Proton Radius Meeting - Event Generator

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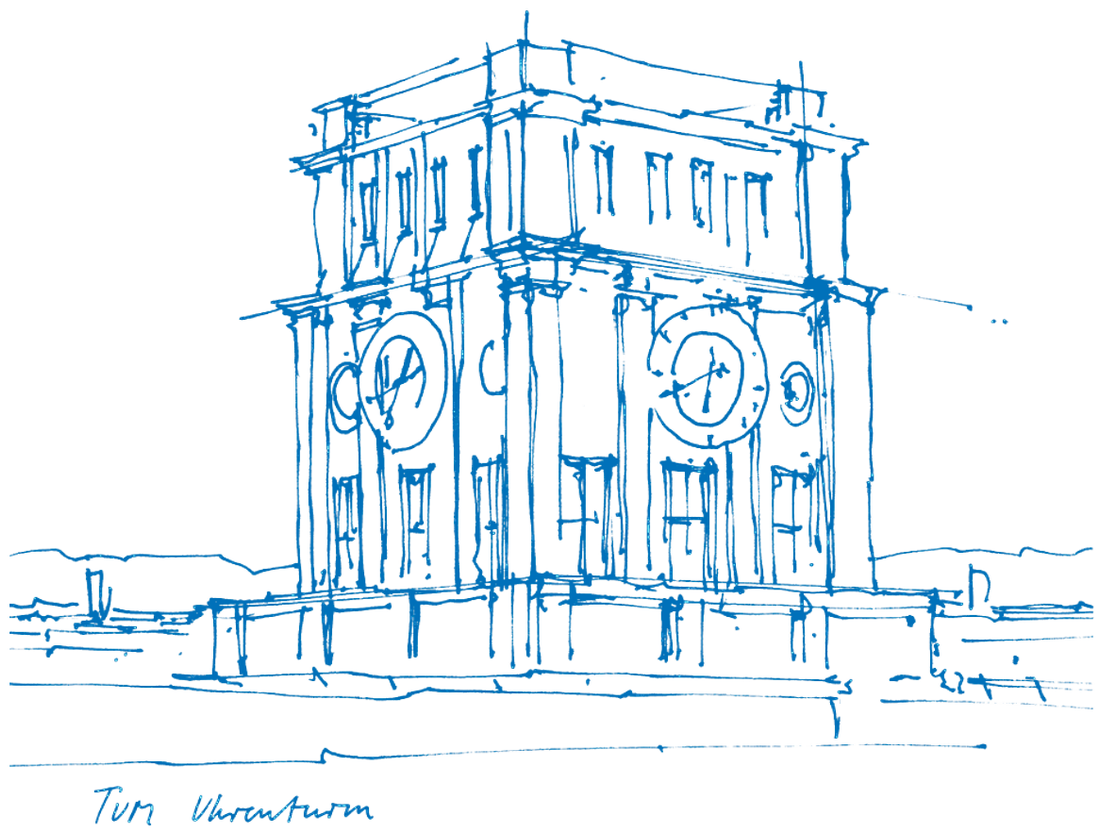
Physics Department

Proton Radius Meeting
November 13th 2019



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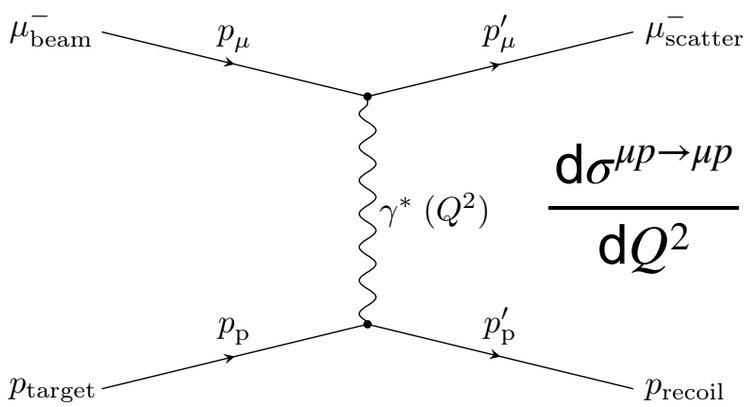
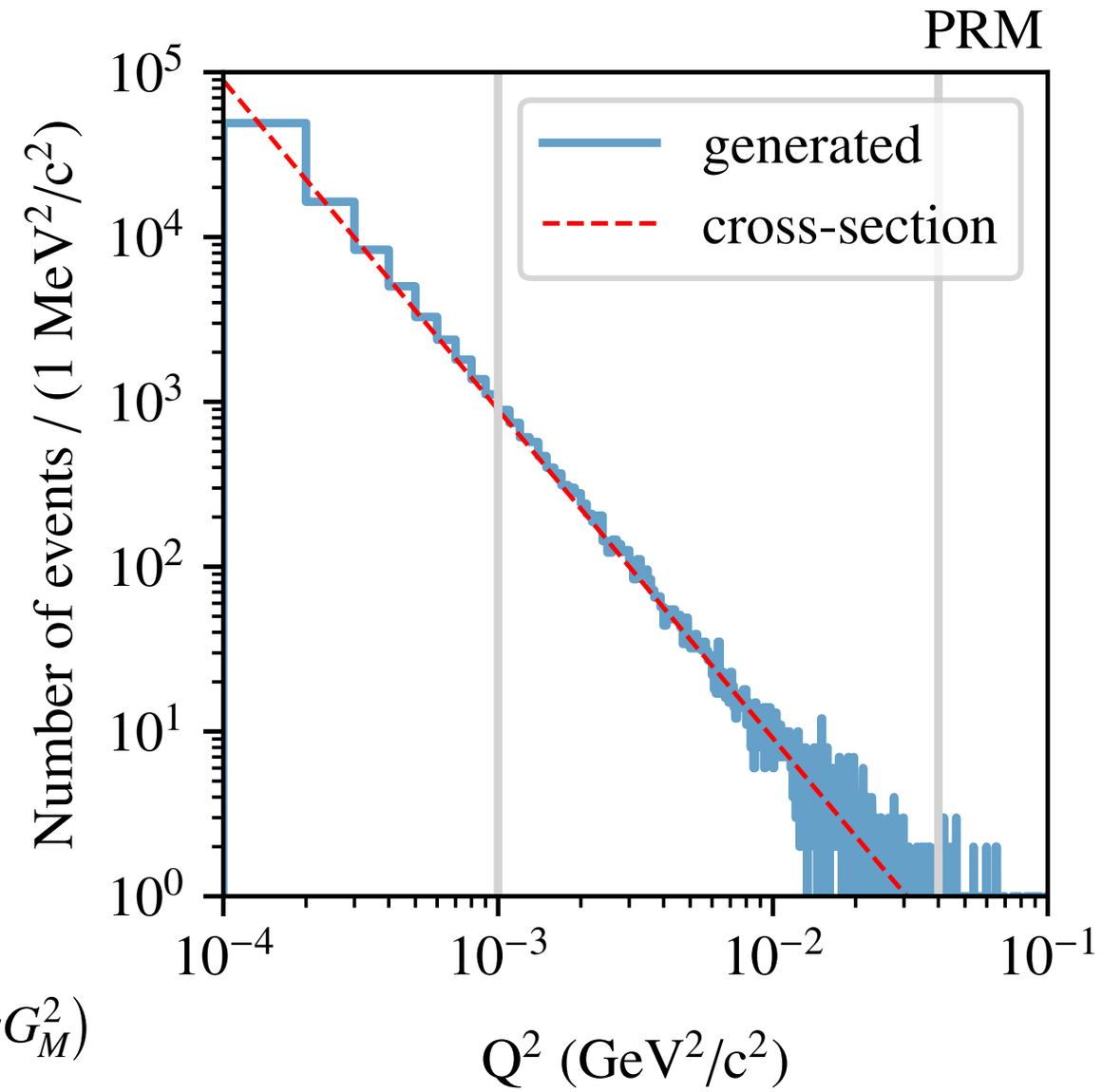
Current Status

Simulate elastic muon-proton scattering
Kinematic based on simple cross-section for momentum transfer.

