Generic Search for Deviations from Standard Model Predictions in CMS

Shahram Rahatlou

INFN ROMA

SAPIENZA UNIVERSITÀ DI ROMA

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Introduction

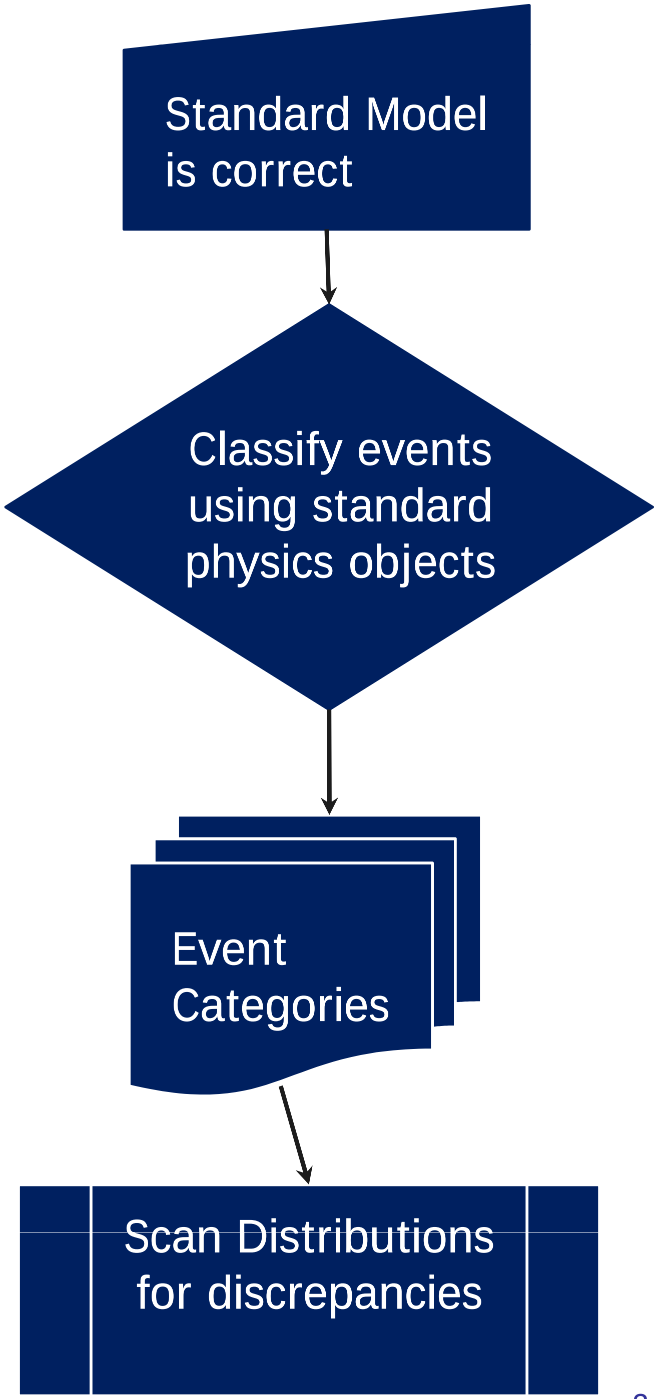
- Generic search strategies already explored at Tevatron and Hera
  - Provide comprehensive comparison between data and Monte Carlo Predictions
  - Complementary strategy to augment dedicated searches
  - Not optimized for specific theoretical models
  - Sensitive to unexpected signatures not covered by specific models

- More appropriate for later stage of data taking with well understood detector response
  - Requires a solid reference for comparison
  - Needs to assume Standard Model to be correct and look for deviation in large number of event topologies

