Massive Young Clusters in Local Group Galaxies

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Motivation

- Local Group Massive Young Clusters (MYCs) are easily resolved with HST
  - Believe it or not, those tiny dots in those far away galaxies do have internal structure!
  - Knowledge of morphology is necessary to understand why the integrated properties are the way they are
- Giant molecular clouds and the formation of massive star clusters
  - Massive stars are parricides
  - How is the detailed morphology of a giant H II region determined?
  - How does differential extinction affect observations?

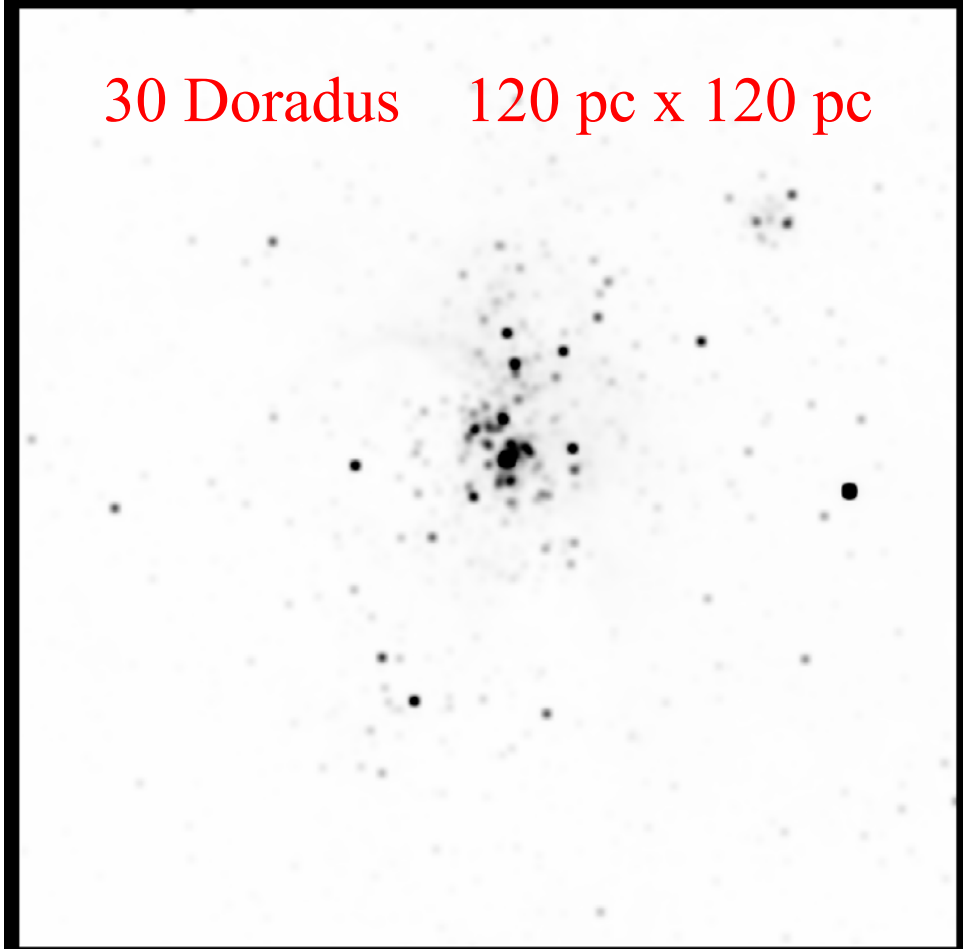
The “standard” sample

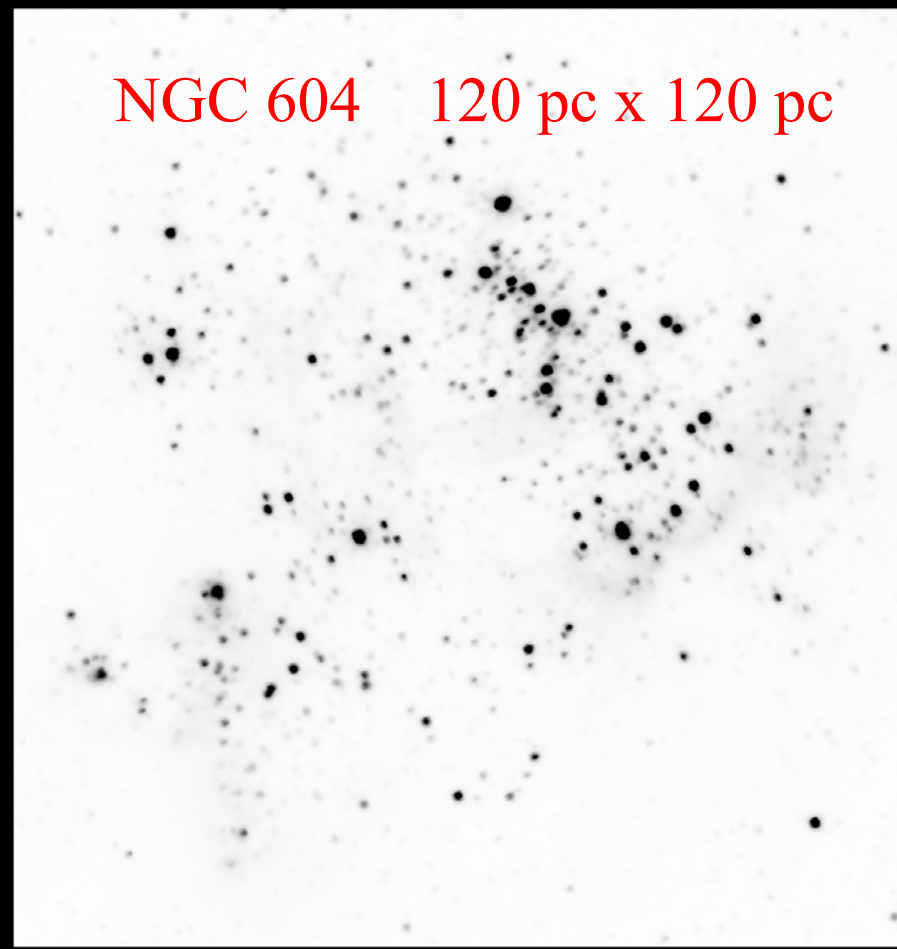
- 30 Doradus
  - LMC, ~2 Ma old (R136) + other generations
  - Rosetta stone... but not fully understood yet!
- NGC 604
  - M33, ~3.5 Ma old
  - Similar to 30 Dor in mass, not in structure
- N11
  - LMC, ~4 Ma old (LH9) + ~1 Ma old (LH10)
  - Less massive

Data (present and future)

- HST
  - WFPC2 + ACS (WFC+HRC) + STIS (NUV MAMA) + NICMOS imaging
  - STIS long-slit CCD + objective-prism UV MAMA spectroscopy
- Ground based
  - NTT narrow-band optical+NIR imaging
  - CO + NIR H_2 data
  - High-resolution optical VLT spectroscopy (hopefully!)

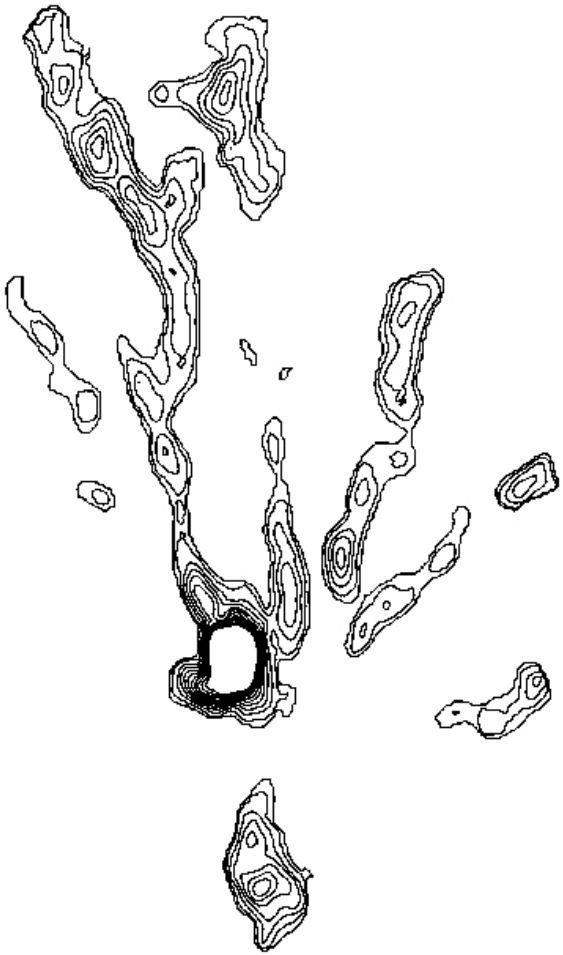
SSCs vs. SOBAs
(Super Star Clusters vs. Scaled OB Associations)





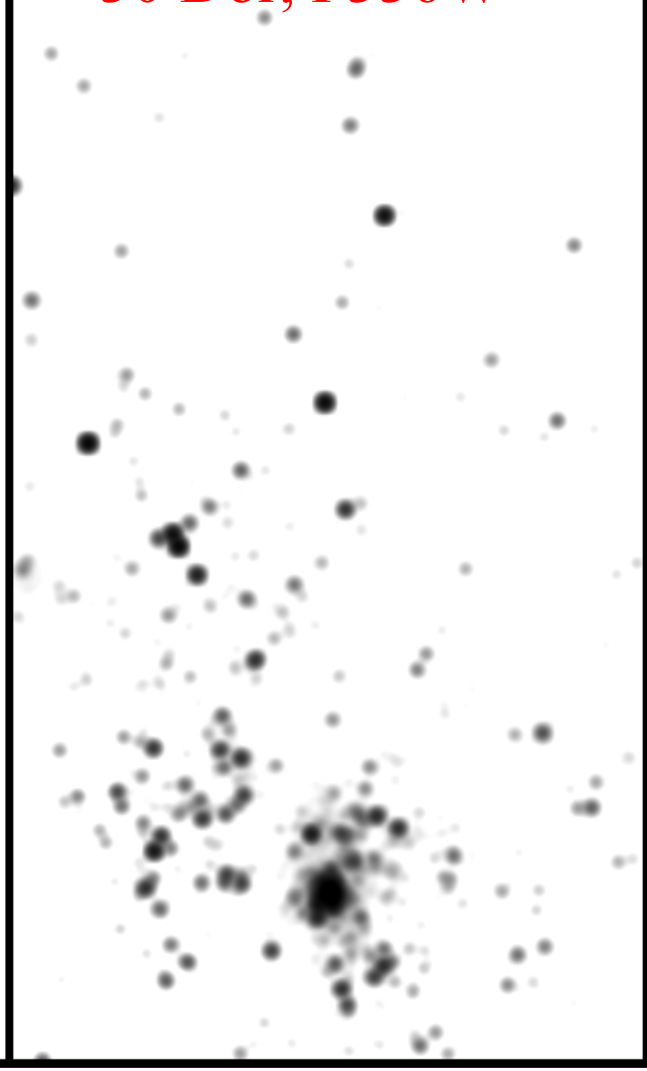
What causes the morphology?

OMC-1, NH_3 (1,1)

