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RUN-II Higgs Multijets Trigger with the SVT

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Abstract

In this note we present a proposal for the RUN-II Higgs Multijets Trigger using the CDF RUN-II capability to trigger on track impact parameter at L2 with the SVT. At L3 the jet-vertexing algorithm SECVTX is applied to select events $H^0 + Z^0/W^\pm \longrightarrow b\bar{b}qq$ intended to be efficient for M_H up to $130\,\mathrm{GeV/c^2}$. At L1 several calorimetric trigger primitives are studied. We conclude that trigger efficiency including double tagging efficiency can be improved by a factor of 6 respect to RUN-I efficiencies. The use of SVT can reduce the L2 output rate up to 0.5 Hz while keeping almost the same efficiency after L3 SECVTX filtering (9% for double tag).

1 Introduction

CDF RUN-I searches for Higgs boson in the multijets channel [1] showed a low trigger efficiency. Those searches were carried out in the multijet trigger data set collected with a multijet trigger optimized for the top quark search.

The essential requirements of this trigger were [3]:

LEVEL 2: $\sum E_T \geq 120\,GeV$, $\sum E_T^{cl} \geq 125\,GeV$, $N_{cl} \geq 4\,(E_T^{cl} \geq 15\,GeV)$

LEVEL 3: $N_{jet}^{0.4} \geq 4$ or $N_{jet}^{0.7} \geq 4$ $(E_T^{jet} \geq 10\,\mathrm{GeV})$.

Due to the fact that this trigger was optimized taking in account the kinematics of the top quark decay into six jets, the trigger was found to be rather inefficient for the Higgs search as shown in table 1.

Since for higgs masses up to $130\,\mathrm{GeV/c^2}$ the favored Higgs channel is $\mathrm{H} \longrightarrow \mathrm{b\bar{b}}$ with a B.R. ranging from $\sim 80\%\,(\mathrm{M_H} = 110\,\mathrm{GeV})$ to $\sim 50\%\,(\mathrm{M_H} = 130\,\mathrm{GeV})$ our goal is exploit the large B-hadron lifetime and the CDF RUN-II capability of trigger on track impact parameter at second trigger level [4] in order to provide an improved rejection while keeping a high efficiency. At level 3 the jet-vertexing algorithm SECVTX is proposed as a L3 b-tag filter. At L1 the *L1 Global SumEt* calorimetric primitive has been studied in order to provide a better L1 rejection factor.

This note is organized as follows. Section 2 contains some considerations about the trigger rates calculation, instantaneous luminosity dependence and data samples used. Sections 3, 4 and 5 describe the studies for the L1, L2 and L3 triggers efficiencies and rates respectively. Section 6 summarizes the study with the proposed trigger cuts and the estimated rates.

M_{H^0} (GeV/c^2)	$\epsilon_{\rm trigger}$(%)	$\epsilon_{\rm cinematical}$(%)	$\epsilon_{\rm doubleb-tag}$(%)	$\epsilon_{\rm P_{b\bar{b}}}$(%)	$\epsilon_{\rm total}$(%)
110	21.2	95.7	14.4	73.5	1.45
120	24.6	95.9	14.6	73.7	1.70
130	27.8	96.0	14.1	73.4	1.84
140	31.5	97.0	14.1	74.1	2.23

Table 1: RUN-I multijets trigger efficiency as function of the Higgs mass [3].

2 Trigger Rate and Instantaneous Luminosity

Since the number of $p\bar{p}$ interactions in a beam crossing follows a poissonian distribution, the trigger rate can be expressed as:

$$R_T = \epsilon_T \cdot \frac{1 - e^{-\mu}}{\mu} \cdot \sigma_{BBC} \cdot \mathcal{L}$$

where ϵ_T is the trigger efficiency defined as the fraction of events that passes our cuts, $\mathcal{L}$ the instantaneous luminosity in $\mathrm{cm}^2 \cdot s^{-1}$, σ_{BBC} the beam-beam counter cross section ($\sigma_{BBC} = 51.15 \pm 1.70\,\mathrm{mb}$ [5]) and

$$\mu = \sigma_{BBC} \cdot \mathcal{L} \cdot \Delta t$$

the average number of interactions per bunch crossing with Δt corresponding to the average time interval between two beam crossings [6].

For the rate estimation data samples from **RUN-IB** such as *minimum bias* and *jet20* were considered. The averaged instantaneous luminosity in these samples was $\approx 3.8 \cdot 10^{30}\mathrm{cm}^2 \cdot \mathrm{s}^{-1}$ (see figure 1) corresponding to an average number of interactions per bunch crossing of 0.7 varing from 0.3 ($\mathcal{L} = 1.9 \cdot 10^{30}\mathrm{cm}^2 \cdot \mathrm{s}^{-1}$) to 2.2 ($\mathcal{L} = 12 \cdot 10^{30}\mathrm{cm}^2 \cdot \mathrm{s}^{-1}$).

In order to make reliable rates estimations extrapolated to higher luminosities we must keep constant the average number of interactions per bunch crossing. In RUN-II, with 36 bunches (the *Low Luminosity Scenario*) we can extrapolate up to luminosities of the order of $0.6 \cdot 10^{32}\mathrm{cm}^2 \cdot \mathrm{s}^{-1}$ and in the 108 bunches regime (the *High Luminosity Scenario*) up to $2.2 \cdot 10^{32}\mathrm{cm}^2 \cdot \mathrm{s}^{-1}$ (see fig 2).

3 L1 trigger rate and efficiency estimation

In Run II with a luminosity of $\mathcal{L} = 1 \cdot 10^{32}$ and assuming a minimum bias cross section of ($\sigma_{BBC} = 51.15 \pm 1.70\mathrm{mb}$) [5] in the 108 bunches scenario a rate of $\approx 3.2\,\mathrm{MHz}$ can be expected. The level 1 trigger maximum bandwidth is around 40 kHz, therefore a rejection factor of $3 \div 4$ orders of magnitude would be needed.

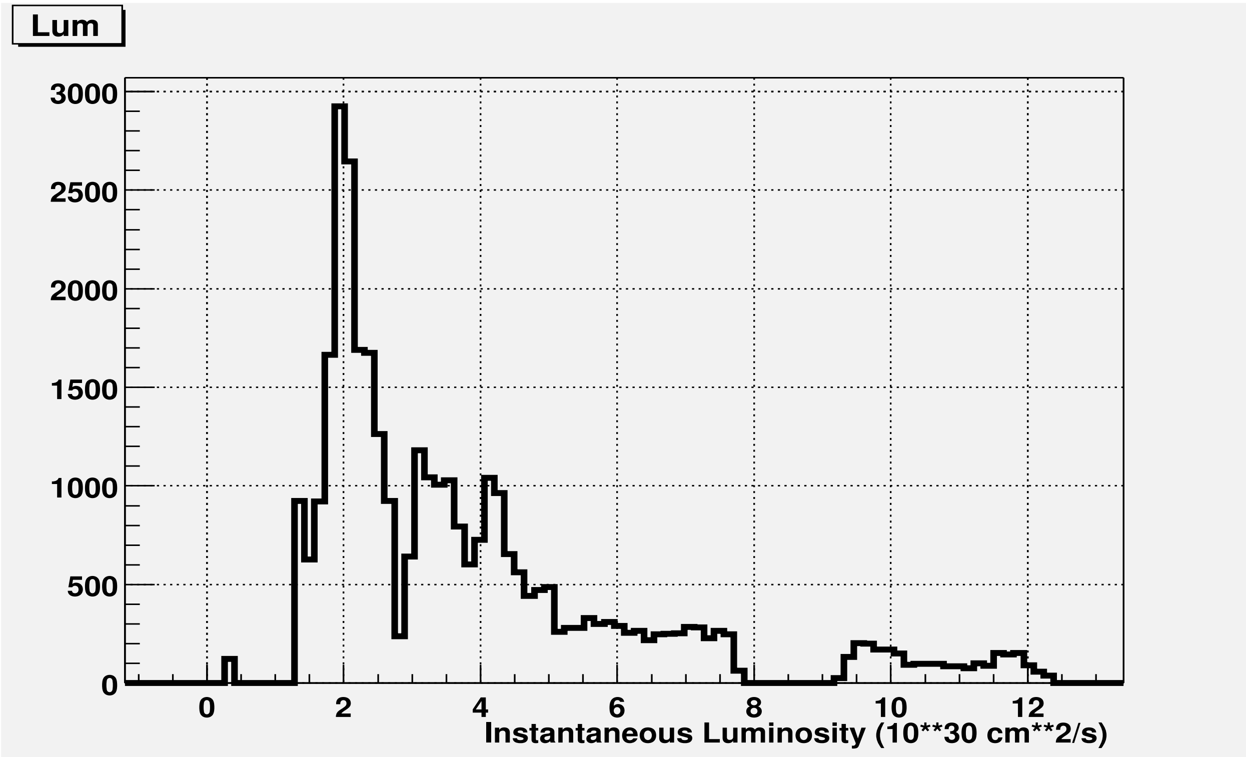

Figure 1: Instantaneous luminosity of the first event in each run for the minimum bias data sample XMBB-5P.

Previous studies of L1 and L2 calorimetric trigger primitives for this channel [8] showed that the unprescaled single calorimetric L1 trigger tower with a threshold of 10 GeV of total transverse energy yields a rate of 2.7 kHz at $\mathcal{L} = 10^{32}\mathrm{cm}^{-}2\mathrm{s}^{-1}$ with an efficiency of 98%. Other L1 calorimetric primitive that could be used is the *Global* $\sum \mathrm{E_T}$, defined as the energy resulting from the sum of the energies of all the trigger towers that are above a certain threshold [10].

For the background rate estimation of this primitive we use $\approx$ 100.000 events from the RUN-IB minimum bias data sample XMBB-5P. 10.000 signal events of $H^0 + Z^0/W^{\pm} \longrightarrow b\bar{b}qq$ ($\mathrm{m}_H = 120\,\mathrm{GeV/c^2}$) at $\sqrt{s} = 2\,\mathrm{TeV}$ are simulated with PYTHIA version 6.115 plus CDF detector simulation QFL. The trigger primitives for L1 are simulated using the package RUN2TRS [11].

In order to study instantaneous luminosity dependence, *Global* $\Sigma\mathrm{E_T}$ background rates and signal efficiencies are computed varing the thresholds above which the trigger towers are added in the total sum. Figures 3 and 4 show the cross section and rate for different *Global* $\Sigma\mathrm{E_T}$ thresholds with different single tower cuts.

The signal efficiency as a function of the *Global* $\Sigma\mathrm{E}_T$ cut depending on the single tower threshold is displayed in Fig 5.

Figure 3 shows that the background rate of this primitive can be greatly reduced increasing the threshold in the single tower that will be added to the sum. For our purposes a threshold of 40 GeV in *Global* $\Sigma\mathrm{E}_T$ with single tower $\mathrm{E}_T > 2.0\,\mathrm{GeV}$ gives a rate of 1.5 kHz with an efficiency of 99 %.

If high rates are observed depending on instantaneous luminosity, this threshold could safely be raised up to 60 GeV while keeping the efficiency at the level of the 95 %.

