STT Studies for $t\bar{t}$ Physics in Run II

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Introduction

- $t\bar{t}$ events generated with ISAJET:
  1. $t\bar{t} \to \mu + jets$ — 1175 events
  2. $t\bar{t} \to all\ jets$ — 2126 events
  3. $t\bar{t} \to all\ jets + 3$ minbias interactions — 500 events

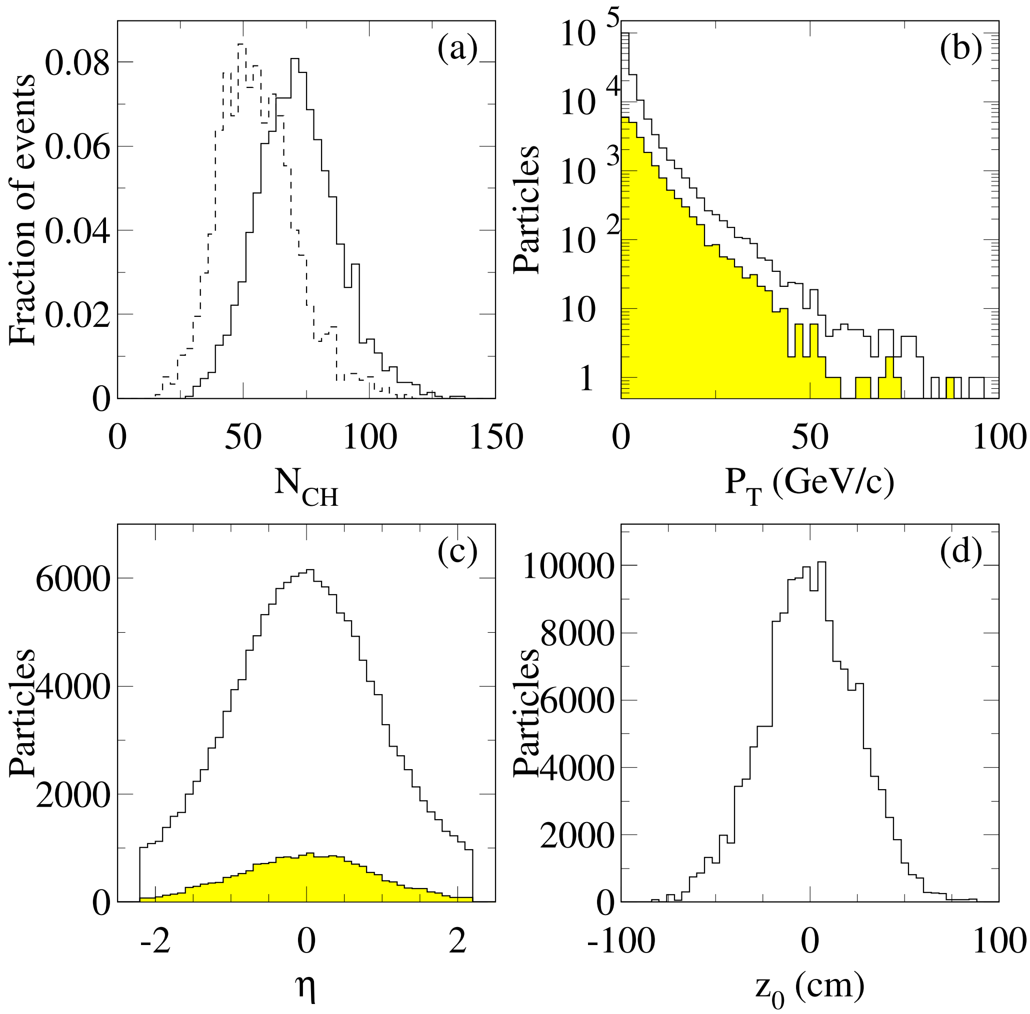
- Simulation of the DØ detector with the FEB97 version of UPG_GEANT: baseline of the SVX detector with six 4-layer barrels.

- Trigger ntuples produced with the latest version of UPG_TRG.

- Background rates:
  1. 'Standard' QCD background samples generated in 6 p_T bins;
  2. Samples with 1, 3, 5 or 7 additional minbias interactions mixed to simulate $\mathcal{L} = 2 \cdot 10^{32}$ cm^{-2}s^{-1} and beam crossing time = 132 ns.

