W + γ Background Study: Generator Level

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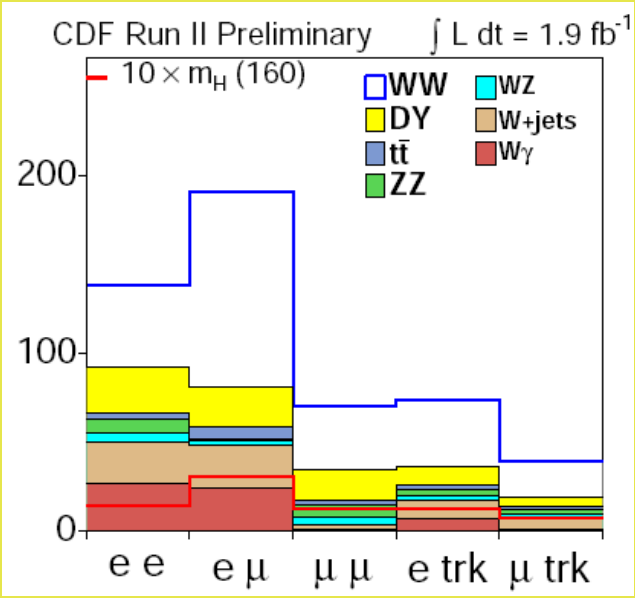
Why Wγ?

One of the most important backgrounds for analyses that focus on the dilepton + MET signature is Wγ, where the W decays leptonically, and a gamma is emitted in the process. If the gamma fakes an electron, you have one real lepton, one good fake, and real MET in the detector.

- Wγ is one of the major background for previous hadron collider experiments.
- It has so far been relatively untouched by CMS



Objectives

Our objective is to establish whether or not this background can be studied using already extant Monte Carlo, specifically the ALPGEN/PYTHIA W + jets inclusive:

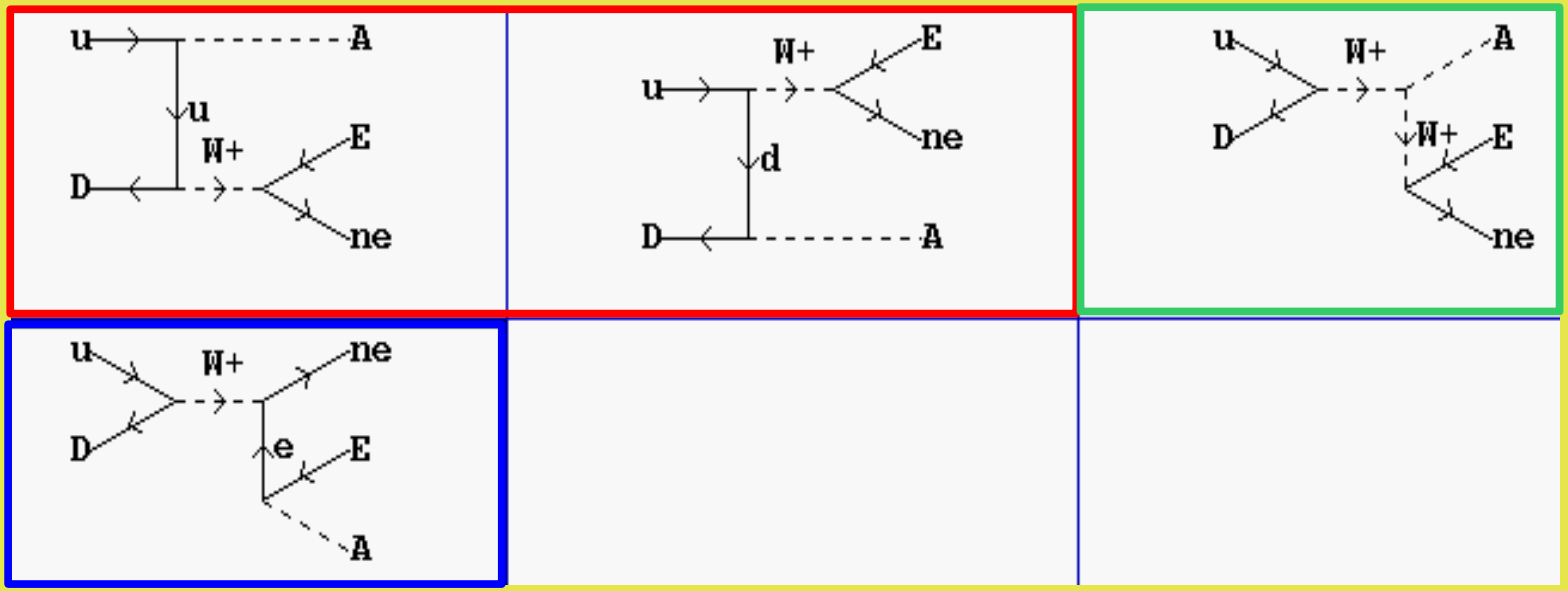
- What goes into the gamma component of the ALPGEN/PYTHIA W + jets inclusive sample?
  - Does our current W Monte Carlo include proper contributions?
  - Do the ratios of photon types actually make sense?
- Can we use the already produced ALPGEN/PYTHIA MC to simulate the Wγ background?
  - Does it agree with various generators?
  - Does it reflect the physics we want in critical variables?

