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NEUTRAL PION MULTIPLICITY STUDIES



MARSHALL B. C. SCOTT

HTTPS://WWW.LINKEDIN.COM/IN/MARSHALL-SCOTT-PH-D-17AB191B9





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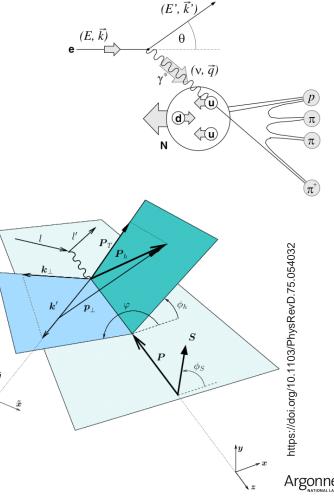
This work is supported in part by the U.S. Department of Energy, Office of Nuclear Physics under contract No. DE-AC02-06CH11357.

SEMI-INCLUSIVE DEEP INELASTIC SCATTERING

- Our analysis is centered on the study of neutral pion hadronization.
- The SIDIS channel of interest involves the detection of the scattered electron and photons coming from neutral pion decays.
- SIDIS variables of interest
 - $Q^2 = -q^2 = -(l' l)^2$: the square of the momentum transferred from the electron to the parton
 - $-x_B = Q^2/2P \cdot q$: the fraction of target momentum the struck parton contained
 - $-z = P \cdot P_h / P \cdot q$: the fraction of transferred momentum the resultant hadron contained
 - p_T : the transverse hadron momentum
 - $\phi_h = \arccos[(q \times I) \cdot (q \times P_h)/(|q \times I| \cdot |q \times P_h|)] : angle between the lepton scattering plane and the hadron plane$







SIDIS MULTIPLICITIES

Goal

-Measure neutral pion multiplicities

$$M_h = rac{d\sigma^h}{dx dQ^2 dz dp_T^2} / rac{d\sigma^{DIS}}{dx dQ^2}$$

 Related to the non-perturbative proton structure, i.e., PDFs and FFs

$$\sigma^{\pi^0}pprox\sigma^{DIS}\otimes f^p(x,Q^2)\otimes D^{p
ightarrow\pi^0}(z,Q^2)$$

- Connected to charged pion multiplicities

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$$D_1^{\pi^0/q} = \frac{1}{2} \left(D_1^{\pi^+/q} + D_1^{\pi^-/q} \right)$$



e'(E') e(E) $\gamma * (Q^2, v)$ $\pi(z)$ dσ 2dNⁿ⁰/(dNⁿ⁺+dNⁿ⁺) 1'4 1'5 1'7 1'7 1'7 (b) https://doi.org/10.1007/s100520100765 **HERMES** Collaboration 0.8 0.6 0.4 0.2 0.70.8 0.9 z

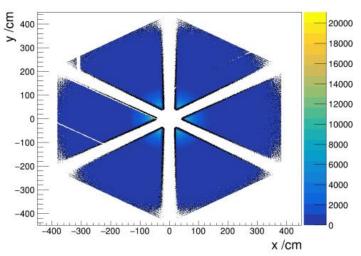
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DATA SELECTION

- Fall 2018 data taking period, which used a 10.6 GeV polarized election beam scattering off an unpolarized liquid hydrogen target.
- Zero net electron polarization over this run period.

General quality cuts

- Data quality cuts
- Fiducial cuts for better data-mc agreement
- Exactly 1 electron in Forward Detector
- At least 2 photons in Forward Detector



Preshower Calorimeter (PCAL) hit plane for electrons. Black points show hits before fiducial cuts were made and the overlayed colored points show the surviving hits after the cut (Internal Documentation : RG-A Analysis note).





SELECTION CUTS FOR ELECTRONS AND PHOTONS

Electron

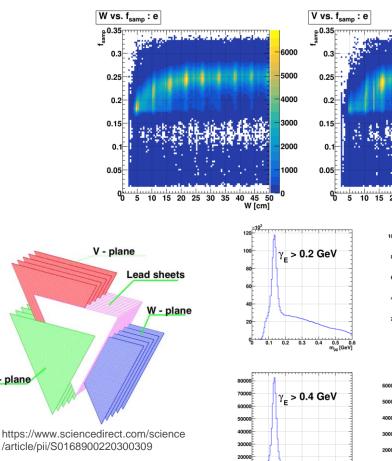
- 2 < p_e < 8 GeV
- $-Q^{2} > 2 \text{ GeV}^{2}$
- -W > 2 GeV [W = |q + P|]
- $v < 0.75 [y = q \cdot P/I \cdot P]$: remove events with large radiative effects
- $-I_{v} \& I_{w} > 9$ cm (constant sampling fraction region)

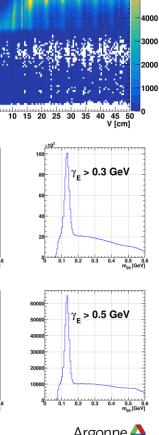
Photon

- $-E_v > 0.5 \text{ GeV}$: background removal
- -e-y opening angle > 8 deg : remove radiative vs
- $-0.9 < \beta < 1.1$: ys with $\beta > 1.1$ are not associated with π^0 s
- $-I_v \& I_w > 15$ cm (constant sampling) fraction region)

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6000

5000

U - plane

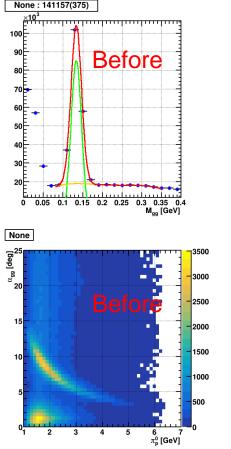
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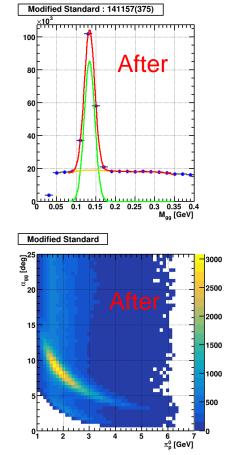
SELECTION CUTS FOR NEUTRAL PIONS

- π⁰ candidates are reconstructed from photon pairs.
- The resulting invariant mass distribution shows a characteristic peak around the π⁰ mass of 0.135 GeV.

Cuts

- x_{F} > 0 [x_{\text{F}} = 2P_{\text{h,L}}/\sqrt{s}] : current fragmentation region
- $-M_x > 1.5 \text{ GeV} [M_x = |q + P P_h|]$: remove exclusive events
- $\alpha_{\gamma\gamma} > 6 \cdot Exp(1 p_{\pi}) + 0.5$: background removal



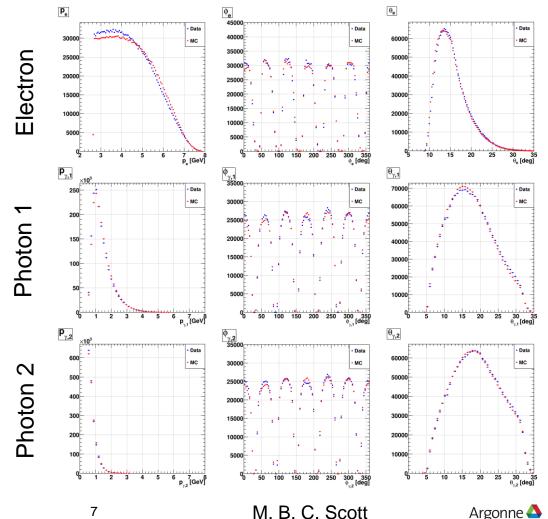






DATA & MONTE CARLO

- The monte carlo is created from a SIDIS generator based on LEPTO.
- The momenta, θ, and φ distributions of the electron and the two photons between the data and monte carlo agree well.

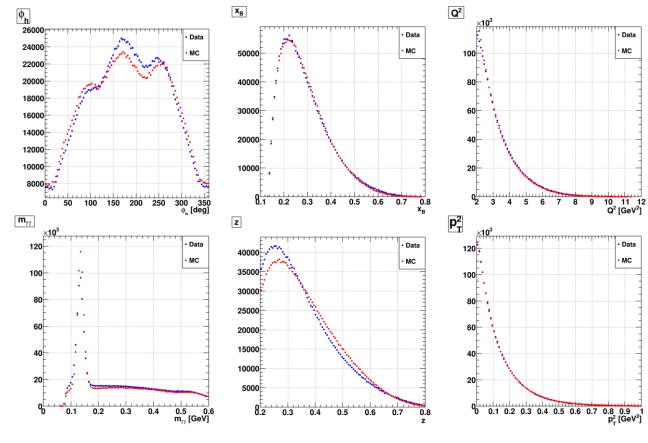




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DATA & MONTE CARLO

 The data and monte carlo also show agreement in the x_B, Q², z, p_T², φ_h, and m_{γγ} distributions.





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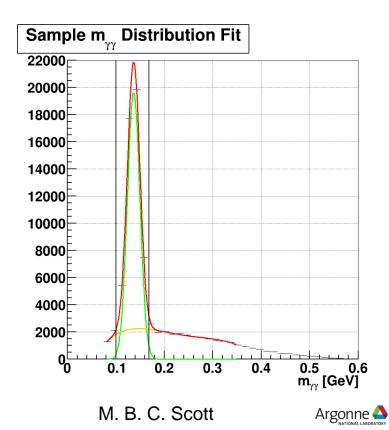


π^0 EXTRACTION

- All photons within an event are combined into unique pairs, which become our neutral pion candidates.
- The resulting invariant mass distributions are fit, and the number of pions is extracted.

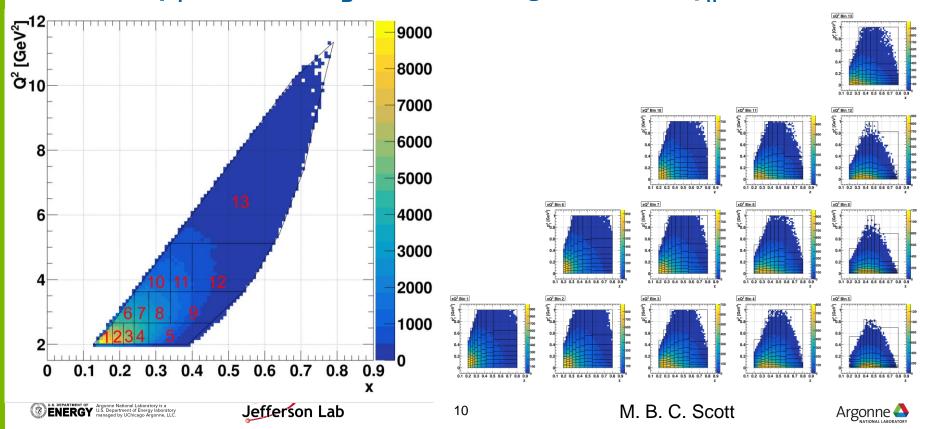
π⁰ extraction

- 20 bins : 0 0.4 GeV
- Fit range : 0.08 0.35 GeV
- Fit function : Gaussian + pol4
- Signal range : 5.5σ
- Error : derived from covariance matrix of fit





PHASE SPACE 8 z bins & 8 p_T^2 bins \in 13 x_B^2 bins ; Integration over ϕ_h



MULTIPLICITIES

5D multiplicity

$$egin{aligned} M_h &= rac{d\sigma}{dxQ^2dzdp_T^2d\phi_h}/rac{d\sigma}{dxdQ^2} \ &= A(1+Bcos(\phi_h)+Ccos(2\phi_h))/rac{d\sigma}{dxdQ^2} \end{aligned}$$

For the results in this presentation, φ_h was averaged over, so the 4D multiplicity was measured, which is the ratio of the neutral pion production to the DIS cross section :

$$M_h ~~= rac{d\sigma}{dxQ^2dzdp_T^2}/rac{d\sigma}{dxdQ^2}$$

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RAW MULTIPLICITIES AND ACCEPTANCE

