Mapping of the Local Interstellar Medium using Absorption Line Spectroscopy

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Abstract: Using the Yale SMARTS 1.5-meter telescope at CTIO and the CHIRON spectrograph, we have developed a program for mapping the local interstellar medium using a sample of over 200 newly observed B stars previously unobserved using Na I absorption lines. This sample includes stars that extend out to map beyond the local bubble to 500 pc. The sample has been observed using high resolution absorption lines, and when combined with previously observed stars with Na I and Ca II data provides a more complete picture of the local ISM than previous surveys. The distances to the stars using the new GAIA database also allows for more accurate determination of distances to features in the local ISM, and new maps of the structure of the ISM have been prepared with the data.

Observations: Beginning in Fall of 2014, over 230 stars were observed with the CTIO Yale SMARTS 1.5-meter telescope and CHIRON spectrograph, operating with the R=80,000 resolution and using the image slicer to improve efficiency. The CHIRON spectrograph provides spectra between 4100-8700 Angstroms, and our sample of B and A0 stars included additional stars to extend the work by Welsh, et al (2010) to include over 230 new targets which had not been observed previously in high resolution spectroscopy, and also to probe a larger range of distances. While the Welsh, et al (2010) sample was intended to map the interstellar absorption to 300 pc, our sample extended to beyond 600 pc. The addition of new and more accurate parallax data from the GAIA DR1 (GAIA Collaboration; Brown et al 2016) has also allowed us to re-compute the distances for both the Welsh et al stars and our new sample, providing the basis for an improved map of the local interstellar medium, and the various clouds in our galactic neighborhood.

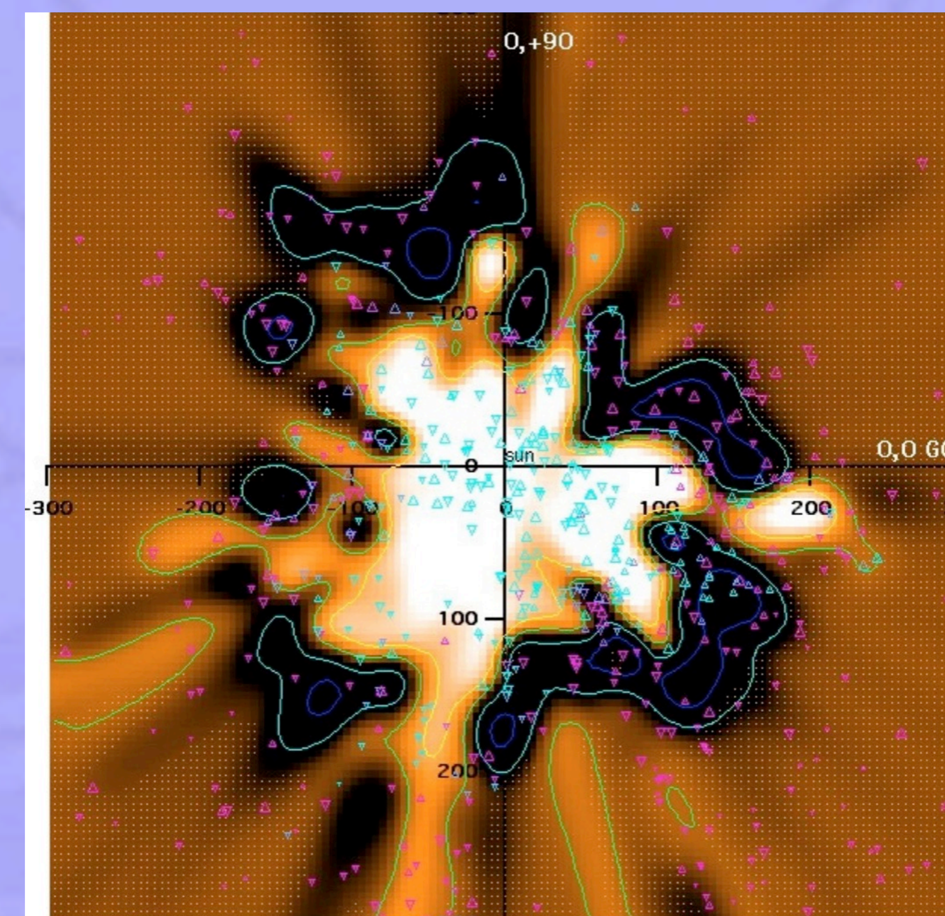


Figure Caption: (above) – Map of galactic plane as provided through Na I absorption profiles from Welsh et al (2011). This map includes a sample of stars extending out to about 300 pc. (right) – Map of galactic plane adapted from figure from Frisch, et al (2009), with stars from our combined sample included as squares and asterisks. For stars with measured NaI the symbol size is proportional to log(N(NaI).

