Event Generator Development at KEK

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NLO Working Group at KEK

Collaboration with the Minami-Tateya group,
since Jan., 2000

Minami-Tateya Group

(a numerical calculation group)

- Development of the GRACE system
- Parton Shower simulations

NLL-jet (QCD final-state)

QEDPS

GRACE

Automatic calculation software package for HEP
by Minami-Tateya

T. Ishikawa et al., GRACE manual, KEK Report 92-19 (1993)
F. Yuasa et al., Prog. Theor. Phys. Suppl. 138, 18 (2000); hep-ph/0007053

- Automatic generation of Feynman diagrams
- Automatic generation of FORTRAN codes to calculate the cross section
- Including an integration/event-generation tool (BASES/SPRING)

⟶ Event-generator generation system

Powerful for multi-body production processes

Libraries: Standard Model, MSSM, EW 1-loop

Products: grc4f, 4f-prod. in KORALW, GRAPE-Dilepton, SUSY23 etc.

Goals of the NLO WG

1. Development of a GRACE-based tree-level event-generator generation system for hadron physics

   Connection to PYTHIA

2. Development of an automatic QCD-NLO event-generator generation system for hadron physics

   Preparation of a QCD 1-loop library of GRACE

   Development of an NLO event-generation technique

3. Development of NLL (Next-to-Leading Log) initial-state QCD parton-shower simulation: NLL-jet

Present Status

Integration of GRACE and PYTHIA

The framework has been established.

GR@PPA (GRace @ P-P and p-Anti-p)

⟶ GR@PPA_4b for 4-*b* production

QCD-NLO Automatic Calculation

The 1-loop library is partially available.

(3-points only; 4-points in preparation)

Going to establish the event-generation technique

⟶ Drell-Yan as an example

Initial-state NLL-jet

The NLL-QCD evolution has been reproduced by MC.

(talk by K. Kato at Les Houche)

Next step: introduction of kinematics

GR@PPA_4b

A complete set of the event generators at the tree-level for the process:

$$pp \text{ or } p\bar{p} \rightarrow b\bar{b}\,b\bar{b} + X$$

- All possible processes in the SM

Higgs, EW, QCD

Pure QCD generation available

- Exact tree-level calculation

- Divided to 8 sub-processes according to the variation in the initial state and the coupling

Separated/combined generation selectable

- Embedded in PYTHIA

NLO Drell-Yan process (QED only)

$$q\bar{q} \to \gamma^* \to \mu^+\mu^-$$

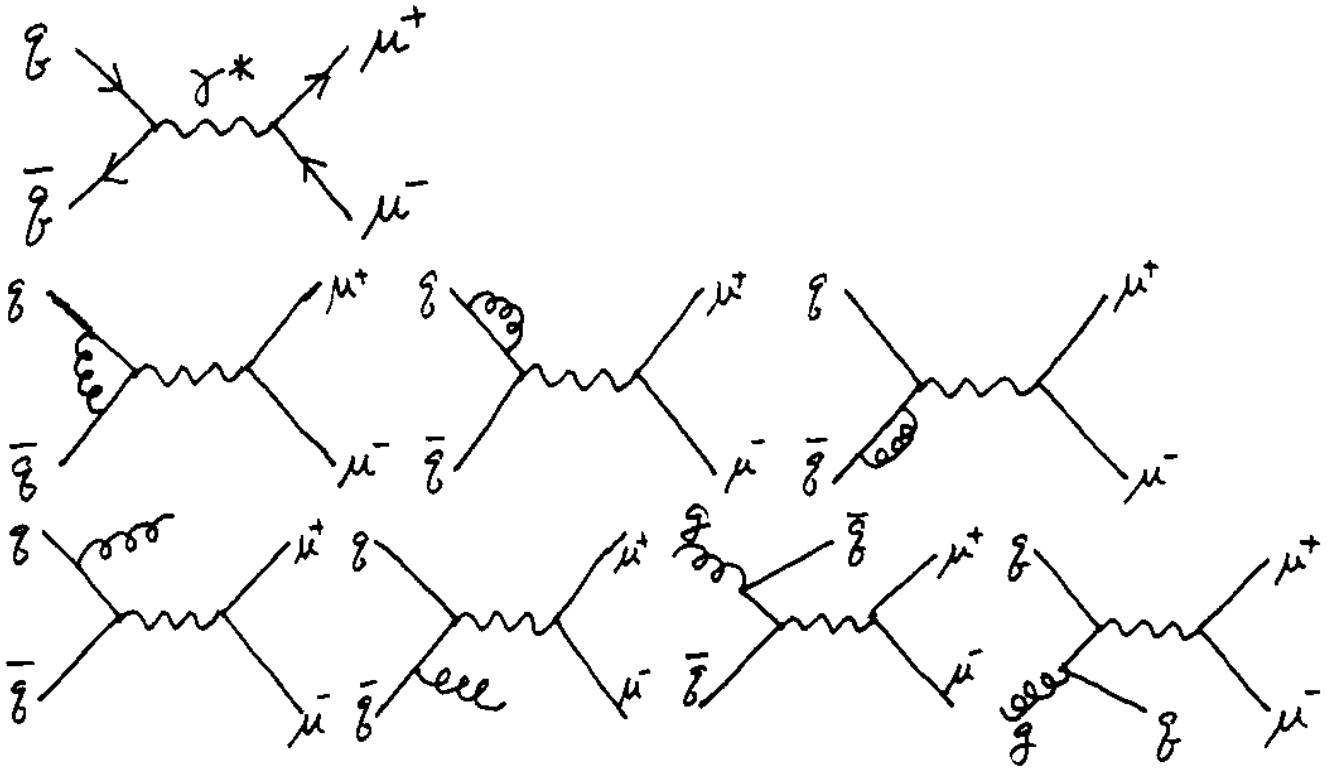
Tevatron Run II condition $\quad q^2_{\mu^+\mu^-} \geq 5\ \mathrm{GeV}^2$

