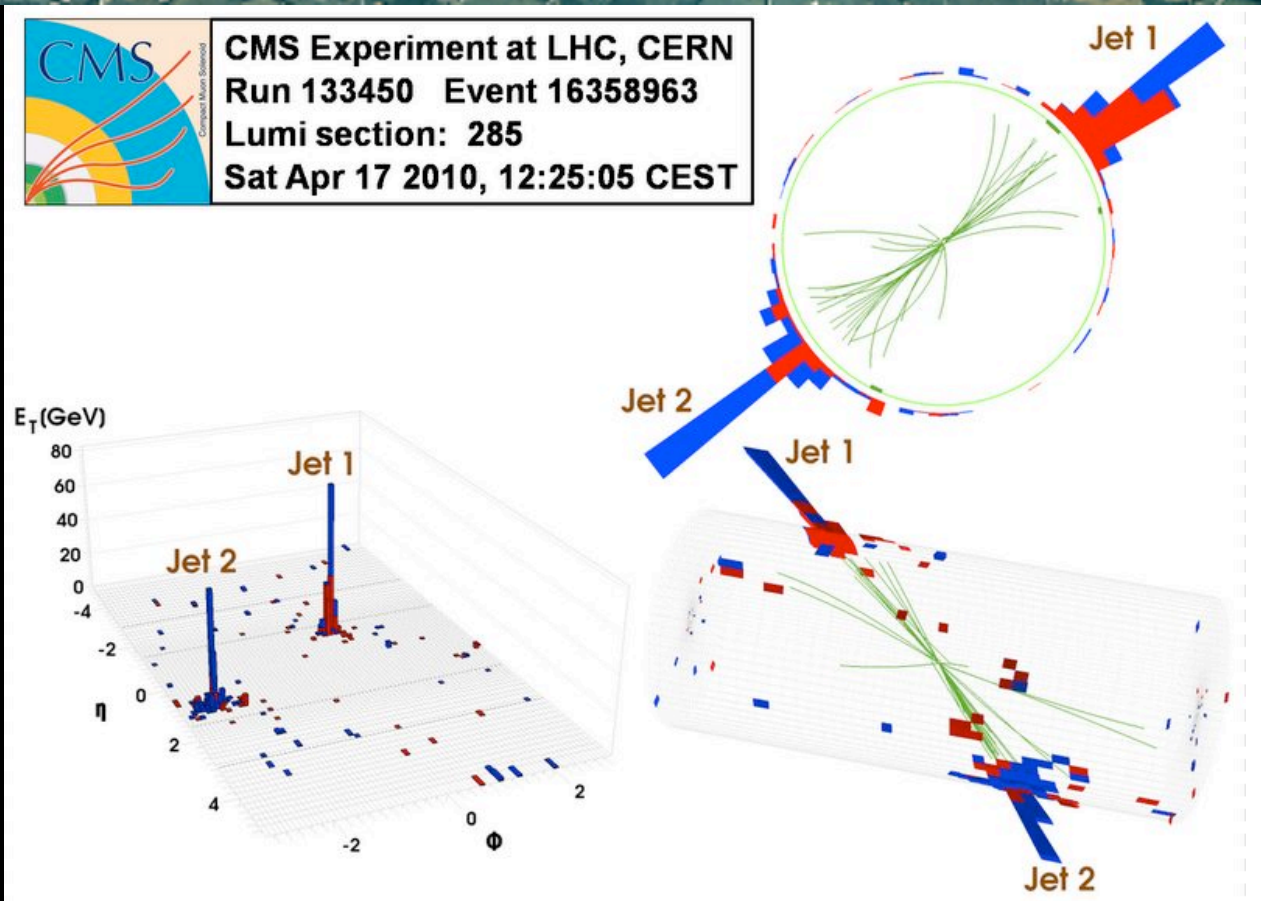
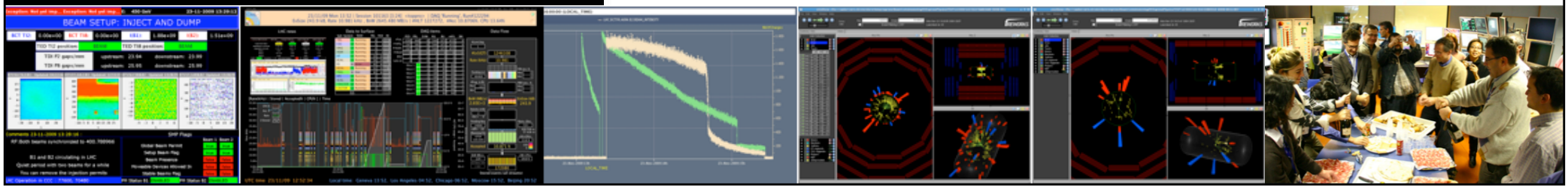
TTU's Contributions to CMS
Part.2: New Physics Searches & MET

