# Measuring Milky Way halo potential with thin stellar streams

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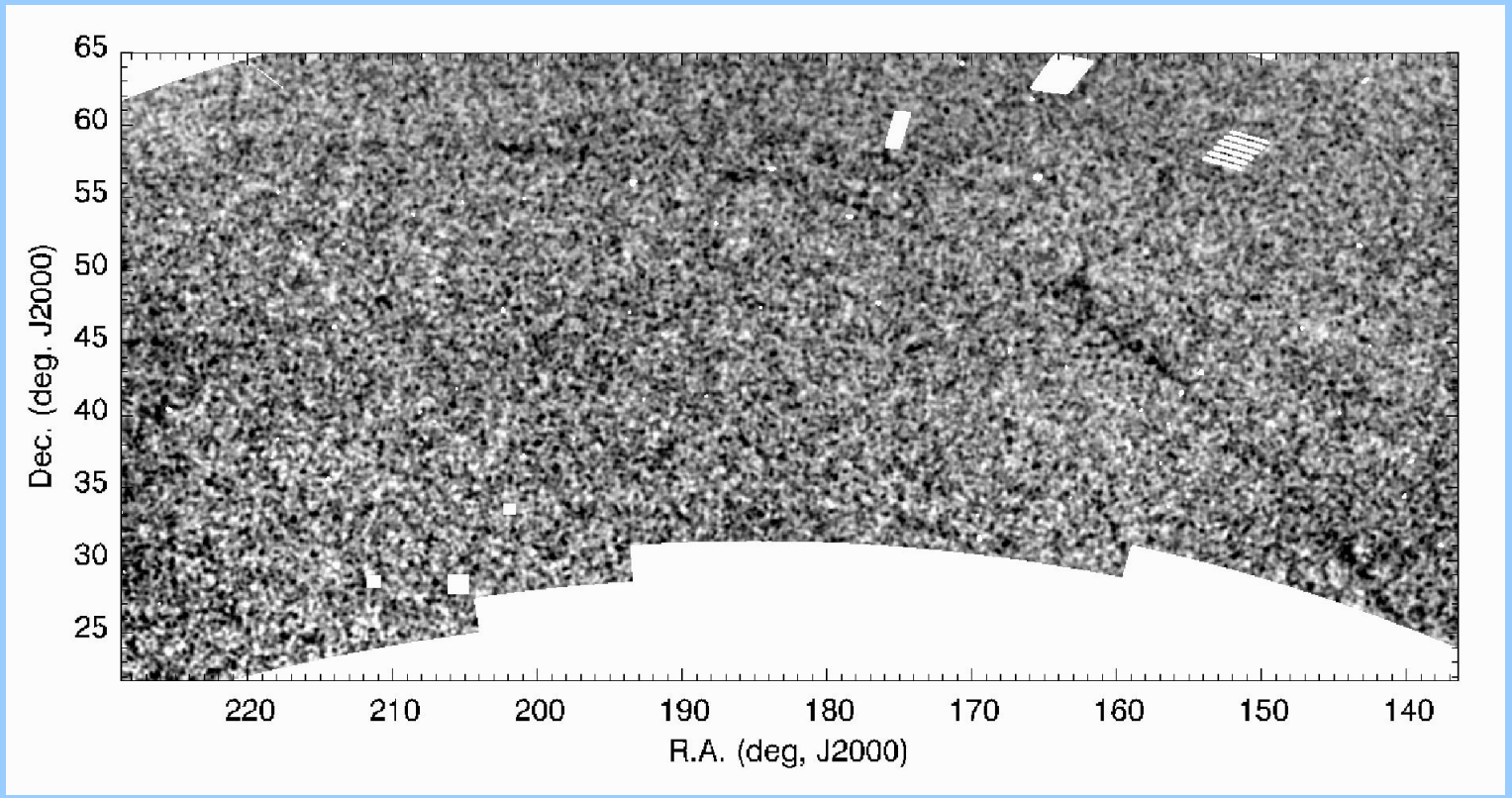
# Discovery of the stream

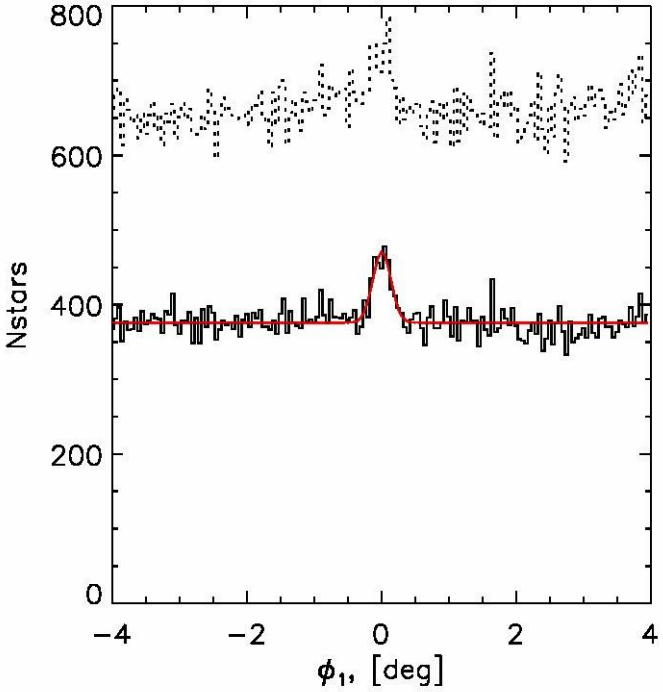
Grillmair, C.J., & Dionatos, O. 2006, ApJL, 643, L17

