The Galactic bulge:
Stellar population and kinematics

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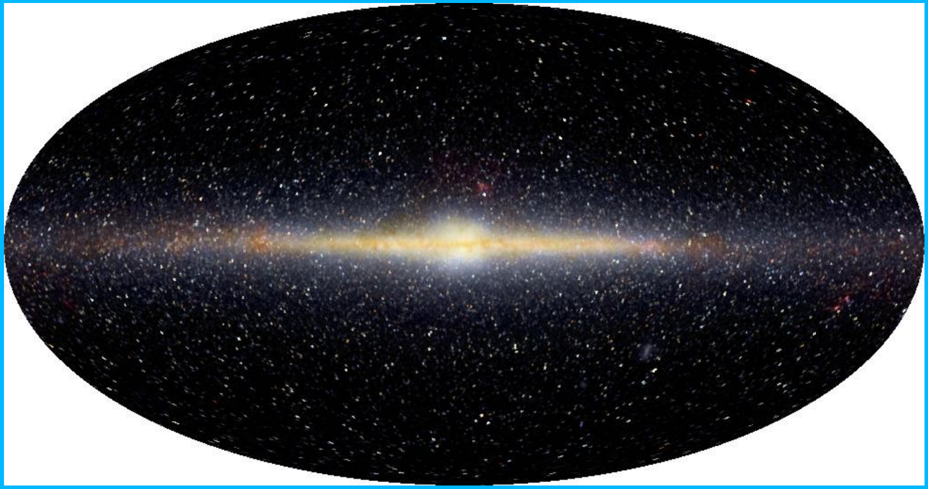
- **Interstellar extinction**
- **Kinematics**
- **Stellar population with WIRCAM**
- **MEGAPRIME+WIRCAM**

Why the galactic Bulge ?

- 75% of the stars are situated in spheroides
- Closest spheroide: the Galactic Bulge
- Understanding of our Bulge: formation et evolution of our Galaxy and extragalactic systems
- The majority of the extragalactic systems do have a Bulge

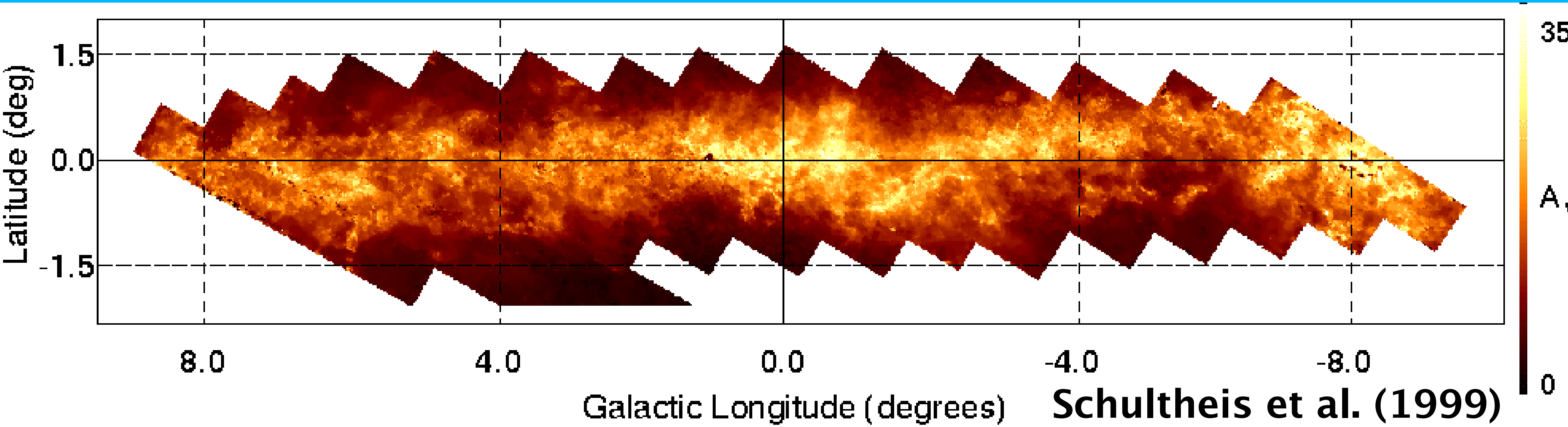


The Galactic Bulge

- Large dispersion in metallicity: $-1.0 < [Fe/H] < 1.0$
  - stellar evolution as a function of [Fe/H]
- The Galactic Bulge is old: 8–12 Gyr
- Stellar density ~ 500 times higher than Galactic disk
- Formation of Bulge? relation with disc, halo?
- Galactic bar with kinematical characteristics
- Star formation rate?
- High interstellar extinction

