Validating Galfast Star Counts

1. Comparing VVV Data to Galfast and Besancon Models

Our original aim was to compare the bulge data from the ESO Vista Variables in the Via Láctea (VVV) (Saito et al. 2012) to Galfast output and use Besançon (Robin et al. 2003) and Trilegal (Girardi et al. 2005) output as a further check on both since Saito et al. (2012) also used it as a comparison. Therefore, the first step was to gather data in a 1 sq. degree region centered at galactic coordinates (l,b) = (0.0, -9.5). The VVV data is in VISTA JHK$_s$ colors, but in Saito et al. (2012) they indicate that the JHK system provided by Besançon output is close enough for comparison purposes. To convert SDSS magnitude output from Galfast to JHK, we used the conversions provided in equation 1 and table 2 of Covey et al. (2007). Furthermore, to account for A_{Ks} and E(J-K$_s$) we followed the same procedure as Saito et al. (2012) using the reddening maps of Gonzalez et al. (2012) along with the extinction law of Cardelli et al. (1989). In the case of the Trilegal data, there is only the option of obtaining circular pointings in simulations rather than the rectangular options available in Galfast and Besançon. Furthermore, the output of Trilegal lacks position information beyond distance modulus so in order to match the Trilegal output processing to the other models we took a 1 sq. deg. region centered at (l,b) = (0.0, -9.5) like the rest and then randomly assigned the output to one of the 16 smaller areas with equal weight before adding in the extinction to each of the areas.

The results of this comparison are shown in Figure 1. Galfast counts seem to be consistently at half the amount of the VVV survey and the corresponding Besançon counts, but seem to be comparable to Trilegal numbers. Figures 2-4 further break down the Thin Disk, Thick Disk, and Bulge counts of the three models. The relationship shown by Galfast to the other models in Figure 1 is fairly consistent across the thin disk up to about K magnitude 16.5. In Figures 3 & 4 Galfast seems to underestimate the Besançon counts consistently and they seem to follow very similar curves. However, comparisons to Trilegal are inconsistent as this model underestimates Thick disc counts compared to the other two models while falling in between Besançon and Galfast in Bulge Counts. Trilegal bulge counts also feature a sharper leveling off at fainter magnitudes than the other models.

In order to make sure that the conversions to J & K magnitudes were not a source of the discrepancy between Galfast and the higher VVV and Besançon counts we decided to check the conversions. We converted V,R,I magnitudes out of Besançon to SDSS g-i values using the transformations from Table 3 in Jordi et al. (2006) and then applied the conversions used above from Covey et al. (2007) to get converted K magnitudes. We then compared these to the K magnitudes out of Besançon for the same catalog and the results are shown in Figure 5. Based upon the results of this comparison we decided that our conversions gave reasonable results and that the underestimation in the plot is actually present.

2. Comparing Galfast to Besancon and Trilegal models in Galactic Bulge Region

Our next goal was to learn more about the differences in the models from each other in the 1 square degree bulge region centered at (l,b) = (0, -9.5) by looking at optical wavelengths. We chose to look at V-Band magnitudes since it was an output available directly from Besançon and Trilegal. We needed to perform more conversions to get Galfast output in the same band. We used the Lupton (2005) equations to convert SDSS magnitudes to the V-Band.

Comparing Galfast to Besançon (see Figures 6 & 7) we see that total Galfast counts are comparable to the Besançon in the V-Band with Galfast slightly lower at brighter magnitudes and higher at fainter magnitudes. When we look at the breakdown of the parts of each model the biggest difference is the contribution of the thick and thin discs between the models. In Galfast, the proportion between the two is fairly equal, but in the Besançon model at magnitudes fainter than V = 17 the thick disc count rapidly begins to grow much larger than the thin disc. The bulge and halo counts between the two seem to match well except for the large population of bright bulge stars of V < 16 in Besançon.

The breakdown of the Trilegal output into model components shows a very similar bulge count to Besançon and similar overall numbers to Galfast. Trilegal has a more similar thin and thick disc distribution to Galfast, but has a significantly smaller thick disc contribution at brighter magnitudes. The biggest difference between Trilegal and the other models is the large contribution from halo stars in this region. Both Galfast and Besançon had less than 5% of total stars marked as halo stars, but Trilegal has over 20%.

3. Comparing Galfast and other models to the SDSS Stripe 82 Data

Finally we decided to compare each of the models to another dataset. We chose to use the SDSS Stripe 82 Data and compare in 10 degree segments of RA and spanning the full -1.25 < Dec < 1.25 range of the Stripe 82 region. This way we were able to plot counts for the Stripe 82 data in g-i vs. r that are comparable to Figure 23 in Sesar et al. (2010). Next we divided these counts by those from each of the models based upon output from the same region. Difficulties arose once again in defining the region to the Trilegal model, but we used circular regions with a radius $\approx 0.63^\circ$ and located at approximately Dec = $\pm\ 0.63^\circ$ and centered 1 diameter apart in RA. We also had to convert Besançon magnitudes to SDSS magnitudes with the Jordi et al. (2006) equations.

Results are shown in figures 9-14 with the color range defining the log[counts] in each bin. The scale factor was a value that we multiplied with the model counts to give us a more accurate match to the total numbers in the model output and the data. The scale factor was calculated by finding the median Stripe 82/Model count for the region defined by 0.4 < g-i < 1.0 and 15 < r < 18.05. This region was chosen in order to get a good representation of thin and thick disc stars and a good number of counts from both models and data. The white spots on the plots are areas where

either the data or the model did not have a count greater than 5. There also appear to be issues with the Besançon g-i results, but this could be due to the binning effects brought about by the lower number of model stars in the region compared to data and the other two models. In order to understand the problem better and make sure there wasn't something in the conversion to g-i that was causing a binning error we decided to look at V-I which is the UBVRI color used to convert to g-i in the Jordi et al. (2006) equations. Figure 15 shows the distributions of V-I in the same region used in figure 9. There is nothing to suggest anything obviously causing the errors in this plot, so we then looked at a comparison of the g-i values after the conversion of Besançon magnitudes to the g-i values of galfast in the same region in figure 16. Here we see that the galfast results present a continuous distribution throughout the values g-i > 0.3 while the Besançon values do not and it seems to be a direct result of the V-I distribution within Besançon.