- Generate events according to cross-section:
  → studies on shape-depending effects
  → time-consuming for statistics/studies
  → radius extraction efficiency (model)
  → for studies - generate events flat
- Beam file and materiel based vertex-z position as input
- Calculate resulting kinematics:



$$\frac{\mathrm{d}\sigma^{\mu p\to\mu p}}{\mathrm{d}Q^2} = \frac{4\pi\alpha^2}{Q^4} R\left(\epsilon G_E^2 + \tau G_M^2\right)$$



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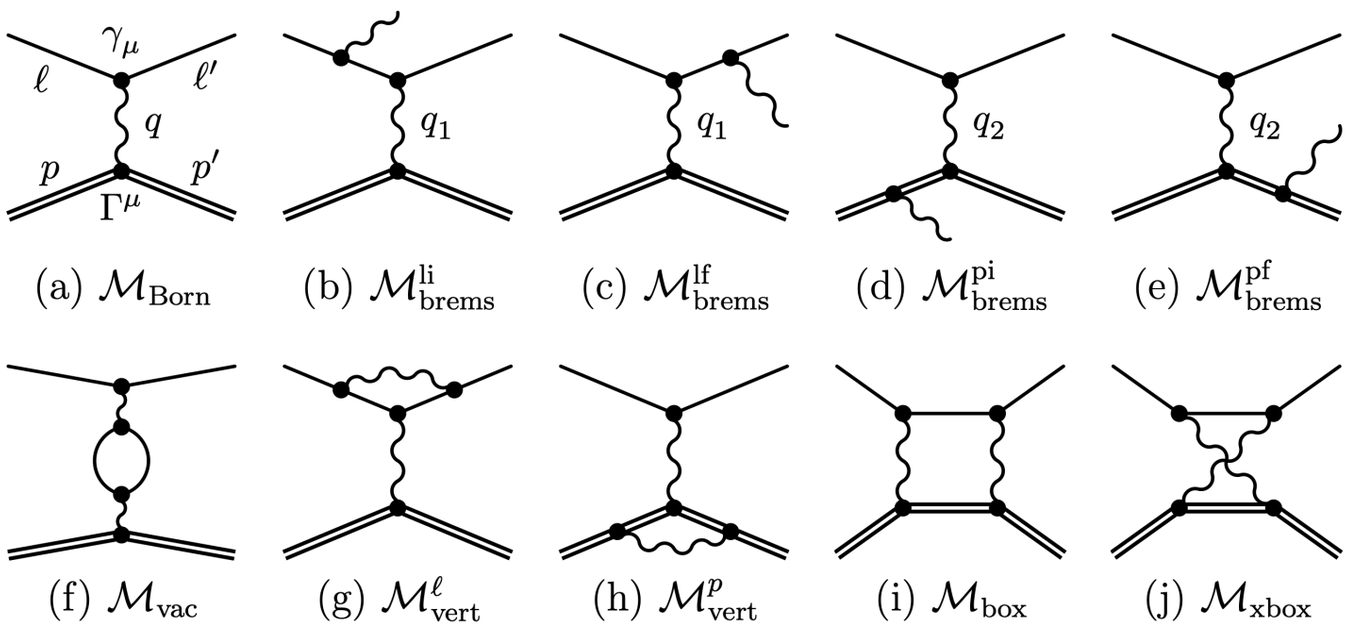
Radiative Effects in Event Simulation

Event Generator including radiative effects
The Elastic Scattering of Electrons and Muons)
Positions on Protons - ESEPP takes radiative
effects into account.

A new event generator for the elastic scattering of charged leptons on protons

A. V. Gramolin*[1], V. S. Fadin[1,2], A. L. Feldman[1,2], R. E. Gerasimov[1,2], D. M. Nikolenko[1], I. A. Rachek[1] and D. K. Toporkov[1,2]

[1] *Budker Institute of Nuclear Physics, 630090 Novosibirsk, Russia*
[2] *Novosibirsk State University, 630090 Novosibirsk, Russia*



$$\sigma(\ell^{\pm}p) \propto |\mathcal{M}_{\text{Born}}|^2 + 2\,\text{Re}\left[\mathcal{M}^{\dagger}_{\text{Born}}\left(\mathcal{M}_{\text{vac}} + \mathcal{M}^{\ell}_{\text{vert}} + \mathcal{M}^{p}_{\text{vert}}\right)\right]$$
$$+ 2\,\text{Re}\left[\mathcal{M}^{\dagger}_{\text{Born}}\left(\mathcal{M}_{\text{box}} + \mathcal{M}_{\text{xbox}}\right)\right] + \left|\mathcal{M}^{\text{li}}_{\text{brems}} + \mathcal{M}^{\text{lf}}_{\text{brems}}\right|^2 + \left|\mathcal{M}^{\text{pi}}_{\text{brems}} + \mathcal{M}^{\text{pf}}_{\text{brems}}\right|^2$$
$$+ 2\,\text{Re}\left[\left(\mathcal{M}^{\text{li}}_{\text{brems}} + \mathcal{M}^{\text{lf}}_{\text{brems}}\right)^{\dagger}\left(\mathcal{M}^{\text{pi}}_{\text{brems}} + \mathcal{M}^{\text{pf}}_{\text{brems}}\right)\right] + \mathcal{O}(\alpha^4),$$

- Sources:
  → GitHub: https://github.com/gramolin/esepp
  → ArXiv: https://arxiv.org/abs/1401.2959

