Resolved Starburst Clusters Near & Far

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E-ELT Science

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Resolved Starburst Clusters Near & Far

1. Outstanding questions of the Milky Way YC sample

2. Three science cases for wide-field imaging

3. Outlook for EELT instruments

The Milky Way Starburst Cluster Zoo

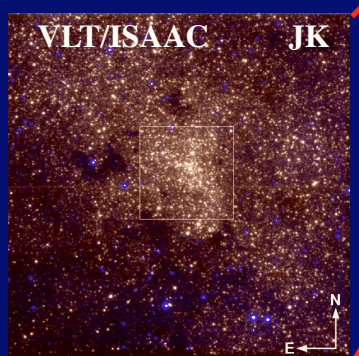
Galactic center

27”

GC Arches
Stolte et al. 2005

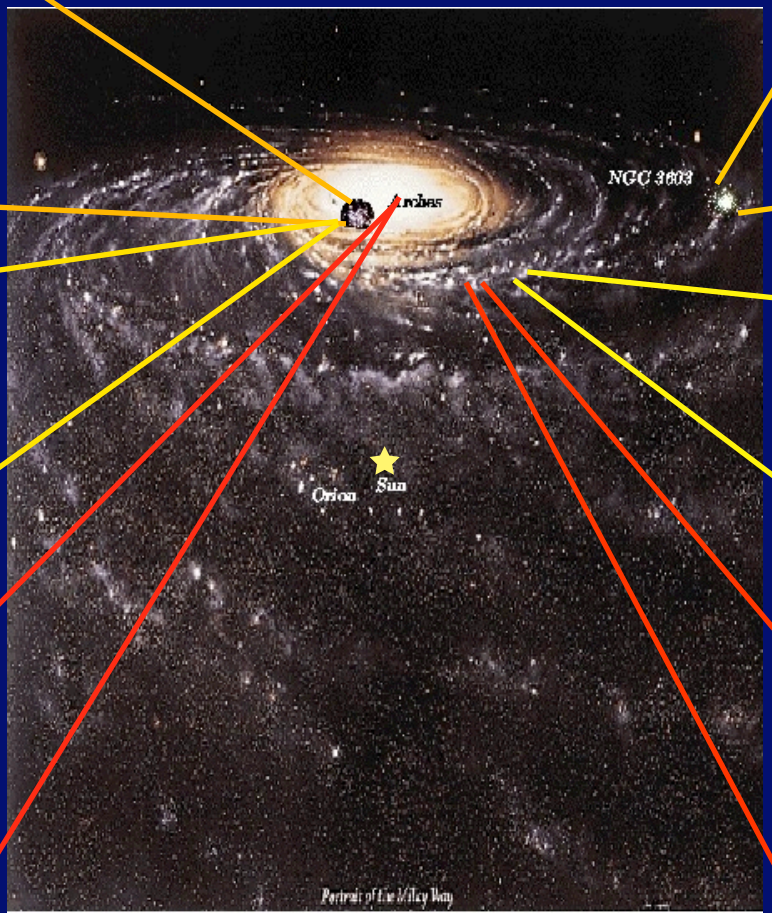
27”

GC Quintuplet
Stolte et al., in prep



2.5’

Nuclear cluster
Schoedel et al. 2007



Portrait of the Milky Way *Jon Lomberg*

Spiral arms

3’

NGC 3603 YC
Stolte et al. 2004

4’

Westerlund 1
Brandner et al. 2008

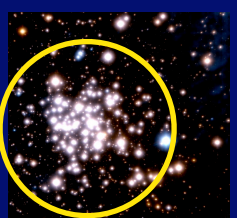
3.6’

Westerlund 2
Ascenso et al. 2007

Outstanding questions in the Milky Way starburst sample

Quintuplet

high-mass stars



Arches

PDMF estimate
(r = 0.4 pc)

