Homeworks

1. Vertex distributions from Empty a and Empty b

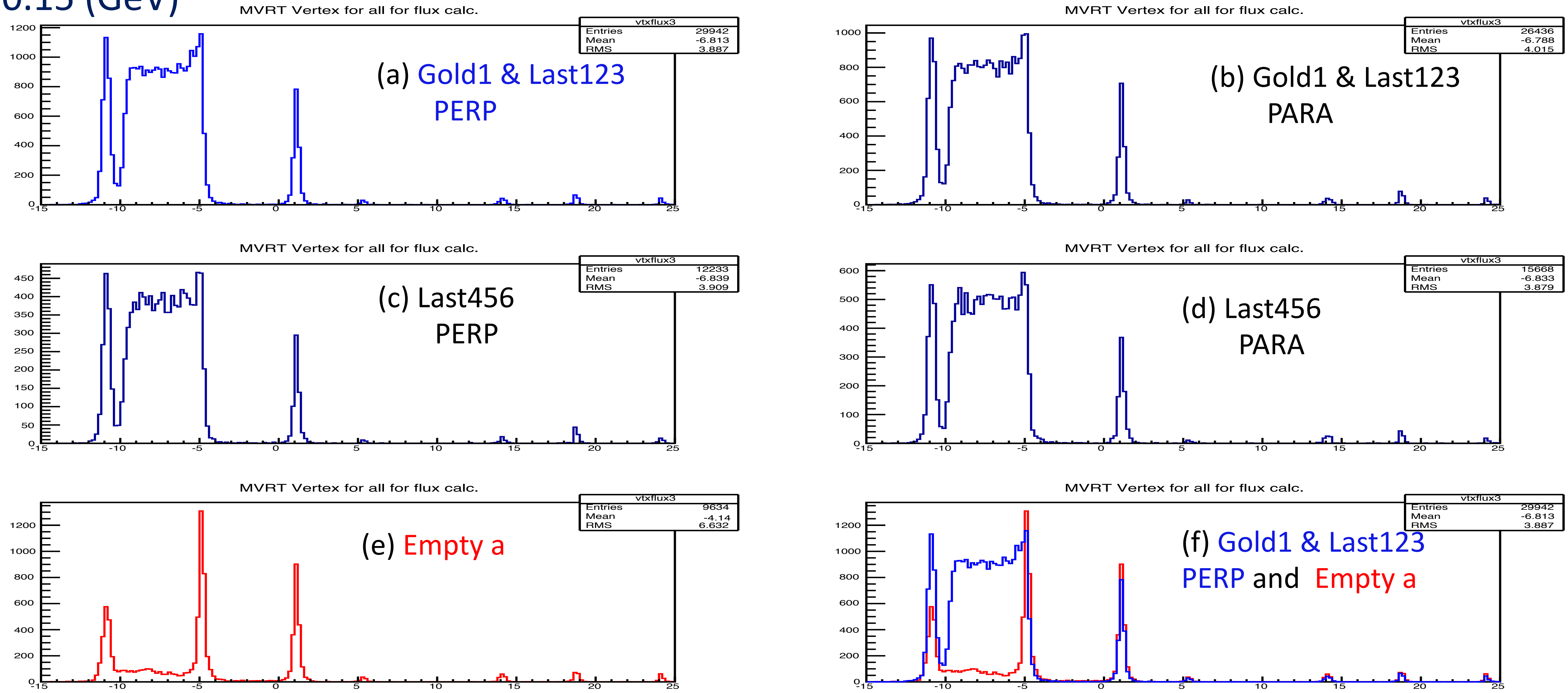
2. Dilution factor from reconstructed vertex distributios for Empty a and Gold1 & Last123 PERP