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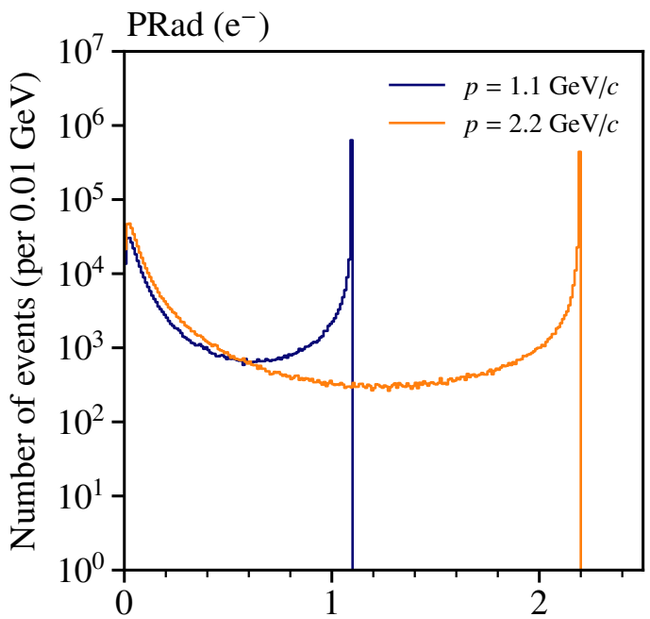
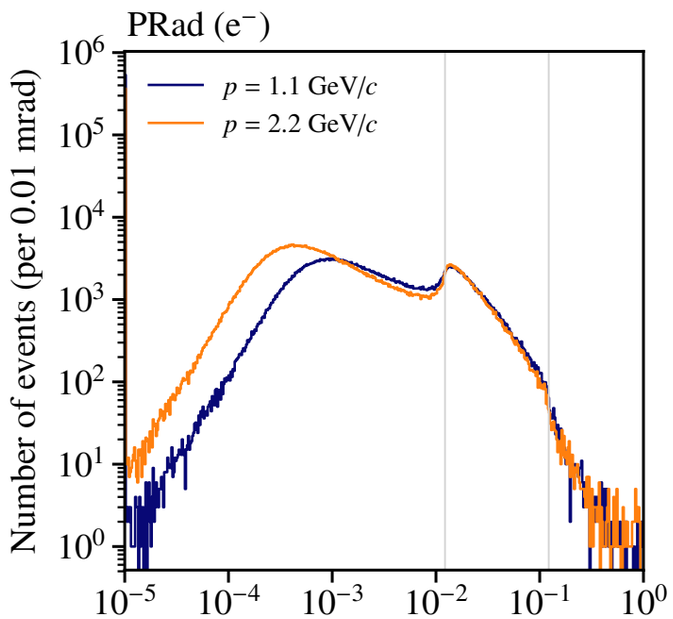
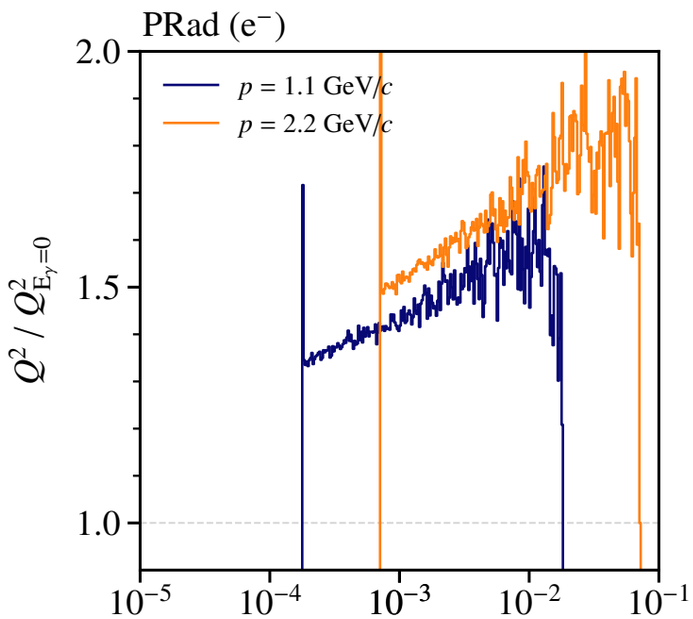
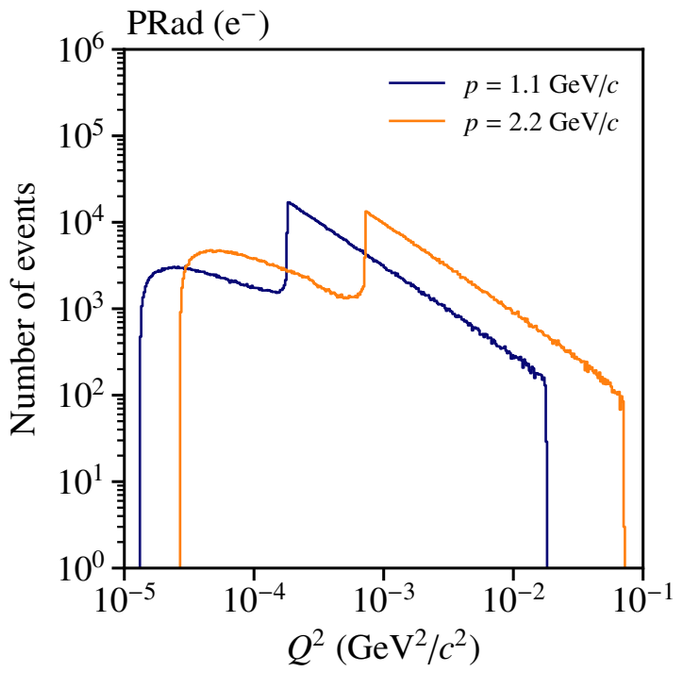
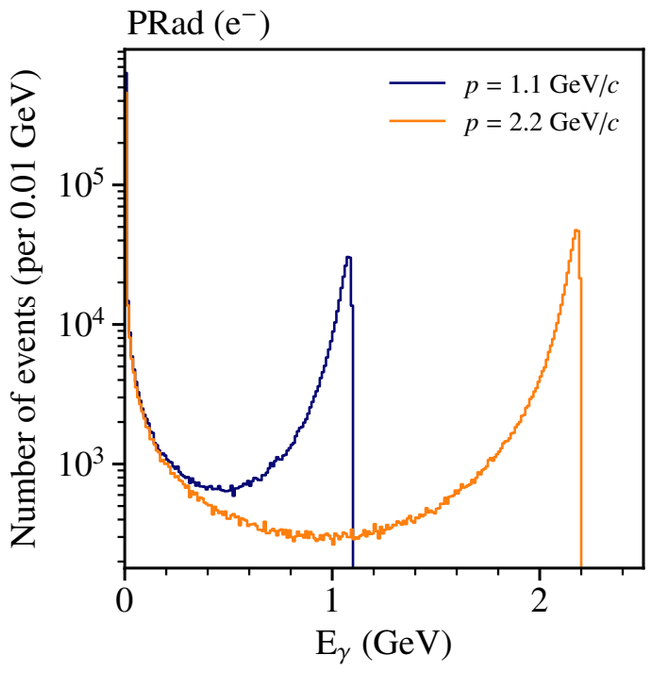
PRad Kinematic











PRad Nature (2019):
"The two e-p generators were found to be in excellent agreement"

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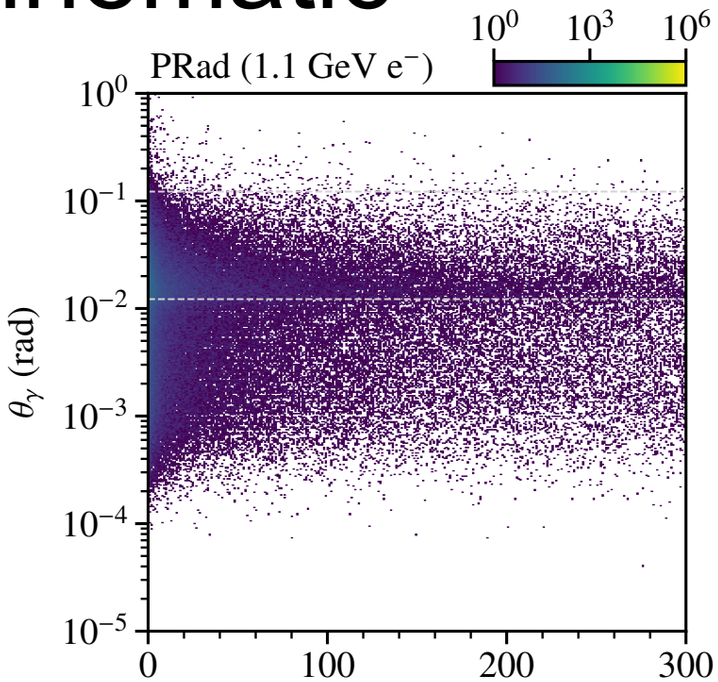

