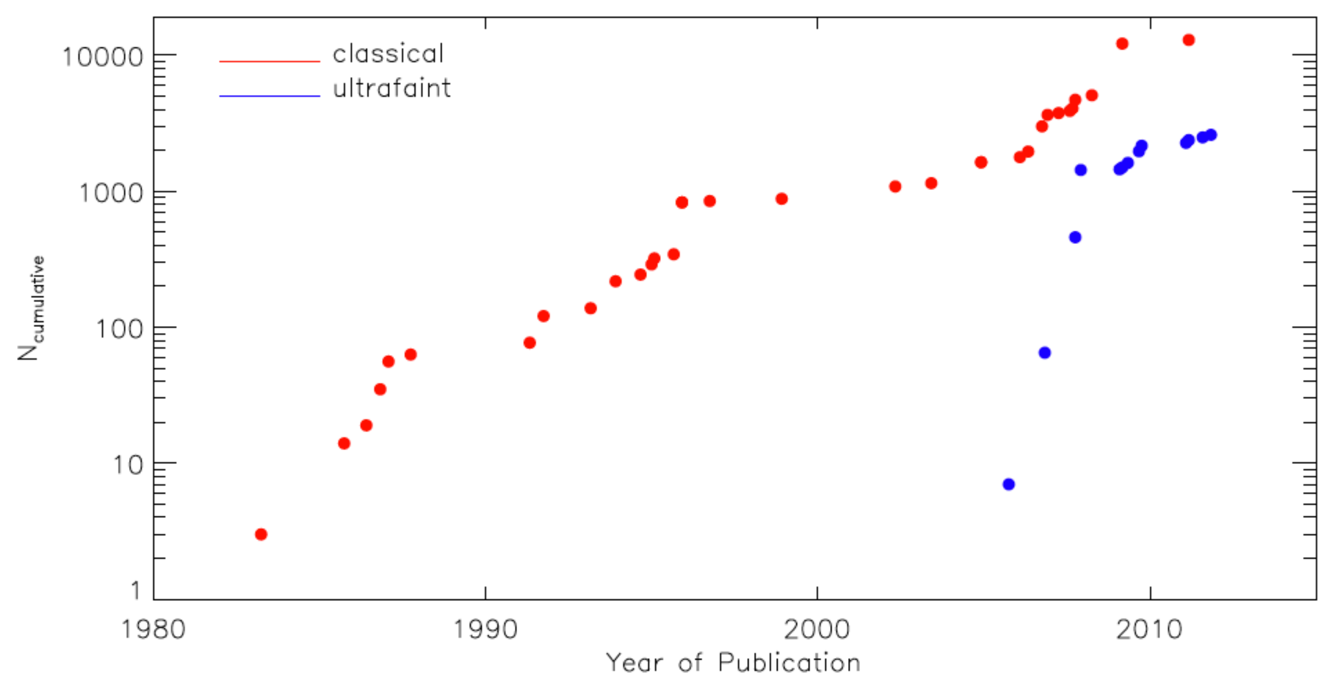
Radial Velocity Data for Milky Way dSphs

Matthew Walker – CfA/Harvard

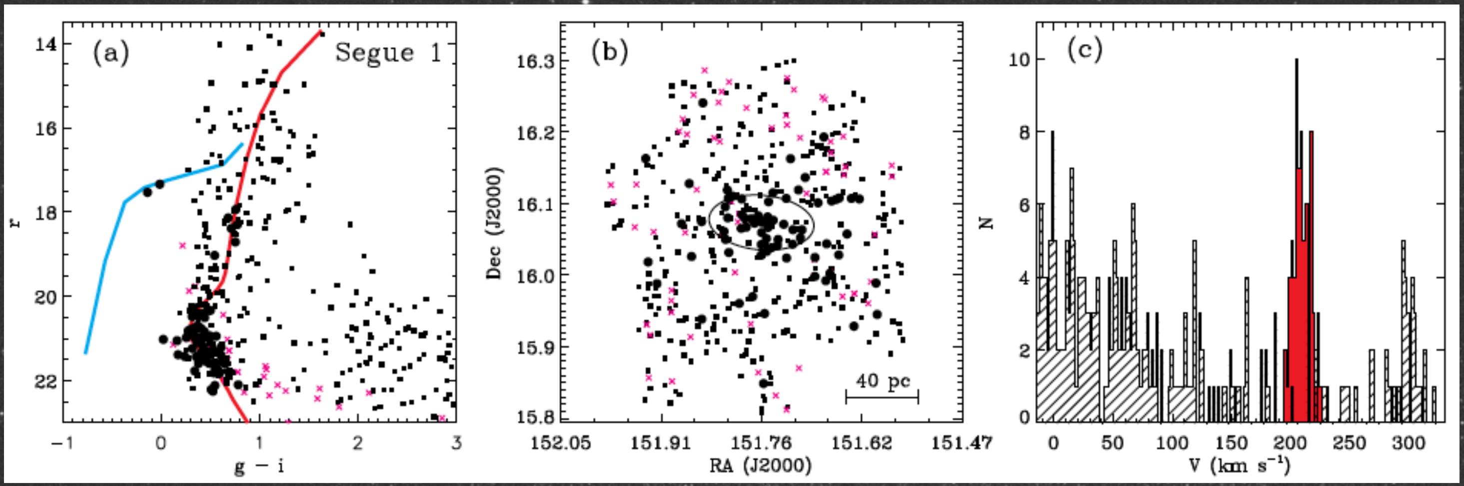


ences: Aaronson (1983); Seitzer & Frogel (1985); Suntzeff et al. (1986); Armandroff & Da Costa (1986); Aaronson & Olszewski (1987b,a); Mateo et al. (1991); Da Costa et al. (1991); Suntzeff et al. (1993); Mateo et al. (1993); Hargreaves et al. (1994b,a); Armandroff et al. (1995); Vogt et al. (1995); Queloz et al. (1995); Olszewski et al. (1995); Hargreaves et al. (1996b); Mateo et al. (1998); Kleyna et al. (2002, 2003); Tolstoy et al. (2004); Kleyna et al. (2005); Muñoz et al. (2006); Muñoz et al. (2006); Battaglia et al. (2006); Westfall et al. (2006); Walker et al. (2006, 2007a); Koch et al. (2007b,a); Martin et al. (2007); Simon & Geha (2007); Sohn et al. (2007); Mateo et al. (2008); Koch et al. (2009); Geha et al. (2009); Walker, Mateo & Olszewski (2009); Walker et al. (2009a); Belokurov et al. (2009); Carlin et al. (2009); Willman et al. (2011); Simon et al. (2011); Adén et al. (2011); Koposov et al. (2011b); Battaglia et al. (2011).

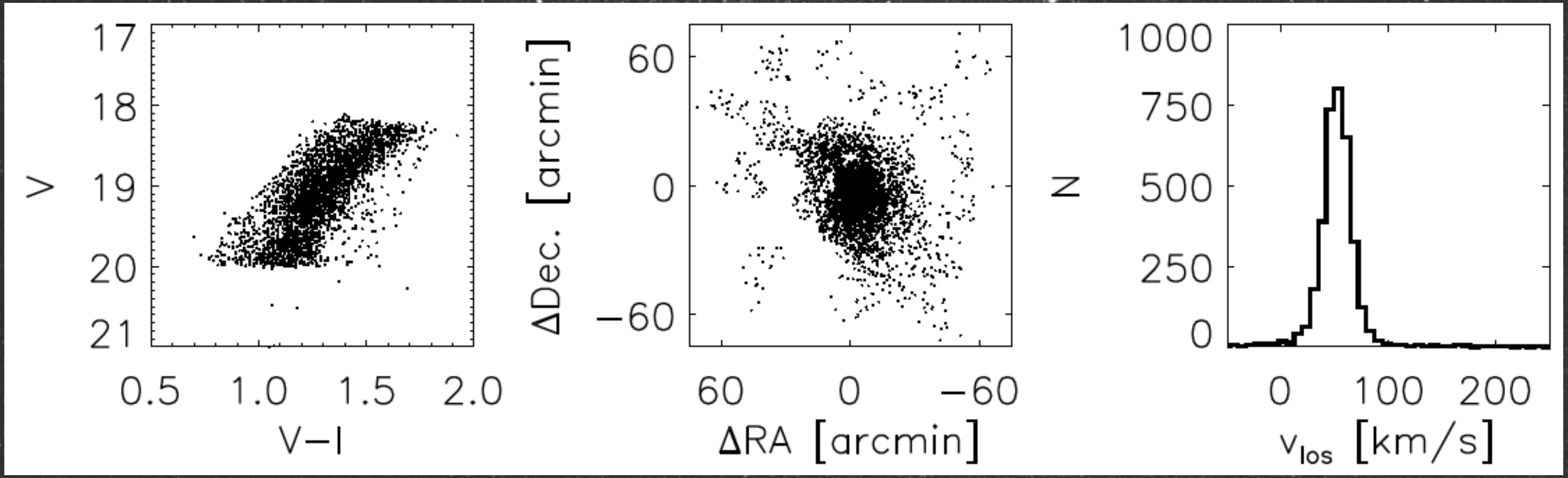
Dynamics Meets Kinematic Tracers

Ringberg, 11 April 2012

‘dynamic’ range of known MW dSphs

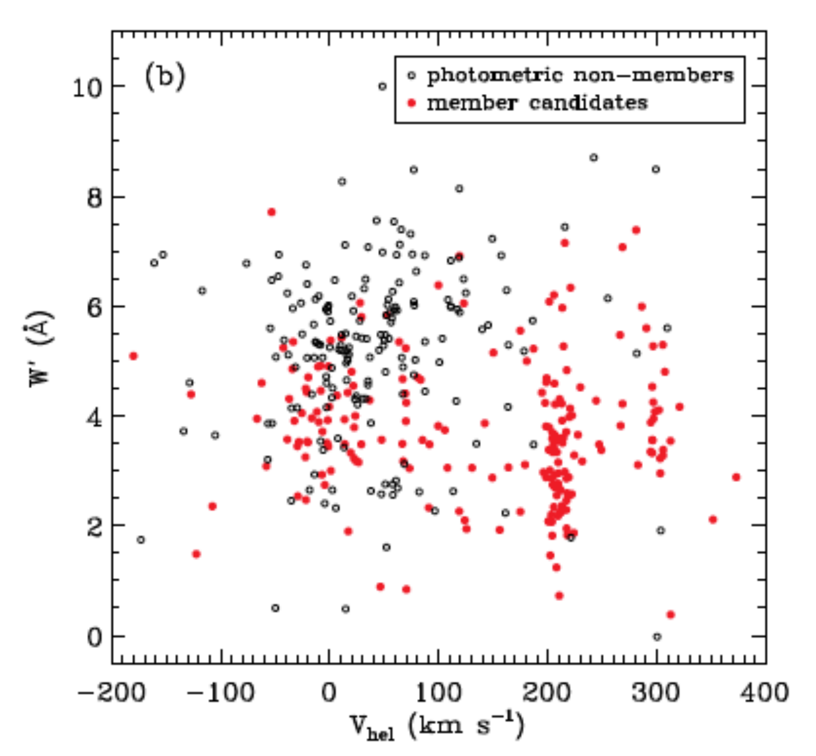


Segue 1 (Simon etal 2011)

