An ACS High-latitude Survey

The stellar perspective……

Neill Reid, STScI

1. Starcounts 101
2. Galactic halo – science issues
3. Observational strategies

Starcounts 101

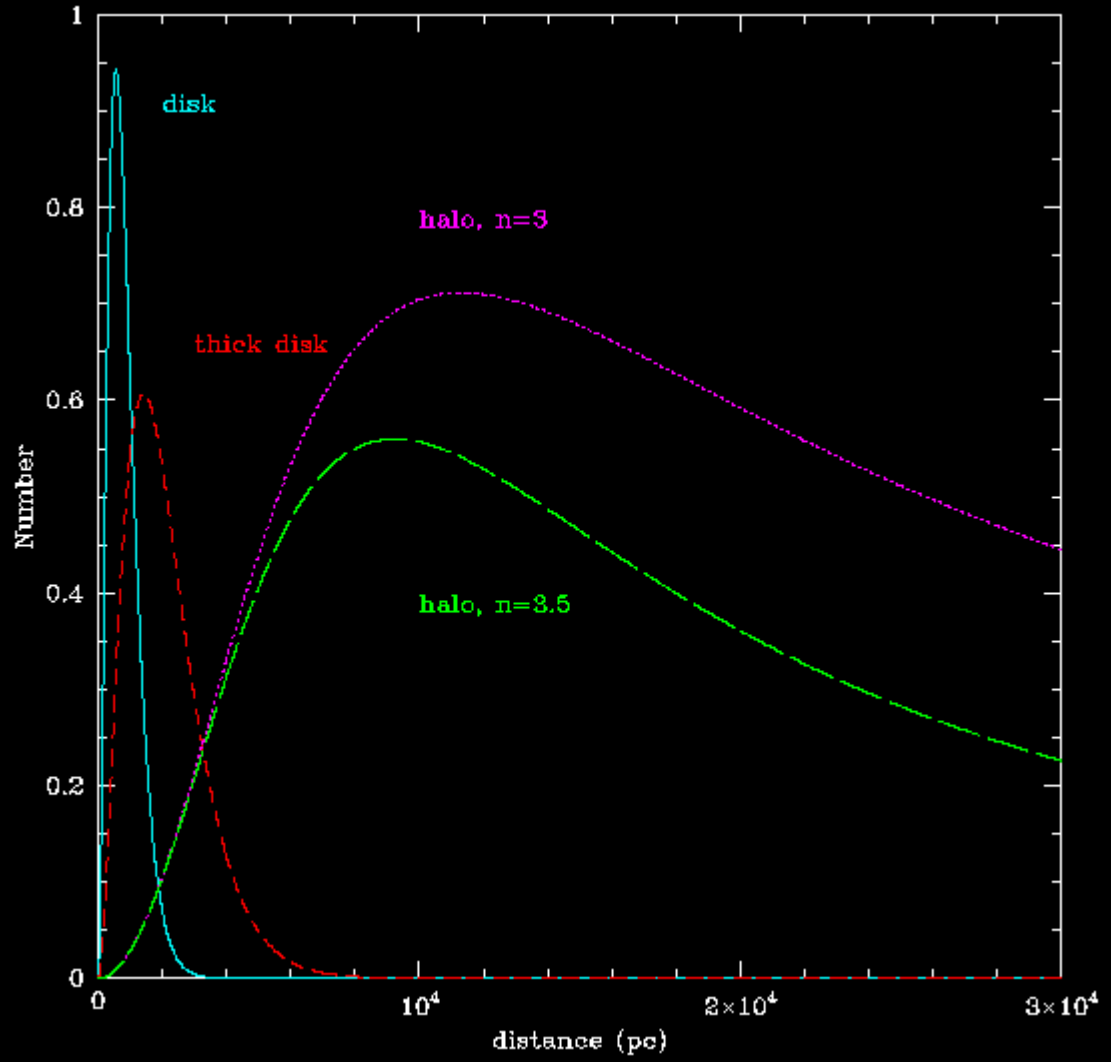
- $N(d) \alpha \rho(d) . V(d) \sim \rho(d) . d^2 . \delta d$
  where d is the distance along the line of sight

