Women in Theoretical Physics

Premio Nazionale "Milla Baldo Ceolin" 2024

Camilla Forgione

GGI, Firenze, 04/11/2025

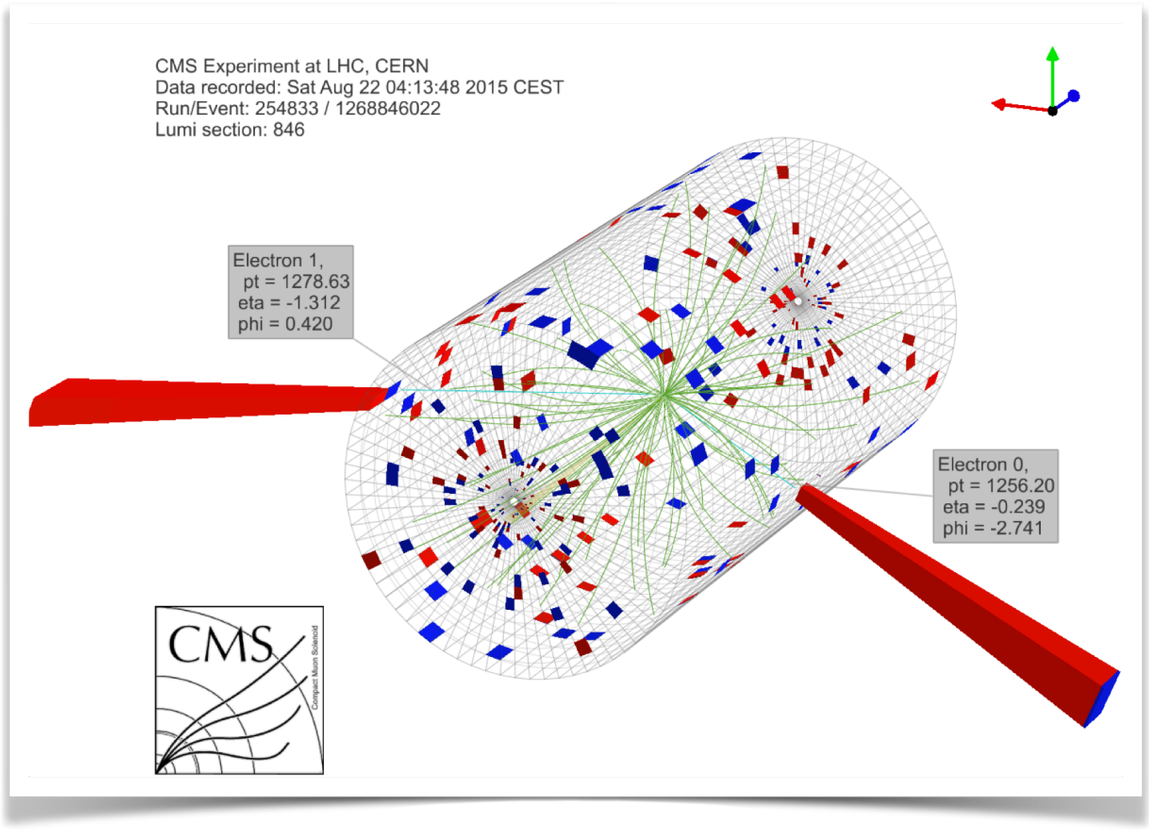
UNIVERSITÀ DI TORINO

Matching NLO QED computations and parton-shower simulations with MC@NLO

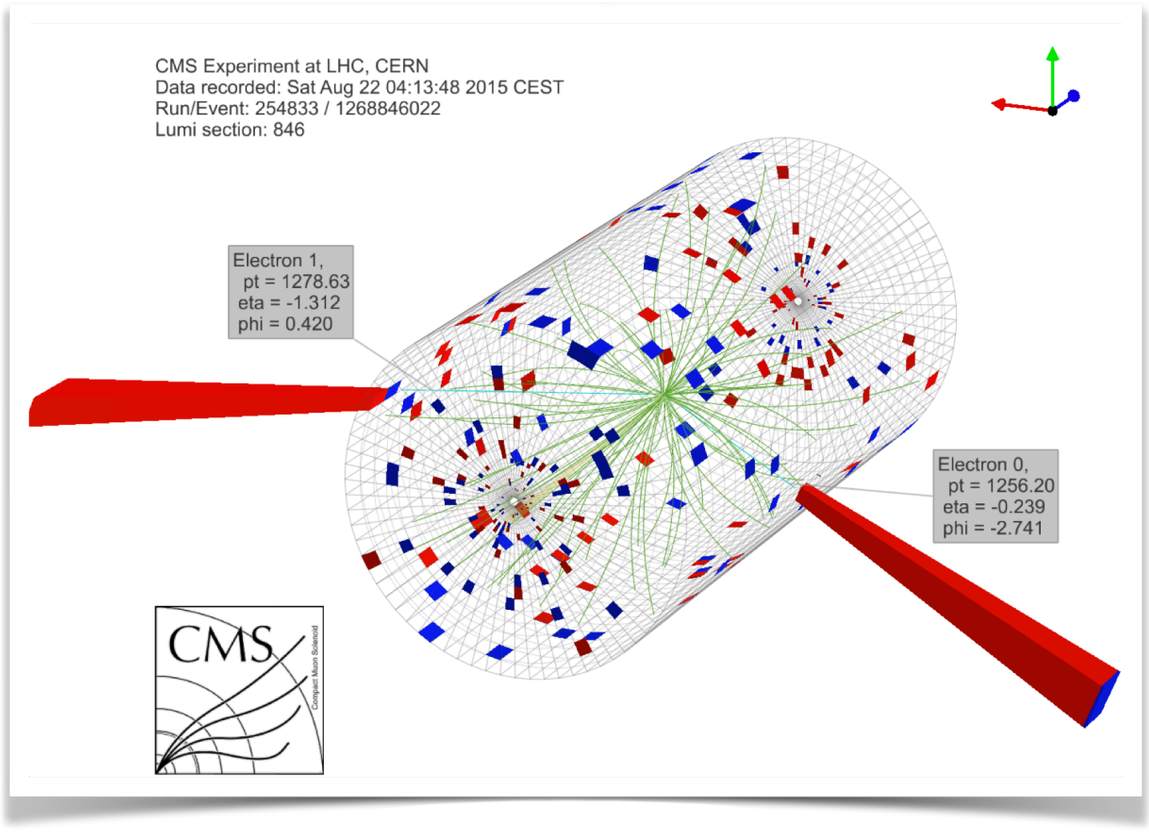
Precise predictions for heavy flavour production at colliders