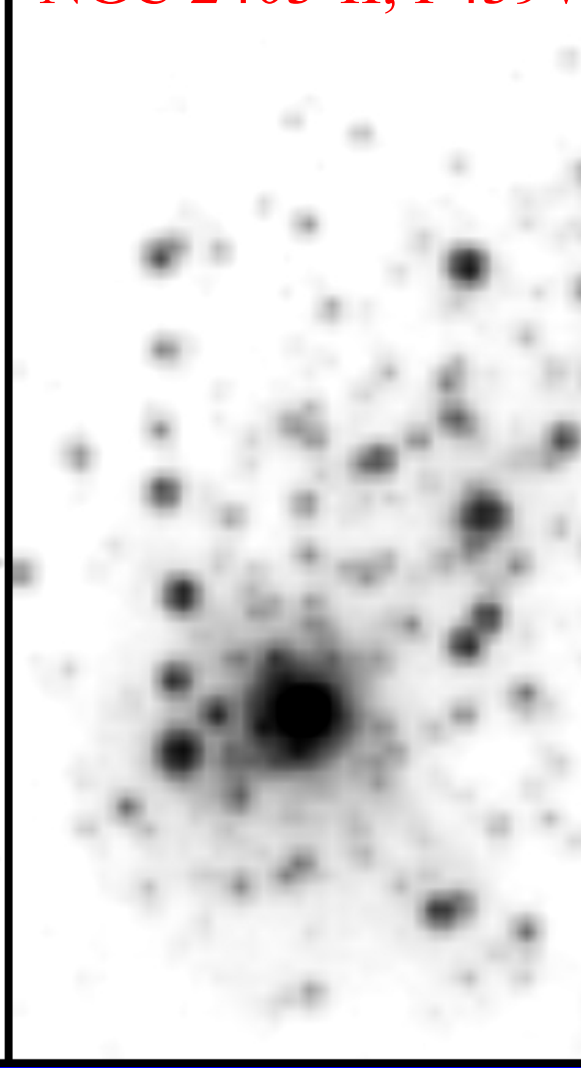


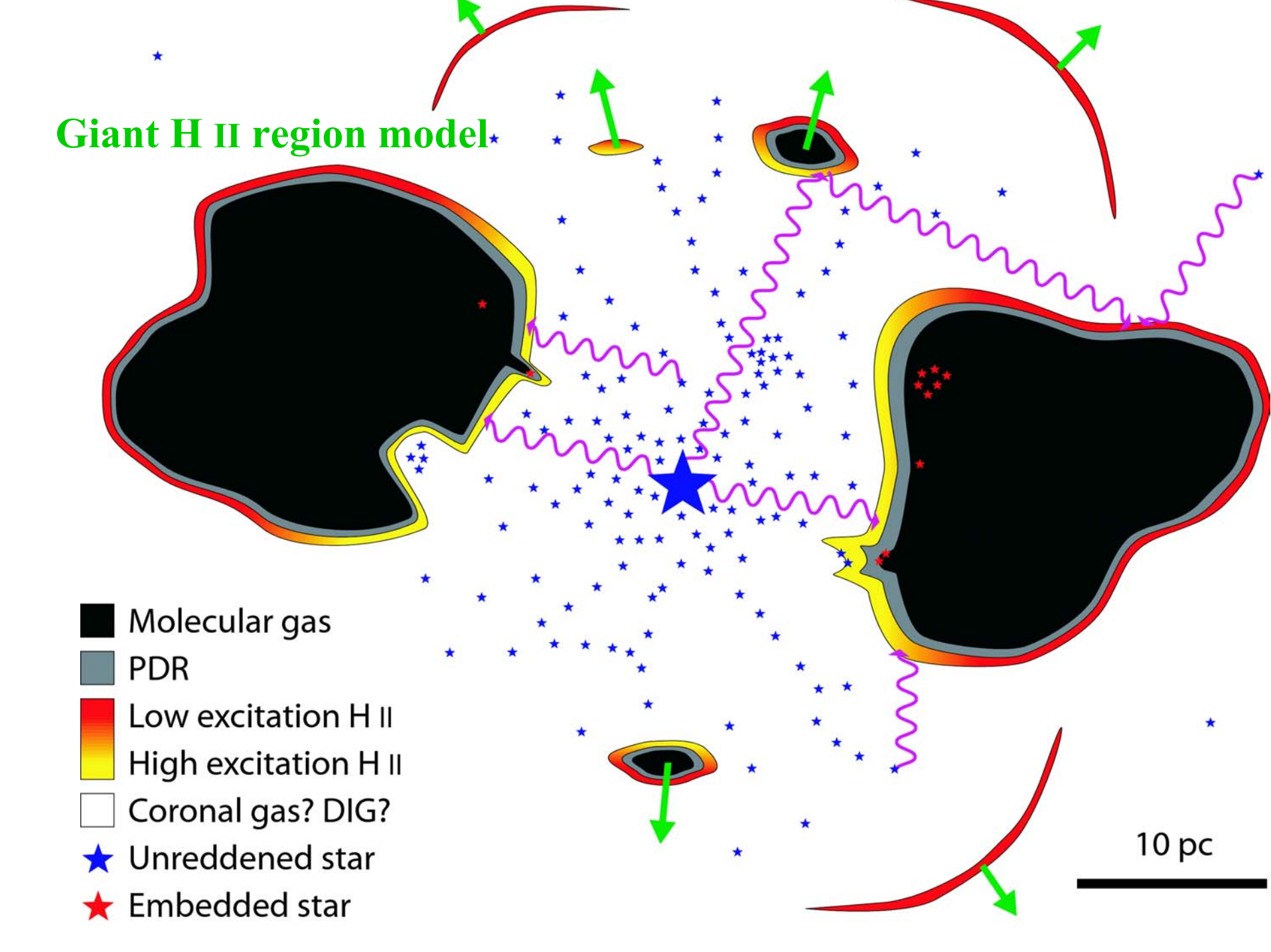
Wiseman & Ho 1998

30 Dor, F336W

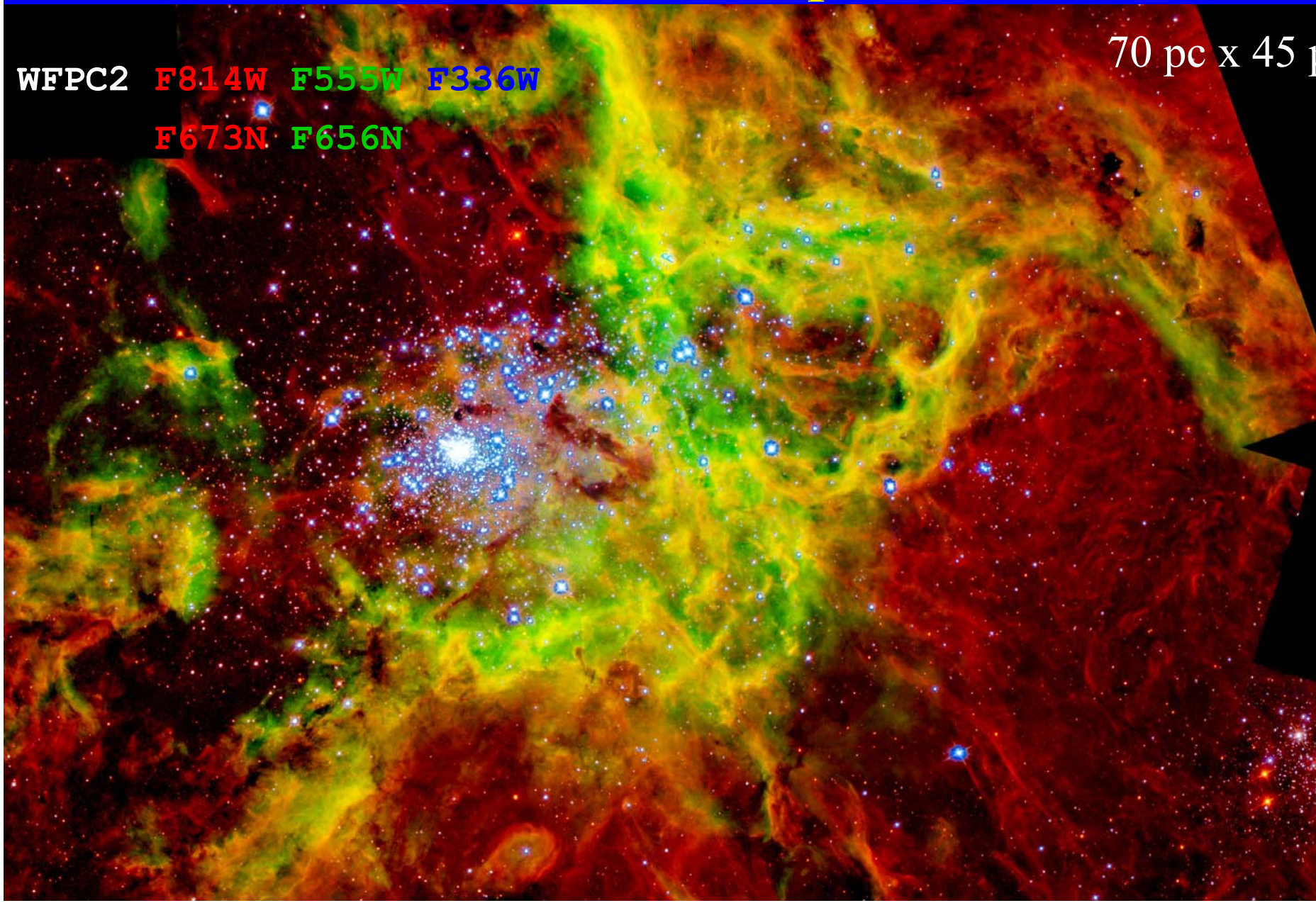


NGC 2403-II, F439W

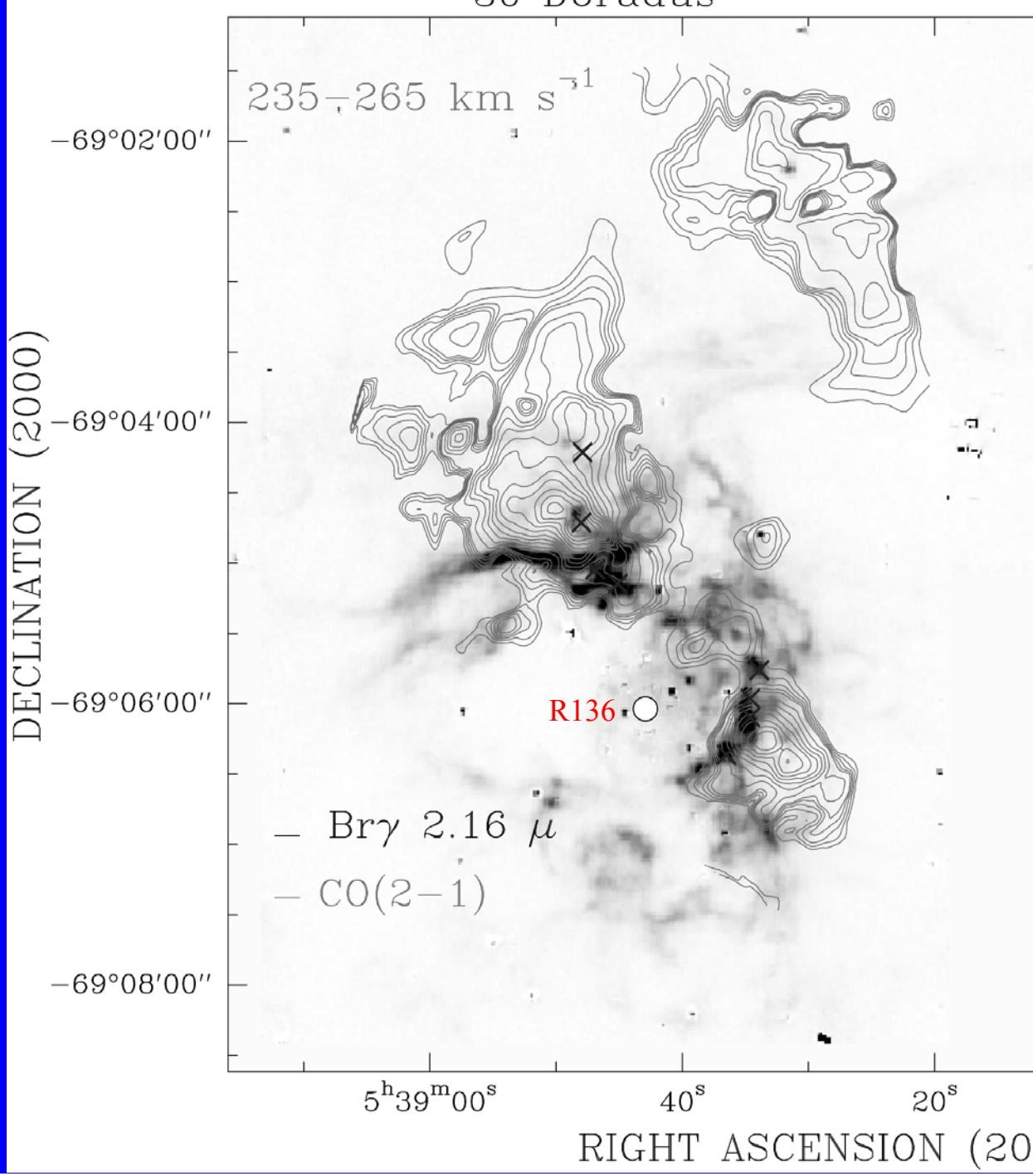



Giant H II region model
Molecular gas
PDR
Low excitation H II
High excitation H II
Coronal gas? DIG?
Unreddened star
Embedded star
10 pc

