DIS Cross Section & Radiative Corrections

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DIS Cross Section Extraction

$$\frac{d^2\sigma}{dxdQ^2}_{DIS} = \frac{N_{DIS}}{\mathcal{L}} \cdot \frac{1}{\eta_{DT} \cdot \eta_{Tracking} \cdot \eta_{s2m} \cdot \eta_{Cer} \cdot \eta_{virt} \cdot \alpha_{RE}^{(x,Q^2)} \cdot \Gamma_{DIS}^{(x,Q^2)}}$$

Experiment

Theory

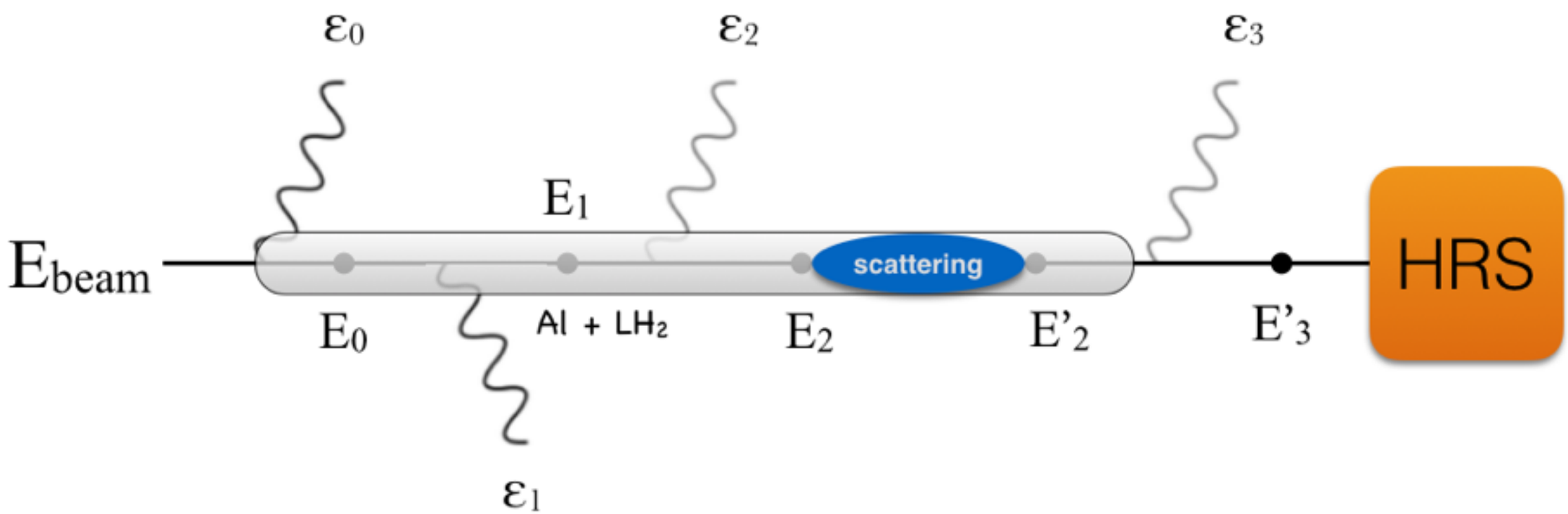
Simulation

Simulation

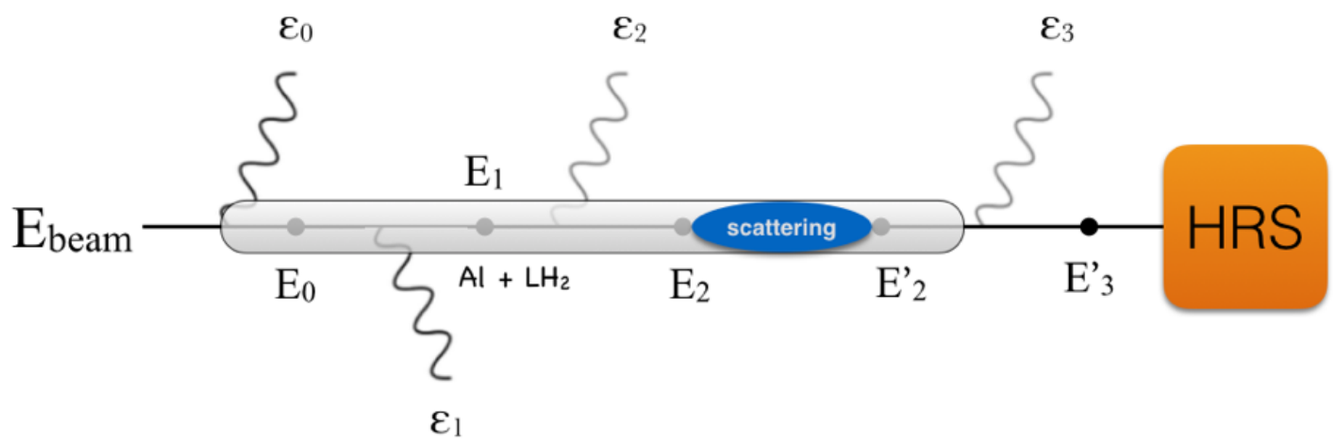
$$\frac{d^2\sigma}{dxdQ^2}_{DIS} = \frac{N_{DIS}}{\mathcal{L}} \cdot \frac{1}{\eta_{DT} \cdot \eta_{Tracking} \cdot \eta_{s2m} \cdot \eta_{Cer} \cdot \eta_{virt} \cdot \alpha_{RE}^{(x,Q^2)} \cdot \Gamma_{DIS}^{(x,Q^2)}}$$

- Γ_{DIS} accounts for the phase space the accepted events N come from.
- α_{RE} accounts for real radiative energy losses.

Monte Carlo Simulation



Simulation



Simulation for Ω, E'

- $0.9 \cdot p_{HRS} \leq E' \leq E_{beam}$
- $0 \leq \cos\theta \leq 1$
- $-\frac{\pi}{2} \leq \phi \leq \frac{\pi}{2}$

Simulation for x, Q^2

- $0 \leq x \leq 1$
- $0 \leq Q^2 \leq 2 \cdot Q^2_{HRS}$
- $-\frac{\pi}{2} \leq \phi \leq \frac{\pi}{2}$

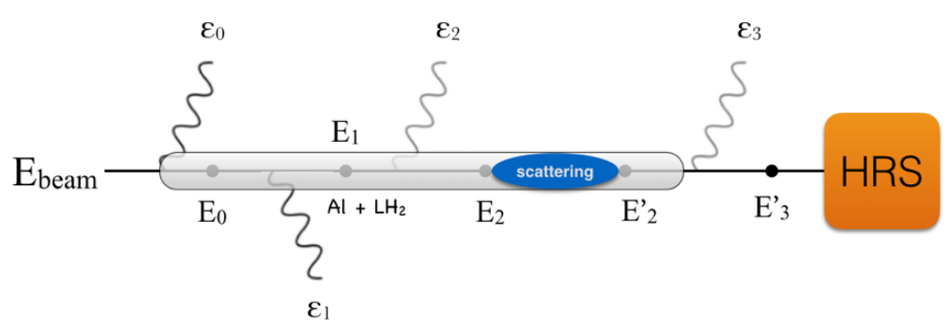
$$\frac{d^2\sigma}{dxdQ^2}_{DIS} = \frac{N_{DIS}}{\mathcal{L}} \cdot \frac{1}{\eta_{DT} \cdot \eta_{Tracking} \cdot \eta_{s2m} \cdot \eta_{Cer} \cdot \eta_{virt} \cdot \alpha_{RE}^{(x,Q^2)} \cdot \Gamma_{DIS}^{(x,Q^2)}}$$

(Factor of 2 for azimuthal symmetry)

