Parameters in Weight Calculations for the BE Effect

K.Fiałkowski, R.Wit

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Implementations of the BE effect in MC

a) Sjoestrand: momentum shifting,

b) Andersson: string symmetrization,

c) Wilk: charge assignment,

d) Pratt; Białas, Krzywicki: weights in factorized approximation

$$W(p_1,\ldots p_n) = \sum_{P\{1\ldots n\}} \prod_{i=1}^{n} w_2(p_i, p_{P(i)})$$

Our version of the weight method:

a) shortening the factorial sum by a clustering procedure,

b) rescaling of weights to restore P(n),

c) cutting weight tail at 500

Technical problems:

a) choice of the „BE ratio"

b) choice of particles to be symmetrized

c) choice of the w_2 factor

Note: only functions of single variable

$$Q^2 = -(p_1 - p_2)^2$$

Distributions from one million of events of Z^0 decays generated by PYTHIA 6.2; background from four million pairs of events;

ratios normalized to approach smoothly the value of 1 at $Q > 1$ GeV.

Ad a): standard ratio for like-sign pions defined as

$$R_{BE}(Q) = \rho_2(Q) / \rho_2^0(Q)$$

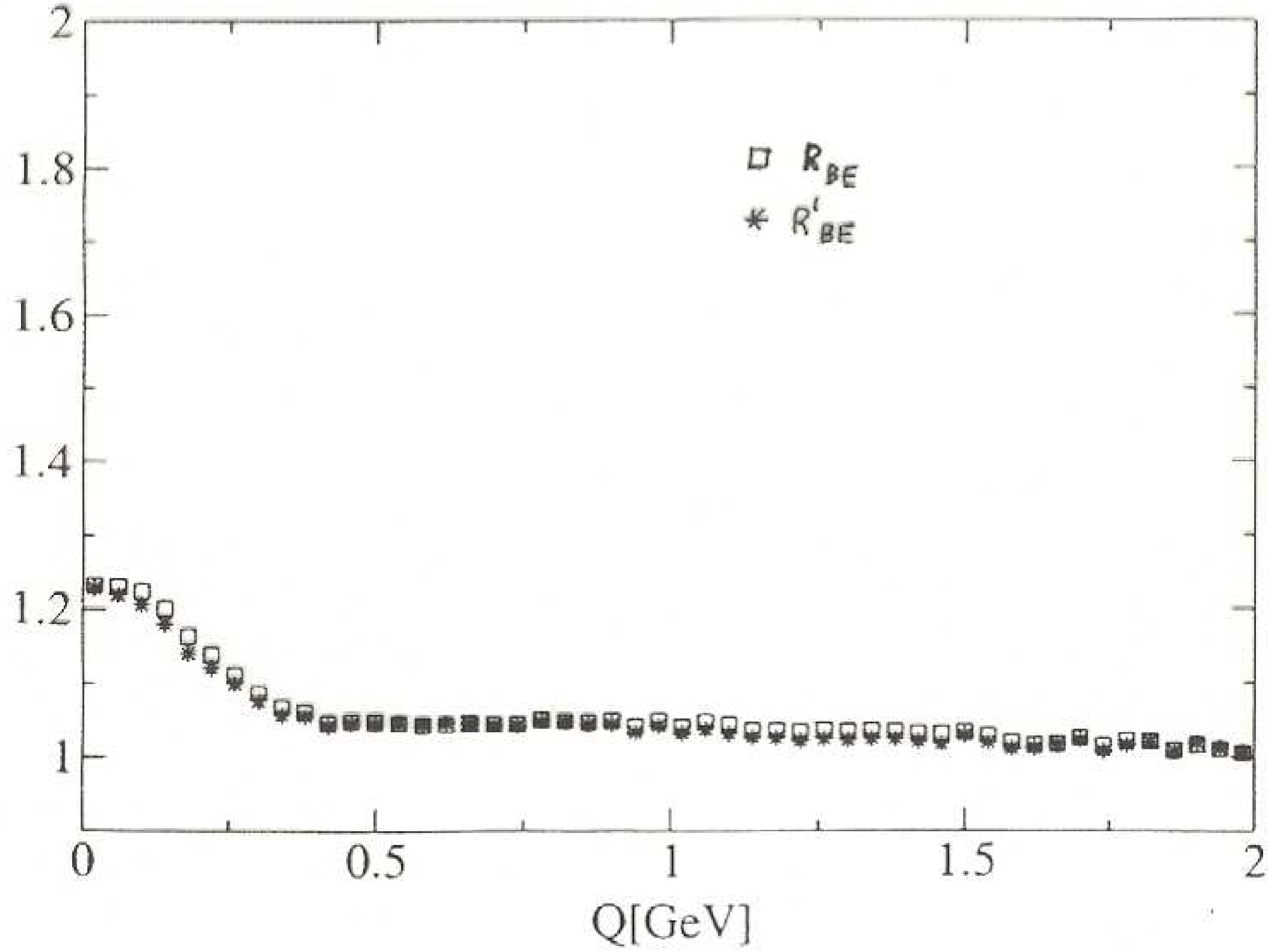
requires defining $\rho_2^0(Q)$ (distribution without BE). Standard choice was the distribution of unlike-sign pions (requires cutting off the resonance regions). Recently more popular is