1. Small-angle AO covers tiny fields

=> Laborious to cover entire clusters

=> only compact cores: no complete IMF

2. 3 + 3 = low-number statistics

=> young clusters e.g. in M31, M83

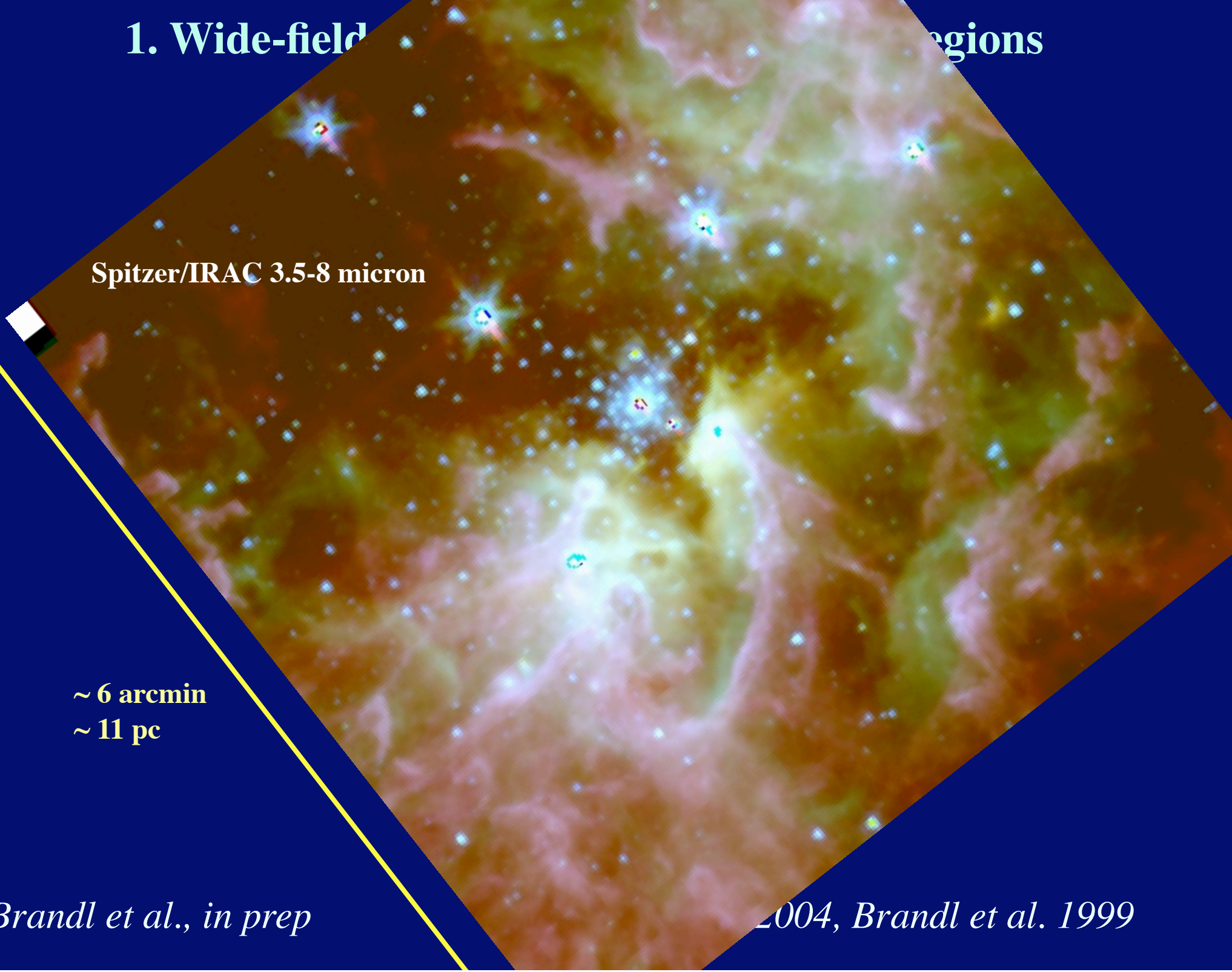
=> tidal arm clusters in M51, Antennae

Requirements:

1. high-resolution AO @ 10 mas
2. wide-angle imaging & IFUs

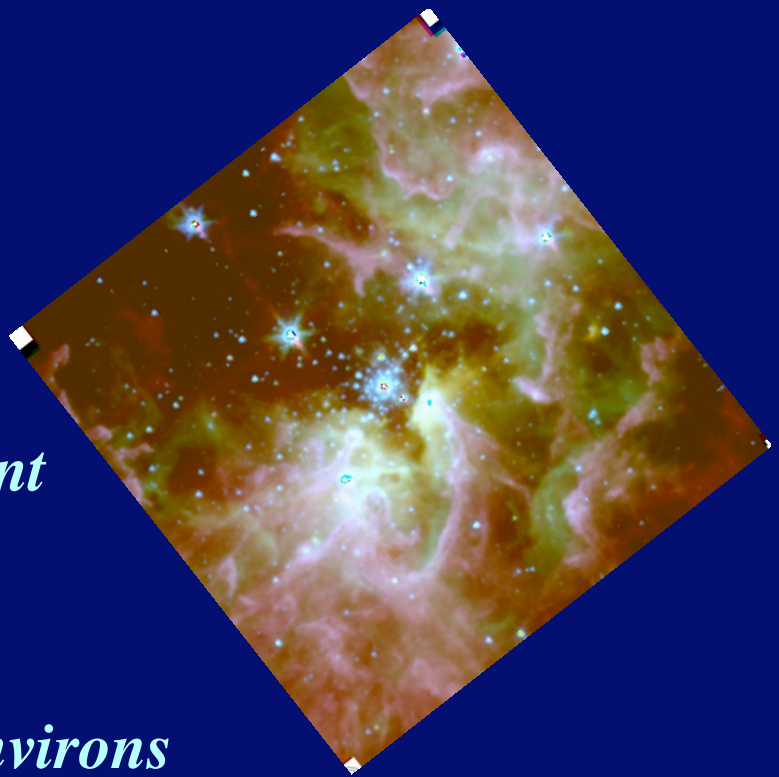
Dream: Wide-field ≥ 30", ≤ K-band diffraction limited camera

1. Wide-field egions



Brandl et al., in prep *2004, Brandl et al. 1999*

1. Wide-field imaging to cover giant HII regions



Cluster extent 1-4 pc

HII region > 10 pc

=> complete IMF

is the mode of star formation different in the densest cluster cores?

=> spatial variation in disk fraction

influence of massive star-forming environs on the survival of disks & planet formation?

=> feedback starburst cluster -> environment

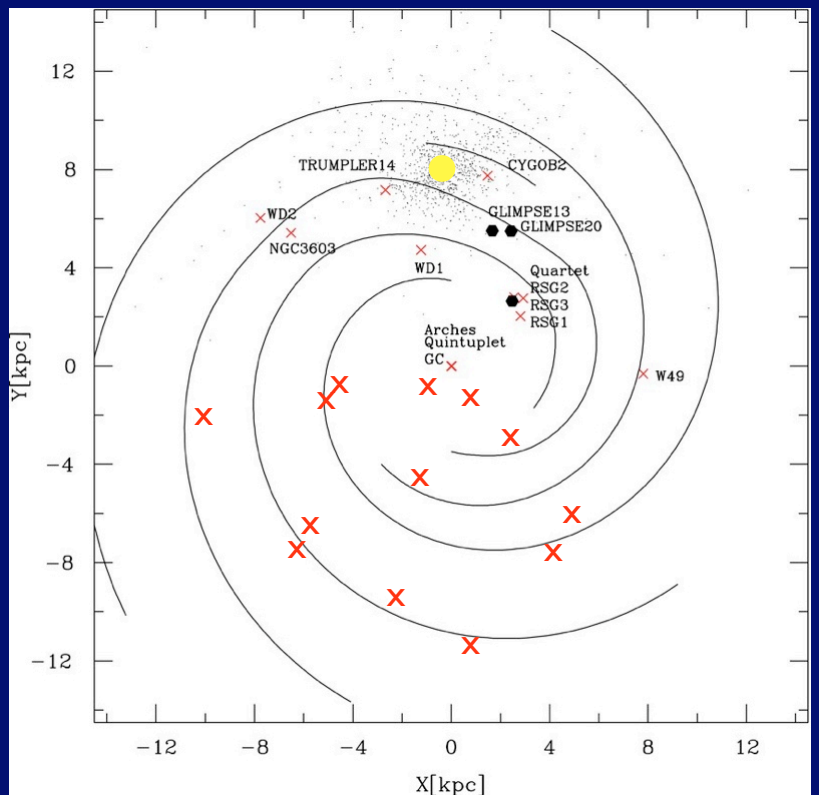
=> Wide-field diffraction limited imaging of massive, Galactic star-forming regions

