Initial State Gluon Radiation in Drell-Yan Dilepton Production

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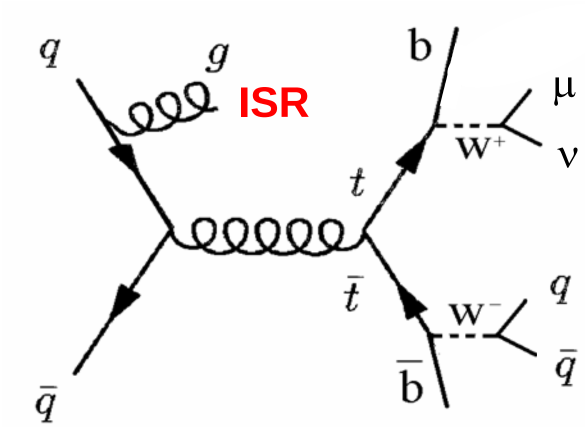
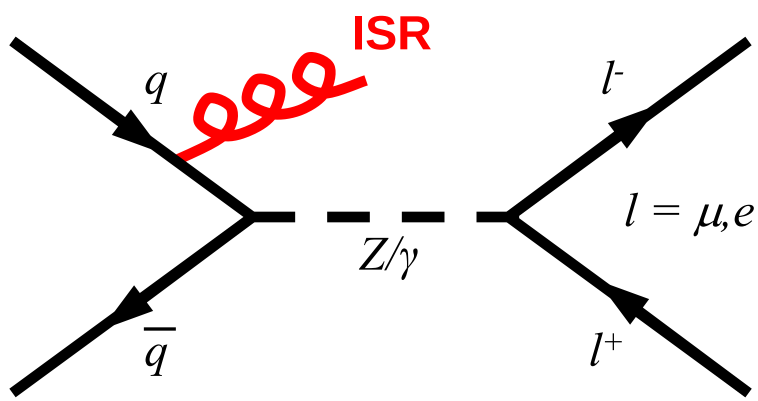
The Top Quark

- Discovered in 1994-5 at Fermilab, currently the focus of many studies
- M_{top} = 172.7±2.9 GeV/c^2 (current world average)
  - Precision measurement of M_{top} is necessary for constraining the Higgs mass
  - Goal by end of Run II: to reduce uncertainty on top mass to <1.5 GeV
- Initial state gluon radiation (ISR) creates uncertainty (~0.5 GeV) because we don't know how often it happens.



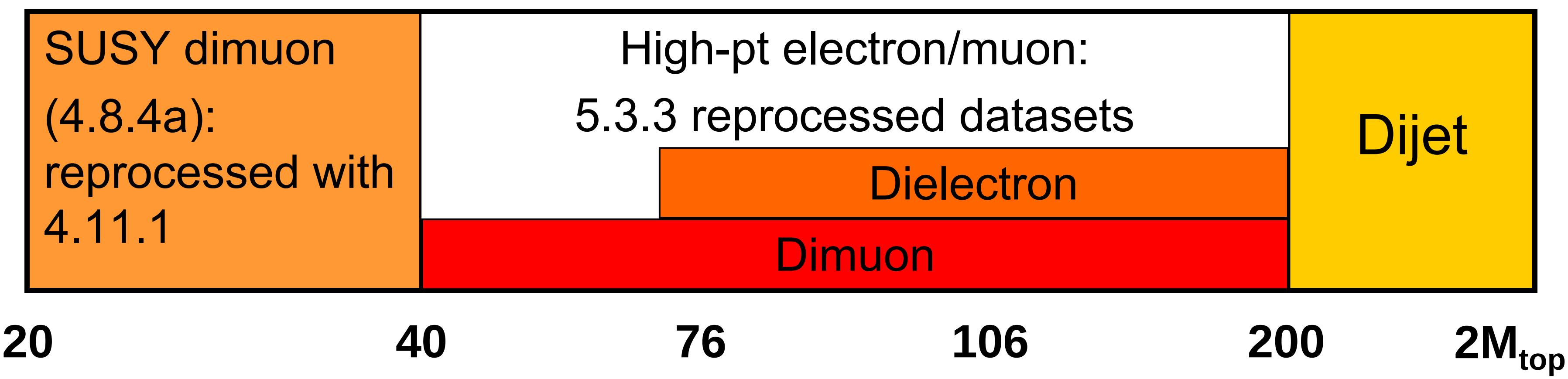
Drell-Yan Process

- Very similar to top production process
- Dominated by quark-antiquark annihilation, but in lower mass region
- Z decays into lepton pairs (**e**, μ, or τ pair)



Analysis

- Datasets: High-P_T e/μ data collected between March 2002 and August 2004
- Based on previous blessed analysis, CDF Note 6804 (190pb^{-1} dataset)
- Parameters of interest: P_T*(dilepton)*, N_{jets}, and $\Delta\phi$*(dilepton)* (sensitive to extra gluon radiation) in the different DY mass regions.



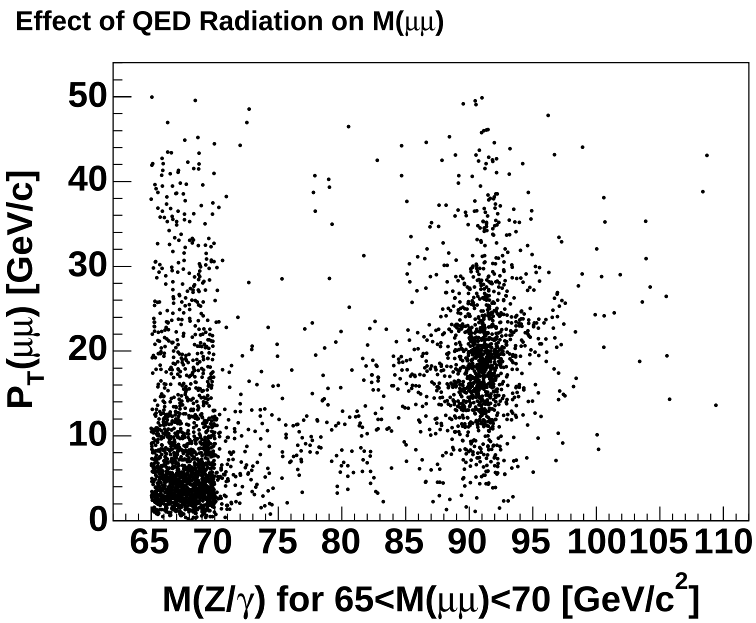
Event Selection

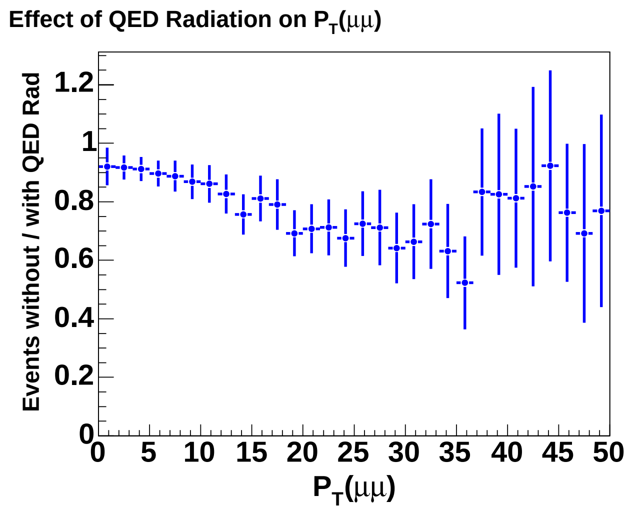
	1st lepton	2nd lepton	*
High-P_T muon (M>40)	Standard CMUP CMX (P_T>20)	Standard CMUP CMX CMP (P_T>10*)	For P_T>10 EM<1 HAD<3
Low-P_T Muon (M<40)	Same as high-P_T muon, but P_T>10*	Same as high-P_T muon	
High-P_T electron (M>76)	Standard CEM	Standard CEM	

