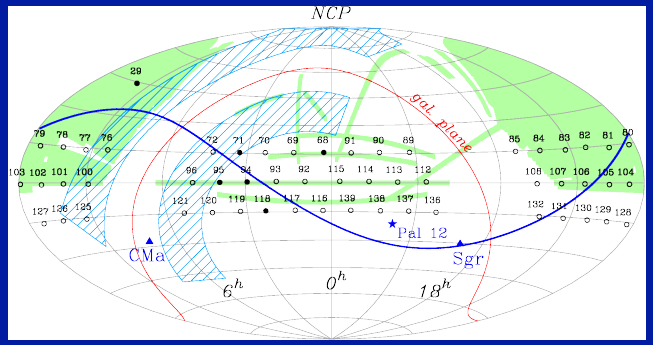
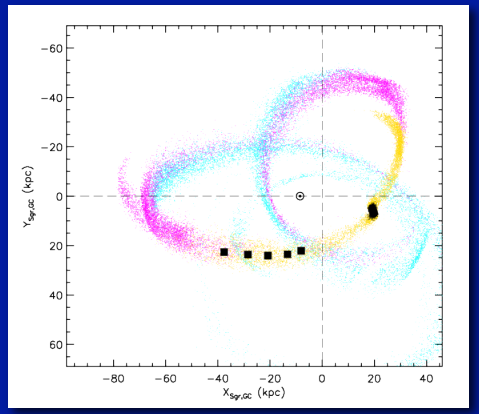
Characterizing Halo Substructure with Kapteyn Proper-motion Survey and SEGUE/SDSS Data

Dana Casetti - Yale University





The Team and Collaborations

- *Yale:* Dana Casetti, Terry Girard
- *Rensselaer P I:* Jeff Carlin
- *University of Virginia*: Steve Majweski

- SDSS

- Mike Siegel, David Law, Kathy Vivas, Ron Wilhelm, Tim Beers, Bill van Altena, Ricky Patterson, Carl Grillmair, Jorge Penarrubia

Outline

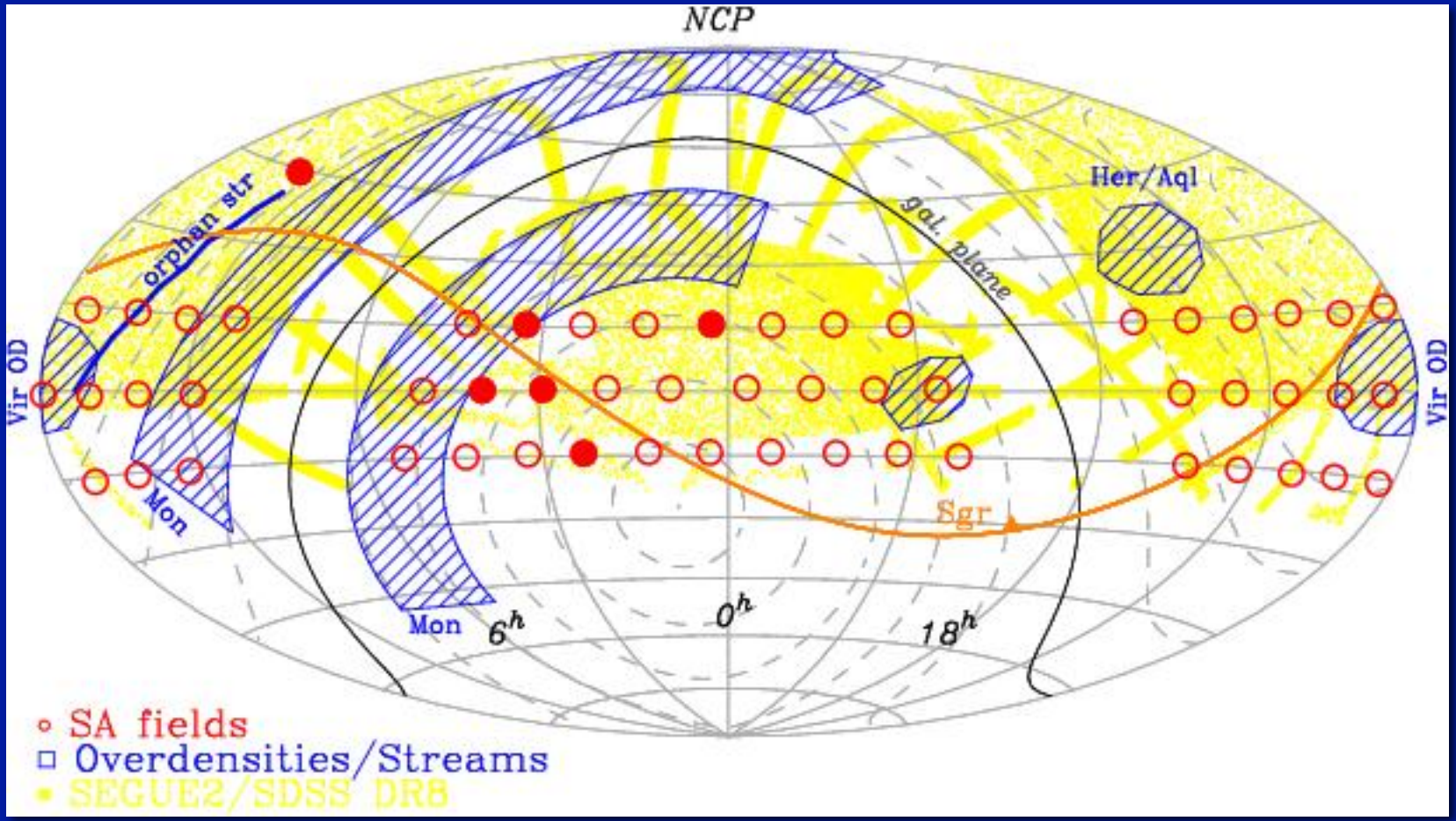
- Survey Description
- Comparison with current proper-motion surveys (Munn et al. 2008-DR7, Bramich et al. 2008)
- Science highlights

Survey Layout and Status

- 51 Kapteyn Selected Area fields of 40’x40’ (originally 55, but plates are not available for 4 fields)
- 3 Dec. zones: 0^o, $+15^o$, -15^o ; every $\sim 15^o$ in RA
- 51 fields measured, 28 reduced
- 35 (of 51) overlap with DR8; 22 (of 28 reduced) overlap with DR8
- 7 are in stripe 82, and overlap with Bramich et al. 2008

