STUDYING TMD NUCLEAR GLUON DISTRIBUTIONS USING PHOTON INITIATED PROCESSES

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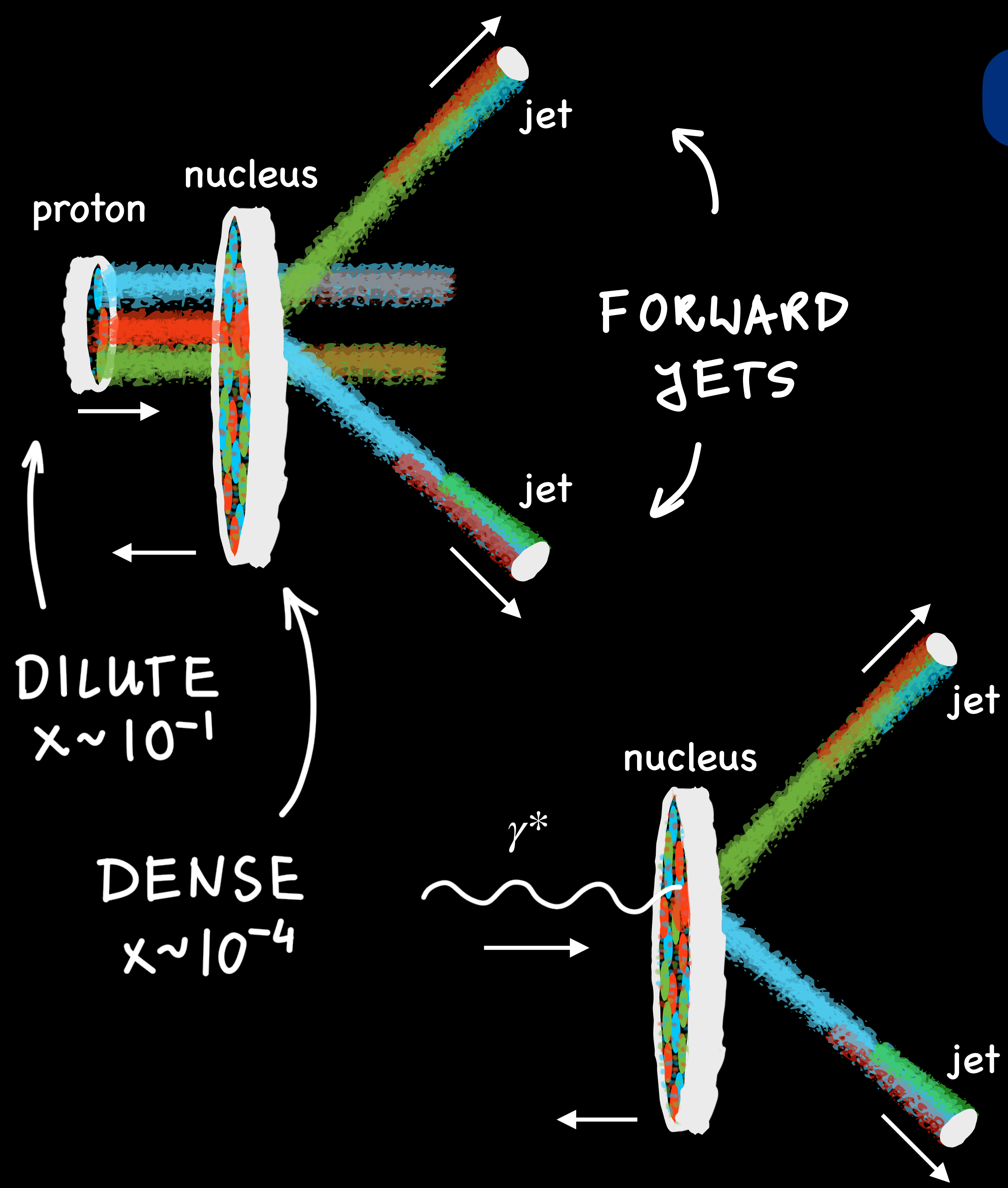
EMMI workshop, Krakow, 09/21/2022

MOTIVATION



Study high energy limit of QCD:

- saturation of gluon density

  Nonlinear evolution of TMD PDFs.

  Interplay of saturation and Sudakov resummation.

  Nonuniversality of TMD gluon PDFs.

- k_T-factorization

  TMD factorization beyond leading power.

PLAN

1. TMD gluon distributions
    A. Operator definitions and non-universality
    B. Two basics gluon distributions
    C. Small x limit
2. Framework
    A. Obtaining TMD gluon distributions at small x
    B. Factorization
3. Results
    A. Dijets at EIC
    B. Dijets in UPC at LHC
4. Summary and Outlook

TMD GLUON DISTRIBUTIONS

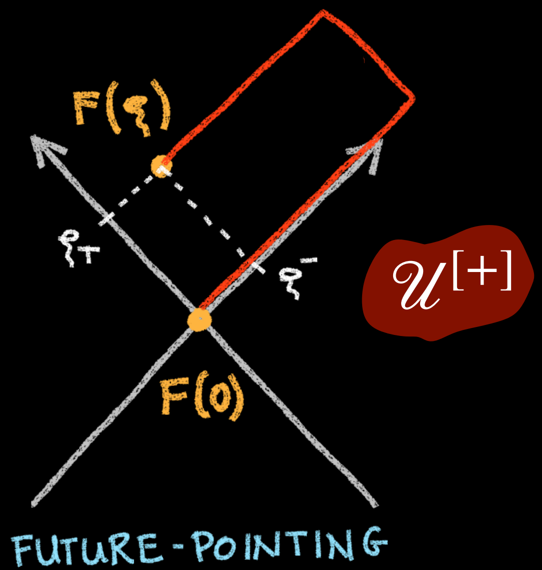
Generic operator definition

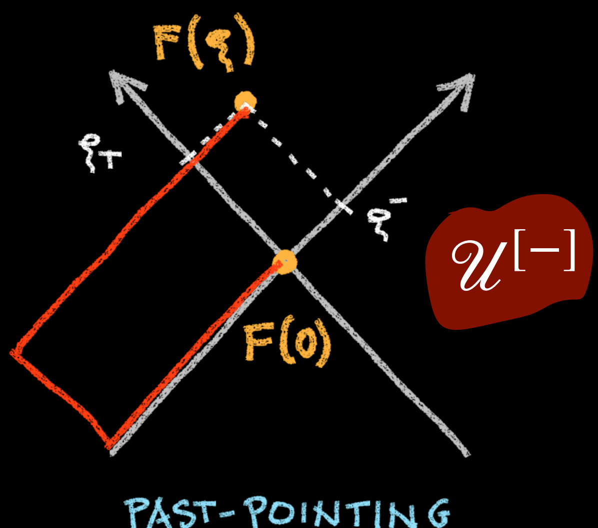
(unpolarized)

$$\mathcal{F}_g(x, k_T) = 2 \int \frac{d\xi^+ d^2\xi_T}{(2\pi)^3 P^-} e^{ixP^-\xi^+ - i\vec{k}_T\cdot\vec{\xi}_T} \langle P | \mathrm{Tr}\left[\hat{F}^{i-}\left(\xi^+, \vec{\xi}_T, \xi^- = 0\right) \mathcal{U}_{C_1} \hat{F}^{i-}(0)\, \mathcal{U}_{C_2}\right] | P \rangle$$

GLUON FIELD $\hat{F} = F_a t^a$

GAUGE LINKS in fundamental color representation





Gauge links $\mathcal{U}_{C_1}, \mathcal{U}_{C_2}$ depend on the color structure of the hard process. They are build from two basic Wilson lines:

[C. Bomhof, P. Mulders, F. Pijlman, 2004]

$$\mathcal{U}^{[\pm]} = [0, (\pm\infty, \vec{0}_T, 0)] \times [(\pm\infty, \vec{0}_T, 0), (\pm\infty, \vec{\xi}_T, 0)] \times [(\pm\infty, \vec{\xi}_T, 0), (\xi^+, \vec{\xi}_T, 0)]$$

$$[x, y] = \mathcal{P} \exp\left\{ ig \int_{\overline{xy}} dz_\mu A_a^\mu(z) t^a \right\}$$

STRAIGHT LINE SEGMENT

Light-cone basis:

$$v^\pm = v^\mu n_\mu^\pm, \quad n^\pm = (1,0,0,\mp 1)$$

$$v^\mu = \frac{1}{2} v^+ n^- + \frac{1}{2} v^- n^+ + v_T^\mu$$

TMD GLUON DISTRIBUTIONS

All possible operators

[M. Bury, PK , K. Kutak, 2018]

$$\mathcal{F}_{qg}^{(1)} \sim \langle P|\,\mathrm{Tr}\left[\hat{F}^{i-}(\xi)\,\mathcal{U}^{[-]\dagger}\hat{F}^{i-}(0)\,\mathcal{U}^{[+]}\right]|P\rangle$$

$$\mathcal{F}_{qg}^{(2)} \sim \langle P|\frac{\mathrm{Tr}\,\mathcal{U}^{[\square]}}{N_c}\mathrm{Tr}\left[\hat{F}^{i-}(\xi)\,\mathcal{U}^{[+]\dagger}\hat{F}^{i-}(0)\,\mathcal{U}^{[+]}\right]|P\rangle$$

$$\mathcal{F}_{qg}^{(3)} \sim \langle P|\,\mathrm{Tr}\left[\hat{F}^{i-}(\xi)\,\mathcal{U}^{[+]\dagger}\hat{F}^{i-}(0)\,\mathcal{U}^{[\square]}\mathcal{U}^{[+]}\right]|P\rangle$$

$$\mathcal{F}_{gg}^{(1)} \sim \langle P|\frac{\mathrm{Tr}\,\mathcal{U}^{[\square]\dagger}}{N_c}\mathrm{Tr}\left[\hat{F}^{i-}(\xi)\,\mathcal{U}^{[-]\dagger}\hat{F}^{i-}(0)\,\mathcal{U}^{[+]}\right]|P\rangle$$

$$\mathcal{F}_{gg}^{(2)} \sim \langle P|\,\mathrm{Tr}\left[\hat{F}^{i-}(\xi)\,\mathcal{U}^{[\square]\dagger}\right]\mathrm{Tr}\left[\hat{F}^{i-}(0)\,\mathcal{U}^{[\square]}\right]|P\rangle$$

$$\mathcal{F}_{gg}^{(3)} \sim \langle P|\,\mathrm{Tr}\left[\hat{F}^{i-}(\xi)\,\mathcal{U}^{[+]\dagger}\hat{F}^{i-}(0)\,\mathcal{U}^{[+]}\right]|P\rangle$$

$$\mathcal{F}_{gg}^{(4)} \sim \langle P|\,\mathrm{Tr}\left[\hat{F}^{i-}(\xi)\,\mathcal{U}^{[-]\dagger}\hat{F}^{i-}(0)\,\mathcal{U}^{[-]}\right]|P\rangle$$

$$\mathcal{F}_{gg}^{(5)} \sim \langle P|\,\mathrm{Tr}\left[\hat{F}^{i-}(\xi)\,\mathcal{U}^{[\square]\dagger}\mathcal{U}^{[+]\dagger}\hat{F}^{i-}(0)\,\mathcal{U}^{[\square]}\mathcal{U}^{[+]}\right]|P\rangle$$

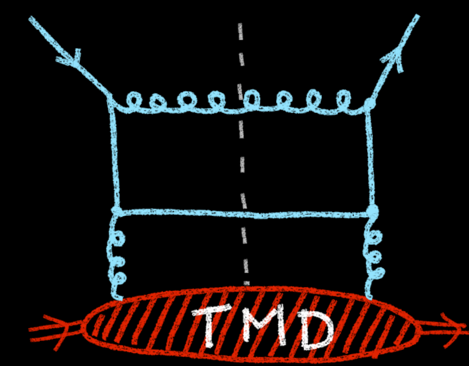
$$\mathcal{F}_{gg}^{(6)} \sim \langle P|\frac{\mathrm{Tr}\,\mathcal{U}^{[\square]}}{N_c}\frac{\mathrm{Tr}\,\mathcal{U}^{[\square]\dagger}}{N_c}\mathrm{Tr}\left[\hat{F}^{i-}(\xi)\,\mathcal{U}^{[+]\dagger}\hat{F}^{i-}(0)\,\mathcal{U}^{[+]}\right]|P\rangle$$

$$\mathcal{F}_{gg}^{(7)} \sim \langle P|\frac{\mathrm{Tr}\,\mathcal{U}^{[\square]}}{N_c}\mathrm{Tr}\left[\hat{F}^{i-}(\xi)\,\mathcal{U}^{[\square]\dagger}\mathcal{U}^{[+]\dagger}\hat{F}^{i-}(0)\,\mathcal{U}^{[+]}\right]|P\rangle$$