Wγ Physics

We should remember this from previous presentations.

Briefly, there are three methods by which a photon is produced concurrently with a W at generator level

- Radiation from the colliding partons (ISR)
- Radiation from the W itself (WWγ)
- Internal radiation from the emitted lepton (FSR)



Generators and MC

The following MC from the full CMS simulation was used in this analysis:

- Wgamma sample: produced independently by UCSD for this analysis.
  - 10 GeV pT flag that applies only to ISR,WWγ
- ALPGEN/PYTHIA W + 0 jets sample
  - Standard CMS Sample (W0jet-alpgen/CMSSW_1_5_2-CSA07-2203/GEN-SIM-DIGI-RECO)
  - If PYTHIA models Wγ correctly, this is the preferred sample for background estimation.
  - 200 pb^{-1} equivalent luminosity generated.

The following generators were used in stand-alone mode:

- MCFM
- ALPGEN (Stand alone)
  - This was in the W + jet + photon mode appropriately adjusted
- CompHEP
- Baur Wgamma
  - Retrieved from Elliot

PYTHIA/ALPGEN Sample

We know that photons are added to the ALPGEN generator mechanics by PYTHIA.

Our first step is to examine the photons created at generator level, and see if they share the parentage that we expect. We categorize photons at generator level by their mother below, under different cuts.

The dR cut is the ΔR between the either the W lepton and the photon, or the emitting lepton and the photon.

Raw results with dR > 0.35 (Red denotes the same cuts as CompHEP)

W + 0 jet, dR>0.35					
Lumi ~ 55pb-1					
Mother Type	**total generated**	**gamma pT> 10 GeV**	**gamma pT> 20 GeV**	**gamma pT> 10 GeV and lepton pT>20 GeV**	**gamma pT> 20 GeV and lepton pT>20 GeV**
Electron	36231	4378	1647	1268	162
Muon	24975	4379	1643	1293	155
Tau	19506	3995	1411	1317	174
Quark	47780	3613	1445	2888	1162
Pi0	31955926	6913	563	5054	401
other	5225412	1743	392	1370	301

PYTHIA/ALPGEN Composition

We must now ask whether the sample contains the same physics. We know that we have photons that:

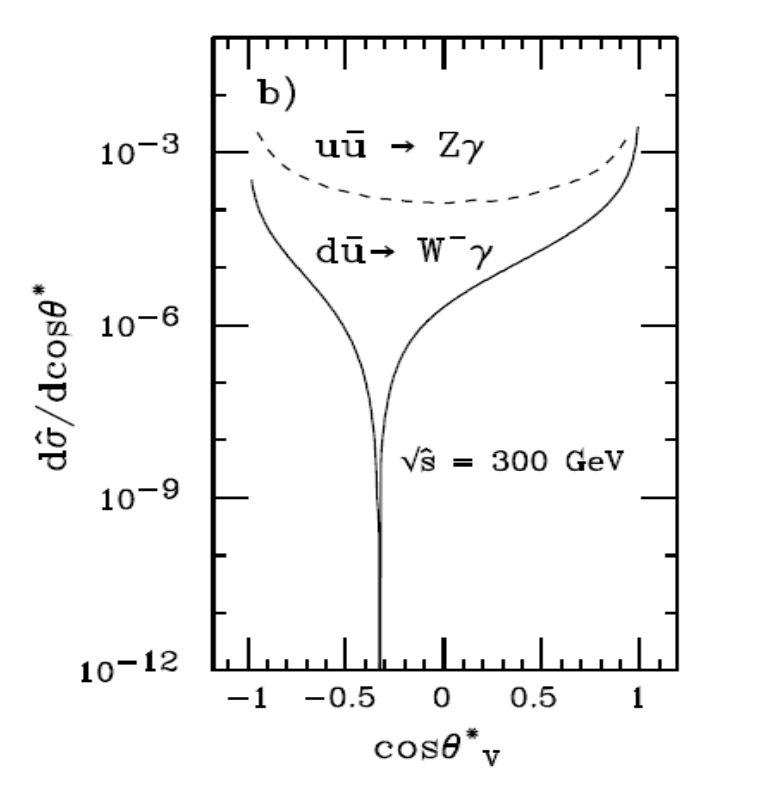
- Come from quarks
- Come from leptons

The question is whether it contains photons from the WWγ vertex.

The easiest way to test this is to see that it has a Radiative Amplitude Zero.

Radiative Amplitude Zero

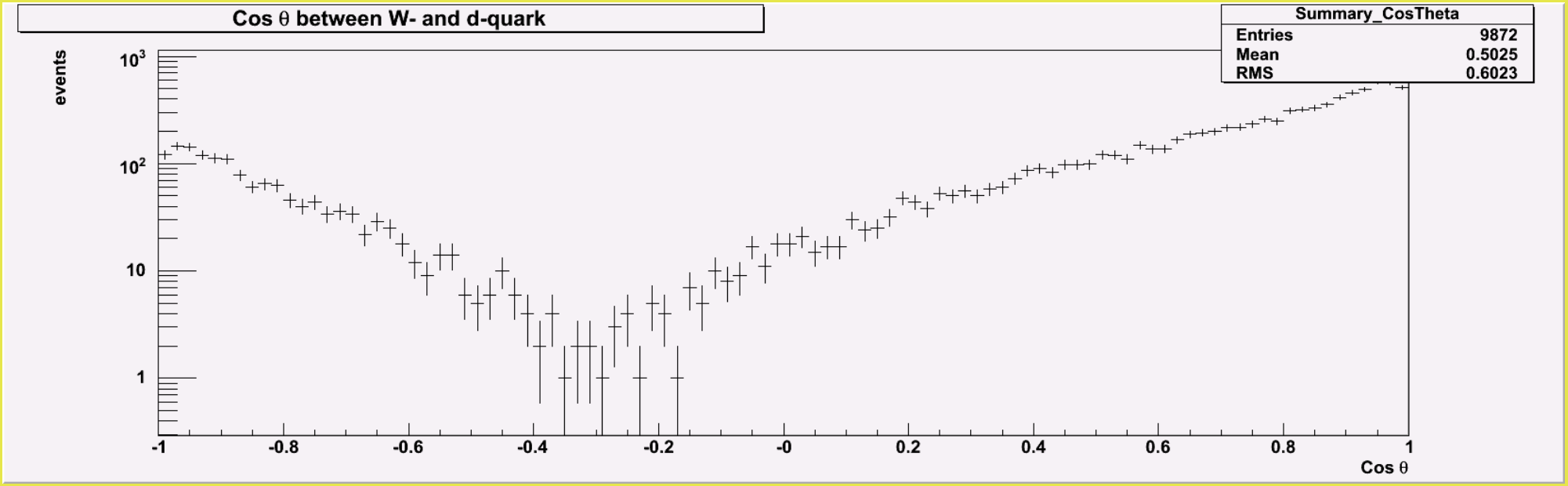
Theory predicts that the interference between the three channels (ISR, FSR, and WWγ) will produce a zero amplitude at cosθ = -1/3 (relative to the d quark).



