SIDIS @ RGB
Fragmentation analysis overview

JLAB SIDIS working group

June-13, 2023

Fragmentation analysis

- We study fragmentation ratio off the deuteron

$$r(z) = \frac{4 - \left(\sigma_d^{\pi^+} / \sigma_d^{\pi^-}\right)}{4\left(\sigma_d^{\pi^+} / \sigma_d^{\pi^-}\right) - 1}$$

- *Goal: SRC-tagged ratio*

- *1st step: untagged ratio*

Fragmentation analysis

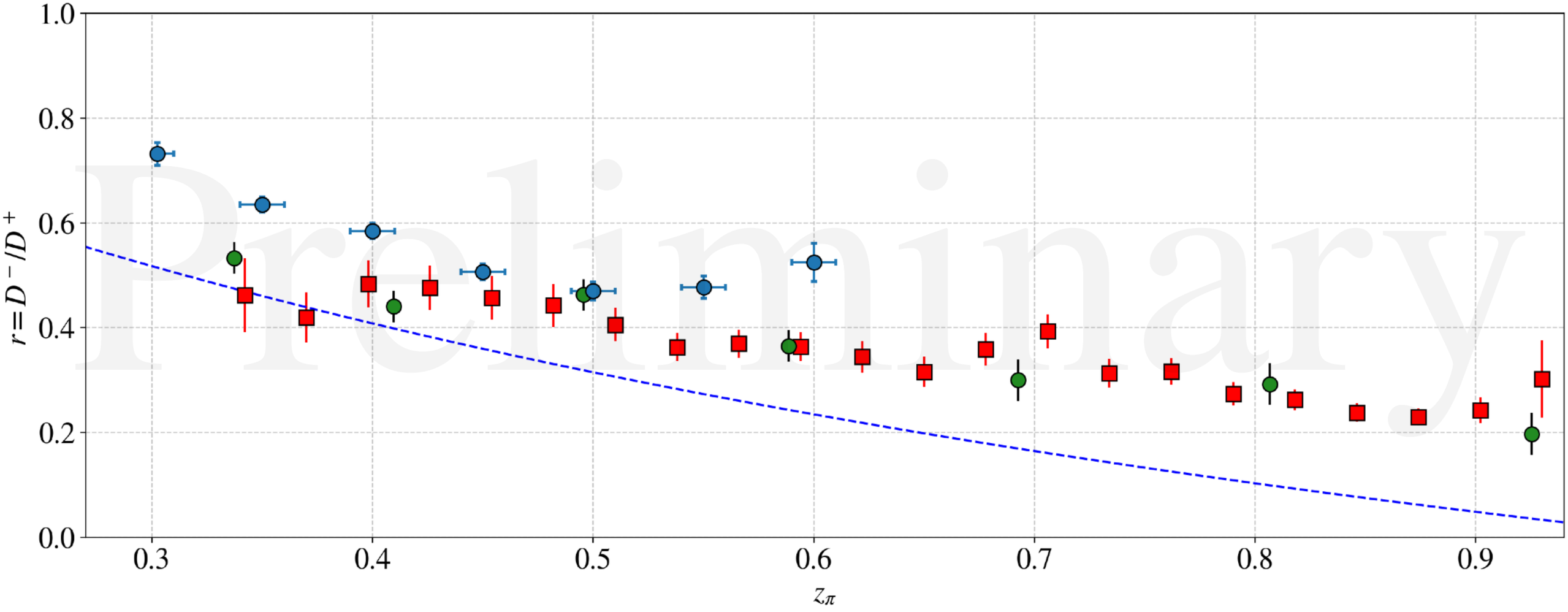
- We study fragmentation ratio off the deuteron

$$r(z) = \frac{4 - \left(\sigma_d^{\pi^+} / \sigma_d^{\pi^-}\right)}{4\left(\sigma_d^{\pi^+} / \sigma_d^{\pi^-}\right) - 1}$$

- *Goal: SRC-tagged* high-virtuality p in np-SRC
- *1st step: untagged* n or p in d

Fragmentation analysis status

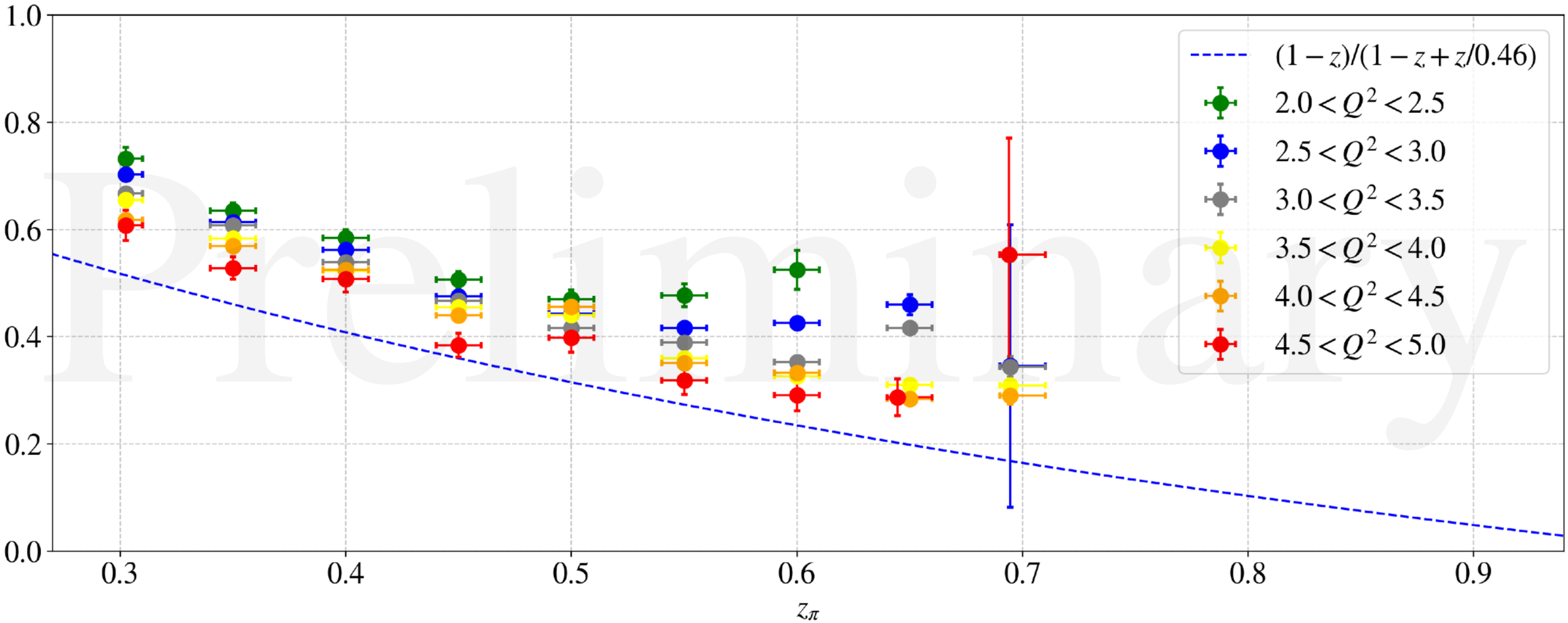
- Low Q^2 - data consistent with published ones



Preliminary

Fragmentation analysis status

- Low Q^2 - data consistent with published ones
- High Q^2 - data approach FF prediction



Fragmentation analysis status

- Low Q^2 - data consistent with published ones
- High Q^2 - data approach FF prediction
- We believe our analysis is ready for review

1. Spring-2019 run at 10.2 GeV beam,

   /cache/clas12/rg-b/production/recon/spring2019/torus-1/pass1/v0/dst/train/sidisdvcs/

2. Spring-2020 run at 10.4 GeV beam,

   /cache/clas12/rg-b/production/recon/spring2020/torus-1/pass1/v1/dst/train/sidisdvcs/

3. Spring-2019 run at 10.6 GeV beam,

   /cache/clas12/rg-b/production/recon/spring2019/torus-1/pass1/v0/dst/train/sidisdvcs/

SIDIS@RGB | Statistics

E_{beam} [GeV]	$d(e, e'\pi^+)$	$d(e, e'\pi^-)$
10.2	12.5 M	7.7 M
10.4	11.0 M	6.8 M
10.6	9.8 M	6.1 M
total	33.3 M	20.6 M

SIDIS@RGB | Event selection cuts

Requirement	Cut
$d(e, e'\pi)$ in the forward detector	
PCAL fiducial cuts	$V_{PCAL} > 19$ cm, $W_{PCAL} > 19$ cm
PCAL minimum energy deposition cut	$PCAL_{dep} > 70$ MeV
Calorimetry sampling fraction	$\frac{PCAL+ECIN+ECOUT}{p_e} > 0.17$
	$\frac{E_{ECIN}}{p} > 0.2 - \frac{E_{PCAL}}{p}$
Vertex z position	-13.0 cm $< v_z < +12.0$ cm
Difference between vertex z-position of the electron and the pion	$\lvert v_z(e) - v_z(\pi)\rvert < 20.0$ cm
Cut on χ^2_{PID} from the Event Builder for the pions	See Section 3.2.2

DC fiducial cuts	See Section 3.3
Enhance DIS contribution	$W > 2.5$ GeV/c^2
Enhance DIS contribution	$Q > 2$ (GeV/c)^2
Suppress QE contribution	$y < 0.75$
Reduce the contamination from exclusive processes	$M_x > 1.7$ GeV/c^2
Suppress Kaon contamination in the pion sample	$1.25 < p_\pi < 5$ GeV/c
Focus on high acceptance the HTCC	$5° < \theta_e < 35°$, $5° < \theta_\pi < 35°$
Leading outgoing pions	$z_\pi > 0.3$
π^+ and π^- acceptance matching	See Section 3.5

SIDIS@RGB | Event selection cuts

e and π Particle ID

e and π fiducial cuts (PCAL, DC)

Calorimetry energy deposition

$5^\circ < \theta_e < 35^\circ, 5^\circ < \theta_\pi < 35^\circ$

$|v_z^e - v_z^\pi| < 20$ cm

$1.25 < p_\pi < 5.0$ GeV/c (π/K separation)

$0.3 < z < 1.0$

π^+/π^- acceptance matching

1.7 GeV $< M_x(e, e'\pi)$

DIS

2 (GeV/c)$^2 < Q^2 < 10$ (GeV/c)^2

2.5 (GeV/c)$^2 < W$

$y = \dfrac{\omega}{E_{beam}} < 0.75$ (avoid QE)

SIDIS@RGB | Event selection cuts

e and π Particle ID

e and π fiducial cuts (PCAL, DC)

Calorimetry energy deposition

$5^\circ < \theta_e < 35^\circ, 5^\circ < \theta_\pi < 35^\circ$

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DIS

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$y = \dfrac{\omega}{E_{beam}} < 0.75$ (avoid QE)

Approved PID developed by RGA SIDIS group

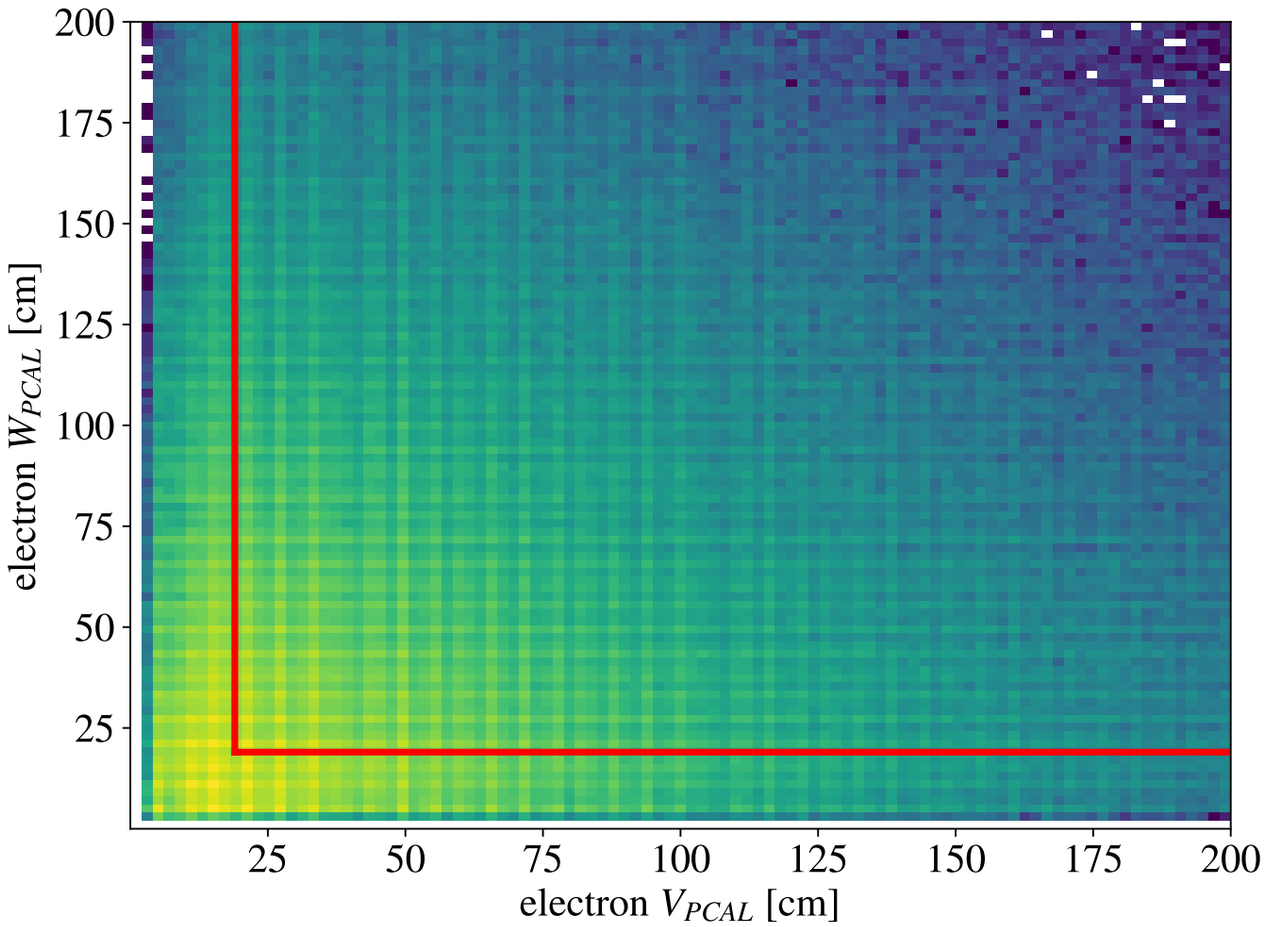
π^+/π^- acceptance matching

$1.7\ \mathrm{GeV} < M_x(e, e'\pi)$

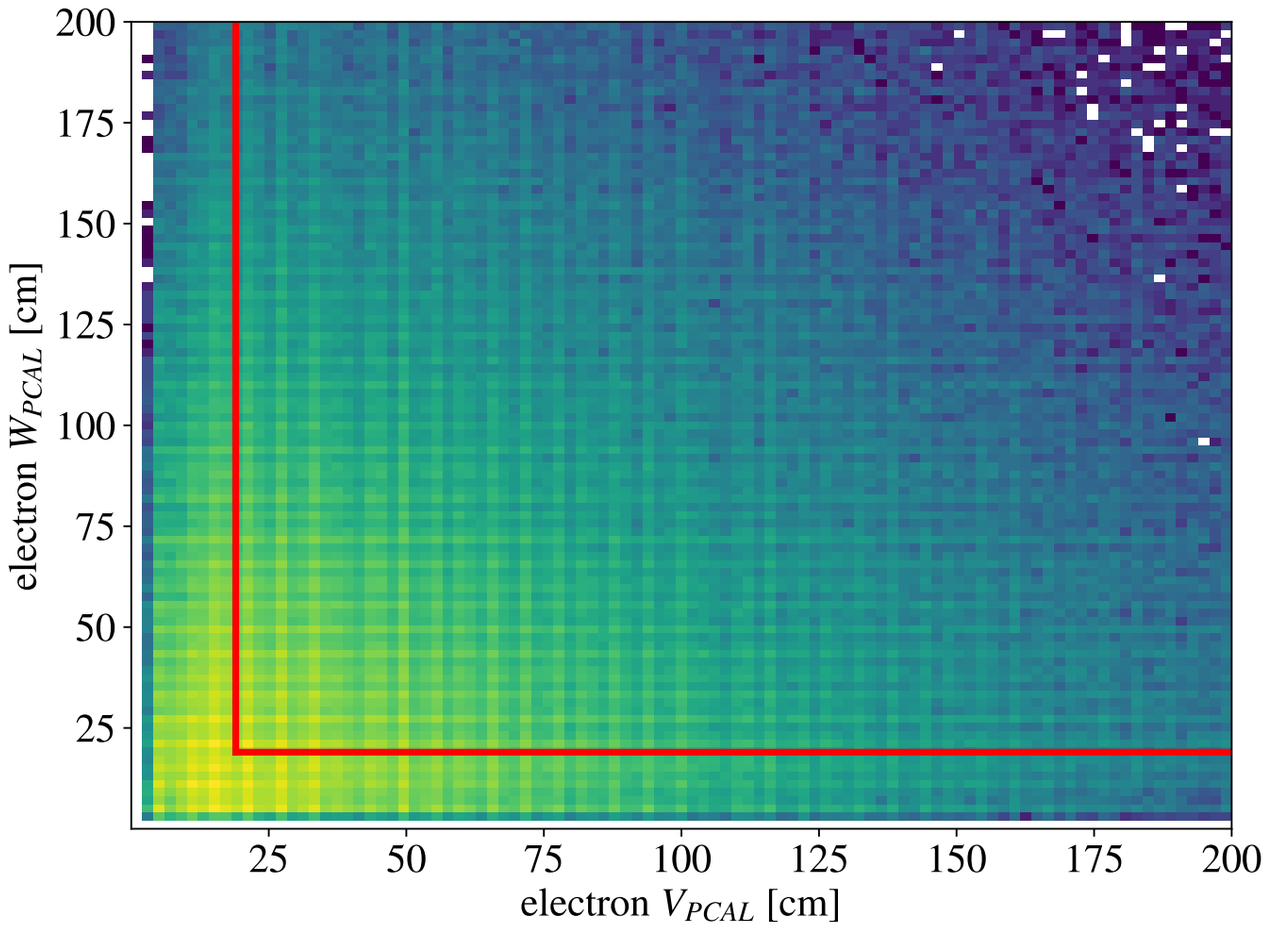
"Cleaning" the event-sample

SIDIS@RGB | *e*-PID cuts - PCAL fiducial cuts

π^+



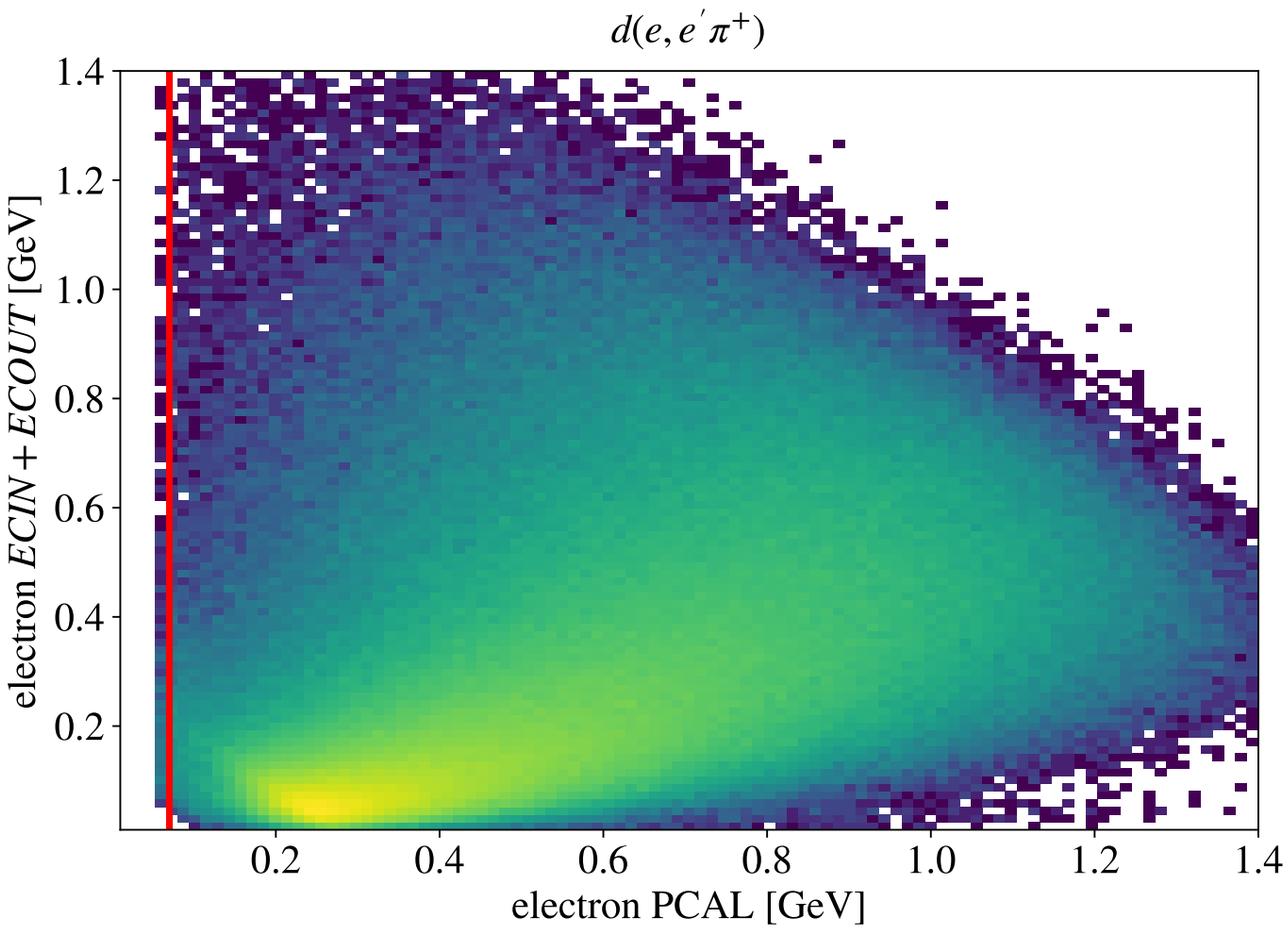
π^-



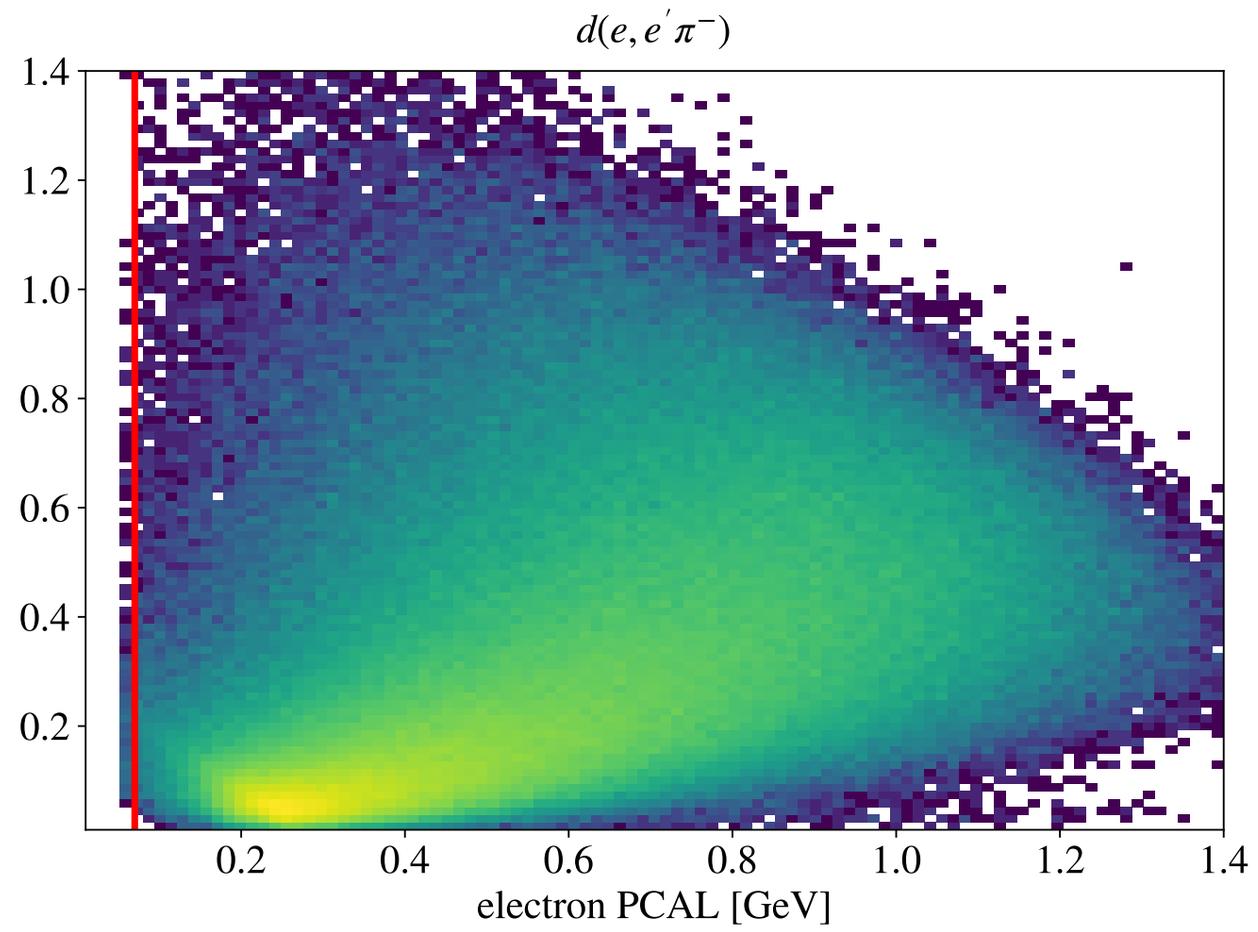
$$V_{PCAL} > 19 \text{ cm}, W_{PCAL} > 19 \text{ cm}$$