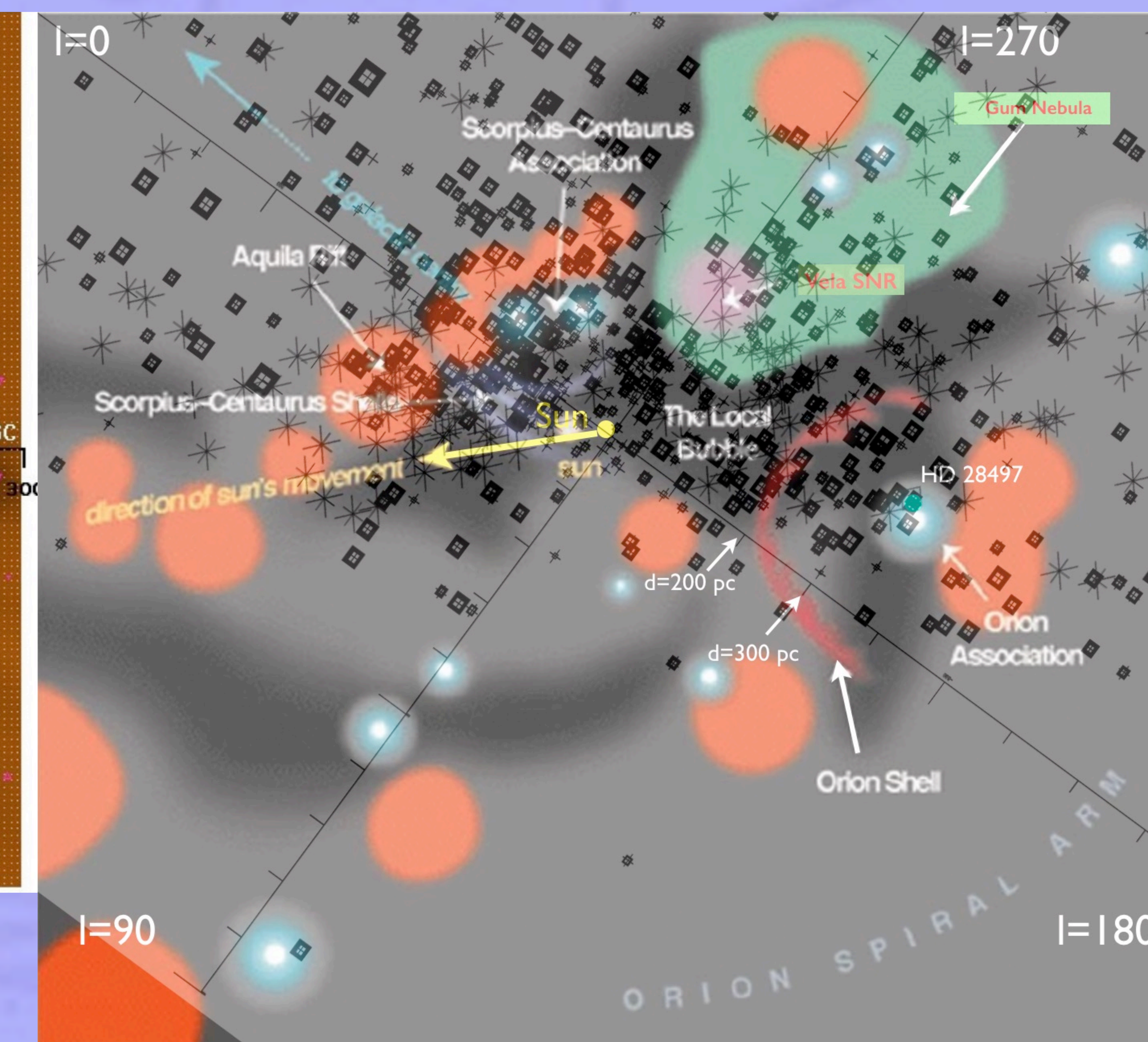


Figure Caption: (above) - Map of galactic plane adapted from figure from Frisch, et al (2009), with stars from our combined sample included as squares and asterisks, and using distances computed from the GAIA DR1 parallaxes. For stars with measured NaI the symbol size is proportional to log(N(NaI)). The new analysis of NaI absorption will help improve our knowledge of the local bubble, and the location sof features such as the Sco-Cen association, the Orion Shell and the geometry of the Vela Supernova and Gum nebula.

