

THE GALACTIC CENTER

The source IRS 13: from a Single Object to a Star Cluster

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A bright object, from X-ray to cm-wave

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IV : SED and extinction law

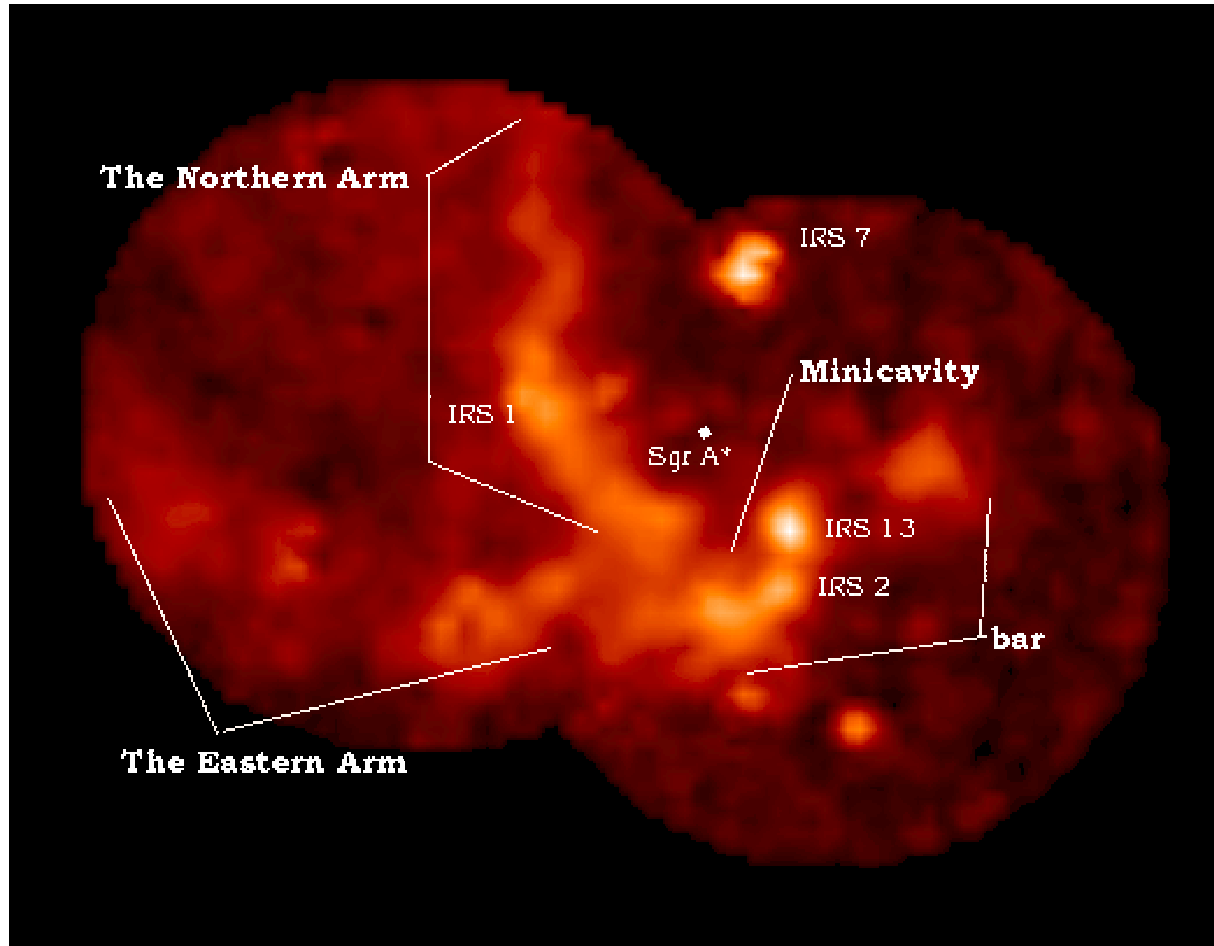
The IRS 13 sources and their environment

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Introduction: IRS 13

A bright object from X-ray to cm-wave: 3.6" SW of SgrA*



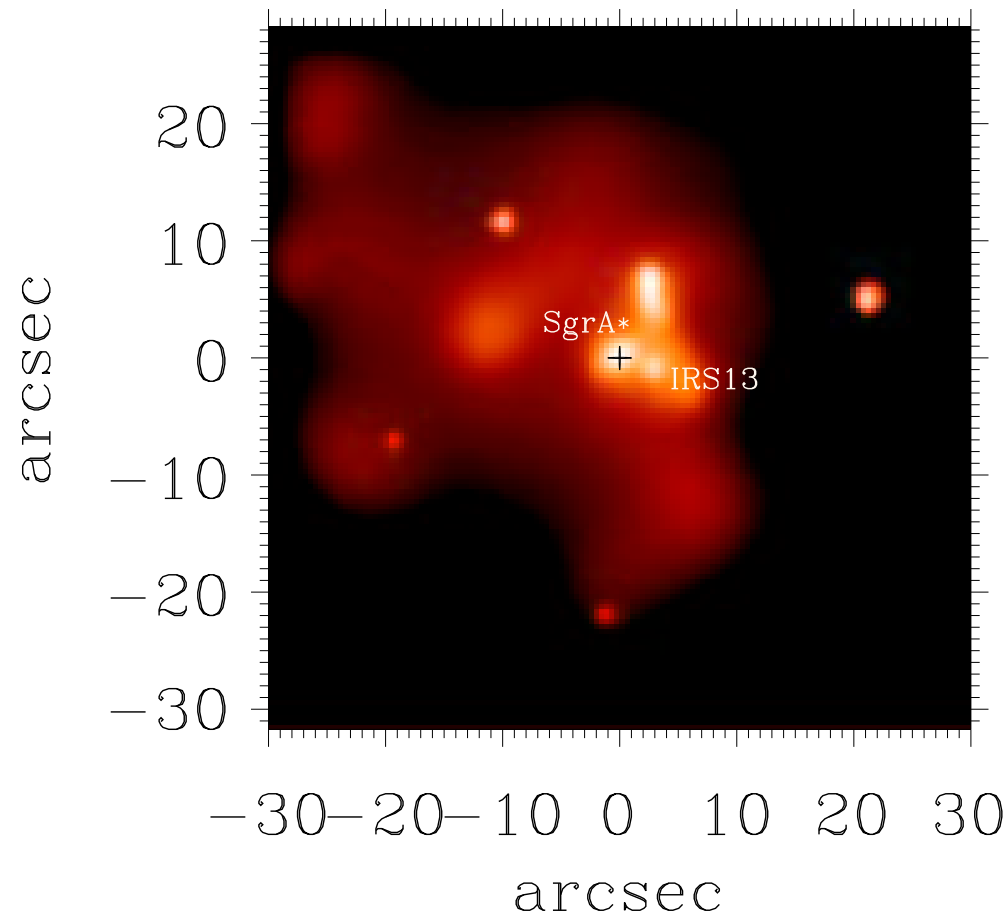
Br γ integrated intensity map toward Sgr A West. IRS 13 appears as the brightest point source.