2. Increasing the Galaxy sampe: the far side...

Galactic sample

uncover starburst clusters of the "far side"

Symmetry suggests a dozen young, massive clusters on the far side...



Messineo et al. 2009

(optical: *Dias et al. 2002*)

Limitations:

1. Extinction AV > 30

2. Extinction AV > 50

3. Resolution

< 0.02 pc @ 16 kpc

< 0.25"

4. Sensitivity

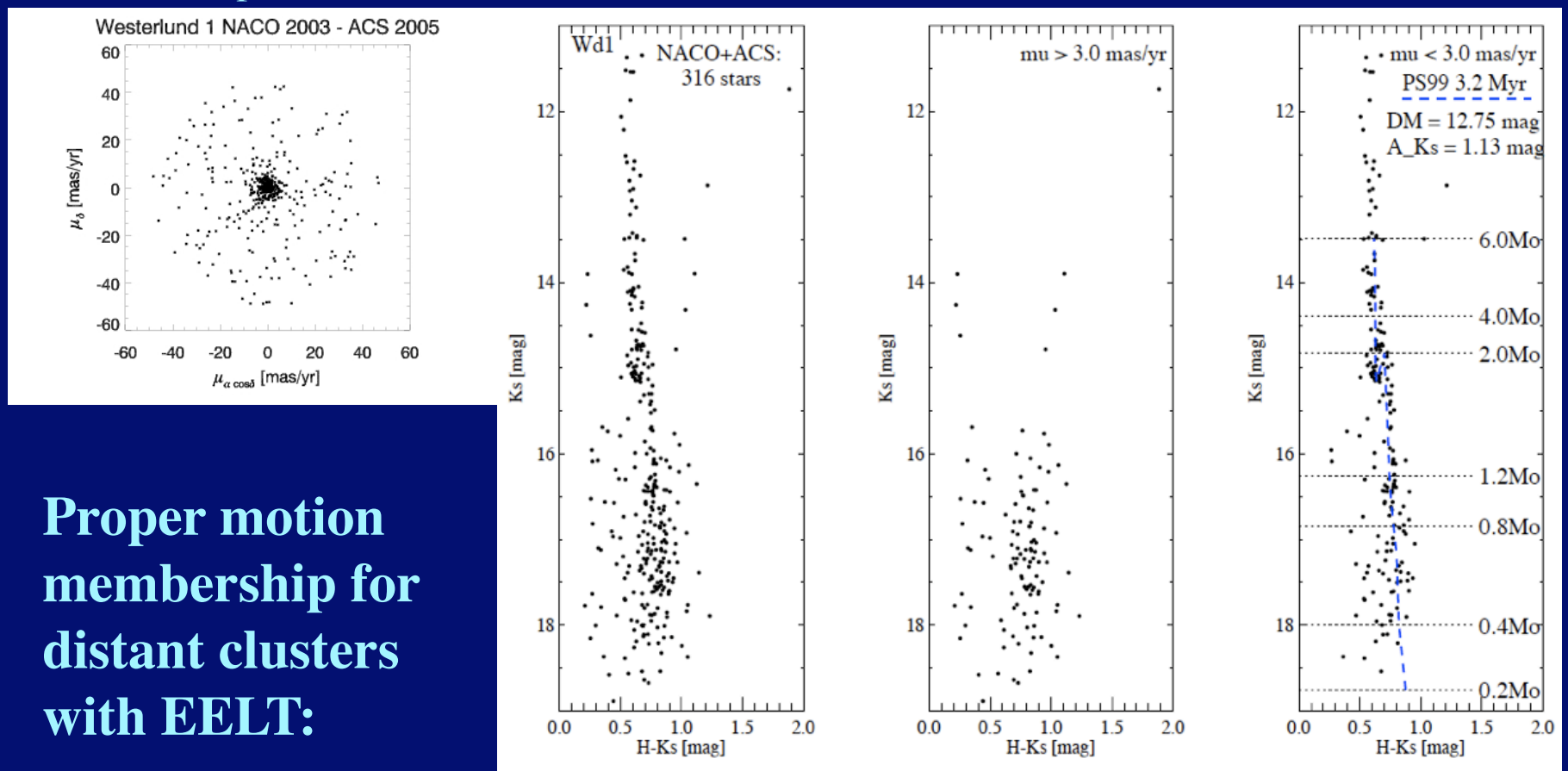
BUT: proper motion membership & velocity dispersion requires
- velocity resolution < 5 km/s (for 10^4 Msun cluster)
- astrometric precision < 0.2 mas/yr @ 16 kpc

