Measurement of α_s in Radiative Hadronic Events

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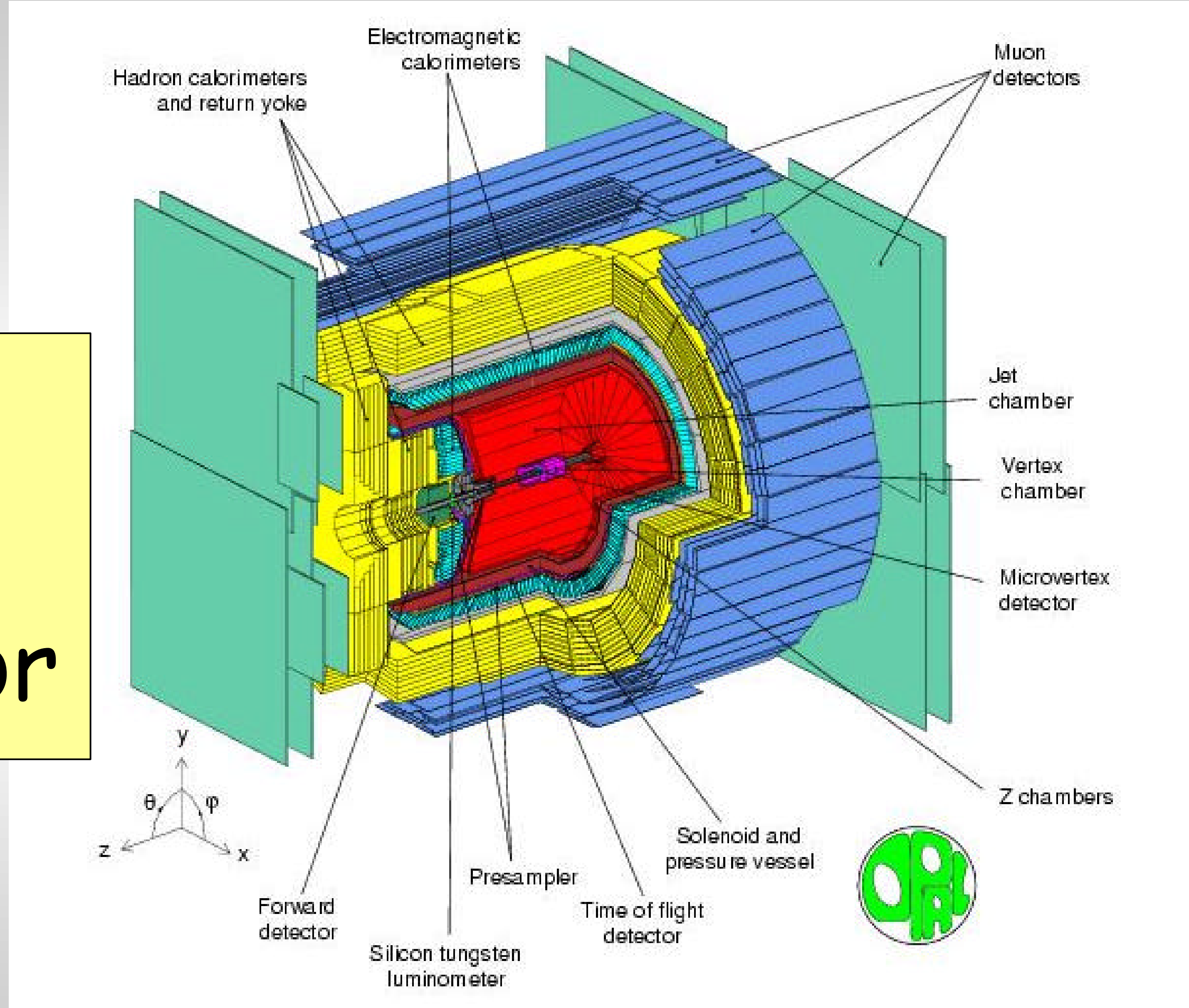
Outline

- Introduction and Motivation
- Event Selection
- Determination of $\sqrt{s'}$
- Event Shape Fits

