Stellar Populations: the Case for a GSMT

Knut Olsen, with input from Bob Blum, Mike Bolte, François Rigaut, and Steve Strom

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Motivation

In what order did the components of galaxies form? What are the star formation and chemical enrichment histories of typical elliptical, spiral, and dwarf galaxies, and how are they related?

- Models predict that bulges formed before disks, apparently confirmed by observations of integrated light (e.g. Abraham et al. 1999, Ellis et al. 2001)

- Milky Way has guided our thinking on these questions: old, metal-poor halo (formed by minor mergers with dwarfs?); old, metal-rich bulge and center; old, mildly metal-poor thick disk; younger (perhaps), more metal-rich thin disk

What is the IMF in star forming regions with a range of density and mass?

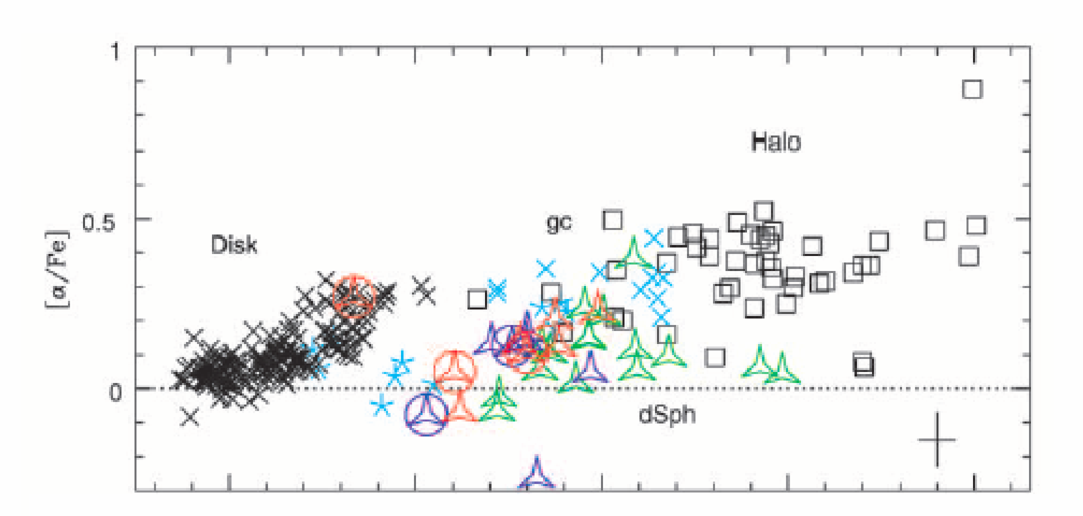
- e.g. Sirianni et al. (2000)

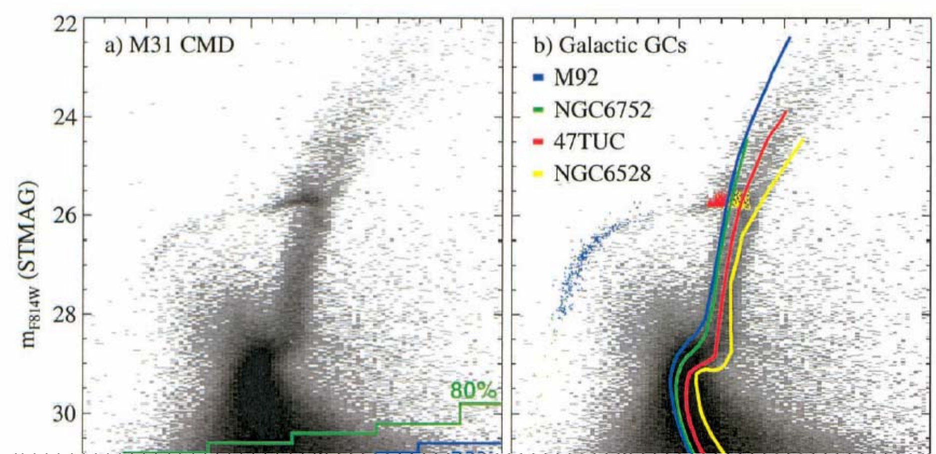
Recent results throw interesting light on this question:

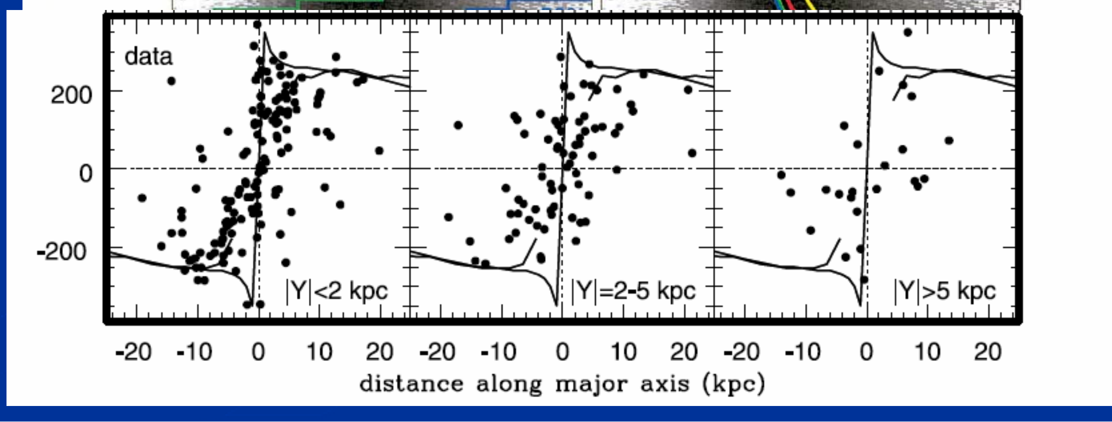
•Difficult to make Milky Way halo out of dSph galaxies (Tolstoy et al. 2003)

•M31 halo has intermediate metallicity and substantial intermediate age contribution (Brown et al. 2003)

•M31 also has a thin disk of presumably old globular clusters (Morrison et al. 2004)







Crowding

•Crowding vs. sensitivity

Imaging: J=30.0, K=28.2 in 10^5 s (S/N=10)

Spectroscopy: H=25 (R=3000, S/N=10) in 5x2000 s

R=21.5 (R=25000, S/N=10) in 5x2000 s

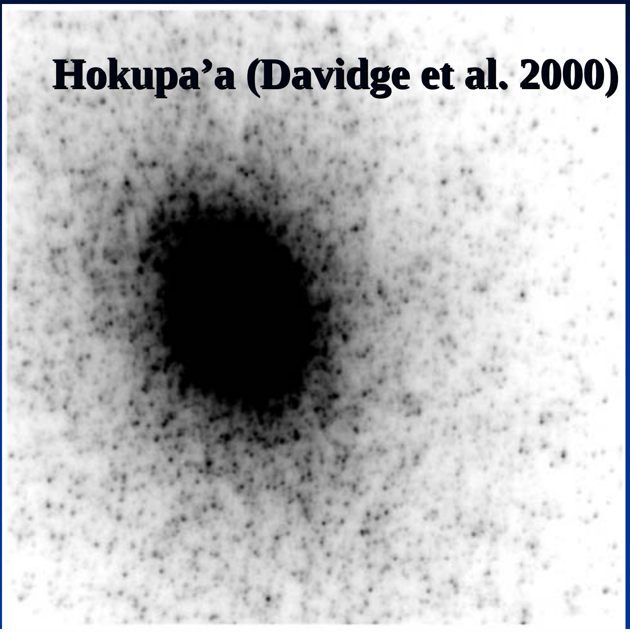
$$\Sigma_m > 2M - 2.5\log(\frac{4}{\pi}(\frac{\sigma_m}{1.086 a_{\mathrm{res}}})^2 \frac{\int_{M_{lo}}^{M} 10^{-0.4M'} N(M')dM'}{\int_{M_{lo}}^{M} 10^{-0.8M'} N(M')dM'}) + (m-M)_\circ$$

