The Galaxy

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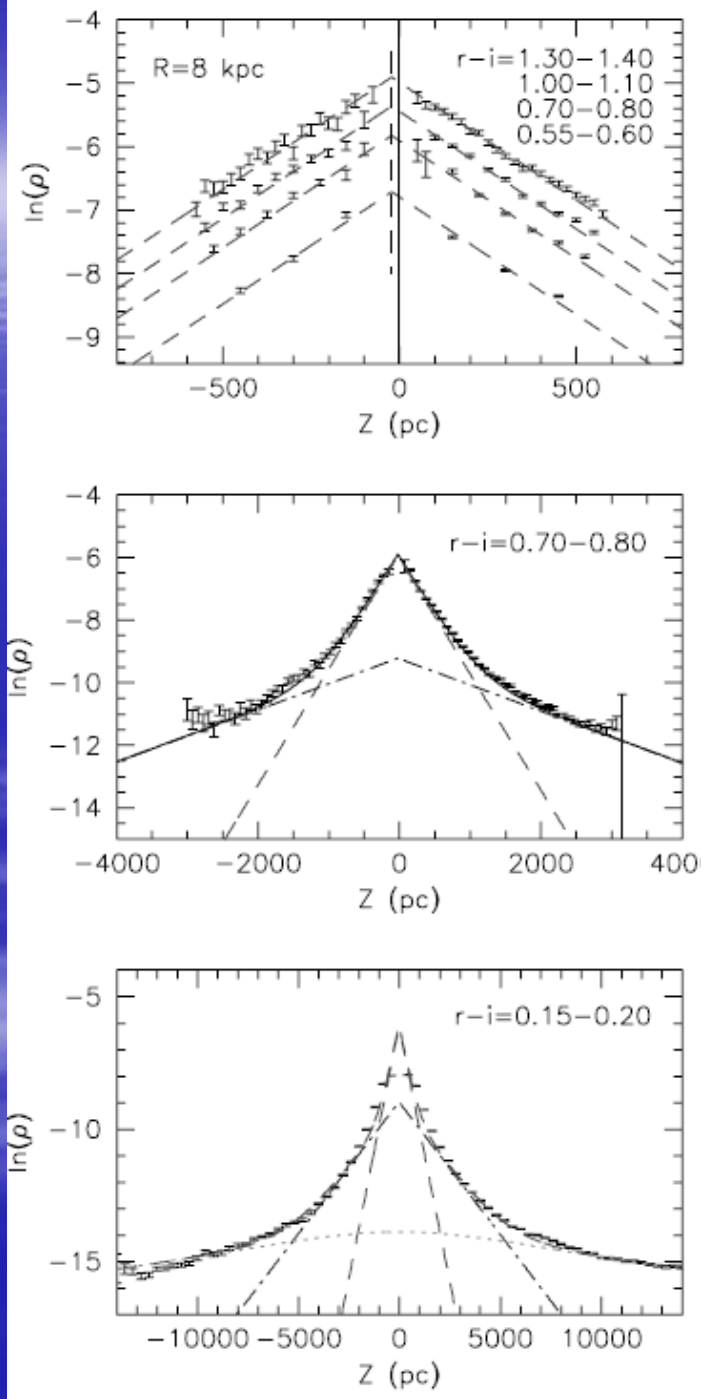
Components

- Disc
  - Thick ($h \simeq 900$pc)
  - Thin ($h \simeq 300$pc)
  - Gas ($h \simeq 100$pc)
- Bulge/bar
- Halo
- Globular-cluster system
- Dark halo

The disc

- Thick & thin
- Assume double exponential
- Thin: R_d=2.5kpc h=300pc
- Thick R_d=3.6kpc h=900pc
- Roughly ¼ L is in thick d.
- h_{thick} and thus $\rho_{thick}(0)$ very uncertain



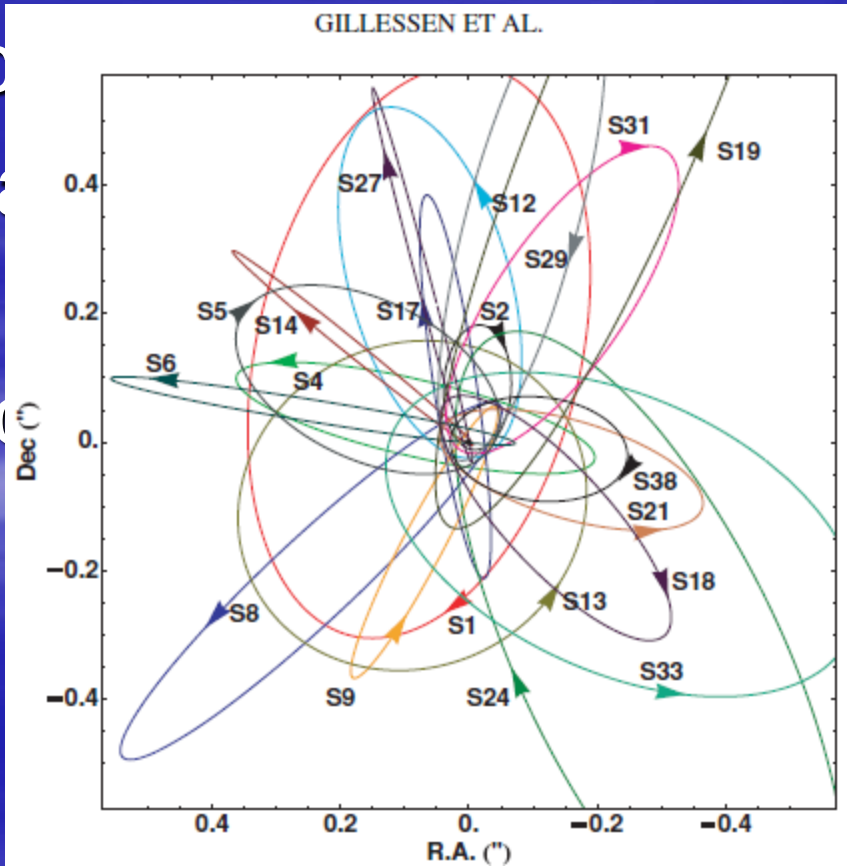
Ivezic+ 2008

Thin disc

- Measure $\rho(R_0,0)$ with proper motions
- $\rho(R_0,0)=0.1\pm0.01 M_\odot$ pc^{-3}
- Then from z_0, $\Sigma(R_0)=60 M_\odot$ pc^{-2}
- Counts of stars & gas $\rightarrow$ $\Sigma_0=49 M_\odot$ pc^{-2} (Flynn+06) and $\Upsilon_I=1.2\pm0.2 M_\odot/L_\odot$
- From R_d, $M_{thin}=4\times10^{10} M_\odot$

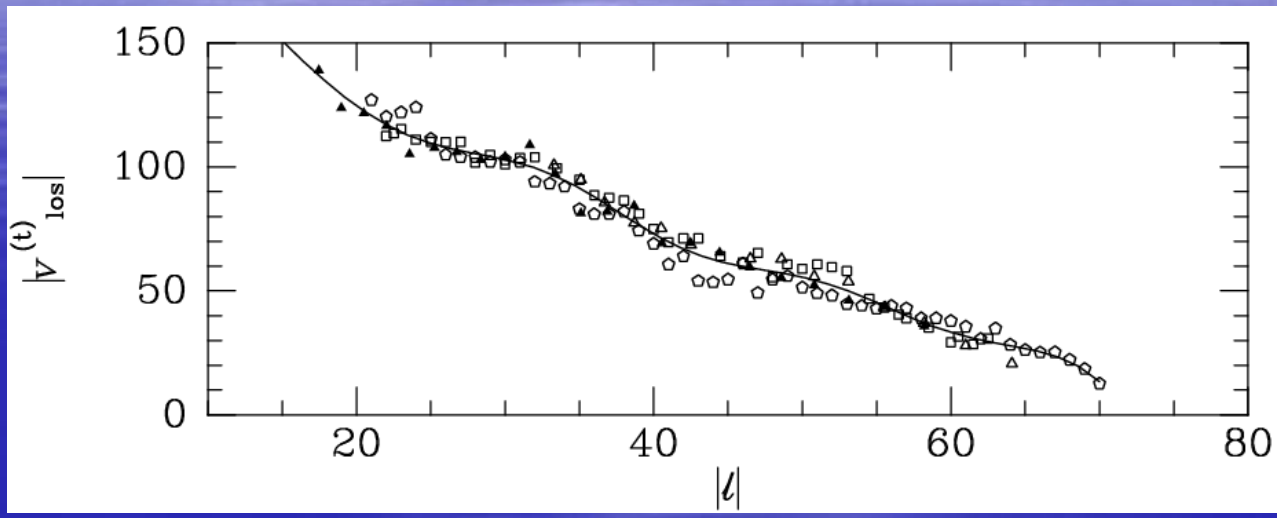
Speed of Sun

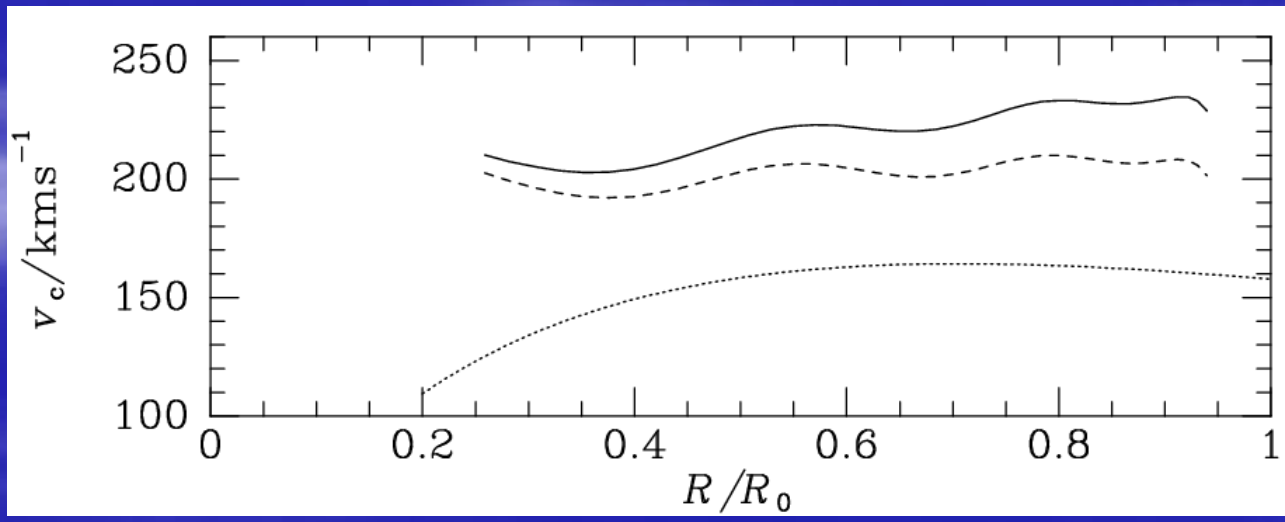
- Thin disc gives $v_c(R_0)$=156 km/s
- Distance to GC from orbits of S stars around Sgr A*: R_0=8.3±0.35 kpc
- Proper motion of Sgr A* a
  $v_c(R_0)$=250 km/s
- Thin disc gives only 0.4 c



Rotation curve

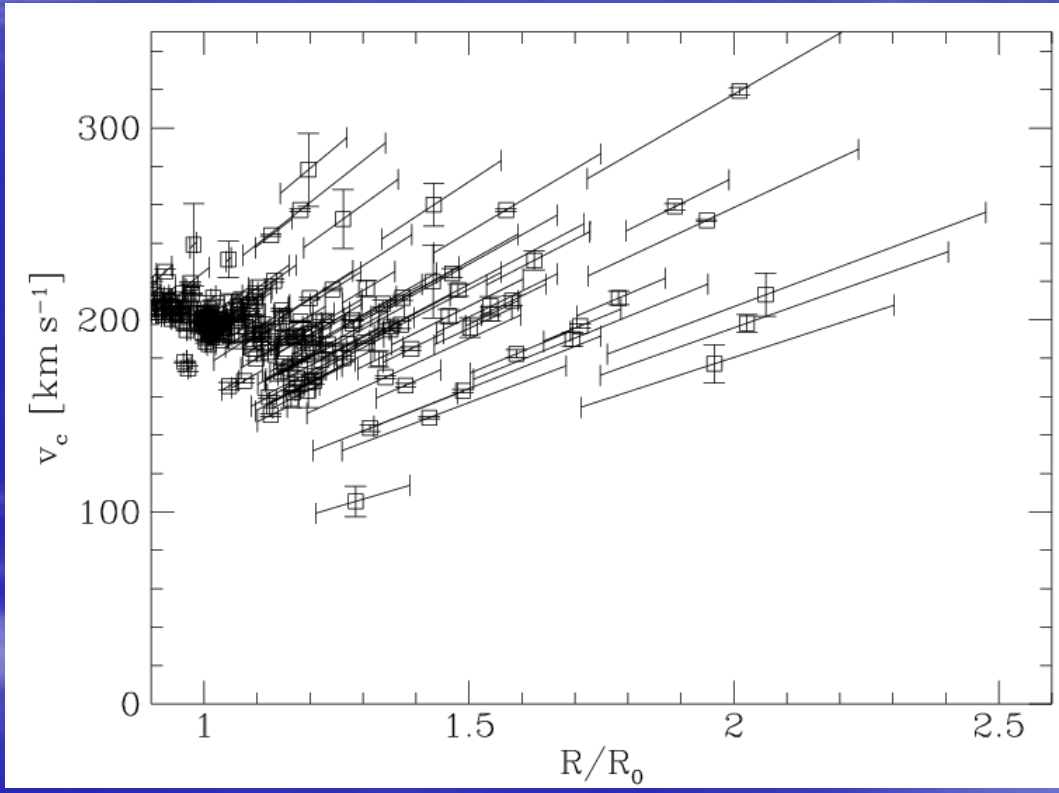
- Obs of HI and CO yield "terminal velocities"
- From these get $v_c(R)$ for $R<R_0$
- More matter needed at all R



