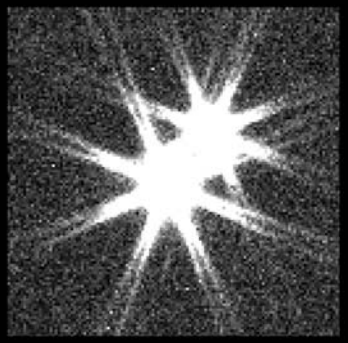


RECONS

Research Consortium on Nearby Stars

Ground-Based Parallax Programs

Todd J. Henry

Georgia State University

Parallax

Parallax Aficionados

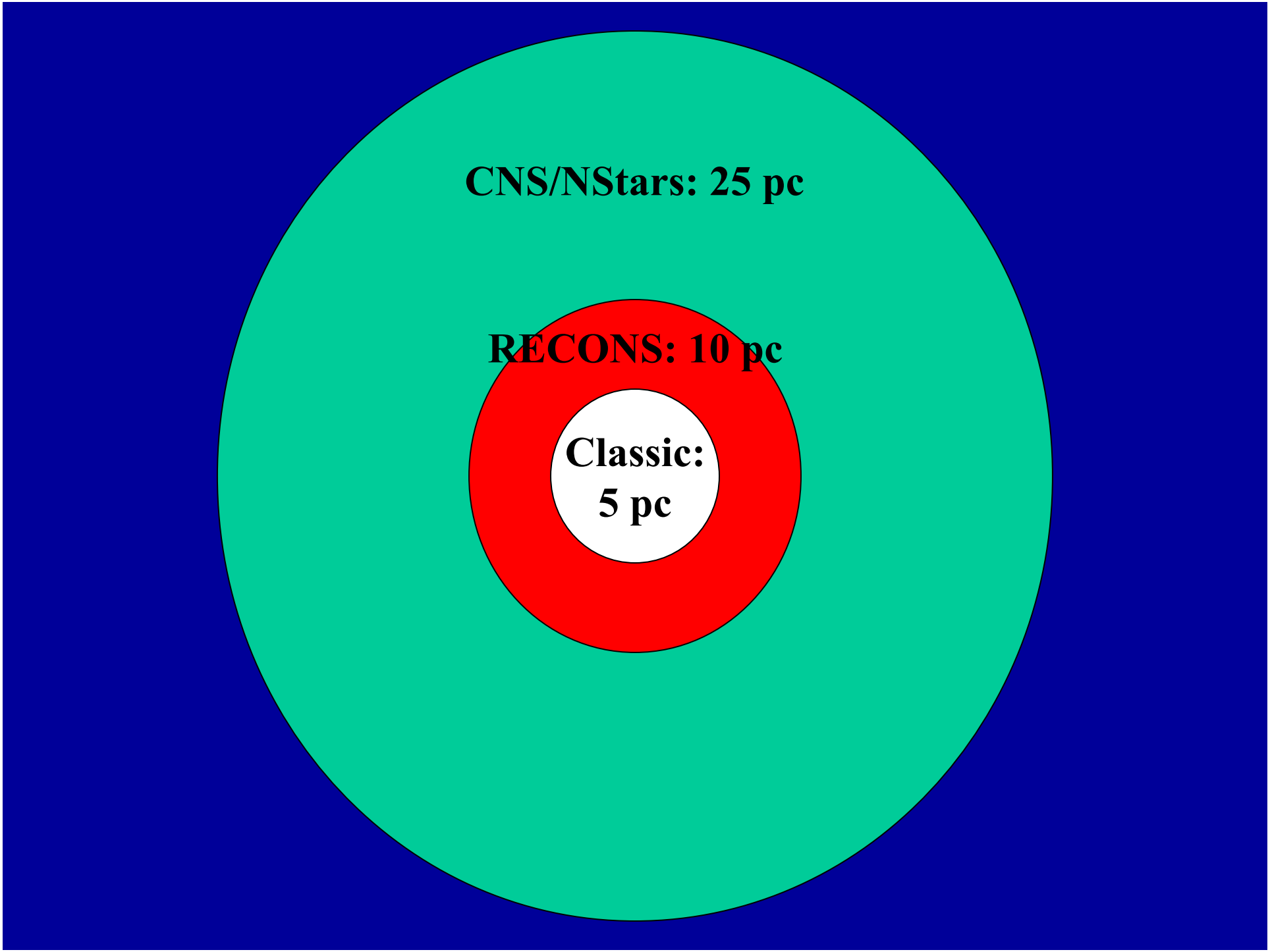
Bessel Struve Henderson (1838-1839)

Schlesinger van Maanen Alden Voute
Fox Dyson Mitchell Miller

van de Kamp Lippincott Murray Harrington Anguita
Strand Woolley Upgren Hershey Worley Heintz

van Altena Gatewood Ianna
Dahn Monet HIPPARCOS

Benedict Tinney Smart
Vrba RECONS


CNS/NStars: 25 pc
RECONS: 10 pc
Classic:
5 pc

The YPC (1995)

definitive summary of ground-based parallaxes

The General Catalogue of Trigonometric Stellar Parallaxes

van Altena, Lee, Hoffleit	4th	1995	4 mas
Jenkins	3rd sup	1963	
Jenkins	3rd	1952	16 mas
Schlesinger and Jenkins	2nd	1935	
Schlesinger	1st	1924	

latest version

8112 stars with 15,994 parallaxes
all parallaxes through November 1995
relative pi converted to absolute pi uniformly

YPC (1995) Details

41 telescope/observatory combinations

first photographic pi by Schlesinger (1910-1) and Russell (1911)

century of work reduced errors from 20 mas to 1 mas

61% of stars have only one pi (leaving 3203 with checks)

"approximately half of the stars have parallaxes that are smaller than their standard errors"

"In the next decade continuing refinements ... should further increase the precision reported, perhaps yielding several stars near the 0.1 mas level."

YMCA

as defined by Ianna, “during their most active periods” up to 1950:

Yale	2029 pi	1925-1950	81 / year
McCormick	1899 pi	1912-1950	50 / year
Cape	1832 pi	1926-1950	76 / year
Allegheny	1870 pi	1914-1950	52 / year
USNO	~1500 pi	1964-present	~ 37 / year

UR YMCA

Parallax Programs Today

Recently finished				π_{trig} *since 1995*
Ianna	SSO	S	opt	34
Tinney	various	N/S	opt/ir	40
Weis/Upgren	Wesleyan	N	opt	48
Continuing				
Gatewood	Allegheny	N	opt	3
Smart	Italy	N	opt	6
Dahn	USNO	N	opt	28
Vrba	USNO	N	ir	40
Henry +	CTIOPI	S	opt	77

Dahn et al. 2002

optical program with scale 352 mas/pixel … errors ~ 1 mas

8	late M dwarfs
17	L dwarfs
3	T dwarfs

issues: 1. binary
2. extreme ages have atypical luminosities
3. dust
4. clouds and changes over time

- M_J vs. I-J relation excellent for M and L types (but not T)
- zJK magnitudes can be used for MLT classification

combination of optical and infrared required

Vrba et al. 2004

infrared program with scale 365 mas/pixel … errors ~ 4 mas

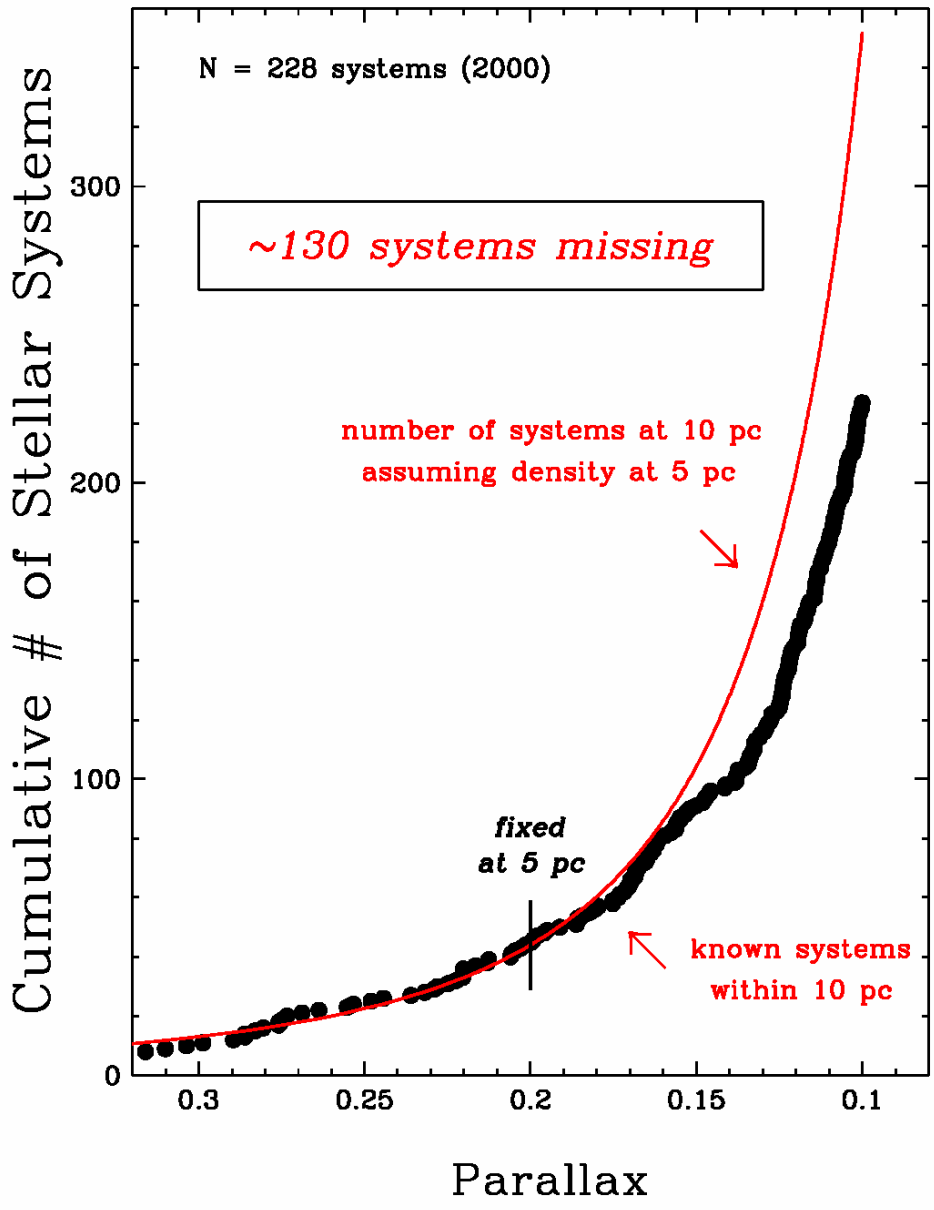
0	late M dwarfs
22	L dwarfs (total now 37 Ls)
18	T dwarfs (total now 19 Ts)

- M_{JHK} / M_{bol} / Lum / Temp table for L0-L8

L	2500 – 1400 K
T	1400 – 800 K

- confirm luminosity excess in early/mid T sequence
- space velocities of Ls consistent with Ms … ~ age
- space velocities of Ts somewhat higher … ~ older

infrared astrometry possible and productive!



RECONS

Research Consortium on Nearby Stars

established 1994

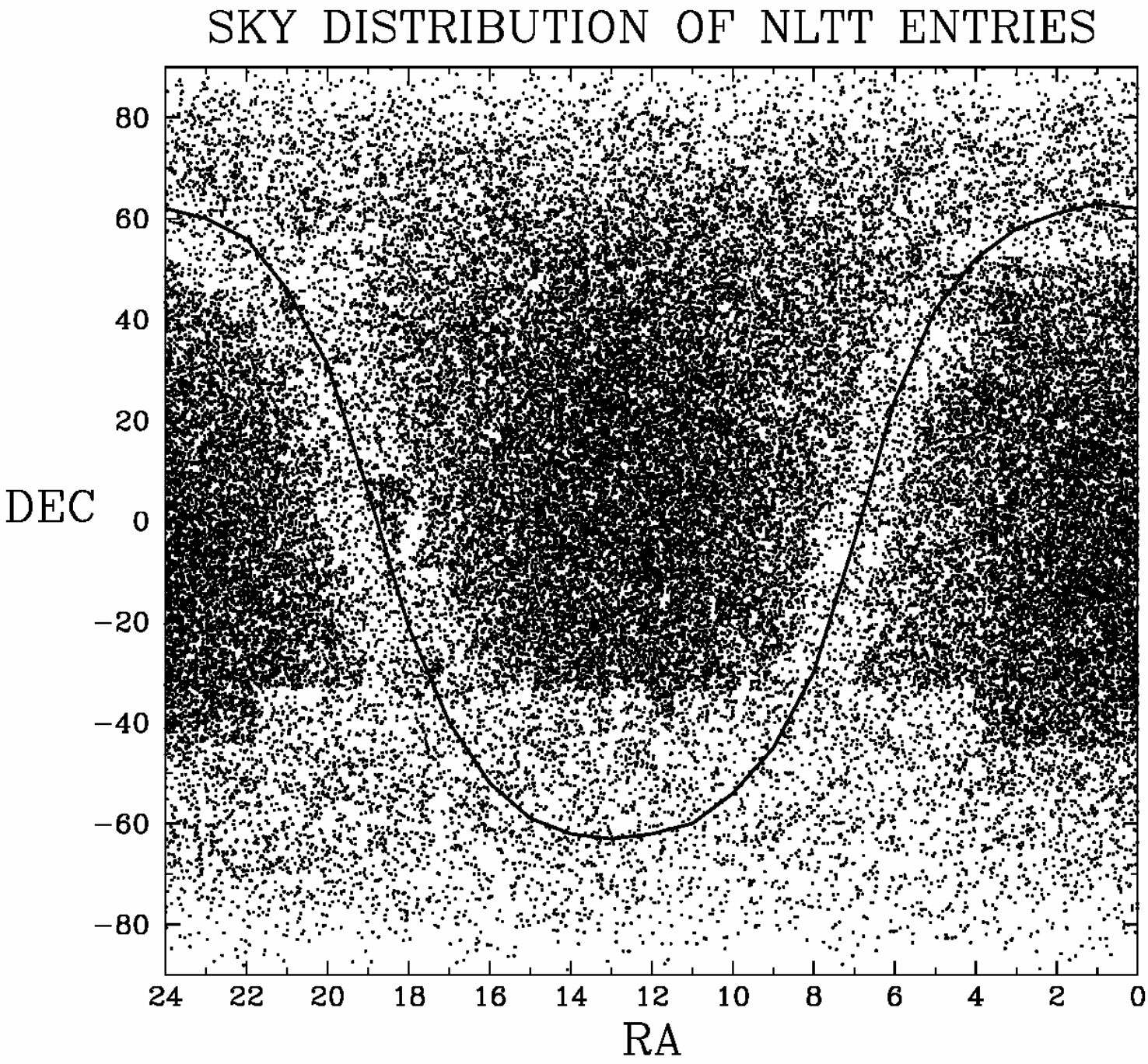
goals:

1. discover new stellar systems within 10 parsecs

2. characterize all stars within 10 parsecs

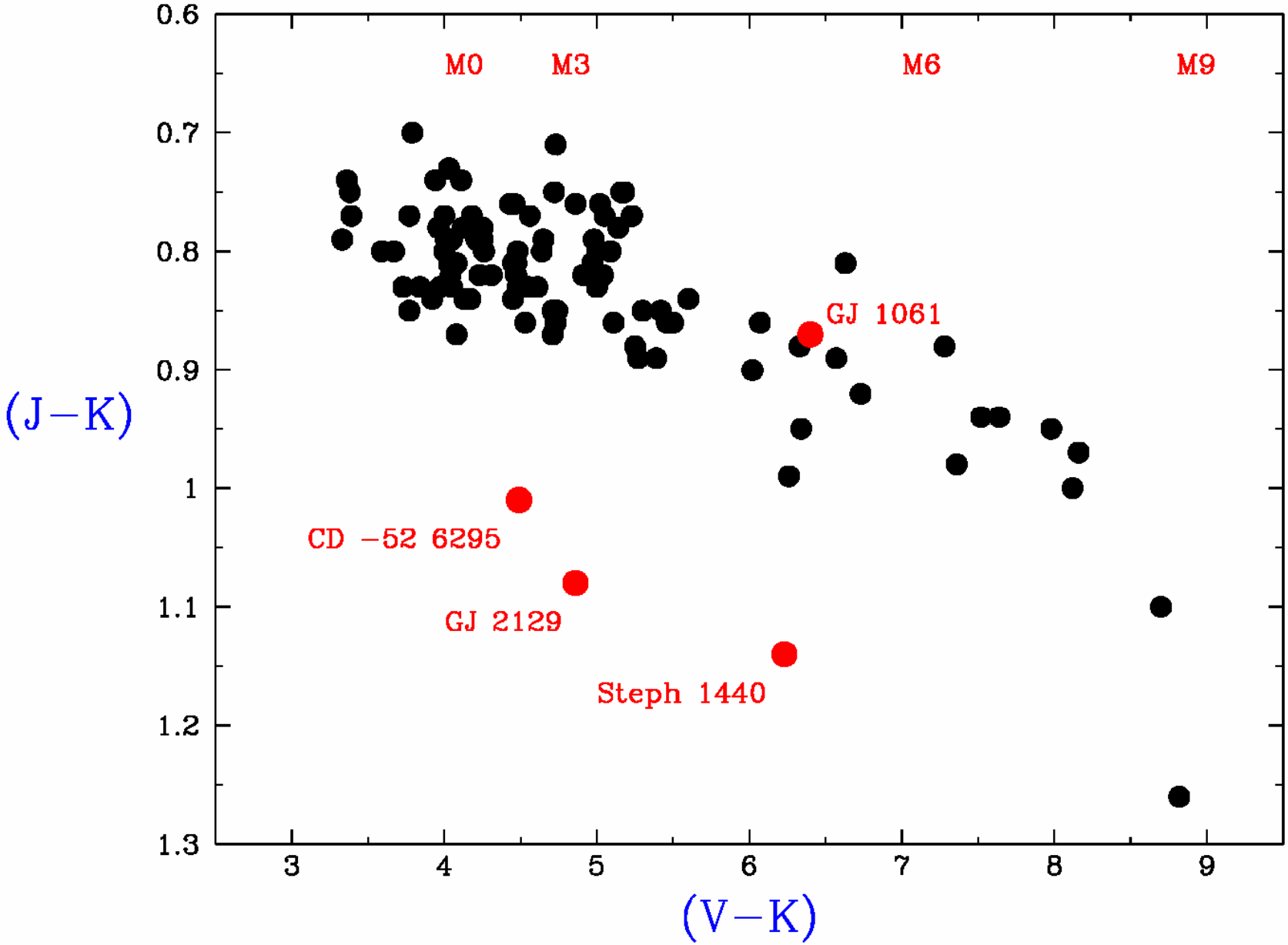
astrometry
photometry, spectroscopy
ages, metallicities
multiplicity, perturbations

The RECONS Search

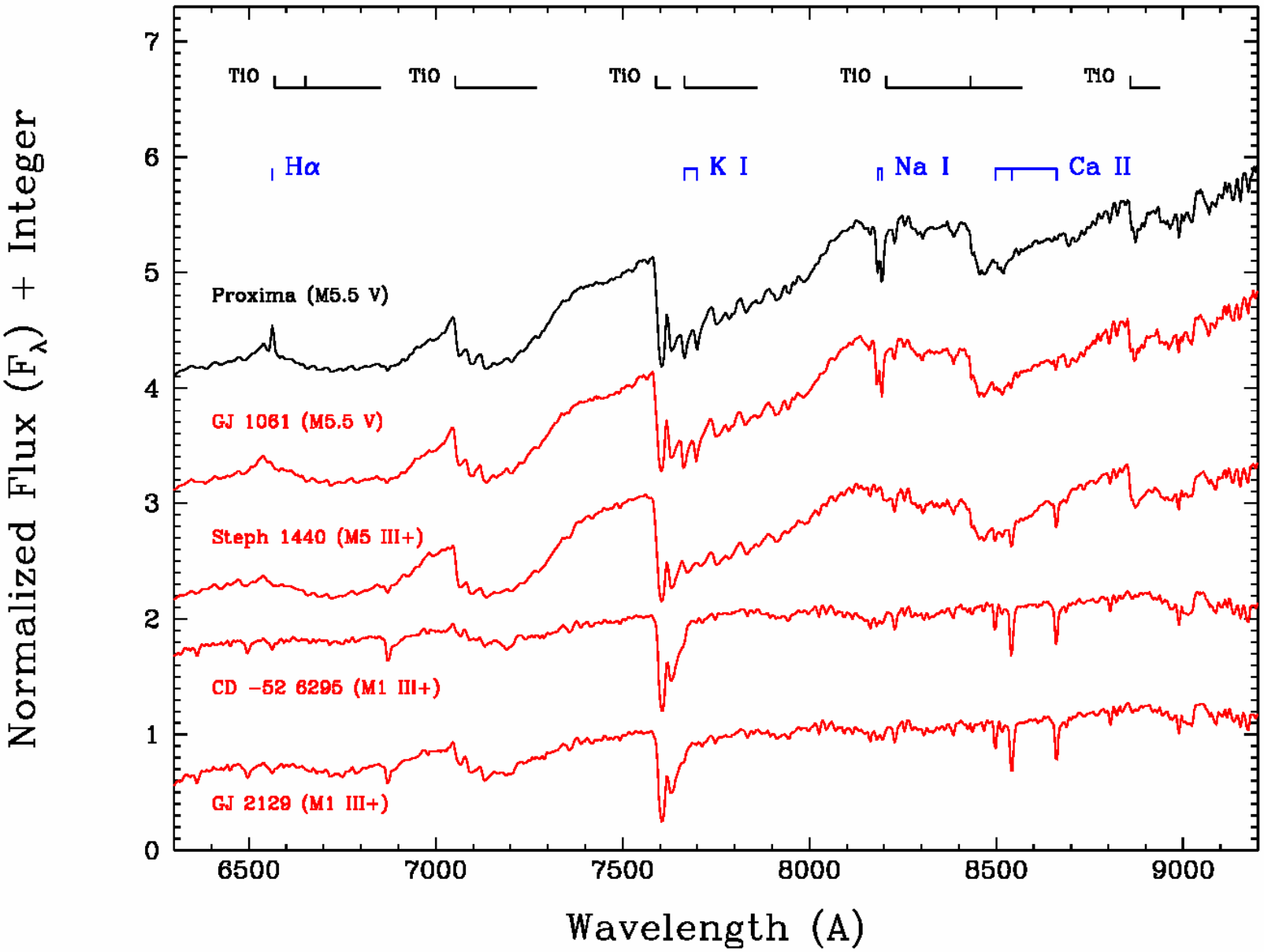

SKY DISTRIBUTION OF NLTT ENTRIES
DEC
80
60
40
20
0
−20
−40
−60
−80
24
22
20
18
16
14
12
10
8
6
4
2
0
RA

The RECONS Search

Step 1: Photometry



Step 2: Spectroscopy



Step 3: Distance

Photometric Parallax:

new relations	VRIJHK photometry of RECONS stars
distance estimate	3.79 ± 0.35 pc

Trigonometric Parallax:

plate measurements	63 images, 18 nights, 1976.677-1990.004
first parallax	π_{trig} = 0.2734″ ± 0.0052″
	3.66 ± 0.07 pc

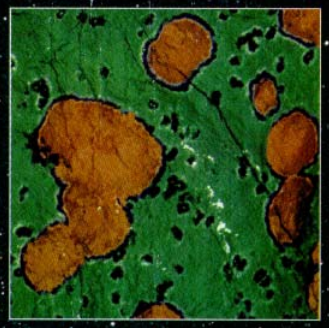
Henry et al. 1997 ***20th nearest star system***

Continuing Work:

CCD measurements	178 images, 25 nights, 1999.63-2004.97
new CTIOPI result	π_{trig} = 0.27069″ ± 0.00181″
	3.69 ± 0.02 pc

S&T Tests Celestron's New 9¼-inch Scopes • Lunar Science and the Cold War

SKY & TELESCOPE



Life on Mars? Find Out Why NASA Scientists Think This Rock Holds Ancient Martian Fossils.

OCTOBER 1996 $3.95 $5.25 CAN.

Do We Know Our Neighbors?

Astronomers struggle to find the nearest stars

The Southern Milky Way

CTIOPI

NOAO Surveys Program AUG 99 to JAN 03

SMARTS Consortium since FEB 03

1.5m IR survey
OPT spectroscopy

1.3m OPT/IR imaging

1.0m OPT imaging

0.9m OPT imaging
*** astrometry ***

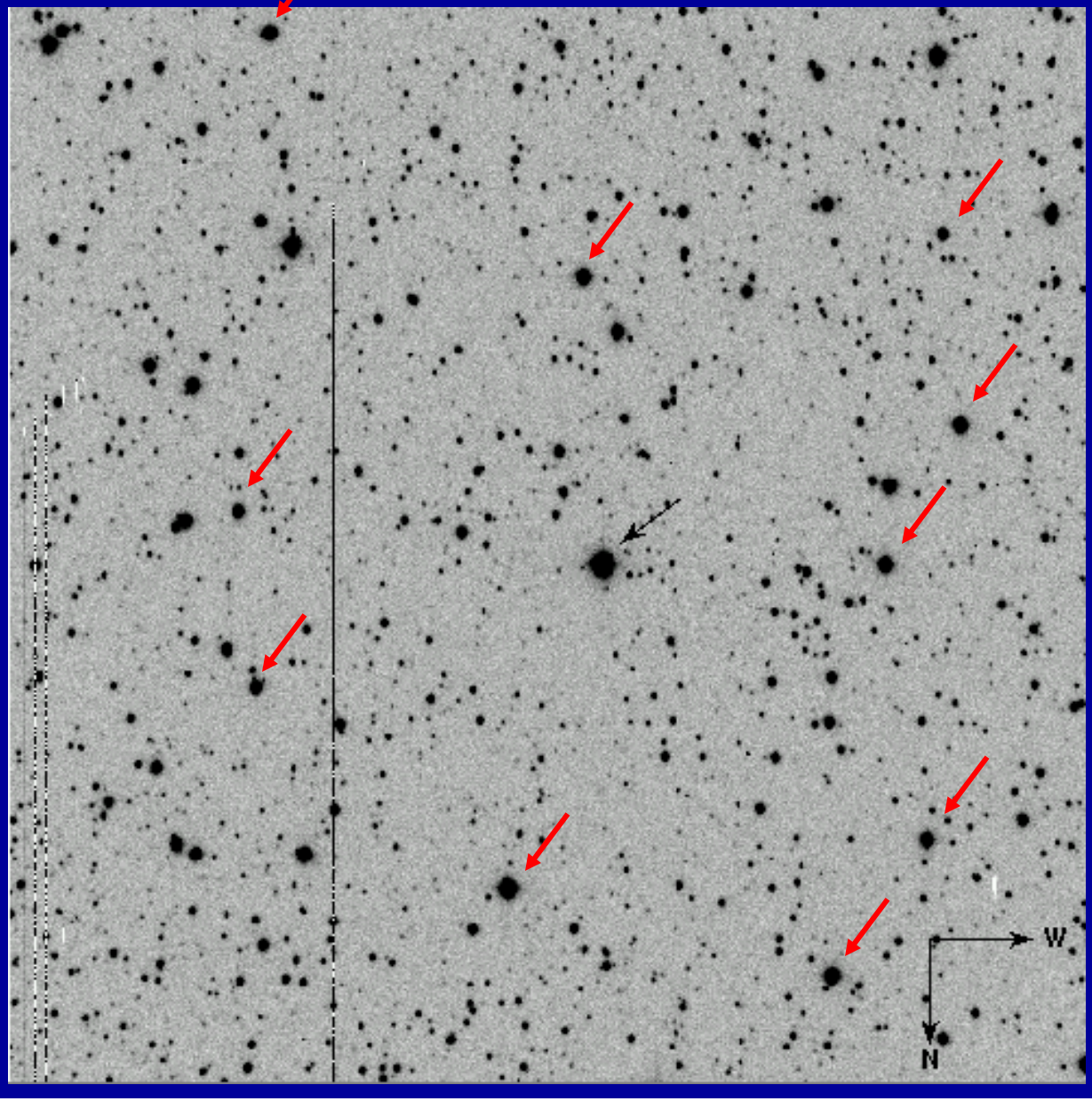
The CTIOPI Team

Georgia State University	Todd Henry	
	Thom Beaulieu	* here
	Misty Brown	
	Charlie Finch	
	Wei-Chun Jao	
	Hektor Monteiro	
	Deepak Raghavan	* here
	John Subasavage	* here
	Jennifer Winters	
University of Virginia	Phil Ianna	
	Jennifer Bartlett	
Universidad de Chile	Edgardo Costa	
	Rene Mendez	

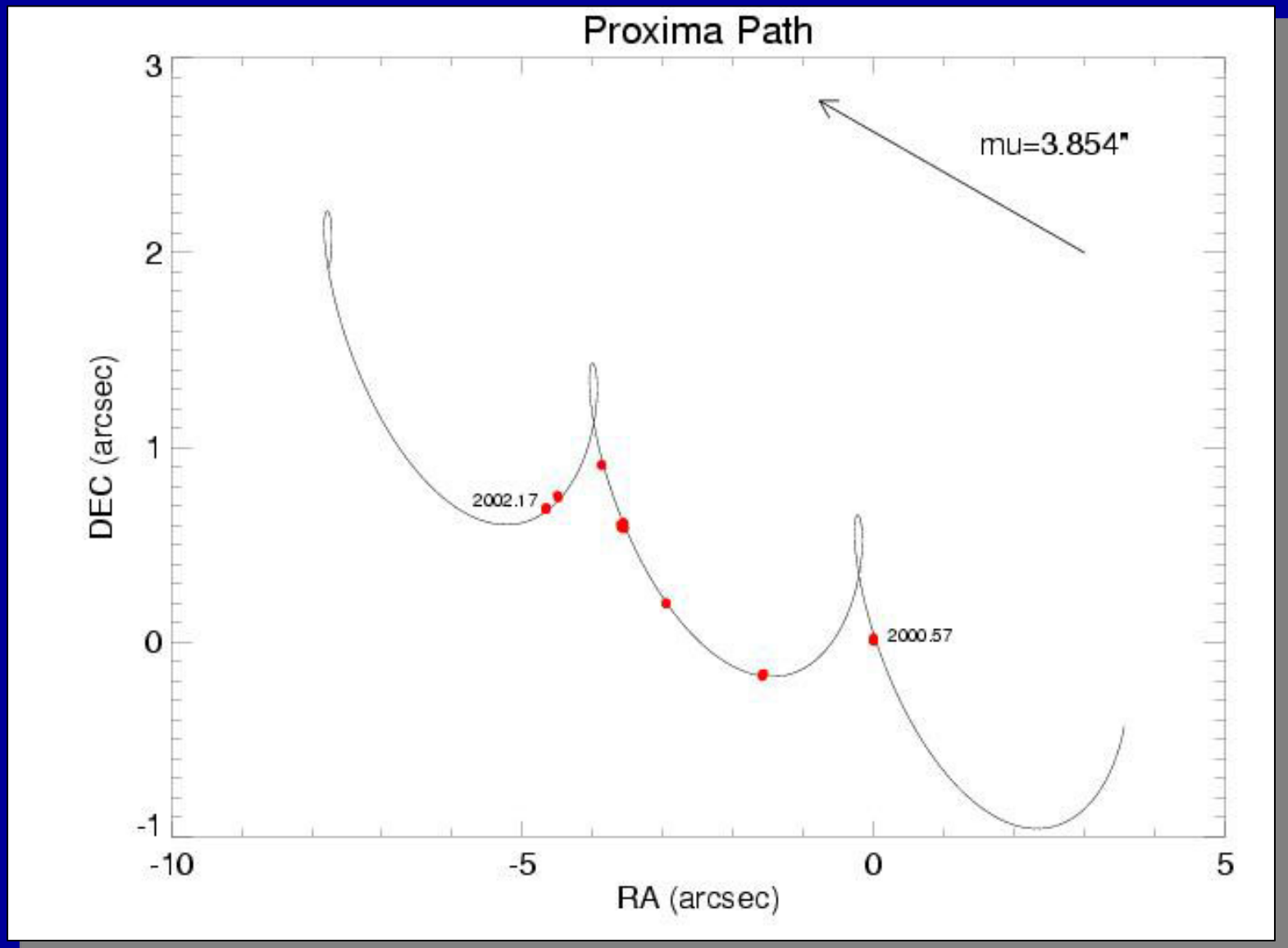
CTIOPI Astrometry

Telescope:	CTIO 0.9m
Field/Scale:	6.8′ field at 401 mas/pixel
Targets:	red, white, brown dwarfs
Brightness:	VRI from 9 to 19
Phase I:	167 targets
Phase II:	209 new targets (as of 7/05)
Coverage:	4 seasons, 3 years, 40 frames
Precision:	2.30 mas for 46 definitive π