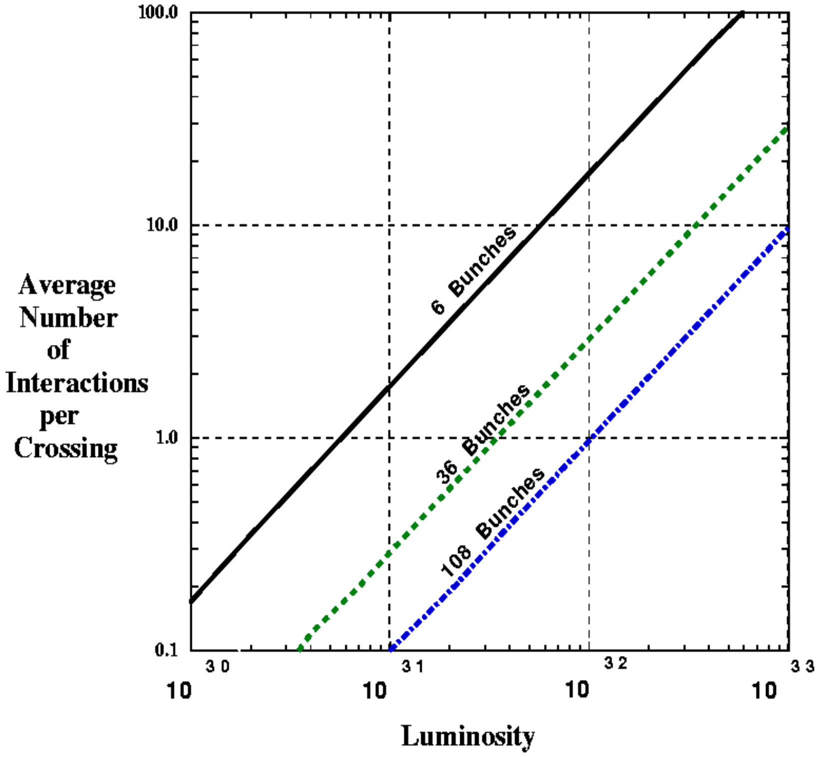

Figure 2: $\bar{N}$ for various conditions at CDF. 36 bunches ≡ 396 ns, 108 bunches ≡ 132 ns [7].

The transverse energy threshold for an individual tower for the *Global* Σ_T must be the same as for the *MET* L1 calorimetric trigger primitive. In case that for this primitive a tower threshold of 1 GeV has to be implemented, our thresholds still give an acceptable rate. (See figure 3).

Our studies show that the *Global* $\sum \mathrm{E_T}$ primitive could yield a lower cross section by a factor of 2 with a high efficiency, however the estimates done on the basis of the RUN-I minimum bias data sample, as is the case, could not be very reliable due to the fact that effects like the pile-up have a very non-linear luminosity dependence. Table 2 summarizes the results for the *Global SumEt L1*.

Global ΣE_T (GeV) E_T tower > 2.0GeV	Rate (kHz) ($L = 1 \cdot 10^{32}$)	Cross Section (μb)	Efficiency (%)
40	1.5	15	99
60	0.25	2.5	95

Table 2: Level 1 Trigger cuts, background rates and signal efficiencies with the single tower trigger. The total L1 budget is 40 kHz (400 μb). The single tower trigger (E_T) rate is 2.7 kHz with an efficiency of ≈ 98 %.

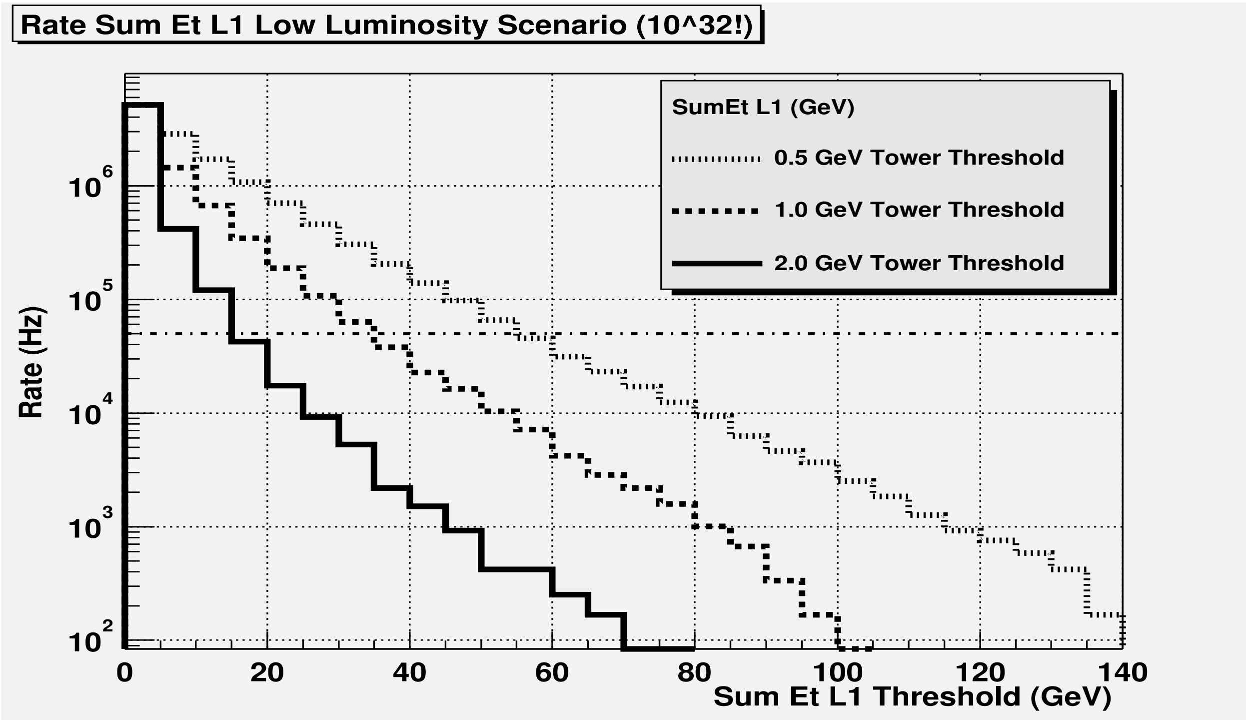

Figure 3: Trigger Level 1 Rate (kHz) for *Global* ΣE_T calorimetric primitive for different single tower E_T thresholds. Single towers with transverse energy below these thresholds are not added to the sum. The horizontal dotted line indicates the maximum L1 bandwidth ($40\text{kHz}\,, \mathcal{L} = 1 \cdot 10^{32}\text{cm}^2 \cdot \text{s}^{-1}$).

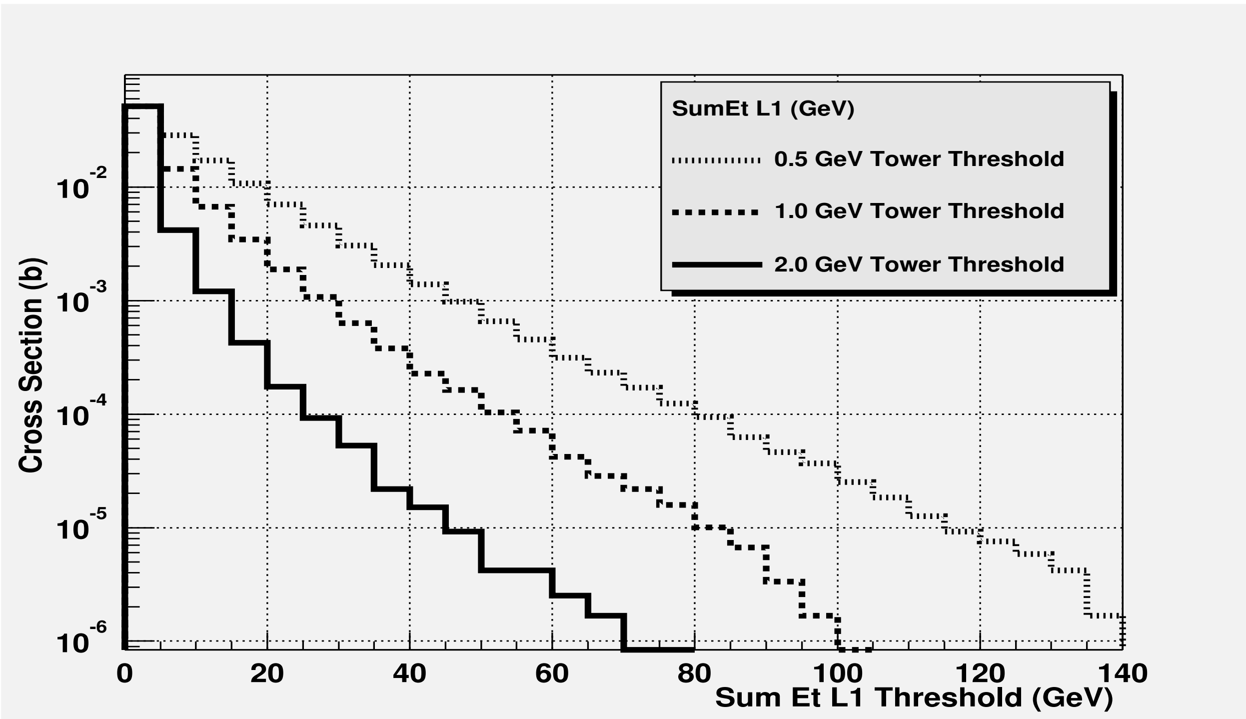

Figure 4: Trigger Level 1 cross section (b) for *Global* ΣE_T calorimetric primitive for different single tower E_T thresholds. Single towers with transverse energy below these thresholds are not added to the sum.

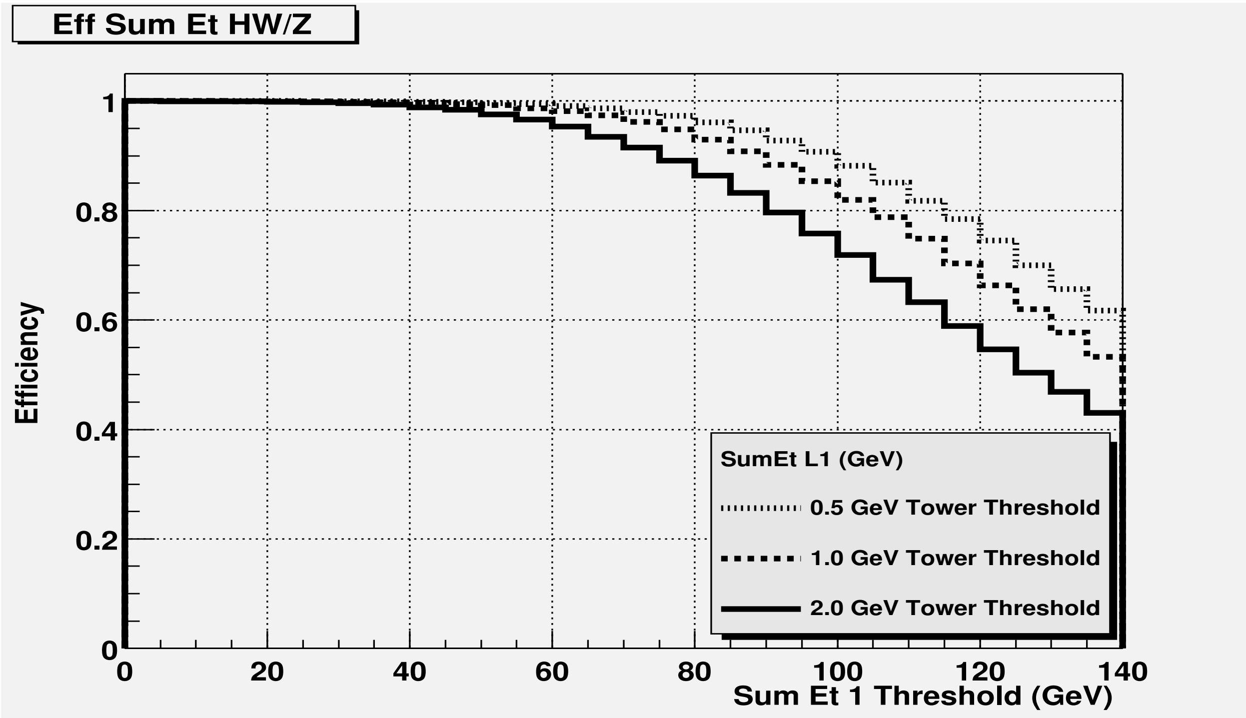

Figure 5: Trigger Level 1 efficiencies for *Global* ΣE_T calorimetric primitive for different single tower E_T thresholds. Single towers with transverse energy below these thresholds are not added to the sum.