Interstellar extinction

- **Is the major obstacle to study the Inner Bulge!**
- **A few low extinction fields (Baade's window,SgrI, etc.): optical studies (OGLE, MACHO, etc..)**
- **For Inner Bulge: 2-D extinction maps (DENIS/2MASS)**
  Schultheis et al. (1999), Dutra et al. (2002)



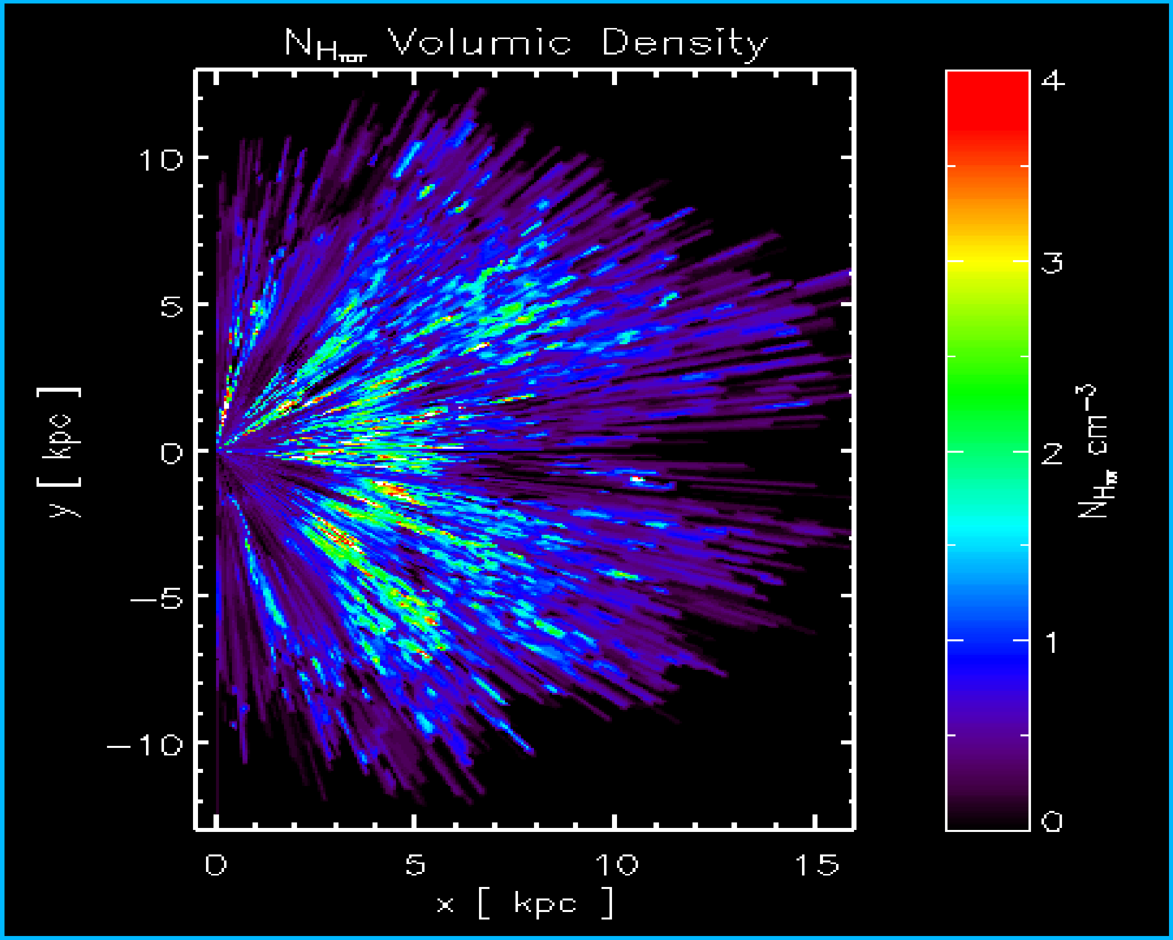
Schultheis et al. (1999)

- **Large uncertainties ($A_V \sim 2{-}3^{mag}$)**
- **Unreliable for Av > 25**
  Þ limit of DENIS/2MASS

3-D maps:

Lopez-Corredoira et al. (2002) - red clump
Drimmel et al. (2003): dust model
Marshall et al. (2004): red giants + Besançon model

Comparison of 2MASS and model of Besançon (Marshall et al. 2004)



- **Near-IR extinction law is still uncertain in J,H,K (~ 20%)**
- **Total extinction: gas + dust?**
- **dust/gas ratio ?**

Interstellar Extinction with WIRCAM

- Much smaller pixel scale than DENIS/2MASS high resolution
- For A_V > 25: reliable extinction determination
- Higher precision in A_V determination by use of M giants: no circumstellar extinction (A_V < 30) !
- With AGB stars: A_V ~40-45 mag