MAX-PLANCK-INSTITUT FÜR PHYSIK

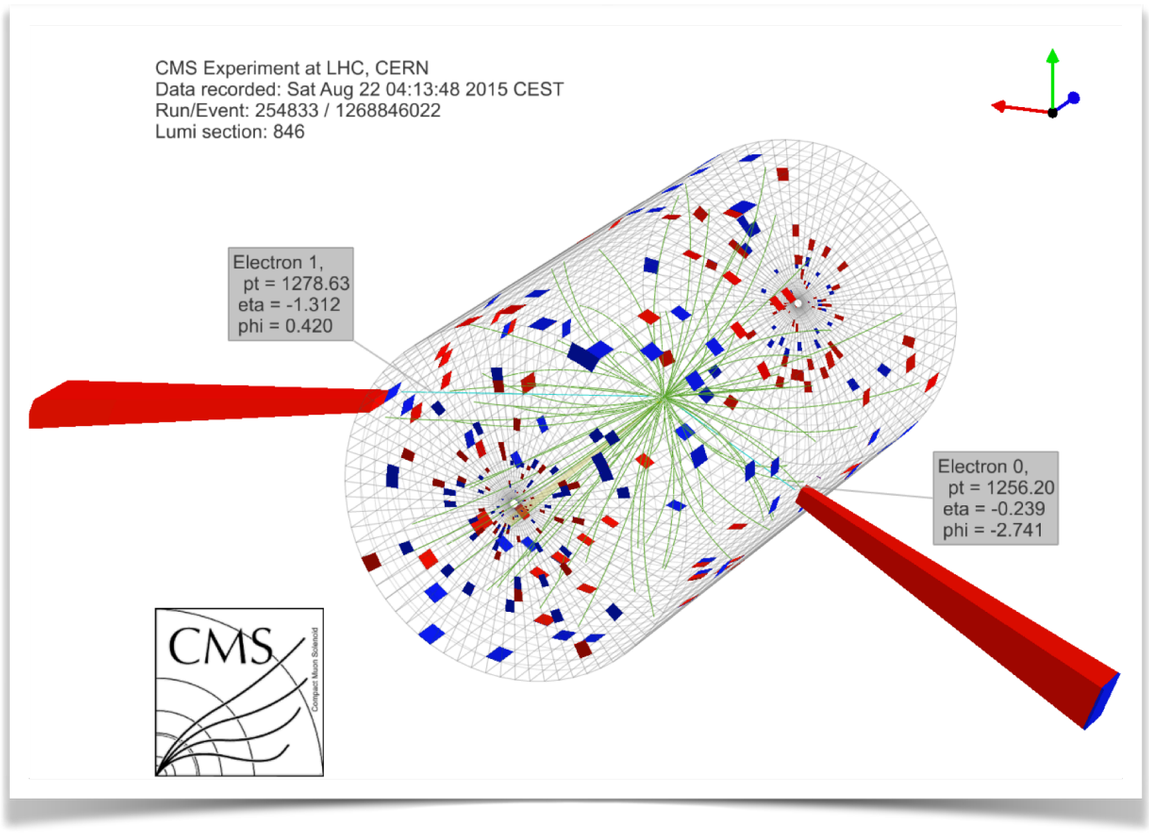
High-precision collider physics



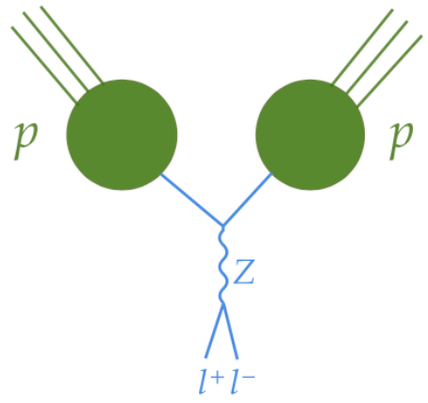
High-precision collider physics

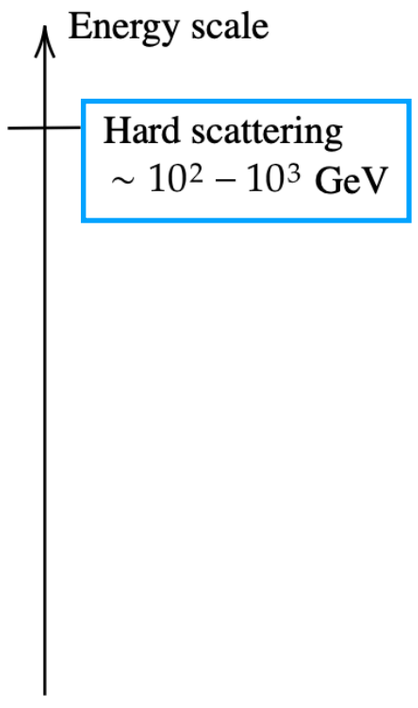


High-precision collider physics



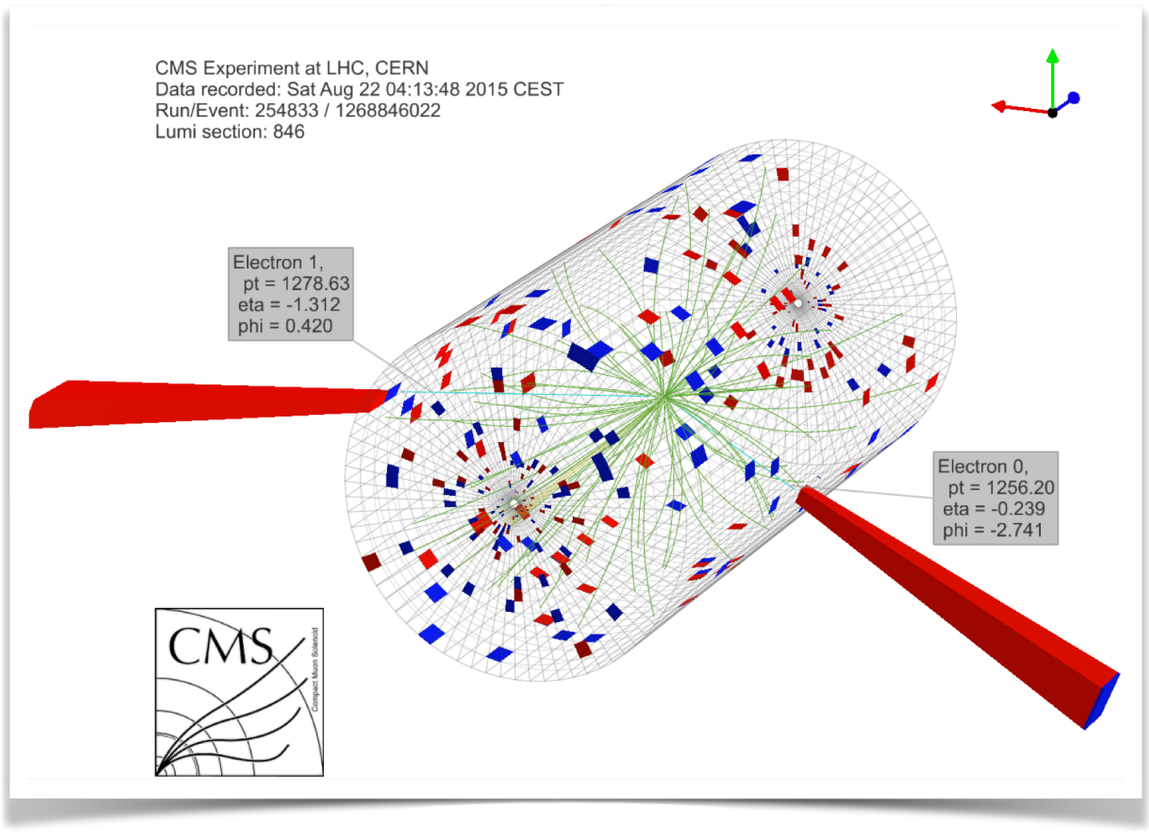
$$pp \to Z \to l^+ l^-$$





Hard scattering:
fixed order (FO)

