Gemini Telescopes: Giant Eyes to Study Young Massive Stars

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Gemini Telescopes: Giant Eyes to Study Young Massive Stars

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Young Massive Stars

The problems
How Gemini is working on them

Warning! This is a biased review.

Young Massive Stars

- They are hot!
  - 20.000 $<T_{eff}<$48.000 K
- They are luminous!
  - $4\times10^3<L<10^6\, L_S$
- They are short lived!
  - 3<t<50 Myr
- They are massive!
  - $M>10M_S$

Part I: The Problems

- Zinnecker & Yorke (2007)

Barbosa & Figer (2004, astro-ph/0408491)

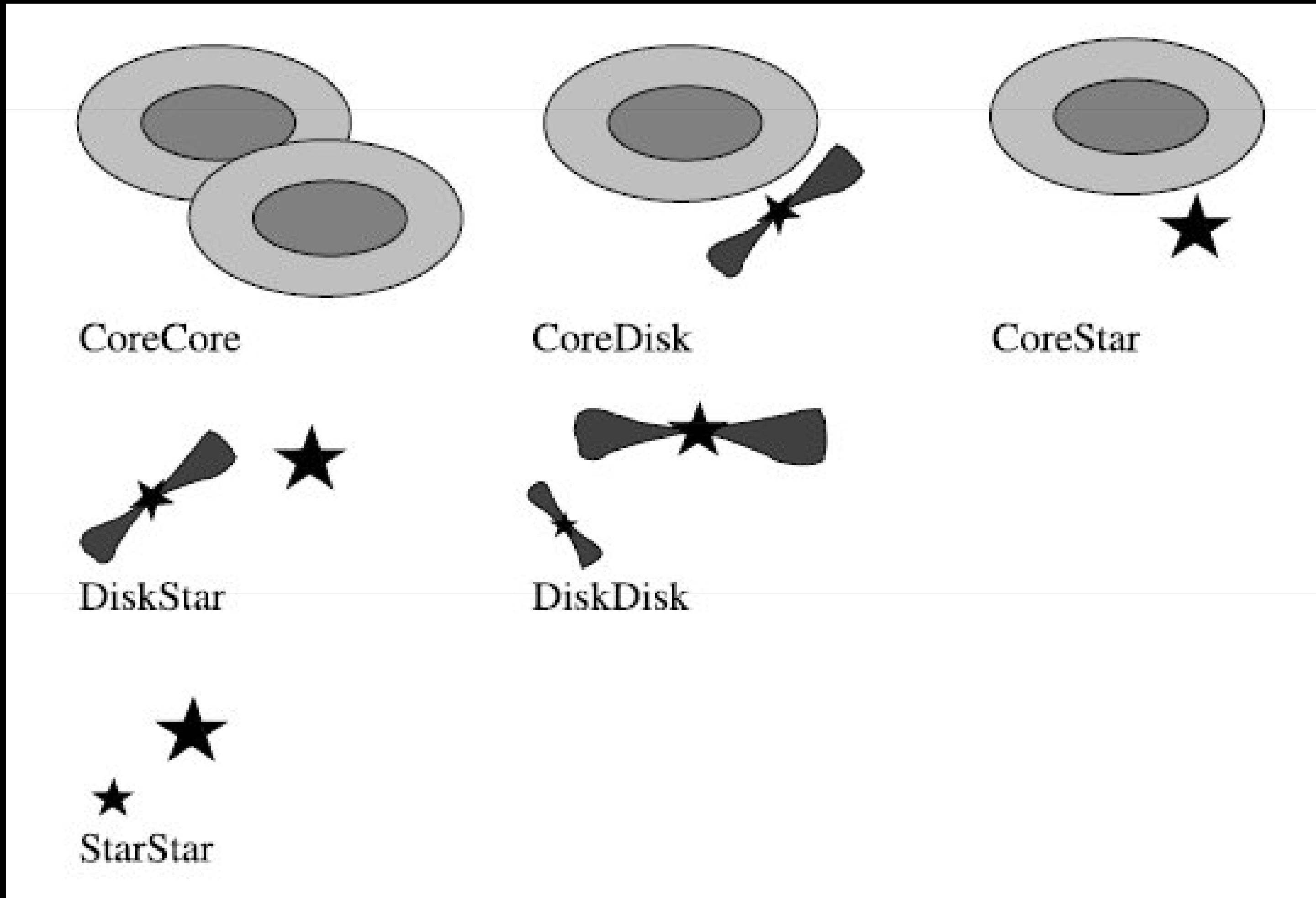
- Main question:
  - How do massive stars form?
- According to standard theory stars more massive than 8 M_S should not exist.
  - radiation pressure > gravity
  - accretion stops

How Gemini is working: star formation

- How do massive stars form?
  - Accretion x coalescence?
- If coalescence:
  - monitor your favourite cluster during ~100 yr (Bally & Zinnecker 2005)
  - expect an flare at MIR-mm wavelengths when a merger occurs

How Gemini is working: star formation

Smooth merger:
more common,
low luminosity



Violent merger:
very rare,
high luminosity

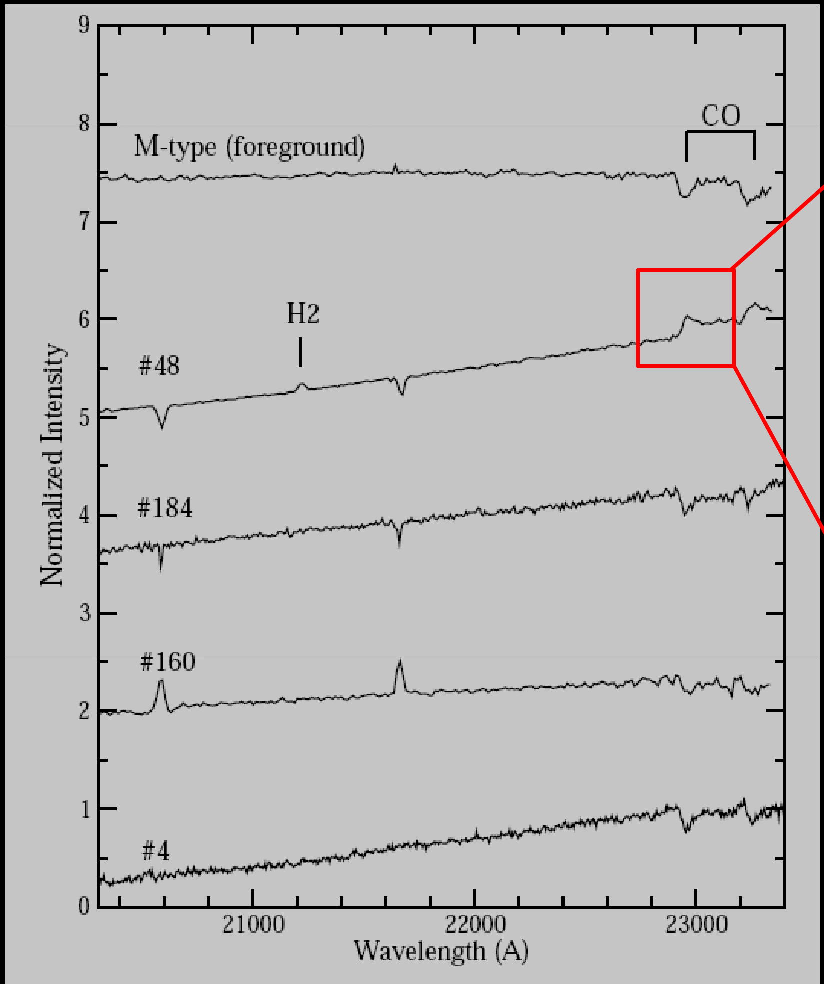
Bally & Zinnecker (2005)

How Gemini is working: star formation

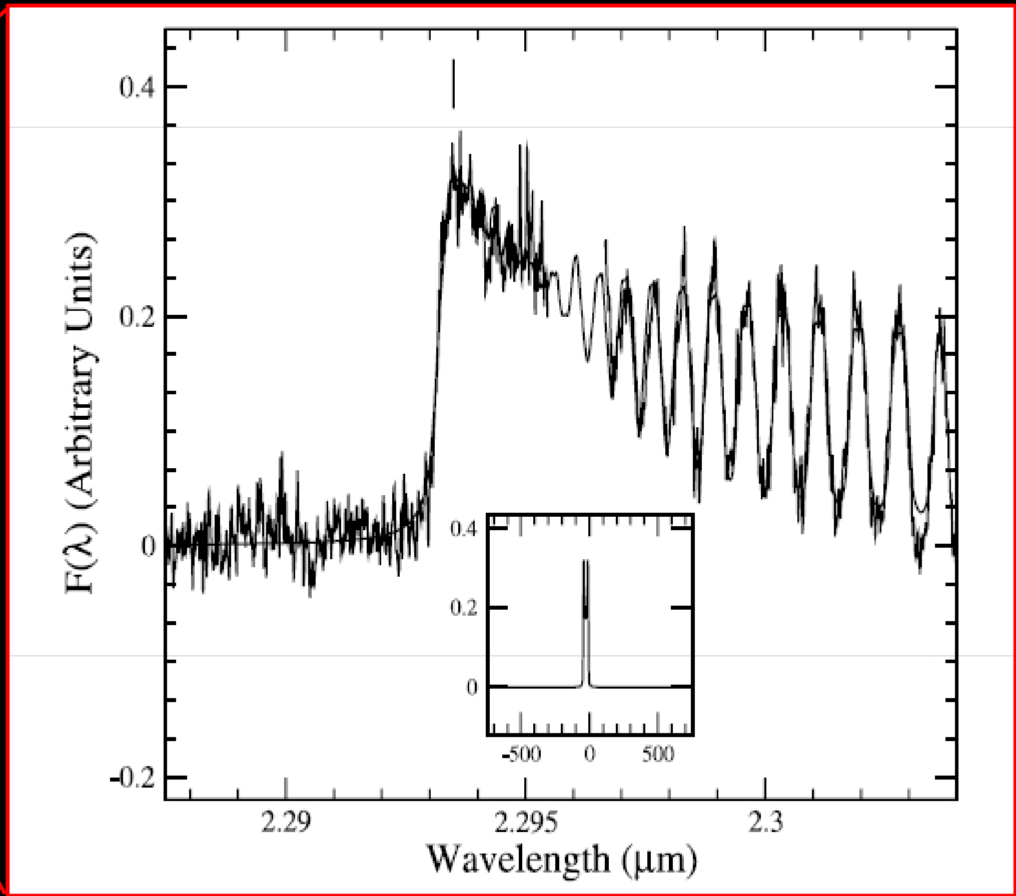
- How do massive stars form?
  - Accretion x coalescence?
- If accretion:
  - find a disk surrounding a massive star.
  - CO bandhead emission at NIR (Najita et al. 1996, Kraus et al. 2000)

