A Di-electron trigger at Level-0

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I. Motivations

II. L0 electron candidates

III. A di-electron trigger at L0 and alternatives

- L0DU algorithm with a di-electron trigger a la di-muon trigger
- An alternative: an "overriding" electron trigger
- Another alternative: double-threshold electron trigger

IV. L0 performance with the various scenarios

V. Conclusions and final remarks

Motivations

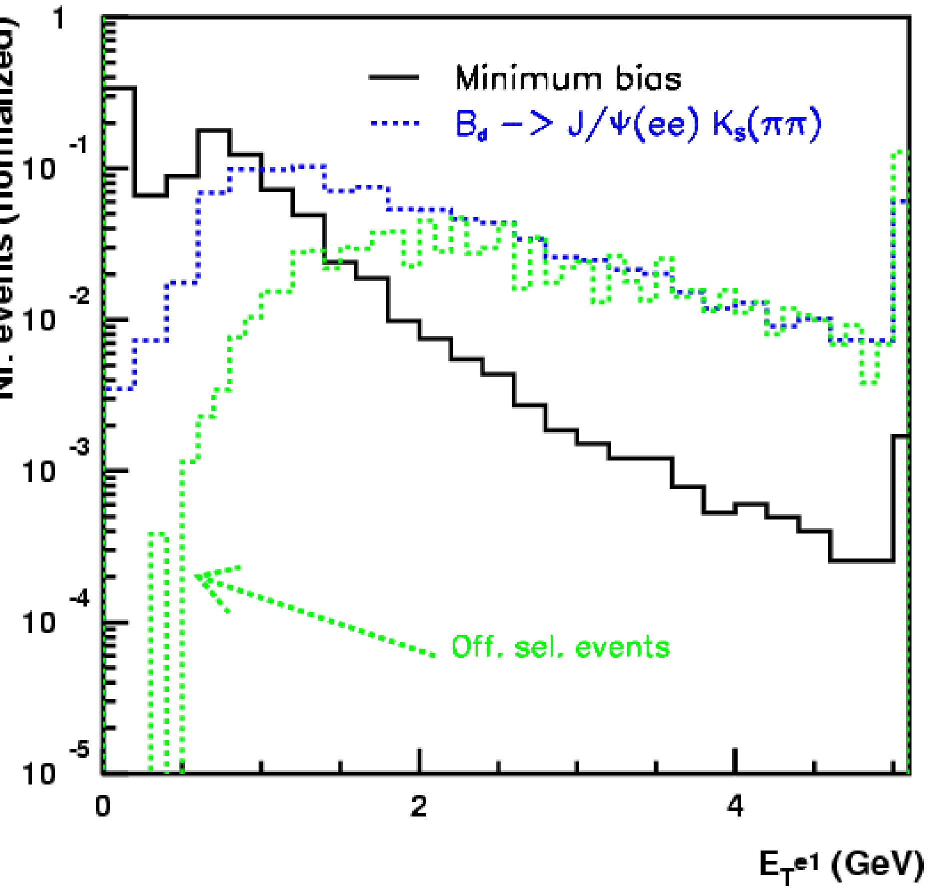
- Di-muon versus di-electron trigger:
  - di-muon trigger mainly focused on identifying J/Ψ -> $\mu\mu$ decays from a b-hadron

