Inter-string Bose-Einstein Correlations in Hadronic Z Events using the L3 Detector at LEP

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- *Motivation of inter-string study*
- *Comparison of 2-jet and 3-jet events*
- *Comparison of quark and gluon jet*
- *Conclusion*

Motivation of our inter-string study

- Fragmentation process is normally described by phenomenological models.

- String model:

  Hadrons are produced coherently within one string

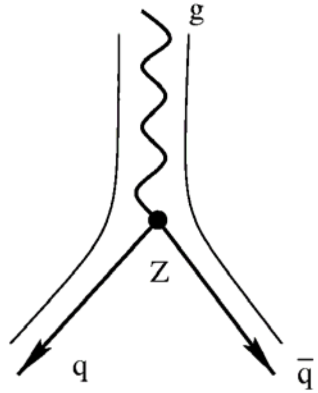
  BEC within one string is predicted by Lund Area Law

  No inter-string correlation is expected

- Combined results from LEP give no evidence for the inter-string BEC between the two W’s.

- Low statistics of WW events may limit the possibility of finding inter-string BEC

- We investigate inter-string BEC using 3-jet Z events which has higher statistics and which also contains two strings.



- Two particle correlation function:

$$R_2(Q) = \frac{\rho_2(Q)}{\rho_{0,2}(Q)}$$

reference sample without BEC

$$\rho_2(Q) = \frac{1}{N_{pairs}} \frac{dn_{pairs}}{dQ} \qquad Q = \sqrt{-(p_1 - p_2)^2}$$

Fitted using Edgeworth expansion

correlation strength

radius of the source

$$R_2(Q) = \gamma(1 + \delta Q + \varepsilon Q^2)\left[1 + \lambda e^{-R^2 Q^2}\left(1 + \frac{\kappa}{3!} H_3(RQ)\right)\right]$$

$$H_3(RQ) = (\sqrt{2}RQ)^3 - 3\sqrt{2}RQ \qquad \text{(Hermite polynomials)}$$

Correlation strength λ gets smaller when the number of independent strings increases

B.Buschbeck, H.C.Eggers, P.Lipa, Phys.Lett. B481 (2000) 187
P.Lipa and B.Buschbeck, Phys.Lett. B223 (1989) 465

If there is no inter-string BEC and overlap between the two strings:

$$\lambda_{2string} < \lambda_{1string}$$

$$R_{2string} \approx R_{1string}$$

If there is inter-string BEC between the two strings:

$$\lambda_{2string} \approx \lambda_{1string}$$

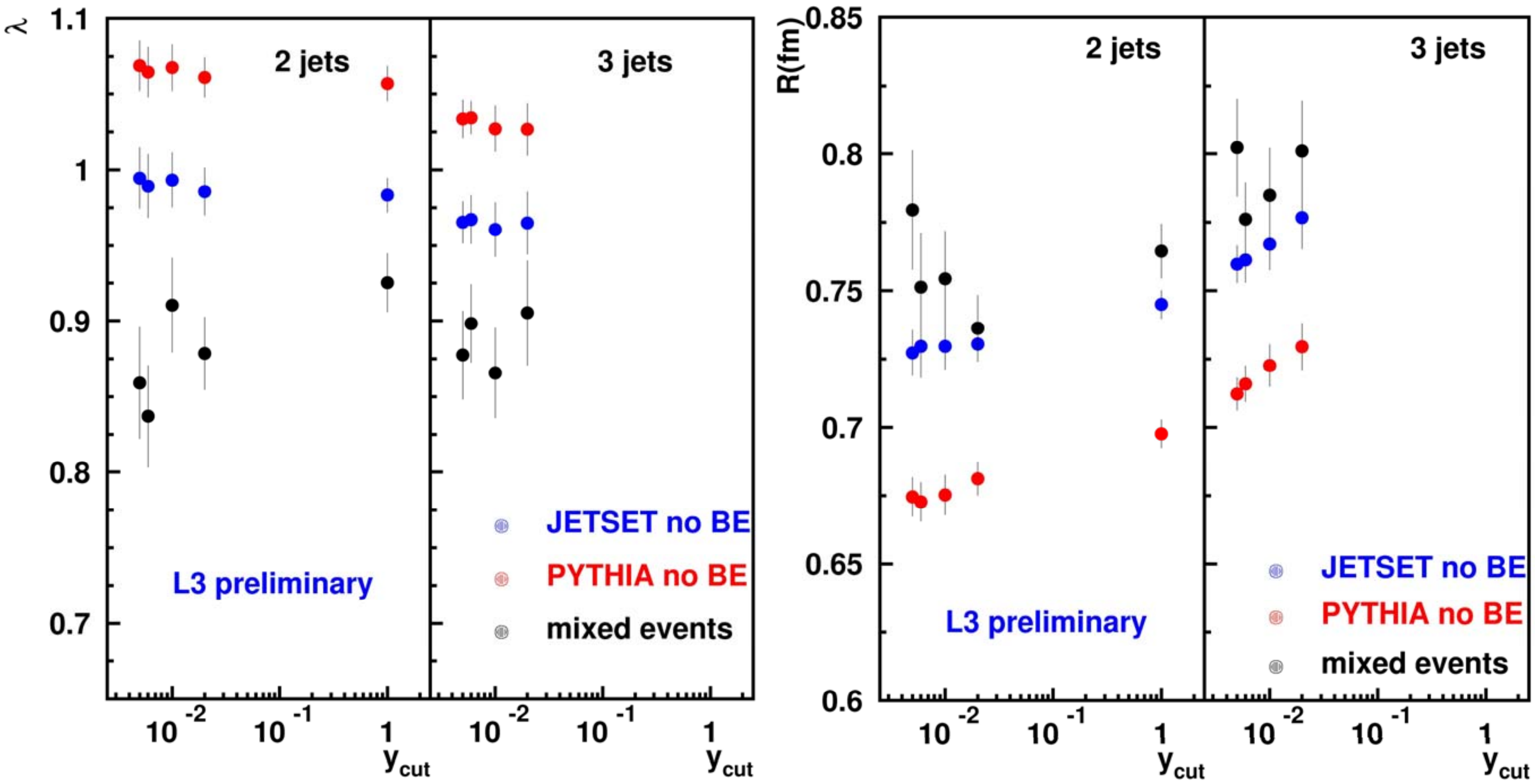
$$R_{2string} >\approx R_{1string}$$

Comparison of 2-jet and 3-jet events

BEC in the b quark events are suppressed, so we use only light quark (-udsc) events

Light quark events are classified as 2-jet and 3-jet events using the DURHAM algorithm with resolution parameter y_{cut} = 0.005, 0.006, 0.01, 0.02, 1

$R_2(Q)$ is calculated using both MC without BEC and mixed events as the reference sample.



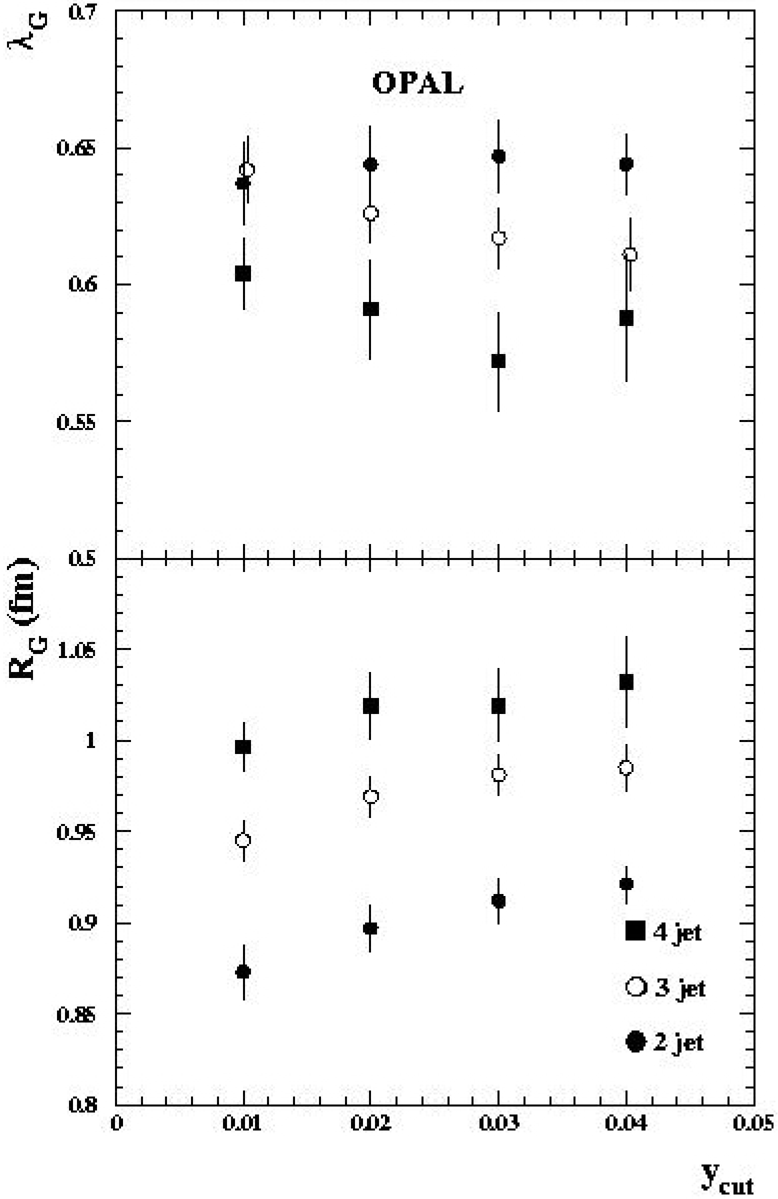
λ does not change with y_{cut} increasing,