- Limit of A_V ~ 40-45 Þ mid-IR (Spitzer)
- With H-K one gain a little bit in A_V but H-K is sensitive to log g, Z, etc.. Þ complex colour

Kinematics in the galactic Bulge

- Important for models of the Bulge formation
- Determination of the galactic potential
- Galactic bar: closest edge: l=27 and 5-6 kpc from the sun
  farthest edge: l=-12 and 11 kpc from the sun
- Separation of disc/bar population
- Kinematics Û chemical composition
- Rotation of the bulge Û global dynamics (velocity gradient)

Up to now:

- Kinematical studies mainly in Baade's window (Sumi et al. 2003)
- Pixel size of near-IR surveys too large (~2”)
- Complementary studies with MEGACAM for |b| > 0.7
- Proper motion studies on small fields

Kinematics with WIRCAM

K/M giant at 8 kpc and tangential v_T ~25 km/s:

Þ **proper motion of ~ 0.5 mas/year**

Þ At a baseline of 3 years: ~ 1mas/an

Þ **S/N ~ 200 is necessary and seeing < 0.7”**

For K = 17: t = 10 min
For H = 17: t =1h
For J = 17: t = 1h

Sampling of the bulge between l=28 and l=-7 and |b| < 2
total: ~ 180 fields ~ 55 nights + 3 years later: 6 nights (only in K)

Þ **61 nights**

BUT: to achieve this precision special treatment is necessary:
e.g. image subtraction (Alard 2003)

Testing the method:

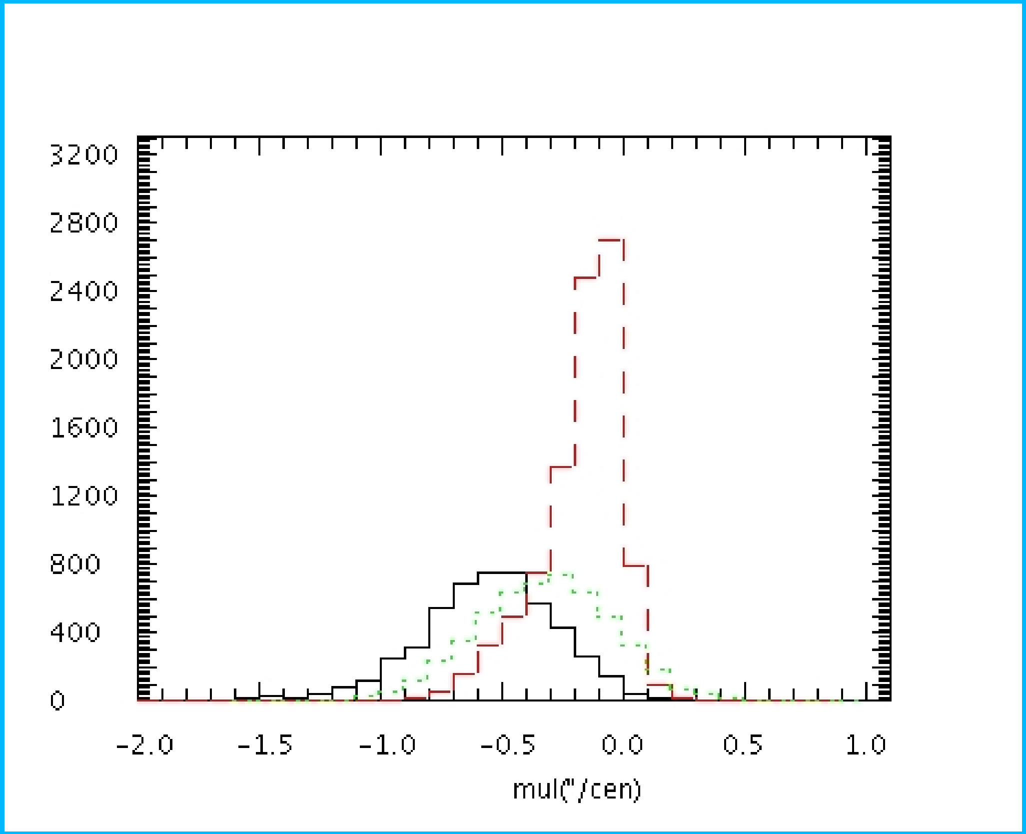
- OGLE data Þ 0.7 mas (Alard 2003)
- MEGACAM data: 20 square degrees of the Bulge, |l| < 5, |b| > 0.5 in r,i,z (10 sq. degree observed in 2004a)

