Disk survival in starburst clusters - combining JWST sensitivity with E-ELT resolution

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E-ELT & JWST Science

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ESO Garching

Disk survival in starburst clusters - combining JWST sensitivity with E-ELT resolution

1. **Disc detections in starburst clusters**
2. **PAH & silicate features as tracers for disc evolution**
3. **JWST & EELT joined perspectives**

Motivation - the paradigm of massive star formation

Massive stars are numerous in starburst clusters

- large samples of early B0-B3 type stars
- detection of discs at various stages of evolution
- disc evolution in UV-rich environments
- differences in grain processing

=> effects on planet formation in dense clusters

No Discs in Massive Clusters?

Massive stars are numerous in starburst clusters, but...

- UV radiation evaporates discs (see Orion)
- both central early B star and environment destructive
- survival timescales for massive star discs < 1 Myr

=> NO discs expected at 2-3 Myr ...

The Arches starburst cluster near the Galactic center

17’

8’

Arches

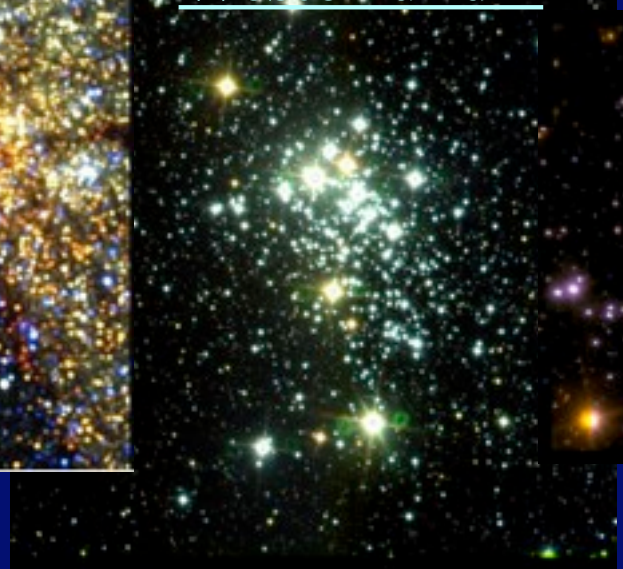
2.5 +- 0.5 Myr

10,000 Msun

projected 30 pc

NGC 3603

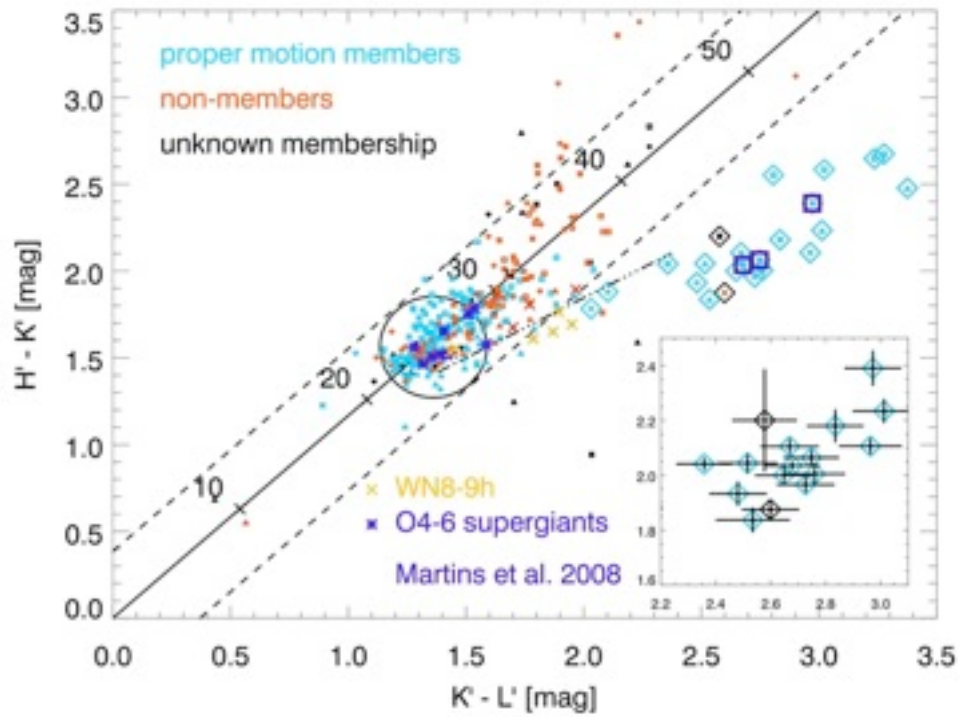
Westerlund 1

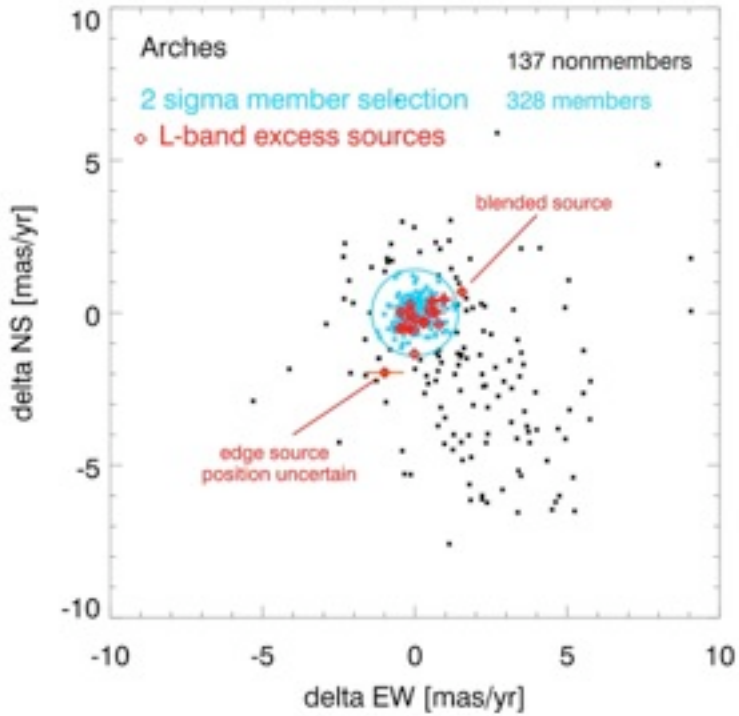


Quintuplet

No Discs in Massive Clusters???