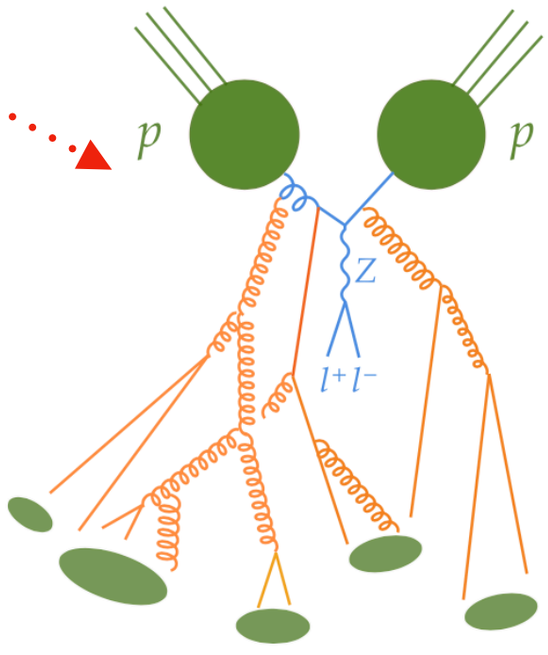
High-precision collider physics

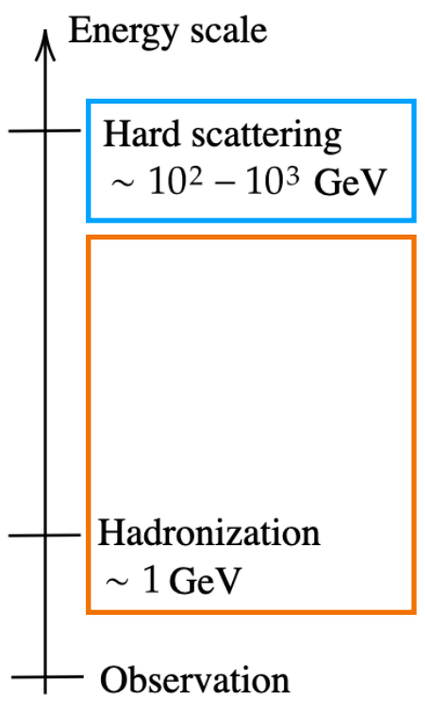


$$pp \to Z \to l^+ l^-$$

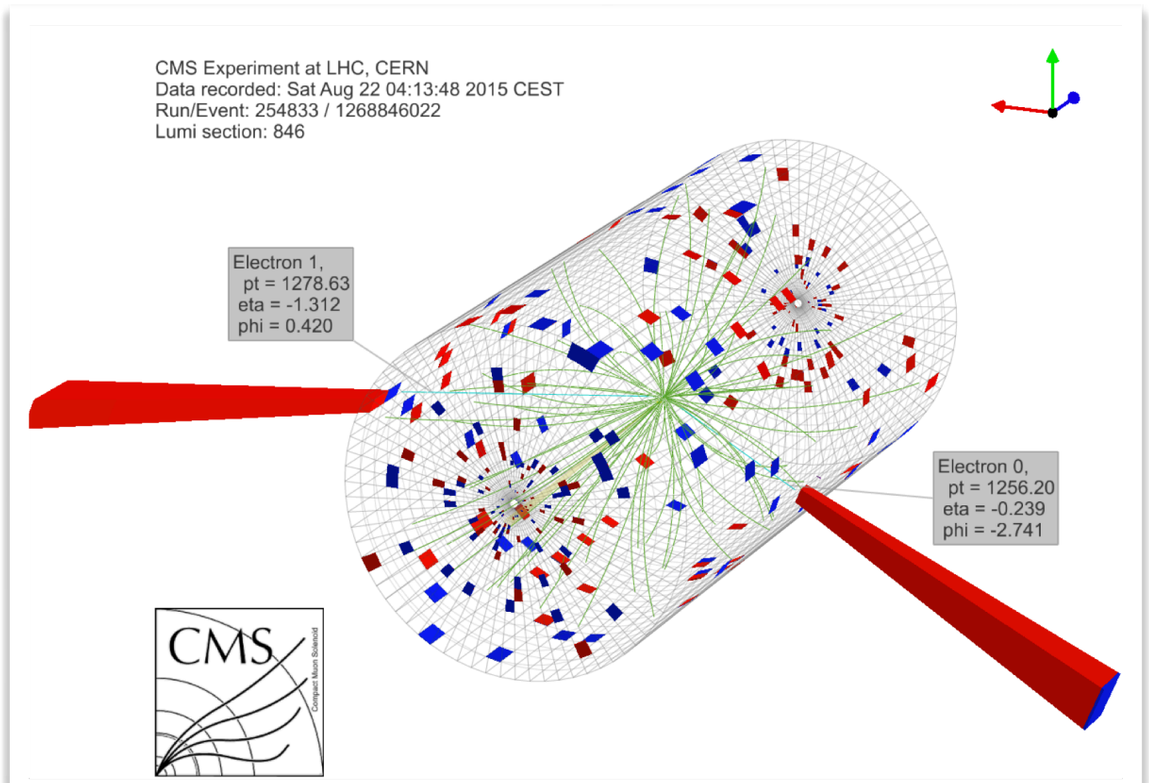
Hard scattering:
fixed order (FO)

Multiple emissions:
parton shower (PS)





High-precision collider physics



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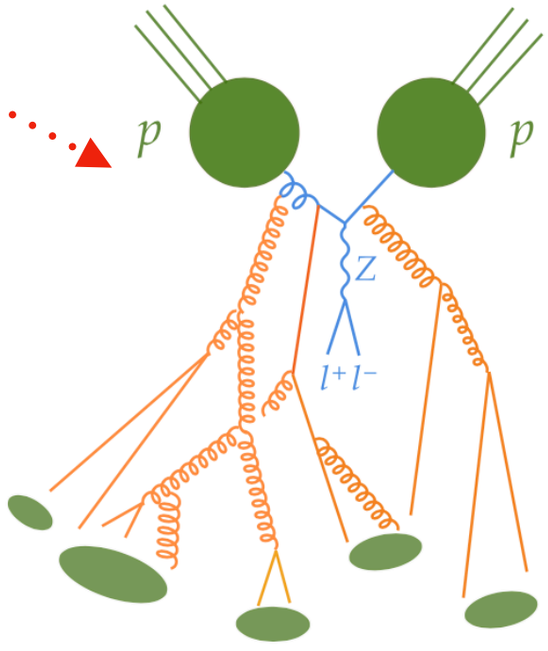
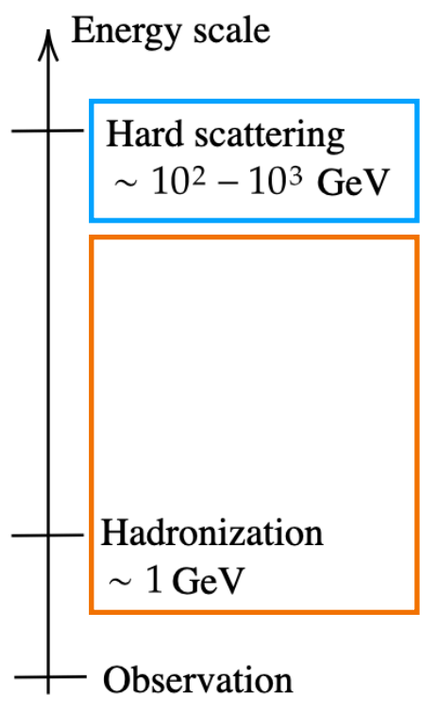
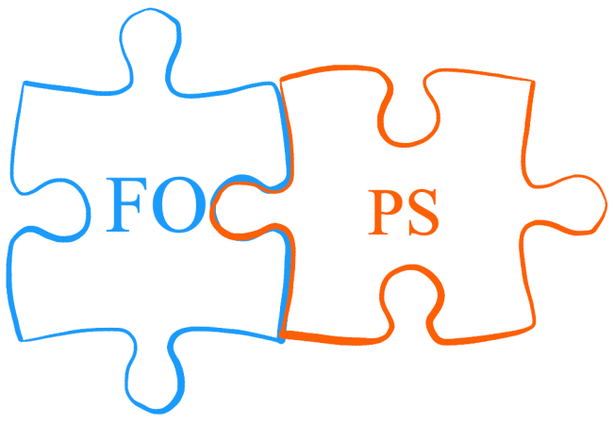




Matching



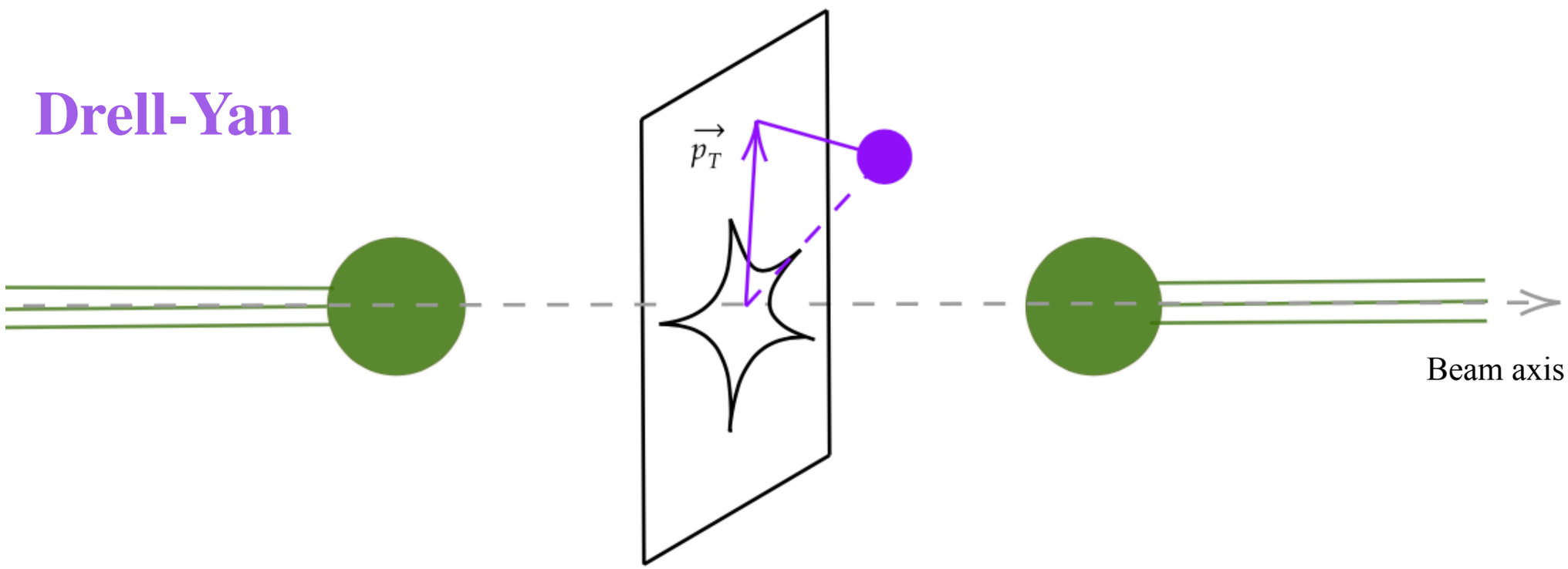
Hard scattering:
fixed order (FO)

Multiple emissions:
parton shower (PS)

Differential collider observables: e.g. transverse momentum

In collider experiments, the focus is on measuring and analysing kinematic distributions: $\frac{d\sigma}{dO}$

An example is the Z transverse momentum p_T.



