Vector mesons and detector complementarity

Spencer Klein, LBNL

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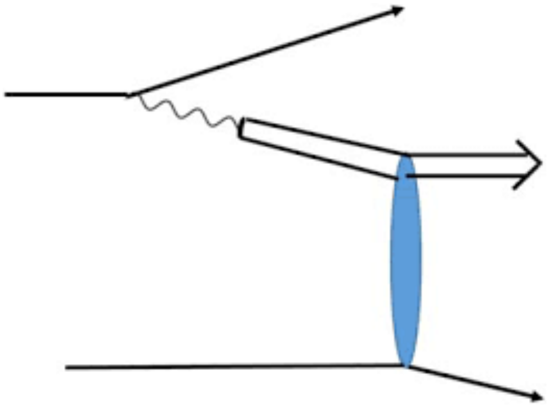
- Rapidity distributions for exclusive vector mesons
- Detector requirements for pseudorapidity coverage
- Ideas about a complementary detector?



Work done in collaboration with Sam Heppelman

Vector meson rapidity

- One key goal of the EIC is to probe parton distributions down to the lowest reachable Bjorken-x.
- Vector meson photo/electroproduction is a key channel for probing gluons at low x.
  - Q^2 (parton) = Q^2 (photon) + $(M_V/2)^2$
    - Low Q^2 requires light mesons.
    - At too low Q^2, pQCD fails, but it is still important to make the measurement.
      - The EIC White Paper highlighted the ϕ
- Bjorken-x maps directly into vector meson rapidity
  - For photoproduction, $y = \ln(2\gamma x M_p/M_V)$
    - Lowest Bjorken-x -> smallest y
    - Kinematic cutoff in y is at $2\gamma x M_p k = M_V^2$
      - N. b. x>1 production in heavy targets extends to larger y
  - The extremes are most important: very low x, and near threshold

