

Jefferson
Lab

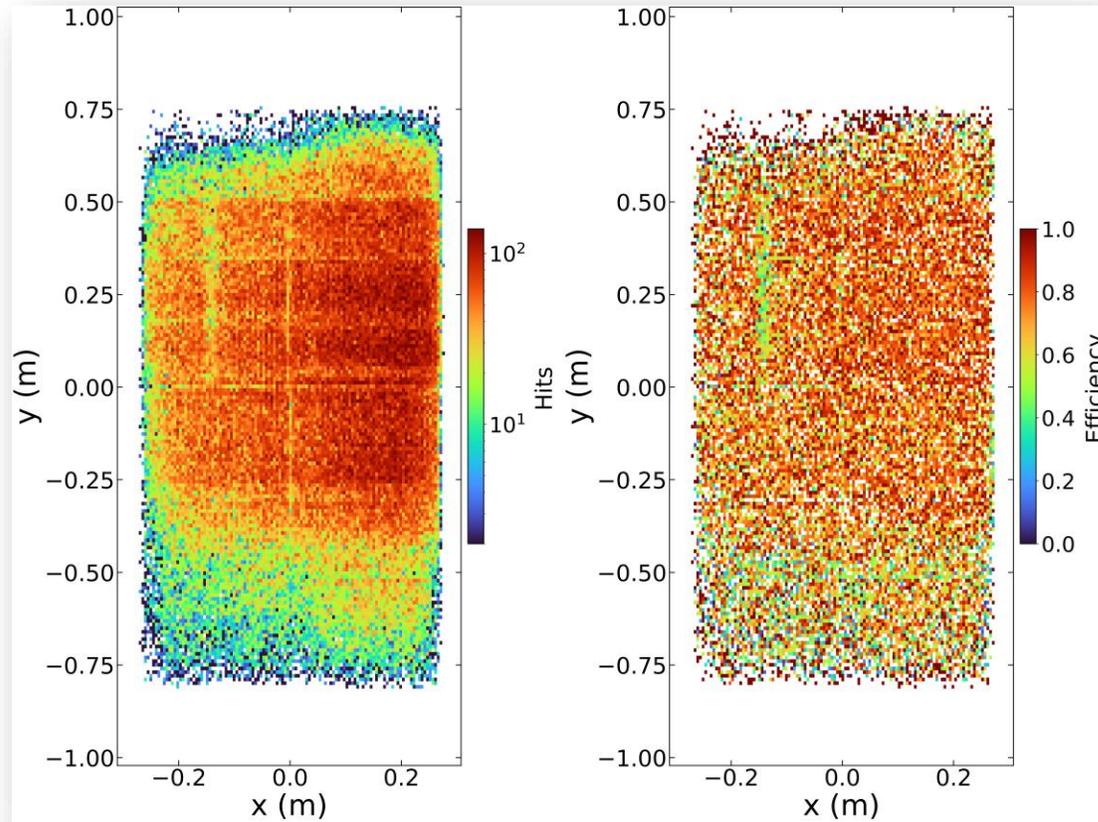

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Hadron Arm Tracking Data in GEn-II

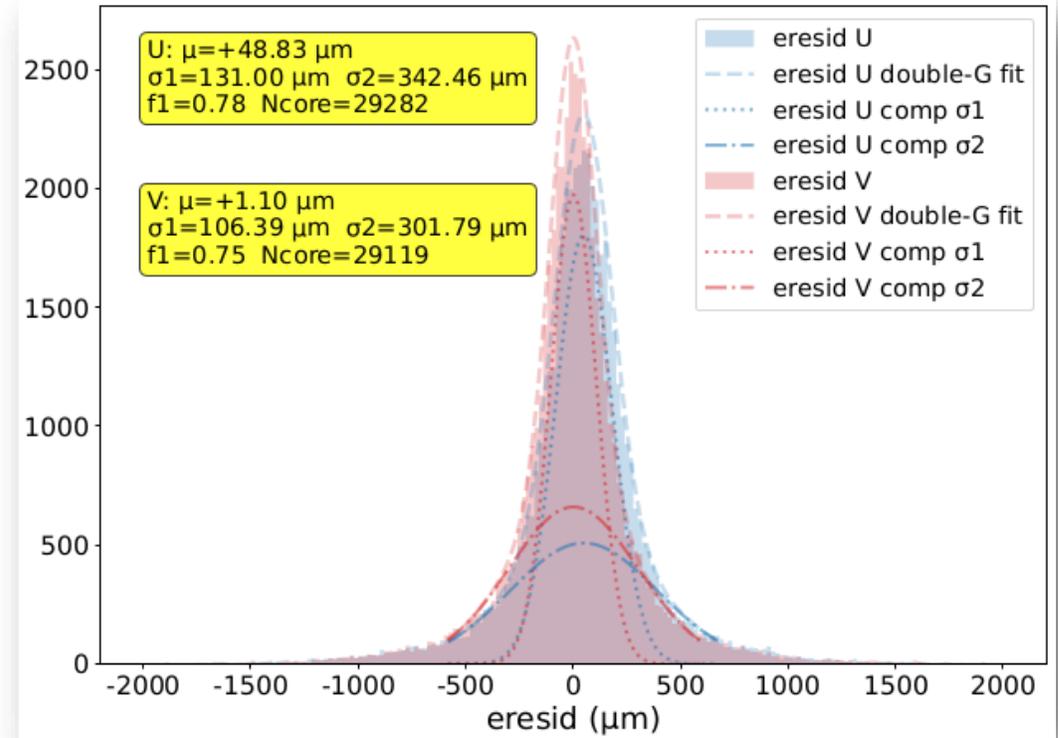
Vimukthi Haththotuwa Gamage

Performance Summary



Hit and efficiency distributions of layer 4 (data from GEN3 ^3He running)

- Total of six operational layers
- Layer Efficiencies : 70-80%
- Residuals : $< 150 \mu\text{m}$
- Operational duration : Table 1

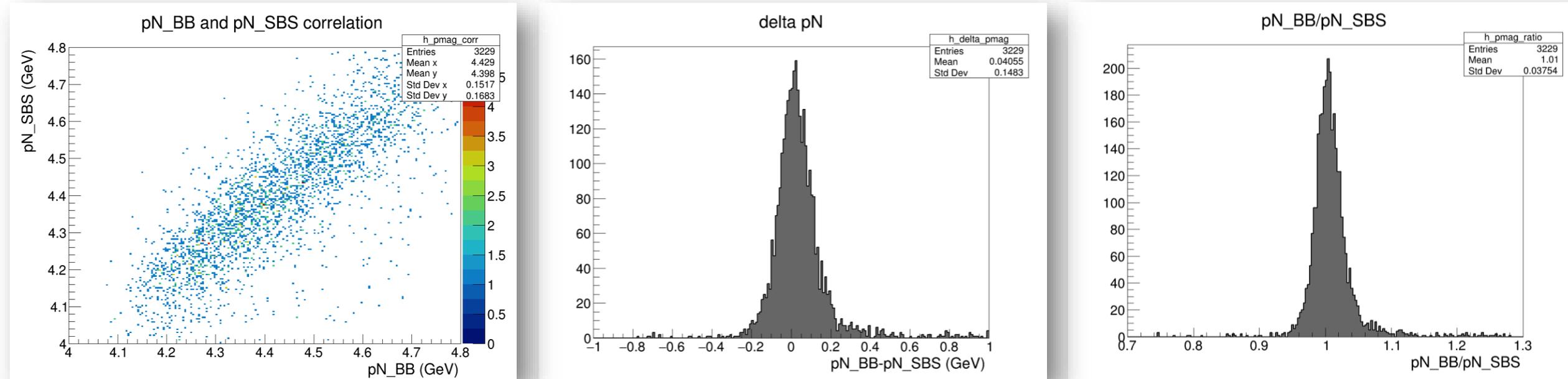


Exclusive residuals of layer 4 module 3 (data from GEN3 ^3He running)

