Star formation in Orion A

Towards Resolved maps of SFR and SFE

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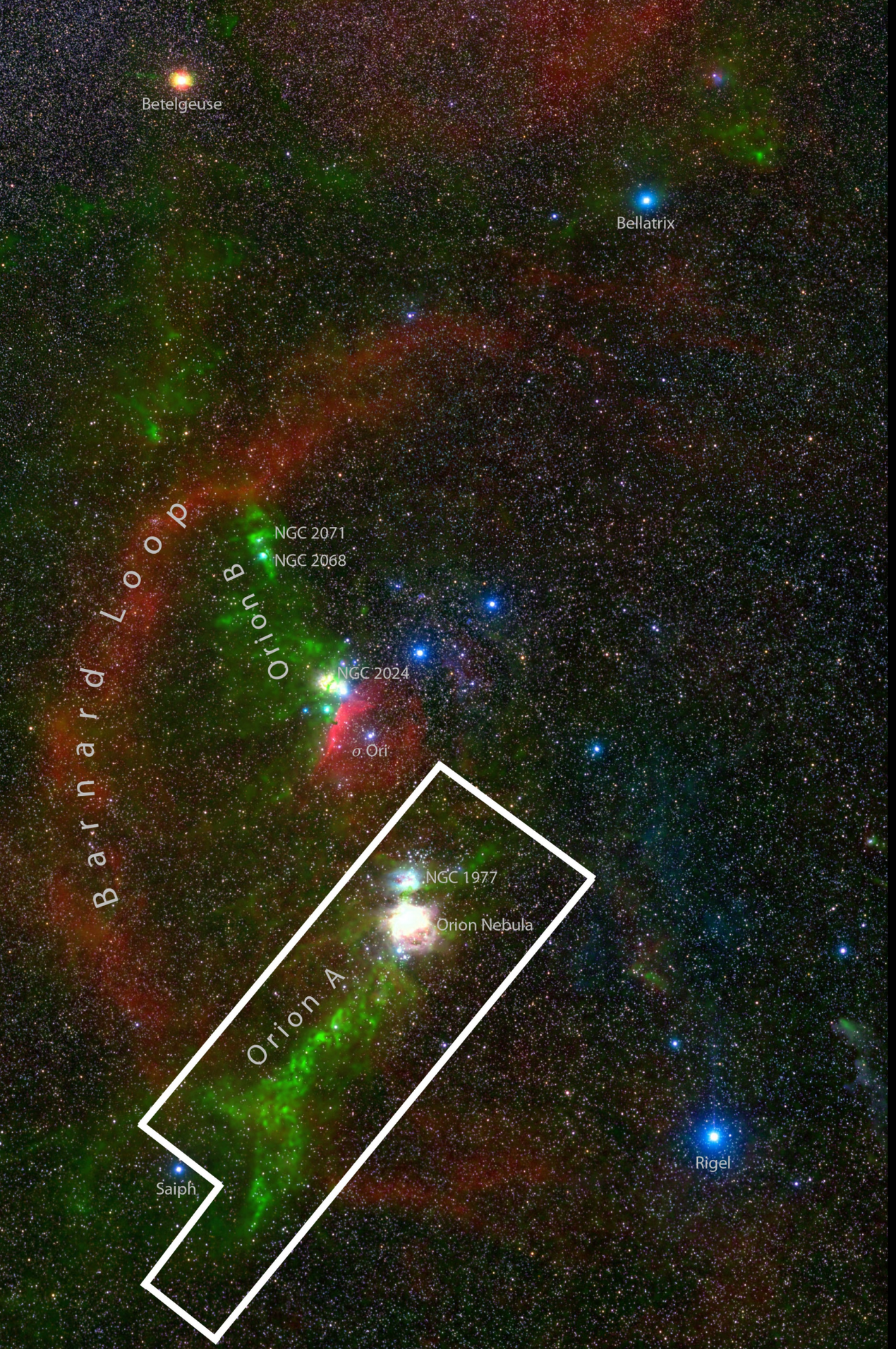
FWF
Der Wissenschaftsfonds.

ESO

SPITZER SPACE TELESCOPE

WISE

HERSCHEL
Exploring the Cold Universe



Introduction & Motivation

Orion A

Closest massive star forming region to earth (~ 414 pc, Menten et al. 2007)

SFR & SFE

Importance of complete and reliable YSO catalog - to derive accurate star formation rates and efficiencies

ESO-VISTA

New deep NIR photometry (VISION, Meingast et al. 2016) higher resolution and sensitivity compared to 2MASS