3. Comparisons of Σ asymmetries for 1.98 < fW < 2.06 Gev, 13 bins

4. How does g13 deal with flux normalization ?

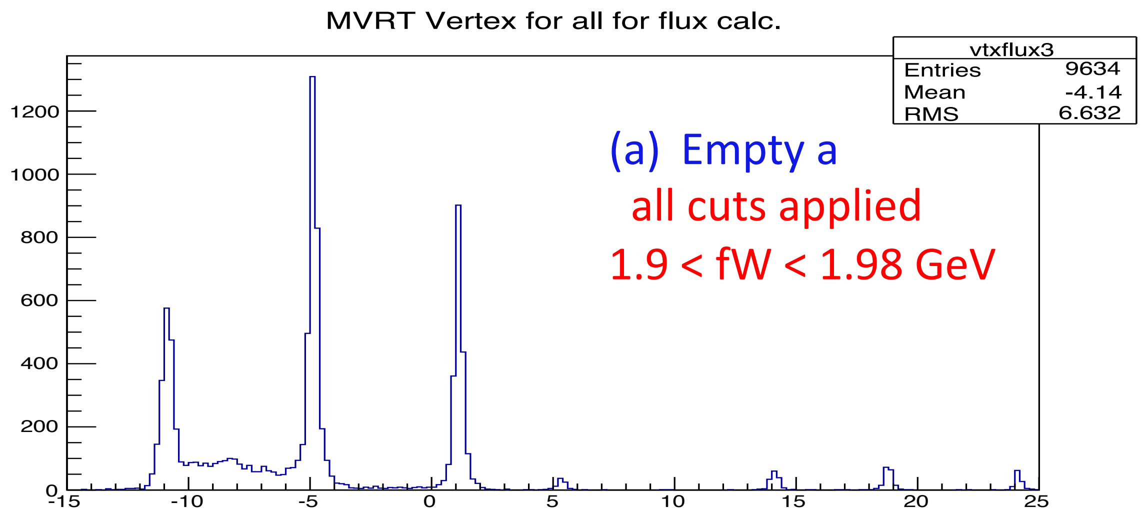
T. Kageya @ g14 meeting, June 10th, 2021

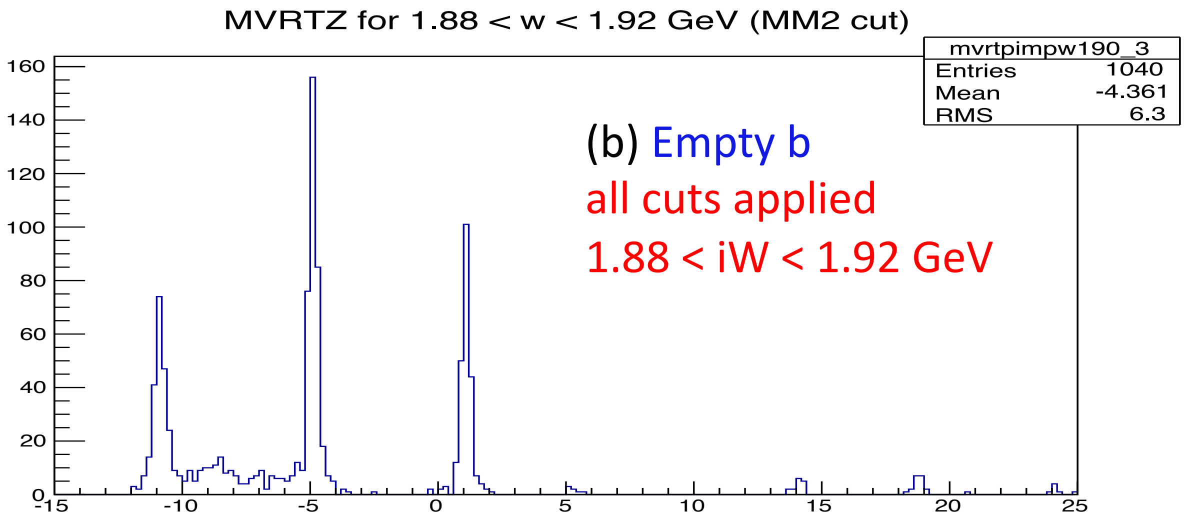
Reconstructed vertex distributios for Gold1 & Last123, Last456 and Empty a data (same Torus polarity) after final cuts for Pi- P (1.9 < fW < 1.98 GeV), 0 < Coherent Edge – Eg < 0.15 (GeV)



