n-^{3}He Analysis Outcome

Asymmetry Extraction From n-^{3}He Data: Part 3

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Outline

Data Analysis Algorithm

1. Divide the entire data set into several (contiguous) batches based on beam power stability.
2. Within each batch, separate the runs as A and B groups based on RFSF state on dropped pulses.
3. Within each group, calculate raw asymmetry by considering two consecutive pulses. The yield is background subtracted and normalized by sum over all the detector signals.
4. Cut: Skip dropped pulse and pulses around it. Consider only 600 sequences with no dropped pulse within the sequence.
5. Fill in the histogram per wire for raw asymmetry over all the runs within each group. Get the mean of raw asymmetry from the histogram.
6. Within each batch combine A and B result using simple averaging. Divide by the geometry factor to get physics asymmetry for each wire.
7. Within each batch, considering either A or B group runs($\leftarrow$), calculate correlations and apply that to get correlation corrected physics asymmetry and its uncertainty for group A and B dataset.
$\rightarrow$ Using covariance of A and B, construct covariance for $\frac{1}{2}$(A+B)
8. Combine physics asymmetry from all the batches to get global physics asymmetry for the entire data set.

Combining Group $\mathcal{A}$ & $\mathcal{B}$ data

$$\bar{A}_{\mathcal{A}+\mathcal{B}} = \frac{\bar{A}_{\mathcal{A}} + \bar{A}_{\mathcal{B}}}{2}$$

$$\Delta\bar{A}_{\mathcal{A}+\mathcal{B}} = \frac{\sqrt{(\Delta\bar{A}_{\mathcal{A}})^2 + (\Delta\bar{A}_{\mathcal{B}})^2}}{2}$$

$$Cov(\bar{A}_{\mathcal{A}+\mathcal{B}}) = \frac{1}{4}\left[\frac{1}{N_{\mathcal{A}}}Cov(A_{\mathcal{A}}) + \frac{1}{N_{\mathcal{B}}}Cov(A_{\mathcal{B}})\right]$$

Correction for correlation : 1.Direct Inversion of Covariance Matrix

$$w_i = \frac{1}{(\delta A_i)^2} = \frac{1}{\sigma_i^2} \longrightarrow w_i = \sum_j Cov(A_p)_{ij}^{-1}$$

$$A_p = \frac{\sum_i w_i A_i^p}{\sum_i w_i} \longrightarrow A_p = \frac{\sum_{ij} Cov(A_p)_{ij}^{-1} A_i^p}{\sum_{ij} Cov(A_p)_{ij}^{-1}}$$

$$\chi^2 = \sum_i \frac{(A_i^p - A_p^{tot})^2}{\sigma_i^2} \longrightarrow \chi^2 = \sum_{ij} (A_i^p - A_p^{tot}) Cov(A_p)_{ij}^{-1} (A_j^p - A_p^{tot})$$

Correction for correlation : 2. Diagonalizing Covariance Matrix

In matrix representation,

$$\bar{A} = bX$$

Where, X is a column matrix filled with all 1 and b is the fit parameter (physics asymmetry).

$$b = (X^T W X)^{-1} X^T W \bar{A}$$
$$(\Delta b)^2 = (X^T W X)^{-1}$$
$$\chi^2 = (\bar{A} - Xb)^T W (\bar{A} - Xb)$$

Where, Weight $W = Cov(A_p)^{-1}$ i.e. inverse of covariance matrix.
Now, let's rotate to a basis where they are uncorrelated,

$$S^T C S = D$$

Where D is a diagonal matrix with diagonal elements

$$D = \mathrm{diag}(\sigma_1^2, \sigma_2^2, \sigma_3^2, \sigma_4^2, ..., \sigma_{144}^2)$$

Correction for correlation : 2. Diagonalizing Covariance Matrix

In the rotated frame,

$$\bar{A}' = bX' \longrightarrow \text{is our fit in rotated frame}$$

$$b = (X'^T W' X')^{-1} X'^T W' \bar{A}'$$

$$(\Delta b)^2 = (X'^T W' X')^{-1}$$

$$\chi^2 = (\bar{A}' - bX')^T W' (\bar{A}' - bX')$$

Where,

$$A' = S^T \bar{A}$$

$$X' = S^T X$$

$$W' = D^{-1}$$

Do The Fit With Graphical Representation :

If we plot $\bar{A}' X'^{-1}$ vs index i (mode#) $\longrightarrow$ we get linear fit (flat line)

If we plot $\bar{A}'$ vs index i (mode#) $\longrightarrow$ we get a fit which is not flat

