# The Galaxy Inside Out:

## S Stars, Rocket Stars

## and the

## Structure of the Galactic Halo

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**Ugly Idea I: RV Survey (individual exposures)**

Basic Fact: High-Speed Coasting $\Rightarrow$

$$\frac{dN}{dr} = \text{const}$$

i.e.,

$$\frac{dN}{dV} = \frac{dN/dr}{dV/dr} \propto r^{-2}$$

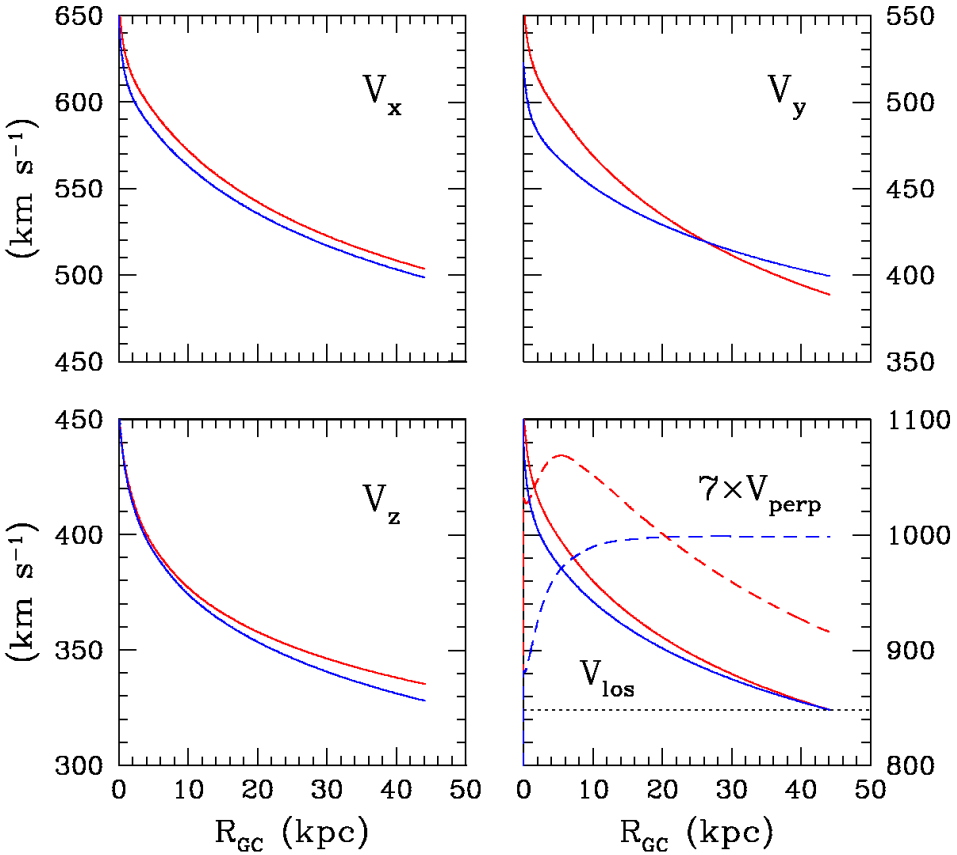
Compare $(dN/dV) \propto r^{-3.5}$ for halo stars.
Farther = cleaner = better??