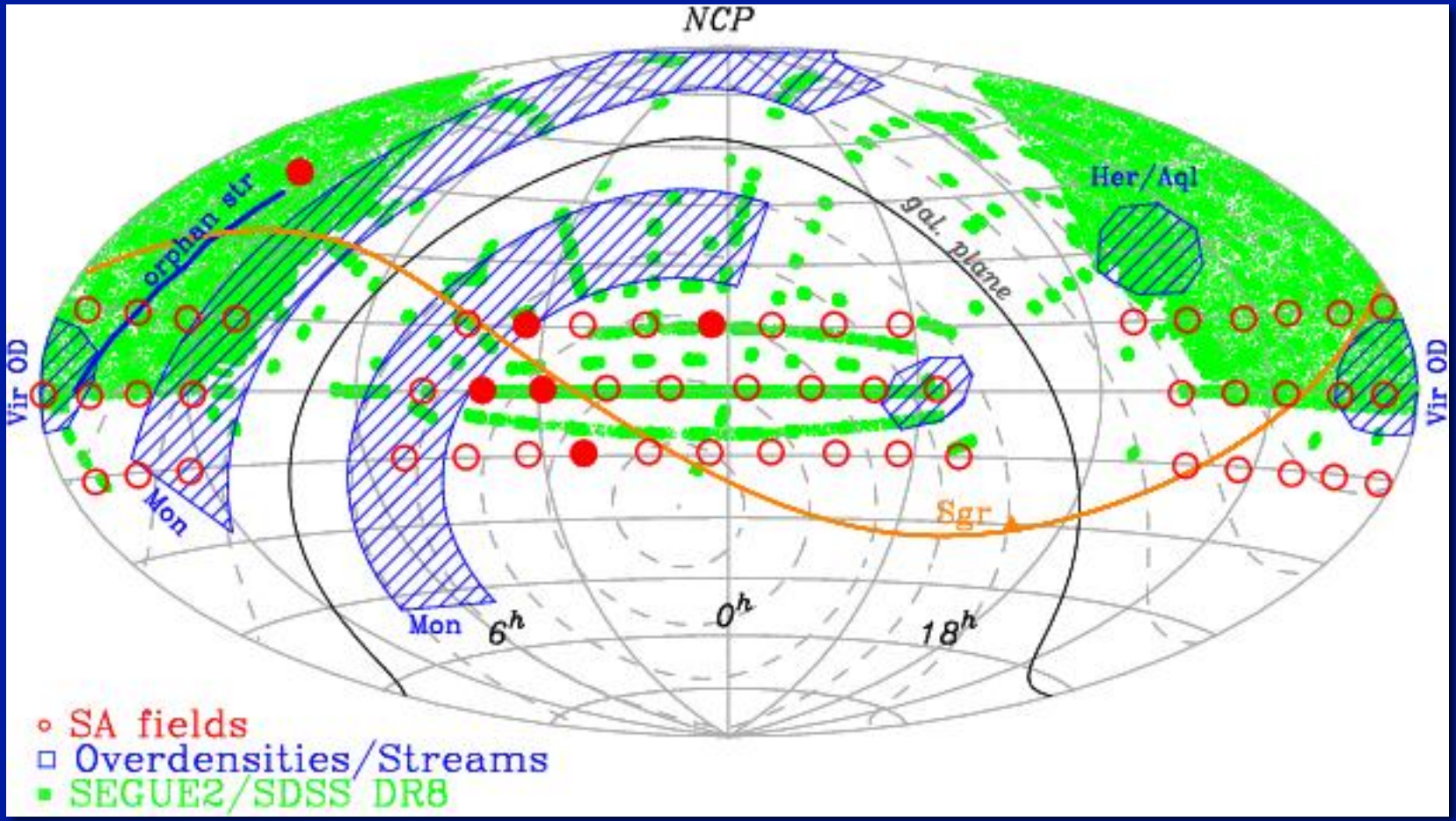
Ref: Casetti-Dinescu et al. 2006

Survey Layout and DR8



DR8 Imaging

Survey Layout and DR8



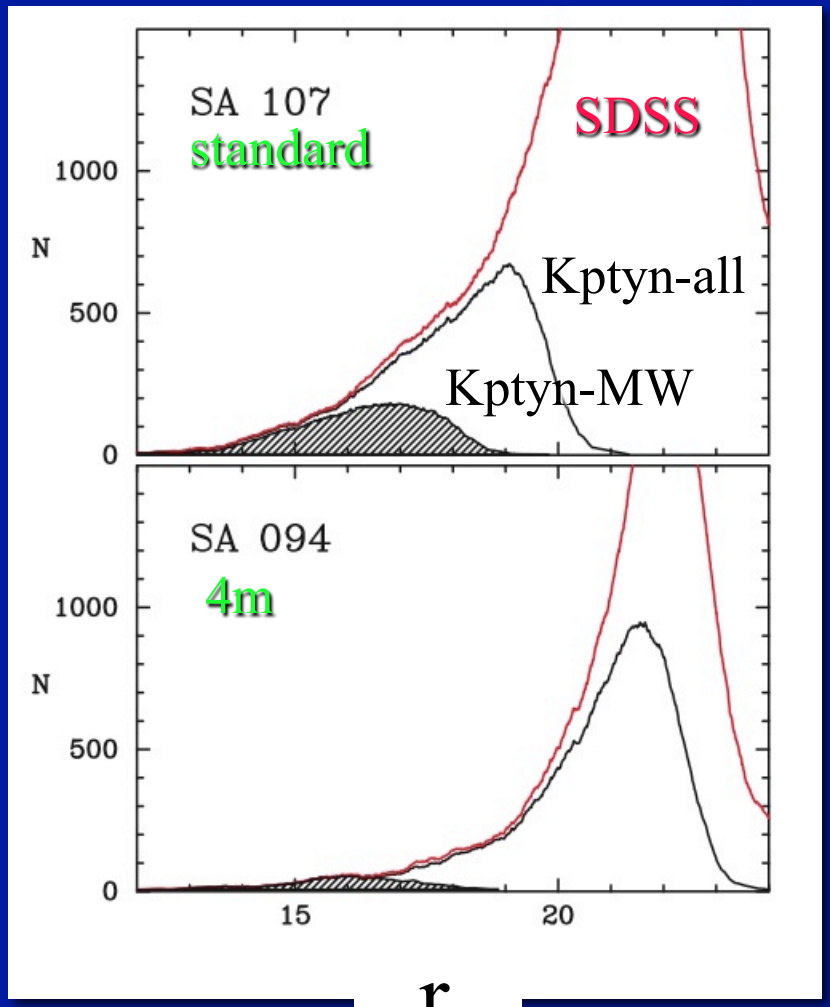
Proper Motions

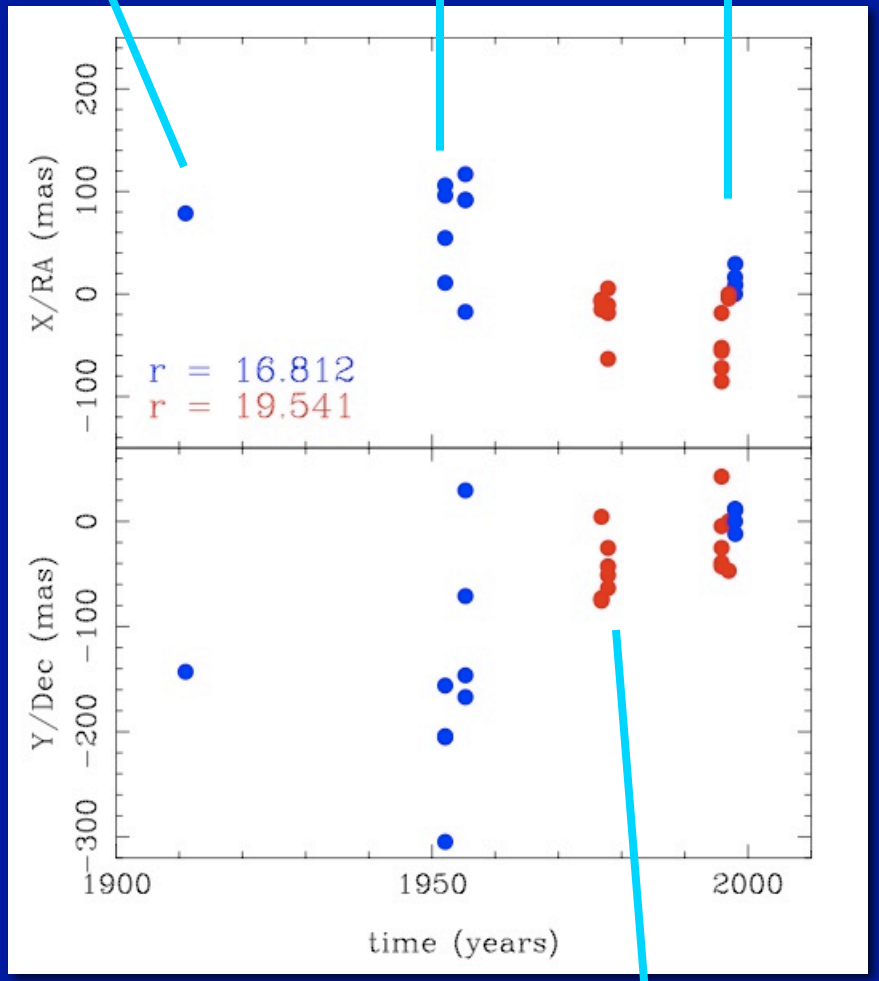
- LCO du Pont 2.5m, 1996-2000, (Majewski), IIIaJ-F; V_{lim}= 21 to 22; 10.9”/mm
- KPNO Mayall 4m PF : mid 1970; (Sandage) and mid 1990s (Majewski); IIaO,D and IIIaJ,F; V_{lim} ~ 23; 18.6”/mm
- Mt. Wilson 60-inch, 1909 - 1912, to V_{lim}= ~ 18; 27.1”/mm
- POSS-I Oschin Schmidt 1.2m, early-mid 1950s; scanned at USNO and STScI (scans processed at Yale); V_{lim}~ 21.5; 67.2”/mm