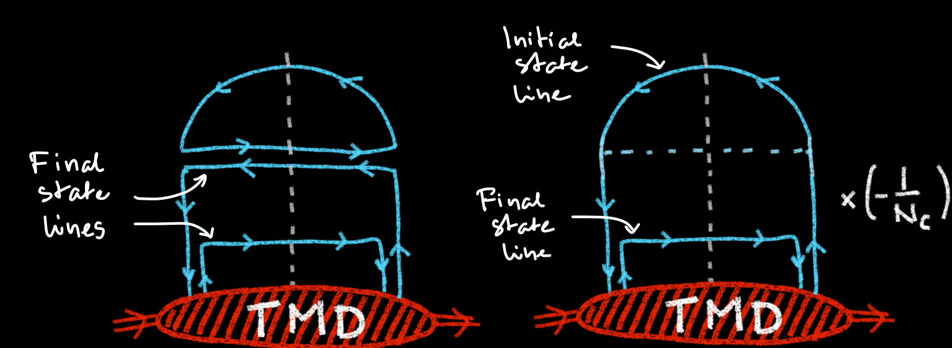
WILSON LOOP → $\mathcal{U}^{[\square]} = \mathcal{U}^{[+]}\mathcal{U}^{[-]\dagger}$

Example

TMD gluon distribution for the following process:



Two independent color flows:



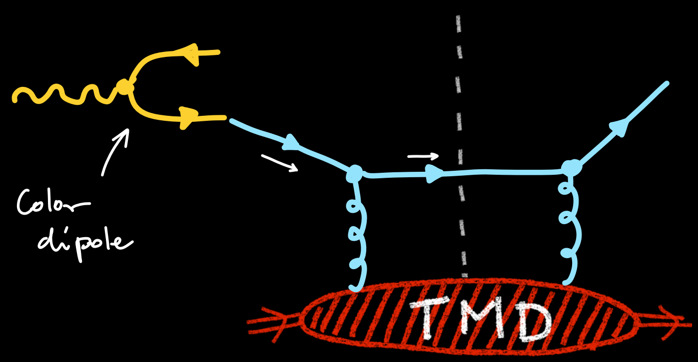
$$\rightsquigarrow \frac{N_c}{2C_F}\mathcal{F}_{qg}^{(2)} - \frac{1}{2N_cC_F}\mathcal{F}_{qg}^{(1)}$$

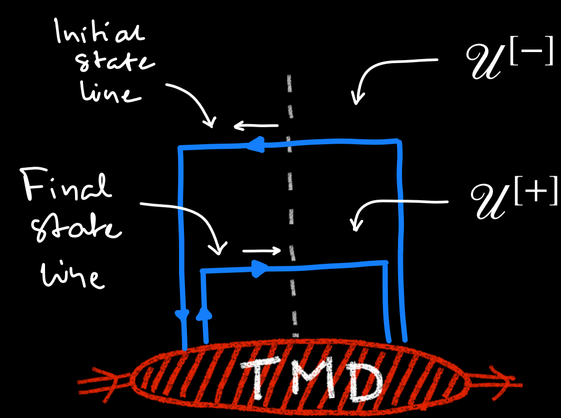
Gluon TMD for any multiparticle process is given by a linear combination of these “basis” TMDs.

TMD GLUON DISTRIBUTIONS

Two basic gluon distributions

- **Inclusive DIS**

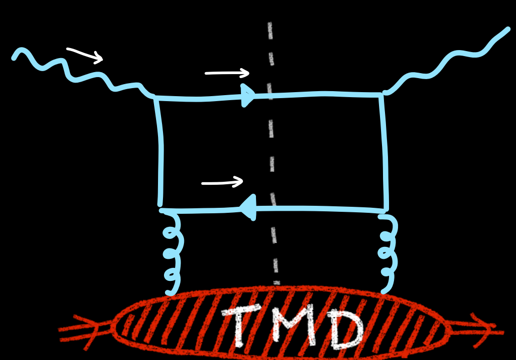


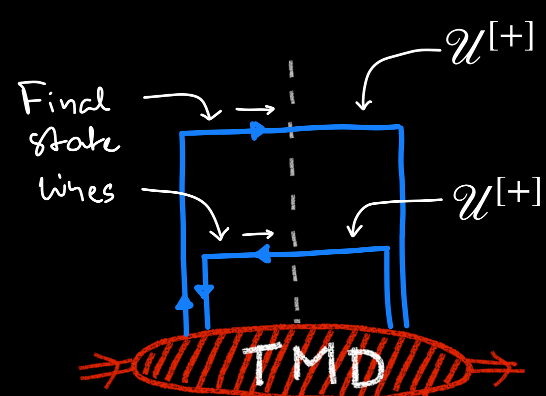


$$\langle P\,|\,\mathrm{Tr}\Big[\hat{F}^{i-}\,(\xi)\,\mathcal{U}^{[-]\dagger}\hat{F}^{i-}\,(0)\,\mathcal{U}^{[+]}\Big]\,|\,P\rangle \sim \mathcal{F}_{qg}^{(1)}$$

"dipole" gluon distribution

- **Dijets in DIS**





$$\langle P\,|\,\mathrm{Tr}\Big[\hat{F}^{i-}\,(\xi)\,\mathcal{U}^{[+]\dagger}\hat{F}^{i-}\,(0)\,\mathcal{U}^{[+]}\Big]\,|\,P\rangle \sim \mathcal{F}_{gg}^{(3)}$$

$\Downarrow$ light cone gauge

$$\langle P\,|\,\mathrm{Tr}\Big[\hat{F}^{i-}\,(\xi)\,\hat{F}^{i-}\,(0)\Big]\,|\,P\rangle$$

gluon number distribution
(Weizsacker-Williams)

TMD GLUON DISTRIBUTIONS

Small-x limit

$$\int \frac{d\xi^+ d^2\xi_T}{(2\pi)^3 P^-} e^{ixP^-\xi^+ - i\vec{k}_T\cdot\vec{\xi}_T} \langle P | \mathrm{Tr}\left[\hat{F}^{i-}\left(\xi^+, \vec{\xi}_T, \xi^- = 0\right)\mathcal{U}_{C_1}\hat{F}^{i-}(0)\,\mathcal{U}_{C_2}\right] | P\rangle$$

$x \to 0.$

Dependence on x is only via the small-x evolution equations:

- BFKL (Balitsky-Fadin-Kuraev-Lipatov).
- BK (Balitsky-Kovchegov) and modifications
- JIMWLK (Balitsky-Jalilian-Marian-Iancu-McLerran-Weigert-Leonidov-Kovner)

Correspondence to Color Glass Condensate (CGC)

Example: dipole gluon distribution

$$\mathcal{F}_{qg}^{(1)} \sim \int \frac{d^2x_T d^2y_T}{(2\pi)^4} k_T^2 e^{-i\vec{k}_T\cdot(\vec{x}_T - \vec{y}_T)} \langle \mathrm{Tr}\left[U(\vec{x}_T)U^\dagger(\vec{y}_T)\right]\rangle_x$$

Wilson lines

$$U(\vec{x}_T) = \mathcal{P}\exp\left\{ig\int_{-\infty}^{+\infty} dx^+\, A_a^-\left(x^+, \vec{x}_T\right) t^a\right\}$$

Average over CGC color sources

$$\langle . \rangle_x = \frac{\langle P| . |P\rangle}{\langle P|P\rangle}$$

Intensively studied:

[D. Kharzeev, Y. Kovchegov, K. Tuchin, 2003]
[B. Xiao, F. Yuan, 2010]
[F. Dominguez, C. Marquet, B. Xiao, F. Yuan, 2011]
[A. Metz, J. Zhou, 2011]
[E. Akcakaya, A. Schafer, J. Zhou, 2012]
[C. Marquet, E. Petreska, C. Roiesnel, 2016]
[I. Balitsky, A. Tarasov, 2015, 2016]
[D. Boer, P. Mulders, J. Zhou, Y. Zhou, 2017]
[C. Marquet, C. Roiesnel, P. Taels, 2018]
[Y. Kovchegov, D. Pitonyak, M. Sievert, 2017,2018]
[T. Altinoluk, R. Boussarie, 2019]
[R. Boussarie, Y. Mehtar-Tani, 2020]

FRAMEWORK

CGC
dilute-dense

three scales:

$Q_s \gg \Lambda_{\rm QCD}$ — saturation scale

k_T — jet transverse momentum imbalance

P_T — jet average transverse momentum

$P_T \gg k_T \sim Q_s$

TMD
GENERALIZED FACTORIZATION

leading twist

[F. Dominguez, C. Marquet, B. Xiao, F. Yuan, 2011]
[C. Marquet, E. Petreska, C. Roiesnel, 2016]
[C. Marquet, C. Roiesnel, P. Taels, 2018]
[T. Altinoluk, R. Boussarie, C. Marquet, P. Taels, 2019, 2020]
[P. Taels, T. Altinoluk, G. Beuf, C. Marquet, 2022]

$P_T \sim k_T \gg Q_s$

$P_T \gg Q_s$

ITMD
"IMPROVED" TMD factorization

all kinematic twists

[PK, K. Kutak, C. Marquet, E. Petreska, S. Sapeta, A. van Hameren, 2015]
[A. van Hameren, PK, K. Kutak, C. Marquet, E. Petreska, S. Sapeta, 2016]
[T. Altinoluk, R. Boussarie, PK, 2019]
[H. Fujii, C. Marquet, K. Wanatabe, 2020]
[T. Altinoluk, C. Marquet, P. Taels, 2021]

DILUTE
k_T-FACTORIZATION
BFKL dynamics

[S. Catani, M. Ciafaloni, F. Hautmann, 1991]
[M. Deak, F. Hautmann, H. Jung, K. Kutak, 2009]
[E. Iancu, J. Leidet, 2013]

FRAMEWORK

Factorization for dijets in DIS at small x

[T. Altinoluk, R. Boussarie, 2019]
[H. Fujii, C. Marquet, K. Wanatabe, 2020]
[T. Altinoluk, C. Marquet, P. Taels, 2021]

$P_T \gg Q_s$

average jet PT → P_T; saturation scale → Q_s

$$d\sigma_{\gamma^* A \to 2j+X} \sim \int \frac{dx}{x} \int d^2k_T \, \mathcal{F}^{(3)}_{gg}(x, k_T, \mu) \, d\sigma_{\gamma^* g^* \to j_1 j_2}(x, k_T, \mu) + \ldots$$

jet imbalance → k_T

Weizsacker-Williams TMD Gluon Distribution → $\mathcal{F}^{(3)}_{gg}$

Off-shell gauge invariant matrix element → $d\sigma_{\gamma^* g^* \to j_1 j_2}$

linearly polarized gluons → $\ldots$

- resummation of kinematic twists
- only leading genuine twist (no hard MPIs)
- no linearly polarized gluons (assume $Q^2/P_T^2 \ll 1$)

[PK, K. Kutak, C. Marquet, E. Petreska, S. Sapeta, A. van Hameren, 2015]
[A. van Hameren, PK, K. Kutak, C. Marquet, E. Petreska, S. Sapeta, 2016]
[PK, K. Kutak, S. Sapeta, A. Stasto, M. Strikman, 2017]
[T. Altinoluk, R. Boussarie, PK, 2019]

Implemented in KaTie Monte Carlo
[A. van Hameren]

Also studied in the back-to-back regime

[L. Zheng, E.C. Aschenauer, J.H. Lee, B-W. Xiao, 2014]
[L. Zheng, E.C. Aschenauer, J.H. Lee, B-W. Xiao, Z-B. Yin, 2018]

Obtaining the Weizsacker-Williams TMD

1. Data driven dipole TMD for proton and nucleus

Balitsky-Kovchegov type equation with kinematic constraint, DGLAP correction and running coupling:

[J. Kwieciński, A. Martin, A. Stasto, 1997]
[K. Kutak, J. Kwieciński, 2003]

$$\mathcal{F}_{gg}^{(1)}\left(x,k_T^2\right) = \mathcal{F}_0\left(x,k_T^2\right) + \frac{\alpha_s N_c}{\pi}\int_x^1 \frac{dz}{z}\int_{k_{T0}^2}^{\infty}\frac{dq_T^2}{q_T^2}\left\{\frac{q_T^2\mathcal{F}\left(\frac{x}{z},q_T^2\right)\theta\left(\frac{k_T^2}{z}-q_T^2\right)-k_T^2\mathcal{F}\left(\frac{x}{z},k_T^2\right)}{\left|q_T^2-k_T^2\right|}+\frac{k_T^2\mathcal{F}\left(\frac{x}{z},k_T^2\right)}{\sqrt{4q_T^4+k_T^4}}\right\}$$

$$+\frac{\alpha_s}{2\pi k_T^2}\int_x^1 dz\left\{\left(P_{gg}(z)-\frac{2N_c}{z}\right)\int_{k_{T0}^2}^{k_T^2}dq_T^2\mathcal{F}\left(\frac{x}{z},q_T^2\right)+zP_{gq}(z)\Sigma\left(\frac{x}{z},k_T^2\right)\right\}$$

$$-\frac{2\alpha_s^2}{R^2}\left\{\left[\int_{k_T^2}^{\infty}\frac{dq_T^2}{q_T^2}\mathcal{F}\left(x,q_T^2\right)\right]^2+\mathcal{F}\left(x,k_T^2\right)\int_{k_T^2}^{\infty}\frac{dq_T^2}{q_T^2}\ln\left(\frac{q_T^2}{k_T^2}\right)\mathcal{F}\left(x,q_T^2\right)\right\}$$

fitted to DIS HERA data

[K. Kutak, S. Sapeta, 2012]

for NUCLEUS: $R_A = A^{1/3} R_p$ ↗

2. Weizsacker-Williams TMD with Sudakov resummation

At large N_c limit and Gaussian approximation:

[F. Dominguez, C. Marquet, B. Xiao, F. Yuan, 2011]
[A. Mueller, B-W. Xiao, F. Yuan, 2013]

$$\mathcal{F}_{gg}^{(3)}(x,k_T,\mu) = \frac{C_F}{2\pi^4\alpha_s}\int d^2b\int\frac{d^2r}{r_T^2}\,e^{-i\vec{k}_T\cdot\vec{r}_T}\left[1-S_F^2(x,r_T)\right]e^{\mathrm{S}(\mu,r_T)}$$

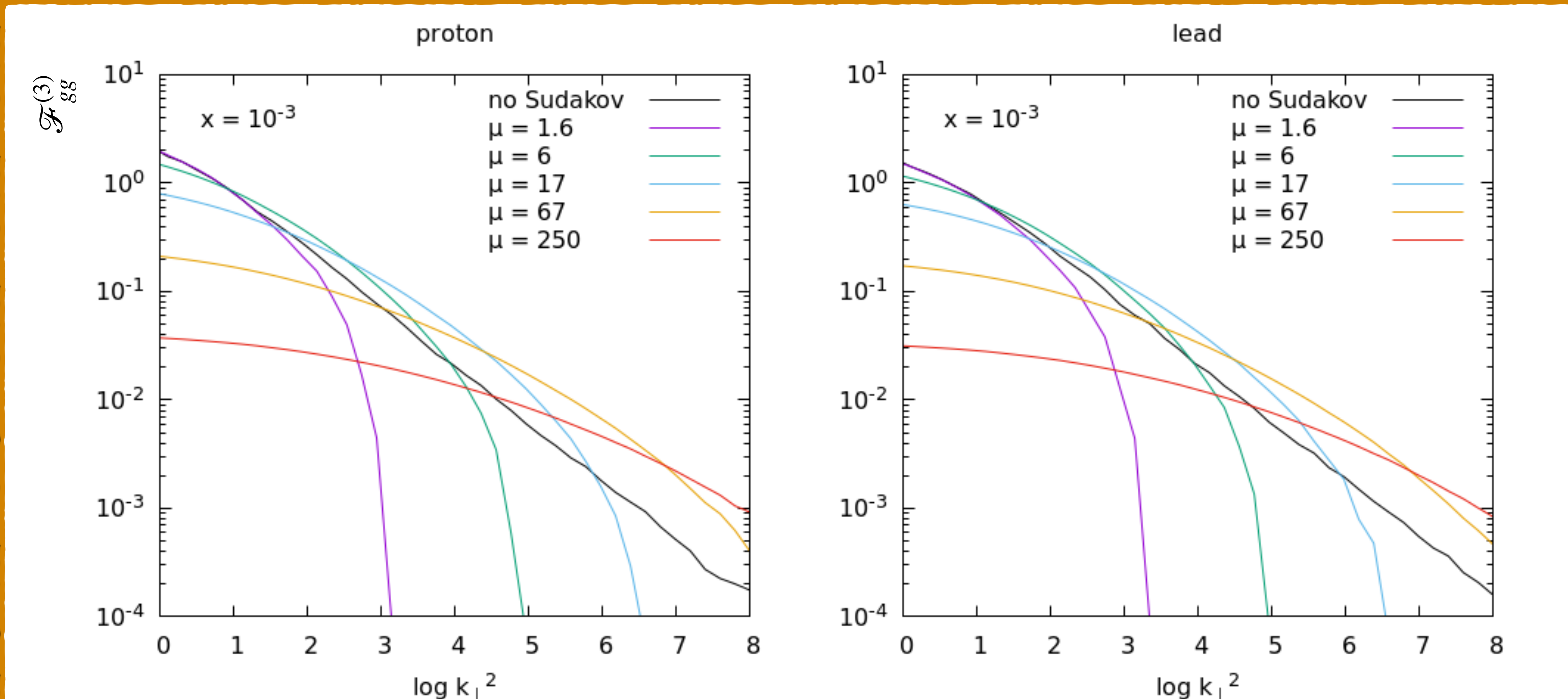
dipole ↑ Sudakov factor ↖

$$S_F(x,r) = \frac{2\pi^2\alpha_s}{N_c S_\perp}\int\frac{d^2k_T}{k_T^2}\,e^{i\vec{k}_T\cdot\vec{r}_T}\,\mathcal{F}_{gg}^{(1)}(x,k_T)$$

$$\mathrm{S}(\mu,r_T) = -\frac{\alpha_s N_c}{4\pi}\ln^2(A\mu^2 r_T^2)$$

RESULTS

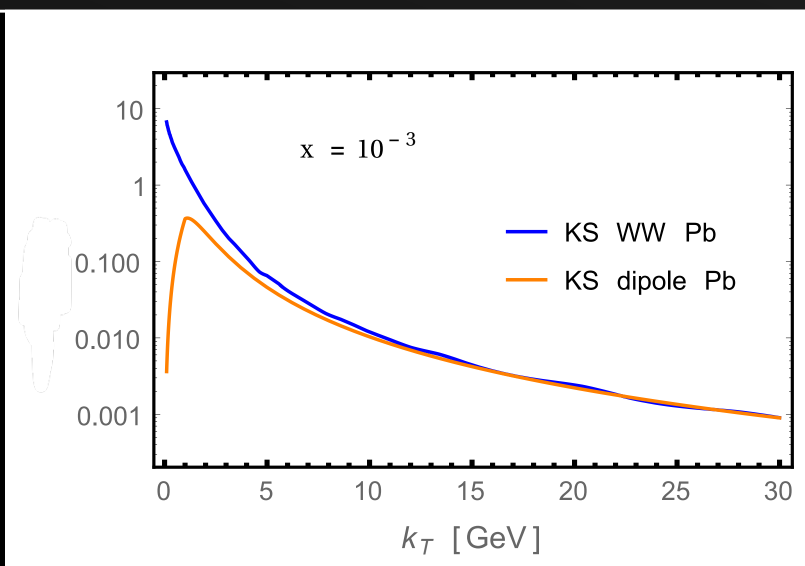
The Weizsacker-Williams TMD with Sudakov resummation



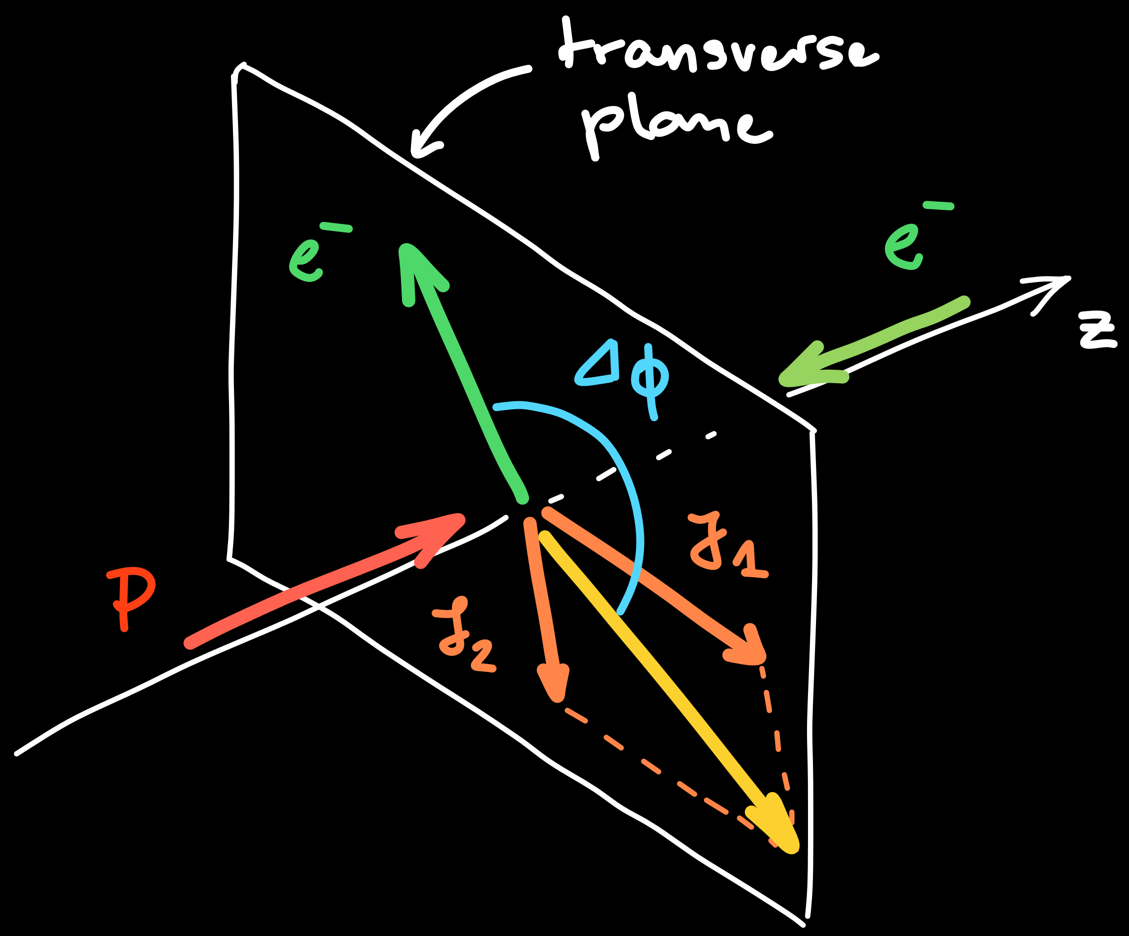
[A. van Hameren, PK, K. Kutak, S. Sapeta, E. Zarow, 2021]

