$R = \sigma_L/\sigma_T$ in SIDIS   (in addition to the theory slides)

➢ Knowledge of $R = \sigma_L/\sigma_T$ in SIDIS is non-existing in principle !

➢ Unpolarized cross section in SIDIS:

$$\frac{d\sigma}{dxdyd\psi dzd\phi_h dP_{h,t}^2} = \frac{\alpha^2}{xyQ^2}\frac{y^2}{2(1-\varepsilon)}\left(1+\frac{\gamma^2}{2x}\right)\Bigg\{F_{UU,T} + \varepsilon F_{UU,L} +$$
$$\sqrt{2\varepsilon(1+\varepsilon)}\cos\phi_h F_{UU}^{\cos\phi_h} + \varepsilon\cos(2\phi_h)F_{UU}^{\cos(2\phi_h)} + \lambda_e\sqrt{2\varepsilon(1+\varepsilon)}\sin\phi_h F_{LU}^{\sin\phi_h}\Bigg\}$$

➢ Integrate over ϕ_h, unpolarized beam; only L and T terms remain; SIDIS → $F(x,Q^2,z,P_t)$, DIS → $F(x,Q^2)$

➢ Integrate over z, P_t, hadron species; R_{SIDIS} → R_{DIS}

  • R_{SIDIS} may vary with z, P_t; Is R_{SIDIS} the same for π^+, π^- (K^+, K^-) ? The same for H and D targets ?

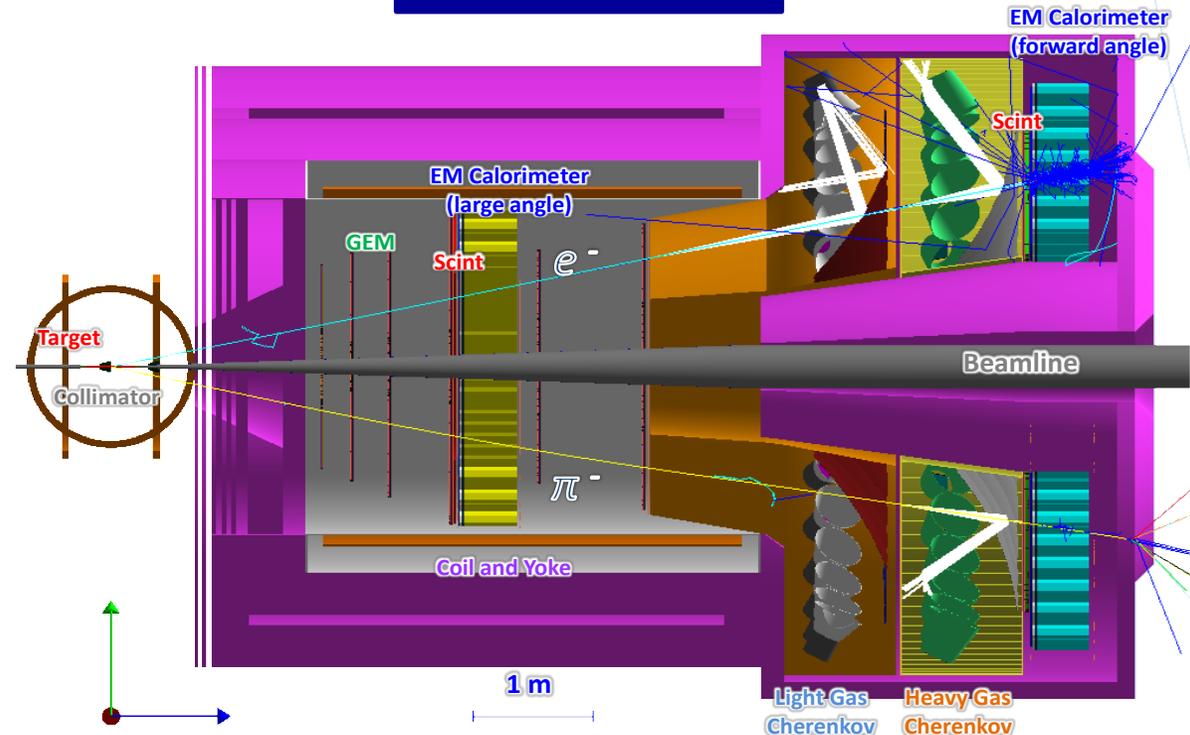 • how does R transition from SIDIS to exclusive ?

$R = \sigma_L / \sigma_T$ with SoLID ?