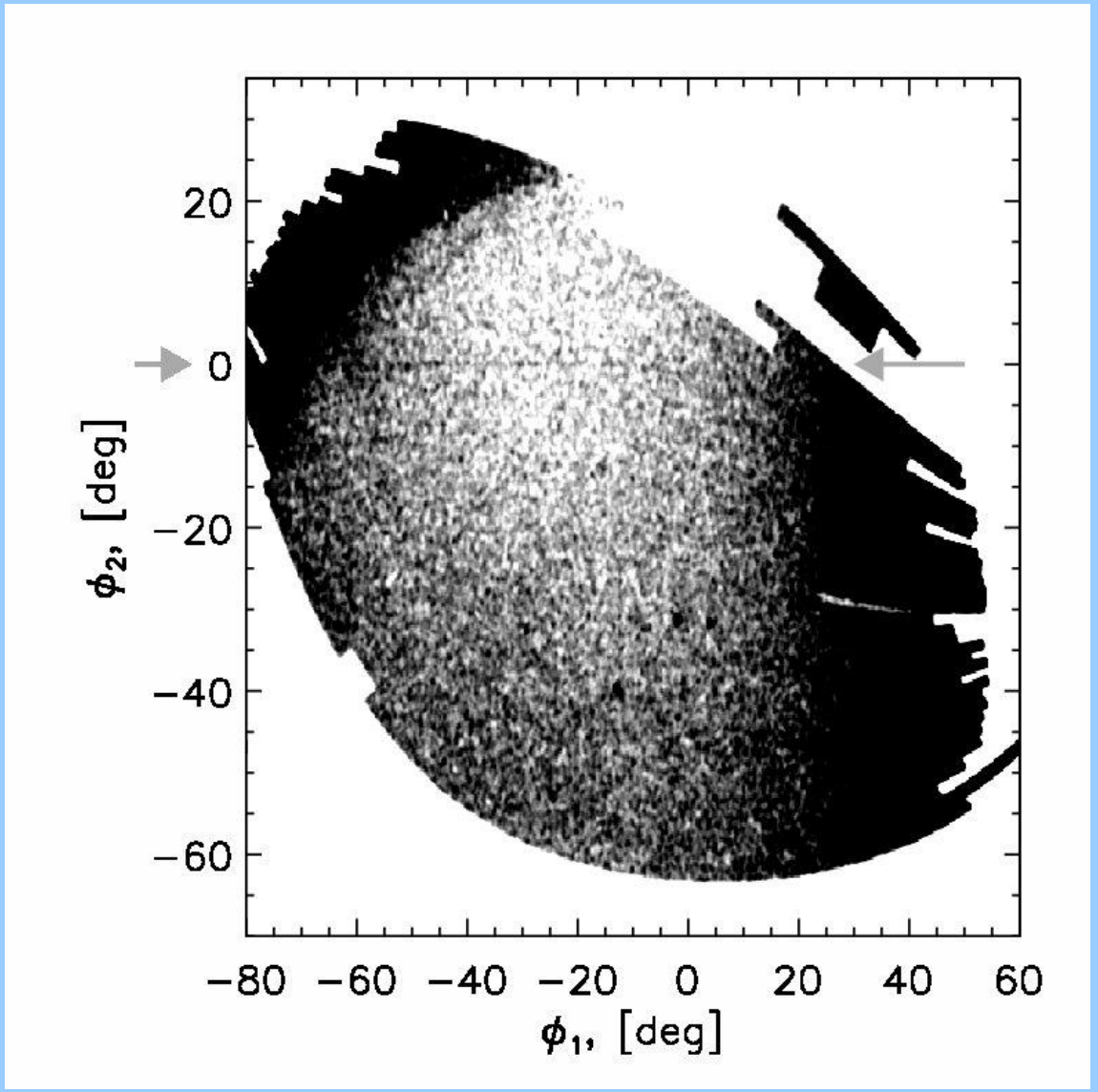


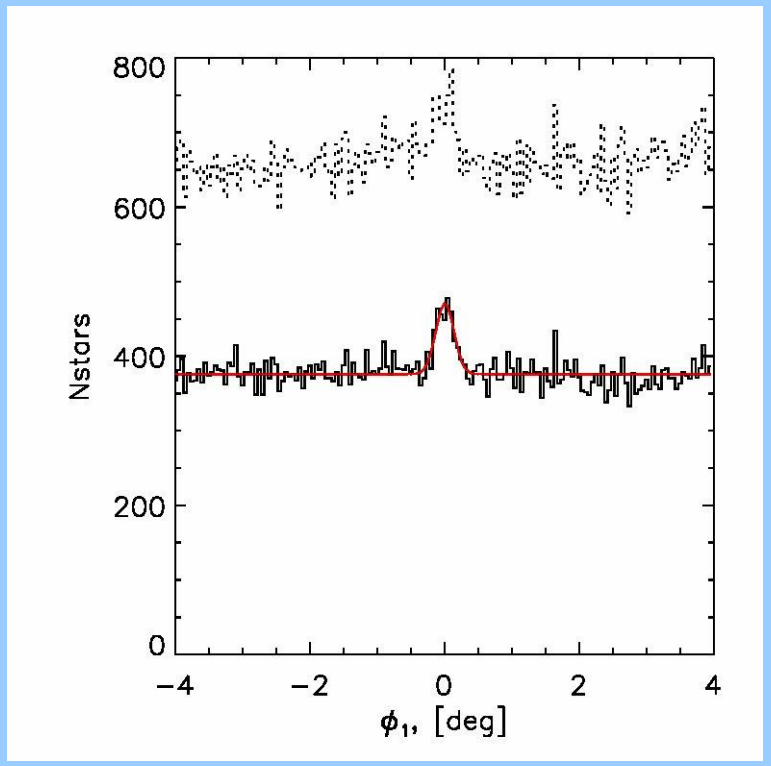

- 60 degrees long
- 0.2 degrees wide

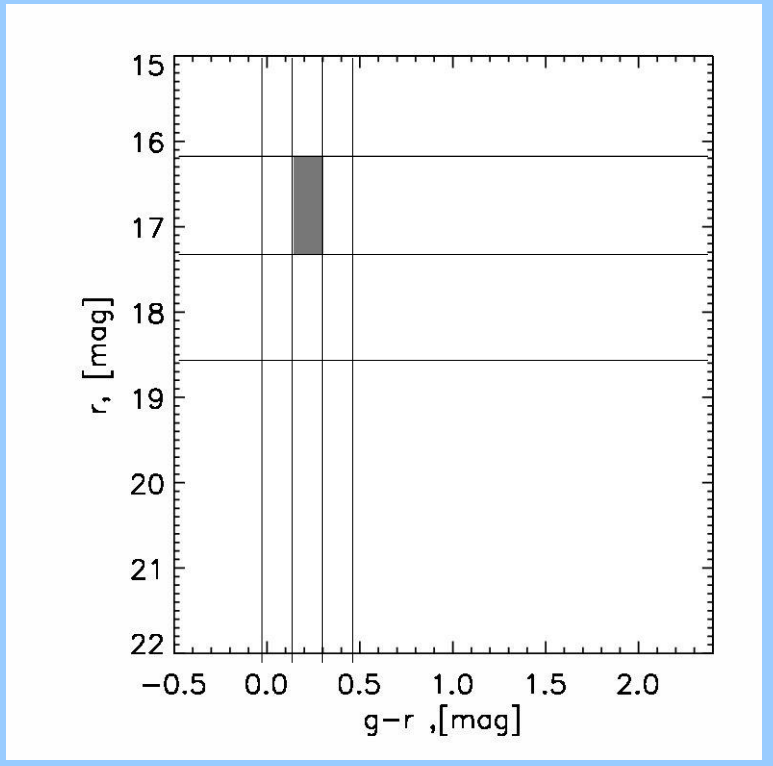
# Tracing the stream

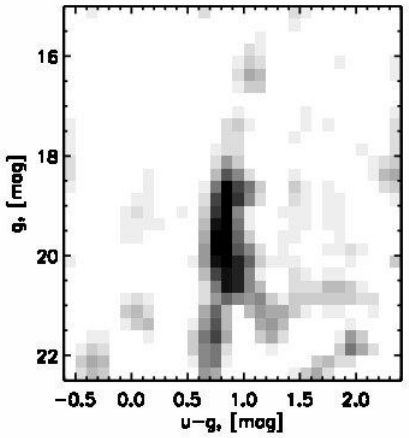
We start by using simple color-magnitude box
0.15<g-r<0.4
18.1<r<19.5