SIDIS@RGB | *e*-PID cuts - ECIN + ECOUT

π^+



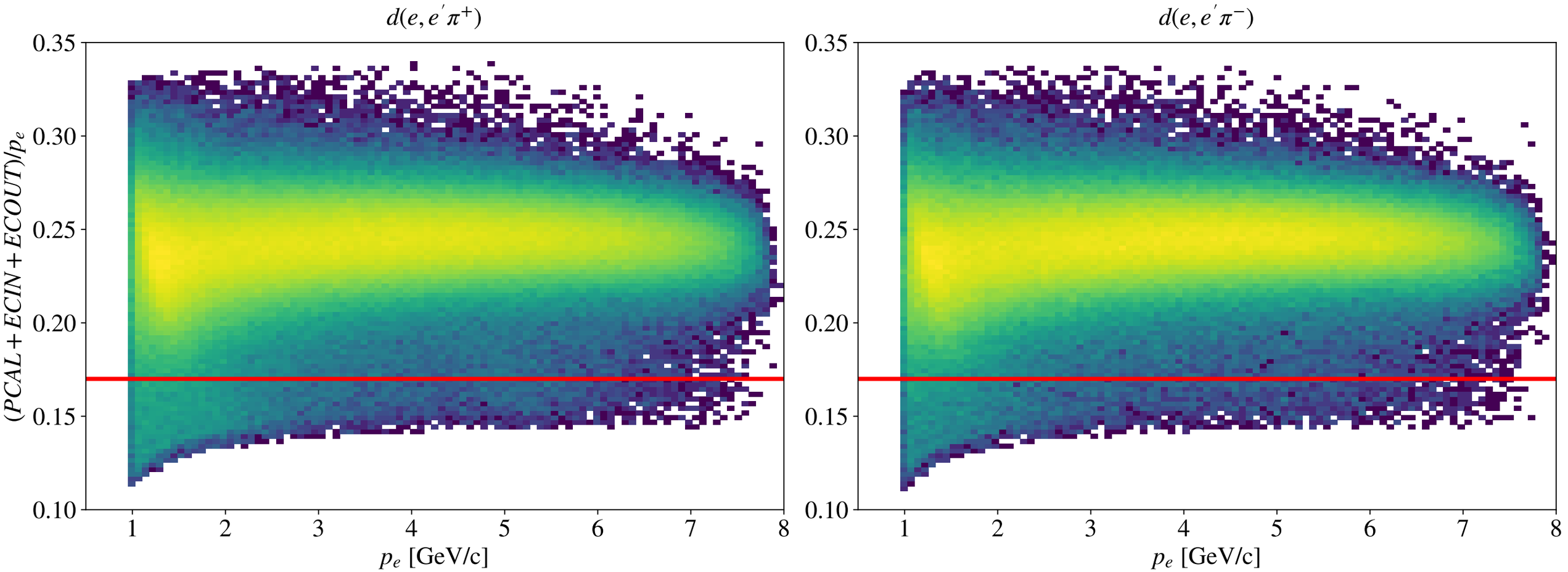
π^-



$$PCAL_{dep} > 70 \text{ MeV}$$

SIDIS@RGB | *e*-PID cuts - Sampling fraction

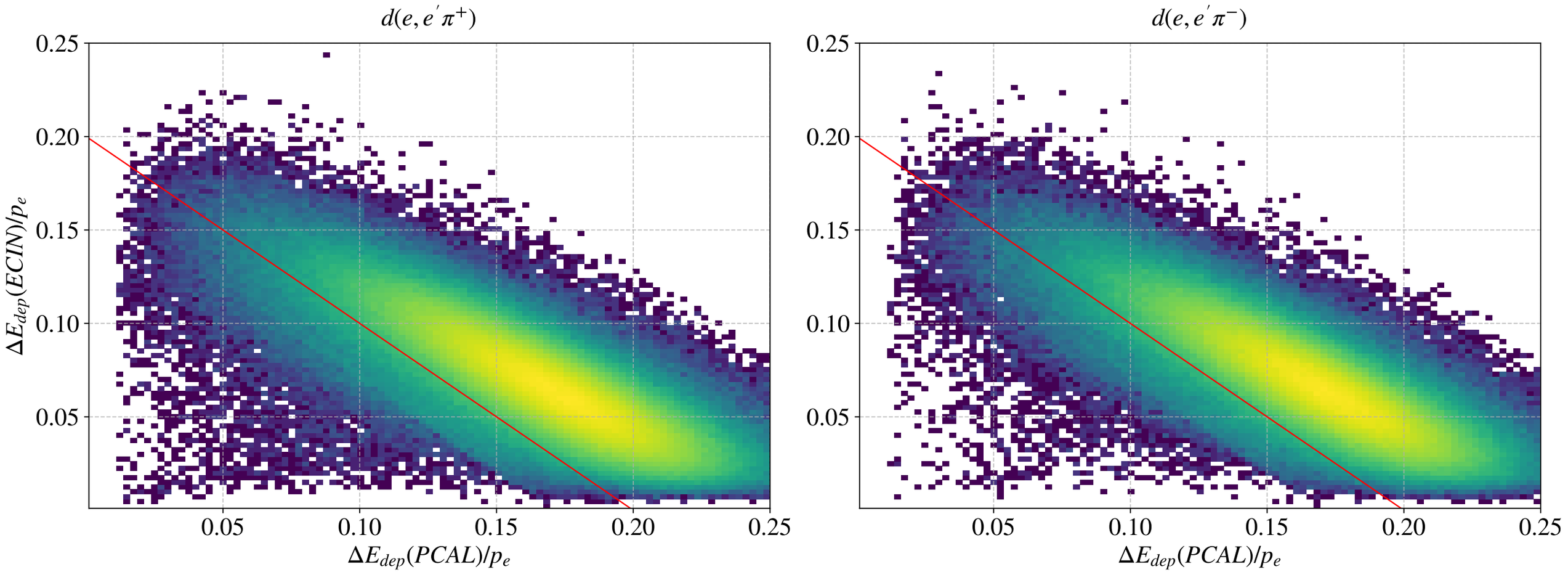
π^+ π^-



$$\frac{PCAL+ECIN+ECOUT}{p_e} > 0.17$$

SIDIS@RGB | *e*-PID cuts - Sampling fraction vs. PCAL

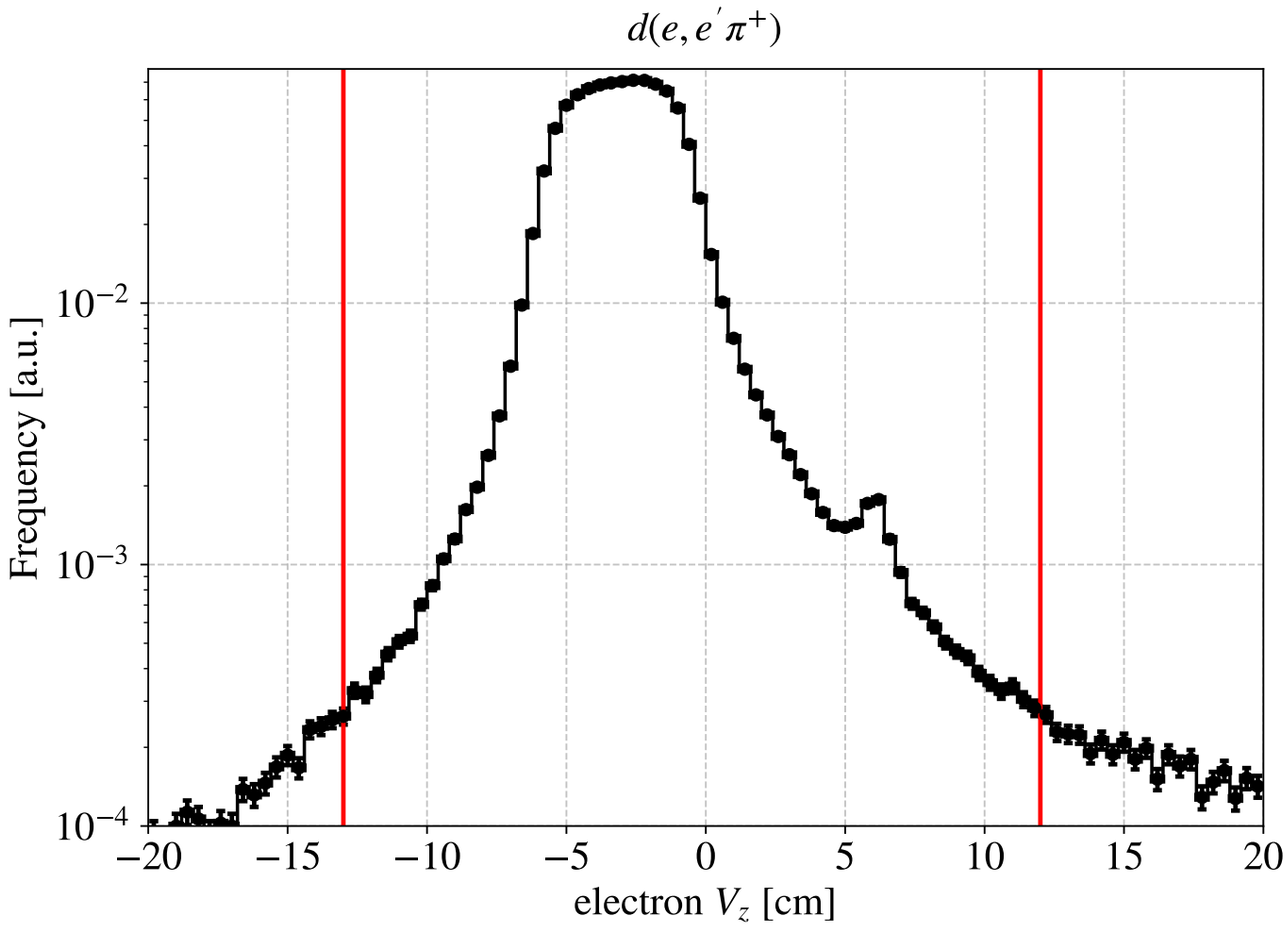
π^+ π^-



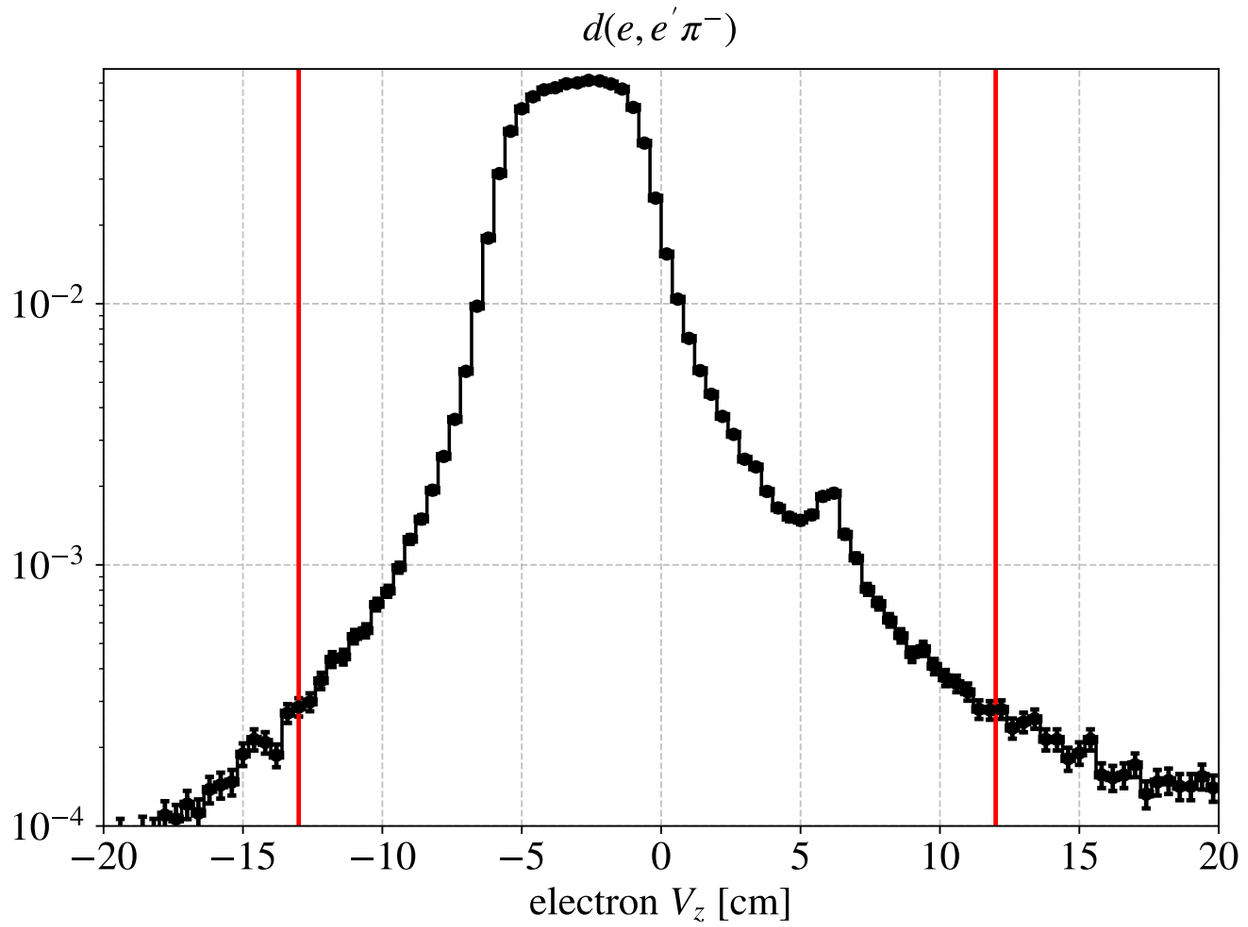
$$\frac{E_{ECIN}}{p} > 0.2 - \frac{E_{PCAL}}{p}$$

SIDIS@RGB | *e*-PID cuts - *e* vertex

π^+



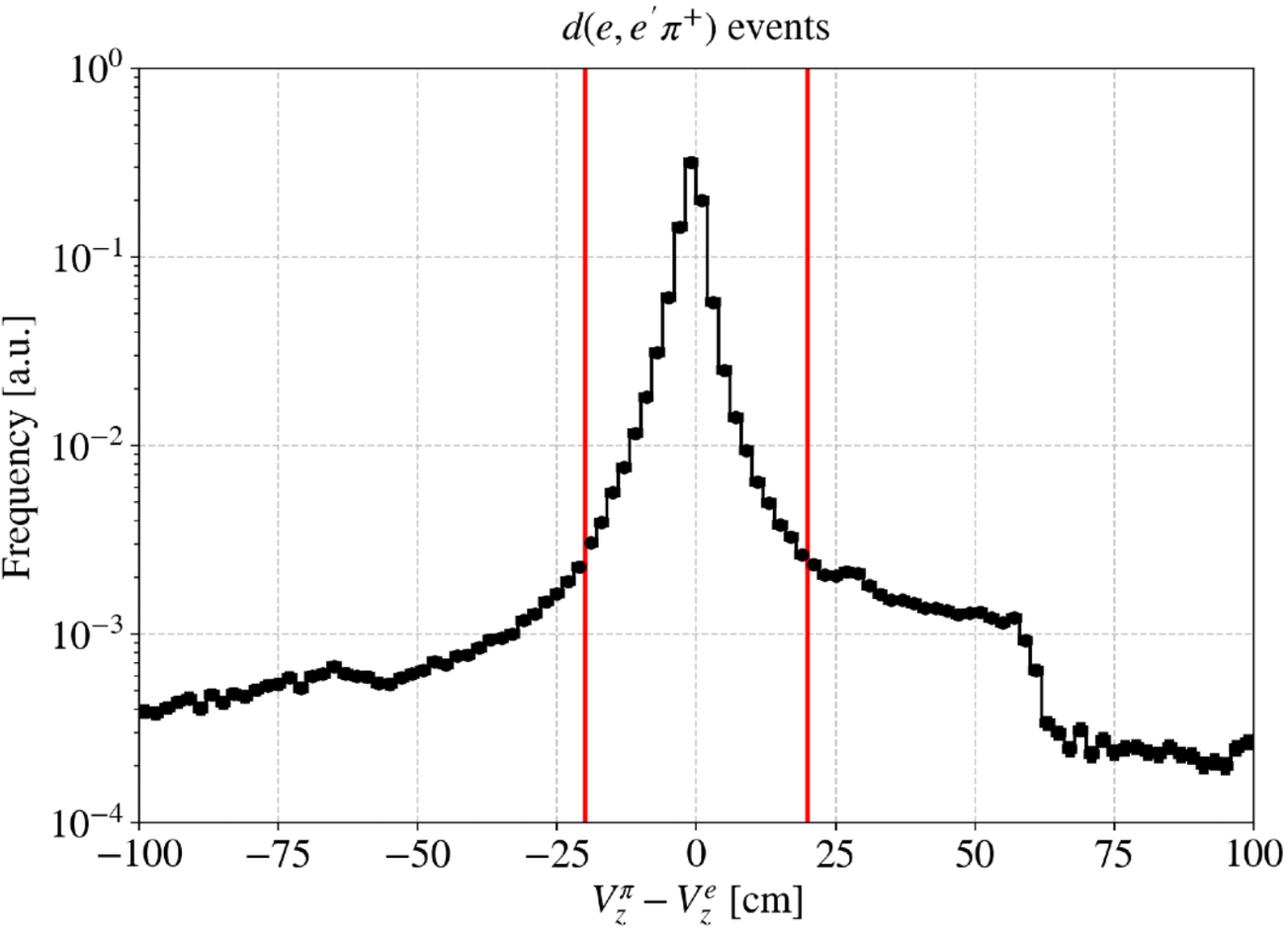
π^-



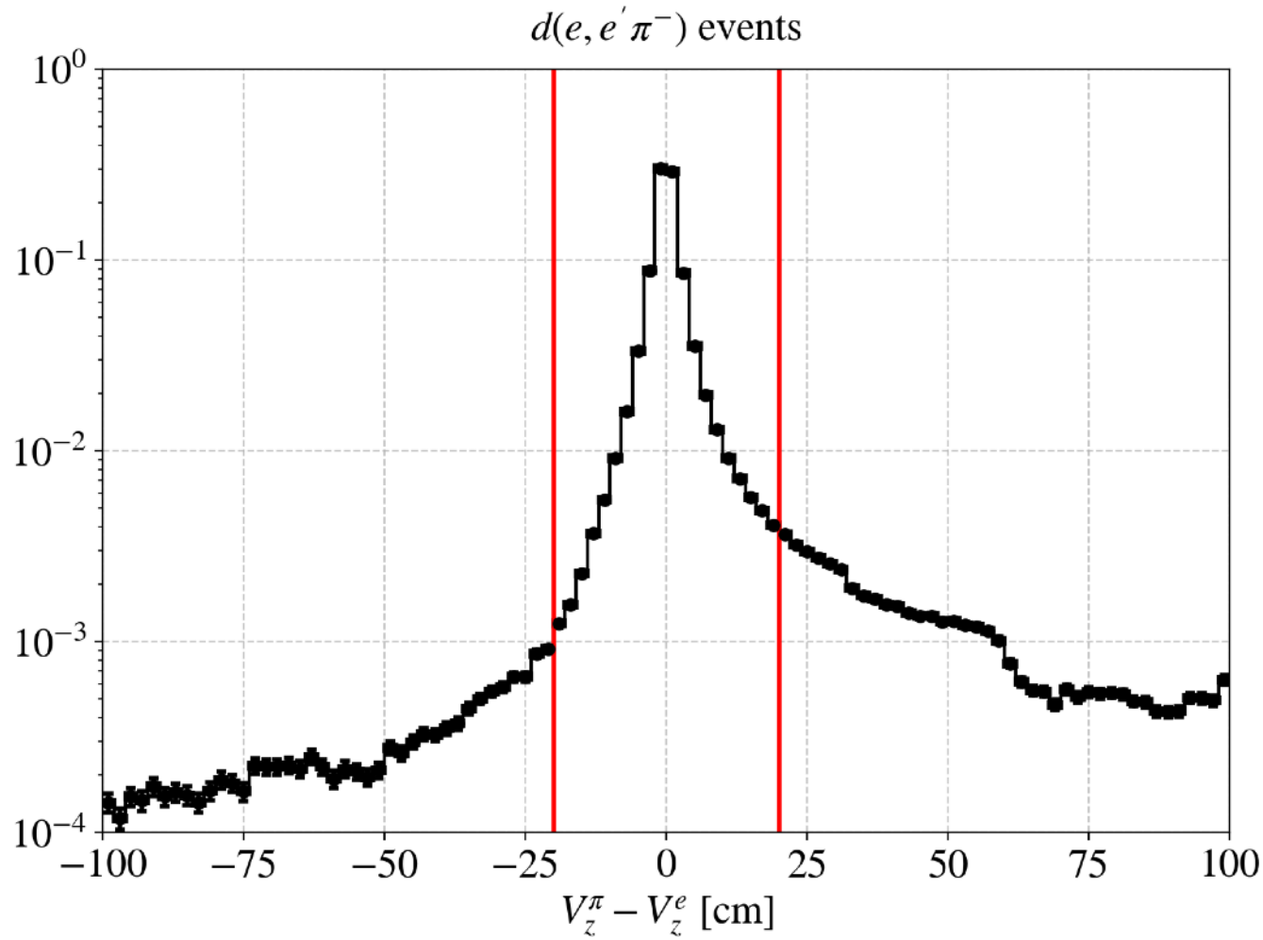
$$-13.0 \text{ cm} < v_z < +12.0 \text{ cm}$$

