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”γ+jet” calibration with used jet+jet events.

- jet+jet events for γ+jet calibration
- calibration coefficients for jets with different E_T structure in the $\eta - \phi$ space.

1. JET+JET EVENTS FOR γ+JET CALIBRATION

The large level of the jet+jet background to γ+jet is expected:

$$\textbf{S/B}<\textbf{1 at } E_T^{\gamma} < 50GeV$$

Therefore we study the possibiity to use the jet+jet events for calibration.

General conditions:

- **PYTHIA 6.156 + CMS121 + ORCA454**
- **low luminosity**
- **jet: iterative 0.5 cone algorithm**
- $|\eta_{jet}| < 1.$

The suitability of jet+jet events with an isolated ”photon” for the calibration was estimated using the value of the imbalance:

$$\Delta_I = E_T^{\gamma} - E_T^{parton}$$

and the systematic error of the calibration koefficient defined as:

$$\Delta_k = k_{jet}^{expect} - k_{jet}^{true},$$

where

$$k_{jet}^{true} = E_{Tjet}^{reco} / E_T^{parton},$$

$$k_{jet}^{expect} = E_{Tjet}^{reco} / E_T^{\gamma}.$$

We used cuts on

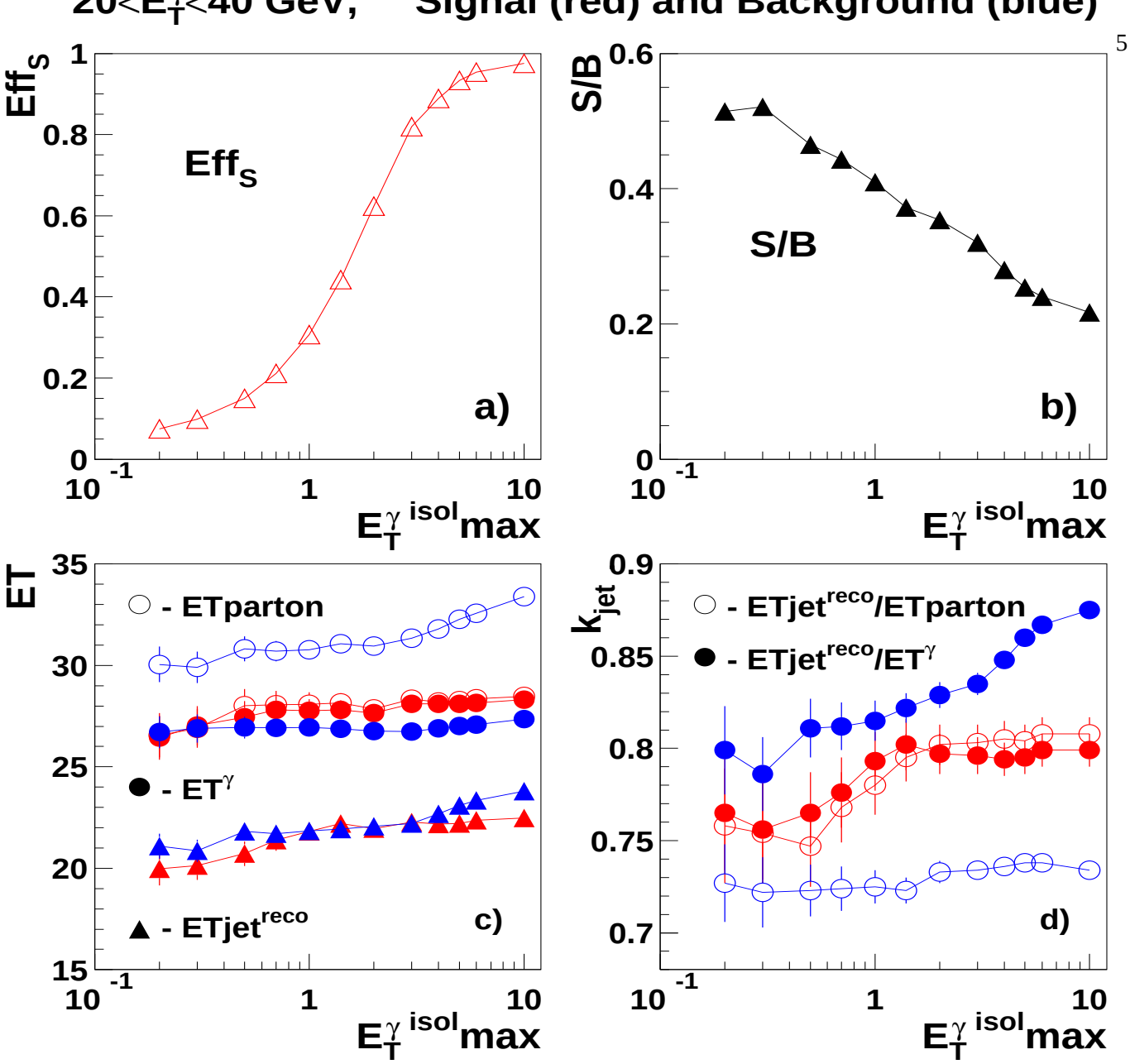
$\mathbf{E}_{T\gamma}^{isol}$ is summarized E_T in cone R=0.5 outside a cone of the size of 7x7 crystals around "γ" with E cuts on cell energy is 3σ E noise.

$\mathbf{E}_{T}^{jet2}$ is E_T of the second leading jet;

$\Delta\phi$ is angle between "γ" and jet;

The hard cuts can deform the sample and give the incorrect values of the calibration koefficient. We kept up that selections should not result in the systematic error:

$$\Delta_S = k_{jet}^{\textbf{no cuts}} - k_{jet}^{\textbf{with cuts}}$$

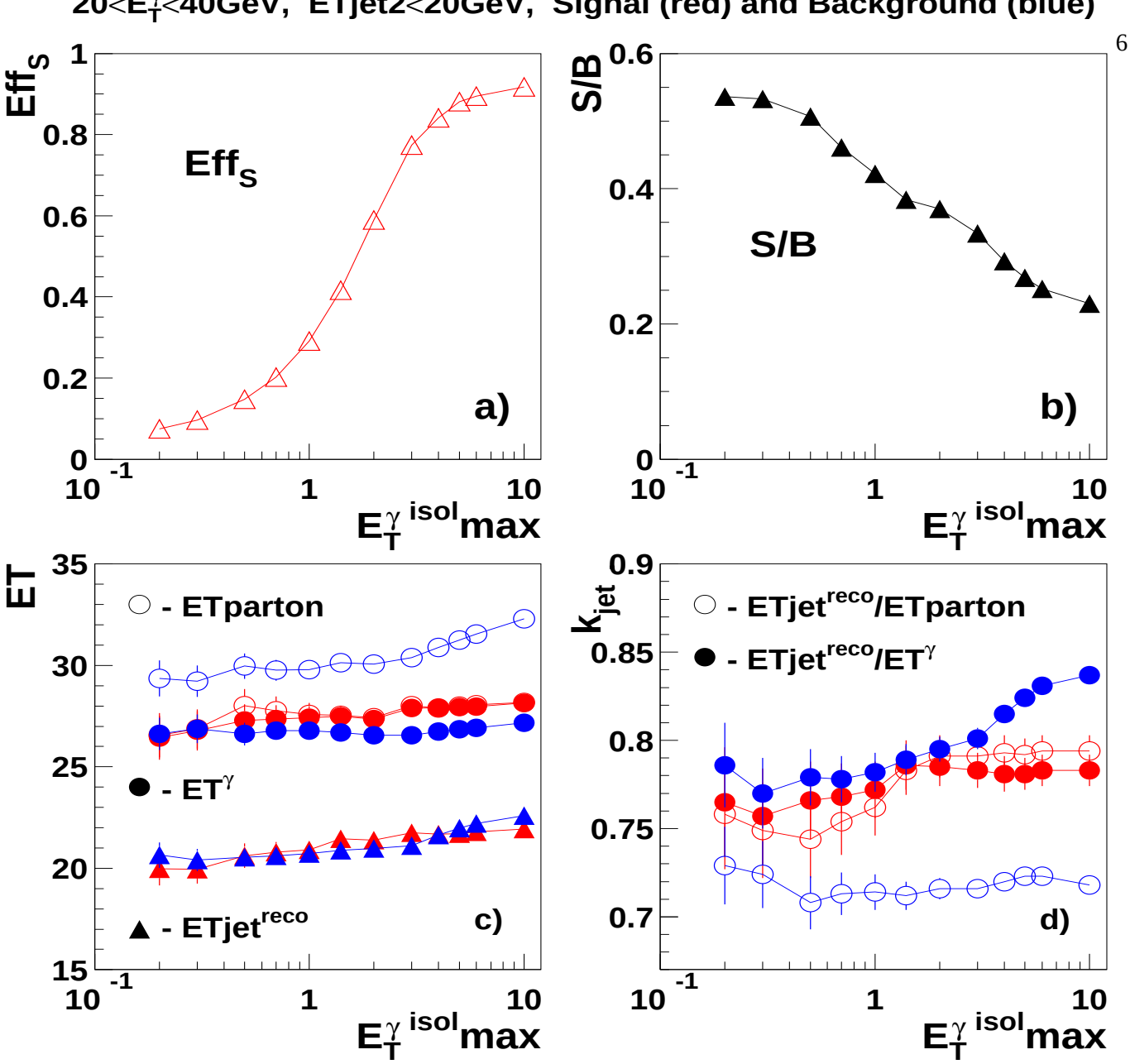


The efficiency of the signal suppression (a), S/B (b), the mean values of E_T^{γ}, E_T^{parton} and E_{Tjet}^{reco} (c) and k_{jet}^{true} and k_{jet}^{expect} (d) v.s. $\mathbf{E}_{T\gamma}^{isol}$ cuts.

For the signal: $k_{jet}^{expect} \approx k_{jet}^{true}$ (d).

For the background: $E_T^{\gamma} - E_T^{parton} > 11\% E_T^{\gamma}$ (c),

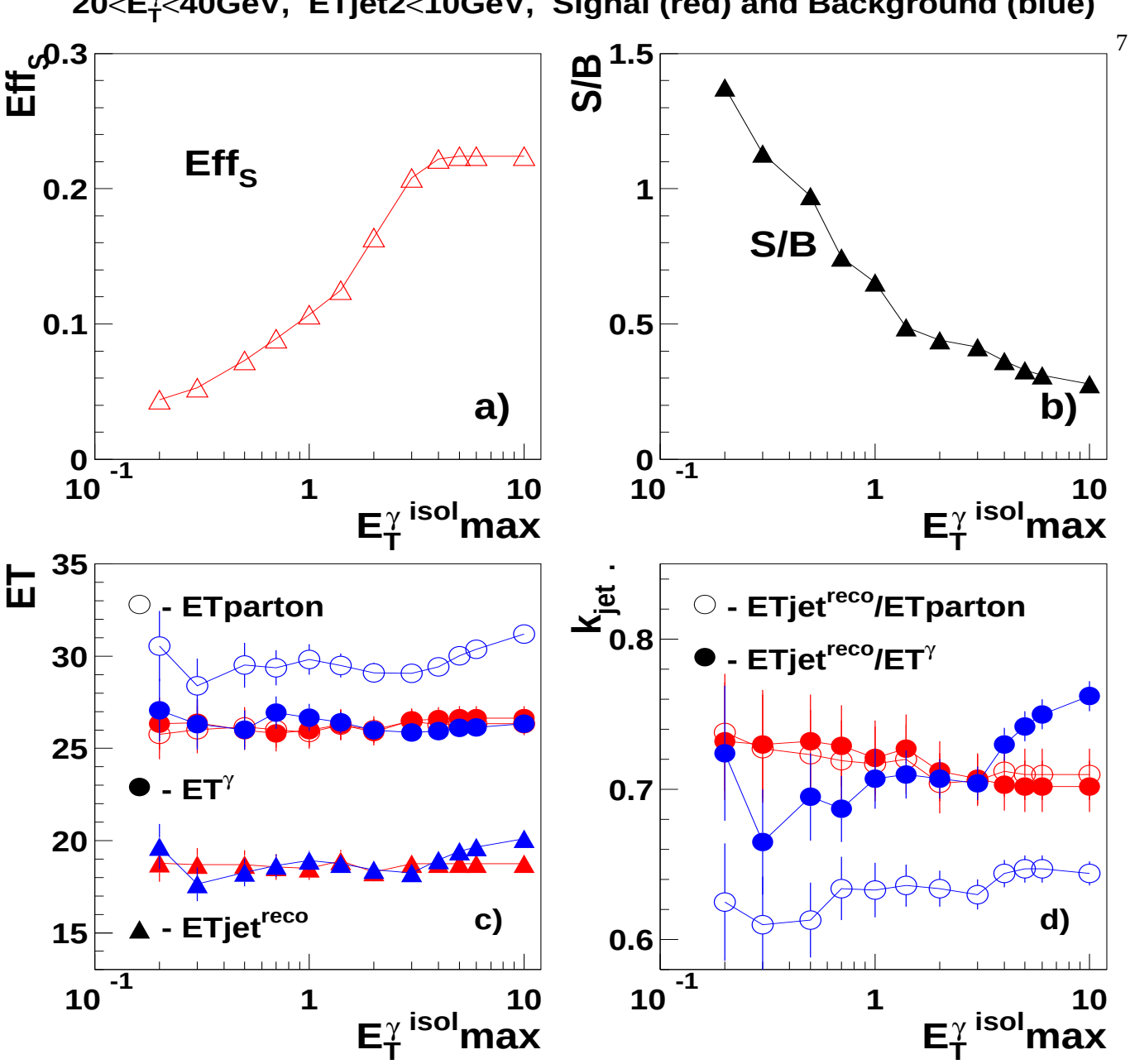
. $k_{jet}^{expect} - k_{jet}^{true} > 12\% k_{jet}^{true}$ (d)



k_{jet}^{expect} of the background and the signal with soft cuts $E_T^{jet2} < 20GeV$ and $E_{T\gamma}^{isol} < 2GeV$ are close (d), but background events are not suitable for calibration:

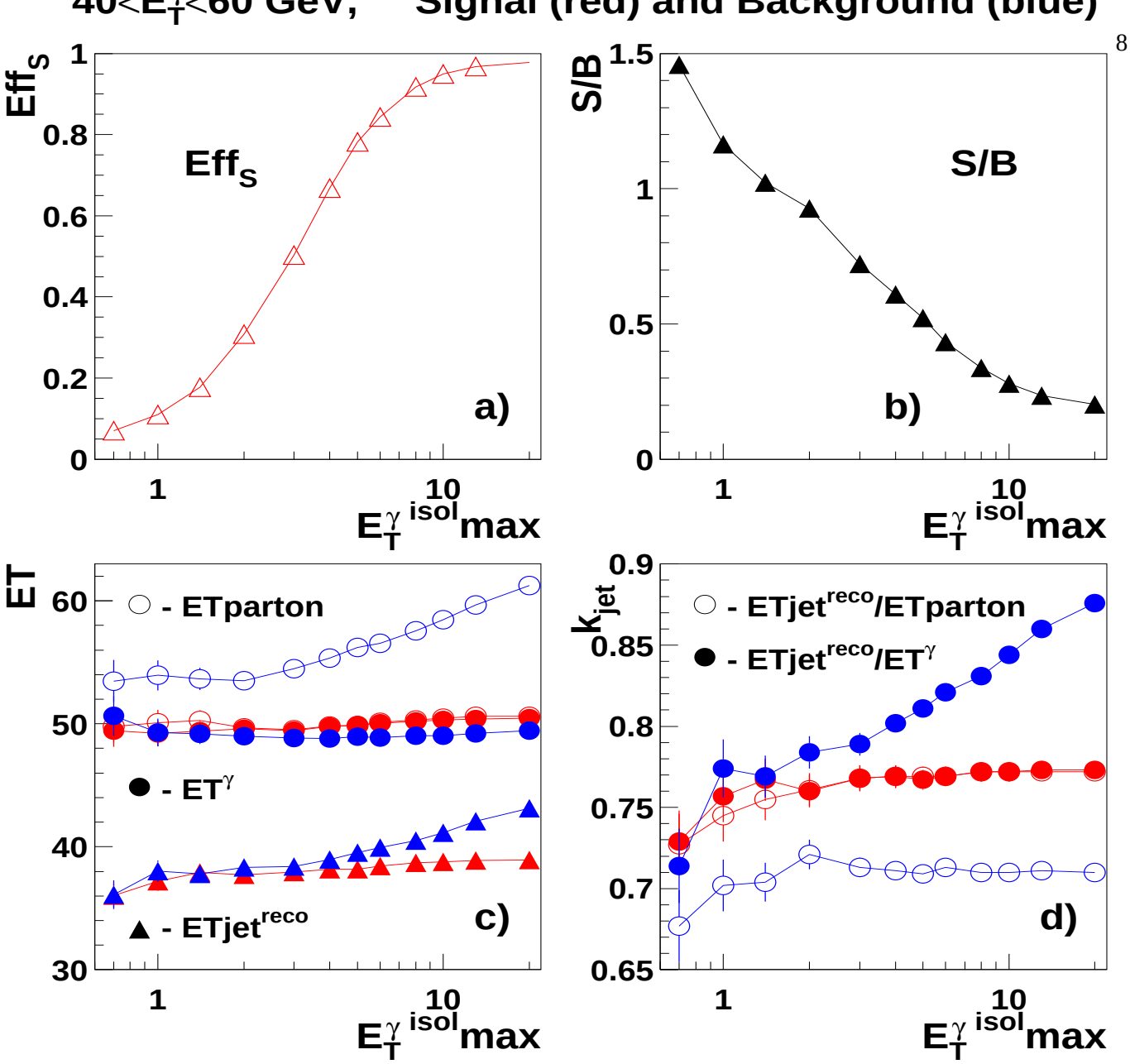
. $E_T^{\gamma} - E_T^{parton} > 9\% E_T^{\gamma}$ (c),

. $k_{jet}^{expect} - k_{jet}^{true} > 10\% k_{jet}^{true}$ (d)



At more hard selections the situation is not improved and besides sample is deformed and the systematic error in calibration koefficient arises (for signal and background):

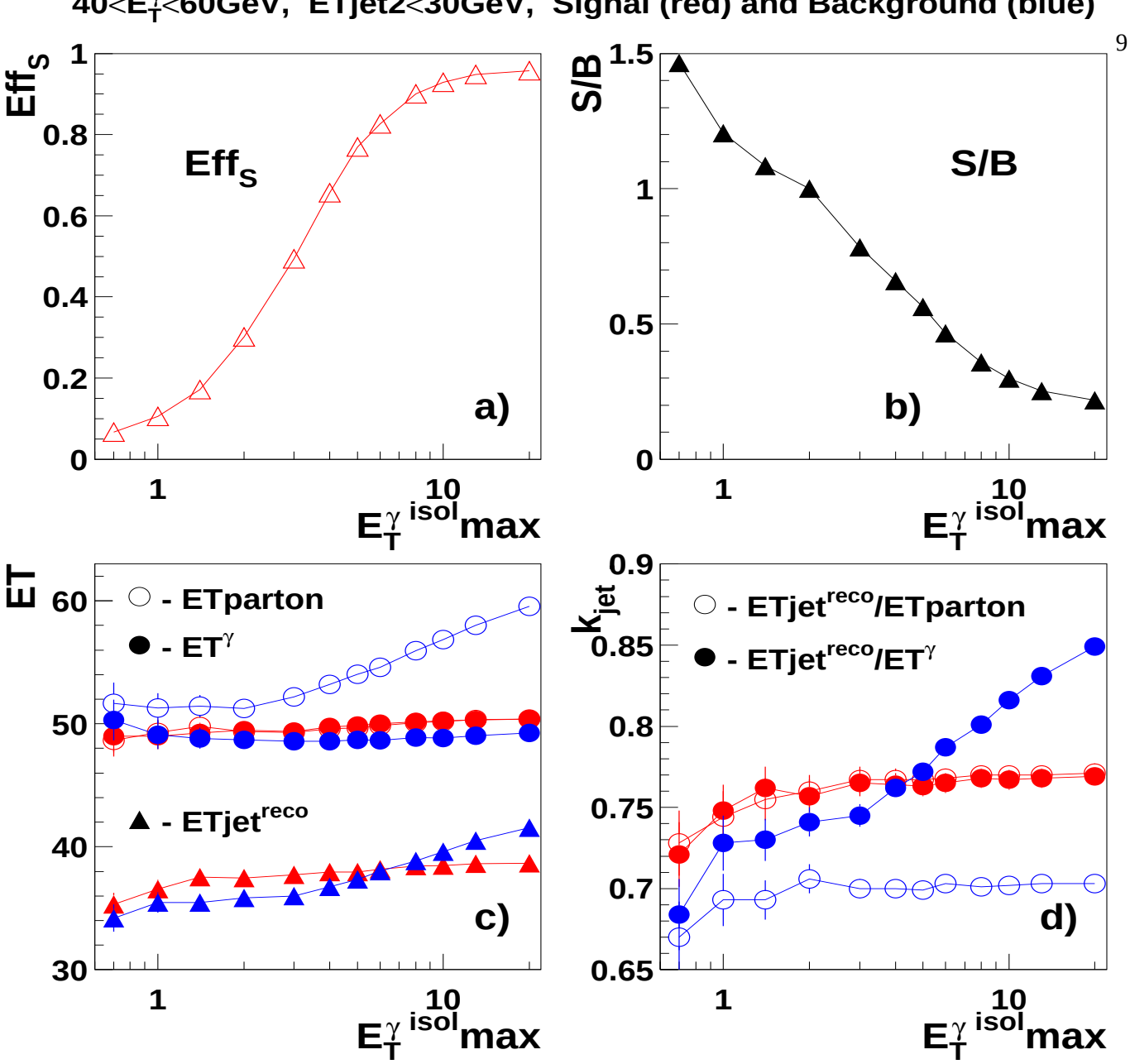
$$k_{jet}^{\textbf{no cuts}} - k_{jet}^{\textbf{with cuts}} \approx 12\% k_{jet}^{\textbf{no cuts}}$$