Raw multiplicity

$$M_{h,raw}=rac{dN^{\pi^0}}{dxQ^2dzdp_T^2}/rac{dN^{DIS}}{dxdQ^2}$$

For the bin-by-bin acceptance*efficiency we divide the reconstructed mc by the generated mc, with the understanding that the generated mc stemmed from an event where the reconstructed electron passed all the DIS cuts.

$$A_h=rac{dN_{rec}^{\pi^0}}{dxdQ^2dzdp_T^2}/rac{dN_{gen}^{\pi^0}}{dxdQ^2dzdp_T^2}$$

• The final multiplicity is the raw multiplicity divided by the acceptance.

$$M_h = M_{h,raw}/A_h$$

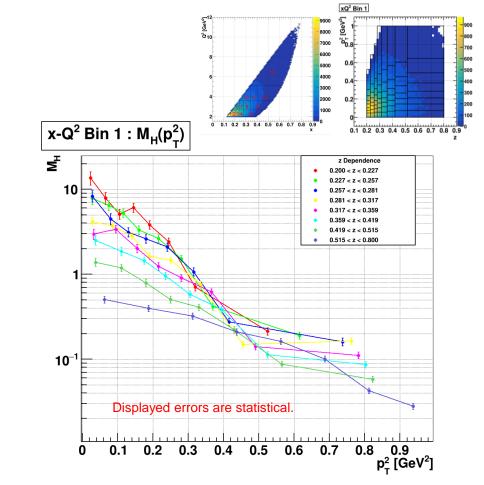




 $x-Q^2 Bin 1 : A_H(p_T^2)$ Å 10⁻¹ z Dependence 0.200 < z < 0.227 0.227 < z < 0.257 0.257 < z < 0.281 0.281 < z < 0.317 0.317 < z < 0.359 0.359 < z < 0.419 0.419 < z < 0.515 0.515 < z < 0.800 0.8 0.9 p₇² [GeV²] 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0

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 $A_{H}(z, P_{T}^{2}) \& M_{H}(z, P_{T}^{2})$ FOR xQ^{2} Bin 1



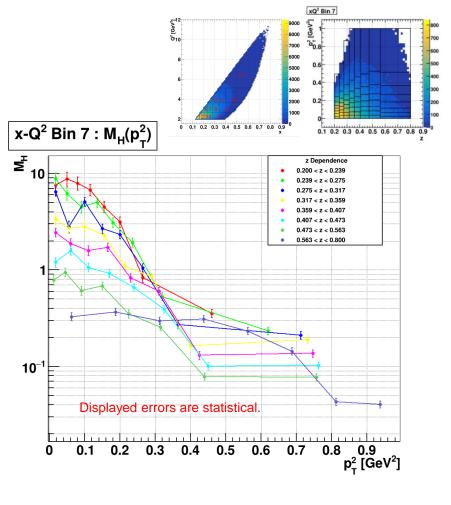




 $x-Q^2 Bin 7 : A_H(p_T^2)$ Å 10⁻¹ z Dependence 0.200 < z < 0.239 0.239 < z < 0.275 0.275 < z < 0.317 0.317 < z < 0.359 0.359 < z < 0.407 0.407 < z < 0.473 0.473 < z < 0.563 0.563 < z < 0.800 0.8 0.9 p₇² [GeV²] 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0

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 $A_{H}(z, P_{T}^{2}) \& M_{H}(z, P_{T}^{2})$ FOR xQ^{2} Bin 7



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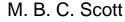
P_T^2 Integrated M_H and Leading Order Theoretical predictions

- The LO predictions used the MAPFF (https://doi.org/10.1103/PhysRevD.104.034007) and NNFF1.1h (https://doi.org/10.48550/arXiv.1807.03310) FFs and the CT10nlo PDF sets.
- $x_{\rm P}$ -Q² Bin 7 : M_H(z) \mathbf{x}_{B} -Q² Bin 1 : M_H(z) The FF plots are drawn ₹ Σ with 1σ error bands. M_L(z) M_(z) Measured Measured 3.5 NNFF contains e⁺e⁻ MAPFF & CT10nlo annihilation and p+p data, whereas MAPFF 2.5 contains annihilation data and multiplicity data. Displayed errors are statistical. Displayed errors are statistical. 1.5 $M_h = \frac{\sum_q e_q^2 f_q(x) D_q(z)}{\sum_q e_q^2 f_q(x)}$ 0.5 0.2 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.3 0.4 0.5 0.6 0.7 0.8 z 7



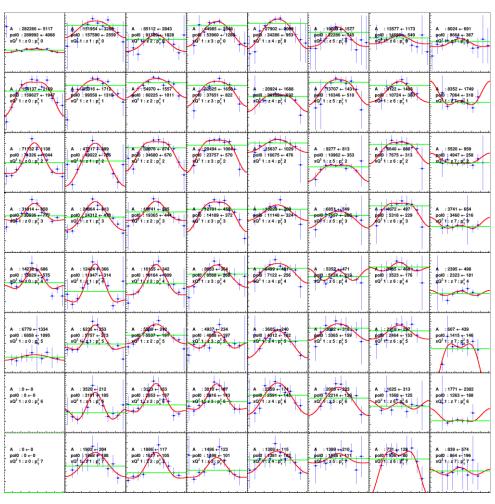
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CURRENT WORK : INCORPORATING PHI TRENTO

- Instead of averaging over the φ_h bins, now the number of pions is fit within each φ_h bin and that distribution is then fit with A(1 + Bcos(φ_h) + Ccos(2φ_h)).
- The resultant number of pions is then the extracted A term.
- The plots to the right show the a preliminary φ_h distribution in x_B-Q² 1 (in the old binning) with the A (1 + Bcos(φ_h) + Ccos(2φ_h)) fit in red along with a pol0 fit in green.
- They are within error of each other for most bins.
- The plots for all x_B-Q² bins are in the backup slides.





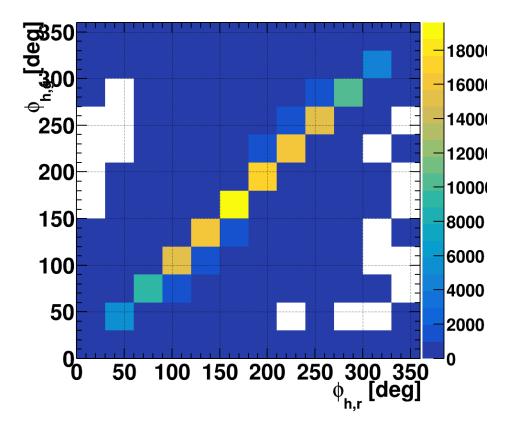




CURRENT WORK : UNFOLDING

- Current acceptance work is using Singular Value Decomposition (SVD) and Bayesian unfolding along with the migration matrix for acceptance corrections in all bins.
- The plot to the right is a portion of the x_B-Q² Bin 1 3D migration matrix showing φ_h migration in the first x_B-Q²-z-p_T² bin.

x-Q² Bin 1, 0 < p_T^2 < 0.125, 0.2 < z < 0.275







CONCLUSION

- Using the invariant mass distributions of photon pairs, the number of neutral pions has been extracted from the Fall 2018 data taking period.
- From these distributions, correcting for acceptance and efficiency, the neutral pion multiplicities was measured in the x_B-Q²-z-p_T², four-dimensional kinematic phase space.
- The p_T² integrated multiplicities have also been extracted and shown to be inline with the MAPFF⊗CT10nlo leading order predictions.
- Ongoing work is fitting the φ_h distributions for pion extraction and utilizing the migration matrix with Bayesian and SVD unfolding for acceptance corrections.
- Future work is studying radiative effects.







THANK YOU FOR YOUR ATTENTION



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BACKUP SLIDES

- SIDIS CROSS SECTION
- ACCEPTANCES AND MULTIPLICITIES FOR ALL X_B-Q² BINS
- P_T² INTEGRATED MULTIPLICITIES FOR ALL X_B-Q² BINS
- Φ_H DISTRIBUTIONS
- M_x STUDIES



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SIDIS CROSS SECTION

$$\frac{d\sigma}{dxQ^2dzdP_{hT}^2d\phi_h} = \frac{\pi\alpha_e^2}{xQ^4}\frac{y^2}{(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right) \times \left\{F_{UU,T} + \varepsilon F_{UU,L} + \sqrt{2\varepsilon(1+\varepsilon)}\cos(\phi_h)F_{UU}^{\cos(\phi_h)} + \varepsilon\cos(2\phi_h)F_{UU}^{\cos(2\phi_h)}\right\}$$

$$\frac{d\sigma}{dxQ^2dzdP_{hT}^2d\phi_h} = A\left(1 + B\cos(\phi_h) + C\cos(2\phi_h)\right)$$

$$\begin{split} A &= \frac{\pi \alpha_e^2}{xQ^4} \frac{y^2}{(1-\varepsilon)} \left(1 + \frac{\gamma^2}{2x} \right) \left(F_{UU,T} + \varepsilon F_{UU,L} \right), \\ B &= \frac{\sqrt{2\varepsilon(1+\varepsilon)} F_{UU}^{\cos(\phi_h)}}{F_{UU,T} + \varepsilon F_{UU,L}}, and \\ C &= \frac{\varepsilon \cos(2\phi_h) F_{UU}^{\cos(2\phi_h)}}{F_{UU,T} + \varepsilon F_{UU,L}}. \end{split}$$







ACCEPTANCES AND MULTIPLICITIES FOR ALL X_B-Q² **BINS AS FUNCTIONS OF Z**



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 $x-Q^2$ Bin 1 : $A_H(p_T^2)$ Å 10 z Dependence 0.200 < z < 0.227 0.227 < z < 0.257 0.257 < z < 0.281 0.281 < z < 0.317 0.317 < z < 0.359 0.359 < z < 0.419 0.419 < z < 0.515 0.515 < z < 0.800 0.1 0.2 0.4 0.8 0.9 p₇² [GeV²] 0.3 0.5 0.6 0.7 0

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$A_{H}(z, P_{T}^{2}) \& M_{H}(z, P_{T}^{2})$ FOR XQ^{2} BIN 1

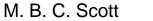
Ъ́0,8 7000 6000 0.6 5000 4000 0.4 3000 2000 1000 $x-Q^2 Bin 1 : M_H(p_T^2)$ 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 ≥ z Dependence 0.200 < z < 0.227 0.227 < z < 0.257 10 0.257 < z < 0.281 0.281 < z < 0.317 0.317 < z < 0.359 0.359 < z < 0.419 0.419 < z < 0.515 0.515 < z < 0.800 10⁻¹ 0.8 0.9 p₇² [GeV²] 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0

¹² [Cer²] 010 xQ² Bin 1

400

200

8000 S



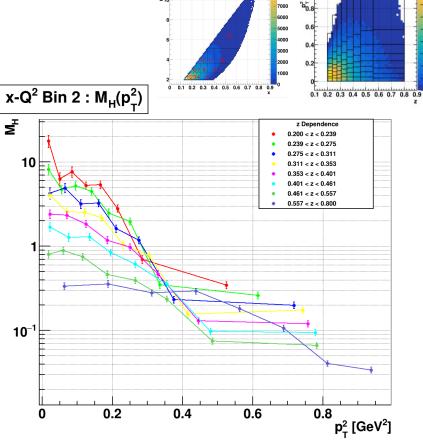




x-Q² Bin 2 : $A_{H}(p_{T}^{2})$ Ā 10⁻¹ z Dependence 0.200 < z < 0.239 0.239 < z < 0.275 0.275 < z < 0.311 0.311 < z < 0.353 0.353 < z < 0.401 0.401 < z < 0.461 0.461 < z < 0.557 0.557 < z < 0.800 0.2 0.4 0.6 0.8 0 ′ p₇ [GeV²]