SIDIS@RGB | π-PID cuts - π and e vertex difference

π^+



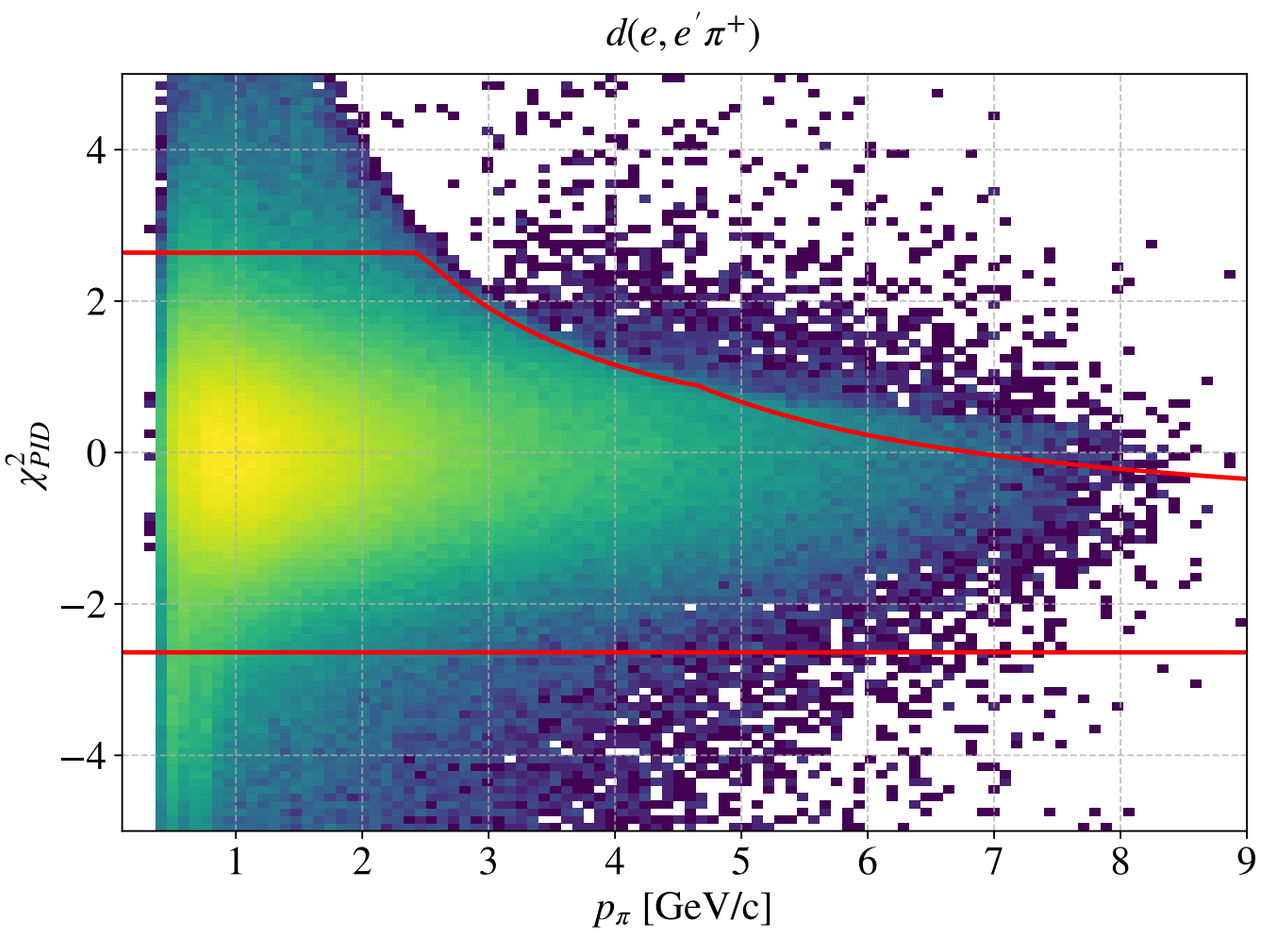
π^-



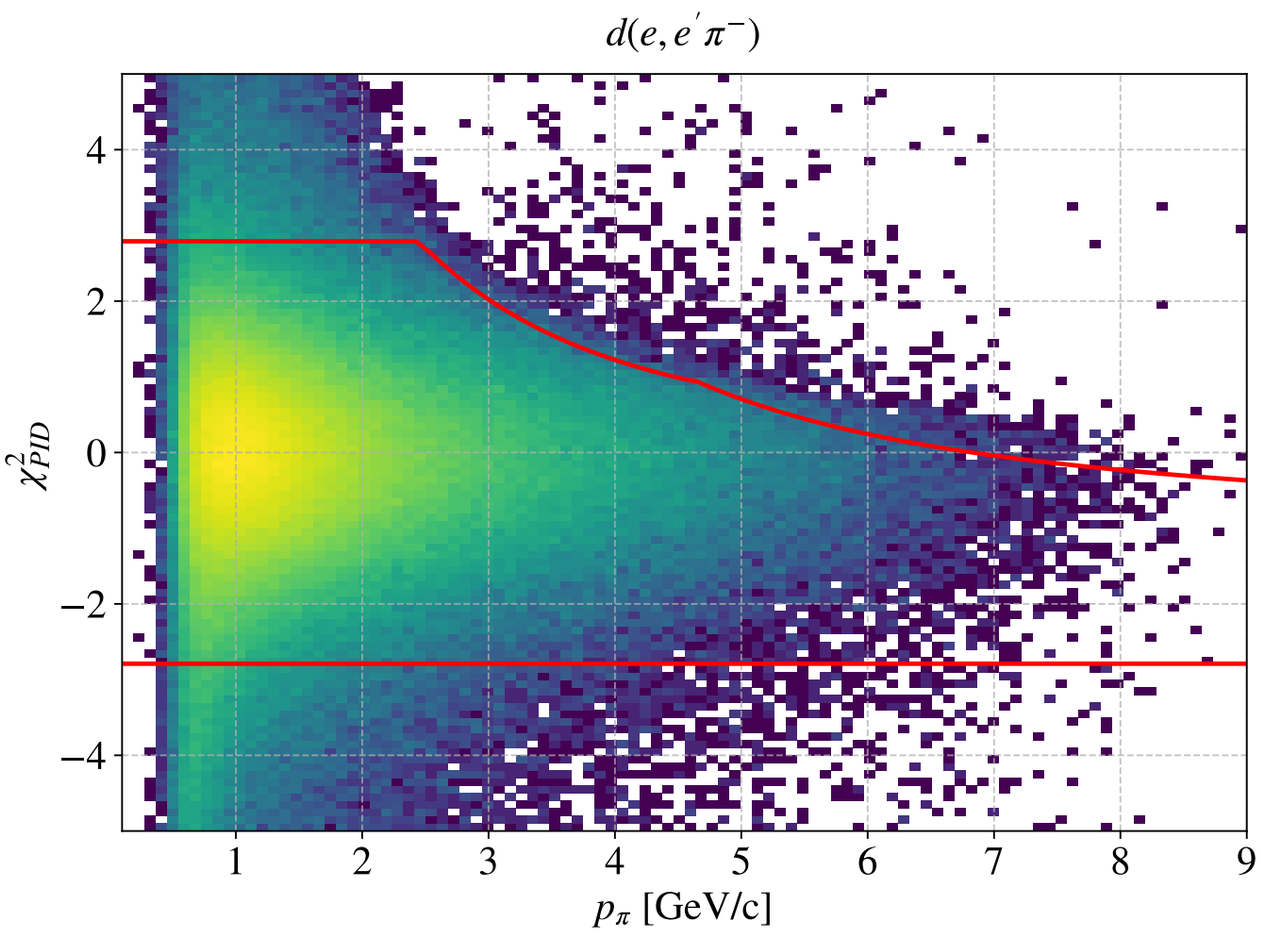
$$|v_z(e) - v_z(\pi)| < 20.0 \text{ cm}$$

SIDIS@RGB | π-PID cuts - χ^2_{PID} for π

π^+



π^-



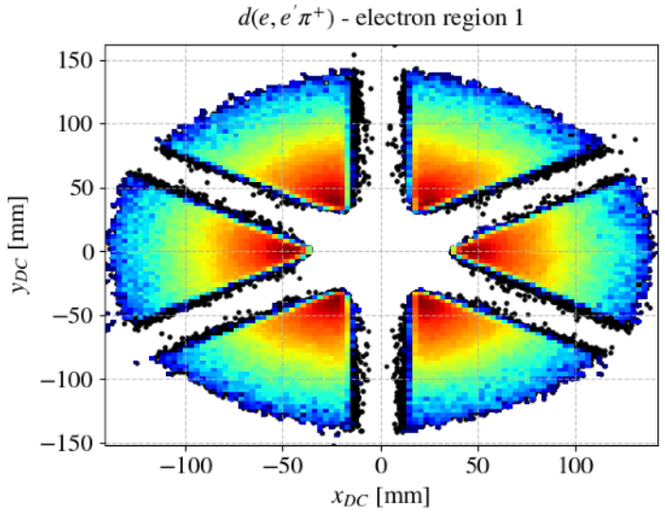
$$-3C < \chi^2_\pi < 3C \qquad p < 2.44 \text{ GeV}$$

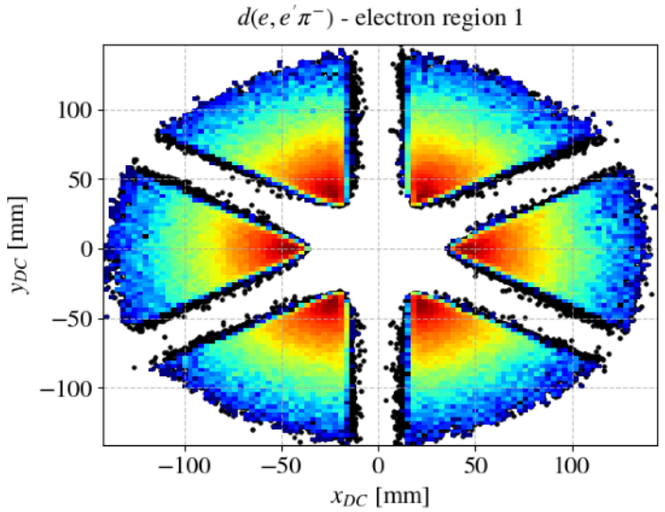
$$-3C < \chi^2_\pi < C(0.0869 - 14.98587e^{-p/1.18236} + 1.811751e^{-p/4.86394}) \qquad 2.44 < p < 4.6 \text{ GeV}$$

$$-3C < \chi^2_\pi < C(-1.14099 + 24.14992e^{-p/1.36554} + 2.66876e^{-p/6.80552}) \qquad 4.6 \text{ GeV} < p$$