  Þ ~ 0.6 mas

Simulated proper motions

disc population
bulge population
bulge + v_{rot} = 150 km/s

Þ **Determination of the rotation of the bulge + gradient!**

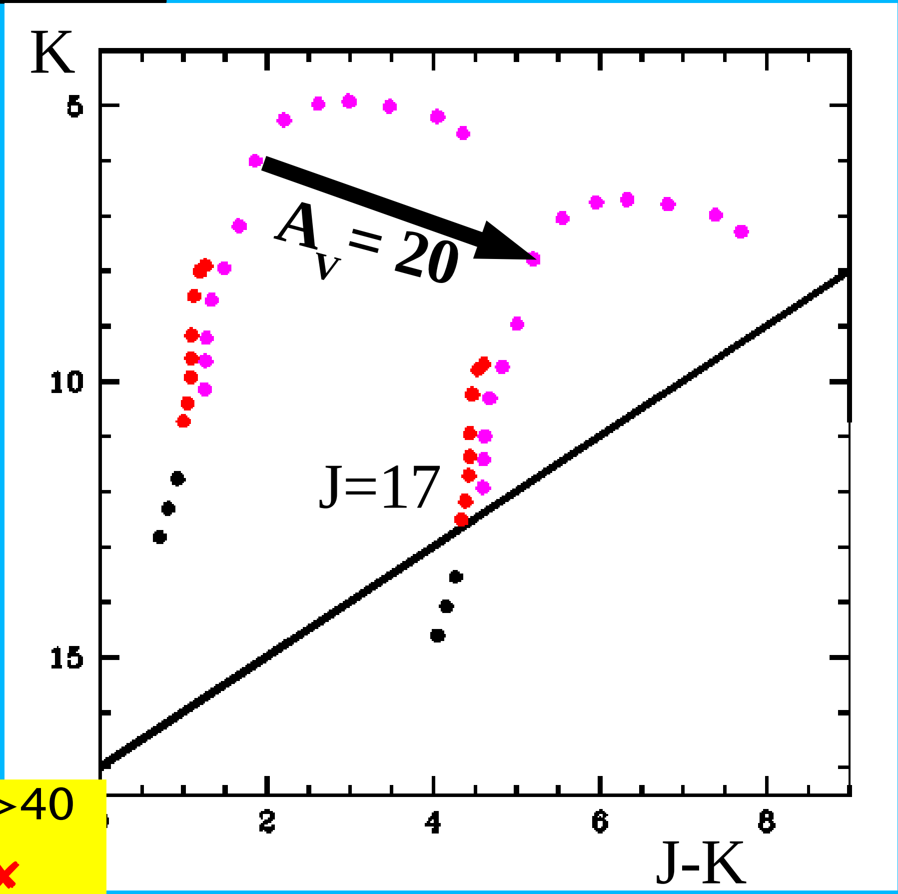


Stellar populations

Simulation for WIRCAM:
for Av=0 et Av=20.0

J = 17

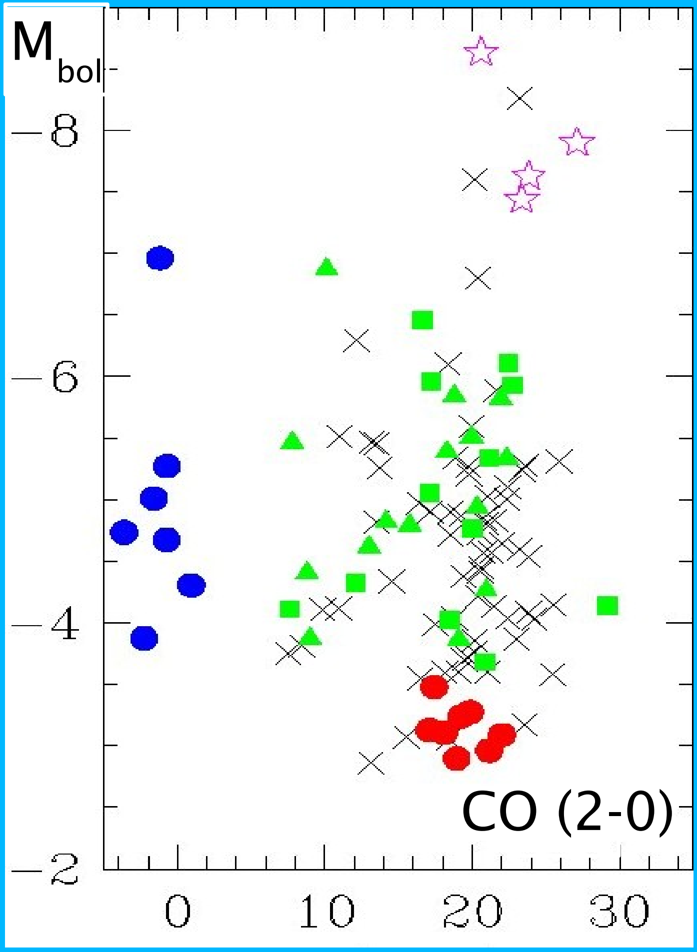
- **M giants: Av < 20**
- **K giants: Av < 12**
- **AGB: Av < 40**