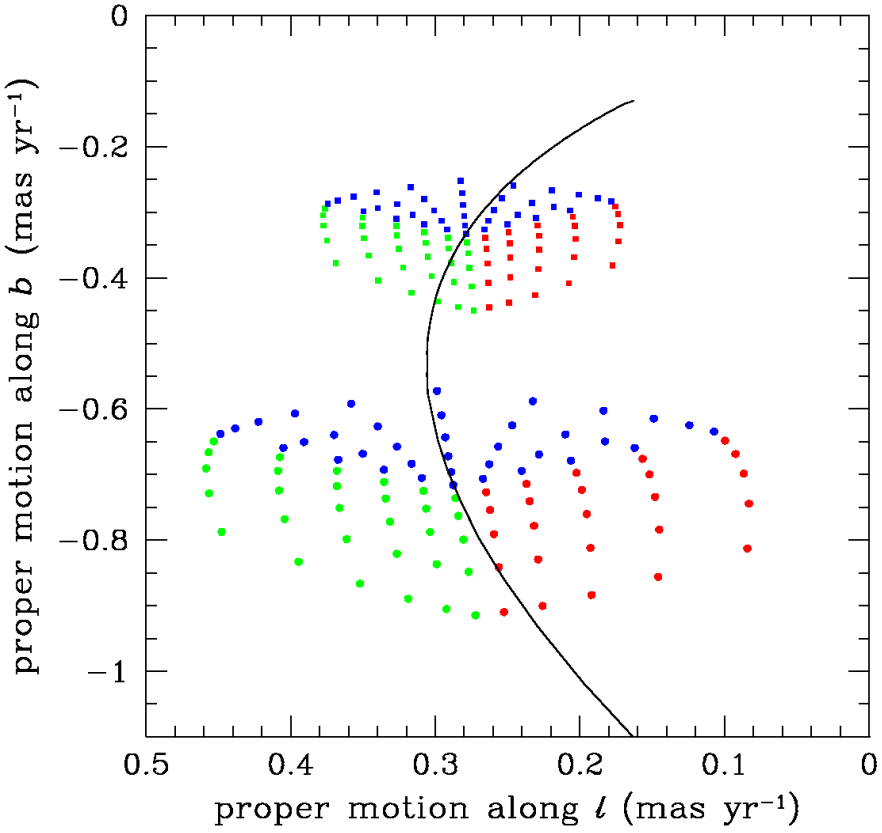
Individual Exposures $t_{\rm exp} \propto r^2$ (above sky)
..... $t_{\rm exp} \propto r^4$ (below sky)

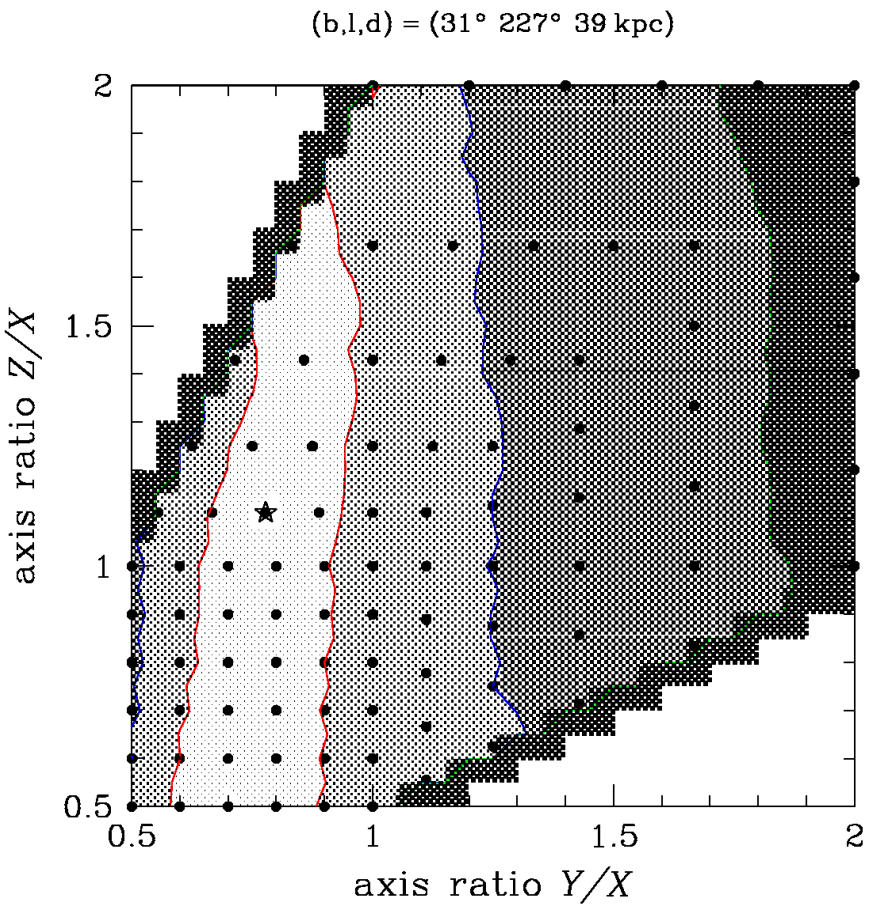
$$t_{\rm total} \propto \frac{(dN/dV)_{\rm rocket}}{(dN/dV)_{\rm halo}} t_{\rm exp} \propto r^{1/2} \quad (r^{5/2})$$

