Measurement of α_s with JADE using Moments of Event Shape Observables and the 4-Jet Rate

Jochen Schieck

Max-Planck-Institut für Physik, München

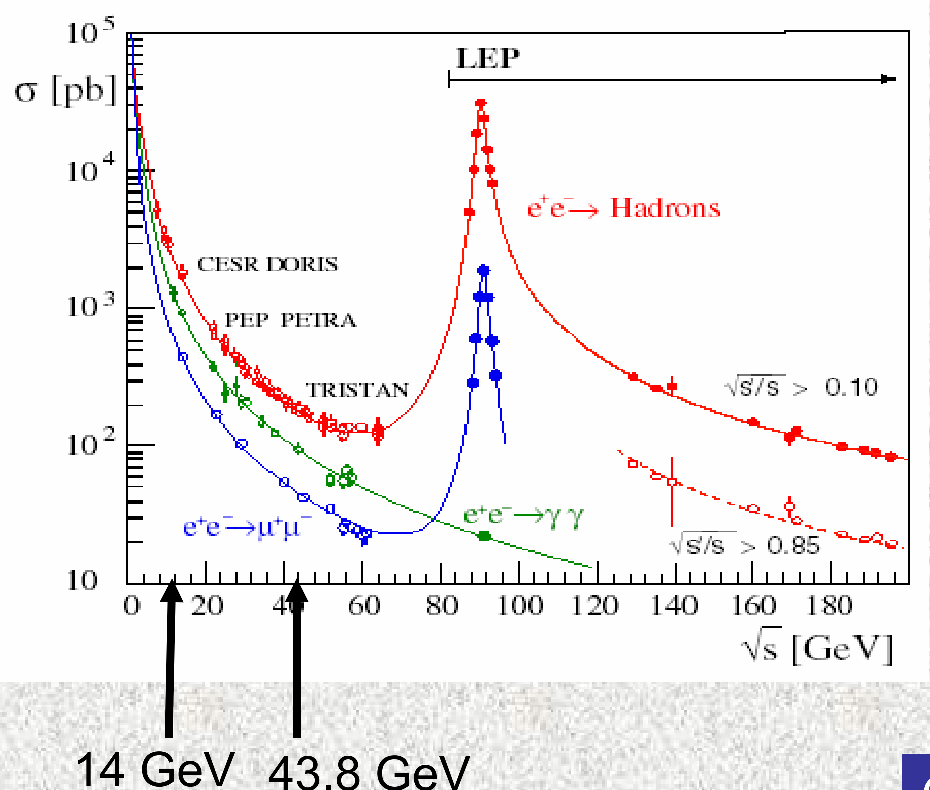
EPS-HEP 2005, Lisbon

Results are Preliminary!

JADE Note JN146,JN147

http://wwwjade.mppmu.mpg.de

The Data Sample



- σ^{had} (PETRA) = 0.1…10nb ≈ 1/100 $\sigma^{had}(M_Z)$

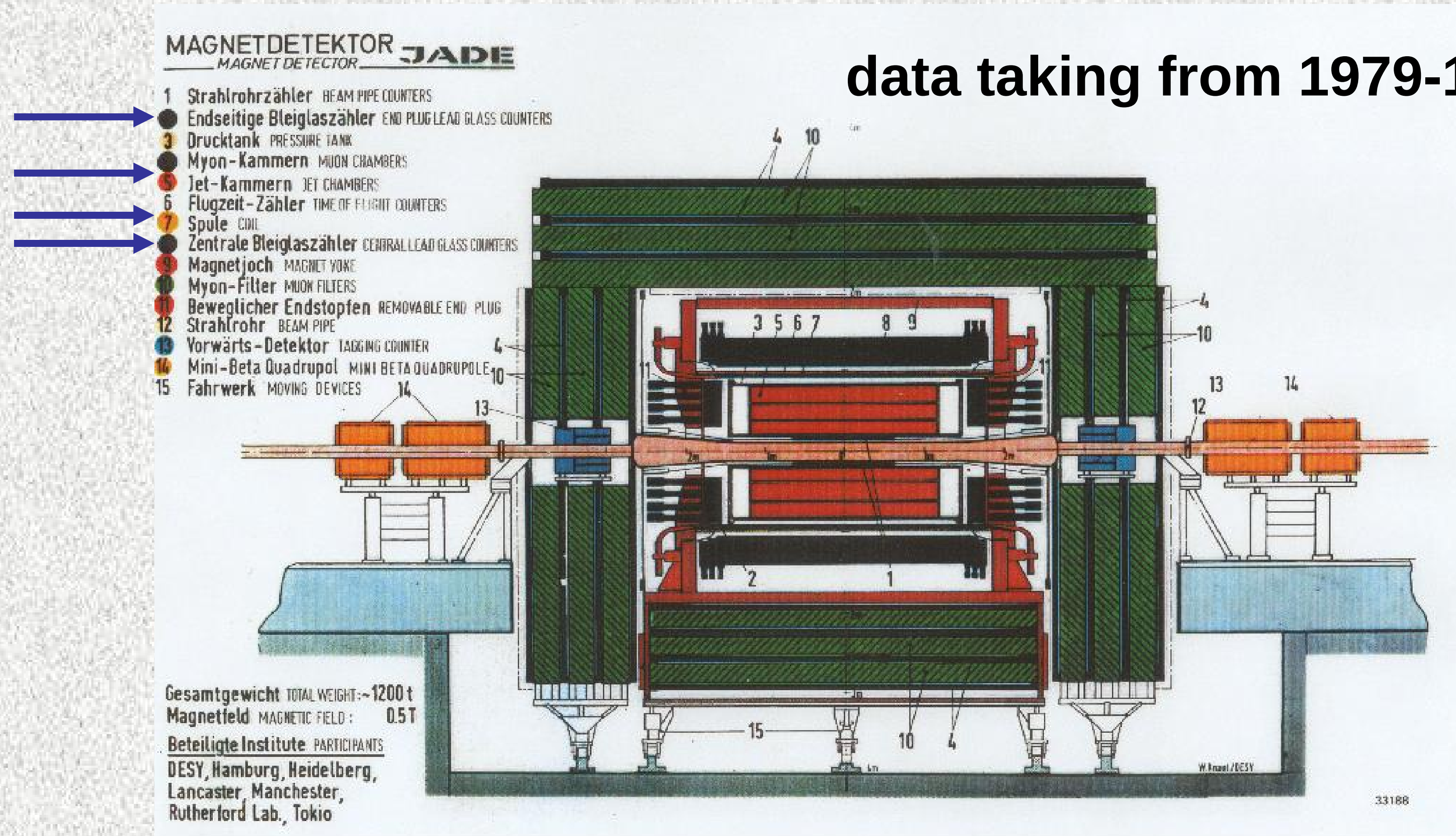
- •216 pb-1
- •43100 multihadrons

average energy in GeV	energy range in GeV	selected events 5/88
14.0	13.0–15.0	1783
22.0	21.0–23.0	1403
34.6	33.8–36.0	14313
35.0	34.0–36.0	20876
38.3	37.3–39.3	1585
43.8	43.4–46.4	4376

OPAL LEP2 calibration Z^0 ~ 400000 events

- •JADE: unique contribution for 14 < √s < 44 GeV
- •analyses using FSR-Z^0 events O(500) / energy point

