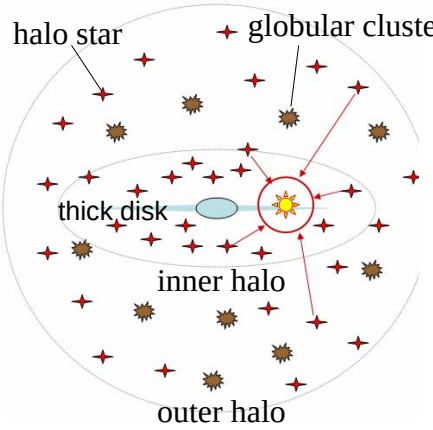
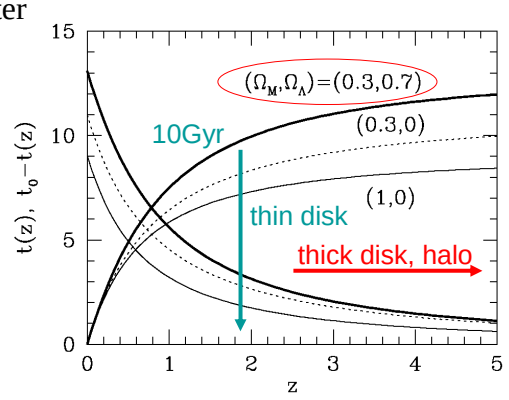
銀河系古成分の動力学構造

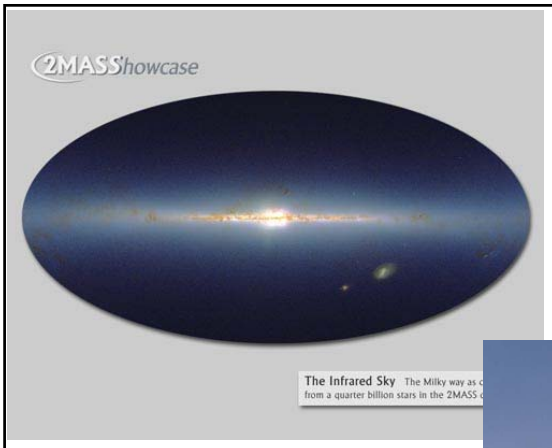
千葉柾司
（東北大）

銀河系古成分

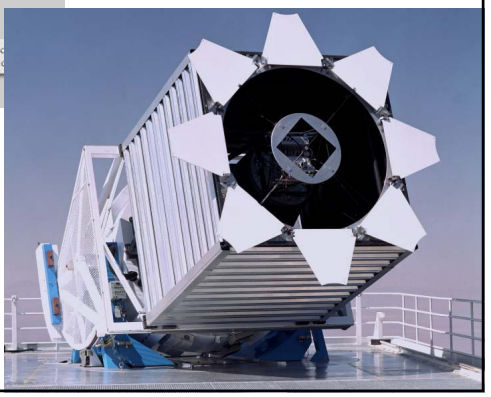




銀河系形成の化石情報

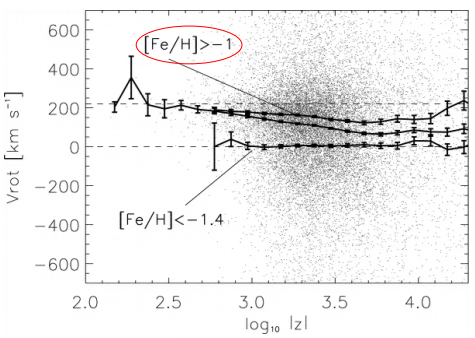


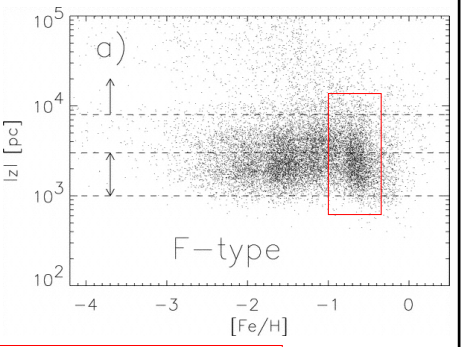
2MASS survey



SDSS survey

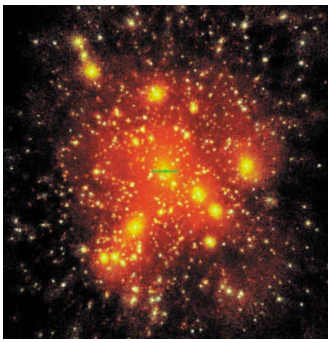
Thick disk revealed from F- and G- stars in SDSS DR3
(Prieto et al. 2005)