2. Increasing the Galaxy sampe: the far side...

VLT-AO: Proper motion membership in starburst clusters out to 8 kpc

Astrometric precision < 1 mas

Pre-main sequence evolution at ages < few Myr



Proper motion membership for distant clusters with EELT:

- astrometric precision **< 0.2 mas**
- proper motion out to **40 kpc distance**

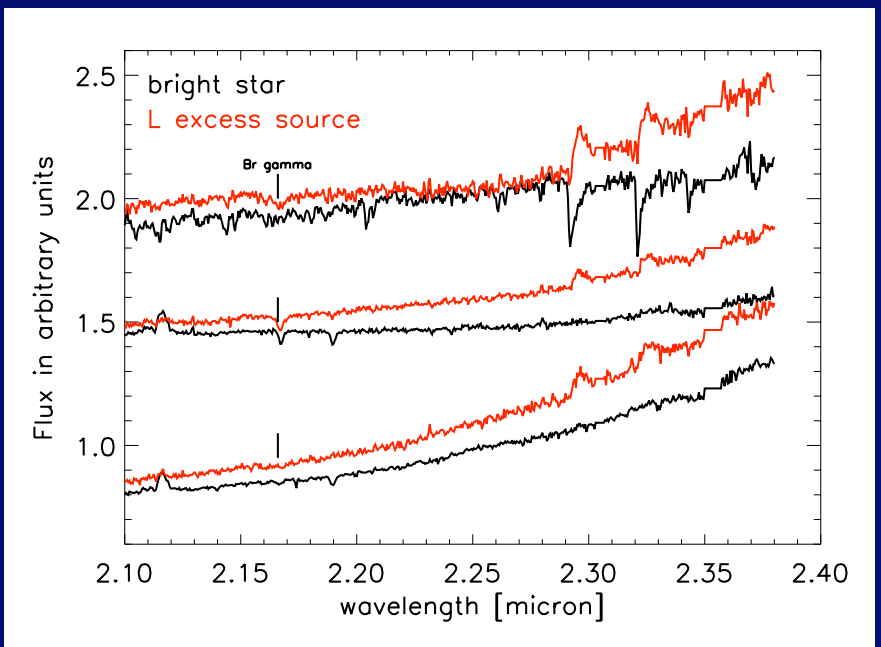
=> feasible for entire disk population!!!

Brandner et al. 2008

3. Disk survival in starburst environments

CO emission sources in the Arches cluster

- protoplanetary disks or not ???