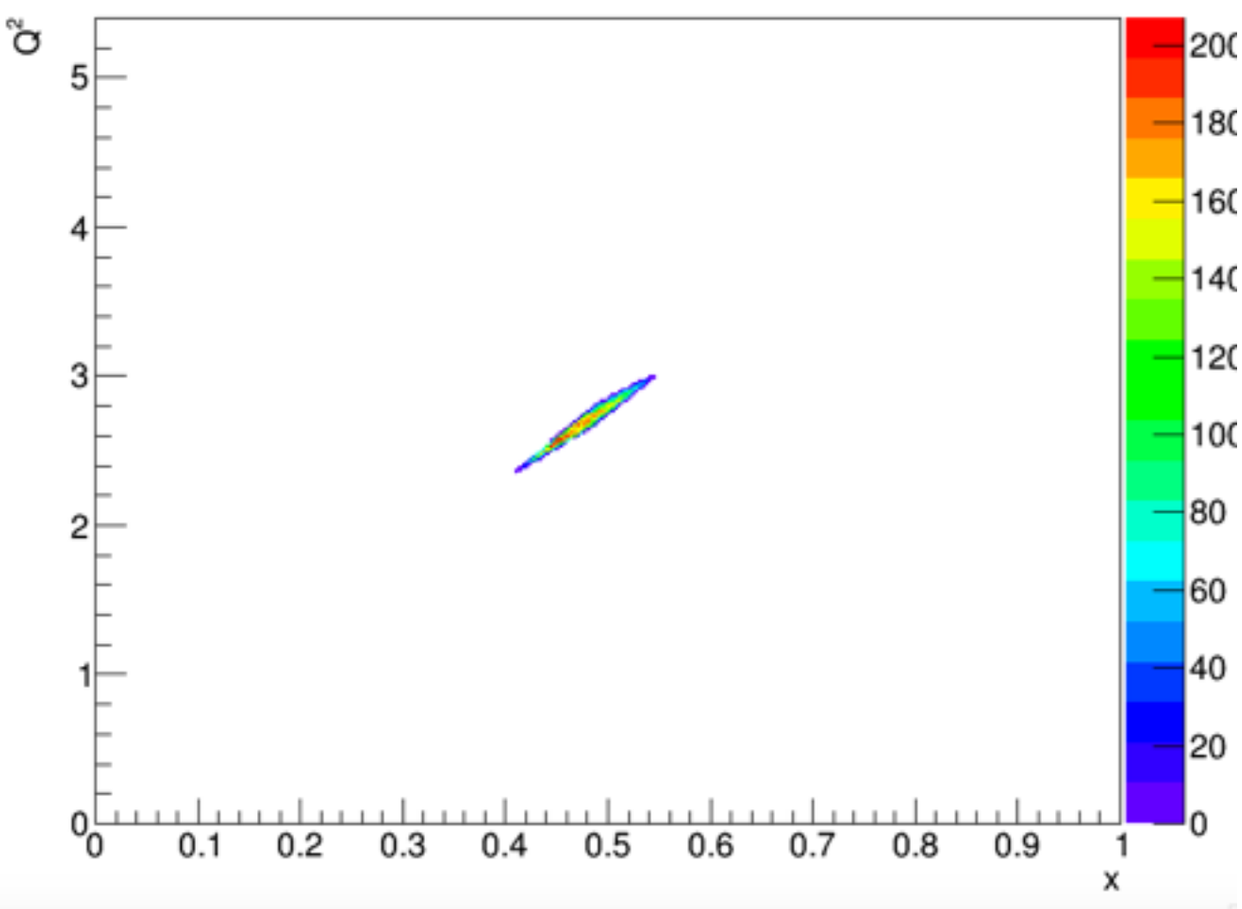
$$\Gamma_{DIS}^{(\Omega,E')} = \Delta\Omega\Delta E' \frac{N_{acc}}{N_{gen}} \qquad \Gamma_{DIS}^{(x,Q^2)} = \frac{1}{2}\Delta x \Delta Q^2 \frac{N_{acc}}{N_{gen}}$$

Γ_{DIS}		
Kin	$\Gamma_{DIS}(E',\Omega) \cdot 10^{-3}[GeV \cdot sr]$	$\Gamma_{DIS}(x,Q^2) \cdot 10^{-3}[GeV^2]$
361	0.960	0.574
362	1.09	0.814
363	1.370	1.240
481	0.484	0.184
482	1.138	1.466
483	0.786	0.580
484	0.973	0.843
601	1.150	1.517
603	1.039	1.000

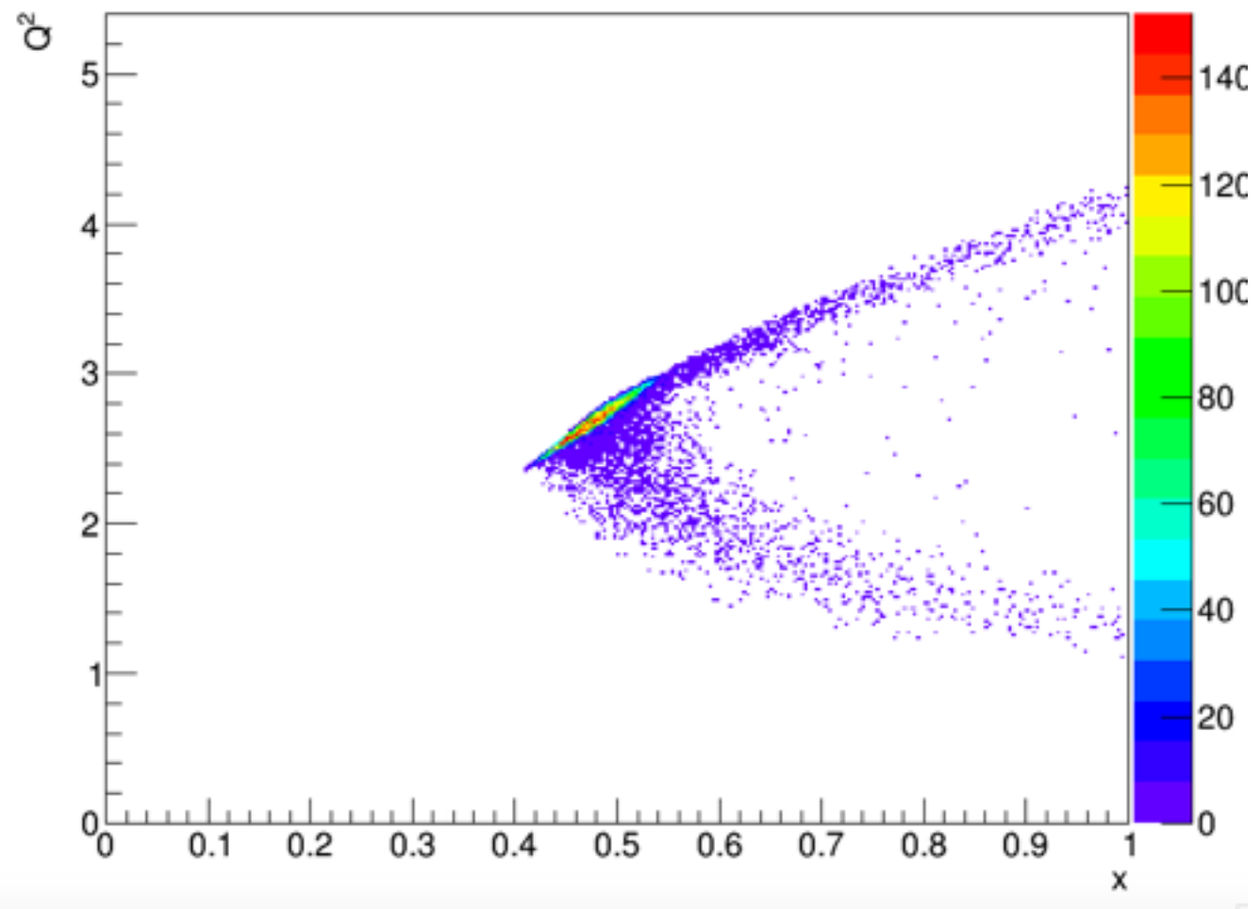
$$\frac{d^2\sigma}{dxdQ^2}_{DIS} = \frac{N_{DIS}}{\mathcal{L}} \cdot \frac{1}{\eta_{DT} \cdot \eta_{Tracking} \cdot \eta_{s2m} \cdot \eta_{Cer} \cdot \eta_{virt} \cdot \alpha_{RE}^{(x,Q^2)} \cdot \Gamma_{DIS}^{(x,Q^2)}}$$



Q^2 vs. x (Kin 481) w/o RE



Q^2 vs. x (Kin 481) with RE



$$\frac{d^2\sigma}{dxdQ^2}_{DIS} = \frac{N_{DIS}}{\mathcal{L}} \cdot \frac{1}{\eta_{DT} \cdot \eta_{Tracking} \cdot \eta_{s2m} \cdot \eta_{Cer} \cdot \eta_{virt} \cdot \alpha_{RE}^{(x,Q^2)} \cdot \Gamma_{DIS}^{(x,Q^2)}}$$

α Values		
Setting	$\alpha_{RE}(x, Q^2)$	$\alpha_{RE}(E', \Omega)$
361	0.941	1.089
362	0.881	1.031
363	0.824	1.021
481	0.917	1.037
482	0.923	1.059
483	0.946	1.074
484	0.949	1.052
601	0.857	0.958
603	0.865	0.963

$$\alpha_{RE}^{(x,Q^2)} = \frac{1}{\frac{d^2\sigma}{dxdQ^2}_{(HRS)}} \sum_{i=0}^{N_{gen}} \mathcal{H}_{acc}(\phi', \theta', E_3')_i \frac{d^2\sigma}{dxdQ^2}_{(Kin),i}$$

$$\alpha_{RE}^{(\Omega,E')} = \frac{1}{\frac{d^2\sigma}{dE'd\Omega}_{(HRS)}} \sum_{i=0}^{N_{gen}} \mathcal{H}_{acc}(\phi', \theta', E_3')_i \frac{d^2\sigma}{dE_2'd\Omega}_{(Kin),i}$$

***See ELOG enry 478 for more details

$$\frac{d^2\sigma}{dxdQ^2}_{DIS} = \frac{N_{DIS}}{\mathcal{L}} \cdot \frac{1}{\eta_{DT} \cdot \eta_{Tracking} \cdot \eta_{s2m} \cdot \eta_{Cer} \cdot \eta_{virt} \cdot \alpha_{RE}^{(x,Q^2)} \cdot \Gamma_{DIS}^{(x,Q^2)}}$$