4 L2 trigger rate and efficiency estimation

At L2 the Multijets Higgs trigger for the all hadronic channel has been already studied using only calorimetric primitives [8]. This study shows that the requirement at L2 of at least 3 calorimetric clusters over 10 GeV of transverse energy with a total energy of 90 GeV yields an efficiency of $\approx 77.6\%$ at an acceptable rate of 15.4 Hz. Respect to the RUN-I searches this means an improvement by a factor of 3 in L2 trigger efficiency.[1] The proposed selection together with efficiencies and rates estimates are summarized in table 3. Since the L2 ouput rate is too high for direct tape storage the Soft Lepton Tag algorithm has been proposed as L3 filter in order to select events $H^0 + Z^0/W^\pm \longrightarrow b\bar{b}qq$ ($\mathrm{m}_H = 120(\mathrm{GeV/c^2})$[9]. This trigger has been designed with the assumption that at L3 full tracking reconstruction will be possible at least a rate of 15.4 Hz. However during RUN-II trigger selection on tracks impact parameter at level 2 will be possible thanks to the SVT [4]. In this section we study the optimization of the proposed calorimetric trigger using the SVT at L2. The aim is to provide a rejection factor at L2 enough to match the L3 full tracking reconstruction input rate while keeping almost the same offline b-tagging efficiency.

Selection	**Efficiency** (%)	**Rate (Hz)** (JET20)
Calorimetry only $\mathrm{N_{cl}}(\mathrm{E_T^{cl}} \geq 10\mathrm{GeV}) \geq 3, \sum E_T^{cl} \geq 90GeV$	77.6 (24.6%)	8.5

Table 3: From [9] Level 2 requirements: ≥ 3 L2 calorimetric clusters with $E_T \geq 10$ GeV with a total energy $\sum E_T^{cl}(E_T \geq 10) \geq 90$ GeV. Efficiencies are calculated in respect to the total number of signal events. In brackets shown the correspondent RUN-I L2 efficiency where the requirements were: $\mathrm{N_{cl}}(\mathrm{E_T^{cl}} \geq 15\,\mathrm{GeV}) \geq 4, \sum E_T^{cl} \geq 125\,\mathrm{GeV}$.

4.1 Data Sample

For background estimates we use a sample of ≈ 100000 events of the RUN-IB JET20 data sample. For the signal simulation we use the same sample that for Level 1: 10.000 signal events of $H^0+Z^0/W^\pm \longrightarrow b\bar{b}qq$ ($\mathrm{m}_H = 120\,\mathrm{GeV/c^2}$) at $\sqrt{s} = 2$ TeV simulated with PYTHIA version 6.115 and CDF detector simulation QFL. The interaction point is simulated with an x, y beam coordinates spread of 30 μm and a z coordinate spread of 30 cm. The beam is assumed to have a X/Z slope of $5.0 \cdot 10^{-4}$ and Y/Z slope of $-5.0 \cdot 10^{-4}$. Calorimetric trigger primitives at this level are simulated using the package RUN2TRS [11].

4.2 SVT tracks

At L2 SVT is expected to provide $\mathrm{P_T}$, ϕ and impact parameter with resolution similar to the offline reconstruction [12]. The reconstruction efficiency respect to the offline has been evaluated [14] and it was found to be about 97 %. Preliminaries studies with the RUN-II CDF simulation and a semiparametric simulation of the SVT had shown that the L2 latency time is enough for SVT to reconstruct and calculate the tracks impact parameter in our

[1] In RUN-I the trigger data set used was the top multijets trigger with a requirement of at least 4 L2 calorimetric clusters over 15 GeV of transverse energy with a total energy bigger than 125 GeV.

signature [15]. Since the full SVT simulation code can not be applied to the RUN 1B JET20 data[2] for rates and rejection factor estimation, we follow here the same procedure developed in [13] in order to evaluate *equivalent* SVT tracks using SVX offline reconstructed tracks as SVT tracks. SVT will fit tracks with $P_T \geq 2.0\,\mathrm{GeV}$, 4 hits on the 4 innermost SVXII layers[3] and an acceptance $|\eta| \leq 1.0$. Tracks found by the SVT will be linked to XFT tracks. Taking in account these constraints from SVX tracks we select those that have $P_T \geq 2.0\,\mathrm{GeV}$, four hits in the silicon and can be matched to an XFT track (smeared CTC track). This procedure underestimates both the efficiency and the number of tracks to be processed [12] because due to the major acceptance in η of the SVXII detector a major number of CDF RUN-II tracks found by the XFT will have four hits in the SVXII. The impact on a possible deterioration of the rejection factor due to this circumstance has to be studied. [4] Since the SVT computes the impact parameter of the tracks respect to the beam line position in our estimation for both signal and background tracks the offline reconstructed impact parameter is calculated respect to the beam line. Beam line position is calculated on a run by run basis via a call to the subroutine C$SVX:SVGEBP.CDF. This module uses the existing $\mathrm{D} - \phi$ correlation between tracks in order to determinate the coordinates of the beam line [16].

4.3 L2 rate and efficiency with SVT

Assuming the proposed calorimetric cuts, the goal is to use the information about the SVT reconstructed tracks in order to provide further rejection factor at L2. At L3 the offline b-tagging efficiency will be evaluated using SECVTX in the next section.

At L2 SVT will send to the Alpha processors a subset of the internal SVT information consisting in the track impact parameter, the track curvature (both signed), ϕ and for the innermost and outermost hits of the track z coordinate information consisting in a bit that is set depending on the SVXII half ladder where the hit belongs. Figures 6 to 11 show the event largest IP and the second largest IP with their correspondent $\mathrm{P_T}$ and statistical significance distribution for JET20 and simulated $H/WZ \rightarrow$ had signal when the L2 calorimetric requirements are applied (≥ 3 L2 clusters, $E_T \geq 10\,\mathrm{GeV}$, $\sum E_T^{cl}(E_T \geq 10) \geq 90\,\mathrm{GeV}$). The strategy will be based mainly in ordering in decreasing value the impact parameters of the tracks provided by the SVT and require events with a certain threshold on the largest impact parameter found. Thresholds on the second largest impact parameter and also on the $\mathrm{P_T}$ of the tracks are studied.

Thresholds on the largest and second largest impact parameter are applied. Figure 14 and 13 show the efficiencies and rates when a threshold is set in the largest impact parameter, the threshold is set in the second largest impact parameter (the largest is left free), and

[2]The SVT needs to know the beam position with respect the SVX axis in order to evaluate correctly the impact parameter. The beam position can be determined from real data using the relation between impact parameter and azimuthal angle [13], so we need a large number of tracks from the same run because the beam position can change from one run to another. Due to the complexity of the procedure, it showed very difficult to calculate alignment constants for a large number of runs containing each only several thousands of events.

[3]Is currently under study other possible configurations as *e.g* the replacement of one of the SVXII layers with the L00.

[4]The SVT reconstruct tracks on the transverse plane. However a certain information from the Z-coordinate is available for the L2 processors. For the innermost and the outermost hits belonging to a reconstructed track a bit is set depending on the SVXII half barrel where the hit has been identified. In principle we could use this information in order to limit impact parameter cut to a more central region where the estimation of this study can be more reliable.

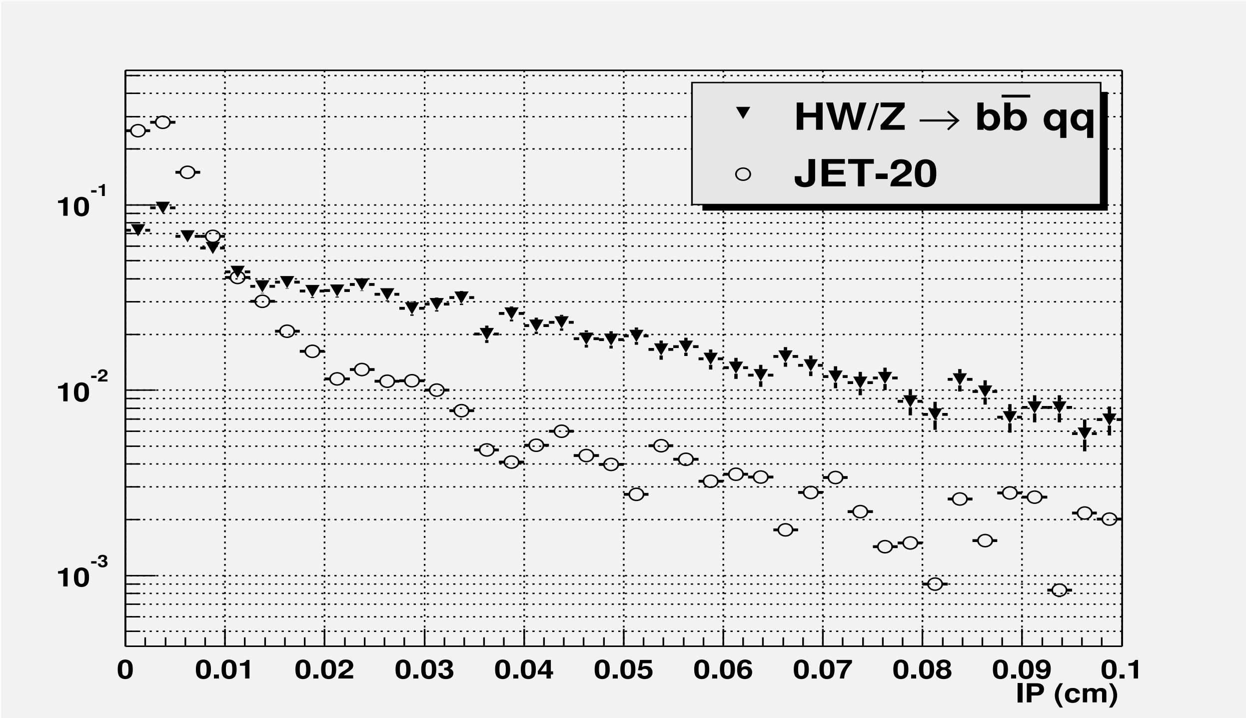

Figure 6: Track maximum impact parameter distribution for events with L2 calorimetric requirements applied ($\mathrm{N_{cl}}(\mathrm{E_T^{cl}} \geq 10\mathrm{GeV}) \geq 3, \Sigma E_T^{cl} \geq 90\, GeV$) Both distributions are normalized to 1.

the threshold is set in the second largest impact parameter while the largest is fixed to $100\,\mu m$. We observe that for thresholds on the largest impact parameter up to $100\,\mu m$ the rate decreases faster than the efficiency, therefore the purity of the sample increases. If we apply a threshold also on the second largest impact parameter, for values up to $80\,\mu m$ we observe the same tendency. We conclude that the optimal selection is to require two SVT tracks: one with impact parameter bigger than $100\,\mu m$ and the other with impact parameter bigger than $80\,\mu m$. As we can see from Fig. 6 and 7 this yield the maximum discrimination from signal to background. For this selection the efficiency is 28% ($\mathrm{M_H} = 120$ GeV) with a rate of 0.5 Hz, less than the 2% of the L3 output rate. As it can be observed from Fig. 8 and 9 thresholds on the $\mathrm{P_T}$ of the tracks reduces in the same amount both rate and efficiency and they are not used. Other combinations like the sum of the first and second largest impact parameters, or a single threshold on the second largest impact parameter have been studied, but they do not improve the rejection factor while keeping the same efficiency.