Weizsacker-Williams vs dipole gluon TMD distribution

different behaviour at small k_T (convergence at large k_T) →

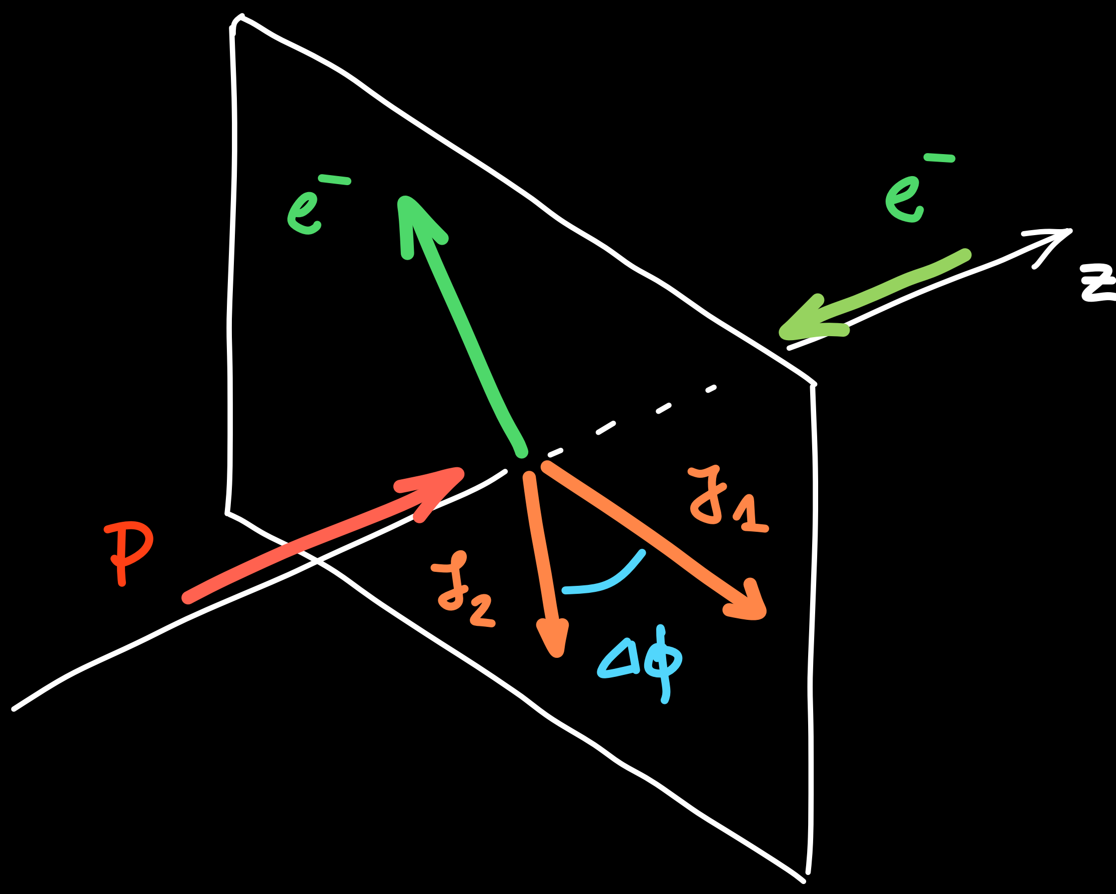


Azimuthal angle between transverse momentum of electron and dijet system



$\Delta\Phi(J_1 + J_2, e^-)$

Azimuthal angle between transverse momenta of jets



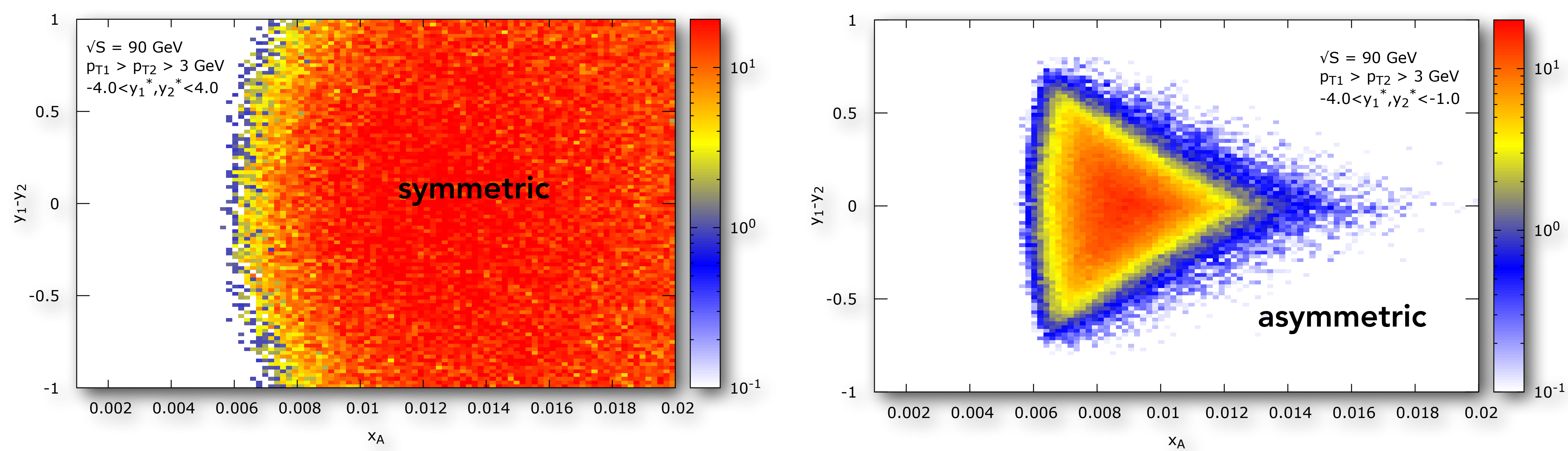
$\Delta\Phi(J_1, J_2)$

RESULTS

Cuts

- CM energy: $\sqrt{s} = 90\,\mathrm{GeV}$ (for e-p and e-Pb)
- inelasticity: $0.1 < \nu < 0.85$
- virtuality: $Q^2 > 1\,\mathrm{GeV}^2$
- jet transverse momenta: $p_{T1} > p_{T2} > 3\,\mathrm{GeV}$ (Breit frame)
- jet radius: $\Delta R > 1$ (Breit frame)
- symmetric rapidity: $-4 < y_1^*, y_2^* < 4$ (CM frame)
- asymmetric rapidity: $-4 < y_1^*, y_2^* < -1$

Symmetric vs asymmetric rapidity window



[A. van Hameren, PK, K. Kutak, S. Sapeta, E. Zarow, 2021]