➢ First explore SoLID's kinematic coverage to overlap with part of Hall C R_{SIDIS} data region

➢ Require $\Delta\varepsilon = \varepsilon(high) - \varepsilon(low) > 0.2$? in any selected (x, Q^2, z, P_t) bin to enable a reliable Rosenbluth-type L/T separation

- Larger $\Delta\varepsilon$ preferred to extract R_{SIDIS}
- Random errors in σ_L magnified by $\Delta\varepsilon$

➢ Difficulties:
any errors in Q^2 and x reconstruction could mean that $\varepsilon(high)$ and $\varepsilon(low)$ bins do not correspond to each other

- assigned Q^2 and x values for these two bins will be wrong by different amounts
- extracted separated cross sections will be incorrect by much more than their statistical uncertainties

High Luminosity
10^{37-39} /cm^2/s
[>100x CLAS12][>1000x EIC]

Large Acceptance
Full azimuthal ϕ coverage

SoLID (SIDIS ^{3}He)

EM Calorimeter (forward angle)
Scint
EM Calorimeter (large angle)
GEM
Scint
e^-
Target
Collimator
Beamline
π^-
Coil and Yoke
1 m
Light Gas Cherenkov
Heavy Gas Cherenkov

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$R=\sigma_L/\sigma_T$ with SoLID ?

➢ L/T separation not possible for CLAS12 / HERMES, e.g., in exclusive $p(e, e'\pi)n$ channel

- angular and energy resolutions are not sufficiently good

➢ SHMS+HMS in Hall C can do Rosenbluth separations

- absolute spectrometer angles (both in-plane and out-of-plane) at about 1mr

- absolute beam and particle momentum calibrations at about 0.1%

➢ SoLID L/T-separation

- Exclusive: challenging; SIDIS: potentially feasible, needs study

➢ Carry out simulation studies and uncertainty propagation to see if SoLID can reach similar (or, not much larger) point-to-point systematic uncertainties (~1.1–1.6%)

- model expected uncertainties in extracted σ_L and σ_T, based on realistic estimates of precision with which detected particles' four-momenta are known

- follow Hall C procedure relying on extensive e+p coincidence elastic data to study and constrain these uncertainties

Check $\Delta\varepsilon$ with SoLID

➤ As mentioned, explore SoLID kinematic coverage to partially overlap with Hall C R-SIDIS data, while preserving SoLID's unique access to higher P_t region

