Importance of M1 for the L0 and L1 Triggers

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Setting the scene

- motivations
- emulation of L0 without the M1 station

Studies

- L0-muon comparisons with/without M1 (O. Leroy)
  - "L0-Muon trigger without M1: status with DC04 data", Trigger meeting 24th Jan. 2005
- L0 bandwidth division without M1 (E. Rodrigues)
  - "Overall L0 optimization without M1", Trigger meeting 7th Feb. 2005
- luminosity issues related to M1 (H. Dijkstra)
  - "M1 and luminosity", Trigger meeting 24th Jan. 2005
  - "M1 and luminosity", T-Rec meeting 14th Feb. 2005
- L1 without M1 (L. de Paula)
  - "L1 without M1 – a first look", T-Rec meeting 28th Feb. 2005

Setting the scene

Motivations

- readiness of M1 for day one might not be granted
  - what are the consequences for the trigger if we do not have M1 from day 1?
  - what is a possible & reasonable scenario without M1?
  - can we in fact have an efficient (muon) trigger system without M1?

but

  - M1 is used by the LO-muon trigger to compute the P_T of muon candidates
  - it is also used at L1

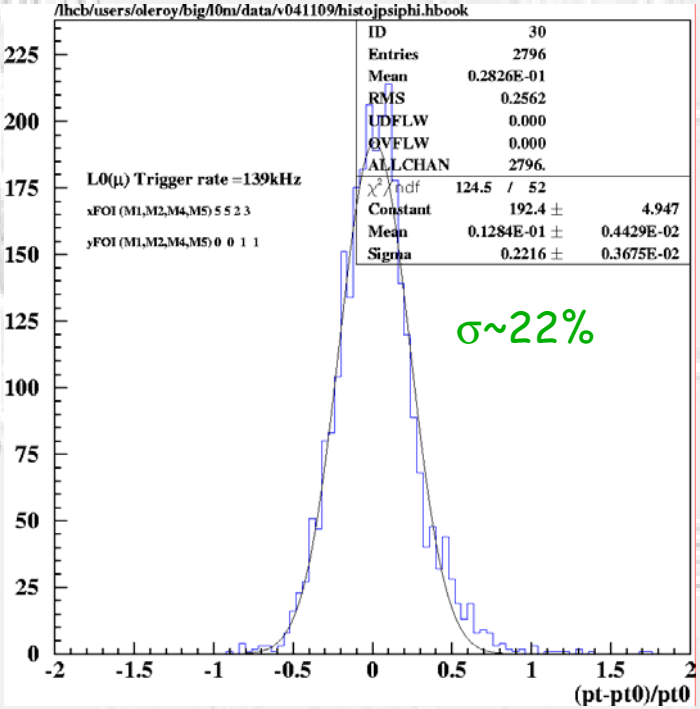
Emulation of L0 without M1

- no request of a M1 hit to select a muon candidate
- P_T computation with M2 & M3 instead of M1 & M2

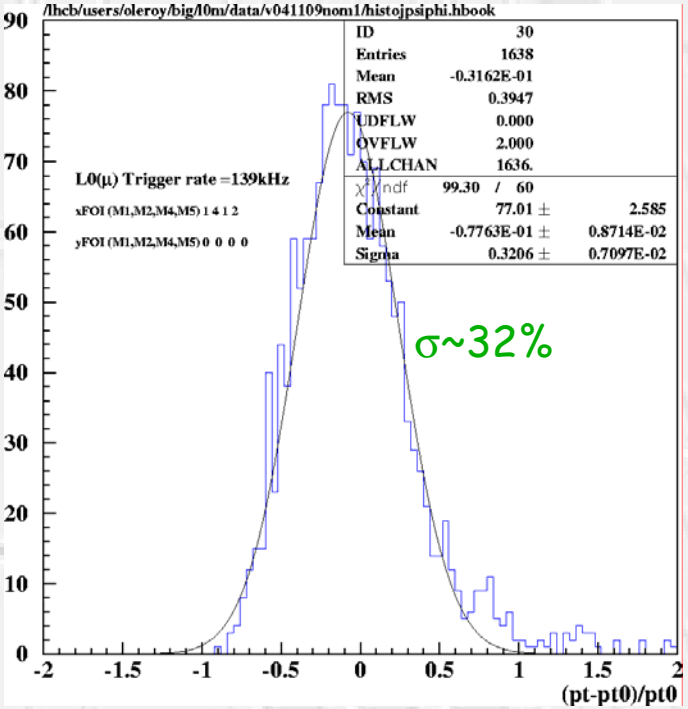
L0–Muon studies without M1 (1/3)