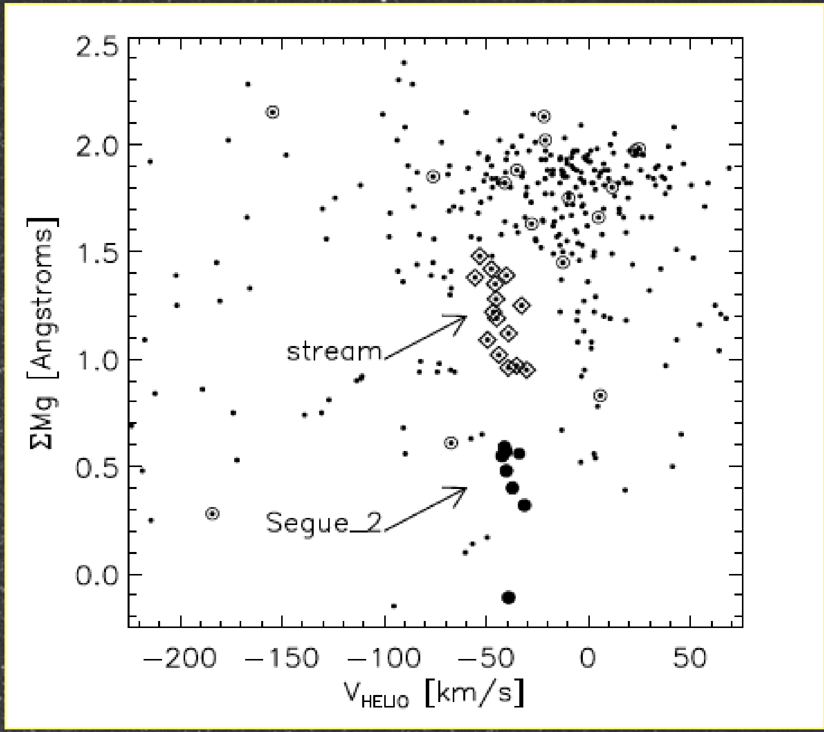


Fornax (Walker, Mateo & Olszewski 2009)

Streams

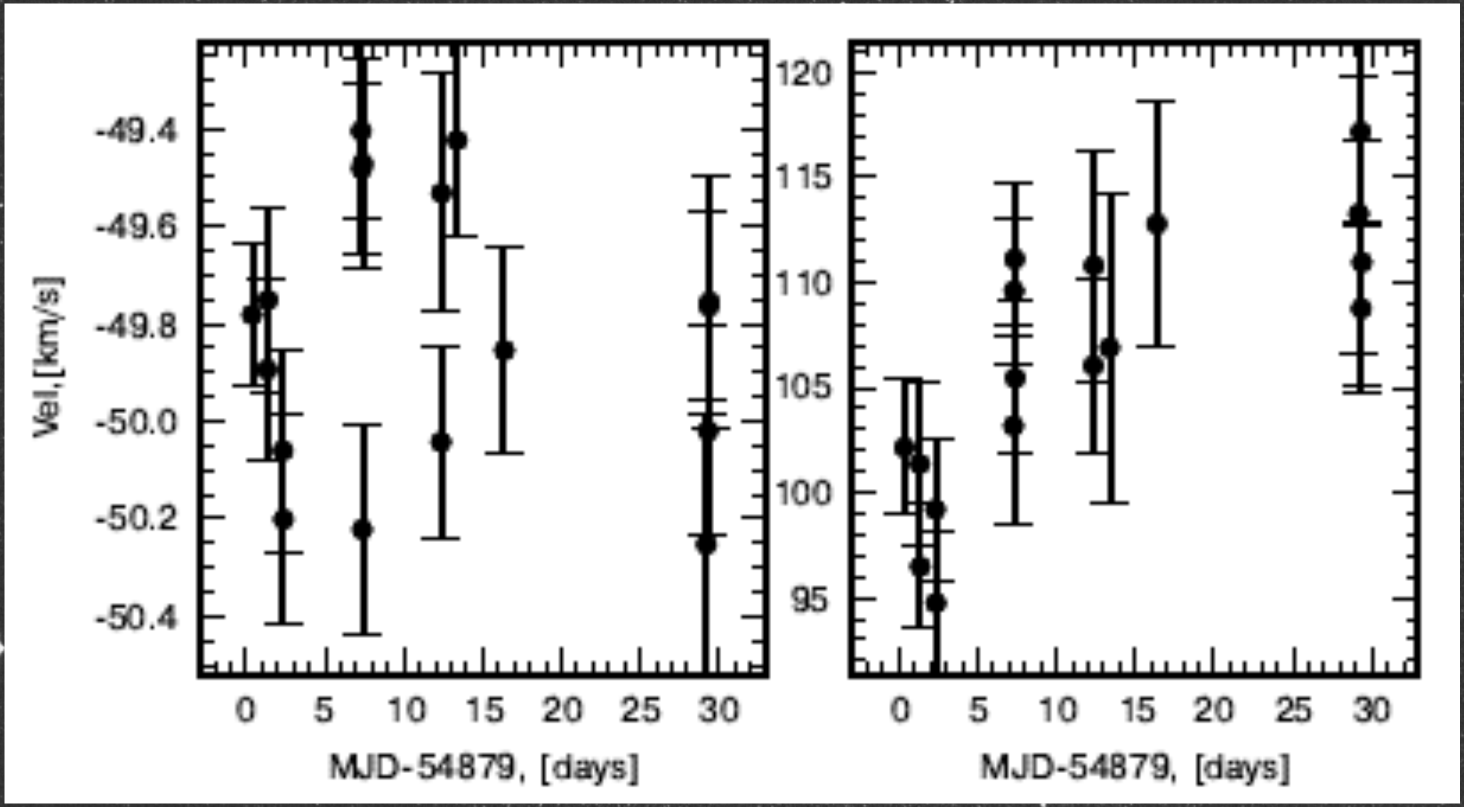


Segue 1 (Simon et al. 2011)



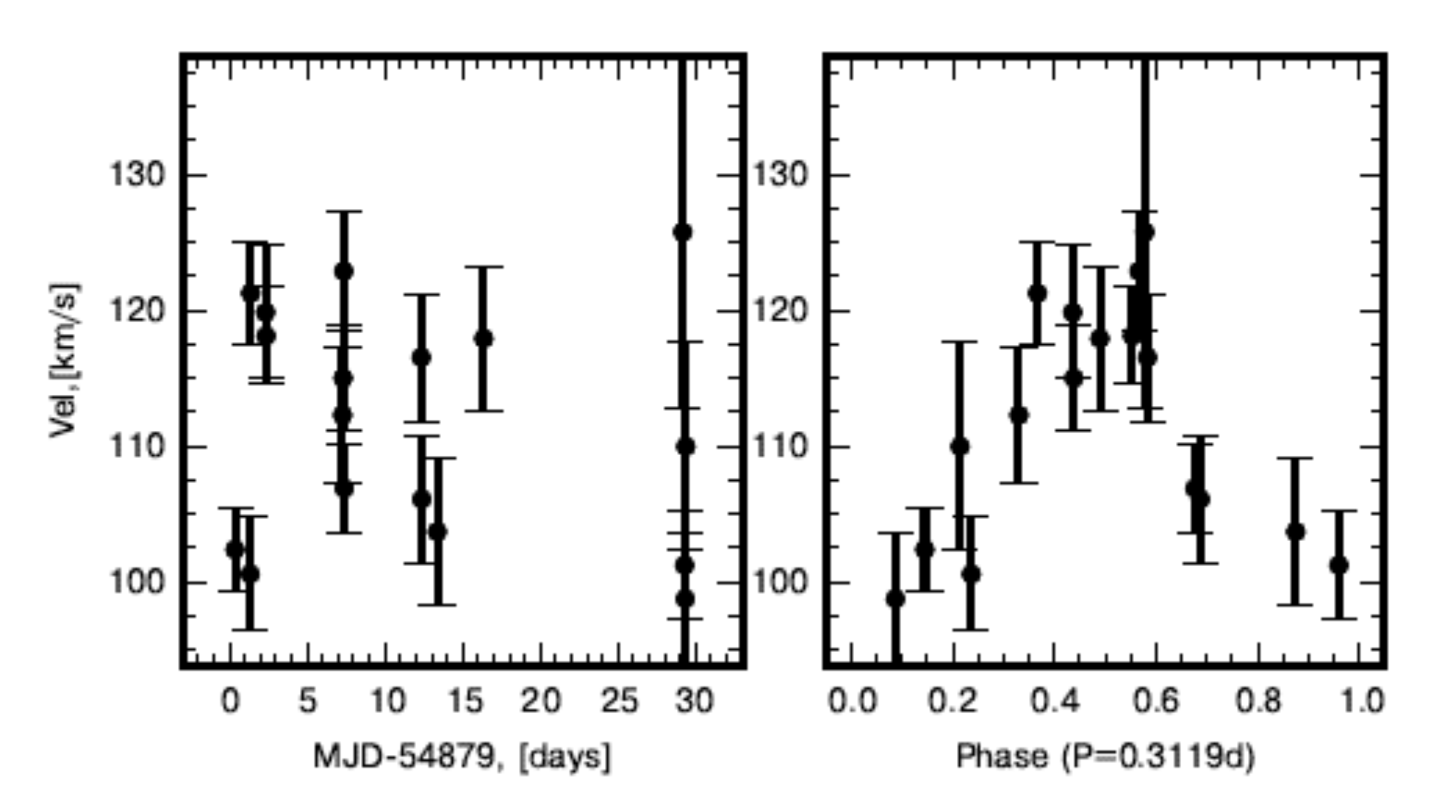
Segue 2 (Belokurov etal. 2009)