How Gemini is working: star formation

NGC 3576



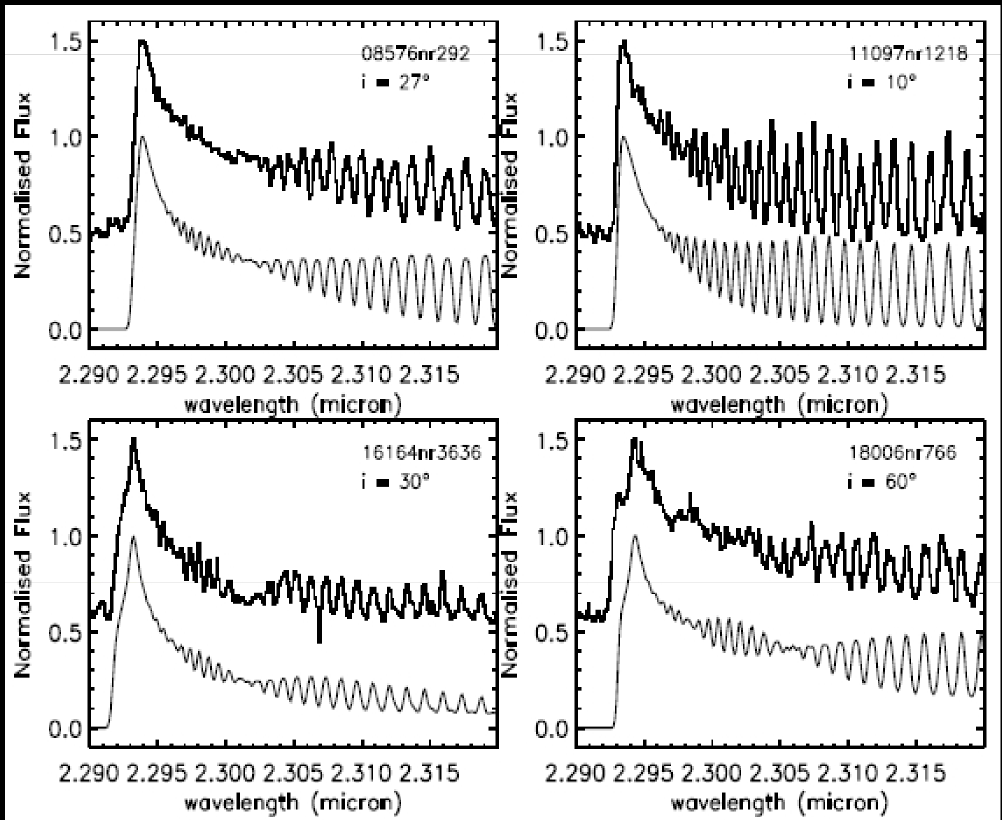
Figueredo et al. (2002)
OSIRIS - CTIO

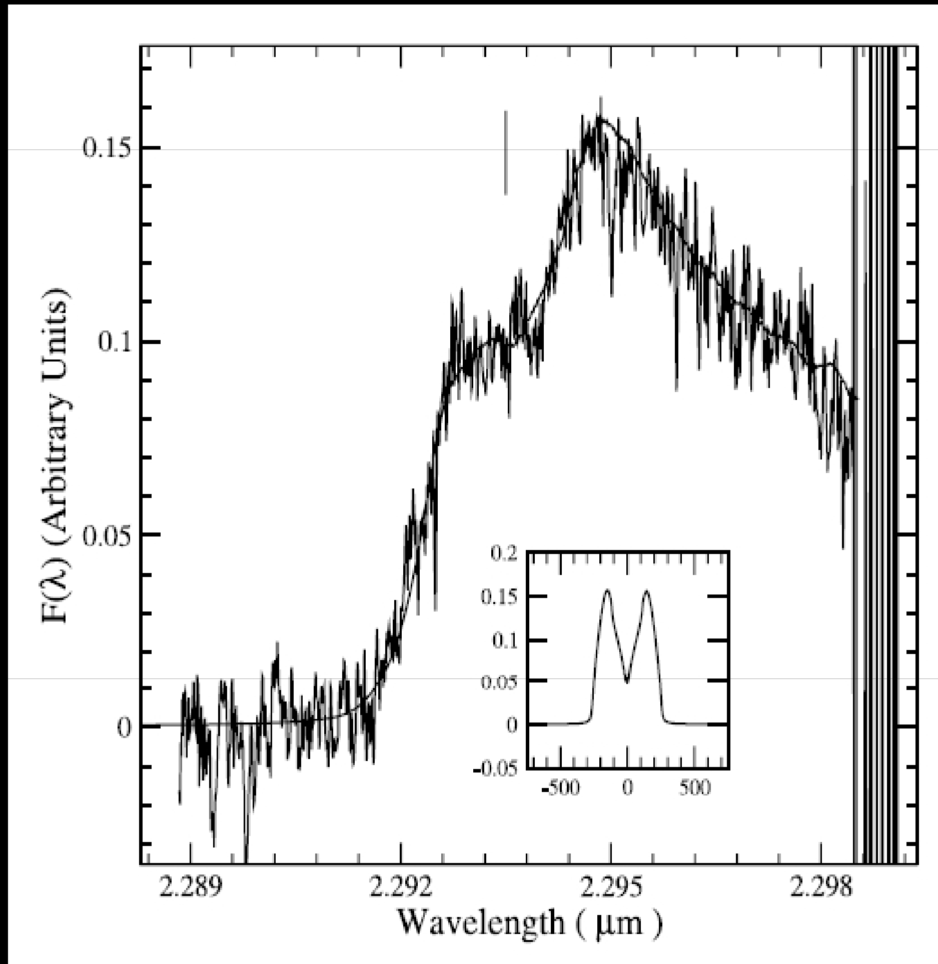


Blum et al. (2005)
PHOENIX - GS

How Gemini is working: star formation

M17 #268

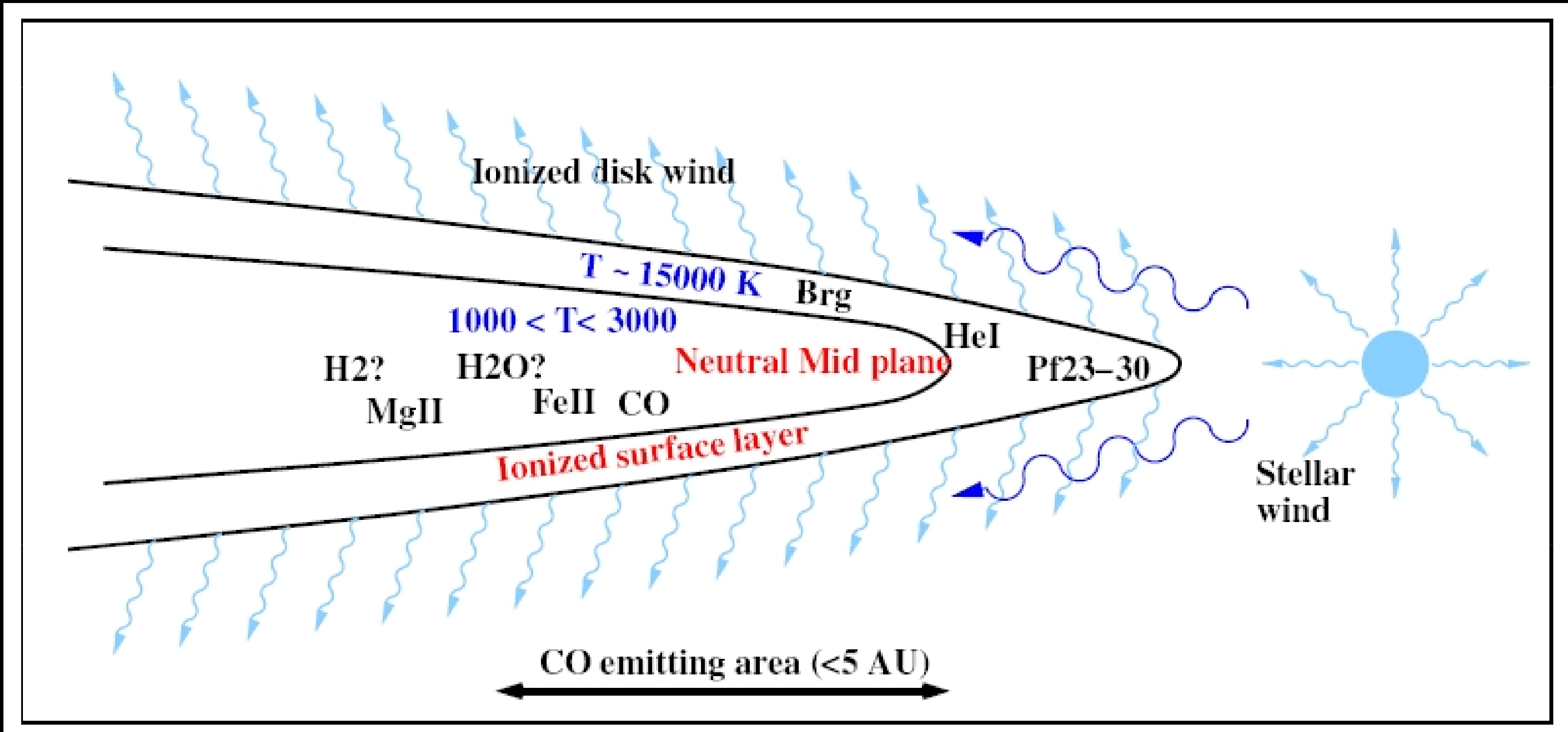




Bik & Thi (2004)
ISAAC - VLT

Blum et al. (2005)
PHOENIX - GS

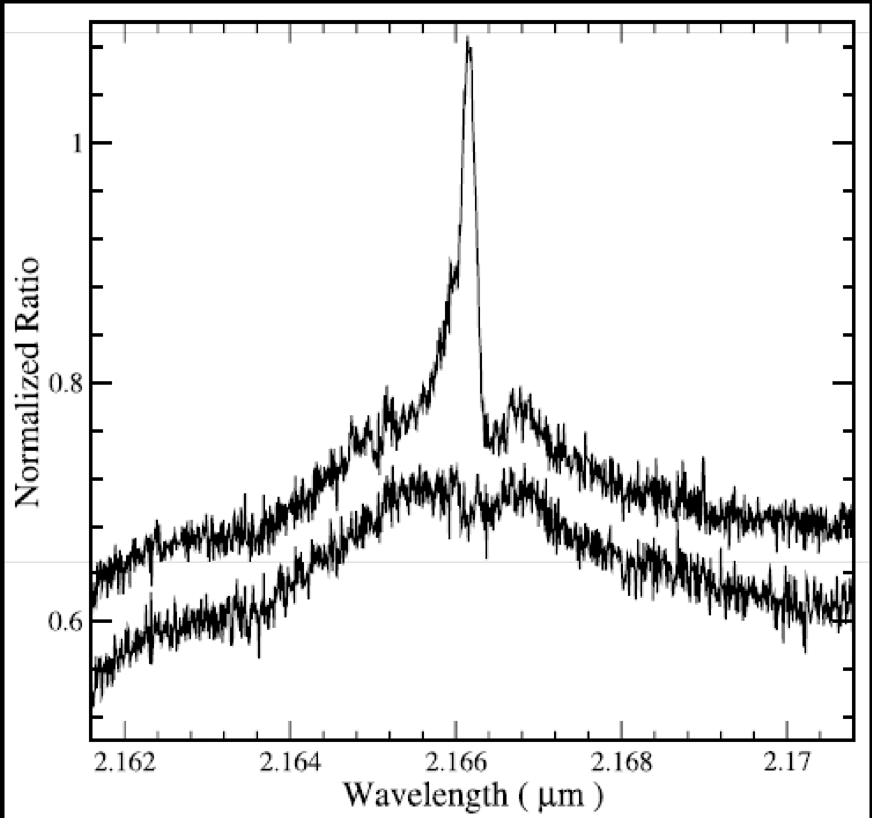
How Gemini is working: star formation



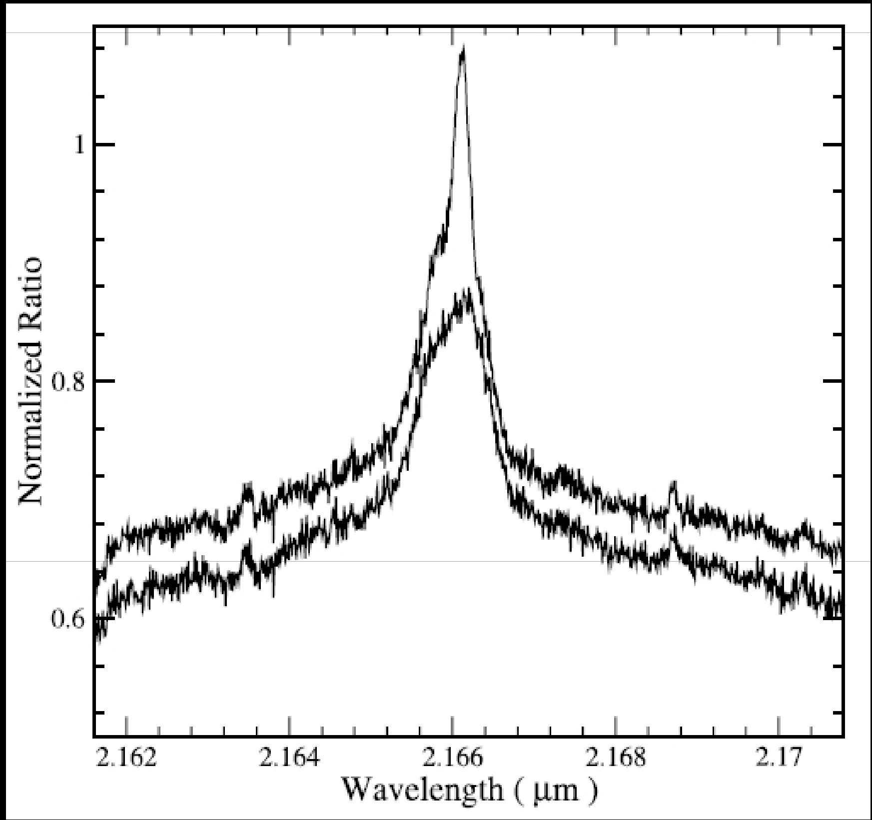
Bik et al. (2005)