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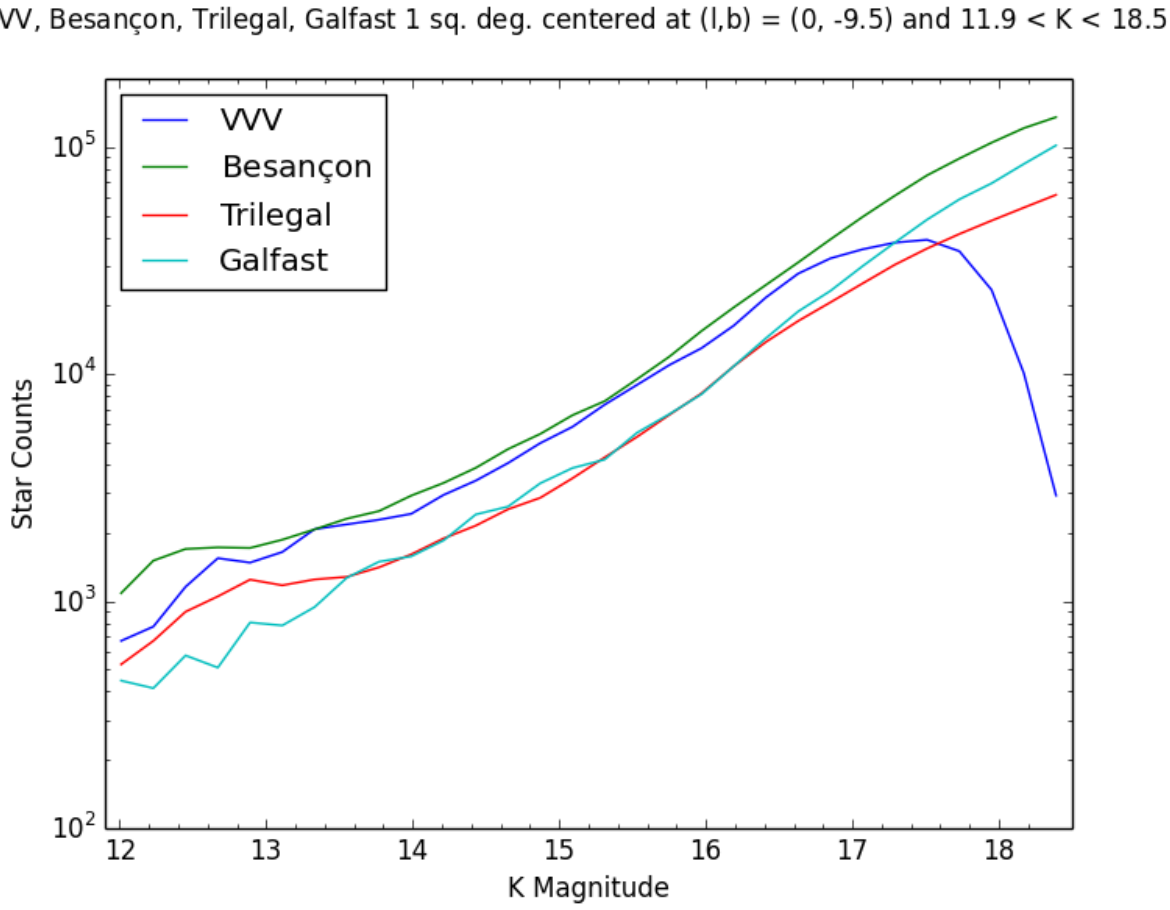

Fig. 1.— Comparing VVV Data to model catalogs from Galfast, Besançon and Trilegal in the bulge region.

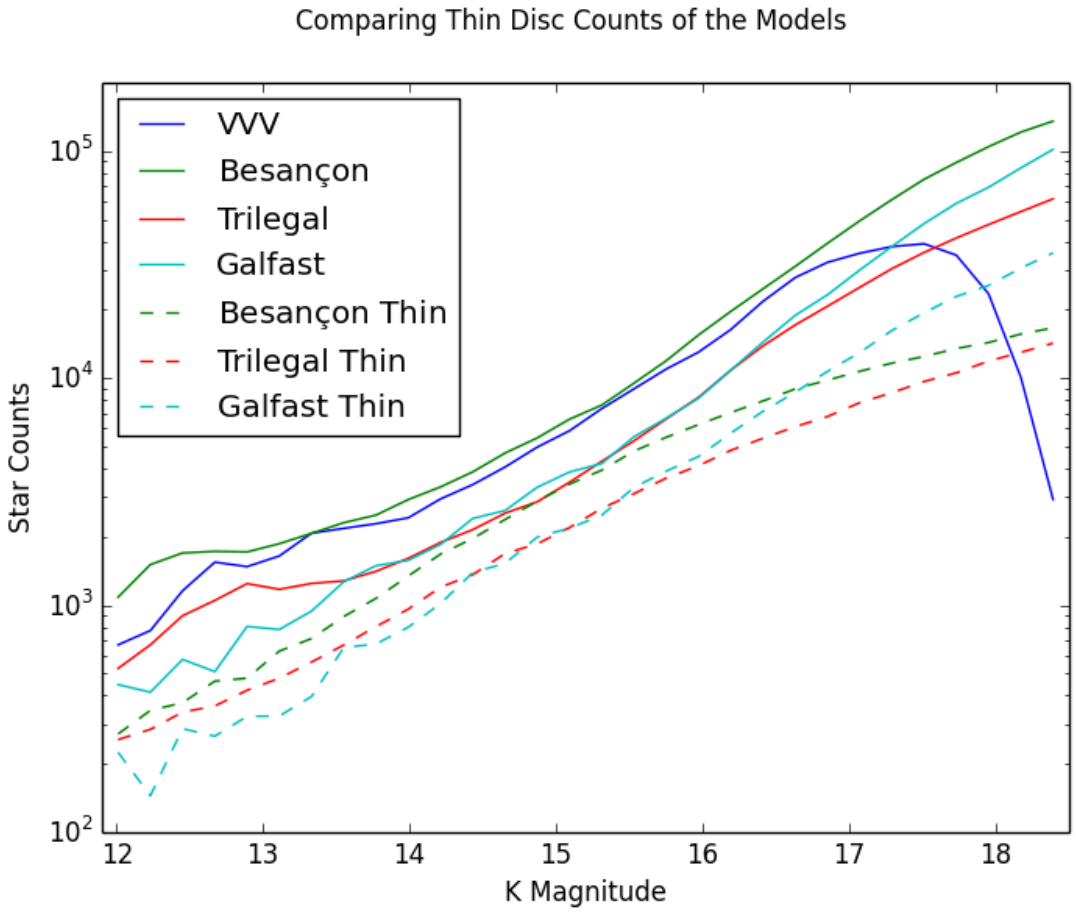

Fig. 2.— Breaking the results of Fig. 1 into thin disc components.