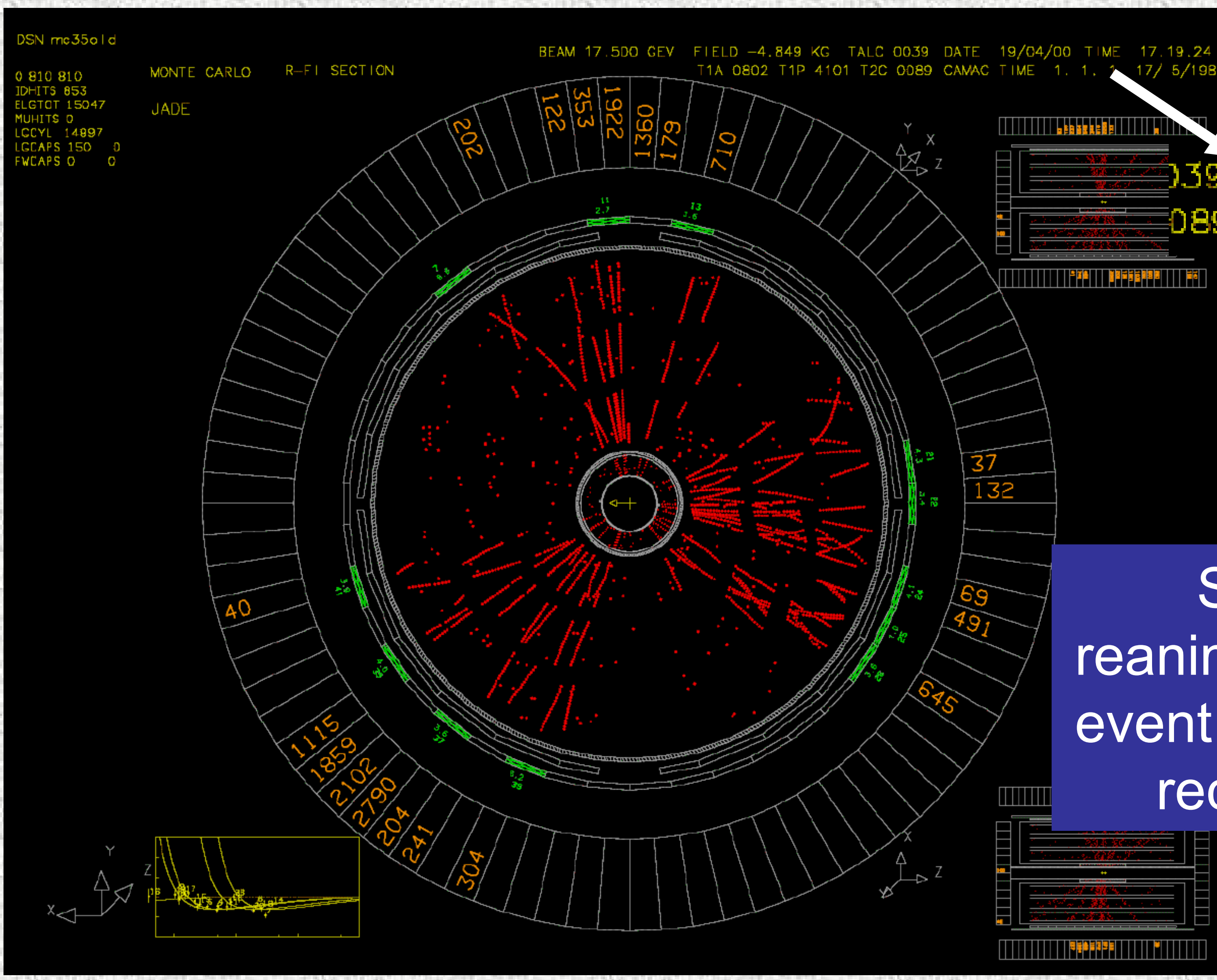
The JADE detector



data taking from 1979-1986

- since 1998 re-analysis of JADE data
- improved Monte Carlo models and theoretical calculations

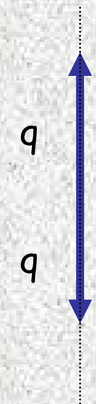
Resurrection of JADE Software



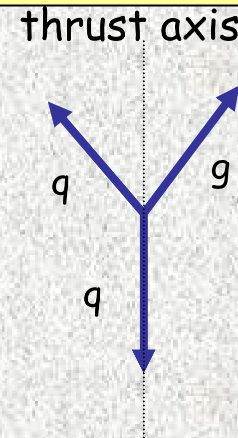
Successful reanimation of JADE event simulation and reconstruction

Moments of Event Shapes

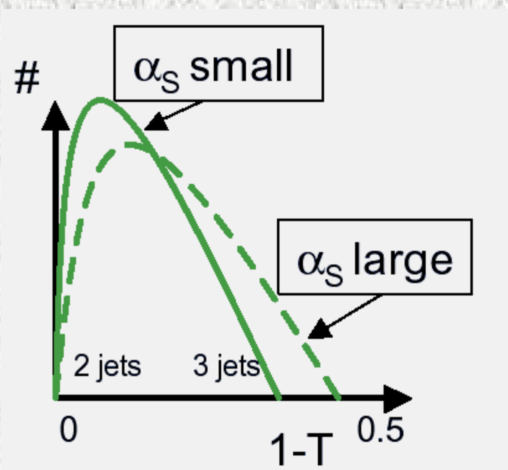
e.g. Thrust: $T = \max_{\vec{n}} \left(\frac{\sum_i |\vec{p}_i \vec{n}|}{\sum_i |\vec{p}_i|} \right)$