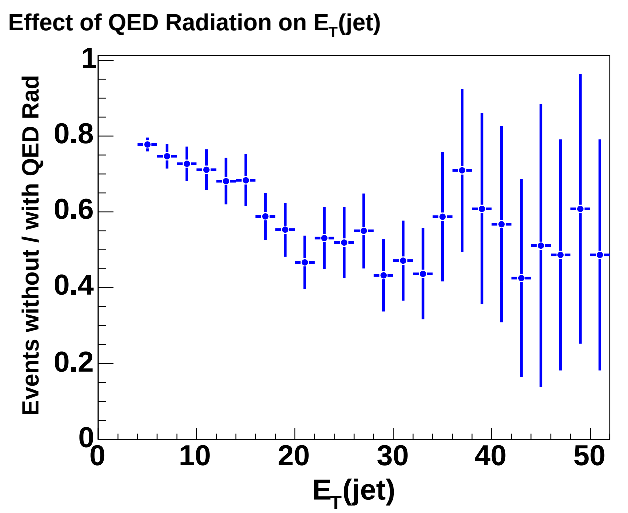
- No trilepton events
- del Z for two leptons<4cm with opposite charge
- MET<25
- No events with QED radiation

Effects of Photon Cut

Variable	cut
E_T	> 5 GeV
E_{had}/E_{em}	$< 0.055 + 0.00045E$
χ^2 (Strips+Wires)/2.0	< 20
Cal Iso / E_T	< 0.2
N track (N3D)	$<= 1$
Track P_t	$1 + 0.02E_t$







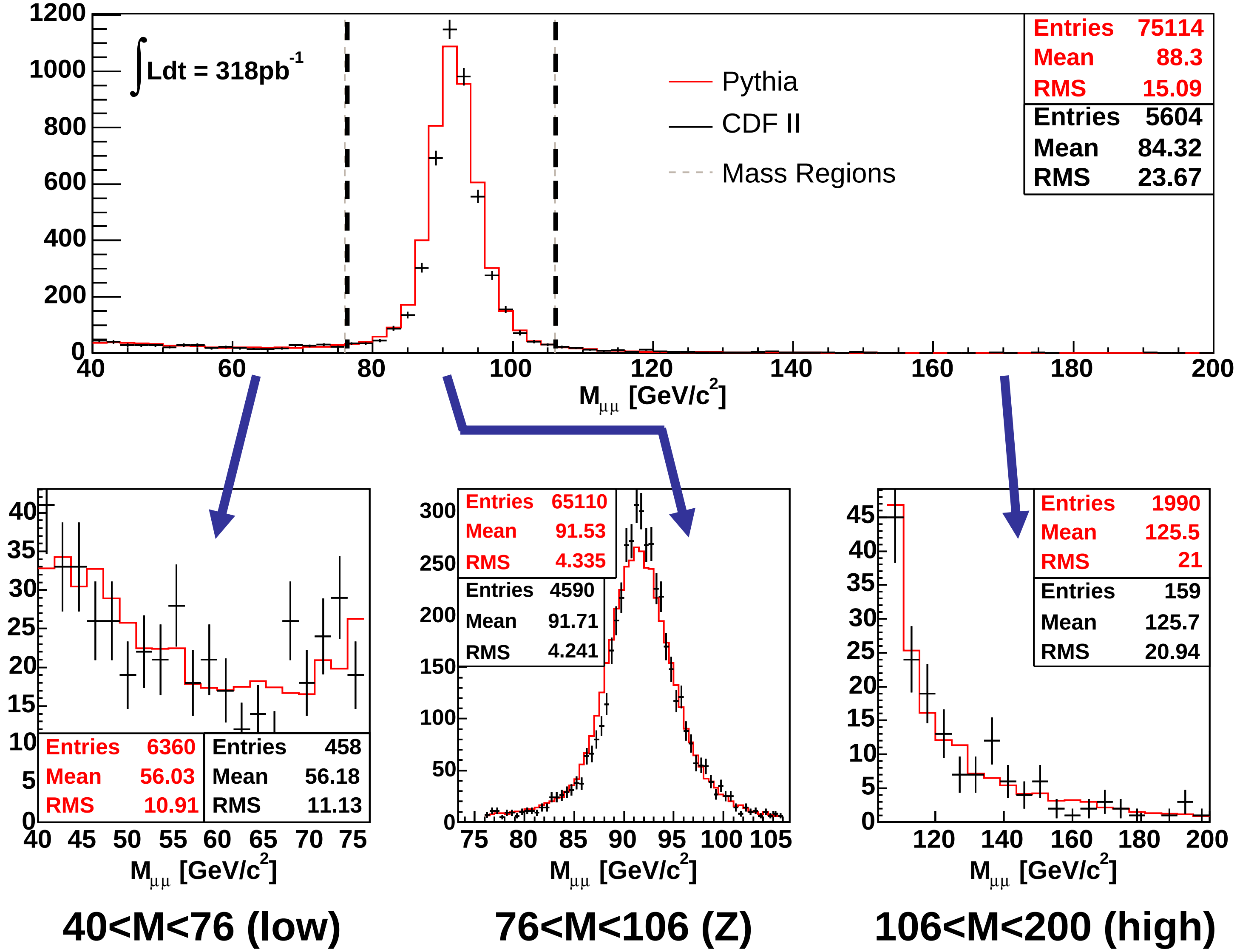
Backgrounds

- Most background processes are accounted for by event selection process
- Small background remaining:

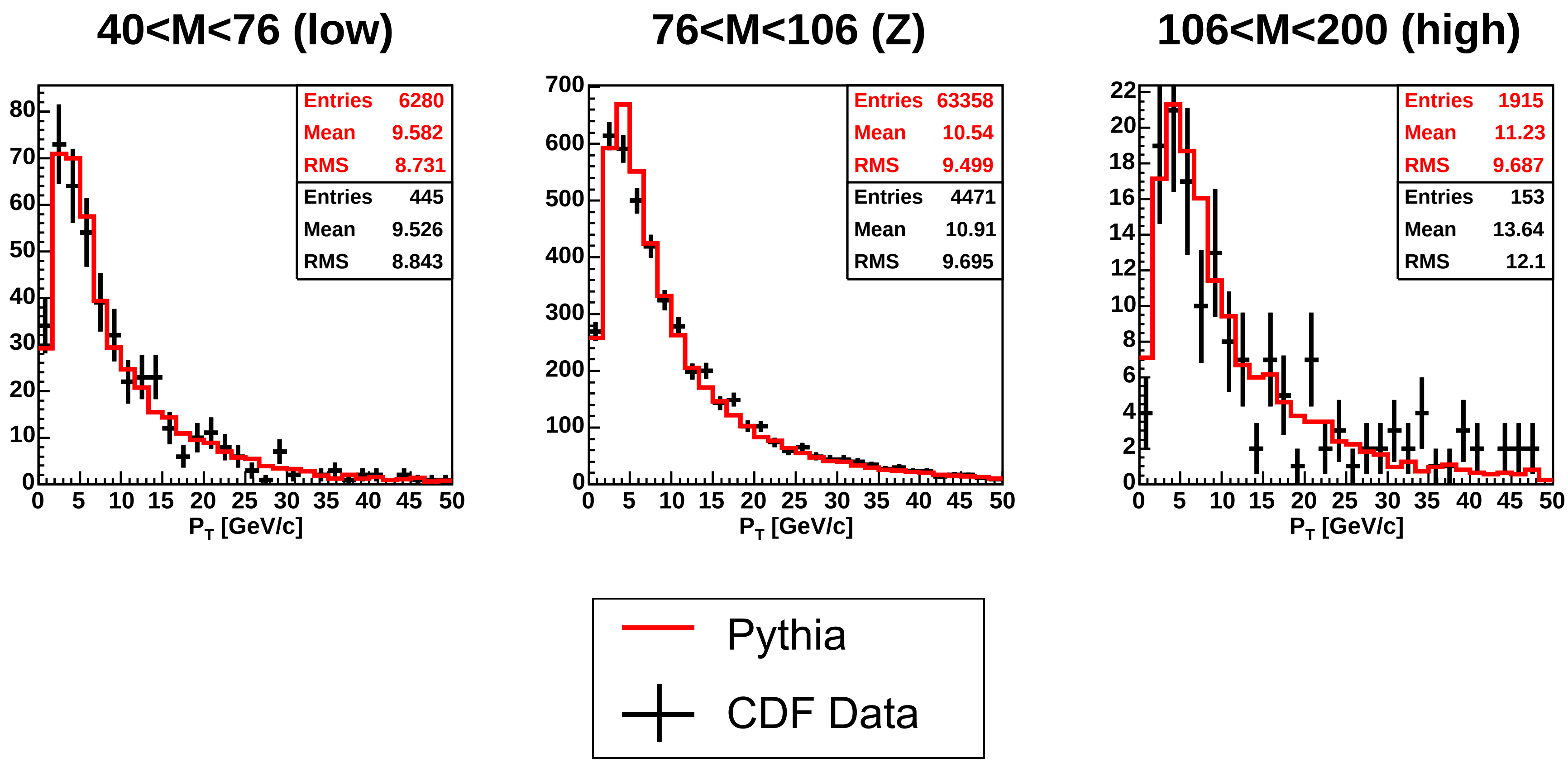
$$Z \rightarrow \tau\tau, \tau \rightarrow l\nu_l\nu_\tau$$

