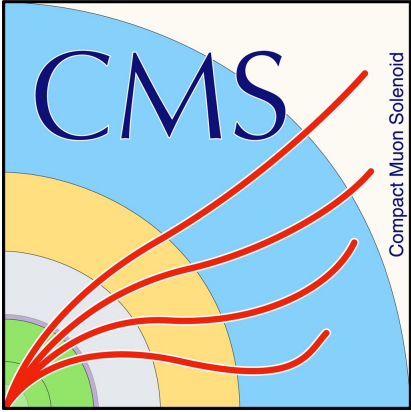




Search for rare decays with four muons in the final state and Machine Learning for DQM

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2°-year **PhD** student

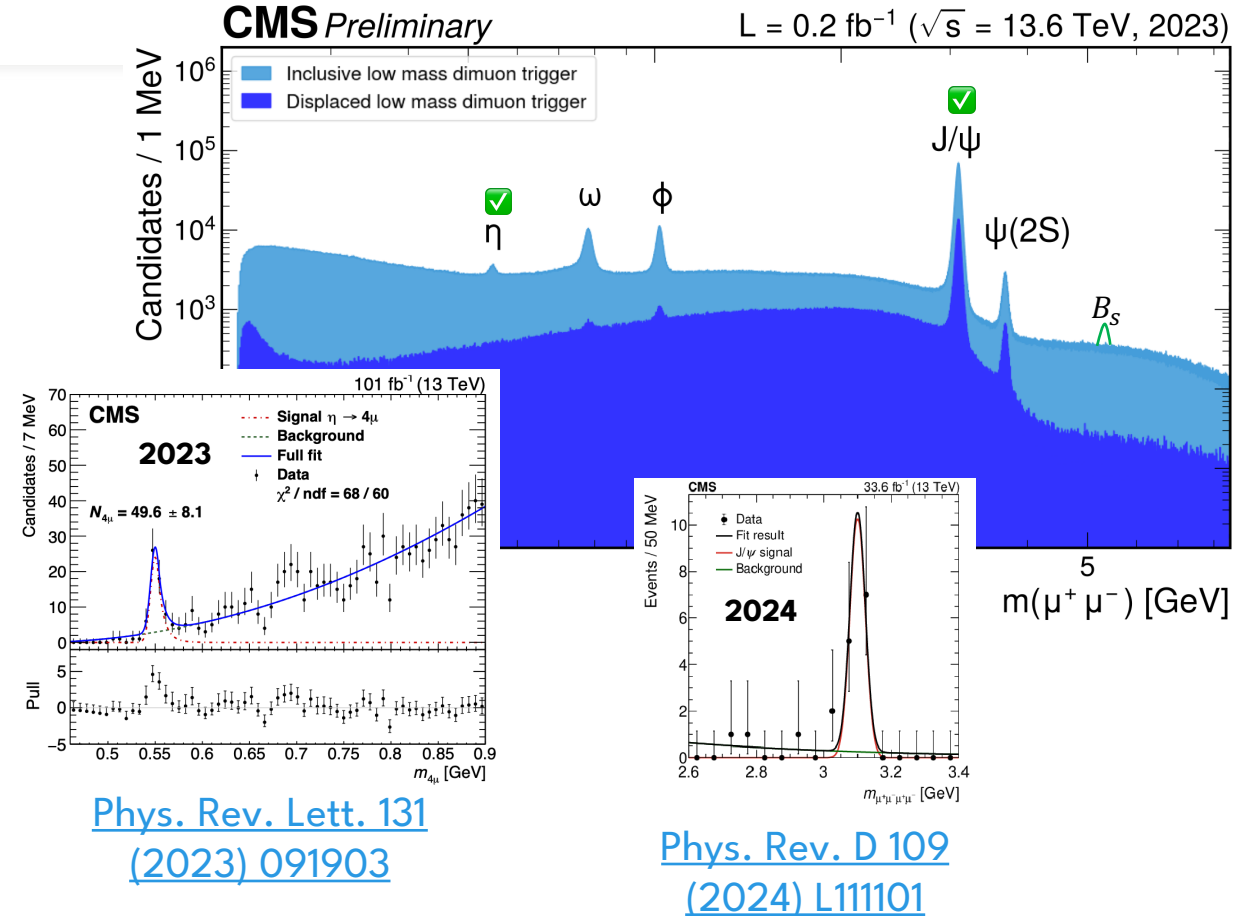
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Rare 4μ decay

