Di-electron trigger at Level-0 – Final Conclusions

Eduardo Rodrigues, CERN

I. Motivations & L0 Electron candidates

-> see previous presentations …

II. A di-electron trigger at L0 and alternative scenarios

1. L0DU algorithm with a di-electron trigger a la di-muon trigger
2. Overriding electron trigger
3. Double-threshold electron trigger
4. Electron and real di-electron trigger with 2 thresholds

III. Comparisons between the various scenarios

IV. Implications for L1 & HLT

V. Conclusions

L0 optimization with Di-electron Trigger (I)

<u>L0DU Algorithm with a di-electron trigger</u>

- L0DU algorithm as in the Trigger TDR

  +

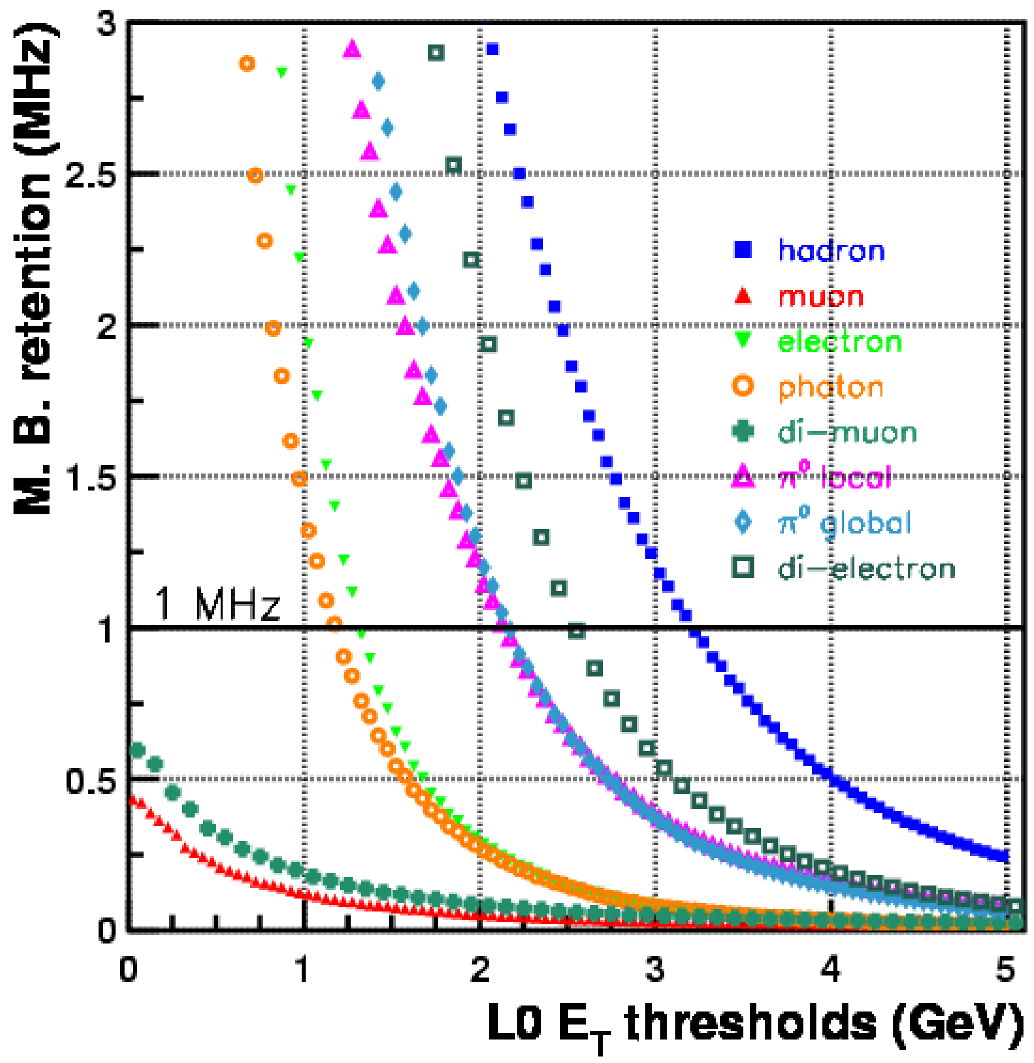
- di-electron trigger "à la di-muon trigger"

  ($E_T^{ee} = E_T^{e1} + E_T^{e2}$ with $E_T^{e2} = 0$ possible)

  - overrides the global event cuts

    (pile-up veto and

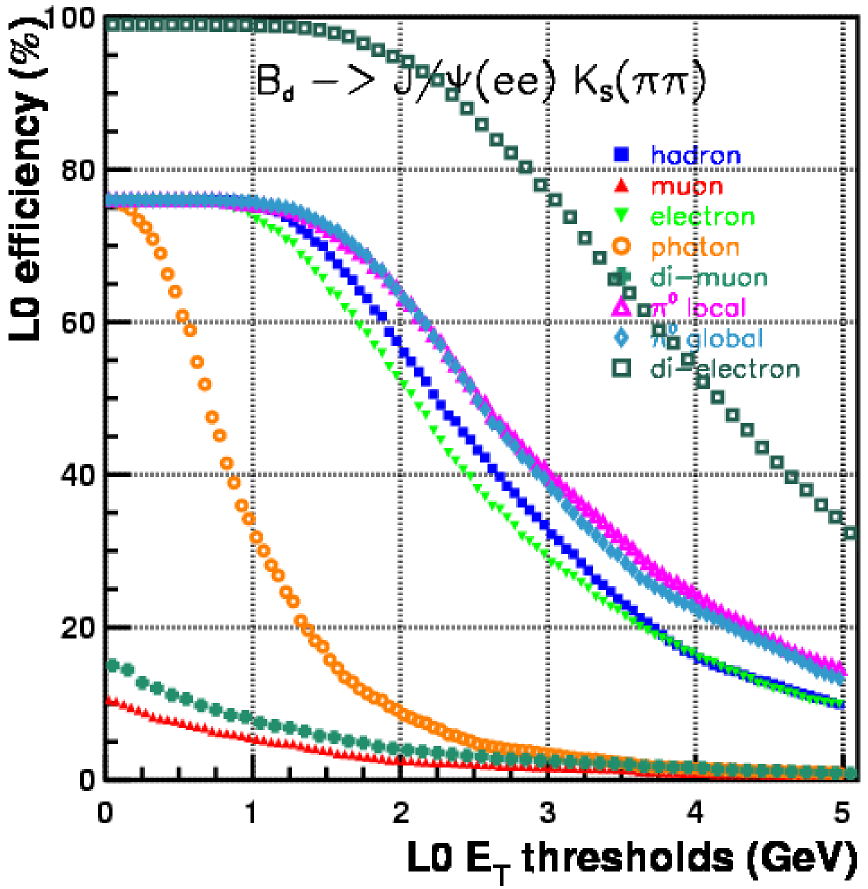
    veto and SPD multiplicity cuts)