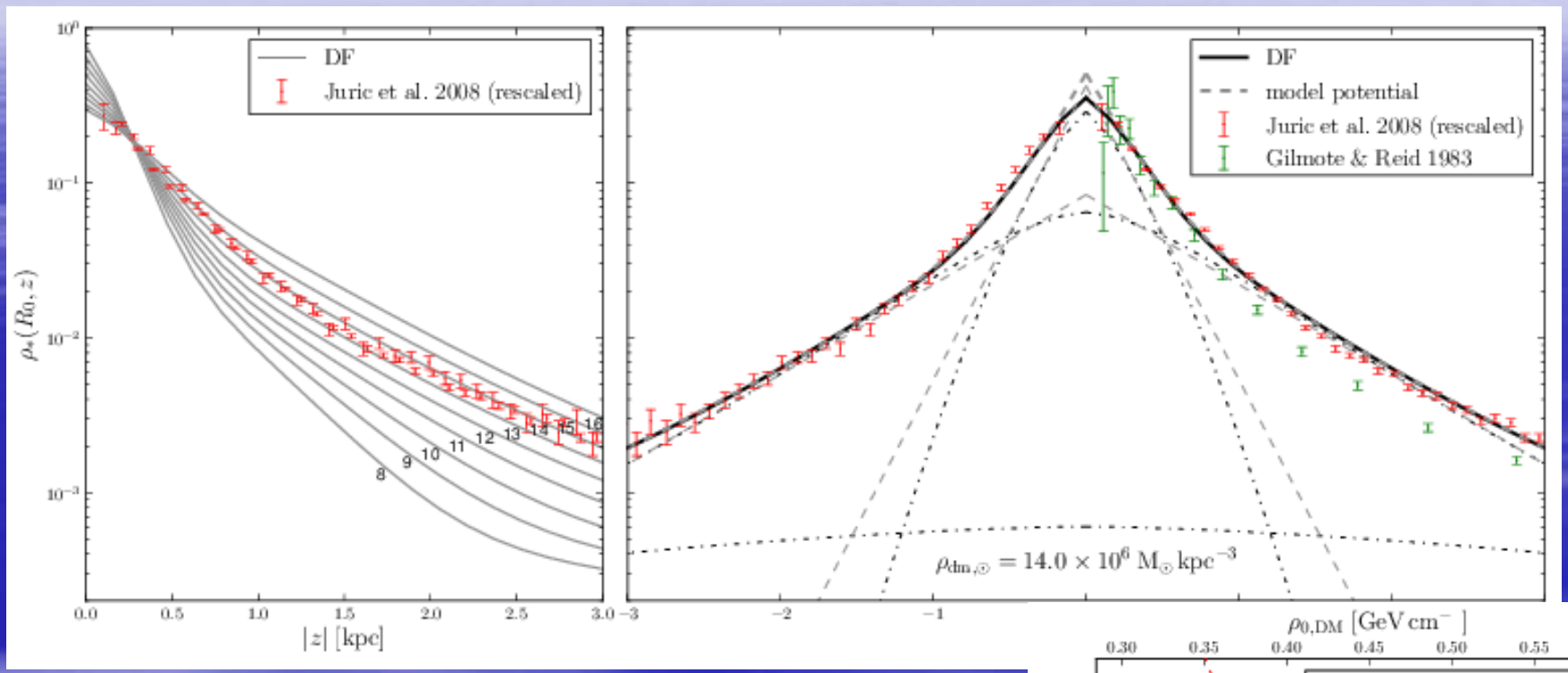


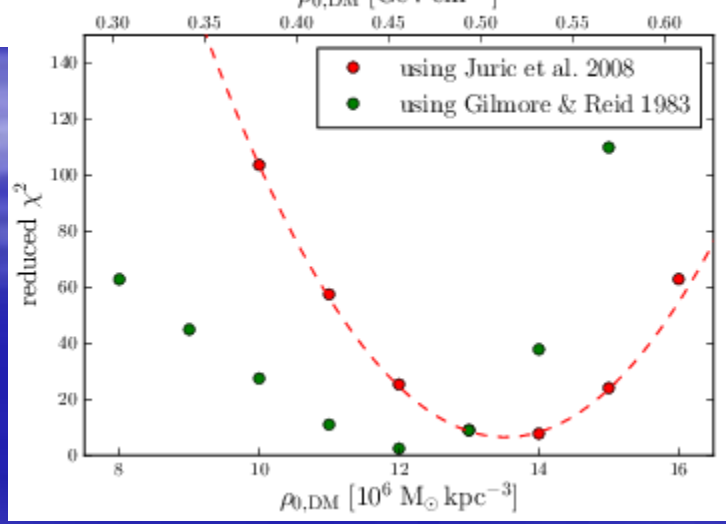
V_c at $R>R_0$

- Beyond R_0 in addition to v_{los} you need a distance
- Distance errors to tracers make v_c uncertain



Disc mass from RAVE giants

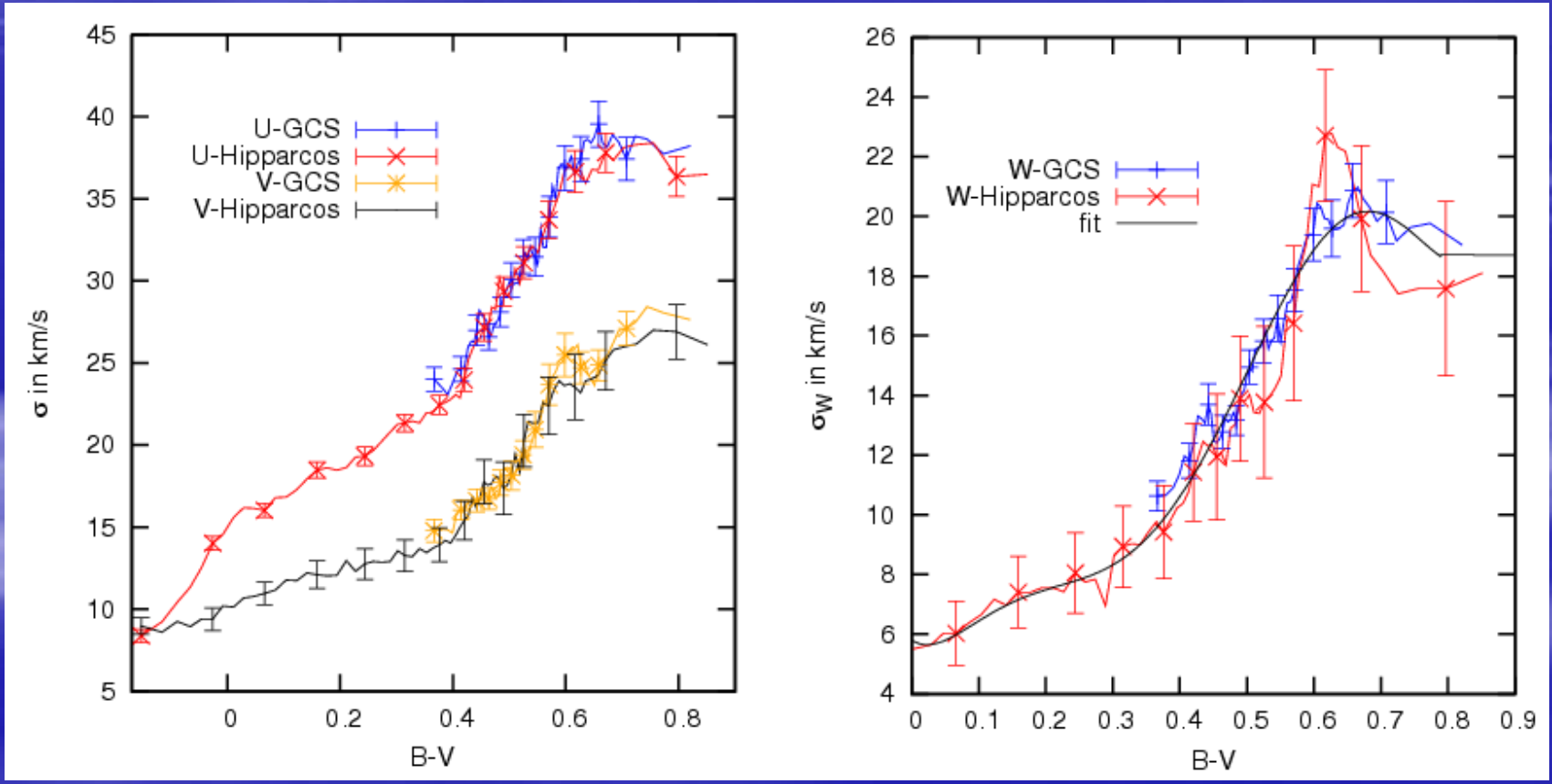




Piffl + 2014

Local kinematics

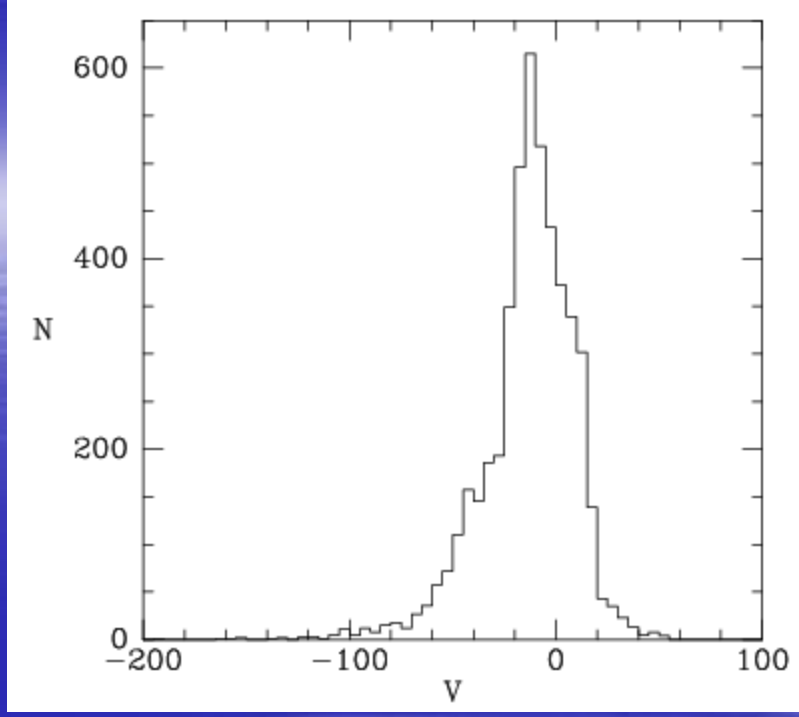
- Random velocities a function of colour

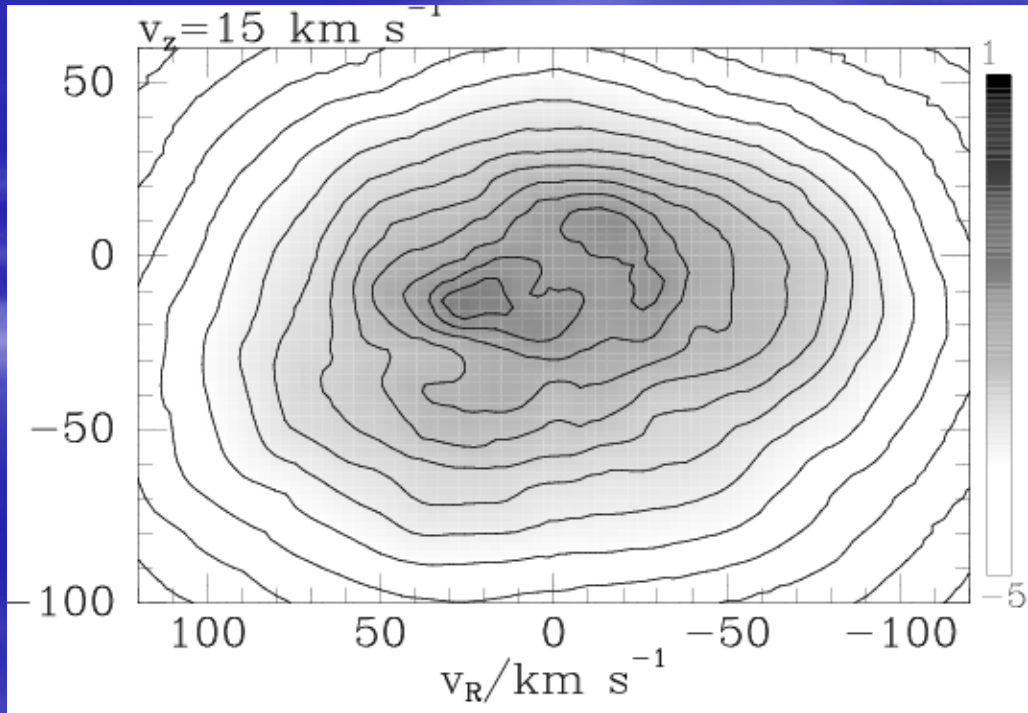


Aumer & Binney 09

kinematics

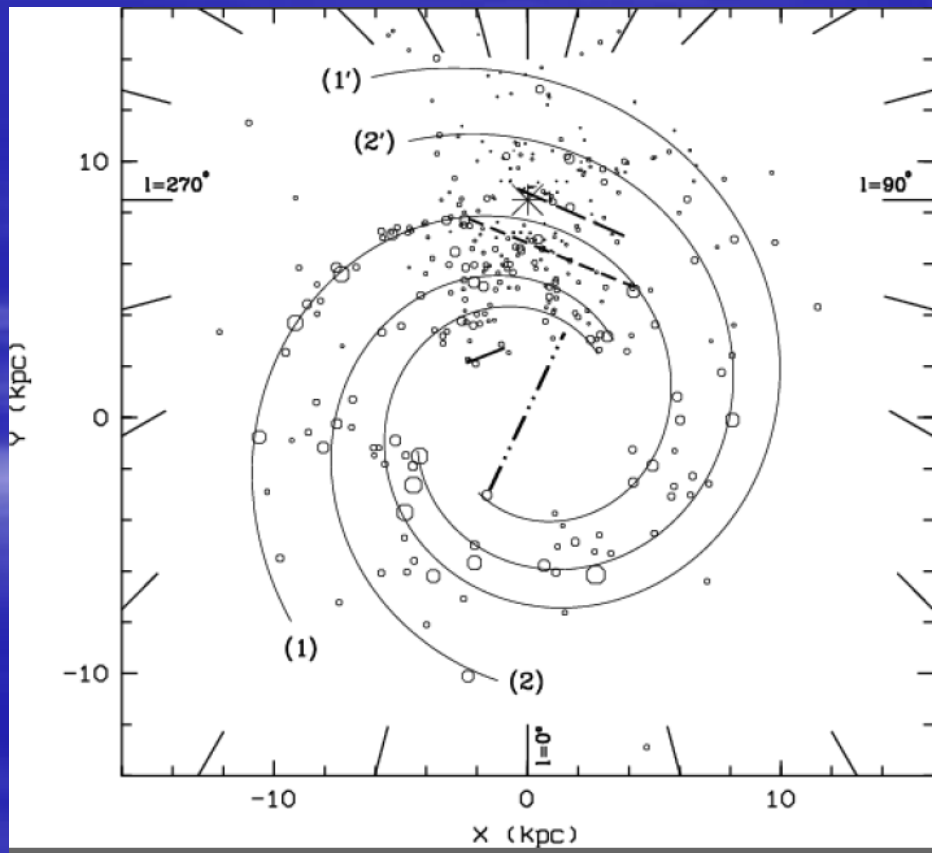
- Stars steadily accelerated by grav fields of spiral arms and molecular clouds
- Distribution in V very skew – long tail to low rotation
- In (U,V) plane many streams (moving groups)