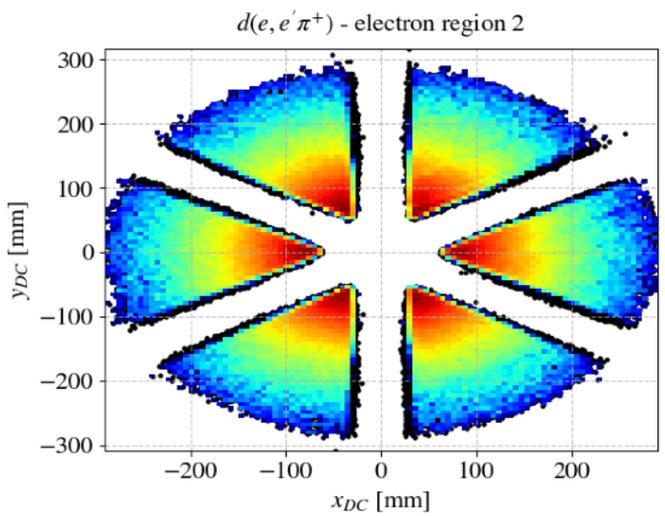
SIDIS@RGB | DC fiducial cuts for e

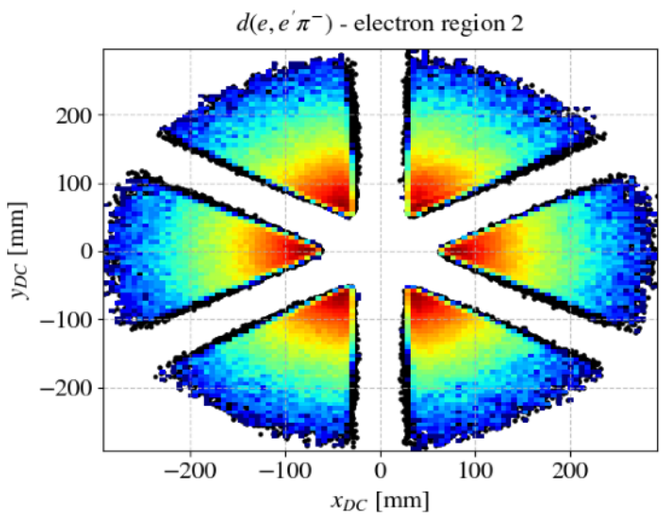
π^+

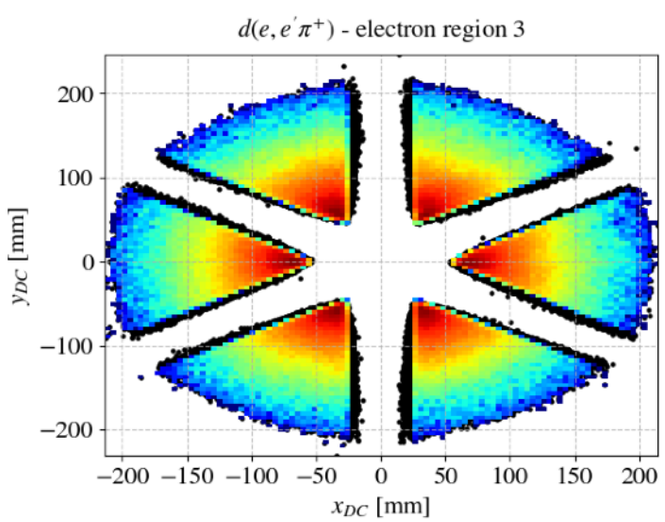


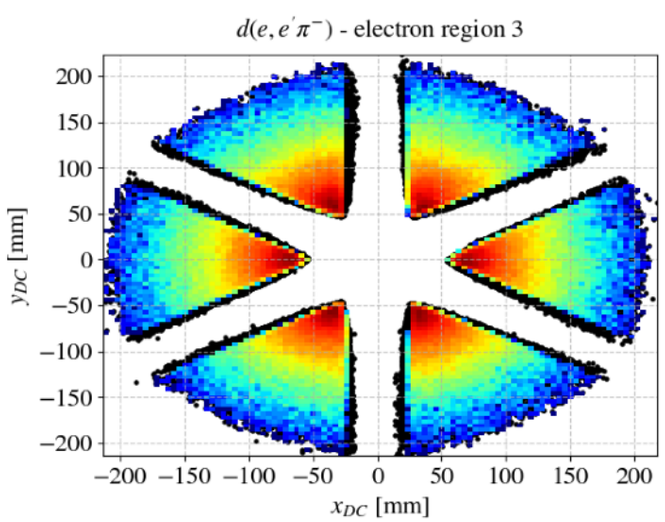


π^-



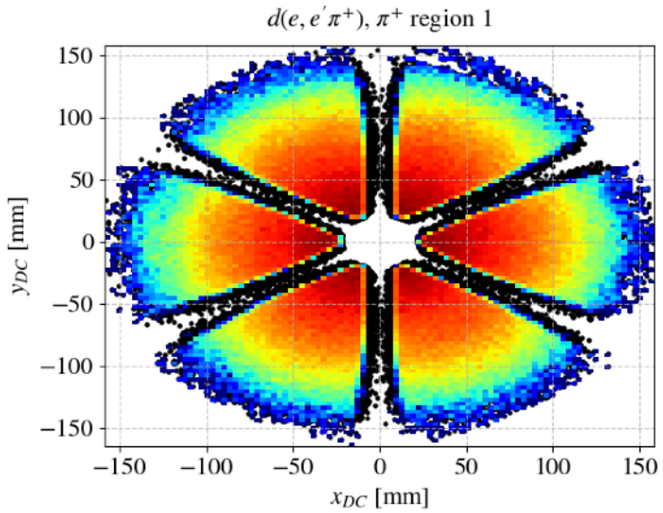


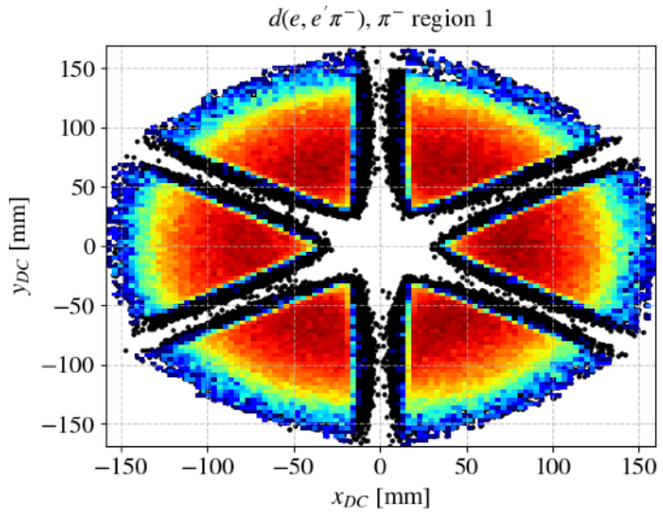




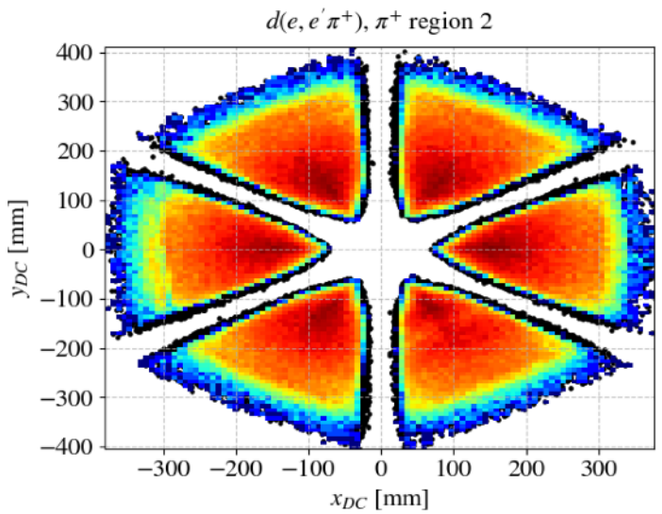
SIDIS@RGB | DC fiducial cuts for π

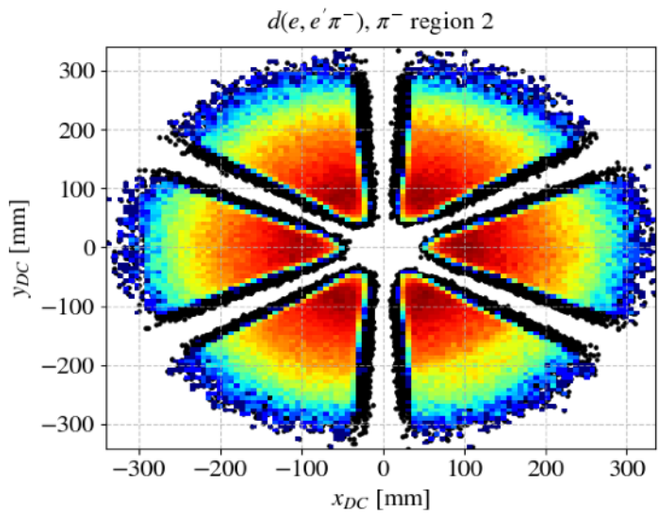
π^+

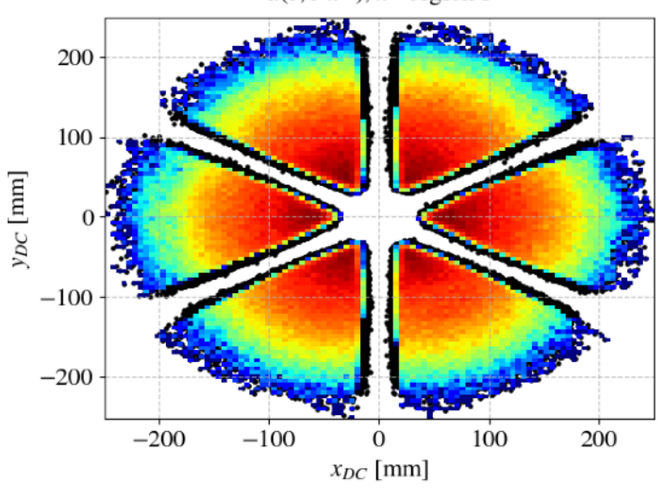


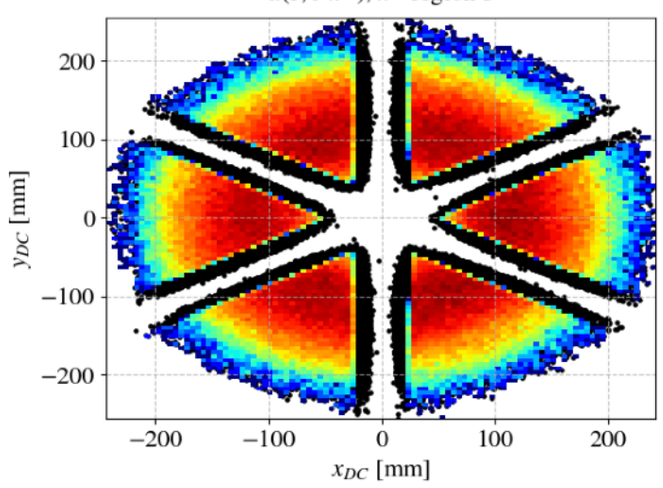


π^-





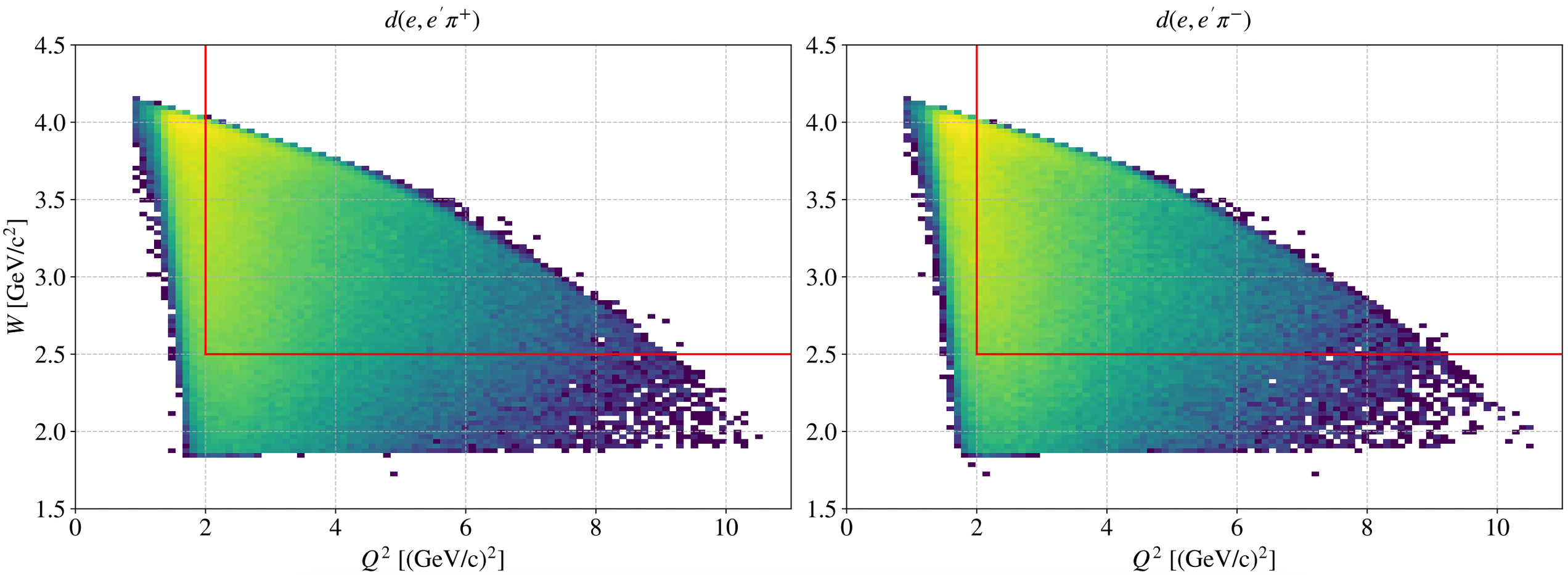




SIDIS@RGB | Kinematical cuts - W & Q^2

π^+

π^-

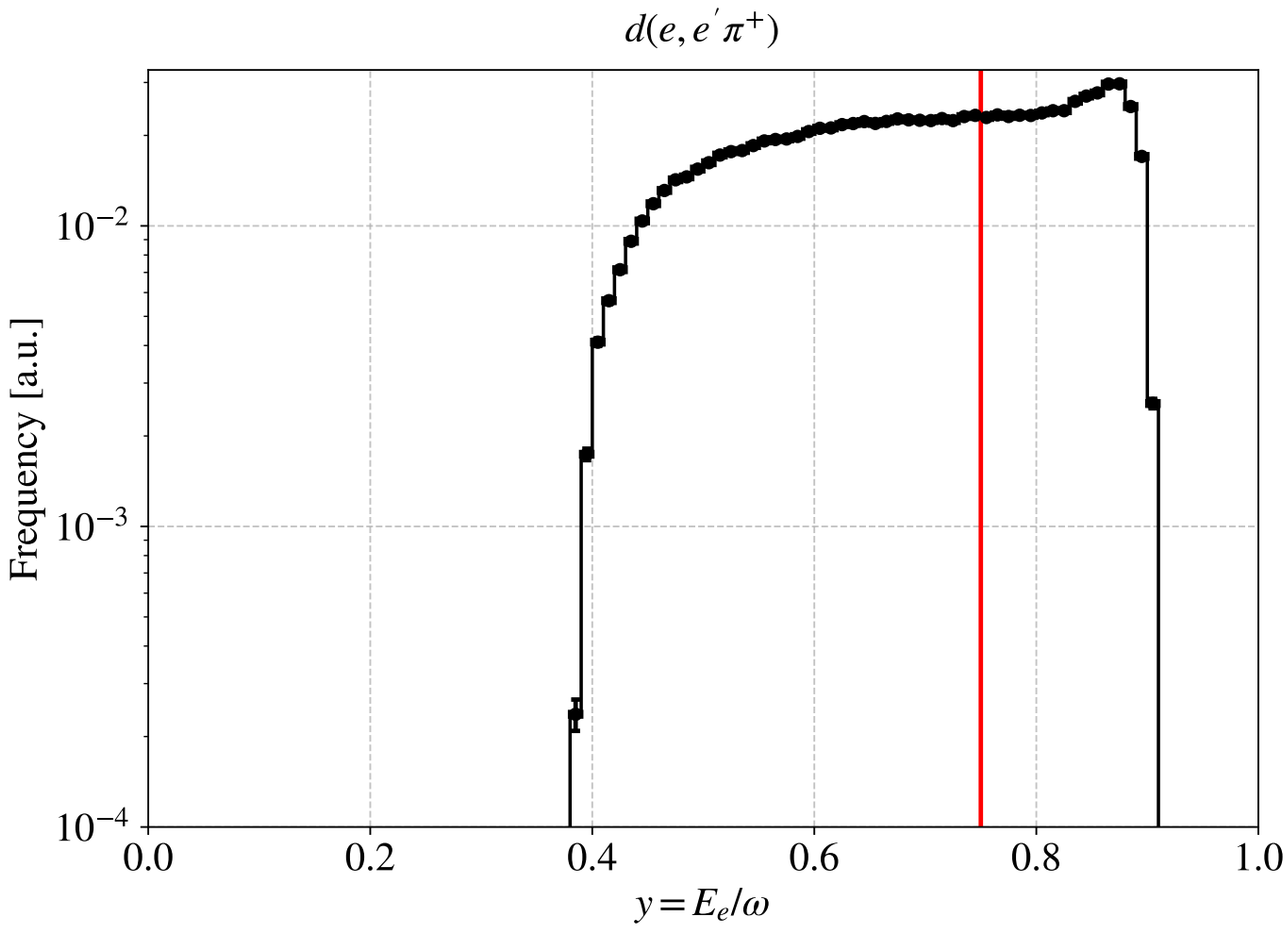


$$W > 2.5 \text{ GeV/c}^2$$

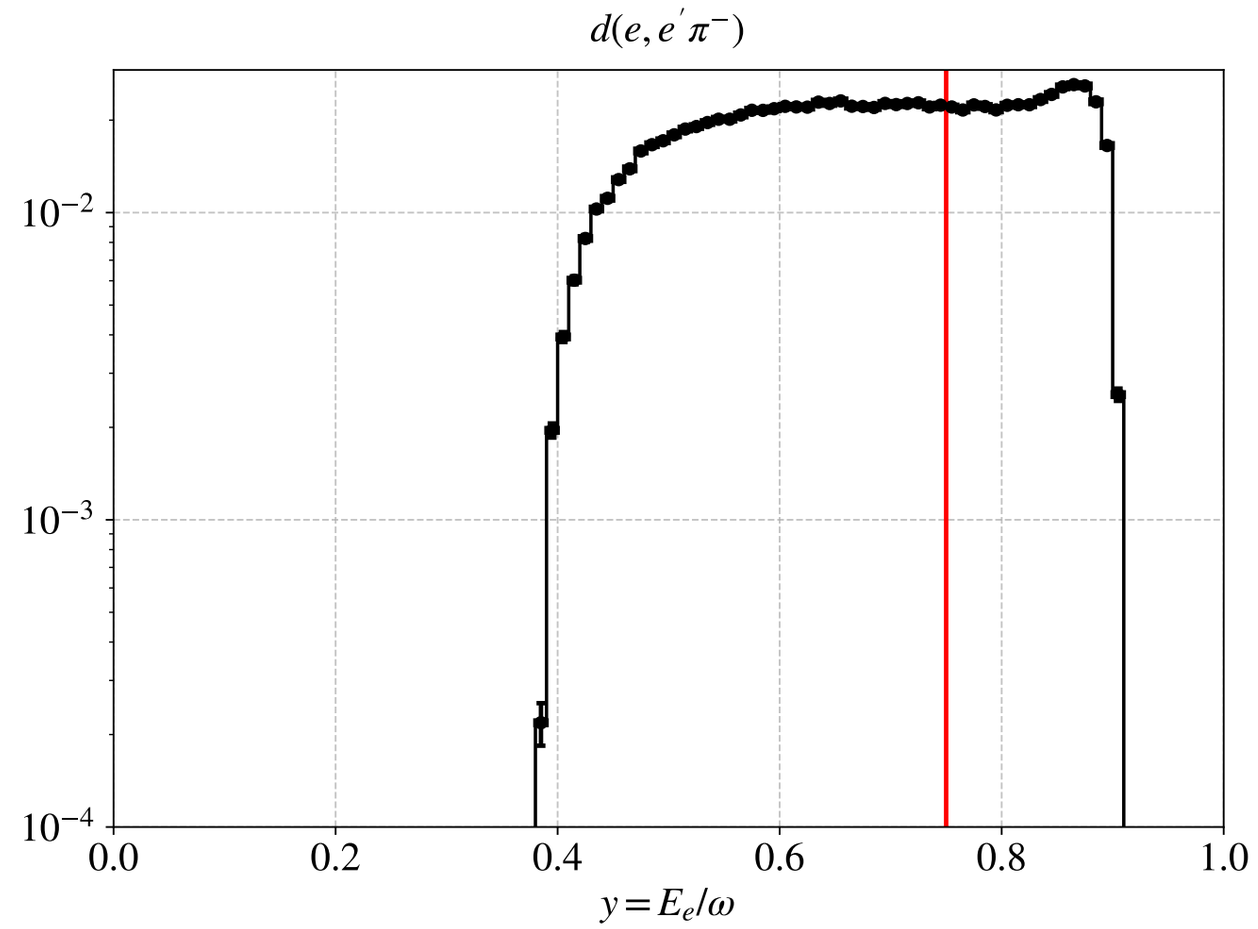
$$Q > 2 \text{ (GeV/c)}^2$$

SIDIS@RGB | Kinematical cuts - y

π^+



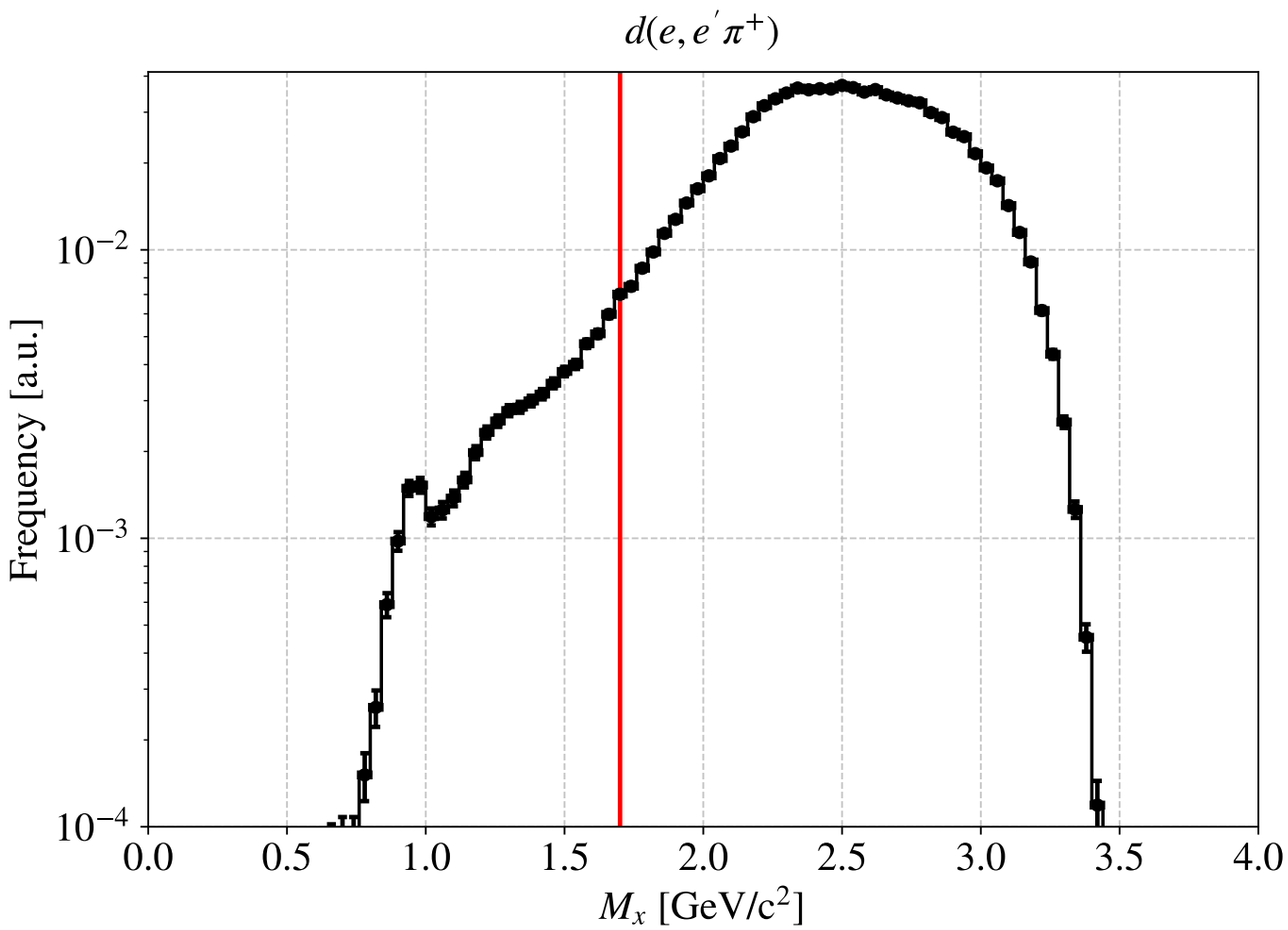
