Comparison of RHRS calibration methods

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Calibration methods

The differences in calibration method are:

- Minimization
  - TMinuit
  - Matrix
- Central block selection
  - Replay cluster
  - Track projection
- Event cuts

TMinuit minimization

$$\chi^2 = \sum_{i}^{events} \left(\sum_{j}^{blocks} C_j A_{ij} - p_i \right)^2$$

Use the TMinuit minimization package in ROOT to minimize C_j values

Matrix minimization

$$\boxed{\chi^2 = \sum_{i}^{events} \left(\sum_{j}^{blocks} C_j A_{ij} - p_i \right)^2}$$

$$\frac{\partial \chi^2}{\partial C_k} = 0 \Rightarrow$$

$$\begin{pmatrix} \sum_i A_{i0}A_{i0} & \sum_i A_{i0}A_{i1} & \dots & \sum_i A_{i0}A_{iN} \\ \sum_i A_{i1}A_{i0} & \sum_i A_{i1}A_{i1} & \dots & \sum_i A_{i1}A_{iN} \\ \vdots & \vdots & \ddots & \vdots \\ \sum_i A_{iN}A_{i0} & \sum_i A_{iN}A_{i1} & \dots & \sum_i A_{iN}A_{iN} \end{pmatrix} \begin{pmatrix} C_0 \\ C_1 \\ \vdots \\ C_N \end{pmatrix} = \sum_i p_i \begin{pmatrix} A_0 \\ A_1 \\ \vdots \\ A_N \end{pmatrix}$$

Central block selection

Replay cluster

- Loop over all blocks and select block with maximum pedestal-subtracted ADC signal

Projection

- Project VDC track to calorimeter and select block with matching physical coordinates

For either central block selection method, any block adjacent to the central block with positive ADC signal is included in the cluster

Cuts

Cuts 1:

- `DR.evtypebits == 48 || 112`
- `R.tr.n == 1`
- `R.vdc.{u1,u2,v1,v2}.nclust == 1`
- `R.cer.asum_c > 5000.`
- `R.tr.p > 0.`
- `(R.ps.e + 0.85*R.sh.e) > 1500.`
- `R.ps.e > 250.`
- `R.sh.e > 750.`
- No events where central block is on the perimeter

Cuts 2:

- `R.tr.n == 1`
- `R.cer.asum_c > 2000.`
- `(R.ps.e + R.sh.e)/(R.tr.p*1000.)  > 0.7`
- `|R.tr.vz| < 0.1`

Runs

Runs used for calibration:

- 90838 (carbon foil)
- 90840 (multifoil)
- 90849, 90850 (hydrogen)
- 90854, 90855, 90856 (helium)
- 90870, 90873, 90874, 90875 (tritium)
- 90876, 90877 (deuterium)

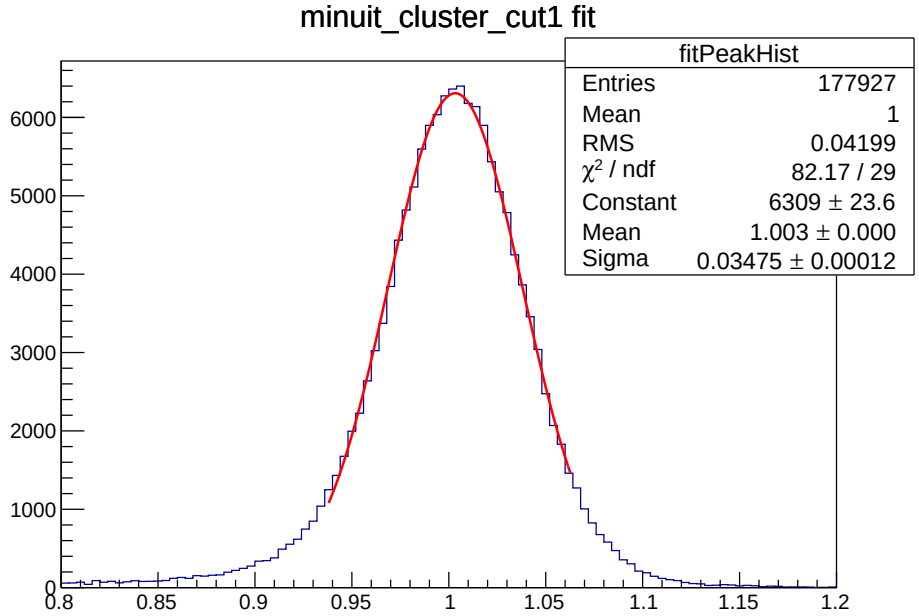
Total events: 45,938,778
Cut 1 events: 2,308,451
Cut 2 events: 1,576,862