Table 4 summarizes the rates, efficiencies and rejection factors for the most relevant sets of cuts assuming the L1 and L2 requirements.

The *L2 SumEt* is defined as the sum of the transverse energy over all clusters above 10 GeV and has been fixed to 90 GeV. In running conditions its value could be varied in order to keep the L2 rate at an acceptable values. Figures 15 and 16 show the rates and signal efficiency depending on the *L2 SumEt* value when the SVT requirements (1 track with IP $\geq 100\,\mu$m and a second track with IP $\geq 80\mu m$) are applied. The shape of the rate curve is much sharper than the efficiency (*e.g* an increase of 10 GeV in *L2 sumEt* reduces the rate by a 76% while efficiency decreases only in a 10%) so with the SVT requirements this variable can be also used for rate control.

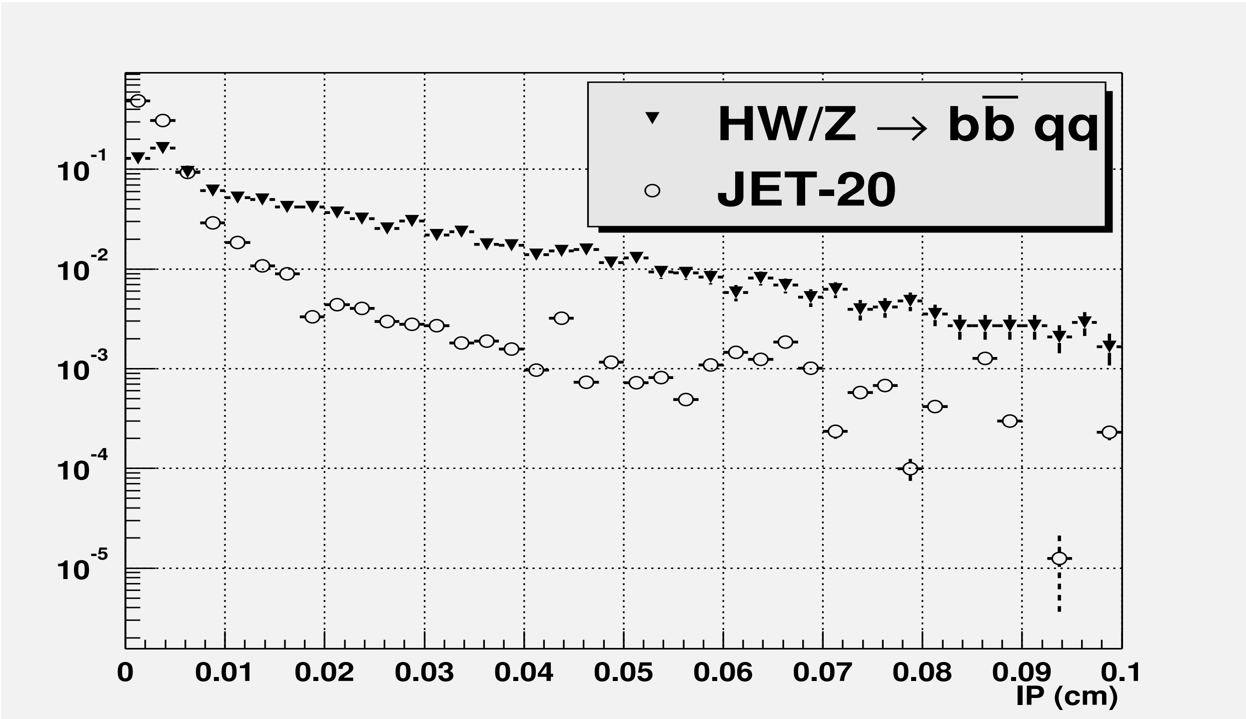

Figure 7: Second track maximum impact parameter distribution for events with L2 calorimetric requirements applied ($\mathrm{N_{cl}}(\mathrm{E_T^{cl}} \geq 10\mathrm{GeV}) \geq 3, \Sigma E_T^{cl} \geq 90\, GeV$) Both distributions are normalized to 1.

Selection Cut (JET20)	**Rate** (Hz)	**Efficiency** (%)	**Rejection factor**
Calorimetry only $\mathrm{N_{cl}}(\mathrm{E_T^{cl}} \geq 10\mathrm{GeV}) \geq 3, \Sigma E_T^{cl} \geq 90 GeV$	8.5	74.	1
Calorimetry + ≥ 1 SVT track $\lvert d\rvert \geq 100\mu m$	1.4	38	6
Calorimetry + ≥ 2 SVT track $\lvert d1\rvert \geq 100\mu m\, , \lvert d2\rvert \geq 80\mu m$	0.5	28	17

Table 4: Level 2 Efficiencies, rates (JET20) and rejections factors.

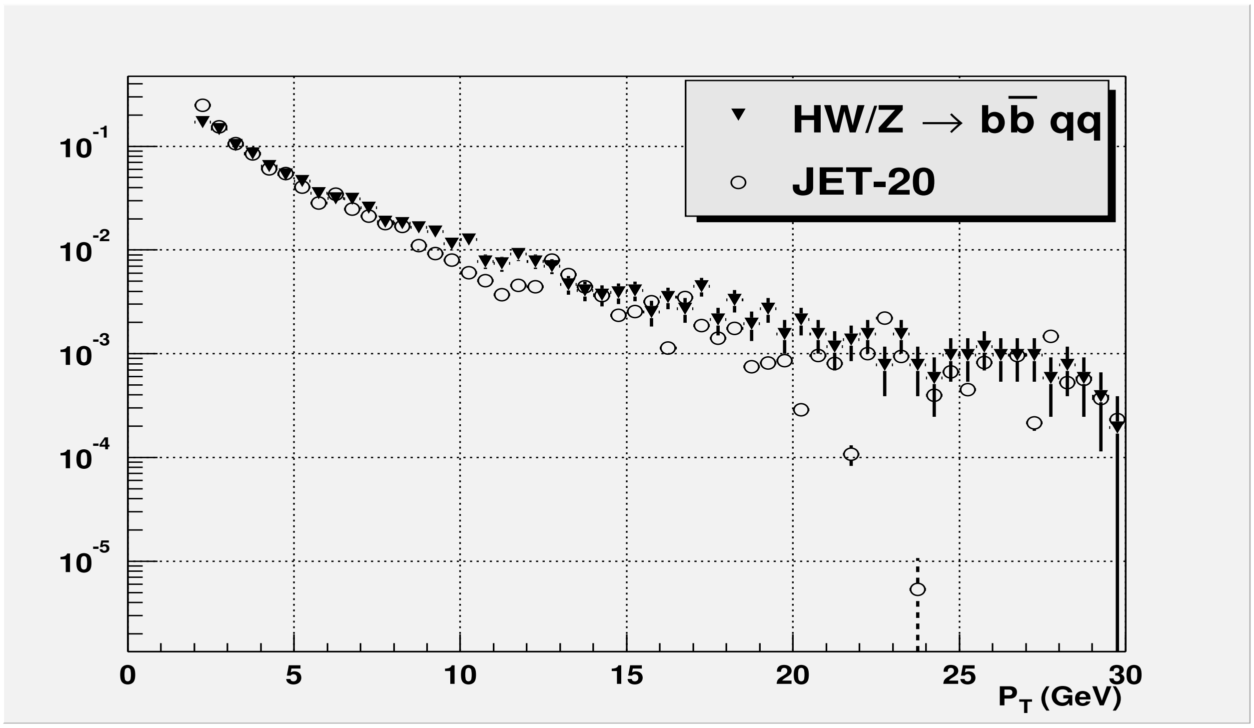

Figure 8: Transverse momentum corresponding to the track with the highest impact parameter found in the event. L2 calorimetric requirements are applied $(\mathrm{N_{cl}}(\mathrm{E_T^{cl}} \geq 10\mathrm{GeV}) \geq 3, \Sigma E_T^{cl} \geq 90\, GeV)$ Both distributions are normalized to 1.

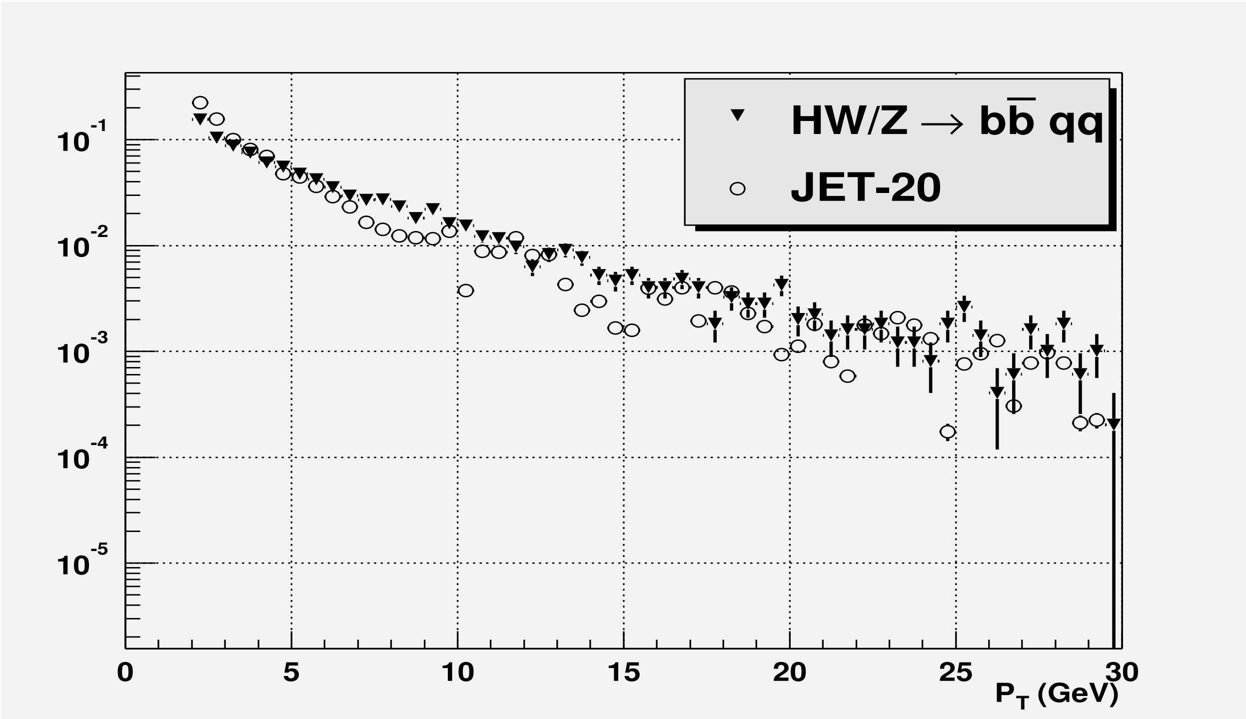

Figure 9: Transverse momentum corresponding to the track with the second highest impact parameter found in the event. L2 calorimetric requirements are applied $(\mathrm{N_{cl}}(\mathrm{E_T^{cl}} \geq 10\mathrm{GeV}) \geq 3, \Sigma E_T^{cl} \geq 90\, GeV)$ Both distributions are normalized to 1.