Table 1 : Polarized ^3He runs with hadron arm GEMs included in the data streak

Kinematic	Total run count	Run count with SBS GEMs	Percentage (%)
GEN2	126	34	26.98
GEN3	354	73	20.62
GEN4	508	76	14.96
GEN4b	510	316	61.96
Total	1,498	499	33.31

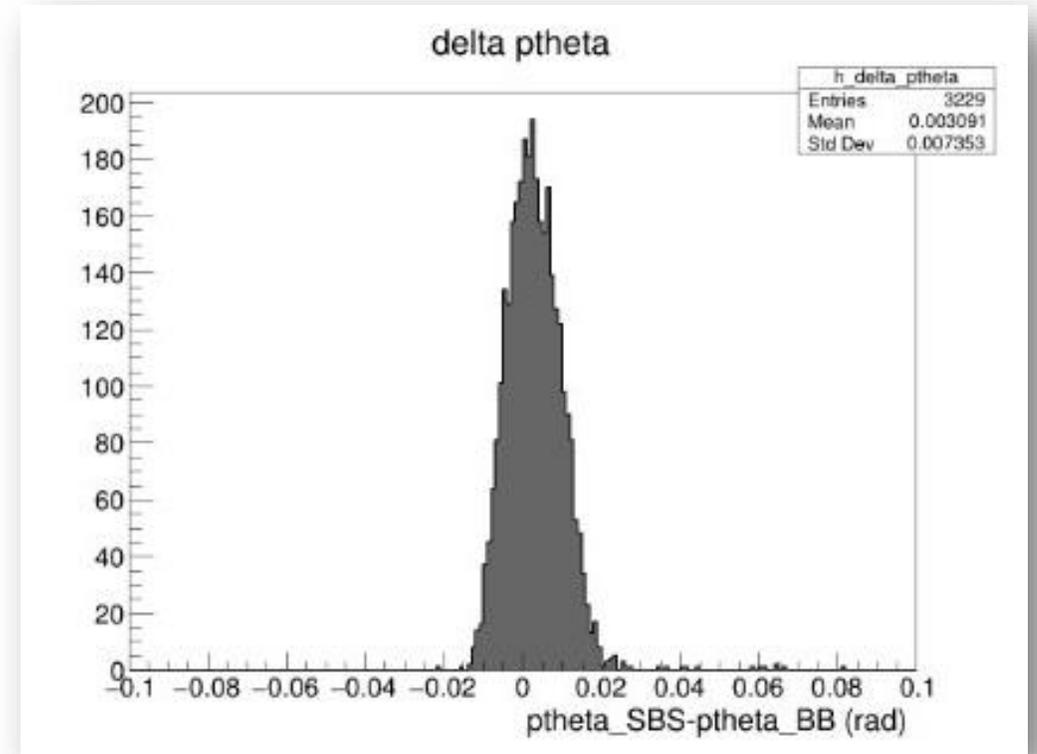
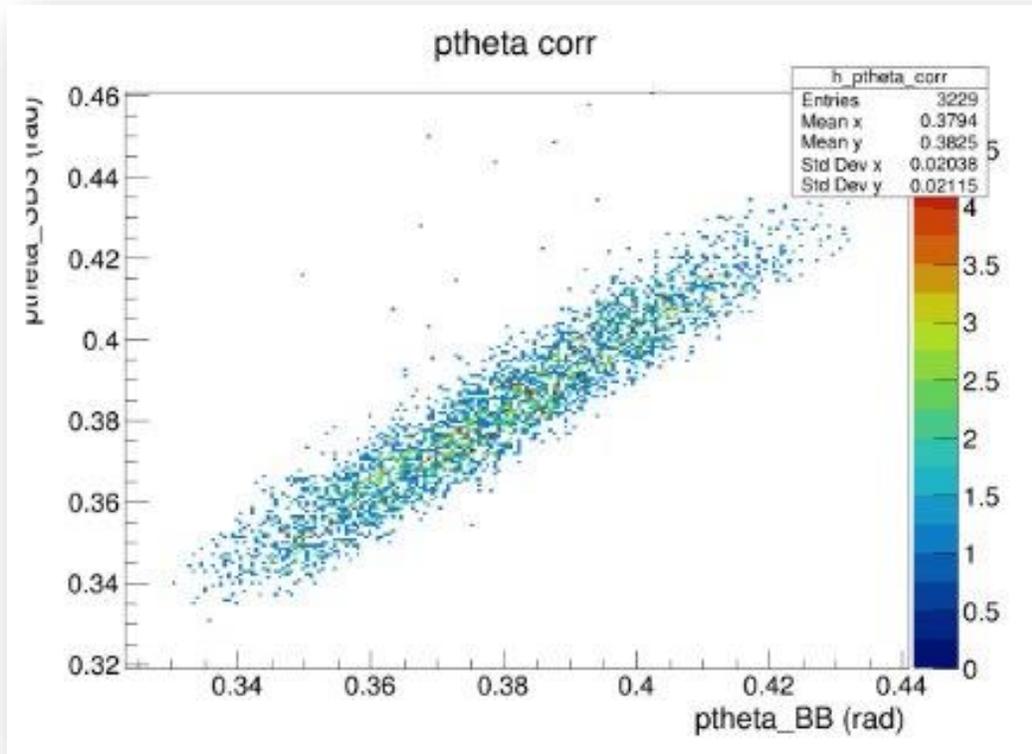
Optics and Momentum Reconstruction in the Hadron Arm