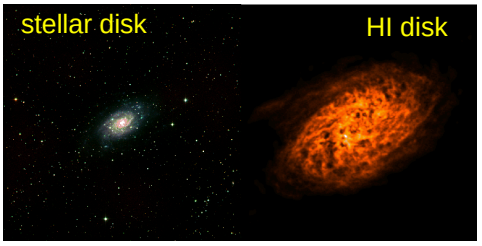


• Vrot ↓ as |z| ↑
• no metallicity gradient
Hints for formation scenario
(e.g. heating by subhalos: Hayashi's talk)

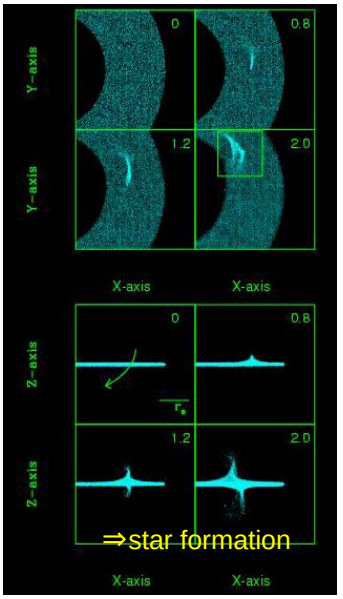
Dark matter distribution (by Moore)



NGC2403



Subhalo impact on extended HI disks
(Bekki & Chiba 2006, ApJL)



Halo and disk structures revealed from SDSS data (Juric et al. 2005)

Model: thin, thick disks, halo

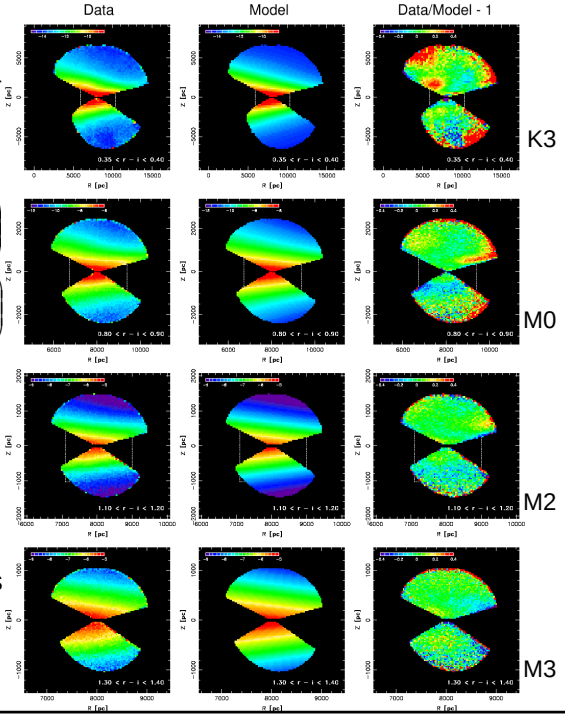
$$\rho = \rho_D(R_{sun})\exp\left(-\frac{R-R_{sun}}{L_1}-\frac{|z+z_{sun}|}{H_1}\right)$$

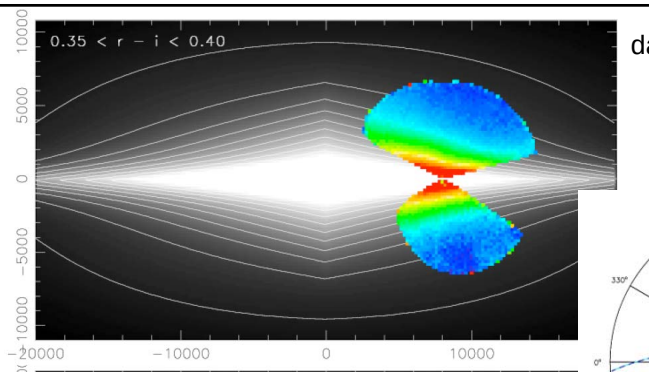
$$+\varepsilon_D\rho_D(R_{sun})\exp\left(-\frac{R-R_{sun}}{L_2}-\frac{|z+z_{sun}|}{H_2}\right)$$

$$+\varepsilon_H\rho_D(R_{sun})\left(\frac{R_{sun}}{\sqrt{R^2+(z/q_H)^2}}\right)^{\alpha}$$