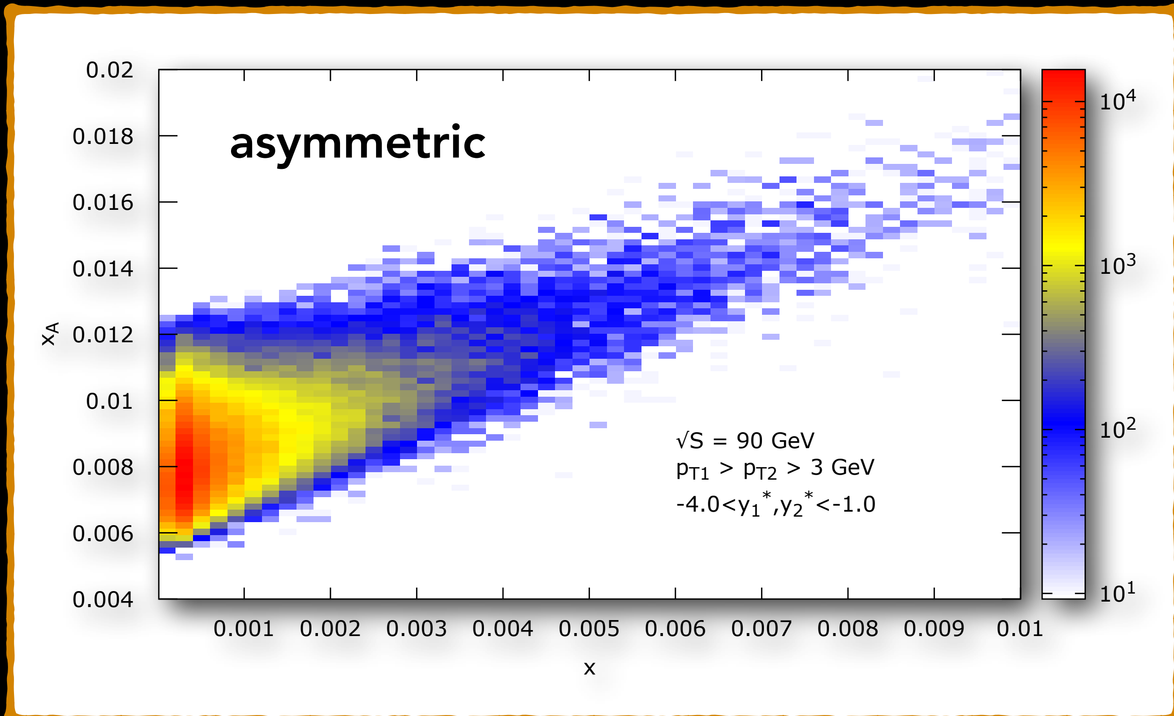
↑ rapidity difference

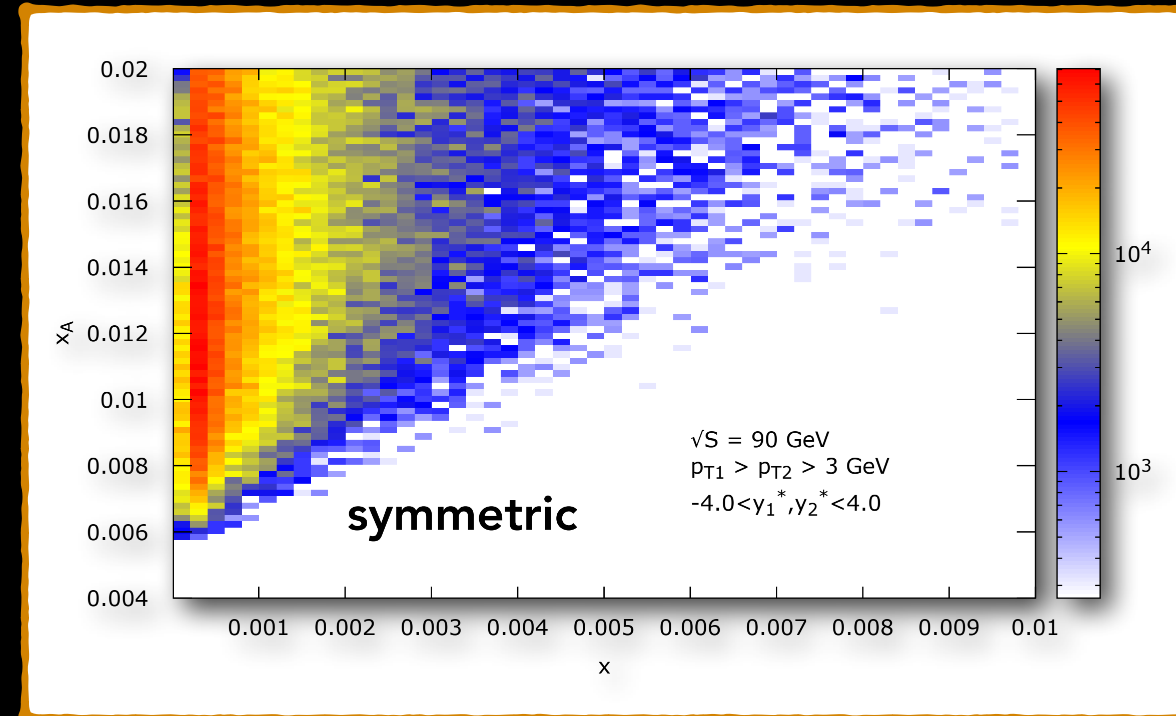
↑ x of gluon $x_A \neq x_{Bj}$

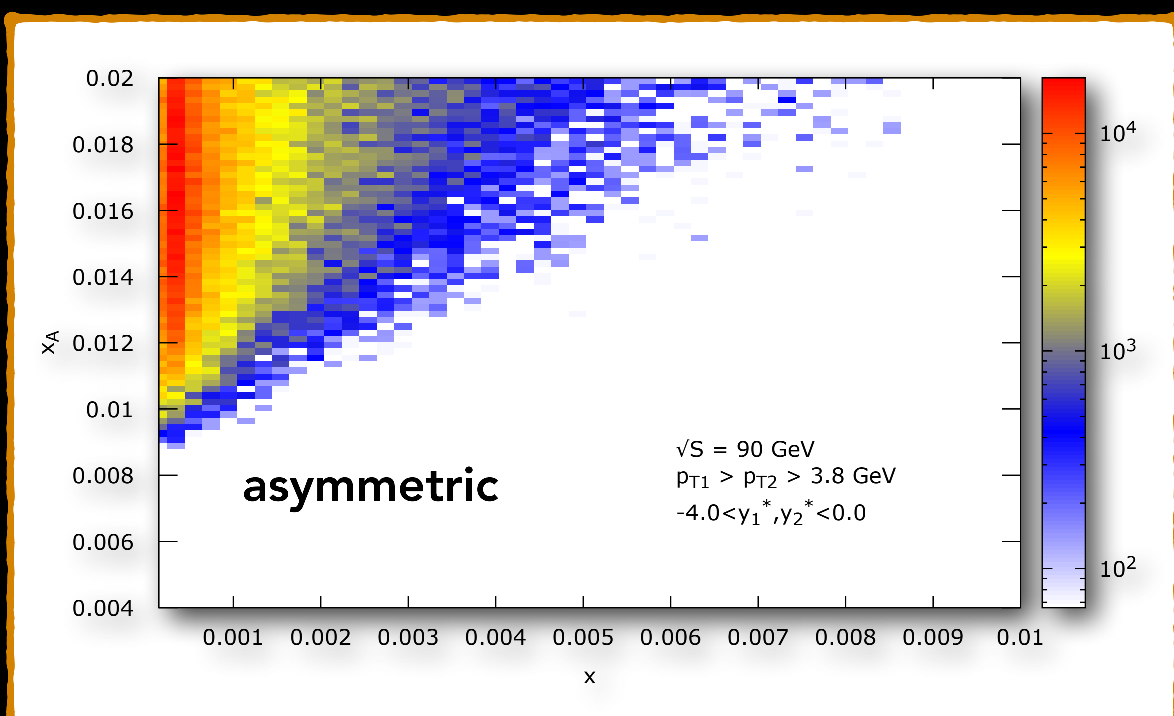
↑ good focus on small x_A

Bjorken x vs Gluon x_A

[A. van Hameren, PK, K. Kutak, S. Sapeta, E. Zarow, 2021]