R increase with y_{cut}, especially in 3-jet events.

λ and R are reference dependent.

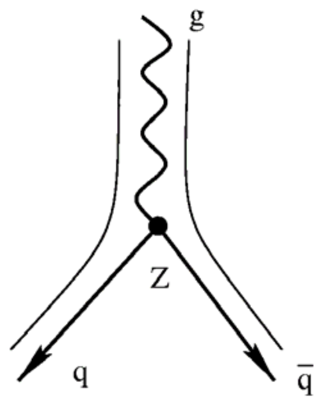
λ in 3-jet is slightly smaller than in 2-jet.

R in 3-jet events is bigger than in 2-jet.



Z.Phys.C 72,389(1996)

Comparison of quark and gluon jet



By looking at gluon jet, we increase the overlap.

Selection of gluon jets:

•DURHAM algorithm : select 3-jet events (y_{cut} = 0.02)

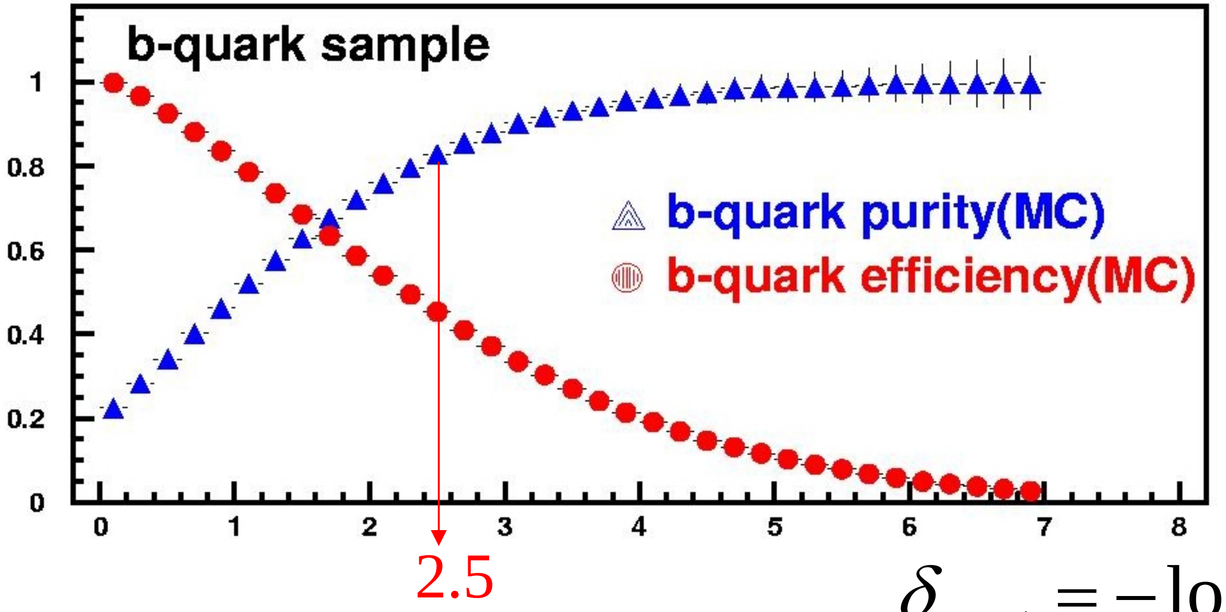
• Energy rank: (light quark 3-jet events)
  least energetic jet : gluon jet (95% purity)