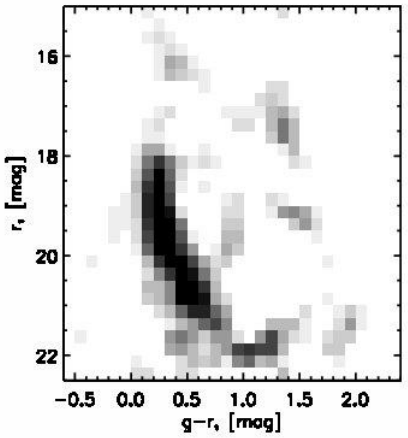


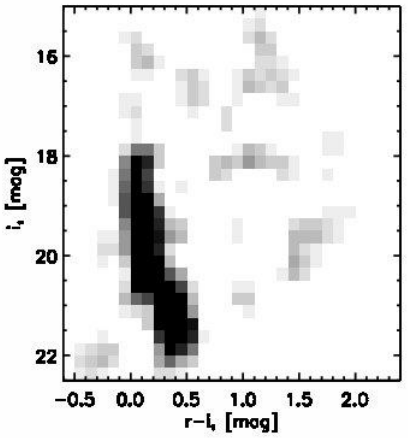



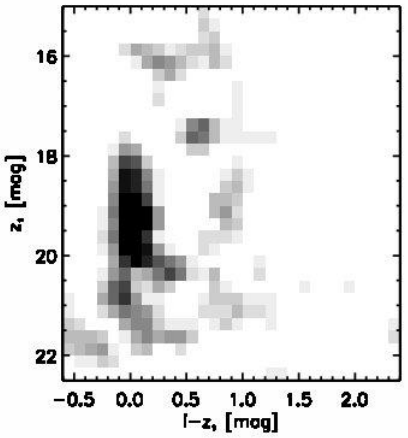

800
600
400
200
0
Nstars
−4
−2
0
2
4
$\phi_1$, [deg]


15
16
17
18
19
20
21
22
r, [mag]
−0.5
0.0
0.5
1.0
1.5
2.0
g−r ,[mag]

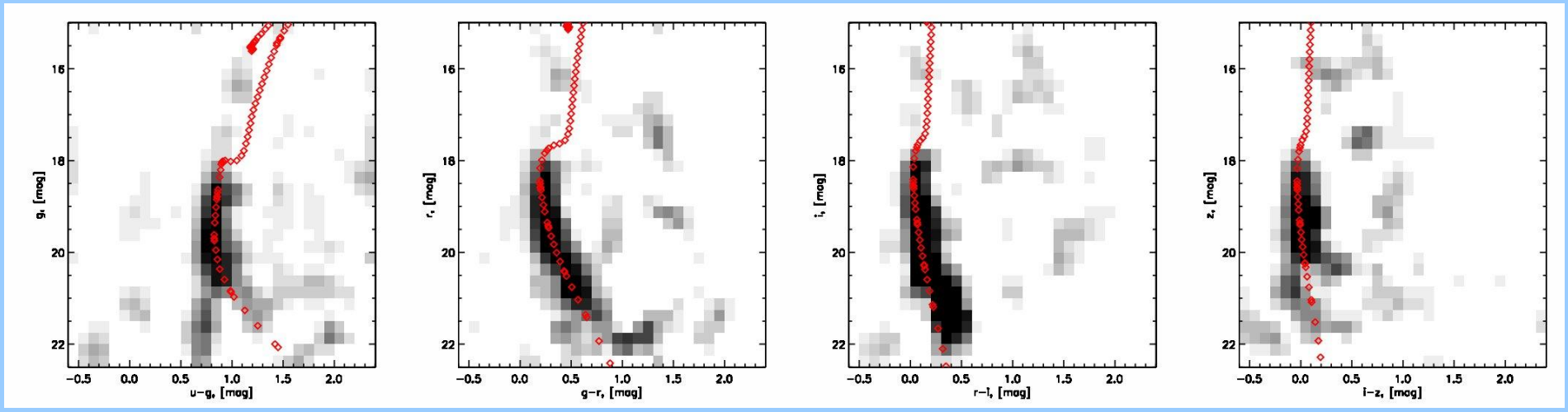

16
18
20
22
g, [mag]
−0.5
0.0
0.5
1.0
1.5
2.0
u−g, [mag]


16
18
20
22
r, [mag]
−0.5
0.0
0.5
1.0
1.5
2.0
g−r, [mag]

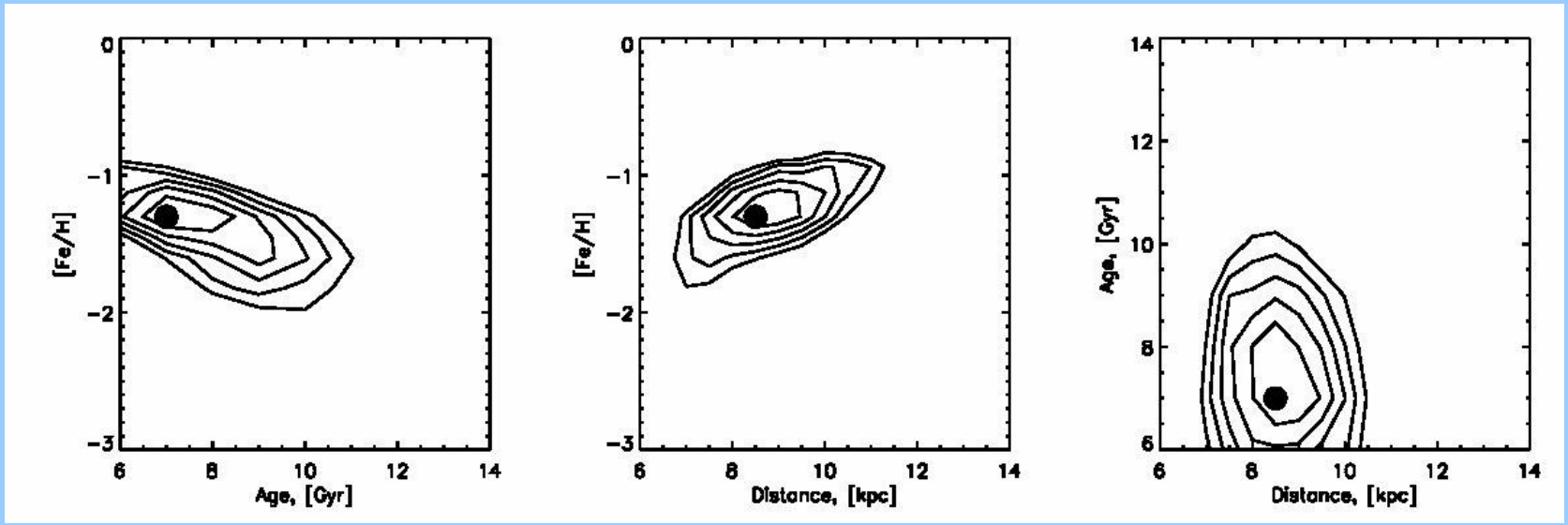

16
18
20
22
i, [mag]
−0.5
0.0
0.5
1.0
1.5
2.0
r−i, [mag]