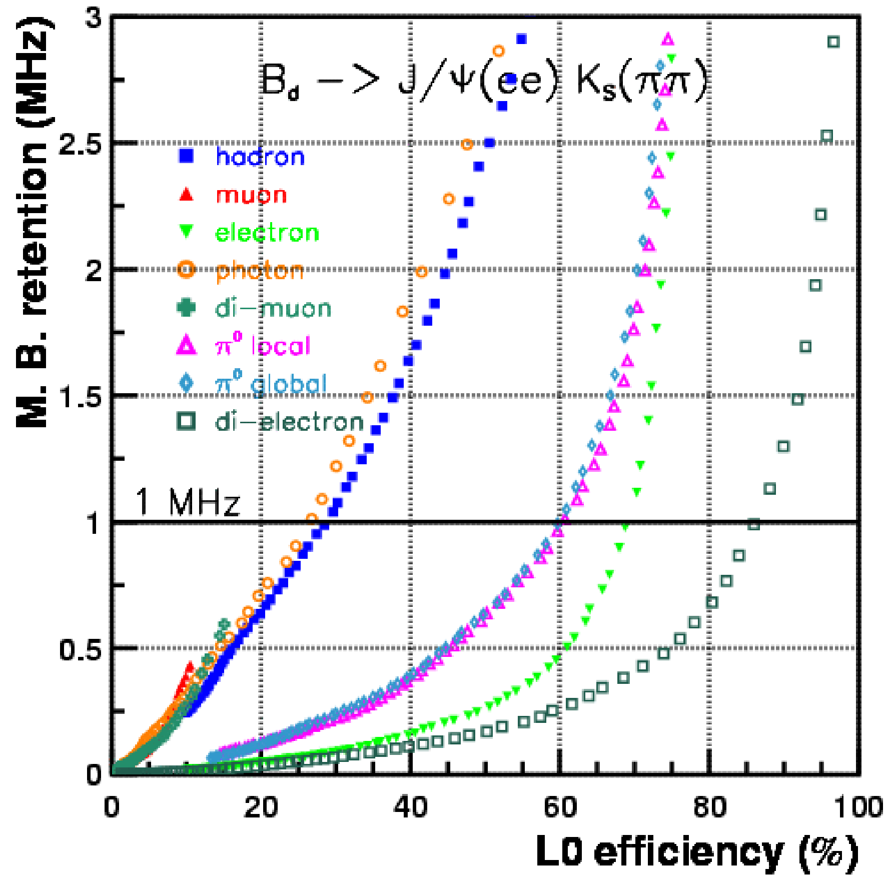


each curve corresponds to considering
separately the combination
L0 trigger = sub-trigger
+ pile-up veto & multiplicity cuts

L0 optimization with Di-electron Trigger (II)

Max. efficiency obtainable inclusively by each trigger!





L0 optimization with Di-electron Trigger (III)

Optimizing each channel separately on the L0 efficiency …

Channels	L0 eff. Max. (%) TDR L0	L0 eff. Max. (%) with new di-elec. Trig.
$B_d \to J/\Psi(ee)\ K_s$	**69.7**	**85.0**
$B_d \to K^*\ \gamma$	**77.6**	**86.8**
$B_d \to J/\Psi(\mu\mu)\ K_s$	93.0	93.2
$B_s \to J/\Psi(\mu\mu)\ \Phi(KK)$	93.0	93.0
$B_d \to \pi\pi$	54.7	56.7
$B_s \to D_s\ K$	48.2	48.2

Max. eff. obtained with separate optimization of each channel

L0 optimization with Di-electron Trigger (IV)

Combined optimization of L0 on the channels below …

Channels	L0 eff. (%) TDR settings	Di-electron trigger L0 eff. (%)	Rel. Gain in eff. w.r.t TDR (%)
$B_d \to J/\Psi(ee)\ K_s$	48.3	70.8	**+ 46.6**
$B_d \to K^*\ \gamma$	72.9	80.2	**+ 10.0**
$B_d \to J/\Psi(\mu\mu)\ K_s$	89.3	89.6	+ 0.3
$B_s \to J/\Psi(\mu\mu)\ \Phi(KK)$	89.7	89.8	+ 0.1
$B_d \to \pi\pi$	53.6	56.5	+ 5.4
$B_s \to D_s\ K$	47.2	47.4	+ 0.4

L0 as in the TDR

"New LODU"

L0 retention on minimum bias events

Bandwidth on minimum bias events (kHz)	HCAL: 593	ECAL: 400	Muons: 161

~ 300 kHz for di-elec-trigger

L0 optimization with Di-electron Trigger (V)

- **L0 settings for this new L0DU algorithm with a di-electron trigger:**

  - muon thresholds kept fixed …

L0 trigger	E_t^{had}	E_T^{μ}	E_T^{e}	E_T^{γ}	$E_T^{\mu\mu}$	π^0_{local}	π^0_{global}	E_t^{ee}
TDR Thresholds (GeV)	3.6	1.1	2.8	2.6	1.3	4.5	4.0	--
Optimized Thresholds (GeV)	3.8	1.1	3.1	3.0	1.3	4.8	4.8	3.6

& Veto, SPD and Pile-up veto multiplicity cuts fixed at 3, 280 and 112, respectively

L0 optimization with “overriding Electron Trigger” (I)