GEN3 ^3He hadron momentum reconstruction

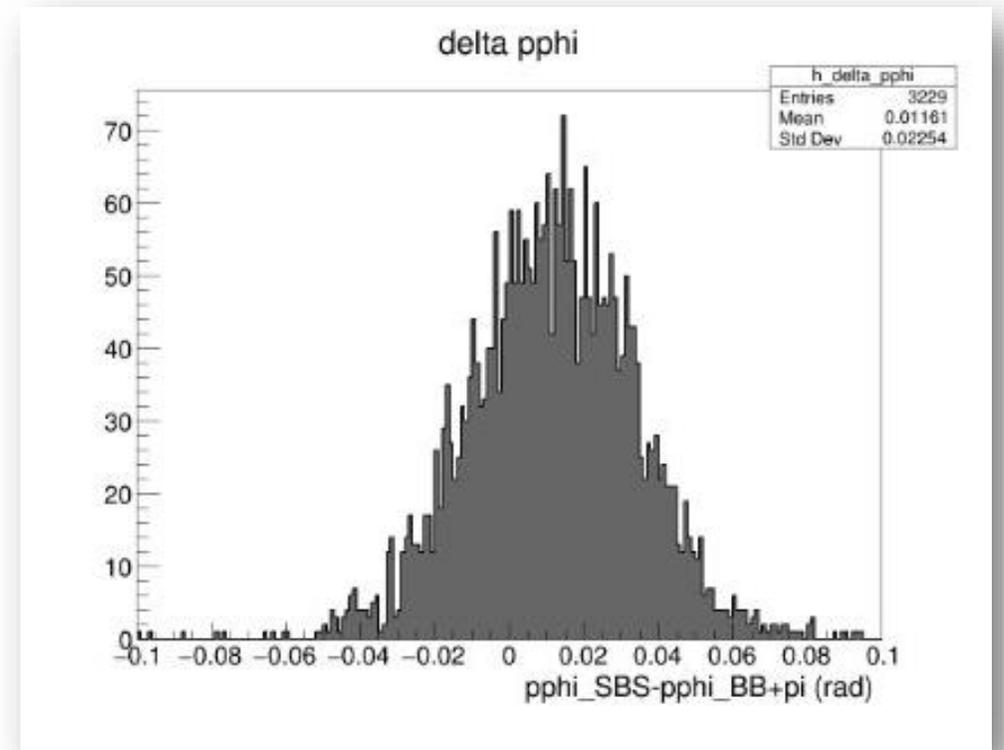
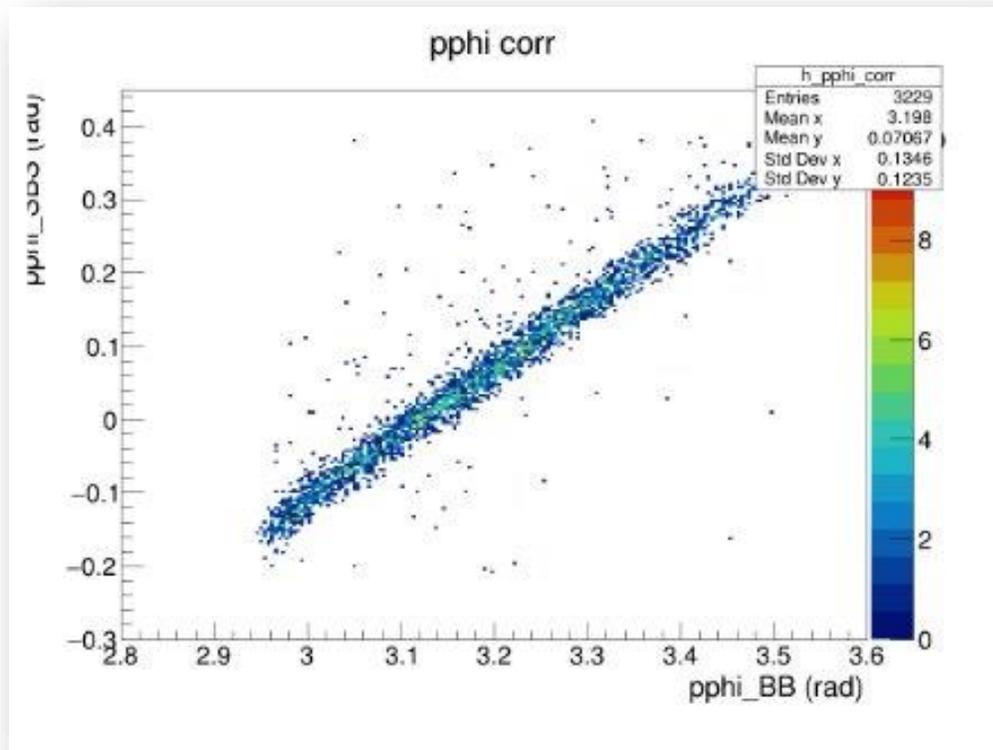
- GEM stack global alignment from GEN-RP
- Starting optics model from the simulation
- Ad hoc corrections to get agreement BigBite reconstruction

Optics and Momentum Reconstruction in the Hadron Arm



GEN3 ^3He hadron angular reconstruction

Optics and Momentum Reconstruction in the Hadron Arm



GEN3 ^3He hadron angular reconstruction

Energy Calibrations of HCal

$$E_i = \nu_i S_f^*$$

with elastic events

$$S_f^* = S_f R$$

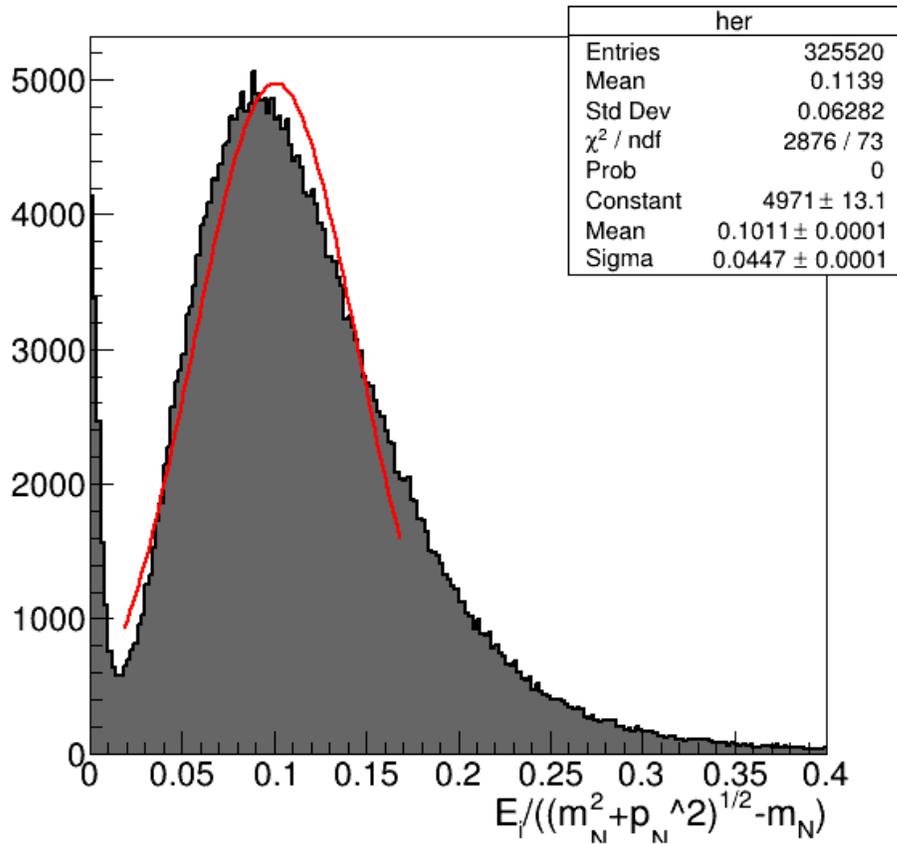
$$E_i = (\sqrt{M_N^2 + P_N^2} - M_N)_i S_f^*$$

with good tracks

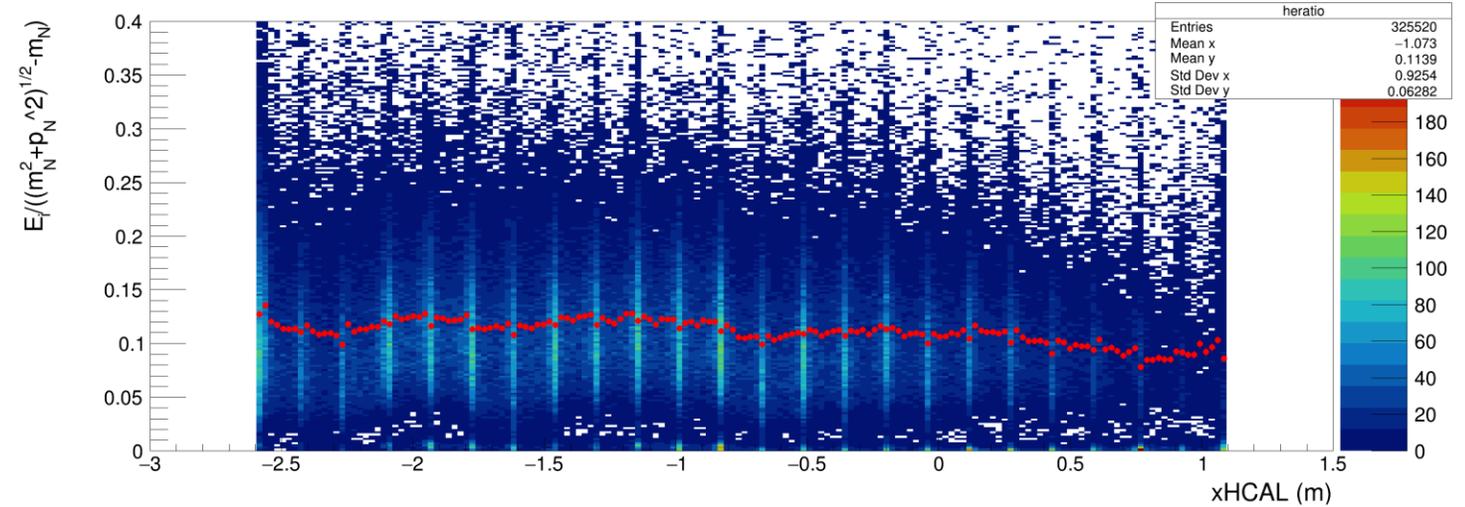
- The standard approach wants a clean sample of elastic events that uniformly illuminates HCal
- Hydrogen elastics were limited so one cannot do a robust calibration
- **Key idea : use hadron arm tracking to get hadron kinetic energy instead of relying on elastic kinematics**
- No longer depends on a good selection of tightly fixed energy transfer
- A broad sample of good tracks can be used for the calibration