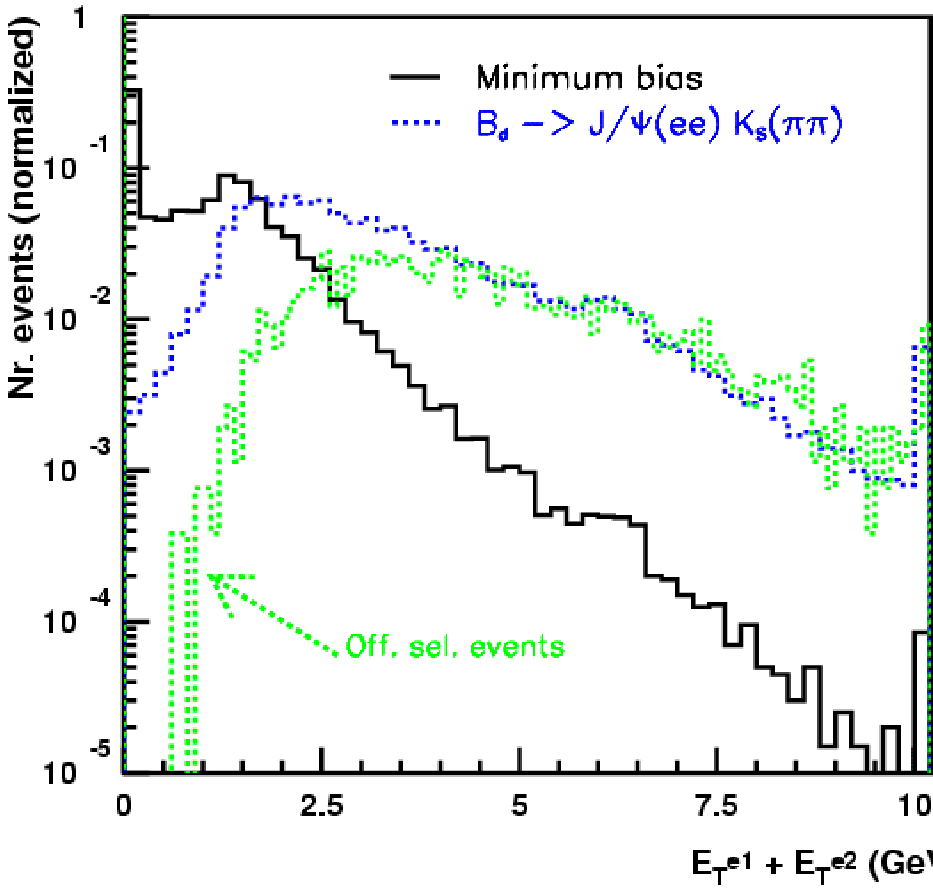
    -> is a di-electron trigger for J/Ψ -> ee decays as useful?
- Usage of di-electrons at L1 have been investigated:
  - refer to the note LHCb-2003-096 of Aras Papadelis (summer student)

    -> can the situation be improved by improving the input to L1?
- Investigations of "extreme" L0DU algorithms:
  - all "possible" scenarios of L0DU algorithms should be assessed and studied

(Di-)electron Distributions

(here $E_T^{e2}=0$ is possible)





Origin of L0 Electrons

Study with the B_d -> J/Ψ(ee) K_s channel

- probabilities for the highest (L0-elec1), second-highest (L0-elec2) and third-highest (L0-elec3) E_T L0-electron candidate to come from the signal-B

	All events	L0-pass	Offline selected	L0-pass & offline selected
L0-elec1 from signal B	52 %	62	86	89
L0-elec2 from signal B	28	34	60	60
L0-elec3 from signal B	16	17	27	27
L0-elec1&2 from signal B	19	25	52	53
L0-elec1&3 from signal B	10	11	21	22

TDR L0DU

-> in ~ 50 % of the L0-pass offline selected events the 2 highest E_T electron candidates come from the signal B

