Kinematics of Nearby Stars from Hipparcos Database

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Introduction

The kinematical description of the local disk stars is a fundamental issue in the understanding of the structure and evolution of the Milk Way. The statistics of velocities in the solar neighborhood provide a database to describe the dependence of the disk kinematics with age, metallicity and spectral class.

Traditionally, the velocity field in the solar neighborhood is described by a single Gaussian corresponding to the Schwarzschild (1907) velocity distribution.

$$f(\mathrm{u}, \mathrm{v}, \mathrm{w}) = \frac{1}{(8\pi^3)^{1/2}\sigma_\mathrm{u}\sigma_\mathrm{v}\sigma_\mathrm{w}} \exp(Q)$$

$$Q = -\frac{1}{2}\left(\frac{\mathrm{u}^2}{\sigma_\mathrm{u}^2} + \frac{\mathrm{v}^2}{\sigma_\mathrm{v}^2} + \frac{\mathrm{w}^2}{\sigma_\mathrm{w}^2}\right)$$

From a selected sample of Hipparcos stars (ESA 1997) divided in six spectral type groups, we investigated the representation of this velocity distribution by a composition of two Gaussians.

Material

Our work is based on a sample of about 22000 Hipparcos stars selected with the same criteria adopted by Mignard (2000): only single stars; stars lying in the distance interval of 0.1-2.0 Kpc; completeness larger than 70% based on the Tycho catalogue (ESA 1997) as a function of the Galactic latitude, magnitude and color; peculiar velocity smaller than 100 Km/s. In Mignard 2000 this limit is 60-90 Km/s depending on the spectral type.

Strategy

We used the Hipparcos proper motions and parallaxes to deduce the galactic components of the velocity field v_l and v_b for each star. The whole data sample was divided in 72 equal area regions in the celestial sphere and in each of these, we determine the velocity dispersion σ_{vl} and σ_{vb} for each Schwarzschild component. From their analysis we obtained the velocity dispersion in the U, V and W directions describing the disk kinematics (Table 1).

Analysis

In Table 1 we give velocity dispersion obtained with the two models. In Figures 1, 2 where blue points correspond to the selected sample and green points to the other Hipparcos stars, we show the HR diagram and the distribution in galactic latitude with the 70% completeness contour. In Figures 3, 4 we present the result of the two Gaussians fit in each sector of the first octant. Finally, the others Figures show the velocities distribution with the fit of the Gaussians and the behavior of the residuals (δN).

Results and discussion

As shown in Figures 5-10, for the early type stars the results are not significantly different from the treatment with only one Gaussian but for the late type stars it is easy to note the better representation of the distribution by two Gaussians instead of one. In this case, from Table 1, the presence of two kinematical populations is clear: one of high velocity dispersion ($\sigma_u \approx 40$ Km/s) and another of low velocity dispersion ($\sigma_u \approx 20$ Km/s), approximately the same that the early type stars. This suggests that for the late type stars, this procedure takes into account the spread of ages inside each group. The oscillation of the residuals in the central regions of the curves even in the two Gaussian solution, suggests the existence of another small population concentrated in the Galactic plane. If true, the statistics used here is not sufficient for a clear detection; a much larger and more accurate sample is necessary for an improved analysis as will be provided by the GAIA space mission.

References

- *ESA 1997, "The Hipparcos and Tycho catalogs", ESA SP-1200*
- *Mignard F., 2000, A&A, 354*
- *Schwarzschild K., 1907, Göttingen Nachr., 614*

Table 1

B – V	Sample	N stars	α %	σ_u Km/s Two Gaussians	σ_u Km/s One Gaussian
0.00-0.15	A0A5	4202	78	19.54±1.60 5.88±1.26	15.25±1.07
0.15 – 0.30	A5F0	3185	53	24.65±2.88 15.18±1.60	19.45±1.22
0.30 – 0.45	F0F5	2837	77	24.50±2.25 19.37±4.57	23.07±1.62
0.85 – 1.15	K0K5	6533	57	40.66±4.48 23.11±2.31	31.37±1.60
1.15 – 1.40	K5M0	3350	65	41.25±5.19 20.02±3.33	31.57±2.84
1.40 – 1.60	M0M5	2285	74	41.28±5.20 20.02±4.34	33.10±3.50

- **α** *give the proportion of high velocity dispersion stars.*
- *the u component of velocity is measured in the Galactic plane toward the Galactic center.*

