Search for low mass dark photons in dimuon channel using data collected by scouting trigger in Run2 in CMS

Swagata Mukherjee, on behalf of the **CMS collaboration**
III. Physikalisches Institut A, RWTH Aachen University, Germany

III. Physikalisches Institut A
RWTH AACHEN UNIVERSITY
GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

ABSTRACT

After several years of running of the LHC, new physics has not yet been found. Therefore one of the best hopes for discovering new physics is exploring the difficult to access corners of phase space, such as low mass regions where collecting the data is challenging. Data scouting or trigger level analysis is one such way to achieve this. This special dataflow, which utilises event-size reduction to significantly reduce event filtering, is presented in this poster. A search for prompt dark photons in the dimuon channel performed by CMS utilising the dimuon scouting data to improve its sensitivity at low mass will be used to demonstrate the benefits of this approach.

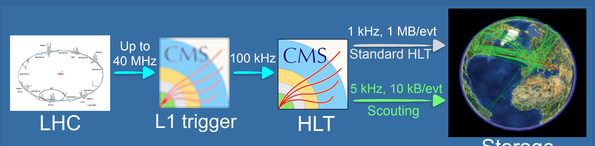
REFERENCE

PRL 124, 12 (2020) 131802
arXiv: 1912.04776
https://cds.cern.ch/record/2703964

CONTACT

Swagata Mukherjee
RWTH Aachen University
Email: s.mukherjee@cern.ch

DATA SCOUTING: A NEW TRIGGER PARADIGM



CMS High Level Trigger (HLT)

- Software-based.
- Read-out detector with full granularity.
- Rate reduction: 100 kHz to about 1 kHz.
- Events accepted by HLT are generally transferred to Tier-0, reconstructed offline and stored world-wide.
- Performance of HLT reconstruction quite close to the offline reconstruction.
- Similar algorithms and calibrations, optimized for speed.
- The challenge at HLT: keeping the rate and timing under control while maintaining good physics acceptance.

Due to trigger thresholds, we have low or zero sensitivity to new physics with low mass. How can we solve this? Relaxing trigger thresholds is the only option, but we are **limited by trigger bandwidth**!

$$\text{Trigger Bandwidth} = \underbrace{\text{Event Rate}}_{\sim 1\text{ kHz}} \times \underbrace{\text{Event Size}}_{\sim 1\text{ MB}}$$

This is the idea of Data Scouting

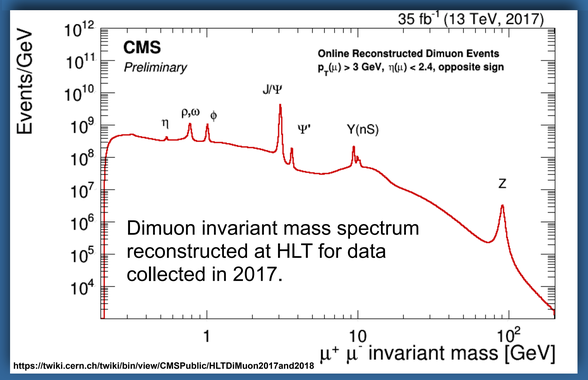
If we want to **increase** rate

We need to **decrease** event size

Do MORE physics analysis **with LESS** event content

To save resources, events collected with scouting triggers are not sent for offline reconstruction. Instead, HLT-level objects are used directly in physics analysis. Moreover, no RAW data is saved for scouting.

CMS is using hadronic scouting since 2011. **First attempt of non-hadronic scouting** was in Run-II, when CMS introduced a dimuon scouting trigger in the HLT menu. A search for dark photon was performed using the data collected by the dimuon scouting trigger during 2017 and 2018.



SEARCH FOR LOW MASS DARK PHOTONS

Dark sector: physics motivations

Possibility of hidden, dark sector is motivated by indirect evidences of dark matter, which is expected to interact very weakly, if at all, with SM particles. We consider a **spontaneously broken dark U(1)$_D$ gauge symmetry**, mediated by a vector boson called the dark photon, Z_D. We focus on **hypercharge portal**, where dark photon's only renormalizable interaction with SM is through **kinetic mixing(ε)** with the hypercharge gauge boson. We assume there are no hidden-sector states below Z_D mass, and dark photon decay exclusively to SM particles, with **sizable branching ratio to muons**.

Curtin et. al. JHEP 02 (2015) 157

$$\mathcal{L} \subset -\frac{1}{4}\hat{B}_{\mu\nu}\hat{B}^{\mu\nu} - \frac{1}{4}\hat{Z}_{D\mu\nu}\hat{Z}_D^{\mu\nu} + \frac{1}{2}\frac{\epsilon}{\cos\theta}\hat{Z}_{D\mu\nu}\hat{B}^{\mu\nu} + \frac{1}{2}m_{D,0}^2\hat{Z}_D^{\mu}\hat{Z}_{D\mu}$$

$U(1)_Y$ (SM) $U(1)_D$ (Dark Sector)

Event selection

Online requirements

Double muon L1 triggers:
- p_T>12/5 or 15/7 GeV
- p_T>4 or 4.5 GeV, opposite charge, ΔR<1.2
- p_T>4.5 GeV, |η|<2, opposite charge, 7<$M_{\mu\mu}$<18 GeV

Scouting dimuon HLT, which is basically L1 pass through.