$t\bar{t}$ Event Properties

- Average charged particle multiplicity = 72 for $t\bar{t} \rightarrow all\ jets$, 56 for $t\bar{t} \rightarrow \mu + jets$ events.
- Contribution from B meson decays: $\sim$ 10 particles per event with an average p_T of 5.4 GeV/c.
- For about 10% of the events, no particles in the acceptance of the SVX because of a large z_{PV}.



STT Analysis

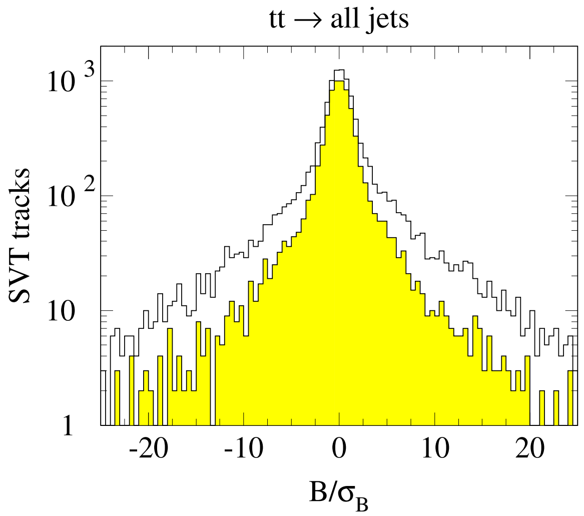
- STT tracks with $\chi^2 > 4$ are refitted after dropping the SVX hit with the largest contribution to the track fit χ^2.
- Good STT tracks are selected using quality cuts:
  1. $N_{layer} \geq 3$;
  2. Track fit reduced $\chi^2 \leq 4$.
- Impact parameter resolution parametrized by:

$$\sigma_B^2 = \sigma_0^2 + \left(\frac{\alpha_{ms}}{P_T}\right)^2 \tag{1}$$

  with $\sigma_0 = 12.6\ \mu m$ and $\alpha_{MS} = 49.7\ (GeV/c) \cdot \mu m$.
- Impact parameter significance defined as:

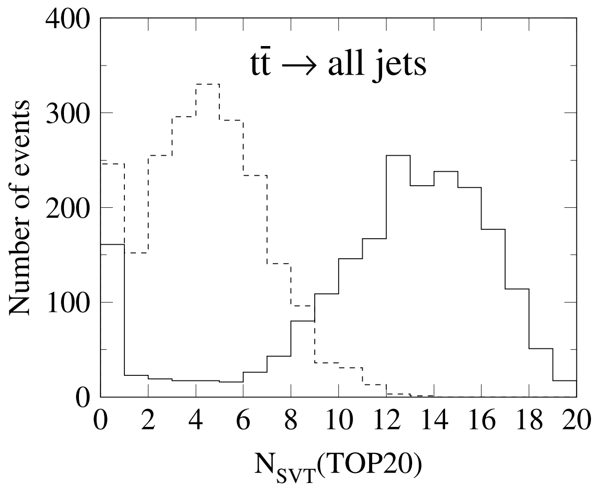
$$S_B = \frac{B}{\sigma_B(p_T)} \tag{2}$$

- IP significance distribution for STT tracks matched to MC tracks: (Open histogram = all tracks, Yellow = tracks from primary vertex)