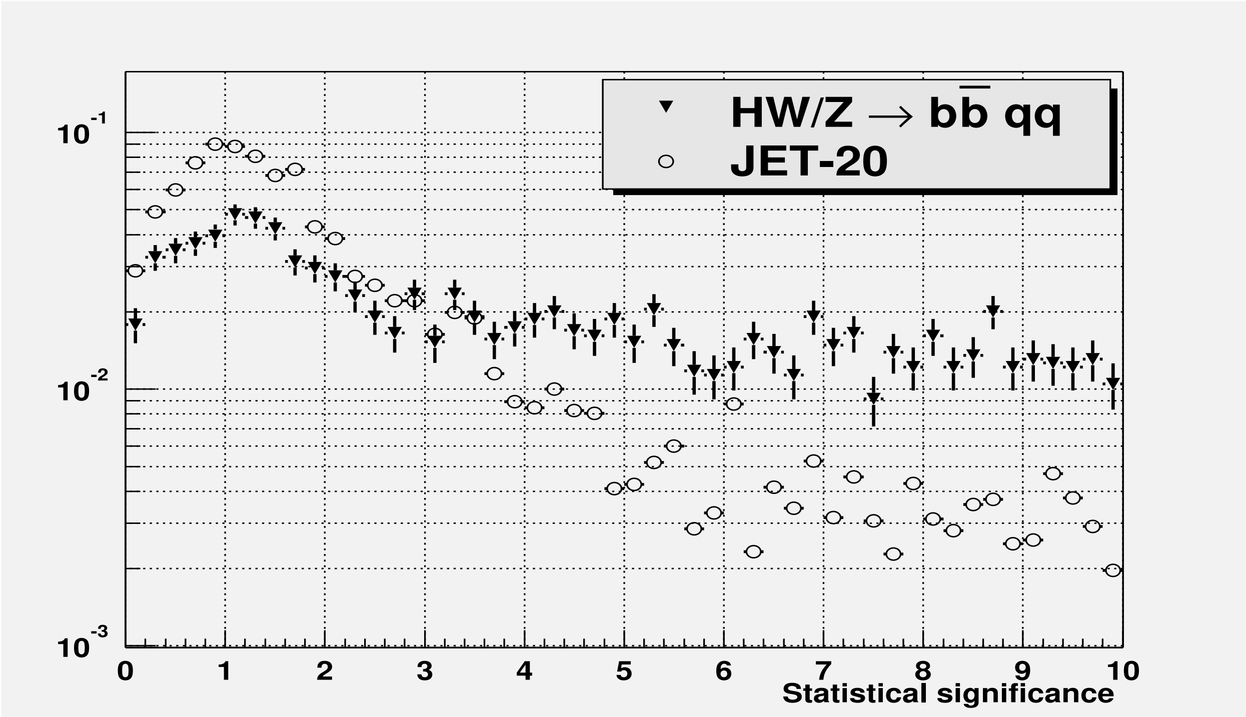

Figure 10: Statistical significance of the track with the highest impact parameter found in the event. L2 calorimetric requirements are applied ($\mathrm{N_{cl}}(\mathrm{E_T^{cl}} \geq 10\mathrm{GeV}) \geq 3, \Sigma E_T^{cl} \geq 90\,GeV$) Both distributions are normalized to 1.

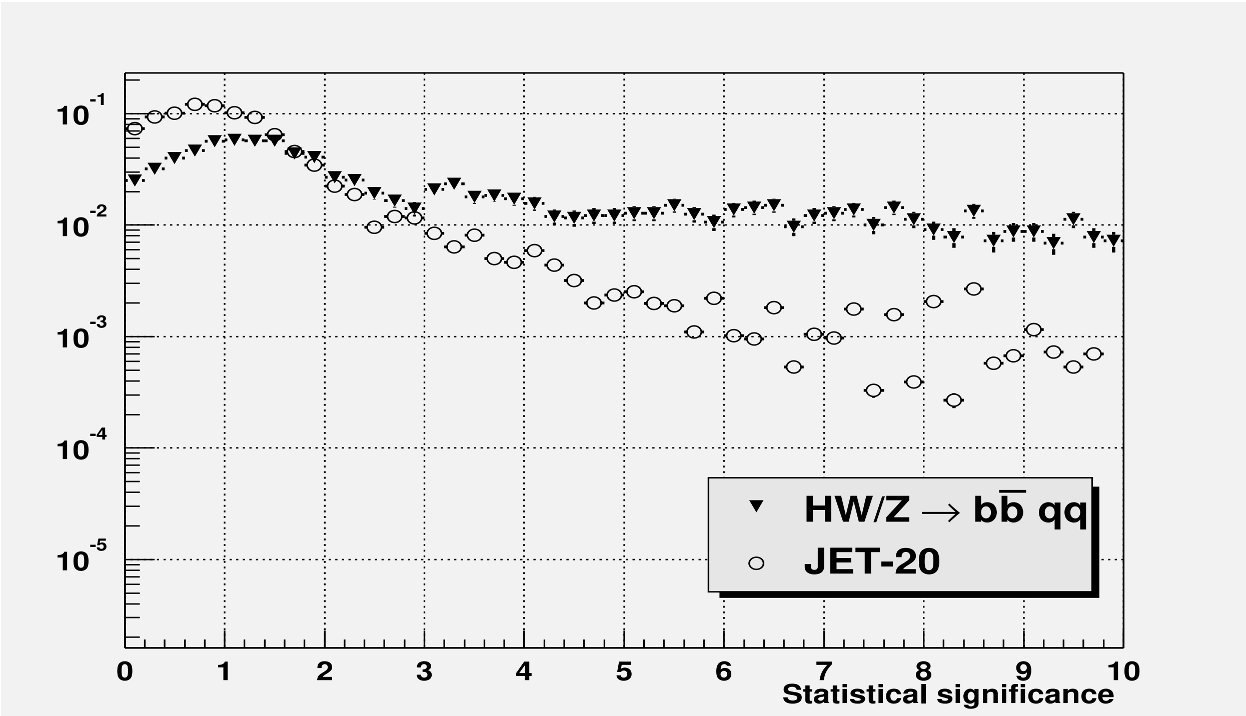

Figure 11: Statistical significance of the track with the second highest impact parameter found in the event. L2 calorimetric requirements are applied ($\mathrm{N_{cl}}(\mathrm{E_T^{cl}} \geq 10\mathrm{GeV}) \geq 3, \Sigma E_T^{cl} \geq 90\,GeV$) Both distributions are normalized to 1.

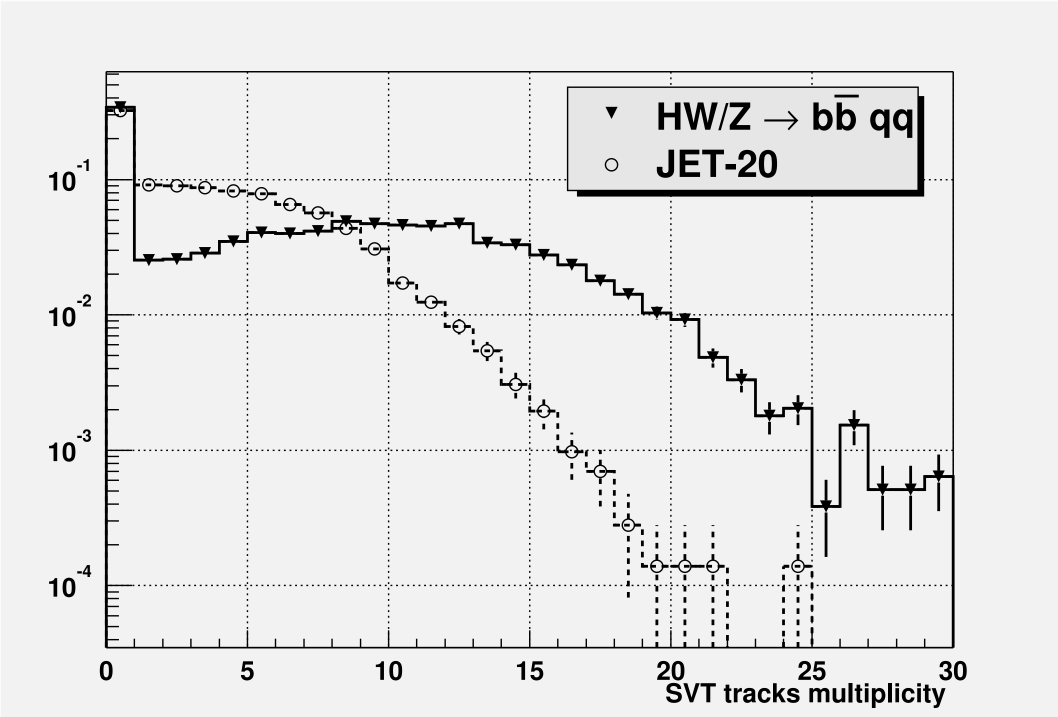

Figure 12: *Equivalent* SVT tracks multiplicity. L2 calorimetric requirements are applied $(\mathrm{N_{cl}}(\mathrm{E_T^{cl}} \geq 10\mathrm{GeV}) \geq 3, \Sigma E_T^{cl} \geq 90\, GeV)$. Both distributions are normalized to 1.

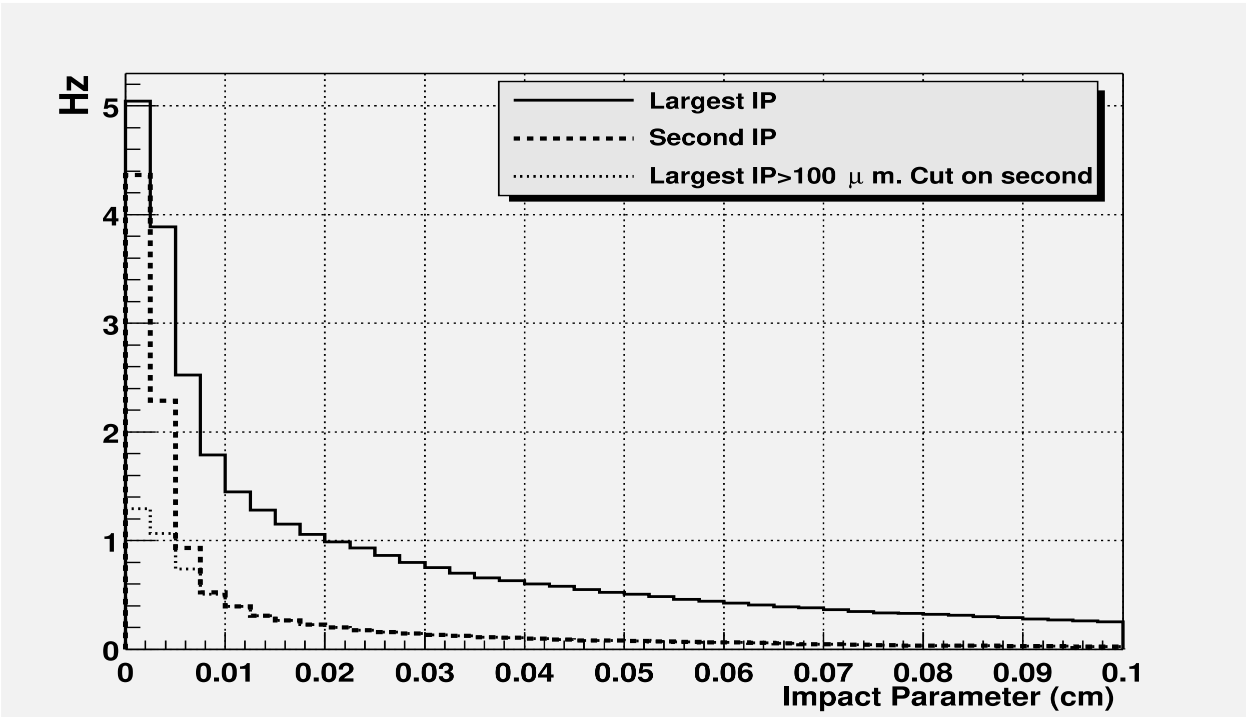

Figure 13: Rates ($\mathcal{L} = 1 \cdot 10^{32}\, cm^{-2}s^{-1}$) as function of the threshold on the largest impact parameter, the threshold on the second largest impact parameter, and the threshold on the second largest parameter when the first is fixed to be $100\mu m$. Trigger Level 2 calorimetric requirements: $N_{clus} \geq 3$, $\sum E_T^{clus} \geq 90$ GeV and $E_T^{3-td} \geq 10$ GeV are applied.