P_T resolution

With M1



Without M1

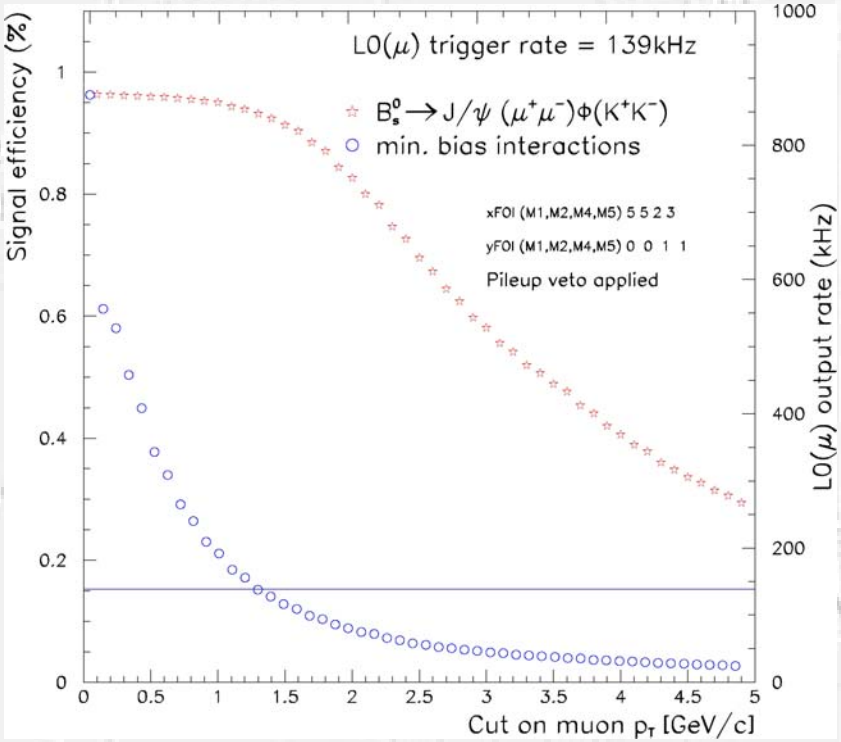


- P_T resolution degraded from 22 to ~32%
  (without M1 le level arm is reduced to compute the P_T)

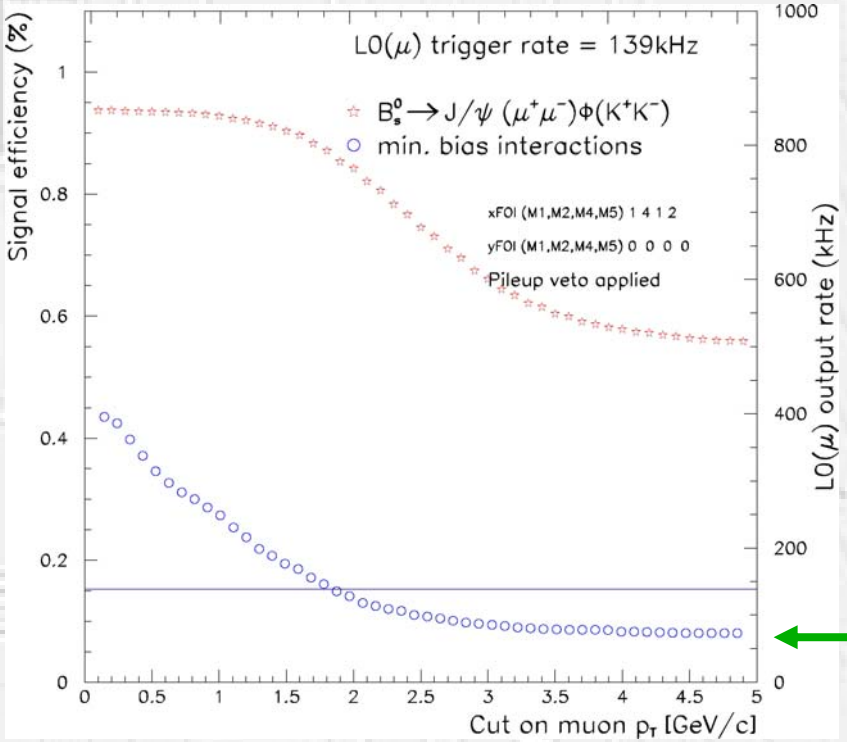
L0–Muon studies without M1 (2/3)

Signal efficiency versus p_T

With M1



Without M1



No M1 ⇒ P_T cut ↗ to keep the same M. B. output rate

⇒ signal efficiency degraded

⇒ M. B. rate cannot be set below ~70kHz (hits aligned in M2 and M3)

L0–Muon studies without M1 (3/3)