The Z transverse momentum spectrum in QCD

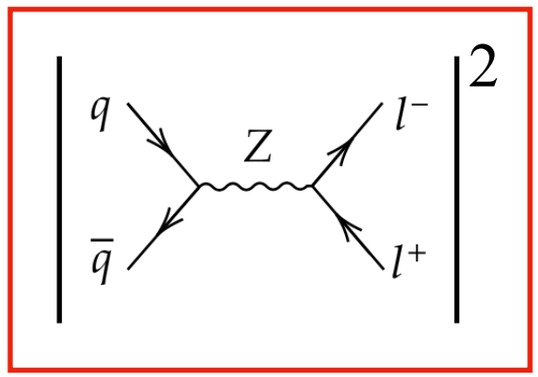
$$\frac{d\sigma}{dp_T} =$$

The Z transverse momentum spectrum in QCD

LO

$$\frac{d\sigma}{dp_T} = \mathcal{O}(\alpha_s^0)$$

Born (B)



Fixed order (FO)

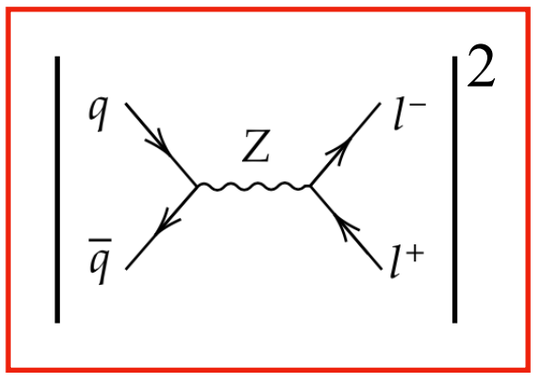
LO = Leading Order

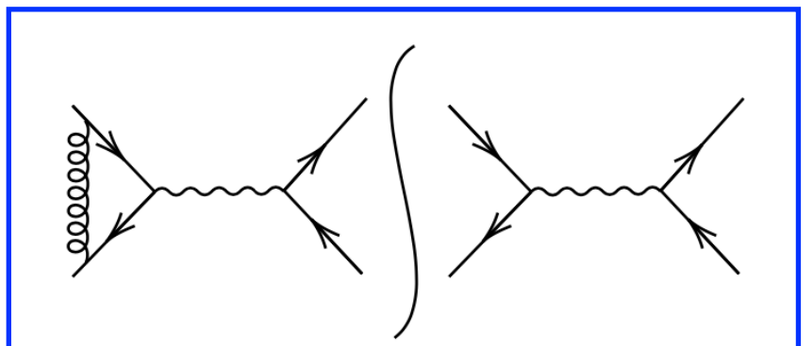
The Z transverse momentum spectrum in QCD

LO **NLO**

$$\frac{d\sigma}{dp_T} = \mathcal{O}(\alpha_s^0) + \mathcal{O}(\alpha_s^1) + \dots$$

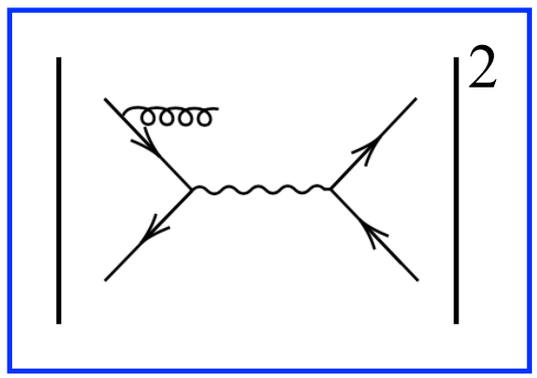
Born (B)





Virtual (V)

...



Real (R)

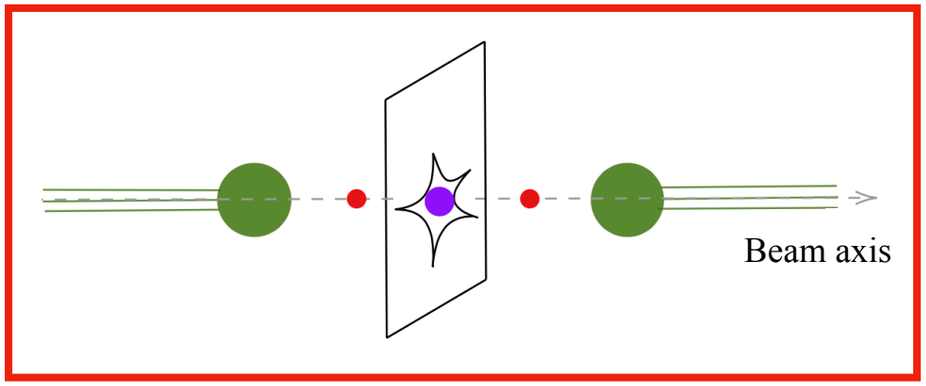
Fixed order (FO)