L0DU with Di-electron Trigger

L0DU Algorithm with a di-electron trigger

- L0DU algorithm as in the Trigger TDR

  +

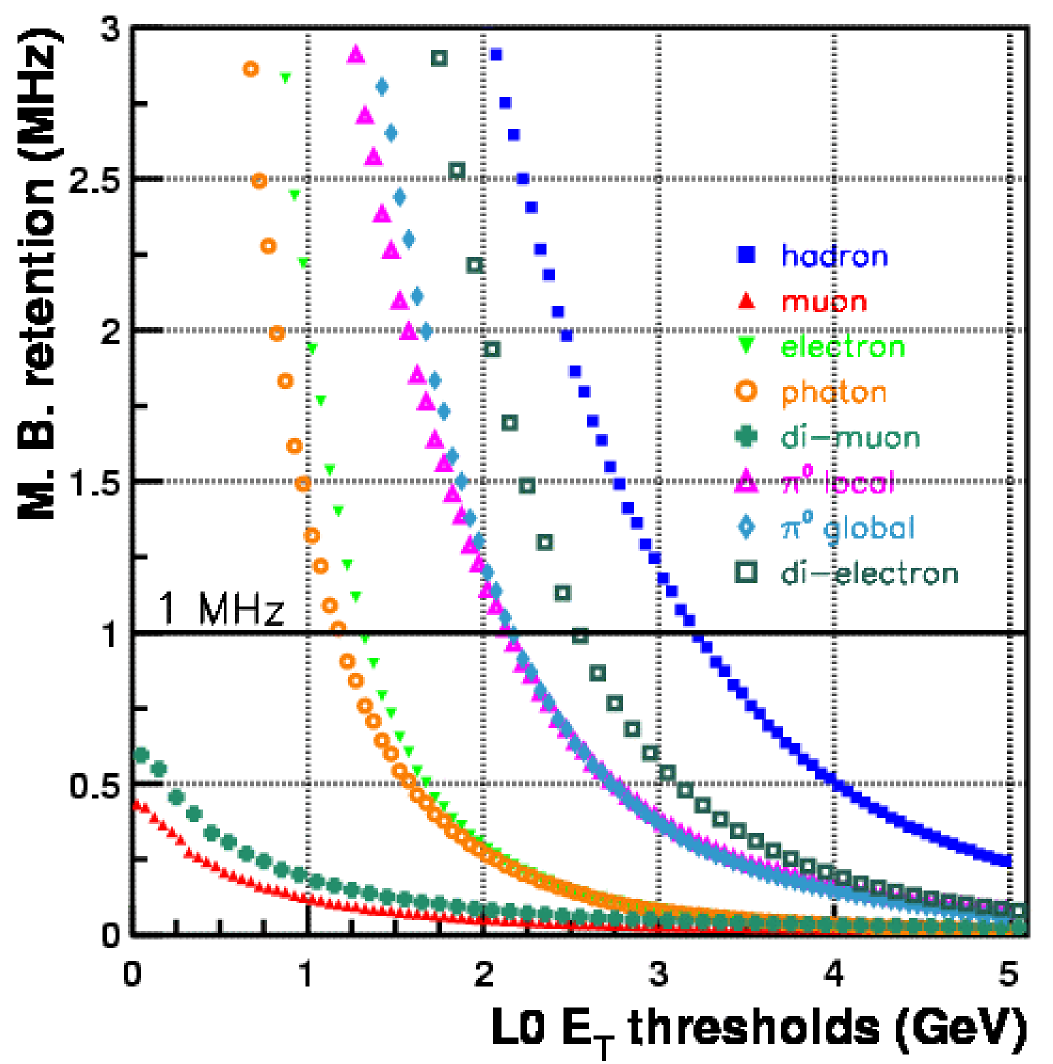
- di-electron trigger “à la di-muon trigger”

  ($E_T^{ee} = E_T^{e1} + E_T^{e2}$ 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

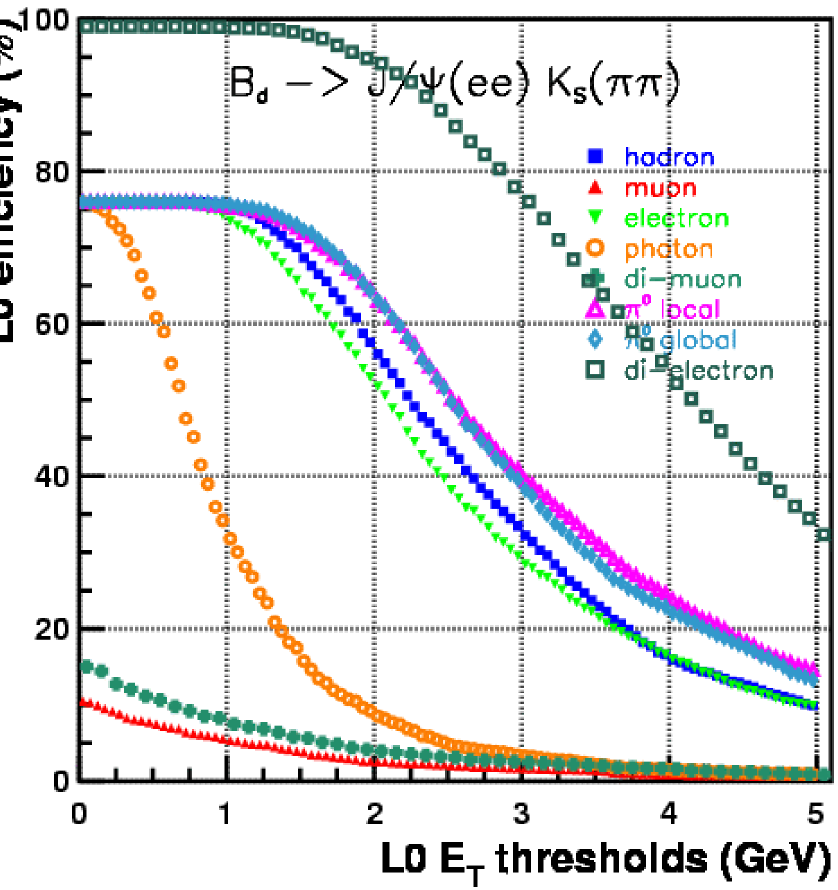
L0 E_t Distributions (I)