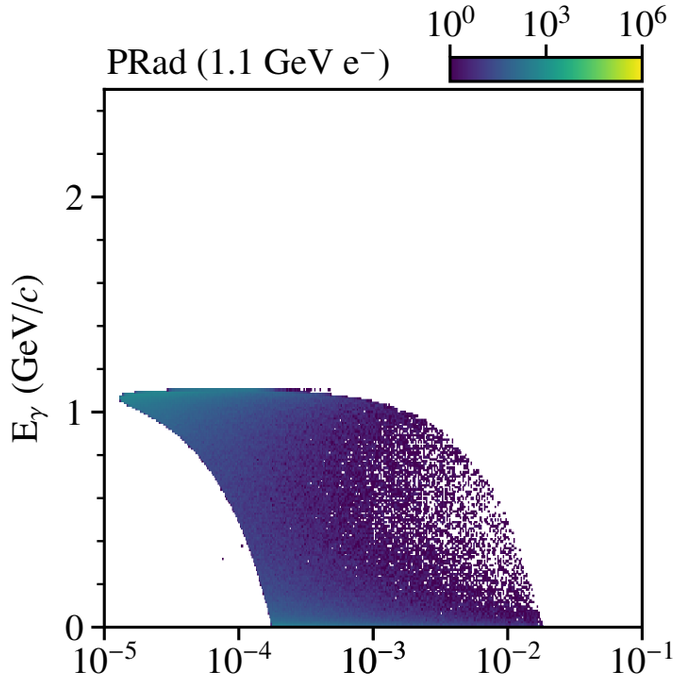

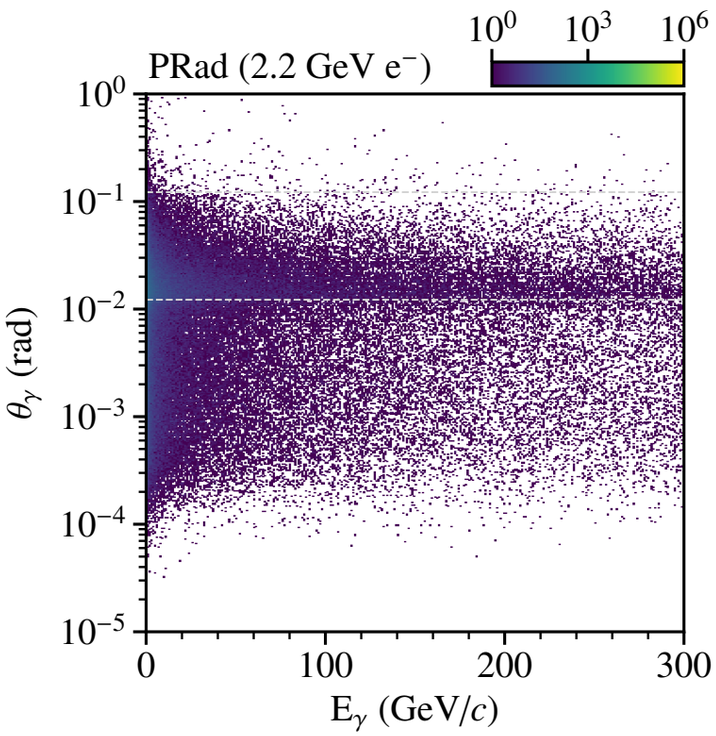

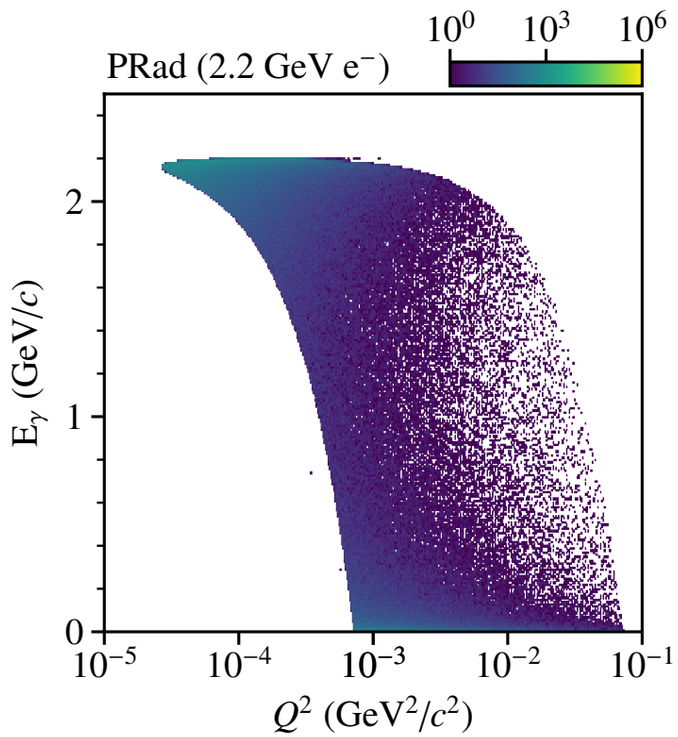

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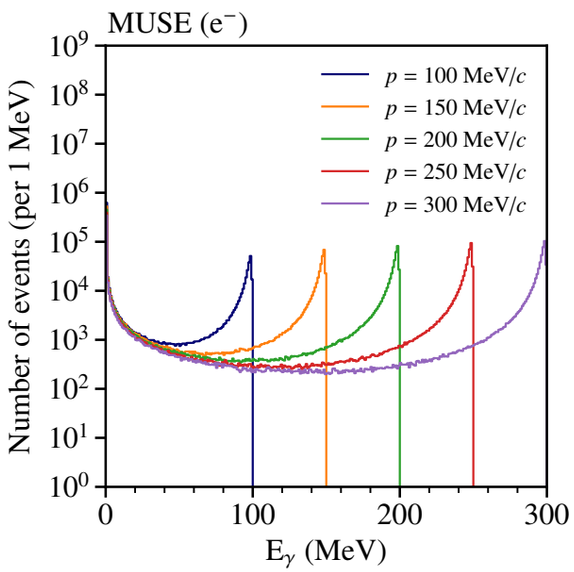
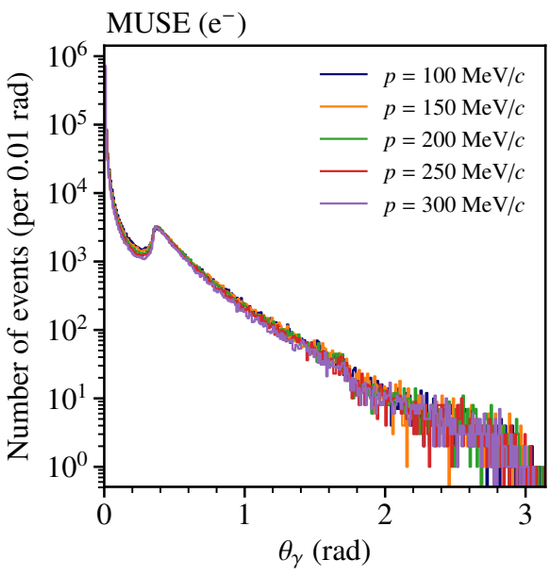
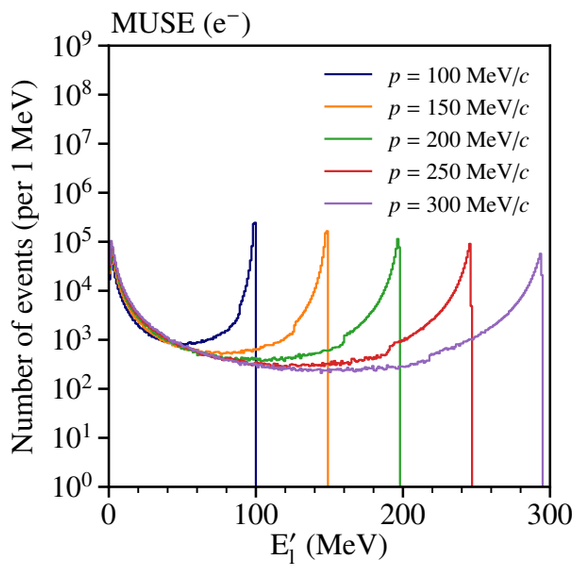
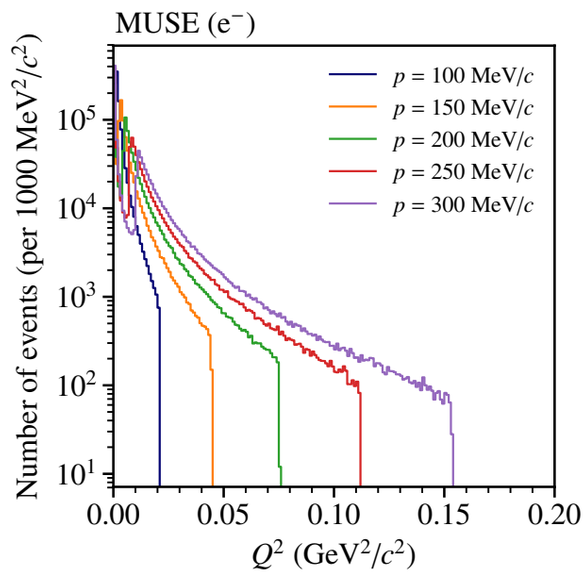
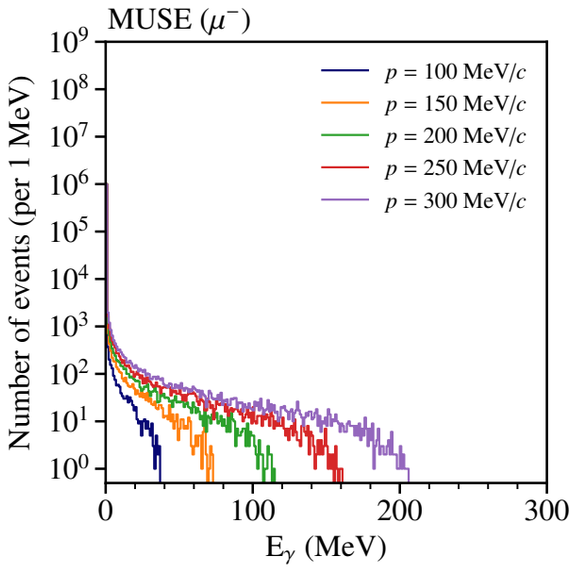
MUSE Kinematic