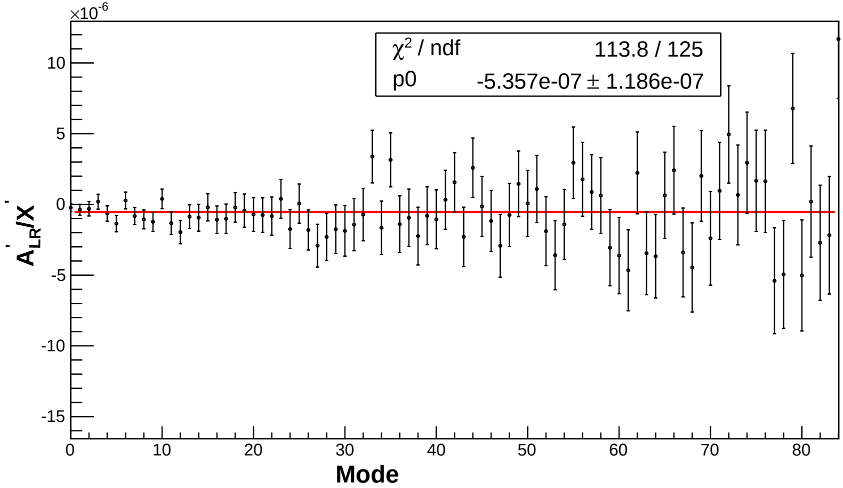
Plots for today's presentation

$\Rightarrow$ we plot $\bar{A}' X'^{-1}$ vs index i (mode#) $\longrightarrow$ to get linear fit (flat line)

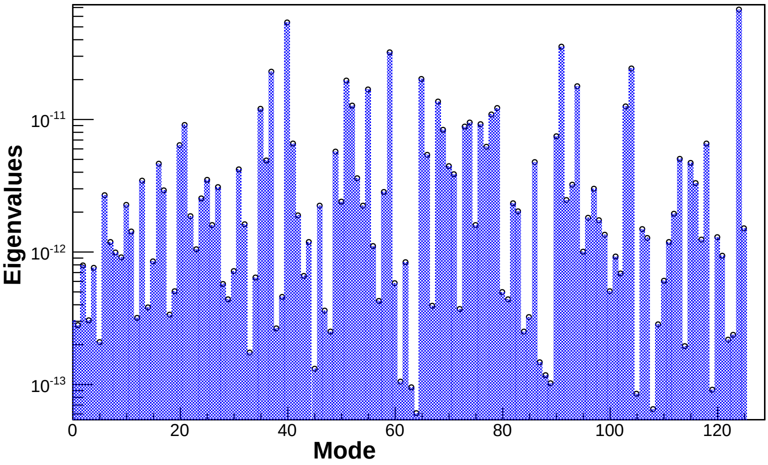
$\Rightarrow$ The error for y-axis is given by $\sqrt{\sigma_i^2 / X_i'}$

$\Rightarrow$ In all cases, the modes are sorted in ascending order in error bar (i.e. most dominating modes first).

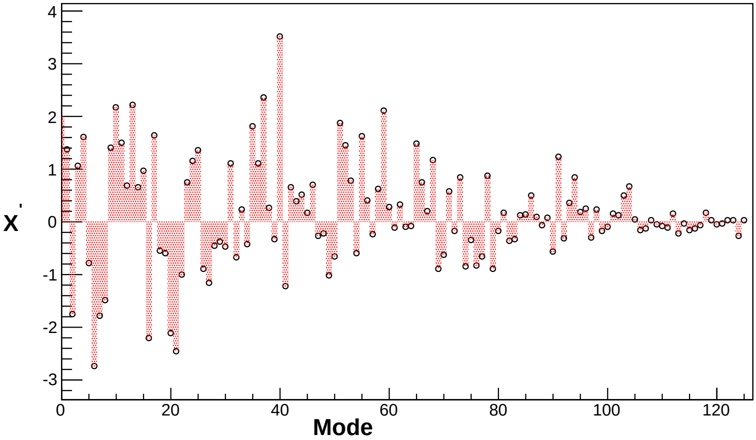
LR Physics Asymmetry for Batch 2 (Corrected)



Eigenvalues for LR Batch 2 (Modes are in sorted order)



Rotated 1s for LR Batch 2 (Modes are in sorted order)



Rotated physics asymmetry for LR Batch 2 (Modes are in sorted order)