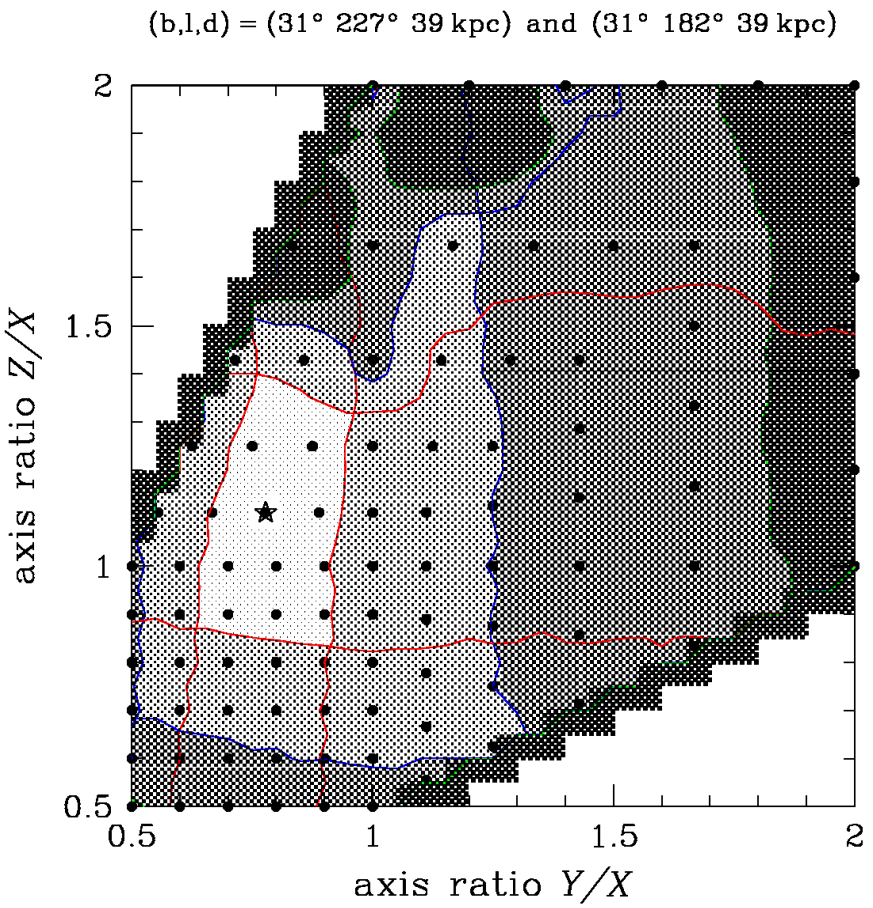
$\Rightarrow$ Closer = Better (Plus PMs are bigger)