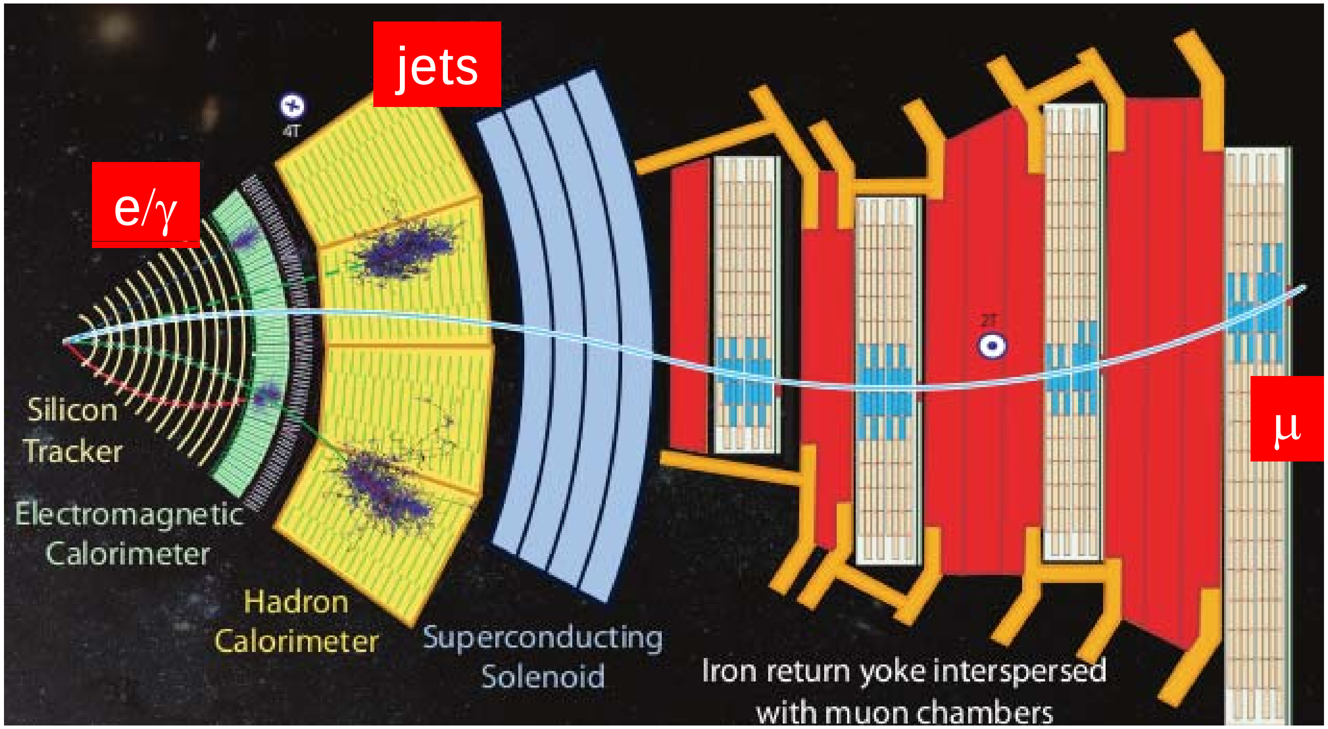
- Useful physics monitoring tool with early data
  - Provide feedback on instrumental effects causing discrepancies
  - Compare different Monte Carlo simulations
  - Tuning of various MC generators with data

Model Unspecified Search in CMS (MUSiC)

- Strategy very similar to that used in H1
- Lepton triggers
  - Reduce overwhelming QCD background
- Standard reconstructed objects
  - Benefit from improved reconstruction and identification studies with first data
    - Reduce systematic uncertainty
- Three distributions sensitive to deviations
  - Scalar sum of transverse momenta Σp_T
    - Sensitive to products from new heavy particles
  - Invariant or transverse mass of event
  - Missing energy
    - Most sensitive to new physics but unreliable with very first data



Physics Objects with CMS Detector



	p_T	$\|\eta\|$	isolation
μ	>30 GeV	< 2.4	Track based
e/γ	> 30 GeV	< 2.5	Calo+track
jets	> 50 GeV	< 2.5	
MET	> 100 GeV		