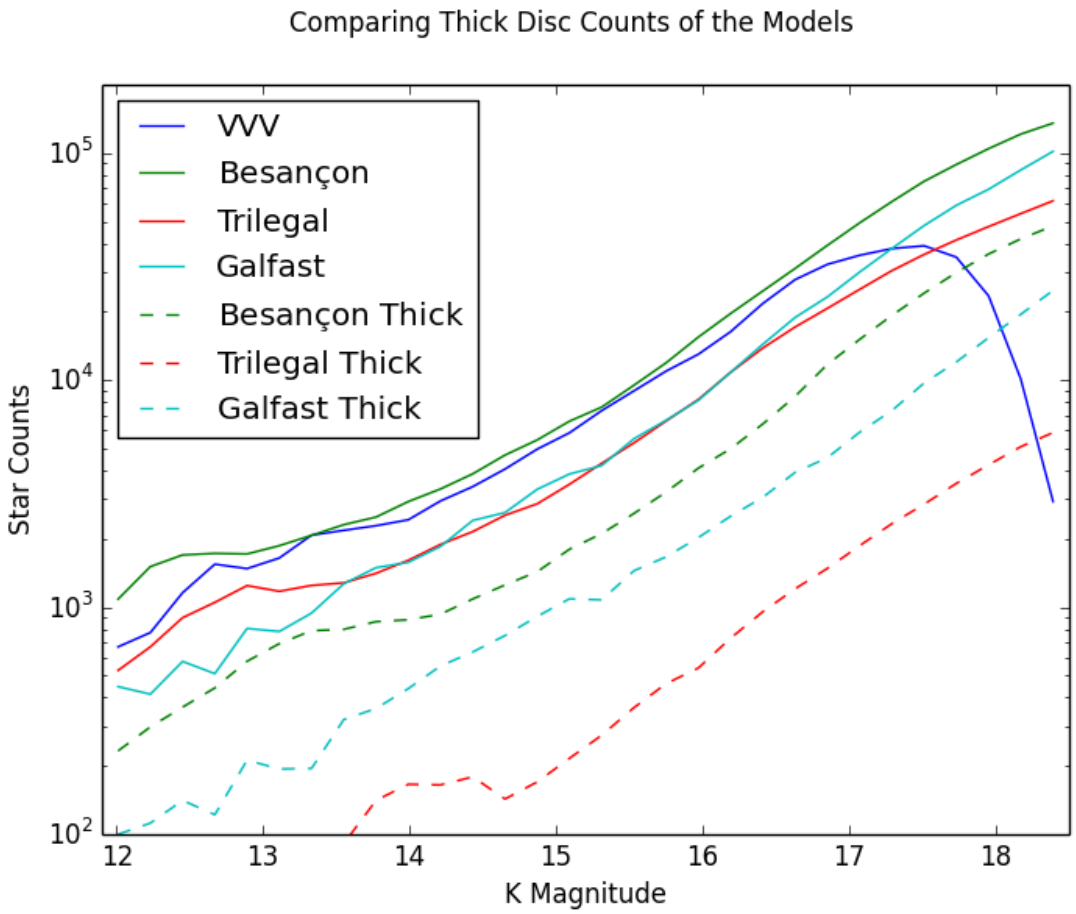

Fig. 3.— Breaking the results of Fig. 1 into thick disc components.

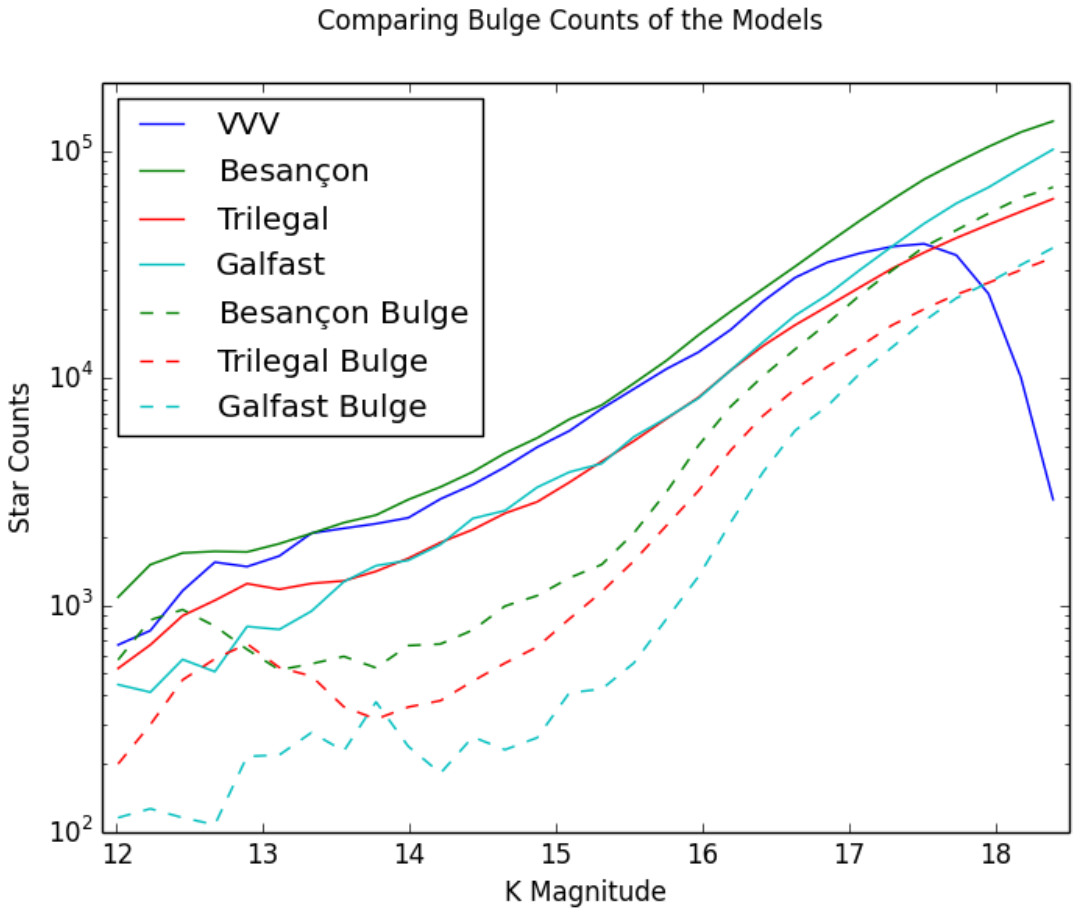

Fig. 4.— Breaking the results of Fig. 1 into bulge components.

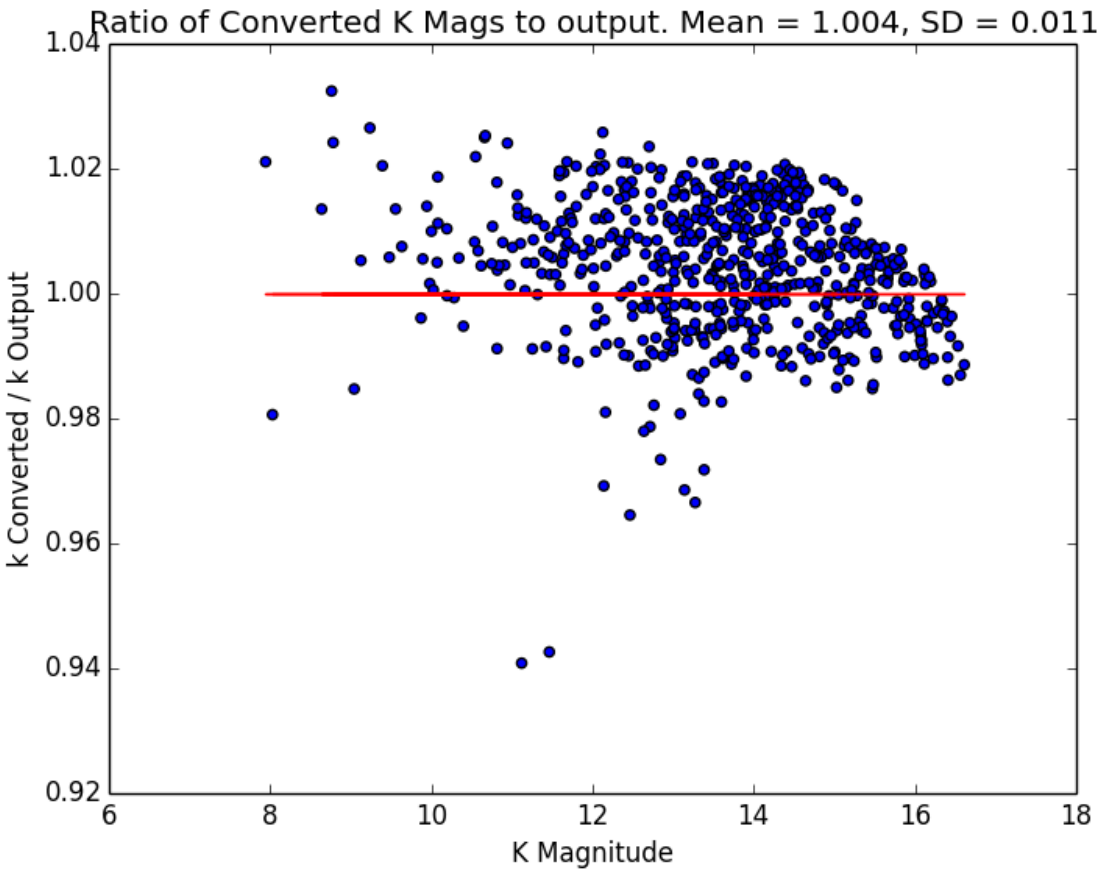

Fig. 5.— Comparing K magnitudes from Besançon output to K magnitudes calculated from Besançon V,R,I magnitudes.