L-band excess sources in the Arches cluster





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

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

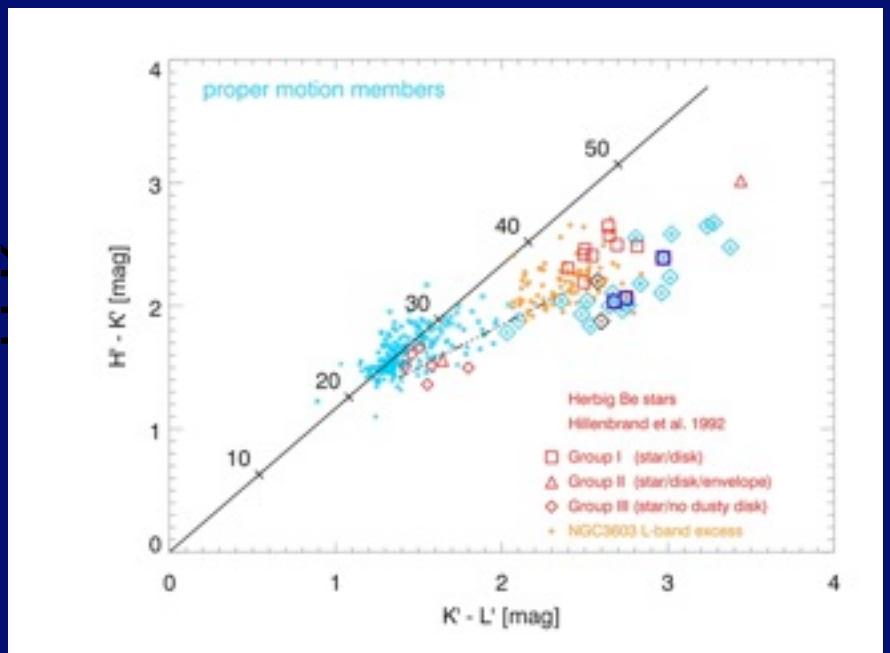
EELT METIS high-sensitivity mid-IR photometry for SEDs

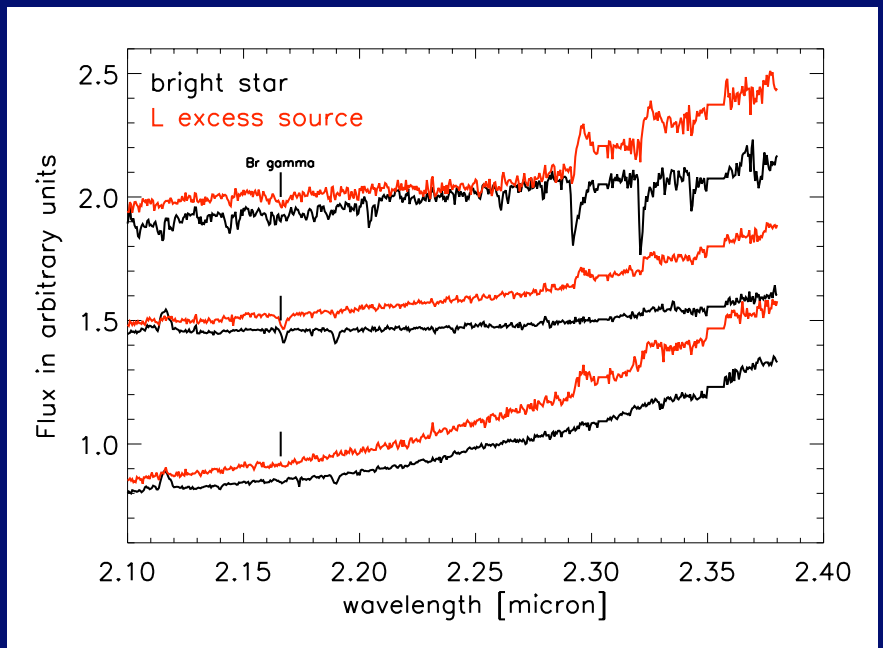
=> temperatures, dust mass, evolutionary state

Disk survival in starburst environments

L-band excess sources in the Arches cluster & NGC 3603

- protoplanetary disks or not ???





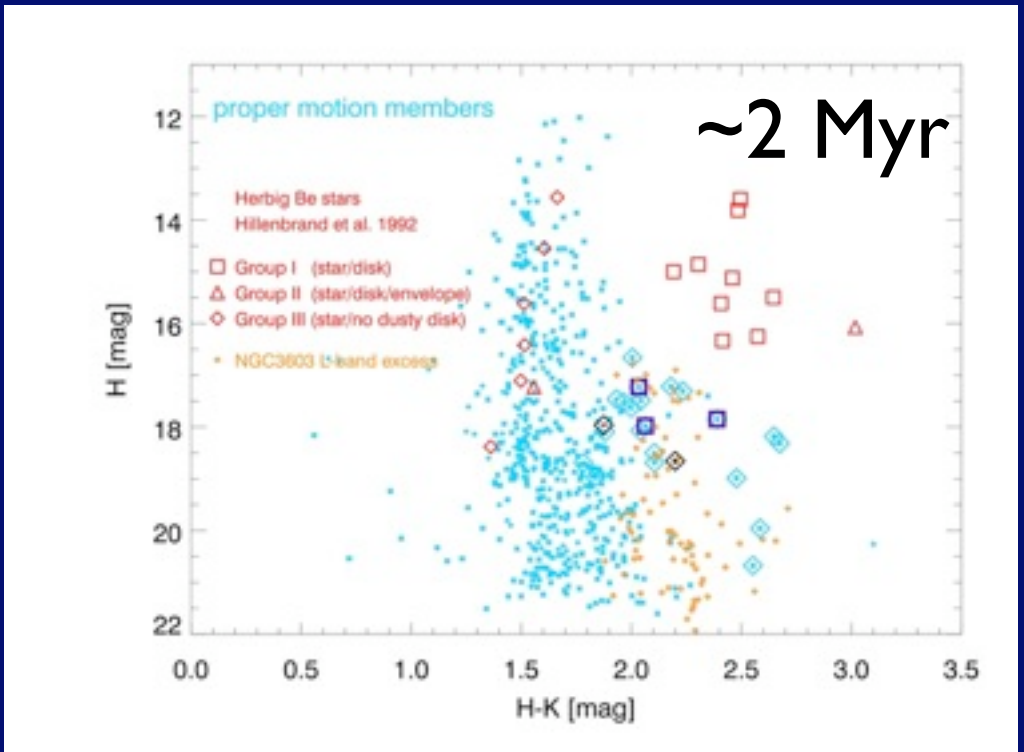
Stolte et al. 2010

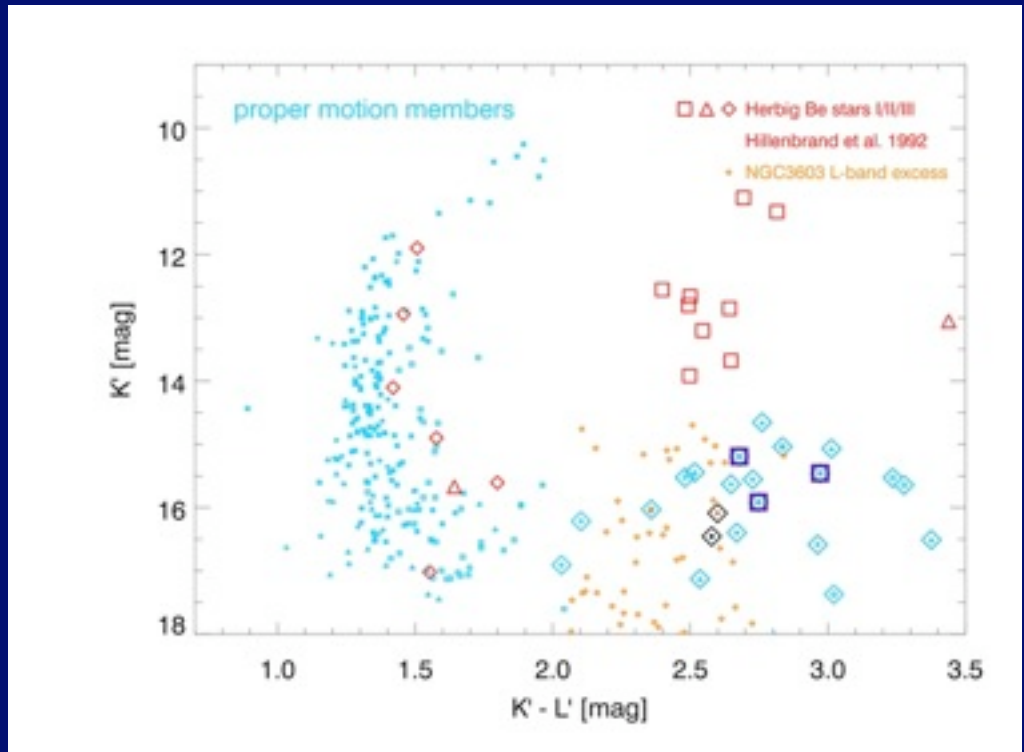
Hillenbrand et al. 1992
Herbig Be stars
at Arches distance & extinction