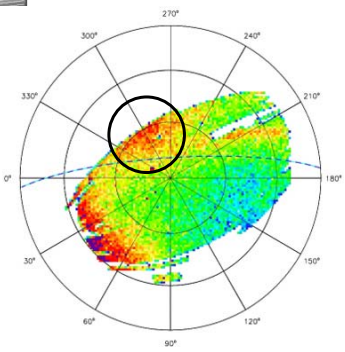
$L_1 = 2.40kpc$
$H_1 = 0.28kpc$
$L_2 = 3.50kpc$
$H_2 = 1.20kpc$
$\varepsilon_D = 0.04$
$\varepsilon_H = 0.001$
$q_H = 0.45$
$\alpha = 2.3$

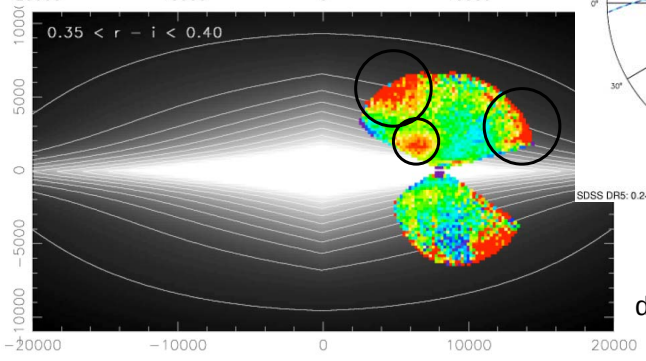
+ substructures (20~40 more clumps are expected)





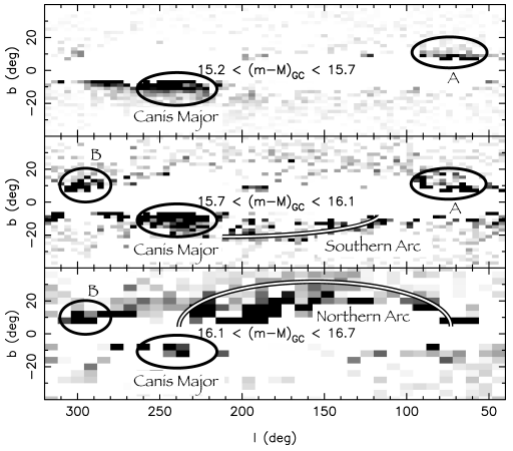
data

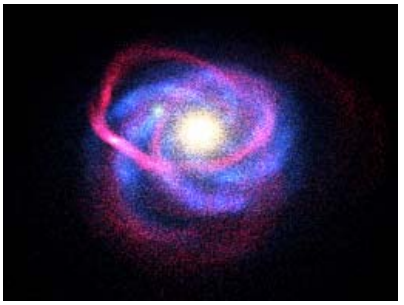


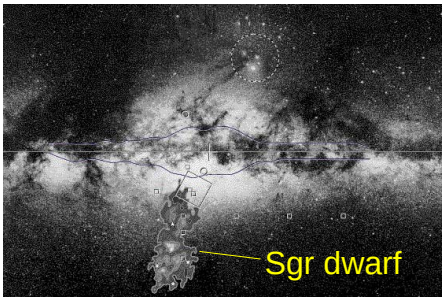


data/model - 1

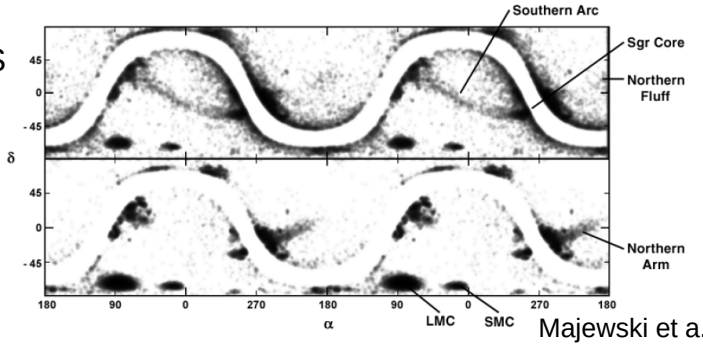
Most nearby satellite revealed from 2MASS
Canis Major (Martin et al. 2004)







