New Event Generator and Onset of SRC Dominance from (e,e’p)

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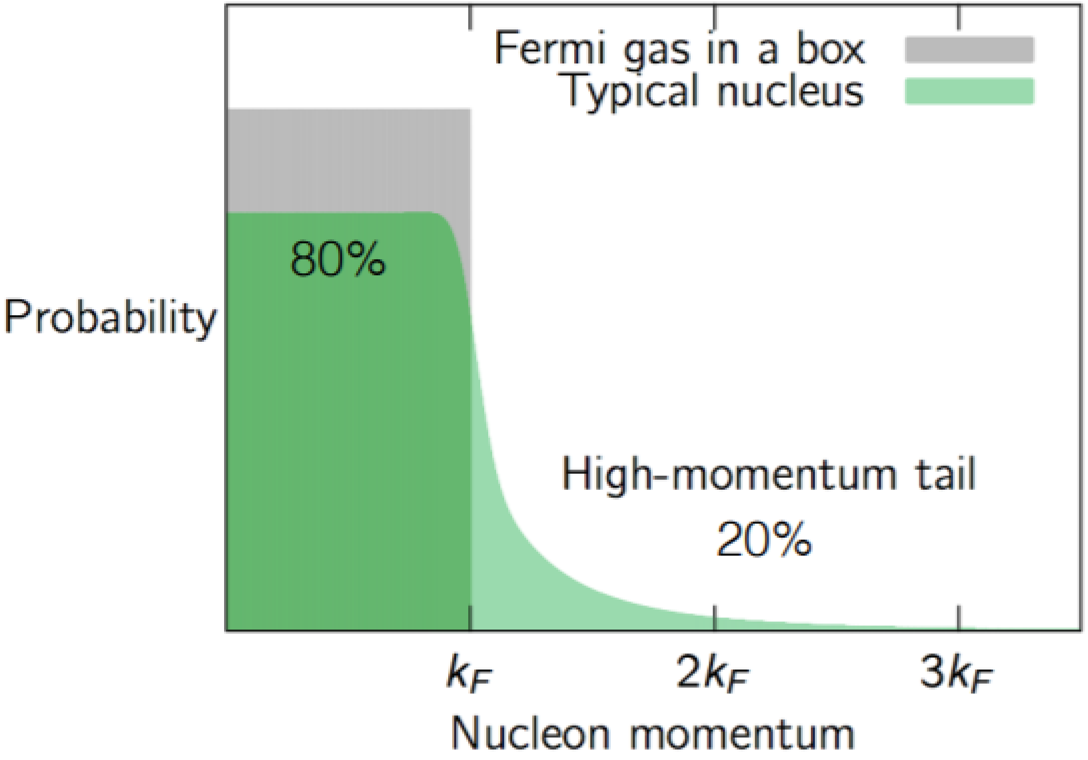
NOVEMBER 15, 2016

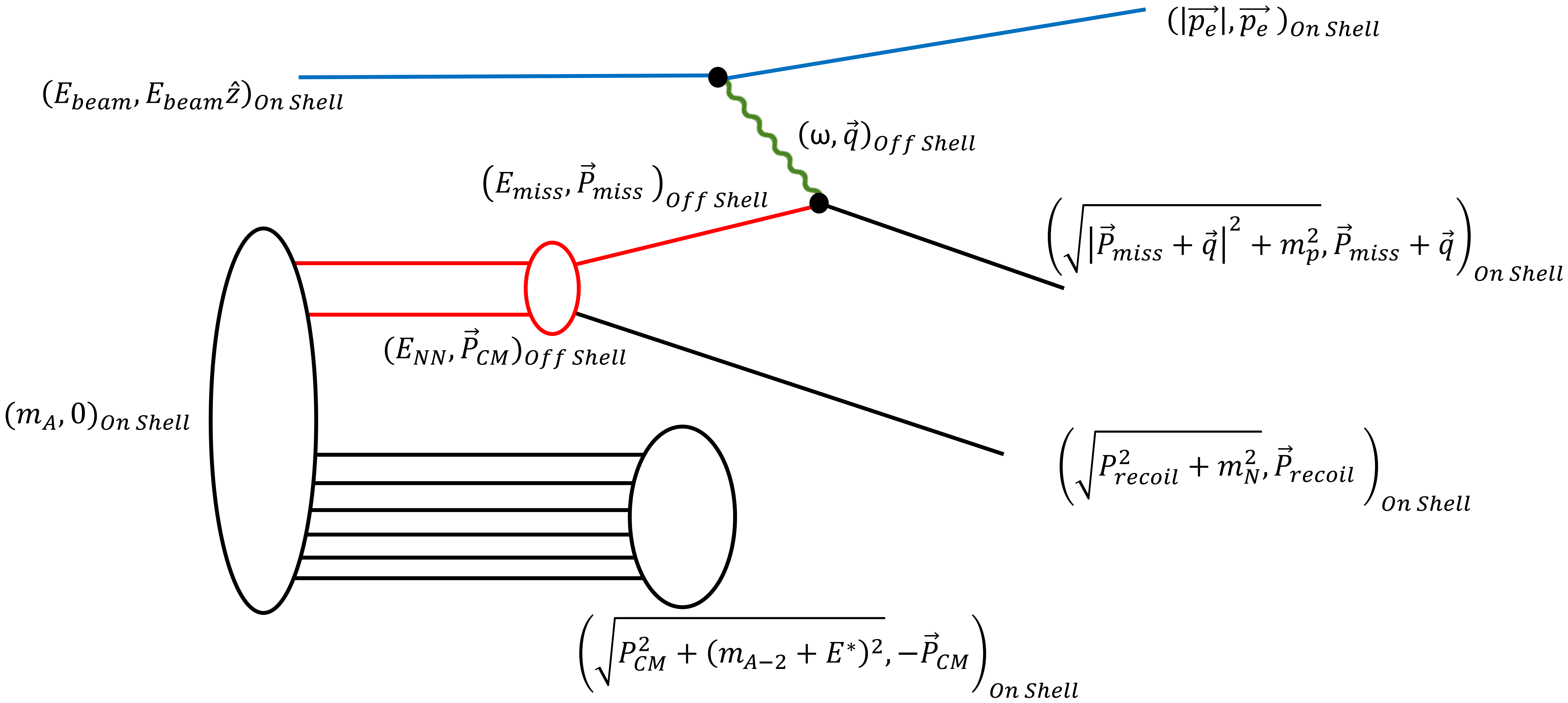
Overview

- New Event Generator
  - Quasi-elastic Scattering of SRC Pairs
  - Contact Formalism and Spectral Function
  - Generating events
- New Observable in Plateau of M_{miss}
  - Explaining M_{miss}
  - Comparing data to generator
  - Further work