How Gemini is working: star formation

M17 #268



M17 #275



Blum et al. (2005)
PHOENIX - GS

How Gemini is working: star formation

TABLE 2

CO Line Profile Parameters and Stellar Properties

Object	p^a	q^b	β^c	Model CO Line Width[d] (km s^{-1})	N_{CO}[e] (10^{21} cm^{-2})	$v \sin i$[f] (km s^{-1})	V_0[g] (km s^{-1})	Mass[h] ($M_\odot$)	Luminosity ($L_\odot$)
NGC 3576 No. 48	0.5	1.0 ± 0.03	2.1 ± 0.04	1.0	13.4 ± 0.1	25.0 ± 0.2	-21.5 ± 1.3[i]	17[j] B0	>50000[j]
M17-268	0.5	3.8 ± 0.1	5.8 ± 0.1	1.0	22.3 ± 1.8	258.7 ± 1.9	0.0 ± 1.3	10	5000
M17-275	0.5	4.1 ± 0.1	6.9 ± 0.3	1.0	3.5 ± 0.2	109.7 ± 0.6	-7.0 ± 1.3	15	20000
G333.1-0.4 No. 4	0.5	3.6 ± 0.3	6.5 ± 1.0	1.0	1.3 ± 0.4	108.0 ± 1.9	-26.0 ± 1.4	5[j]	>300[j]

Blum et al. (2005)
PHOENIX - GS

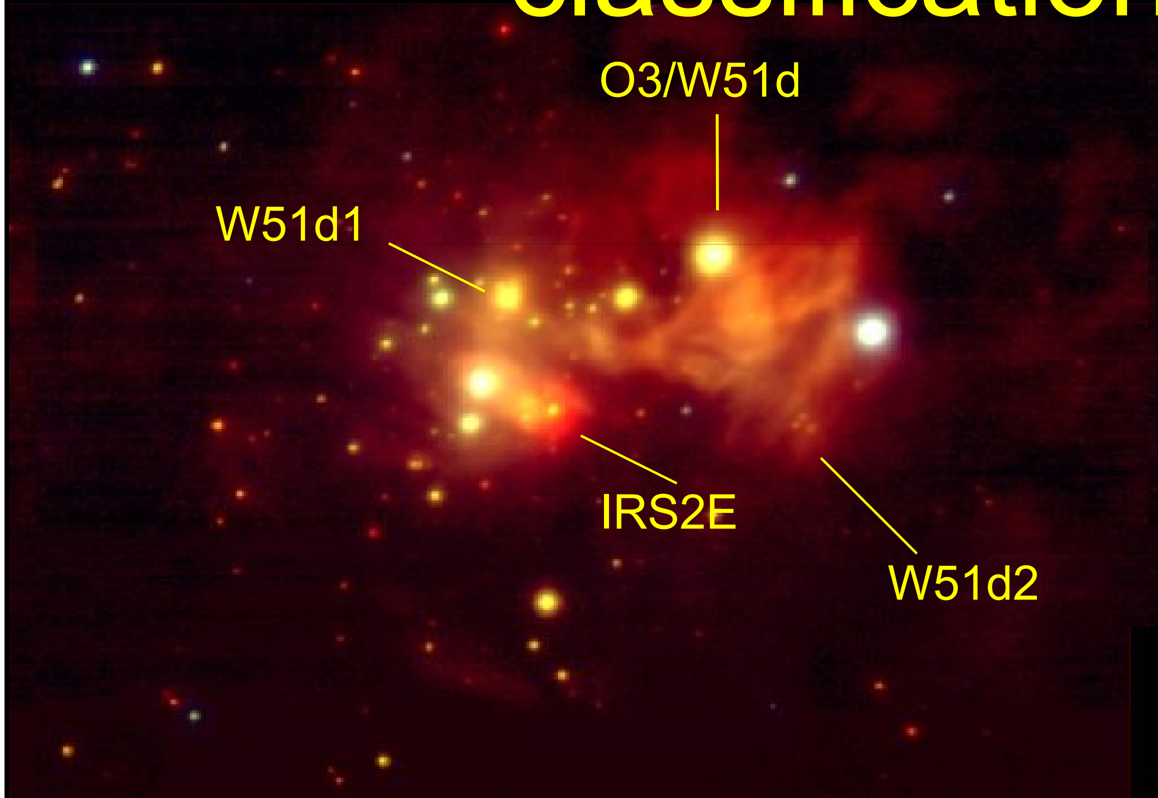
IRAS	Object	Mass ($M_\odot$)	d (kpc)	T_{ex} (K)	N(CO) (cm^{-2})	i (°)	R_{min} (AU)	R_{max} (AU)	M(CO) ($M_\odot$)	χ^2_ν
16164-5046	16164nr3636	30 O8	3.6	4480	3.9×10^{20}	30^{+6}_{-23}	$3.1^{+18.2}_{-2.9}$	$3.2^{+123.5}_{-3.0}$	2.0×10^{-9}	0.99
11097-6102	11097nr1218	11	2.8	2710	8.9×10^{20}	10^{+10}_{-5}	$0.6^{+0.1}_{-0.4}$	$3.3^{+13.5}_{-3.1}$	2.6×10^{-7}	1.51
18006-2422	18006nr766	11	1.9	1800	1.0×10^{21}	60^{+20}_{-30}	$0.2^{+0.24}_{-0.06}$	$1.9^{+2.5}_{-1.6}$	6.2×10^{-8}	1.72
08576-4334	08576nr292	6	0.7	1660	3.9×10^{21}	27^{+2}_{-14}	$0.2^{+1.1}_{-0.1}$	$3.6^{+70}_{-3.4}$	8.4×10^{-7}	2.01

Bik & Thi (2004)
ISAAC - VLT

How Gemini is working: classification scheme

- Do massive stars also follow the low-mass YSO scheme?
  - Class 0 → Class I → Class II → Class III
- The classification may be applied to MYSOs, but they may be more subtle
  - not only IR emission, but also radio
- Prestellar core → Hot core → HypCHII → UCHII → Compact HII (Churchwell 2005)
- Does W51 IRS2 have the answer?

How Gemini is working: classification scheme

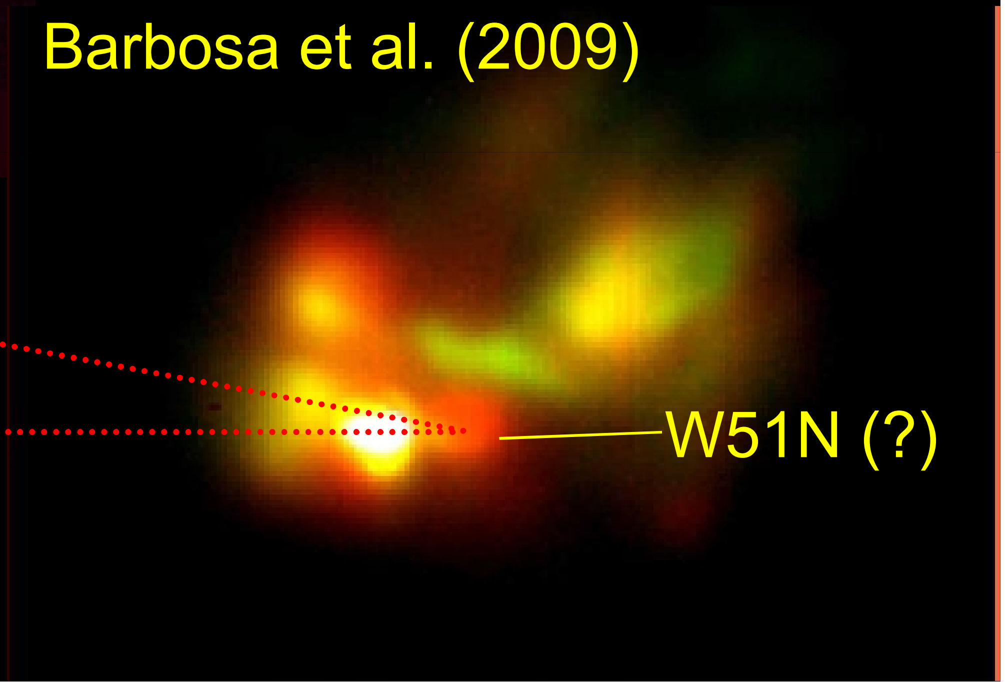


NACO-VLT
KHJ RGB

W51 IRS2

Barbosa et al. (2008)

T-ReCS
24-12-7 RGB

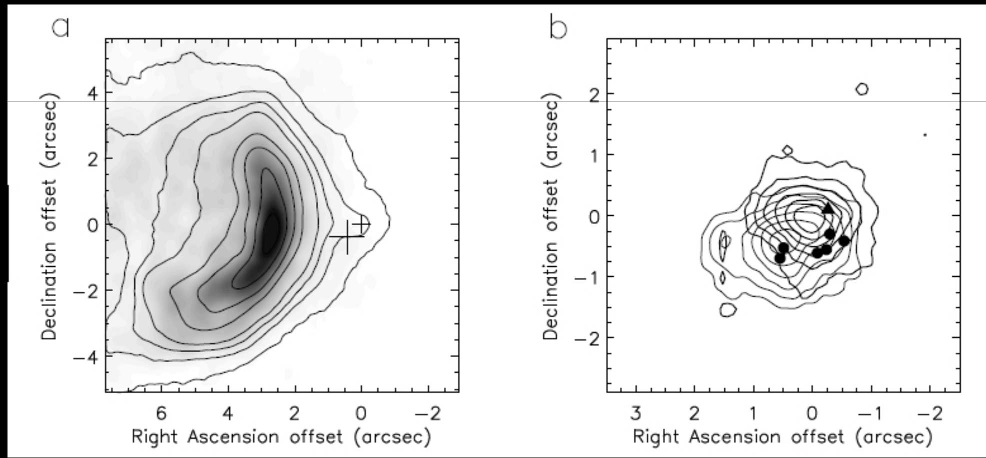


Zapata et al. (2009)

Lacy et al. (2007)

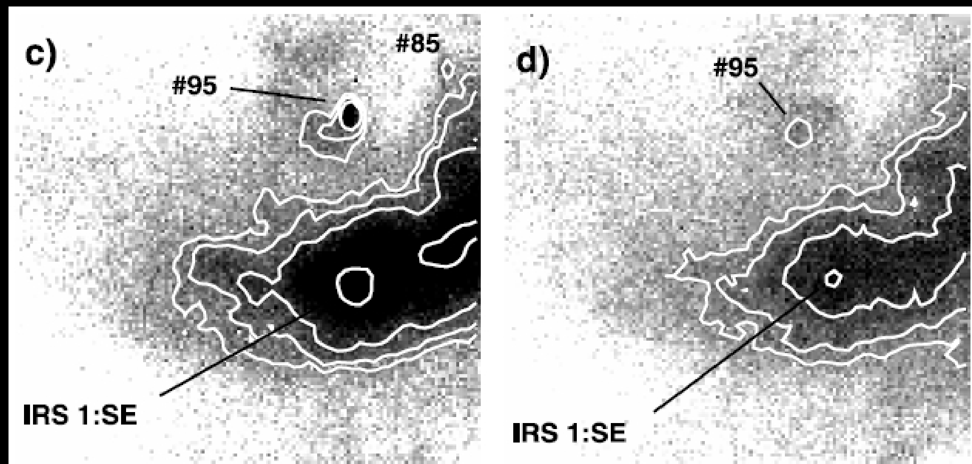
How Gemini is working: The environment

De Buizer et al. (2002)
HMC G29.96-0.02



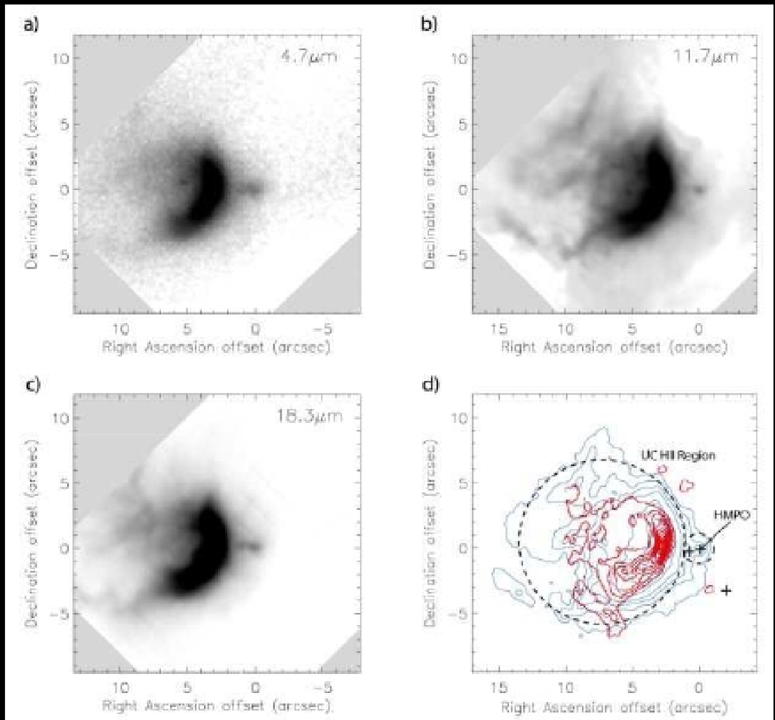
OSCIR Gemini South
(retired)