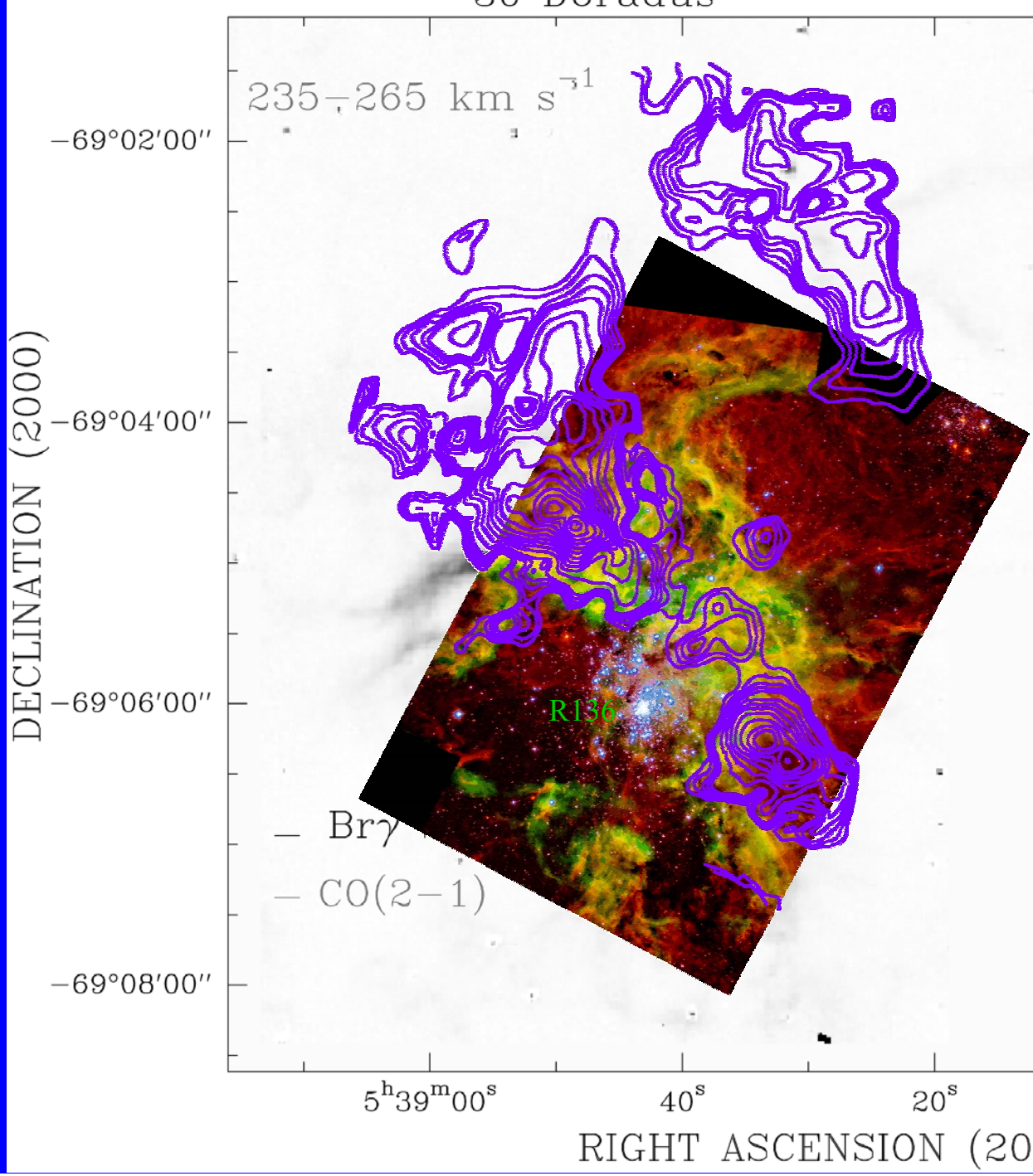
30 Doradus: The complete mosaic



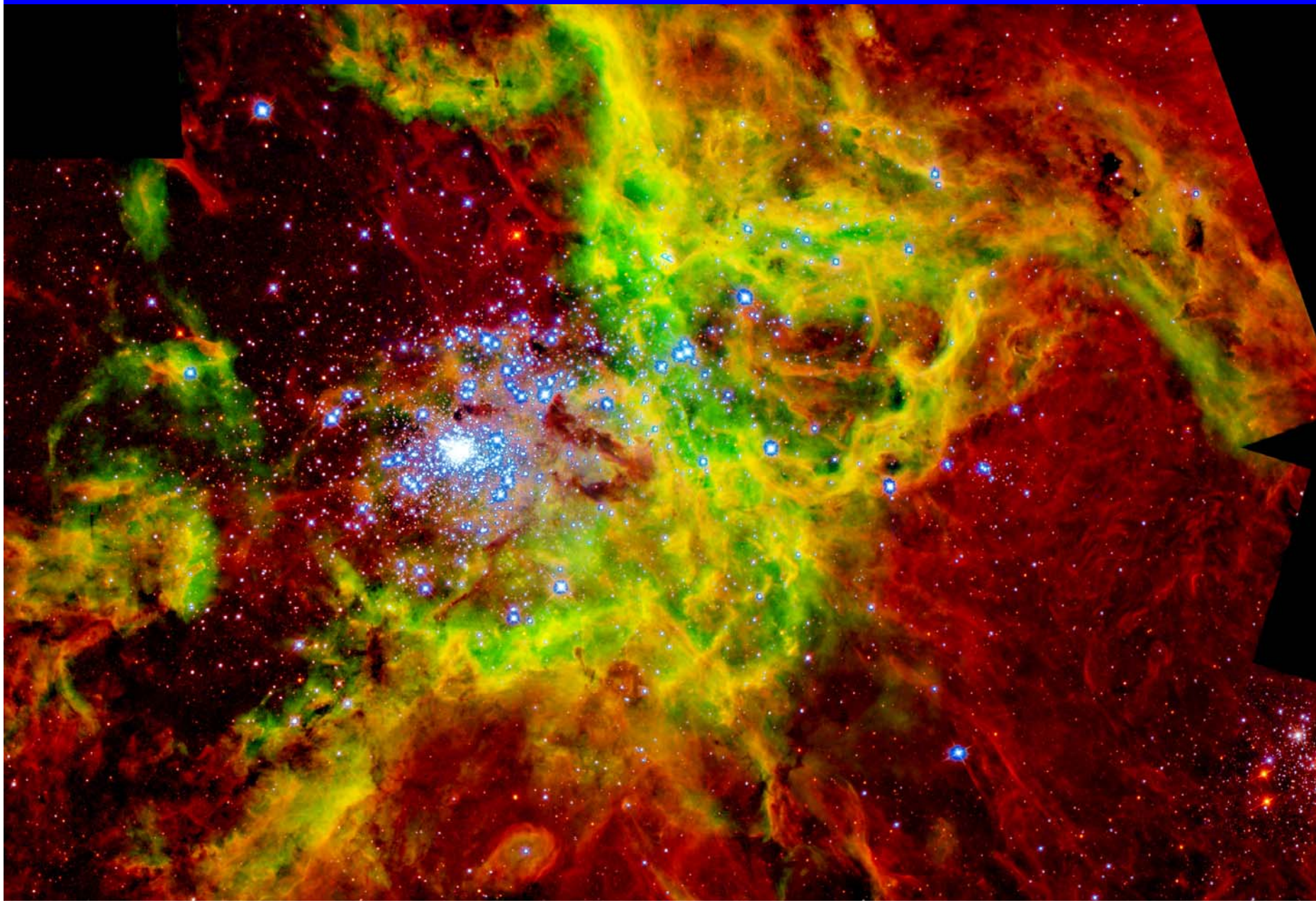
30 Doradus in Brγ + CO



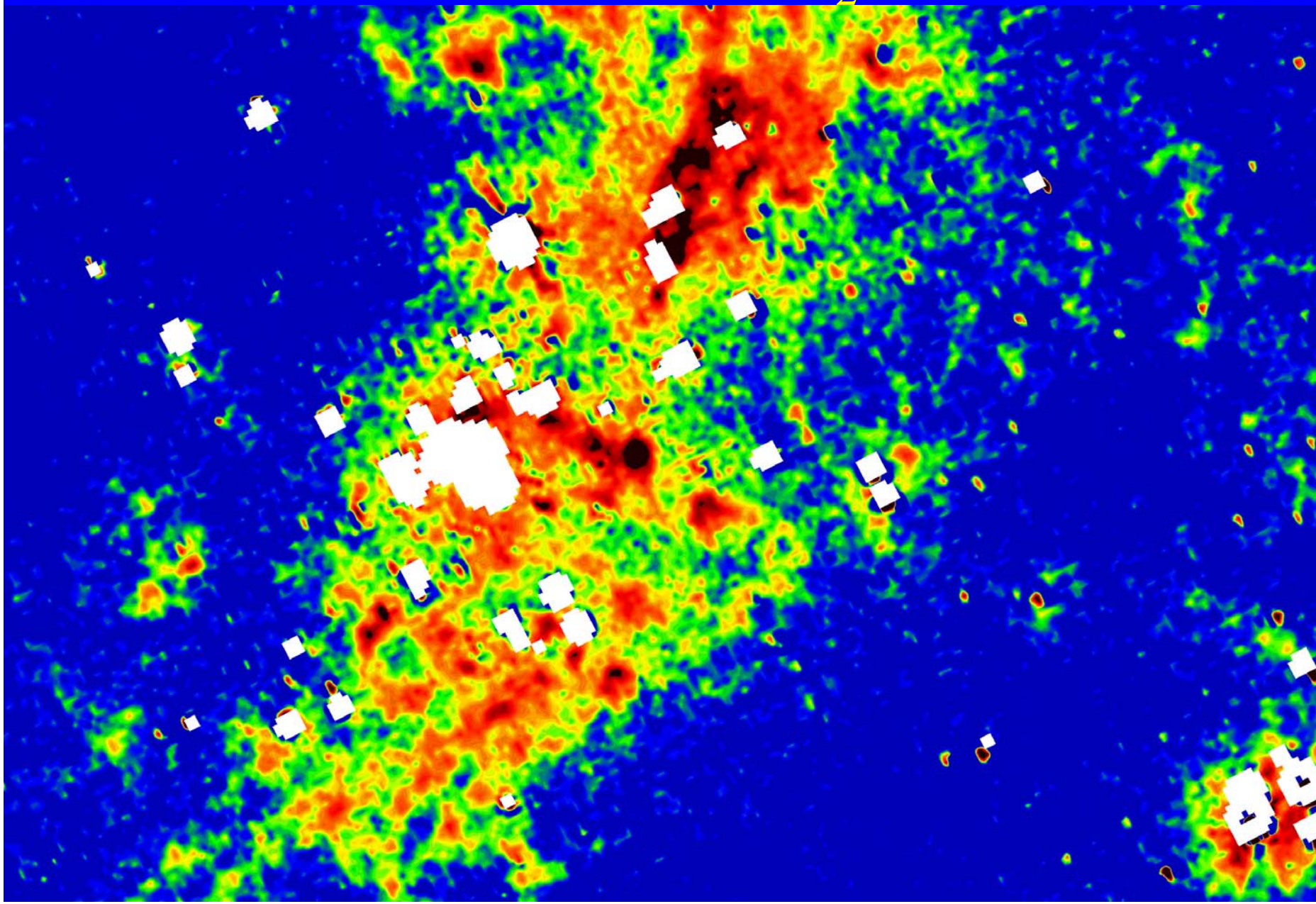
30 Doradus mosaic + CO



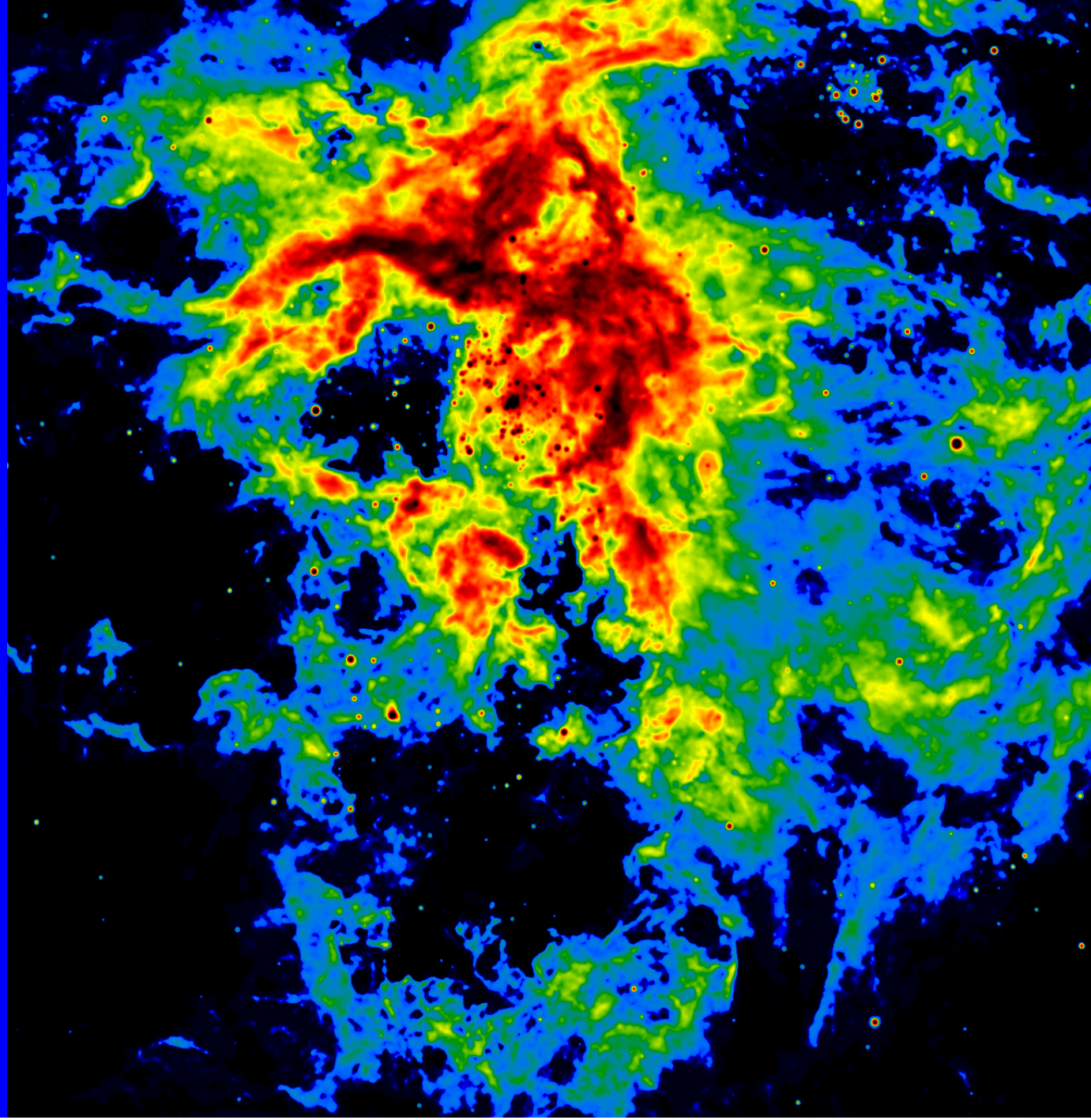
WFPC2 nebular + continuum mosaic



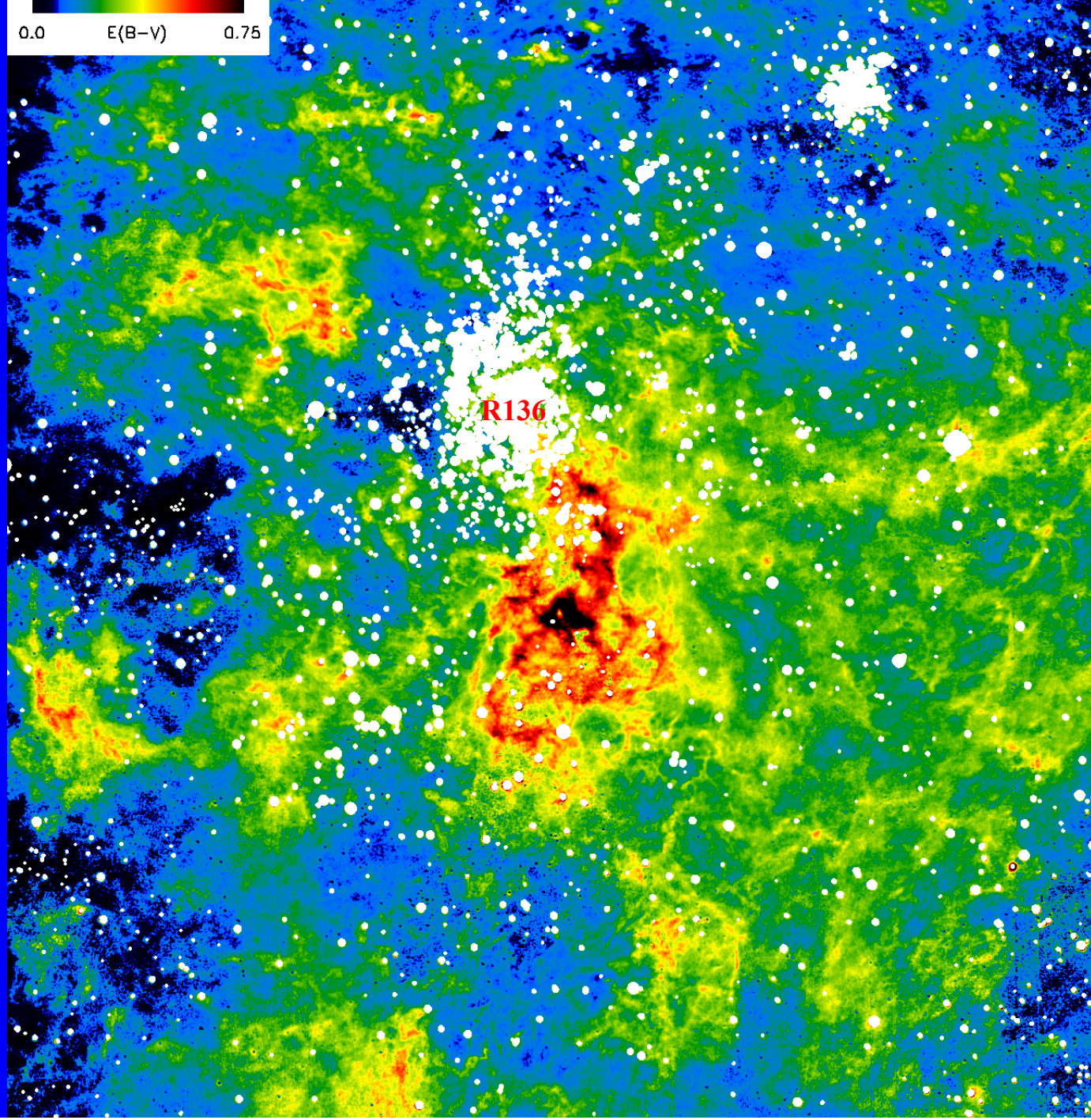
Ground-based NIR H_2 emission



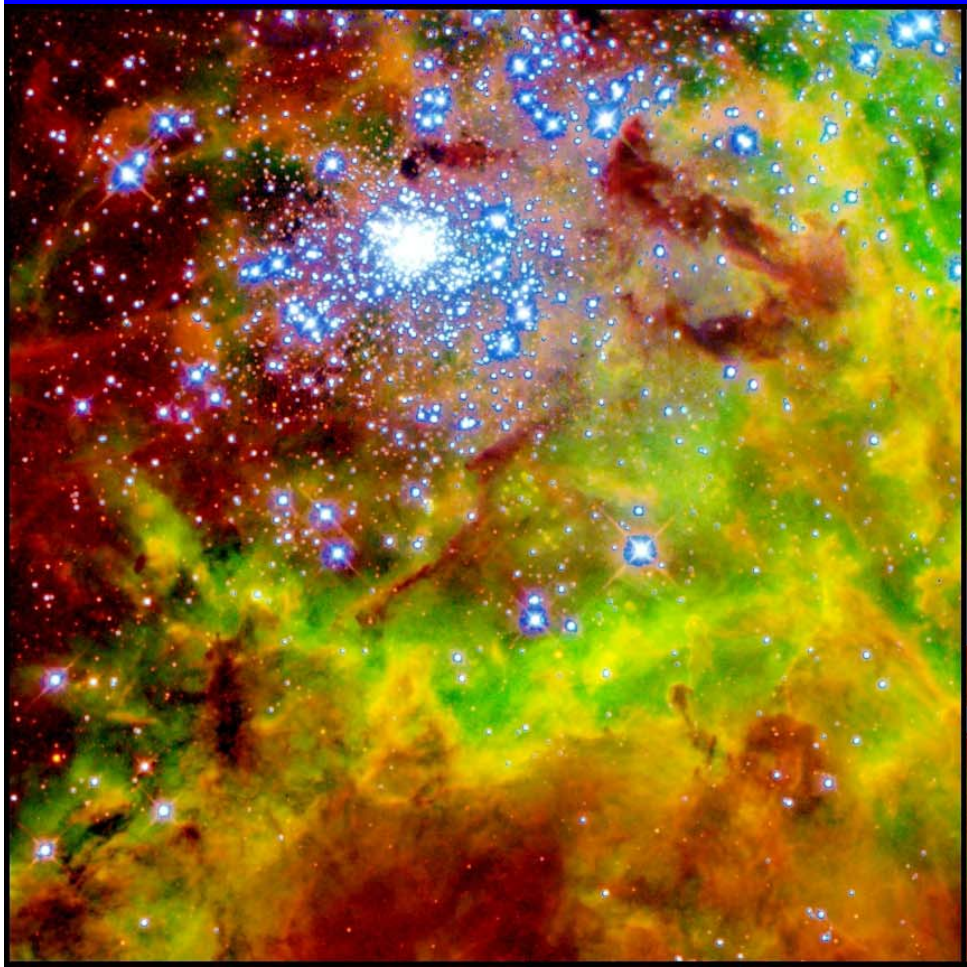
30 Doradus in Hα + continuum



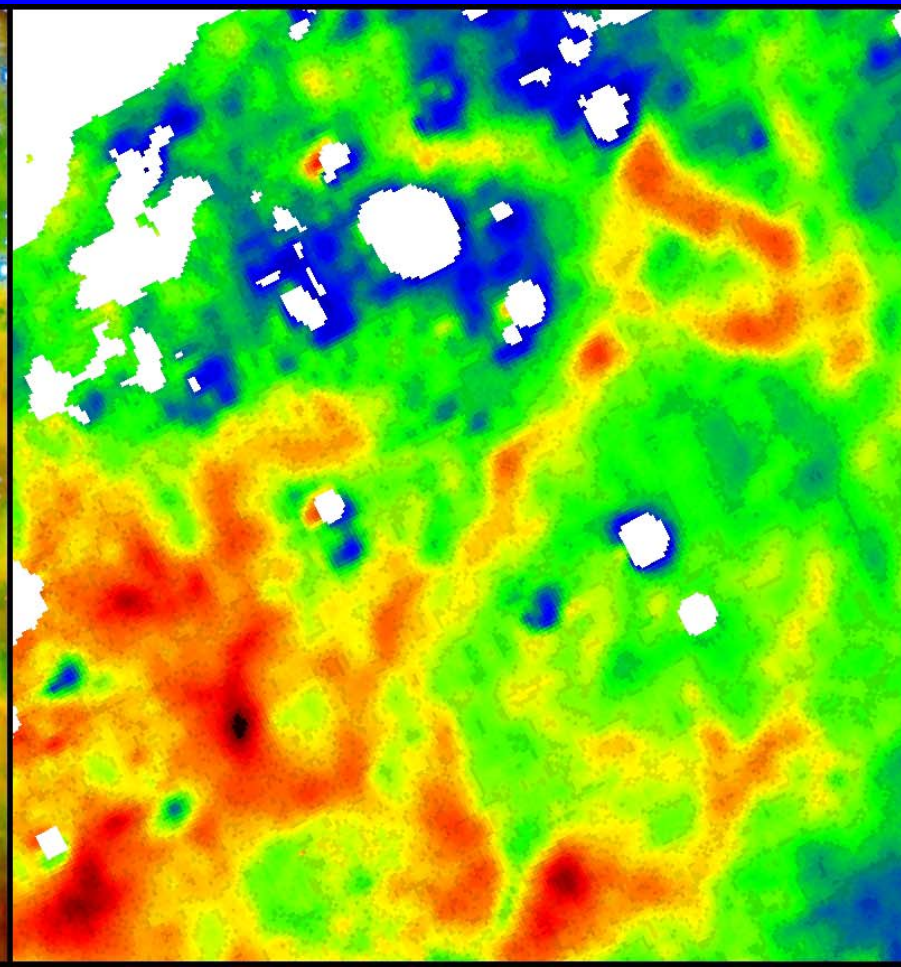
