Estimate of the Correction factor (CF).

A correction factor is needed for the determination of triple to double ratios: (e,e'pn)/(e,e'p) and (e,e'pp)/(e,e'p). The correction factor correct for the recoiled nucleons that missed our detectors due to their finite acceptance.
In the case of LD2 target, for each detected (e,e'p) event we know exactly were the recoiled neutron went (this is the way we determined neutron detection efficiency). For He target this is not the case. For He target we have CM motion of the pair that can smear the momentum and the direction of the recoiled nucleon.
The best way to determine the CM motion of the pair is to look event by event basis on the $p_{miss}+p_{recoil}$ distribution. This can be done only using BigBite detector (almost now background). Unfortunately in this case the statistical uncertainties are to high. Alternatively we can use the neutrons at HAND for this purpose. With a recoil neutron at HAND we reconstruct the CM distribution by subtracting the random background.

We determined the cm motion in a coordinate system in which the $\hat{z}$ axis is in the direction of Pmiss. The physical reason for this rotation is following: high Pmiss, can be constructed from relative momentum together with contribution from CM momentum. This mean that we can have biased momentum distribution in the Pmiss direction while the orthogonal direction to pmiss will remain unchanged.
In fig 1, the Pcm distribution for 750 MeV/c. The nominal cuts are: in plane angle +-4 deg, out of plane +-14 deg, and TOF 30 – 60 ns (~900 – 300 ns).

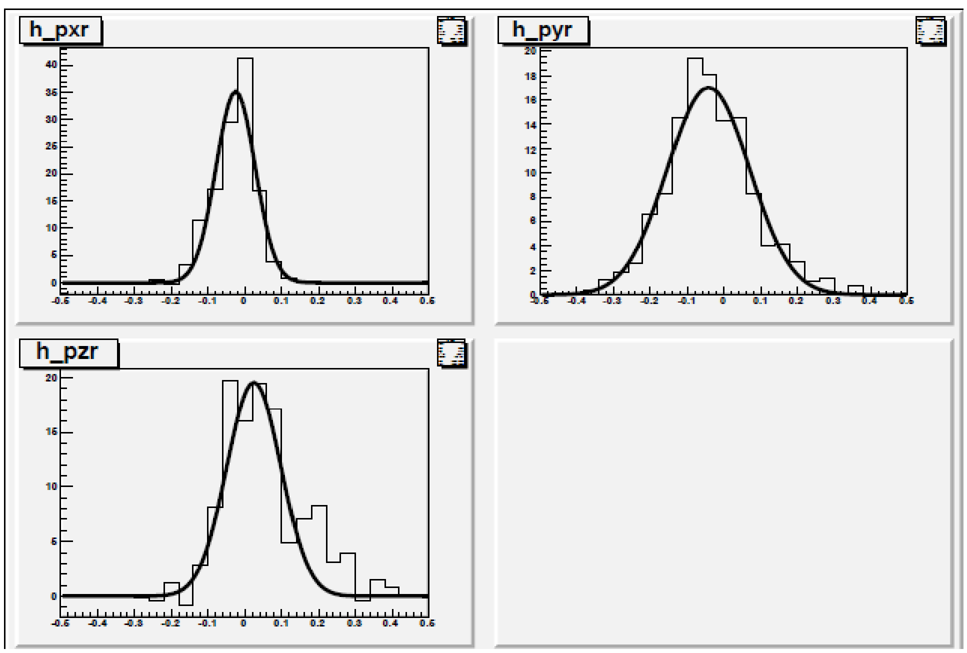

Fig 1: Pcm distribution for 750 MeV/c kinematics

The measured CM momentum is not the real momentum because it truncated by the finite acceptance of HAND (BigBite). We must simulate the (e,e'pn) events from the (e,e'p) based on some physical model. We assume a simple model with Gaussian distribution and equal widths ~ $\sigma_x=\sigma_y=\sigma_z=100$ MeV/c. In the case of z-axis, along Pmiss, we allow some offset.

The results for simulation for 3 different axis for 750 MeV/c settings are shown in fig 2-4.