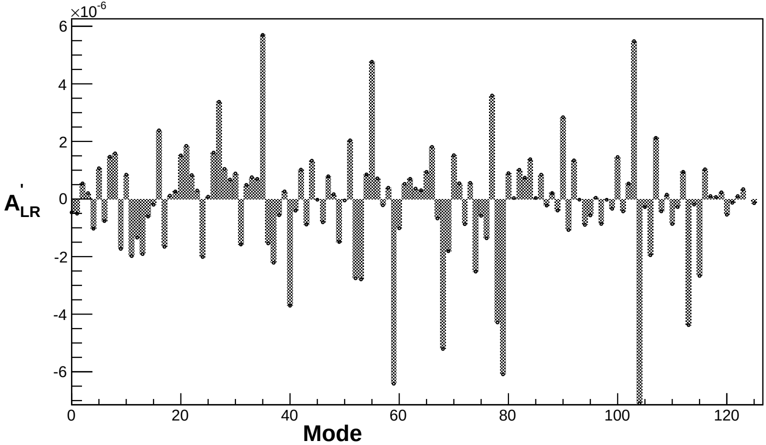
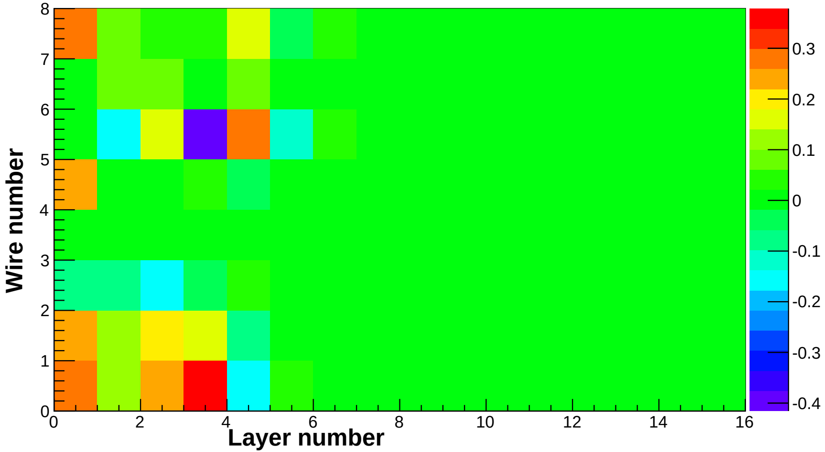
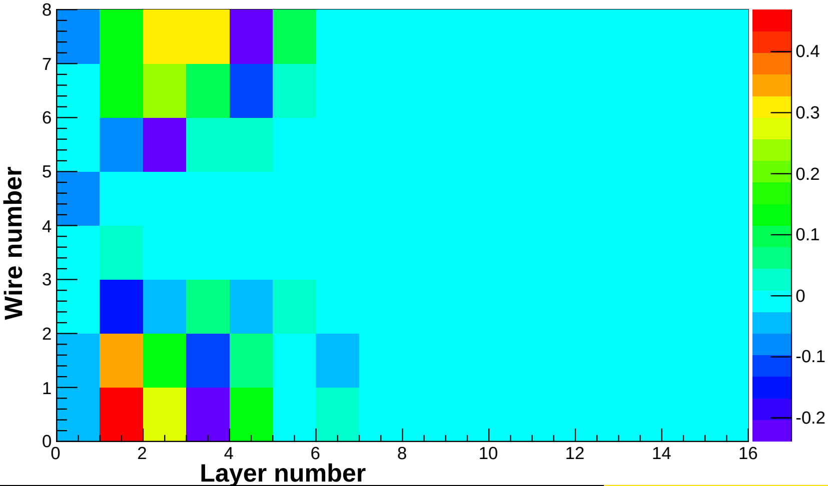


Figure:

Eigenvector for LR Batch 2: Mode 0 (Modes are in sorted order)



Eigenvector for LR Batch 2: Mode 1 (Modes are in sorted order)



Eigenvector for LR Batch 2: Mode 100 (Modes are in sorted order)