- Resonances decaying to $\mu^+\mu^-$:
 - Clean experimental signature
 - Most already observed with high significance
- In SM: $BR(?? \rightarrow 4\mu) \sim \frac{1}{\alpha_{em}^2} BR(?? \rightarrow 2\mu)$
- Smaller BR $\rightarrow$ higher possibility to highlight presence of **new physics**
- New Run 3 **inclusive di-muon trigger** enables further 4μ searches at CMS

Di-muon resonances

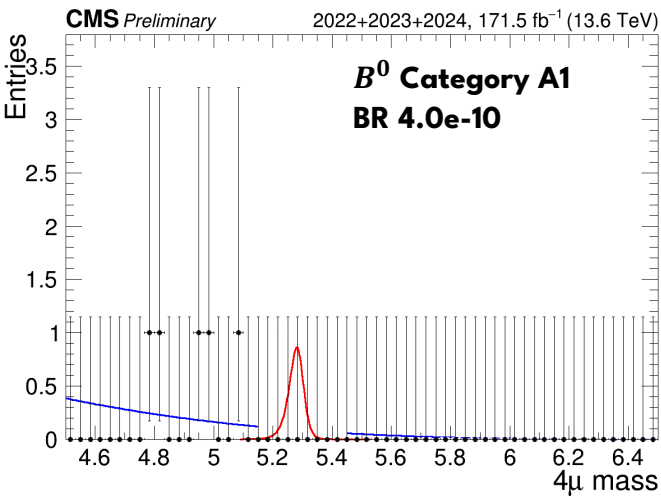
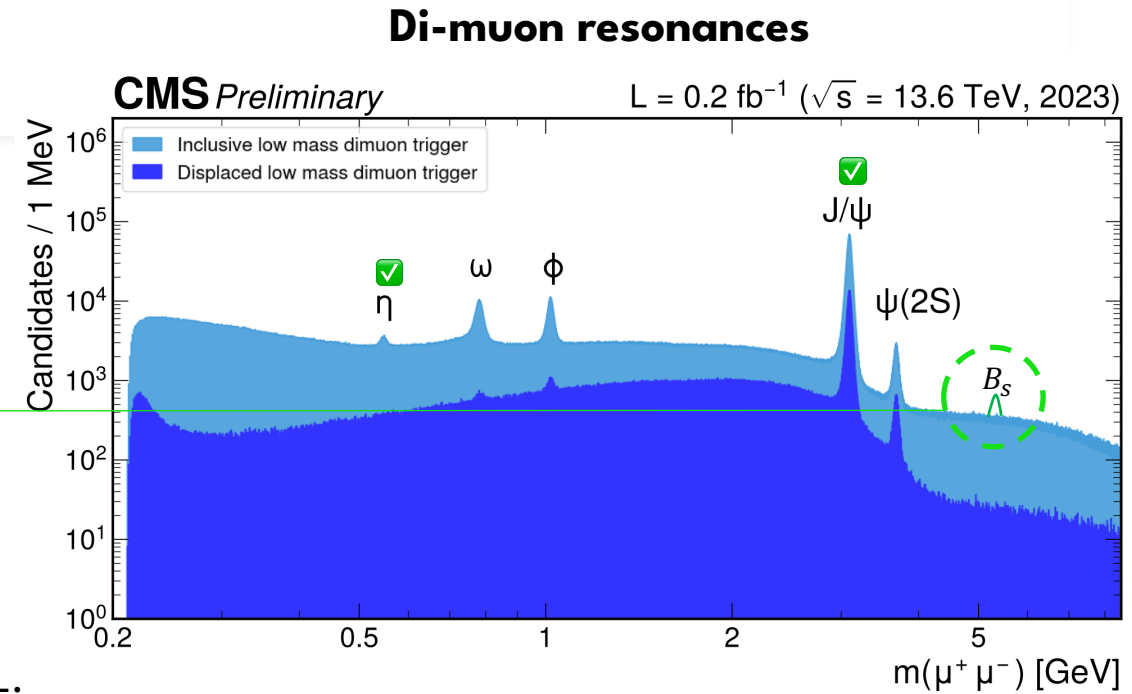


CMS is leading the Way!