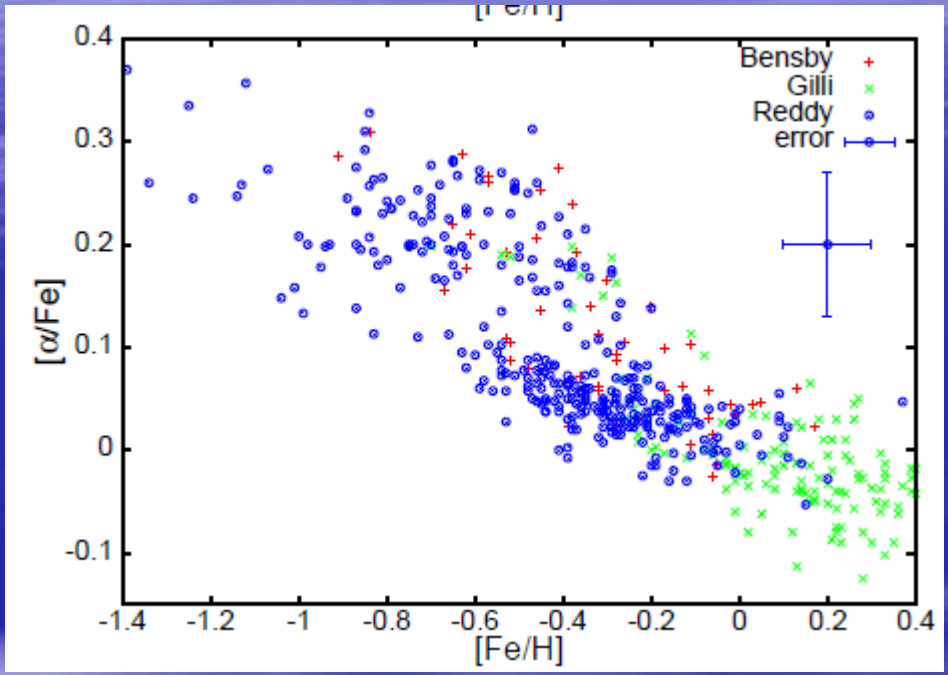


Spiral structure

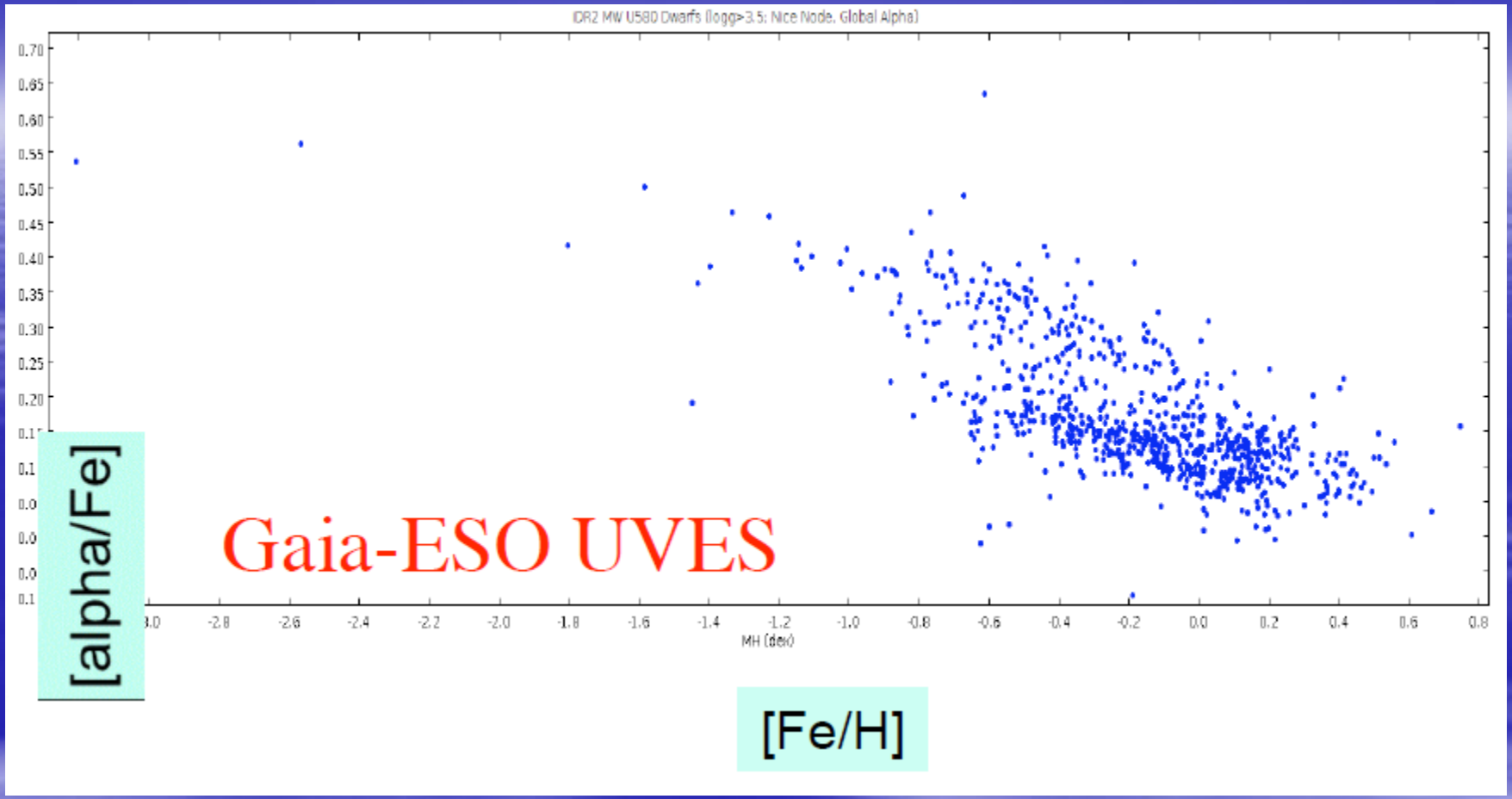
- An important phenomenon as heats disc and moves gas inwards
- Poorly understood: traced by OB associations
- Dust
- Gas



Thin versus thick disc

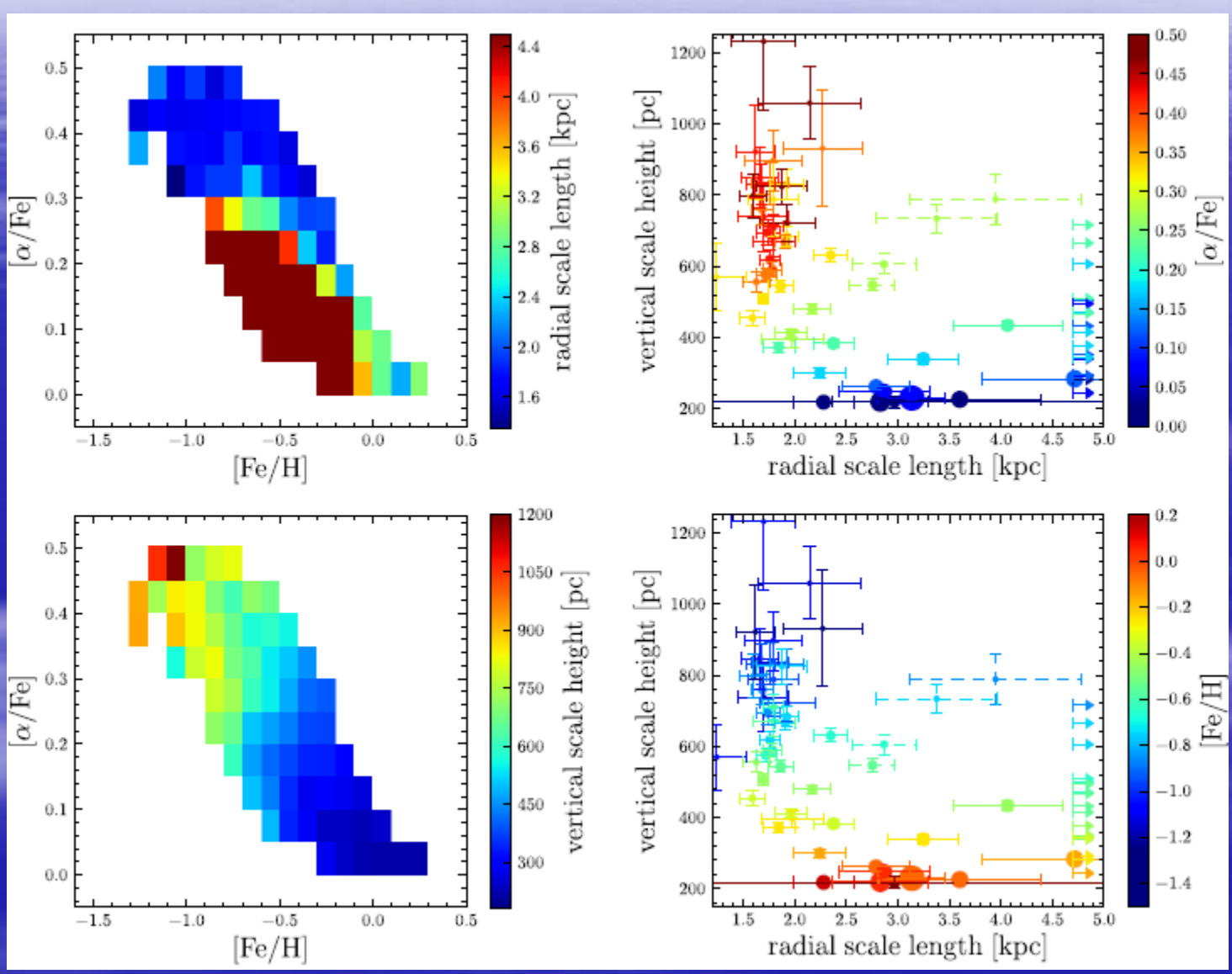


- Recently Bovy ++ have been arguing from SDSS that there's just one disc: a superpositon of perfectly isothermal chemically homogeneous discs with scaleheight increasing with α/Fe



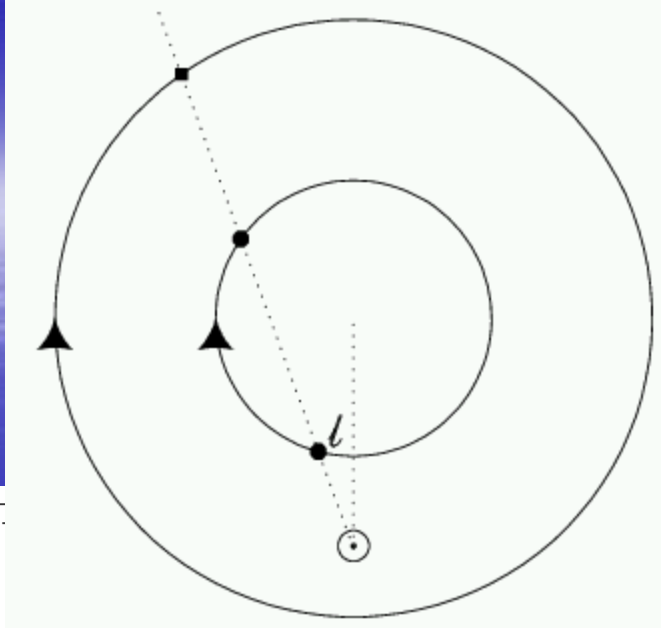
- Photometrically selected sample of FG stars within ~2kpc of Sun
- No kinematic bias!