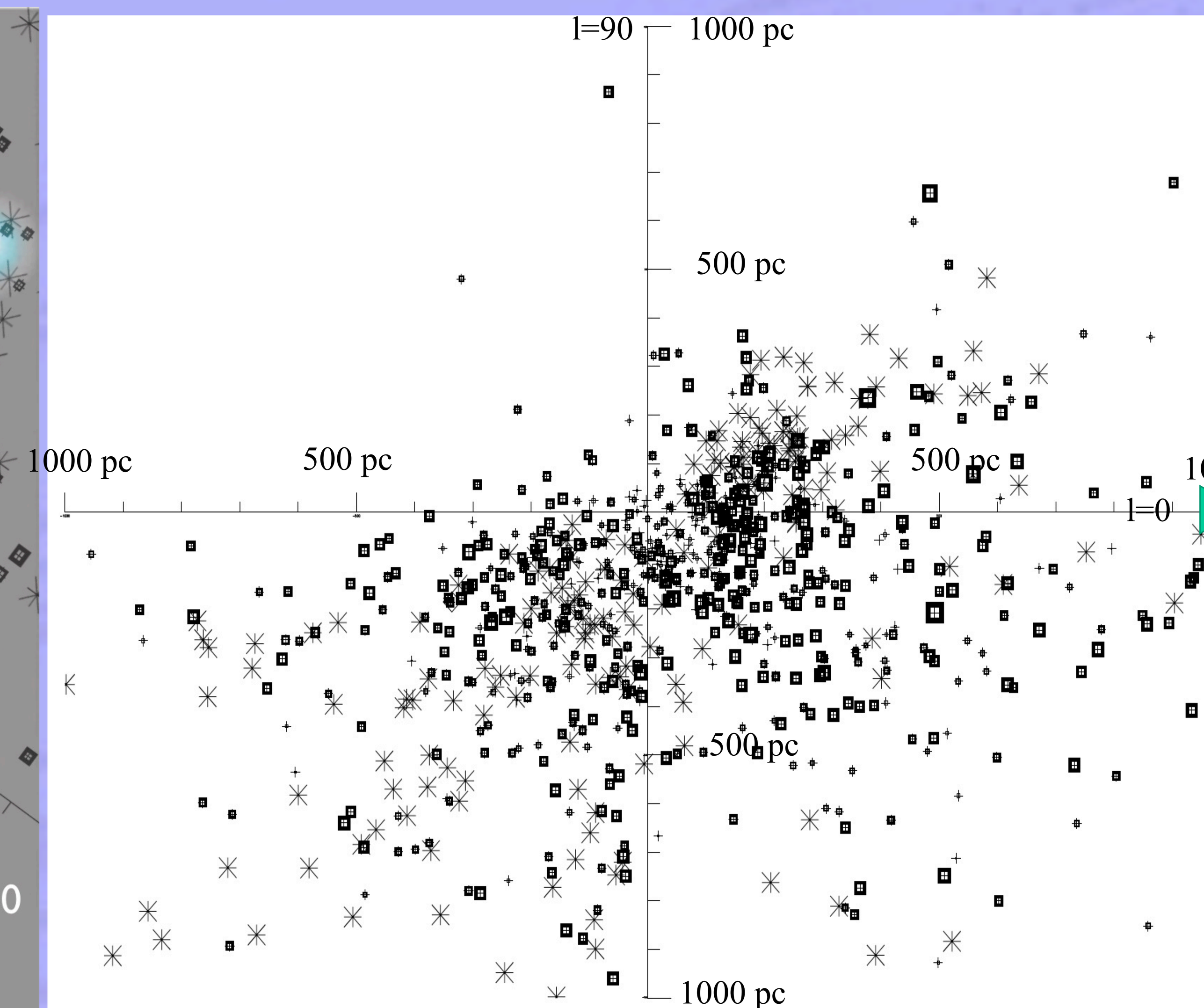


Figure Caption: (above) - Map of galactic plane with locations of stars observed with CHIRON (asterisks), and from Welsh et al (2011). The distances of the stars have been recomputed using the GAIA parallax data and the locations of strong NaI absorption are indicated with symbols size scaling with log (N(NaI)). The Green Arrow points toward the galactic center (l=0)

