Multiplicities of $\pi^\pm$ and $K^\pm$ Production in Semi-inclusive DIS on a Proton and Deuteron Target

Sylvester J. Joosten
University of Illinois at Urbana-Champaign
on behalf of the HERMES Collaboration

Goals

- Provide the most precise multi-dimensional dataset from semi-inclusive DIS (SIDIS) to date
- Evaluation of the quality of modern parametrizations for fragmentation functions (FFs) and parton distribution functions (PDFs)
- Input for the next generation of parametrizations
- Multidimensional access to transverse momentum distributions
- Invaluable information for future experiments
  - test the applicability of a LO, leading twist approach at intermediate energies
  - investigate the limits of the analysis techniques

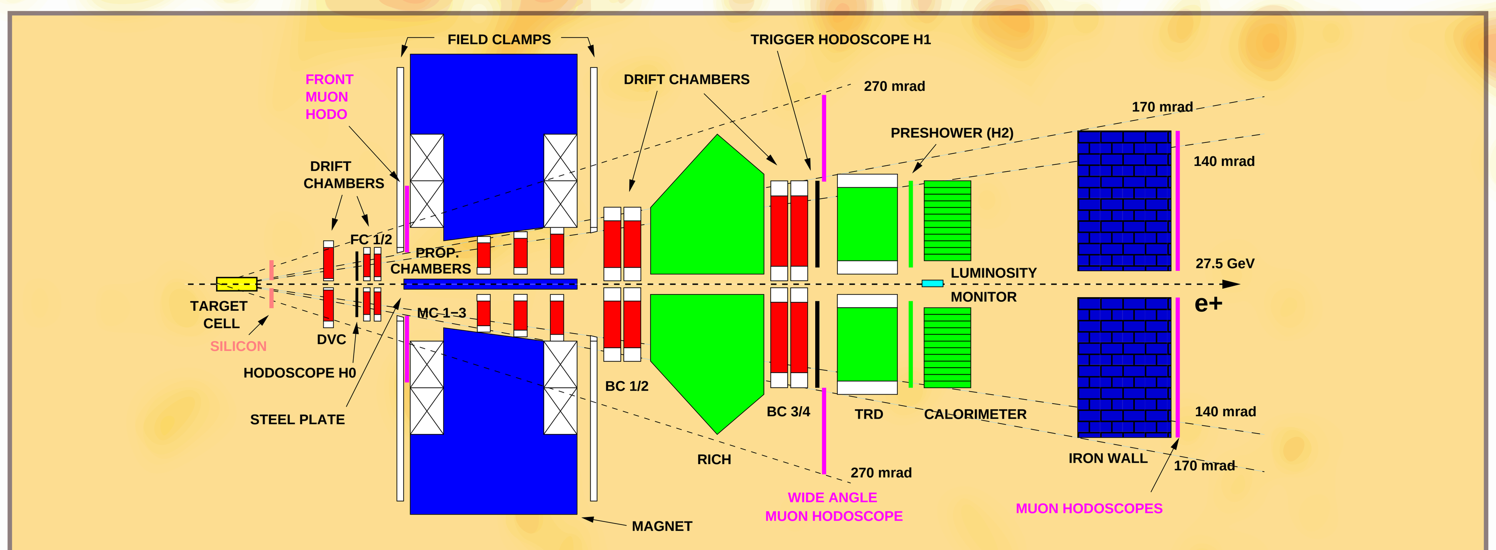
Multi-dimensional Multiplicities

- 3D analysis (in x, z, p_T and Q^2, z, p_T)

$$M_t^h(Q^2, x, z, p_T) = \frac{dxdQ^2}{d^2N_t^{DIS}(Q^2, x)} \frac{d^4N_t^h(Q^2, x, z, p_T)}{dxdQ^2dzdp_T}$$

