Model Independent Searches at D0

Pheno 2007

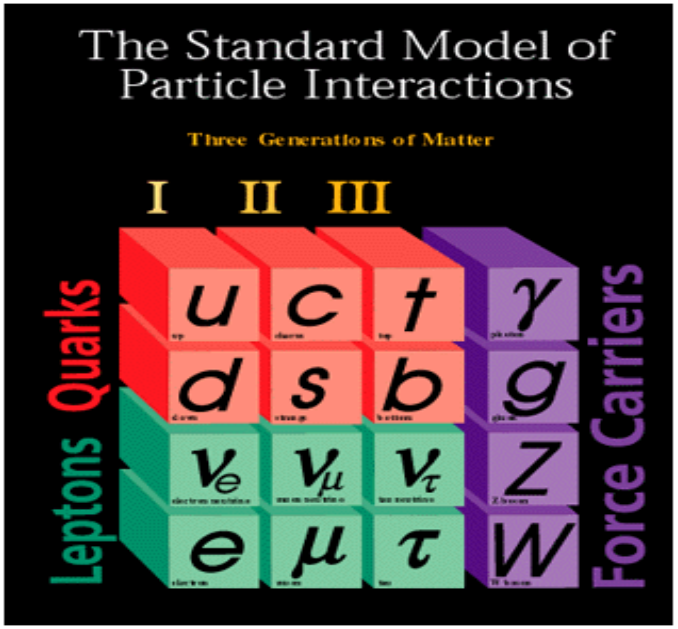
Joel Piper

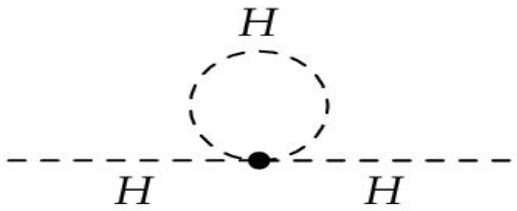
Oleksiy Atramentov, Jim Kraus, Jim Linnemann,
Arnd Meyer, Md. Naimuddin, Serban Protopopescu

May 7, 2007

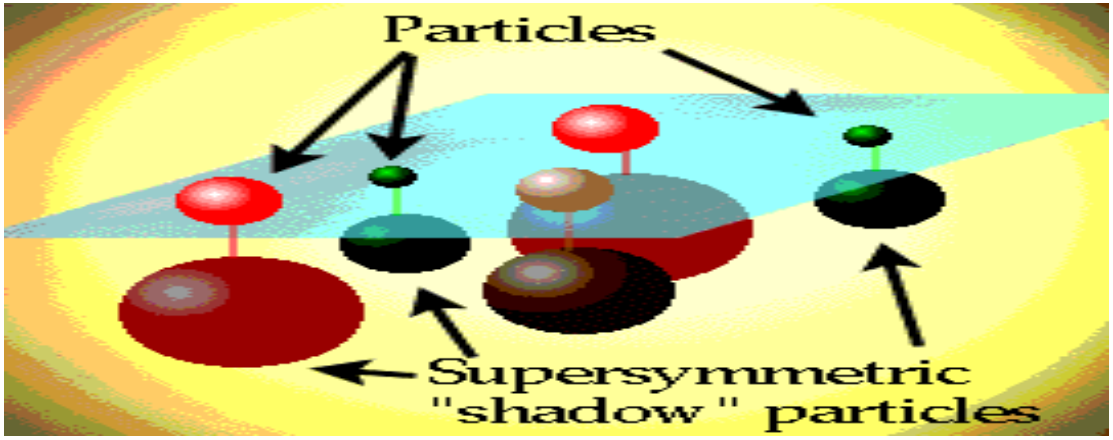
Motivation

- Standard Model has guided us for the past 35 years
- However, it is incomplete and leaves some aesthetic difficulties
  - Gravity not incorporated
  - Fine-tuning of Higgs mass
  - Lack of unification of forces at high energy
- Theorists have devised numerous extensions to the Standard Model to deal with these difficulties.....





....but with limited time and resources where do we look?



- Many extensions to the Standard Model can predict an overwhelming amount of possible signals with quite unique characteristics
- In this environment, it is impossible to investigate every theoretical model
- We must choose among these models and the parameters within them to determine where to invest our resources
  - Which are the most interesting?
  - Where do we have reasonable acceptance?

