VISTA Science Verification:

A Mini-Survey in Orion

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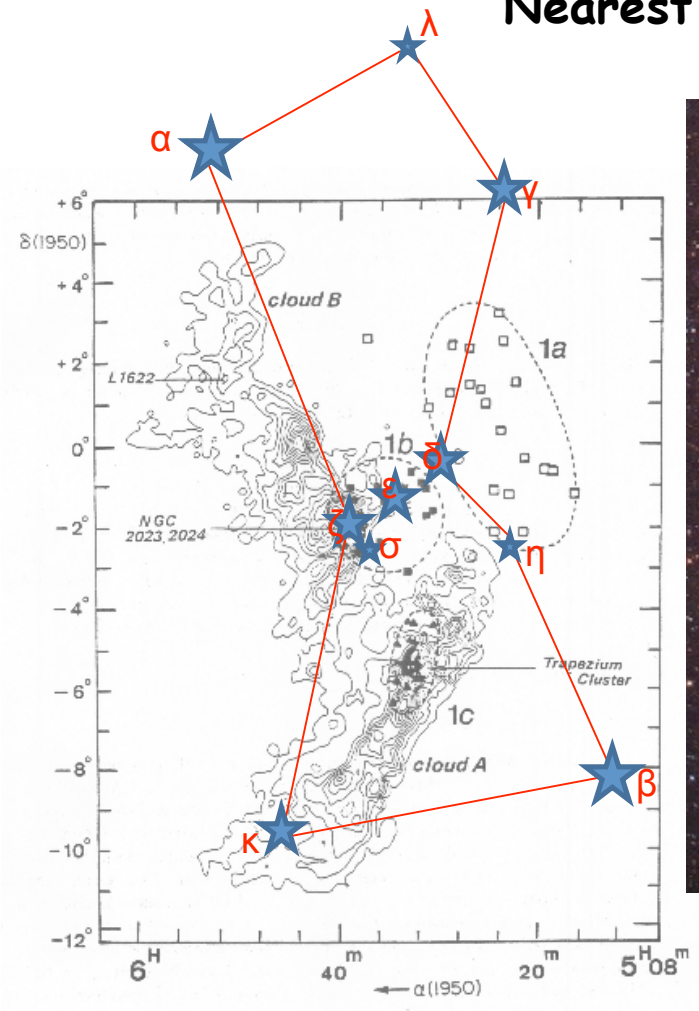
The Orion Star Forming Region

