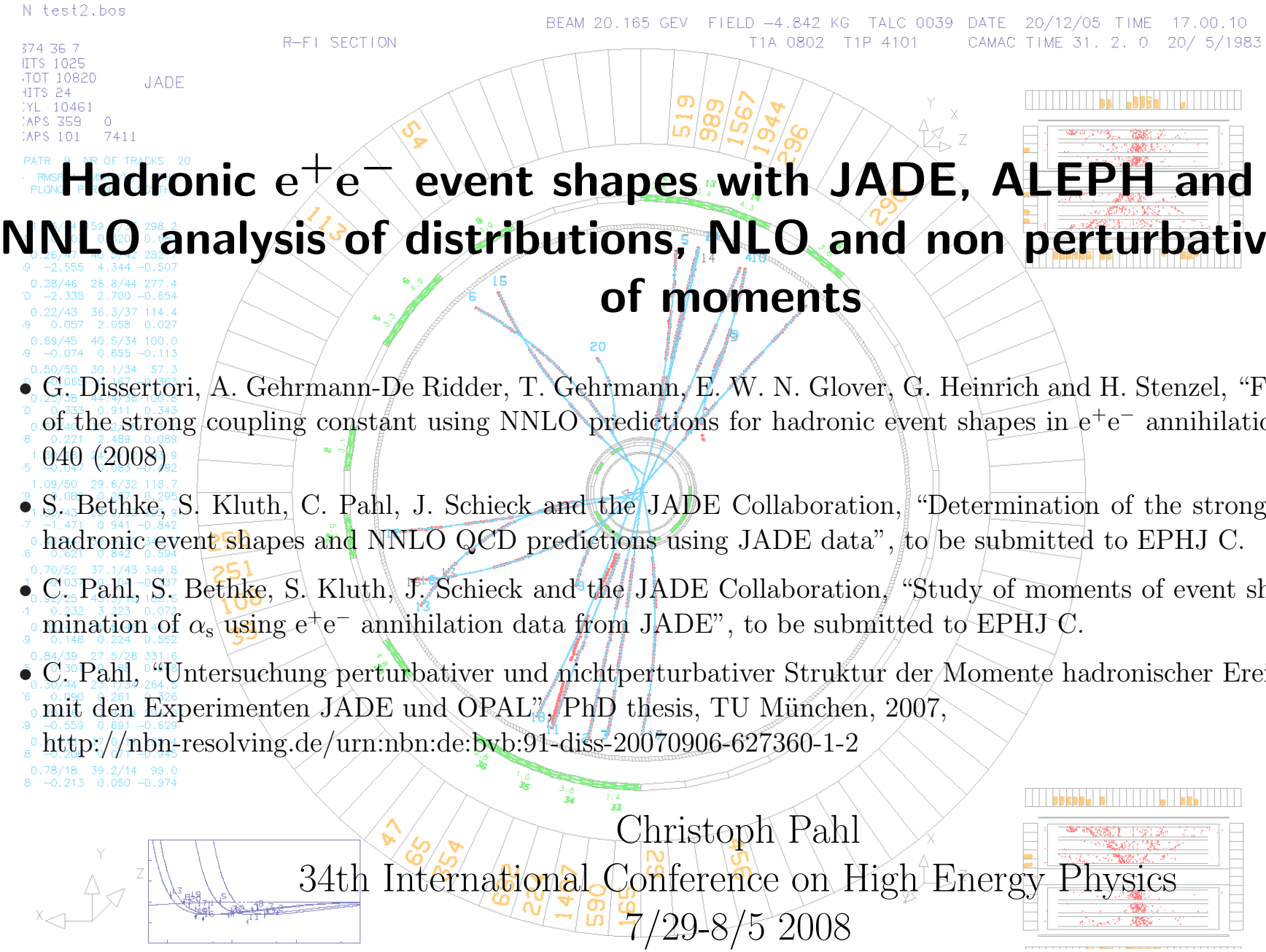
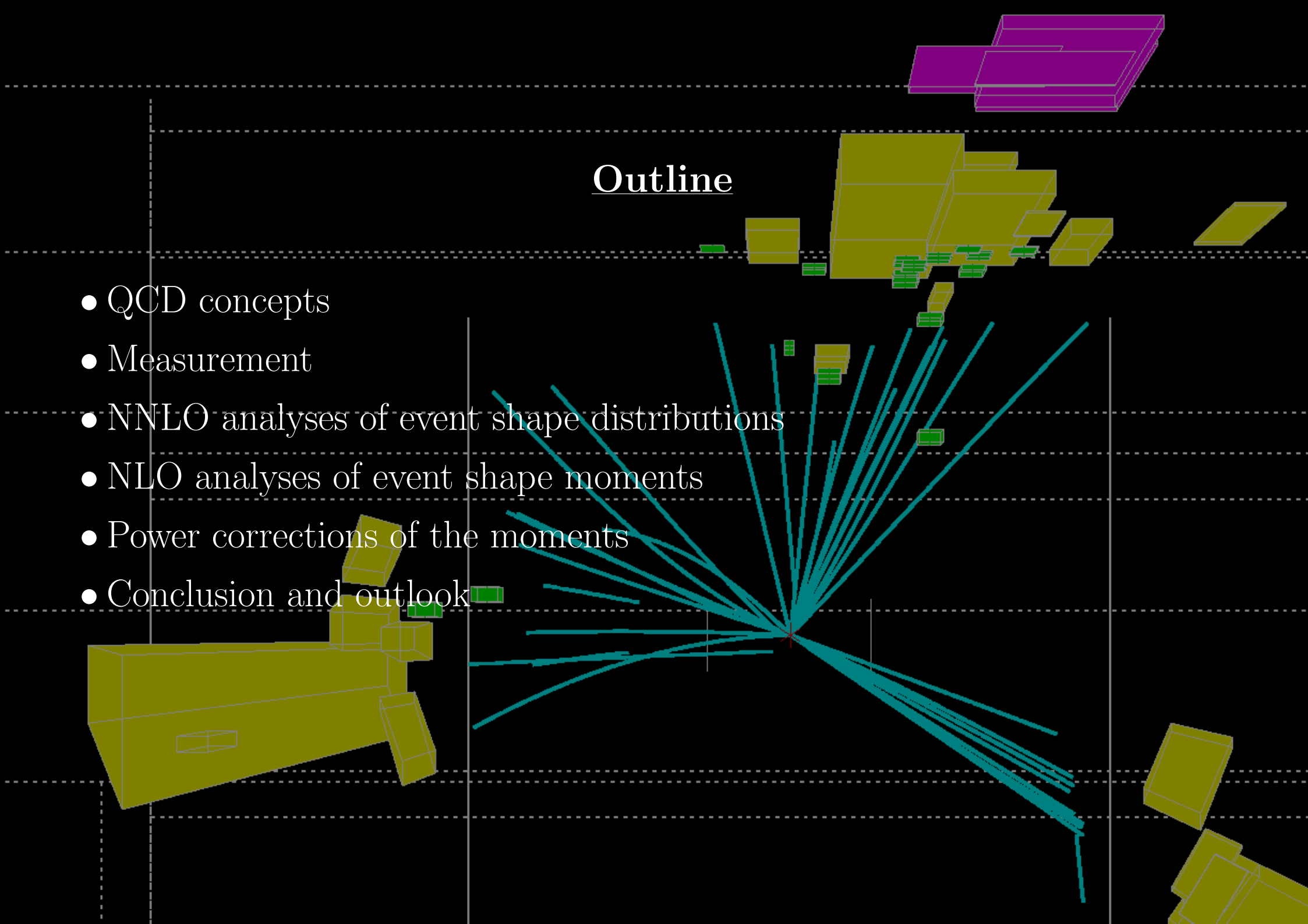


Hadronic e^+e^- event shapes with JADE, ALEPH and OPAL: NNLO analysis of distributions, NLO and non perturbative analysis of moments

- G. Dissertori, A. Gehrmann-De Ridder, T. Gehrmann, E. W. N. Glover, G. Heinrich and H. Stenzel, "First determination of the strong coupling constant using NNLO predictions for hadronic event shapes in e^+e^- annihilations", JHEP **0802**, 040 (2008)
- S. Bethke, S. Kluth, C. Pahl, J. Schieck and the JADE Collaboration, "Determination of the strong coupling α_s from hadronic event shapes and NNLO QCD predictions using JADE data", to be submitted to EPHJ C.
- C. Pahl, S. Bethke, S. Kluth, J. Schieck and the JADE Collaboration, "Study of moments of event shapes and a determination of α_s using e^+e^- annihilation data from JADE", to be submitted to EPHJ C.
- C. Pahl, "Untersuchung perturbativer und nichtperturbativer Struktur der Momente hadronischer Ereignisformvariablen mit den Experimenten JADE und OPAL", PhD thesis, TU München, 2007, http://nbn-resolving.de/urn:nbn:de:bvb:91-diss-20070906-627360-1-2