16
18
20
22
z, [mag]
−0.5
0.0
0.5
1.0
1.5
2.0
i−z, [mag]

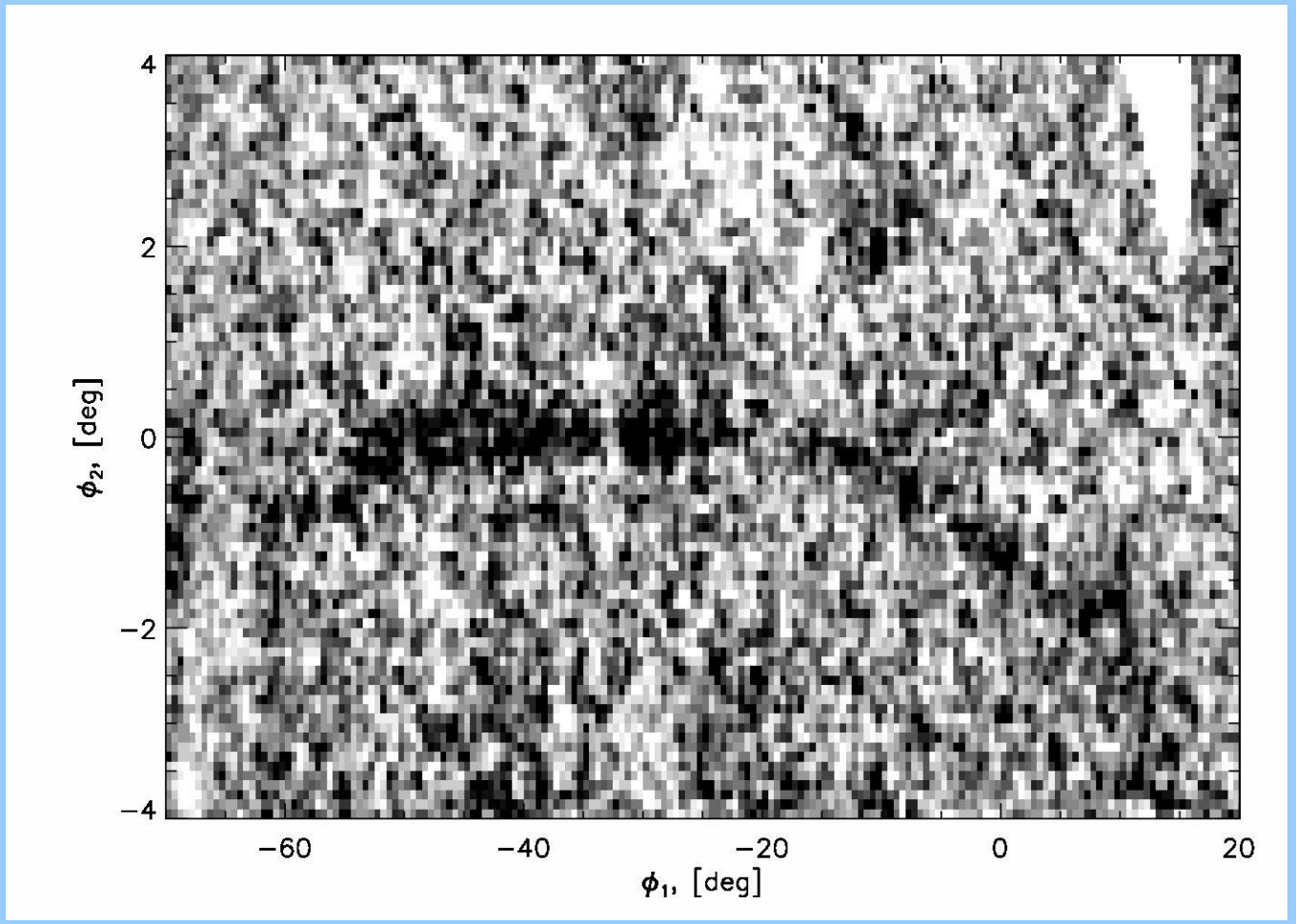
# CMD fitting




Note: we have u-g MS color – it means we have good metallicity (Juric,2008



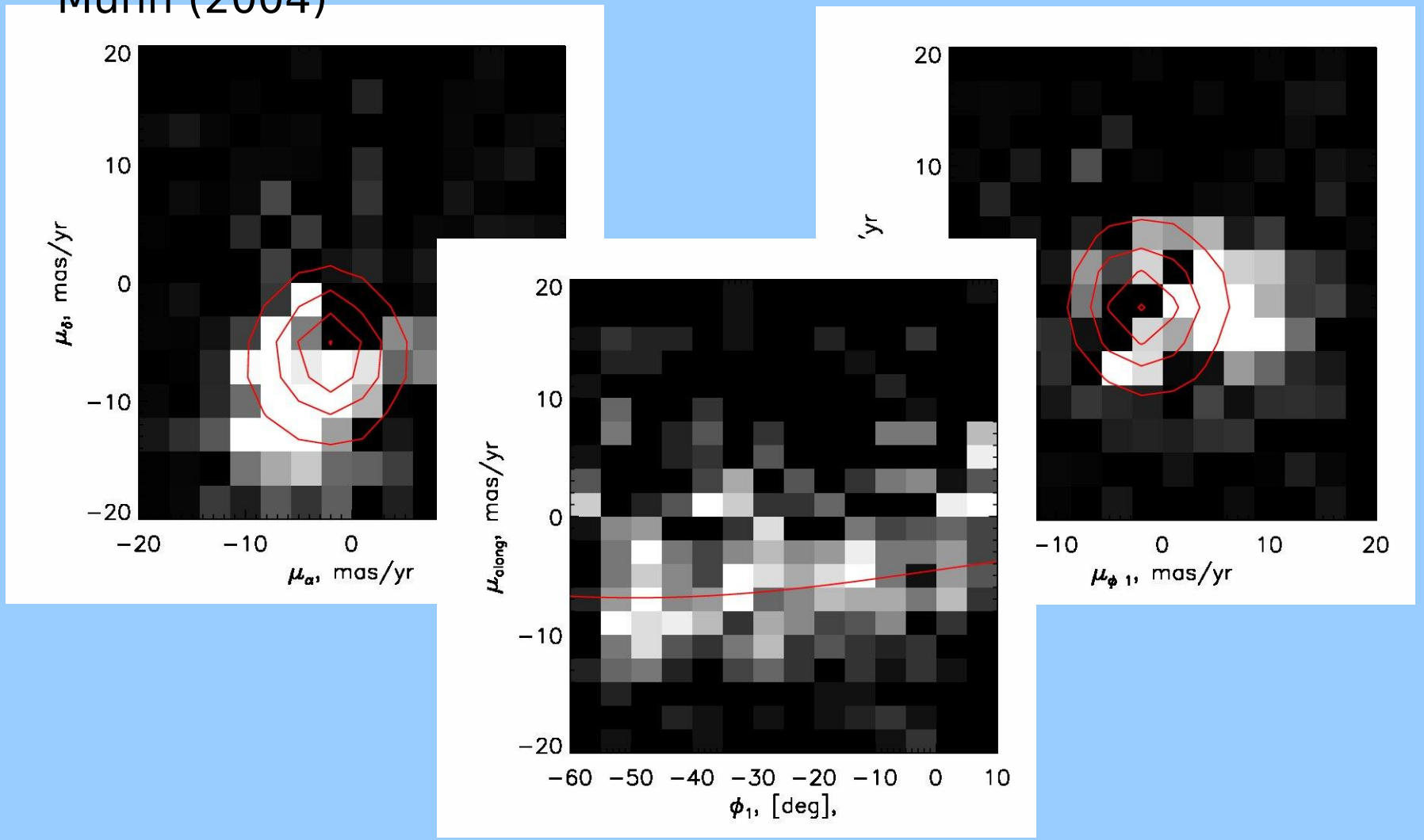