Average distance: 400pc

Nearest site of low- and high-mass star formation



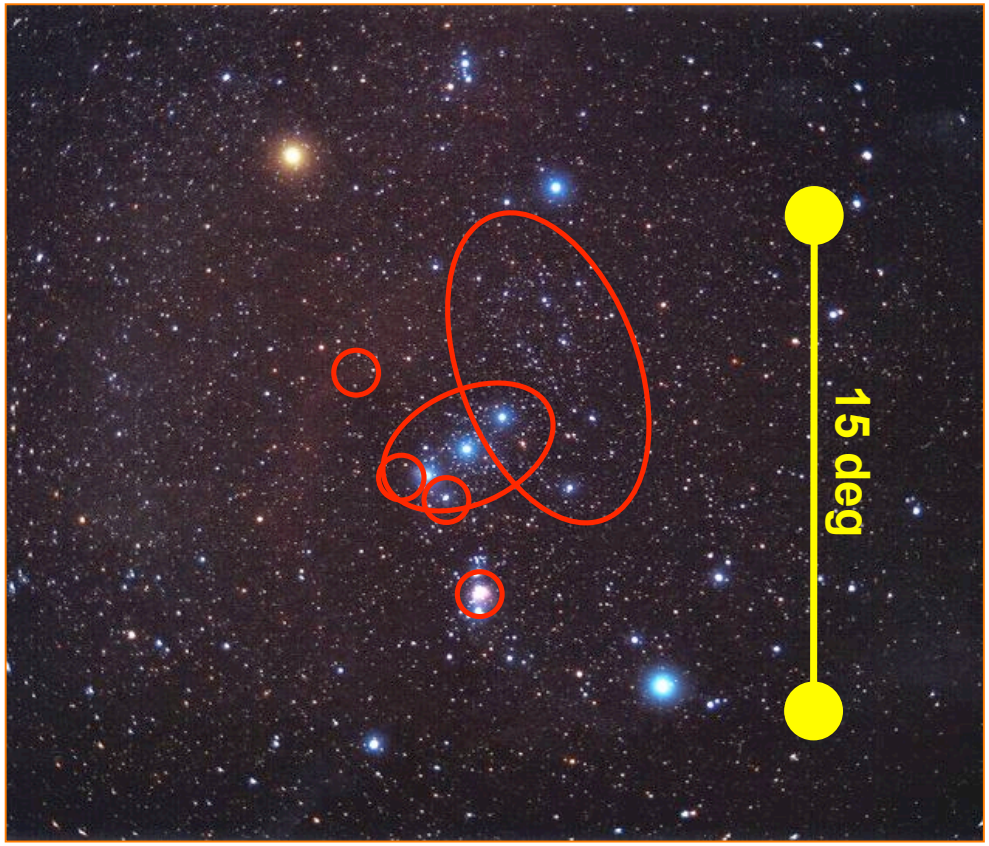
Optical image

http://antwrp.gsfc.nasa.gov/apod/image/0302/orion_spinelli_full.jpg

Orion displays stellar populations with ages <1Myr … 10Myr

Contours: CO-emission from Maddalena et al. (1986)
Designation of regions from Blaauw (1991)

The Orion Star Forming Region



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- Ori OB 1a ~ 10 Myr
- Ori OB 1b ~ 5 Myr
- Sigma Ori cluster ~ 3-5 Myr
- Ori OB 1c/d = Orion Nebula Cluster ~ 1 Myr
- Embedded clusters (NGC2024, NGC2068/71) and Molecular Cloud cores ~ <1 Myr

Comparative studies across these groups of different age (but same genetic /same molecular cloud origin!!)