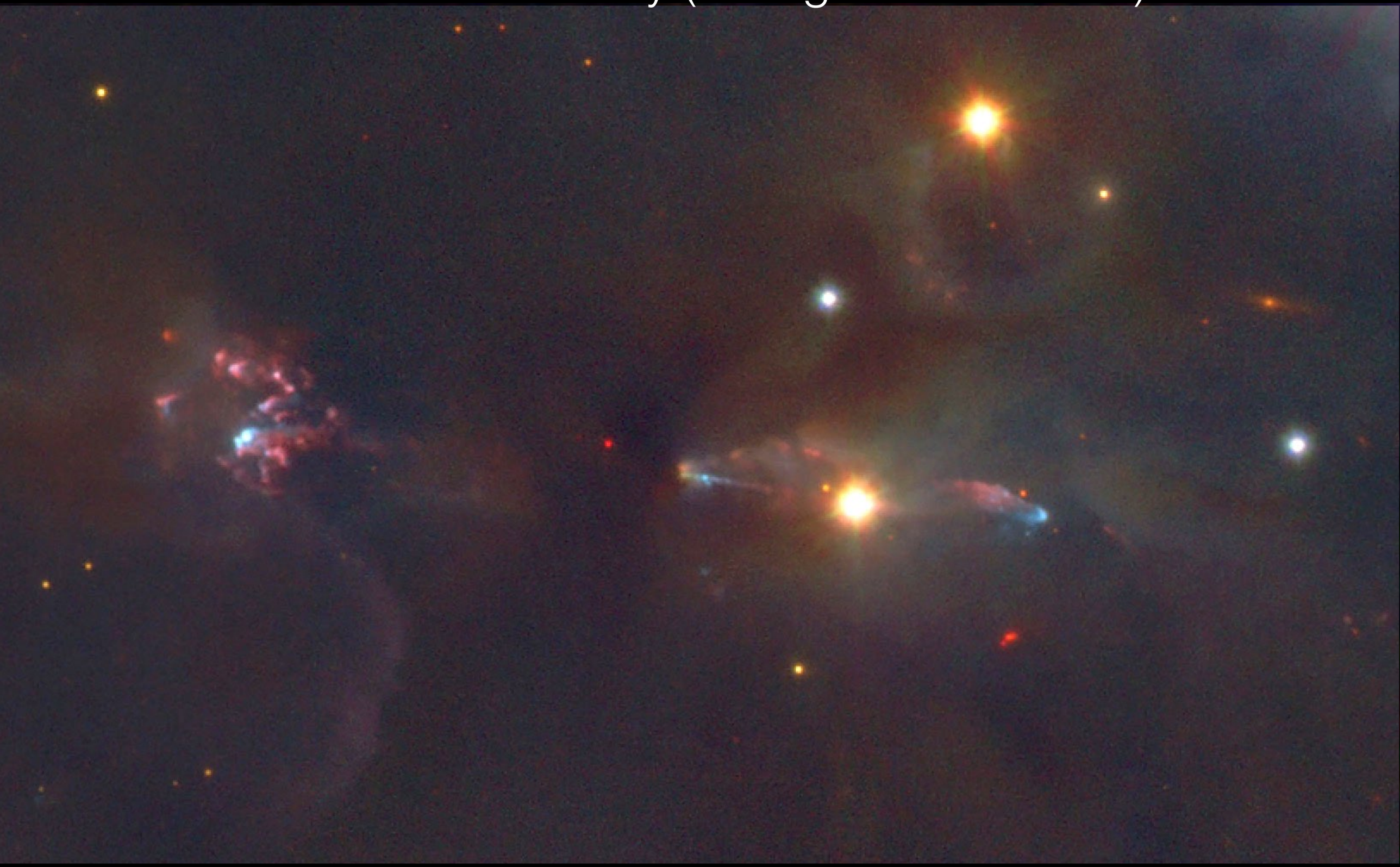
NIR extinction map (Lombardi et al. 2011)
Optical (Wei-Hao Wang, IfA, University of Hawaii)

VISTA resolution & sensitivity (Meingast et al. 2016)

2MASS *vs.* ***VISTA***

V2669 Ori, HH 1&2

VISTA resolution & sensitivity (Meingast et al. 2016)



2MASS *vs.* ***VISTA***

V2669 Ori, HH 1&2

Conclusions

1) Orion A YSO catalogue - Revisited and New candidates
   contamination fraction ~ 5% in previous catalogs
   ~ 200 new YSO candidates

2) Distribution of the YSO classes (Protostars, Flats, Disks)
   Are Flats a distinct evolutionary stage?
   Distribution suggests: YES!

3) Preliminary results on resolved maps of SFR and SFE
   SFE roughly constant across cloud while SFR varies by factor ~10!
   Suggesting: Variations depend on external conditions
   Feedback from local massive stars or SNe?