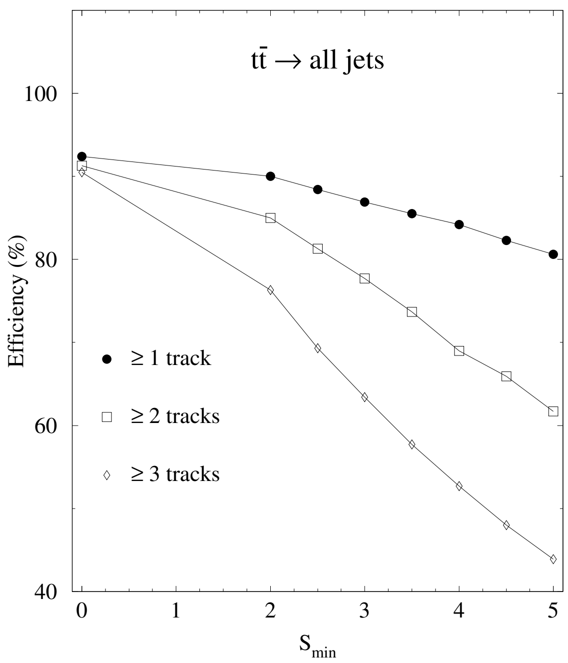


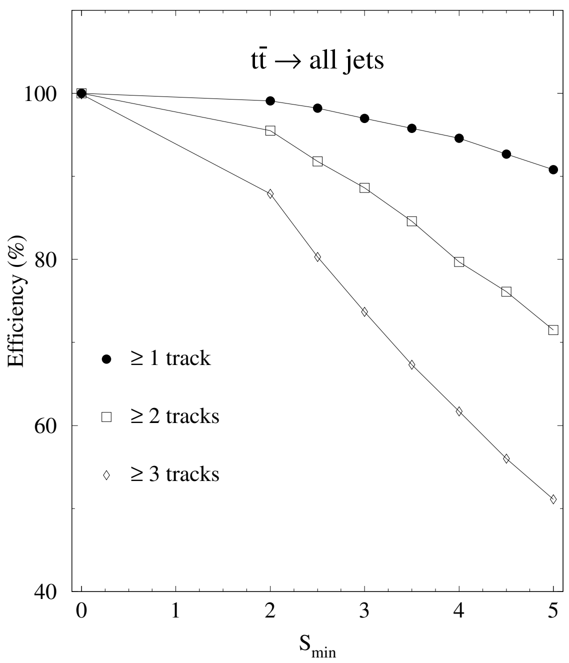
How to tag $t\bar{t}$ Events with STT

- **Compute multiplicity of tracks with $\mid S_B \mid \geq S_{min}$:**



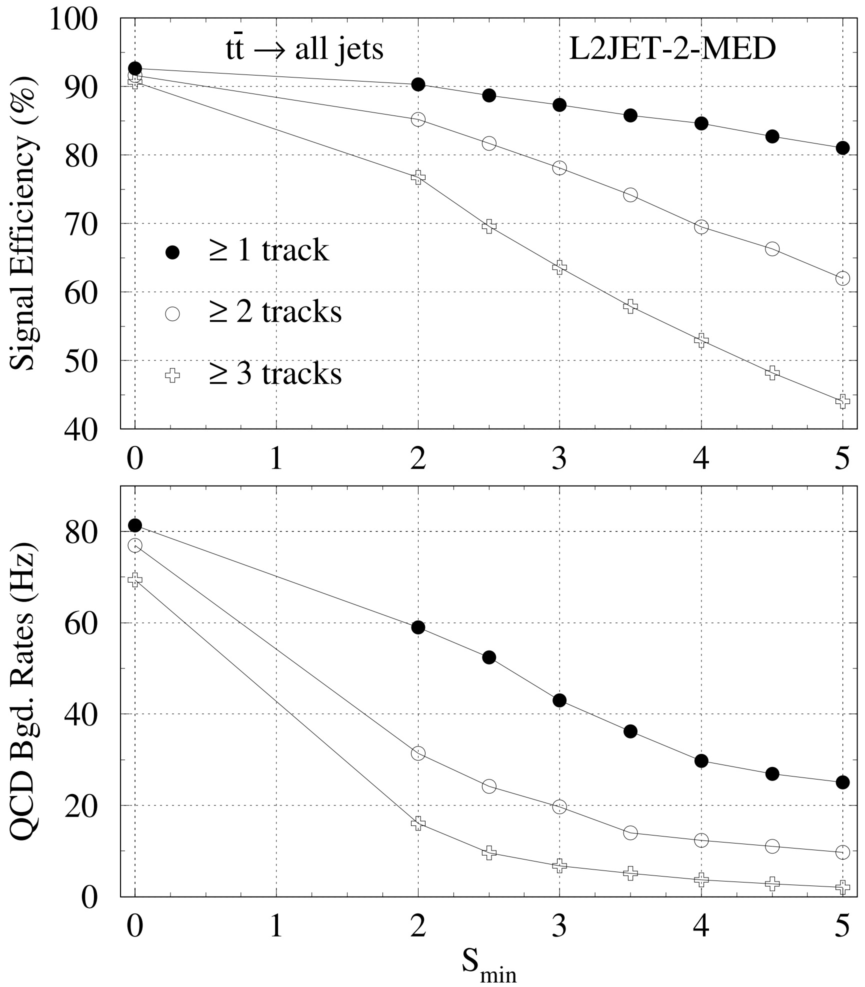
- **Tag $t\bar{t}$ events by demanding a given number of track with $\mid S_B \mid \geq S_{min}$:**





