Observing the Galactic Center with JWST/MIRI

JWST and the ELTs: An Ideal Combination
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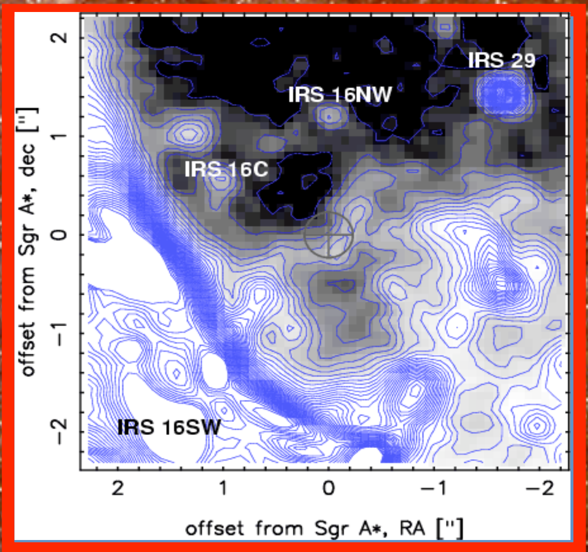
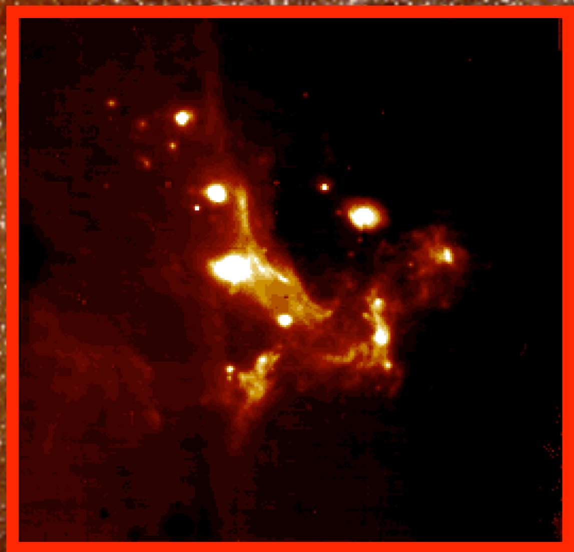
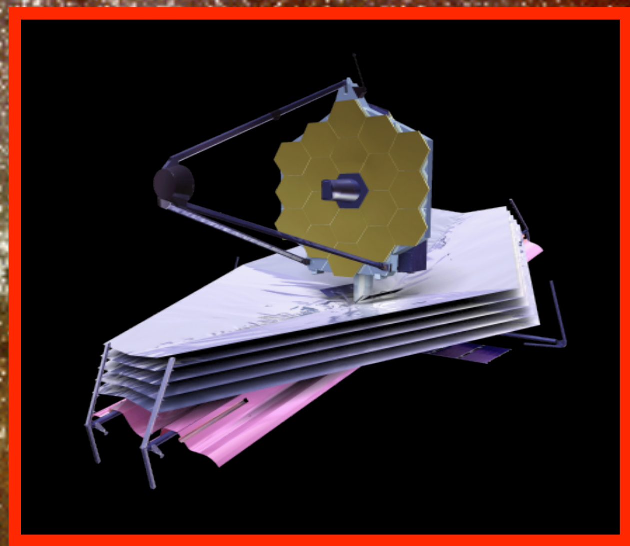
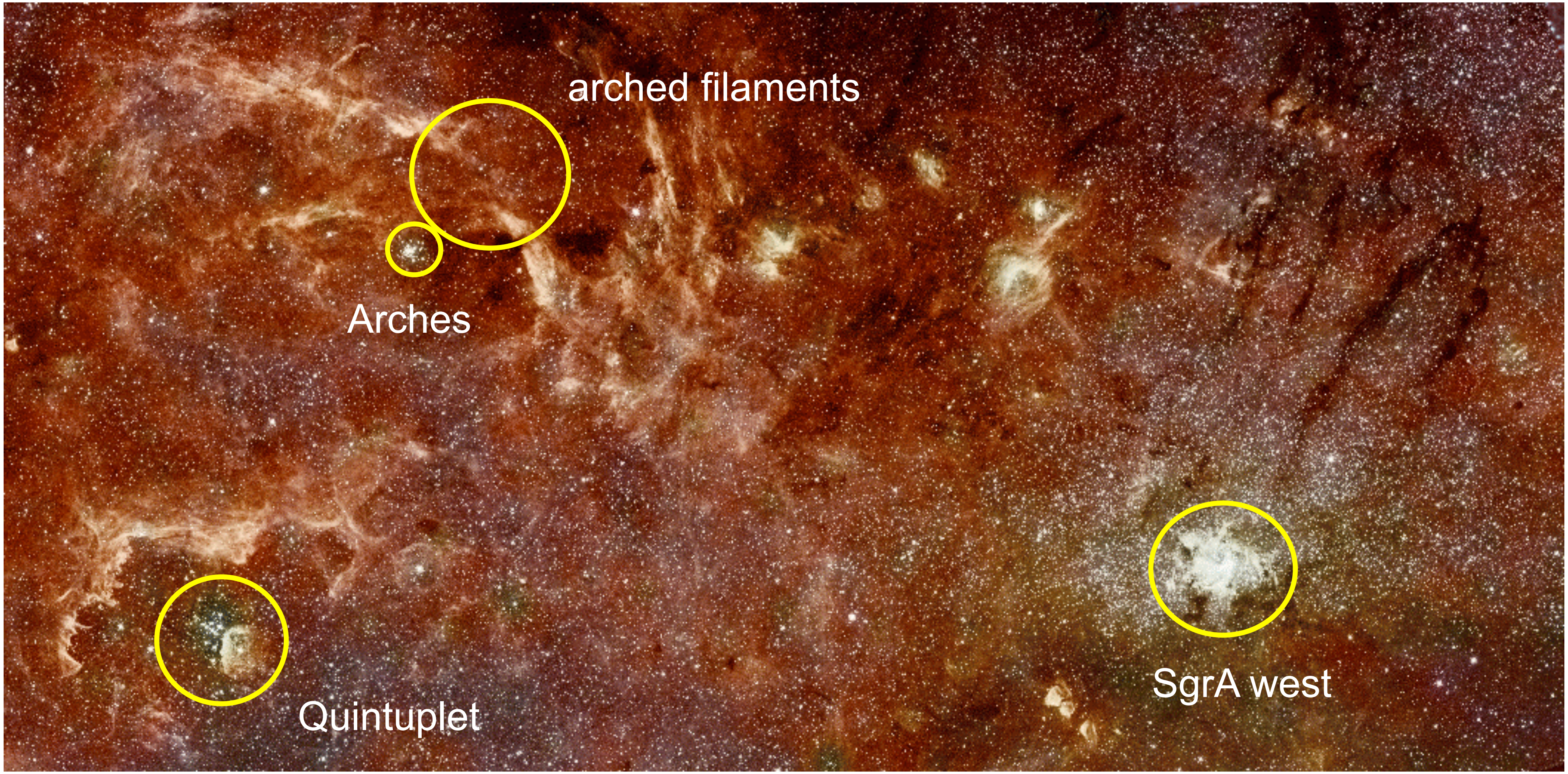






Cologne MIRI team: S. Fischer, M.G. Marin, C. Straubmeier, A. Eckart

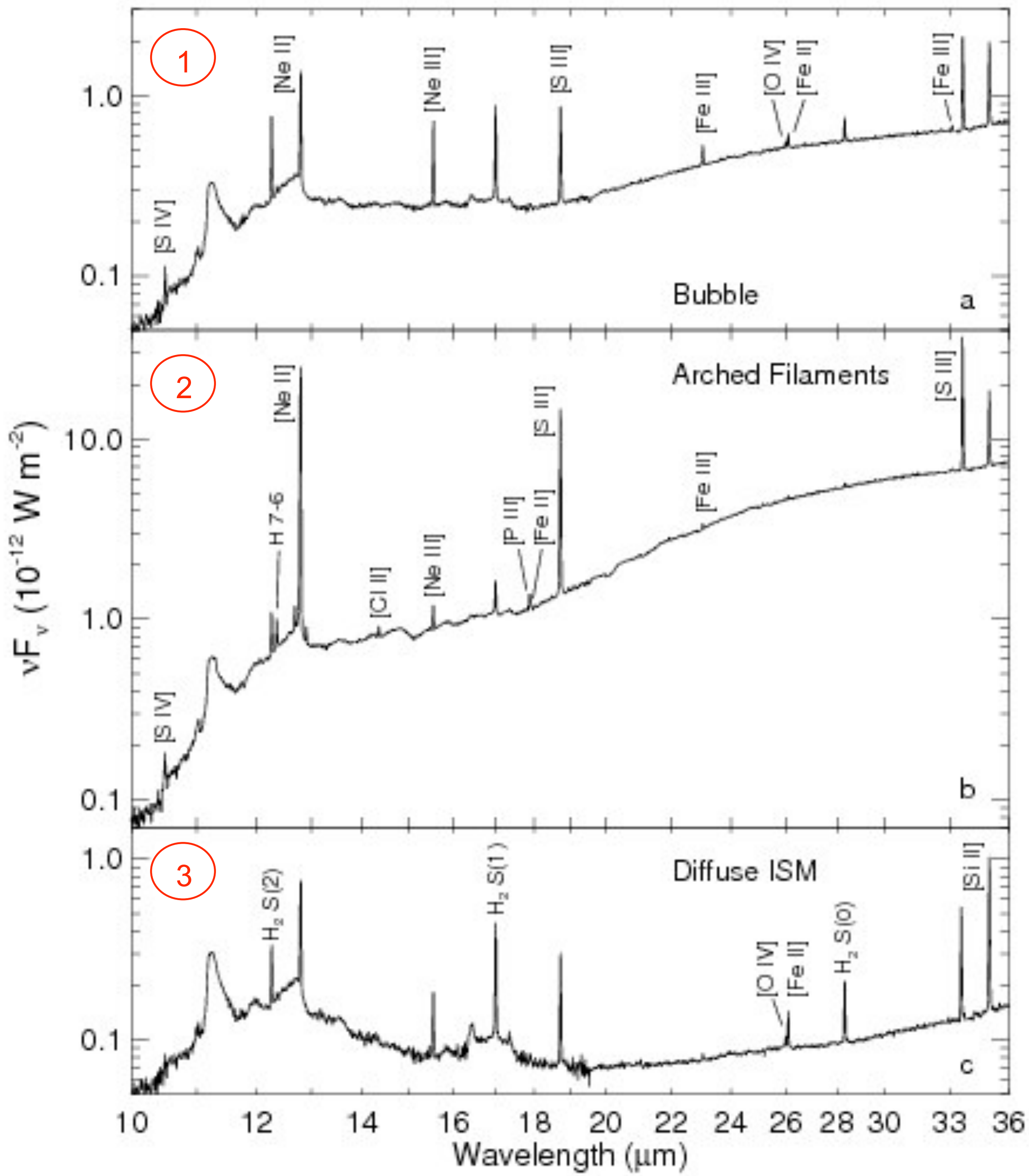
The Galactic Center as seen by SPITZER and HUBBLE