Single-μ L0 output rate (kHz)	With M1		Without M1		Relative $B_s \to J/\psi\phi$ efficiency loss (%)
	pT cut (GeV/c)	$B_s \to J/\psi\phi$ efficiency (%)	pT cut (GeV/c)	$B_s \to J/\psi\phi$ efficiency (%)	
80	1.45	85.6±0.4	2.56	66.0±2.9	-23
139 (TDR)	1.30	93.1±0.2	1.87	85.8±1.1	-8
220	1.04	96.2±0.2	1.32	93.0±1.0	-3

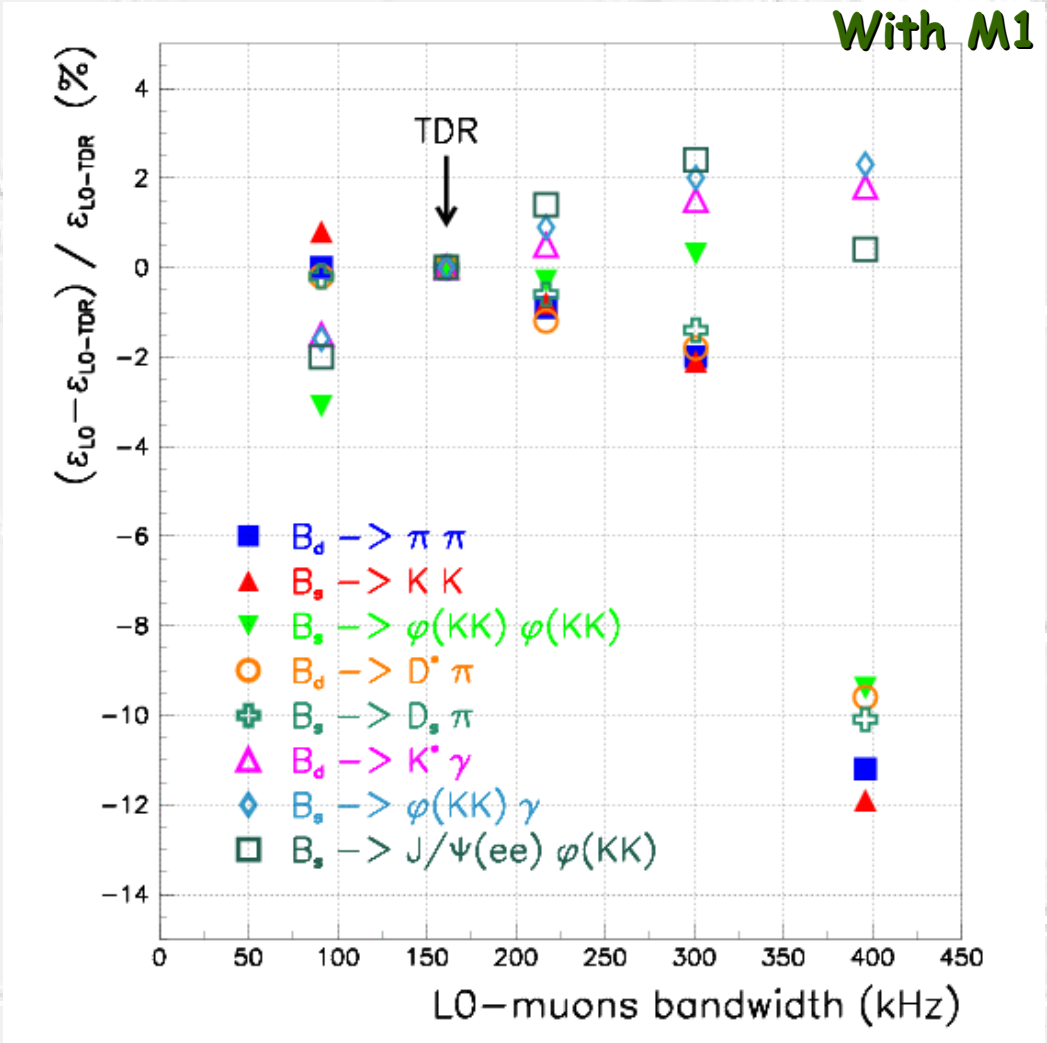
- ✓ **No M1 ⇒ drop of efficiency between 3 and 23% depending on the M. B. output rate**
- ✓ **Possibility to have the same $B_s \to J/\psi\phi$ efficiency (93%) if single-μ output rate increased from 140 to 220kHz**

… but what is the loss for hadronic channels?