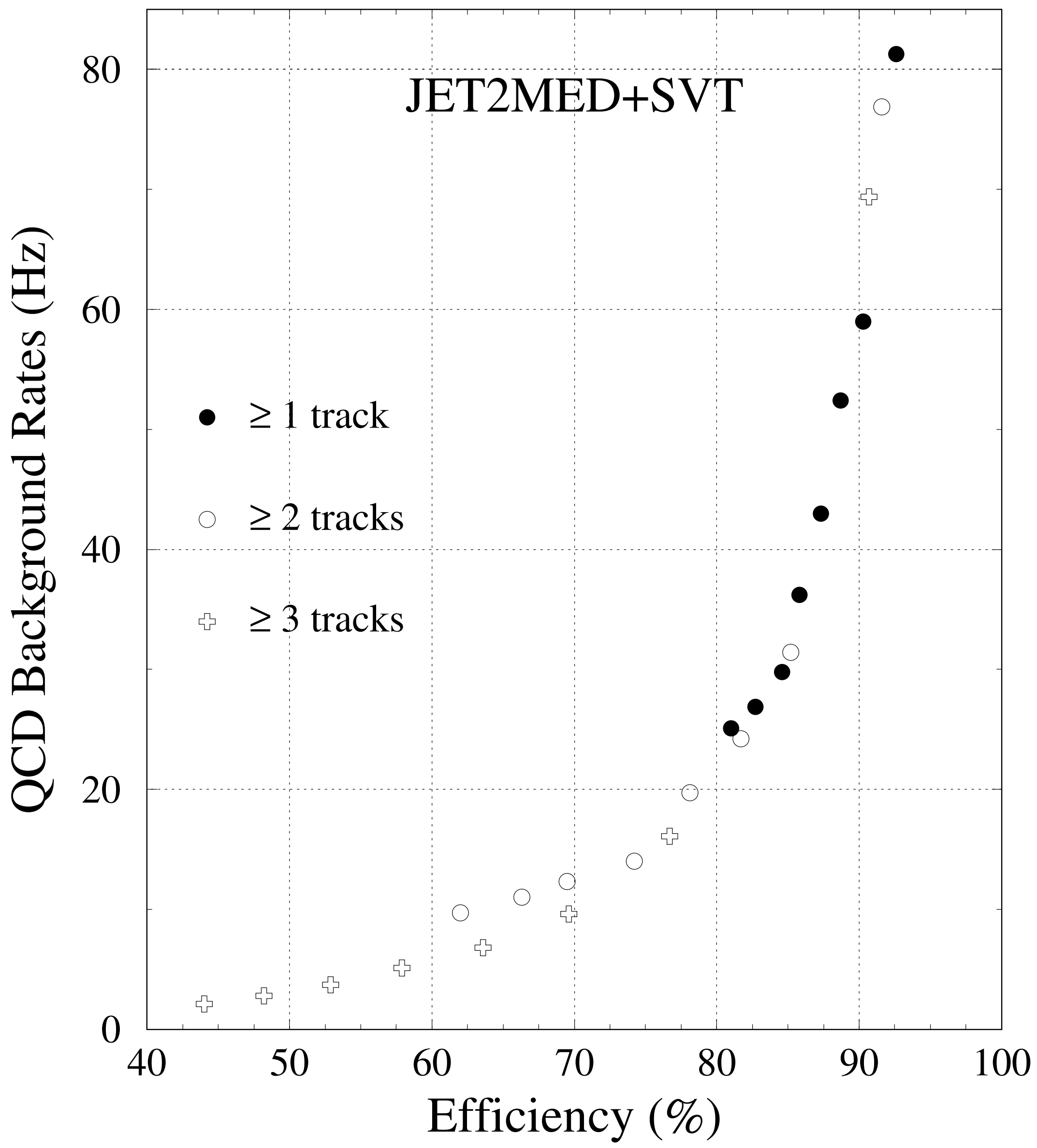
Efficiency and Background

- **Select events satisfying the JET_2_MED trigger (at least 2 jets with $E_T \geq 20$ GeV).**
- **Signal efficiency and background trigger rate for the trigger combination L2JET_2_MED + STT:**



- **Requiring at least 1 track with $|S_B| \geq 3$ allows a factor 2 reduction of the background rate while keeping 87% of the signal.**