1-T=0

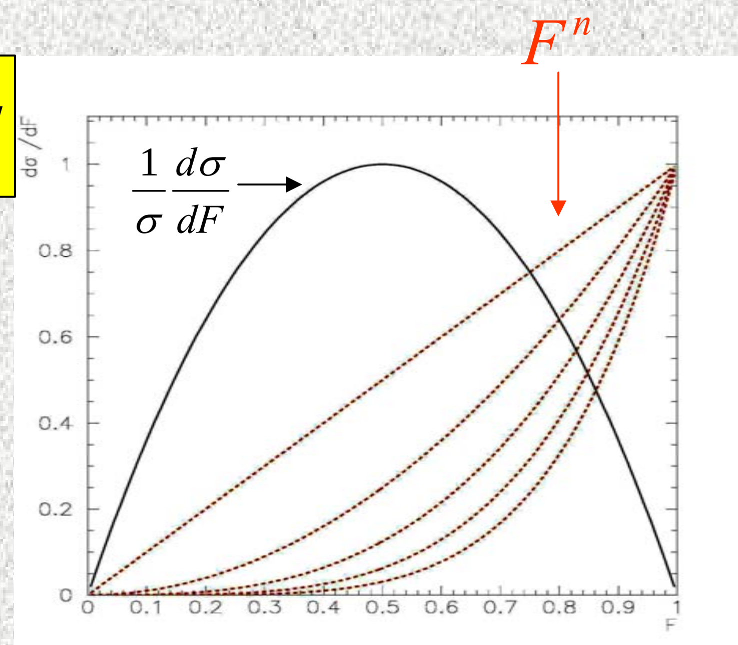


1/3>1-T>0



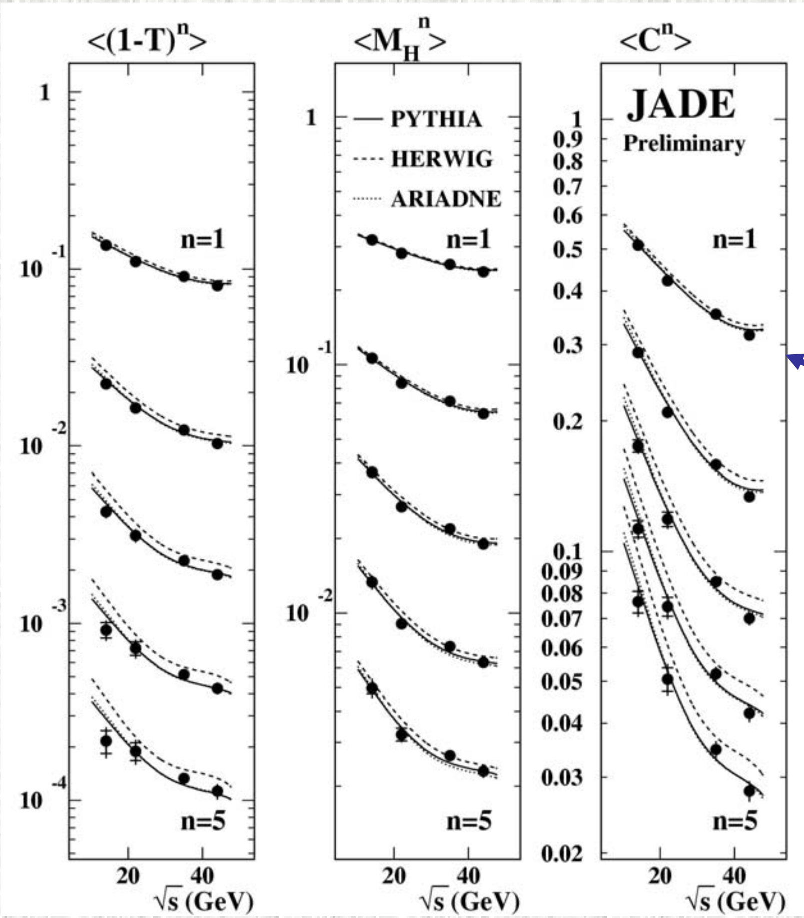
$$\langle F^n \rangle = \int F^n \frac{1}{\sigma}\frac{d\sigma}{dF} dF$$

probes all of the available phase space

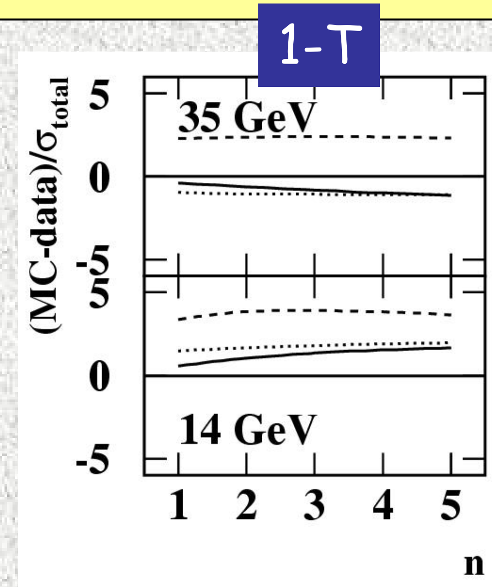


event shapes observables:
1-T, C, B_T, B_W, y_{23} and M_H

Moments of Event Shapes



comparison between data and Monte Carlo:



'running' of α_S

Observables:

1-T,M_H,C,B_T,B_W,y_{23}(D)

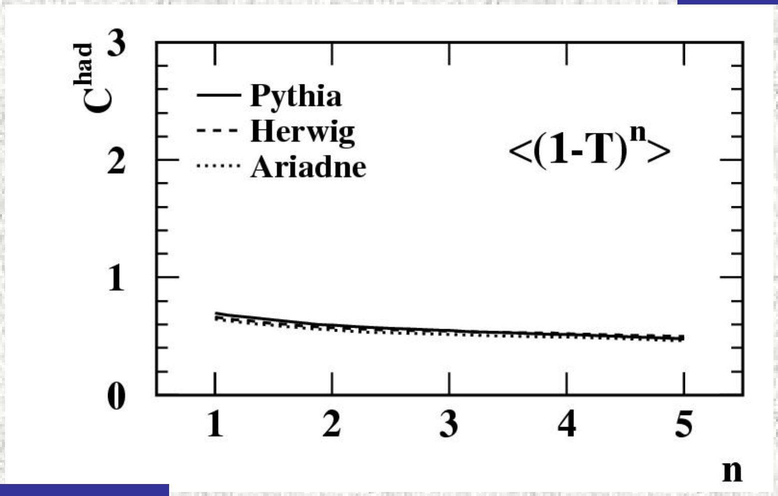
• $O(\alpha_S^2)$ NLO predictions :

$$\left\langle y^n \right\rangle = A_n \frac{\alpha_S(\mu)}{2\pi} + B_n \left(\frac{\alpha_S(\mu)}{2\pi} \right)^2$$

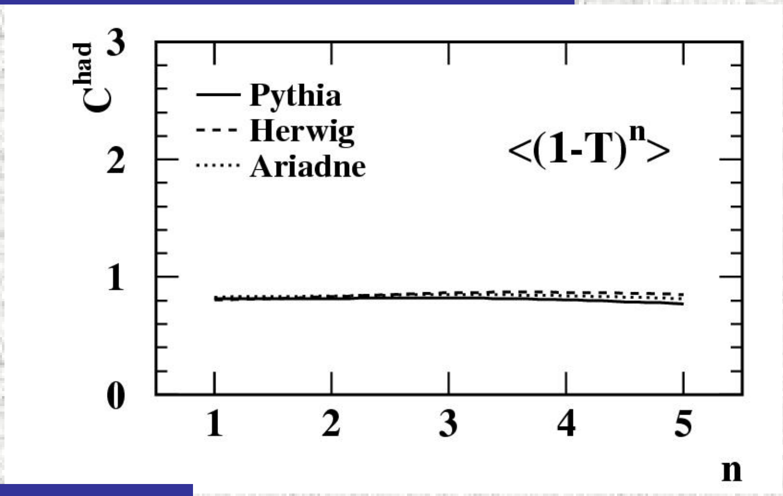
Hadronization Correction

•Hadronization and detector correction using modern Monte Carlo

hadronization correction:



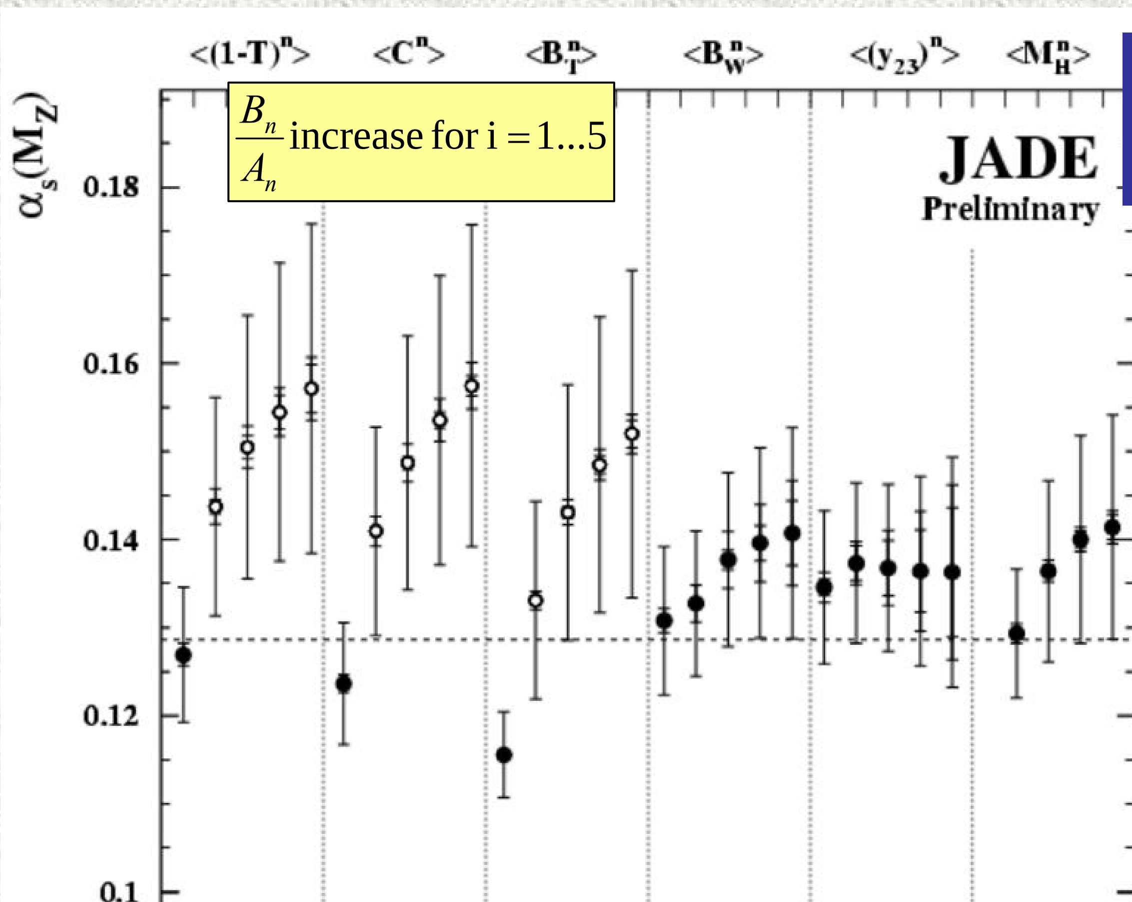
14 GeV



35 GeV

•detector correction up to 50%

α_S with event shape moments



$\frac{B_n}{A_n}$ increase for $i = 1 \ldots 5$

result consistent with fit to distribution

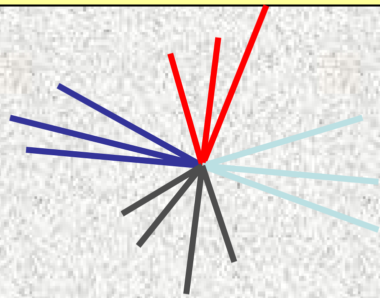
Require:

$$\frac{B_n}{A_n} \cdot \frac{\alpha_S}{2\pi} < 0.5$$

Combined result:

$$\alpha_s(M_{Z^0}) = 0.1286 \pm 0.0007(\text{stat.}) \pm 0.0011(\text{exp.}) \pm 0.0022(\text{had.}) \pm 0.0068(\text{theo.})$$
$$= 0.1286 \pm 0.0072$$

Measurement of the 4 Jet-Rate

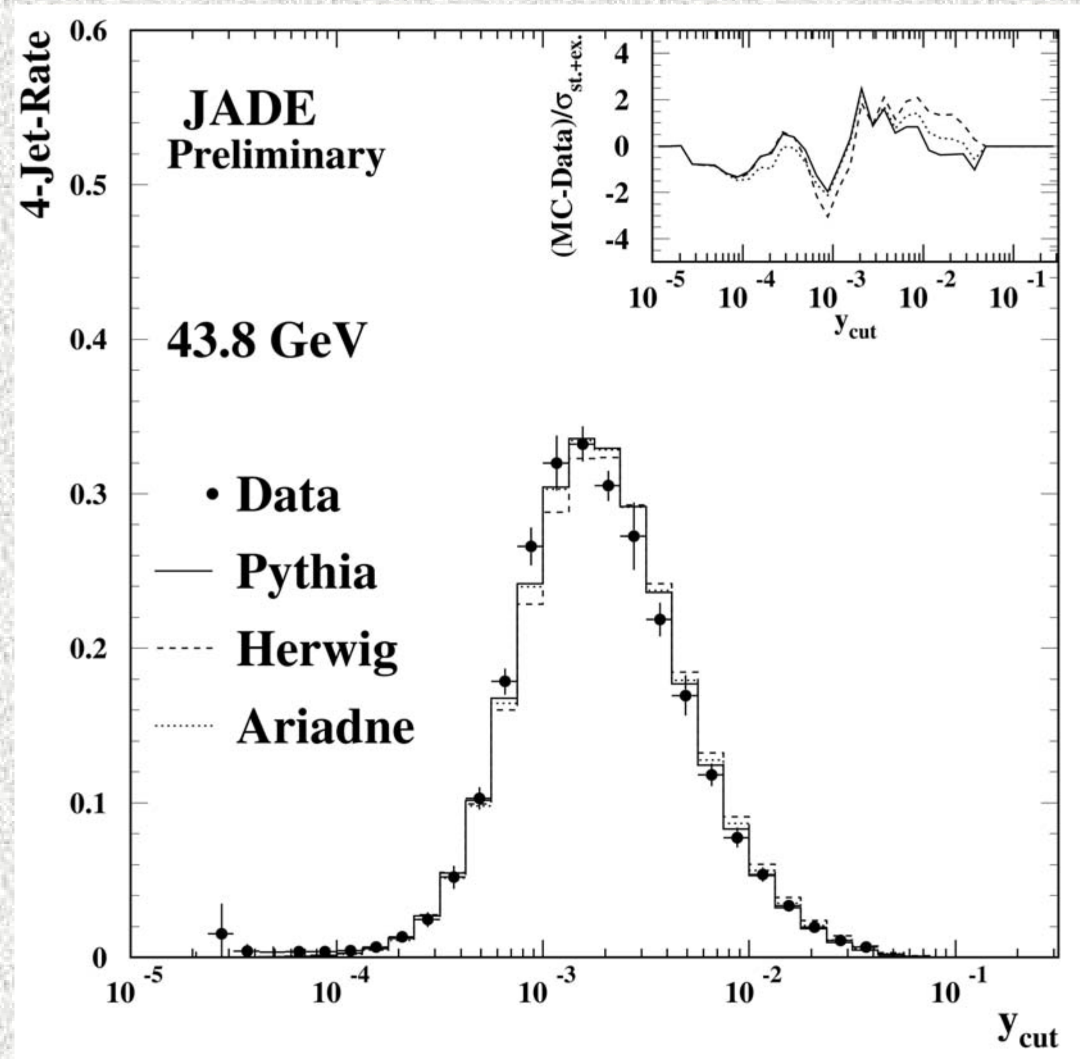


•cluster events according to the Durham algorithm:

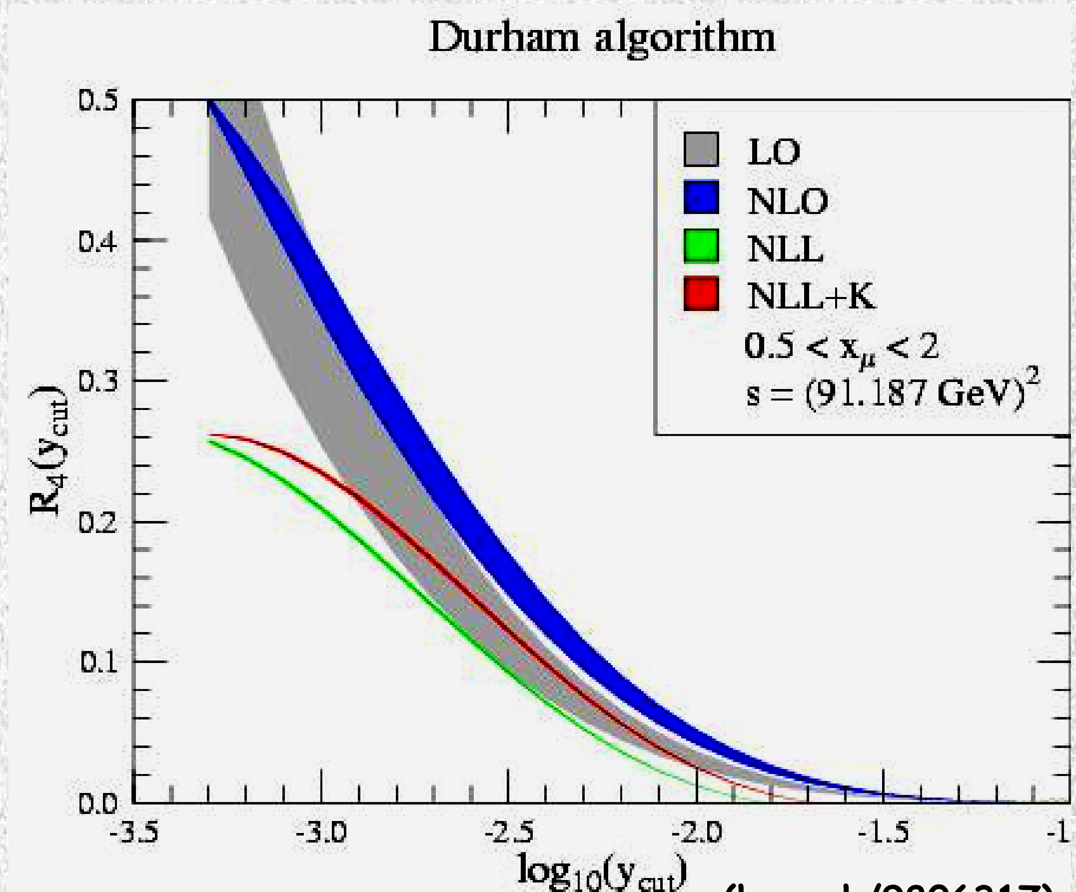
$$y_{ij} = \frac{2\min(E_i^2, E_j^2)}{E_{vis}^2}(1-\cos\theta_{ij})$$

•combine particles with smallest y_{ij}

•calculate y_{34} > $\mathbf{y_{cut}}$ > y_{45}



Theoretical Prediction



(hep-ph/9806317)

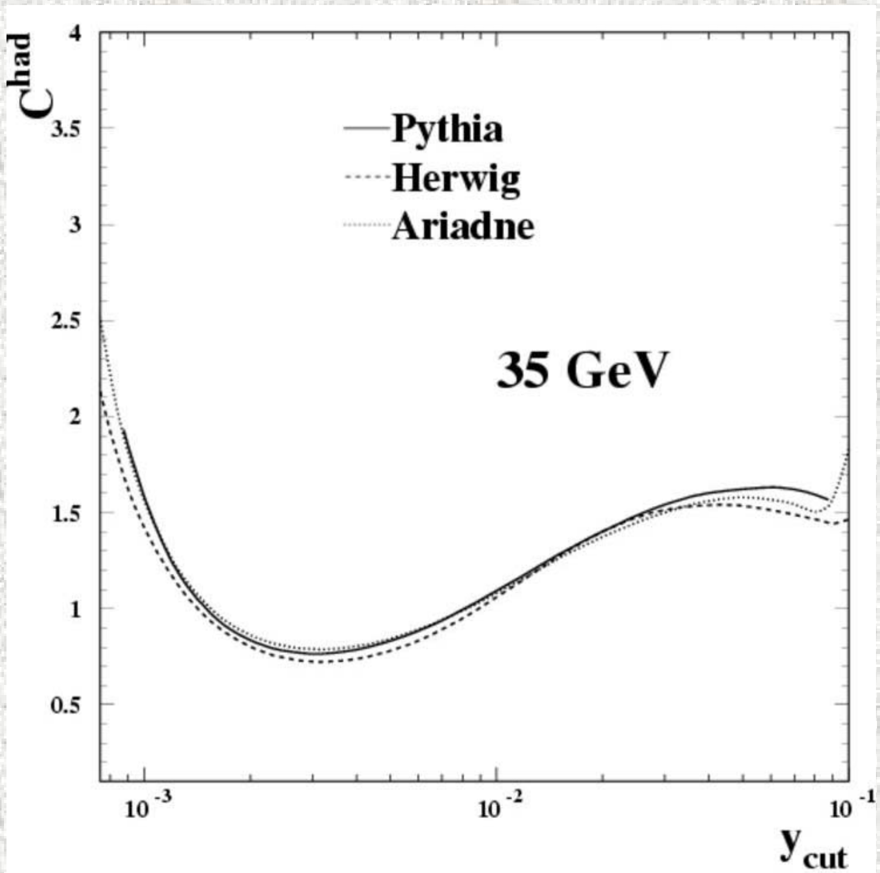
- reduced scale sensitivity:

$$\Delta R_4(x_\mu) \propto \alpha_S{}^3 \cdot \ln x_\mu$$

- combined NLO+ resummed NLLA calculations:

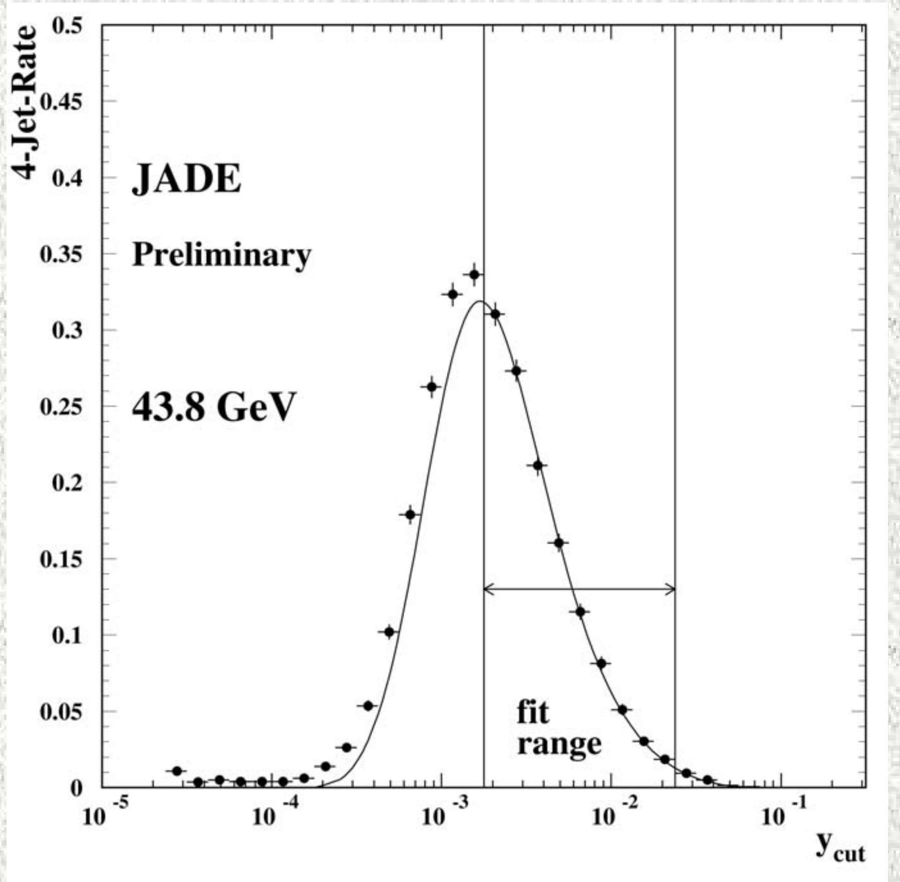
$R_4 = \sigma_{4\text{-}Jet}/\sigma_{tot} = \alpha_s{}^2 B(y_{cut}) + \alpha_s{}^3 C(y_{cut}) + \text{NLLA terms}$

