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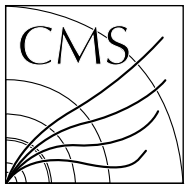
**CMS DP -2023/026**



**The Compact Muon Solenoid Experiment**

CMS Performance Note

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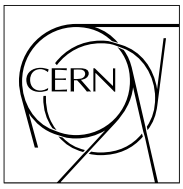

**22 May 2023**

# First Data Taken with the Level-1 Data Scouting System

CMS Collaboration

**Abstract**

The Level-1 40 MHz data scouting system will record trigger objects created by the Phase-2 Level-1 trigger at the bunch crossing rate, enabling novel analyses and improving monitoring capabilities.

At the end of 2018 and from the beginning of LHC Run-3 a demonstrator system has been in operation, taking data initially from the CMS Phase-1 Global Muon Trigger and recently, from mid-2021, also from the CMS Phase-1 Calorimeter Trigger. First data obtained this novel system are shown here. Particular emphasis is placed on the utility of recording data from subsequent bunch crossings and the resulting ability to correlate arbitrary bunch crossings with each other.

# First data taken with the Level-1 data scouting system

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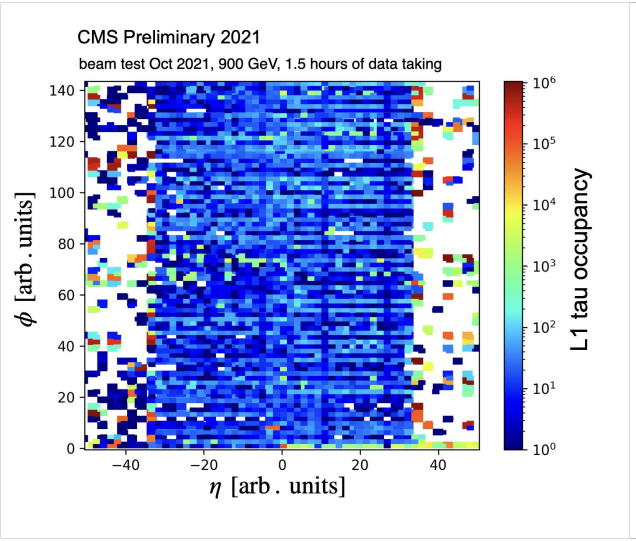
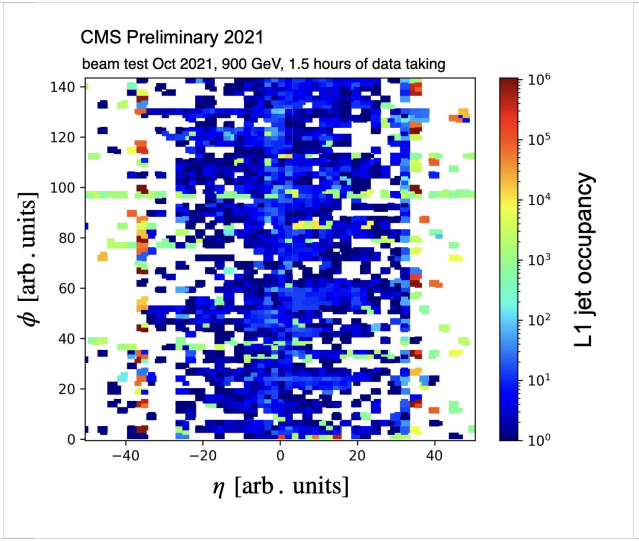
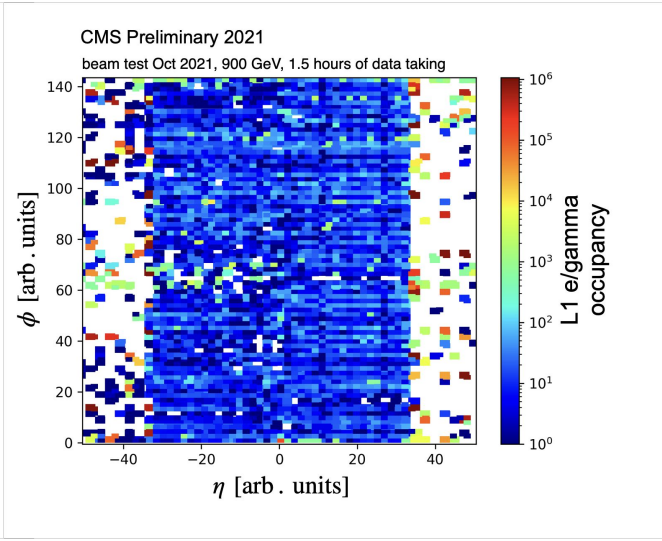
# Introduction

The Level-1 40 MHz data scouting system will record trigger objects created by the Phase-2 Level-1 trigger at the bunch crossing rate, enabling novel analyses and improving monitoring capabilities. More details in [CMS-TDR-021].

