e,e’p_{Recoil} from eg2c Data

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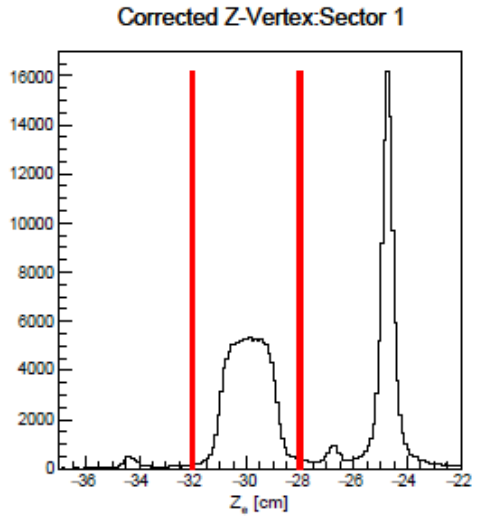
Outline

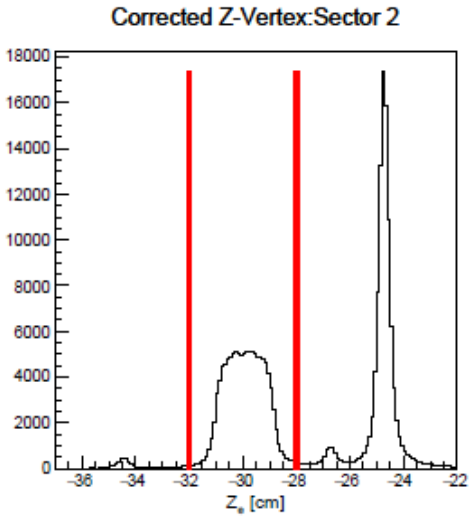
1. I will discuss results e,e'p_{Recoil} for Deep Inelastic Scattering (DIS) events. I will show yield results for D, C, Al, Fe, Sn, and Pb targets; but I will only show ratios for the solid targets to C, since I'm finalizing the acceptance corrections for the recoiling protons.
2. I will show an attempt to select Quasi-elastic (QE) e,e'p_{Recoil} events.
3. Lastly, I will discuss some checks I do to make sure the yields are being properly normalized.

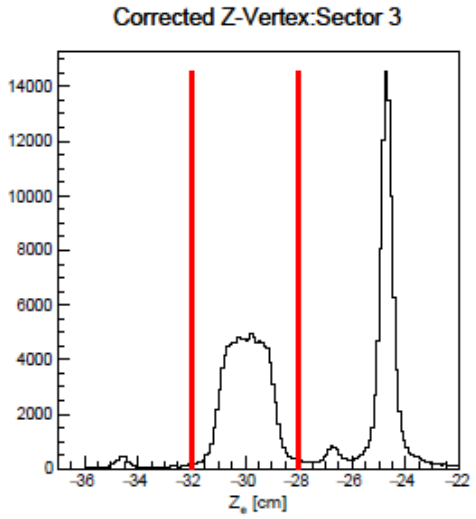
Target and Event Selection

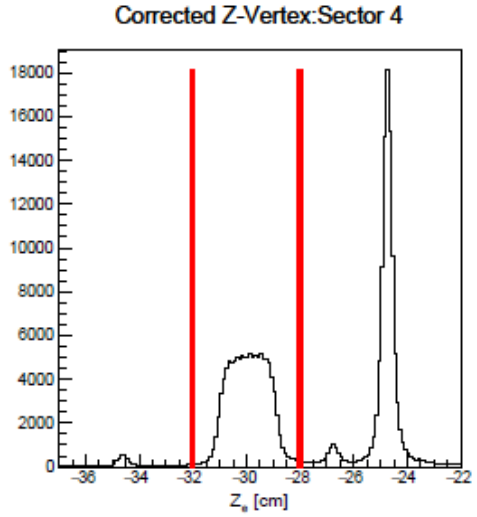
- The deuterium target and a solid target are usually present in the beam at the same time.
- One electron is reconstructed per event; multiple protons may be reconstructed per event.
- I only consider protons which track back to the same target as the scattered electron.
- I then apply a ‘standard’ DIS cut. I then look for protons with large angles relative to the momentum transfer vector. I also generally require the protons to have momentum than 250 MeV/c.

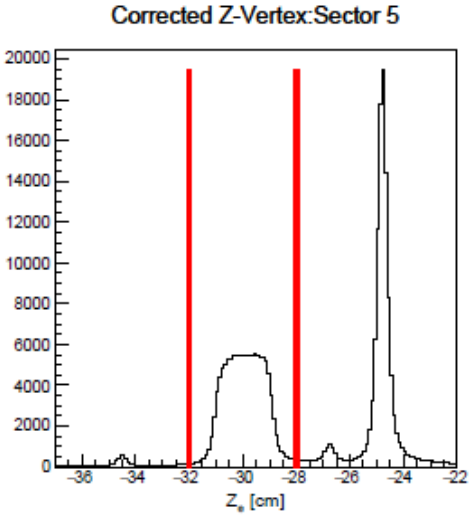
Reconstructed Electron Vertex

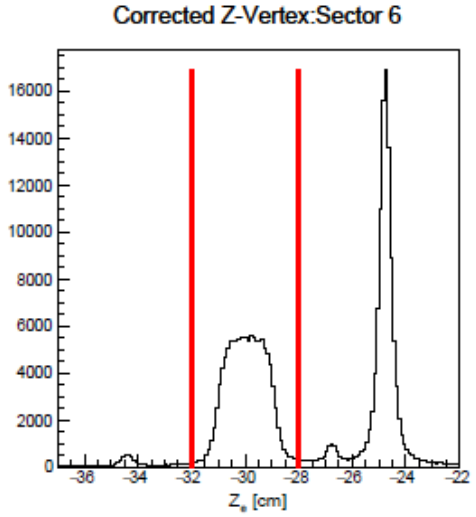


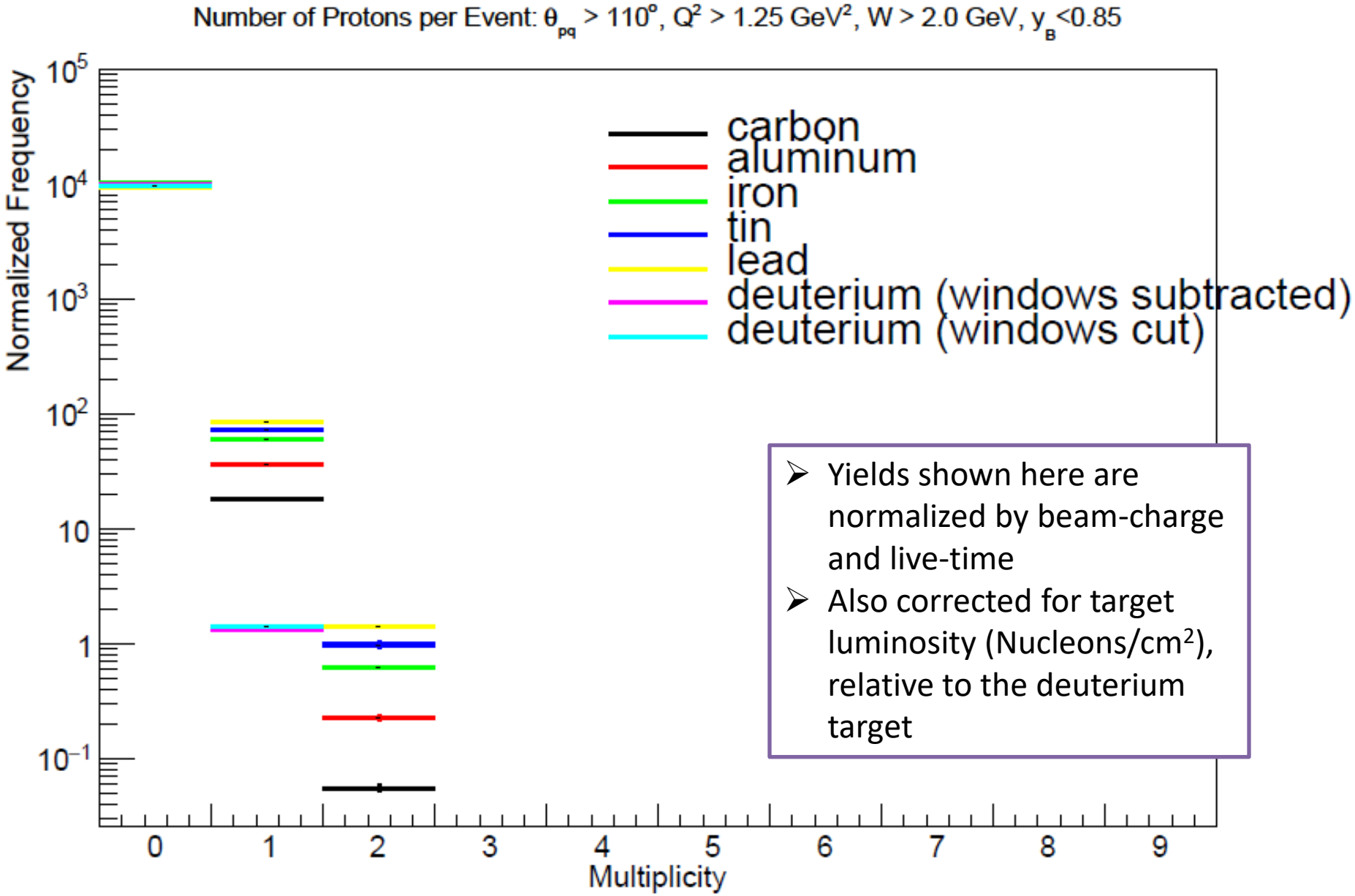




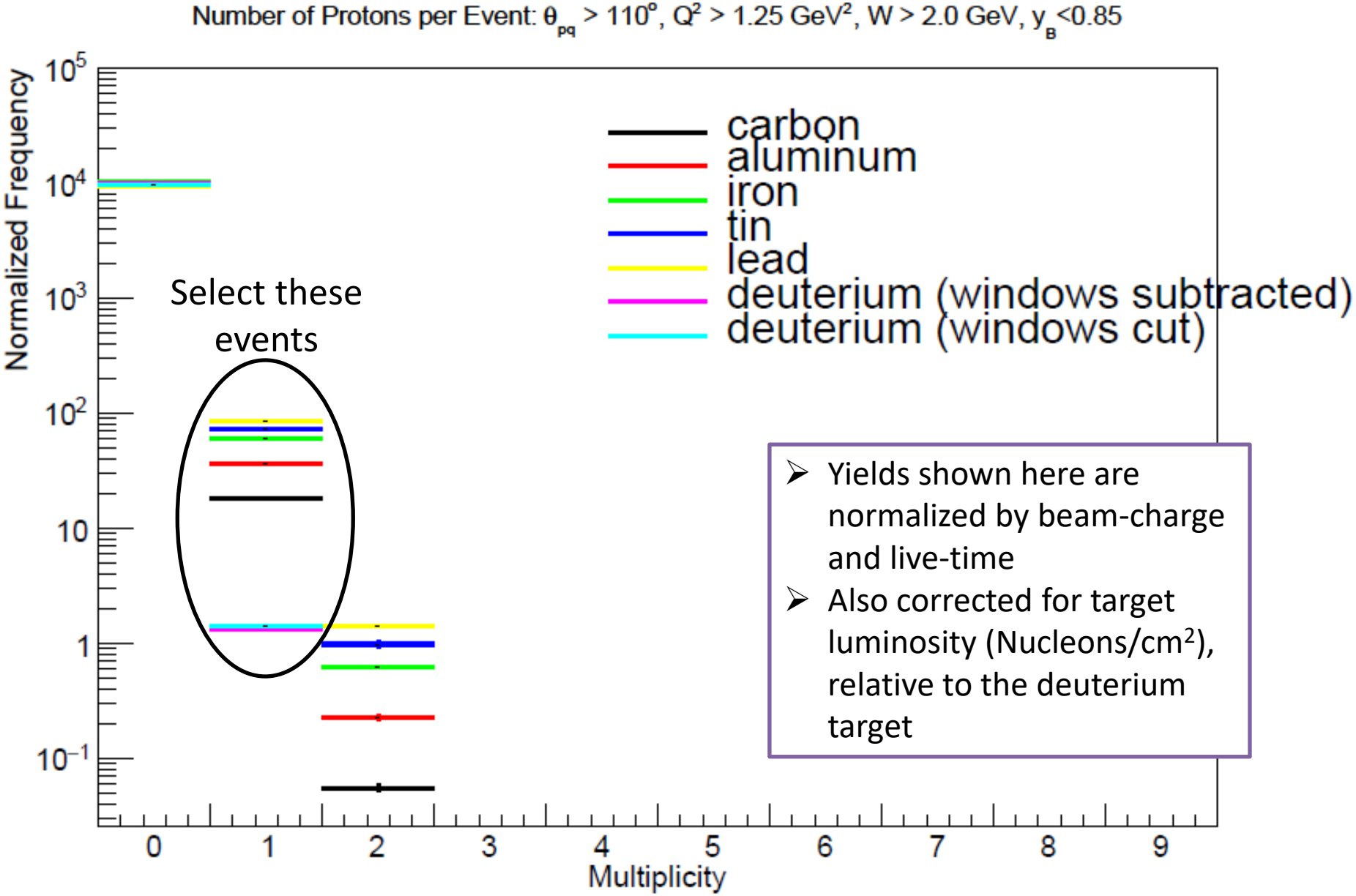








- Yields shown here are normalized by beam-charge and live-time
- Also corrected for target luminosity (Nucleons/cm^2), relative to the deuterium target



