# Prospects for Some Important Early Measurements with Initial CMS Data

Kalanand Mishra

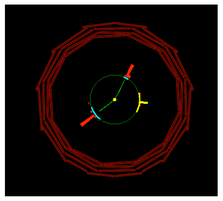
*Fermi National Accelerator Laboratory, CMS Collaboration*

## Abstract


- First set of measurements are likely with ~10 pb$^{-1}$ of data.
- Initial calibration and alignment to be established first, missing $E_T$ & b-tagging will likely come later.
- Among the early measurements, of particular interest are:
  - ★ jet multiplicity and $p_T$ distributions, inclusive jet cross section
  - ★ inclusive W/Z boson cross section and asymmetry
  - ★ new physics searches in dilepton/ dijet channels.
- Precision of the early measurements to be limited by luminosity and jet energy scale uncertainties.

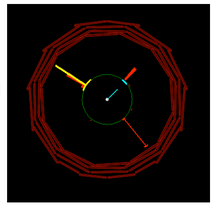

## W/Z cross section & asymmetry

- pp→W/Z + X are fundamental benchmark electroweak processes.
- Well-understood theoretically (PDF, radiative correction etc.); clean experimental signatures.
- High cross section (W: ~100 nb, Z: ~30 nb at 10 TeV).
- Expect about 8000 Z and 80k W events in each lepton channel.



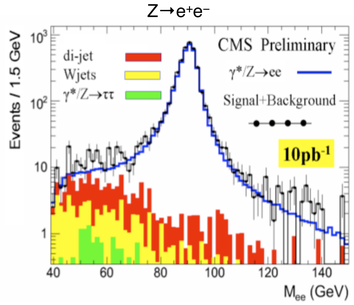
Z→e⁺e⁻ events. Two electrons coming from Z vertex and hadronic recoil (jet).

W→eν events. An electron and missing $E_T$ coming from W vertex and hadronic recoil.

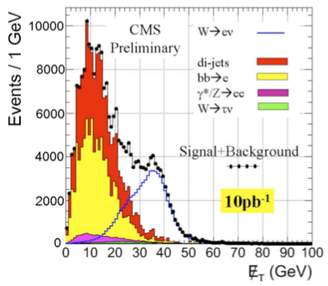


### Overview of the cross section measurements

Z→e⁺e⁻




W→eν



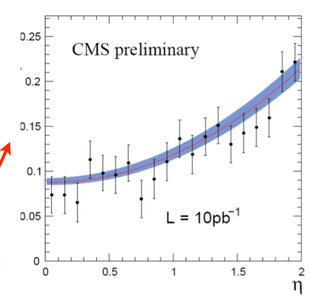

The cross section is given by

$$\sigma \cdot \mathrm{BR} = \frac{N^{pass} - N^{bkg}}{A \cdot \epsilon \cdot \int L dt}$$

$N^{pass}$ : # events passing the selection
$N^{bkg}$ : # background events
A : acceptance
ε : selection efficiency for signal
$\int L\,dt$ : integrated luminosity

### W/Z production asymmetry

- W/Z created by quark-antiquark annihilation. Quark may be valence.
- Valence quarks carry higher momentum than sea quarks.
- Thus boost direction indicates quark direction, especially at high rapidities.
- This causes charge asymmetry in W± and forward-backward asymmetry in Z production.

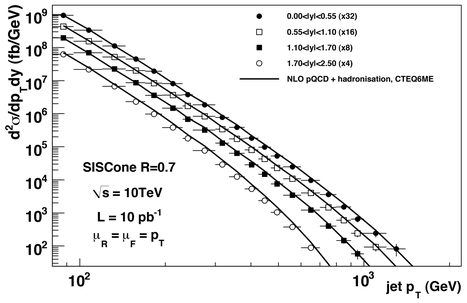



W± charge asymmetry as a function of η in μν channel. Solid line shows theoretical prediction & shadow region theoretical uncertainty.