IRS 13 observations history

- Infrared photometry: Rieke *et al.* 1989
- Lunar occultation: 13E and 13W Simon *et al.* 1990
distance: $\sim 1.2''$ 13E $m_K=9.4$ 13W $m_K=10.4$
- Hel star at 13E position Genzel *et al.* 1996
- VLA, bright at 7 & 13 mm Zhao & Goss 1998
- PUEO, central pc in K Paumard *et al.* 2001
IRS 13E separated in 13E1, 13E2, 13E3
- First AO map of IRS 13E in L Clénet *et al.* 2001
- CHANDRA, discrete X-ray source Baganoff *et al.* 2001
- NICMOS, GEMINI, BEAR Maillard *et al.* 2003

X-ray emission at IRS 13 position

CHANDRA IMAGE of SgrA* and IRS13

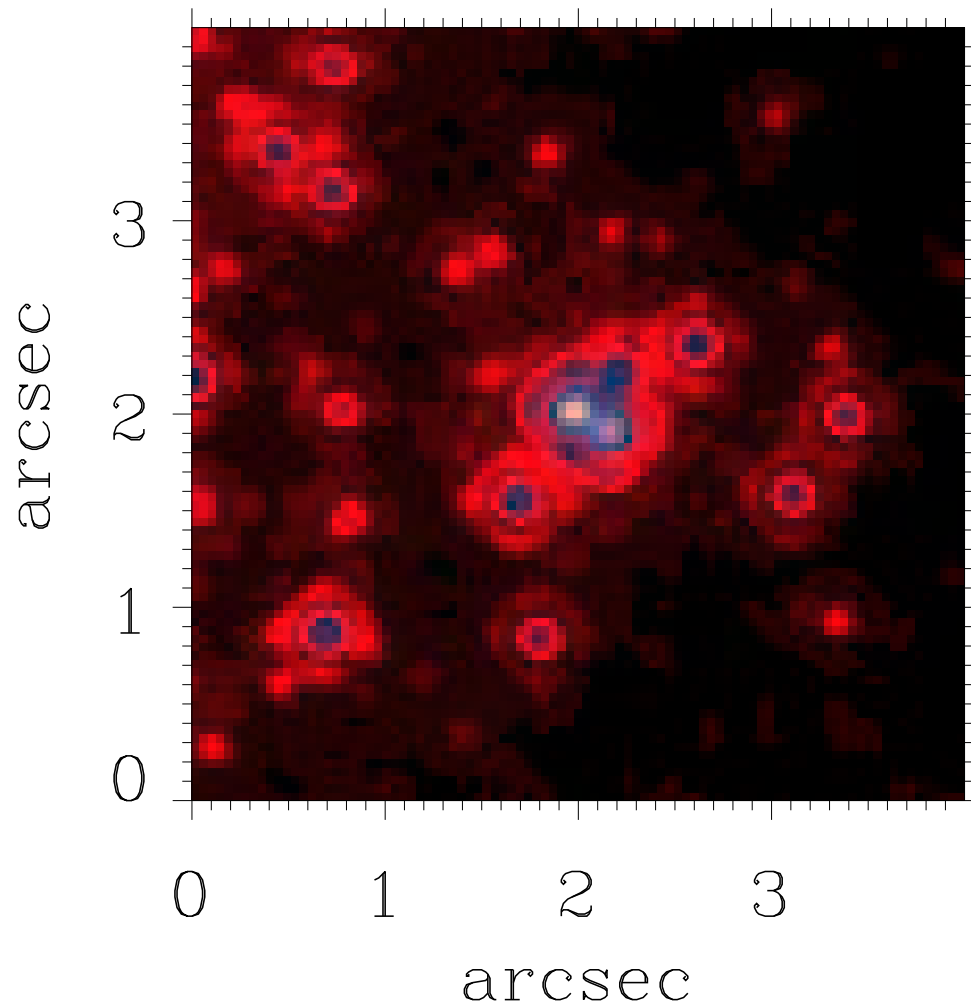


Central arcmin with hot gas surrounding SgrA* and discrete sources (NASA/MIT/PSU).