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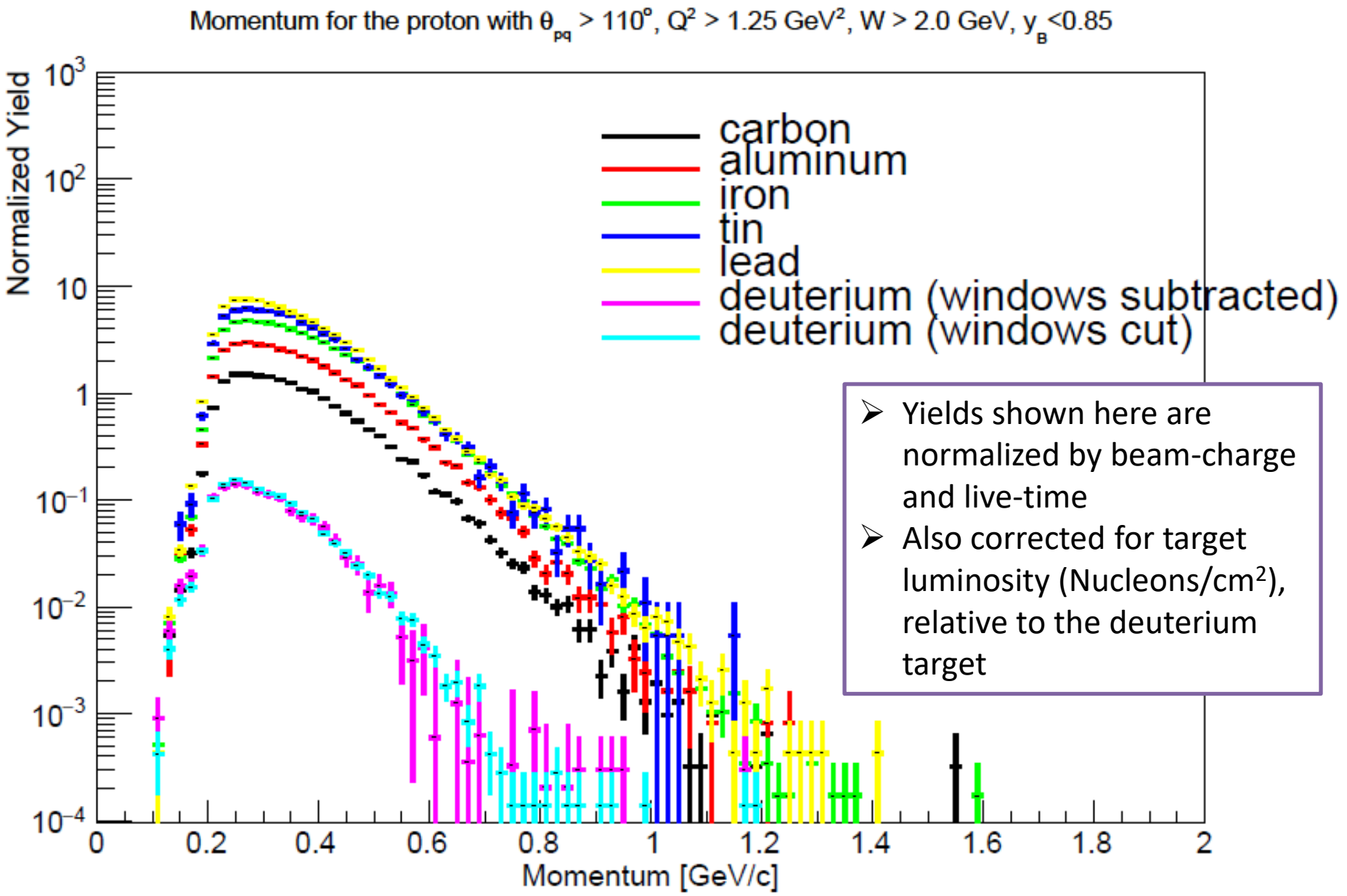
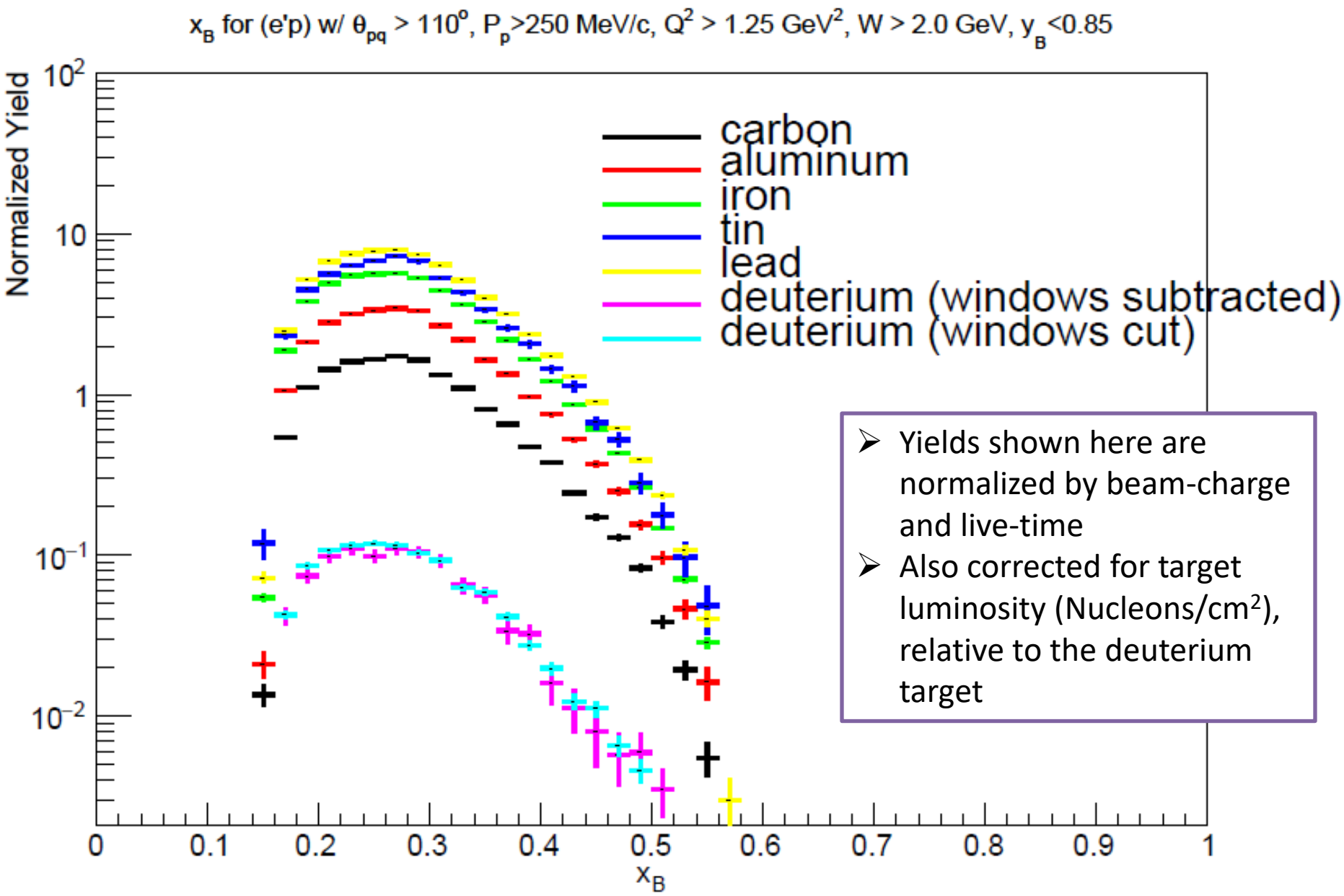
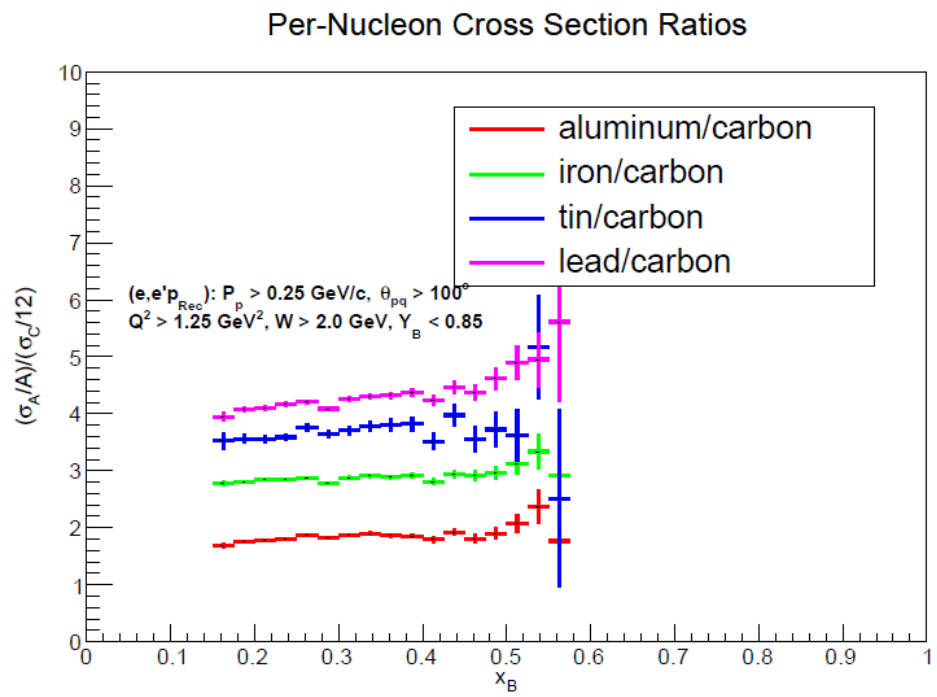
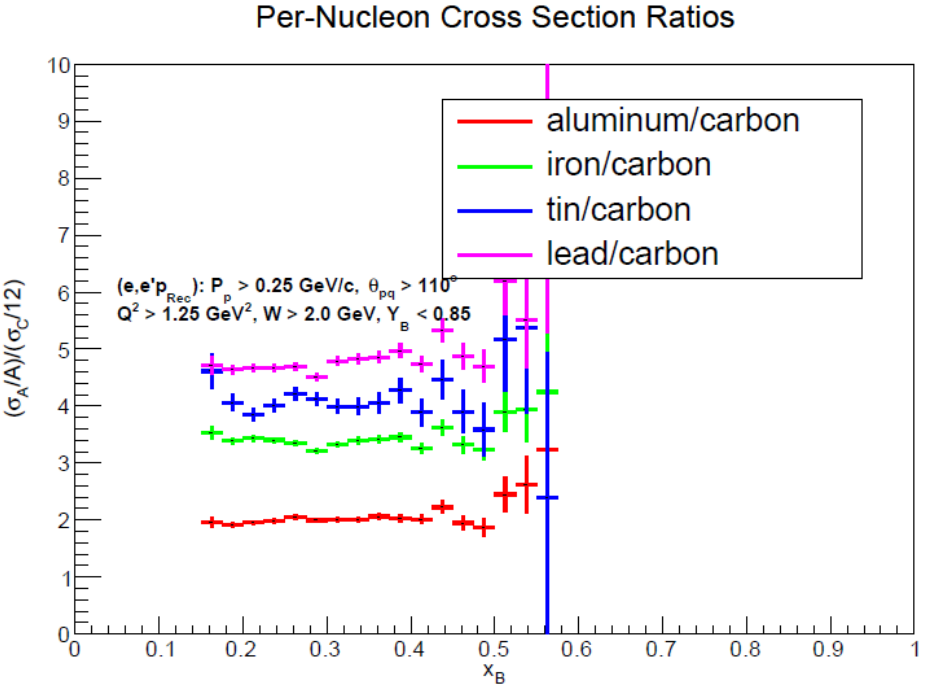
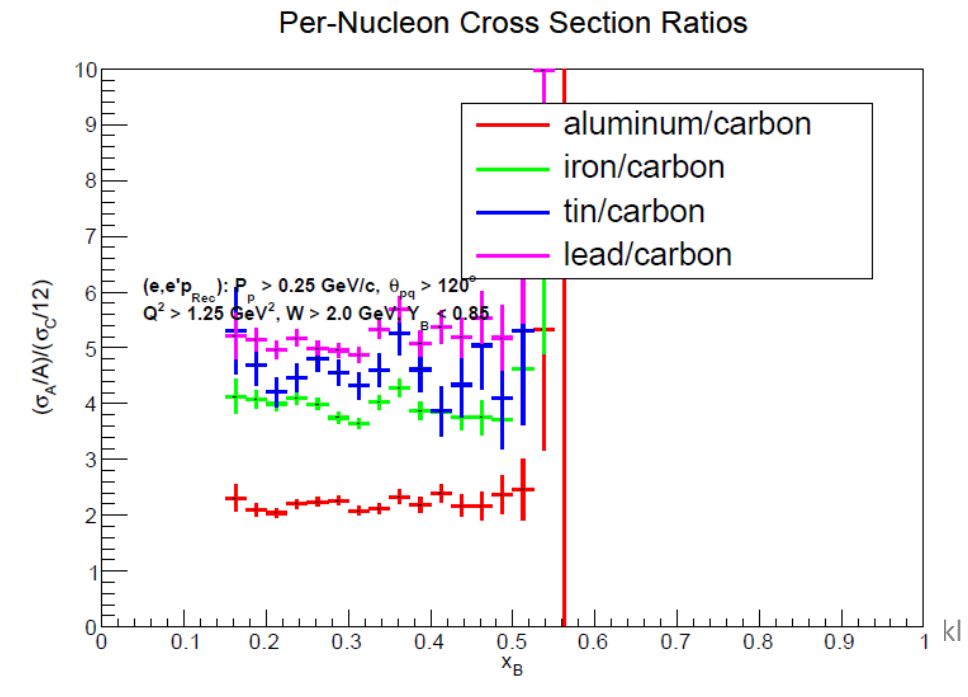