Christoph Pahl

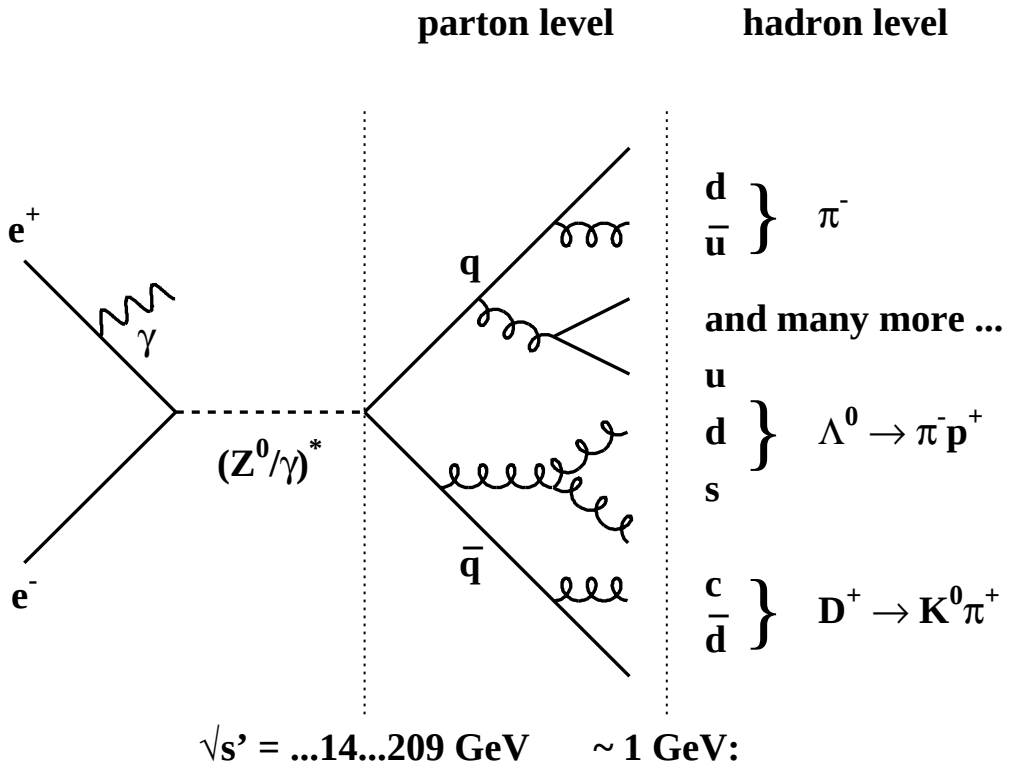
34th International Conference on High Energy Physics
7/29-8/5 2008



Outline

- QCD concepts
- Measurement
- NNLO analyses of event shape distributions
- NLO analyses of event shape moments
- Power corrections of the moments
- Conclusion and outlook

Hadronic event in e^+e^- annihilation

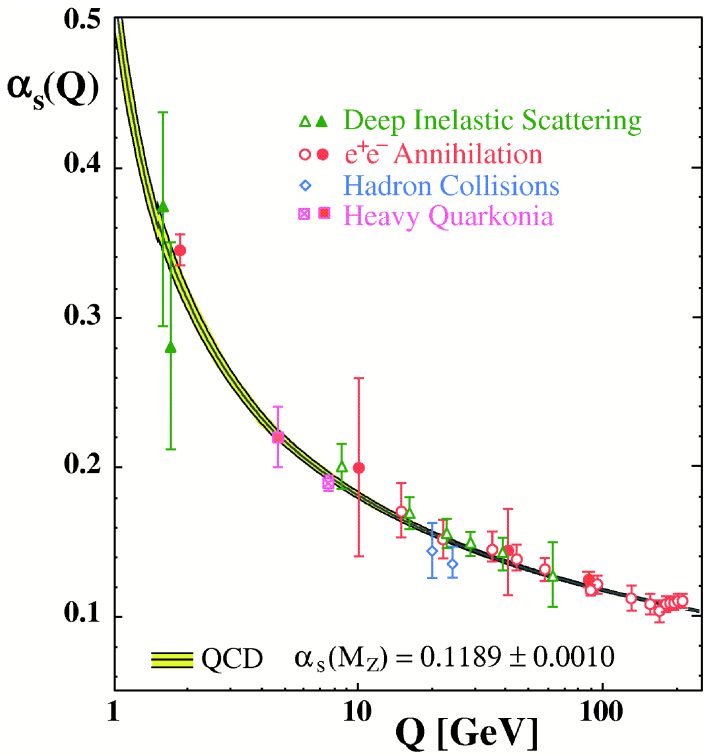


Hadronisation:

- Monte Carlo models
- Analytical models – power corrections

Running coupling

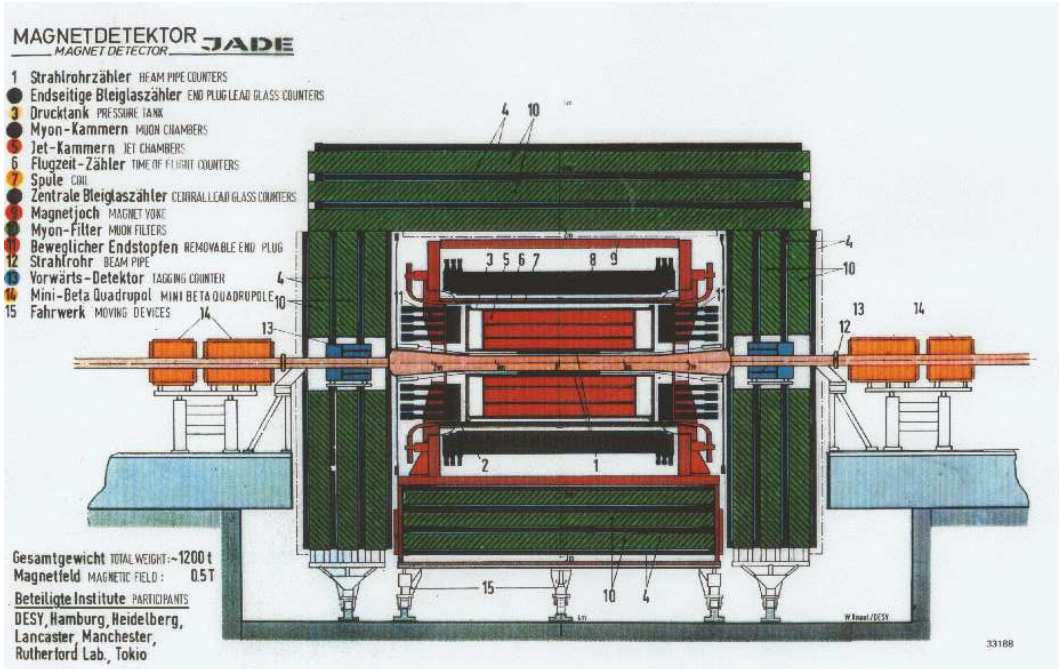
(S. Bethke, Prog. Part. Nucl. Phys., 58:351)