- 5% contribution in low mass region → 1% change in $P_T(\mu\mu)$

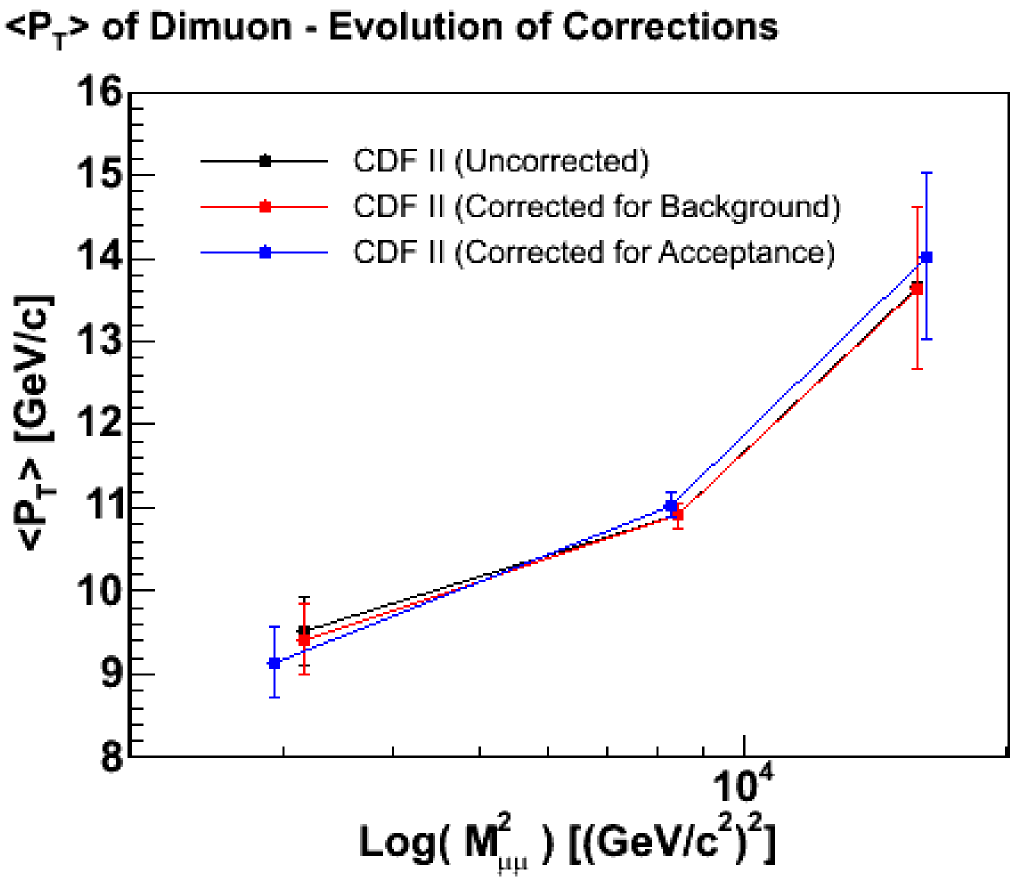
Invariant Mass of Dimuon



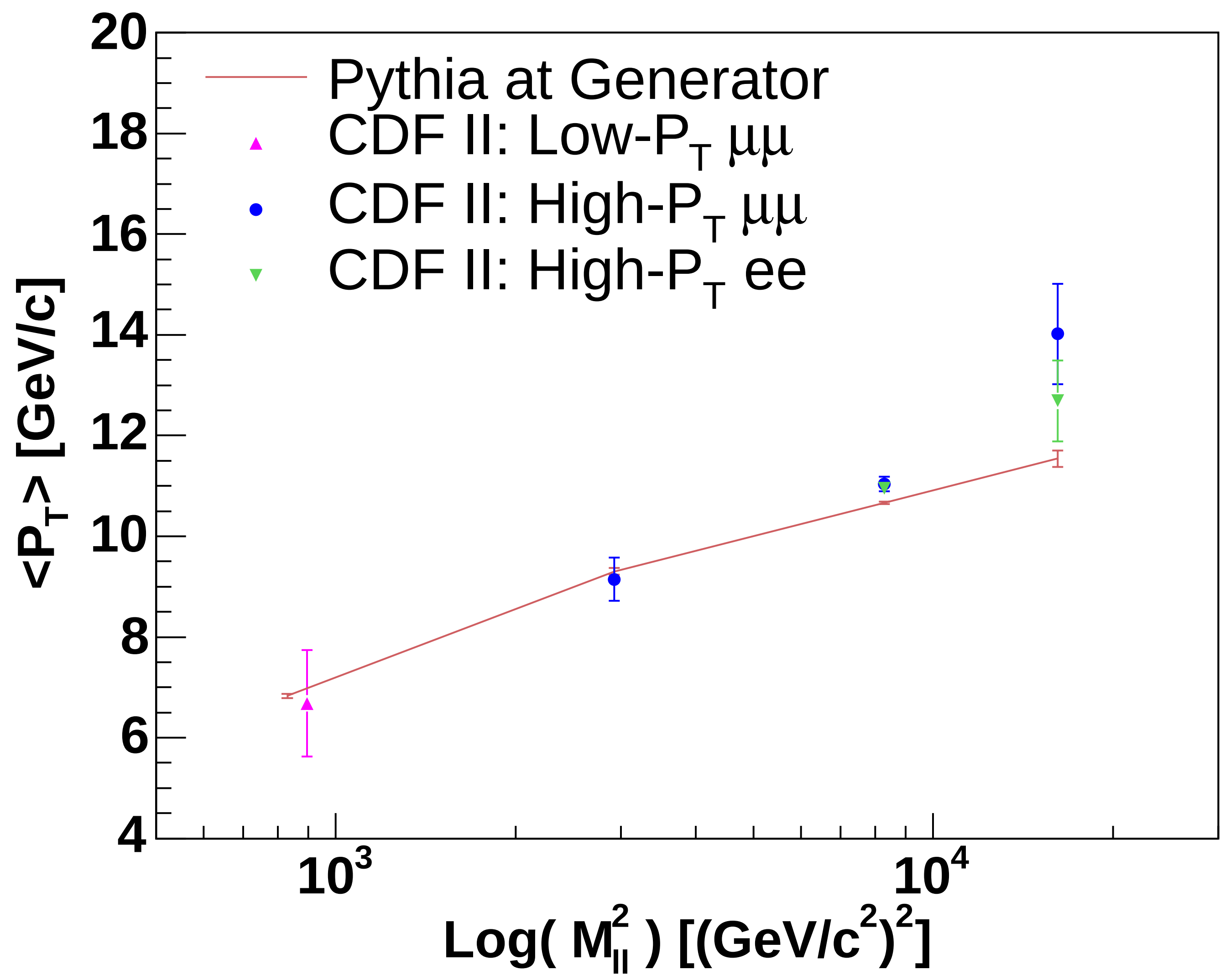