Why use a Generator



Scattering electrons off SRC pairs



Plane Wave QE Cross Section

$$\frac{d^6\sigma}{d^2\Omega_k dE_k d^2\Omega_{p_1} dE_1} = p_1 E_1 \sigma_{e,N} S$$

Spectral Function → Contact Formalism

Contact formalism

$$\Psi_i^A \xrightarrow{(|\vec{p}_1-\vec{p}_2|)\to\infty} \sum_{\alpha} \tilde{\varphi}_{ab}^{\alpha}(|\vec{p}_1-\vec{p}_2|) \times \tilde{A}_{ab}^{\alpha}(\vec{P}_{12},\{\vec{p}_k\}_{\{k\neq 1,2\}})$$

$\alpha \rightarrow$spin
$a, b \rightarrow$ proton, neutron

$$S_{ab}^{\alpha}(\epsilon^1,\vec{p}^1) = \frac{1}{4\pi}\int \frac{d^3\vec{p}_2}{(2\pi)^3}\,\delta\big(f(\vec{p}_2)\big)\,|\tilde{\varphi}_{ab}^{\alpha}(|\vec{p}_1-\vec{p}_2|)|^2\, n_{ab}^{\alpha}(\vec{p}_1+\vec{p}_2)$$

- Integral over recoil momentum
- Delta function for legal kinematics

- Two body wavefunction
- In momentum Space
- Amplitude as a function of $\vec{p}_{rel}$

- Wavefunction of the SRC pair
- In momentum Space
- Amplitude as a function of $\vec{p}_{CM}$

R. Weiss, Rey Cruz-Torres et al., PLB 780 (2018) 211–215

Contact formalism

$$\Psi_i^A \xrightarrow{(|\vec{p}_1 - \vec{p}_2|) \to \infty} \sum_\alpha \tilde{\varphi}_{ab}^\alpha (|\vec{p}_1 - \vec{p}_2|) \times \tilde{A}_{ab}^\alpha(\vec{P}_{12}, \{\vec{p}_k\}_{\{k \neq 1,2\}})$$

α →spin
a, b → proton, neutron

$$S_{ab}^\alpha(\epsilon^1, \vec{p}^1) = \frac{1}{4\pi} \int \frac{d^3\vec{p}_2}{(2\pi)^3} \, \delta\big(f(\vec{p}_2)\big) \, |\tilde{\varphi}_{ab}^\alpha (|\vec{p}_1 - \vec{p}_2|)|^2 \, n_{ab}^\alpha(\vec{p}_1 + \vec{p}_2)$$

$$S^p = C_{pn}^1 S_{pn}^1 + C_{pn}^0 S_{pn}^0 + 2C_{pp}^0 S_{pp}^0$$

$$S^n = C_{pn}^1 S_{pn}^1 + C_{pn}^0 S_{pn}^0 + 2C_{nn}^0 S_{nn}^0$$

$$\left[\frac{\hat{p}^2}{2m} + V(\vec{r})\right] \varphi = \mathrm{E}\varphi$$

Gaussian Distribution

R. Weiss, Rey Cruz-Torres et al., PLB 780 (2018) 211–215

Final Cross Section

$$\frac{d^6\sigma}{d^2\Omega_k dE_k d^2\Omega_{p_1} dE_1} = p_1 E_1 \sigma_{e,N} S$$

$$\frac{d^6\sigma}{d^2\Omega_k\, dE_k\, d^3\vec{p}_{CM}} = \frac{\sigma_{e,N}}{4\pi} \sum_{\alpha} \int \frac{p_2^2\, dp_2 d^2\Omega_{p2}}{(2\pi)^3} \delta(p_2 - p_2^*)\, C^\alpha\, |\tilde{\varphi}^\alpha(|\vec{p}_{CM} - 2\,\vec{p}_2|)|^2\, n^\alpha\, (\vec{p}_{CM})\mathcal{J}$$

$$\frac{d^8\sigma}{d\phi_k dQ^2 dx_B d^3\vec{p}_{CM} d\Omega_{p2}} = \frac{\sigma_{e,N}}{32\pi^4} \sum_{\alpha} C^\alpha\, |\tilde{\varphi}^\alpha(|\vec{p}_{CM} - 2\,\vec{p}_2|)|^2\, n^\alpha\, (\vec{p}_{CM})\mathcal{J}$$