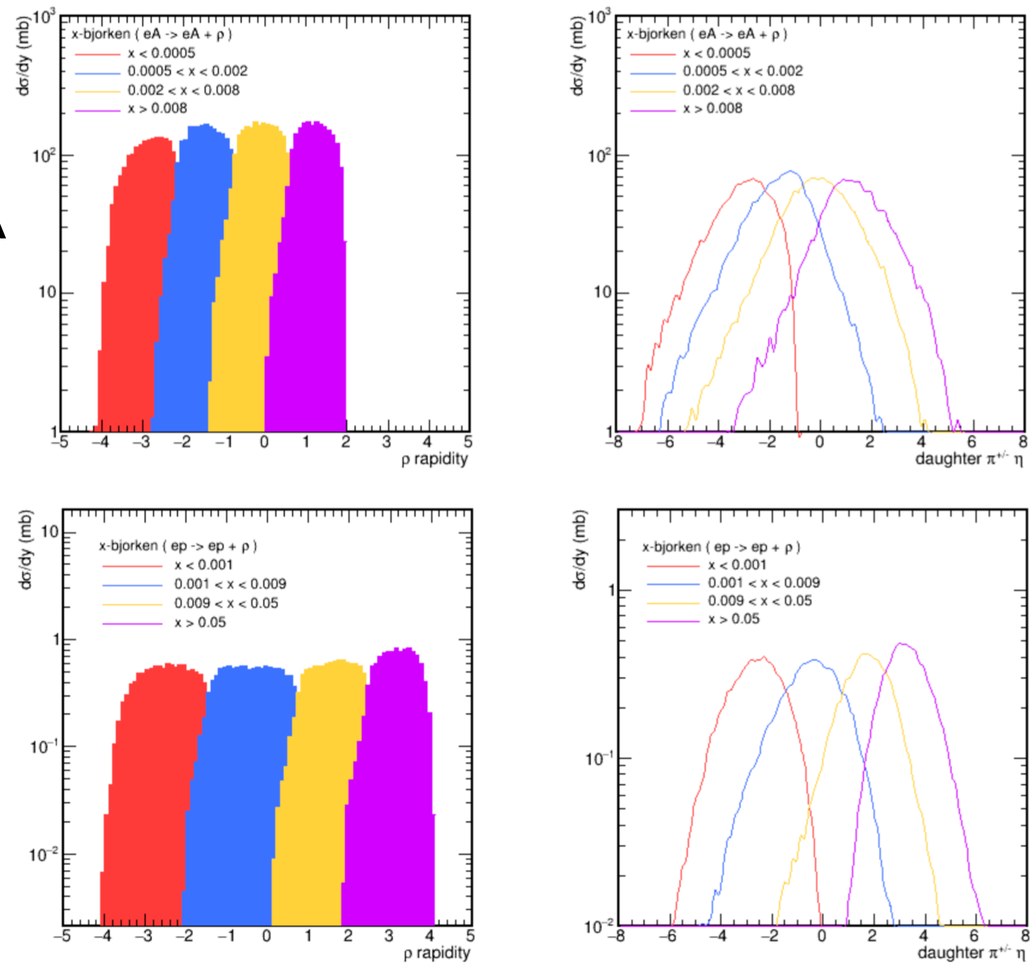
Rapidity ranges for ep and eA

- eA has lower per-nucleon energy
  - Lower energy/nucleon –> shifted scale wrt Bjorken-x
  - Lower $\sqrt{s_{eN}}$ -> Narrower rapidity range

