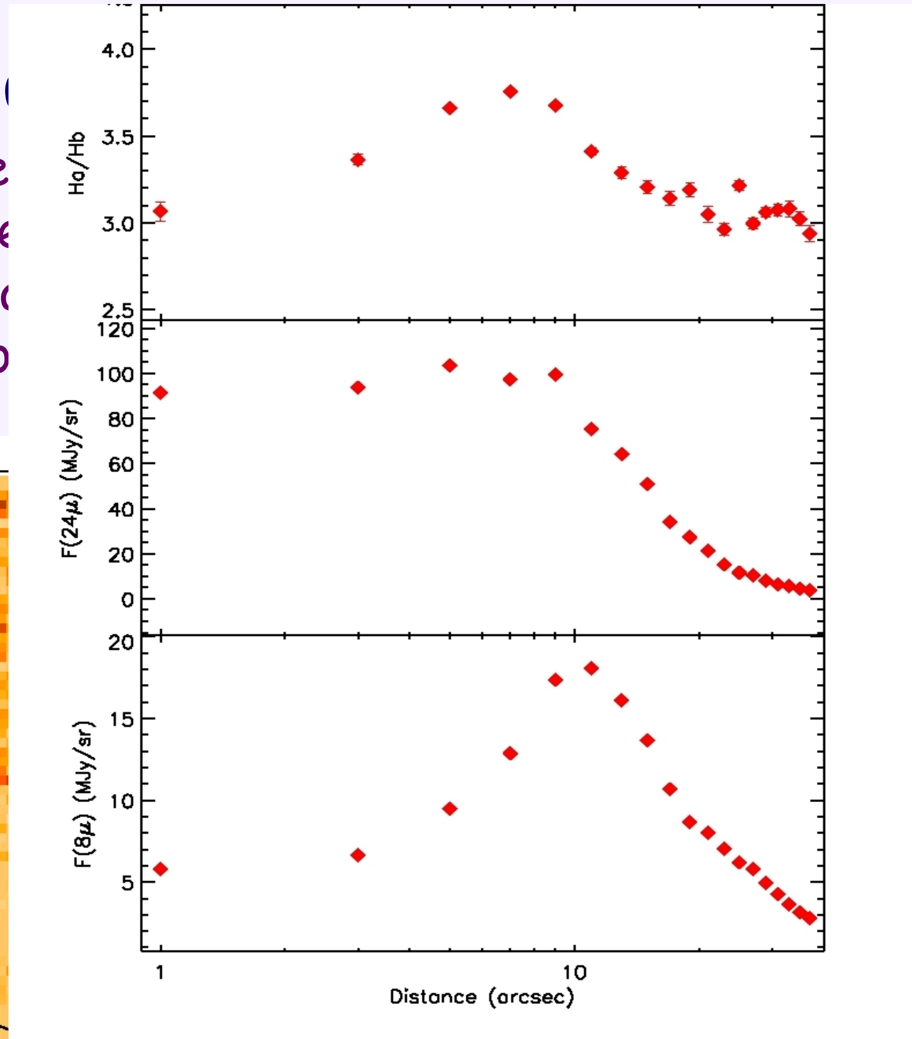
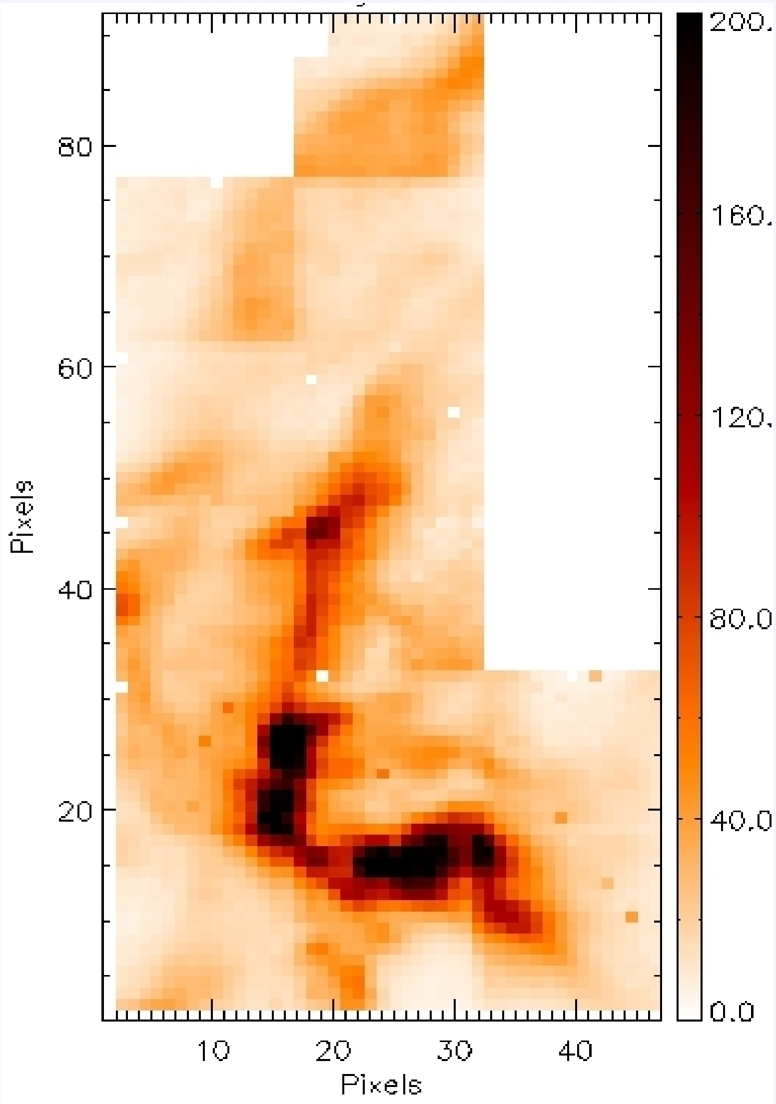
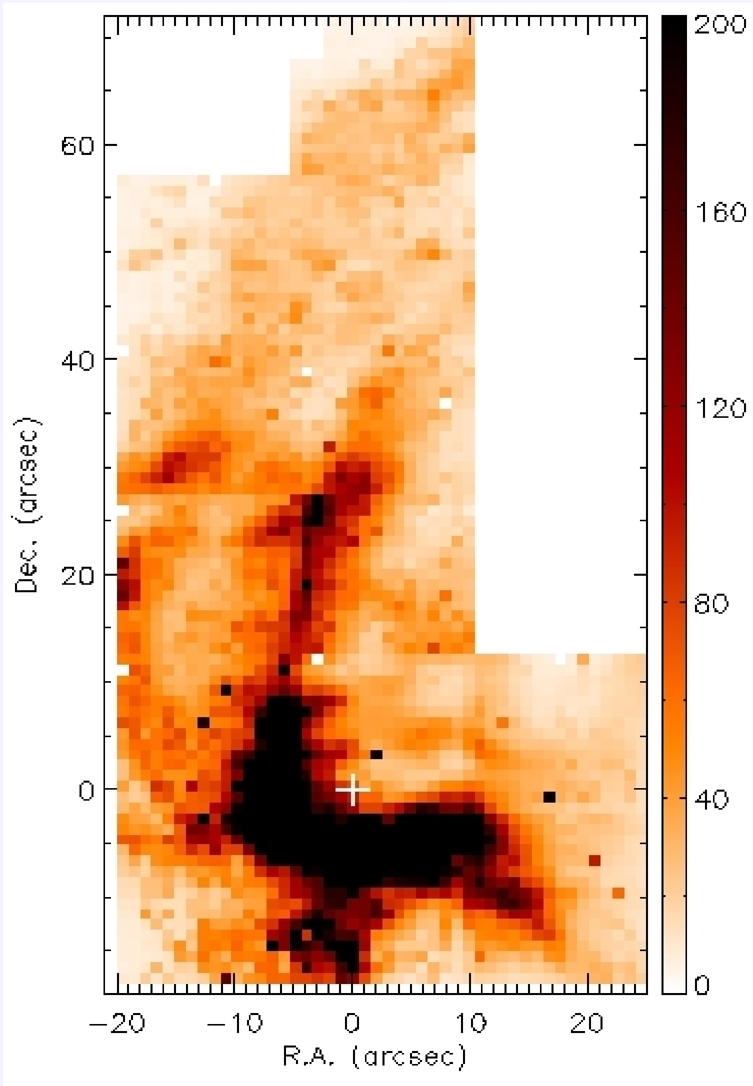