Science issues to study …

Science issues for star formation

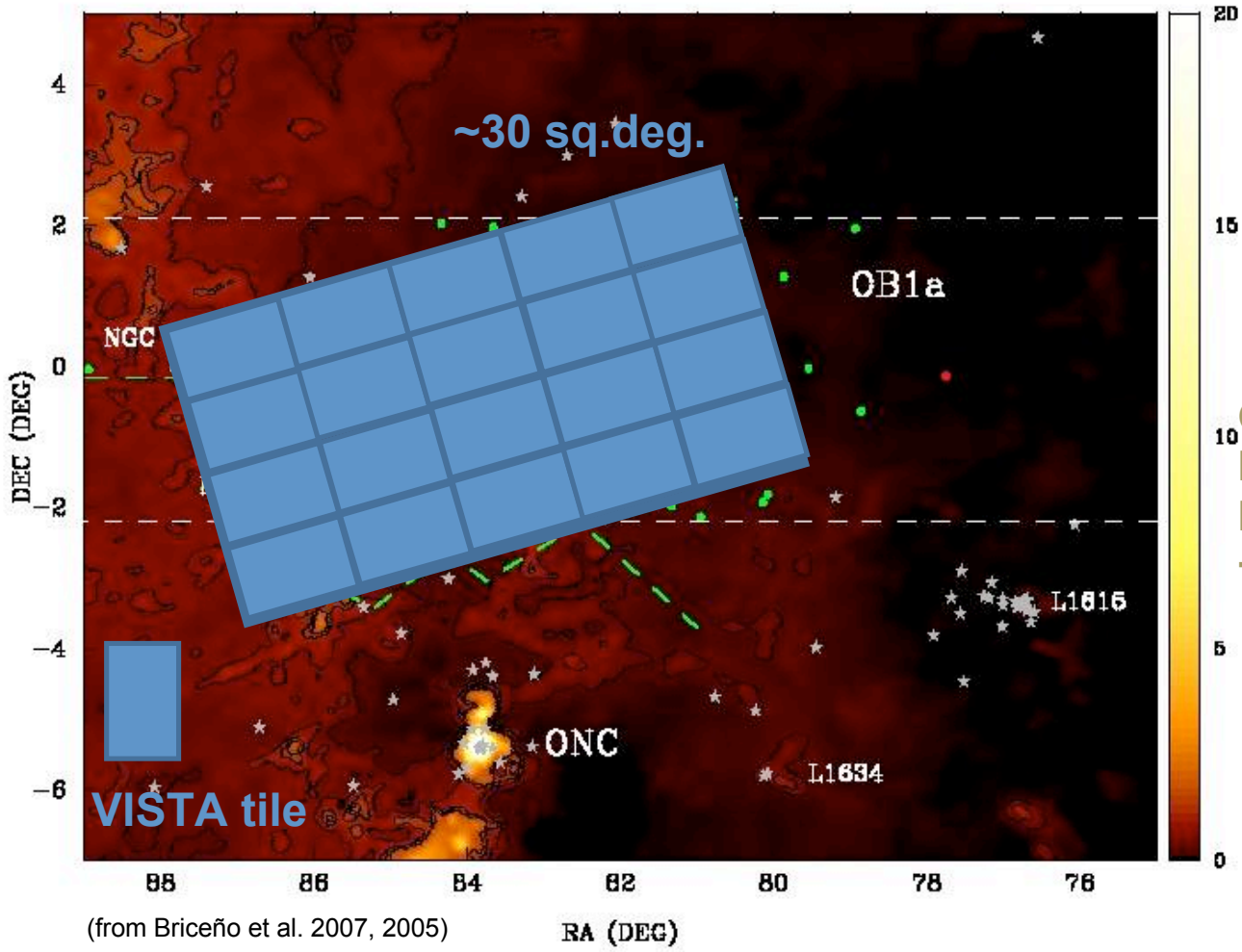
- The very low-mass star/brown dwarf (BD) content as a function of environment (IMF/BD formation)

- Circumstellar (protoplanetary) disk evolution over 1-10Myrs
  → timescale on which giant-planets are formed

- Detail studies of protostars
  → to establish a clear picture of early evolution

→ Infrared wide-field imaging surveys as possible with VISTA are optimal for such large-scale studies

Target area/Orion VISTA survey field: OB 1a/1b association + molecular cloud B (clusters) → spanning ages 10 Myr – 1 Myr



(from Briceño et al. 2007, 2005)

Green dots: wTTauris

Red dots: cTTauris

Grey stars: PMS stars from Herbig-Bell cat. + Alcala et al. 2004

Contour map: Dust emission from Schlegel et al. (1998)

20 VISTA tiles covering ~30sq.deg in YZJHKs

Image deep (!) …

Very low-mass stars and brown dwarfs (BDs)

Large-scale areas/widely dispersed young pop.
(e.g. Ori OB1a/b) not yet fully surveyed