LO = Leading Order

NLO = Next to Leading Order

The Z transverse momentum spectrum in QCD

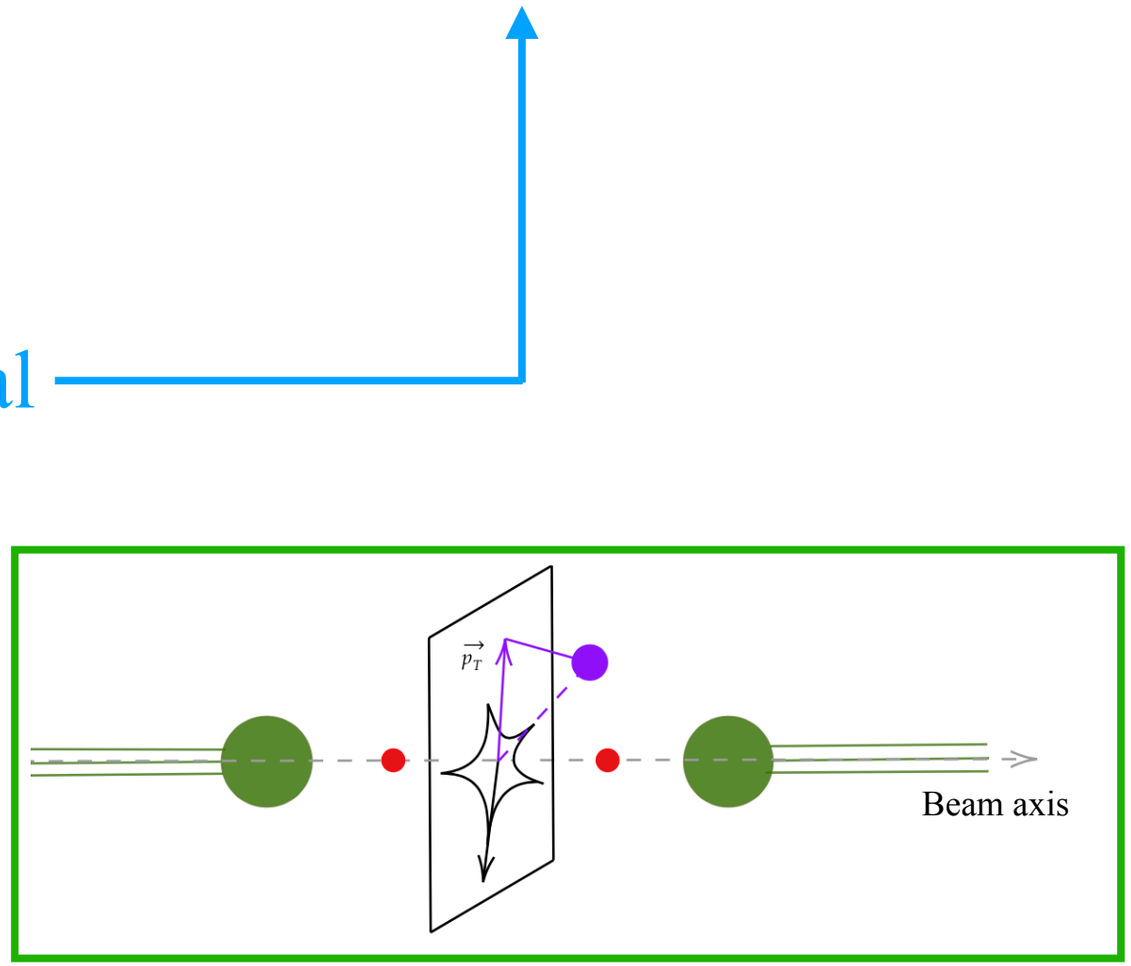
LO

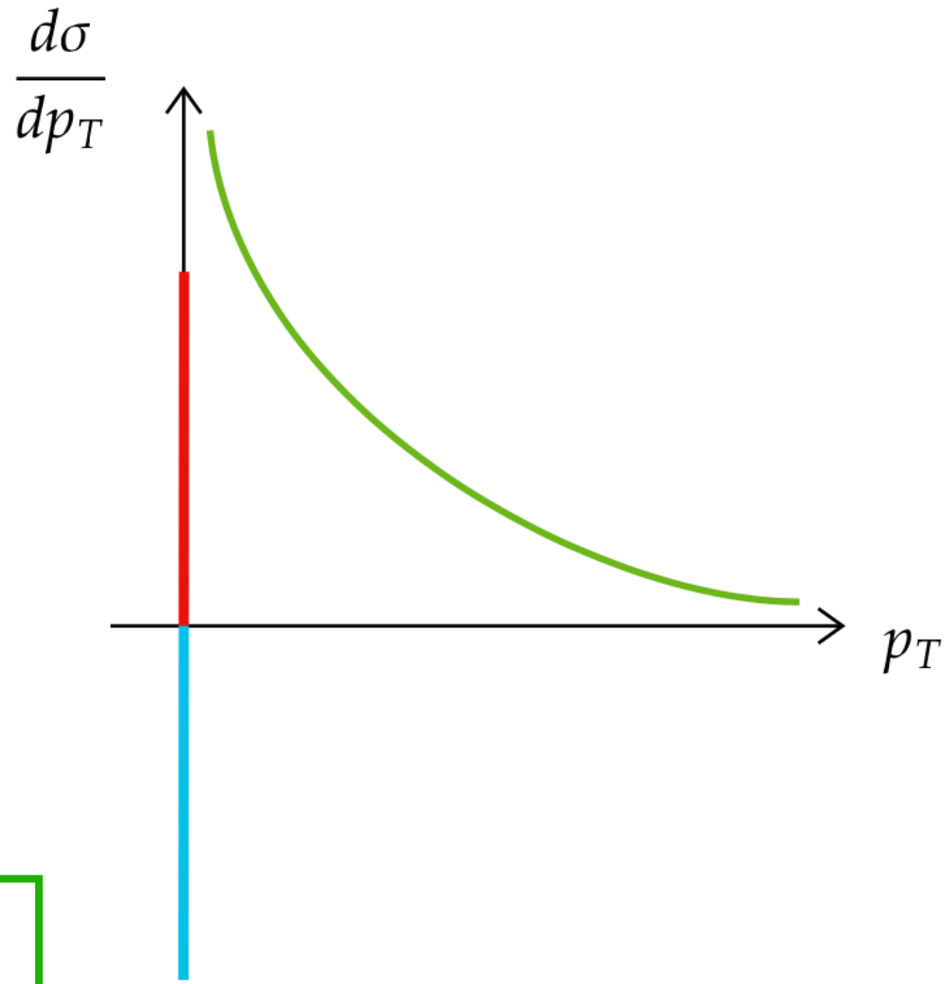


NLO

Virtual

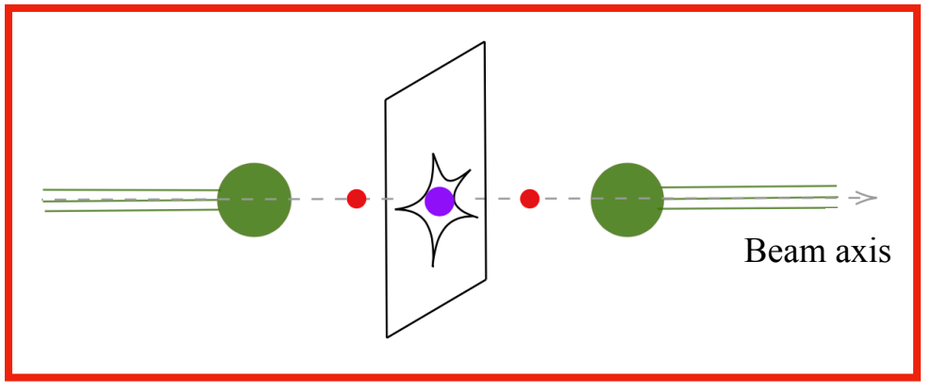
Real





The Z transverse momentum spectrum in QCD

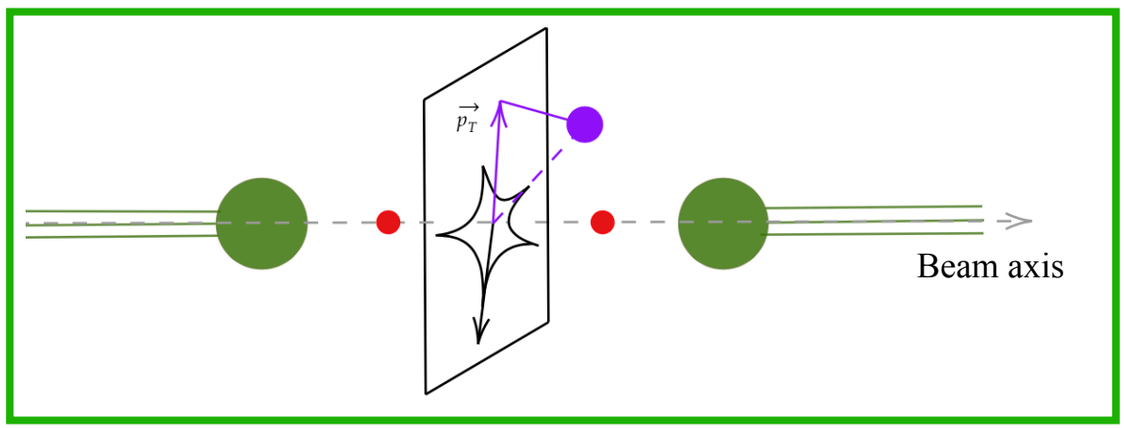
LO