Efficiency versus Background



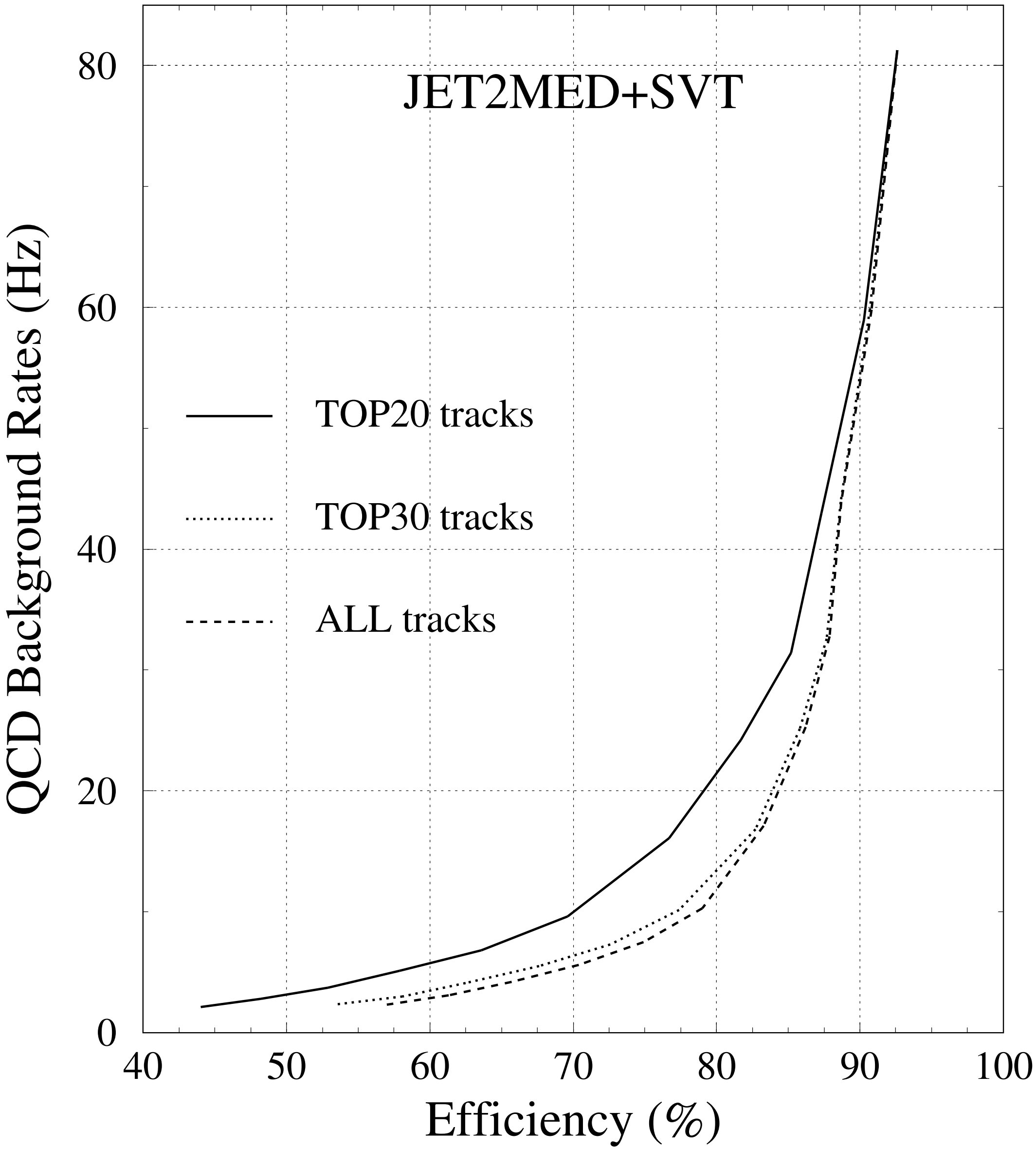
Benefits of a STT for $t\bar{t}$

	Bgd.(Hz)		$t\bar{t} \to \mu + jets$		$t\bar{t} \to all\ jets$	
Trigger	**L1**	**L2**	**L1(%)**	**L2(%)**	**L1(%)**	**L2(%)**
1–JMULT	49.7	2.1	88.9	27.4	98.6	69.8
2–MJTMET	55.2	3.3	93.4	68.5	82.0	48.7
3–JMAX	49.7	13.0	88.9	68.3	98.6	84.2
4–MUJET	64.1	41.6	75.4	74.3	53.2	53.6
5–JET2MED	186	85.2	96.5	88.3	99.3	98.3
$\Sigma\,(1 \to 3)$	82.5	17.2	96.0	86.0	99.6	96.2
$\Sigma\,(1 \to 5)$	239	113	98.4	96.1	99.9	99.8
$\Sigma\,(1 \to 3) + \Sigma(4 \to 5) \times STT$	239	38.5	98.4	92.9	99.9	98.6