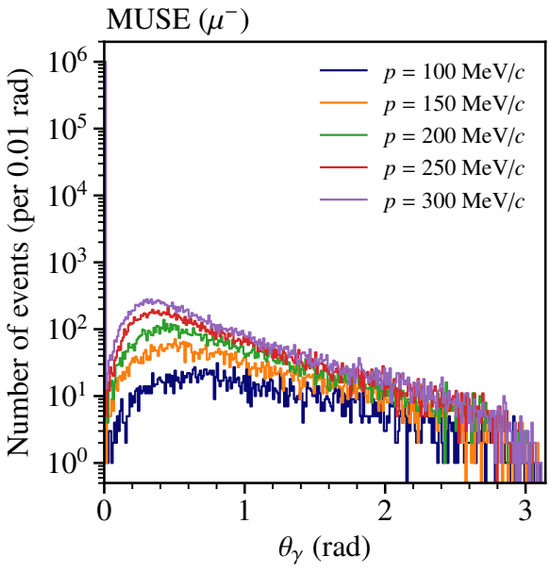


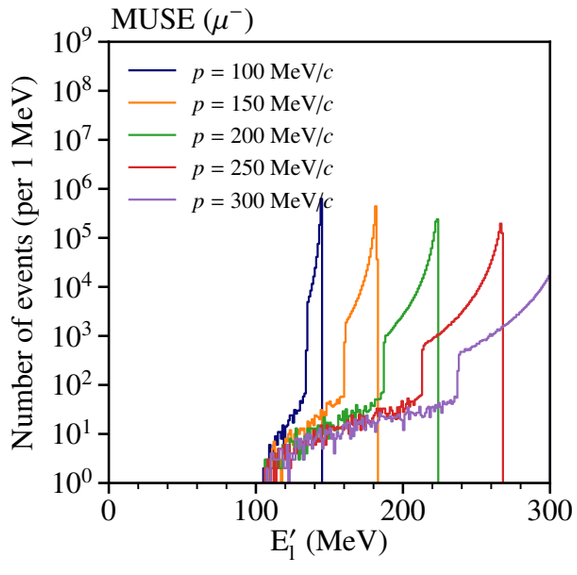


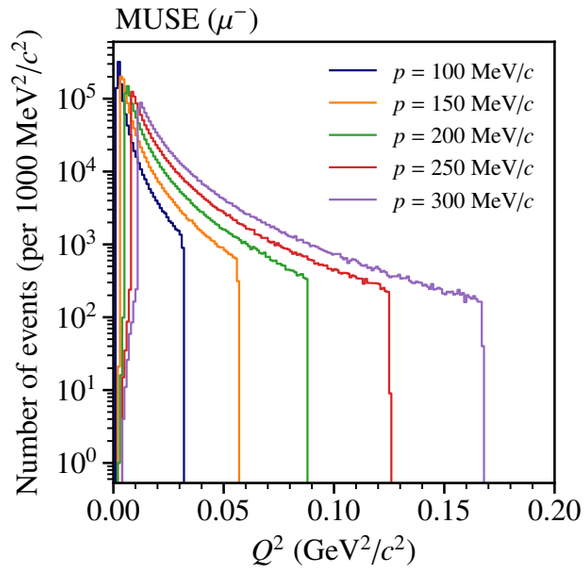












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