π^-



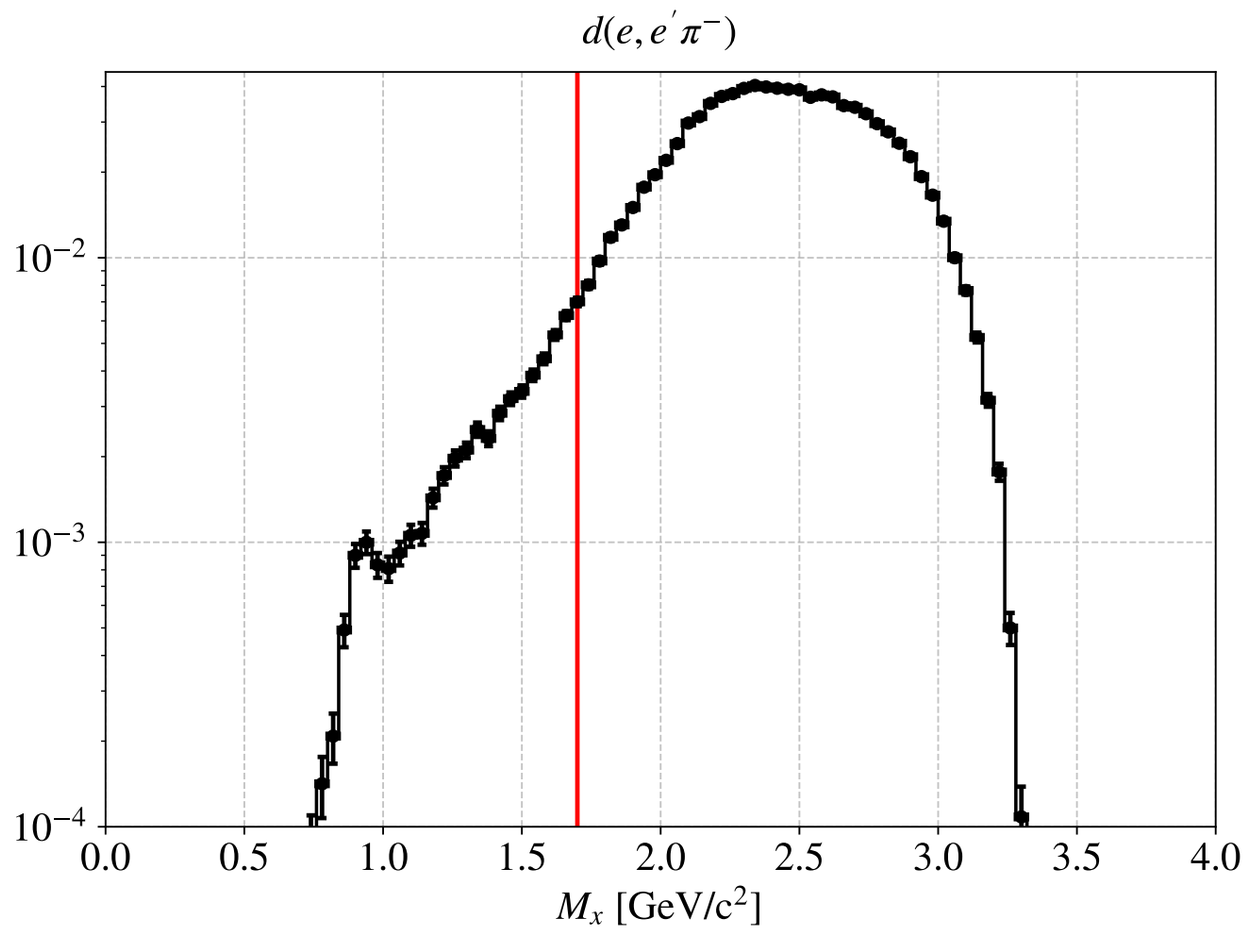
$$y < 0.75$$

SIDIS@RGB | Kinematical cuts - Missing mass

π^+



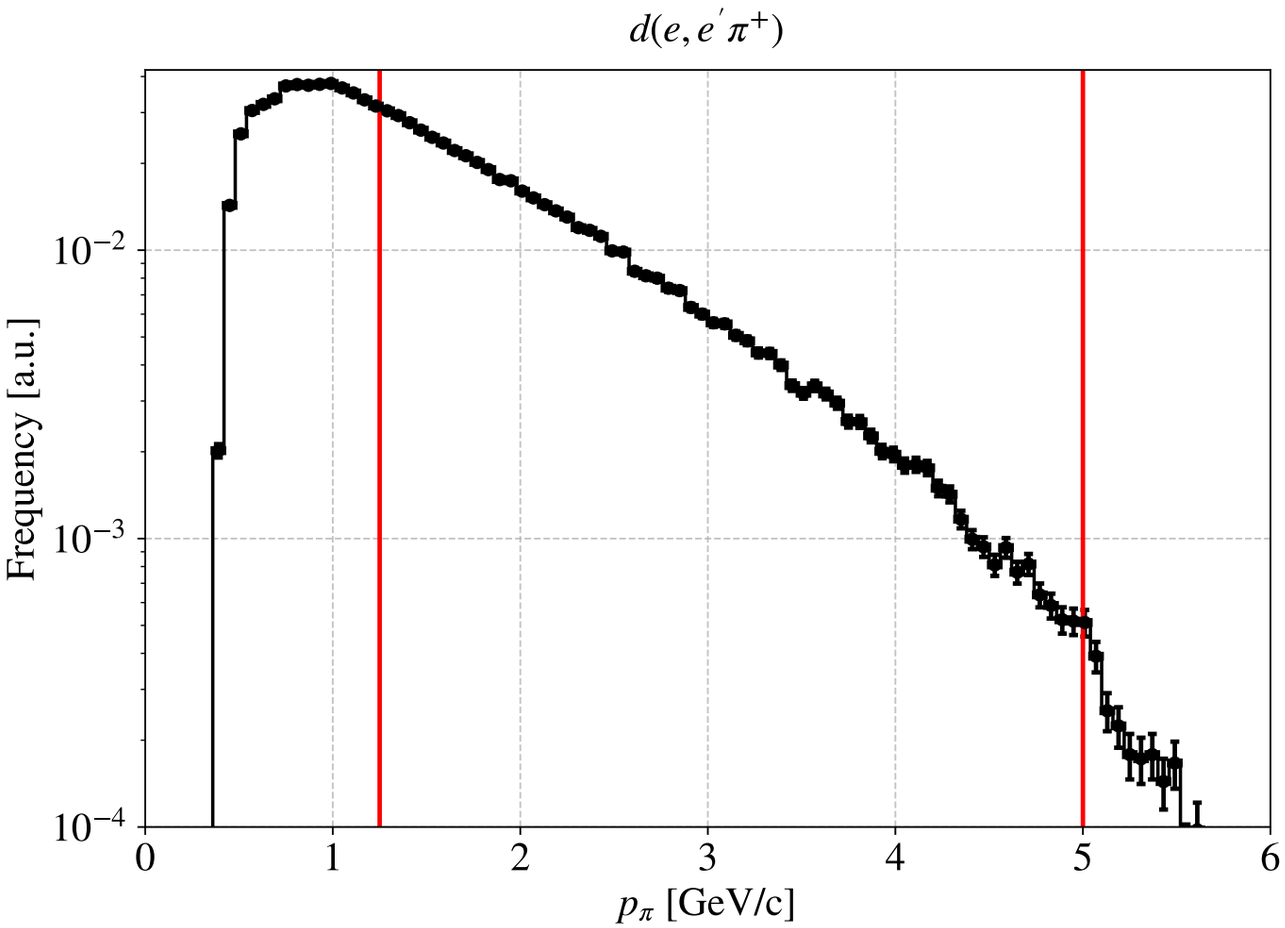
π^-



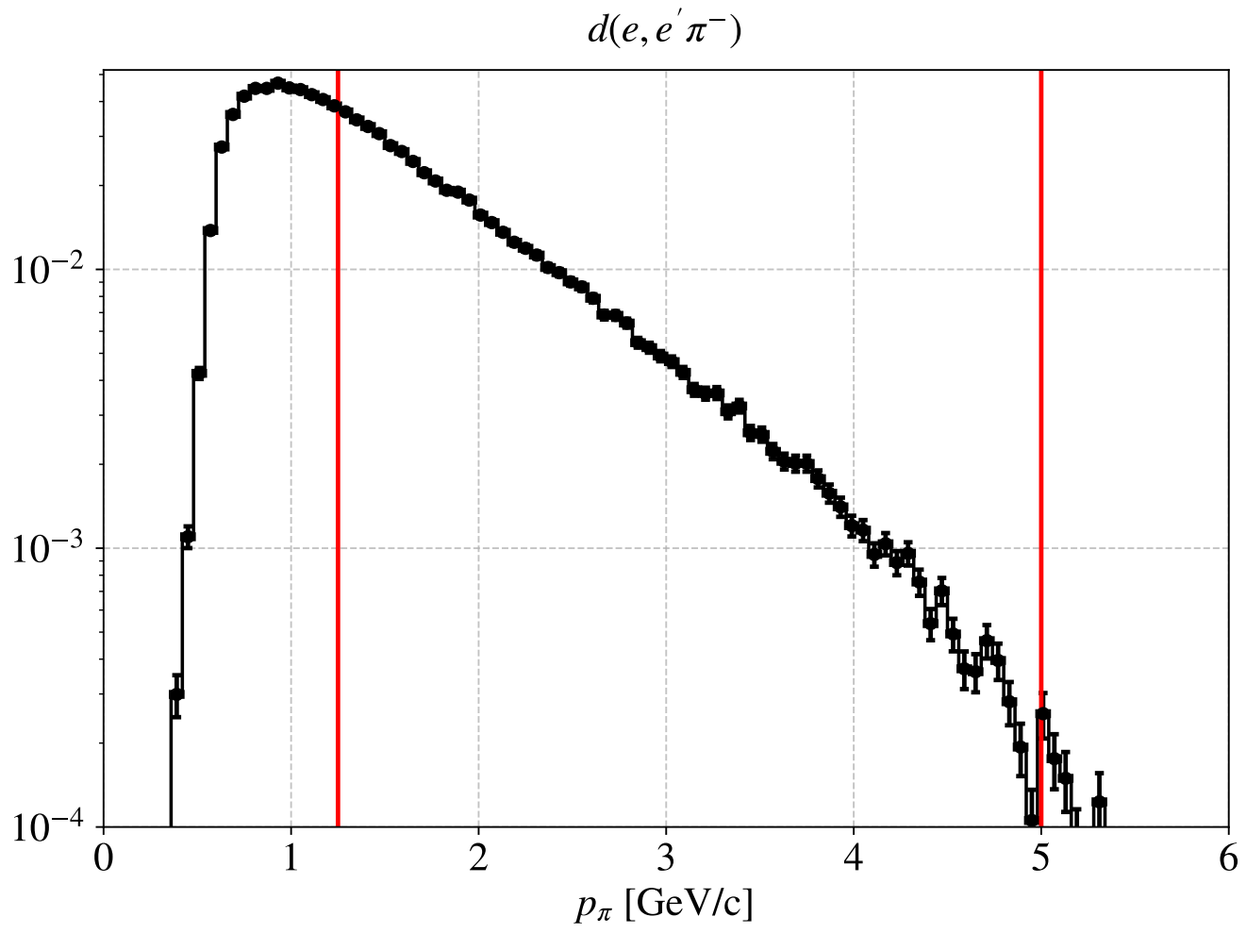
$$M_x > 1.7 \text{ GeV/c}^2$$

SIDIS@RGB | Kinematical cuts - Pion momentum

π^+



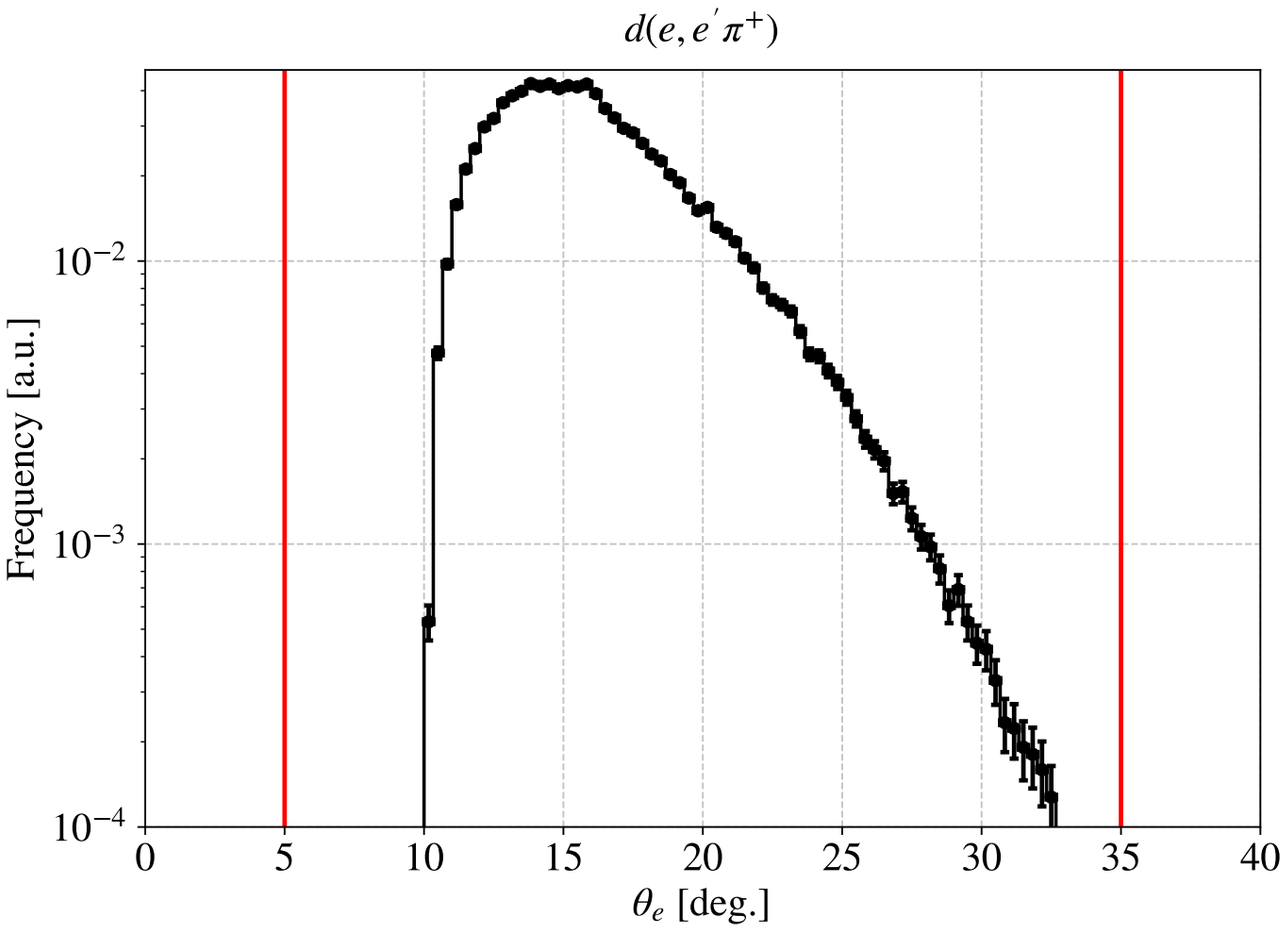
π^-



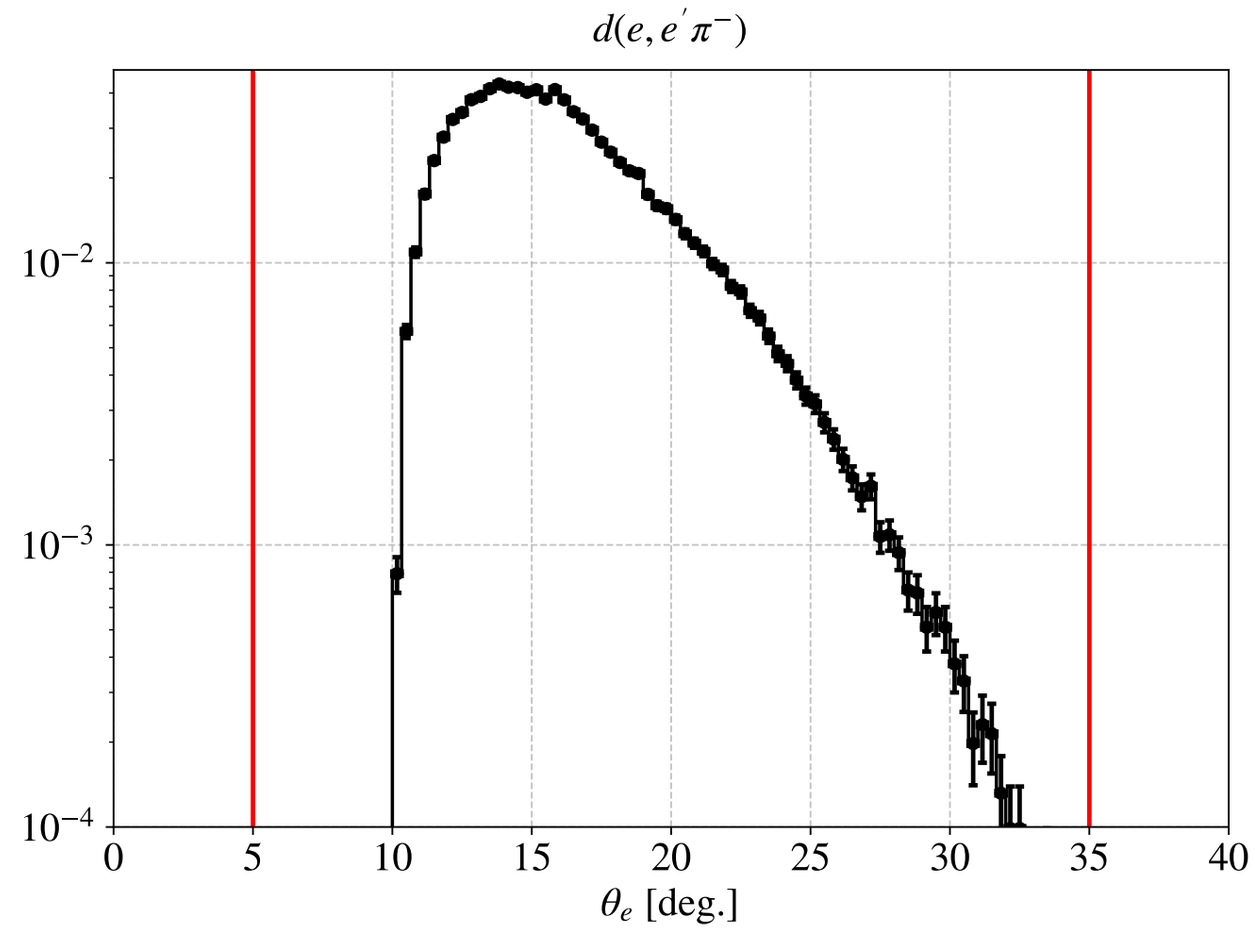
$$1.25 < p_\pi < 5 \text{ GeV/c}$$

SIDIS@RGB | Kinematical cuts - θ_e

π^+



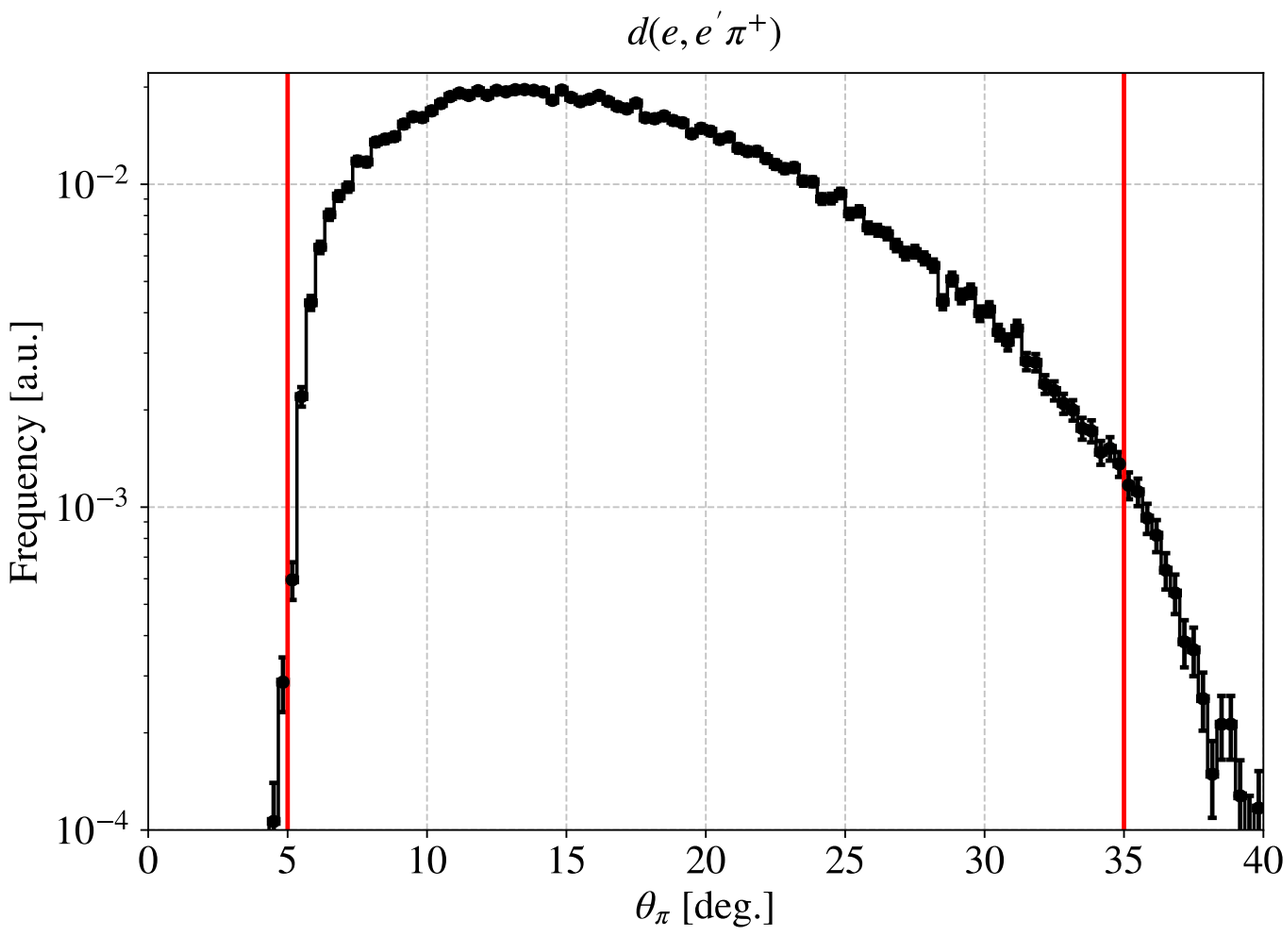
π^-



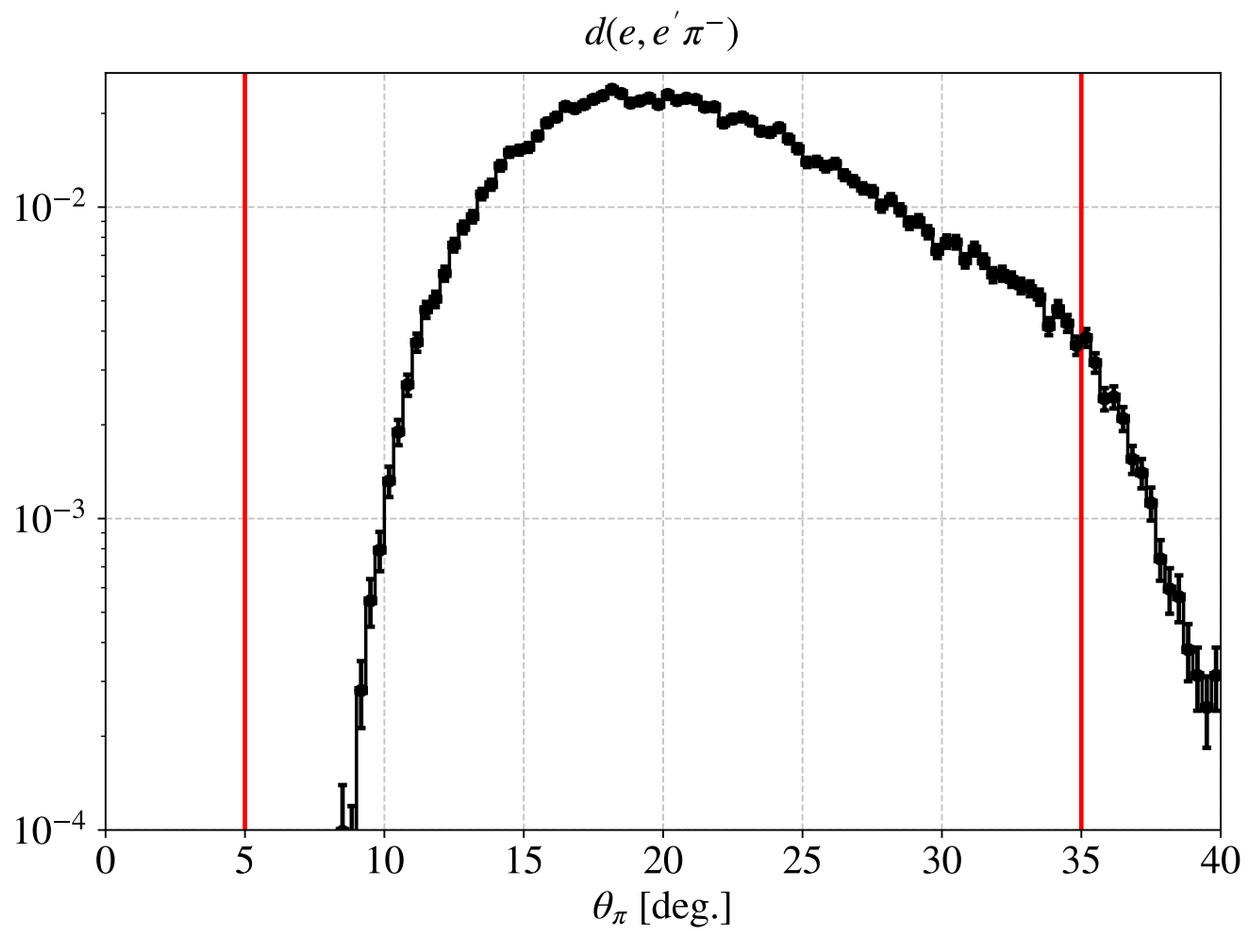
$$5^\circ < \theta_e < 35^\circ,\ 5^\circ < \theta_\pi < 35^\circ$$

SIDIS@RGB | Kinematical cuts - θ_π

π^+



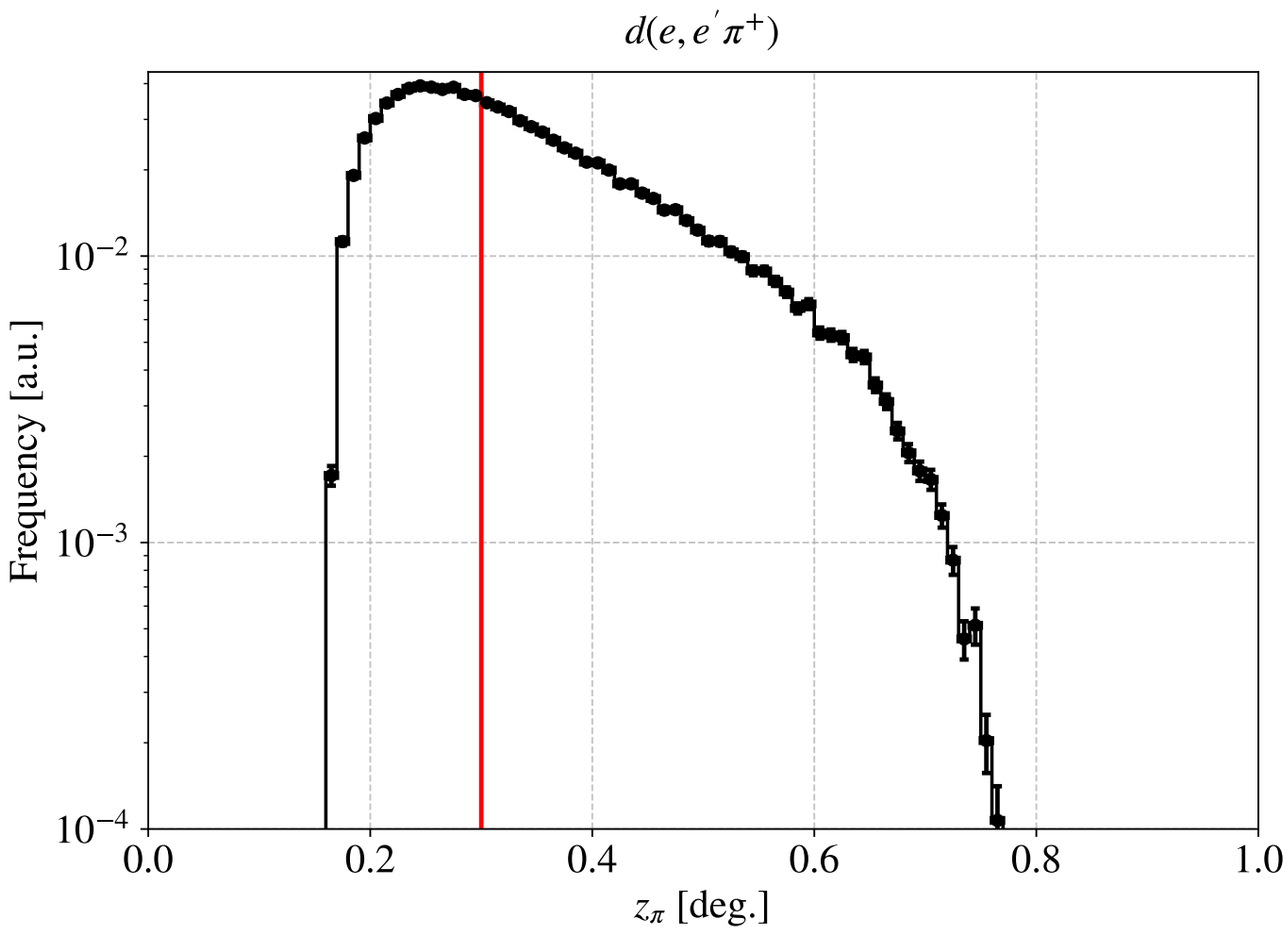
π^-



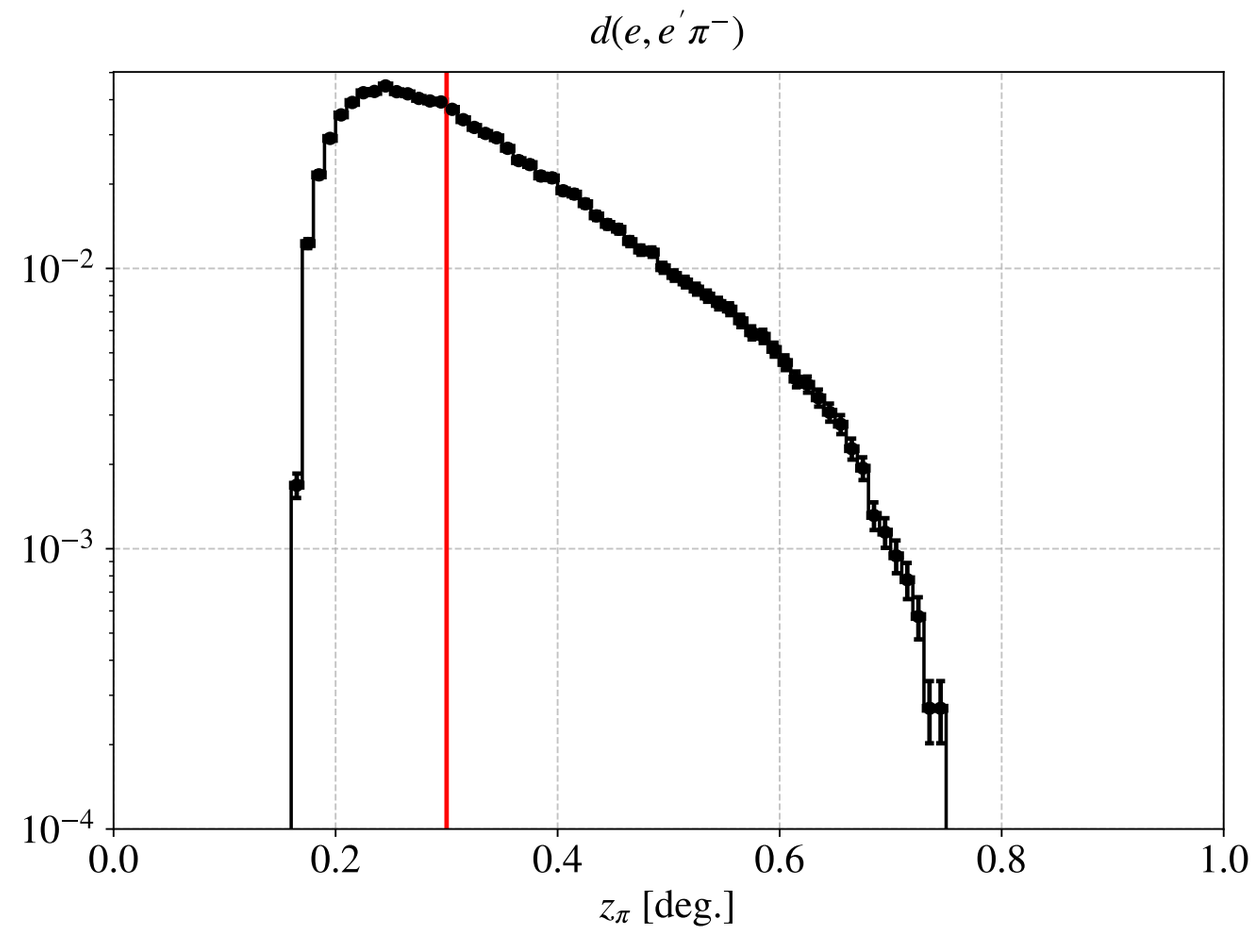
$$5^\circ < \theta_e < 35^\circ,\ 5^\circ < \theta_\pi < 35^\circ$$

