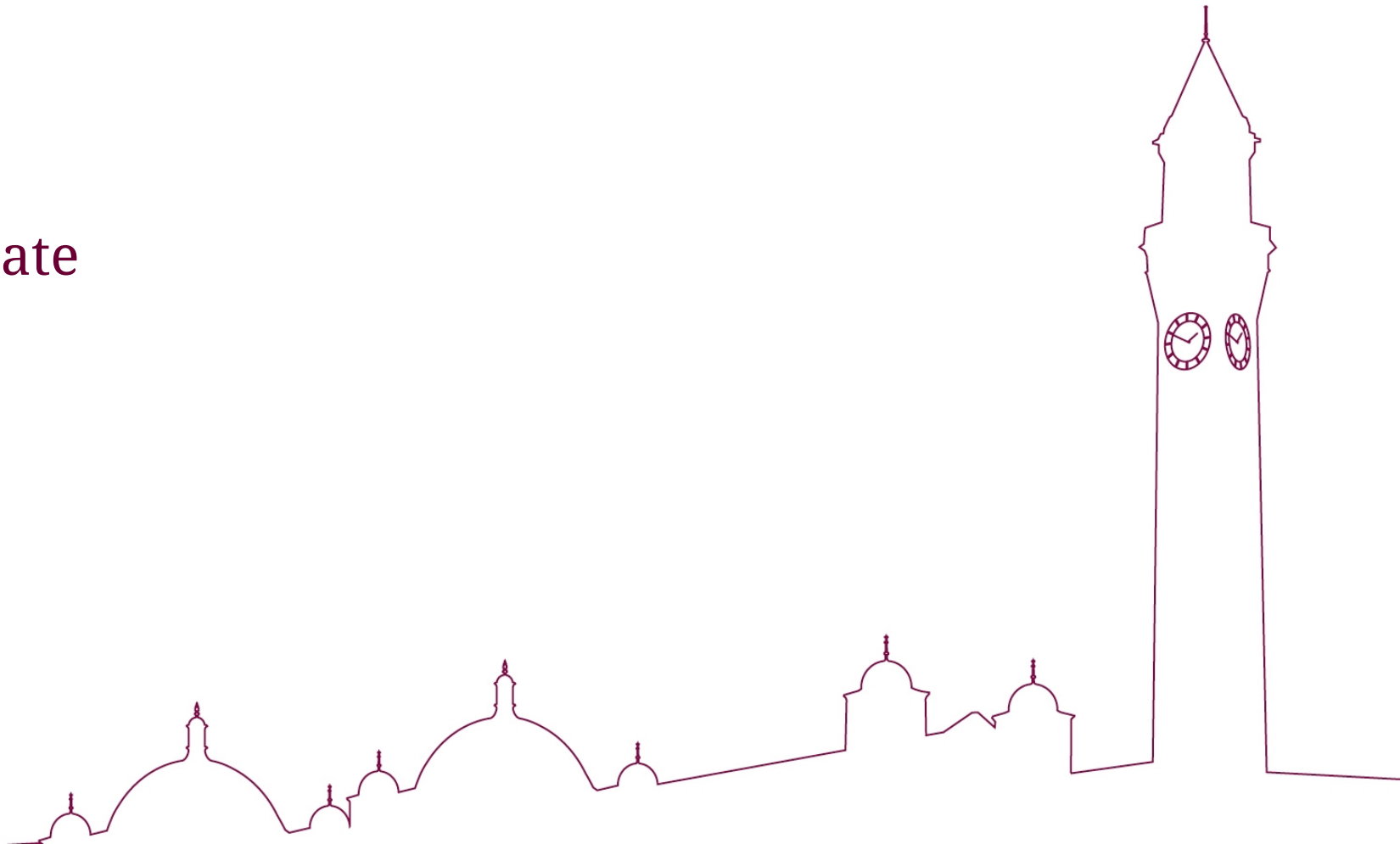
UNIVERSITY OF BIRMINGHAM | SCHOOL OF PHYSICS AND ASTRONOMY

Djangoh Update

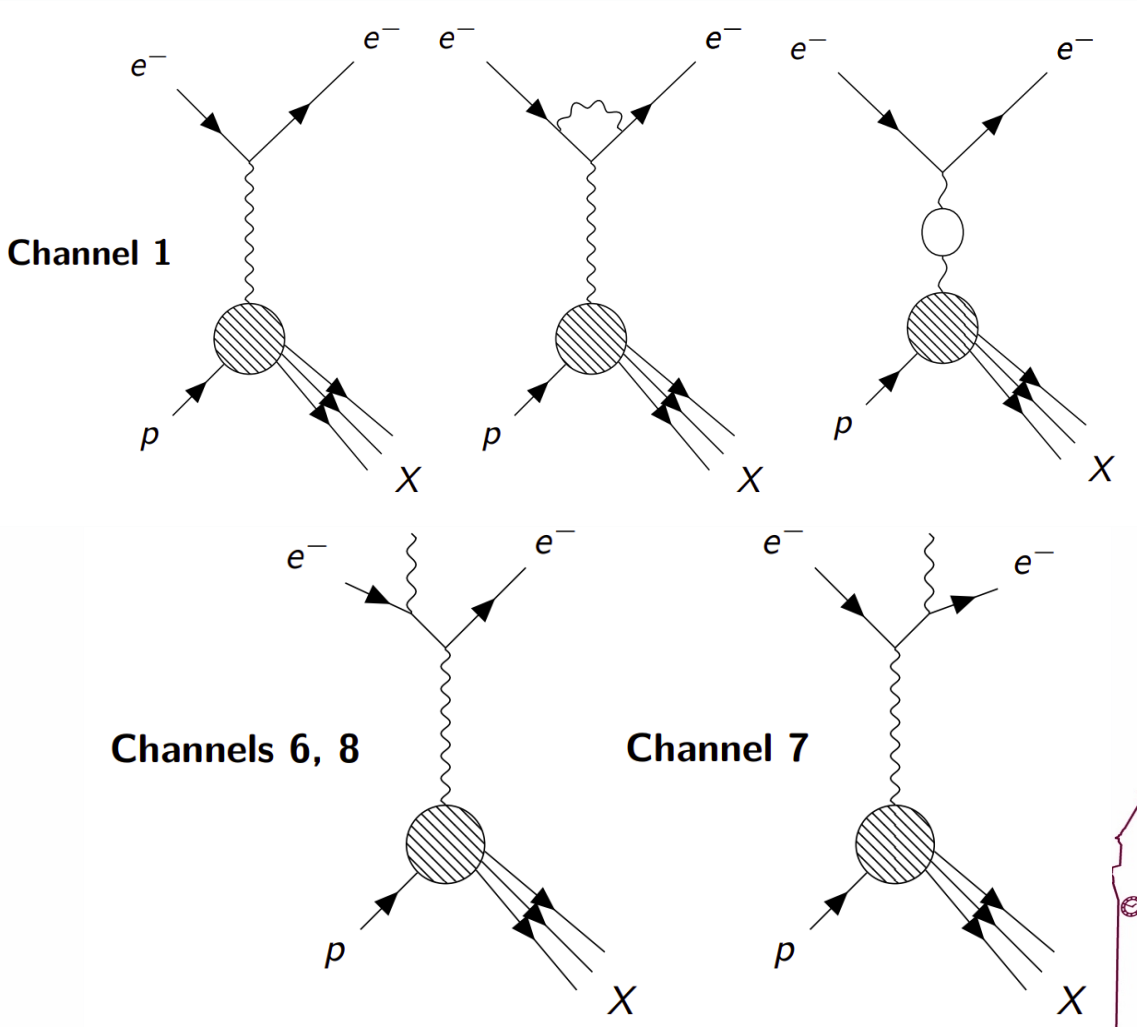
S. Maple



Recap

Event generation

- Djangoh 4.6.21 used to generate 18x275 GeV^2 e-p events
  - ISR/FSR=ON and OFF
  - Q^2>1,10,100,1000
  - W>3GeV
- Channel 1: Non Radiative NC
- Channel 6: ISR
- Channel 7: FSR
- Channel 8: “Compton event”



Simulation and Reconstruction

- Simulated and reconstructed samples in eic-shell version 25.09.0-stable
- Calculate reconstructed kinematics manually from ReconstructedParticles branch
- Radiative truth kinematics from InclusiveKinematicsTruth
- Born truth kinematics manually calculated from scattered/beam electron four-vectors (and radiated photon four-vectors where applicable)
- Radiative events identified by looking for final state photons with either the beam or scattered electron as its parent