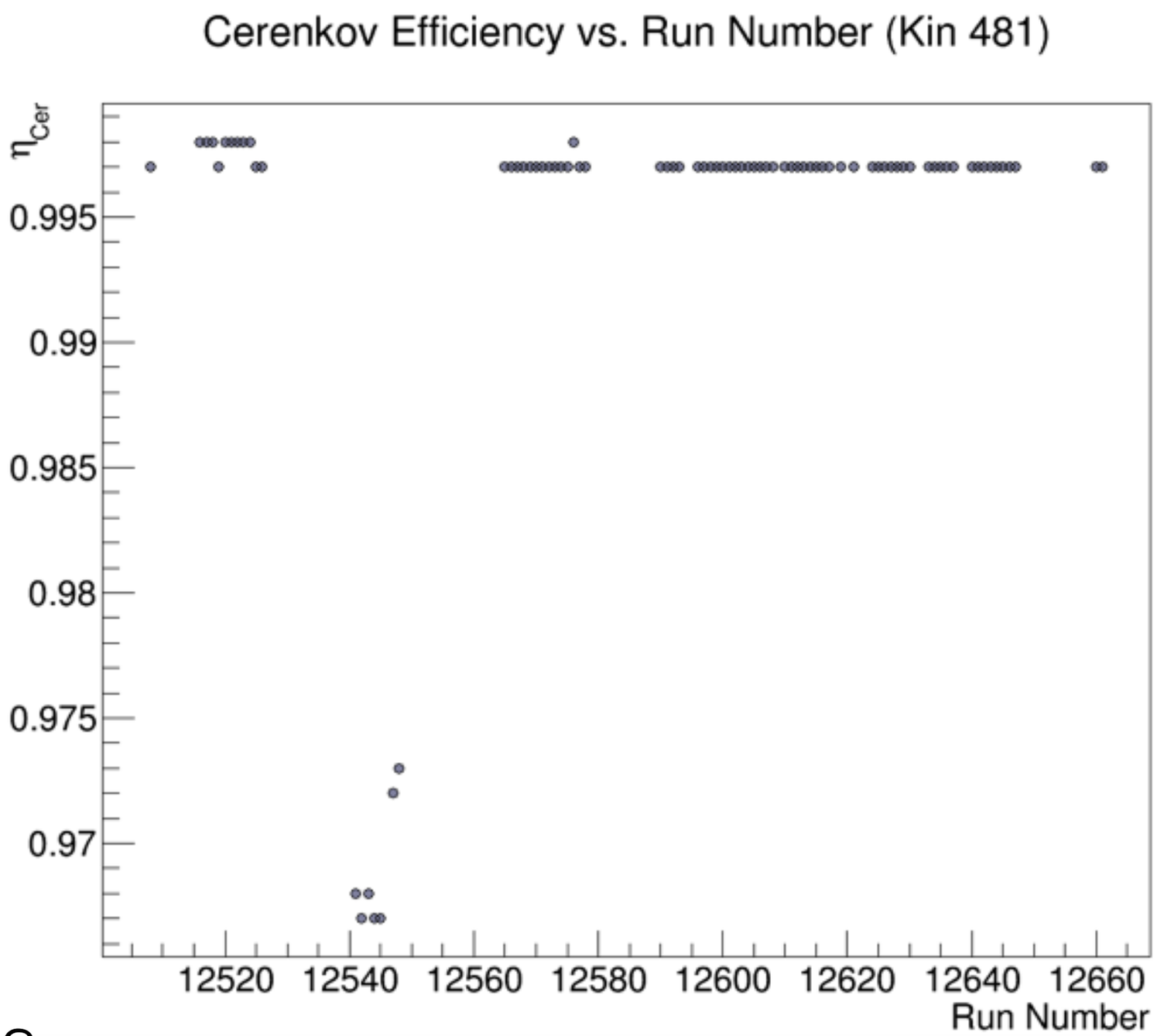
$$\eta_{virt} = \frac{e^{\delta_R^{(0)} + \delta_{ver}}}{(1 - \frac{\delta_{vac}}{2})^2}$$

- $\delta_R^{(0)} = \frac{\alpha}{\pi}\left[Sp(\cos^2\frac{\theta}{2}) - \frac{\pi^2}{3} + \frac{1}{2}\ln^2(\frac{Q^2}{m_e^2})\right]$
- $\delta_{vac} = \frac{2\alpha}{3\pi}\left[\ln(\frac{Q^2}{m_e^2}) - \frac{5}{3}\right]$
- $\delta_{ver} = \frac{\alpha}{\pi}\left[\frac{3}{2}\ln(\frac{Q^2}{m_e^2}) - 2 + \frac{\pi^2}{6} - \frac{1}{2}\ln^2(\frac{Q^2}{m_e^2})\right]$

η_{virt} Values	
Setting	η_{virt}
361	1.077
362	1.078
363	1.079
481	1.076
482	1.079
483	1.080
484	1.082
601	1.080
603	1.083

***See ELOG enry 478 for more details

$$\frac{d^2\sigma}{dxdQ^2}_{DIS} = \frac{N_{DIS}}{\mathcal{L}} \cdot \frac{1}{\eta_{DT} \cdot \eta_{Tracking} \cdot \eta_{s2m} \cdot \eta_{Cer} \cdot \eta_{virt} \cdot \alpha_{RE}^{(x,Q^2)} \cdot \Gamma_{DIS}^{(x,Q^2)}}$$

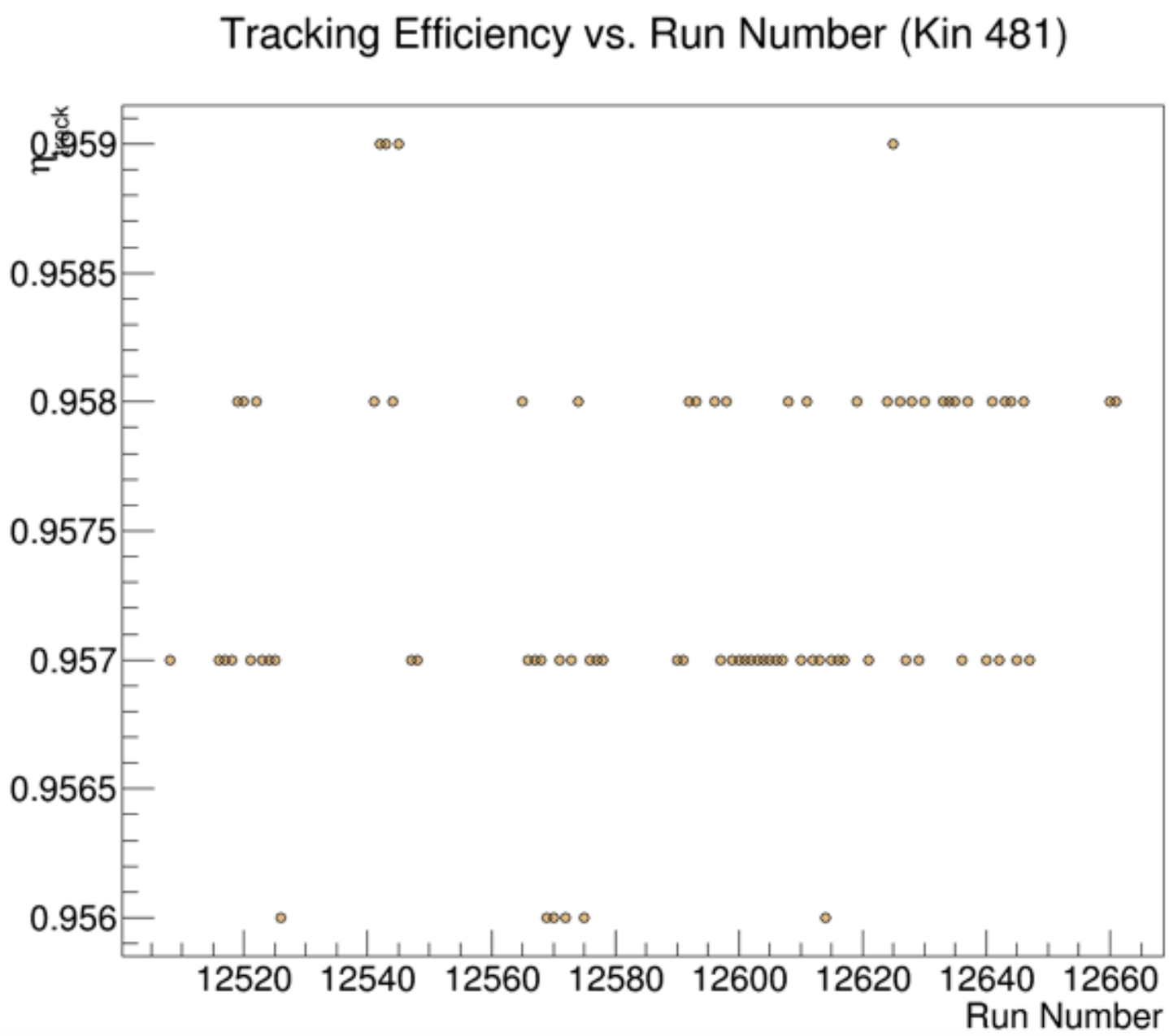


$$\eta_{cer} = \frac{N_{Cer+PR}}{N_{PR}}$$

$$\frac{d^2\sigma}{dxdQ^2}_{DIS} = \frac{N_{DIS}}{\mathcal{L}} \cdot \frac{1}{\eta_{DT} \cdot \eta_{Tracking} \cdot \eta_{s2m} \cdot \eta_{Cer} \cdot \eta_{virt} \cdot \alpha_{RE}^{(x,Q^2)} \cdot \Gamma_{DIS}^{(x,Q^2)}}$$

