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Diffraction Across Colliders

Philipp Aretz

MIT

The XXIII Annual Workshop on Soft Collinear Effective Theory - 03/26, KIAS Seoul

Outline

1

Introduction

2

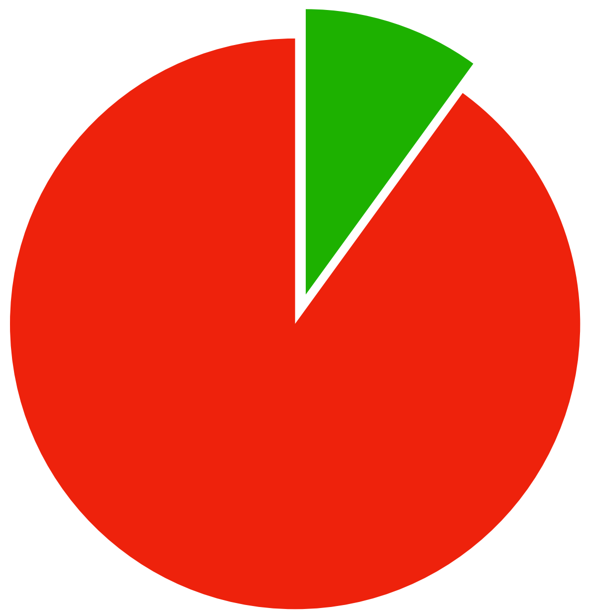
Factorisation and Universality

What is Diffraction?

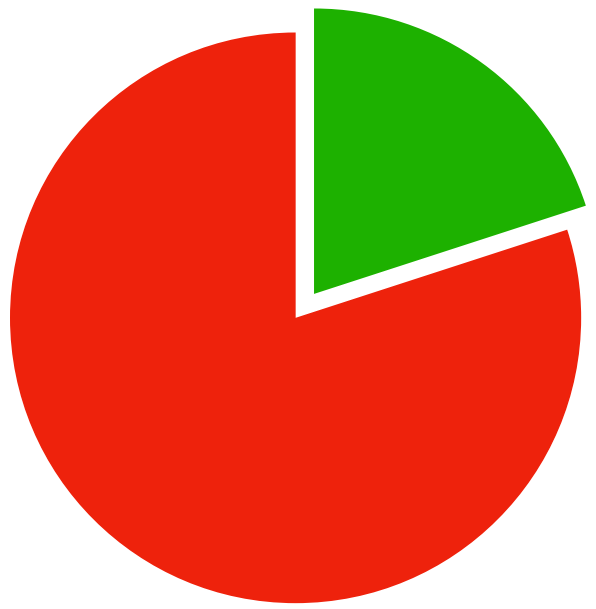
Initial State

One or more hadrons:

$$ep \to ?$$



10% Hera



20% EIC

$$pp \to ?$$

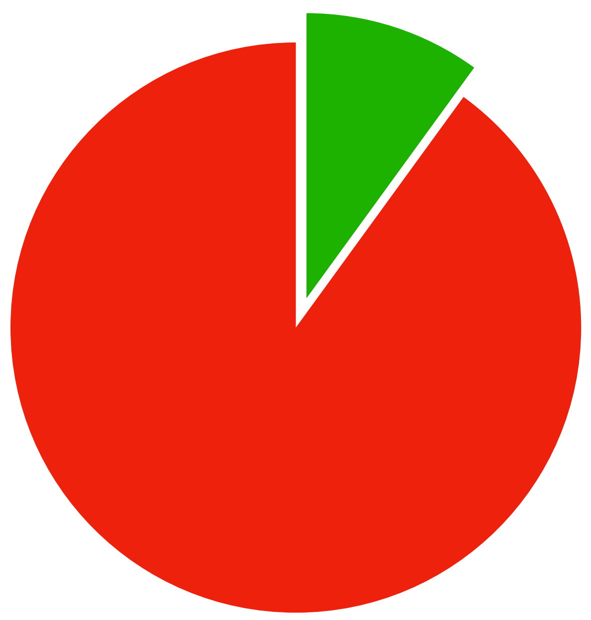
40% of LHC

What is Diffraction?

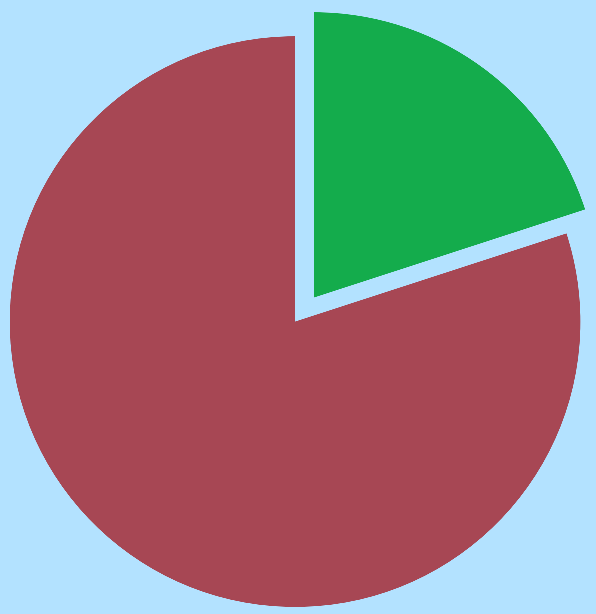
Initial State

One or more hadrons:

$ep \to ?$



10% Hera



20% EIC

EIC Flagship

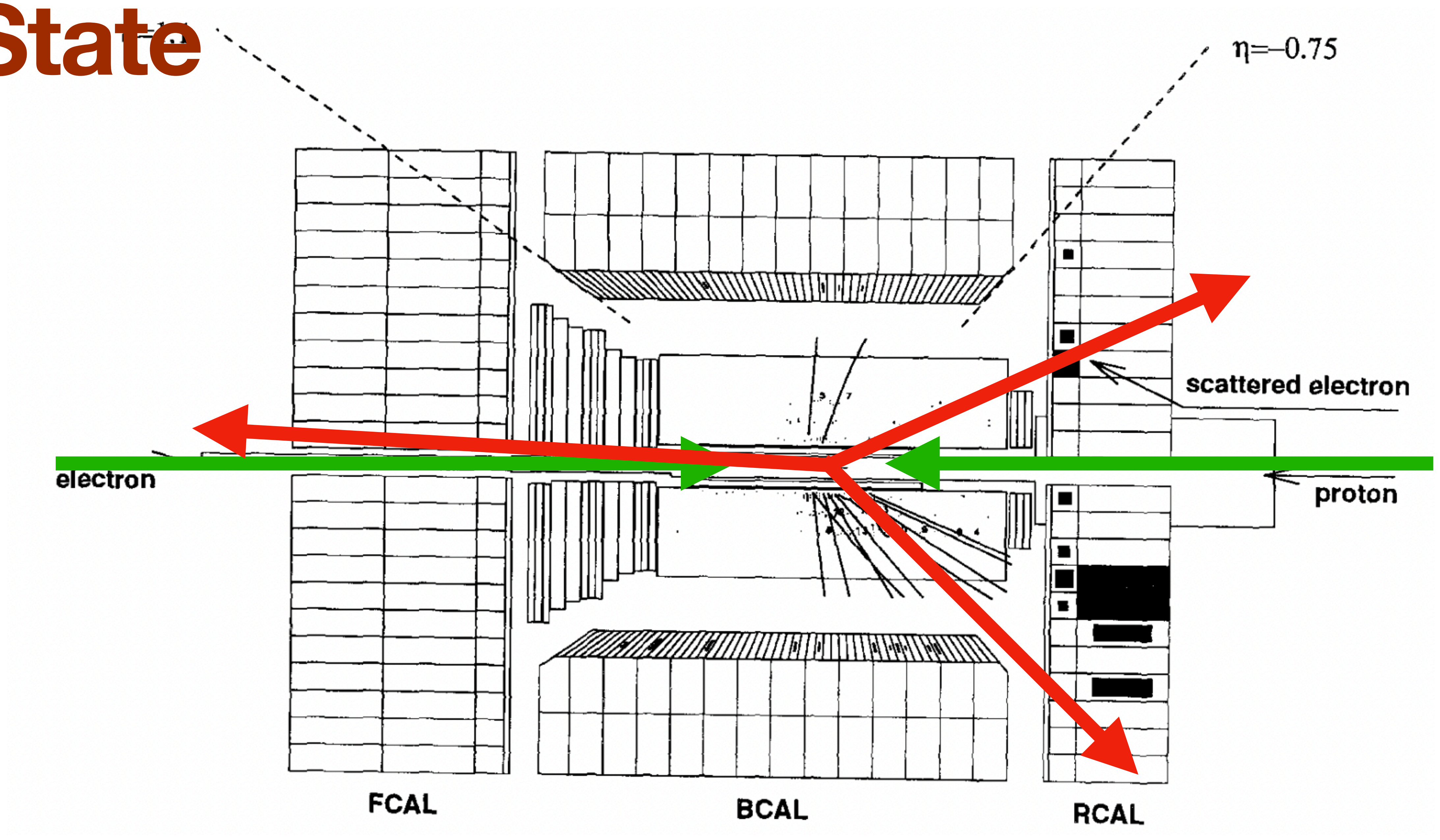
$pp \to ?$

40% of LHC

What is Diffraction?

Final State

$$e^- p \to e^- XY$$

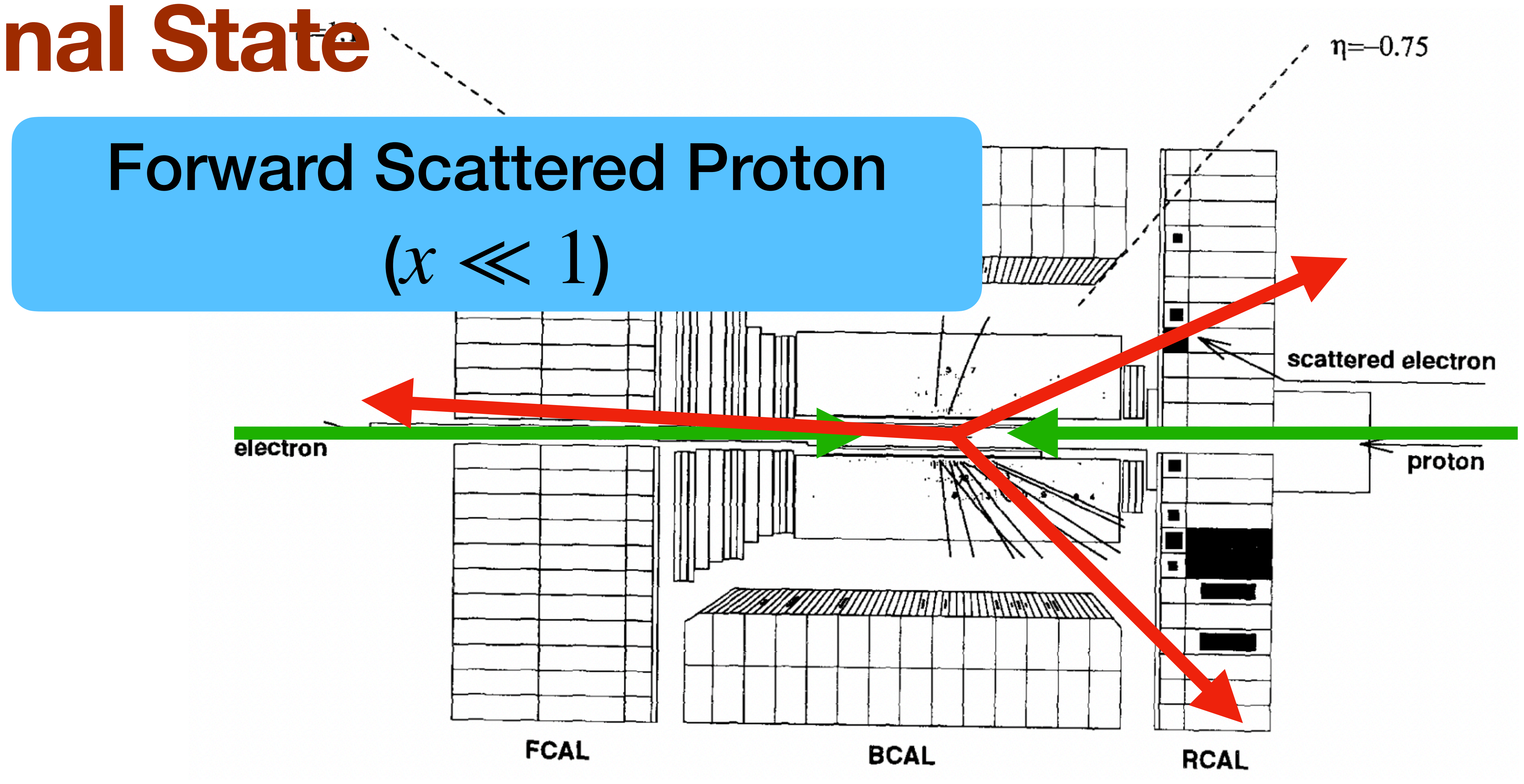


Y = proton or jet

What is Diffraction?

Final State

$$e^- p \rightarrow e^- XY$$

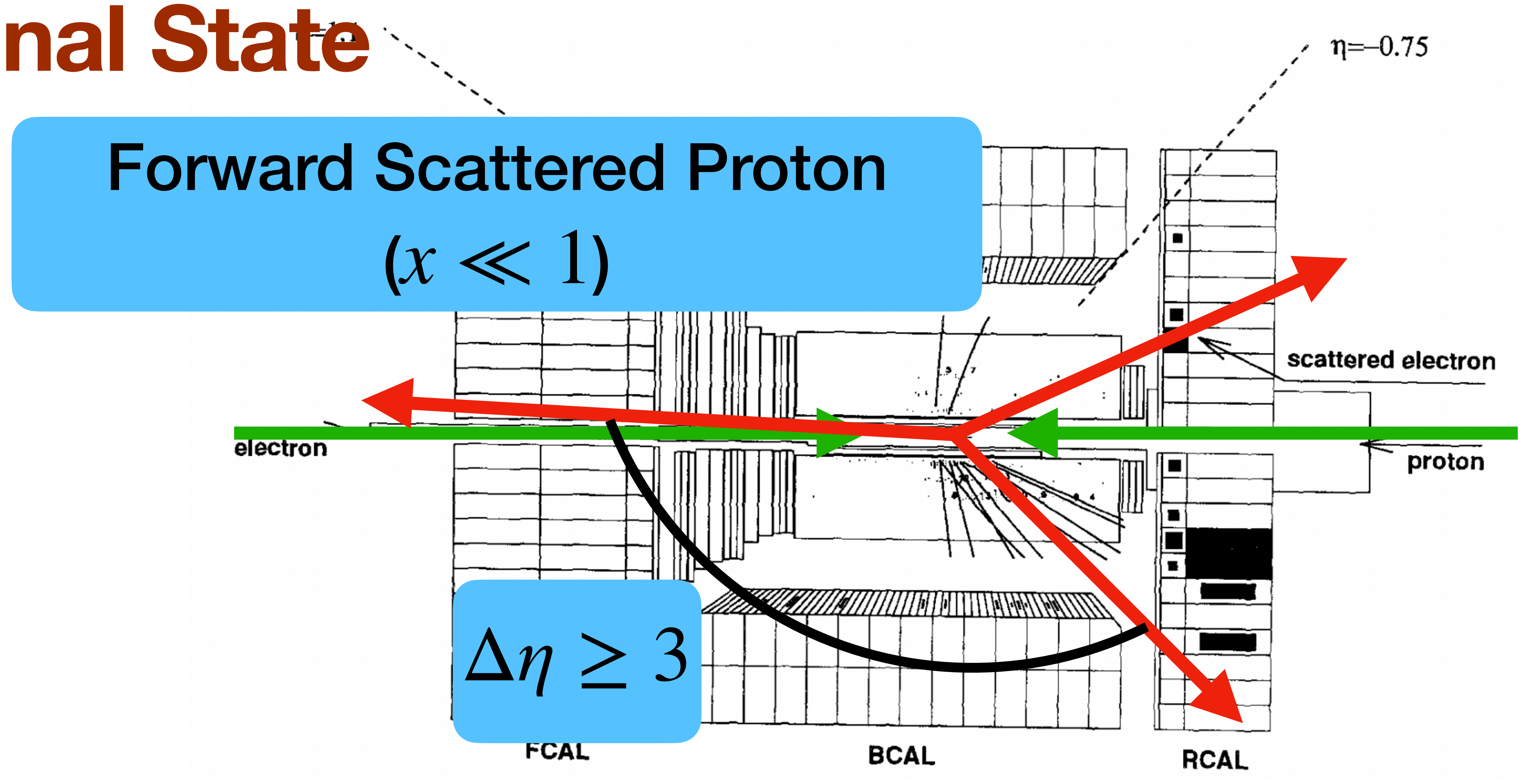


Y = proton or jet

What is Diffraction?

Final State

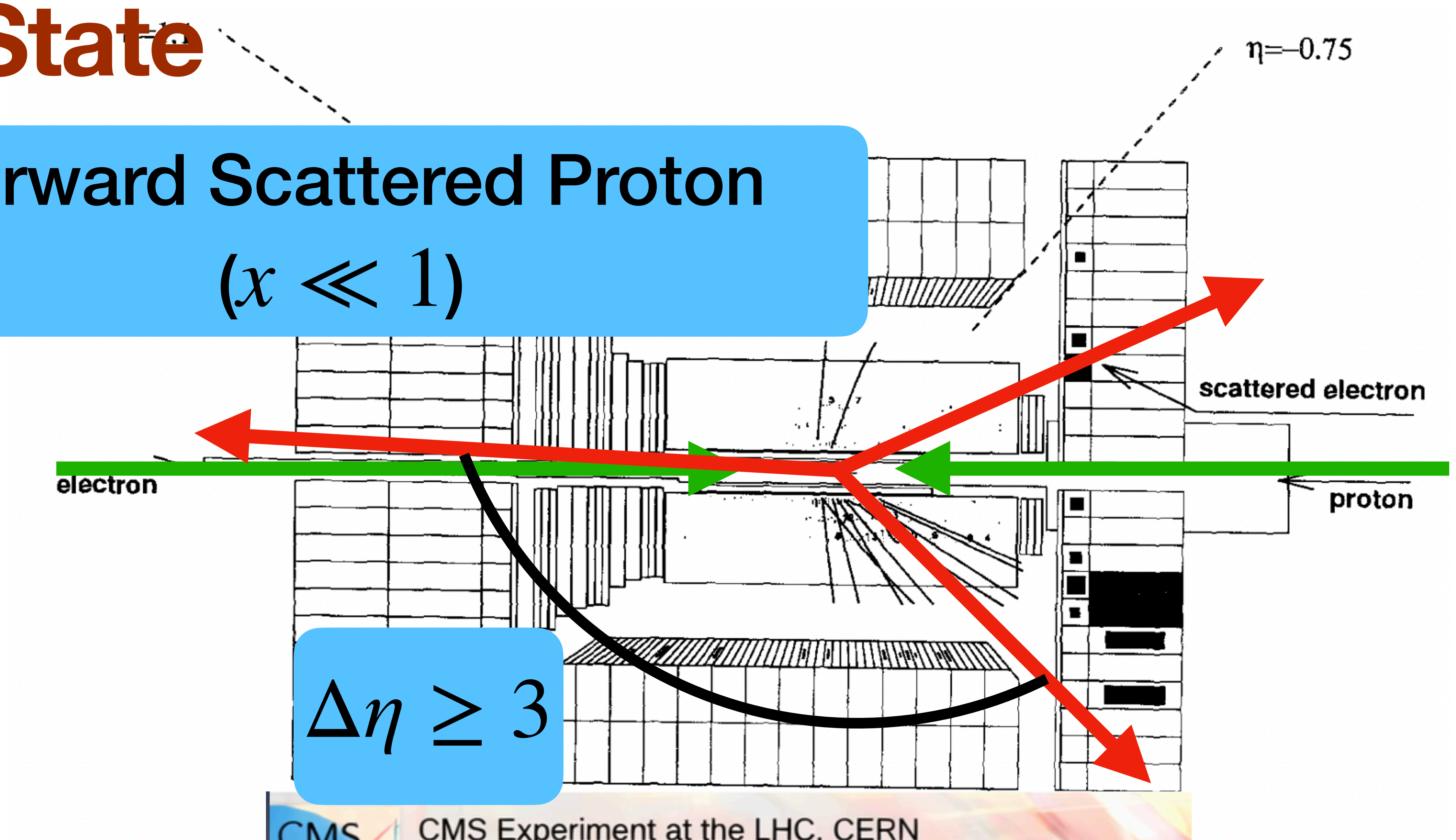
$$e^- p \to e^- X Y$$



Y = proton or jet

What is Diffraction?