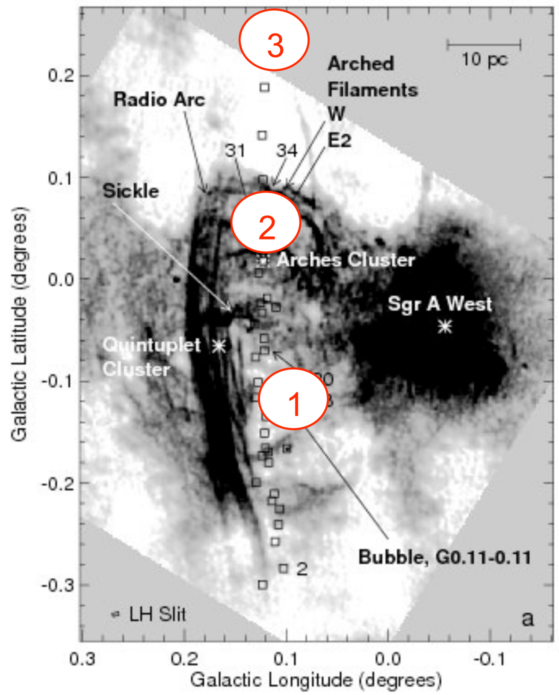
300 x 115 light years = 91 x 34.8 parsec = 38.3 x 14.7 arcmin

NASA ESA D. Q. Wang U. Mass, Amherst NASA JPL SSC/Caltech

Spectroscopic probes



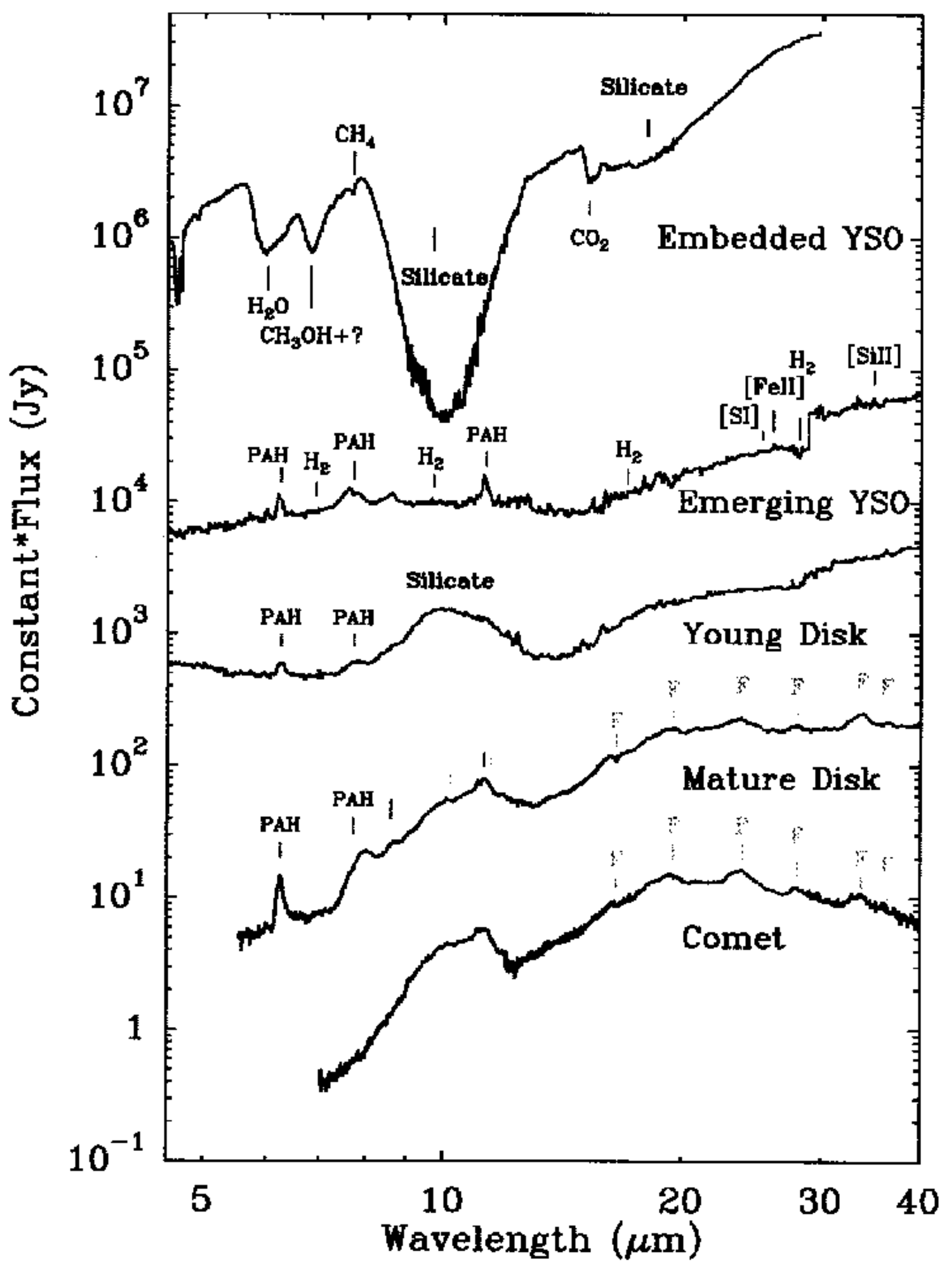
SPITZER spectra towards two characteristic regions in the Galactic Center
Simpson et al. 2007



Spectroscopic probes

One strength of the MIRI IFUs: Full spectral coverage!

Both spectroscopic and overall SED properties of target sources will allow us to identify and classify young stars and disks.



ISO SWS MIR spectra of young stars and circum-stellar disks at different stages of their evolution
Malfait et al. 1998; Gibb et al. 2000, Ancker et al. 2000a,b, Crovisier et al. 1997

Spectroscopic probes

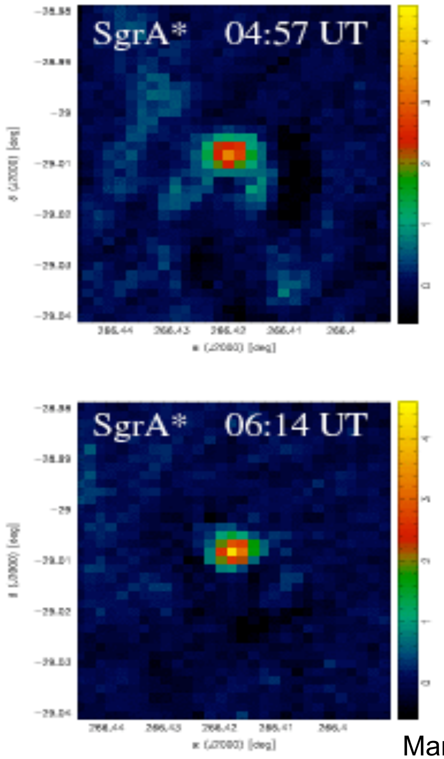
NH_3 (9um), CH_3OH (9.7um C-0 stretching) features
5.5-7.5 H_2O ice features as reported by
Boogert et al. 2008 (Spitzer) and Bottinelli et al. 2008

Shocked gas in arcs, bow shocks and interaction zones
could be observed in emission through lines from
neutral molecular and atomic hydrogen species
H_2 S(0), S(1), S(2) @ 28.2, 17.0, 12.3 um
HI 7-6 @ 12.37 um