OPAL Physics Note 519

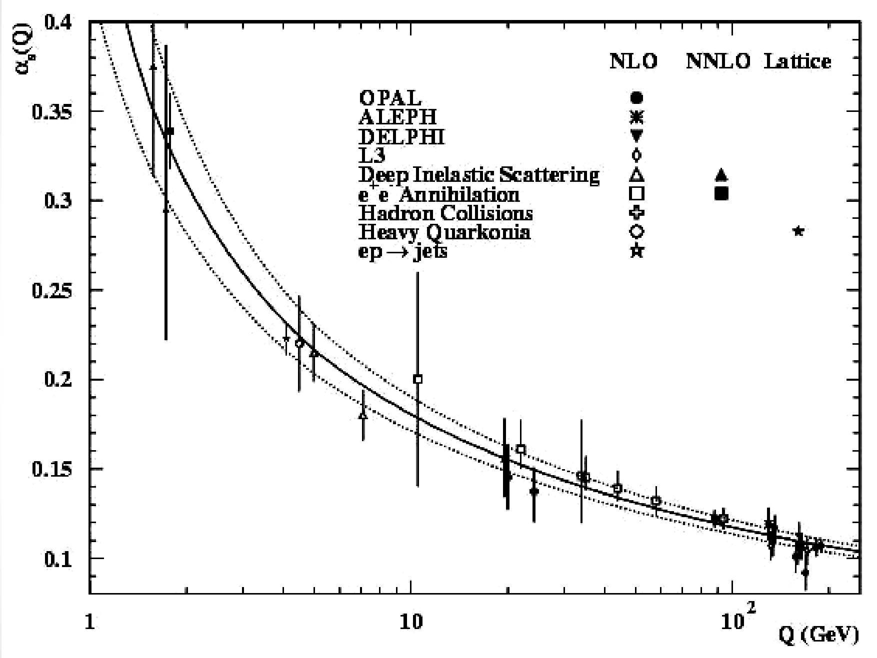
The OPAL Detector



Introduction and Motivation

- QCD predicts running of α_s as a function of the energy scale μ
- e^+e^- collider experiments:

  energy scale $\approx \sqrt{s}$



radiative hadronic events allow QCD studies at reduced CME

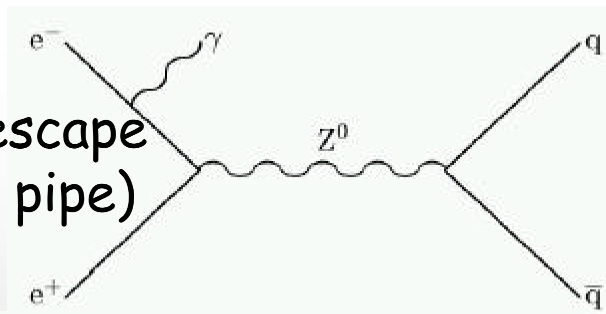
3×10^6 hadronic Z^0 decays selected at 91.2 GeV

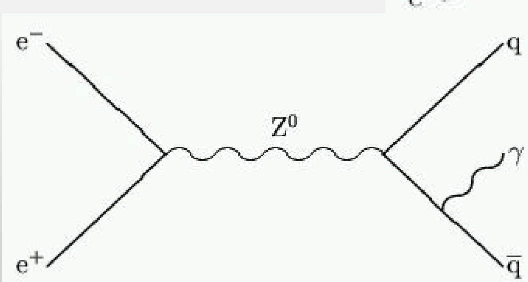
Radiative Hadronic Events

Photon emission before or immediately after Z^0
Production do not interfere with QCD process

Initial State Radiation

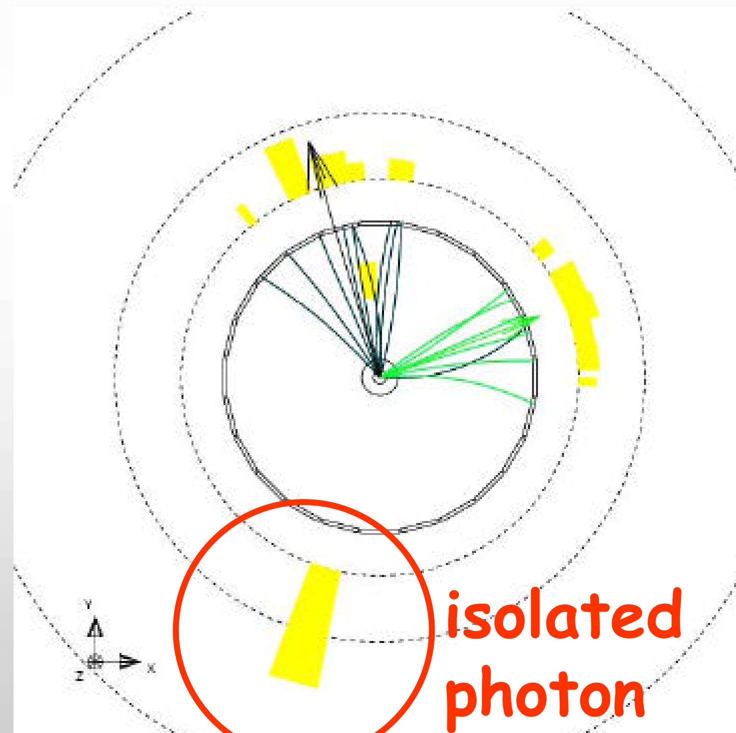
(most photons escape along the beam pipe)