Extracting SIDIS Multiplicities at HERMES

- Hydrogen and deuterium atomic gas target
  - no dilution due to nuclear effects
  - effectively pure proton and deuteron targets
- Correction for trigger inefficiencies
  - based on momentum and event topology
- Lepton-hadron separation
  - uses the combined response of a TRD, a RICH, a preshower detector and a lead-glass calorimeter
  - lepton-hadron separation > 98% with <1% contamination
- Charge-symmetric background correction
- Pion-kaon separation
  - RICH detector
  - Event-levent direct ray tracing (EVT) algorithm yields hadron type
  - Construct probability $P_{h1,h2}$ that $h1$ is misidentified as $h2$
  - Use the inverse of the P-matrix to unfold to the true particle types
  - π, K and p are considered during RICH unfolding
- Smearing-unfolding to correct for radiative effects, limited acceptance and detector smearing
  - Effects lead to bin-to-bin migration and a detection efficiency < 100%
  - Evaluated using 2 Monte Carlo simulations
  - Probabilistic information summarized in the smearing matrix S
  - Solve matrix equation to obtain Born level multiplicities
  - Resulting covariance matrix not diagonal!



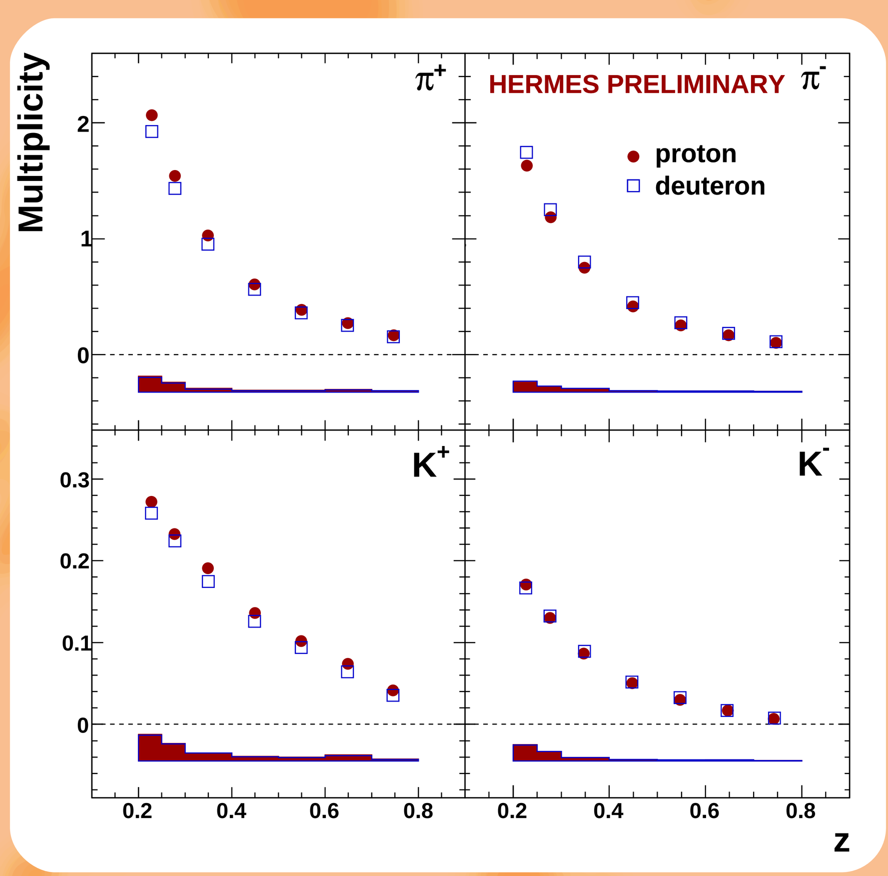
Selection of a Clean SIDIS Sample

- DIS regime: $Q^2 > 1\,\text{GeV}^2$
- avoid resonance region: $W^2 > 10\,\text{GeV}^2$
- optimal resolution and trigger efficiency: $y > 0.1$
- avoid large radiative corrections: $y < 0.85$
- supress target fragmetation: $z > 0.2$
- exclude exclusive region: $z < 0.8$