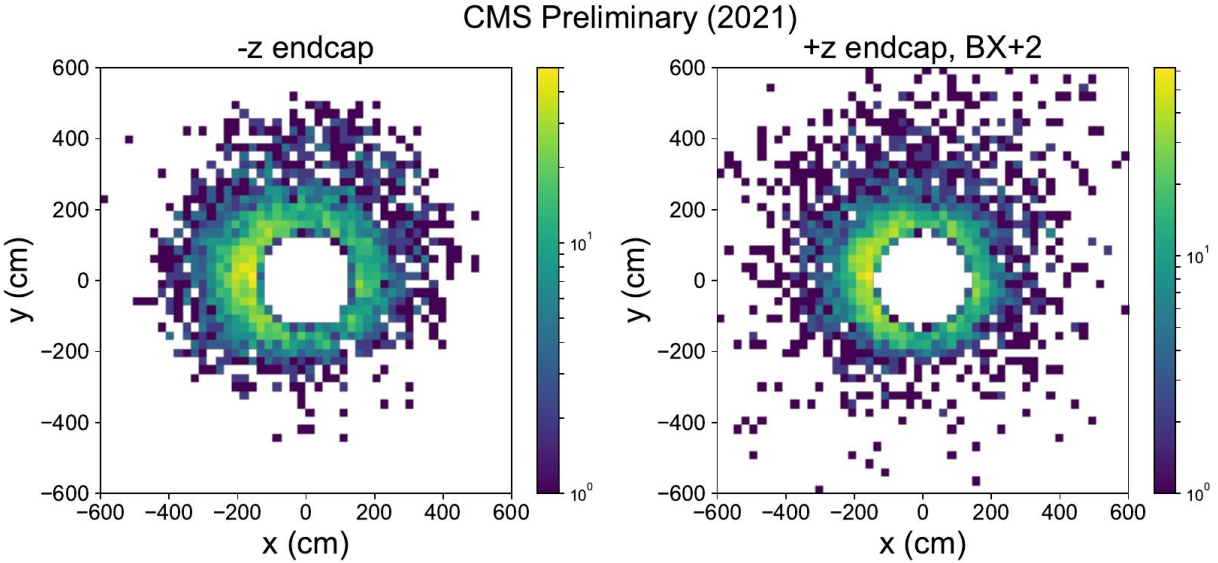
At the end of 2018 and from the beginning of LHC Run-3 a demonstrator system has been in operation, taking data initially from the CMS Phase-1 Global Muon Trigger and recently, from mid-2021, also from the CMS Phase-1 Calorimeter Trigger. First data obtained this novel system are shown here. Particular emphasis is placed on the utility of recording data from subsequent bunch crossings and the resulting ability to correlate arbitrary bunch crossings with each other.



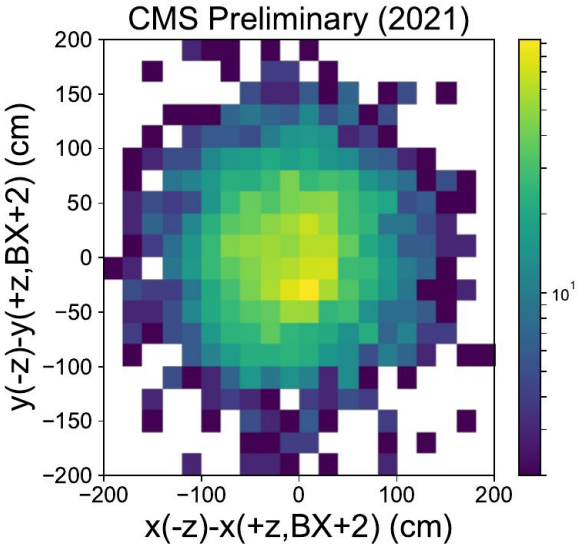




Occupancy of tau, jet, and e/gamma candidates reconstructed by the CMS Phase-1 Level-1 trigger during the LHC beam test in October 2021 and recorded by the Level-1 40 MHz data scouting system. The data shown corresponds to 1.5 hours of data taking.