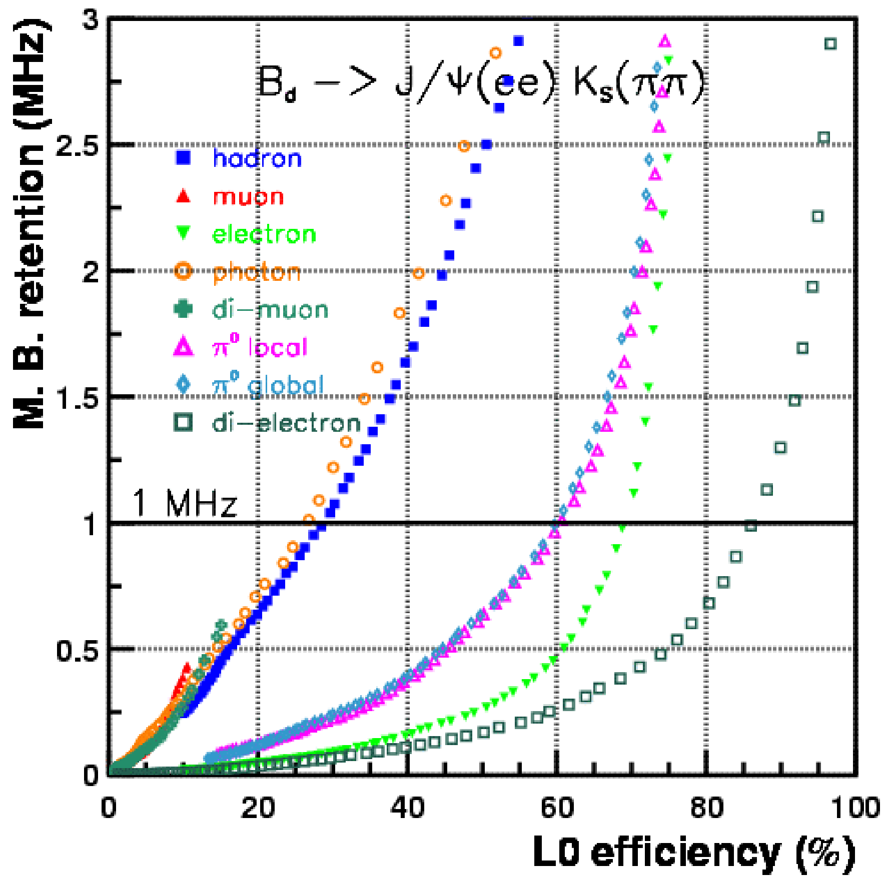
✓ each curve corresponds to considering separately the combination

L0 trigger = sub-trigger + pile-up veto & multiplicity Cuts

-> it shows how much one could in principle obtain independently from each trigger