	Av=5	Av=10	Av=20	Av=30	Av>40
K giants	✔	✔	✘	✘	✘
M giants	✔	✔	✔	> M5	✘
AGB	✔	✔	✔	✔	✘
Supergiants	✔	✔	✔	✔	✔
PN	✔	✔	?	✘	✘
YSO	✔	✔	?	✘	✘

With WIRCAM: large proportion of disc M dwarfs
Þ H filter necessary!

Schultheis et al. (2003)



- Luminosity function in the Bulge
- Initial mass function
- Confrontation with stellar population synthesis models
- Star formation history
- Age distribution
- Metallicitiy distribution and gradient?

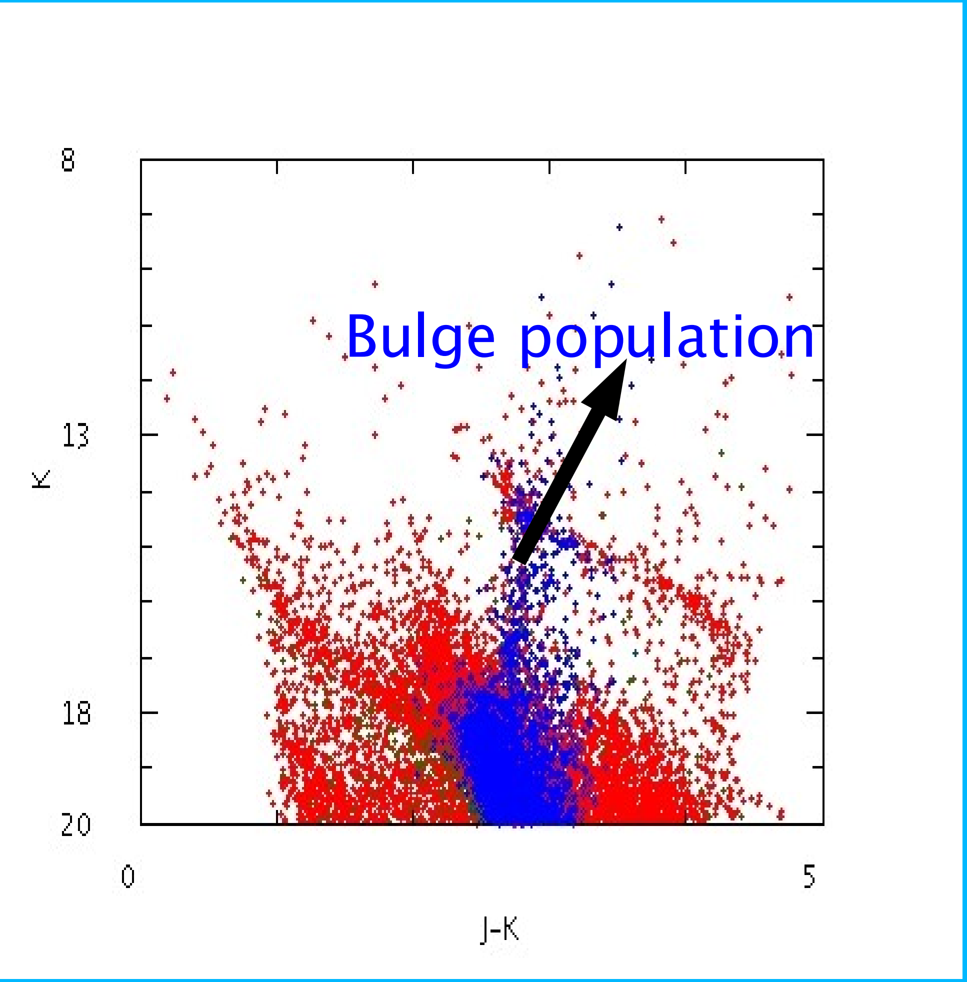
difficult with broad-band filters, narrow band filters (Na, Ca) + spectroscopic follow-ups

