HMS H(e,e'p) Elastics:

Update on
Chi2 Minimization Procedure

Recall:

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 Uncorrected Central Momenta (Obtained from EPICS)
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Run Summary (HMS ELECTRONS)
#! kin_group[s,0]/    Run[i,1]/        nmr_true[f,2]/      nmr_P[f,3]/     hms_Angle[f,4]/   shms_P[f,5]/    shms_Angle[f,6]/   beam_e[f,7]/   x_BPM[f,8]/    y_BPM[f,9]/    hmsX_MisPoint[f,10]/   hmsY_MisPoint
*   g1_coin          0                0.988186            3.6096          27.502            3.609           27.619             6.42765        0.04499        0.005489       0.091246               0.170270
*   g2_coin          0                0.988187            3.6096          27.511            3.609           27.62              6.42765        0.04465        0.005356       0.091228               0.170358
*   g3_coin          0                0.510311            1.864           50.002            5.41            15.38              6.42765        0.044736       0.007145       0.107000               0.324000
*   g4_coin          0                0.583401            2.131           45.109            5.122           17.119             6.42765        0.04453        0.005324       0.093241               0.324000
*   g6_coin          0                0.816369            2.982           39.28             8.505           12.799             10.6005        0.008632       0.005428       0.084342               0.313448
*   g10_coin         1929             0.786085            2.8714          35.0              4.38            22.049             6.42765        0.04431        0.005469       0.083000               0.255000


Deuteron Heep Summary (HMS PROTONS)
#! Run[i,1]/    nmr_true[f,2]/      nmr_P[f,3]/     hms_Angle[f,4]/   shms_P[f,5]/    shms_Angle[f,6]/   beam_e[f,7]/   x_BPM[f,8]/    y_BPM[f,9]/    hmsX_MisPoint[f,10]/   hmsY_MisPoint[f,11]/   shmsX_MisPoint
   3288         0.804333            2.938           37.338            8.7             12.194             10.6005
   3371         0.952715            3.48            33.545            8.7             13.93              10.6005
   3374         0.632393            2.31            42.9              8.7             9.928              10.6005
   3377         0.517404            1.8899          47.605            8.7             8.495              10.6005
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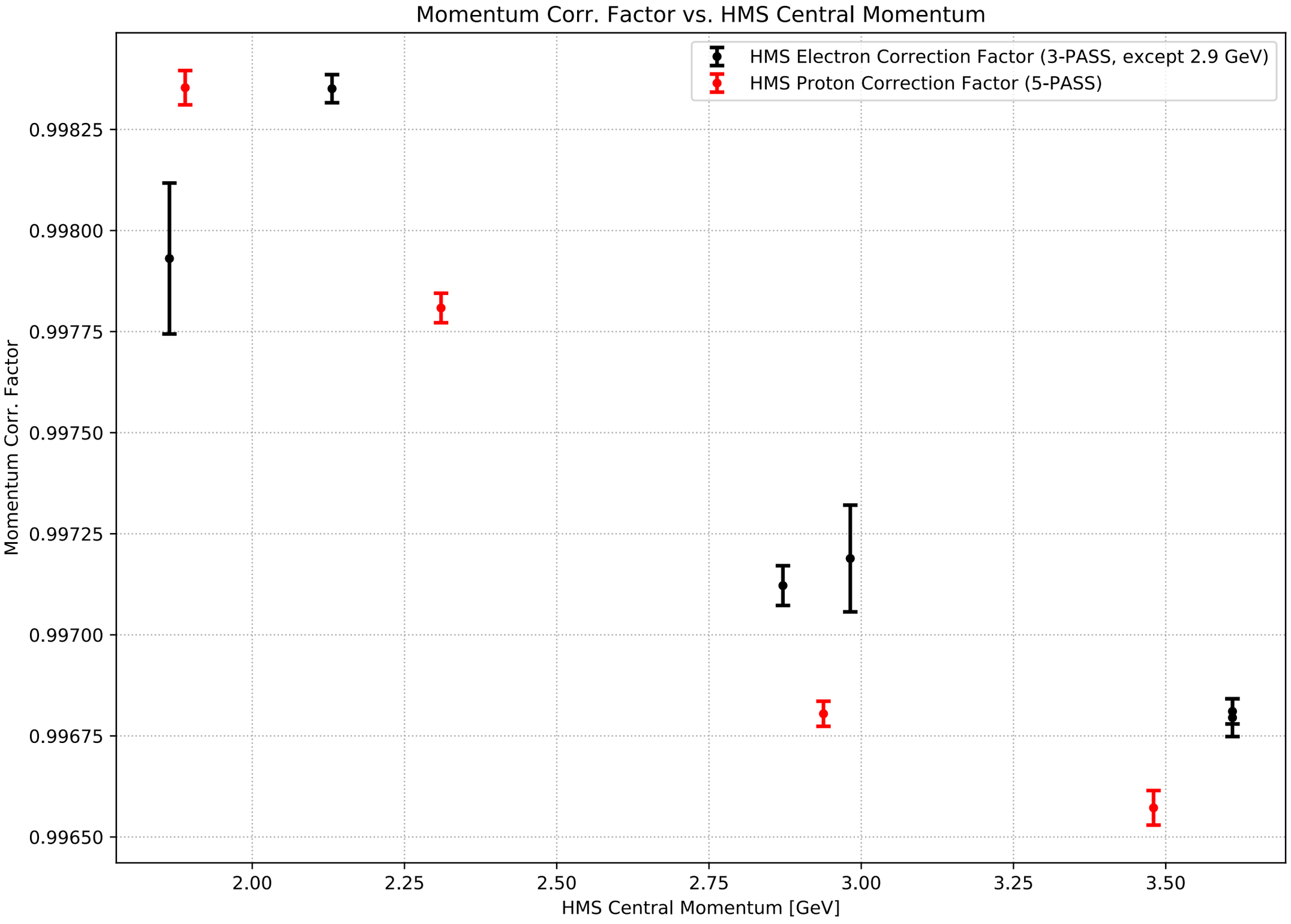
```
#HMS H(e,e'p) Elastics Kinematic File
#Contains data with '+' and '-' polarity
#Main Purpose is to Minimize Chi2 to determine p1,p2,p3
#p1 =  dEb / Eb,  p2 = dP / P,   p3 = dth
#(   beam[GeV], momentum[GeV],  angle[rad]  relative uncertainties  )
#Startng with run 6595 corresponds to LT HMS Heep singles. Some columns still need to be updated
#particle[s,2]/  --> refers to the detected HMS Particle

#! kin_group[i,0]/    Run[i,1]/   particle[s,2]/       nmr_true[f,3]/      nmr_P[f,4]/     hms_Angle[f,5]/   shms_P[f,6]/    shms_Angle[f,7]/   beam_e[f,8]/
   1                 0           e                   0.988186            3.6096          27.502            3.609           27.619             6.42765
   2                 0           e                   0.988187            3.6096          27.511            3.609           27.62              6.42765
   3                 0           e                   0.510311            1.864           50.002            5.41            15.38              6.42765
   4                 0           e                   0.583401            2.131           45.109            5.122           17.119             6.42765
   6                 0           e                   0.816369            2.982           39.28             8.505           12.799             10.6005
   7                 0           e                   1.22593             4.478           28.505            7.001           17.829             10.6005
   10                1929        e                   0.786085            2.8714          35.0              4.38            22.049             6.42765
   -1                3288        p                   0.804333            2.938           37.338            8.7             12.194             10.6005
   -1                3371        p                   0.952715            3.48            33.545            8.7             13.93              10.6005
   -1                3374        p                   0.632393            2.31            42.9              8.7             9.928              10.6005
   -1                3377        p                   0.517404            1.8899          47.605            8.7             8.495              10.6005
   -1                6595        e                   0.0                 3.007           21.12             0.0             0.0                3.83350
   -1                6601        e                   0.0                 2.834           23.980            0.0             0.0                3.83350
   -1                6602        e                   0.0                 2.713           25.970            0.0             0.0                3.83350
   -1                6609        e                   0.0                 2.583           29.185            0.0             0.0                3.83350
   -1                6611        e                   0.0                 2.478           29.985            0.0             0.0                3.83350
   -1                6634        e                   0.0                 2.026           38.60             0.0             0.0                3.8335
   -1                6871        e                   0.0                 4.371           12.710            0.0             0.0                4.93090
   -1                6875        e                   0.0                 4.184           15.00             0.0             0.0                4.93090
   -1                6876        e                   0.0                 3.923           18.02             0.0             0.0                4.93090
   -1                6879        e                   0.0                 2.583           34.23             0.0             0.0                4.93090
   -1                6881        e                   0.0                 3.124           27.17             0.0             0.0                4.93090
```