ρ photoproduction

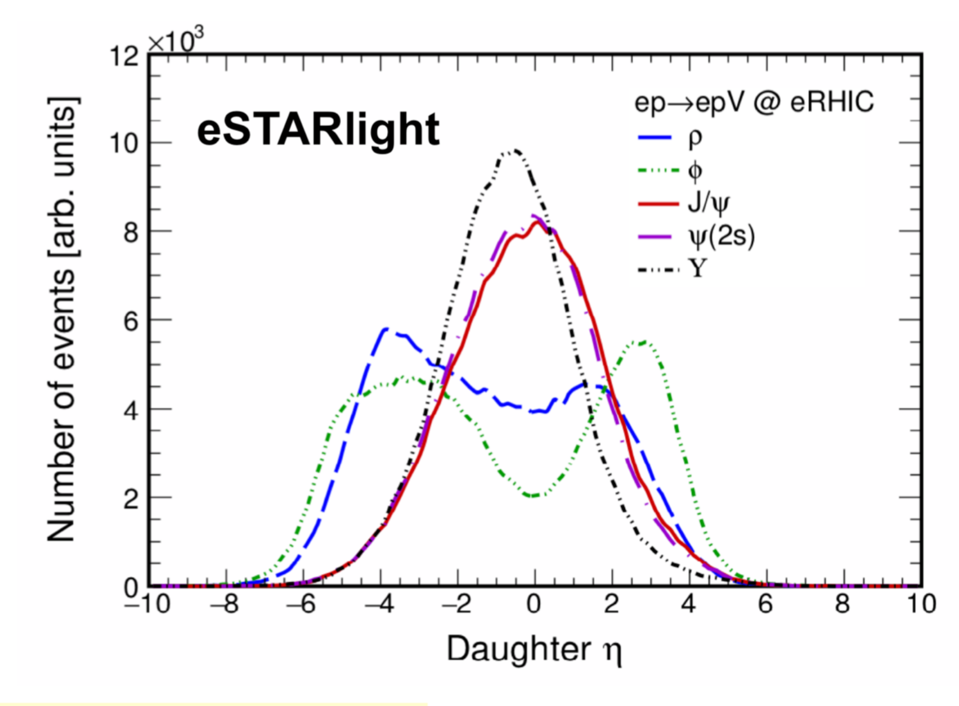
eA

ep



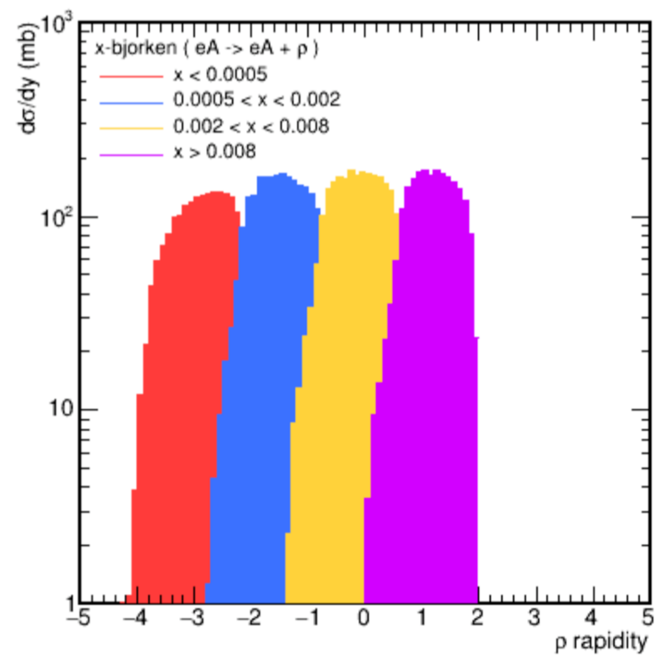
From VM rapidity to π/K/e/μ pseudorapidity

- The relationship between VM rapidity and daughter pseudorapidity depends on the angular distribution of the decay in the VM rest frame.
  - Clebsch-Gordon coefficients for J=1 decays to two J=1/2 particles are different from decays to two J=0 particles

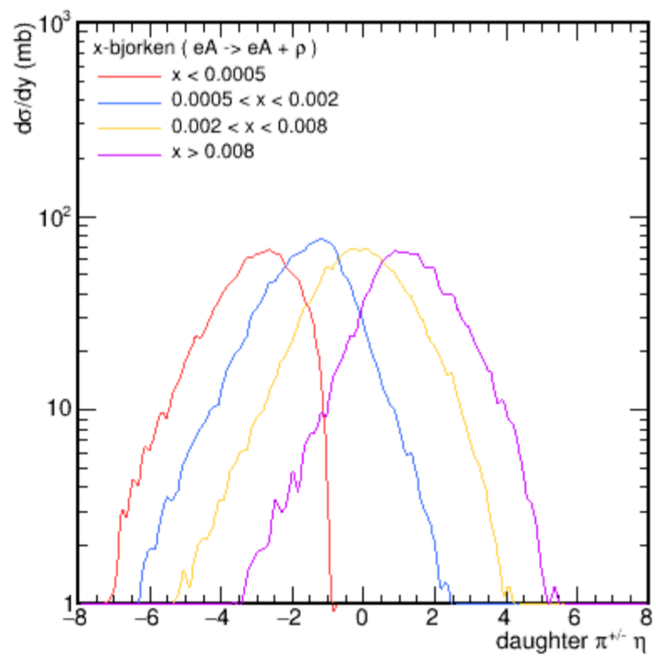


Pseudorapidity & Bjorken-x

- VM daughter particles usually have pseudorapidity within ± 1 of the parent rapidity.
  - Coverage for -4< |y| < 4 vector mesons requires -5 < |η|<5
- Rates for light mesons are high, so could push this a little.



ρ rapidity



π pseudorapidity

18 GeV e on 275 GeV p

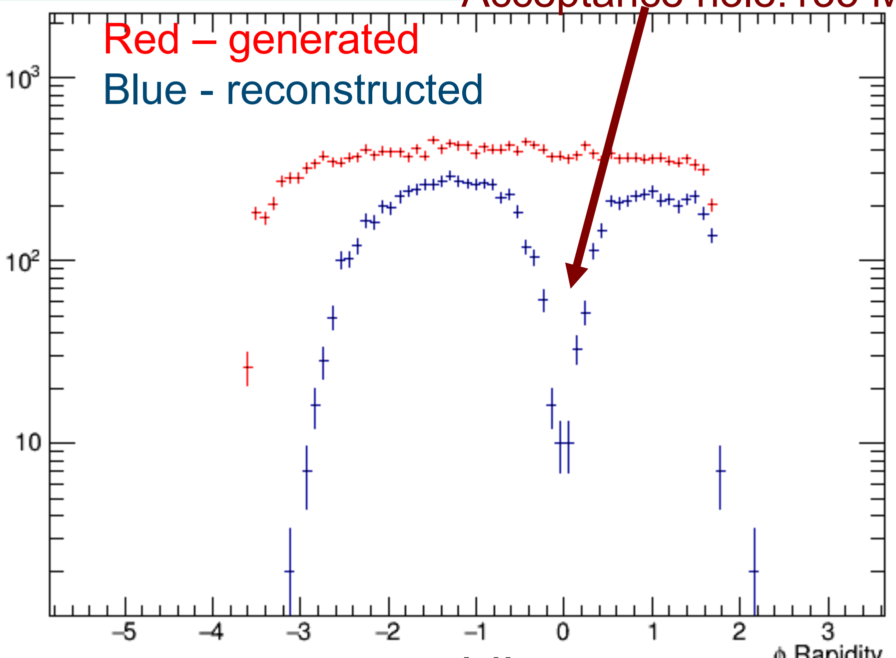
Is the full (pseudo) rapidity range really needed?