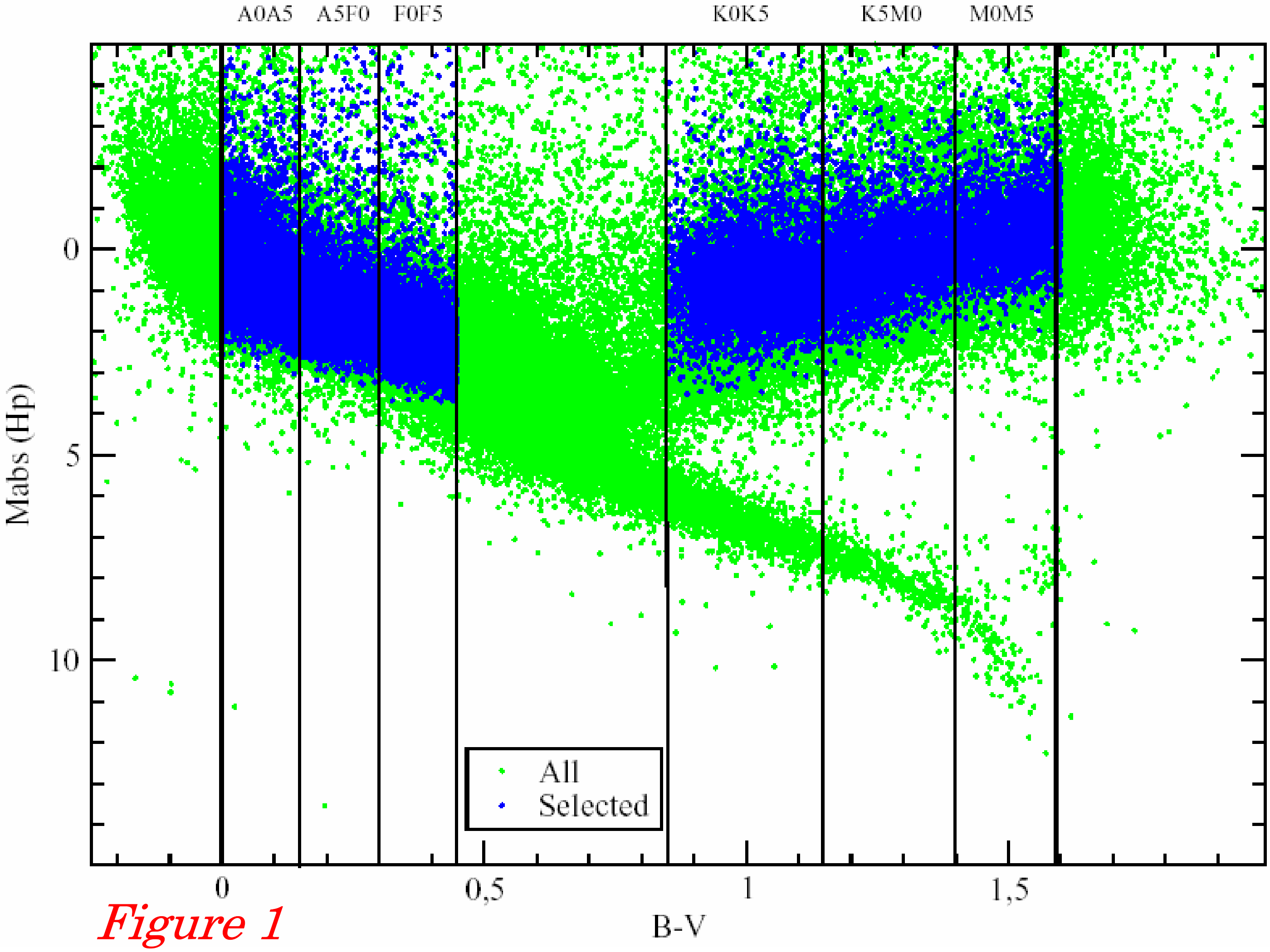


Figure 1