Sung-Won Lee

Texas Tech University





TTU Contribution to CMS [Part.2]

Searching for New Physics & MET

Understanding Physics Objects

Jet

- Jet Energy Scale Evaluation
- DQM/Jet Validation: Data vs MC

MET

- MET Correction
- MET Scale & Resolution
- High MET Events Scans

HCAL Performances

DPG / POG / PAG

Performing the Physics Analyses using early LHC data

Exotics

- BSM Searches using Multijets
- Searches for Dijet Resonances

SUSY

- Hadronic W Decays in Jets+MET
- EW & Top Measurements

Jet Validation I

We regularly run our jet validation code on prerelease RelVal samples

- For FullSim vs FastSim comparisons, we use Flat p_T=15-3000 GeV sample.
- Allow use to explore the wide range in jet p_T

The results are posted to: **http://highenergy.phys.ttu.edu/~keng/validation/**

More recently, Pileup MC Validation & Collision data vs MC

Jet Algorithms

- Icone5 Calo-jets
- Icone5 JPT-jets
- Icone5 PF-jets
- KT4, KT6 Calo-jets
- Anti-KT Calo-jets
- Anti-KT JPT-jets
- Anti-KT PF-Jets

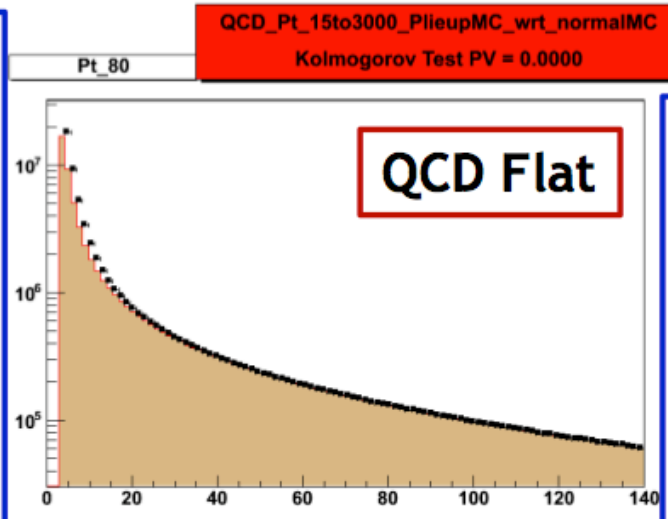
Observables

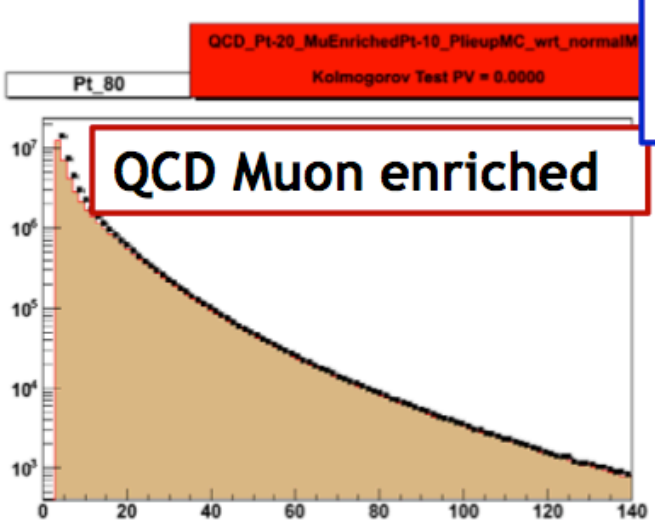
- Jet p_T scale [p_T(calo)/p_T(true)]
- Jet E, p, p_T, mass, eta, phi, # of constituents distribution etc
- Energy in EB, EE, HB, HE, HF, HO
- Simple but comprehensive set for validation.
- 2010 Summer: Chiyoung → Keng