- Global cuts applied (pile-up system, SPD, ΣET>5GeV)
- Di-muon and calorimeter sub-triggers ignored
- Fields of interest optimized in each case

Dependence of the L0 performance on the muon bandwidth

Losses in efficiency wrt TDR values:



* losses less than 4% up to 300 kHz

* losses only become significant if muons given a very large share of the total BW

* Electromagnetic channels less affected by the h/μ bandwidth division

Note:
- no optimizations done
- each setting is a change in the h/μ BW
- total HCAL+ECAL+MUONS BW = 1 MHz
- at each BW the settings are the same for all channels

Single-channel optimization without M1

Samples

- set of (LHCb) benchmark channels
  - "representatives" of hadronic / electromagnetic / muon channels

Outcome

- single-channel optimizations with or without M1 give roughly the same L0-max efficiencies
  - this means are roughly as at the time of the TDR
  - slightly worse for muon channels

(DC'04 data)

Ex.:

Channels	L0 eff. Max. (%) With M1	L0 eff. Max. (%) without M1
B_d -> $\pi\pi$	55.0 ± 0.9	54.1 ± 0.9
B_d -> $J/\Psi(\mu\mu)$ K_s	95.4 ± 0.4	94.5 ± 0.4
B_s -> $\phi\gamma$	76.0 ± 1.6	76.2 ± 1.3

Overall L0 optimization without M1 (1/2)

Optimized cuts:

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=======================
Optimized L0 cuts (GeV)
=======================
Hadron         =   3.60
Electron       =   2.60
Photon         =   2.70
Pi0 Local      =   4.50
Pi0 Global     =   3.70
Muon           =   1.30
Di-muon        =   1.40
Sum Et         =   5.00
VetoSumPeak2   =   3.00
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A re-optimization of the L0 bandwidth is successful !

Channels	L0 eff. (%) With M1	L0 eff. (%) without M1
B_d -> $\pi\pi$	53.1 ± 0.9	52.5 ± 0.9
B_d -> $K\pi$	54.3 ± 0.8	53.8 ± 0.8
B_s -> KK	53.3 ± 0.8	52.9 ± 0.8
B_d -> $D^*\pi$	51.0 ± 1.0	50.5 ± 1.2
B_d -> $J/\Psi(\mu\mu)$ K_s	93.5 ± 0.5	93.2 ± 0.5
B_d -> $K^*\mu\mu$	95.5 ± 0.6	95.2 ± 0.6
B_s -> $\mu\mu$	98.1 ± 0.3	98.3 ± 0.3
B_s -> $\phi\gamma$	72.1 ± 1.7	72.1 ± 1.4

(DC'04 data)

Overall L0 optimization without M1 (2/2)

Inclusive efficiencies for "no M1" L0 trigger and bandwidth optimization

Channels	HCAL	ECAL	Muons
B_d -> $\pi\pi$	44.4 ± 0.9	12.0 ± 0.6	9.3 ± 0.5
B_s -> K K	44.5 ± 0.8	11.5 ± 0.5	10.6 ± 0.5
B_d -> $J/\Psi(\mu\mu)$ K_s	17.6 ± 0.7	6.5 ± 0.5	92.1 ± 0.5
B_d -> $K^*\mu\mu$	19.0 ± 1.1	7.6 ± 0.8	94.5 ± 0.6
B_s -> $\phi\gamma$	30.7 ± 1.5	66.3 ± 1.5	11.7 ± 1.0

(DC'04 data)