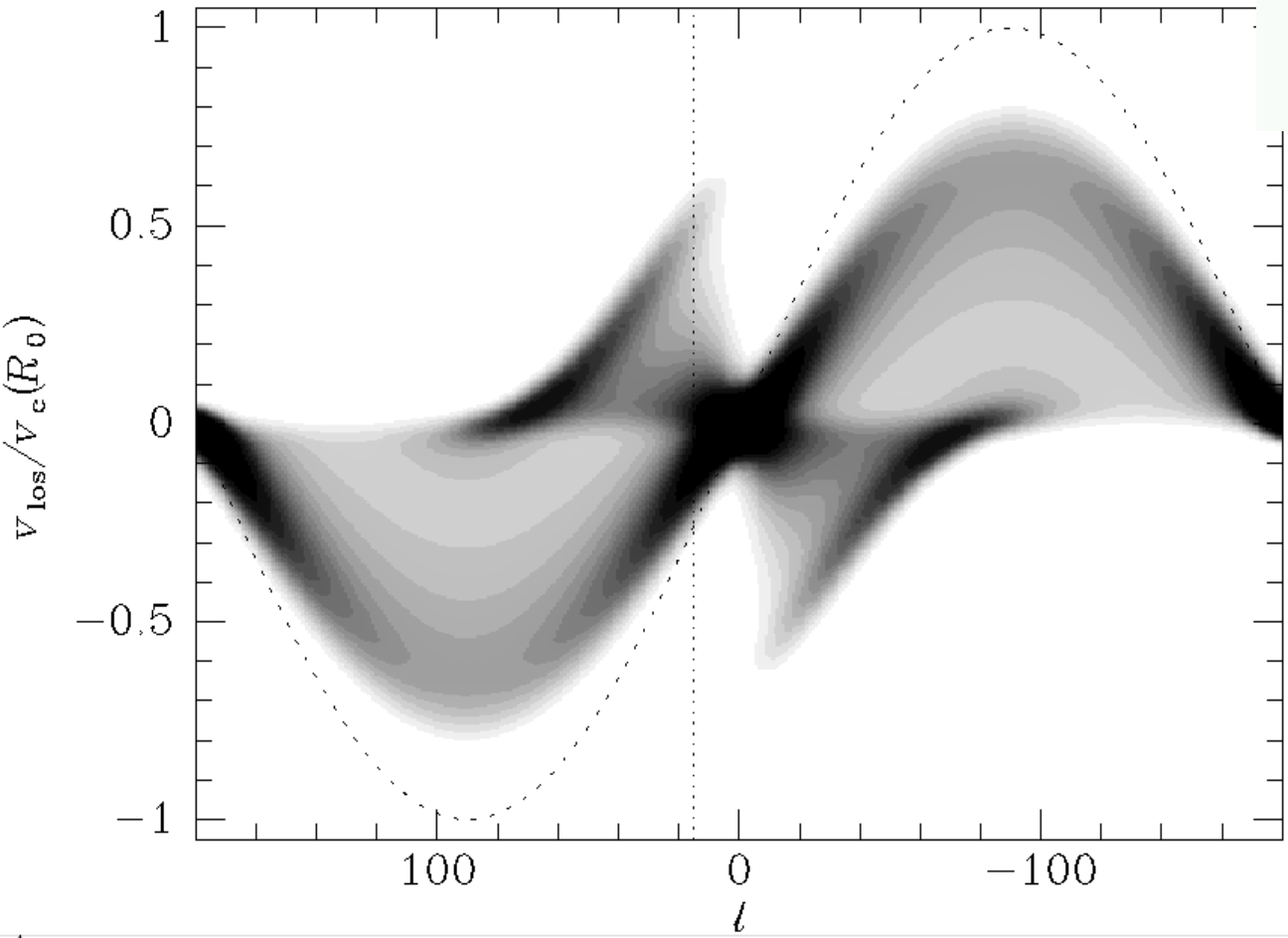
Bovy + 2012

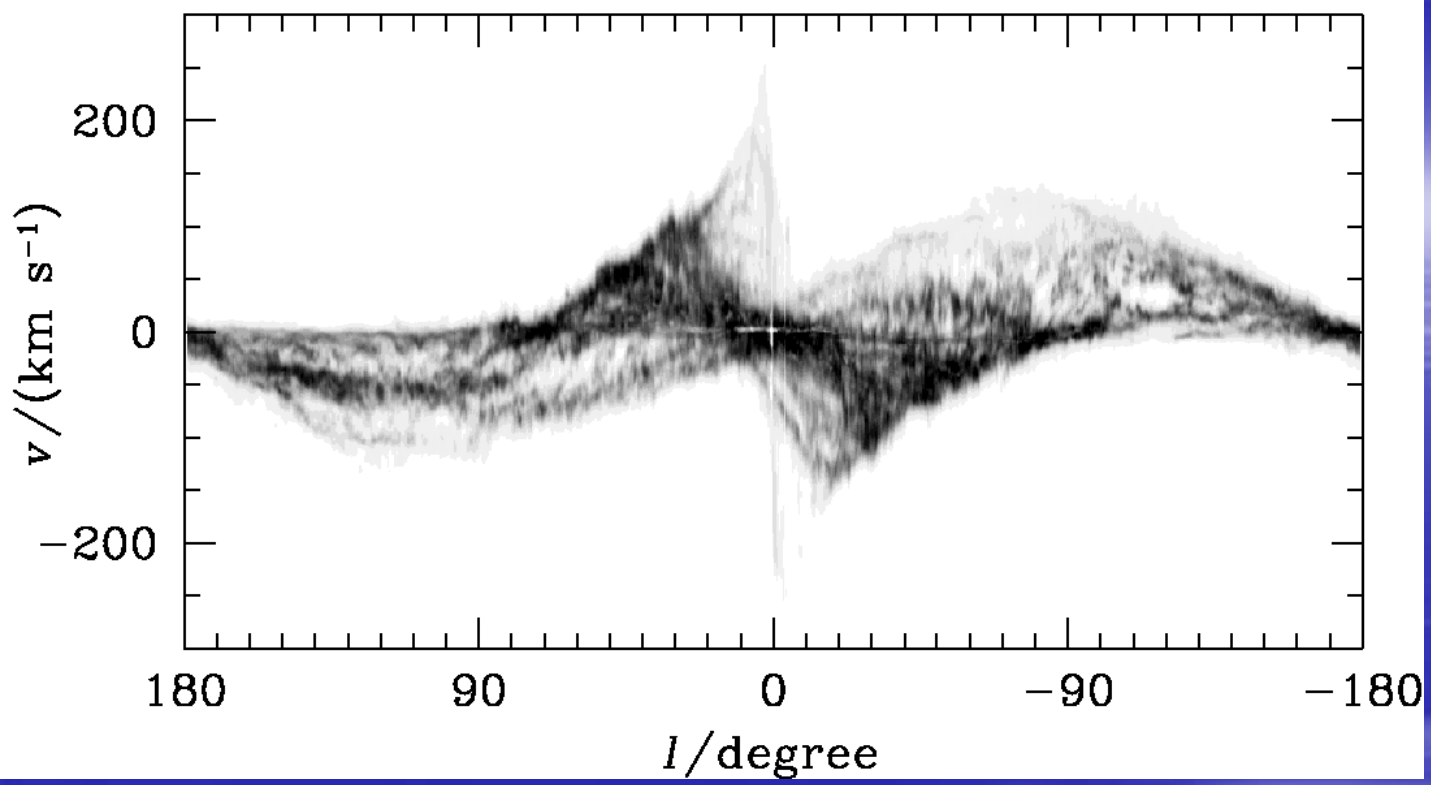

[α/Fe]
[Fe/H]
radial scale length [kpc]
vertical scale height [pc]
radial scale length [kpc]
[α/Fe]
[α/Fe]
[Fe/H]
vertical scale height [pc]
[Fe/H]
vertical scale height [pc]
radial scale length [kpc]

Interstellar Gas

- Systematic effect: circular streaming





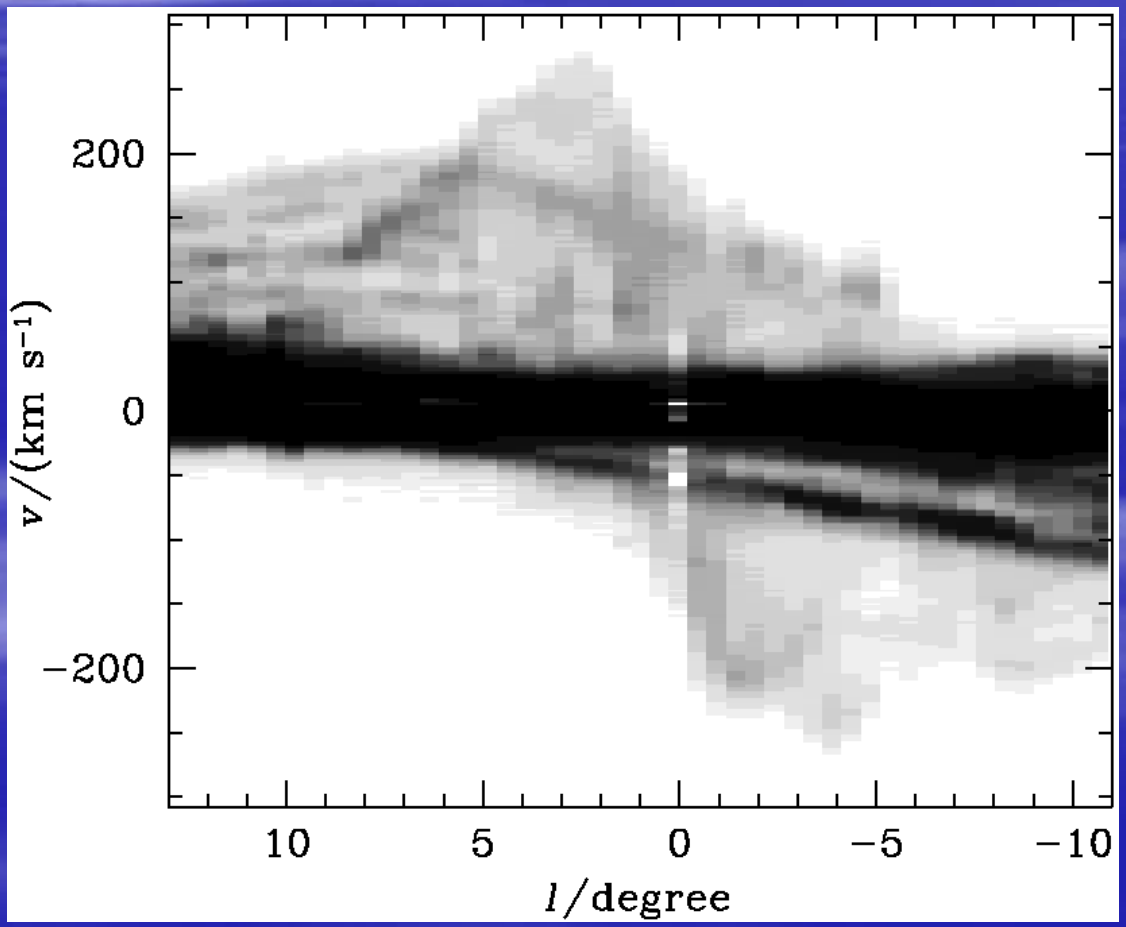


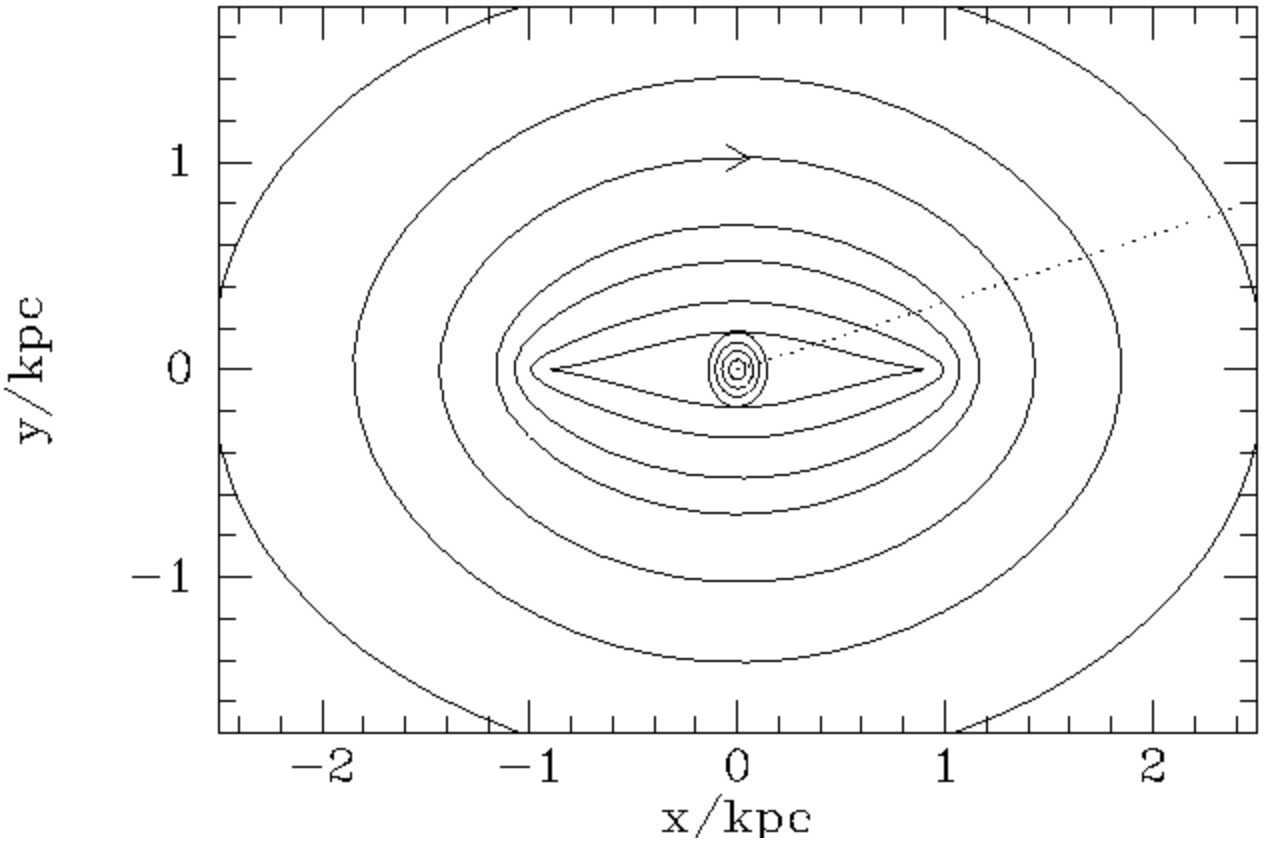
HI

CO

The Galactic Bar

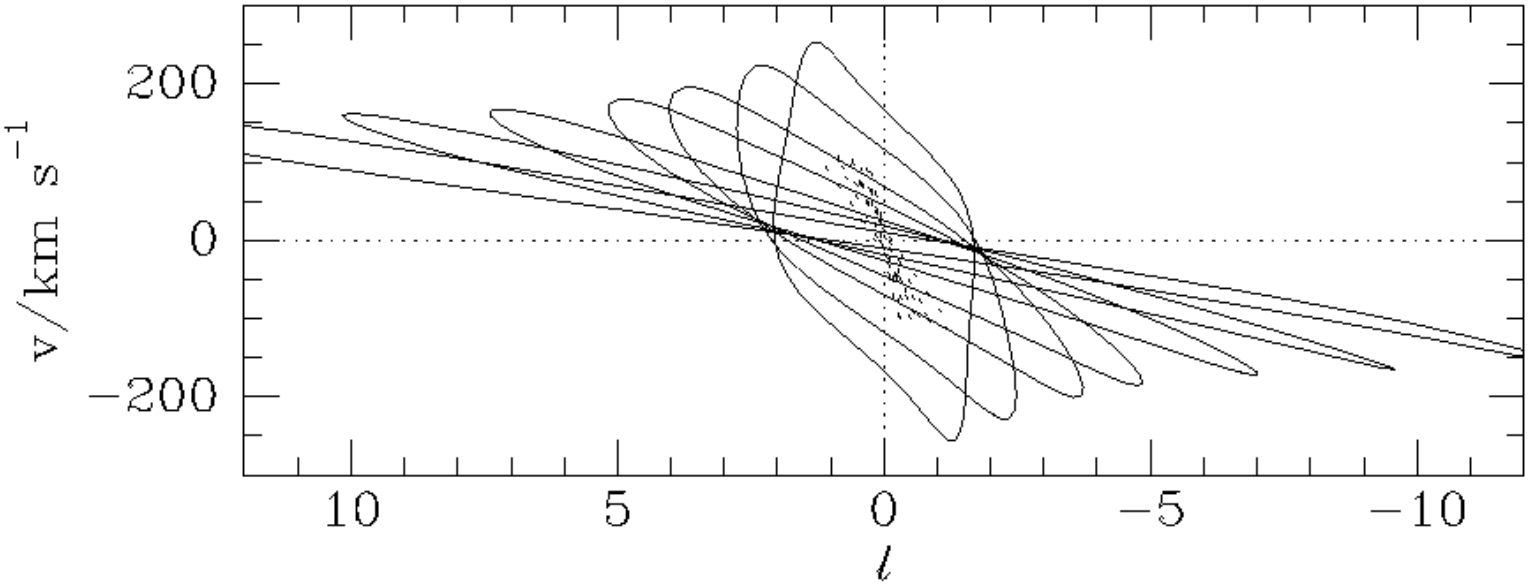
- Gas towards the GC moving towards & away at ~150km/s