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$A_{H}(Z, P_{T}^{2}) \& M_{H}(Z, P_{T}^{2})$ FOR XQ² BIN 2 $x-Q^{2} Bin 2 : A_{H}(p_{T}^{2})$ $x-Q^{2} Bin 2 : M_{H}(p_{T}^{2})$



[GeV

°010

xQ² Bin 2

400

300

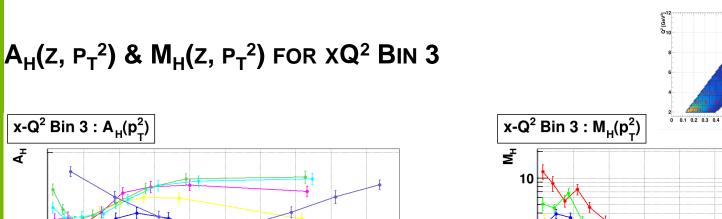
200

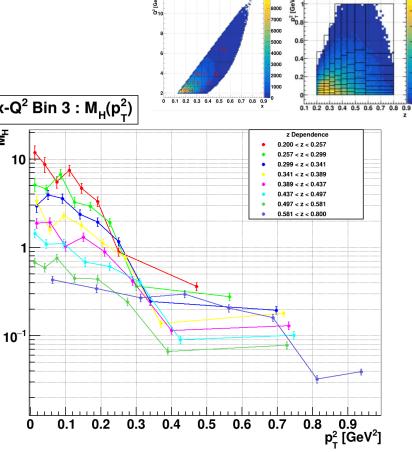




x-Q² Bin 3 : $A_{H}(p_{T}^{2})$ Å 10⁻¹ z Dependence 0.200 < z < 0.257 0.257 < z < 0.299 0.299 < z < 0.341 0.341 < z < 0.389 0.389 < z < 0.437 0.437 < z < 0.497 0.497 < z < 0.581 0.581 < z < 0.800 0.8 0.9 p₇² [GeV²] 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0

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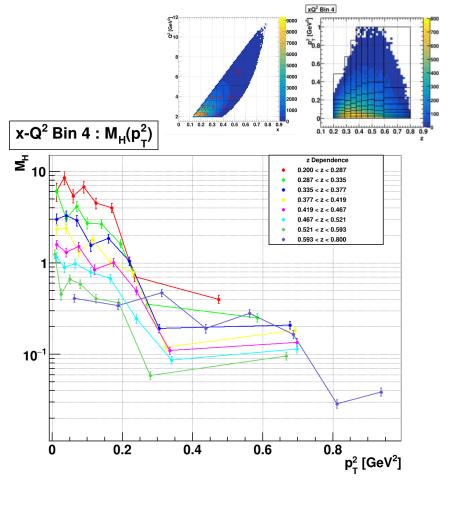
xQ² Bin 3



 $x-Q^2$ Bin 4 : A_H(p_T²) Å 10⁻¹ z Dependence 0.200 < z < 0.287 0.287 < z < 0.335 0.335 < z < 0.377 0.377 < z < 0.419 0.419 < z < 0.467 10⁻² 0.467 < z < 0.521 0.521 < z < 0.593 0.593 < z < 0.800 0.2 0.4 0.6 0.8 0 ´p_τ² [GeV²]

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 $A_{H}(z, P_{T}^{2}) \& M_{H}(z, P_{T}^{2})$ FOR xQ^{2} Bin 4

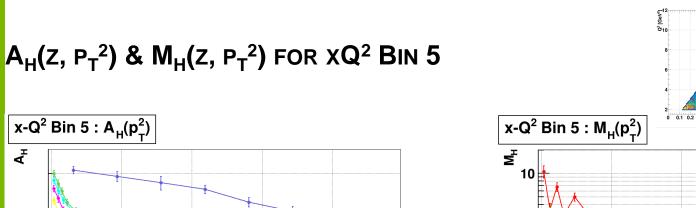


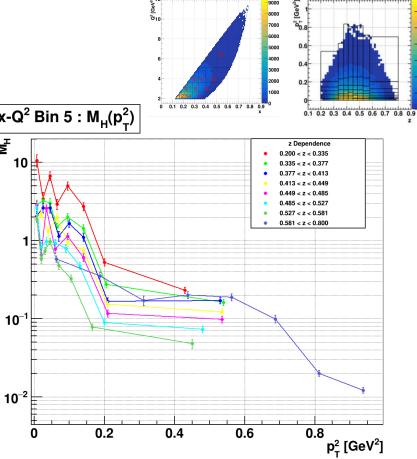




 $x-Q^2$ Bin 5 : $A_H(p_T^2)$ Ā **10**⁻¹ z Dependence 0.200 < z < 0.335 0.335 < z < 0.377 10⁻² 0.377 < z < 0.413 0.413 < z < 0.449 0.449 < z < 0.485 0.485 < z < 0.527 0.527 < z < 0.581 0.581 < z < 0.800 0.2 0.4 0.6 0.8 0 ′ p₇ [GeV²]

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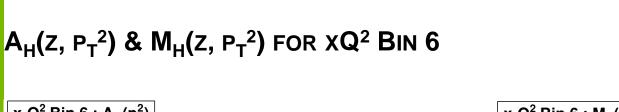
xQ² Bin 5

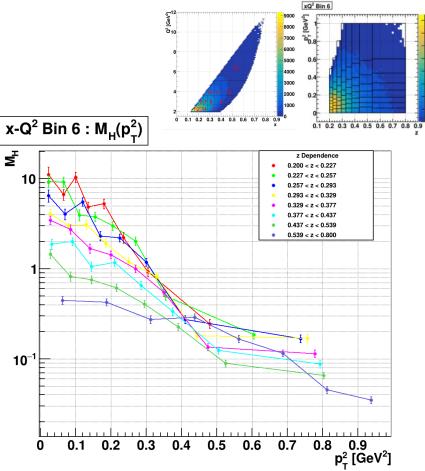




 $x-Q^2$ Bin 6 : $A_H(p_T^2)$ Å 10⁻¹ z Dependence 0.200 < z < 0.227 0.227 < z < 0.257 0.257 < z < 0.293 0.293 < z < 0.329 0.329 < z < 0.377 0.377 < z < 0.437 0.437 < z < 0.539 0.539 < z < 0.800 0.8 0.9 p₇² [GeV²] 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0

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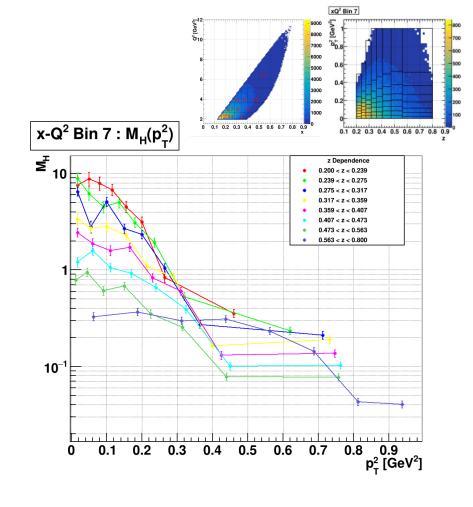




 $x-Q^2 Bin 7 : A_H(p_T^2)$ Å 10⁻¹ z Dependence 0.200 < z < 0.239 0.239 < z < 0.275 0.275 < z < 0.317 0.317 < z < 0.359 0.359 < z < 0.407 0.407 < z < 0.473 0.473 < z < 0.563 0.563 < z < 0.800 0.8 0.9 p₇² [GeV²] 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0

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 $A_{H}(z, P_{T}^{2}) \& M_{H}(z, P_{T}^{2})$ FOR xQ^{2} Bin 7



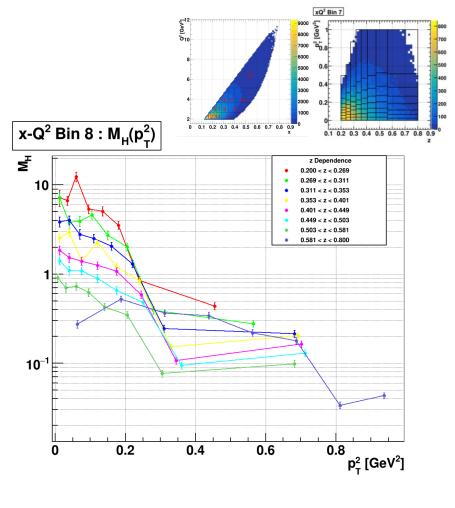




 $x-Q^2$ Bin 8 : A_H(p_T²) Å **10**⁻¹ z Dependence 0.200 < z < 0.269 0.269 < z < 0.311 0.311 < z < 0.353 0.353 < z < 0.401 0.401 < z < 0.449 0.449 < z < 0.503 0.503 < z < 0.581 0.581 < z < 0.800 0.2 0.4 0.6 0.8 0 ´p_τ² [GeV²]

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 $A_{H}(z, P_{T}^{2}) \& M_{H}(z, P_{T}^{2})$ FOR xQ^{2} Bin 8



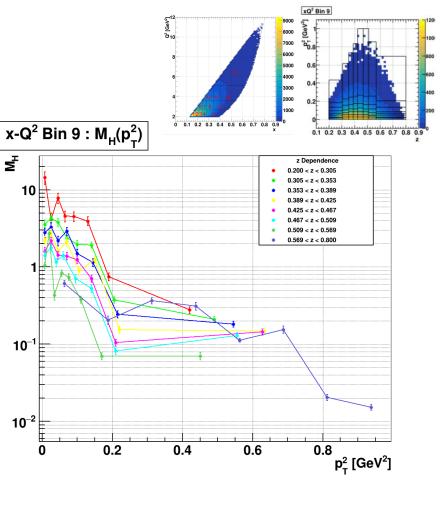




 $x-Q^2$ Bin 9 : $A_H(p_T^2)$ Ā 10z Dependence 0.200 < z < 0.305 0.305 < z < 0.353 0.353 < z < 0.389 10⁻² 0.389 < z < 0.425 0.425 < z < 0.467 0.467 < z < 0.509 0.509 < z < 0.569 0.569 < z < 0.800 0.2 0.4 0.6 0.8 0 ′ p₇ [GeV²]

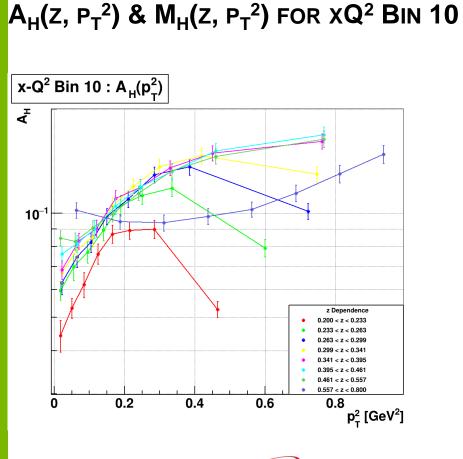
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 $A_{H}(z, P_{T}^{2}) \& M_{H}(z, P_{T}^{2})$ FOR xQ^{2} Bin 9

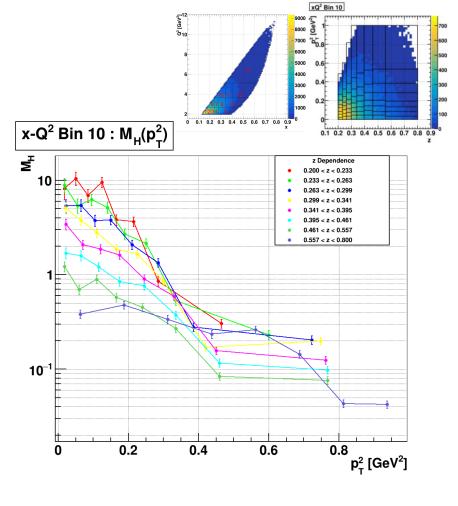


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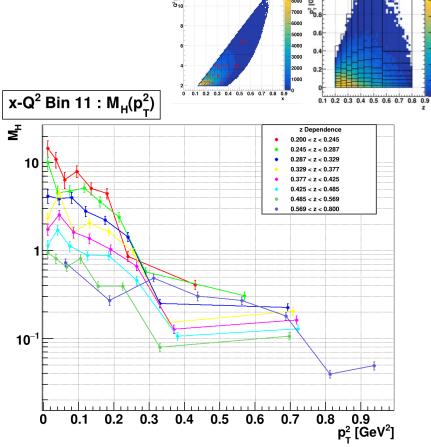