Jet Validation II

MC with PU vs MC without PU: Jets in float MC samples

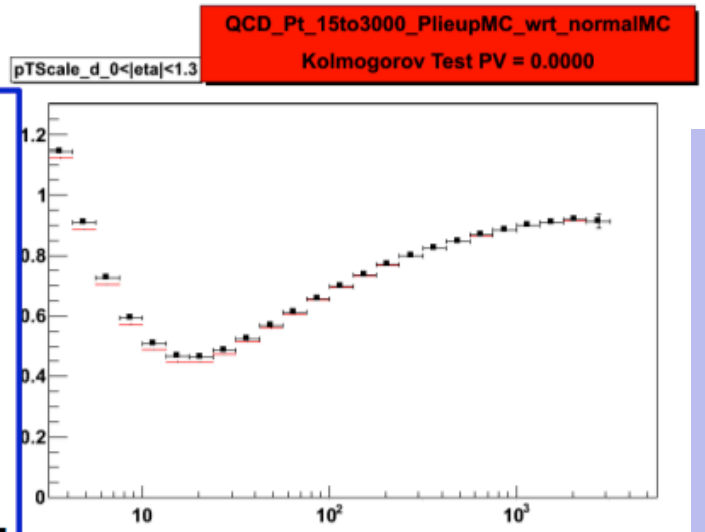
Number of jets normalized to same luminosity

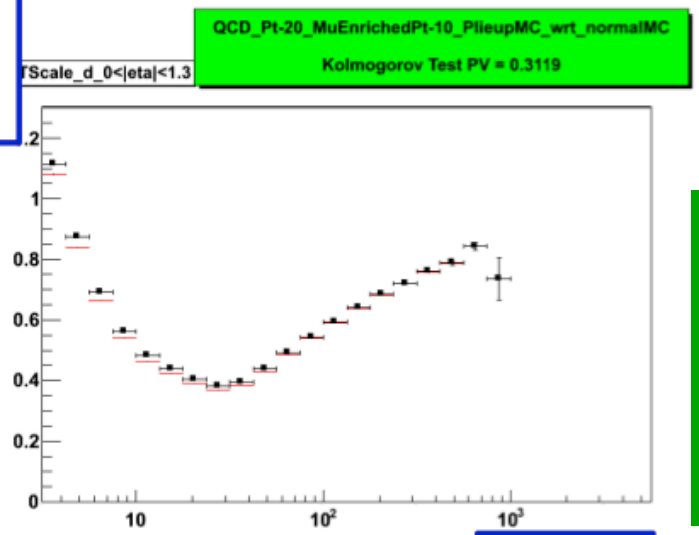




Jet Pt

Jet Response: Reco/Gen





Jet Pt

- **Black: Pileup**
- **Red: non-pileup**

2 MCs are normalized to the same lumi. (not shape comparison)

PU effects appears at low jet p_T, and gradually vanishes at high p_T as expected

Jet Energy Scale

- The correct JES for tagging quarks in the qqH could only be estimated correctly using a quark-rich sample.
- Instead of using γ+jet events (good for central jet) for corrections, Z(→ ll)+jet, can be used; almost background free and the ratio of quark and gluon jets is well known from the theoretical predictions.