Event Categories

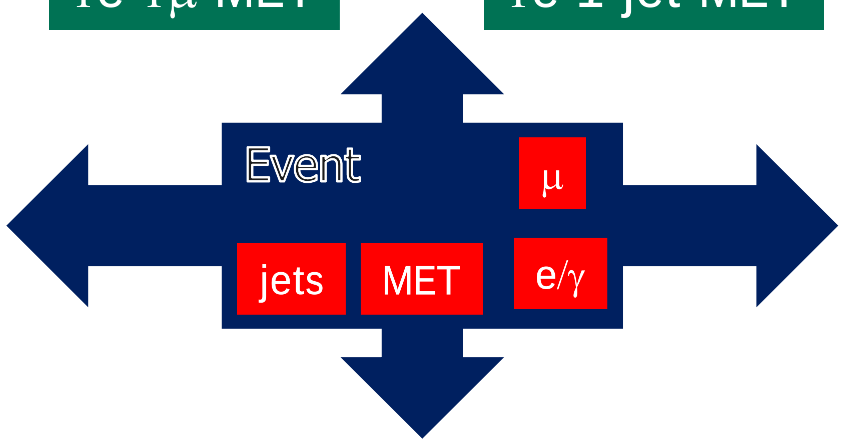
1e 1μ MET

1e 1 jet MET

1jet 1e 1μ + X

2 jet 1e 1μ + X

4 jet 1e 1μ + X



1jet 1e 1μ

2 jet 1e 1μ

4 jet 1e 1μ

1e 1μ

2e 1μ

1γ 1μ

Robust Background Estimate

- Key ingredient for robust and credible search of deviations
  - Any quantitative measure of deviation washed away by large uncertainties on expected background

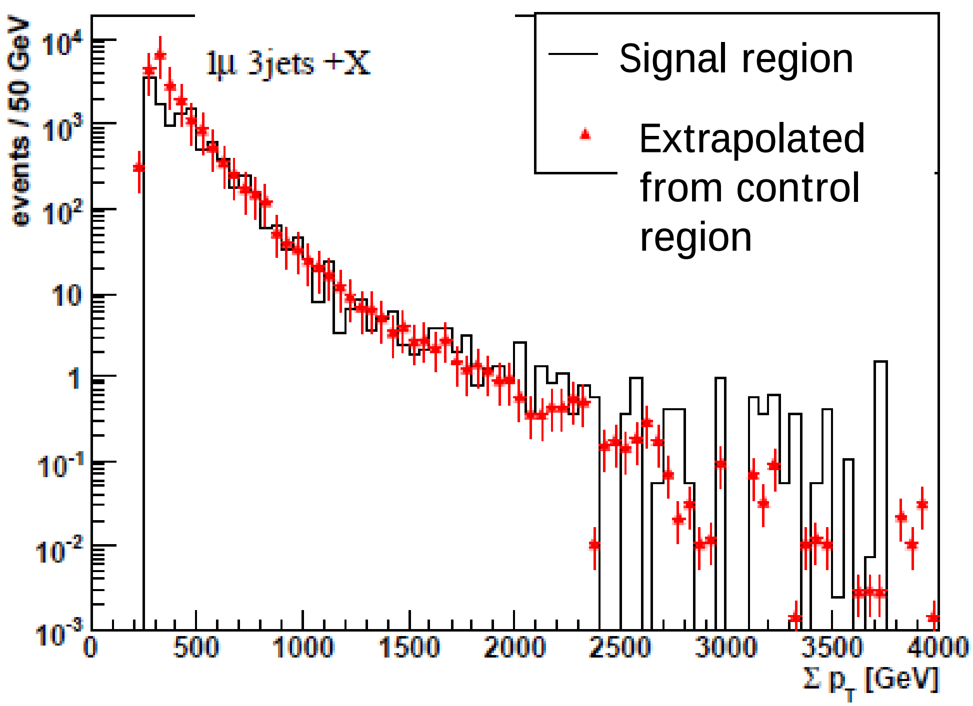
- Monte Carlo expectations good enough for most of electroweak backgrounds
  - Main deviations in high p_T regions with very small SM expectation
  - Even 30% uncertainty reasonable for such regions
  - Large MC samples can reduce