• Double b-tagging:

Event b-tagging : select b quark events

$$P_{event} = \frac{\prod_{j=1}^{N_+} P(S_j)}{2^N} \sum_{i=0}^{N-1} \sum_{j=i+1}^{N} C_j^N \frac{(-\ln \prod_{j=1}^{N_+} P(S_j))^i}{i!}$$

puri/eff



$$\delta_{event} = -\log P_{event}$$

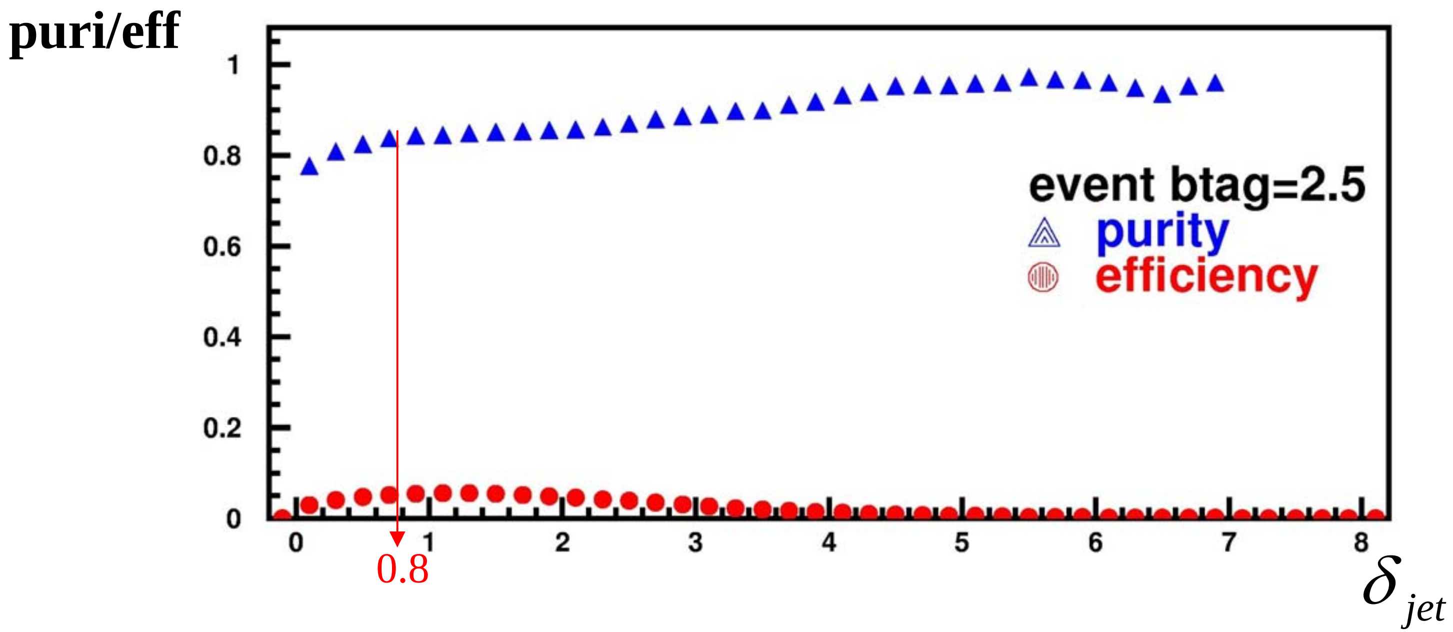
- In the 3-jet b quark events, jet b-tagging:

On 3 jets: $\delta_1 \geq \delta_{cut}$ and $\delta_2 \geq \delta_{cut}$ and

$$\delta_3 \leq \delta_{cut} \longrightarrow \text{jet 3 is the gluon jet}$$

On 2 jets: Jet 1 is the most energetic jet

$$\delta_2 \geq \delta_{cut} \text{ and } \delta_3 \leq \delta_{cut} \longrightarrow \text{jet 3 is the gluon jet}$$