Methods

The calibration coefficients for the quark jets, c_q, can be obtained from:

$$< C(E_T^j(raw), \eta^j) > = \frac{< p_T^Z >}{< E_T^j(raw) >} = \frac{< c_q >}{< w_q > + < k^{q/g} >< w_g >}$$

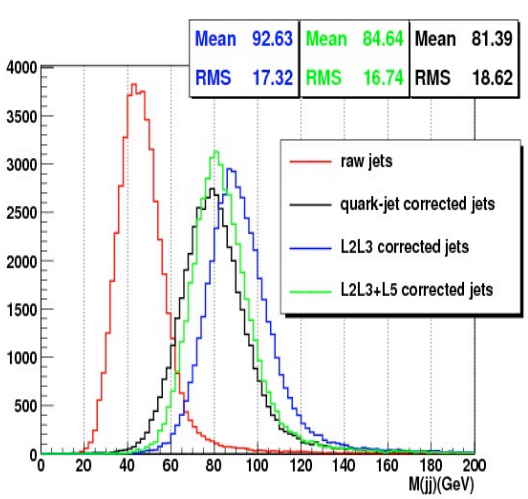
measure

$\sigma(Z+q)/\sigma_{TOT}$

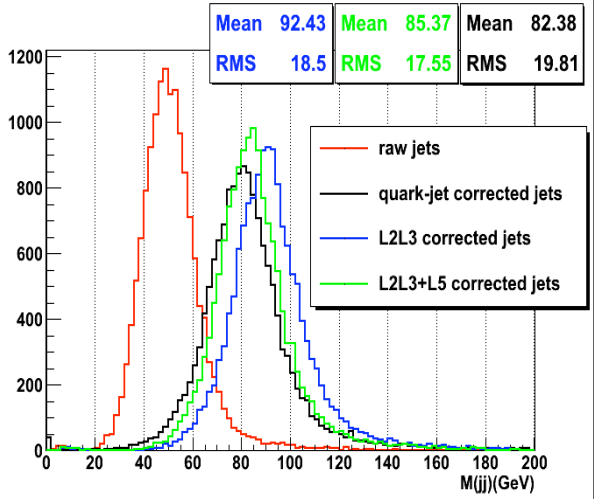
$\sigma(Z+g)/\sigma_{TOT}$

c_q/c_q=ratio of the quark And gluon jet calib. Coefficients from MC (E_T^j and η^j dependent)

Ratio of Z+q (Z+g) Cross section to the Total cross section. (function of P_T^Z and η^j)



Top pair



WW

The QJE give the best calibration for reconstructing hadronic W boson

MET in Photon + Jet Events

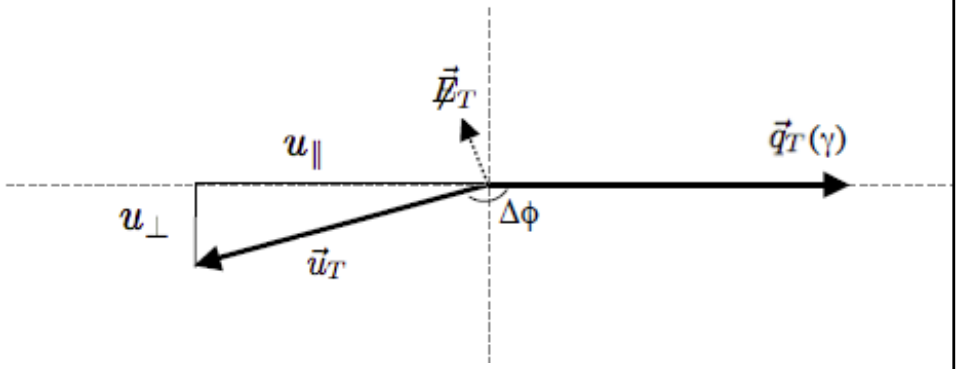
Goal: To evaluate the CMS MET performance with data

- ❑ events with no intrinsic MET
- ❑ cross-section larger than that of Z
- ❑ induce MET by removing deposit in calorimeter from photon
- ❑ magnitude of induced MET well known.
- ❑ several MET algorithms are tested on data & compared with the prediction from the simulation.