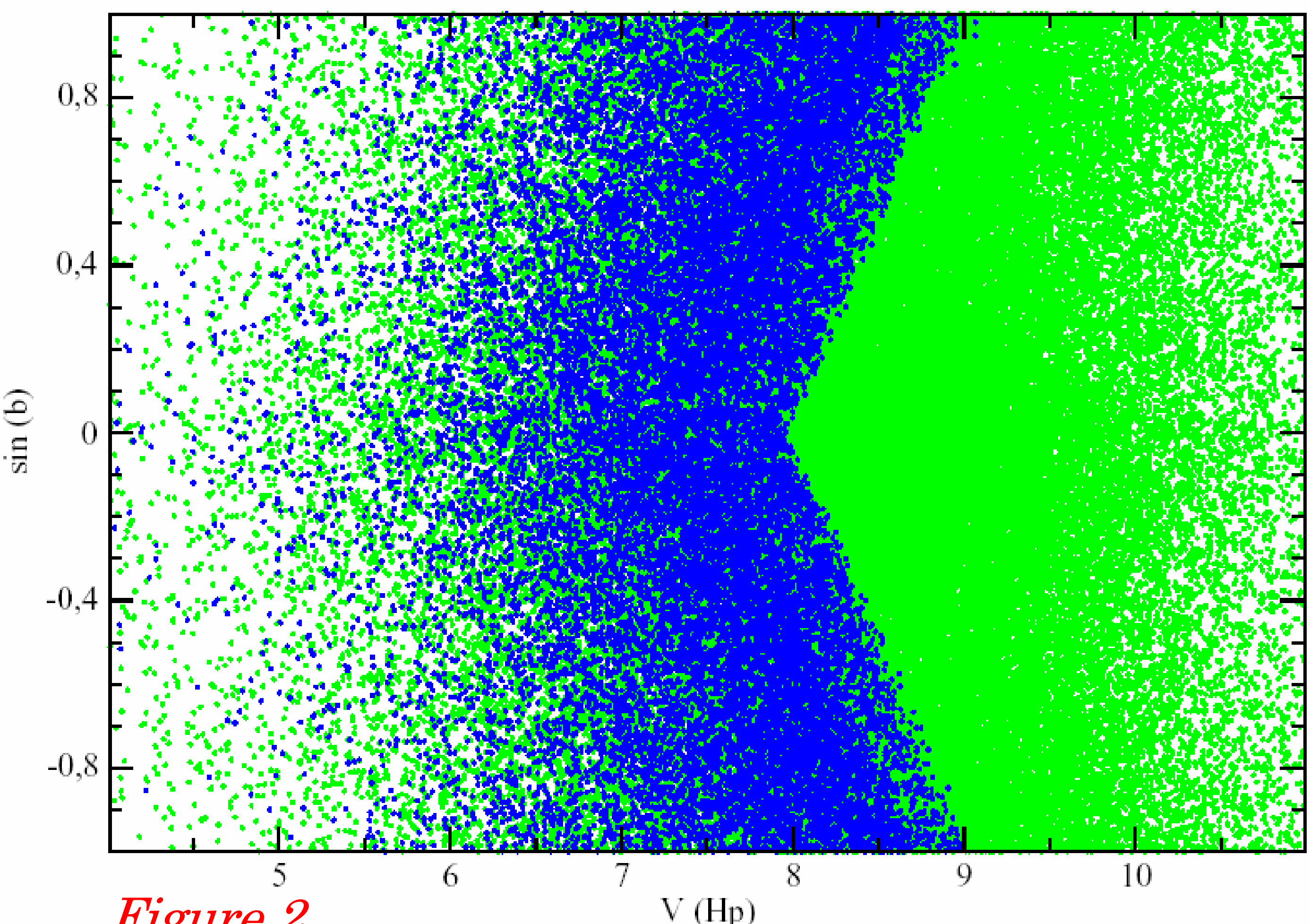
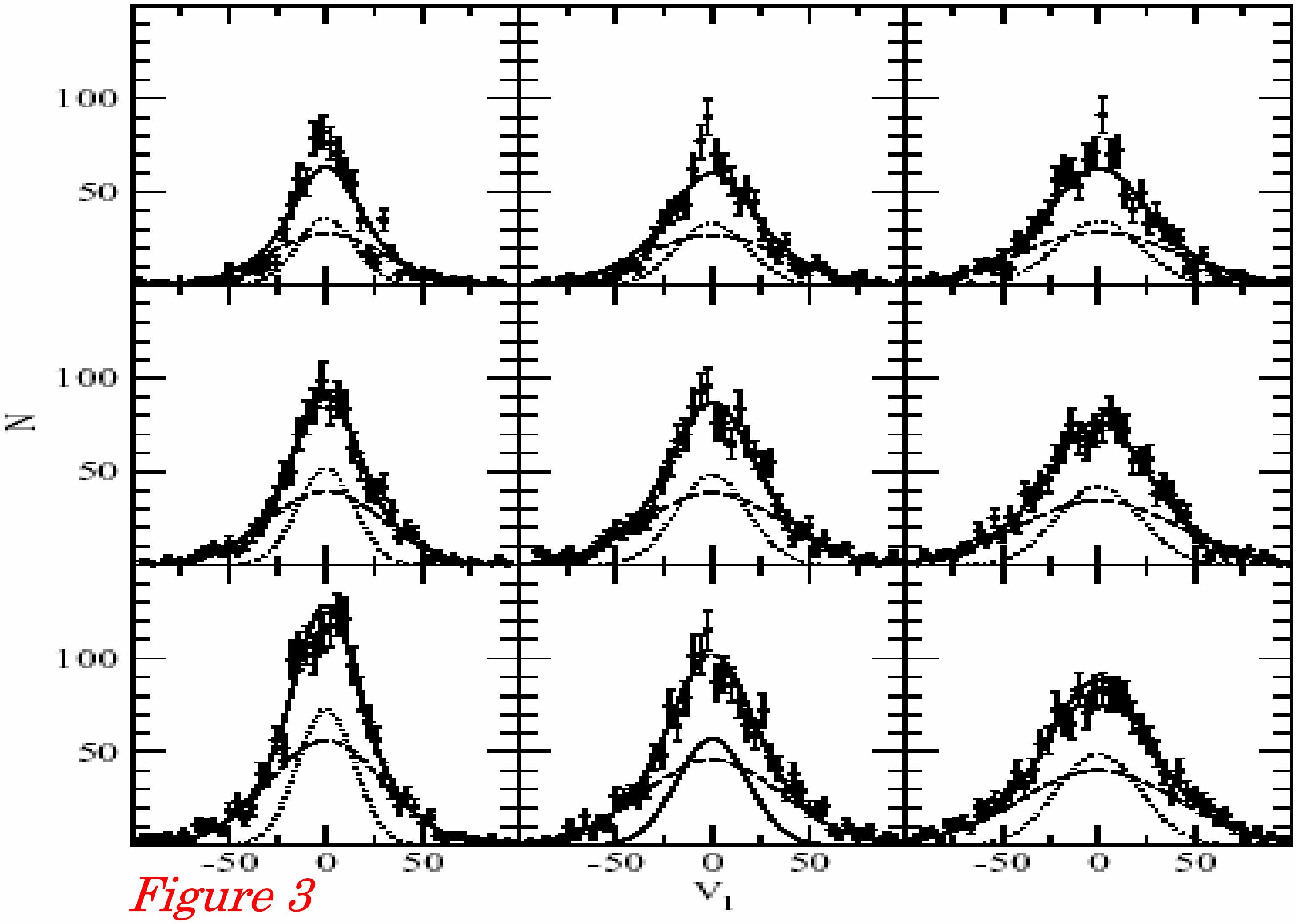