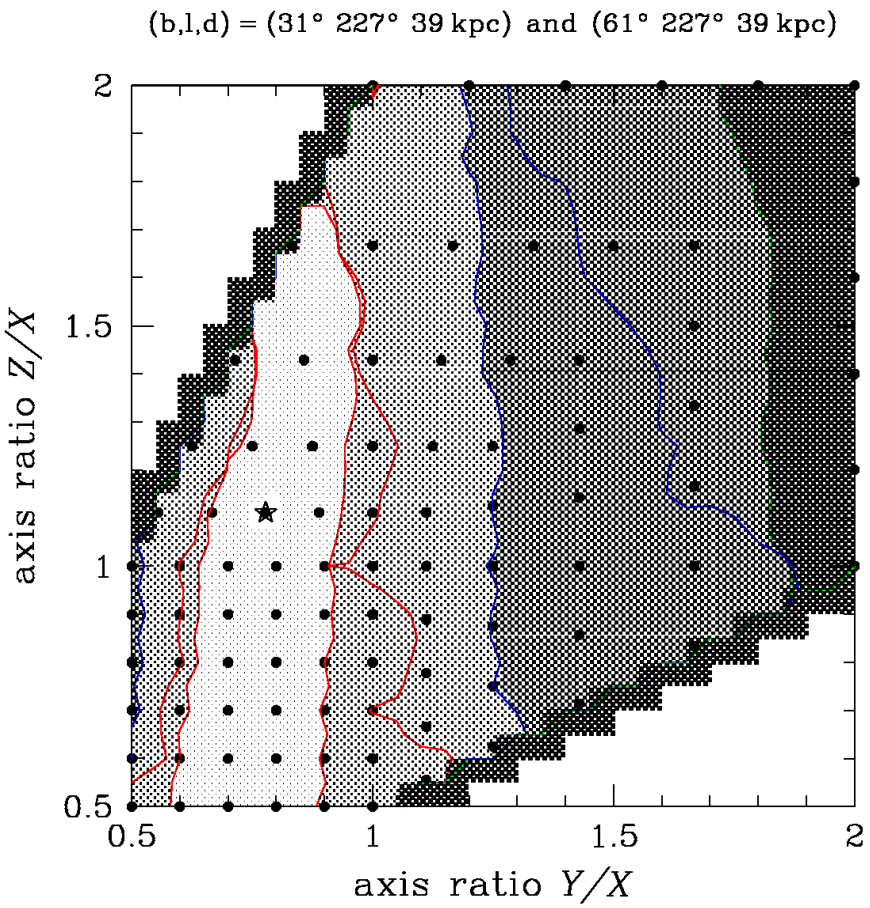
Very time consuming

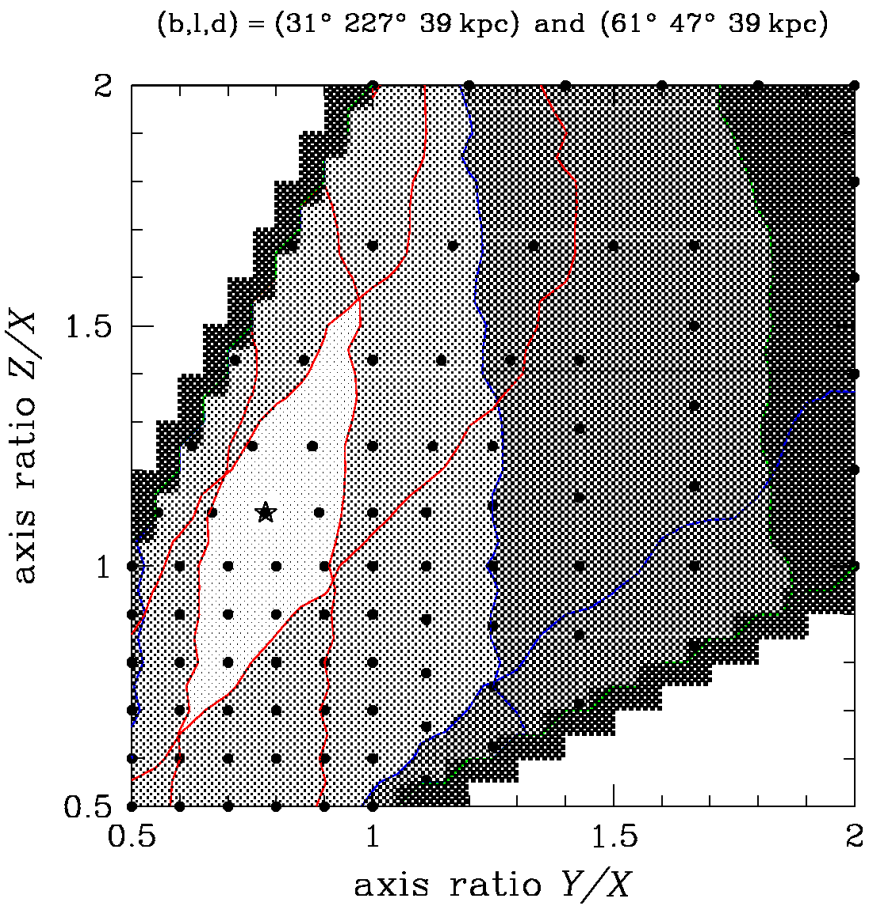

V_x
V_y
V_z
7×V_perp
V_los
(km s⁻¹)
R_GC (kpc)
650
600
550
500
450
550
500
450
400
350
450
400
350
300
1100
1000
900
800
0
10
20
30
40
50