 $x-Q^2$ Bin 11 : A_H(p_T²) Å **10**⁻¹ z Dependence 0.200 < z < 0.245 0.245 < z < 0.287 0.287 < z < 0.329 0.329 < z < 0.377 0.377 < z < 0.425 0.425 < z < 0.485 0.485 < z < 0.569 0.569 < z < 0.800 0.8 0.9 p₇² [GeV²] 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0

A_H(z, p_T²) & M_H(z, p_T²) for xQ² Bin 11

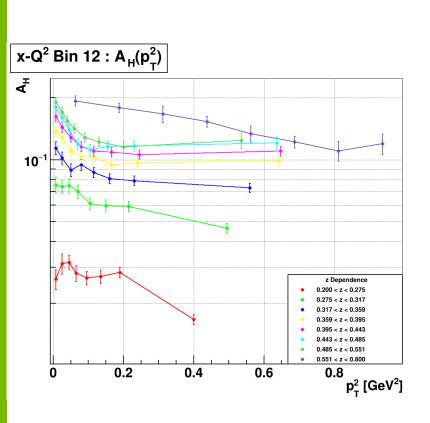
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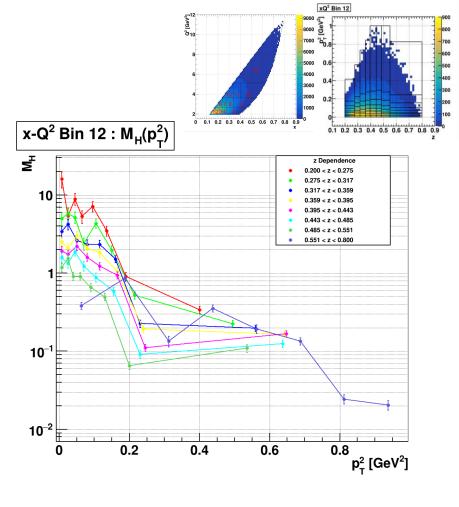
xQ² Bin 11





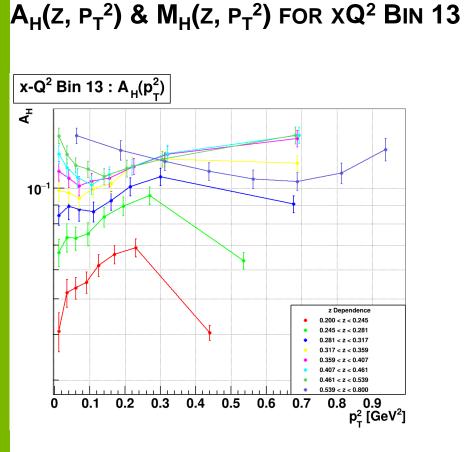
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 $A_{H}(z, P_{T}^{2}) \& M_{H}(z, P_{T}^{2})$ FOR xQ^{2} BIN 12

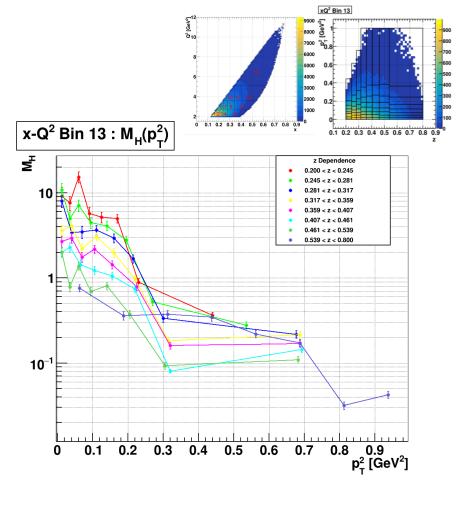








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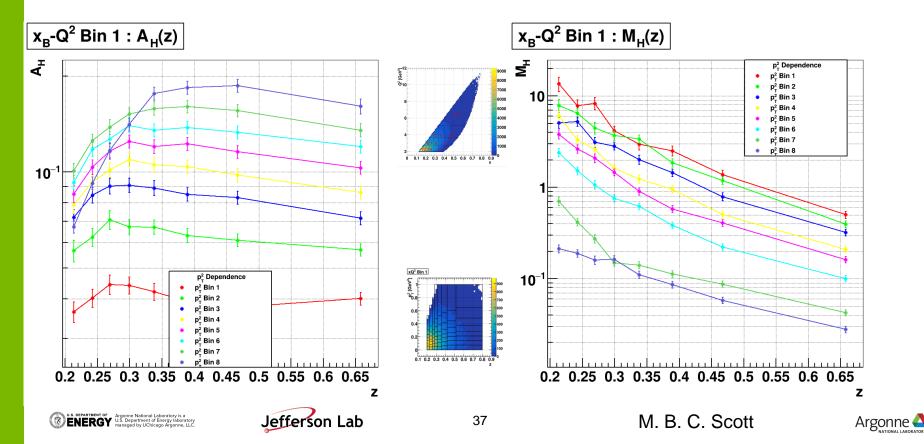
ACCEPTANCES AND MULTIPLICITIES FOR ALL $X_{\rm B}\text{-}Q^2$ BINS AS FUNCTIONS OF $P_{\rm T}{}^2$



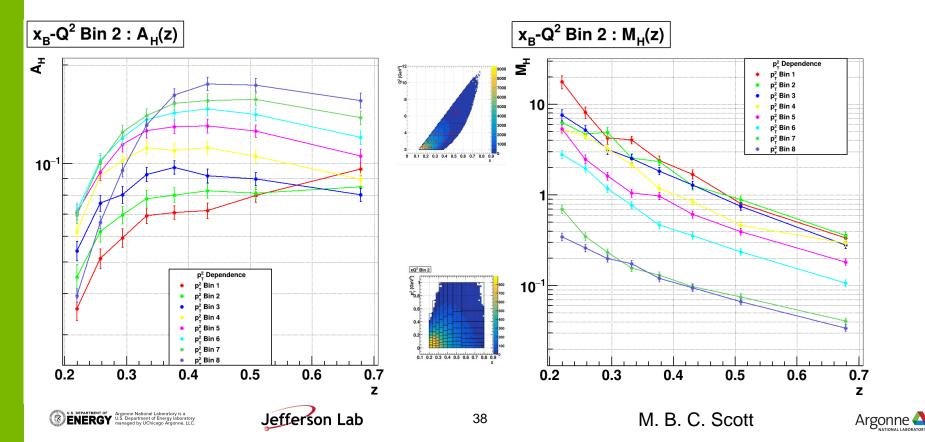
Argonne National Laboratory is a U.S. Department of Energy laboratory managed by UChicago Argonne, LLC.



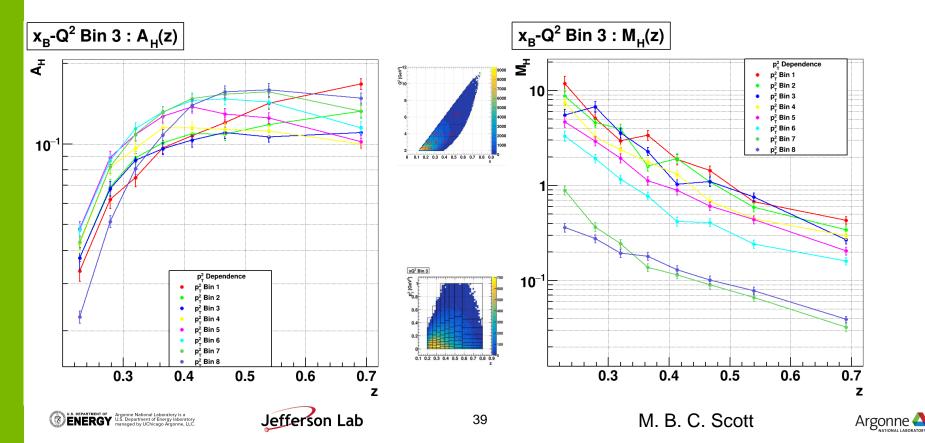
 $A_{H}(z, P_{T}^{2}) \& M_{H}(z, P_{T}^{2})$ for xQ^{2} Bin 1



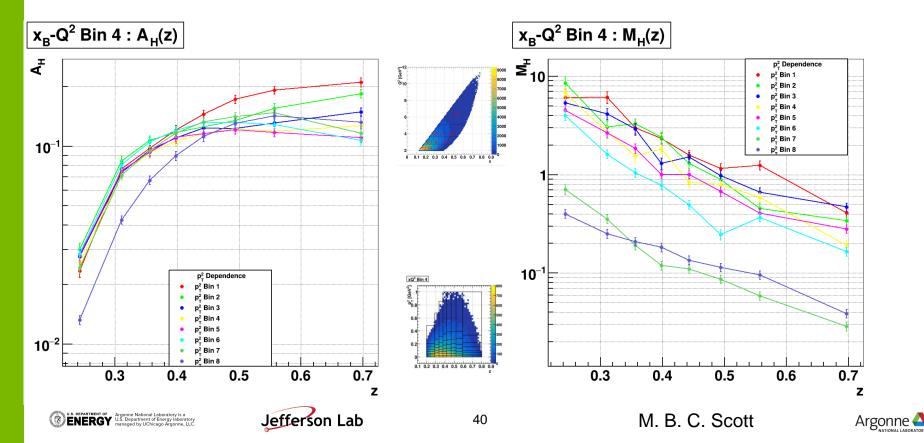
 $A_{H}(z, P_{T}^{2}) \& M_{H}(z, P_{T}^{2})$ FOR XQ^{2} BIN 2



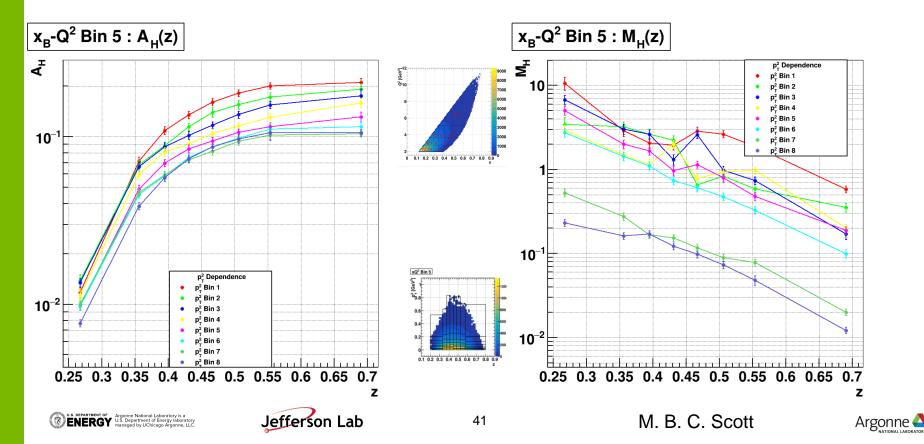
 $A_{H}(z, P_{T}^{2}) \& M_{H}(z, P_{T}^{2})$ FOR xQ^{2} Bin 3