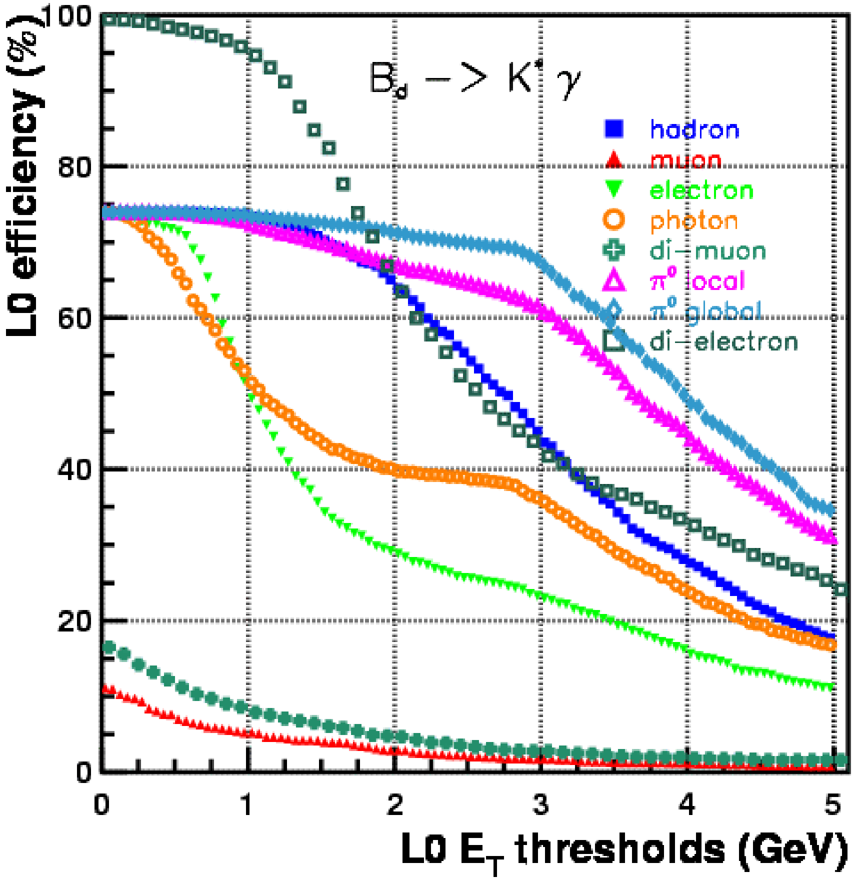
x. efficiency obtainable inclusively by each trigger!