Use 0.999 for all runs

$$\frac{d^2\sigma}{dxdQ^2}_{DIS} = \frac{N_{DIS}}{\mathcal{L}} \cdot \frac{1}{\eta_{DT} \cdot \eta_{Tracking} \cdot \eta_{s2m} \cdot \eta_{Cer} \cdot \eta_{virt} \cdot \alpha_{RE}^{(x,Q^2)} \cdot \Gamma_{DIS}^{(x,Q^2)}}$$



$$\eta_{tracking} = 1 - \eta_{MultiTrack} - \eta_{MultiCluster}$$

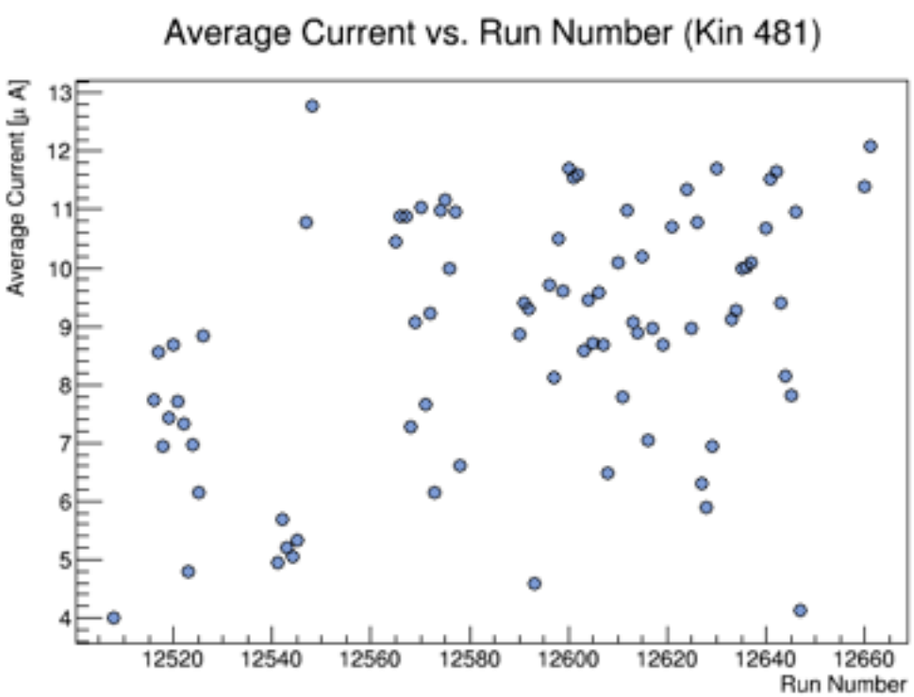
$$\eta_{MultiTrack} = \frac{N_{MultiTrackElectrons}}{N_{SingleTrackElectrons}}$$

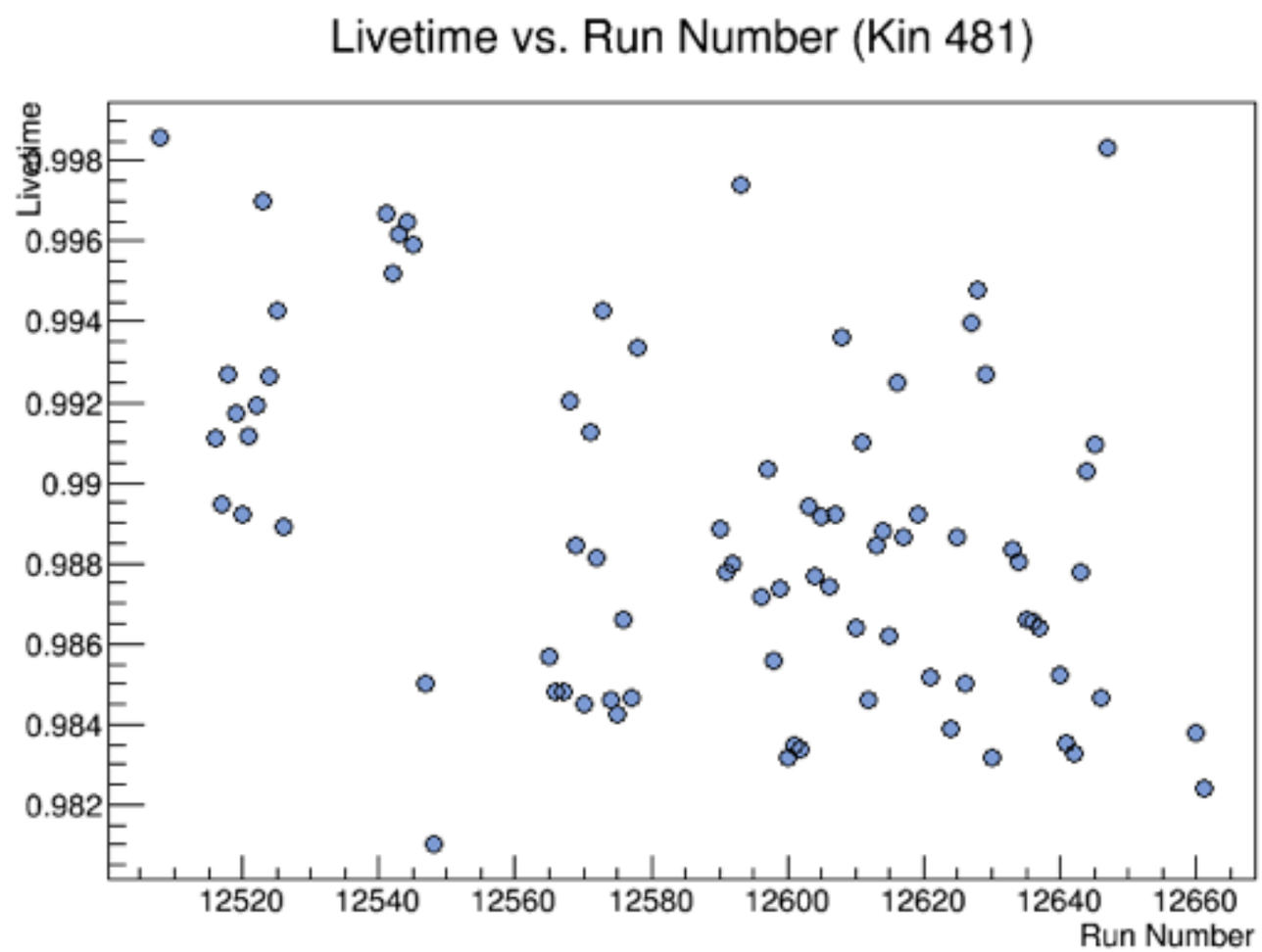
$$\eta_{MultiCluster} = \frac{N_{MultiClusterElectrons}}{N_{SingleTrackElectrons}}$$

$$\frac{d^2\sigma}{dxdQ^2}_{DIS} = \frac{N_{DIS}}{\mathcal{L}} \cdot \frac{1}{\eta_{DT} \cdot \eta_{Tracking} \cdot \eta_{s2m} \cdot \eta_{Cer} \cdot \eta_{virt} \cdot \alpha_{RE}^{(x,Q^2)} \cdot \Gamma_{DIS}^{(x,Q^2)}}$$