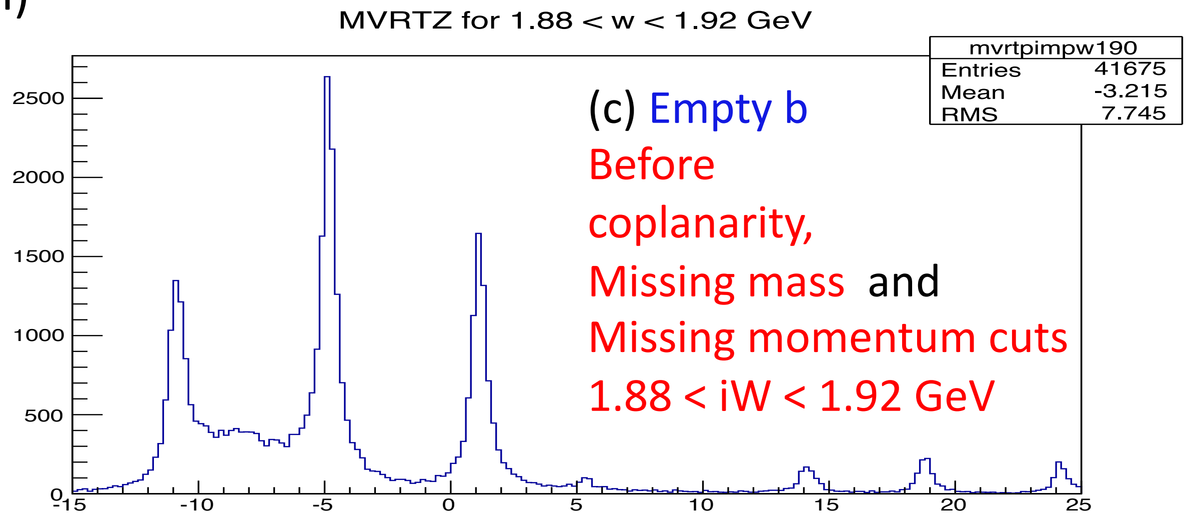
Reconstructed Z-vertex (cm)

1. Reconstructed vertex distributios for Empty a data (Torus: - polarity) and Empty b (Torus: + polarity). Empty b has ~ 1/5 statistics of Emptya.