30 Doradus Hα / Hβ extinction



The variable extinction around R136

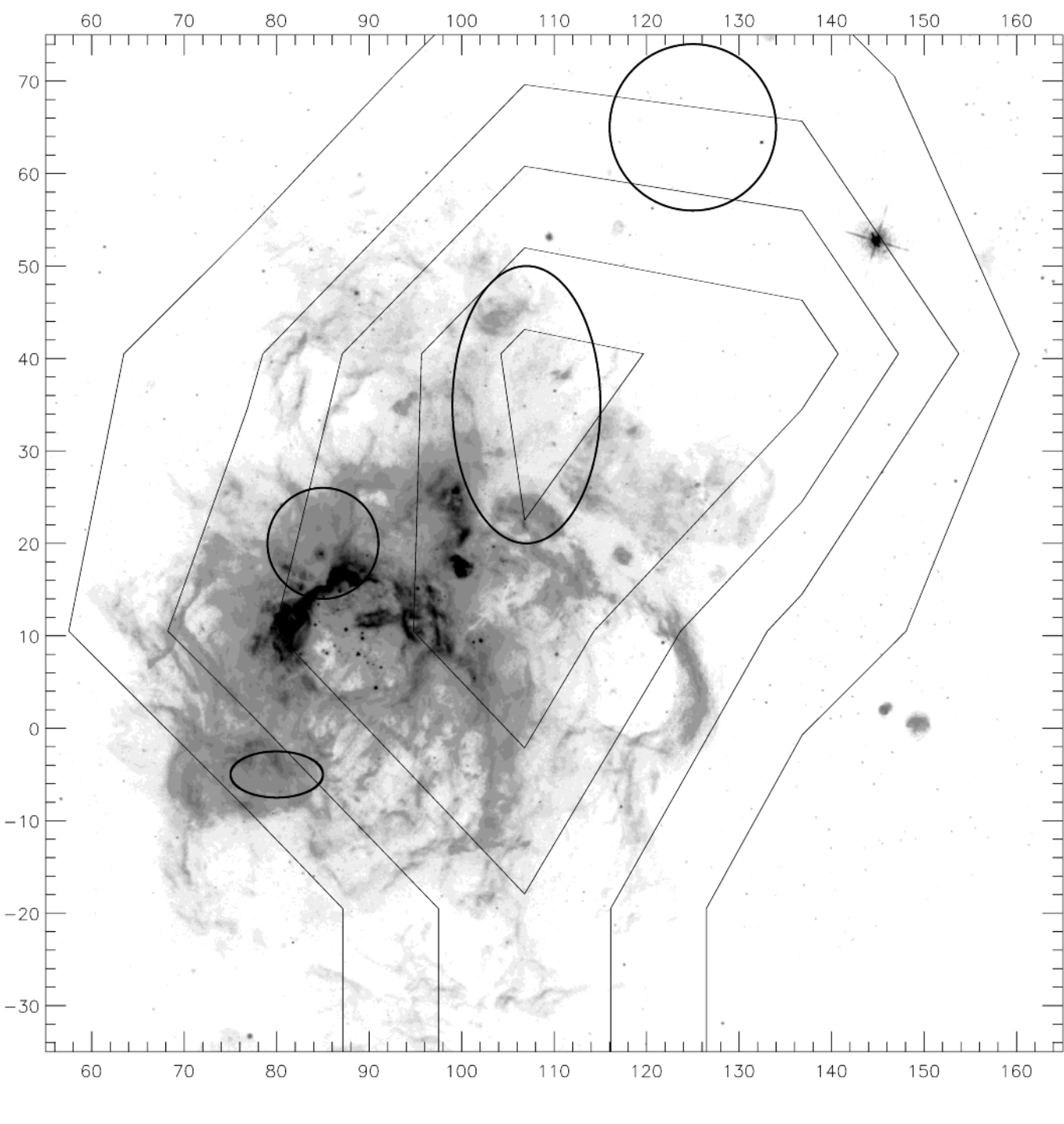


WFPC2 neb.+cont. mosaic

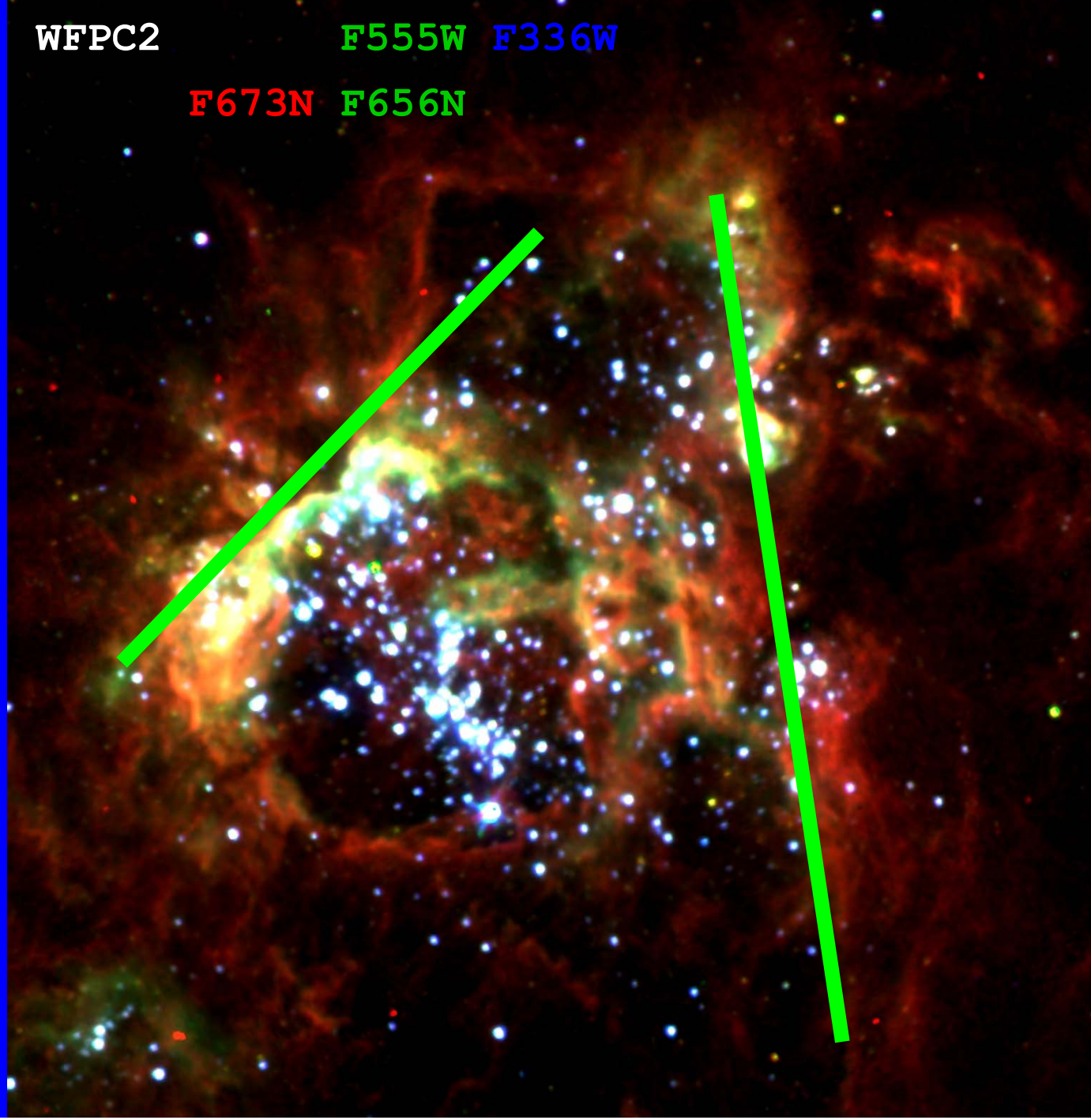


Brγ/Hα extinction

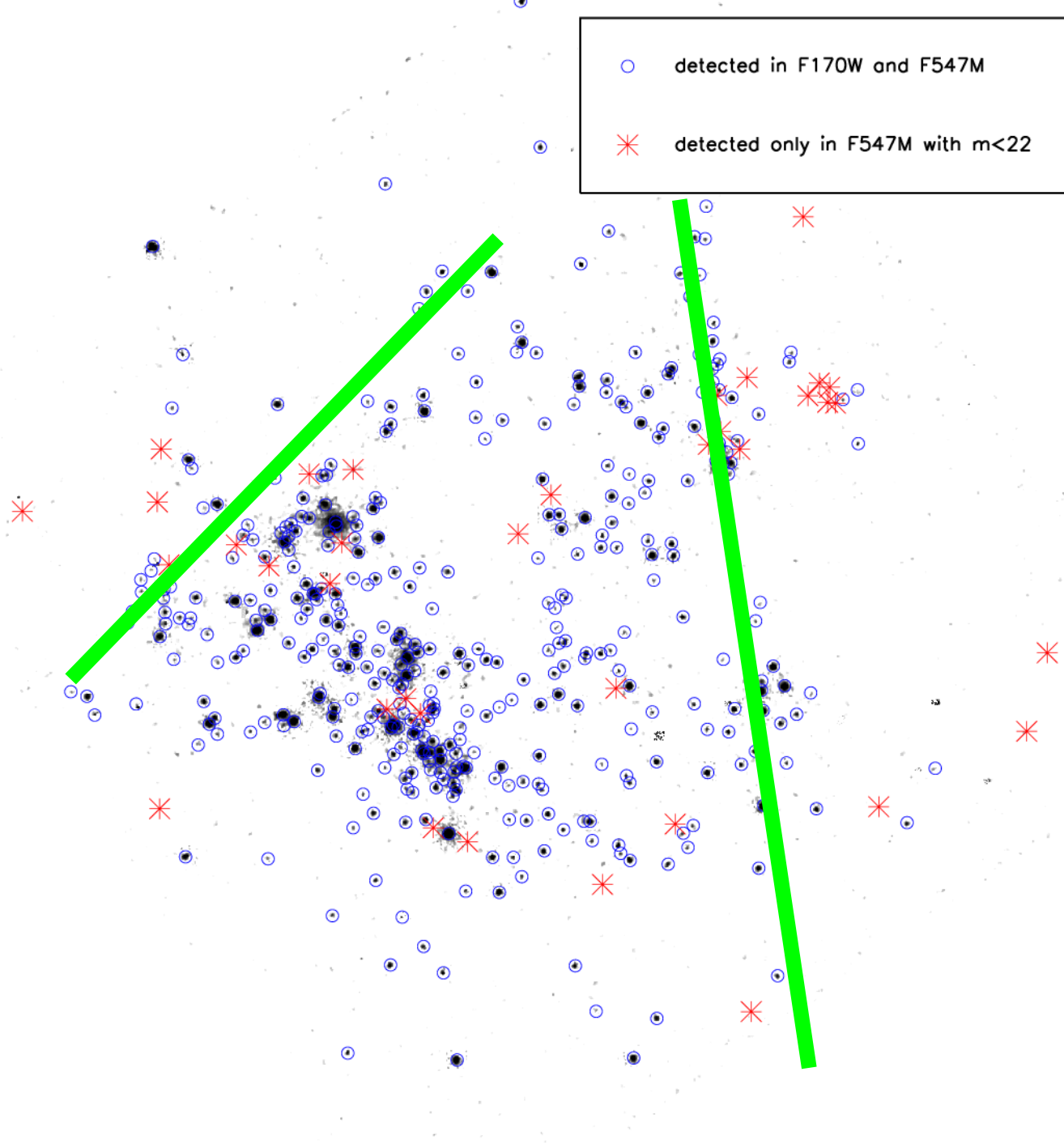
NGC 604 in Hα and CO



NGC 604 optical



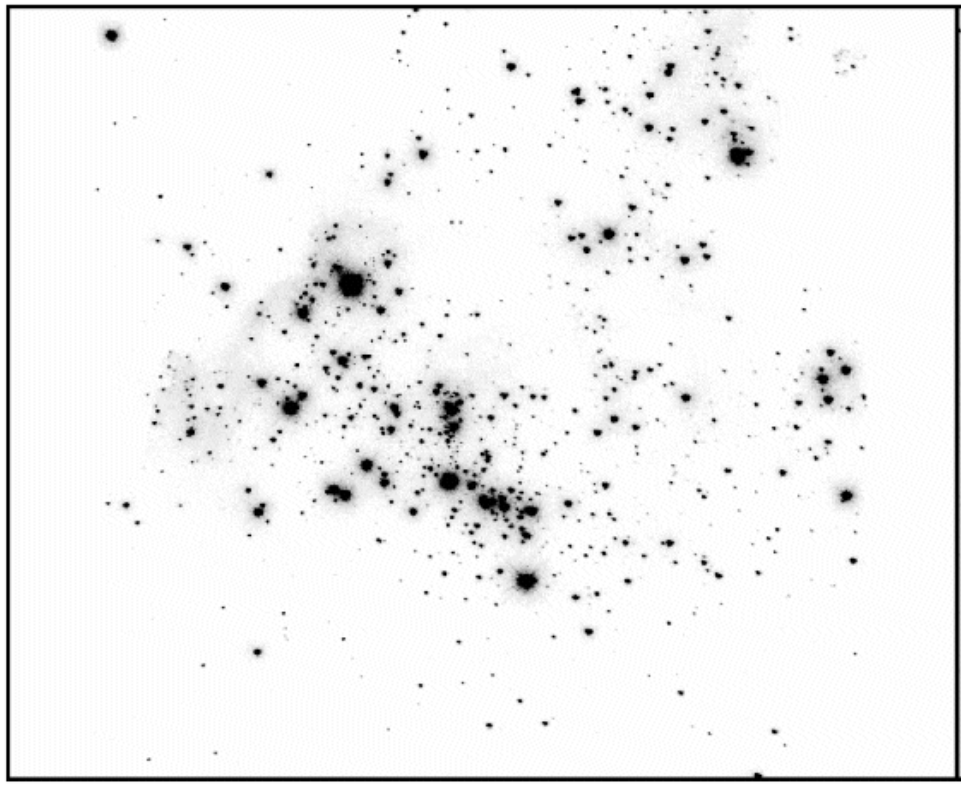
NGC 604
FUV

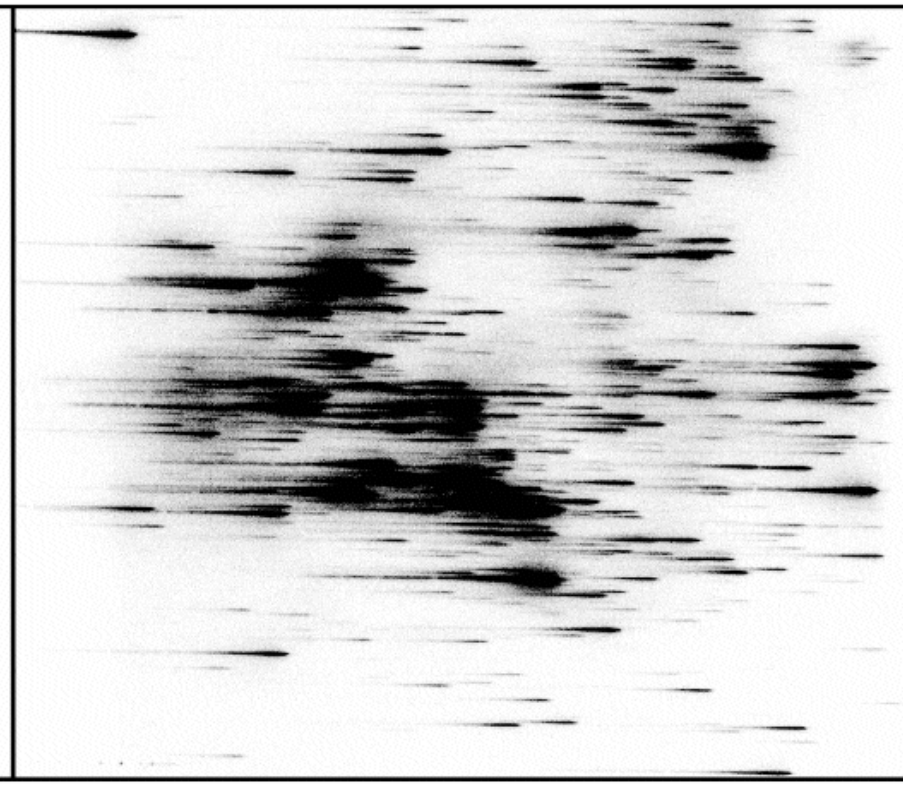


Objective-prism UV spectroscopy

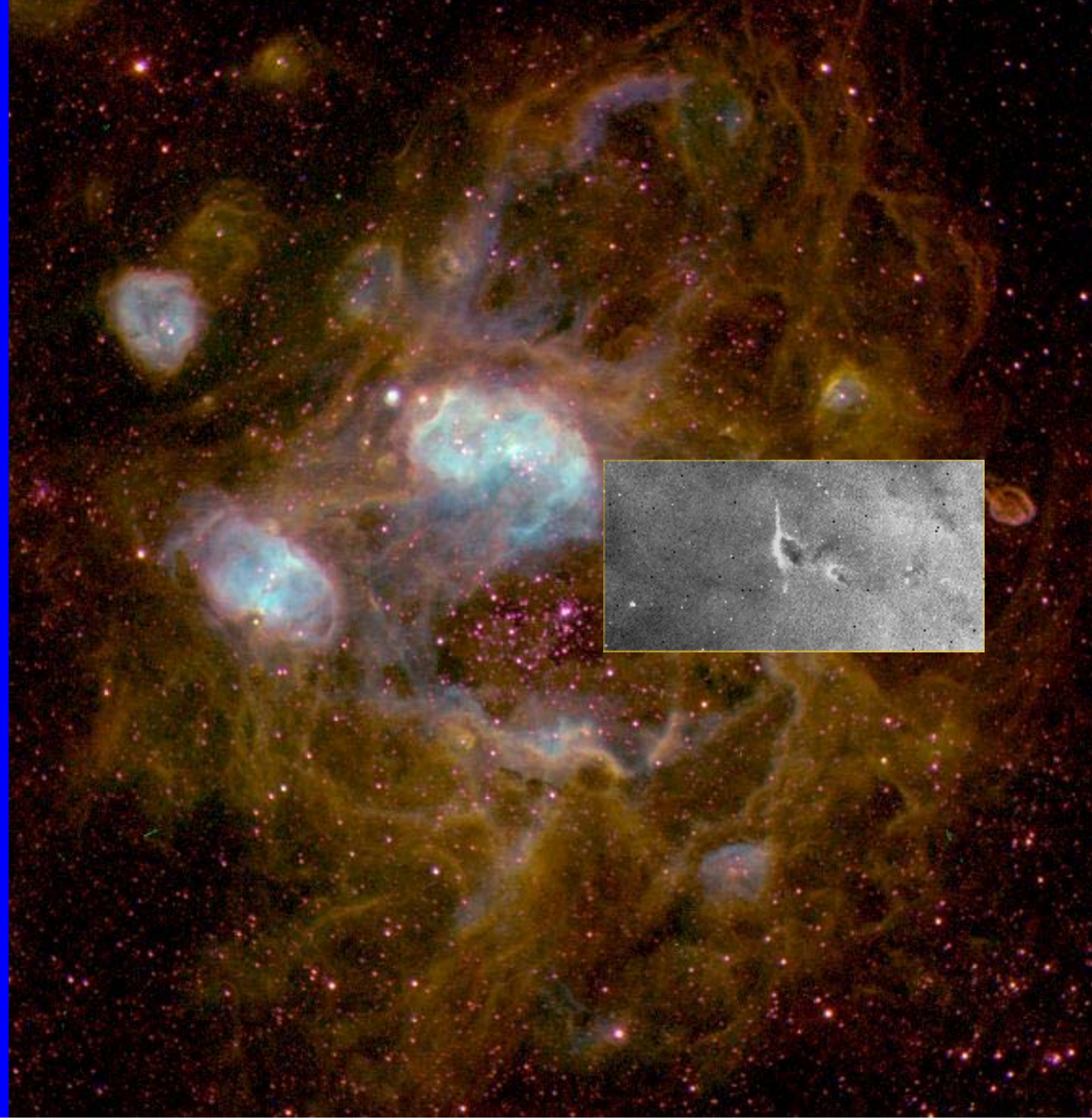
NUV image

Objective-prism exposure