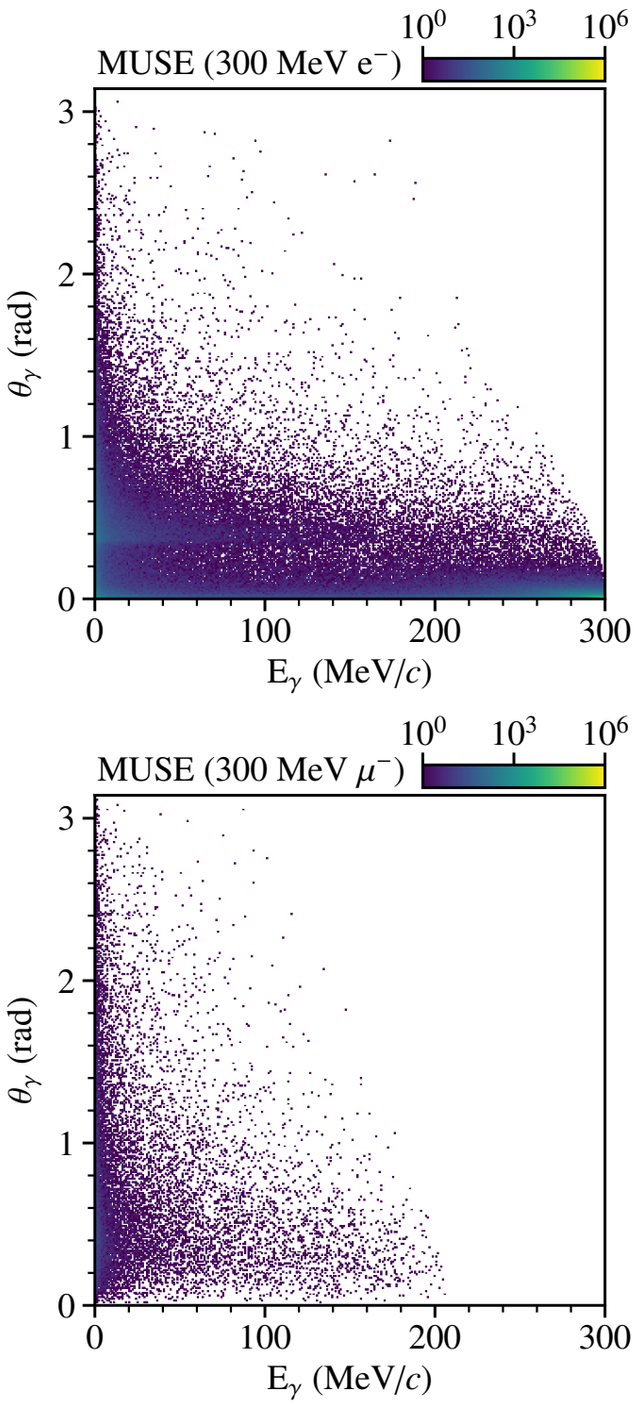
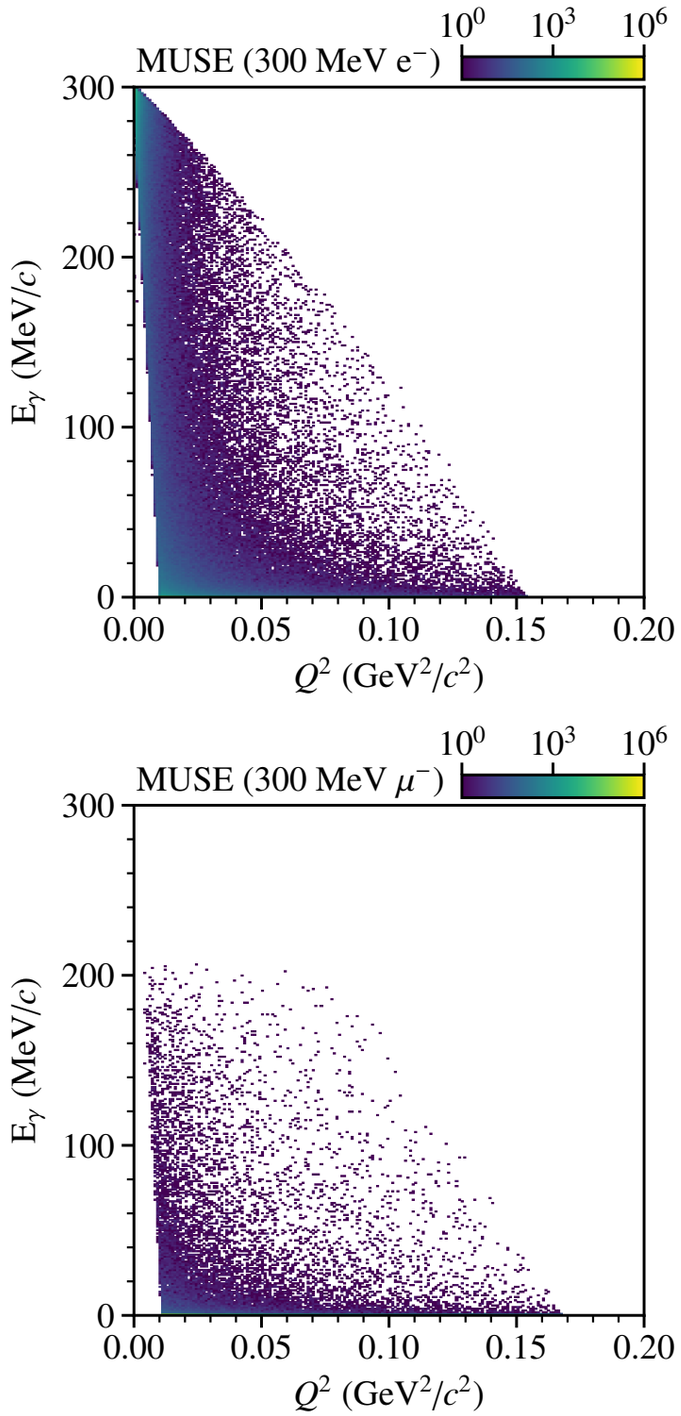
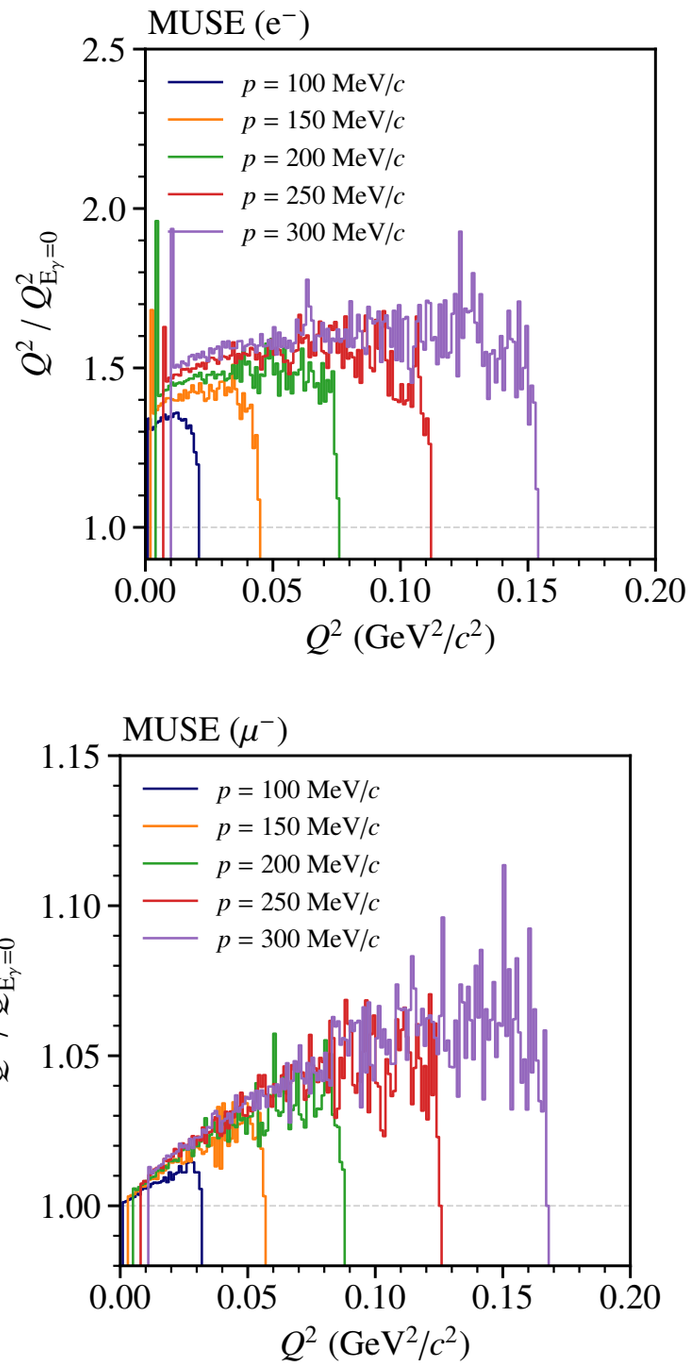
MUSE Kinematic