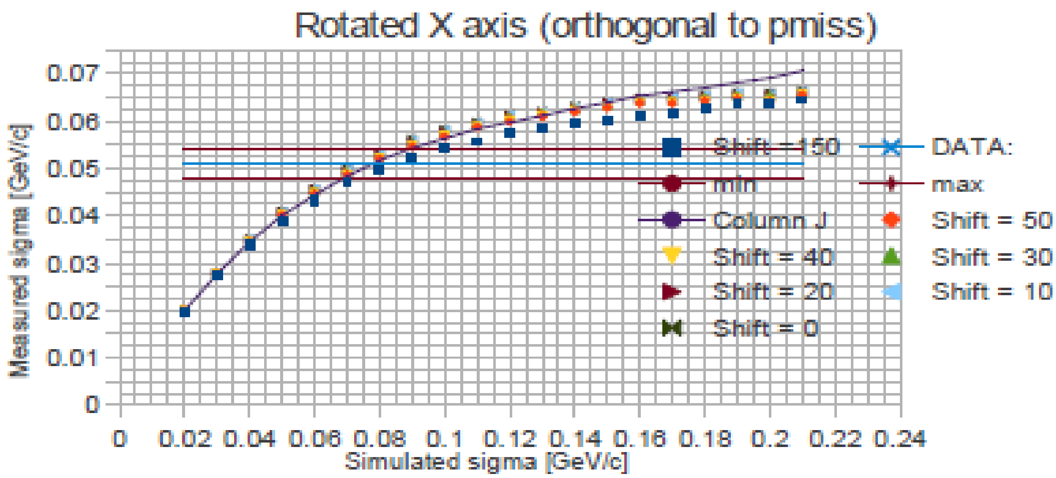

Fig 2: The vertical axis of the graph represents the "measured width" after we apply acceptance cut on the data with the "simulated width". Different colors represent various shifts in Pmiss_z direction. Horizontal lines represent the data (Fig 1) with one sigma deviation. The solid purple line represent the result **without** a cut on TOF.

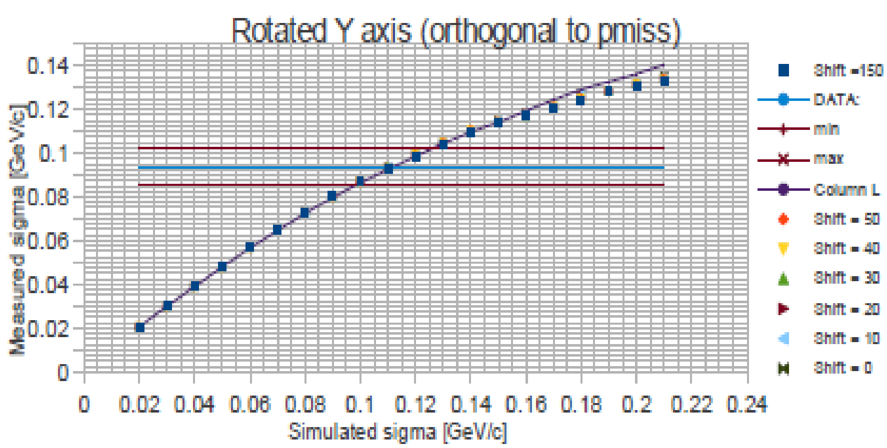

Fig 3: same as fig 2.

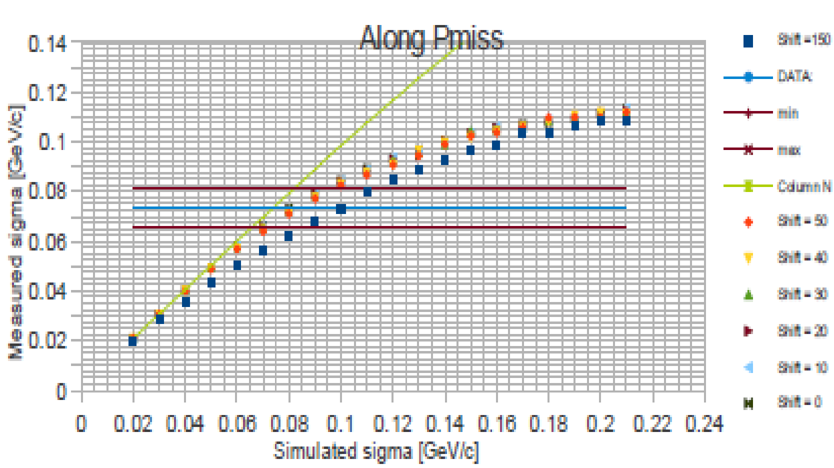

Fig 4: same as fig 2

from the results we see that all possible shifts (with a reasonable values) in the CM have small effect on the results given our uncertainties. Notice that only in the Pmiss_z direction the results are sensitive to the cut on TOF.

