The Importance of a New Transverse Spin Program at RHIC and Its Impacts on Future e+p Physics

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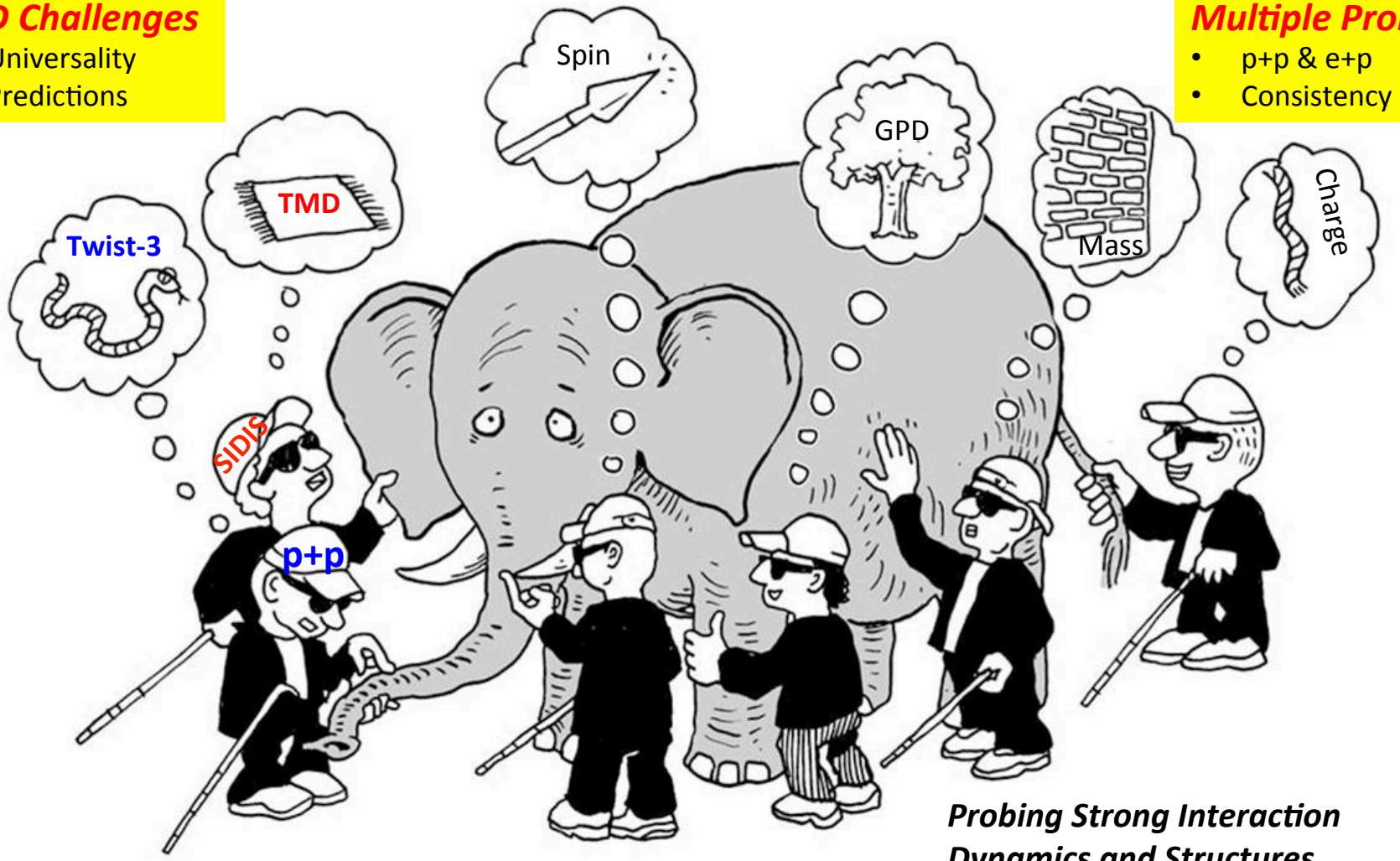
QCD Challenges
- Universality
- Predictions