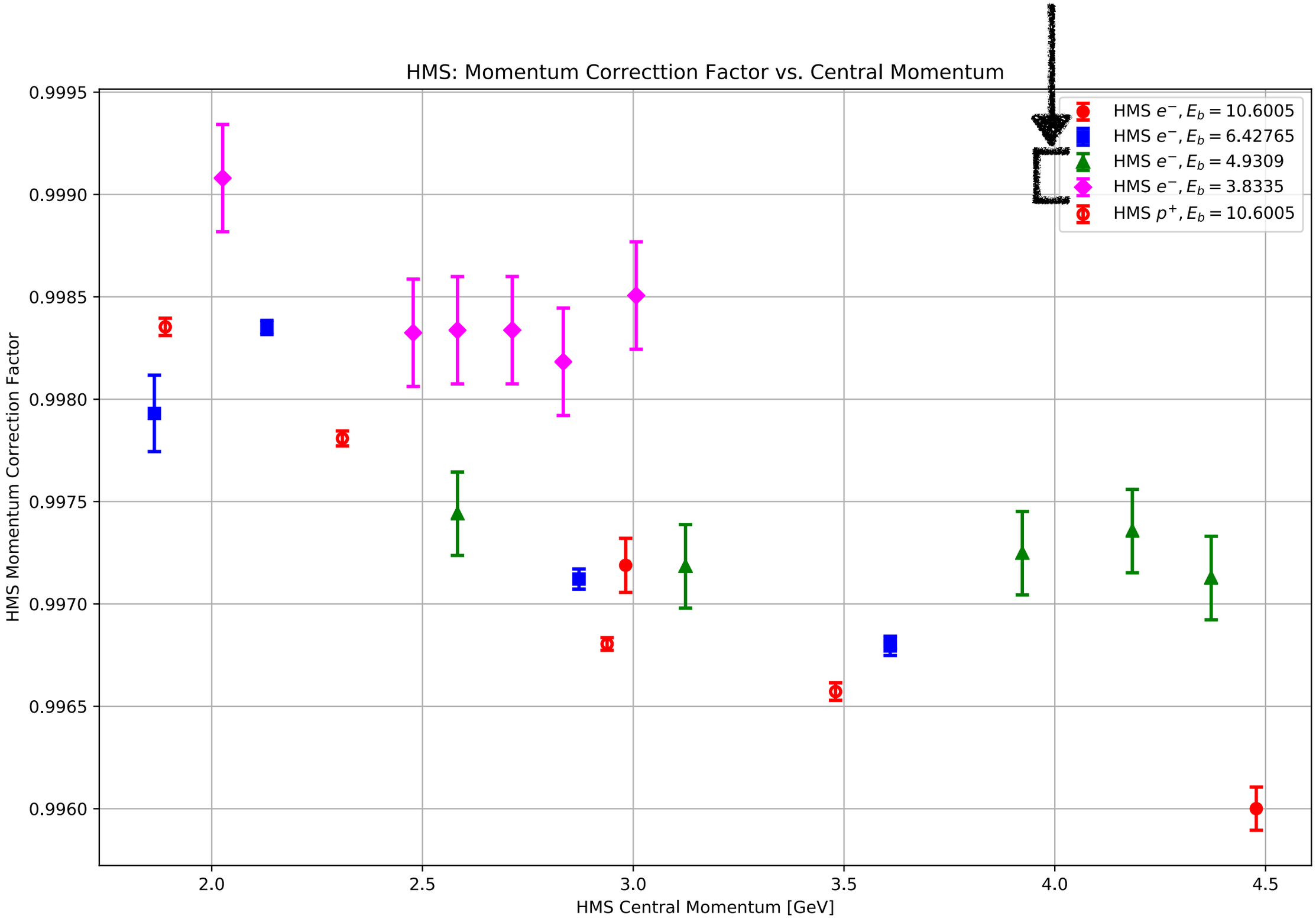
Added Kaon LT H(e,e'p) Elastics from Mark

