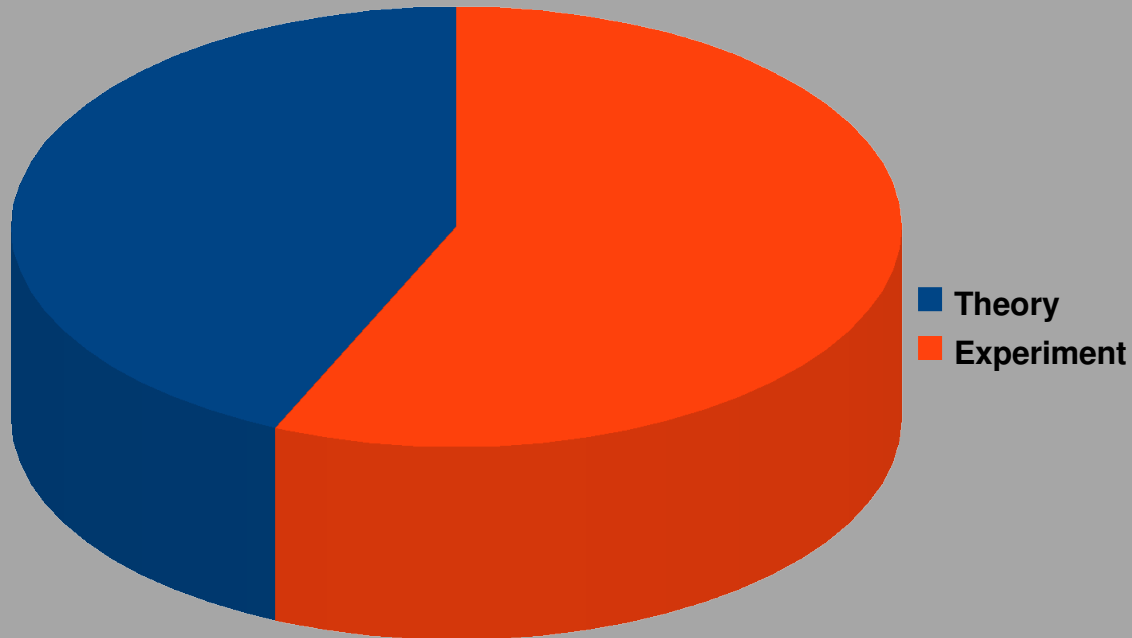


Summary of WG6: Spin Physics Theory

Alexei Prokudin
Jefferson Laboratory

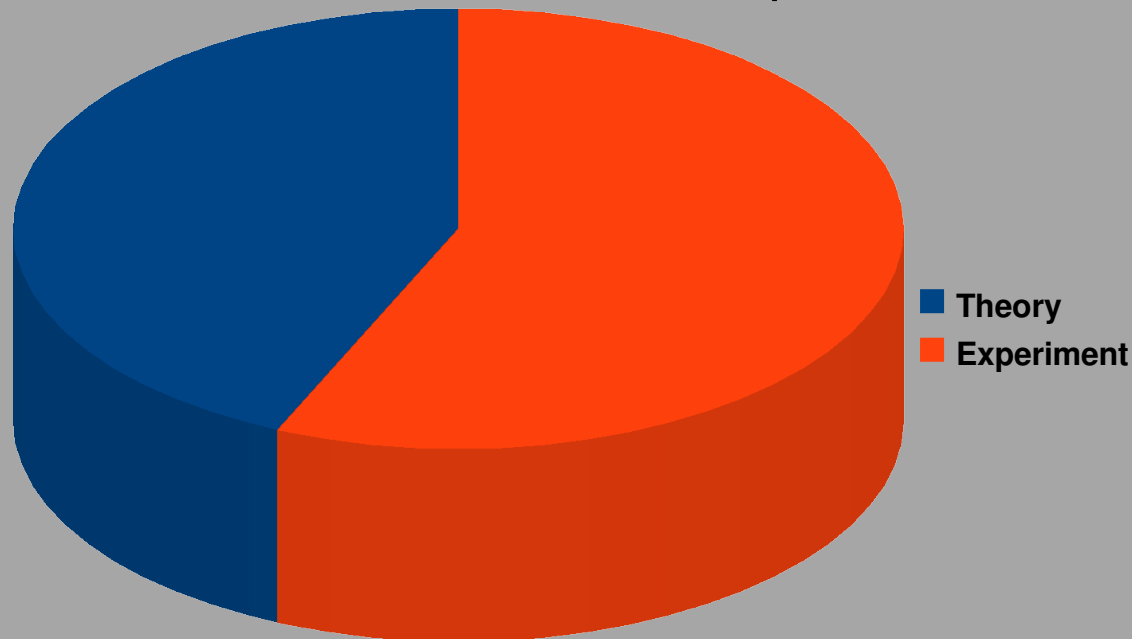
WG6:Spin Physics

- TOTAL - 60 talks
- Theory - 26 talks
- Experiment - 34 talks



WG6:Spin Physics

- TOTAL – 60 talks
- Theory - 26 talks
- Experiment - 34 talks



- Oleg Eyser (UCRiverside)
- Ami Rostomyan (DESY)
- Alexei Prokudin (JLab)



Open Issues

1. Longitudinal Spin Structure

- What is Δg at low x ?

$$\frac{1}{2} = \frac{1}{2}(\Delta q + \Delta \bar{q}) + \Delta G + L_z$$

~30% ~0%(?) ~70(?)
Jaffe, Manohar (1990)

Presence of OAM suggests

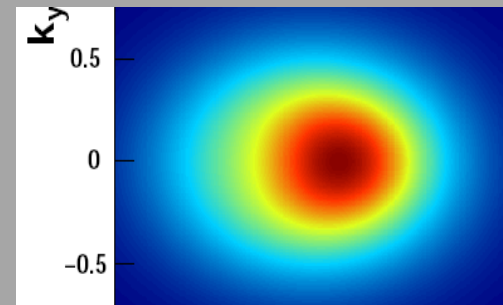
Transverse Momentum Dependent Distributions (TMDs)

2. Transverse Spin Structure

- Can the sign change of the Sivers effect be confirmed in Drell-Yan (or in W-production)?

$$f_{1T}^\perp|_{DY} = - f_{1T}^\perp|_{DIS}$$

Collins (2002)