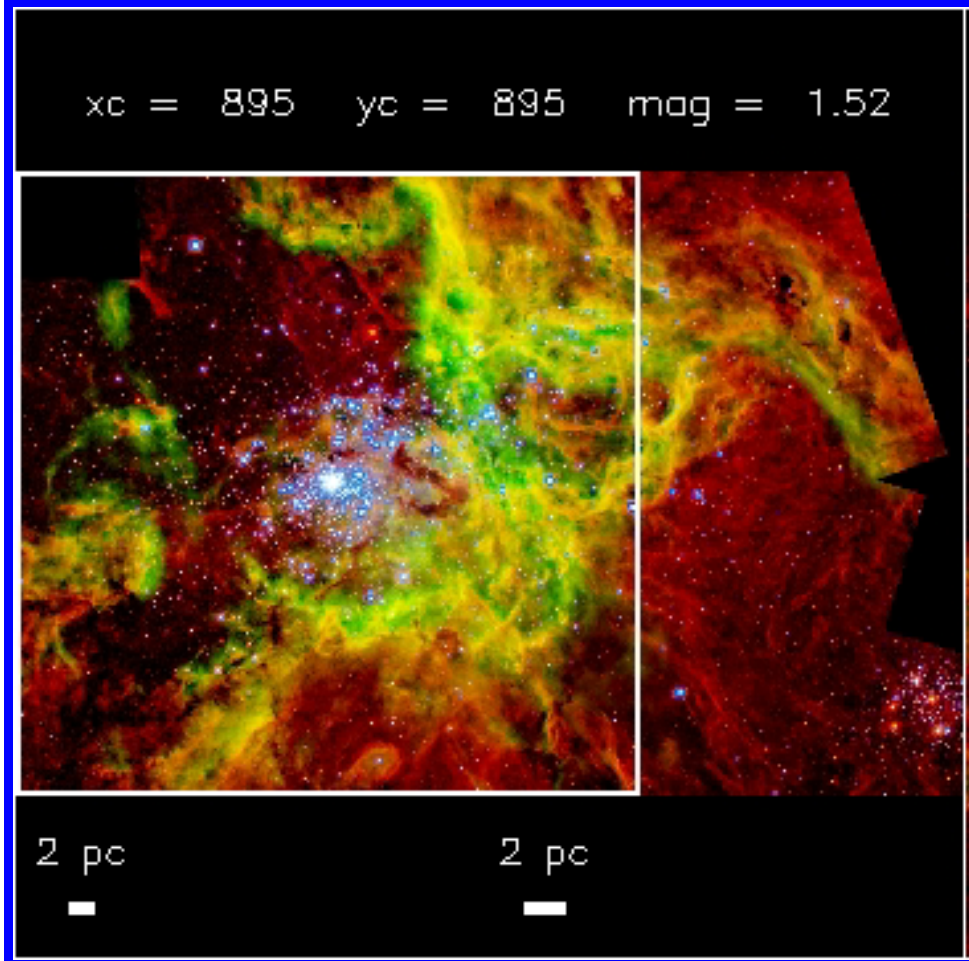


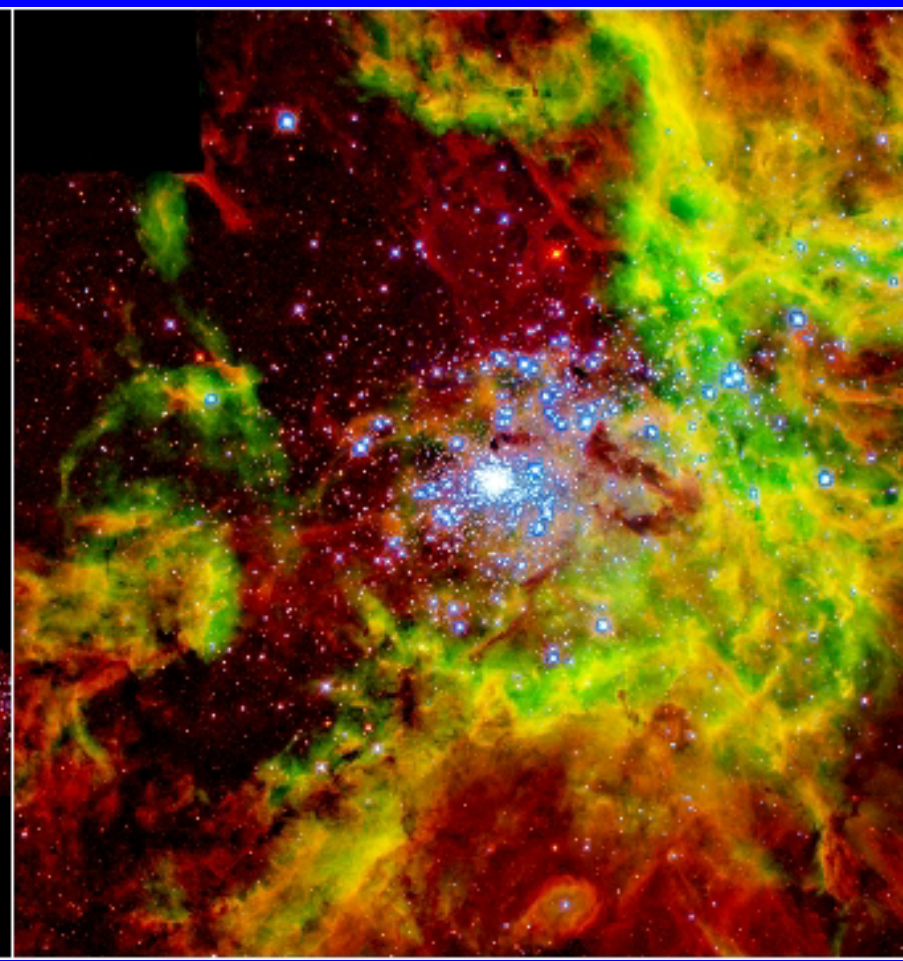


N11: 30 Dor in the future



The new generation: Knot 3

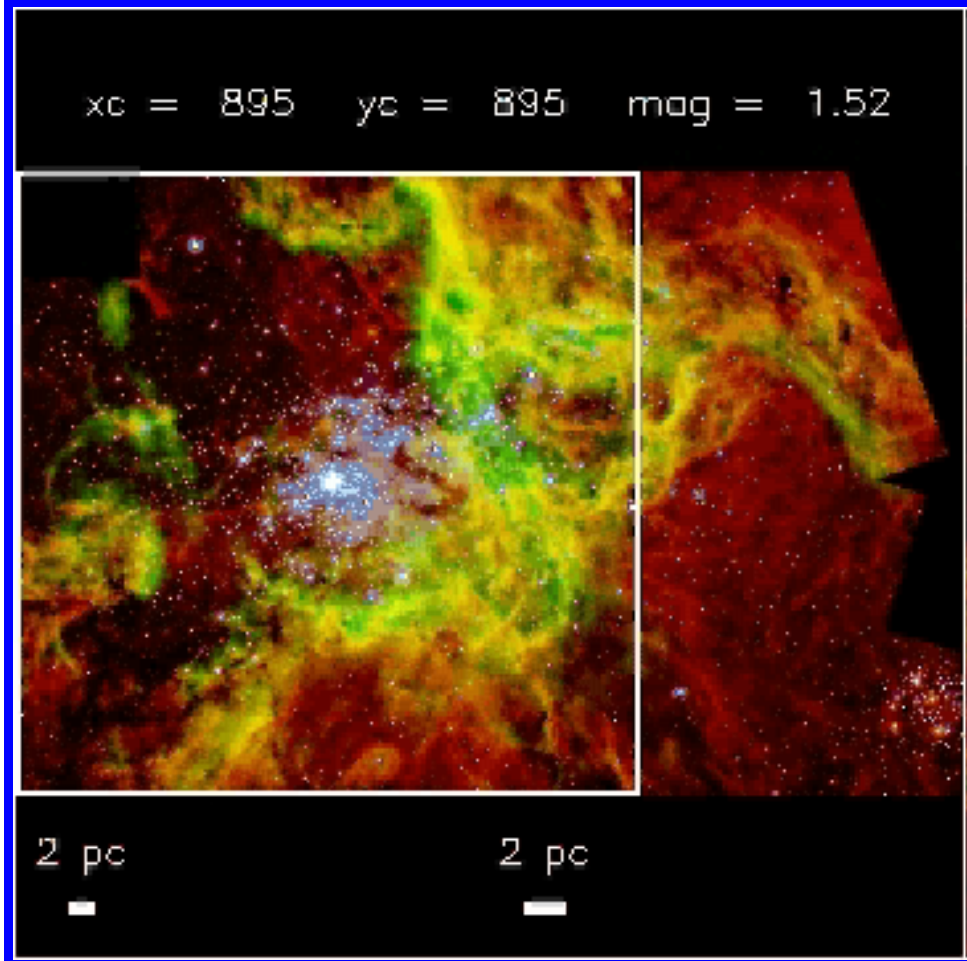


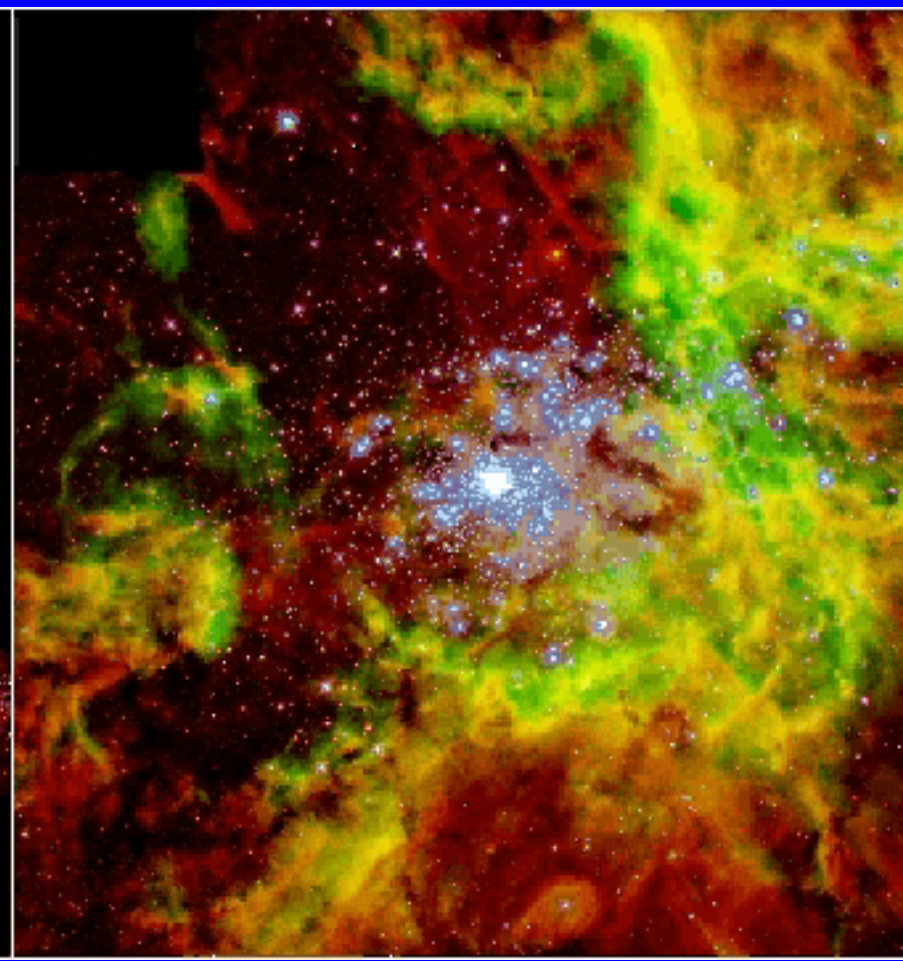


WFPC2 F814W F555W F336W

F673N F656N

The new generation: Knot 3

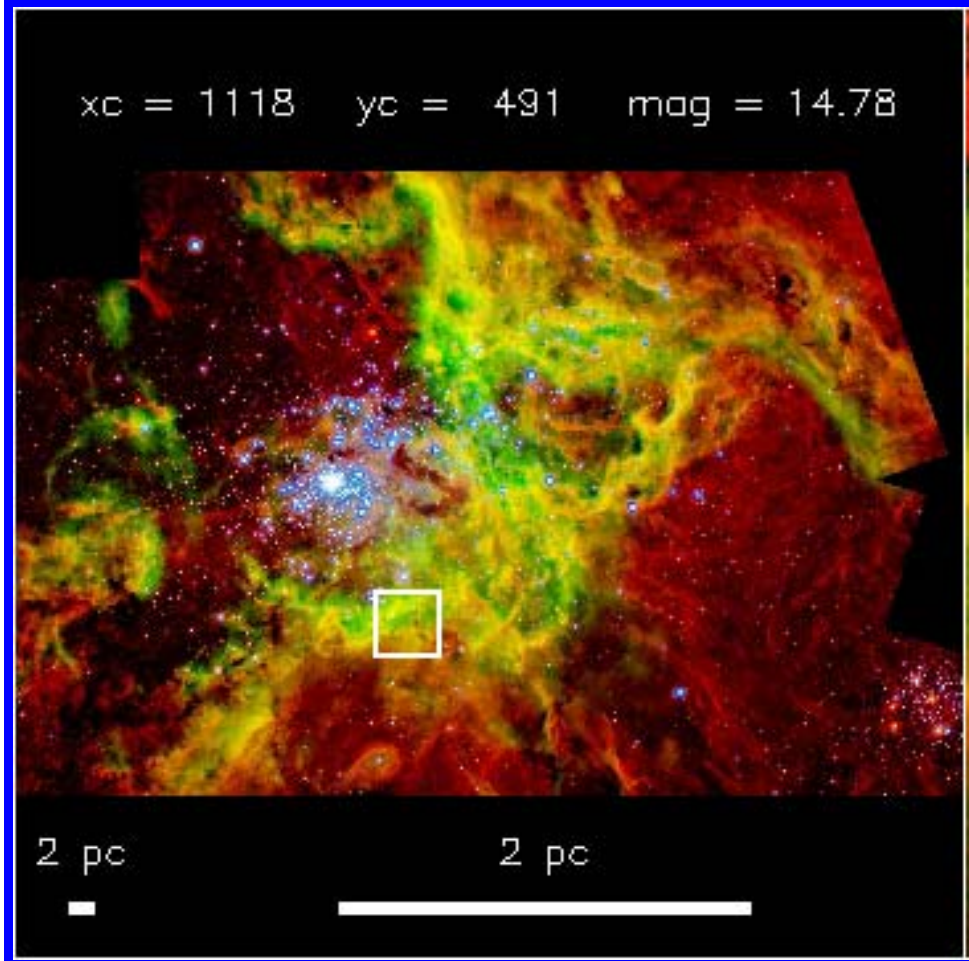


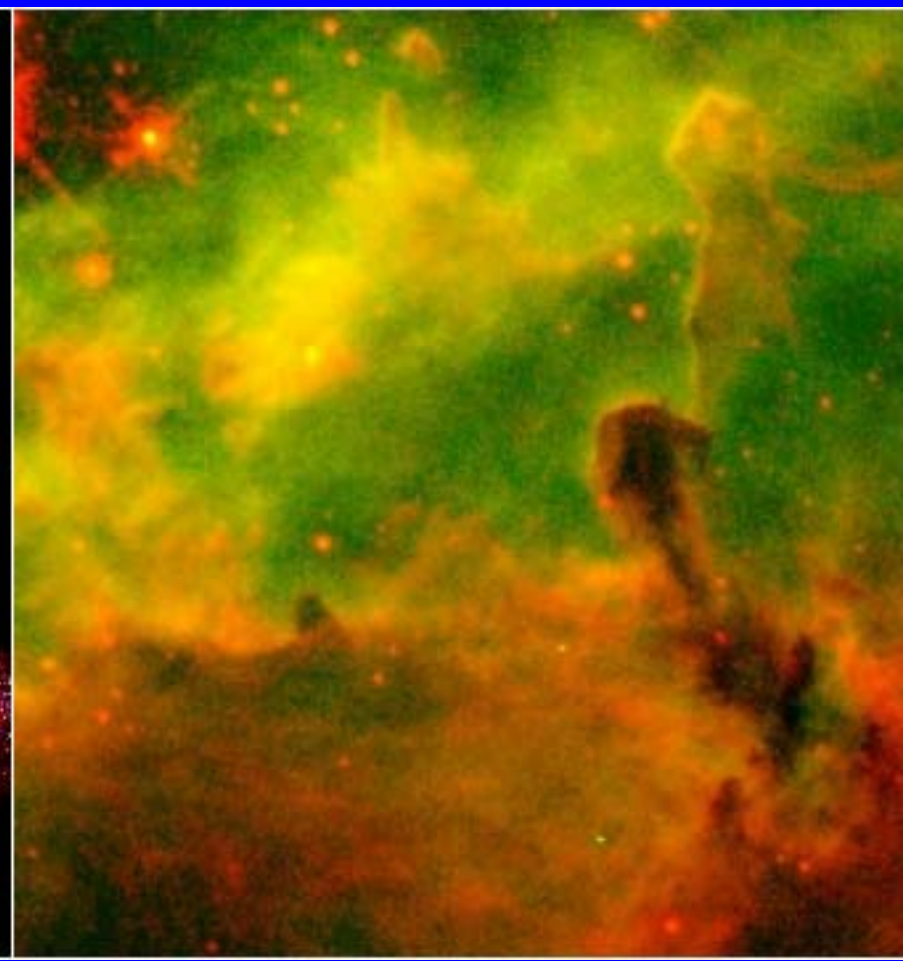


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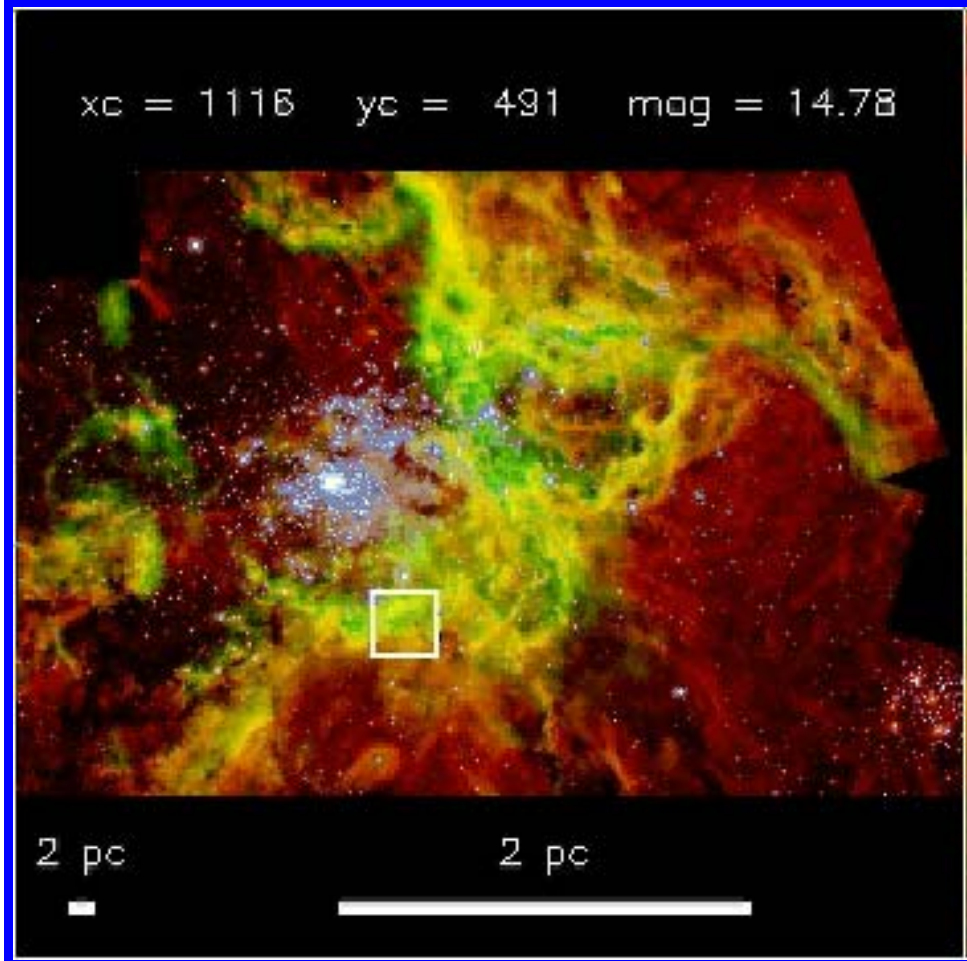