Momentum for the proton with θ_{pq} > 110°, Q^2 > 1.25 GeV², W > 2.0 GeV, y_B<0.85
Normalized Yield
Momentum [GeV/c]
carbon
aluminum
iron
tin
lead
deuterium (windows subtracted)
deuterium (windows cut)
➢ Yields shown here are normalized by beam-charge and live-time
➢ Also corrected for target luminosity (Nucleons/cm²), relative to the deuterium target

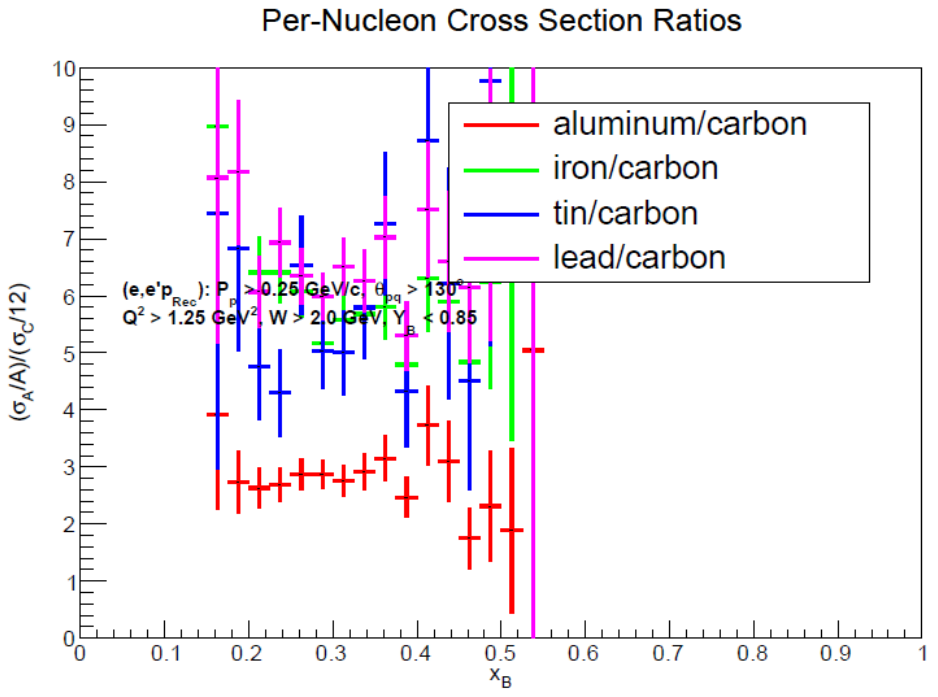


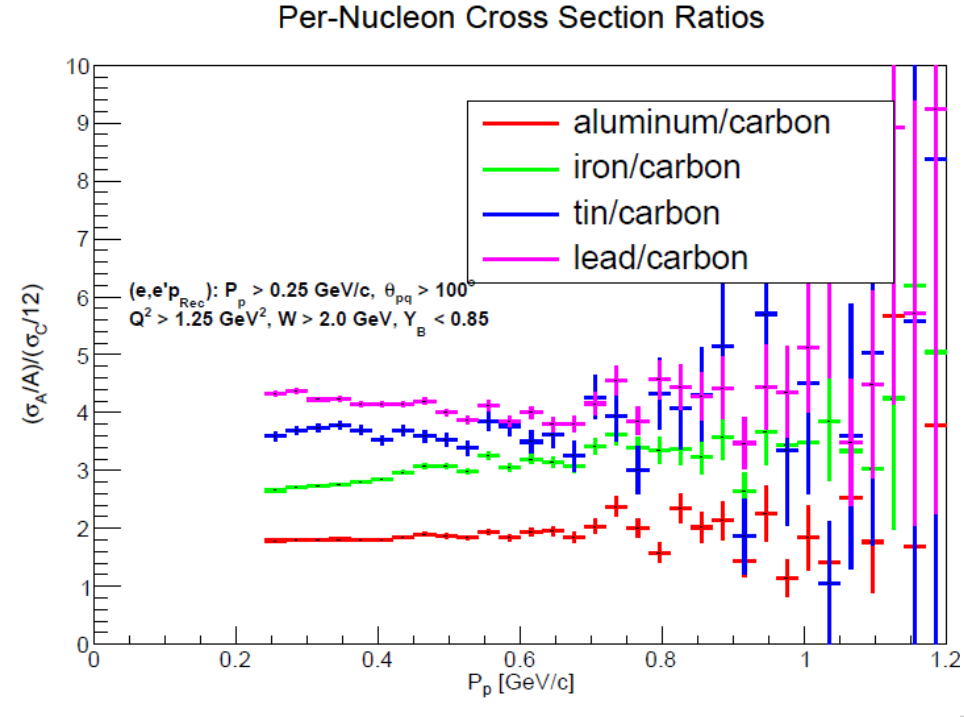
- Yields shown here are normalized by beam-charge and live-time
- Also corrected for target luminosity (Nucleons/cm^2), relative to the deuterium target


Per-Nucleon Cross Section Ratios
aluminum/carbon
iron/carbon
tin/carbon
lead/carbon
(e,e'p_Rec): P_p > 0.25 GeV/c, θ_pq > 100°
Q² > 1.25 GeV², W > 2.0 GeV, Y_B < 0.85
(σ_A/A)/(σ_C/12)
x_B


Per-Nucleon Cross Section Ratios
aluminum/carbon
iron/carbon
tin/carbon
lead/carbon
(e,e'p_Rec): P_p > 0.25 GeV/c, θ_pq > 110°
Q² > 1.25 GeV², W > 2.0 GeV, Y_B < 0.85
(σ_A/A)/(σ_C/12)
x_B


Per-Nucleon Cross Section Ratios
aluminum/carbon
iron/carbon
tin/carbon
lead/carbon
(e,e'p_Rec): P_p > 0.25 GeV/c, θ_pq > 120°
Q² > 1.25 GeV², W > 2.0 GeV, Y_B < 0.85
(σ_A/A)/(σ_C/12)
x_B