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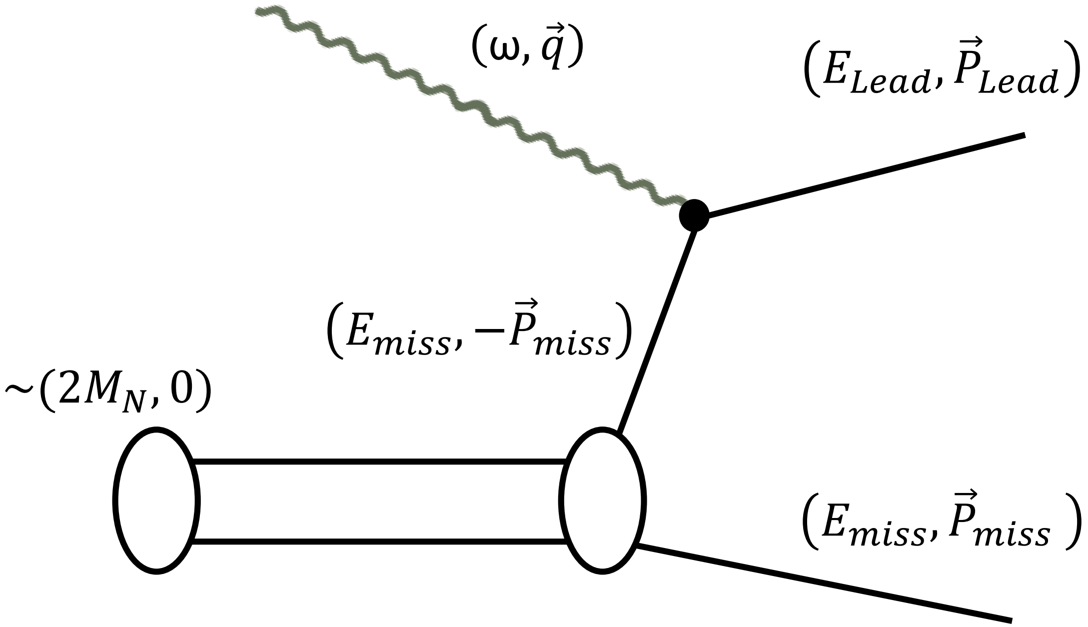
P_{miss} and M_{miss}



$$P_{miss} = (E_{miss}, \vec{P}_{miss}) = (\omega, \vec{q}) + (2M_N, 0) - (E_{Lead}, \vec{P}_{Lead})$$

$$|\vec{P}_{miss}|^2 = \left|\vec{q} - \vec{P}_{Lead}\right|^2$$

$$M^2_{miss} = \left((\omega, \vec{q}) + (2M_N, 0) - (E_{Lead}, \vec{P}_{Lead})\right)^2$$