$$R_{BE}(Q) = C_2^{BE}(Q) = \frac{\rho_2(Q)}{\rho_1 \otimes \rho_1(Q)}$$

where the denominator is constructed by mixing events. To remove biases, double ratios are also used (same shape)

$R'_{BE}(Q) = C_2^{BE}(Q) / C_2^{MC}(Q)$. (Fig.1)

Fig. 1



Ad b) as in Sjoestrand's method: only „direct" pions should be symmetrized, since decay products of long-living particles are born far from others, and contribute to BE ratios only for very small Q (below the resolution limit).

Standard definition of „long-living": $\Gamma<20$MeV. Not obvious; including ω decay products enhances strongly the effect (Fig.2). Specific PYTHIA parameters (fitted e.g. to L3) give also different results from default values (Fig.3).

Fig. 2.

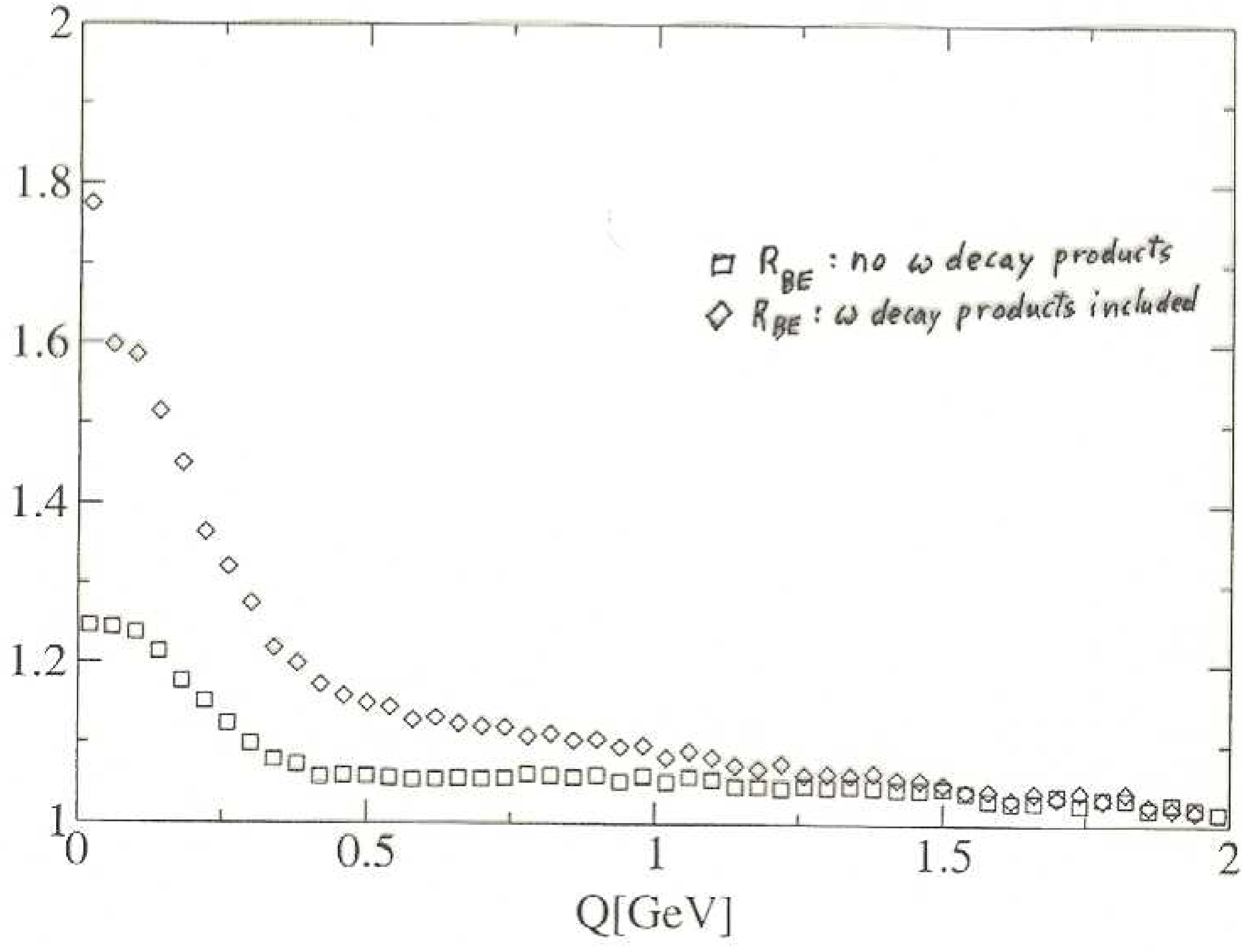
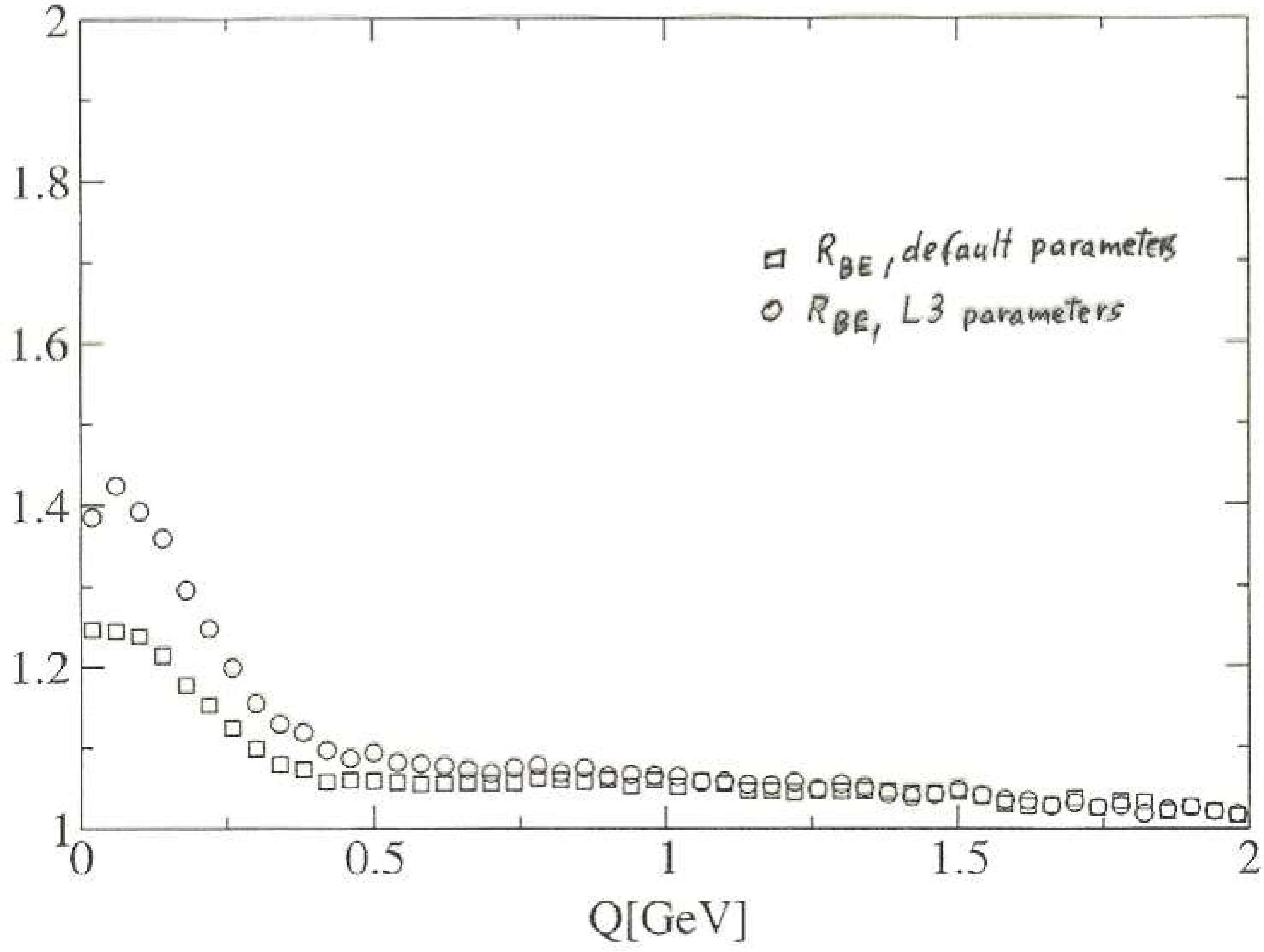