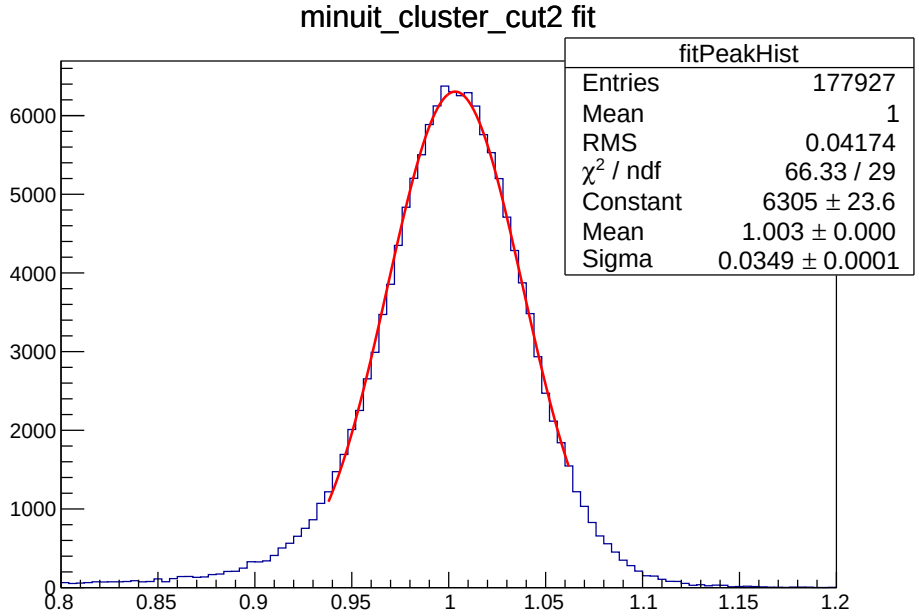
Summary of different calibrations

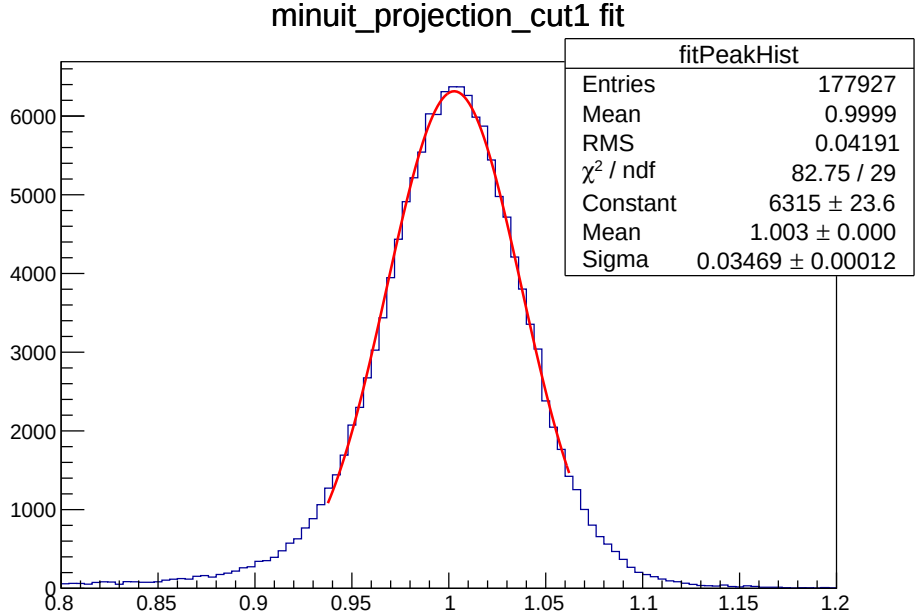
$$\begin{pmatrix}\text{TMinuit}\\ \\ \text{matrix}\end{pmatrix} \times \begin{pmatrix}\text{cluster}\\ \\ \text{projection}\end{pmatrix} \times \begin{pmatrix}\text{cut 1}\\ \\ \text{cut 2}\end{pmatrix} = 8 \text{ calibrations}$$