Resolved Velocity Variability



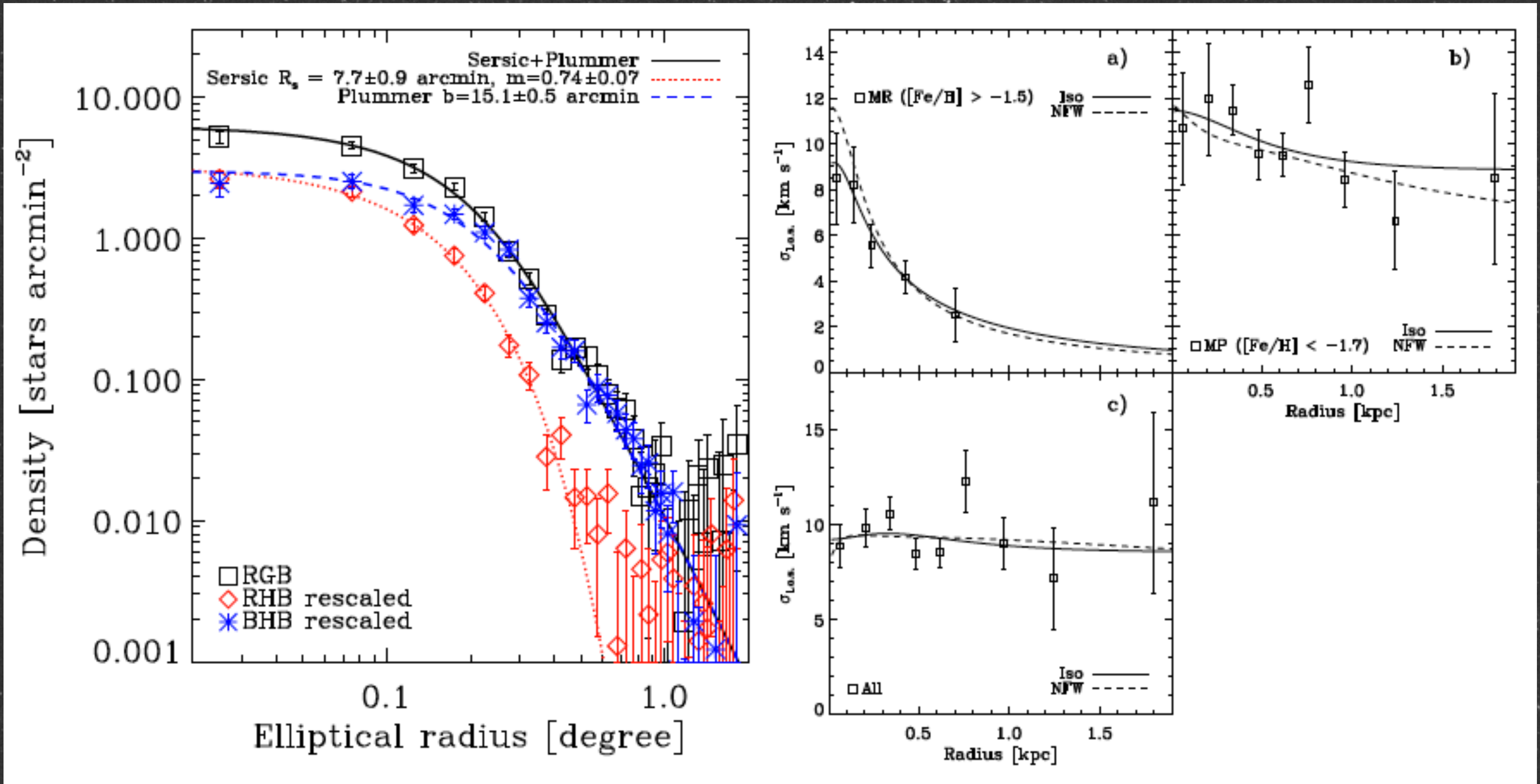
Bootes I (Koposov et al 2011)

Resolved Velocity Variability



Bootes I (Koposov et al 2011)

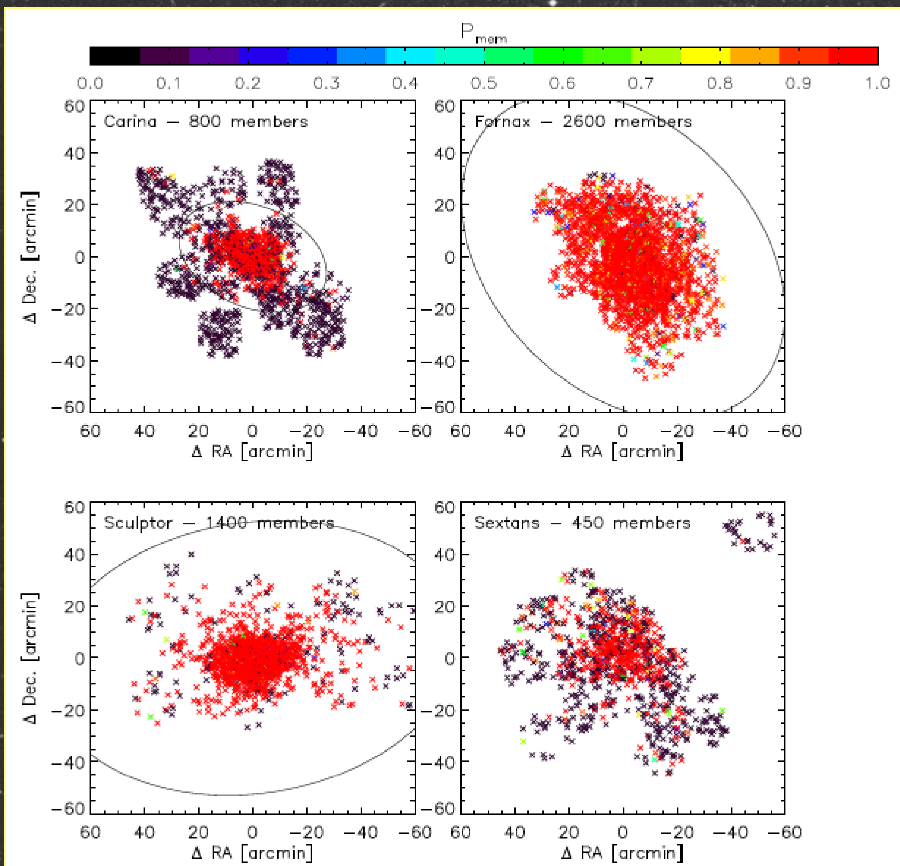
Multiple stellar components

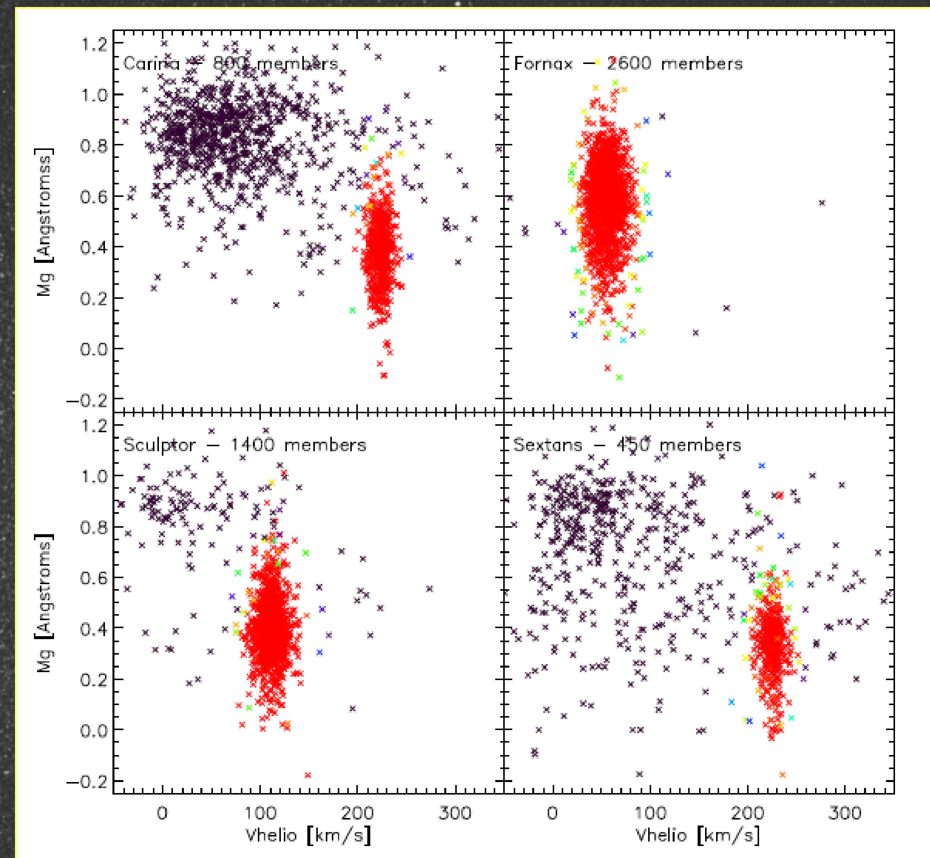


Sculptor (Tolstoy et al. 2004, Battaglia et al. 2008)