Systematic Uncertainties

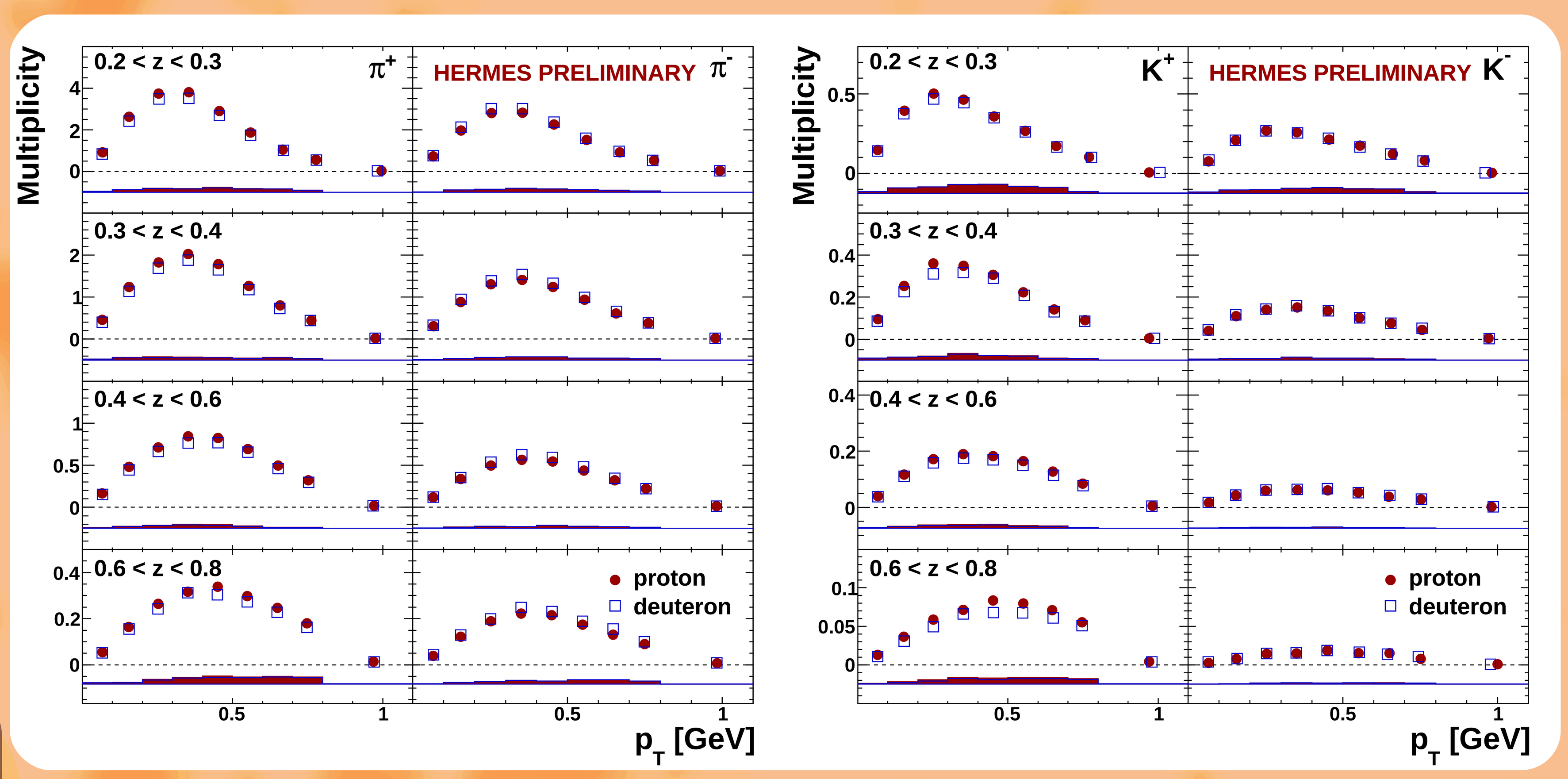
- Time dependence to account for detector fluctuations between 2000–2005
- MC model dependence of the smearing-unfolding
- Azimuthal modulations of the SIDIS cross section not taken into account during acceptance correction
- EVT algorithm sensitive to PMT background hit assumption.

