Performance of the CLC Minbias Trigger

- The CLC consists of two modules (one per side) covering the interval \(3.7 < |\eta| < 4.7\)
- Each module has 48 Cherenkov counters and PMTs
- The Minbias trigger forms coincidences of the discriminated signals

Tight trigger:
- Require at least two hits on each side
- Used until June 4

Loose trigger:
- Require only one hit per side
- In place since June 4

I will report only on this configuration
Efficiency of the CLC Minbias Trigger

- Many L1 triggers use the CLC in coincidence, so it’s important to understand its efficiency.
- Use an orthogonal trigger to *tag* min bias events, then measure fraction of events that fire CLC trigger.
- But there aren’t so many unbiased triggers!
- Typical L1 triggers used for this purpose:
  - L1_CEM0_PT4, L1_CMU0_PT8
  - L1_CEM4_PT4, L1_CEM8_PT8
  - L1_CMU1.5_PT1.5, L1_CMU6_PT8
Estimate of proton loss and non-beam fractions

- For events with a hit in both CLC modules:

\[ f^{\text{loss}} = \frac{N(\Delta t_{CLC} > 10 \text{ ns})}{N_{\text{tot}}} \]  
fraction of tags from losses

- Events without a hit in either CLC module are expected to be negligible for hard-core events:

\[ \varepsilon_{\text{mb}}^{\text{hc}} \approx 95\% \quad \text{coincidence in both modules} \]

\[ \varepsilon_{\text{side}}^{\text{hc}} = \sqrt{\varepsilon_{\text{mb}}^{\text{hc}}} \approx 97.5\% \quad \text{hit in one module} \]

\[ \Rightarrow \varepsilon_{\text{CLC}}^{\text{non}} = (1 - 0.975)^2 \approx 0.06\% \]

So \[ f^{\text{non}} = \frac{N(0 \text{ hits in both CLC modules})}{N_{\text{tot}}} \]

Hits with only bad times in just one module are also included in numerator
Method to unfold trigger efficiencies

- Experimentally, we measure a trigger efficiency from the tagged events as:

\[ \varepsilon_{\text{meas}}^{\text{trig}} = \frac{N_{\text{trig}*\text{tag}}}{N_{\text{tag}}} = \frac{\sigma_{\text{trig}*\text{tag}}}{\sigma_{\text{tag}}} \]

- We can extract the CLC hard-core efficiency from:

\[ \varepsilon_{\text{trig}}^{h} = \frac{\varepsilon_{\text{meas}}^{\text{trig}}}{1 - f_{\text{loss}}^{\text{tag}} - f_{\text{non}}^{\text{tag}}} \]

- Assume that tagging triggers have negligibly small acceptance for diffractive scattering
## Results from Tracking Triggers

### Minbias Efficiency from L1 Track Triggers

<table>
<thead>
<tr>
<th>Run Number</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1160</td>
<td>0.9</td>
</tr>
<tr>
<td>1165</td>
<td>0.91</td>
</tr>
<tr>
<td>1170</td>
<td>0.92</td>
</tr>
<tr>
<td>1175</td>
<td>0.93</td>
</tr>
<tr>
<td>1180</td>
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</tr>
<tr>
<td>1185</td>
<td>0.95</td>
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<tr>
<td>1190</td>
<td>0.96</td>
</tr>
<tr>
<td>1195</td>
<td>0.97</td>
</tr>
<tr>
<td>1200</td>
<td>0.98</td>
</tr>
</tbody>
</table>

**Level 1 Triggers:**
- PT1.5 (Stream I, raw)
- PT3 (Stream I, raw)
- PT8 (Stream I, raw)

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</tr>
<tr>
<td>1290</td>
<td>0.95</td>
</tr>
</tbody>
</table>

**Level 1 Triggers:**
- PT4 (Stream B, raw)
- PT4 (Stream B, ISOT strip)
- PT4 (Zero Bias, raw)
- PT8 (Stream B, raw)
Results from CEM Triggers

Minbias Efficiency from L1 CEM Triggers

June

Sep

Oct

Level 1 Triggers:
- CEM3 (Stream I, raw)
- CEM4 (Stream I, raw)
- CEM5 (Stream B, raw)
- CEM8 (Stream B, raw)

Level 1 Triggers:
- CEM4 (Stream B, raw)
- CEM4 (Stream B, ISOT strip)
- CEM8 (Stream B, raw)
- CEM8 (Stream B, ISOT strip)
Results from CMU Triggers

Minbias Efficiency from Stream J (raw data)

Level 1 Triggers:
- CMU1.5 PT1.5 (stream J, raw)
- CMU6 PT8 (stream J, raw)

~7% non-collision triggers
Efficiency vs. Highest Track $P_T$

PT4 trigger, Stream B, ISOT strip

TrigEff: MB Efficiency vs. Maximum Track Pt (PT4 Trigger)

- Nent = 22
- Mean = 12.03
- RMS = 4.605
- Under = 0
- Over = 0.9927
- Integ = 15.43
Efficiency vs. Track Multiplicity

PT4 trigger, Stream B, ISOT strip

TrigEff: MB Efficiency vs. Number of Tracks (PT4 Trigger)
CLC Loose Minbias Trigger Rate

![Graph showing the relationship between Instantaneous Luminosity and Loose Min. Bias Rate.]

- **250 kHz**
- **Prescale:** 50K
  - $\Rightarrow 5$Hz

Higher proton losses
CLC Tight Minbias Trigger Rate

\[ \varepsilon_{\text{tight}} \approx 85\% \]
Conclusions

- CLC minbias trigger efficiency has been stable despite variations in the PMT gain
- Efficiency is ~96\% for events with a $P_T > 4$ track
- Actual efficiency depends on hardness of event