# Mapping the stream



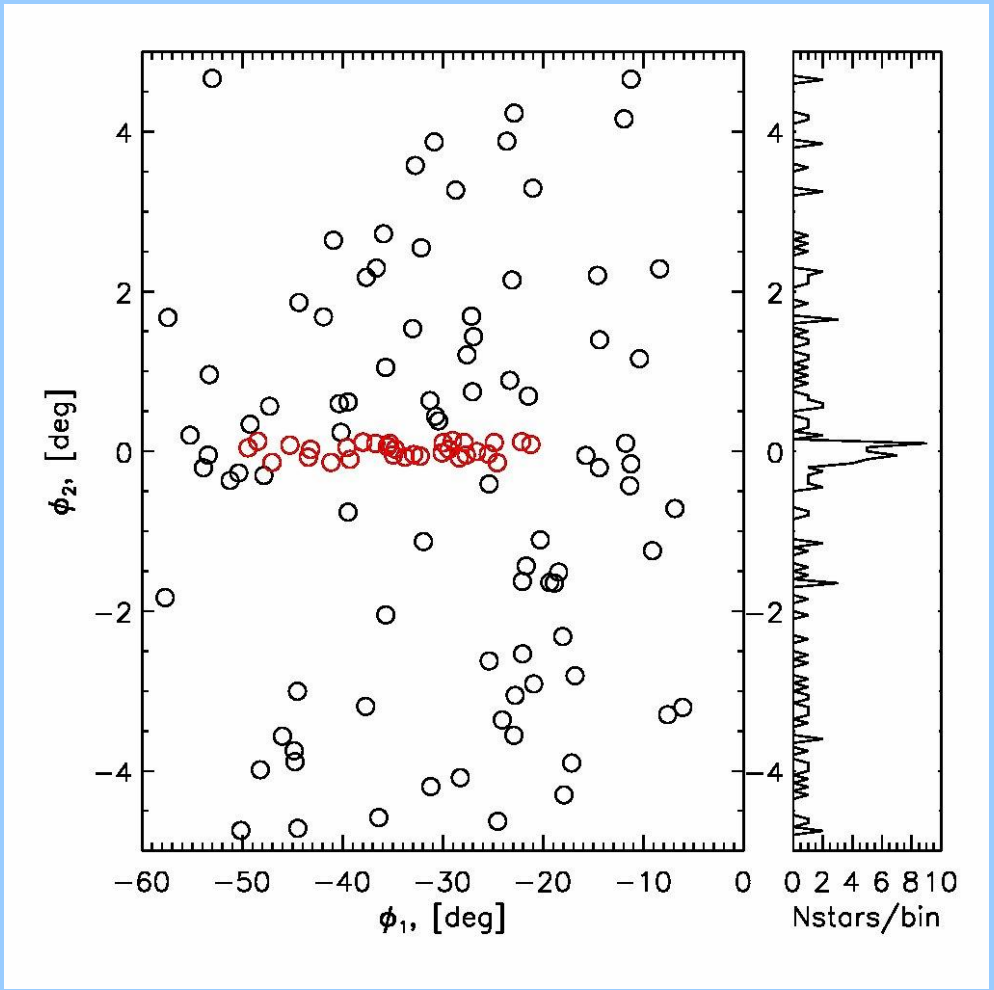

$\varphi_1$,$\varphi_2$ are spherical coordinates in the rotated coordinate system aligned with the stream

# Proper motions

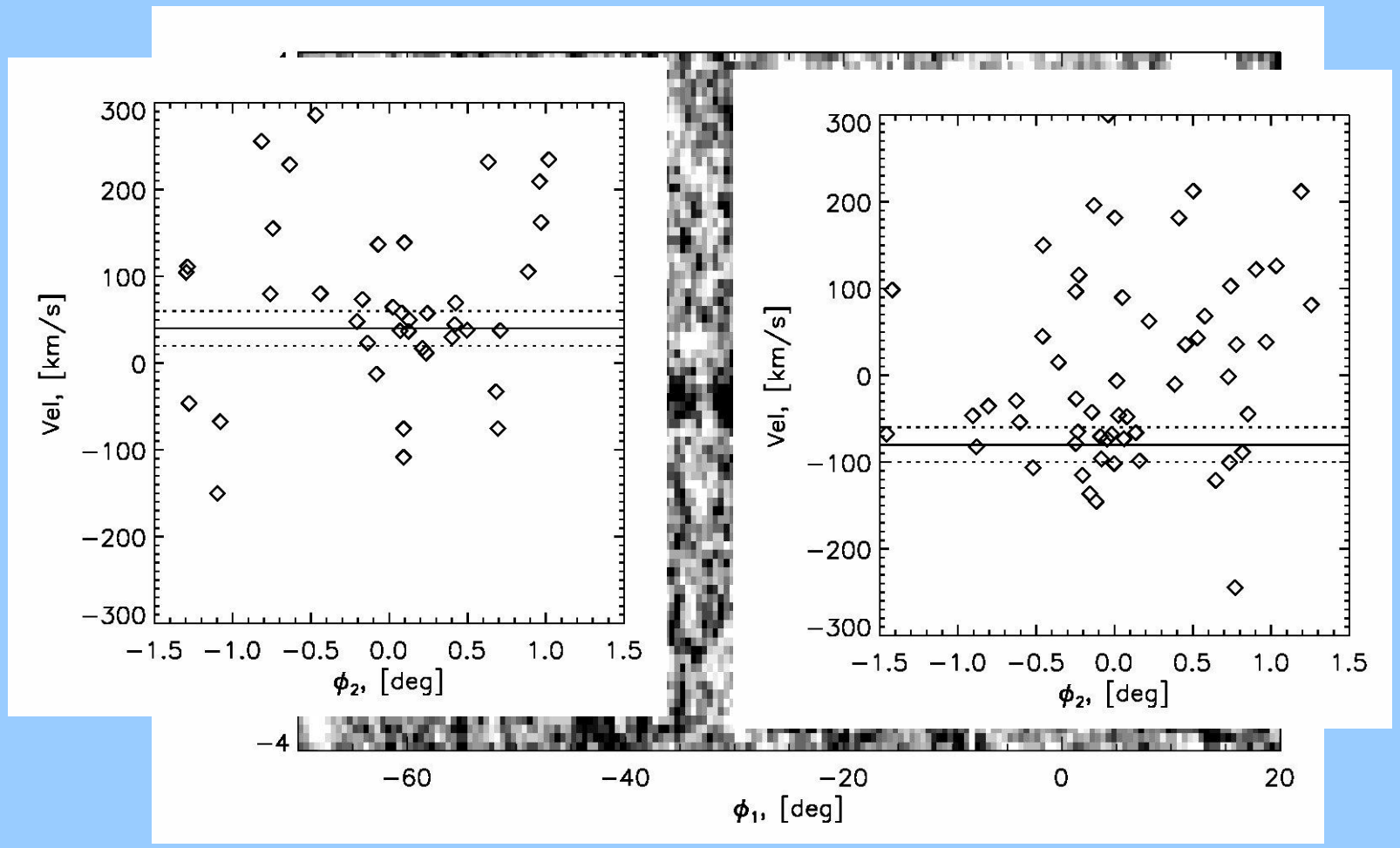
SDSS+USNO-B1.0 DR7 proper motions
Munn (2004)