SIDIS@RGB | Kinematical cuts - high z_π

π^+

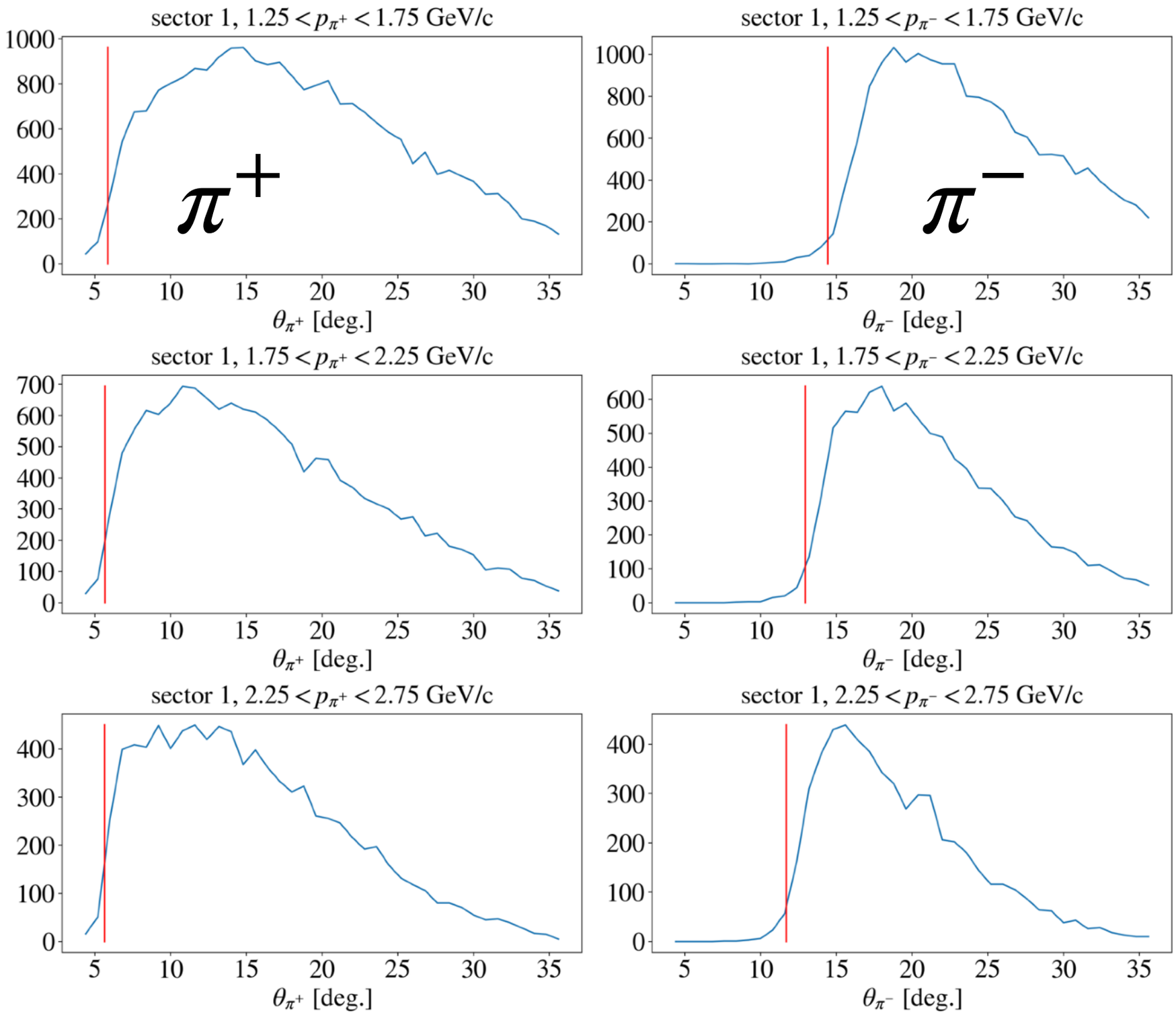


π^-



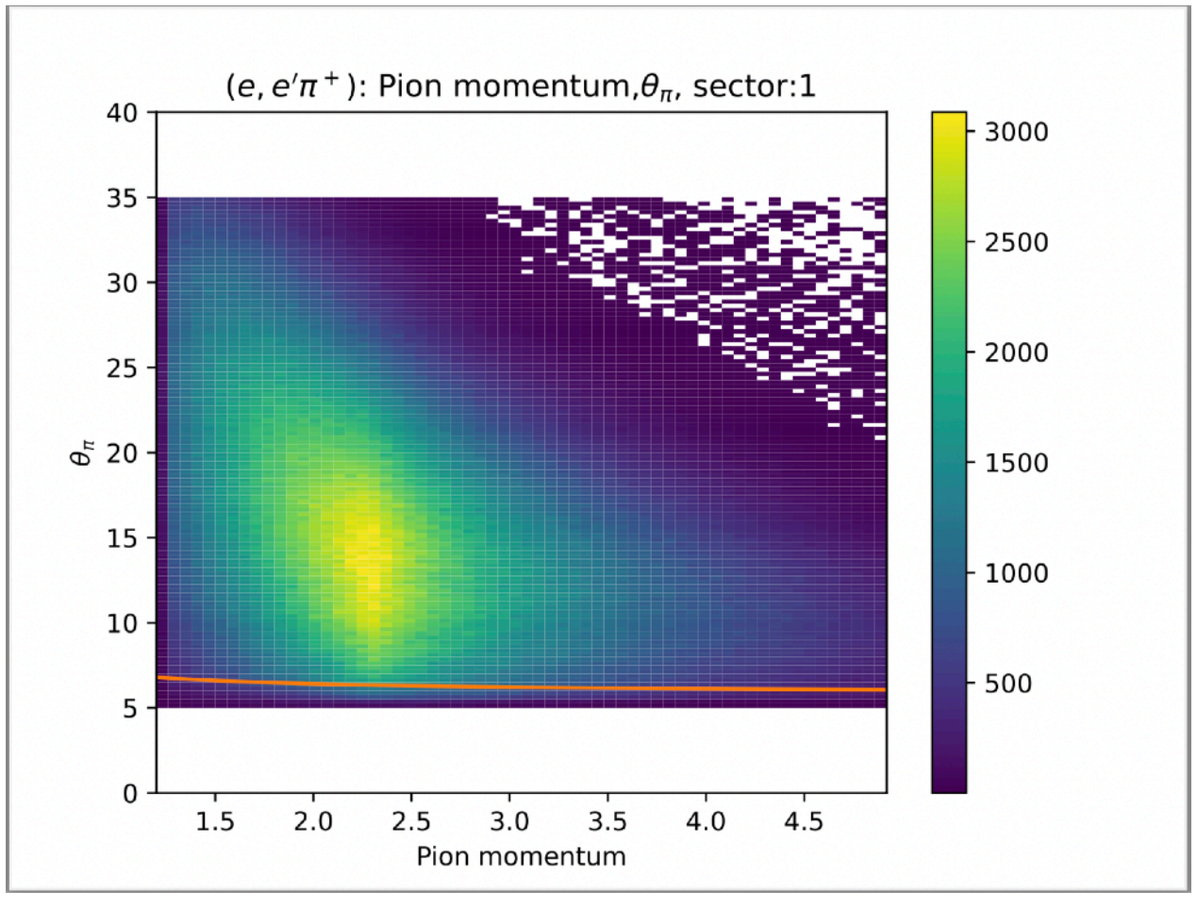
$z_\pi > 0.3$

SIDIS@RGB | π^+ and π^- acceptance matching

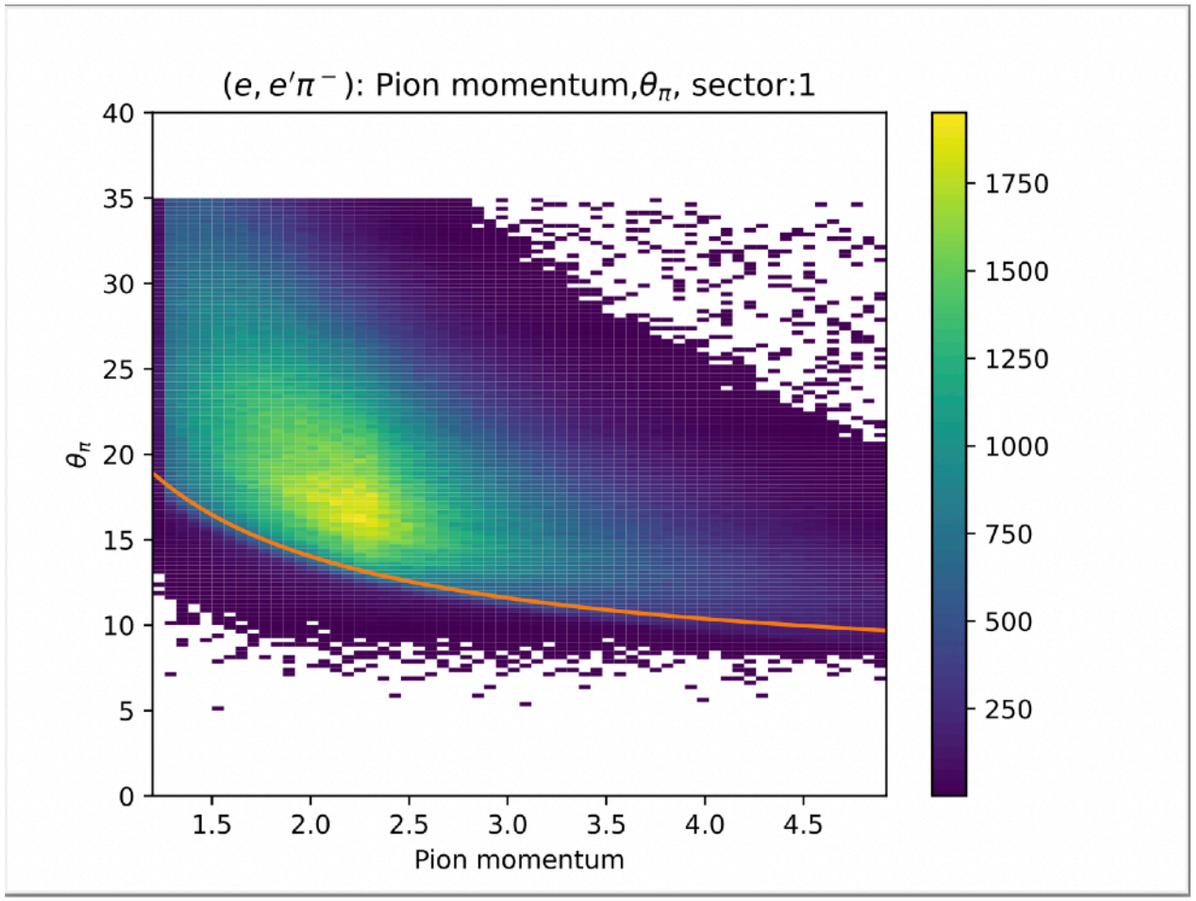


SIDIS@RGB | π^+ and π^- acceptance matching

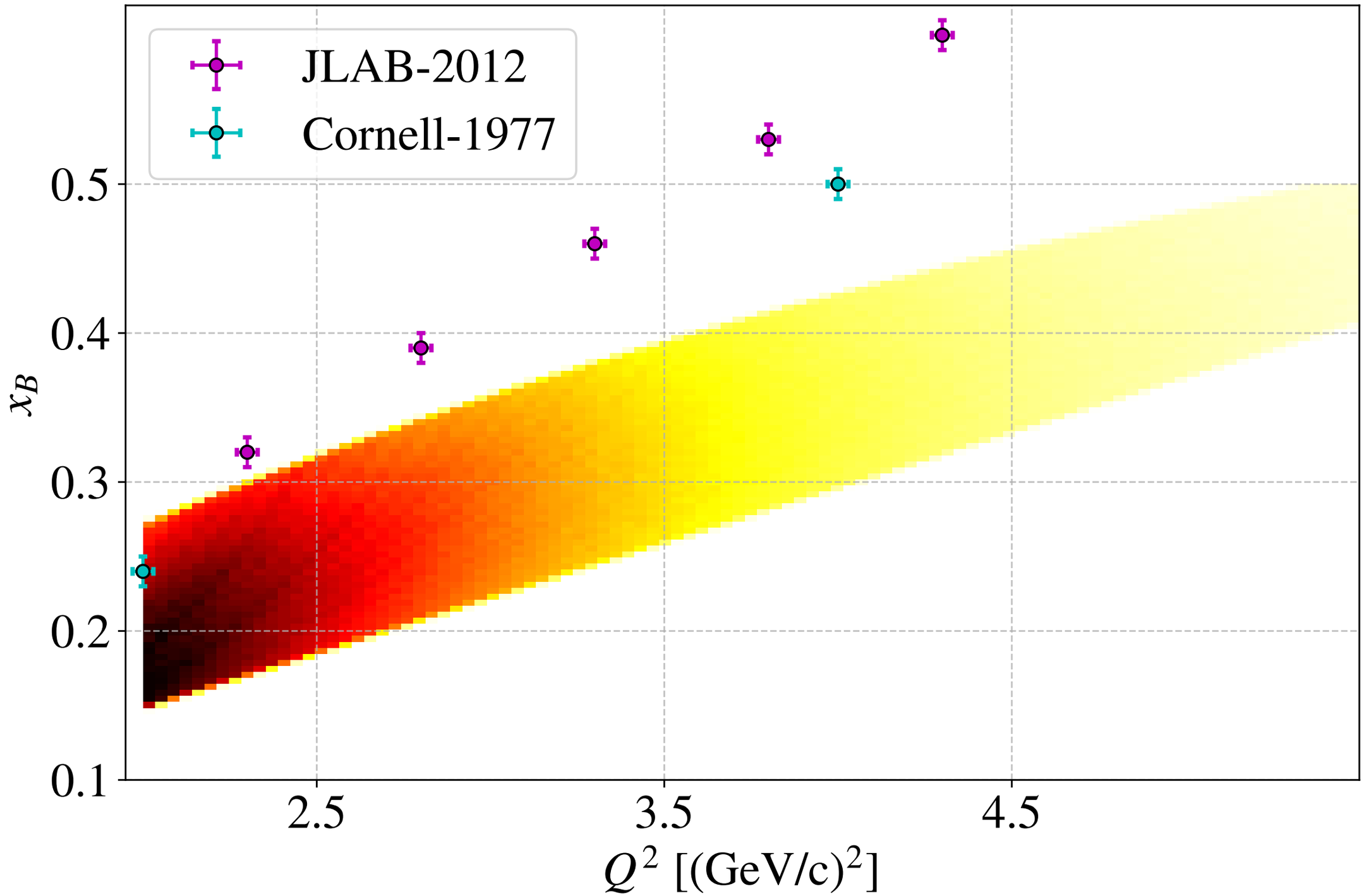
π^+



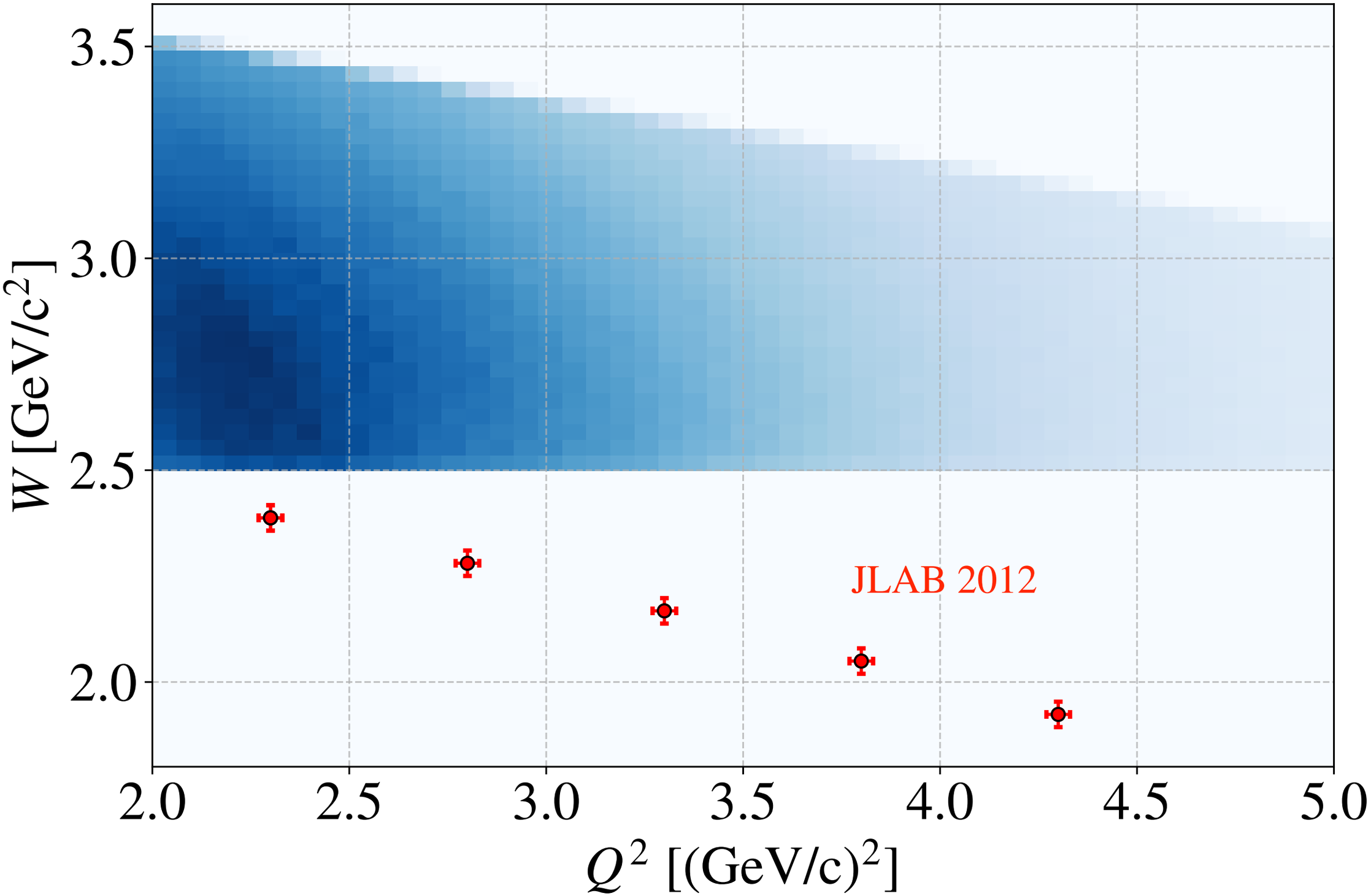
π^-



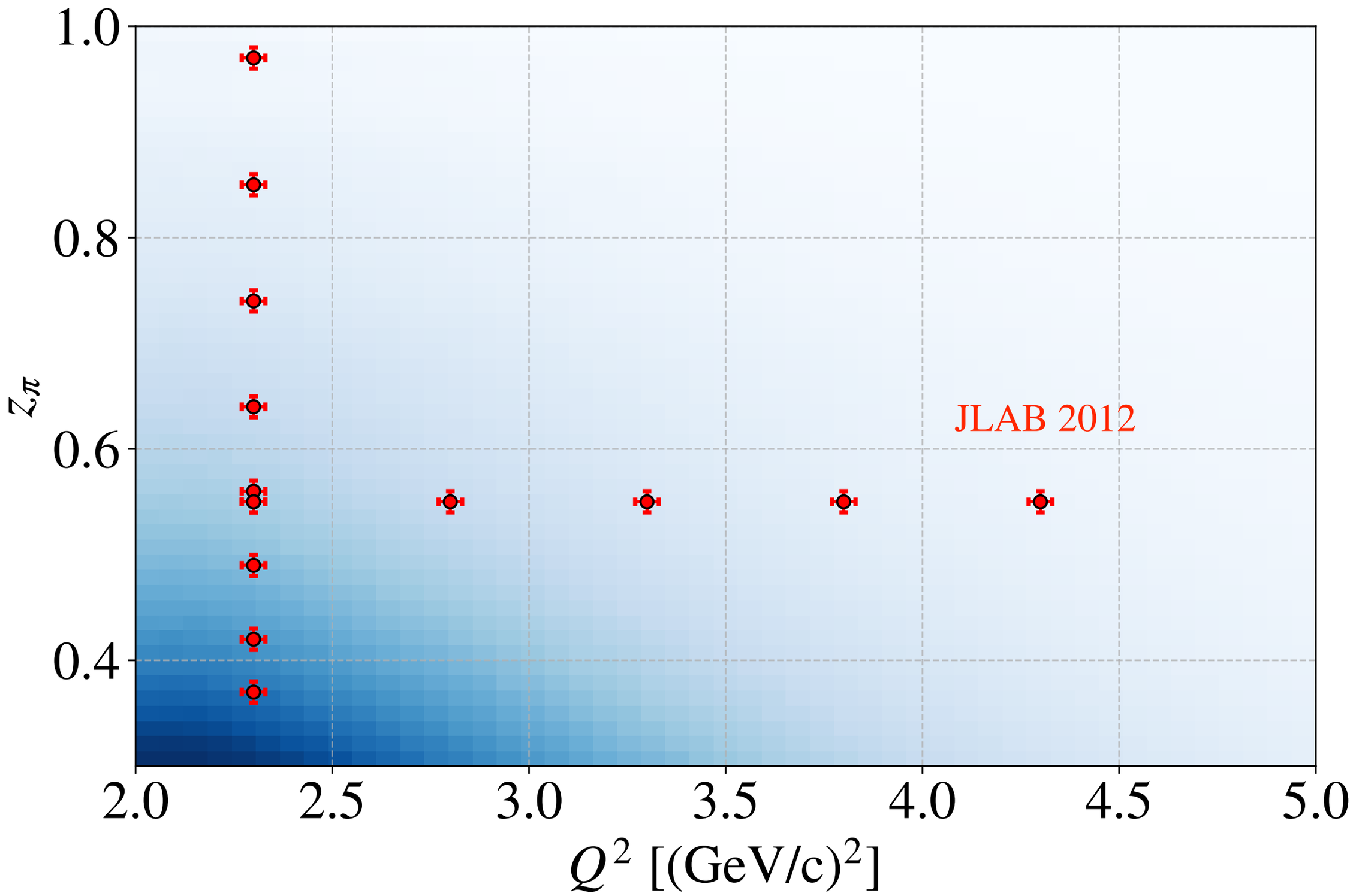
SIDIS@RGB | Electron kinematics - x_B vs. Q^2



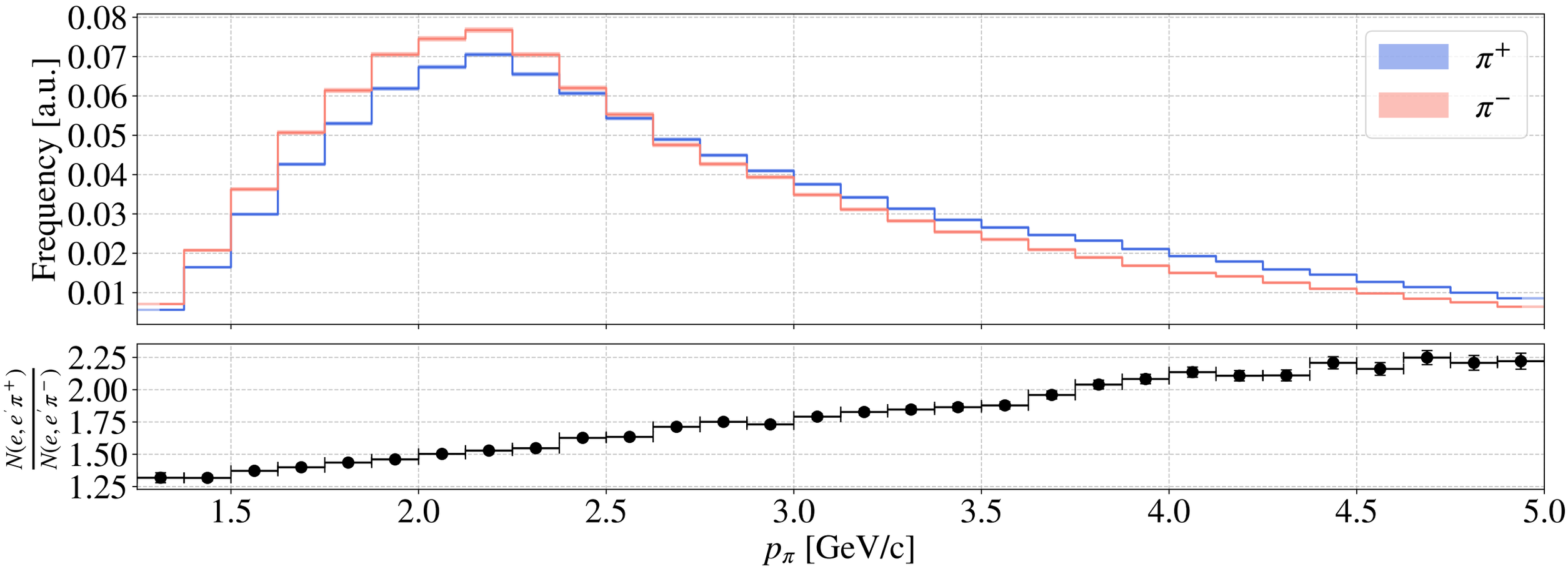
SIDIS@RGB | Electron kinematics - W vs. Q^2