2MASS

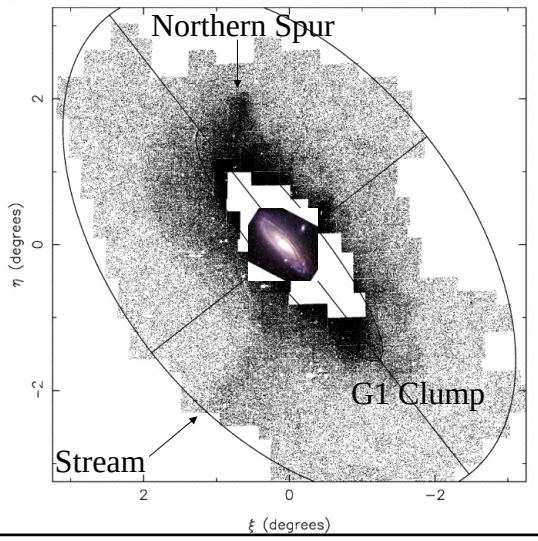


Majewski et a. 2003

FIG. 3.—Smoothed maps of the sky in equatorial coordinates for two color-magnitude windows of the (nondereddened) 2MASS point-source catalog filtered optimally to show the southern arc (*top*) and the northern arm (*bottom*): $11 < K_s < 12$ and $1.00 < J - K_s < 1.05$ (*top*), and $12 < K_s < 13$ and $1.05 < J - K_s < 1.15$ (*bottom*). We show two cycles around the sky to demonstrate the continuity of features.

Stream is confined onto an orbital plane
⇒ round dark halo

Substructure in M31's halo (Ferguson et al. 2002)