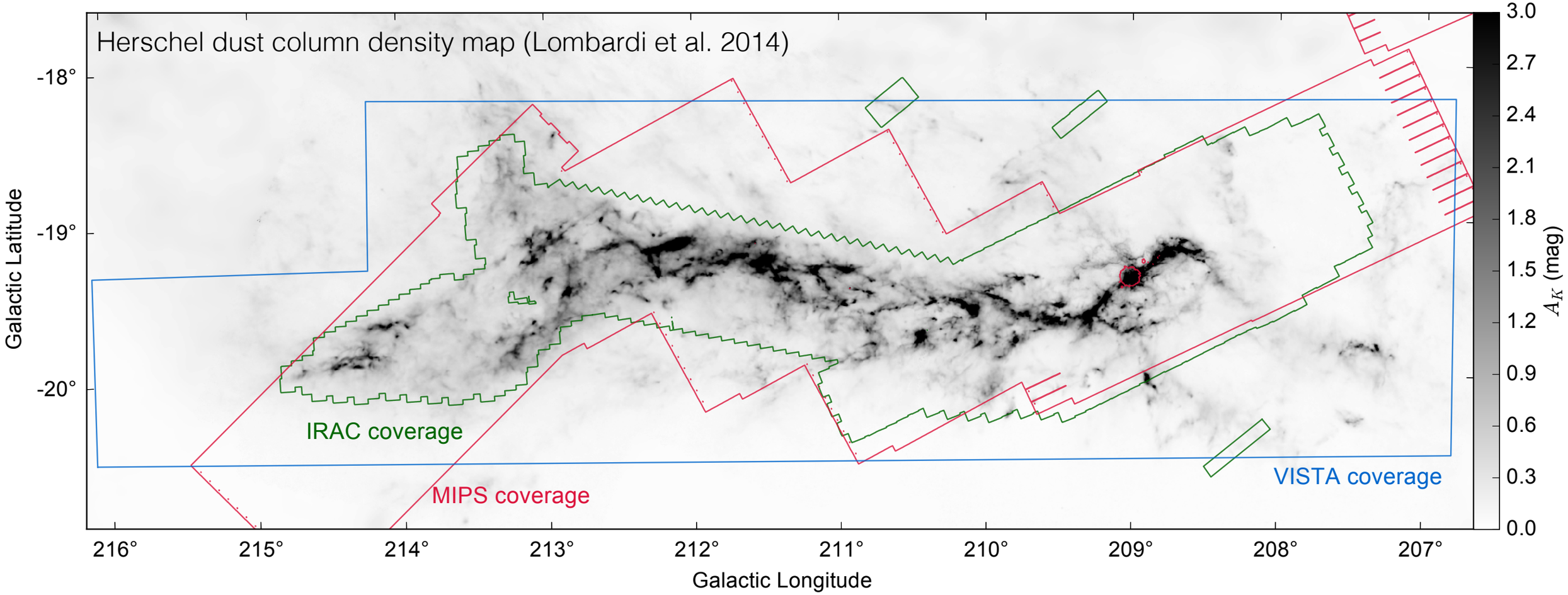
Revisiting existing Orion A YSO catalogs

DATA

NIR - **ESO-VISTA** J, H, Ks (VISION, Meingast et al. 2016)

MIR - **Spitzer** IRAC & MIPS (3.6, 4.5, 5.8, 8, 24 microns) (Megeath et al. 2012, 2016)
WISE allsky (3.4, 4.6, 12, 22 microns) (Wright et al. 2012)

FIR - **Herschel** HOPS (PACS 70, 100, 160 microns) (Stutz et al. 2013, Furlan et al. 2016)



Revisiting existing Orion A YSO catalogs

Catalogues:
Megeath et al. (2012, 2016)
+ HOPS sources (Herschel Orion Protostar survey)
Stutz et al. (2013), Furlan et al. (2016)

Goal:
eliminating false positives (galaxies, nebulosities)
because of the VISTA resolution & sensitivity