world average:
$\alpha_s(M_{Z^0})$=0.1189±0.0010

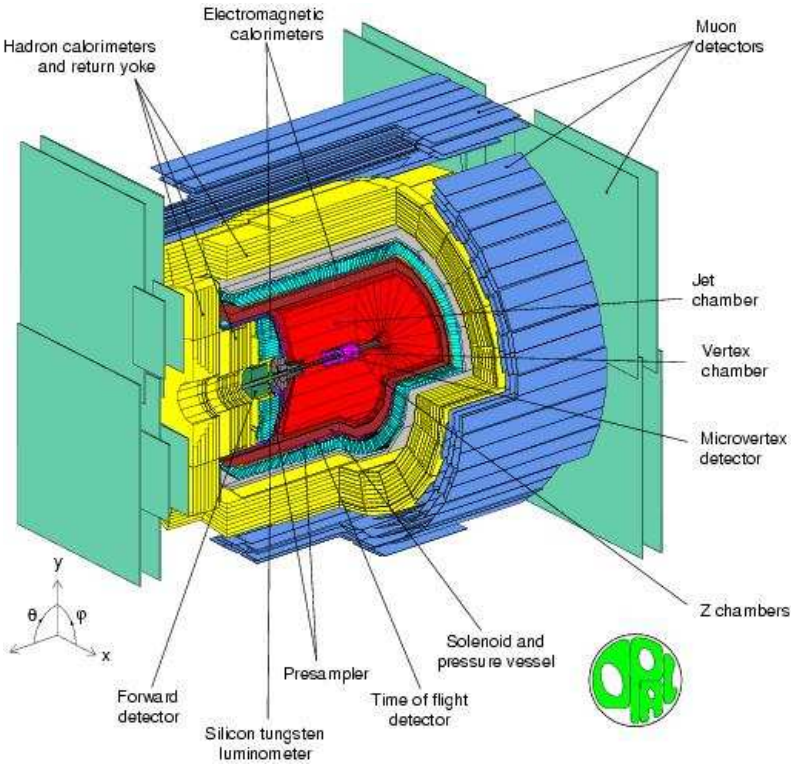
Experiments

JADE



12-44 GeV
1978-1986

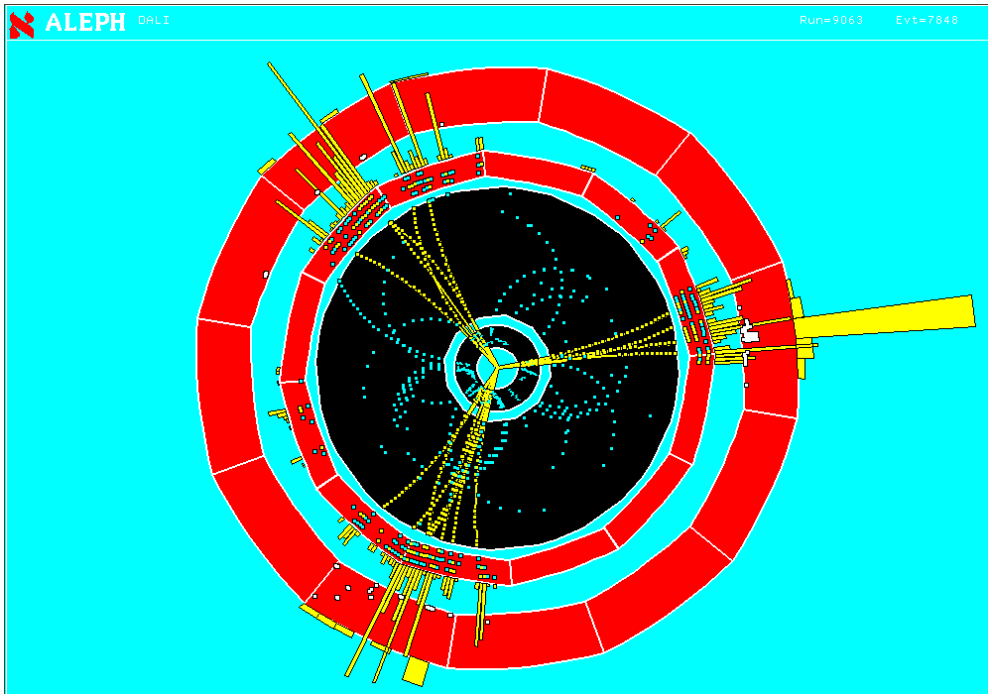
OPAL



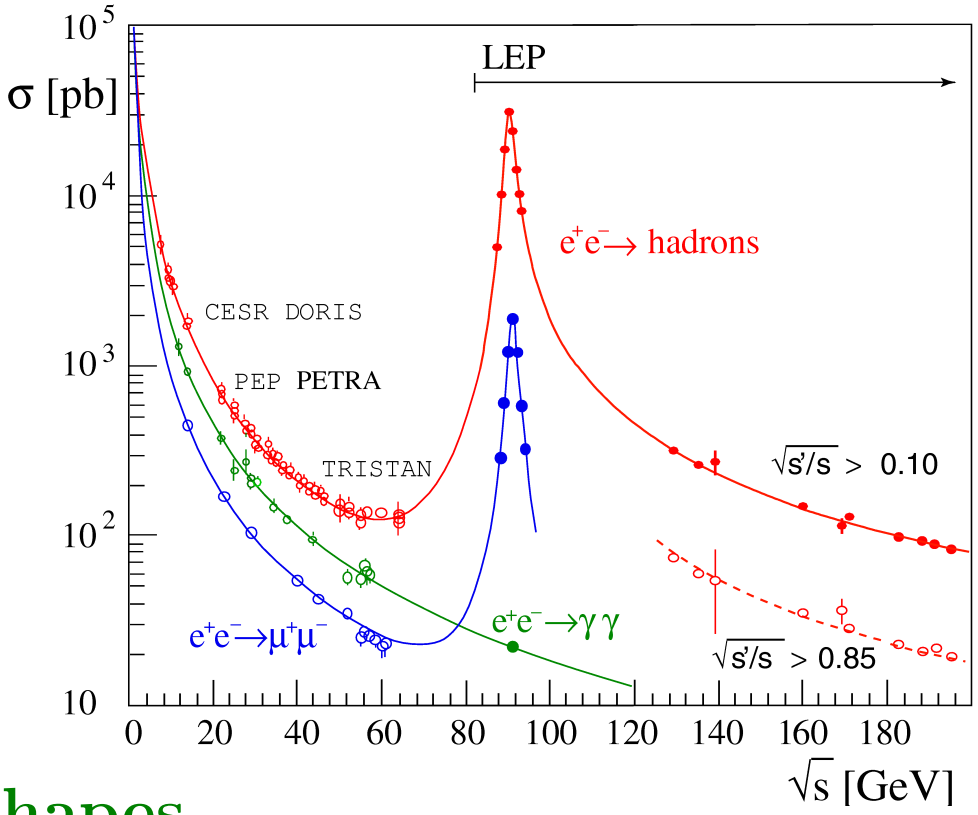
91-209 GeV
1989-2000

Comparable measurement

ALEPH



Hadronic cross section



Event shapes

Thrust $1-T$.

C-Parameter C ,

Total Jet Broadening B_{T} .
(Two-hemisphere variables)

Heavy Jet Mass M_{H} .

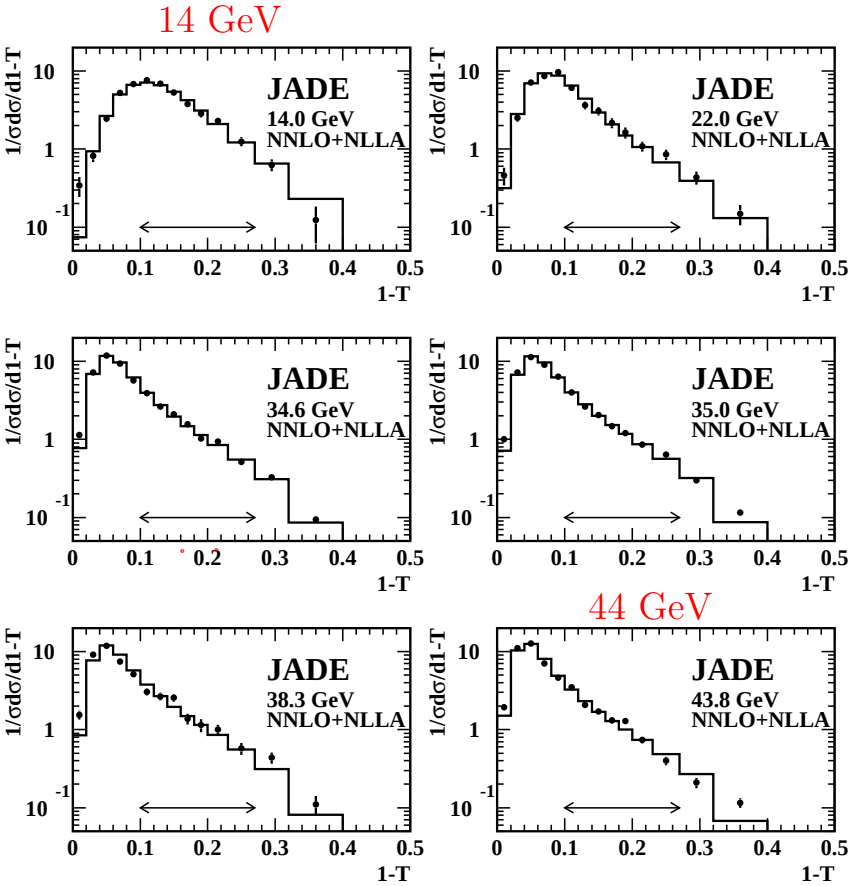
Wide Jet Broadening B_{W} ,

Durham two-jet flip parameter $y_{23}^{\mathrm{D}} \equiv y_3$.
(One-hemisphere variables)

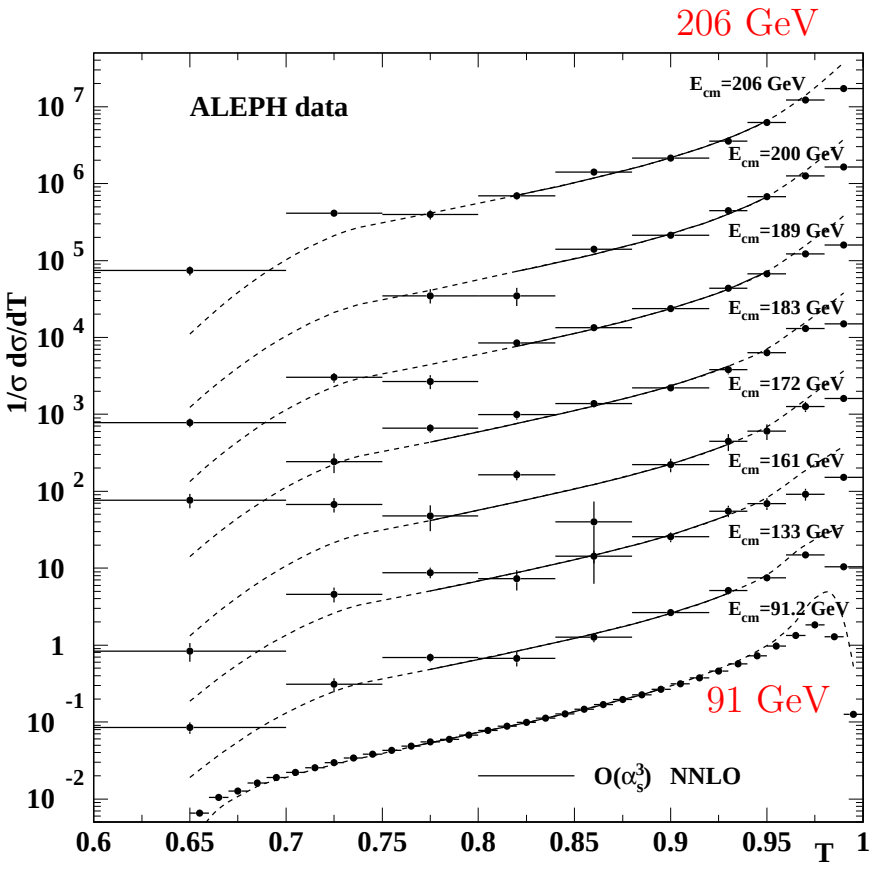
Fits of event shape distributions: Thrust

$$\frac{1}{\sigma_0}\frac{\mathrm{d}\sigma}{\mathrm{d}y}(s,y) = \left(\frac{\alpha_s(\mu^2)}{2\pi}\right)\frac{\mathrm{d}\bar{A}}{\mathrm{d}y} + \left(\frac{\alpha_s(\mu^2)}{2\pi}\right)^2\frac{\mathrm{d}\bar{B}}{\mathrm{d}y} + \left(\frac{\alpha_s(\mu^2)}{2\pi}\right)^3\frac{\mathrm{d}\bar{C}}{\mathrm{d}y} \quad + \text{normalisation} + \text{scale dependence}$$

JADE: NNLO+NLLA (prelim.)