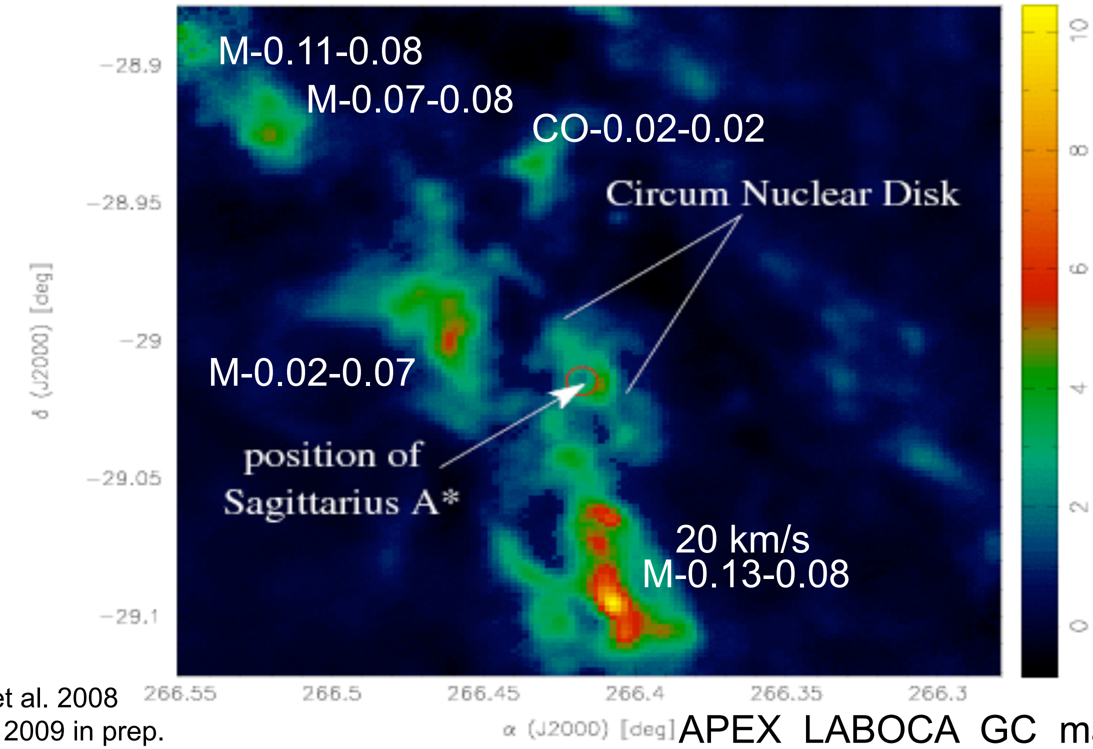
and fine structure lines from ionized species
[Ne II] 12.8 um, [Ne III] 15.55 um, [S IV] 10.51 um, [CII] 14.37 um
with ionization potentials between 20 and 40 eV
(e.g. Simpson et al. 2007 using Spitzer)

Arched shocked features and PDR regions will also show strong
6 and 8um PAH emission (Archers/Spitzer Cotera et al. 2006)

Spectroscopic probes



Eckart et al. 2008



Marin et al. 2009 in prep.

APEX LABOCA GC map

The foreground absorption by the 20 km/s and 50 km/s cloud may be a problem for the tracers of cold gas and ices.

Close to the position of SgrA* this may in part be calibrated for using the spectra of the high velocity B-stars (see Moultaka et al. 2004, 2005).

For lines that trace higher excited gas in emission this is probably not a problem (see Spitzer work on larger scales towards the arched filaments (Simpson et al. 2007))

MIRI observing the Galactic Center

Star Formation and Black Hole physics

- Central stellar cluster
  - IRS13N young disks stars candidates
  - low luminosity bow shocks
  - mini-cavity shock filaments
  - cluster of high velocity stars
  - SgrA*
  - IRS 29
- Archers cluster
  - young disk stars
  - arched interaction filaments
- Foreground ISM studies

MIRI JWST targeting the Galactic Center

The central pointing contains some of the most exciting sources at the Galactic Center !

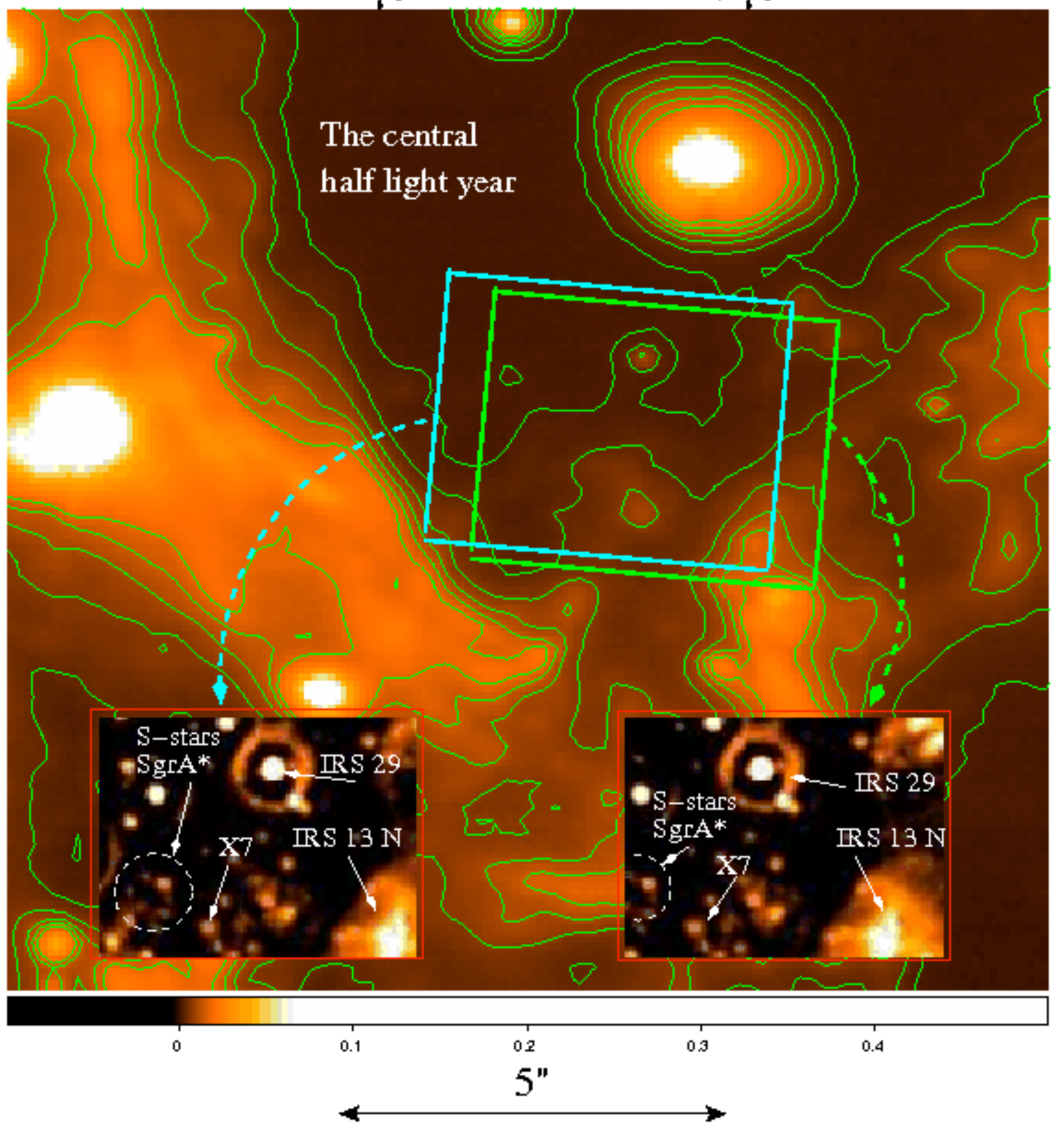
Both the
5.0 – 7.7 μm and the
7.7 – 11.9 μm IFUs
can be placed comfortably between the bright GC stars without violating the upper sensitivity limits of the array.

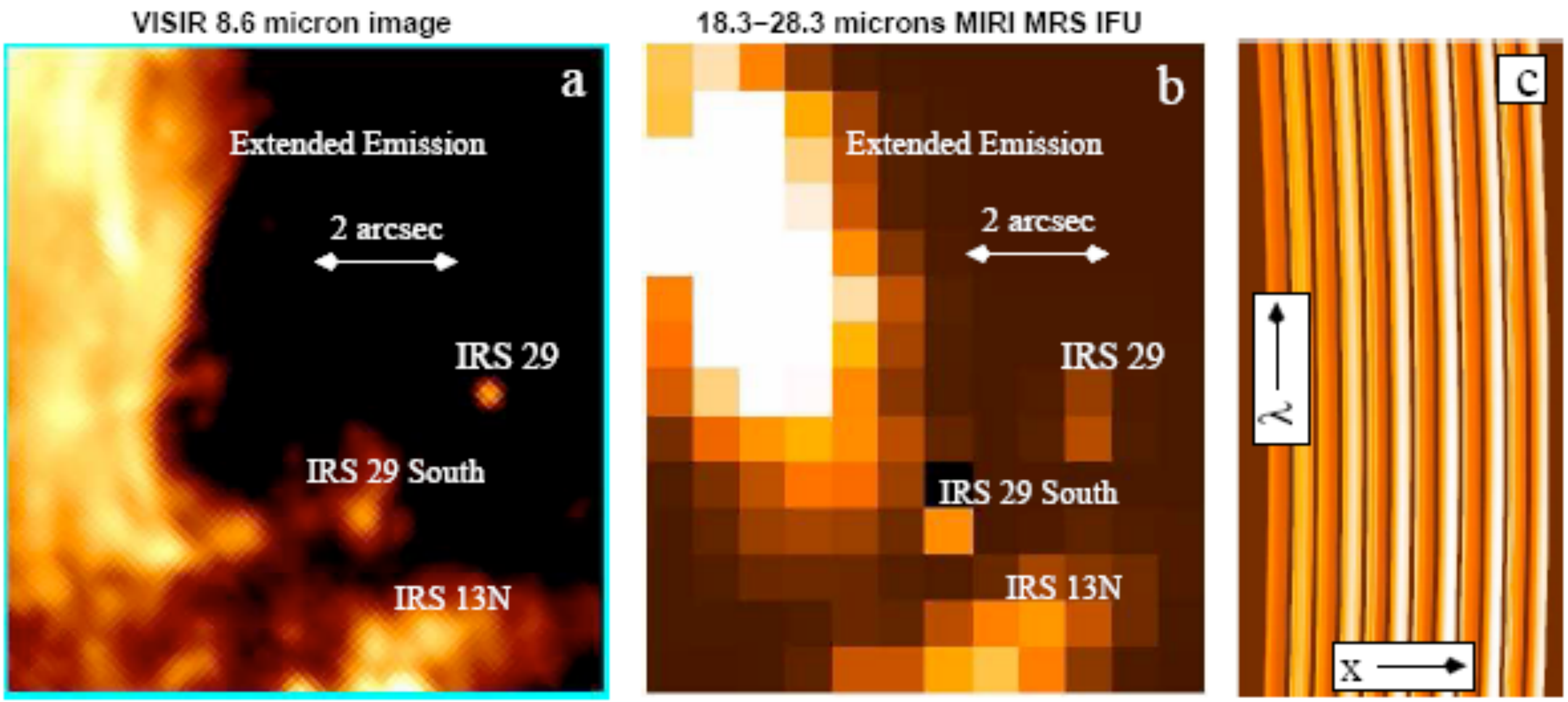
8.6 μm VISIR image
(Schödel, Eckart et al. 2007).
angular resolution 0.25”