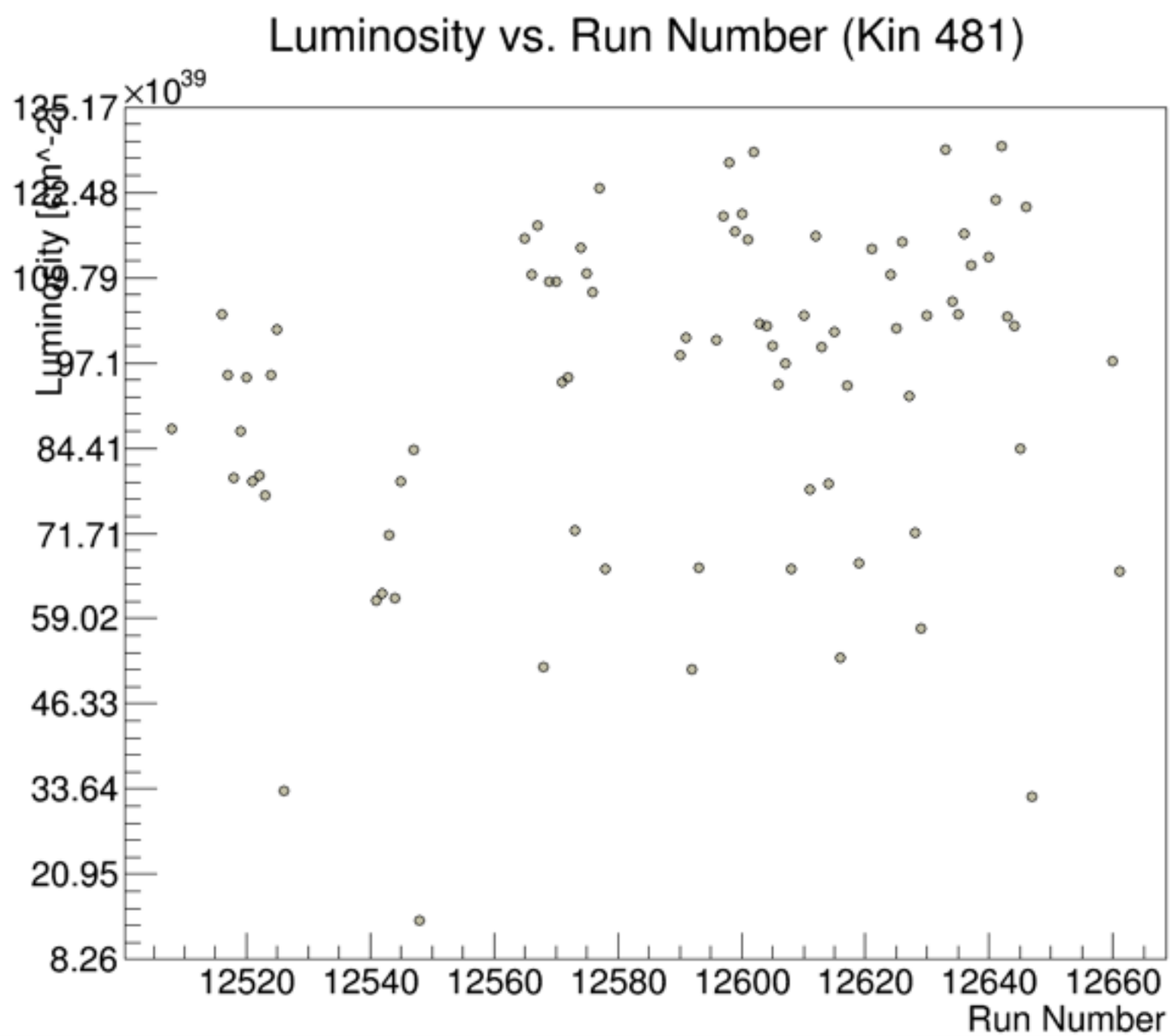
Current (μA)	S2m&&Cer LT	Rate: no cuts	DIS Normalized Rate	DVCS Normalized Rate	DIS $\frac{signal}{total}$	DVCS Normalized Rate corrected
10.61	0.985	9.27	3.422	5.212	0.7889	4.111
15.32	0.976	10.26	3.450	5.615	0.7470	4.194
20.53	0.965	11.26	3.449	5.936	0.6507	3.863

Linearly interpolating LT for average current of the run for now…



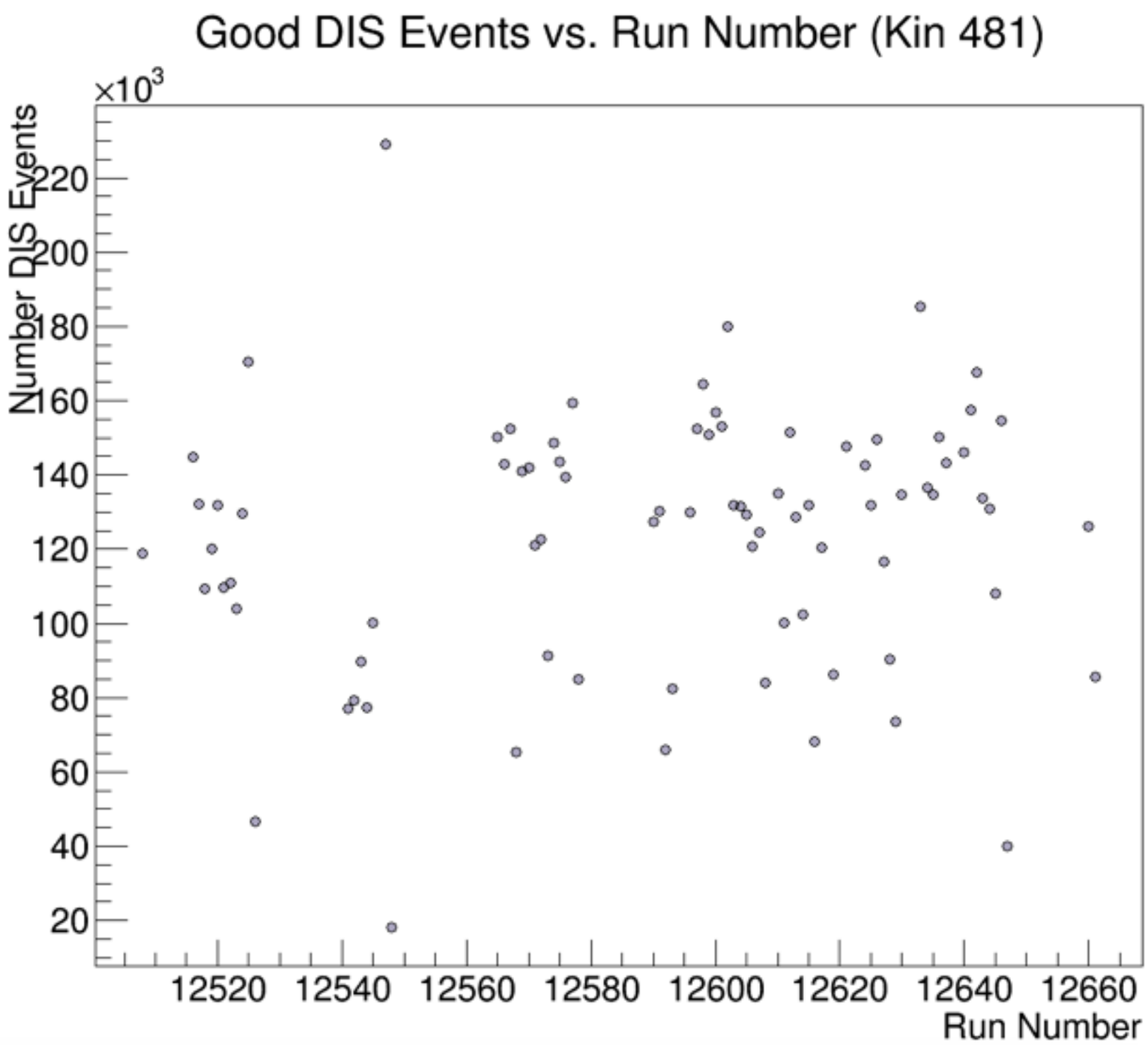


$$\frac{d^2\sigma}{dxdQ^2}_{DIS} = \frac{N_{DIS}}{\mathcal{L}} \cdot \frac{1}{\eta_{DT} \cdot \eta_{Tracking} \cdot \eta_{s2m} \cdot \eta_{Cer} \cdot \eta_{virt} \cdot \alpha_{RE}^{(x,Q^2)} \cdot \Gamma_{DIS}^{(x,Q^2)}}$$