JMULT: ≥ 4 jets with $E_T \geq 15$ GeV
MJTMET: ≥ 3 $E_T^{jet} \geq 10$ GeV + missing $E_T \geq 20$ GeV
JMAX: ≥ 1 jet with $E_T \geq 45$ GeV
MUJET: ≥ 1 $p_T^{\mu} \geq 6$, $E_T^1 \geq 20$ GeV and $E_T^2 \geq 10$ GeV
JET2MED: ≥ 2 jets with $E_T \geq 20$ GeV
STT: at least 2 tracks with $\mid S \mid \geq 2.5$ ($\epsilon_{signal} = 80\%$)

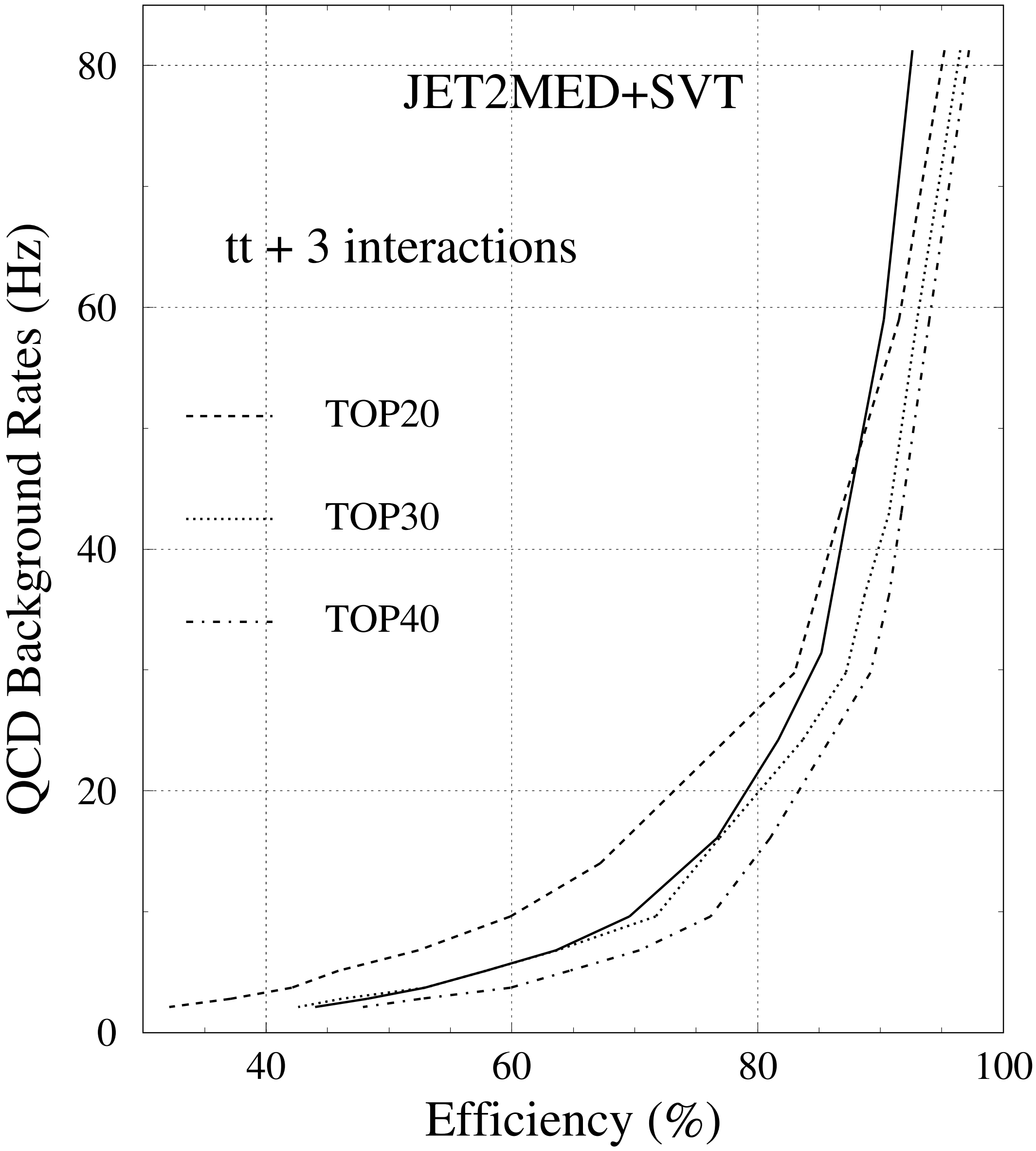
$\Rightarrow$ Using STT provides an additional rejection of ~ 3 for the same efficiency at Level 2.