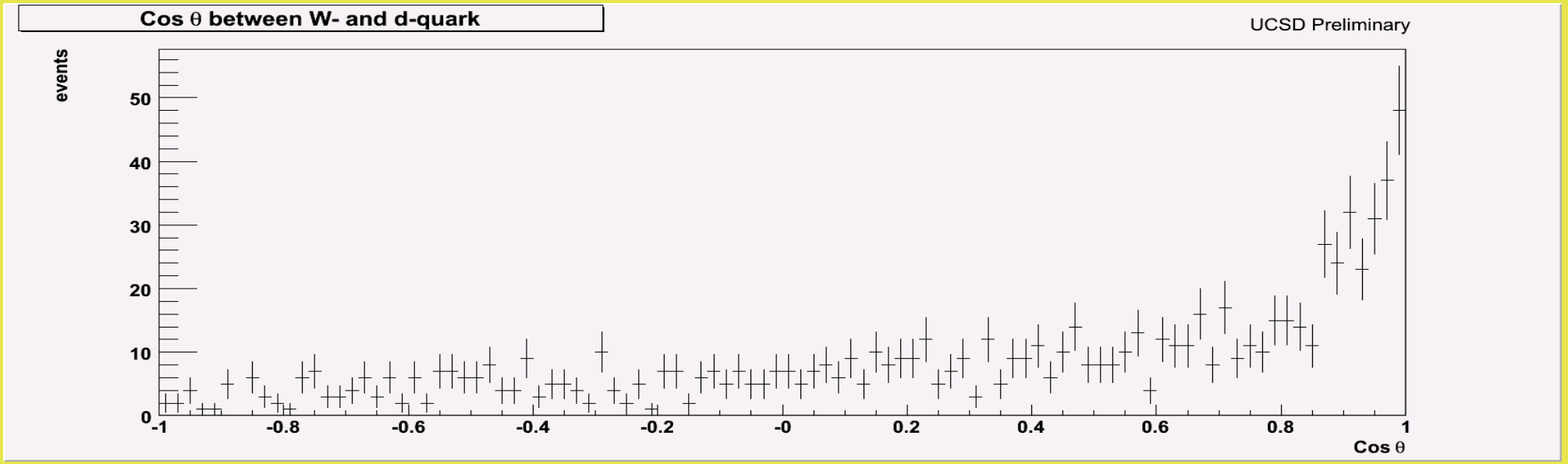
Radiative Amplitude Zero as predicted by
Baur et. al. in hep-ph/9702364

Without all three channels, the interference will not produce the RAZ, allowing us to determine easily whether out sample contains the WWγ channel.

Radiative Amplitude Zero II



Cosθ plot for the Wgamma MC (above) and the ALPGEN W + 0 jets (below)