High-resolution images of IRS 13

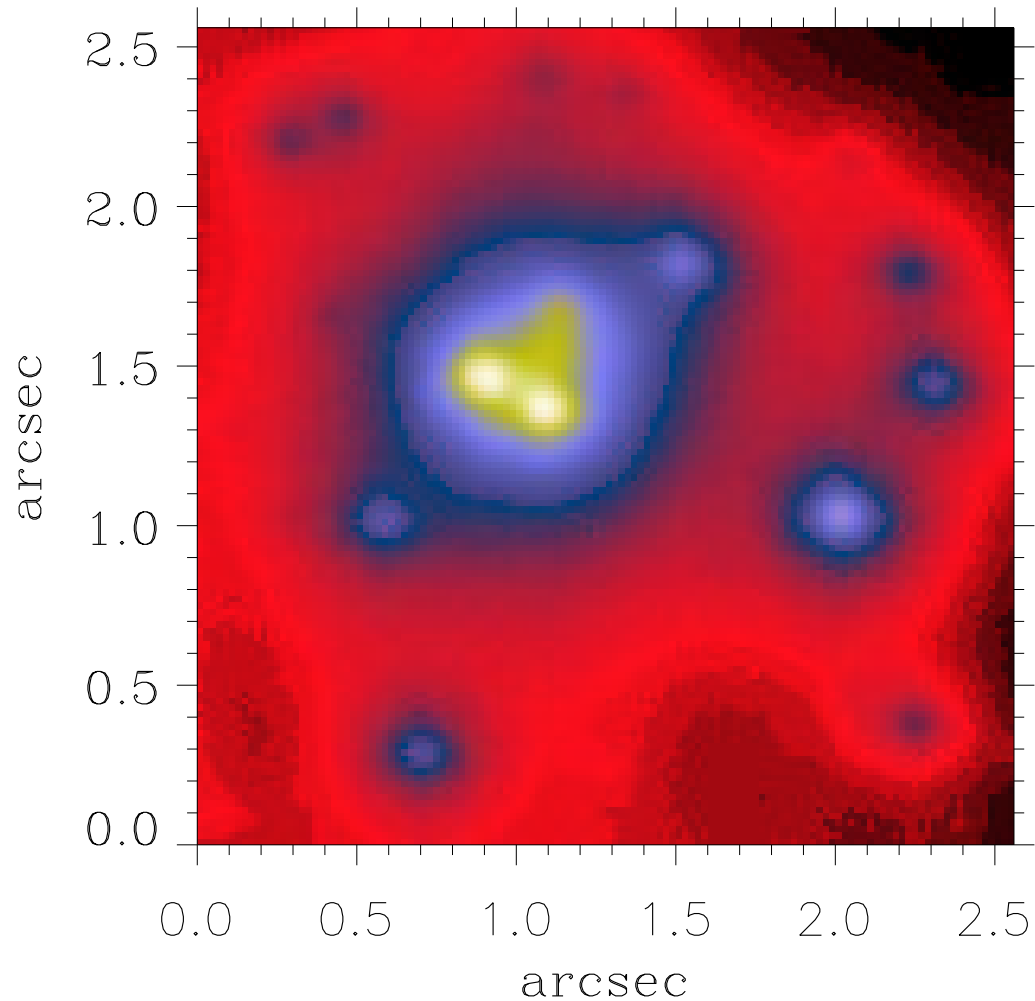
Filter	Instrument / Telescope	λ / FWHM (μm)	Year
F110M	NICMOS / HST	1.10 / 0.200	1998
F145M	NICMOS / HST	1.45 / 0.197	1998
F160W	NICMOS / HST	1.60 / 0.400	1998
H	Hokupa'a+Quirc / Gemini N	1.65 / 0.296	2000
Pa α	NICMOS / HST	1.87 / 0.019	1998
F190N	NICMOS / HST	1.90 / 0.017	1998
K'	Hokupa'a+Quirc / Gemini N	2.12 / 0.410	2000
K	PUEO+KIR / CFHT	2.20 / 0.340	1998
F222M	NICMOS / HST	2.22 / 0.144	1998
L	ADONIS+COMIC / 3.6 m ESO	3.48 / 0.590	2000

NICMOS image at $1.45 \mu\text{m}$



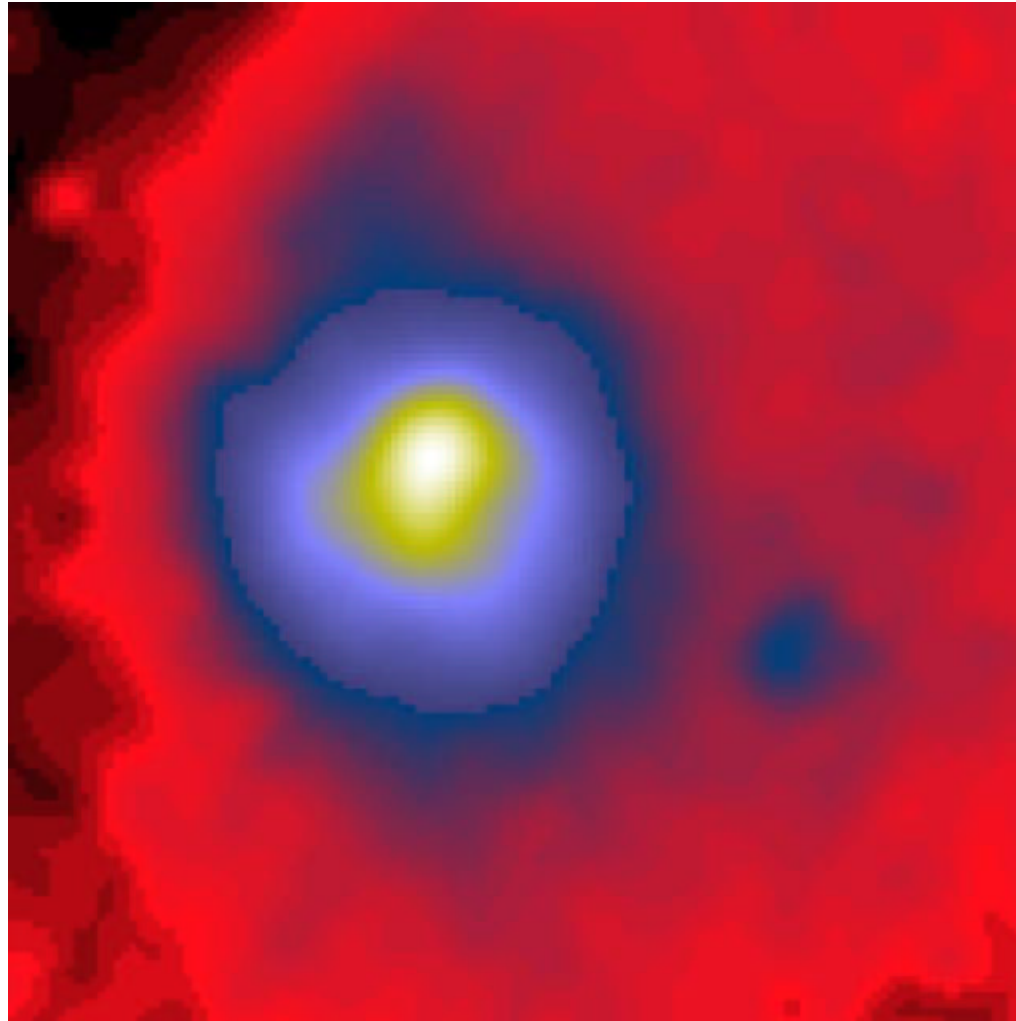
4"×4" field centered on IRS 13 from NICMOS F145M image

Gemini K' AO image



2.5"×2.5" of the 19"×19" AO image centered on IRS 13 (July 2000)

AO image of the IRS 13 field in L



2.5"×2.5" from the Adonis L-band image showing IRS 13E and 13W (Clenet *et al.* 2001).