Extinction corrected emission line maps

- Reddening coefficient map is used to correct the observed spectrum in each spaxel

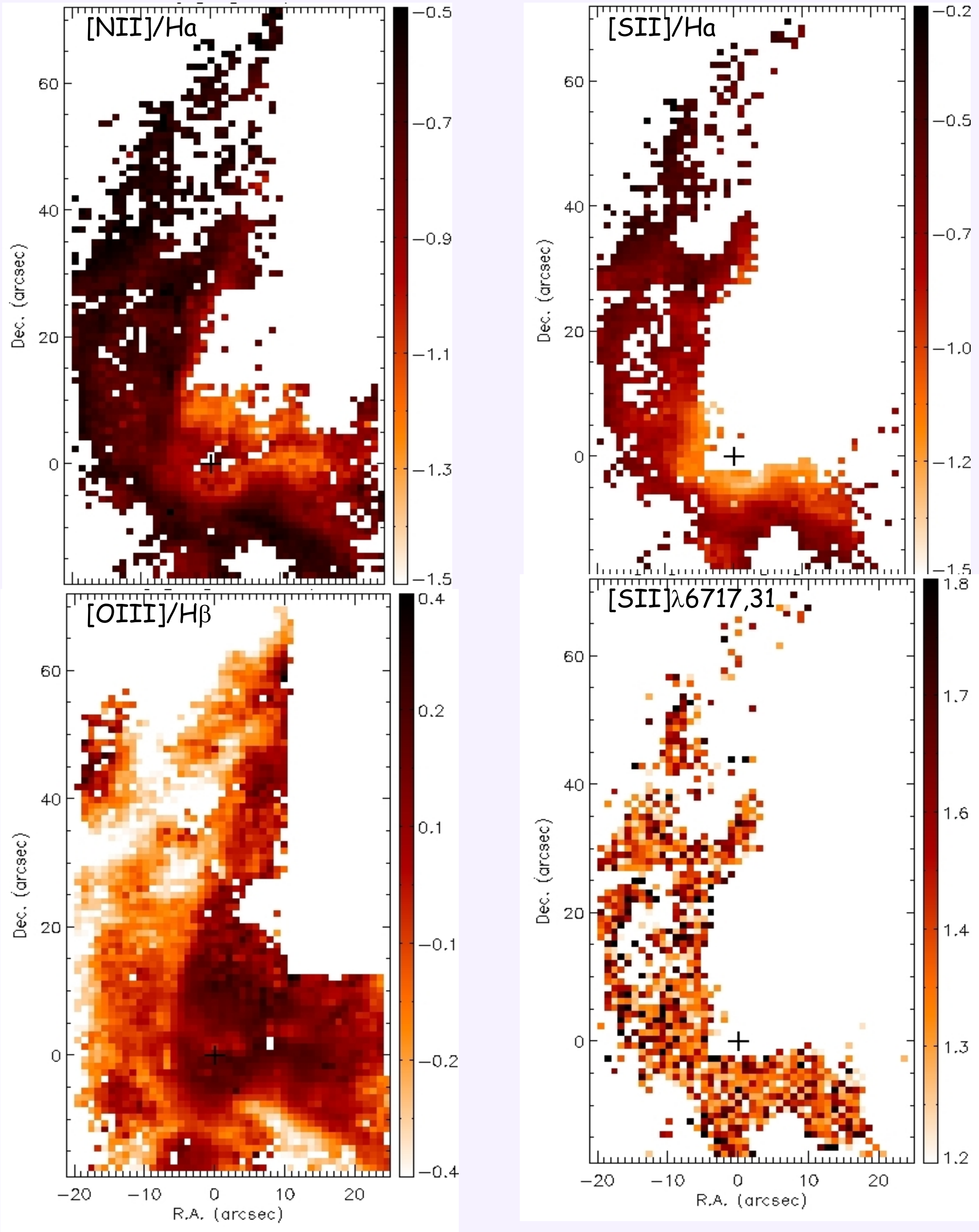


Observed Hα map



Ext. corrected Hα map

Emission line maps



<u>Ionization structure</u>

- [SII]/Hα and [NII]/Hα:

Low values ==> high excitation zone

- [OIII]/Hβ:

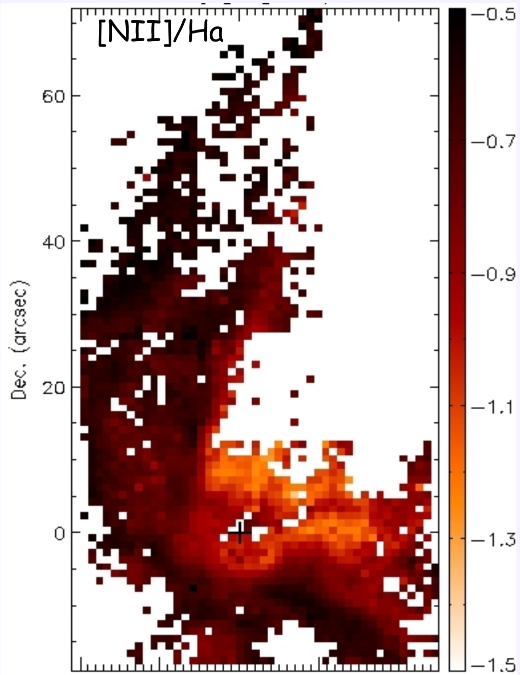
Low values ==> low excitation zone

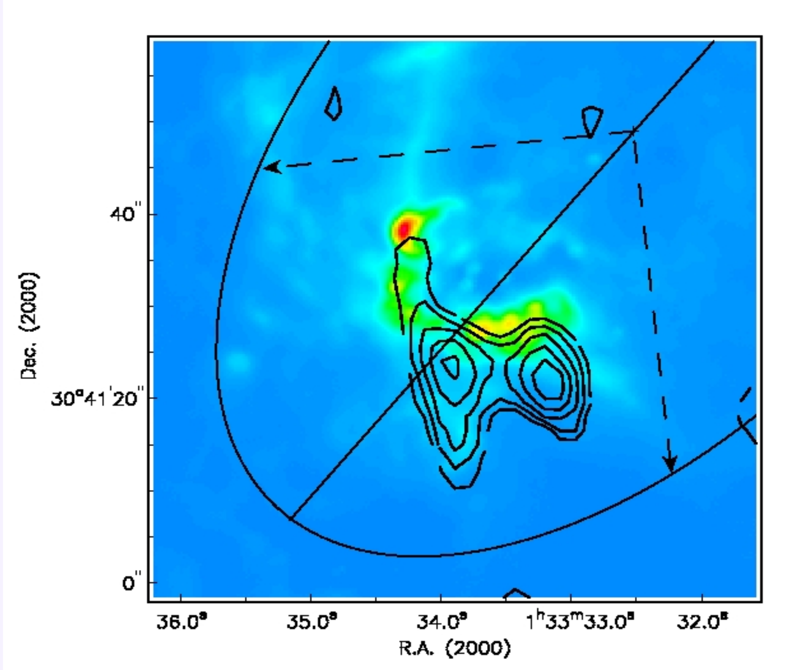
<u>Density structure</u>

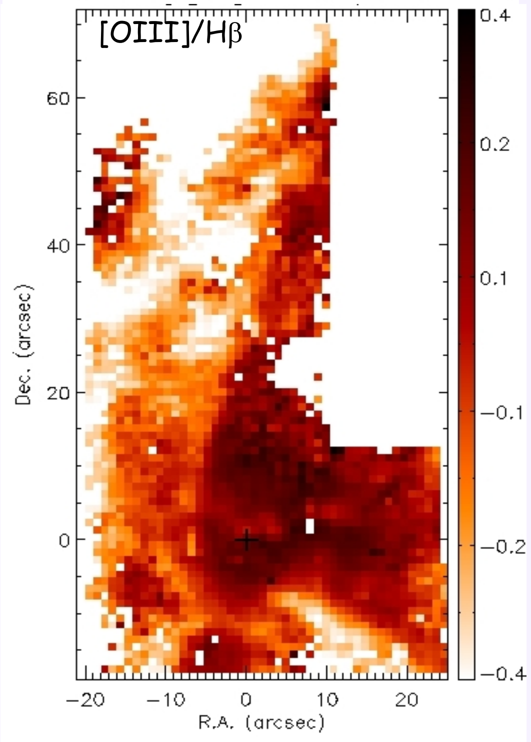
-[SII]λ6717/6731 map with values of 1.2-1.8: low electronic density

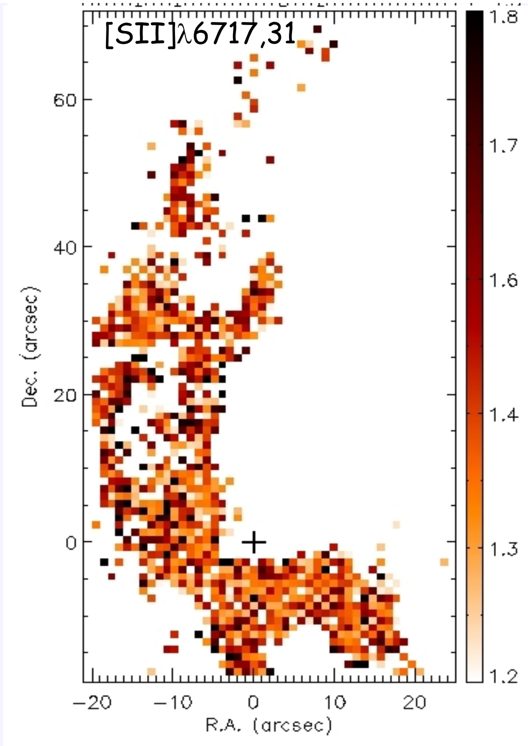
-No density structure observed within the region

Emission line maps









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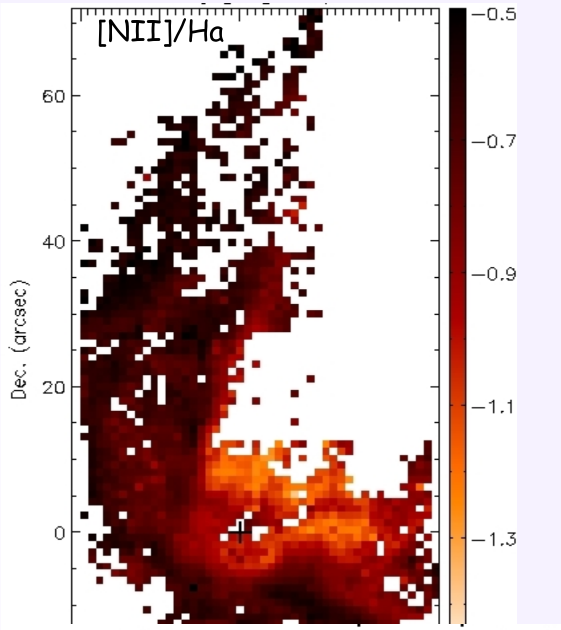