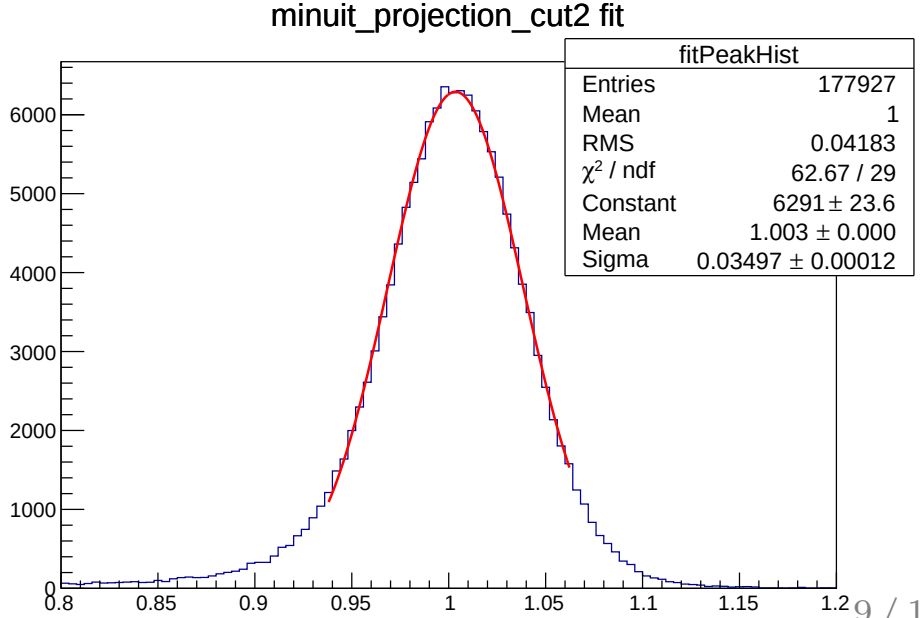
- minuit_cluster_cut1
- minuit_cluster_cut2
- minuit_projection_cut1
- minuit_projection_cut2
- matrix_cluster_cut1
- matrix_cluster_cut2
- matrix_projection_cut1
- matrix_projection_cut2