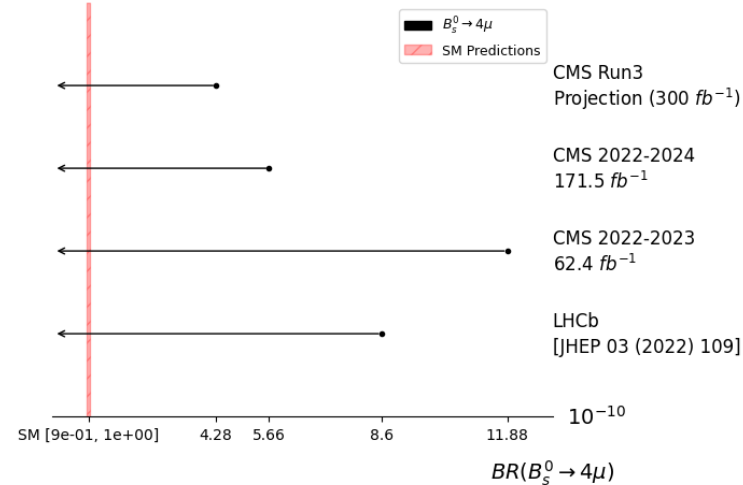
Rare 4μ decay

Search for the $B_{(s)}^0 \rightarrow 4\mu$ decay

- The SM decay only via **FCNC** $\rightarrow$ very small BR ($\mathcal{O}(10^{-10} - 10^{-12})$) $\rightarrow$ BSM physics could modify it
- CMS Run3 data** (22-24) $\rightarrow$ HLT_DoubleMu4_3_LowMass (171.5 fb^{-1})
- Current exp. **ULs** $\sim$ **30% better than LHCb**



$$BR(B_s^0 \rightarrow 4\mu) < 5.7 \times 10^{-10} \text{ @95\% C.L.}$$

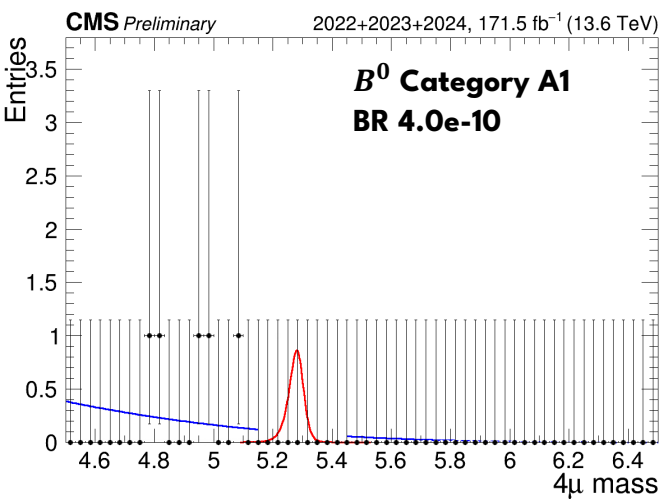


CADI Line: [BPH-24-007](#)