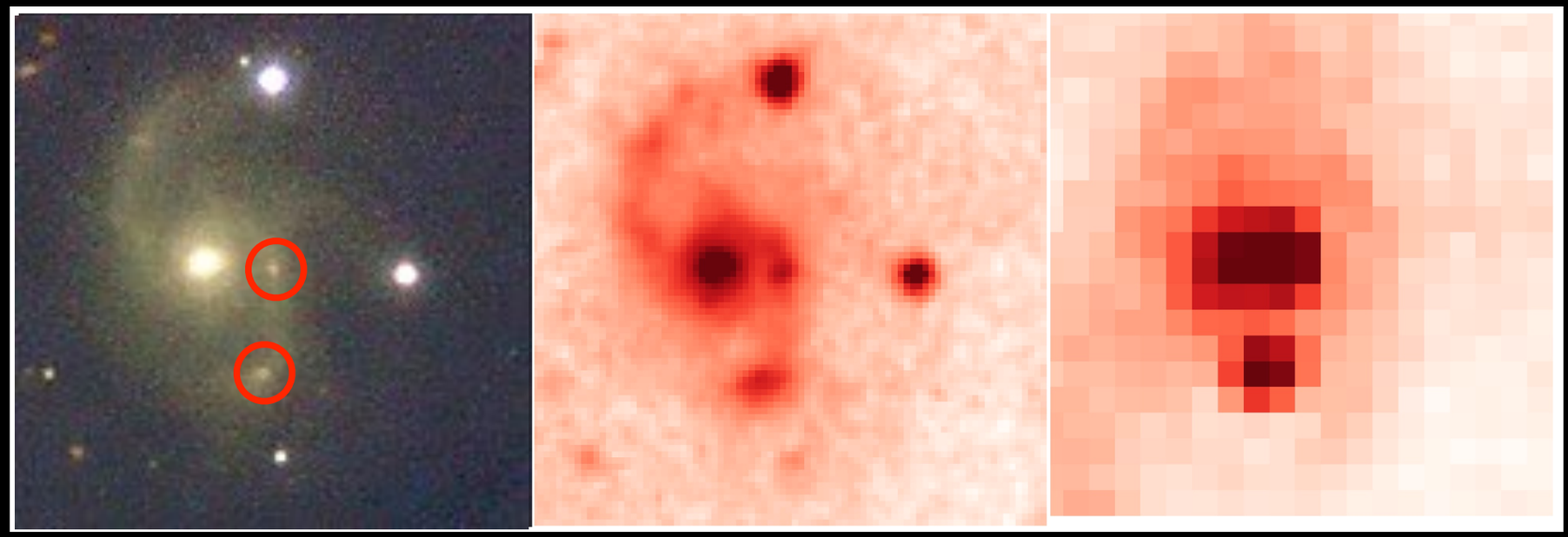
Methods:
Visual Inspection ⇨ Morphological identification
+ colours, magnitudes, extension flags, extinction

Visual Inspection

Megeath et al. (2012) YSOs revisited

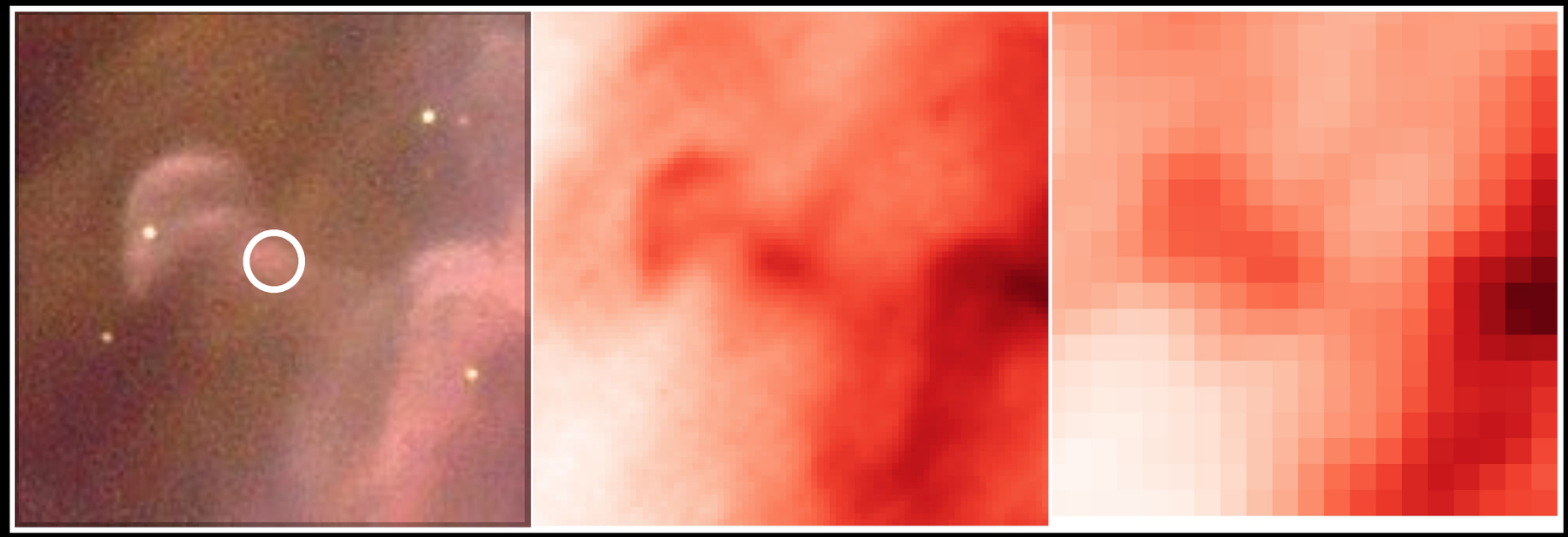
VISTA JHKs | IRAC2 [4.5] | MIPS1 [24]