Similar for Fornax (Battaglia et al. 2006) and Sextans (Battaglia et al. 2011)

Magellan samples
(see also VLT surveys of same galaxies)

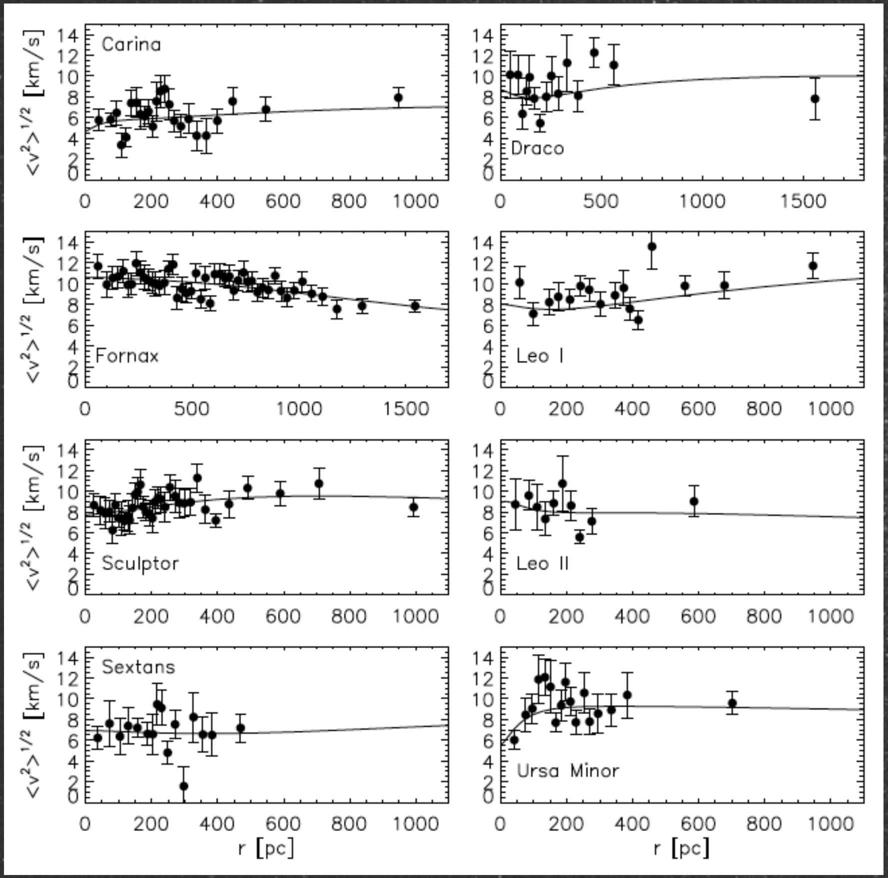


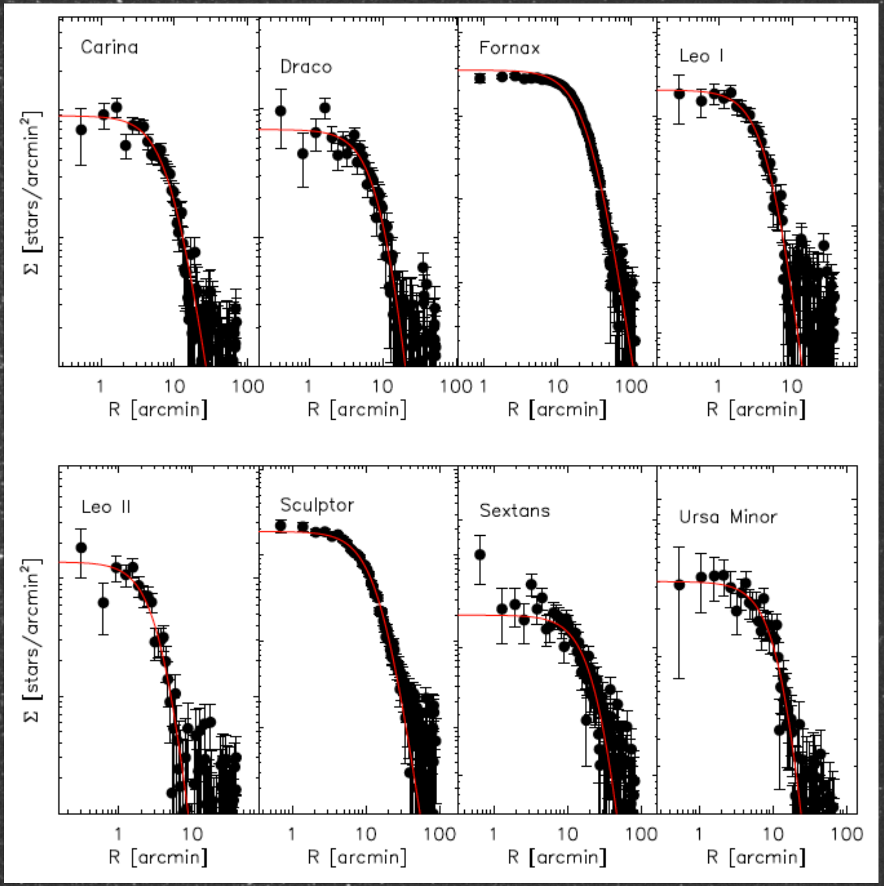


Walker, Mateo & Olszewski (2009)

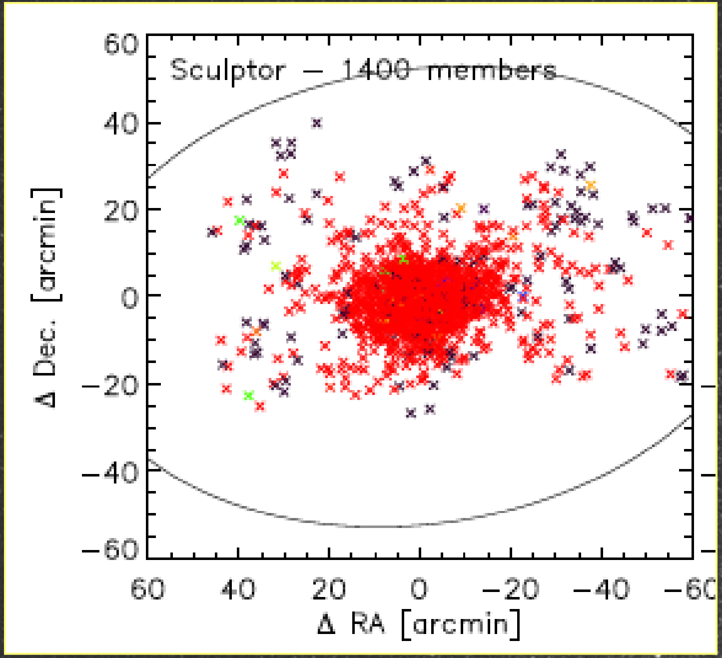
Jeans models

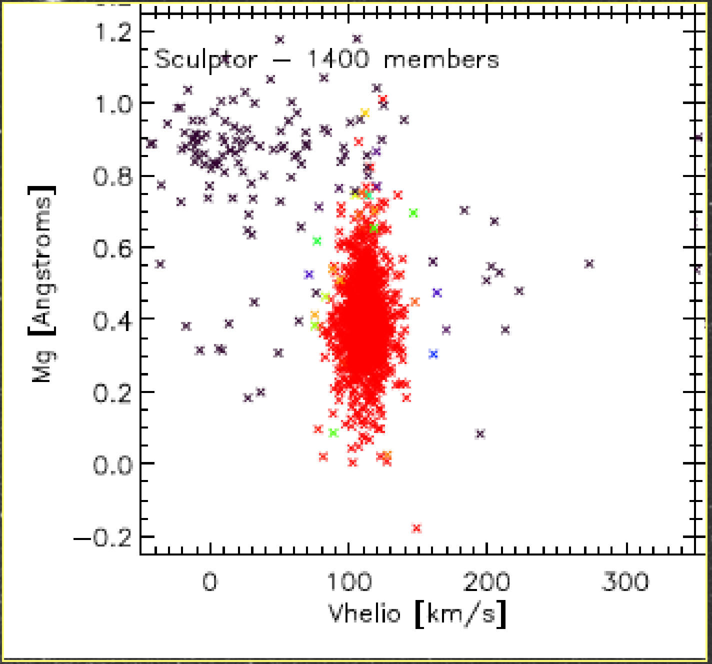
$$\sigma_p^2(R) = \frac{2}{I(R)} \int_R^\infty \left(1 - \beta \frac{R^2}{r^2}\right) \frac{\nu(r) \bar{v_r^2} r}{\sqrt{r^2 - R^2}} dr$$