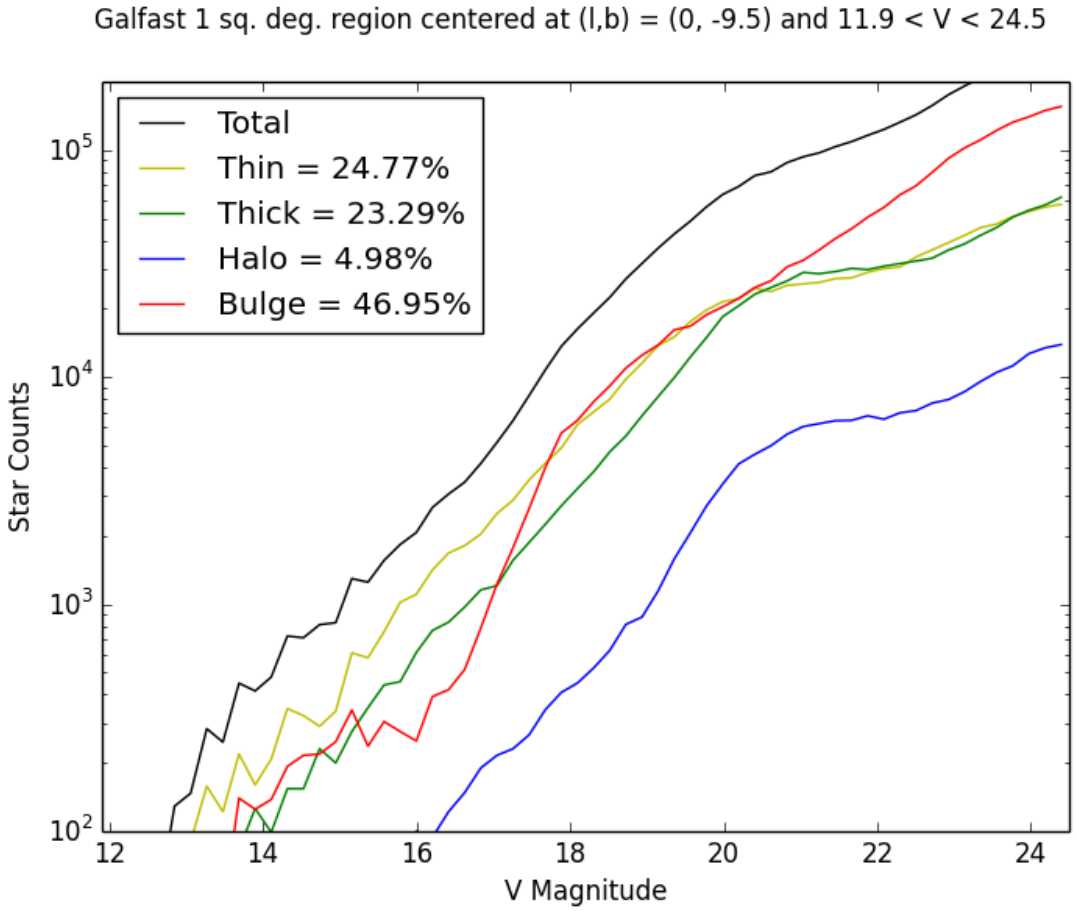

Fig. 6.— A breakdown of counts from Galfast output in V magnitude for same area on sky as Part 1.

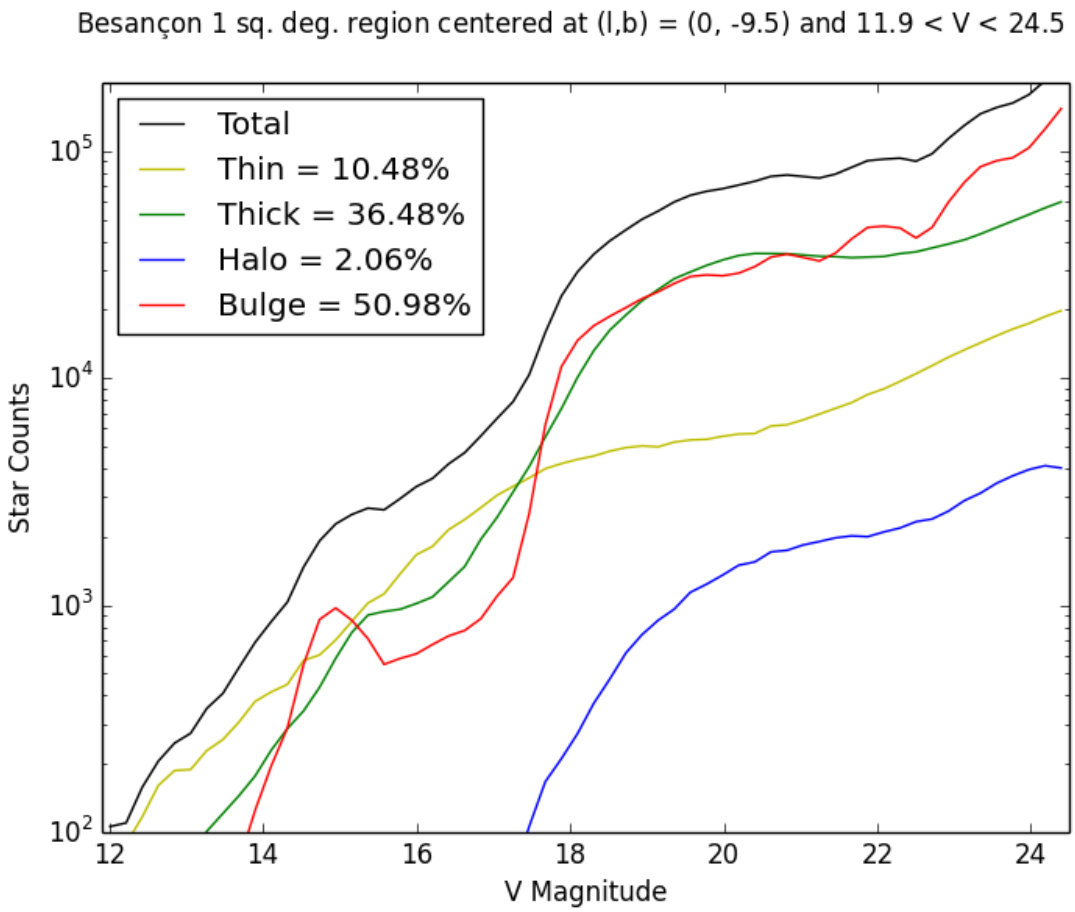

Fig. 7.— A similar plot as the previous figure for the Besançon output.