P_T of Dimuon: Data vs. Simulation



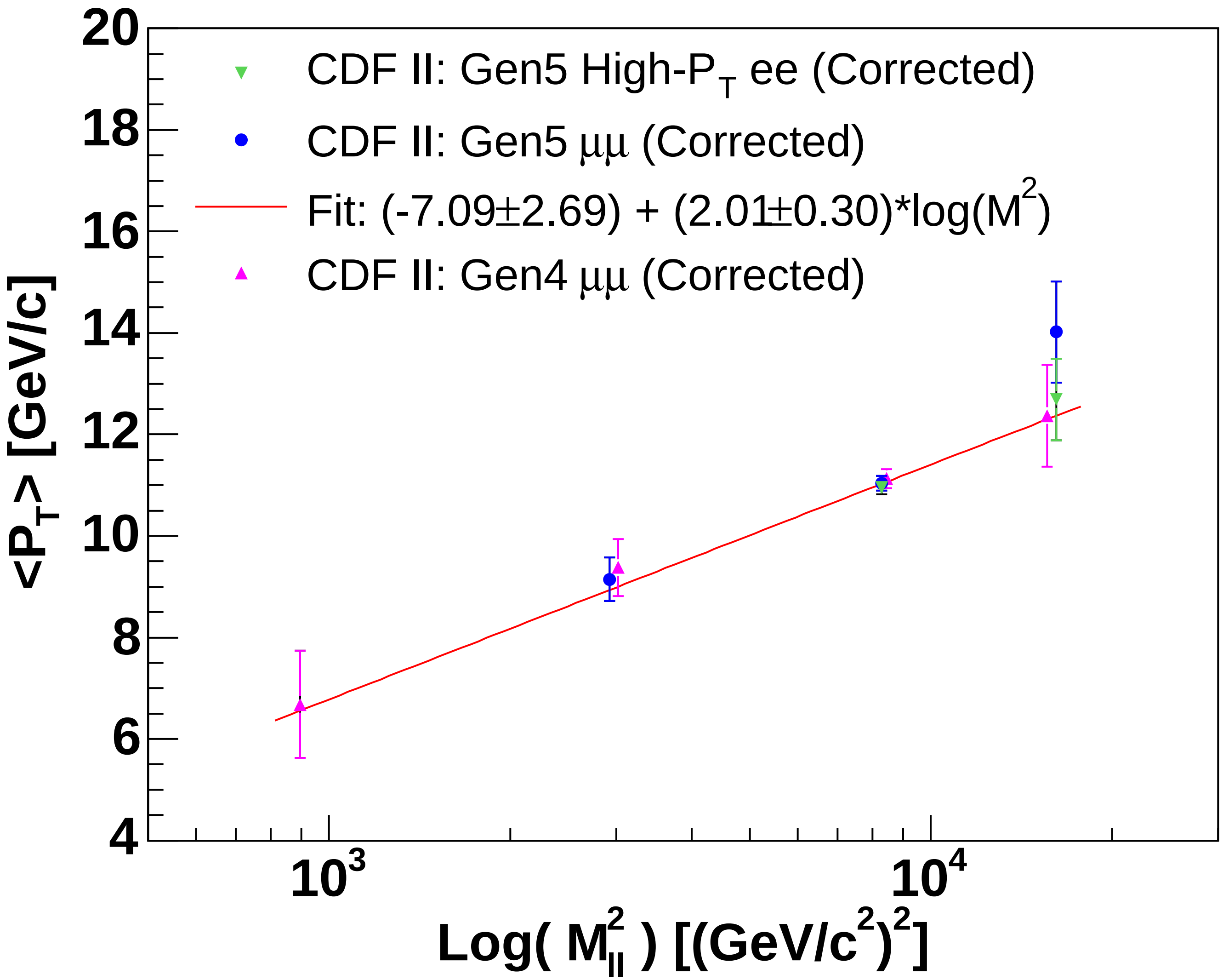
Corrections to <$P_T(\mu\mu)$>



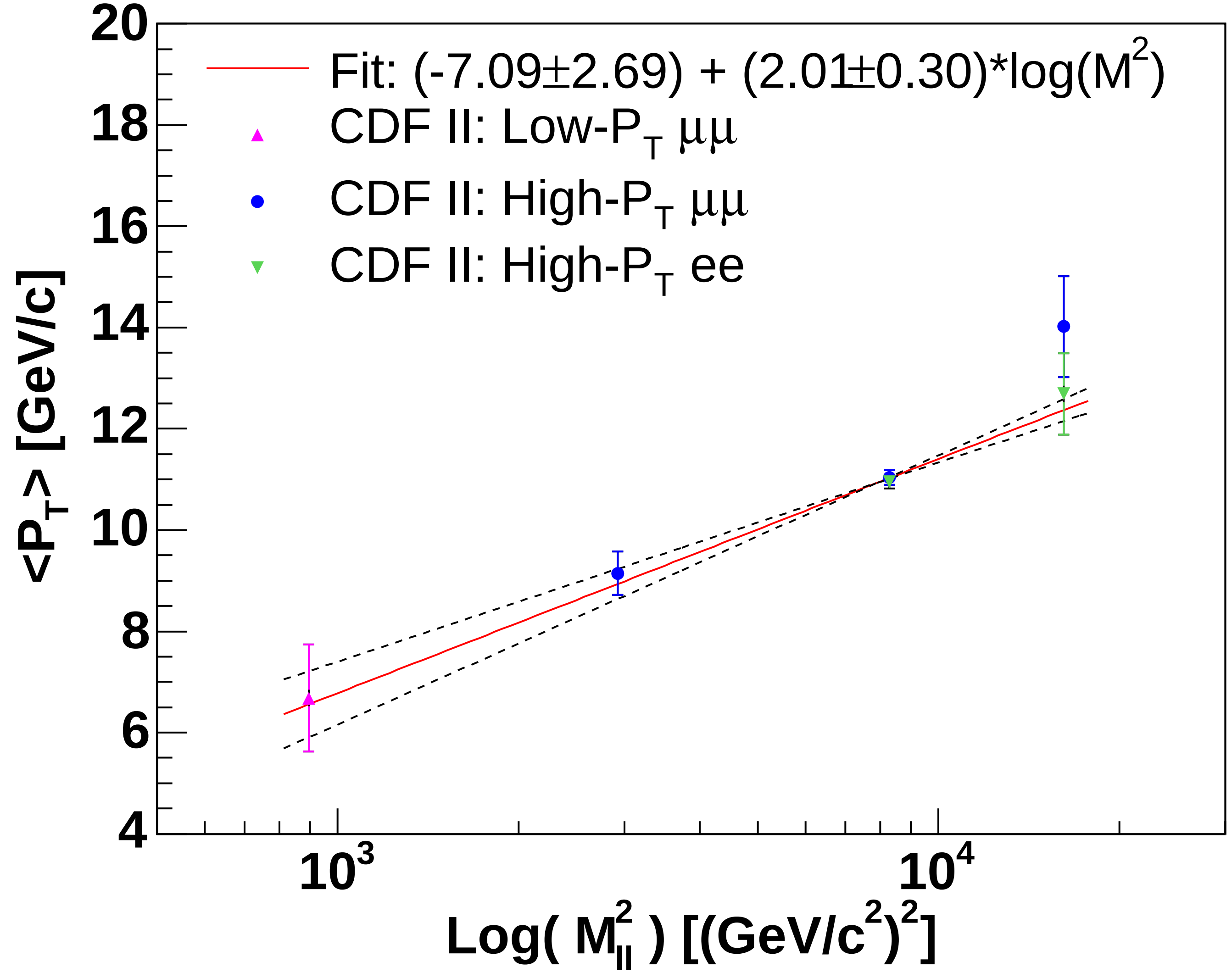
$<P_T>$ of Dilepton - Comparison of Data and Simulation