Recall:


Momentum Corr. Factor vs. HMS Central Momentum
HMS Electron Correction Factor (3-PASS, except 2.9 GeV)
HMS Proton Correction Factor (5-PASS)
Momentum Corr. Factor
0.99825
0.99800
0.99775
0.99750
0.99725
0.99700
0.99675
0.99650
2.00
2.25
2.50
2.75
3.00
3.25
3.50
HMS Central Momentum [GeV]

Recall:

Added Kaon LT H(e,e'p) data

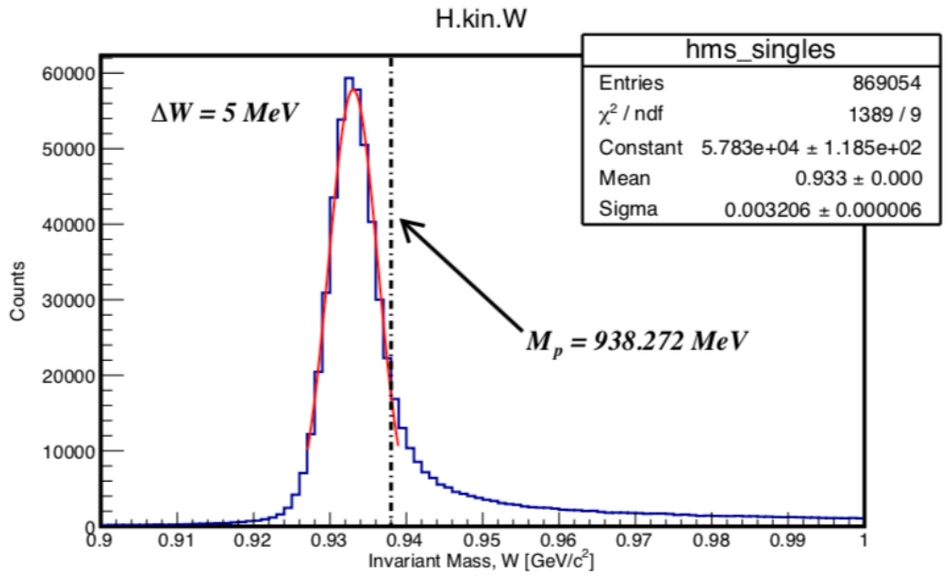


Recall: Variations in W

Elastic Hydrogen Scattering: $W^2 \rightarrow M_p^2$

In general e-N scattering: $W^2 \rightarrow W^2(E, E', \theta_e)$

Variations in the elastic W-peak come from:



$$\frac{\delta W}{\delta E_b} = \frac{E'}{E_b}$$ **Variations with Beam Energy**

$$\frac{\delta W}{\delta E'} = -\frac{E_b}{E'}$$ **Variations with scattered electron Momentum**

$$\frac{\delta W}{\delta \theta_e} = -\frac{2E_b E'}{M_p} \sin\frac{\theta_e}{2} \cos\frac{\theta_e}{2}$$ **Variations with electron scattering Angle**

Variations in Proton Momentum

H(e,e'p) Elastics in HMS (protons): Cannot use W peak. What is the solution?