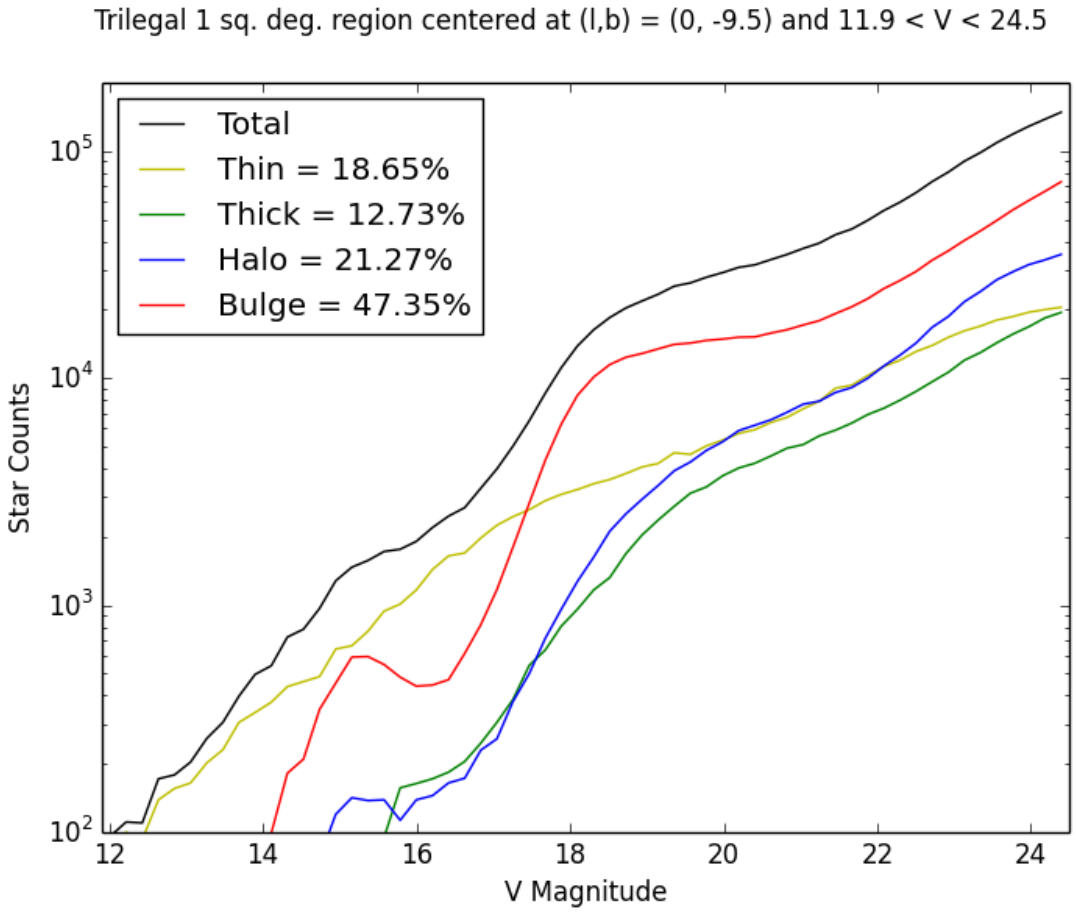

Fig. 8.— A similar plot as the previous figure for the Trilegal output.

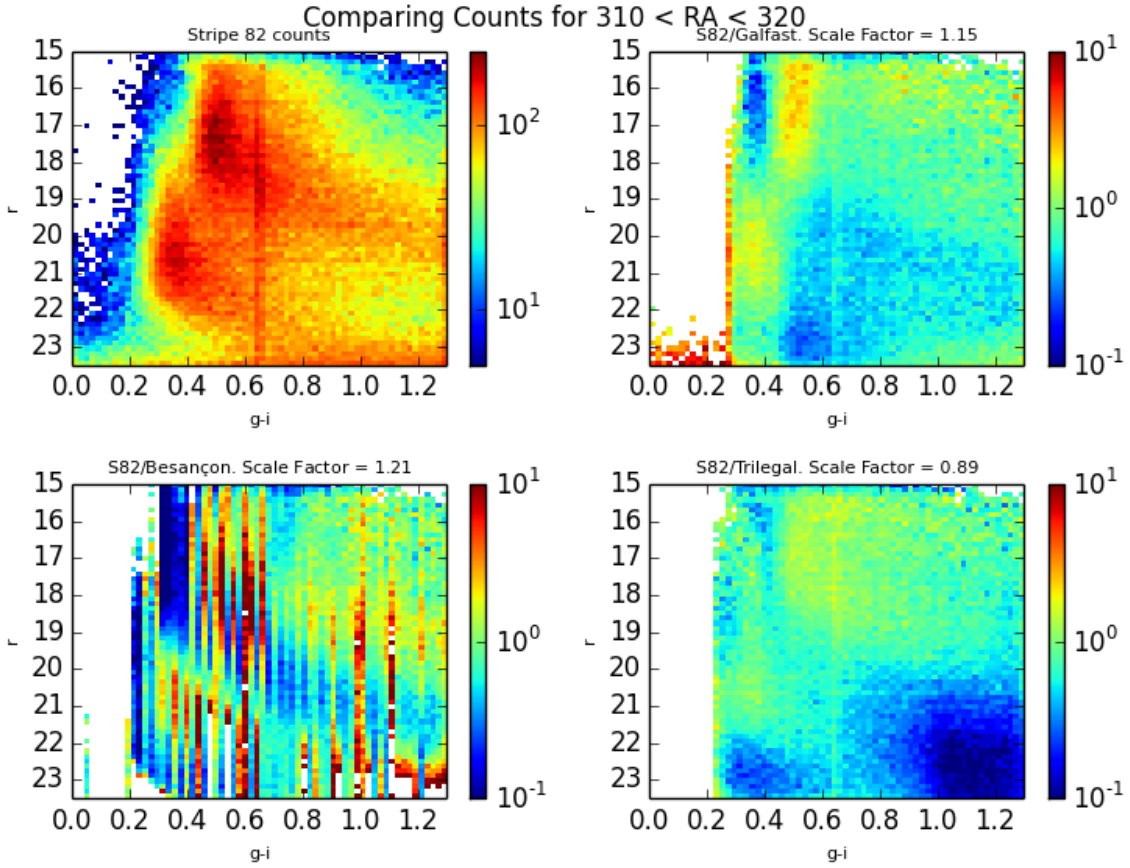

Fig. 9.— A plot comparing the log[counts] of the various models to those of the SDSS Stripe 82 data in the region with 310 < RA < 320. Scale Factor refers to the constant by which the models counts were multiplied to give a median Stripe 82/Model count value of 1.0 in the region 0.4 < g-i < 1.0 and 15 < r < 18.05.