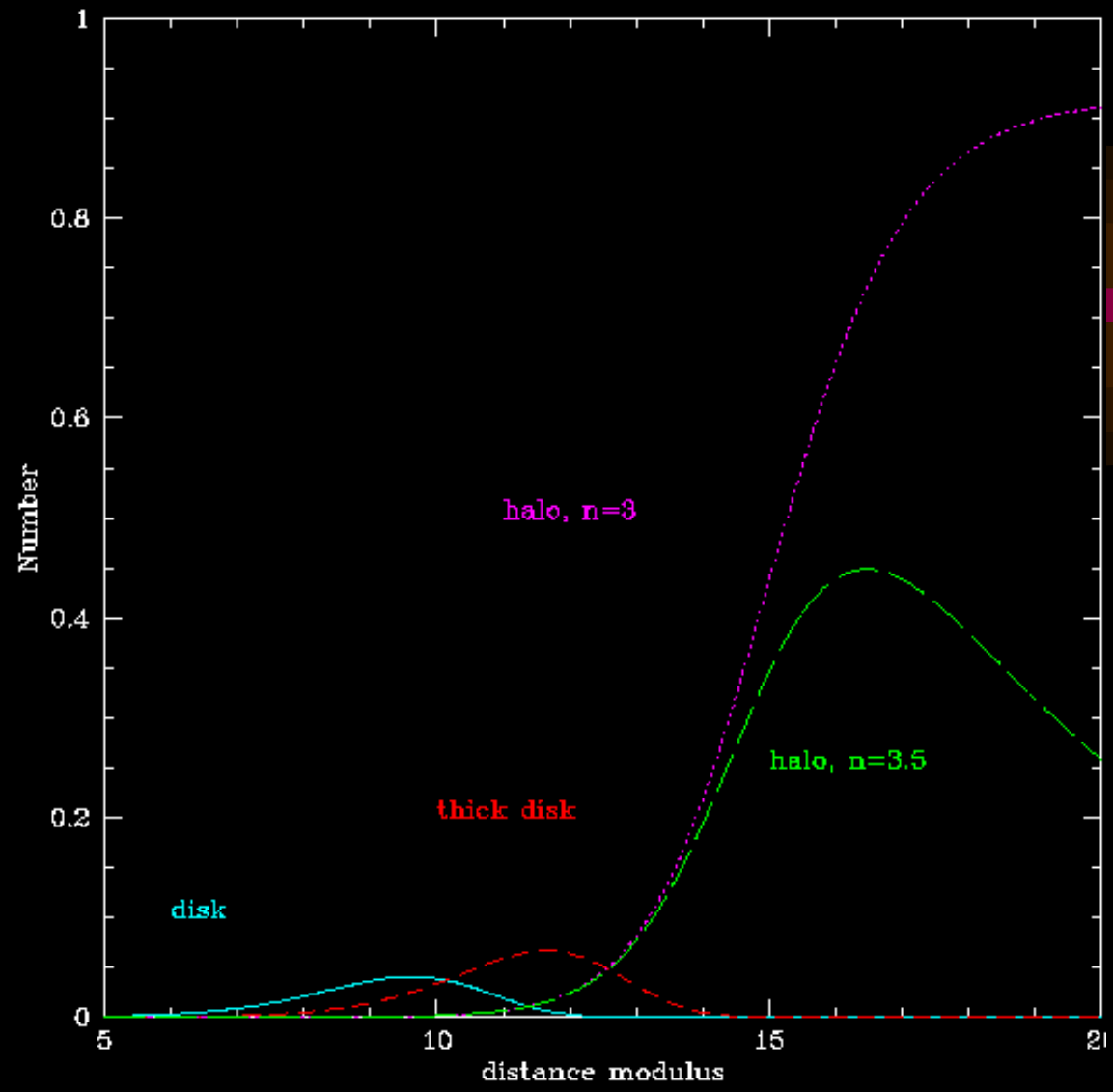
- Density laws

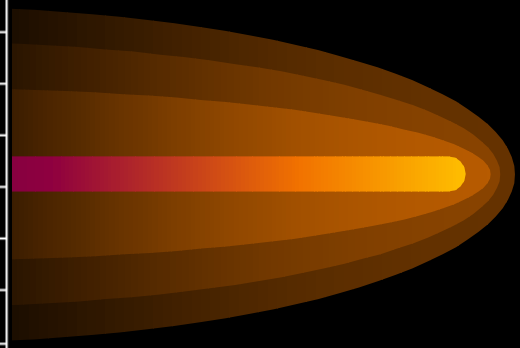
disk -	double exponential	H~2500 pc (radial) h~300 pc (vertical)	92%
thick disk -	double exponential	H~3500 pc h~700 pc	8%
halo -	radial power-law, n ~ 3 to 3.5		0.1%