Fit to the 4-Jet Rate

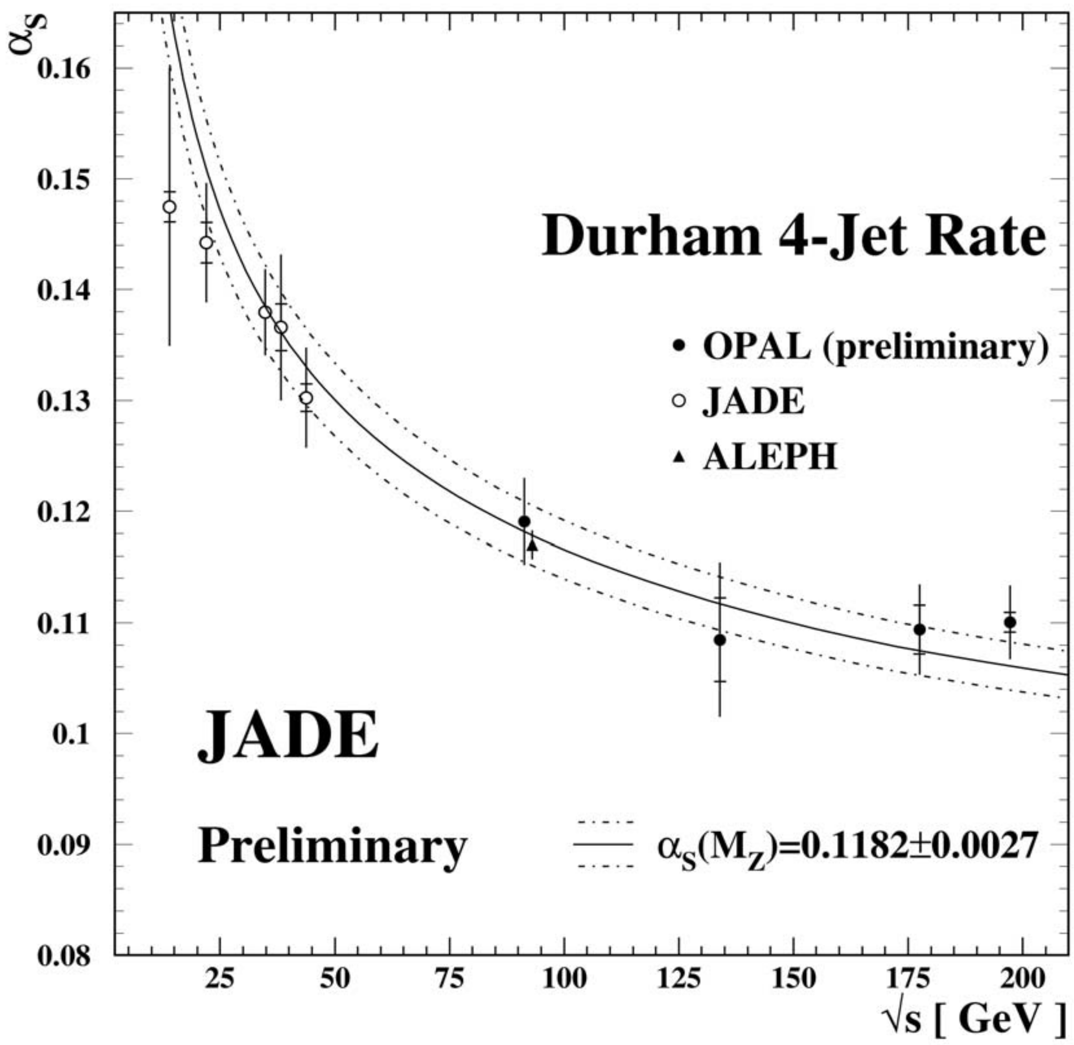


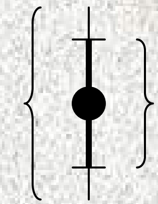
Hadronization Correction

Fits to the 4-Jet Rate



α_S with the 4-Jet Rate

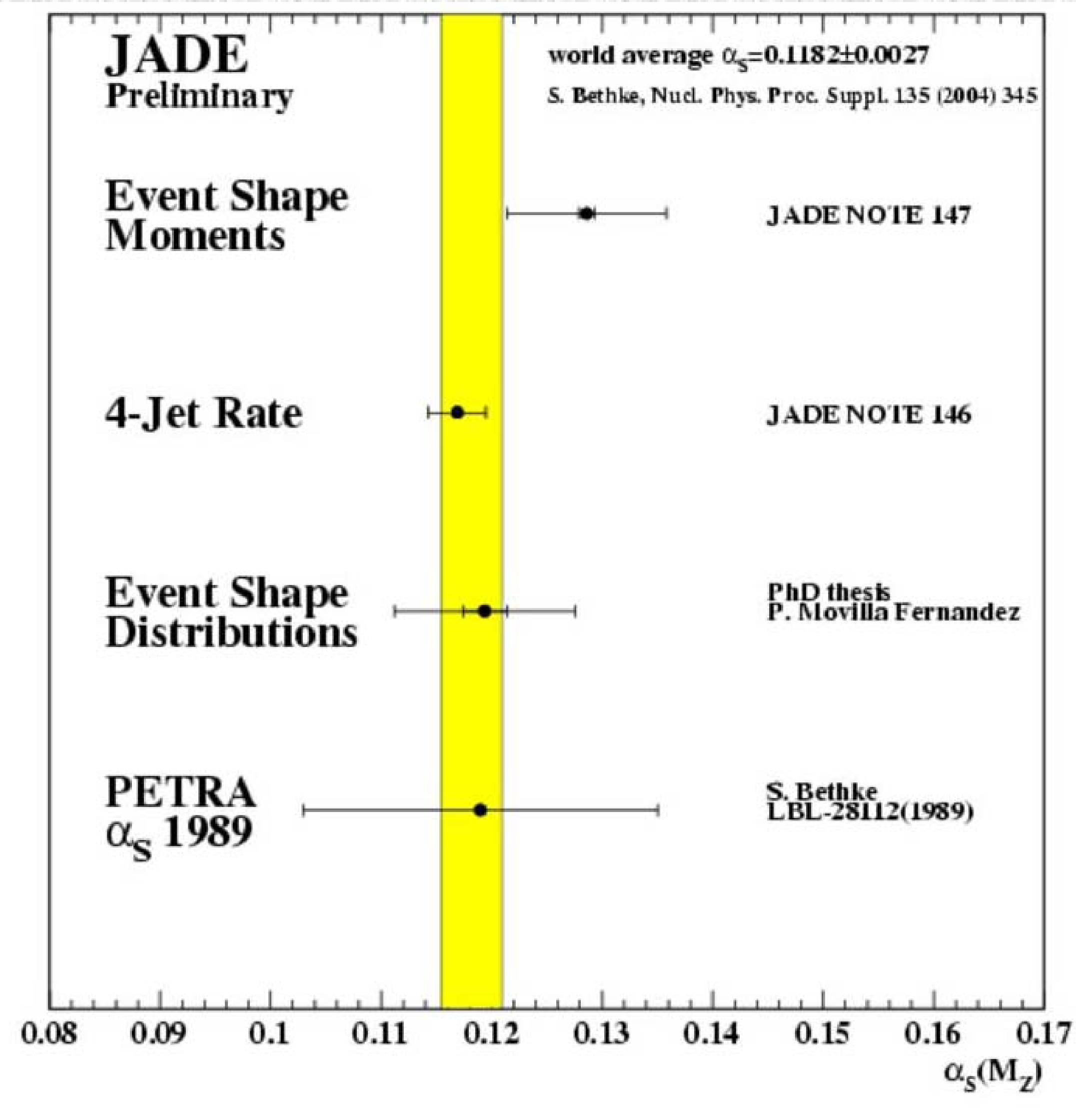




Combined result:

$$\alpha_s(M_{Z^0}) = 0.1169$$
$$\pm 0.0004(\text{stat.})$$
$$\pm 0.0012(\text{exp.})$$
$$\pm 0.0021(\text{had.})$$
$$\pm 0.0007(\text{theo.})$$
$$= 0.1169 \pm 0.0026\,(\text{tot.})$$