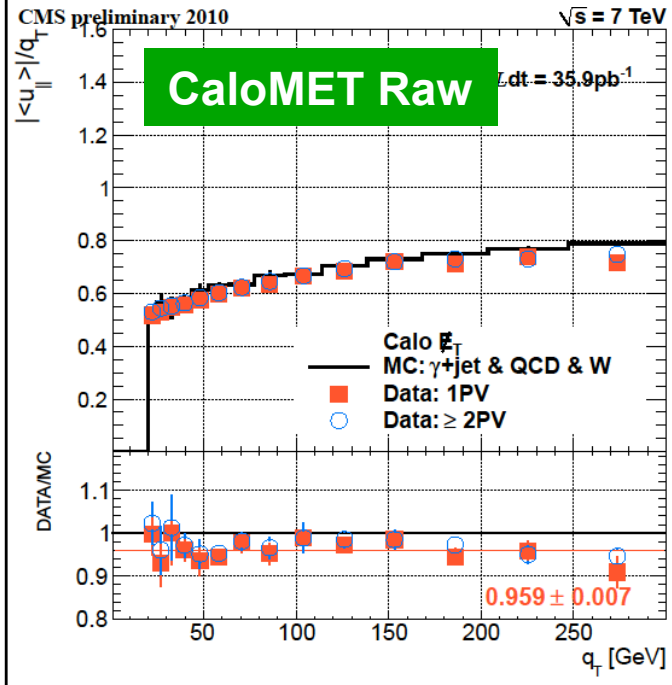
*** Currently, preparing a publication to JINST (J.Damgov)

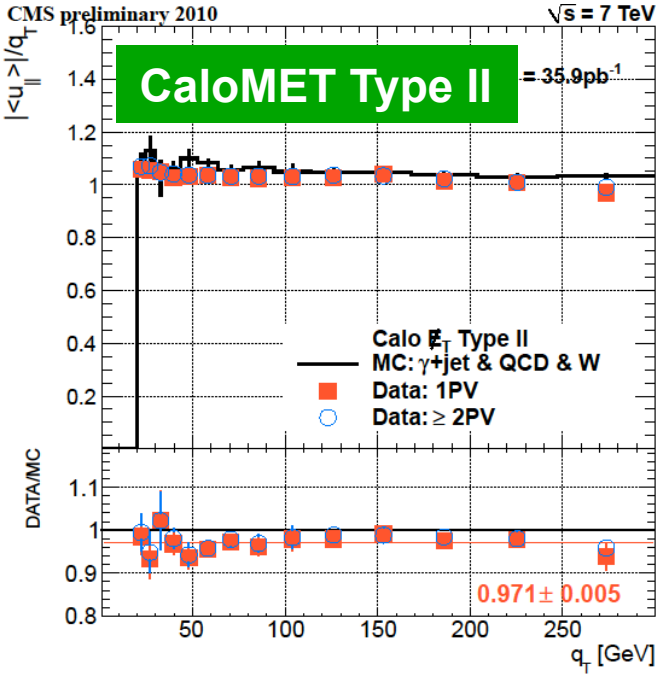
The hadronic recoil can be projected onto photon axis(q_T), yielding two components, parallel ($u_{||}$) and perpendicular (u_T) to the event axis.