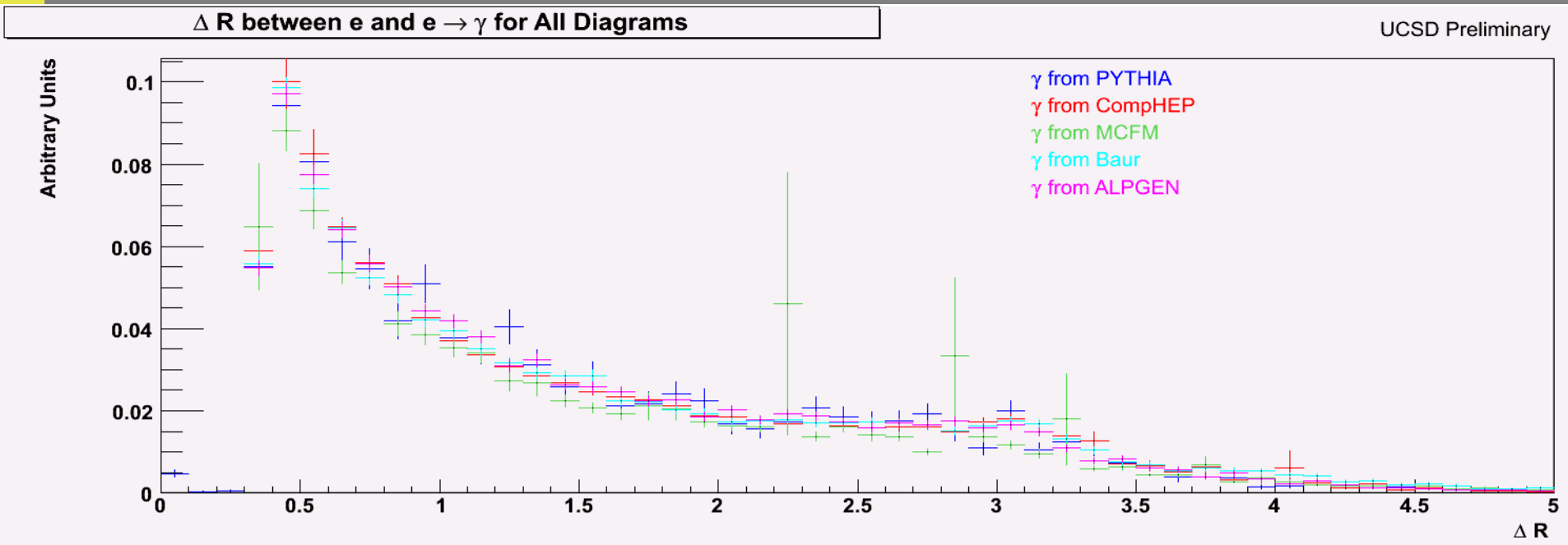
Kinematic Distributions

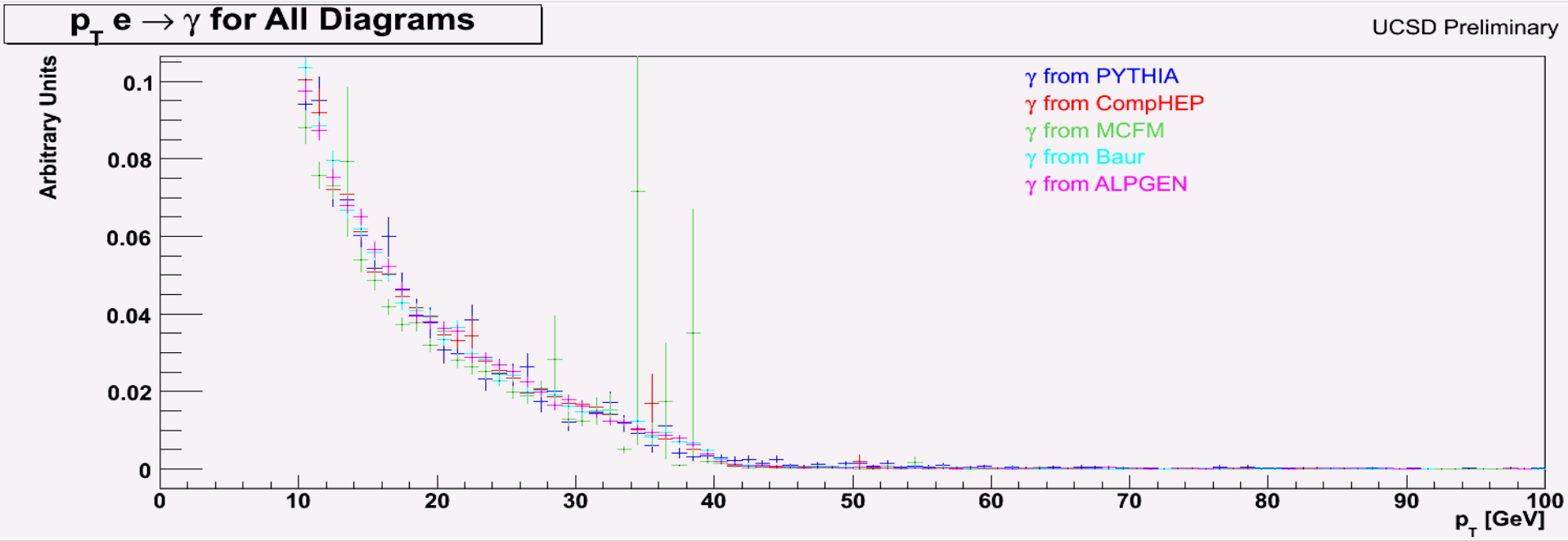
We now know the basics of our ALPGEN/PYTHIA Monte Carlo:
- It contains photons produced from quarks and leptons in amounts that seem reasonable.
- It does NOT contain the WWγ vertex

We must now answer our second question: Does the ALPGEN/PYTHIA Monte Carlo sample contain physics that is similar enough, at generator level, to reality that we can use it?