-Errors: 1-2 mas/yr per well-measured star (V~17 and V~19 for 4m); zero point ~0.3 to 0.6 mas/yr

-Status: 28 fields reduced with ~57,000 objects

Proper Motions





Radial Velocities

-WIYN 3.5m (Hydra): ~1600 spectra; errors ~ 5 -10 km/s

λ = 5200Å (4400-7200Å, R~1500) and λ = 5170Å (R ~ 5400)

-CTIO 4m (Hydra): ~500 spectra; errors 10-20 km/s

λ = 5500Å (4600-7000Å, R~1600)

-MMT 6.5m (Hectospec): ~1000 spectra; errors ~10-15 km/s

λ = 6400Å (3700-9150Å, R~1300)

-SDSS / SEGUE

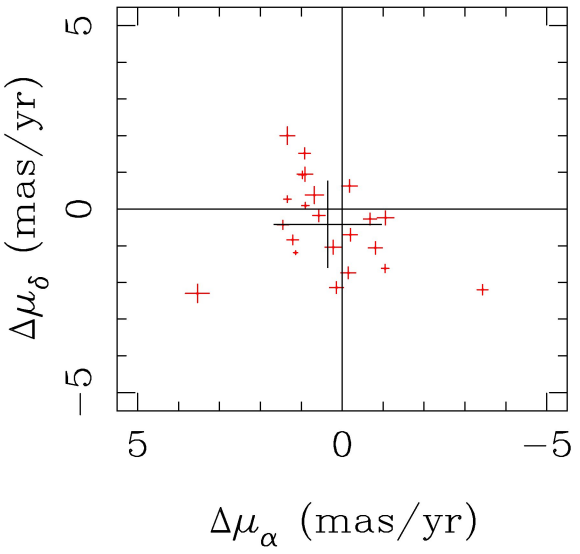
Photometry/Object classification

-SDSS

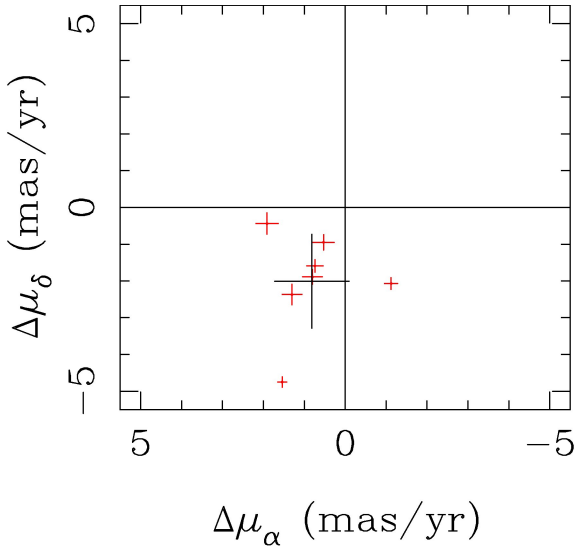
-Other: LCO Swope 1m, KPNO 0.9m, literature