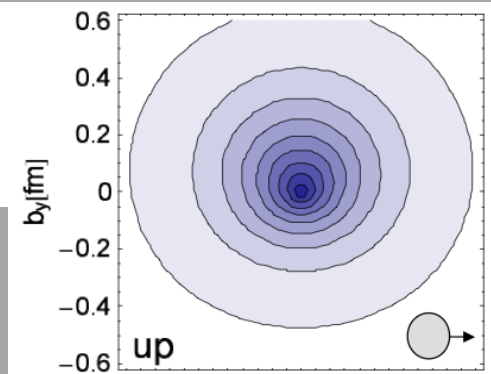
Generalized Parton Distributions (GPDs)

3. GPDs and Spin Sum Rule of the Nucleon

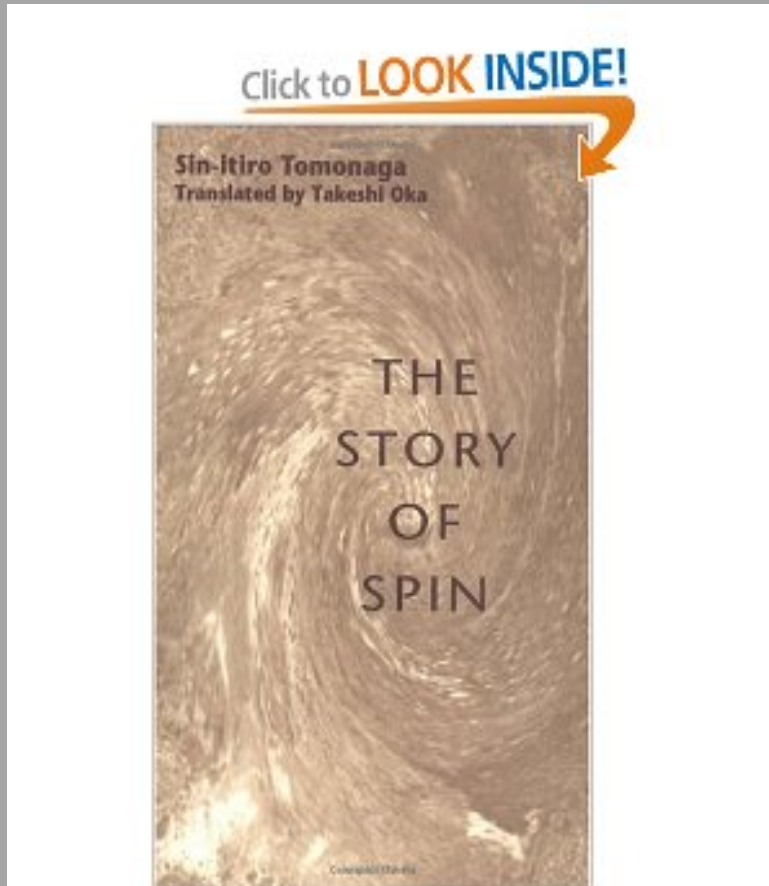
- Is there an 'optimal' version of the spin sum rule?

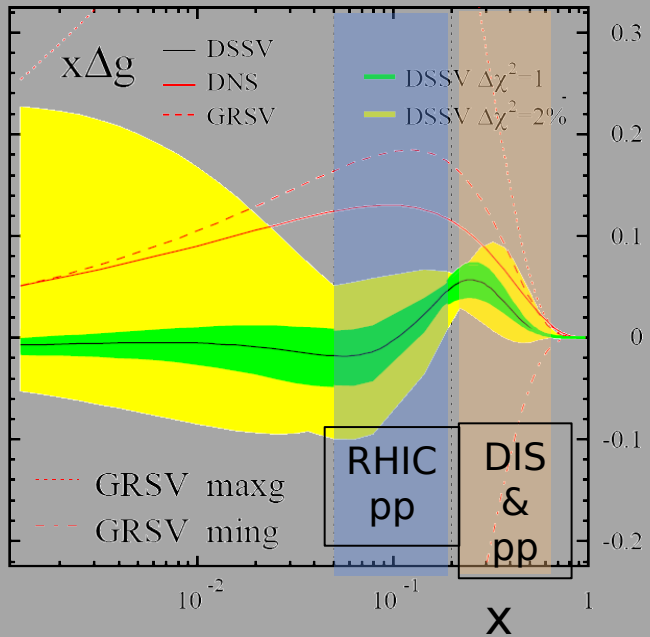
$$\frac{1}{2} = \sum_q J^q + J^g$$

Ji (1996)