for asymmetric window

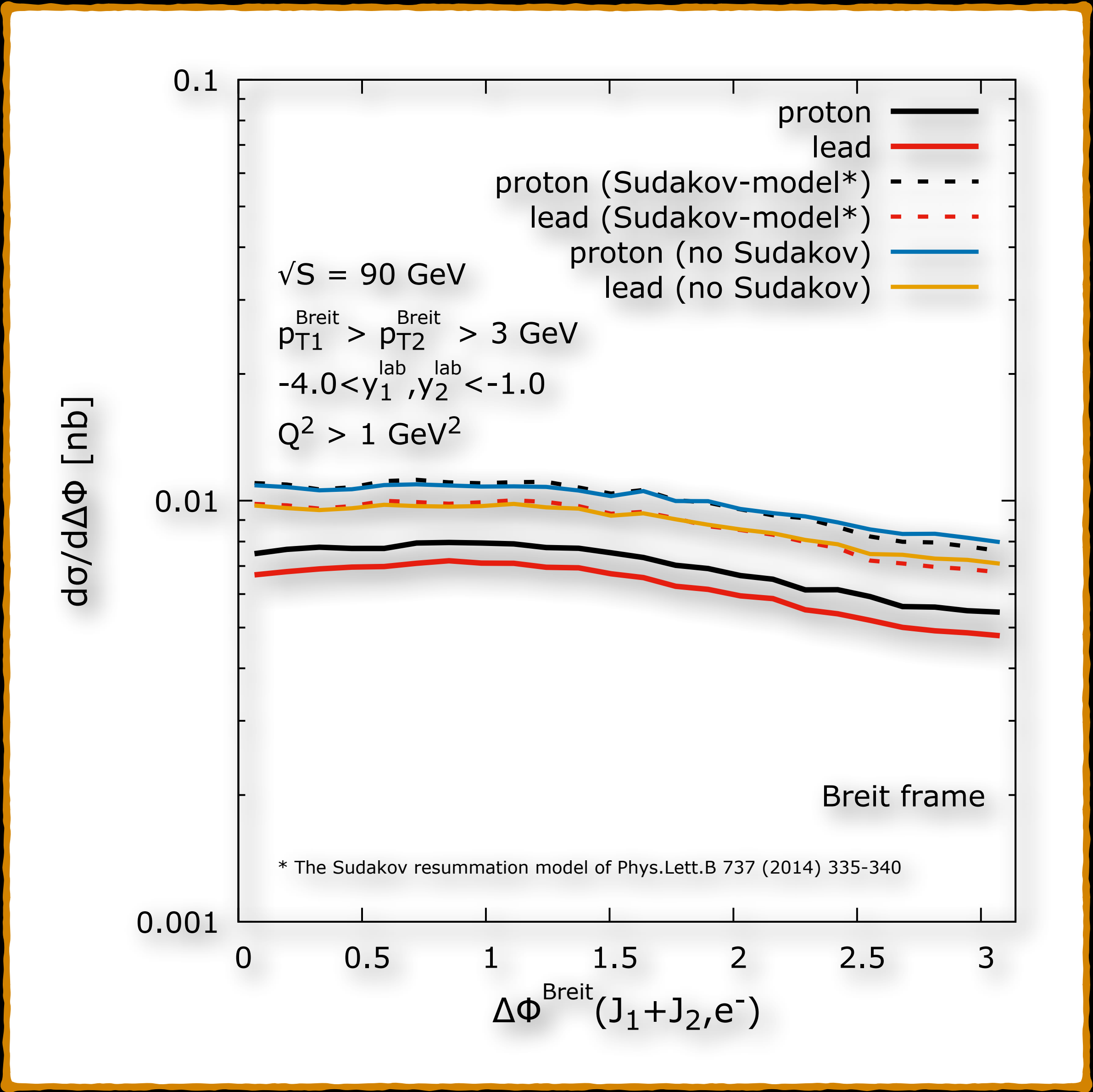
$x_{Bj} \sim 10^{-4}$

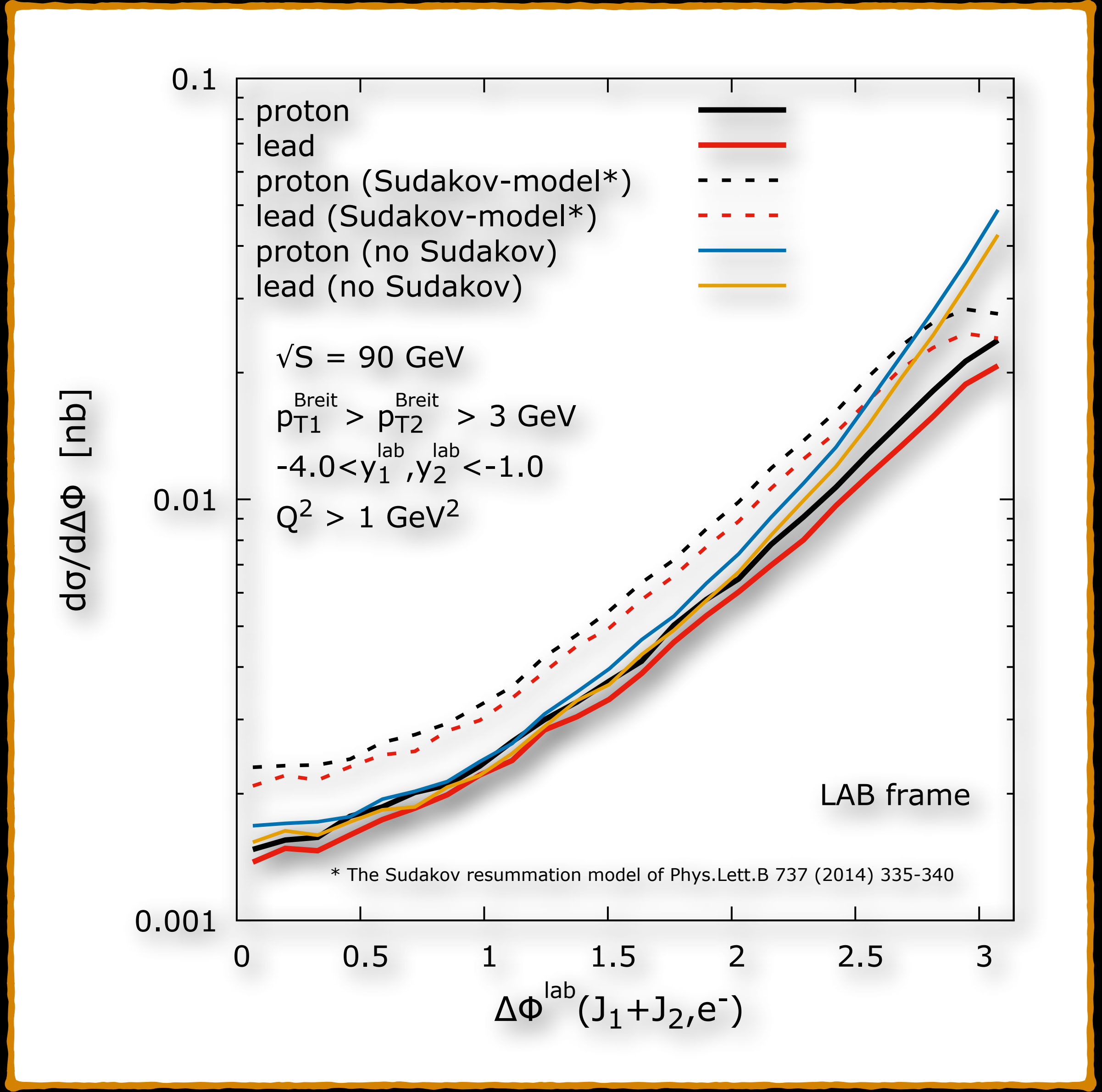
⇓

$x_A \sim 6\times 10^{-3}$

Larger p_T cut

Azimuthal angle between jet plane and electron $\Delta\Phi(J_1 + J_2, e^-)$



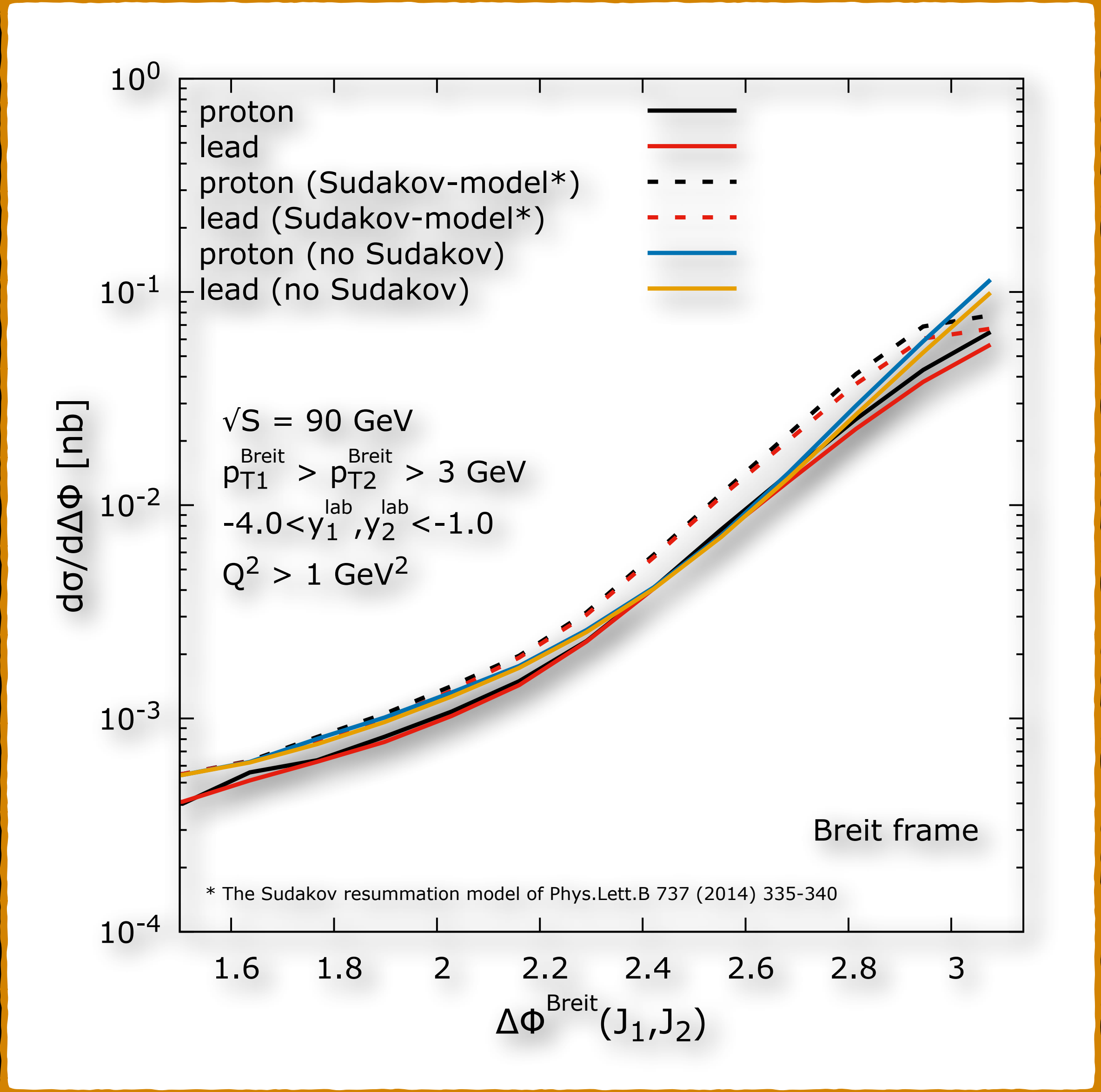


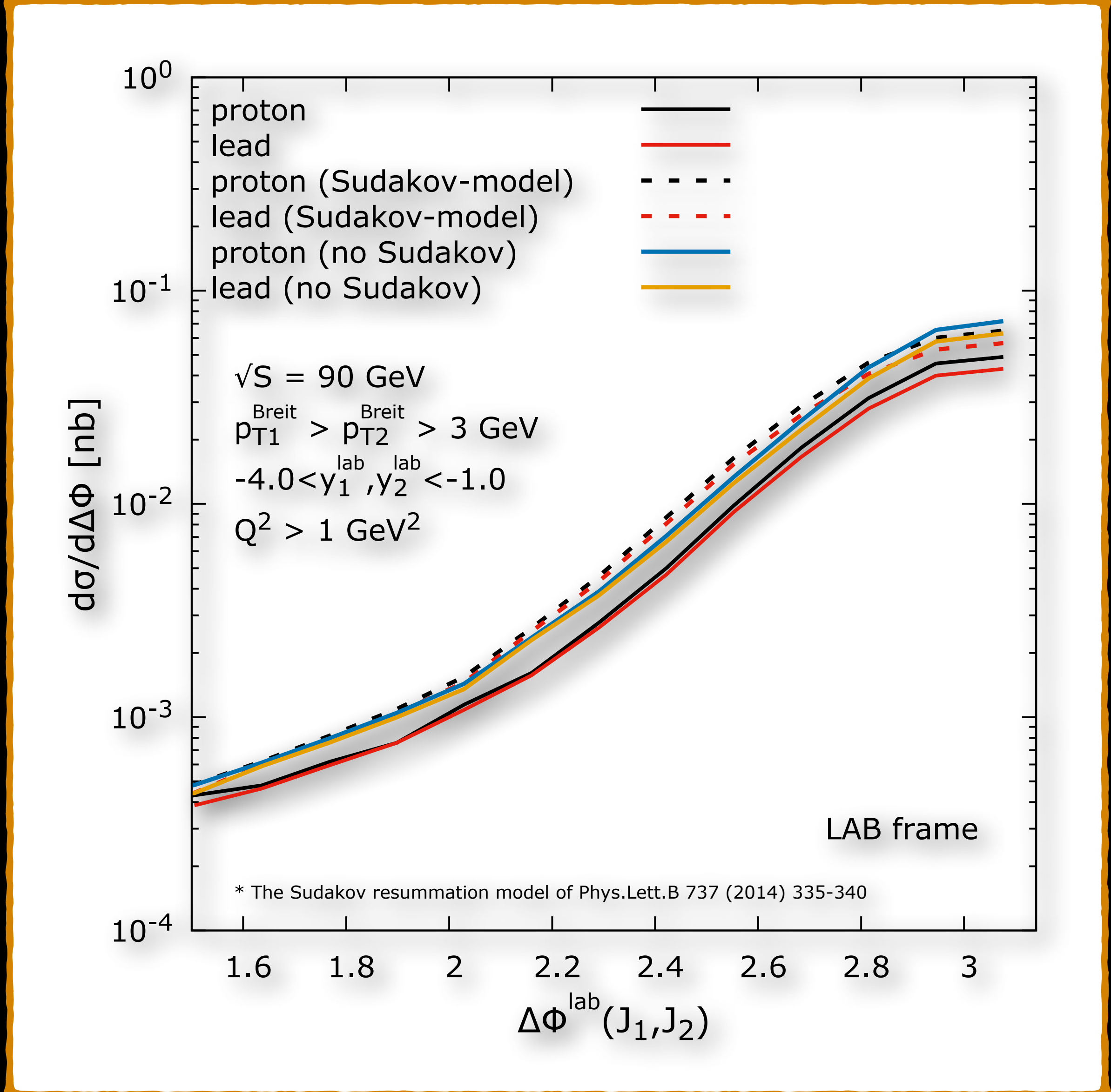
[A. van Hameren, PK, K. Kutak, S. Sapeta, E. Zarow, 2021]

Large Sudakov effects.

Saturation effects: up to 15% suppression.

Azimuthal angle between the jets $\Delta\Phi(J_1, J_2)$





[A. van Hameren, PK, K. Kutak, S. Sapeta, E. Zarow, 2021]

Very steep distributions.

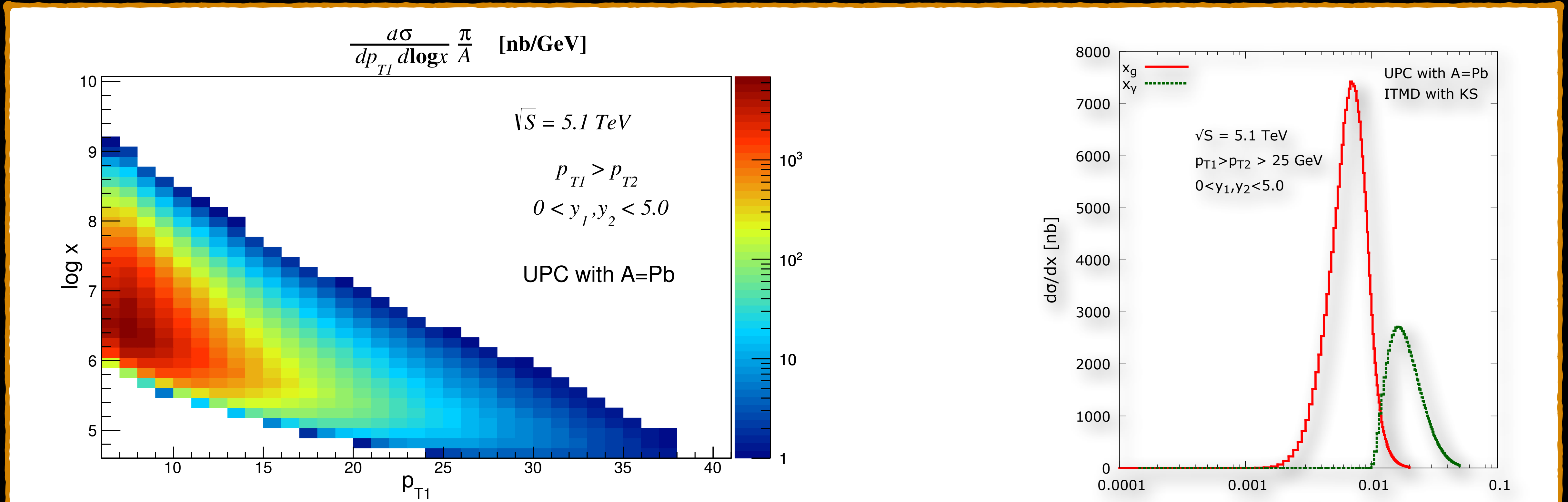
Sudakov effects significant for smaller $\Delta\phi$.

Dijets in UPC at LHC

Cuts

- CM energy: $\sqrt{s} = 5.1\,\mathrm{TeV}$
- rapidity: $0 < y_1^*, y_2^* < 5$
- jet transverse momenta: $p_{T1} > p_{T2} > 6 \div 25\,\mathrm{GeV}$
- jet radius: $\Delta R > 0.5$

Can we probe small x?



[PK, K. Kutak, S. Sapeta, A. Stasto, M. Strikman, 2017]

Small x_g requires small p_T.

Asymmetric rapidity cut provides good focusing in x_g.

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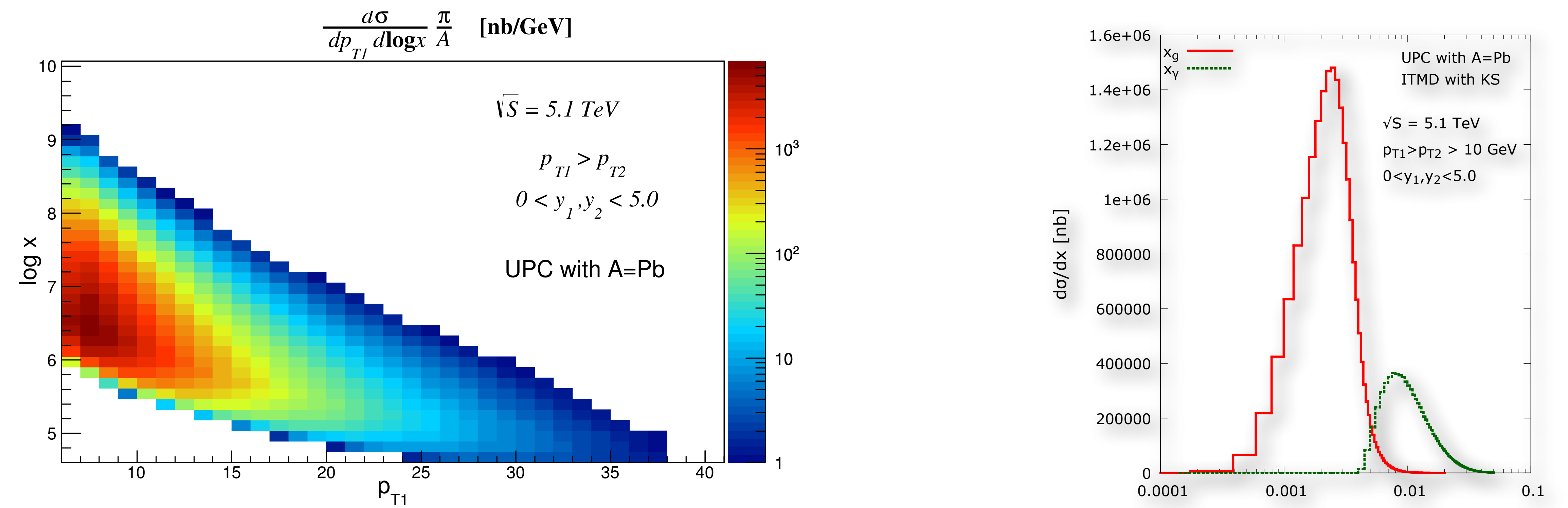

