

Hypervelocity Stars Ejected from Galactic Nuclei

CSIRO Conference

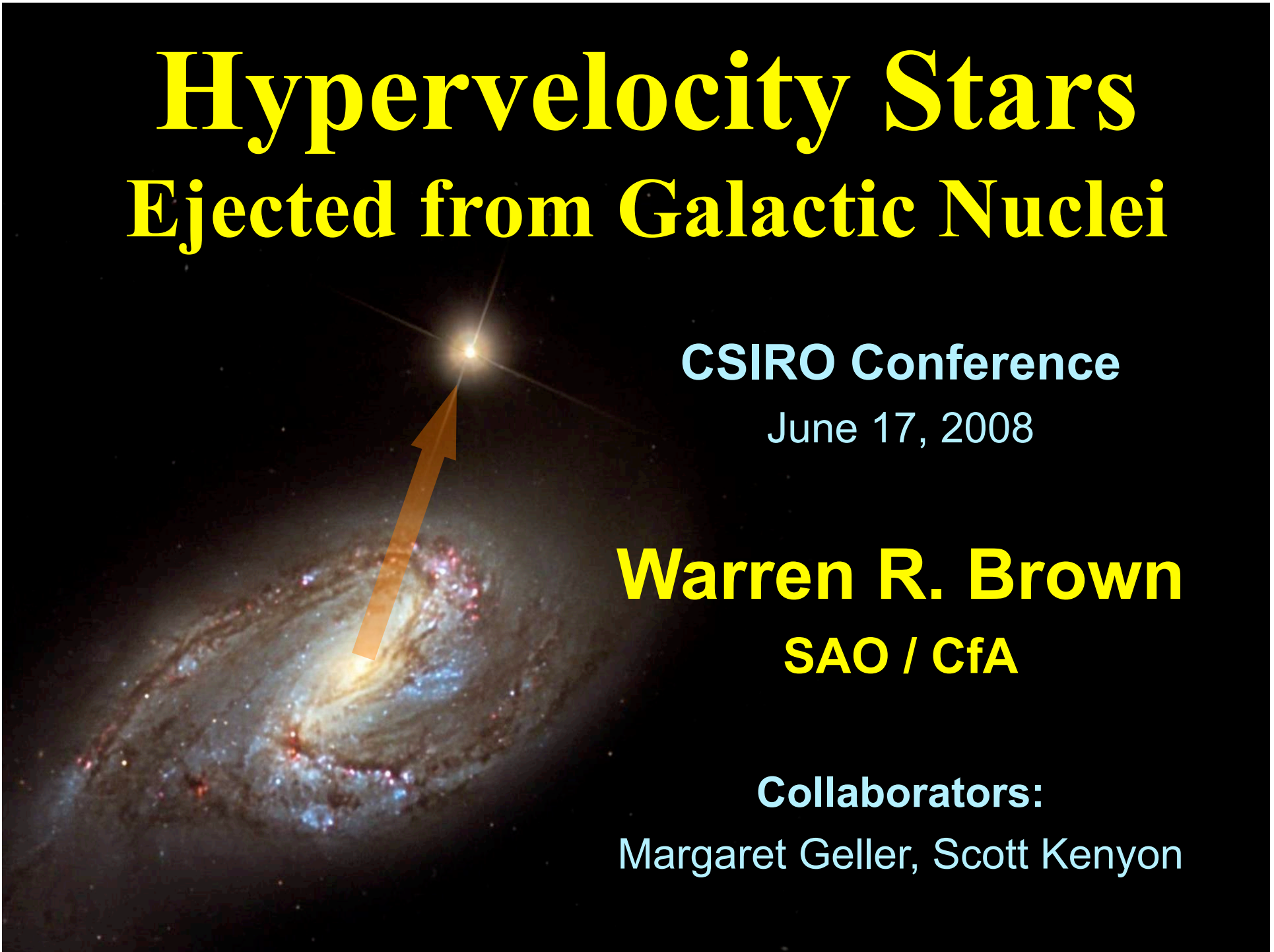
June 17, 2008