Stolte et al. 2004
NGC 3603 L-band excess sources

Disk survival in starburst environments

L-band excess sources in the Arches cluster & NGC 3603

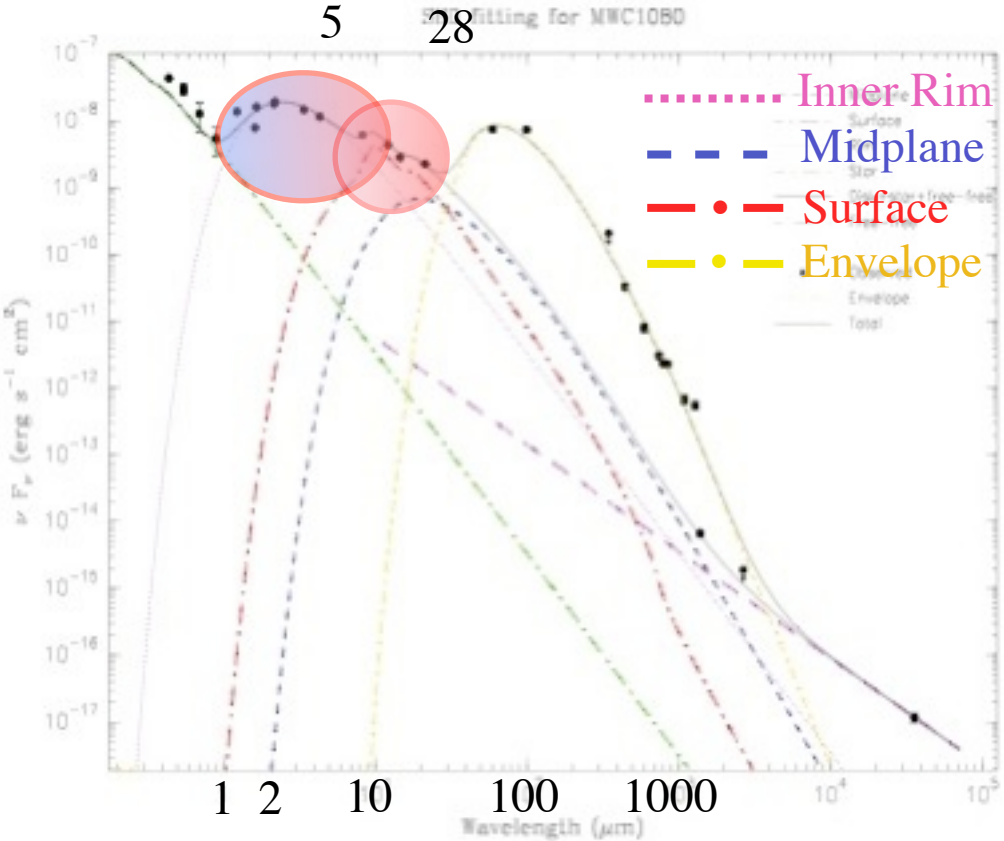


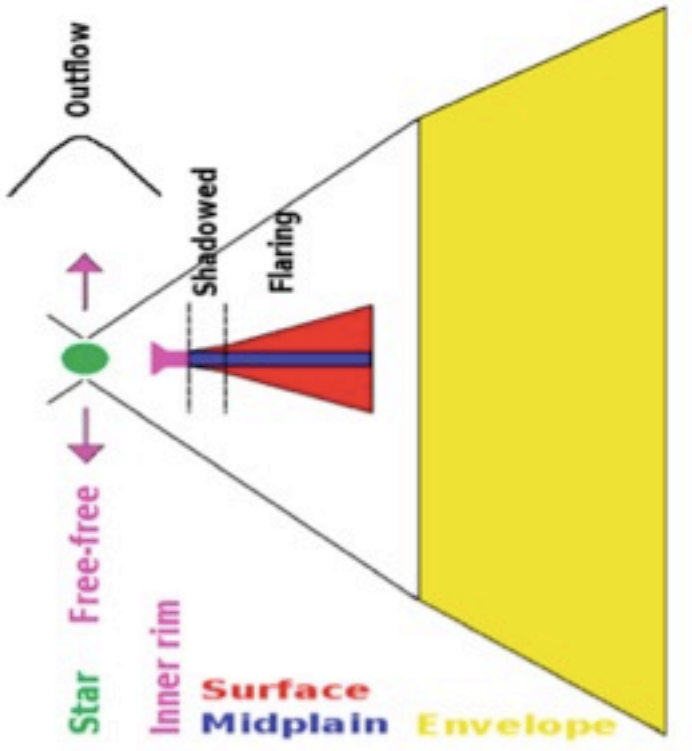


Stolte et al. 2010

Note of caution: ***Use longer wavelengths if you can!!!***

Covering the disc SED with HARMONI, METIS & MIRI





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

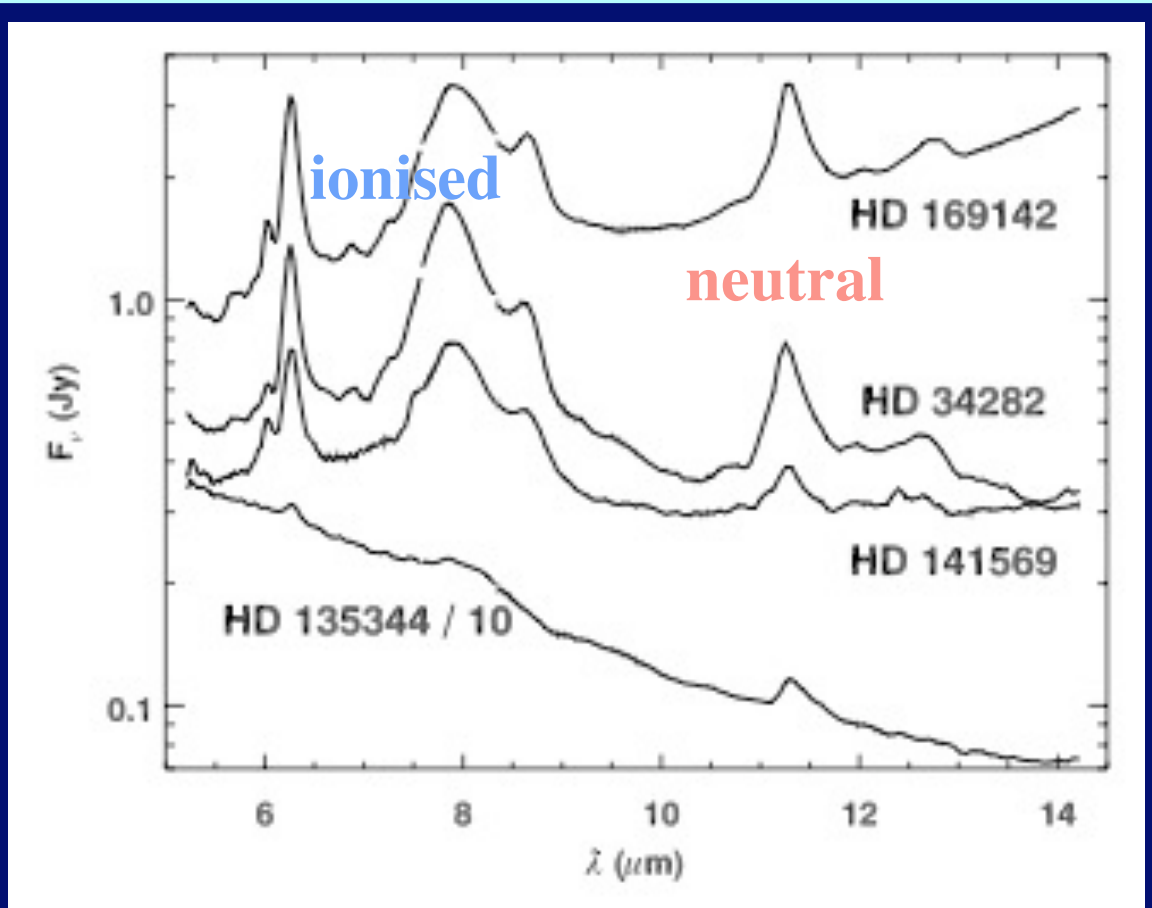
Inner disk rim & disc surface layer probed by METIS

Midplane & flared inner & outer disc probed by MIRI