➤ Study P_t coverage with 11 GeV and 8.8 GeV beams as a starting point

   • Identify bins with sufficient ε separation and high acceptance
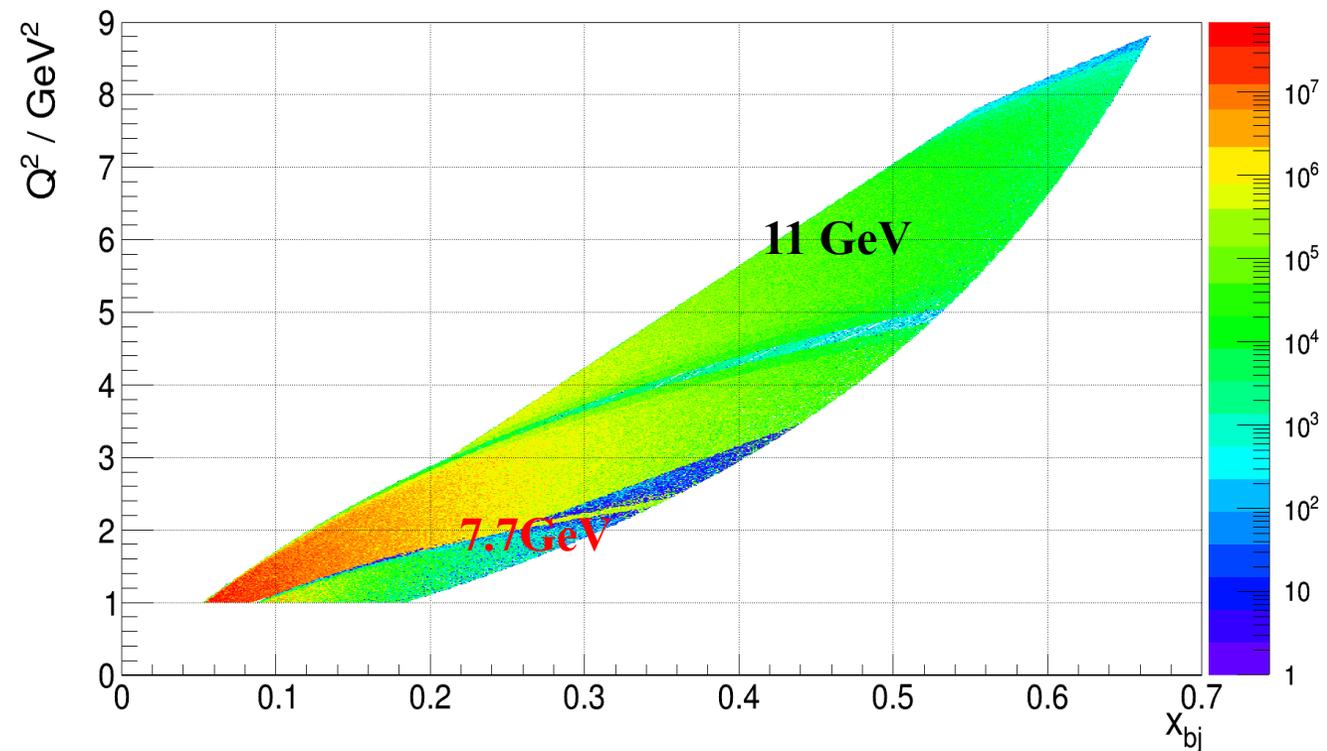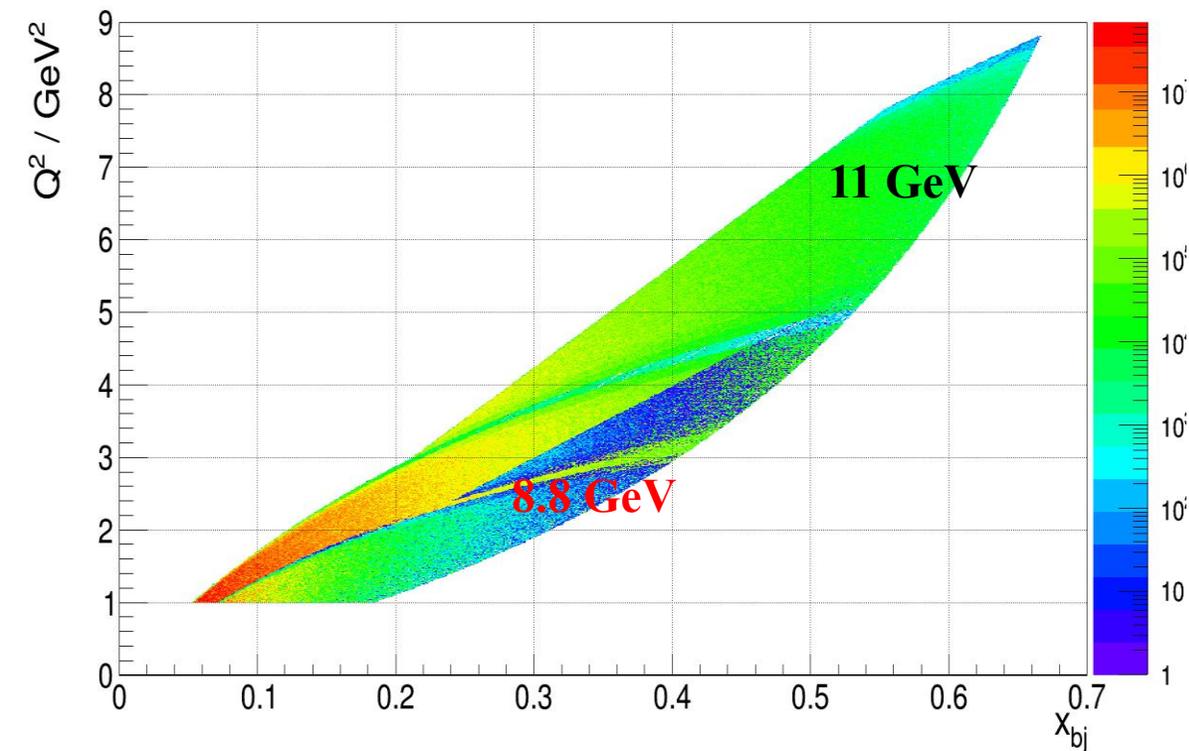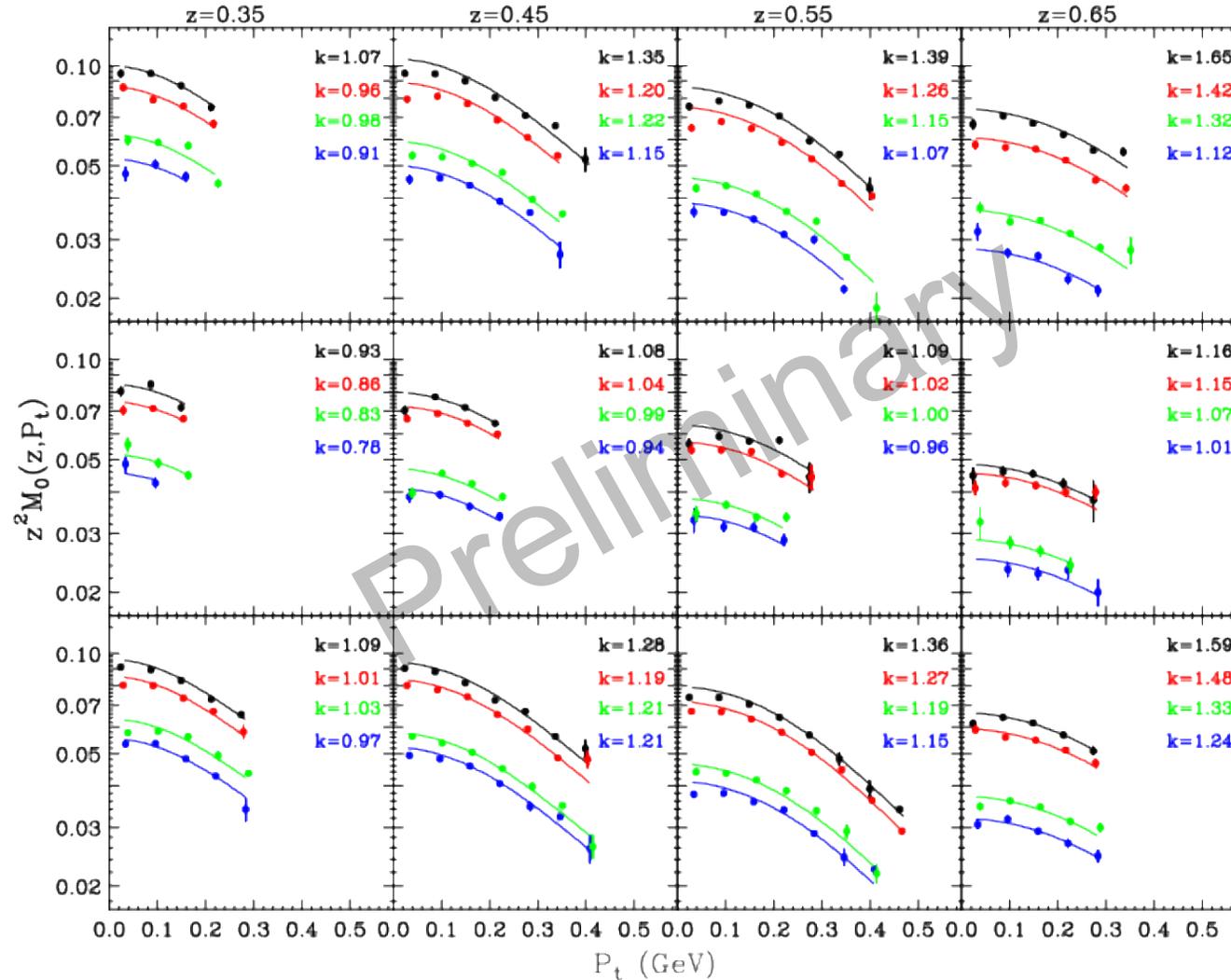