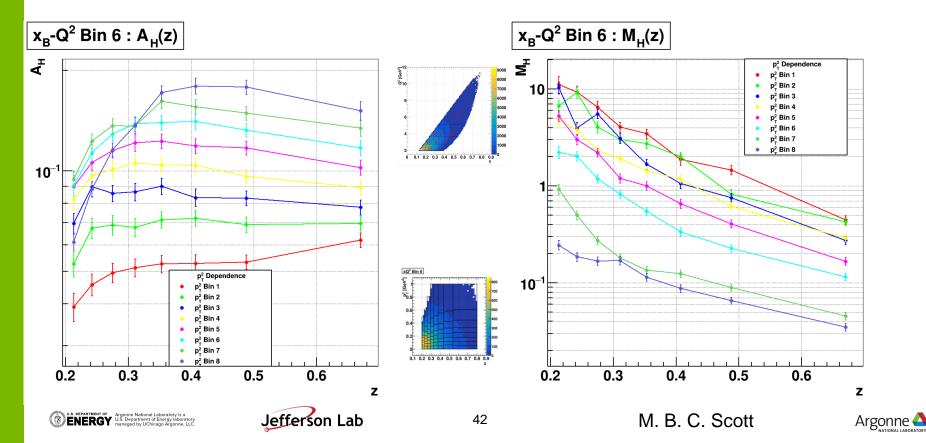
 $A_{H}(z, P_{T}^{2}) \& M_{H}(z, P_{T}^{2})$ for xQ^{2} Bin 4



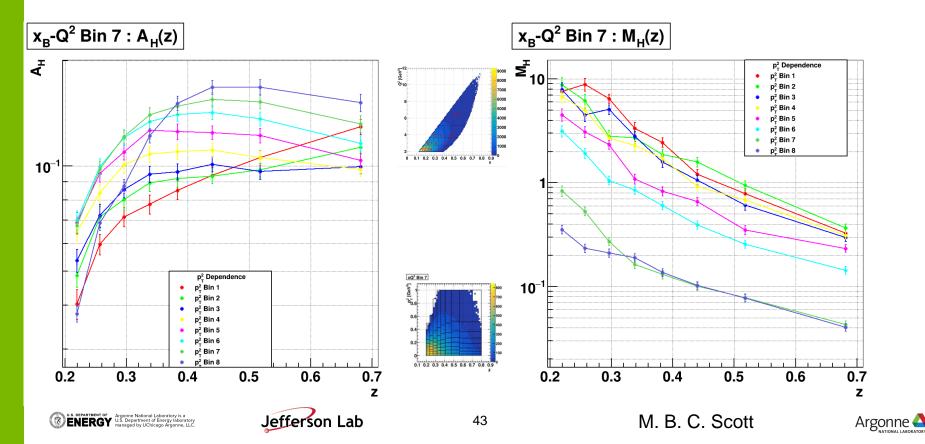
 $A_{H}(z, P_{T}^{2}) \& M_{H}(z, P_{T}^{2})$ FOR XQ^{2} Bin 5



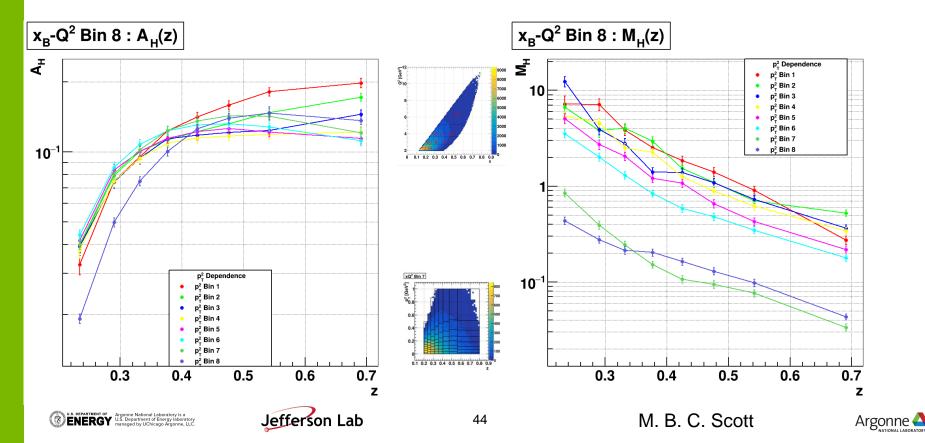
 $A_{H}(z, P_{T}^{2}) \& M_{H}(z, P_{T}^{2})$ FOR XQ^{2} BIN 6



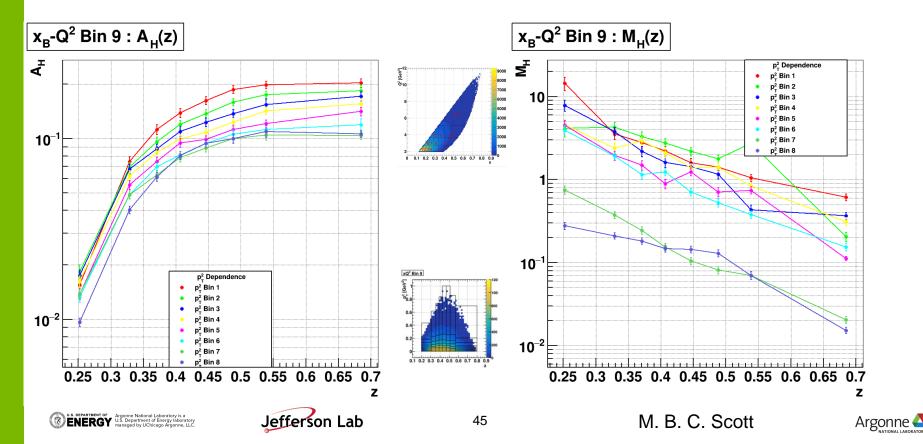
 $A_{H}(z, P_{T}^{2}) \& M_{H}(z, P_{T}^{2})$ for xQ^{2} Bin 7



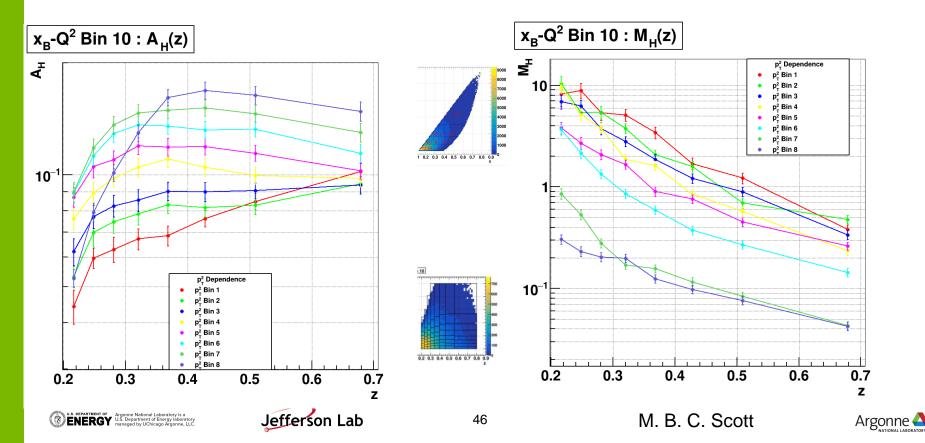
 $A_{H}(z, P_{T}^{2}) \& M_{H}(z, P_{T}^{2})$ FOR XQ^{2} BIN 8



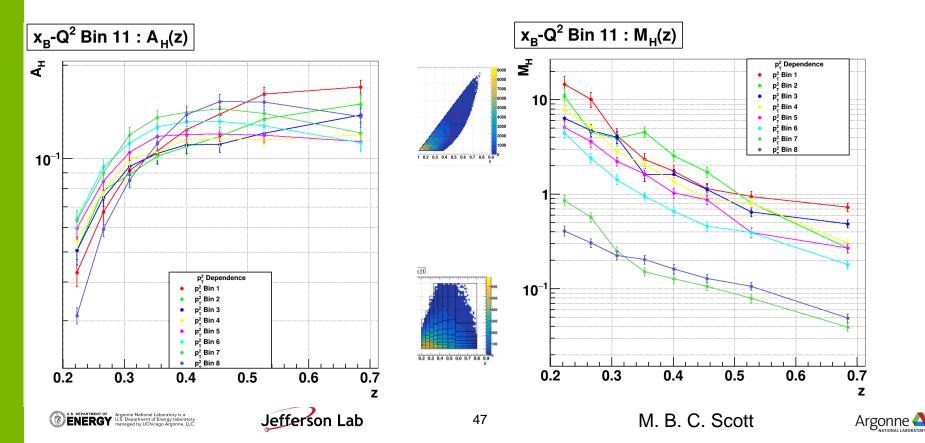
 $A_{H}(z, P_{T}^{2}) \& M_{H}(z, P_{T}^{2})$ FOR XQ^{2} BIN 9



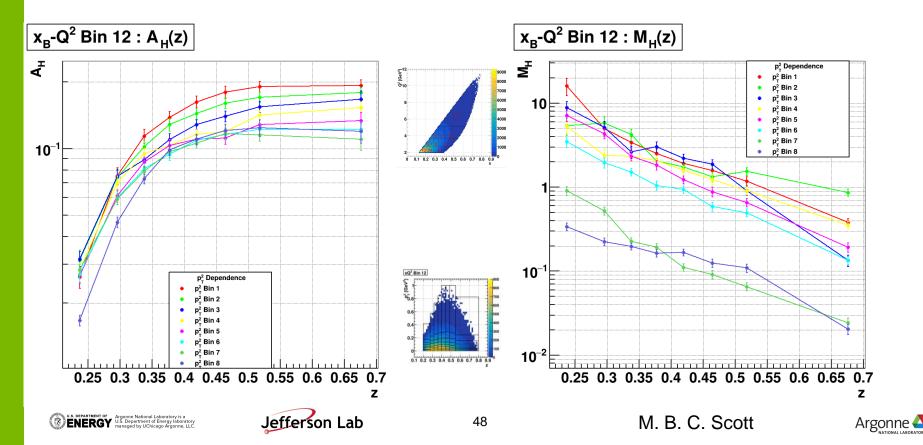
 $A_{H}(z, P_{T}^{2}) \& M_{H}(z, P_{T}^{2})$ FOR xQ^{2} Bin 10



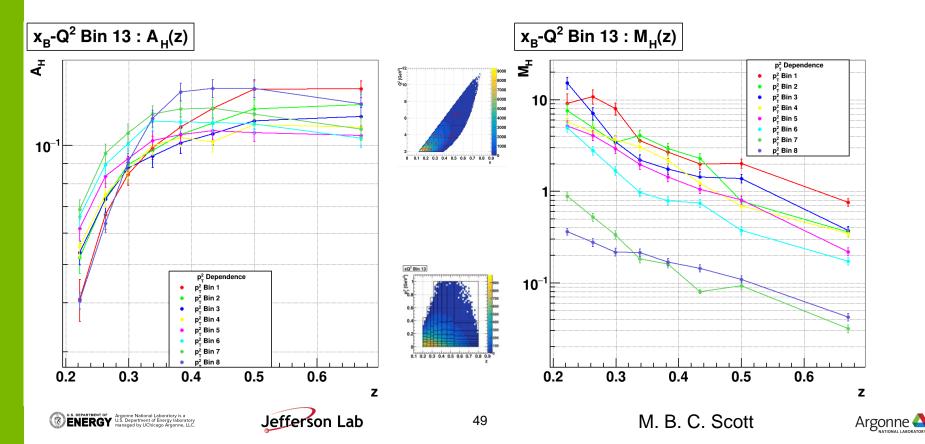
 $A_{H}(z, P_{T}^{2}) \& M_{H}(z, P_{T}^{2})$ FOR XQ^{2} BIN 11