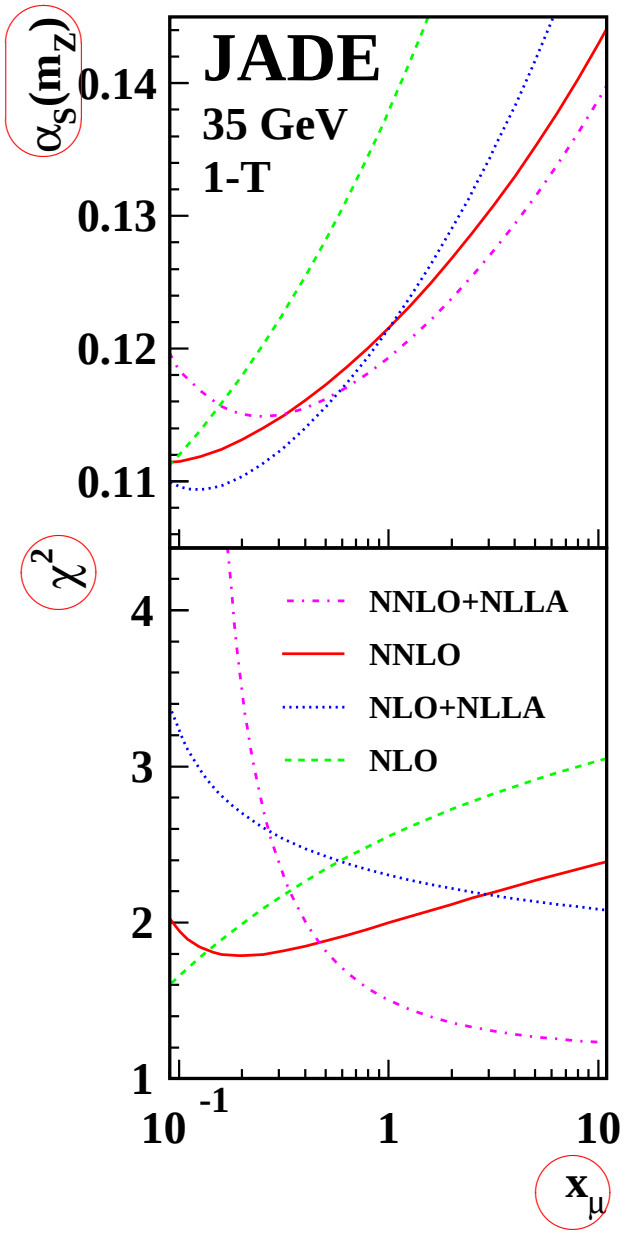
ALEPH: NNLO



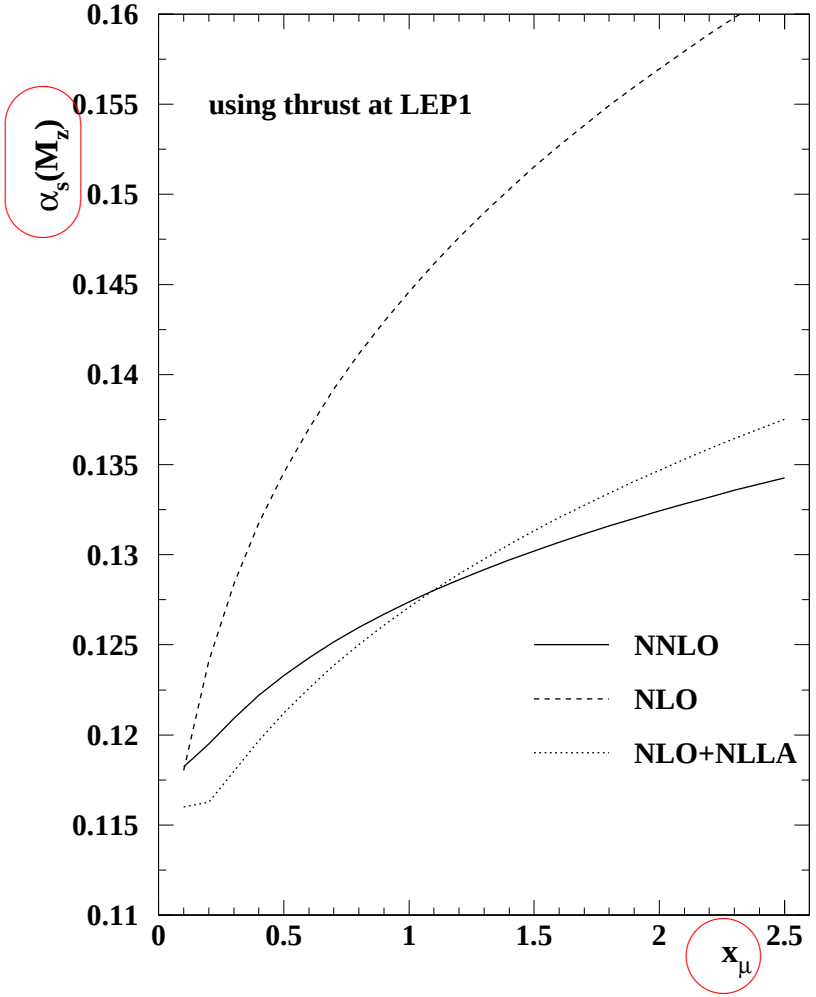
(Hadron level with statistical errors)

α_s, χ^2/d.o.f. vs. x_μ

JADE (prelim.)