Example of an event containing FSR

P ID ParentID PDG

```
E 0 17 31 @ -6.5024151476483341e-02 -3.2340523959240464e-03 7.2836286194717754e+00 -1.1102591305812023e+01
U GEV MM
W 1.0000000000000000000000e+00
A 0 GenCrossSection 1.00000000e+00 0.00000000e+00 -1 -1
P 1 0 11 4.2508797487305905e-03 -5.8584259099664689e-03 -1.7998543321755243e+01 1.7998544777182211e+01 5.0999998347833753e-04 4
P 2 1 23 -1.4987102777775796e+00 3.0605648596599666e-01 -8.2423872424536387e-02 1.6787012230887466e-02 -1.5317679643630981e+00 21
P 3 0 2212 -6.9311465581052065e+00 5.4207924557558296e-02 2.7497615832191337e+02 2.7506509088589996e+02 9.3830001354217529e-01 4
P 4 1 11 8.4569052695003066e-01 -1.8006336808800588e-01 -1.0062361416782567e+01 1.0099441918012110e+01 5.1099999109283090e-04 1
P 5 4 22 6.5727062928571922e-01 -1.3185154379459121e-01 -7.8537580325481429e+00 7.8823159503240765e+00 0.0000000000000000e+00 1
P 6 3 2 1.6633901664053902e-02 -9.6425321126547961e-02 1.2190123779769774e+01 1.2190516144475161e+01 -0.0000000000000000e+00 21
P 7 6 2 1.6633901664053902e-02 -9.6425321126547961e-02 1.2190123779769774e+01 1.2190516144475161e+01 -0.0000000000000000e+00 21
```

Simulation and Reconstruction

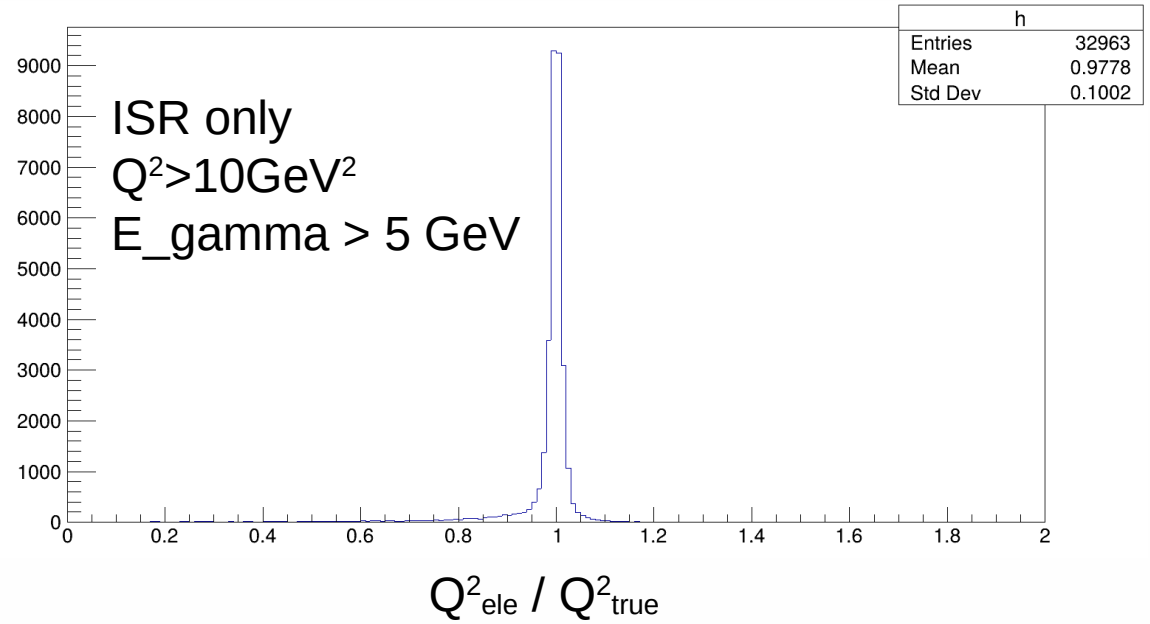
- Simulated and reconstructed samples in eic-shell version 25.09.0-stable
- Calculate reconstructed kinematics manually from ReconstructedParticles branch
- Radiative truth kinematics from InclusiveKinematicsTruth
- Born truth kinematics manually calculated from scattered/beam electron four-vectors (and radiated photon four-vectors where applicable)
- Radiative events identified by looking for final state photons with either the beam or scattered electron as its parent

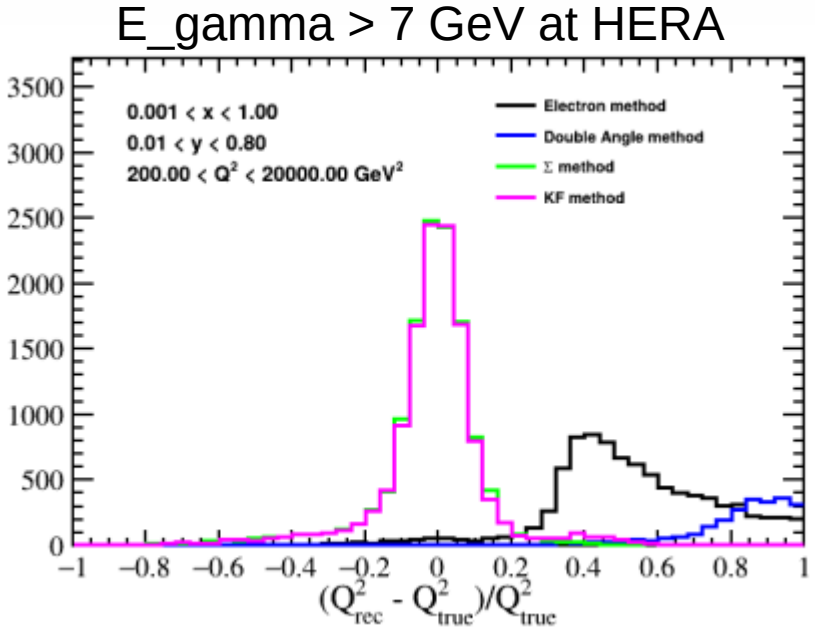
Example of an event containing ISR

P ID ParentID PDG

```
E 7 64 147 @ 1.6012185733788062e-01 -4.7490747321960415e-03 -2.0748446038297086e+00 1.0020203454212252e+01
U GEV MM
W 1.0000000000000000000000e+00
A 0 GenCrossSection 1.00000000e+00 0.00000000e+00 -1 -1
P 1 0 11 -2.5068112324858061e-03 4.1249875436205254e-03 -1.7998604003829065e+01 1.7998604651091053e+01 5.0999998347833753e-04 4
P 2 1 23 1.3006943859613391e+00 5.3136958329518003e-01 -1.2044042330374824e+01 1.1799994981284147e+01 -2.7916390895843506e+00 21
P 3 0 2212 -6.8885281123426703e+00 8.9282705102835924e-02 2.7497708540380222e+02 2.7506495621145075e+02 9.3830001354217529e-01 4
P 4 1 11 -1.3023291964206973e+00 -5.2736128534009141e-01 -3.9226089551434651e+00 4.1666572915681410e+00 5.1099999109283090e-04 1
P 5 1 22 -8.7200722271252307e-04 1.1668950423773378e-04 -2.0319517183883327e+00 2.0319519015206349e+00 0.0000000000000000e+00 1
P 6 3 21 -5.5575237362920493e+00 2.6065923383987660e-01 2.3122515536748480e+02 2.3129208541825975e+02 -0.0000000000000000e+00 21
P 7 6 21 9.5443660479677683e-01 8.5441304671546270e-01 1.6073344261683296e+00 5.7413160236073968e-01 -1.9735870361328125e+00 21
```

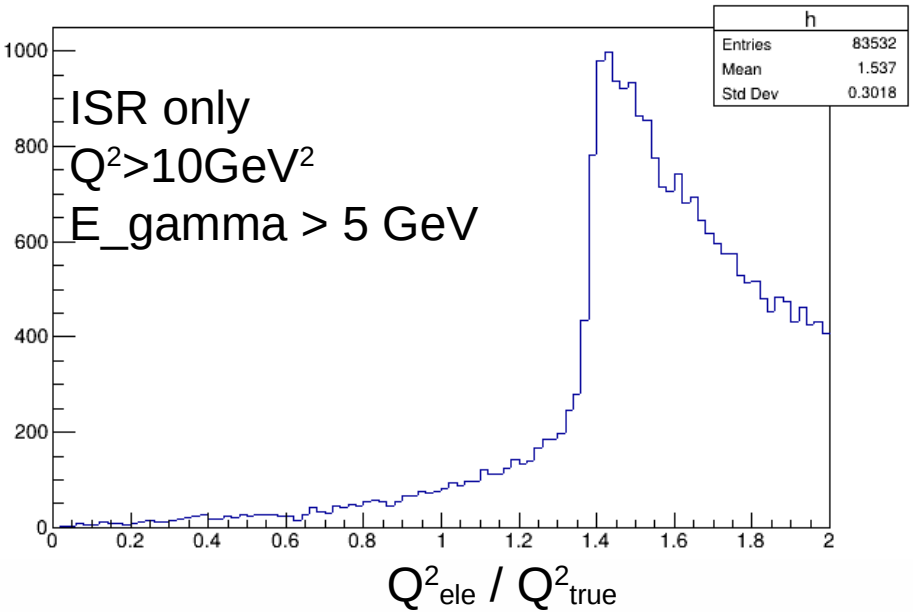
Kinematics reconstruction (last time)