Stolte et al. 2009

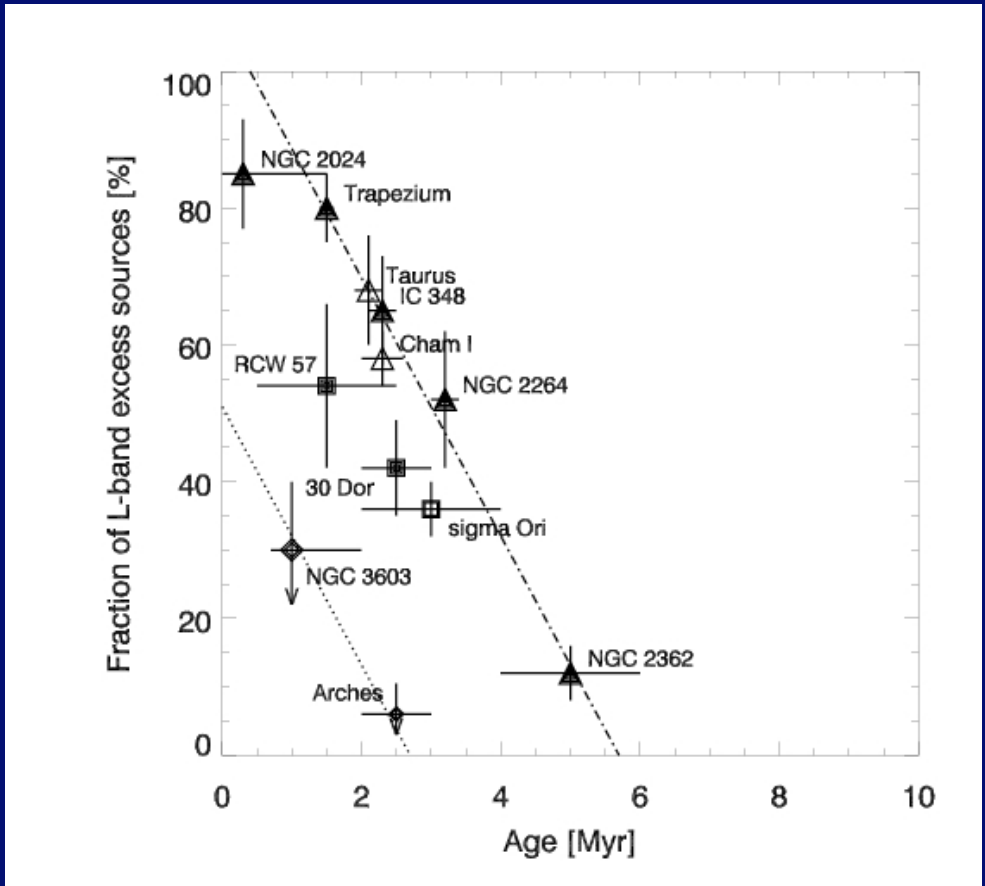
Requirements: wide 1'-2' field for realistic disk fractions

Resolving disks: spatial resolution << 60 mas (400-500AU)

EELT METIS high-sensitivity mid-IR photometry for SEDs

=> ***temperatures, dust mass, evolutionary state***

3. Disk survival in starburst environments



Stolte et al. 2009

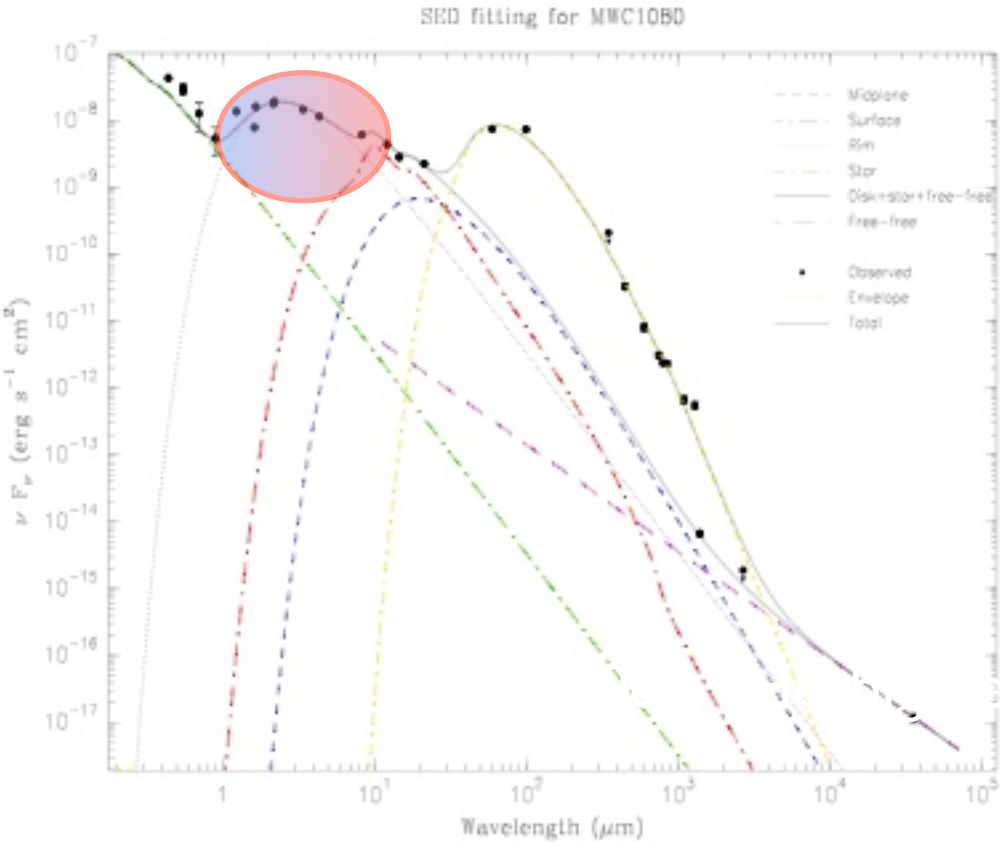
Starburst cluster environments alter the disk survival timescale