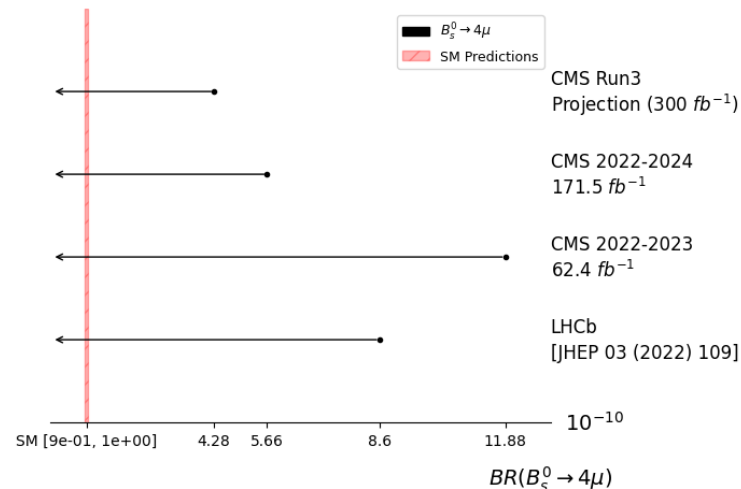
Rare 4μ decay

Search for the $B_{(s)}^0 \rightarrow 4\mu$ decay

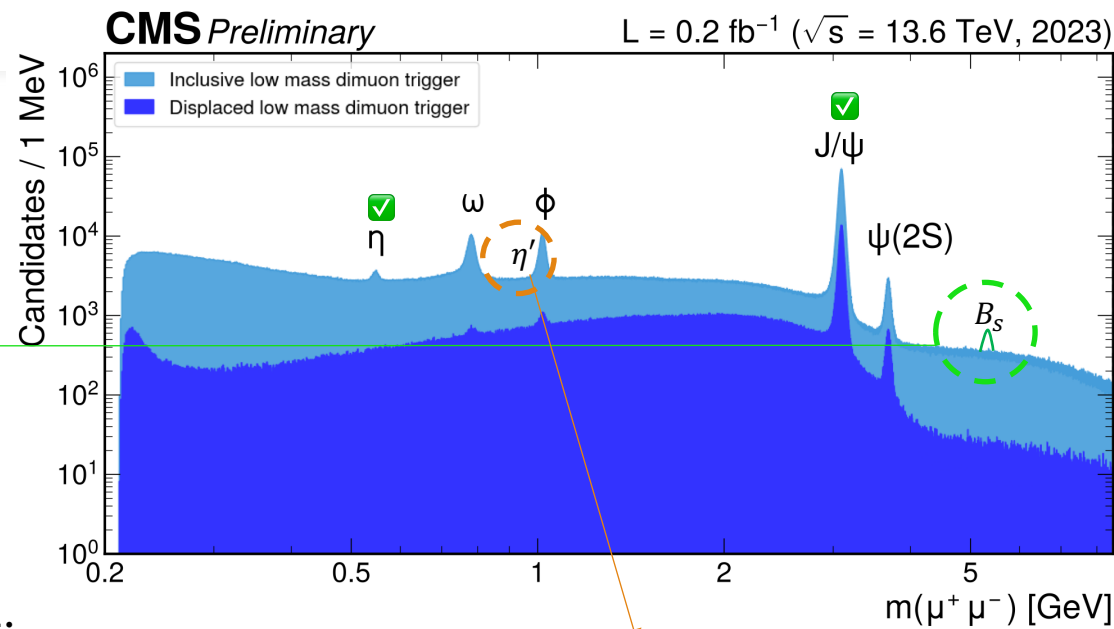
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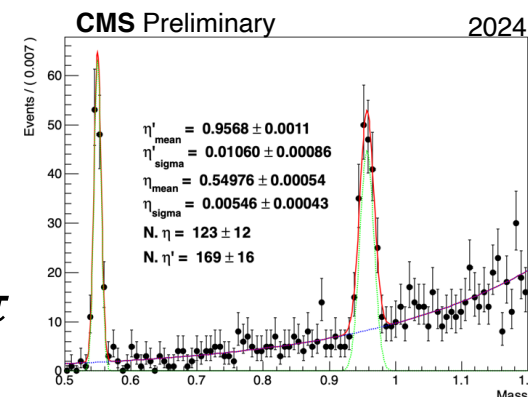


CADI Line: [BPH-24-007](#)



First observation of $\eta' \rightarrow 4\mu$

- Never observed and sensible to NF
- Clear signal peak**
- BR computation relative to $\eta' \rightarrow 2\mu 2\pi$ ongoing



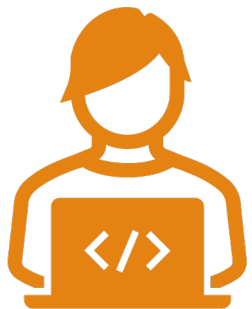
Started a few months ago

Machine Learning for DQM

Ongoing effort by the CMS DQM team (and sub-detector groups) to automate monitoring - and DC - using machine learning

Present

DQM Shifter

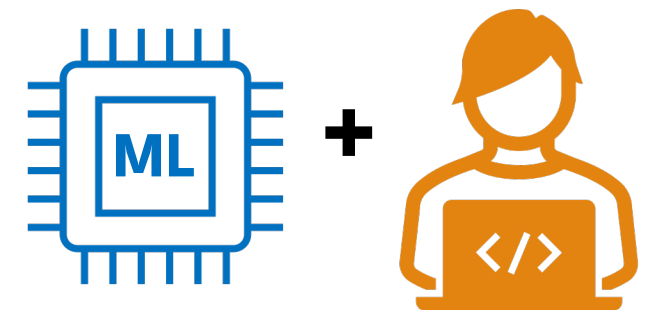


DQM relies on real-time human monitoring of histograms

Effective granularity: ~ Run

Future (HL-LHC)