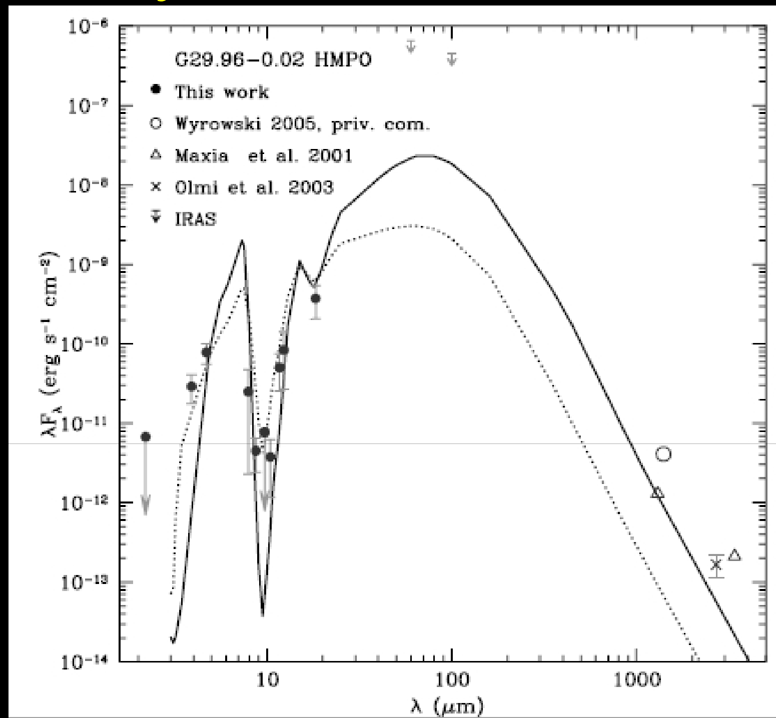
Barbosa et al. (2003)
HMC NGC 3576



How Gemini is working: The environment

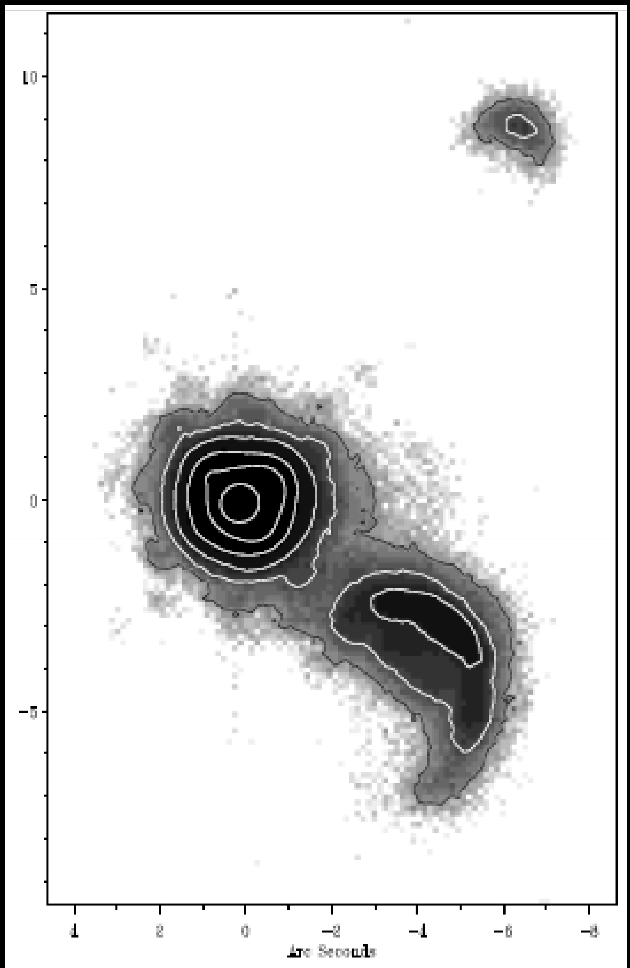
De Buizer et al. (2005)
NIR-MIR modeling e.g. G29.96-0.02
Depart from spherical symmetry





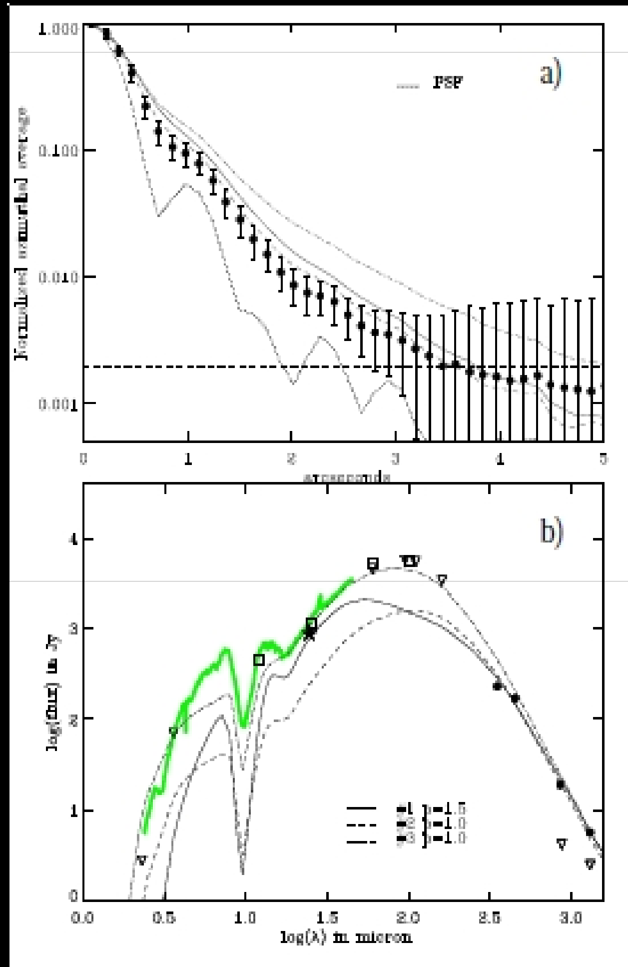
T-ReCS
Gemini South

How Gemini is working: The environment



de Wit et al. (2009)
NIR-MIR modeling
e.g. AFGL 2591
Rotating envelopes
see poster E-2

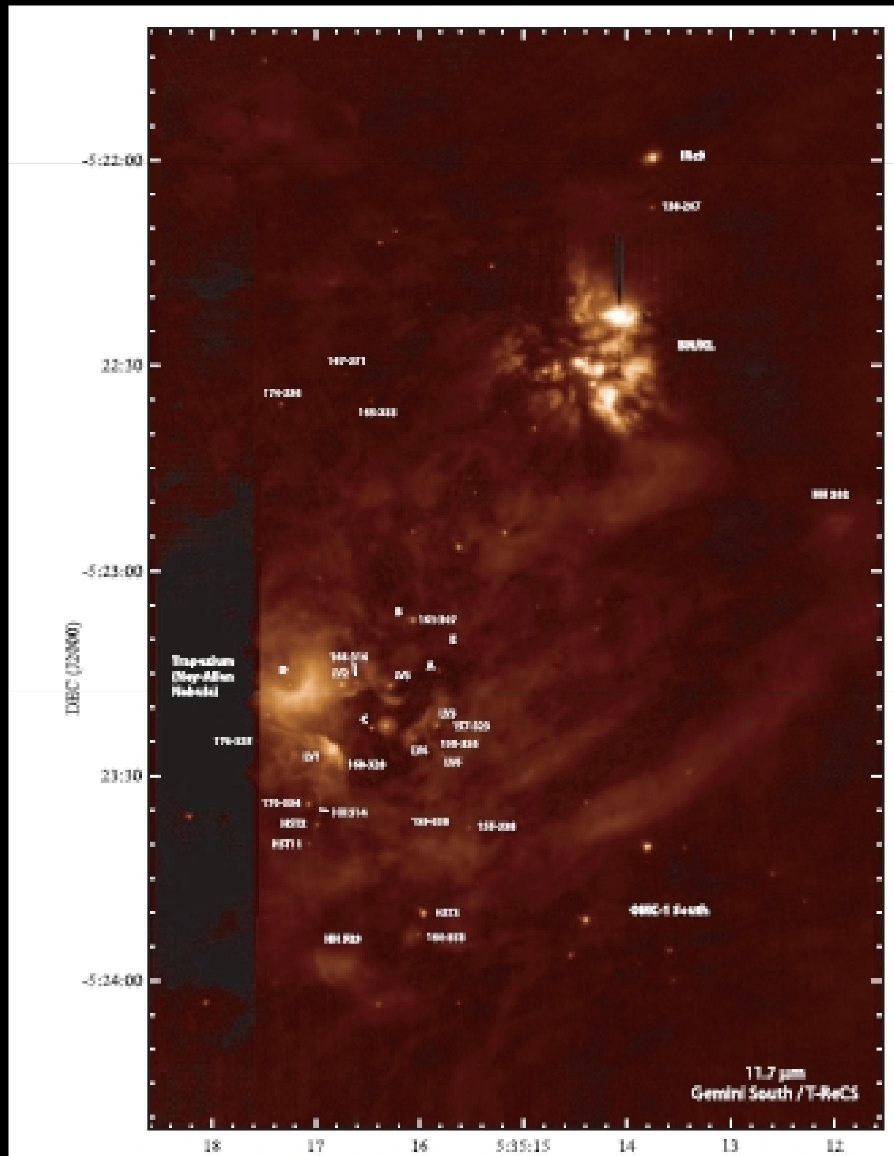
COMICS
Subaru



How Gemini is working: The environment

T-ReCS
Gemini South

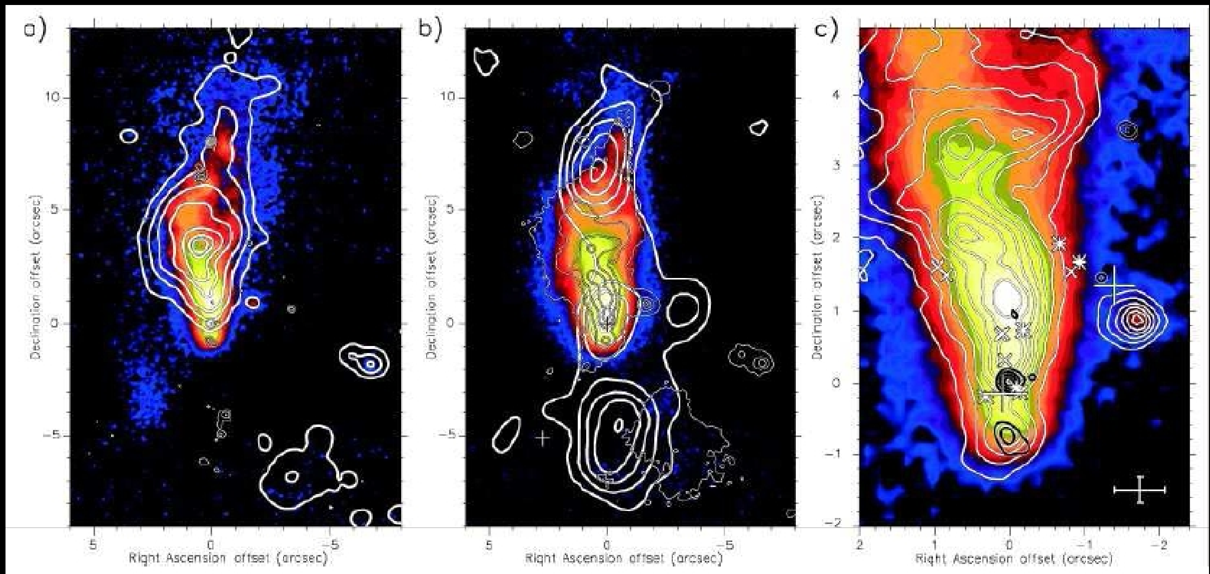
Smith et al. (2005)
Proplyds, shocks, disks: Orion