Influence of Number of Available Tracks



⇒ Using the 30 largest p_T tracks instead of 20 gives a 10% increase on the signal efficiency.

Influence of additional interactions



⇒ The effect of additional interactions on the signal efficiency is marginal if the number of tracks available for the STT is at least 30.

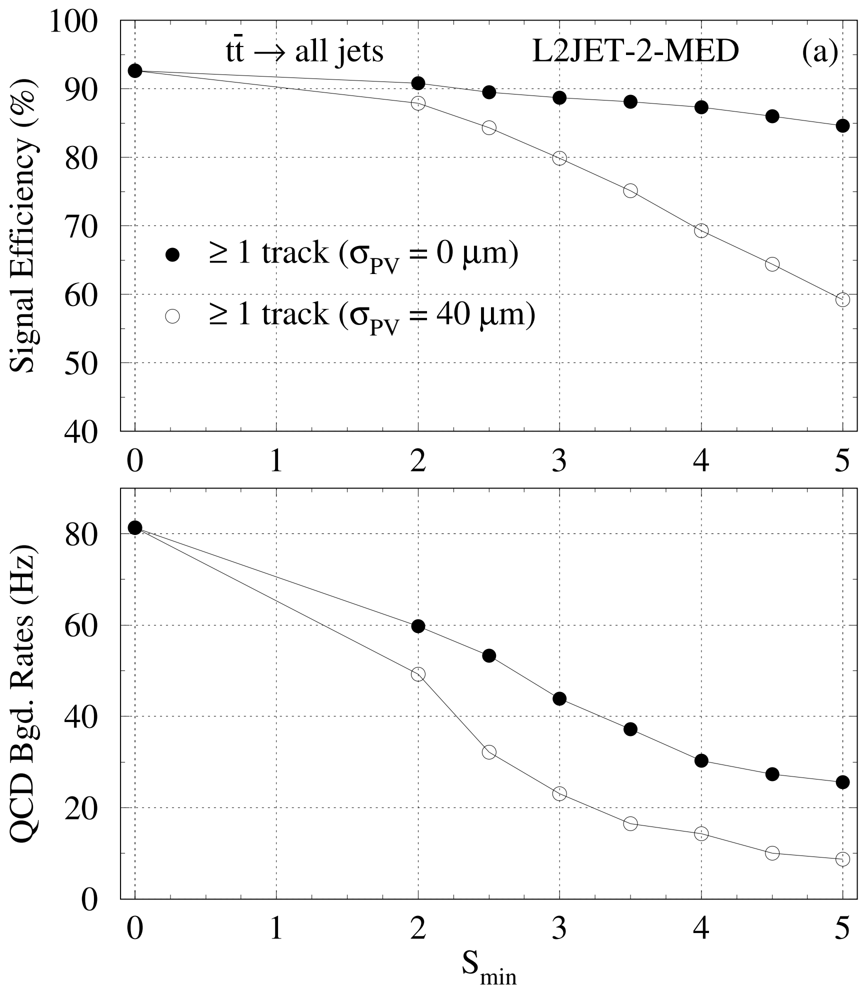
Influence of Primary Vertex Smearing

- **The uncertainty on the position of the PV was not taken into account in previous studies.**
- **To simulate this effect, replace S_B definition by:**