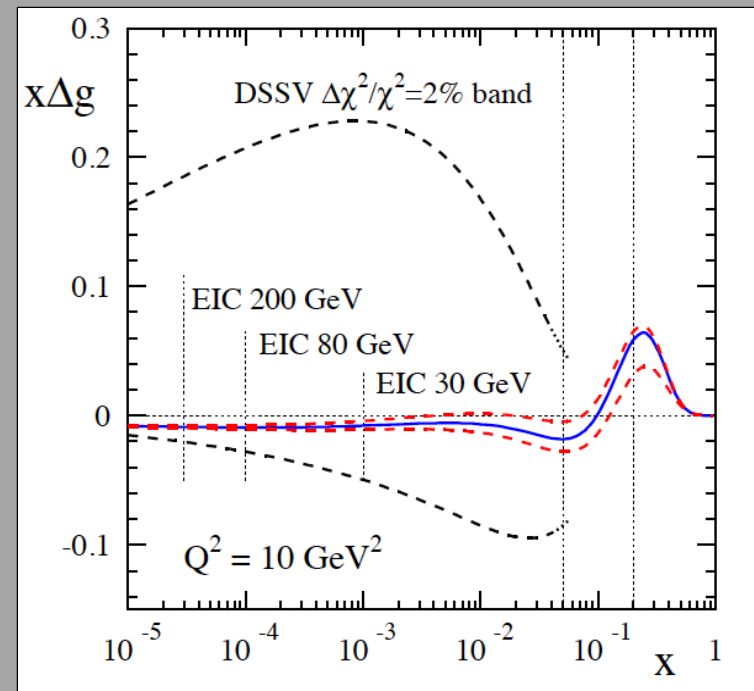
Helicity structure





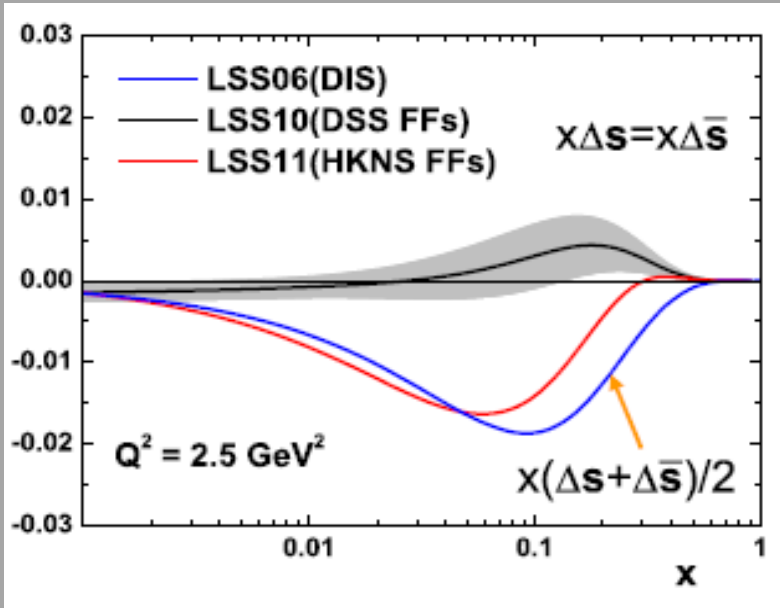
- Low x behavior unconstrained
significant polarization still possible
- DSSV global fit [De Florian, Sassot, Stratmann, Vogelsang](#)

Opportunities of spin studies
 at Electron Ion Collider



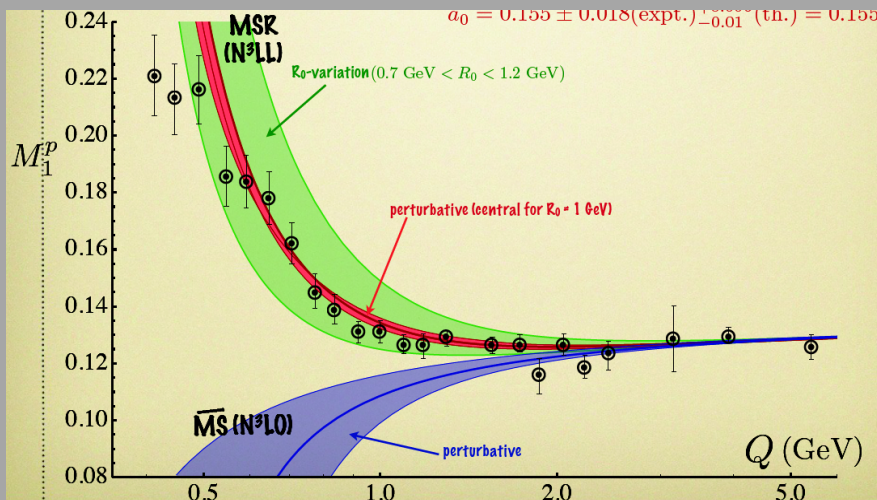
Dimiter Stamenov

- Reliable Fragmentation Functions are needed for $\Delta s(x)$



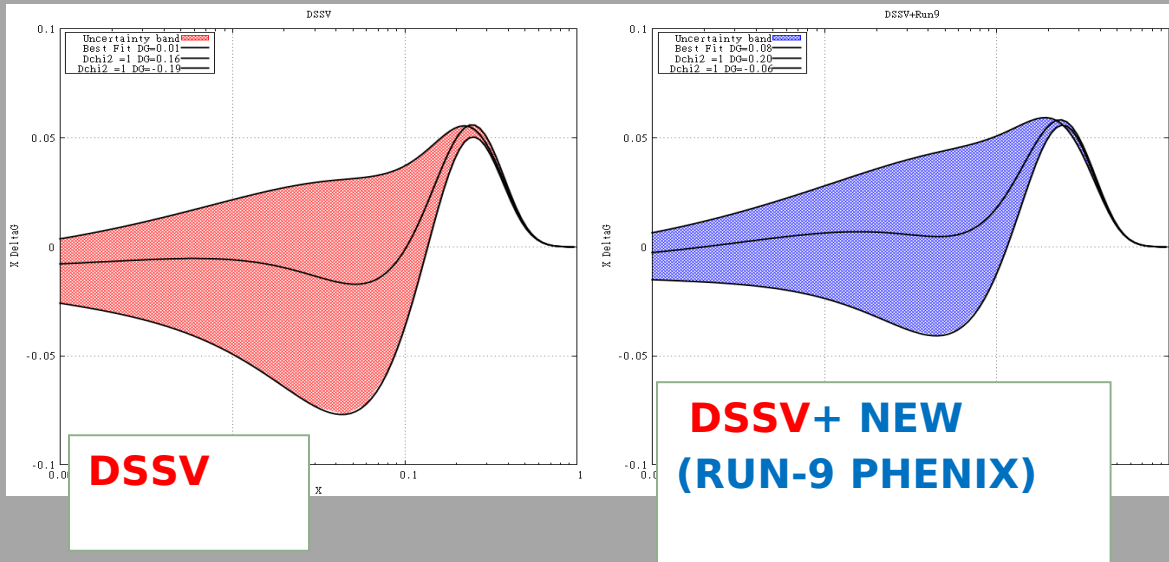
Ambar Jain

- Ellis-Jaffe sum rule can be improved with “R-evolution” up to low values of Q

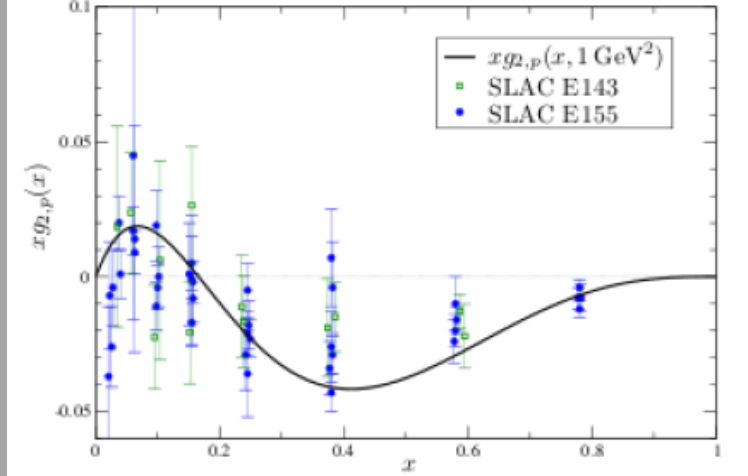


Swadhin Taneja

Impact of the newest RHIC data on $\Delta g(x)$



$xg_2(x)$ Proton/Neutron



Bjoern Pirnay

- Higher (>3) twist parton distributions and evolution
- $g_2(x)$ is described fairly well using LCWF