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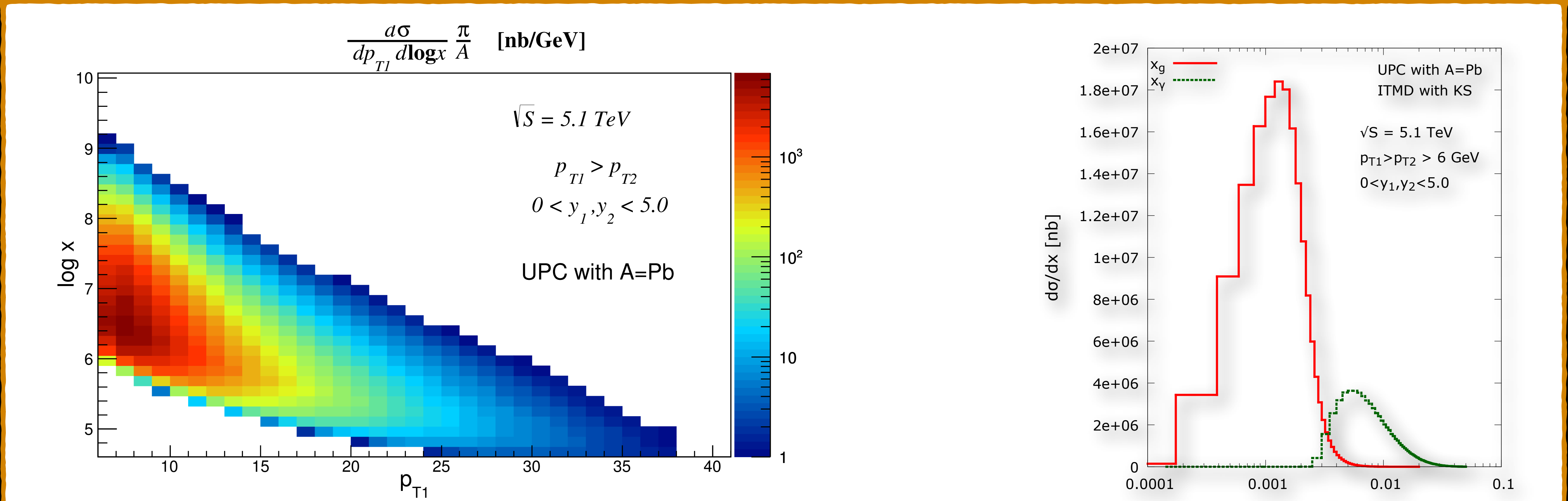
- jet radius: $\Delta R > 0.5$

Can we probe small x?



[PK, K. Kutak, S. Sapeta, A. Stasto, M. Strikman, 2017]

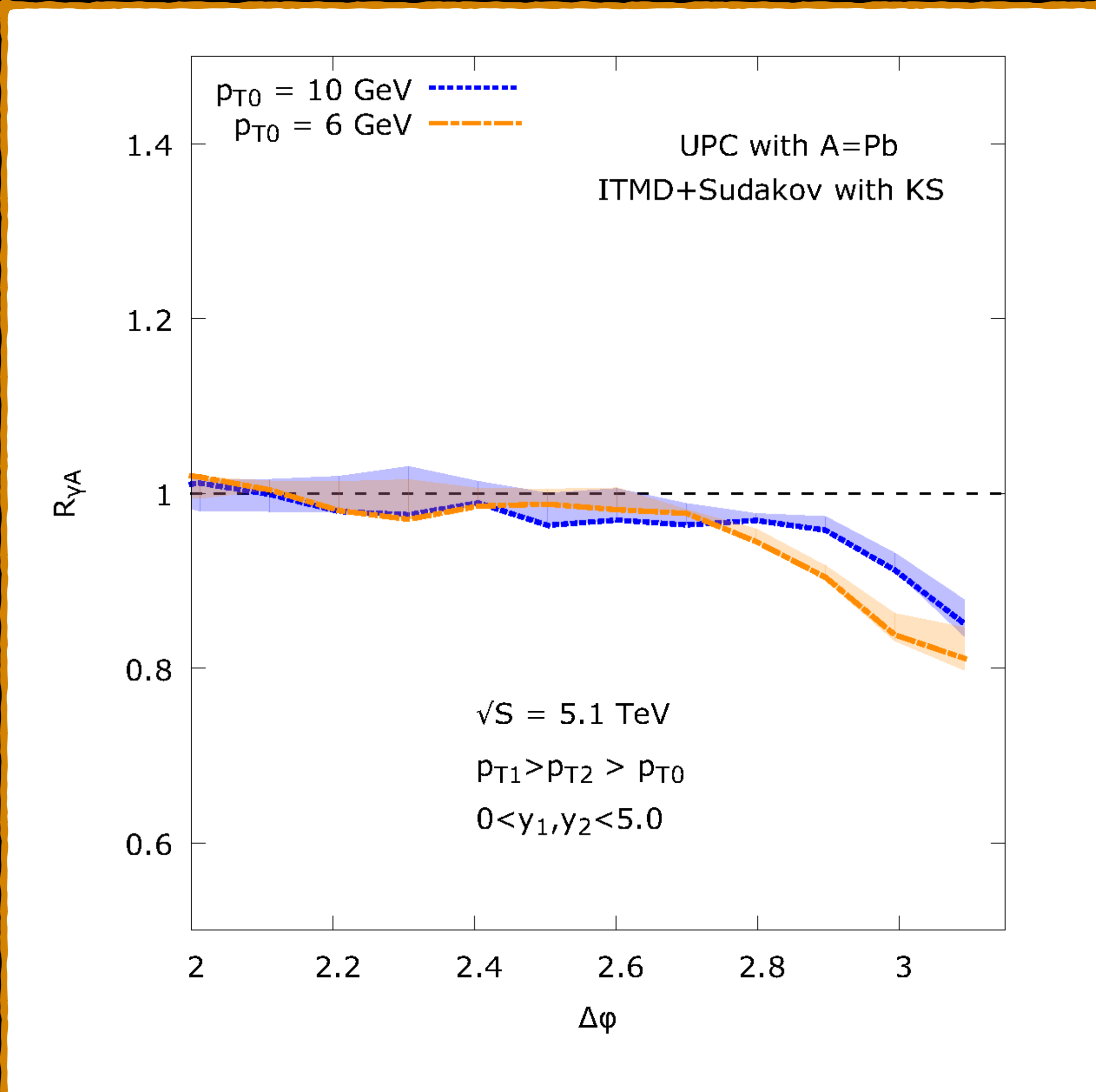
Small x_g requires small p_T.

Asymmetric rapidity cut provides good focusing in x_g.

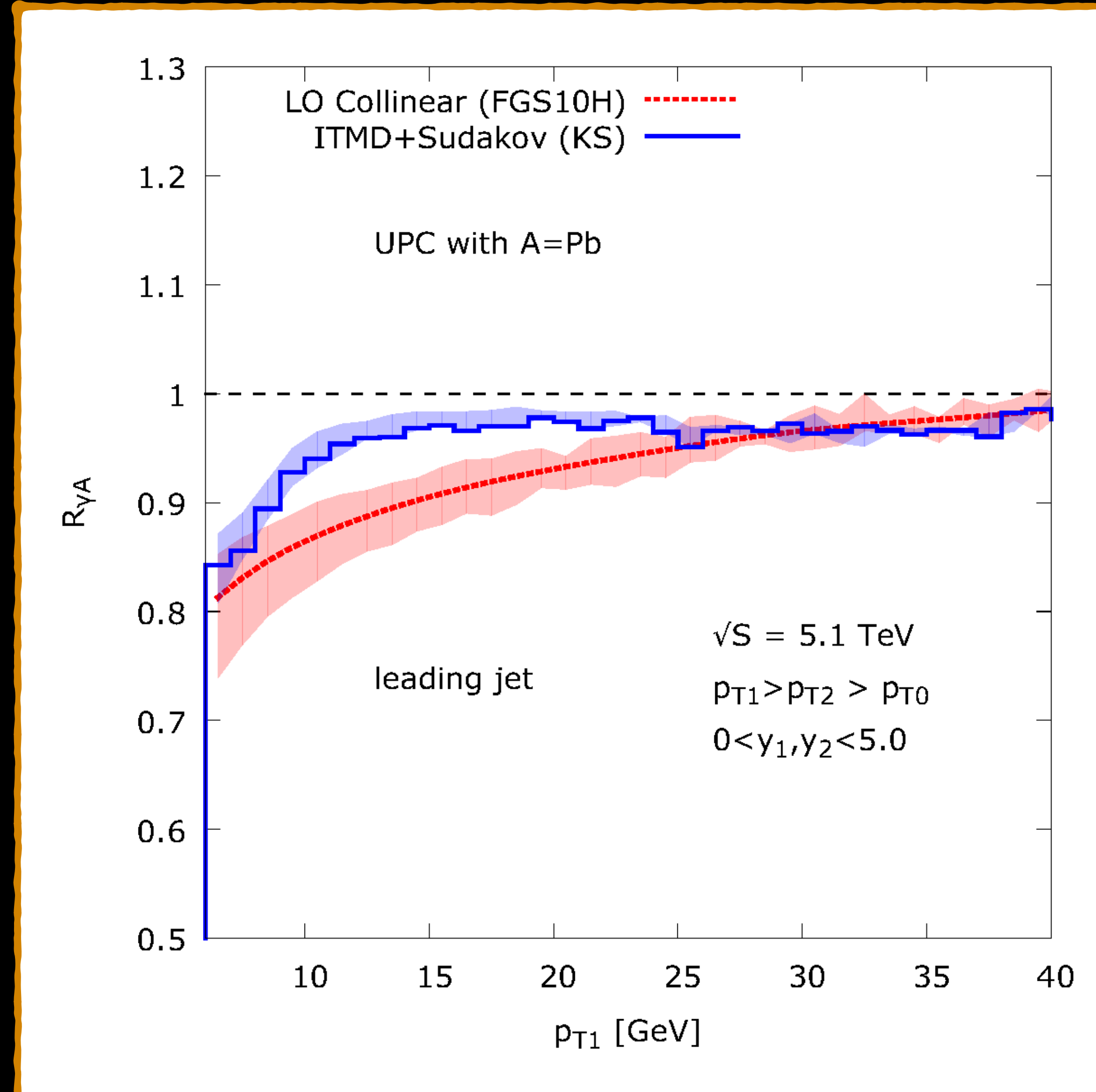
RESULTS

Dijets in UPC at LHC

Azimuthal angle between jets



p_T spectrum



[PK, K. Kutak, S. Sapeta, A. Stasto, M. Strikman, 2021]

↑ Nuclear modification ratio

Suppression up to 20% for $p_T > 6$ GeV.

Saturation gives similar suppression to "leading twist" shadowing.

SUMMARY

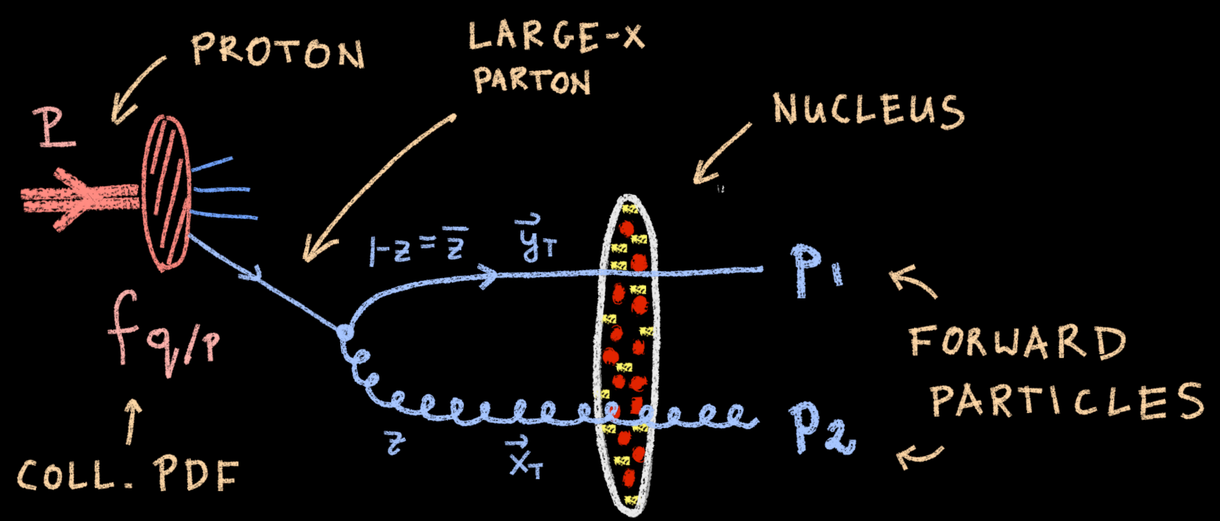
- For processes sensitive to the internal gluon transverse momenta, in general, there are no universal TMD distributions.
- Lack of universality is the QCD prediction. It is seen both in pQCD and high energy effective theories, like Color Glass Condensate.
- There are two most basic gluon TMDs:
  - dipole - accessible in inclusive processes, but not having interpretation of a gluon number distribution,
  - Weizsacker-Williams (WW) - gluon number distribution, but accessible in less exclusive processes.
- They both exhibit saturation, but have very different behavior at small k_T.