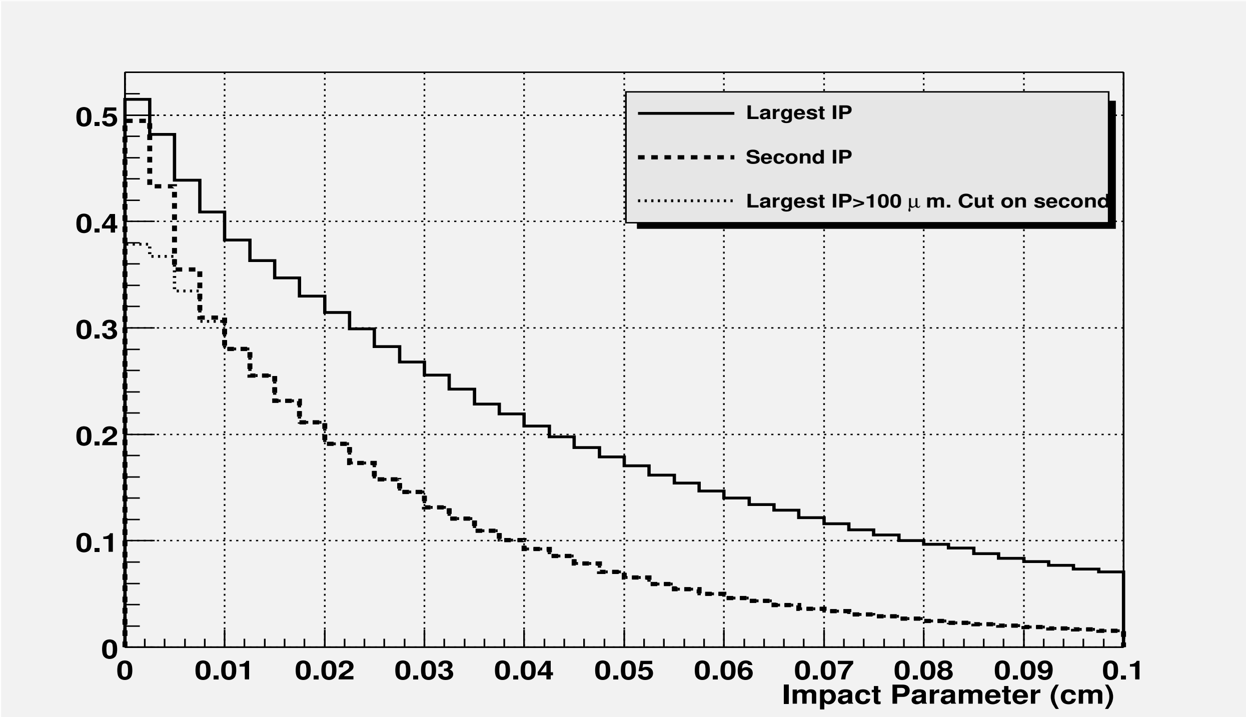

Figure 14: Signal Efficiencies ($M_H = 120$ GeV) as function of the threshold on the largest impact parameter, the threshold on the second largest impact parameter, and the threshold on the second largest parameter when the first is fixed to be $100\mu m$. Trigger Level 2 calorimetric requirements: $N_{clus} \geq 3$, $\sum E_T^{clus} \geq 90$ GeV and $E_T^{3-td} \geq 10$ GeV are applied.

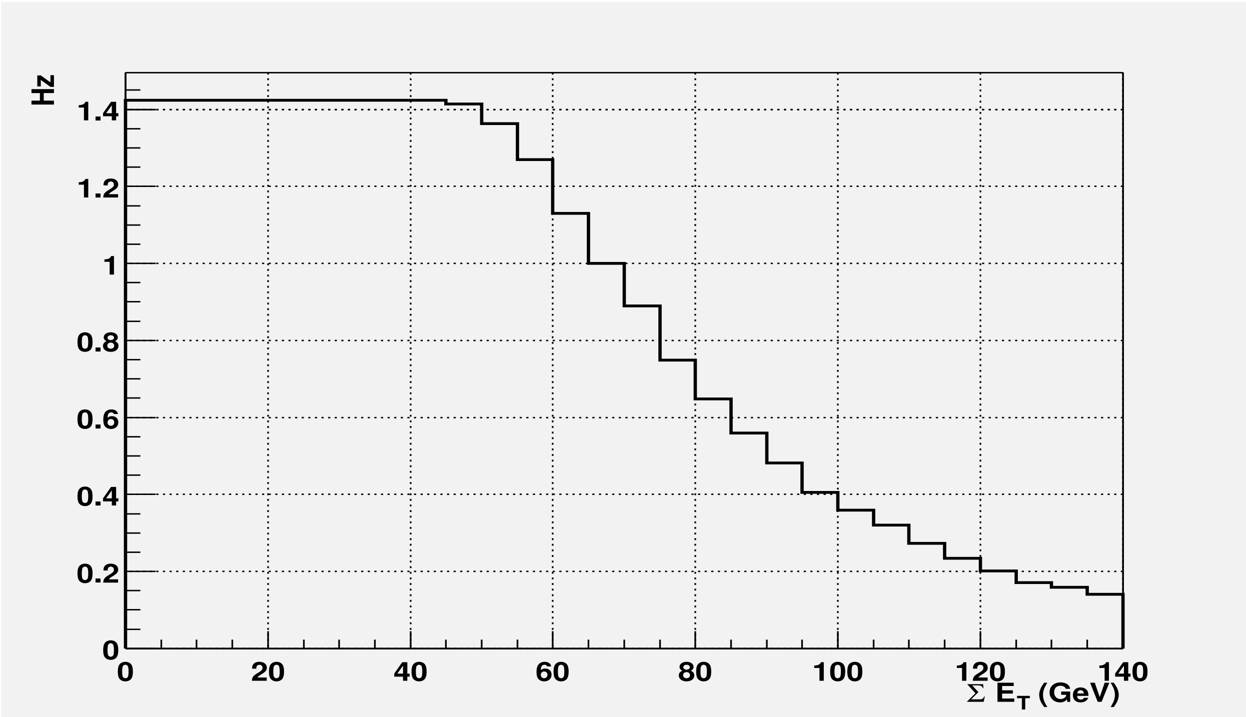

Figure 15: JET 20 rates as a function of the *L2 Sum Et* threshold when L2 SVT requirements are applied (1 track with IP $\geq 100\mu$m and a second track with IP $\geq 80\mu m$).

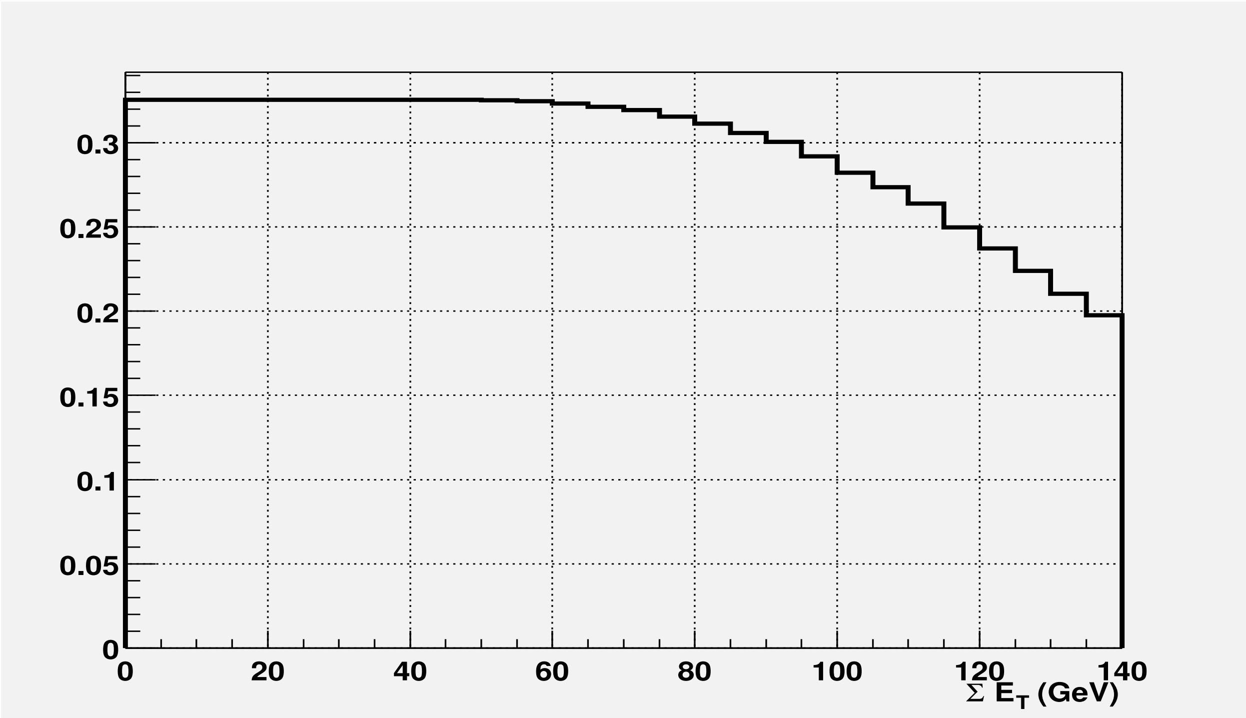

Figure 16: Signal efficiency as a function of the *L2 Sum Et* threshold when L2 SVT requirements are applied (1 track with IP $\geq 100\mu$m and a second track with IP $\geq 80\mu m$).

5 L3 trigger rate and efficiency estimation

At L3 two different scenarios are possible depending if full L3 tracking reconstruction is available or not. In the first case a L3 b-tagger could be used as a filter providing complementary rejection factor. Eventually the L2 requirements could be relaxed in order to obtain a better efficiency. If L3 full tracking reconstruction will be not available the L2 constrains play a major role requiring at L3 basically a confirmation of the calorimetric conditions with the offline jet reconstruction algorithms.

At L2 the lowest output rate can be achieved with the use of the SVT requiring a threshold of $100\,\mu m$ in the largest IP and $80\,\mu m$ of the second largest together with the calorimetric conditions. This will yield an output rate of 0.5 Hz with a signal efficiency of 28 %. Figure 17 shows the rate when at L3 when 3 jets reconstructed by JETCLU with more than 10 GeV of transverse energy are required depending on *sumEtL3*, defined as the sum of the transverse energy over all the jets with more than 10 GeV. Figure 18 shows the same for the signal efficiency. A slightly decrease of both rate and efficiency for any value of *sumEtL3* is observed due to an inefficiency on the number of clusters [5]. A requirement of 3 jets with *sumEt L3* bigger than 100 GeV seems to be safe enough. This yield a rate of 2 Hz with an efficiency of 33%.