Energy Calibrations of HCal

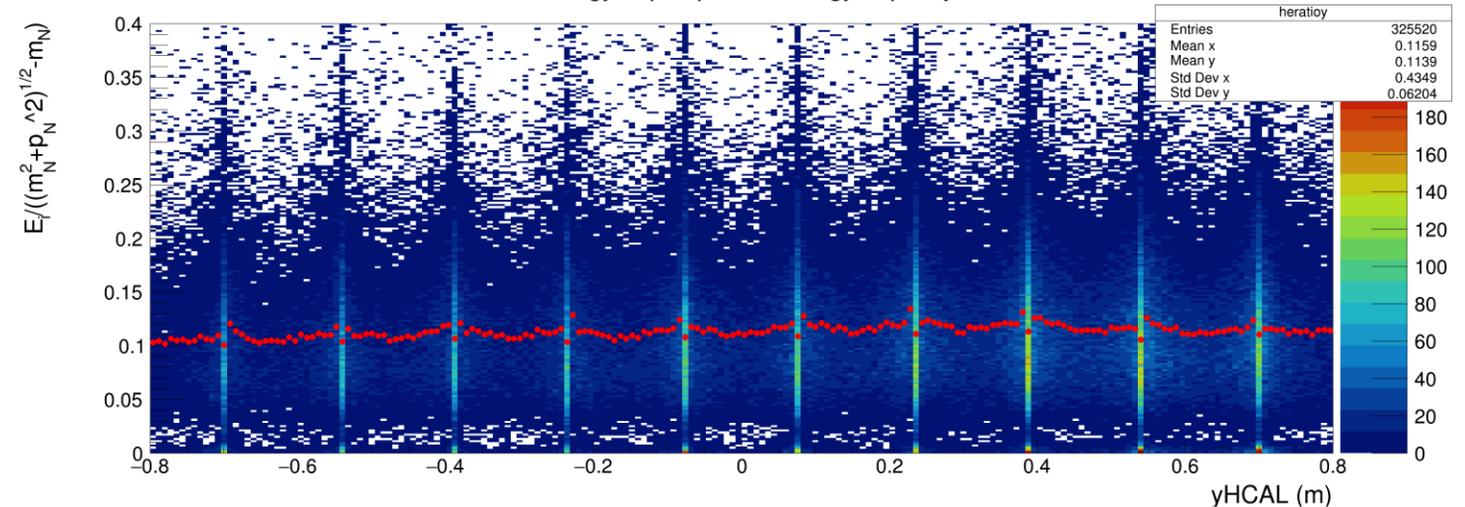
Actual energy dep/expected energy dep



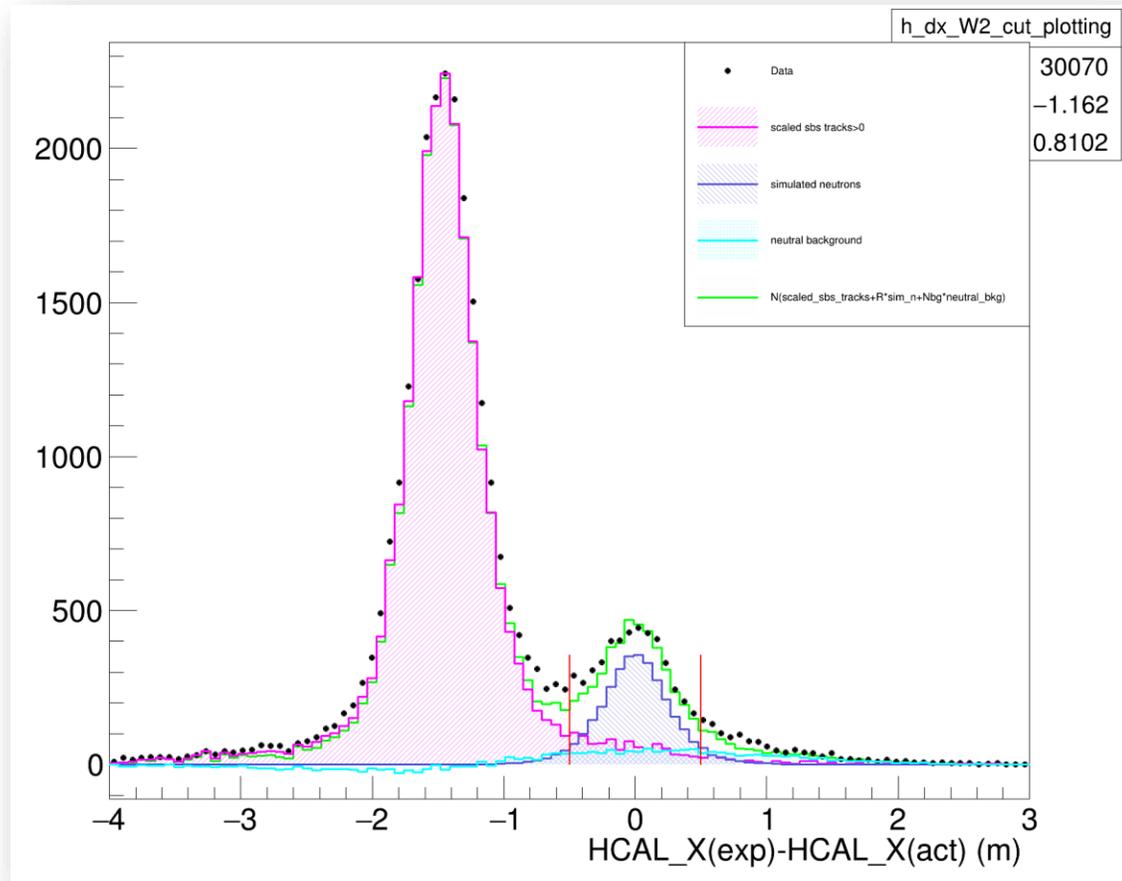
Actual energy dep/expected energy dep vs xHCAL