Per-Nucleon Cross Section Ratios
aluminum/carbon
iron/carbon
tin/carbon
lead/carbon
(e,e'p_Rec): P_p > 0.25 GeV/c, θ_pq > 130°
Q² > 1.25 GeV², W > 2.0 GeV, Y_B < 0.85
(σ_A/A)/(σ_C/12)
x_B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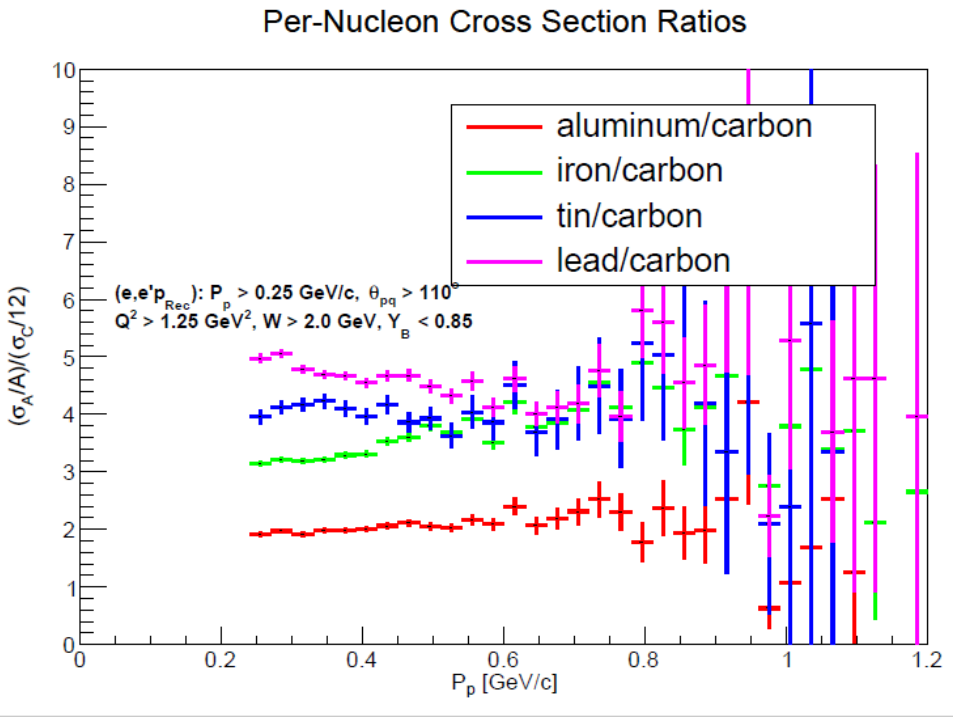
tin/carbon
lead/carbon
(e,e'p_Rec): P_p > 0.25 GeV/c, θ_pq > 100°
Q² > 1.25 GeV², W > 2.0 GeV, Y_B < 0.85
(σ_A/A)/(σ_C/12)
P_p [GeV/c]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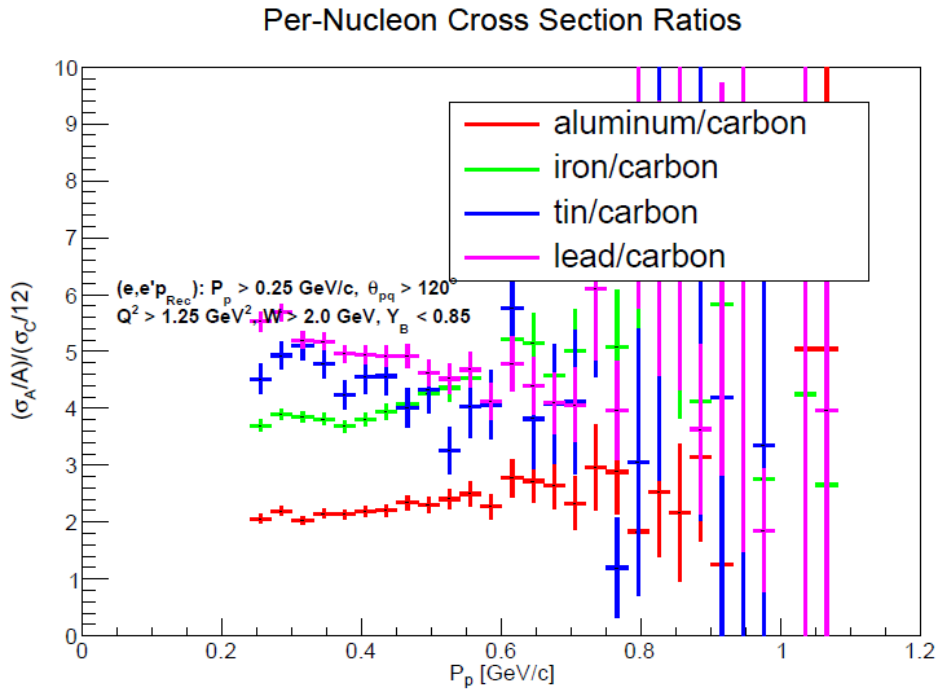
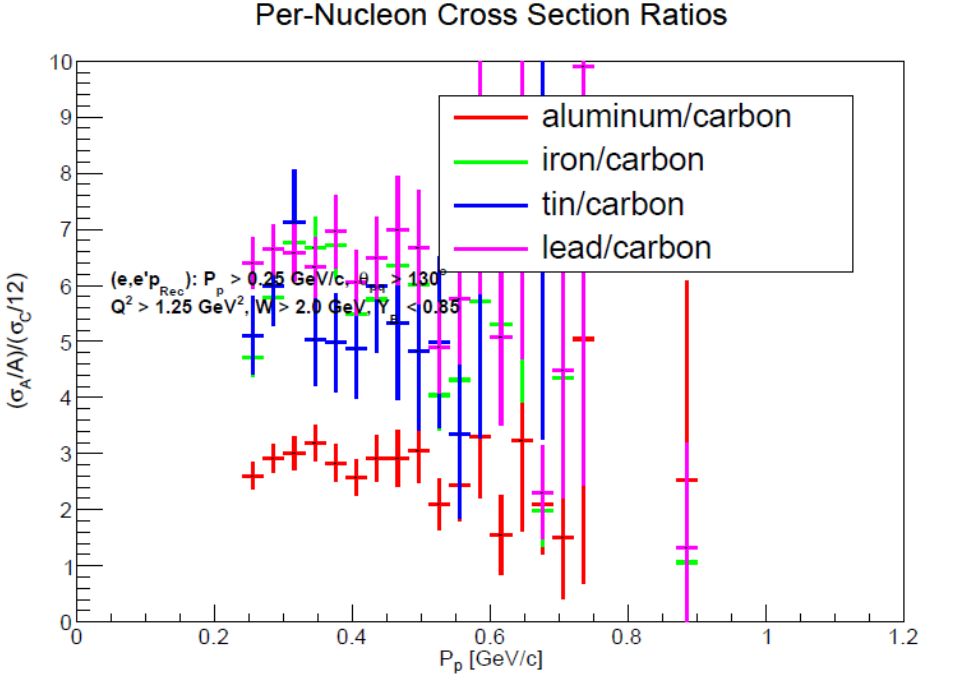
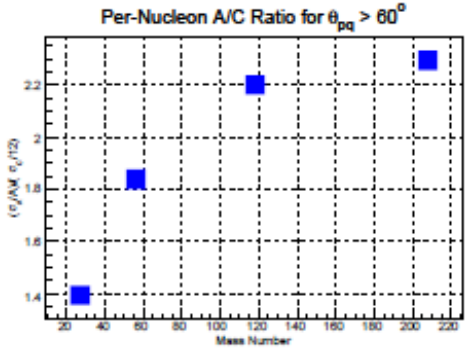
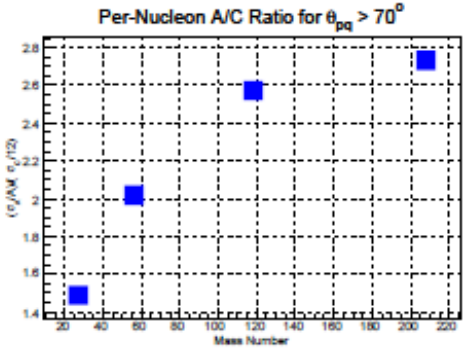
lead/carbon
(e,e'p_Rec): P_p > 0.25 GeV/c, θ_pq > 110°
Q² > 1.25 GeV², W > 2.0 GeV, Y_B < 0.85
(σ_A/A)/(σ_C/12)
P_p [GeV/c]

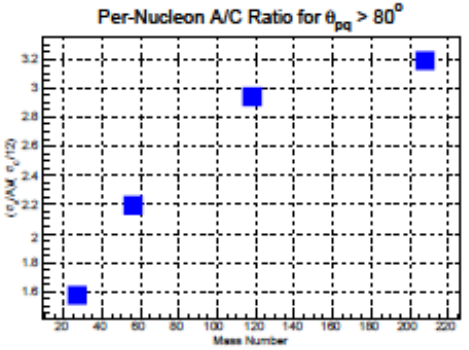

Per-Nucleon Cross Section Ratios
aluminum/carbon
iron/carbon
tin/carbon
lead/carbon
(e,e'p_Rec): P_p > 0.25 GeV/c, θ_pq > 120°
Q² > 1.25 GeV², W > 2.0 GeV, Y_B < 0.85
(σ_A/A)/(σ_C/12)
P_p [GeV/c]

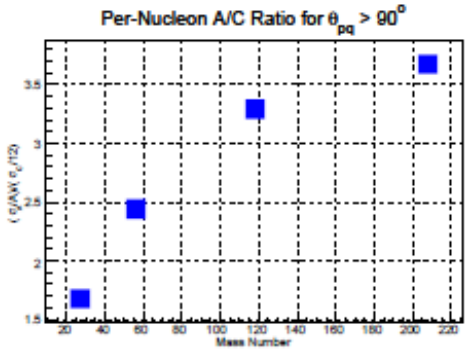

Per-Nucleon Cross Section Ratios
aluminum/carbon
iron/carbon
tin/carbon
lead/carbon
(e,e'p_Rec): P_p > 0.25 GeV/c, θ_pq > 130°
Q² > 1.25 GeV², W > 2.0 GeV, Y_B < 0.85
(σ_A/A)/(σ_C/12)
P_p [GeV/c]

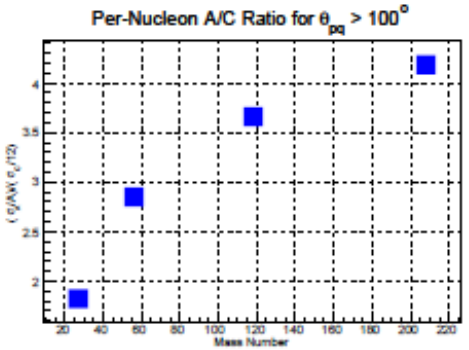
Cross-Section Ratio vs. A for various θ_{pq} Cuts