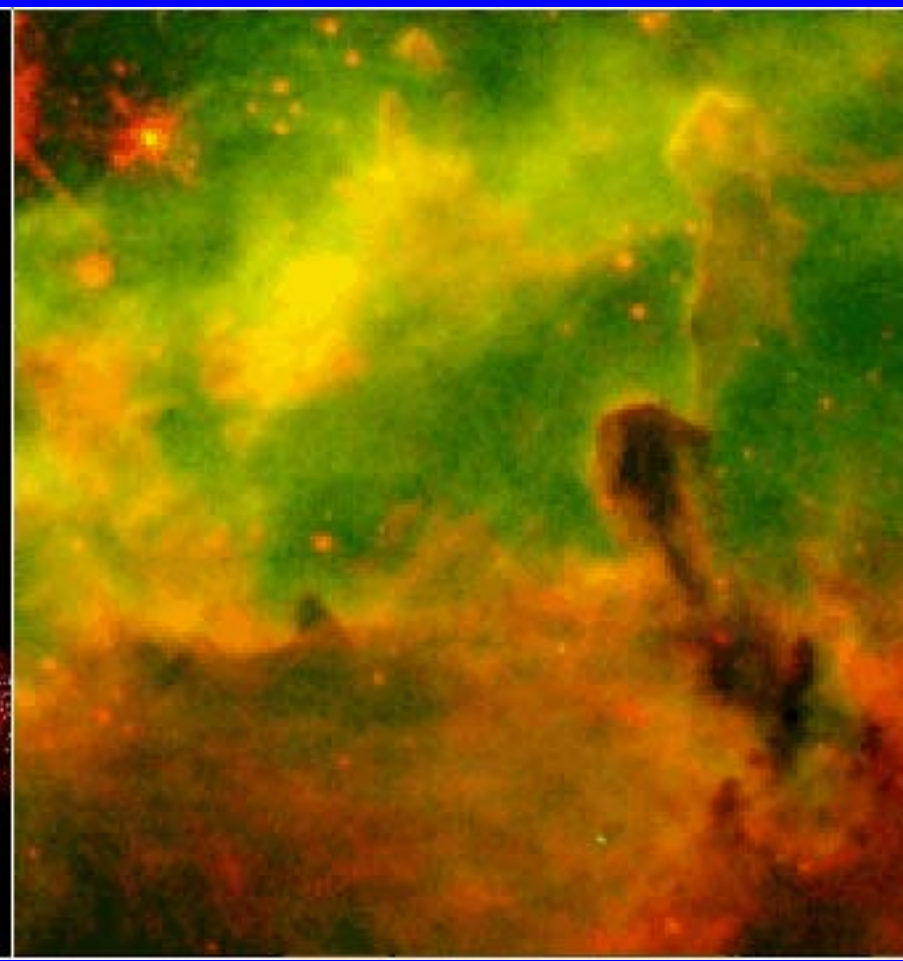


WFPC2 F814W F555W F336W
F673N F656N

PC F673N F502N

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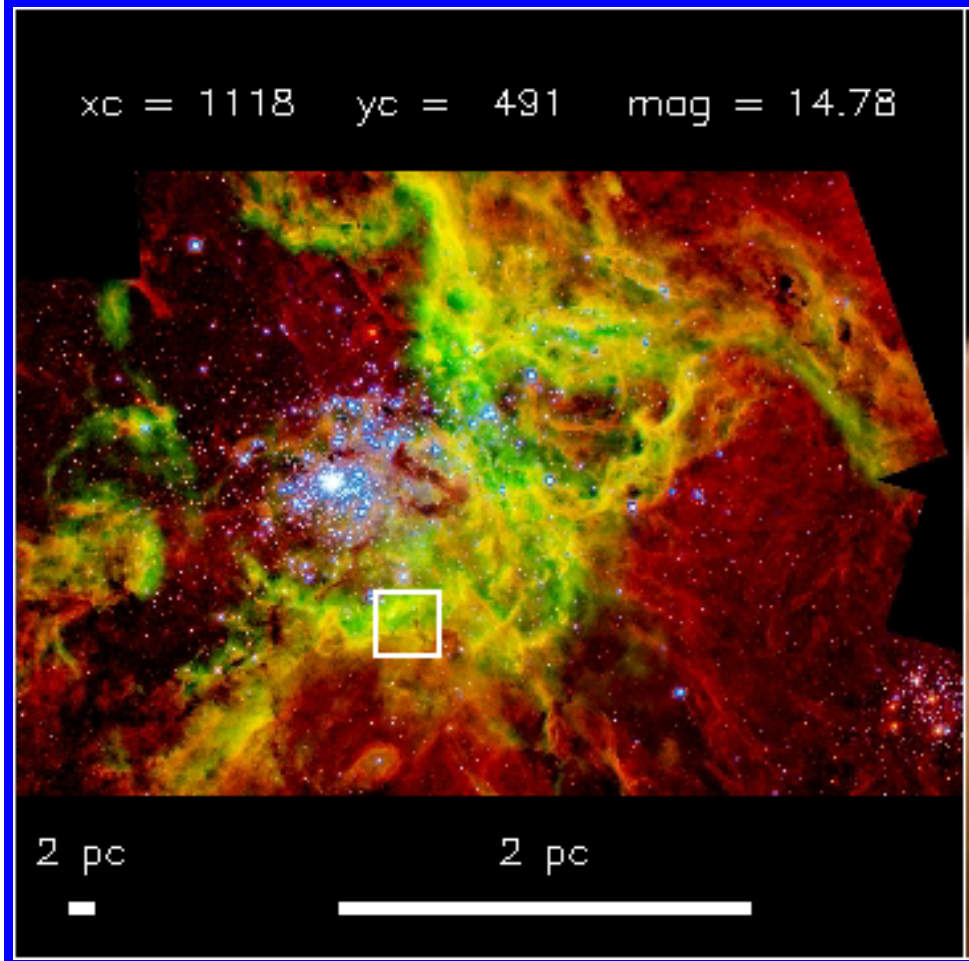


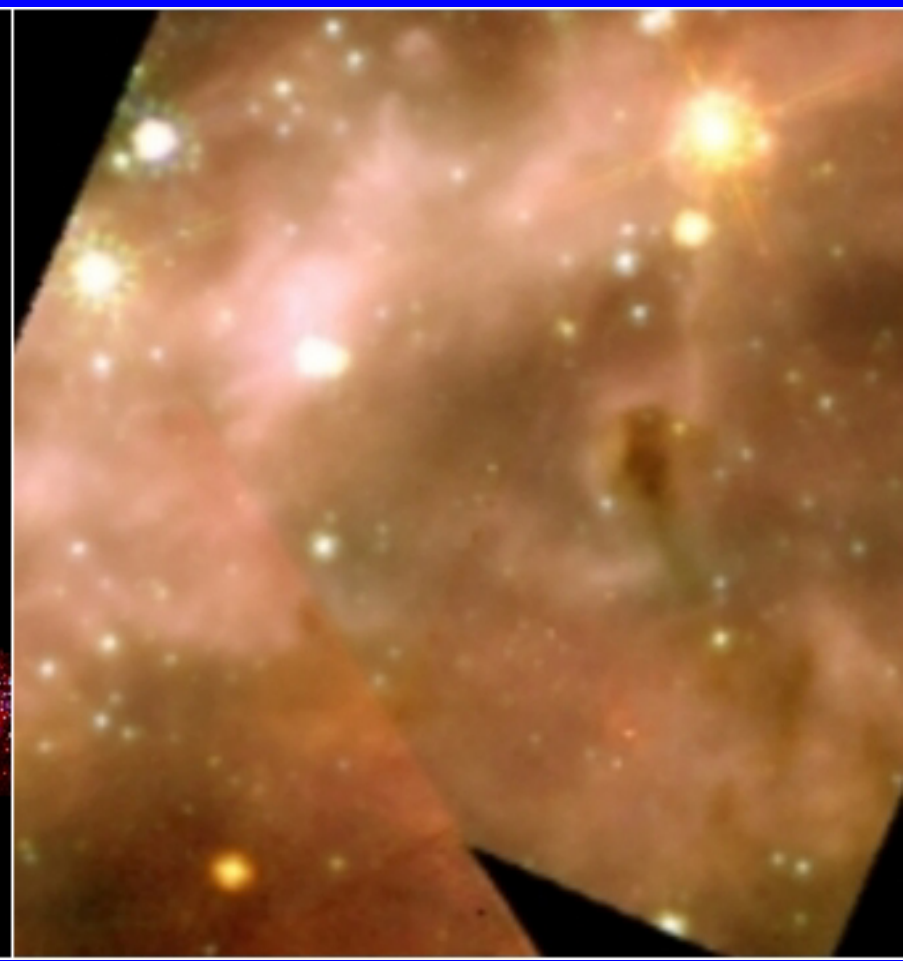


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F673N F656N

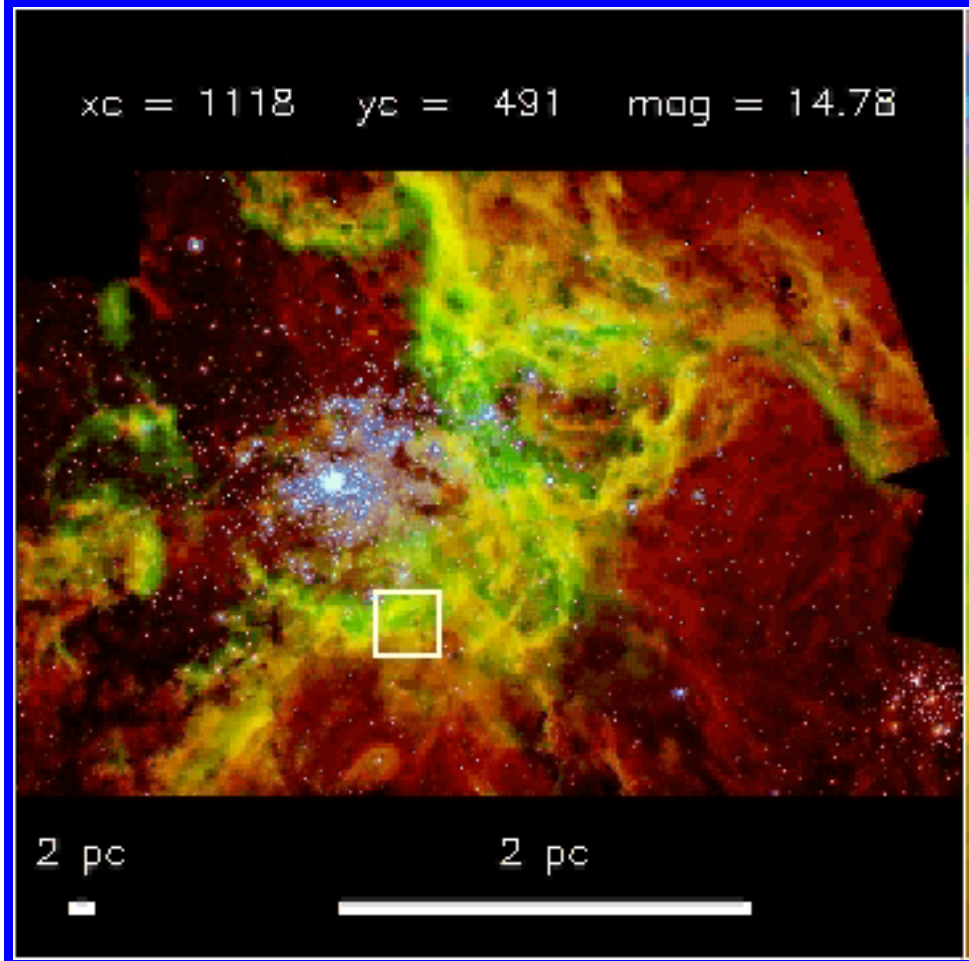
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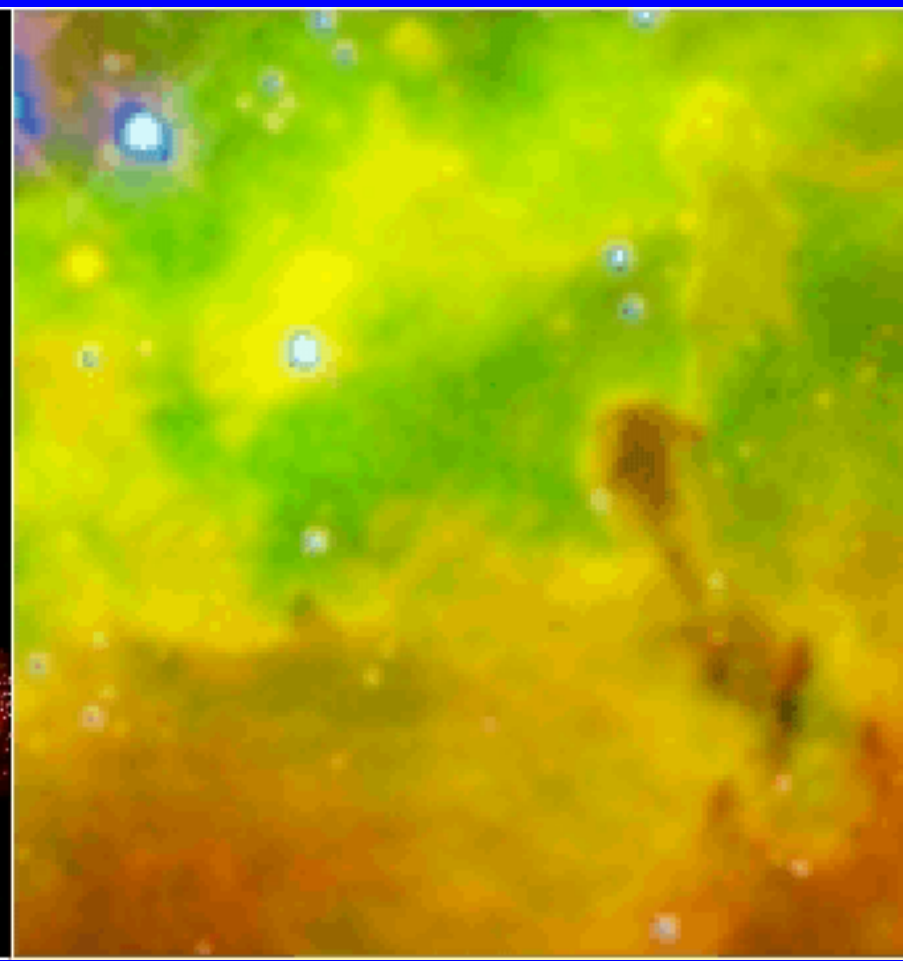