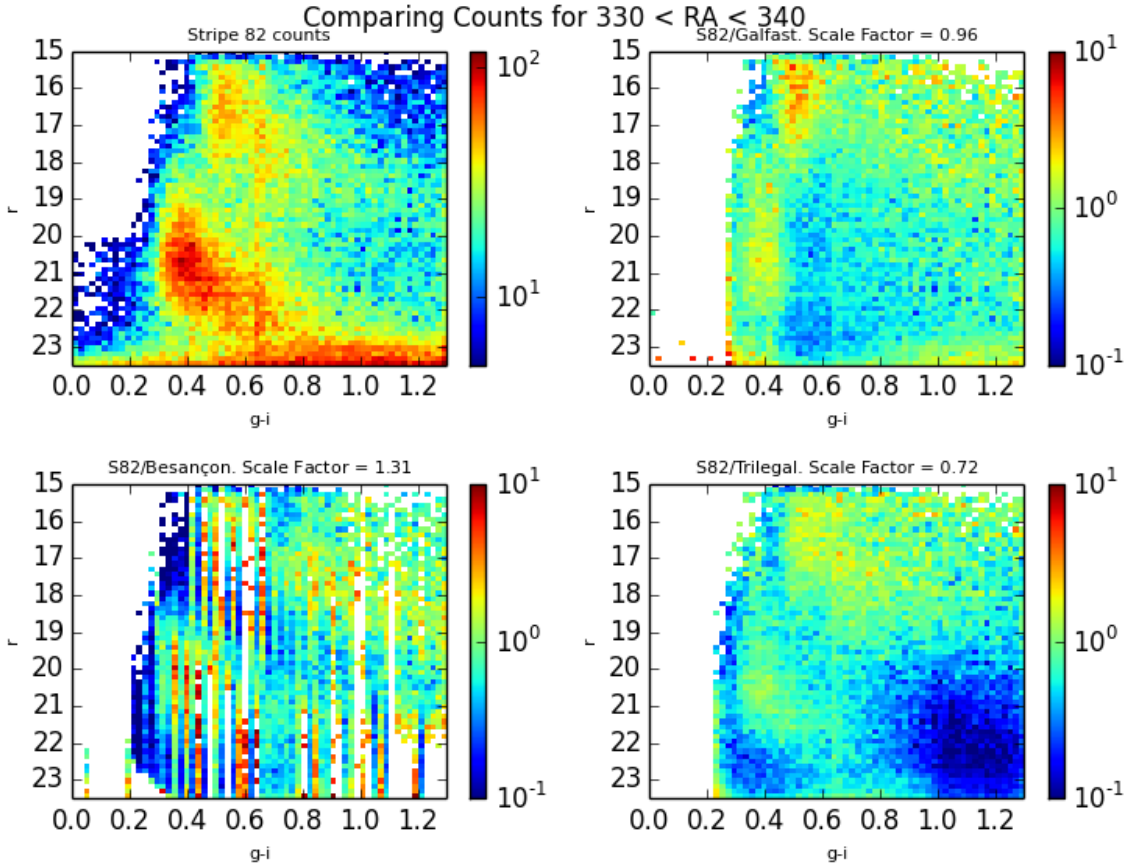

Fig. 10.— A plot comparing the log[counts] of the various models to those of the SDSS Stripe 82 data in the region with 330 < RA < 340. Scale Factor refers to the constant by which the models counts were multiplied to give a median Stripe 82/Model count value of 1.0 in the region 0.4 < g-i < 1.0 and 15 < r < 18.05.

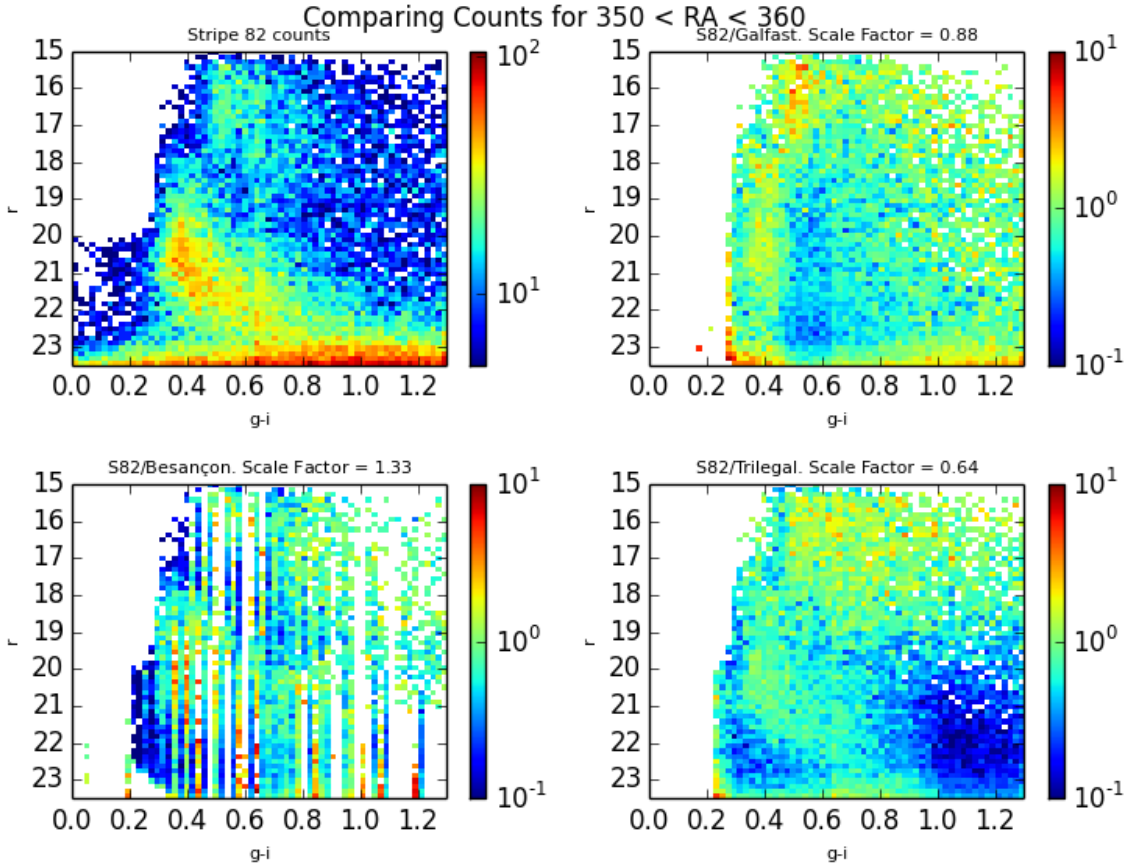

Fig. 11.— A plot comparing the log[counts] of the various models to those of the SDSS Stripe 82 data in the region with 350 < RA < 360. Scale Factor refers to the constant by which the models counts were multiplied to give a median Stripe 82/Model count value of 1.0 in the region 0.4 < g-i < 1.0 and 15 < r < 18.05.