Is there another way?

- Questions:
  - Is it possible to conduct a generic search for physics beyond the Standard Model?
  - Can we introduce a practice to complement dedicated searches with a quantitative search for deviations from the Standard Model expectation?
- Answer:
  - It has been done before
    - At D0 for Run I
    - CDF Run II (previous talk), H1, ALEPH, L3
- But:
  - Finding a deviation does not necessarily imply new physics

So, we find a deviation. What does it mean?

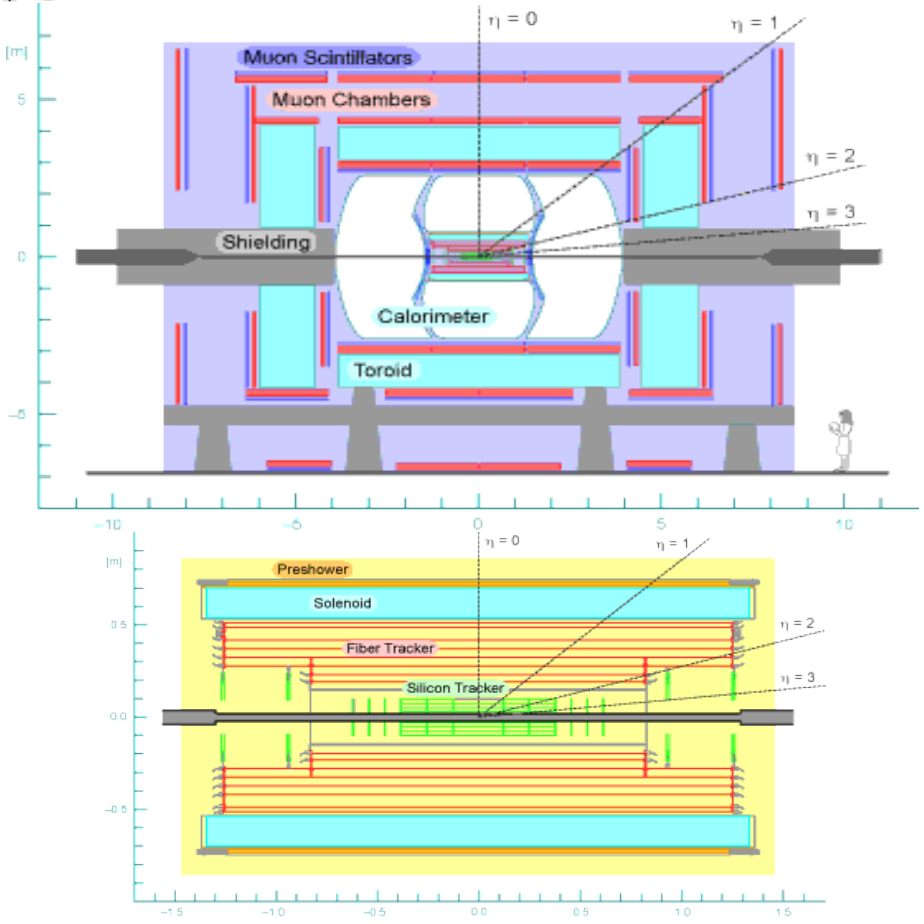
- What can cause an unexpected deviation
  - Statistical fluctuations
  - Imperfect background models
    - Most standard model processes have only been calculated to leading order or next-to-leading order, and we do not possess the processing power to incorporate everything that has been calculated into our Monte Carlo
  - Detector Effects
    - Detector described in next slide

The more places that are searched, the more likely one is to find something

May not simulate actual outgoing particles

Detector model may not respond in expected way to incoming particles

The D0 Detector



- General purpose detector for the study of short-distance phenomena in high energy antiproton-proton collisions at the Fermilab Tevatron Collider at $\sqrt{s} = 1.96\,TeV$
  - Silicon microstrip tracker
  - Central fiber tracker
  - Uranium/liquid argon calorimeter
  - Central and forward muon systems
  - Three-level trigger system

Our Search Strategy

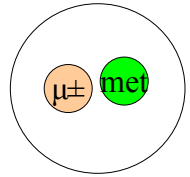
- Introduce a new data format so we can quickly fine-tune our background modelling
- In a small fraction of the full dataset, look for gross differences between data and Monte Carlo
- Investigate and resolve these, improving our implementation of the Standard Model.....
- ...or find new physics
- Once we have understood discrepancies from detector modelling and Monte Carlo, we will do a rigorous search for smaller deviations in the full dataset.