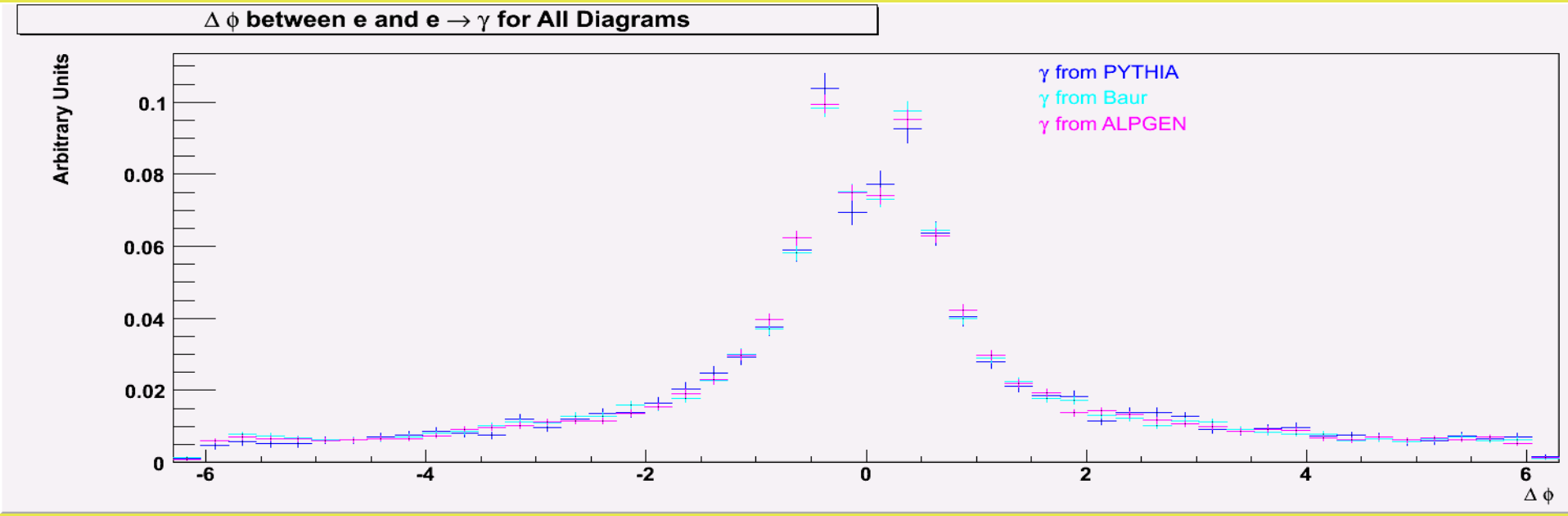
We propose the following tests:
- If the PYTHIA photon production matches that of other generators in the key variables, we can use it to accurately simulate W + photon backgrounds at the preliminary level. The key variables are:
  - Delta R distribution between the photon and the lepton.
  - Photon p_T
- Also, we should look to see that we also compare favorably in the H→WW variables:
  - ϕ(l, gamma)
  - M(l,l)