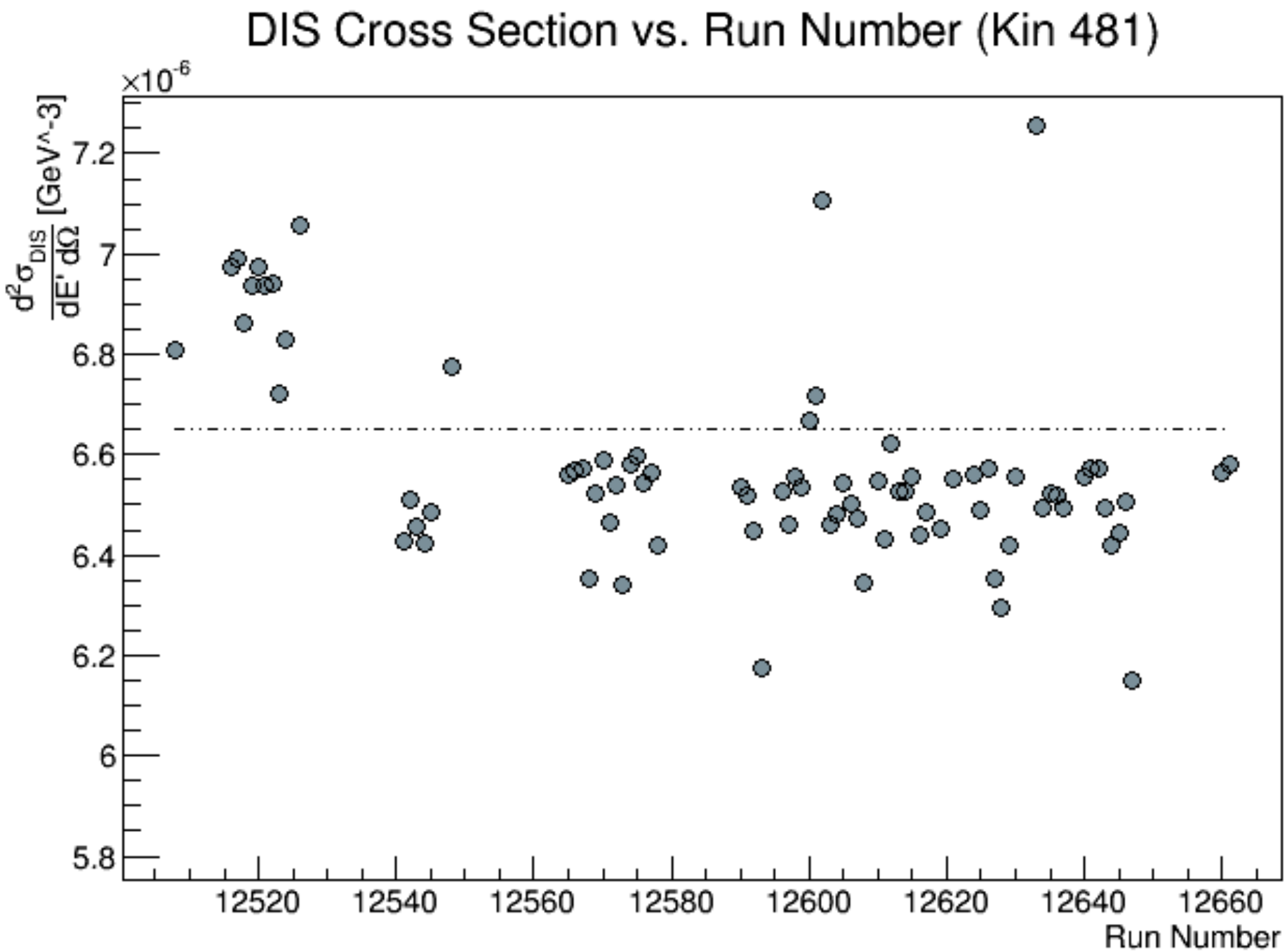


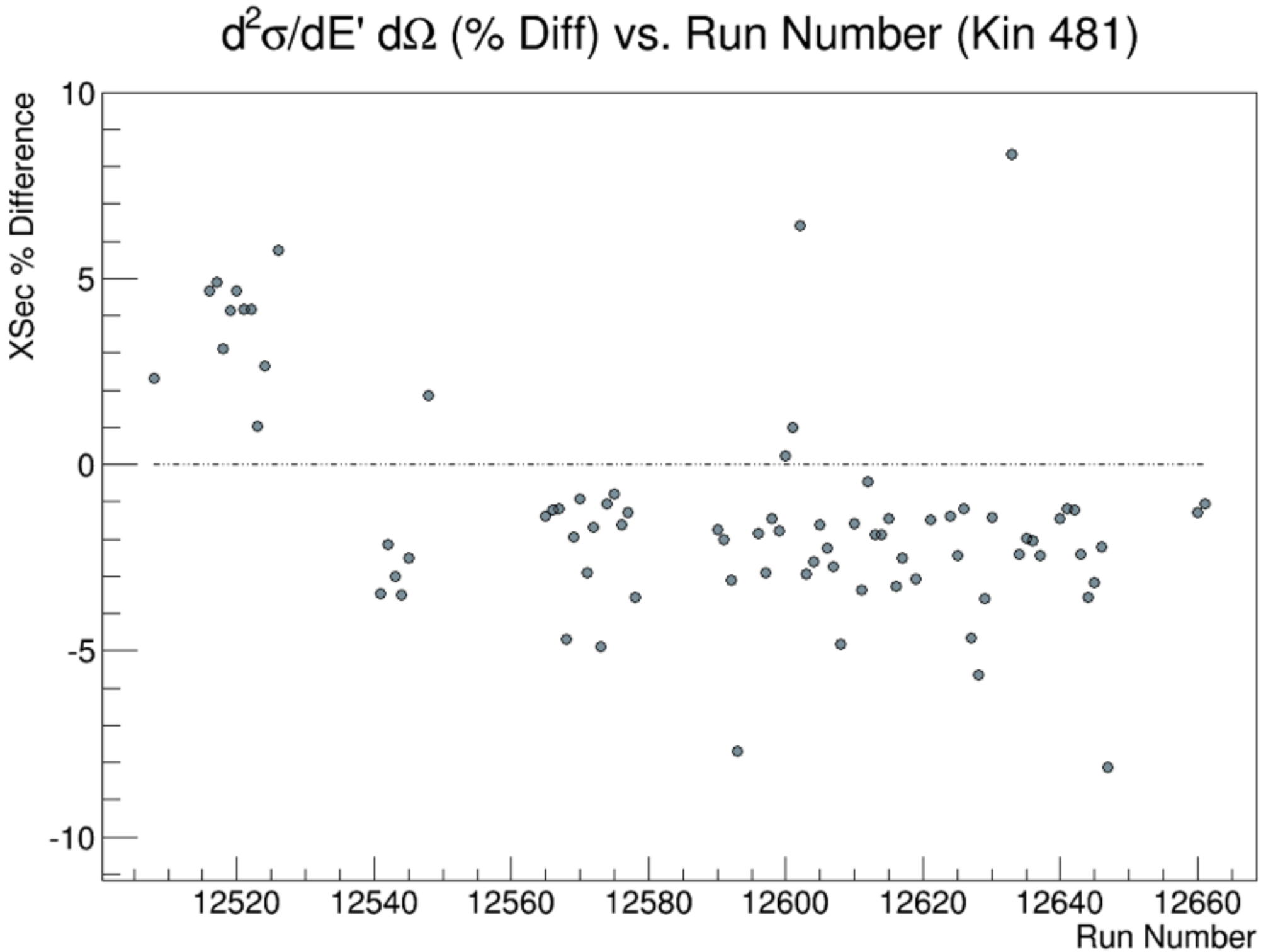
$$\mathcal{L} = \int \frac{d\mathcal{L}}{dt} dt = \frac{Q}{e} \frac{N_A \rho l}{A_H}$$

$$\frac{d^2\sigma}{dxdQ^2}_{DIS} = \frac{N_{DIS}}{\mathcal{L}} \cdot \frac{1}{\eta_{DT} \cdot \eta_{Tracking} \cdot \eta_{s2m} \cdot \eta_{Cer} \cdot \eta_{virt} \cdot \alpha_{RE}^{(x,Q^2)} \cdot \Gamma_{DIS}^{(x,Q^2)}}$$