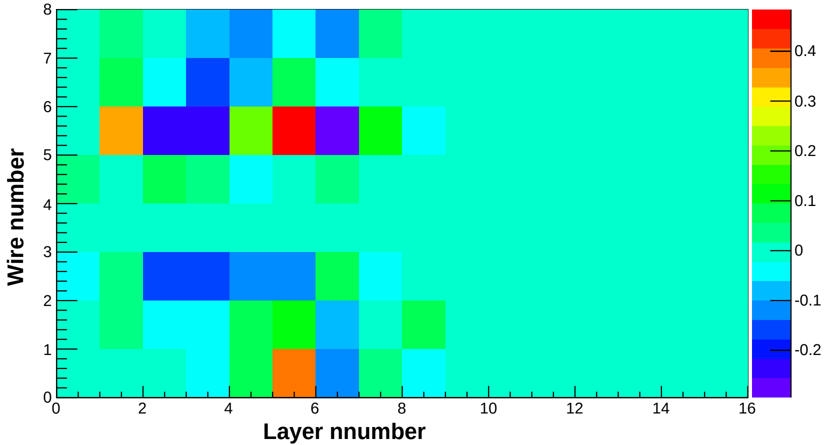
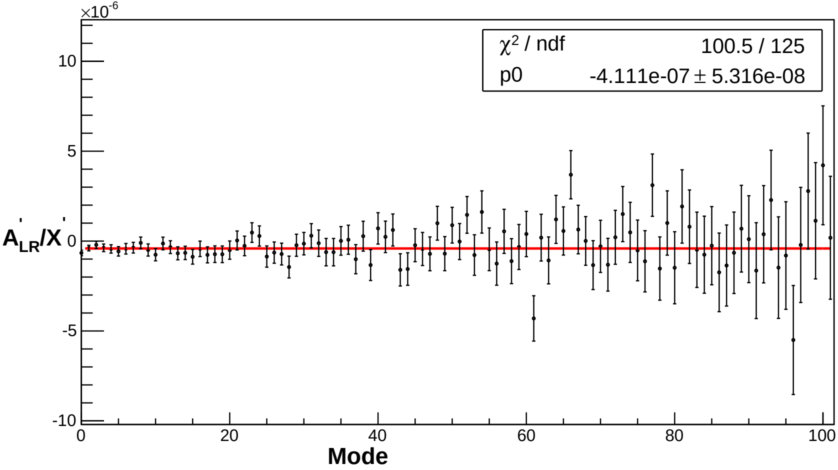
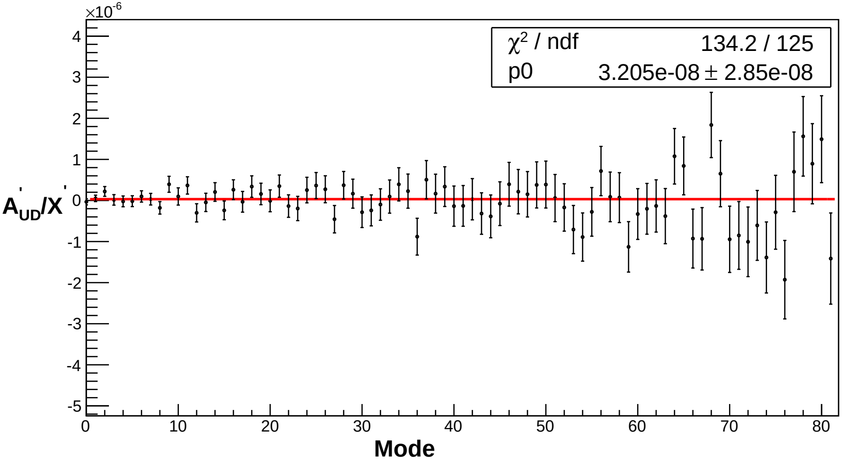


Figure:

LR physics asymmetry from all batches

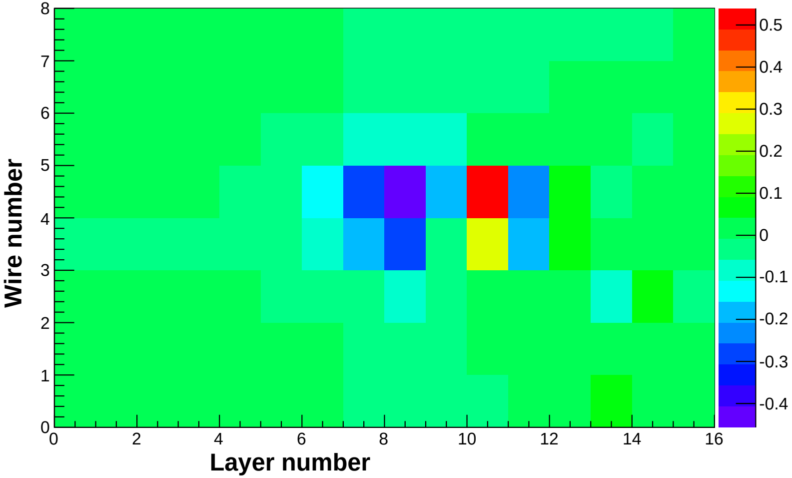


UD physics asymmetry from batch 2



Backup slides

Eigenvector for LR Batch 2: Mode 20 (Modes are in sorted order)



Eigenvector for LR Batch 2: Mode 125 (Modes are in sorted order)