to Sun

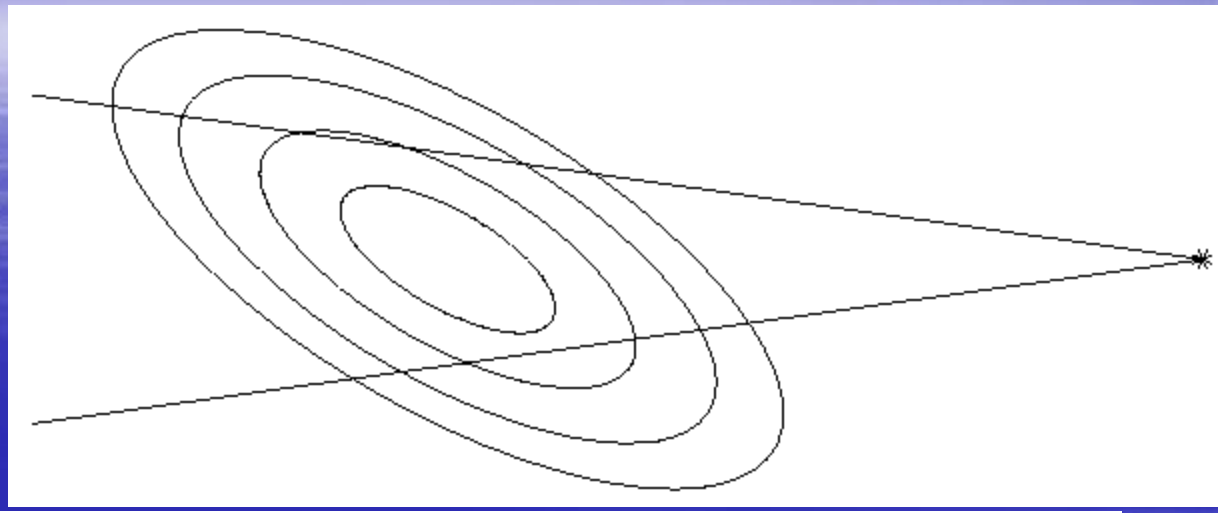
- Expected if Galaxy barred

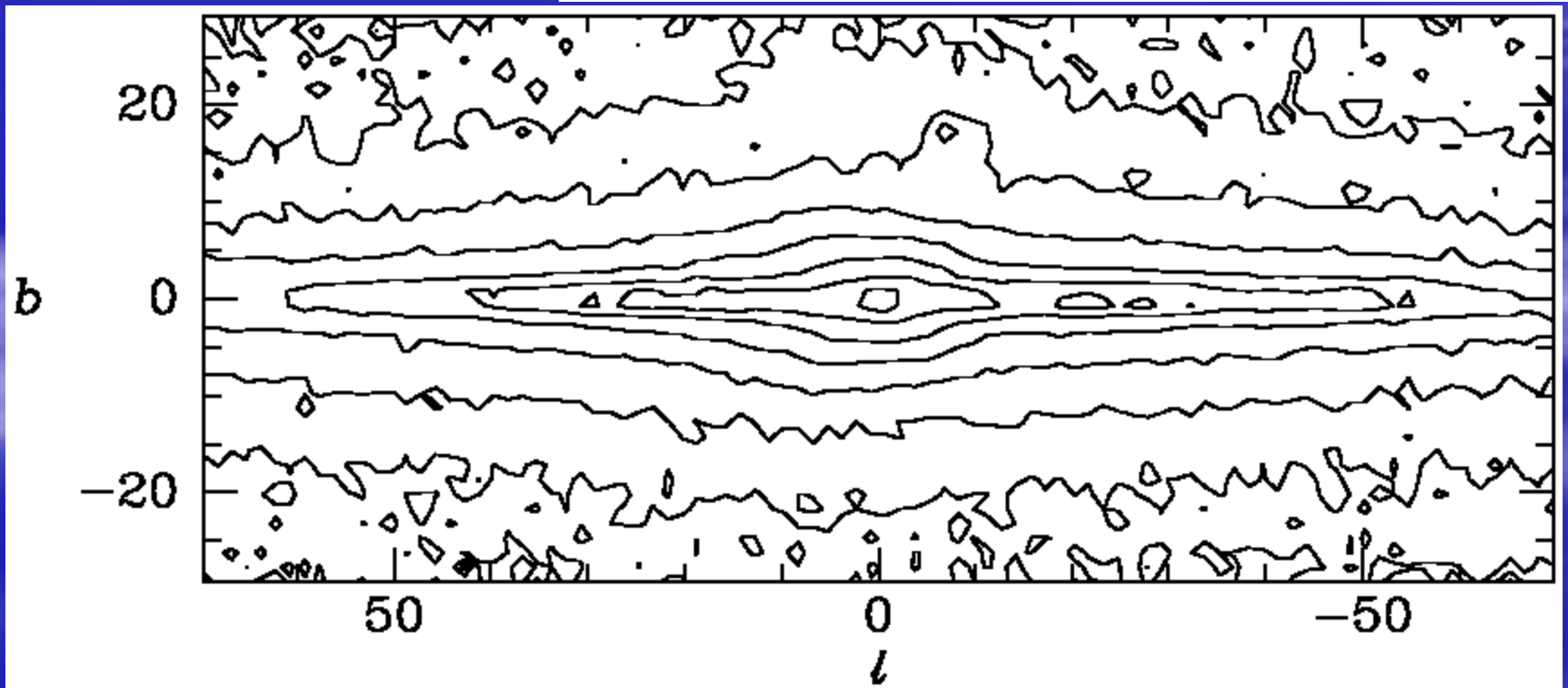


If we could look down

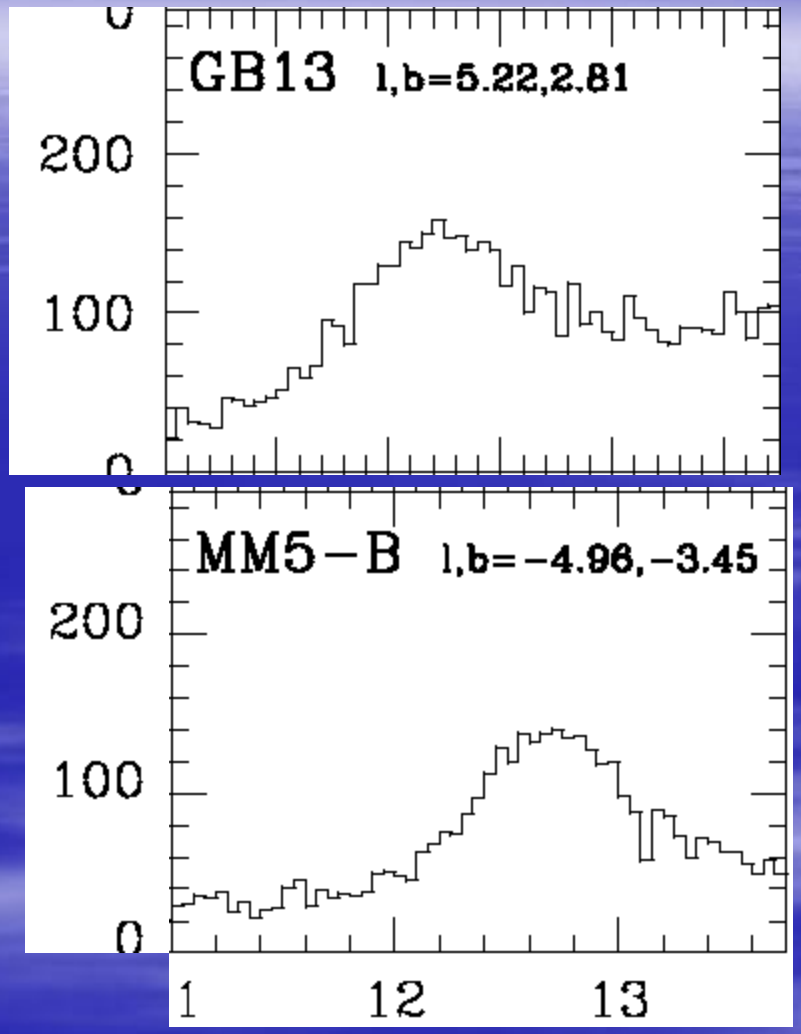
Near IR Photometry

- Galaxy brighter on left of GC





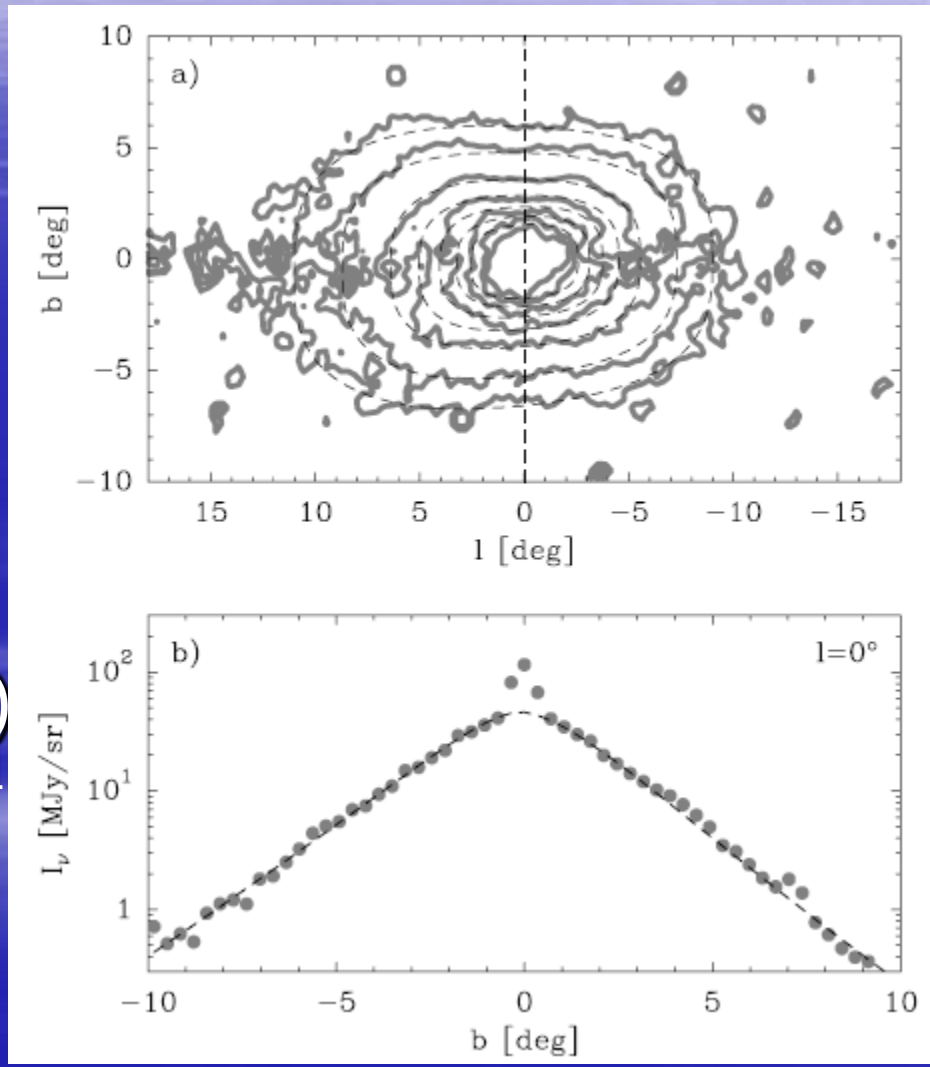
- Individual objects (eg HB stars) also brighter on left



Stanek 1995

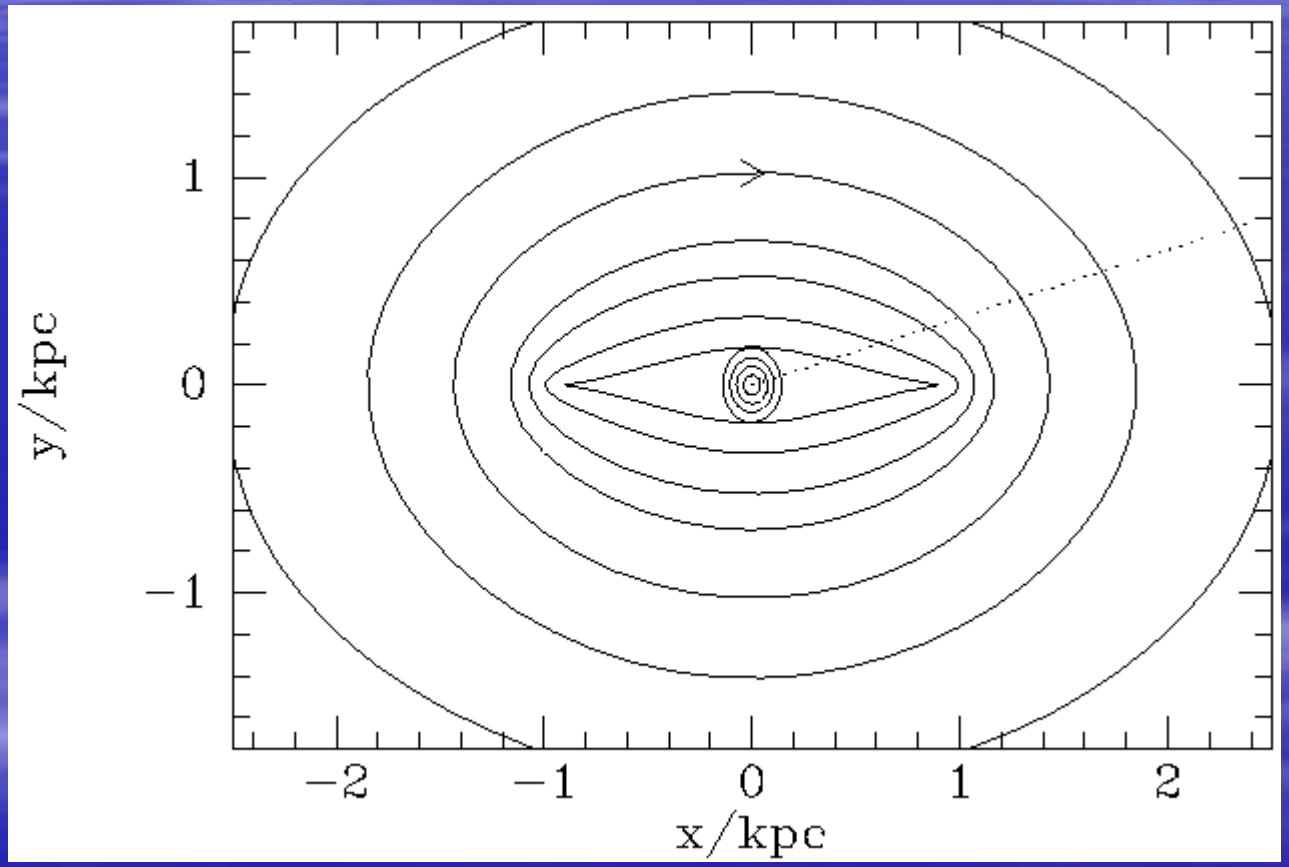
Bulge/bar

- A pseudobulge
- (buckled disc)
- $L \simeq 10^{10} L_{\odot}$
- $a \simeq 3.5$kpc
- a:b:c $\simeq$ 1:0.4:0.3
- Rapid rotator (Dehnen99)
  $\omega_p \simeq$ 53km/s/kpc=54Gyr^{-1}
- R_c=3.4kpc