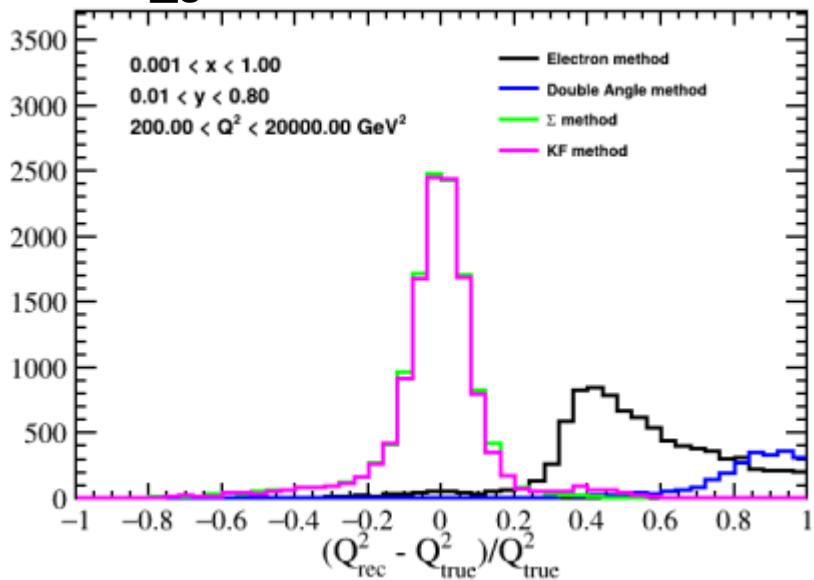


- Expect to see more skewing in reconstructed Q^2 → likely that the “true” kinematics are being calculated using the beam electron pre ISR emission
- Need to correct for this
  - subtract ISR photon from beam electron before calculating truth kinematics in ISR events
  - Add FSR photon to scattered electron before calculating truth kinematics in FSR events

Kinematics reconstruction (now)



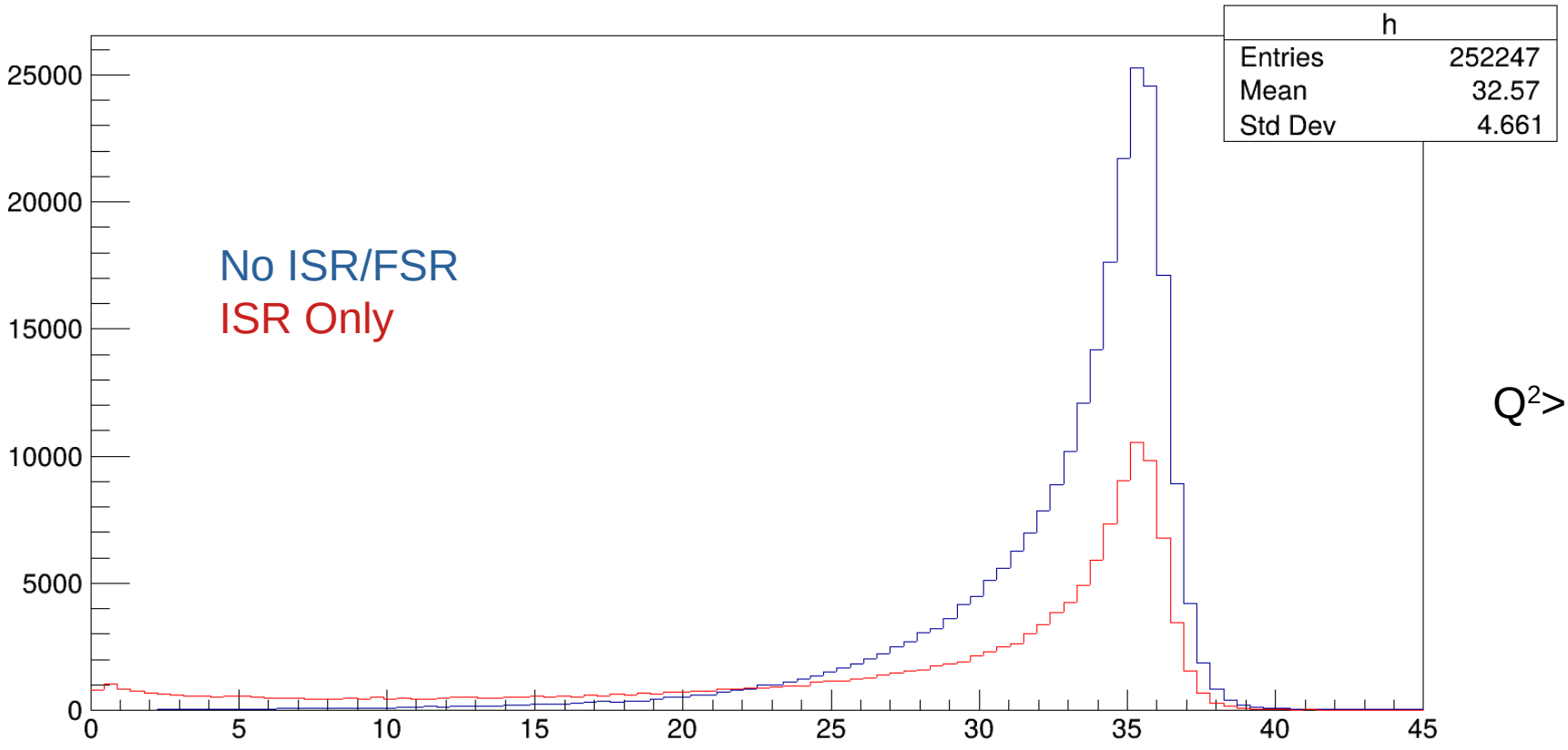
E_gamma > 7 GeV at HERA



- Updated to store separate values for born truth and radiative truth
  - i.e. whether or not the radiated photon is merged with the radiating electron

Total E-pz

For now I'll cut on $32<\Sigma_{tot}<40$ GeV



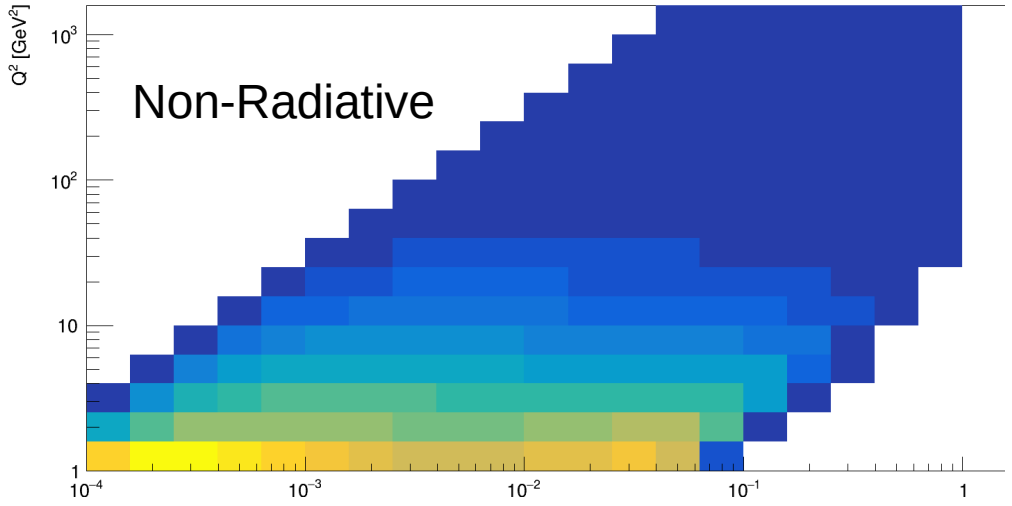
$Q^2>10$ GeV^2

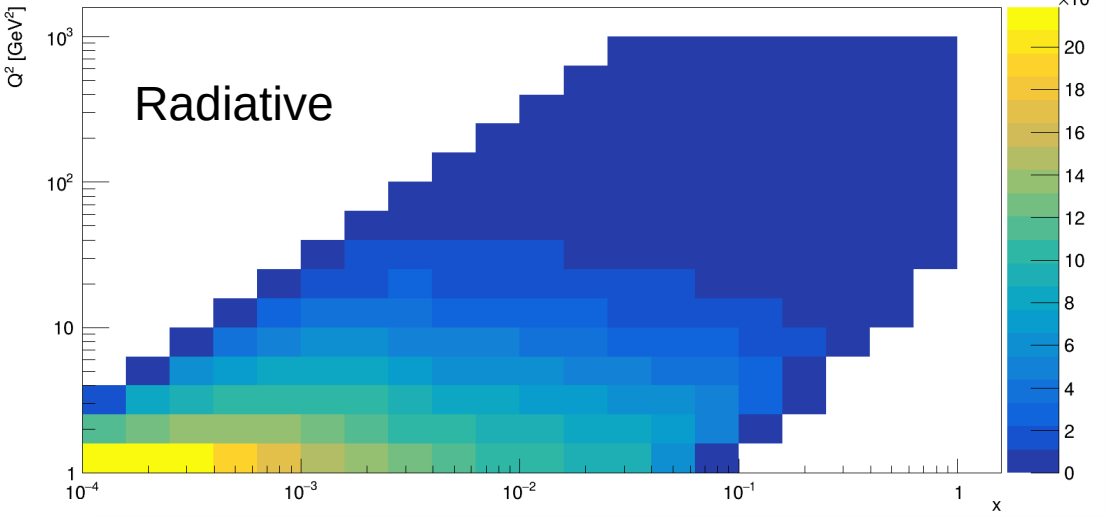
$\Sigma_{tot}=sum_i(E_i - p_{z,i})$ over all fs particles i