- Dijet production in DIS or UPC on nuclear targets are good probes of WW at small-x, but rather small p_T jets are needed.
- Complementary processes to forward jet production at LHC.
- Azimuthal correlations are the best observables, due to the direct relation to internal gluon transverse momentum.
- The predictions show noticeable saturation effects (proton target vs nuclear target) and rather large sensitivity to the Sudakov logarithms.

BACKUP

BACKUP

Dilute-dense collisions in CGC



$$\frac{d\sigma_{qA\to 2j}}{d^3p_1\, d^3p_2} \sim \int \frac{d^2x}{(2\pi)^2}\frac{d^2x'}{(2\pi)^2}\frac{d^2y}{(2\pi)^2}\frac{d^2y'}{(2\pi)^2}\, e^{-i\vec p_{T1}\cdot(\vec x_T-\vec x'_T)}\, e^{-i\vec p_{T2}\cdot(\vec y_T-\vec y'_T)}$$

$$\times\, \psi_z^*(\vec x'_T-\vec y'_T)\,\psi_z(\vec x_T-\vec y_T)$$

← QUARK WAVE FUNCTION

$$\times \Big\{ S_x^{(6)}(\vec y_T,\vec x_T,\vec y'_T,\vec x'_T) - S_x^{(4)}(\vec y_T,\vec x_T,\bar z\vec y'_T+z\vec x'_T) - S_x^{(4)}(\bar z\vec y_T+z\vec x_T,\vec y'_T,\vec x'_T) - S_x^{(2)}(\bar z\vec y_T+z\vec x_T,\bar z\vec y'_T+z\vec x'_T)\Big\}$$

CORRELATORS OF WILSON LINES

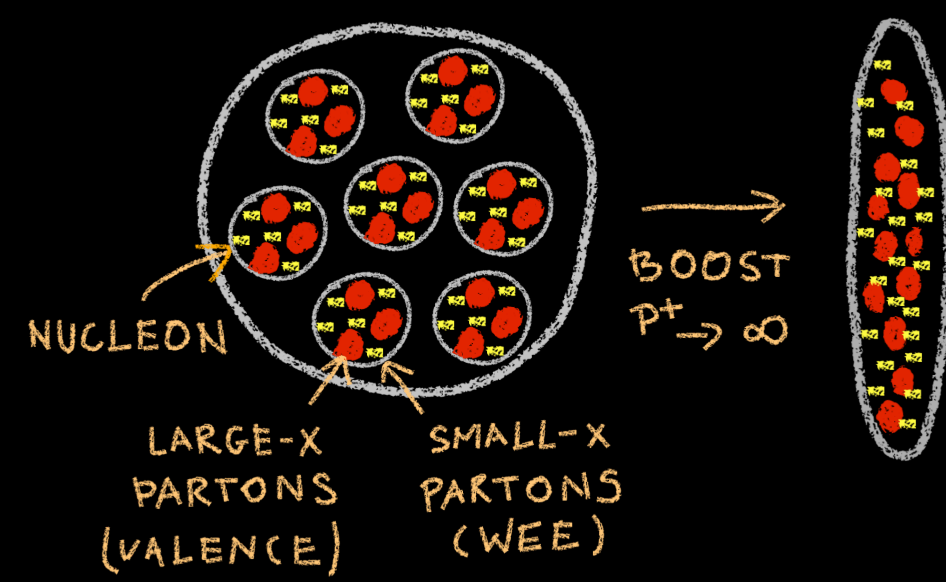
$$S_x^{(2)}(\vec y_T,\vec x_T) = \frac{1}{N_c}\left\langle \mathrm{Tr}\, U(\vec y_T)U^\dagger(\vec x_T)\right\rangle_x$$

$$S_x^{(4)}(\vec z_T,\vec y_T,\vec x_T) = \frac{1}{2C_FN_c}\left\langle \mathrm{Tr}\left[U(\vec z_T)U^\dagger(\vec y_T)\right]\mathrm{Tr}\left[U(\vec y_T)U^\dagger(\vec x_T)\right]\right\rangle_x - S_x^{(2)}(\vec z_T,\vec x_T)$$

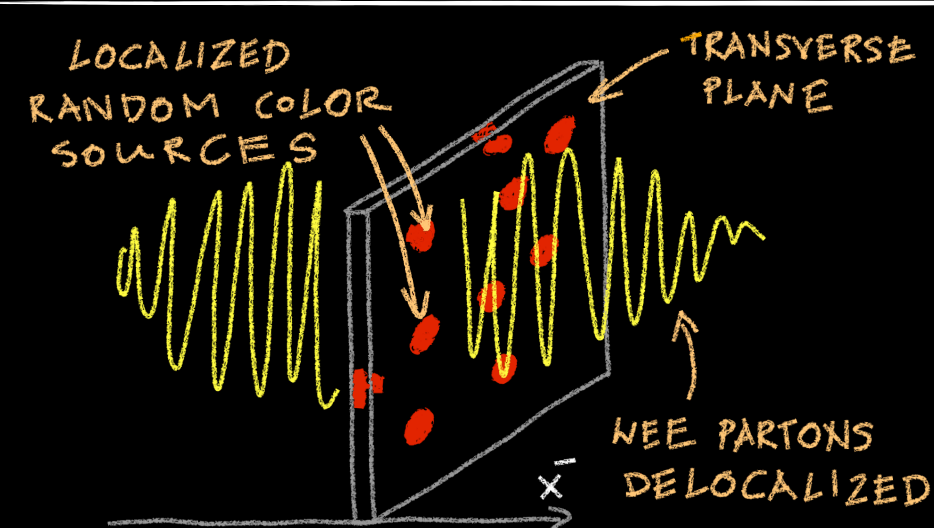
etc...

$$U(\vec x_T) = \mathscr{P}\exp\left\{ ig\int_{-\infty}^{+\infty} dx^+\, A_a^-(x^+,\vec x_T)\, t^a\right\}$$

[C. Marquet, 2007]



[L. McLerran, R. Venugopalan, 1993]



Large-x partons — the color source for wee partons:

$$(D_\mu F^{\mu\nu})_a(x^-,\vec x_T) = \delta^{\nu+}\rho_a(\vec x_T)\delta(x^-)$$

RANDOM DISTRIBUTION OF COLOR SOURCES

AVERAGE OVER COLOR SOURCES

GAUSSIAN FUNCTIONAL

B-JIMWLK EVOLUTION IN X → $\mathscr{W}_x[\rho]$

[Balitsky-Jalilian-Marian-Iancu-McLerran-Weigert-Leonidov-Kovner, 1996-2002]

TMD gluon distributions

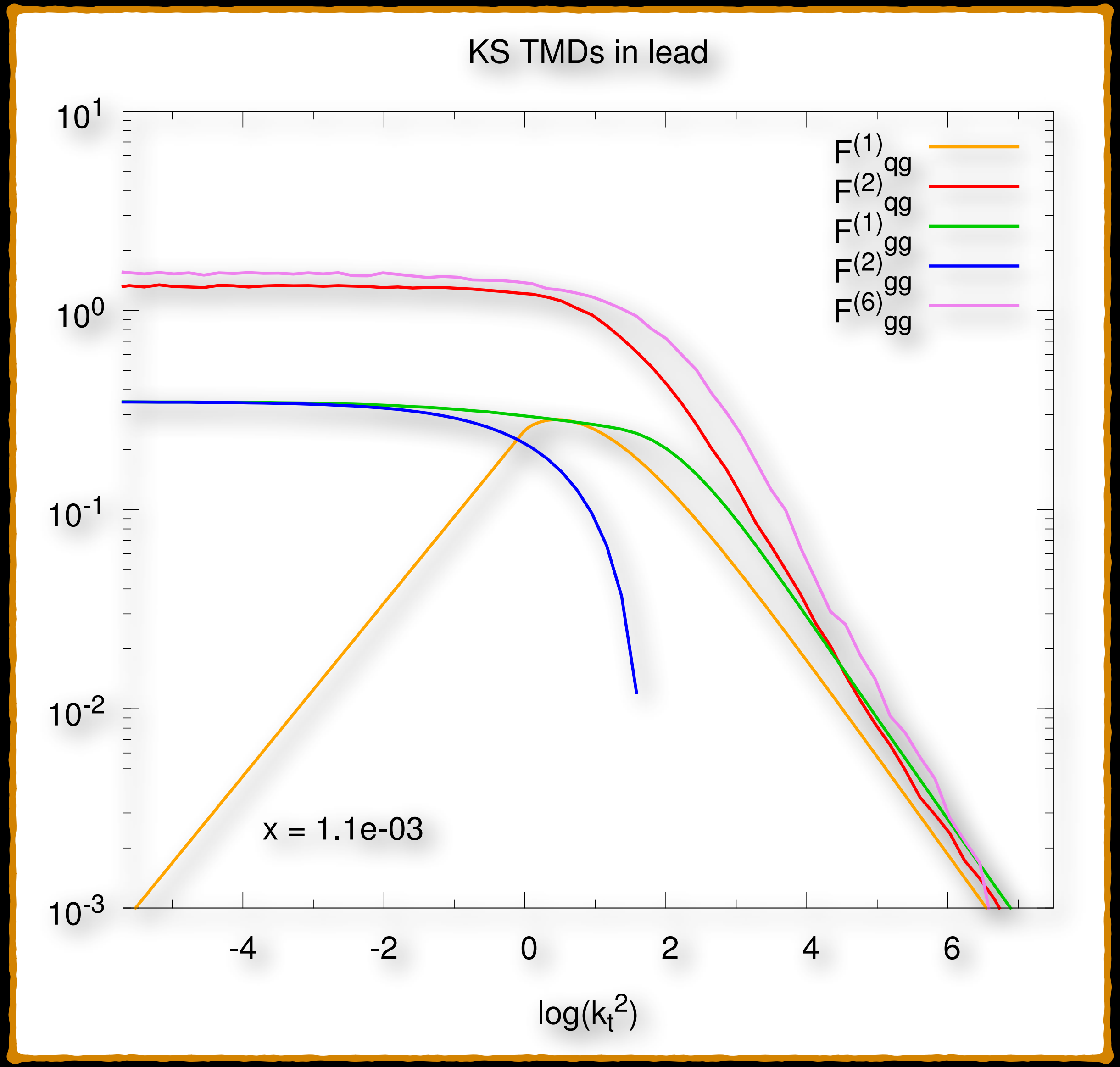
How to get various TMD distributions?

Using CGC theory one can derive a relation between the small-x TMDs using:

(i) large N_c limit

(ii) mean field (Gaussian) approximation.

All TMDs needed for dijet production can be calculated from the dipole gluon distribution $\mathscr{F}_{qg}^{(1)}$.



[A. Van Hameren, PK, K. Kutak, C. Marquet, E. Petreska, S. Sapeta, 2016]

It is possible to relax the assumptions (i) and (ii) using the JIMWLK equation.

Prove of concept:

[C. Marquet, E. Petreska, C. Roiesnel, 2016]

Improvements:

[S. Cali, K. Cichy, P. Korcyl, PK, K. Kutak, C. Marquet, 2021]

KaTie Monte Carlo

KaTie https://bitbucket.org/hameren/katie

- parton level event generator, like ALPGEN, HELAC, MADGRAPH, etc.
- arbitrary processes within the standard model (including effective Higgs-gluon coupling) with several final-state particles.
- 0, 1, or 2 off-shell intial states.
- produces (partially un)weighted event files, for example in the LHEF format.
- requires LHAPDF. TMD PDFs can be provided as files containing rectangular grids, or with TMDlib.
- a calculation is steered by a single input file.
- employs an optimization stage in which the pre-samplers for all channels are optimized.
- during the generation stage several event files can be created in parallel.
- event files can be processed further by parton-shower program like CASCADE.
- (evaluation of) matrix elements now separately available, including C++ interface.

A. van Hameren, EIC yellow report seminar

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