Final State



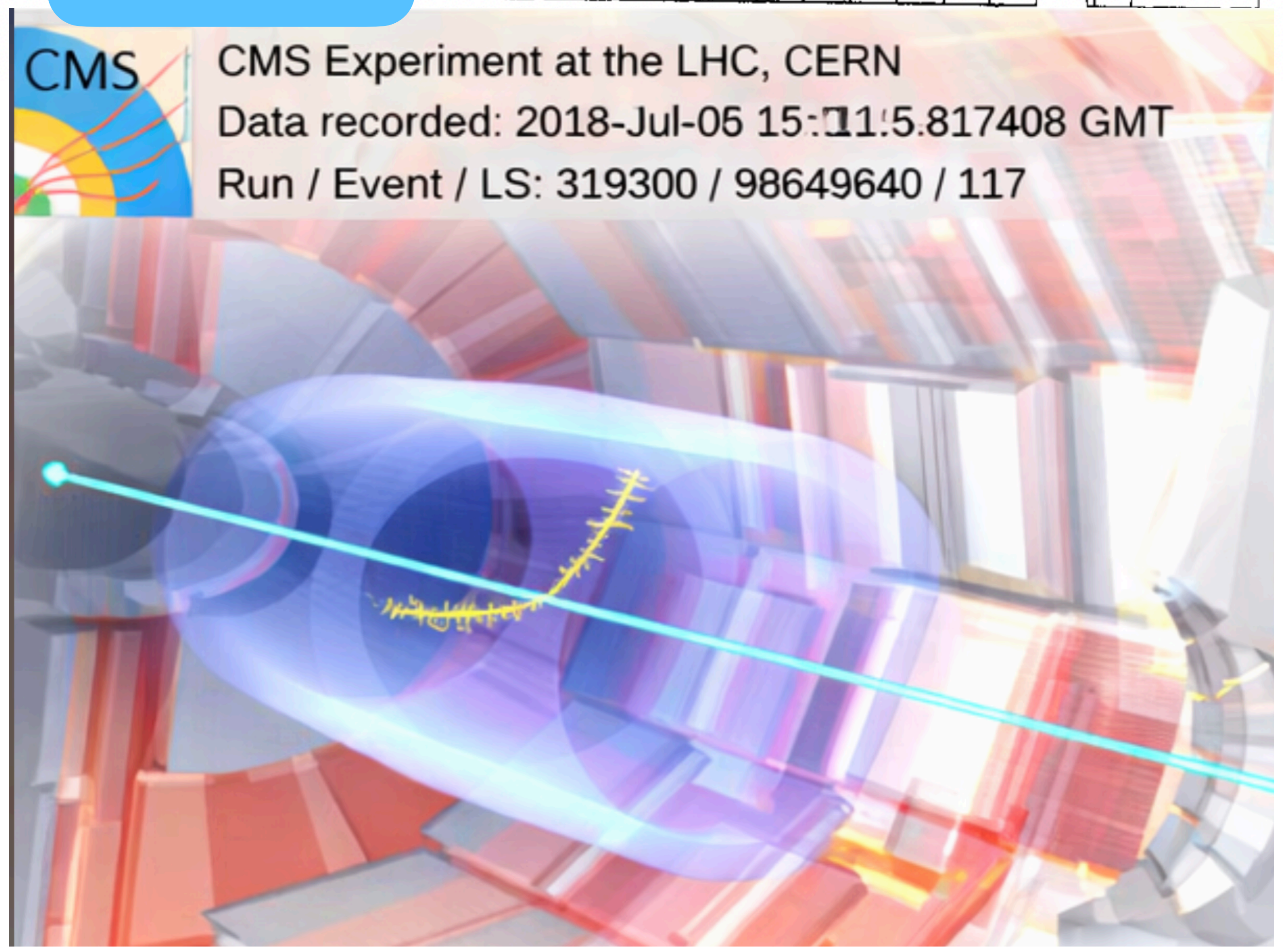
Forward Scattered Proton

$(x \ll 1)$

$\Delta\eta \geq 3$

$$e^- p \rightarrow e^- XY$$

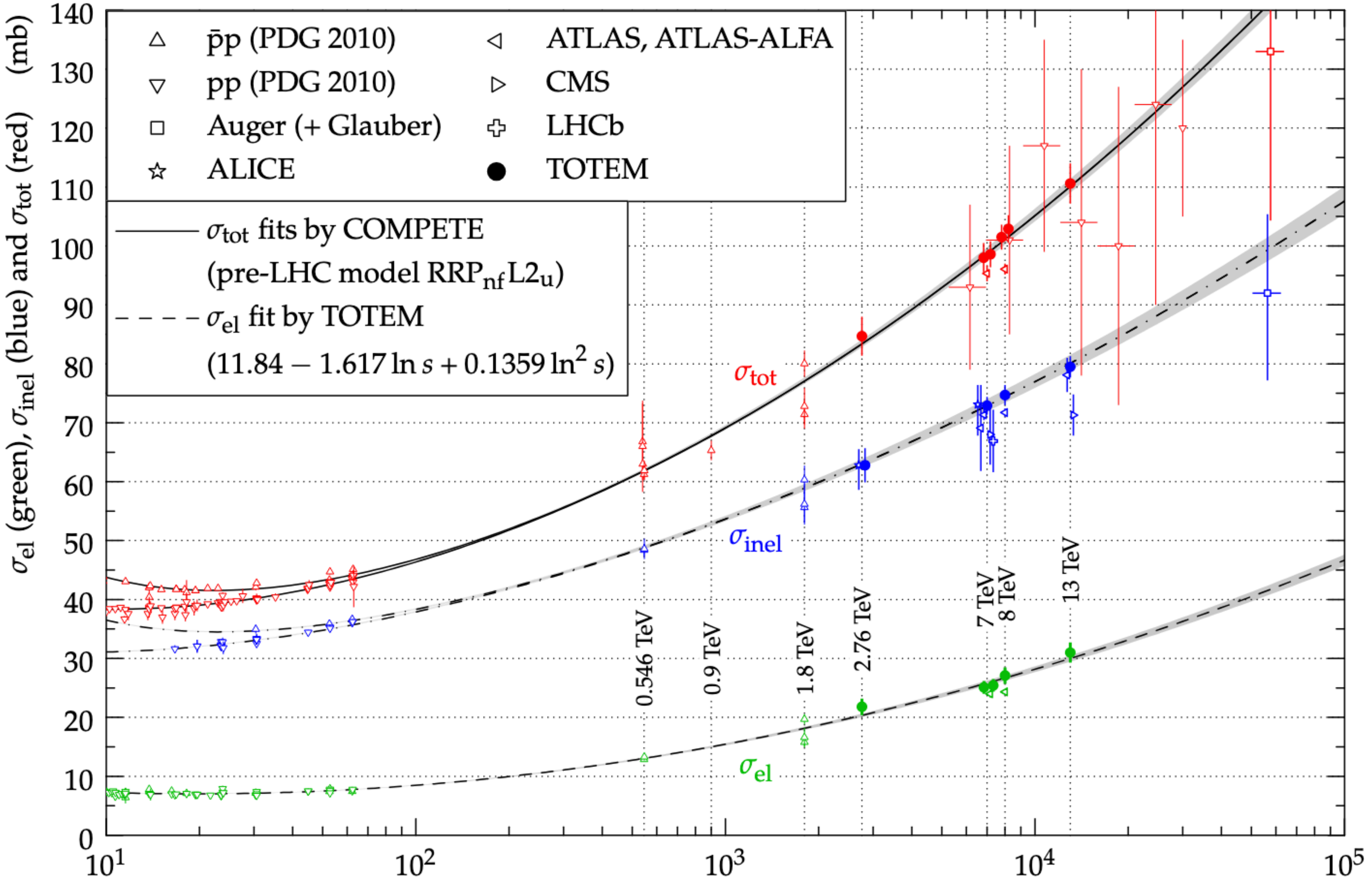
$$pp \rightarrow XYZ$$



Y,Z = proton or jet

Why study Diffraction?

Total Cross Section



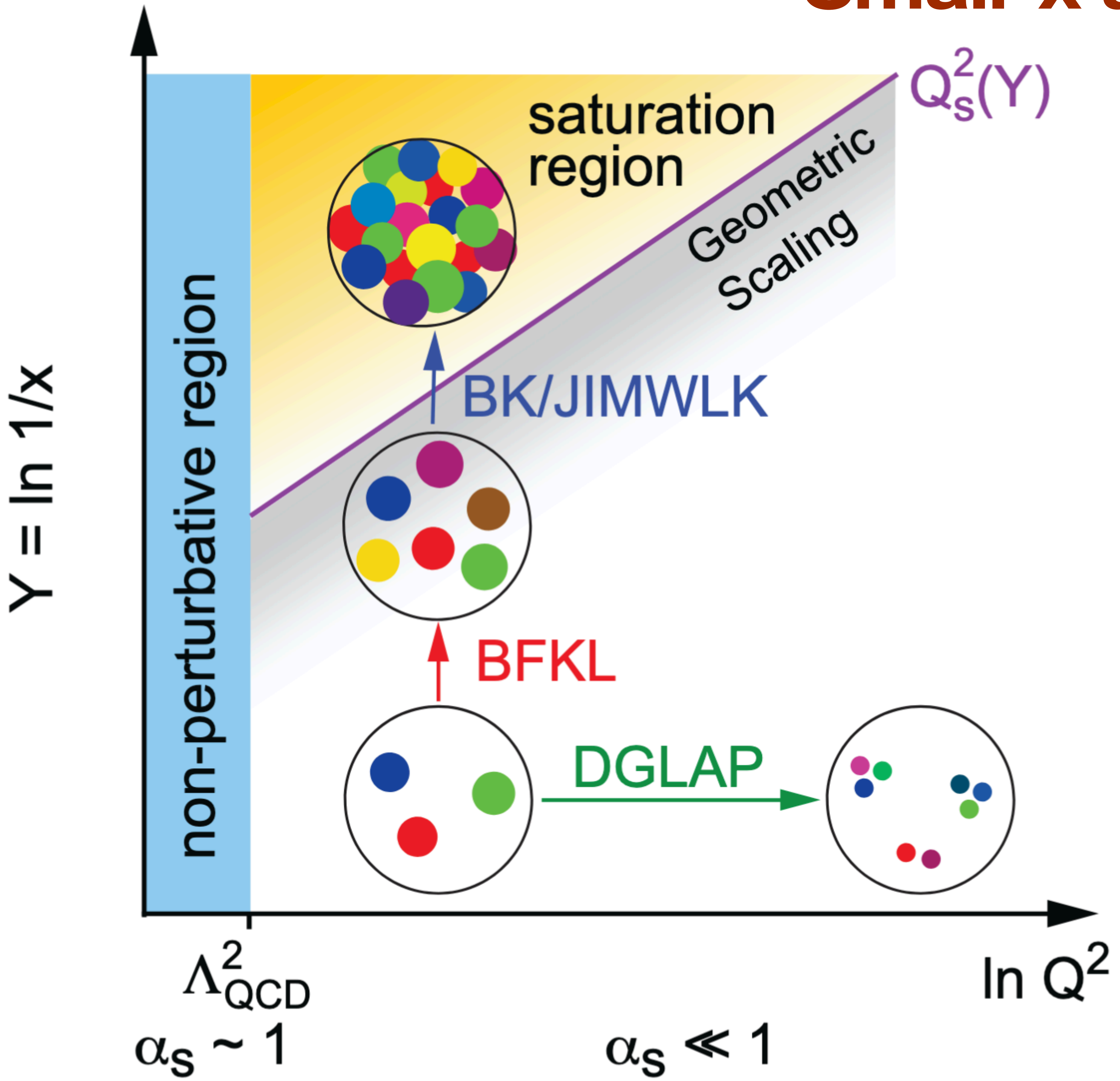
TOTEM 1712.06153v2

$$\sigma_{tot}(s) \propto \lim_{t \to 0} \mathrm{Im}\left(\mathscr{M}(\mathrm{pp} \to \mathrm{pp})\right)$$

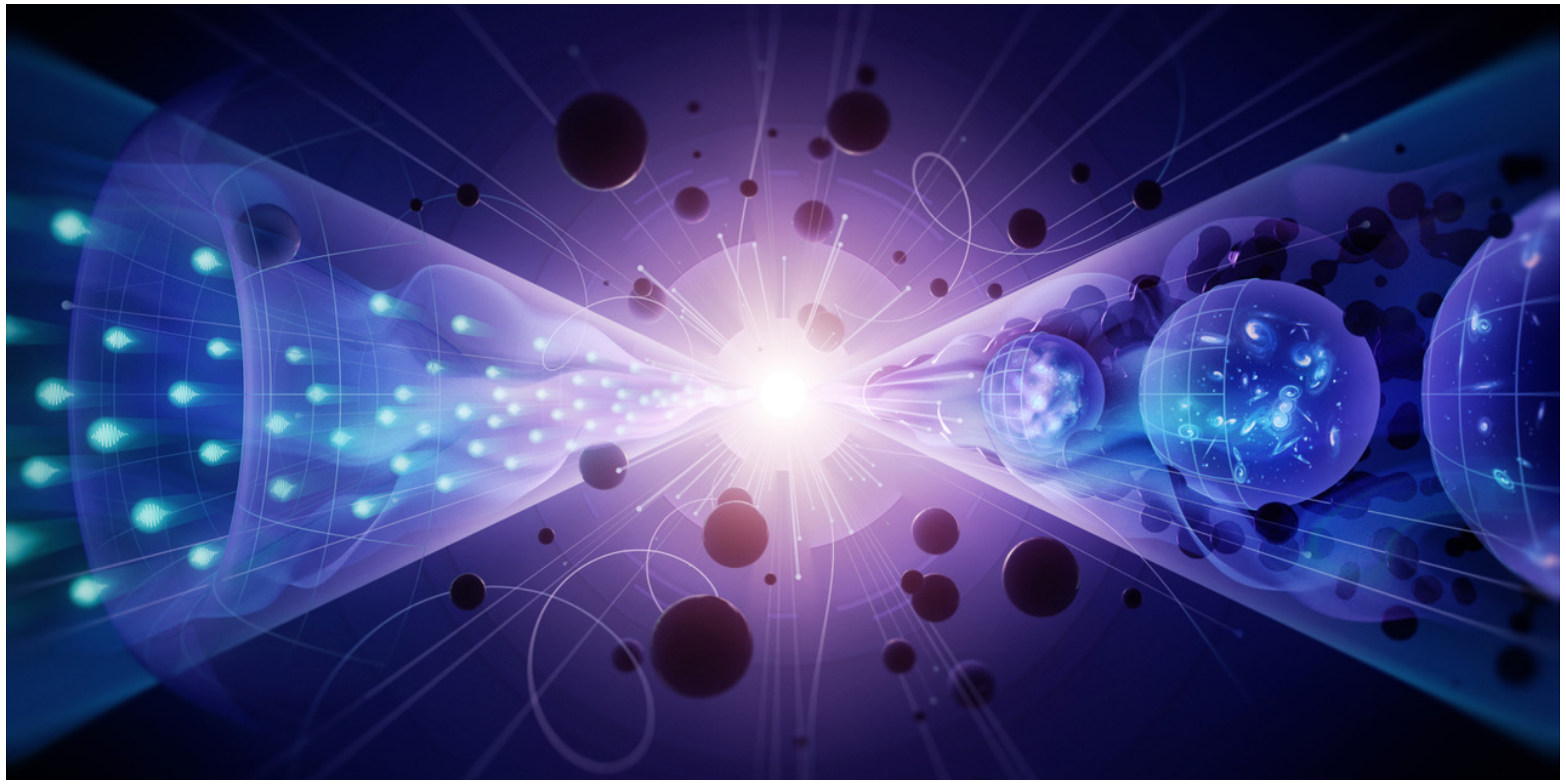
Forward: $-t \ll s$

Why study Diffraction?

Small-x and Exotic Physics



Accardi et al, 1212.1701



P5 Report

Why study Diffraction?