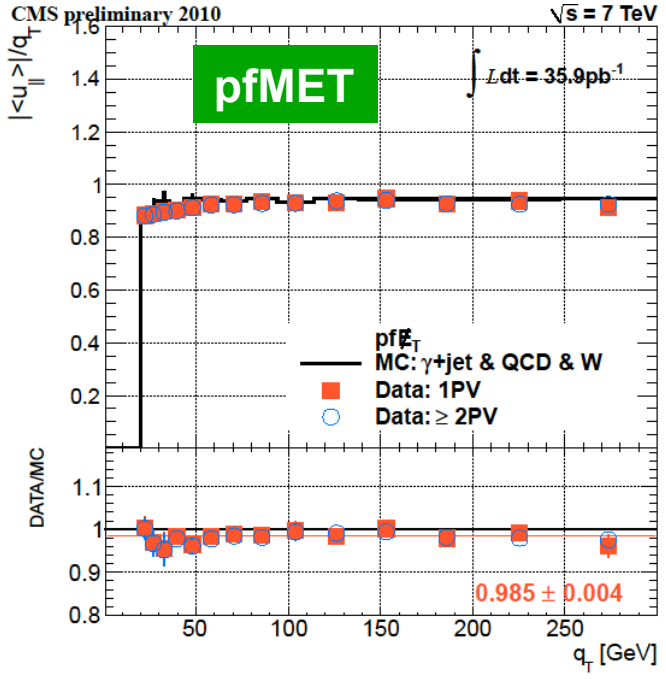
$|u_{||}|/q_T$ measures the scale factor of the MET, while u_T is dominated by the underlying event and calorimeter noise.