Proper-motion Comparisons: Differences

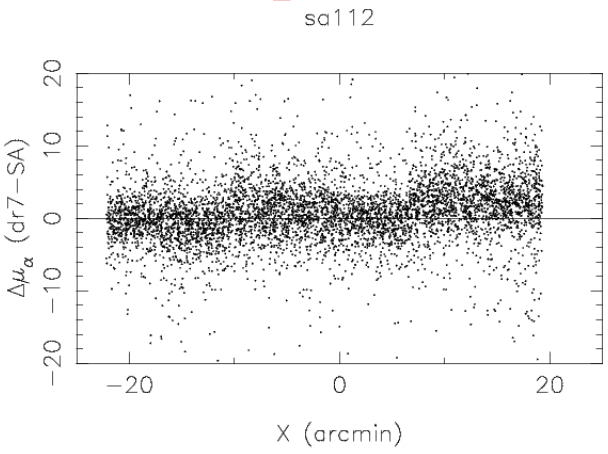
dr7-K : 22 fields



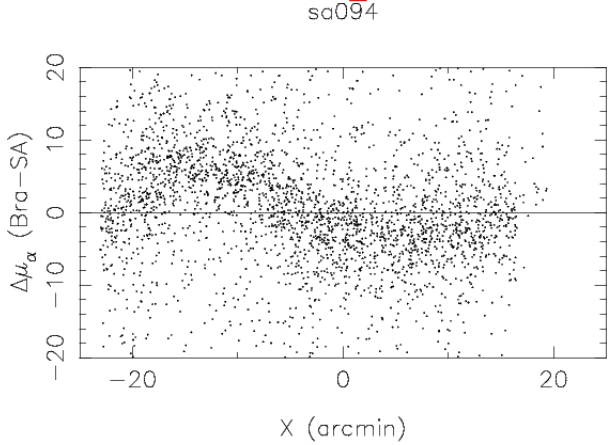
Bramich-K : 7 fields



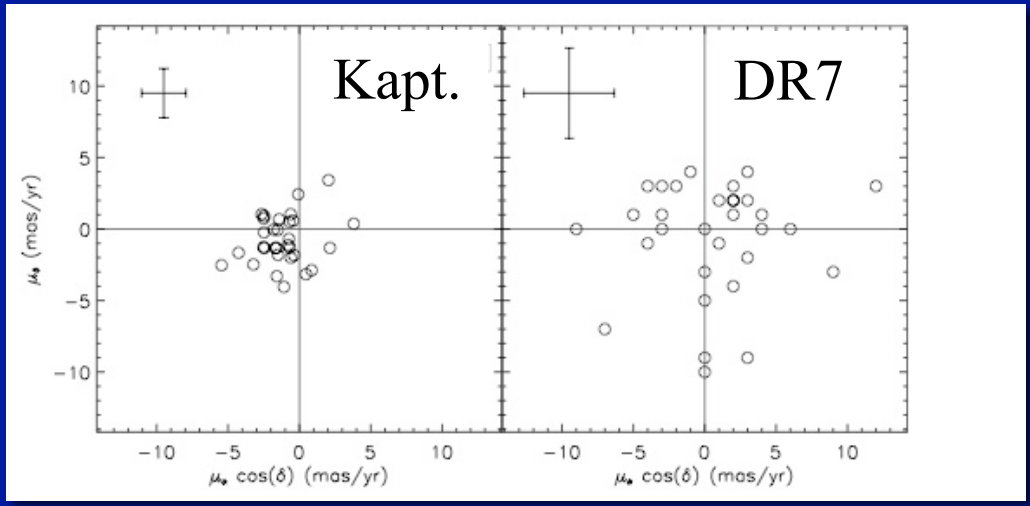
dr7-K : per field



Bramich-K : per field



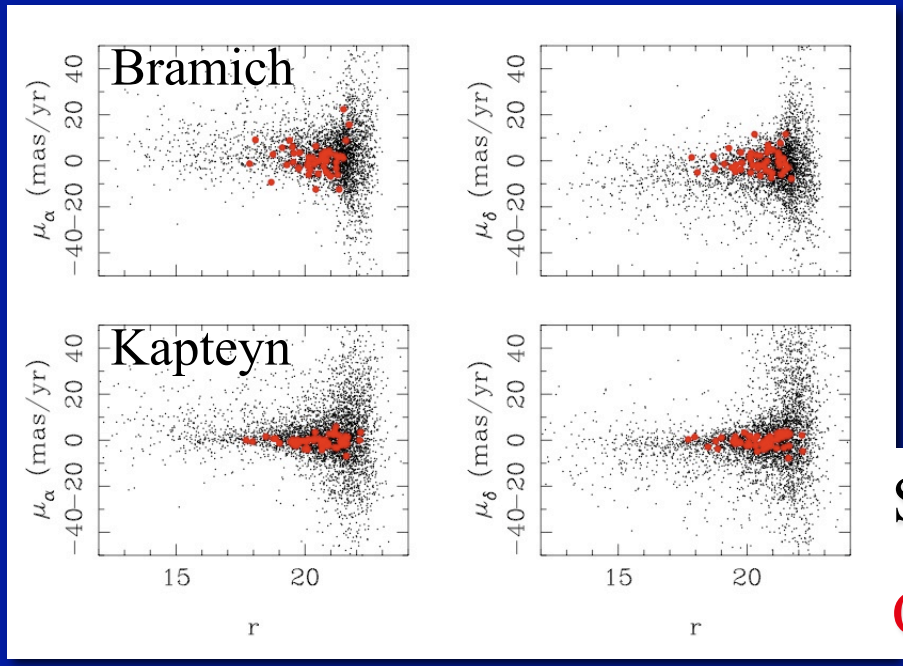
Proper-motion Comparisons: Actual values



SA 76 - comparison with dr7

Stars in the Mon/Anticenter stream (RV-CMD selected)