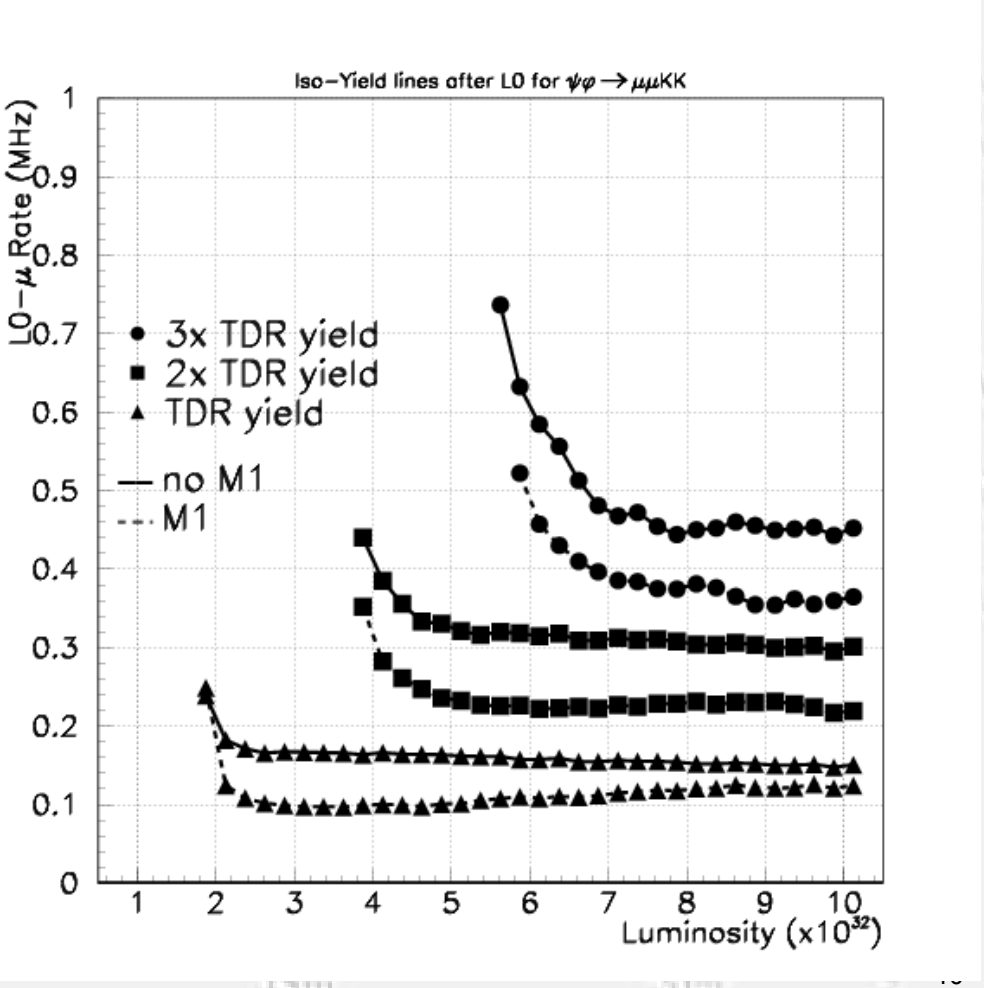
Bandwidth on minimum bias events (kHz)	608	231	312

was ~ 700 kHz in TDR

Almost doubles compared to TDR

Luminosity dependence

- **Study L0-muon rate as a function of the luminosity**
- **For a reasonable P_T-μ cut ~1.2 GeV, close to 5.5 x 10^{32} $cm^{-2}s^{-1}$ all the bandwidth is given to the muon trigger without M1 whereas the share is ~500kHz with M1**



- at constant muon bandwidth share
  "no M1" configuration requires
  ~ 0.5 x 10^{32} higher luminosity

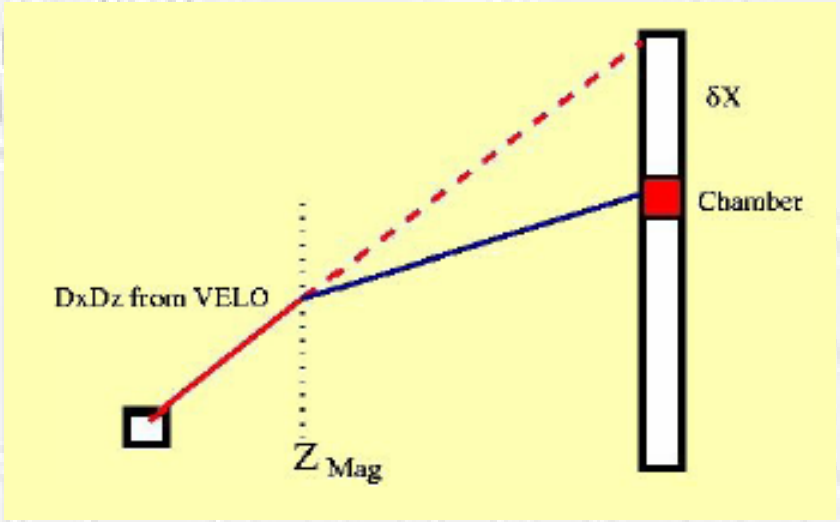
- at constant luminosity "no M1" configuration requires
  ~100 kHz more bandwidth

-> difference with/without M1 not very
lunimosity dependent

L1 without M1 (1/4)

Samples (DC'04 data)