Warren R. Brown

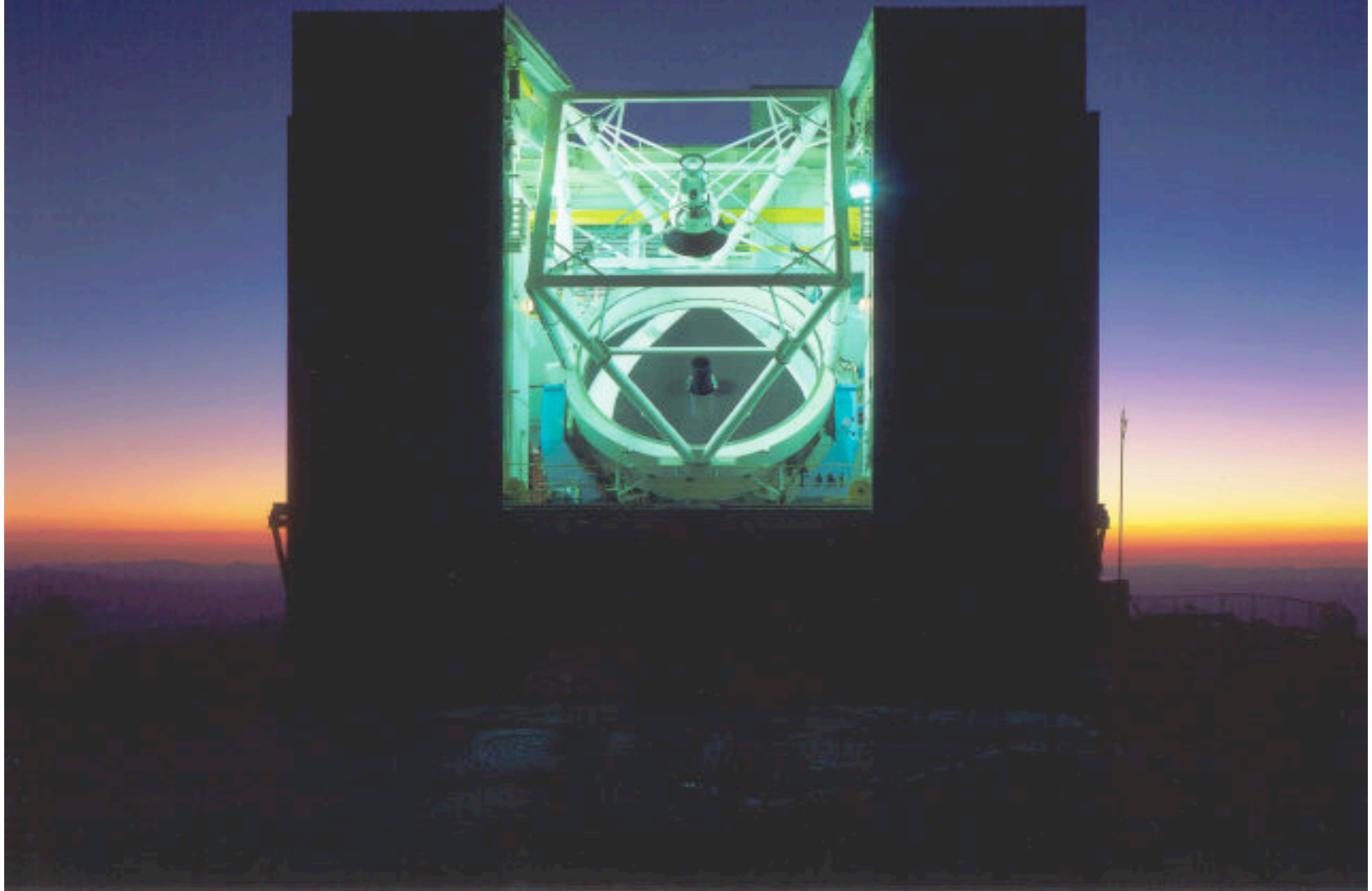
SAO / CfA

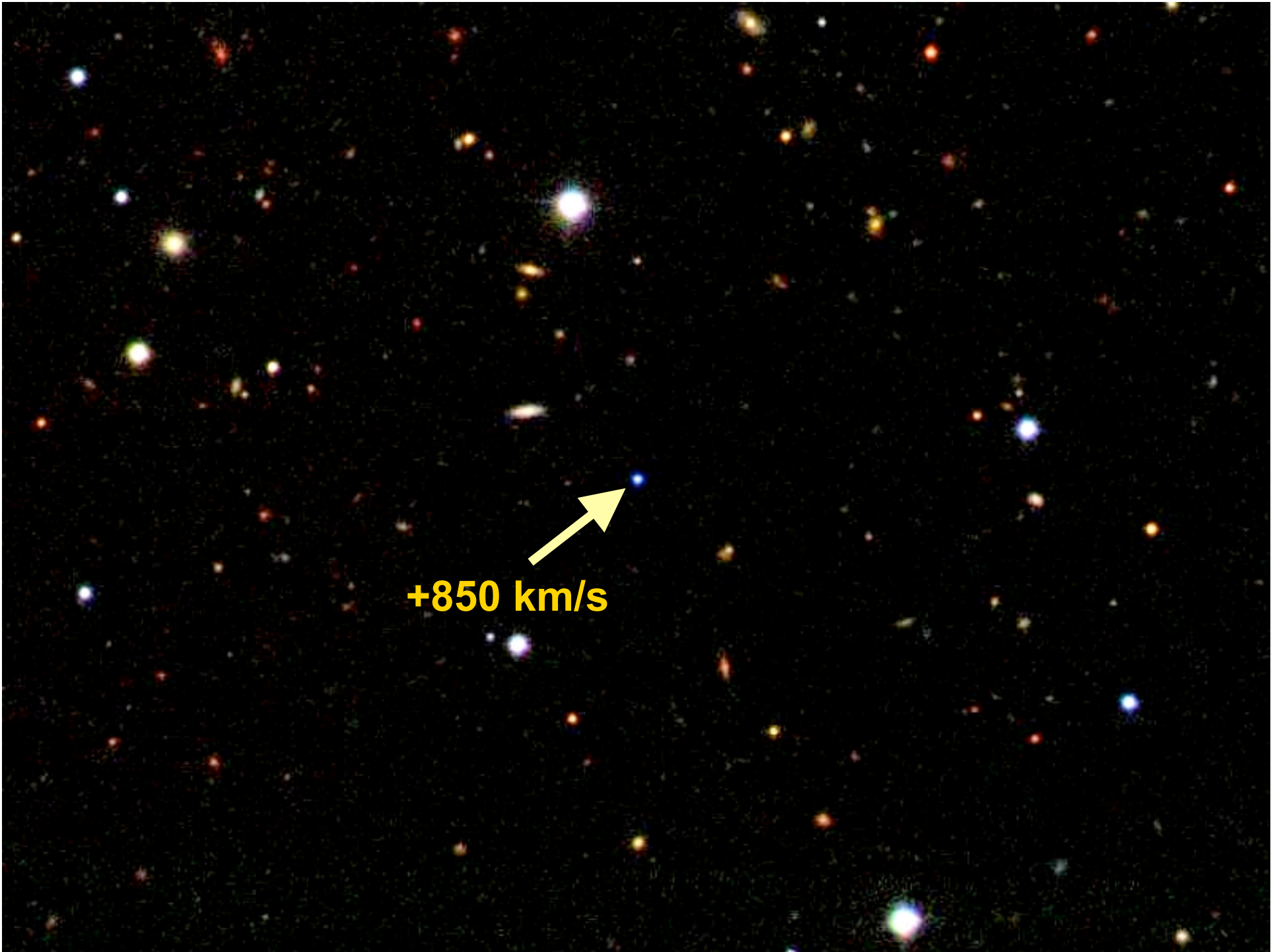
Collaborators:

Margaret Geller, Scott Kenyon



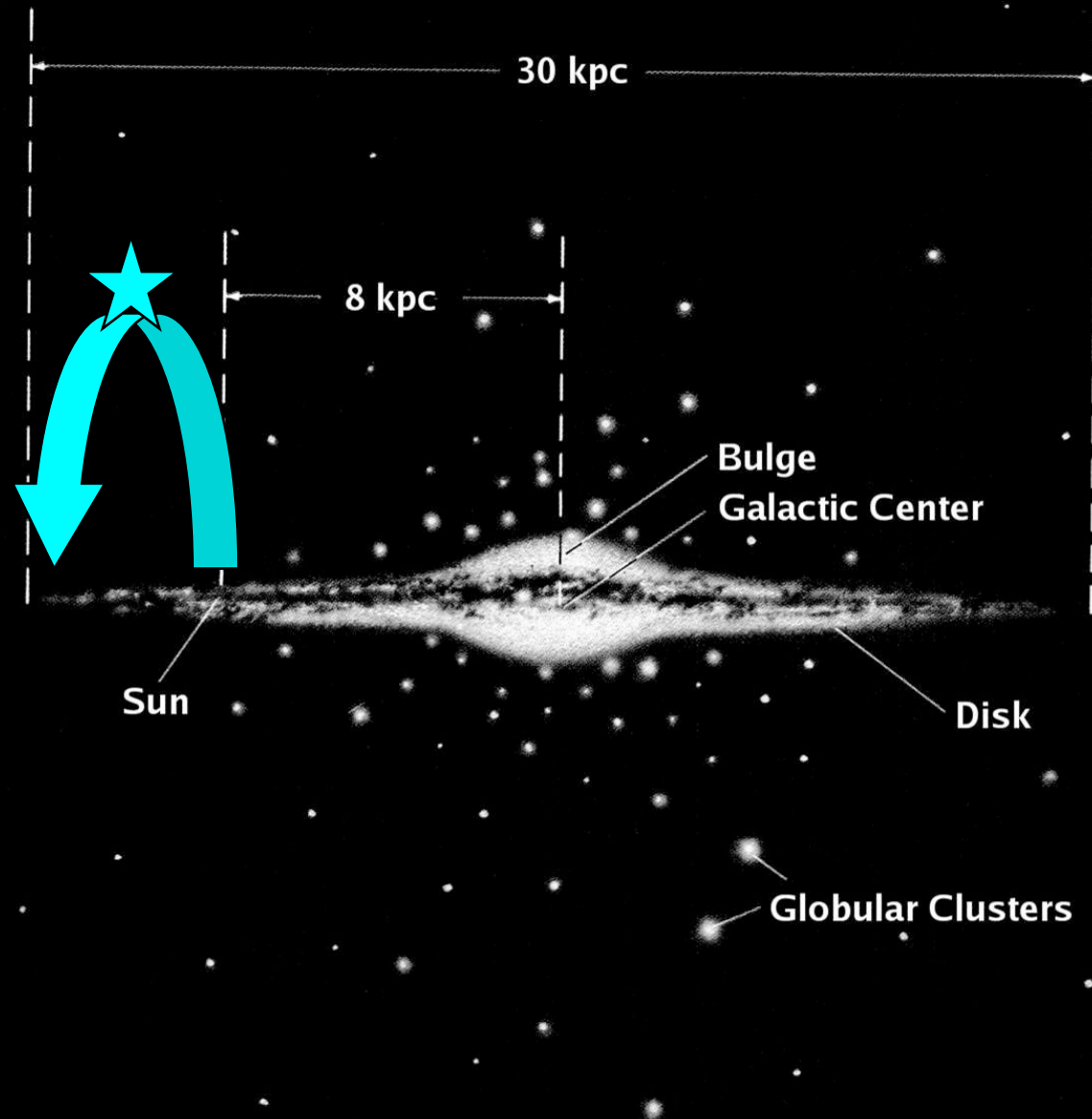
Radial Velocities from the MMT



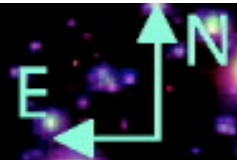


+850 km/s

The Milky Way



H/K_s/L'

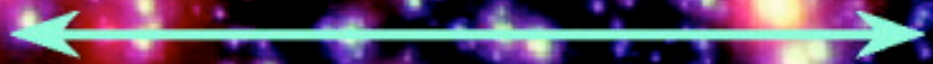


IRS 3

IRS 1W



IRS 21



10" (0.39 pc)

Three-body exchange

Near the MBH:

$$|E| \approx GM/r; \quad \mathbf{v} = (GM/r)^{1/2} \approx \mathbf{10^4} \text{ km/s}$$

If perturbed by $\delta\mathbf{v} \approx \mathbf{10^2} \text{ km/s} \ll \mathbf{v}$,