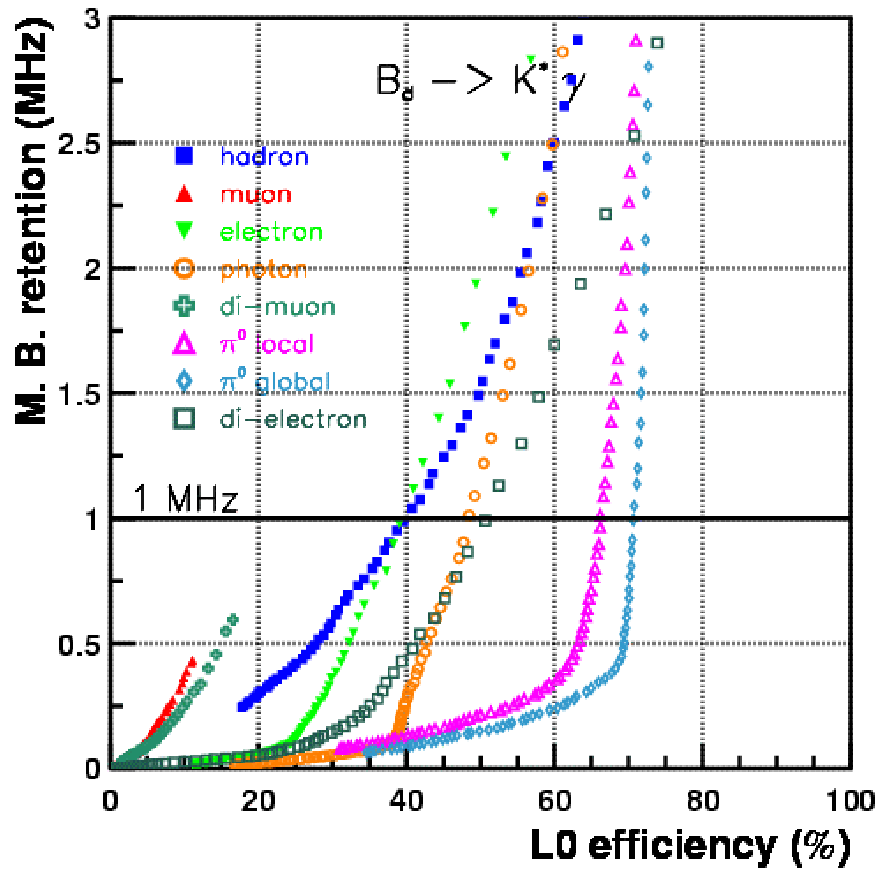




L0 E_t Distributions (II)

Max. efficiency obtainable inclusively by each trigger!





L0 optimization with Di-electron Trigger (I)

1. Optimizing each channel separately on the L0 efficiency ...

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

Max. eff. obtained with separate optimization of each channel

L0 optimization with Di-electron Trigger (II)

2. 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 -> J/Ψ(ee) K_s	48.3	70.8	**+ 46.6**
B_d -> K* γ	72.9	80.2	**+ 10.0**
B_d -> J/Ψ(μμ) K_s	89.3	89.6	+ 0.3
B_s -> J/Ψ(μμ) Φ(KK)	89.7	89.8	+ 0.1
B_d -> π π	53.6	56.5	+ 5.4
B_s -> D_s K	47.2	47.4	+ 0.4

L0 as in the TDR

"New L0DU"

L0 optimization with Di-electron Trigger (III)

- 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 Di-electron Trigger (IV)

Inclusive efficiencies with new L0 trigger and bandwidth optimization

Channels	HCAL	ECAL	Muons
B_d -> $J/\Psi(ee)$ K_s	18.5	**64.9**	7.0
B_d -> K^* γ	30.0	**75.2**	7.5
B_d -> $J/\Psi(\mu\mu)$ K_s	16.1	13.0	**87.0**
B_s -> $J/\Psi(\mu\mu)$ $\Phi(KK)$	17.5	12.7	**87.3**
B_d -> $\pi\pi$	**44.7**	19.8	6.4
B_s -> D_s K	**35.3**	16.2	8.5
Bandwidth on minimum bias events (kHz)	593	399	161

~ 80 / 300 kHz for e / ee triggers ↗ (ECAL)

Effectively a "transfer" in bandwidth of ~ 100kHz hadron -> electromagnetic triggers w.r.t TDR

L0 optimization with “overriding Electron Trigger” (I)

- What about an alternative?

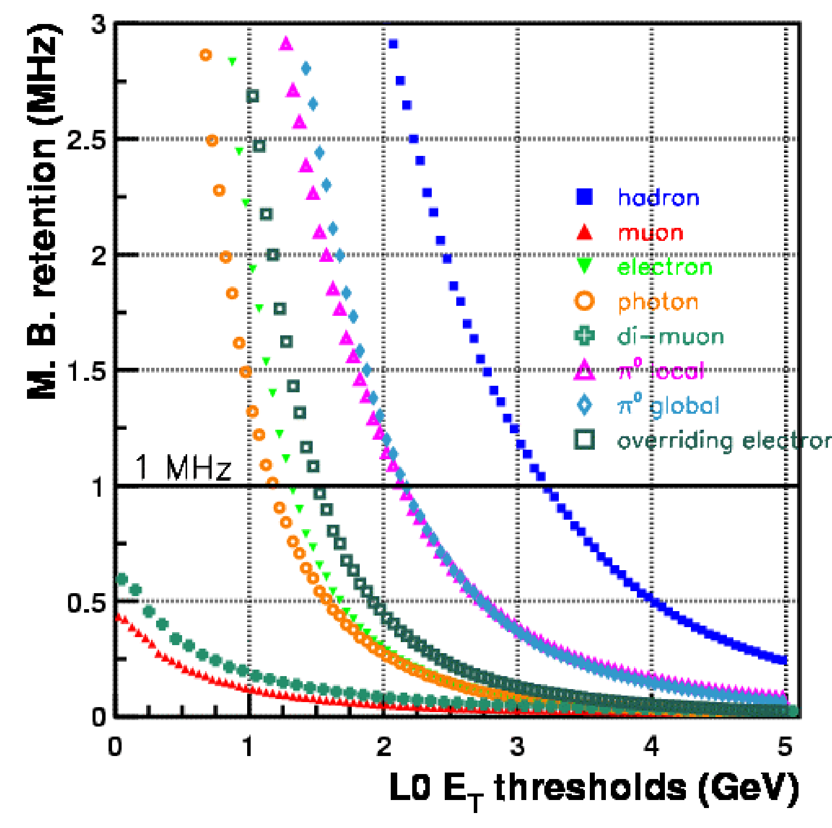
  simply override the veto and multiplicity cuts with the electron trigger