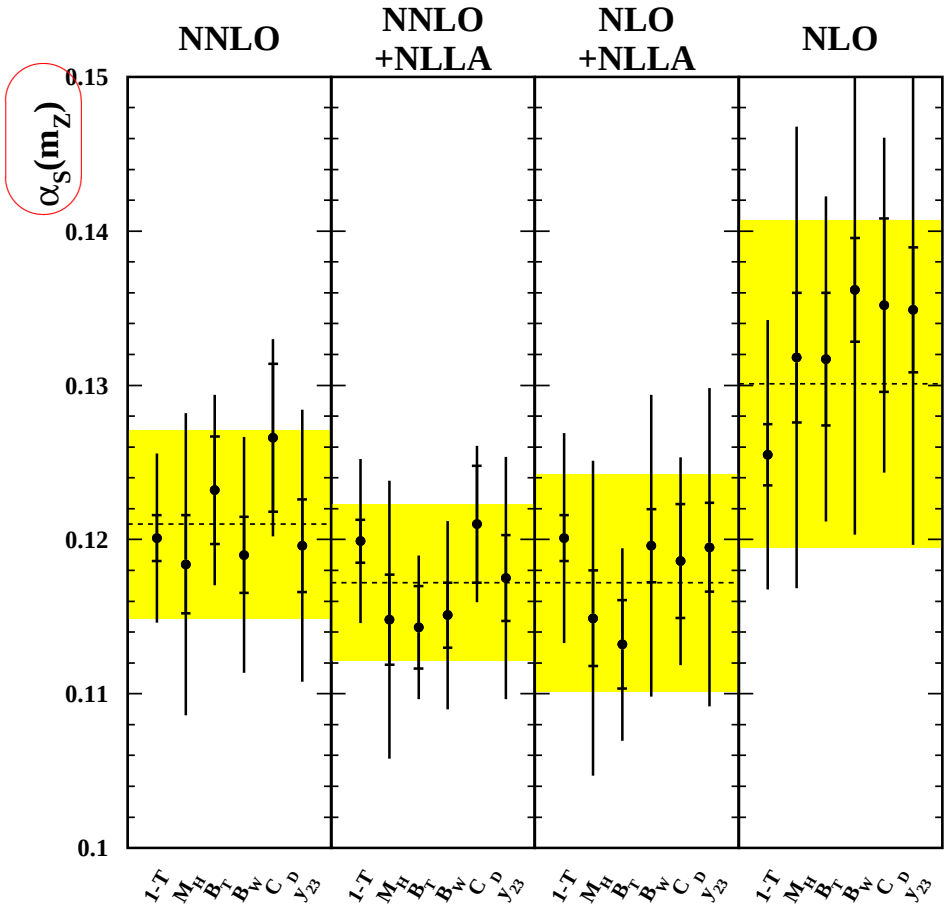
ALEPH



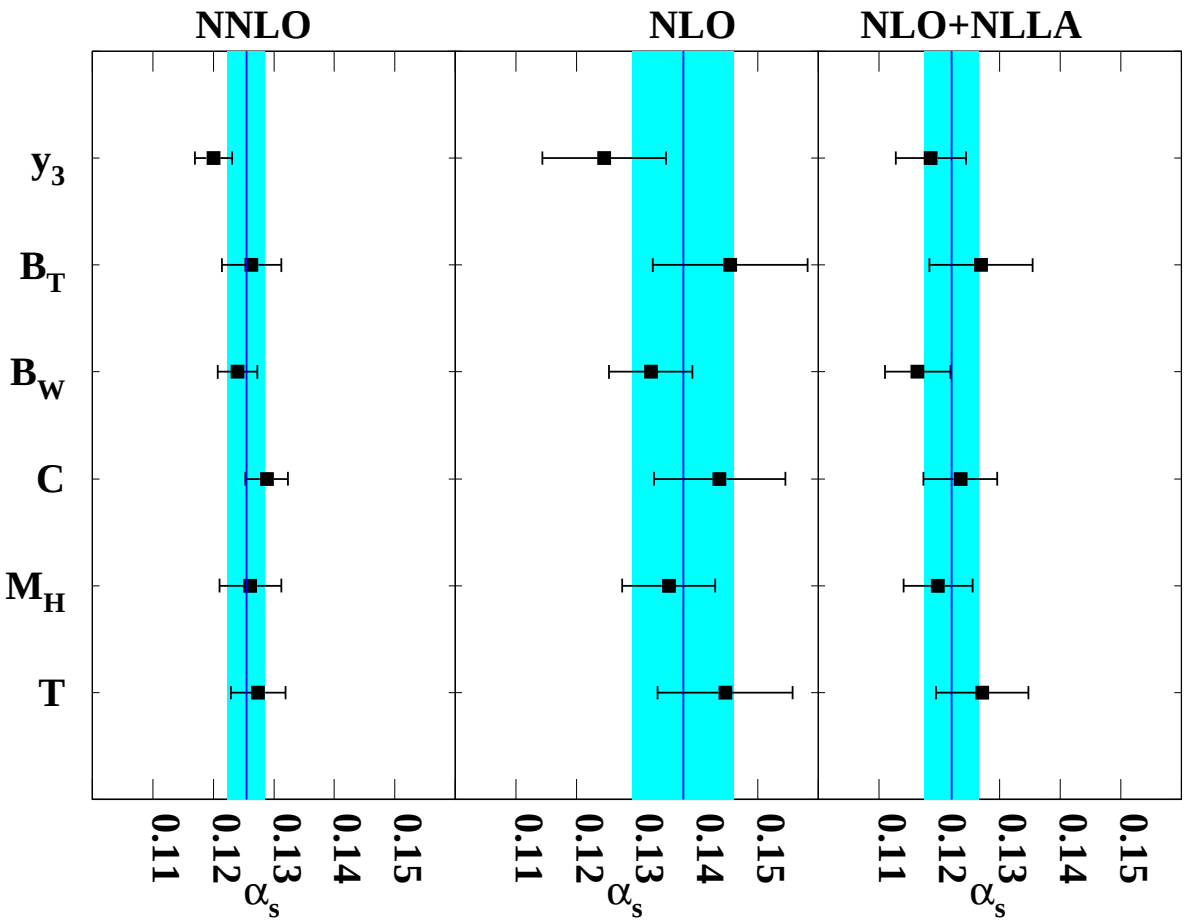
$$x_\mu \equiv \mu_R/\sqrt{s}$$

$\alpha_s(M_{Z^0})$ results

JADE (prelim.)



ALEPH

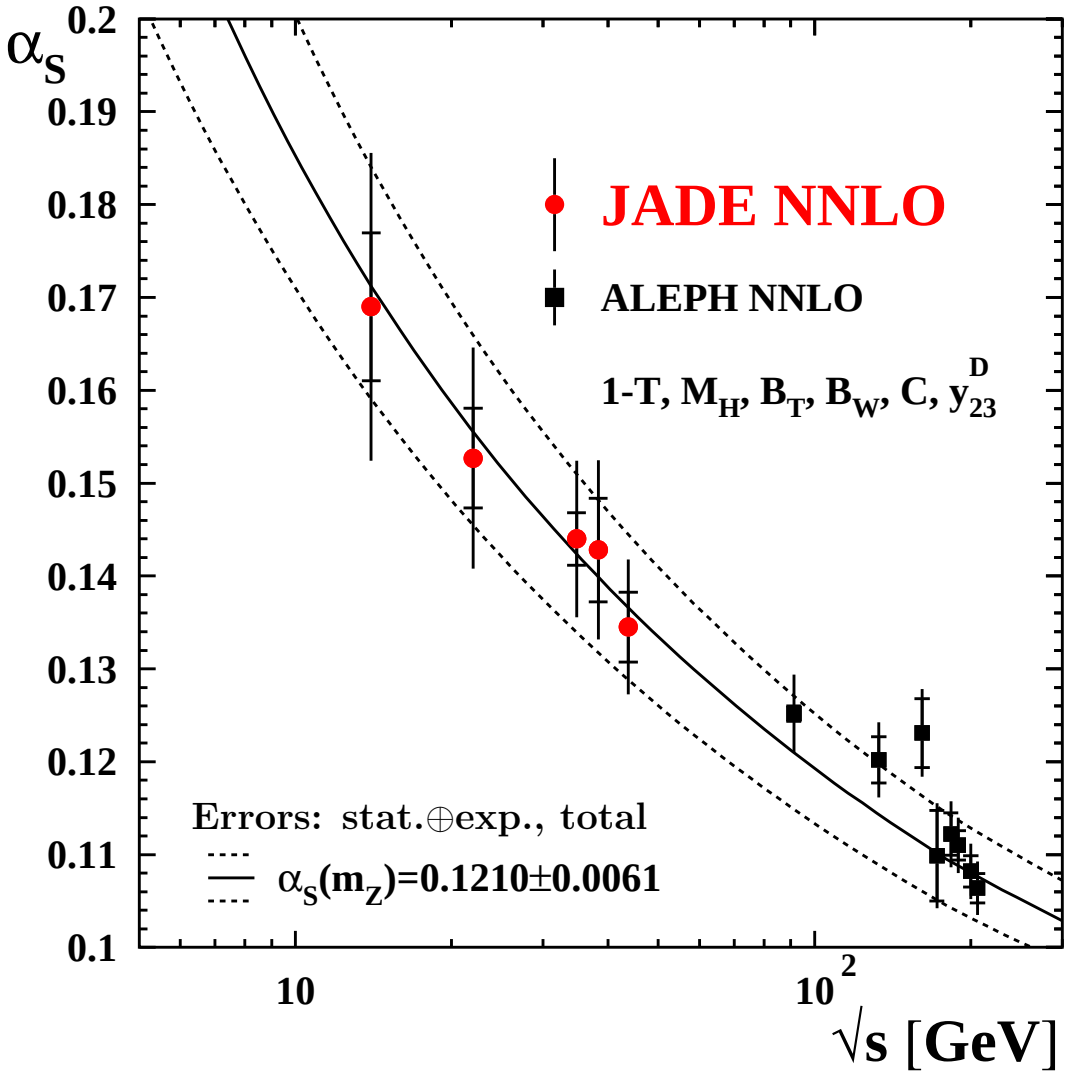


Results from $1-T$, M_{H}, B_{T}, B_{W}, C, y_{23}^{D}, M_{H}, and combination.

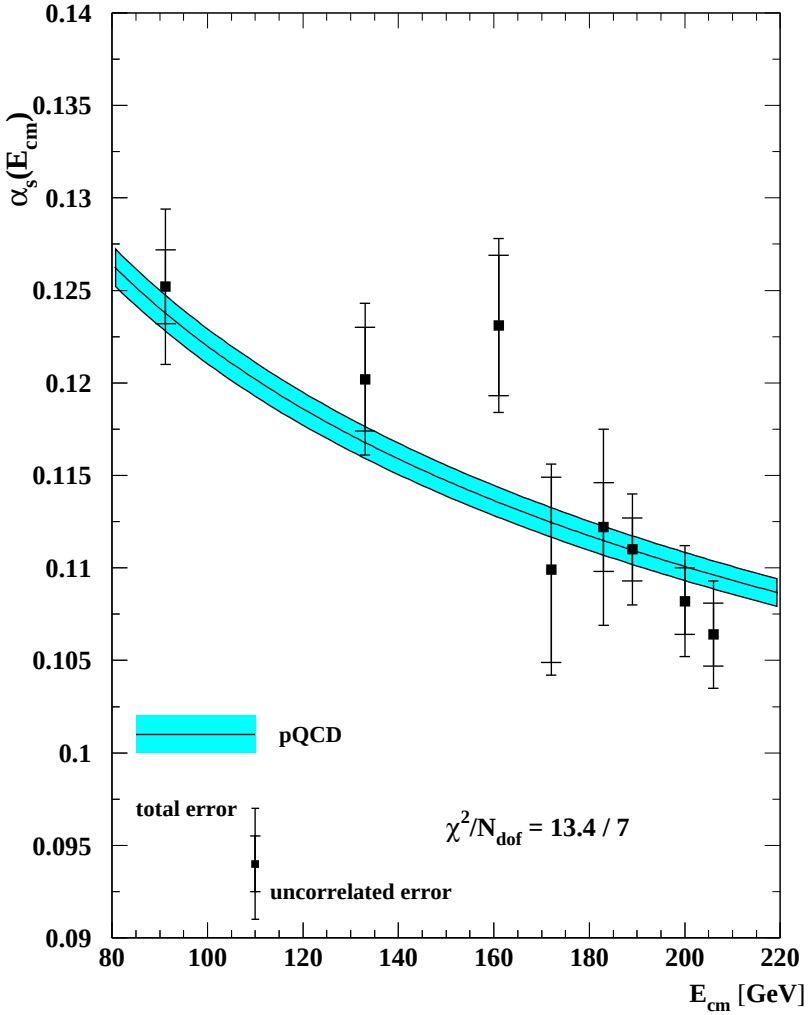
± 0.0036 ± 0.0086 ± 0.0029 (Theoretical errors)

Running $\alpha_s(\sqrt{s} = E_{cm})$ results

JADE NNLO (prelim.)