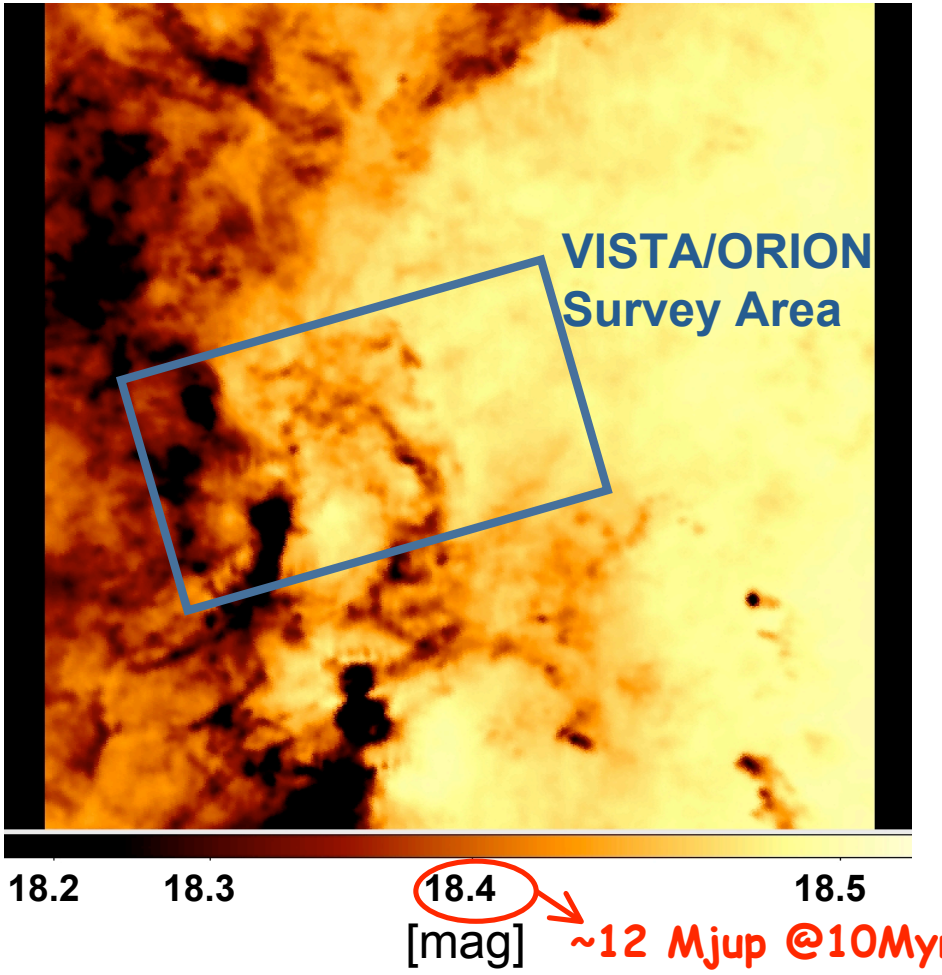
Deep I-band (I~21.5mag) + 2MASS survey (Downes et al. 2008) identified VLMs and BDs down to 50M_{Jup} in Ori OB1a/1b

VISTA Goal:
Deep YZJHKs imaging down to the deuterium burning mass limit
i.e. 12M_{Jup}

→ J~20.2 H~19.2 K~18.4
Z~22.7 Y~21.0
(based on Chabrier et al. 2000, 10Myr, Av=1)

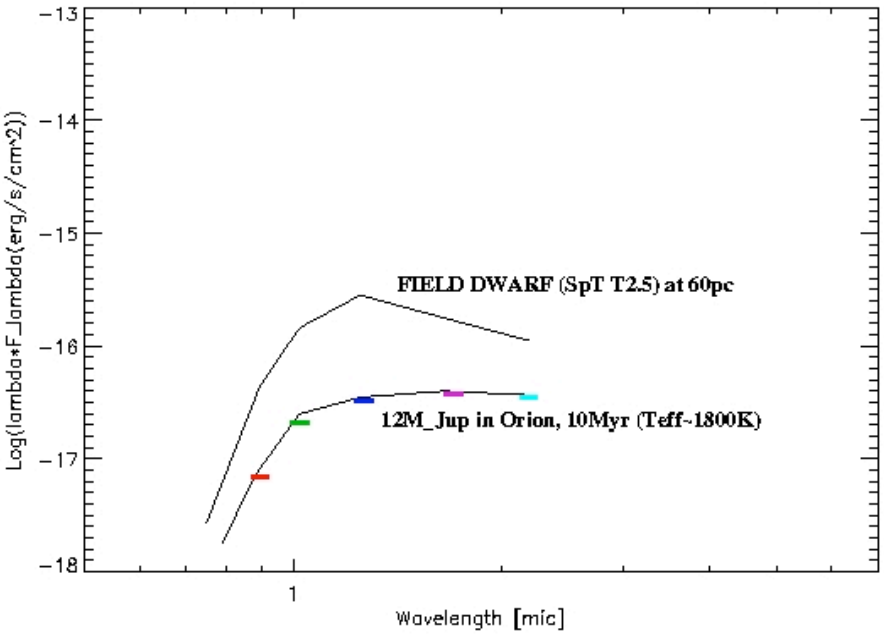
But at 5 Myr: Ks~18.0

Survey Ks-detection limit map



Very low-mass stars and brown dwarfs (BDs)