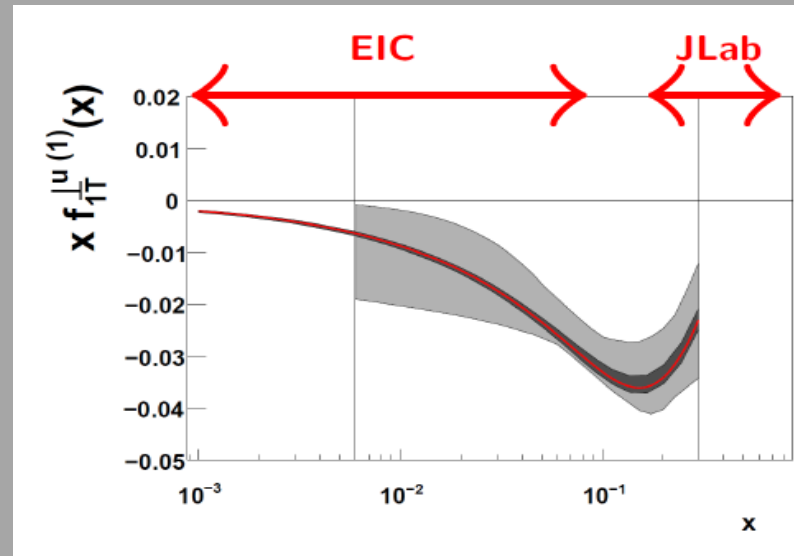
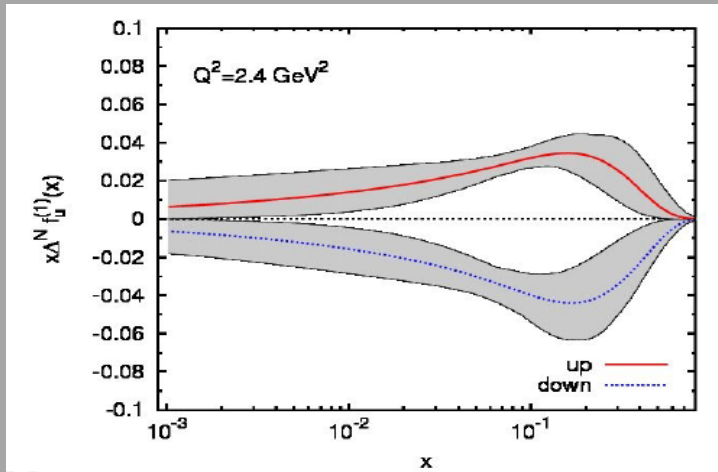
$$|p\rangle = |uud\rangle + |uudg \uparrow\rangle + |uudg \downarrow\rangle$$

Transverse structure

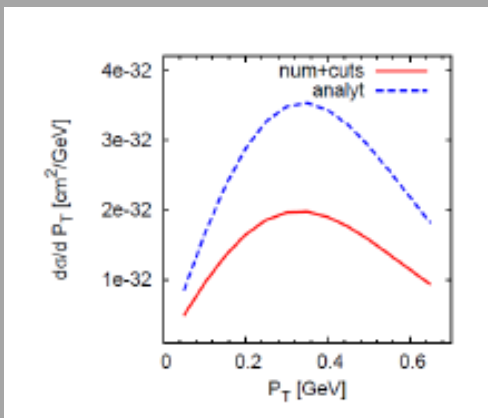


Stefano Melis

- Sivers function (T-odd, transverse momentum dependent) extraction from **newest data HERMES, COMPASS**
- Opportunities of TMD studies at **EIC**



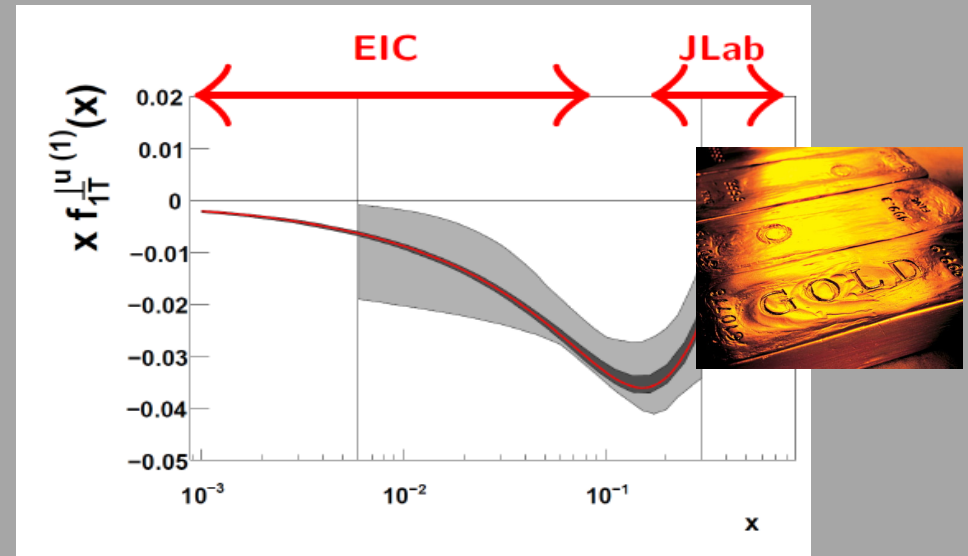
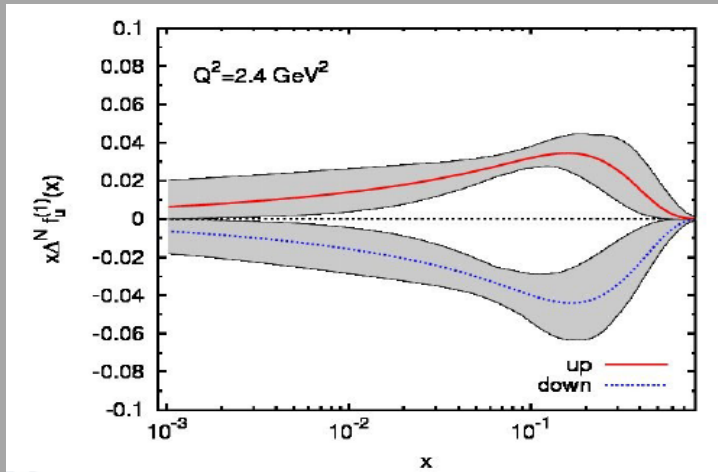
Elena Boglione