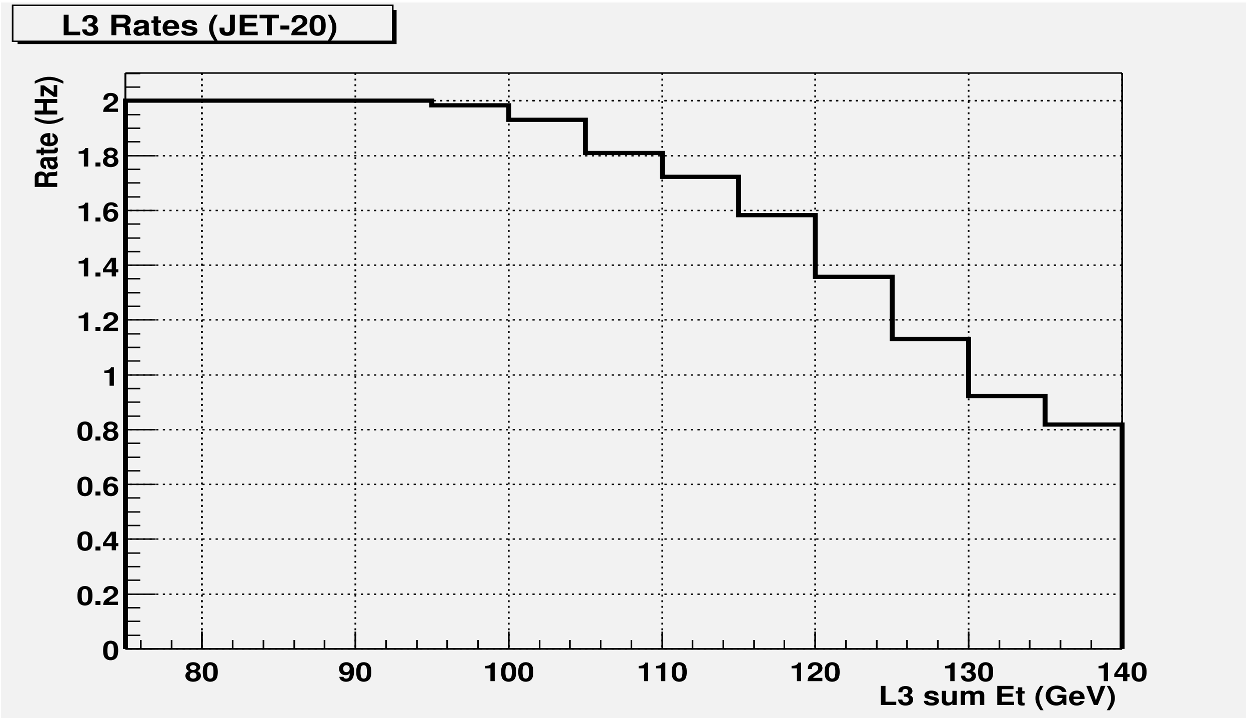

Figure 17: JET 20 rates as a function of the *L3 Sum Et* threshold when L2 SVT + Calorimetry cuts and 3 JETCLU jets ($E_T \geq 10$ GeV) are required.

In case full L3 track reconstruction will be available as a possible L3 b-tagger filter the offline SECVTX algorithm with the top search defaults parameters is used[6]. We are interested in the rates and efficiency when L2 options (calorimetry or calorimetry plus SVT) are

[5]3 L2 clusters can be seen as only 2 jets by JETCLU.

[6]SECVTX searches for displaced vertexes inside of jets with $E_T \geq 15 GeV$ and cone size of 0.7. No attempt to optimize this requirements had been done in the present study.

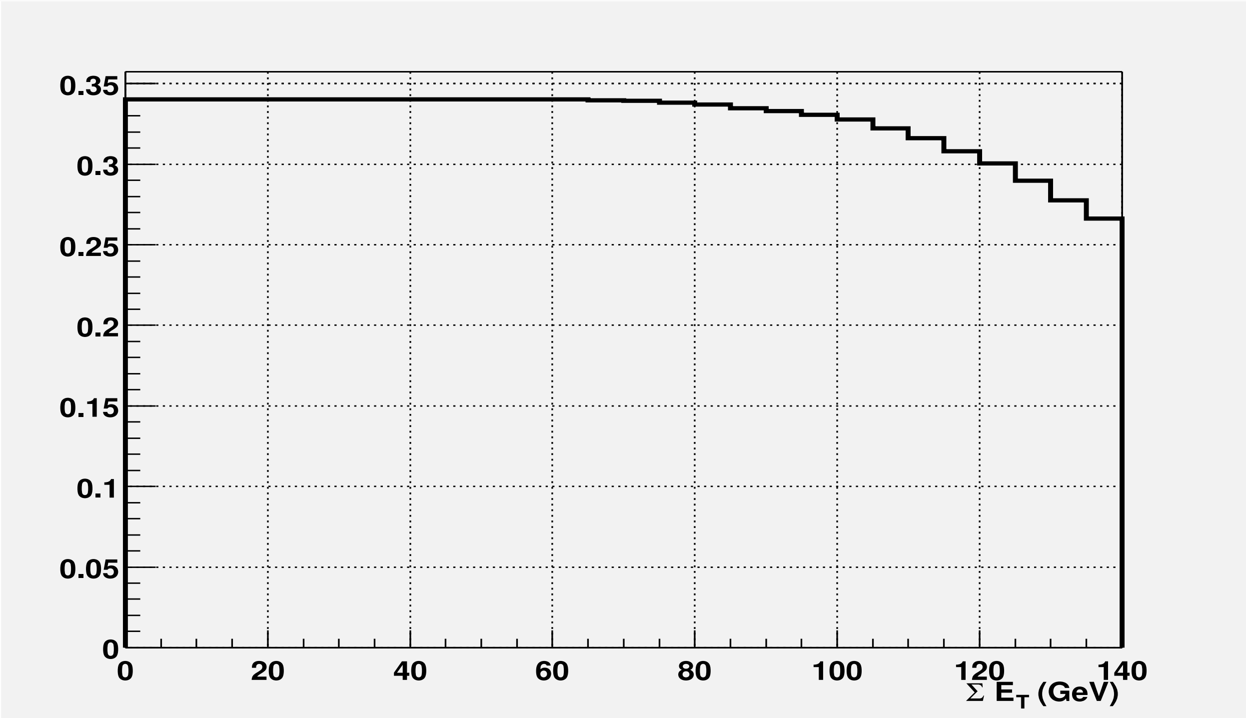

Figure 18: Signal efficiency as a function of the *L3 Sum Et* threshold when L2 SVT + Calorimetry cuts and 3 JETCLU jets ($E_T \geq 10$ GeV) are required.

combined with the L3 filtering. Since SECVTX relies on the track IP statistical significance, any cut on track IP will affect its efficiency. The SECVTX algorithm computes the track IP parameter respect to the primary vertex found in the event. SVT calculates the track IP respect to the beam line and in our studies for L2 we used the beam line coordinates provided by the beam position data base (see section 2). Figure 21 shows the difference between the x and y coordinates of the beam position (BPO) and the primary vertex as found by *vxprim* and used by SECVTX when $|zbpo - zvprim| < 2.$ cm, *i.e.* assuming a well reconstructed primary vertex. This is the case for about the 80% events of the JET20 data sample used. The spread of $\approx 30\,\mu m$ falls in the limits of the primary vertex position resolution. Figure 19 and 20 show the single and double SECVTX tagging efficiency as function of tye SVT cut on the second largest impact parameter.

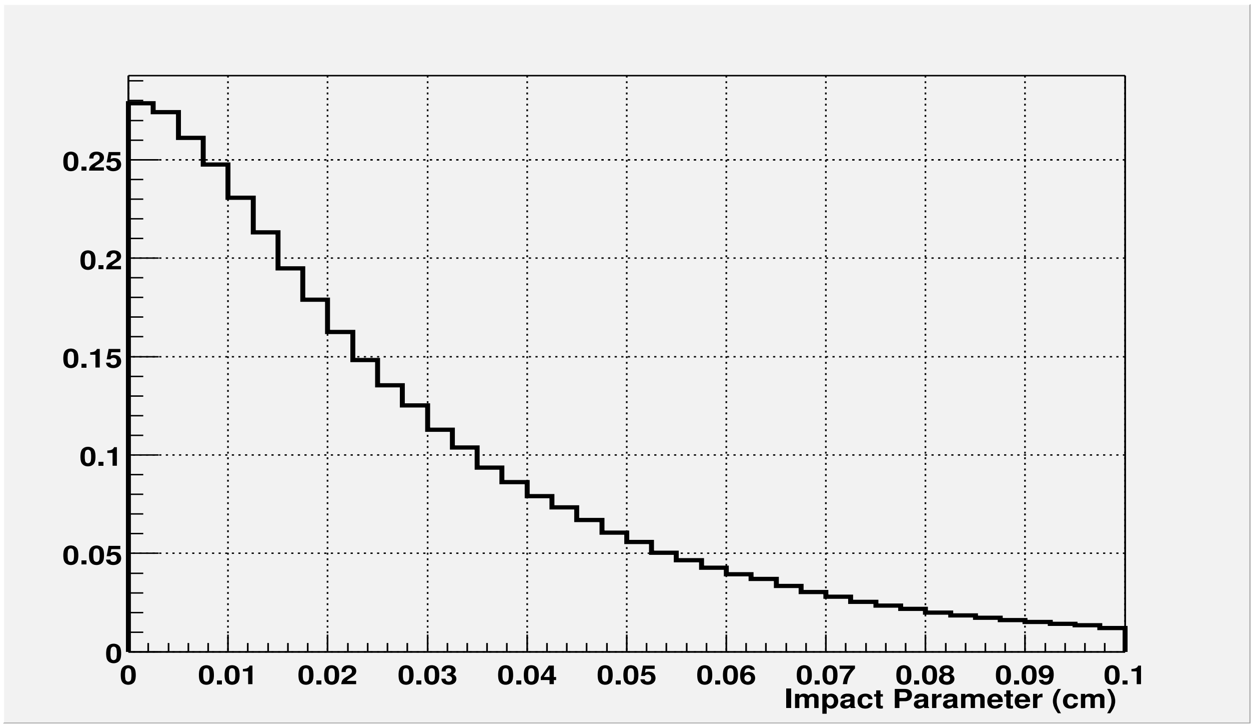

Figure 19: Single SECVTX tagging efficiency as function of tye SVT cut on the second largest impact parameter. The largest impact parameter is set to $100\mu m$.