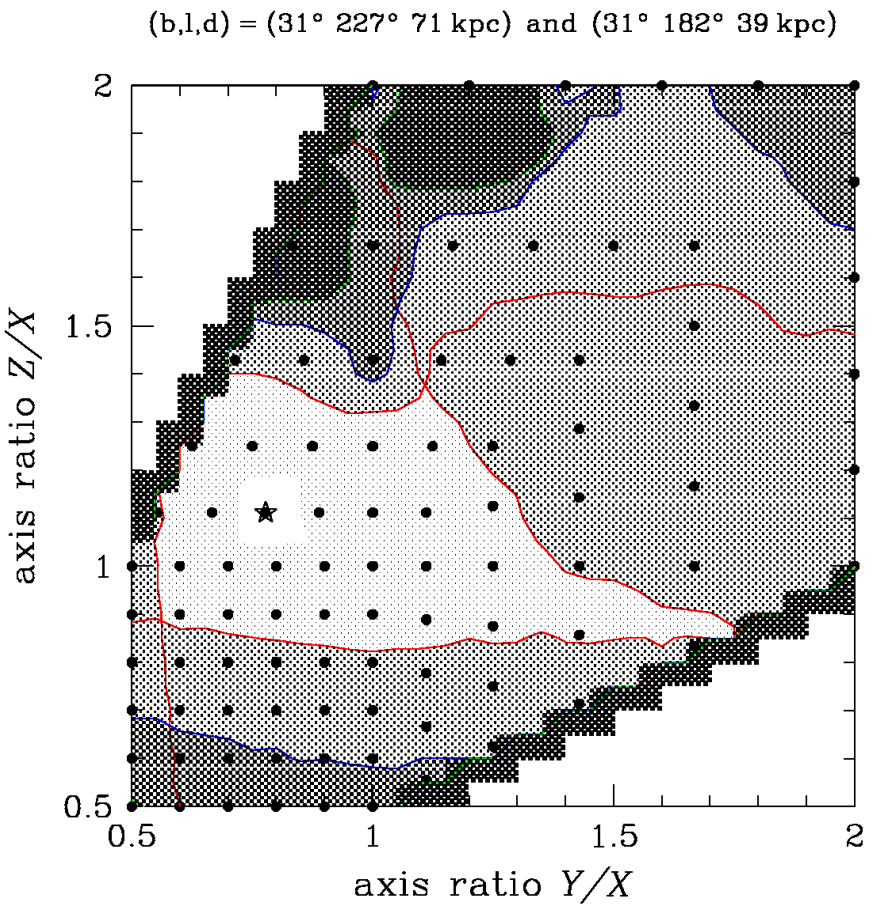

proper motion along b (mas yr⁻¹)
proper motion along ℓ (mas yr⁻¹)
0
−0.2
−0.4
−0.6
−0.8
−1
0.5
0.4
0.3
0.2
0.1
0


(b,l,d) = (31° 227° 39 kpc)
axis ratio Z/X
axis ratio Y/X
0.5
1
1.5
2


(b,l,d) = (31° 227° 39 kpc) and (31° 182° 39 kpc)
axis ratio Z/X
axis ratio Y/X
0.5
1
1.5
2


(b,l,d) = (31° 227° 39 kpc) and (61° 227° 39 kpc)
axis ratio Z/X
axis ratio Y/X
0.5
1
1.5
2


(b,l,d) = (31° 227° 39 kpc) and (61° 47° 39 kpc)
axis ratio Z/X
axis ratio Y/X
0.5
1
1.5
2




# Parameter Counting

## 2 Rocket Stars

6 measurements [2 RVs, 4 PMs = (2 stars X 2 direc.)]

– 2 halo parameters (z/x, y/x)

= 4 star parameters [2 distances, 2 launch times]

## 5 Rocket Stars

15 measurements [5 RVs, 10 PMs = (5 stars X 2 direc.)]

– 10 star parameters [5 distances, 5 launch times]

= 5 halo parameters (z/x, y/x, 3 orientation angles)

## N>5 Rocket Stars

3N measurements

2N star parameters

5 halo parameters

N–5 degrees of redundancy

# Back to the Galactic Center

## Rocket–Star Fits Yield:

1. Distance ==> Luminosity ==> Spectral Class
2. Launch time ==> Launch velocity

## Permits Reconstruction

1. Individual Launches
2. Correlations between launch times

If binary disruption events
generate Rocket Stars ...
... may even allow individual ID
of S–Star/Rocket–Star pairs

## Ideas For Finding Rocket Stars

Good Ideas

Bad Ideas

Ugly Ideas

## Good Ideas

1.

2.

3.

4.

5.

## Bad Idea

1. Wait for GAIA

Rocket–Star PMs

Are Similar to

Halo Star PMs

# Ugly Idea II: RV Fiber Survey

## 1. Halo HB Stars

100 Myr Lifetime (so 50 kpc at 500 km/s)

Easily identified photometrically

Few per $deg^2$ (wasteful)

Piggy–back on other surveys (SDSS II?)

## 2. Halo RGB Stars

10 times more stars

1 Gyr Lifetime (still RGB at GC)

Difficult to eject?

Reject Halo K dwarfs with RPM diagram?

Need 1 mas/yr precision

# Conclusions

1. Rocket stars may be associated with S stars
2. PM measurement of the one known rocket star could already constrain the Galactic potential
3. Discovery and PM measurement of 5 rocket stars could measure full shape and orientation of Galactic halo
4. Same PM measurements would simultaneously determine luminosities launch times of rocket stars
5. Could thereby learn about processes that trapped S stars into close–in orbits around Sgr A*
6. Aggressive RV surveys needed to find new rocket stars