- At positive rapidities:
  - Jlab covered the light meson (ρ,…J/ψ) threshold region
    - But EIC can reach higher Q^2
    - Is overlap needed? How much?
  - For nuclei, the region x>1 is interesting, increasing the relevant rapidity range
- At negative rapidities:
  - HERA already covered the highest energy photons for ep
    - EIC will have higher statistics
  - For eA, there is no alternative.
    - eA has a slightly narrower rapidity range than ep -> less difficult
- Good pseudorapidity acceptance needed for polarization measurements (longitudinal vs. transverse polarization)

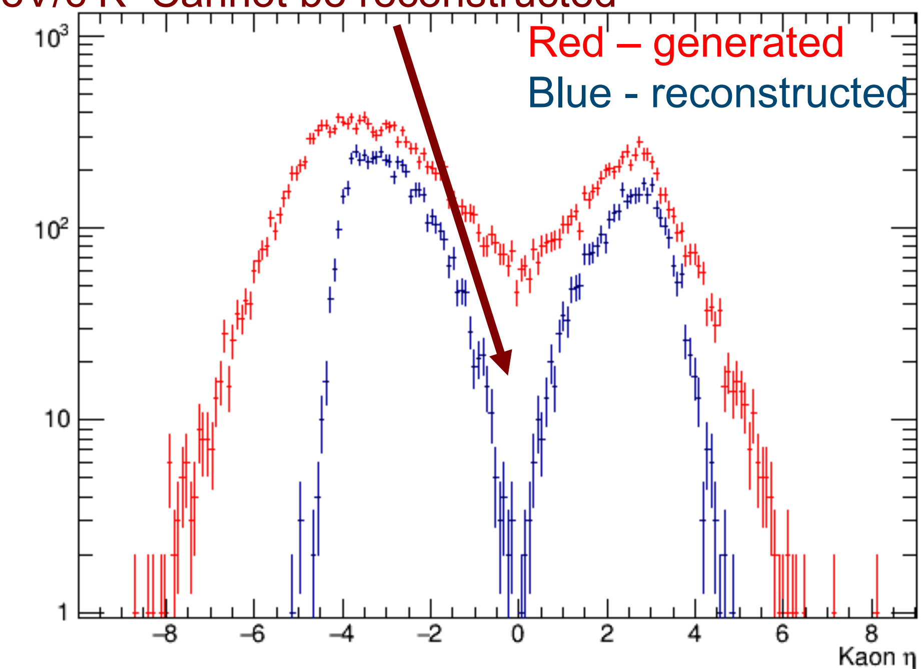
ϕ detection efficiency

- All Q^2, but dominated by low Q^2
- Acceptance hole at mid-rapidity (for low Q^2)
  - No acceptance for p_T=135 MeV kaons at η=0.
- ϕ->$K_S K_L$ seems tough, and ϕ-=> ee, $\mu\mu$ have very small ($3*10^{-4}$) branching ratios

Acceptance hole:135 MeV/c $K^{\pm}$ Cannot be reconstructed



Φ rapidity



Kaon pseudorapidity

A complementary detector

- Vector mesons are an important probe of gluon distributions
  - Rapidity maps into Bjorken-x values
  - Wide acceptance is needed to cover the full Bjorken-x range
- Full ρ^0 reconstruction requires $-5 < |\eta| < 5$
- This is impossible with the reference IR and detector design
  - Coverage over roughly $-3.5 < |\eta| < 3.5$
- One could imagine a detector with designed for forward/backward coverage.
  - Like two copies of LHCb (or just 1)?
    - Dipole magnets?
    - Very different IR design
  - Cover the region that is missed by the reference design