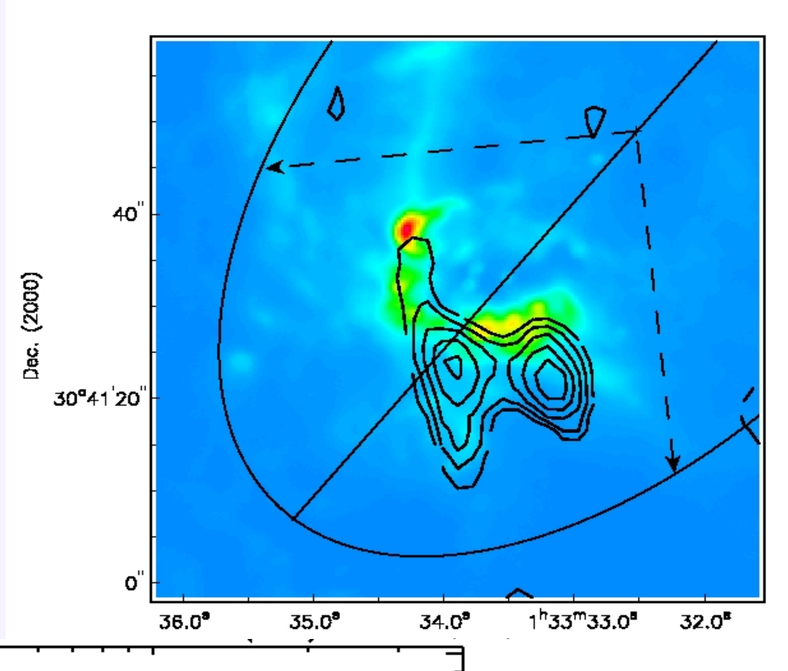

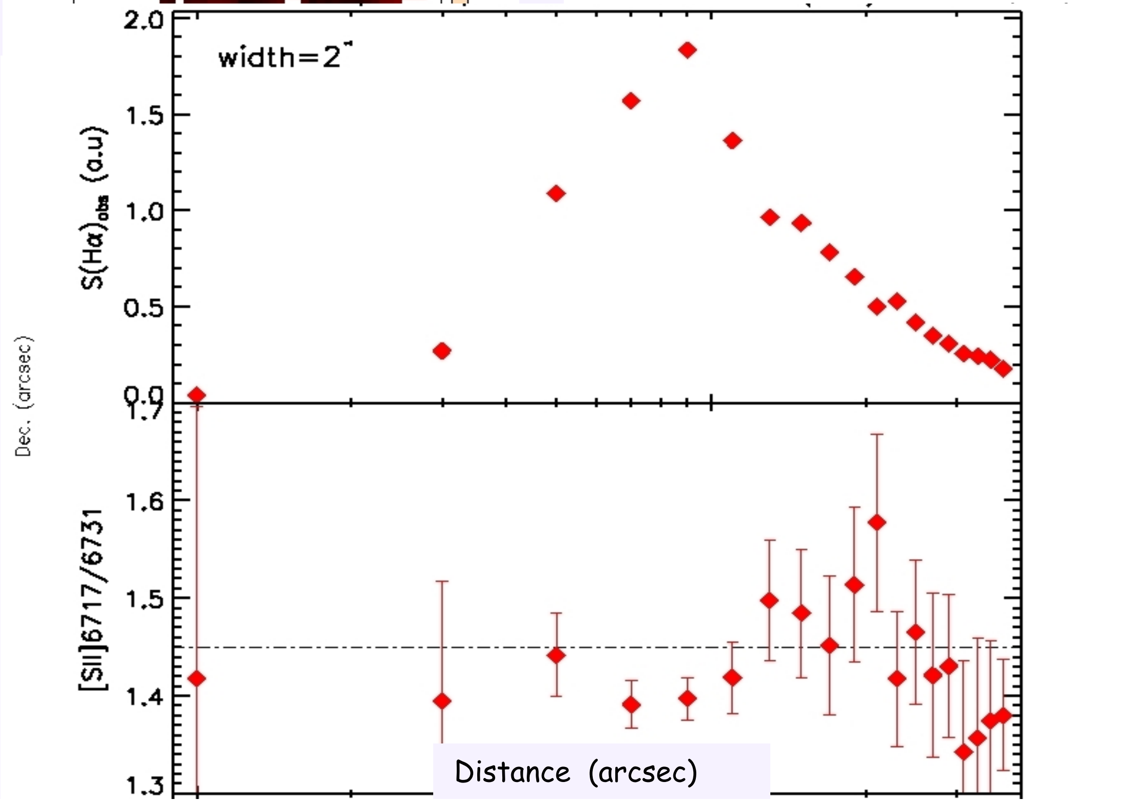

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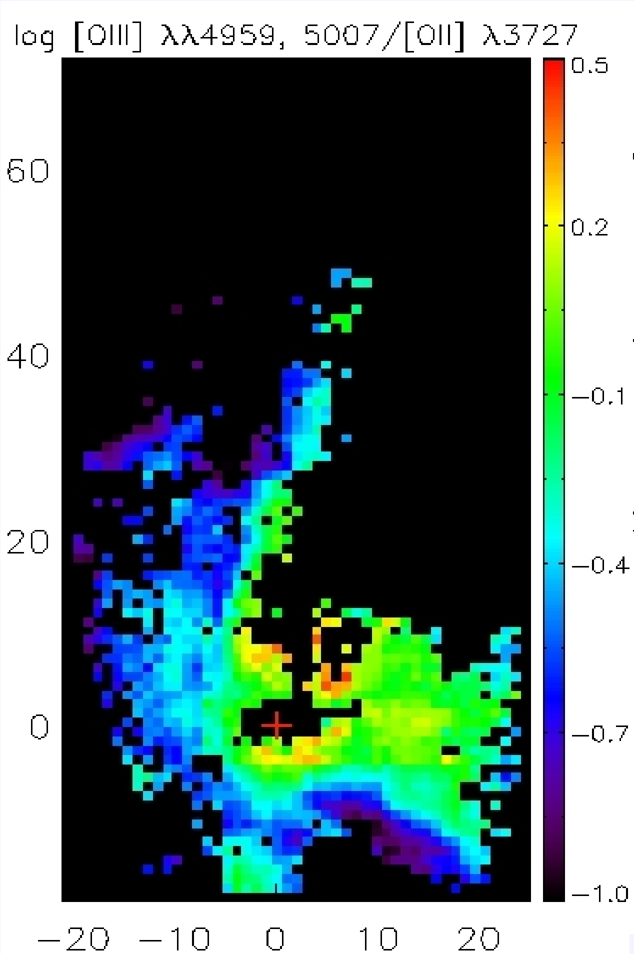
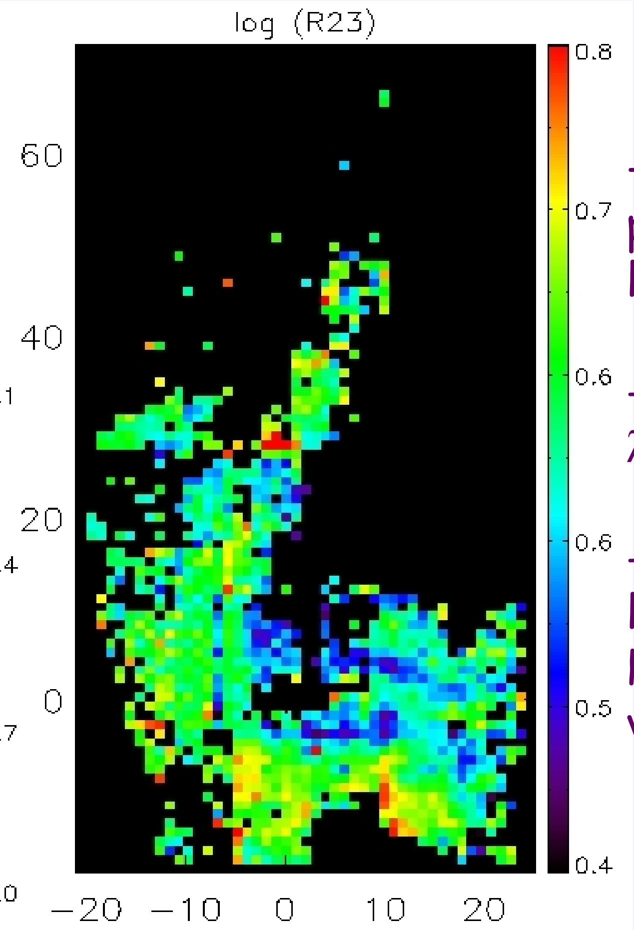
-No density structure observed within the region