Multiple Probes
- p+p & e+p
- Consistency



Probing Strong Interaction Dynamics and Structures

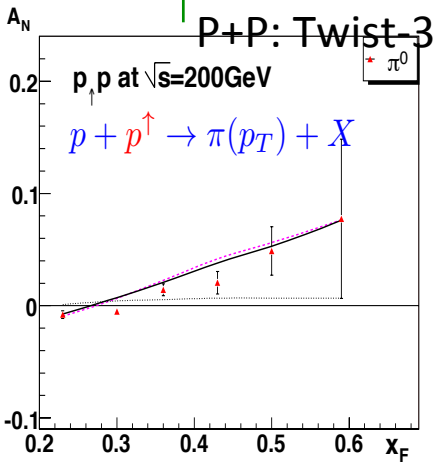
When "pp" and "DIS" Confront Each Other: ***A Surprise!***

First attempt to test the universal QCD descriptions of TSSA in p+p and e+p

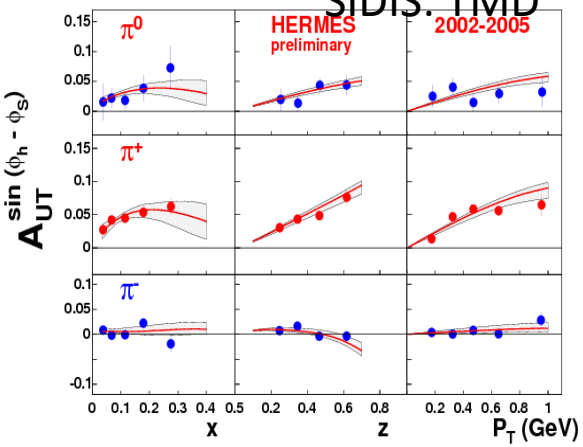
- What are the sources of the large TSSA in p+p?
  - Long-standing puzzle ~40 years!
  - Sivers and Collins effects observed in SIDIS
- Are they universal?
  - p+p vs SIDIS

$$gT_{q,F}(x,x) \overset{?}{=} -\int d^2k_\perp \frac{|k_\perp|^2}{M} f_{1T}^{\perp q}(x,k_\perp^2)|_{\text{SIDIS}}$$

P+P: Twist-3



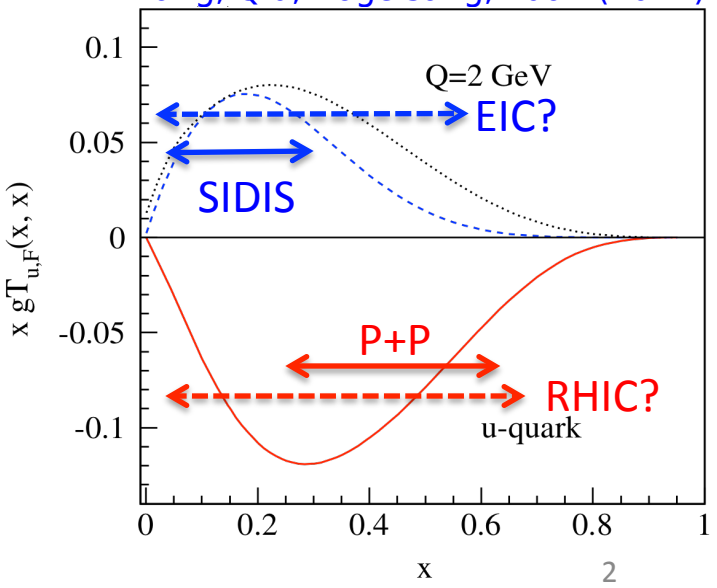
SIDIS: TMD



Urgency: Experimental resolution!

- SIDIS:
  - Sivers and Collins separated
  - Limited to "small" (x,Q^2)
  - Need EIC to help!
- p+p:
  - Inclusive TSSA, mix of effects
  - Limited to "large" (x, Q^2)
  - Need new data to overlap SIDIS!

