

Precision QCD at the ILC: $e^+e^- \rightarrow 3 \text{ jets}$

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Jet production in e^+e^- -annihilation

Jets at LEP

- precision test of QCD: coupling constant, structure of gauge group, non-perturbative power corrections, ...
- precise determination of α_s from 3-jet production rate and related event shape observables, extracted using NLO calculation

$$\alpha_s(M_Z) = 0.1202 \pm 0.0003(\text{stat}) \pm 0.0009(\text{sys}) \\ \pm 0.0009(\text{had}) \pm 0.0047(\text{scale})$$

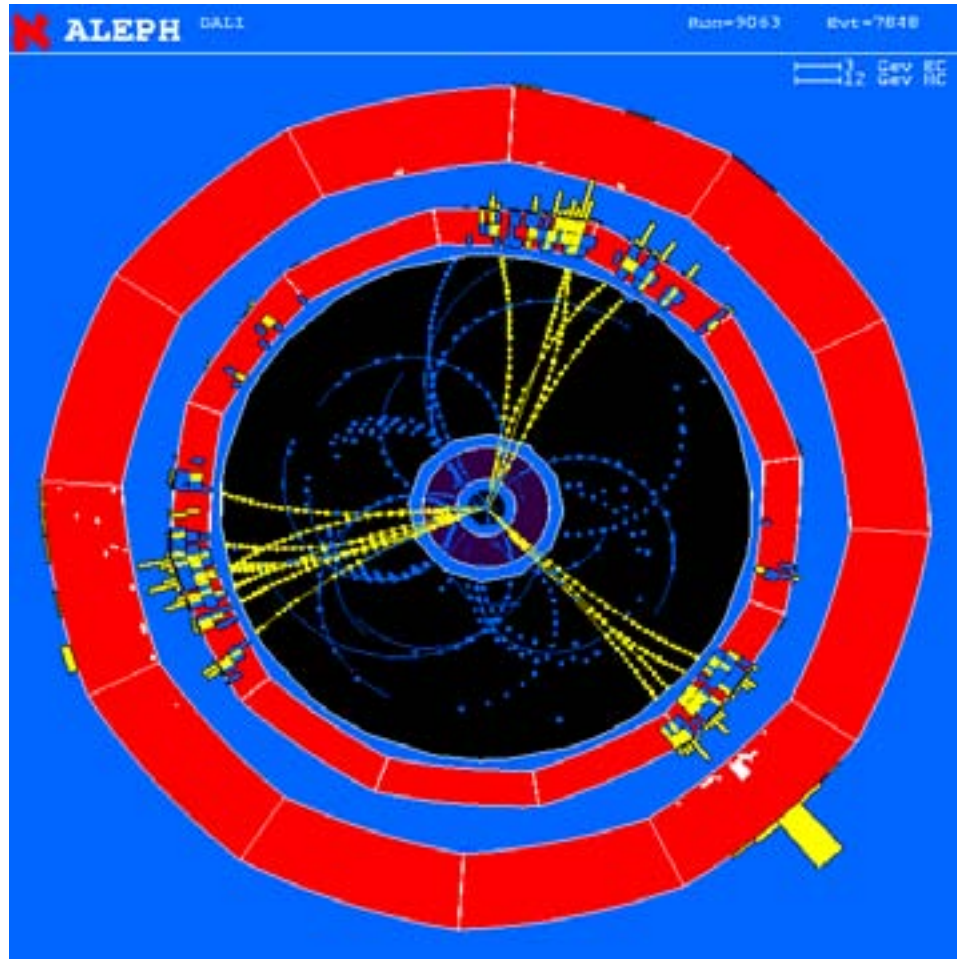
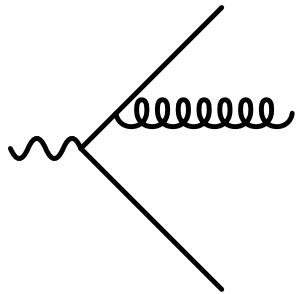
- error on α_s from jet observables dominated by theoretical uncertainty

Jets at ILC

- measure the evolution of $\alpha_s(\sqrt{s})$; sensitive to new physics thresholds
- power corrections (hadronization) less important than at LEP
- relative scale uncertainty comparable to LEP
- up to now: no detailed studies of experimental aspects

Jet observables

$e^+e^- \rightarrow 3 \text{ jets}$
event at LEP



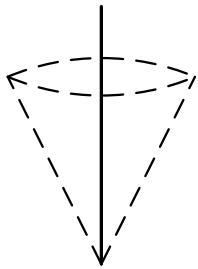
Jet observables

Theoretical description



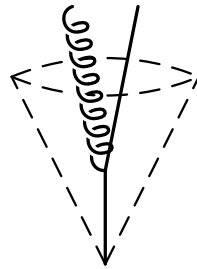
Partons are combined into jets using the same jet algorithm (recombination procedure) as in experiment

LO



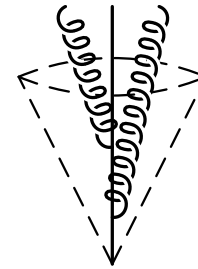
each
parton
forms 1 jet
on its own

NLO



2 partons in
1 jet, 1 parton
experimentally
unresolved

NNLO



3 partons in
1 jet, 2 partons
experimentally
unresolved

Current state-of-the-art: NLO

Expect from NNLO:



reduced error on α_s



better matching of **parton level** and **hadron level** jet algorithm

Status of NNLO corrections to e^+e^-

Ingredients



$\gamma^* \rightarrow q\bar{q}ggg$ and $\gamma^* \rightarrow q\bar{q}q\bar{q}g$ at tree-level

K. Hagiwara, D. Zeppenfeld; F.A. Berends, W.T. Giele, H. Kuijf;
N. Falck, D. Graudenz, G. Kramer



$\gamma^* \rightarrow q\bar{q}gg$ and $\gamma^* \rightarrow q\bar{q}q\bar{q}$ at one loop

Z. Bern, L. Dixon, D. Kosower, S. Weinzierl;
J. Campbell, D.J. Miller, E.W.N. Glover; Z. Nagy, Z. Trocsanyi



$\gamma^* \rightarrow q\bar{q}g$ at two loops

L. Garland, E.W.N. Glover, A. Koukoutsakis, E. Remiddi, TG

Implementation



aim: **parton level event generator**, allowing to compute jet rates and event shapes



method: **antenna subtraction** for infrared real radiation singularities

A. Gehrmann-De Ridder, E.W.N. Glover, TG



present status: **3 of 7 colour structures implemented**

A. Gehrmann-De Ridder, E.W.N. Glover, G. Heinrich, TG

Summary

- ILC can perform precision QCD measurements
 - extraction of $\alpha_s(\sqrt{s})$ from three-jet event shapes is only an example
 - expect smaller non-perturbative hadronization effects than at LEP
 - more studies on experimental aspects are needed
- expect QCD studies at ILC to be limited by theoretical accuracy of NLO calculations
- derivation of NNLO corrections to jet production in e^+e^- in progress