2
1.8
1.6
1.4
1.2
1
0
0.5
1
1.5
2
Q[GeV]
R_{BE} : no ω decay products
R_{BE} : ω decay products included

Fig. 3



2
1.8
1.6
1.4
1.2
1
0
0.5
1
1.5
2
Q[GeV]
□ R_{BE}, default parameters
○ R_{BE}, L3 parameters

Ad c): standard form is

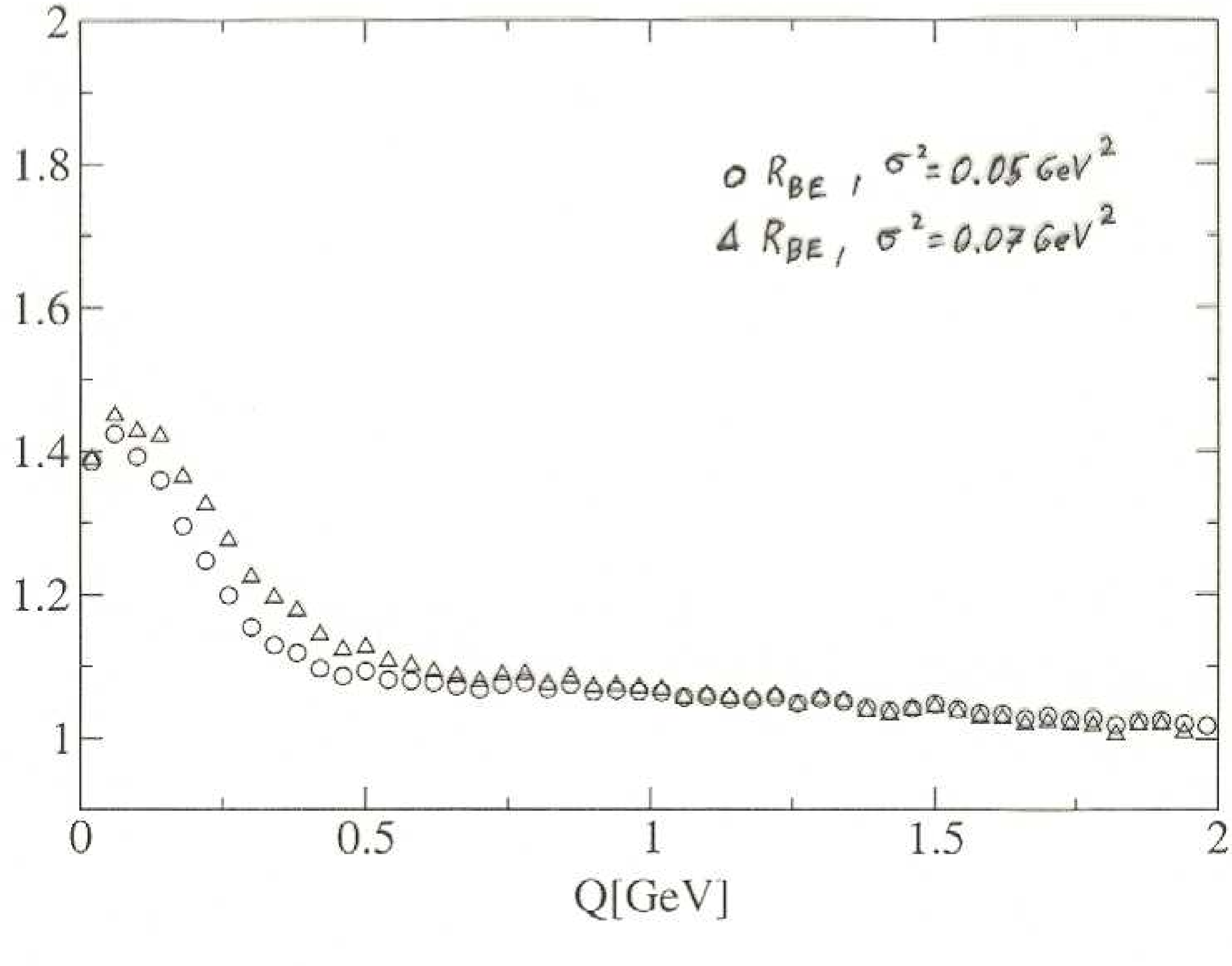
$$w_2(p_1, p_2) = \exp\left(\frac{(p_1 - p_2)^2}{\sigma^2}\right)$$

If R' is fitted to $1 + \lambda \exp(-Q^2 / Q_0^2)$, Q_0 grows approximately linearly with σ, while λ is almost constant (Fig.4).

Changing shape of w_2 we find it is approximately reflected in $R'-1$ (Fig.5).