Comparison of gluon and quark jet

total selected events	b quark events	selected gluon jet
706014	85875	10040(b tag on 3 jets) 10711(b tag on 2 jets)

Quark jet:

Quark jets in the light quark 2-jet and 3-jet events

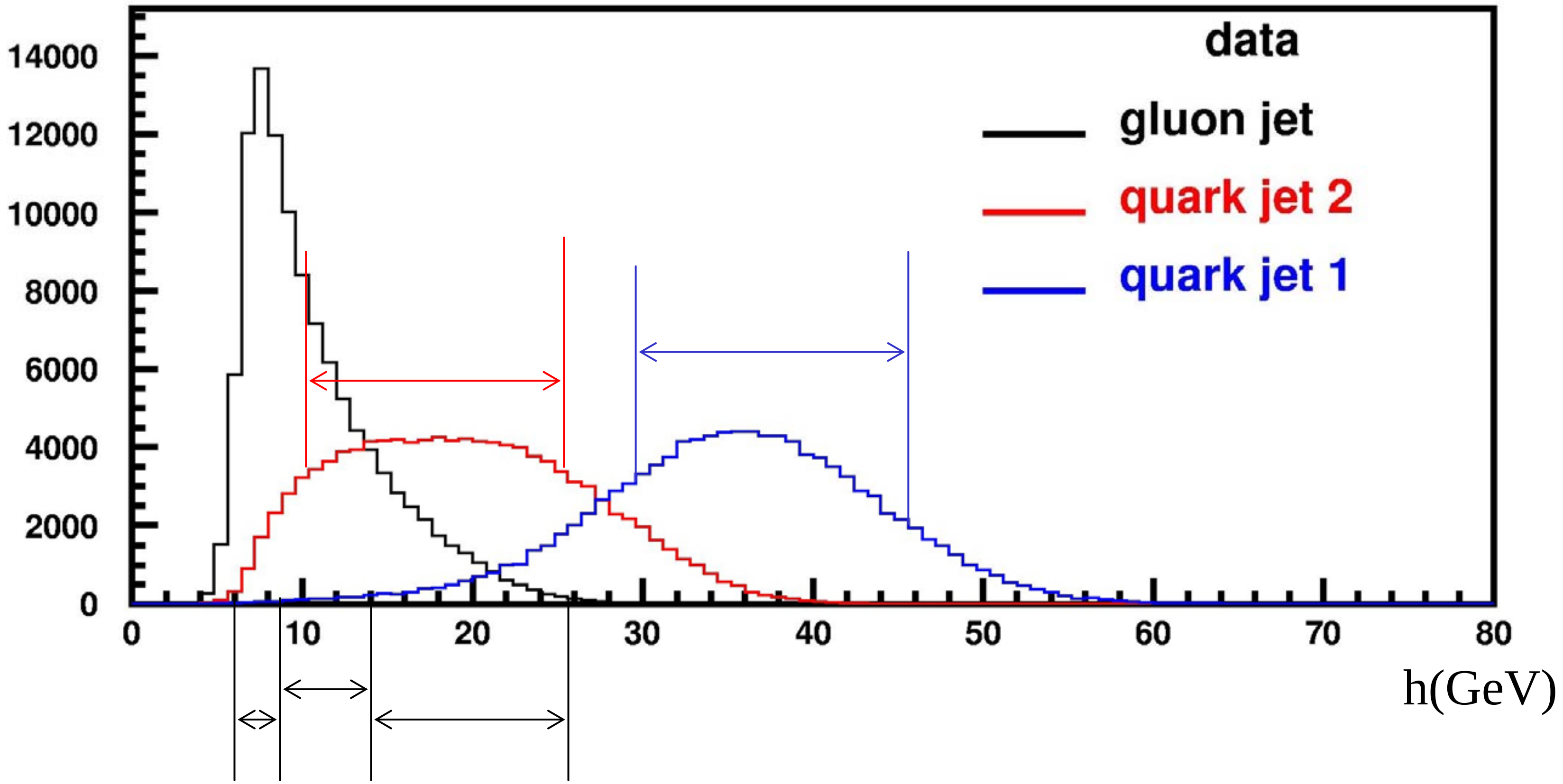
$$R_2(Q) = \frac{\rho_2(Q)}{\rho_{0,2}(Q)} \qquad \rho_{0,2}(Q): \text{ MC no BE}$$