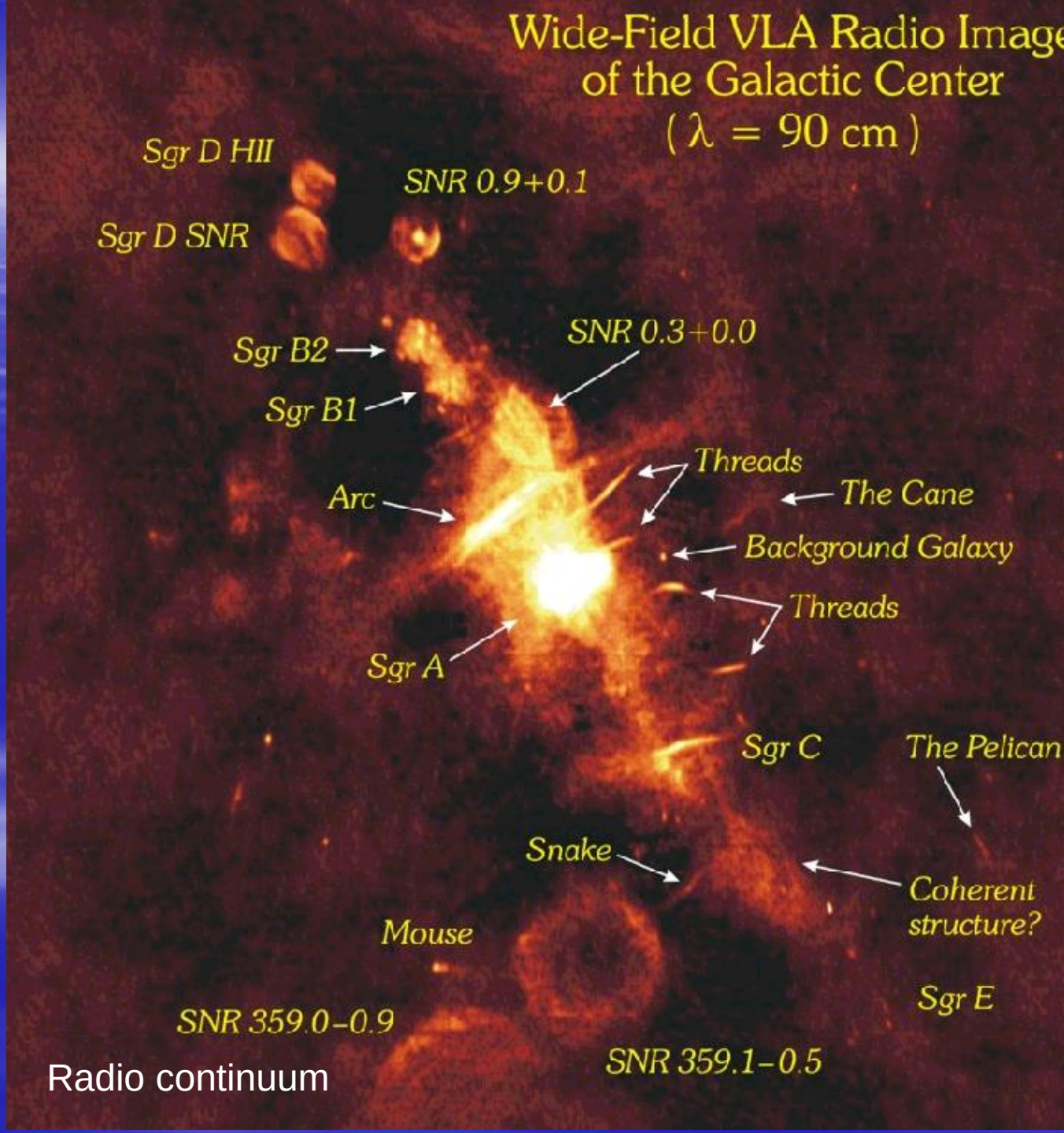


Launhardt+ 02

Nuclear star-forming disc



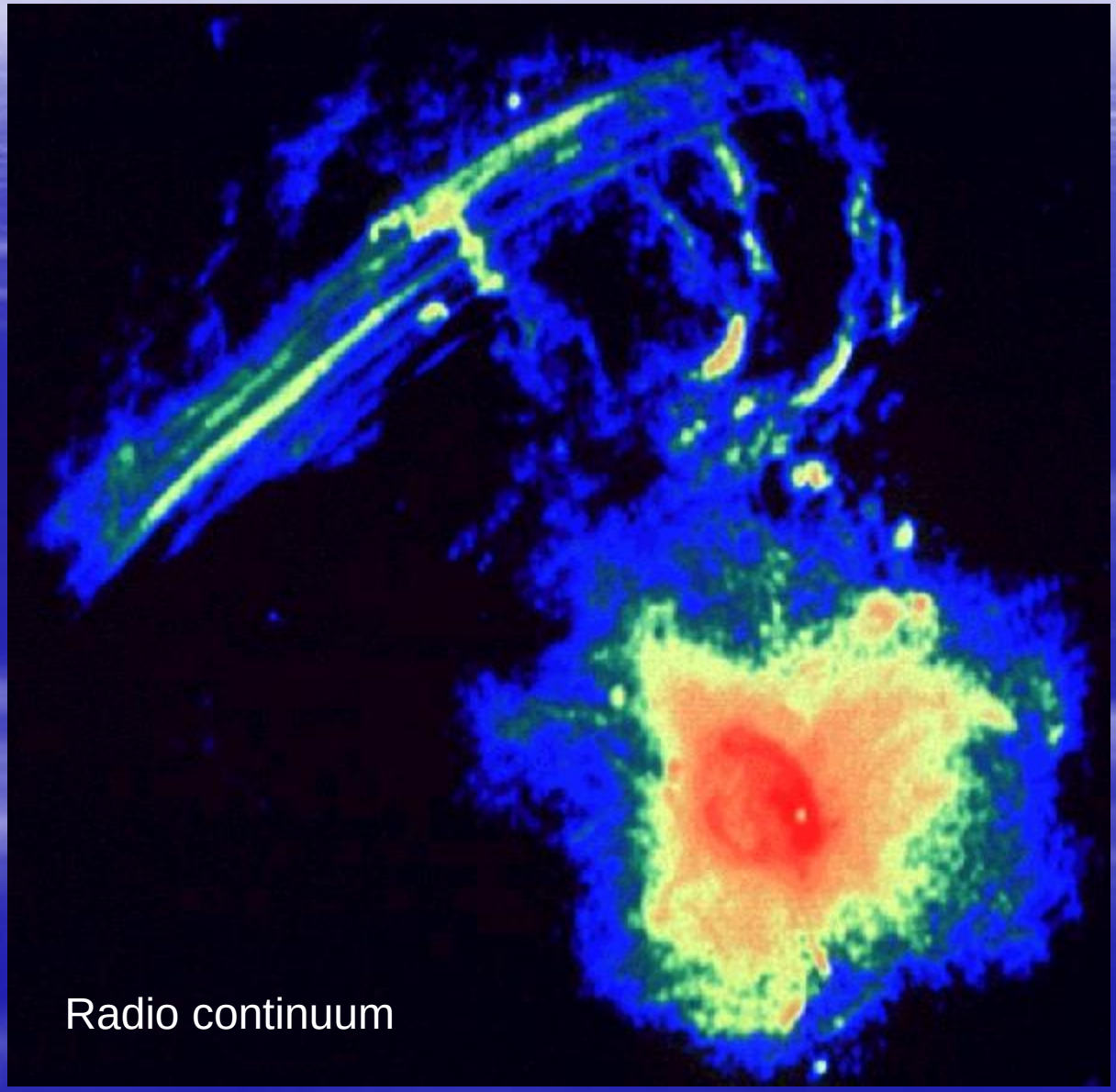
The Galactic Centre



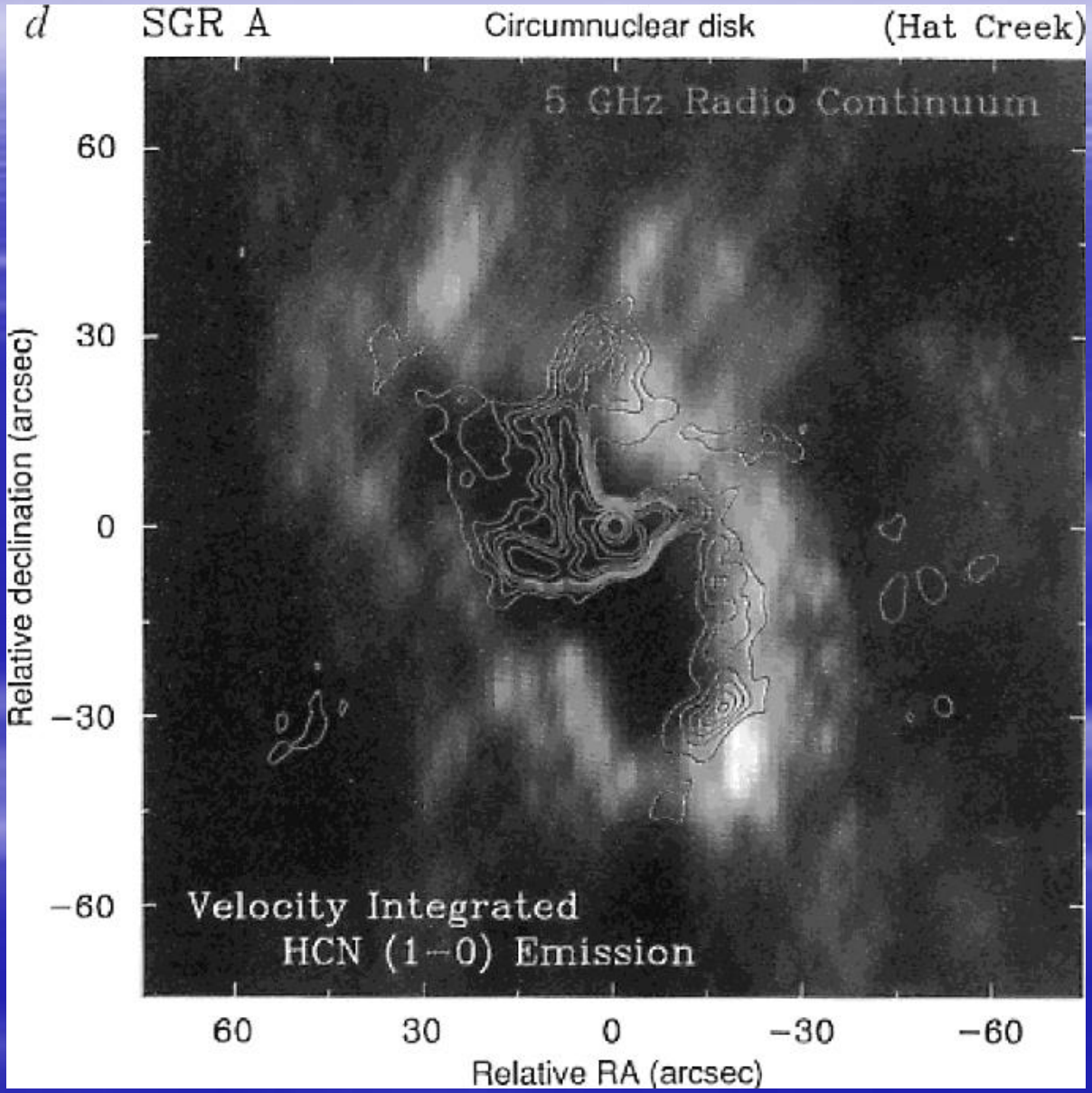
70 pc

Radio continuum

Sgr A and Filaments



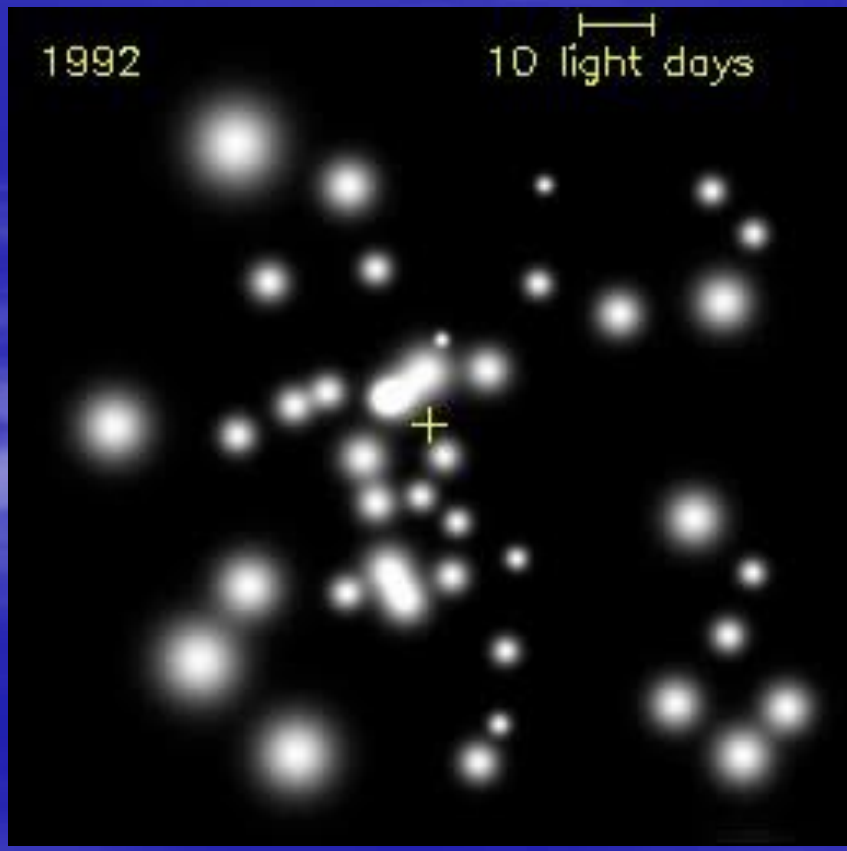
Inclined Nuclear Disk



Arcmin = 2.4 pc

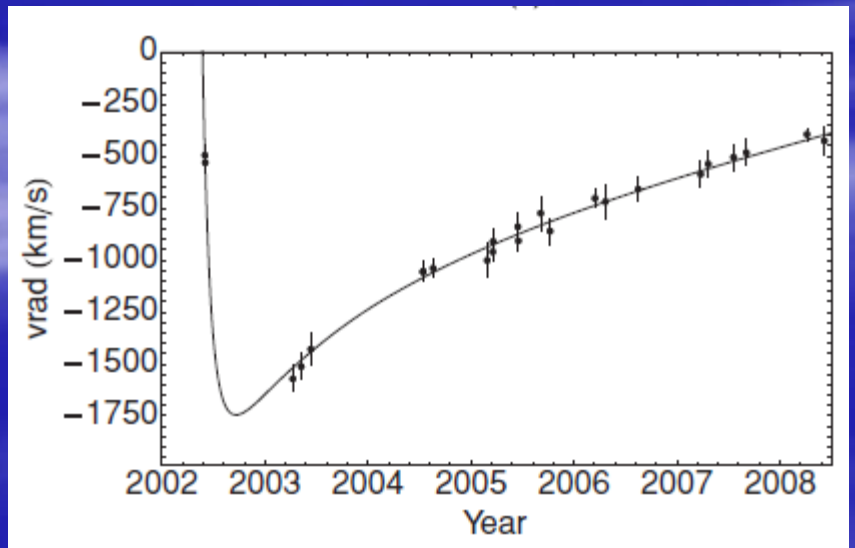
The Black Hole

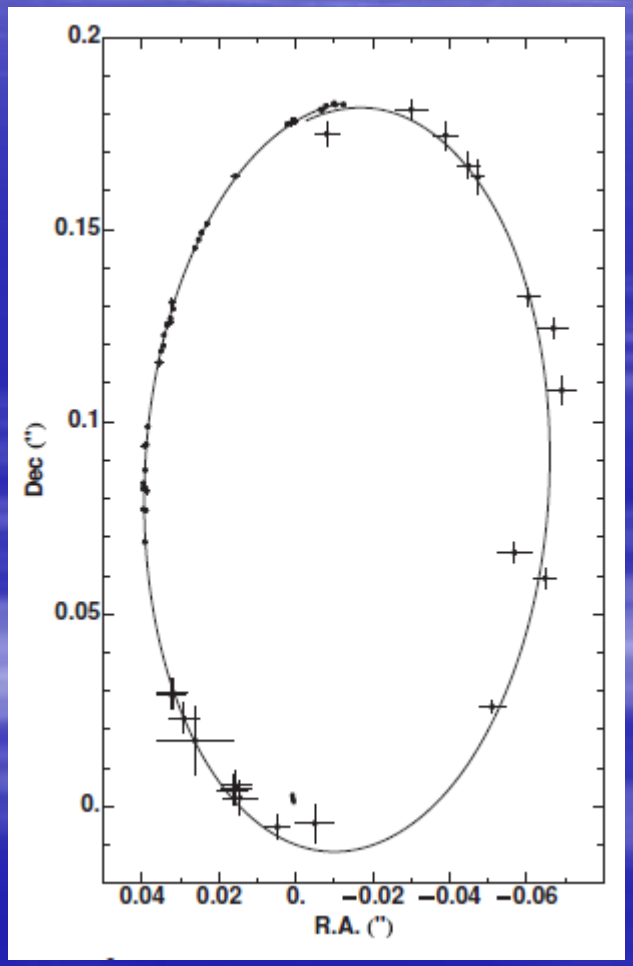
- Weak radio source Sgr A* marks spot
- Orbiting stars reveal its force-field