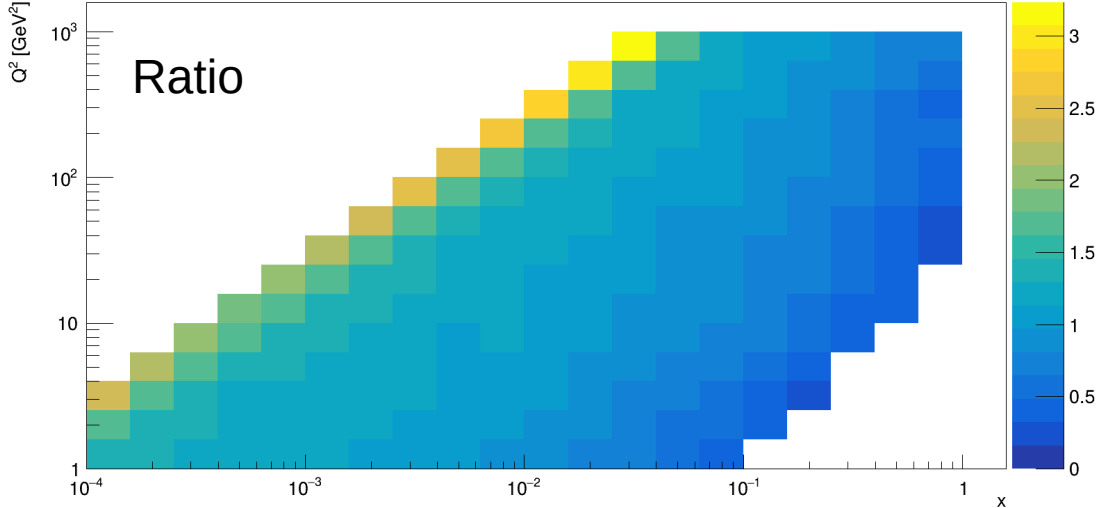
Update

Non-Radiative vs Radiative Truth (x-Q^2)

Ratio = Num Radiative / Num Non-Radiative in bin

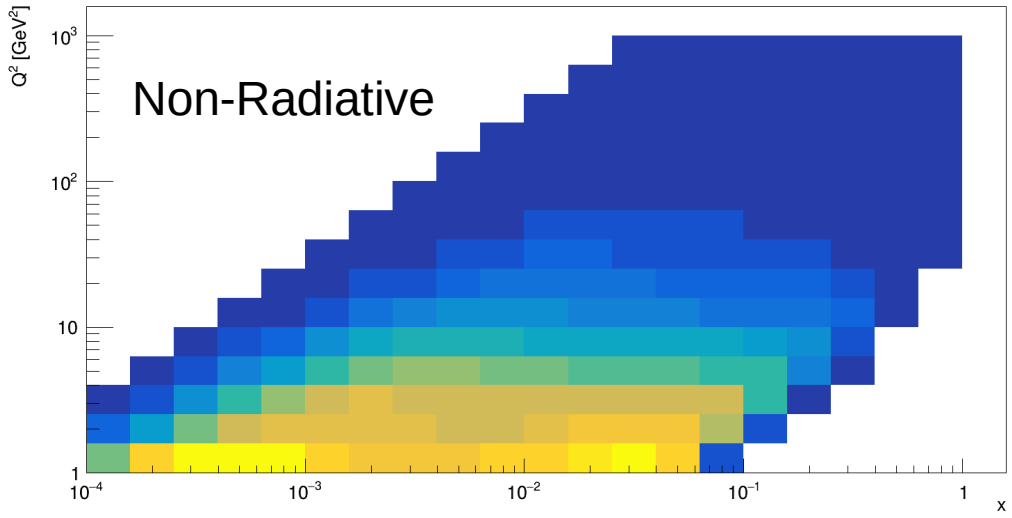


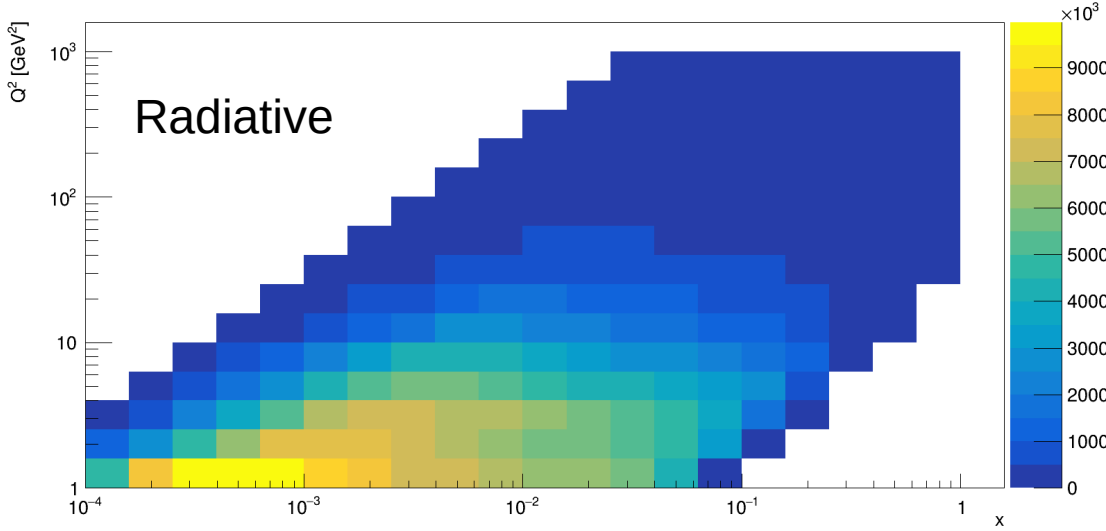


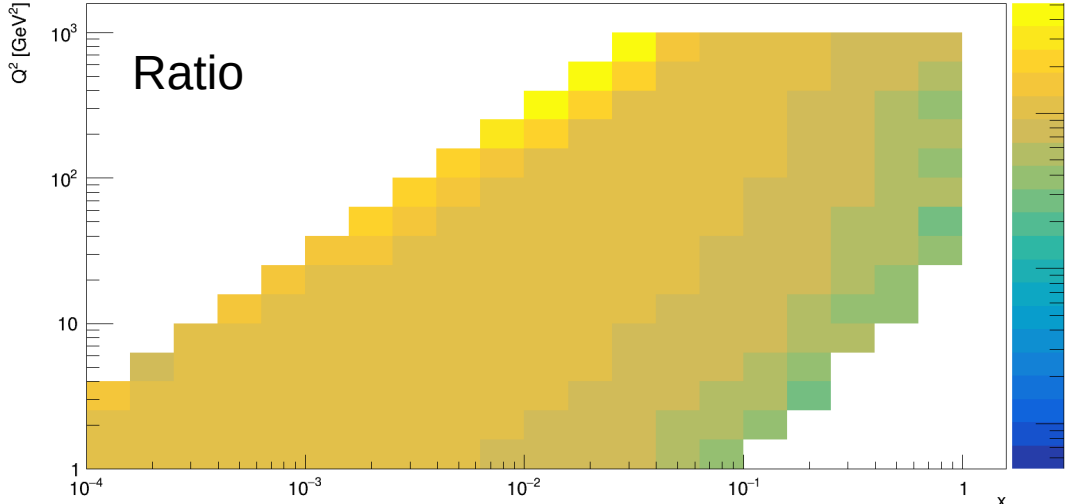


- Radiative events shift kinematics to higher y
- Up to ~3x as many events at high y (and Q2) → highest y bins will be removed by y<0.9-0.95 cut → more like 2x

Non-Radiative vs Radiative Truth (E-p_z cut) (x-Q^2)