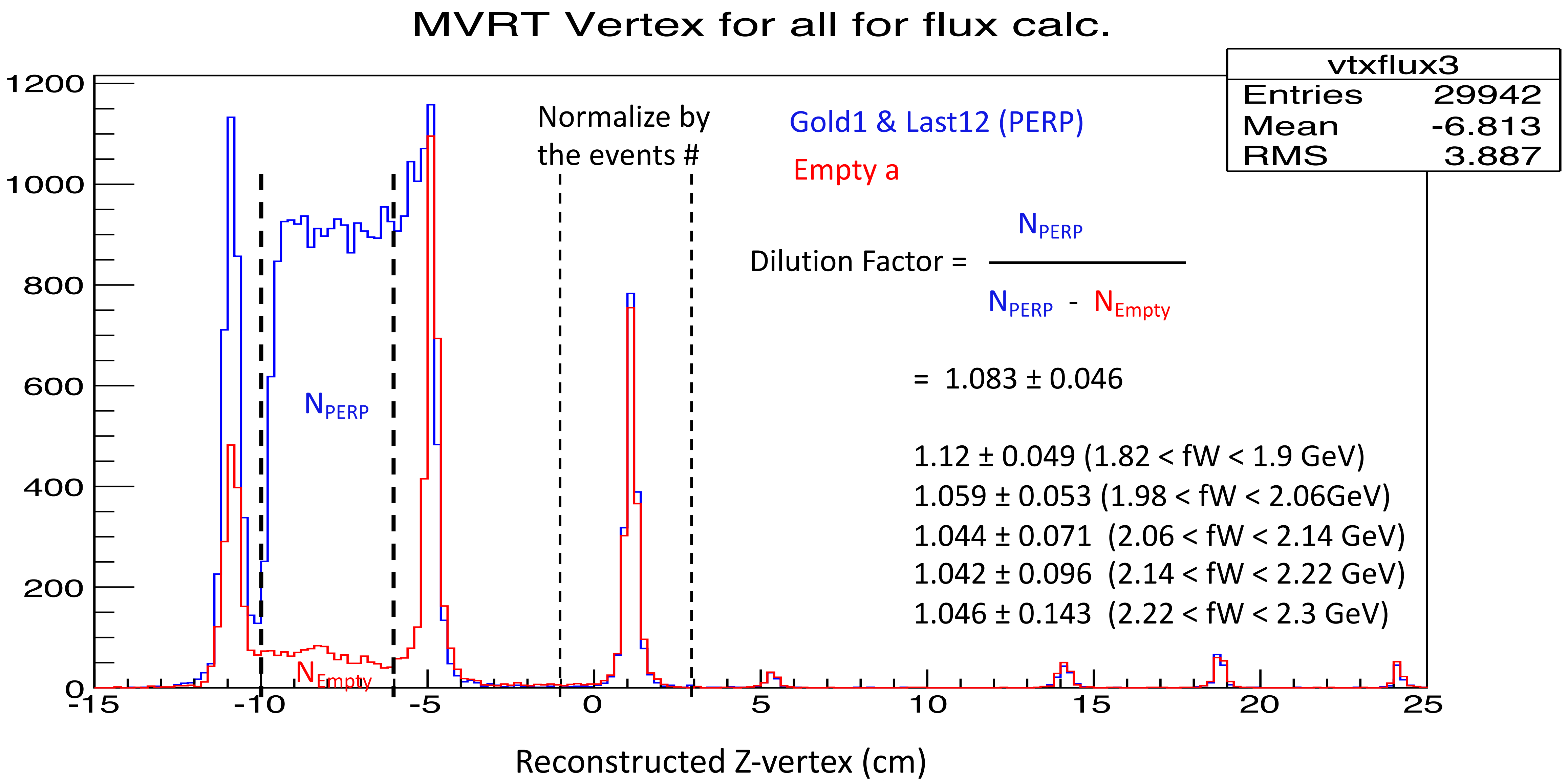


Reconstructed Z-vertex (cm)



Reconstructed Z-vertex (cm)

2. Dilution factor from reconstructed vertex distributios for Empty a and Gold1 & Last123 PERP. all cuts applied (1.9 < fW < 1.98 GeV)