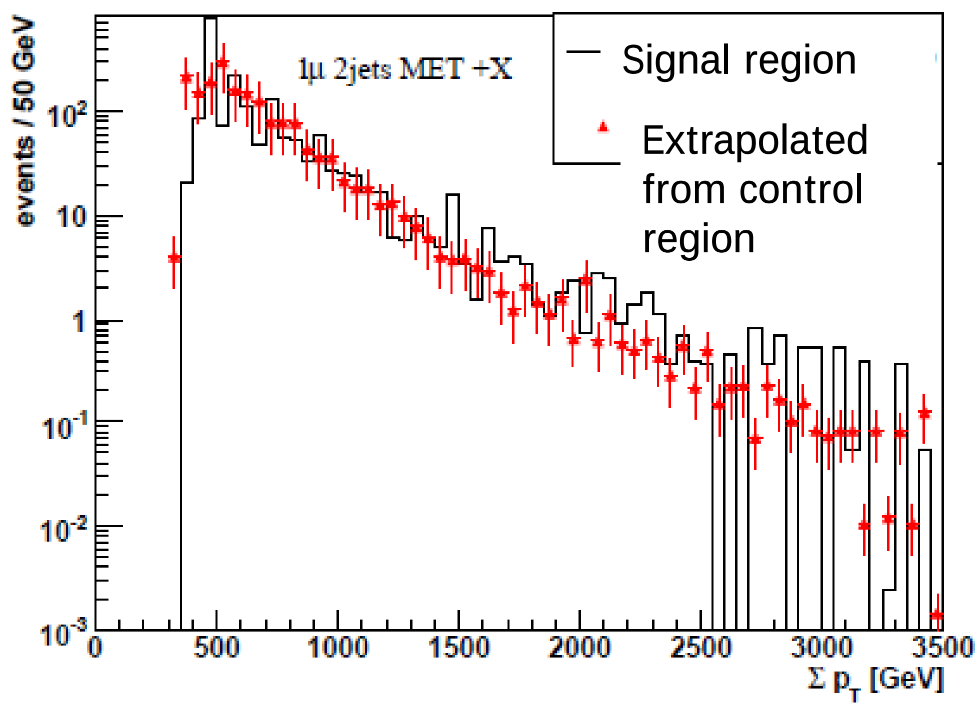
- QCD background as main source of concern
  - Predictions with large uncertainties
  - More difficulties in producing large samples

- Data driven approach used to estimate QCD background
  - Systematic uncertainty to shrink with more statistics

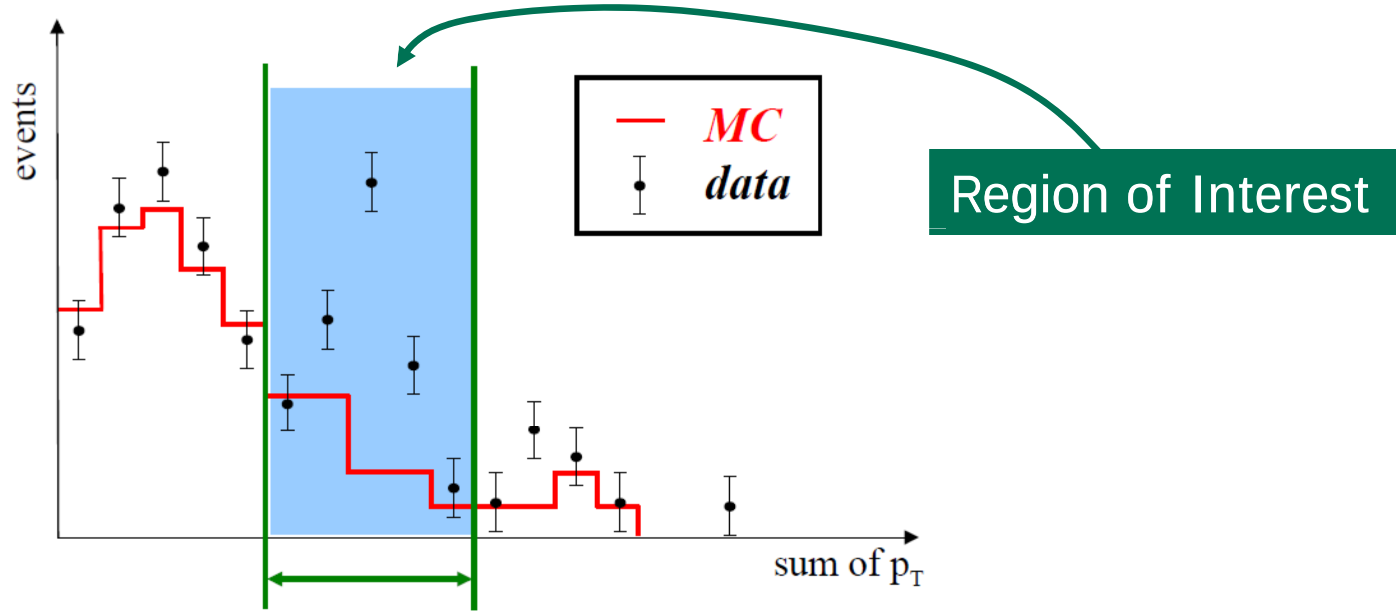
Data Driven Estimate of QCD Background

- Control region defined by using looser isolation criteria to estimate background in data
- Two inclusive final states used to define single scale factor for all event categories
  - Dedicated region for each of ~400 states not feasible nor practical
  - Normalization estimated from low p_T regions dominated by Standard Model
    - Systematic uncertainty of 50%