- **Alternative**

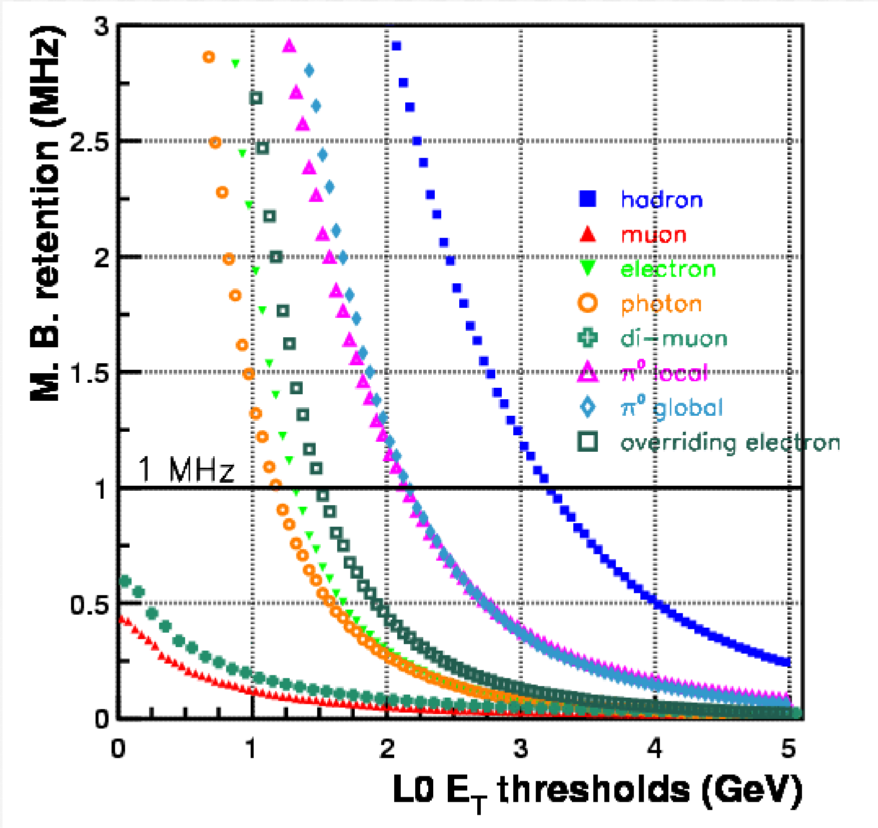
  simply override the veto and multiplicity cuts with the electron trigger

  - all steps were redone …

    … and after L0 optimization …

- performance for hadronic and muon channels as with the di-electron trigger
- performance for $B_d \to K^* \gamma$ roughly the same (marginally better)
- performance for $B_d \to J/\Psi(ee)\ K_s$ worse by ~ 10% in relative efficiency

-> details follow …



L0 optimization with "overriding Electron Trigger" (II)

Combined optimization of L0 on the channels below …

Channels	L0 eff. (%) TDR settings	Over. E-trigger L0 eff. (%)	Rel. Gain in eff. w.r.t TDR (%)
$B_d \to J/\Psi(ee)\ K_s$	48.3	66.3	**+ 37.3**
$B_d \to K^*\ \gamma$	72.9	81.8	**+ 12.2**
$B_d \to J/\Psi(\mu\mu)\ K_s$	89.3	89.6	+ 0.3
$B_s \to J/\Psi(\mu\mu)\ \Phi(KK)$	89.7	89.8	+ 0.1
$B_d \to \pi\pi$	53.6	56.3	+ 5.0
$B_s \to D_s\ K$	47.2	46.7	- 1.1

L0 as in the TDR

"New L0"

L0 retention on minimum bias events

Bandwidth on minimum bias events (kHz)	HCAL: 553	ECAL: 470	Muons: 161

~ 260 kHz for e-trigger

Double-threshold Electron Trigger (I)

- Combination of previous scenarios: a double-threshold electron trigger
  - a "standard" electron trigger with a low threshold
  - a higher electron-trigger threshold able to override the veto and multiplicity cuts

-> all steps were redone …

… and after L0 optimization …

-> scenario slightly more performant than the overriding electron trigger

-> ~ 5 % less performant than the di-electron trigger

Double-threshold Electron Trigger (II)

- L0 settings for this new L0DU algorithm with a double-threshold electron trigger:

L0 trigger	E_t^{had}	E_T^{μ}	E_T^{e}	E_T^{γ}	$E_T^{\mu\mu}$	π^0_{local}	π^0_{global}
TDR Thresholds (GeV)	3.6	1.1	2.8	2.6	1.3	4.5	4.0
Optimized Thresholds (GeV)	3.9	1.1	2.2 / 2.5	2.8	1.3	4.3	3.8

& Veto, SPD and Pile-up veto multiplicity cuts fixed at 3, 280 and 112, respectively

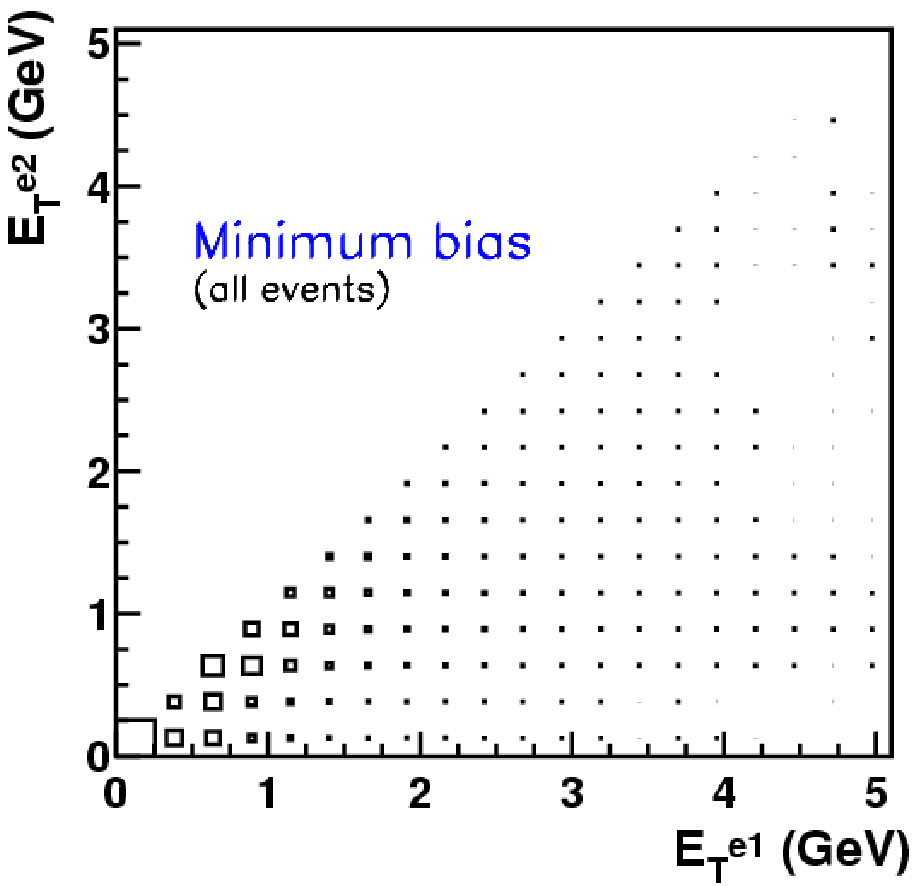
- L0 retention rate on minimum bias events