Offline requirements

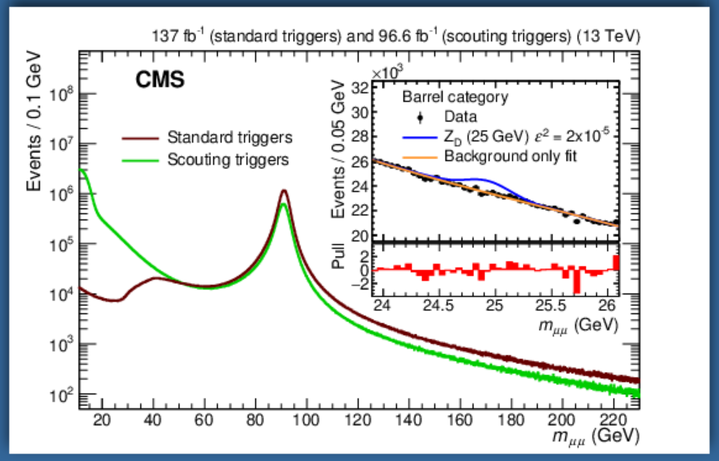
$\mu^+\mu^-$ with p_T>4 GeV, |η|<1.9, consistent with originating from the same vertex.

Custom muon identification based on track quality requirements.

Muon track isolation<15% of muon p_T.

To suppress heavy flavor background:

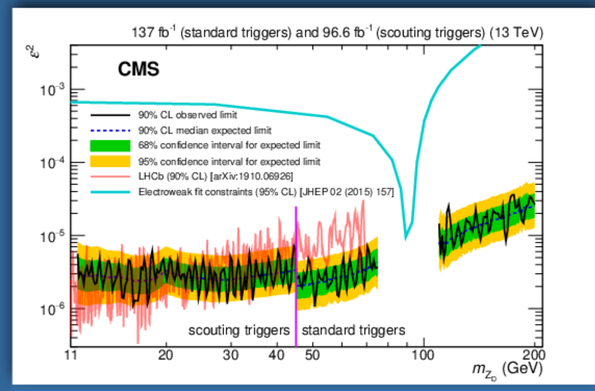
$p_T(1)>m_{\mu\mu}/4$, $p_T(2)>m_{\mu\mu}/3$



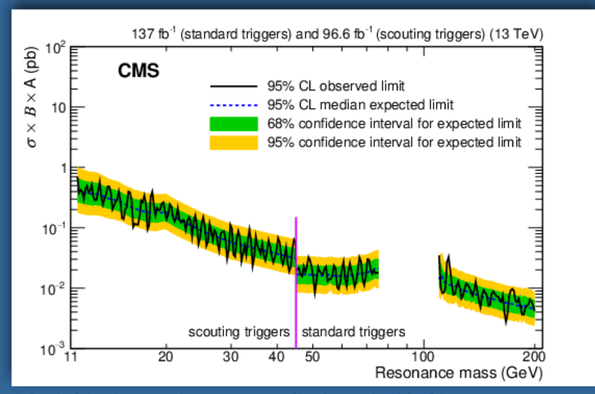
Significant acceptance loss for $M_{\mu\mu}$<45 GeV for events collected with standard dimuon triggers, with p_T thresholds 17 GeV and 8 GeV at HLT. This low mass region becomes accessible by scouting.

RESULTS

The low mass search is performed using data collected with high-rate dimuon scouting triggers, corresponding to an integrated luminosity of 96.6 fb^{-1}. The Z_D signal is simulated at leading order using the **Hidden Abelian Higgs Model (HAHM)**. The signal shape is modeled using double-sided crystal ball function. The background, which is dominated by DY events, is modeled using a fourth order Bernstein polynomial, in the low mass search. For statistical analysis, a simultaneous binned maximum likelihood fit is performed to the $m_{\mu\mu}$ distribution, in a range of ±5σ around the probed resonance mass.
Efficiency of scouting trigger is measured w.r.t offline reconstructed muons using events selected with independent standard triggers. The average uncertainty in the trigger efficiency is ~5%.



Upper limit at 90% CL on ϵ^2 as a function of mass of dark photon. Limits from this search are competitive with those obtained by LHCb at low masses. **This is the first search in CMS that uses data with reduced trigger-level muon information collected with dimuon scouting triggers, probing as low as 11.5 GeV.**



Model independent upper limit at 95% CL.