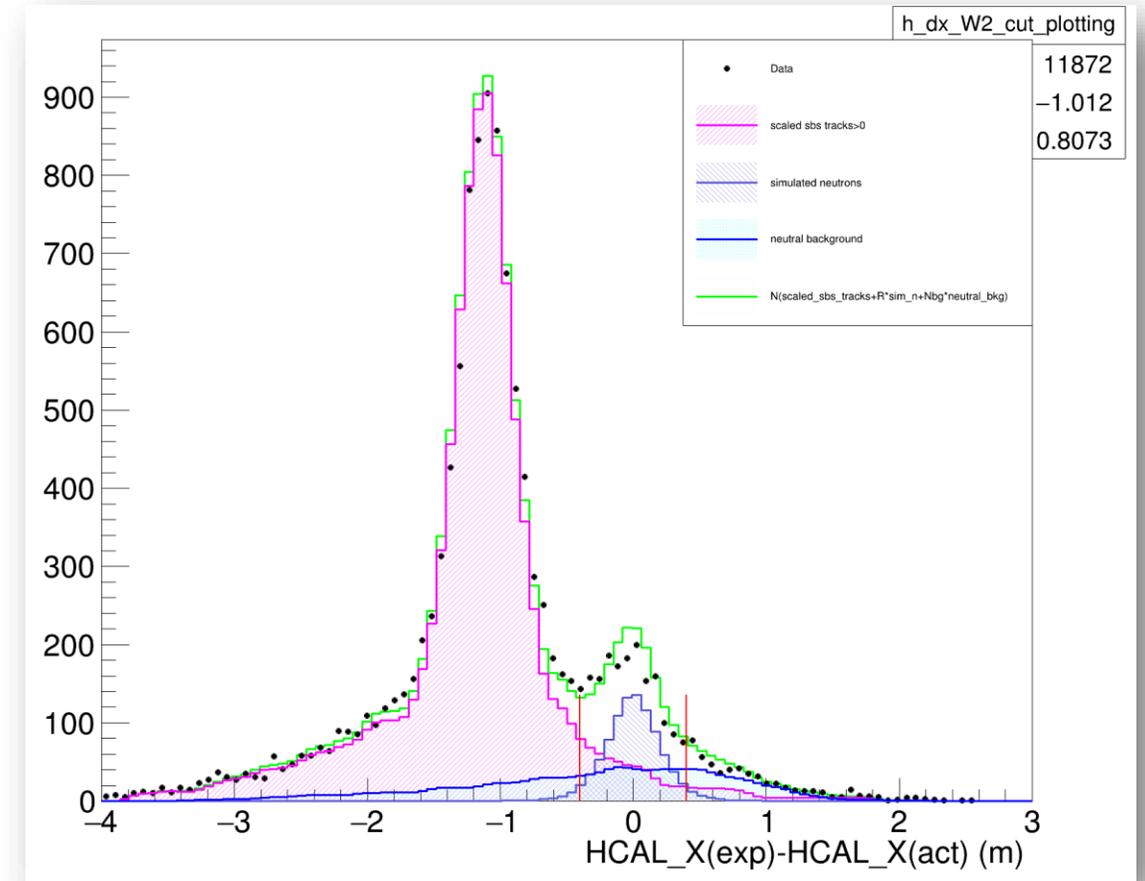
Actual energy dep/expected energy dep vs yHCAL



Understanding the charged Background



GEN3



GEN4b

Missing Mass for Calculation

$$P_e(e_{beam}, 0, 0, e_{beam})$$

$$P_{e'}(P, P_x, P_y, P_z)$$

$$P_N(M_N, 0, 0, 0)$$

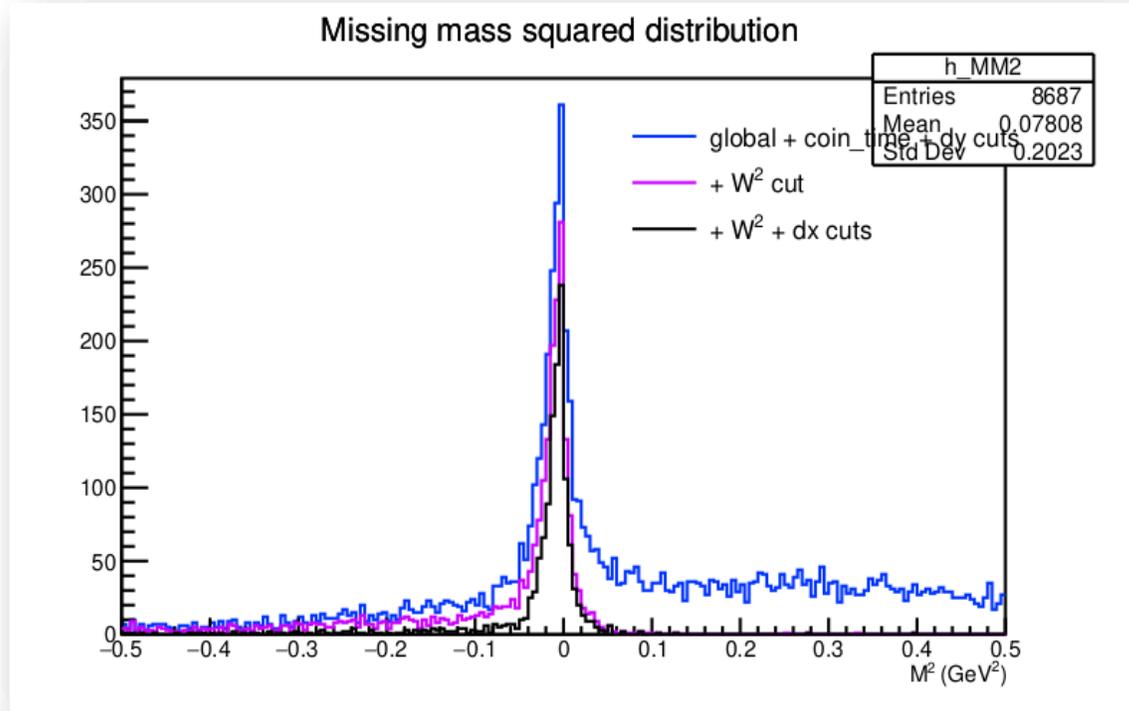
$$P_{N'}(\sqrt{P_N^2 + M_N^2}, P_{N_x}, P_{N_y}, P_{N_z})$$

- With the hadron arm tracking we can reconstruct the momentum of the outgoing nucleon
- Hence the missing mass, missing energy and missing momentum calculations are possible
- Helps us with
 - Understanding the background
 - Studying the cuts

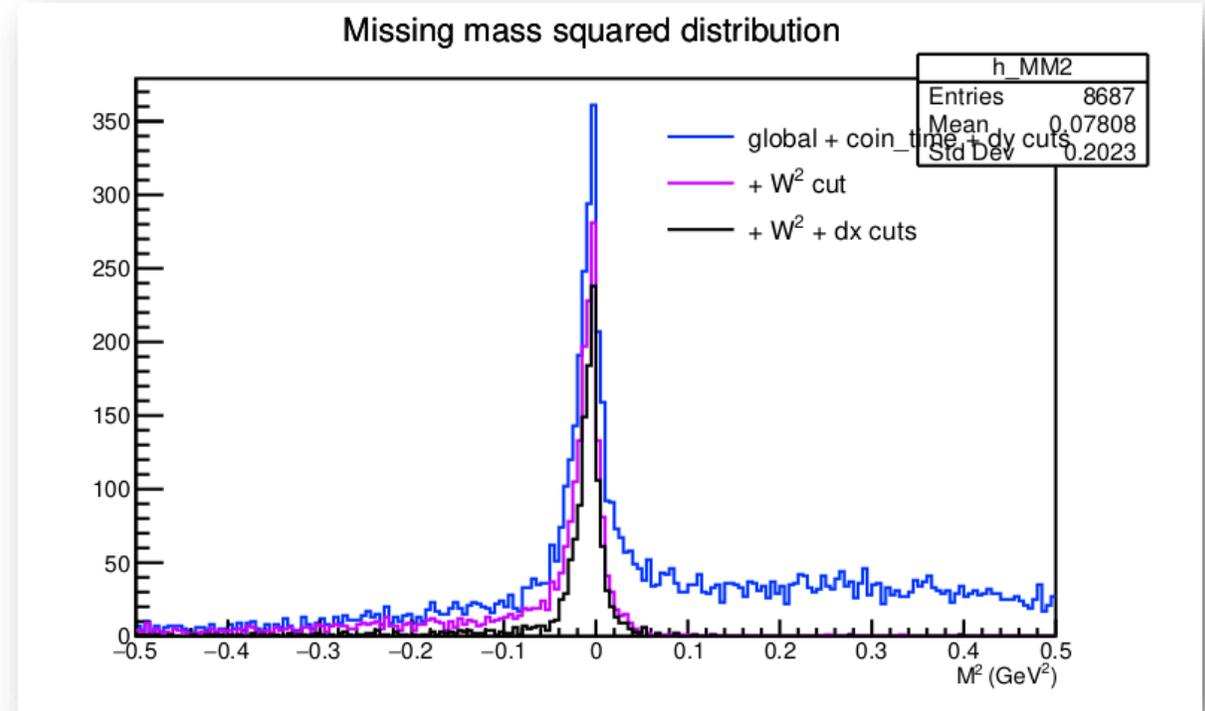
$$P_{miss} = P_e + P_N - P_{e'} - P_{N'}$$