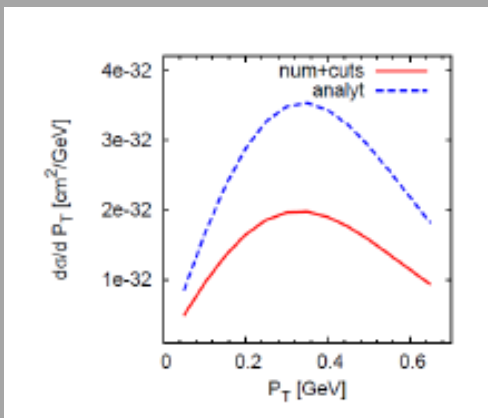
- Influence of physical cuts on parton momenta $k_{\perp}/Q \ll 1$ on variables at low Q

Stefano Melis

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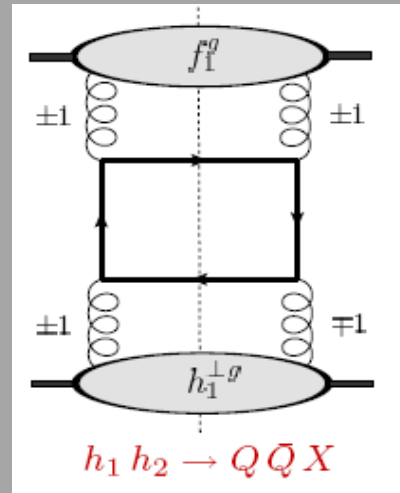
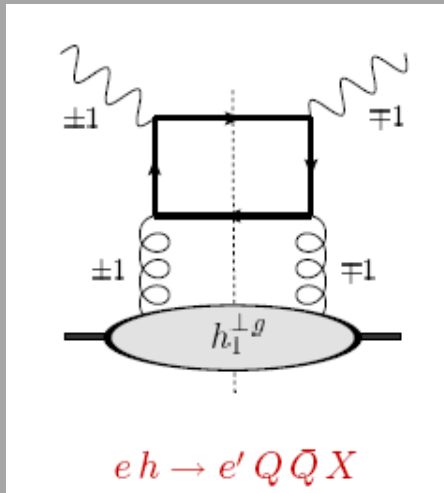
Elena Boglione



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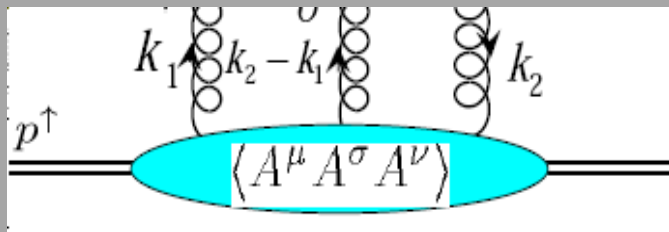
Cristian Pisano

- Linearly polarized gluons can be accessed in various channels
- Opportunities of studies at **EIC**, **LHeC**



Kazuhiro Tanaka Shinsuke Yoshida

- Tri-gluon correlations, Qiu-Sterman matrix elements
- SSA in open charm production,
- **SIDIS** and **PP**



Wilco den Dunnen

- Background study for **transversity** study at **RHIC**

Ted Rogers

- Related: Factorization Theorems:
 - Semi-Inclusive deep inelastic scattering. ✓
 - Drell-Yan. ✓
 - e^+/e^- annihilation. ✓
 - ~~$p + p \rightarrow h_1 + h_2 + X$!!~~

- **Transverse Momentum Dependent** distribution factorization and evolution

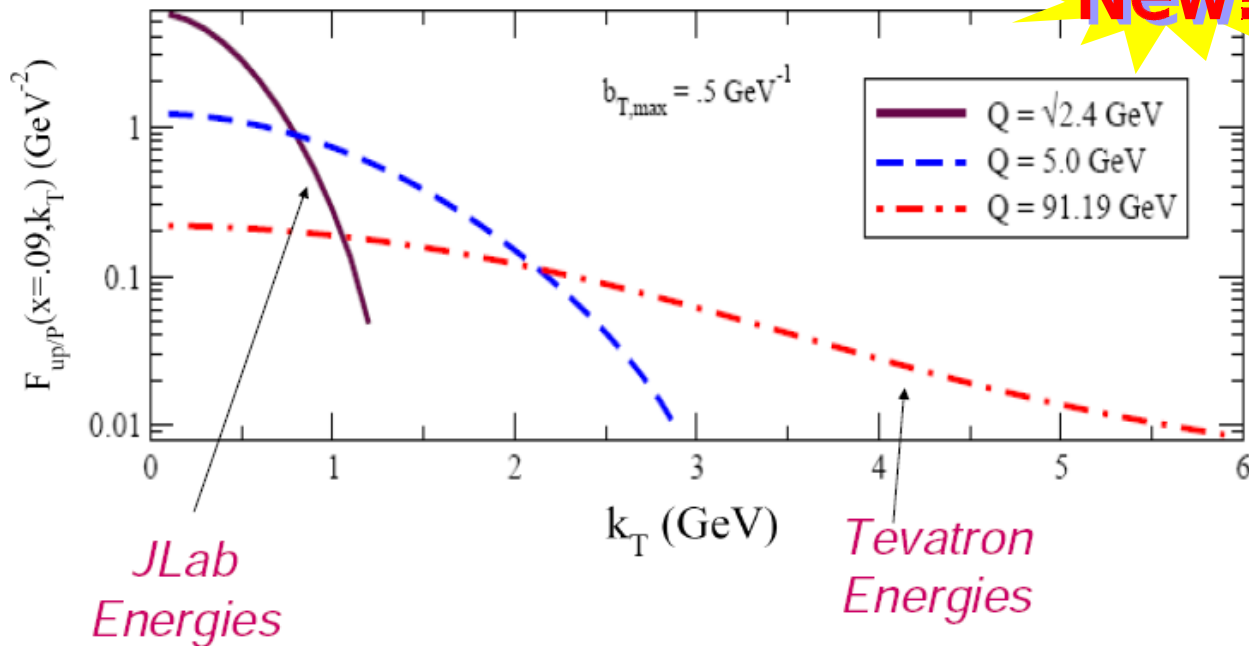
NLO of Collins-Soper-Sterman factorization is implemented