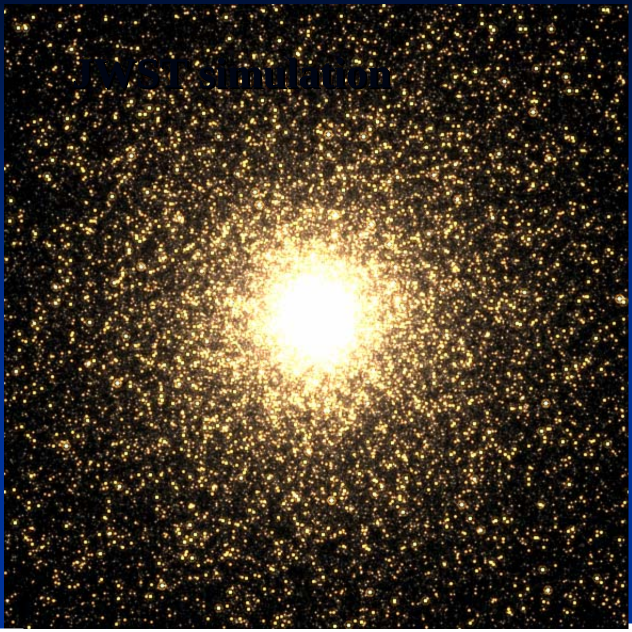
•What Strehl can we live with?

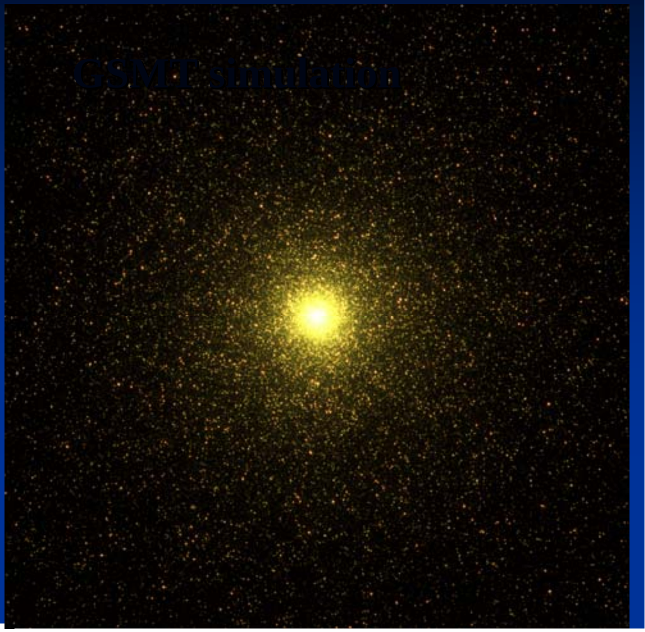
•Lower Strehl only raises the sky background

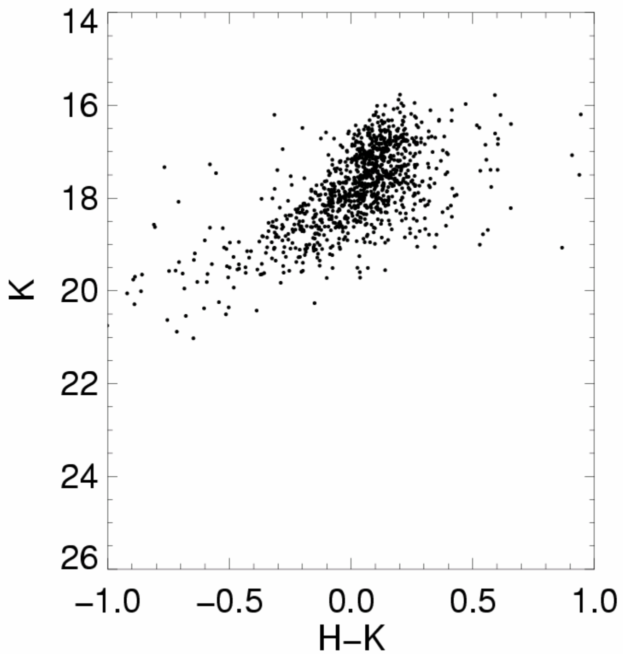
•Difficult or impossible to measure the contribution from the PSF halo