Observations in all VISTA filters YZJHKs to allow a photometric selection of candidate young Orion low-mass members



SED of a field T-dwarf (Chiu et al. 2008) and of a 12MJup object at 10 Myr

Steep SED slope at wavelength Shorter ~1mic
→ Distiction from reddened background sources

Expected numbers of BDs with [0.012-0.05] Msun:

~300 !

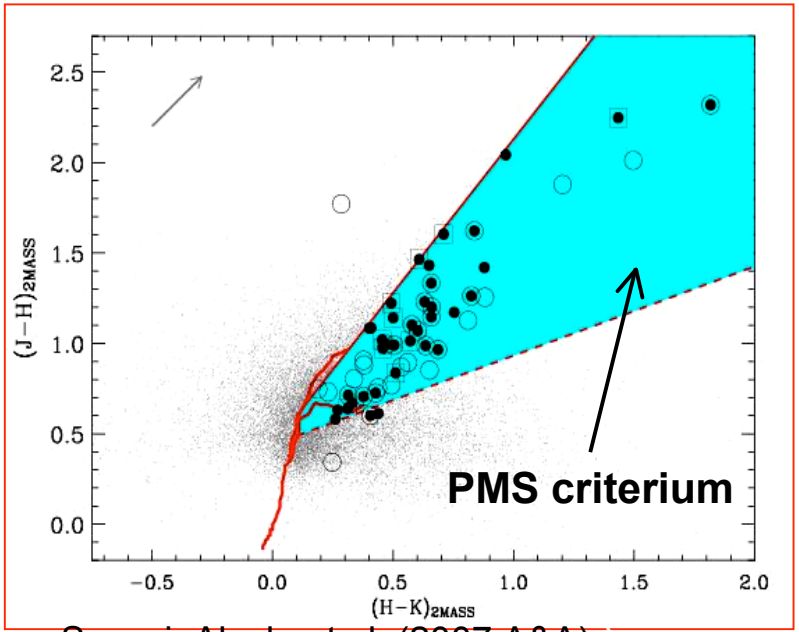
(assuming IMF from Chabrier 2005)

Spectroscopic follow-up for confirmation of youth and membership e.g. with X-shooter

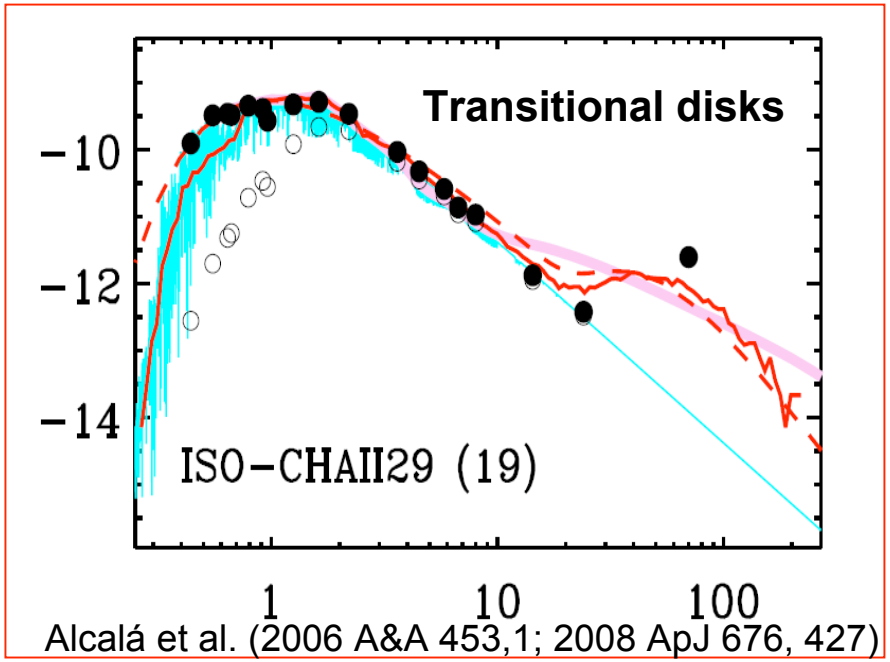
Circumstellar (protoplanetary) disk evolution