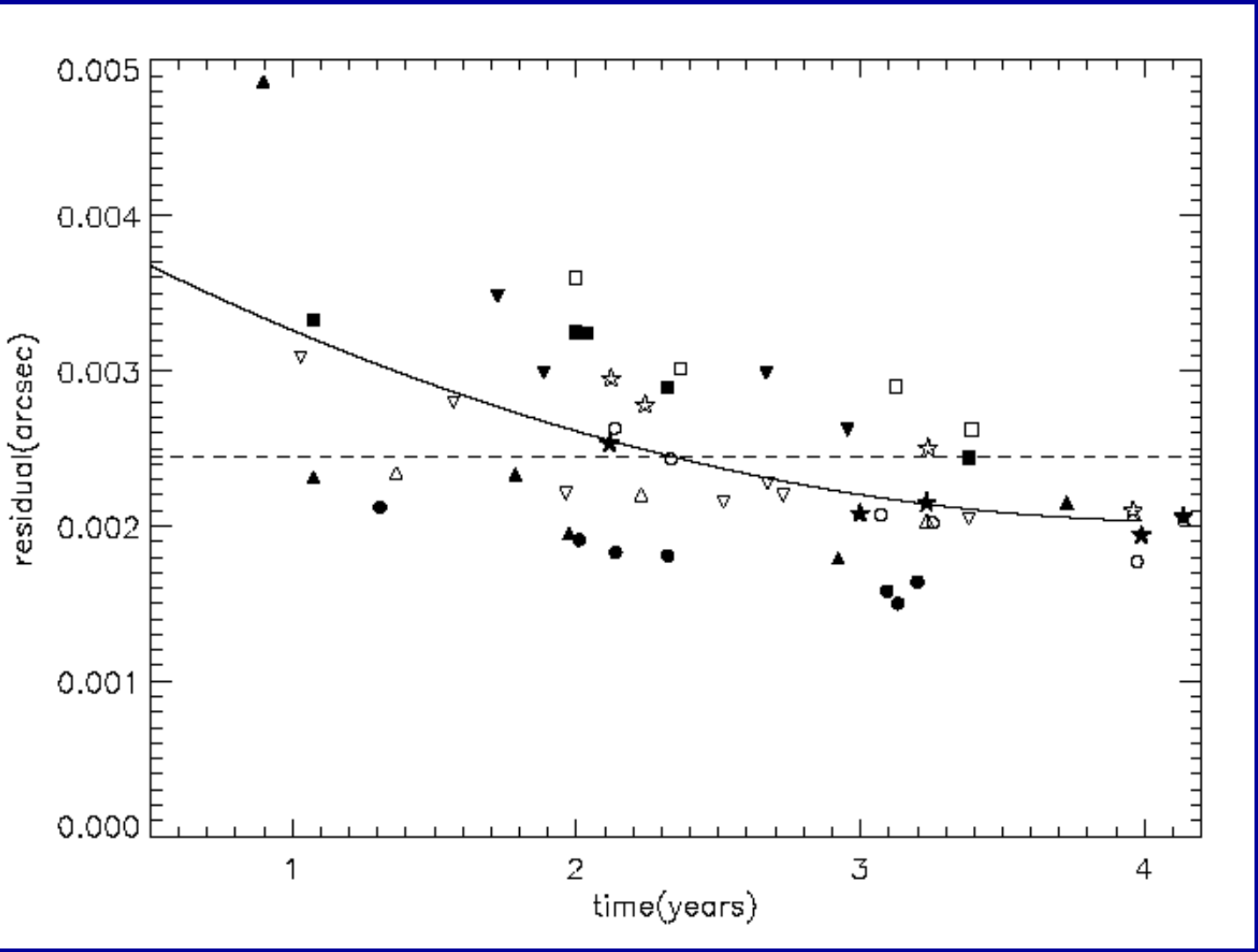
Proxima



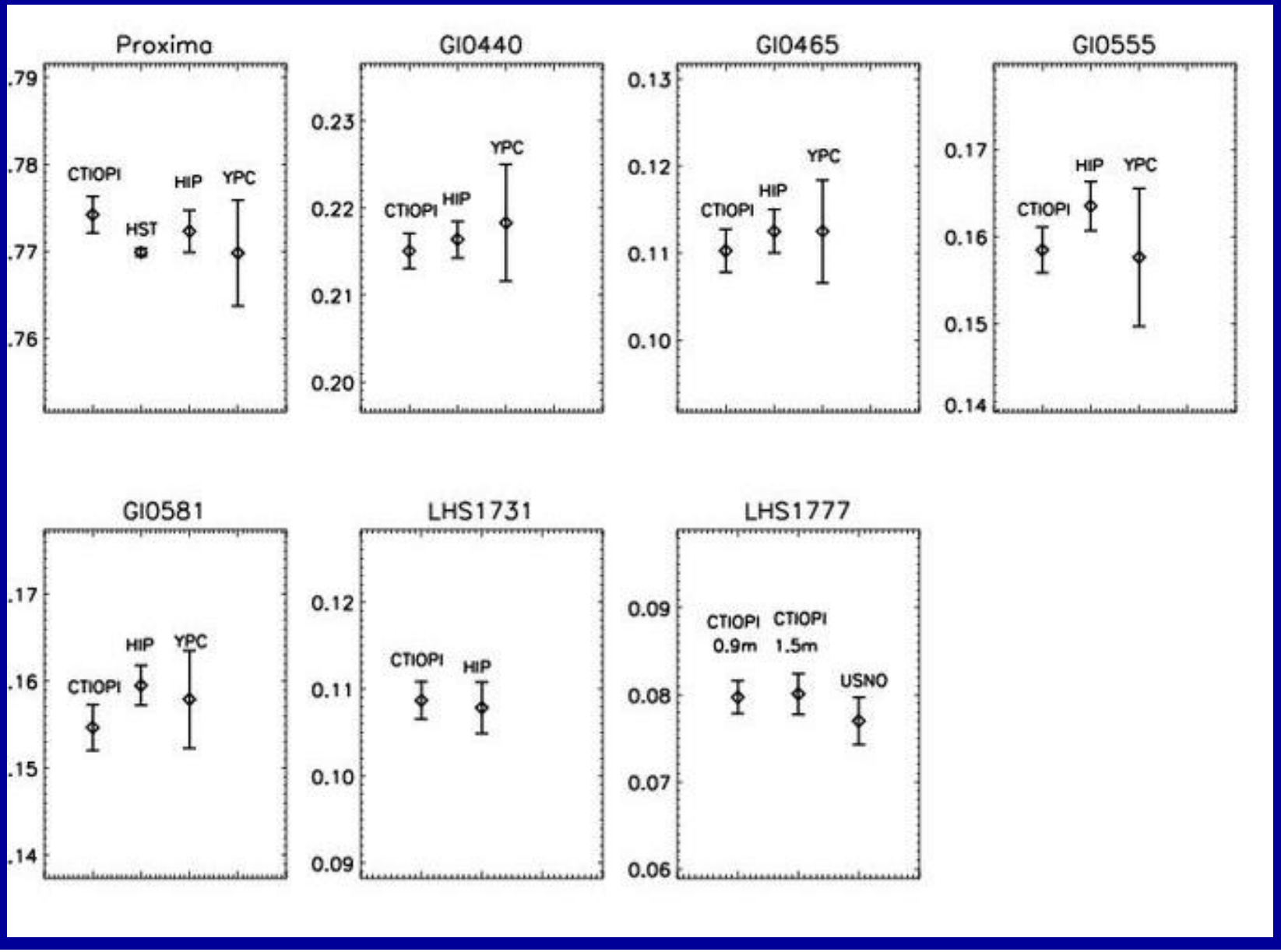
Stellar Path



Two Years for Answer

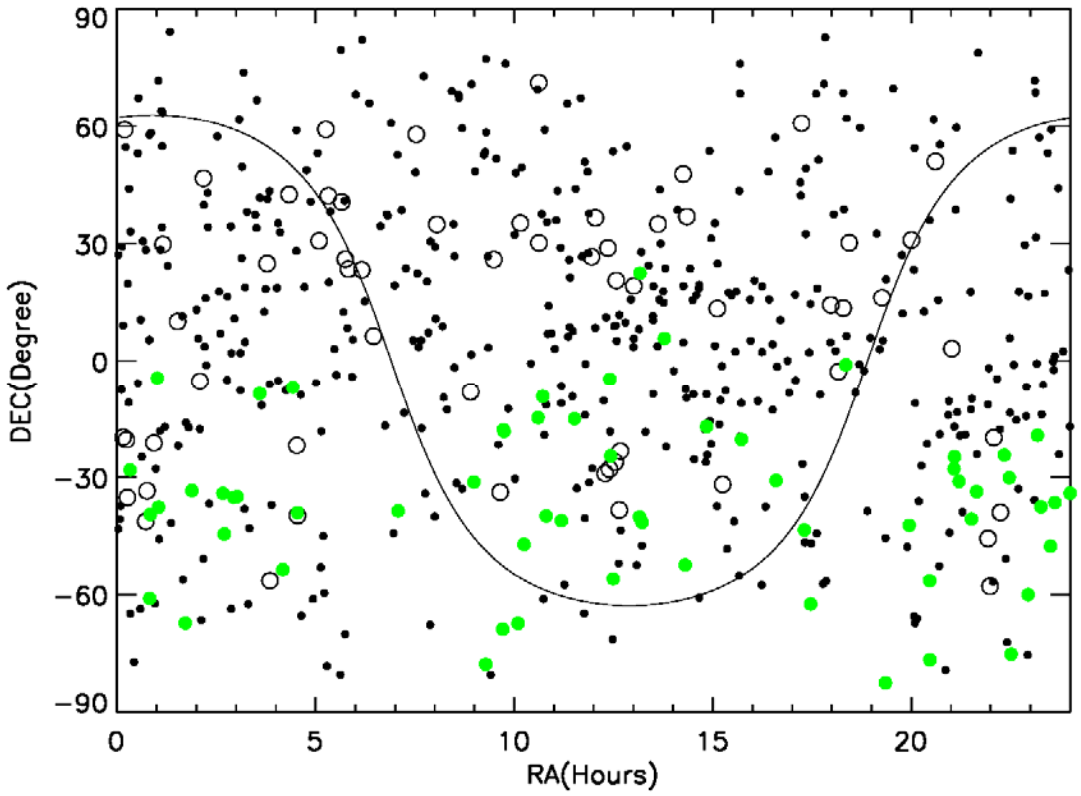


Standard Stars



I. MOTION Sample

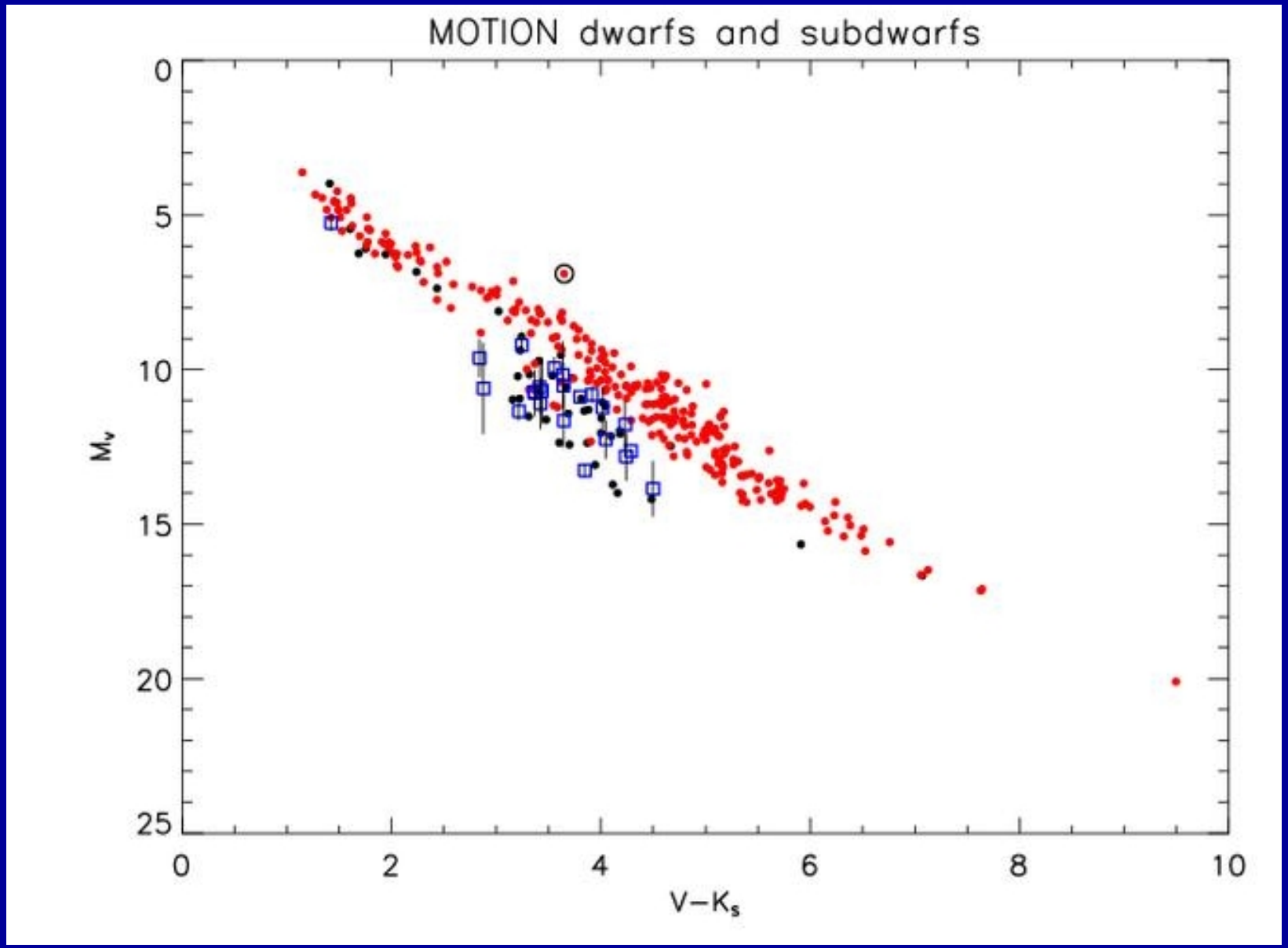
led by Wei-Chun Jao (GSU) ***CTIOPI targets = 103***