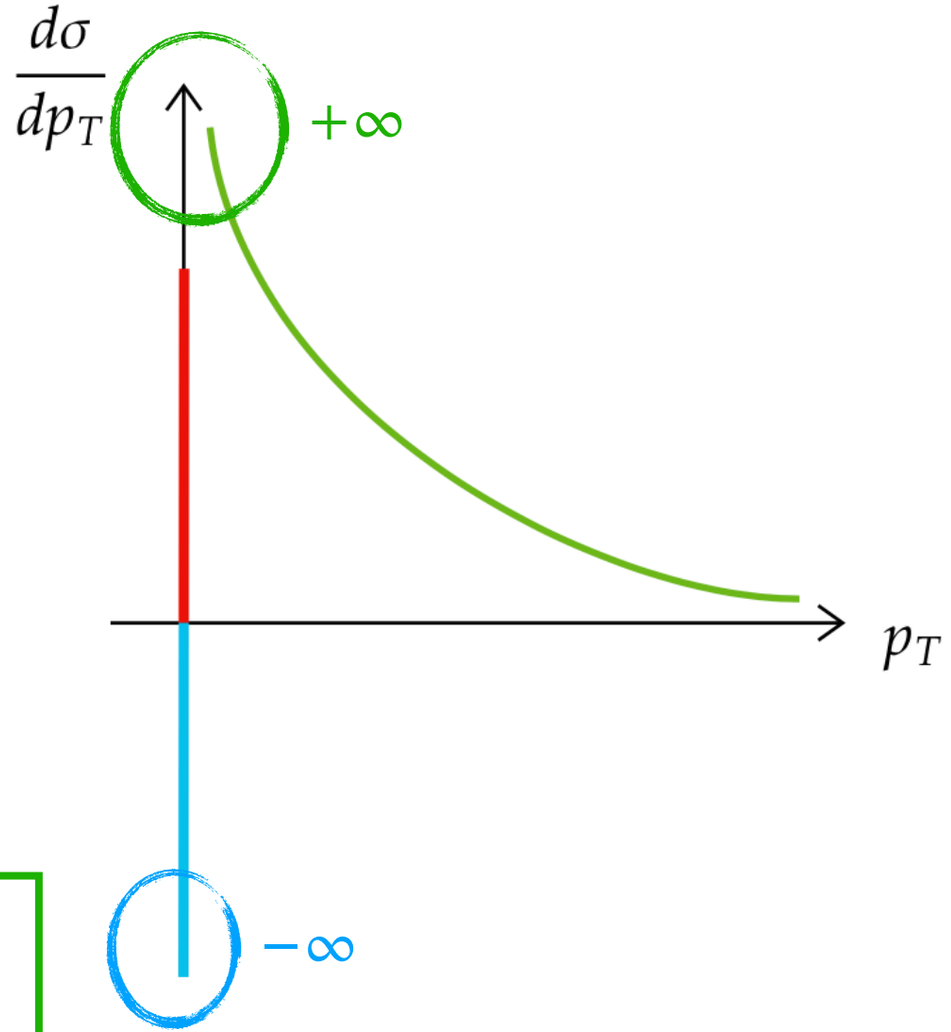


NLO

Virtual

Real

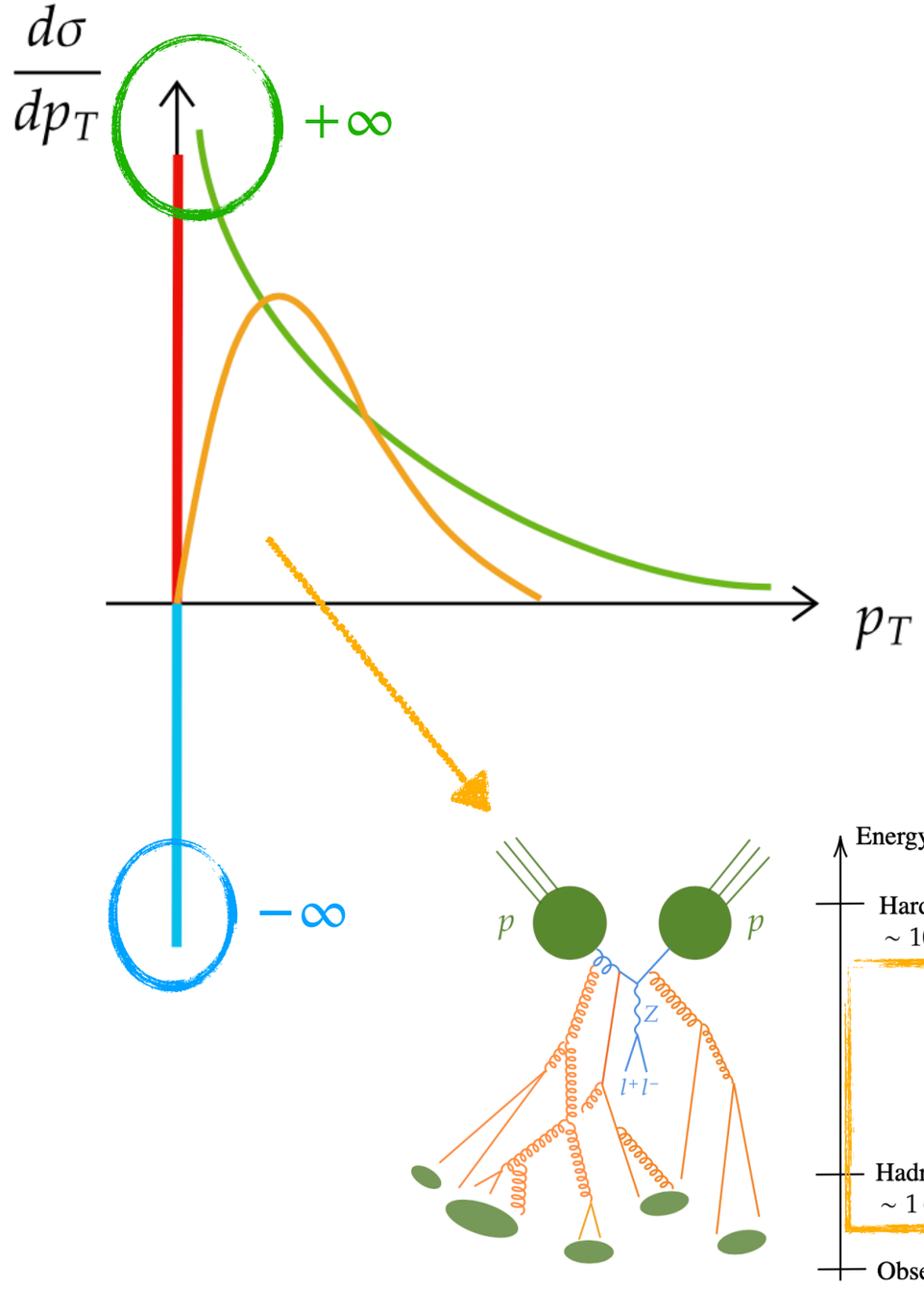




The Z transverse momentum spectrum in QCD

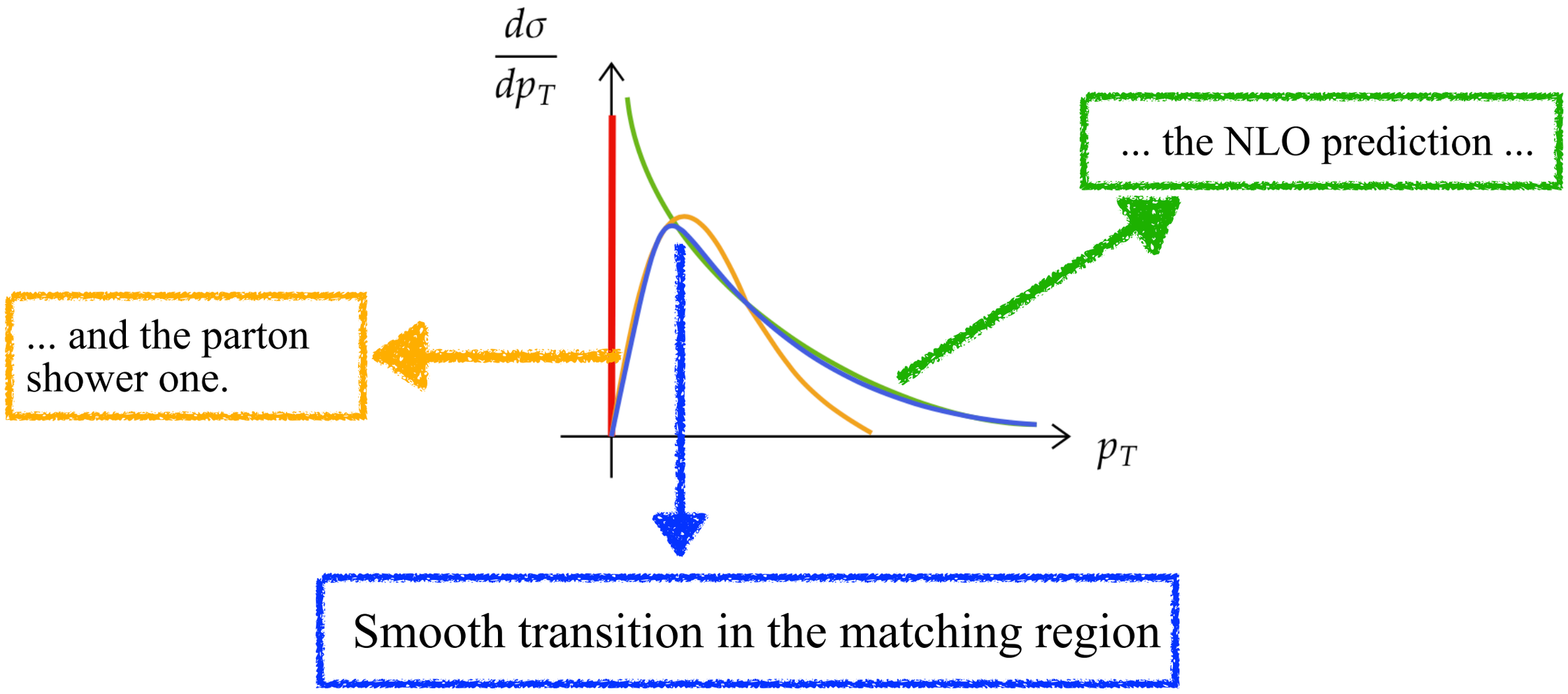
The fixed-order description breaks down.
We need for multiple emissions to describe the low p_T region.

PARTON SHOWERS



Matching formalism

The matched prediction combines...