P_t Coverage
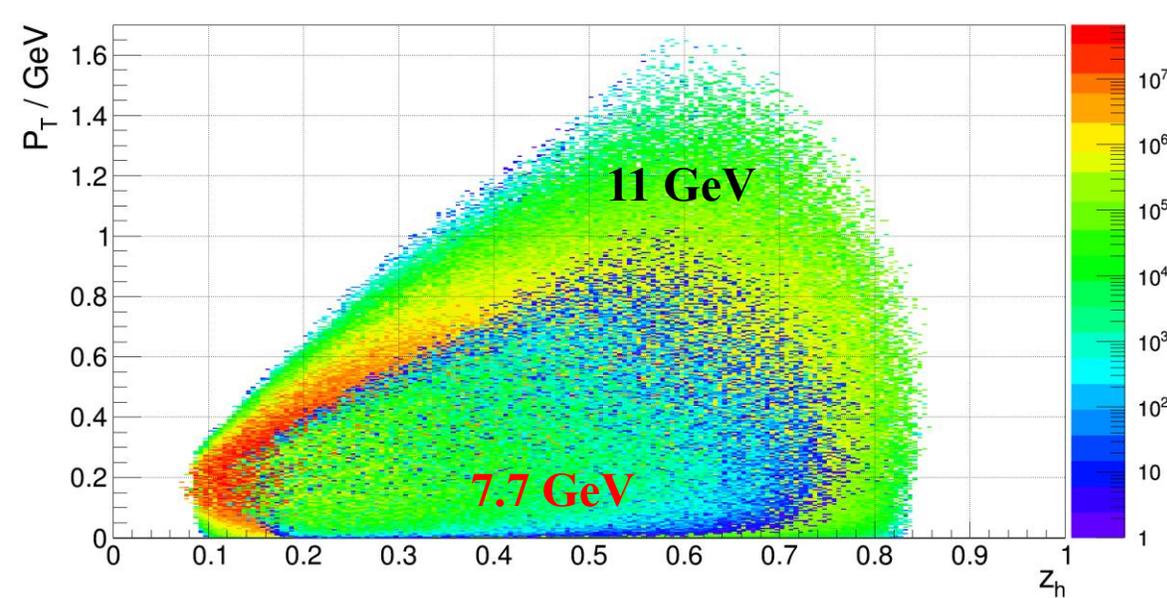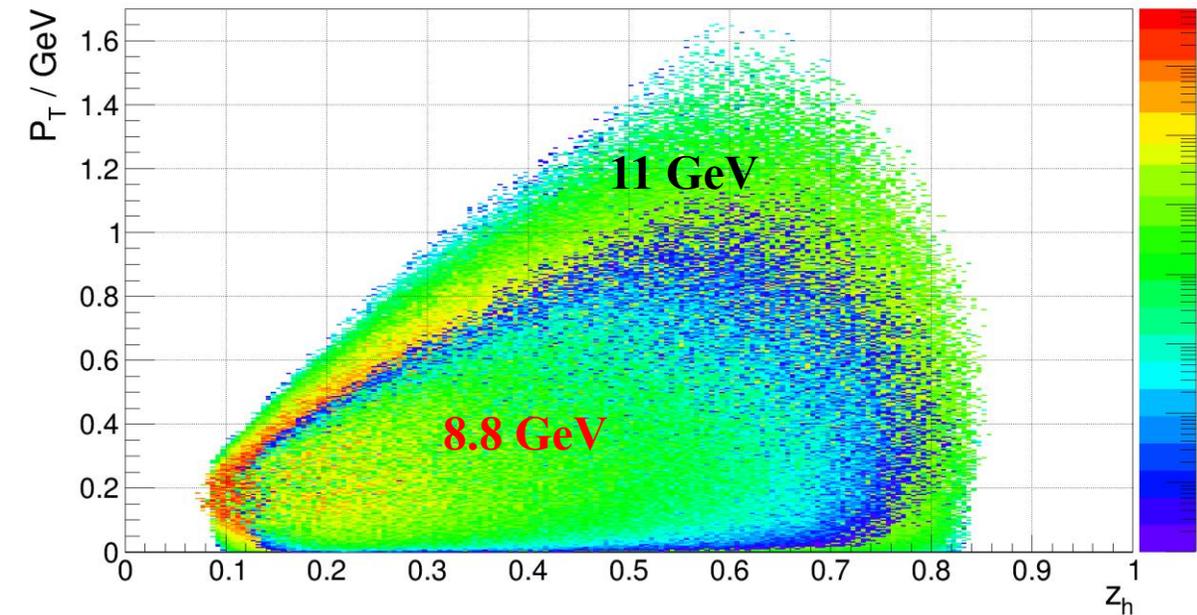