Parametrization:

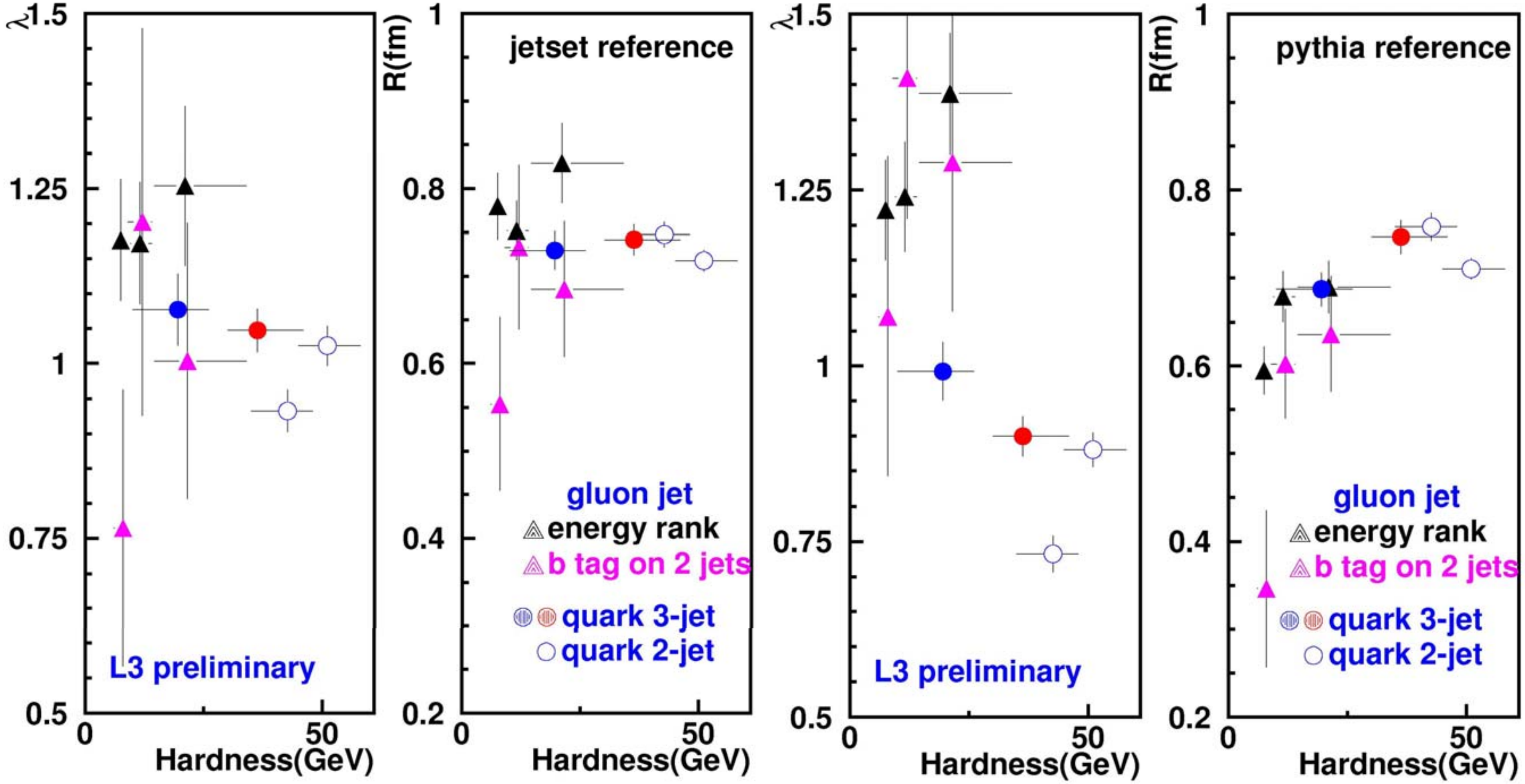
$$R_2(Q) = \gamma\left[1 + \lambda e^{-R^2Q^2}\left(1 + \frac{\kappa}{3!}H_3(RQ)\right)\right]$$

