Results from CSC Track-Finder Simulation

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Outline:

- Re-visit Single Track Finding Efficiency
  - using LCT efficiency at 95%, 90%
  - No ME4, or ME4/1 only, or ME4/2 only
    - effect on Single Muon Rate

- Ghostbusting in CSC Track Finder
**Single Muon Trigger Efficiency**

- Track-Finder performs Pt assignment based on either 2-station or 3-station sagitta measurements.
- Require one LCT measured in ME1 for good Pt resolution.
- Motivation for using 3-station sagitta measurement ⇒ to improve the resolution of Pt measurement for low Pt tracks.

**2-Stn Pt measurement Track Types**
- ME1-ME2-X-X
- ME1-ME3-X (when there is no LCT in ME2) ⇒ does not matter if no ME4

**3-Stn Pt measurement Track Types**
- ME1-ME2-ME3-X
- ME1-ME2-ME4 (when there is no LCT in ME3) ME1-ME3-ME4 (when there is no LCT in ME2) ⇒ only restrict to type ME1-ME2-ME3 if no ME4

- Use old LCT simulation in CMSIM (Acosta, Rowe) to simulate trigger primitives.

- Standalone Fortran code was used to simulate CSC Track Finder.

- Exist a C++ version of Track Finder.
\[ \sigma \left( \frac{1}{Pt_{\text{rec}}} - \frac{1}{Pt_{\text{gen}}} \right) \]

- Pt = 5 GeV (2 Stn) (ME1-ME2)
- Pt = 5 GeV (3 Stn) (ME1-ME2-ME3)

\[ Pt = 5 \text{ GeV} \] (2 Stn)

\[ (\text{ME1-ME2}) \]

\[ (\text{ME1-ME2-ME3}) \]

\[ \eta_{\text{rec}} \]
Track Finding Eff vs $\eta$ (2-Stn Pt Measurement)

- LCT efficiency in CMSIM (old LCT simulation) is $\approx 97\%$
- Use statistical treatment to lower the efficiency to 95% and 90%
Track Finding Eff vs $\eta$ (3-Stn Pt Measurement)

**Single $\mu$ Trk Finding Eff (3-Station Pt Assignment)**

- If trigger to $|\eta| \lesssim 2.1$, $\Rightarrow$ higher efficiency with ME4/2

- Dips at $\eta \sim 1.6, 1.7$ are due to gaps in ME2 and ME3
Track Finding Eff vs $\eta$ (ME4/1 only, or ME4/2 only)

- To improve efficiency:
  - Use 2-Stn or 3-Stn Pt measurements in $\eta$ region with no ME4
  - Use 3-Stn Pt measurement in $\eta$ region with ME4
• ME4/1 and ME4/2 are separated at $\eta \approx 1.8$
L1 CSC Single $\mu$ Trigger Rate (per unit rapidity)

- Rates for cases with 4, or 3 CSC (no ME4) stations
- Rates for using 2-Stn, or 3-Stn Pt Measurements
- Consider trigger rate in the range $1.2 < \eta < 2.4$

**Single $\mu$ Rate (Min Bias sample 14 collisions in 1 BX)**

- **3-Stn Pt 4 CSC Stns**
- **3-Stn Pt 3 CSC Stns**
- **2-Stn Pt 4 CSC Stns**
- **2-Stn Pt 3 CSC Stns**

| $|\eta| > 1.2$ |
|----------------|
| $L = 10^{34} \text{cm}^{-2} \text{s}^{-1}$ |

**NOTE:** LCT efficiency is $\approx 97\%$ (from CMSIM), did not perform additional statistical treatment to lower the efficiency.
L1 CSC Single $\mu$ Trigger Rate (per unit rapidity)

- Rates for cases with 3 full CSC stations + ME4/1 or ME4/2
- Consider trigger rate in the range $1.2 < \eta < 2.4$

**Single $\mu$ Rate (Min Bias sample 14 collisions in 1 BX)**

- Rate from “ME4/1 only” is lower than “ME4/2 only” because most of the soft muons (Min. Bias) are at high $\eta$
• At high lumi \( (L \sim 10^{34}\text{cm}^{-2}\text{s}^{-1}) \), need to apply a threshold at \( \sim 35 \text{ GeV/c} \) for the case “ME4/1 only” (to stay at 1 kHz rate). May not be low enough due to many uncertainties in the single muon rate.