MET Scale Validation

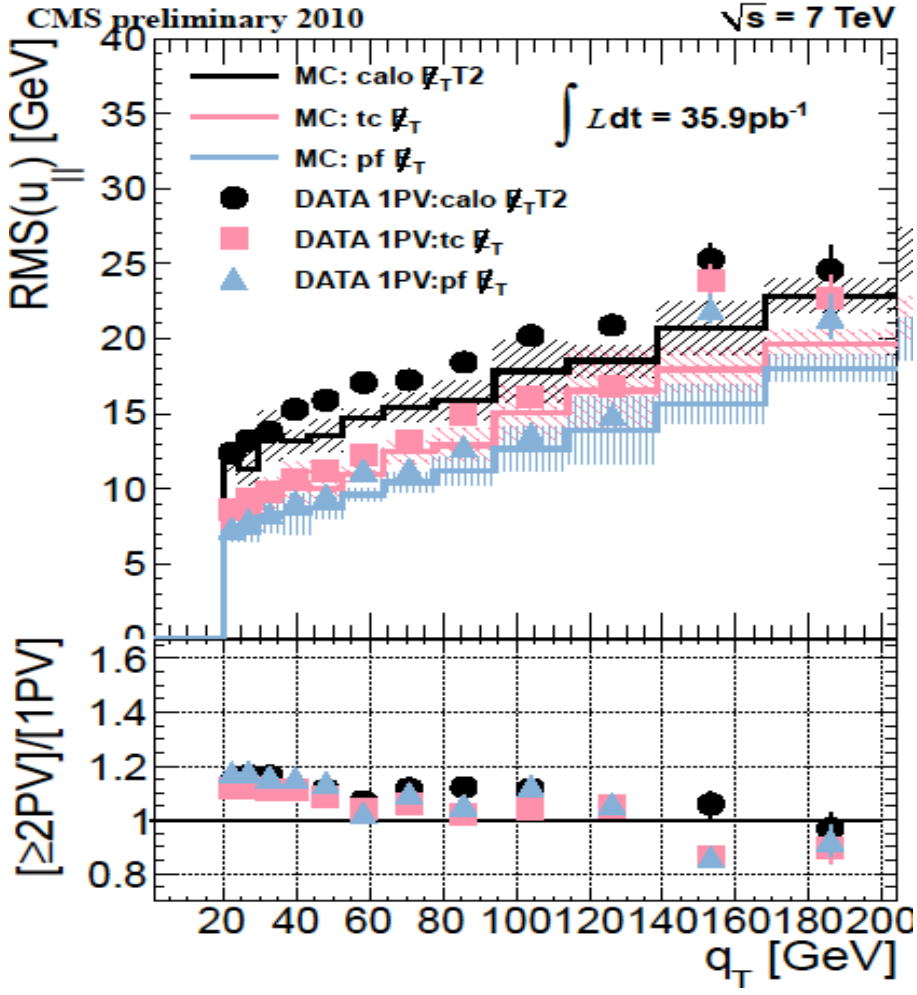


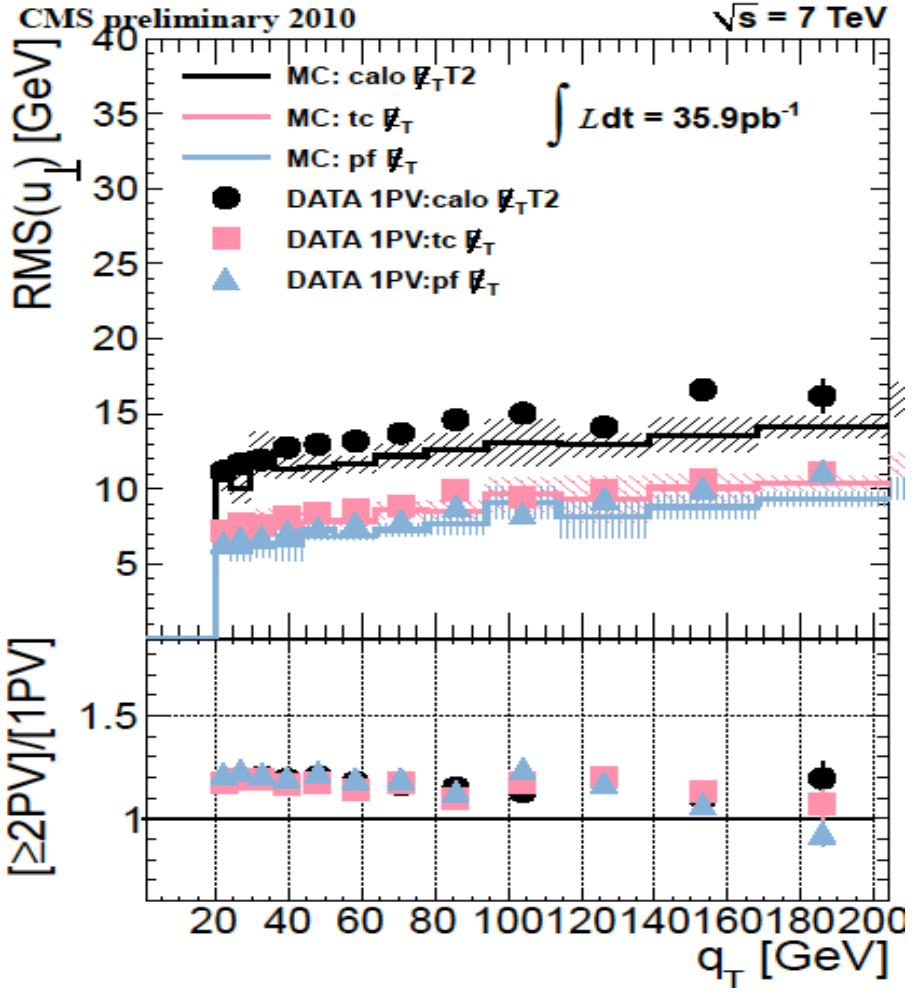




- Good agreement between data and MC prediction
- Type II correction greatly improves the missing ET scale.
- Presence of pileup doesn't affect the missing ET scale.
- More advanced algorithms (like pfMET) have already scale closer to 1
- Type I/II corrections to pfMET offers additional improvement.