mainly at LEP I

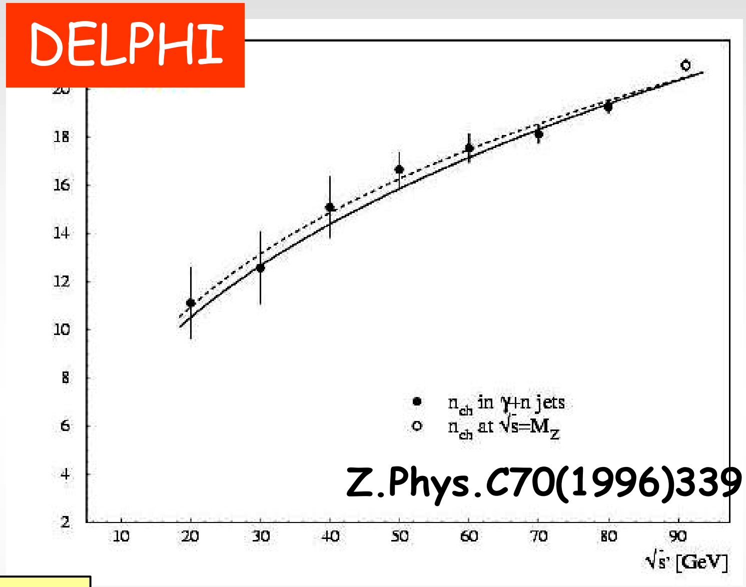
Final State Radiation

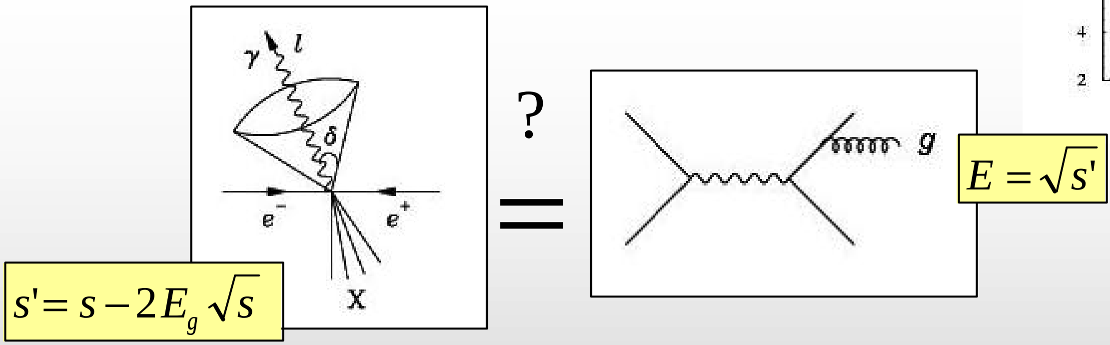


isolated photon

Introduction and Motivation

- $\langle n_{ch} \rangle$ as a function of $\sqrt{s'}$ in radiative events
  - probes soft QCD

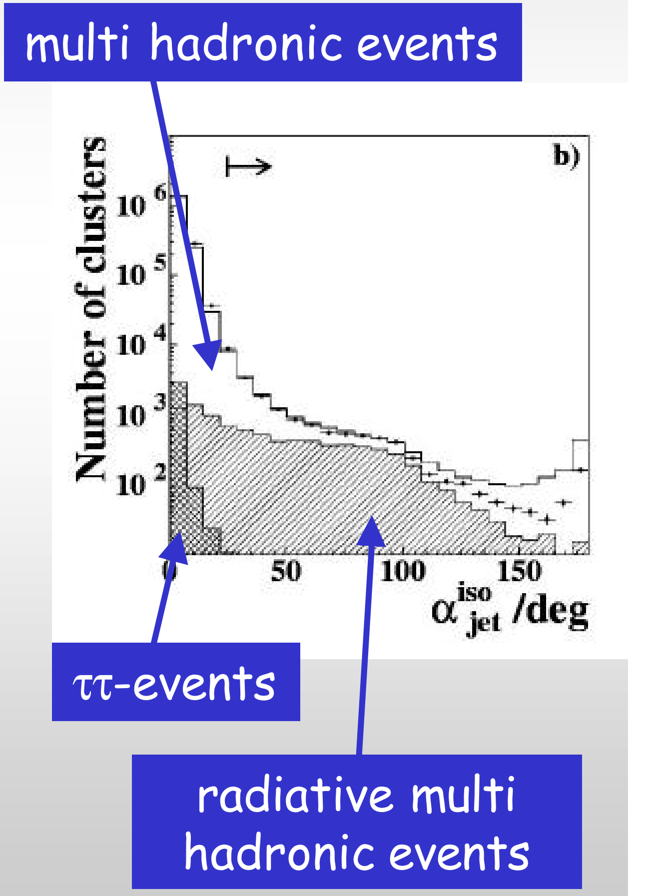




- time scale of photon radiation has to be less than scale of parton shower
- experimental selection cuts: photon with large k_T to recoiling qq pair