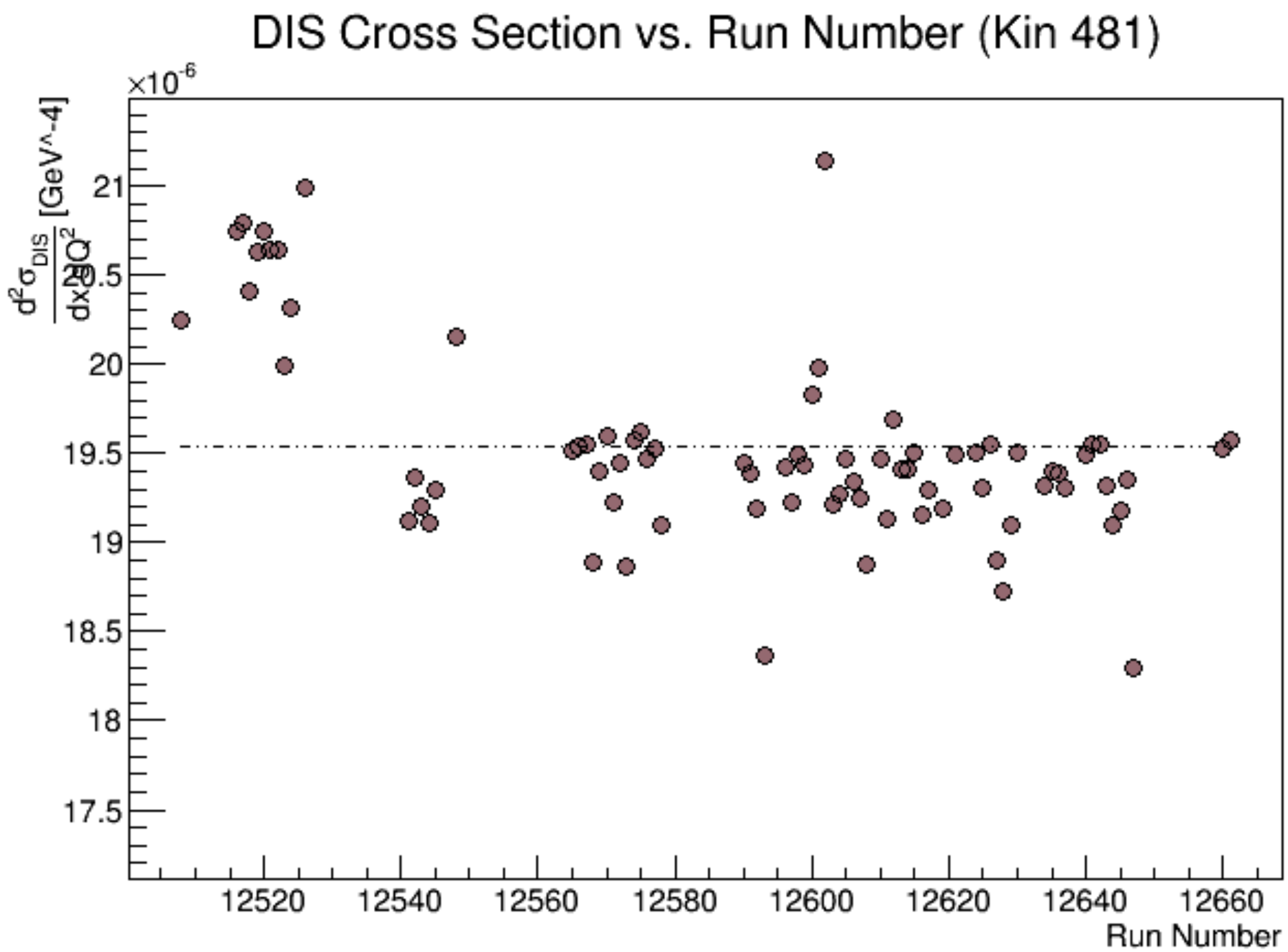


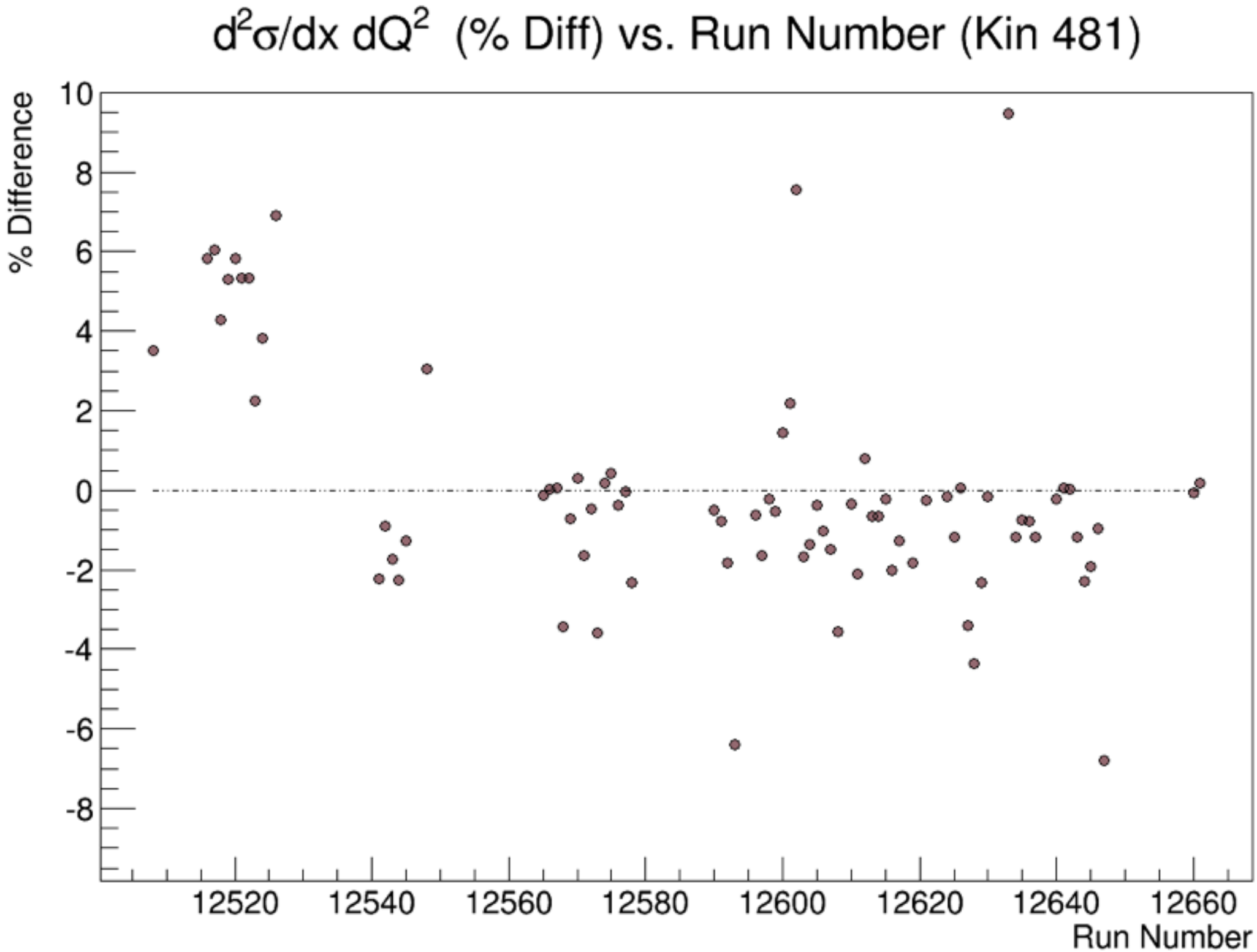
Extraction in E', Omega….




d²σ/dE' dΩ (% Diff) vs. Run Number (Kin 481)
XSec % Difference
10
5
0
-5
-10
12520
12540
12560
12580
12600
12620
12640
12660
Run Number

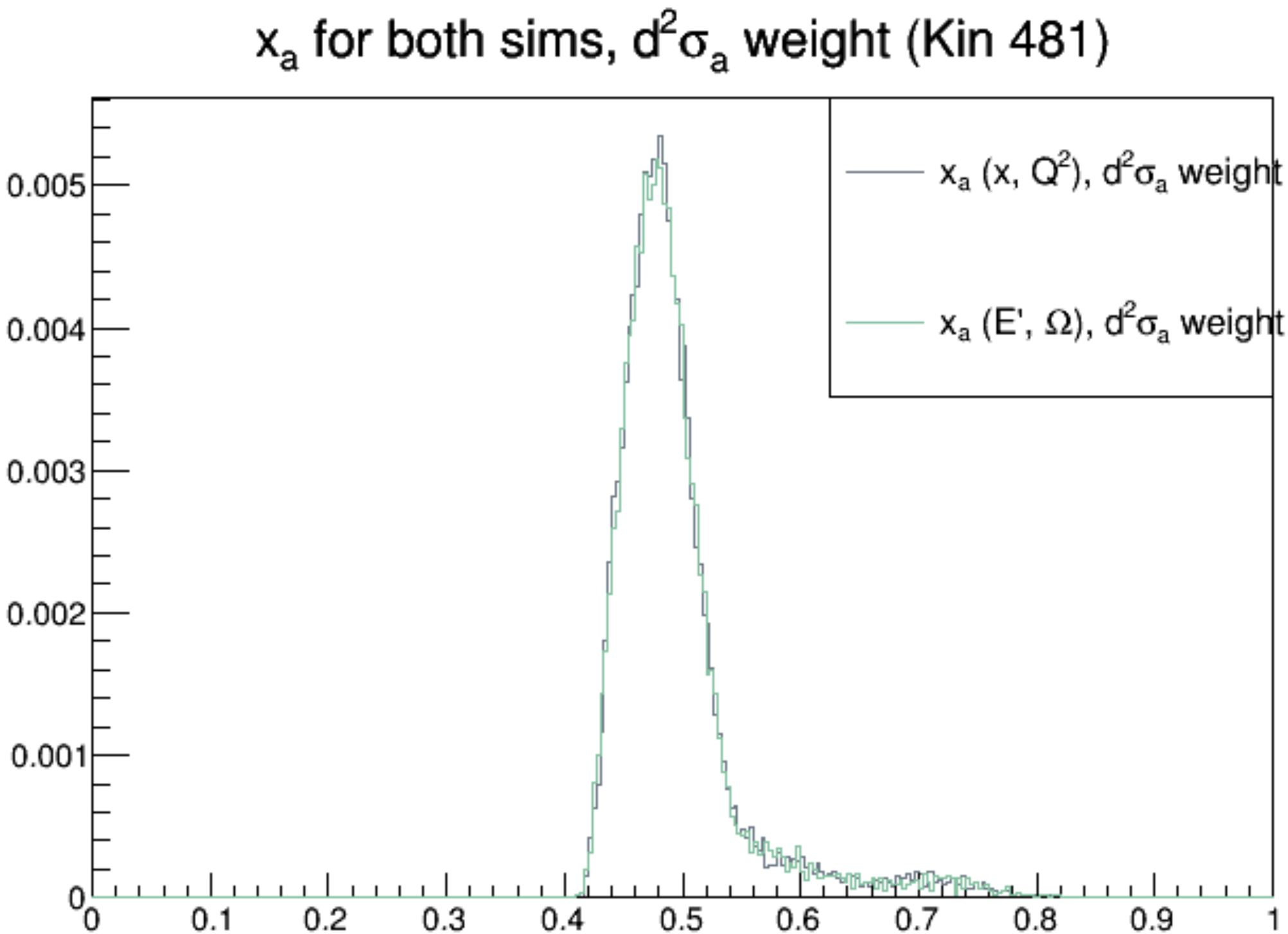
Extraction in x, Q2...




d²σ/dx dQ² (% Diff) vs. Run Number (Kin 481)
% Difference
10
8
6
4
2
0
-2
-4
-6
-8
12520
12540
12560
12580
12600
12620
12640
12660
Run Number

Future Tasks

- Error bars
- Determine systematic error from R-Cut
- Extract cross section for remaining kinematics