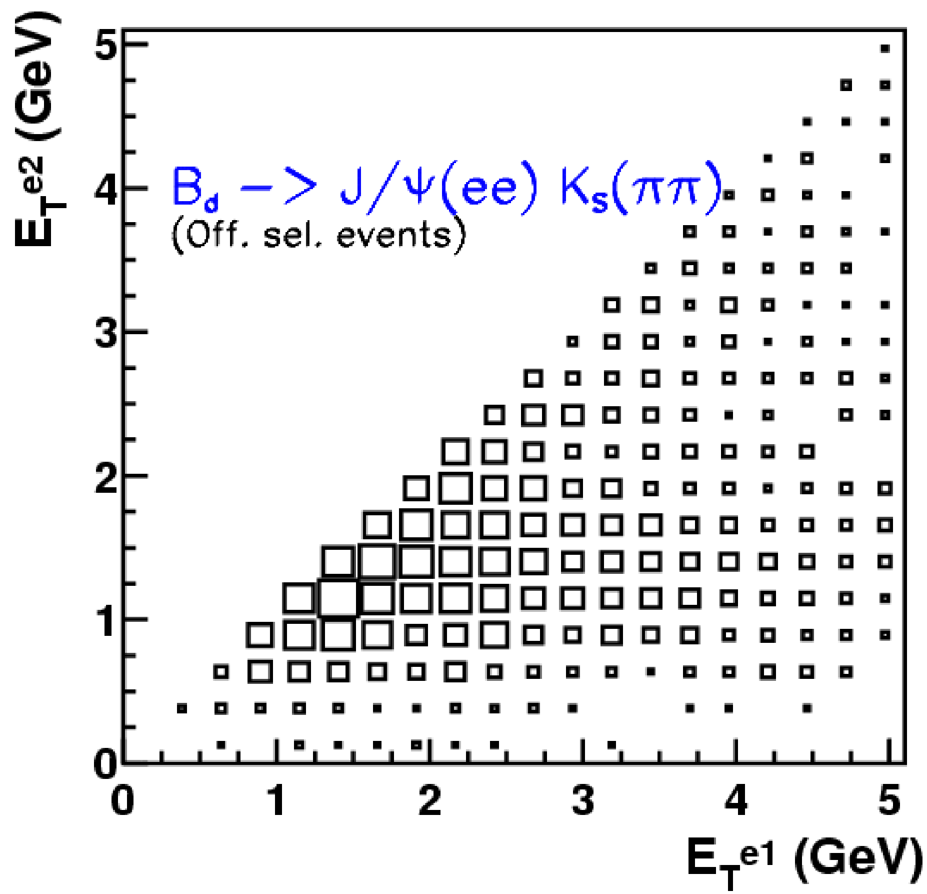
	HCAL	ECAL	Muons
Bandwidth on minimum bias events (kHz)	553	456	161

~ 225 / 225 kHz for e-triggers with low/high threshold

Electron & Real Di-electron Trigger with 2 thresholds (I)

Why a real di-electron trigger?

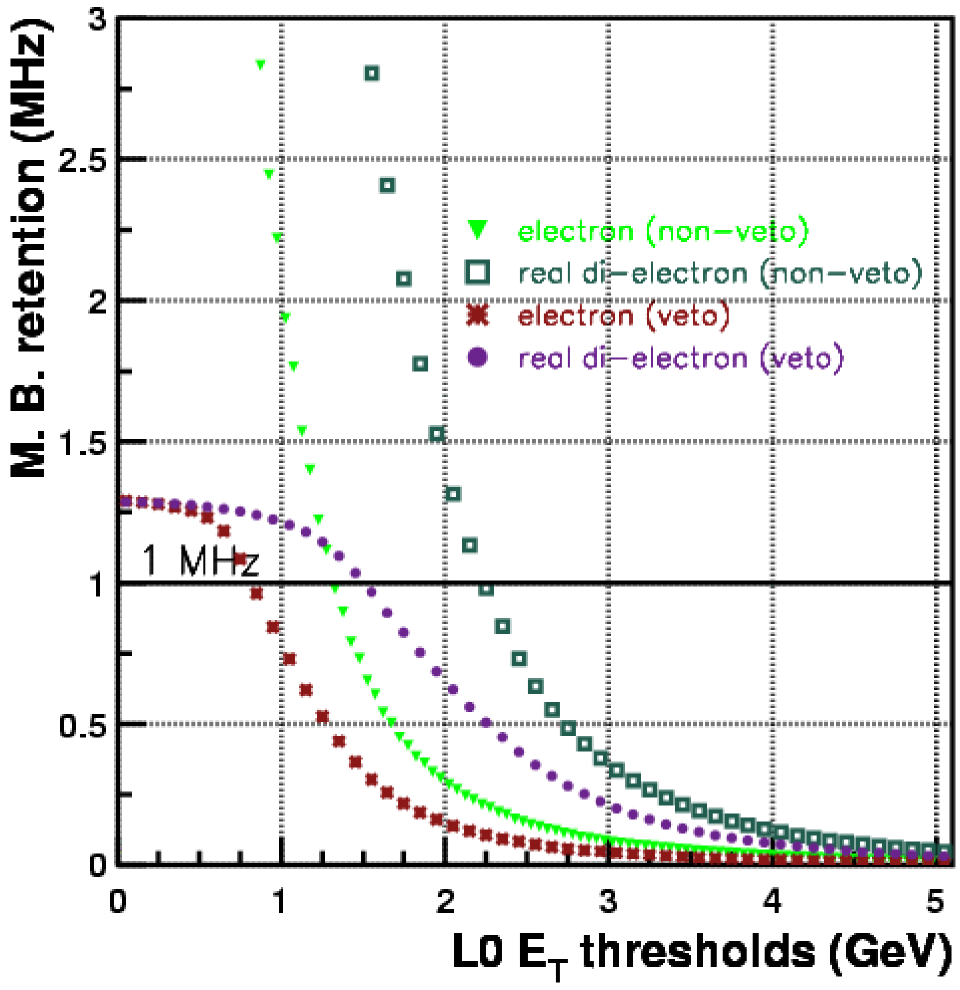




Strikingly different "correlations: a cut $E_T^{e2} > 0.5$ GeV seems useful ...