Event Selection (I): Isolation Cuts

- EM cluster in barrel region
- Select EM cluster with 10 GeV energy
- angle between the photon and any jet is required to be larger than 25^0
- energy and momentum in a 0.2 radian cone around the cluster less than 0.5 GeV/(c)



Event Selection (II): Likelihood

Likelihood Photon Selection:

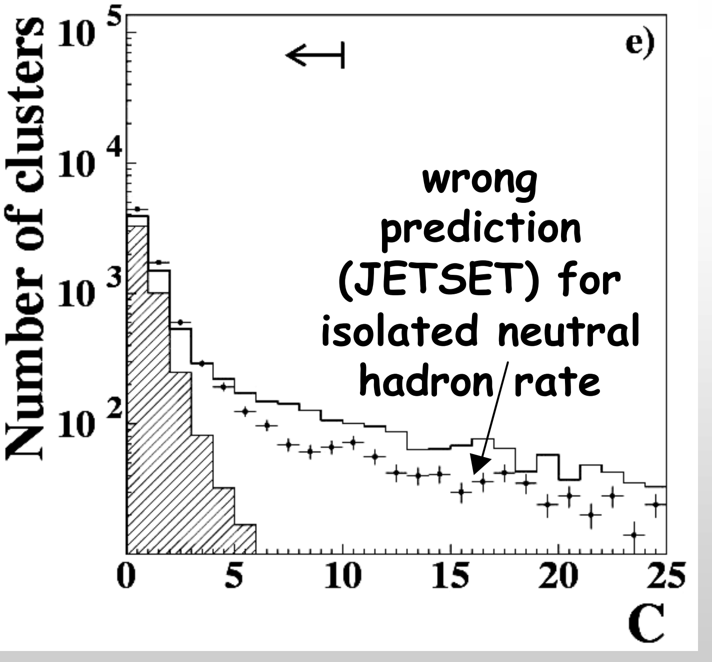
- barrel region and isolation
- difference to presampler measurement

•cluster shape fit variable :

measured energy deposit → $E_{meas,i}$

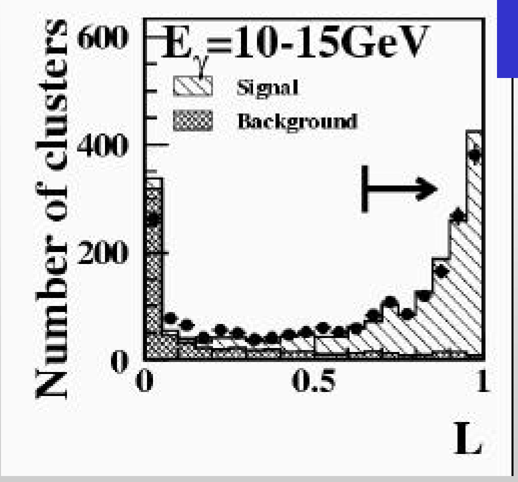
expected energy deposit (from MC) → $E_{\exp,i}$

$$C = \frac{1}{N_{block}} \sum_i \frac{(E_{meas,i} - E_{\exp,i})^2}{s^2_{meas,i}}$$



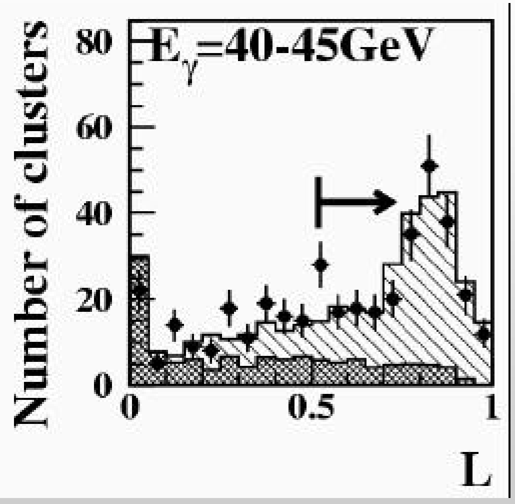
Event Selection: Background

- number of isolated neutral hadrons from fit to data
- isolated neutral hadrons are the dominant source of background
    - non-radiative events which are classified as radiative events fake events at higher scale (impact on α_s)