 $A_{H}(z, P_{T}^{2}) \& M_{H}(z, P_{T}^{2})$ FOR xQ^{2} BIN 12



 $A_{H}(z, P_{T}^{2}) \& M_{H}(z, P_{T}^{2})$ FOR xQ^{2} Bin 13



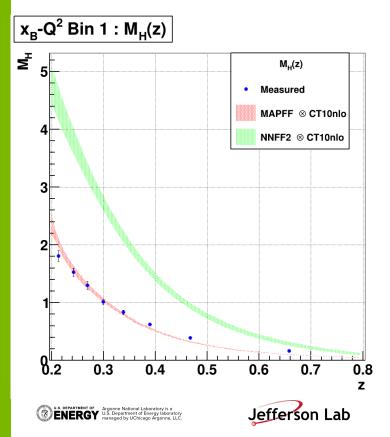
P_T² INTEGRATED MULTIPLICITIES

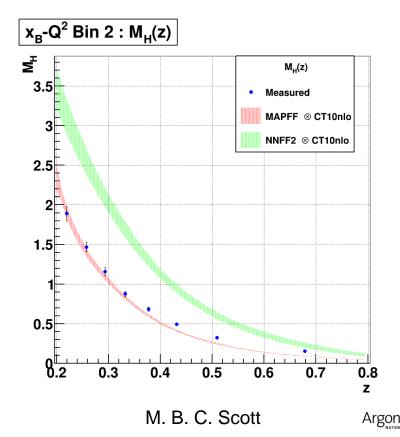


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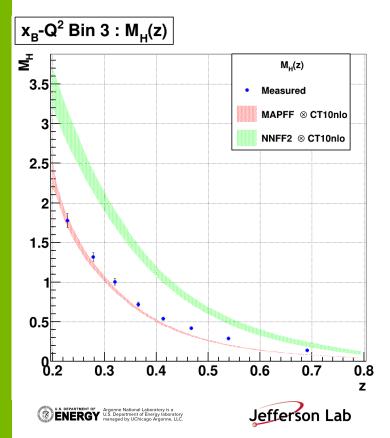
P_T² INTEGRATED M_H WITH LO THEORY PREDICTIONS : XQ² BINS 1 & 2

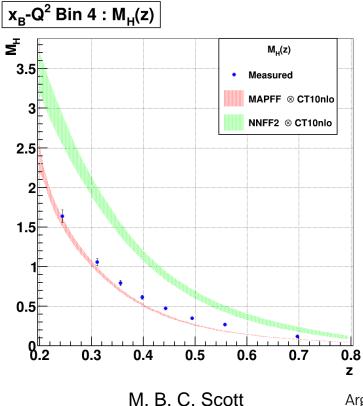




P_T² INTEGRATED M_H WITH LO THEORY PREDICTIONS : XQ² BINS 3 & 4

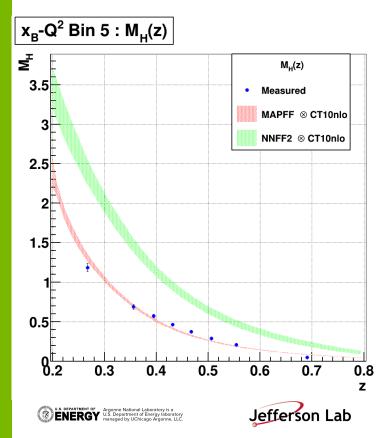
52

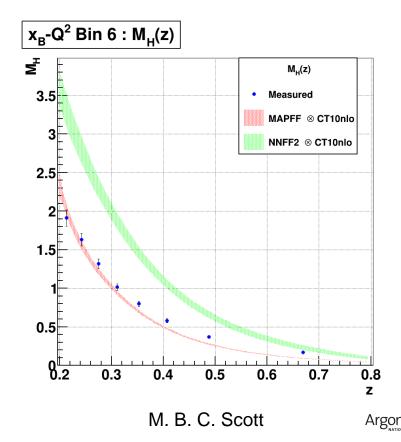




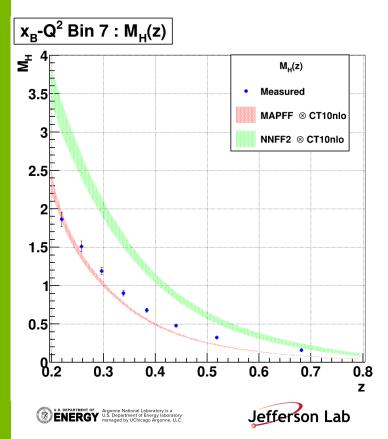
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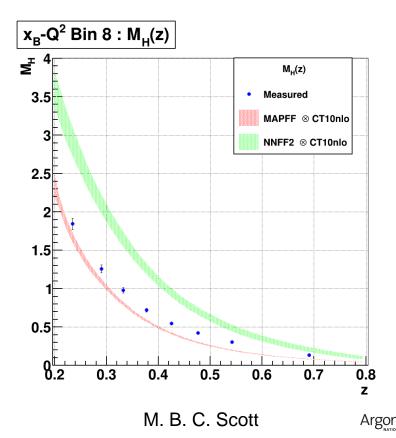
P_T² INTEGRATED M_H WITH LO THEORY PREDICTIONS : XQ² BINS 5 & 6



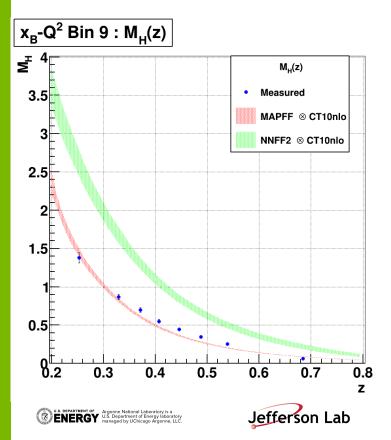


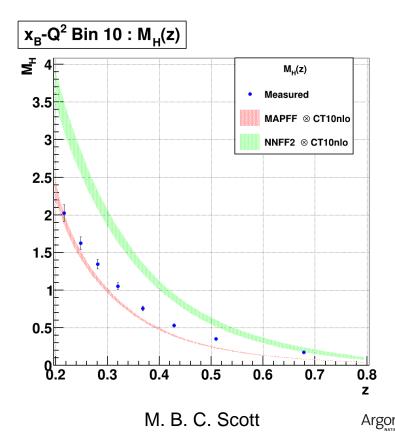
P_T² INTEGRATED M_H WITH LO THEORY PREDICTIONS : XQ² BINS 7 & 8





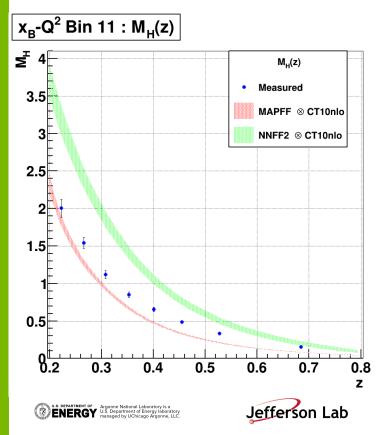
P_T² INTEGRATED M_H WITH LO THEORY PREDICTIONS : XQ² BINS 9 & 10

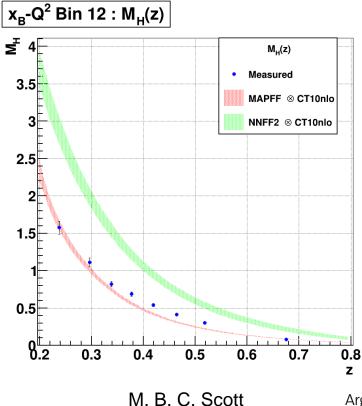




P_T² INTEGRATED M_H WITH LO THEORY PREDICTIONS : XQ² BINS 11 & 12

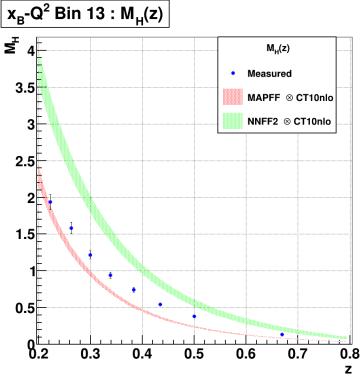
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P_T^2 Integrated M_H with LO Theory Predictions : xQ^2 bin 13









Phi Trento Studies

- The previous results just integrated over φ_h instead of fitting the distributions and extracting the A term.
- The results that follow are a first look at the φ_h distributions within each x-Q²-zp_T² bin.
- For these results, the binning scheme has been modified
 - Same each x-Q²-z- p_T^2 binning as before
 - $-\,12\;\phi_h$ bins
 - $-20~m_{_{\gamma\gamma}}$ bins
- Within each φ_h bin the m_{γγ} distribution is fit and the number of pions and associated error is extracted. The fit range has been extended to 0.03-0.35 GeV, to help bring down the fit on the left side of the mass peak, but the signal region is the same.







PHI TRENTO STUDIES 2

- Within each ϕ_h bin the m_{yy} distribution is fit and the number of pions and the integral error is extracted.
- 1st Order cuts
 - -Bin content > 1 pion
 - -Acceptance > 1e-4
 - Bin content > bin error
 - -Background ≥ 0
 - Some of the polynomial fits will give negative background in the signal region
 - The polynomial power was decreased and refit if this happened







$\varphi_{H}(Z, P_{T}^{2})$ DISTRIBUTIONS

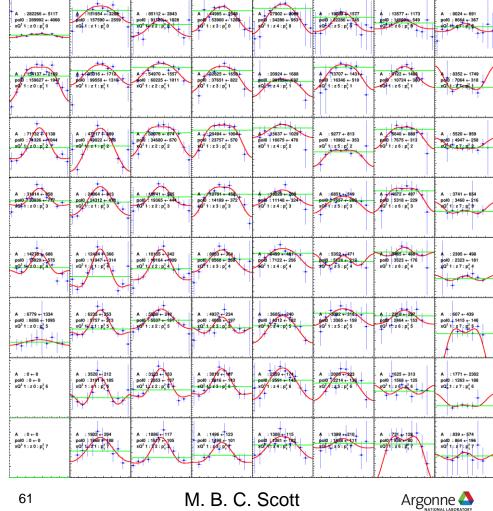
- The following results show the φ_h distribution with the A (1 + Bcos(φ_h) + Ccos(2φ_h)) fit in red along with a pol0 fit in green.
- The A and the pol0 terms are also listed.







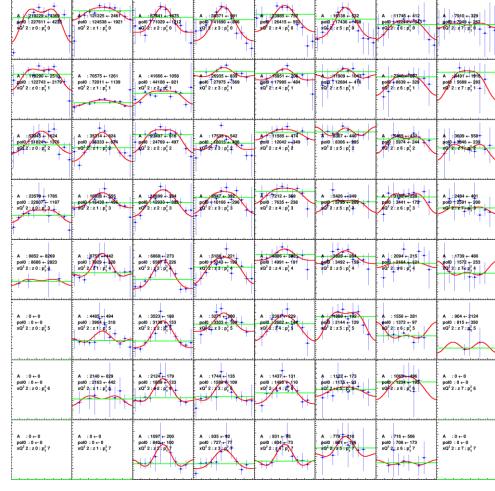
X-Q² BIN 1 : $\varphi_{H}(Z, P_{T}^{2})$







X-Q² BIN 2 : $\varphi_{H}(Z, P_{T}^{2})$



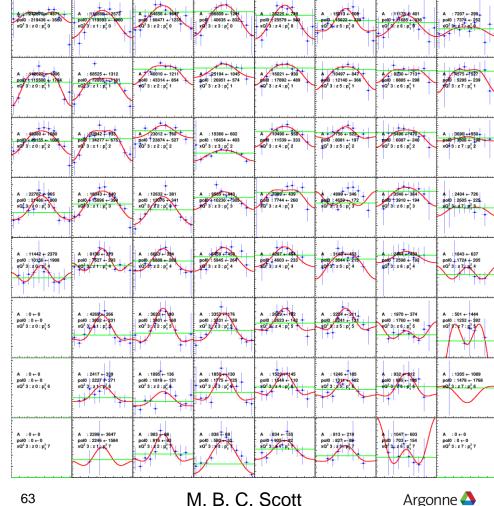




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X-Q² BIN 3 : $\varphi_{H}(Z, P_{T}^{2})$