(V, Ic) bands

observed

unobserved

CFHT Megacam

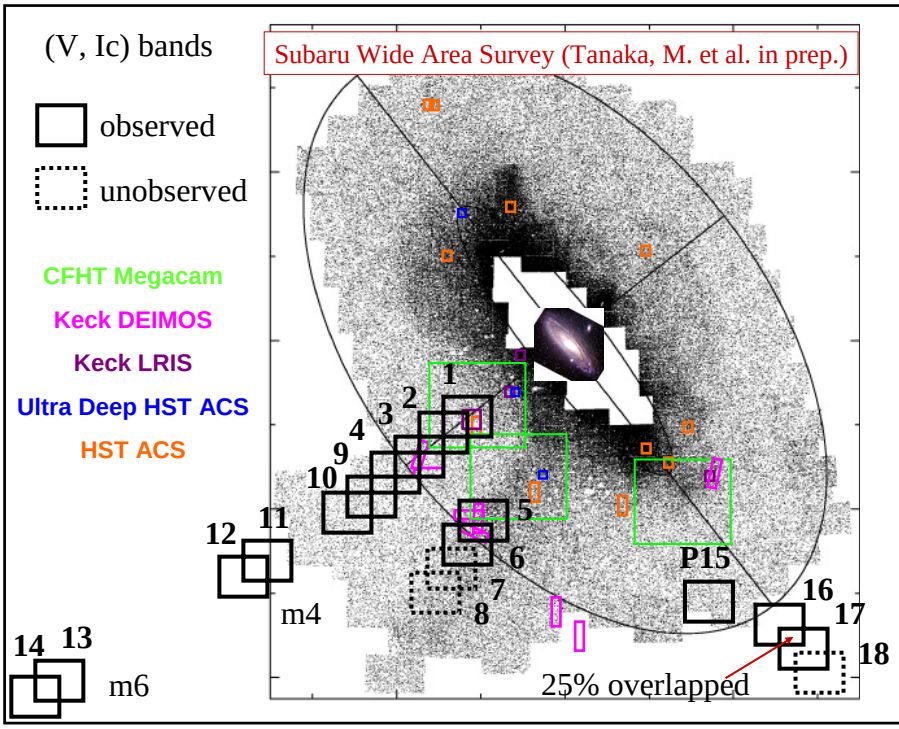
Keck DEIMOS

Keck LRIS

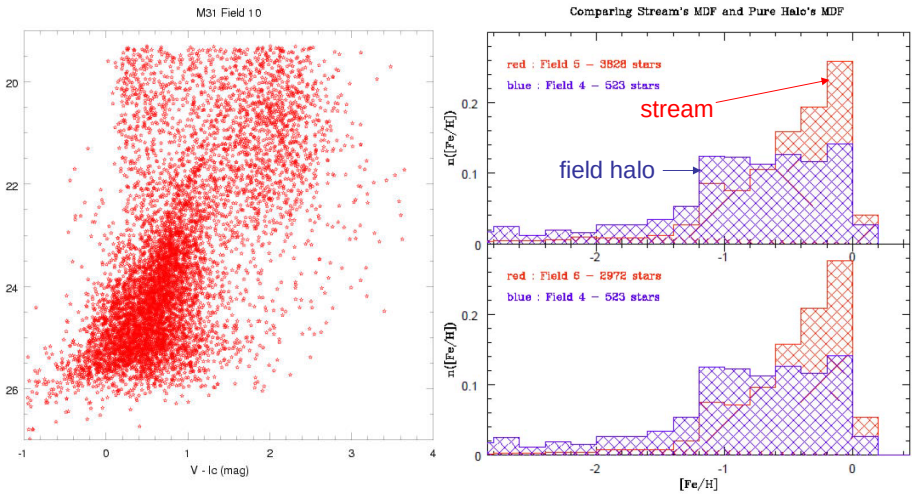
Ultra Deep HST ACS

HST ACS

Subaru Wide Area Survey (Tanaka, M. et al. in prep.)



Tentative results (Tanaka, M. et al. in prep)

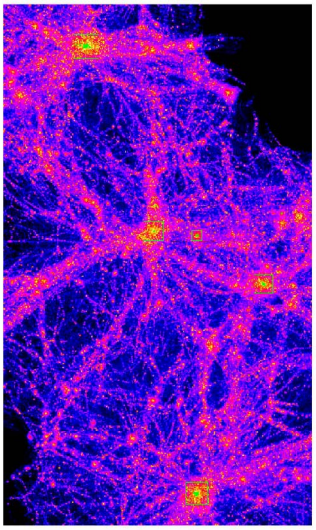


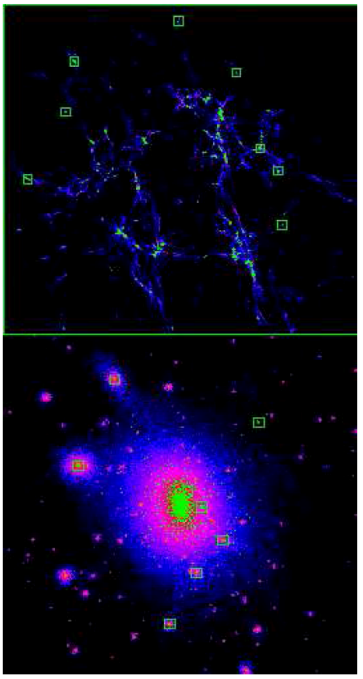
銀河系古成分の特徴

- Extended
  - Halo: $\rho \propto r^{\alpha}$, $\alpha \sim -3$
  - Thick disk: $\rho \propto \exp(-z/H)$, H~1kpc
- Lots of substructures
  - Evidence for dwarf merging
- Old age (>10Gyr)
- [α/Fe] overabundant

CDM-based galaxy formation?

High-resolution numerical simulation
for a galactic collapse
(green: $M=10^8$-$10^{10}M_{sun}$, $T>10^4K$)
Moore et al. 2005, astro-ph/0510370