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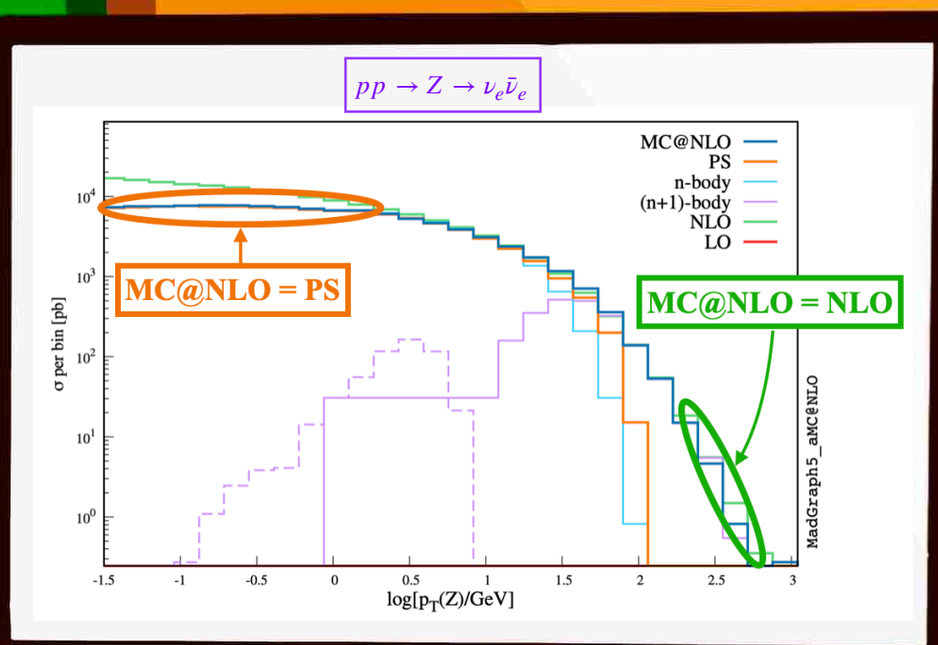
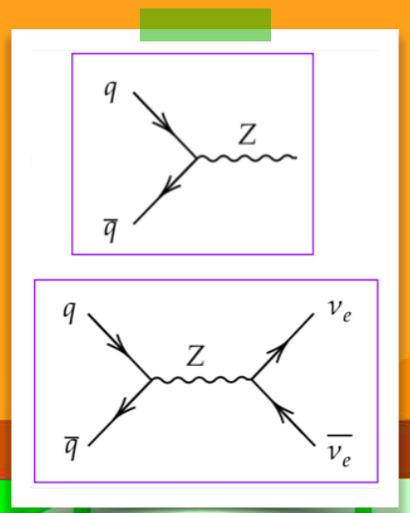
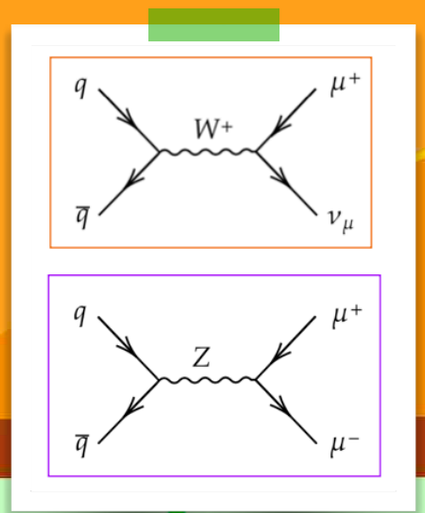
Matching NLO QED computations and parton-shower simulations with MC@NLO

Supervisor: Paolo Torrielli (UniTo), in collaboration with Marco Zaro (UniMi) and Davide Pagani (UniBo)

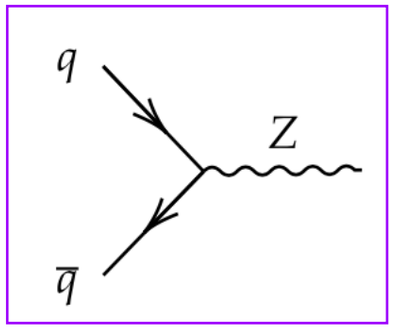
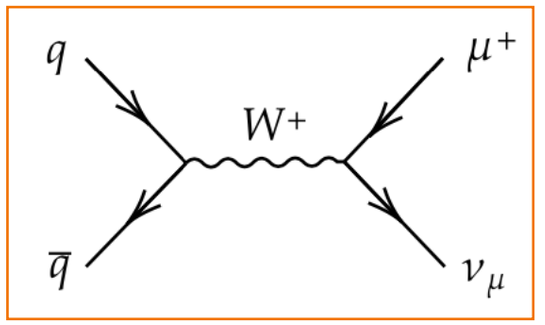
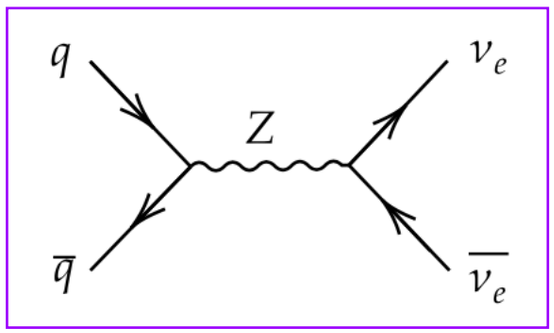
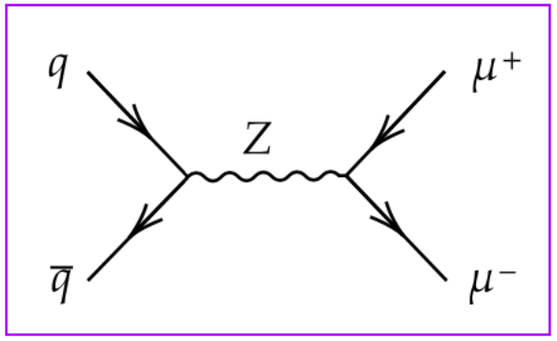






Studied processes

We simulated two processes: charged Drell-Yan and neutral Drell-Yan (in 3 versions)

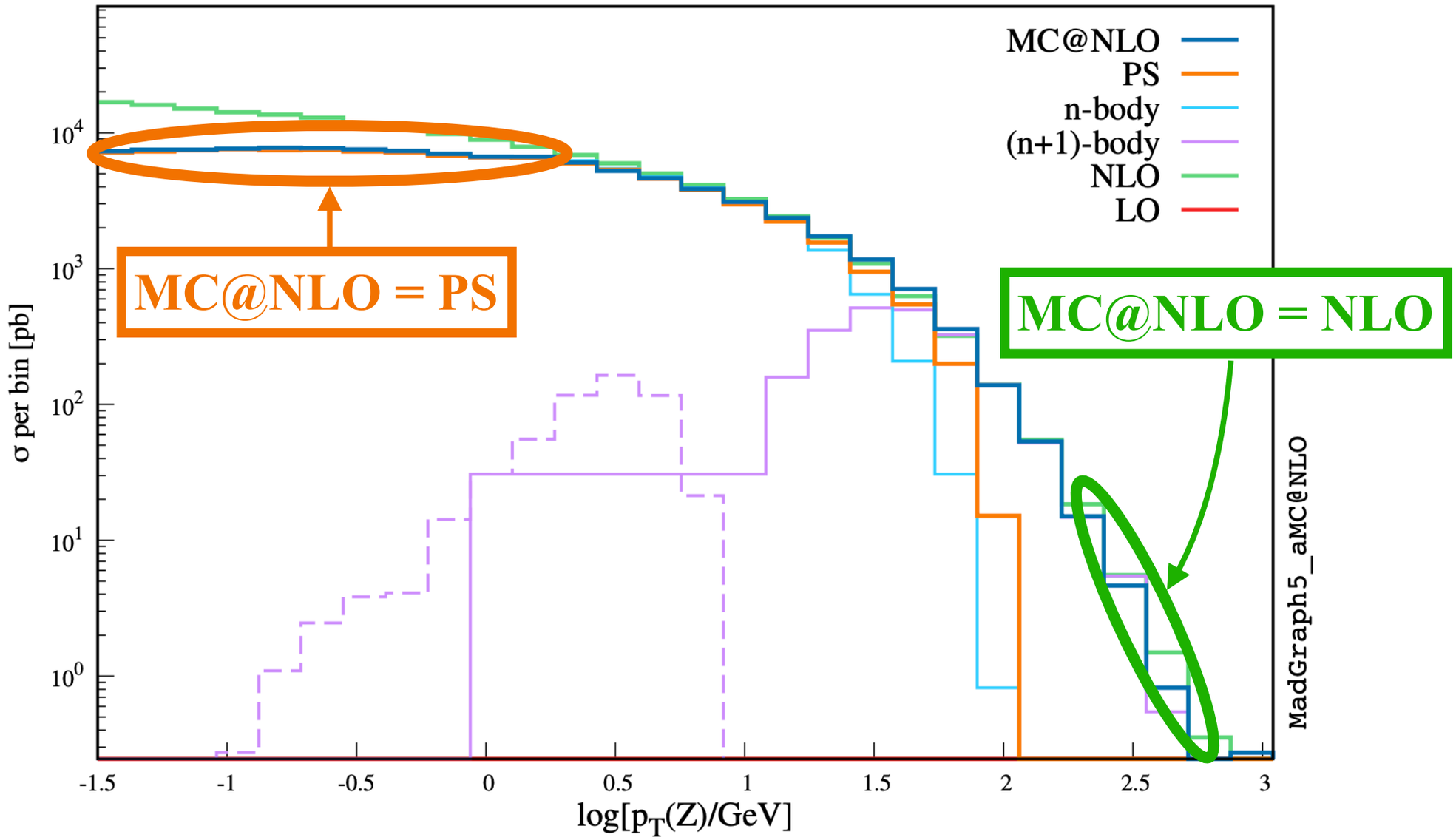
ISR	ISR + FSR
$pp \to Z$ (stable) 	 $pp \to W^+ \to \mu^+\nu_\mu$
$pp \to Z \to \nu_e\bar{\nu}_e$ 	 $pp \to Z \to \mu^+\mu^-$