Figure 2



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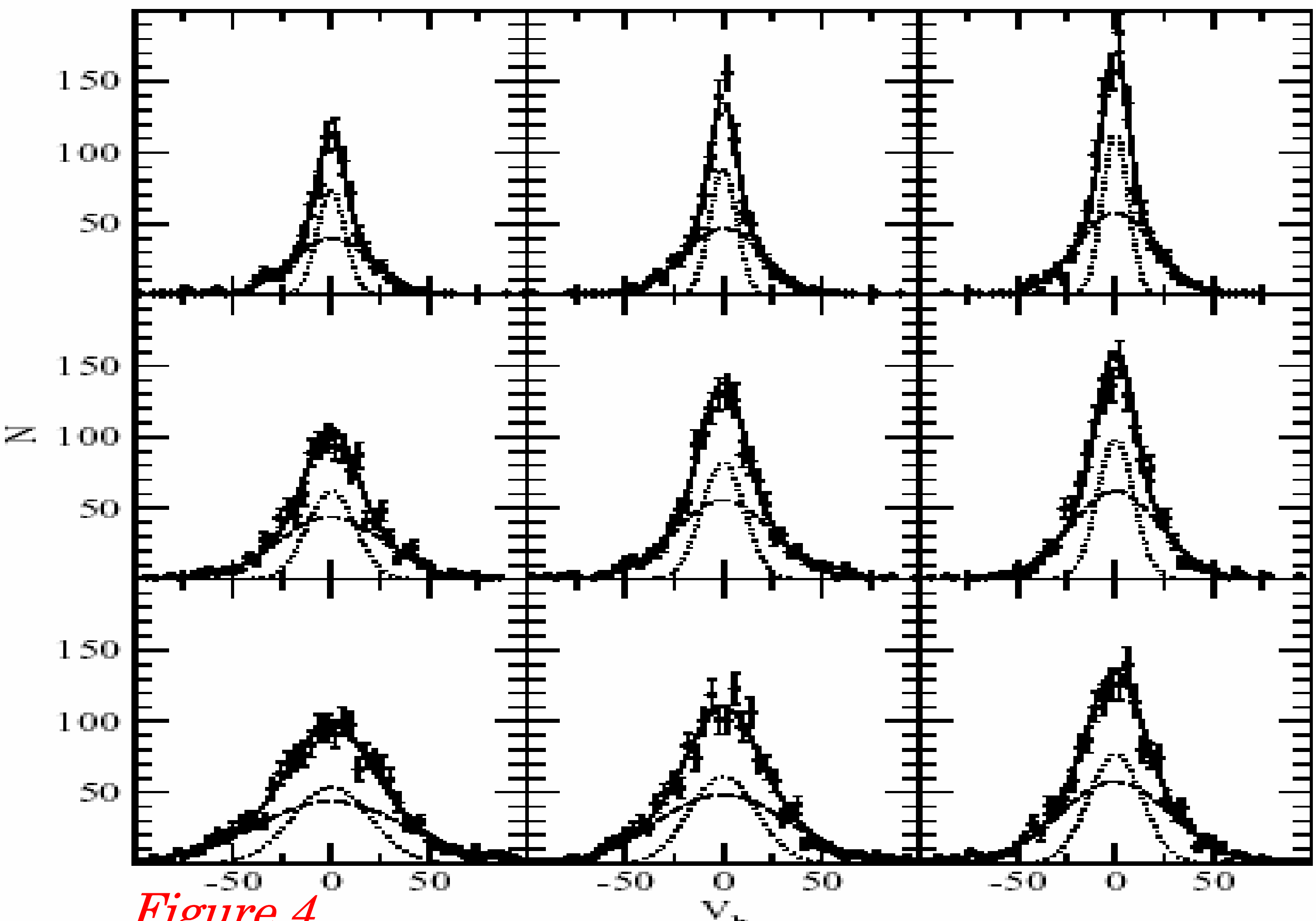