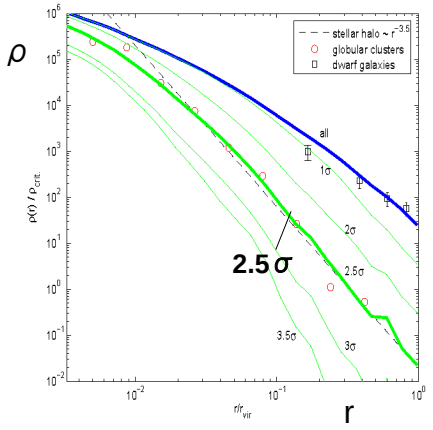




z=12

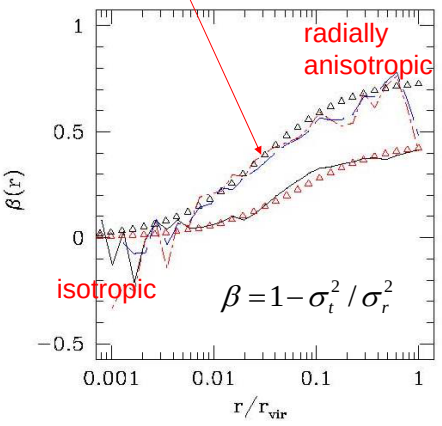
z=0

Spatial distribution of old stellar systems



Moore et al. 2005
astro-ph/0510370

Velocity distribution of $2.5\,\sigma$ density peaks

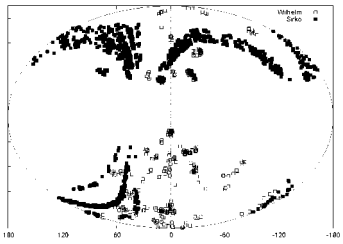


Diemand, Madau, Moore 2005
astro-ph/0506615

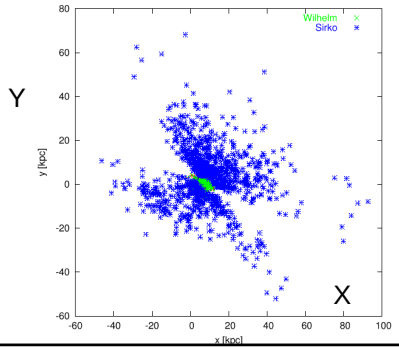
Field Horizontal Branch (FHB) stars as halo tracers

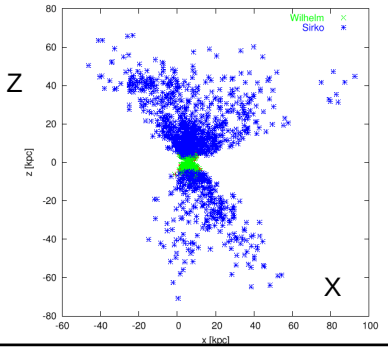
- Bright and many
- Accurate distance is available

⇒ halo kinematics,
mass distribution of a dark halo

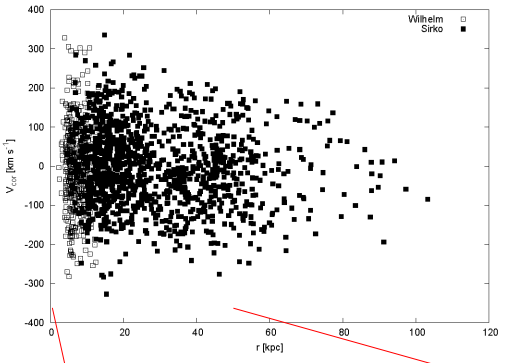


Yamada, M. (2006, Master thesis)
using 444 FHBs in Wilhelm et al. (1999)
1169 FHBs in Sirko et al. (2003)