MIR features in Herbig Ae/Be stars

A wealth to learn from PAH and silicate bands

Herbig Ae
A0, A0, A5, F4



PAH without any silicate features *Sloan et al. 2005*

***"clean"* PAH lines & flux ratios**

ionised 6-9 micron / 10-13 micron neutral

=> distinguish between ionisation states: effect of UV environment!

MIR features in Herbig Ae/Be stars

Herbig AeBe MIR spectra are NOT uniform...

PAH line centers

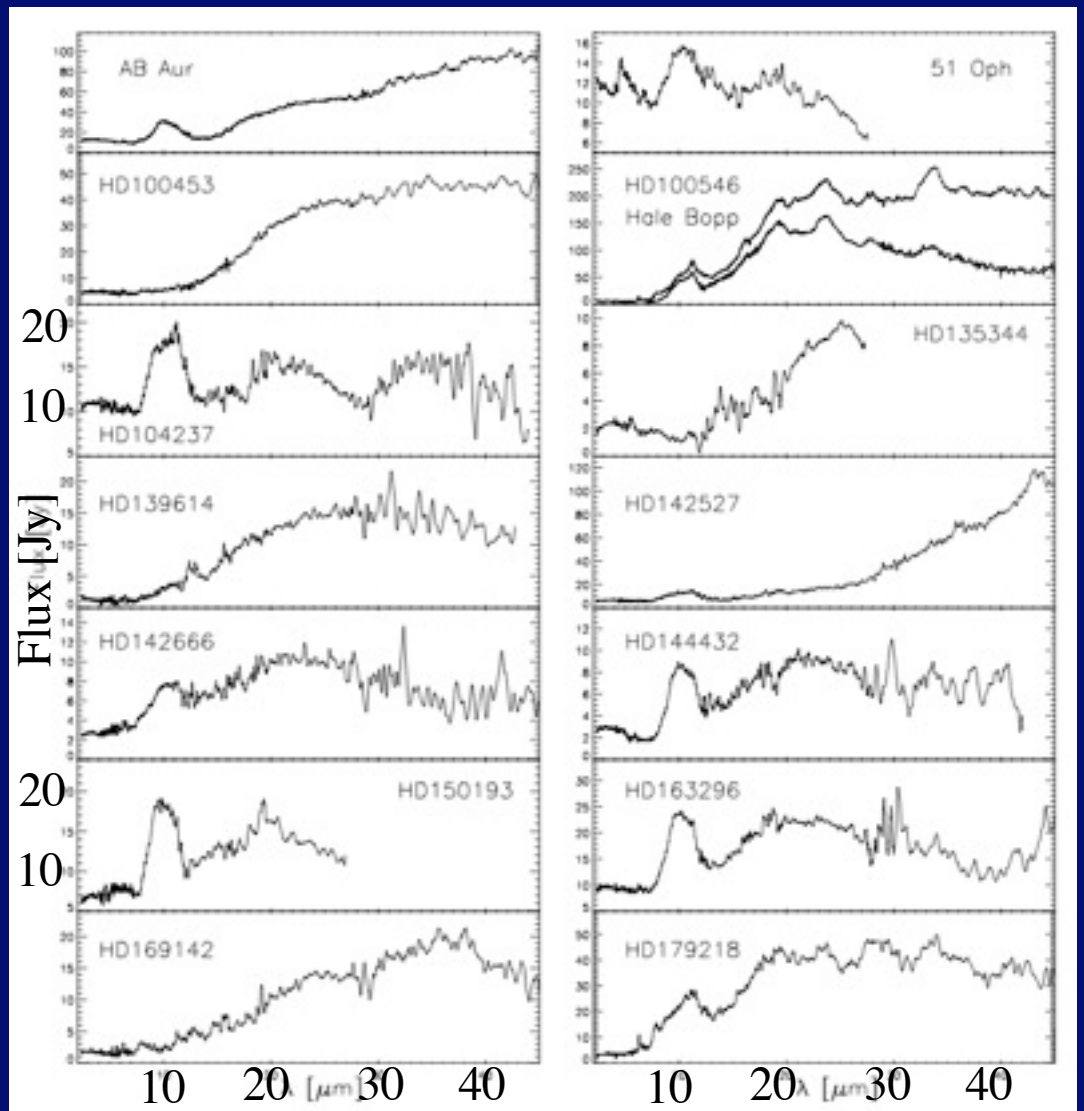
shift redwards

with smaller T★

=> disc evolution

and grain growth

in massive B stars



MIRI sensitivity...

... is not a problem!