attempted respect of data



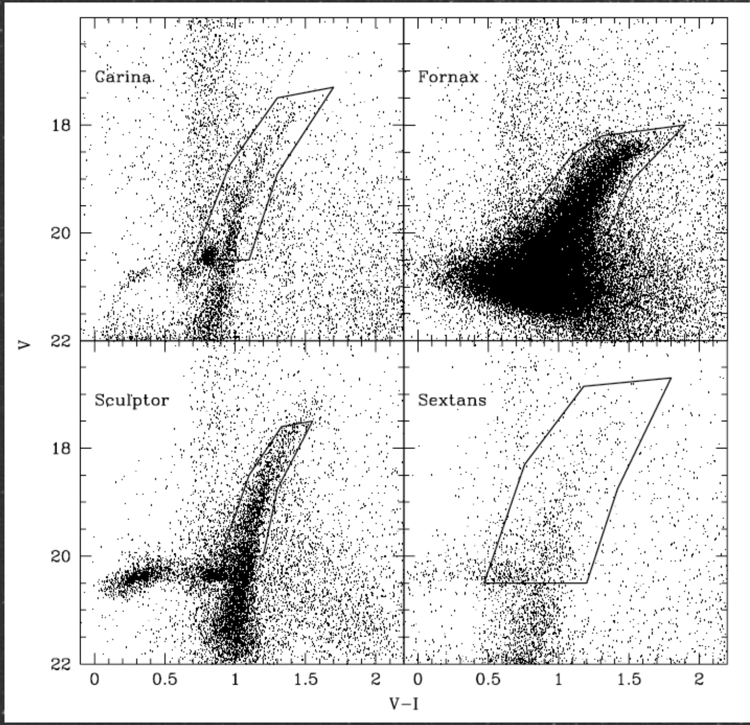


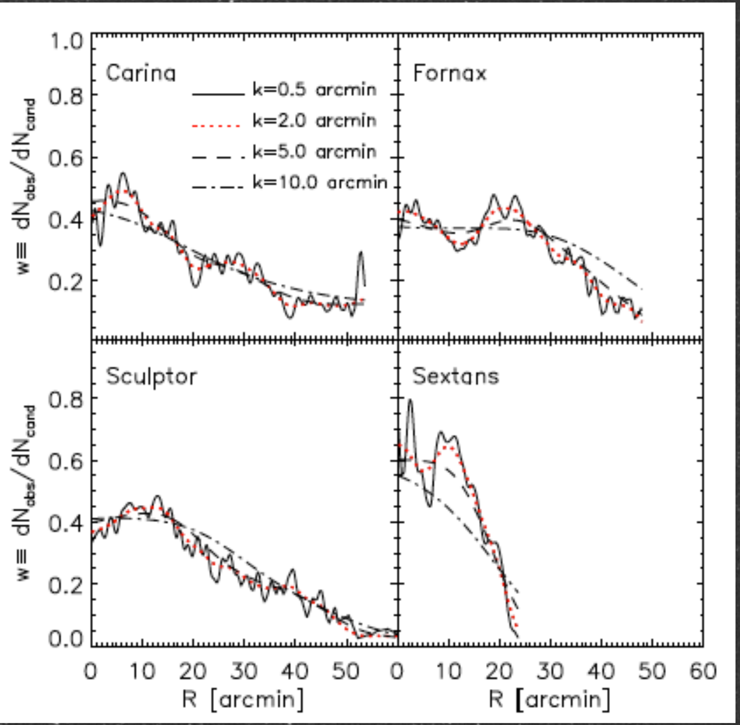
$$L(\{R_i, V_i, W_i'\}_{i=1}^{N_{\rm sample}} | \vec{S}) = \prod_{i=1}^{N_{\rm sample}} \left[f_1 \frac{w(R_i) p_1(R_i, V_i, W_i')}{\int\int\int w(R) p_1(R, V, W') dR dV dW'} + f_2 \frac{w(R_i) p_2(R_i, V_i, W_i')}{\int\int\int w(R) p_2(R, V, W') dR dV dW'} + (1 - f_1 - f_2) \frac{w(R_i) p_{\rm MW}(R_i, V_i, W_i')}{\int\int\int w(R) p_{\rm MW}(R, V, W') dR dV dW'} \right]$$

Walker & Peñarrubia (2011)

(spatial) sampling bias

$$L(\{R_i,V_i,W_i'\}_{i=1}^{N_{\rm sample}}|\vec{S}) = \prod_{i=1}^{N_{\rm sample}}\Bigg[f_1\frac{w(R_i)p_1(R_i,V_i,W_i')}{\int\int\int w(R)p_1(R,V,W')dRdVdW'}+f_2\frac{w(R_i)p_2(R_i,V_i,W_i')}{\int\int\int w(R)p_2(R,V,W')dRdVdW'}$$
$$+(1-f_1-f_2)\frac{w(R_i)p_{\rm MW}(R_i,V_i,W_i')}{\int\int\int w(R)p_{\rm MW}(R,V,W')dRdVdW'}\Bigg]$$





Assumptions

$$L(\{R_i,V_i,W_i'\}_{i=1}^{N_{\rm sample}}|\vec{S}) = \prod_{i=1}^{N_{\rm sample}} \left[f_1 \frac{w(R_i)p_1(R_i,V_i,W_i')}{\int\int\int w(R)p_1(R,V,W')dRdVdW'} + f_2 \frac{w(R_i)p_2(R_i,V_i,W_i')}{\int\int\int w(R)p_2(R,V,W')dRdVdW'} + (1-f_1-f_2)\frac{w(R_i)p_{\rm MW}(R_i,V_i,W_i')}{\int\int\int w(R)p_{\rm MW}(R,V,W')dRdVdW'} \right]$$

$$p_{R,1}(R) = \frac{2R/r_{h,1}^2}{\left(1+R^2/r_{h,1}^2\right)^2}$$

Plummer

$$p_{V,1}(V,\alpha_*,\delta_*) = \frac{1}{\sqrt{2\pi(\sigma_{V,1}^2+\epsilon_V^2)}} \exp\left[-\frac{1}{2}\frac{(V-\langle V\rangle_{\alpha_*,\delta_*})^2}{\sigma_{V,1}^2+\epsilon_V^2}\right]$$

Gaussian

$$p_{W,1}(W) = \frac{1}{\sqrt{2\pi(\sigma_{W,1}^2+\epsilon_W^2)}} \exp\left[-\frac{1}{2}\frac{(W-\langle W\rangle_1)^2}{\sigma_{W,1}^2+\epsilon_W^2}\right]$$

Gaussian

12 free parameters

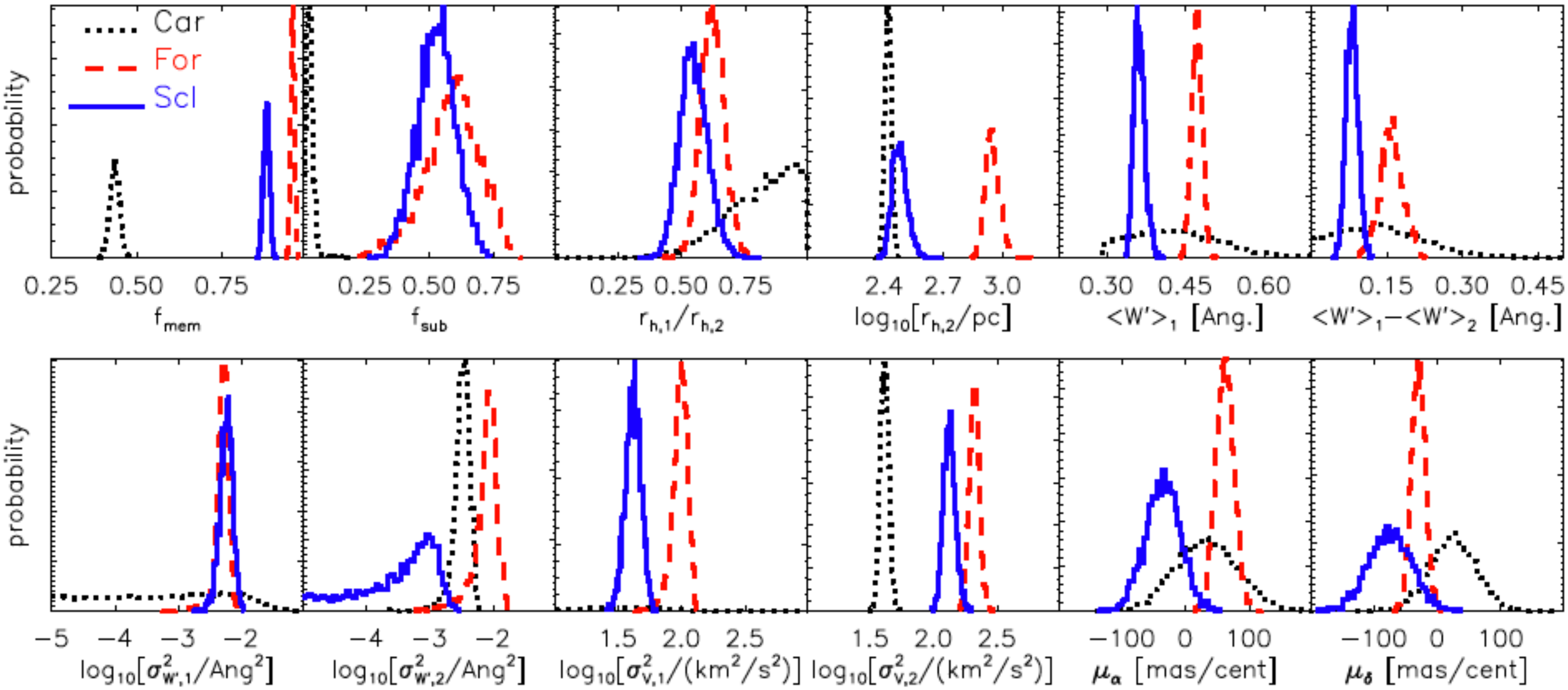
$$L(\{R_i,V_i,W_i'\}_{i=1}^{N_{\rm sample}}|\vec{S}) = \prod_{i=1}^{N_{\rm sample}} \left[f_1 \frac{w(R_i)p_1(R_i,V_i,W_i')}{\int\int\int w(R)p_1(R,V,W')dRdVdW'} + f_2 \frac{w(R_i)p_2(R_i,V_i,W_i')}{\int\int\int w(R)p_2(R,V,W')dRdVdW'} + (1-f_1-f_2)\frac{w(R_i)p_{\rm MW}(R_i,V_i,W_i')}{\int\int\int w(R)p_{\rm MW}(R,V,W')dRdVdW'} \right]$$