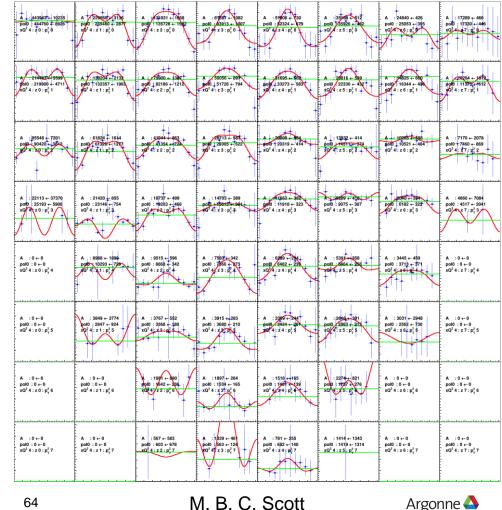


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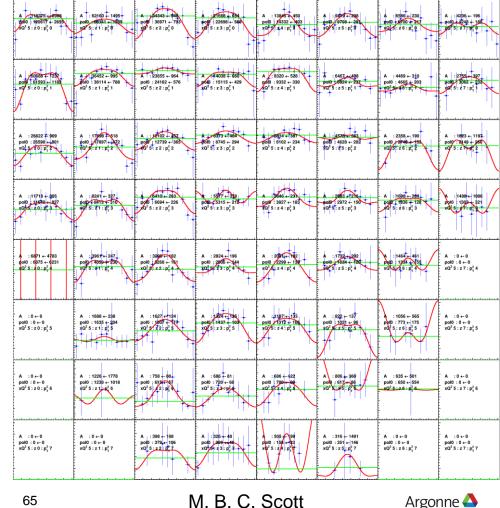
X-Q² BIN 4 : $\varphi_{H}(Z, P_{T}^{2})$



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X-Q² BIN 5 : $\varphi_{H}(Z, P_{T}^{2})$

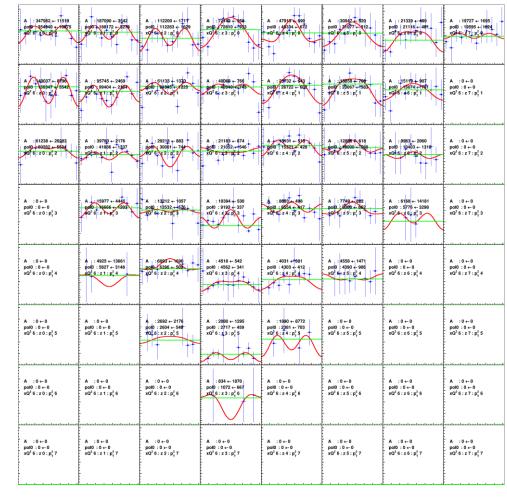


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X-Q² BIN 6 : $\varphi_{H}(Z, P_{T}^{2})$



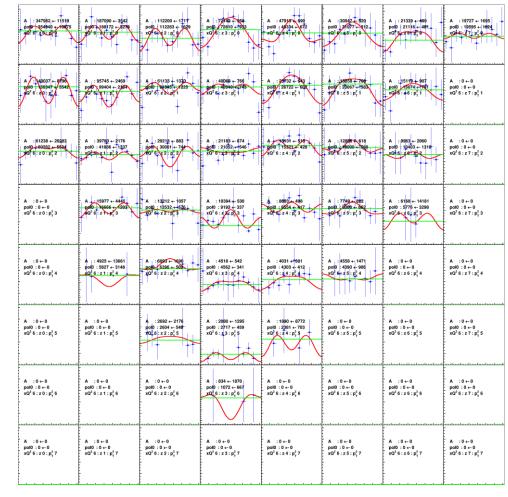




66



X-Q² BIN 7 : $\varphi_{H}(Z, P_{T}^{2})$









X-Q² BIN 8 : $\varphi_{H}(Z, P_{T}^{2})$

A +: 132909 +: 6678	A +: 73474 +- 1998	A : 44649 +- 932	A : 29606 + 649	A : 18809 +- 446-	A : 12348 +- 439	A : 8511 + 780	A :0+-0
gold : 133744 +: 6883	pol00: 74266 +: 1973	pcD + 44301 +- 919	pol0 : 29581 + 633	pol0 : 18983 +- 434	pol0 : 12339 +- 432	polb : 8525 - 775	pol0:0+-0
GG 8 +: 0 -: 52 - 9	- 40° 8 v 1: p° 0 +-	AQ' 8 \x 2 : p 0 +	x0 6: 4 3: p 0	x0 ² 8 : 3 46 n ² 0	xQ ² 8 : z 5 : p ⁺ ₁ 0	- x0' 8 - 2 6 : 1 0	xQ ² 8:z7:p _y ² 0
A 83354 + 5891 Folo 52031 + 5891 YaQ 8 : 0 : 0 : 0 : 0 : 0 : 0 : 0 : 0 : 0 :	4723 + 147 600 127064 + 164 x0' 8.2 1 : p.1	A : 23594 + 739 potp: 22754 + 739 \$0' 8, 22.19 \$0' 9, 22.19 \$0' 9, 22.19 \$10' 9, 22.19 \$10' 9, 22.19 \$10' 9, 22.19 \$10' 10' 10' 10' 10' 10' 10' 10' 10' 10'	A 14754 + 522 pot N985 + 500 0 8: 2 3 6, 1	A :9580 + 498 pol0 :9781 + 467 x0 ² 8:24 P	A : 6770 + 715 pol0 : 7272 + 616 x0 ² 8; z 5; p ² + +	A :0 +-0 pol0 :0 +-0 x0 ² 8 : z6 : p ² ₇ 1	A :0+-0 pol0 :0+-0 xQ ² 8 : z 7 : p ₁ ² 1
A : 15867 +- 14760 pol0 : 15971 +- 14902 $x0^2 8 : z 0 : p^2 2$	A : 13930 + 2087 500 15619 + 800 x0 ² 8 1 1 p ²	A : ND64 + 691 pol0 ; 113954 - 520 xQ'8 : z2 ; p 2	A 7769 - 504 polo : 619 - 419 x0° 8 : z 3 : p ² ₇ 2	A : 4810 +- 576 poly : 5231 + 497 x0 8: 2 3 + 497 	A :3038 + 9707 pol0 : 3956 + 1598 x0° 6 : 2 5 : p ² 2	A :0 +0 pol0:0 +0 x0 ² 8:z6:p ² ₁ 2	A : 0 + 0 pol0 : 0 + 0 $x0^2 8 : z 7 : p_{T}^2 2$
A :0+-0 pol0:0+0 x0 ² 8:z0:p ₇ ² 3	A : 5096 + 14383 pol0 : 6659 + 2174 sQ18; z1 : p ² ₇ 3	A 5049 +- 1618 Fol0 : 5133 507 xQ ² 8: z 2: p ² _y 3	A : 3219 + 633 pol0 : 3531 + 477 pol0 : 3531 + 477	A : 4429 + 1790 pol0 : 3057 + 822 pol 8 : z 4 : p 3 pol 9 : z 4 : p 3	A : 0 +- 0 pol0 : 0 +- 0 $xQ^2 8 : z 5 : p_y^2 3$	A :0+-0 pol0:0+-0 x0 ² 8:z6:p ₇ ² 3	A :0+-0 pol0:0+-0 x0 ² 8:z7:p ₇ ² 3
A :0+-0	A : 0 +- 0	A : 3395 + 3097	A : 3483 + 5605	A :0+-0	A : 0 +- 0	A :0+-0	A :0 ⊷ 0
pol0:0+0	pol0 : 0 +- 0	Pol0 : 287 + 878	polD : 3415 + 2615	pol0:0+-0	pol0 : 0 +- 0	pol0:0+-0	pol0:0 ← 0
x0 ² 8:z0:p ₇ ² 4	$xQ^2 8: z 1: p_T^2 4$	O ² 8 /z 2 : p ² 4	xQ [↑] 8 : z 3 : p ₁ ² 4	xQ ² 8:z4:p _y ² 4	$xQ^2 8: z 5: p_y^2 4$	xQ ² 8:z6:p ² ₇ 4	xQ ² 8:z7:p ₇ ² 4
A :0+-0	A : 0 +- 0	A : 0 +- 0	A :0+-0	A : 0 +- 0	A : 0 +- 0	A :0+-0	A :0 +-0
pol0:0+0	pol0 : 0 +- 0	pol0 : 0 +- 0	pol0:0+-0	pol0 : 0 +- 0	pol0 : 0 +- 0	pol0:0+-0	pol0:0 +-0
xQ ² 8:20:p ₇ ² 5	$xQ^2 8 : z 1 : p_T^2 5$	$xQ^2 8 : z 2 : p_y^2 5$	xQ ² 8:z3:p ₁ ² 5	$xQ^2 8 : z 4 : p_y^2 5$	$xQ^2 8 : z 5 : p_y^2 5$	xQ ² 8:z6:p ₁ ² 5	xQ ² 8:z7:p _y ² 5
A :0+-0	$A : 0 \leftarrow 0$	A : 0 +- 0	A :0 +-0	A : 0 ← 0	A : 0 ← 0	A :0 +-0	A : 0 +- 0
pol0:0+0	pol0 : 0 \leftarrow 0	pol0 : 0 +- 0	pol0:0 +-0	pol0 : 0 ← 0	pol0 : 0 + 0	pol0:0 +-0	pol0 : 0 +- 0
xQ ² 8:z0:p ₇ ² 6	x Q ² 8 : z 1 : p _x ² 6	$xQ^2 8 : x 2 : p_y^2 6$	x0 ² 8:z3:p ² ₇ 6	x Q ² 8 : z 4 : p ₁ ² 6	xQ ² 8 : z 5 : p _x ² 6	x0 ² 8:z6:p ² ₁ 6	$xQ^2 8: z7: p_{\gamma}^2 6$
A :0+−0	A : 0 +- 0	A : 0 + 0	A :0 +-0	$ \begin{array}{c} A : 0 \leftarrow 0 \\ pol0 : 0 \leftarrow 0 \\ x O^{2} 8 : z 4 : p_{\psi}^{2} 7 \end{array} $	A :0 +-0	A :0++0	A :0 +-0
pol0:0+0	pol0 : 0 +- 0	pol0 : 0 + 0	pol0:0 +-0		pol0 :0 +-0	pol0:0+-0	pol0:0 +-0
xQ ² 8:20:p ² ₇ 7	$x \Omega^2 8 : z 1 : p_{\pi}^2 7$	xQ ² 8 : x 2 : p_{χ}^2 7	x0 ² 8:z3:p ₁ ² 7		x0 ² 8 : z 5 : p ² ₇ 7	x0 ² 8:z6:p ₁ ² 7	xQ ² 8:z7:p ₇ ² 7



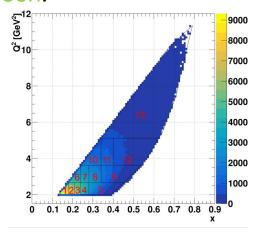


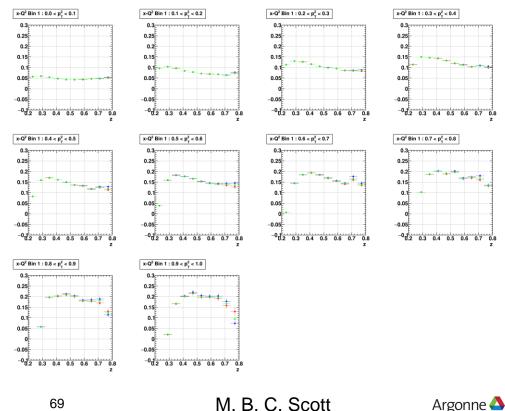
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A(z) IN X-Q² BIN 1

- To the right is the acceptance of the z distributions.
- The uncut distributions are in blue, $M_x > 1.5$ in red, and $M_x > 1$ in green.