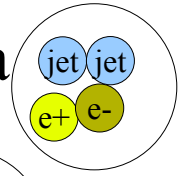
New High-p_T Dataset

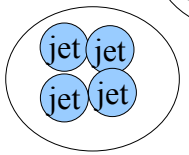
- Preliminary conditions for keeping an event:
  - An isolated μ with $p_T > 20$ GeV
  - An isolated e with $p_T > 25$ GeV
  - An isolated γ with $p_T > 75$ GeV
  - An isolated τ with $p_T > 30$ GeV
  - A jet with $p_T > 150$ GeV
  - Missing transverse energy > 80 GeV
  - A photon with $p_T > 30$ GeV and missing transverse energy > 30 GeV
  - A pair of either: isolated leptons, lepton-photon, or photon-photon with $p_T > 12$ GeV

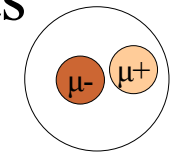
Search for Deviations- Vista

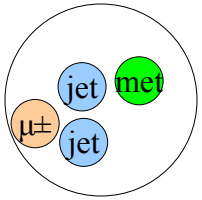
- We are currently comparing 10% of the Run IIa dataset with 100's of Pythia and Pythia-matched Alpgen Monte Carlo samples
- First, events are converted from our high-p_T format to the ascii format used by the experiment-independent Vista program
- Vista is then run for a preliminary comparison
  - Developed by Bruce Knuteson for CDF Run II
  - Optimized to fit D0 Run II data
- Vista divides events into exclusive final states based on our strictly defined physics objects
- No overlap of final states