In table 1, we summarize the results for different kinematics and axises. The errors estimated by looking on the intersection between the simulation and one standard deviation from the measured value. The intersection points were projected to the simulated width in order to determine the errors.

Table 1:

	500 MeV/c	**625 MeV/c**	**750 MeV/c**
X	90 ± 20	75 ± 20	75 ± 15
Y	110 ± 20	125 ± 15	110 ± 15
Z	120 ± 25	105 ± 15	85 ±15

In fig 5, all the data are plotted on the same graph and fitted to constant.

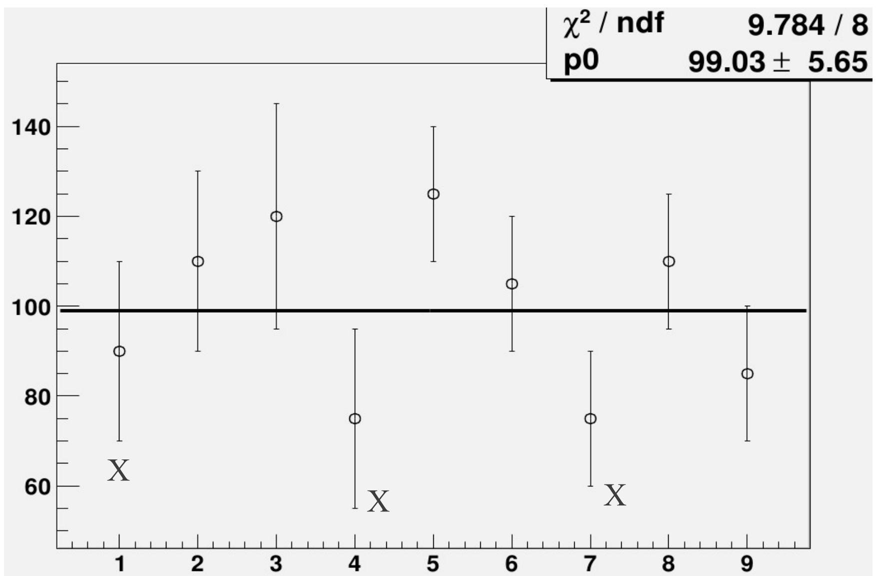

Fig 5: From left to right we have 500, 625 and 750 MeV/c. The “X” on the graph mark the X axis for each kinematics.

Additional measure for the CM distribution is the opening angle between the Pmiss and Precoil.
In fig 6, we present the data with the simulated result for three different Pcm values: 80, 100 and 120 MeV/c.

Following Ran analysis we just took the weighted average and deviation for all kinematics and axis.

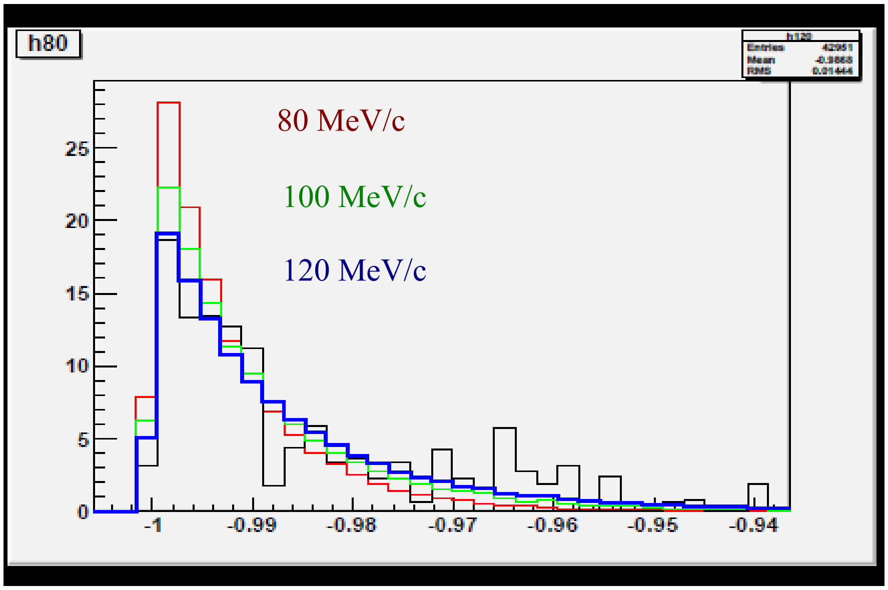

Fig 6: opening angle for 750 MeV/c kinematics. Black line represent the data, blue simulation with 120 MeV/c Pcm momentum, green with 100 MeV/c and red with 80 MeV/c Pcm momentum.