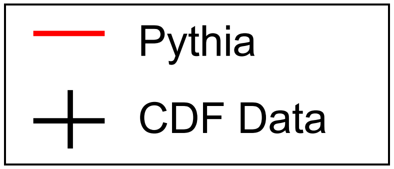


$\langle P_T \rangle$ of Dilepton - Gen4 vs. Gen5



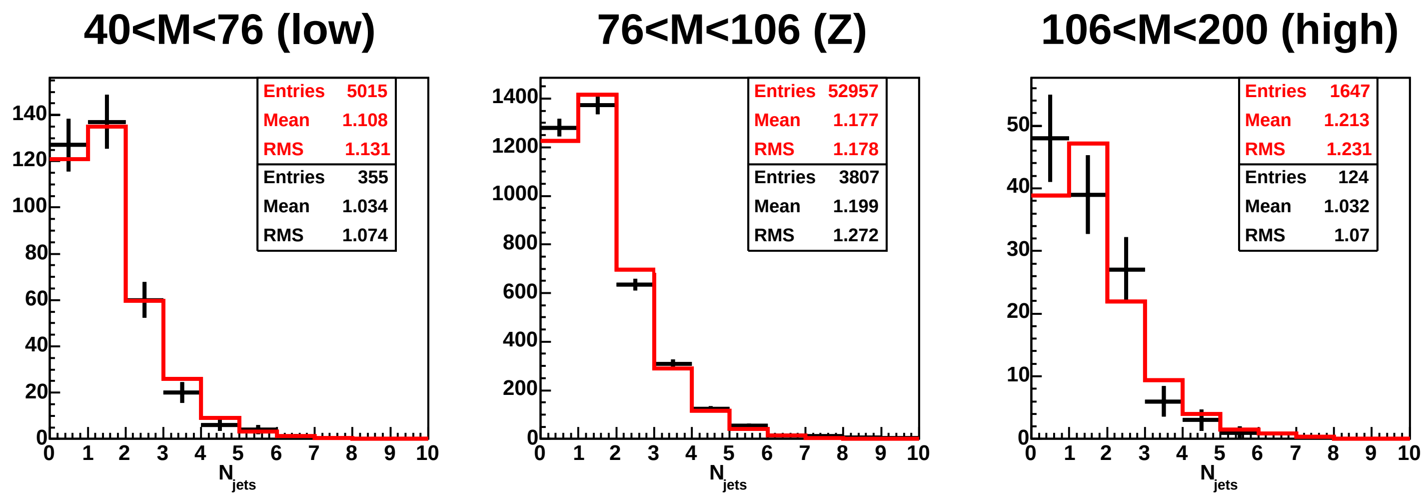
$<P_T>$ of Dilepton - Fit to Data

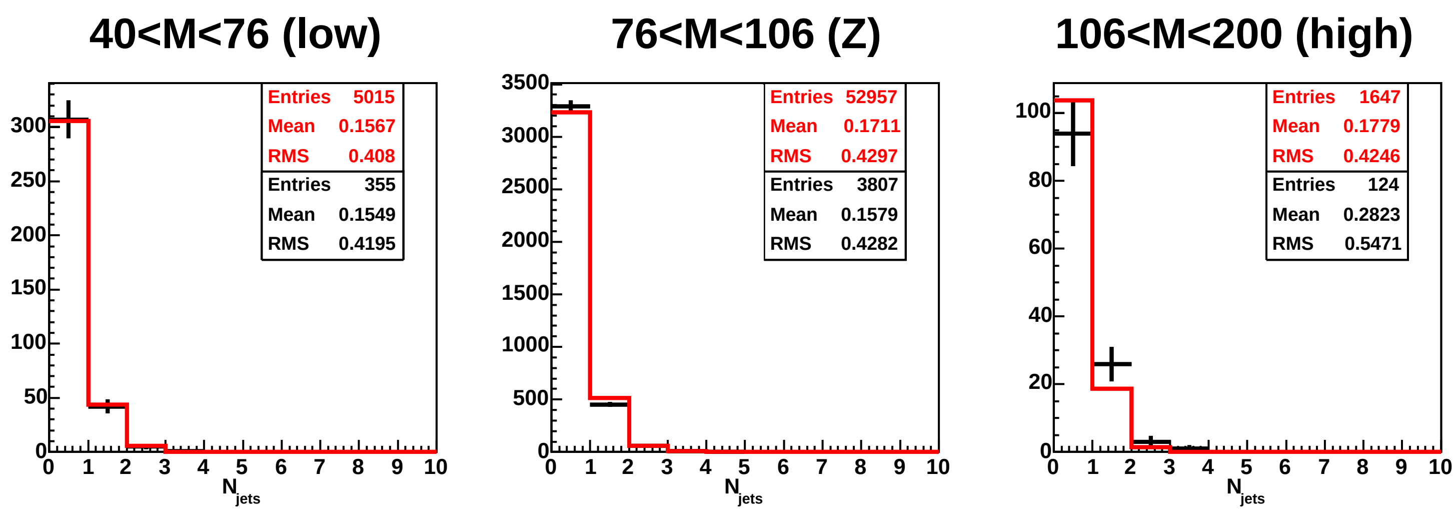




N_{jets} Distribution

$4 < E_T < 15$ GeV
(Soft Jets)