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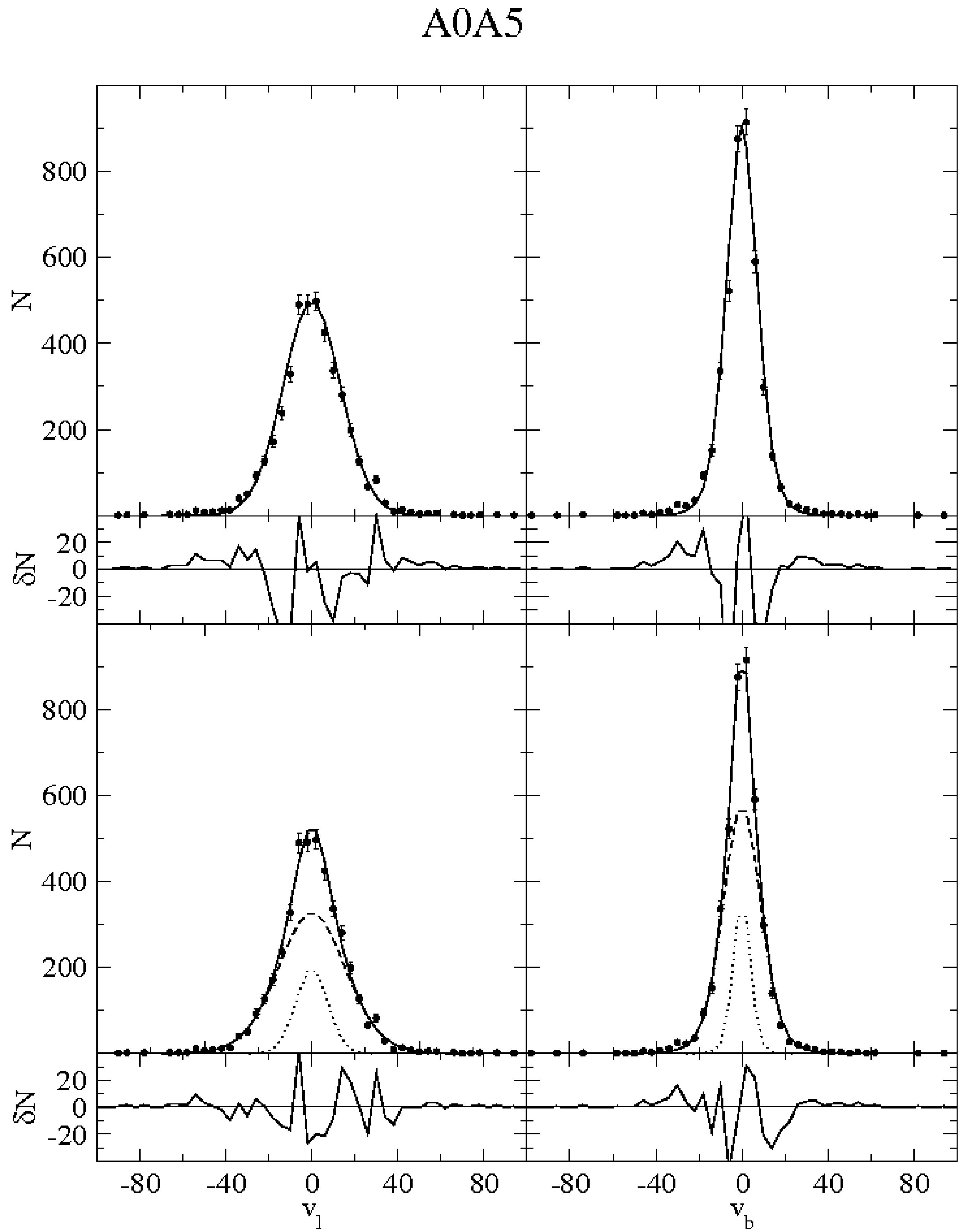