After we determined the CM momentum we can extract the correction factor for each kinematics. In figure 7, we have the correction factor as function of different settings and as function of Pcm.

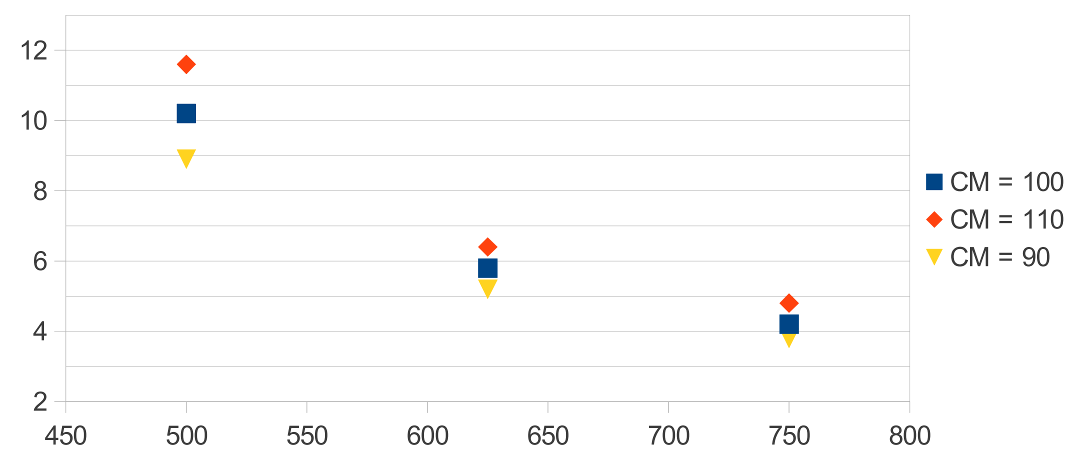

Fig 7: Correction factor for different kinematics with different Pcm motion.

Correction Factor table:

	500	625	750
$\sigma=90$ MeV/c	8.9 (9.1)	5.2 (5.1)	3.8 (4.1)
$\sigma=100$ MeV/c	10.2 (10.1)	5.8 (5.7)	4.2 (4.5)
$\sigma=110$ MeV/c	11.6 (11.2)	6.4 (6.3)	4.8 (5.1)

*The CF extracted using the nominal cut on Y-scaling. Values in brackets also include cut on MM<1.

To extract the triple/double ratio we assume the CF calculated for $\sigma=100$ MeV/c.
From the above table, we can estimate the systematic uncertainty in the CF. The systematics is changing slightly from 500 to 750 MeV/c between 11 – 15 %.

This CF determination method is similar to Ran's work that can be found in his thesis on pages 67 – 71.
From Ramesh thesis we have the correction factor as a function of Pmiss, fig 8:

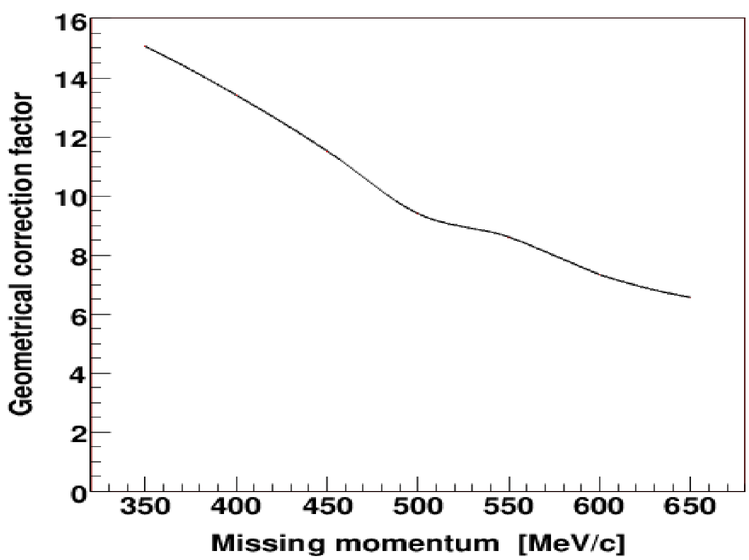

fig 8: Correction factor from Ramesh thesis, page 109.

