MUSiC: Model Unspecific Search in CMS

Lorenzo Vigilante on behalf of the
CMS Collaboration

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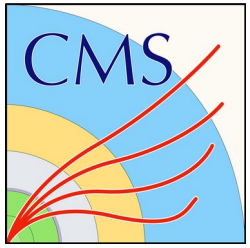

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MUSiC in a nutshell

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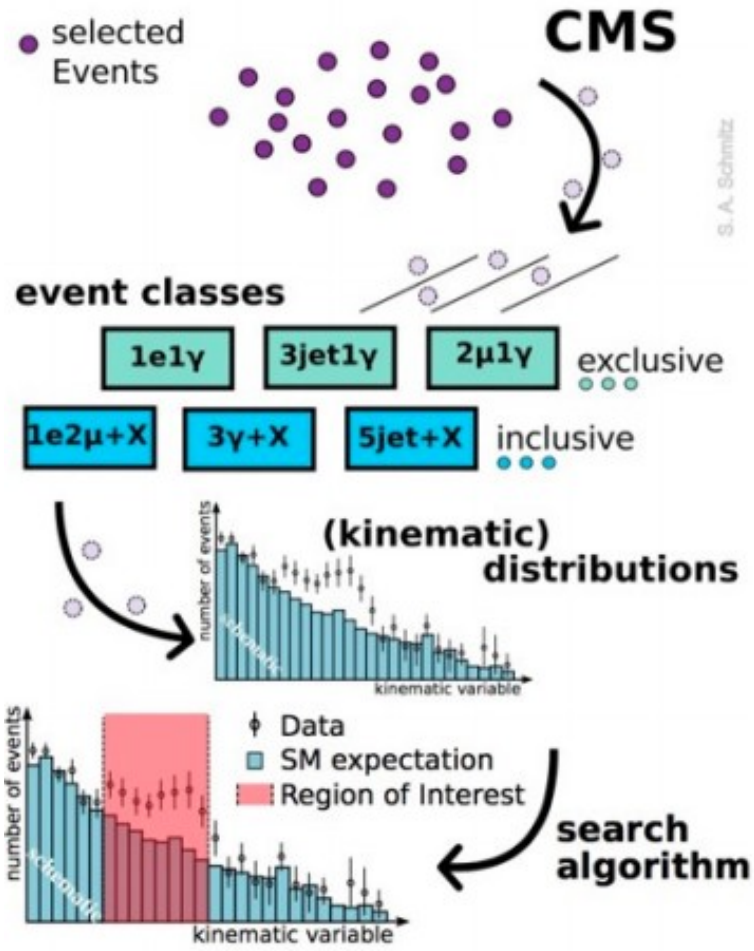
Features:

- Search for deviations from Standard Model (SM) expectation in hundreds of different final states.
- No specific input of any particular new physics model.
- Complementary approach to dedicated analyses.
- Sensitive to new physics model for which no dedicated analysis exists, or unconsidered new physics phenomena.

Analysis:

1) Use proton collision data collected by CMS in 2016 (35.9 fb^{-1}) with $\sqrt{s}=13\,TeV$.
2) Well reconstructed physics objects (e, μ, γ, jets, b-jets, p_T^{miss}) are considered.
3) Sort events into different event classes (final states) based on event content: exclusive, inclusive and jet-inclusive.
4) Scan kinematic distributions (Invariant Mass (M), S_T, p_T^{miss}) for discrepancies between data and simulation.
5) Identify regions with significant deviation.



RoI scan and sensitivity studies

Regions building and RoI scan:

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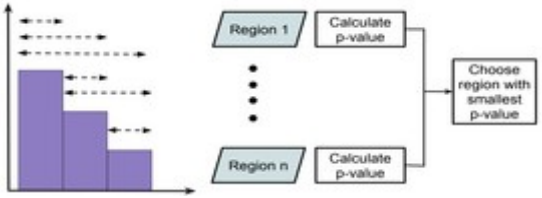
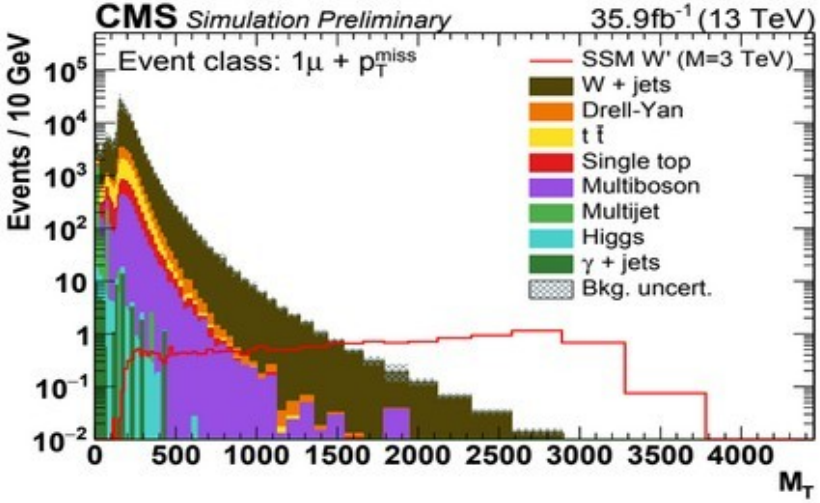
$$p_{\text{data}} = \begin{cases} \sum_{i=N_{\text{data}}}^{\infty} C \cdot \int_0^{\infty} d\lambda \exp\left(-\frac{(\lambda - N_{\text{SM}})^2}{2\sigma_{\text{SM}}^2}\right) \cdot \frac{e^{-\lambda}\lambda^i}{i!} & \text{if } N_{\text{data}} \geq N_{\text{SM}} \\ \sum_{i=0}^{N_{\text{data}}} G \int_0^{\infty} d\lambda \exp\left(-\frac{(\lambda - N_{\text{SM}})^2}{2\sigma_{\text{SM}}^2}\right) \cdot \frac{e^{-\lambda}\lambda^i}{i!} & \text{if } N_{\text{data}} < N_{\text{SM}}, \end{cases}$$

- Scan for deviation in kinematic distribution in different event classes.
- Define p-value to describe the agreement between simulation and data.
- Consider all possible bin regions and define the Region of Interest (RoI) as the region with smallest p-value.
- Use pseudo-experiments to correct for look-elsewhere effect.





Sensitivity studies:

- Demonstrate capability of the analysis to identify deviation.
- W' simulated samples are added on top of SM processes. Different final states with significant deviations beyond expectation are found.

Results

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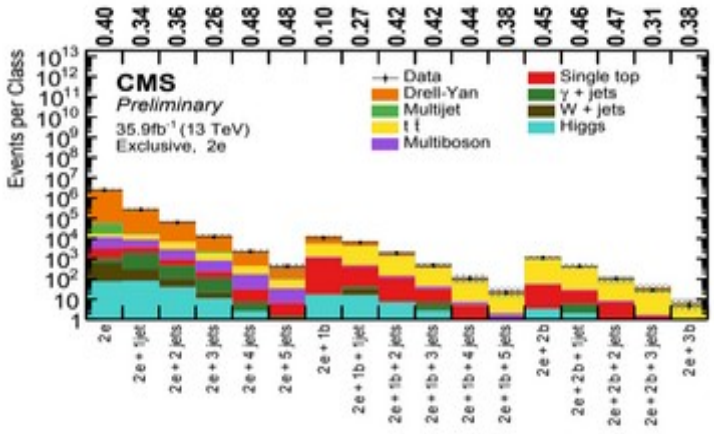
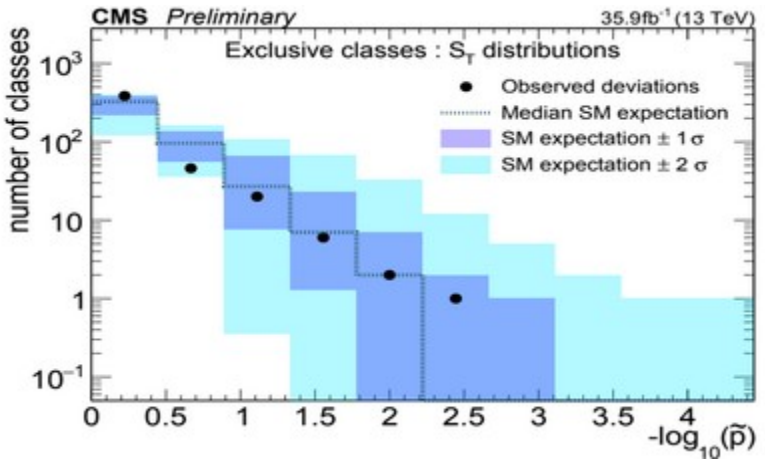
Total yield scans:

- The MUSiC algorithm has identified 498 exclusive event classes and 571 (530) inclusive (jet-inclusive) event classes with at least one data event.
- First: evaluate p-value for each event class based on total yield.
- Then event classes grouped by their object content e.g. 2e object group consists of all classes with exactly two electrons and any number of (b-)jets.
- No particular event class being found to have a very significant deviation.





Global overview:

- Distributions of M, S_T, p_T^{miss} in each event class are scanned to search for deviations
- Due to the large number of different event classes a global overview of the scan is required.
- $\tilde{p}$-values calculated for each kinematic distribution are summarized in a single histogram and compared with SM only expectation obtained from pseudo experiments.
- Largest deviations are along expectation based on the SM only hypothesis, within uncertainties.