Failure of current Monte Carlo

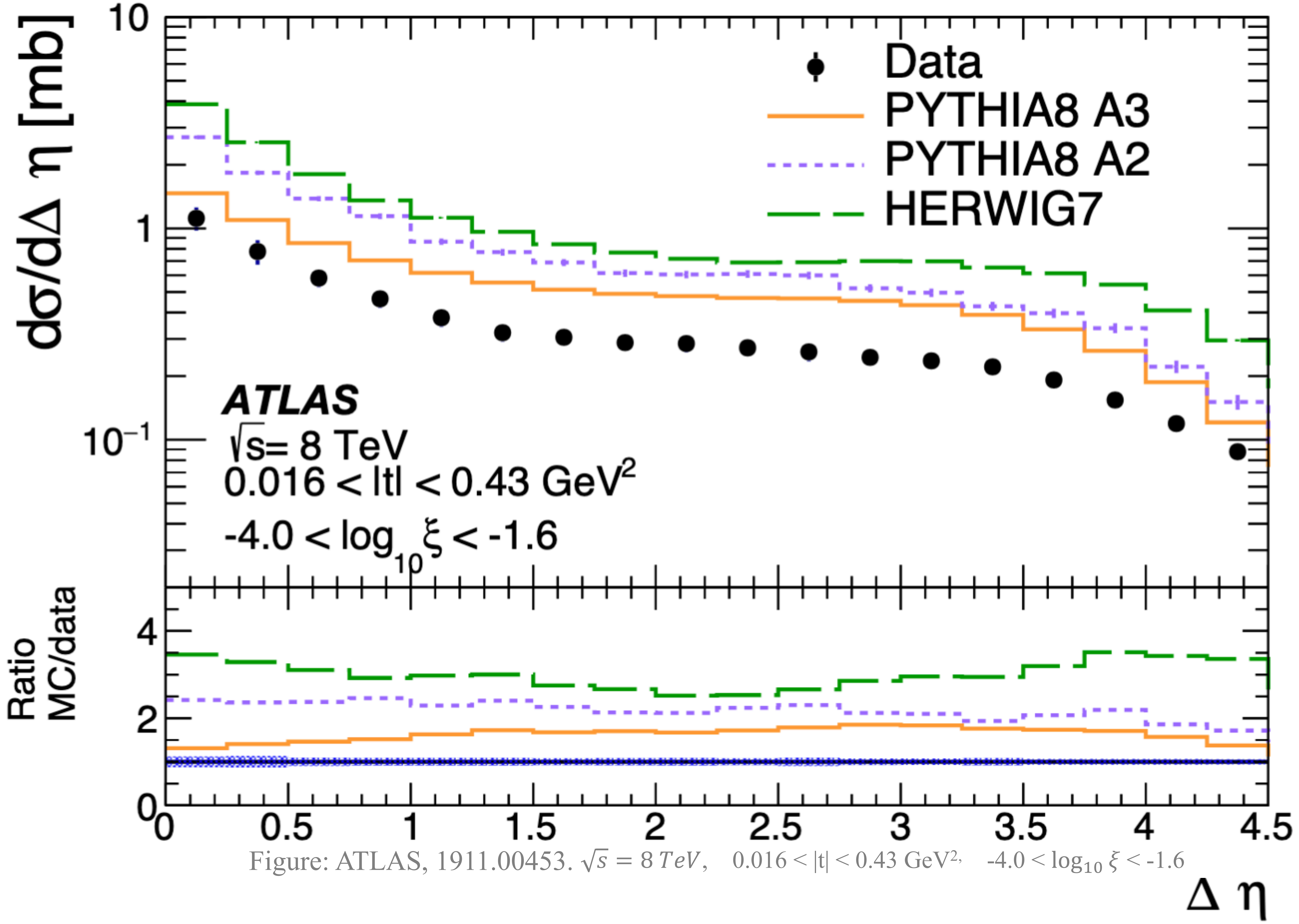


Figure: ATLAS, 1911.00453. $\sqrt{s}$ = 8 TeV, 0.016 < |t| < 0.43 GeV^2, -4.0 < $\log_{10} \xi$ < -1.6

Outline

1

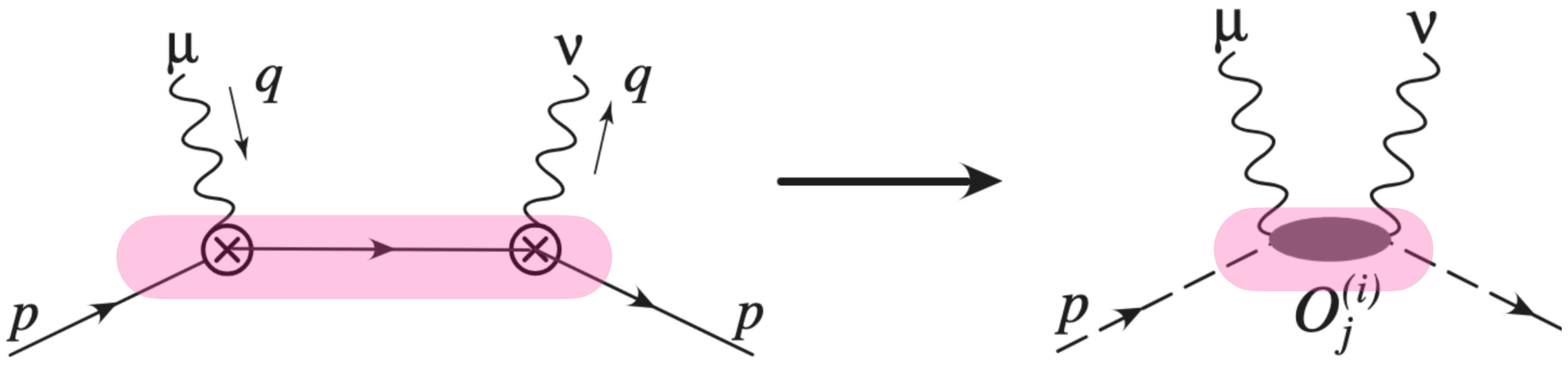
Introduction

2

Factorisation
and Universality

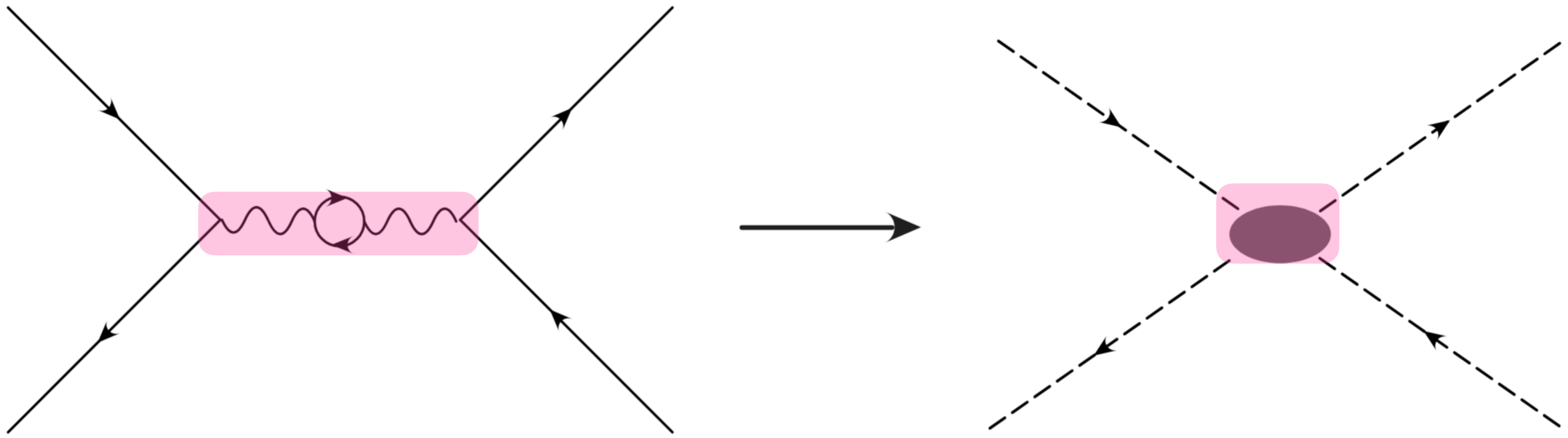
Hard Factorisation

DIS



$$F_{2/L}(x,Q) = \sum_i \int_x^1 \frac{d\xi}{\xi} H_i^{2/L}\left(\frac{x}{\xi}, Q, \mu\right) f_{i/p}(\xi,\mu)$$

Drell Yan

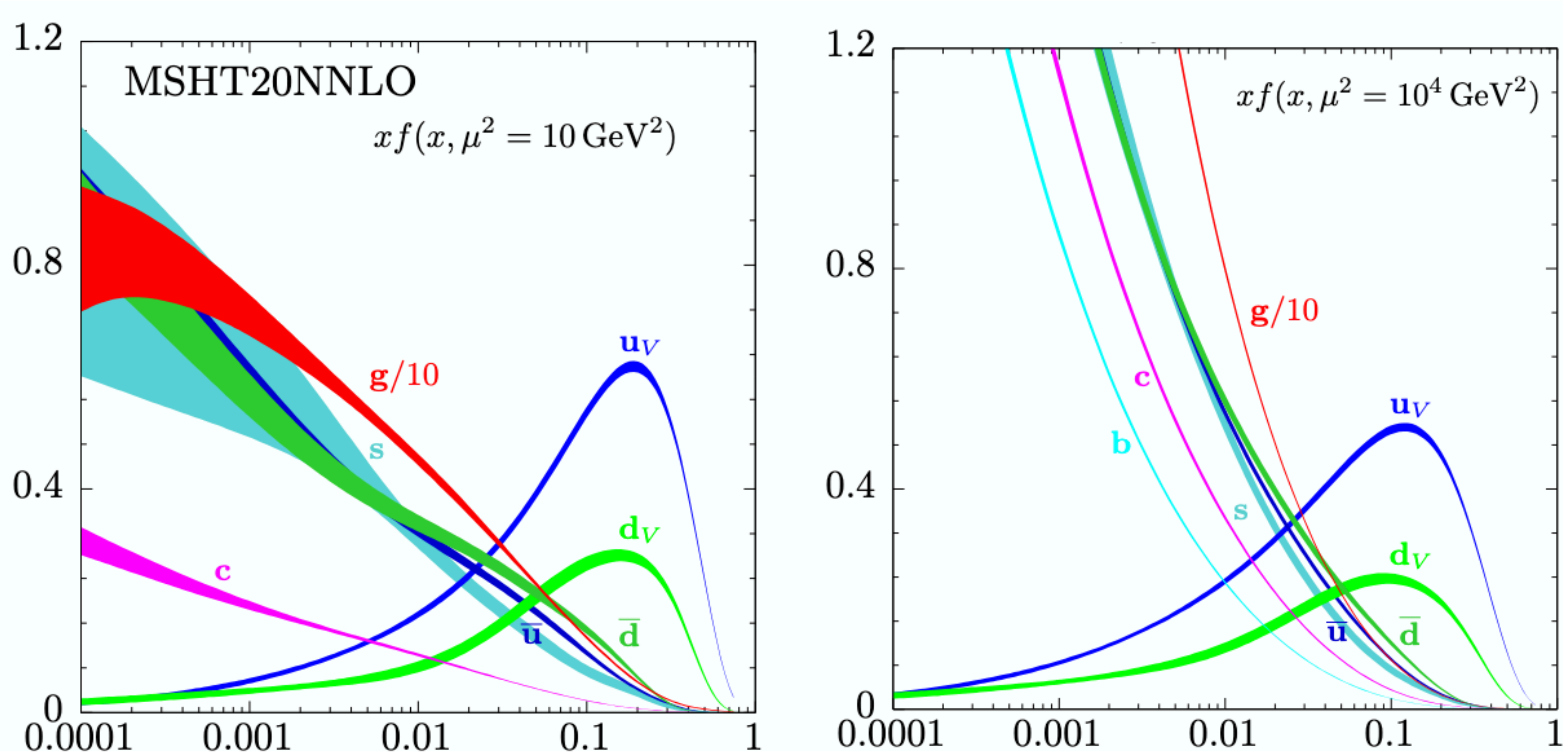


CSS ‘80s ;Bauer, Fleming, Pirjol, Rothstein,Stewart, 0202088

$$\frac{d\sigma}{dQ^2\,dy} \sim \sum_{a,b} \int_{x_A}^1 d\xi_A \int_{x_B}^1 d\xi_B f_{a/A}(\xi_A,\mu)\, H_{ab}\left(\frac{x_A}{\xi_A}, \frac{x_B}{\xi_B}, Q; \frac{\mu}{Q}, \alpha_s(\mu)\right) \times f_{b/B}(\xi_B,\mu)$$

Universality in Hard Factorisation

Universality



MSHT20

- Extraction across processes and energy scales

Regge Factorisation

What is it?

Hard scattering

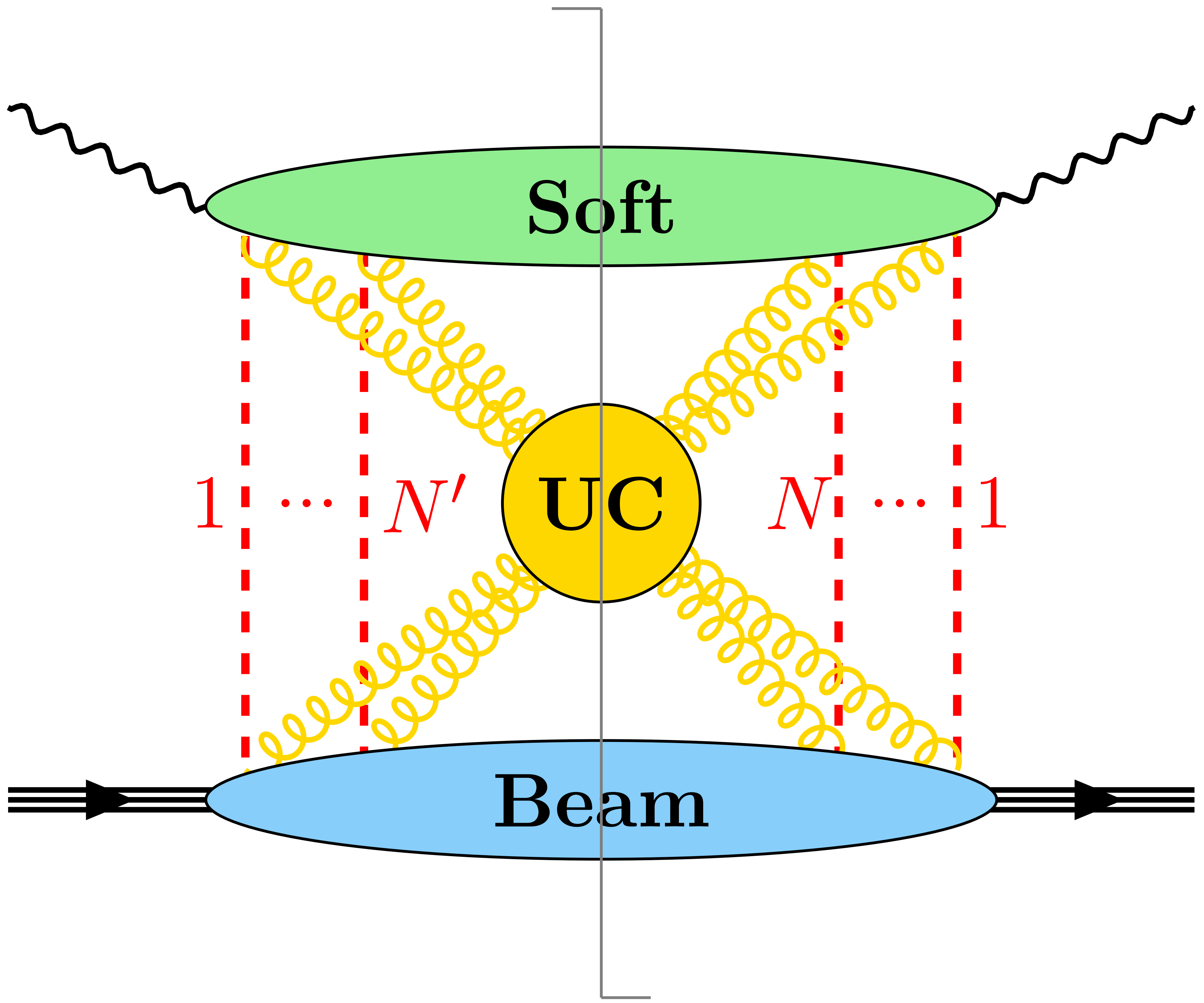
$$\lambda_\Lambda = \frac{\Lambda_{QCD}}{Q}$$

Regge / Forward Scattering

$$\lambda = \sqrt{\frac{-t}{s}}$$

Regge Factorisation

$$e^- p \to e^- XY$$



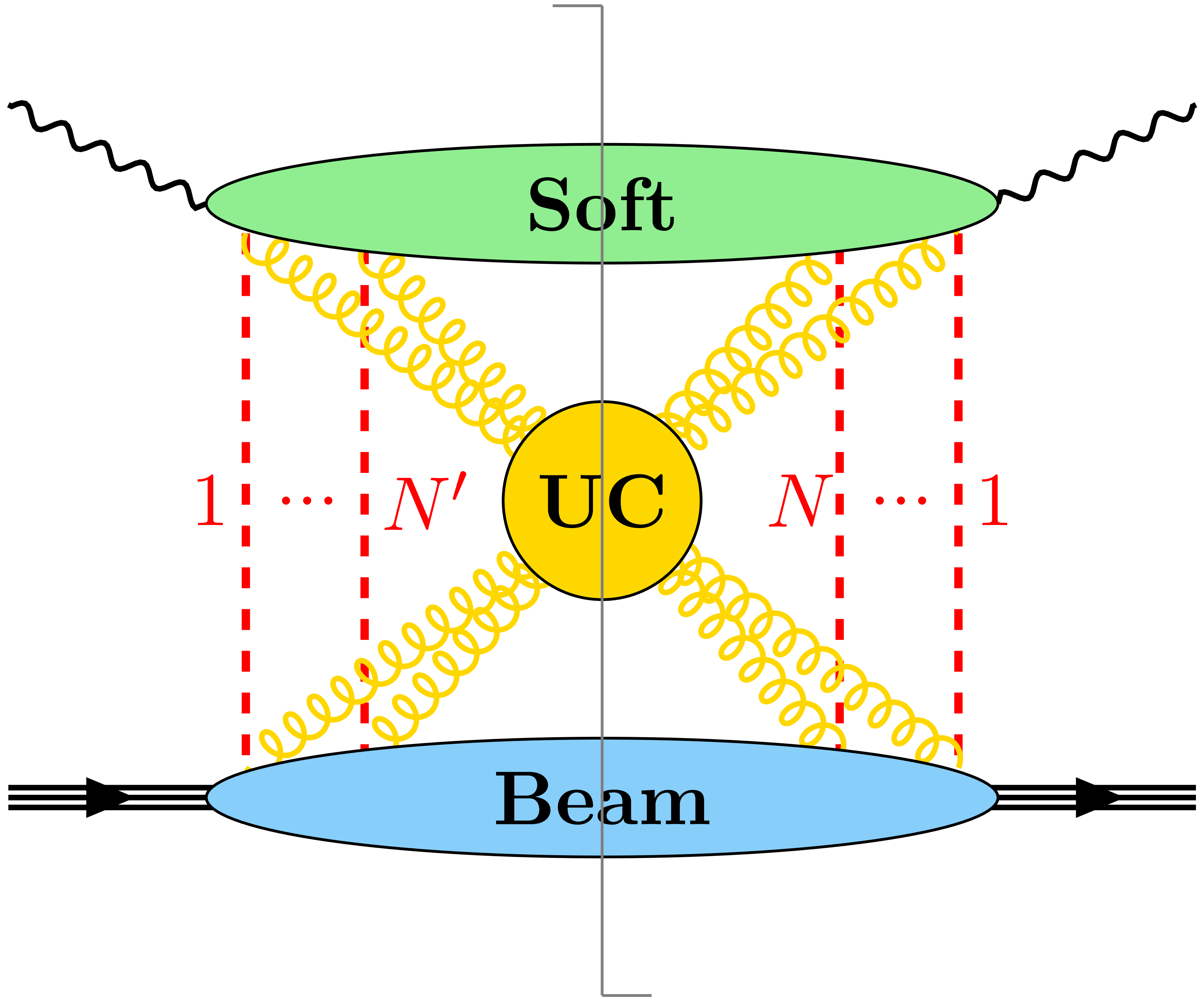
Mode	Momentum
Collinear	$(\lambda^3, \lambda^{-1}, \lambda^2)$
Soft	$(\lambda, \lambda, \lambda)$
Ultracollinear	$(\lambda^3, \lambda, \lambda^2)$
Glauber	$(\lambda^3, \lambda, \lambda)$

$$F_i^D = \sum_{\{R_X\}} \sum_{N,N'} B_{N,N'}^{R_A^{N,N'}} \otimes_\perp S_{i,N,N'}^{R_B^{N,N'}} \otimes_\pm U_{N,N'}^{R_A^{N,N'} R_B^{N,N'}}$$

Lee, Schindler, Stewart, 2508.10231

Regge Factorisation

Incoherent: $e^- p \to e^- XY$



$$F_i^D = \sum_{\{R_X\}} \sum_{N,N'} B^{R_A^{N,N'}}_{N,N'} \otimes_\perp S^{R_B^{N,N'}}_{i,N,N'} \otimes_\pm U^{R_A^{N,N'} R_B^{N,N'}}_{N,N'}$$