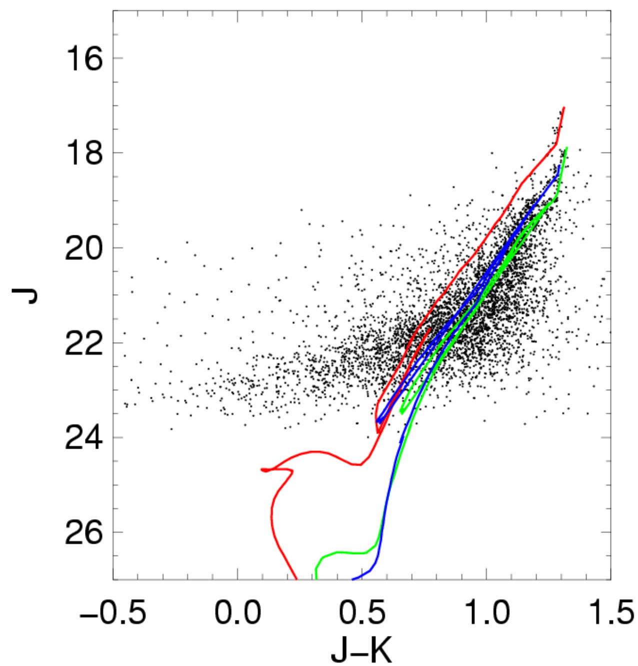
The Center of M32

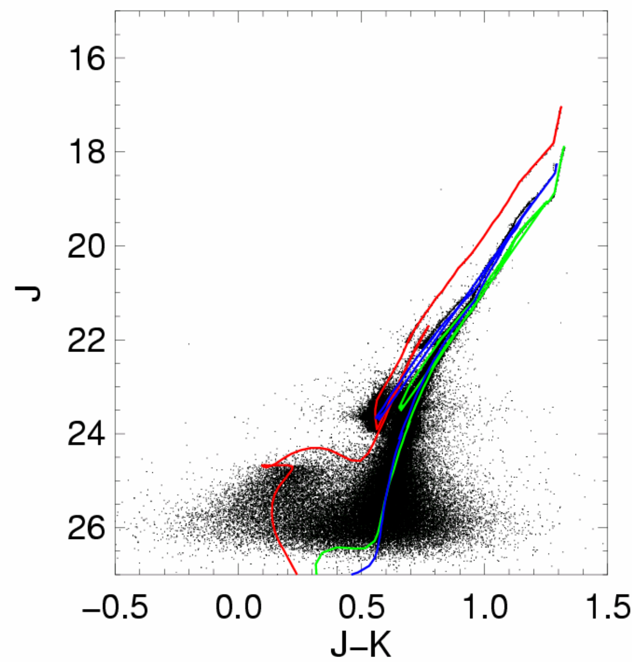








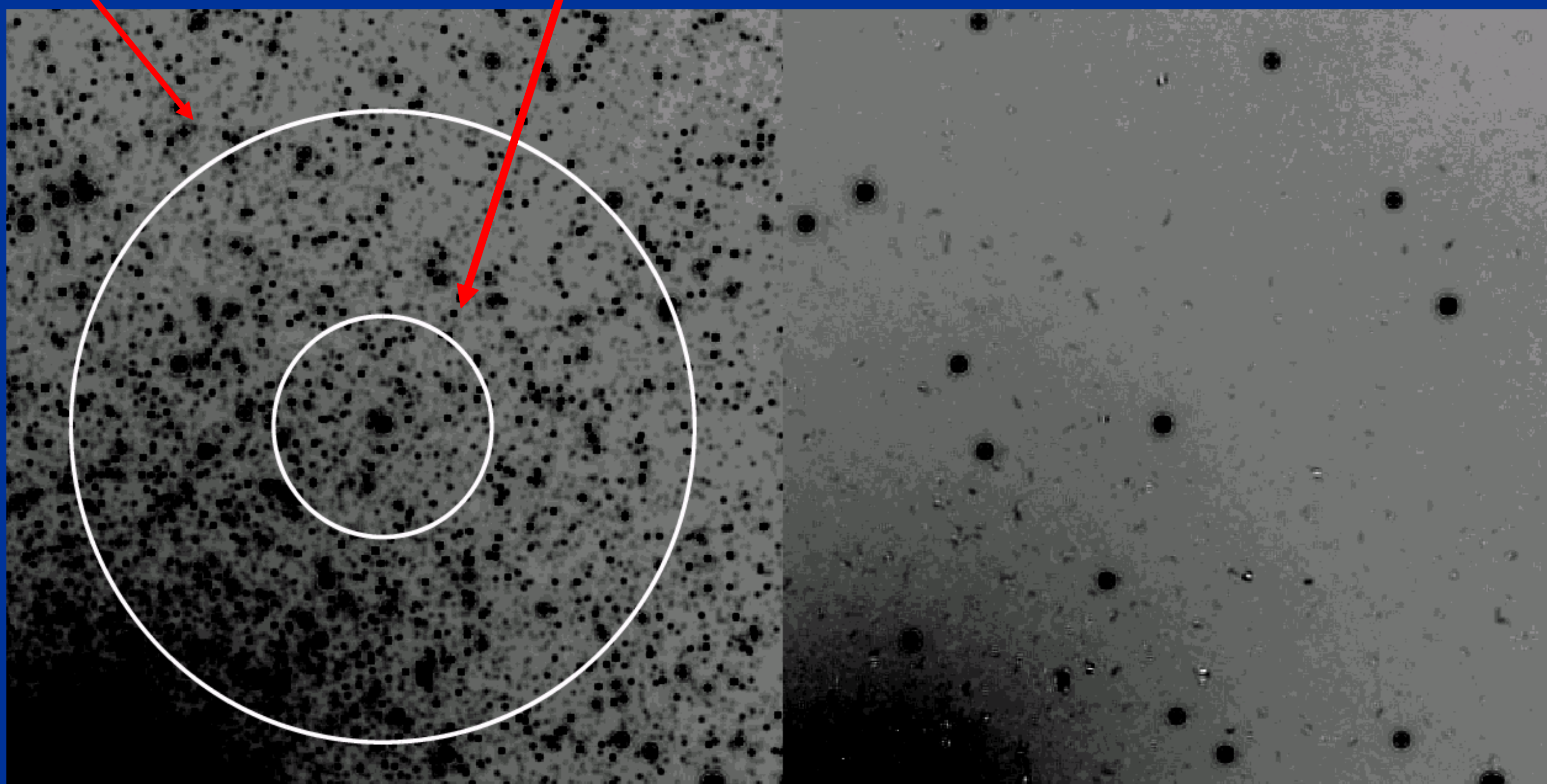




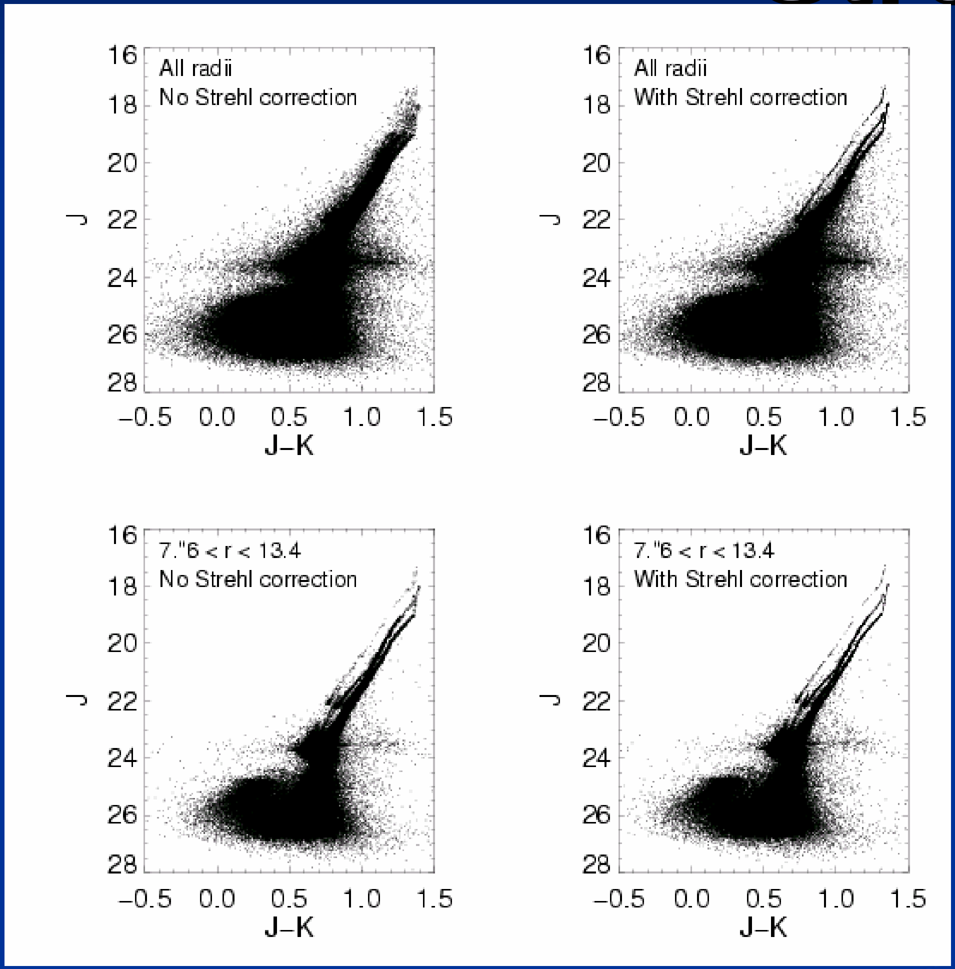
Why aperture corrections are difficult

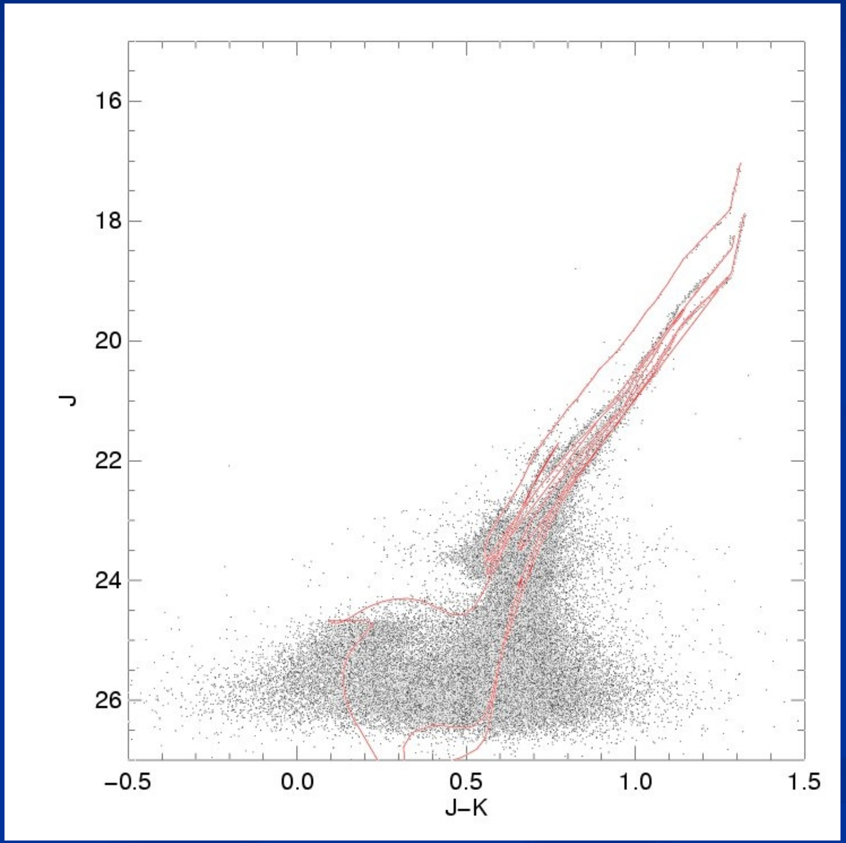
Radius for 5% *absolute* photometry

Radius for 2% *relative* photometry