Flux of IRS29 ~200 mJy

LIMIT 500 mJy
~0.1” pointing accuracy
targeting within 30”

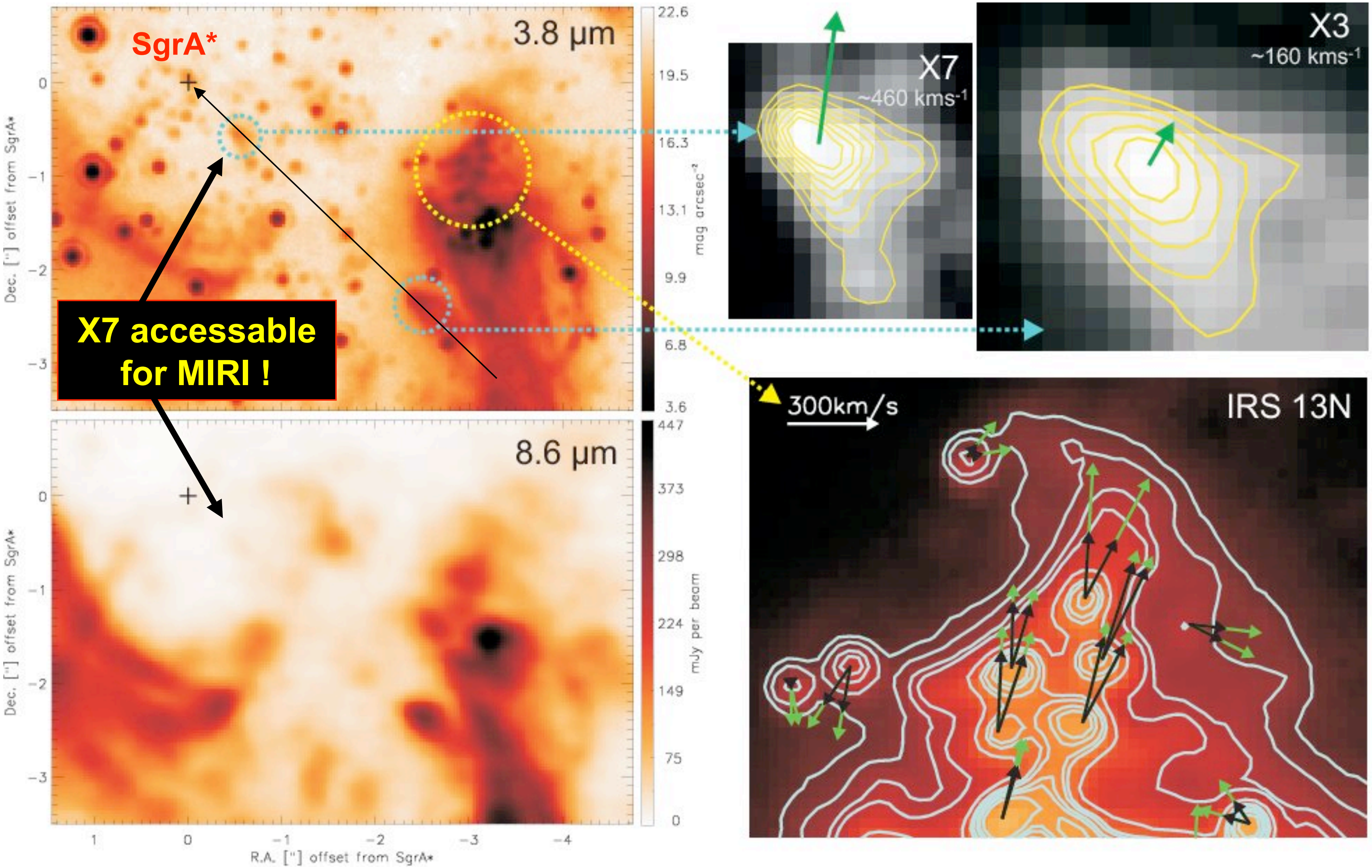
5.0–7.7 μm and 7.7–11.9 μm IFU



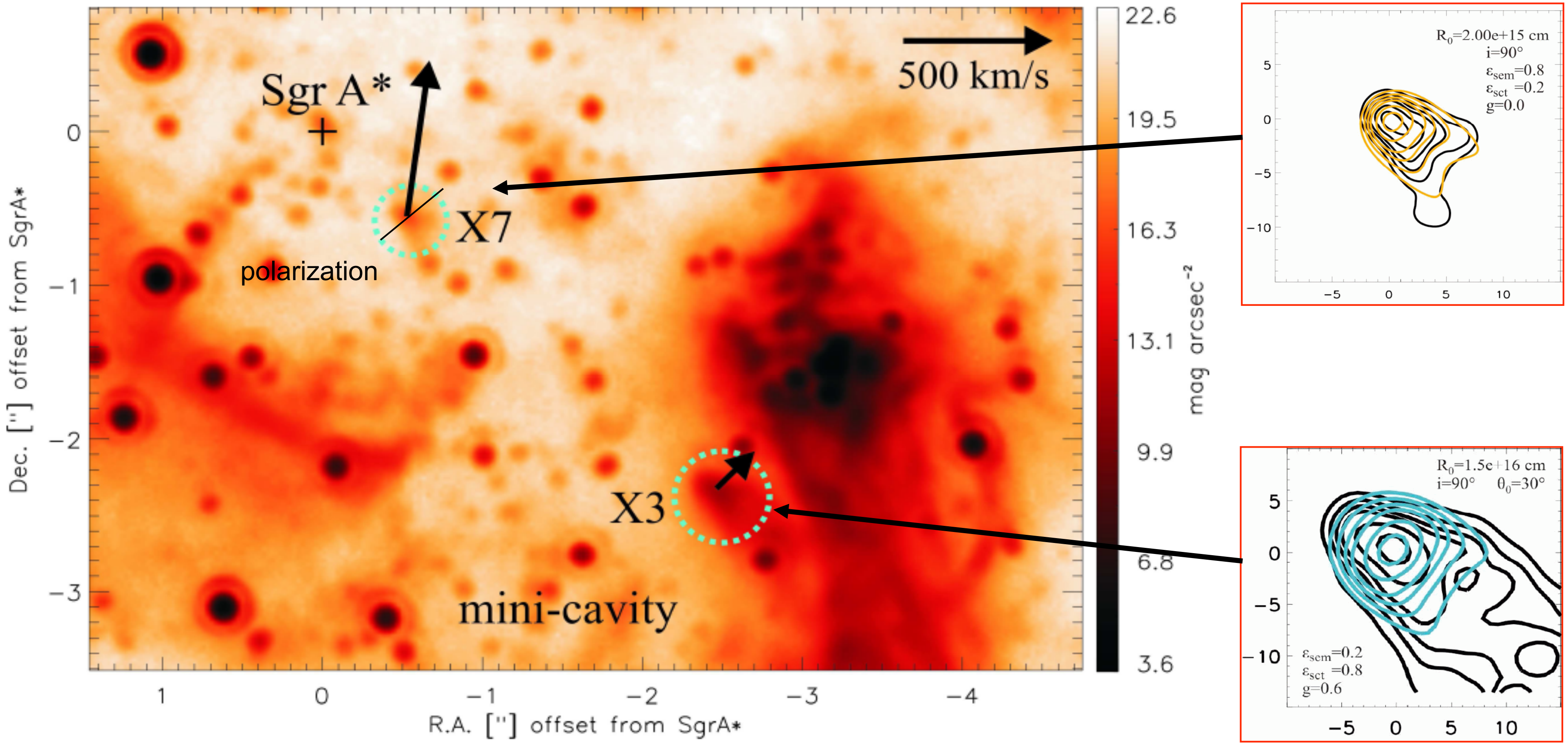


Pointing towards the central few arcseconds of the Milky Way:
a) image section at 8.6µm; b) modeled FOV through the 11.9-18.3 µm IFU;
c) dispersed detector signal of IFU;

Cometary source X7 can be covered by MIRI IFUs



Cometary Sources: Shaped by a Wind from SgrA*?