- No density variation with the Hα surface brightness

Metallicity and ionization parameter



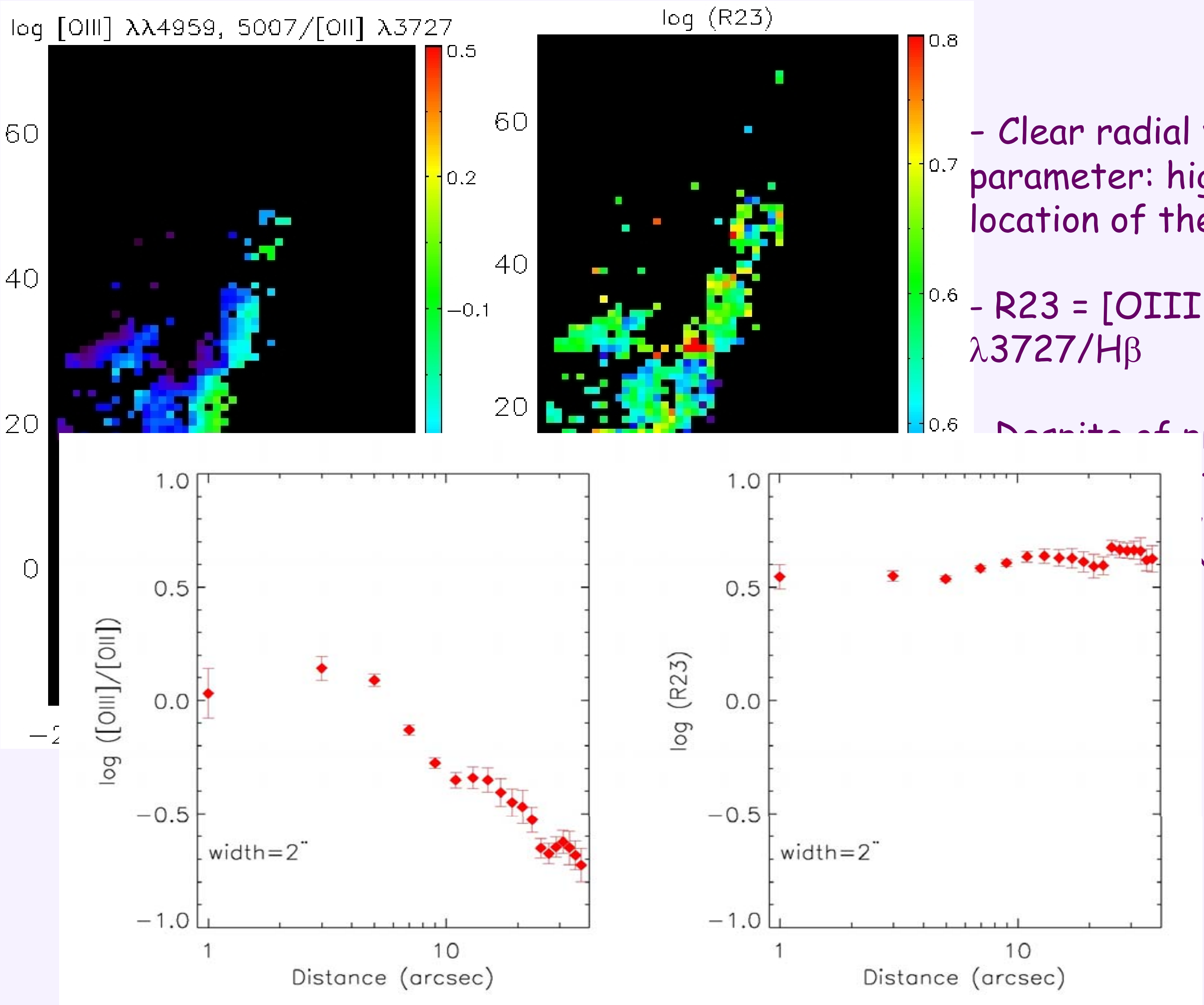


- Clear radial variation of the ionization parameter: higher values close to the location of the stars.

- R23 = [OIII] λ4959,5007+[OII] λ3727/Hβ

- Despite of previous suggestions in the literature that R23 could vary within the HII regions we do not detect a strong variation for NGC 595.

Metallicity and ionization parameter



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WR population

-Presence of WR can be recognized by:
a) blue WR bump at $\lambda \sim 4650$Å
b) red WR bump at $\lambda \sim 5808$Å

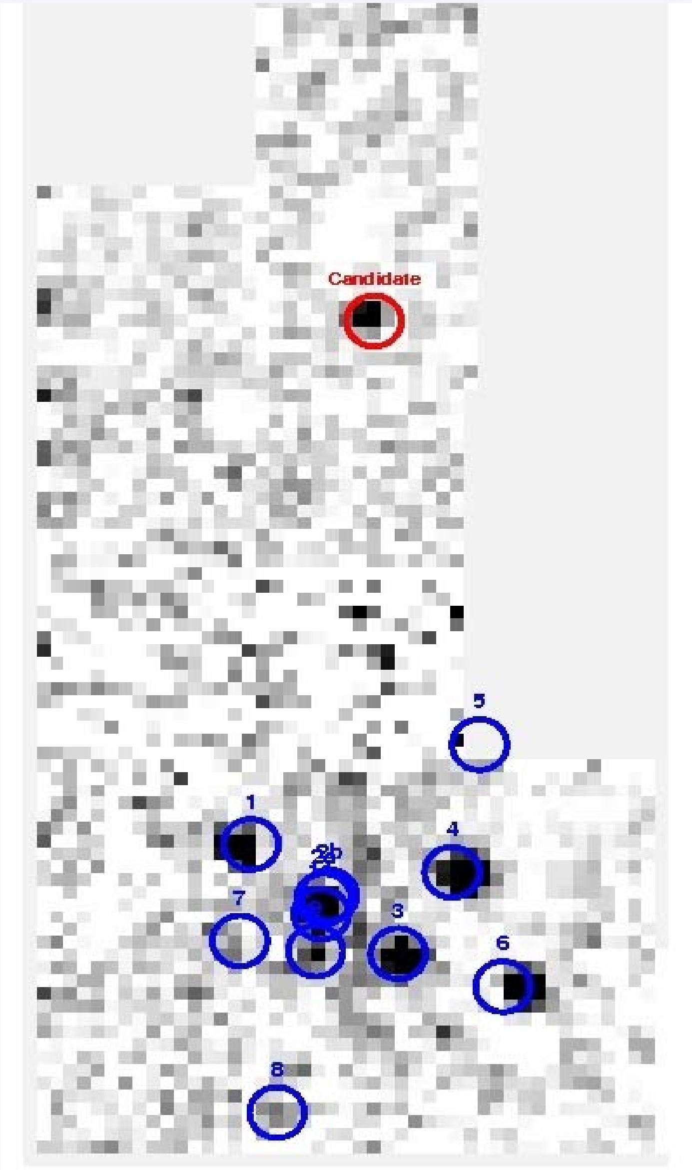
-WR population of NGC 595 already catalogued by Drissen et al. (2008, 1993)

-Capability of IFU data to detect WR features: detection of the WRs in a 4490-4540Å map.

-Integrated spectra of the WR candidates by coadding 3-10 spaxels at the location of the stars.

-They show clearly the blue bump of WR stars from Drissen et al. (2008)

-We also show the blue bump for the new candidate.



4490-4540Å map derived from the PMAS data. Continuum has been substracted by averaging the spectral ranges of 4650-4750Å and 4755-4805Å. We have overerplot the positions of the WR candidates listed by Drissen et al. (1993) with blue circles.