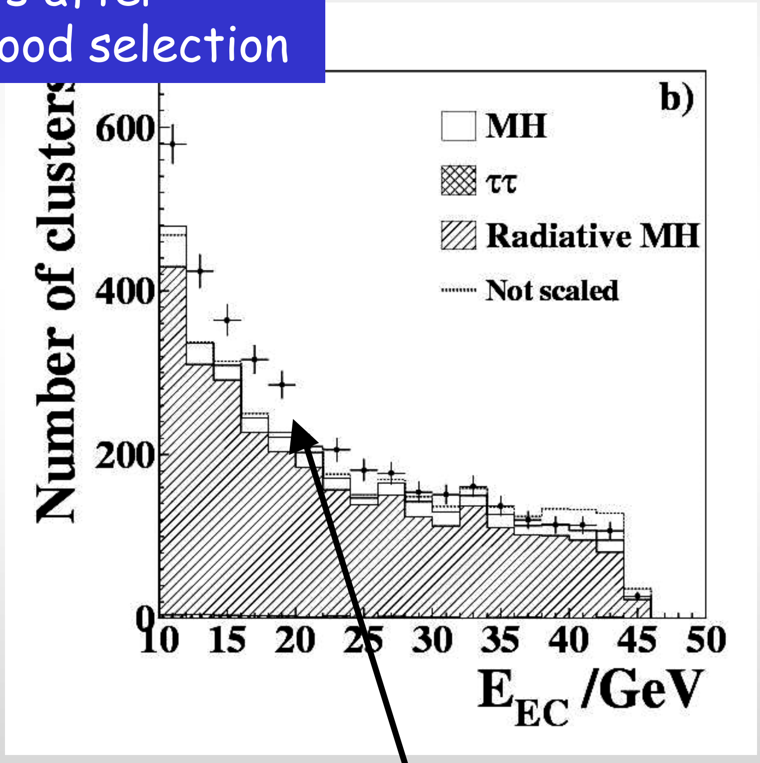
Likelihood distribution

- 7 different energy bins



Selected Events

number of selected clusters after Likelihood selection



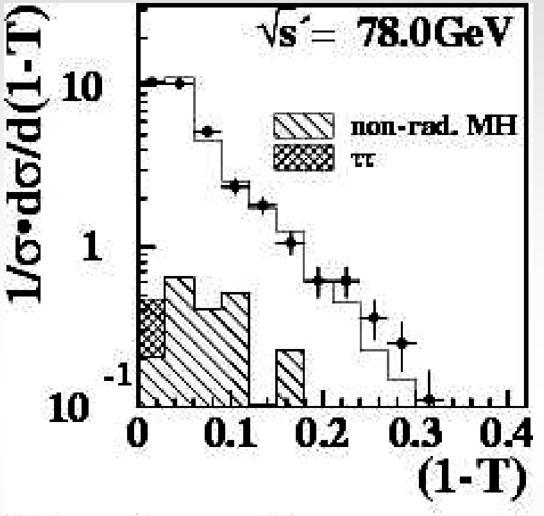
E_γ	Events	$\sqrt{s'}_{Mean}$
10-15	1200	78.0±1.7
15-20	764	71.7±1.8
20-25	511	65.0±2.1
25-30	418	57.6±2.3
30-35	383	48.9±2.6
35-40	303	38.5±3.4
40-45	248	24.3±5.3

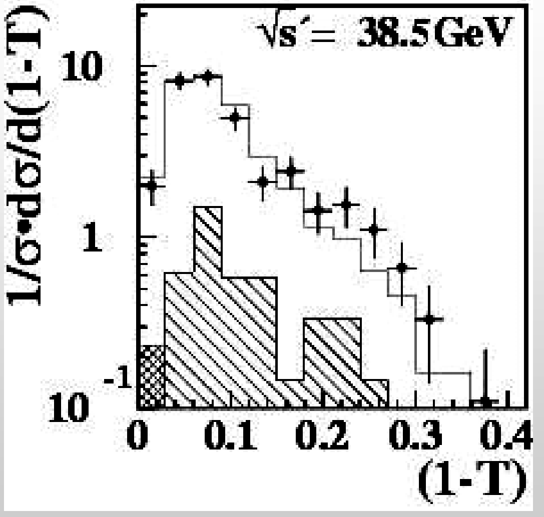
JETSET fails to reproduce the isolated photon rate