We have with $E_{T\gamma}^{isol}$ cut for background:

. $$E_T^\gamma - E_T^{parton} > 9\% E_T^\gamma \text{ (c)},$$

. $$k_{jet}^{expect} - k_{jet}^{true} > 10\% k_{jet}^{true} \text{ (d)}$$



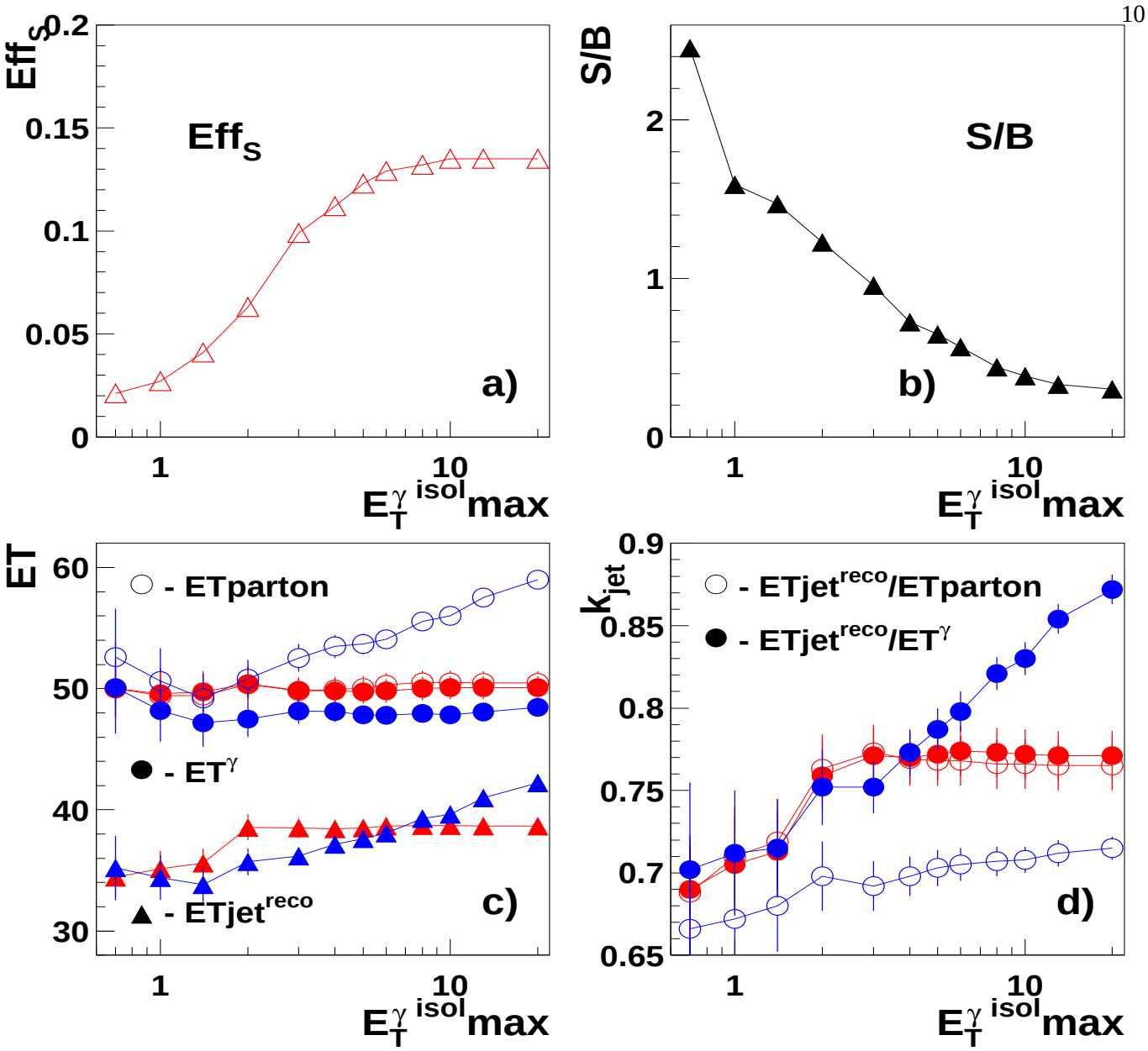
And with soft E_T^{jet2} cuts for background:

. $$E_T^\gamma - E_T^{parton} > 5\% E_T^\gamma \text{ (c)},$$

. $$k_{jet}^{expect} - k_{jet}^{true} > 6\% k_{jet}^{true} \text{ (d)}.$$

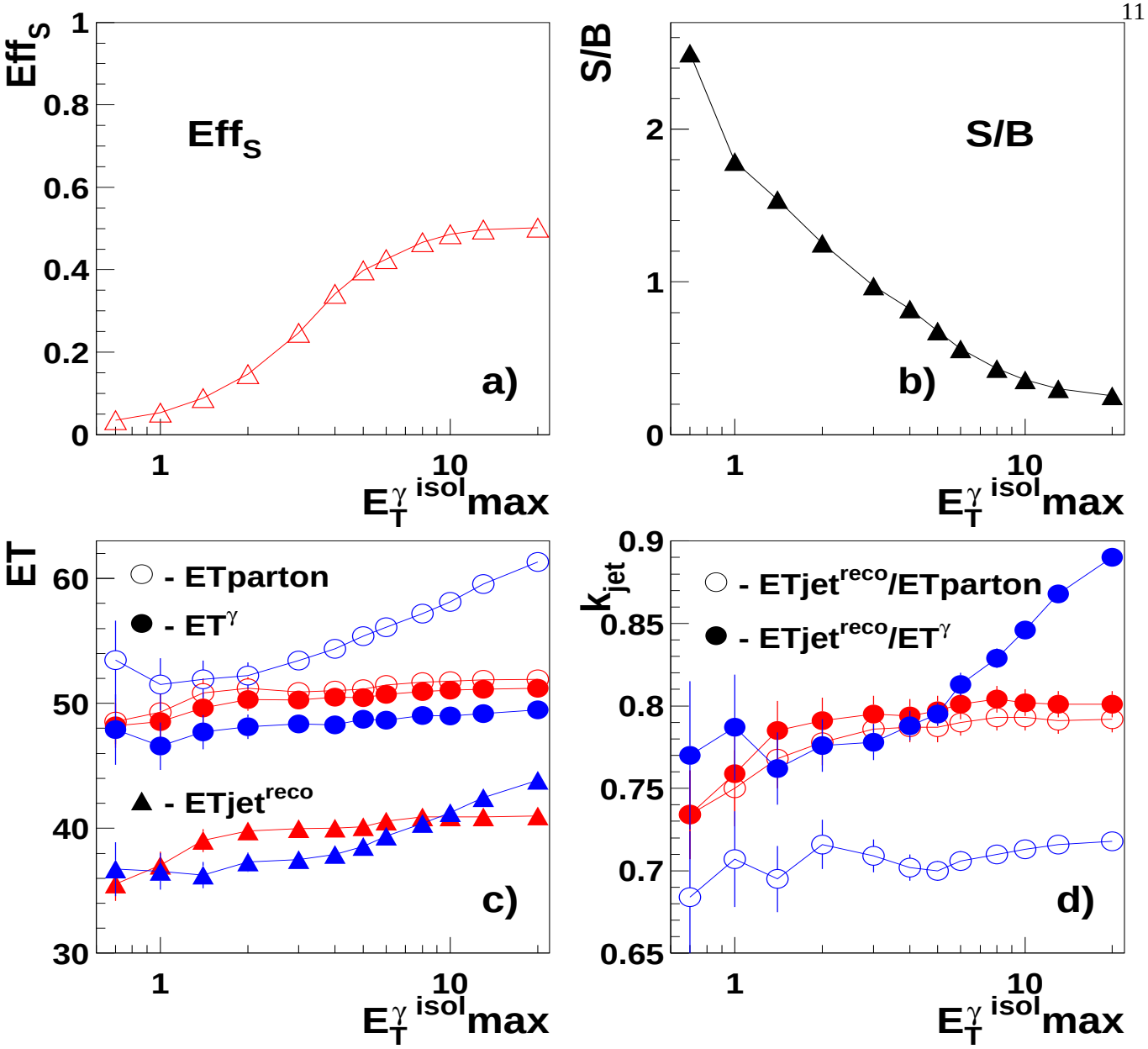
But, probably, these errors will be insignificant at $E_{T\gamma}^{isol} < 2GeV$. It can be checked up with the larger statistics.