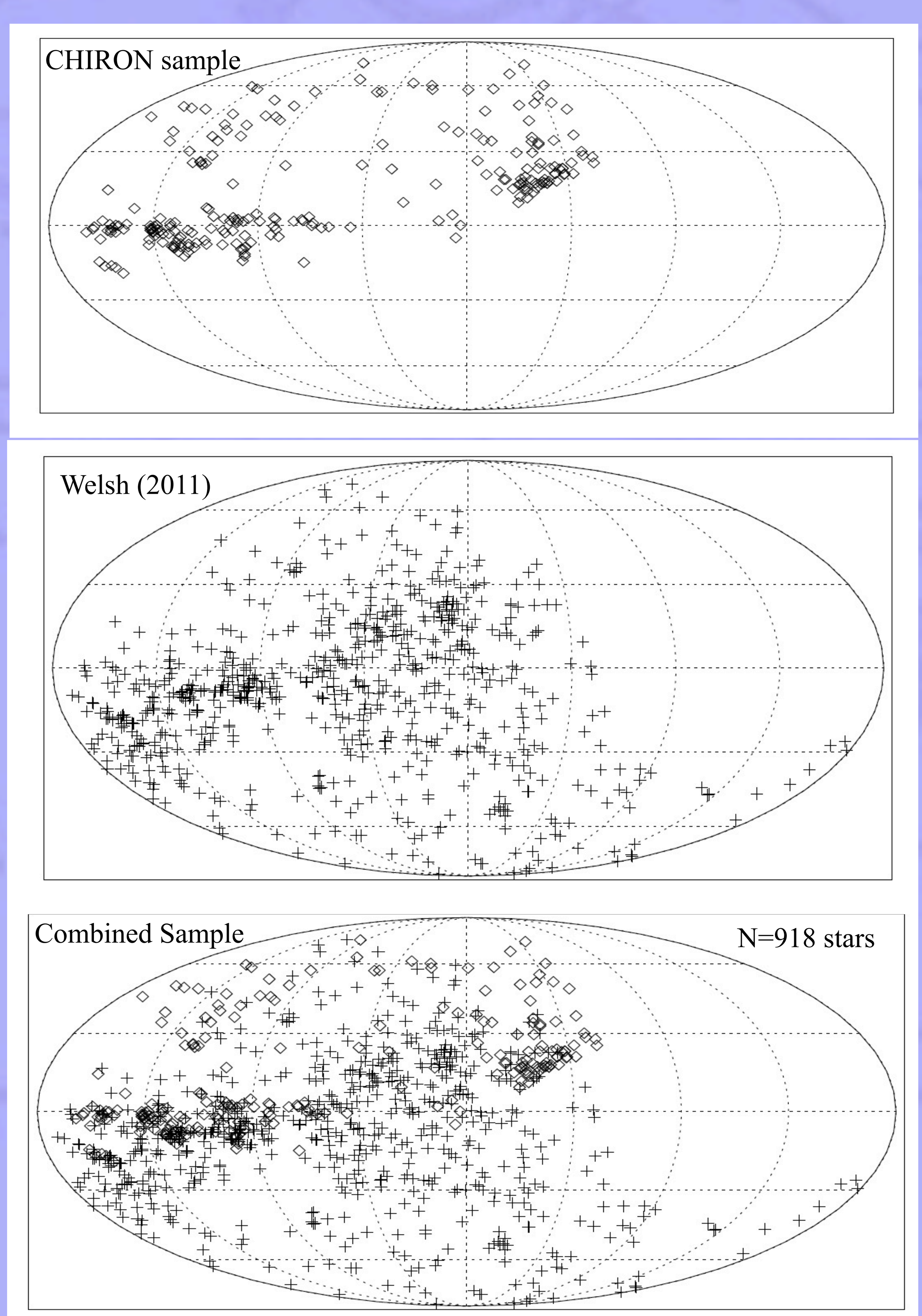


Figure Caption: (top) Mollweide projection of the CHIRON sample of 230 stars in galactic coordinates. The stars were selected to include better sampling of intermediate distances and to fill in additional regions not covered by the Welsh et al (2010) sample (middle). The bottom panel shows the entire sample of our study, which includes 918 stars.