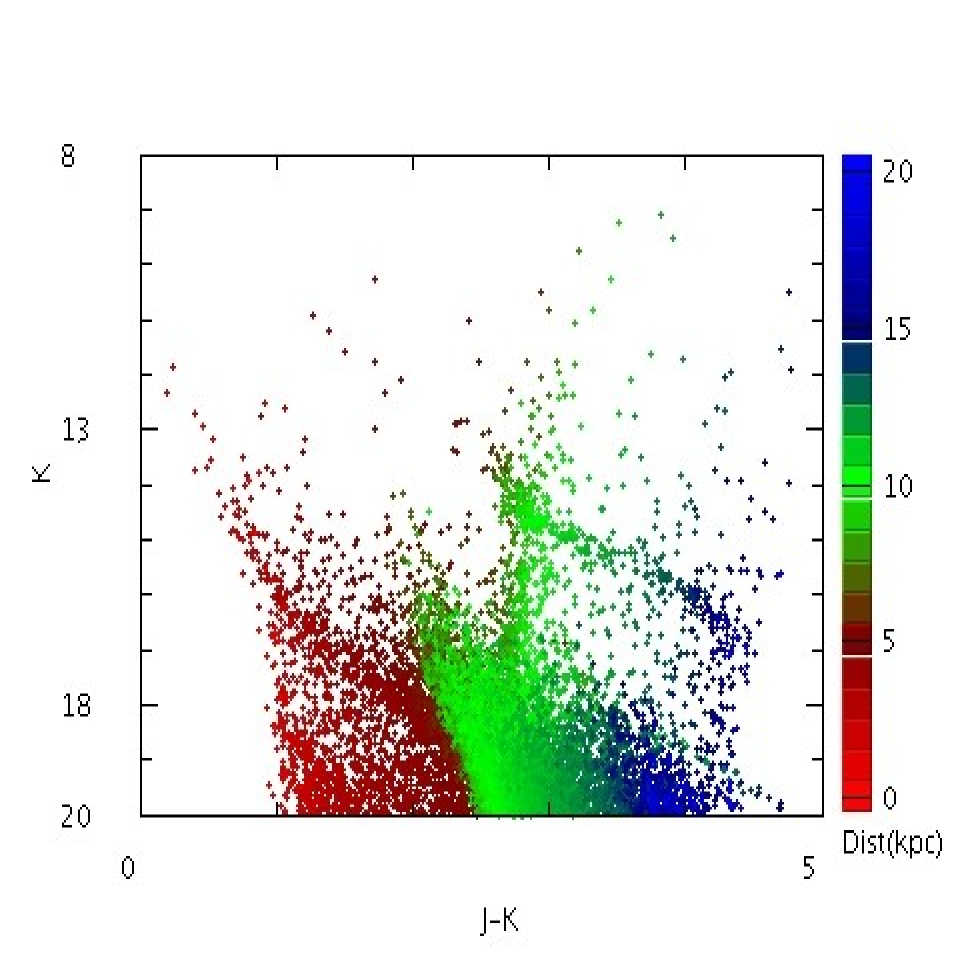
To separate stellar populations in high extincted regions: need of additional narrow band filters (CO, H_2O, Br)

What do we expect from WIRCAM ?

Simulations with the Besançon model (Robin et al. 2003)