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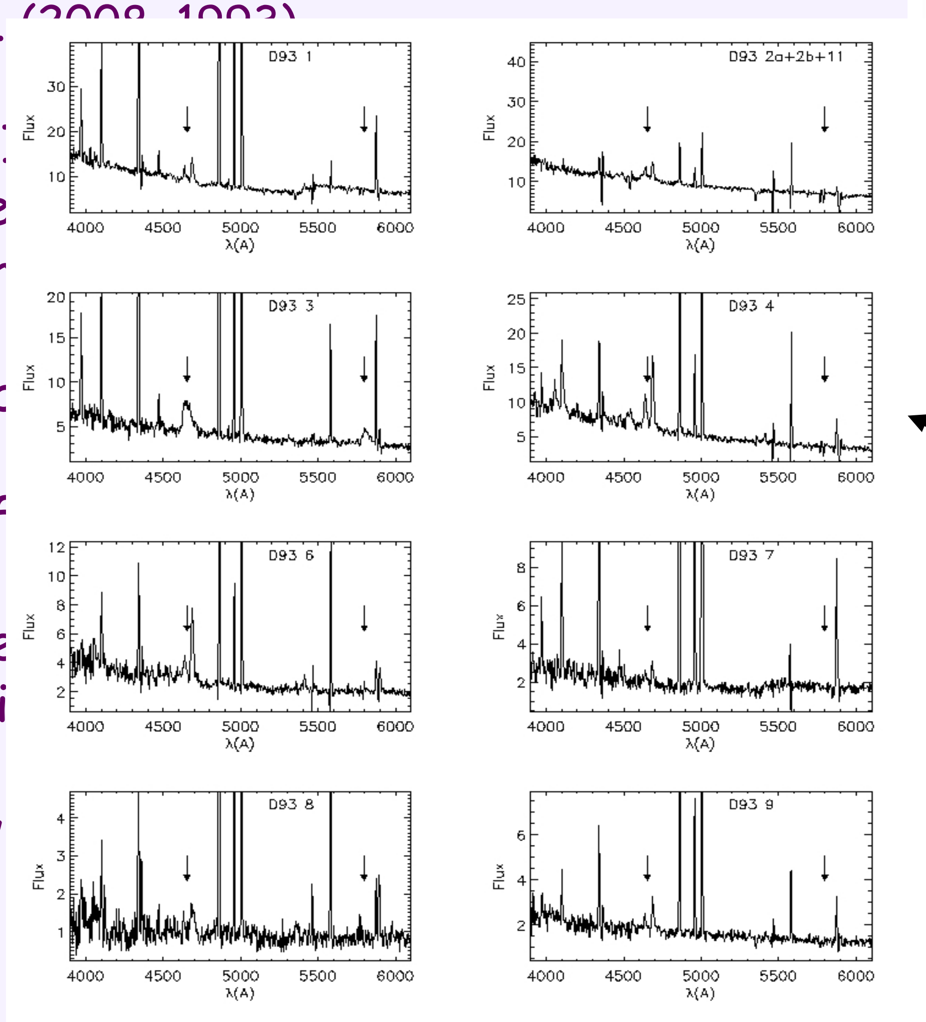

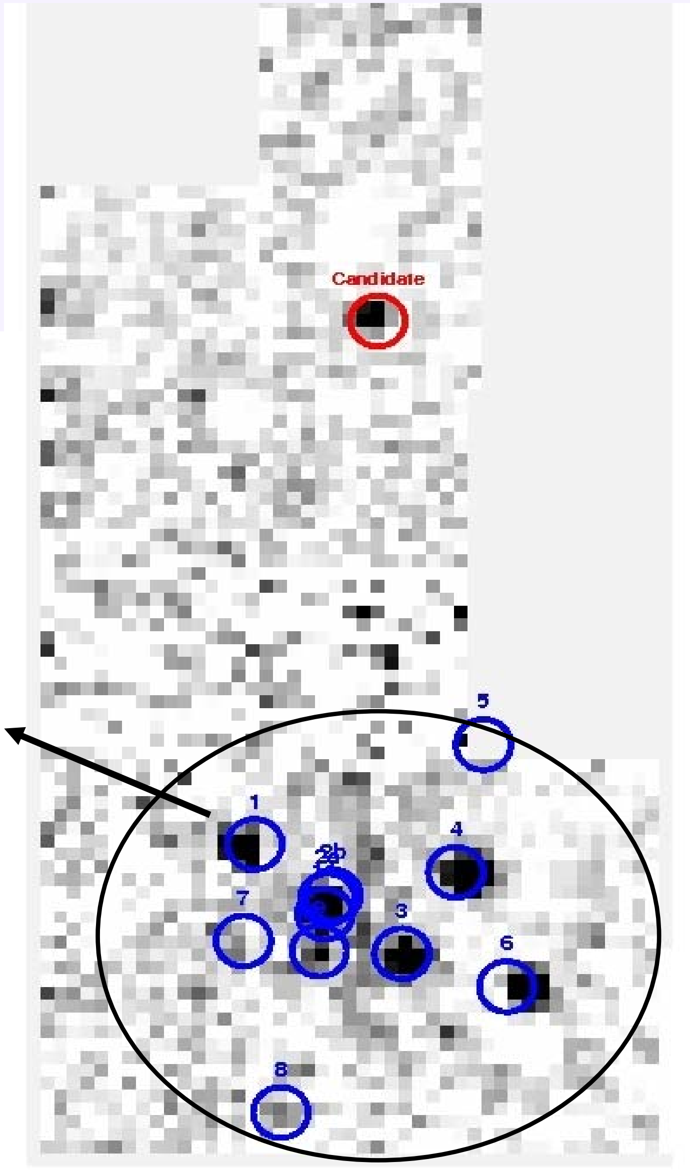

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a) blue WR bump at λ ~ 4
b) red WR bump at λ ~ 58

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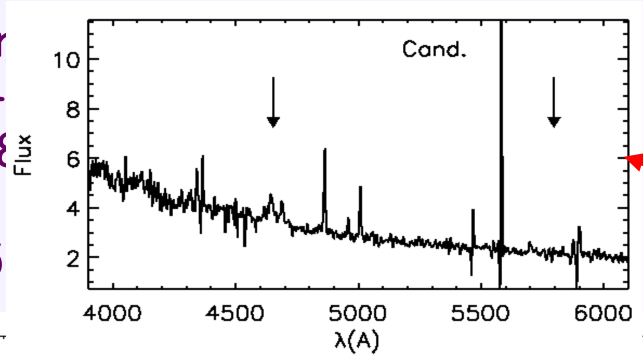