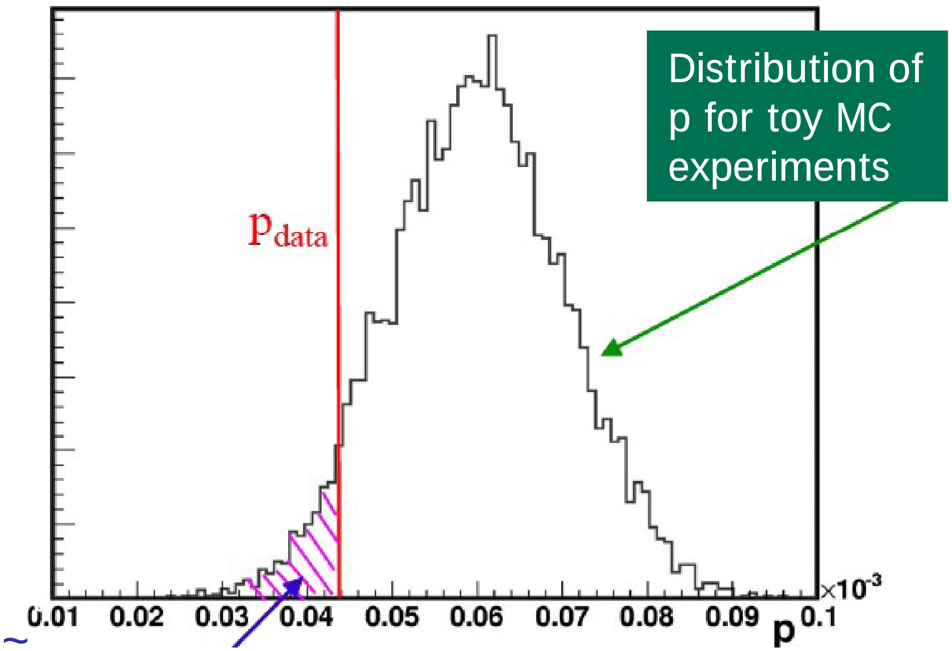
Regions of Interest showing Discrepancies



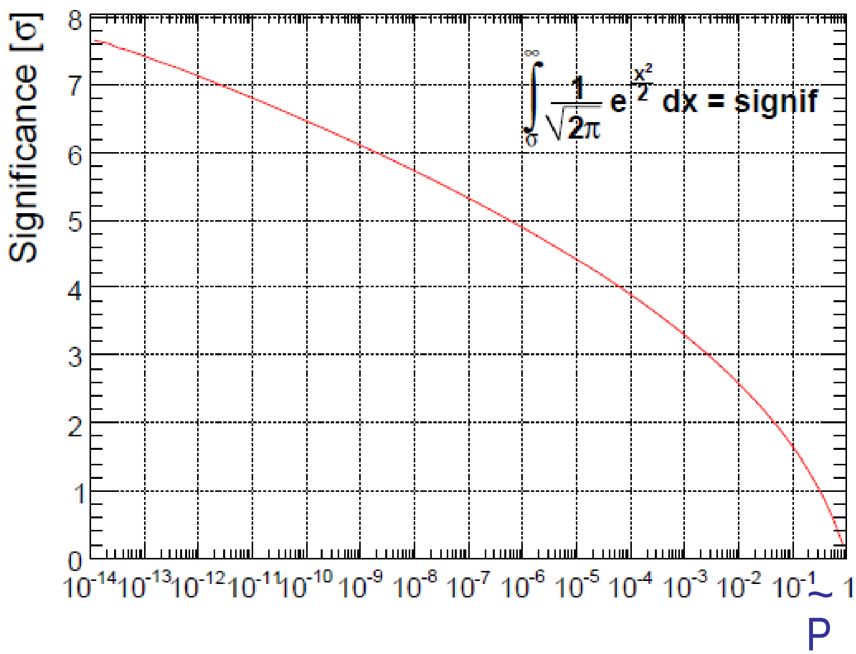
- Consider any single bin or group of adjacent bins with deviations
- Compute Poisson probability p_{data} for $N_{MC} \pm \delta N_{MC}$ to fluctuate up or down to N_{data}
  - Convolution with Gaussian to account for systematic uncertainties
- Region with largest discrepancy (smallest p_{data}) called Region of Interest
- Define a quantitative measure of such discrepancy with pseudo-experiments based on Standard Model predictions