ISR = initial state radiation

FSR = final state radiation

Differential cross section w.r.t. the Z transverse momentum

ISR $pp \to Z \to \nu_e \bar{\nu}_e$

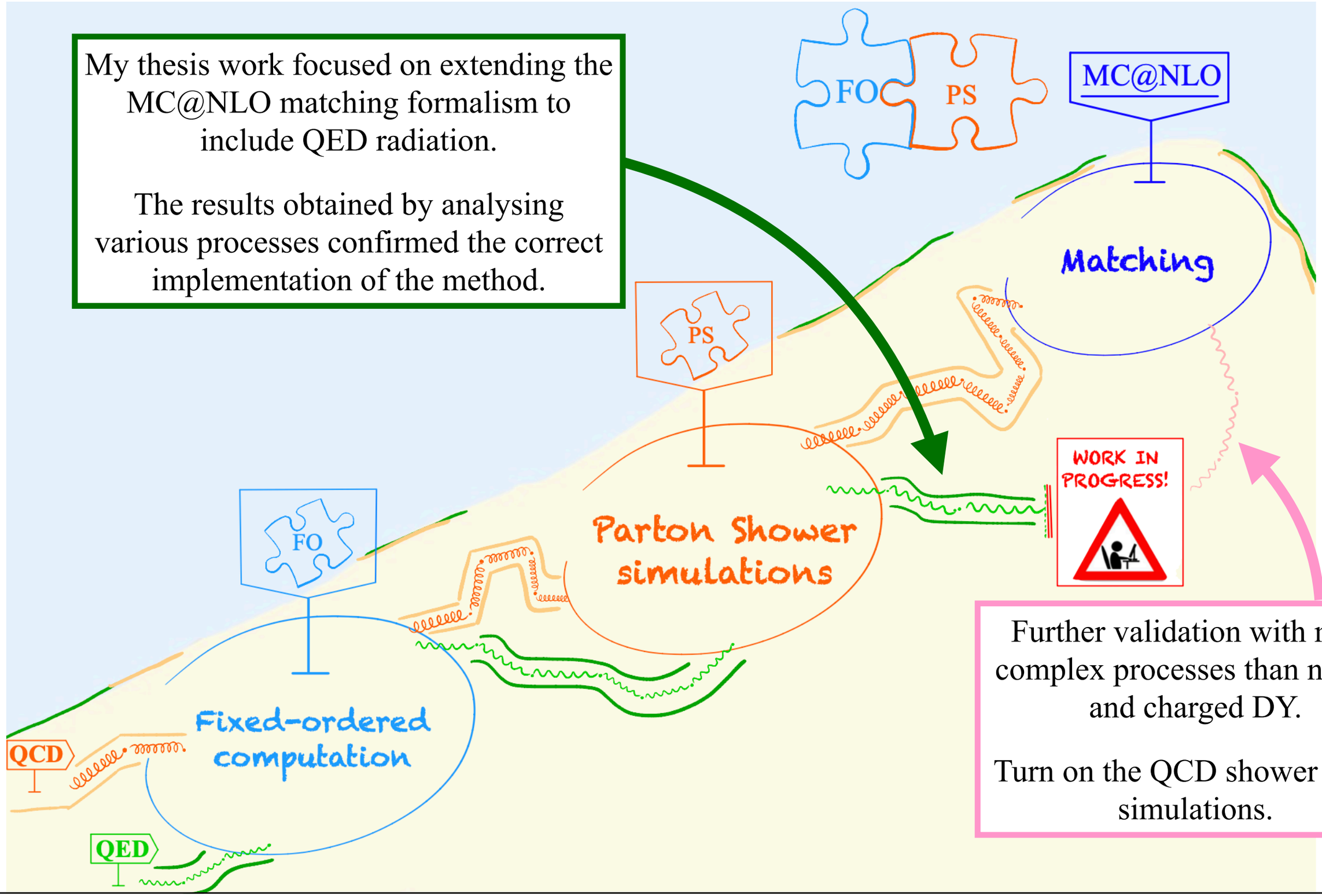


Validation phase

Conclusions and future prospects

My thesis work focused on extending the MC@NLO matching formalism to include QED radiation.

The results obtained by analysing various processes confirmed the correct implementation of the method.



Further validation with more complex processes than neutral and charged DY.

Turn on the QCD shower in the simulations.


LHC
Ice Cube
CUORE
PhD
CERN
ESPLANADE
DES
PARTICULES
If your dreams do not scare you, they are non big enough
and yet it moves
CERN
Be less curious about people, and more about ideas.

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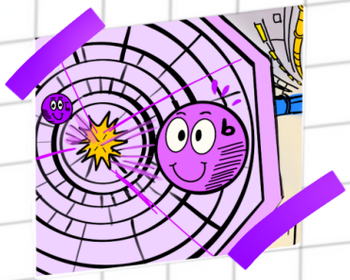
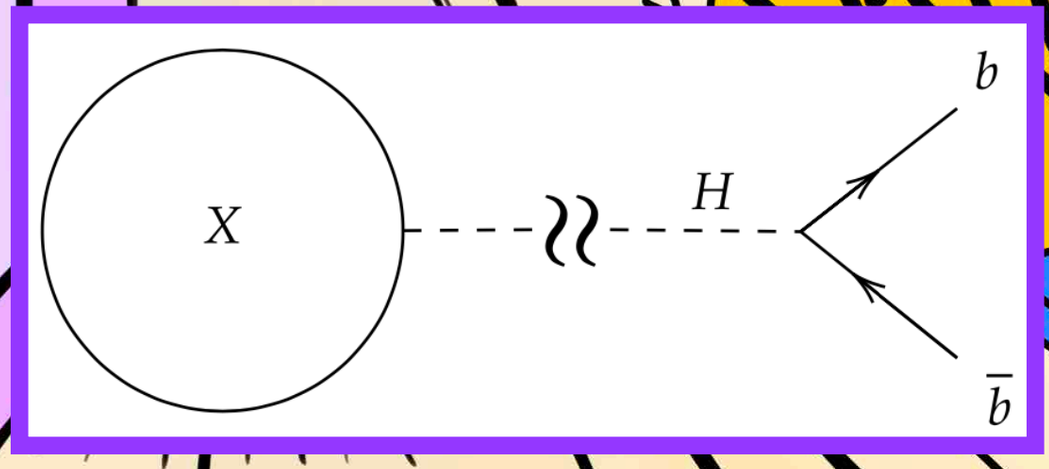
Projects



Collider Phenomenology

Supervisor: Giulia Zanderighi, in collaboration with Arnd Behring, Rhorry Gauld and Marius Wiesemann



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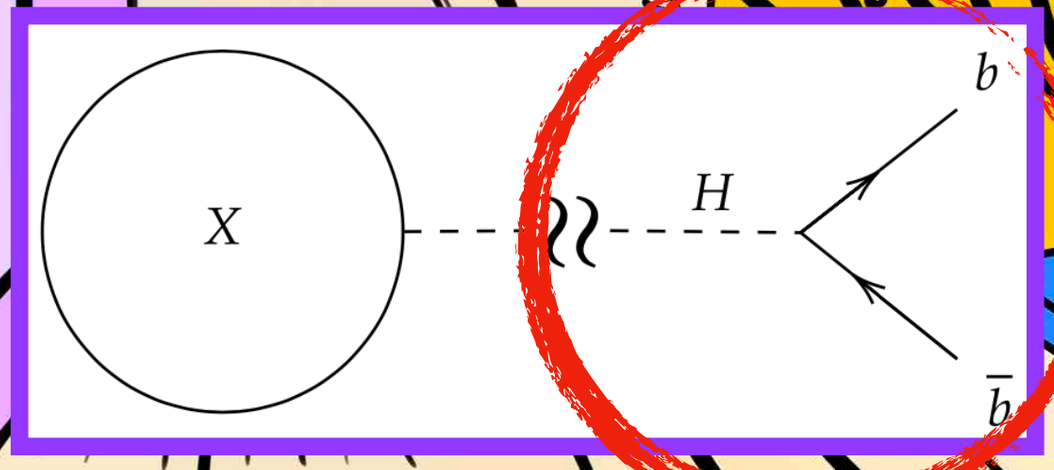
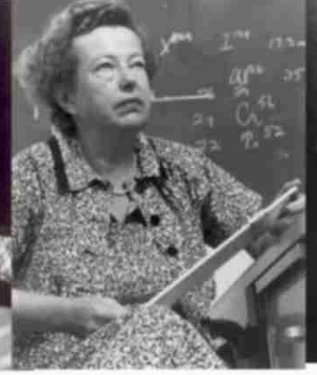








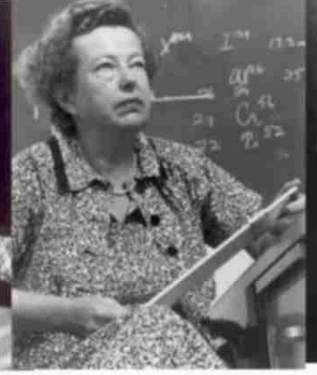






La loro luce si è spenta, com'è destino tra gli esseri umani.

Ma la loro traccia è indelebile, lungo il cammino del progresso, non solo scientifico, dell'umanità.













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Thank you!