M_{miss} Data

Lead Proton

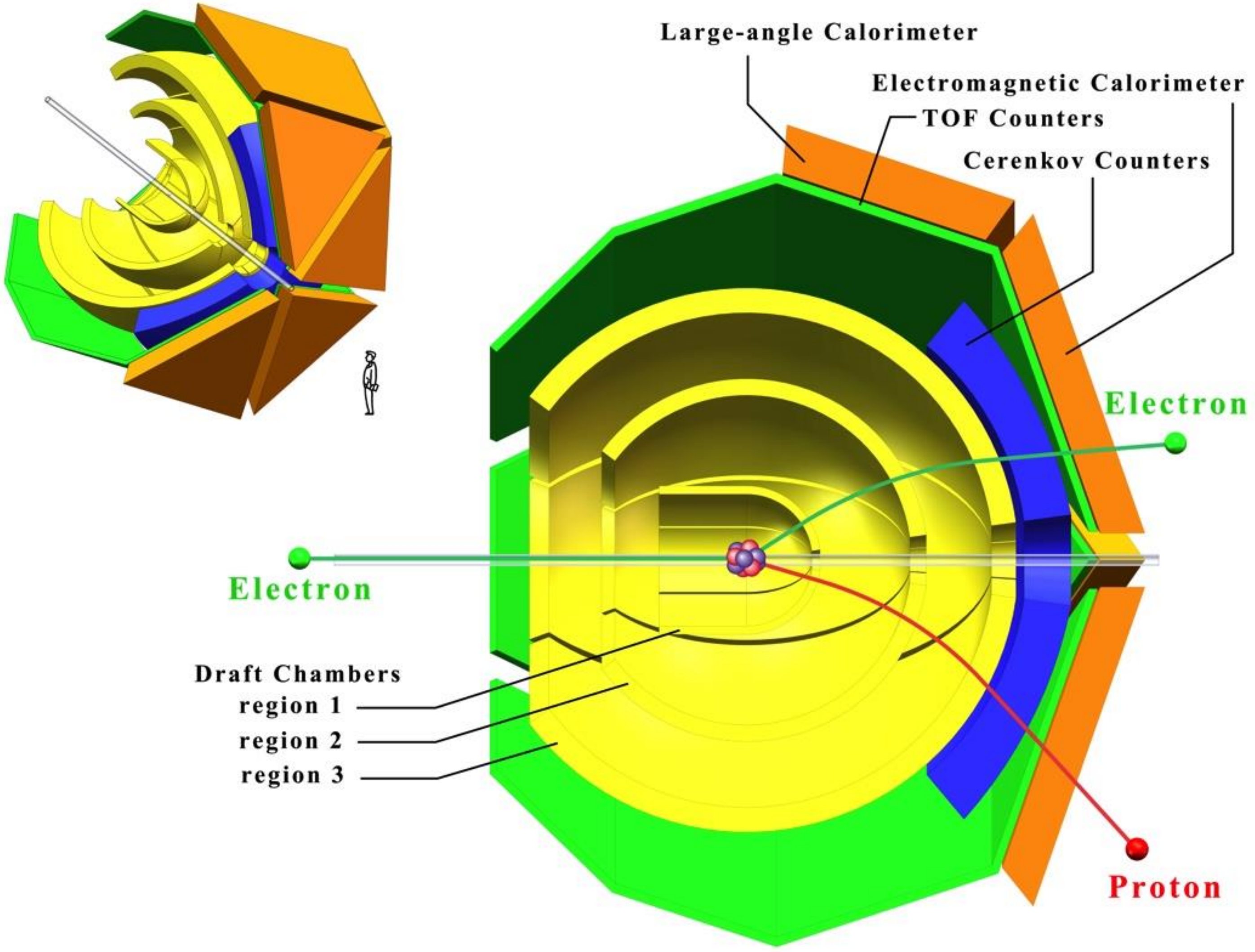
$x_B > 1.15$

$\theta_{p_1,q} < 25°$

$0.62 < \frac{|\vec{P}_1|}{|\vec{q}|} < 0.96$

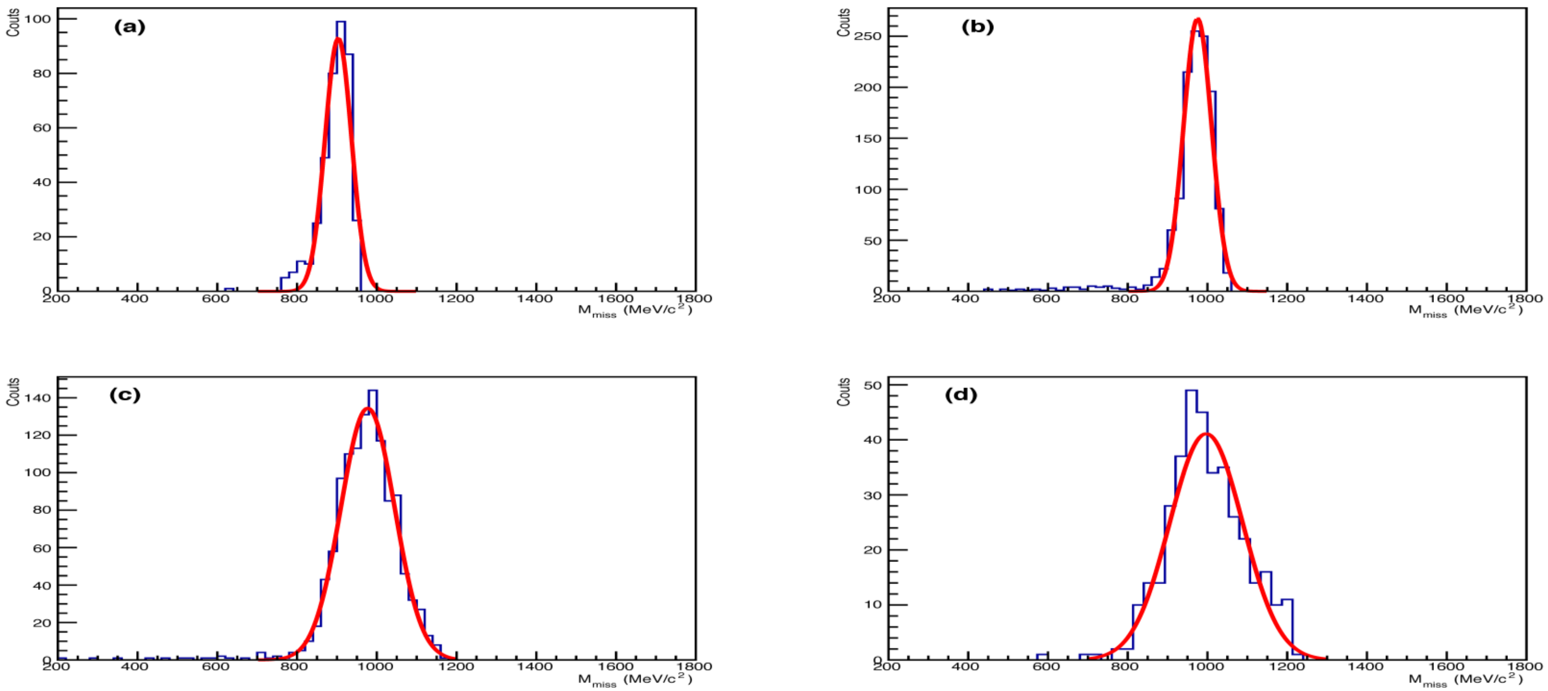
Looked at $50MeV/c < \vec{P}_{miss}$

E2a



M_{miss} Projections (E2a Data)

$$M_{miss}^2 = \left((\omega, \vec{q}) + (2M_N, 0) \; - \left(E_{Lead}, \vec{P}_{Lead}\right)\right)^2$$