Event Shape Variables

- Thrust (1-T)
- Heavy Jet Mass M_H
- Jet Broadening B_T and B_W

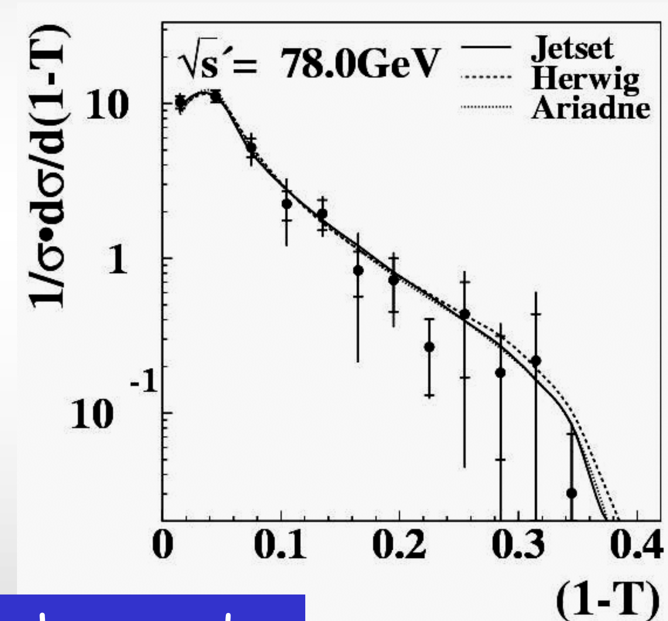
event is boosted back into center of mass system of hadrons





Correction of Event Shape Distributions

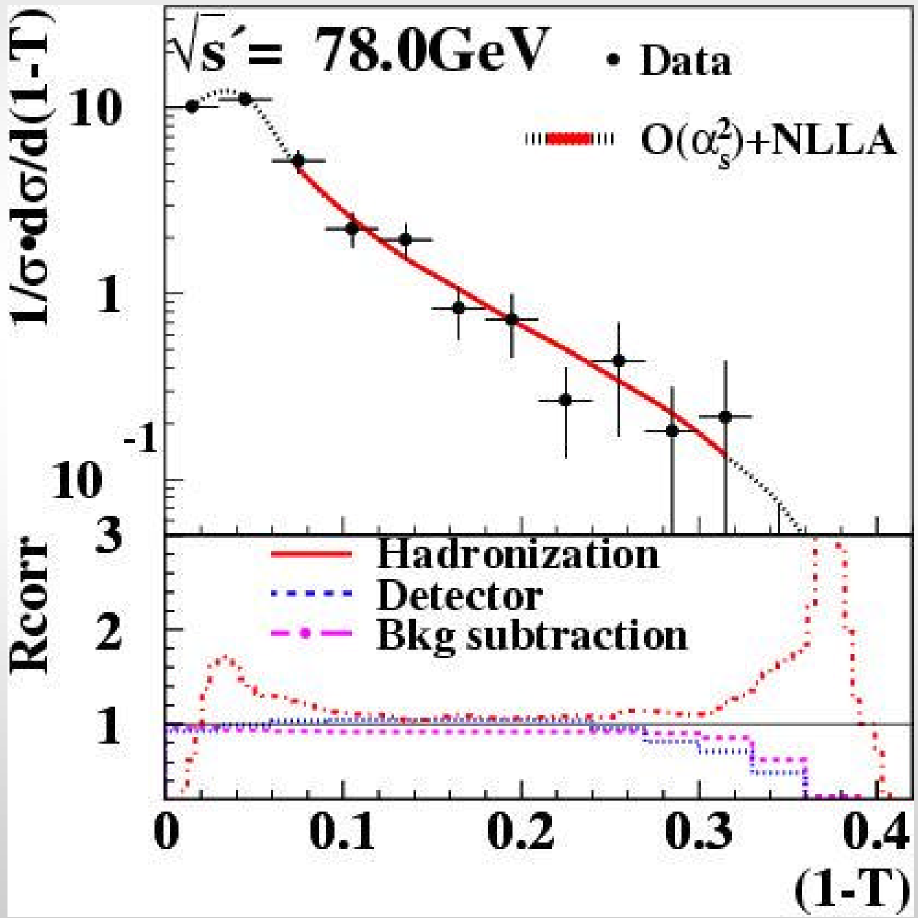
- background contributions subtracted with Monte Carlo
  - non-radiative Multihadrons (~5-15%)
  - $\tau\tau$ events (~1%)
- bin-by-bin correction for detector effects