- **Selection of young stellar & sub-stellar objects with disks**
  - ⇨ Color-Magnitude & Color-Color diagrams

- **Study Spectral energy distribution (SED)**
  - ⇨ combination with optical and Spitzer data
  - ⇨ search for transitional objects
  - ⇨ disk parameters from accretion and reprocessing disk models
  - ⇨ Central object parameters
  - ⇨ Link between disk and central object parameters



Spezzi, Alcala et al. (2007 A&A)

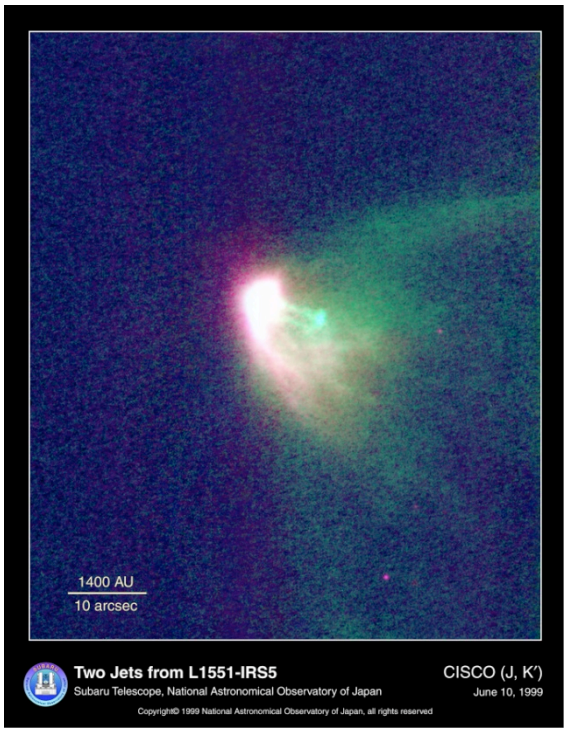


Alcalá et al. (2006 A&A 453,1; 2008 ApJ 676, 427)

Detailed study of protostars

About 350 protostars (class 0 to class I sources), distributed all over the Orion molecular cloud A and B, have been identified by Spitzer imaging (Megeath et al. 2005, Allen et al. 2007)

VISTA Goal: detect and study large extended scattered emission from protostellar envelopes



Multiwavelength modeling of circumstellar envelope.

Evolutionary picture of envelope properties over the lifetime of a protostar.

Observing Strategy

- 20 contiguous VISTA tiles (6 pawprint exposures per tile), plus a few sky frames for the most crowded regions

- Filters ZYJHKs (each tile), with all filters in one OB because of possible variability of young objects