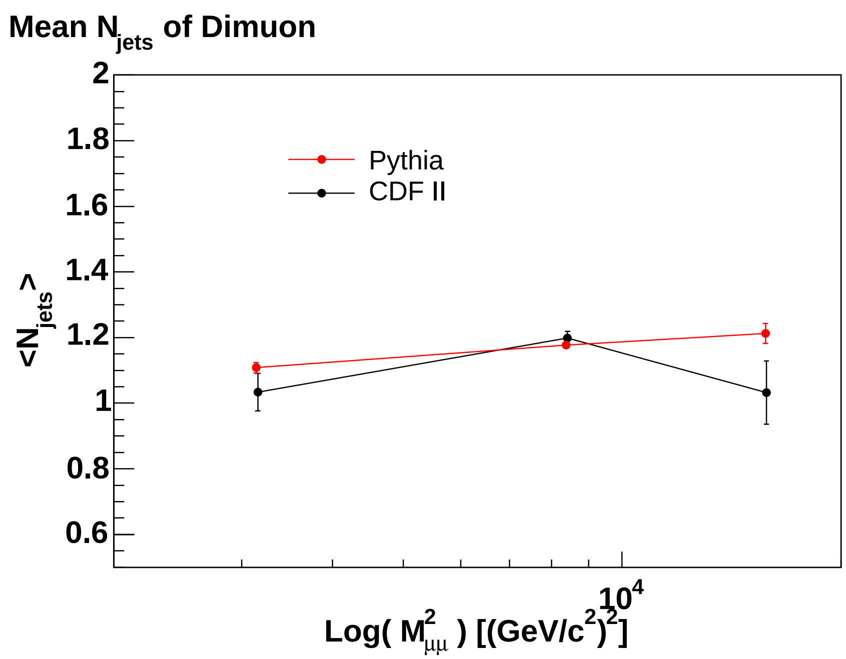




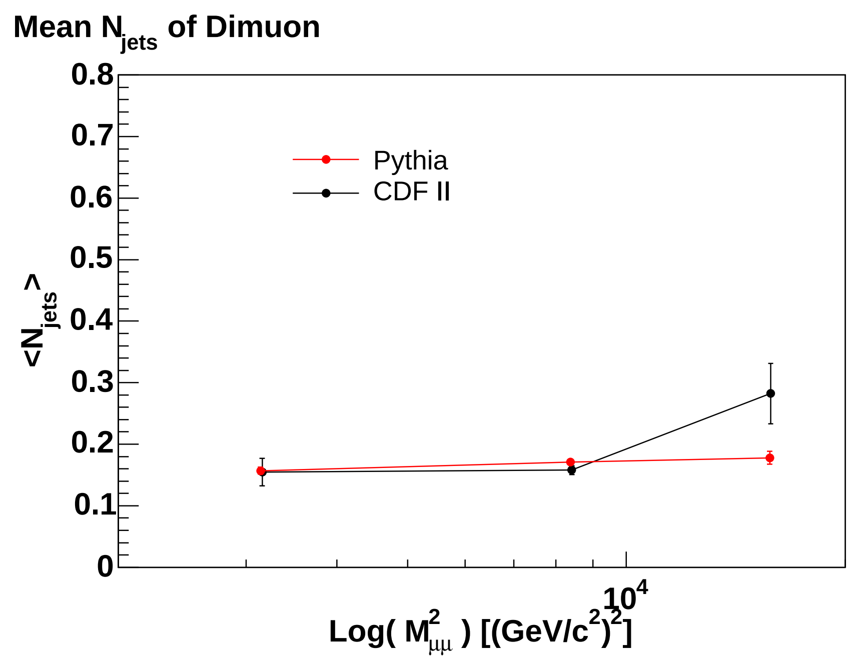
$E_T > 15$ GeV
(Hard Jets)

N_{jets}: Q^2 Dependence

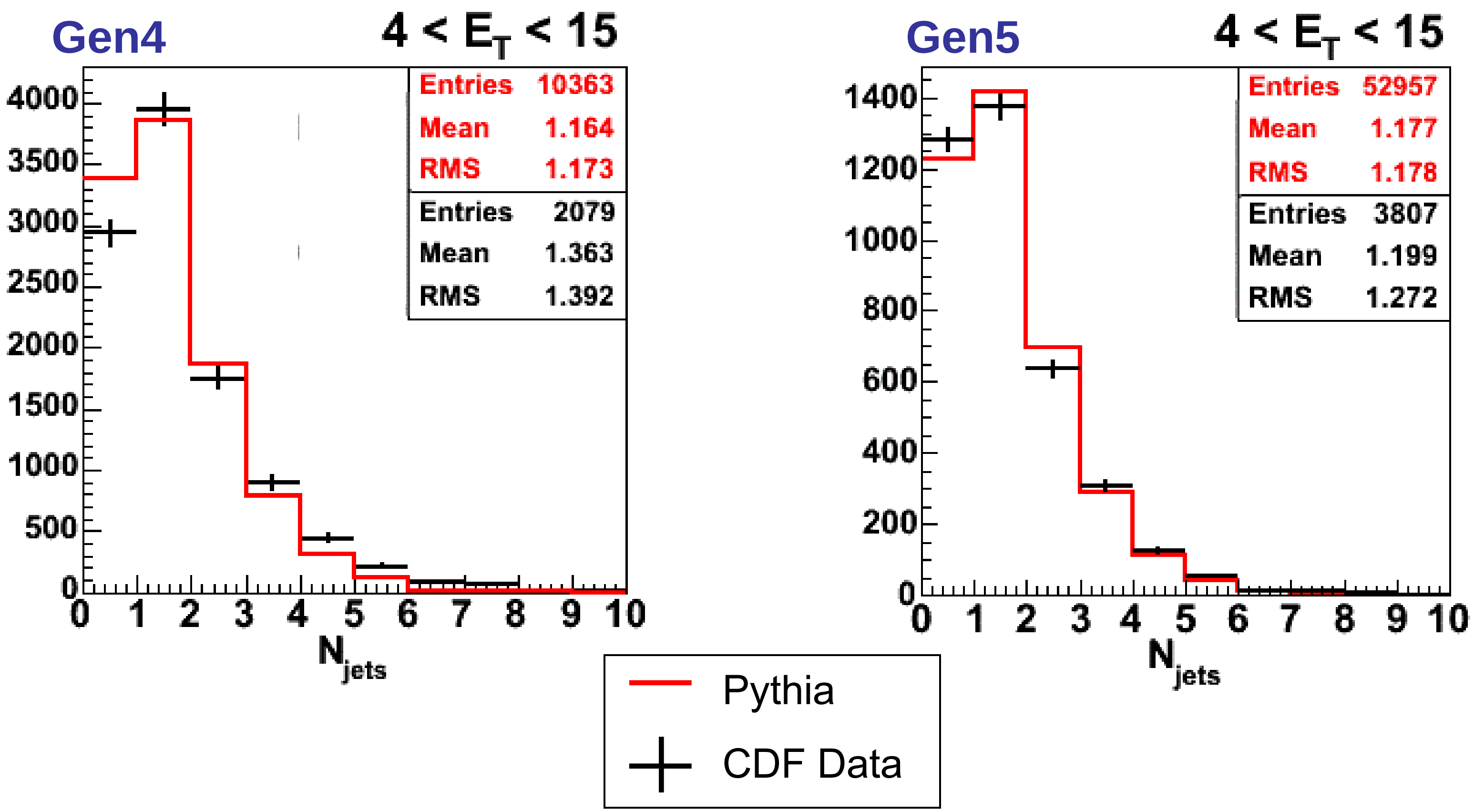
Soft Jets ($4 < E_T < 15$ GeV)



Hard Jets ($E_T > 15$ GeV)