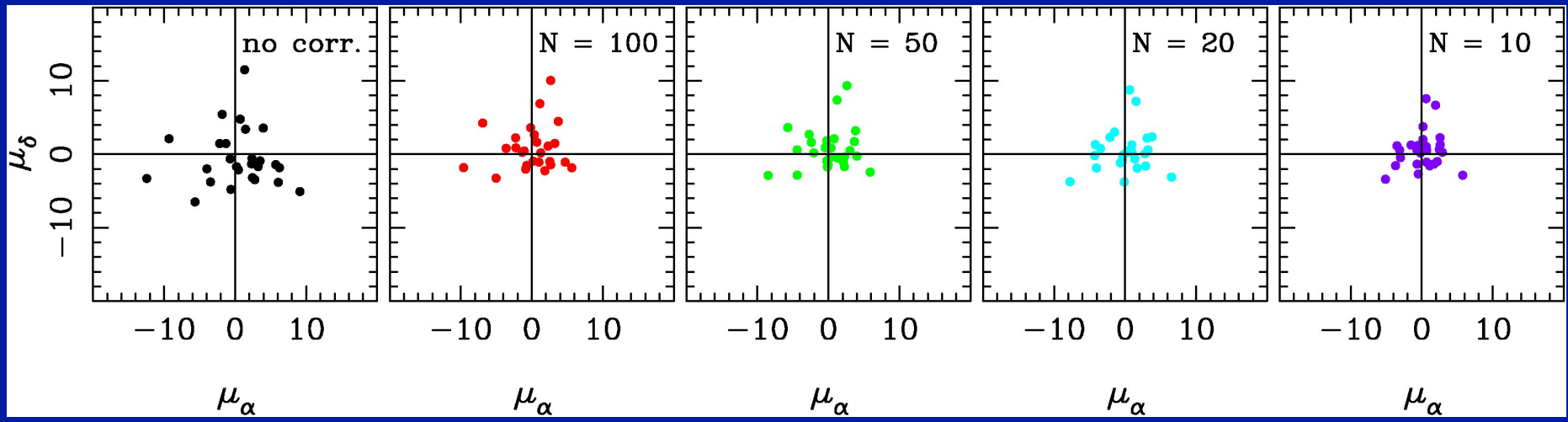
Carlin et al. 2010



SA 94 – comparison with Bramich2008, stripe 82

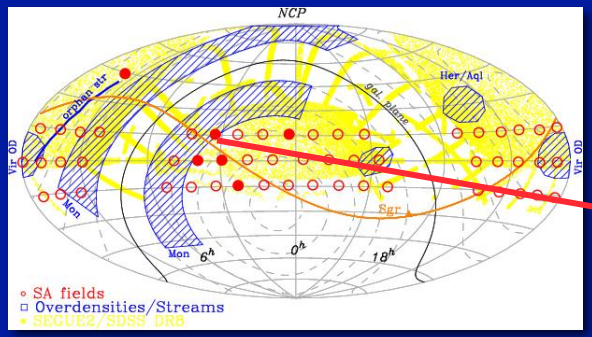
Proper-motion Corrections to Bramich 2008

SA 94
Proper-motion distribution of QSOs (mas/yr)