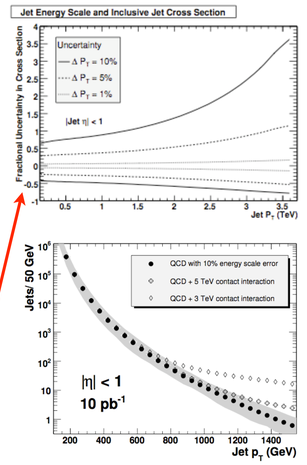
## High $p_T$ jet measurements

- Jets will be the first & most abundant object to be reconstructed at CMS.
- Crucial to understand jet topology & basic QCD processes at LHC energy.
- Often the most important background to Ewk, top, and new physics signals.
- Potentially sensitive to new physics: probing distances ~ 10$^{-19}$ m.

Inclusive jet cross section

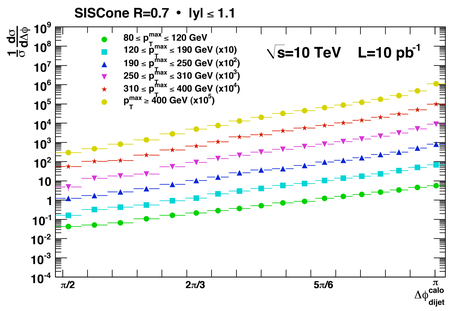



- **A fundamental QCD measurement: must do it !**
- **Precision tests for pQCD, proton PDFs constraints, sensitivity to New Physics.**
- **Heavily dependent on jet energy scale ⇒ a major source of uncertainty.**



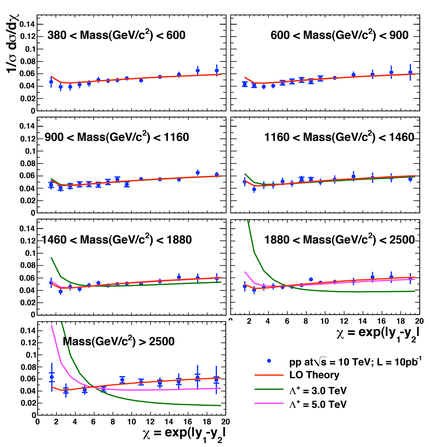

Dijet falling spectra and effect of new physics

Dijet azimuthal de-correlation



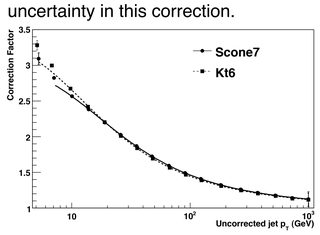

- **Simple measurement testing the pQCD description of multi-parton radiation.**
- **Possibly the first publication !!!**
- **Sensitivity to non-perturbative effects (hadronization).**
- **Important for MC tuning.**

Dijet angular distribution



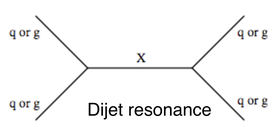

- **Simple measurement.**
- **Sensitive to new physics.**
- **Systematic uncertainty from jet energy scale.**

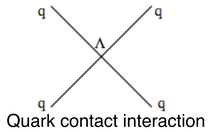
Current understanding of the jet energy scale correction. We expect ~10% initial uncertainty in this correction.




## New physics searches

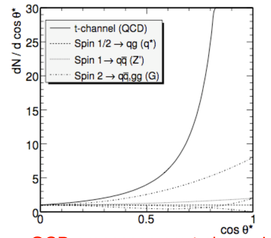
Dijet resonances and contact interactions




Contact interaction Lagrangian: $L_{qq} = \frac{Ag^2}{2\Lambda^2}(\bar{q}_L\gamma^\mu q_L)(\bar{q}_L\gamma_\mu q_L)$

where A = ±1 determines the sign of the interference with QCD, Λ is the contact interaction scale, and Λ± denotes Λ with the choice A = ±1.