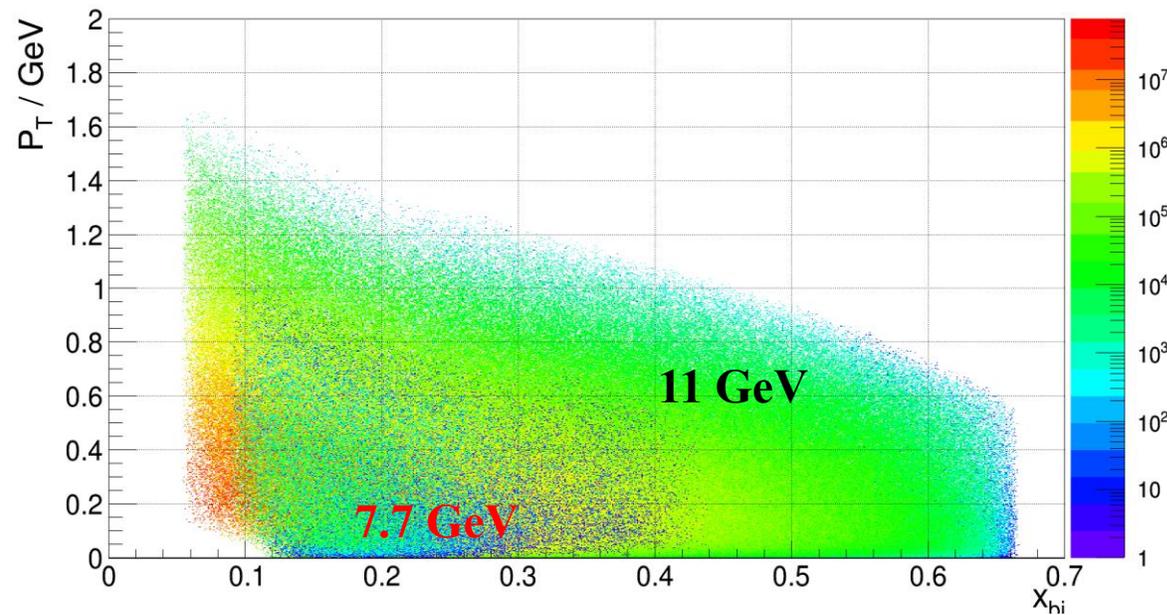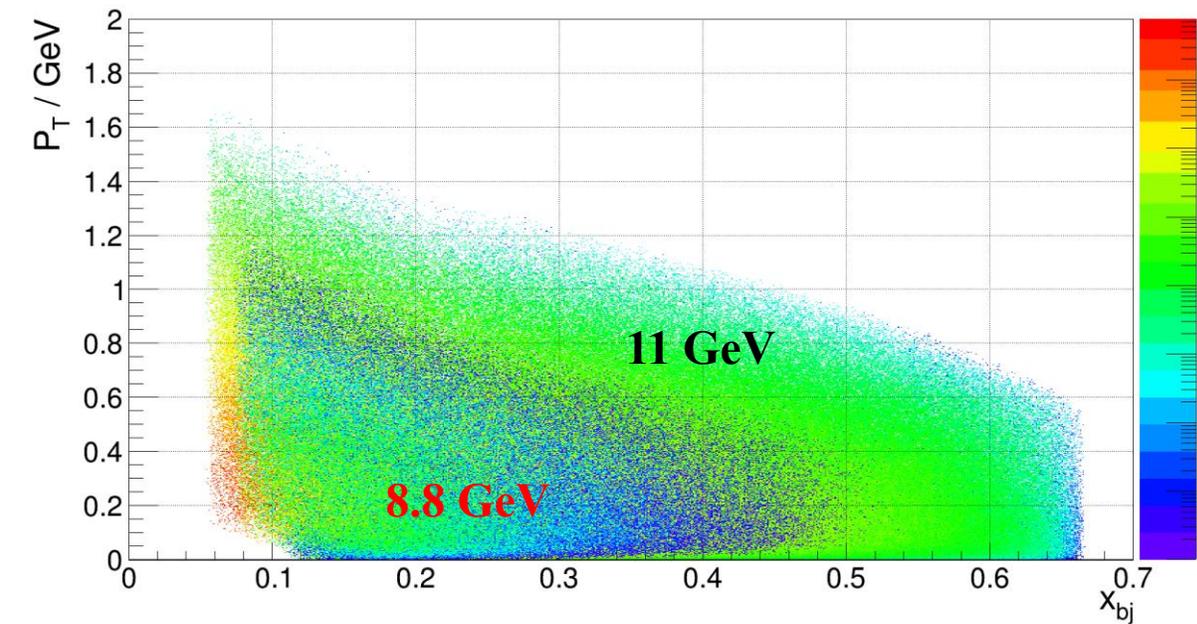
Multiplicities: P_T Dependence at Hall C kinematics