$$\begin{aligned}
 W^{\mu\nu} = & \frac{8\pi^2 s}{Q^2} \sum_f H_f^{\mu\nu}(\hat{k}_A, \hat{k}_B) \int d^2\mathbf{b}_T e^{i\mathbf{q}_{h_T} \cdot \mathbf{b}_T} e^{-S(b_T; Q; \mu_Q, \mu_0)} \times \\
 & \times \tilde{f}_{f/H_A}(x_A, \mathbf{b}_T; m^2, \mu_0) \tilde{f}_{\bar{f}/H_B}(x_B, \mathbf{b}_T; m^2, \mu_0) \\
 & + \text{polarized terms} + \text{large } q_{h_T} \text{ correction, } Y + \text{p.s.c.}
 \end{aligned}$$

$$\begin{aligned}
 e^{-S(b_T; Q; \mu_Q, \mu_0)} = & \exp \left\{ \ln \frac{Q^2}{m^2} \tilde{K}(b_T; \mu_0) \right\} \times \\
 & \times \exp \left\{ \int_{\mu_0}^{\mu_Q} \frac{d\mu'}{\mu'} \left[2\gamma(g(\mu'); 1) - \ln \frac{Q^2}{(\mu')^2} \gamma_K(g(\mu')) \right] \right\}
 \end{aligned}$$

Ted Rogers

New!



Collins (2011)

Aybat, Rogers (2011)

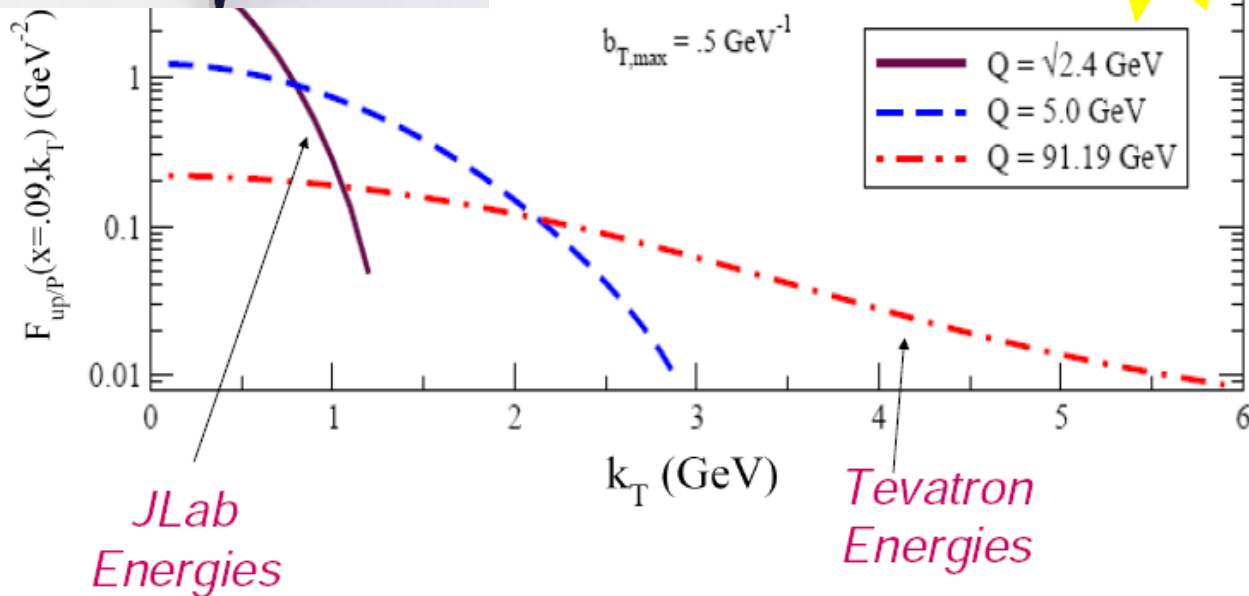
First implementation of NLO evolution of
Transverse Momentum Dependent distributions

Ted Rogers

New!

Collins (2011)

Aybat, Rogers (2011)



Breakthrough of TMD phenomenology and theory in 2011

Igor Cherednikov

$$\theta \frac{\partial}{\partial \theta} \mathcal{F}_{[A_n]}(x, \mathbf{b}_\perp; \mu, \theta) = [K_n(\mu, \mathbf{b}_\perp) + G_n(\mu, \theta)] \mathcal{F}_{[A_n]}(x, \mathbf{b}_\perp; \mu, \theta)$$

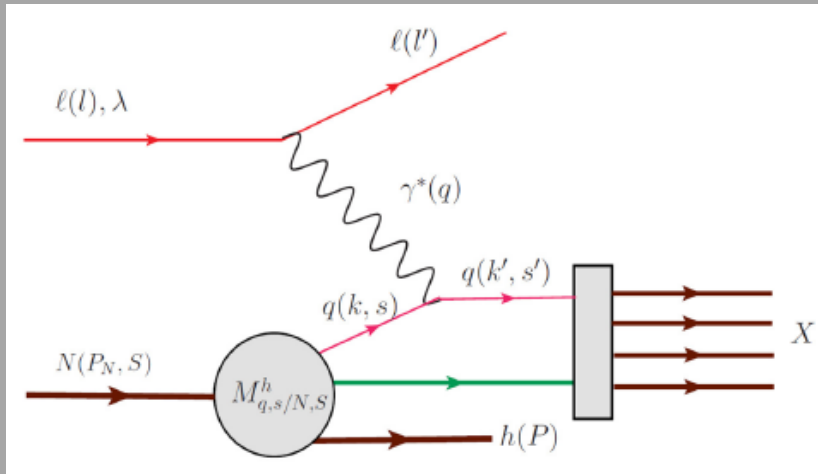
$$\mu \frac{d}{d\mu} K_n = -\mu \frac{d}{d\mu} G_n = \gamma_{\text{cusp}}$$

$$K_n(\mu, \mathbf{b}_\perp) + G_n(\mu, \theta) = -\frac{\alpha_s C_F}{\pi} \ln \theta^2 \mathbf{b}_\perp^2 C_n$$