—> Use Proton Momentum Formula (Assuming H(e,e'p))

$$P_{calc}(E_b, \theta_p) = \frac{2M_p E_b (E_b + M_p)\cos(\theta_p)}{M_p^2 + 2M_p E_b + E_b^2 \sin^2(\theta_p)}$$

$$\boxed{P_{fr}(E_b, \theta_p, P_{meas}) \equiv \frac{P_{calc}(E_b, \theta_p) - P_{meas}}{P_{meas}}}$$ ***"Fractional Momentum"***

Taking Full Derivatives . . .

Electron:

$$dW_{predicted} = \frac{\partial W}{\partial E_b}\delta E_b + \frac{\partial W}{\partial P^{(e)}}\delta P^{(e)} + \frac{\partial W}{\partial \theta^{(e)}}\delta\theta^{(e)}$$

$$dW_{meas} = W_{simc} - W_{data}$$

$$\sigma_{dW_{meas}} = \sqrt{\sigma^2_{W_{simc}} + \sigma^2_{W_{data}}}$$

"Obtained from Gaussian Fit"

Proton:

$$dP_{fr,predicted} = \frac{\partial P_{fr}}{\partial E_b}\delta E_b + \frac{\partial P_{fr}}{\partial P^{(p)}}\delta P^{(p)} + \frac{\partial P_{fr}}{\partial \theta^{(p)}}\delta\theta^{(p)}$$

$$dP_{fr,meas} = P_{fr,simc} - P_{fr,data}$$

$$\sigma_{dP_{fr,meas}} = \sqrt{\sigma^2_{P_{fr,simc}} + \sigma^2_{P_{fr,data}}}$$

"Obtained from Gaussian Fit"

Chi2 Minimization Procedure

Define parameters: $p_1 = \dfrac{\delta E_b}{E_b}, p_2 = \dfrac{\delta P}{P}, p_3 = \delta\theta$

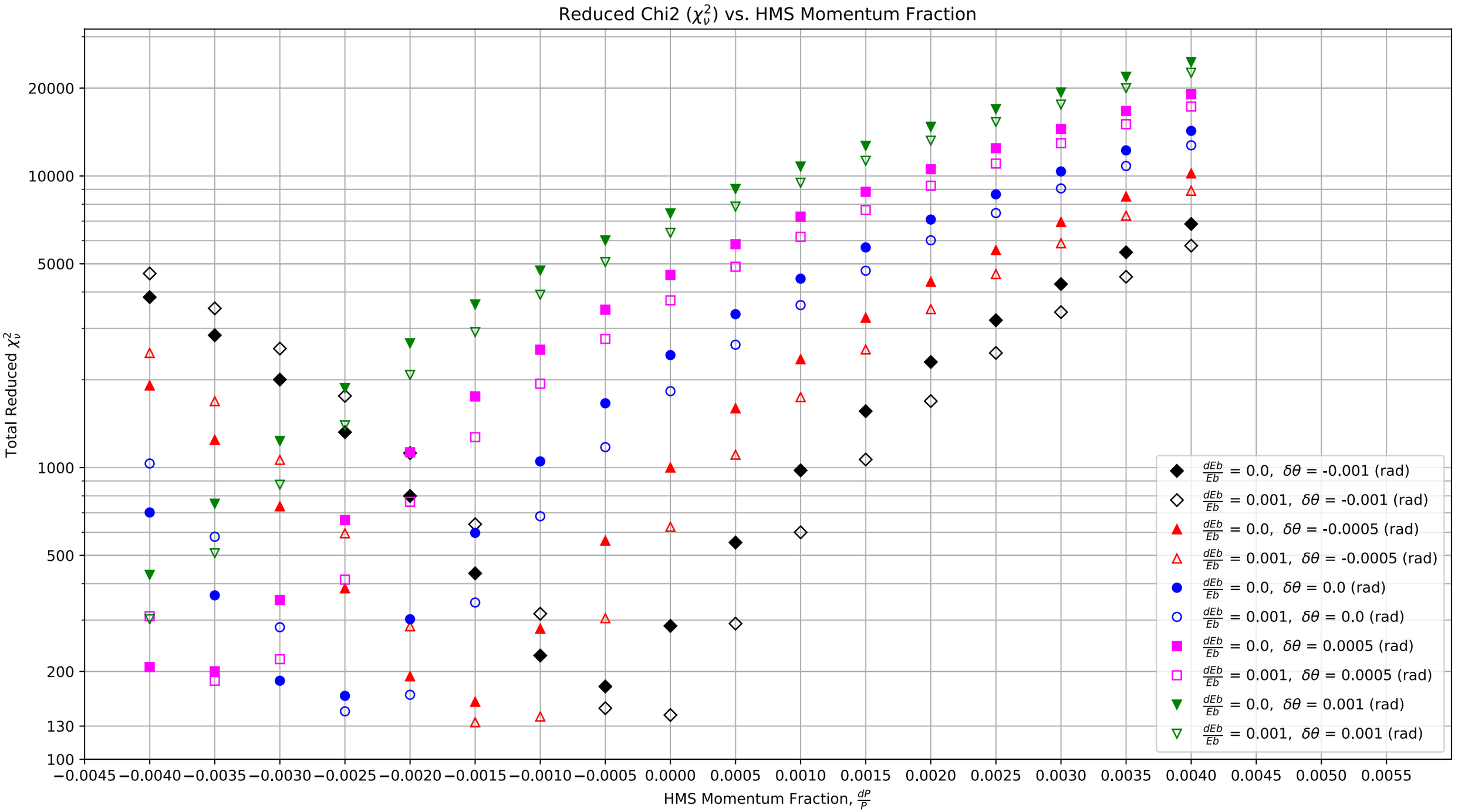
$\delta W_{predicted} \rightarrow \delta W(E_b, P^{(e)}, \theta^{(e)}; p1, p2, p3)$