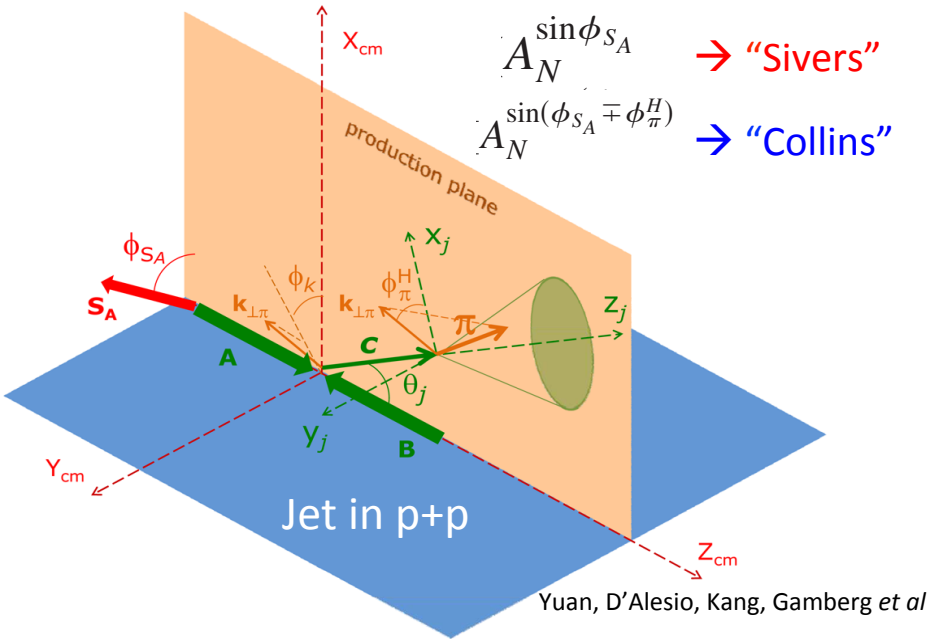
Kang, Qiu, Vogelsang, Yuan (2011)

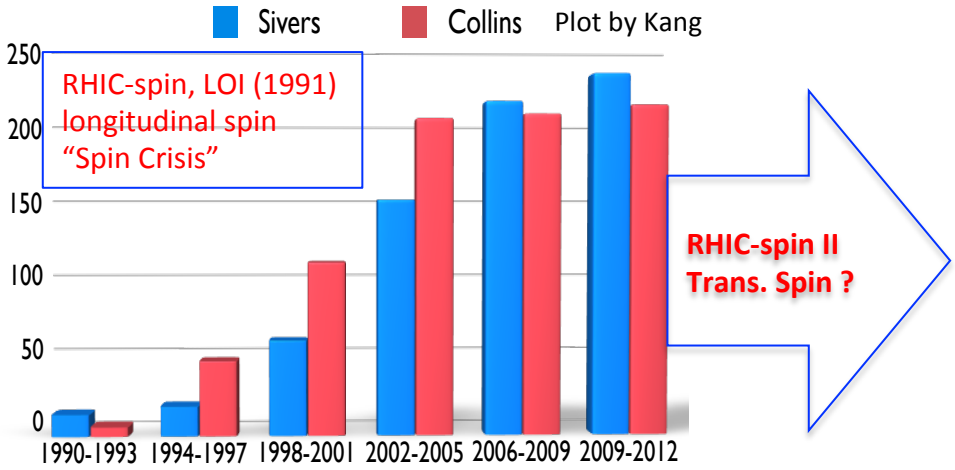


Proposal: New Transverse Spin/TMD Physics at RHIC

Discover Novel QCD Structures and Dynamics at RHIC

- New Opportunity at RHIC - the world only polarized p+p Collider
  - First unambiguous measurements of initial and final state spin asymmetries in p+p
    - Jet "Sivers" asymmetry
    - Intra-Jet "Collins" asymmetry
    - Direct comparison with SIDIS
  - Access new **quark** and **gluon** TMDs
    - Boer-Mulders, Warm-Gear etc
  - Requires new experimental capabilities
    - Full jet, forward rapidity
    - Drell-Yan and other probes possible
- Recent revolution in "TMD physics"
  - Universal QCD descriptions being developed
  - EIC physics focus
- Unique opportunity, discovery physics!
  - Harvest early investment with moderate detector upgrade (also EIC ready)
  - Critical for EIC physics interpretation