Beam

$$B^{R_X}_{NN'}(p^- k_n^+, \{\tau^u_{i\perp}, \tau'^u_{j\perp}\}, t) = \sum_{X_n} \langle p | \bar{\mathrm{T}} \left\{ \prod_{i=1}^{N-1} \mathcal{O}_n^{A_i} \bar{\mathcal{O}}_n^{A_N} \right\} P^N_{R_X} | X_n \rangle \langle X_n | P^{N'}_{R_X} \mathrm{T} \left\{ \prod_{j=1}^{N'-1} \mathcal{O}_n^{A'_j} \bar{\mathcal{O}}_n^{A'_{N'}} \right\} | p \rangle$$

Soft

$$S^{R_Y}_{NN'}(q^+ k_s^-, \{\tau_{i\perp}, \tau'_{j\perp}\}, Q, t) = \sum_{X_S} \langle 0 | \bar{\mathrm{T}} J^\mu_S \left\{ \prod_{i=1}^{N} \mathcal{O}_S^{B_i} \right\} P^N_{R_Y} | X_S \rangle \langle X_S | P^{N'}_{R_Y} \mathrm{T} J^\nu_S \left\{ \prod_{j=1}^{N'} \mathcal{O}_S^{B'_j} \right\} | p \rangle$$

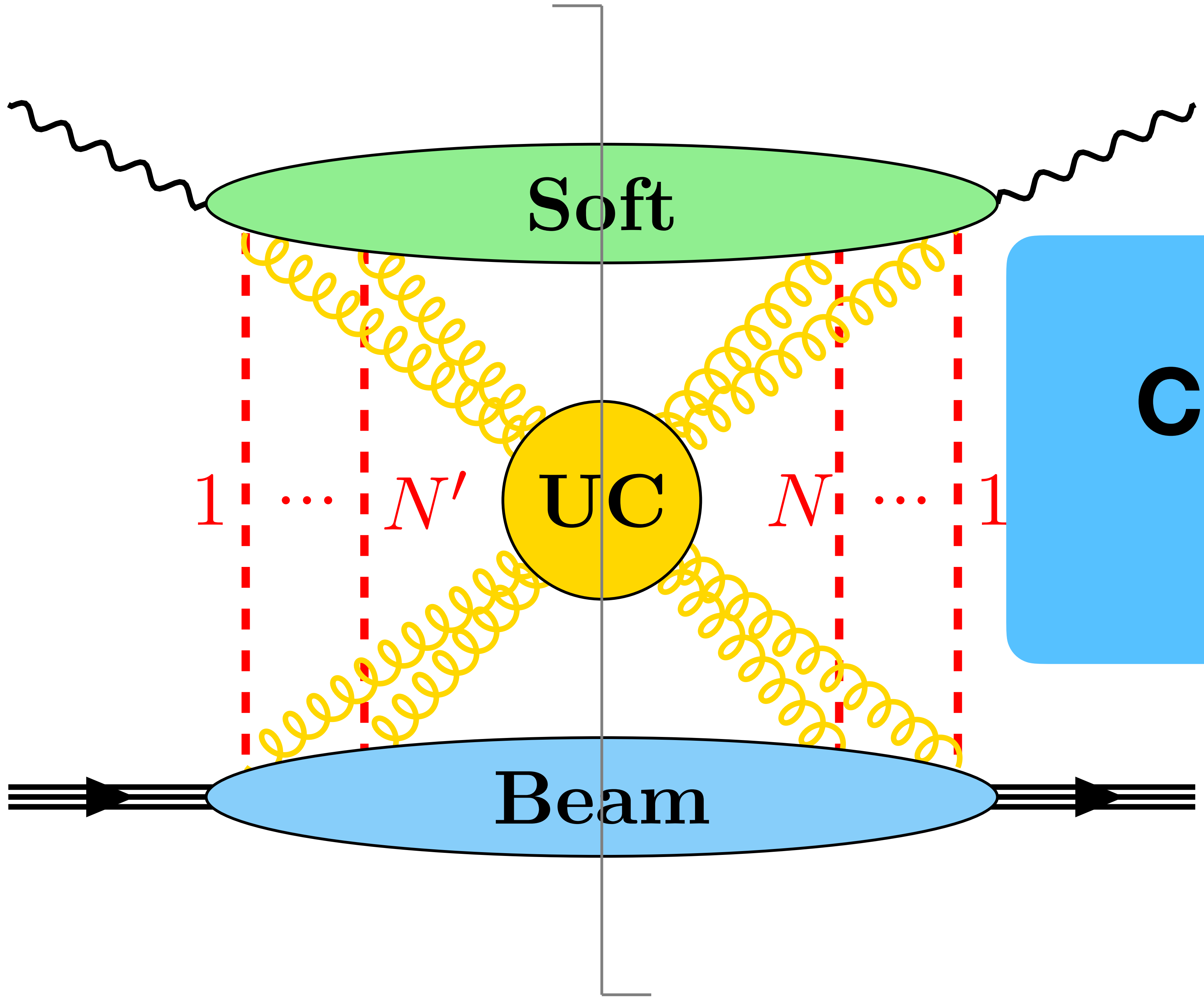
UC

$$U^{R_X,R_Y}_{NN'}(p_H^+, p_H^-\}, Q, t) = \sum_{Z_U C} \langle 0 | P^N_{R_X} \bar{\mathrm{T}} \prod_{i=1}^{N} \mathbb{U}^{A_i B_i}_{n\bar{n}} P^N_{R_Y} | X_S \rangle \langle X_S | P^{N'}_{R_Y} \mathrm{T} \prod_{j=1}^{N'} \mathbb{U}^{A'_j B'_j}_{n\bar{n}} P^N_{R_X} | 0 \rangle$$

Lee, Schindler, Stewart, 2508.10231

Regge Factorisation

Incoherent: $e^- p \rightarrow e^- XY$



$$F_i^D = \sum_{\{R_X\}} \sum_{N,N'} B^{R_A^{N,N'}}_{N,N'} \otimes_\perp S^{R_B^{N,N'}}_{i,N,N'} \otimes_\pm U^{R_A^{N,N'} R_B^{N,N'}}_{N,N'}$$

Beam

$$B^{R_X}_{NN'}(p^- \tilde{p}^+_{Xi}, \{\tau^u_{i\perp}, \tau'^u_{j\perp}\}, t) = \sum_{X_n} \langle p | \bar{\mathrm{T}} \Big\{ \prod_{i=1}^{N-1} \mathcal{O}^{A_i}_n \bar{\mathcal{O}}^{A_N}_n \Big\} P^N_{R_X} | X_n \rangle \langle X_n | P^{N'}_{R_X} \mathrm{T} \Big\{ \prod_{j=1}^{N'-1} \mathcal{O}^{A'_j}_n \bar{\mathcal{O}}^{A'_{N'}}_n \Big\} | p \rangle$$

$$\Big\} P^N_{R_Y} | X_S \rangle \langle X_S | P^{N'}_{R_Y} \mathrm{T}\, J^\nu_S \Big\{ \prod_{j=1}^{N'} \mathcal{O}^{B'_j}_S \Big\} | p \rangle$$

Can we do the same for pp?
Universality?

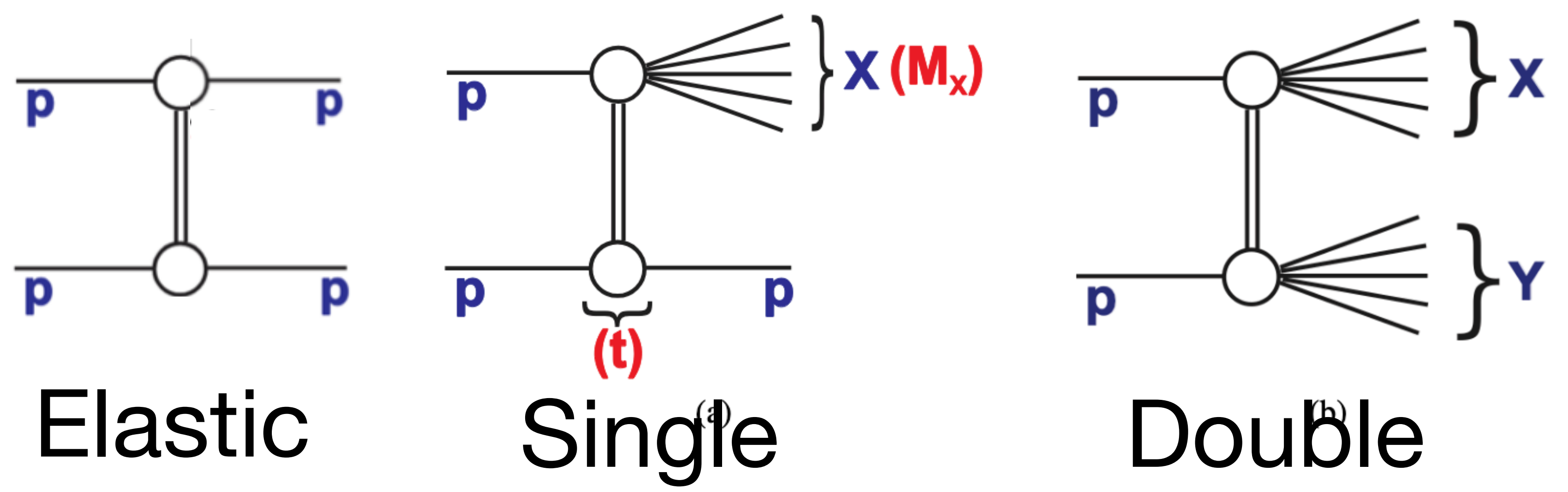
UC

$$U^{R_X,R_Y}_{NN'}(p^+_H, p^-_H\}, Q, t) = \sum_{Z_U C} \langle 0 | P^N_{R_X} \bar{\mathrm{T}} \prod_{i=1}^{N} \mathbb{U}^{A_i B_i}_{n\bar{n}} P^N_{R_Y} | X_S \rangle \langle X_S | P^{N'}_{R_Y} \mathrm{T} \prod_{j=1}^{N'} \mathbb{U}^{A'_j B'_j}_{n\bar{n}} P^N_{R_X} | 0 \rangle$$

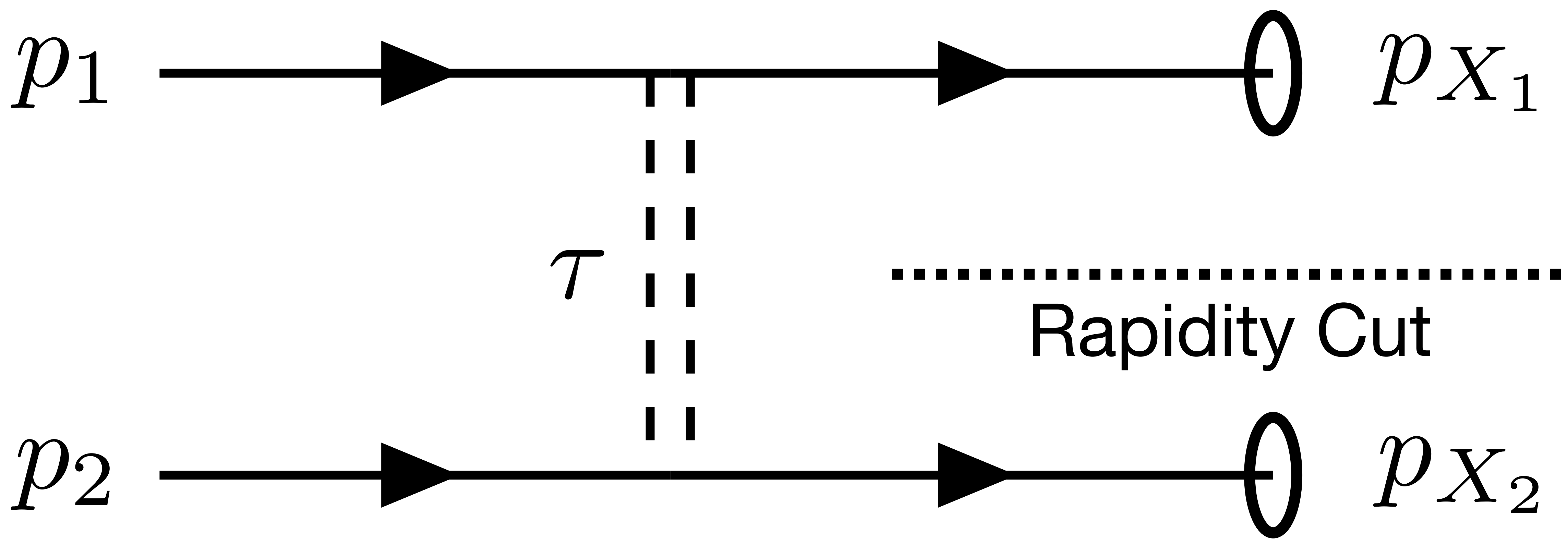
Lee, Schindler, Stewart, 2508.10231

Regge Factorisation

Double: $pp \to XY$



Kinematics



Lorentz Invariants ($m_p \approx 0$):

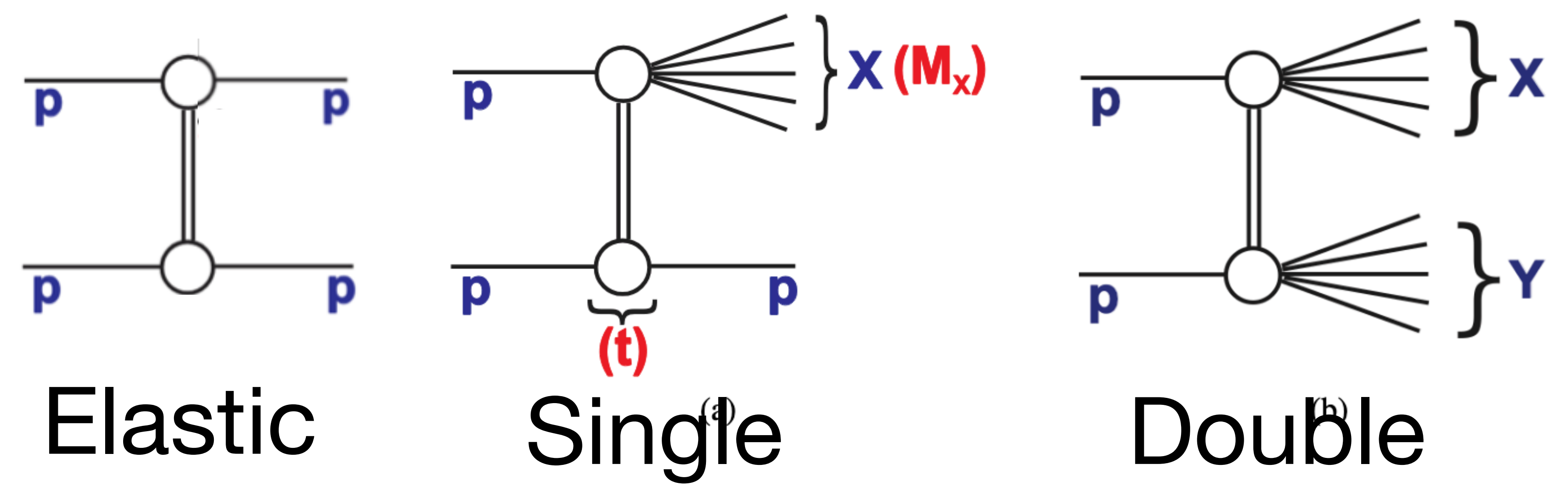
$$M_i^2 = p_{X_i}^2 \qquad s = (p_1 + p_2)^2 \qquad t = \tau^2$$

Power counting:

$$\lambda = \sqrt{\frac{-t}{s}} \qquad \rho_i = \frac{M_i}{\sqrt{-t}} \qquad \lambda_\Lambda = \frac{\Lambda_{QCD}}{\sqrt{-t}}$$

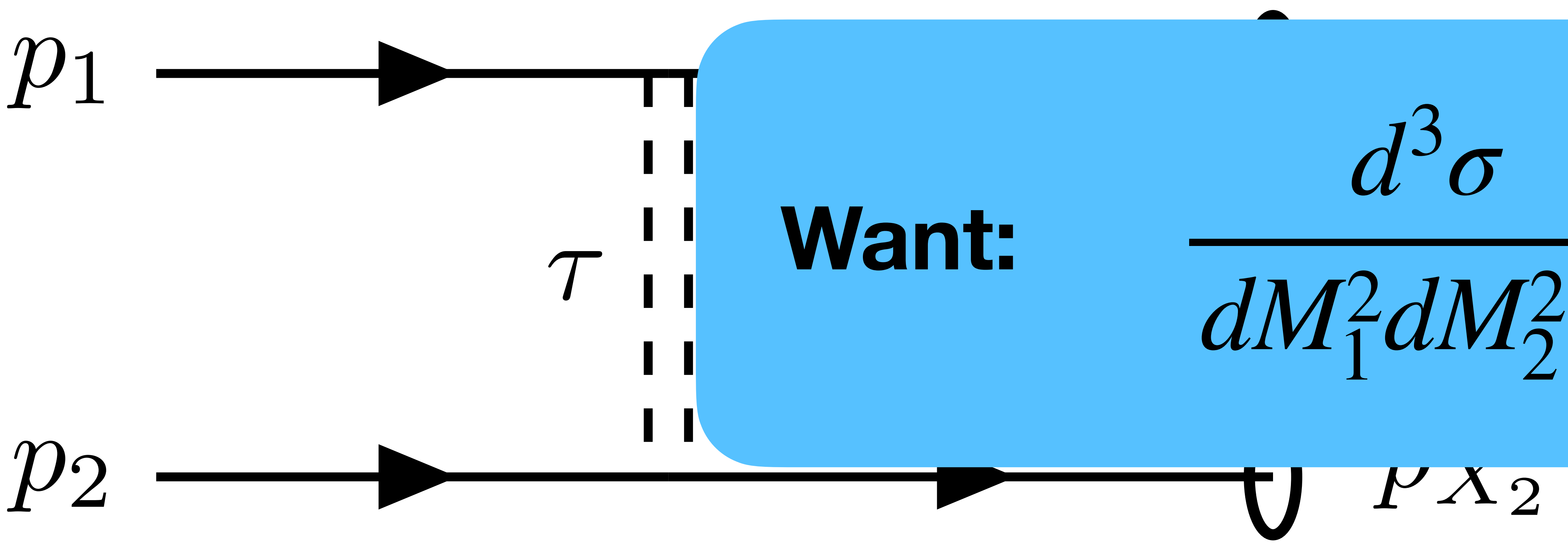
Regge Factorisation

Double: $pp \rightarrow XY$



Kinematics

Lorentz Invariants ($m_p \approx 0$):



$M_i^2 = p_{X_i}^2$ $\quad s = (p_1 + p_2)^2$ $\quad t = \tau^2$

Want: $$\frac{d^3\sigma}{dM_1^2 dM_2^2 dt}$$ **in Diffractive Regime**

$$\lambda = \sqrt{\frac{-t}{s}} \qquad \rho_i = \frac{M_i}{\sqrt{-t}} \qquad \lambda_\Lambda = \frac{\Lambda_{QCD}}{\sqrt{-t}}$$

