Trigger in Muon TDR

Substantial amount of space in the Muon TDR is devoted to the Muon Trigger. This is because:

- ***Triggering is one of the most important tasks of the Muon System.***
- ***It drives many requirements on the detectors.***
- ***It is impossible to understand many features of the Muon System without knowing the trigger algorithms.***

One cannot simply refer to the TriDAS TDR, because it will come ~2 years today.

Therefore the Muon TDR should contain the following information concerning the trigger:

- ***physics goals and expected performance for benchmark processes***
- ***overview of the algorithms***
- ***those technical implementation aspects which are known today and have an impact on the detector design***

TriDAS TDR will contain more detailed description of the algorithms and all technical details of their implementation.

Structure of Chapter 6

Physics motivation

$\Downarrow$

Requirements

$\Downarrow$

Algorithms

$\Downarrow$

Implementation

$\Downarrow$

Simulated performance

Physics motivation

Particles to be studies at LHC

	light	medium	heavy
mass	**<< 100 GeV**	**~ 100 GeV**	**>> 100 GeV**
particle	**b-quark**	**t, W, Z light higgs**	**heavy h, Z', W' SUSY part.**
luminosity	$10^{33}cm^{-2}s^{-1}$	10^{33}-10^{34}	$10^{34}cm^{-2}s^{-1}$

Their decay products can be registered by LV1 as the following objects:

- **muon**
- **electron/photon** — not distinguishable for LV1
- **jet**
- **total deposited energy** ΣE_t
- **missing transverse energy** $E_{t miss}$

Most of the interesting physics processes produce at least 2 trigger objects. Only very few channels require per se single object trigger:

- h,A,H $\rightarrow \tau\tau \rightarrow l^{\pm}$ τ-jet X
- $B^0{}_d \rightarrow \pi\pi$ with $b \rightarrow \mu_{tag}$ or $b \rightarrow \mu_{tag}$
- $B^0{}_S \rightarrow D^{\pm}{}_S$, $D^{\pm}{}_S \rightarrow \phi\pi^{\pm}$, $\phi \rightarrow K^+K^-$, $b \rightarrow \mu_{tag}$
- inclusive W

Multi-object triggers are of primary importance.

Different thresholds can be optimal for different combination of objects.

Muon and Calo. Trigger should <u>measure</u> p_t or E_t.

Cuts should be applied by Global Trigger only.

Physics $\rightarrow$ requirements

Medium and heavy particles can be effectively recognised applying a logical OR of the following conditions:

Condition	Background	Rate at 10^{34}
1γ of E_t<60 GeV	$\pi^0 \rightarrow \gamma\gamma$	10 Hz
2γ of E_t<15 GeV	$\pi^0 \rightarrow \gamma\gamma$	10 Hz
$1l^{\pm}$ of p_t<15 GeV	$W \rightarrow l^{\pm}$, jet $\rightarrow l^{\pm}$	10 Hz
$2l^{\pm}$ of p_t<15 GeV	$Z^0 \rightarrow l^+l^-$	20 Hz
E_t^{miss} > 150 GeV	QCD jets	10 Hz

The resulting rate is ~100 Hz, which sets the requirement for the mass storage (tape) capacity.

Physics $\rightarrow$ requirements

<u>LV1 threshold:</u>

maximal ~ 100 GeV — above it, efficiency for heavy objects is degraded

minimal ~ 20 GeV — below it, efficiency for heavy and medium particles cannot be improved; the rate is anyway dominated by π,K and c-,b-quark decays.

Expected LV1 thresholds [GeV]

lumi	e/γ	2 e/γ	e_b	2 e_b	μ	2 μ
10^{33}	15-40	10	10	5	10	5
10^{34}	20-100	15	—	—	20-100	10

For these thresholds the rate of each object is ~1 kHz.

Adding all channels together and leaving some room for an instrumental background one can expect the total LV1 rate ~ 10^4 Hz.

Thus, in order to have some safety margin the LV2 should be able to receive ~10^5 Hz of events.

Numbers to be remembered

Mass storage input

100 Hz

LV2 input

100 kHz

assuming a safety margin of factor 3

LV1 output

30 kHz

assuming 50% / 50% division for muon / calo. triggers

Muon LV1 output

15 kHz

Trigger Detectors

CMS LV1 trigger use both kind of muon detectors:

CSC and DT

- **excellent spatial precision ⇒ sharp p_t threshold**
- **multilayer structure ⇒ effective background rejection**

RPC

- **superior time resolution ⇒ unambiguous b.x. ident.**
- **high granularity ⇒ resistance to background**
- **ϕ, η, t carried by the same signal ⇒ no ambiguities**

It would be ideal to have a single detector which combines all the good features of CSC, DT and RPC, but such a detector* has not yet been invented.

***) which fits into our budget**

RPC and DT/CSC deliver independently muon candidates to the GMT

What we can do with them?

OR - better efficiency, worse background rejection

AND - better background rejection, worse efficiency

We can do much better, because:

- **the two subsystems use different algorithms**
- **they respond differently to different backgrounds**
- **they deliver an information about the quality of candidates**

The proper GMT algorithm can improve BOTH efficiency and background rejection!