- Preferred distance for each population
  $\langle d \rangle \sim 2h$

- N(d) α ρ(d) . V
  where d is
- Density laws
  disk - dc
  thick disk - d(
  halo - r
- Preferred distance for each population
  <d> ~ 2h







	m-M
disk	9
TD	12
halo	16

Fainter apparent magnitude = Fainter absolute magnitude

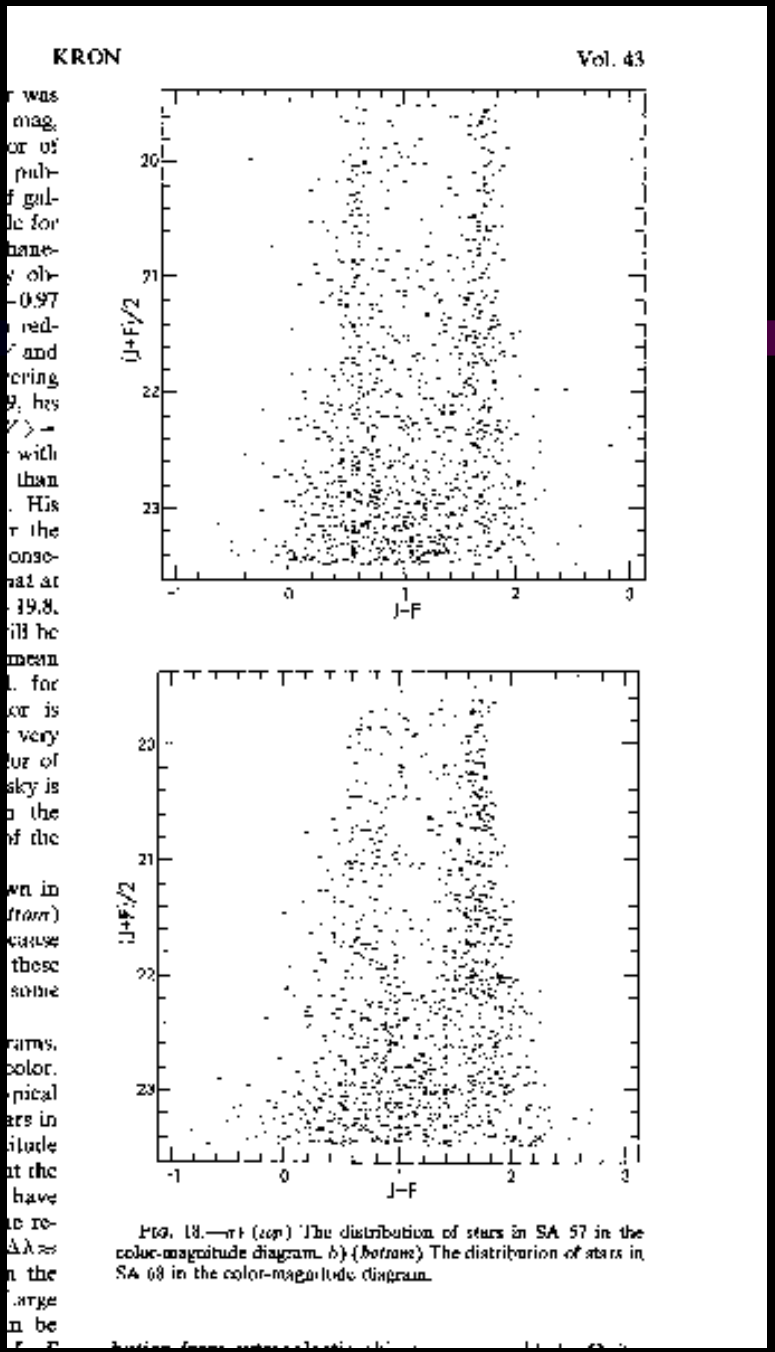
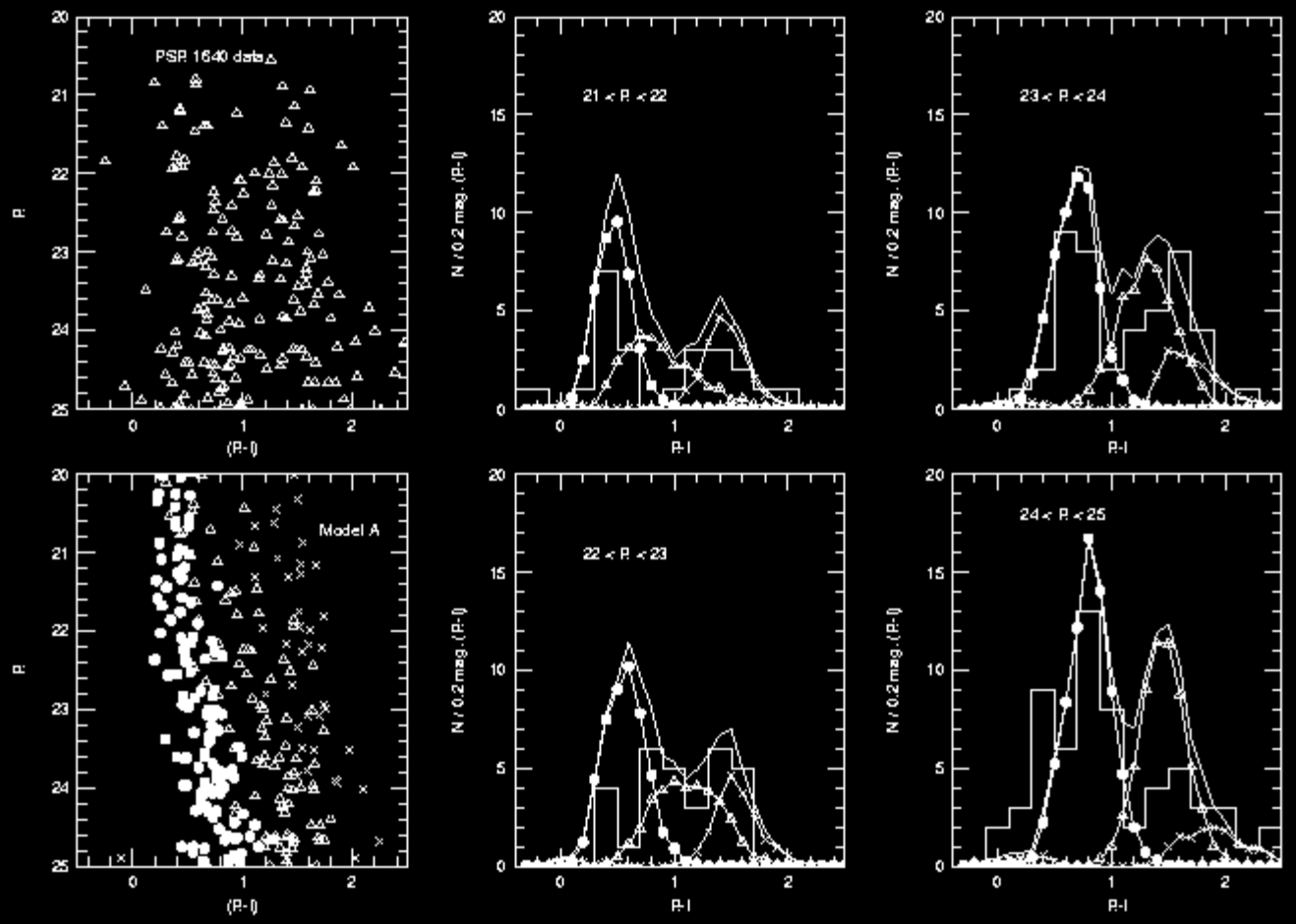