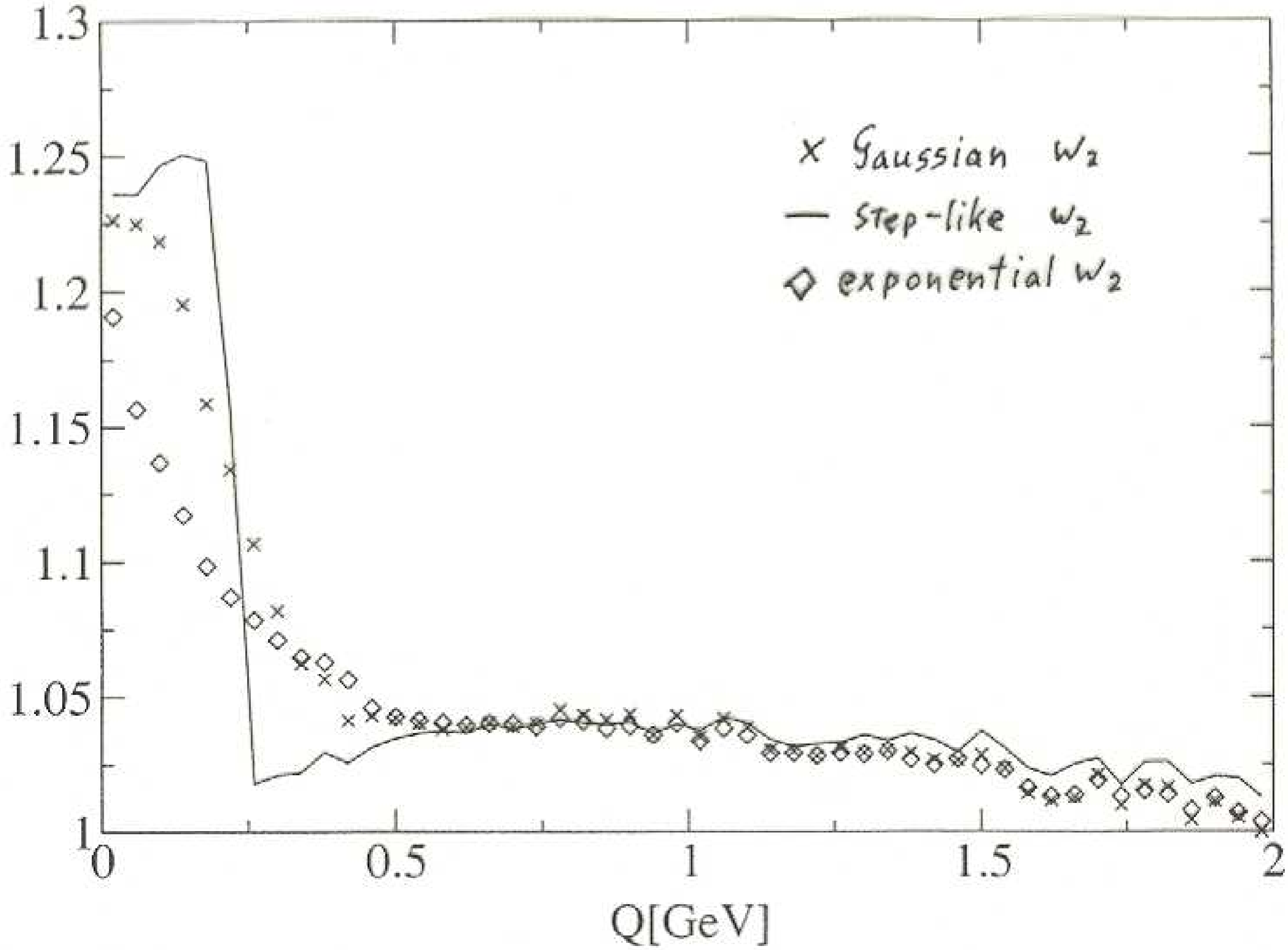
The freedom of w_2 (and of the choice of pions to be symmetrized) seems to be sufficient to describe the data (Fig.6).

Fig. 4.