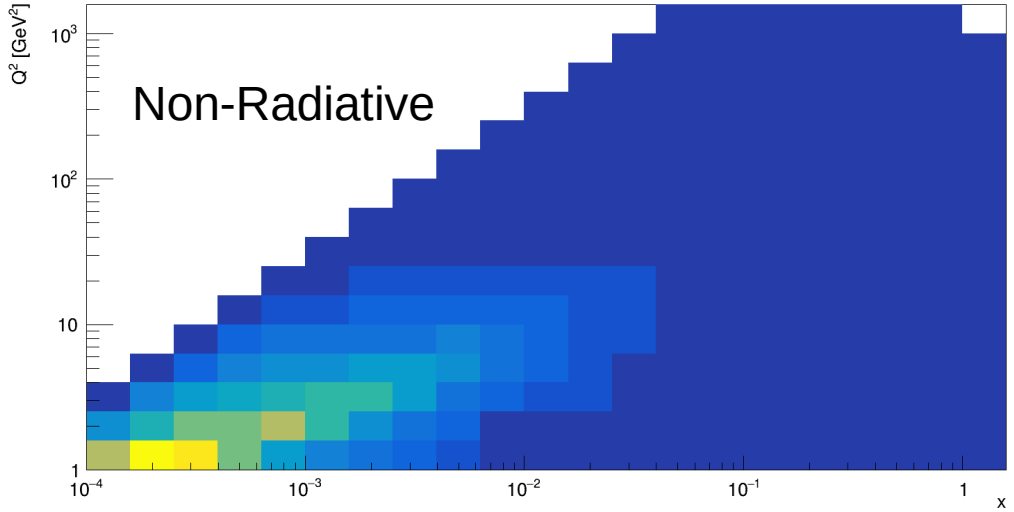


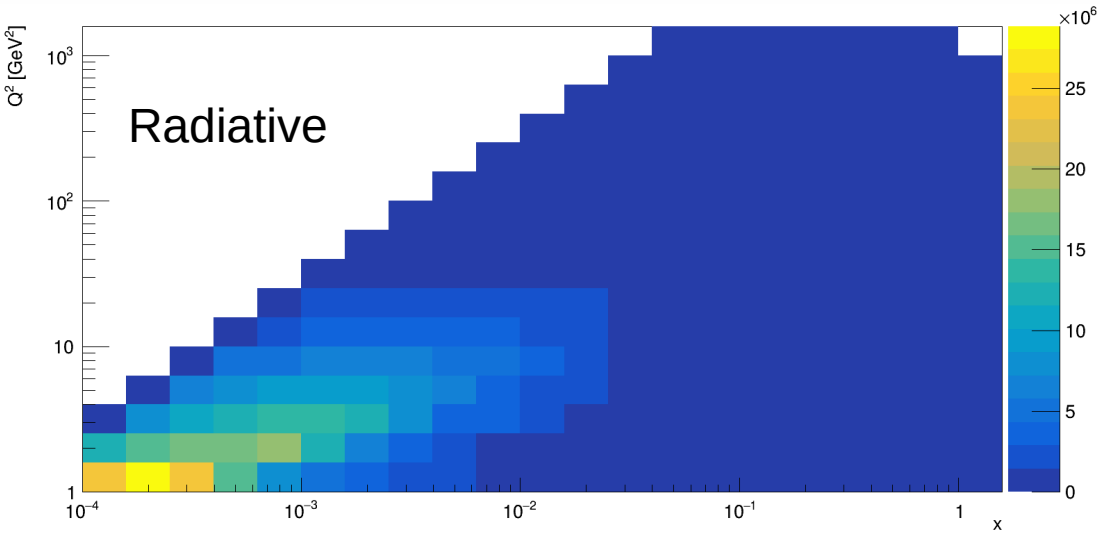


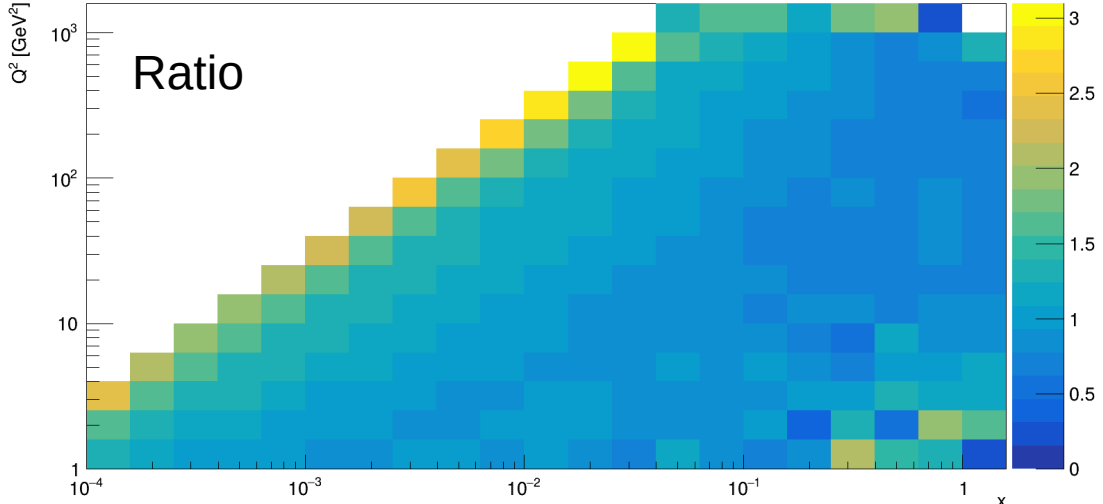


- Log scale on ratio for visibility
- Typically ratio is ~1
  - Bins at high y high Q^2 may actually increase with cut
  - Lower y bins comparable with or without the cut

Non-Radiative vs Radiative: Ele method (x-Q^2)

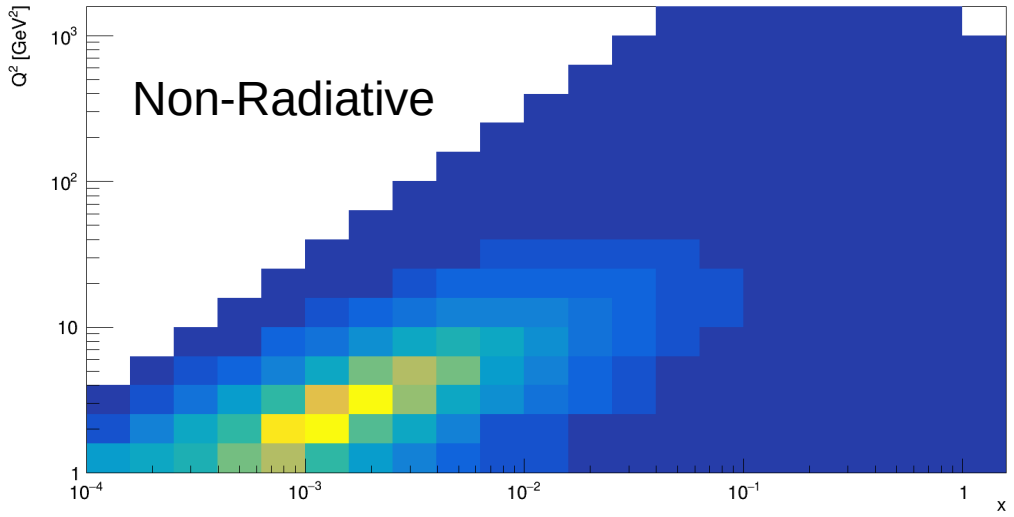


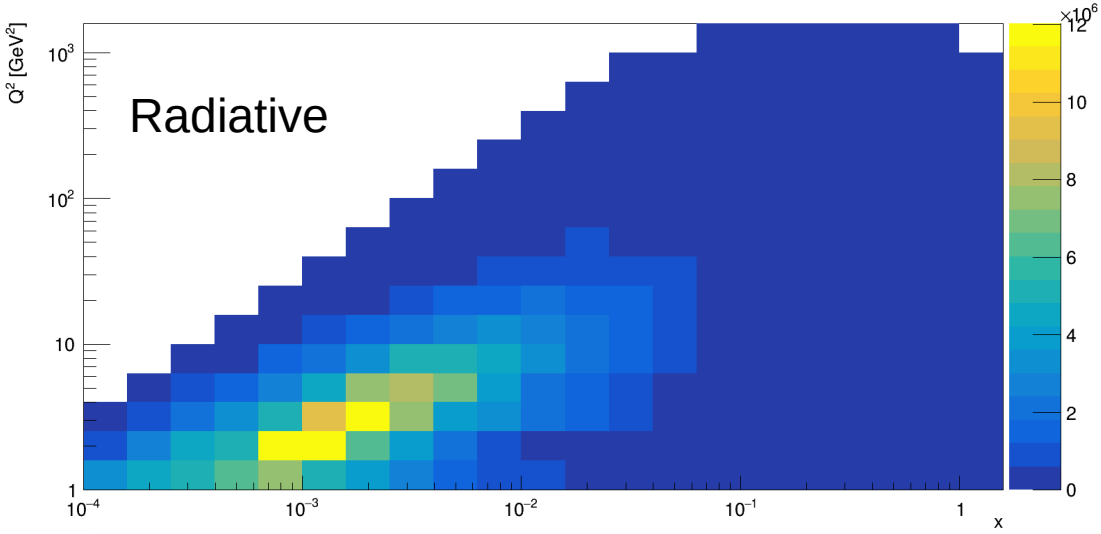


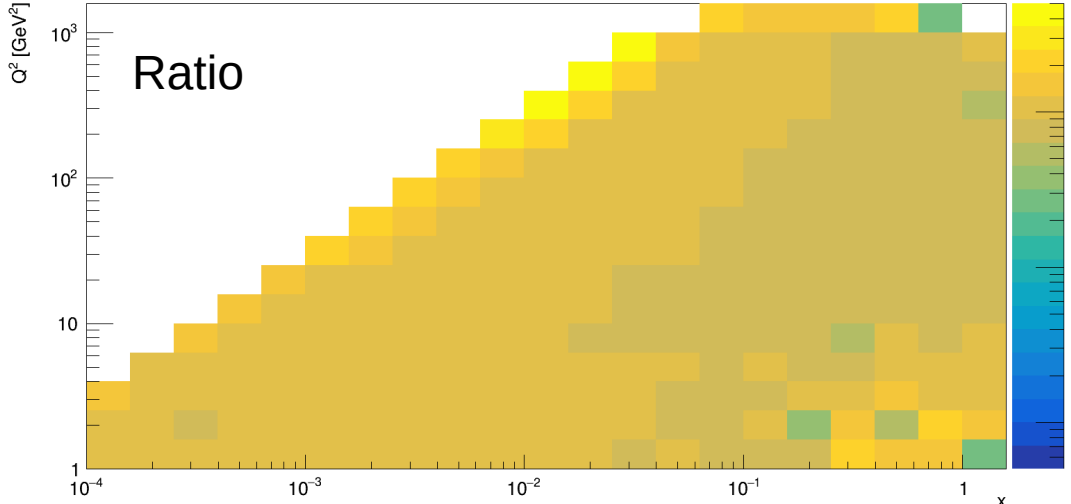


- Ratio mostly ~1
- Some deviation at high y high Q2 and low y

Non-Radiative vs Radiative: Ele method (E-p_z cut) (x-Q^2)