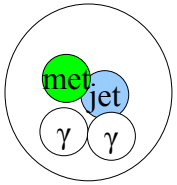




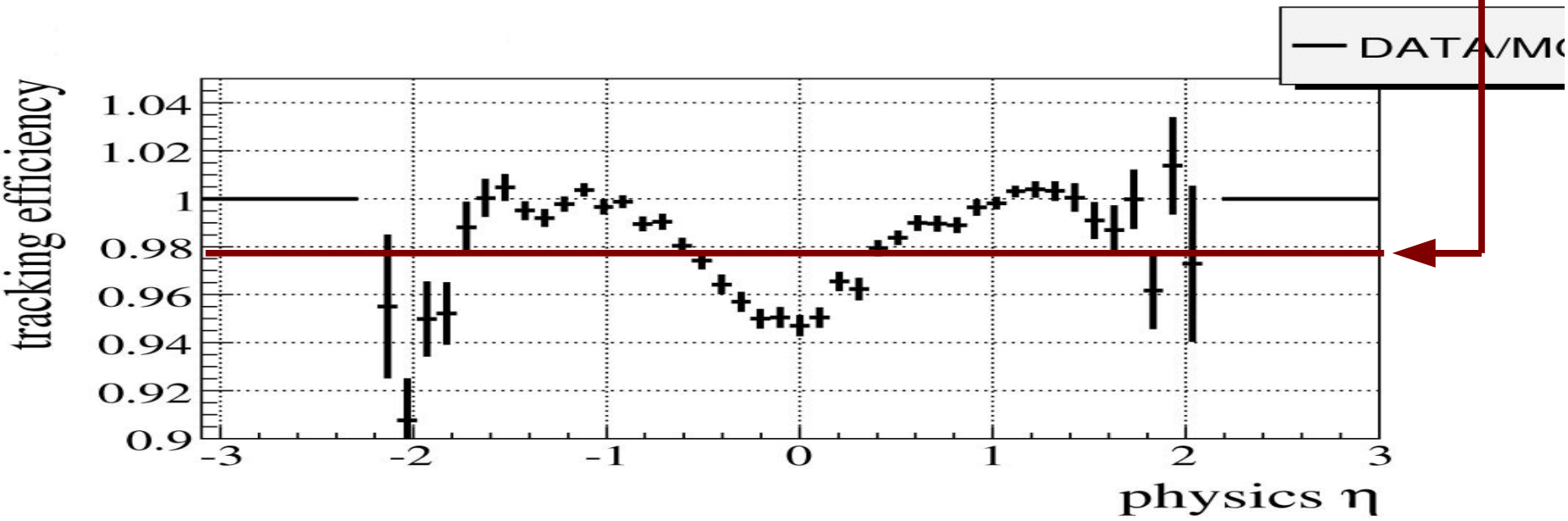






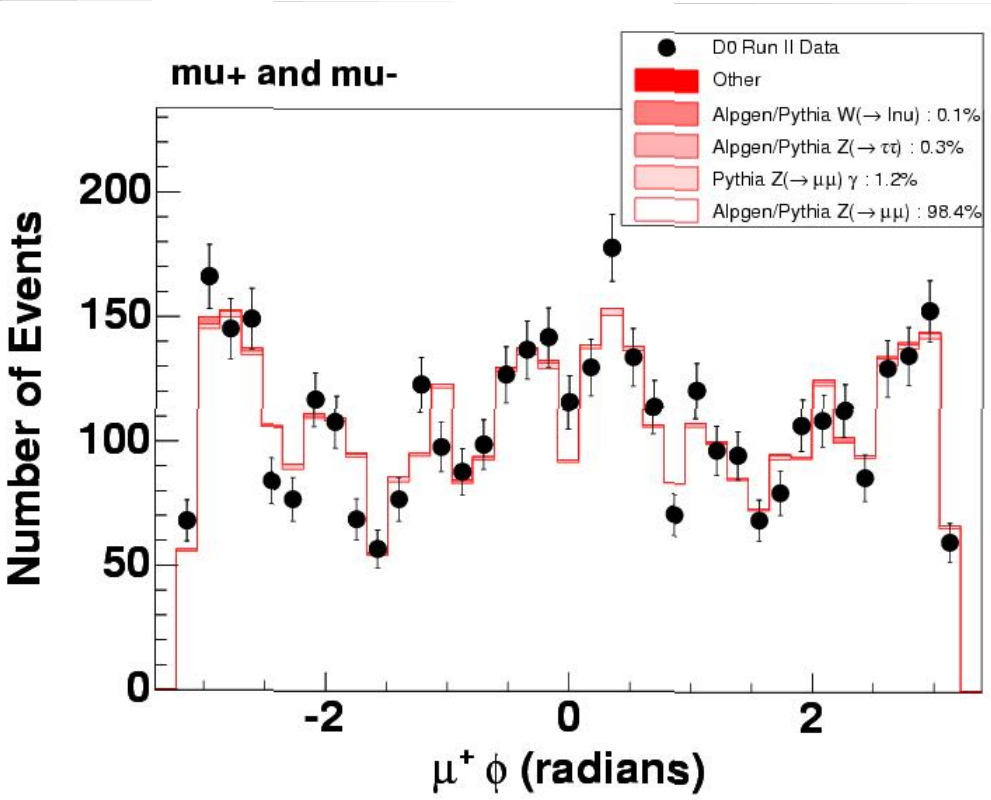


Vista "Fudge Factors"