How Gemini is working: The environment

De Buizer et al. (2005)
Jet G35.20-0.74

T-ReCS
Gemini South

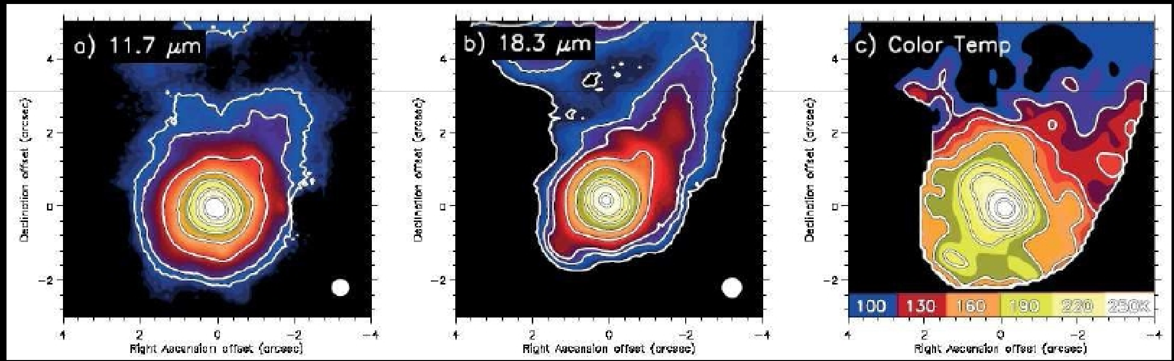


Lacy et al. (2007)
Jet W51 IRS2

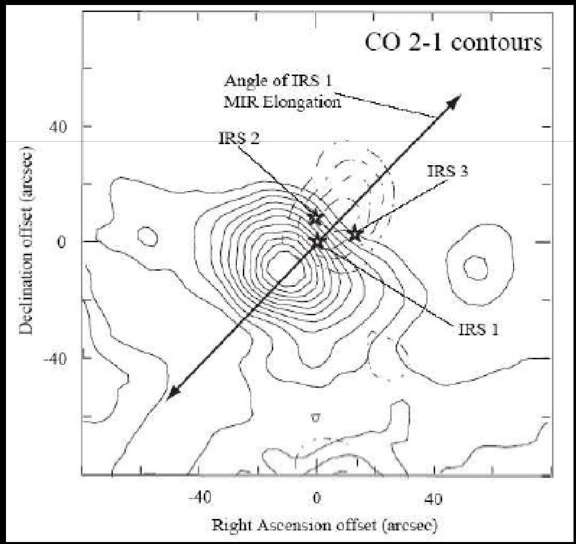
TEXES
Gemini North

How Gemini is working: The environment

De Buizer & Minier (2005)
NGC 7538 IRS1
Outflow



MICHELLE
Gemini North

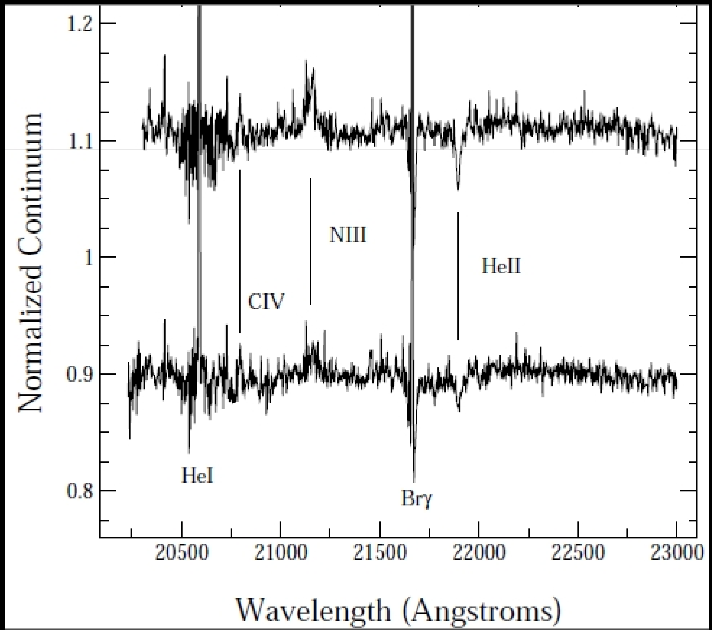


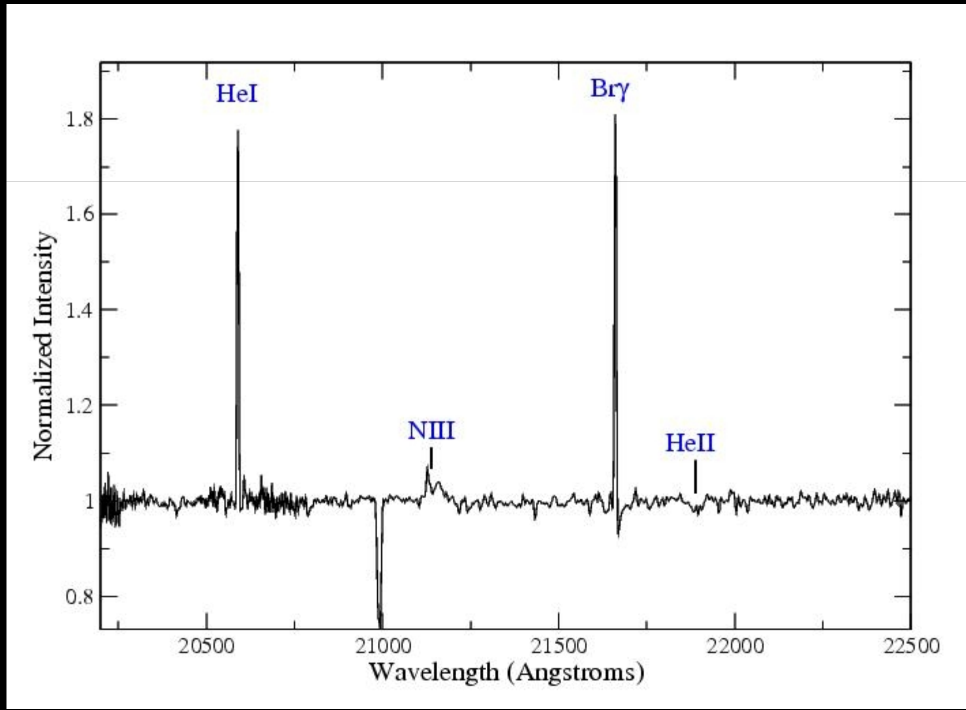
De Buizer & Minier (2005)
NGC 7538 IRS1
Disk

How Gemini is working: UCHII regions

- Stellar content inferred by indirect means
  - radio continuum
  - MIR fine structure lines [NeII], [ArIII], [SIV] + photoion model (Okamoto et al. 2001,2003)
    - Stellar clusters rather than a single hot star
  - See poster E-1 by Crowther & Furness
- Direct accessing the photosphere of the ionizing star

How Gemini is working: UCHII Regions





NIFS + ALTAIR
Gemini North

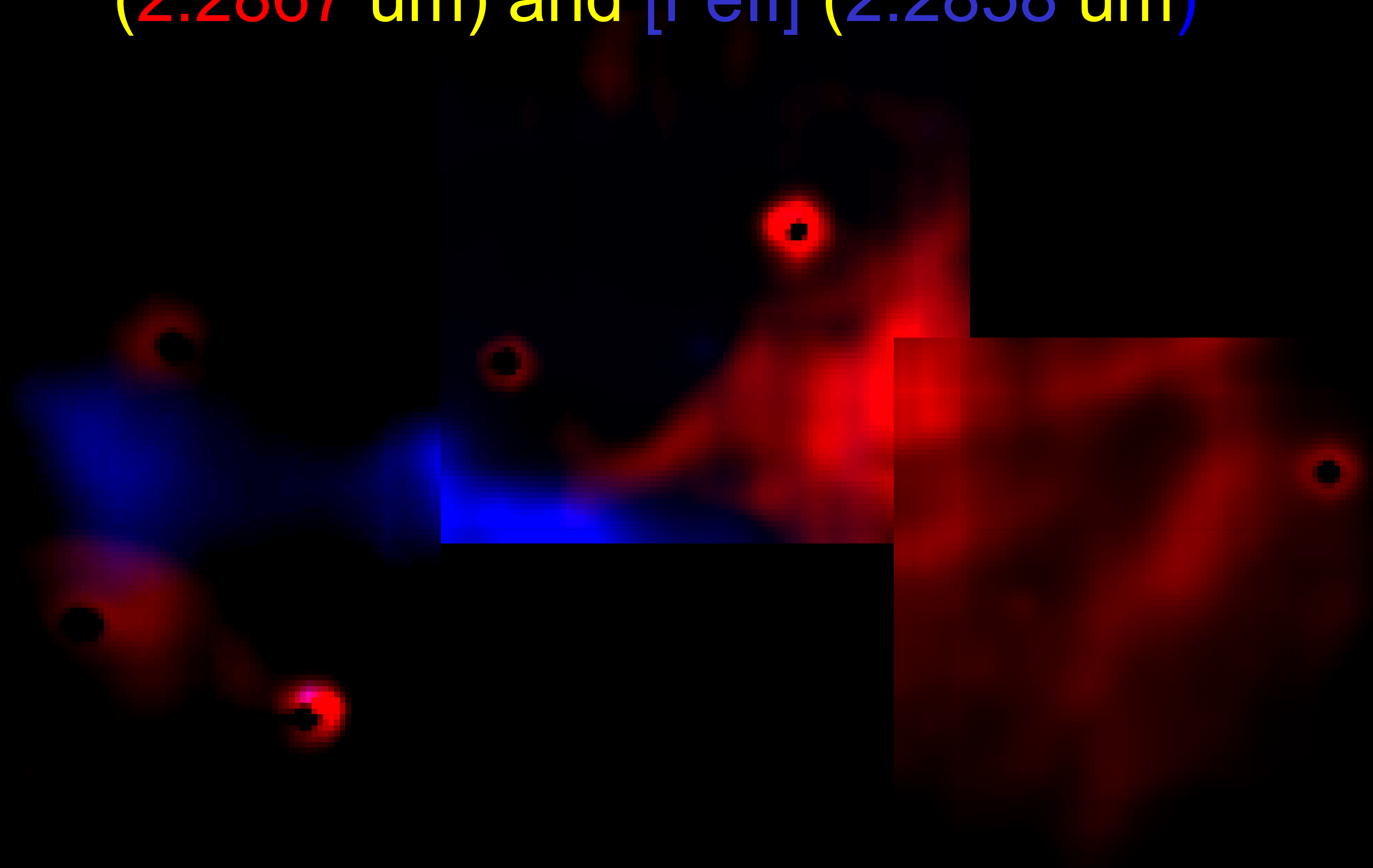
Blum & McGregor (2007)
2O6+cluster G45.45+0.0