< 30 micro-Jansky

at 25 micron

10 Jy @ 100 pc

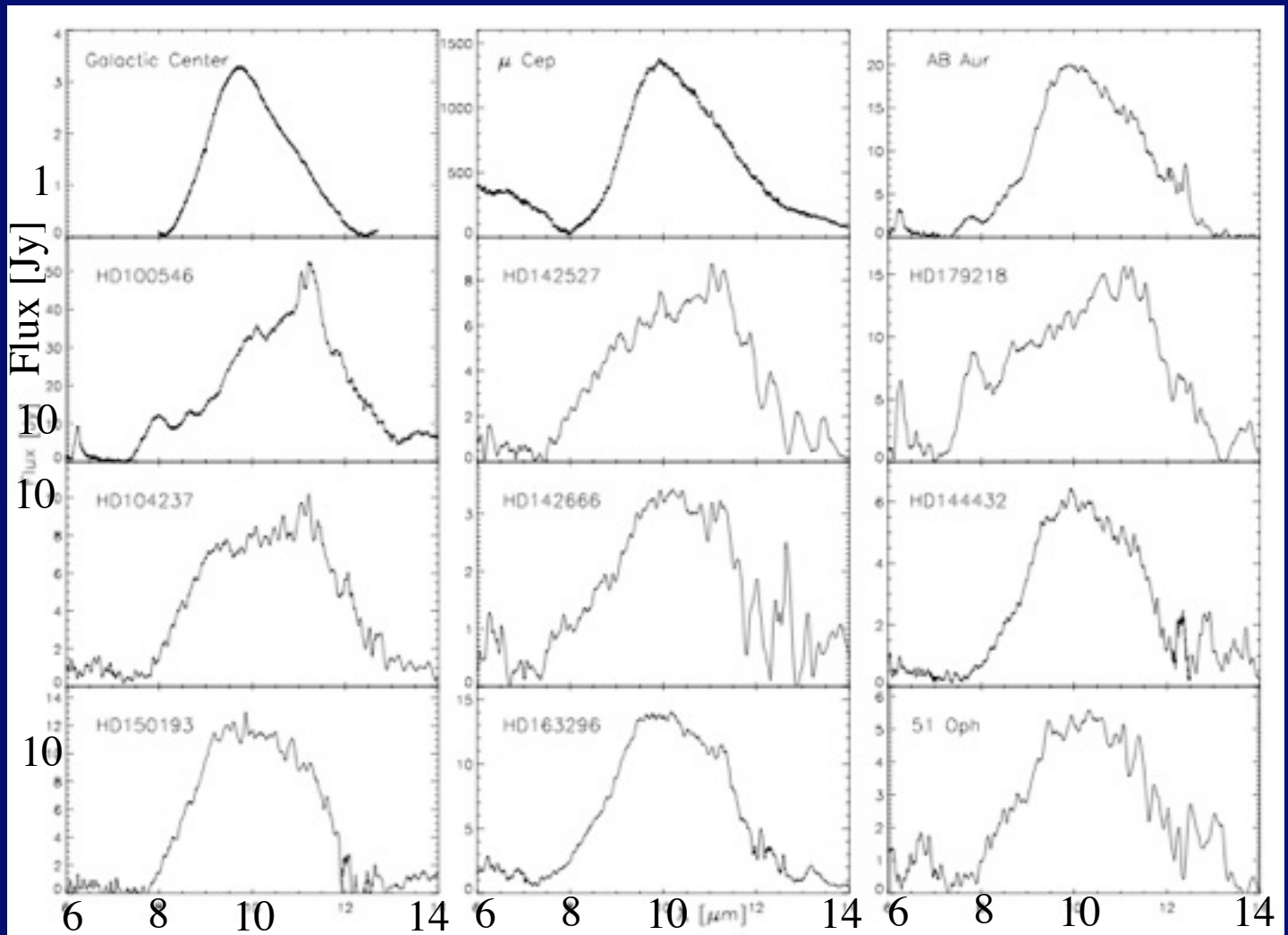
1.5 mJy @ 8 kpc

= 1500 micro-Jy

Meeus et al. 2001

MIR features in Herbig Ae/Be stars

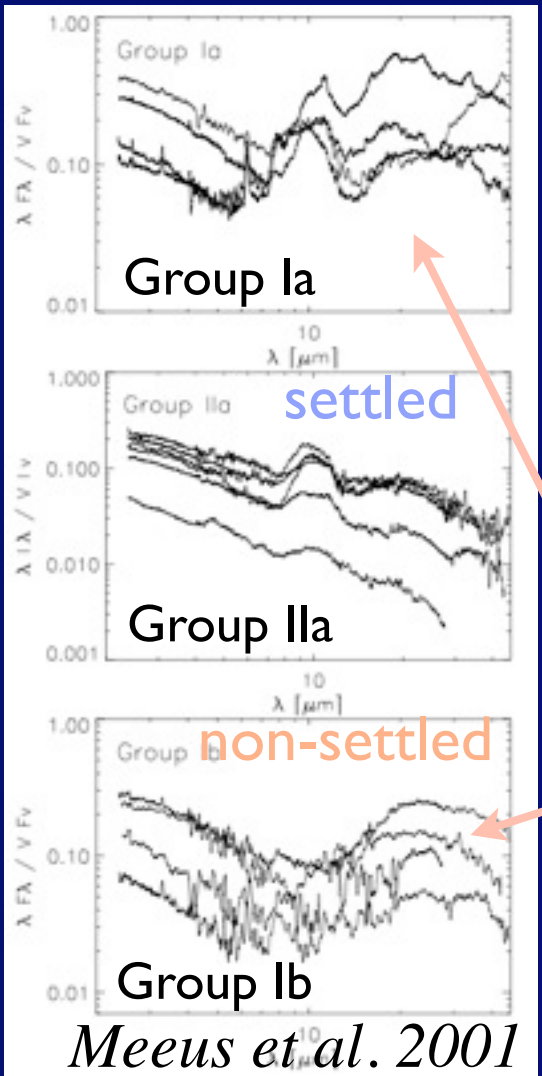
Herbig AeBe *silicate features* are NOT uniform either...



Disc modelling: amorphous or crystalline silicates? *Meeus et al. 2001*

=> *crystalline silicates indicate UV processing*

Defining disc evolution from MIR features



Meeus et al. 2001

Disc evolution

Transition from

HAeBe to Vega?

Low vs High-mass

small grains or PAHs?

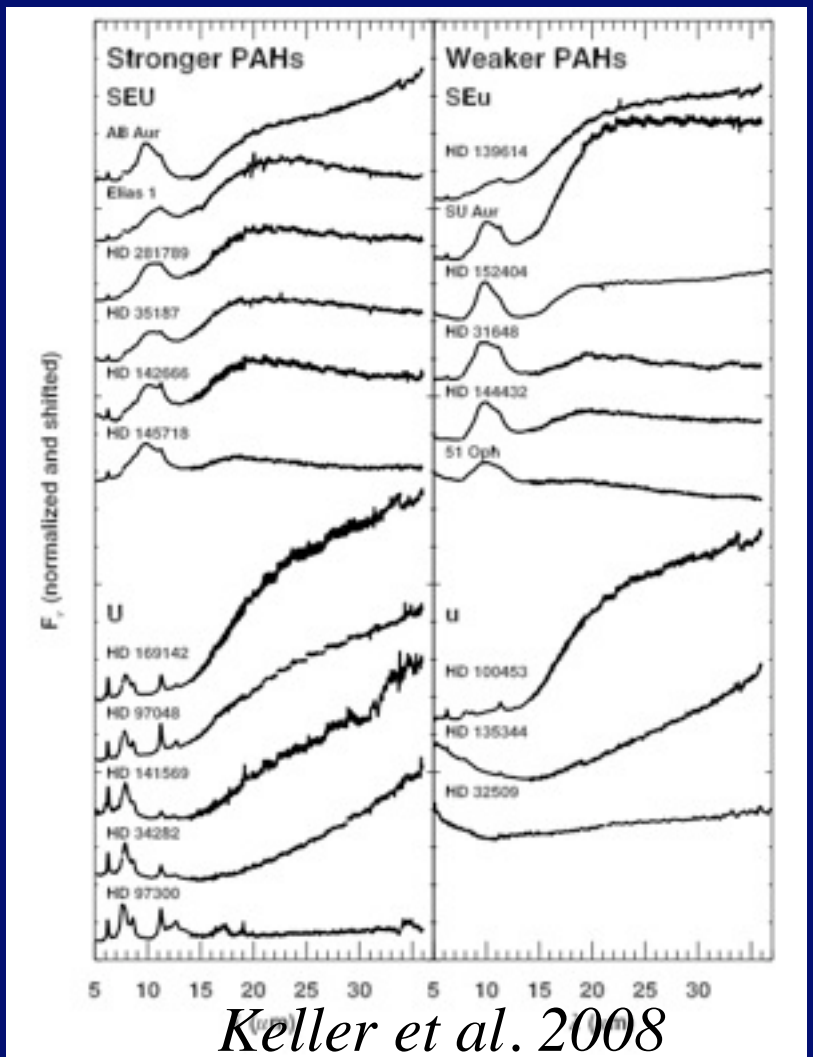
=> *inner holes*

Disc geometry

flared or flat?