Star content: method of analysis

Extraction of the stars in the IRS 13 field performed with:

- *IDL procedure StarFinder* Diolaiti *et al.* 2000

Specially written for AO data. PSF made from few images of bright, isolated stars

- *MCS deconvolution code* Magain *et al.* 1998

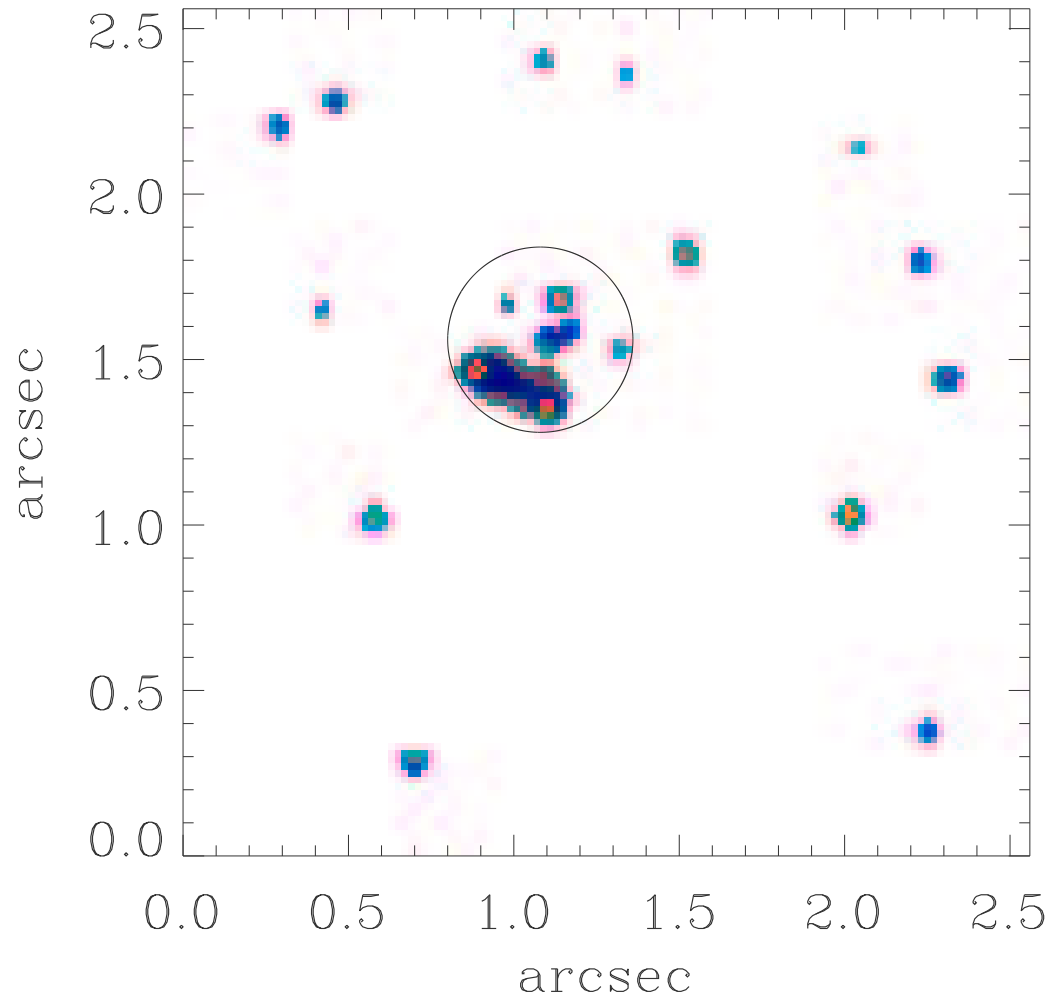
Analytic shape of the PSF, compatible with image sampling, thus, narrower than the observed one. Matching of the diffuse background. Not ready to apply on NICMOS images. Used only on H, K' and L AO images because of poor Strehl ratio.

Spectroscopic data:

- *Pa α NICMOS image and BEAR cubes*

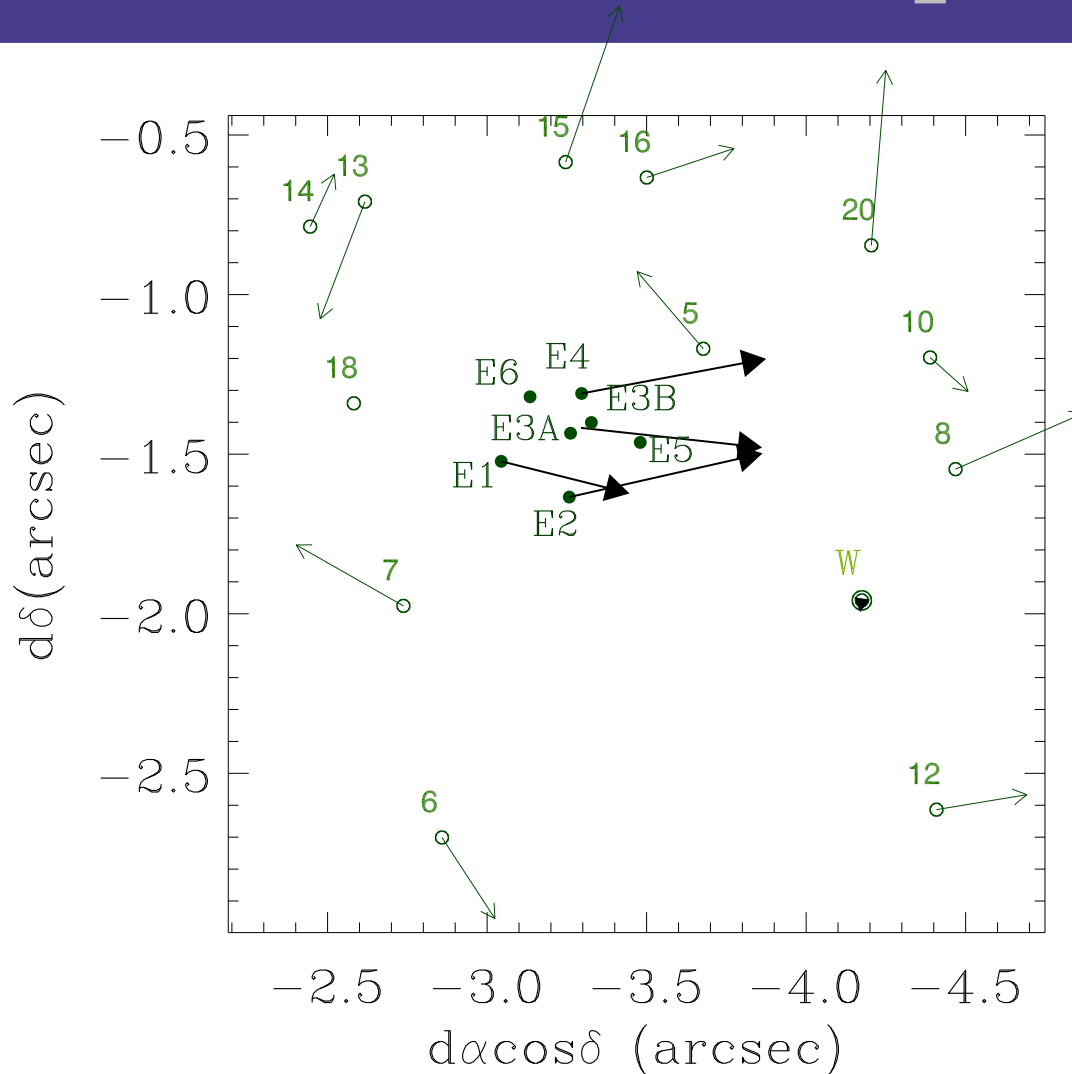
BEAR data: spectro-imagery in HeI 2.06 μm , Br γ , HeII 2.19 μm

Stellar content: results



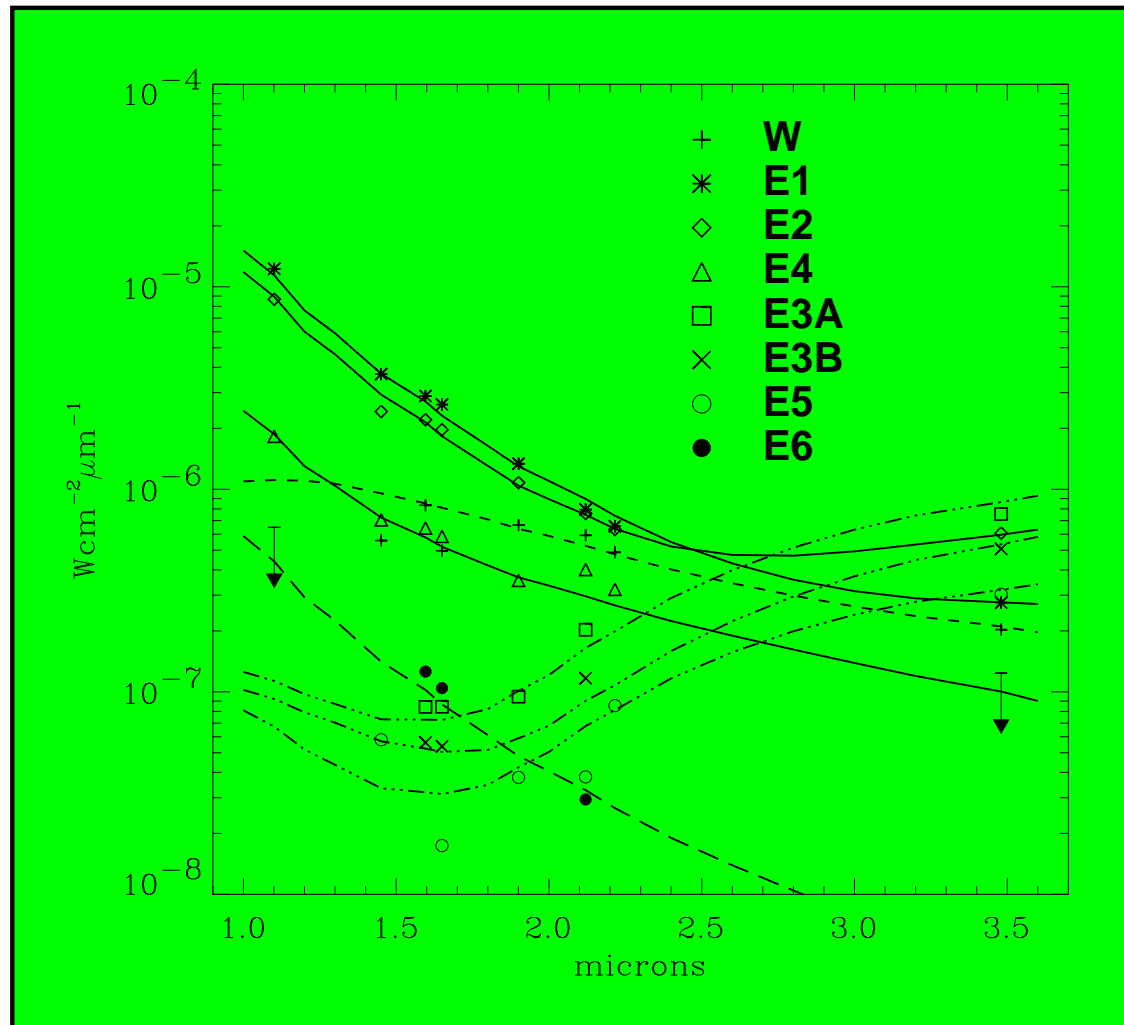
Result of deconvolution of $2.5'' \times 2.5''$ from the Gemini AO K'-band image. IRS 13E (circle) appears as a cluster of 7 sources. Resolution: $0.040''$. Gain of a factor 4.3 from original data.