  - all steps were redone …

    … and after L0 optimization …

- performance for hadronic and muon channels as with the di-electron trigger
- performance for B_d -> $K^* \gamma$ roughly the same (marginally better)
- performance for B_d -> $J/\Psi(ee)$ 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	"Optimal trigger" L0 eff. (%)	Rel. Gain in eff. w.r.t TDR (%)
B_d -> $J/\Psi(ee)$ K_s	48.3	66.3	**+ 37.3**
B_d -> K^* γ	72.9	81.8	**+ 12.2**
B_d -> $J/\Psi(\mu\mu)$ K_s	89.3	89.6	+ 0.3
B_s -> $J/\Psi(\mu\mu)$ $\Phi(KK)$	89.7	89.8	+ 0.1
B_d -> $\pi\,\pi$	53.6	56.3	+ 5.0
B_s -> 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 as performant as the overriding electron trigger (differences of ~ 1%)

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)	3.8	1.1	2.2 / 3.2	2.8	1.3	4.9	3.7

& 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)	593	418	161

~ 230 / 110 kHz for e-triggers with low/high threshold

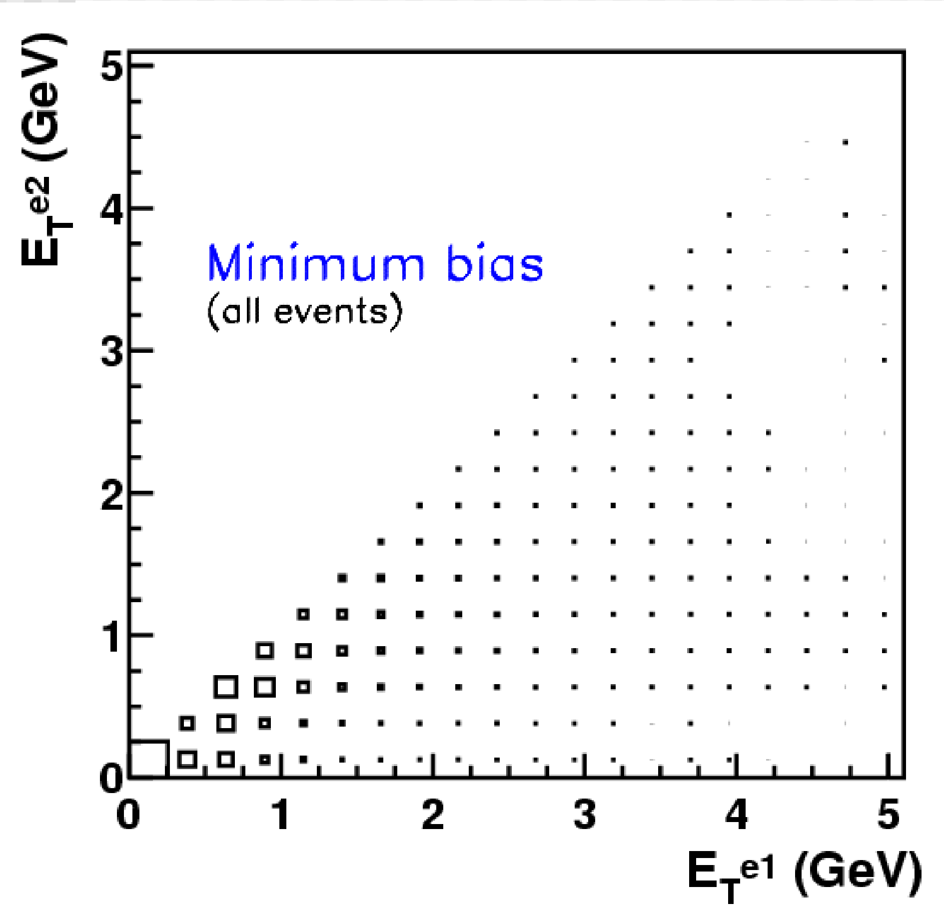
Conclusions and Final Remarks (I)