- B_s -> $J/\Psi(\mu\mu)\,\phi$
- B -> $\pi\,\pi$
- minimum bias



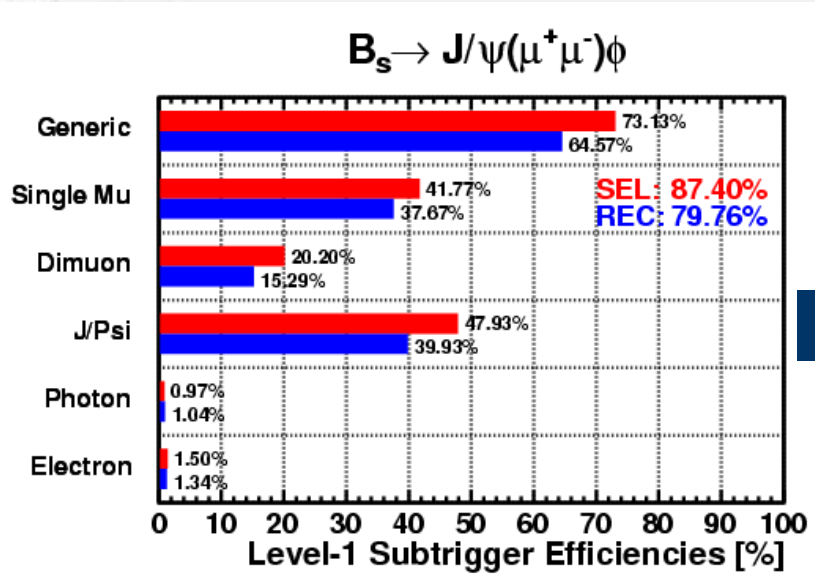
L1 default settings

- default parameters (i.e. with M1) provided by Th. Schietinger

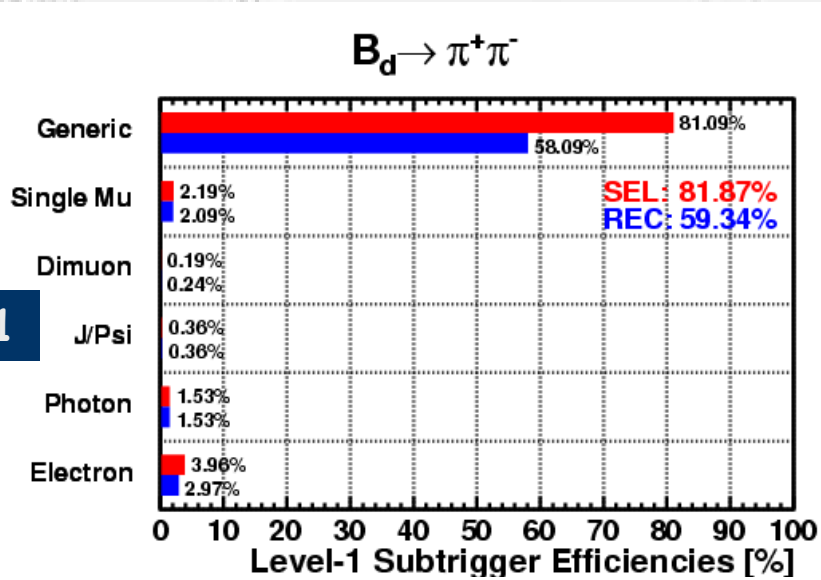
L1 trigger without M1

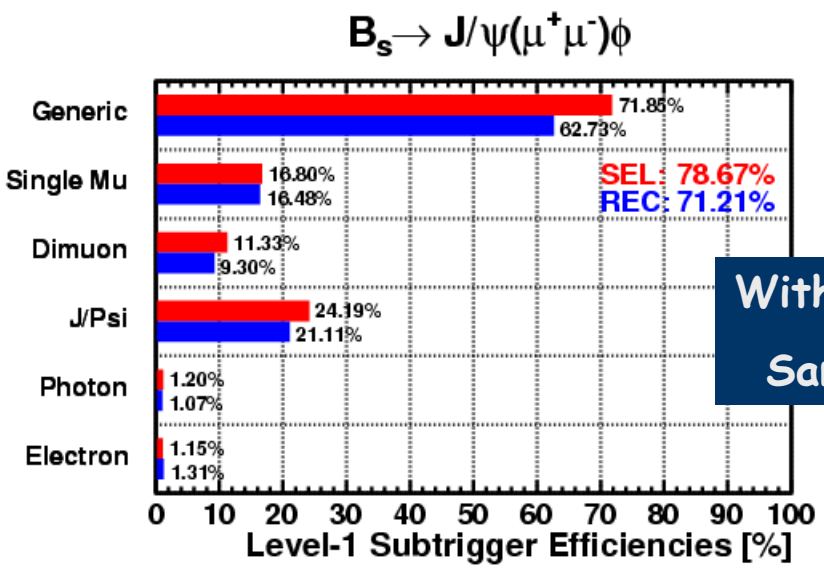
- loss in momentum determinations due to « no M1 »
  - -> substantial loss in efficiency for muon sub-triggers
  - -> need to open search windows for matching of L0MuonCandidates to VELO tracks
  - -> change in χ^2 for the matching

L1 without M1 (2/4)