Dependence on hardness:

$$h = E_{jet}\sin\left(\frac{\theta_{1,2}}{2}\right)$$

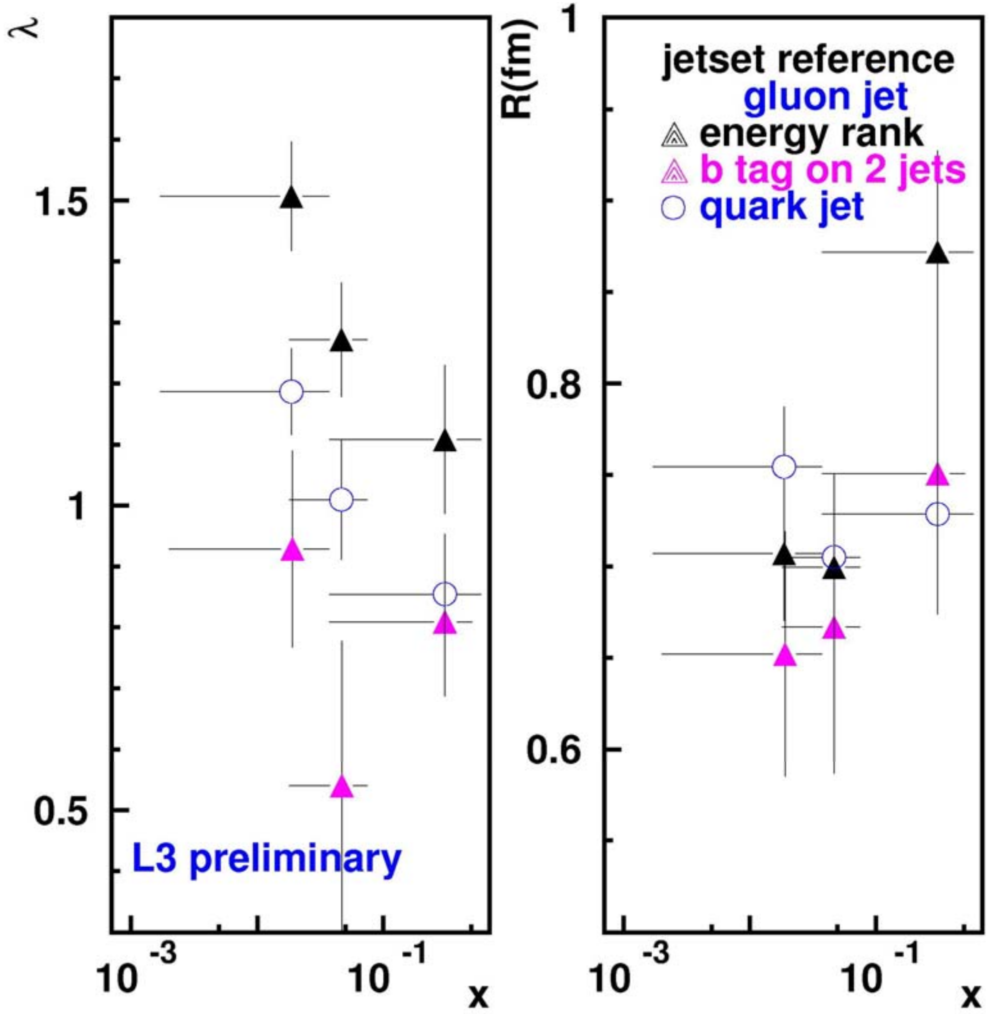


Dependence on hardness



- λ and R do not show obvious hardness dependence when using JETSET.
- λ and R show some hardness dependence when using PYTHIA.
- λ is slightly higher in gluon jet, R is the same in quark and gluon jet.

λ and R in different x windows



$$x = p_z / E_{jet}$$

λ shows x dependence, *R* does not.

No significant difference between quark and gluon jet for λ and *R*

Conclusions

2-jet and 3-jet difference:

λ is slightly smaller in the 3-jet events than in 2-jet events.

R is slightly bigger in 3-jet events than in 2-jet events.

These differences are not enough to establish inter-string BEC.