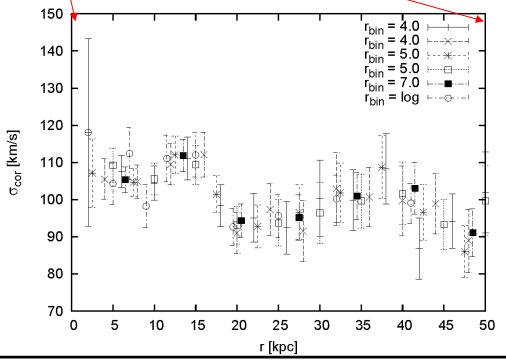


L-o-s velocities of
1613 FHB stars
V_{corr} corrected for
LSR + the solar motion



V_{corr} vs. r

σ_{corr} vs. r

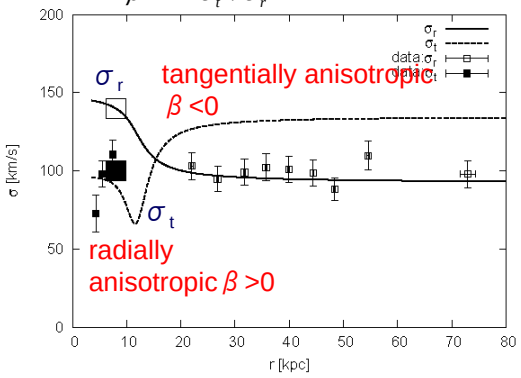


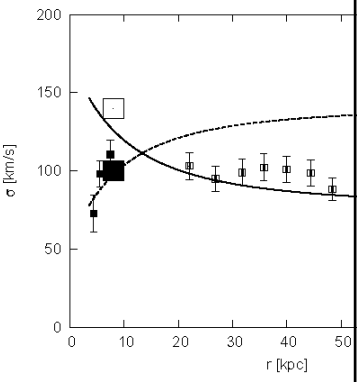
Jeans eq. in spherical limit

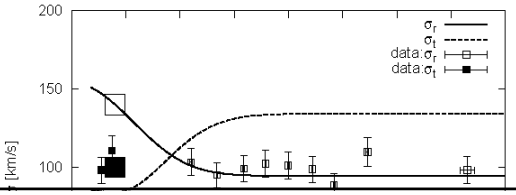
$$\frac{1}{n}\frac{dn\sigma_r^2}{dr}+2\frac{\beta\sigma_r^2}{r}=-\frac{V_c^2}{r}$$

$$\beta\equiv 1-\sigma_t^2/\sigma_r^2$$

$n \propto r^{-3.5}$, V_c = const.

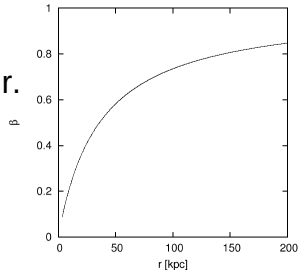


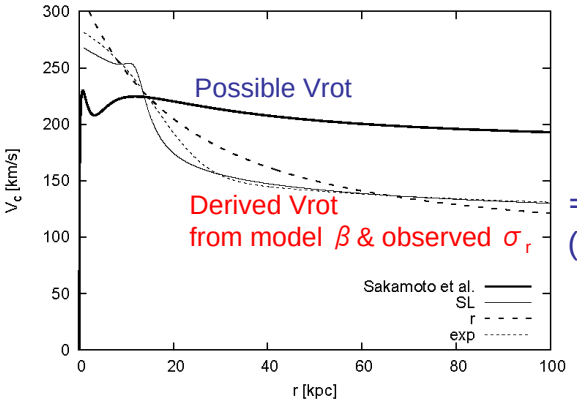




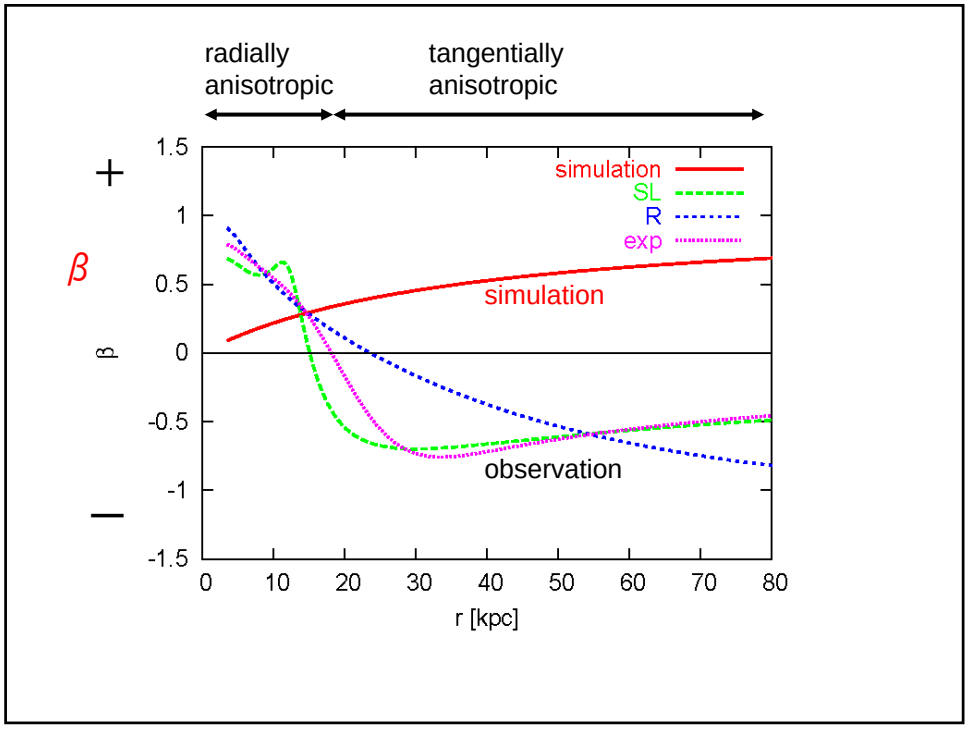
Simulations suggest
$\beta \geq 0$ and increasing with r.
(radially anisotropic in
the outer halo)

Really?