FIG. 18.—(*top*) The distribution of stars in SA 57 in the color-magnitude diagram. (*bottom*) The distribution of stars in SA 68 in the color-magnitude diagram.

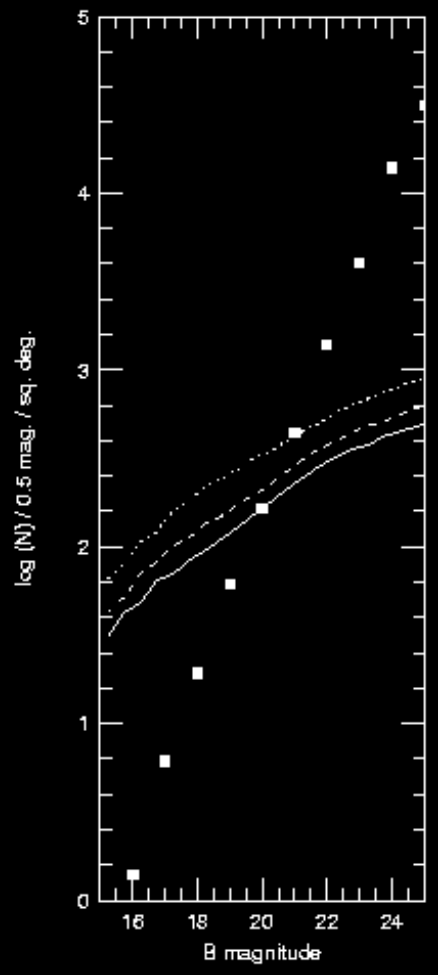
Bimodal distribution (J, (J-F))
Kron (1978) - NGP