μ > 1.0 ″ / yr

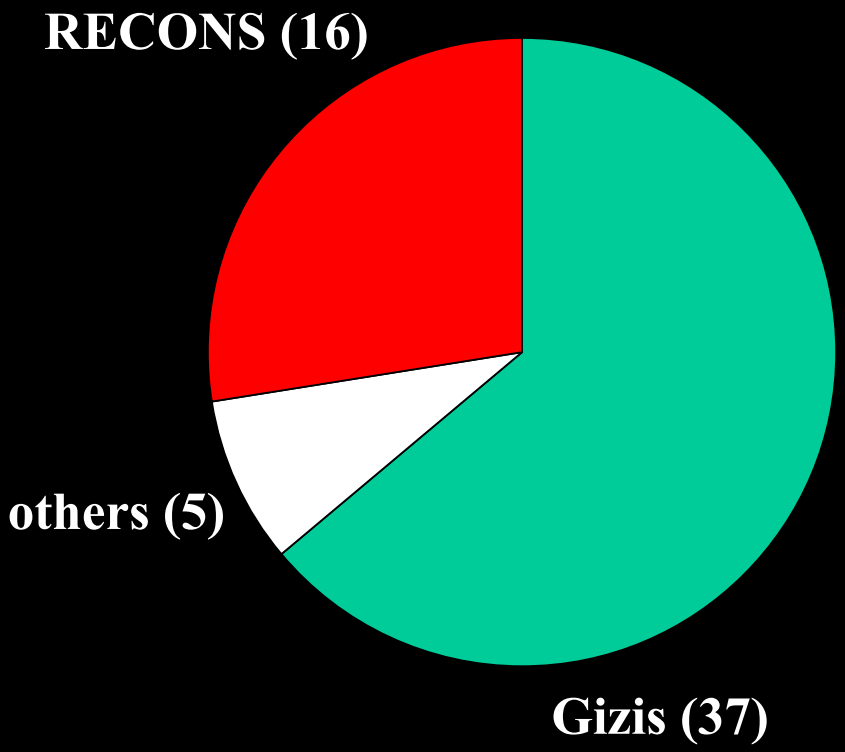
+90 to +30	143
+30 to +00	153
–00 to –30	129
–30 to –90	126
Total	551

New Subdwarfs

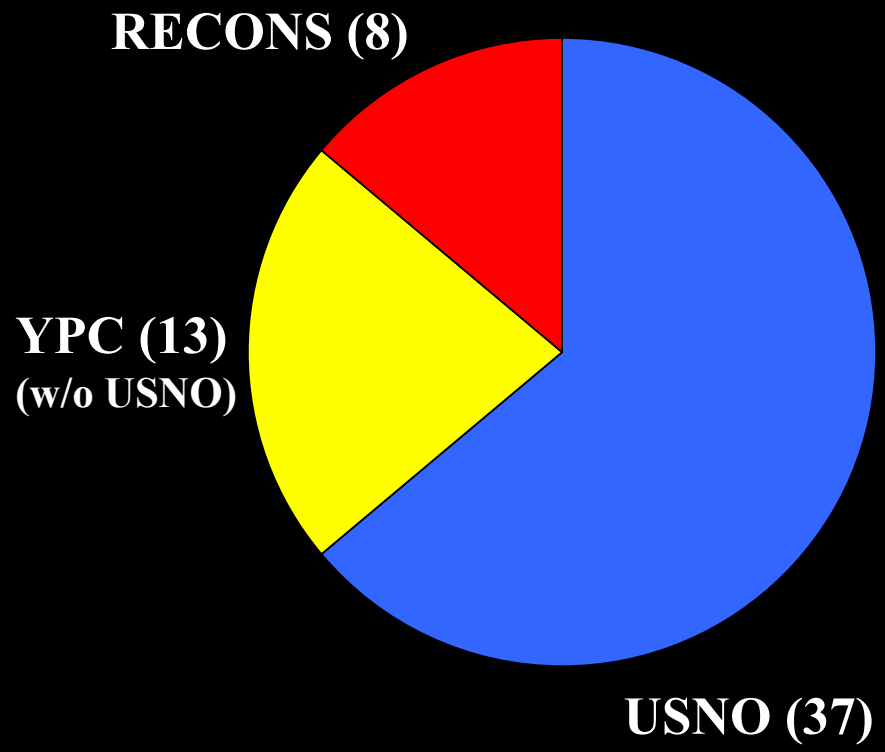


Red Subdwarfs within 60 pc

Spectral Types

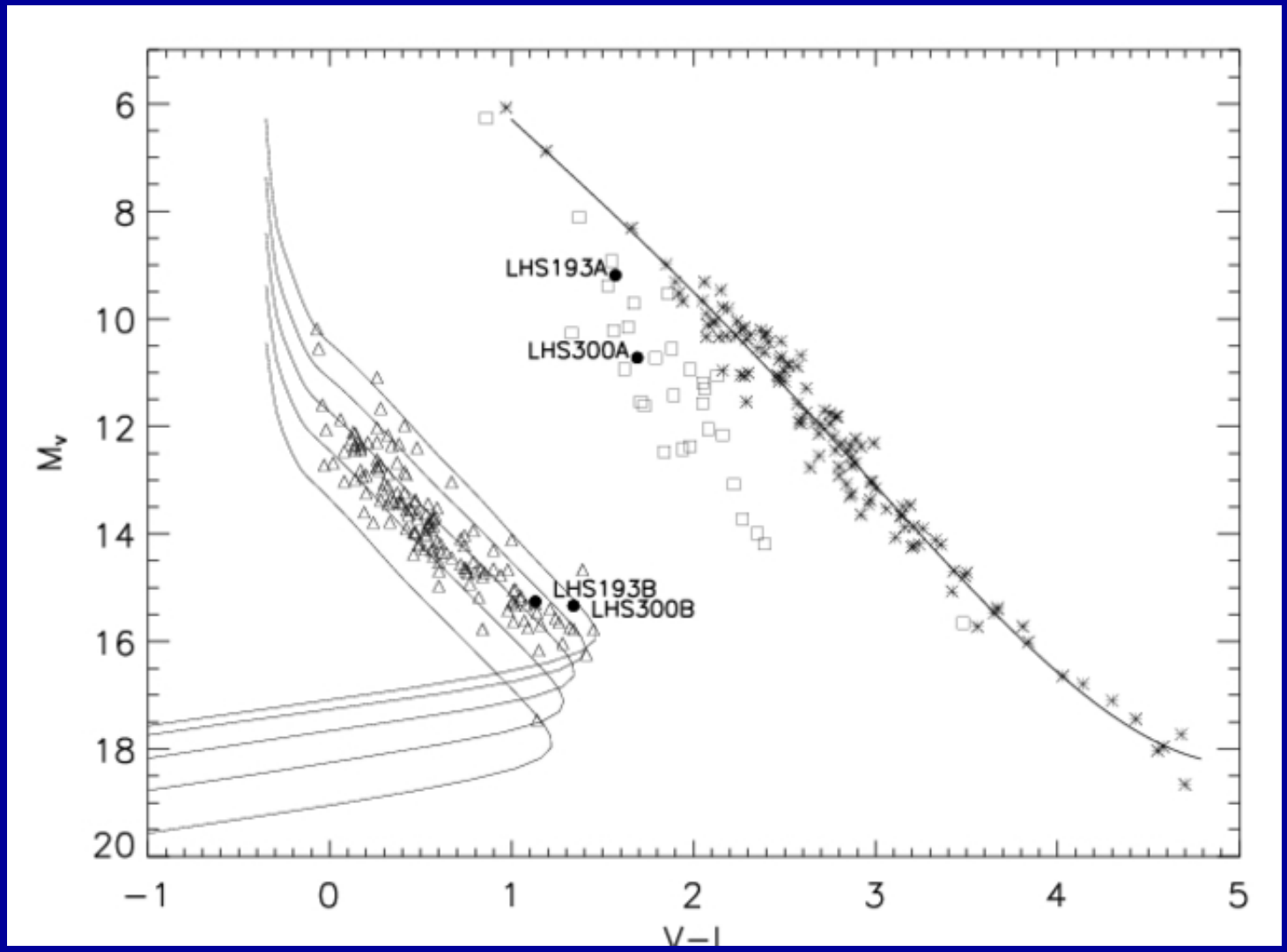


Parallaxes



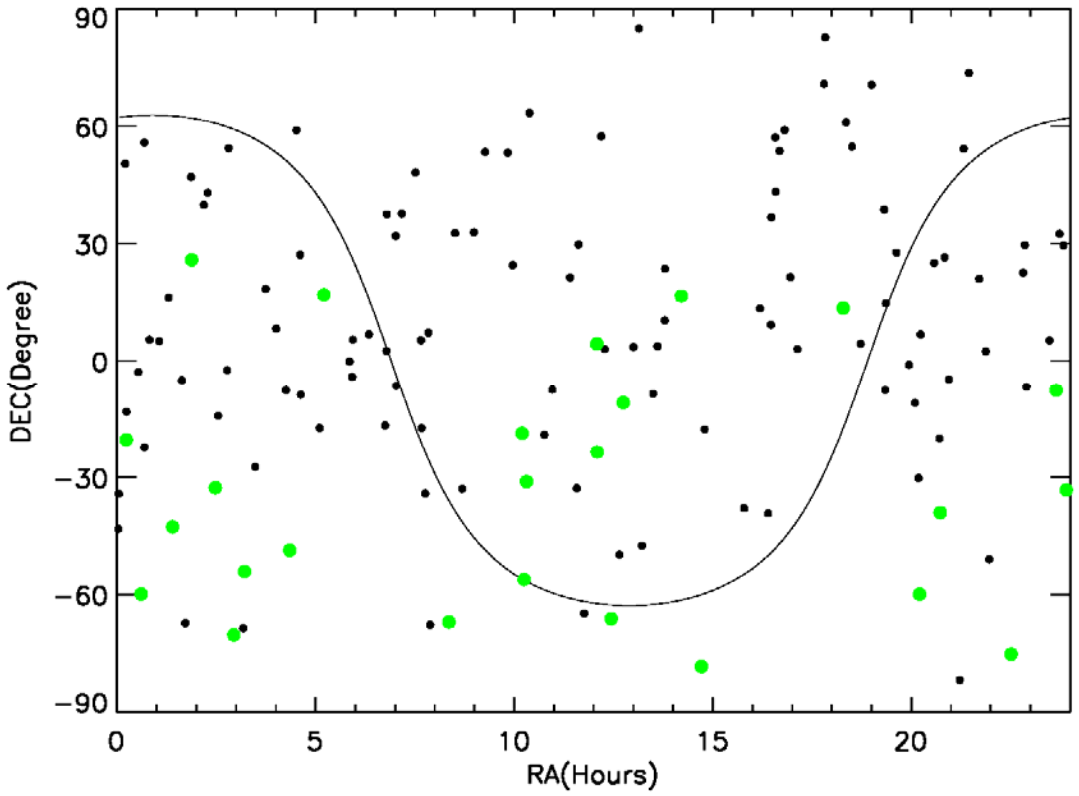
Weird White Dwarfs

ages of red subdwarfs and white dwarfs = 6-9 Gyr



II. White Dwarf Sample

led by John Subasavage (GSU) ***CTIOPI targets = 56***

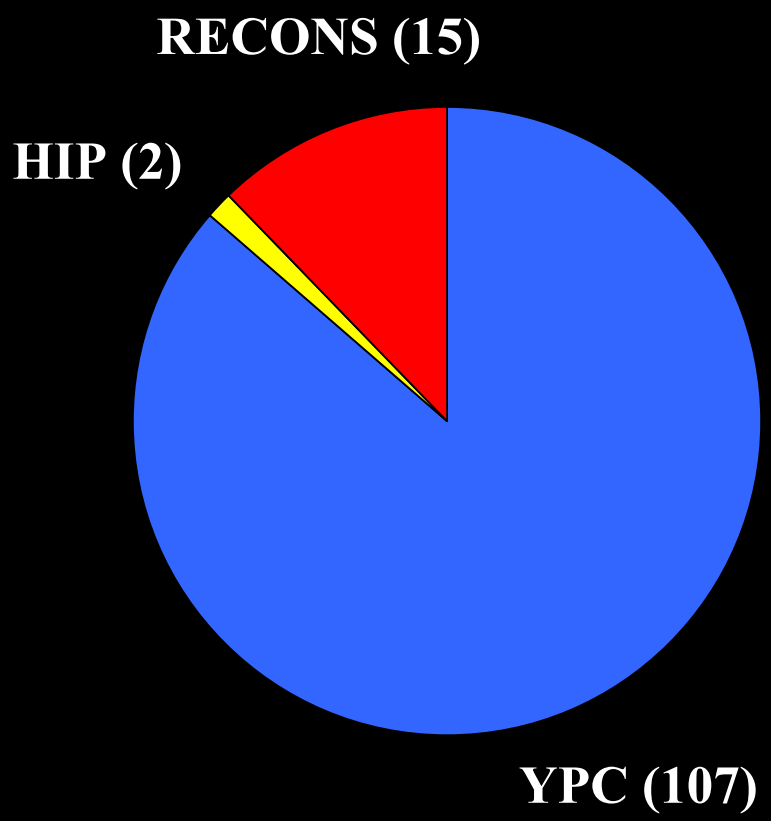


within 25 pc

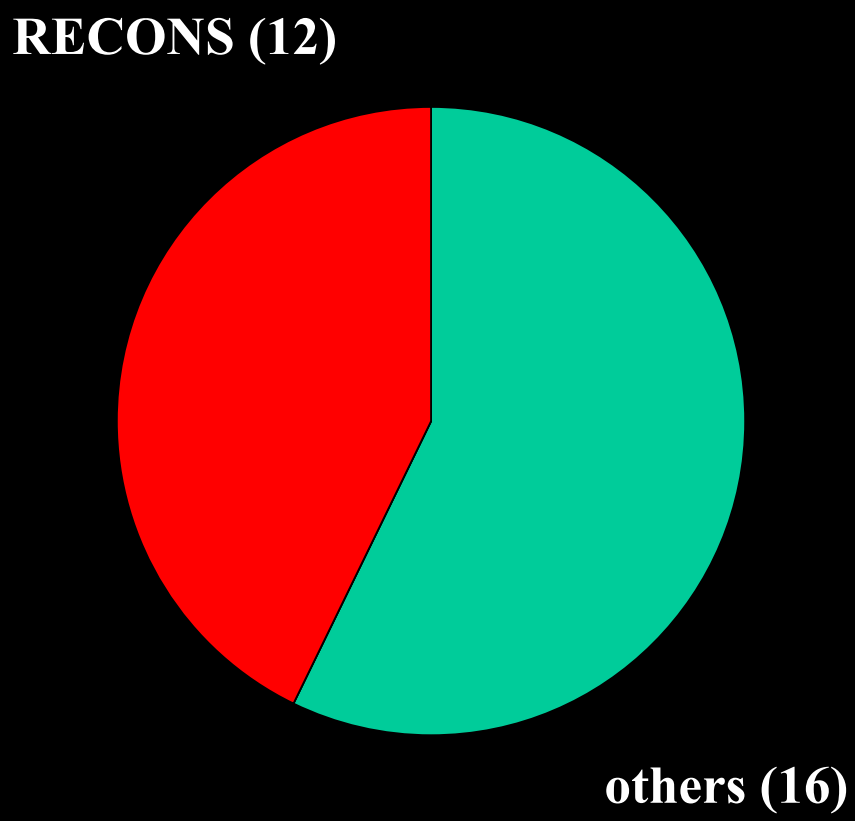
+90 to +30	32
+30 to +00	36
–00 to –30	26
–30 to –90	16
Total	110