40<E_T^γ<60GeV, ETjet2<10GeV, Signal (red) and Background (blue)



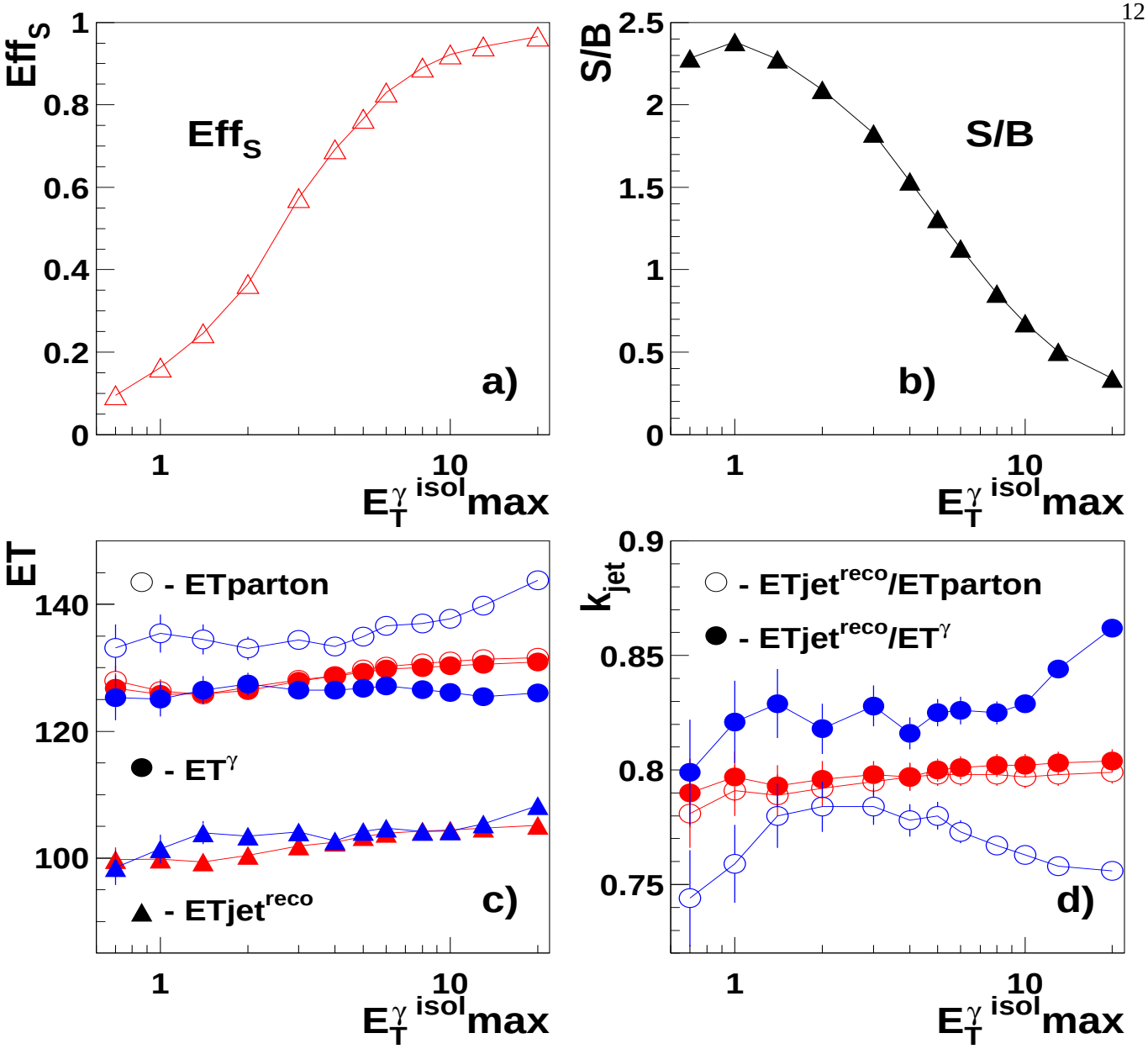
The more hard selections essentially does not improve a situation

$40<E_T<60GeV$, $ETjet2<30GeV$, $\Delta\phi > 3$



... and also selection on a angle between a photon and a jet.

100<E_T<200GeV, Signal (red) and Background (blue)