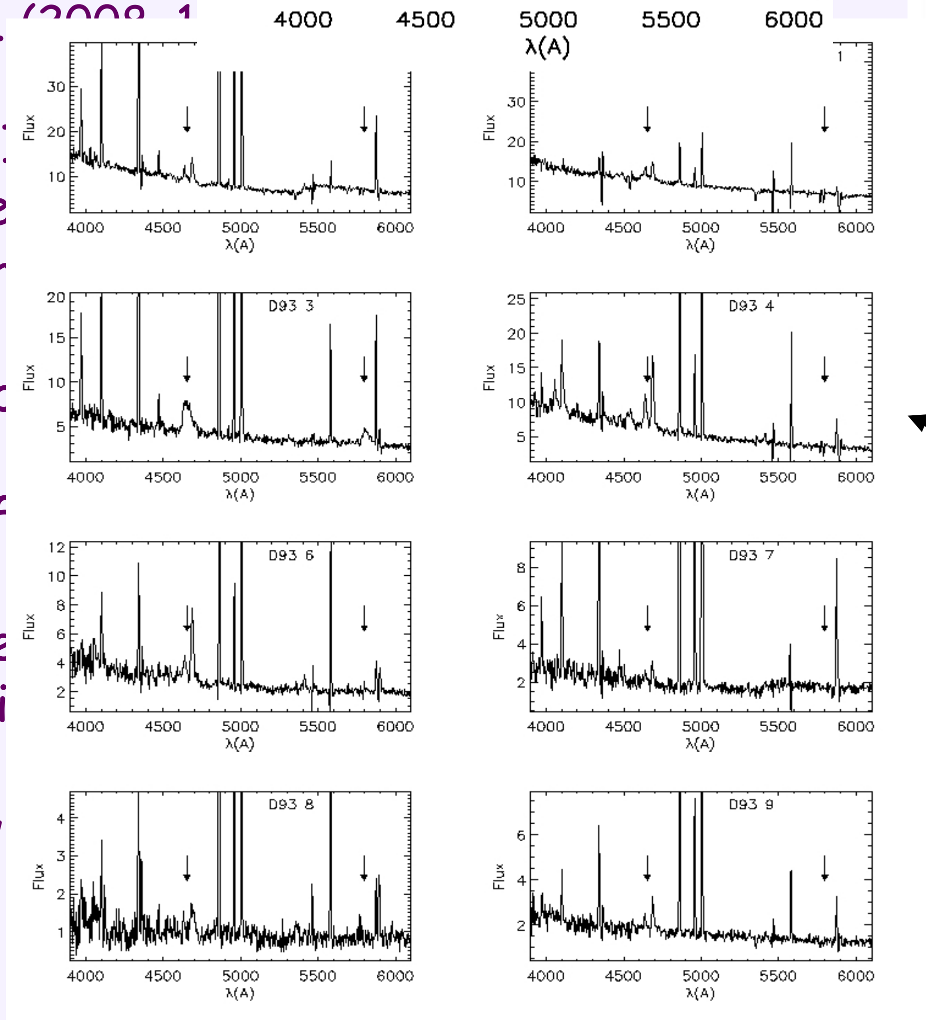

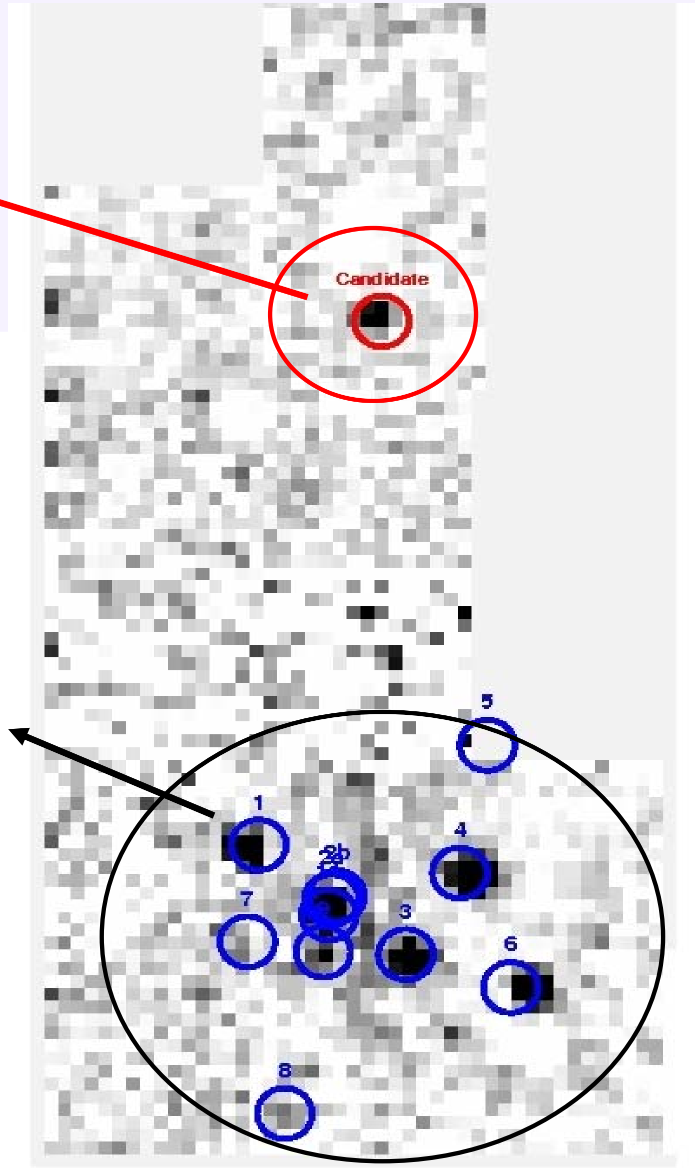

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CONCLUSIONS

- We present PMAS observations of the second most luminous HII region in M33 in a mosaic configuration that covers the total surface of the region.
- We are able to perform an analysis of the variations of the physical properties of the region in its interior, the main conclusions are:

    - The extinction map derived from the Balmer decrement shows good spatial correlation with the emission at 24μm and 8μm from SPITZER.

    - Due to the shell structure of the region, the ionization structure is clearly seen relative to the location of the stars using the corresponding emission line ratio maps.

    -We find no evidence of density structure within the region.

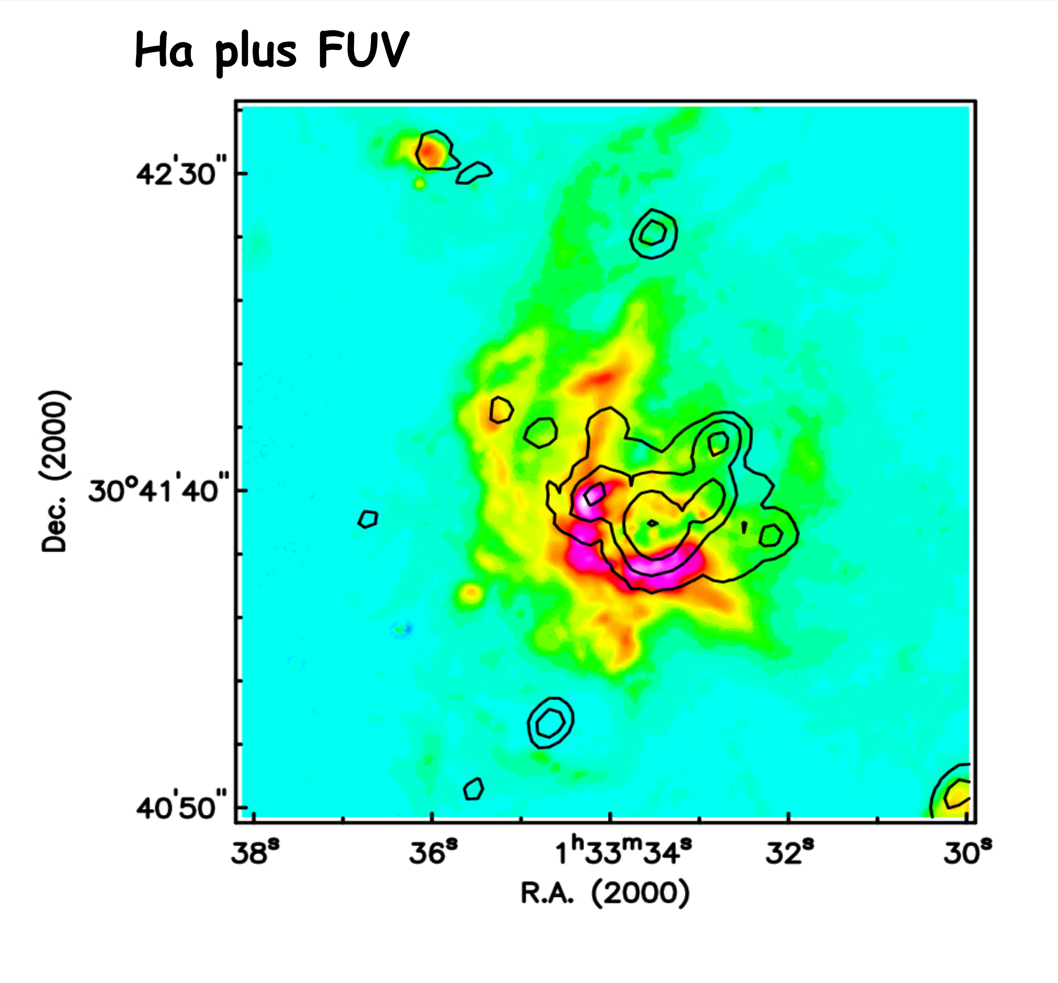
    -We show the capability of the IFS to study the existence of the WR stars, indentifying the previously catalogued WRs and detecting a new candidate.