CTEQ4L $\quad \mu^2_{\mathrm{fact}} = \mu^2_{\mathrm{renorm}} = \hat{s}$

Tree

Virtual correction

Emission



$\sigma_{\text{non-rad}} = \sigma_0 + \sigma_v + \sigma_c(\text{invis})$

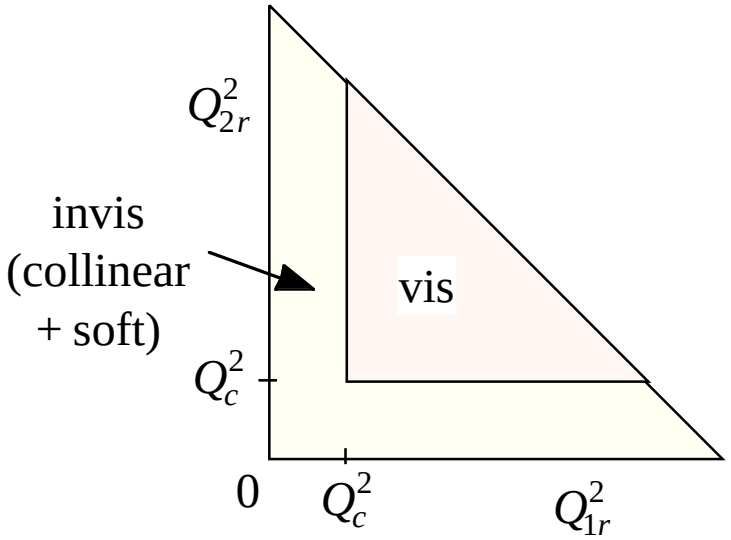
$\sigma_{\text{rad}} = \sigma_{\text{emission}}(\text{vis})$

$\sigma_c =$ collinear approximation

$\sigma_{\text{NLO}} = \sigma_{\text{non-rad}} + \sigma_{\text{rad}}$

Q_c^2 (GeV^2)	$\sigma_{\text{non-rad}}$ (nb)	σ_{rad} (nb)	σ_{NLO} (nb)
10^{-1}	–149.22	219.25	70.03
10^{-2}	–346.22	416.91	70.69
10^{-3}	–605.18	675.93	70.75
10^{-4}	–925.83	996.83	71.00

$Q_{ir}^2 = |t|$ of the radiation



Stable but large negative exists

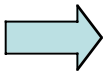
PDF/PS: collinear approximation integrated over whole phase space

$\rightarrow$ the whole σ_c should be in "non - rad".

Q_c^2 (GeV^2)	$\sigma_{\text{non-rad}} + \sigma_c$ (vis) (nb)	$\sigma_{\text{rad}} - \sigma_c$ (vis) (nb)	σ_{NLO} (nb)
10^{-2}	54.21	16.48	70.69

The large negative vanished.

But, not positive definite in the whole phase space.



Further cancellation

or negative-weight events