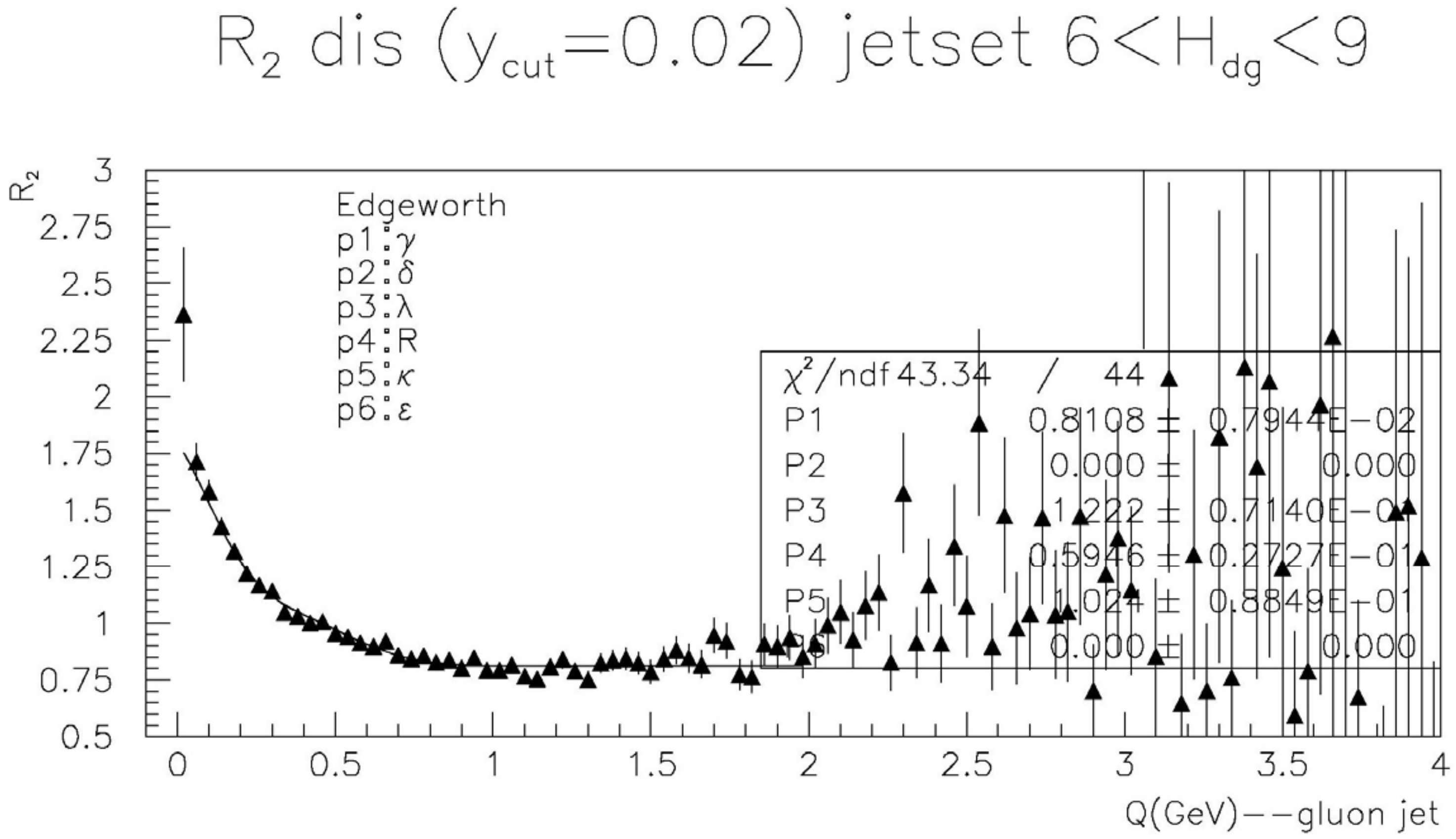
Quark and gluon jet difference (preliminary) :

λ tends to show no big difference in quark and gluon jets,

R is the same in quark and gluon jets,

i.e. there may be inter-string BEC or no overlap.

Backup


R2 dis (ycut=0.02) jetset 6<Hdg<9
R2
Edgeworth
p1:γ
p2:δ
p3:λ
p4:R
p5:κ
p6:ε
χ²/ndf 43.34 / 44
P1 0.8108 ± 0.7944E−02
P2 0.000 ± 0.000
P3 1.222 ± 0.7140E−01
P4 0.5946 ± 0.2727E−01
P5 1.024 ± 0.8849E−01
P6 0.000 ± 0.000
Q(GeV)−−gluon jet

R_2 distribution (Pythia as reference sample)