Beam halo seen in the CMS muon endcaps during the LHC beam test in October 2021. The beam halo consists of muons created by the interaction of the LHC beam with elements of the accelerator or beam gas and moves in parallel to the beamline. Pairs of muons were selected in opposite endcaps with opposite charge, and with $\Delta$BX=2. Only bunch crossings with non-colliding bunches and sufficiently "distant" from collisions were selected. In this fill, beam 2 (traveling from the negative z side to the positive z side in CMS coordinates) exhibited a large halo. Thanks to the capability of recording all bunch crossings, the scouting system allows to reconstruct the halo which is otherwise generally precluded due to detector readout limitations.

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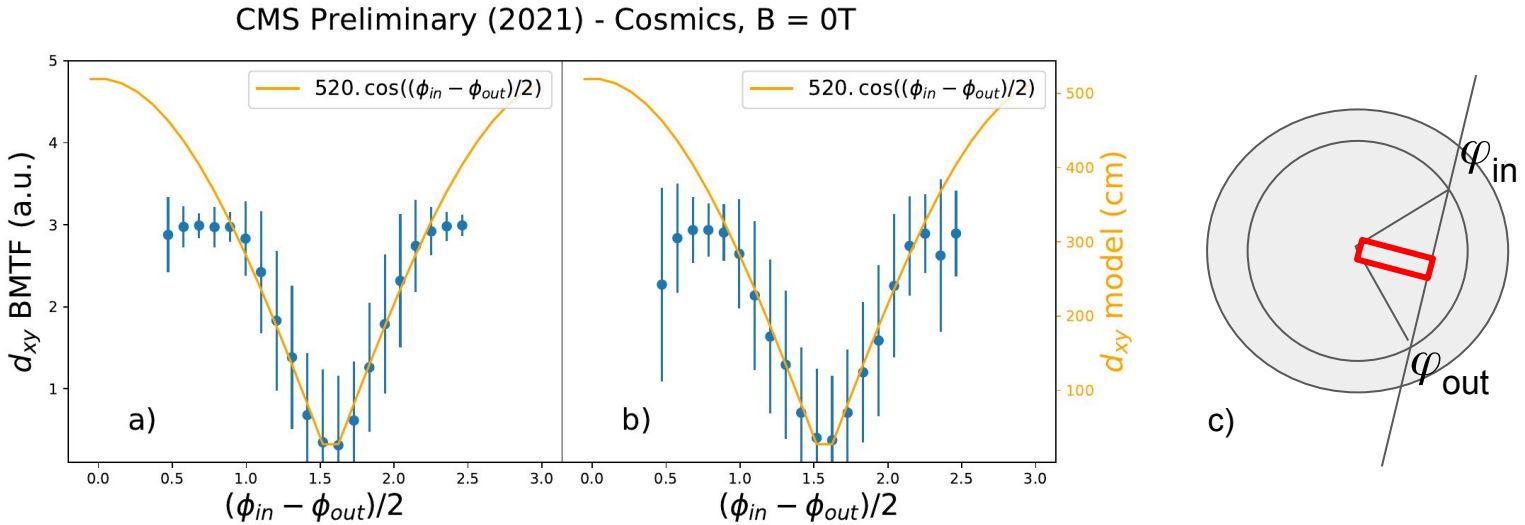
In this plot, the difference in transverse coordinates between the two muons is shown. The fact that the coordinates are strongly correlated (a charged particle traveling parallel to the magnetic field is not deflected) is clear indication that the muon pairs separated by two bunch crossings indeed correspond to a single halo muon traversing the detector.




Impact parameter of cosmic muons measured by the Barrel Muon Track Finder (BMTF) for a) incoming (found at bunch crossing N in the top half of the detector) and b) outgoing (found at bunch crossing N+2 in the bottom half of the detector) cosmic muons vs. difference between the azimuthal angle of the incoming and outgoing legs measured in the muon system of the CMS detector **without magnetic field** recorded by the Level-1 40 MHz data scouting system. The measured i.p. is consistent with the simple relationship shown in the inset and illustrated in c), corresponding to a scale of about 100 cm for the BMTF unit i.p. The i.p. scale received by the uGMT is limited to four values and therefore saturates at value 3, leading to reduced error bars at that value. This same fact causes the model to diverge from the data for large displacements. The factor 520 corresponds to the distance of 5.2 metres of the measuring muon station from the beamline.

Thanks to its capability of recording all bunch crossings, the scouting system allows to correlate observations in adjacent bunch crossings. In this plot, the outgoing muon is required to be observed two bunch crossings after the incoming muon. This is quite exactly the travel time of a muon across the CMS barrel detector.