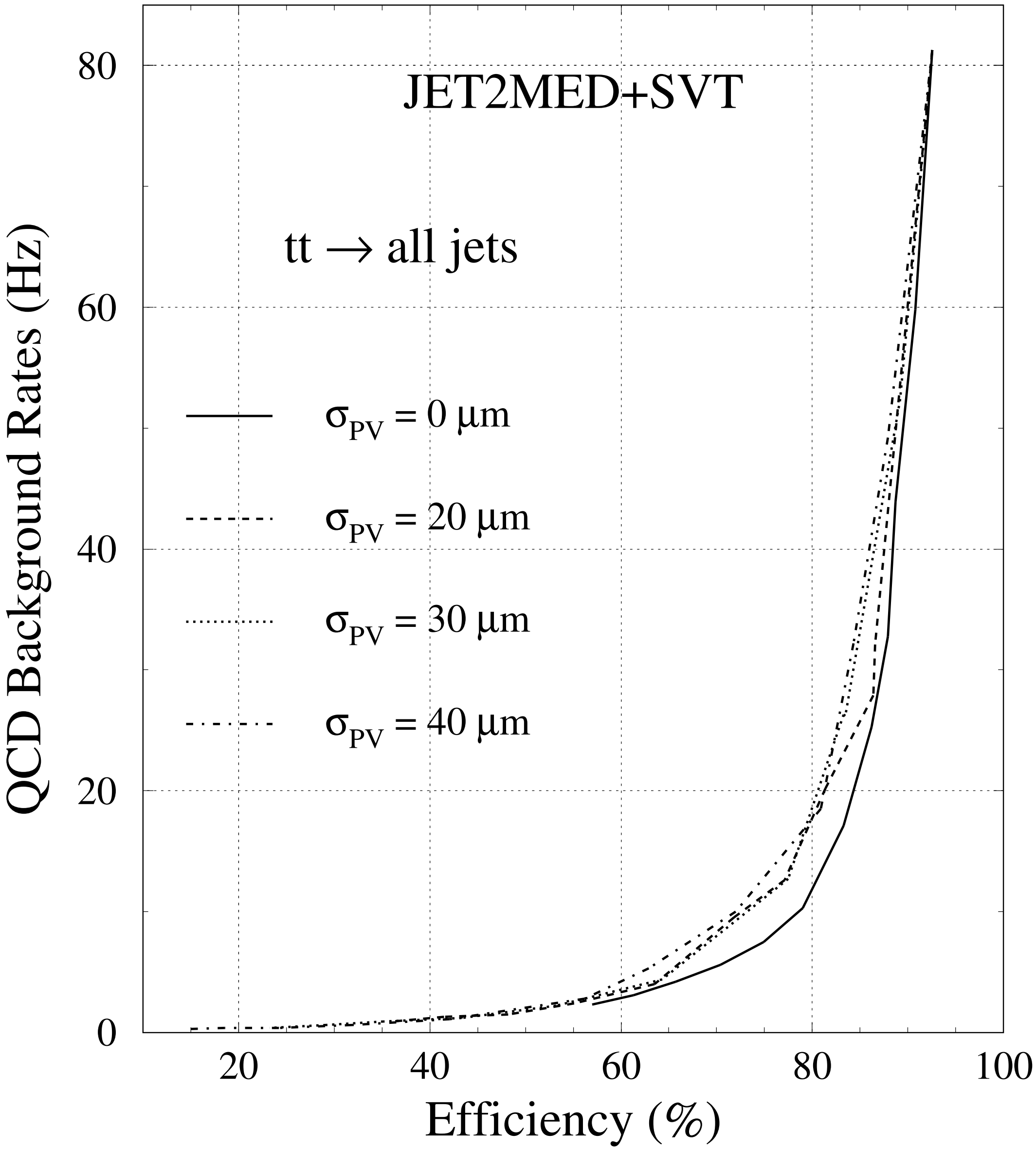
$$S_B = \frac{B + B_{PV}}{\sqrt{\sigma_B^2 + \sigma_{PV}^2}} \quad (3)$$

where:

- σ_{PV} **= uncertainty on the PV position**
- B_{PV} **= correction to the IP due to PV smearing (generated following a Gaussian of width σ_{PV}).**



Influence of Primary Vertex Smearing



⇒ **The uncertainty on the primary vertex position has a marginal effect on the background rate — signal efficiency correlation.**

Conclusions

- We have investigated the benefits for the selection of $t\bar{t}$ that could result from the installation of a Silicon Track Trigger at L2.

- STT is a powerful tool to reduce the background rates: the JET_2_MED background rate can be reduced by a factor 4 while preserving 80% of the $t\bar{t}$ signal.

- The influence of additional minimum bias interactions and primary vertex smearing on this result is marginal.

- The STT would allow to optimize the $t\bar{t}$ trigger efficiency without increasing the background rate.