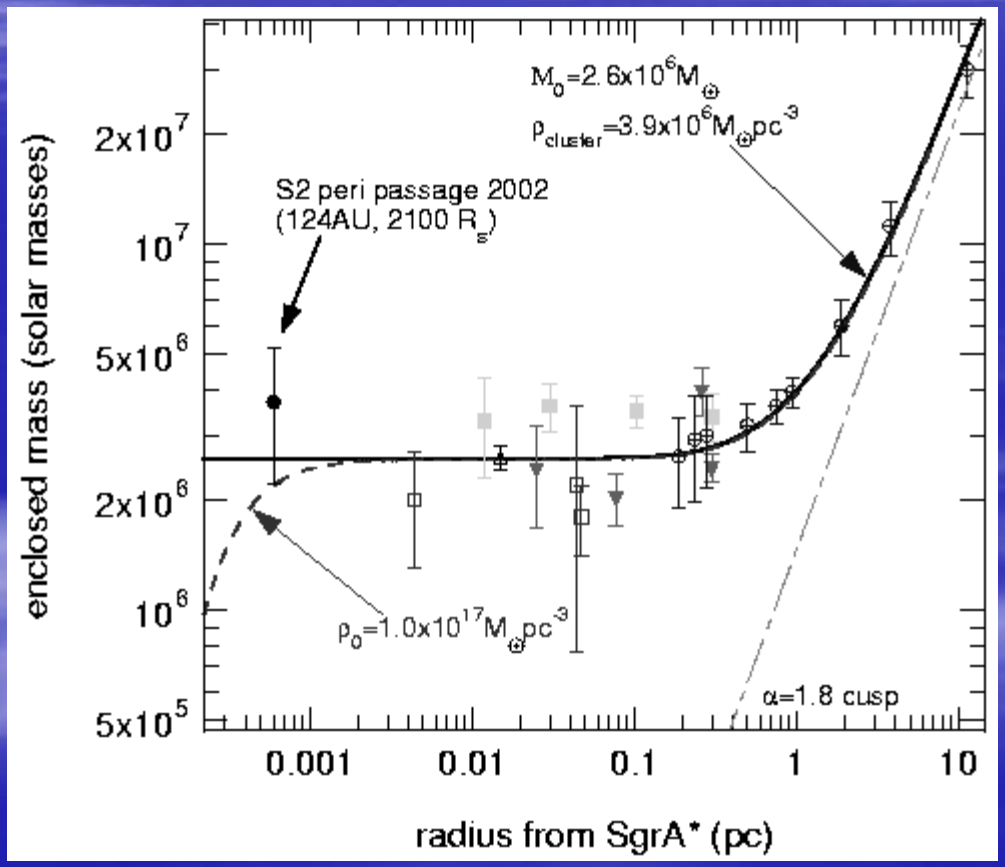
The Black Hole

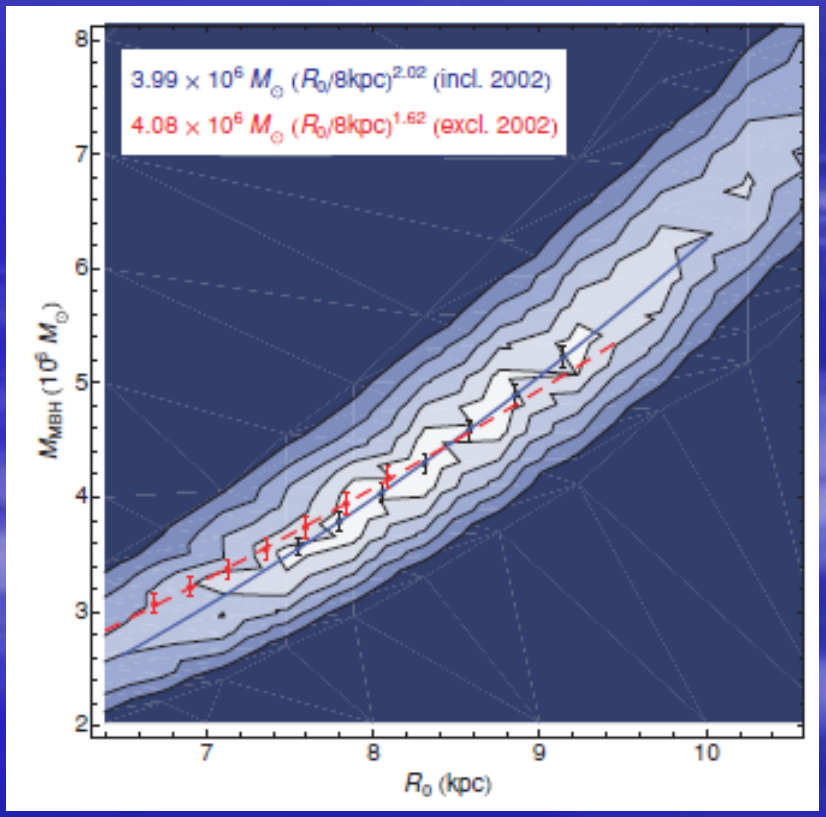
- Weak radio source Sgr A* marks spot
- Orbiting stars reveal its force-field
- $M=4.3\pm0.36\times10^{6}M_{\odot}$
- $M\propto R_0^{2.2}$





Resulting mass estimates

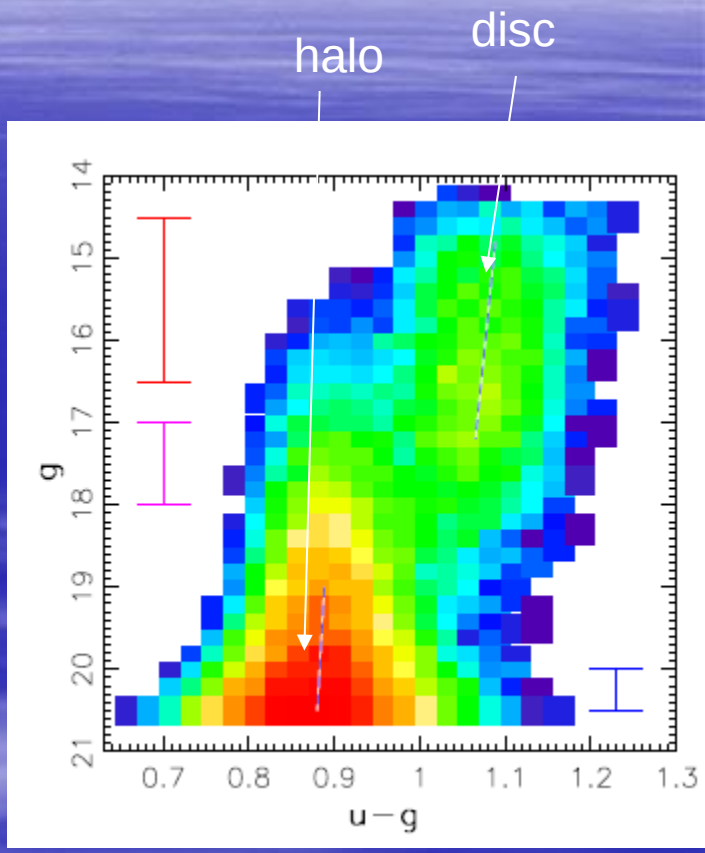




Gillessen + 09

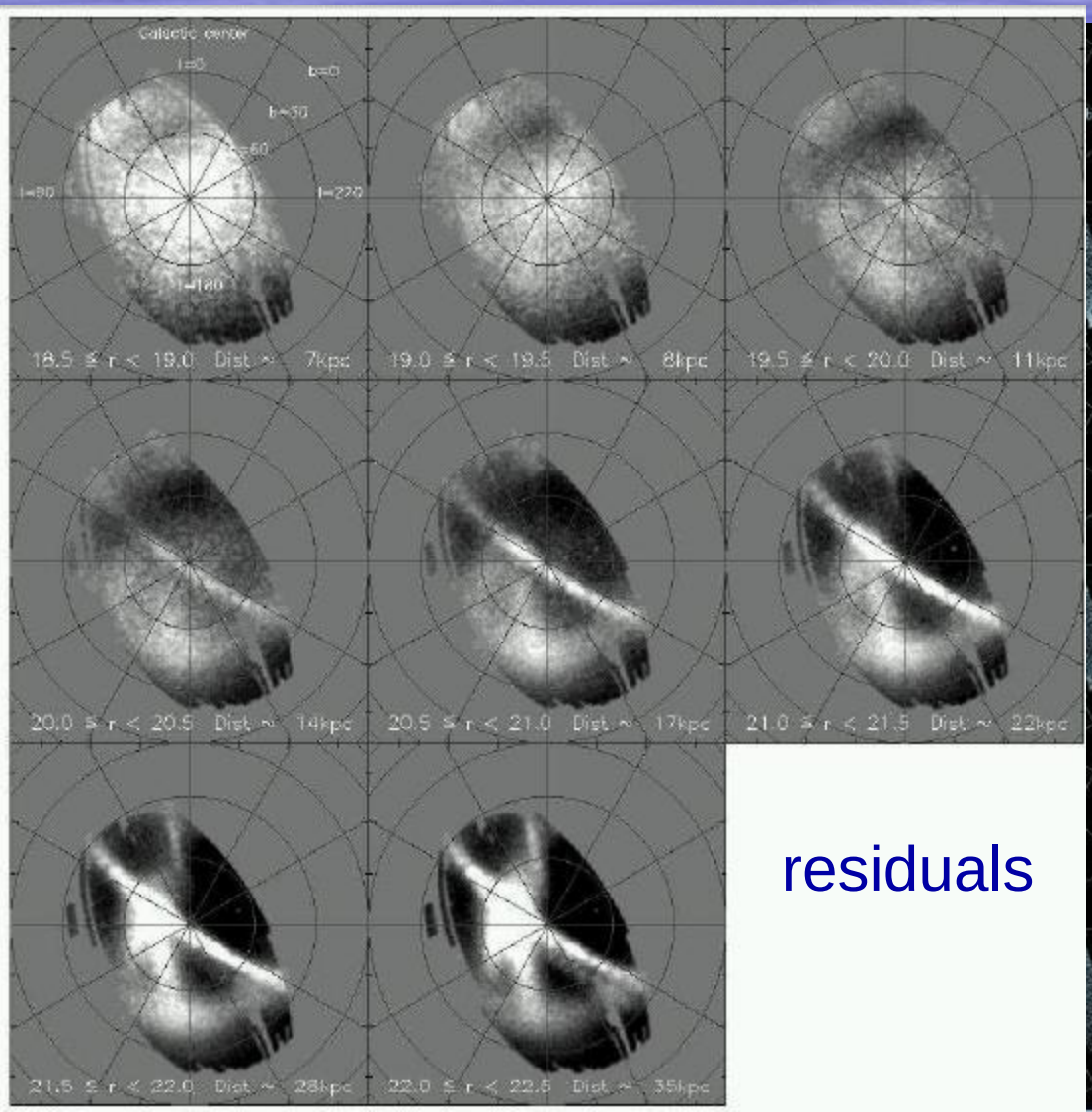
The stellar halo

- Classically traced by blue horizontal branch stars & RR Lyrae stars
- SDSS traces with MS stars
- Metal-poor:
  $-5.5 < [Fe/H] < -1$
- Old
- Smooth component $q \simeq 0.8$ and $\rho \propto r^{-2.8}$
- $M(<40\ kpc) = 3.7 \pm 1.2 \times 10^8\ M_\odot$
- Much substructure

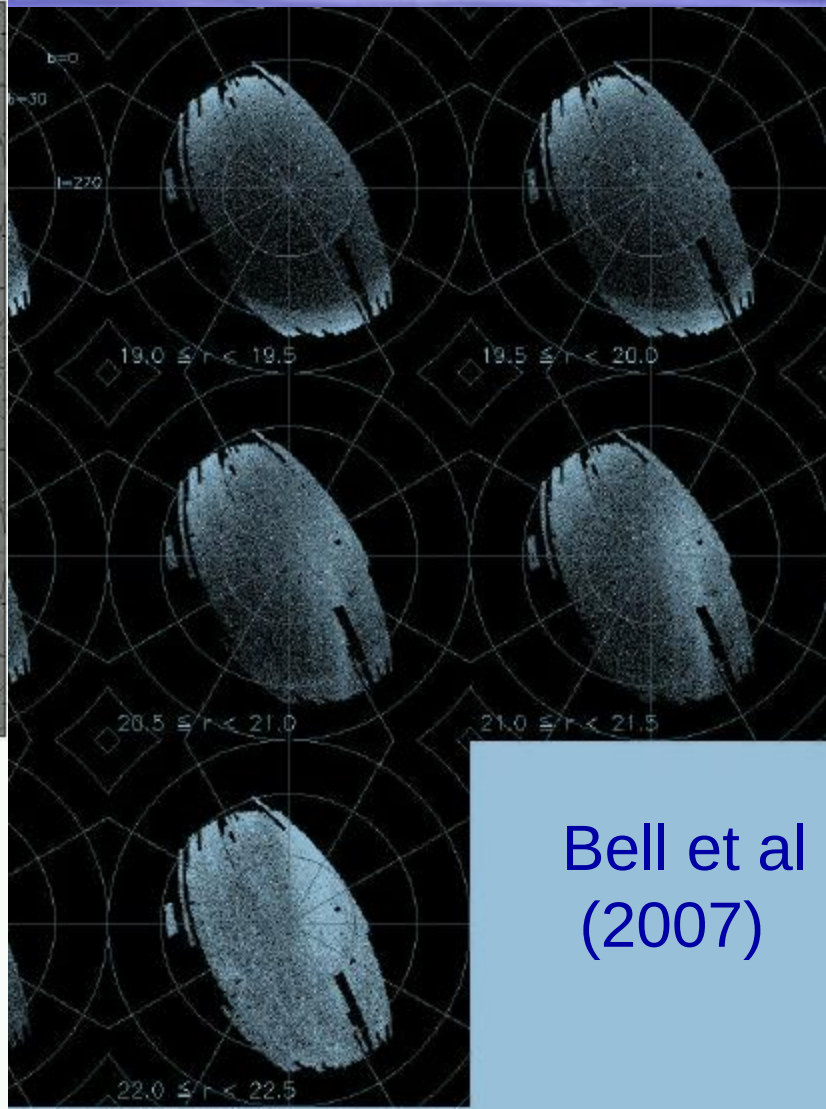


Ivezic+ 08 (SDSS)

Stellar halo
(SDSS)