Kinematic Plots I

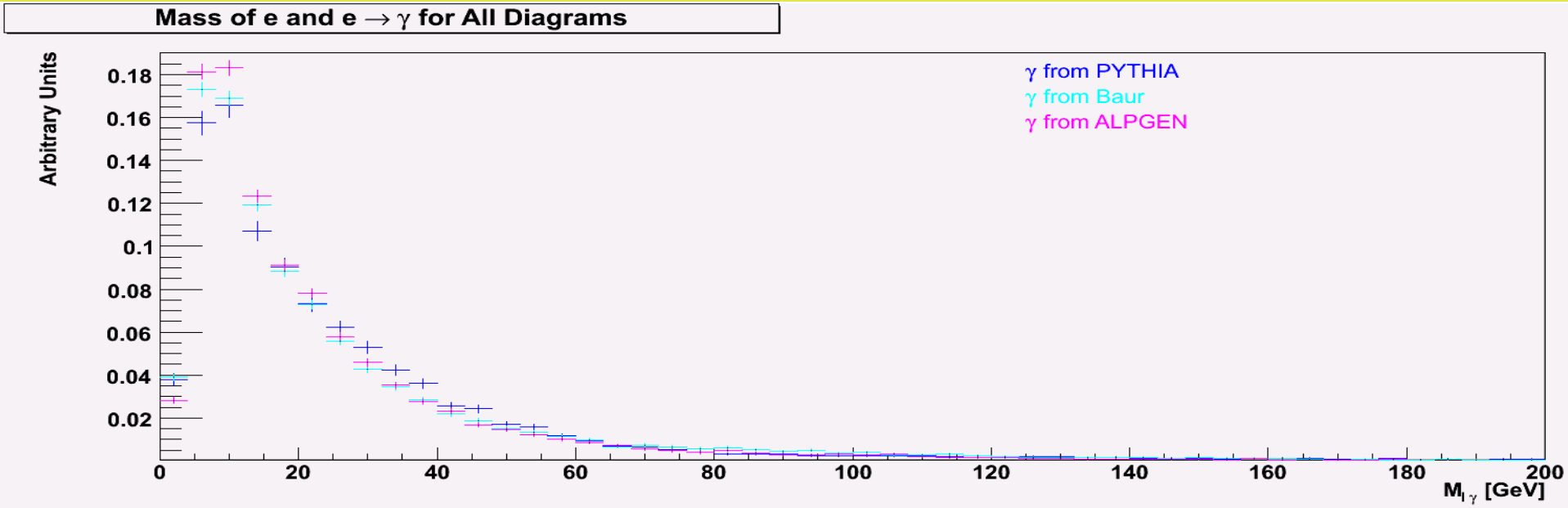




Kinematic Plots II



CompHEP does not produce these variables, and we have an error with MCFM we don't understand.



Conclusions

We have answered our two questions.

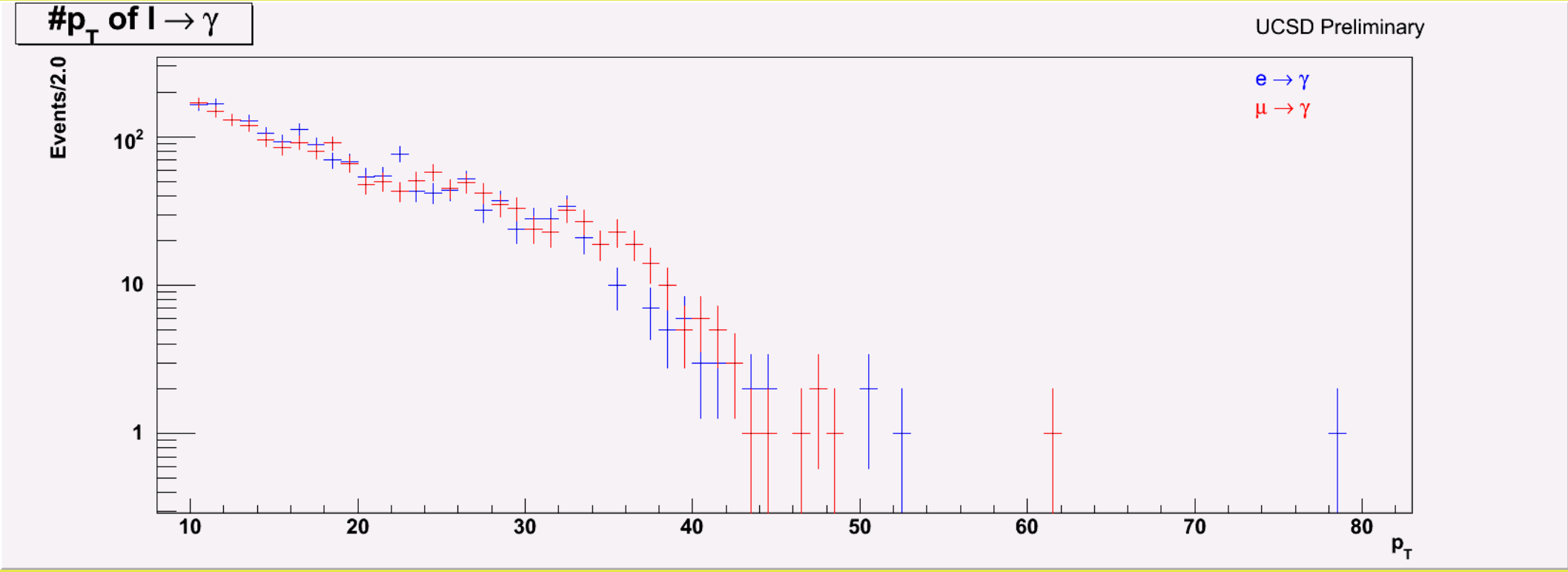
- We know what goes into the ALPGEN/PYTHIA Monte Carlo
  - Photons emitted from leptons and from quarks
  - Nothing from the $WW\gamma$ vertex.
- We can use the Monte Carlo produced by ALPGEN/PYTHIA to simulate our background.
  - Cross-sections agree (see previous talk)
  - Kinematic Distributions agree
  - H→WW distributions agree.
- We intend to use the W + jets inclusive datasets for all future background estimations.

