1 Signal: Trigger selection

1.1 First level trigger

The hardware (L1 for ATLAS/CMS and L0 for LHCb) trigger strategy relies on the single muon and di-muon trigger streams. The ATLAS/CMS experiments collect majority of their signal events through the di-muon trigger with the muons transverse momentum of $p_T \geq 6(3)GeV/c$ at luminosity of $2 \times 10^{33}cm^{-2}s^{-1}$ respectively. LHCb triggers on a single muon with $p_t \geq 1.1GeV/c$ and on di-muons with $\Sigma p_T(\mu\mu) \geq 1.3GeV/c$. Such cuts result in a trigger rate of about 1kHz for ATLAS/CMS and about 200kHz for LHCb (see Table 1).

Table 1: L1(0) trigger p_T cuts and rates

Experiment	L1(0) momentum cut	L1(0) Rate
ATLAS	$p_T(\mu) \geq 6.0GeV/c$	1kHz
CMS	$p_T(\mu) \geq 3.0GeV/c$	0.9kHz
LHCb 1μ	$p_T(\mu) \geq 1.1GeV/c$	110kHz
LHCb 2μ	$\Sigma p_T(\mu\mu) \geq 1.3GeV/c$	145kHz

1.2 High level trigger

HLT strategy is similar for all three experiments. First, one confirms a presence of trigger muon(s) reconstructing tracks in the RoI around muon and maching reconstructed tracks with muon candidates from a muon system. CMS and LHCb (single muon stream) apply futher p_T cut on muons: $p_T \geq 4(3)GeV/c$ respectively.

Then, primary and secondary vertices are reconstructed. Cuts on vertex quality $\chi^2 \leq 20$ and on flight path of B_s^0 candidates $L_{xy} \geq 200\mu m$ (ATLAS) and $L_{3D} \geq 150\mu m$ (CMS) are applyed. LHCb (single muon stream) uses an impact parameter cut: $IP(\mu) \geq 3\sigma_{IP}$ and for the di-muon stream the secondary vertex quality cut $\chi^2 \leq 20$.

Finally, a cut on the invariant mass of two muons is applyed: $4GeV/c \leq M(\mu\mu) \leq 6GeV/c^2$ (ATLAS), $M(\mu\mu) \geq 2.5GeV/c^2$ (LHCb di-muon stream) or mass window around nominal B_s^0 mass of $\pm 150MeV/c^2$ (CMS).

HLT trigger rate is less than 1.7Hz for CMS and about 660Hz for LHCb. Detail description of trigger algorithms one can find in [1, 2, 3].

2 Signal: Off-line selection

For off-line analysis full event information is available. Charged tracks momenta and vertices are recalculated and refitted. Main cuts remain the same as at HLT level but due to higher reconstruction precision they are more tight. All three experiments introduce another very powerfull cut - B_s^0 candidate isolation. Below a more detailed description of the off-line selection procedures are reviewed separately for each experiment.

2.1 ATLAS

Isolation cut in the ATLAS experiment is defined as no charged tracks with $p_T \geq 0.8GeV/c$ in a cone $\theta \leq 15°$ around the B_s^0 candidate. More tight cuts on the reconstructed vertices are applyed: the significance of the reconstructed flight path in the transverse plane $L_{xy}/\sigma_L \geq 11$ and the vertex reconstruction quality $\chi^2 \leq 15$. A space separation between two muon candidates is $\Delta R = \sqrt{\Delta\phi^2 + \Delta\eta^2} \leq 0.9$. Details of the study are in [4].

2.2 CMS

In CMS isolation is defined as $I = \frac{p_T(B_s^0)}{p_T(B_s^0)+\Sigma_{trk}|p_T|} \geq 0.85$. A value of $\Sigma_{trk}|p_T|$ is calculated for all charged tracks in a cone with $R = 1$ around the B_s^0 candidate. For the muon separation the value of ΔR sould be in a range [0.3, 1.3]. Vertex cuts are following: $L_{xy}/\sigma_L \geq 18$ and $\chi^2 \leq 1$. The B_s^0 candidate momentum should point to the primary vertex: $cos(\alpha) \geq 0.995$, where α is an angle between the B_s^0 candidate momentum and the vector connected the primary and seondary vertices $\vec{V}_{sec} - \vec{V}_{prim}$. A more tight mass cut is applied: $|M(\mu\mu) - M_{B_S}| \leq 100MeV/c^2$. Details of the study are in [5].

2.3 LHCb

First, soft selection cuts are applied: $|M(\mu\mu) - M_{B_S}| \leq 600MeV/c^2$, vertex $\chi^2 \leq 14$, $IP/\sigma_{IP} \leq 6$ for the B_s^0 candidate, the secondary and primary vertex separation $|Z_{sec} - Z_{prim}|/\sigma_V \geq 0$, the pointing angle $\alpha < 0.1rad$, the soft muon identification for both candidates (ϵ_μ =95% and ϵ_π =1%).

Then, three categories of discriminant variables are introduced: Geometry (lifetime, B_s^0 and μ impact parameter, DOCA and isolation), PID (partical identification) and IM (invariant mass). These variables are used to compute the S/B ratio event by event, but no further cut is aplied. Each event is weighted with its S/B ratio in the sensitivity calculation. Without cuts on any of the distributions it is expected to reconstruct about 70 signal events per $2fb^{-1}$ [6]. If, for example, a cut on the Geometrical discriminant variable is required such that no background event from the MC sample survives the cuts (G> 0.7), then about 20 signal events are reconstructed.

3 Summary

In Table 2 the number of signal events is shown for each experiment for different integrated luminosities. For ATLS/CMS the number for $2fb^{-1}$ is a simple scale from the one for $10fb^{-1}$. In the same way the LHCb number for $10fb^{-1}$ is obtained by scaling the number for $2fb^{-1}$. Here important to mention that LHCb integrated luminosity of $2fb^{-1}$ is expected to be collected during the time when ATLAS/CMS collect $40fb^{-1}$ each. Details of the CMS study for $100fb^{-1}$ are descibed in [7].

Table 2: Number of signal events vs integrated luminosity

Experiment	$2fb^{-1}$	$10fb^{-1}$	$30fb^{-1}$	$100fb^{-1}$
ATLAS	1.4	7.0	21.0	92
CMS	1.2	6.1	18.3	26
LHCb	20	100	-	-

References

[1] ATLAS Trigger strategy

[2] P. Sphicas [CMS Collaboration], "CMS: The TriDAS project. Technical design report, Vol. 2: Data acquisition and high-level trigger," CERN-LHCC-2002-026

[3] LHCb Trigger strategy

[4] N. Nikitin *et al.*, "Rare B-decays at ATLAS," J. *Nuclear Physics B* **156** (2006) 119-123.

[5] C. Eggel, U. Langenegger and A. Starodumov, "Discovery Potential for $B_s^0 \to \mu^+\mu^-$," CMS AN 2006/097

[6] "New approach ...", LHCb note 2007-?? (2007)

[7] A. Nikitenko, A. Starodumov and N. Stepanov, "Observability of $B_{s(d)}^0 \to \mu\mu$ decay with the CMS detector," arXiv:hep-ph/9907256.