disk candidate



➪ Galaxy

protostar candidate



➪ Nebulosity

Updated YSO catalog

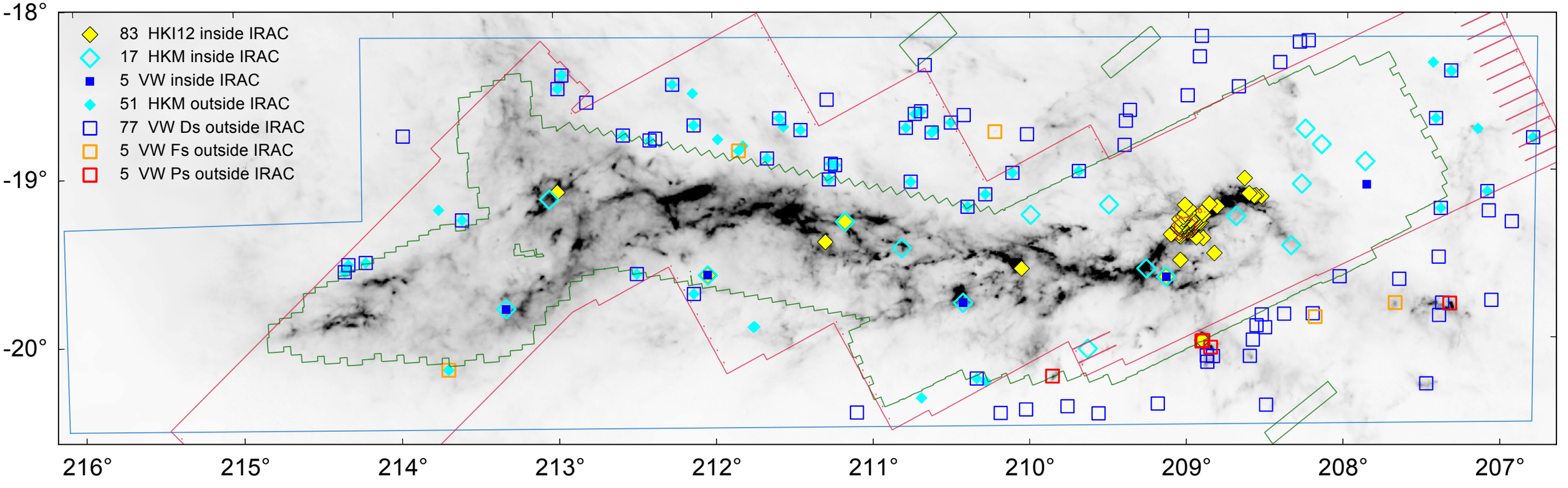
Revisited **2840** YSO candidates

- **140 false positives** (extra-galactic, nebulosities & uncertain cand.)
  - ~ 9% protostar contamination fraction
  - ~ 3% disk contamination fraction

+ **200 NEW** YSO candidates added
  - ~100 inside IRAC
  - ~100 outside IRAC

~ **2900** YSO candidates

Distribution of the **NEW** candidates



New YSOs - examples VISTA stamps (Meingast et al. 2016)

new isolated edge-on disk

new protostar

new protostar

YSO classification

Spectral Index α (2 - 24 μm): (extinction corrected)

Class 0/I (Protostars):	$\alpha > 0.3$
Flat spectrum:	$-0.3 < \alpha < 0.3$
Class II (Disks):	$-1.6 < \alpha < -0.3$
Class III (anemic Disks & PMS without disks):	$\alpha < -1.6$

181 (~ 6%) Protostars (Class0/I)

190 (~ 7%) Flats

2532 (~ 87%) Disks (ClassII/III)

YSO Classification

Are Flat spectrum sources an evolutionary stage?