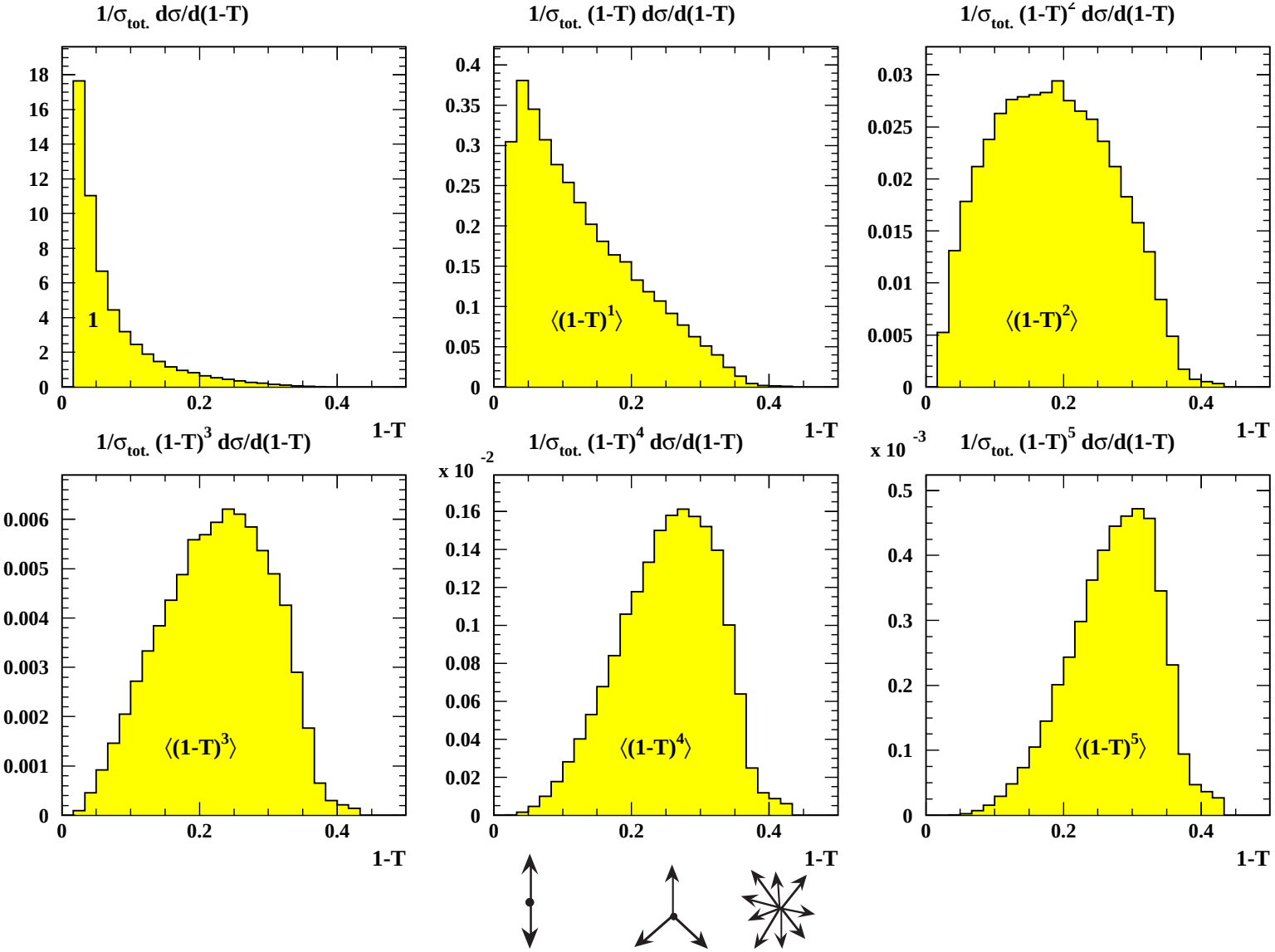
ALEPH NNLO



$$\alpha_s(m_Z) = 0.1240 \pm 0.0033$$

Moments of the distribution of event shape variables

$$\langle y^n \rangle = \frac{1}{\sigma_{\text{tot.}}} \int y^n \frac{\mathrm{d}\sigma}{\mathrm{d}y} \mathrm{d}y \,,$$



$$\frac{1}{\sigma_{\text{tot.}}}(1-T)^n \frac{\mathrm{d}\sigma}{\mathrm{d}(1-T)},$$

n=0...5 .

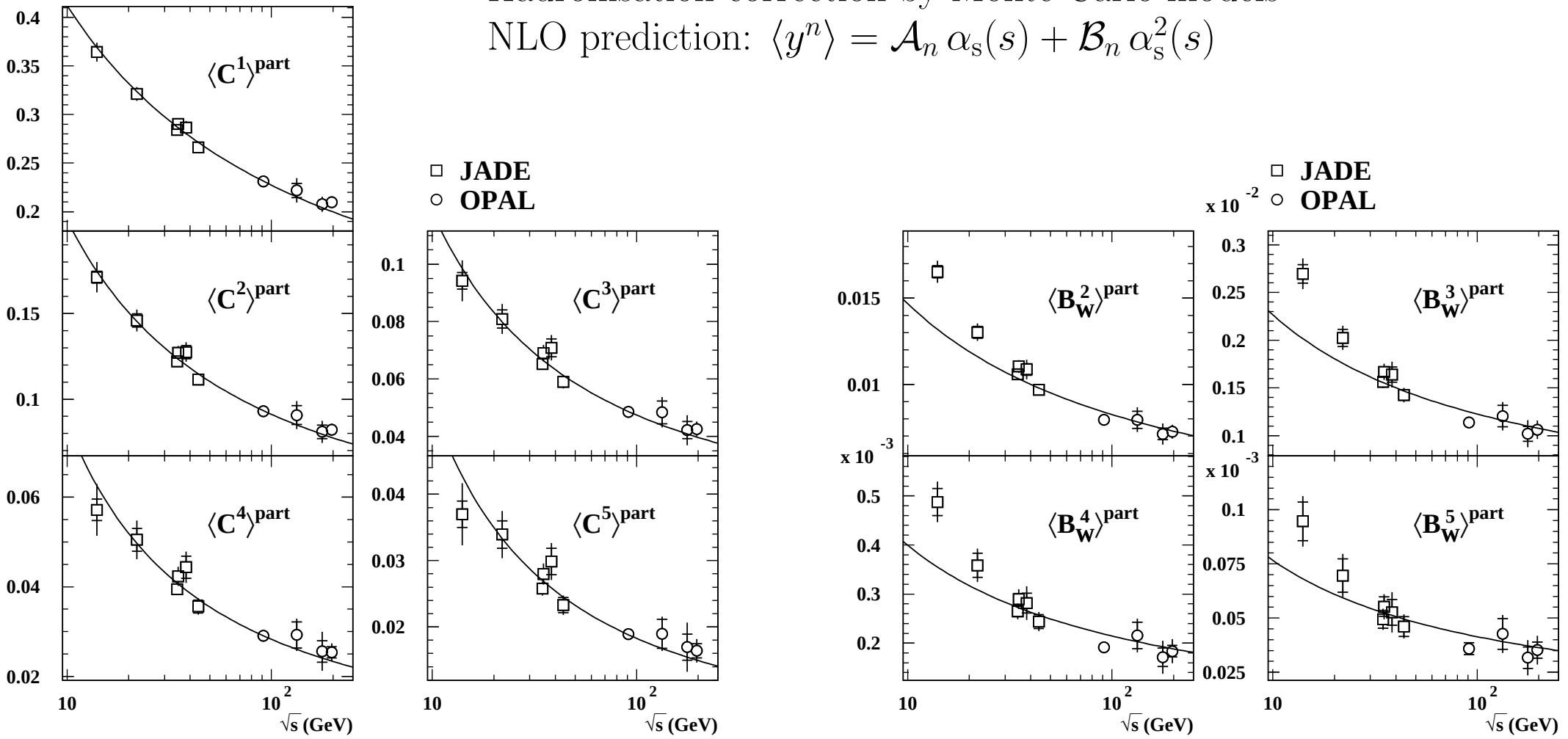
Higher moments probe the multi-jet region.

Perturbative moment fits

$\langle y^n \rangle$, $y = 1 - T\,,\ C\,,\ B_{\mathrm{T}}\,,\ B_{\mathrm{W}}\,,\ y_{23}^{\mathrm{D}},\ M_{\mathrm{H}}\,;\ n = 1...5\,.$

Hadronisation correction by Monte Carlo models

NLO prediction: $\langle y^n \rangle = \mathcal{A}_n\,\alpha_{\mathrm{s}}(s) + \mathcal{B}_n\,\alpha_{\mathrm{s}}^2(s)$



(Parton level with statistical, experimental systematic errors)