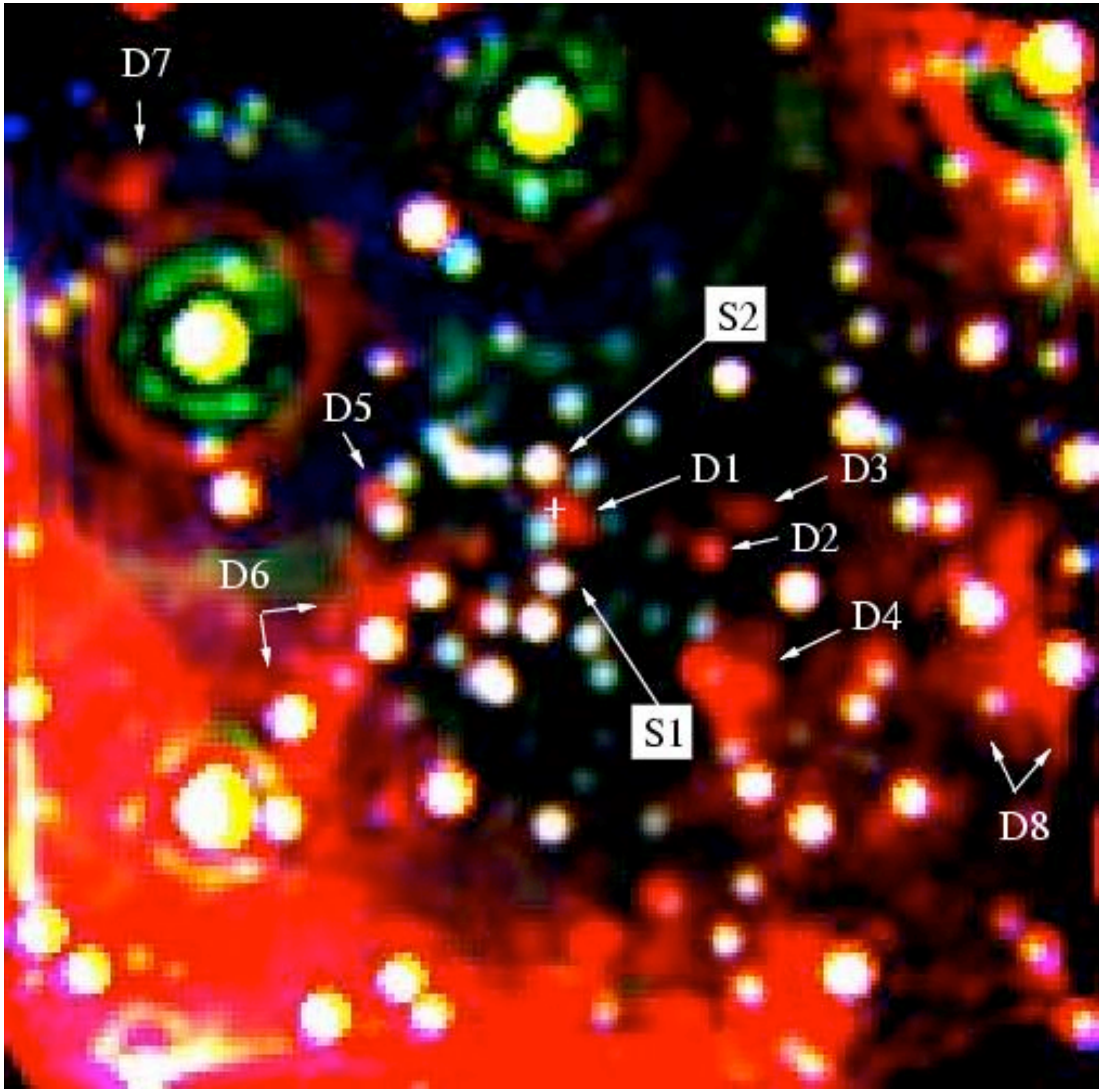


X7 polarized with 30% at PA -34+-10
Mie → bow-shock symmetry along PA 56+-10
includes direction towards SgrA*

Besides the Mini-Cavity – the comerary sources are the strongest indication for a fast wind from SgrA*!

Muzic, Eckart, Schödel et al. 2007, A&A, 469, 993 and 2009

Detection of a Dust Component along the Line of Sight towards SgrA*



HKL multi-color image of the central 5“x5“ taken with NACO. L-band is in red.

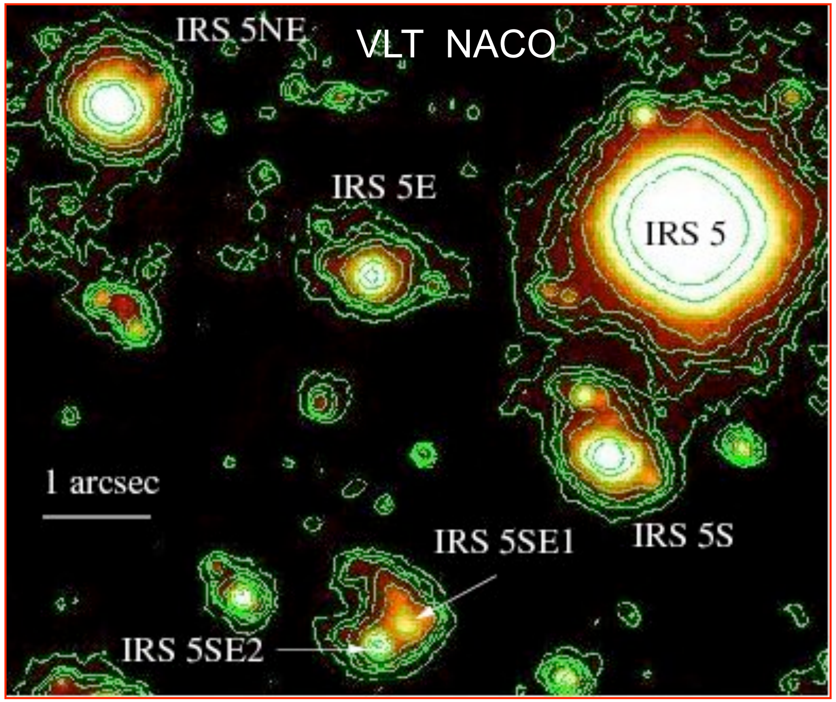
Fore-/Backgrond dust component 26mas west of SgrA*
~1000 AU at 8 kpc

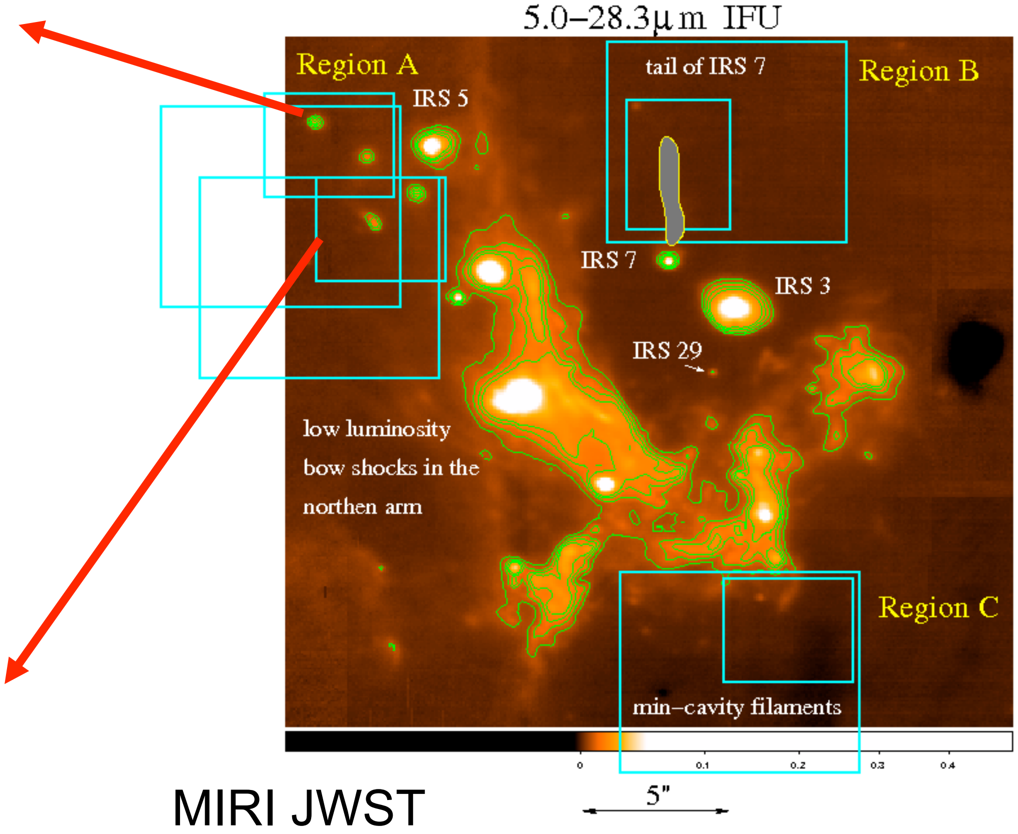
High angular resolution required in the MIR!!