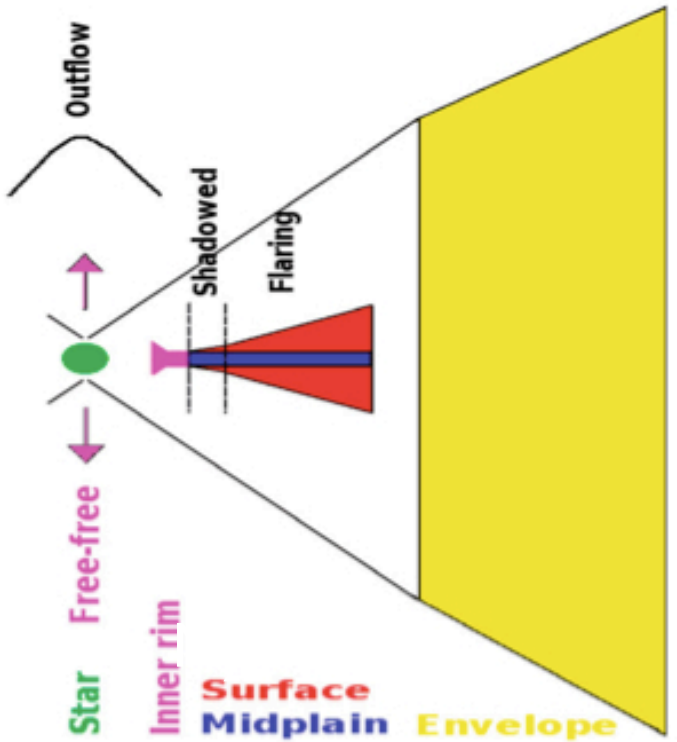
Resolving disks with E-ELT provide size scales, truncation radius, ...

=> disk structure & mass estimates

Do these disks survive long enough to form planets???

3. Disk survival in starburst environments





MWC1080 Herbig Be 10 Msun < 1 Myr *Alonso-Albi et al. 2009*

Inner disk rim & disk surface layer probed by METIS

E-ELT wide-field imaging of starburst clusters

- **Initial stellar mass function -- extended molecular clouds**
  - **cover full cluster extend**
  - **IMF in clusters vs. giant HII regions**
- **Young, massive clusters on the far side - towards a complete sample**
  - **increase number and age statistics**
  - **proper motion membership in ALL clusters**
- **Disk survival in starburst clusters**
  - **how does the starburst cluster environment affect disks ?**
  - **L=15 to L=22.9: from B-stars to 0.5 Msun star disks**
  - **earliest stages of planet formation in massive star clusters**

Milky Way wide-field ELT -AO:

discover the "hidden" cluster population

each cluster area can be completely covered

Nearby galaxies wide-field ELT -AO:

resolve very massive, extended clusters

cluster survival & formation of globular clusters