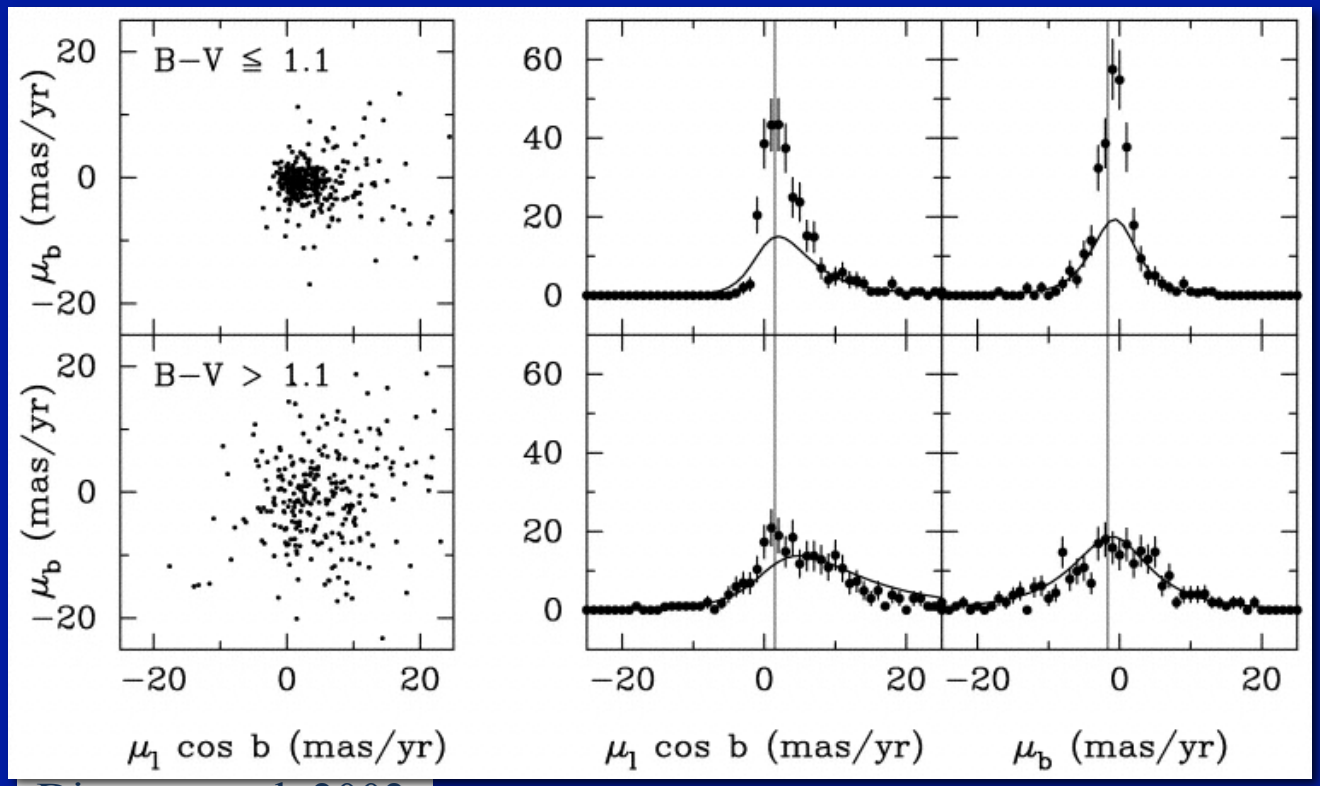


sdev μ_α	4.8	3.5	3.3	3.1	2.4
sdev μ_δ	3.9	3.1	2.9	2.9	2.6

Finding Streams in Proper-motion Space



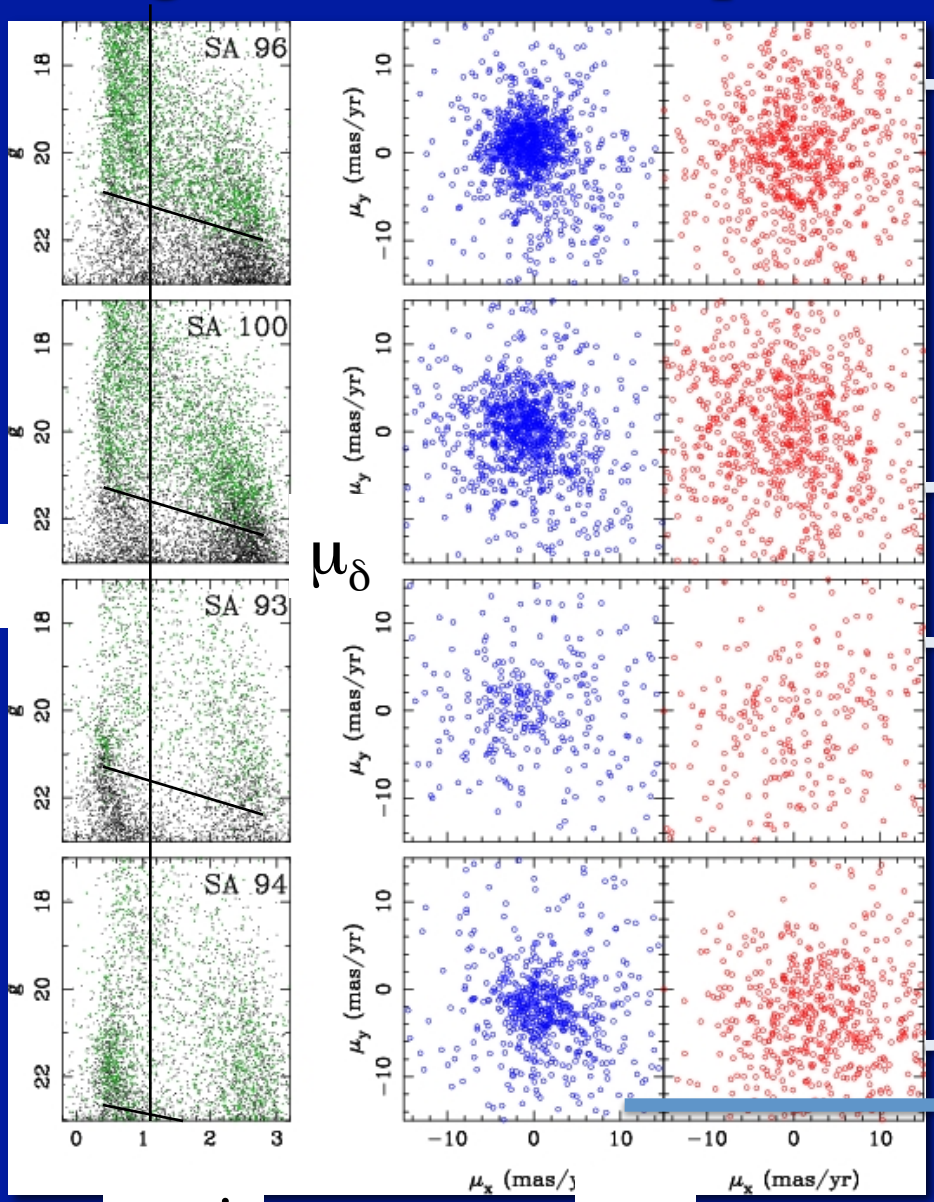
SA 71

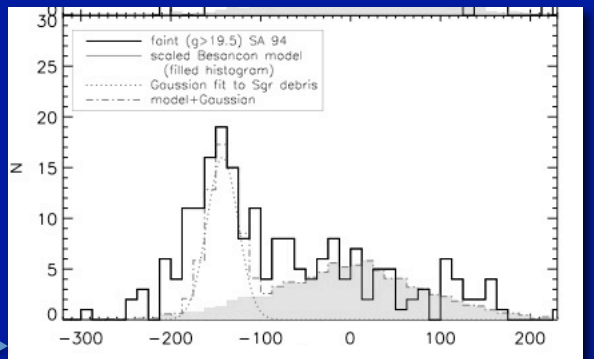


-clumpiness
-stellar excess

Dinescu et al. 2002

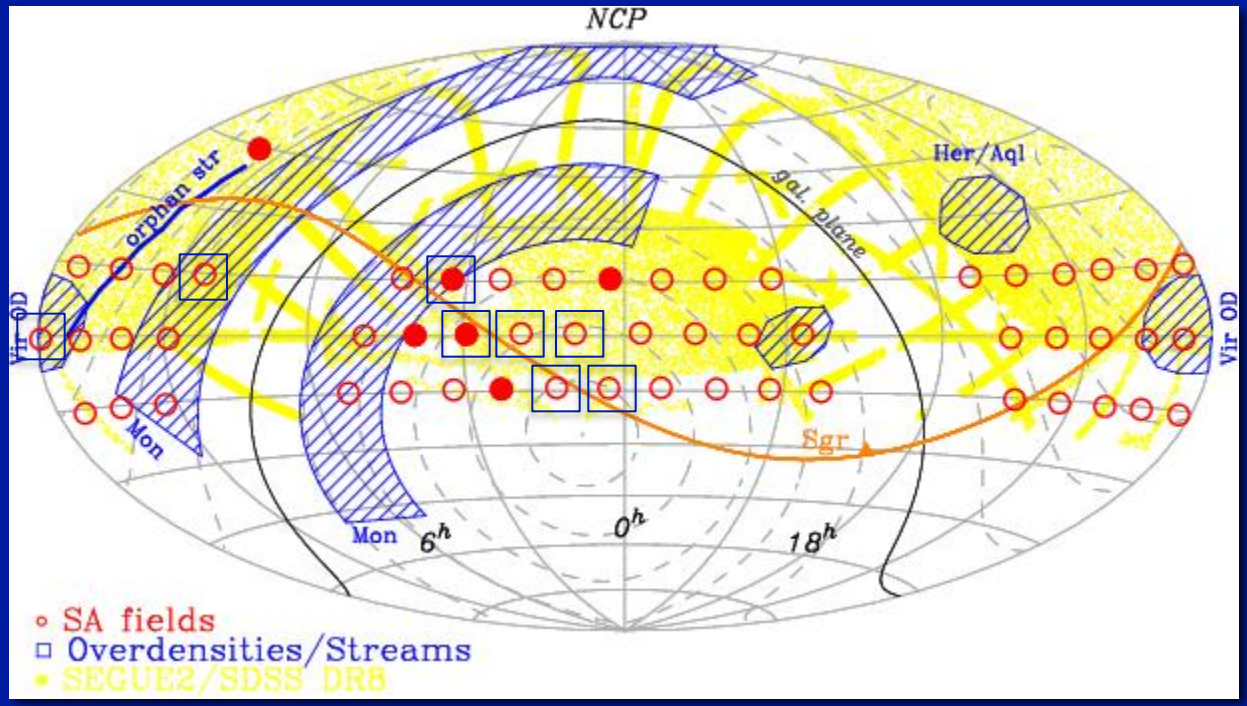
Finding Streams in Proper-motion,CMD and RV Space