$$M_x^2 = P_{miss}^2$$

Missing Mass Squared for ${}^3\text{He}$ Proton Data



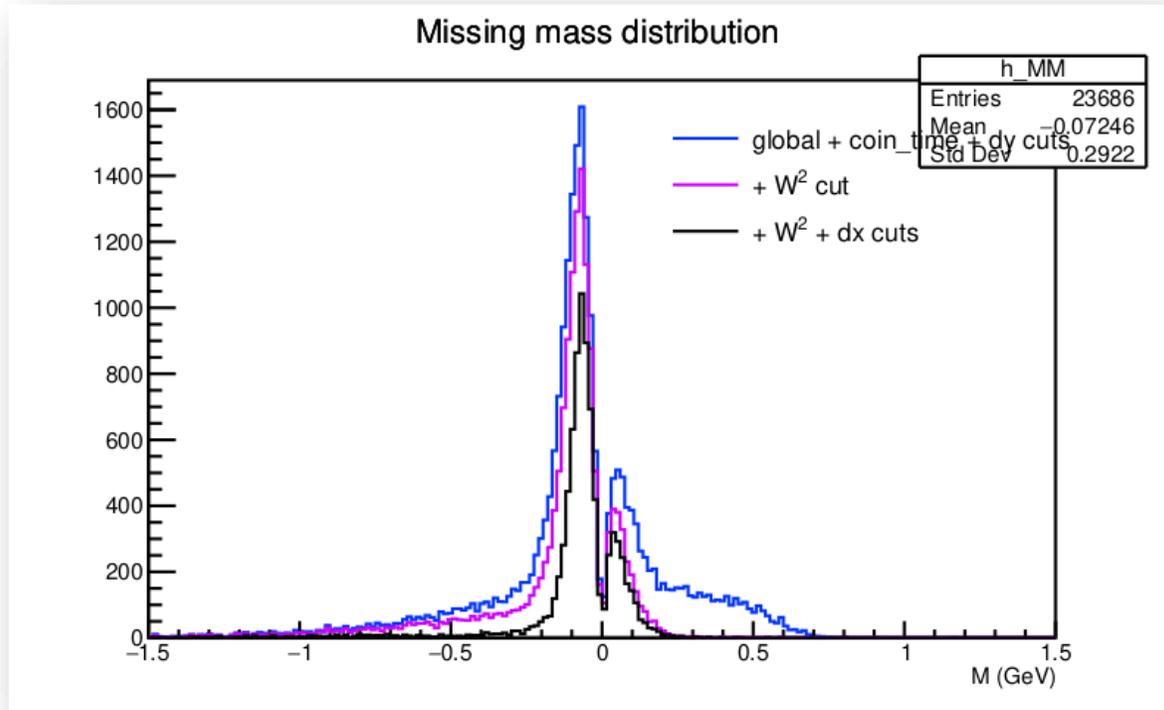
GEN3



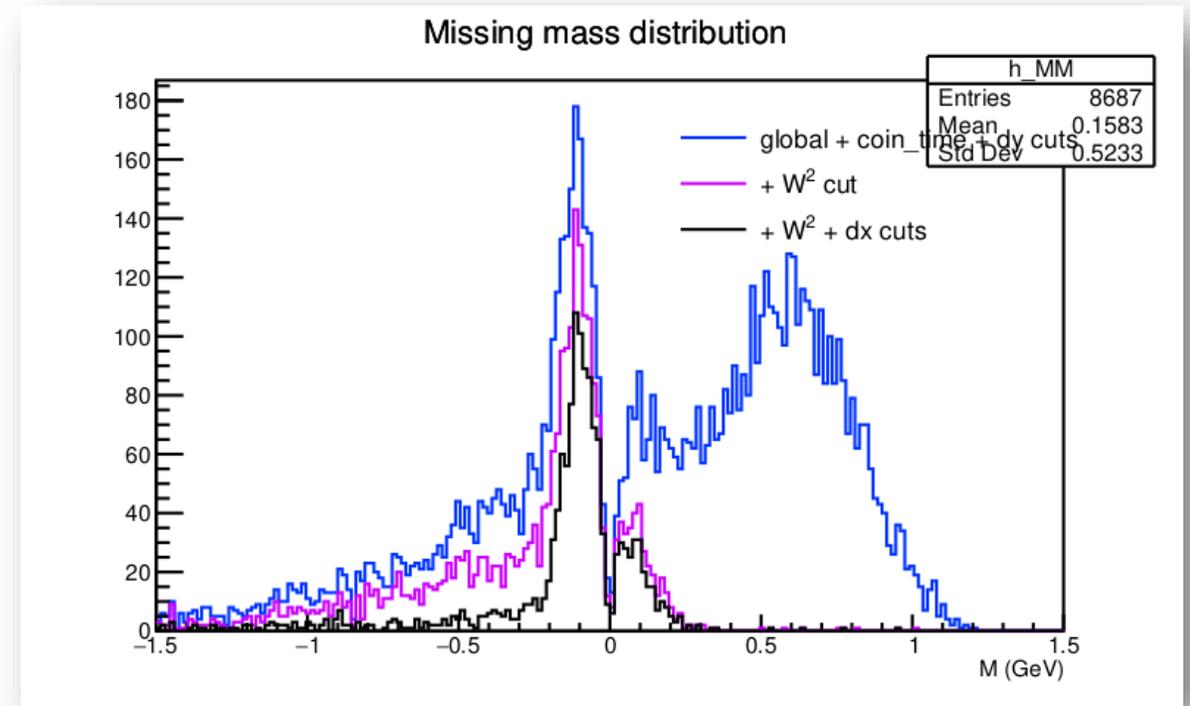
GEN4b

- Negative M_x^2 could be due to finite resolution of reconstructed four momenta and assumption of taking the initial nucleon at rest