Barbosa et al. (2008)
O3 W51d

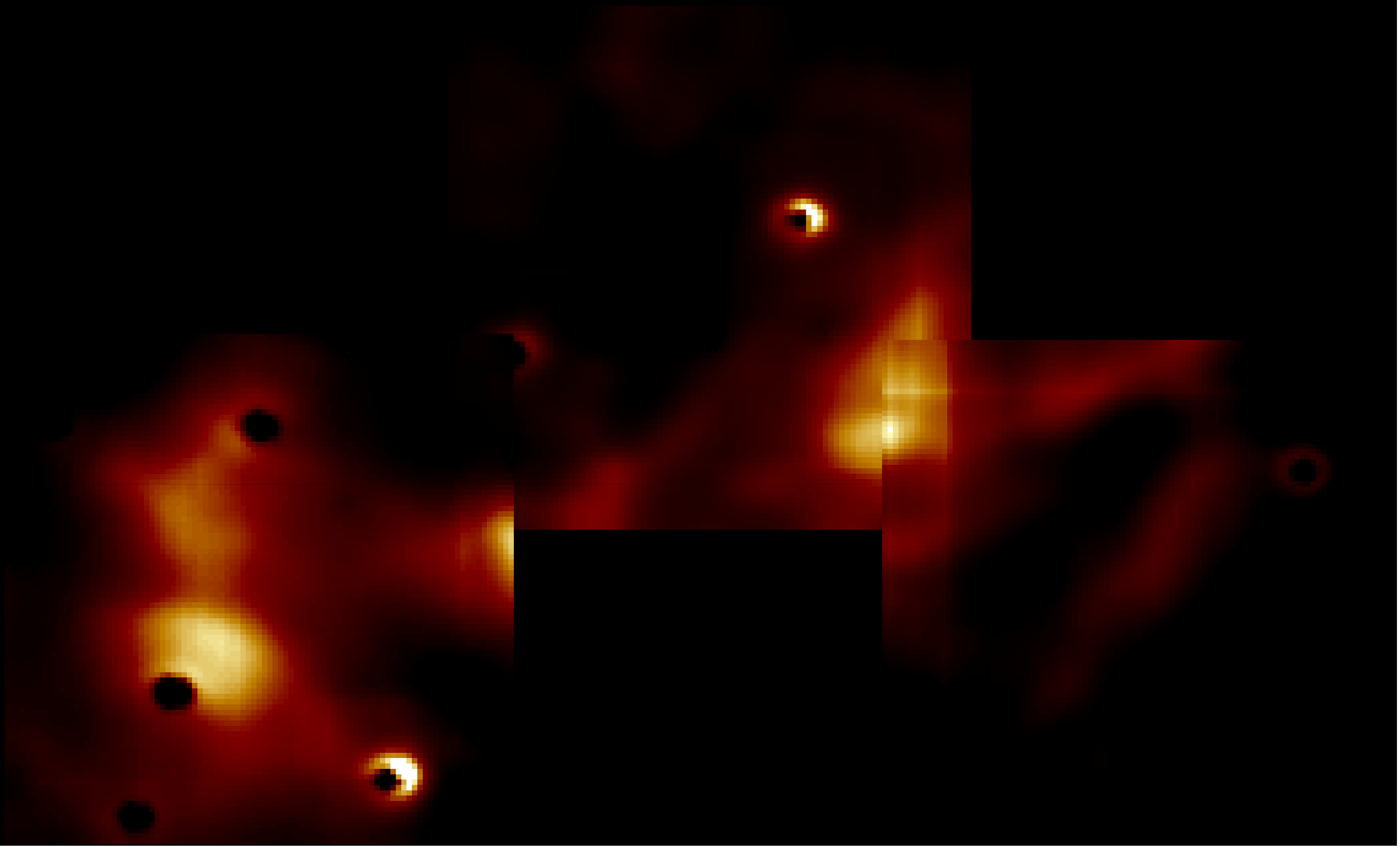
How Gemini is working: UCHII Regions

- Stellar content inferred by indirect means
  - radio continuum
  - MIR fine structure lines [NeII], [ArIII], [SIV] + CLOUDY
  - See poster by Crowther & Furness
- Direct accessing the photosphere of the ionizing star
- More: De Buizer's talk

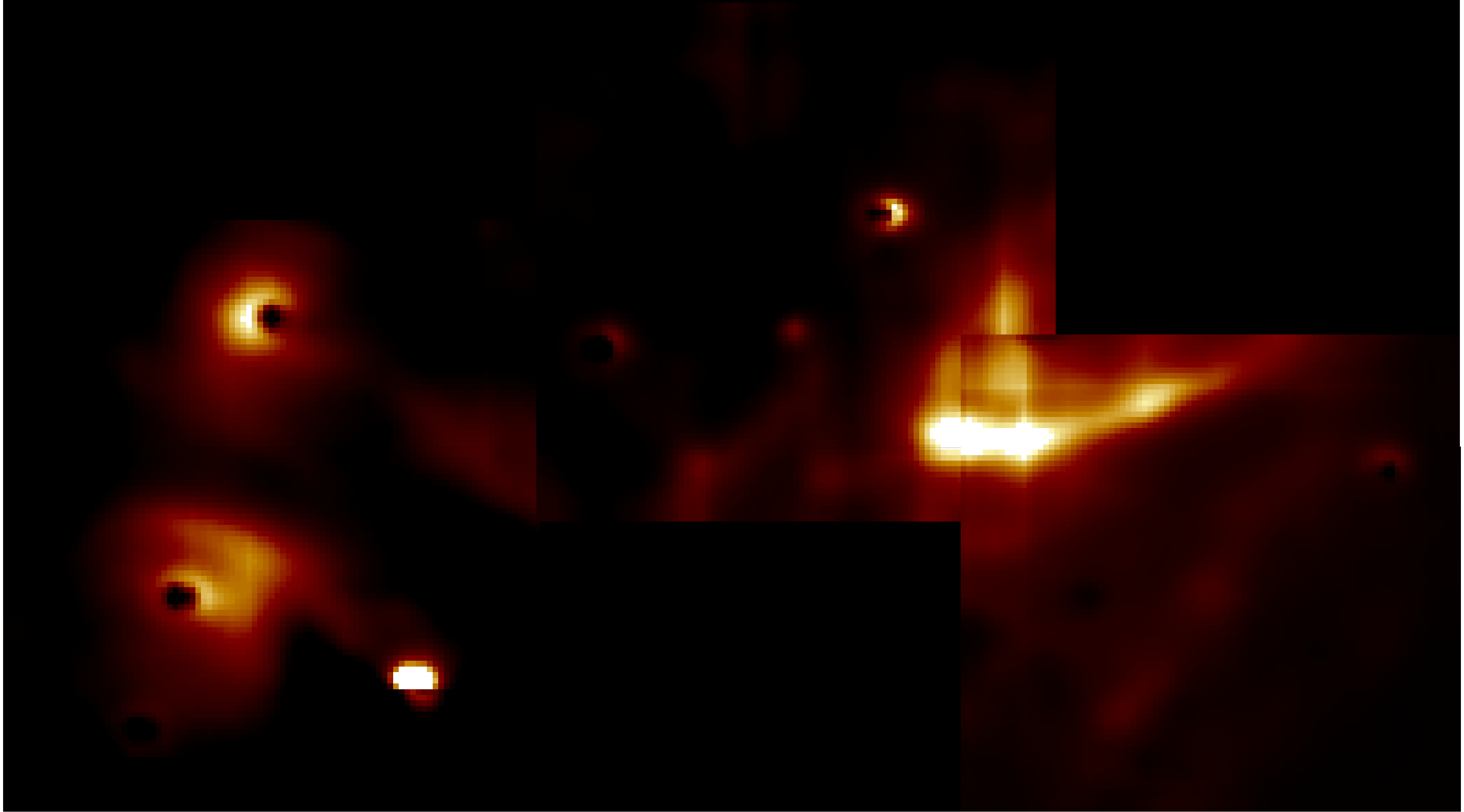
Nebular emission from the lines [Se IV] (2.2867 um) and [FeII] (2.2858 um)