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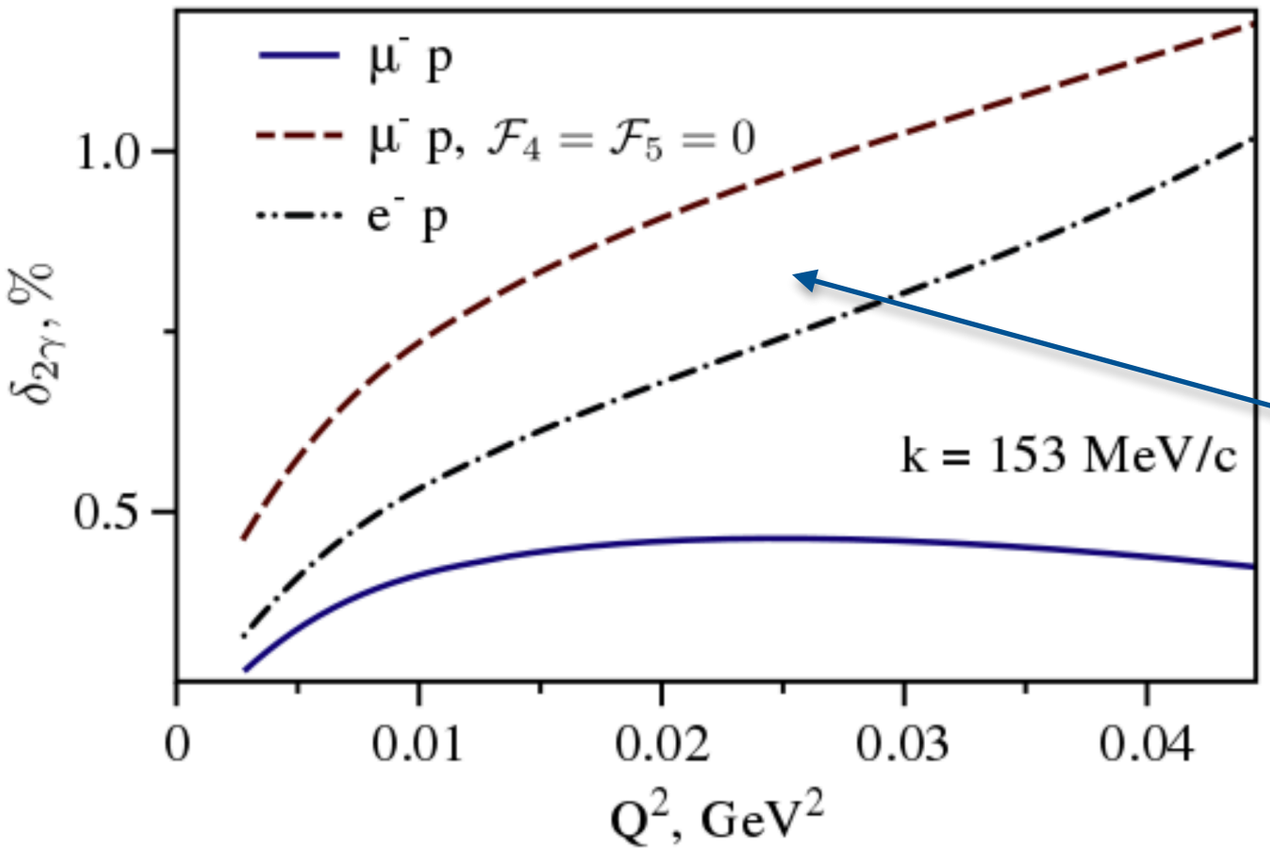
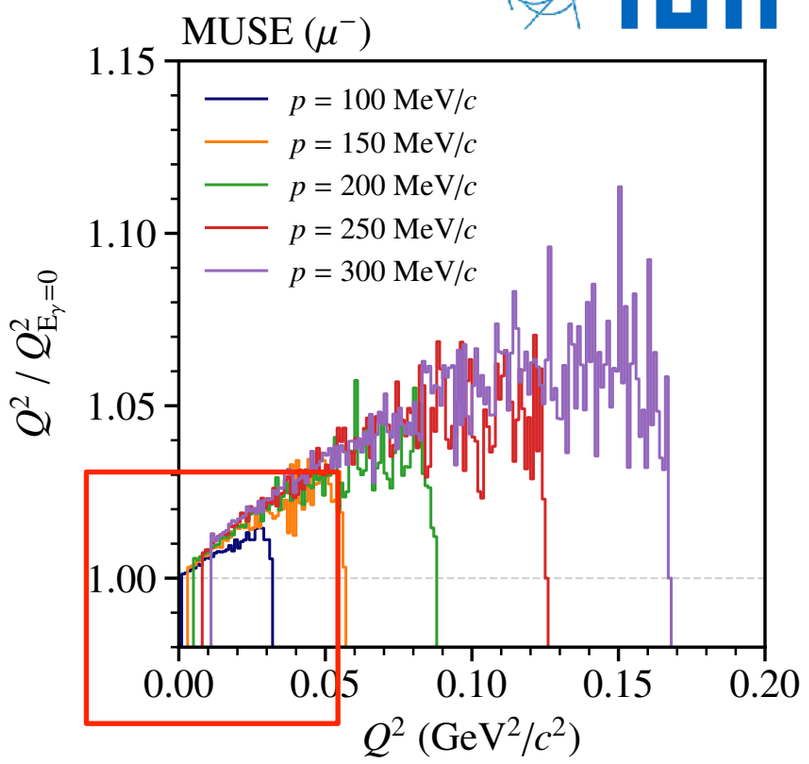
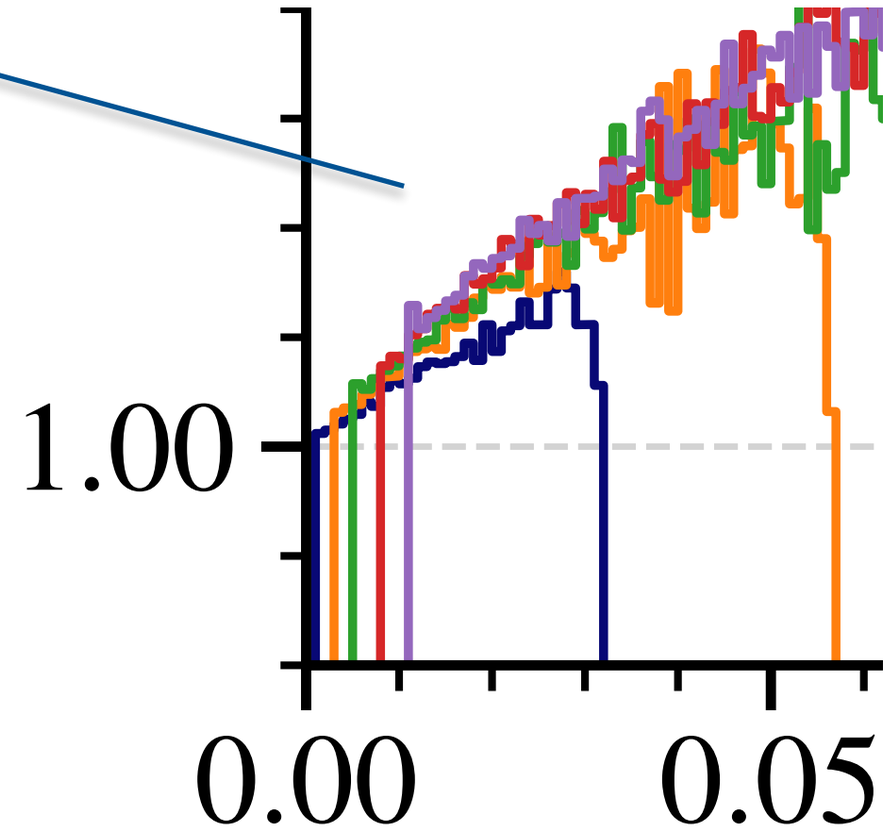
MUSE Kinematic

MUSE Technical Design Report 2017 (R-12-01.1)





2x difference ?