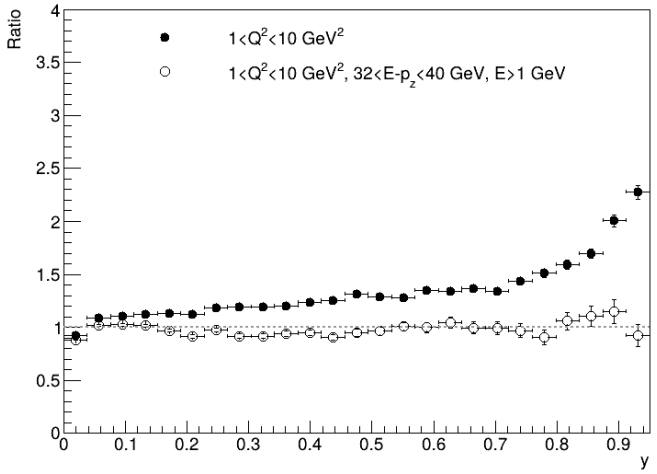


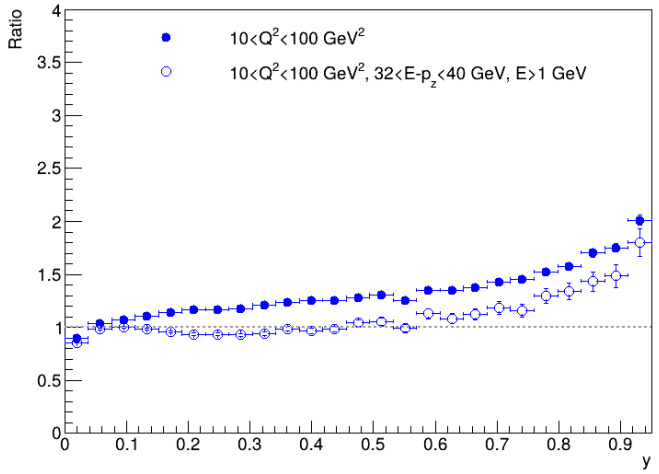


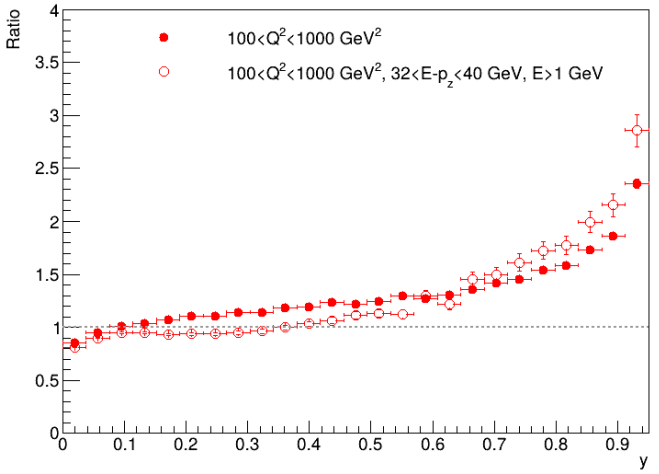


- Log scale on ratio for visibility
- Typically ratio is ~1
  - Bins at high y high Q^2 may actually increase with cut
  - Lower y bins comparable with or without the cut

Ratio with and without E-p_z cut: Truth (vs y)

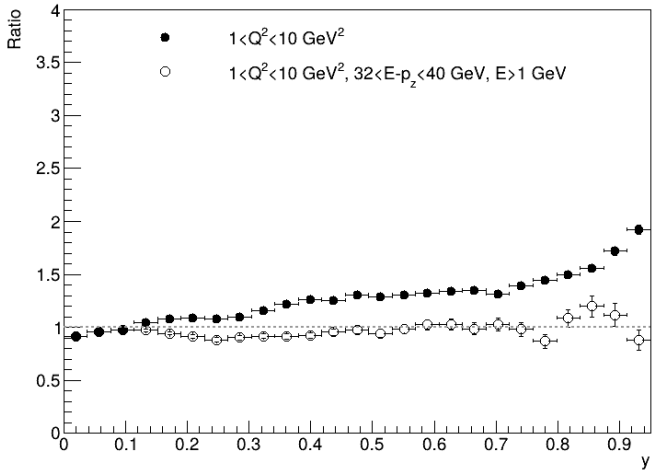


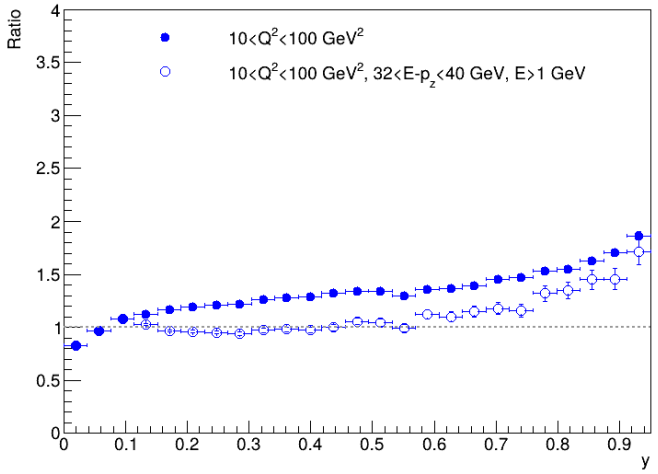


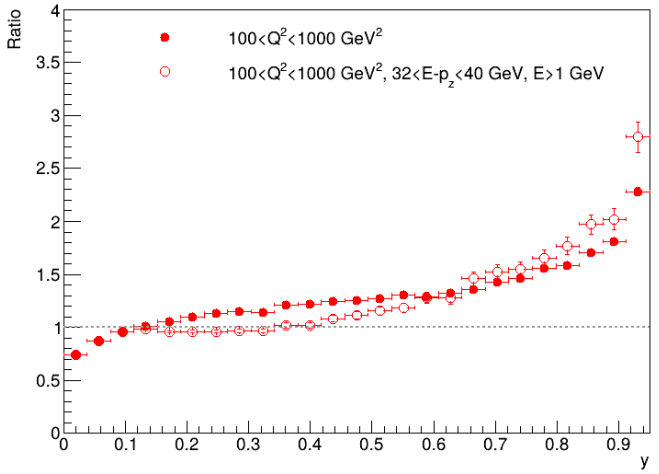


- Low Q^2 looks pretty good → E-p_z cut corrects to ~1
- For higher Q^2 the ratio starts at 1 with the E-pz cut then increases with y from y~0.5
- E-pz cut actually increases ratio at high y for Q2>100

Ratio with and without E-p_z cut: Electron method (vs y)

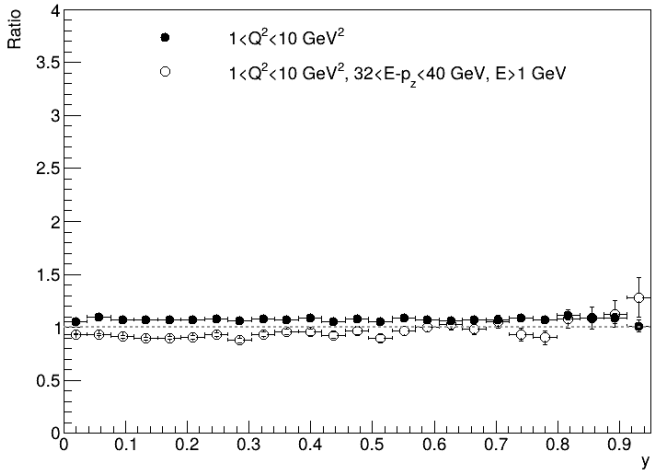


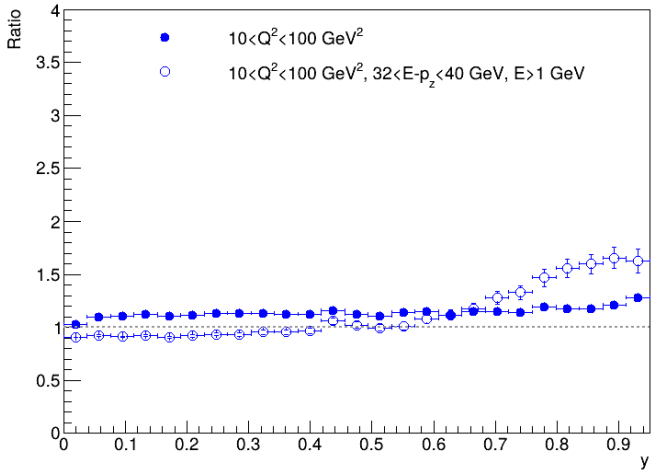


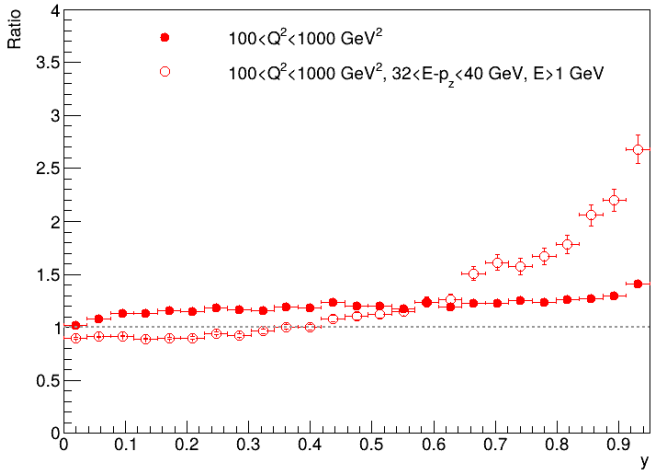


- Low Q^2 looks pretty good → E-p_z cut corrects to ~1 as with truth
- For higher Q^2 the ratio starts at 1 with the E-pz cut then increases with y from y~0.5
- E-pz cut actually increases ratio at high y for Q2>100