All fits χ^2/d.o.f.$\simeq 1...10\,.$

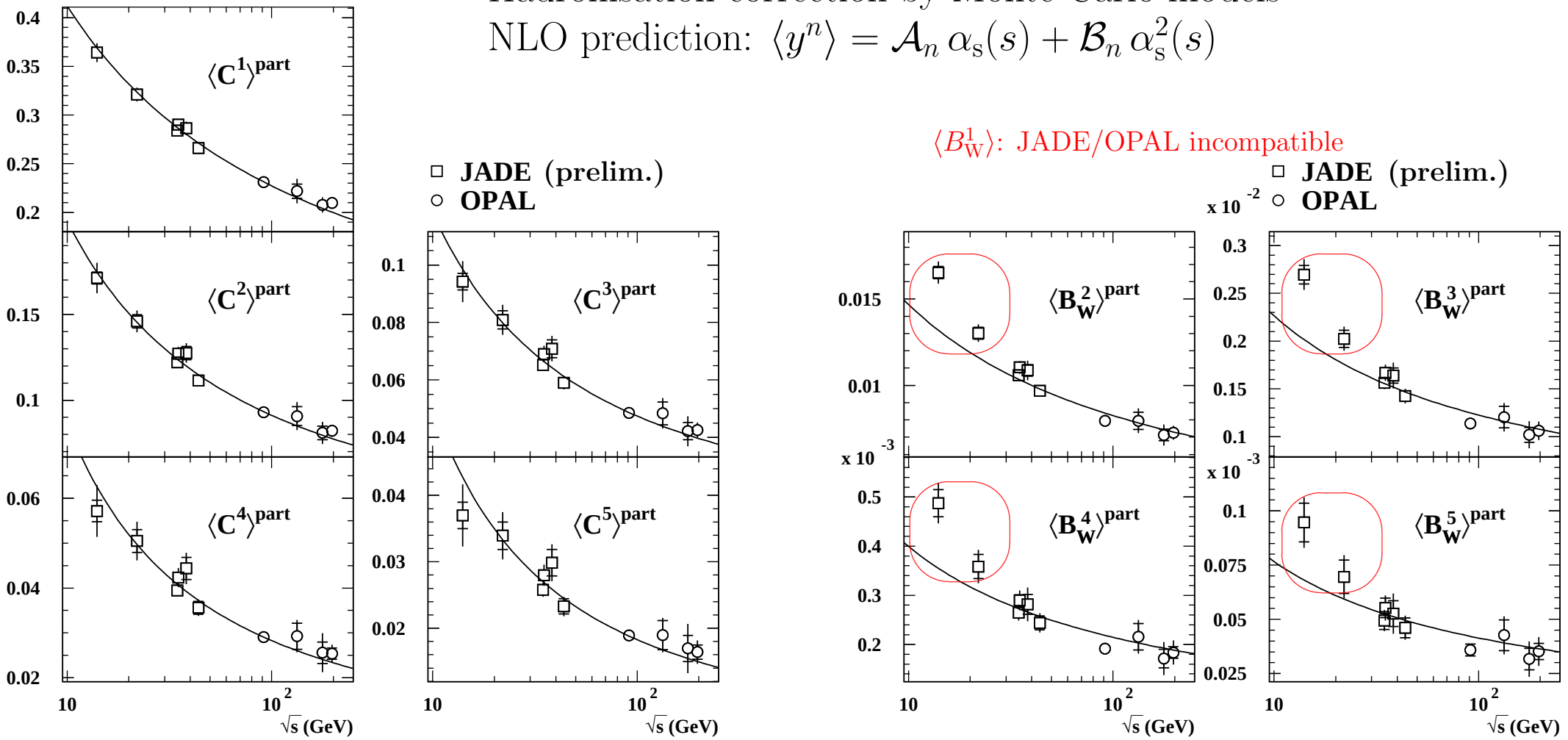
Perturbative moment fits

$\langle y^n \rangle$, $y = 1 - T\,,\ C\,,\ B_{\mathrm{T}}\,,\ B_{\mathrm{W}}\,,\ y_{23}^{\mathrm{D}},\ M_{\mathrm{H}}\,;\ n = 1...5\,.$

Hadronisation correction by Monte Carlo models

NLO prediction: $\langle y^n \rangle = \mathcal{A}_n\,\alpha_{\mathrm{s}}(s) + \mathcal{B}_n\,\alpha_{\mathrm{s}}^2(s)$

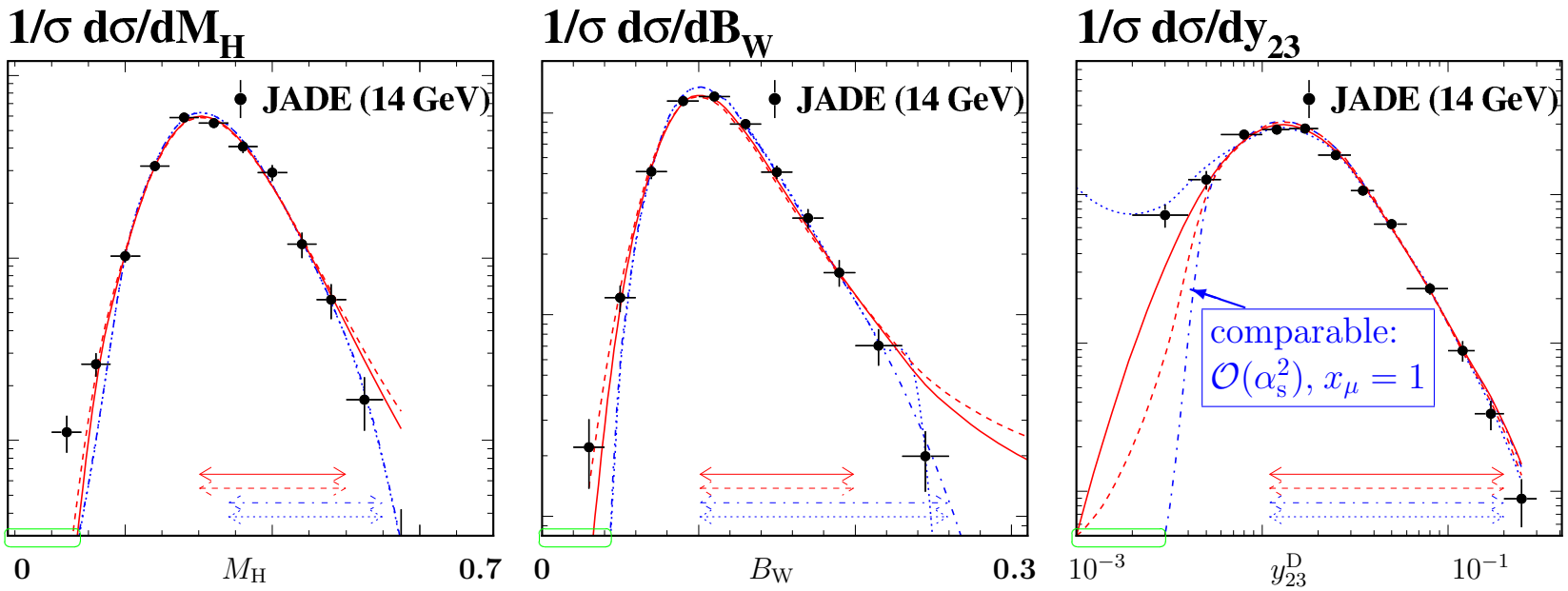
$\langle B_{\mathrm{W}}^1 \rangle$: JADE/OPAL incompatible



(Parton level with statistical, experimental systematic errors)

All fits χ^2/d.o.f.$\simeq 1...10\,.$

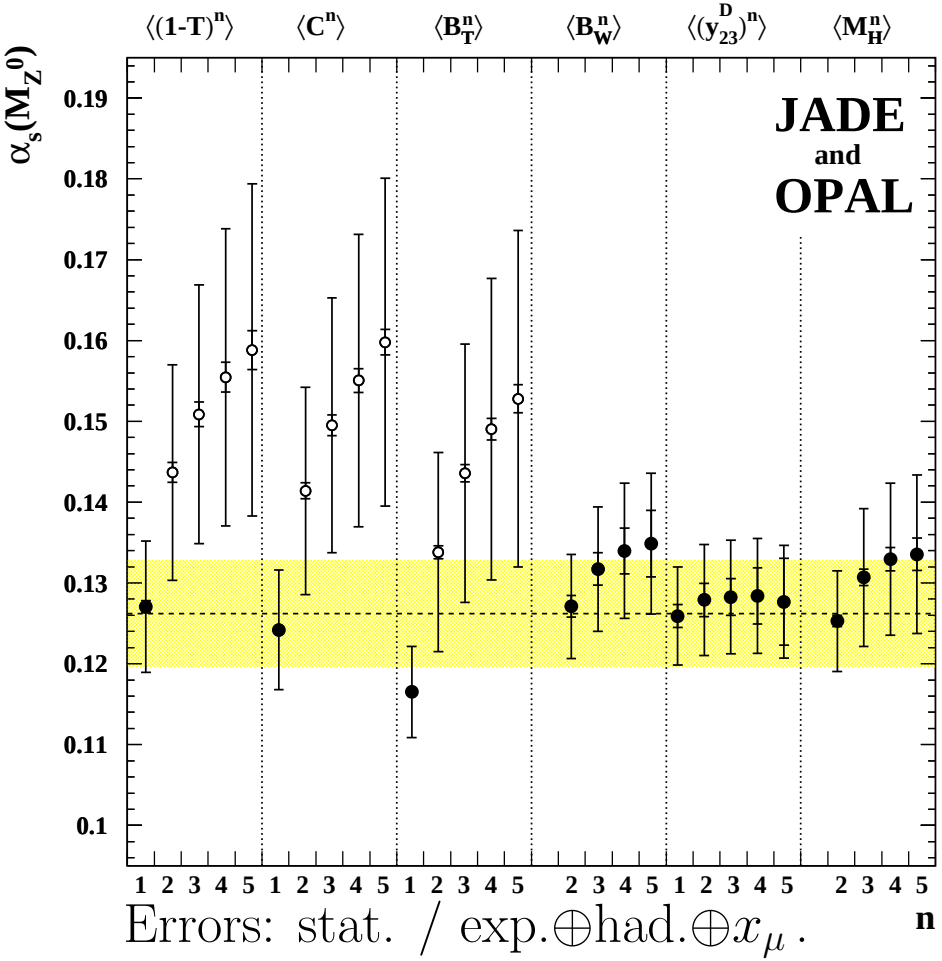
Incompleteness of the one-hemisphere observables in NLO



(PhD thesis P. Movilla Fernandez)