Curves from MAP collaboration, scaled by factor k

MAP uses Gaussian plus weighted Gaussian for P_t dependence

Generally good agreement

● π^+ from p

● π^+ from d

● π^- from d

● π^- from p

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Experimental summary

➢ L-T separation requires deep understanding of SoLID acceptance to have good control of point-to-point systematic uncertainties

➢ Specific regions of phase space to be studied to have some trade-off using different energies

➢ Potential SoLID measurements to be complementary to Hall C experiment E12-06-104

➢ Bacchetta-Cerutti new model for $F_{UU,L}$ structure function and therefore for R-ratio upcoming

➢ Good opportunity with SHMS+HMS in Hall C **+** SoLID in Hall A to utilize

    • at small P_t, R-ratio scales as Q^2 and at JLab kinematics its effect going to be sizable

    • having good number of bins in P_t (at fixed x, z, and Q^2) will help understand interface between TMD physics and collinear physics

➢ After more studies, in the case of promising results, we may prepare LOI, afterwards new proposal

Backups

Role of Hall C in JLab SIDIS Program

Hall C uses magnetic focusing spectrometers with moderate acceptance

Optimal Hall C SIDIS program:
→ Targeted measurements in specific regions of phase space (i.e., low-rate processes)
→ **Absolute cross sections**, **L-T separations**, **ratios**

Complementary to large acceptance devices that can access large phase space all at once

Excellent control of point-to-point systematic uncertainties required for precise L-T separations
→ Ideally suited for focusing spectrometers
→ One of the drivers for SHMS design

SHMS

HMS
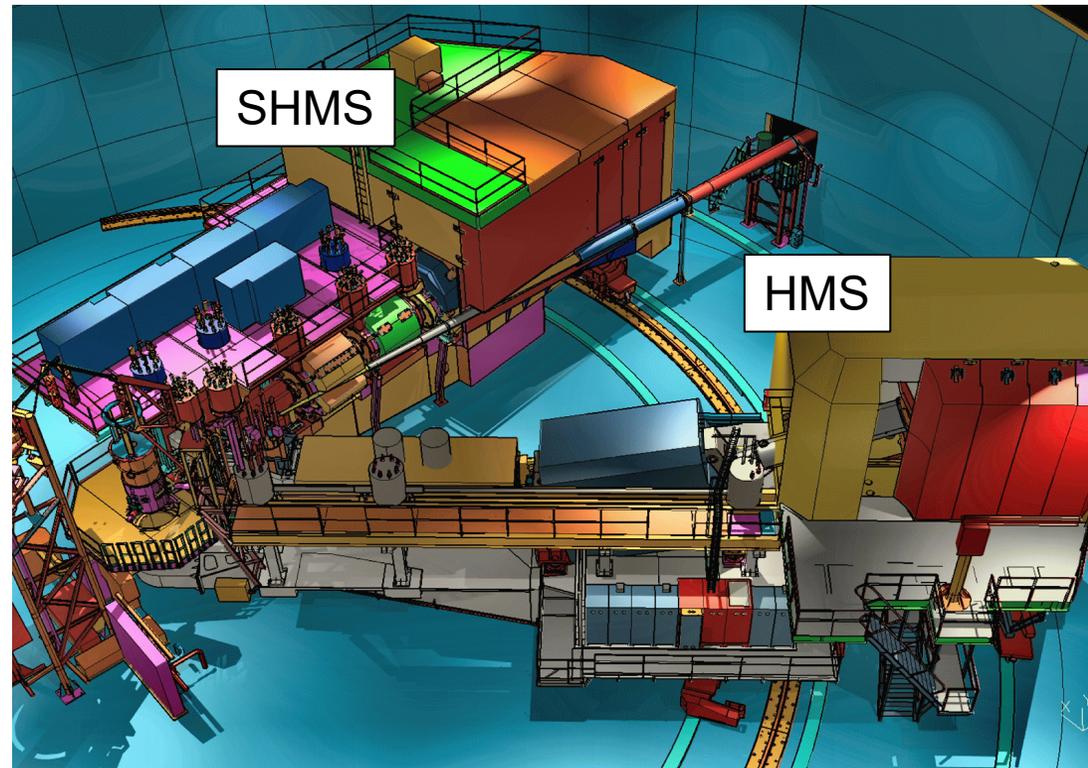
Identical acceptance for positive and negative polarity
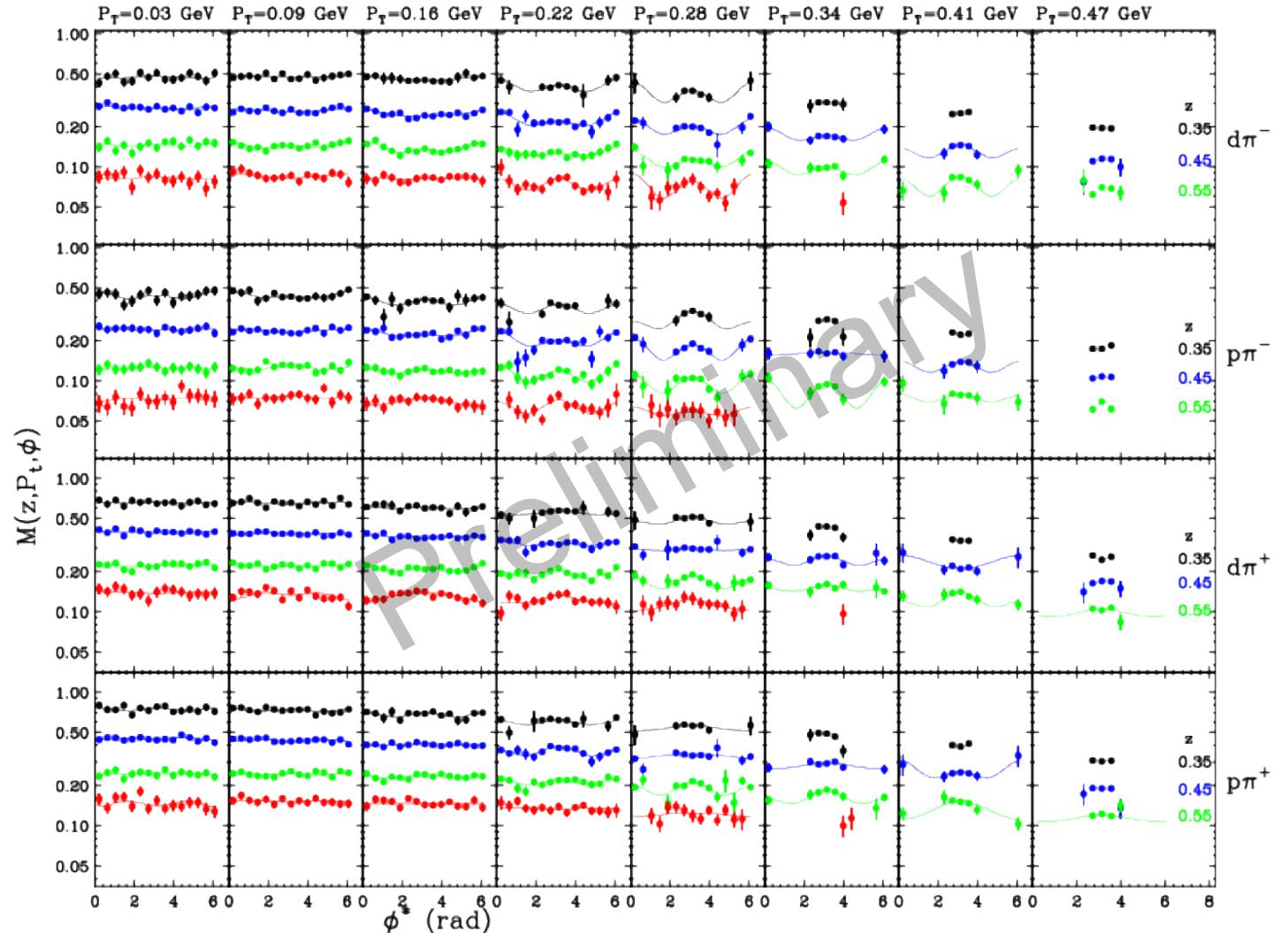→ Precision measurement of charged meson ratios