Probability of discrepancy to occur in data

- Determine distribution of p_{data} for toy MC experiments based on SM expectation
- Large fraction $\tilde{P}$ of toy experiments with $p < p_{data}$ indication of potential deviation
- Traditional interpretation in terms of standard deviations if considering $\tilde{P}$ as tail of Gaussian distribution
- Use a 3σ threshold in automatic search for deviations



$\tilde{P}$: Fraction of toy experiments with $p < p_{data}$



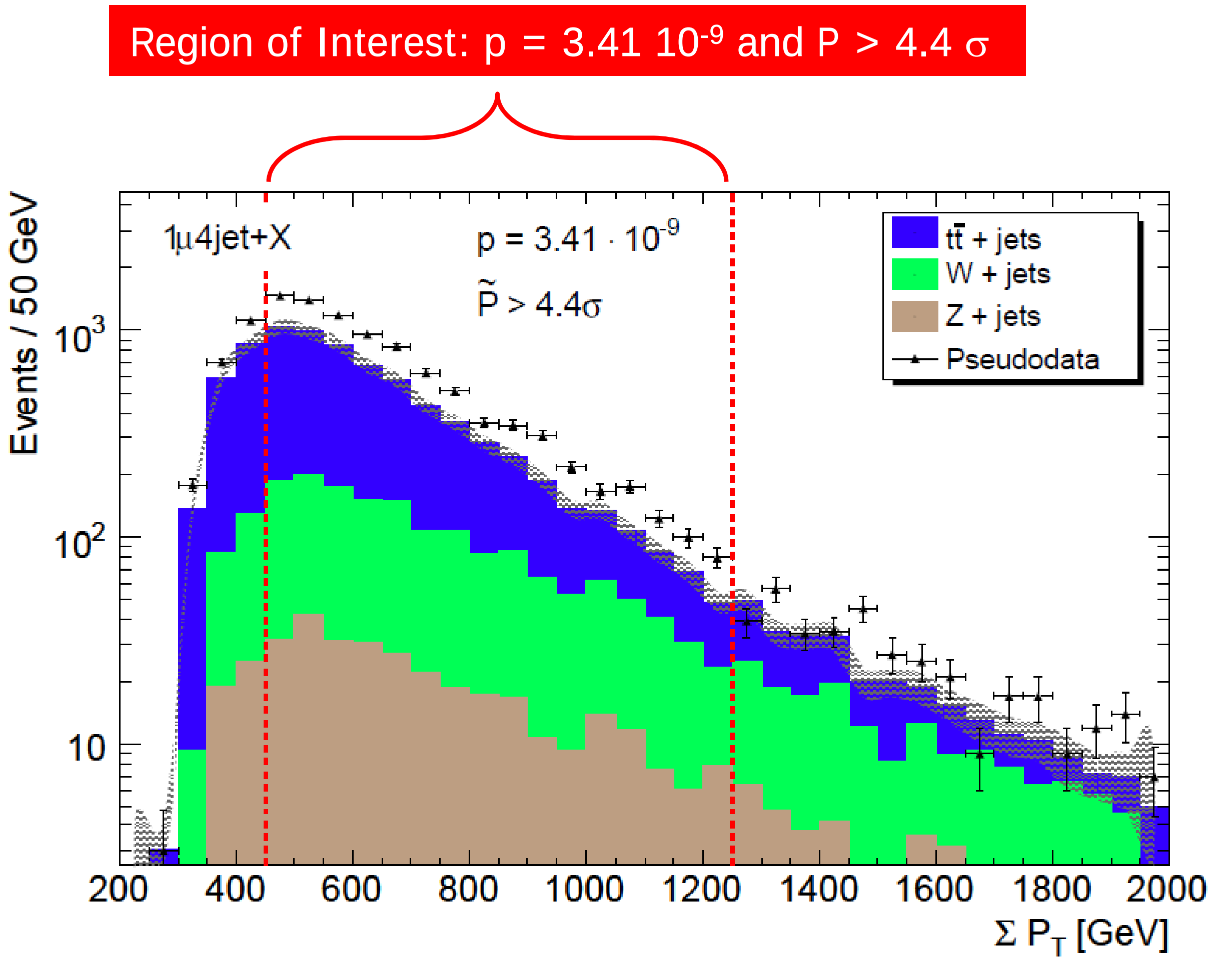
Physics Commissioning With Early Data

- Uncertainty of 5% assumed for Jet Energy Scale (JES) and included in probability calculation