Planet formation

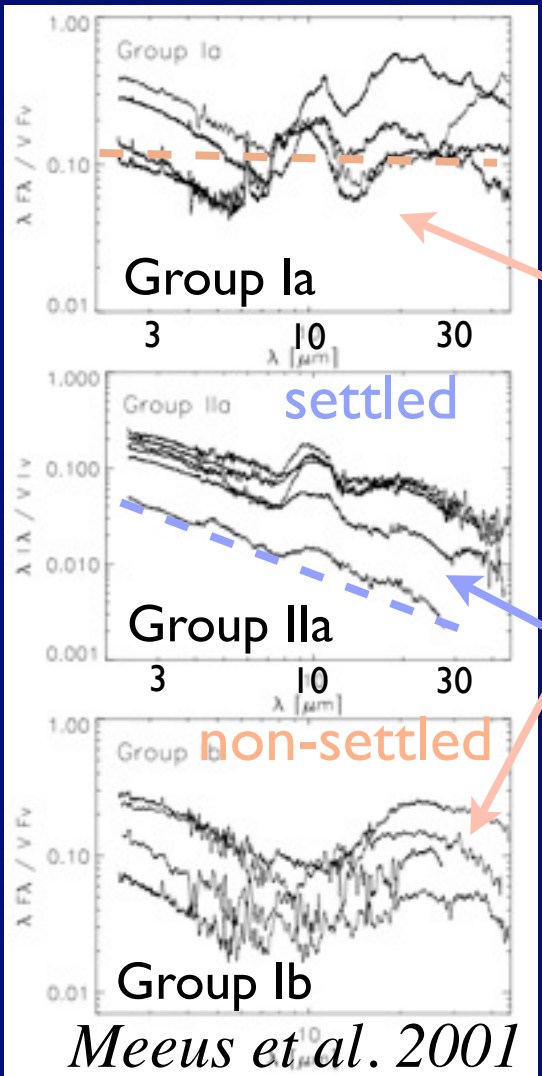
NIR excess from warm small bodies?