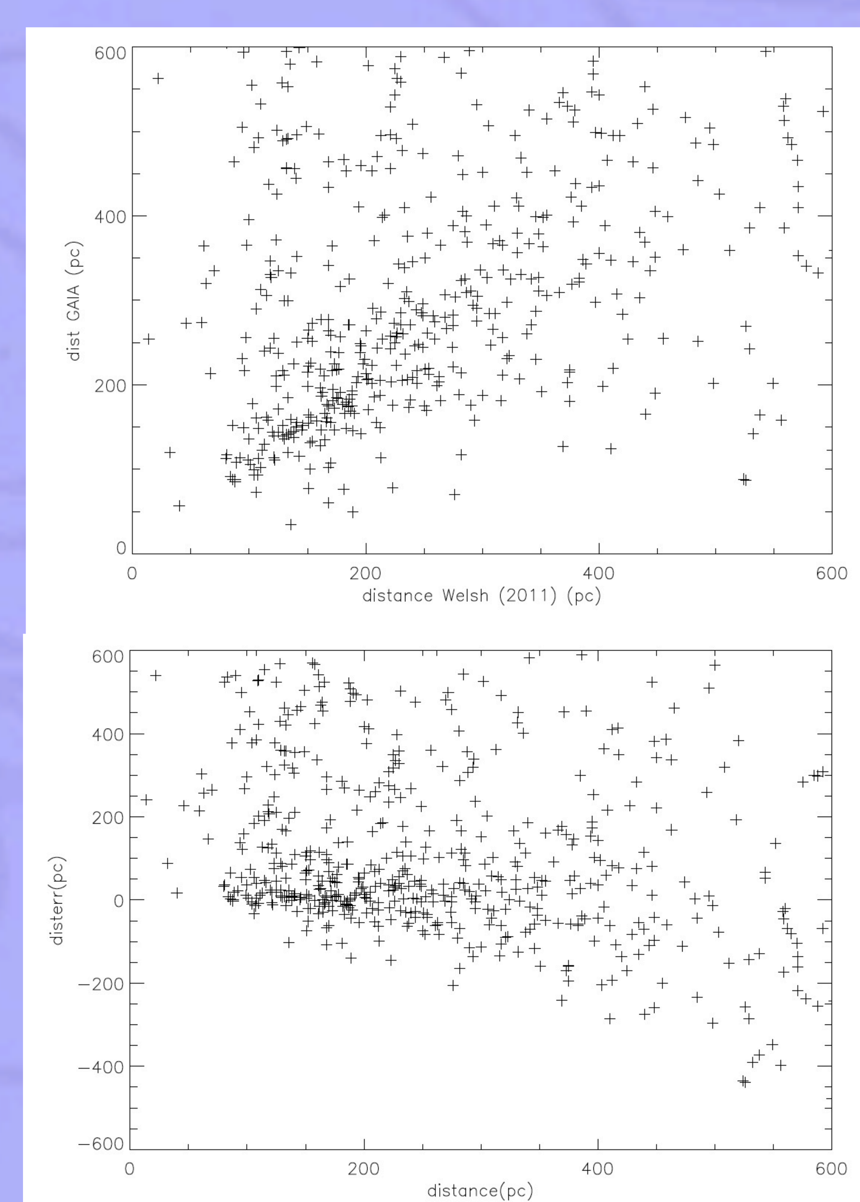
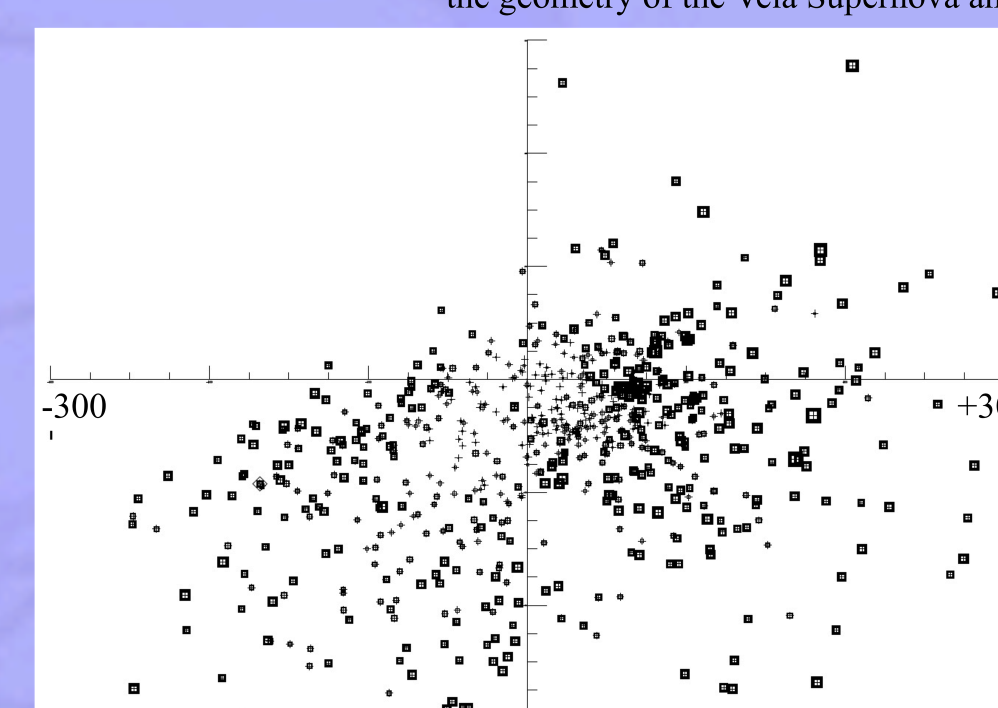