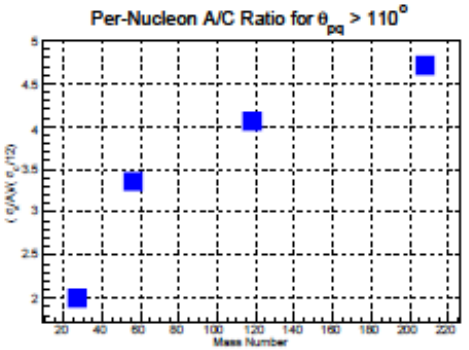


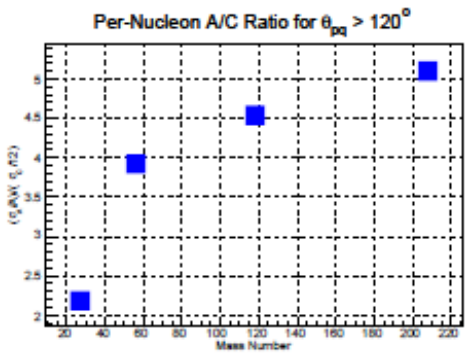


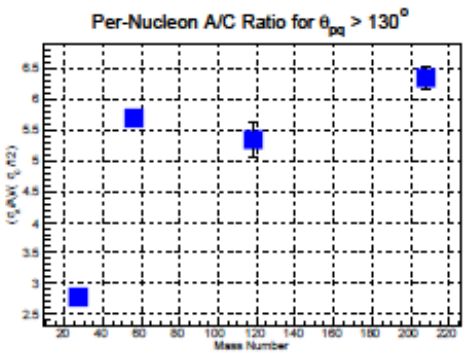


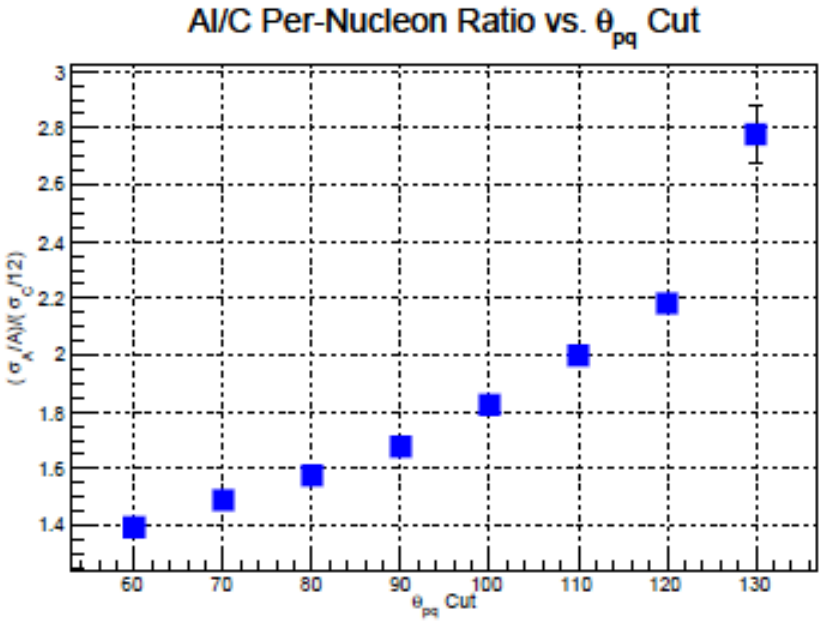


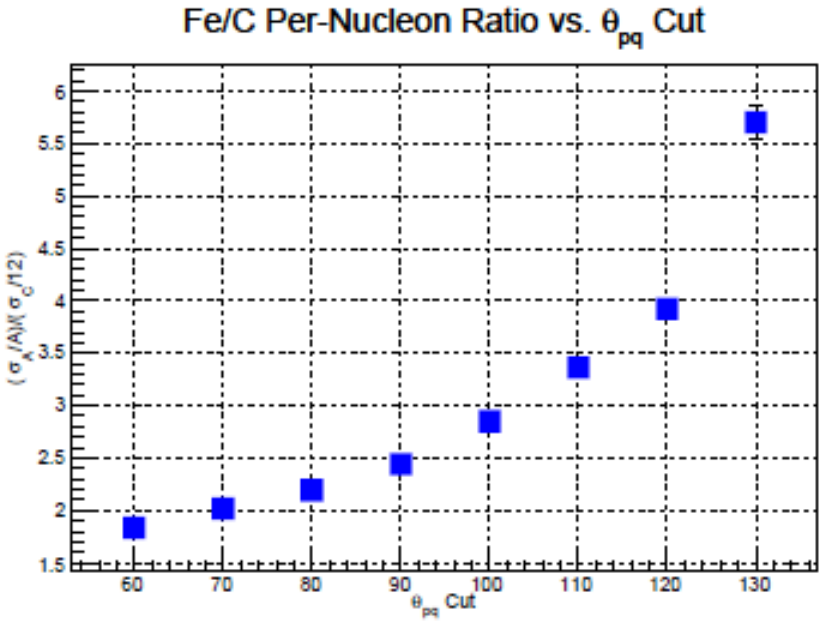


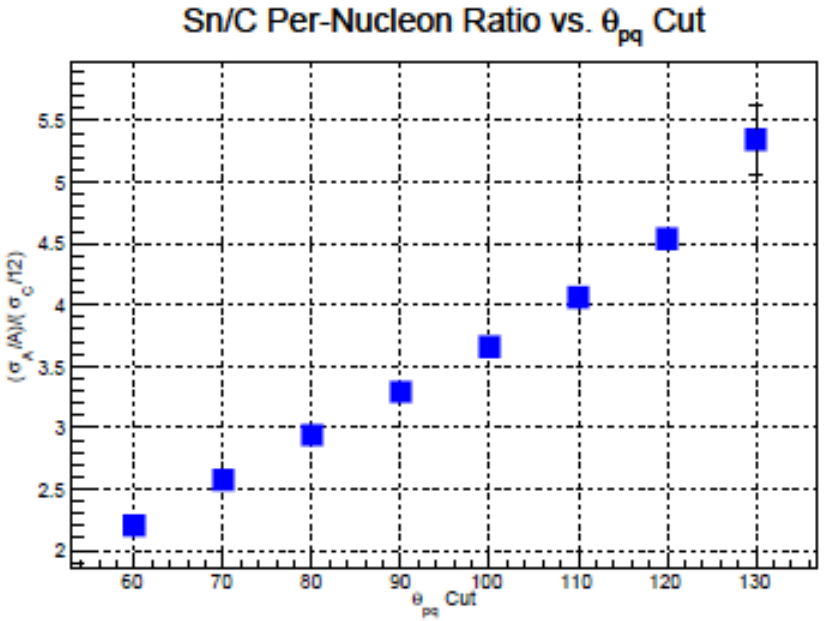


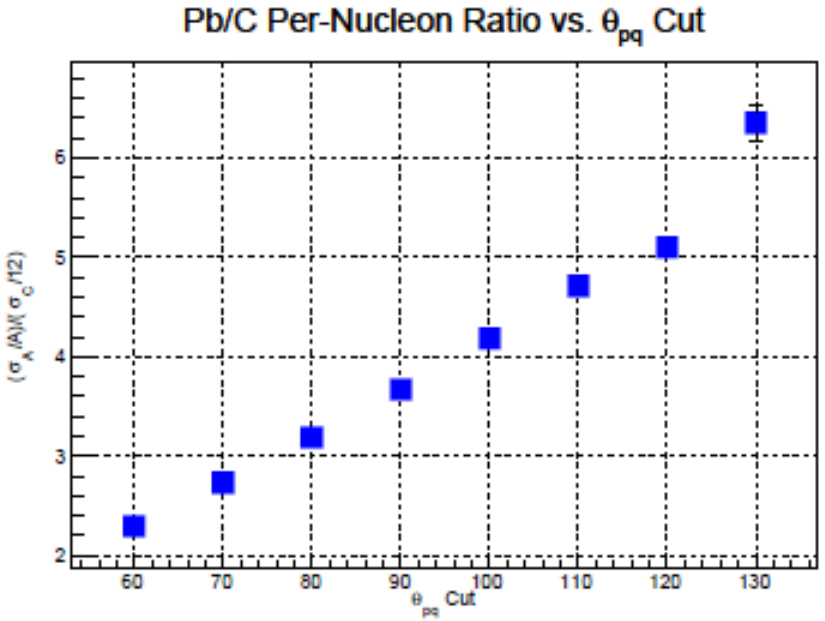





Al/C Per-Nucleon Ratio vs. θpq Cut
(σA/A)/(σC/12)
θpq Cut


Fe/C Per-Nucleon Ratio vs. θpq Cut
(σA/A)/(σC/12)
θpq Cut


Sn/C Per-Nucleon Ratio vs. θpq Cut
(σA/A)/(σC/12)
θpq Cut


Pb/C Per-Nucleon Ratio vs. θpq Cut
(σA/A)/(σC/12)
θpq Cut

Quasi-Elastic e,e'p_{Recoil}

- The momentum of the initial electron is known and the target nucleus is at rest.
- I select events where the electron and a proton are reconstructed.
- Then the missing momentum 4-vector is calculated as follows:

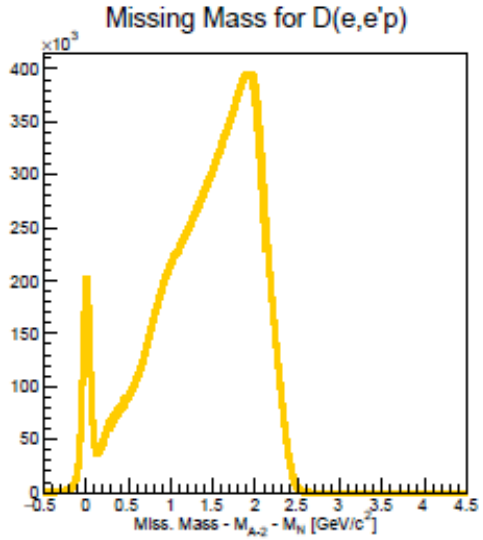
$$mm = ei + Ai - ef - pf$$

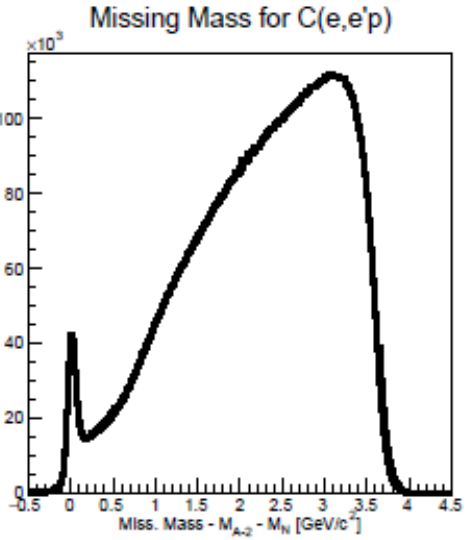
- I then calculate the missing mass and plot the following:

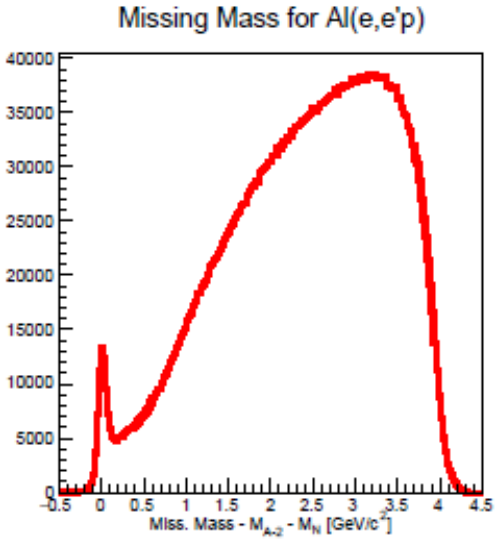
Missing Mass – Mass of A-2 nucleus – Mass of Nucleon

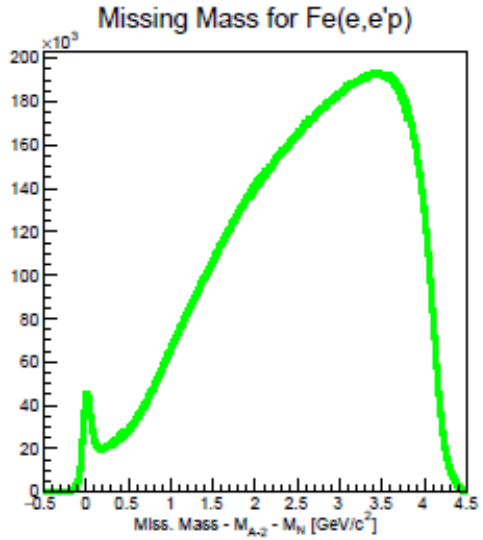
*Note that Mass of A-2 + Mass of Nucleon ≈ Mass of A-1