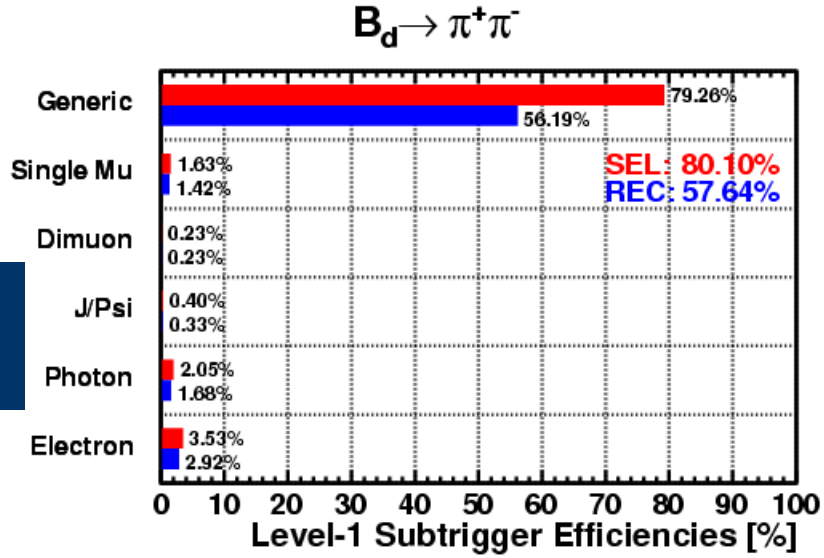


With M1





Without M1
Same BW



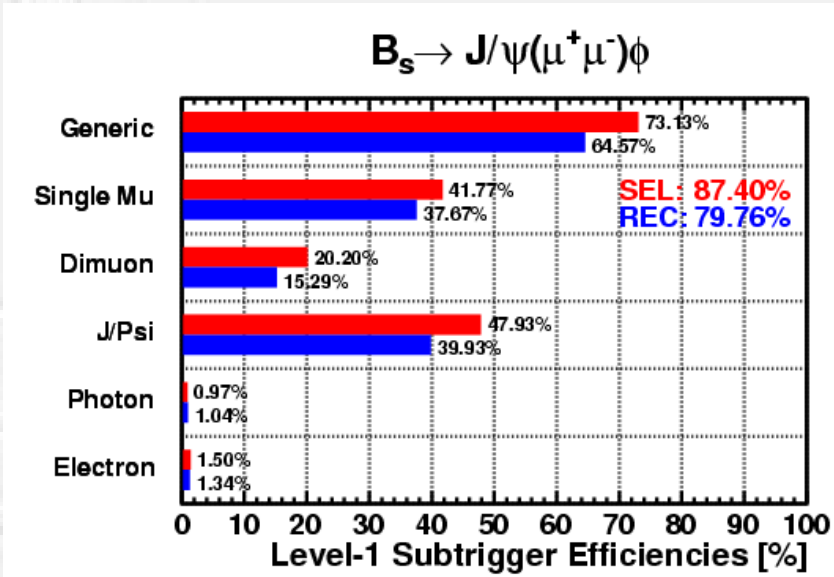
L1 without M1 (3/4)

- **To recuperate the single-μ efficiency (42%)**
  -> need to increase its bandwidth from 8.8 to 18 kHz
- **For the di-muon sub-trigger the efficiency drops from 26 to 18%**
  even if one doubles its bandwidth (from 1.5 to 3 kHz)
- **The J/Ψ sub-trigger efficiency drops from 50 to 30% going from 3 to 4.5 kHz**

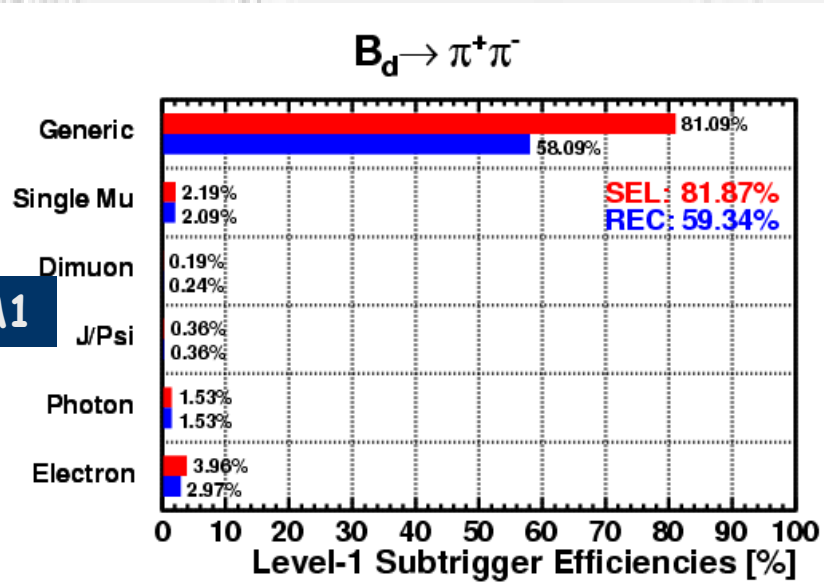
⇒ set a possible operation point = "tuned BW":