MCMC PARAMETERS AND TOP-HAT PRIORS FOR TWO-COMPONENT MODEL

Parameter	Minimum	Maxium	Description
$f_{\rm mem}$	0	1	$\equiv (N_1+N_2)/(N_1+N_2+N_{\rm MW})$, fraction of stars belonging to dSph
$f_{\rm sub}$	0	1	$\equiv N_1/(N_1+N_2)$, fraction of members belonging to MR component
$r_{h,1}/r_{h,2}$	0	1	ratio of half-light radii for metal-rich (MR) and metal-poor (MP) components
$\log_{10}[r_{h,2}/{\rm pc}]$	0	3	half-light radius of MP component
$\langle W\rangle_1/$Å	−3	+3	mean reduced Mg index of MR component
$(\langle W\rangle_1-\langle W\rangle_2)/$Å	0	3	offset of mean Mg indices
$\log_{10}[\sigma^2_{W,1}/{\rm Å}^2]$	−5	+1	squared dispersion of reduced Mg index, MR component
$\log_{10}[\sigma^2_{W,2}/{\rm Å}^2]$	−5	+1	squared dispersion of reduced Mg index, MP component
$\log_{10}[\sigma^2_{V,1}/({\rm km^2s^{-2}})]$	−5	+5	squared velocity dispersion, MR component
$\log_{10}[\sigma^2_{V,2}/({\rm km^2s^{-2}})]$	−5	+5	squared velocity dispersion, MP component
$\mu_\alpha/$(mas/century)	−1000	+1000	RA proper motion of dSph
$\mu_\delta/$(mas/century)	−1000	+1000	Dec. proper motion of dSph

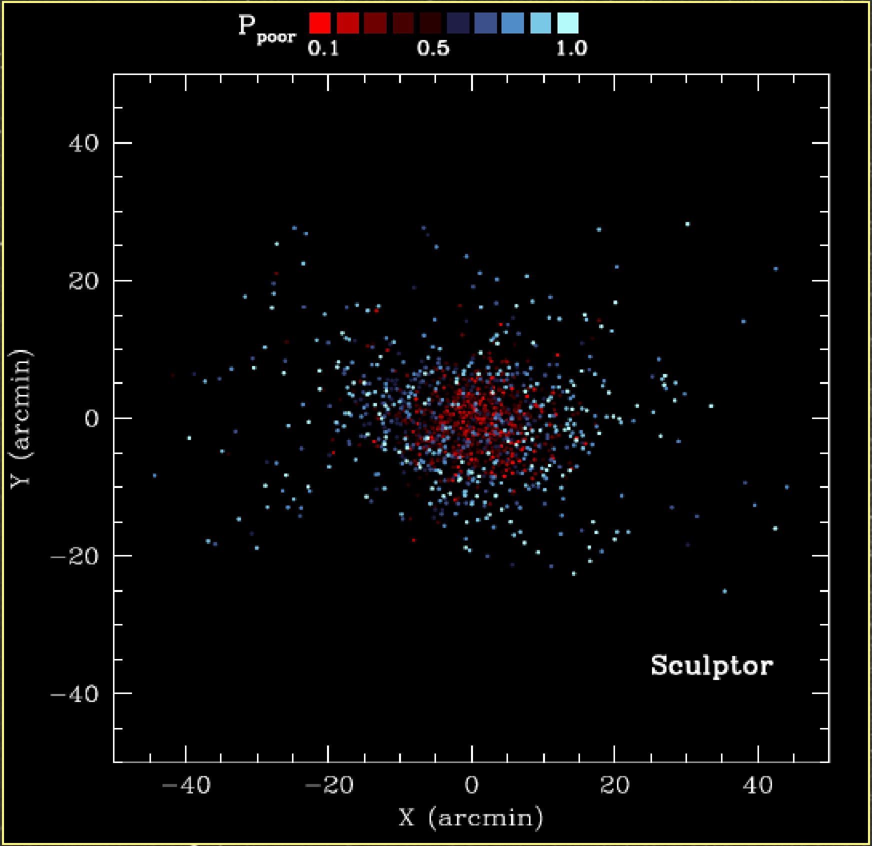
Walker & Peñarrubia (2011)

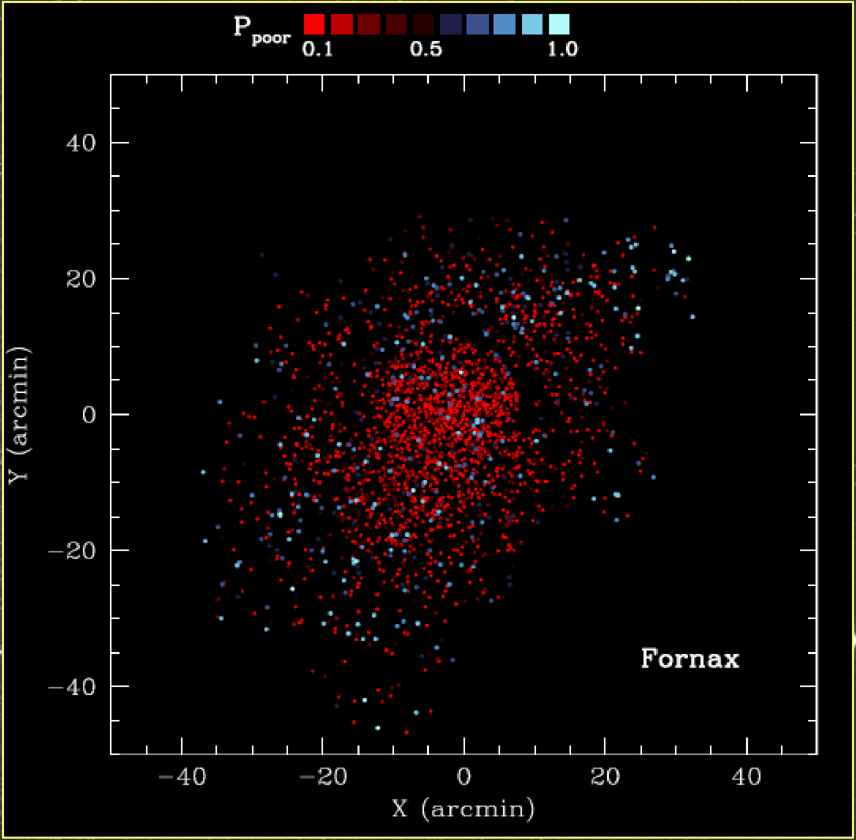
Results



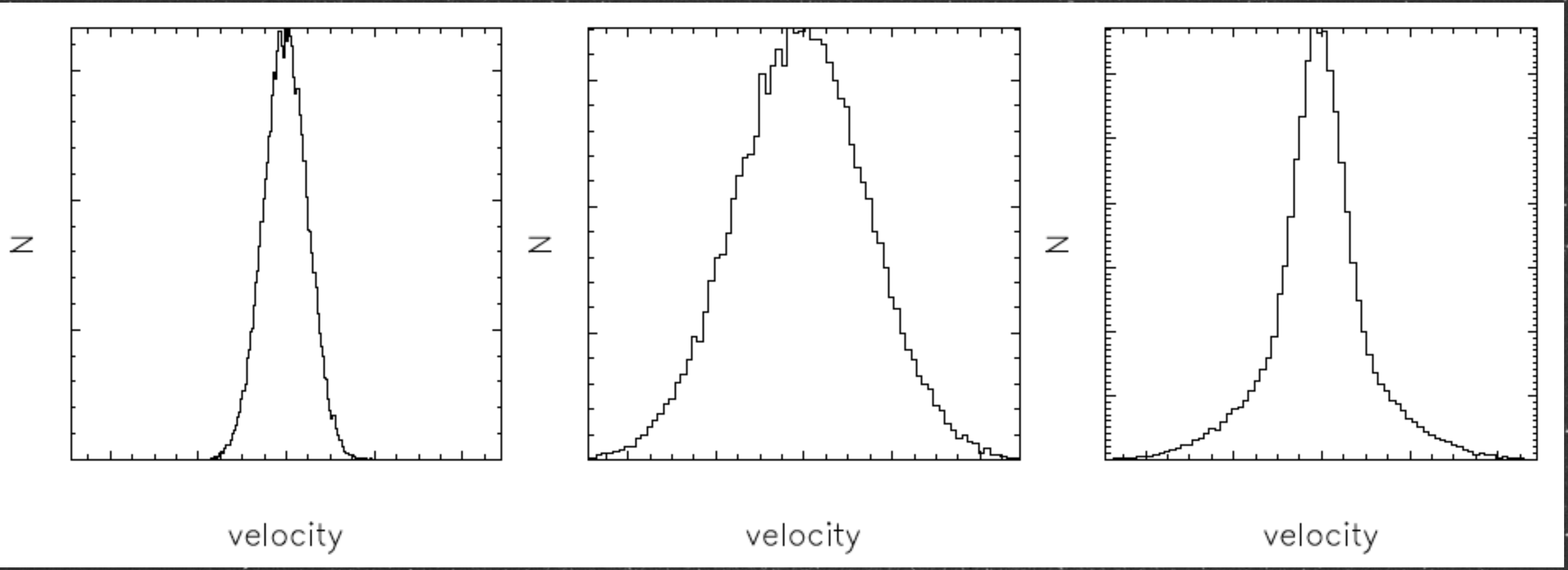
Walker & Peñarrubia (2011)