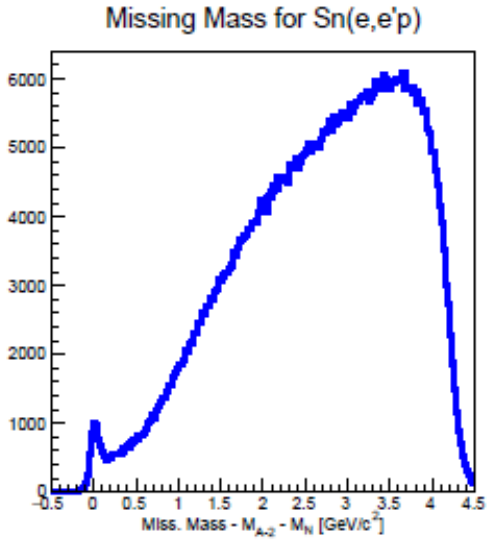
Distributions for all e,e'p Events

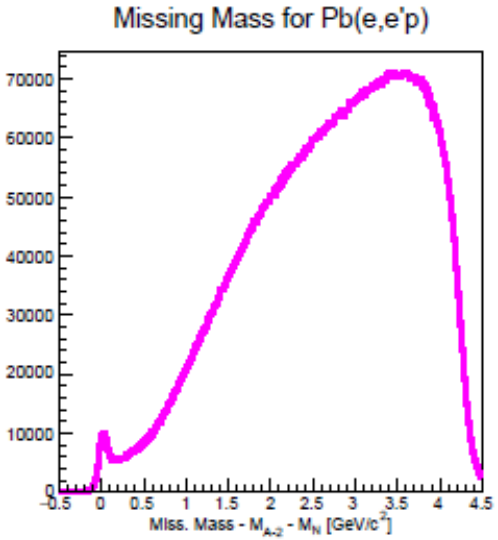




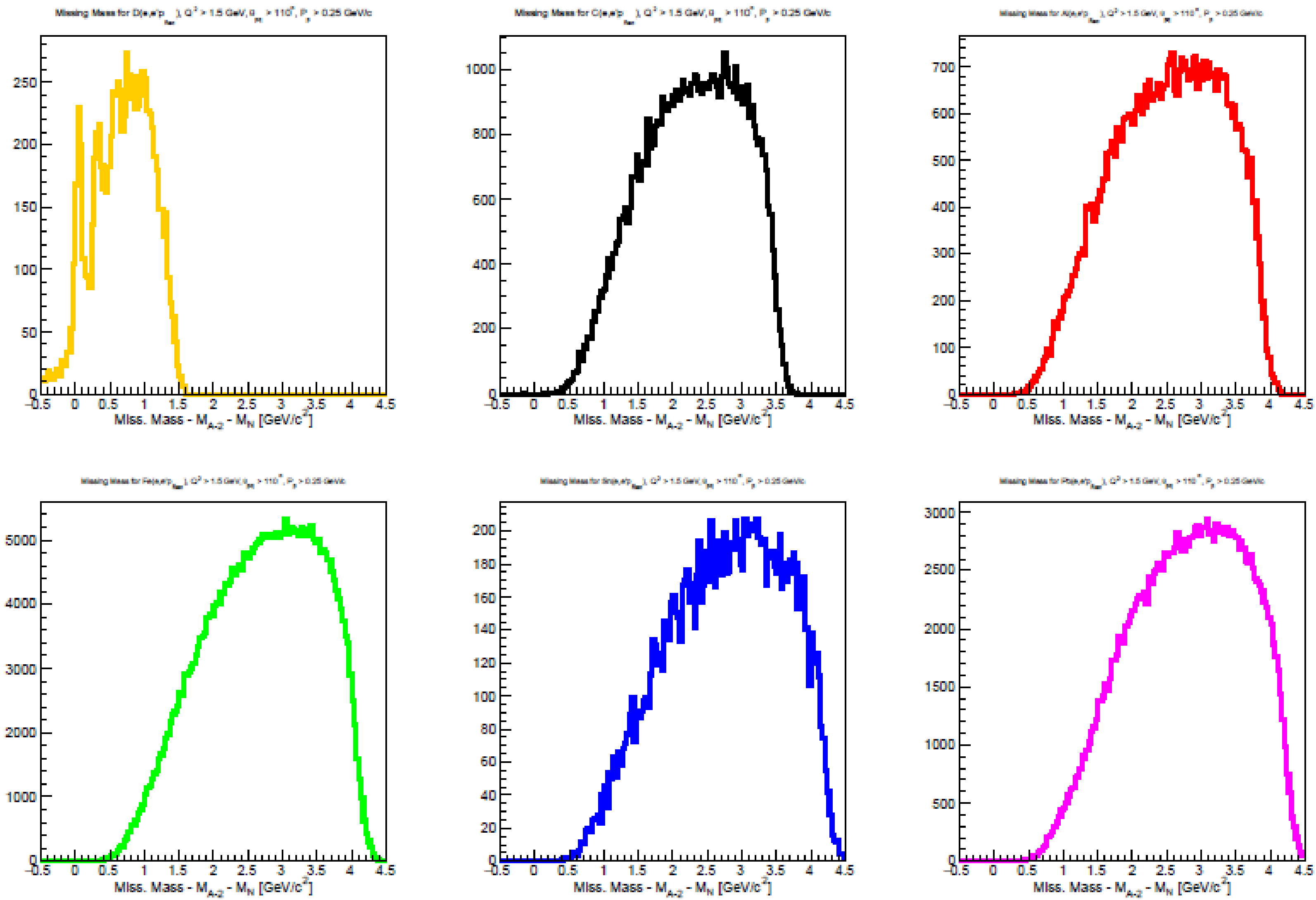








Distributions for e,e'p_{Recoil} Events



What are We Seeing Here?

- In the first plot, we see a nice quasi-elastic peak. These are probably events where the detected proton is the struck nucleon. So, the recoiling system (whether it's 2BB, 3BB, etc…) will not have much relative motion.
- In the second plot, however, we are looking at recoiling protons. So, in the case of quasi-elastic scattering, the detected proton is not the leading (struck) nucleon. In this case, we at least have 3BB (except for deuterium). The leading nucleon will have a large motion relative to the A-2 system; so, the missing mass will be a lot larger than the sum of the mass of the nucleon + A-2 nucleus.

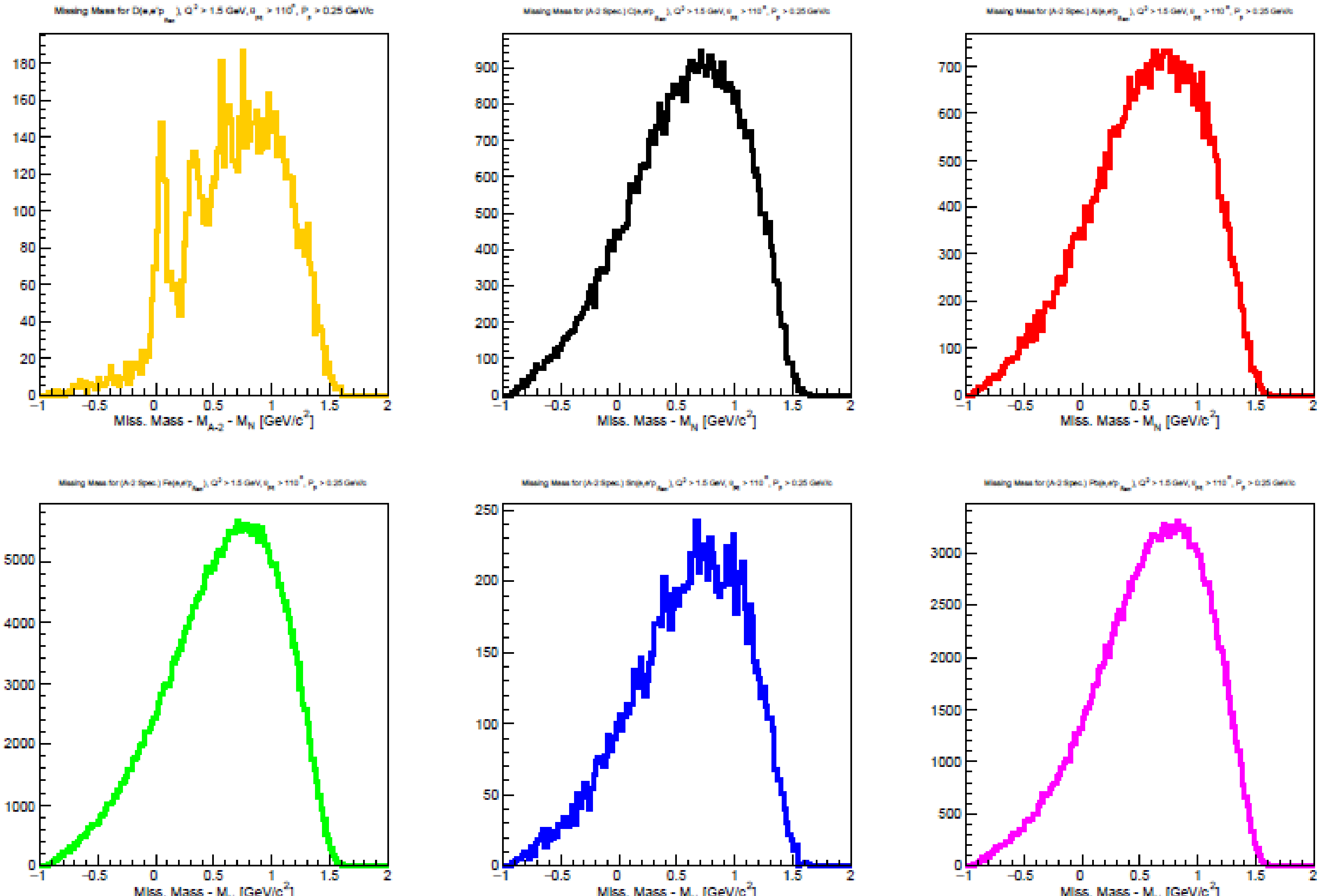
One Other Thing to Try

- We can calculate the missing momentum 4-vector assuming the A-2 is just a spectator. Then we just have an nucleon-nucleon pair initially. But we have to assume it's at rest. So, we can calculate the missing momentum as follows:

$$mm = ei + Di - ef - pf$$

- Here 'Di' is a stationary pair having the deuteron mass.