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P_T and ϕ Dependent Multiplicities measured in Hall C

P_t and ϕ dependence extracted for several kinematics

I) x=0.31, Q^2=3 GeV^2
II) x=0.30, Q^2=4.1 GeV^2
III) x=0.45, Q^2=4.5 GeV^2

Fit to the following form:

$$M(z, P_t, \phi) =$$
$$M_0 \left[1 + A\cos\phi + B\cos 2\phi\right]$$

x=0.31, Q^2=3 GeV

E12-06-104: SIDIS L-T Separations

E12-06-104: Measurement of the Ratio $R=\sigma_L/\sigma_T$ in Semi-Inclusive Deep-Inelastic Scattering

→ *Will start running in mid-July, this summer!*

Precise measurements of R_{SIDIS} in

$e+p \to e'+\pi^{+/-}+X$, $e+D \to e'+\pi^{+/-}+X$

L-T separation requires excellent understanding of acceptance, control of point-to-point systematic errors

→ ideally suited to Hall C equipment at 12 GeV

1. Scans in z at $Q^2 = 3.3$ ($x = 0.25$) and 4.4 GeV^2 ($x = 0.44$) → behavior of σ_L/σ_T for large z.
2. Cover $Q^2 = 1.6 - 4.4$ GeV^2, → both H and D at $Q^2 = 3.1, 3.3, 4.4$ GeV^2
3. P_T up to ~ 0.8 GeV. Coverage in ϕ is excellent (o.k.) up to $P_t = 0.2$ (0.4) GeV.

$R = \sigma_L/\sigma_T$ in SIDIS (ep → e'$\pi^{+/-}$X)

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