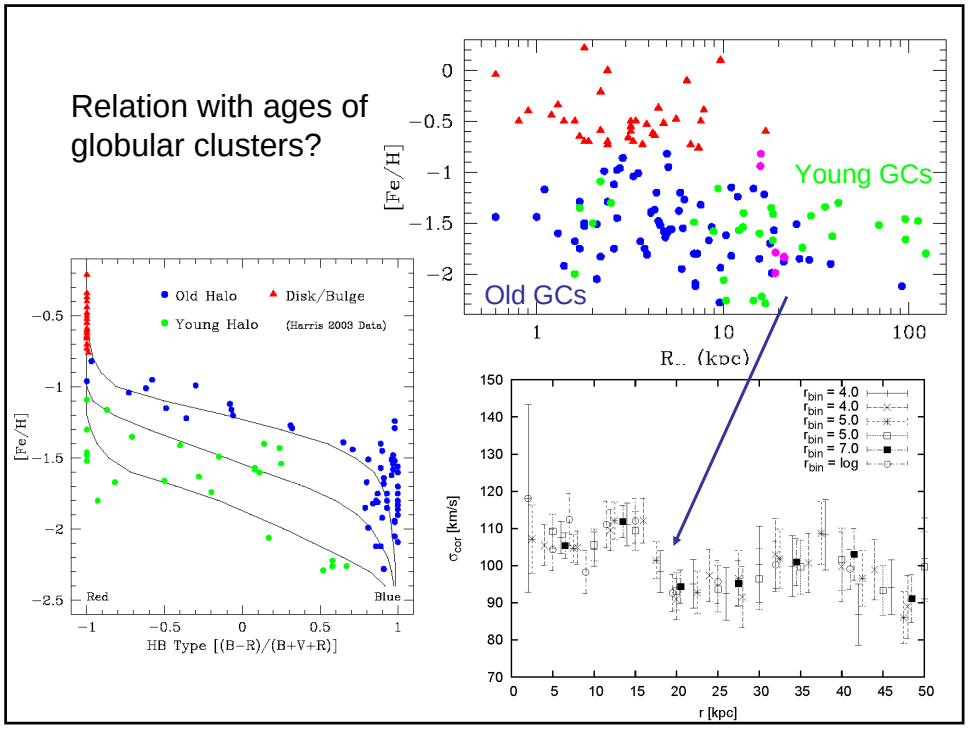




⇒unlikely!
(many distant
halo objects
are unbound)



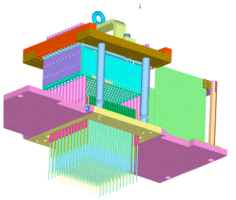
Relation with ages of globular clusters?



Issues

- ハロー天体の速度構造の理解
  - 銀河形成数値実験、データ解析の改良
  - 球状星団の年齢分布の関連
- ダークハローの大局的な質量分布
  - 総質量、分布、形、サブストラクチャー
- 化学元素パターンと動力学構造との関連
  - 矮小銀河降着の効果

Wide-field, fiber-fed, multi-object spectrograph (WFMOS)



- Dark energy survey (determination of w)
- Galactic archaeology survey

~4,500 targets in a FOV~1.5deg,
R~1,000 - 40,000
Operation 2012? ~

Table 1. Summary of the Baseline Survey Parameters.

Survey	R_{lim} (AB mag)	Target Surface Density (deg^{-2})	Total Area (deg^2)	Total Sample Size (# objects)	Total Survey Time[1] (hrs/nights)
Dark Energy $z = 0.5 - 1.3$	22.7	1000	2000	2×10^6	1530/153
Dark Energy $z = 2.3 - 3.3$	24.5	2000	300	6×10^5	1360/136
Galactic High-Res	17	500	3000	1.5×10^6	4900/490
Galactic Low-Res	21	1000	500	0.5×10^6	1400/140

[1] Includes factor of 1.7 to account for weather and assumes average of 10 hours per night.