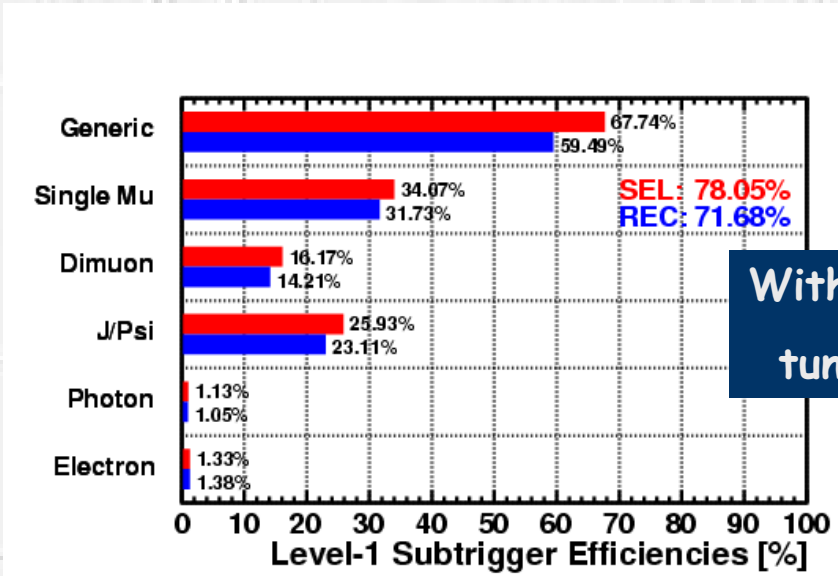
	BW with M1	BW without M1 & tuning
generic	29.4	25.2
single-μ	8.8	15.1
μμ	1.5	3.6
J/Ψ	3.1	4.4
electron	3.7	3.7
Photon	4.1	4.0

L1 without M1 (4/4)

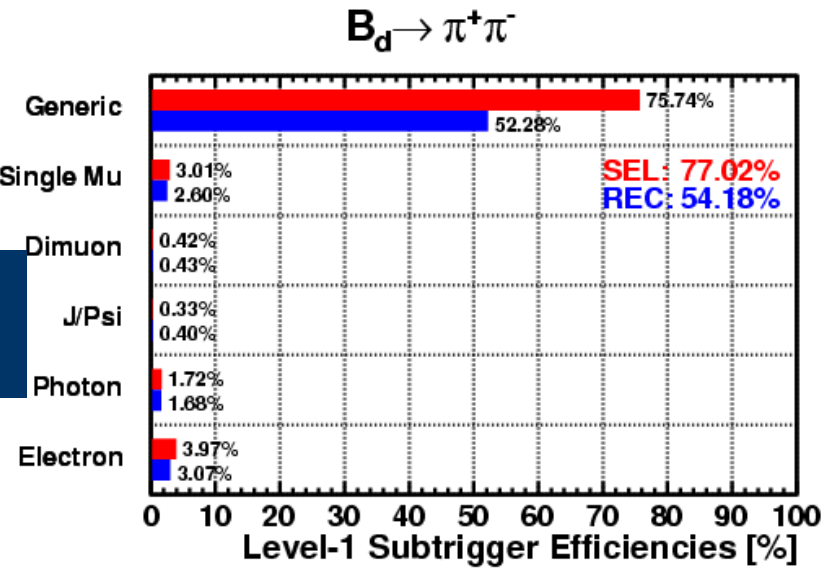


With M1





Without M1 tuned BW



Conclusions (1/2)

For Level-0

- **stagging of the M1 station is not critical !**
  - without M1 the B_s -> $J/\Psi(\mu\mu)\phi$ efficiency decreases by up to ~20% depending on the running conditions (muon bandwidth)
  - losses in efficiency for muon channels can be recovered with a larger share of the L0 bandwidth being taken by the muon triggers
  - optimization of the L0 bandwidth division also prevents the hadronic and electromagnetic channels from losses in efficiency
    -> it is possible to find an operating point giving similar results as with M1
  - these conclusions are rather independent on the luminosity

For Level-1

- **losses are somewhat larger than at L0**
  - losses for muon channels ~ 10%
  - losses for hadronic channels ~6% (more checks with other channels needed)
    … can this be recovered using the T stations at L1 … ? Very likely …

… do we now want this ?