Measurement of the Proton Virtual Compton Spin Asymmetry A_1^p at high Bjorken x, Draft of Packing Fraction

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Draft of the Packing Fraction part of J. D. Maxwell and N. Kalantarians's paper.

I. DATA ANALYSIS

A. Event Reconstruction and Selection

1. Packing Fraction

The main target material is granular type solid ammonia, so the empty space between grains of it is filled with liquid helium during the experiment. Due to the lack of information of exact volume filled with ammonia, it should be determined by the data and simulation. The packing fraction pf of the target cell is defined as the volume ratio of ammonia to the whole cell. It can be translated into the effective length fraction filled with ammonia, assuming cylindrical symmetry. Packing fraction is crucial to the determination of dilution factor.

The data from High Momentum Spectrometer (HMS) is analyzed to get pf. The yield Y of HMS is a linear function of pf,

$$Y = IA\Bigg(\frac{\rho_{NH_3}}{M_{NH_3}} z_c pf(3\sigma_1 + \sigma_{14}) + \frac{\rho_{He}}{M_{He}} z_c(1-pf)\sigma_4 + \frac{\rho_{He}}{M_{He}} z_{He}\sigma_4 + \frac{\rho_{Al}}{M_{Al}} z_{Al}\sigma_{27}\Bigg), \quad (1)$$

where I is the beam current and A the HMS acceptance, $\rho_{material}$ the density of the material, $M_{material}$ the atomic weight, z_c the length of target cell, $z_{material}$ the beam direction length of material outside of the cell, and σ_A the electron-nucleus cross section of the mass number A of the nucleus.

If a Monte Carlo (MC) simulation generate the yield of two different packing fraction assumed, therefore, the slope and intercept of the linear function of pf. Then, the actual yield of data can determine the packing fraction of the specific target cell. The simulation used is called Hall C HMS single arm MC, based on an empirical fit of inelastic cross section [**?**]. It contains realistic HMS and target system structure and the magnetic field map. It runs with 50% and 60% packing fraction assumptions. The simulated yield should be rightly corrected by the data/MC ratio of the reference carbon target runs. Carbon runs' data/MC ratio is between 0.867477 and 1.03192. It is usually lower at runs with perpendicular magnetic field than parallel.

Run 73014, for example, is used to get the packing fraction of the insert B, material # 10. The data/MC ratio in Fig. 1 shows overall agreement of Data and MC. To avoid its fluctuation, the selection of the stable W region in data/MC plot was tried, but showing almost same result within error bar. The error of Y/m, where m is the slope, is estimated by 5 % of Y_T/m, studied in Ref. [**?**]. Fig. 2 and 3 shows that data reconstruction is well established and MC mimics it well. Of course, every MC data is corrected by total charge of beam, dead time, and tracking efficiency.

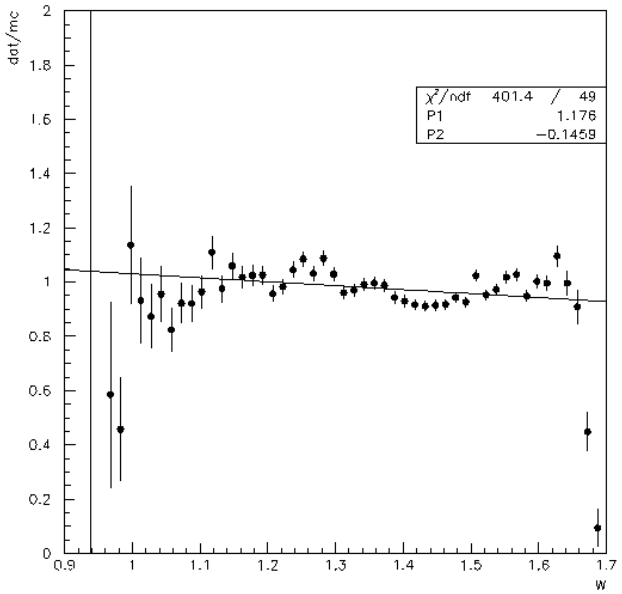

FIG. 1. Data/MC ratio of Run 73014, assuming 59.4% packing fraction.

Table I is the list of packing fraction and its calculation. There are runs with the same material, but having different HMS setting: # 2 - (72213,72278), # 13 - (72247,72281), # 8& 5 - (72658,72790), # 5& 6 - (72672,72795), # 3 (72828,72957), # 9 (72984,73019), # 10 (72991,73014) (Target material number - (Runs using the same target)). They agree each other within error bars. Experiment and MC result show good enough agreement to determine the packing fractions. Overall, SANE packing fractions are 56 - 62 % with 4.5 % point error.