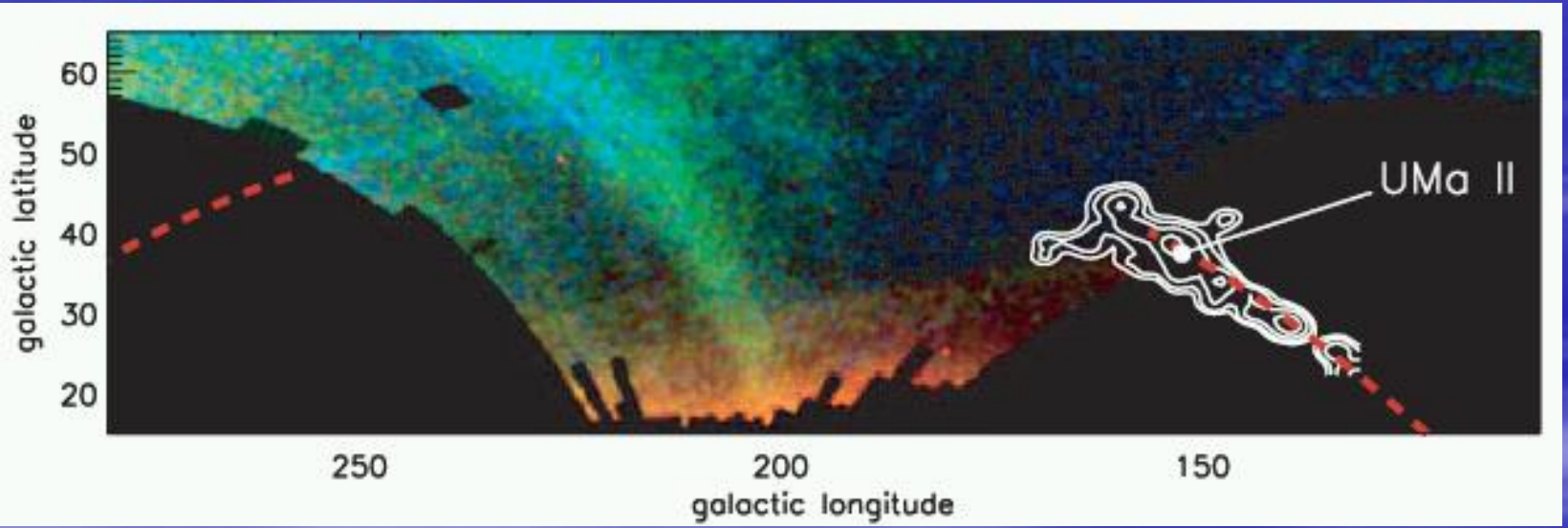


residuals

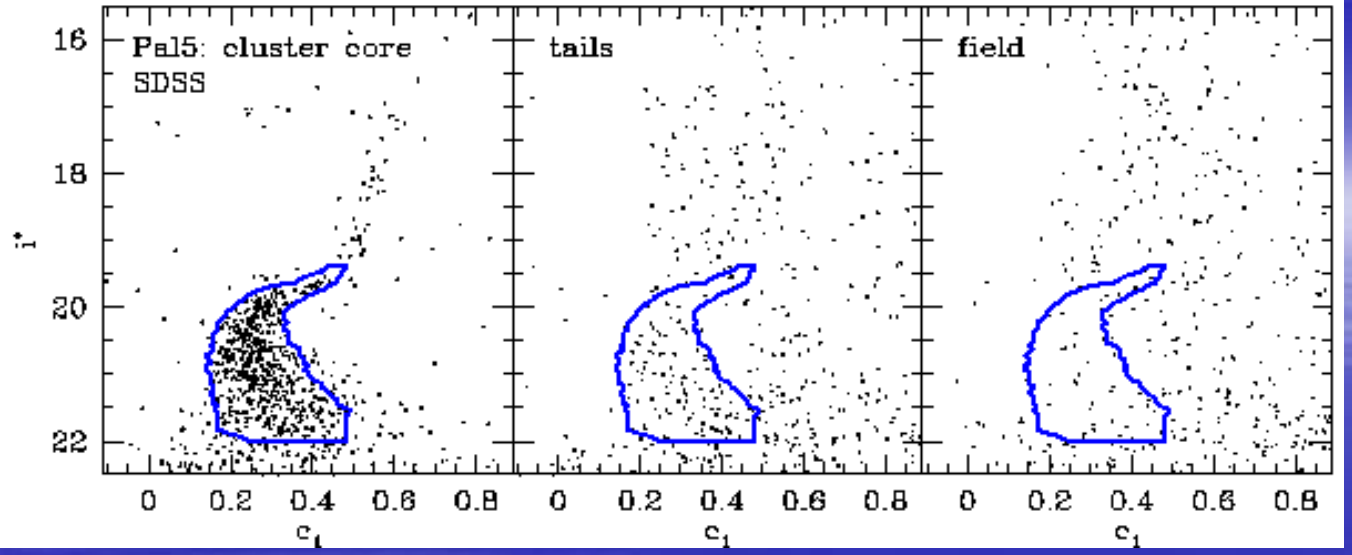


Bell et al (2007)

Stellar streams

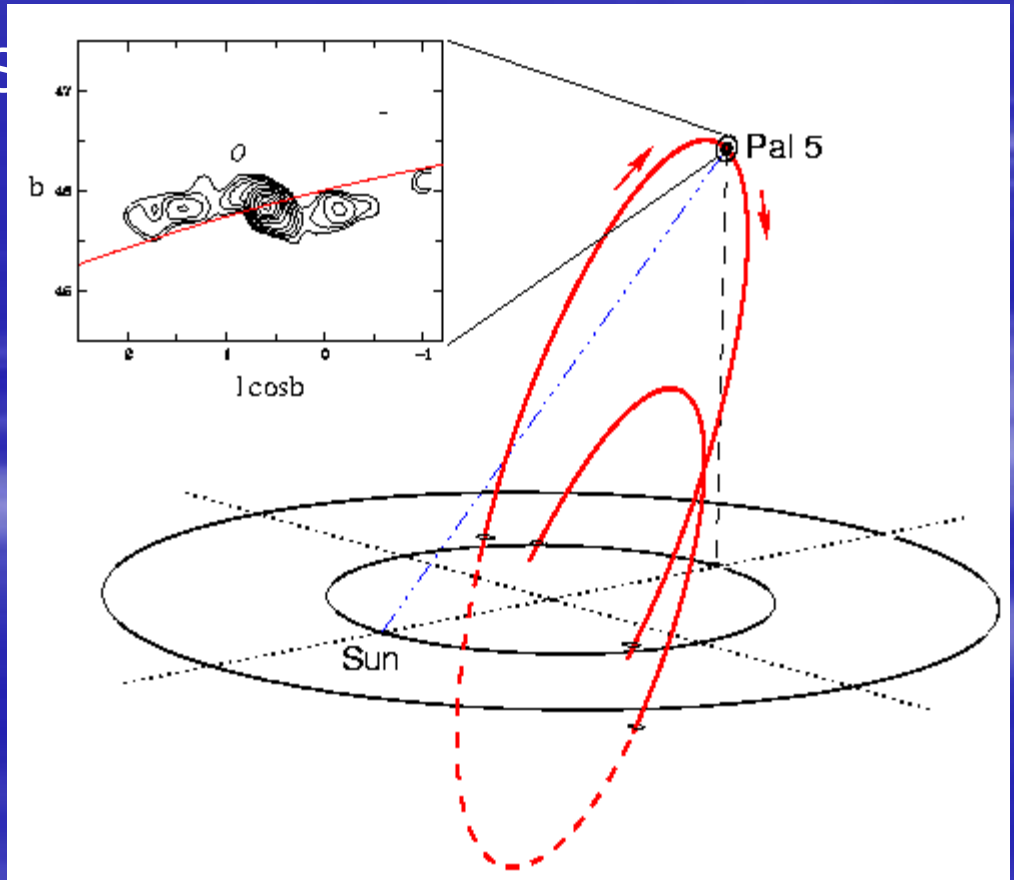


Belokurov et al (2007)



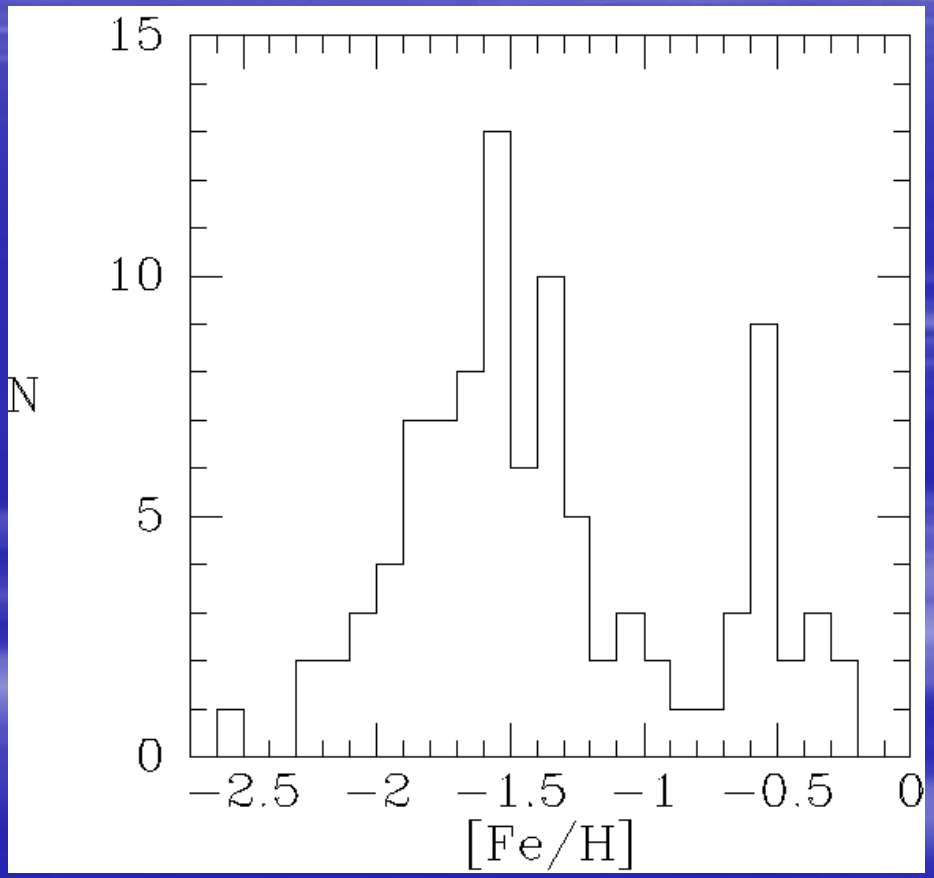
Sloan digital sky survey (SDSS

Tidal streams (Pal 5)



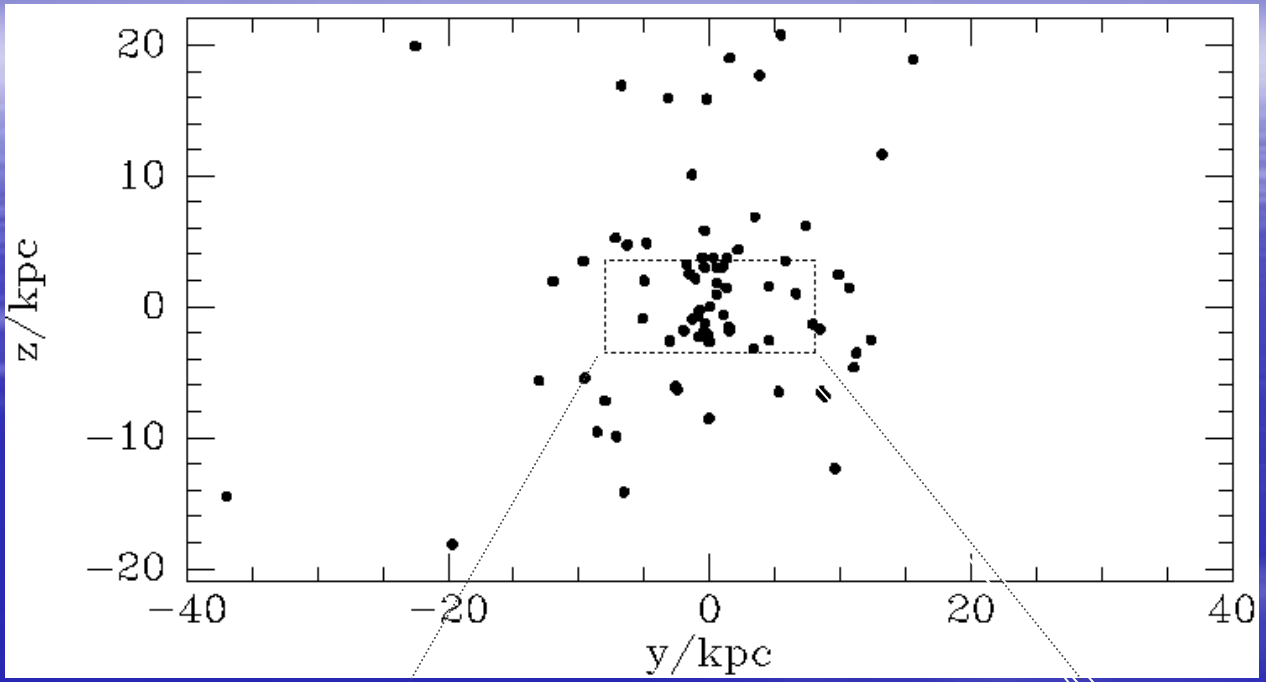
Globular clusters

- About 160 globular clusters
- Bimodal metallicity distribution
- Disk clusters (20%) more metal-rich
- Share Z distribution with bulge & thick disc

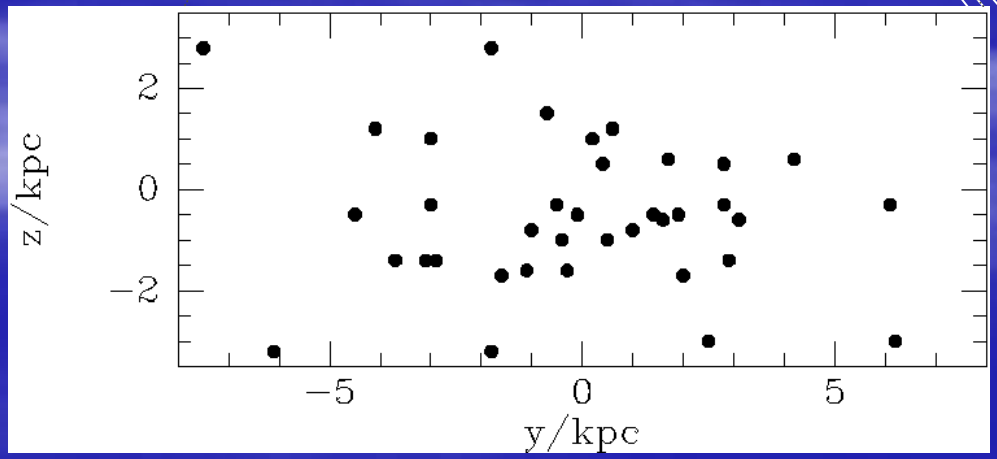


Halo & Disk Clusters

Halo



Disk



Dark halo

- DM simulations without baryons $\rightarrow$ NFW profile

$$\rho(r) = \frac{\rho_1 a^3}{r(r+a)^2}$$

- ρ_1 and a correlated to 1-parameter family
- Klypin+ 02 favour a=21.5kpc $\rightarrow$ v_{max}=163km/s and $\rho_{DM}(R_0)$=0.007$M_\odot$ pc^{-3}
- Contributes 15.4$M_\odot$ pc^{-2} to $\Sigma_{1.1}$ and 0.31 of g_r needed by $v_c(R_0)$=220km/s
- Implies $M_{DM}=3.1\times10^{11}M_\odot$
- Test prediction for M(>R_0) with satellites
- Problem is poor proper motions
- M(<50kpc)=$5.4^{+0.2}_{-3.6}\times10^{11}M_\odot$