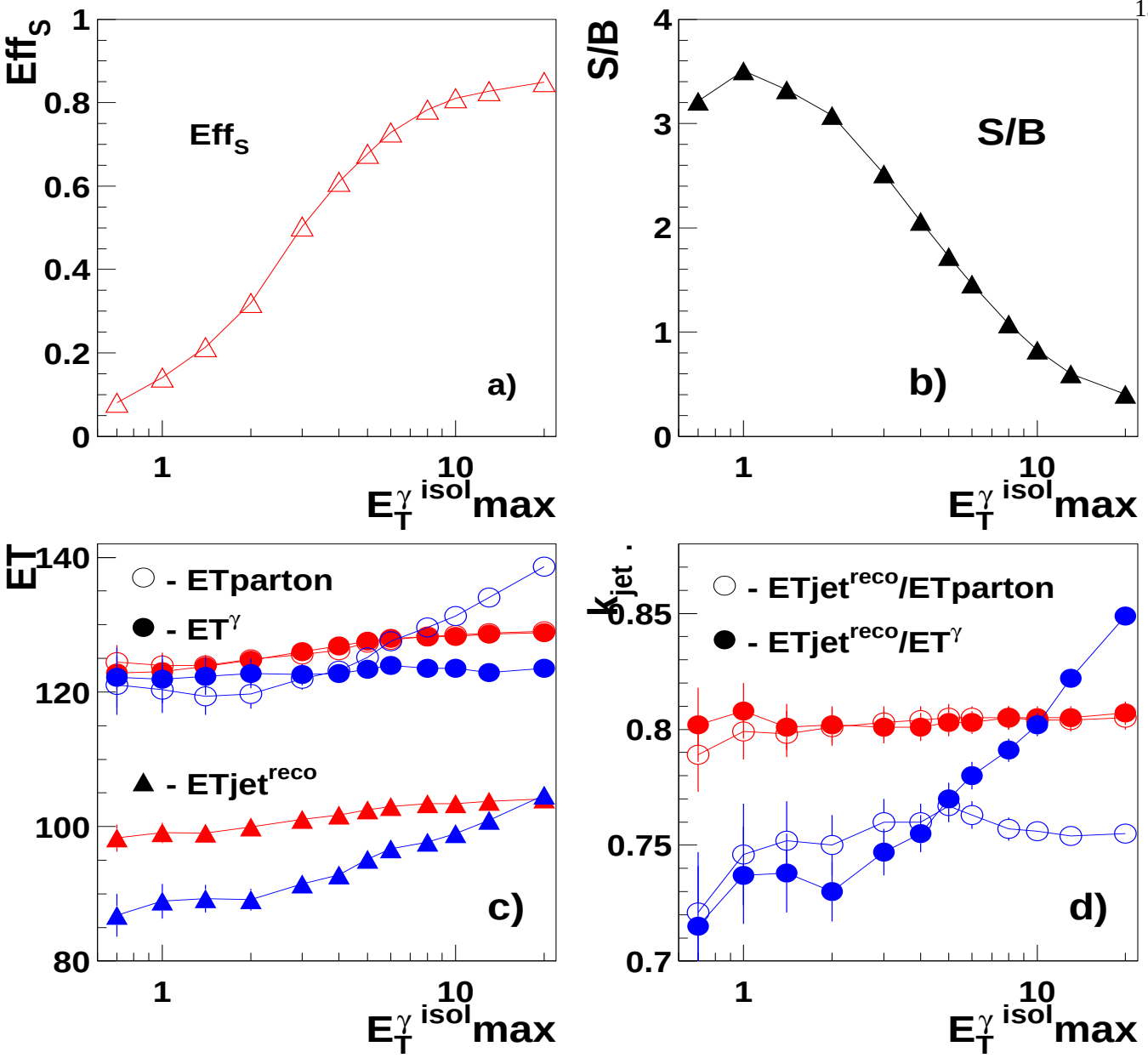


We have with $E_{T\gamma}^{isol}$ cut for background:

. $$E_T^\gamma - E_T^{parton} > 5\% E_T^\gamma \text{ (c)},$$

. $$k_{jet}^{expect} - k_{jet}^{true} > 5\% k_{jet}^{true} \text{ (d)}$$

100<E_T<200GeV, ETjet2<40GeV, Signal (red) and Background (blue)



And with soft cuts $E_T^{jet2} < 40GeV$ and $E_{T\gamma}^{isol} < 5GeV$:

. $E_T^{\gamma} \approx E_T^{parton}$(c),

. $k_{jet}^{expect} \approx k_{jet}^{true}$ (d)

. $k_{jet}^{\textbf{with cuts}} \approx k_{jet}^{\textbf{no cuts}}$

- background events are suitable for calibration (B≈S).

2. JETS WITH DIFFERENT E_T STRUCTURE IN THE $\eta - \phi$ SPACE

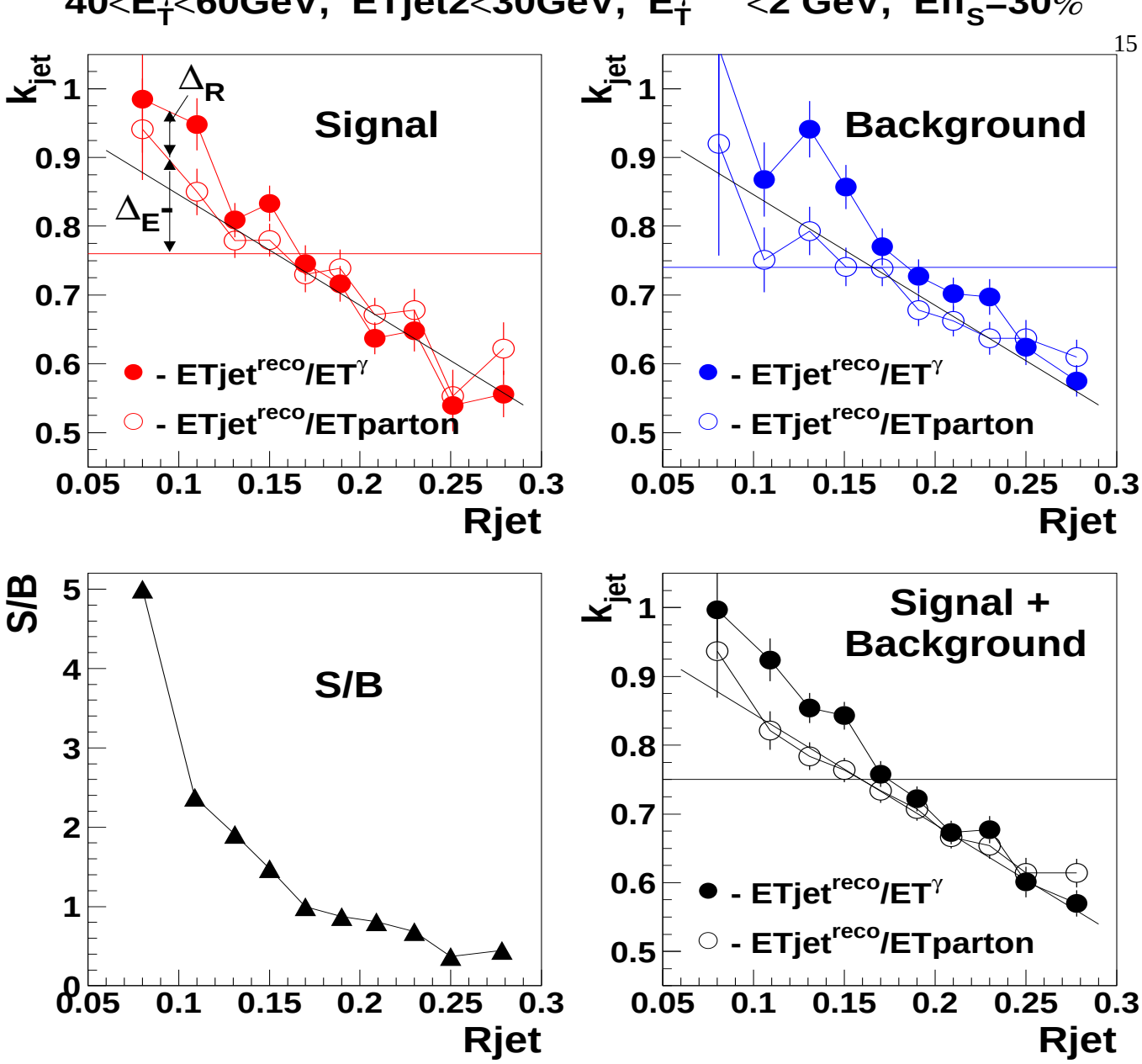
So, the jet+jet events can be suitable for the calibration, but they will give k$_{jet}$ distinguished from γ+jet. The main reason is the prevalence of quark jets in the signal events , and gluon jets in the background. If to select events only with quark or gluon jets k$_{jet}$ in case of a signal and a background will be close.

