These selections target background rejection levels that should match the various higher levels. In Run 1, the only requirement of these triggers was that one or more muons had a $p_T$ greater than 4 or 6 GeV. The yields for these triggers in Run 2 (thus far) are shown right (Figure 1).

The ATLAS L1Topo system provides the functionality to pair Level-1 primitives and select events based on their combined kinematic and topological properties. Two-Level-1 muon (see Figure 2) can be combined in L1Topo to coarsely construct quantities such as the invariant mass $m(\mu\mu)$, $\Delta R$, azimuthal $\Delta \phi$ and pseudorapidity $\Delta \eta$ differences between the two muons. Due to the coarse resolution of these quantities at Level-1, the di-muon selection discrimination can be maximized selecting events based on $m(\mu\mu)$ and a secondary correlated quantity.

The optimizations from section 3 do not preserve the low $m(\mu\mu)$ region to which the $B_s \rightarrow \mu\mu$ analysis is highly interested (see Figure 4). The large amount of background in this region (see Figure 3 right) means it is not possible to keep the background rejection sufficiently high without sacrificing the low $m(\mu\mu)$ events. Low mass events are kept by complementing topological selections with higher $p_T$ di-muon triggers (such as MU10, MUMuS and MUMu10).

The ATLAS B Physics programme for Run 2 probes for signs of new physics and provides precision constraints of the Standard Model. There are four final states ($B_d \rightarrow \mu\mu$, $B_s \rightarrow J/\psi \phi$, $B_s \rightarrow \mu\mu K$, $\Theta(s) \rightarrow \mu\mu$) that can be considered prototypical of the Run 2 programme with regards to online event selection. This study maximizes their collection potential by exploiting the ATLAS Level-1 Trigger upgrade.

**Topological Selections: “L1Topo”**

The ATLAS B Physics signals are typically detected in ATLAS by triggering on muons that pass given transverse momentum ($p_T$) thresholds. In Run 1, the only requirement of these triggers was that one or more muons had a $p_T$ greater than 4 or 6 GeV. The yields for these triggers in Run 2 (thus far) are shown right (Figure 1).

**B Physics Optimizations**

The B Physics L1Topo Optimizations were optimized by maximizing the signal to background ratio. Rectangular selections in $m(\mu\mu)$ and $p_T$ were chosen as they provided the best discrimination power. The prototype signals were modelled with simulated MC samples, while the background was realistically evaluated with a high pile-up minimum bias run (see Figure 3).

**L1Topo Menu for B Physics**

The B Physics menu (see Table 3 and Figure 4) was constructed from the optimized selections described in section 3. These selections target increasing levels of background rejection. The ATLAS provides a set of working points that match the range luminosity of conditions expected in Run 2. It is a comparable scheme to the existing set of di-muon triggers but... for high luminosities it improves the signal yield by a factor of $x5 \times 10^6$.

**Conclusions**

- ATLAS Run 2 B Physics programme is dependent on statistics
  - At higher luminosities the potential statistics would be reduced due to bandwidth limitations
  - New strategy needed
  - The new strategy was developed using topological selections
  - These selections target background rejection levels that should match the various luminosity conditions expected in Run 2
  - The strategy will be well optimized for three prototypical channels
  - The remaining $B_s \rightarrow \mu\mu K$ channel will be well optimized for single signal but...
  - $p_T$ di-muon triggers must be used to recover the low $m(\mu\mu)$ events

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**Figure 1:** Impact of trigger selections for signs of new physics. The strategy is shown for the high luminosity region (HLO) of Run 2. The ATLAS detector is expected to achieve a performance in the high level trigger that is comparable to that of Run 1 (LLO).

**Figure 2:** Highly simplified overview of the Level-1 trigger with the sub-systems most pertinent to B Physics.

**Figure 3:** Normalized distributions of $\Delta R$ and invariant mass, as reconstructed with the granularity of L1Topo. Simulated $B \rightarrow \mu\mu$ events and run 201317 events (right) that pass the Level 1 2MU4 triggers are shown. The largest portion of background events reside in the low $m(\mu\mu)$, $\Delta R$ region while the majority of the $B \rightarrow \mu\mu$ signal is situated in higher regions. This demonstrates how rectangular cuts can be used to improve rejection power.

**Figure 4:** Trigger efficiencies binned in the di-muon invariant mass squared $m(\mu\mu)^2$ for simulated $B_d \rightarrow \mu\mu$ events passing various di-muon L1 triggers. For each selection, the efficiencies are normalized per $m(\mu\mu)^2$, to the number of events in that bin passing offline reconstruction. While topological selections are inefficient at low $m(\mu\mu)$, higher $p_T$ di-muon triggers still preserve this region.

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