probabilistic view of two components





two components and line profiles

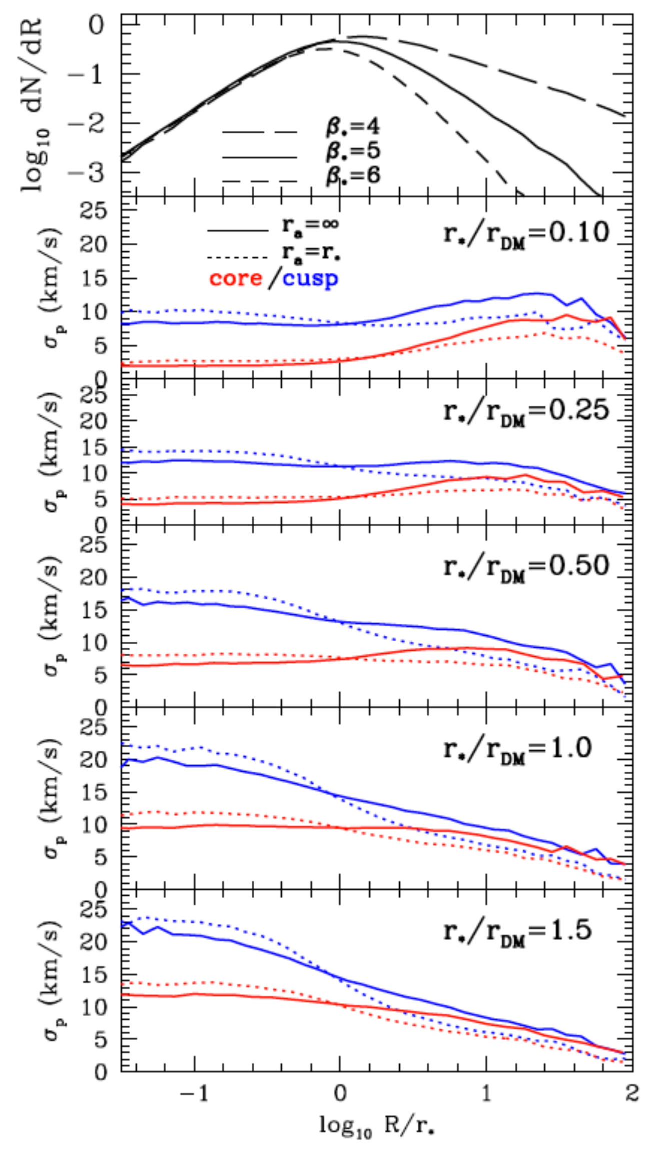



END

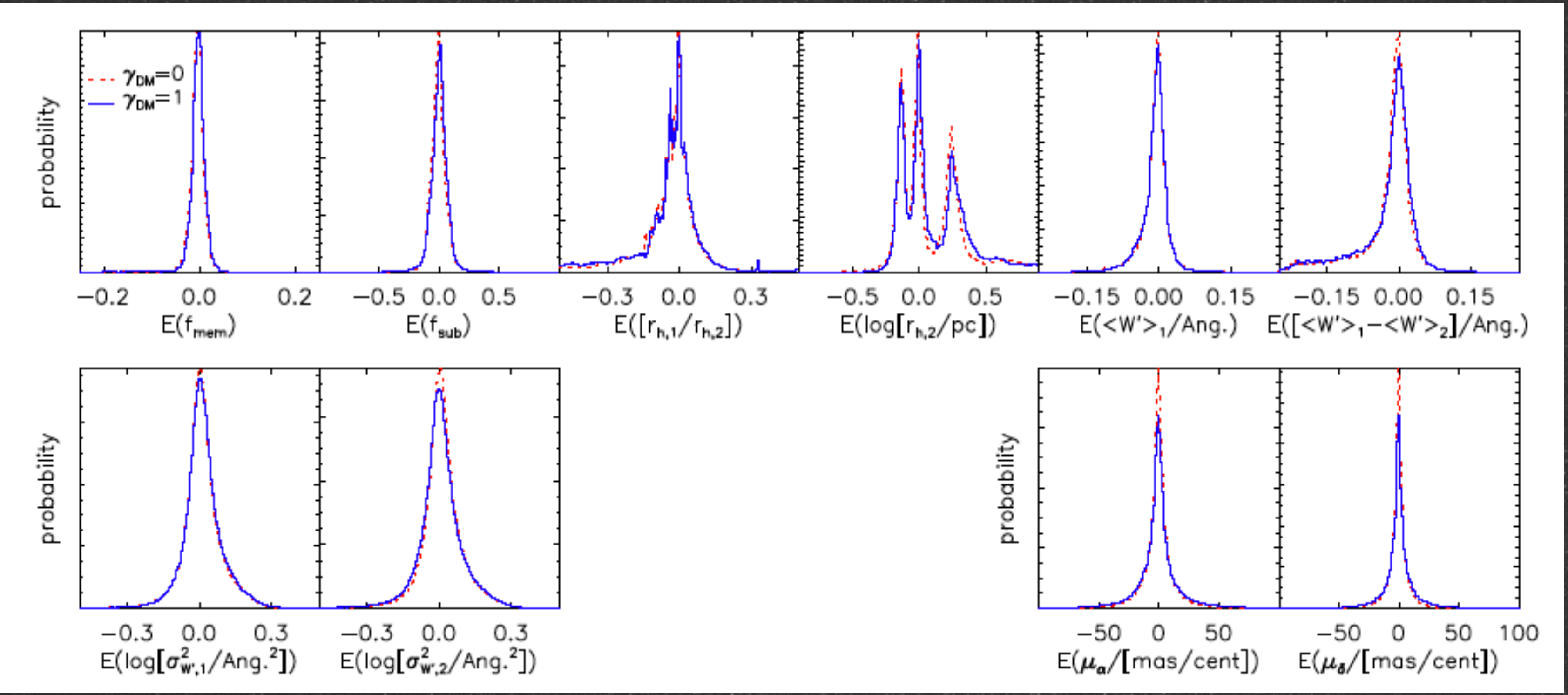
Tests

TABLE 3
TESTS ON SYNTHETIC DATA: GRID OF INPUT PARAMETERS FOR DYNAMICAL TEST MODELS

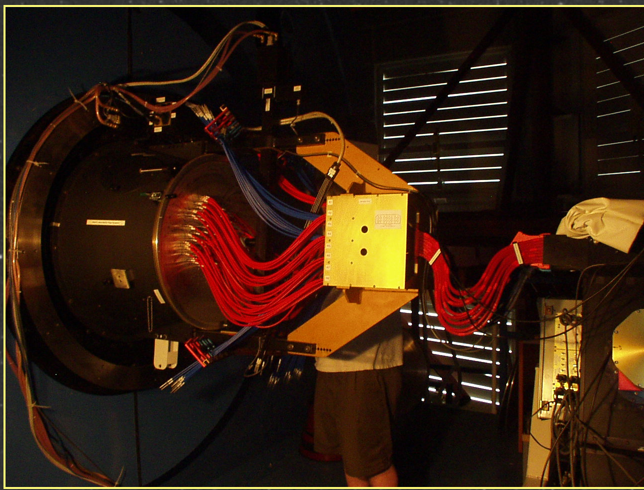
Profile	Parameter	values considered
Stellar Subcomponent (Eq. 15)		
	r_*/r_{DM}	0.10, 0.25, 0.50, 1.0, 1.5
	α_*	2
	β_*	4, 5, 6
	γ_*	0.1
	r_a/r_*	$1, \infty$
Dark Matter Halo (Eq. 16)		
	$\rho_0/(M_\odot \mathrm{pc}^{-3})$	0.064
	r_{DM}/kpc	1
	α_{DM}	1
	β_{DM}	3
	γ_{DM}	0, 1