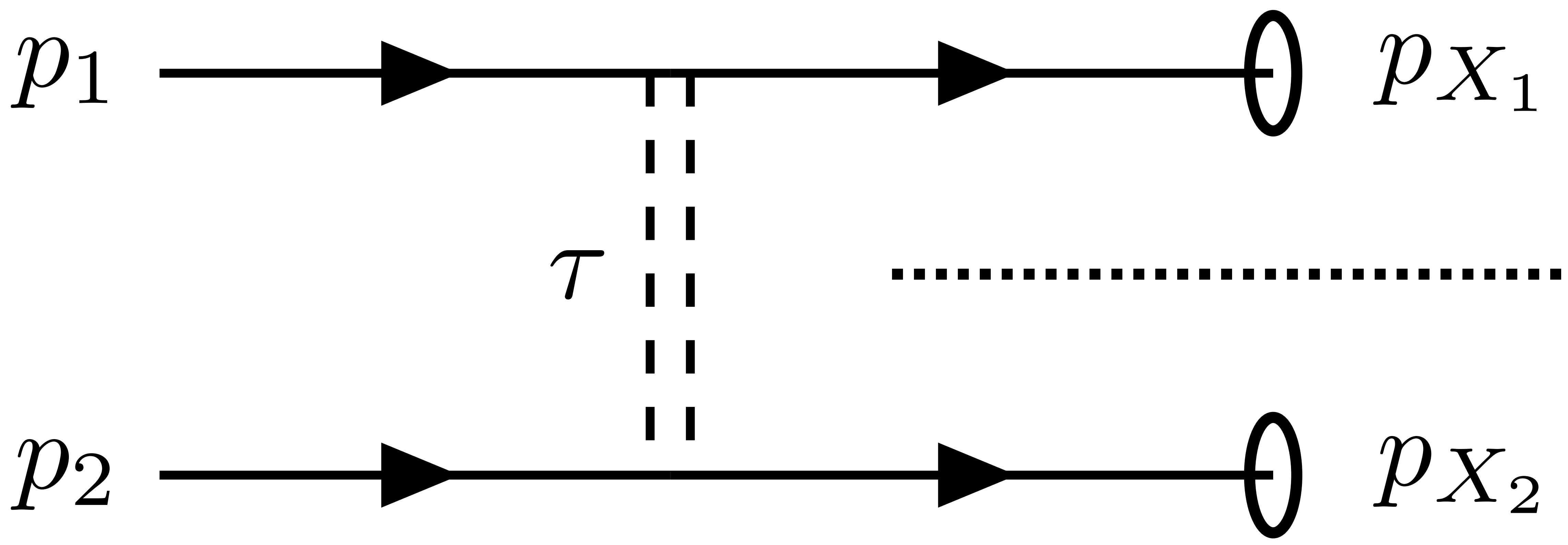
Regge Factorisation

Double: $pp \to XY$

Hard Scattering

$|t| \sim s$

Diffractive Constraints



1. Forward

$$|t| \ll s$$

2. Collimated Jets or Protons

$$M_i^2 \ll s$$

3. Rapidity Seperation

$$\frac{p^-_{X_2}}{p^+_{X_2}} \ll \frac{p^-_{X_1}}{p^+_{X_1}}$$

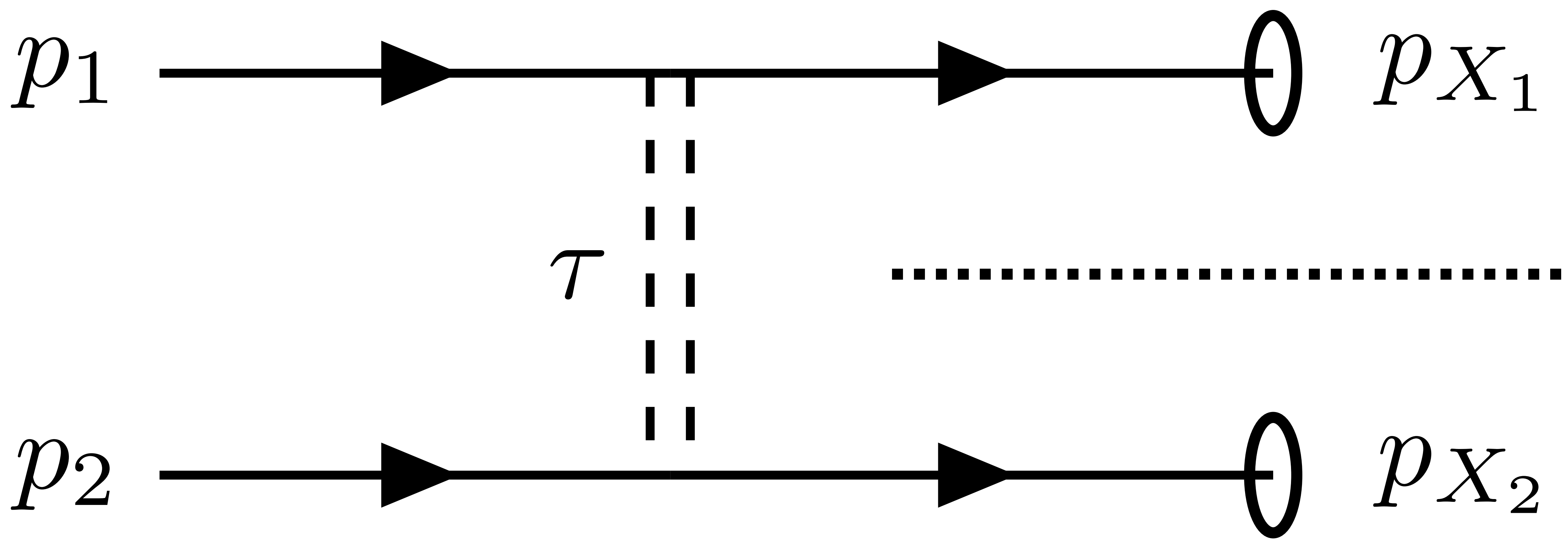
Regge Factorisation

Double: $pp \to XY$

Hard Scattering

$|t| \sim s$

Diffractive Constraints



$$\lambda = \sqrt{\frac{-t}{s}} \ll 1$$

1. Forward

$$|t| \ll s$$

2. Collimated Jets or Protons

$$M_i^2 \ll s$$

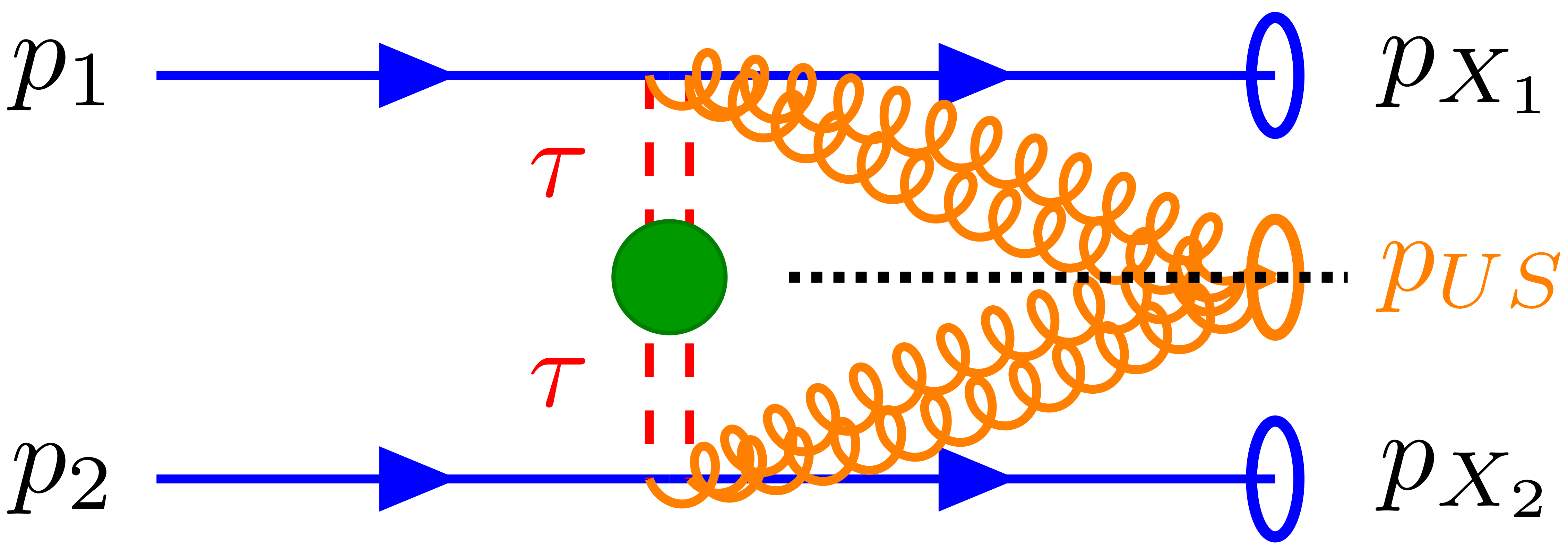
3. Rapidity Seperation

$$\frac{p^-_{X_2}}{p^+_{X_2}} \ll \frac{p^-_{X_1}}{p^+_{X_1}}$$

Regge Factorisation

Double: $pp \to XY$

Modes

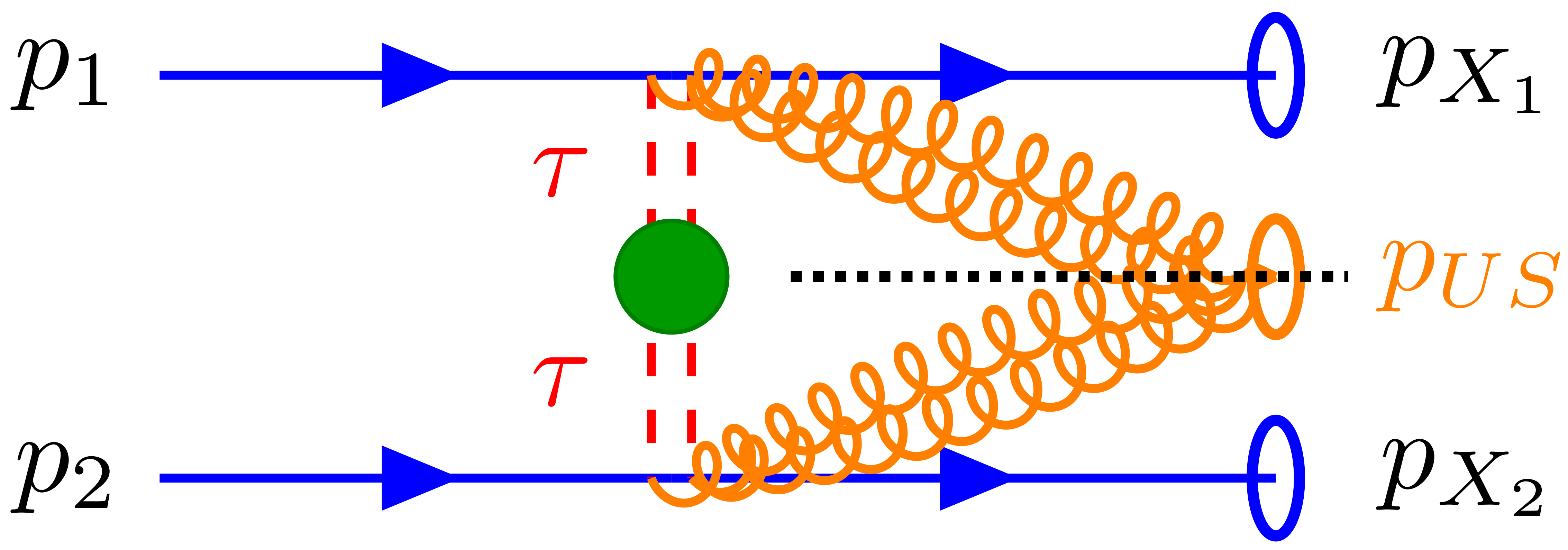


Mode	Momentum	
Collinear	$(\lambda^2, 1, \lambda)$	$\sim p_1, p_{X_1}$
Anticollinear	$(1, \lambda^2, \lambda)$	$\sim p_2, p_{X_2}$
Glauber	$(\lambda^2, \lambda^2, \lambda)$	$\sim \tau$
Soft	$(\lambda, \lambda, \lambda)$	$\sim p_S$
Ultrasoft	$(\lambda^2, \lambda^2, \lambda^2)$	$\sim p_{US}$

Regge Factorisation

Double: $pp \to XY$

Modes



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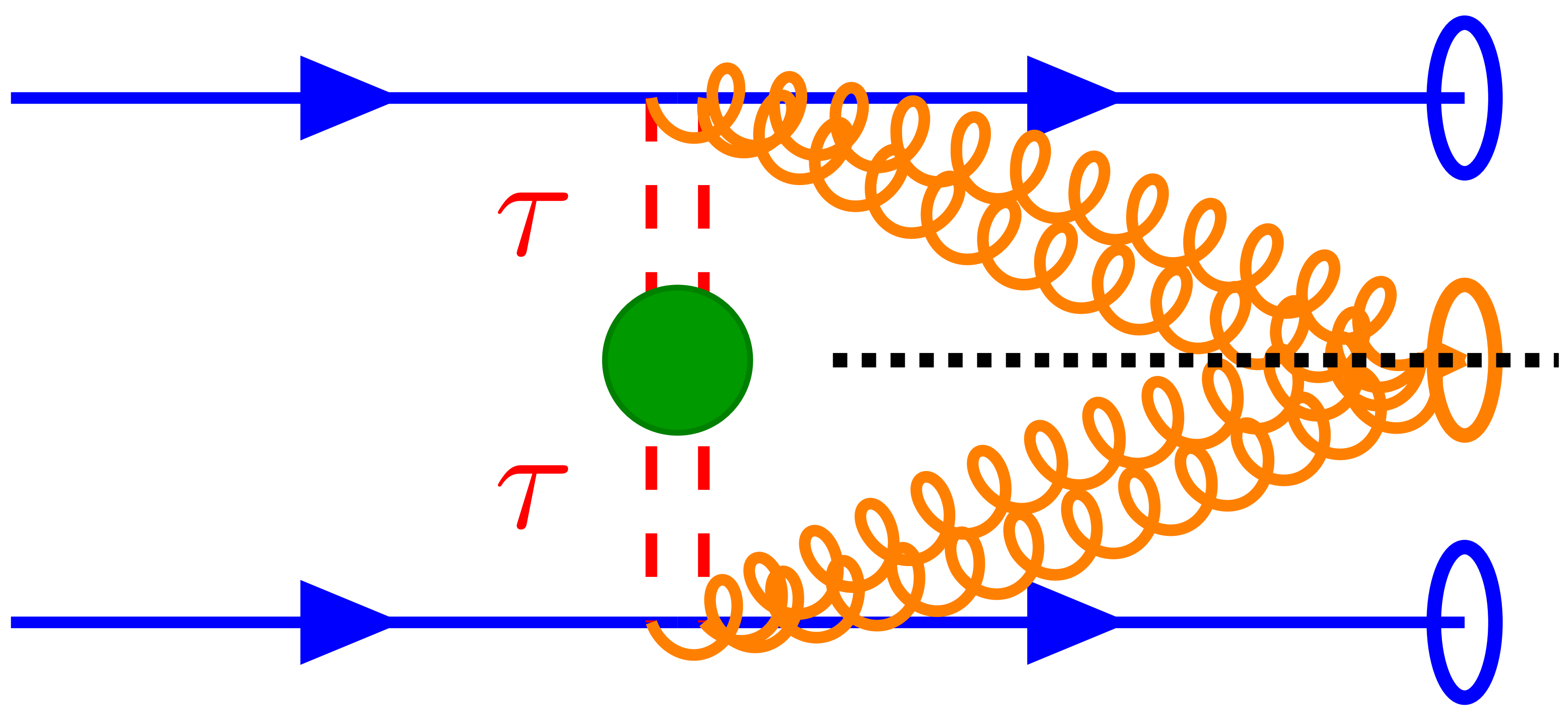
Glauber ties it all together

Regge Factorisation

Double: $pp \to XY$

Modes



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Soft	$(\lambda, \lambda, \lambda)$	$\sim p_S$
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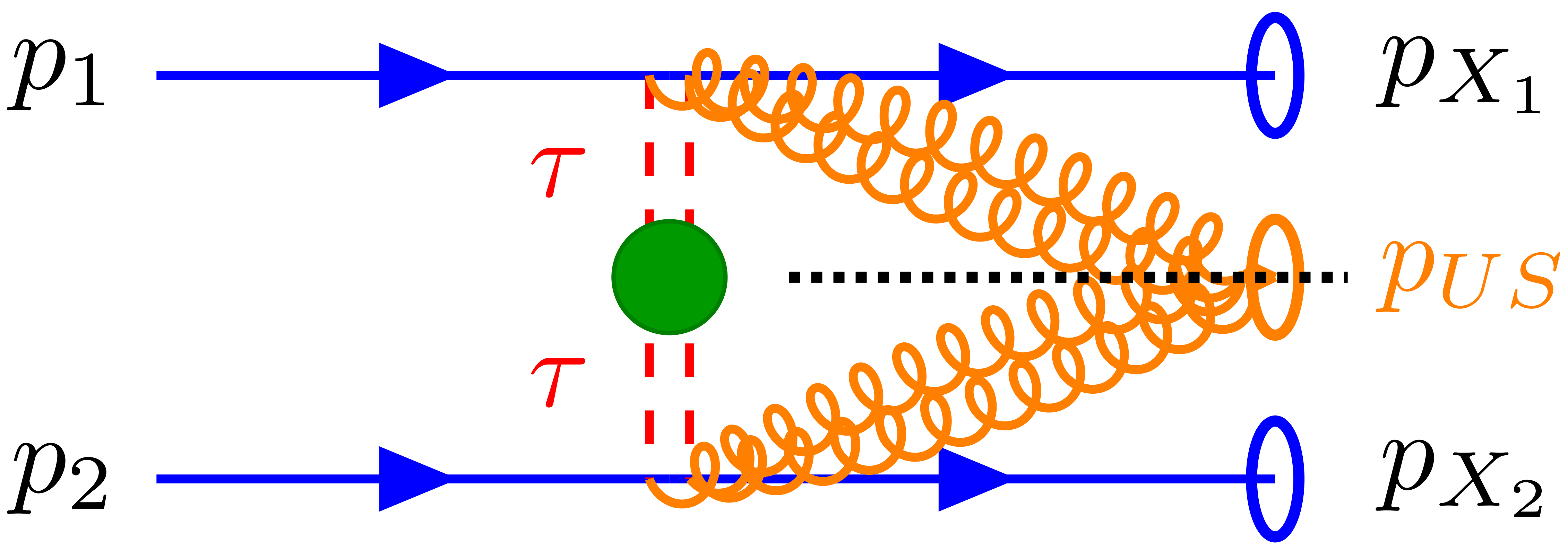
Constraints prevent soft radiation

Regge Factorisation

Double: $pp \to XY$

Modes



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Anticollinear	$(1, \lambda^2, \lambda)$	$\sim p_2, p_{X_2}$
Glauber	$(\lambda^2, \lambda^2, \lambda)$	$\sim \tau$
Soft	$(\lambda, \lambda, \lambda)$	$\sim p_S$
Ultrasoft	$(\lambda^2, \lambda^2, \lambda^2)$	$\sim p_{US}$

Ultrasoft radiates into the gap!