- Evolution of TMDs
- Both UV and rapidity dependence

Aram Kotzinian

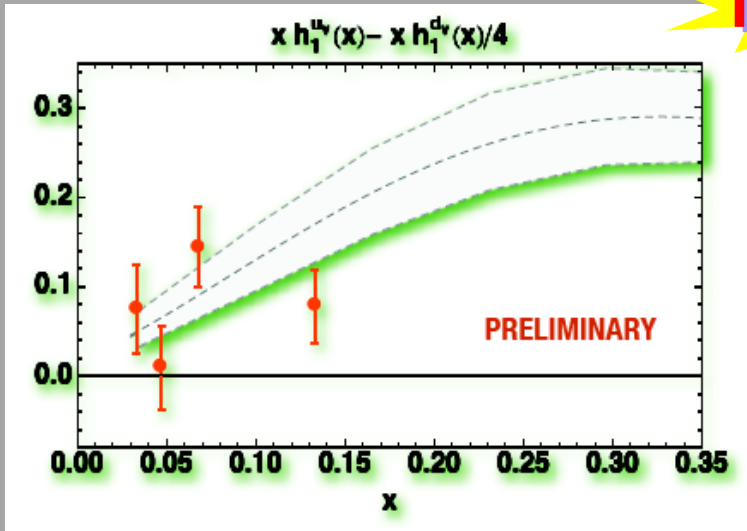
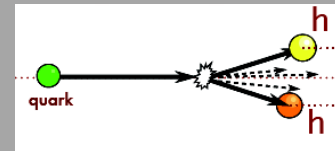
- Fracture functions
- SIDIS in **target fragmentation** region



Aurore Courtoy

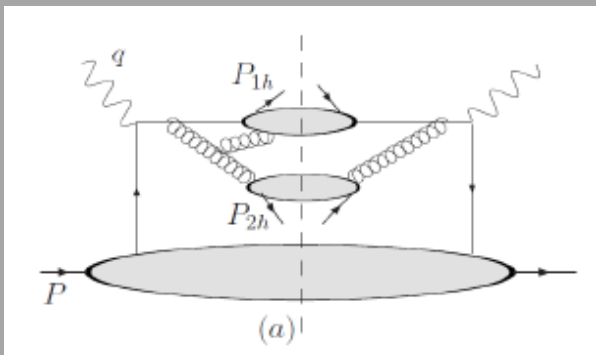
New!

- **Transversity** from dihadron interference fragmentation
- **BELLE + HERMES**



Jian Zhou

- Dihadron fragmentation functions for large mass
- Matching with collinear approach with single hadron FF



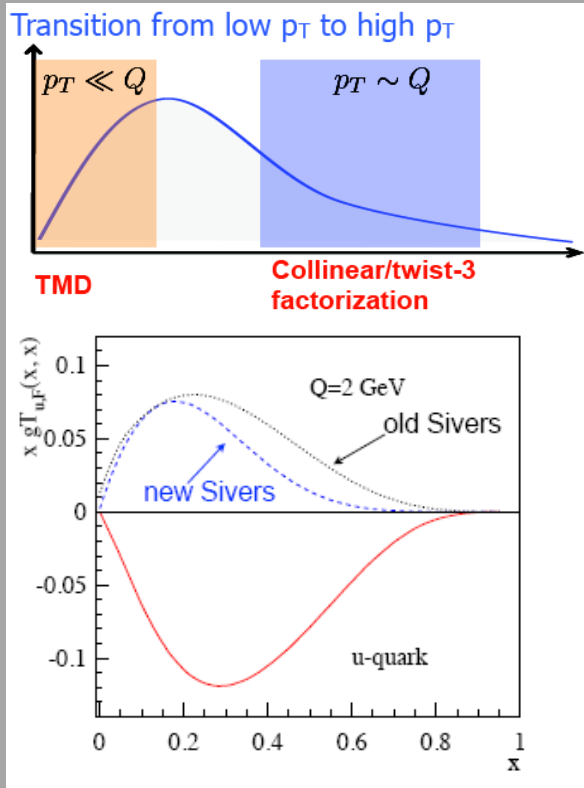
Zhongbo Kang

- **Transition** from low to high p_T
- **"sign mismatch"** and possible solutions

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

Leonard Gamberg

- Bessel-weighted asymmetries in **SIDIS**
- Possibility to study directly **Fourier transformed TMDs** experimentally

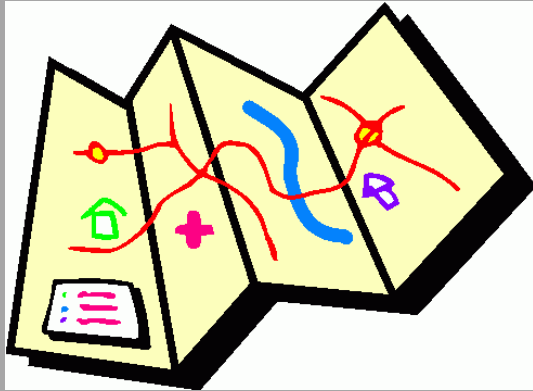


$$\tilde{f}_{1T}^{\perp a(1)}(x, z^2 \mathbf{b}_T^2)$$

Generalized Parton Distributions and models

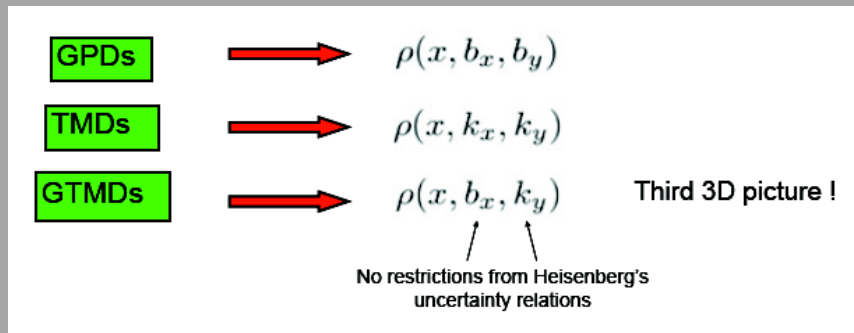


$$\mathcal{L} = \bar{\psi} (i\partial\!\!\!/ - m) \psi - \frac{1}{2} \phi (\partial^2 + \lambda^2) \phi + g\bar{\psi}\psi\phi$$