Star identification and proper motions



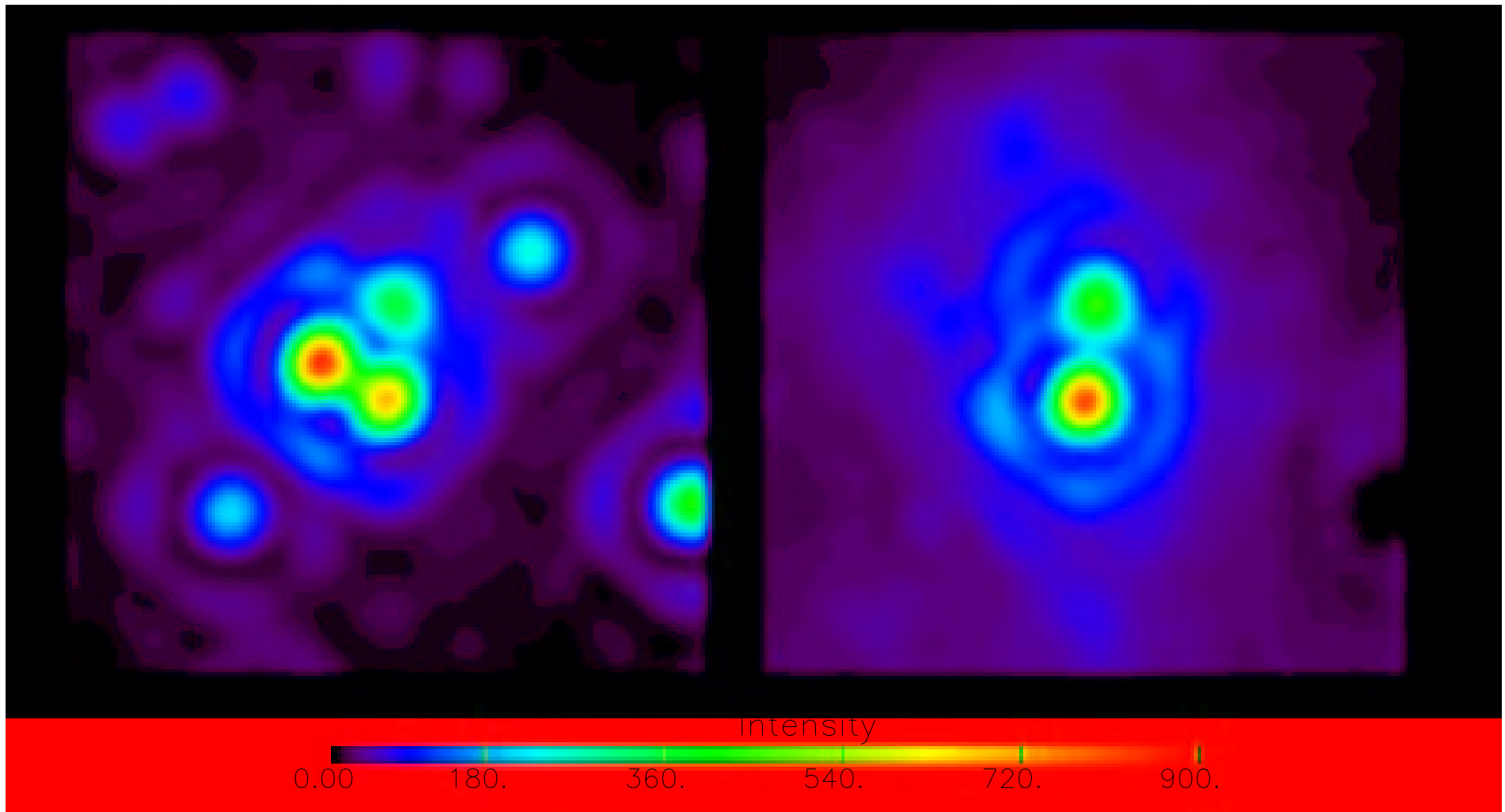
Stars with direction and amplitude of proper motions from SHARP data (*Ott et al. 2003*)