Regge Factorisation

Double: $pp \to XY$

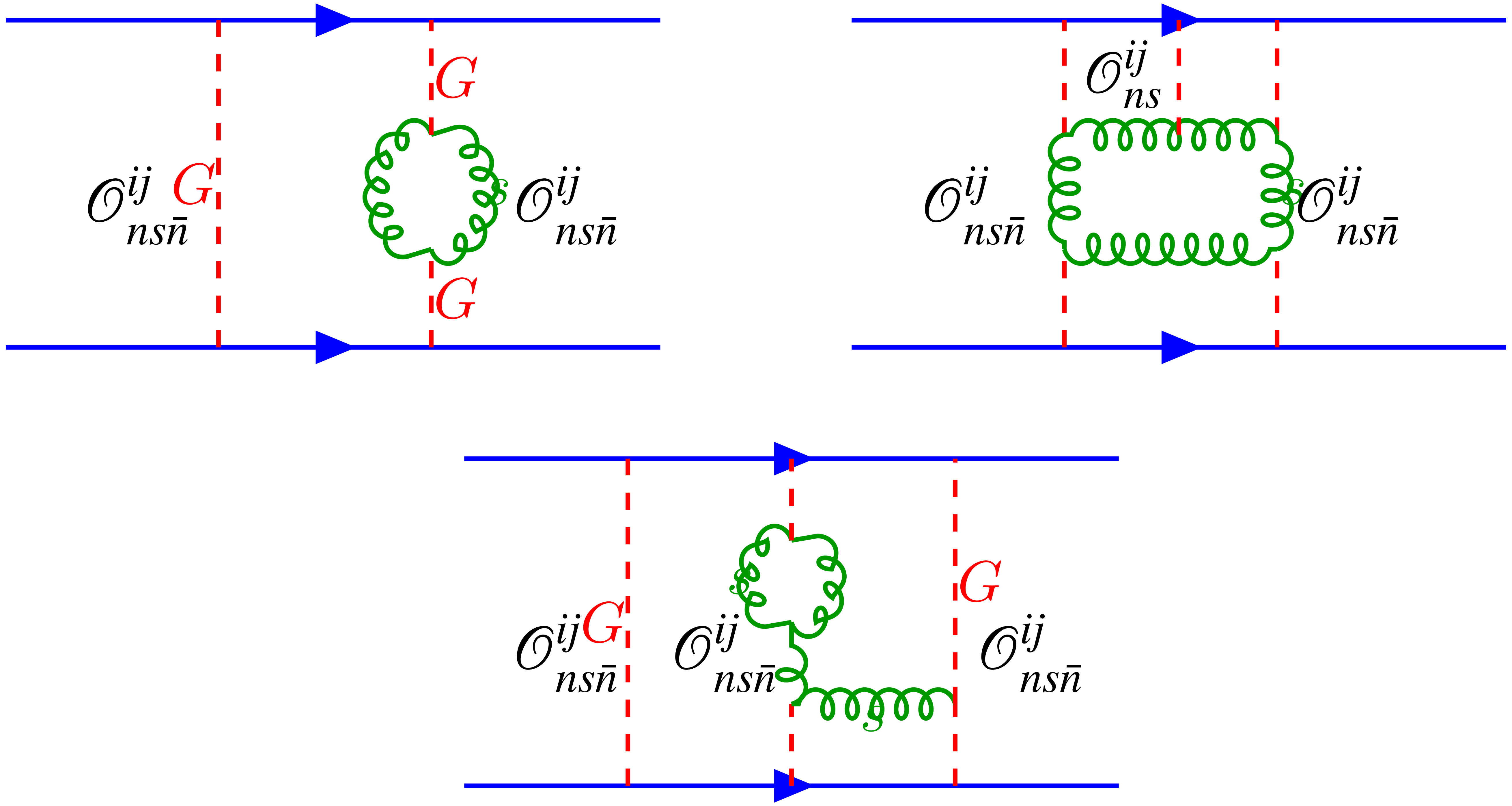
Glauber SCET

$$\mathscr{L}_{\text{SCET}} = \mathscr{L}_{\text{Collinear}} + \mathscr{L}_{\text{Soft}} + \mathscr{L}_{\text{Ultrasoft}} + \mathscr{L}_{\text{Glauber}}$$

Glauber Operators:

$$\mathcal{O}^{ij}_{ns\bar{n}} = \mathcal{O}^{iB}_{n} \frac{1}{\mathcal{P}^2_\perp} \mathcal{O}^{BC}_{s} \frac{1}{\mathcal{P}^2_\perp} \mathcal{O}^{jC}_{\bar{n}}$$

$$\mathcal{O}^{ij}_{ns} = \mathcal{O}^{iB}_{n} \frac{1}{\mathcal{P}^2_\perp} \mathcal{O}^{i_n B}_{s}$$



Regge Factorisation

Double: $pp \to XY$

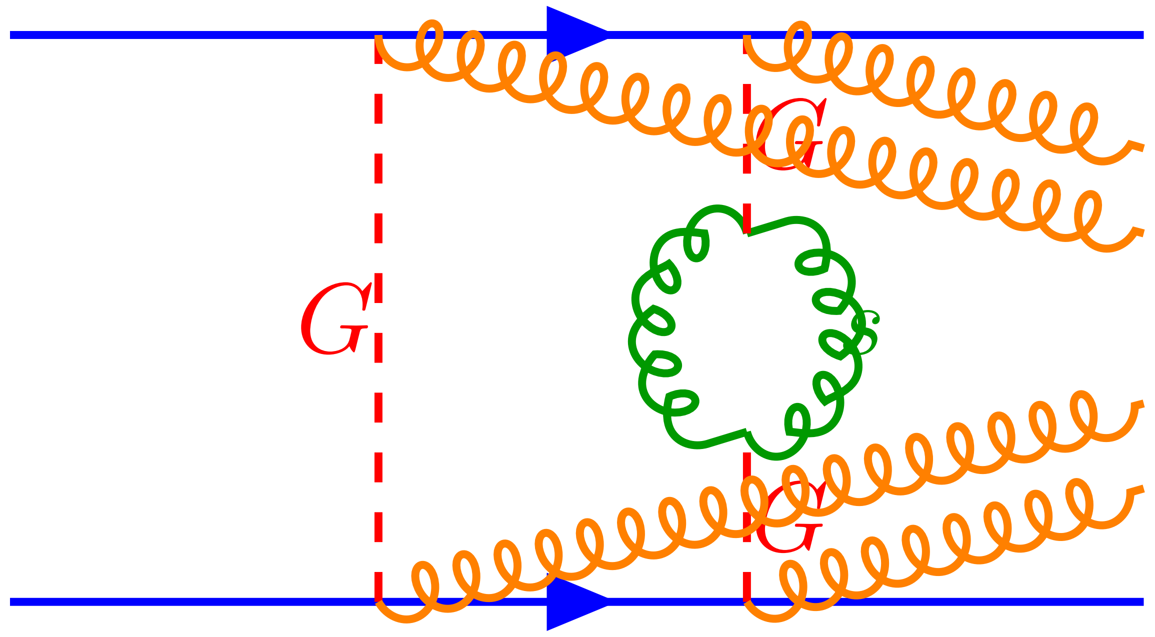
Glauber SCET

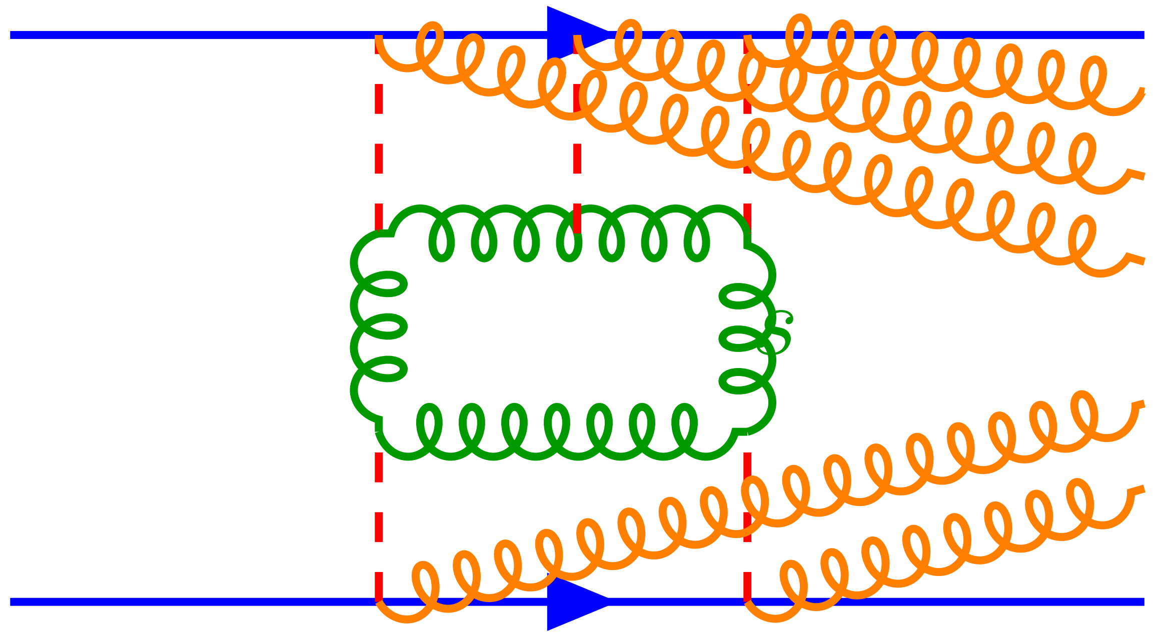
$$\mathscr{L}^0_{\rm SCET} = \mathscr{L}^0_{\rm Collinear} + \mathscr{L}^0_{\rm Soft} + \mathscr{L}^0_{\rm Ultrasoft} + \mathscr{L}^0_{\rm Glauber}$$

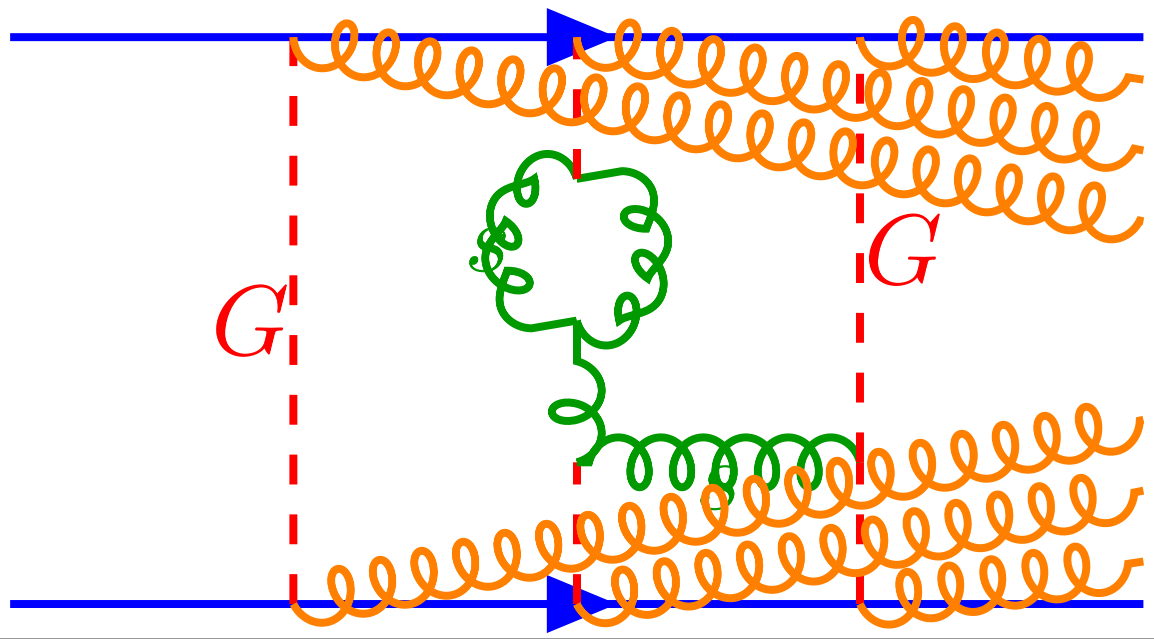
BPS field redefinition:

$$\mathcal{O}^{ij}_{ns\bar{n}} = \mathcal{U}^{BA}_n \mathcal{U}^{CD}_{\bar{n}} \mathcal{O}^{iA}_n \frac{1}{\mathcal{P}^2_\perp} \mathcal{O}^{BC}_s \frac{1}{\mathcal{P}^2_\perp} \mathcal{O}^{jD}_{\bar{n}}$$

$$\mathcal{O}^{ij}_{ns} = \mathcal{U}^{BA}_n \mathcal{O}^{iA}_n \frac{1}{\mathcal{P}^2_\perp} \mathcal{O}^{i_n B}_s$$



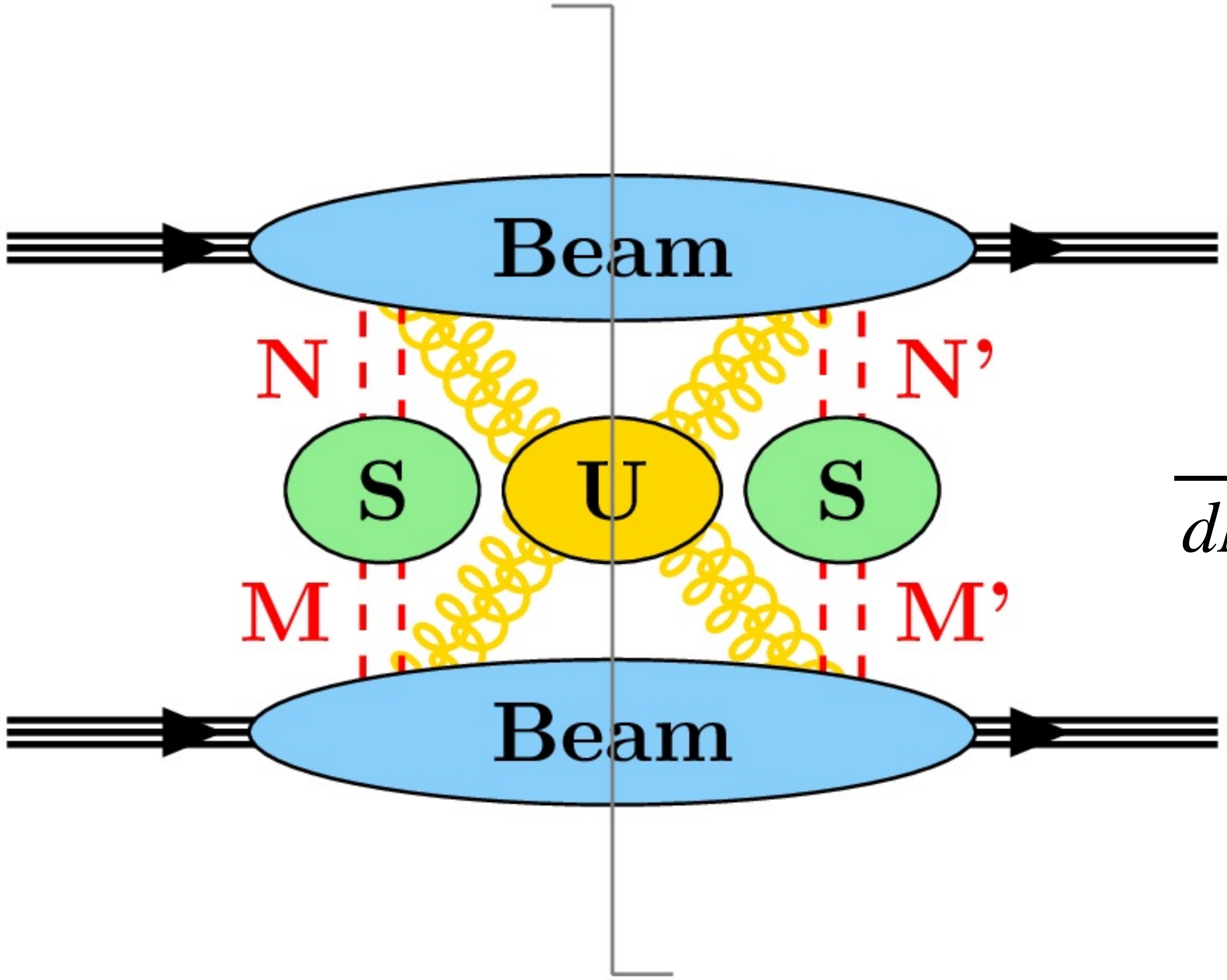




Regge Factorisation

Double: $pp \to XY$

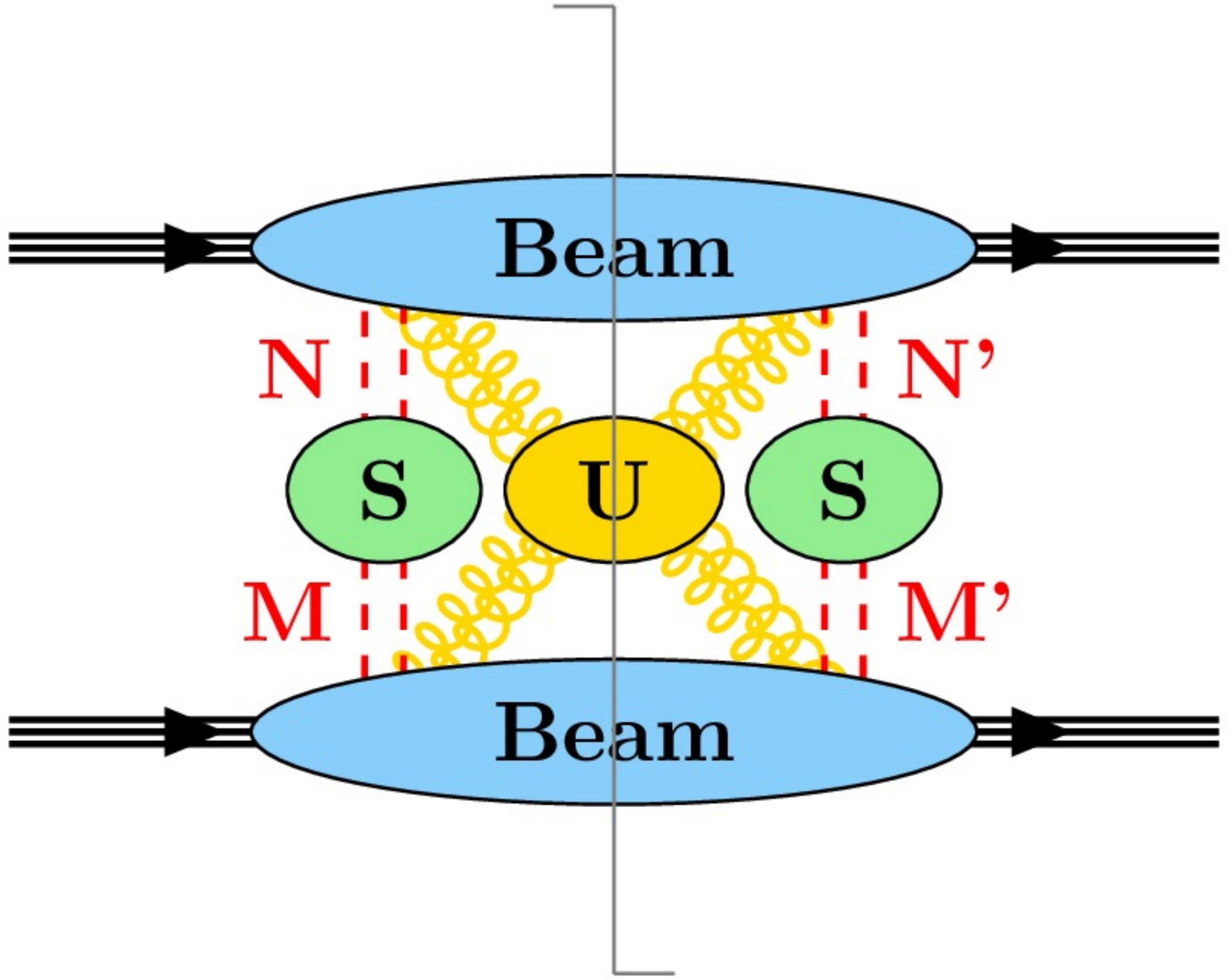
Factorisation



$$\frac{d^3\sigma}{dM_1^2 dM_2^2 dt} = \sum_{\{R_X\}} \sum_{\substack{N,N'\\M,M'}} S_{NM}^{\hat{R}_A} \otimes_\perp B_{NN'}^{R_A} \otimes_\perp S_{N'M'}^{\hat{R}_A} \otimes_\perp B_{MM'}^{R_B} \otimes_\pm U_{NN'MM'}^{R_A R_B \hat{R}_A}$$