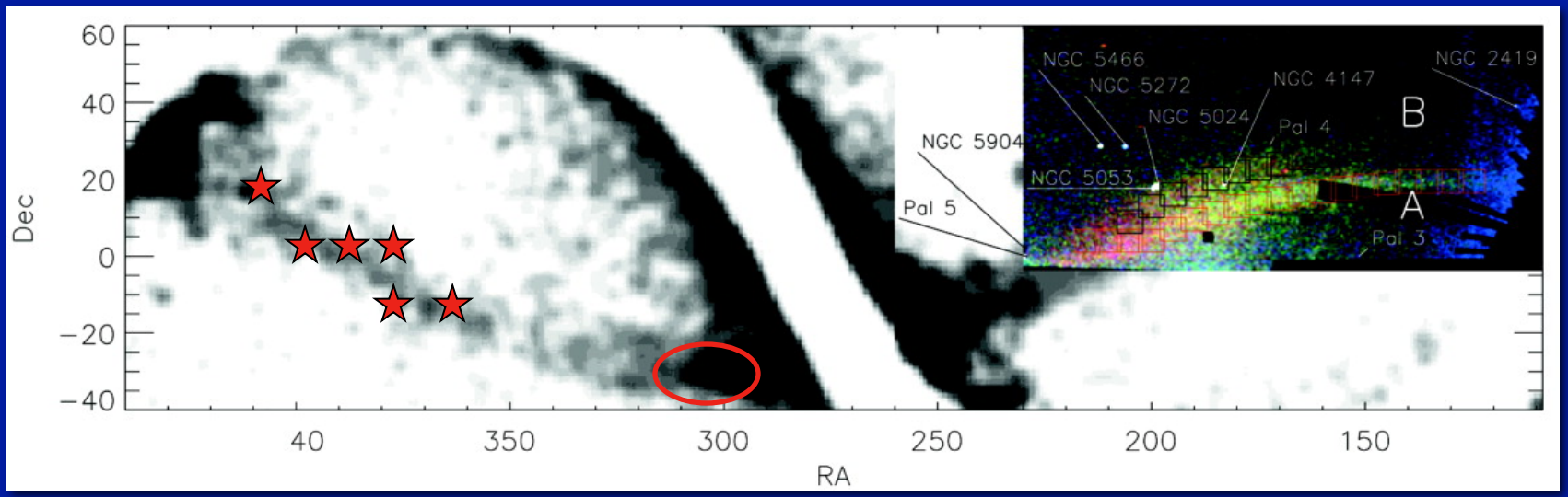
Science Highlights: Results

- The Monoceros/Anticenter structure (SA 71, 76)
- The Virgo Stellar Stream (SA 103) - poster by Yam et al.
- The Sagittarius trailing tail (SA 71, 93, 94, 117, 92, 116)



Science Highlights: Characterizing Streams

Sagittarius trailing tidal tail and constraining Θ_{LSR}

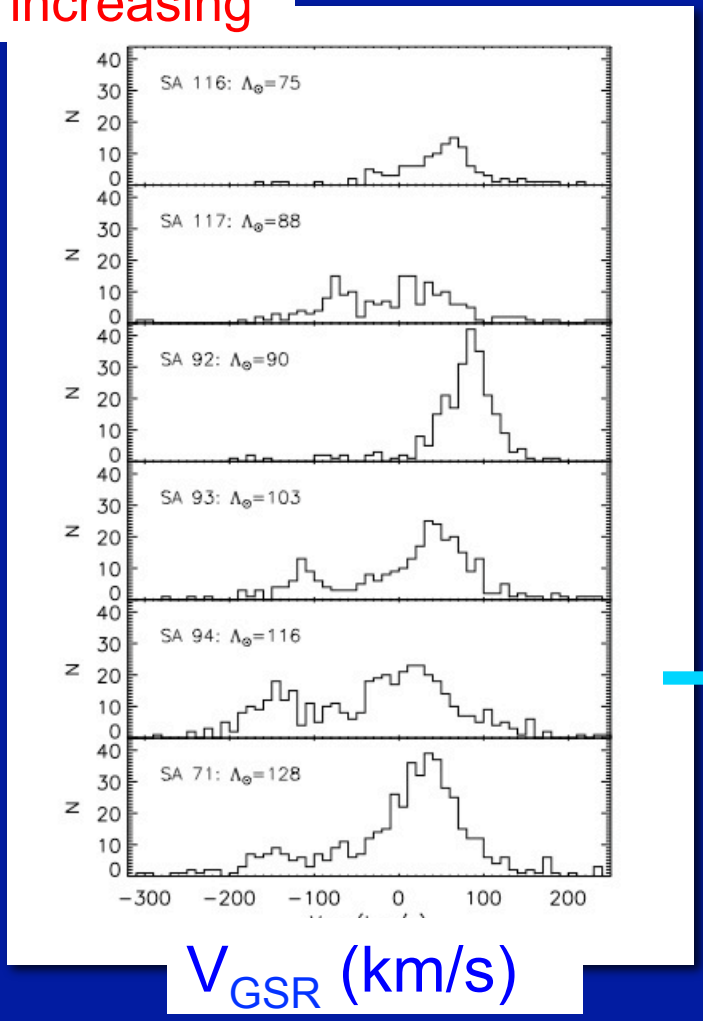


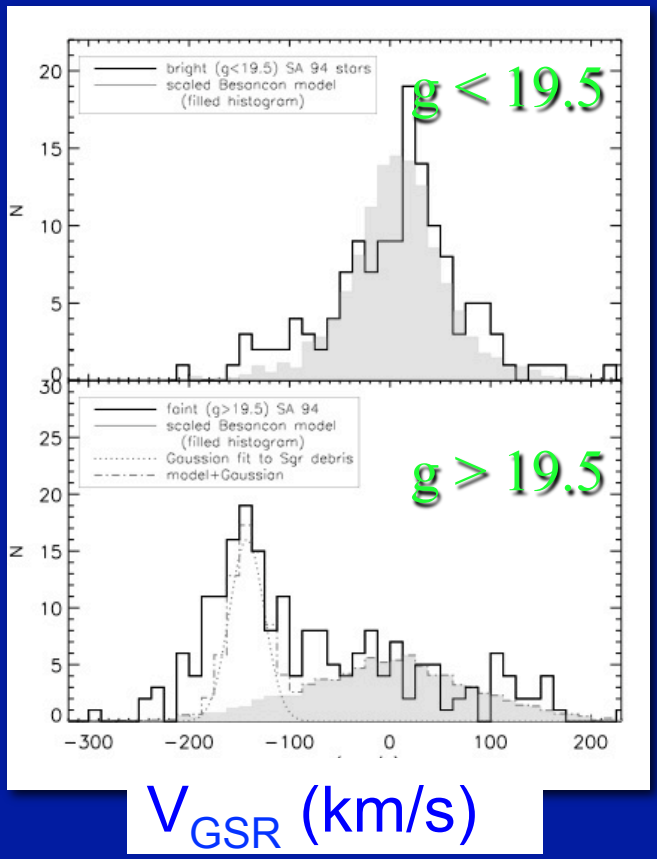
SDSS and 2MASS: Belokurov et al. 2006, 2007, 2008, Majewski et al. 2003