    -R23 is constant within the region despite of the strong variation of the ionization parameter as a function of the radial distance from the ionzing stars.

WHAT DO WE KNOW ABOUT NGC 595 ?

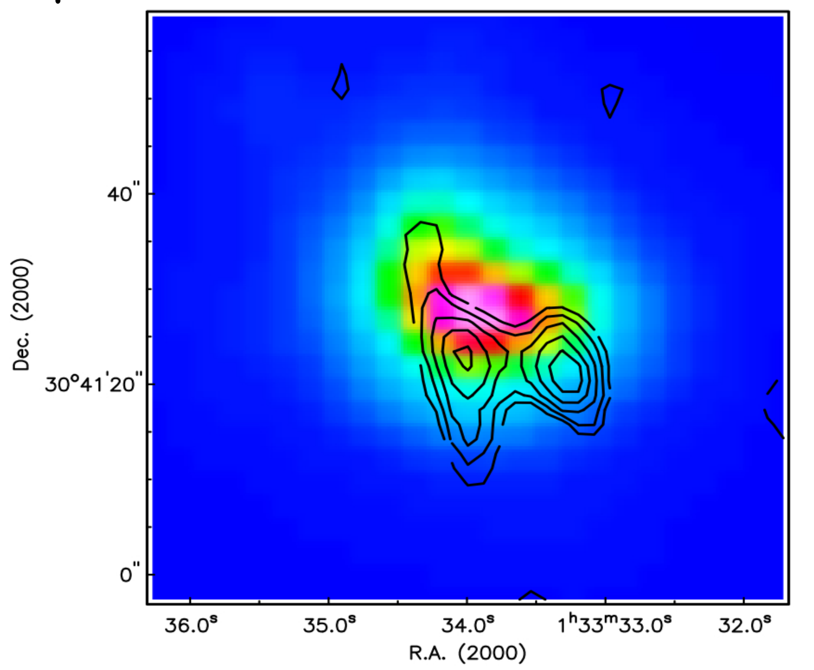
- PAPER M33:

- The Hα emission is in general surrounding the UV emission, especially in the shell-like structures within the HII regions.
- Also observed in Calzetti et al. (05) and Thilker et al. (03).

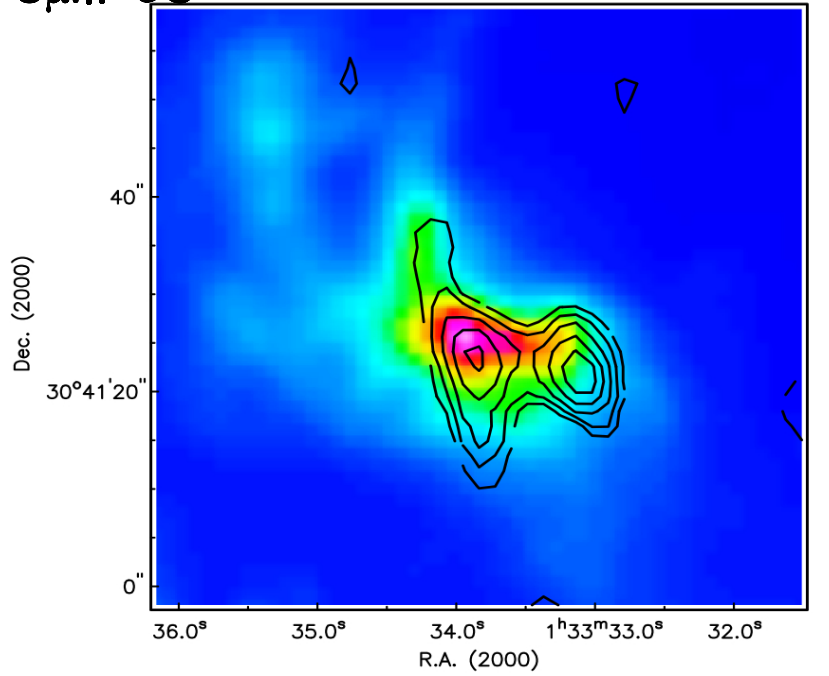


Comparison with CO molecular gas

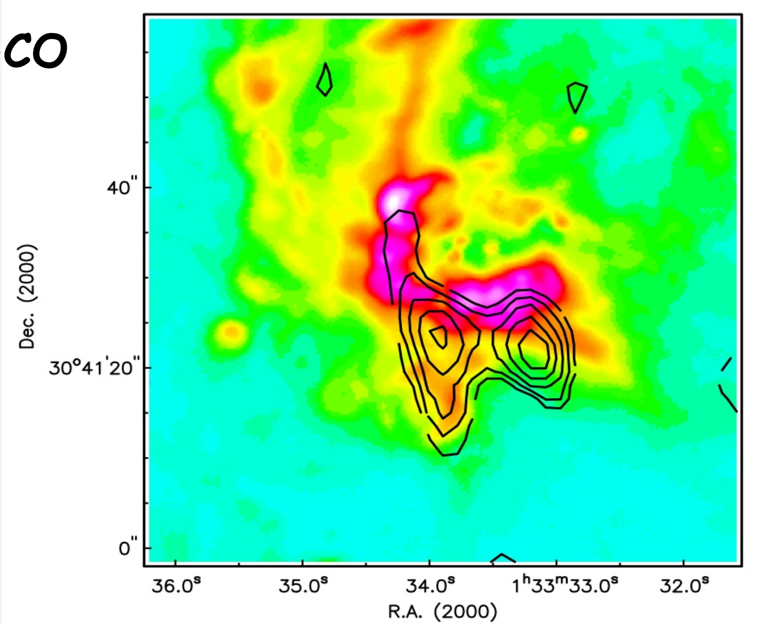
24μm+CO



8μm+CO



Hα+CO



UV+CO