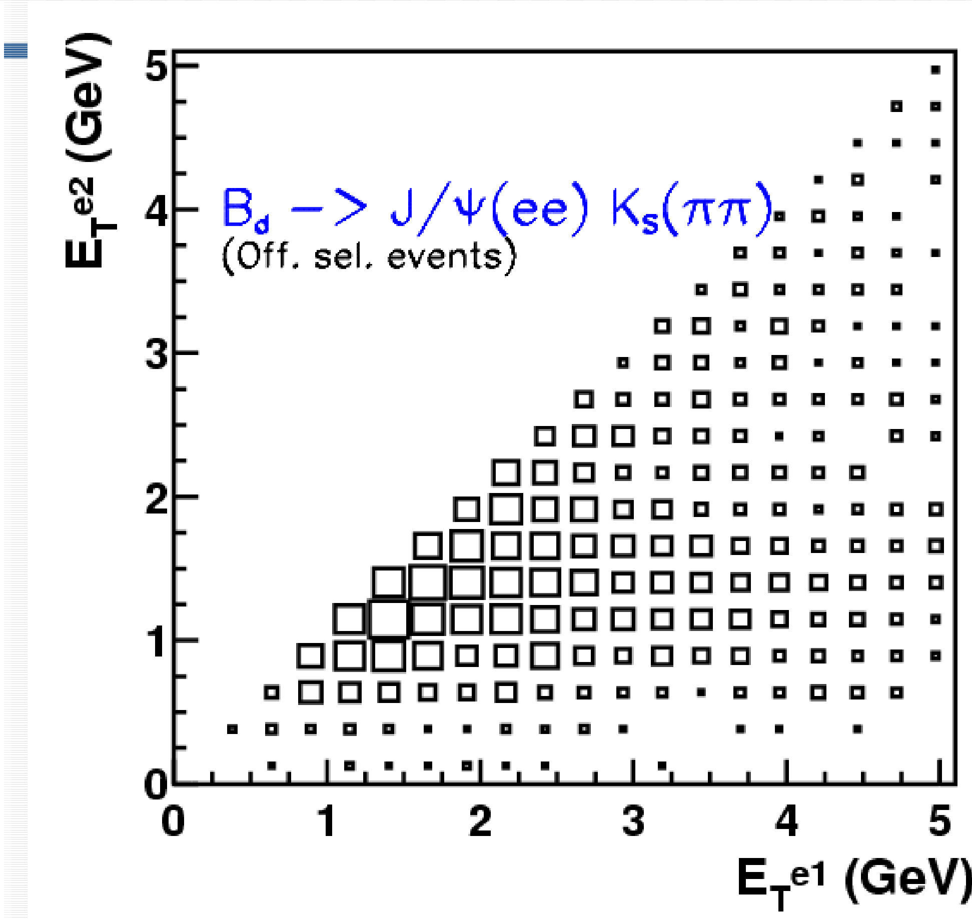
- the second highest E_T L0-electron candidate contains useful information on J/Ψ -> ee decays
  -> exploitable feature at L0
- possible improvement w.r.t TDR L0 for electromagnetic channels
  while keeping all the other efficiencies (basically) unchanged
- a di-electron trigger significantly improves 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" (~10% less) performance to be achieved
  that have the advantage of not requiring any changes to the L0 hardware design

Conclusions and Final Remarks (II)





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

Conclusions and Final Remarks (III)

- hint that a true di-electron trigger – E_T^{e1} , $E_T^{e2} > 0$ – might help, closely following the offline selection …
  -> study under way and close to conclusion

- 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?

- (further) details of these studies in the (being finalised) note LHCb-2004-002