Keller et al. 2008

=> *the large sample of early B star (massive) discs traces disc evolution*

Defining disc evolution from MIR features



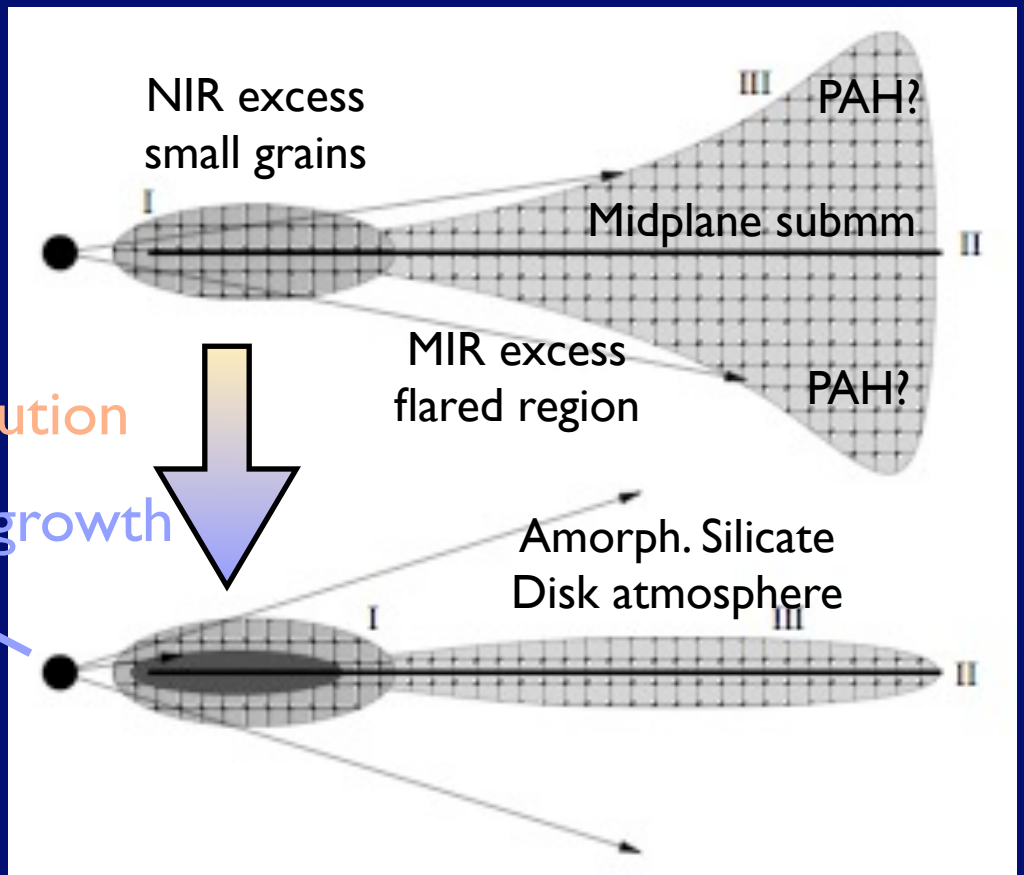
settled

non-settled

Meeus et al. 2001

evolution

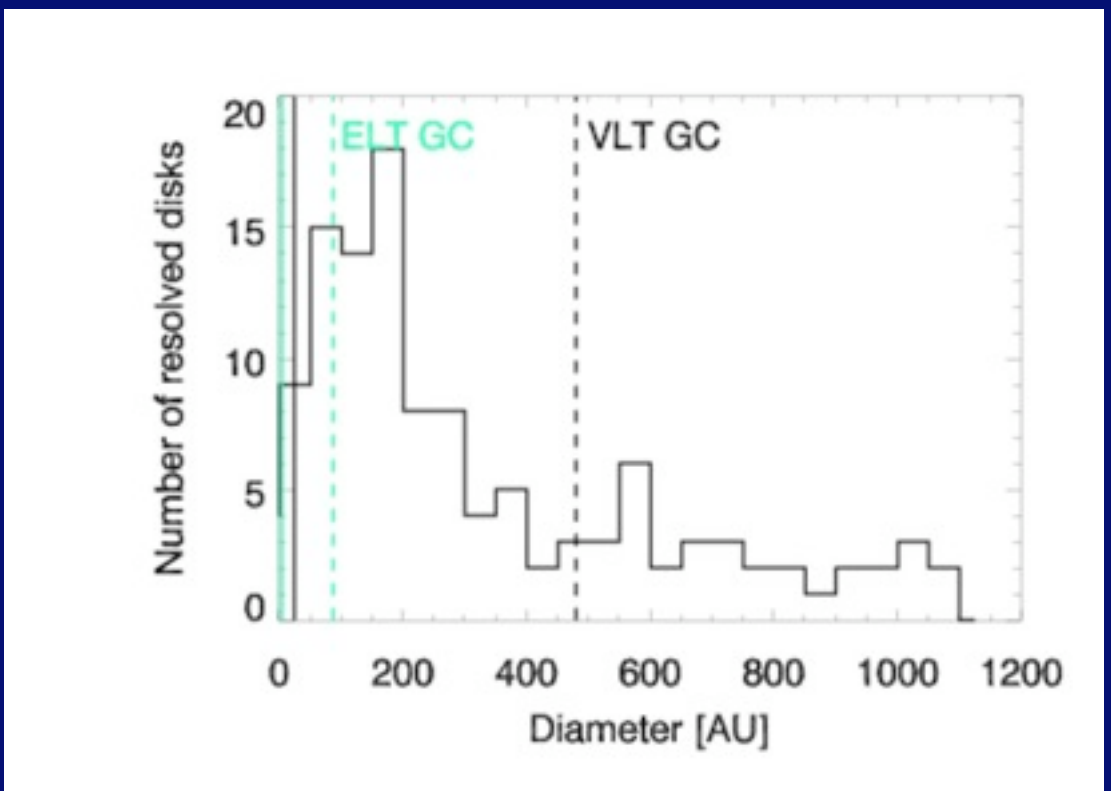
grain growth



JWST & EELT joined perspectives

Disc science in starburst clusters = nearby ~1.5 kpc regions today

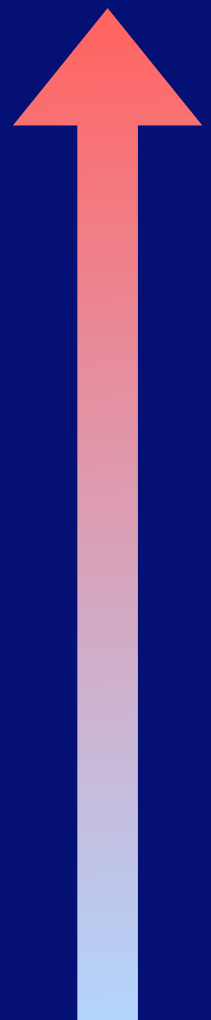
	Distance	VLT 8m *60 mas*	EELT 42m *11 mas*
Orion	414 pc	25 AU	5 AU
Gal. Center	8 kpc	480 AU	87 AU
Sensitivity		mJy	micro-Jy



www.circumstellardisks.org *maintained by Care McCabe*

Science cases by instrument

Instrument	wavelength	Science case
JWST/MIRI	5 - 28 micron	- PAH & silicate features - effect of UV environment - disc evolution & geometry
=> **Midplane & flared inner & flared or shadowed disc**		
EELT/METIS	3.5-13 micron	- disc extent at MIR wavelengths - PAH & silicate features, SEDs
=> **Inner disk rim & inner surface layer**		
JWST/NIRSpec	0.6 - 5 micron	- CO bandhead modelling - Keplerian rotation? - where's the Brγ emission???
EELT/MICADO	1.6-2.2 micron	- disc extent at NIR wavelengths - density & temperature profile



Discs in starburst clusters with JWST & E-ELT

- **Disk survival in starburst clusters**
  - **how does the starburst cluster environment affect discs ?**
  - **L=15 to L=22.9: from B-stars to 0.5 Msun star discs**
  - **earliest stages of planet formation in massive star clusters**
- **Combination of JWST and E-ELT**
  - **SEDs and spectra: PAH and silicate features**
  - **resolution, resolution, resolution: density profiles & extent**
  - **distinguish influence of cluster environment**

& more.....

Starburst clusters:

Large sample of discs in uniform environment, at same age

Disc evolution in massive stars & clusters

Discs in starburst clusters with JWST & E-ELT

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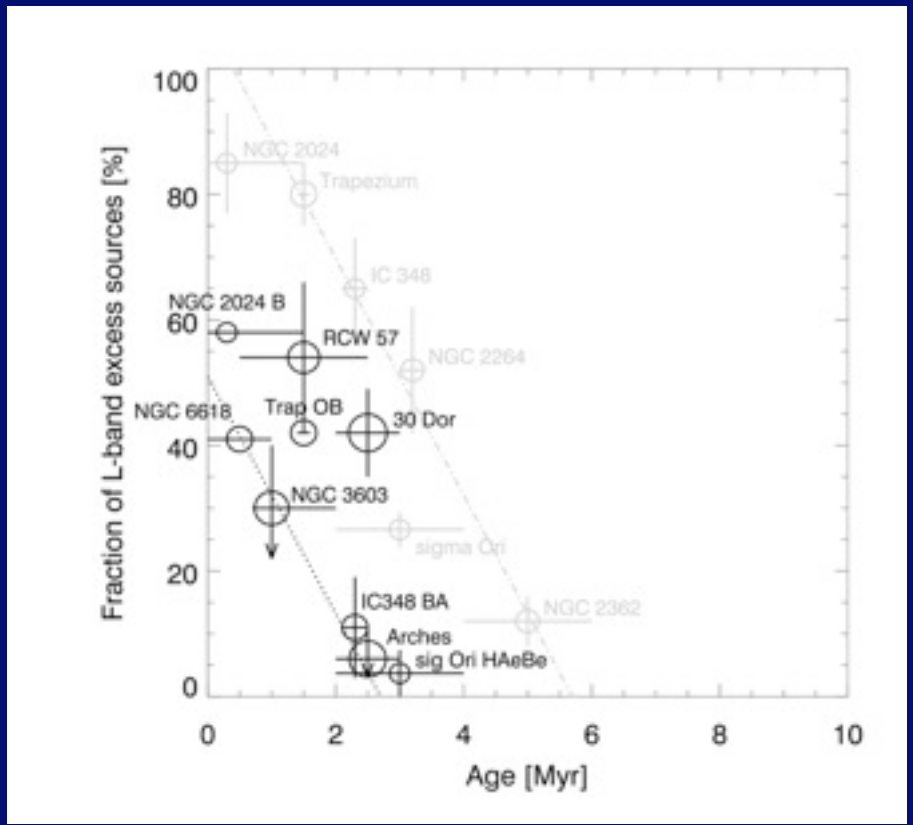
Starburst clusters:

Large sample of discs in uniform environment, at same age

Disc evolution in massive stars & clusters

Thanks!