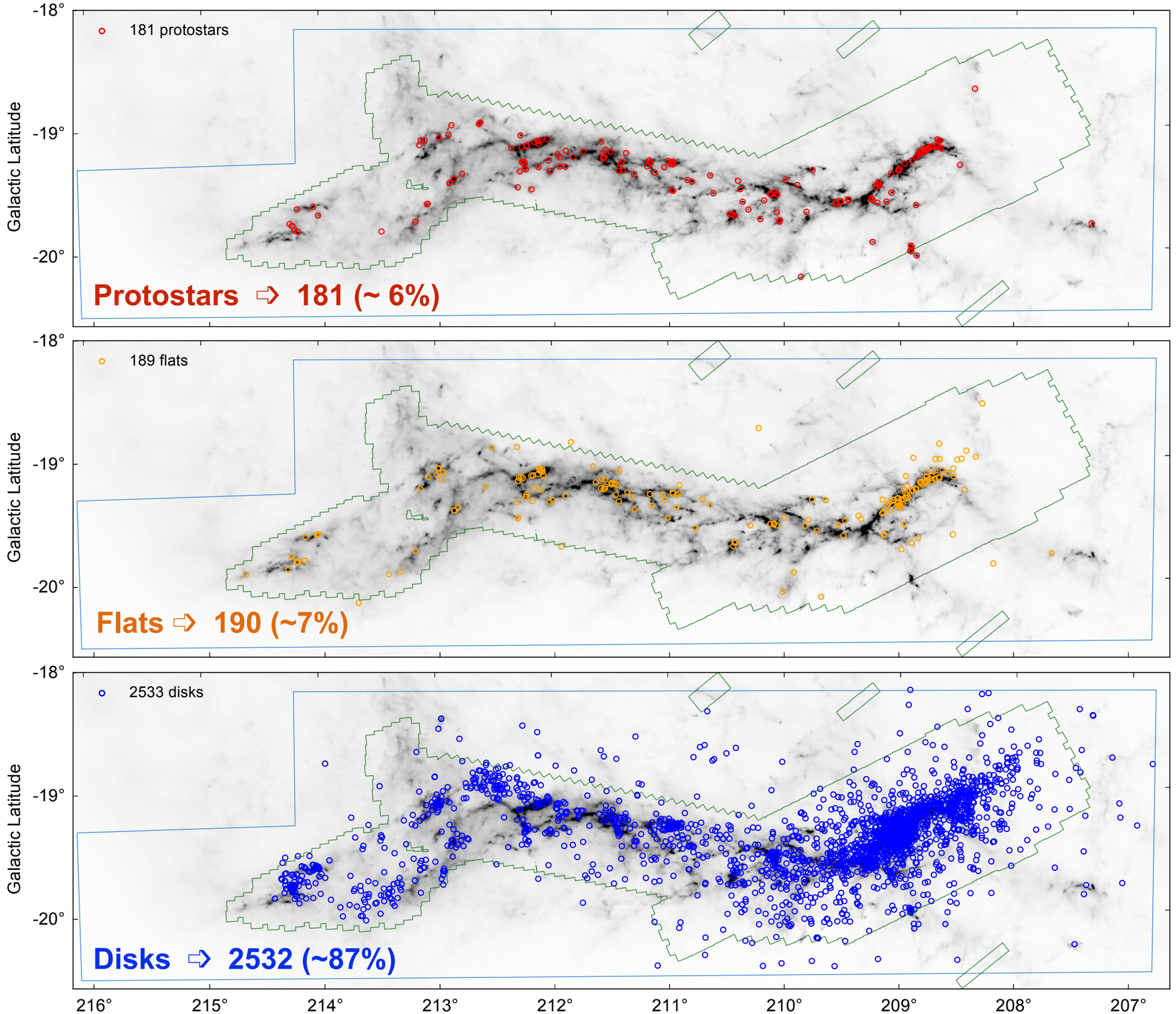
Protostars

VISTA stamps (Meingast et al. 2016)