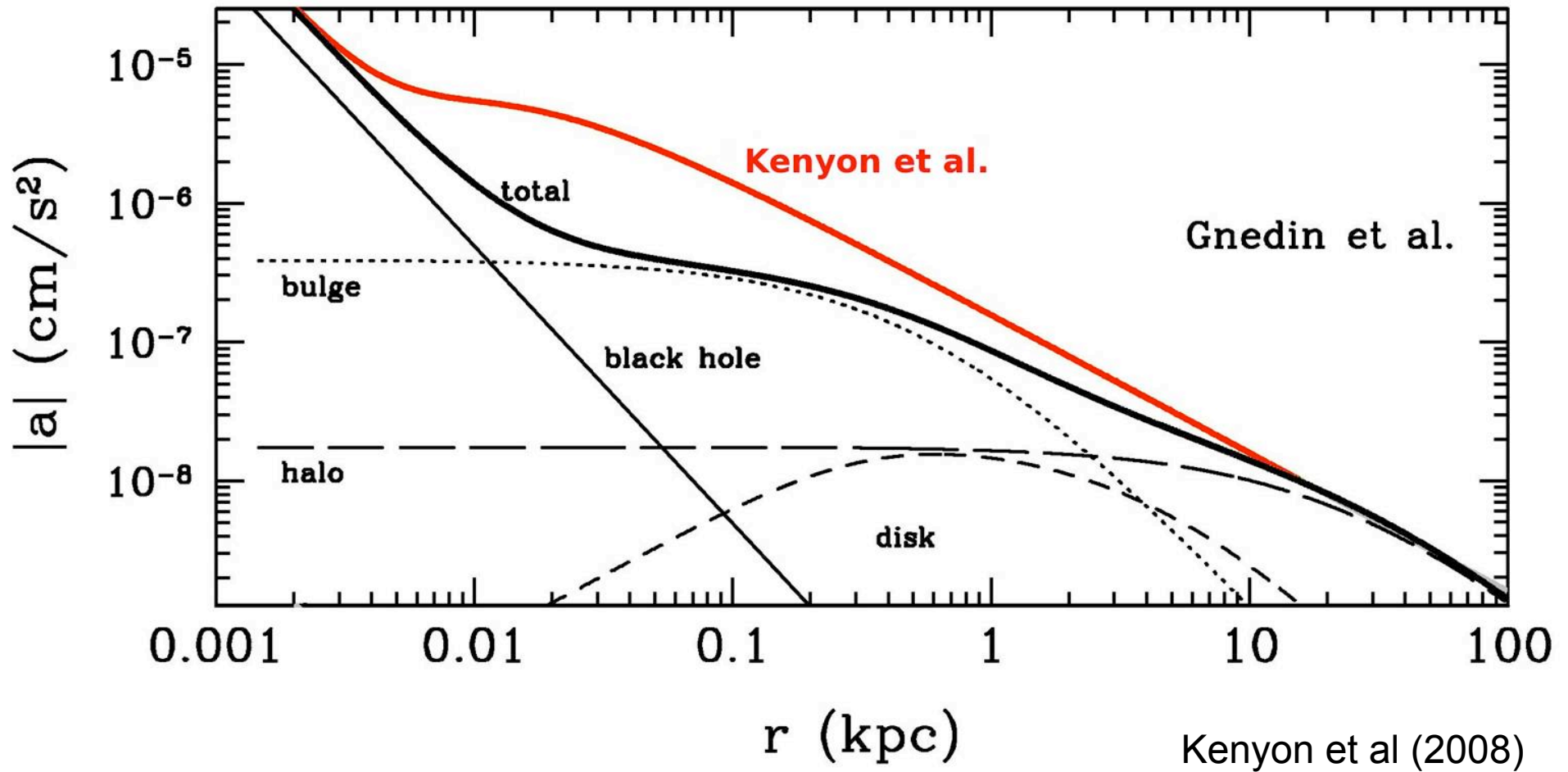
$$\delta E = \frac{1}{2} (v+\delta v)^2 - \frac{1}{2} v^2 \approx v \delta v.$$

Thus the velocity at infinity is:

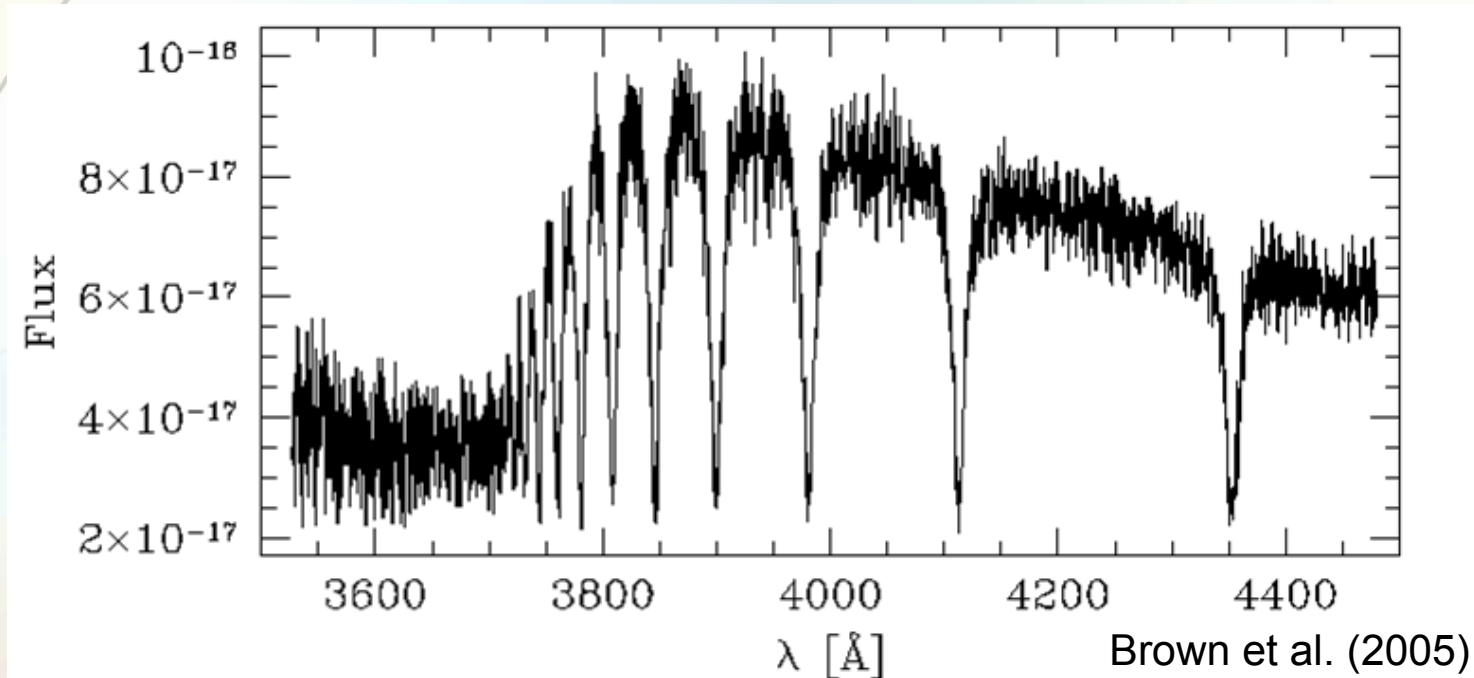
$$v_\infty = (2 v \delta v)^{1/2} \approx \mathbf{10^3} \text{ km/s}$$

Bromley 2005

Theoretical Application: Dark Matter



The First Hypervelocity Star



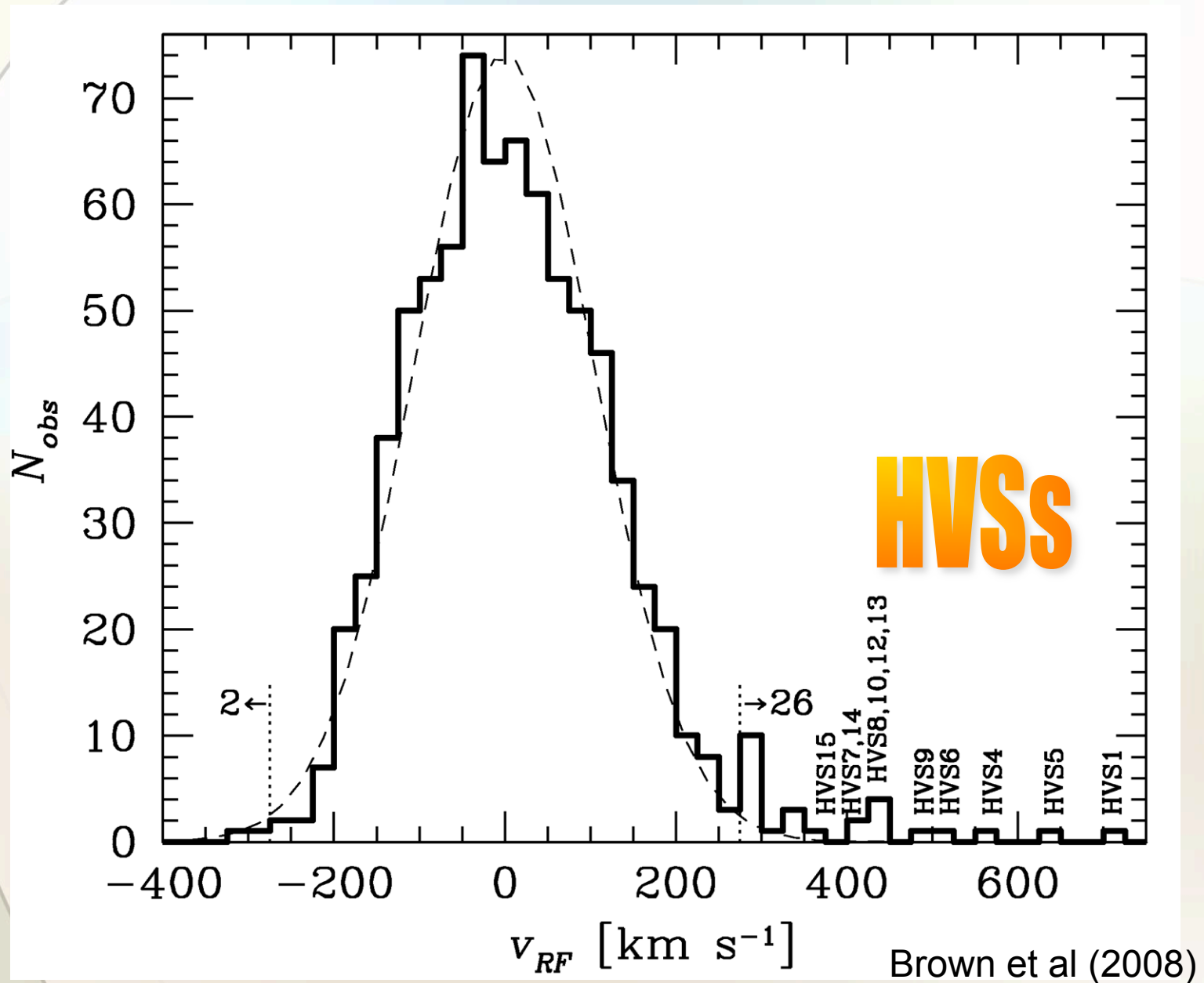
- **B9 main sequence star.** - Jack Hills
SF Chronicle 2/11/2005
- **Solar metallicity.**

19.8 thus $d \approx 110$ kpc.