Figure 5

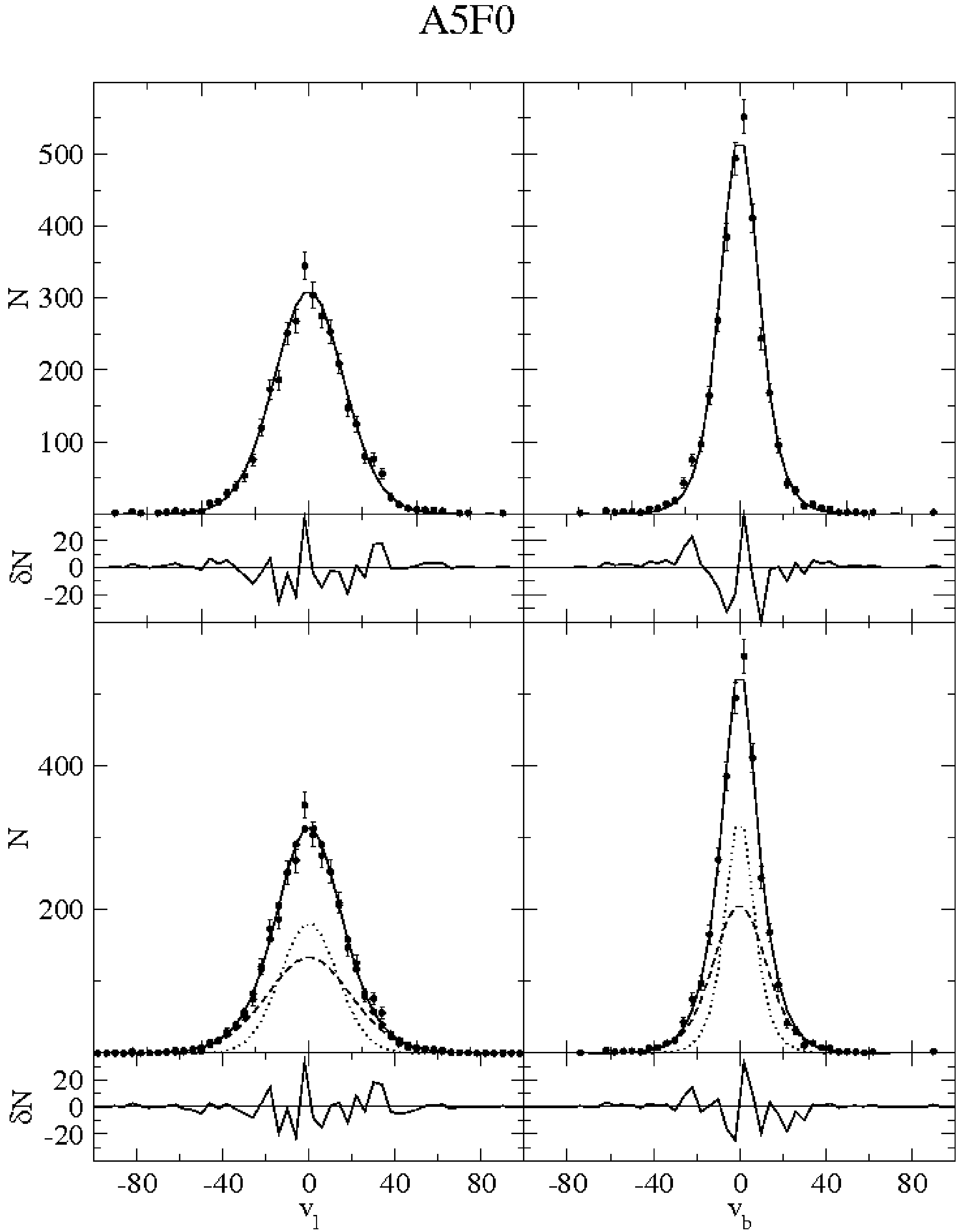

Figure 6

F0F5

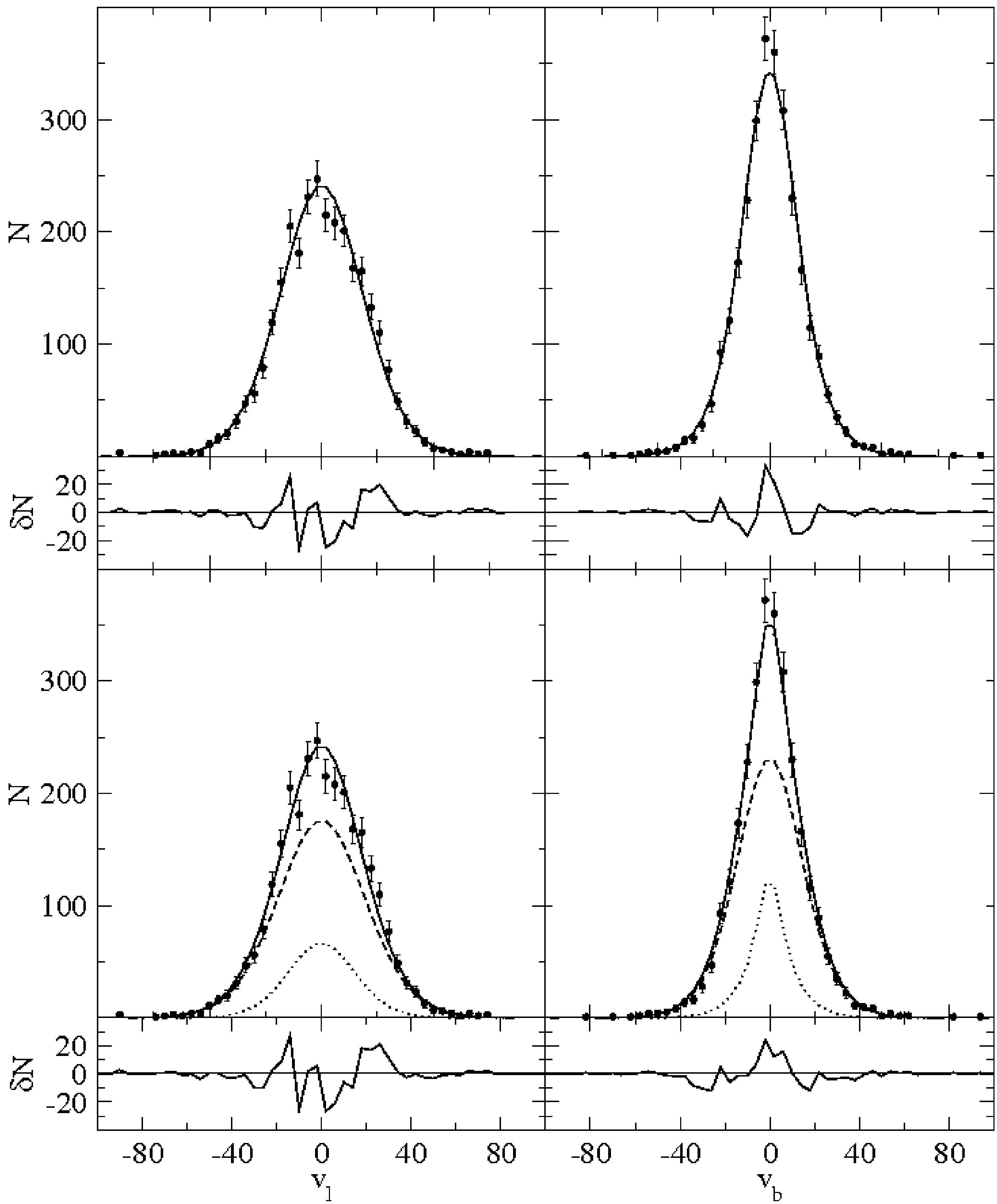