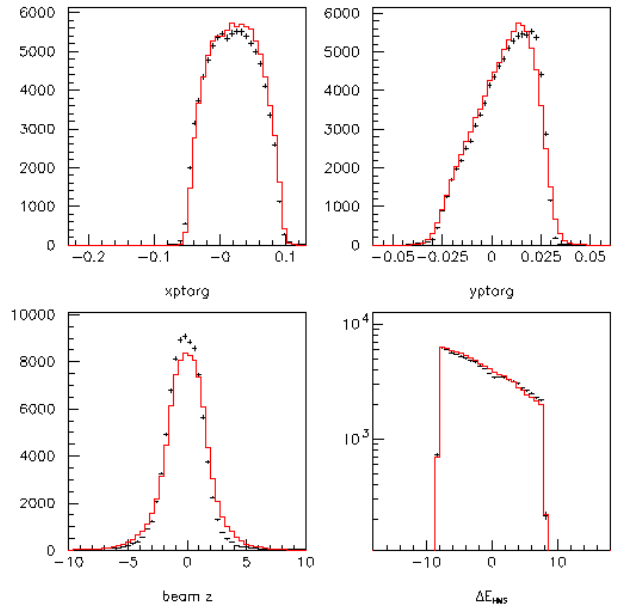

FIG. 2. Reconstructed beam position of Run 73014, points are data and red line is MC, (From top left, clockwise) X'_{tar},Y'_{tar},δ,and Z_{beam}.

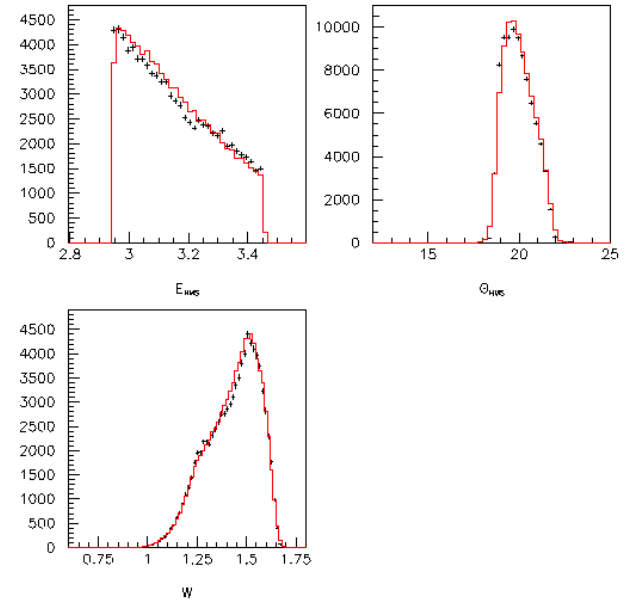

FIG. 3. Energy and angle of scattered electron of Run 73014, points are data and red line is MC, (From top left, clockwise) Energy, scattering angle, and W measured at HMS.

TABLE I. Packing fractions of each run, C is the data/MC of reference carbon run, Ydata is the yield of data, Ymc50(60) the MC yield assuming pf of 50(60)%, m is the slope and b is the intercept.

Run#	C	Y_{data}	Y_{mc50}	Y_{mc60}	m	b	pf	error
72213	0.8675	182612	154601	176787	221860	43671	0.626	0.0412
72247	0.8675	93341	79551	90833	112817	23142.4	0.622	0.0414
72278	0.9520	357790	319639	359001	393620	122829	0.597	0.0454
72281	0.9520	455353	405312	458155	528430	141097	0.595	0.0431
72658	0.9333	232893	209182	234720	255380	81492	0.593	0.0456
72672	0.9333	232978	214514	240090	255760	86634	0.572	0.0455
72790	0.9803	115049	105666	116458	107920	51706	0.587	0.0533
72795	0.9803	123604	115433	127973	125400	52733	0.565	0.0493
72828	0.8675	332739	297932	339271	413390	91237	0.584	0.0402
72957	0.9822	326976	291949	330787	388380	97759	0.590	0.0421
72959	0.9822	315150	283400	319627	362270	102265	0.588	0.0435
72984	0.9408	603843	508959	582642	736830	140544	0.629	0.0410
72991	0.9408	556527	485503	553661	681580	144713	0.604	0.0408
73014	1.0319	88392	80670	89930	92600	34369.8	0.583	0.0477
73019	1.0319	142414	127061	141092	140310	56906	0.609	0.0507