Photometry with variable Strehl



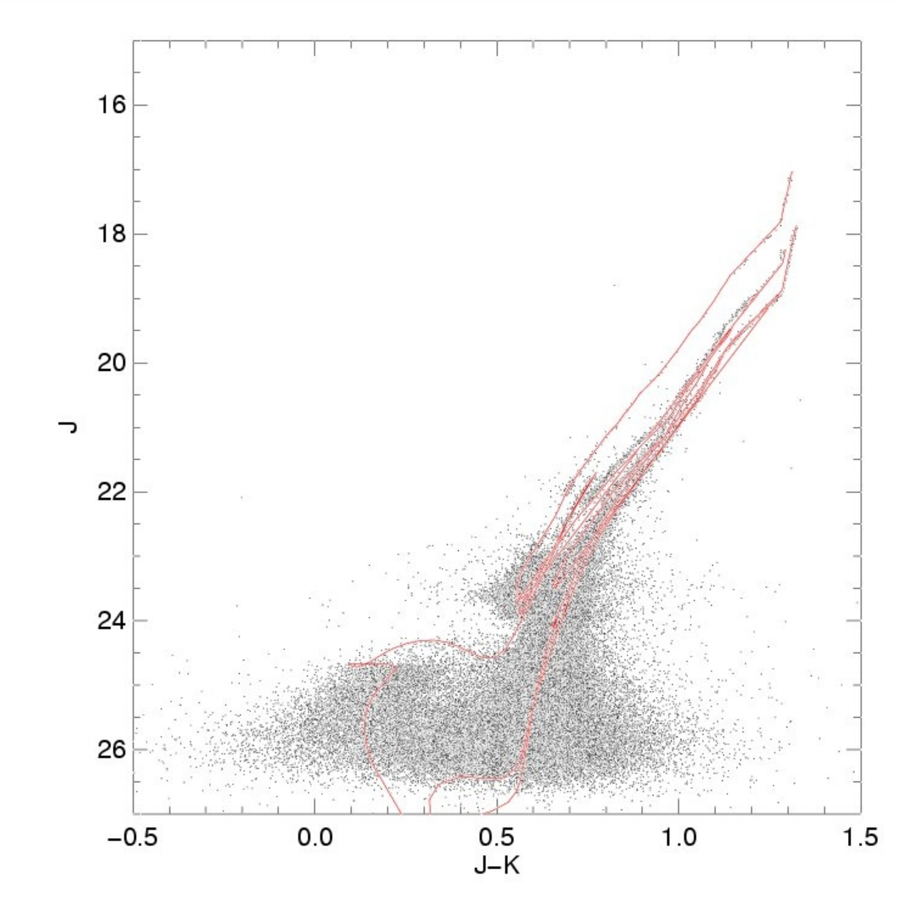


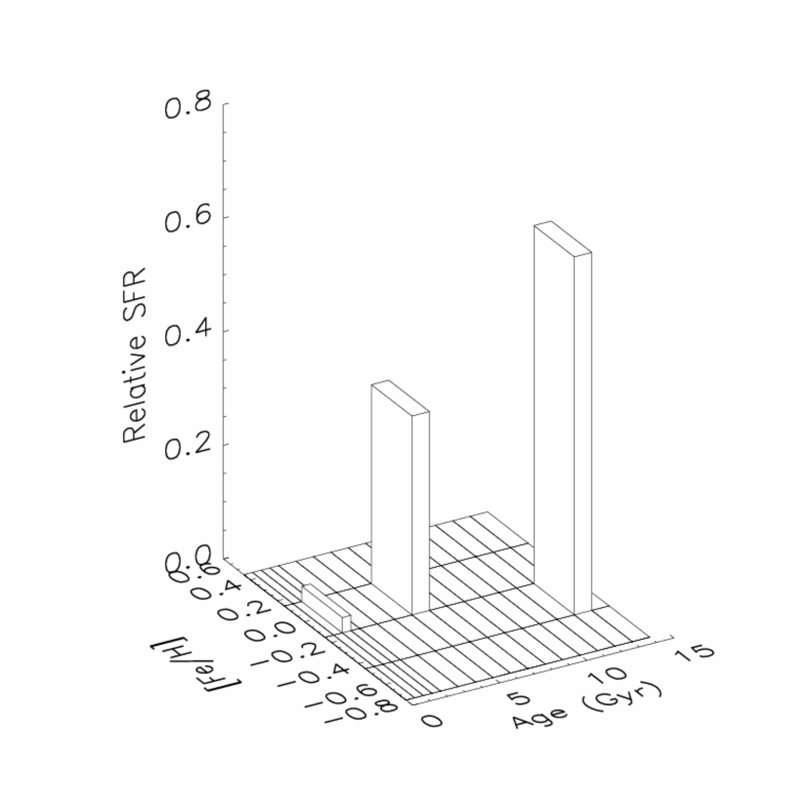
PSFs from Brent Ellerbroek

Uniform Strehl

80 - 85% Strehl in K, 50 - 62% in J

Measuring star formation and chemical enrichment histories





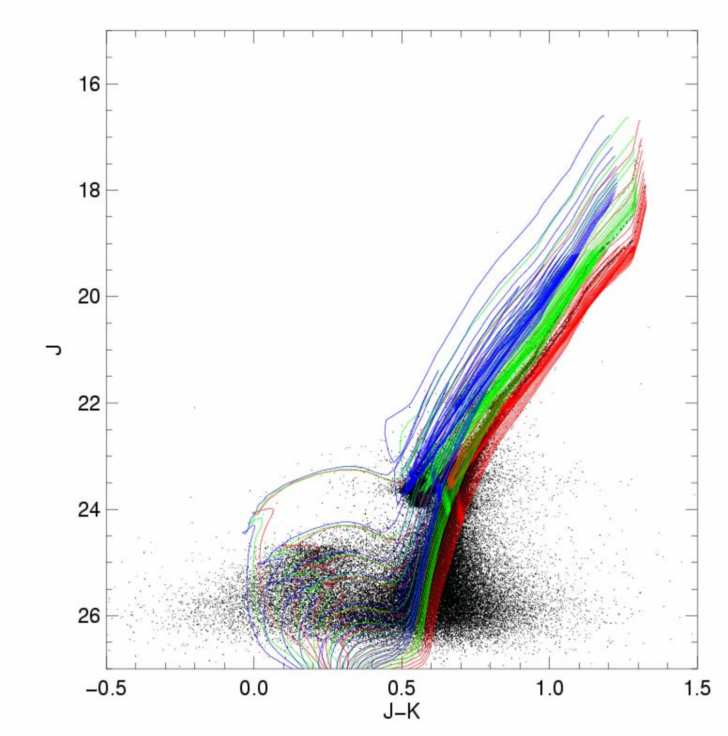
Uniform Strehl photometry

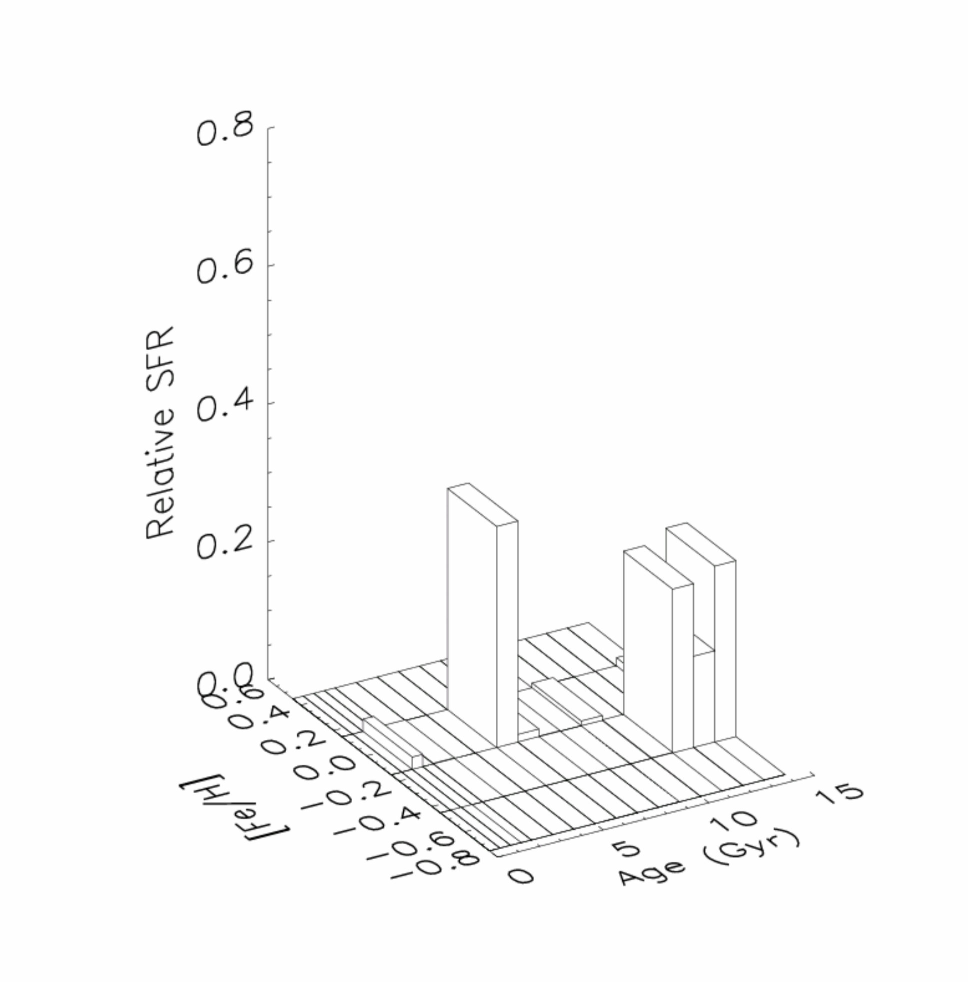