Missing Mass for ^3He Proton Data



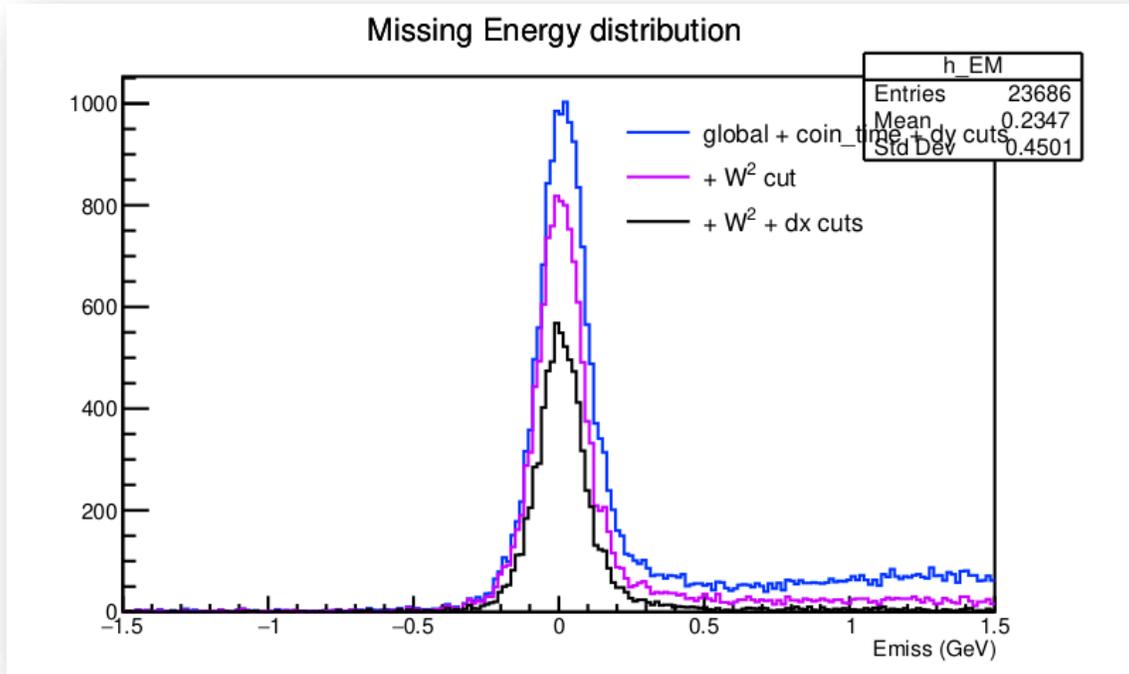
GEN3



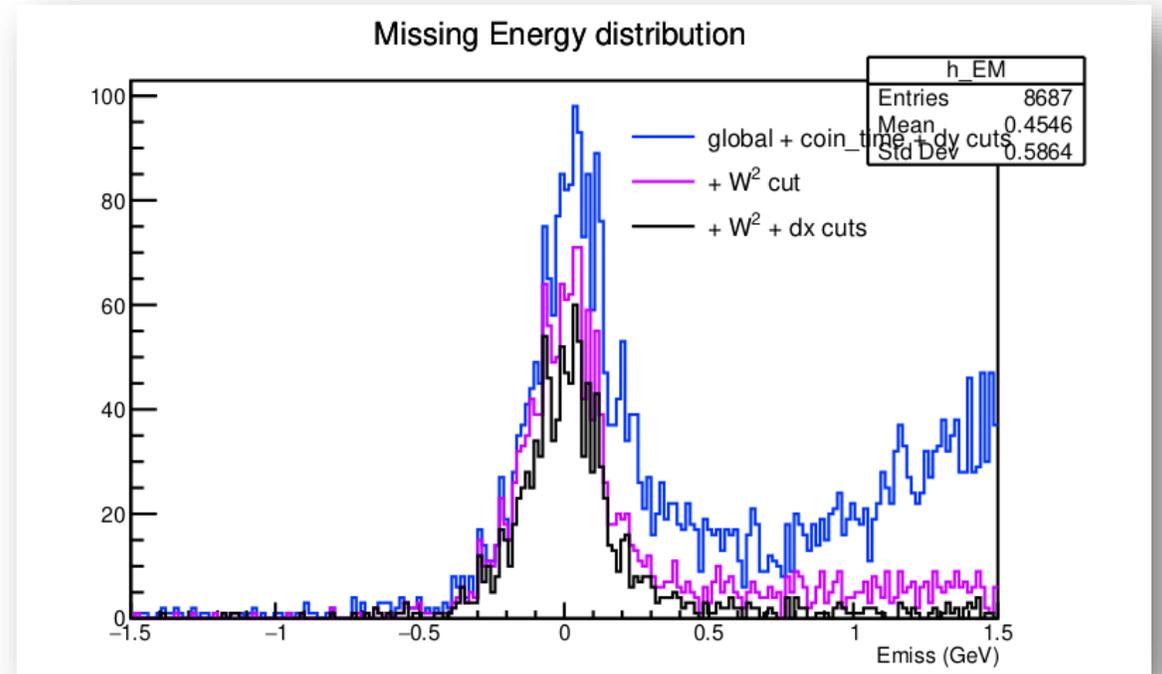
GEN4b

- ROOT takes solutions to $M_x^2 < 0$ to be $M_x < 0$
- Structure at larger M_x is consistent with inelastic channels (pion production and multi-hadron final states)