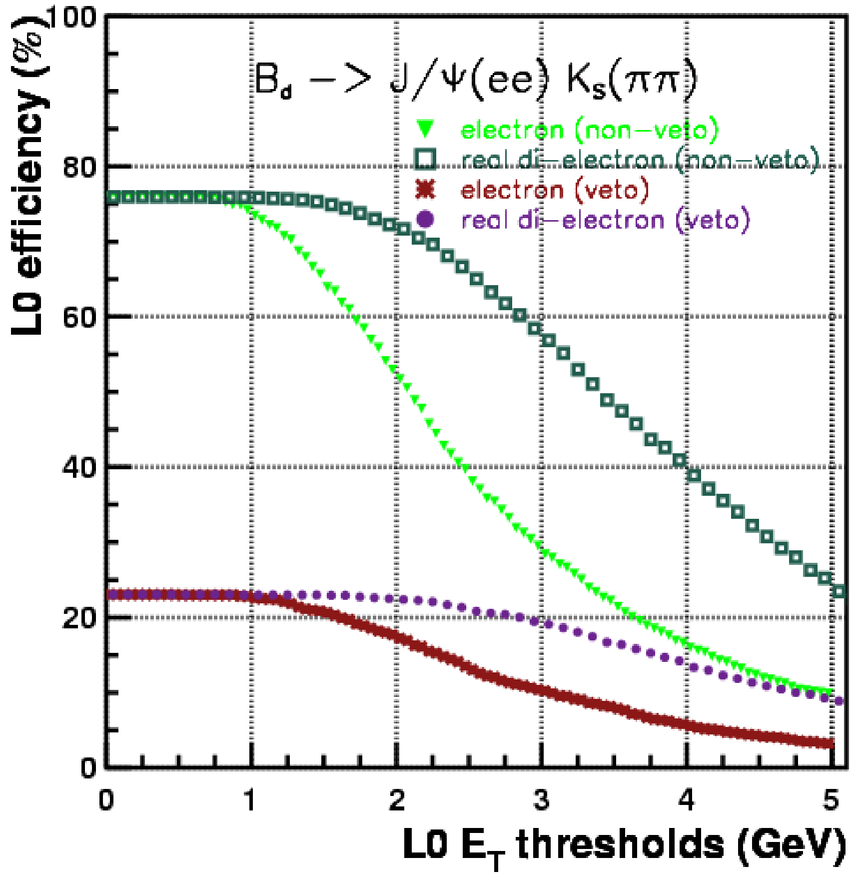
Electron & Real Di-electron Triggers with 2 thresholds (II)

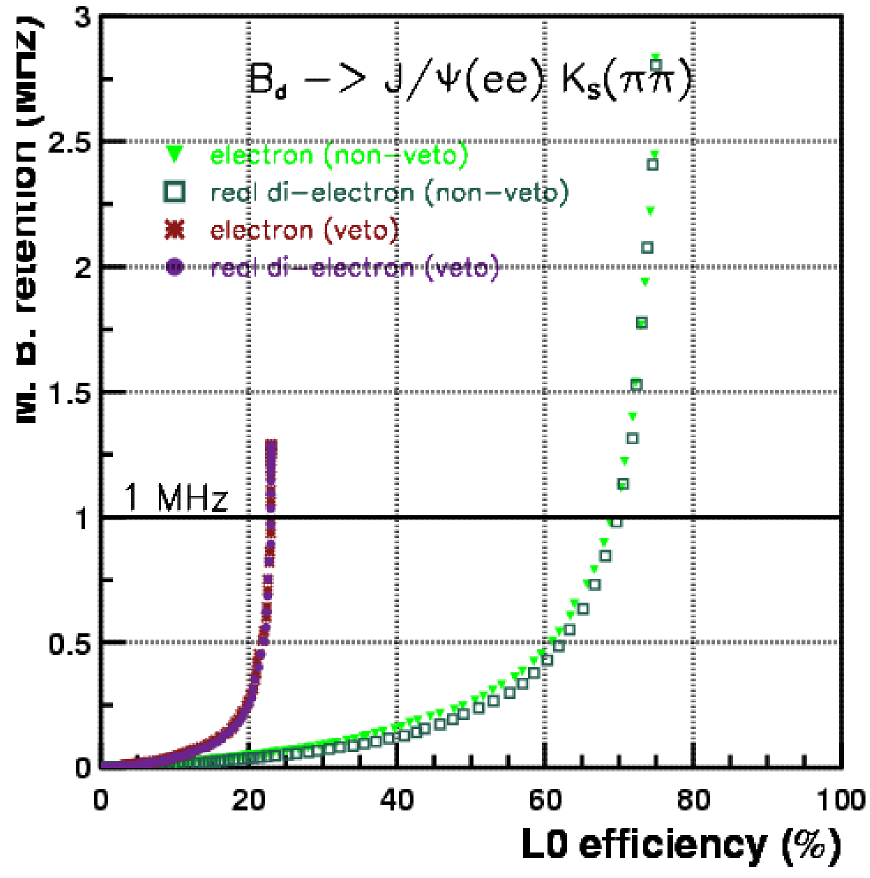
- **Electron and real di-electron trigger with double thresholds**
  - $E_T^{ee} = E_T^{e1} + E_T^{e2}$
    with E_T^{e1} , E_T^{e2} > 0
  - events separated in 2 exclusive categories: pass/ no-pass global event cuts
  - one set of (di-)electron thresholds for "global-veto-pass events"
  - one set of overriding (di-)electron thresholds for "global-vetoed events"
- LODU algorithm as in the Trigger TDR for hadron / muon / π^0 triggers



Electron & Real Di-electron Triggers with 2 thresholds (III)

Max. efficiency obtainable inclusively by each trigger!