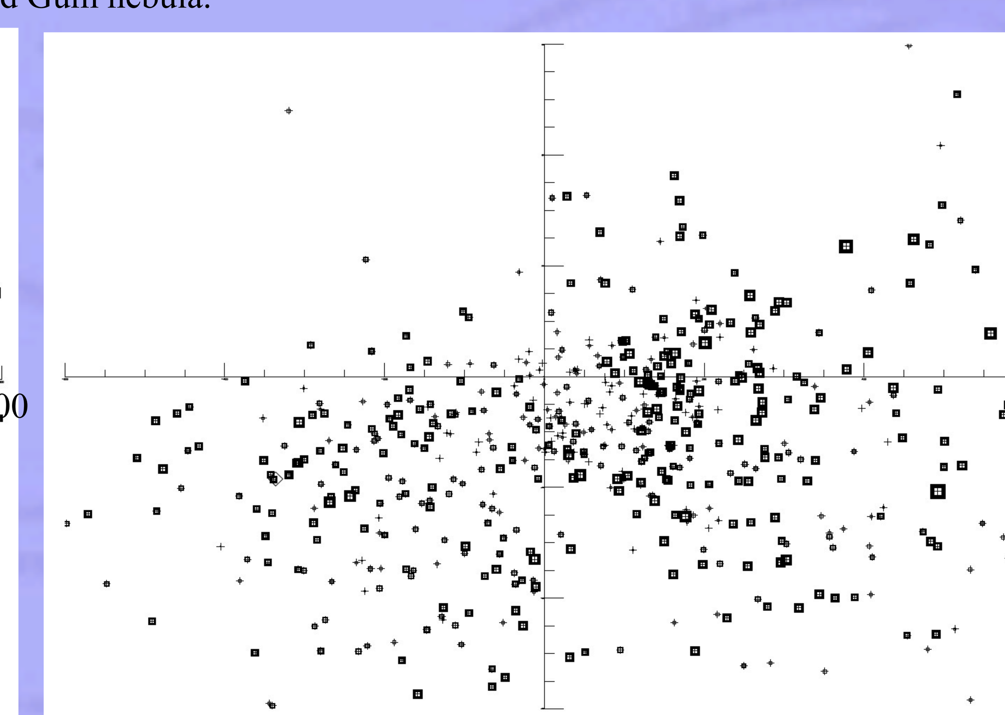
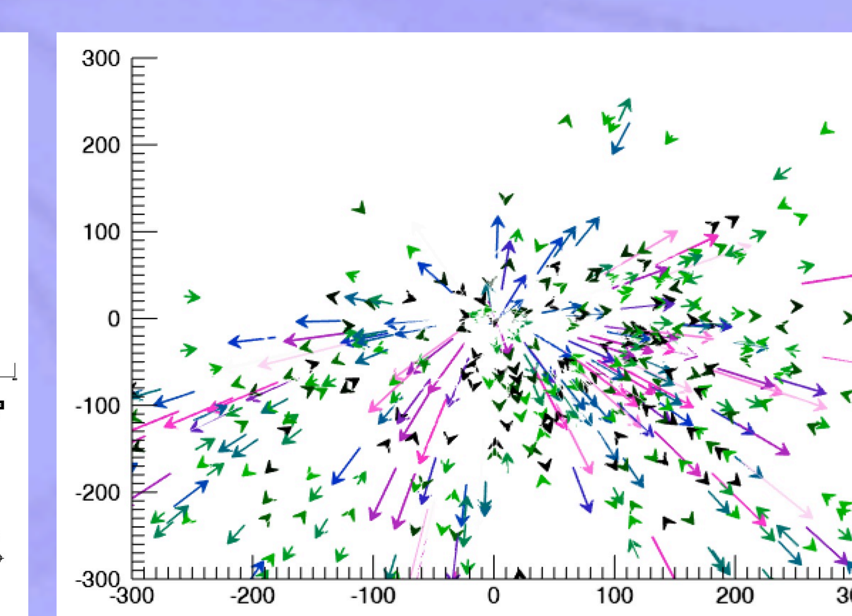