WFPC2 F814W F555W F336W
F673N F656N

NICMOS F205W F160W F110W

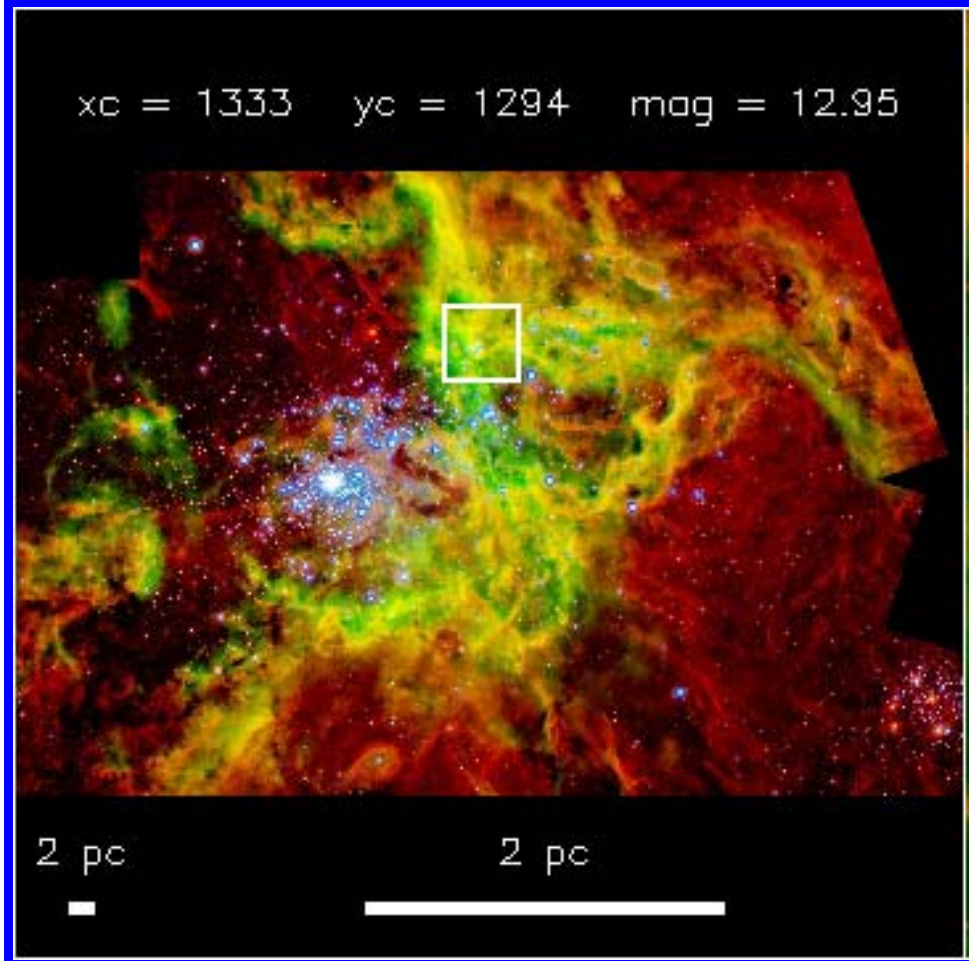


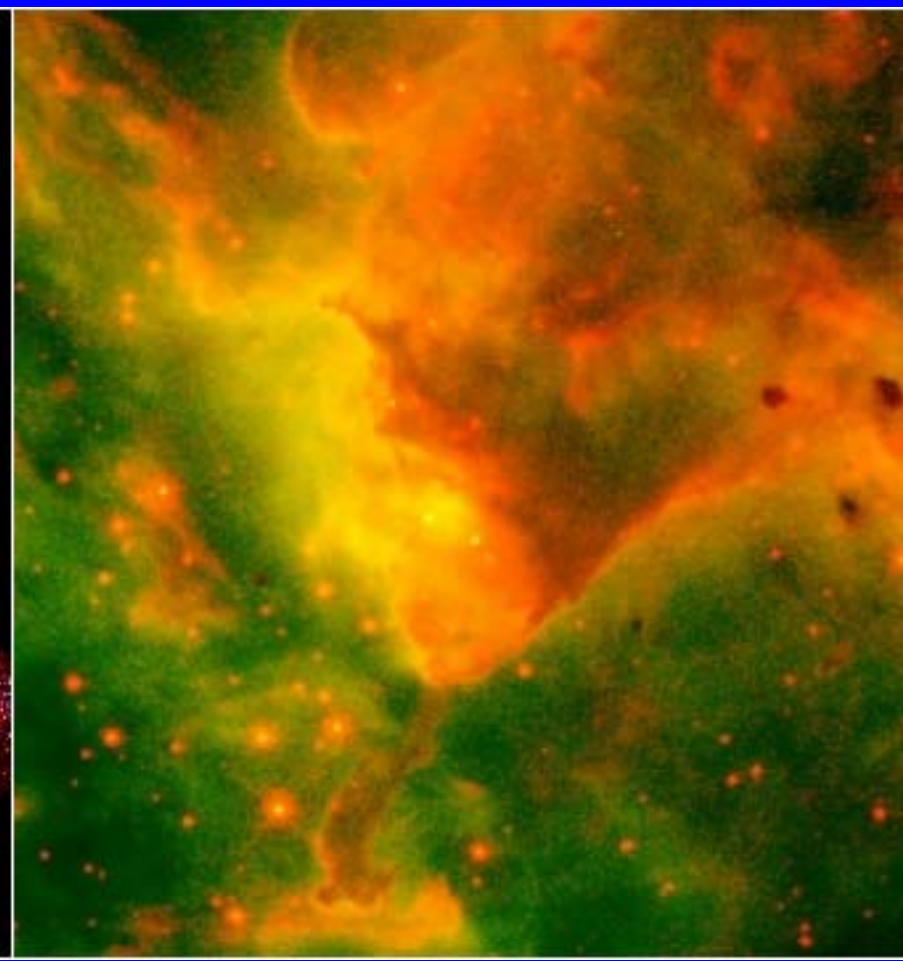


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F673N F656N

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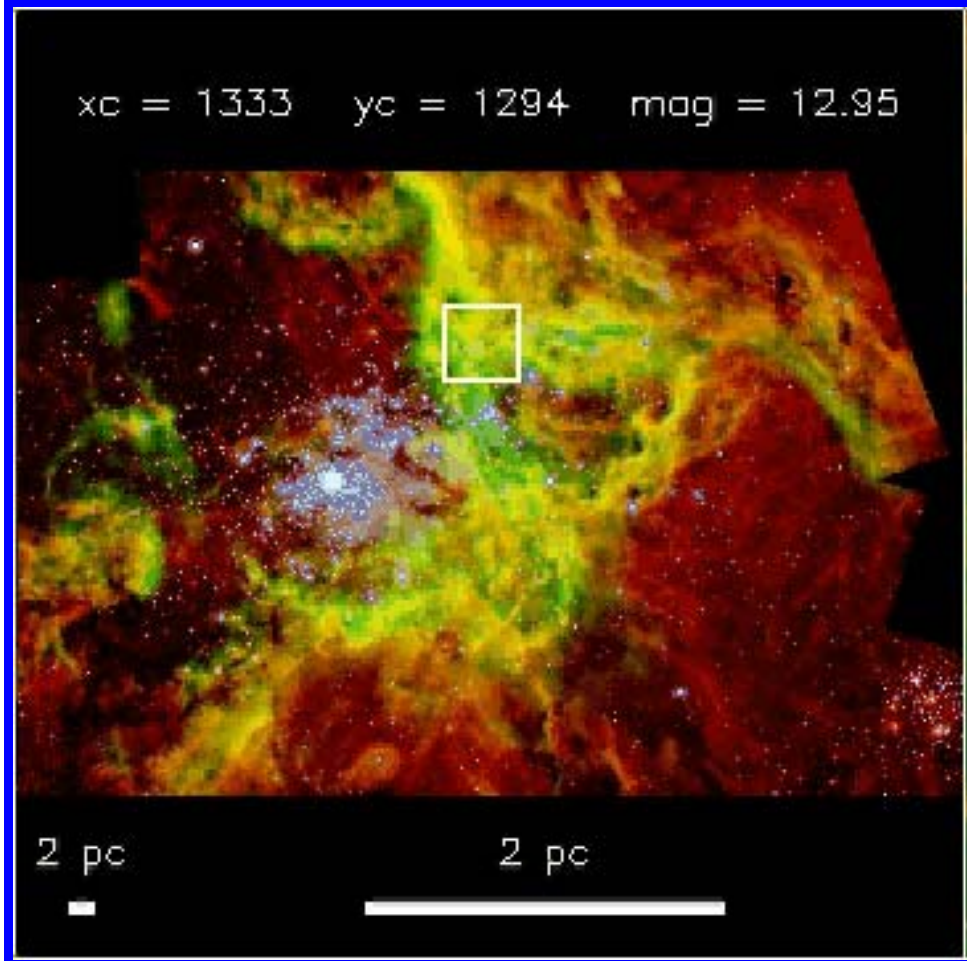


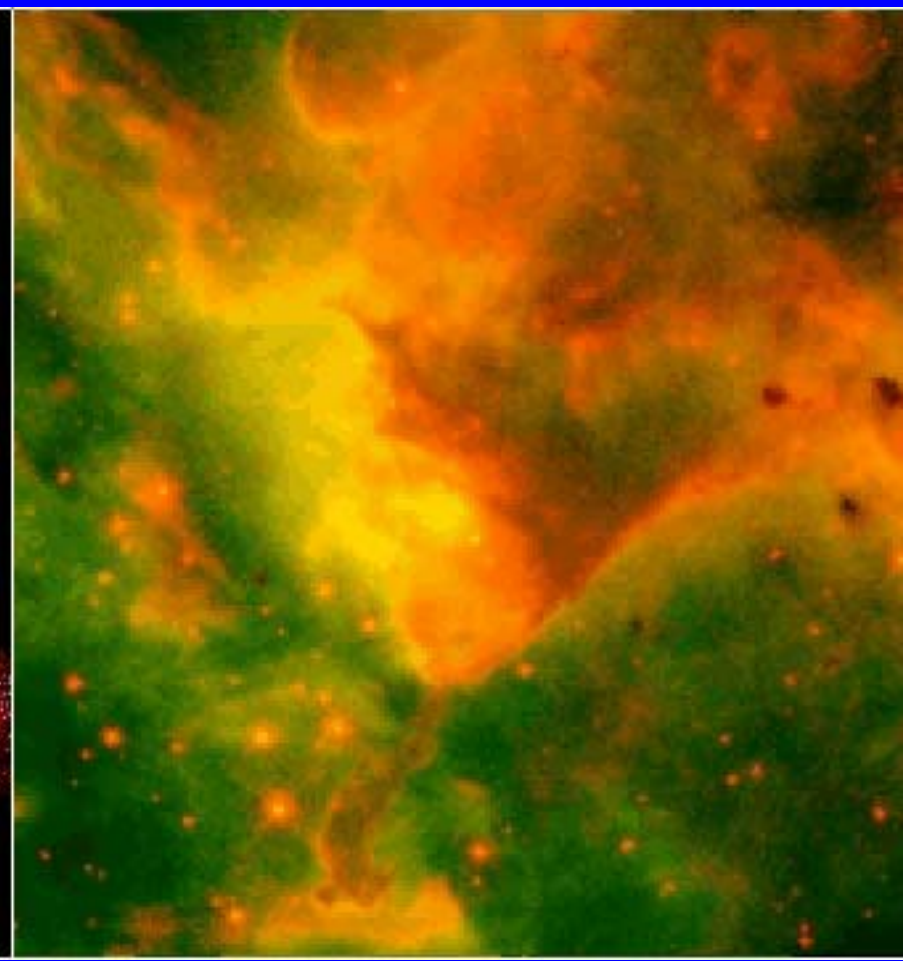


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PC F673N F502N

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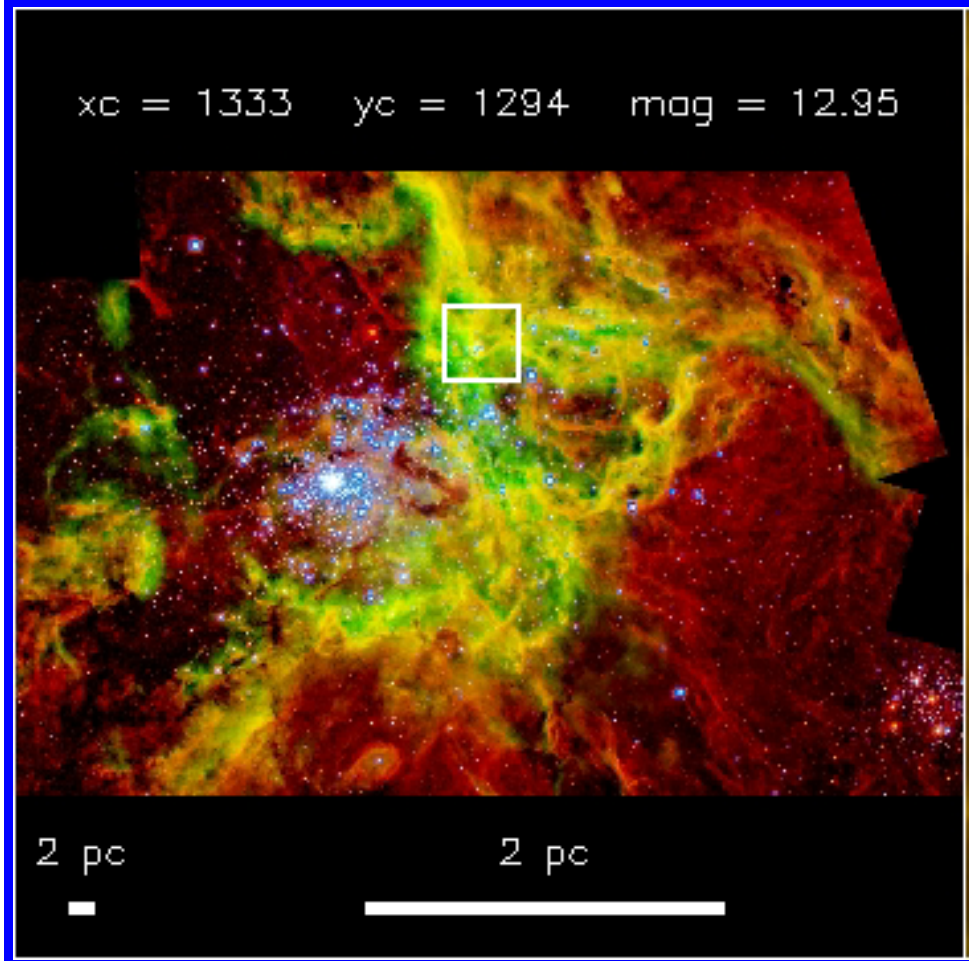


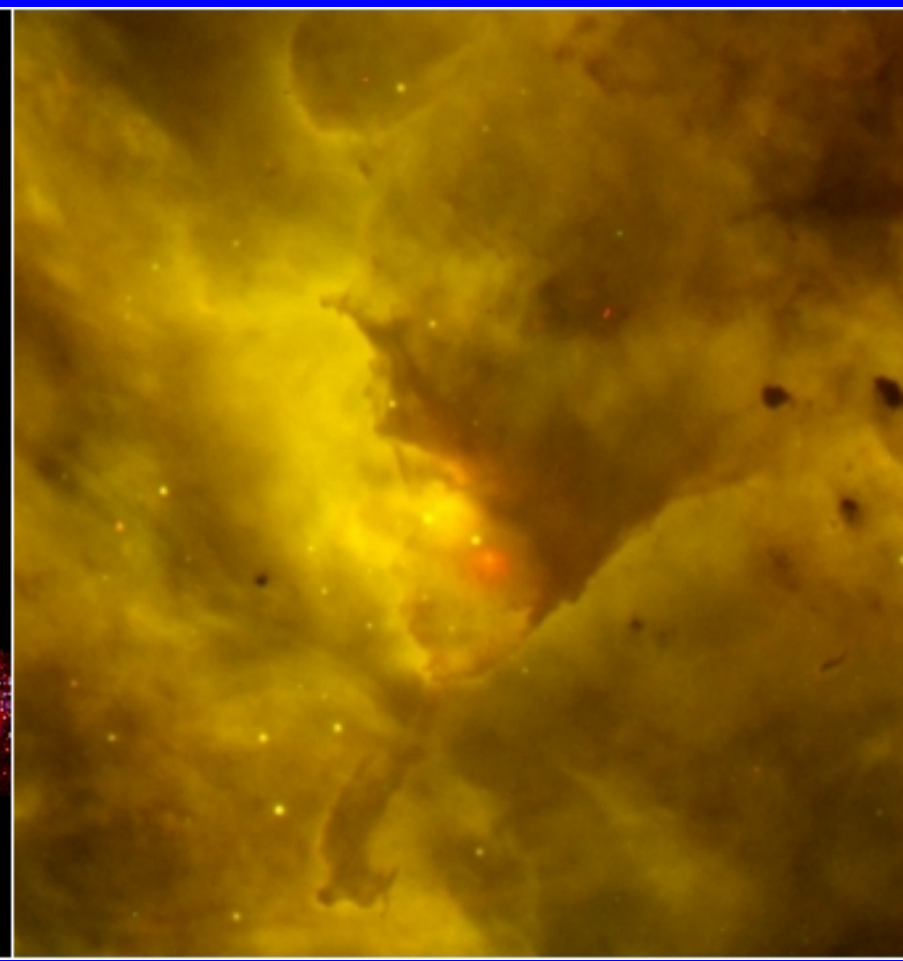


WFPC2 F814W F555W F336W

F673N F656N

The new generation: Knot 1



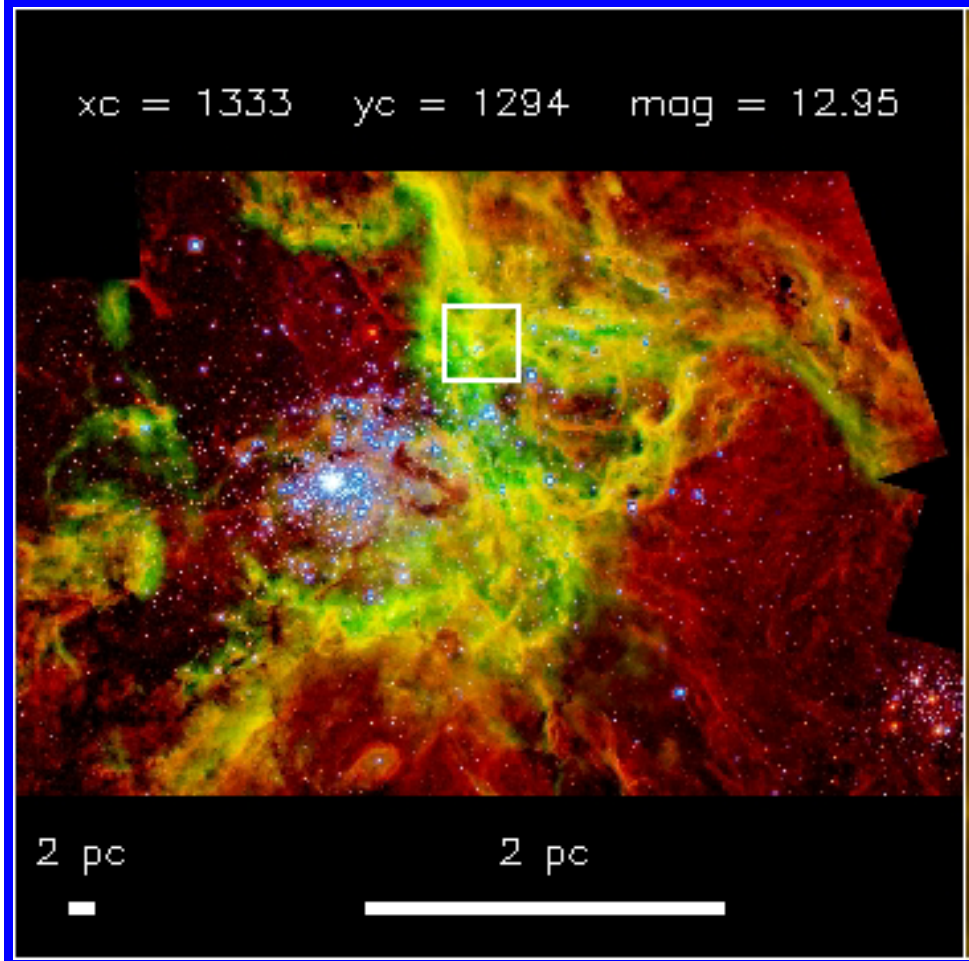


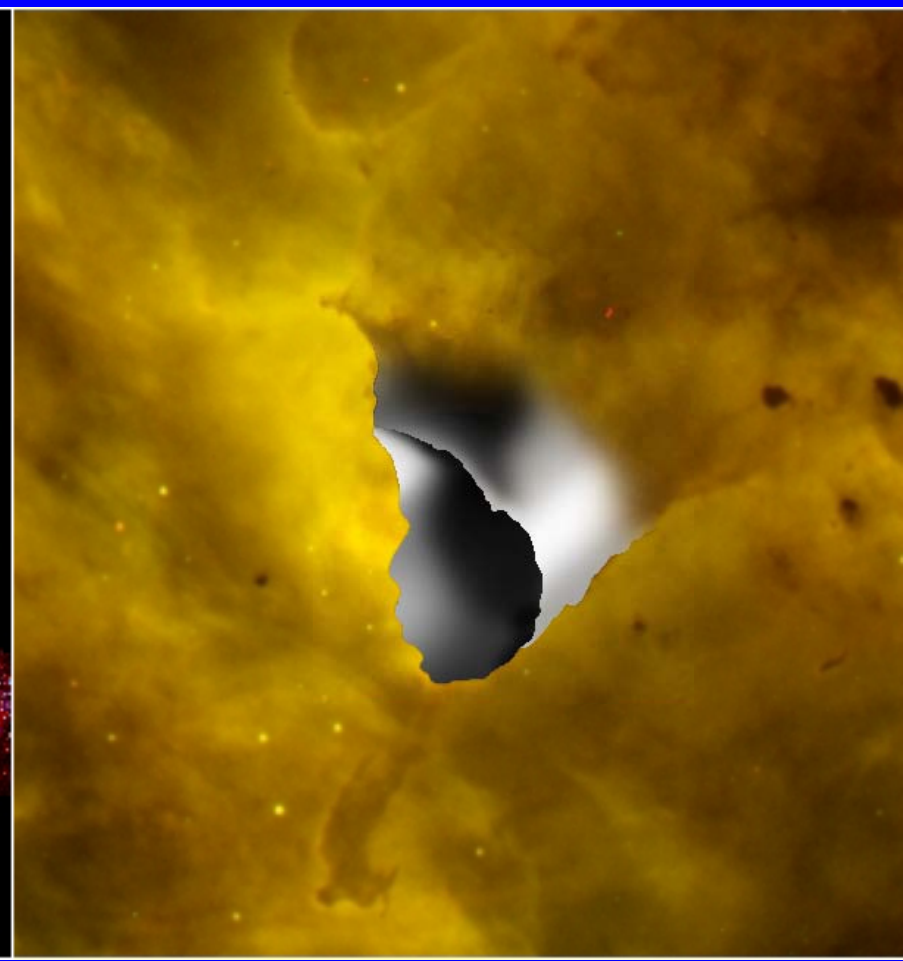
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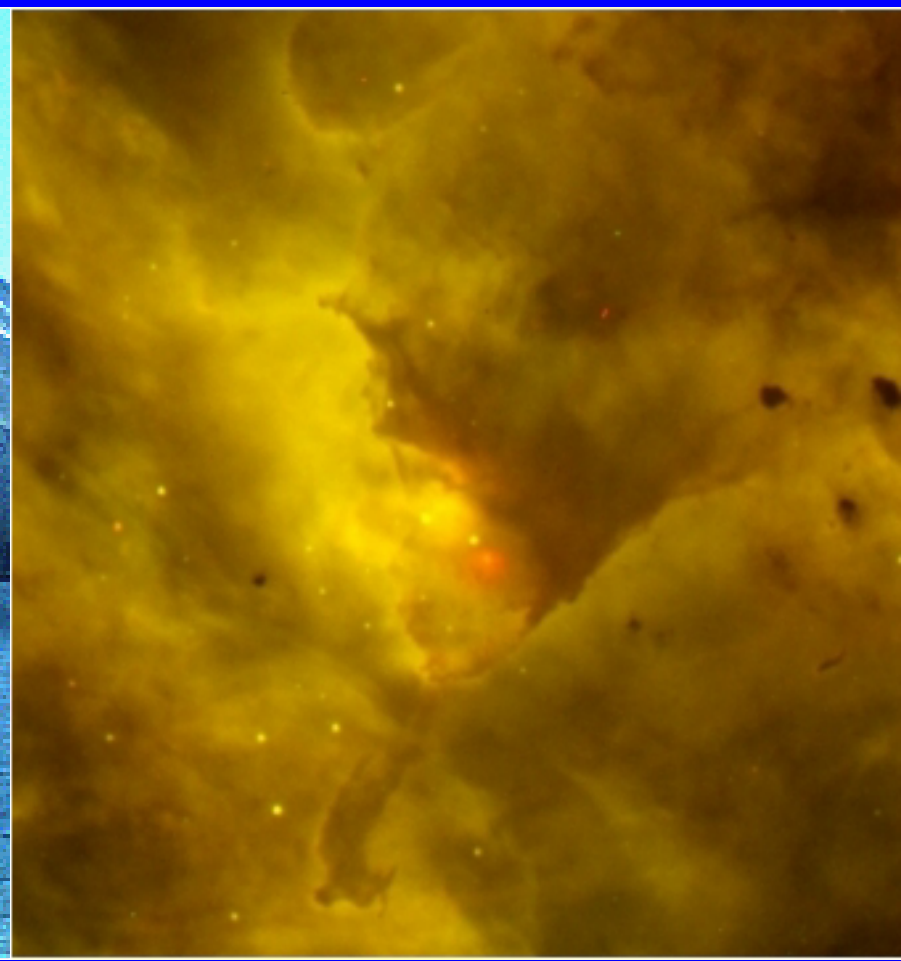