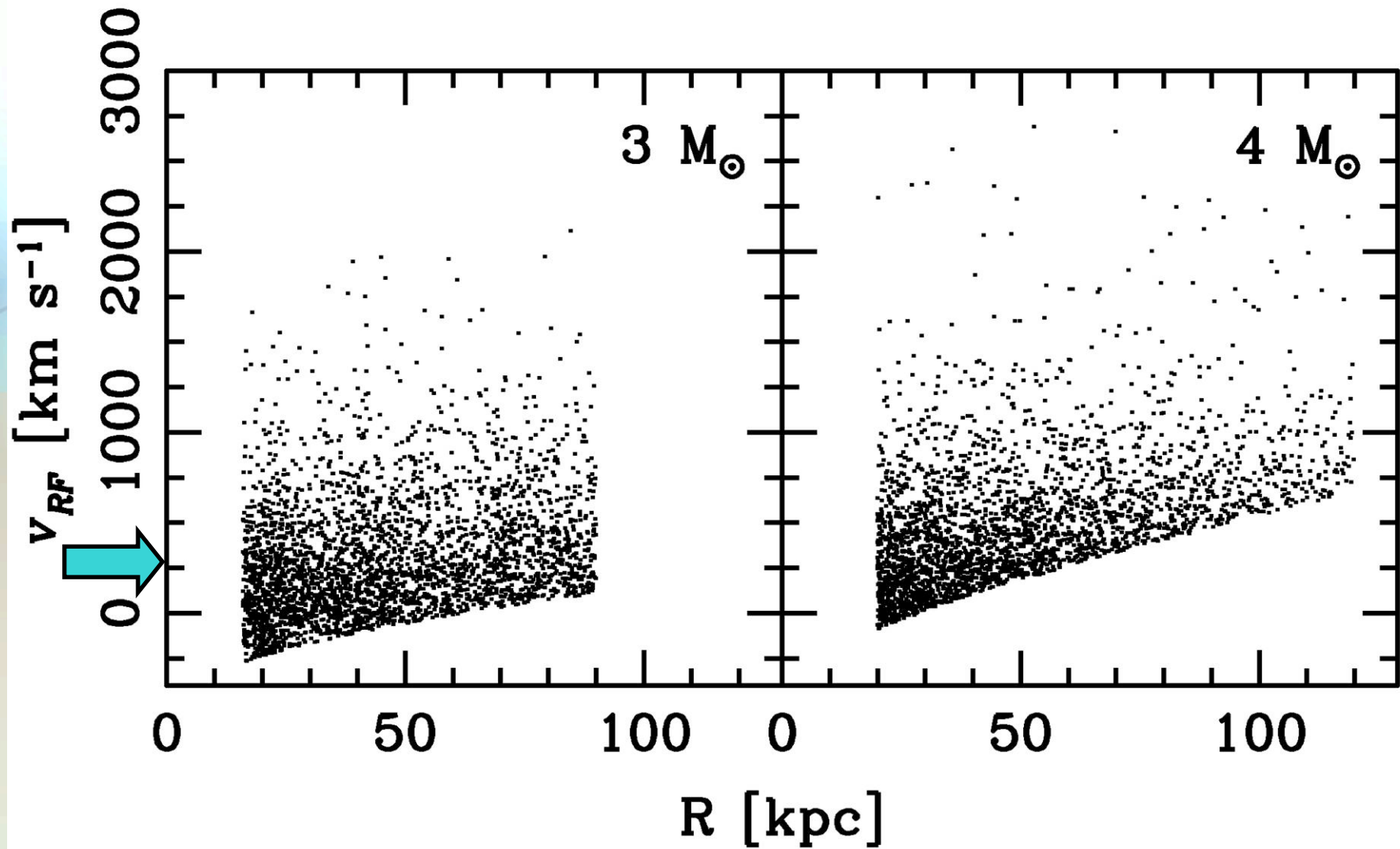
Travel time 1 Myr.