SIDIS@RGB | Kinematics - z_π vs. Q^2

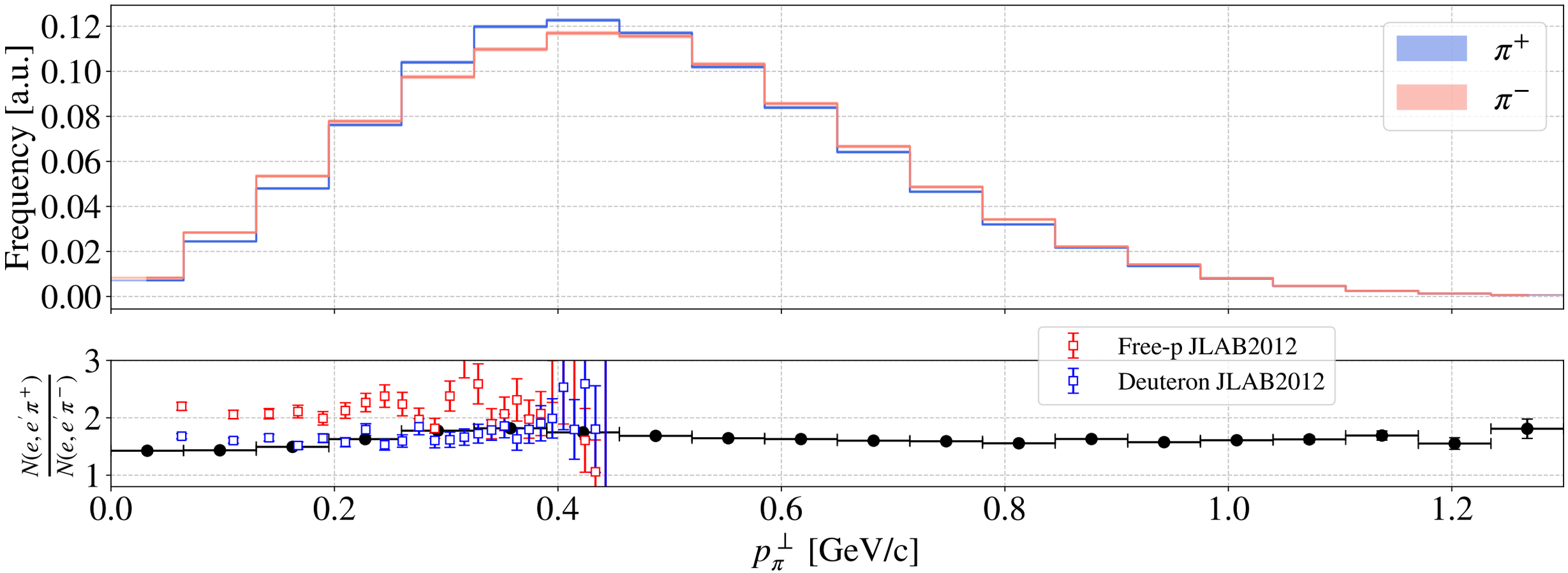


SIDIS@RGB | Kinematics - pion momentum



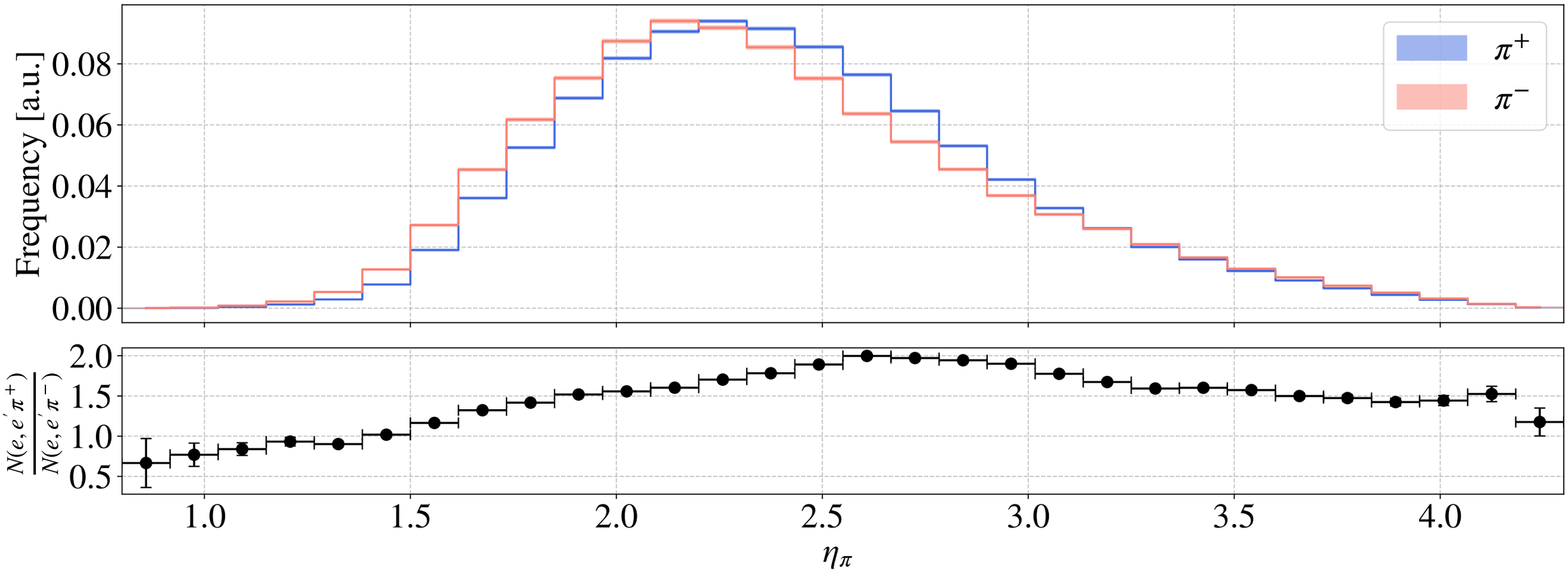
No acceptance corrections

SIDIS@RGB | Kinematics - pion p_T



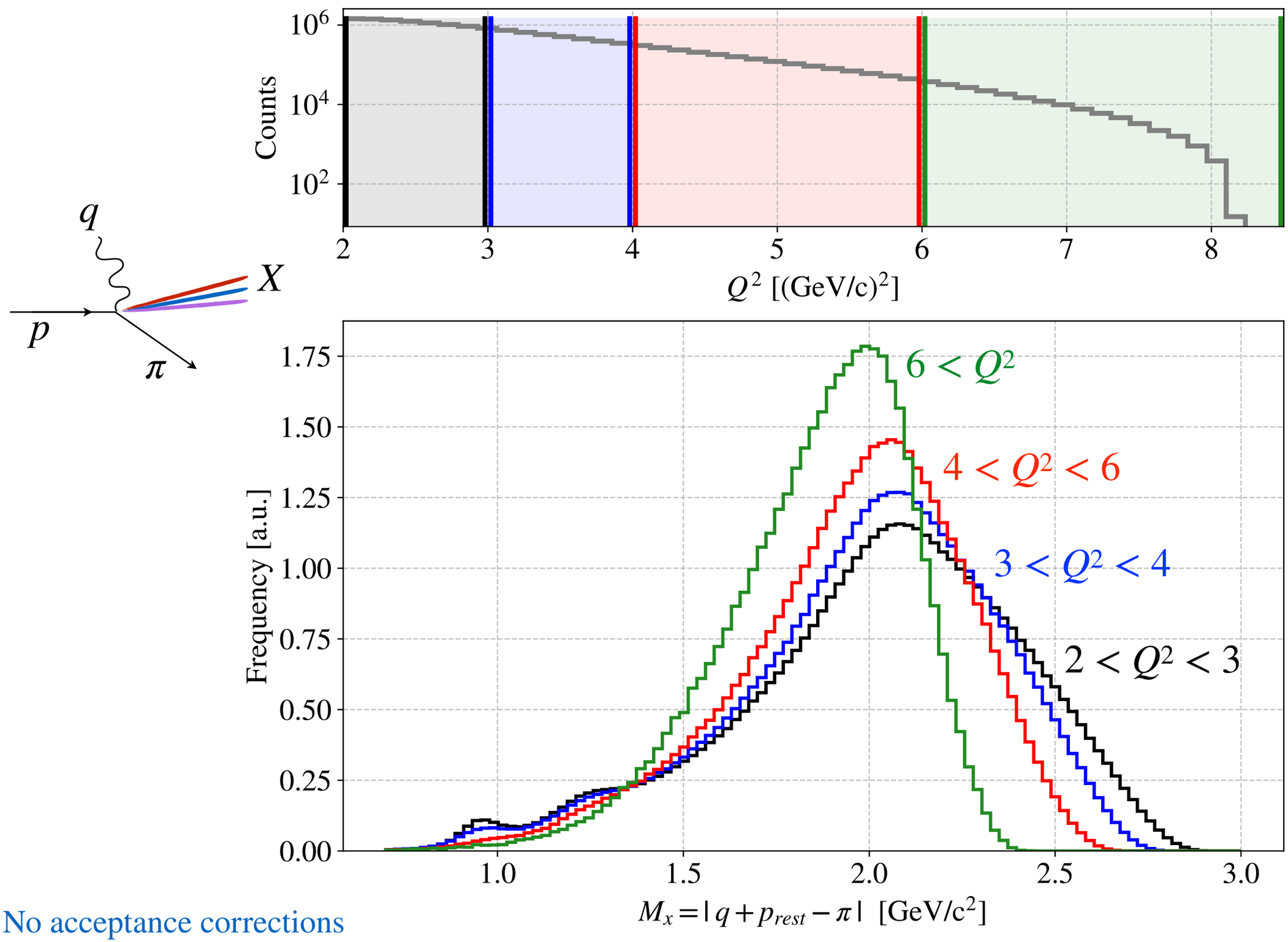
No acceptance corrections

SIDIS@RGB | Kinematics - pseudo rapidity



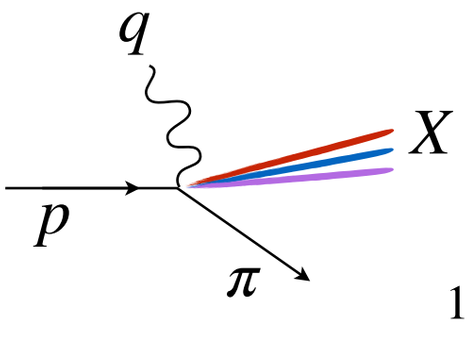
No acceptance corrections

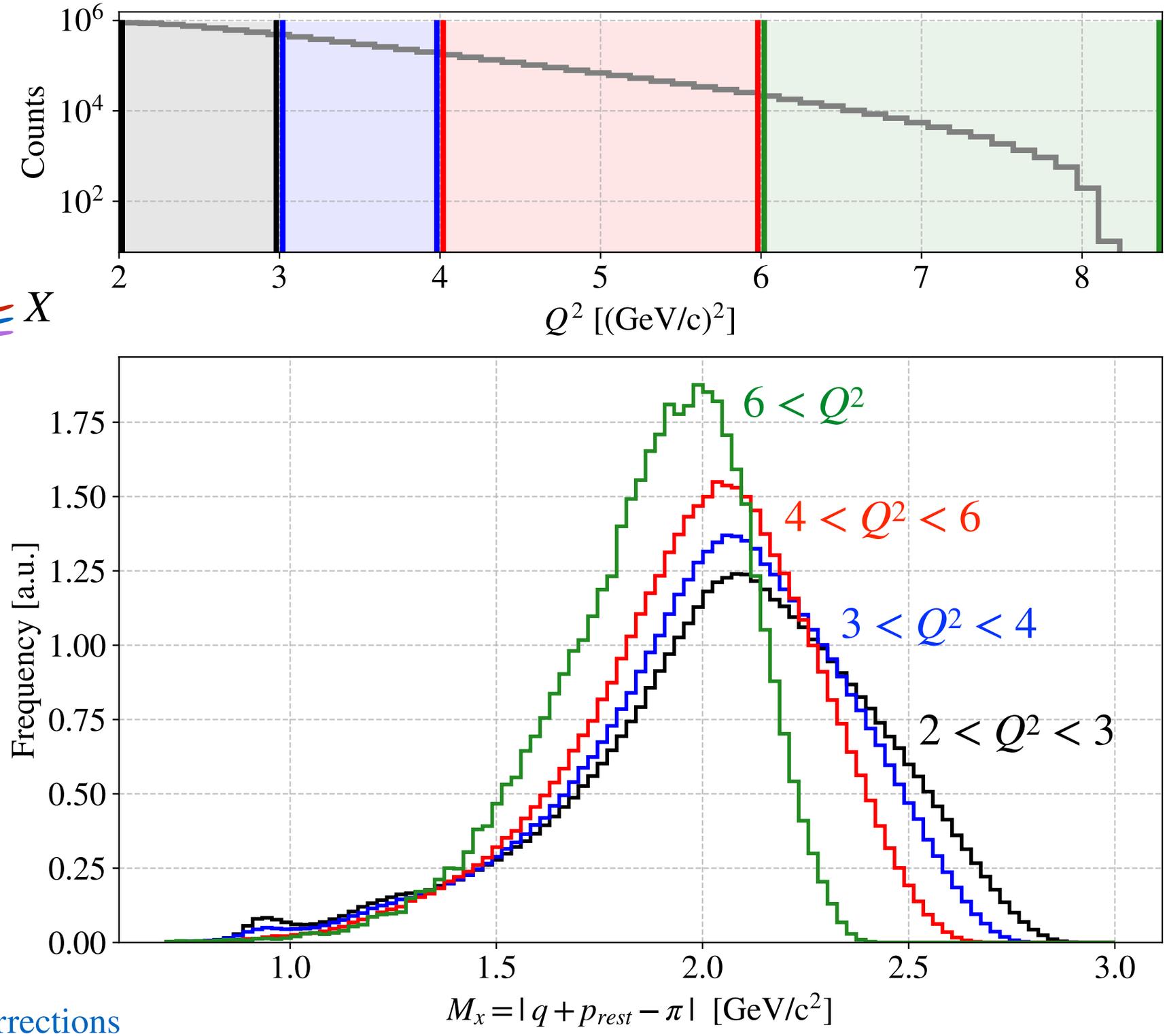
SIDIS@RGB | M_X in bins of Q^2 - $d(e, e'\pi^+)$



No acceptance corrections

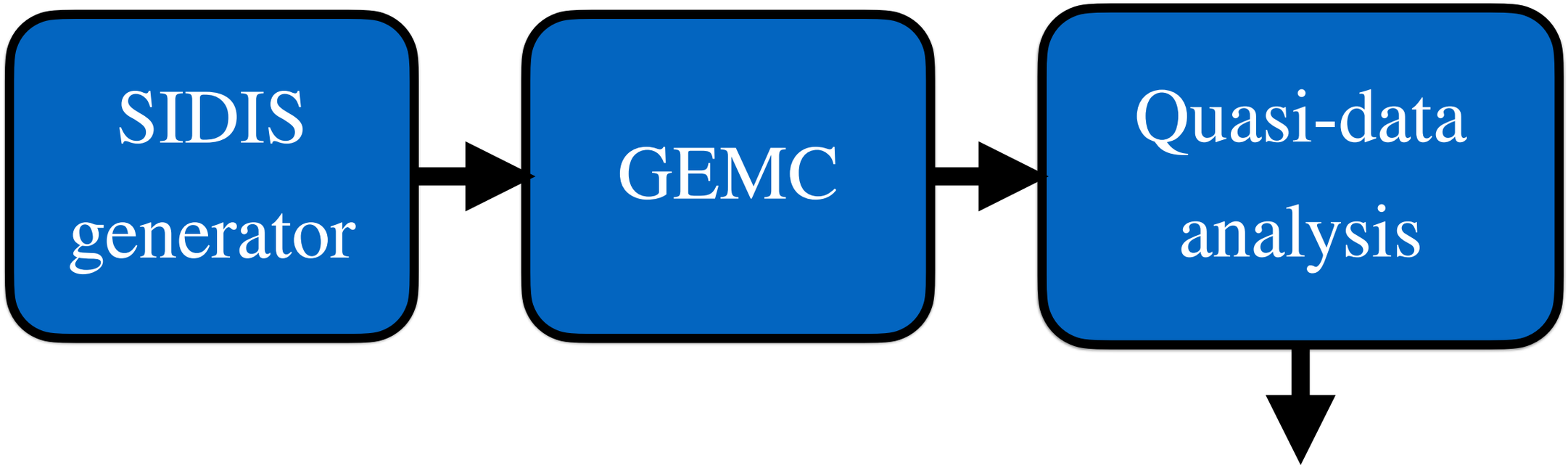
SIDIS@RGB | M_X in bins of Q^2 - $d(e, e'\pi^-)$





No acceptance corrections

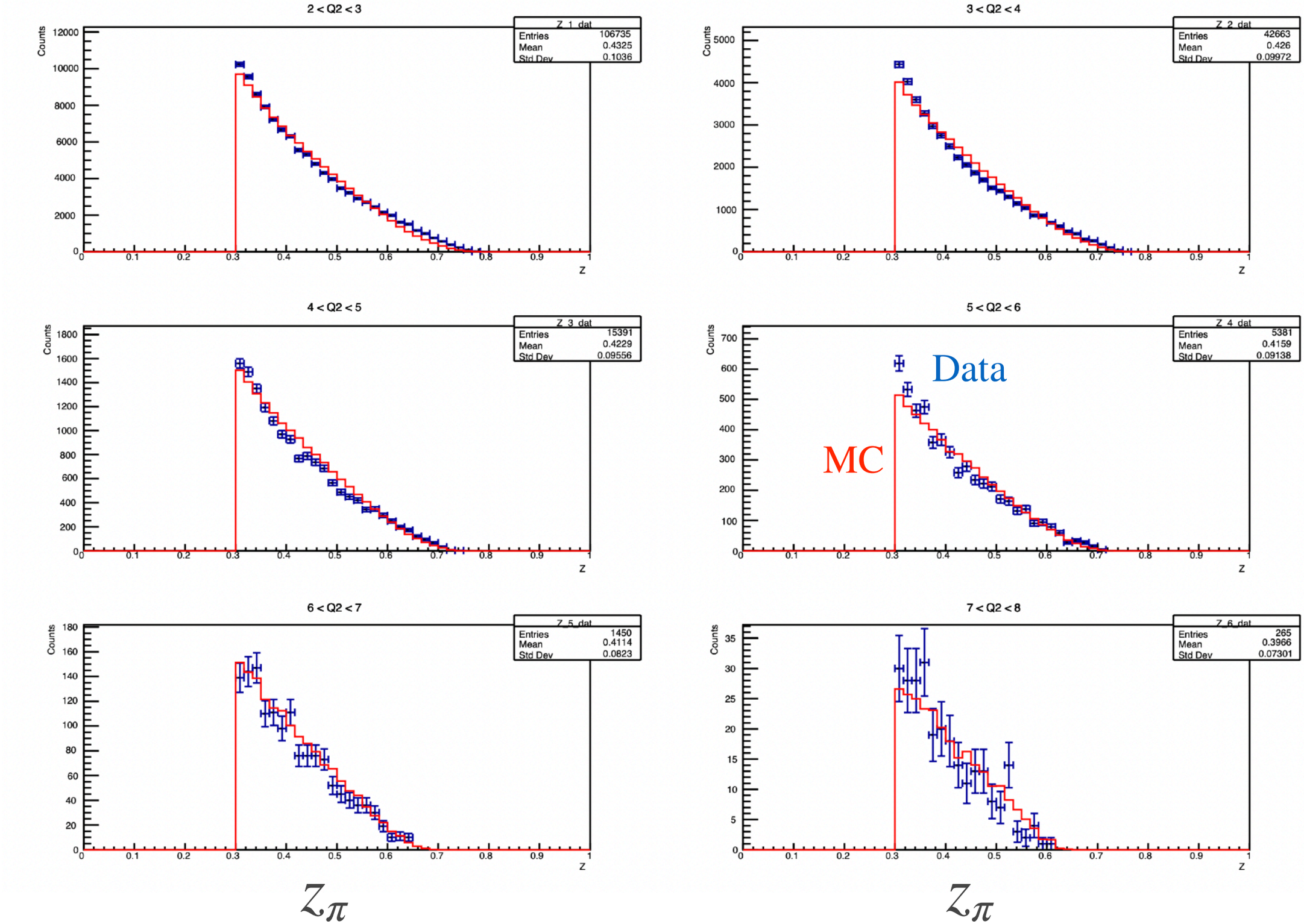
SIDIS@RGB | Acceptance corrections corrections



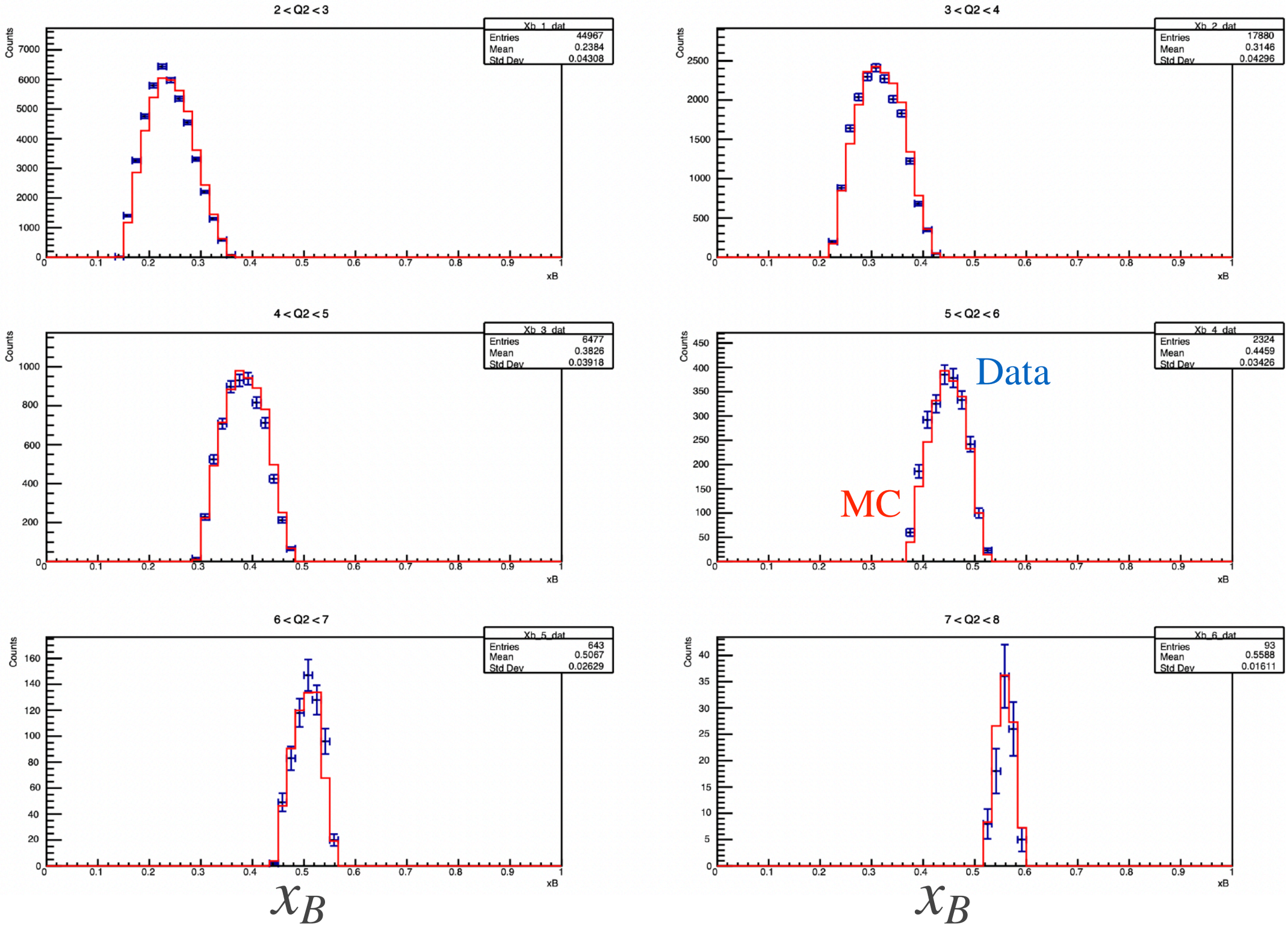
MC Corrections:

- Bin migration
- Acceptance
- ρ production

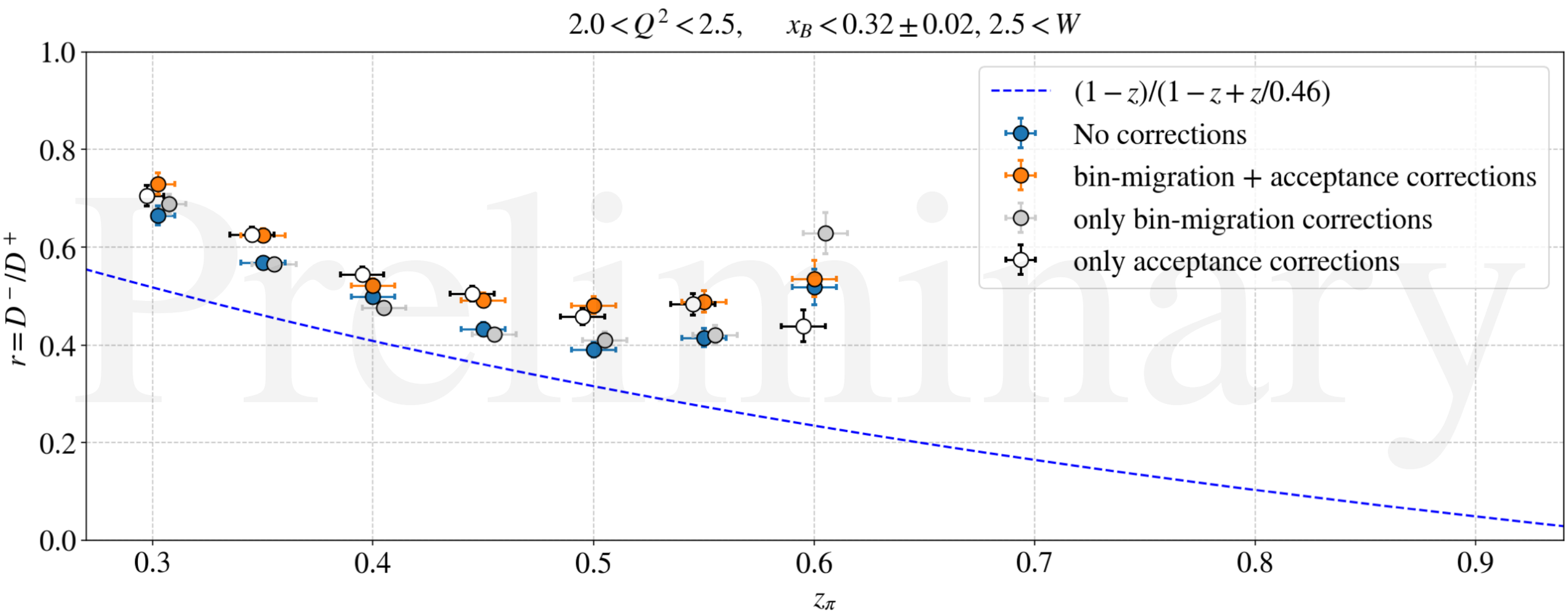
SIDIS@RGB | Reliable MC for correction calculations



SIDIS@RGB | Reliable MC for correction calculations



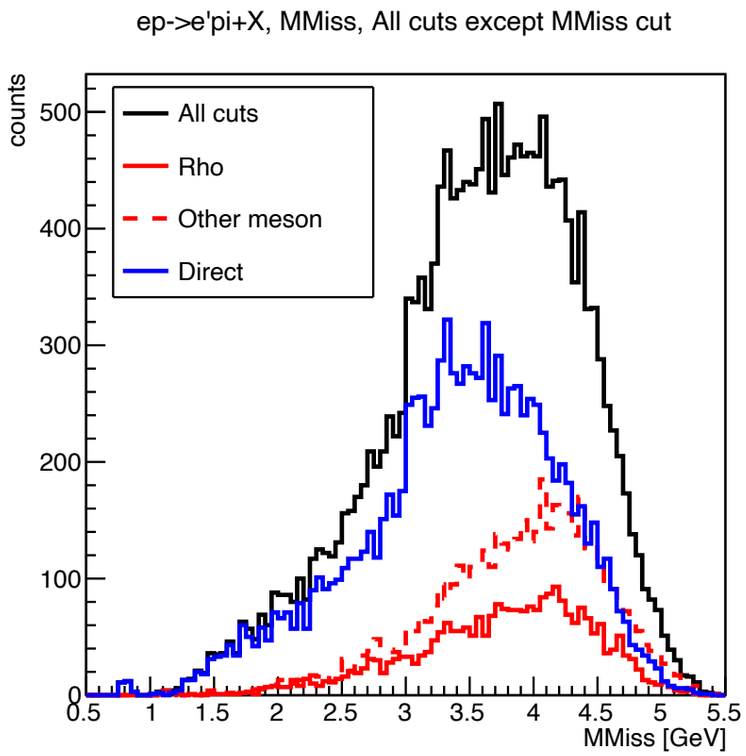
SIDIS@RGB | Impact of MC weights

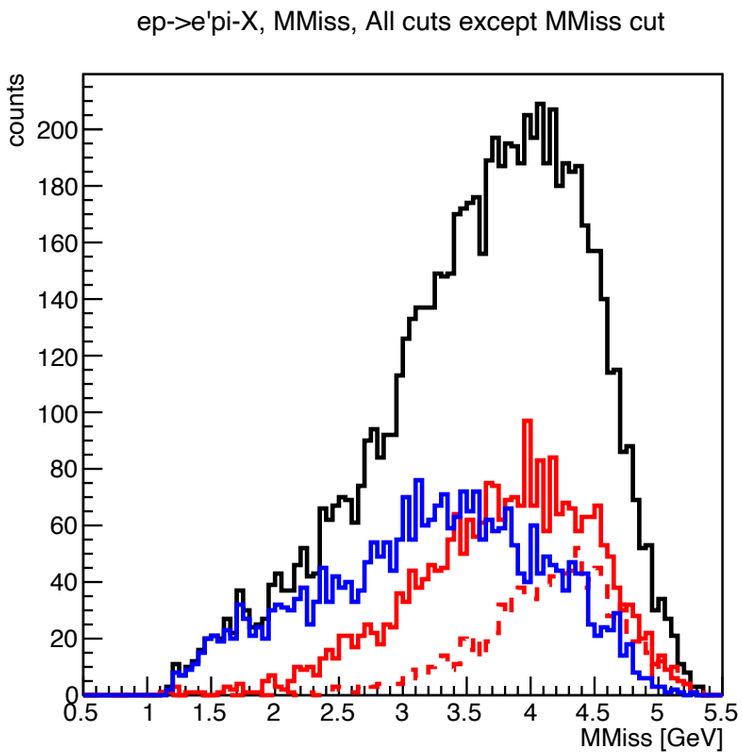


Preliminary

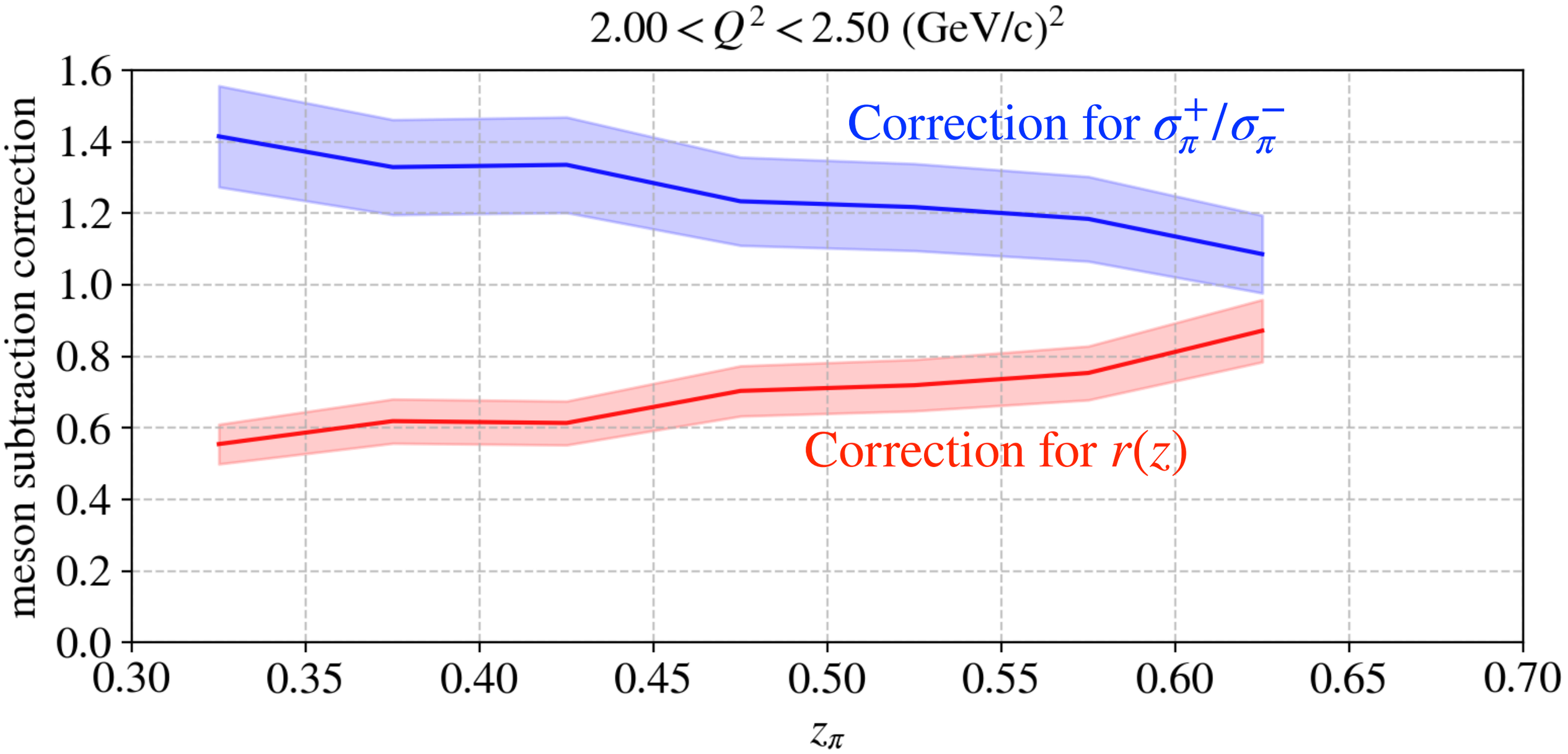
SIDIS@RGB | ρ contamination quantification