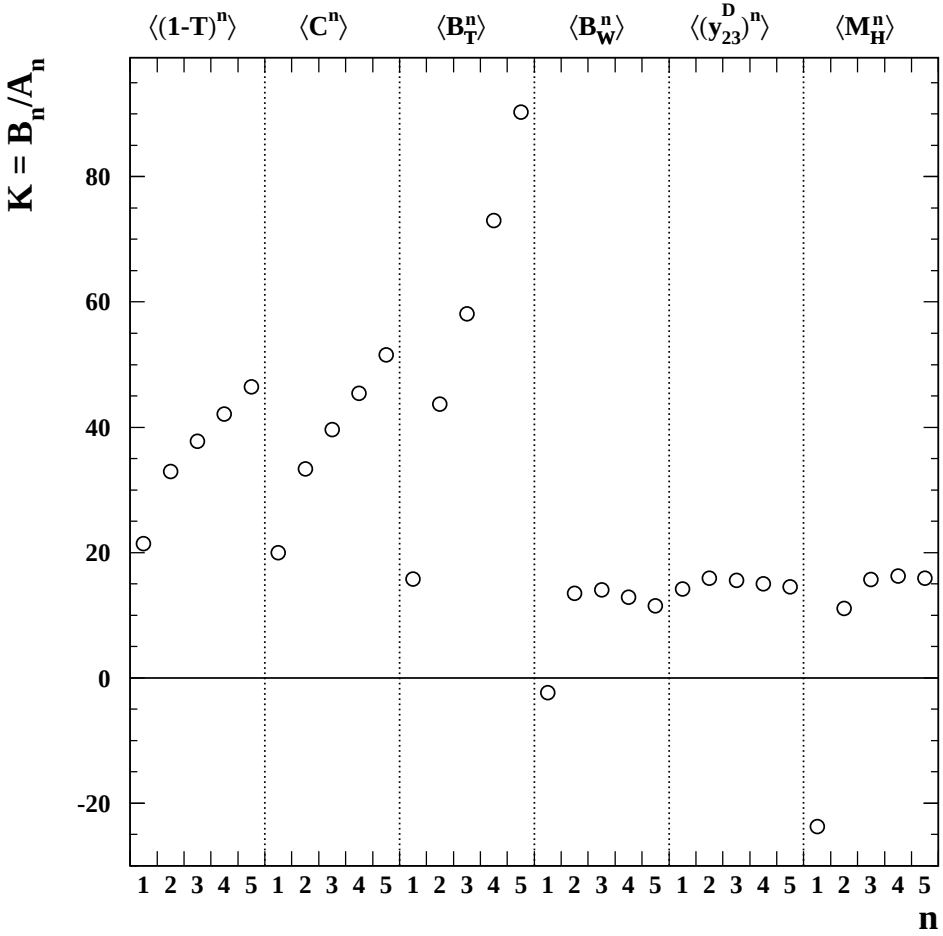
Large regions of unphysically negative cross section lead to "unphysically low" $\mathcal{O}(\alpha_s^2)$-coefficients, especially for moments of low order.

Fit results: $\alpha_s(M_{Z^0})$



Errors: stat. / exp.$\oplus$had.$\oplus x_\mu$.

Predictions: $K = B_n/A_n$



Significant rise of $\alpha_s(M_{Z^0})$ with order n for two-hemisphere observables

Combination of results from predictions with $NLO < 0.5 \cdot LO$:

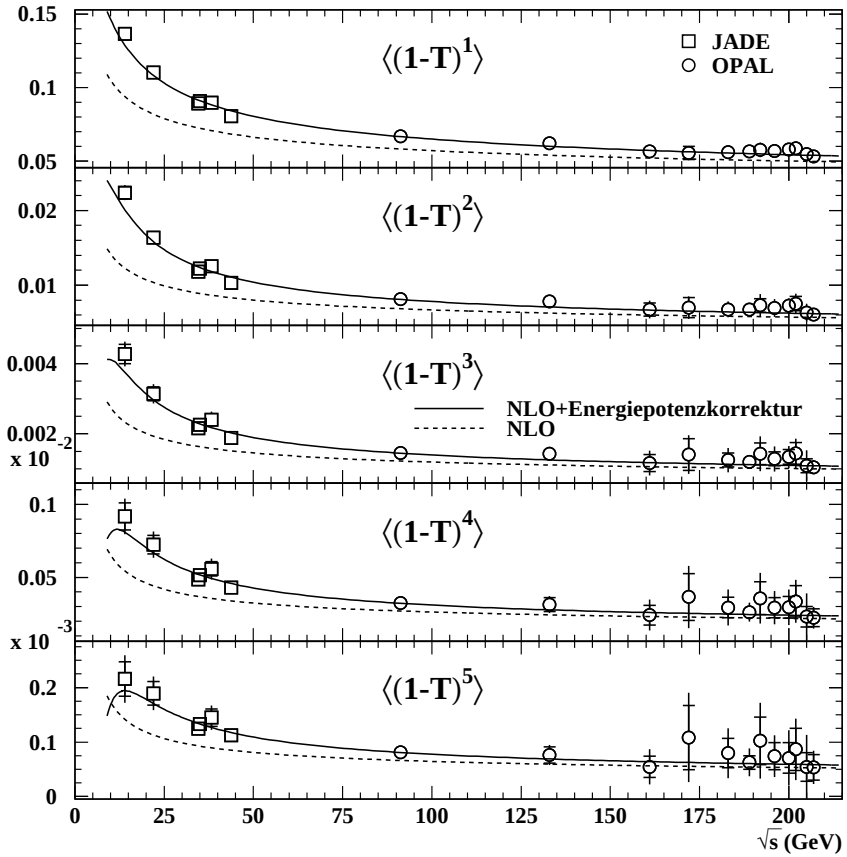
$$\begin{aligned}\alpha_s(M_{Z^0}) &= 0.1262 \pm 0.0006(\text{stat.}) \pm 0.0010(\text{exp.}) \pm 0.0007(\text{had.}) \pm 0.0064(\text{theo.}) \\ &= 0.1262 \pm 0.0065\ (\text{tot.})\,, \text{ consistent with the world average.}\end{aligned}$$

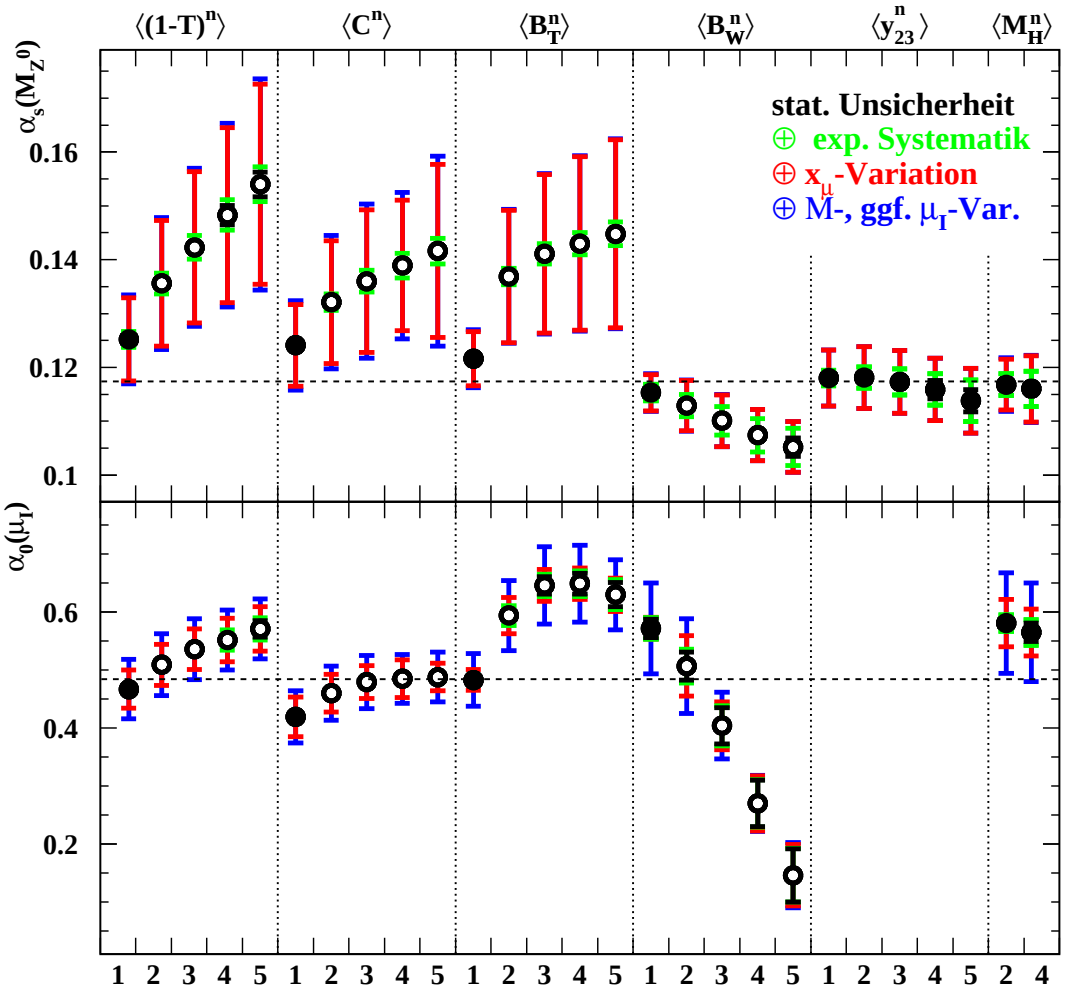
Non perturbative QCD: Dispersive model (Dokshitzer et al.)

Shift of the differential distribution

$$\frac{d\sigma}{dy} = \frac{d\sigma_{pt.}}{dy}(y - a_y \cdot \mathcal{P}) ,$$

observable dependent a_y, observable independent power correction $\mathcal{P}(\alpha_0)$.





$$\alpha_s(M_{Z^0}) = 0.1174 \pm 0.0050(\text{tot.}) ,$$
$$\alpha_0(\mu_I) = 0.484 \pm 0.053(\text{tot.}) .$$

Conclusion

- NNLO, NNLO+NLLA fits of event shape distributions measured by JADE and ALEPH:
  - reduced scale uncertainty
  - reduced scatter for different variables
  - $\alpha_s(M_{Z^0}) = 0.1240 \pm 0.0033$; precision of 3% by ALEPH.
- Moments (and variance) of event shape distributions measured by JADE and OPAL:
  - Perturbative NLO prediction adequate for some moments
  - Incomplete perturbative description shows up in non perturbative models
  - Passing from first to higher moments: Perturbative and non perturbative problems

Outlook

- Better resummation
- NNLO predictions of moments awaited
- Qualitative explanations?