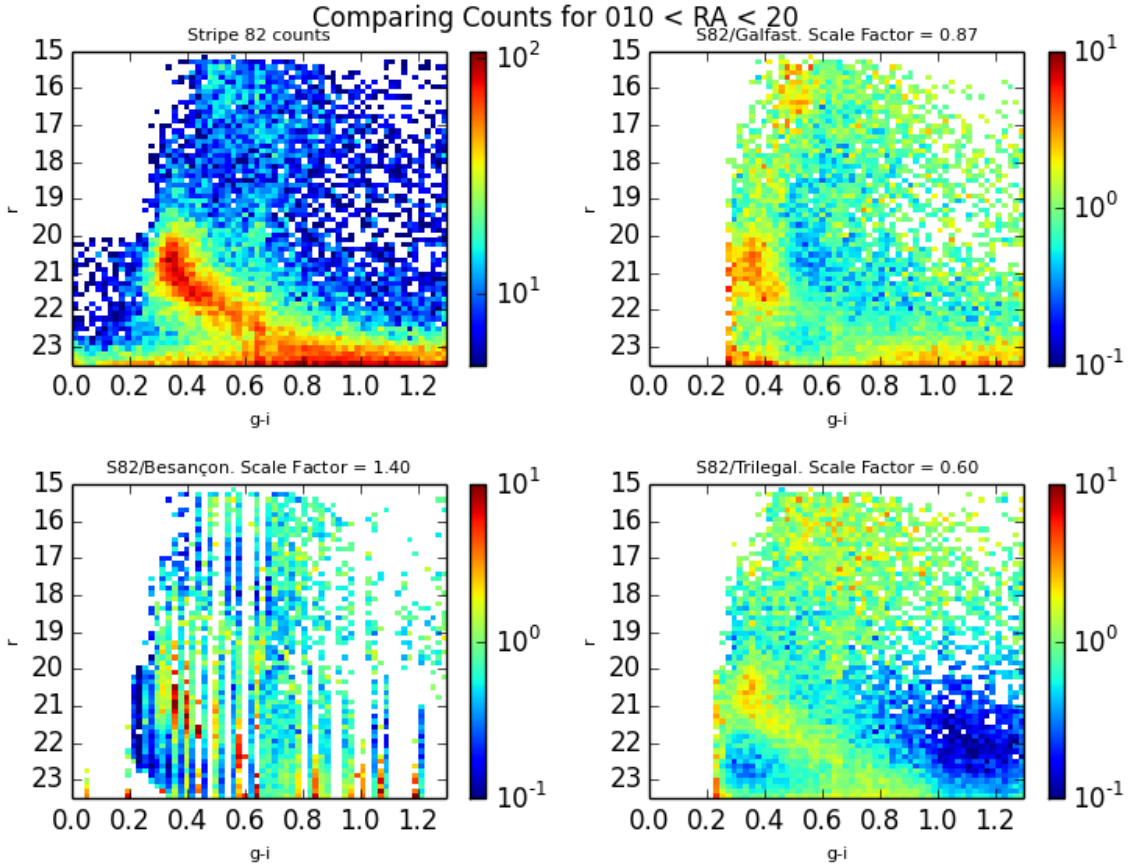

Fig. 12.— A plot comparing the log[counts] of the various models to those of the SDSS Stripe 82 data in the region with 10 < RA < 20. Scale Factor refers to the constant by which the models counts were multiplied to give a median Stripe 82/Model count value of 1.0 in the region 0.4 < g-i < 1.0 and 15 < r < 18.05.

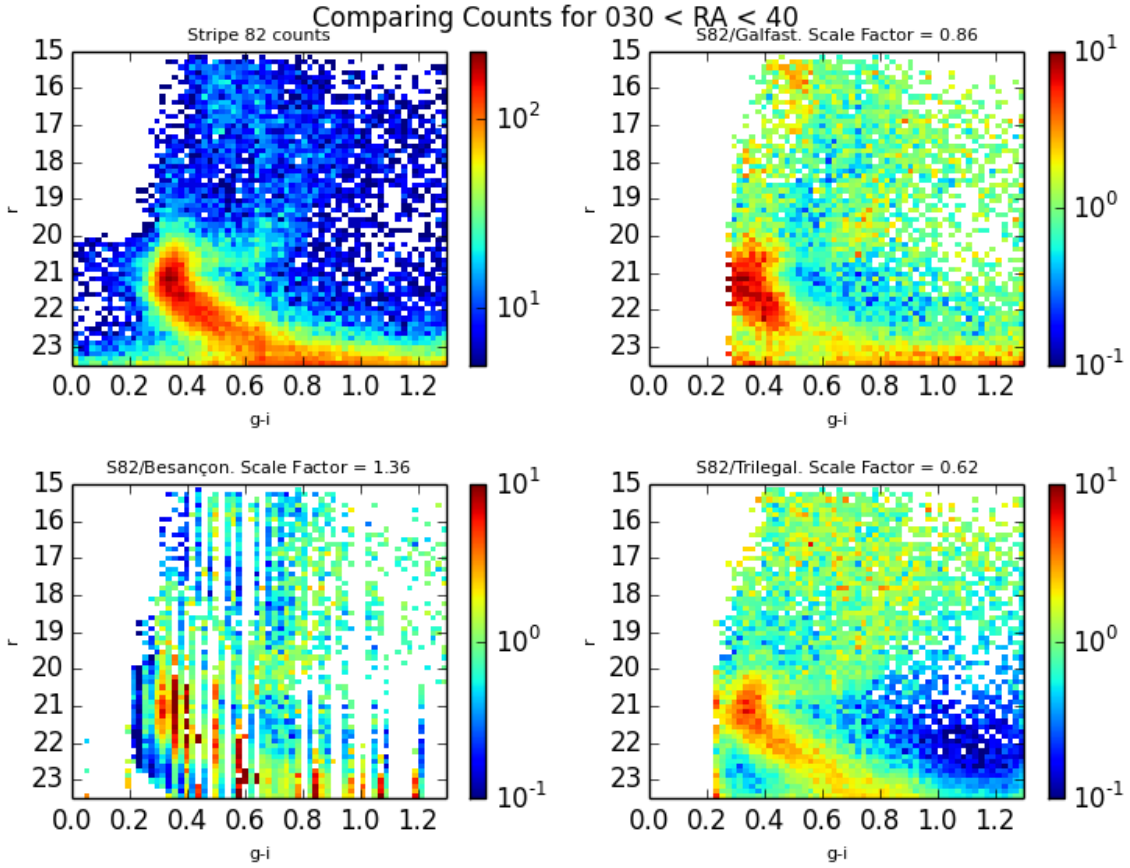

Fig. 13.— A plot comparing the log[counts] of the various models to those of the SDSS Stripe 82 data in the region with 30 < RA < 40. Scale Factor refers to the constant by which the models counts were multiplied to give a median Stripe 82/Model count value of 1.0 in the region 0.4 < g-i < 1.0 and 15 < r < 18.05.

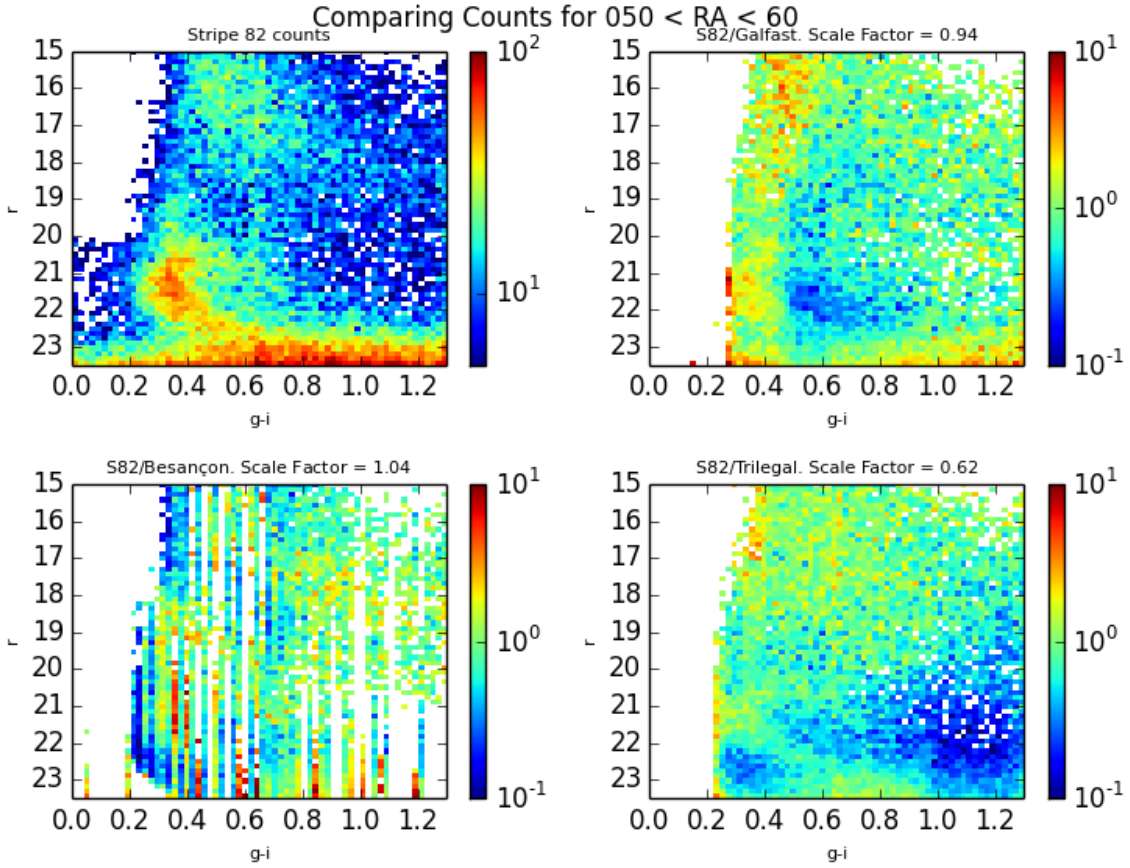

Fig. 14.— A plot comparing the log[counts] of the various models to those of the SDSS Stripe 82 data in the region with 50 < RA < 60. Scale Factor refers to the constant by which the models counts were multiplied to give a median Stripe 82/Model count value of 1.0 in the region 0.4 < g-i < 1.0 and 15 < r < 18.05.