Figure Caption: (top) – A reanalysis of the distances of stars reported in Welsh et al (2010) shows substantial discrepancies between pre-GAIA stellar distances, and more accurately determined parallaxes based on the GAIA DR1. (bottom) – A plot of the difference in distance between the GAIA parallax distances and the values reported in Welsh et al (2010). The differences in distances with the new parallax data implies substantial modifications in the shape and extent of the local bubble as derived from stellar spectroscopy.







(Right) - The central element of the Pomona College Cyclotron appears within this case, and this circular metal device was capable Of accelerating protons to energies of several million electron Volts, and was housed in the basement of Millikan Laboratory. Newer equipment such as electron and AFM microscopes, quadropole spectroscopy and non-linear optics labs, a And a new Bose-Einstein condensate laboratory are part of the present-day Pomona College physics Laboratory facilities.

References

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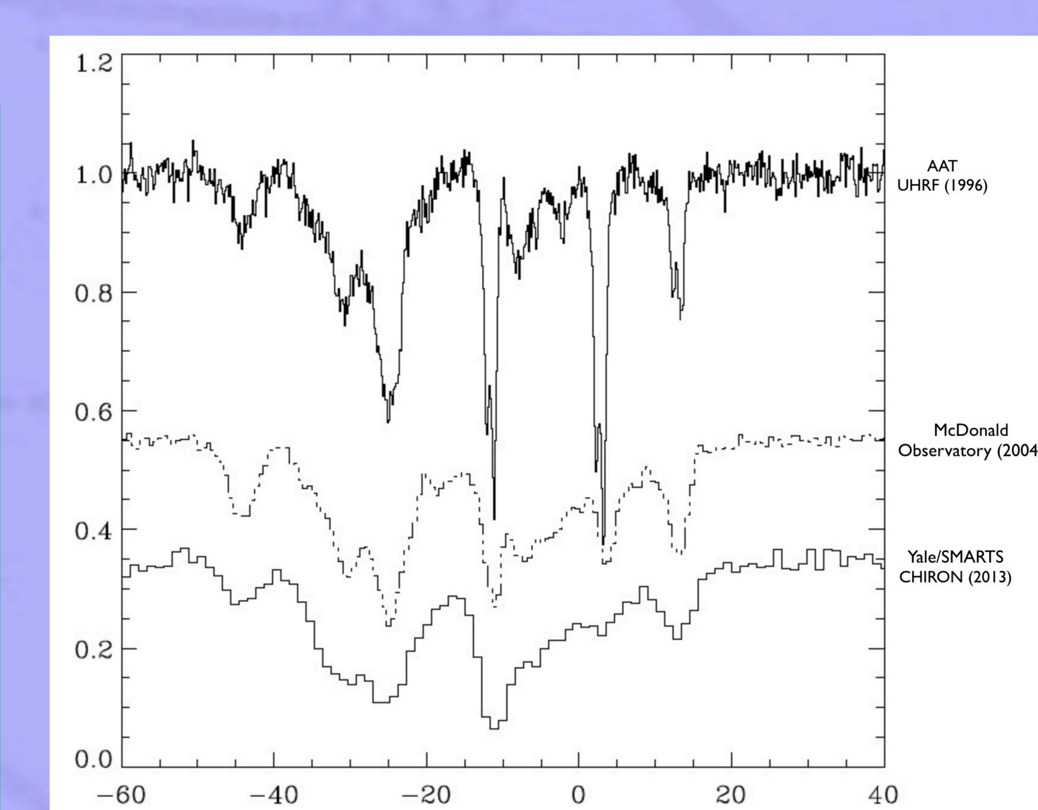

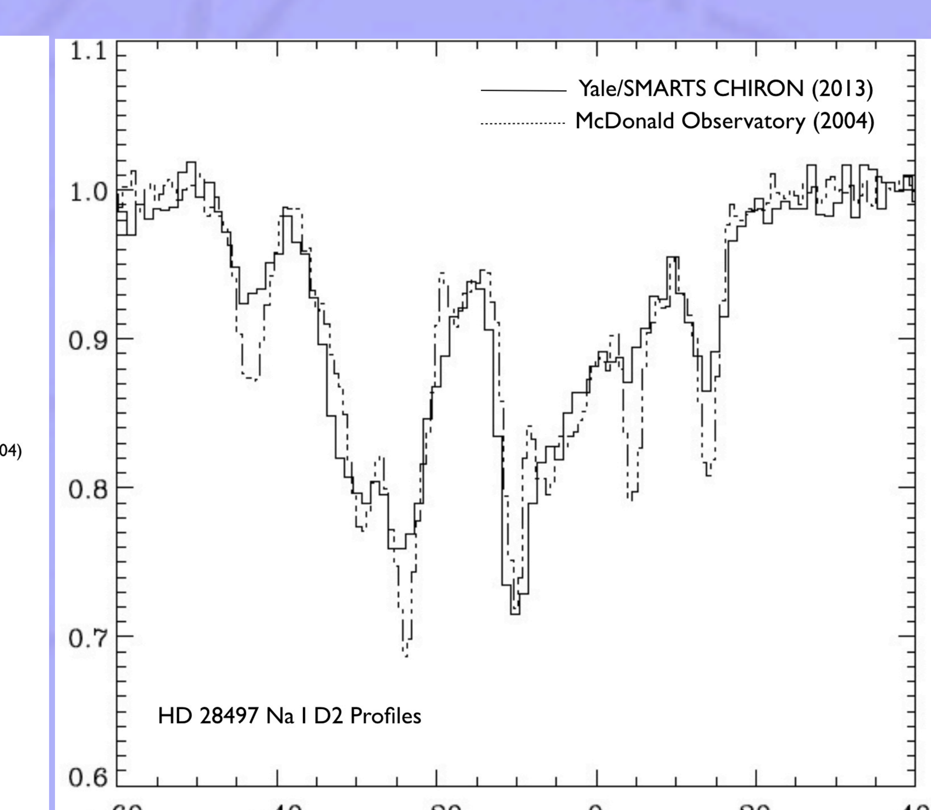

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