White Dwarfs within 25 pc

Have Parallaxes

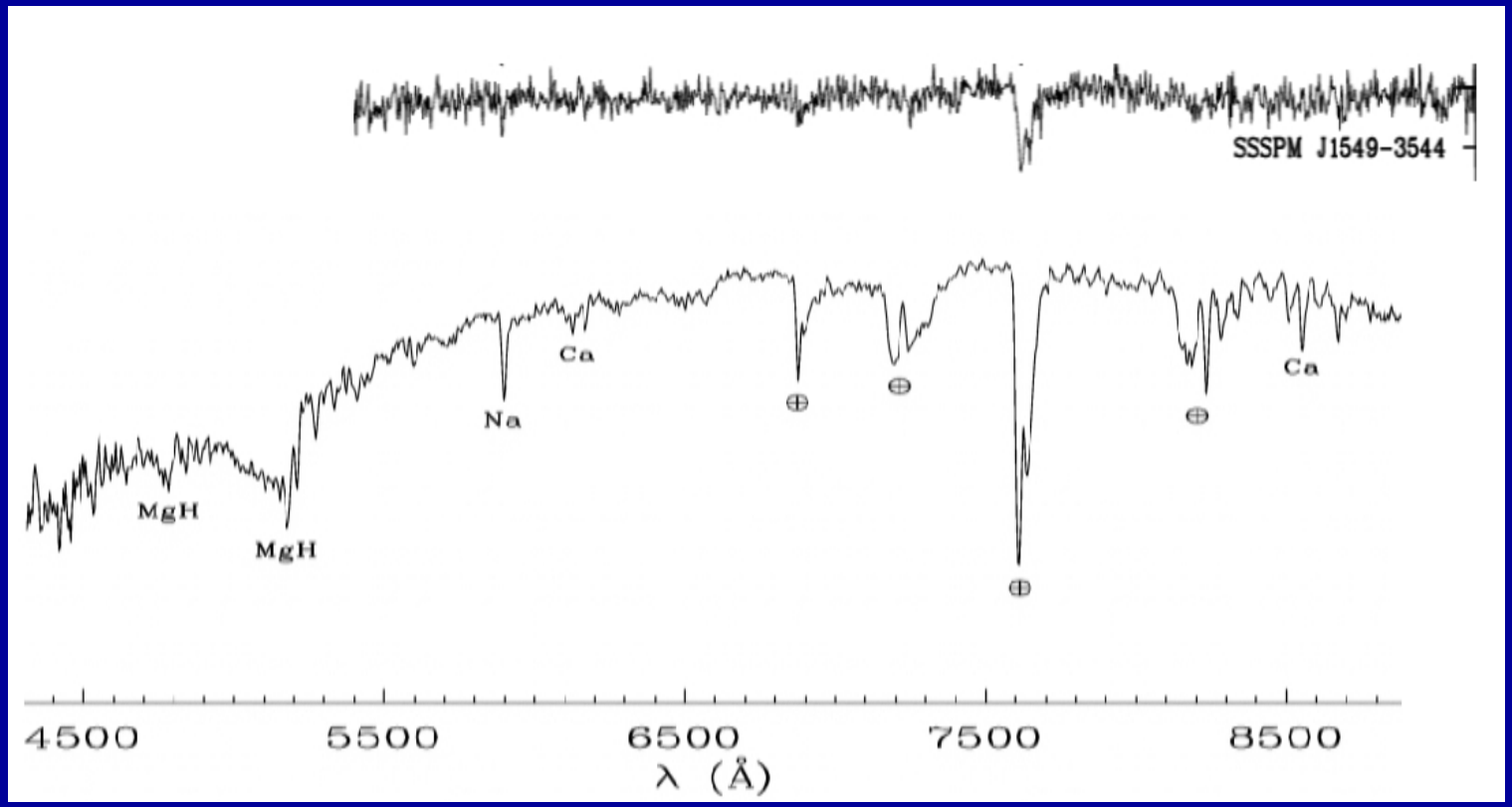


New Targets



WD Failure

reported to be at 4 pc (Nameless et al.)
our preliminary parallax ~ 0
high velocity, metal-poor star (Farihi et al.)



Nearest 5 New White Dwarfs

		RANK
1. Secret WD #1	9.2 pc	16th
2. Secret WD #2	9.6 pc	19th
3. Secret WD #3	9.8 pc	20th
4. Secret WD #4	11.3 pc	30th
5. Secret WD #5	14.4 pc	45th

III. SCR Search

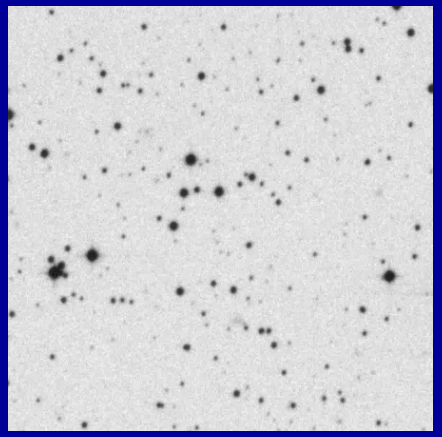
a SuperCOSMOS RECONS search
with Nigel Hambly (Royal Observatory, Edinburgh)
CTIOPI targets = 26

Bright Search

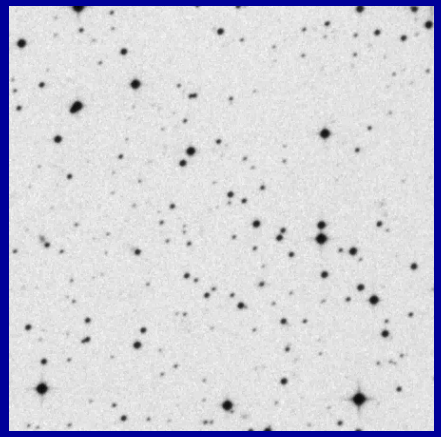
DEC –90 to 00
BRI plates used
$0.4 < \mu < 10.0$ ″/yr
$R < 16.5$