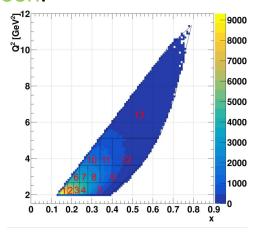


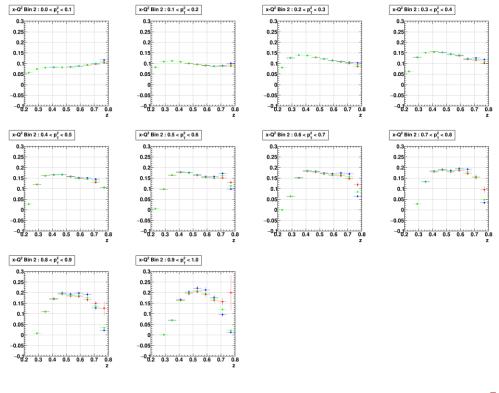




A(z) in x-Q² bin 2

- To the right is the acceptance of the z distributions.
- The uncut distributions are in blue, M_x > 1.5 in red, and M_x > 1 in green.







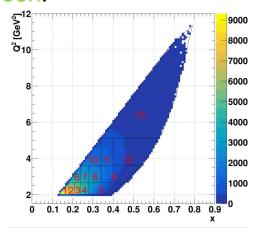
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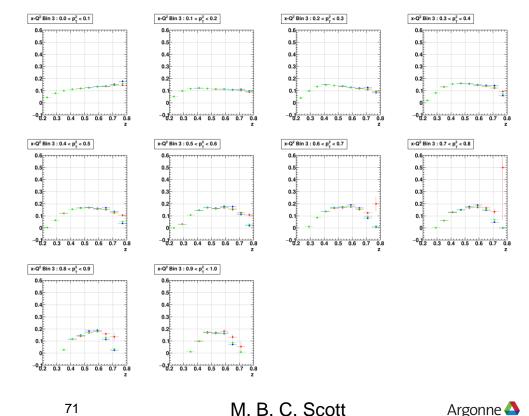
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A(z) in x-Q² bin 3

- To the right is the acceptance of the z distributions.
- The uncut distributions are in blue, M_x > 1.5 in red, and M_x > 1 in green.

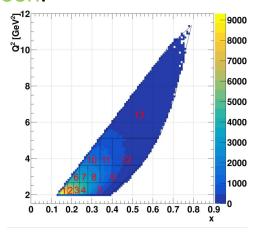




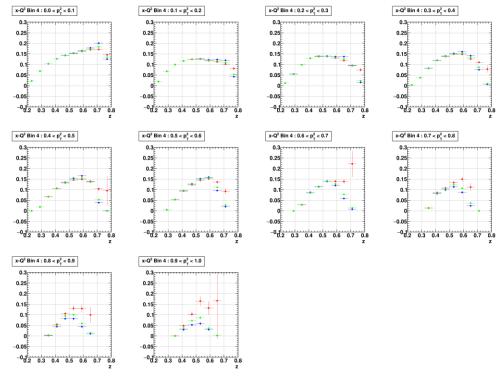


A(z) in x-Q² bin 4

- To the right is the acceptance of the z distributions.
- The uncut distributions are in blue, M_x > 1.5 in red, and M_x > 1 in green.



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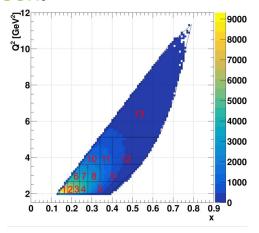


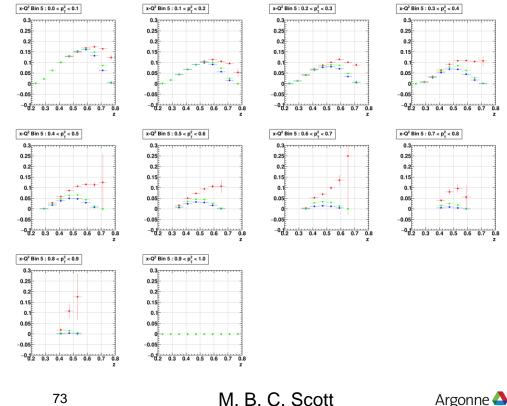




A(z) IN X- Q^2 BIN 5

- To the right is the acceptance of the z distributions.
- The uncut distributions are in blue, $M_x > 1.5$ in red, and $M_x > 1$ in green.

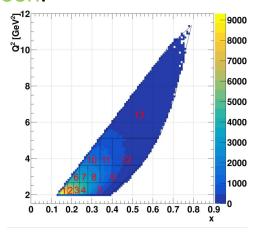


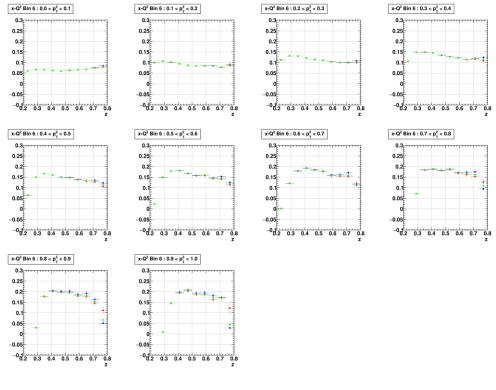






- To the right is the acceptance of the z distributions.
- The uncut distributions are in blue, M_x > 1.5 in red, and M_x > 1 in green.



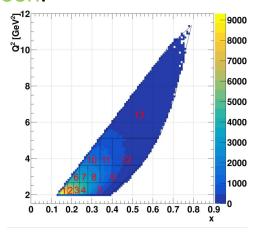


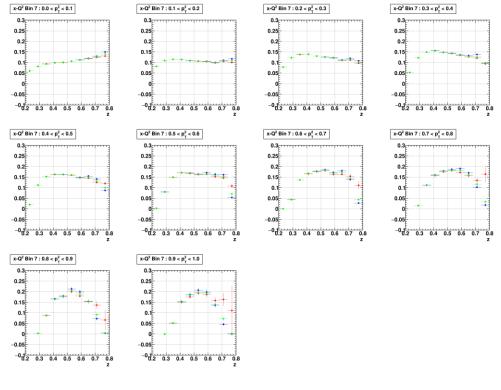
M. B. C. Scott



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- To the right is the acceptance of the z distributions.
- The uncut distributions are in blue, M_x > 1.5 in red, and M_x > 1 in green.



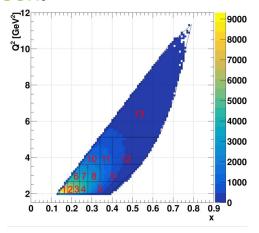


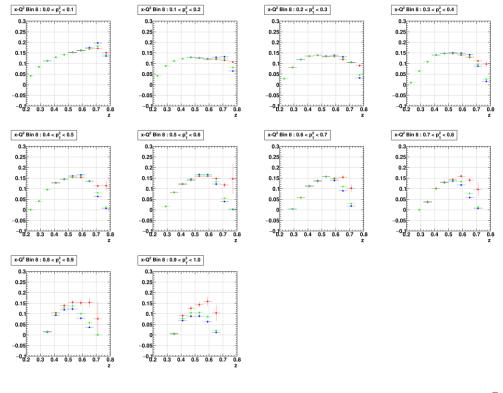




A(z) in x-Q² bin 8

- To the right is the acceptance of the z distributions.
- The uncut distributions are in blue, M_x > 1.5 in red, and M_x > 1 in green.







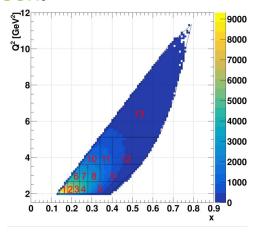
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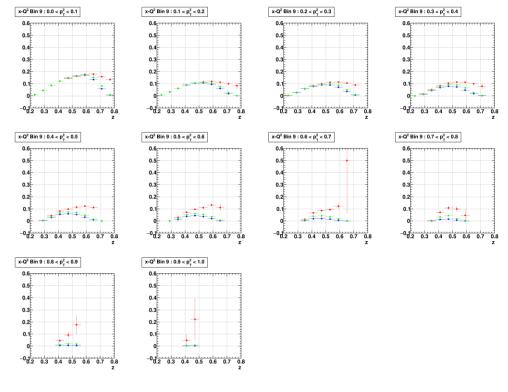
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A(z) in x-Q² bin 9

- To the right is the acceptance of the z distributions.
- The uncut distributions are in blue, M_x > 1.5 in red, and M_x > 1 in green.





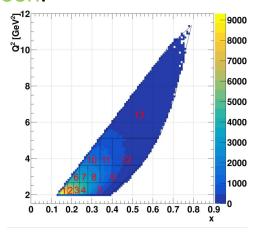


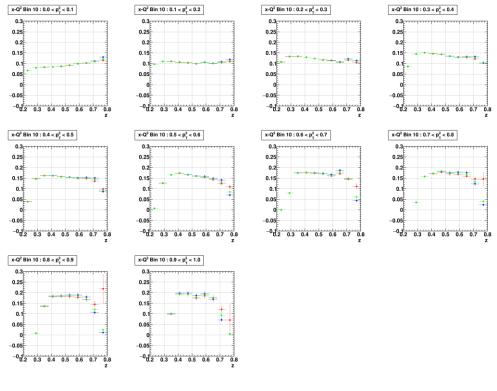
77



A(z) IN X-Q² BIN 10

- To the right is the acceptance of the z distributions.
- The uncut distributions are in blue, M_x > 1.5 in red, and M_x > 1 in green.





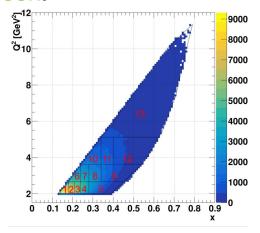


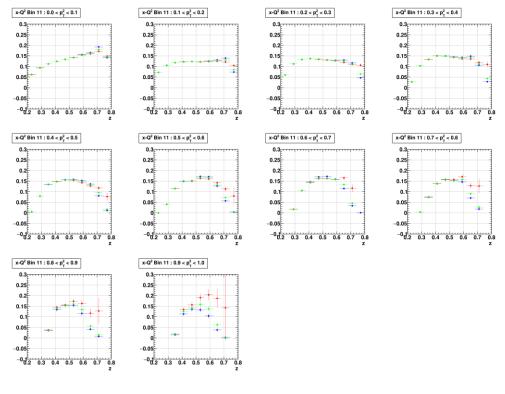




A(z) IN x-Q² BIN 11

- To the right is the acceptance of the z distributions.
- The uncut distributions are in blue, M_x > 1.5 in red, and M_x > 1 in green.







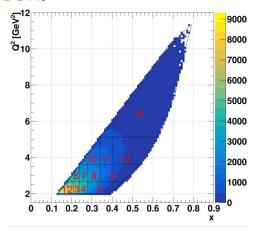
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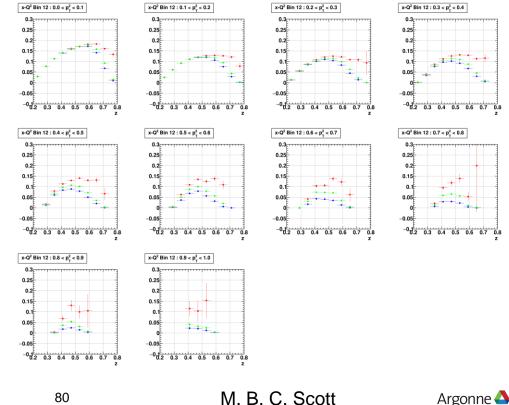
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A(z) IN X-Q² BIN 12

- To the right is the acceptance of the z distributions.
- The uncut distributions are in blue, $M_x > 1.5$ in red, and $M_x > 1$ in green.



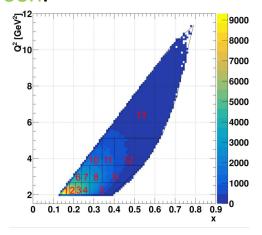




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A(z) IN X-Q² BIN 13

- To the right is the acceptance of the z distributions.
- The uncut distributions are in blue, M_x > 1.5 in red, and M_x > 1 in green.



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