A full summary, including more figures, is available on:
http://hepuser.ucsd.edu/twiki/bin/view/CMSPhysics/WgammaSummary

Backup Slides

Kinematic Plots III

PYTHIA self-check (comparing photons from muons and electrons).



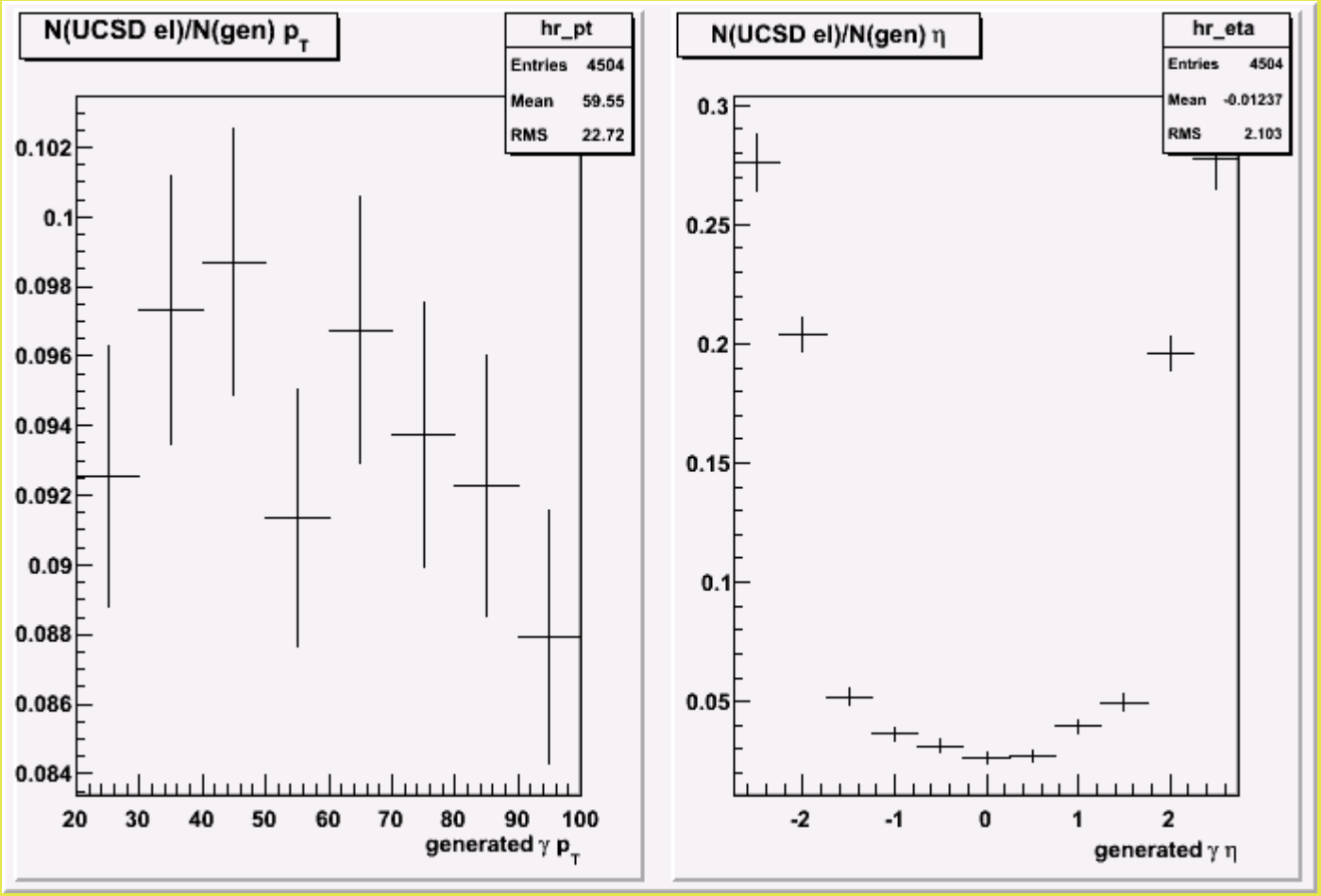
Disclaimer

There Is No Physics Past This Point!

Plots Included for Interest ONLY

Photon Efficiencies

Efficiency for a photon from a particle gun with p_T between 20 and 100 GeV being reconstructed as a function of p_T (left) and η (right)



Pi0 Comparison

Same plot for pi0s. Note the same functional form of the η dependence, probably a result of detector material budget.