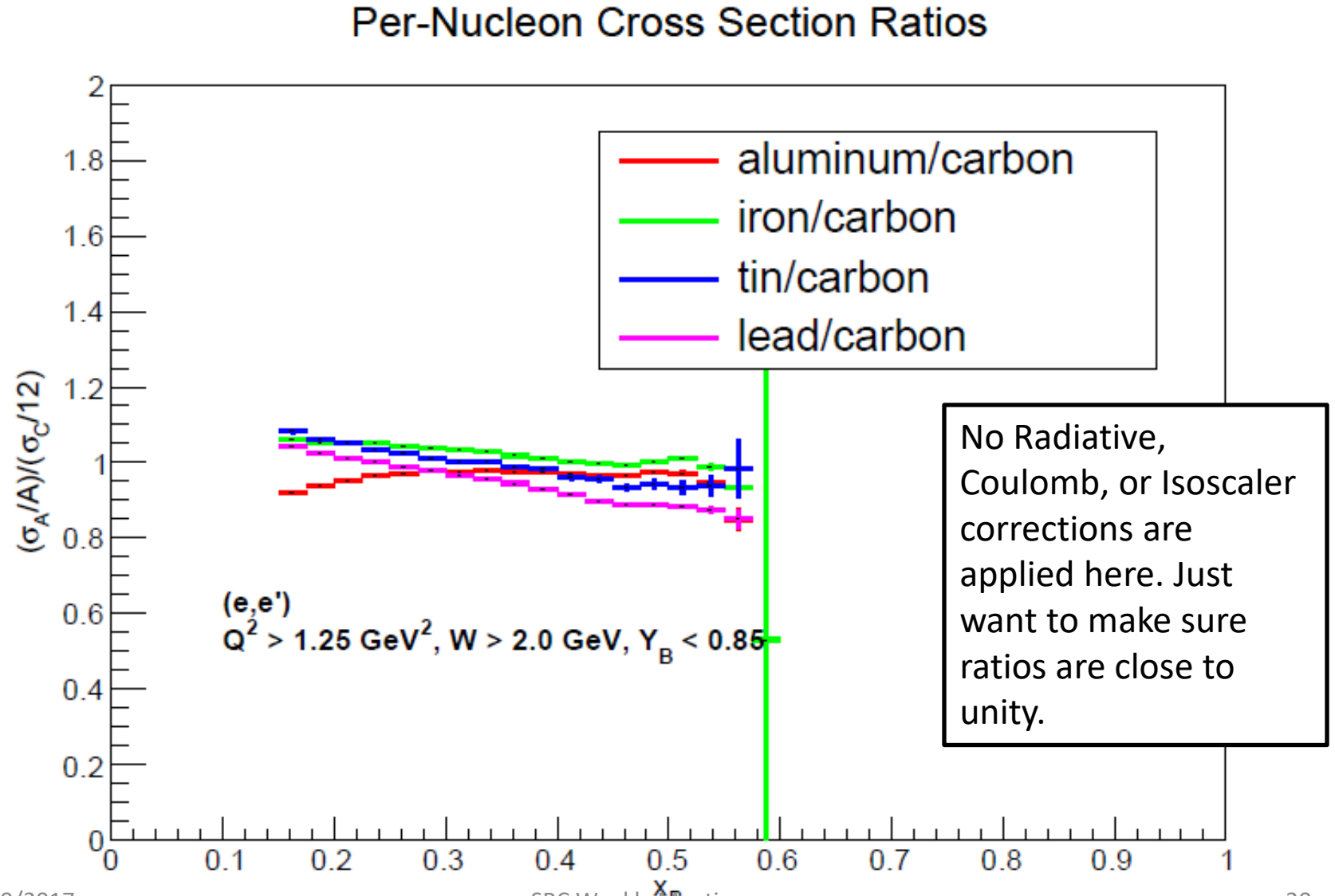
Distributions for e,e'p_{Recoil} Events

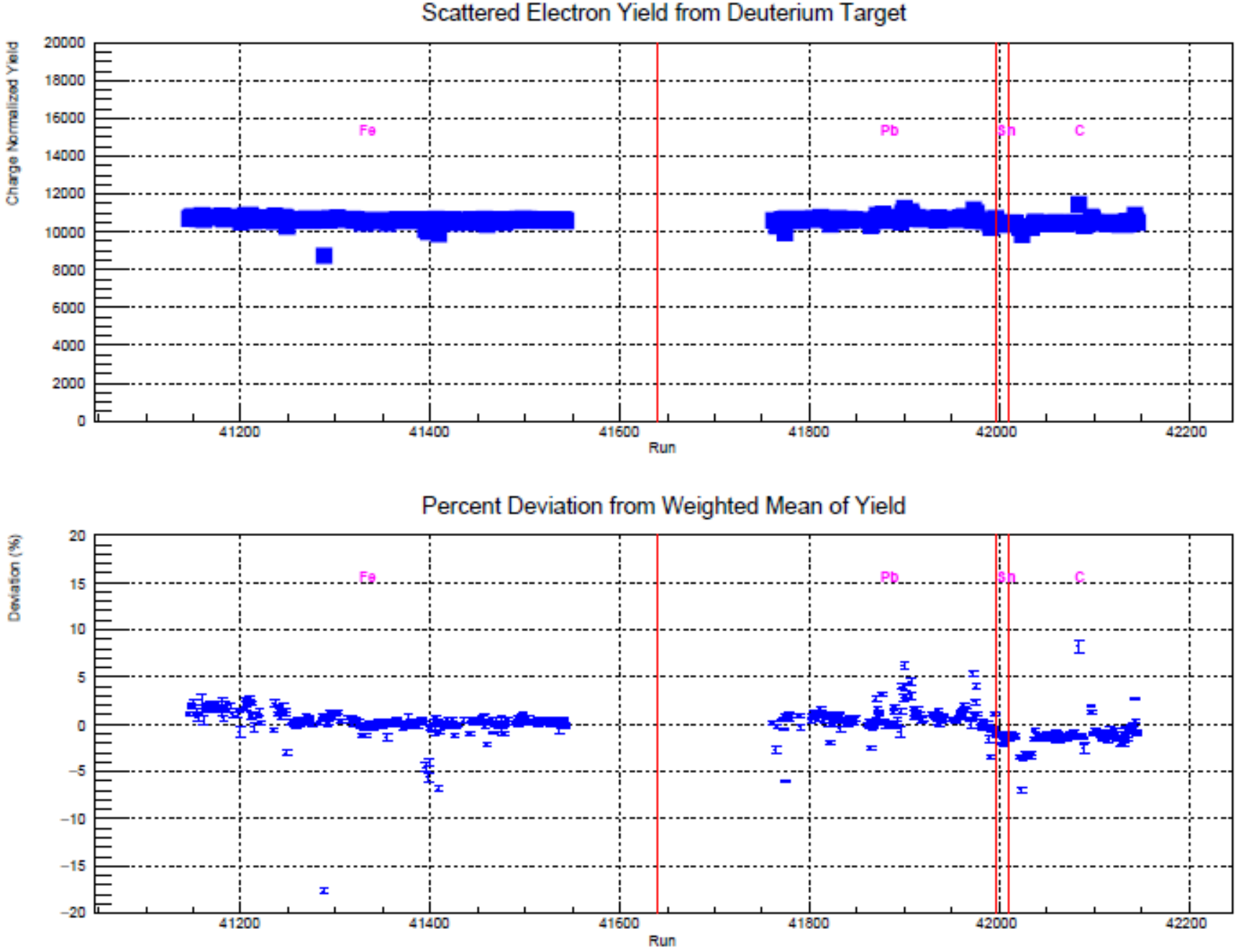


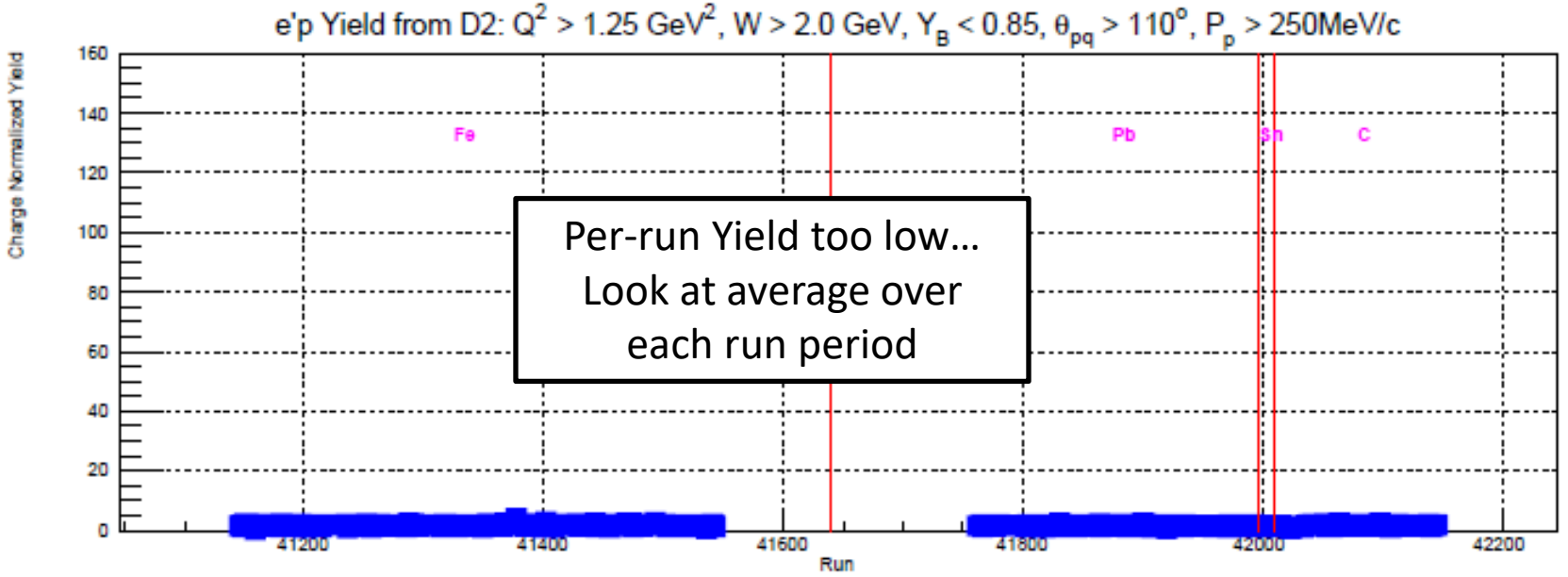
Checking the Yield Normalization and Stability

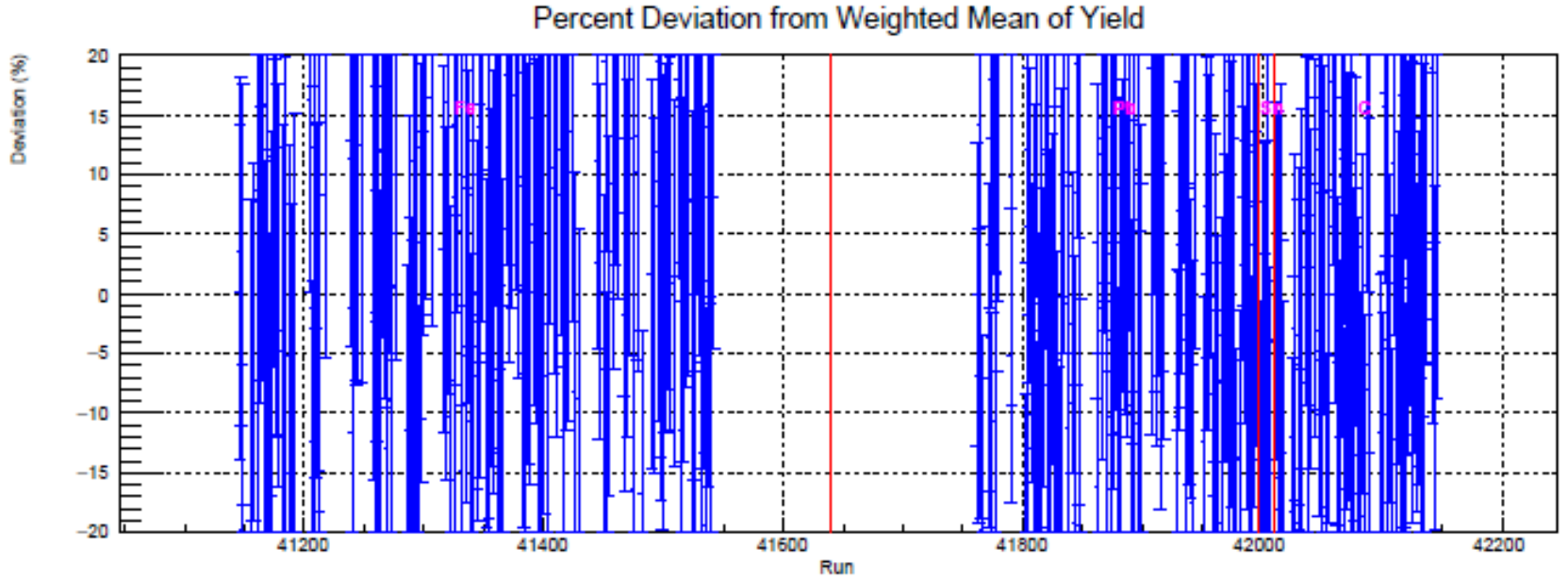
- In order to determine if I'm converting from raw yield to normalized yield correctly, I perform several checks.
  1. I look at the ratio of the solid targets to carbon for (e,e') DIS events. The ratio should be close to unity.
  2. I look at the stability of the normalized yield vs. run number for the deuterium and solid targets.