Ratio with and without E-p_z cut: DA method (vs y)

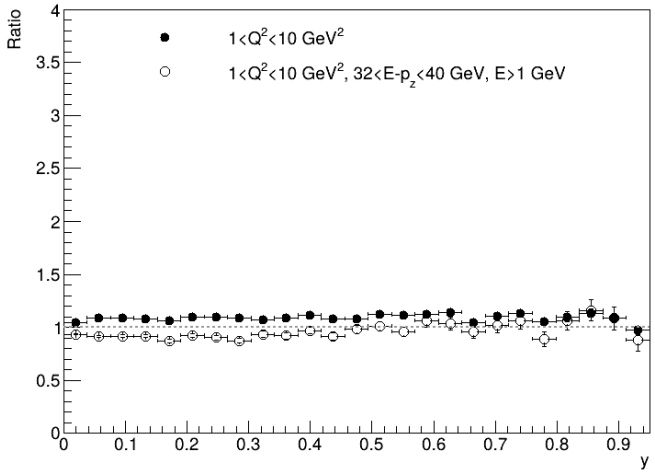


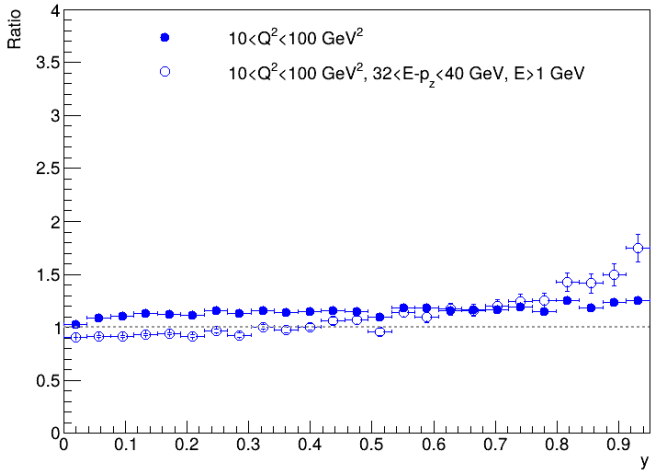


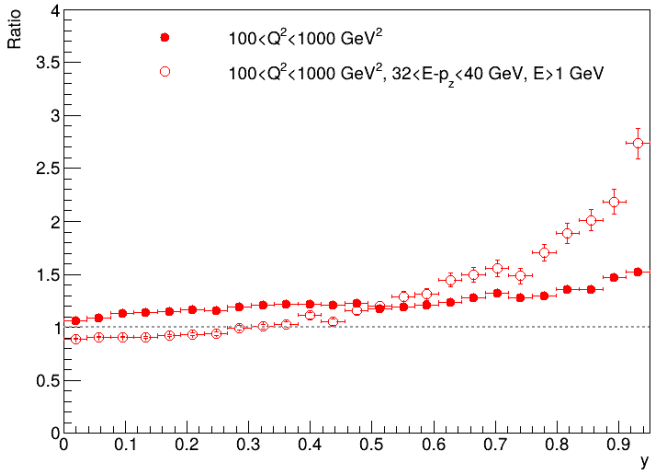


- E-p_z cut seemingly not that helpful
- Ratio ~1 at low Q^2 regardless of cut
- For higher Q^2 the cut actually makes things worse at high y

Ratio with and without E-p_z cut: Σ method (vs y)



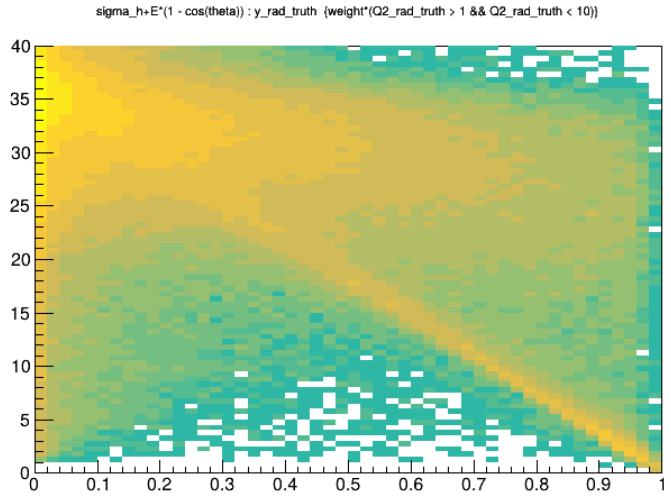


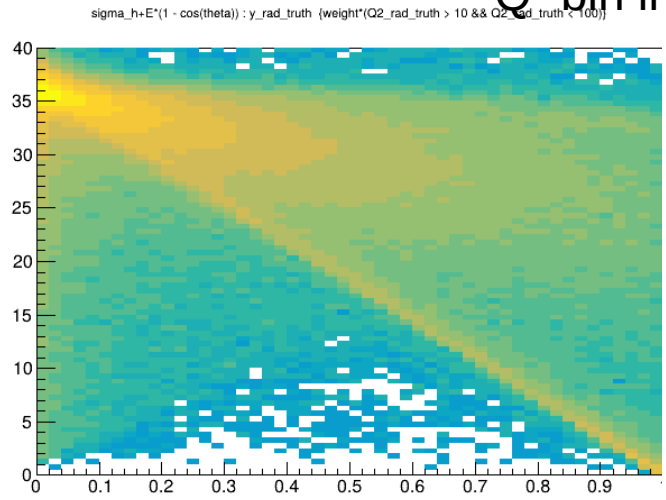


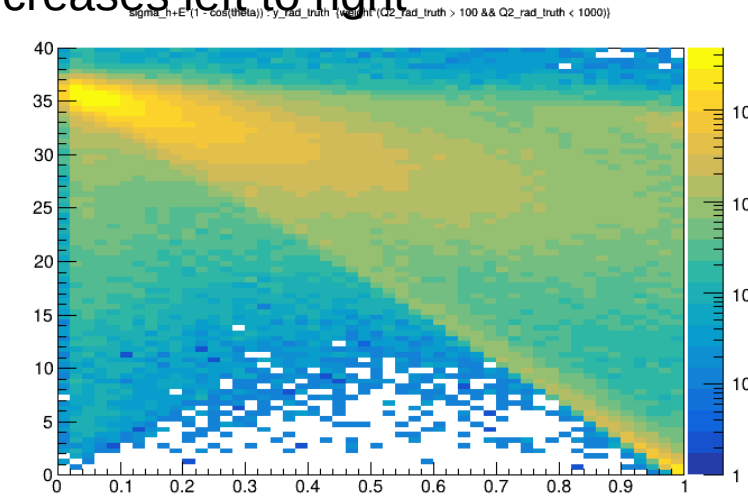
- E-p_z cut seemingly not that helpful
- Ratio ~1 at low Q^2 regardless of cut
- For higher Q^2 the cut actually makes things worse at high y

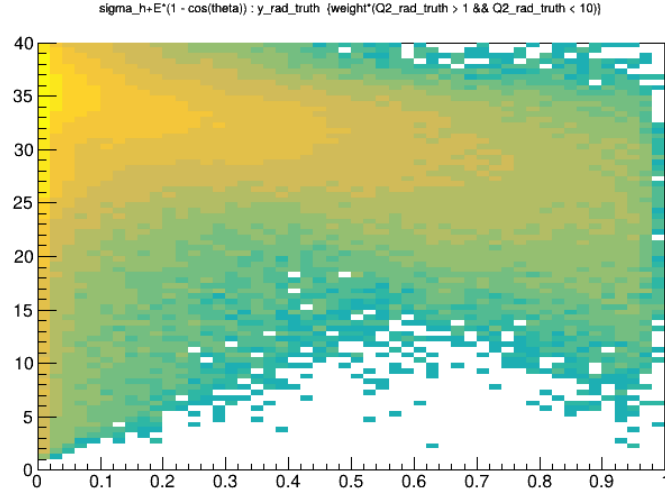
E-p_z vs y in different Q^2 ranges

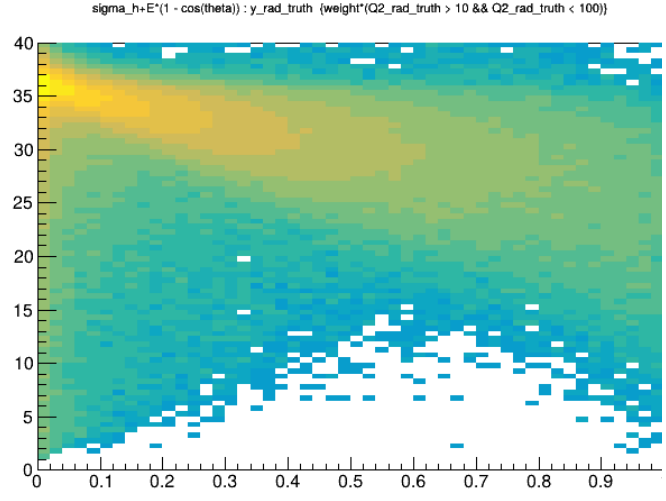
Top: Rad=On
Bottom: Rad=Off
Q^2 bin increases left to right