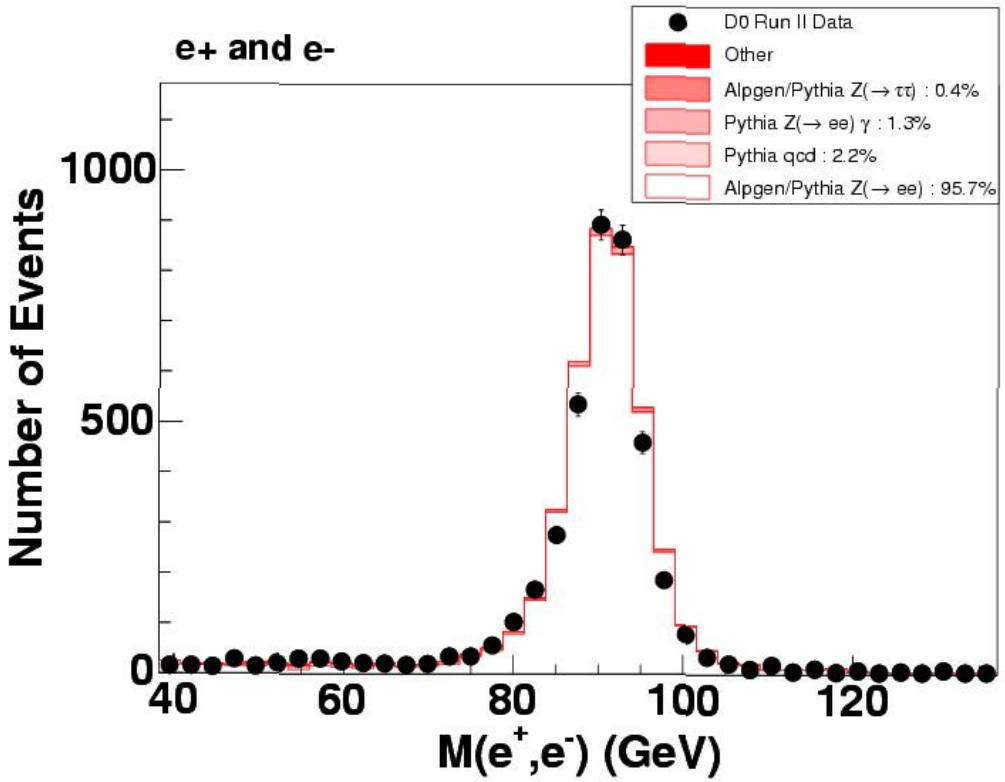
- Need correction factors to model detector effects and event kinematics
  - Efficiencies, k-factors, misreconstruction probabilities
- Use official D0 measurements

Comparison



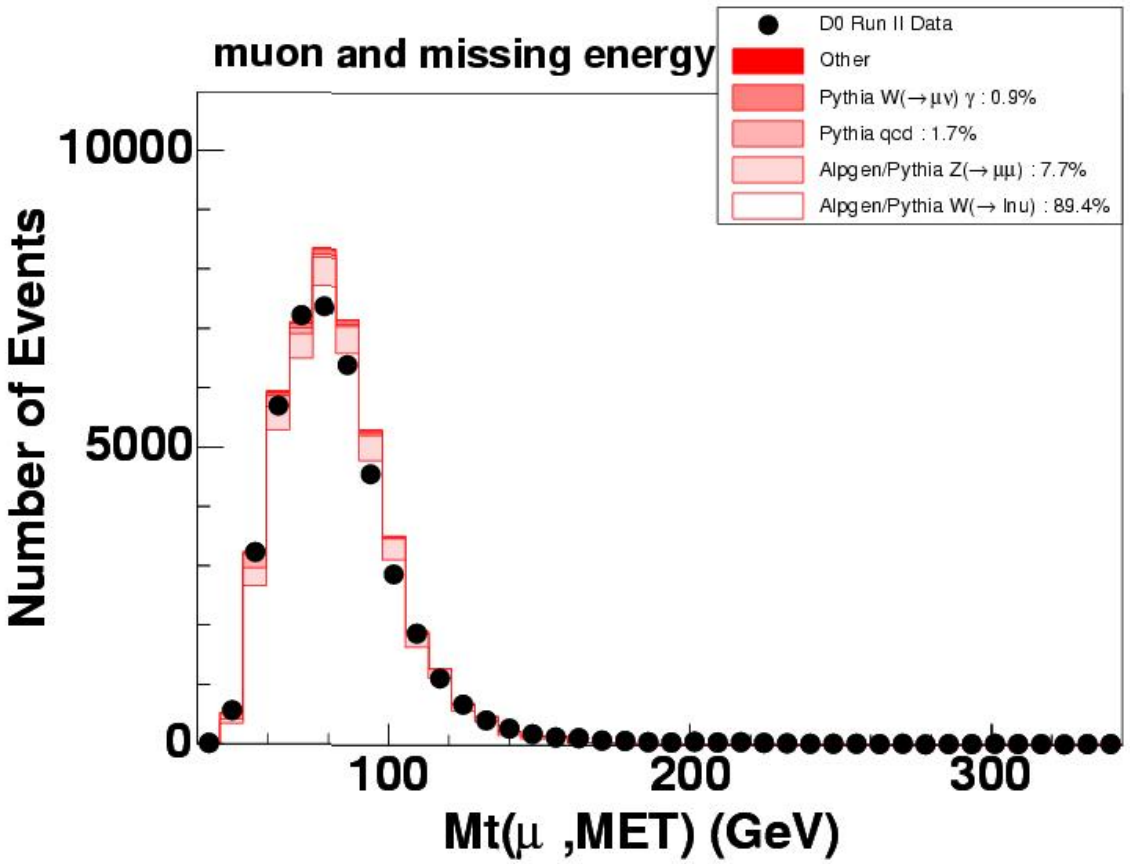
- Compare raw numbers of expected events that fall into particular final states
- Look at the shapes of 1-D histograms and use Kolmogorov-Smirnov test to quantify agreement