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The new generation: Knot 1

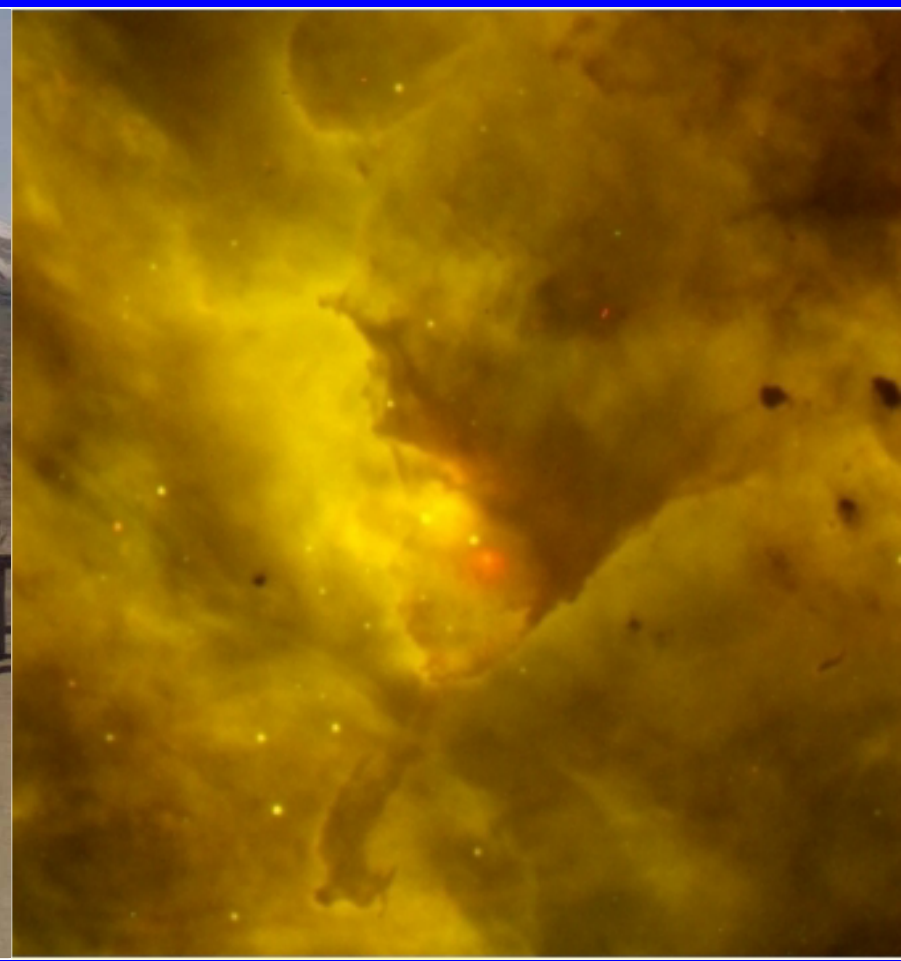




PC F656N F502N

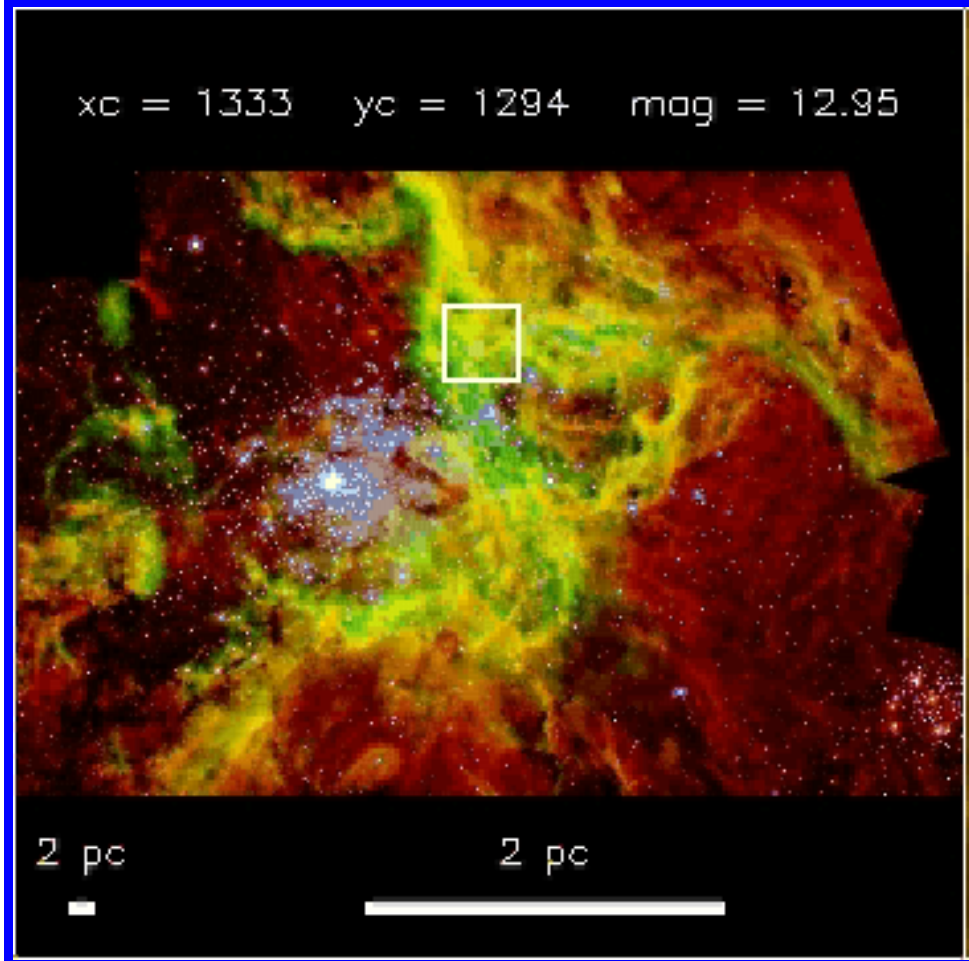
The new generation: Knot 1

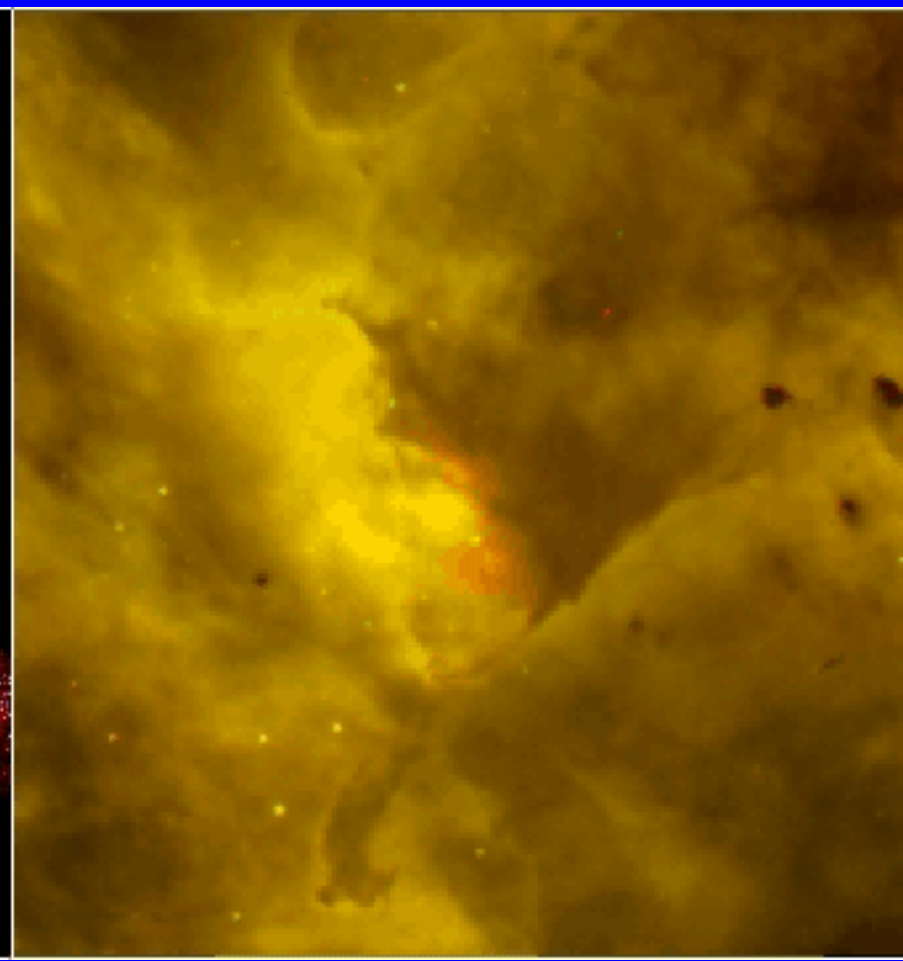




PC F656N F502N

The new generation: Knot 1

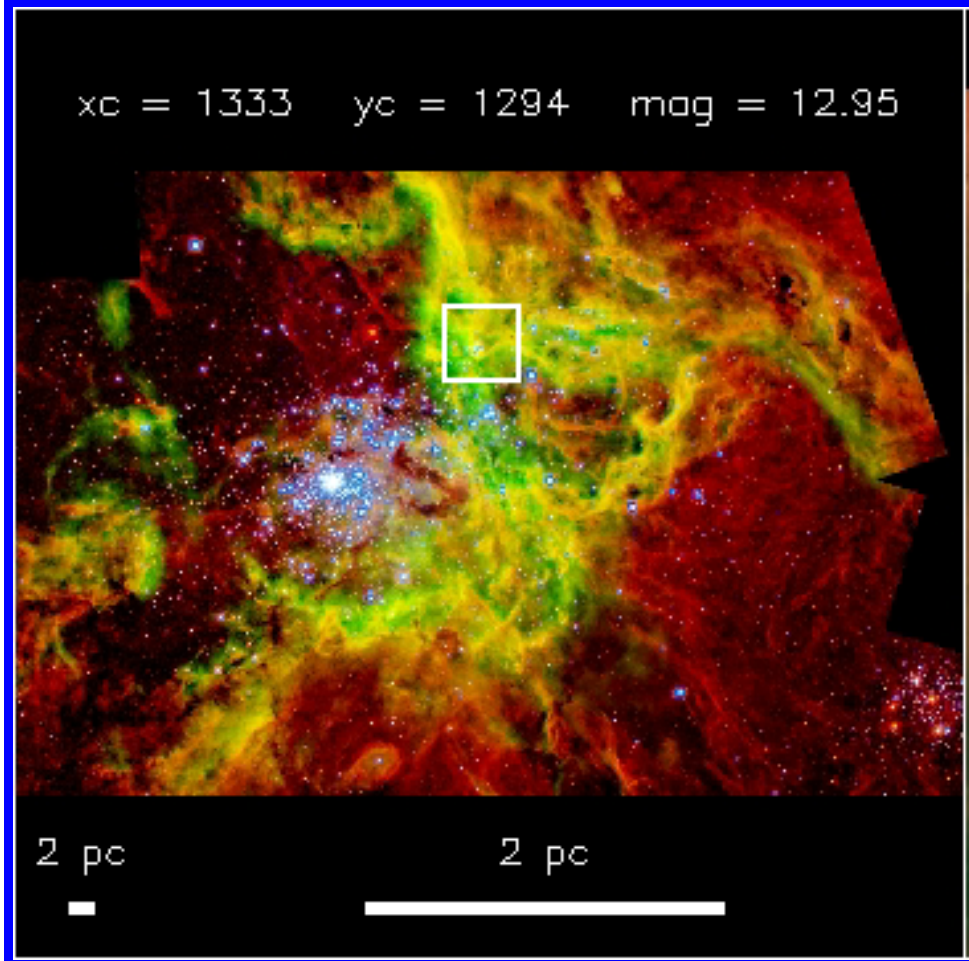


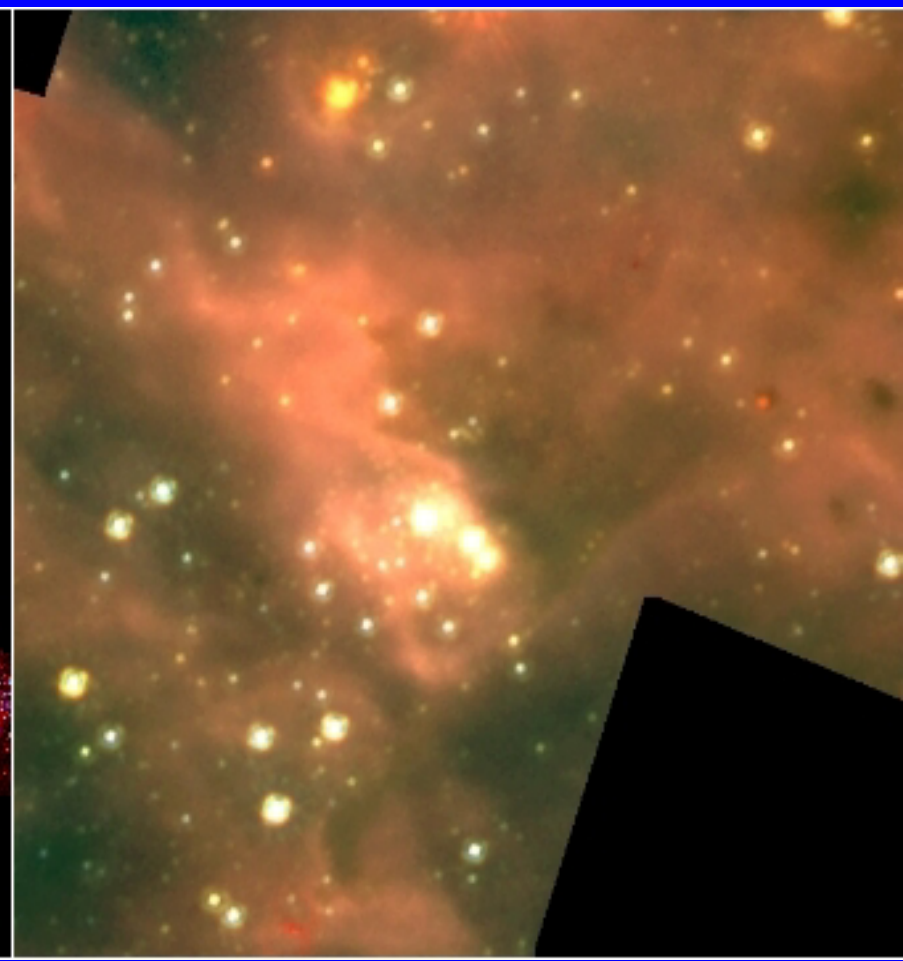


WFPC2 F814W F555W F336W

F673N F656N

The new generation: Knot 1





WFPC2 F814W F555W F336W
F673N F656N

NICMOS F205W F160W F110W

Summary

- Massive Young Clusters (MYCs) can be either Super Star Clusters (SSCs) or Scaled OB Associations (SOBAs)
- ~2-3Ma old MYCs still retain some of the molecular cloud original morphology
- The H II region originates on the wall of the molecular cloud $\Rightarrow$ 2-D, not 3-D
- Extinction is not uniform... what about the extinction law?
- A lot of finger-pointing is going on

References

- Barbá, R. H., Rubio, M., Roth, M. R., García, J. 2003, astro-ph/0212525
- Maíz-Apellániz, J. 2001, ApJ, 563, 151
- Maíz-Apellániz, J., Walborn, N. R., & Barbá, R. H. 2002, in Extragalactic Star Clusters, IAU Symposium 207, p.691
- Maíz-Apellániz, J., Walborn, N. R., MacKenty, J. W., Norman, C. A., Pérez, E., & Mas-Hesse, J. M. 2003, in Galaxies: the Third Dimension, ASP Conf. Series
- Rubio, M., Garay, G., & Probst, R. 1998, The Messenger, 93, 38
- Tenorio-Tagle, G., Muñoz-Tuñón, C., Pérez, E., Maíz-Apellániz, J. & Medina-Tanco, G. 2000, ApJ 541, 720
- Walborn, N. R., Barbá, R. H., Brandner, W., Rubio, M., Grebel, E. K. & Probst, R. G. 1999, AJ 117, 225
- Walborn, N. R., Maíz-Apellániz, J., & Barbá, R.H. 2002, AJ 124, 1601