$\delta P_{fr,predicted} \rightarrow \delta P_{fr}(E_b, P^{(p)}, \theta^{(p)}; p1, p2, p3)$

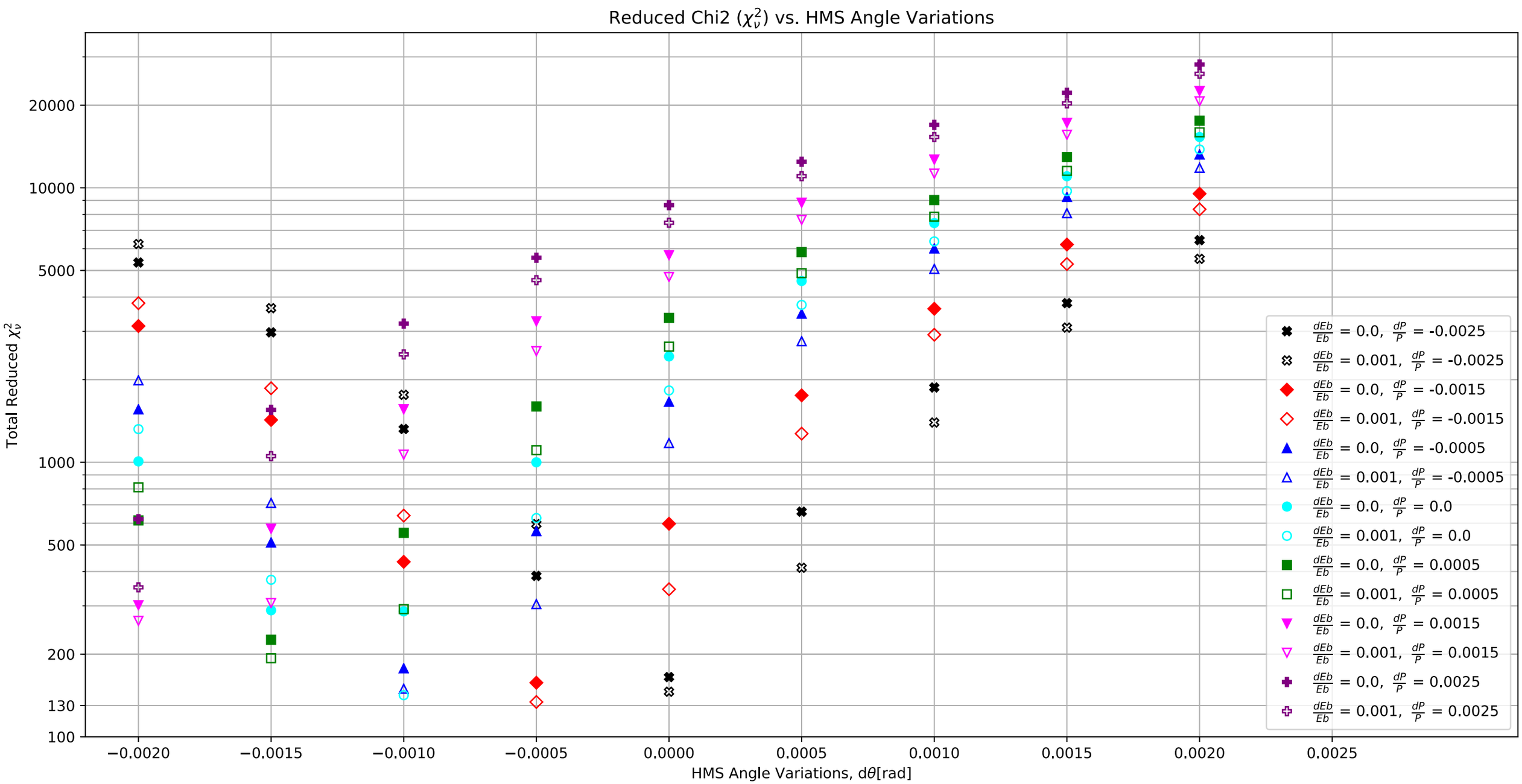
$$\chi^2_{e^-} \equiv \sum_{e^- \text{ runs}} \left[\frac{\delta W_{meas} - \delta W_{pred}}{\sigma_{\delta W_{meas}}} \right]^2, \chi^2_{p^+} \equiv \sum_{p^+ \text{ runs}} \left[\frac{\delta P_{fr,meas} - \delta P_{fr,pred}}{\sigma_{\delta P_{fr,meas}}} \right]^2$$