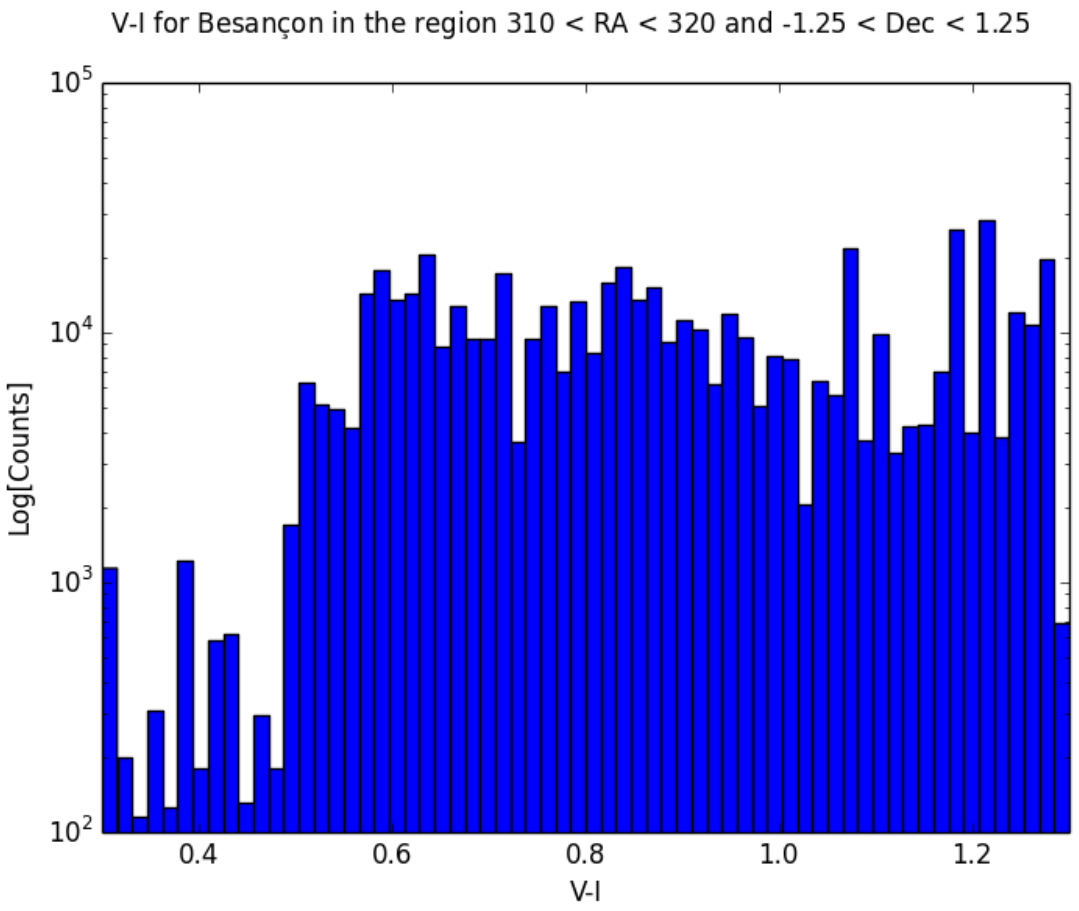

Fig. 15.— V-I for Besançon model in region plotted in figure 9.

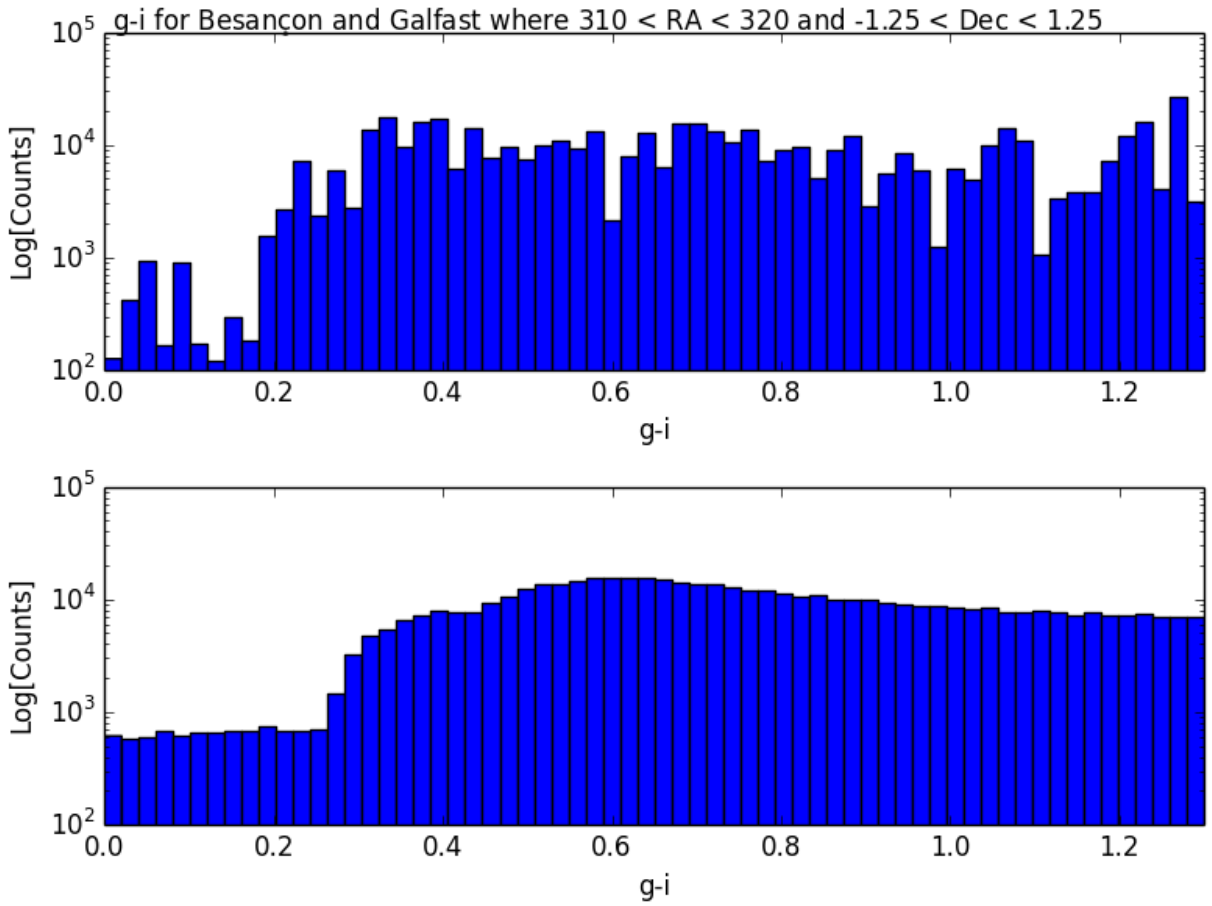

Fig. 16.— Comparing g-i for Besançon and Galfast models in region plotted in figure 9.