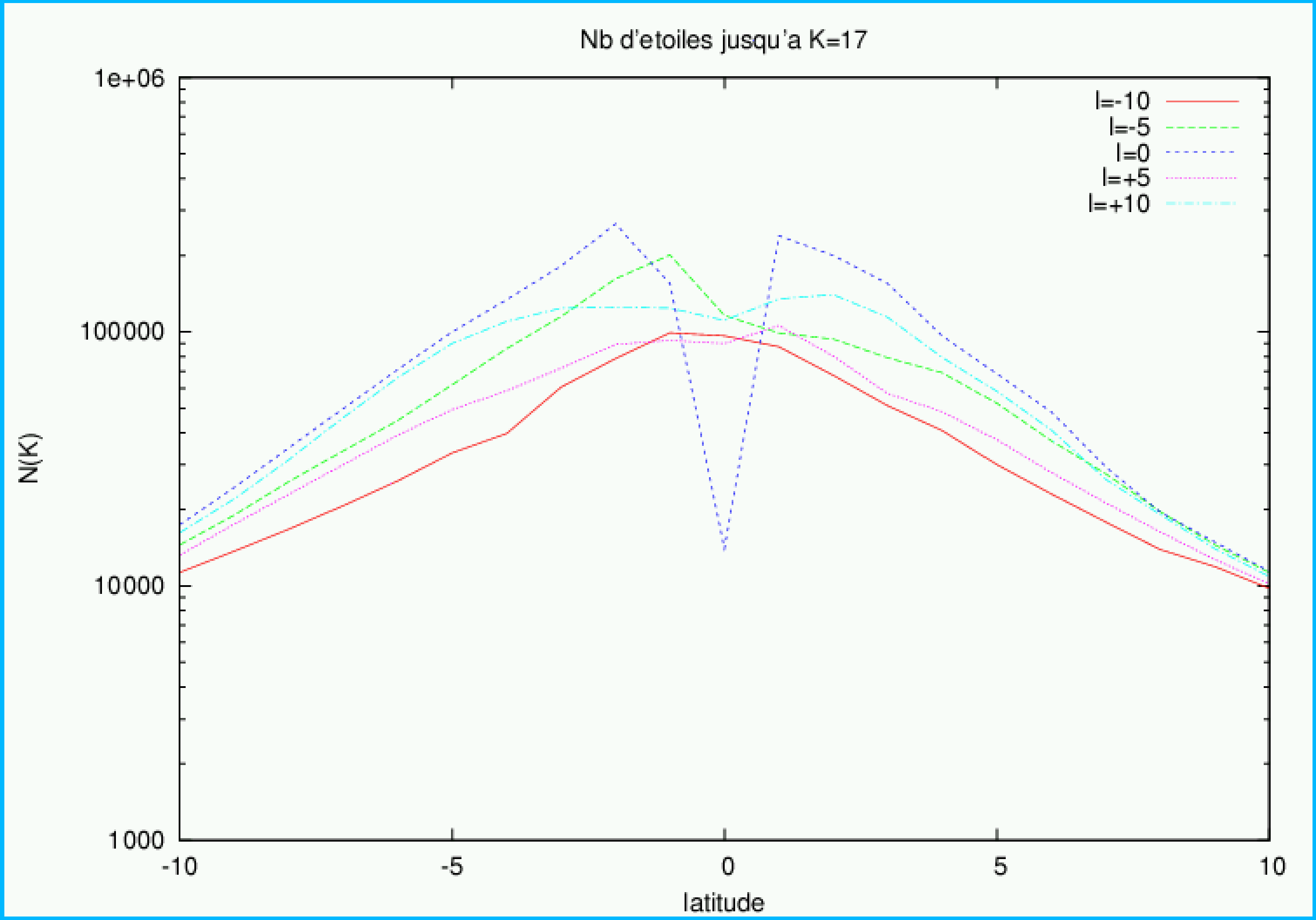
- extinction model of Drimmel et al.
- Field: l =-5, b = -0.7, 0.1 sq. degree