3% 1 Gyr/[Fe/H]=0.0

35% 5 Gyr/[Fe/H]=0.0

62% 10 Gyr/[Fe/H]=-0.3

Results





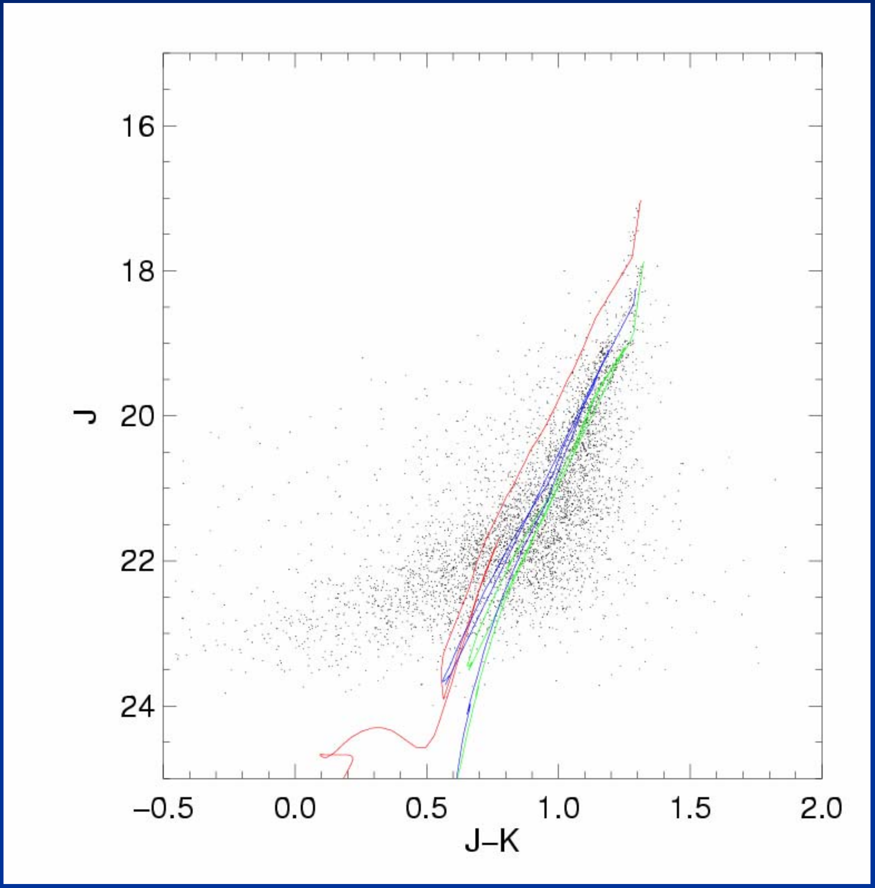
- Maximum likelihood method of Dolphin (1997)
- 45 model isochrones with ages from 0.5 - 13 Gyr and [Fe/H]=0.0,-0.3,-0.6 compared with data
- Analytical photometric errors from Olsen, Blum, & Rigaut (2003; astro-ph/0304163)