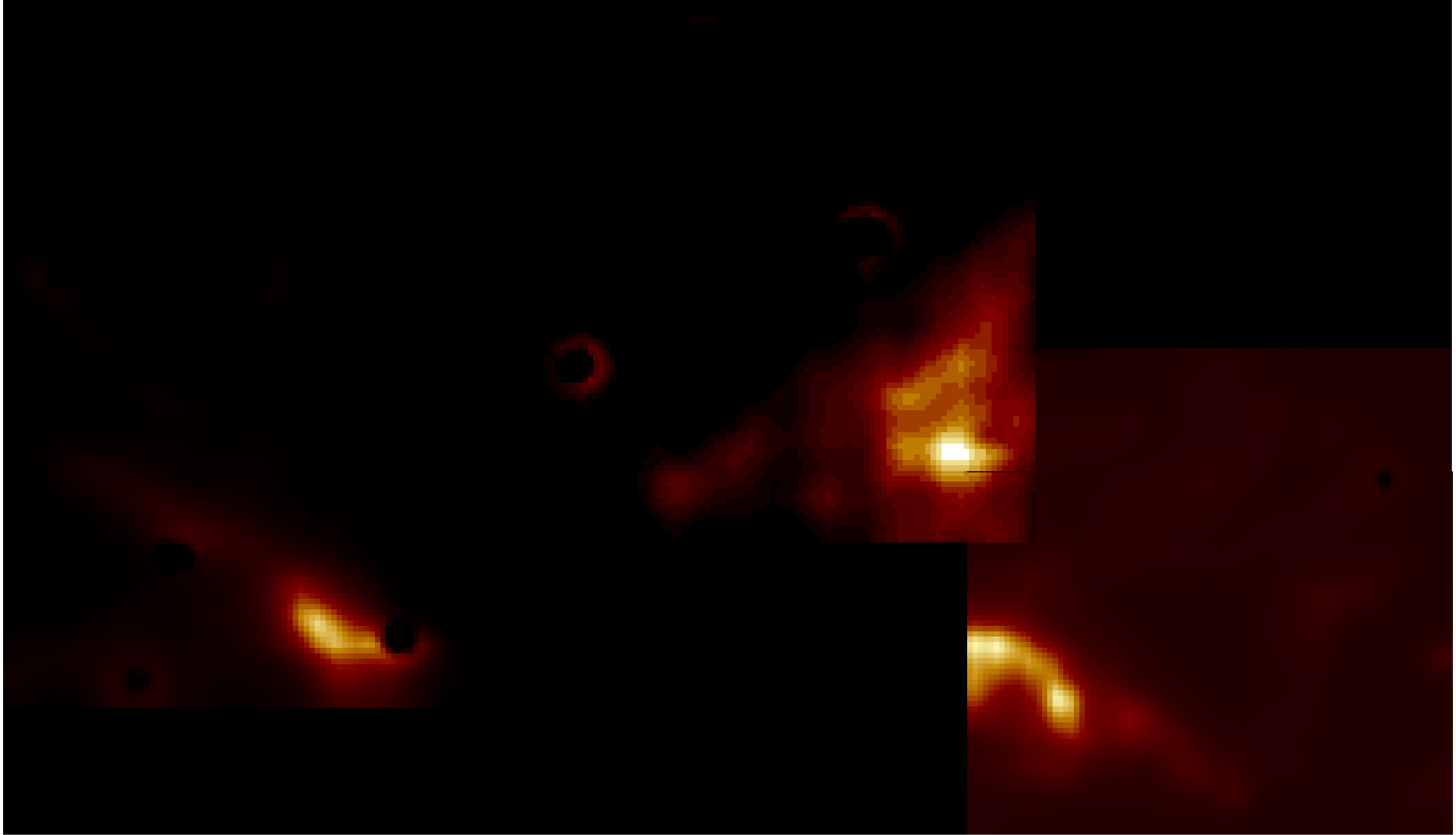
The He I 21 126 A emission



The [Fe III] 22 184 A emission

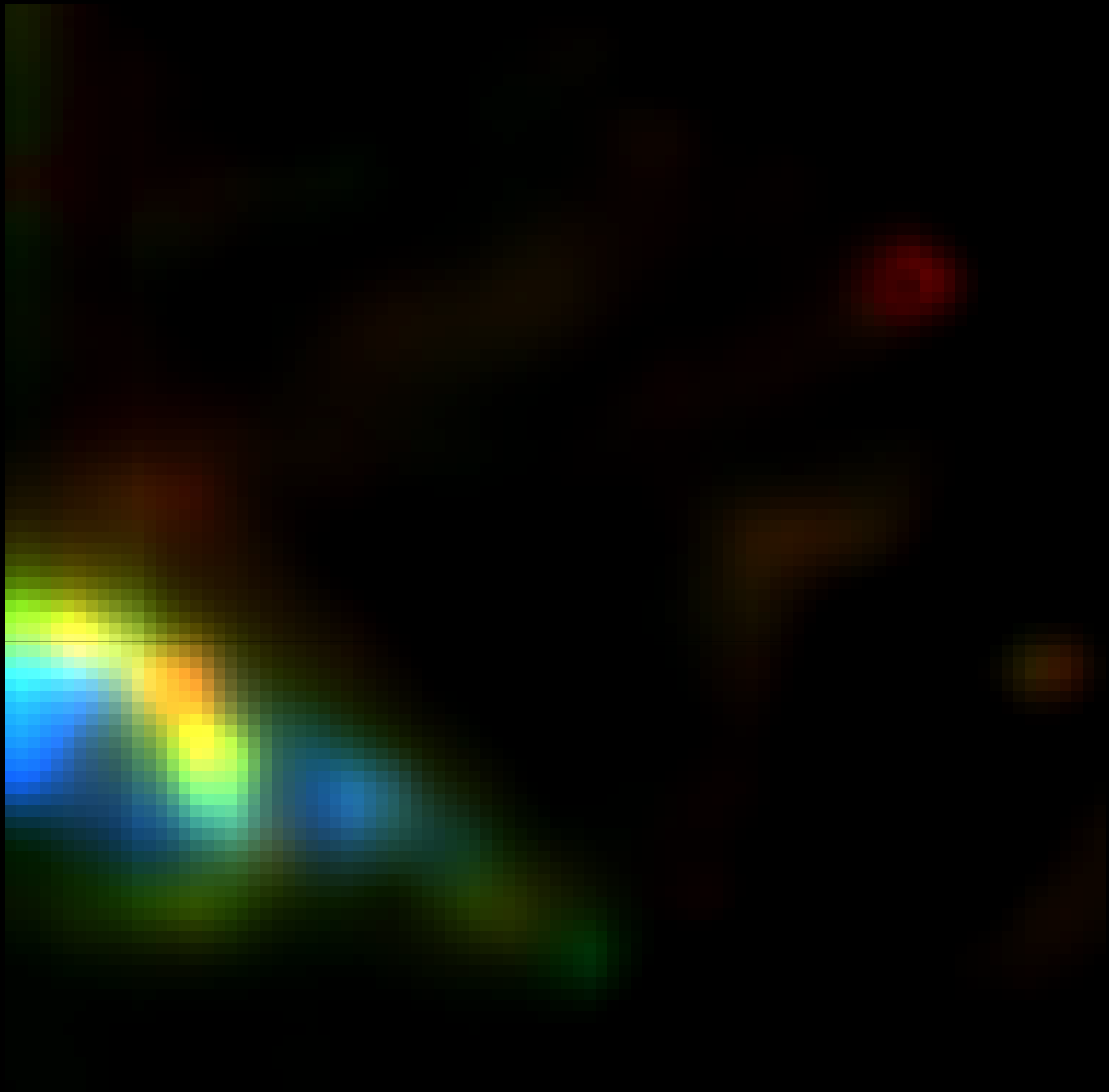


The H_2 21 218 A emission



The W51IRS2 fragmented H2 cloud

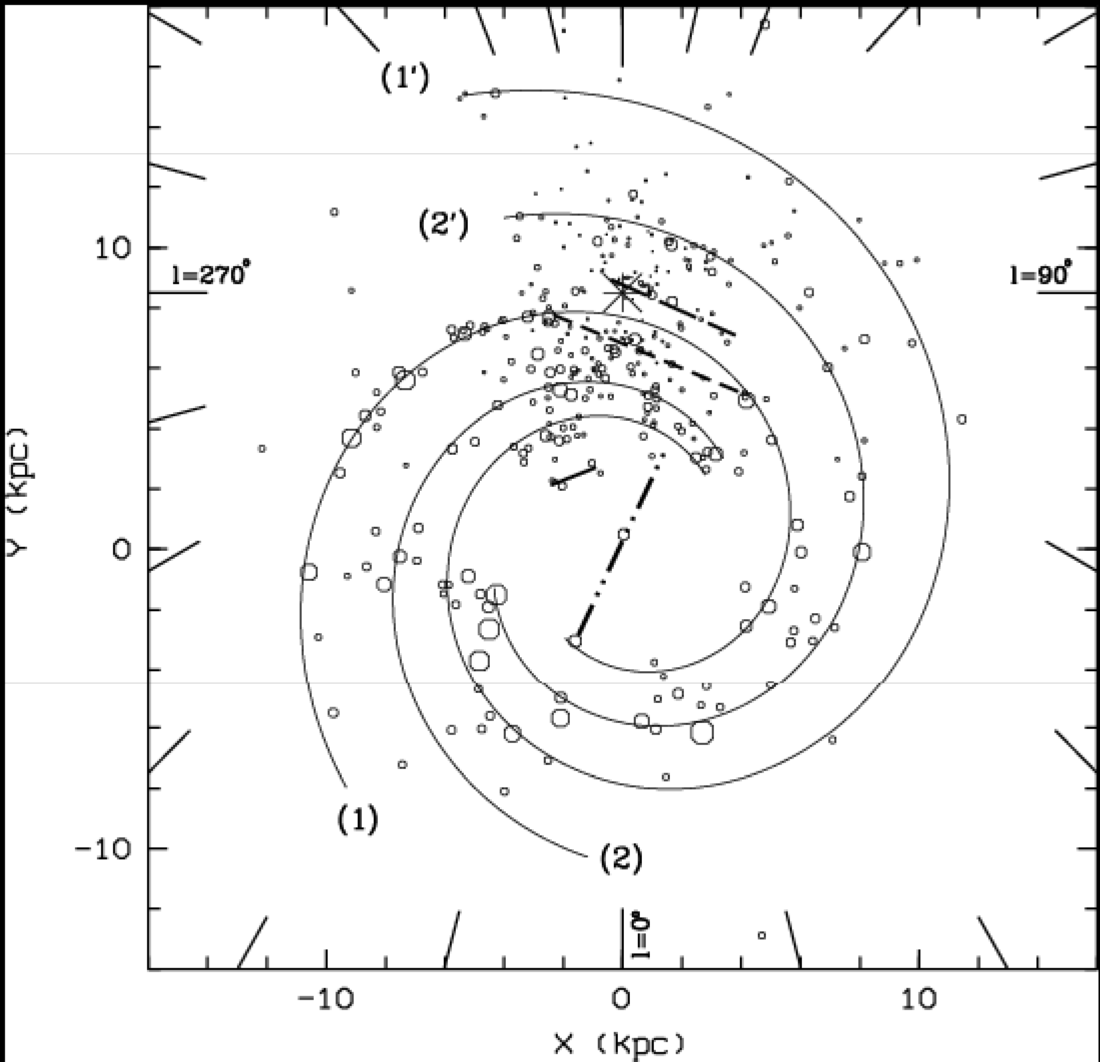
H_2 at rest + red and blue wings



How Gemini is working: mapping the Galaxy

- The Incredible Mutant Galaxy
  - how many arms in the Milky way?

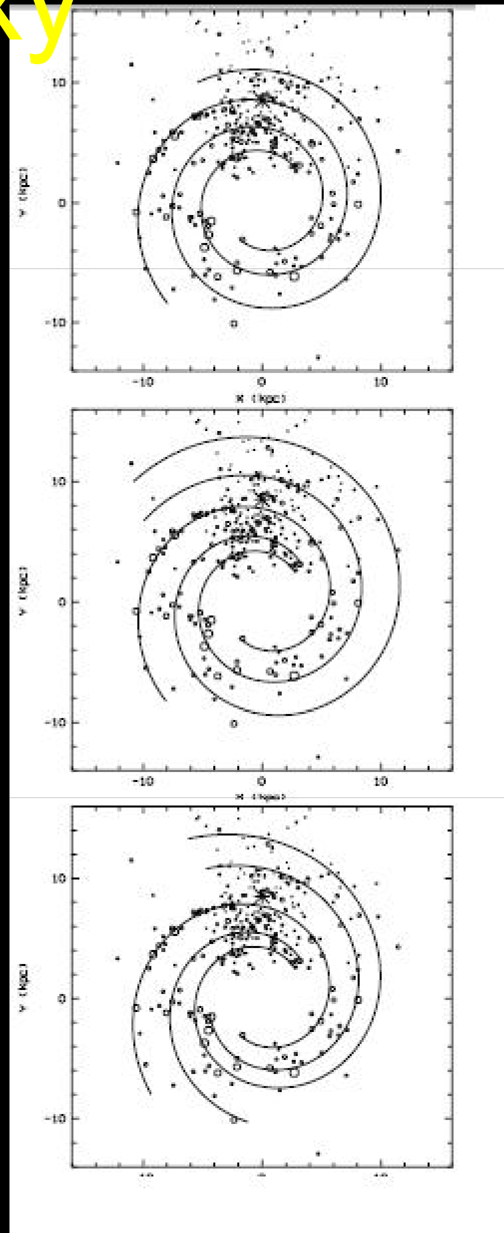
How Gemini is working: mapping the Galaxy



2?

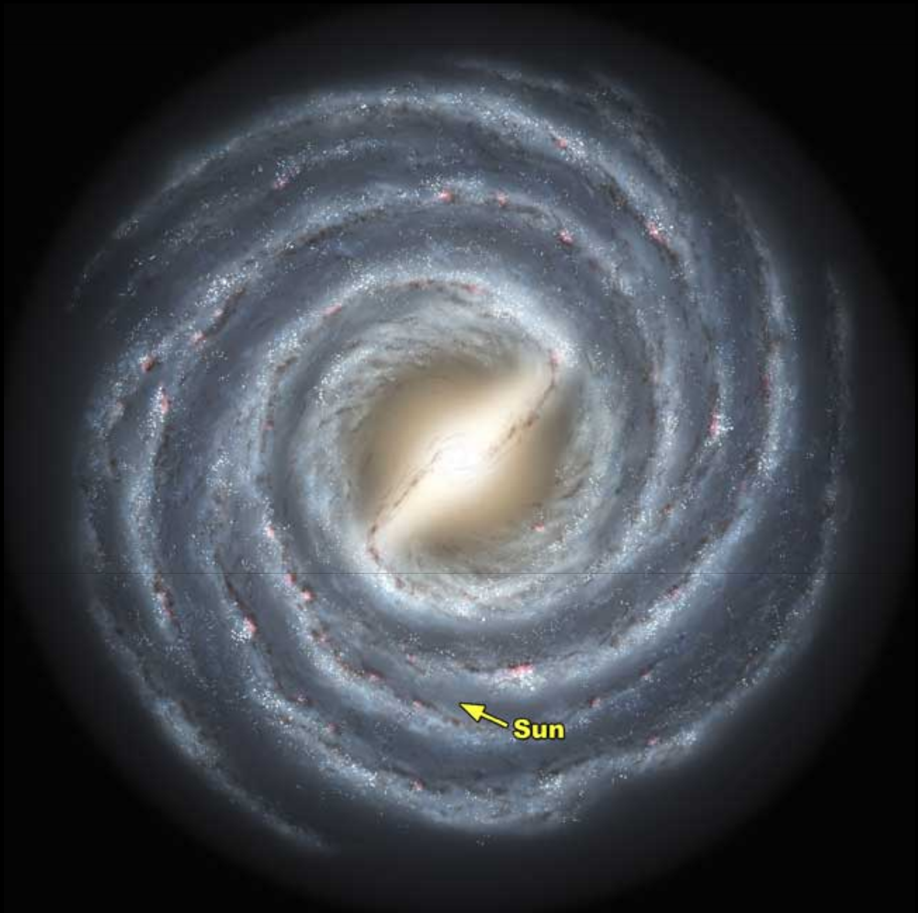
3?