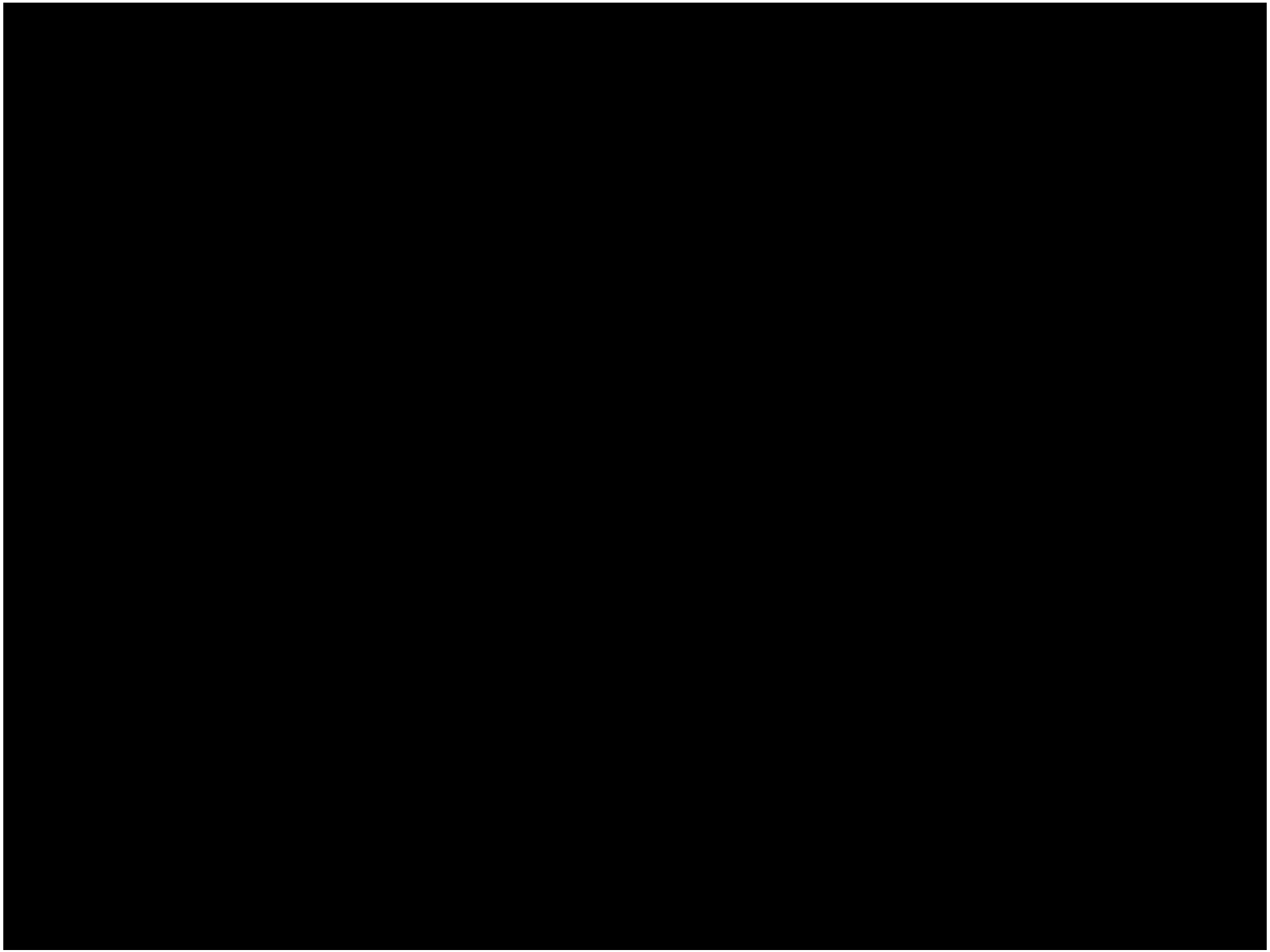
- Detection limits (based on aim to detect 12Mjup/10Myr/400pc/Av=1.0mag)

Filter	Exposure time per tile	Mag limit (Vega)	S/N	Mass detection limit at 5 Myr	Mass detection limit at 10 Myr
Z	2880.0	22.7	5	$8M_{Jup}$	$12M_{Jup}$
Y	960.0	21.0	8	$8M_{Jup}$	$12M_{Jup}$
J	540.0	20.2	8	$8M_{Jup}$	$12M_{Jup}$
H	540.0	19.2	8	$8M_{Jup}$	$12M_{Jup}$
K_s	720.0	18.4	8	$8M_{Jup}$	$12M_{Jup}$