Summary

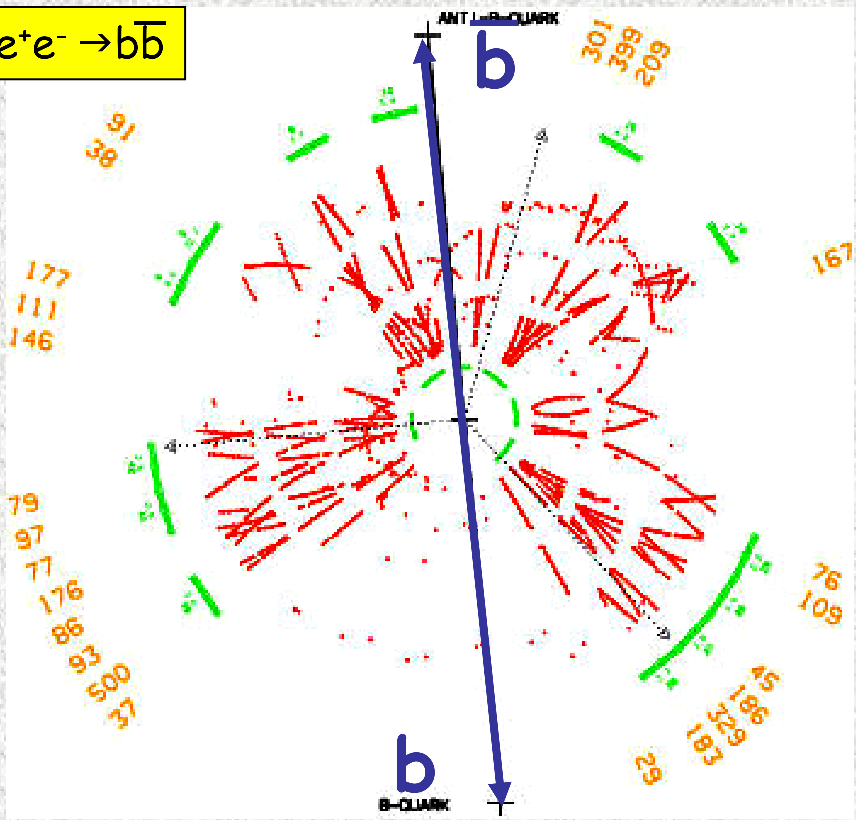


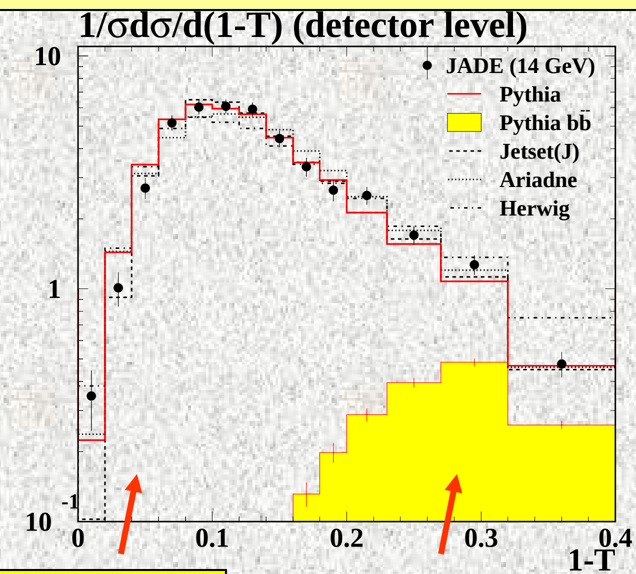
- JADE data allow unique access to e^+e^- data below Z^0
- α_S from moments of event shape observables and 4-Jet Rate
- uncertainties comparable to LEP results

Backup Slides

Correction for $b\bar{b}$-Events

$e^+e^- \rightarrow b\bar{b}$





2-jet region

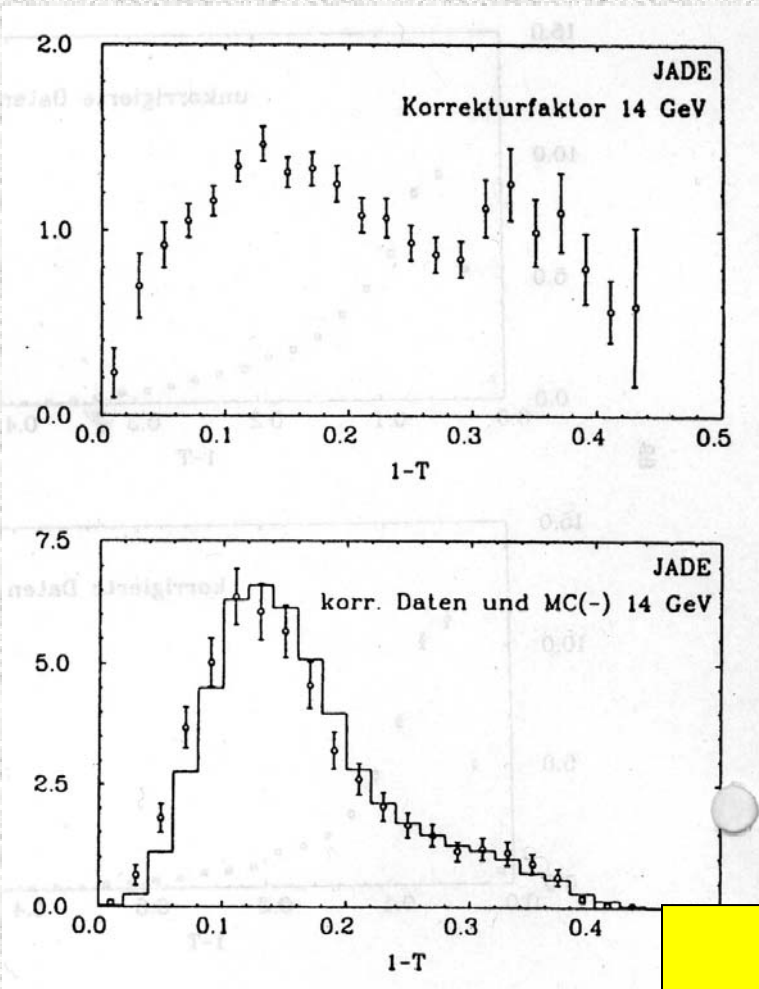
$b\bar{b}$ events

~about 9% $b\bar{b}$-events

•$b\bar{b}$ events fakes events with gluon radiation (electro weak decay)