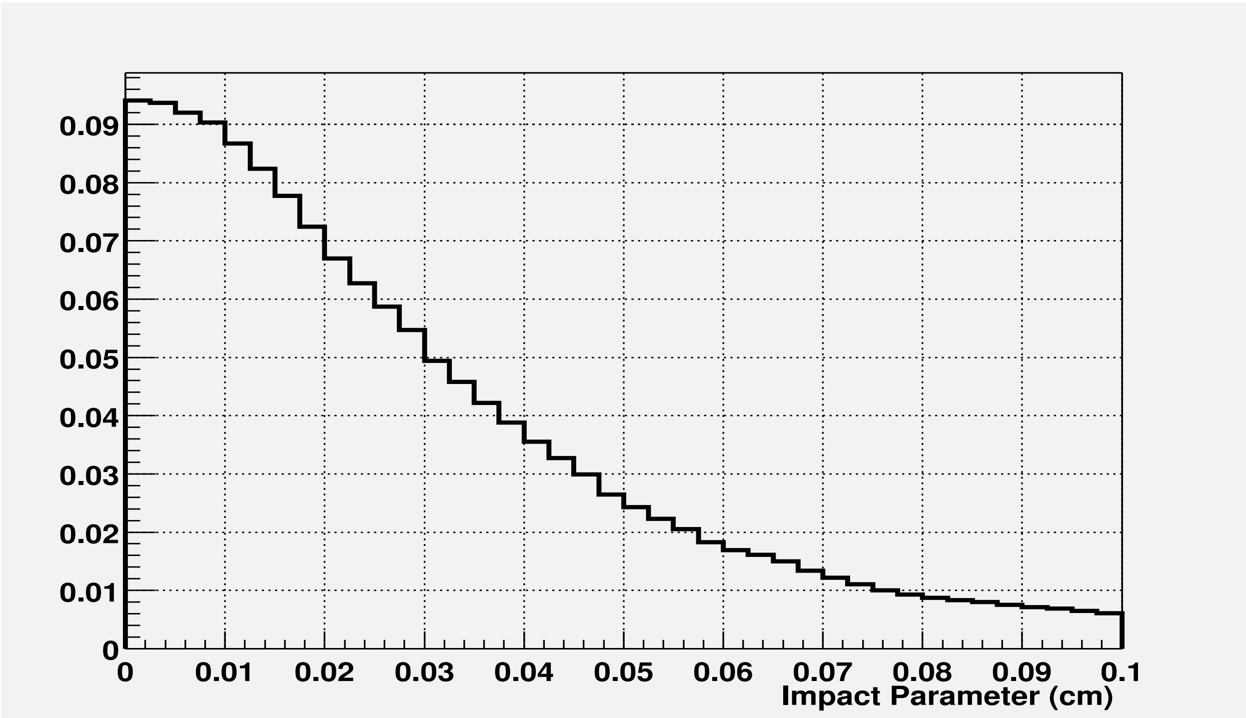

Figure 20: Double SECVTX tagging efficiency as function of tye SVT cut on the second largest impact parameter. The largest impact parameter is set to $100\mu m$.

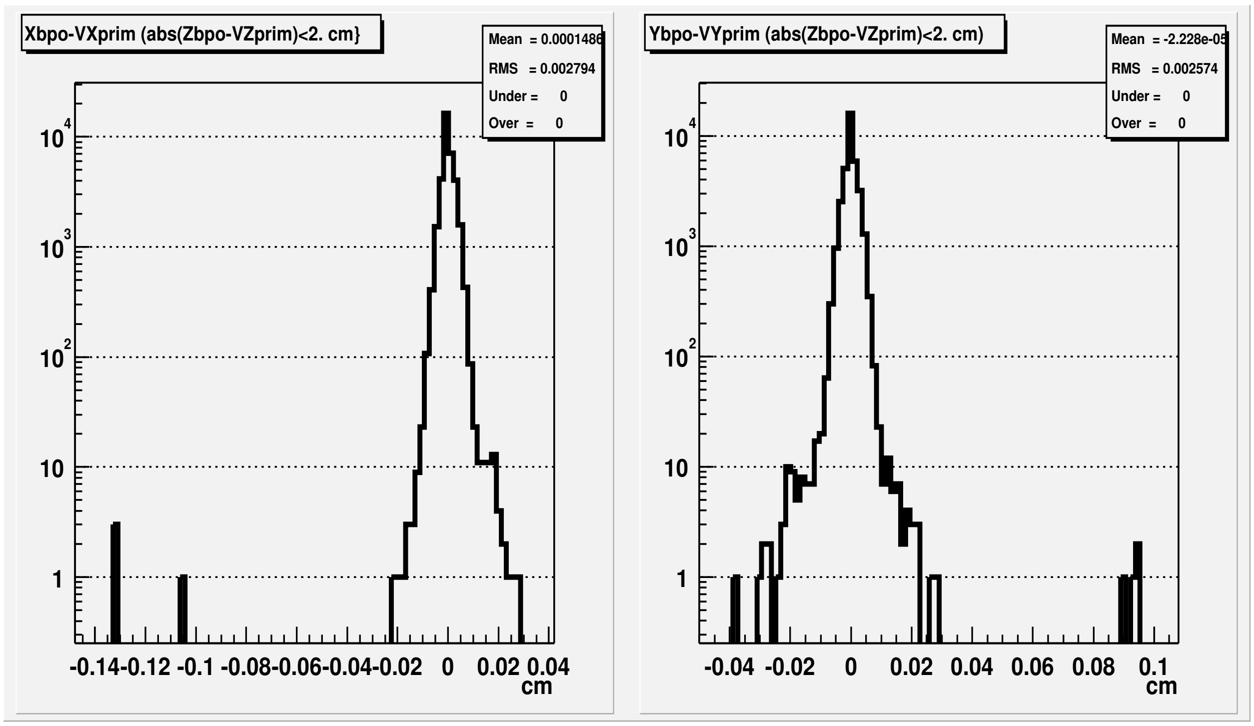

Figure 21: Difference between X and Y coordinates from BPO and VPRIM when $|Zbpo - Zvprim| < 2.$ cm. for JET-20 data sample (80% of the total number of events).

Tables 5 and 6 show the rates and efficiencies with L2 cuts and L3 SECVTX single and double tag requirements. The final proposal depends on the available input L3 rate with full tracking reconstruction. If input L3 rates of 8.5 Hz or higher are available the option with only L2 calorimetry plus 1 L3 SECVTX tag provides the highest efficiency (31.0%) and an output to tape rate of 0.43 Hz (L3 rejection factor of ≈ 30). An intermediate situation can take place in case of limited L3 input rate. In that case introducing SVT requirements the L2 output rate can be successfully modulated imposing thresholds in the largest track IP. In the extremal case when L3 tracking reconstruction will be not available SVT plus calorimetry requirements will yield an output rate of 0.5 Hz with an efficiency of 28% ($M_H = 120\,\mathrm{GeV}$). In this sample the *a posteriori* SECVTX single and double tagging efficiency is of the order of 28% and 9.0%.

Selection Cut (JET20)	**L2 Rate** (Hz)	**L3 SECVTX Rate** (Hz) **1 tag / 2 tag**
Calorimetry only $\mathrm{N_{cl}}(\mathrm{E_T^{cl}} \geq 10\mathrm{GeV}) \geq 3, \Sigma E_T^{cl} \geq 90GeV$	8.5(1)	0.43 / 0.03
Calorimetry + ≥ 1 SVT track $\lvert d\rvert \geq 100\mu m$	1.4 (6)	0.2 / 0.03
Calorimetry + ≥ 2 SVT track $\lvert d1\rvert \geq 100\mu m\,, \lvert d2\rvert \geq 80\mu m$	0.5 (17)	0.07 / 0.018

Table 5: L2 and combined L2 plus L3 rates. L3 Calorimetry with one or two SECVTX tags. In brackets showed the rejection factor respect when only L2 calorimetry is required.

Selection Cut (JET20)	**L2 Efficiency** (%)	**L3 SECVTX Efficiency 1 tag / 2 tag**(%)
Calorimetry only $N_{cl}(E_T^{cl} \geq 10\mathrm{GeV}) \geq 3, \Sigma E_T^{cl} \geq 90GeV$	74.	33.0 / 10.1
Calorimetry + ≥ 1 SVT track $\|d\| \geq 100\mu m$	38.	30.5 / 9.5
Calorimetry + ≥ 2 SVT track $\|d1\| \geq 100\mu m\,, \|d2\| \geq 80\mu m$	28.	28.0 / 9.0

Table 6: Combined L2 and L2 plus L3 efficiencies. Efficiencies are referred to the total number of generated events. L3 requirements: $\mathrm{N_{jets}}(\mathrm{E_T^{jets}} \geq 10\,\mathrm{GeV}) \geq 3,\ \sum \mathrm{E_T^{jets}} \geq 100$ with one or two SECVTX tags.

Summary

We summarize here the essential requirements:

OPTION A: L3 Full Track reconstruction rate at ≥ 15.1 Hz.
LEVEL 1:
single trigger-tower $E_T^{tow} \geq 10\,\mathrm{GeV}$.
LEVEL 2:
$\sum \mathrm{E_T^{clus}}(10\,\mathrm{GeV}) \geq 90$ GeV, $\mathrm{N_cl} \geq 3$ ($\mathrm{E^cl_T} \geq 10\mathrm{GeV}$)
LEVEL 3:
$\sum \mathrm{E_T^{jet}} \geq 100\,\mathrm{GeV}$, $\mathrm{N_{jet}} \geq 3$ ($\mathrm{E_T^{jet}} \geq 10\,\mathrm{GeV}$), 1 SECVTX tag.

OPTION B: L3 Full Track reconstruction rate at ≤ 2 Hz.
LEVEL 1:
idem.
LEVEL 2:
$\sum \mathrm{E_T^{clus}}(10\,\mathrm{GeV}) \geq 90$ GeV, $\mathrm{N_cl} \geq 3$ ($\mathrm{E^cl_T} \geq 10\mathrm{GeV}$),
≥ 2 SVT track $|d1| \geq 100\mu m\,, |d2| \geq 80\mu m$
LEVEL 3: $\sum \mathrm{E_T^{jet}} \geq 100\,\mathrm{GeV}$, $\mathrm{N_{jet}} \geq 3$ ($\mathrm{E_T^{jet}} \geq 10\,\mathrm{GeV}$)

Option A yields an L3 output rate of 0.43 Hz with a total efficiency of 31.0% (single tag) and 9.0 % (double tag). Option B yields an L3 output rate of 2.0 Hz with an efficiency of 21.3 % (single tag) and 7.0 % (double tag). SECVTX efficiency is considered as it was in RUN-I without accounting on the extended η coverage and improved stereo tracking capabilities.

Conclusions

In this note we present a proposal for a multijet trigger for Standard Model Higgs in the associated production with a vector boson intended to be efficient in the full hadronic decay channel up to Higgs masses of the order of 130 GeV. The trigger strategy is based in the search for secondary vertexes due to the large B-hadron lifetime using the SVT at L2. At L3 this strategy is complemented with the use of the SECVTX algorithm as a L3 b-tagging filter. Including double b-tagging efficiency, an improvement by a factor of 3 respect to RUN-I efficiencies is reached. If we scale this efficiency by a factor of 2 in order to account for SVXII larger acceptance [17] then we reach a total improvement by a factor of 6. This approach is complementary to other triggers as the Soft Lepton Tag multijet trigger, aimed to the tagging of the soft leptons produced in the semileptonic decay of the B-hadrons [9].

At L1 different options had been studied in order to minimize the cross section: the *L1 sumEt* calorimetric primitive seems to have a lower cross section by a factor of 2 but the estimates done on the basis of the RUN-I Minimum bias data could be not very reliable due to the fact that effects such as the pile-up have a very non linear luminosity dependence and need further confirmation with early RUN-II data. The single trigger tower $E_T \geq 10\,\mathrm{GeV}$ with an output rate of $2.7\,\mathrm{kHz}$ and an efficiency of $\approx 98\%$ is enough for our porpouses.

At L2 the SVT together with calorimetric requirements is applied. At L3 the SECVTX b-tagging algorithm is used as a L3 filter depending on L3 full track reconstruction input rate.

Studies in the RUN-II framework with the new calorimeter trigger and the SVT emulation are in progress.

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