Values of k_{jet}^{true} for $40 < E_T^{\gamma} < 60GeV$

Jets	**Signal**	**Background**
all jets	**0.76**	**0.71**
quark jets	**0.77**	**0.76**
gluon jets	**0.69**	**0.69**

k$_{jet}$ can differ on a $\approx 10\%$ depending on a ratio in sample of quark and gluon jets. But it is possible to try to determine universal k$_{jet}$ which depends on the weighted radius of a jet:

$$R_{jet} = \sum_{i \in jet} E_{Ti}/E_{Tjet}$$



Selection on R_{jet} specifies k_{jet} on size:

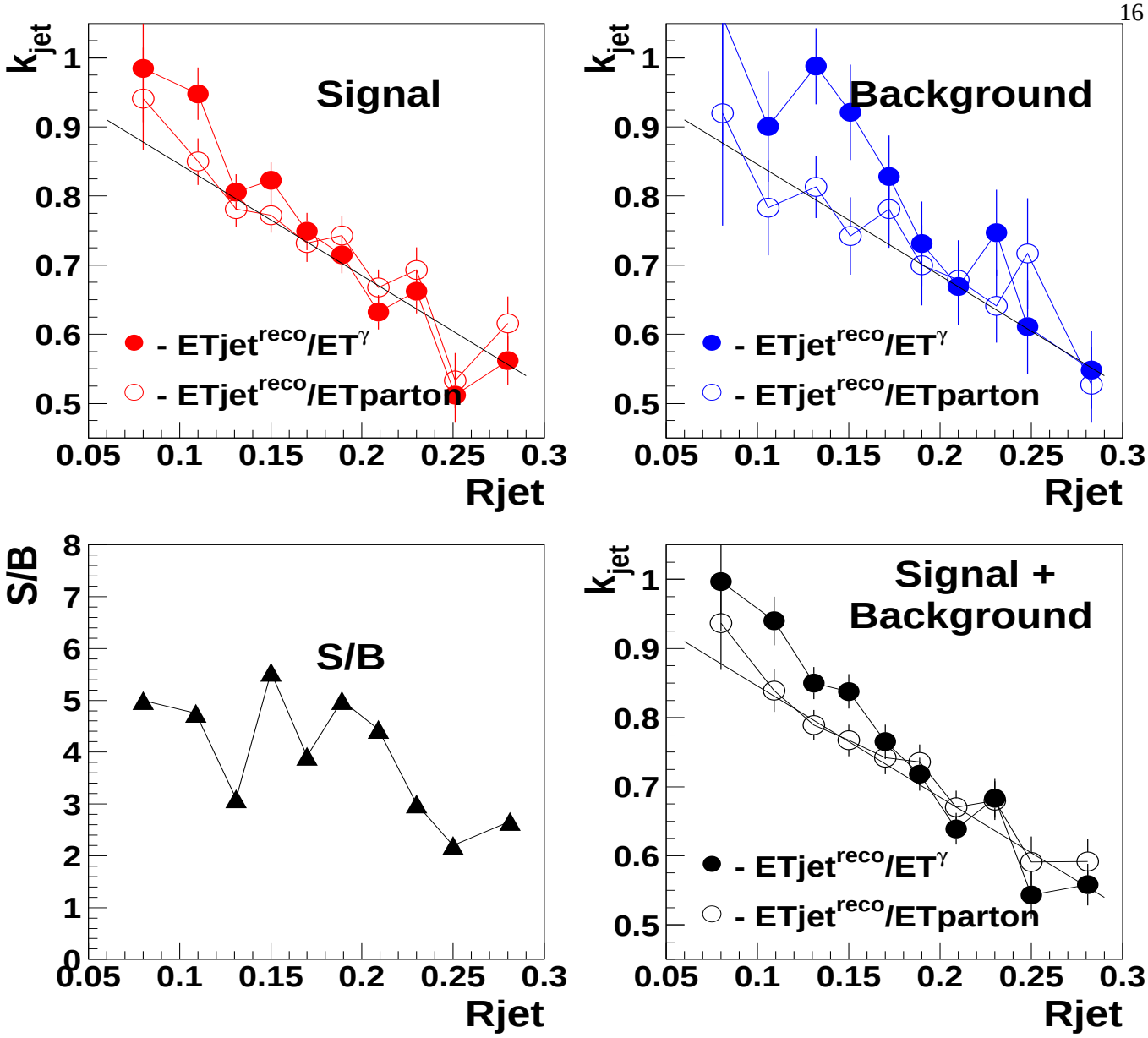
$$\Delta_E = k_{jet}^{true}(E_T^{\gamma}) - k_{jet}^{true}(R_{jet}),$$

but brings an error:

$$\Delta_R = k_{jet}^{expect}(R_{jet}) - k_{jet}^{true}(R_{jet}).$$

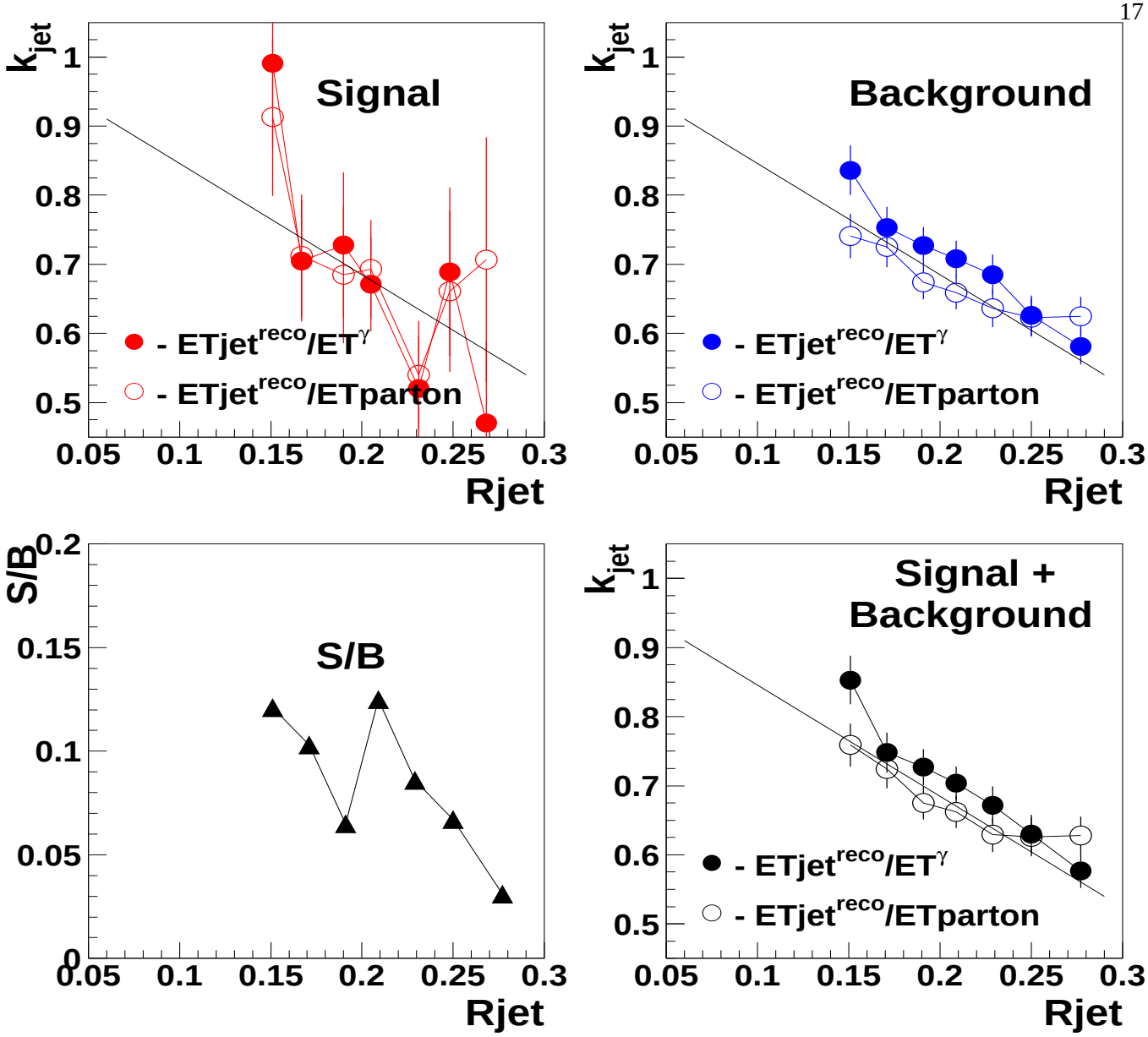
The values of $k_{jet}^{true}(R_{jet})$ in case of a signal and a background will be close. The values of Δ_R is small at $R_{jet} > 0.17$ (case S+B) - condition for calibration.