SCR Portraits

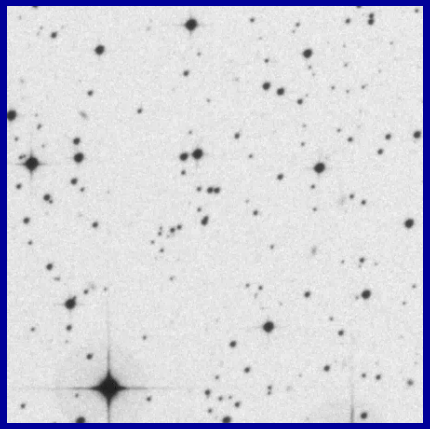
SCR 1138-7721
R–K ~ 5.6



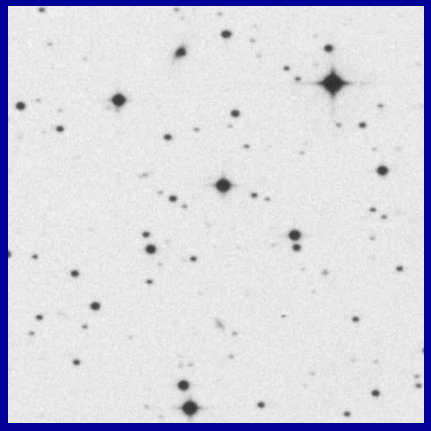
SCR 1845-6357
R–K ~ 7.7



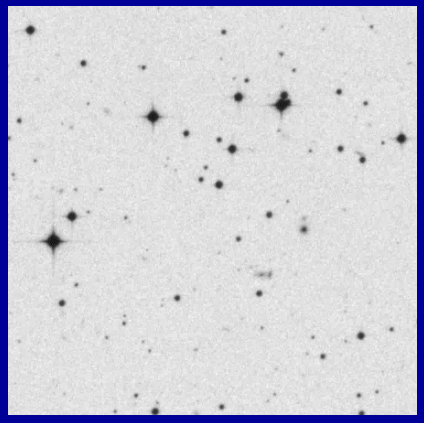
SCR 1848-6855
R–K ~ 5.3



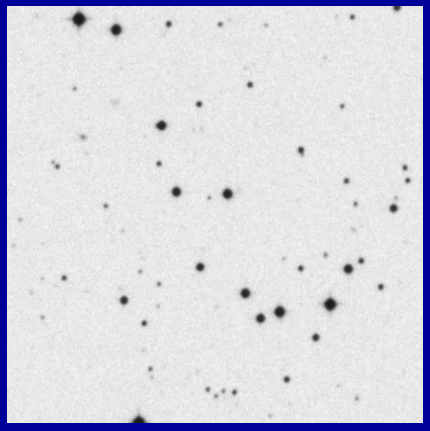
SCR 1920-8233
R ~ 11.5



SCR 2012-5956
R–K ~ 0.6

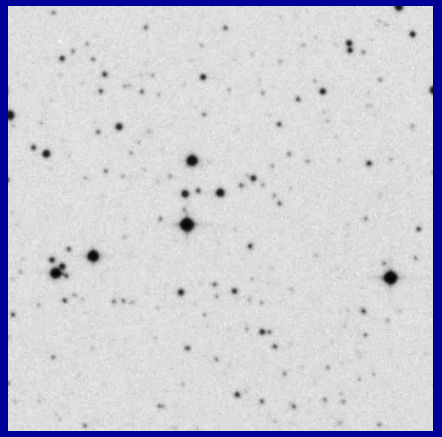


SCR 2115-7541
R–K ~ 2.0

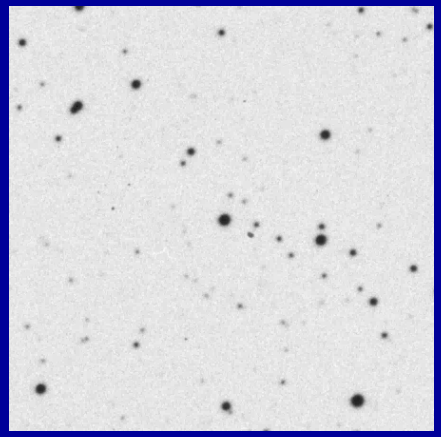


SCR Portraits

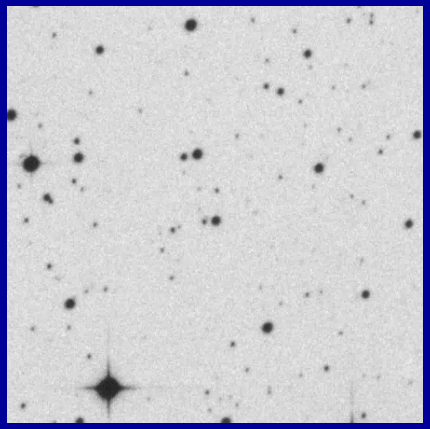
SCR 1138-7721
2.14″/yr



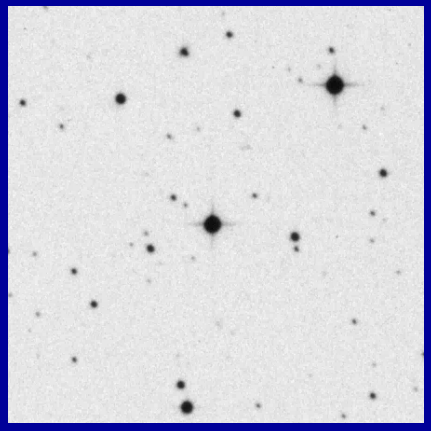
SCR 1845-6357
2.56″/yr



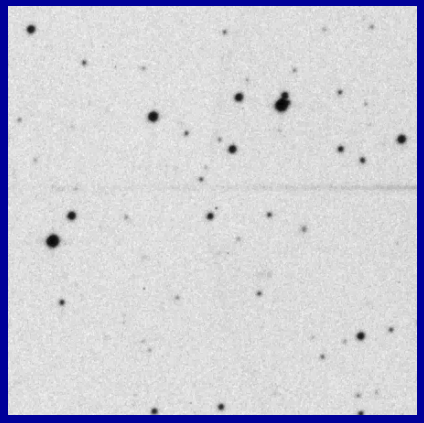
SCR 1848-6855
1.29″/yr



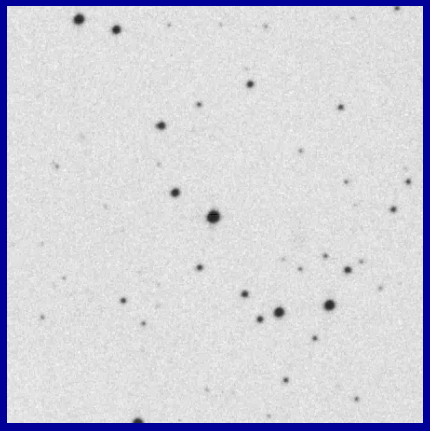
SCR 1920-8233
1.28″/yr



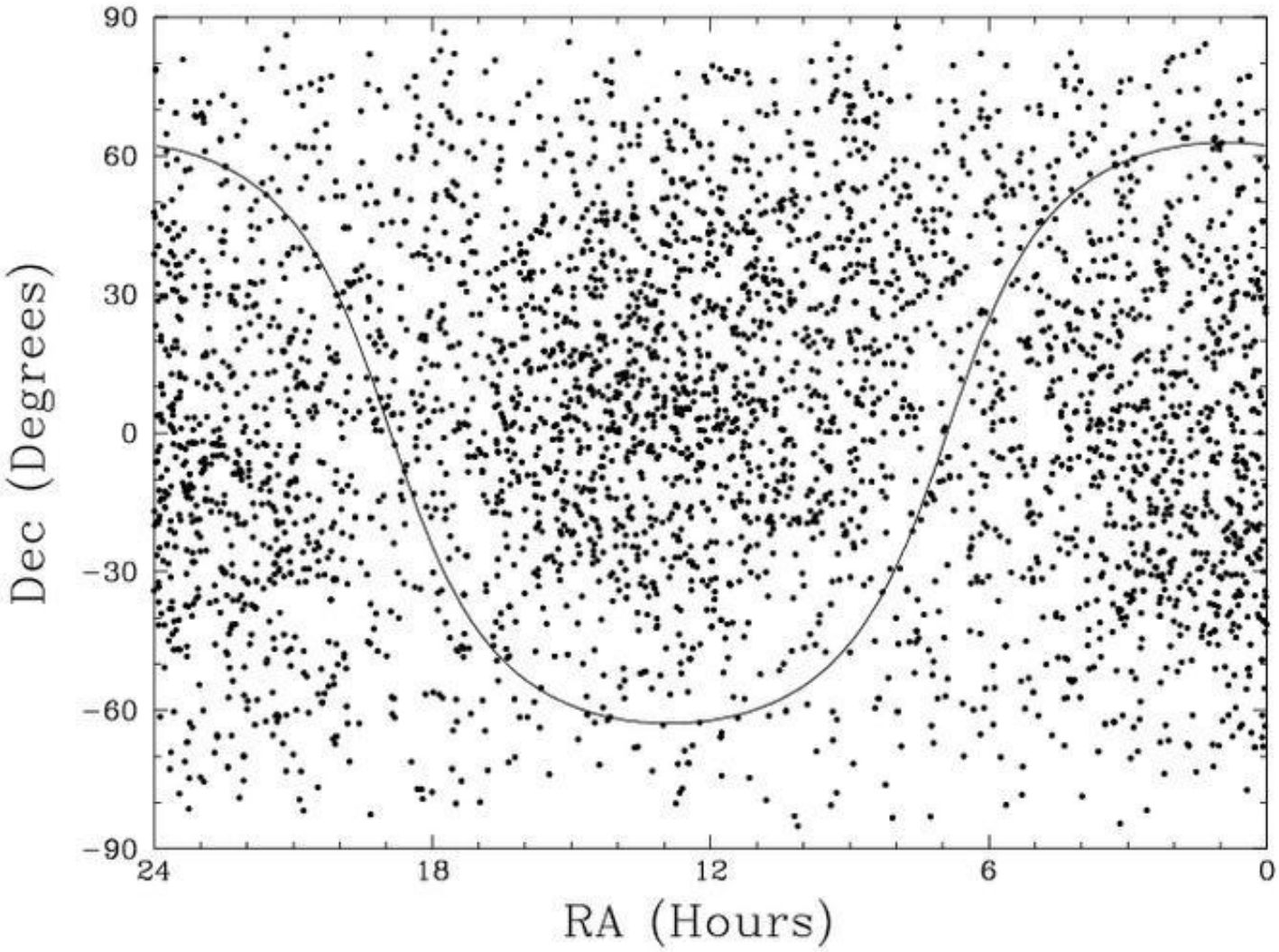
SCR 2012-5956
1.44″/yr



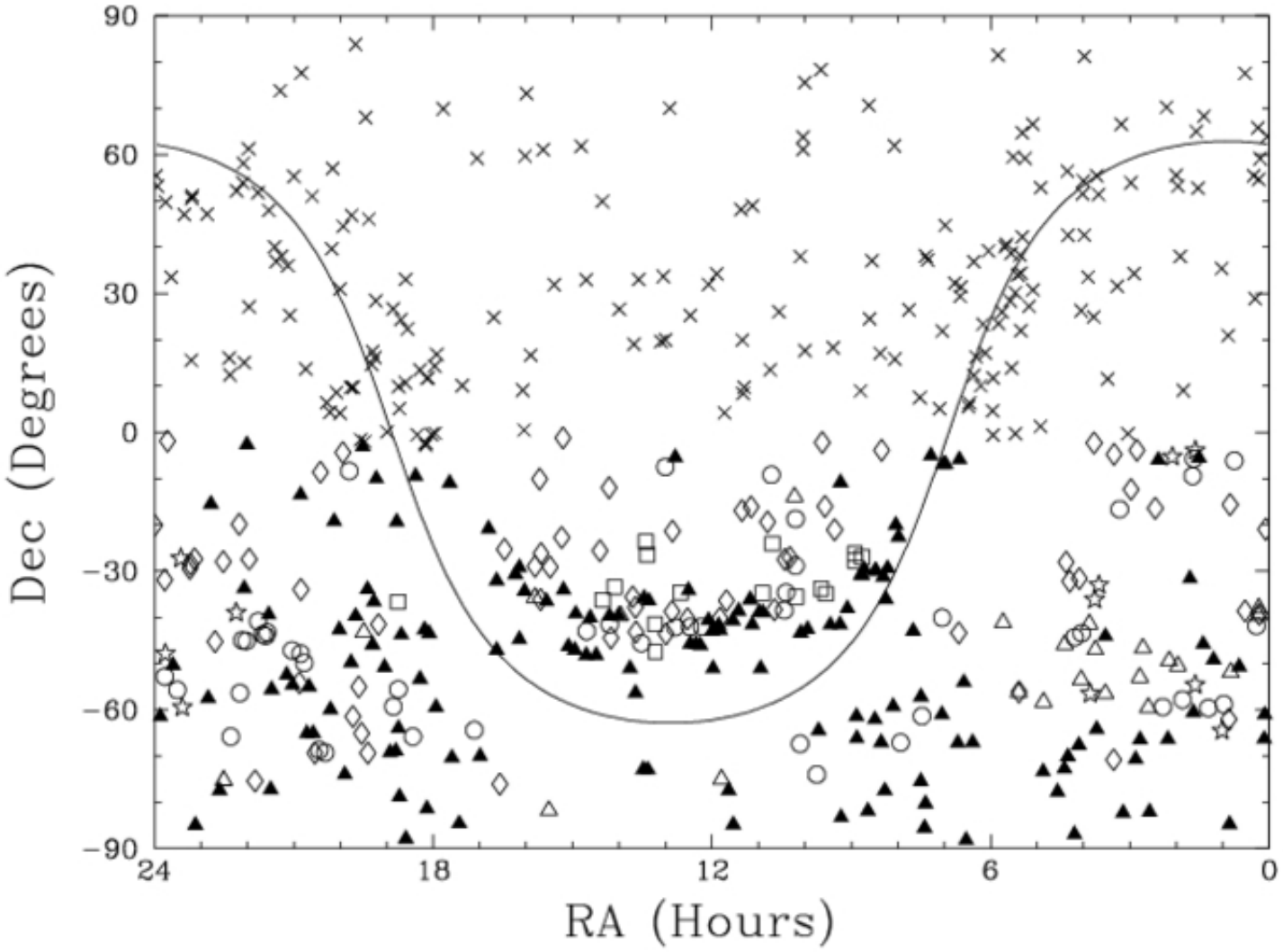
SCR 2115-7541
1.08″/yr



Known LHS Stars



New LHS Stars



SCR Search Results

Hambly et al. 2004

5 new stars $\mu > 1.0$ ″/yr
new distance relations: plt BRI+JHK good to 26%
2 SCR + 3 LHS candidates within 10 pc

Henry et al. 2004

4 new stars M6.0V or later
uniform phot + spec for M6.0V and later
new distance relations: ccd VRI+JHK good to 15%
1 SCR binary + 1 LHS candidate within 10 pc

Subasavage et al. 2005a+b

299 total systems $\mu > 0.4$ ″/yr
148 new LHS members
5 systems within 10 pc
38 additional systems 10-25 pc

most in slowest proper motion bin!

CTIOPI Perturbations

ASPENS

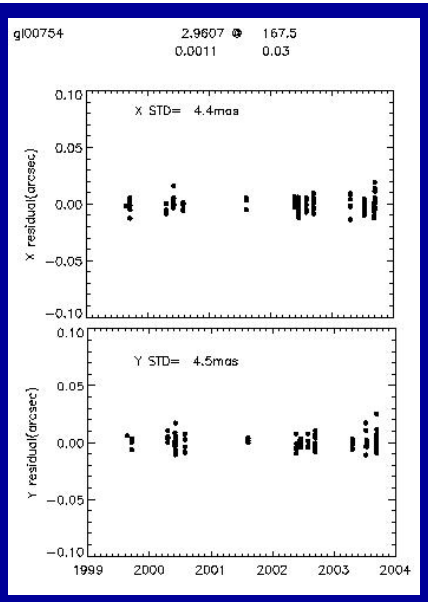
Dave Koerner

Northern Arizona University

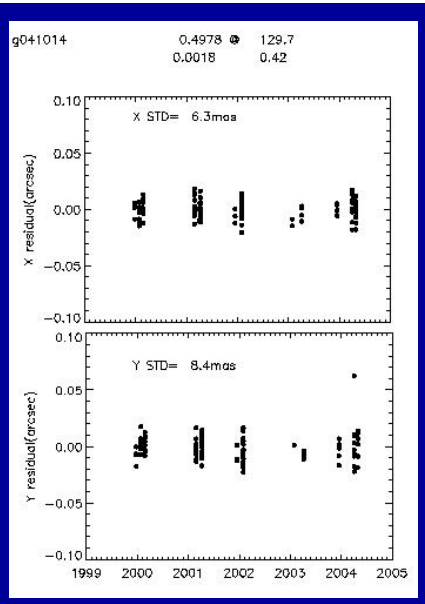
aggressive perturbation search

detection limit ~ 20 Jup for nearby red dwarfs

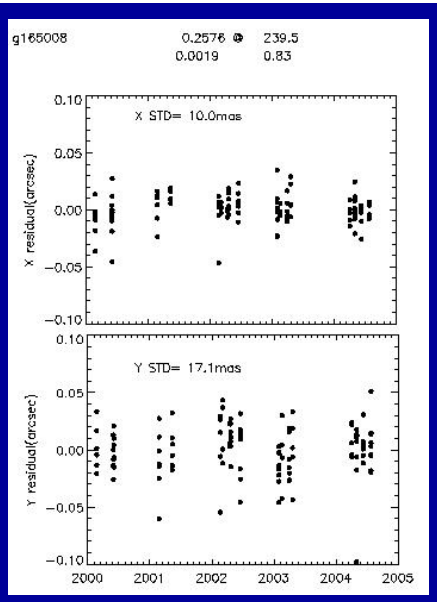
goal is 2 yrs data on 100 nearby stars by February 1, 2006



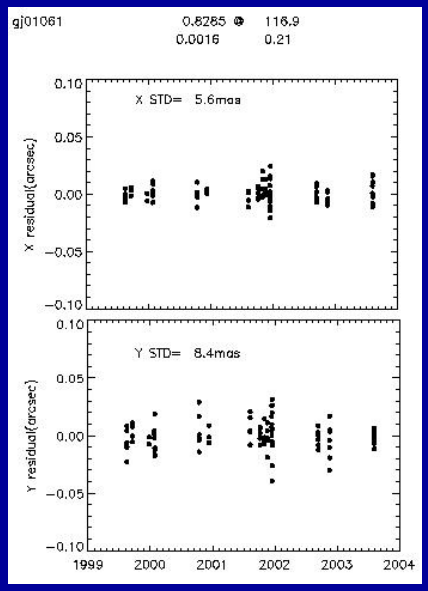
4.5 mas single?



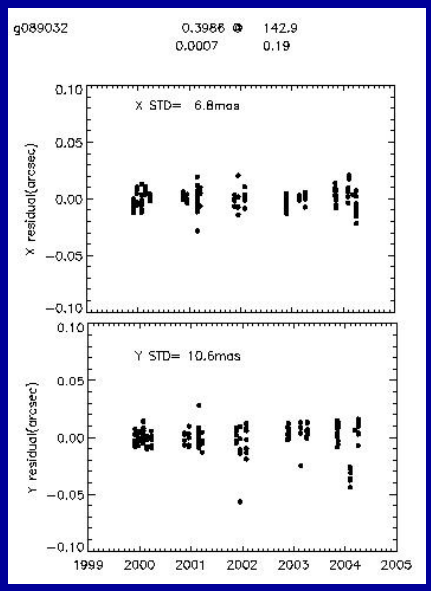
8.4 mas 0.62″ 4.2 AU



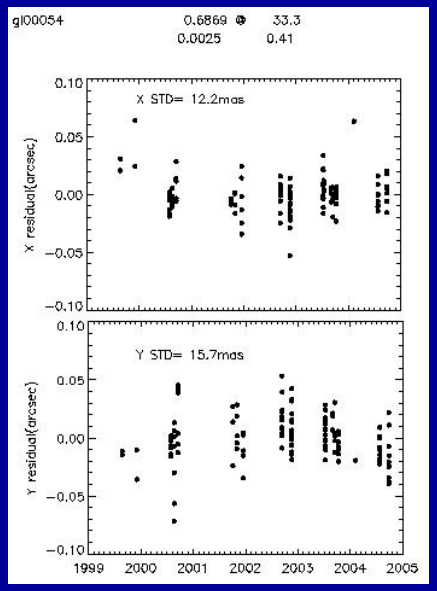
17.1 mas 0.17″ 3.2 AU



8.4 mas single?