Electron & Real Di-electron Triggers with 2 thresholds (IV)

Combined optimization of L0 on the channels below …

Channels	L0 eff. (%) TDR settings	"Optimal trigger" L0 eff. (%)	Rel. Gain in eff. w.r.t TDR (%)
$B_d \to J/\Psi(ee)\ K_s$	48.3	74.7	**+ 54.7**
$B_d \to K^*\ \gamma$	72.9	83.9	**+ 15.1**
$B_d \to J/\Psi(\mu\mu)\ K_s$	89.3	89.7	+ 0.5
$B_s \to J/\Psi(\mu\mu)\ \Phi(KK)$	89.7	90.0	+ 0.3
$B_d \to \pi\pi$	53.6	55.7	+ 3.9
$B_s \to D_s\ K$	47.2	45.9	- 2.8

L0 as in the TDR

"New L0"

L0 retention on minimum bias events

Bandwidth on minimum bias events (kHz)	HCAL: 460	ECAL: 550	Muons: 161

~ 260 kHz for e-trigger

Electron & Real Di-electron Triggers with 2 thresholds (V)

- L0 settings for this new L0DU algorithm:

L0 trigger	E_t^{had}	E_T^{μ}	E_T^{e}	E_T^{γ}	$E_T^{\mu\mu}$	π^0_{local}	π^0_{global}	E_t^{ee}
TDR Thresholds (GeV)	3.6	1.1	2.8	2.6	1.3	4.5	4.0	--
Optimized Thresholds (GeV)	4.1	1.1	3.6 / 4.0	2.8	1.3	3.7	3.6	3.4 / 3.4

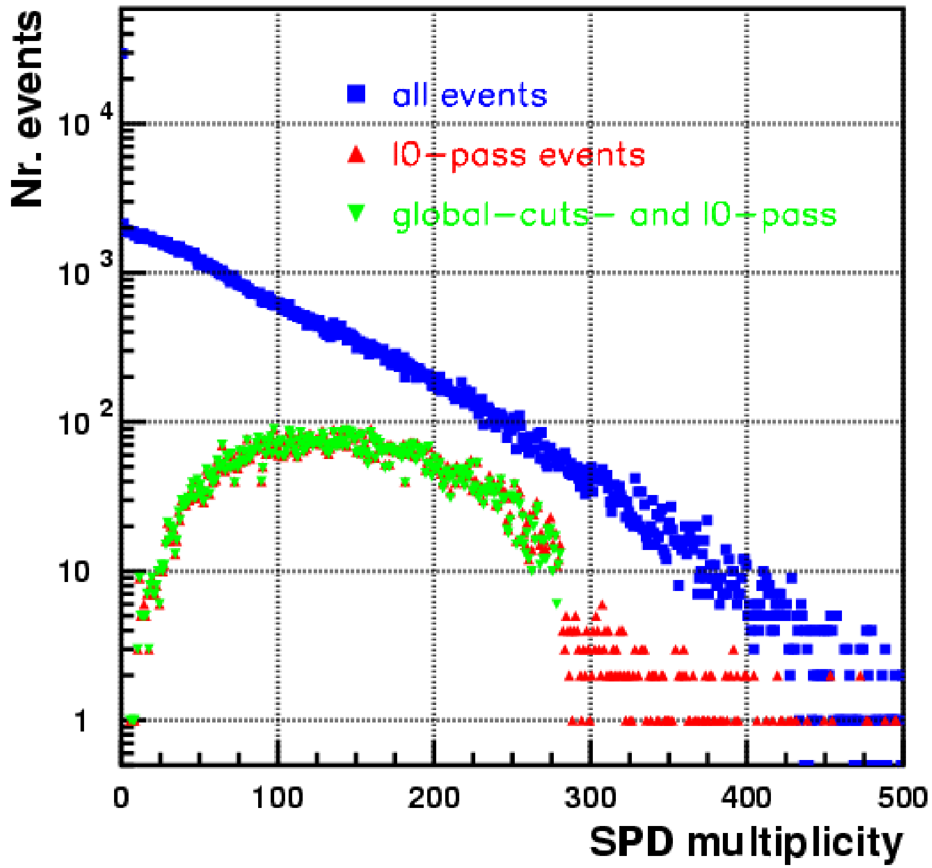
& Veto, SPD and Pile-up veto multiplicity cuts fixed at 3, 280 and 112, respectively

Comparisons

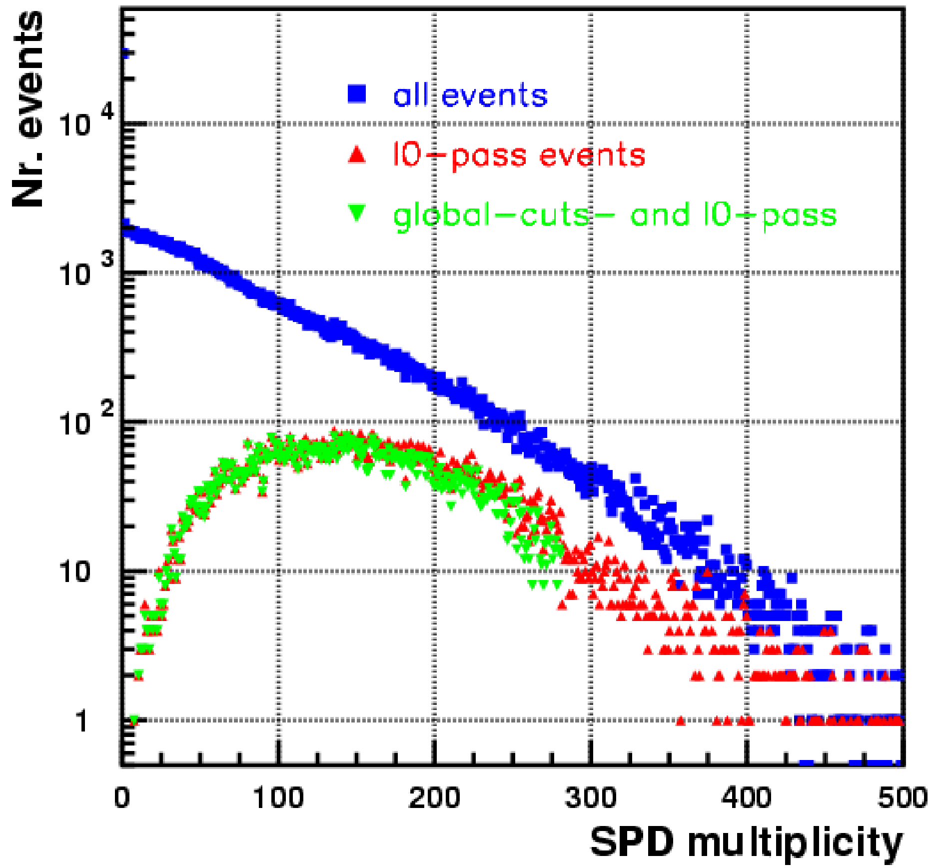
Decay Channel	$\varepsilon_{L0-max}(\%)$				
	TDR	Scen. 1	Scen. 2	Scen. 3	Scen. 4
$B_d^0 \to J/\psi(e^+e^-)K_S^0(\pi^+\pi^-)$	69.7 ± 0.9	85.0 ± 0.7	84.9 ± 0.7	84.8 ± 0.7	85.9 ± 0.7
$B_d^0 \to K^{*0}(K^+\pi^-)\gamma$	77.6 ± 1.0	86.8 ± 0.8	84.3 ± 0.9	84.5 ± 0.9	89.6 ± 0.8
$B_d^0 \to J/\psi(\mu^+\mu^-)K_S^0(\pi^+\pi^-)$	93.0 ± 0.4	93.2 ± 0.4	93.2 ± 0.4	93.2 ± 0.4	93.2 ± 0.4
$B_s^0 \to J/\psi(\mu^+\mu^-)\phi(K^+K^-)$	93.0 ± 0.1	93.0 ± 0.1	93.0 ± 0.1	93.0 ± 0.1	93.1 ± 0.1
$B_d^0 \to \pi^+\pi^-$	54.7 ± 0.4	56.7 ± 0.7	56.7 ± 0.7	56.7 ± 0.7	58.8 ± 0.6
$B_s^0 \to D_s^-(K^+K^-\pi^-)K^+$	48.2 ± 0.3	48.2 ± 0.4	48.2 ± 0.4	48.2 ± 0.4	48.4 ± 0.4
$B_s^0 \to J/\psi(e^+e^-)\phi(K^+K^-)$	67.3 ± 0.5	84.8 ± 0.6	84.8 ± 0.6	84.8 ± 0.6	85.2 ± 0.6
$B_d^0 \to \pi^+\pi^-\pi^0$	81.6 ± 1.5	86.2 ± 2.3	85.3 ± 2.4	85.3 ± 2.4	84.8 ± 2.4