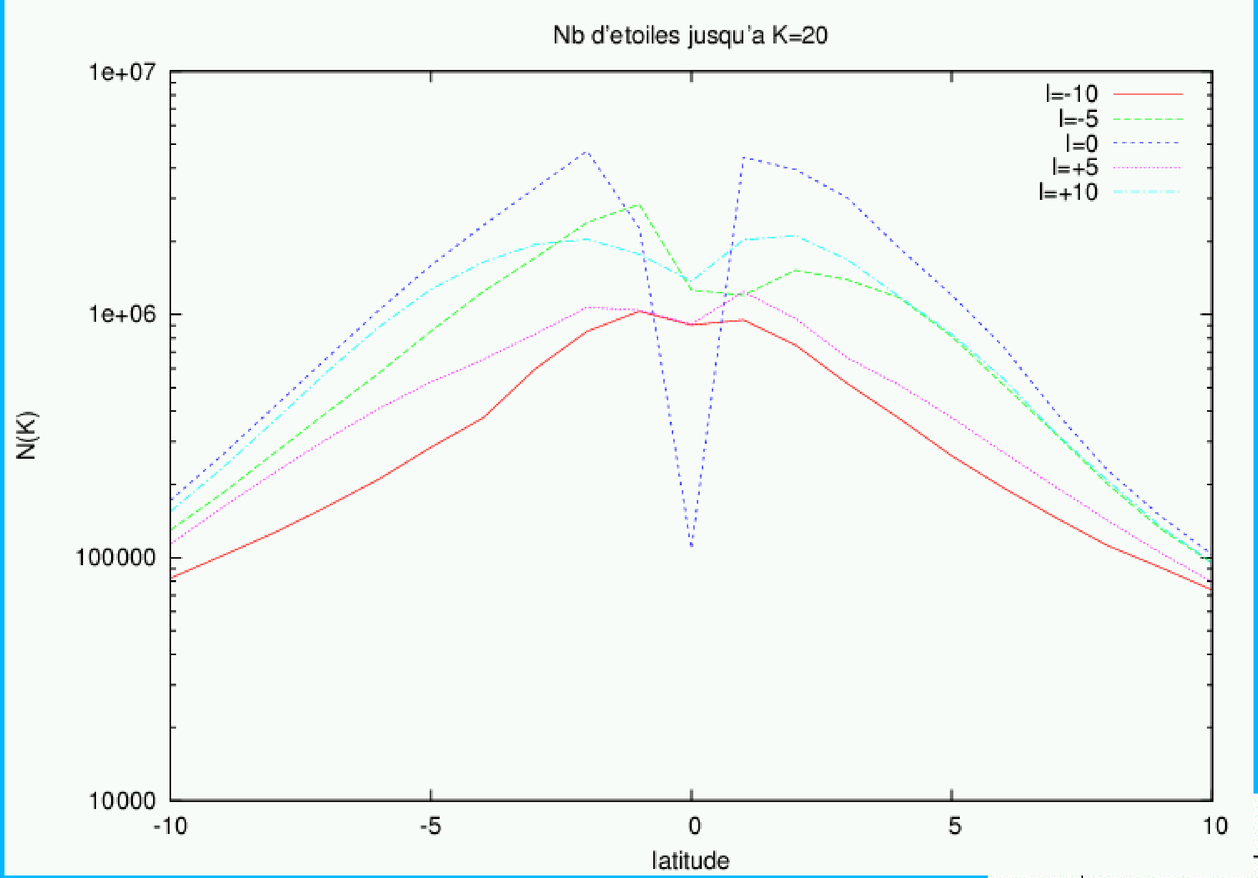




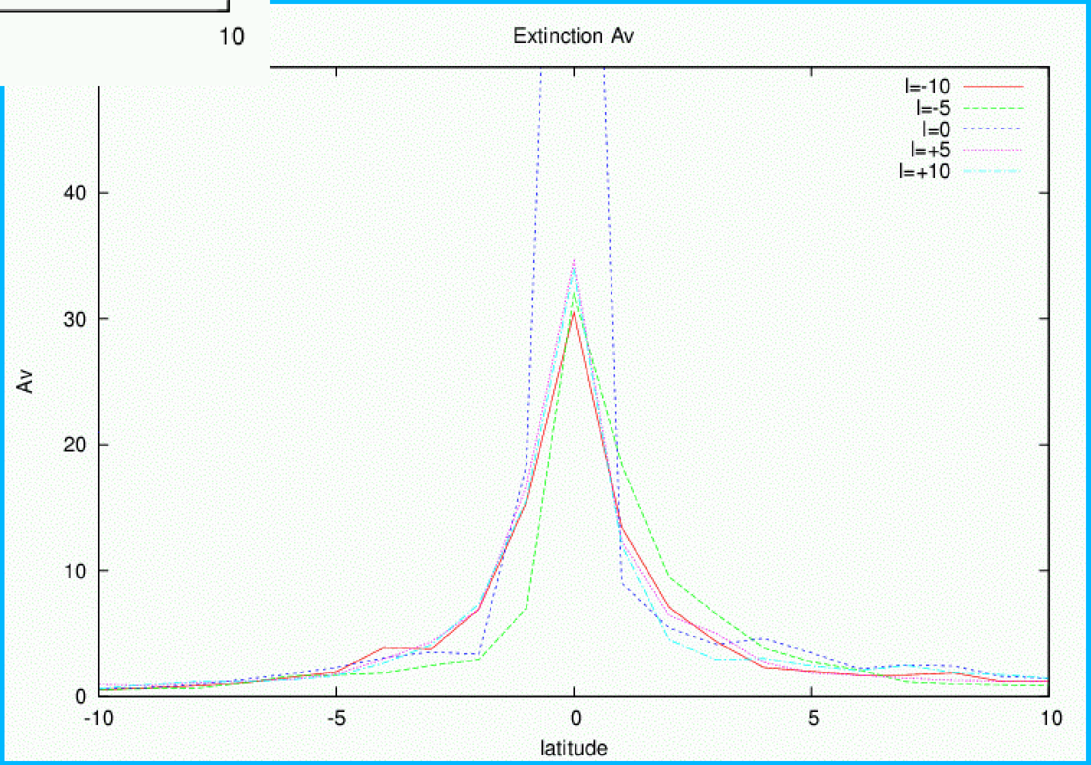
Number densities for a typical WIRCAM field based on the Besançon model

depend on extinction model (Drimmel)





Crowding problem
only for K=20
at l=0 and b=1-2 deg



WIRCAM and MEGAPRIME

- Multi-wavelength studies for better characterize the SED
- MEGACAM filters sensitive to metallicity and gravity
- WIRCAM for mass-loss, extinction

General remarks:

- Stellar populations are **probes of photometric calibration** (CFHTLS)
- Besançon models can be served globally as calibration check!
- CFHTLS + WIRCAM: resolves problem of contamination of galaxies!
  Þ Need of clean stellar and non-stellar catalogs!
- PSF photometry is essential, especially for crowded fields and proper motions!
- In crowded fields: problem with cross-identification !