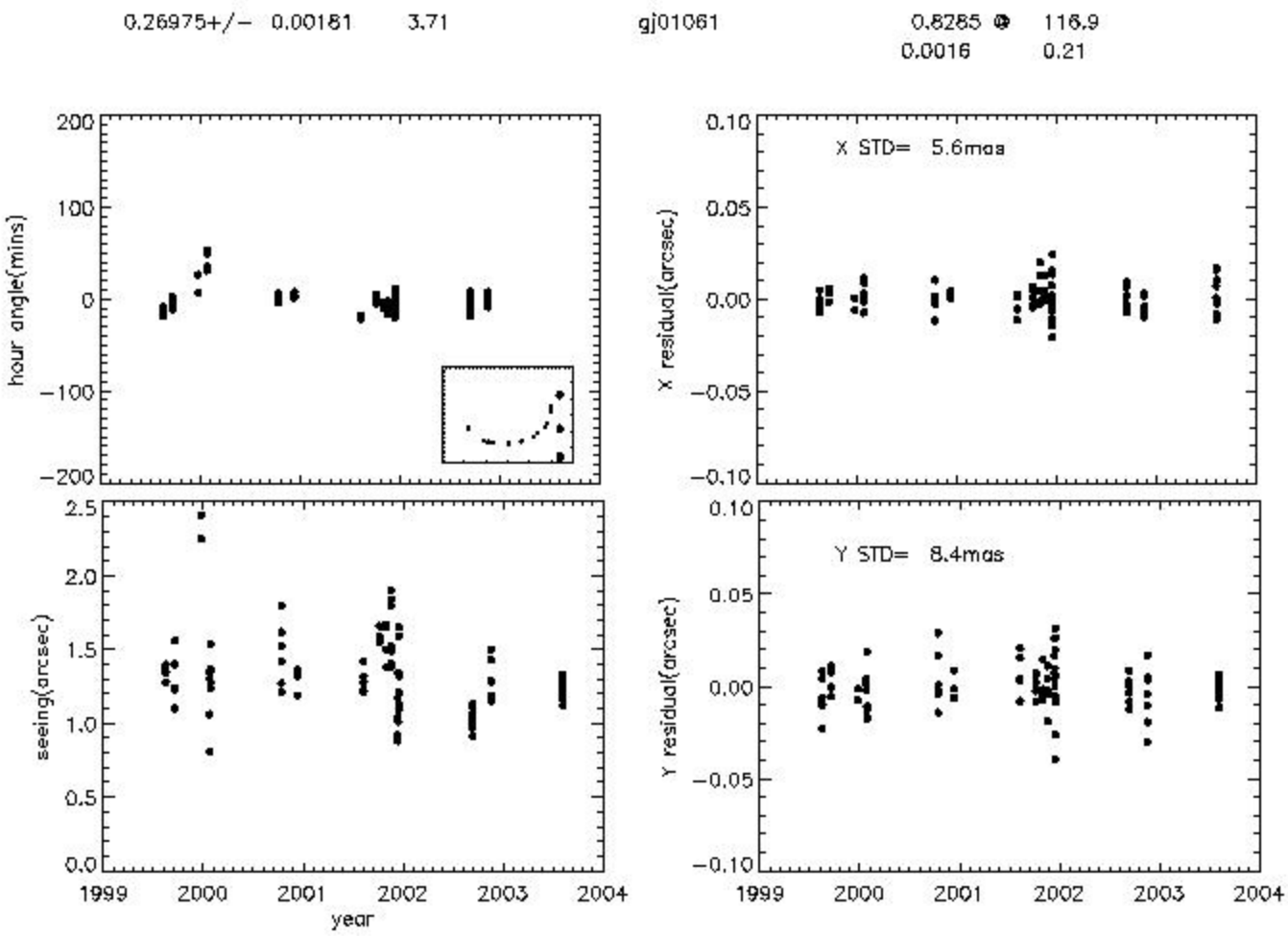


10.6 mas 0.73″ 6.3 AU

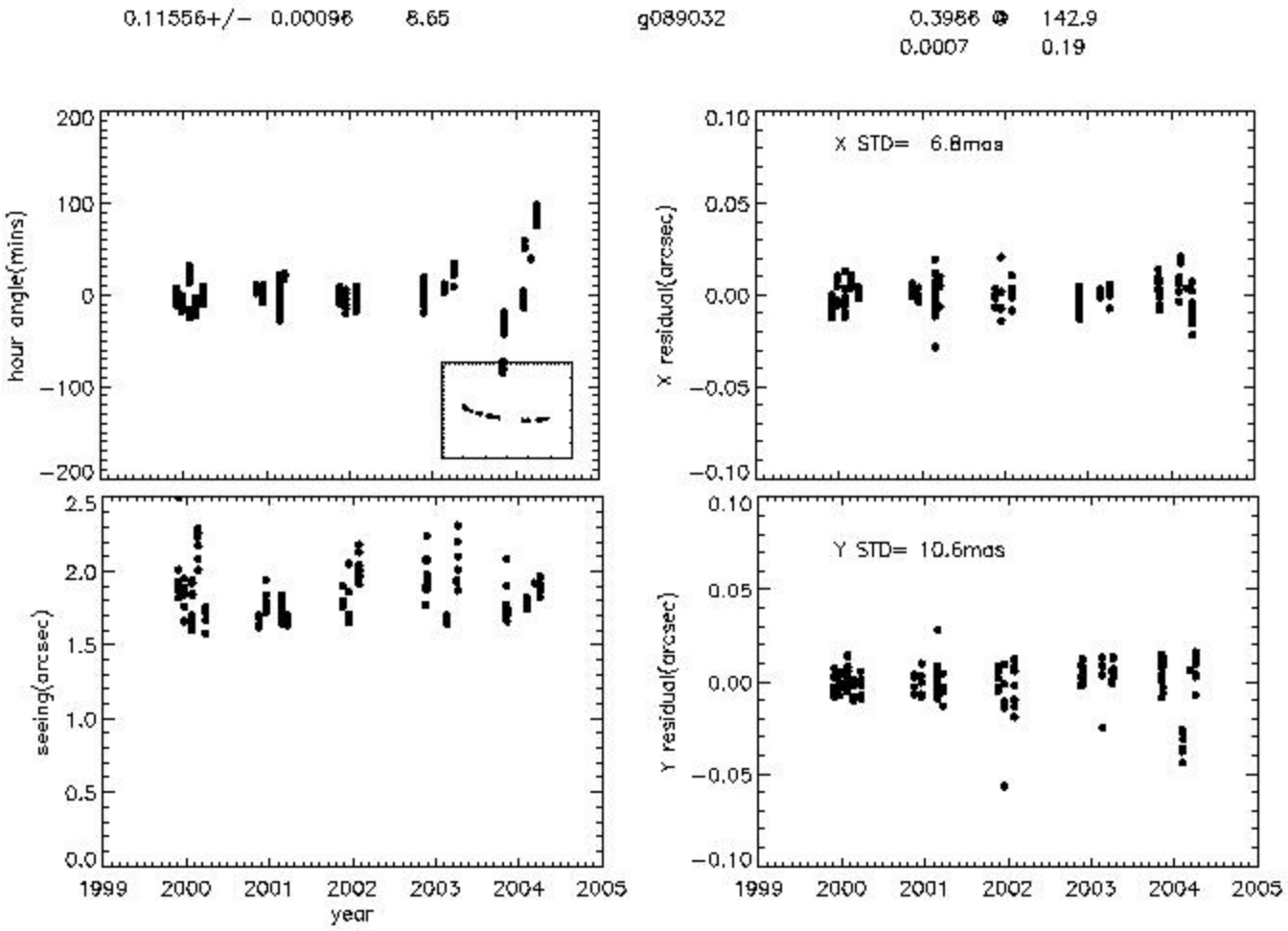


15.7 mas 0.12″ 1.0 AU

GJ 1061

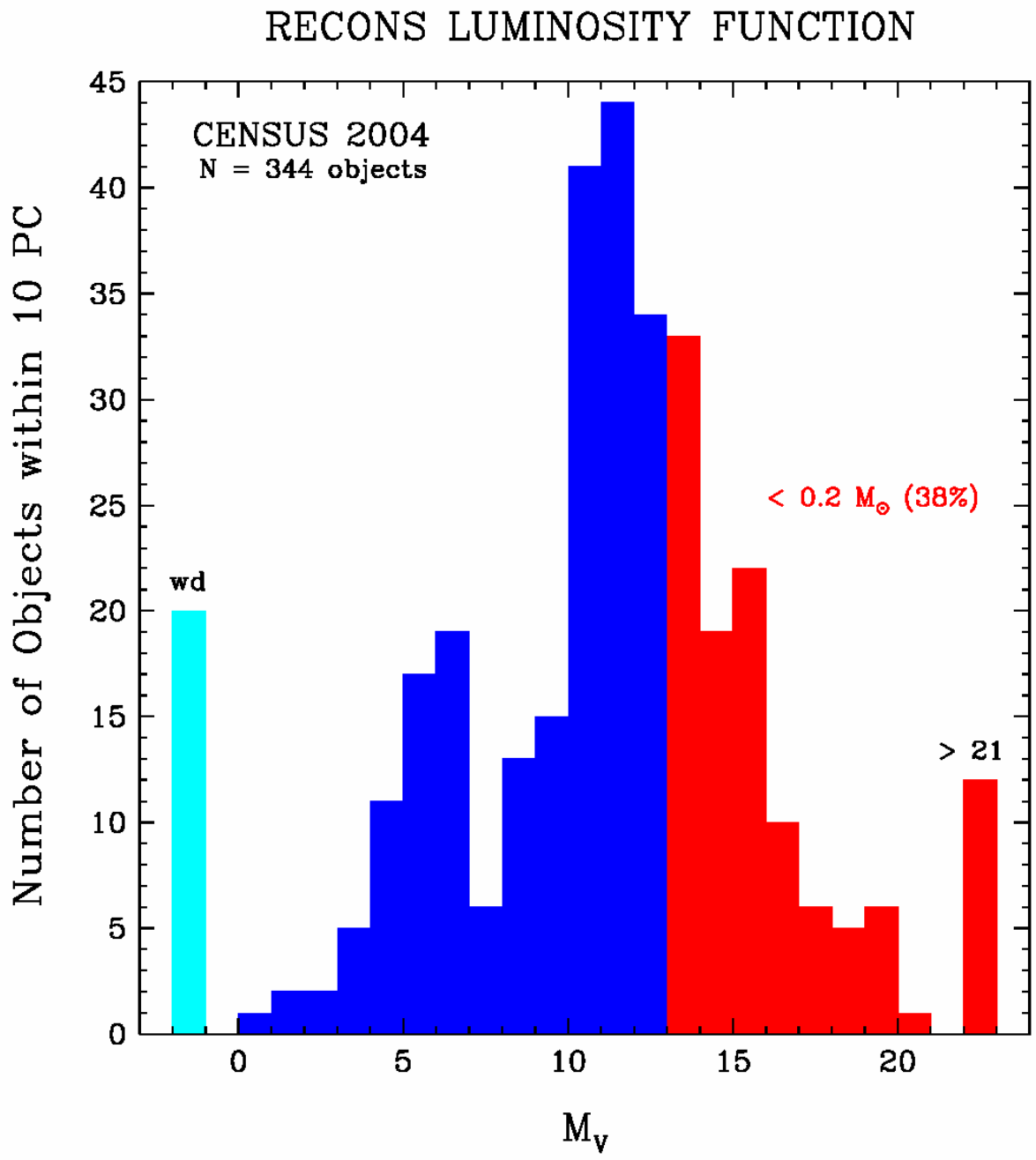

0.26975+/- 0.00181 3.71
gj01061
0.8285 @ 116.9
0.0016 0.21
hour angle(mins)
seeing(arcsec)
year
X STD= 5.6mas
Y STD= 8.4mas
X residual(arcsec)
Y residual(arcsec)

G 089-032 AB

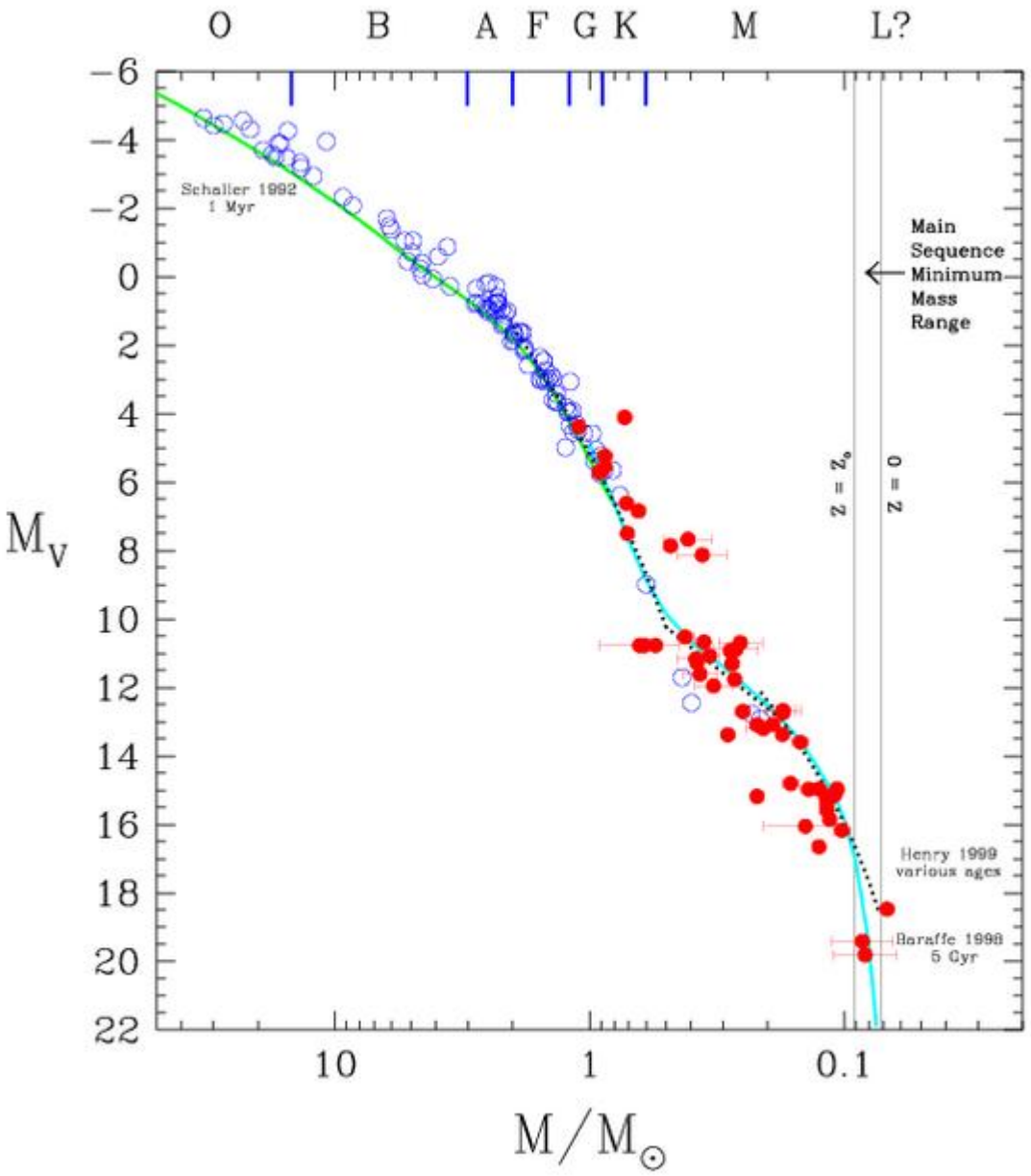

0.11556+/- 0.00096 8.65 g089032 0.3986 @ 142.9
0.0007 0.19
hour angle(mins)
seeing(arcsec)
year
X STD= 6.8mas
Y STD= 10.6mas
X residual(arcsec)
Y residual(arcsec)