Implications for L1 & HLT (I)

TDR L0DU

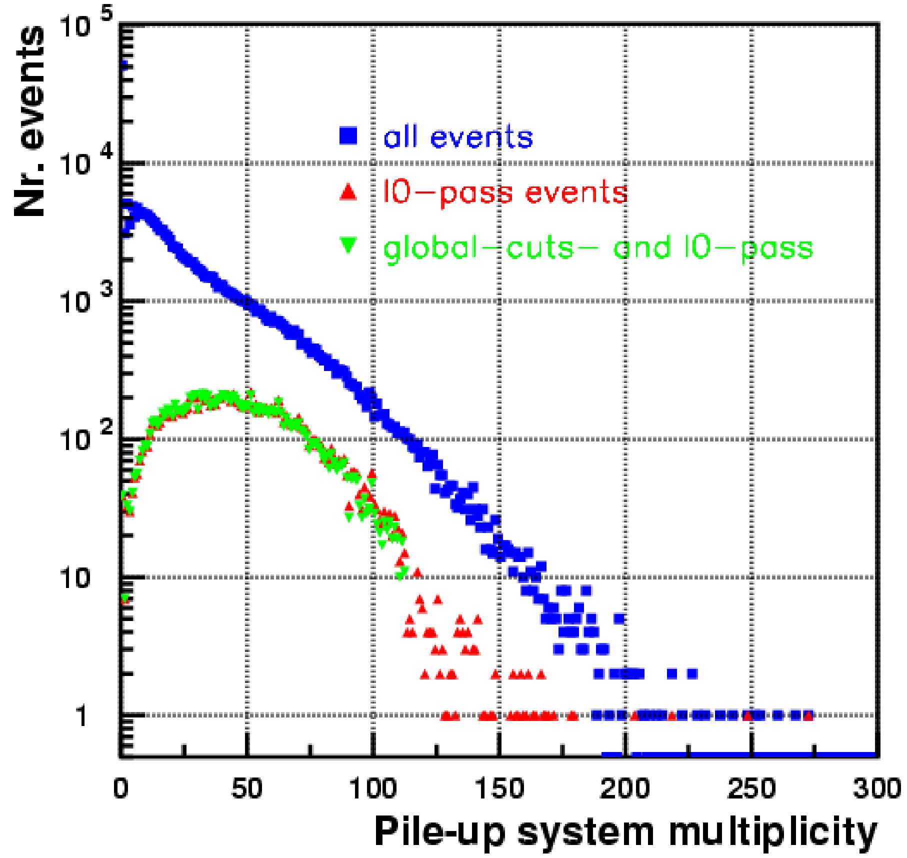


2- threshold real di-elec. trigger

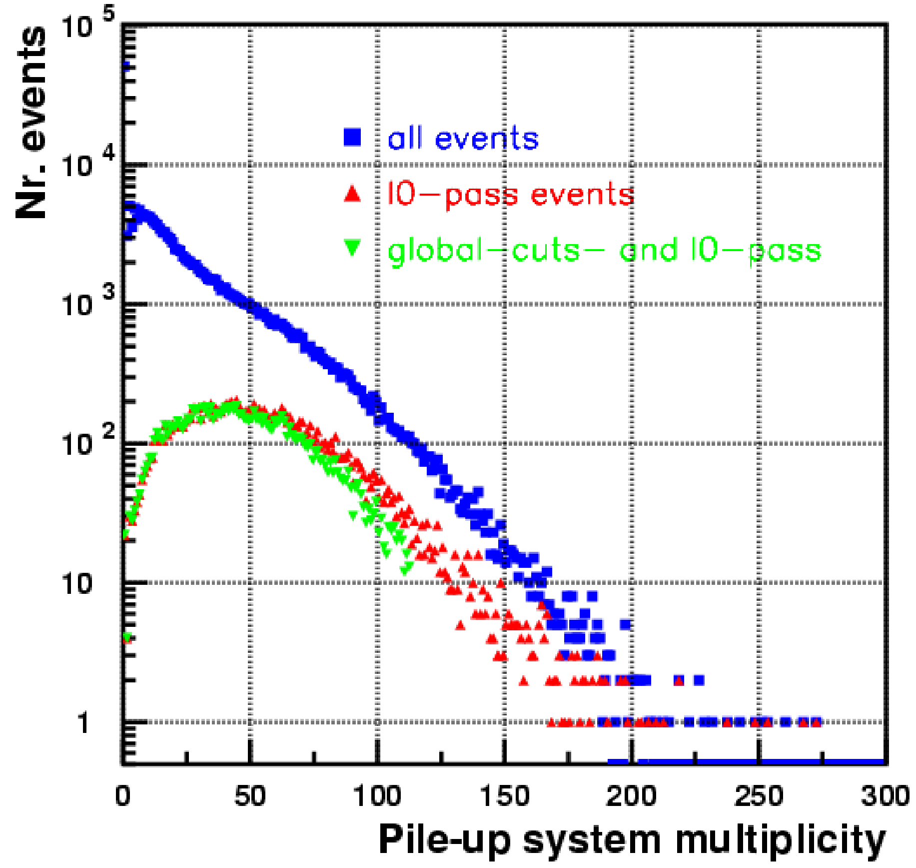


Implications for L1 & HLT (II)