Adjustment of SEDs after dereddening



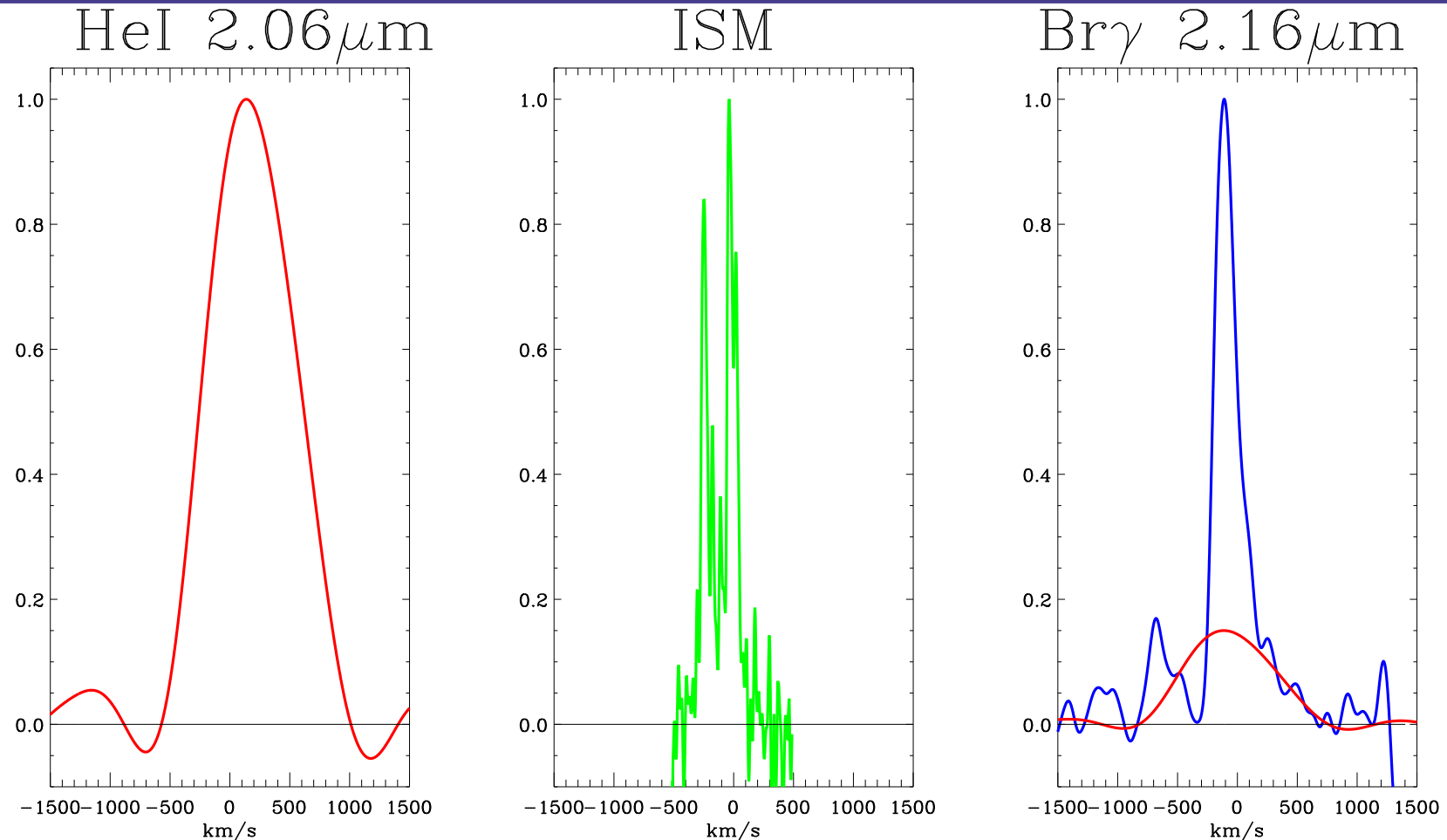
SED of IRS 13 sources from 1 to $3.5 \mu\text{m}$ (dereddening law *Moneti et al. 2001*, $A_v = 35$)

Spectroscopic data: Pa α emission



Left: NICMOS F187N; right: F187N-F190N. IRS 13E2 and 13E4 appear as emission line stars.

Spectroscopic BEAR data



HeI 2.06 μm and Brγ stellar line profiles at IRS 13E, and interstellar emission (ISM)

$$\text{FWHM}(\text{HeI } 2.06\mu\text{m}) = 880 \text{ km s}^{-1} \quad \text{FWHM}(\text{Br}\gamma) = 216 \text{ km s}^{-1}$$

Spectral type of the IRS 13E sources

Star	$Coef_1$	T_1 K	$Coef_2$	T_2 K	Sp. Type
W	23.00	2600	1700	650	M5III
E1	0.500	\geq 25000	12000	550	O5I
E2	0.450	\geq 25000	40000	550	WC9
E4	0.070	\geq 25000	45	1550	O5IIIe
E3A	0.460	3800	33000	610	d. WR ^a
E3B	0.375	3800	29000	580	d. WR
E5	0.070	6000	9800	630	d. WR
E6	0.008	\geq 25000			O5V

Two blackbody curves needed to adjust the SED of most of the IRS 13E components
 Temperatures T_1 and T_2 , and intensity factors $Coef_1$ and $Coef_2$.

$T_1 \geq 25000$ means Rayleigh-Jeans approximation. The temperature cannot be more constrained. T_2 is indicative of an infrared excess.

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Maillard et al. A&A, 2003

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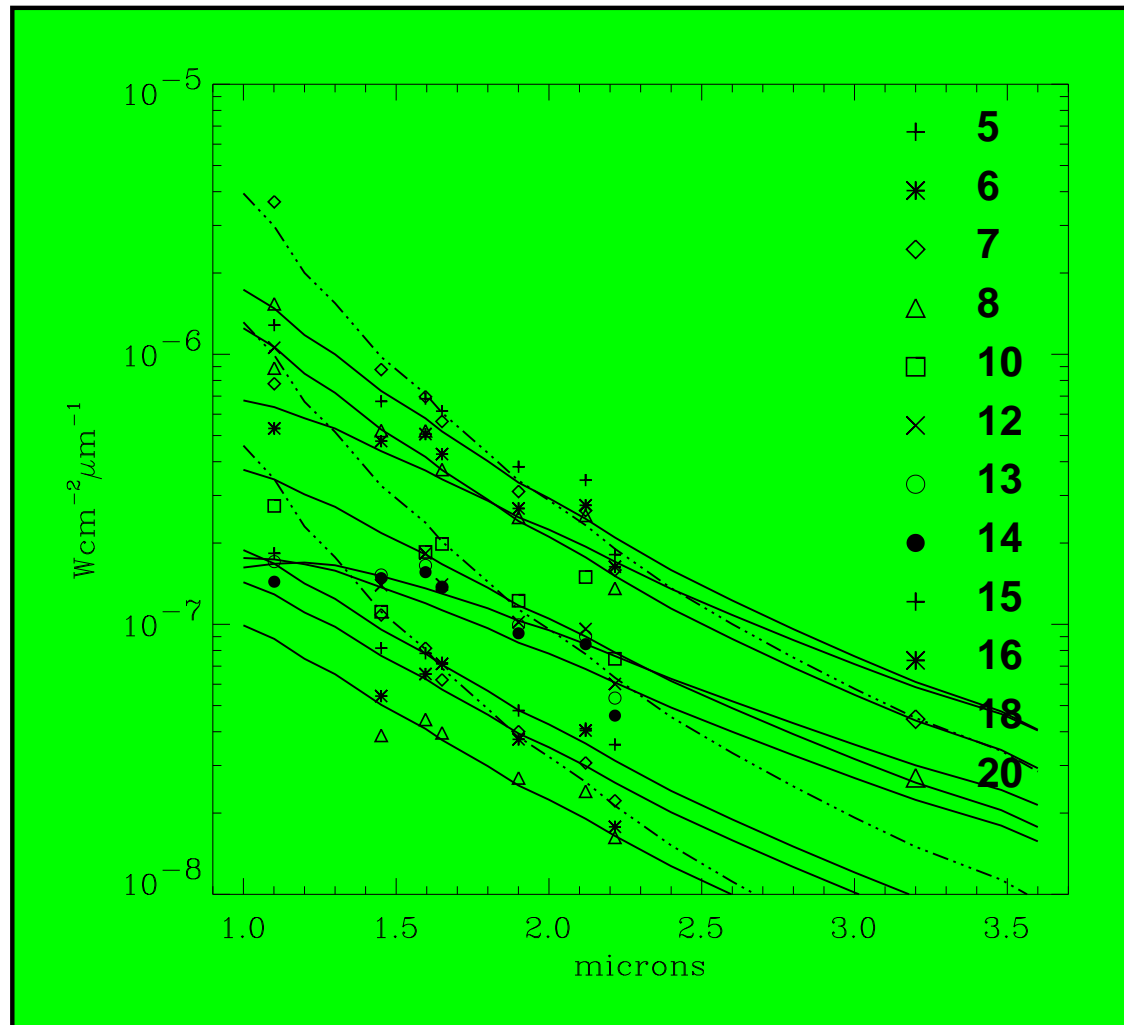
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Conditions:

- a star cluster of initial mass $\geq 10^5 M_{\odot}$,
- born at a distance of ~ 10 pc,
- for an inspiral time ≤ 5 Myr

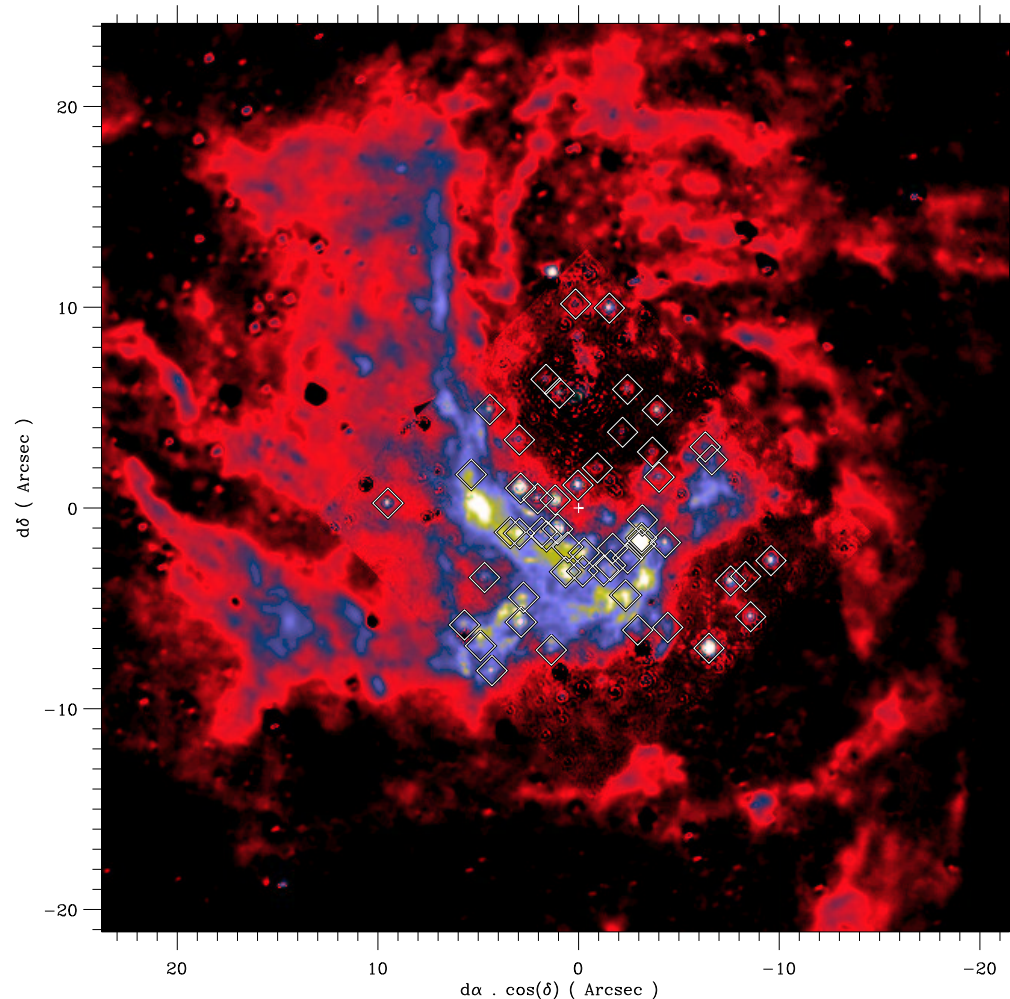
Gerhard (2001), Kim & Morris (2002), McMillan & Zwart (2003)

QUESTION: the young star population



SED of the sources near IRS 13. Most of them are, old population, main sequence K and M stars. **Three weak, hot stars are detected (dash-dot line)**

Pa α emission line stars in the central pc



40 stellar points detected in the F187N-F190N image = candidates for emission stars.
~20 are identified as helium stars. **What are the other ones?**

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GOAL: the IMF of the initial massive cluster

with PUEO NUI

a program to answer these questions:

- observation of the GC down to $1 \mu\text{m}$,
demonstrated as rewarding by NICMOS-HST.
- necessary to go deeper: $m_J \simeq 20$
must be feasible: a larger telescope (3.6 m)

Conditions:

a AO system with high Strehl ratio at 1 micron
a AO reference system in the infrared

General conditions to work on high extinction
fields: galactic, extragalactic star forming regions