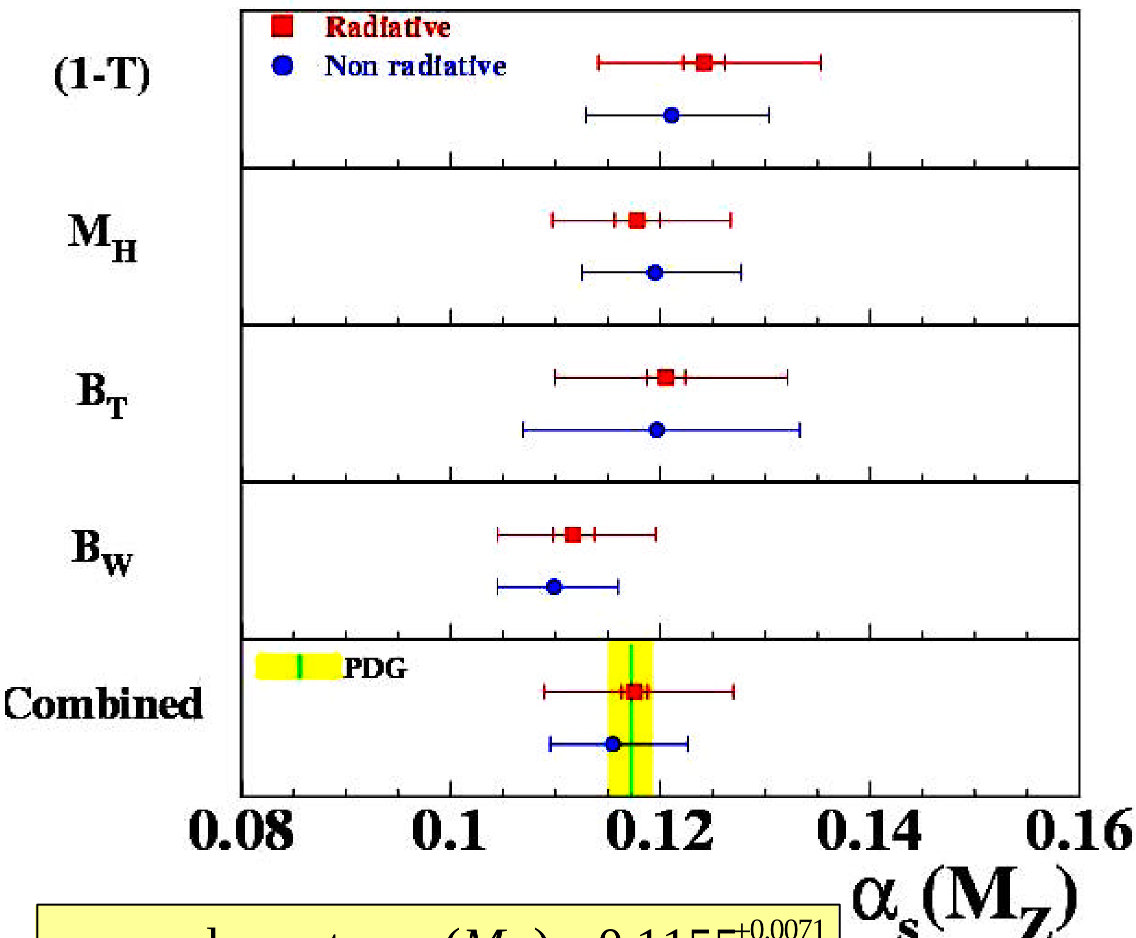
(1-T) after background subtraction and correction for detector effects

Measurement of α_s

- $O(\alpha_s^2)$ and NLLA perturbative QCD predictions combined with ln(R) matching scheme
- MC at √s′ used for bin-by-bin hadronisation correction
- fit performed in the region with small corrections



Combined Result for $\alpha_s(M_Z)$



non-rad.events: $a_s(M_Z) = 0.1155^{+0.0071}_{-0.0060}$

combined value for α_s propagated to energy scale of M_Z:

$$a_s(M_Z) = 0.1176 \pm 0.0012(stat.)^{+0.0093}_{-0.0085}(syst.)$$

Systematic Uncertainties

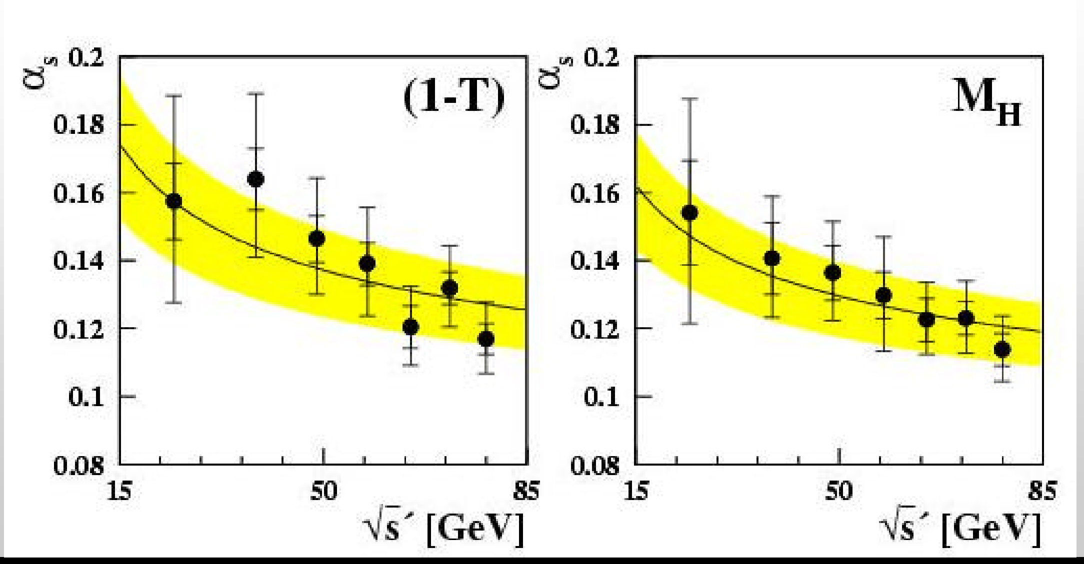
- experimental uncertainty :**0.0034**
  - largest contribution:
    tighter cut on thrust axis (0.0031)
- hadronisation uncertainty: **0.0061**
  - largest contribution:
    HERWIG instead of JETSET (-0.0050)
- theoretical uncertainty **+0.0062-0.0049**
  change of scale x_μ =0.5 … 2

Total systematic error: $^{-0.0085}_{+0.0093}$

Energy dependence of α_s

combined NNLO fit to renormalisation group equation with $\Lambda^{(5)}_{\overline{MS}}$ as free parameters

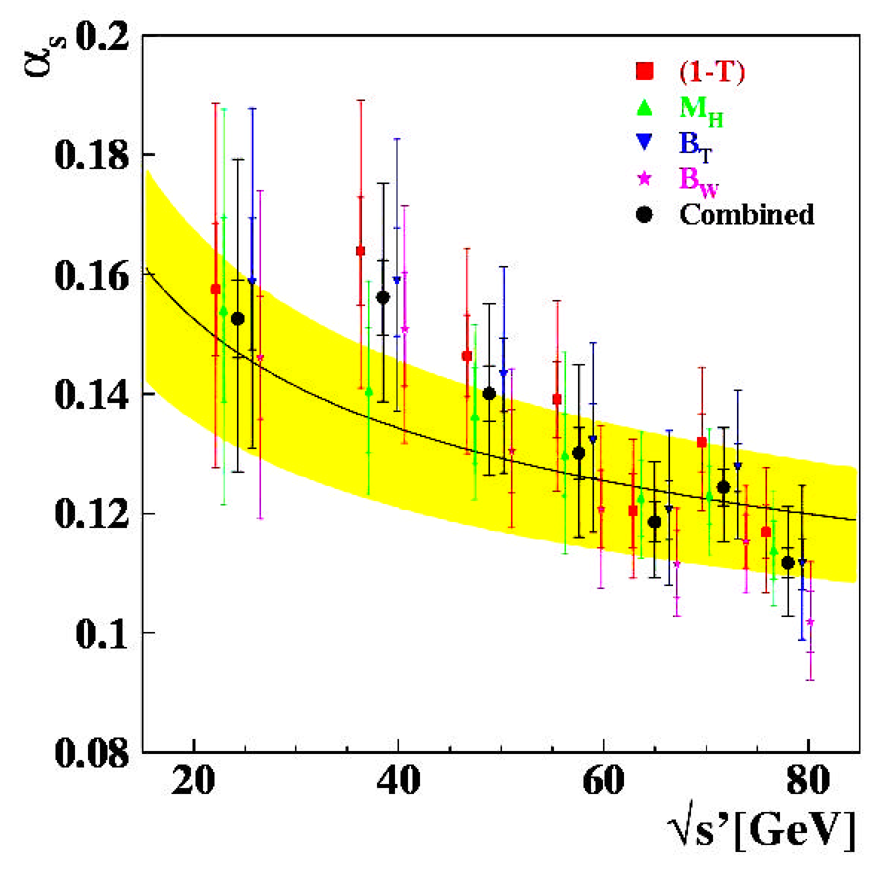
$$\Lambda^{(5)}_{\overline{MS}} = 0.203 \pm 0.014(stat.)^{+0.113}_{-0.094}(syst.)GeV$$



(value for α_s in agreement with combined measurement)

Conclusion

- measurement of α_s with radiative Z^0 events
  - FSR allows access to lower energy scales at the same experiment
- value of α_s consistent with measurement with non-radiative events



$$a_s(M_Z) = 0.1176 \pm 0.0012(stat.)^{+0.0093}_{-0.0085}(syst.)$$