• At low lumi \( (L \sim 10^{33}\text{cm}^{-2}\text{s}^{-1}) \), need to apply threshold at :
  - \( \sim 20 \text{ GeV/c} \) for using 2-Stn Pt measurement only
  - \( \sim 15 \text{ GeV/c} \) for the case “ME4/2 only”
  - \( \sim 10 \text{ GeV/c} \) for the case “ME4/1 only”

\[ \Rightarrow \text{B physics at low lumi!} \]
  - \( \sim 25\% \) of muons from b quarks enter the region \( 1.8 < |\eta| < 2.4 \) (Acosta)
\( \eta \) Distribution of Tracks Found in CSC

![Graph of \( \eta \) Distribution of Tracks Found in CSC](image)
L1 CSC Single $\mu$ Trigger Rate (per unit rapidity)

- Rates for cases with 4, or 3 CSC (no ME4) stations
- Rates for using 2-Stn, or 3-Stn Pt Measurements
- Consider trigger rate in the range $1.2 < \eta < 2.1$

**Single $\mu$ Rate (Min Bias sample 14 collisions in 1 BX)**

- Reduction in rate by excluding high $\eta$ region
- Can apply lower threshold
L1 CSC Single $\mu$ Trigger Rate (per unit rapidity)

- Rates for cases with 3 full CSC stations + ME4/1 or ME4/2
- Consider trigger rate in the range $1.2 < \eta < 2.1$

### Single $\mu$ Rate (Min Bias sample 14 collisions in 1 BX)

- Rate from “ME4/1 only” is similar to “ME4/2 only” because most of the soft muons (Min. Bias) are at high $\eta$ ($\eta > 2.1$)
- Still need to apply high Pt threshold (at high lumi)
Single $\mu$ Rate (Min Bias sample 14 collisions in 1 BX)

Rate $dN/d\eta dt$ (kHz)

$1.2 < |\eta| < 2.1$

$L = 10^{34} \text{ cm}^{-2} \text{s}^{-1}$

Pt$_{\text{min}}$ (GeV)
Ghostbusting in CSC Track Finder

- In the original Track Finder design (w/o ghostbusting) the fake hits may lead to fail extrapolations, or wrong Pt assignment.

- A possible way to resolve ghost hits in ME1. (Acosta)
  - Has minimum impact on Sector Processor
  - Require minor modification to Sector Receiver and back plane (to send info on whether the hits are from the same chamber)

- Details on the implementation ⇒ refer to Acosta’s talk
Test Ghostbusting

- Generate two muons (Pt=25 GeV/c) that enter into 1 ME1/2 chamber (1.2 < η < 1.6)
- Keep only one hit in each ME2,3,4 chambers
- For “No Mix” sample:
  The ALCT/CLCT pairs in ME1/2 chamber are not mixed ⇒ the ALCTs and CLCTs are correctly associated
- For “Mix” sample:
  Half of the events with ALCTs and CLCTs wrongly associated

- Run TF (C++) over these two samples
The “Mix” sample after treated by Ghostbusting gives a slightly higher track finding efficiency. This is because the TF tends to select from the extrapolation combinations the one that gives a higher Pt measurement.
Summary

- It is important to have high LCT efficiency

- If there will be either ME4/1 or ME4/2 only:
  - At Low Lumi \( (L \sim 10^{33}\text{cm}^{-2}\text{s}^{-1}) \)
    * ME4/1 may be more preferable than ME4/2 (if we want to trigger to \(|\eta| \lesssim 2.4\), using 2-Stn and 3-Stn Pt measurement)
  - At High Lumi \( (L \sim 10^{34}\text{cm}^{-2}\text{s}^{-1}) \) and trigger to \(|\eta| \lesssim 2.1\)
    * ME4/2 may be more preferable than ME4/1 (using 3-Stn Pt measurement)

- The method to resolve ghost hits in ME1 has been successfully tested. Need to study how would the ghostbusting affect single muon rate.

- Trigger Primitive simulation from ORCA is now in good state. Eager to use it in TF simulation and compare results with the ones from using CMSIM