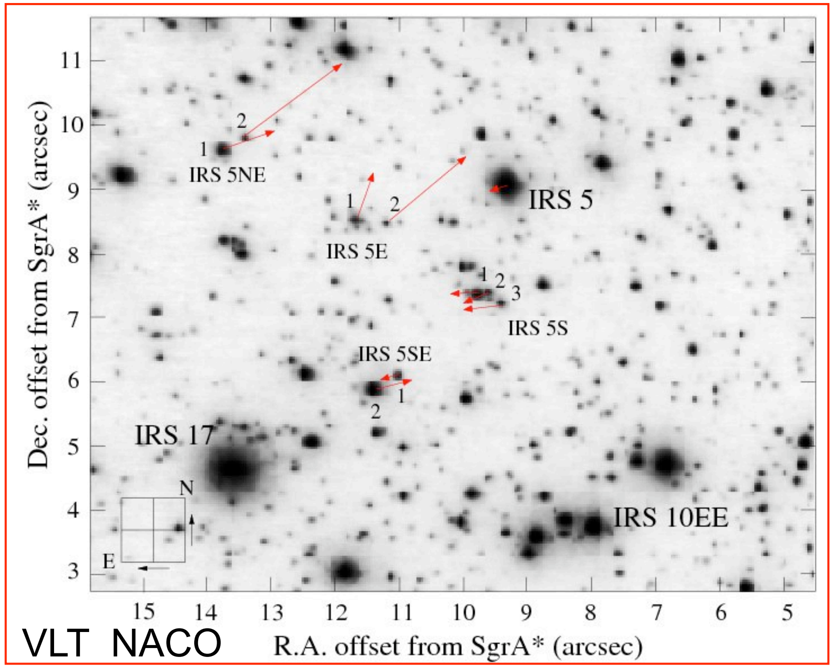
Several of those dust blobs are seen across the field

Eckart et al. 2005

Low Luminosity Bow Shock Sources East of IRS5 in the Northen Arm







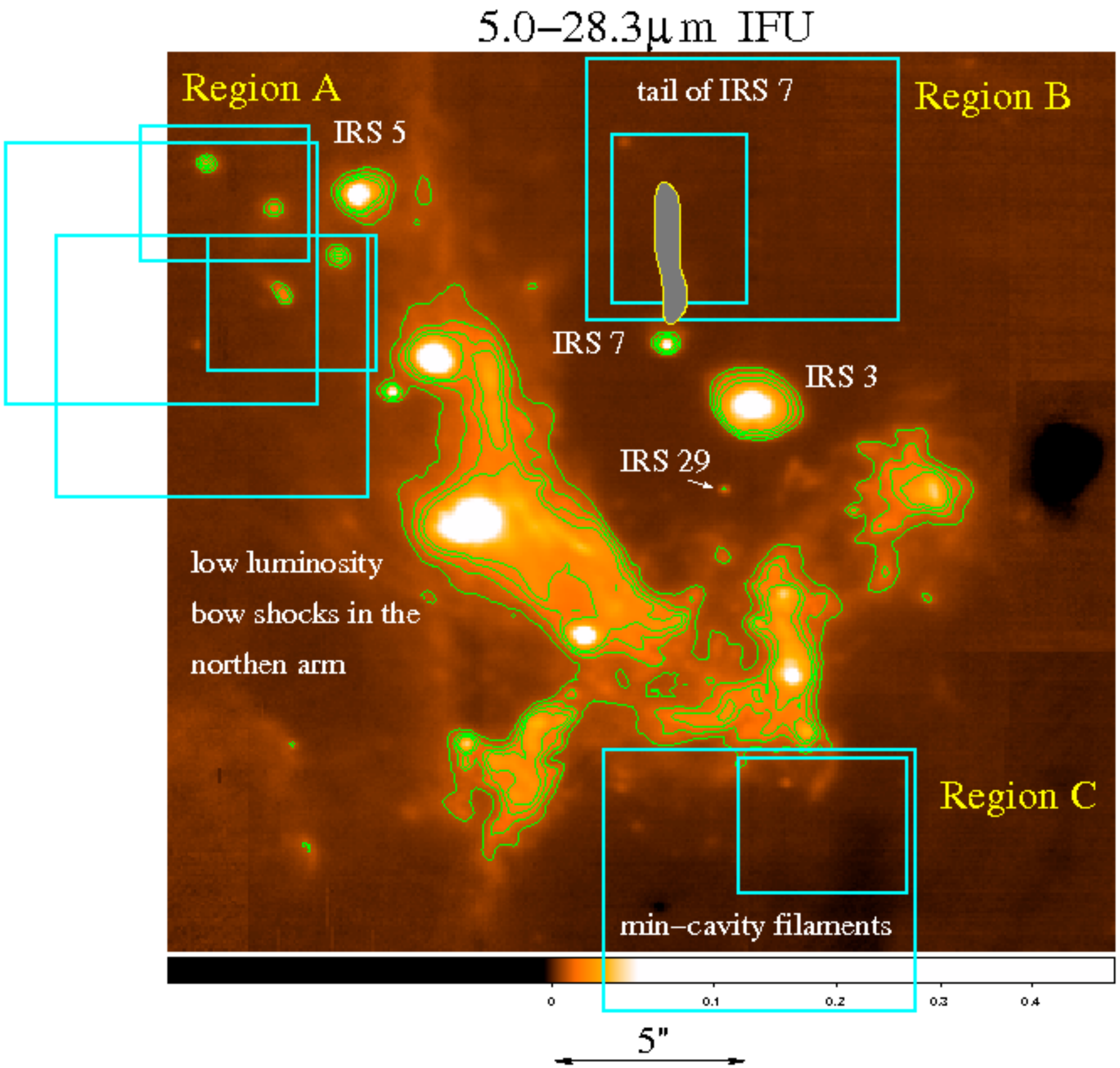
Compact MIR excess sources located in comoving small clusters as indicated by imaging and proper motion

MIRI JWST targeting the Galactic Center

Tracing stellar bow shocks and interaction with the wind from the central half light year

All 4 MIRI IFUs
5.0 – 7.7 μm
7.7 – 11.9 μm
11.9 – 18.3 μm
18.3 – 28.3 μm
can be placed comfortably next to the bright GC stars to target e.g. the

low luminosity bow shock sources west of IRS5 (region A)
or
the infrared emission of the IRS 7 tail (region B)
or
stellar/mini-cavity bow shock features (region C)



MIRI can trace 8 Myrs of star formation at the closest center of a galaxies!

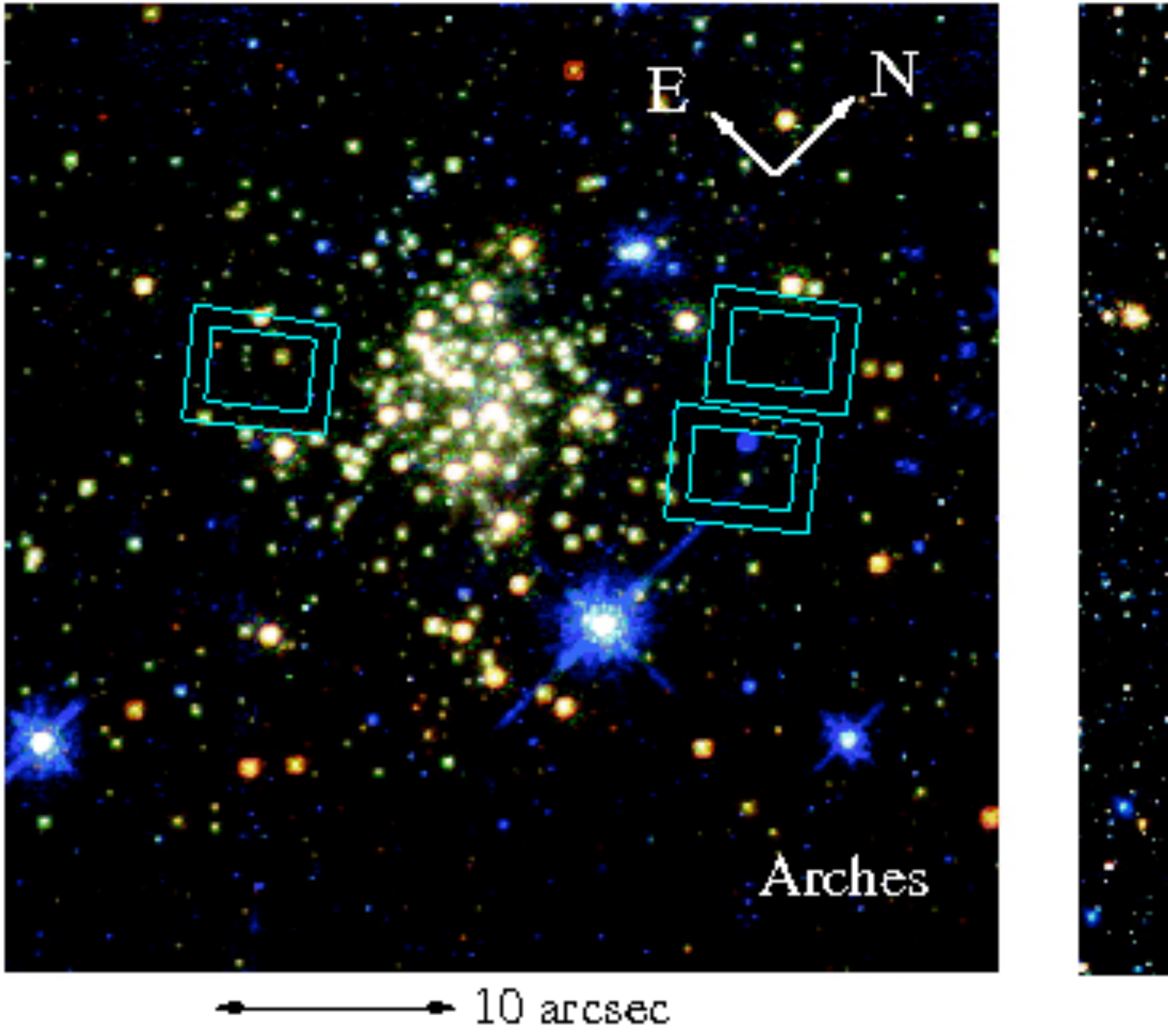
ARCHES cluster	2-3 Myr	at ~95 km/s
QUINTUPLET	4-5 Myr	at ~113 km/s
GC stellar cluster	6-8 Myr	at ~ 0 km/s