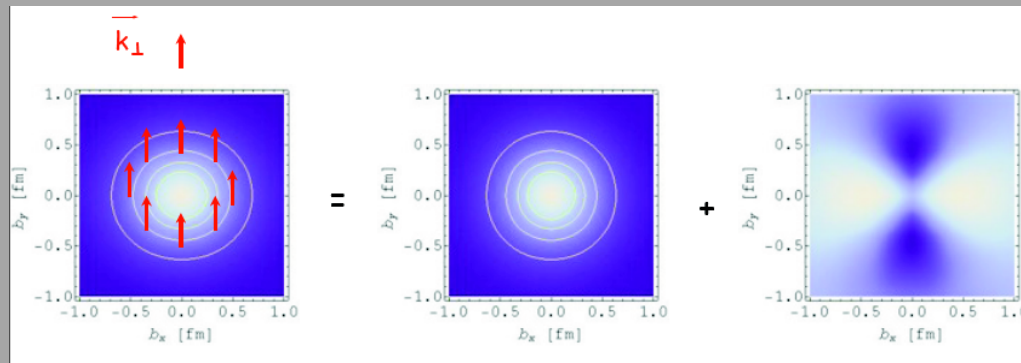
Dieter Mueller

- **Road map** of Light Cone Waive Function modelling for
- **GPDs** and **TMDs**
- Effective LCWF valid at $Q^2 = 4 \text{ GeV}^2$



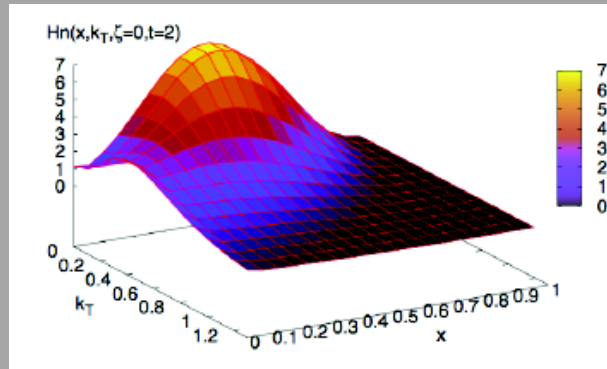
Barbara Pasquini

- Wigner function modelling
- Nucleon tomography



Simonetta Liuti

- Wigner function, GPDs, TMDs and OAM



Chiral odd GPDs

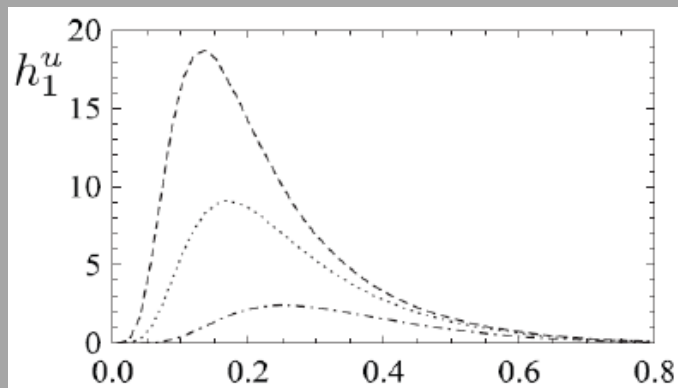


Gary Goldstein

- Chiral odd GPDs, possibilities at **JLab**

Petr Zavada

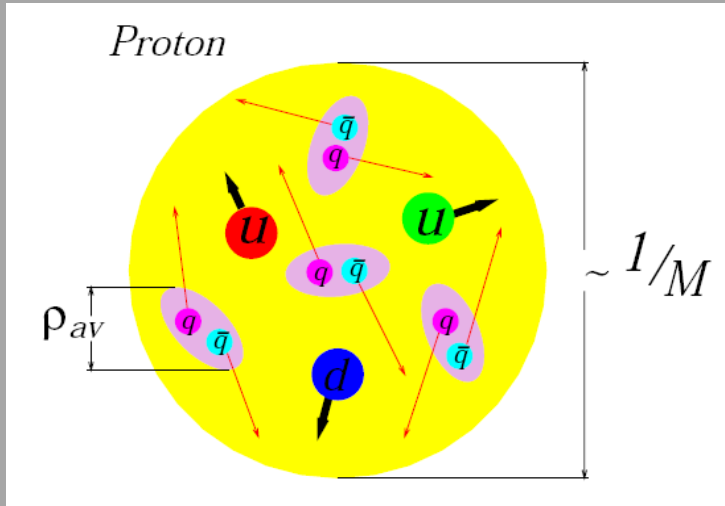
- Relation among TMDs in models
- 3D covariant model



Peter Schweitzer

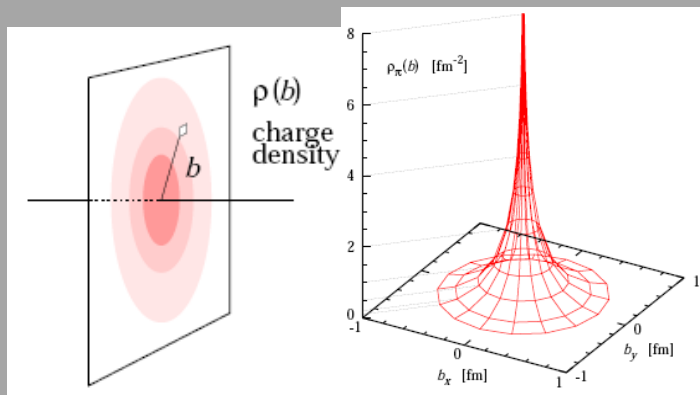
- Intrinsic pT from QCD vacuum

$$\langle p_T^2 \rangle_{\text{sea}} \sim 3 \langle p_T^2 \rangle_{\text{val}}$$



Christian Weiss

- Transverse charge densities from form factors



CONCLUSIONS

CONCLUSIONS



CONCLUSIONS