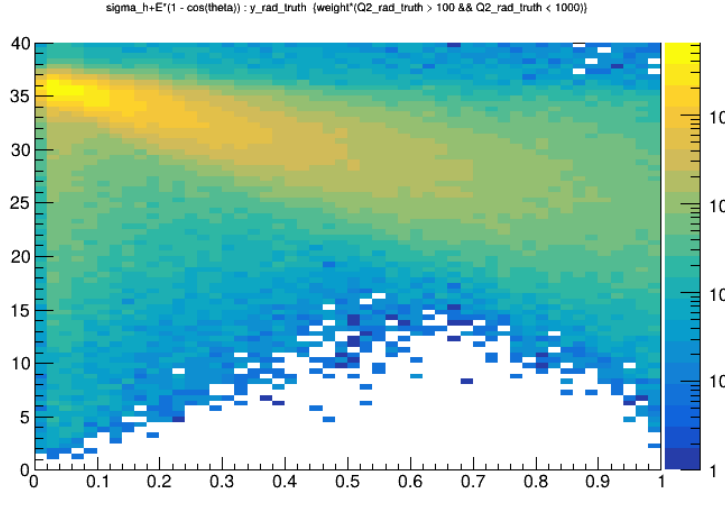






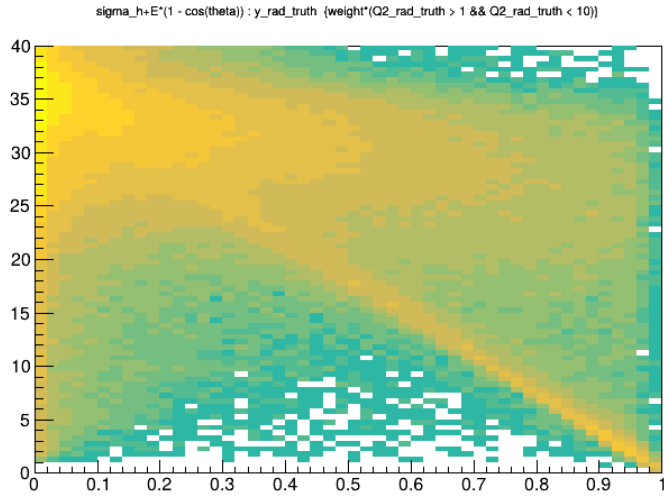


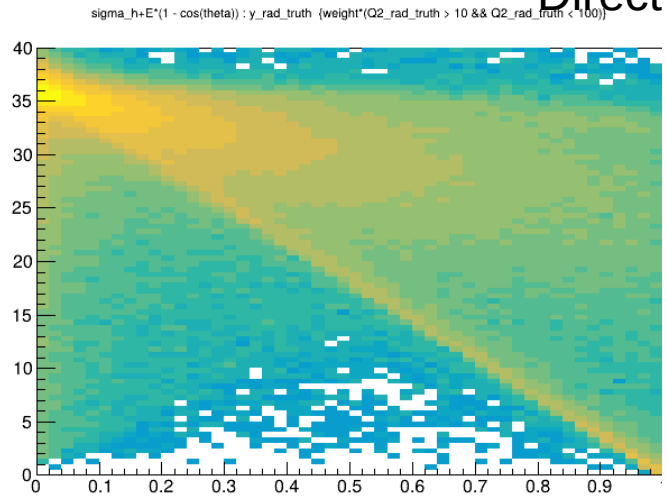


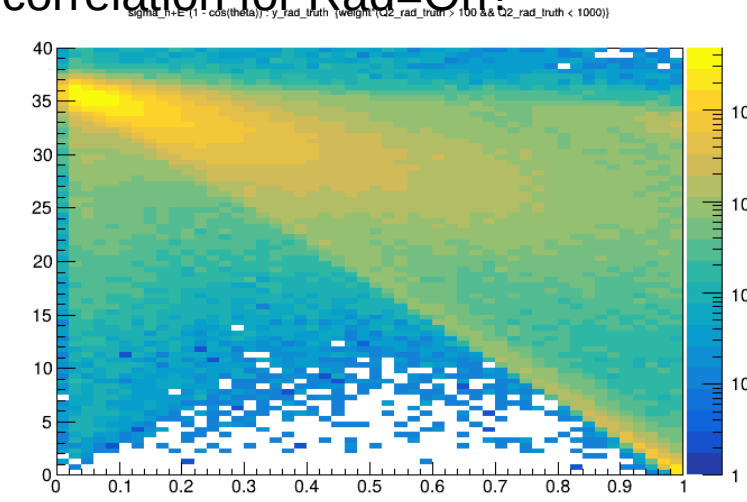


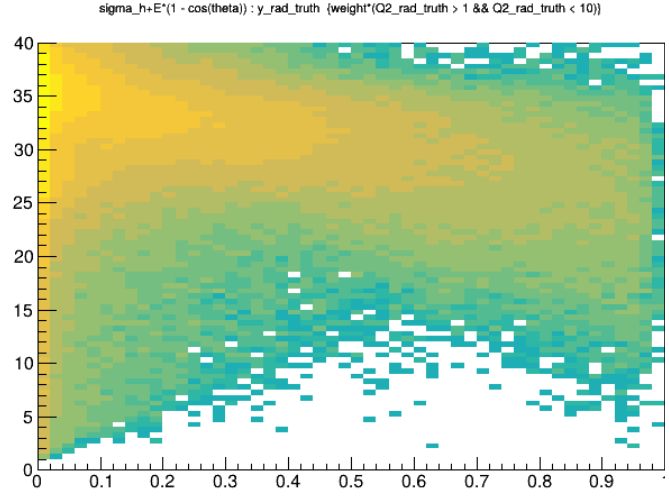
$E\text{-}p_z$ vs y in different Q^2 ranges

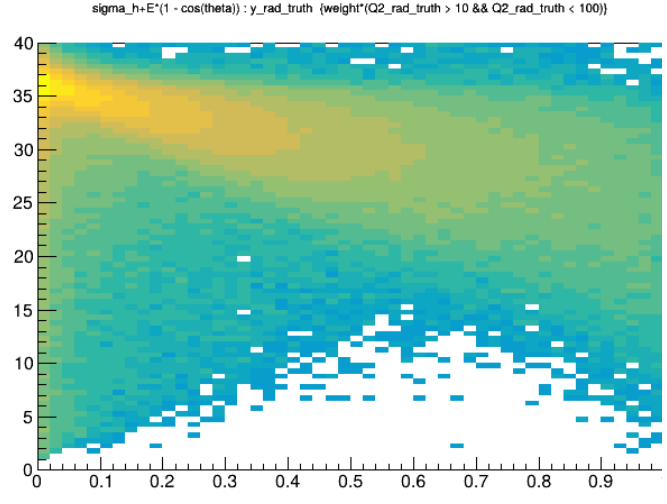
- Underestimation of HFS in both cases
- Direct correlation for Rad=On?

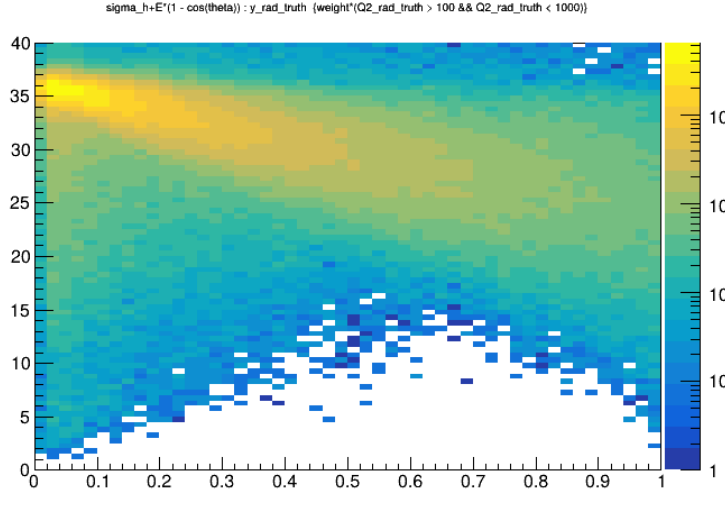












Summary

- Fixed kinematic recon
- Aimed to differences between radiative and non-radiative samples by their number ratio vs x-Q2 or y
- Also study relationship between ratio and E-pz cut
- Reconstructed E-pz appears to show broad negative correlation with y for both Rad=On and Rad=Off samples
  - Rad sample shows broad negative correlation, and a strong second negative correlation that intercepts E-pz=0 y=1