Problem: Find configuration of parameters that minimizes Chi2

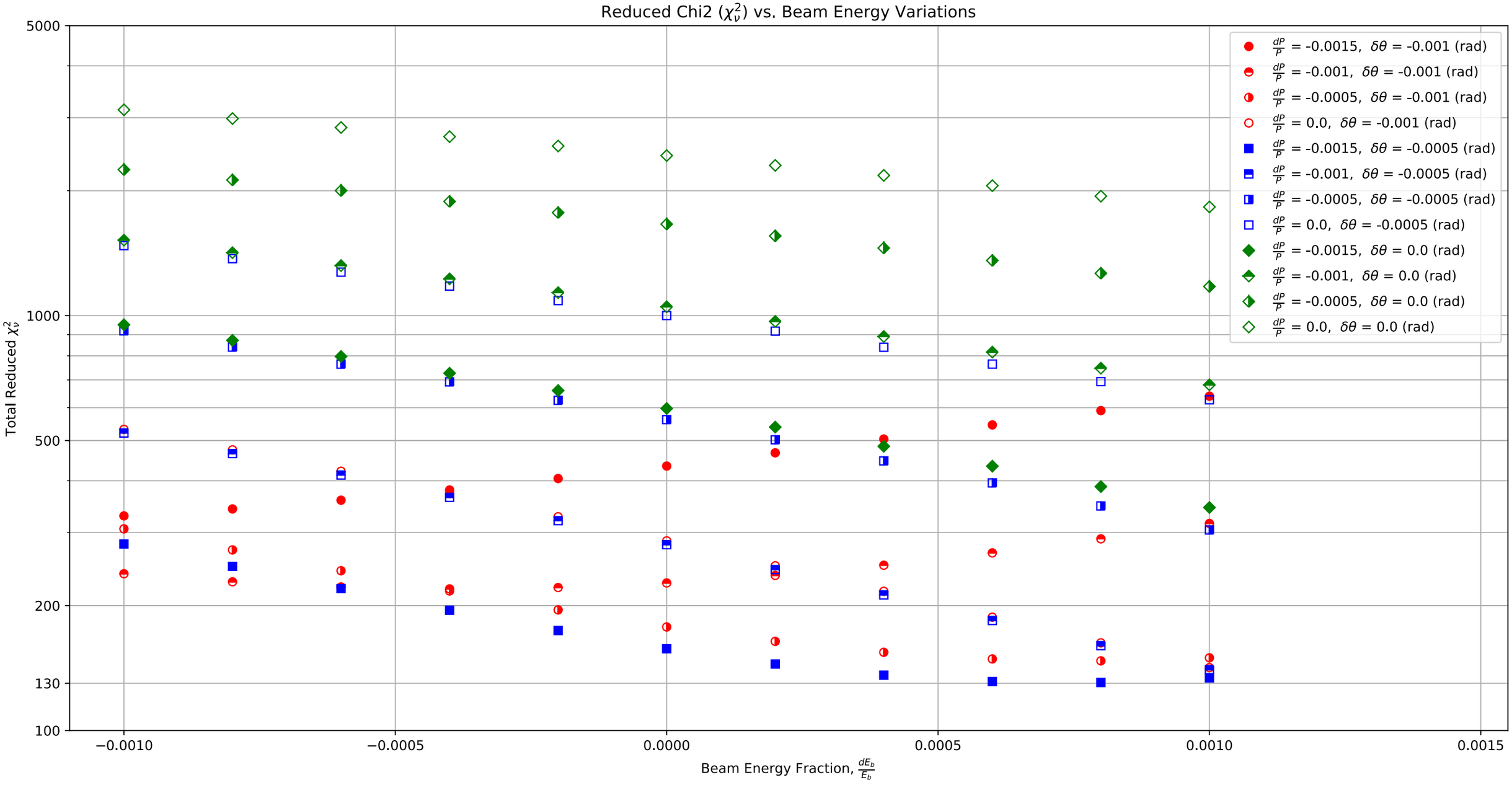
Total Reduced Chi2 vs. dP / P



Total Reduced Chi2 vs. dTheta

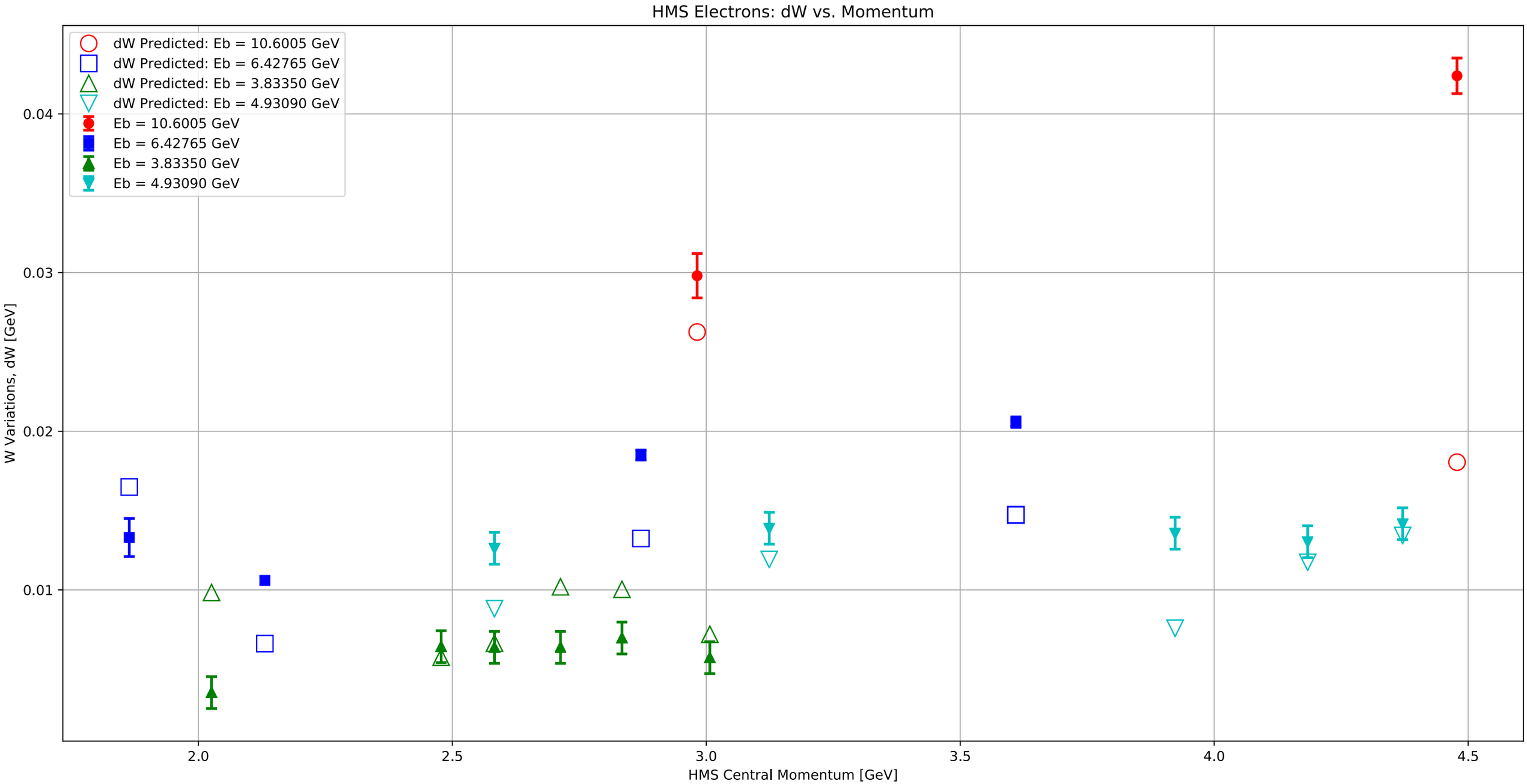