Using VISTA ETC
Seeing 0.8"
Airmass 1.4
N_{jitter}=3-4

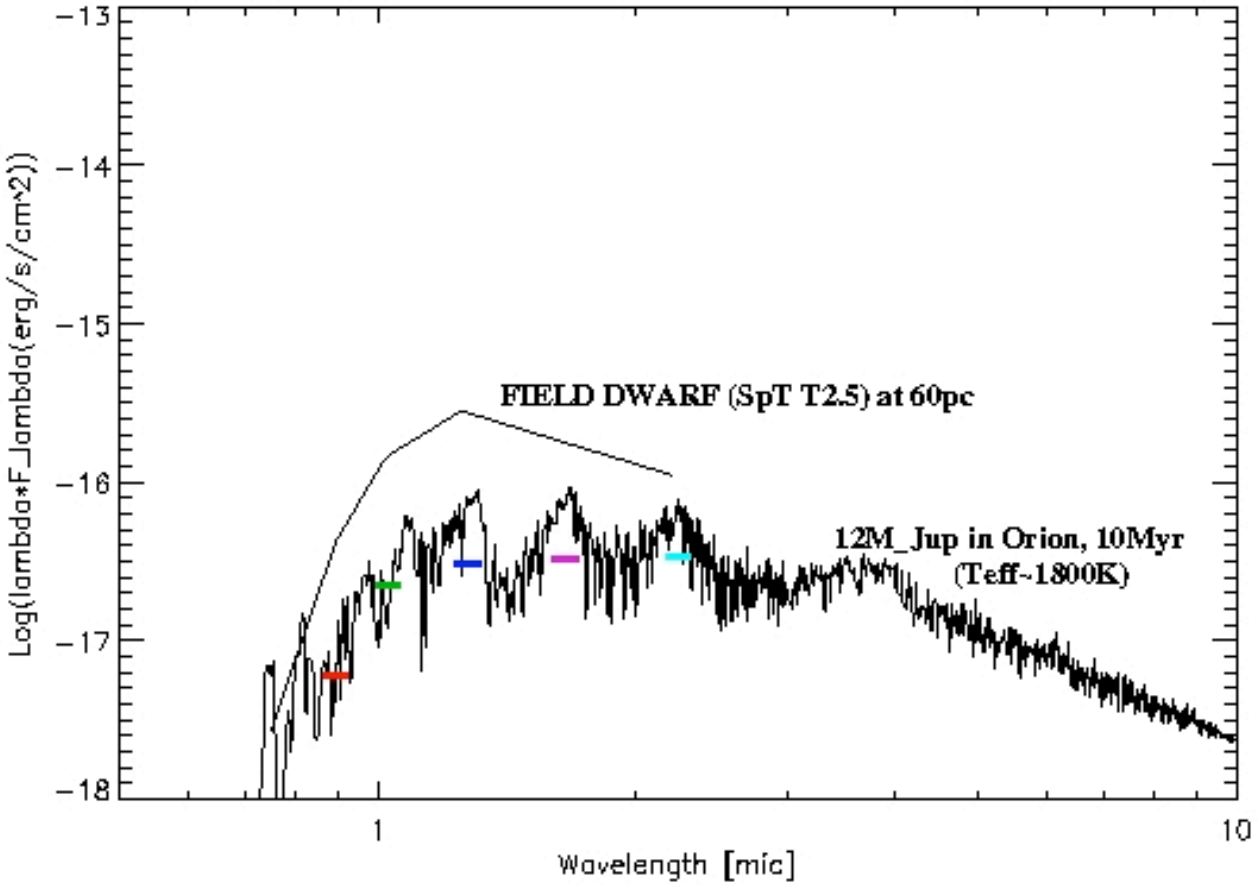
Sum of exp.times + overheads = approx. 2hrs (per OB/or per tile)

→ 40 hrs total observing time



Quality assessment

- **Photometry**
  - ⇨ cross-check with previous data
  - ⇨ CM, CC diagrams
- **Astrometry**
  - ⇨ precision & homogeneity
  - ⇨ cross-check with previous catalogs (2MASS, Spitzer)
- **PSF checks**
- **Limiting magnitude vs. wavelength**
- **Completeness limit vs. wavelength**
- **Star - Galaxy separation**
  - ⇨ morphology
  - ⇨ Spectral energy distribution
- **Source density (stellar and galaxy counts)**



http://weblogs.marylandweather.com/Orion.jpg