More Hypervelocity Stars

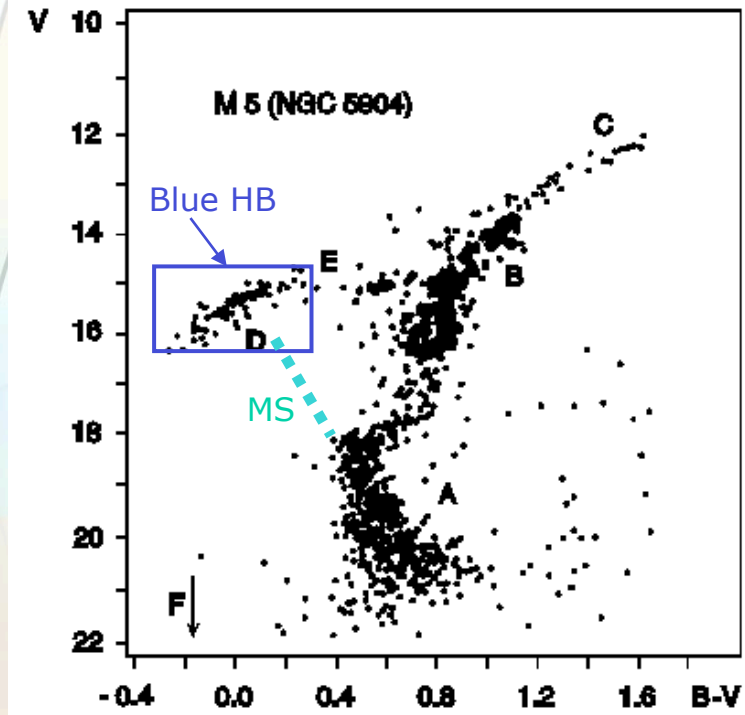


HVS Model Predictions

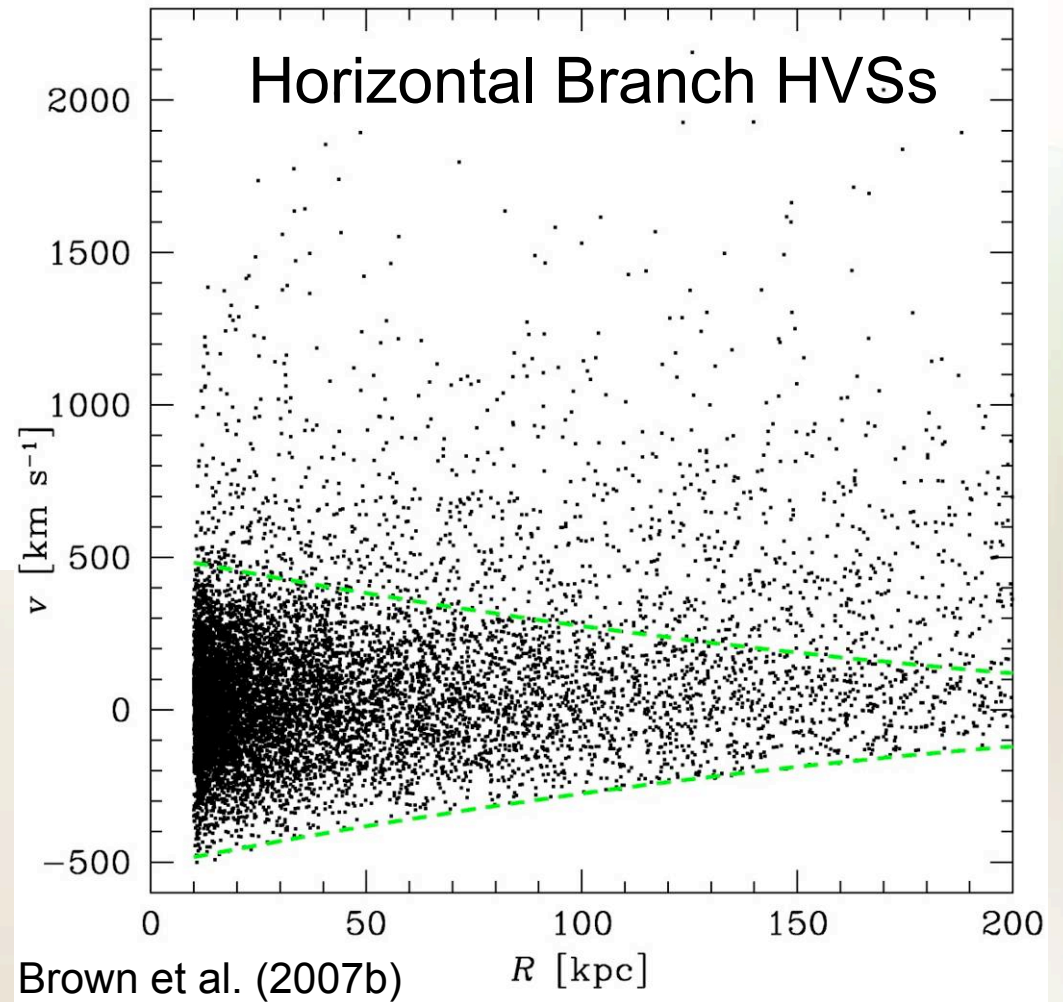


Bromley et al (2006); Brown et al. (2007a); Kenyon et al (2008)