MIRI JWST targeting ARCHES stellar cluster

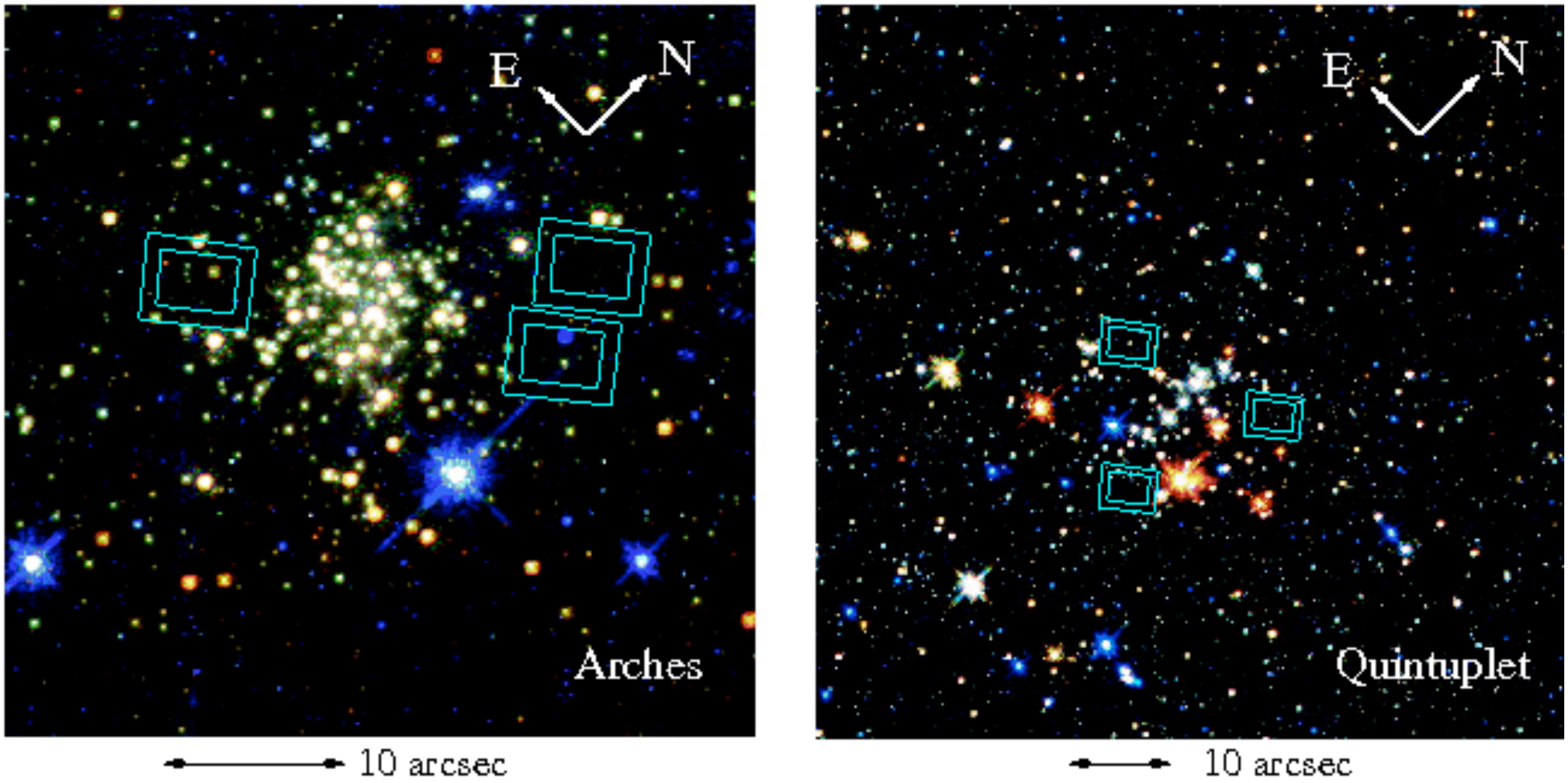
Tracing star formation at the Galactic Center: Stellar disks in the GC ARCHES cluster.

All 4 MIRI IFUs
5.0 – 7.7 μm
7.7 – 11.9 μm
11.9 – 18.3 μm
18.3 – 28.3 μm
can be placed comfortably next to the ARCHES cluster to obtain full spectra of faint stellar disks

m(L) = 12 – 14 mag
m(K) = 17 mag



MIRI JWST targeting the Arches and Quintuplet stellar cluster



Color composite of the Arches cluster and **Right:** of the Quintuplet cluster (Figer et al. 1999) containing 3 images obtained in the following filters: F205W (red), F160W (green), and F110W (blue). The blue rectangles indicate the simultaneous field of views for the 2 short and the 2 long wavelength IFUs. For the Arches cluster the pointings contain a number of disk candidates as they have been identified by Stolte et al. (2009) For the Quintuplet cluster we demonstrate that a similar positioning is possible without containing bright stars. In each case we show 3 selected IFUs placed with a position angle of -5° as given by the instrument mounting. The alternative (half a year later) or role angle variations of ±5° will allow a comfortable positioning of the IFU as well.

Uniqueness – Integration Times

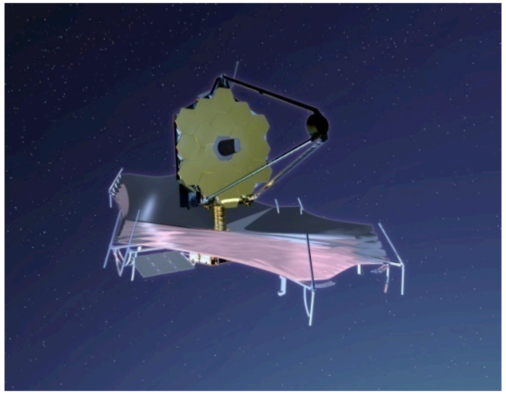
For the SgrA* pointing a stabile and sensitive unique imaging through the IFUs will allow to clearly separate the thermal dust from the non-thermal SgrA* spectrum and will lead to a MIR detection of SgrA*

- use of full spectral range
- high PSF stability
- and high relative and absolute calibration stability

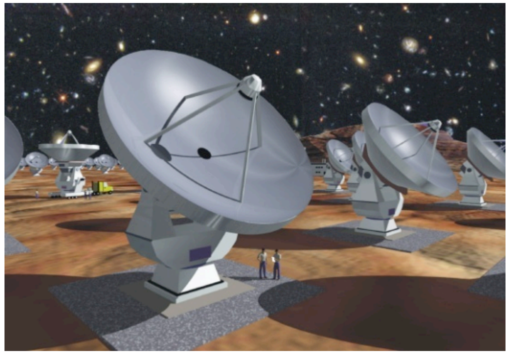
Integration times in general should be short.Several (of order) 10 minutes per IFU per pointing.Possibly repeated (multi epoch) pointings on the SgrA* position.

Combination with complementary and/or follow-up NIRspec observations possible

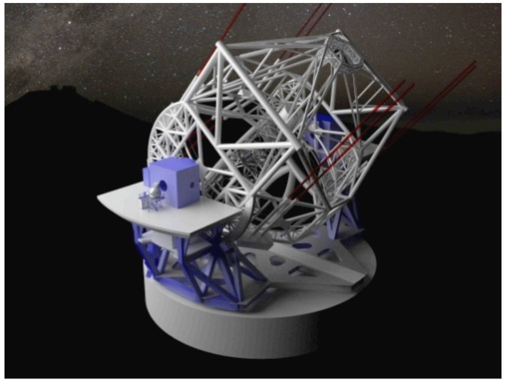
JWST Synergy with ALMA & E-ELT METIS



- JWST with respect to METIS:
  - broad wavelength coverage – no atmosphere
  - higher sensitivity to extended sources
  - high PSF stability

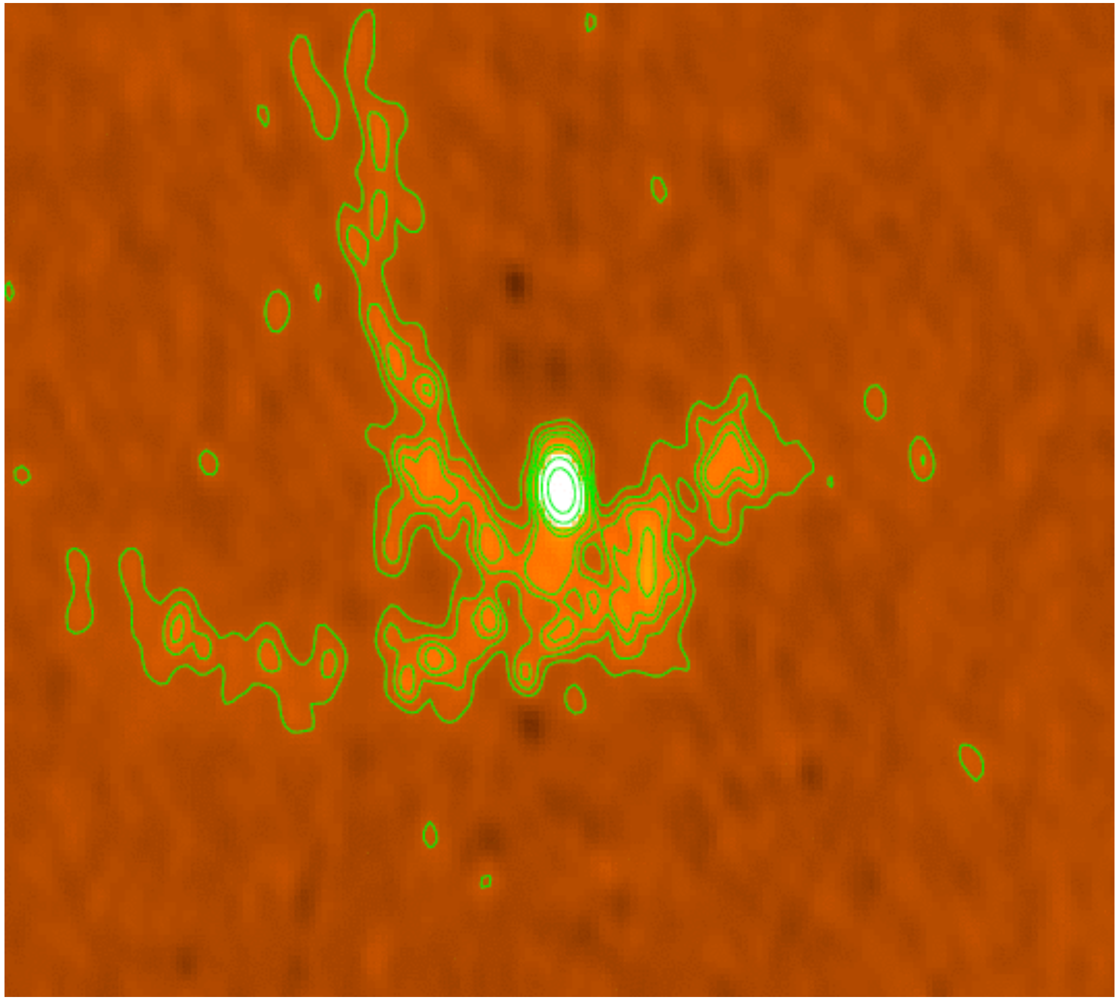


- ALMA with respect to METIS/MIRI
  - complementary **temperature** zones
  - complementary **molecular species**