Figure 7

K0K5

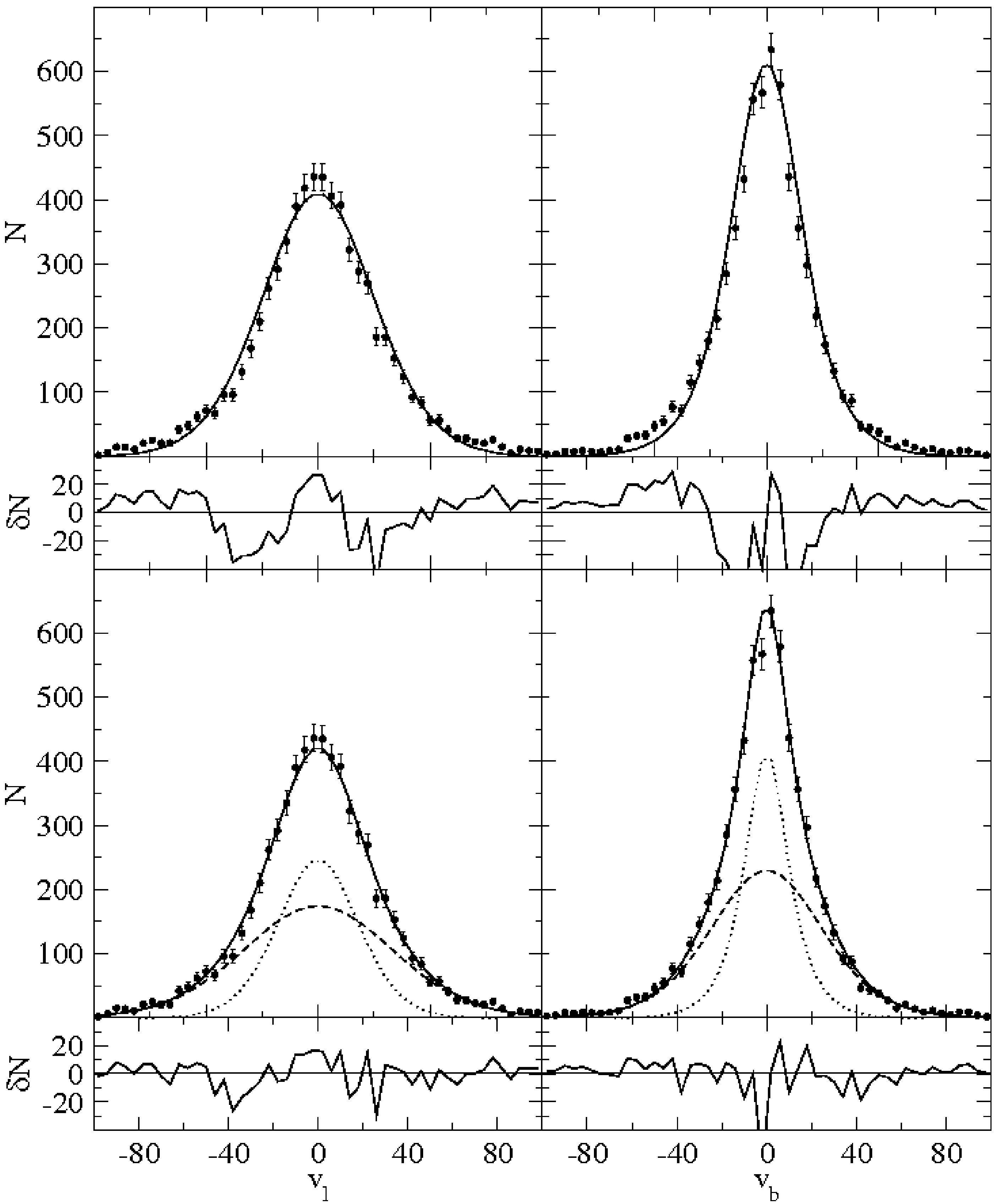

Figure 8