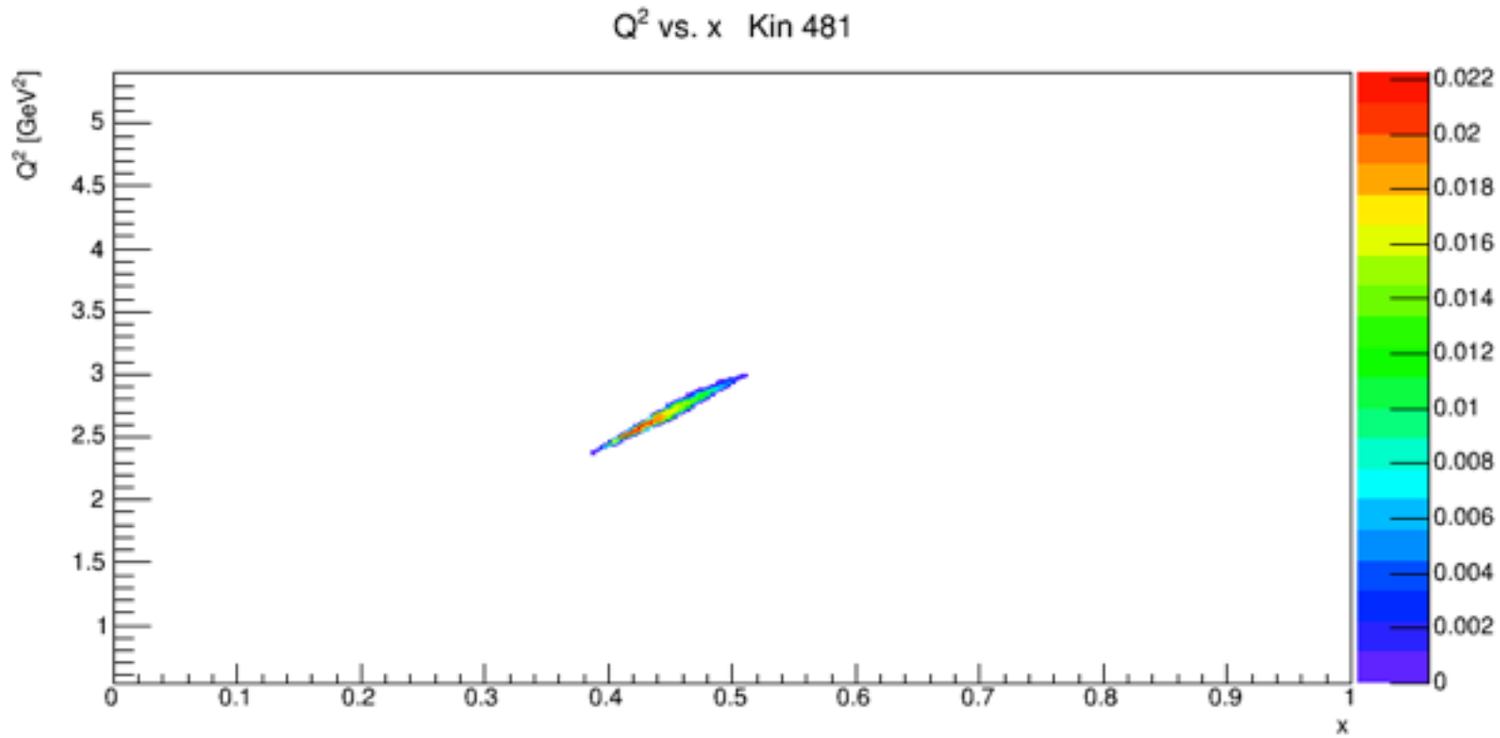

x_a for both sims, $d^2\sigma_a$ weight (Kin 481)
x_a (x, Q^2), $d^2\sigma_a$ weight
x_a (E', Ω), $d^2\sigma_a$ weight
0.005
0.004
0.003
0.002
0.001
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

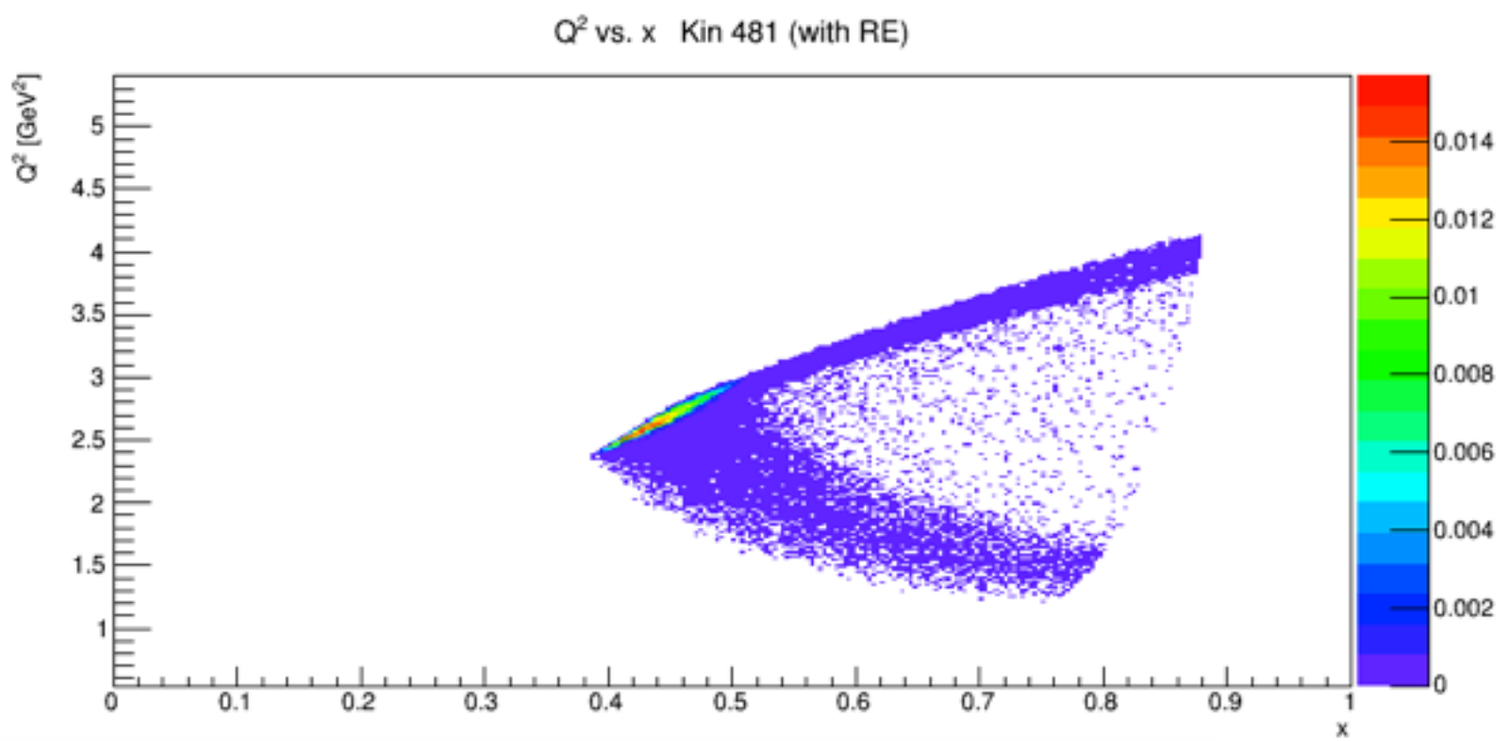
$$\frac{d^2\sigma}{dE'd\Omega} = \frac{d\sigma}{d\Omega}_{Mott}\left(\frac{F_{2,p}}{\nu} + \frac{2}{m_p}F_{1,p}\tan^2\frac{\theta}{2}\right)$$

$$\frac{d\sigma}{d\Omega}_{Mott} = \frac{\alpha_{str}^2}{4E^2\sin^4(\frac{\theta}{2})}\cos^2\frac{\theta}{2}$$

$$\frac{d^2\sigma}{dxdQ^2} = \frac{4\pi\alpha_{str}^2}{Q^4}\left[(1 - y - \frac{m_p^2x^2y^2}{Q^2}) \cdot \frac{F_{2,p}}{x} + y^2 \cdot F_{1,p}\right]$$

Weighted


Q² vs. x Kin 481
Q² [GeV²]
x
0.022
0.02
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0


Q² vs. x Kin 481 (with RE)
Q² [GeV²]
x
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0

[1] F. Halzen and A. D. Martin, Quarks & Leptons: An Introductory Course in Modern Particle Physics (1984)

[2] M.E. Christy and P.E. Bosted, Empirical Fit to Precision Inclusive Electron-Proton cross Sections in the Resonance Region. *Phys. Rev.*, C81:055213, 2010.

[3] L. W. MO and Y. S. TSAI. Radiative corrections to elastic and inelastic ep and up scattering. *Rev. Mod. Phys.*, 41:205-235, Jan 1969.

[4] M. Vanderhaeghen, J.M. Friedrich, D. Lhuillier, D. Marchand, L. Van Hoorebeke, et al. QED radiative corrections to virtual Compton scattering. *Phys.Rev.*, C62:025501, 2000.