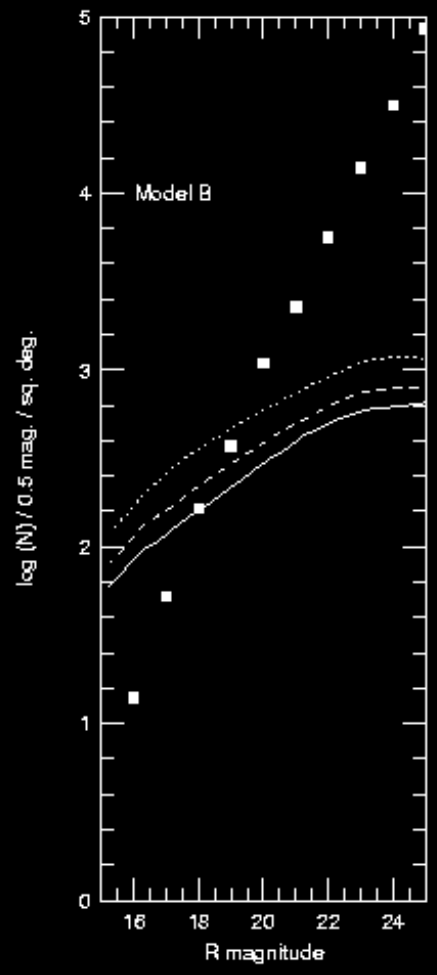
blue stars – halo
red stars - disk

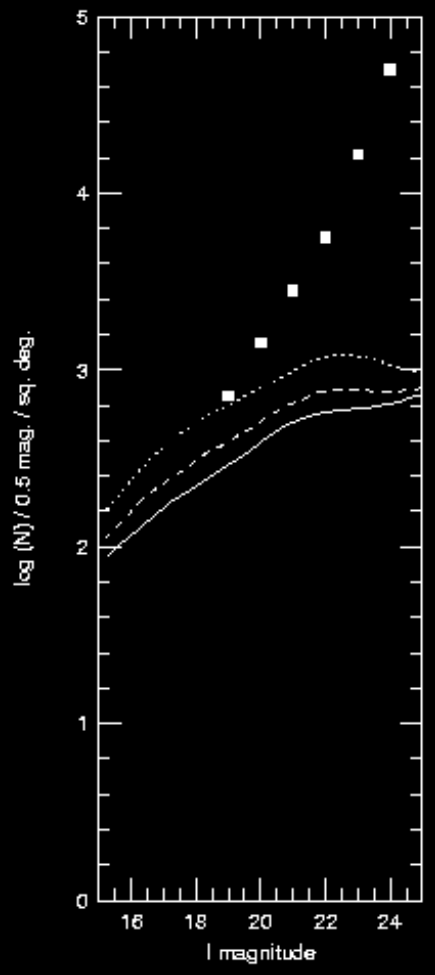

PSR 1640 data
Model A
21 < R < 22
22 < R < 23
23 < R < 24
24 < R < 25
R
(R-I)
N / 0.2 mag. (R-I)

Analysing starcounts

1. Galactic structure analyses are based on photometric parallax
   (colour, mag.) > ([M/H], luminosity) > distance
2. The disk is well-sampled at bright magnitude (V<19)
   The halo is well sampled at faint magnitudes (V>20)
3. Stars outnumber galaxies V < 20
   Galaxies outnumber stars V > 21
   high spatial resolution is essential at faint magnitudes