The uncertainties on CF is the largest component of the systematic uncertainty, to be compared with the statistical uncertainties:

	500 MeV/c		625 MeV/c		750 MeV/c	
	(e,e'pp)	(e,e'pn)	(e,e'pp)	(e,e'pn)	(e,e'pp)**	(e,e'pn)**
Statistical	47%*	18%	23%	21%	25%	28%
CF systematic	15%	15%	15%	15%	15%	15%

* For the e,e'pp at 500 MeV/c we have only part of the data that can be used to determine the number of (e,e'pp) events.
** Statistical uncertainties after the Missing mass cut.

Appendix:

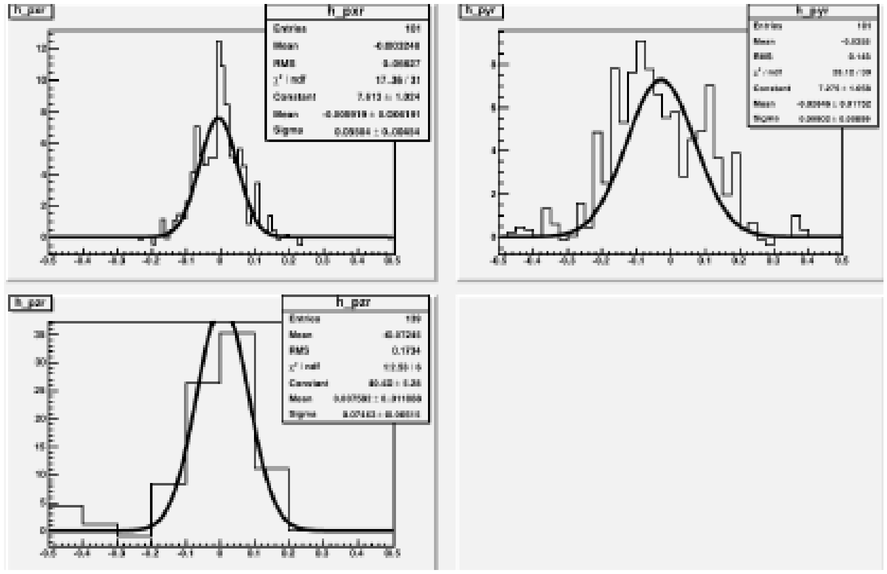

Fig A1: 500 MeV/c

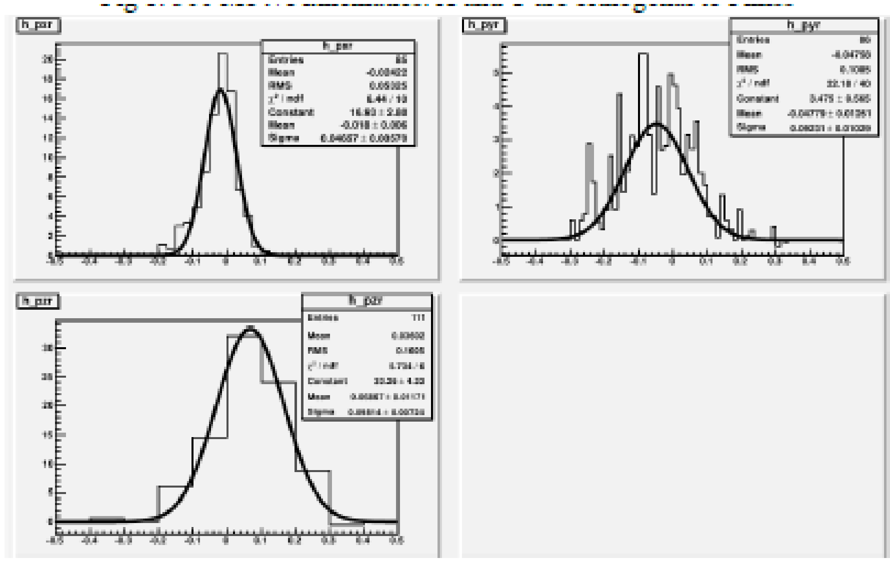

fig A2: 625 MeV/c

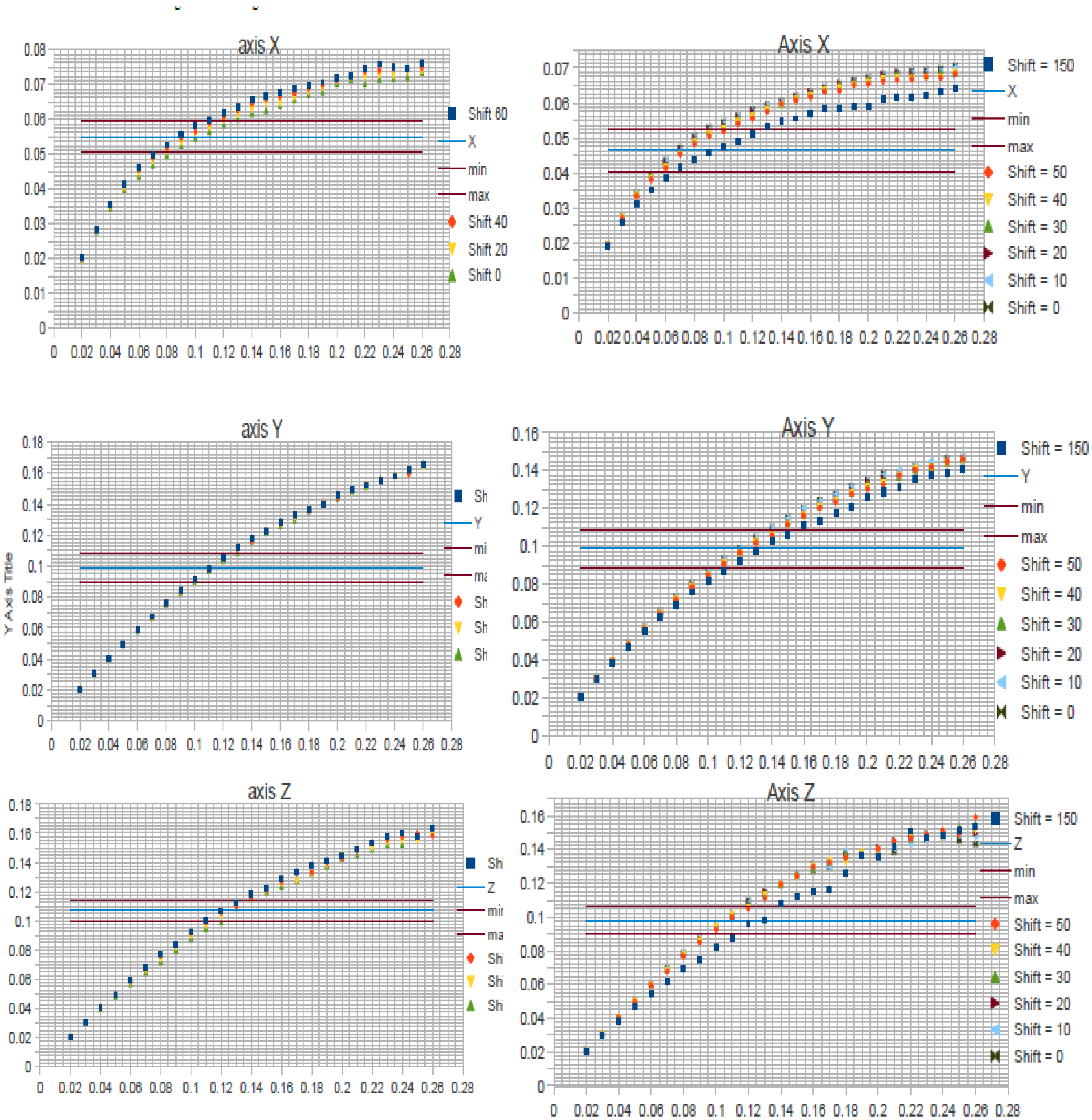

fig A3: Measured width vs simulated width. On the left side 500 MeV/c and right side 625 MeV/c