# Using proper motions to trace structures in the halo

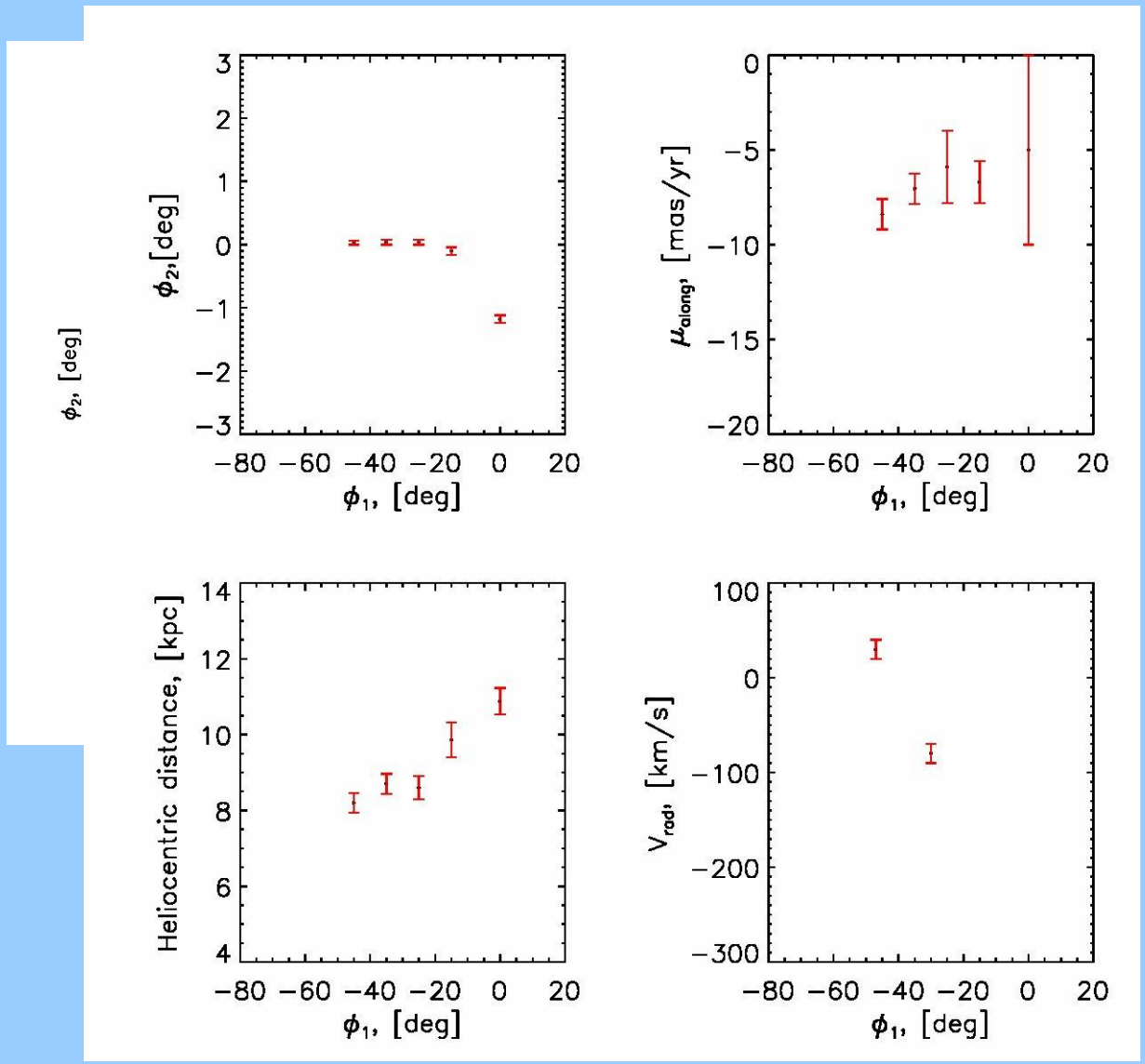


# Radial velocities



# Fit everything

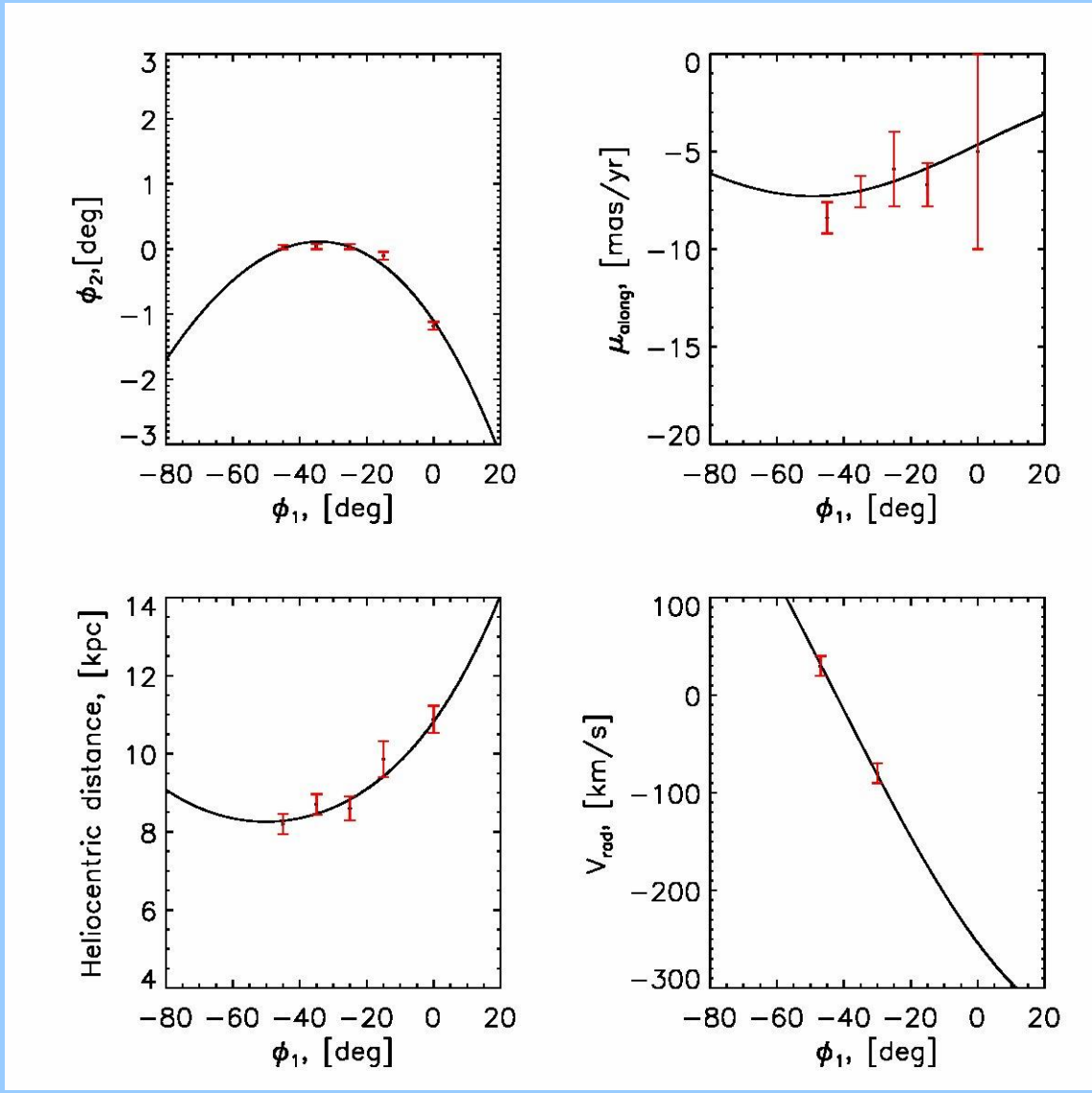
$$L(ra,dec,u,g,r,i,z) = f\,CMD(u,g,r,i,z,\textit{Distance})*S(ra,dec,\mu_\alpha,\mu_\beta,\textit{position, width},\mu_\alpha{}^0,\mu_\beta$$