Carlin et al. 2012

Sagittarius trailing tidal tail and constraining Θ_{LSR}

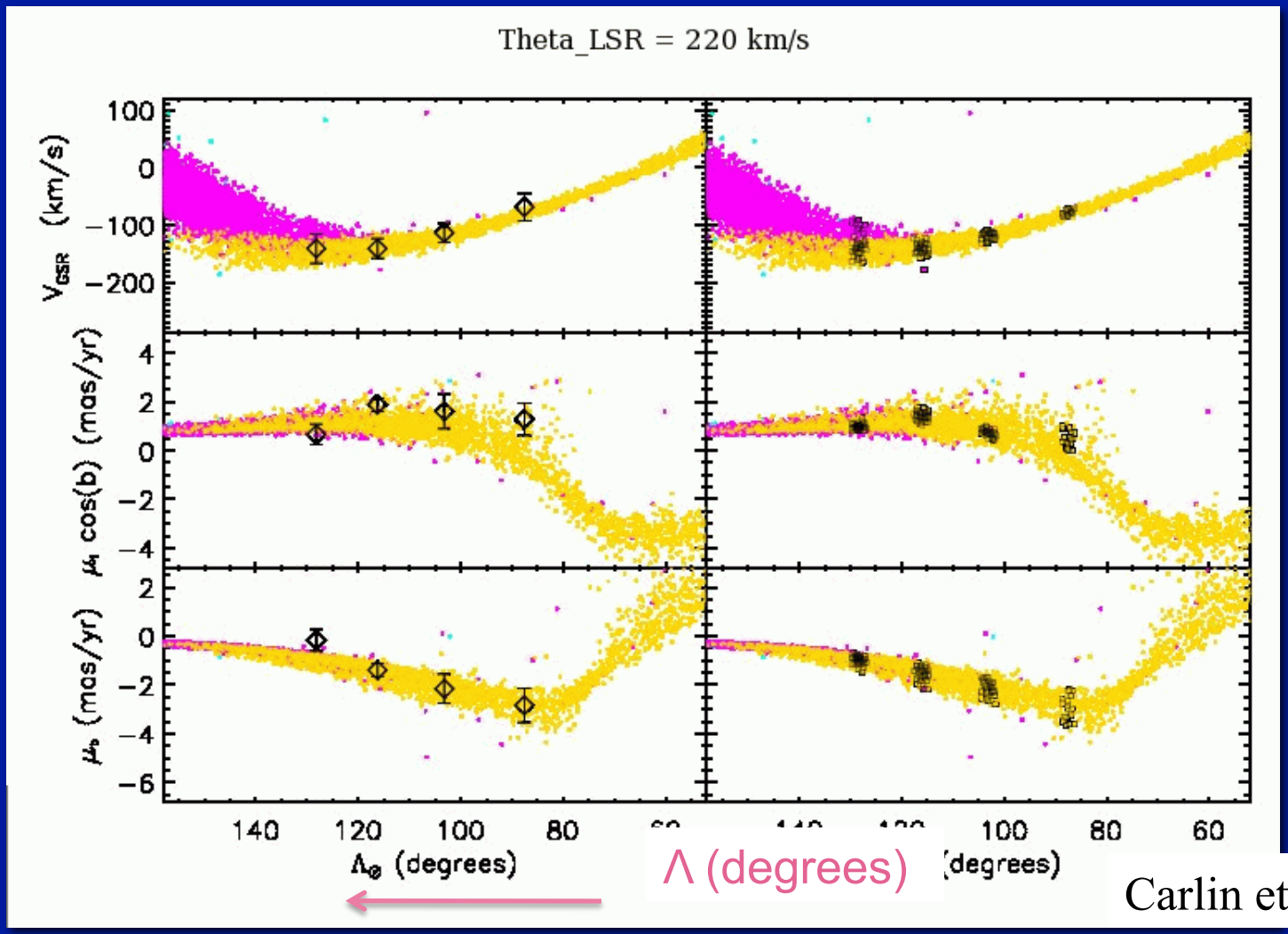
Λ increasing





Carlin et al. 2012

Sagittarius trailing tidal tail and constraining Θ_{LSR}

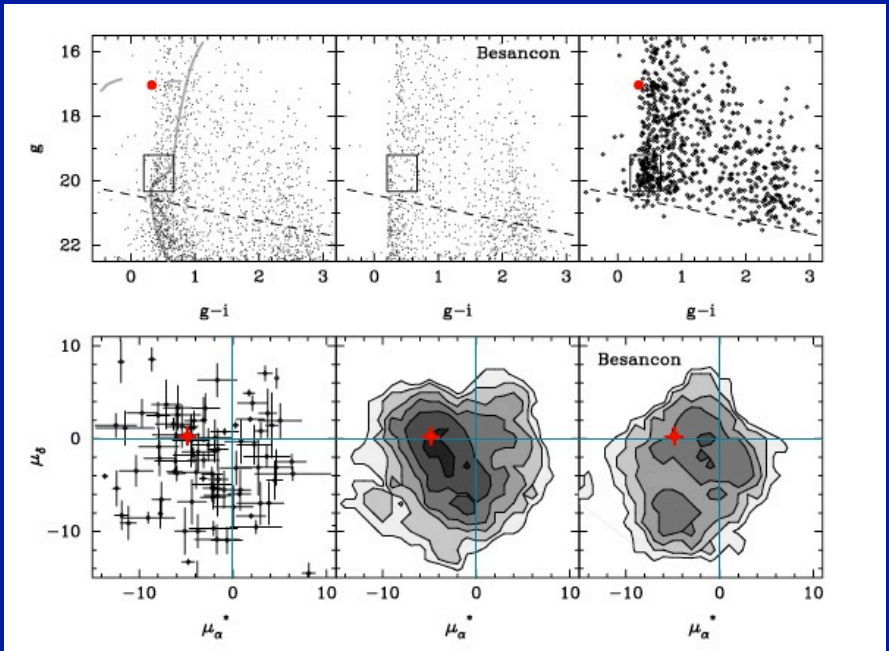


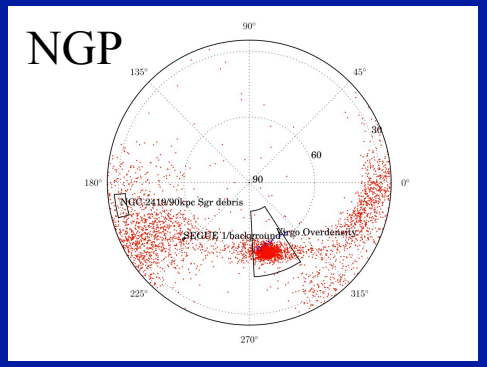
Carlin et al. 2012

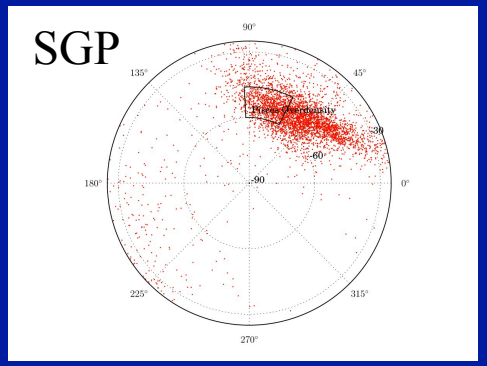
3D vel.fit => Θ_{LSR} = 232 ±14 km/s

Science Highlights: Characterizing Streams

SA 103: Virgo Stellar Stream







Casetti-Dinescu et al. 2009
1 RR Lyr => ecc ~ 0.8;
R_p~11kpc; R_a~90kpc
Pericentric debris of a former satell.
Assoc with NGC 2419

Yam et al. 2012 – poster 252.16
16 stars => similar orbit as CD09
Assoc with NGC 2419, Segue1b/ Segue, Pisces

Summary

- To date, this survey is best suited for the study of 3D kinematics of streams
- More fields to be reduced/analyzed
- Potential for calibrating other surveys
- Du Pont plates to be used in combination with modern ccd data for deeper/more precise catalogs
- Sgr trailing tail=> constraining MW potential
- VSS/VOD – its nature/formation