Total Reduced Chi2 vs. dEb / Eb

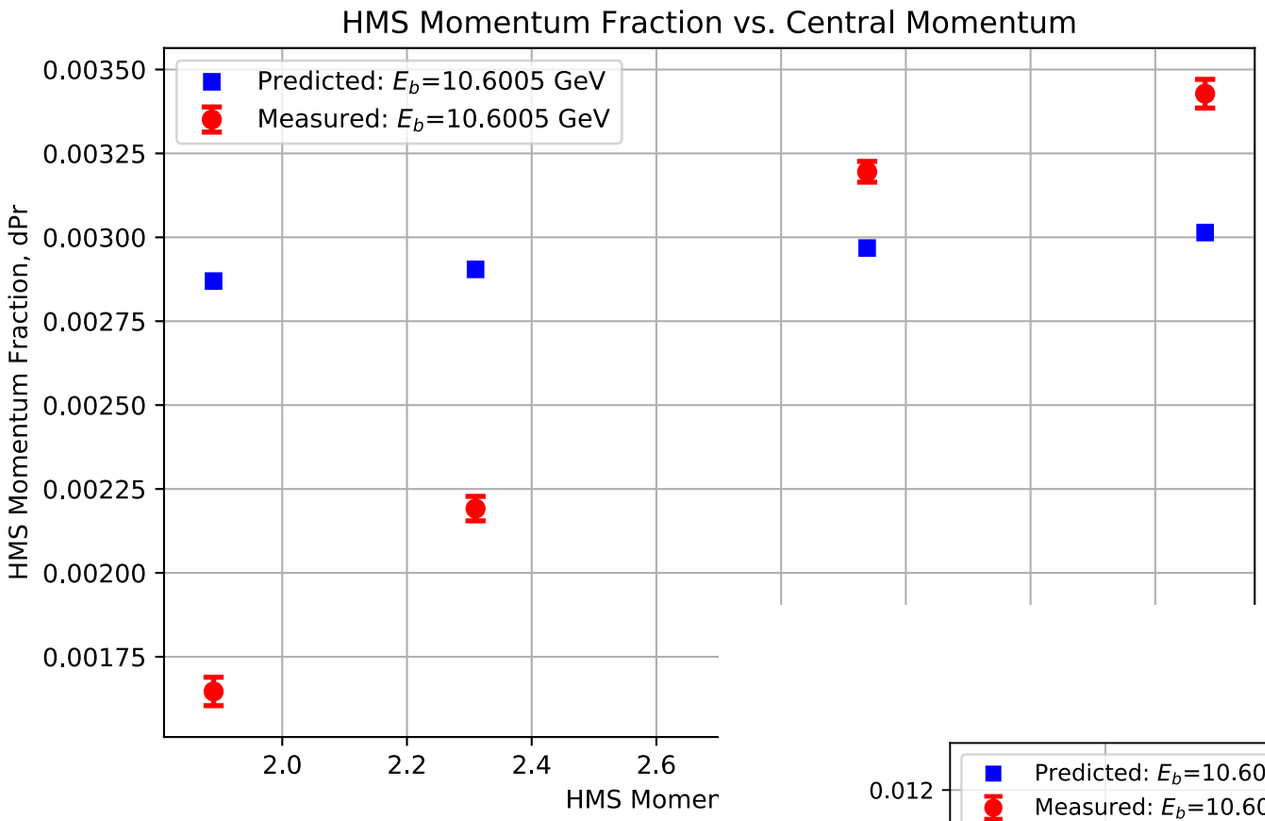


dW vs. HMS Central Momentum

$$\boxed{\frac{dE_b}{E_b} = 0.0008, \frac{dP}{P} = -0.0015, \delta\theta = -0.0005 \text{ rad}}$$ ← **Min. Chi2 Param.**