Disk survival in starburst environments



Stolte et al. 2010

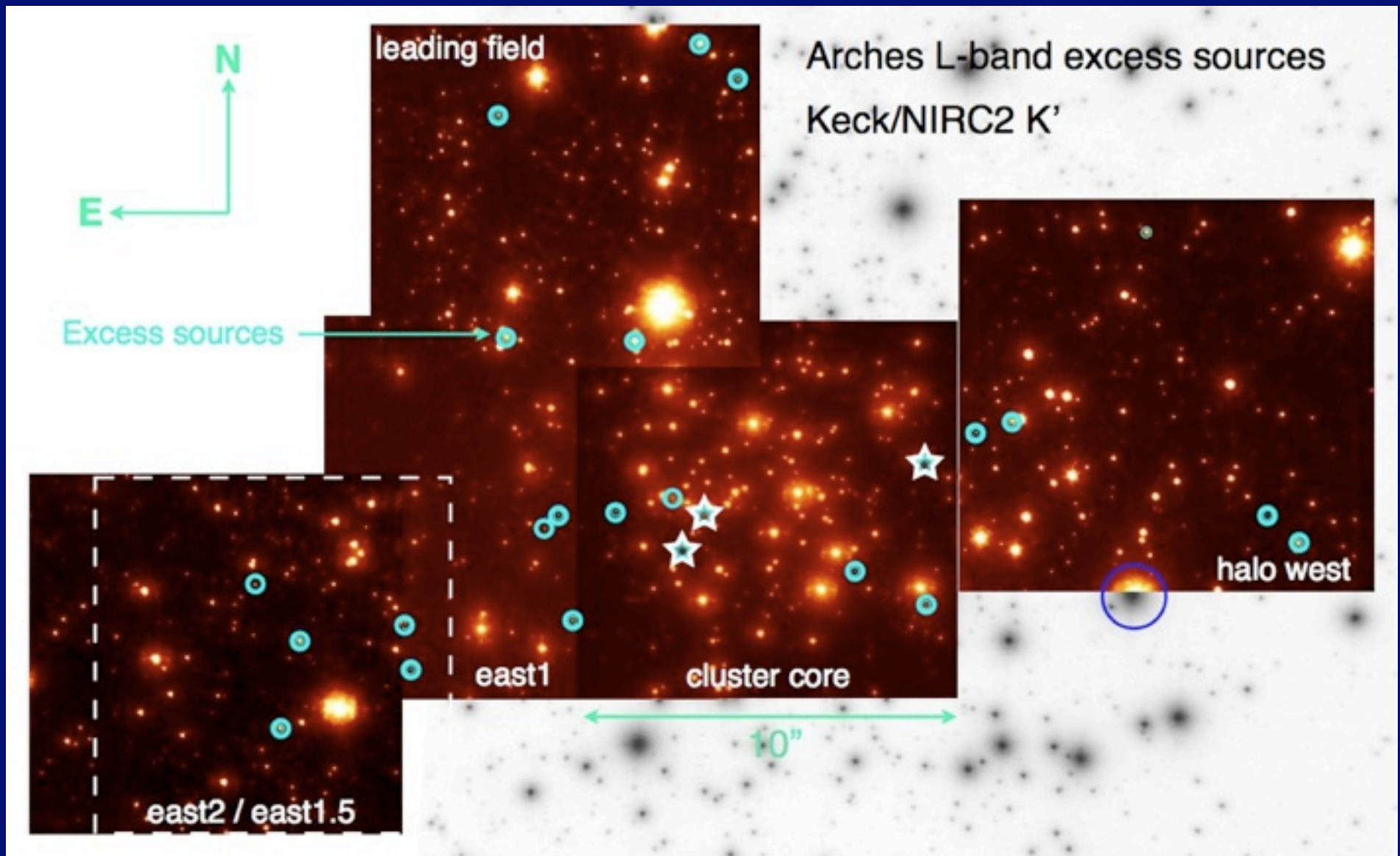
Starburst cluster environments alter the disk survival timescale

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

=> disk structure & mass estimates

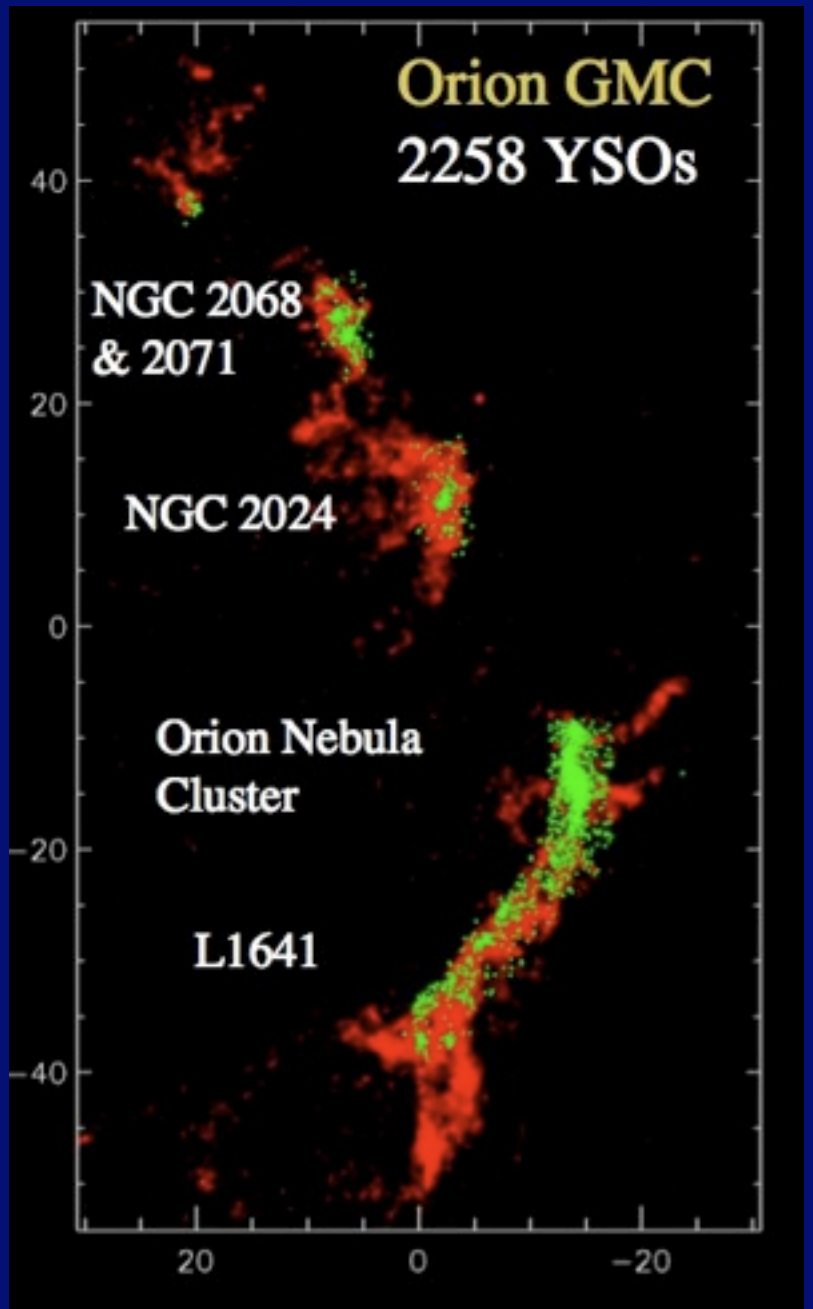
Do these disks survive long enough to form planets???

Keck/NIRC2 HKL mosaic for extinction measurements



34" ~ 1.3 pc

Outlook into space.....



~16 pc

2 deg

Megeath et al.

16 pc in K-band:

400 resolution elements @ M31

200 resolution elements @ M83

80 resolution elements @ M51