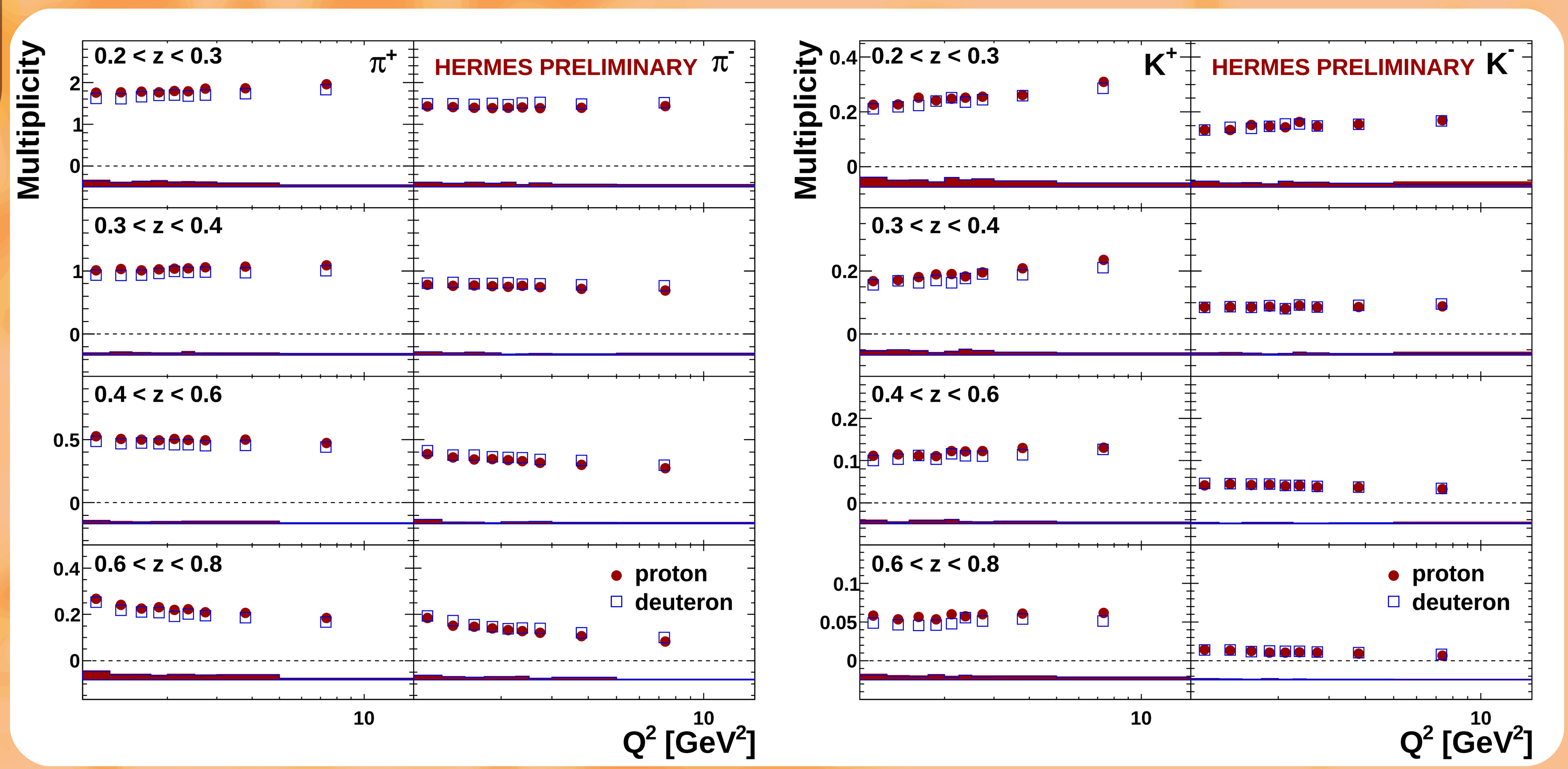
Results: Projection vs z



Results: Projection vs p_T and Q^2 in z slices

- Disentanglement of (z, p_T) and (z, Q^2), third dimension is projected out



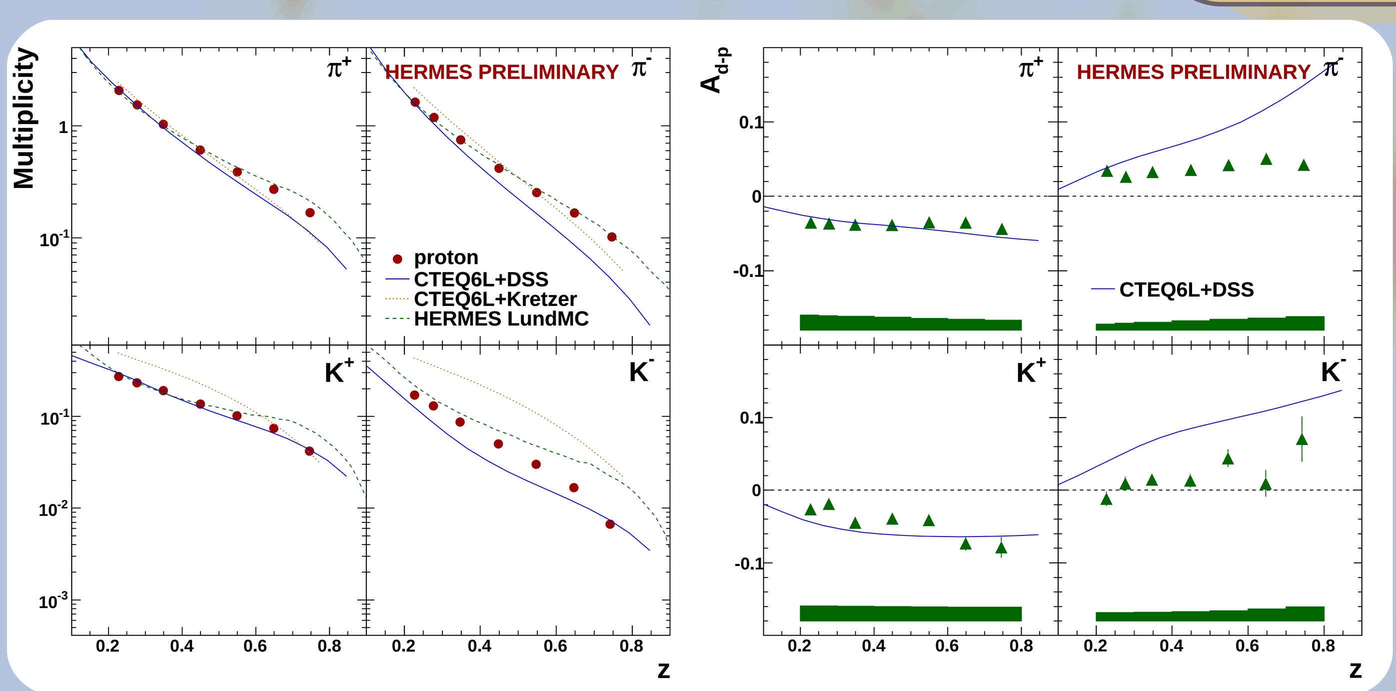


Comparison with LO Predictions

- Good agreement for CTEQ6 PDFs with DSS FFs for π^+ and K^+
- CTEQ6 with Kretzer performs well for pions
- Larger deviations for π^-
- Agreement with K^- rather poor
- (Some disagreement at higher z expected due to exclusive VM contributions)

Target Comparison

$$A^h_{d\text{-}p} = \frac{M_d^h - M_p^h}{M_d^h + M_p^h}$$



ILLINOIS