TMinuit E/P results

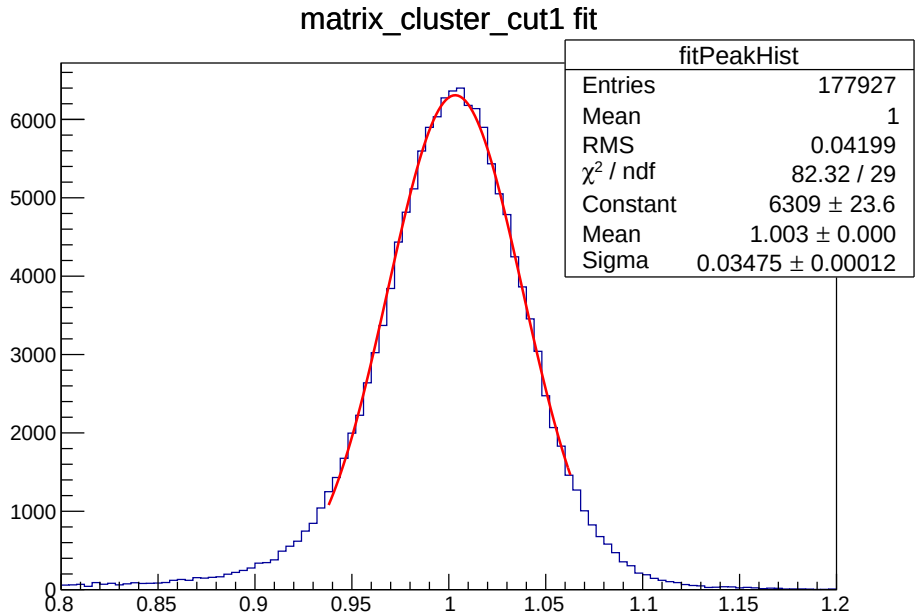


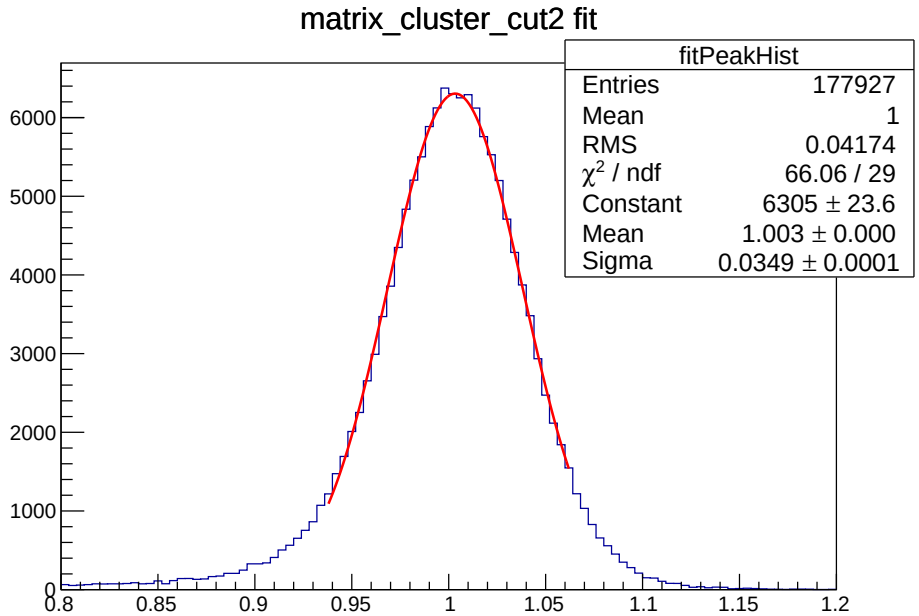


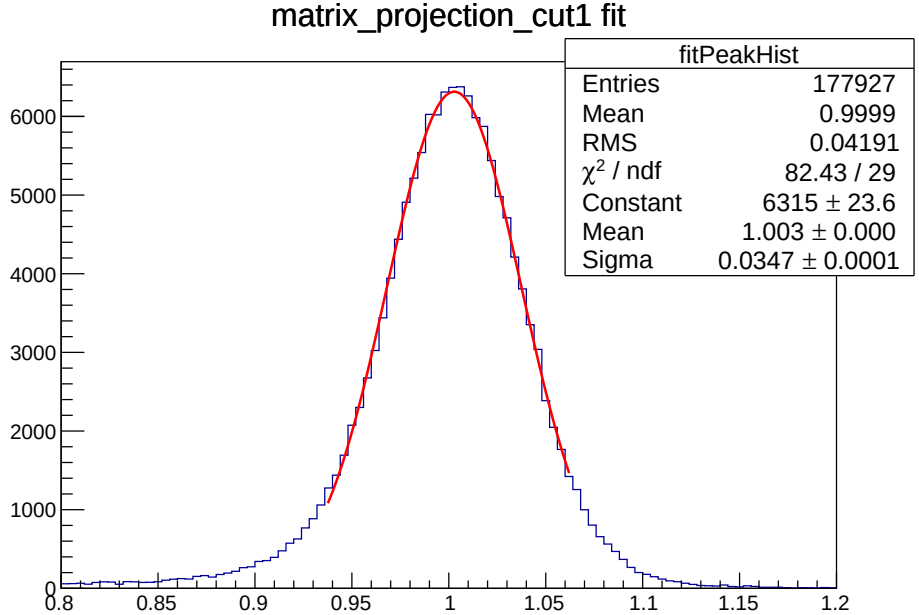


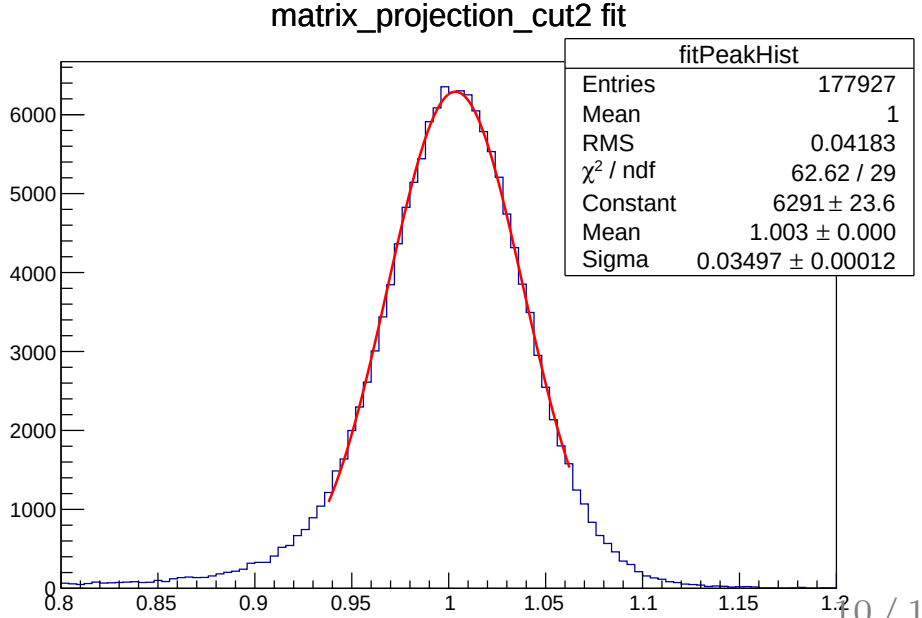


Matrix E/P results









E/P summary

Calibration	Mean	RMS
minuit_cluster_cut1	1.003	0.03475
minuit_cluster_cut2	1.003	0.03490
minuit_projection_cut1	1.003	0.03469
minuit_projection_cut2	1.003	0.03497
matrix_cluster_cut1	1.003	0.03475
matrix_cluster_cut2	1.003	0.03490
matrix_projection_cut1	1.003	0.03470
matrix_projection_cut2	1.003	0.03497

- Very little difference as long as sufficient events are used
- Perhaps previous discrepancy was due to not enough events being used for matrix calibration
- Best calibration is from TMinuit, projection, cut 1