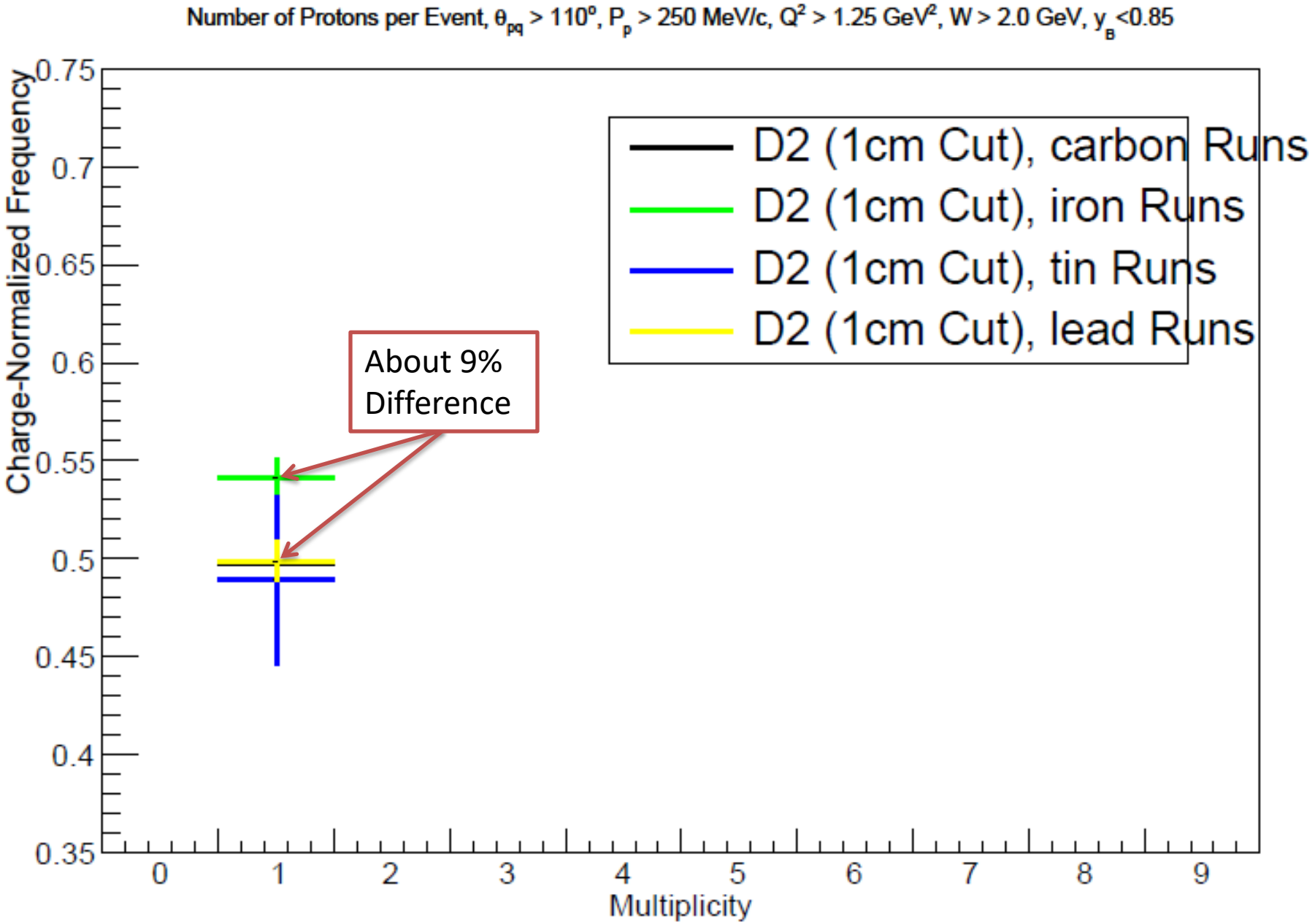
Inclusive (e,e’) DIS Ratios

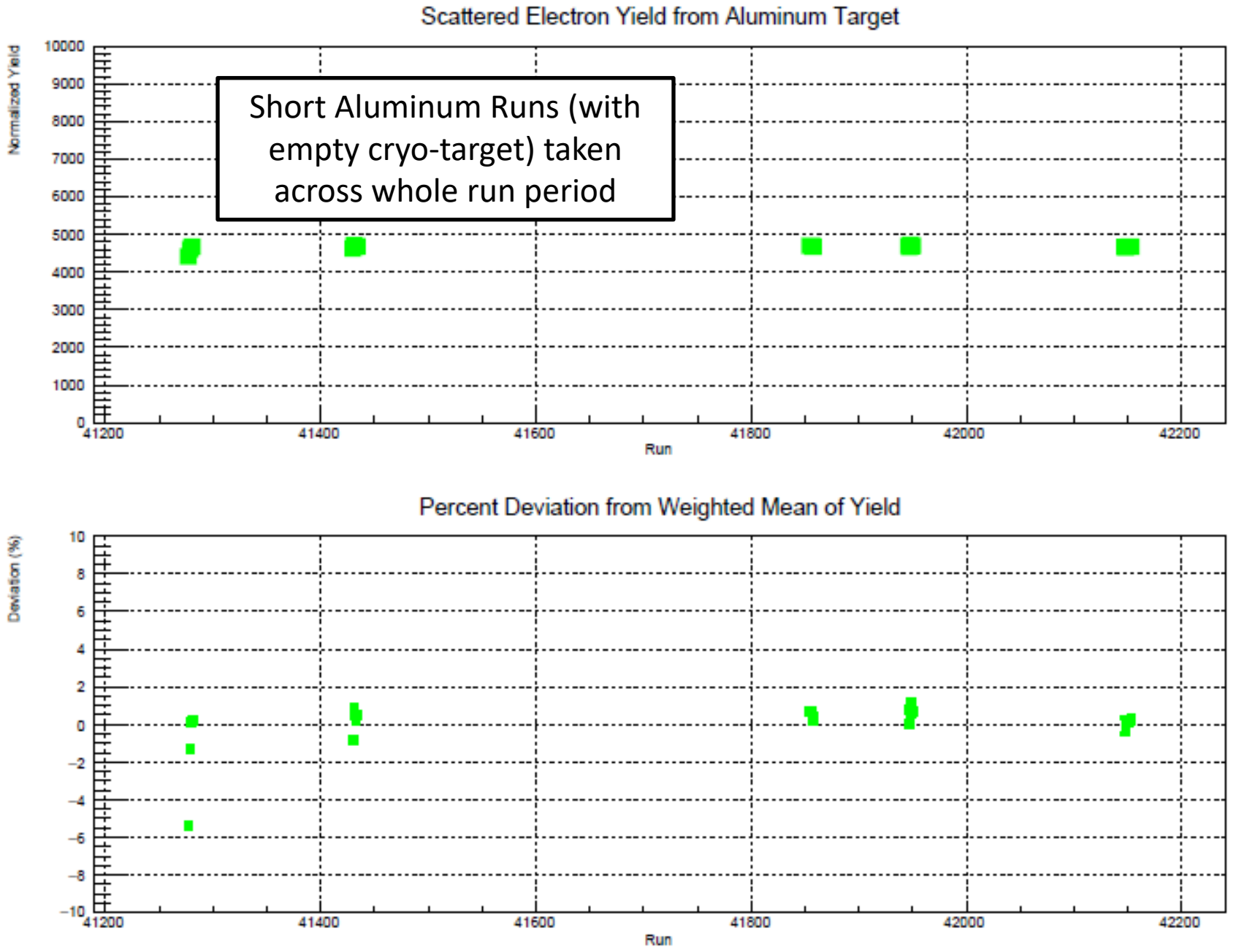


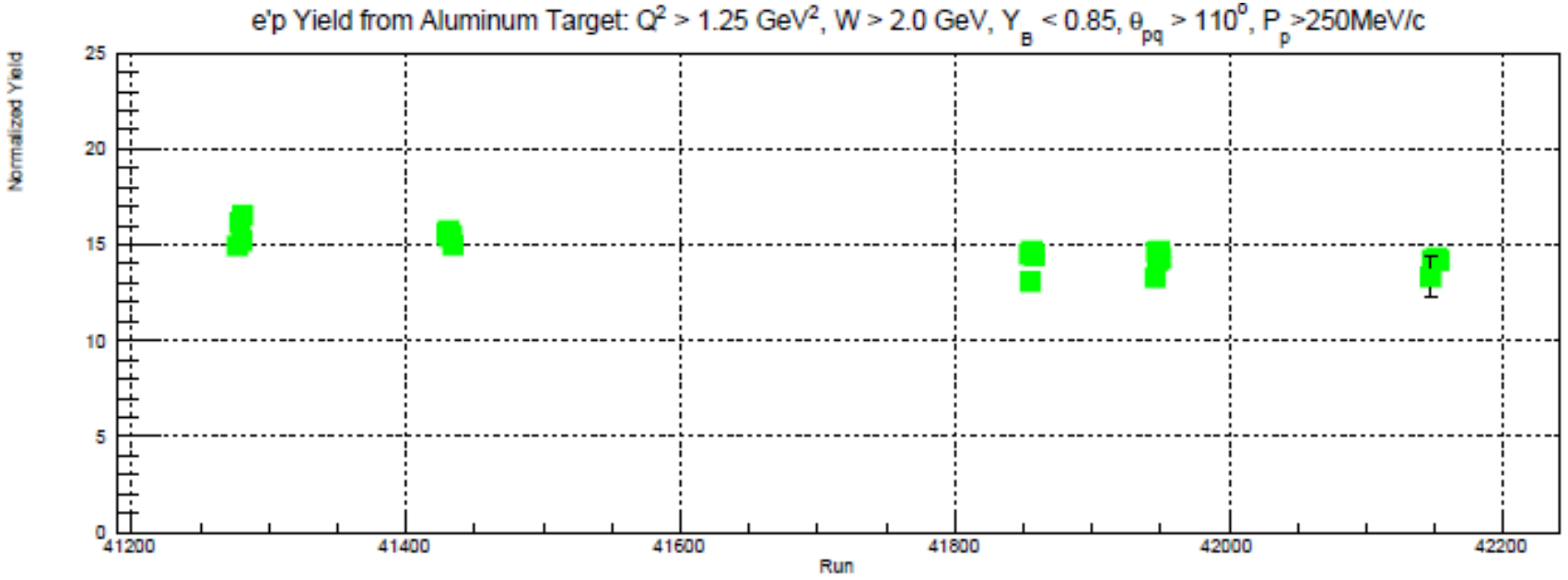

Scattered Electron Yield from Deuterium Target
Charge Normalized Yield
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Fe
Pb
Sn
C
41200
41400
41600
41800
42000
42200
Run
Percent Deviation from Weighted Mean of Yield
Deviation (%)
20
15
10
5
0
−5
−10
−15
−20
Fe
Pb
Sn
C
41200
41400
41600
41800
42000
42200
Run

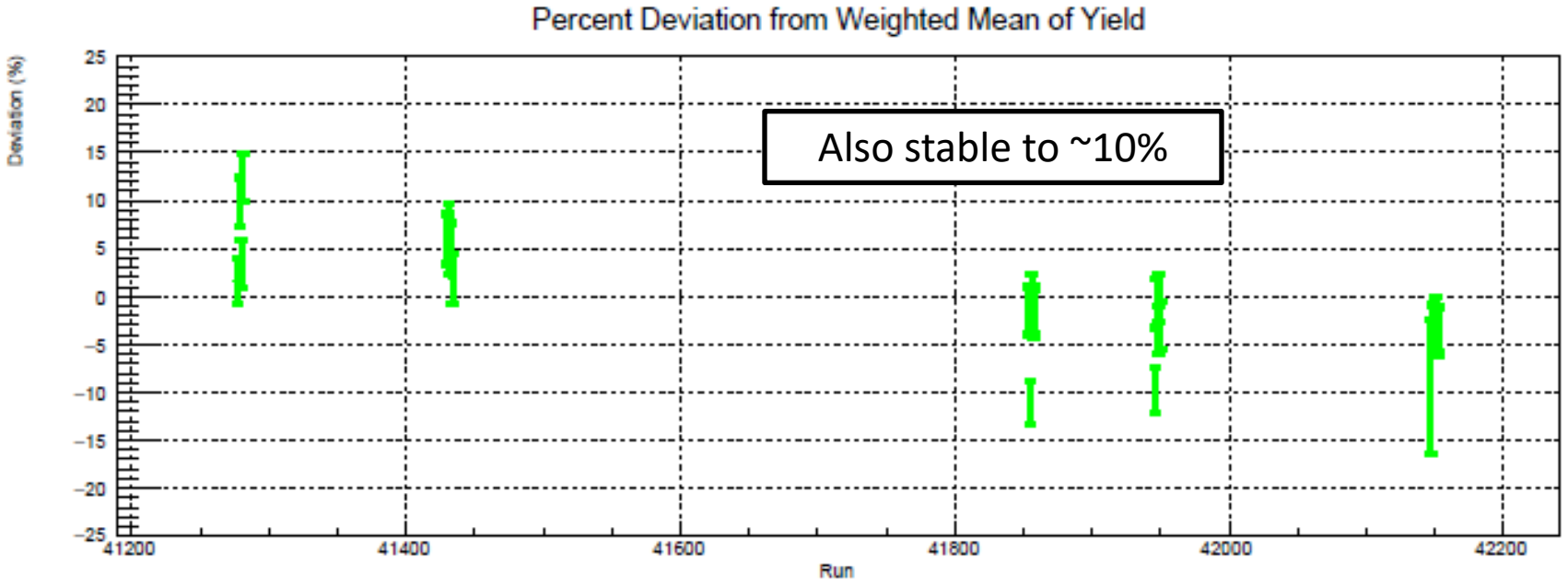

e'p Yield from D2: $Q^2 > 1.25$ GeV^2, $W > 2.0$ GeV, $Y_B < 0.85$, $\theta_{pq} > 110^\circ$, $P_p > 250$MeV/c
Charge Normalized Yield
Fe
Pb
Sn
C
Per-run Yield too low…
Look at average over
each run period
Run


Percent Deviation from Weighted Mean of Yield
Deviation (%)
Run


Number of Protons per Event, $\theta_{pq} > 110^{o}$, $P_p > 250$ MeV/c, $Q^2 > 1.25$ GeV^2, $W > 2.0$ GeV, $y_B < 0.85$
Charge-Normalized Frequency
0.75
0.7
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0
1
2
3
4
5
6
7
8
9
Multiplicity
D2 (1cm Cut), carbon Runs
D2 (1cm Cut), iron Runs
D2 (1cm Cut), tin Runs
D2 (1cm Cut), lead Runs
About 9% Difference


Scattered Electron Yield from Aluminum Target
Normalized Yield
Short Aluminum Runs (with empty cryo-target) taken across whole run period
Run
Percent Deviation from Weighted Mean of Yield
Deviation (%)
Run


e'p Yield from Aluminum Target: $Q^2 > 1.25$ GeV^2, W > 2.0 GeV, $Y_B < 0.85$, $\theta_{pq} > 110^o$, P_p >250MeV/c
Normalized Yield
25
20
15
10
5
0
41200
41400
41600
41800
42000
42200
Run


Percent Deviation from Weighted Mean of Yield
Deviation (%)
25
20
15
10
5
0
−5
−10
−15
−20
−25
41200
41400
41600
41800
42000
42200
Run
Also stable to ~10%