Missing Energy for ^3He Proton Data



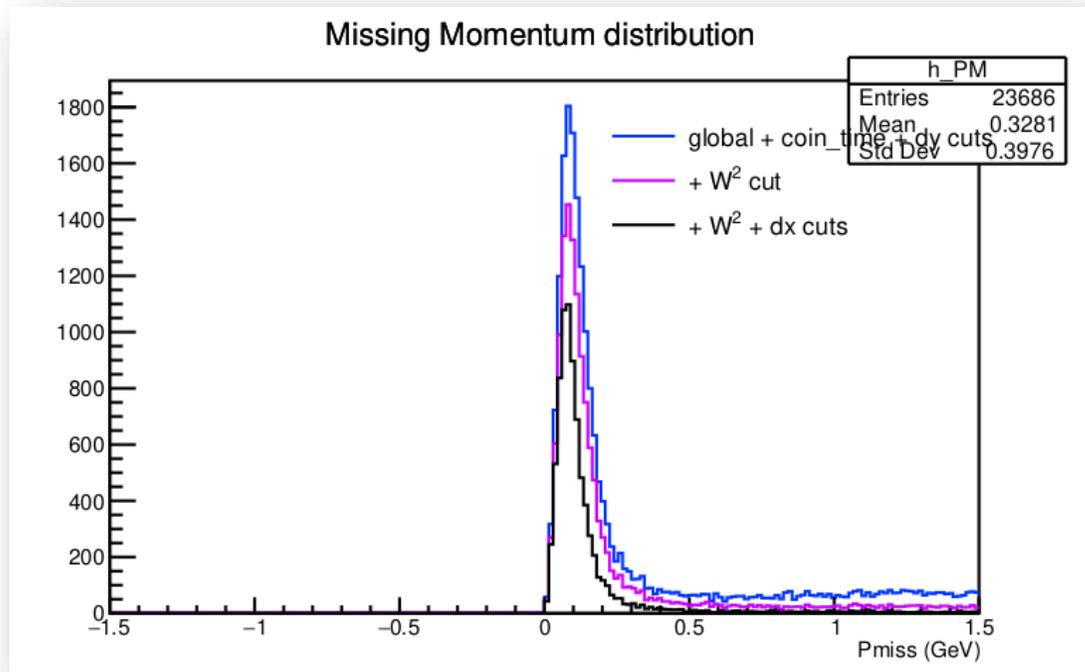
GEN3



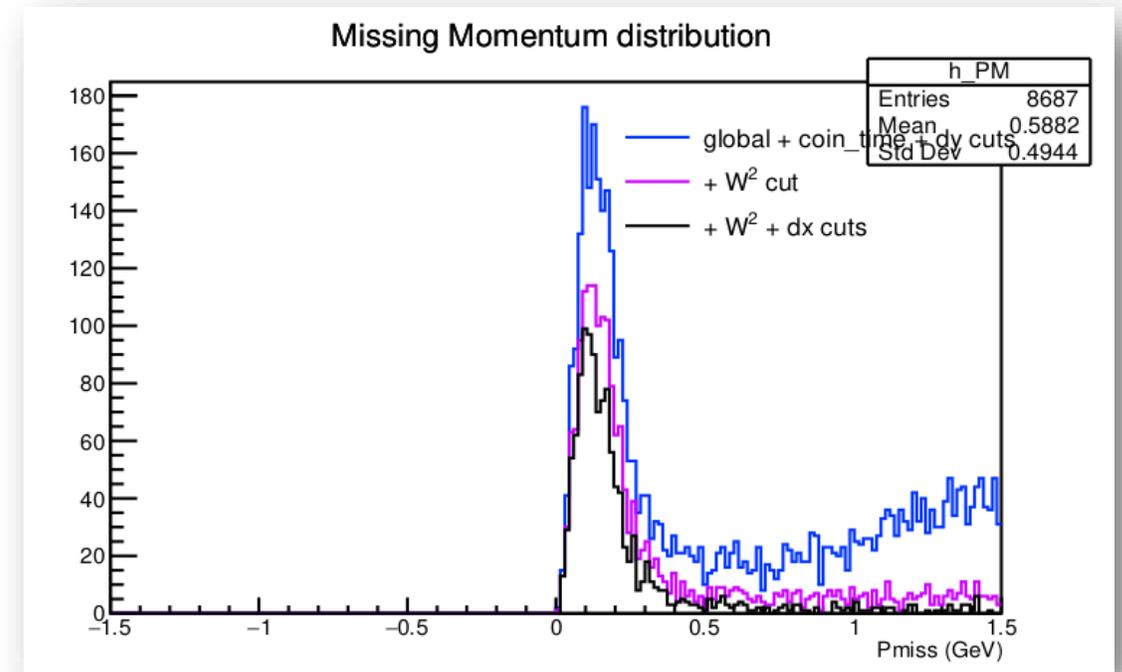
GEN4b

- Radiative tail
- Illustrates the effect of the exclusivity cuts

Missing Momentum for ^3He Proton Data



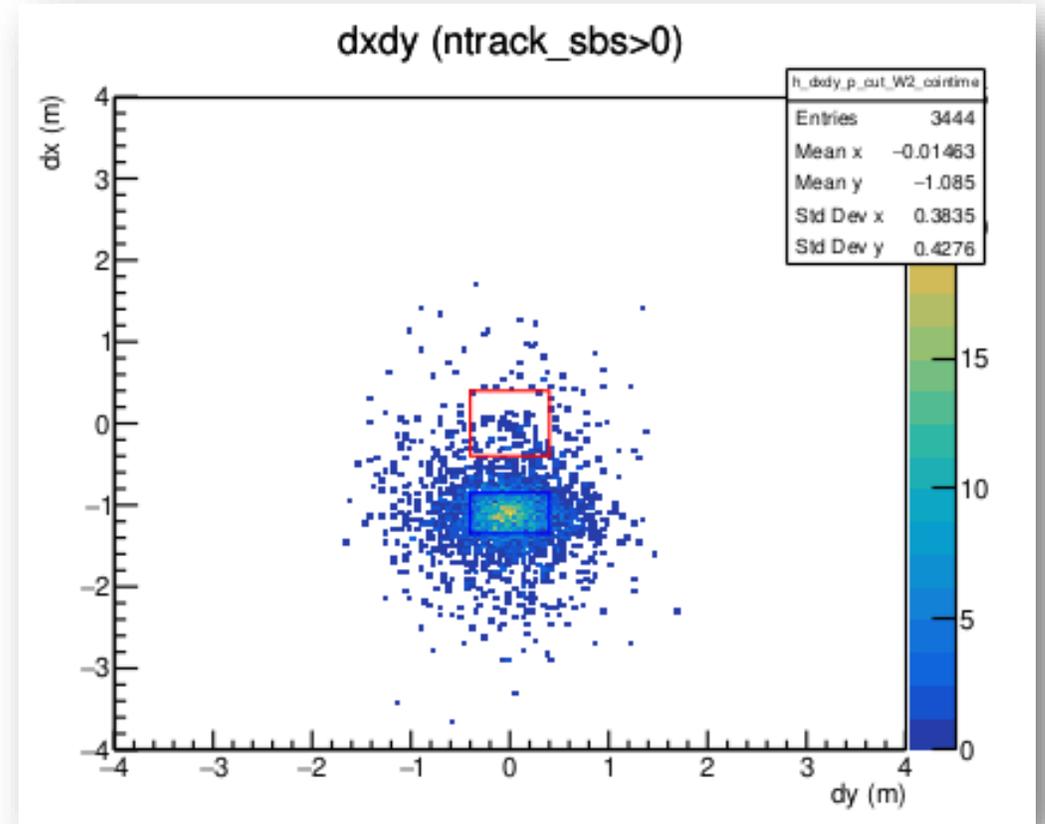
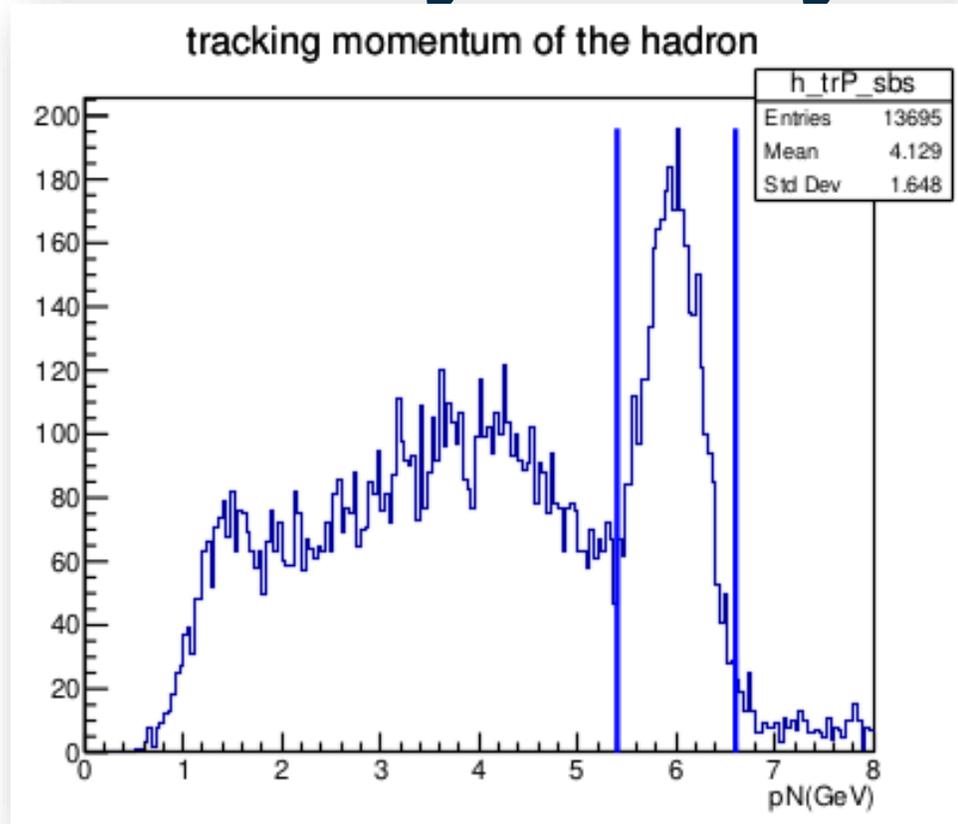
GEN3



GEN4b

- Radiative tail
- Illustrates the effect of the exclusivity cuts

Proton Asymmetry and Fraction



- Consider only runs taken with sbs gems included in the DAQ
- Proton asymmetry = $(N^+ - N^-)/(N^+ + N^-)$ in the proton spot (sbs track + QE + P_N)
- Proton fraction = events that pass (sbs track + QE + P_N) in neutron spot / events that pass QE cuts in neutron spot / tracking efficiency

Thank You