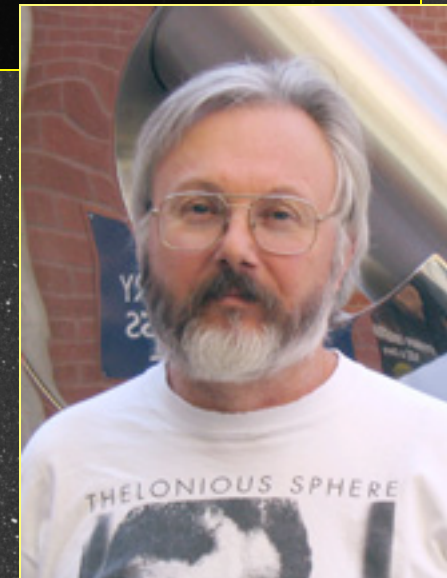


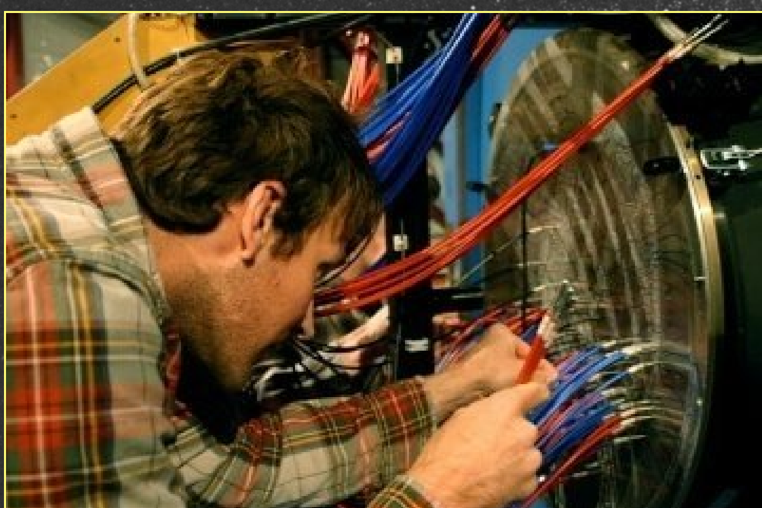
Errors—parameter estimates

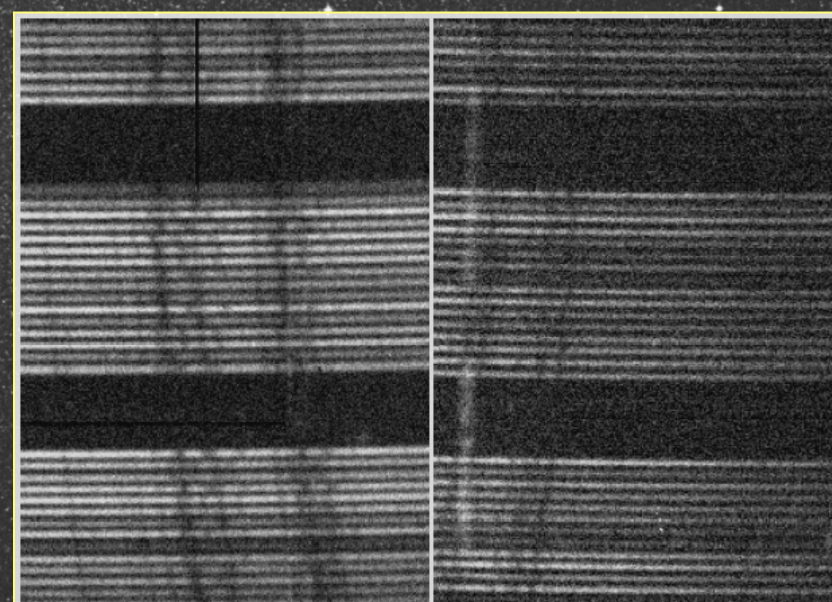


Magellan Spectroscopic Observations
w/ Mario Mateo & Ed Olszewski





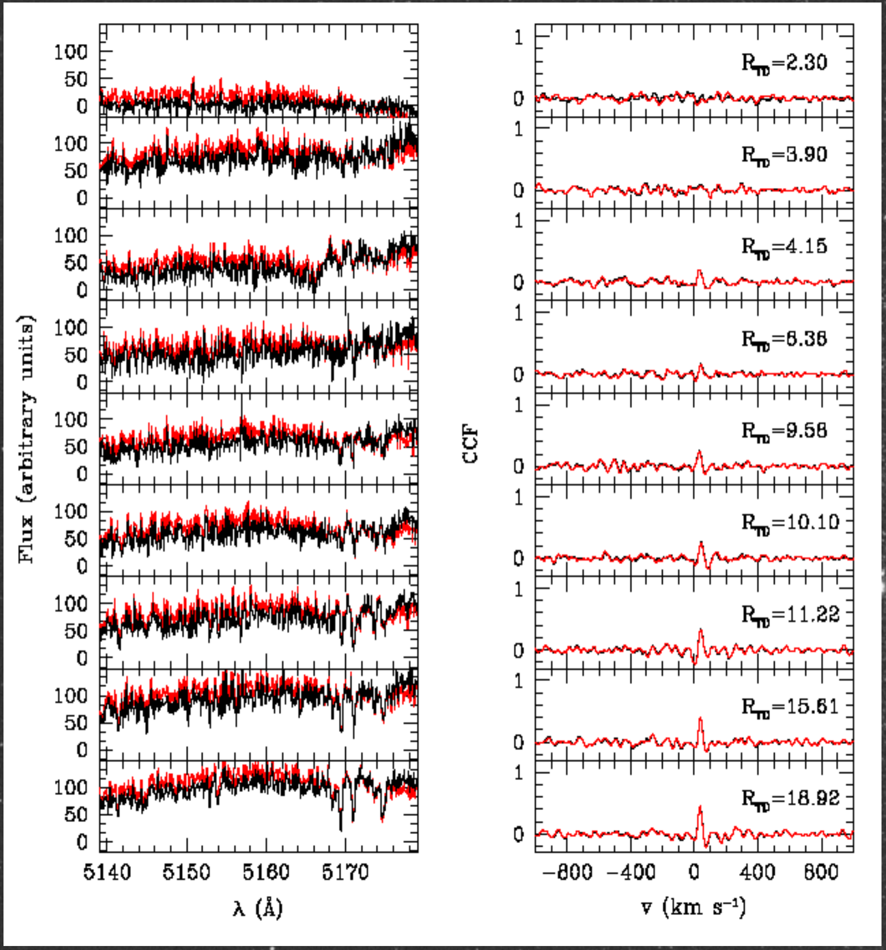


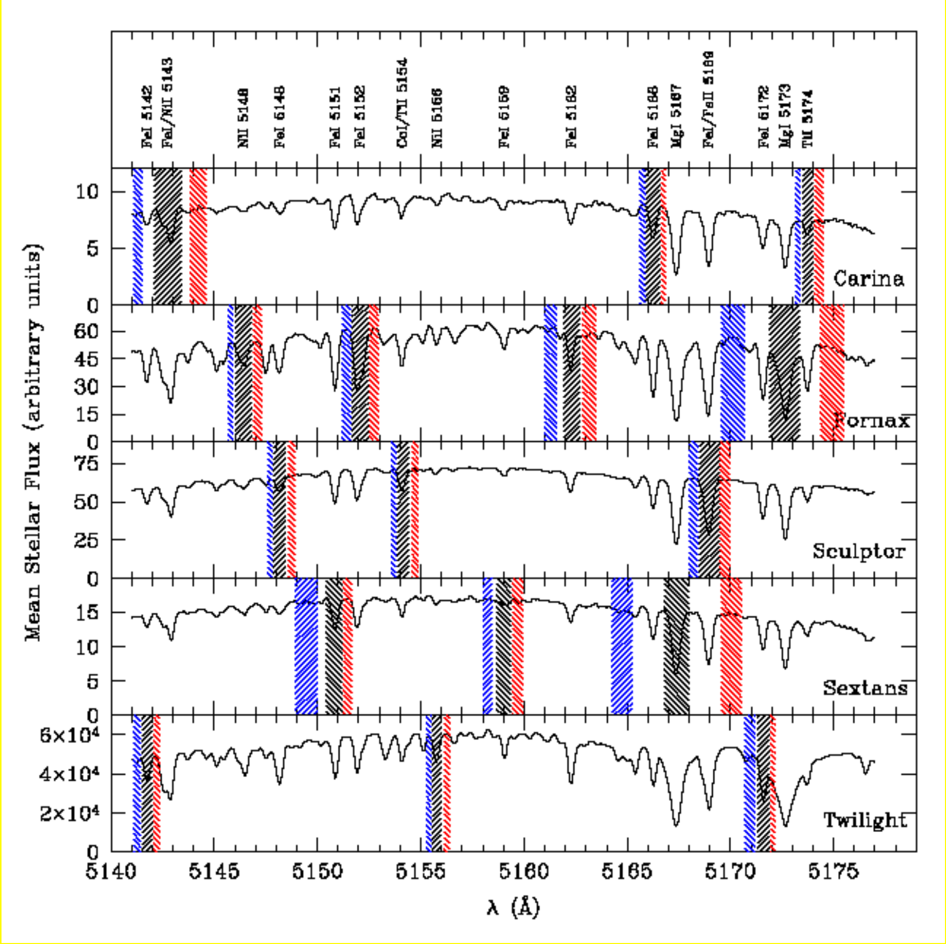


Observations: Spectroscopy of "Classical" dSphs

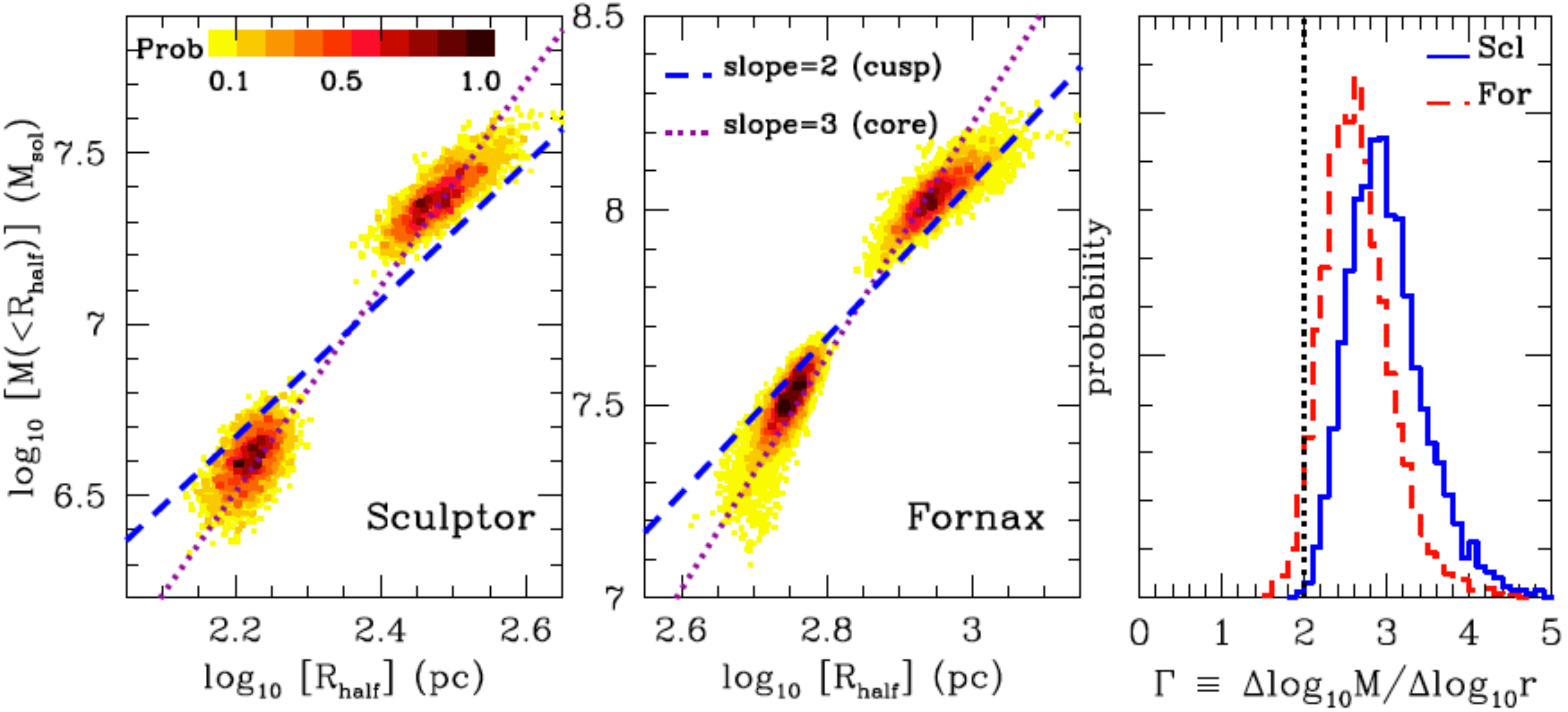
$$CCF(v) = \int S(v)[T(v) - v]\, dv$$

$$W = \int_{\lambda 1}^{\lambda_2} [1 - S(\lambda)/C(\lambda)]\, d\lambda$$





Results



$$\Gamma \equiv \frac{\Delta \log M}{\Delta \log r} = \frac{\log[M(r_{\mathrm{h},2})/M(r_{\mathrm{h},1})]}{\log[r_{\mathrm{h},2}/r_{\mathrm{h},1}]} \approx 1 + \frac{\log[\sigma^2_{V,2}/\sigma^2_{V,1}]}{\log[r_{\mathrm{h},2}/r_{\mathrm{h},1}]}$$