Invariant mass of dielectron events

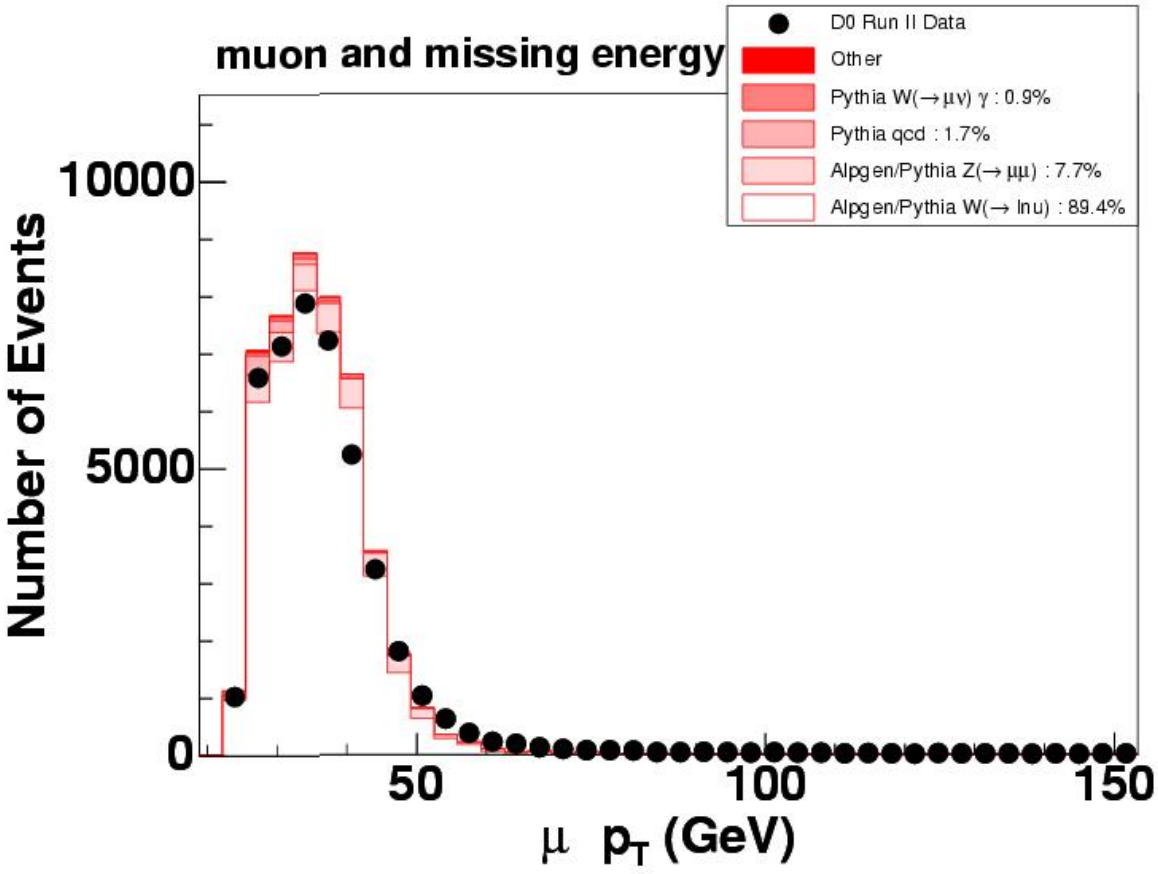


- The data/MC comparisons here are a work-in-progress
- A number of known corrections still need to be applied
  - Trigger efficiencies
  - Corrections to account for known MC deficiencies in W/Z production
  - Insufficient MC statistics in some channels