2% 1 Gyr/[Fe/H]=0.0

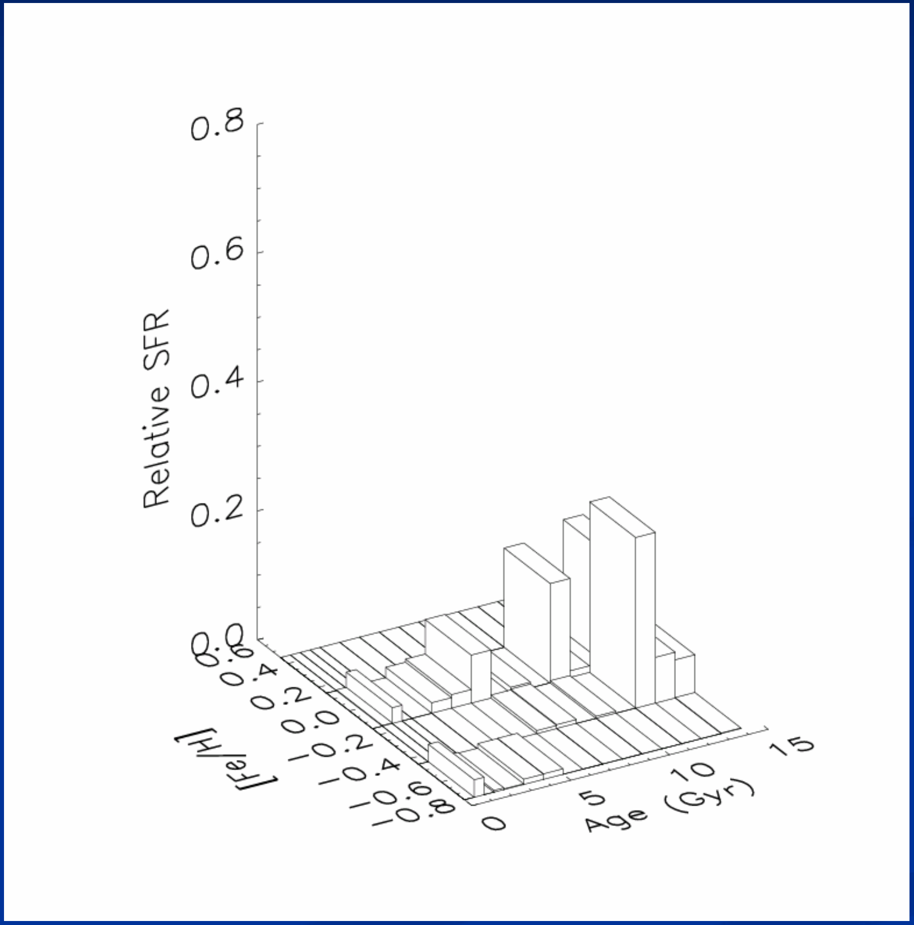
34% 5 Gyr/[Fe/H]=0.0

64% 10+/-1 Gyr/[Fe/H]=-0.3

30-m vs. 8-m



8-m NGST

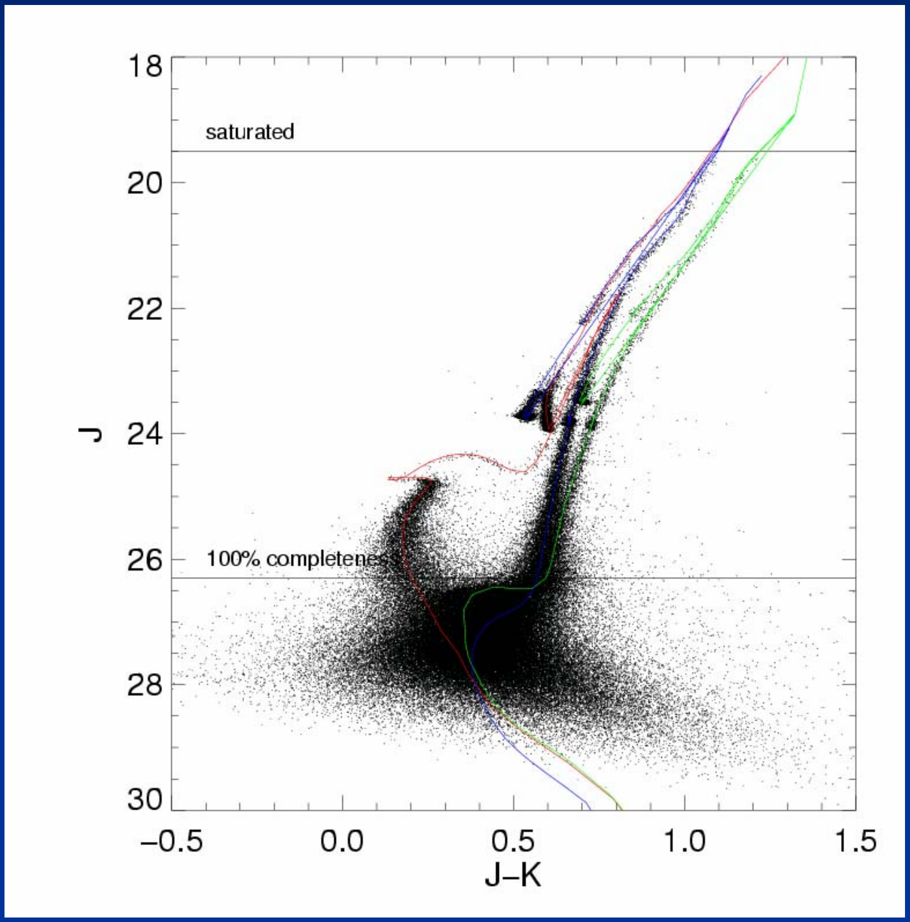


5% 0.5--1 Gyr/[Fe/H]= -0.6 -- 0.0

15% 3--7 Gyr/[Fe/H]=0.0

80% 9--13 Gyr/[Fe/H]=-0.3 -- 0.0

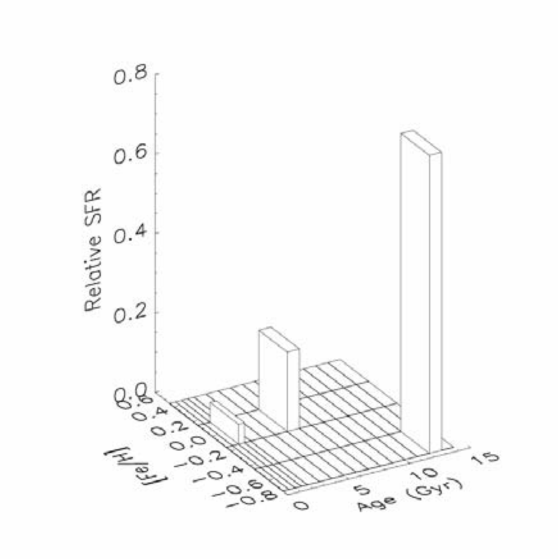
The Bulge of M31



5% 1 Gyr/[Fe/H]=0.0

20% 5 Gyr/[Fe/H]=0.0

75% 12 Gyr/[Fe/H]= -0.6

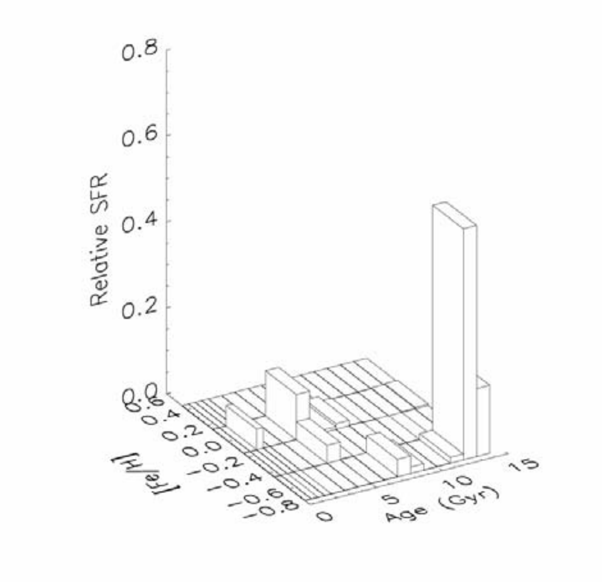


5% 1 Gyr/[Fe/H]=0.0

15% 4 Gyr/[Fe/H]=-0.3 -- 0.0

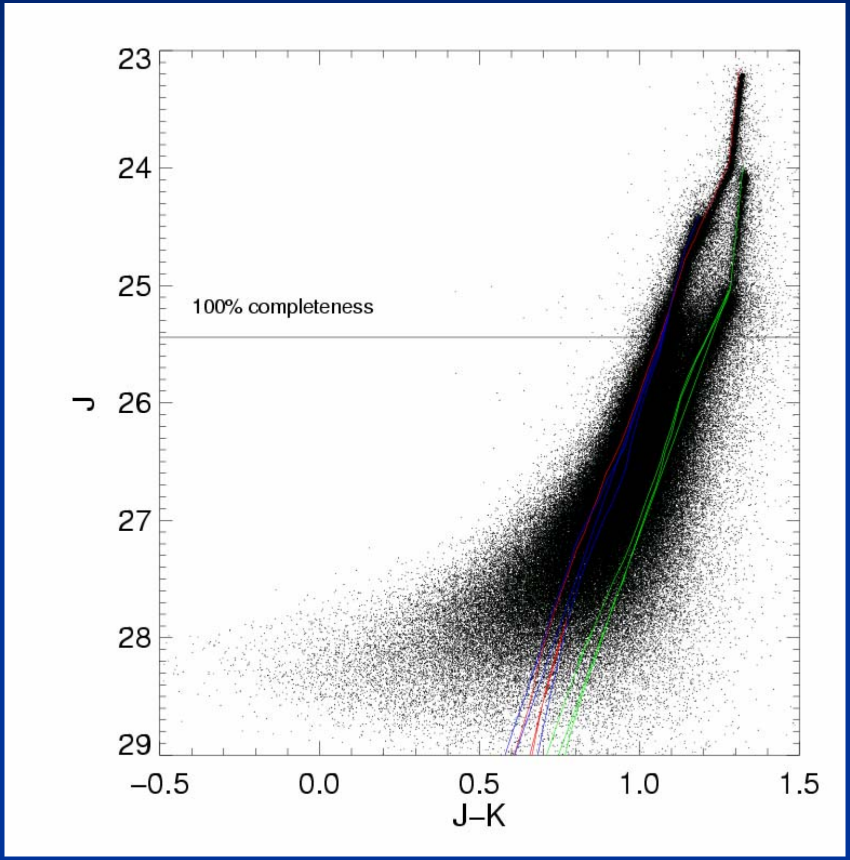
5% 7 Gyr/[Fe/H]=-0.6

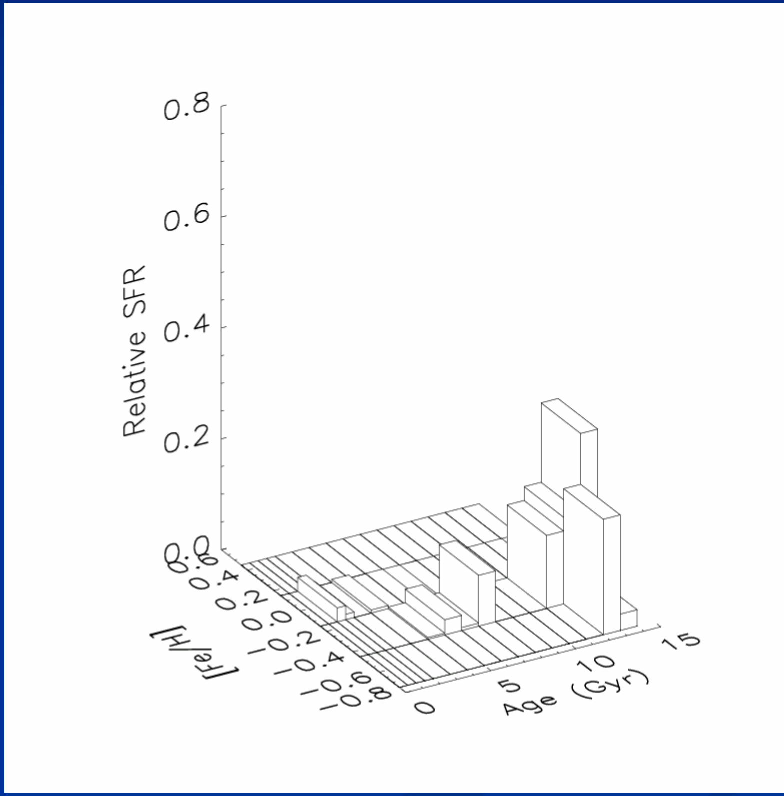
75% 12+/-1 Gyr/[Fe/H]= -0.6



Includes differential reddening