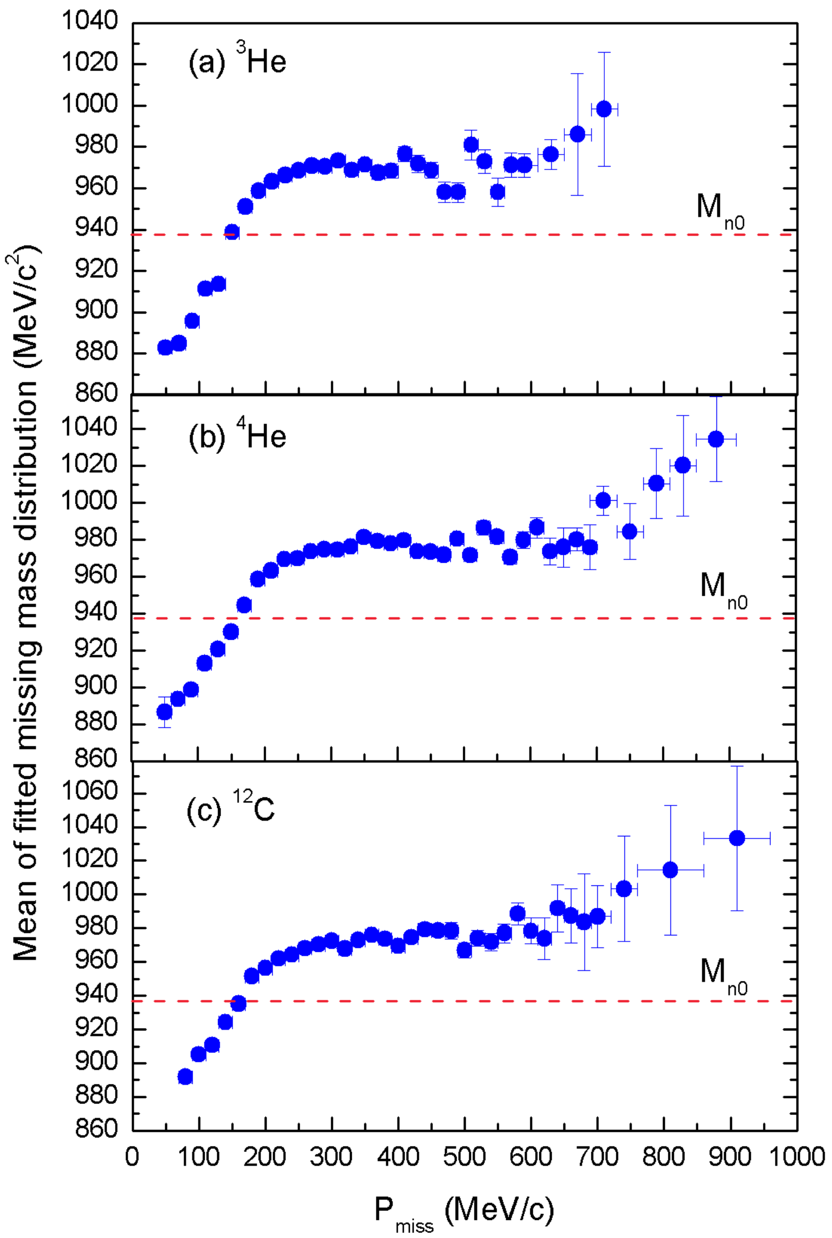
(a) 90 MeV <P_{miss}< 110 MeV/c,

(b) 290 MeV <P_{miss}< 310 MeV/c,

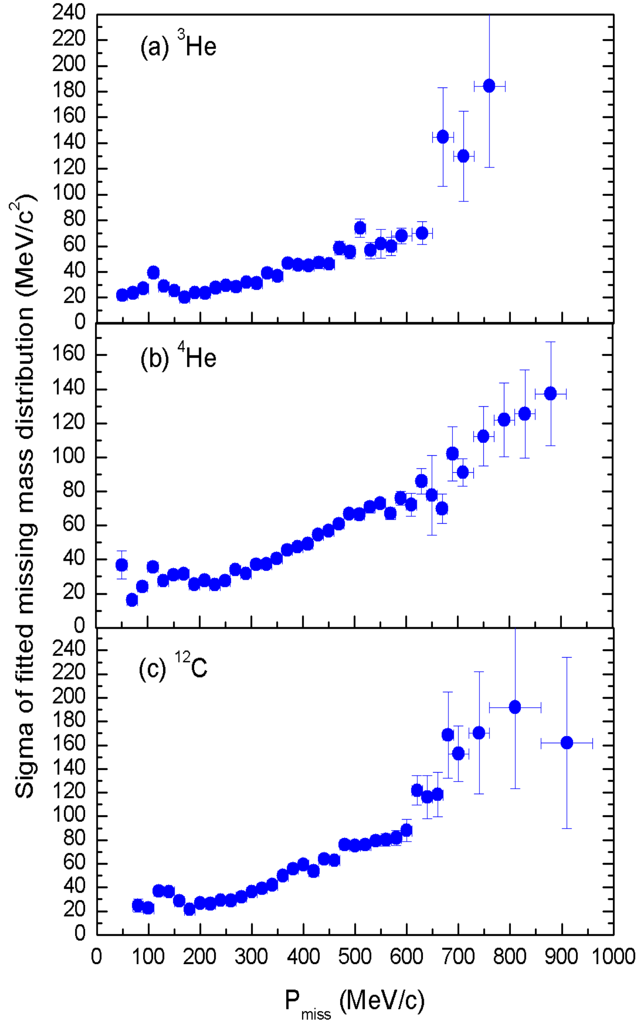
(c) 480 MeV <P_{miss}< 520 MeV/c,

(d) 670 MeV <P_{miss}< 730 MeV/c

M_{miss}



(a) ³He
(b) ⁴He
(c) ¹²C
M n0
Mean of fitted missing mass distribution (MeV/c²)
P miss (MeV/c)



(a) ³He
(b) ⁴He
(c) ¹²C
Sigma of fitted missing mass distribution (MeV/c²)
P miss (MeV/c)