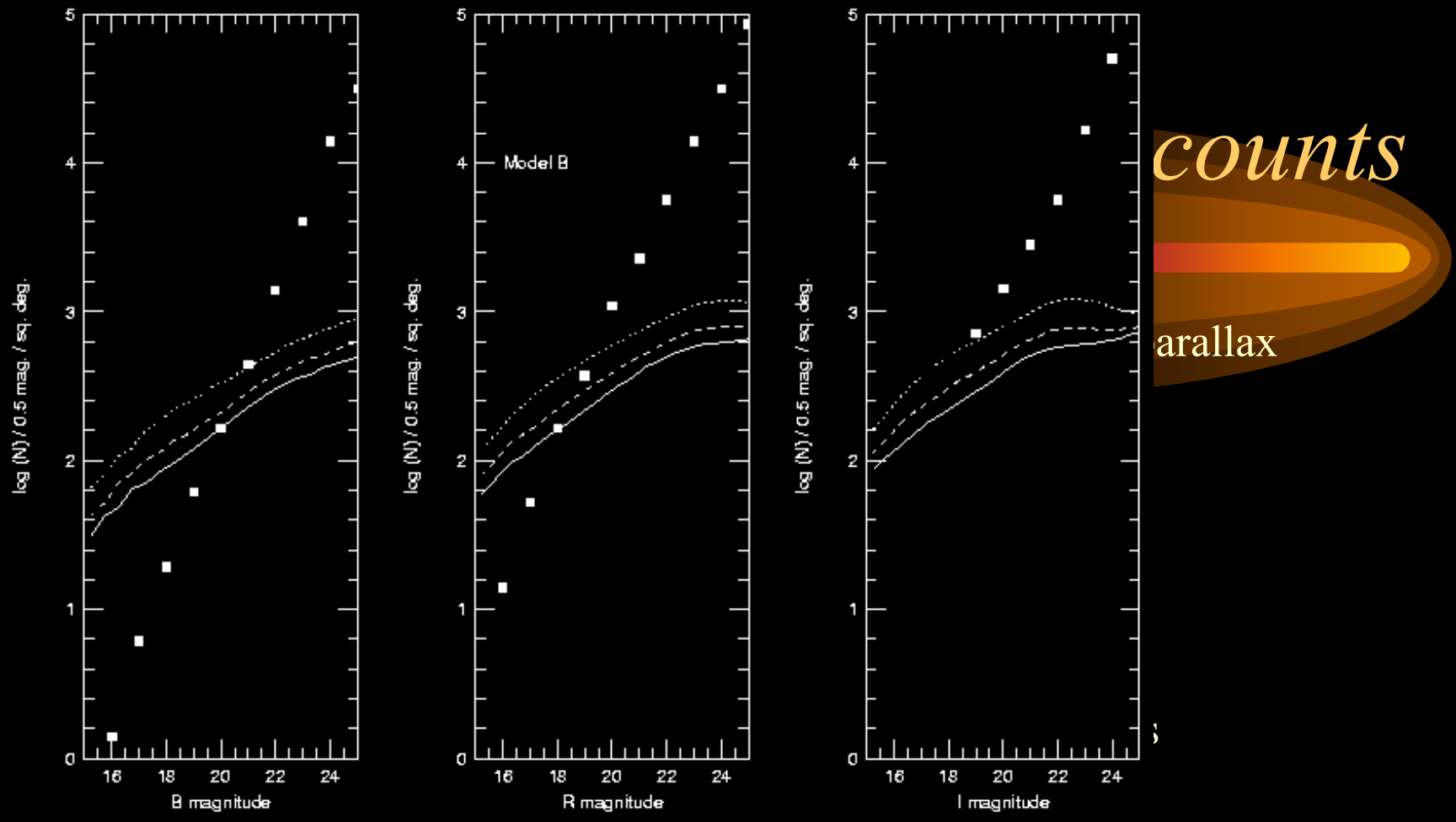






counts

arallax



HST is favoured for studies of the Galactic Halo

Stellar Number Densities

Baseline – Keck LRIS observations of PSR1640 field

(l=41, b=38) 42 sq. arcmin VRI (Reid et al, 1996)

~4 ACS WFC fields

R	N(stars)	N(galaxies)
21.5	30	99
22.5	33	208
23.5	44	435
24.5	75	911

~50% Halo, ~50% Disk (all components)

Baseline – K

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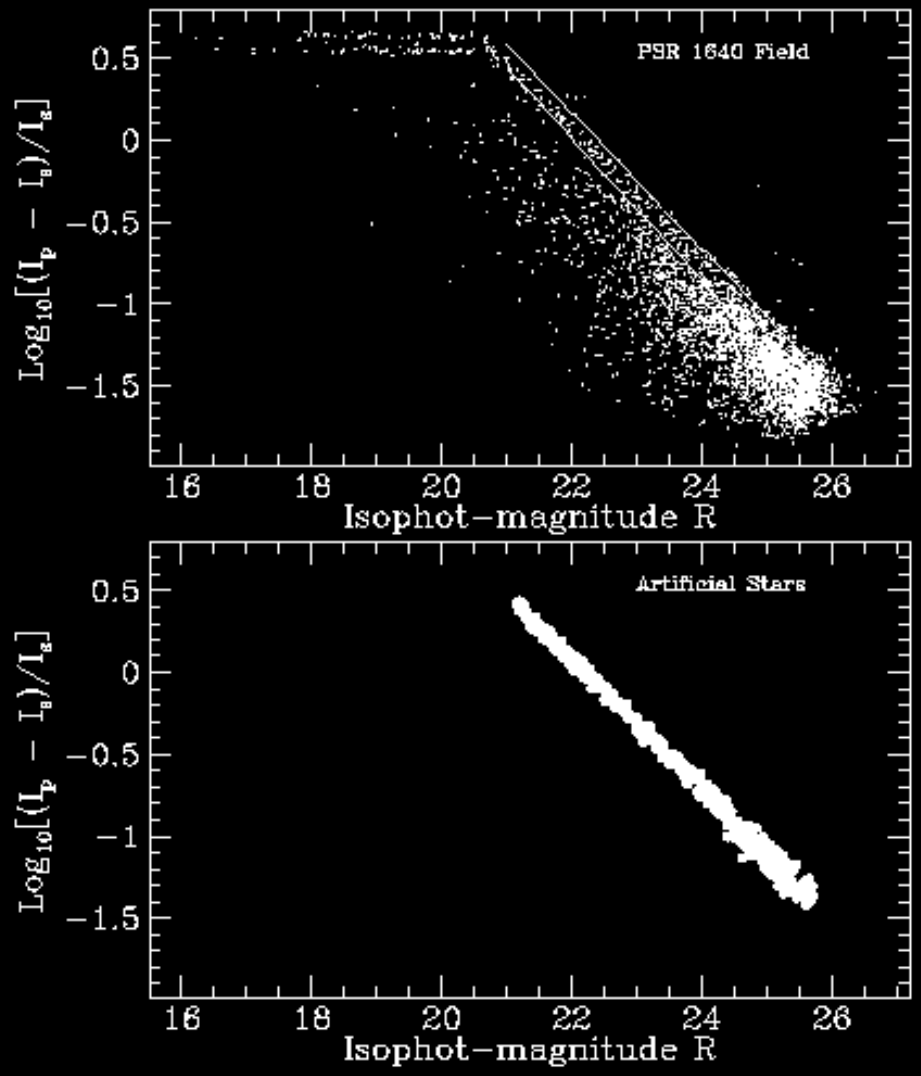
R