The Effective radius of NGC 3379





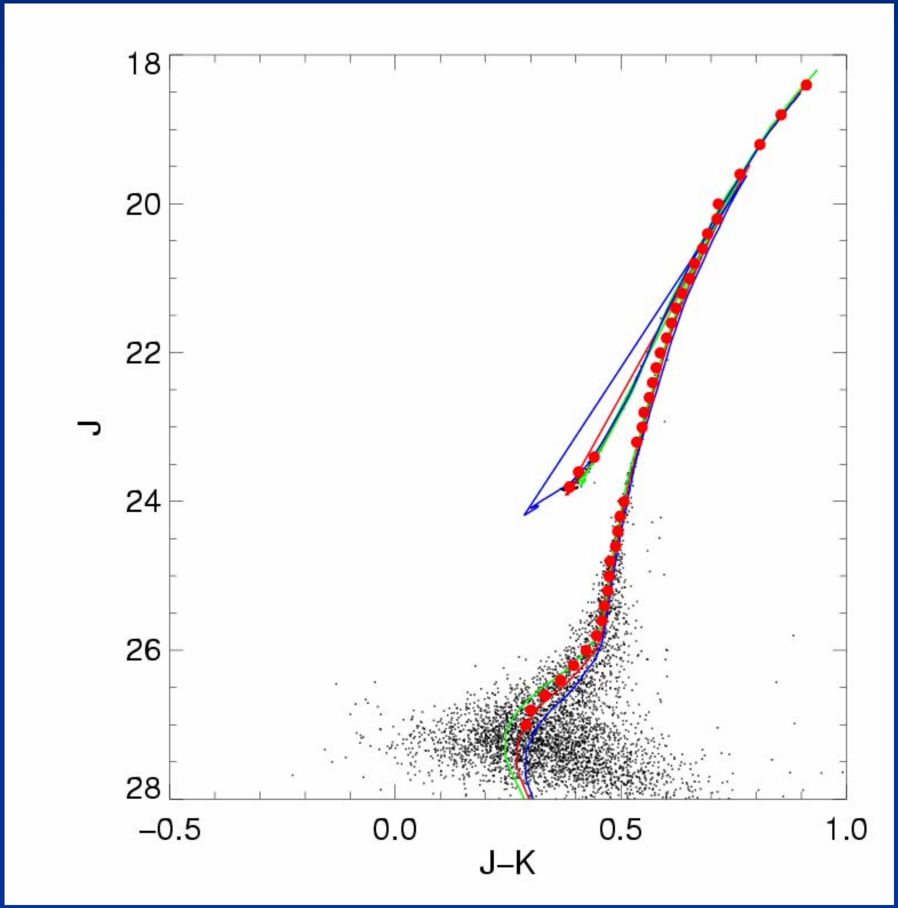
4% 1+/-0.5 Gyr/[Fe/H]=0.0

12% 5--7 Gyr/[Fe/H]=-0.3

84% 12+/-1 Gyr/[Fe/H]= -0.6 -- -0.3

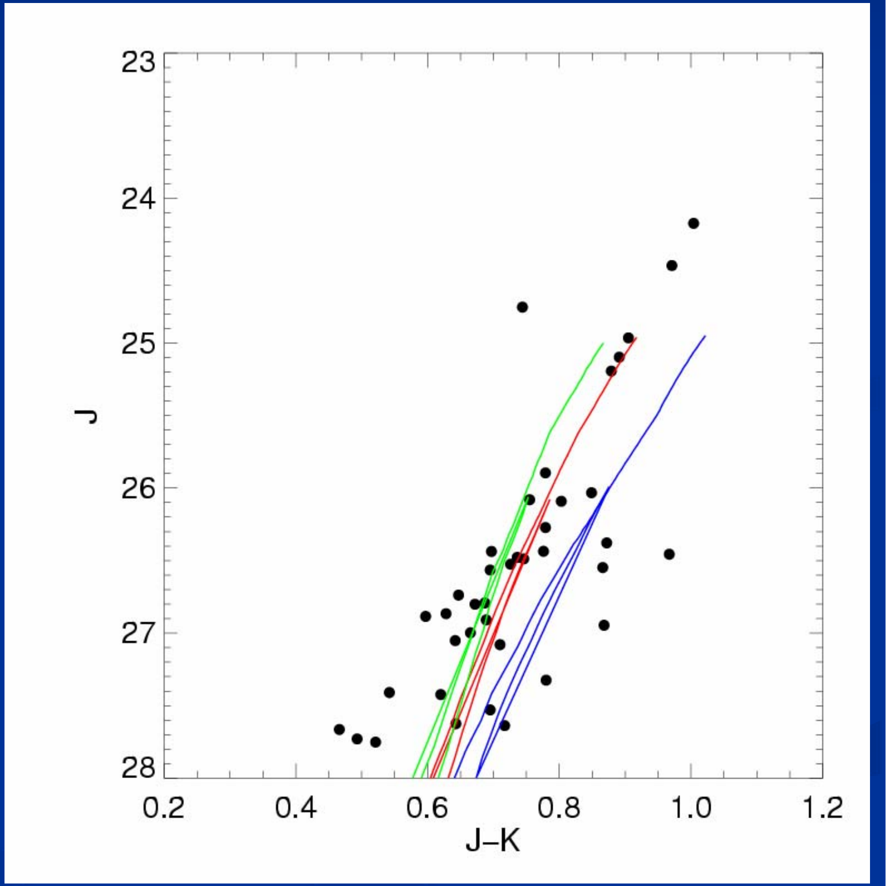
Globular clusters in M31 and Virgo

m-M = 24.3



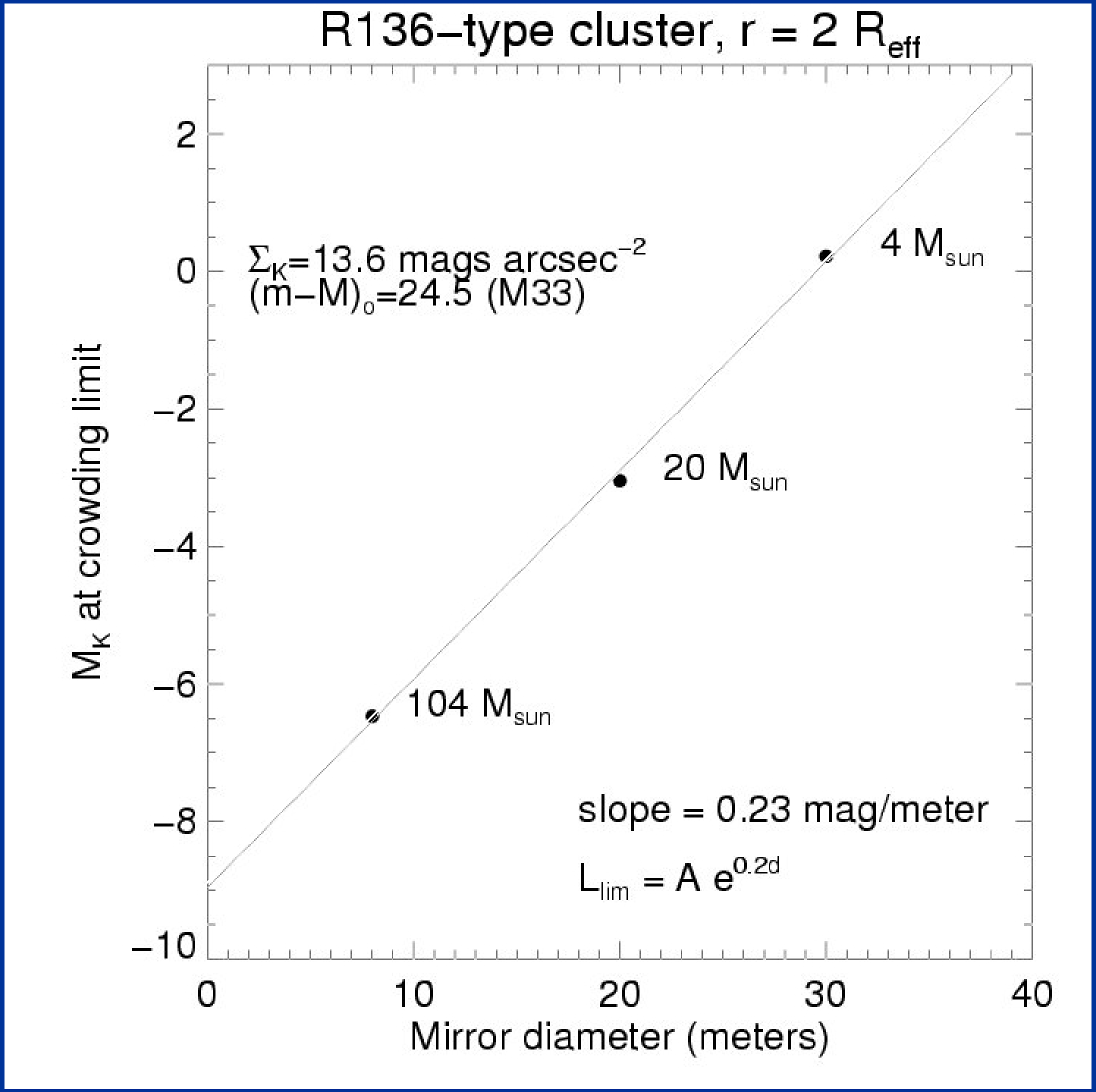
Age = 12+/- 2 Gyr, [Fe/H] from spectroscopy

m-M = 30.9



[Fe/H] = -1.5 +/- 0.3

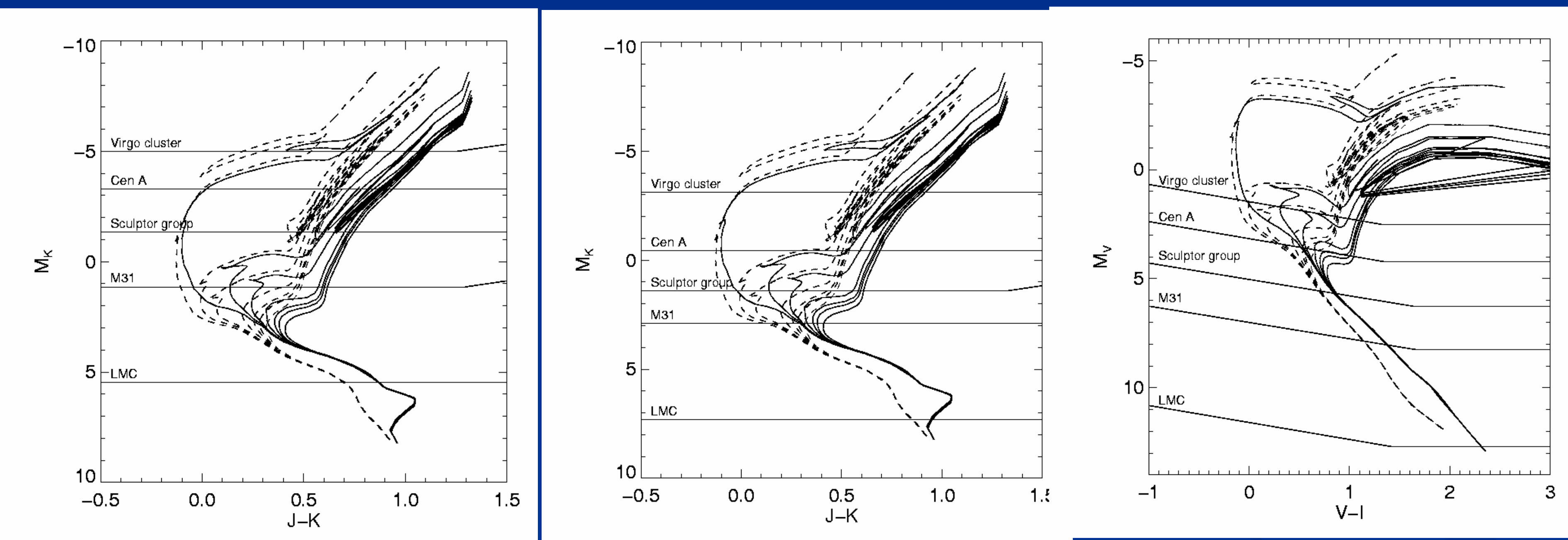
Lower Mass Limit for IMF Studies: R136-Like Cluster in M33



Results: 30-m GSMT

	Limiting M_K			Limiting mass			Exposure time		
	LMC	M33	M82	LMC	M33	M82	LMC	M33	M82
$0.5R_{1/2}$	>9.0	-7.5	<-8.0	~0.01	~150	>150	10000	0.01	<0.2
$R_{1/2}$	>9.0	-5.6	<-8.0	~0.01	83	>150	10000	0.08	<0.2
$2R_{1/2}$	>9.0	-2.2	-7.8	~0.01	9.4	>150	10000	2.2	0.2
$5R_{1/2}$	>9.0	3.0	-3.9	~0.01	0.4	28	10000	10000	16.6

30-m vs. 100-m



Magnitudes at which 10% photometry is possible in regions of surface brightness Σ_V=22, Σ_K=19 for galaxies at the indicated distances.

Conclusions

- GSMT can study the star formation and chemical enrichment histories of galaxies out to Cen A
- GSMT can study the IMF in massive star clusters out to M33
- 100-m is needed to derive star formation histories for the galaxies of the Virgo cluster
- 100-m will measure the massive star IMF in M82's super star clusters