$$(1-f)\,CMD_{BG}(u,g,r,i,z)*S_{BG}(ra,dec,\mu_\alpha,\mu_\beta)$$



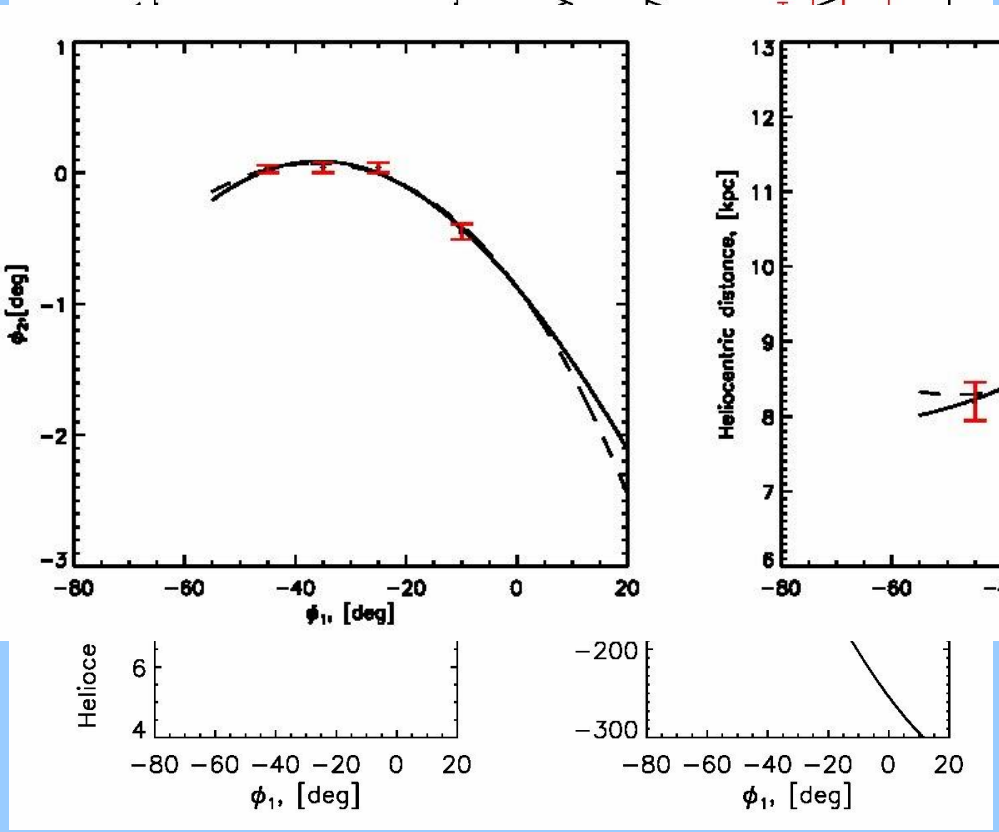
# Orbit modeling

Fit parameters:
X(0), Y(0), Z(0)
X'(0), Y'(0), Z'(0)

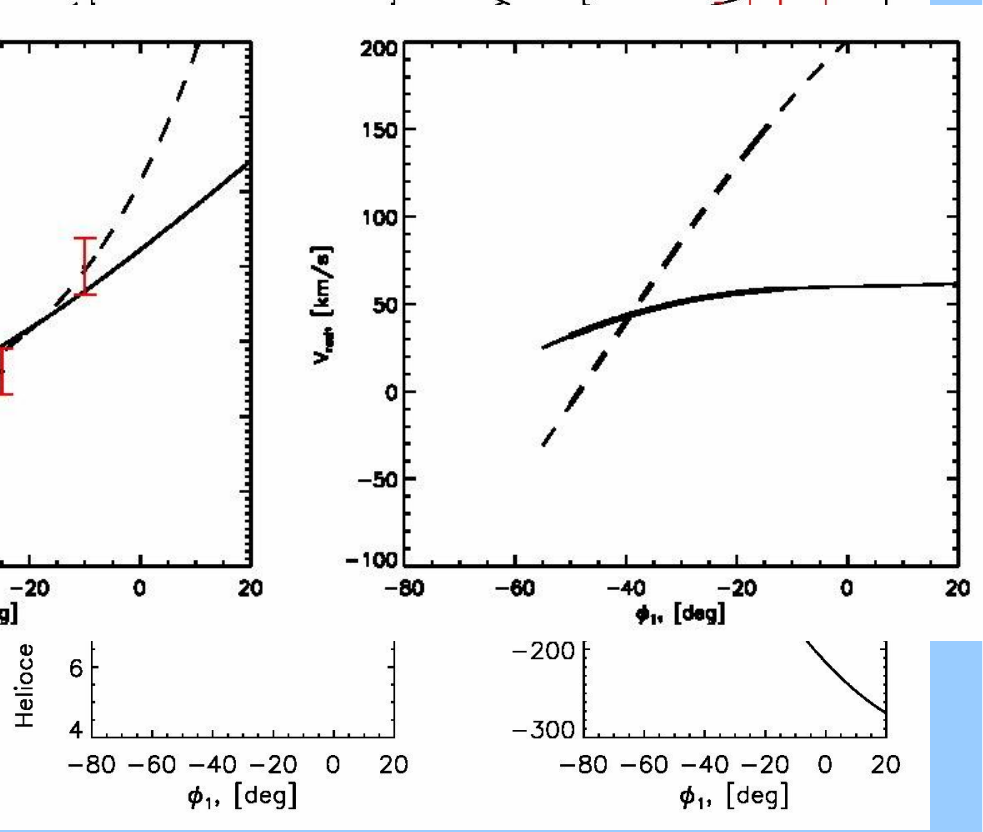
Potential:
Myamoto-Nagai disk,
Logarithmic halo,
Hernquist bulge