Gen4 vs Gen5: N_{jets} Distribution

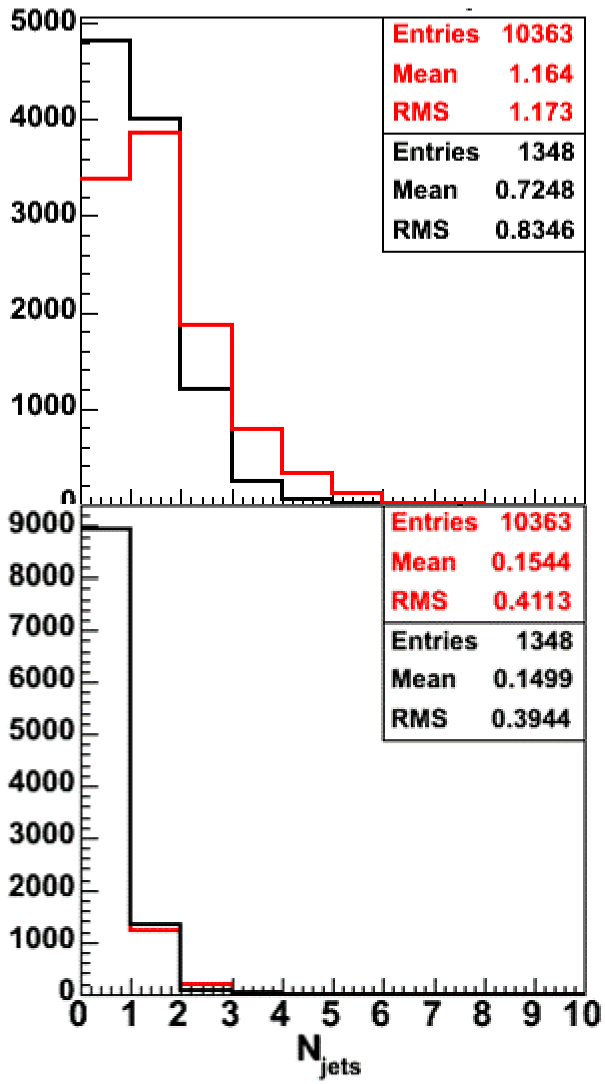


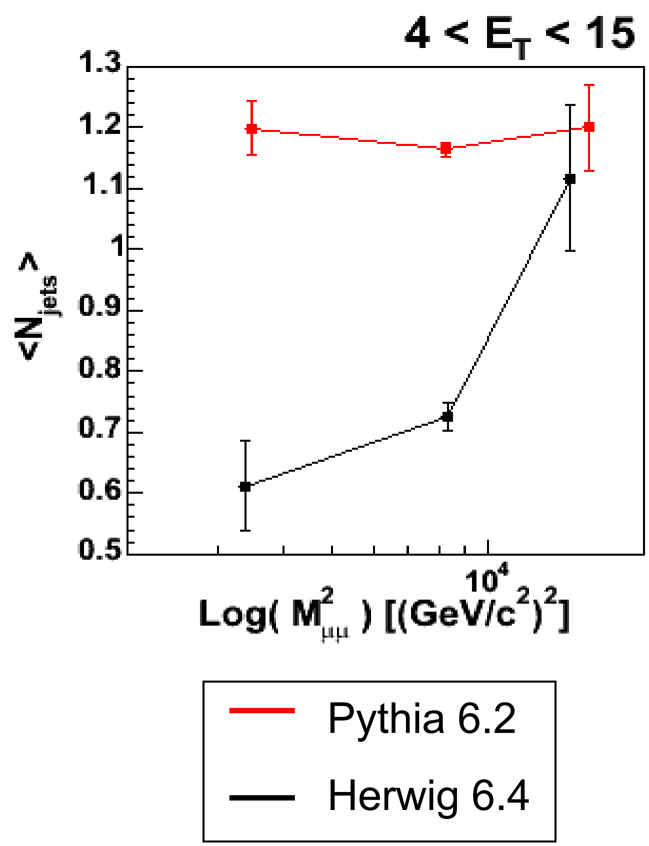
N_{jets} dist. has improved in Gen5!

Pythia vs. Herwig (Gen4)