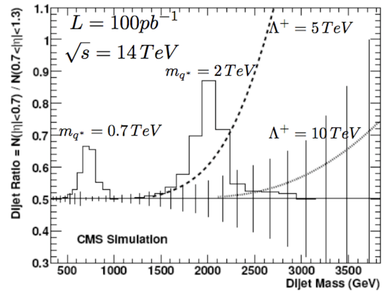



QCD processes are t-channel. New physics is expected to be s-channel.

| Model | J | Color | Cross Section (pb) M=0.7 TeV $\|\eta\|<1$ | M=0.7 TeV $\|\eta\|<1.3$ | M=2.0 TeV $\|\eta\|<1$ | M=2.0 TeV $\|\eta\|<1.3$ | M=5.0 TeV $\|\eta\|<1$ | M=5.0 TeV $\|\eta\|<1.3$ |
|---|---|---|---|---|---|---|---|---|
| q* | 1/2 | Triplet | $7.95\times10^{2}$ | $1.27\times10^{3}$ | 9.01 | $1.36\times10^{1}$ | $1.82\times10^{-2}$ | $2.30\times10^{-2}$ |
| A,C | 1 | Octet | $3.22\times10^{2}$ | $5.21\times10^{2}$ | 5.79 | 8.82 | $1.55\times10^{-2}$ | $2.04\times10^{-2}$ |
| D | 0 | Triplet | $8.11\times10^{1}$ | $1.26\times10^{2}$ | 4.20 | 5.97 | $4.65\times10^{-2}$ | $5.75\times10^{-2}$ |
| G | 2 | Singlet | $3.57\times10^{1}$ | $5.47\times10^{1}$ | $1.83\times10^{-1}$ | $2.60\times10^{-1}$ | $2.64\times10^{-4}$ | $3.19\times10^{-4}$ |
| W' | 1 | Singlet | $1.46\times10^{1}$ | $2.37\times10^{1}$ | $3.49\times10^{-1}$ | $5.31\times10^{-1}$ | $8.72\times10^{-4}$ | $1.17\times10^{-3}$ |
| Z' | 1 | Singlet | 8.86 | $1.44\times10^{1}$ | $1.81\times10^{-1}$ | $2.77\times10^{-1}$ | $5.50\times10^{-4}$ | $7.26\times10^{-4}$ |

The models are excited quarks ($q^*$), axigluons (A), colorons (C), $E_6$ diquarks (D), Randall Sundrum gravitons (G), a heavy W boson (W'), and a heavy Z boson (Z').

Expected cross sections for predicted particles in the models considered

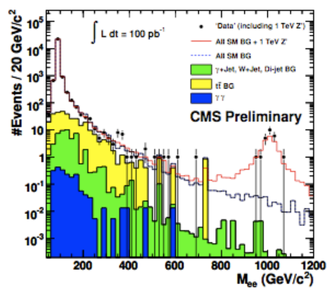


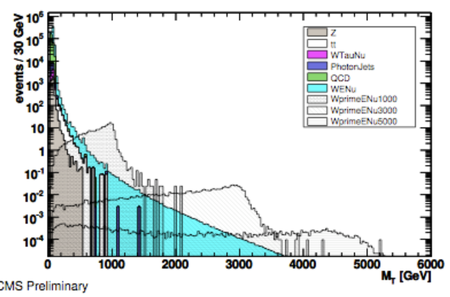

Selling points

- **Extremely sensitive to New Physics (resonances, contact interactions).**
- **Very robust due to cancellation of systematic uncertainties.**
- **Potentially can be the first search publication**

Search for high mass Z', Randall-Sundrum graviton in dilepton channels

Many models beyond the Standard Model predict the existence of new particles decaying to lepton-antilepton pairs. The specific examples are E6 gauge group Z's and Randall-Sundrum graviton. Even though leptonic channels may have lower branching ratios, they offer cleaner experimental signatures, smaller background, and better $E_T/p_T$ resolutions.




Systematic uncertainties come from electron, muon, missing $E_T$ reconstruction and from theory.

## Conclusion

- Eagerly waiting for pp collisions. Need to understand intial data and detector performance quickly.
- Exciting prospects for important early measurements: both standard candles and new physics searches.
- The initial emphasis is on measuring ratio-based observables since these are *a priori* robust against detector systematics. More ambitious analyses will follow afterwards.