21.5

22.5

23.5

24.5



Science Issues

Halo structure : average density distribution
sub-structure/tidal tails
chemical abundance distribution
stellar luminosity/mass function

Miscellania : lensing/MACHOs
intrinsic variability
rare objects

H1: The Halo Density Law

Two principal parameters : power-law exponent, n
axial ratio, c/a

Ground-based starcounts – overall (V, (B-V))
RR Lyraes
globular clusters
generally favour $n \sim 3$ to 3.5, $c/a \sim 0.8$ to 1

Halo structure may be complex – flattened inner halo (bulge?)
- near-spherical outer halo
Tri-axial?
Truncation – where does the halo end?

H2: Sub-structure

Originally detected kinematically – Majewski, Munn & Hawley (1994)

- signature of merger fragments
- tidal disruption evident in Sagittarius dwarf, globulars

At least a subset of the halo is not kinematically well-mixed

Surveys – Majewski, Johnston *et al*

Morrison, Mateo *et al* (Spaghetti group)

Are there perceptible spatial variations in the general halo starcounts?

How lumpy is the halo?

H3: Chemical Abundance

The halo abundance distribution is known locally

- high-resolution spectroscopy of proper motion stars

Limited information in the far halo – globular clusters

- metal-poor giants (selection?)

<[M/H]> as f (R) probes formation mechanisms

- relative importance of monolithic collapse and fragment accretion

H4: The Luminosity Function

Φ(mag) + *M/L* relation gives Ψ *(M)*

Ψ *(M)* is well measured for local stars – solar abundance Disk

- globular clusters (dynamical effects?)