# Orbits in halos with different flattening



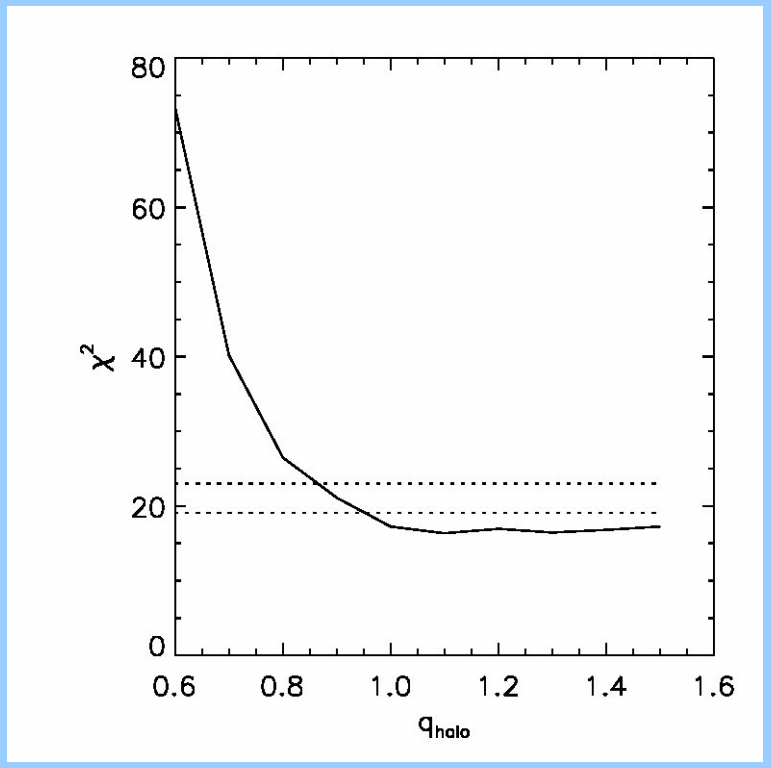

q=1

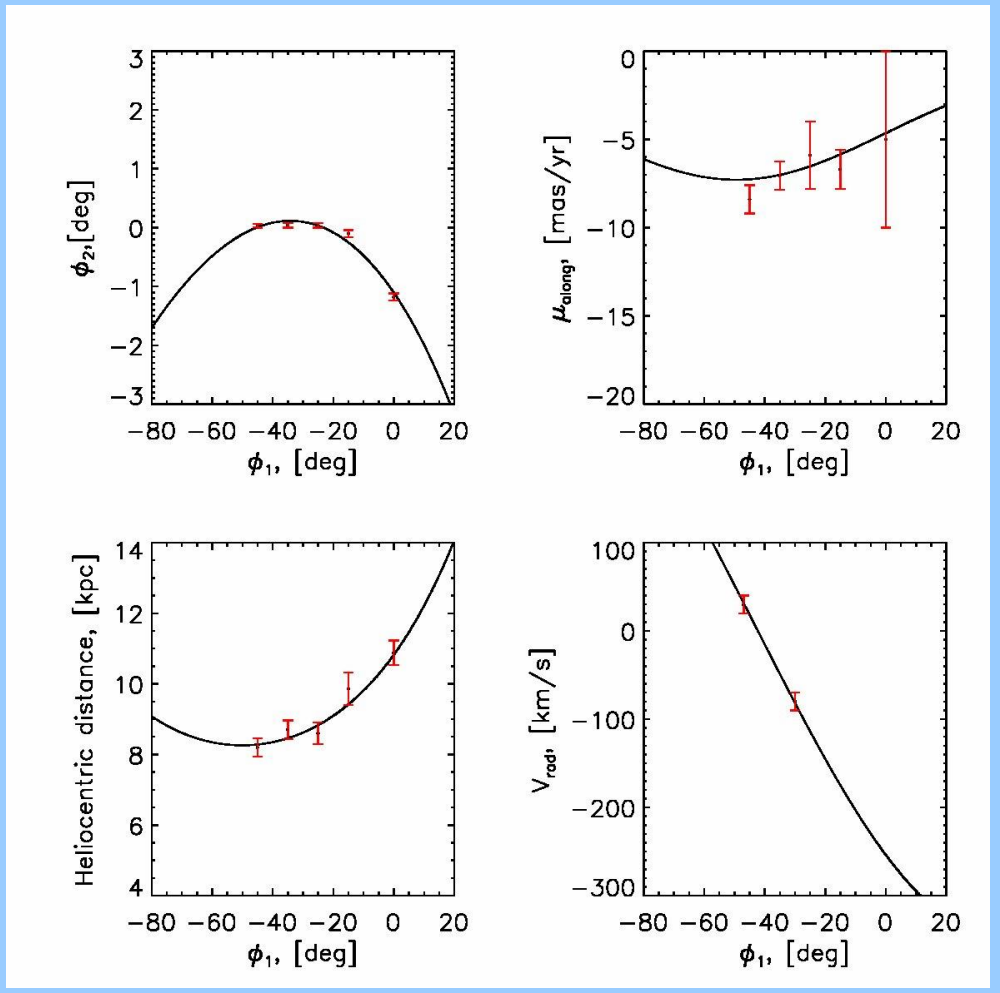



q=0.6

Halo potential $\Phi = v_0^2 \log(x^2+y^2+(z/q)^2+d^2)$

# Determination of the halo shape




$q_{halo} > 0.95$ with 90% confidence

$q_{halo} > 0.85$ with 99% confidence

# Conclusions

- 6D information obtained for the stream in the halo along 60 degrees
- The fit of the observational data allows to put tight constraint on the halo flattening (and probably other Galaxy potential parameters)
- Thin streams are much better than thick streams to determine the potential of the Galaxy