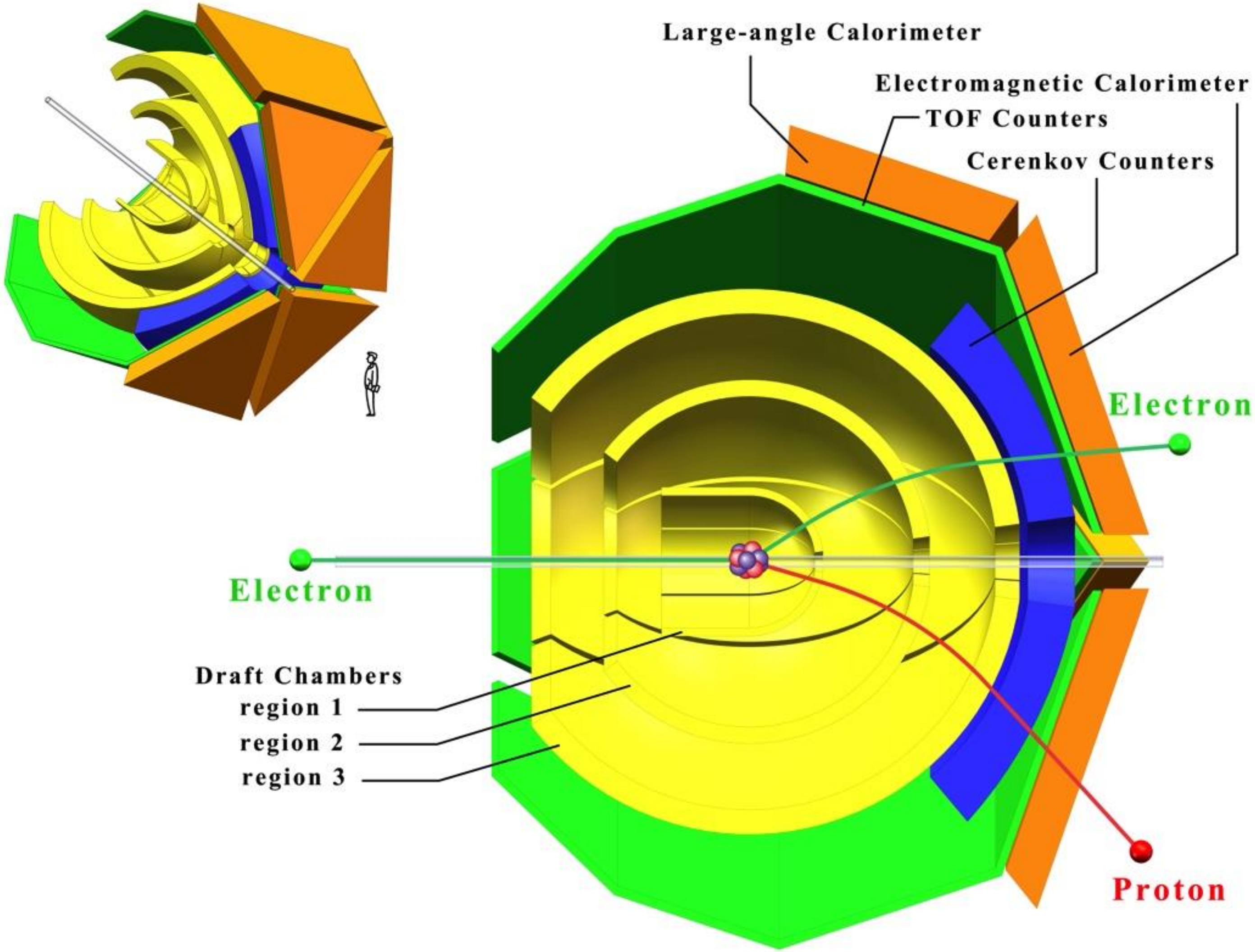
M_{miss} Simulation

Same cuts

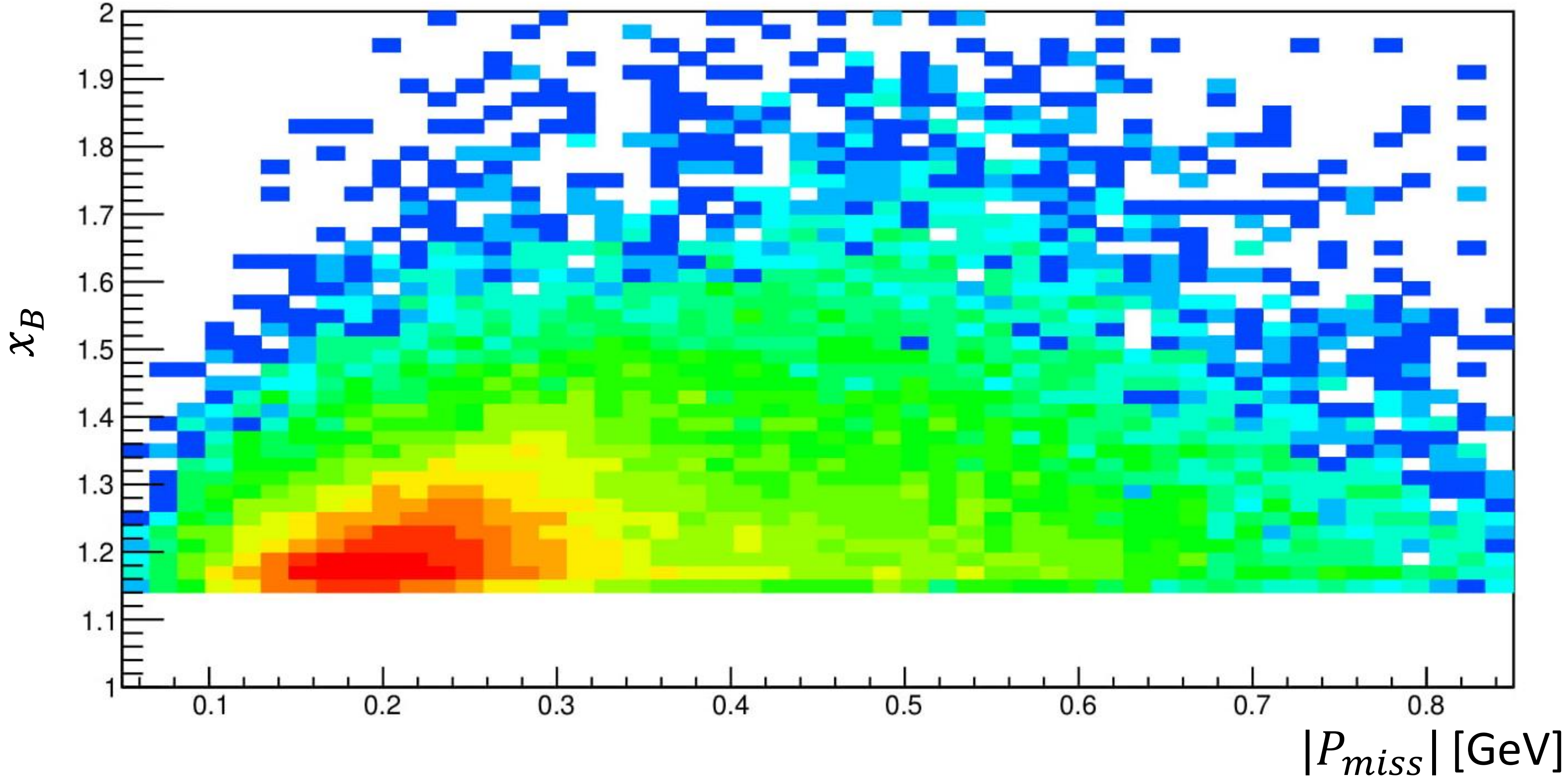
Looked at $200MeV/c < \vec{P}_{miss} < 850MeV/c$

Smeared electron and proton momentum:

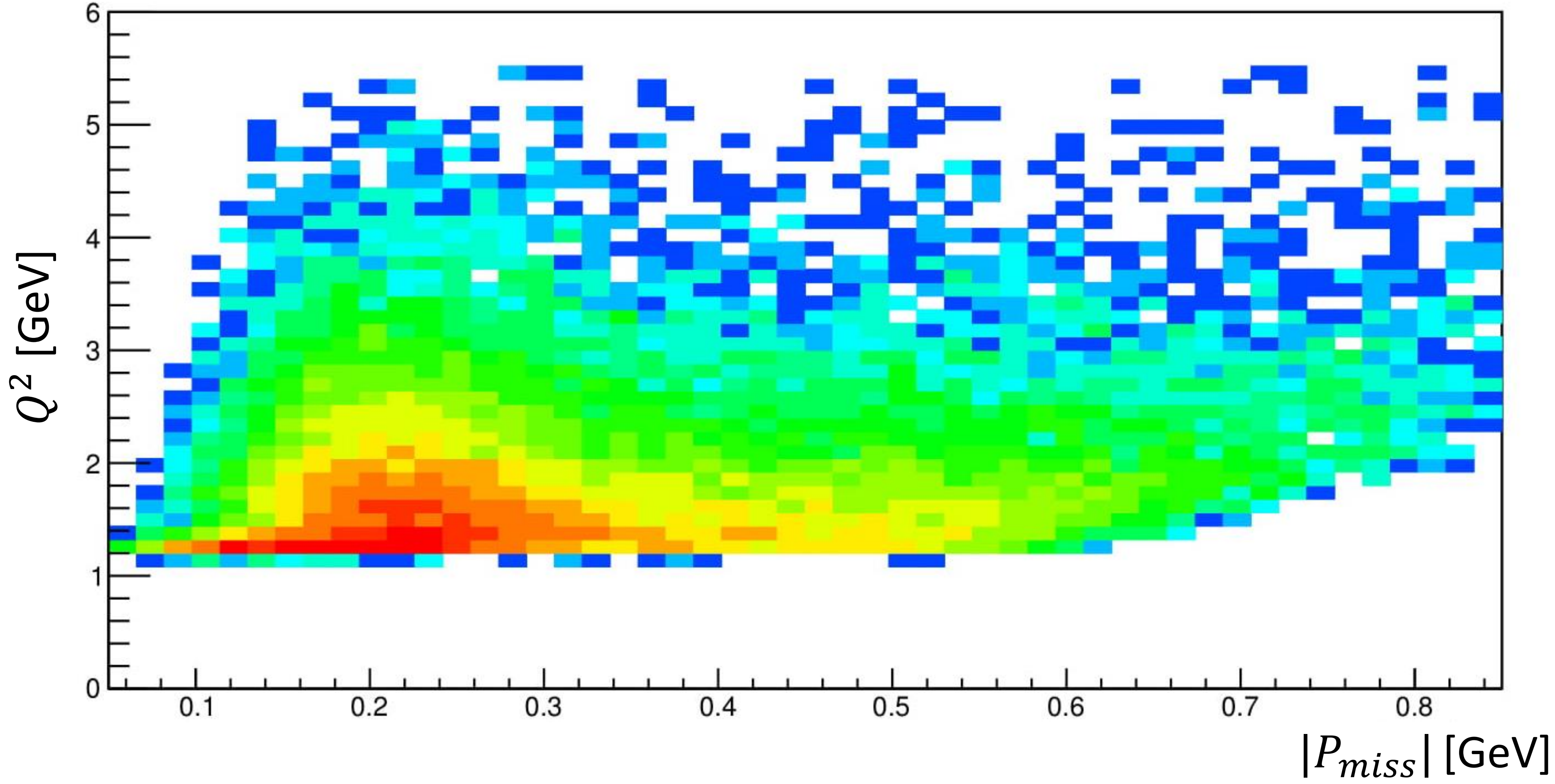
- p_e smeared by 0.5%
- P_{Lead} smeared by 1%



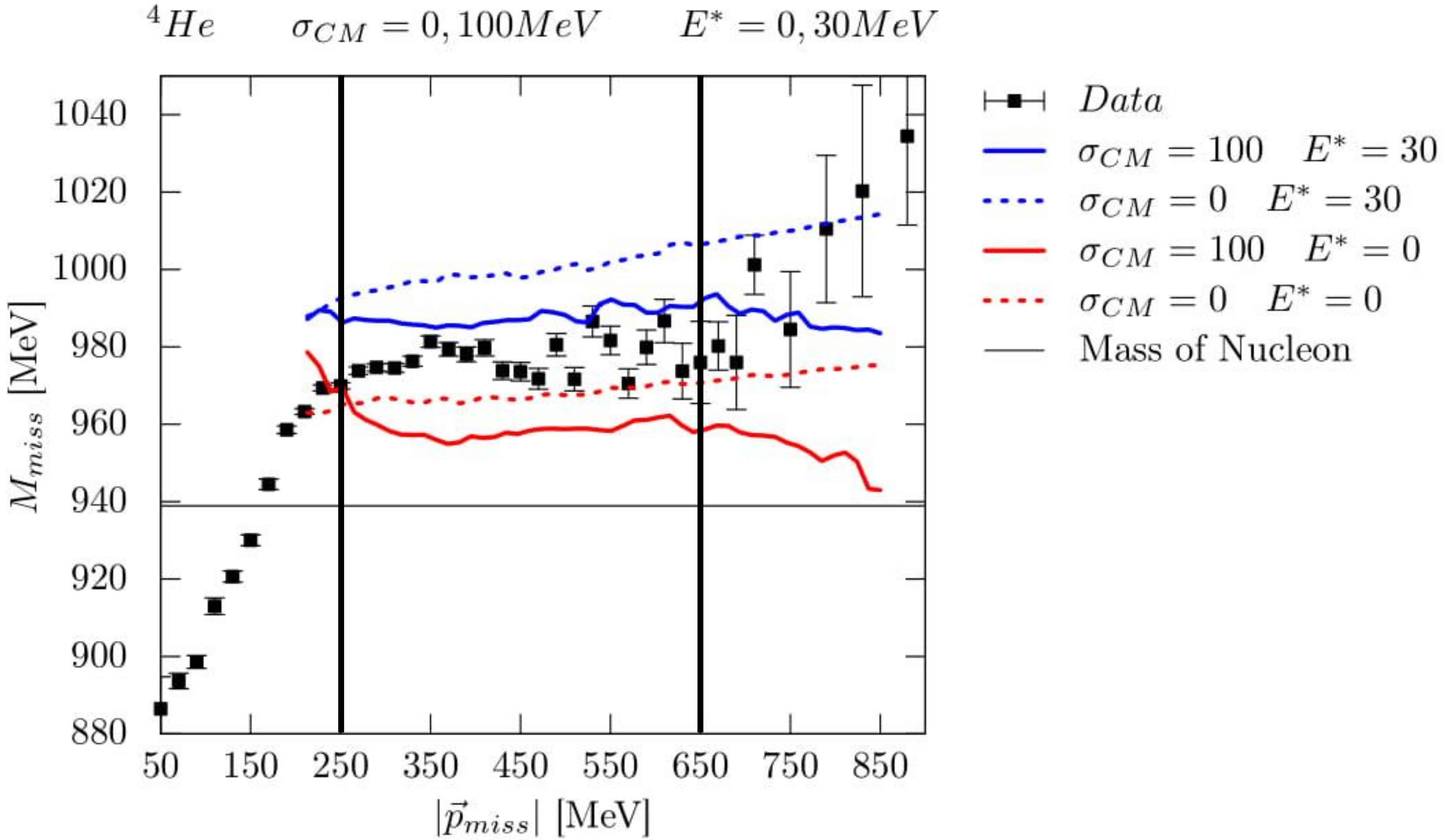
Generated 2D Histogram of x_B in ^4He with applied Cuts