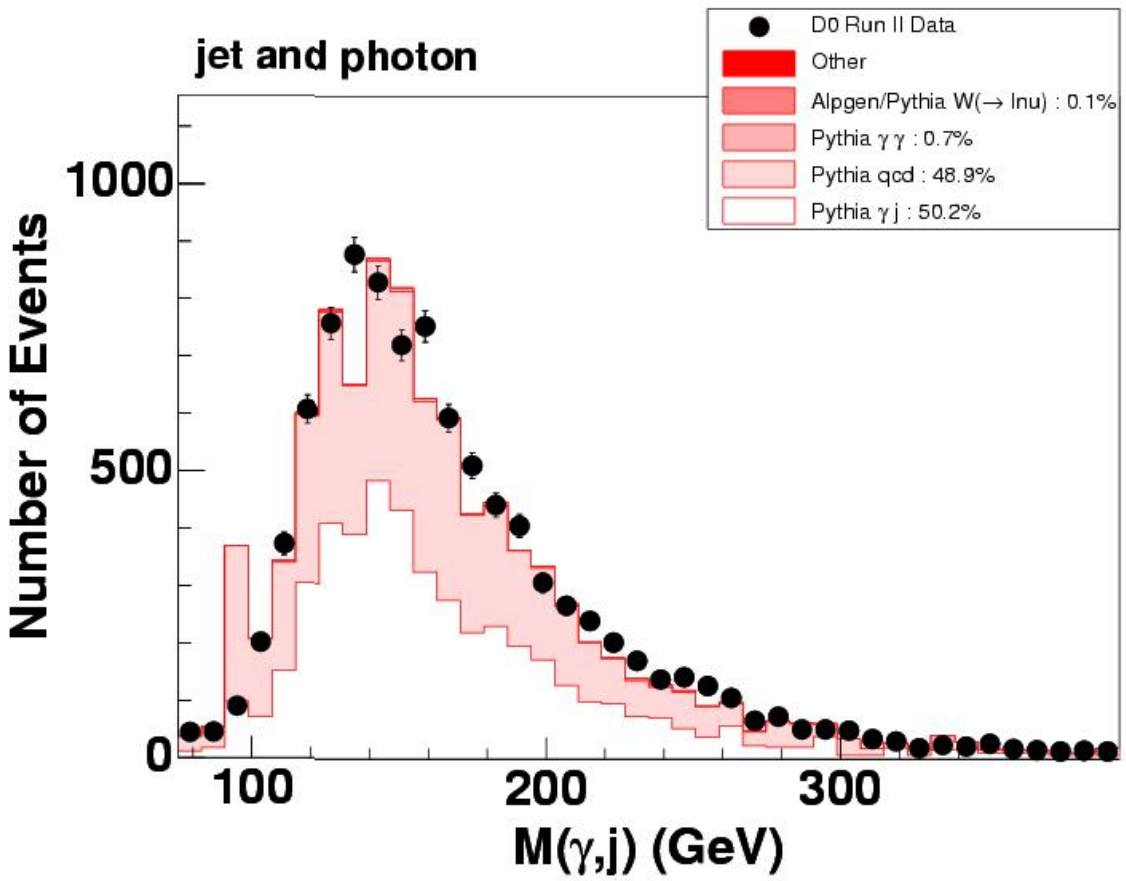
Transverse mass in muon and missing energy final state



Muon p_T in muon and missing energy final state



Invariant mass of jet and photon



Conclusion and Next Steps

- With ~100 pb^{-1} of data, a vast majority of final states are in good agreement with the Standard Model
  - With 100 pb^{-1} dataset, continue to improve corrections to the simulation for detector and physics effects not properly described
  - Develop ahead of time, a search strategy for finer deviations from the Standard Model expectation
  - Move on to full Run IIa dataset
- The Tevatron is currently running well and we expect ~ 8 fb^{-1} by 2009
  - Effectively quadruples our current dataset, improving our chance of seeing new physics and providing valuable insight into the early search strategy at the LHC
- We would like to thank Bruce Knuteson for his support in getting this analysis off the ground and look forward to an eventual combination with CDF