3. Bin issues

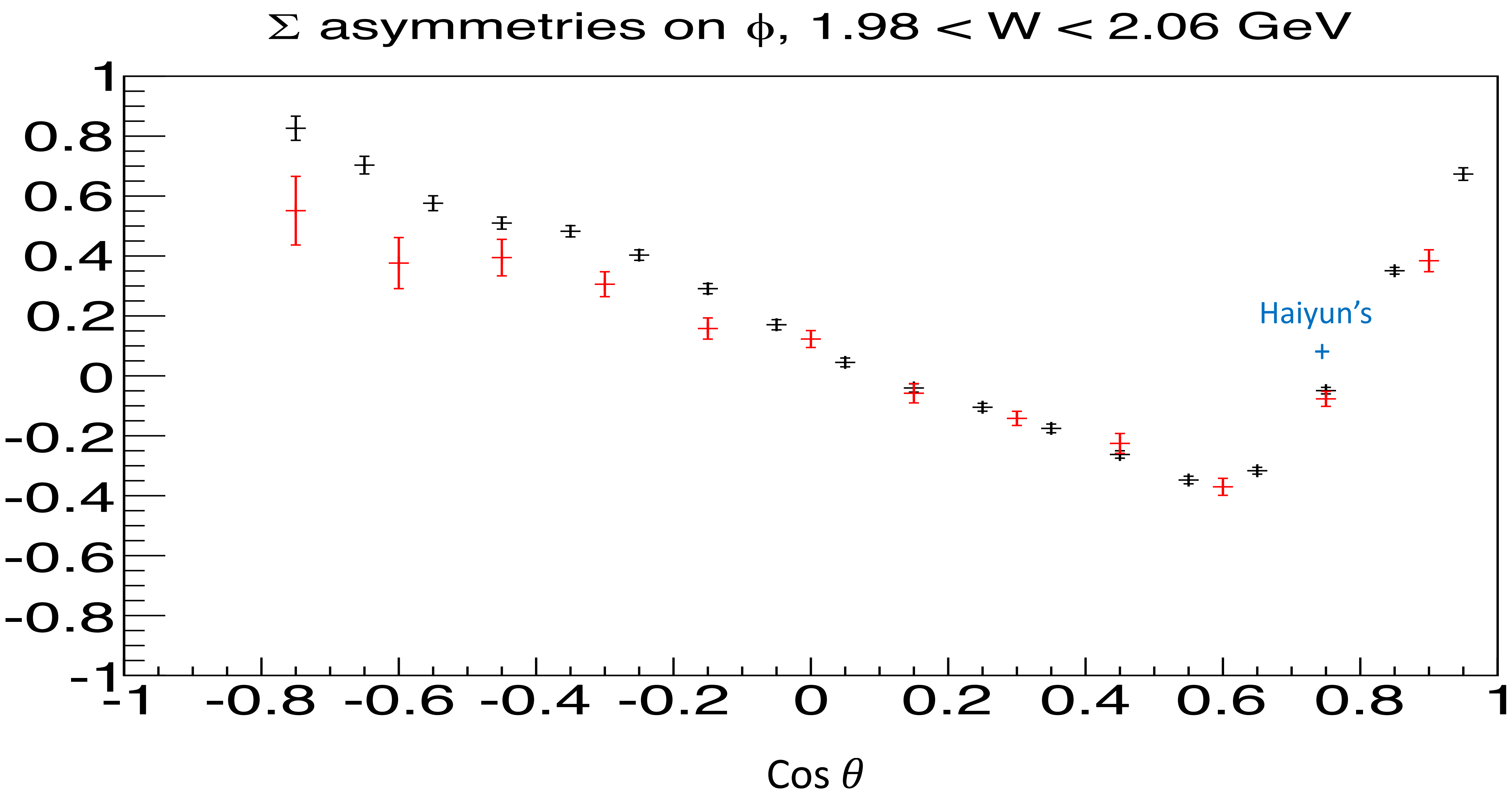
13 bins
(center values)

- 0.91
- 0.85
- 0.6
- 0.45
- 0.3
- 0.15
0.0
0.15
0.3
0.45
0.6
0.75 (0.675 – 0.825)
0.85
0.91

20 bins
(center values)

- 0.95
- 0.85
- 0.75
- 0.65
- 0.55
- 0.45
- 0.35
- 0.25
- 0.15
- 0.05
0.0
0.05
0.15
0.25
0.35
0.45
0.55
0.65
0.75 (0.7 – 0.8)
0.85
0.95

Σ asymmetries for 1.98 < fW < 2.06 Gev, 13 bins, +no empty subtraction



4.

g13 (from Daria's thesis)

7.4 Σ extraction method

As can be seen from Fig. 7.4 it is in principle possible to extract the beam asymmetry from a fit to the ratio of polarised to unpolarised ϕ distributions. This method is not optimal, however, due to the poorer statistics of the amorphous dataset dominating the statistical uncertainty. A better method which makes use of only the polarised data to extract Σ from the cross-section ratios of PARA and PERP data is described below.

The separate normalised cross-sections for PARA and PERP are given by:

$$\begin{aligned} \sigma_{\perp} &= \sigma_0 (1 + P_{\perp} \Sigma \cos(2\phi)) \\ \sigma_{||} &= \sigma_0 (1 + P_{||} \Sigma \cos(2\phi + \pi)) \\ &= \sigma_0 (1 - P_{||} \Sigma \cos(2\phi)). \end{aligned} \tag{7.3}$$

If the assumption is made that $P_{\perp} = P_{||}$, the asymmetry of these cross-sections gives:

$$\frac{\sigma_{\perp} - \sigma_{||}}{\sigma_{\perp} + \sigma_{||}} = P \Sigma \cos(2\phi). \tag{7.4}$$

In the more general case, however, the polarisations $P_{\perp}$ and $P_{||}$ are not necessarily equal. Further, the polarisation orientations may not be exactly parallel and perpendicular to the laboratory floor and could be rotated by an angle ϕ_0 with respect to the lab axes. This would introduce a phase shift into the cosine modulation of the cross-section.