40<E_T<60GeV, ETjet2<30GeV, E_T <2 GeV, quark jets

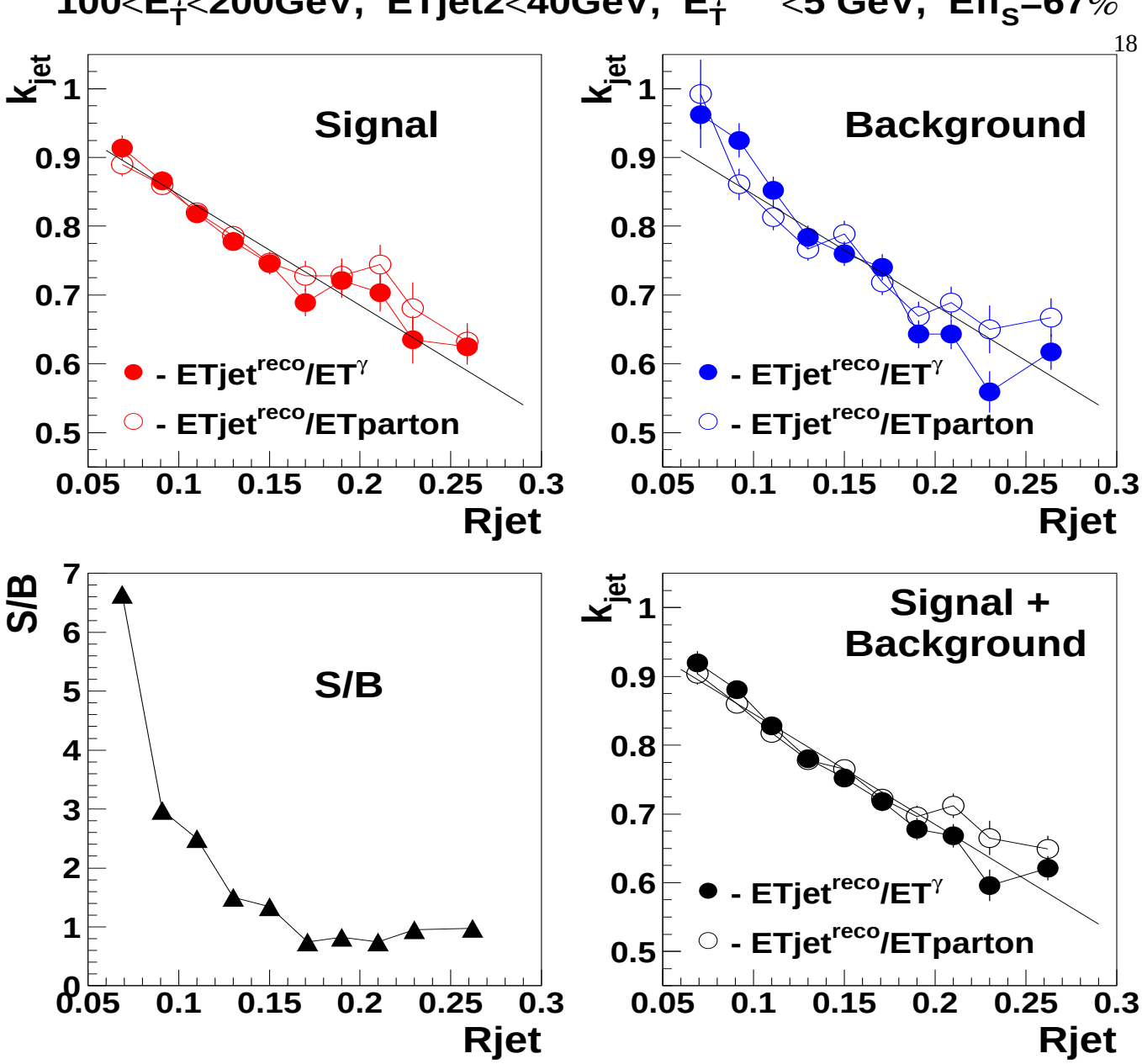


Preliminary: $k_{jet}^{true}(R_{jet})$ dependence is stable for quark jets ...

40<E_T^{γ}<60GeV, ETjet2<30GeV, E_T^{γ} <2 GeV, gluon jets



and for gluon jets ...



... and for different E_T^γ intervals.

Values of $k_{jet}^{expect}(R_{jet}) - k_{jet}^{true}(R_{jet})$ is small at $E_T^\gamma > 100GeV$ and $R_{jet} < 0.2$.

Conclusions

- At $E_T^\gamma < 40GeV$ in the events selected for calibration the background events which has bad balance on P_T between a photon and a jet prevails and brings the essential systematic error in calibration.
- It is possible to expect, that γ+jet calibration will be possible, since $E_T^\gamma \approx 50GeV$.
- The background can not spoil calibration. So, at $E_T^\gamma > 100GeV$ already at soft selections (Eff$_S = 67\%$ we have the large number of events (B≈S), suitable for calibration.
- The calibration koefficient depends on E_T structure of jet in the $\eta - \phi$ space (The coefficient, for example, differs for $\approx 10\%$ for quark and gluon jets and for γ+jet and jet+jet events). It is possible to determine the universal calibration koefficient (identical to quark and gluon jets and for γ+jet and jet+jet events) if find them in bins on the weighted radius of the jet.