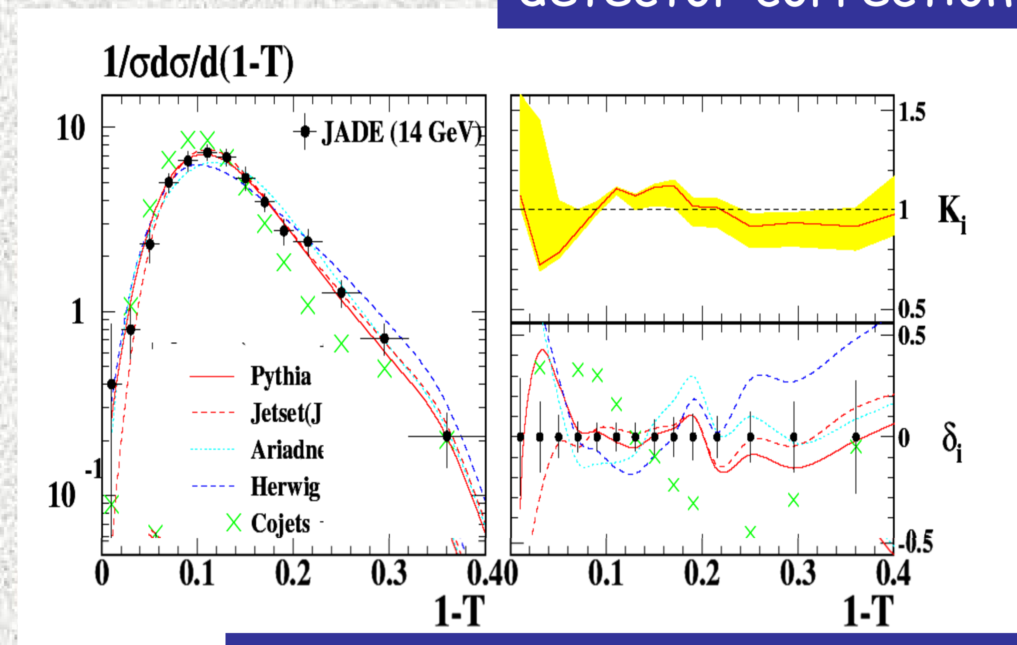
➢subtraction at detector level

Quality of Simulation



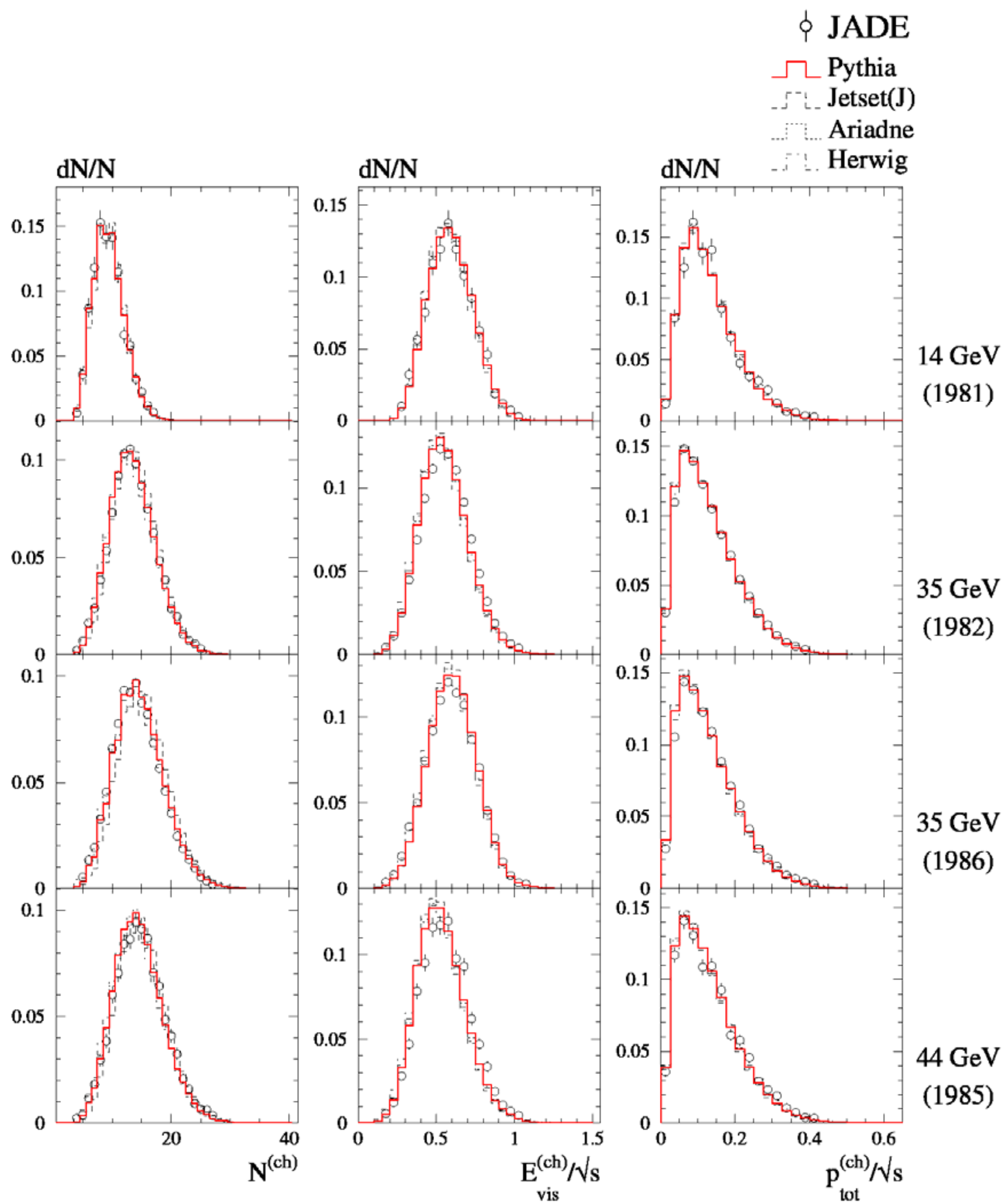
(PhD thesis Andreas Dieckmann, 1987)

detector correction



normalised deviation from data

significant improvement of data description by Monte Carlo (LEP tune)



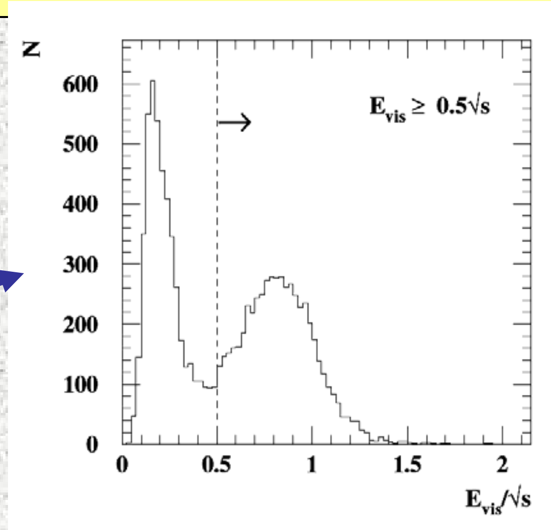
Quality of Simulation

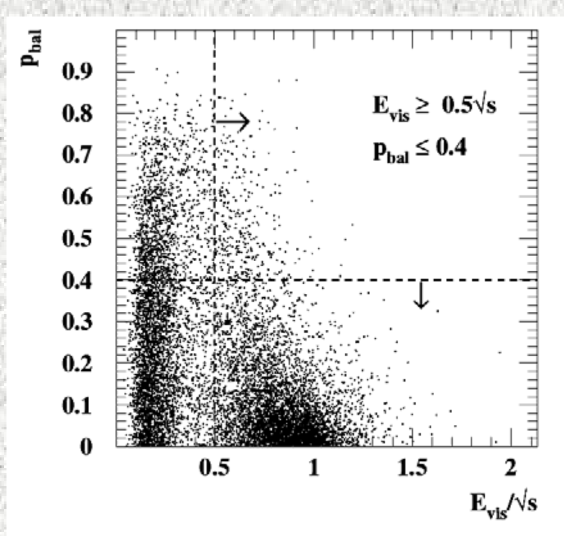
Hadronic Event Selection

- main selection cuts:
  - 4 tracks from vertex region
  - 3 'long+good' tracks
  - visible energy > $0.5\sqrt{s}$
  - momentum balance < 40%
  - missing momentum < $0.3\sqrt{s}$
  - $|\cos\Theta_t| < 0.8$

residual background ~ 1%:

- $e^+e^- \to e^+e\,\gamma\gamma$
- $e^+e^- \to \tau^+\tau^-$





K-factor for Moments