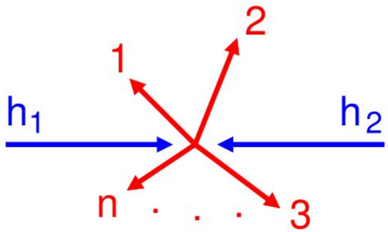
Unifying the parton reggeization and the auxiliary parton method at NLO (UPRAP)

Andreas van Hameren (IFJ PAN)
Maxim Nefedov (IJCLab)

Collinear factorization

To separate a perturbatively calculable from the universal in hadron scattering.



$$\sigma_{h_1,h_2\to n}(p_1,p_2) = \sum_{a,b}\int dx_1\,dx_2\; f_a(x_1,\mu)\, f_b(x_2,\mu)\; \hat{\sigma}_{a,b\to n}(x_1p_1, x_2p_2;\mu)$$

PDFs are related to the structure of the hadrons, universal to the scattering process

$$\hat{\sigma}_{a,b\to n}(p_a,p_b;\mu) = \int d\Phi(p_a,p_b\to\{p\}_n)\; |\mathcal{M}_{a,b\to n}(p_a,p_b\to\{p\}_n;\mu)|^2\; \mathcal{O}(p_a,p_b,\{p\}_n)$$

Phase space (includes spin/color summation) governs the kinematics

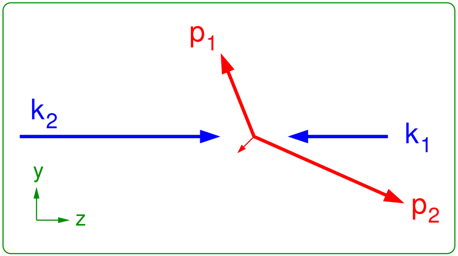
Matrix element (squared) contains model parameters, governs the dynamics

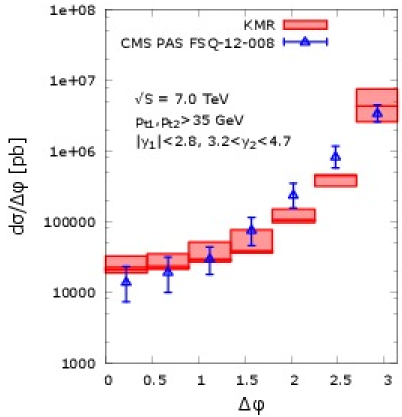
Observable, imposes phase space cuts

Forward-central dijet decorrelations $pp \to 2j$

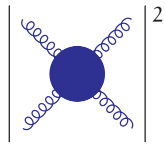
Example of an observable for which collinear factorization requires at least NLO

Collinear factorization

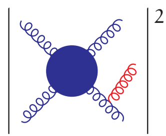




LO: $\hat{\sigma}^{\mathrm{LO}}_{a,b\to n} = \int d\Phi_n \left|\mathcal{M}^{(0)}_{a,b\to n}\right|^2 \mathcal{O}^{\mathrm{LO}}_n$

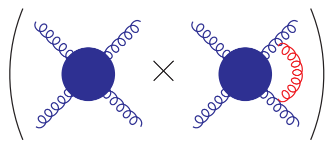


NLO: $\hat{\sigma}^{\mathrm{NLO}}_{a,b\to n} = \int d\Phi_{n+1} \left|\mathcal{M}^{(0)}_{a,b\to n+1}\right|^2 \mathcal{O}^{\mathrm{NLO}}_{n+1}$



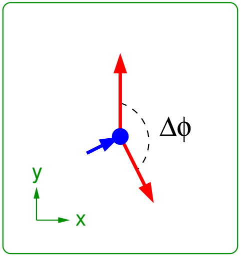
$+ \int d\Phi_n \, 2\mathrm{Re}\left(\mathcal{M}^{(0)}_{a,b\to n} \mathcal{M}^{(1)}_{a,b\to n}\right) \mathcal{O}^{\mathrm{LO}}_n$

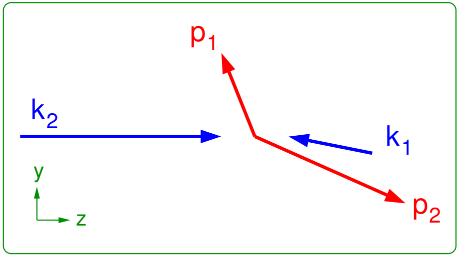
2Re

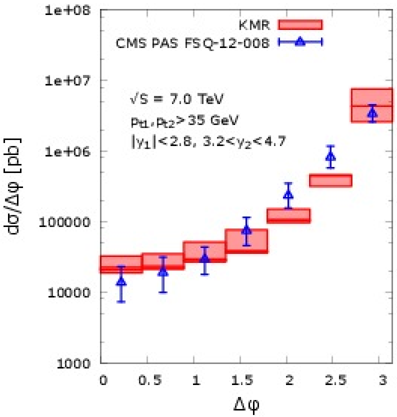


Forward-central dijet decorrelations pp $\to$ 2j

Hybrid k_T-factorization has momentum imbalance built in and works already at leading order







Hybrid factorization:

$$d\sigma_{pp\to X} = \int dk_T^2 \int dx_A \int dx_B \sum_b \mathcal{F}_{g^*}(x_A, k_T, \mu)\, f_b(x_B, \mu)\, d\hat{\sigma}_{g^* b\to X}(x_A, x_B, k_T, \mu)$$

$$k_1^\mu = x_A P_A^\mu + k_T^\mu \qquad P_A^2 = 0 \qquad k_1^2 = k_T^2$$

$$k_2^\mu = x_B P_B^\mu \qquad P_B^2 = 0 \qquad k_2^2 = 0$$

$$x_B \gg x_A \qquad |\vec{p}_1 + \vec{p}_2| = |\vec{k}_T|$$

The project

- collinear factorization is well-established to higher orders in perturbation theory, hybrid k_T-factorization is not

- the definition and calculation of the matrix elements in the partonic cross section $d\hat{\sigma}_{g^*b\to X}(x_A, x_B, k_T, \mu)$ for hybrid k_T-factorization is non-trivial compared to collinear factorization

- the "parton reggeization approach" (PRA) and the "auxiliary parton method" (APM) both achieve this, and agree at tree level (LO)

- hybrid k_T-factorization needs to be promoted to NLO, but the two methods do not seem to agree beyond tree level

- we want to resolve this ambiguity

- IFJPAN: Andreas van Hameren (expert on APM) + PhD student
- IJCLab: Maxim Nefedov (expert on PRA)

- the budget is 1500EUR each for travel in 2024