Status and Future prospects of the Muon Drift Tubes System of CMS

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on behalf of CMS Collaboration

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CMS Drift Tubes

<table>
<thead>
<tr>
<th>Gas</th>
<th>Ar 85% - CO₂ 15%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Pressure</td>
<td>~ 1 atm</td>
</tr>
<tr>
<td>Max Drift Time</td>
<td>~380 ns</td>
</tr>
<tr>
<td>Average Resolution</td>
<td>~200 μm</td>
</tr>
<tr>
<td>Drift Velocity</td>
<td>~54 μm/ns</td>
</tr>
<tr>
<td>Gas gain</td>
<td>10⁵</td>
</tr>
</tbody>
</table>

250 chambers
172k read-out channels
Drift Tubes performance

Fraction of active channels during LHC operation

Long Shutdown 1 maintenance

The Drift Tube efficiency to detect a single hit

CMS
Preliminary
Data 2016

DT Overall Efficiency

4.42 fb⁻¹ (13 TeV)

Entries 250
Mean 98.53
RMS 0.3795
Underflow 0
DT: Hit Resolution

DT single hit resolution as a function of station and wheel.

~200-250 um for cells that measure the muon bending coordinate (phi)
DT Trigger Upgrade

Major upgrade of the CMS Level1 Muon Trigger during the Winter Shutdown 2015/2016:
- More powerful electronics based on μTCA
- With the new Trigger architecture, we can move from a sub-detector centric concept to a geographical one.

MB4 covering up to $|\eta|<0.8$

MB1 covering up to $|\eta|<1.2$
DT: Local Trigger Performance

DT Local Trigger efficiency, station by station, versus the Global Muon transverse momentum, compared to the measurement from 2015 data.
CMS: L1 Muon Trigger Efficiency

gaps between wheel YB0 and YB±1

Single Muon Trigger Efficiency (18 GeV threshold) as a function of the offline reconstructed muon pseudo-rapidity (left) and transverse momentum (right)
Local Trigger: Future Improvement

With the new L1 architecture, we can exploit the good DT spatial resolution with RPC time resolution.

Early combinations of DT+RPC+HO can be useful for improving the LV1 trigger efficiency in the gaps between wheel YB0 and YB±1.
Read Out: Future Improvement

- More robust and powerful electronic based on μTCA (same board used for the DT trigger chain)
- More bandwidth to DAQ

Test crate already installed
DT: LHC phase II

HL-LHC:
Integrated Lumi: 3000 fb$^{-1}$
Peak Lumi: $5 \times 10^{34}$ cm$^{-2}$s$^{-1}$

Needs to evaluate the longevity of the DT chambers and electronics, as well as the performance of the system in the HL-LHC environment.
DT: GIF++ Aging Test

New **Gamma Irradiation Facility** in North Area of the SPS:
It combines a projected 14 TBq 137Cs source with a 100 GeV muon beam in the SPS H4 beam line

**Spare DT chamber under irradiation to evaluate aging effect**

The on-detector electronics is expected to heavily deteriorate after the Long Shutdown 3 (~2025).

The on-detector electronics will be replaced during the Long Shutdown 3.
DT: Detector Shielding

Neutron-induced background in DT has been measured in Run1 and Run2:
- Good linearity with luminosity up to $1.2 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$
- Rate observed is close to the TDR expectation

Linear extrapolation to HL-LHC luminosity indicate an expected background rate of ~25 Hz/cm²

A shield is under test (~50% rate reduction)

borated-polyethylene plus lead shield

DT chamber
Conclusions

• The Drift Tubes system (and in general the CMS Muon System) is operating efficiently since the beginning of LHC operation in 2010

• Several upgrades have been done in order to improve the CMS Muon System performance

• HL-LHC will be a challenging environment for the Drift Tubes:
  ■ several tests and activities are ongoing to ensure the same performance of the muon system for the full life time of CMS
backup
DT Time Resolution

DT time information is obtained from a 3-parameter fit of segments, where position, direction and time of a crossing track are determined simultaneously.

Time-at-vertex distribution for standalone muons in the barrel, using the times measured from DT chambers.
The measured local trigger efficiency for each DT chamber

CMS Preliminary, 2016 data, 13 TeV, 4.42 fb⁻¹

- entries = 240
- mean = 93.66
- r.m.s. = 1.88