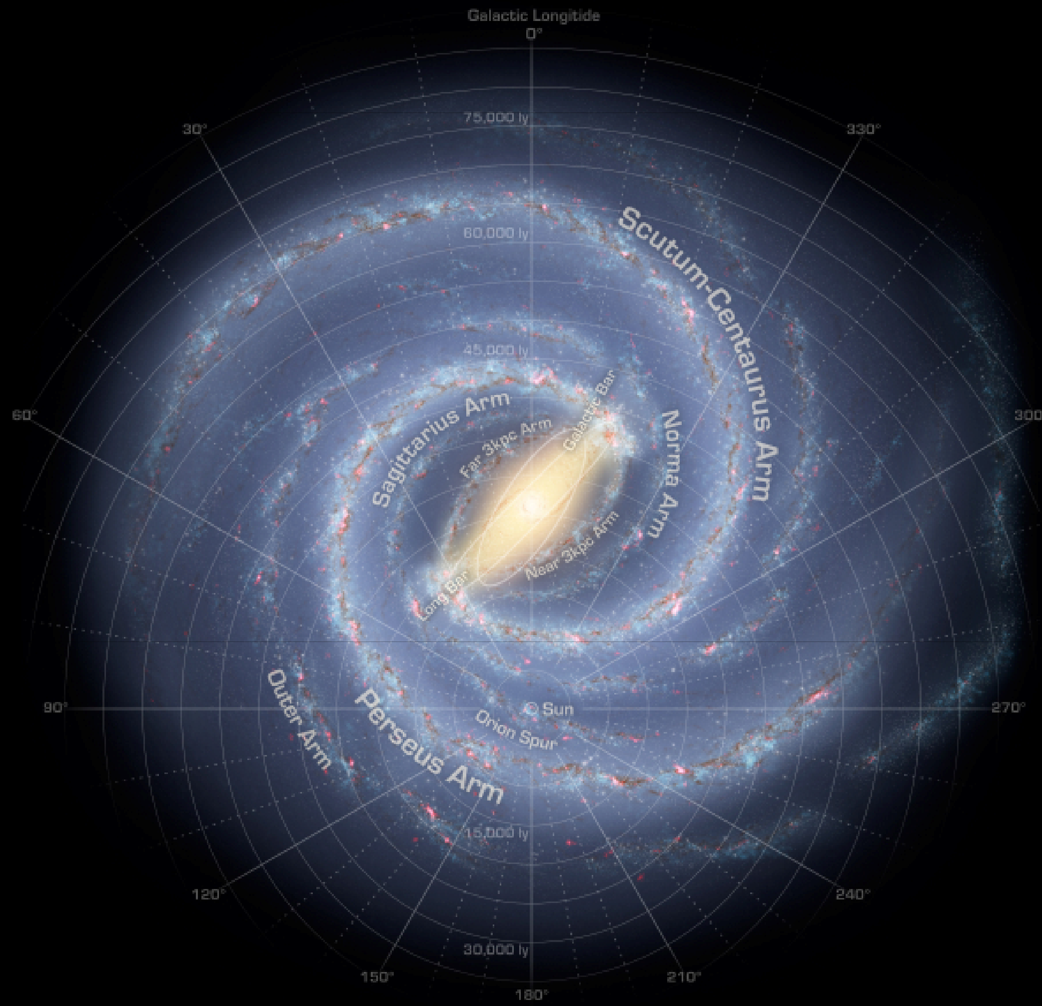
4?



Russeil et al. 2007 radio kinematic distances

How Gemini is working: mapping the Galaxy





Young Massive Stars

- Distances based on galactic rotation models
  - 2 solutions for the inner galaxy: distant/far
- Spectroscopic parallaxes
- Massive stars at GHII regions
  - no ambiguity
  - not based on galactic (uncertain) models
- Needs a robust reddening law
  - best: a line-of sight law

Young Massive Stars

Proposal Information for 2007A-0129

PI: Robert Blum, NOAO, rblum@noao.edu

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CoI: Augusto Damineli, Universidade do Sao Paulo, Brasil

CoI: Peter Conti, JILA, USA

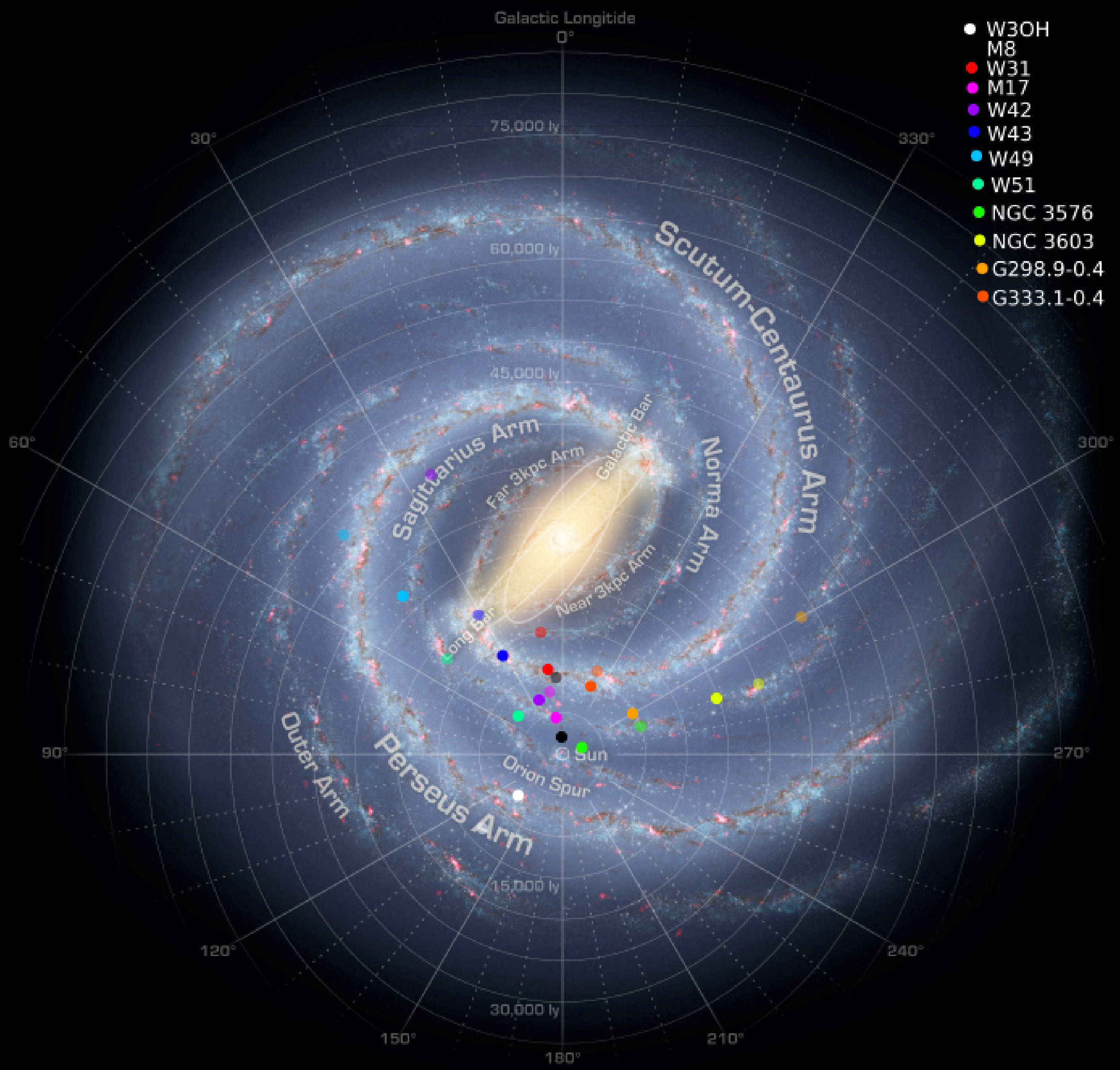
CoI: Alessandro Moises, Universidade do Sao Paulo, Brasil

CoI: Elysandra Figueredo, Open University, UK

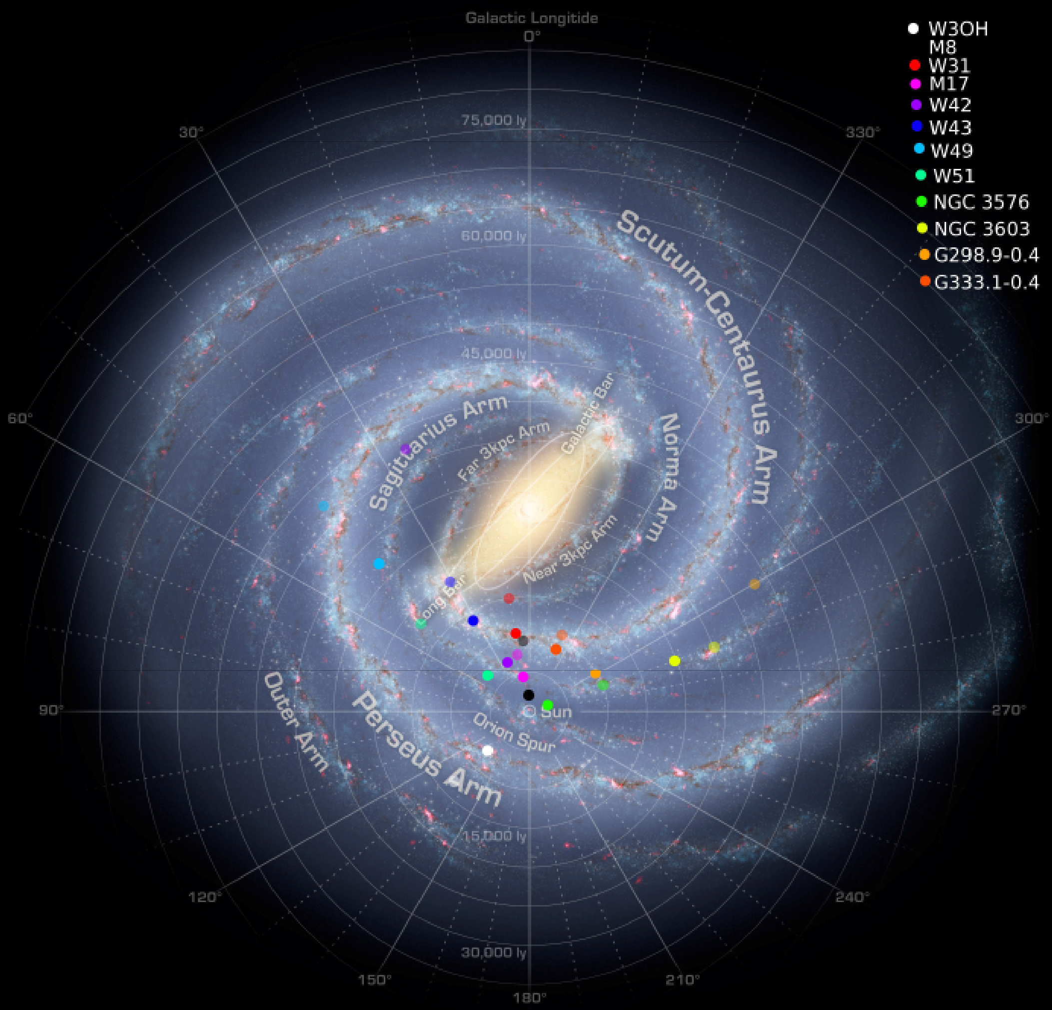
Title: The Incredible Shrinking Milky Way

Abstract: We propose to obtain near infrared spectra of OB stars embedded in Galactic giant HII regions (GHII) in order to trace the spiral structure of our Galaxy. Our distance determinations are based upon spectroscopic parallaxes of newly born OB stars. Radio recombination line+rotation models suffer from the classic near--far ambiguity which our method resolves. However, initial results show that even the near distances are systematically overestimated by kinematic techniques. Our spectroscopic distances to embedded clusters in GHII present a serious problem for models of the Milky Way that use radio recombination line distances to trace spiral structure and suggest that fundamental characteristics of the Galaxy such as Lyman continuum and mechanical input to the interstellar medium as well as the global star formation rate are still very uncertain. Give us time and we will fix this

Young Massive Stars



Young Massive Stars



- Results are showing:
  - shorter distances
  - smaller MK
  - lower SF rates
  - 2 arms
- Reid et al. (2009)
  - masers agree kinematic distances
  - larger MK
  - higher SF rates
  - 4 arms
- Stay tuned!

IAU 2009 General Assembly

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AUGUST, 2009 • RIO DE JANEIRO • BRAZIL

no masks!
just trunks and bikinis!!
more Pluto
controversy!

IAU 2009 General Assembly

Brazilian Geiko!

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XXVII GENERAL ASSEMBLY

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http://www.astronomy2009.com.br/

Summary

- Massive stars do exist!
- Accretion is possible
    - no disks for mid/early O?
- Progress on understanding massive star formation and its environment
    - jets, outflows, envelopes, cloud frag.
- Progress on understanding the morphology of the MK (or not?)
- Don't discontinue MIR instruments!