TDR L0DU

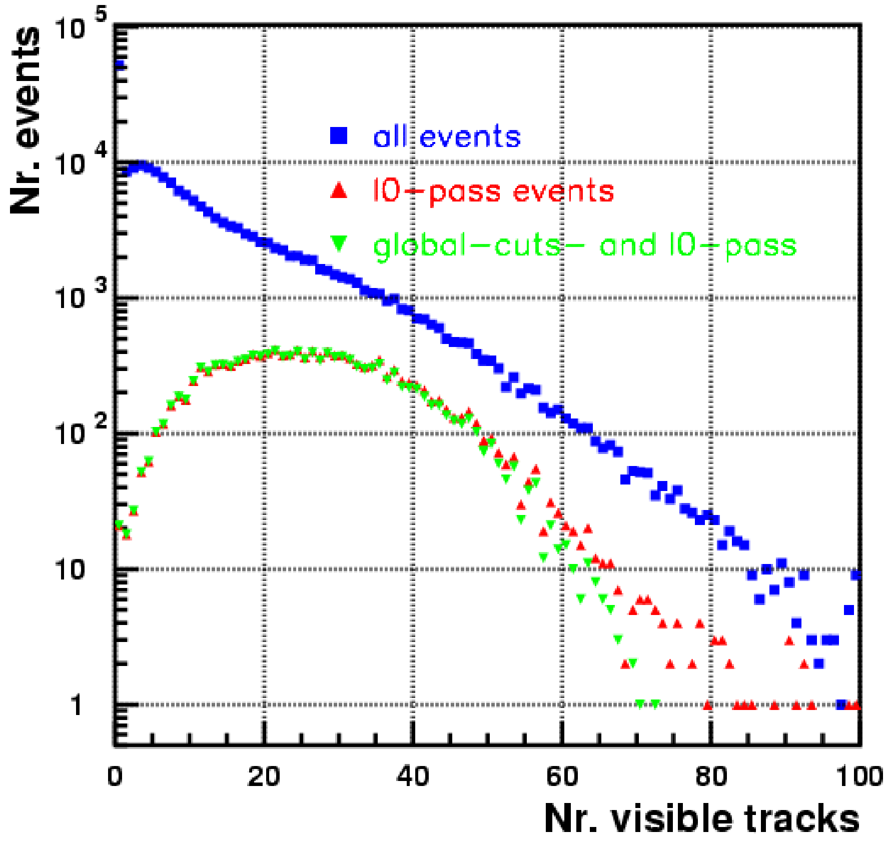


2- threshold real di-elec. trigger

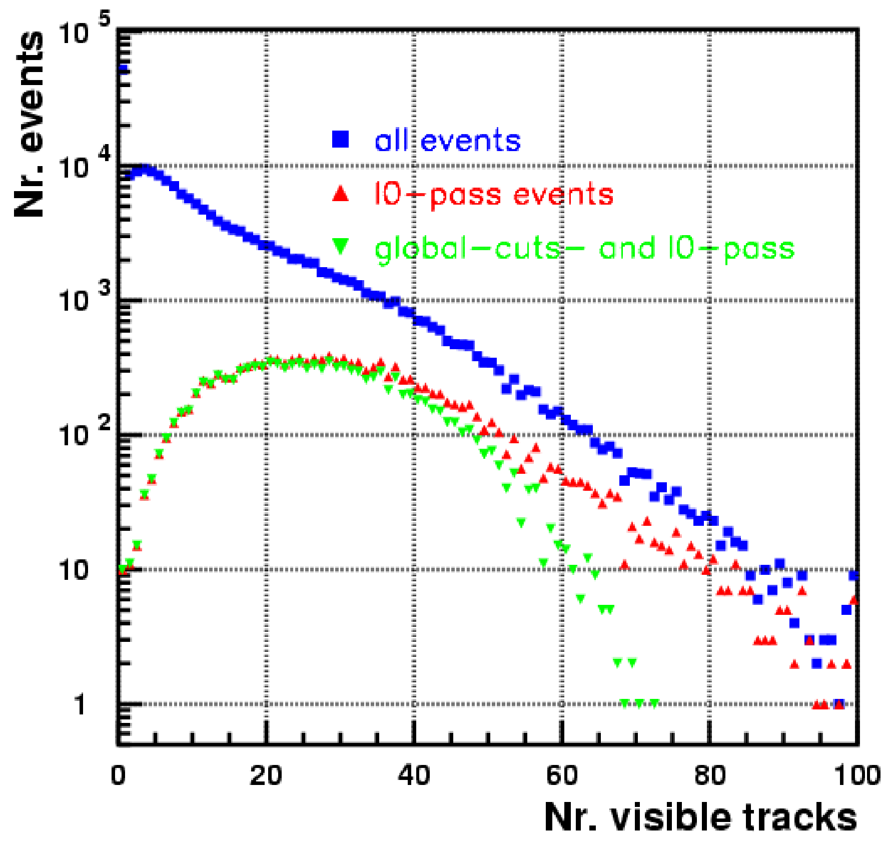


Implications for L1 & HLT (III)

TDR L0DU



2- threshold real di-elec. trigger



Conclusions

- the second highest E_T L0-electron candidate contains useful information on J/Ψ -> ee decays
  -> exploitable feature at L0

- possible improvement w.r.t TDR L0 for electromagnetic channels
  while keeping all the other efficiencies (basically) unchanged

- a di-electron trigger significantly improves the L0 performance for electromagnetic channels
  and in particular enhances the efficiency on b -> J/Ψ + X -> (ee) + X decays

BUT

- info on 2nd highest-E_T electron @ L0 needs hardware changes in selection crate
- alternative scenarios allow an "almost equivalent" (~15-20% less) performance to be achieved
  that have the advantage of not requiring any changes to the L0 hardware design

- double-threshold triggers (hadron/electrom./muons) could/should be further investigated
  to address other channels
  - separate events between vetoed/non-vetoed by global event cuts

- Implications for L1 and HLT need to be studied …

- Full details of these studies in the note LHCb-2004-002