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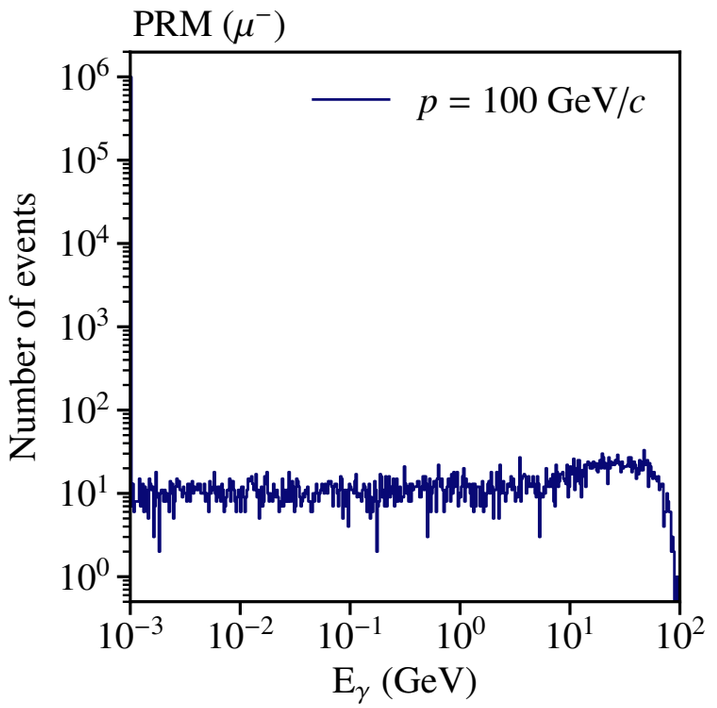
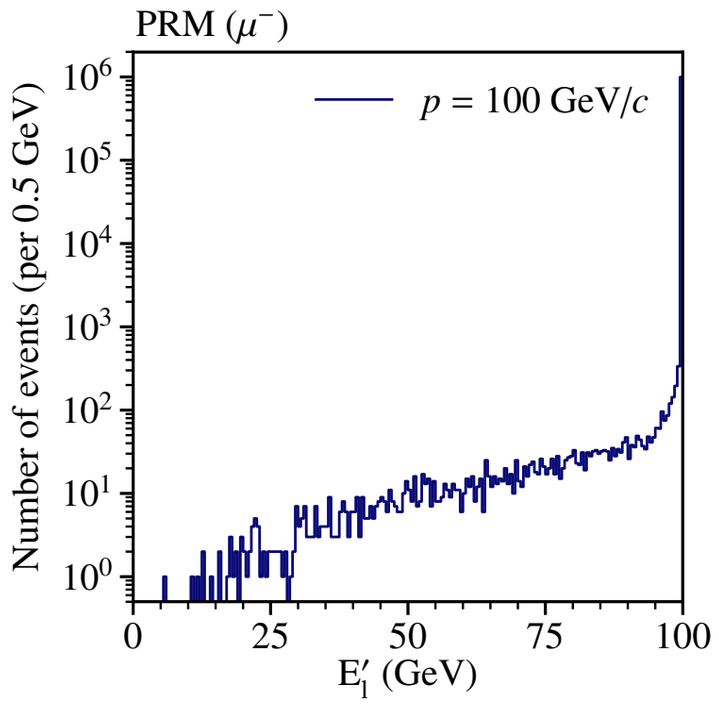
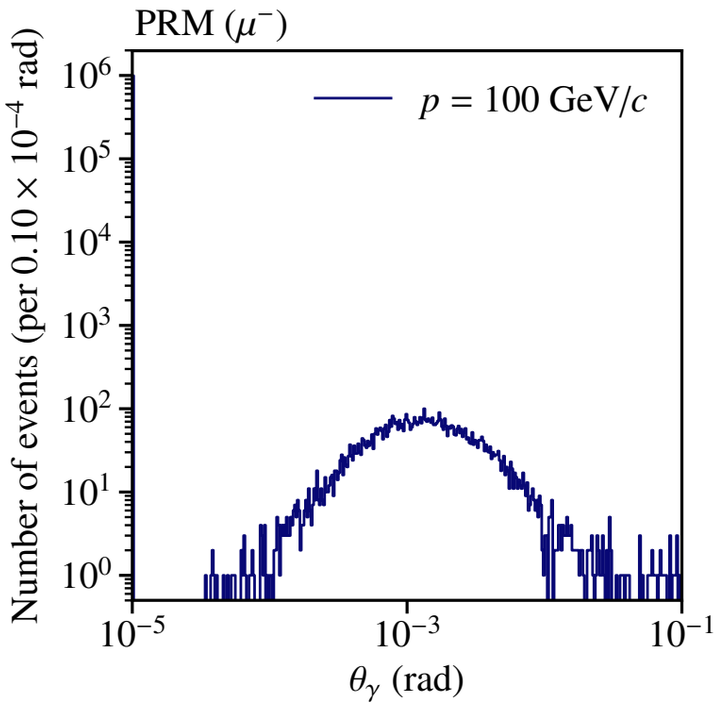
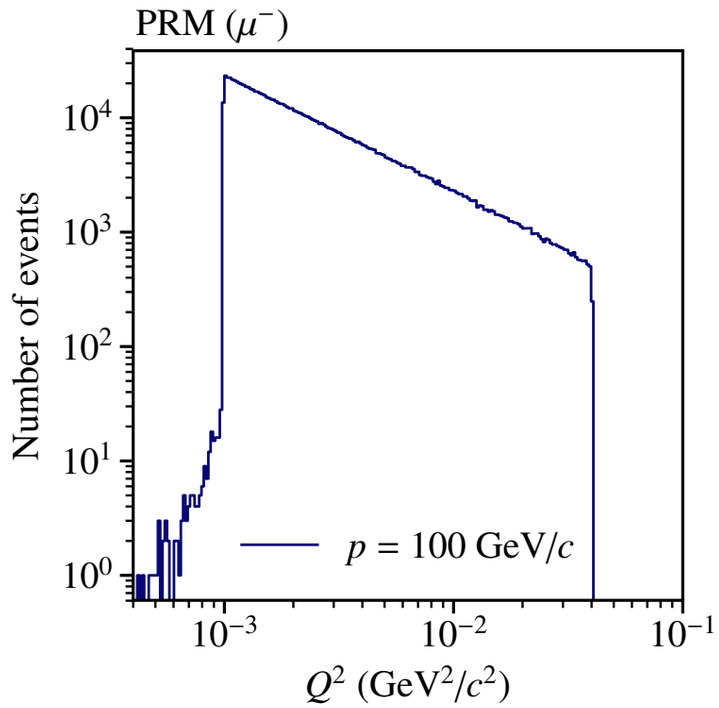
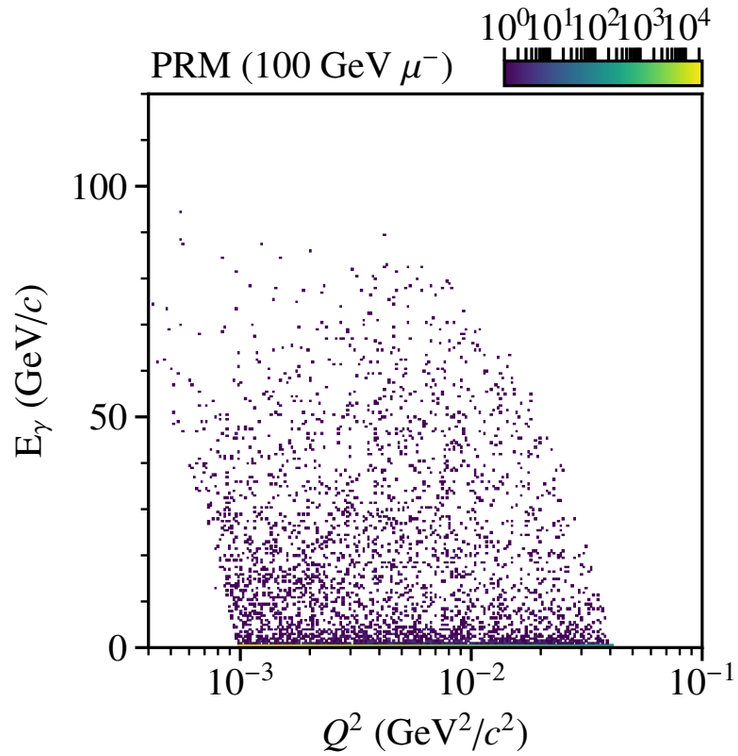
COMPASS++/AMBER Kinematic











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COMPASS++/AMBER Kinematic