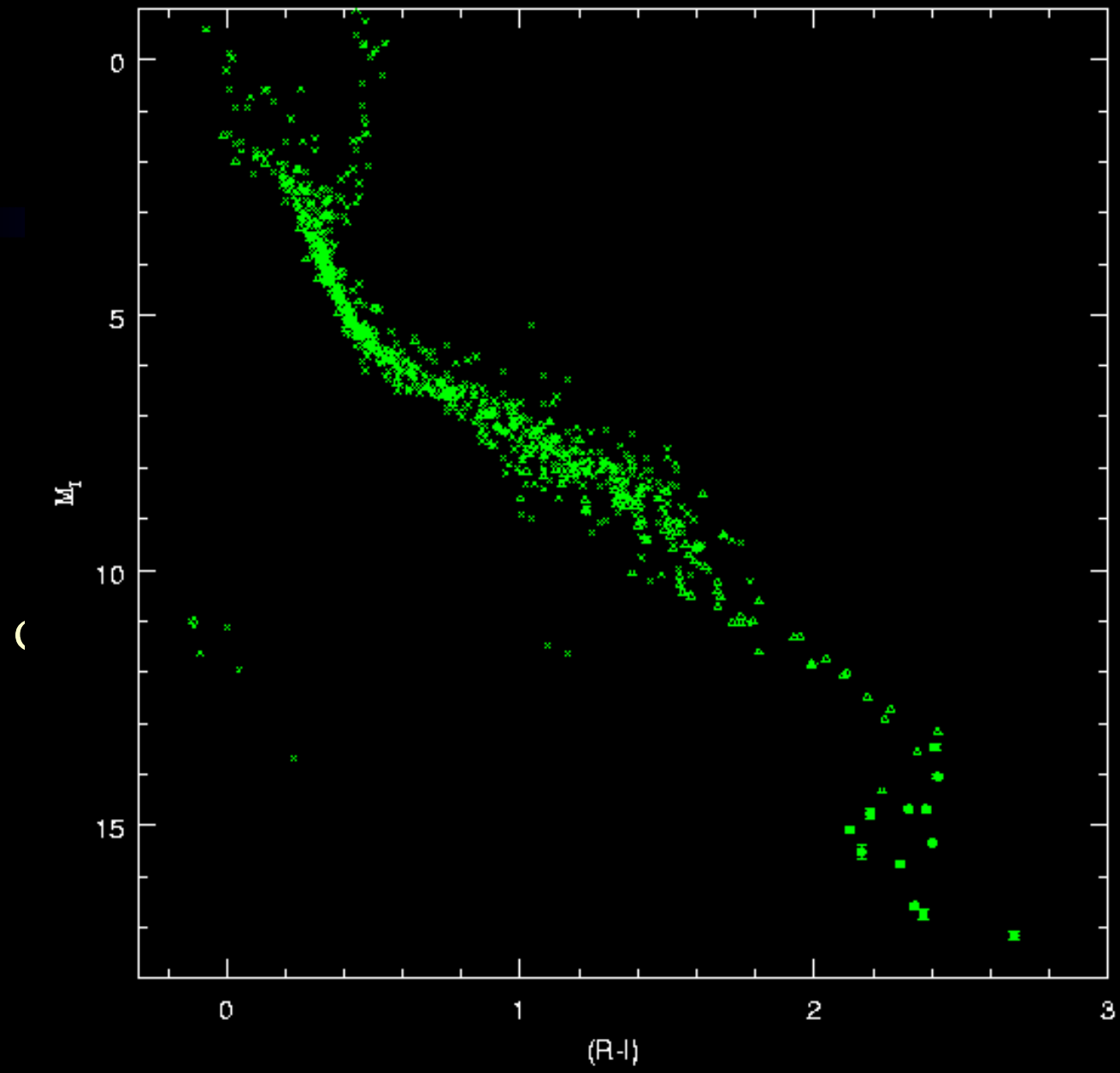
What of the field halo?

Complications: distances from photometric parallaxes

- CMD varies a f([M/H])

  non-linearities can bias Ψ *(M)*

- very few VLM dwarfs



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?)

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Miscellania

1. Lensing/Machos – low density of background sources
   individual events are likely to be rare
   possible detection of high motion objects
   - but faint, distant, difficult to confirm
2. Variability – interacting binaries
   - flare stars
3. Rare objects – carbon dwarfs
   - ultracool M, L and T dwarfs

Limited search volume – e.g. ~100 cubic parsecs for T dwarfs
(2MASS ~ 14,000 cubic parsecs)

Strategies: Halo Structure

1. Multiple lines of sight over a range of (*l, b*) [H1, H2, H3, H4]
   - *(l=90; b=30, 60)* gives *c/a*
   - *(l=90, 180; b=30/60)* measures triaxiality
   - 2+ fields at similar *(l, b)* for substructure
2. Multicolour data are crucial – VRI(z) [H1, H2, H4]
   - add g (or ramp filters at Mgb?) for [M/H] [H3]
3. How deep? V ~ 26, R ~ 25, I ~ 25 S/N ~ 20
   - ~4000 secs VRI, ~6000 secs with z : 2 orbits/pointing
4. How wide? 4 LRIS fields (~0.05 sq. deg.) – 16 ACS WFC/field
   100-300 stars / mag R=21 to 25
5. Supplementary groundbased BVRI(z) V > 14, ~1 sq. deg.
   - disk starcounts in the same fields

Strategies: Miscellania

1. Require multiple epochs [M1, M2]
   - $\Delta t > 2$ years for astrometry
   - many visits for variability statistics
2. Multicolour – at least 2 passbands [M1, M2]
   - gVRIz (+ Ramp filters?) for rare object detection

Desire for solid angle coverage competes against necessity for nultiple visits

Tentative Conclusions

A medium-deep, moderate solid-angle survey can provide interesting constraints on halo structural parameters

Desiderata: a) well-sampled in *(l, b)*
b) contiguous fields not required, but
at least 10-16 ACS WFC fields within ~10 deg.
c) 2 passbands essential, 3 more than useful

Baseline survey: 4 fields, 16 WFC pointings/field
2 orbits/pointing
= 128 orbits