Regge Factorisation

Double: $pp \to XY$



Beam

$$B^{R_X}_{NN'}(p^-\tilde{p}^+_{Xi}, \{\tau^u_{i\perp}, \tau'^u_{j\perp}\}, t) = \sum\!\!\!\!\!\!\int_{X_n} \langle p \,|\, \bar{\mathrm{T}} \left\{ \prod_{i=1}^{N-1} \mathcal{O}^{A_i}_n \bar{\mathcal{O}}^{A_N}_n \right\} P^N_{R_X} \,|\, X_n \rangle \langle X_n \,|\, \mathrm{T}\, P^{N'}_{R_X} \left\{ \prod_{j=1}^{N'-1} \mathcal{O}^{A'_j}_n \bar{\mathcal{O}}^{A'_{N'}}_n \right\} |\, p \rangle$$

Soft

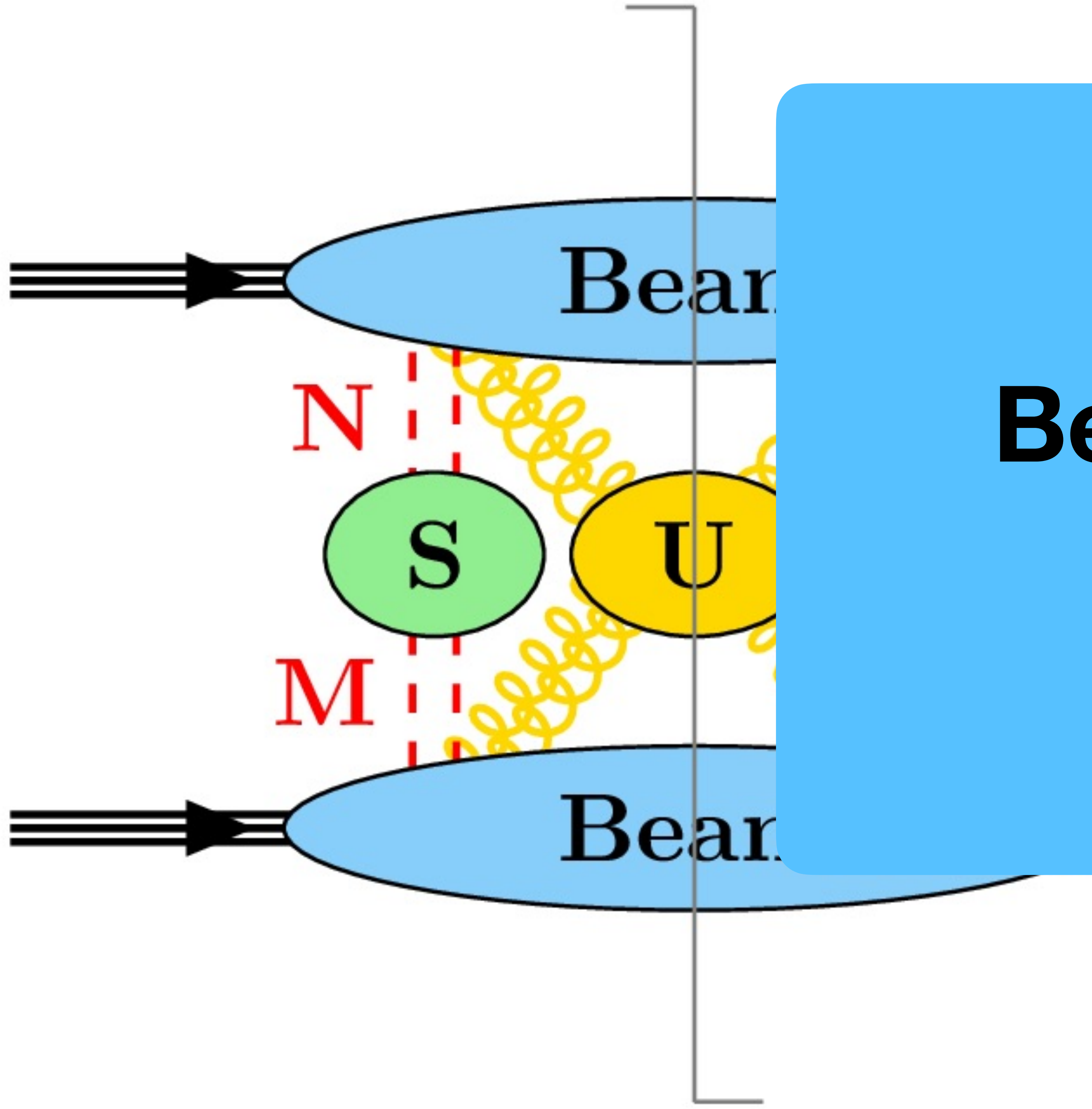
$$S^{\hat{R}_A}_{NM}(\{\tau^u_{i\perp}, \tau^d_{k\perp}\}, t) = \langle 0 \,|\, \mathrm{T}\, P^N_{\hat{R}_A} \mathbb{O}_{NM} P^M_{\hat{R}_A} \,|\, 0 \rangle$$

US

$$U^{R_A\hat{R}_A R_B \hat{R}_B}_{NN'MM'}(p^+_g, p^-_g) = \sum\!\!\!\!\!\!\int_{Z_{uc}} \langle 0 \,|\, P^N_{R_A} P^M_{R_B} \bar{T} \prod_{i,j=1}^{N,M} \mathcal{U}^{A_i \hat{A}_i}_n \mathcal{U}^{B_j \hat{B}_j}_{\bar{n}} P^N_{\hat{R}_A} P^M_{\hat{R}_A} \,|\, Z_{uc} \rangle \langle Z_{uc} \,|\, P^{N'}_{\hat{R}_A} P^{M'}_{\hat{R}_A} T \prod_{i,j=1}^{N',M'} \mathcal{U}^{A'_i \hat{A}'_i}_n \mathcal{U}^{B'_j \hat{B}'_j}_{\bar{n}} P^{N'}_{R_A} P^{M'}_{R_B} \,|\, 0 \rangle$$

Regge Factorisation

Double: $pp \to XY$



Beam

$$B^{R_X}_{NN'}(p^- \tilde{p}^+_{Xi}, \{\tau^u_{i\perp}, \tau'^u_{j\perp}\}, t) = \sum \langle p | \bar{\mathrm{T}} \Big\{ \prod^{N-1} \mathcal{O}^{A_i}_n \bar{\mathcal{O}}^{A_N}_n \Big\} P^N_{R_X} | X_n \rangle \langle X_n | \mathrm{T} P^{N'}_{R_X} \Big\{ \prod_{j=1}^{N'-1} \mathcal{O}^{A'_j}_n \bar{\mathcal{O}}^{A'_{N'}}_n \Big\} | p \rangle$$

Beam Fcts. are equivalent between *ep* & *pp*
(Ultra-)Soft functions are not!

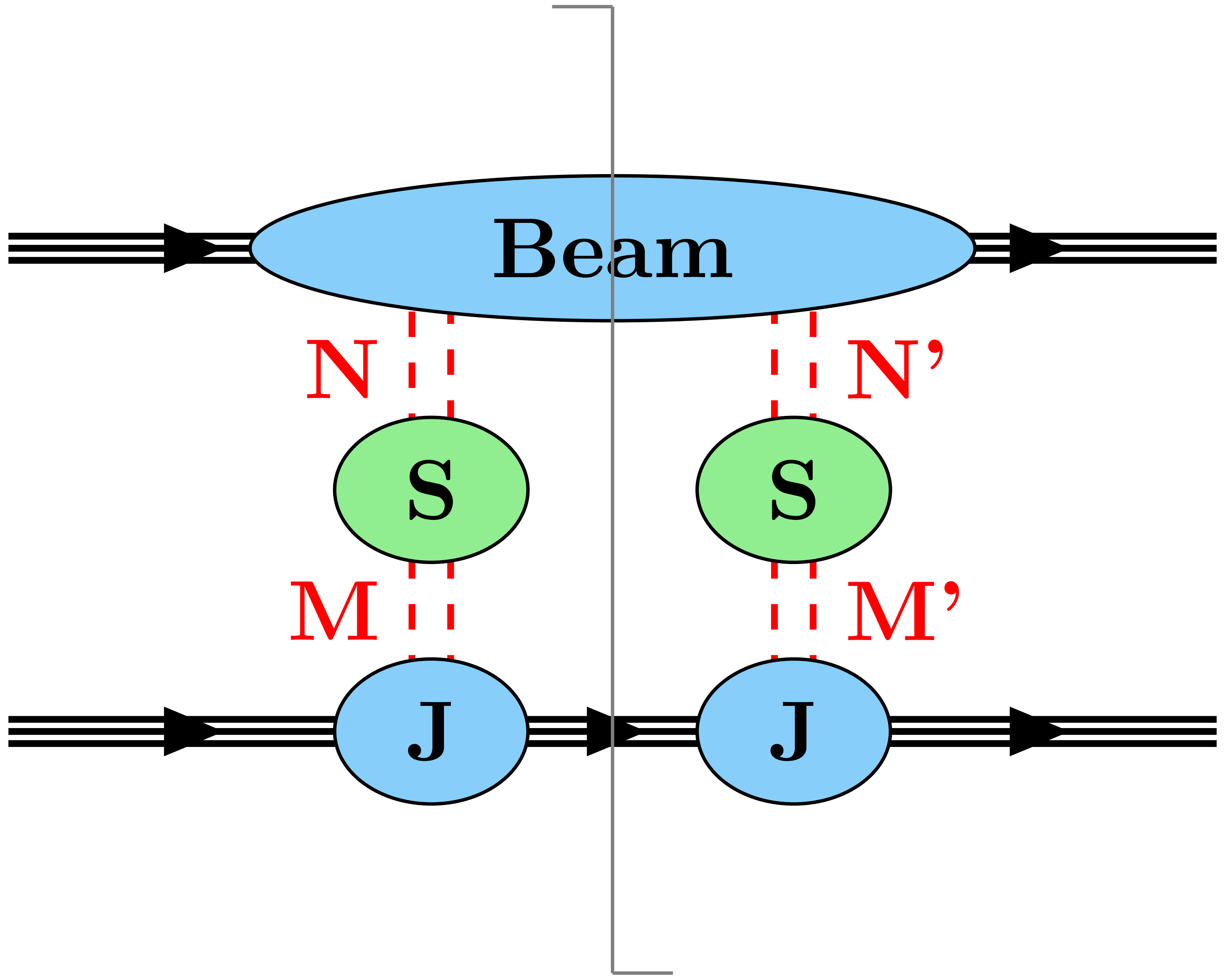
US

$$U^{R_A \hat{R}_A R_B \hat{R}_B}_{NN'MM'}(p_g^+, p_g^-) = \sum_{Z_{uc}} \langle 0 | P^N_{R_A} P^M_{R_B} \bar{T} \prod_{i,j=1}^{N,M} \mathcal{U}^{A_i \hat{A}_i}_n \mathcal{U}^{B_j \hat{B}_j}_{\bar{n}} P^N_{\hat{R}_A} P^M_{\hat{R}_A} | Z_{uc} \rangle \langle Z_{uc} | P^{N'}_{\hat{R}_A} P^{M'}_{\hat{R}_A} T \prod_{i,j=1}^{N',M'} \mathcal{U}^{A'_i \hat{A}'_i}_n \mathcal{U}^{B'_j \hat{B}'_j}_{\bar{n}} P^{N'}_{R_A} P^{M'}_{R_B} | 0 \rangle$$

Regge Factorisation

Single: $pp \to Xp$

Factorisation



Ultrasoft Vanishes due to Singlet Projection:

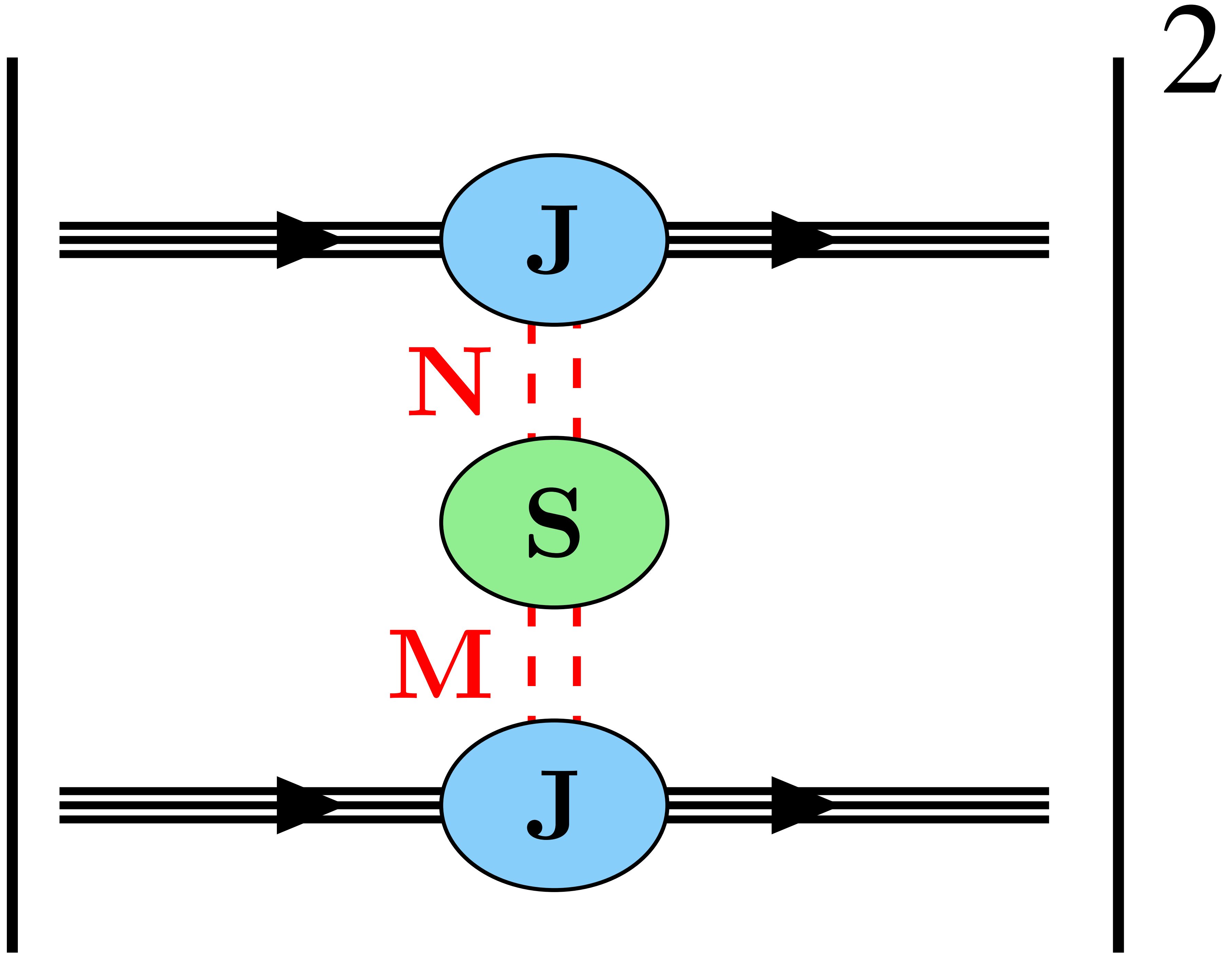
$$B \to J \cdot J$$

$$\frac{d^3\sigma}{dM_1^2 dM_2^2 dt} = \sum_{\{R_A=1\}} \sum_{\substack{N,N' \\ M,M'}} B_{NN'}^{R_A} \otimes_\perp S_{NM}^{R_A} \otimes_\perp J_M^{R_A} \otimes_\perp S_{N'M'}^{R_A} \otimes_\perp J_{M'}^{R_A}$$

Regge Factorisation

Elastic: $pp \to pp$

Factorisation



Gao, Moult, Raman, Ridgway, Stewart, 2401.00931

Amplitude Level Factorisation:

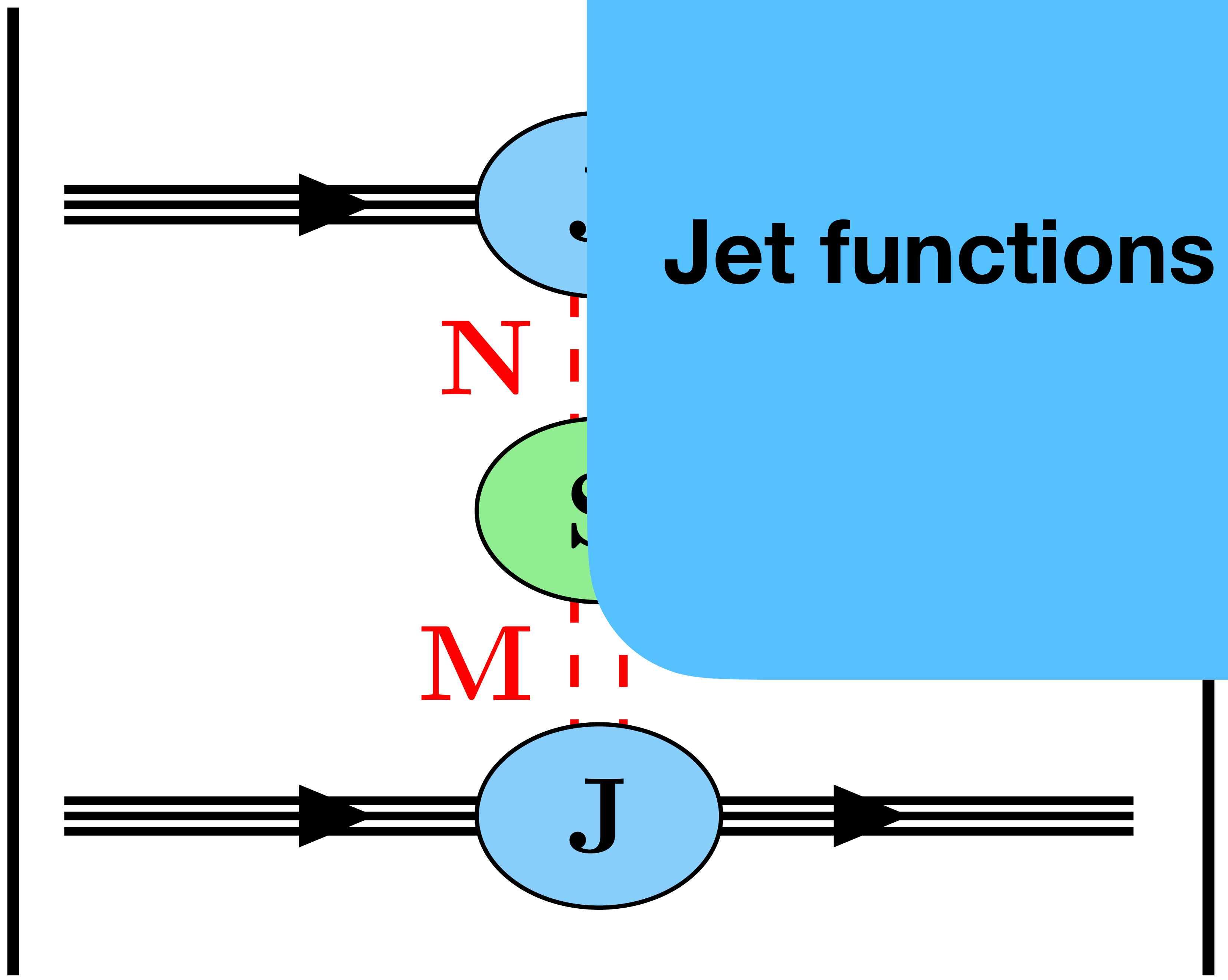
$$B \to J \cdot J$$

$$\frac{d^3\sigma}{dM_1^2 dM_2^2 dt} = \left| \sum_{\{R_A=1\}} \sum_{N,M} J_N^{R_A} \otimes_\perp S_{N,M}^{R_A} \otimes_\perp J_M^{R_A} \right|^2$$