- Ignoring this uncertainty and increasing JES by 10% in pseudo-experiments cause of 4.4 σ discrepancy

- Such scenario can easily occur in early data taking
  - physics monitoring

- Including systematic uncertainty reduces discrepancy to ~1.6 σ

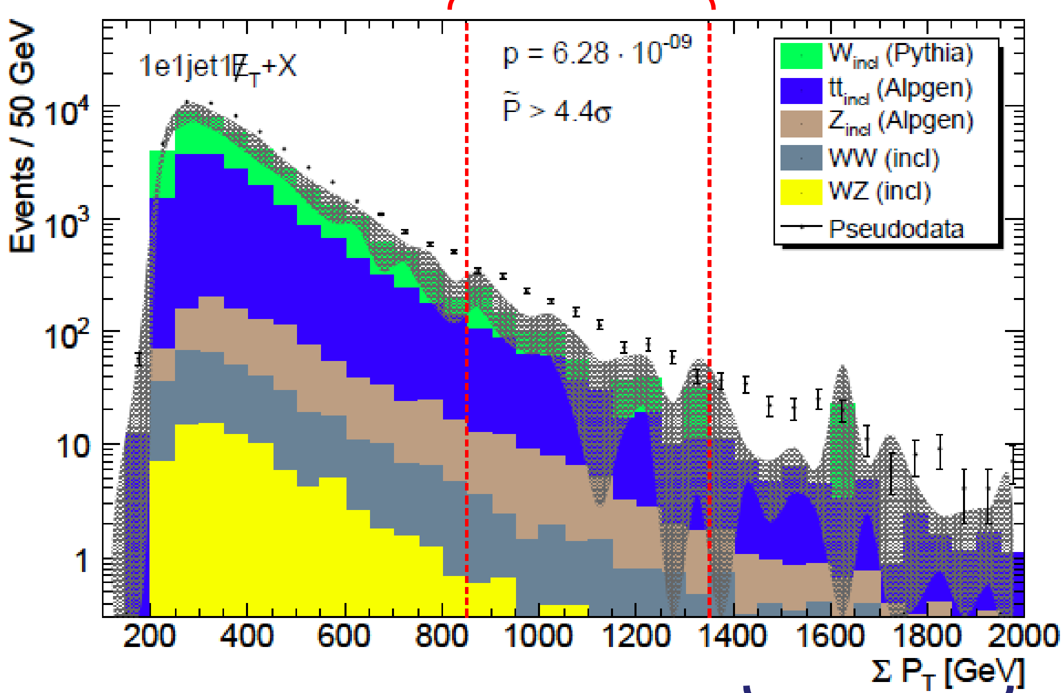


Comparison of Generators with MUSiC

- ALPGEN and PYTHIA have different momentum spectrum and multiplicities spectra for harder jets

- Toy experiments of W+jets with ALPGEN compared to inclusive $W \rightarrow e\,\nu$ PYTHIA MC

Region of Interest: $p = 6.28\ 10^{-9}$ and $P > 4.4\ \sigma$



Excluded due to lack of stat. for PYTHIA

Outlook

- A model-independent tool for automatic search of deviations from standard Model tested in CMS
- Function as physics monitor in early data
  - Contribute to identifying major detector effects affecting all physics objects
- Prove robustness as more data become available
  - Improved expectation to gain confidence in automatic search outcome
- In longer term with well understood detector and under-control systematic uncertainties attempt at search for new signals
  - Missing energy will be understood and corrected for instrumental effects
  - Deviations of missing energy crucial for search of unexpected signals
- With 1 fb^{-1} of data hints of deviations due to mSUGRA (LM4) on top of Standard Model expectation in many final states
  - 36% of inclusive final states in Σp_T spectrum
  - 59% of inclusive final states in MET spectrum