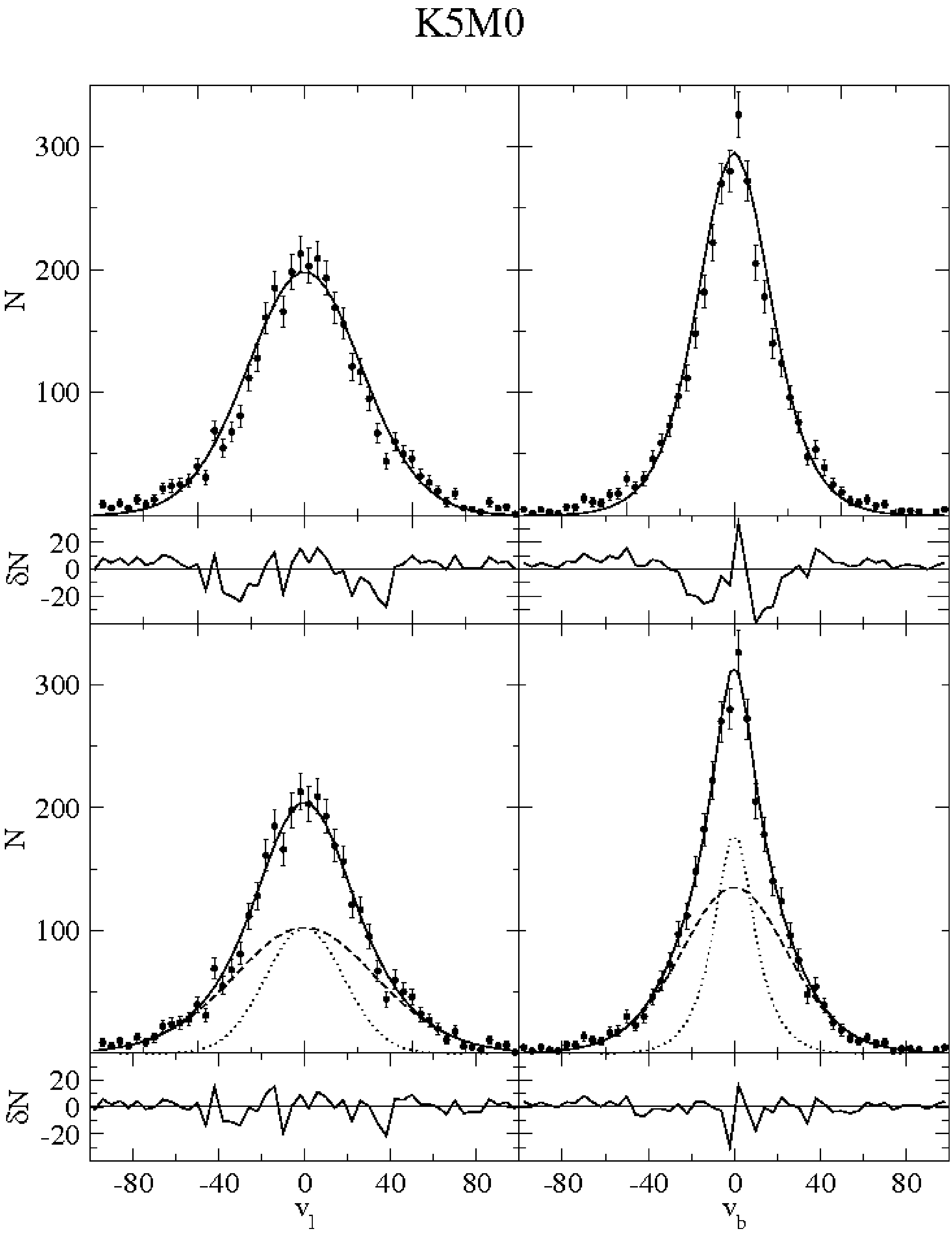

Figure 9

M0M5

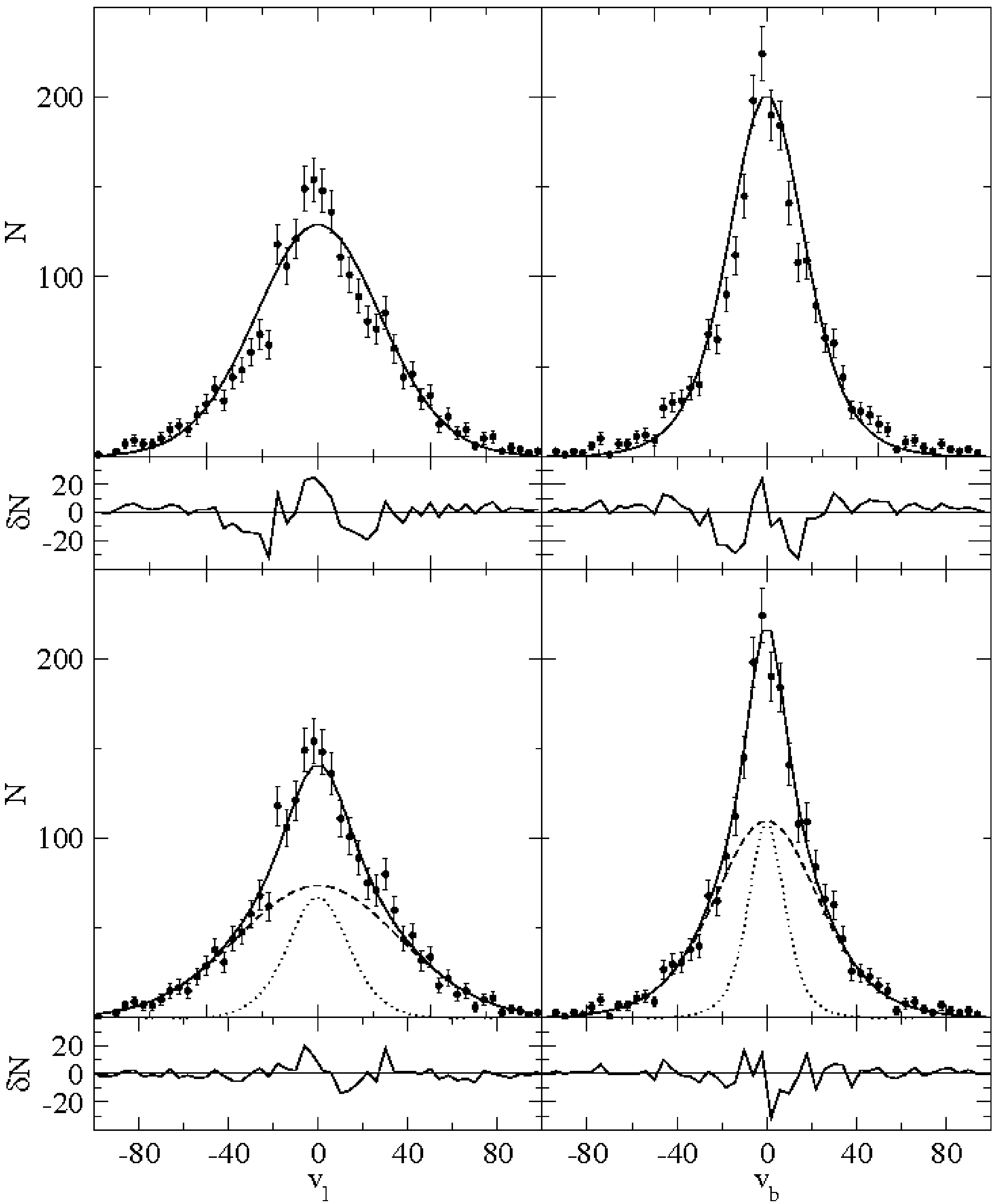

Figure 10