Regge Factorisation

Elastic: $pp \to pp$

Factorisation



n:

$\cdot J$

Jet functions are the same everywhere

$\{R_A=1\}\; N, M \quad J_N^{R_A} \otimes_\perp S_{N,M}^{R_A} \otimes_\perp J_M^{R_A} \Big|^2$

Gao, Moult, Raman, Ridgway, Stewart, 2401.00931

Universality in Regge Factorisation

RG Evolution

Renormalised Quantities:

$$B^0(\varepsilon, \eta) = B(\mu, \nu) \otimes_{\pm, \perp} Z_B(\varepsilon, \eta, \mu, \nu)$$

$$U^0(\varepsilon) = Z_U^T(\varepsilon, \mu) \otimes_+ U(\mu) \otimes_- Z_U(\varepsilon, \mu)$$

$$S^0(\eta) = Z_s^T(\eta, \nu) \otimes_\perp S(\nu) \otimes_\perp Z_S(\eta, \nu)$$

RG Consistency ➡

$$\Gamma_B^\mu + \Gamma_U^{\mu\, T} = 0$$

$$\Gamma_B^\nu + \Gamma_S^{\nu T} \Gamma_S^{\nu T} = 0$$

Universality in Regge Factorisation

RG Evolution

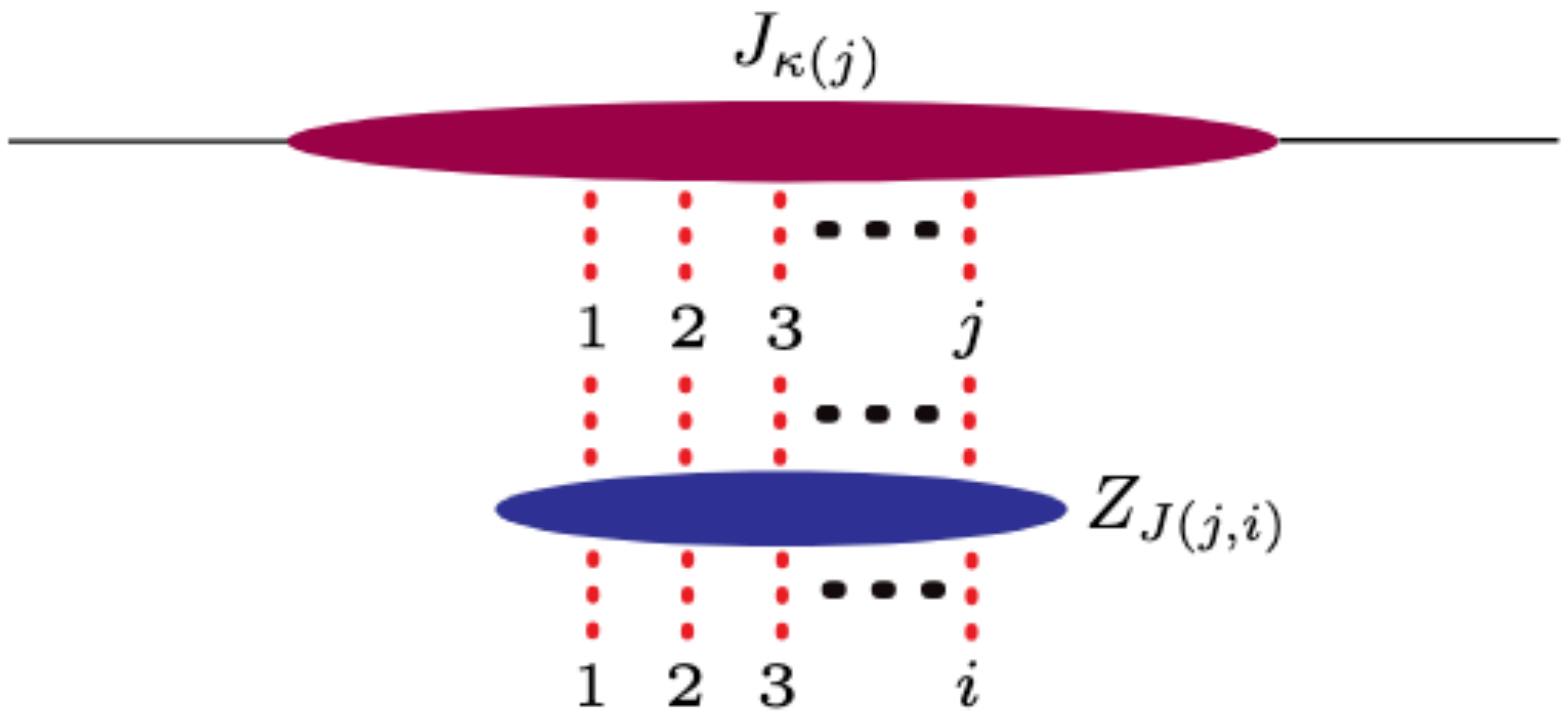
Amplitude Level:

$$B^0(\varepsilon, \eta) = B(\mu, \nu) \otimes_{\pm,\perp} Z_B(\varepsilon, \eta, \mu, \nu)$$

$$\Downarrow$$

$$J^0(\eta) = J(\nu) \otimes_{\perp} Z_J(\eta, \nu)$$

$$Z_J^{-1} = Z_S^T$$
$$\Gamma_J = -\Gamma_S^T$$



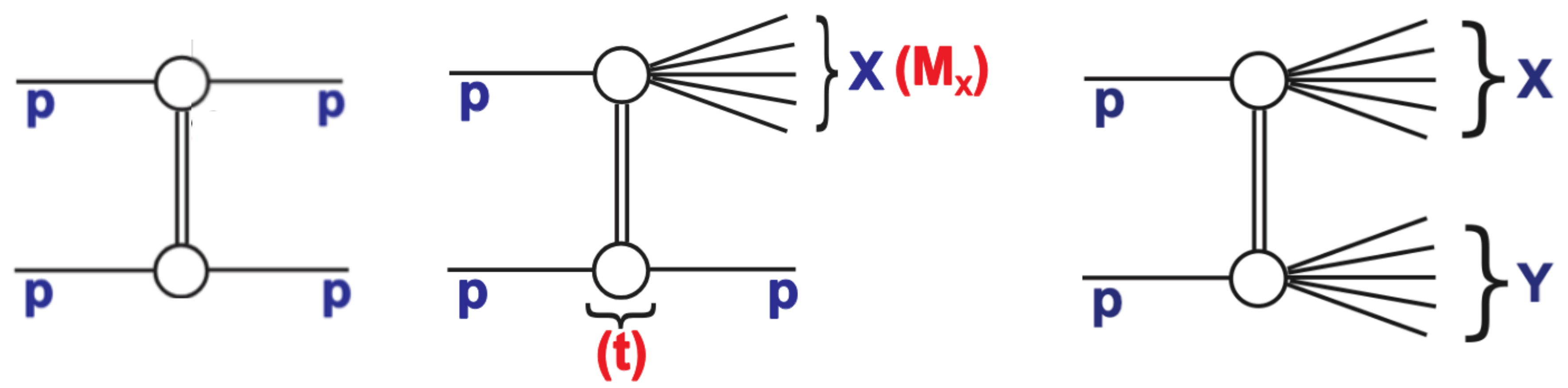
Gao, Moult, Raman, Ridgway, Stewart, 2401.00931

Universality in Regge Factorisation

RG Evolution

Rapidity Evolution ($\partial_{\ln \nu}$): $B \xrightarrow{\nu} S$

$\nu_B \sim \sqrt{-t}$ $\qquad$ $\nu_S \sim \sqrt{s}$



Elastic $\qquad$ Single $\qquad$ Double

	PP Elastic	PP Single	ep Coherent	PP Double (Singlet)	ep Incoherent (Singlet)
Collinear Beam	$(J \otimes_\perp \Gamma_J)^2$	$B \otimes_\perp \Gamma_J \Gamma_J$	$(J \otimes_\perp \Gamma_J)^2$	$B \otimes_\perp \Gamma_J \Gamma_J$	$B \otimes_\perp \Gamma_J \Gamma_J$
Soft	$(-\Gamma_J \otimes_\perp S - S \otimes_\perp \Gamma_J^T)^2$	$(-\Gamma_J \otimes_\perp S - S \otimes_\perp \Gamma_J^T)^2$	$-\Gamma_J \Gamma_J \otimes_\perp S$	$(-\Gamma_J \otimes_\perp S - S \otimes_\perp \Gamma_J^T)^2$	$-\Gamma_J^T \Gamma_J^T \otimes_\perp S$
Anticollinear Beam	$(\Gamma_J^T \otimes_\perp J)^2$	$(\Gamma_J^T \otimes_\perp J)^2$	-	$\Gamma_J^T \Gamma_J^T \otimes_\perp B$	-

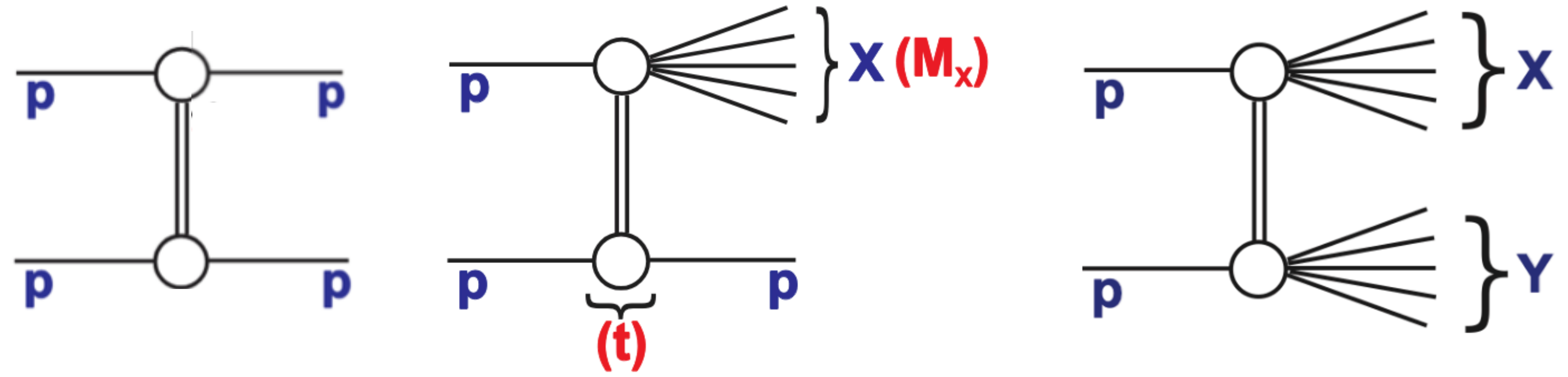
All evolve with Γ_J !

Universality in Regge Factorisation

RG Evolution

Rapidity Evolution ($\partial_{\ln \nu}$): $B \xrightarrow{\nu} S$

$\nu_B \sim \sqrt{-t}$ $\qquad$ $\nu_S \sim \sqrt{s}$



Elastic $\qquad$ Single $\qquad$ Double

	PP				ep Incoherent (Singlet)
Collinear Beam	$(J$				$B \otimes_\perp \Gamma_J \Gamma_J$
Soft	$(-\Gamma_J^T \otimes_\perp$				$-\Gamma_J^T \Gamma_J^T \otimes_\perp S$
Anticollinear Beam	$(\Gamma_J^T \otimes_\perp J)^2$	$(\Gamma_J^T \otimes_\perp J)^2$	-	$\Gamma_J^T \Gamma_J^T \otimes_\perp B$	-

- **Boundary Conditions are generically different**
- **Anomalous dimensions are universal**
- **Isolates Contributions to “Pomeron“**

All evolve with Γ_J !

Universality in Regge Factorisation

RG Evolution

Collimated Jets: $\frac{M_i^2}{s} \ll 1$

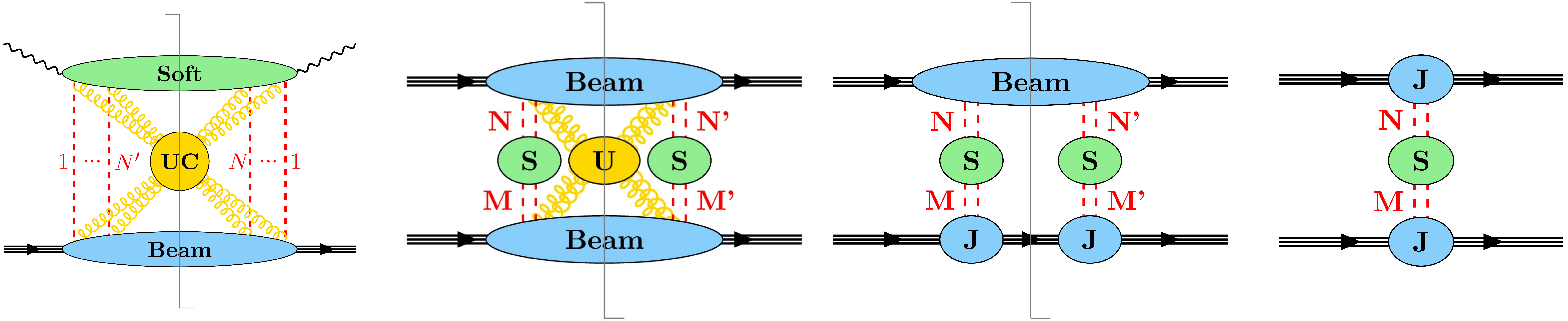
Virtuality Evolution ($\partial_{\ln\mu}$): $B \xrightarrow{\mu} U$, $\mu_B^2 \sim M_i^2$, $\mu_U^2 \sim \frac{M_i^4}{s}$

	PP Elastic	PP Single	Coherent ep	PP Double	Incoherent ep
Collinear Beam	0	0	0	$B \otimes_+ \Gamma_B$	$B \otimes_+ \Gamma_B$
Soft	0	0	0	0	$\Gamma_B^T \otimes_- S$
Anticollinear Beam	-	-	-	$\Gamma_B^T \otimes_- B$	-
Usoft	-	-	-	$-U \otimes_+ \Gamma_B - \Gamma_B^T \otimes_- U$	$-U \otimes_+ \Gamma_B - \Gamma_B^T \otimes_- U$

All evolve with Γ_B !

Suppresses Gap radiation

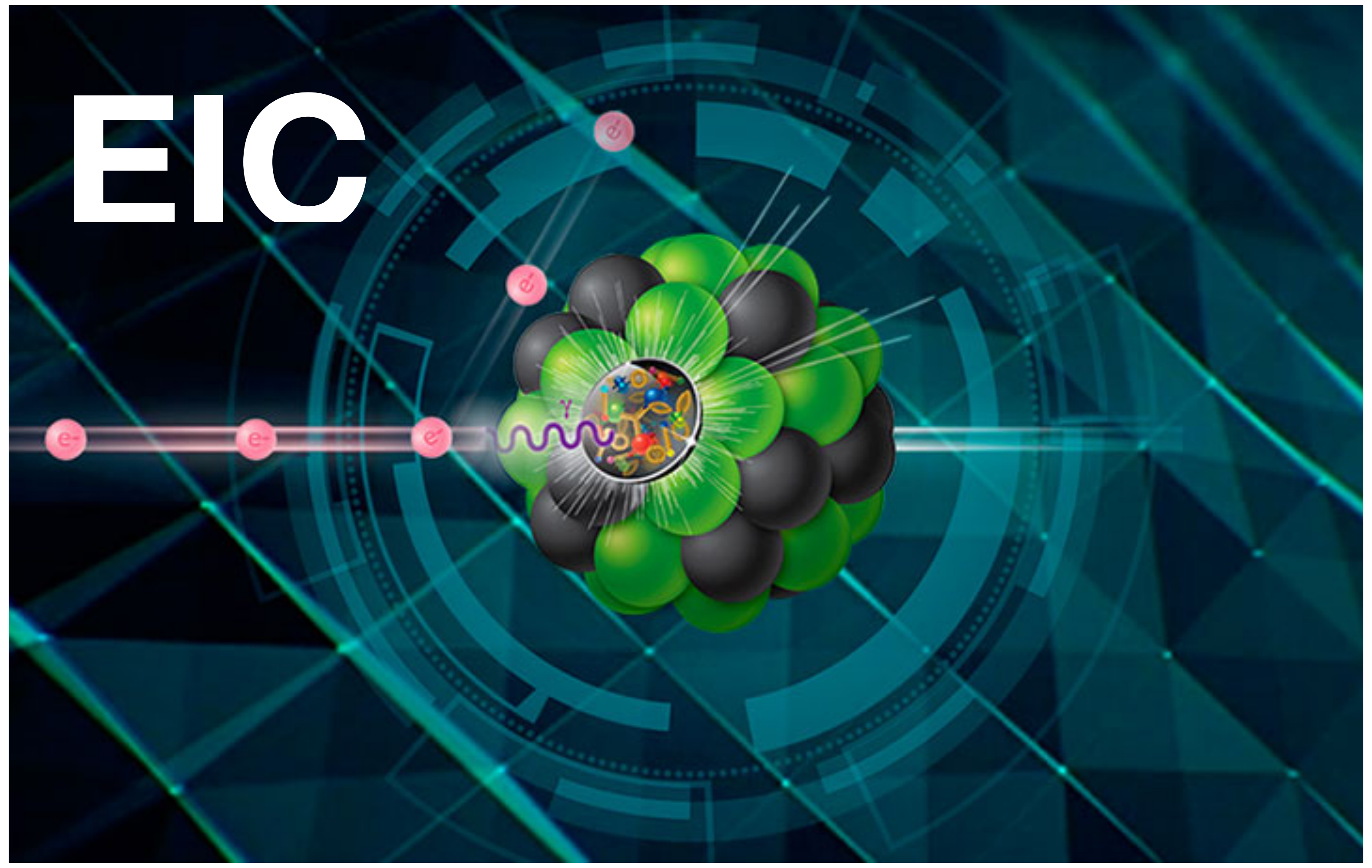
Summary



- Factorisation of elastic scattering as well as Single and Double Diffraction
- Universal Beam functions between *ep*&*pp* diffraction
- Universality in the evolution w.r.t rapidity and virtuality

A Bright Future for Diffraction across Colliders

- Universality beyond ep and pp
- Small-x evolution and saturation
- Hadron Structure



FAIR

HiLumi
HL-LHC PROJECT