Soft Jets
$4 < E_T < 15$

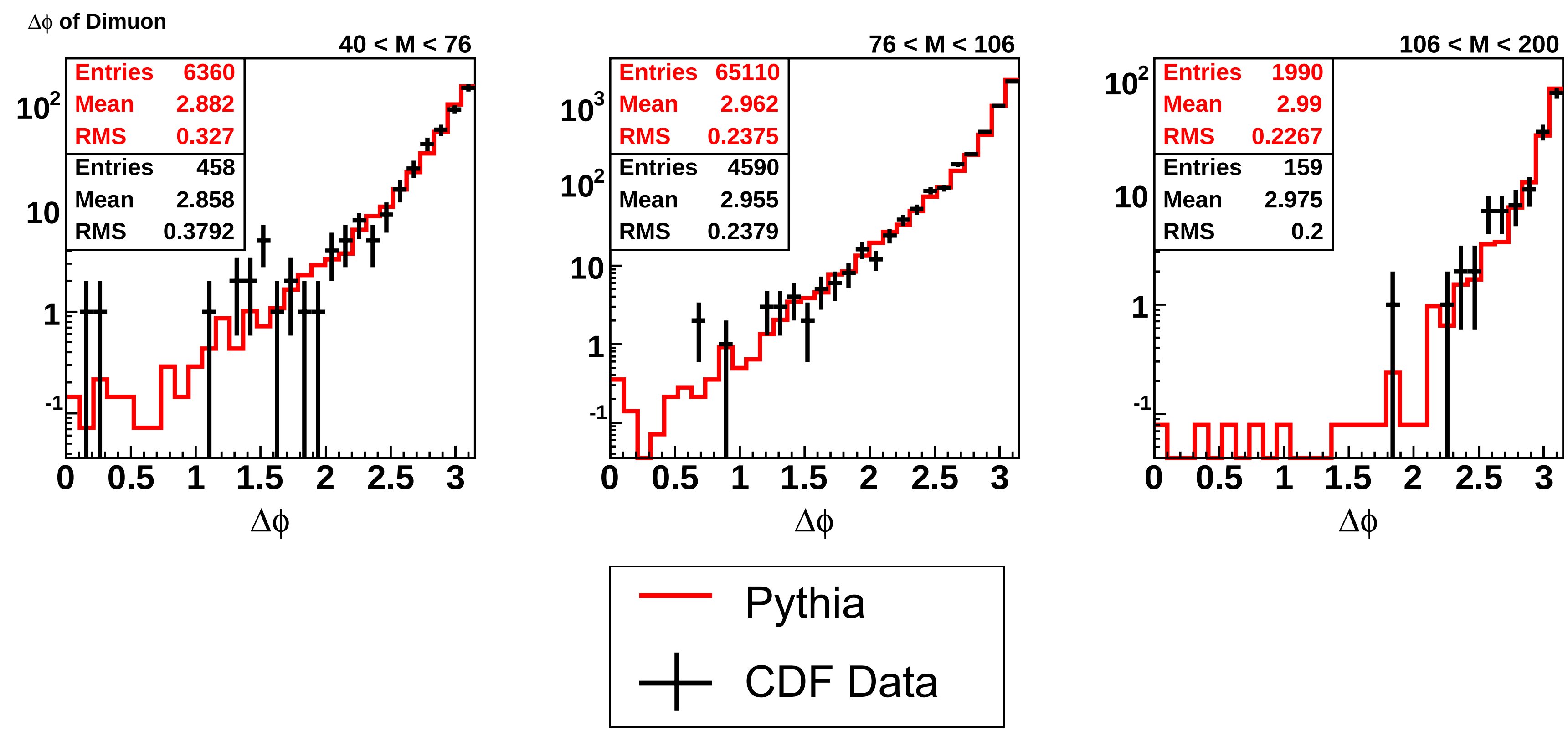
Hard Jets
$E_T > 15$



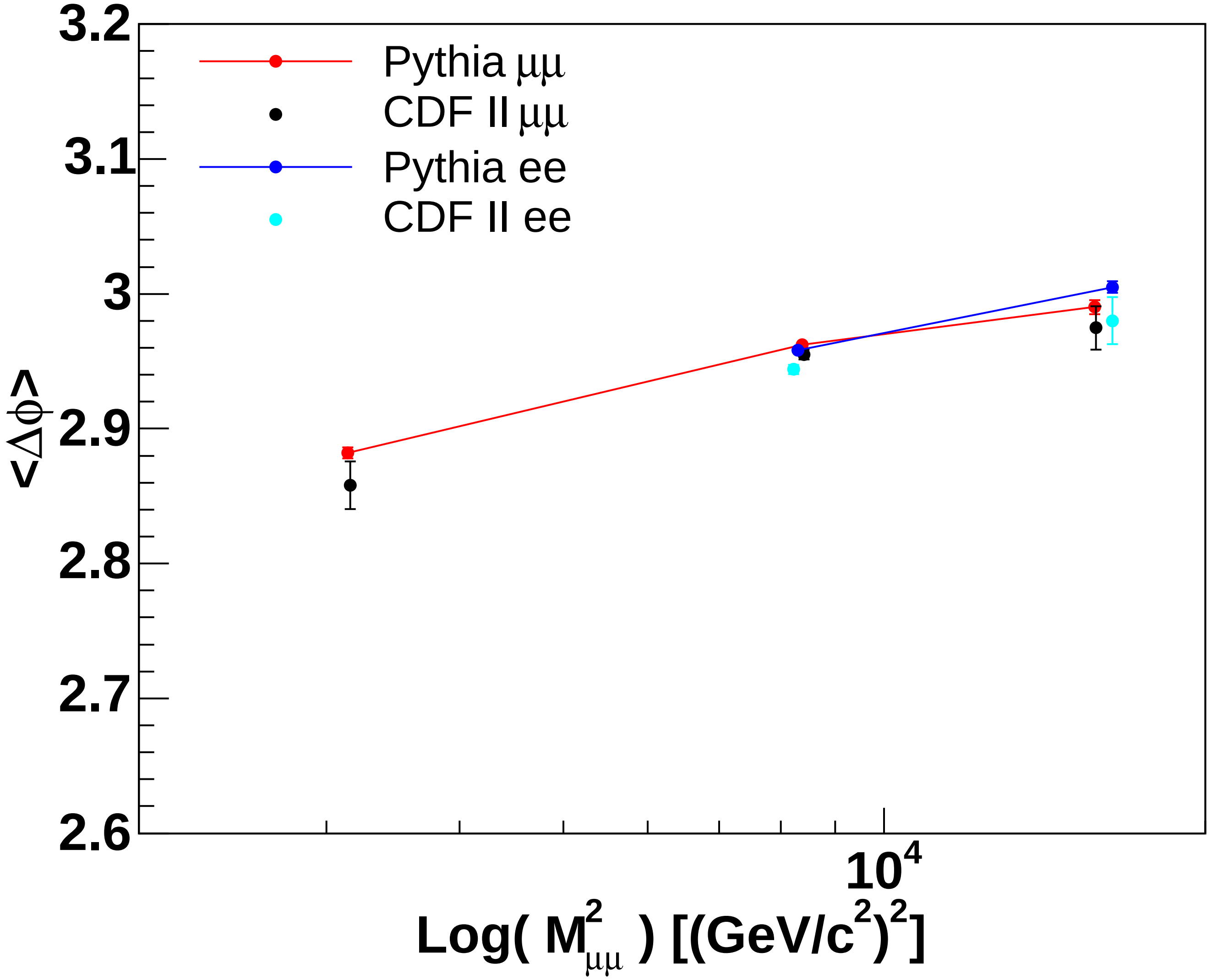


Large difference in soft jet ($4<E_T<15$) due to missing MPI in Herwig, but no difference in hard jet ($E_T > 15$)

$\Delta\phi(\mu\mu)$ Distribution



Mean Δφ of Dilepton



Summary

- We find that the Pythia MC describes the ISR activities reasonably well over a wider rage of the DY mass regions in P_T(dilepton), N_{jets}, and $\Delta\phi$(dilepton) distributions
- A good logarithmic dependence on M^2(dilepton) is observed in the average P_T of the dilepton
  - Gen5 Fit: $<P_T> = (-7.09\pm2.69) + (2.01\pm0.30)*\log(M^2)$
  - Gen4 Fit: $<P_T> = ($

Future Plans

- Future plans:
  - Include full dataset in very low mass region
  - Study Q^2 dependence of N_{jets} and $\Delta\phi$(dilepton)
  - Produce MC samples with $\pm 1\sigma$ of ISR systematic based on our results

Acknowledgements

- Dr. Un-Ki Yang and Prof. Young-Kee Kim
- The Chicago CDF Group
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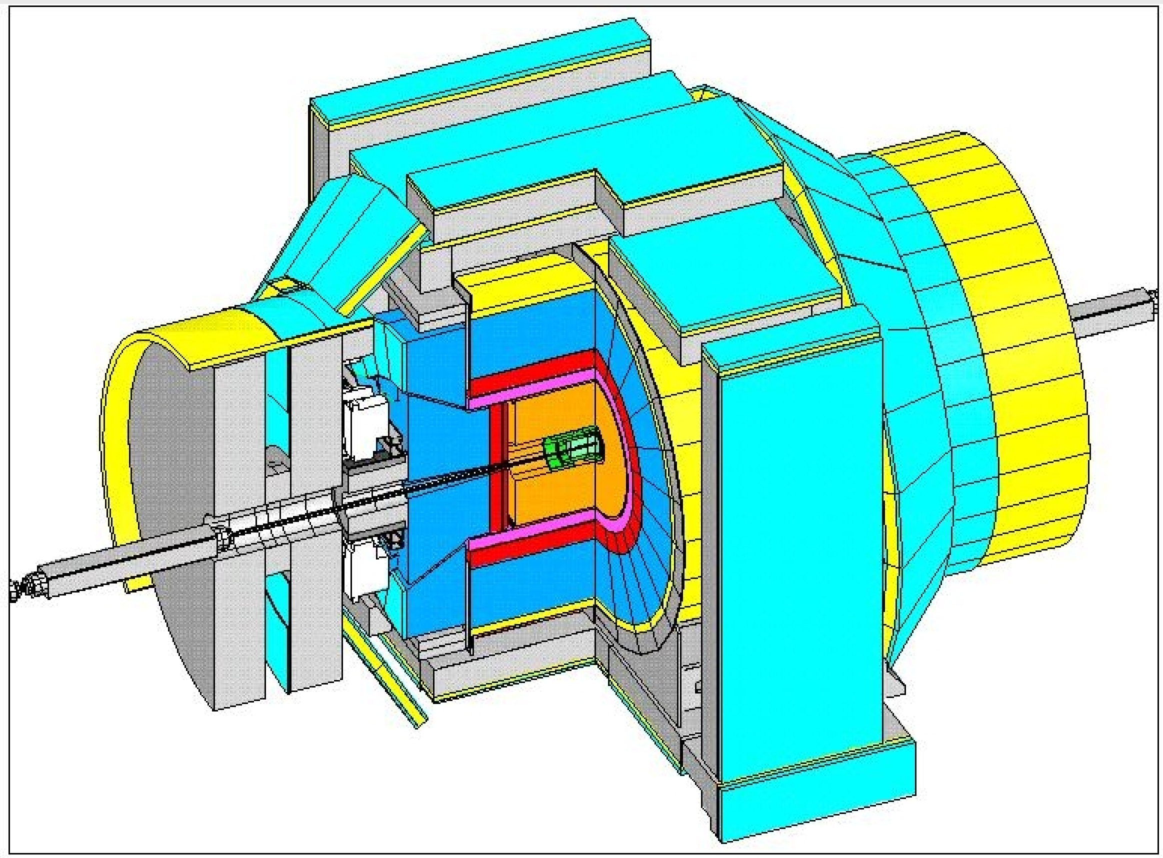
Backup Slides

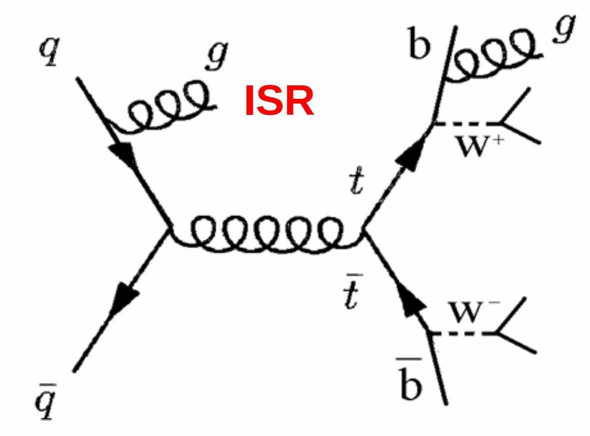
Collider Detector at Fermilab

- **Silicon Vertex Tracking**
- **Central Drift Chamber**
- **Solenoid**
- **Electromagnetic Calorimeters**
- **Hadronic Calorimeters**
- **Muon Drift Chambers**
- **Muon Scintillator Counters**
- **Steel Shielding**



Gluon Radiation

- Current studies at the Tevatron focus on minimizing uncertainties on the top mass
- One of largest uncertainties is due to extra gluon radiation
- Probability of radiating a gluon ~α_s (strong coupling parameter, ~0.1)
- Final state gluon radiation (FSR) is indistinguishable from initial state gluon radiation (ISR) in top production…



Monte Carlo Simulation

- Based on the current understanding of the Standard Model *and* the detector
- Generate and reconstruct a large sample of events
- We use the **Pythia** Monte Carlo
- Purpose of simulation:
  - Determine how much the reconstructed events deviate from the generated events, and apply correction to data accordingly
  - Determine contribution of background processes
  - Compare to data to check understanding of physics

P_T of Dimuon at Generator