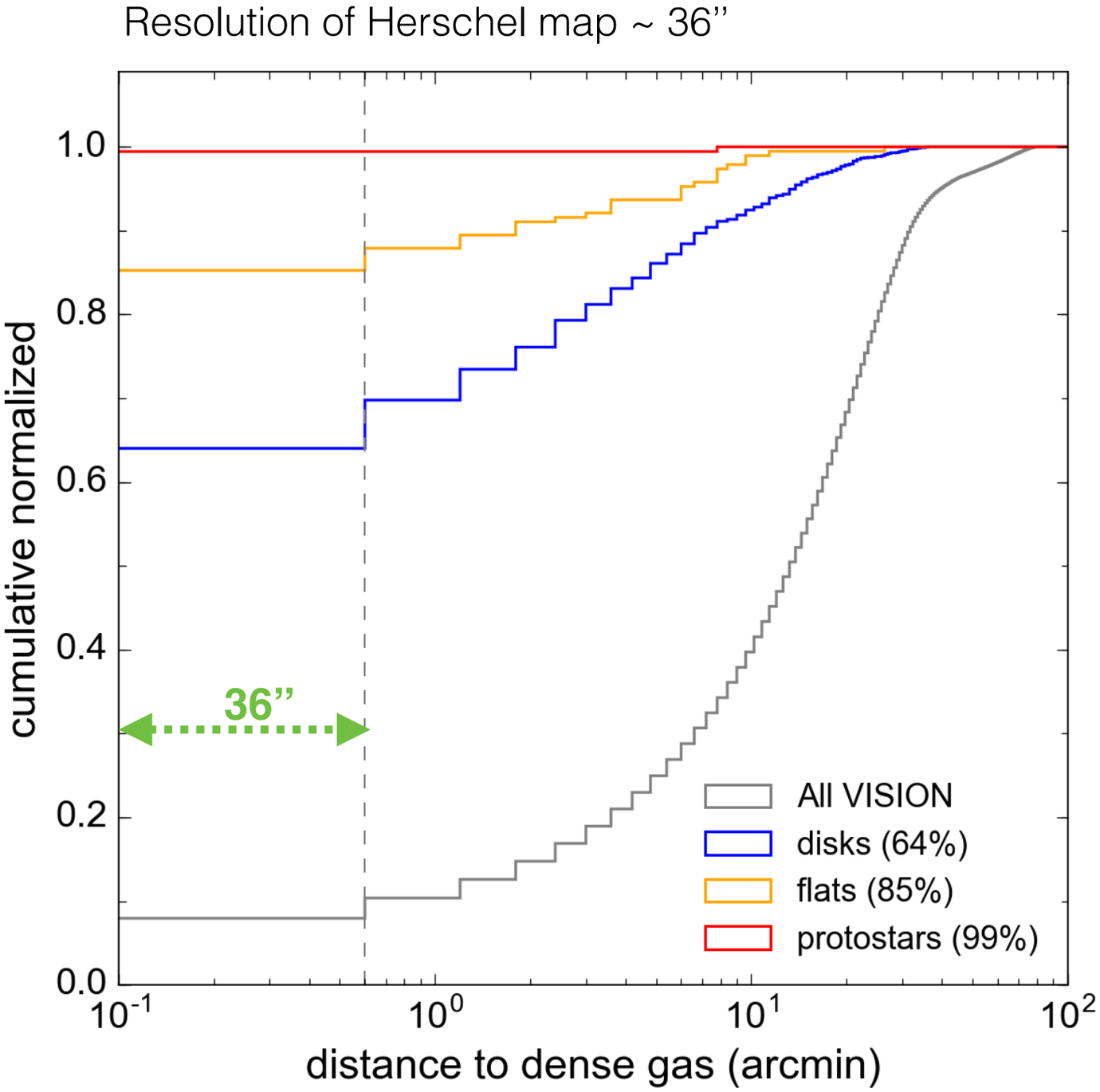
Flats

Disks

Spatial Distribution of the Orion A YSO candidates



YSO Spatial Distribution - Distance to dense gas



Protostars almost 100% connected to dense gas
(AK > 0.8 mag, Lada et al. 2010)

Flats show a stronger connection to dense gas than Disks
(see also Johnstone 2017)

We corrected for extinction effects
(e.g. Forbrich et al. 2010)

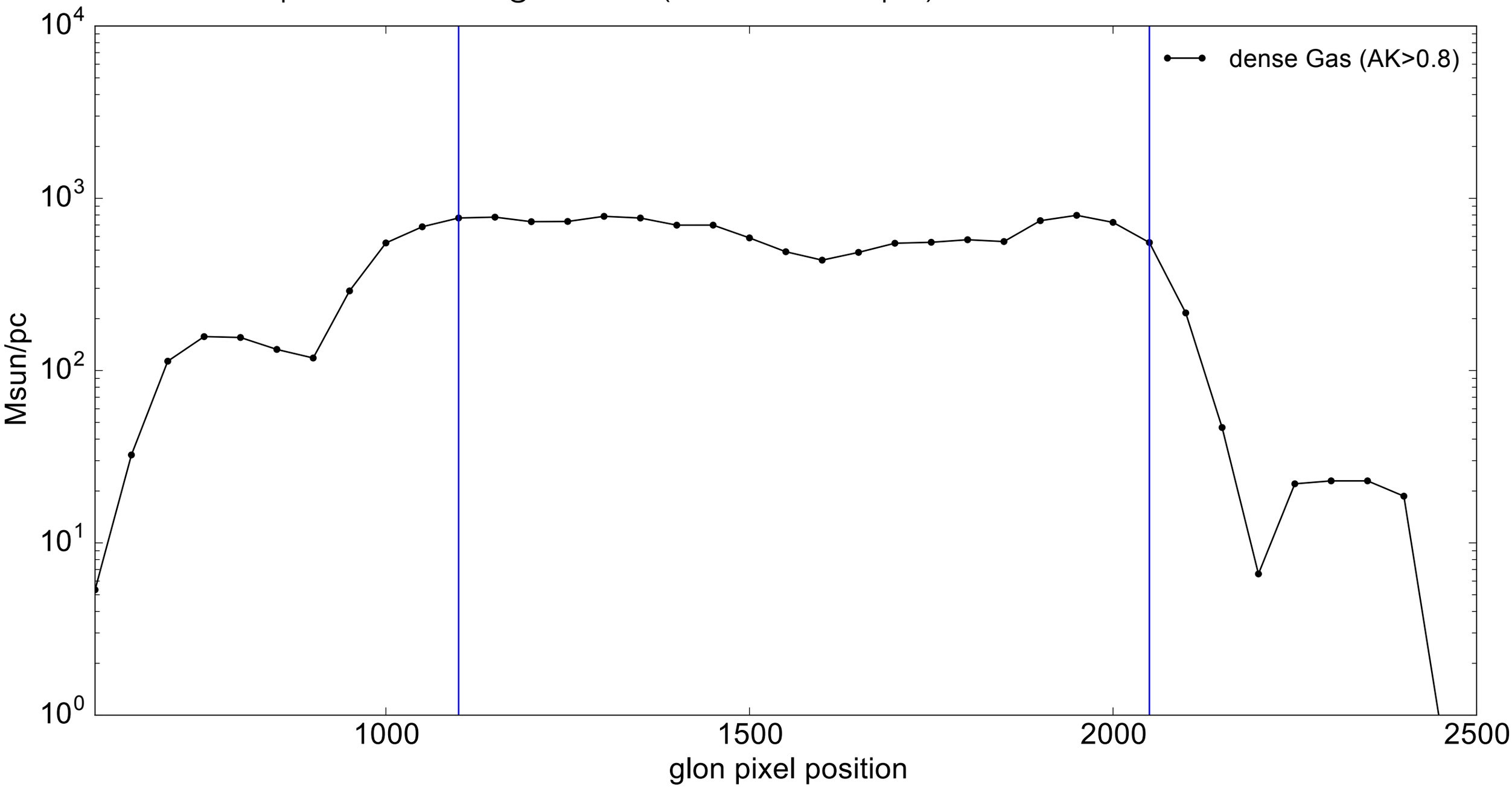
Inclination effects of disks
(e.g. Whiney et al. 2003a,b, Crapsi et al. 2008)
should not be connected to spatial distribution