SIDIS generator → GEMC → Quasi-data analysis → Quantify π from ρ production





Example correction for $r(z)$ for $x_B = 0.3\text{-}0.35$, $Q^2 = 2\text{-}2.5$



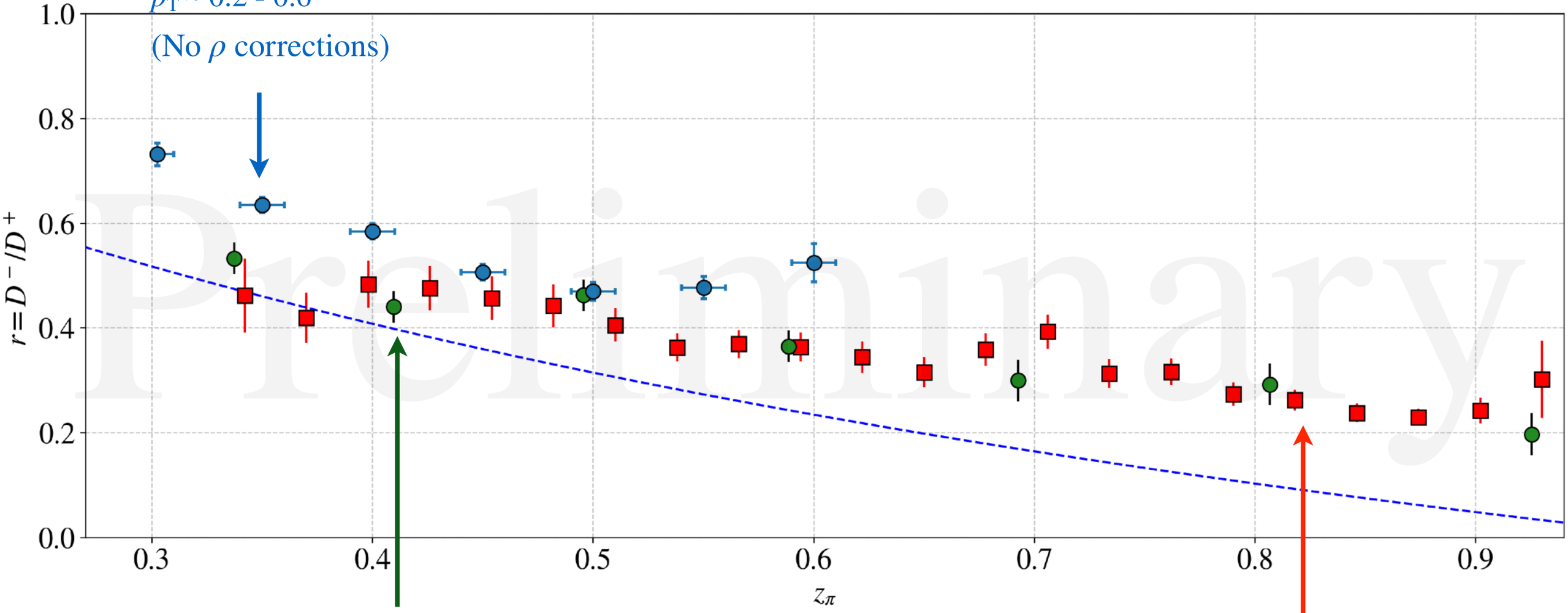
SIDIS@RGB | Validation plot

This work,

$x_B = 0.32 \pm 0.02,\ 2.0 < Q^2 < 2.5,\ W > 2.5$

$p_T \sim 0.2$ - 0.6

(No ρ corrections)



HERMES 2000

$x = 0.32,\ Q^2 > 1,\ W > 3.3$

Hommez thesis, Ghent 2003

JLAB 2012

$x = 0.32,\ Q^2 = 2.3,\ W = 2.4$

$p_T \sim 0.2$ - 0.45

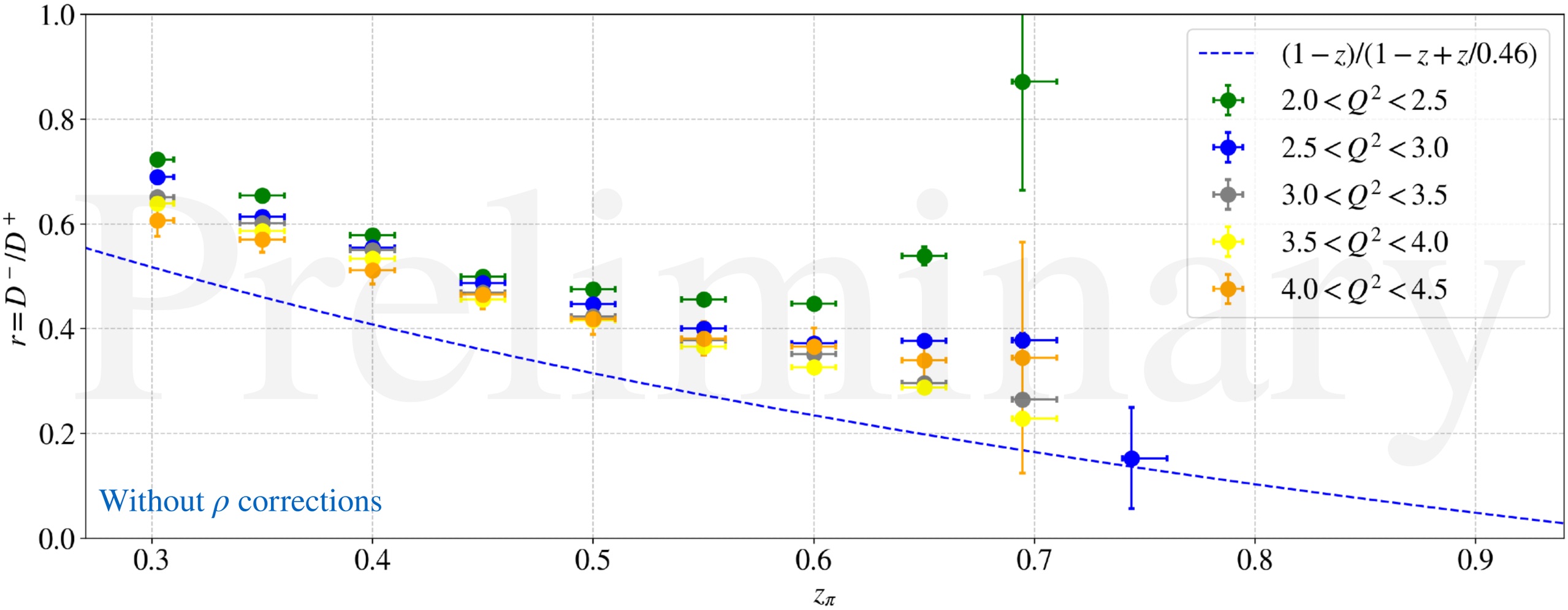
Phys. Rev. C 85, 015202

Errorbars - systematic uncertainties

Preliminary

SIDIS@RGB | $r(z)$ evolution with Q^2

$$x_B = 0.28 \pm 0.02$$

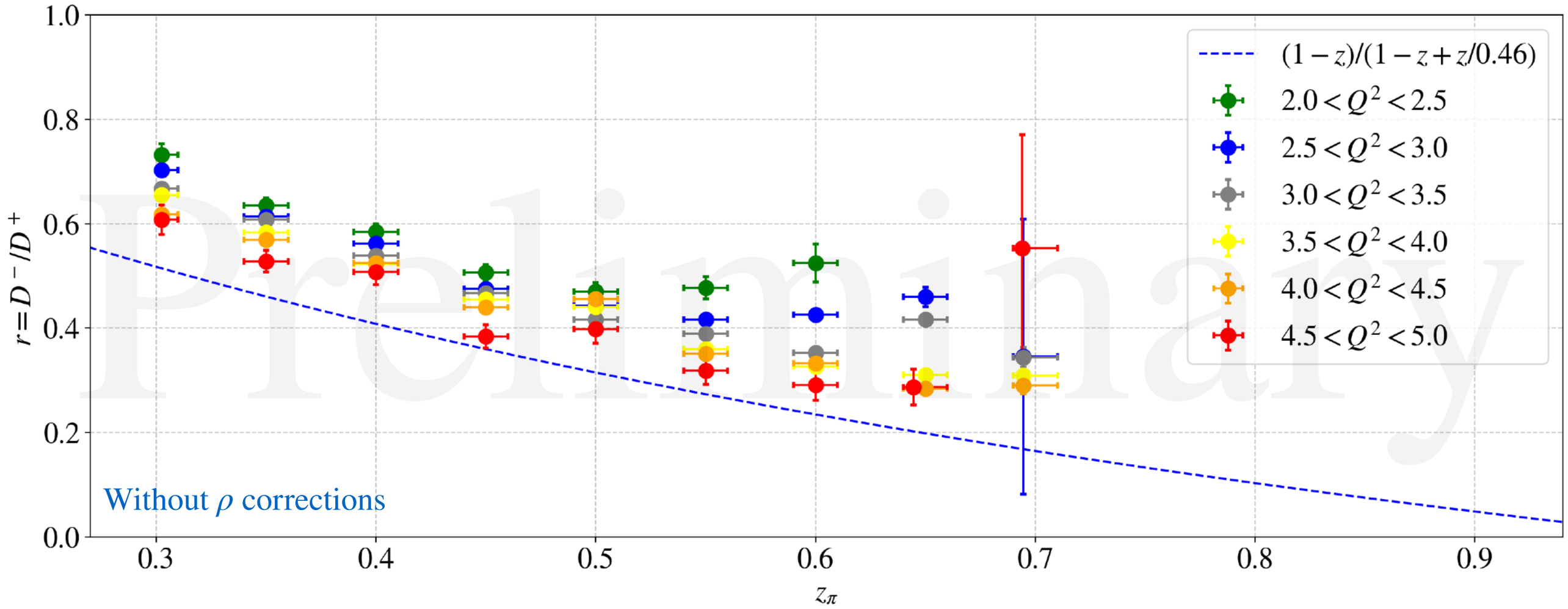


Errorbars - systematic uncertainties

Preliminary

SIDIS@RGB | $r(z)$ evolution with Q^2

$$x_B = 0.32 \pm 0.02$$

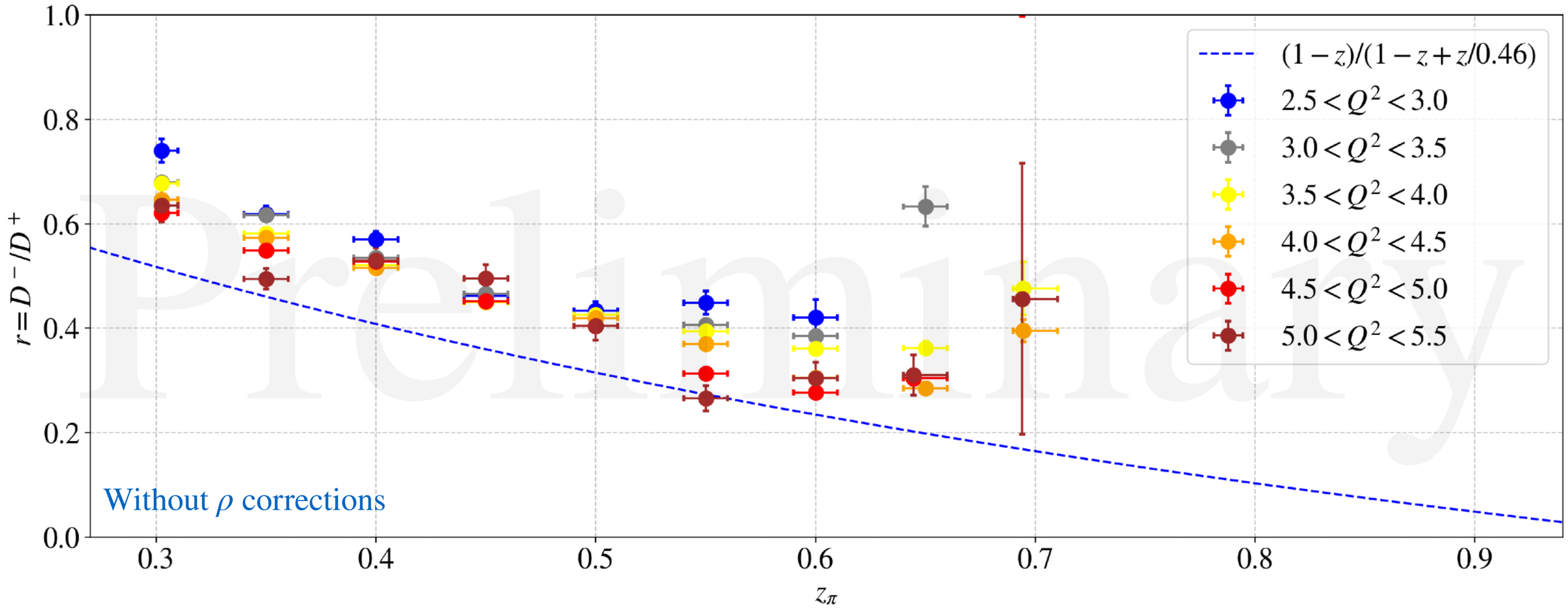


Errorbars - systematic uncertainties

Preliminary

SIDIS@RGB | $r(z)$ evolution with Q^2

$$x_B = 0.36 \pm 0.02$$

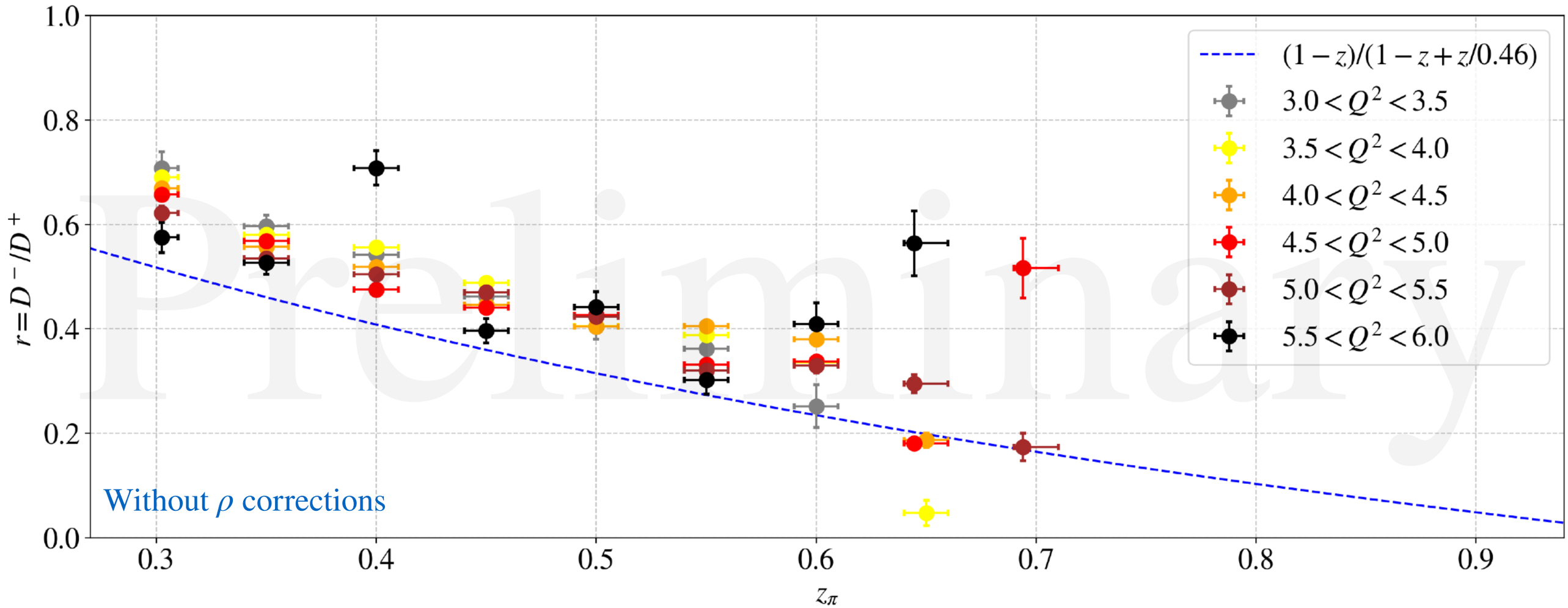


Preliminary

Errorbars - systematic uncertainties

SIDIS@RGB | $r(z)$ evolution with Q^2

$$x_B = 0.40 \pm 0.02$$

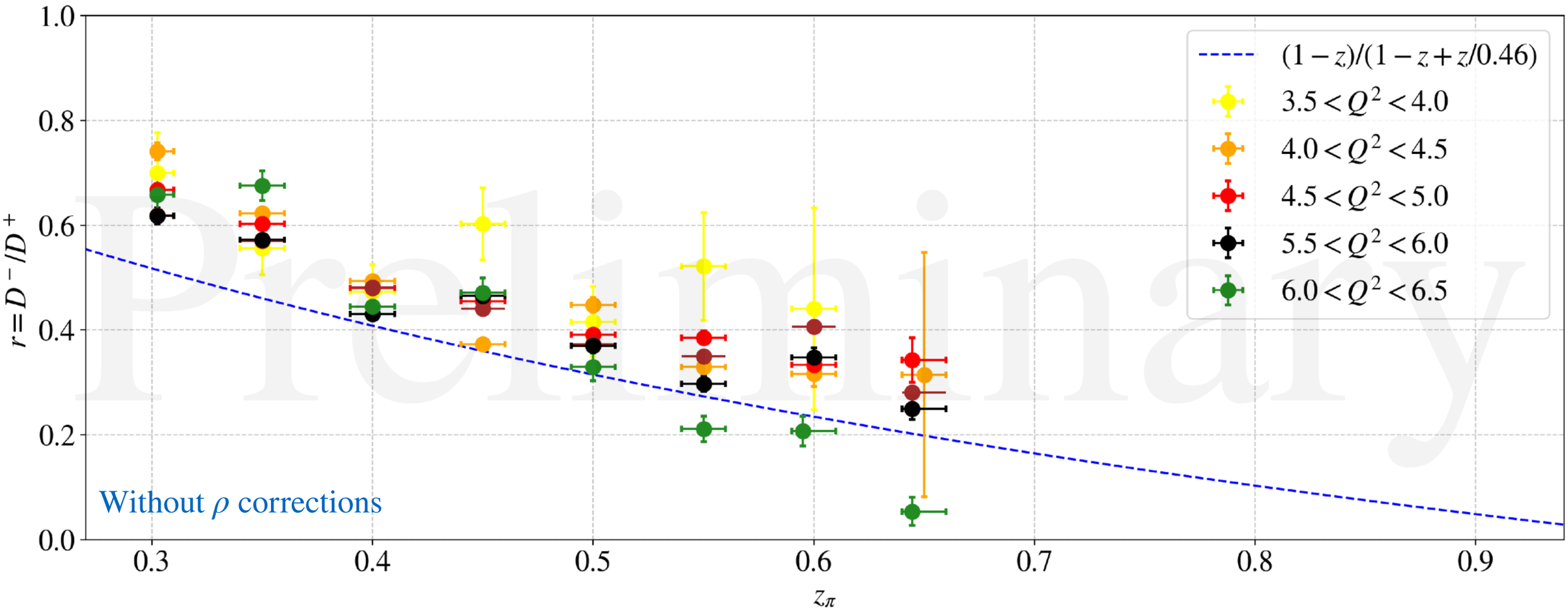


Errorbars - systematic uncertainties

Preliminary

SIDIS@RGB | $r(z)$ evolution with Q^2

$$x_B = 0.44 \pm 0.02$$



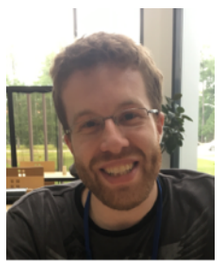
Preliminary

Errorbars - systematic uncertainties

Summary

- Low Q^2 - data consistent with published ones
- High Q^2 - data approach FF prediction
- Analysis is ready for review - we welcome comments and corrections

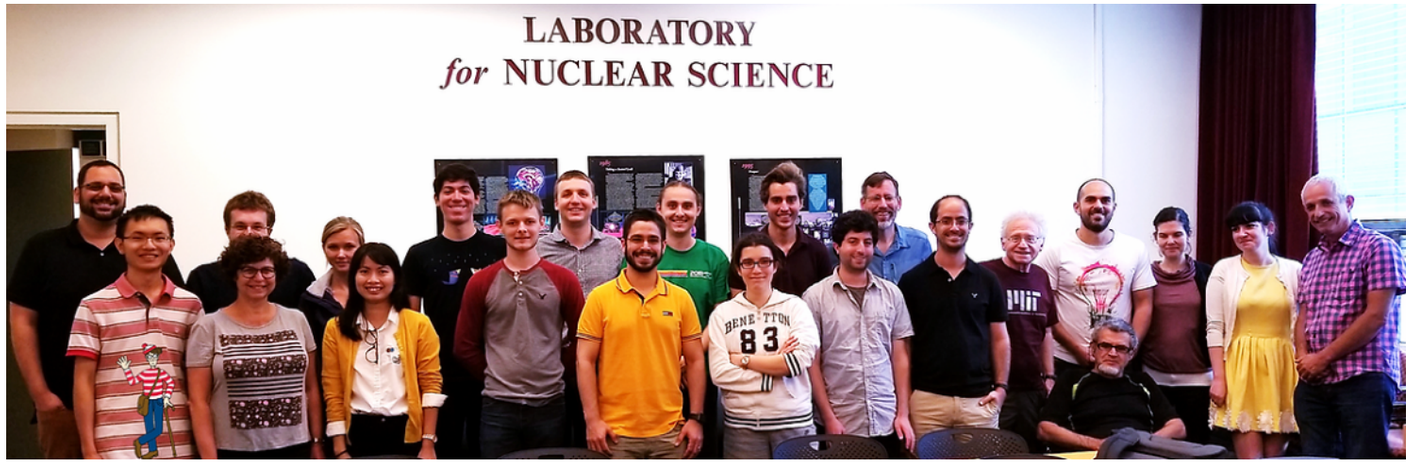
Thank you for your time



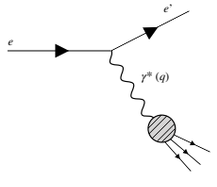










cohen.erez7@gmail.com

Backups