- METIS with respect to JWST:
  - lower point source sensitivity, but...
  - 6.5 times higher **angular resolution**
  - unique **high spectral resolution**
  - unique **polarimetric** measurements

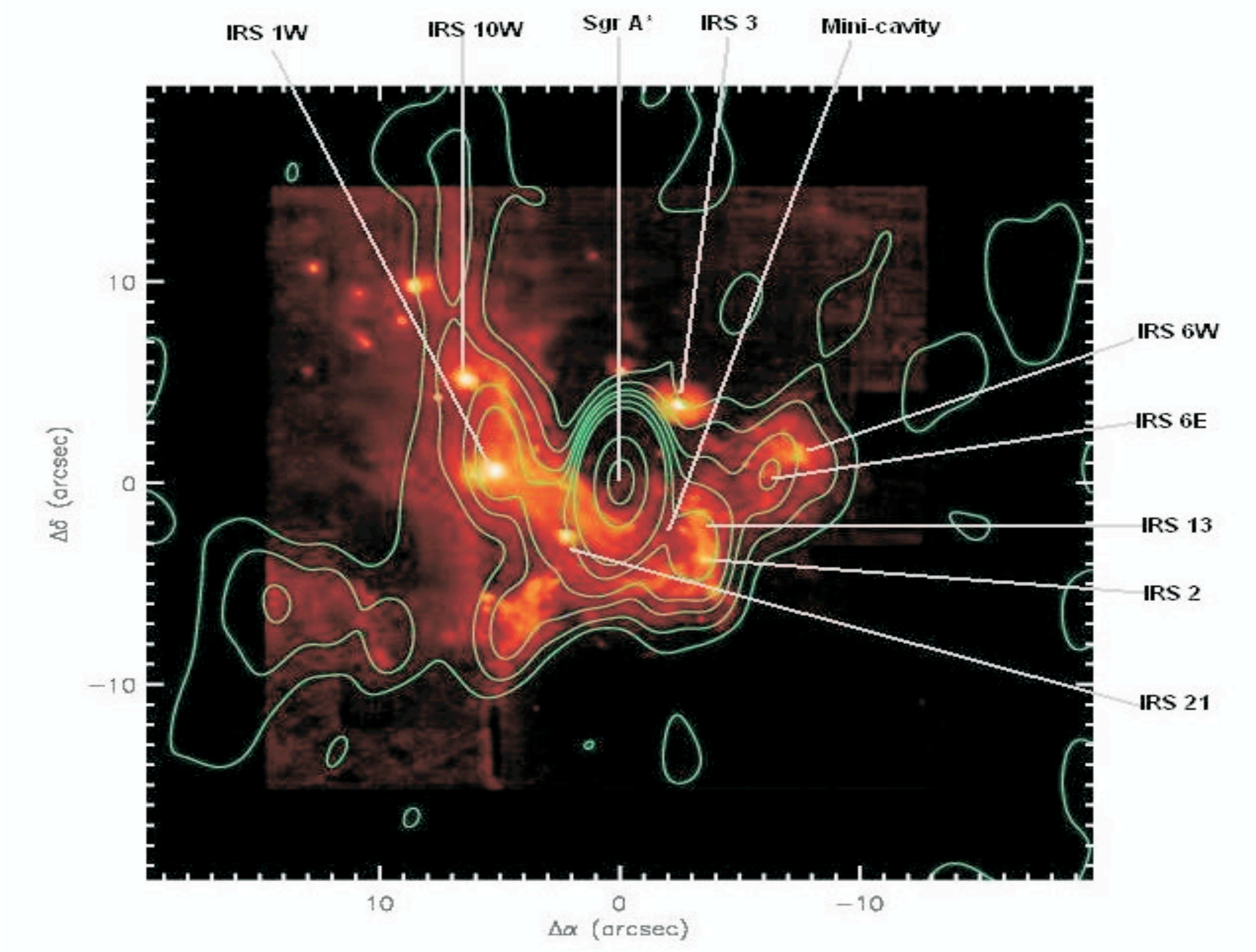
CARMA mm-continuum and VLT NIR/MIR images of the mini-spiral



Kunneriath et al. 2010 in prep.

CARMA BCD 230 GHz

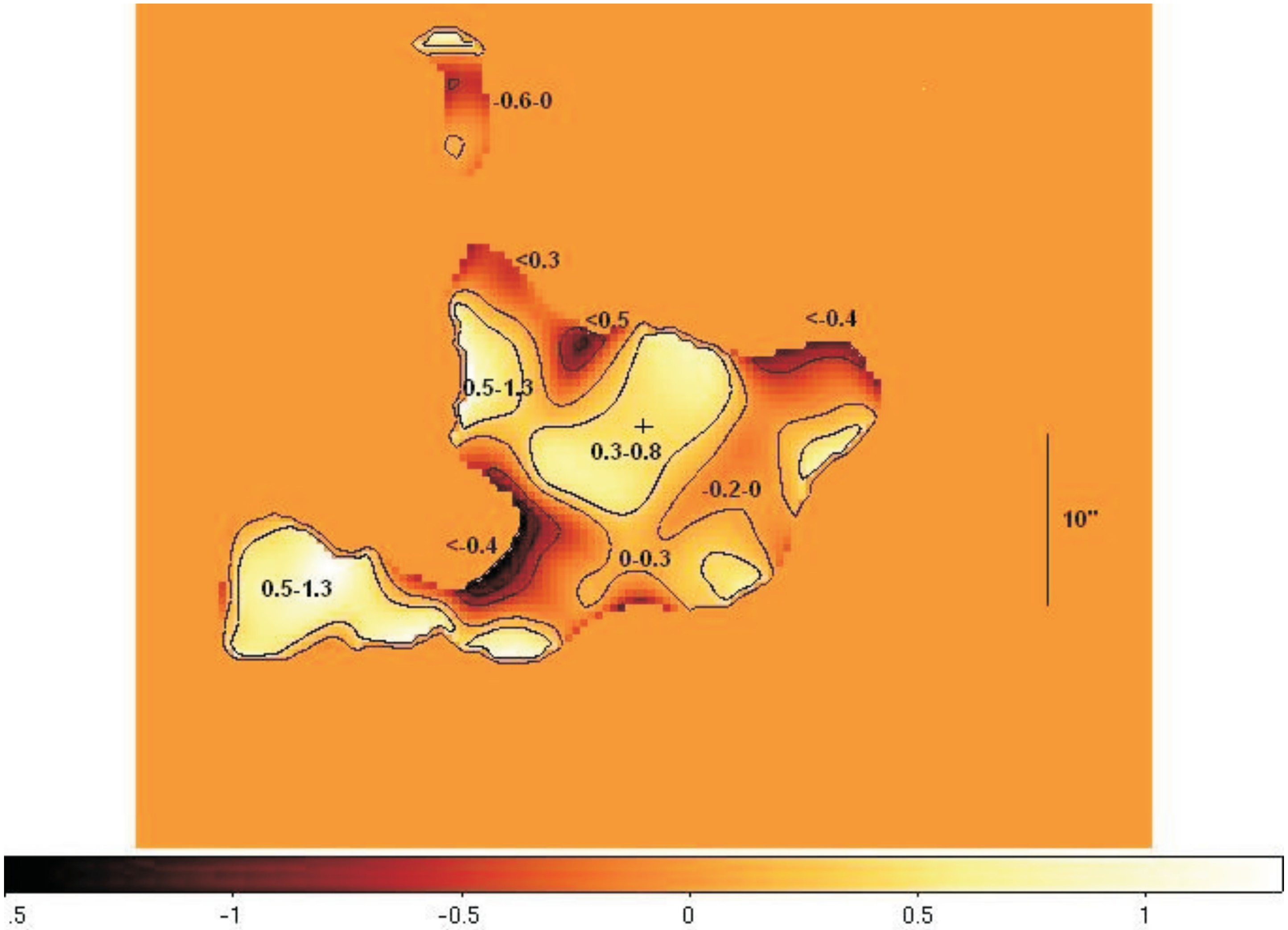
CARMA mm-continuum and VLT NIR/MIR images of the mini-spiral



Kunneriath et al. 2010 in prep.

CARMA 100 GHz

CARMA 1 and 3 mm-continuum spectral index of the mini-spiral



Kunneriath et al. 2010 in prep.

The Galactic Center observed with JWST/MIRI

Unique opportunity for MIRI:

Full spectral coverage of
- stellar disks candidates – 8 Myrs of star formation
- cometary shaped bow-shock sources
- filaments
- MIR SgrA* detection

The project requires and can only be done with MIRI on board the JWST at the given sensitivity, stability, and wavelength coverage combined with unique IFU multiplexing advantage