Flats may be a separate evolutionary stage!
(e.g. Greene 1994)

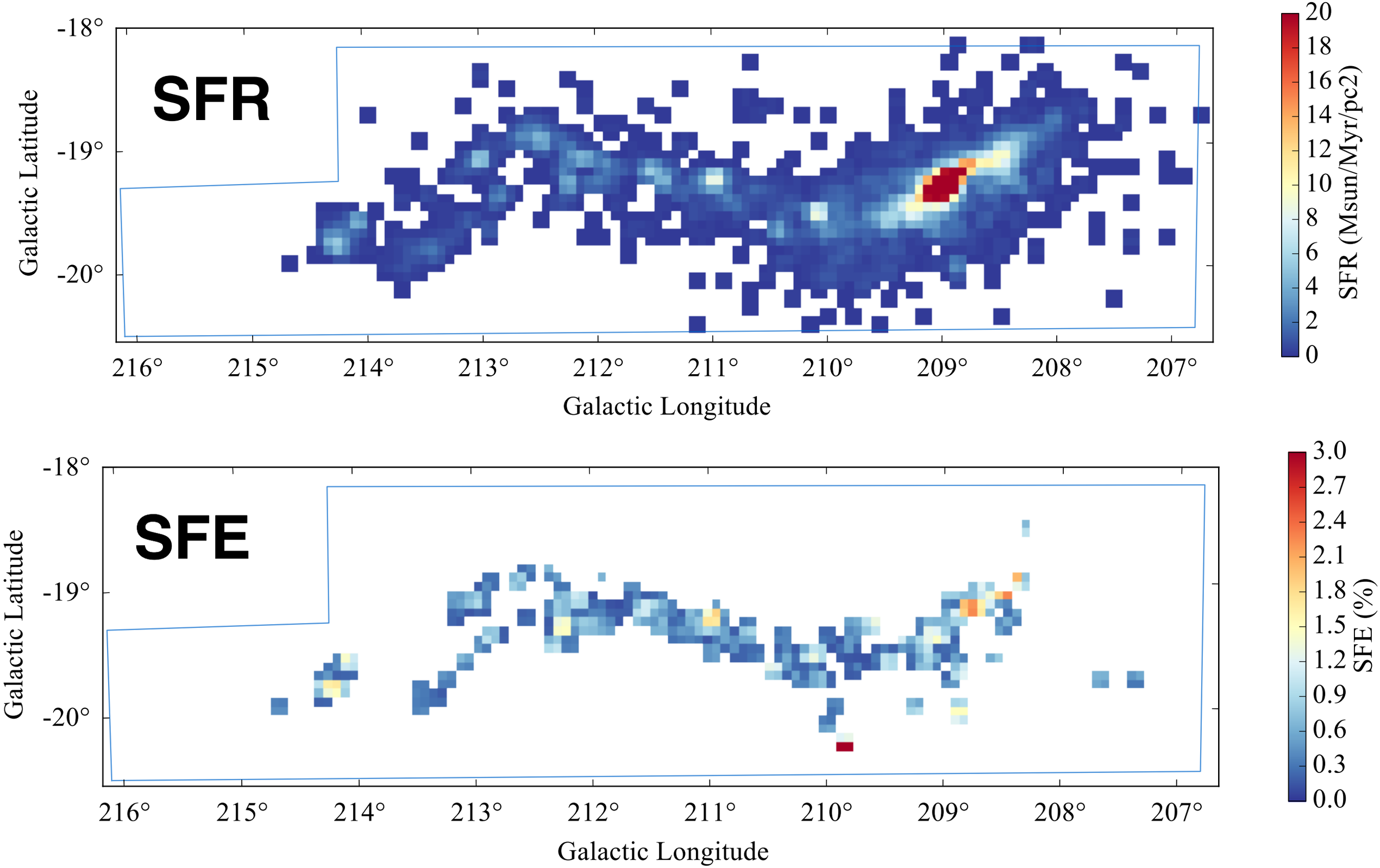
Preliminary results on SFR and SFE

Dense gas mass distribution along Orion A

summed up in bins along GLON (bin size ~ 6 pc)



Maps of Star Formation Rate and Efficiency



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