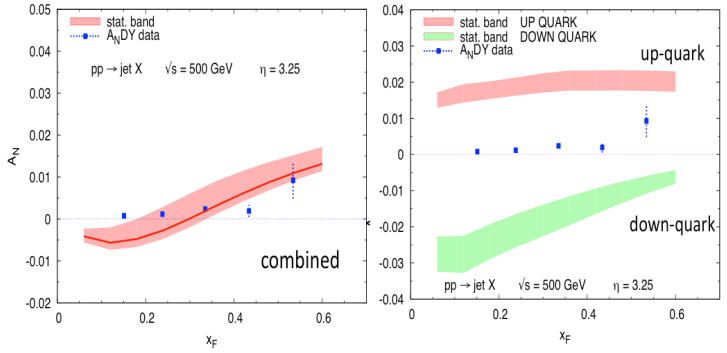


Backup Slides

Jet "Sivers" and "Collins" Measurements

A Proposed EIC Detector, eta={-1, +4}

- Jet "Sivers" Asymmetry

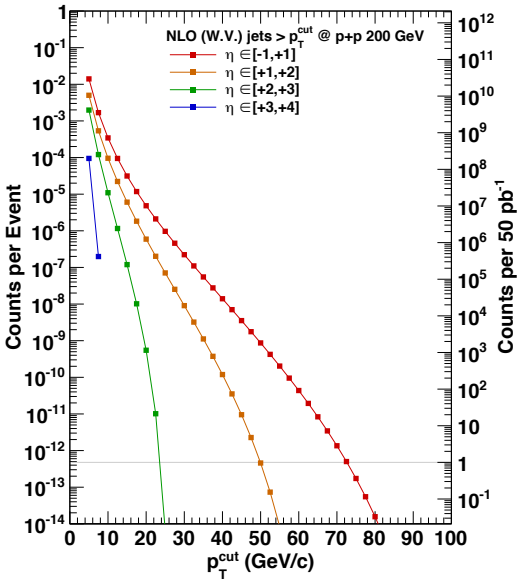


Jet Kinematic:

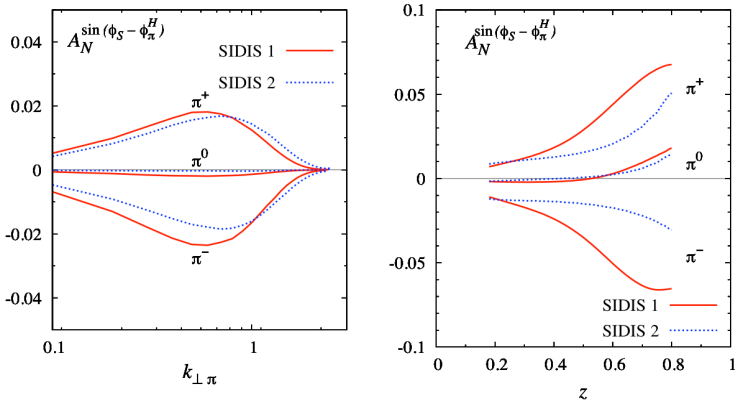
X = 0.1 ~ 0.6

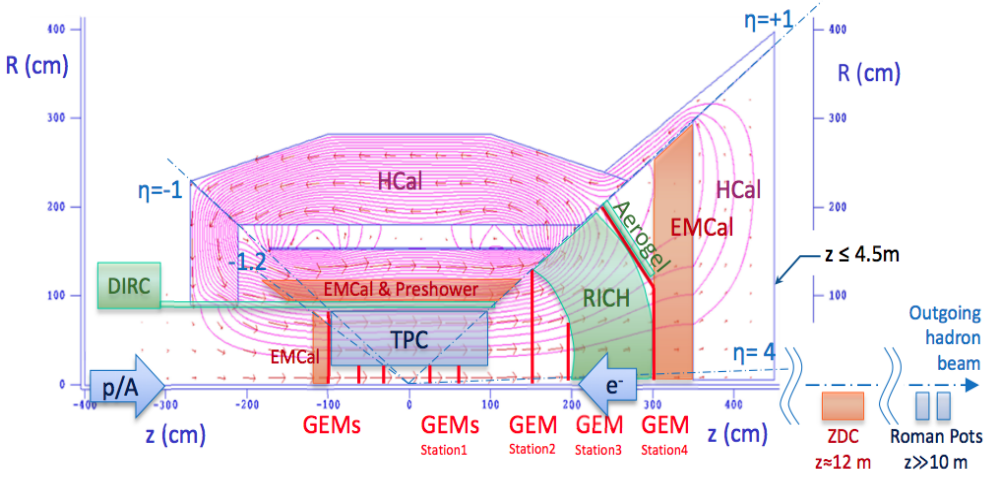
Q^2 = 16 ~ 1000

Huge statistics for precision



- Intra-Jet "Collins" Asymmetry





Gluons are Important at Large x Too!

incoming parton flavors

- CTEQ 10, NLO
- Q^2 = 10 GeV^2

There are a lot of gluons at X1 > 0.1

Access gluon TMDs in p+p in leading order processes

Forward jets: x1 >> x2

u(x1) + g(x2) -> jets
g(x1) + g(x2) –> jets
d(x1) + g(x2) -> jets

g(x1) + q_sea(x2) -> jets
q(x1) + q_sea(x2) -> jets