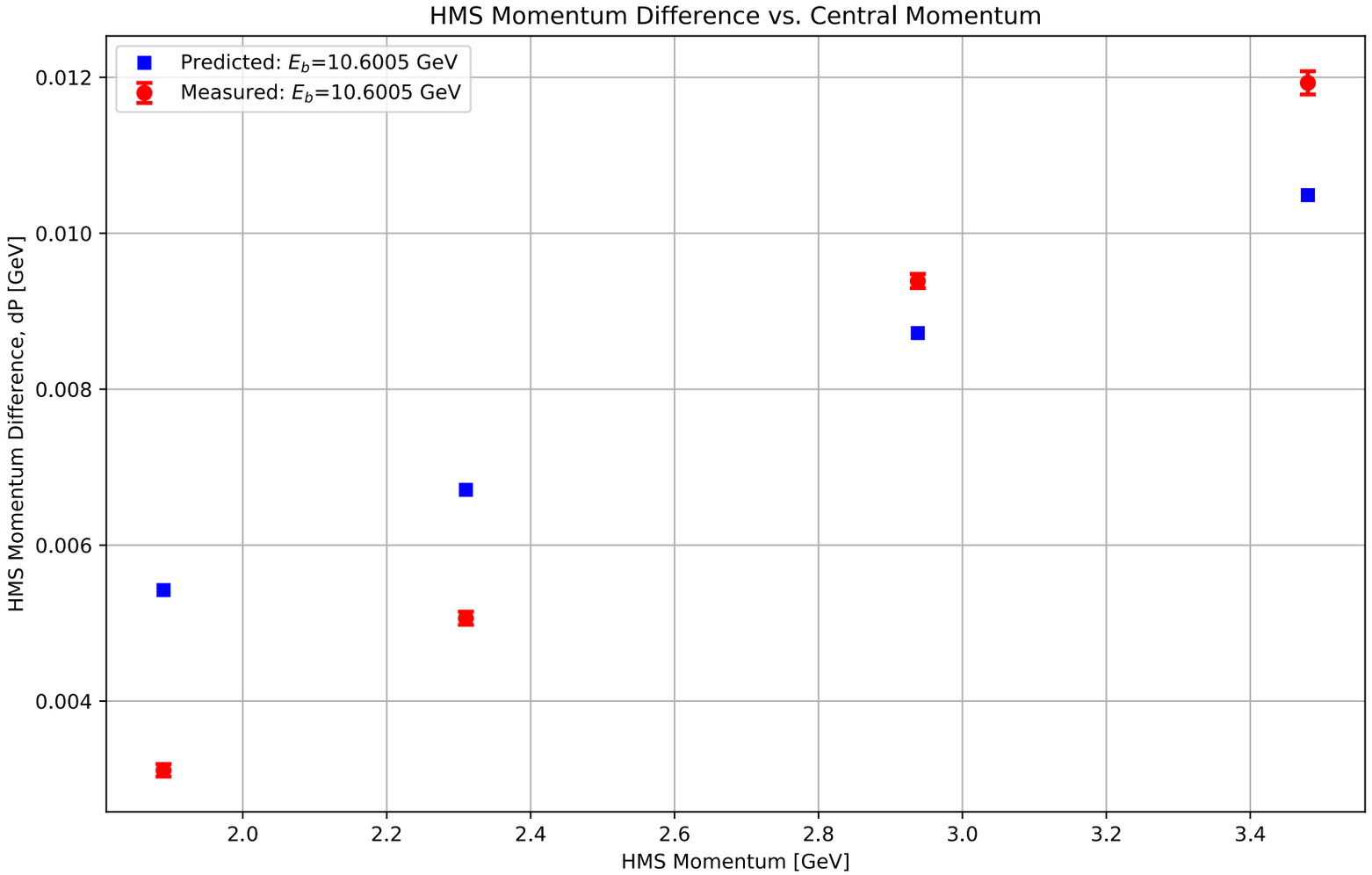
dP vs. HMS Central Momentum



$$\frac{dE_b}{E_b} = 0.0008, \frac{dP}{P} = -0.0015, \delta\theta = -0.0005 \text{ rad}$$

Min. Chi2 Param.

Converted fraction to Momentum Units



Questions?