ML to assist shifters, enabling fast identification of potential issues

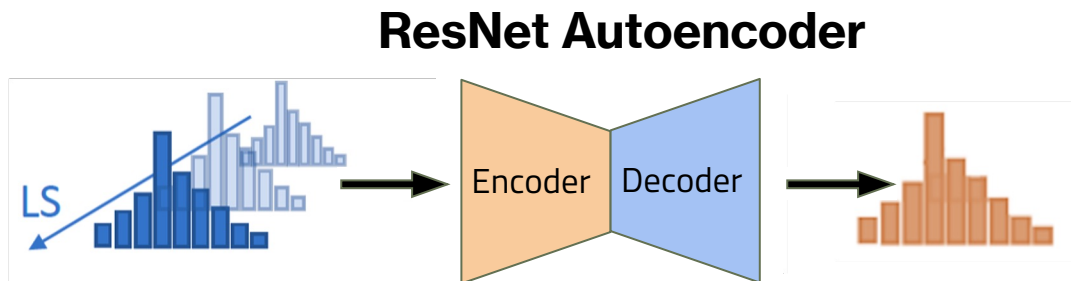
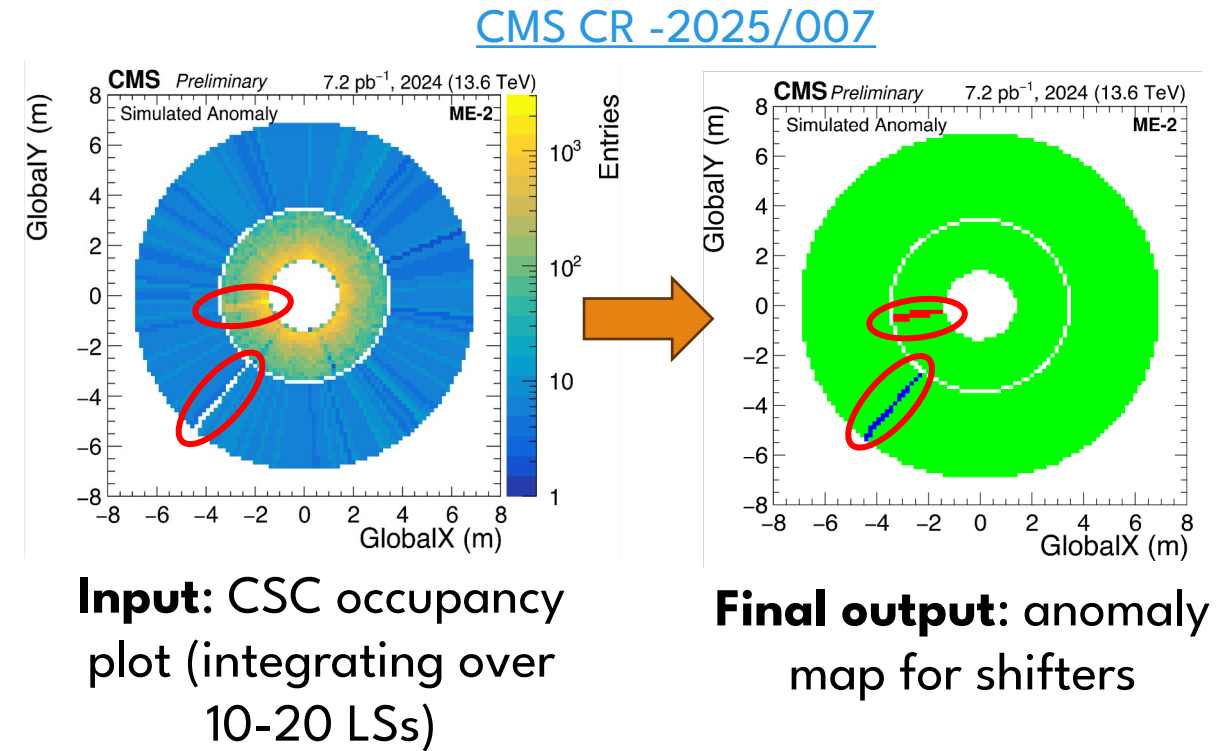


Expected granularity: 1 (or few) LS(s)

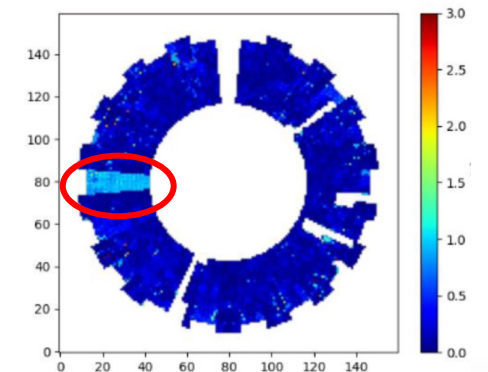
ML models already developed for [ECAL](#) and [HCAL](#), with ongoing work for the Tracker.

Machine Learning for muon-DQM

- **Goal:** Develop a flexible ML anomaly detection tool
- **Inputs:** Occupancy plots from muon system sub-detectors
 - Tested with **CSC** occupancy plots **150k** LSs (from 2024 data taking)
- **Next Steps:** Include the model in the online DQM workflow



Prospects:
Preliminary study ongoing on extend the tool to the GEMs



Thanks for your attention!