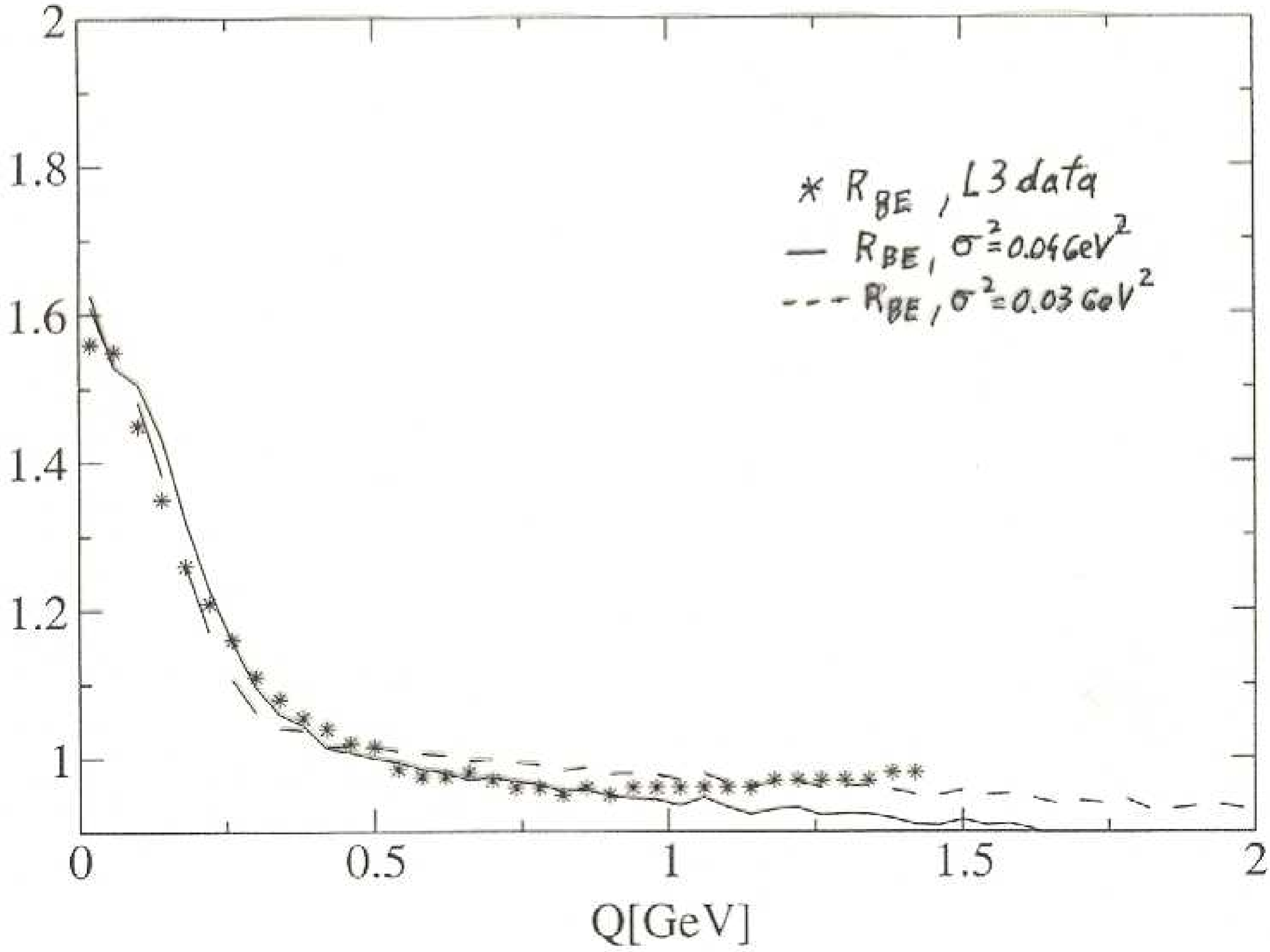
2
1.8
1.6
1.4
1.2
1
0
0.5
1
1.5
2
Q[GeV]
○ R_{BE}, $\sigma^2 = 0.05\ GeV^2$
△ R_{BE}, $\sigma^2 = 0.07\ GeV^2$

Fig. 5



× Gaussian w_2
— step-like w_2
◇ exponential w_2
1.3
1.25
1.2
1.15
1.1
1.05
1
0
0.5
1
1.5
2
Q[GeV]

Fig. 6



2
1.8
1.6
1.4
1.2
1
0
0.5
1
1.5
2
Q[GeV]
* R_BE , L3 data
— R_BE , σ² = 0.04 GeV²
--- R_BE , σ² = 0.03 GeV²

Summary:

a) the weight method is flexible, but not arbitrary

b) the freedom in parameter choices is sufficient to describe data and allows to draw conclusions on the space-time structure of the source (by Fourier transforming w_2),

c) weight method is quite easy to use and allows to discuss effects difficult to describe in other methods (e.g. anisotropy of the source).