$$\mathrm{LF} + \mathrm{MLR} = \mathrm{MF}$$

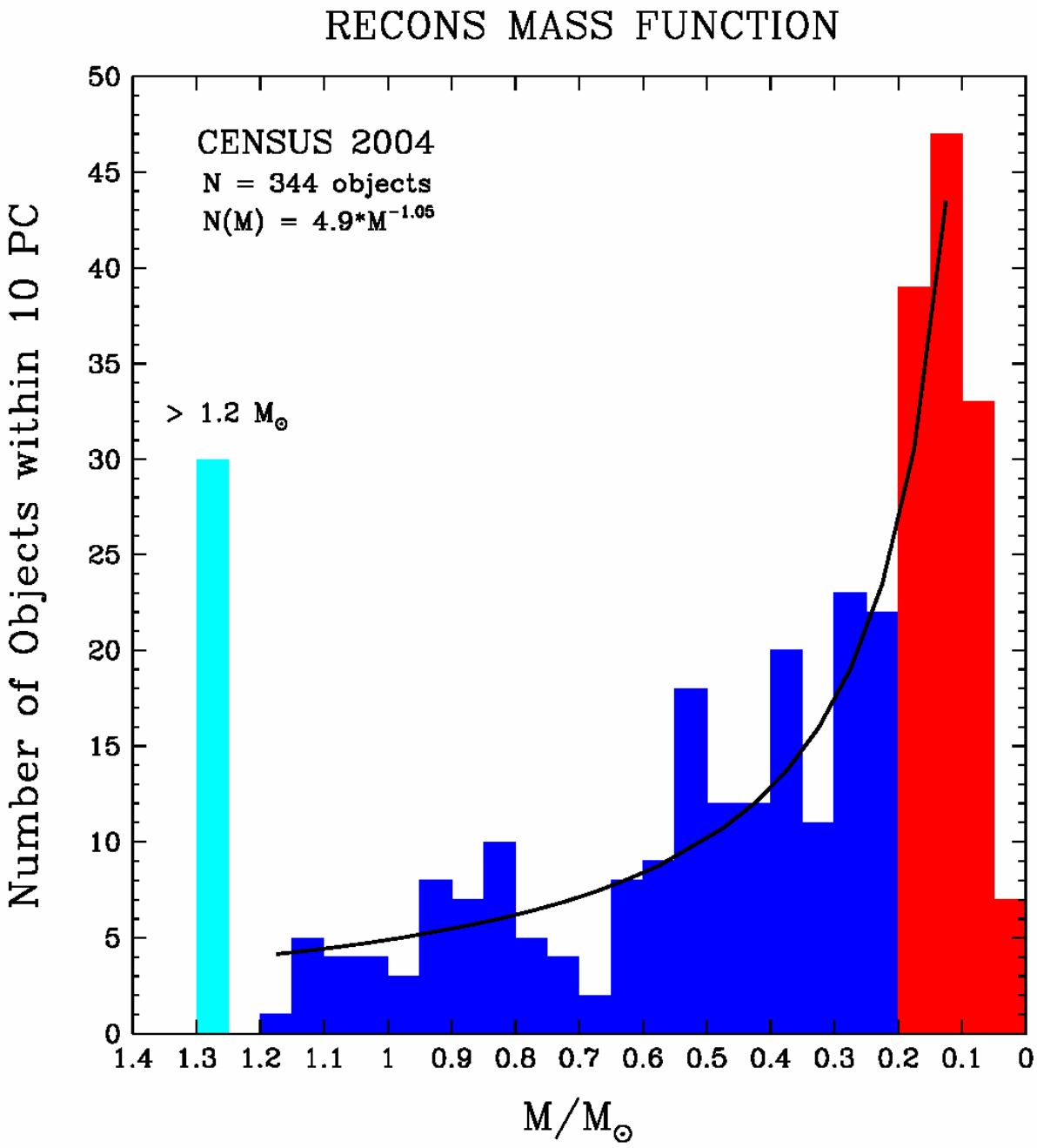
Henry 2004

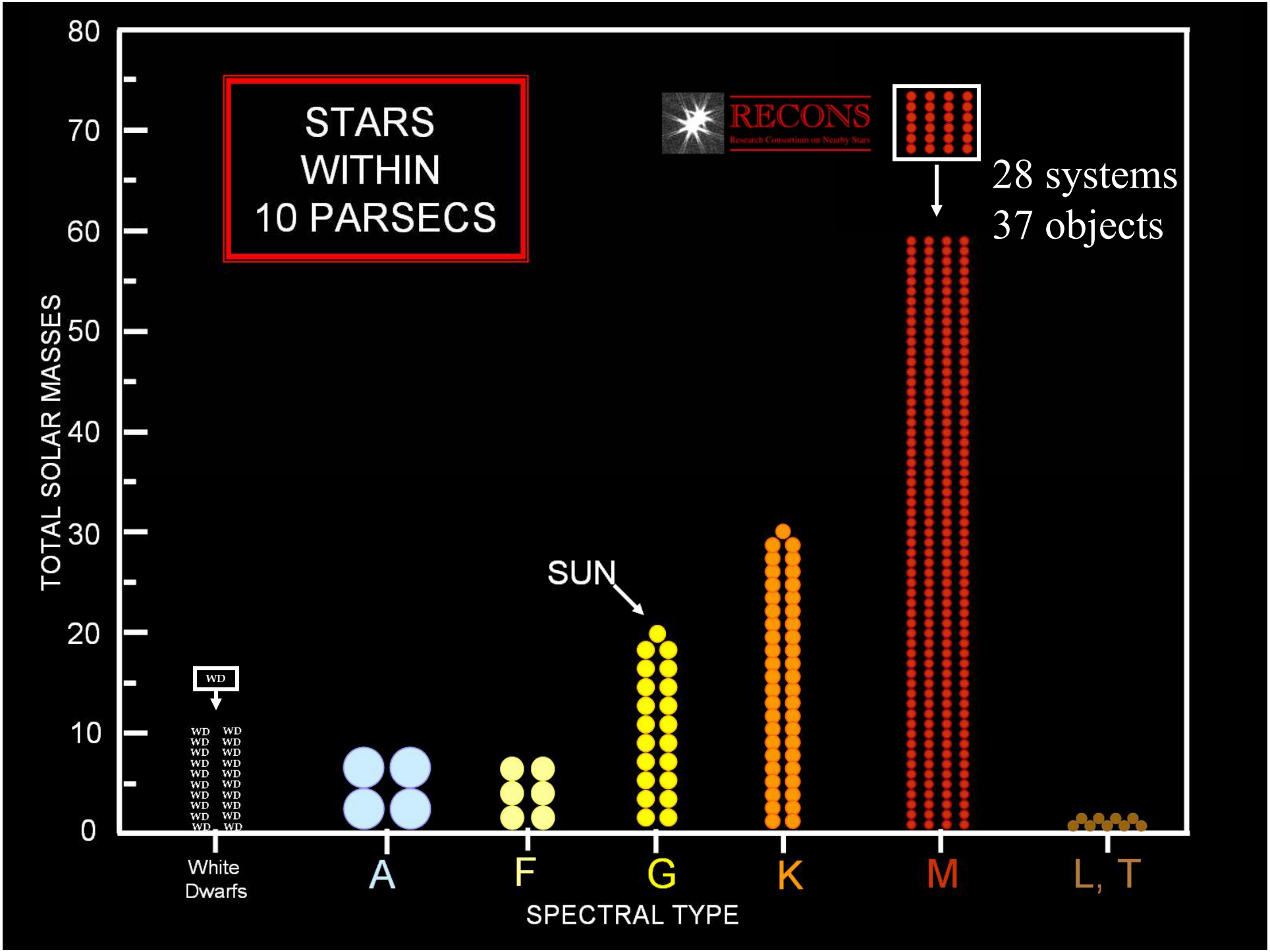

RECONS LUMINOSITY FUNCTION
CENSUS 2004
N = 344 objects
Number of Objects within 10 PC
M_V
wd
< 0.2 M⊙ (38%)
> 21
0
5
10
15
20
25
30
35
40
45

Henry & Torres 2004



Henry 2004


RECONS MASS FUNCTION
CENSUS 2004
N = 344 objects
N(M) = 4.9*M^-1.05
> 1.2 M⊙
Number of Objects within 10 PC
M/M⊙
0
5
10
15
20
25
30
35
40
45
50
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0


STARS
WITHIN
10 PARSECS
RECONS
Research Consortium on Nearby Stars
28 systems
37 objects
TOTAL SOLAR MASSES
80
70
60
50
40
30
20
10
0
SUN
WD
WD WD
WD WD
WD WD
WD WD
WD WD
WD WD
WD WD
WD WD
WD WD
WD WD
White
Dwarfs
A
F
G
K
M
L, T
SPECTRAL TYPE

RECONS Census Update

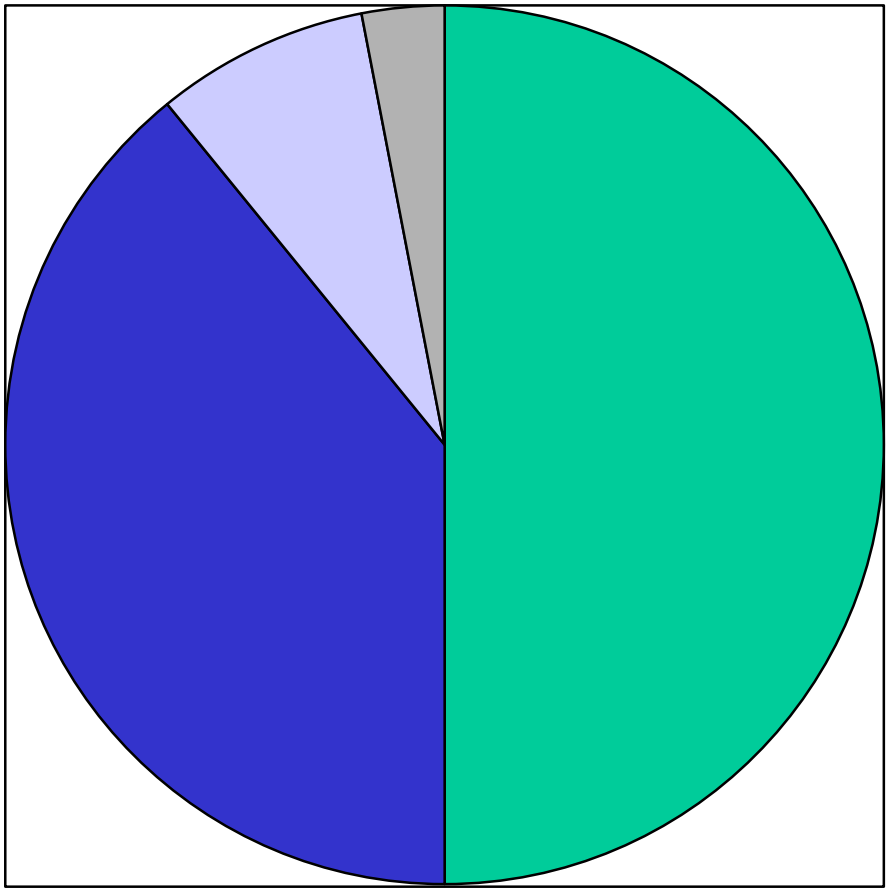
	Systems	Objects	
CENSUS 2000	216	299	
phantoms	0	– 3	
booted	– 1	– 1	
other groups	+ 7	+ 16	4 M, 2 L, 7 T, 3 P
RECONS Research Consortium on Nearby Stars	+ 31	+ 40	3 WD, 37 M
CENSUS 2005.5	253	351	
Change	+ 17 %	+ 17 %	

RECONS Census Update

trigonometric parallax > 100 mas and error < 10 mas

	2000.0	2005.5	
WD	18	21	+ 17 %
A	4	4	
F	6	6	
G	21	21	
K	45	45	
M	203	240	+ 18 %
% M	68 %	71 %	
L	0	2	
T	1	8	
P	1	4	
Total	299	351	+ 17 %

Parallaxes in the RECONS Sample



YPC	212	50%
HIP	166	39%
RECONS	33	8%
other	13	3%
	424	total

RECONS

Research Consortium on Nearby Stars

Summary

- accurate census of solar neighborhood
- 17 % increase in 10 pc sample (so far)
- fundamental photometry and spectroscopy
- multiplicity of all stars = 30-40%

- Mk and Mv vs. color relations for dist estimates
- pushing toward true LF, MLR, MF
- target lists for HST, Spitzer, SIM, TPF, SETI

New Neighbors from Trucks

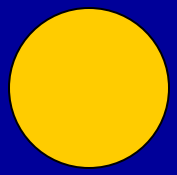
HIP	LP 816-060 ESA 1997	M5.0 V 5.49 ± 0.11 pc	V = 11.41 Hipparcos trig
2MA	2MASS 1835+3259 Dahn et al. 2002	M8.5 V 5.67 ± 0.02 pc	V = 18.27 USNO trig

… more to come …

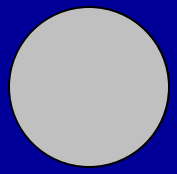
SDS	SDSS 1624+0029 Dahn et al. 2002	T6.0 V 10.93 ± 0.27 pc	K = 15.61 USNO trig

… more to come …

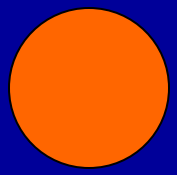
New Neighbors from Vans



SO 0253+1652	M7.0 V	V = 15.20
Teegarden et al. 2003	3.6 ± 0.4 pc	phot
Teegarden et al. 2003	2.4 ± 0.5 pc	plate trig
Henry et al. 2004	3.73 ± 0.59 pc	RECONS phot
RANK = 23rd	**3.82 ± 0.06 pc**	**RECONS trig**



SCR 1845-6357	M8.5 V	V = 17.40
Hambly et al. 2004	3.5 ± 0.7 pc	plate phot
Deacon et al. 2004	3.6 ± 0.3 pc	plate trig
Henry et al. 2004	4.63 ± 0.75 pc	RECONS phot
RANK = 25th	**3.94 ± 0.04 pc**	**RECONS trig**



DEN 1048–3956	M8.5 V	V = 17.33
Delfosse et al. 2001	4.1 ± 0.6 pc	phot
Deacon & Hambly 2001	5.2 ± 1.0 pc	plate trig
Henry et al. 2004	4.53 ± 0.73 pc	RECONS phot
RANK = 28th	**4.04 ± 0.03 pc**	**RECONS trig**

Proxima found by Voute (1917)

GJ 1061 found by Henry et al. 1997

Parallax Science Projects

L + T dwarfs	USNO
true LF + MF	RECONS (Henry)
subdwarf population	RECONS (Jao)
white dwarf population	RECONS (Subasavage)
cluster memberships	
multiplicity studies	
sexy targets	e.g. RECONS (Raghavan)

Spinoff Science

variability	spots, flares, eclipses
future target lists	SIM, TPFs, SETI

SETI's 1 Million Stars?

G	362 parsecs	1180 light years
F-K	240 parsecs	782 light years
A-M (now)	147 parsecs	479 light years
A-M (pred)	126 parsecs	411 light years

The Dream … 1000 Light Year Catalog

Names and Addresses

Spectroscopic Parallaxes — **not terribly good, painful**

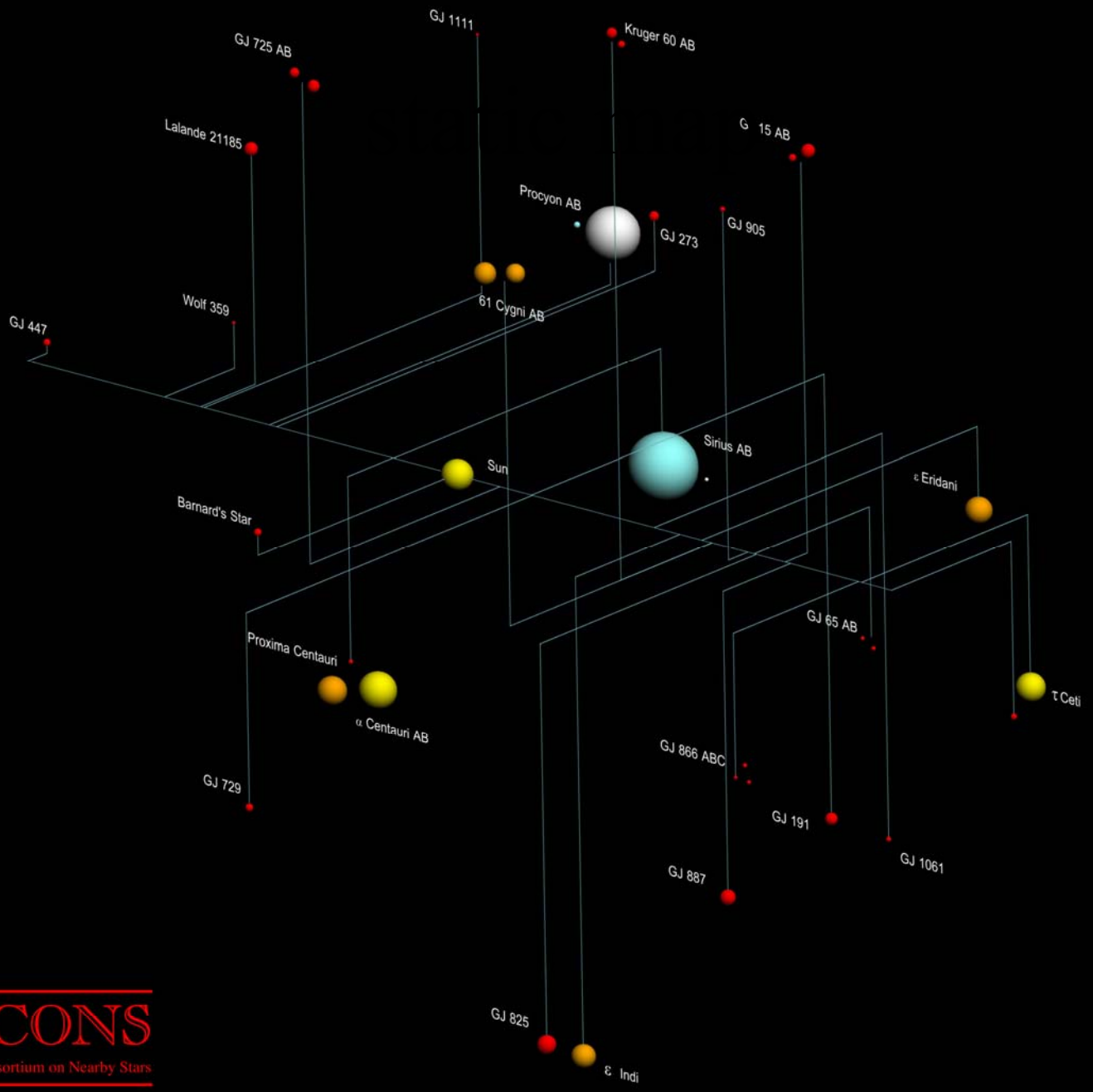
Photometric Parallaxes — **pretty good**

plate BRI + JHK	26 % errors
CCD VRI + JHK	15 % errors

Trigonometric Parallaxes — **superb, but excruciating**

Yale Parallax Catalog	~ 10,000 stars
Hipparcos	~ 100,000 stars
.....	
ground-based efforts	~ 1,000 stars
Pan-Starrs/LSST	a lot
SIM	~ 10,000 stars
GAIA	a lot

25 Nearest Star Systems



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