HVSs are Main Sequence Stars



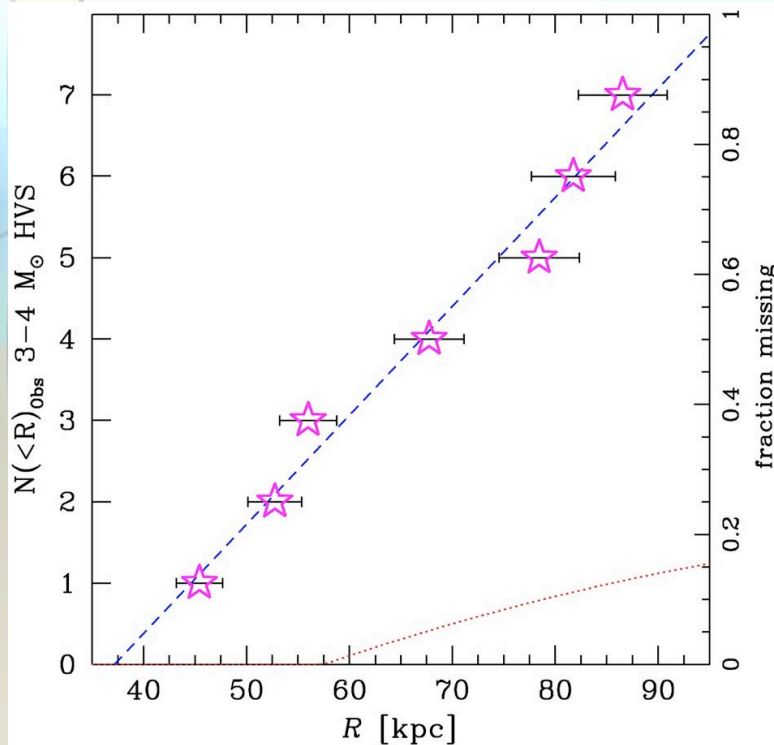
Kaufmann



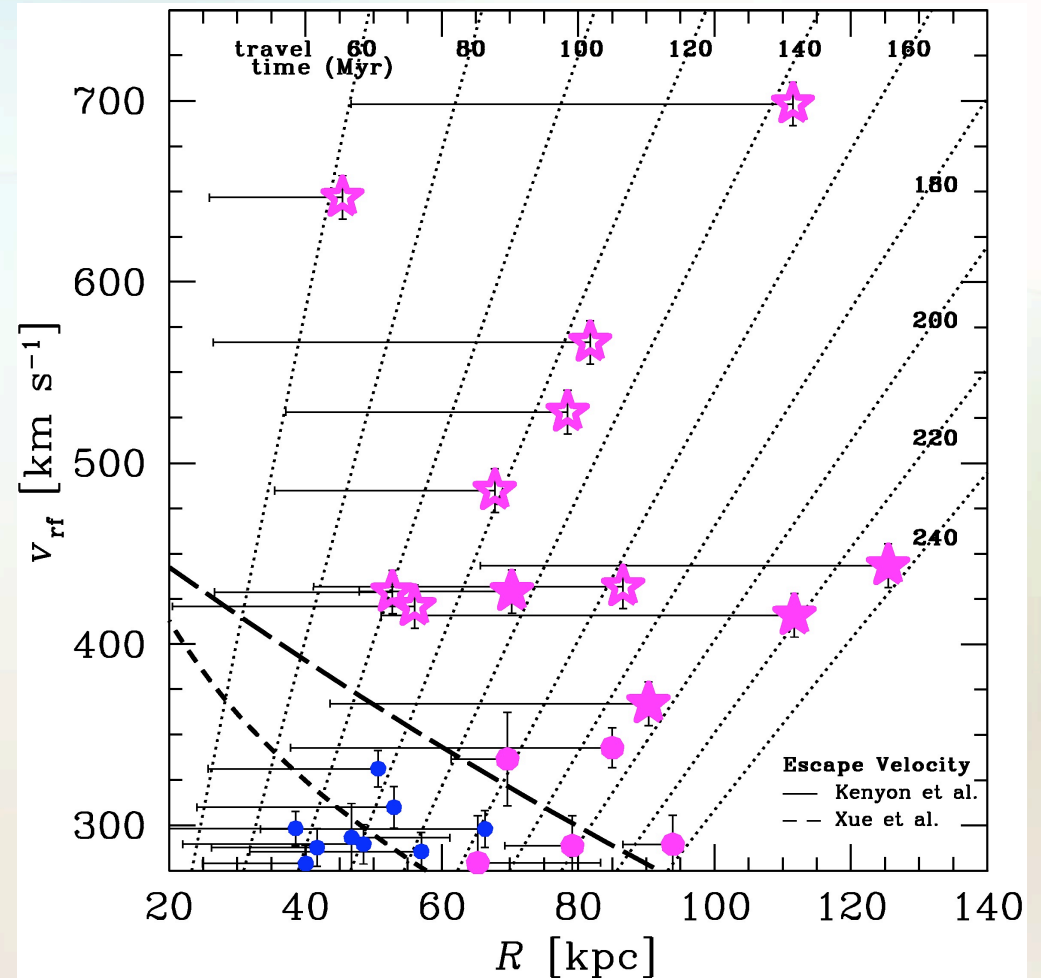
Brown et al. (2007b)

R [kpc]

HVS Space Density & Ejection History

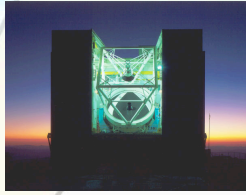


Brown et al. (2007b)



Brown et al. (2008)

Future Work



- **Discovery survey: MMT, Magellan.**
- **Proper Motions: HST (Gnedin, Anderson).**
- **Numerical simulations: (Bromley, Kenyon).**

Conclusions

- **MBH = hypervelocity stars.**
- **HVS distributions linked to MBH.**
- **Statistical sample will answer:**
 - **Black hole (binary?) ejection**
 - **In-fall history**
 - **Mass function of stars**
 - **Dark matter potential**



(Old) HVS Table

ID	Type	g' (mag)	$V_{\min\text{RF}}$ (km/s)	d (kpc)	t_{GC} (Myr)	Citation
HVS1	B	19.8	+709	110	160	Brown et al. (2005)
HVS2	sdO	18.8	+717	19	32	Hirsch et al. (2005)
HVS3	B	16.2	+548	61	100?	Edelmann et al. (2005)
HVS4	B	18.4	+558	75	140	Brown et al. (2006a)
HVS5	B	17.9	+638	55	90	Brown et al. (2006a)
HVS6	B	19.1	+508	75	160	Brown et al. (2006b)
HVS7	B	17.7	+423	55	120	Brown et al. (2006b)
HVS8	B	17.9	+430	45	100	Brown et al. (2007b)
HVS9	B	18.6	+490	55	110	Brown et al. (2007b)
HVS10	B	19.2	+432	85	190	Brown et al. (2007b)
HVS11	B	19.6	+429	105	200	Brown et al. (2008)
HVS12	B	20.0	+443	125	235	Brown et al. (2008)