Moreover, if the normalisation of the distributions has also not been perfectly performed before calculating the asymmetry then Eq. 7.4 would be generalised as:

$$\frac{\sigma_{\perp} - \sigma_{||}}{\sigma_{\perp} + \sigma_{||}} = \frac{(\frac{N_{\perp}}{N_{||}} - 1) - (\frac{N_{\perp}}{N_{||}} P_{\perp} + P_{||}) \Sigma \cos(2(\phi - \phi_0))}{(\frac{N_{\perp}}{N_{||}} + 1) - (\frac{N_{\perp}}{N_{||}} P_{\perp} - P_{||}) \Sigma \cos(2(\phi - \phi_0))} \tag{7.5}$$

where $N_{\perp}$ and $N_{||}$ are the integrals of the polarised distributions. In the case of $N_{\perp} = N_{||}$ and $P_{\perp} = P_{||}$, Eq. 7.5 simplifies to Eq. 7.4.

Equation 7.5 can, for the purpose of applying it as a fit to extract Σ, be more usefully expressed in terms of polarisation ratios:

$$\frac{\sigma_{\perp} - \sigma_{||}}{\sigma_{\perp} + \sigma_{||}} = \frac{(N_R - 1) - \frac{N_R P_R + 1}{P_R + 1} 2 \bar{P} \Sigma \cos(2(\phi + \phi_0))}{(N_R + 1) - \frac{N_R P_R - 1}{P_R + 1} 2 \bar{P} \Sigma \cos(2(\phi + \phi_0))} \tag{7.6}$$

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g13 used liq. Deuterium target

no sin(2ϕ) terms

g13 (from Daria's thesis)

where

$$
\begin{aligned}
N_R &= \frac{N_\perp}{N_{||}} \\
P_R &= \frac{P_\perp}{P_{||}} \\
\bar{P} &= \frac{1}{2}(P_\perp + P_{||})
\end{aligned}
\tag{7.7}
$$

The corresponding fit function is

$$
y = \frac{(A-1) - \frac{AB+1}{B+1} 2\,C\cos(2(x+\phi_0))}{(A+1) - \frac{AB-1}{B+1} 2\,C\cos(2(x+\phi_0))} \tag{7.8}
$$

where $A = N_R$, $B = P_R$ and $C = \bar{P}\Sigma$. The least constrained fit using Eq. 7.8 would have A, B, C and ϕ_0 as free parameters.

7.5 Optimisation of fit parameters

The ϕ_0 phase depends upon the accuracy of the alignment of the diamond radiator in the goniometer, which was aligned at the start of the experiment. As this value can be established with high accuracy and did not vary through the experiment this parameter was extracted in a separate analysis and its value fixed in the fit. The ϕ_0 determination was obtained from fits using Eq. 7.8 to high statistics ϕ distributions. An example can be seen in Fig. 7.5, where the distribution was integrated over all the $\cos\theta$ bins in the range 1.6 – 1.9 GeV having a positive asymmetry. The extracted value of ϕ_0 was $0.125° \pm 0.172°$.

The polarisation ratio $P_\perp/P_{||}$ varied by no more than 3% from the peak ratio of 0.96. It was therefore decided to constrain the fit with the calculated ratio. This induces little systematic error in the extracted asymmetries as discussed later (Chapter 8, Section 2.1).

The constraints on ϕ_0 and $P_\perp/P_{||}$ reduced the free parameters in the fit of Eq. 7.8 to two: N_R and $\bar{P}\Sigma$. Both of these parameters were extracted from the fit. The possibility of normalising the ϕ asymmetry-distributions in order to fix N_R was investigated and it was found that this could not be done to a high enough accuracy. Better fit results were obtained if the parameter was left free, however a starting value of N_R was determined

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Fix P_R = 0.96

Obtain ϕ_0 = 0.125 ± 0.172 °

Fit with two parameters

$N_R = N_\perp / N_{||}$ and $\bar{P}\Sigma$