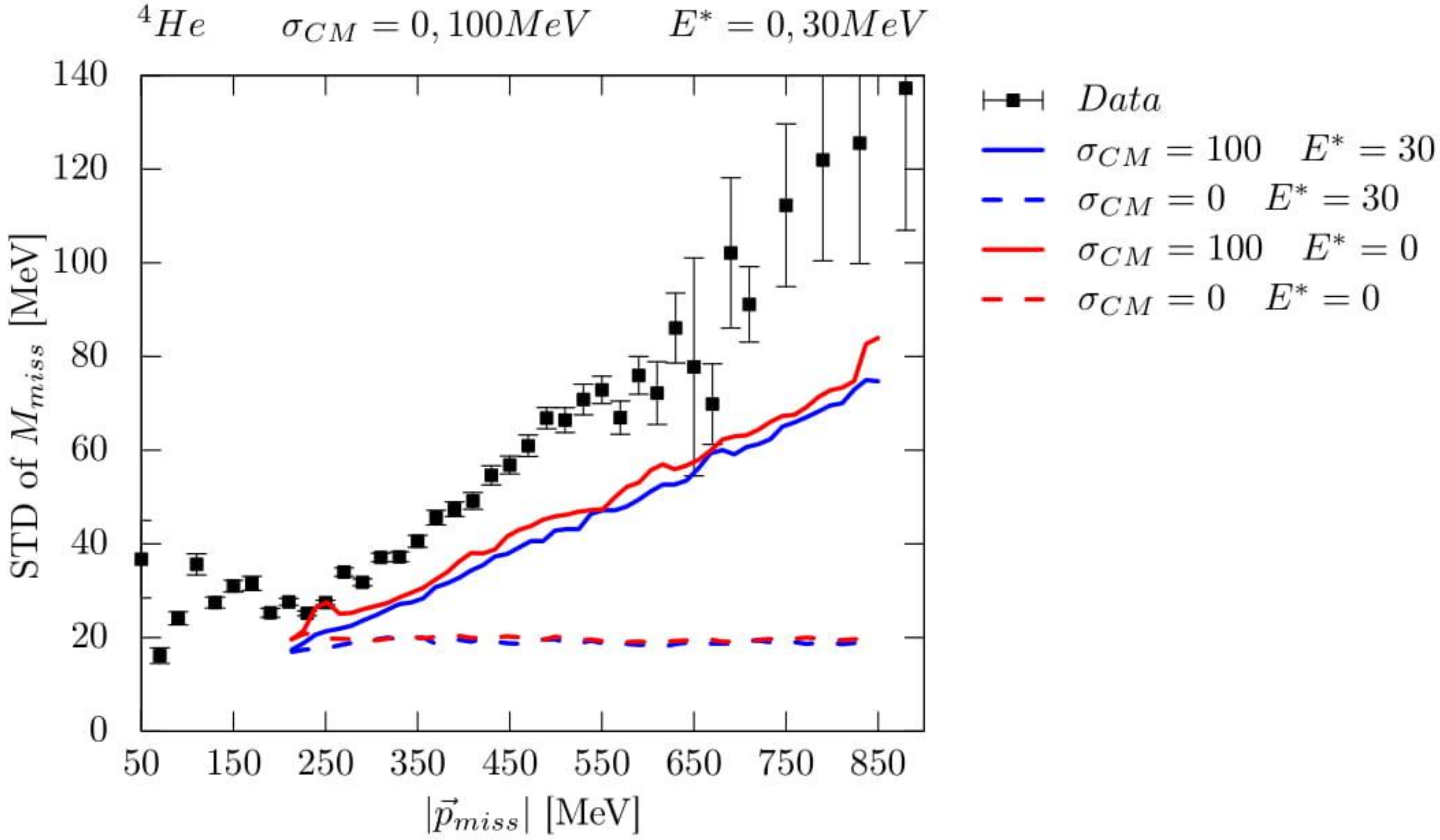
Generated 2D Histogram of Q^2 in ^4He with applied Cuts



Generator and Experiment are Consistent for M_{miss}



Generator Results for STD of M_{miss}



Next Steps for M_{miss}

- Apply acceptance maps to generator data
- Use a mean field generator with SRC generator
- Make a confidence band for E^* and σ_{CM} and compare to data
- Determine the resolutions in the M_{miss} calculation

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End