MET Resolution





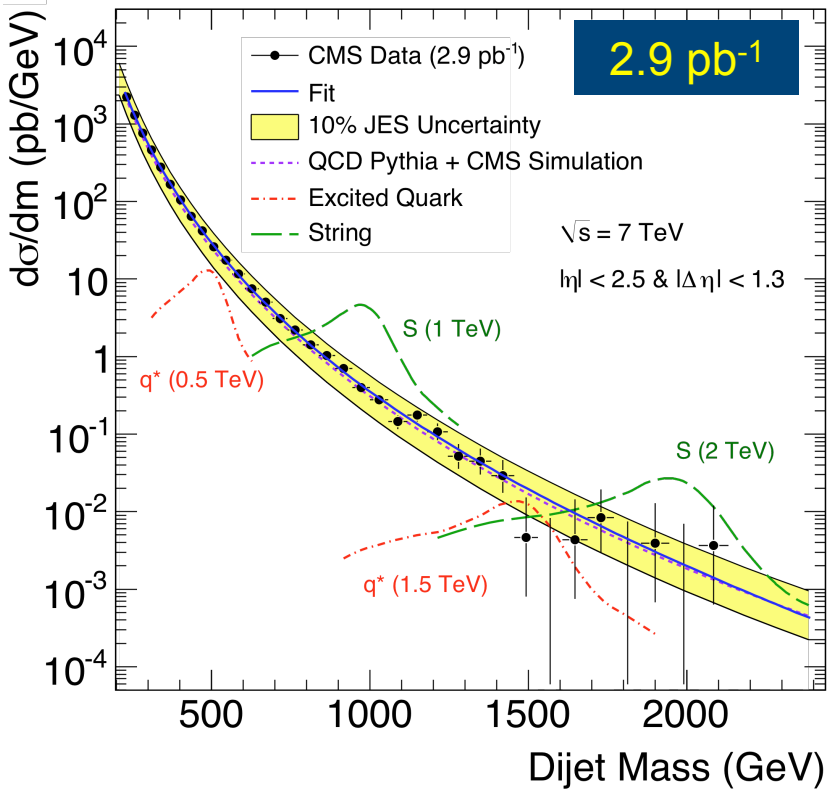
- MET resolution is improved for the algorithms, which use the tracking info.
- MET resolution is sensitive to the number of PU events. PU contribution to the resolution is well parameterized as a function of the number of PU events.

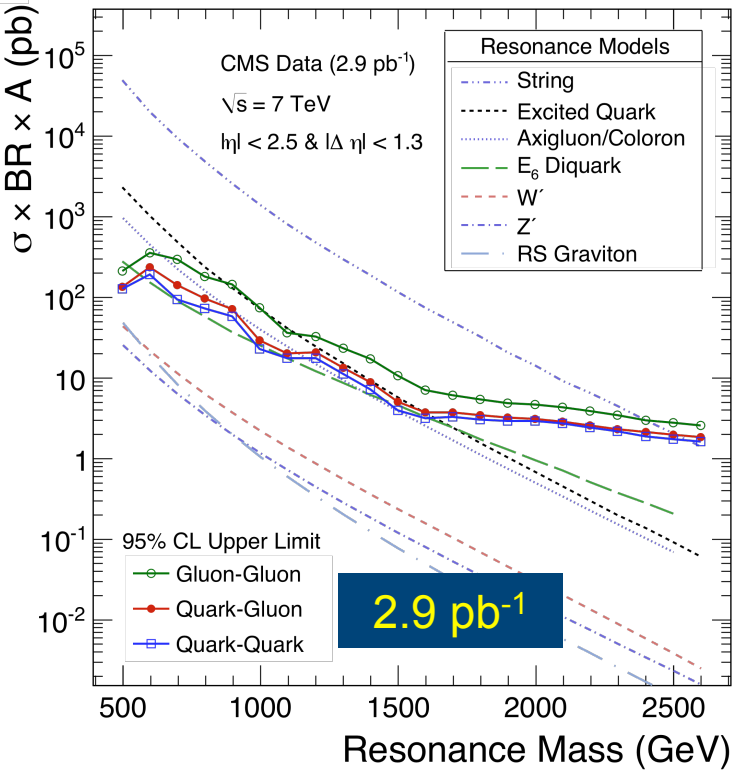
Search for Dijet Resonances in 7 TeV

PRL 105, 211801 (2010), 11/19/2010

We have measured, in 2.9pb^{-1} of data, the dijet mass differential cross section for $|\eta_1,\eta_2|<2.5$ and $|\Delta\eta_2|<1.3$. The distribution is sensitive to the coupling of any new massive object to quarks and gluons.

***** The first of the "new physics" search paper produced from the CMS**

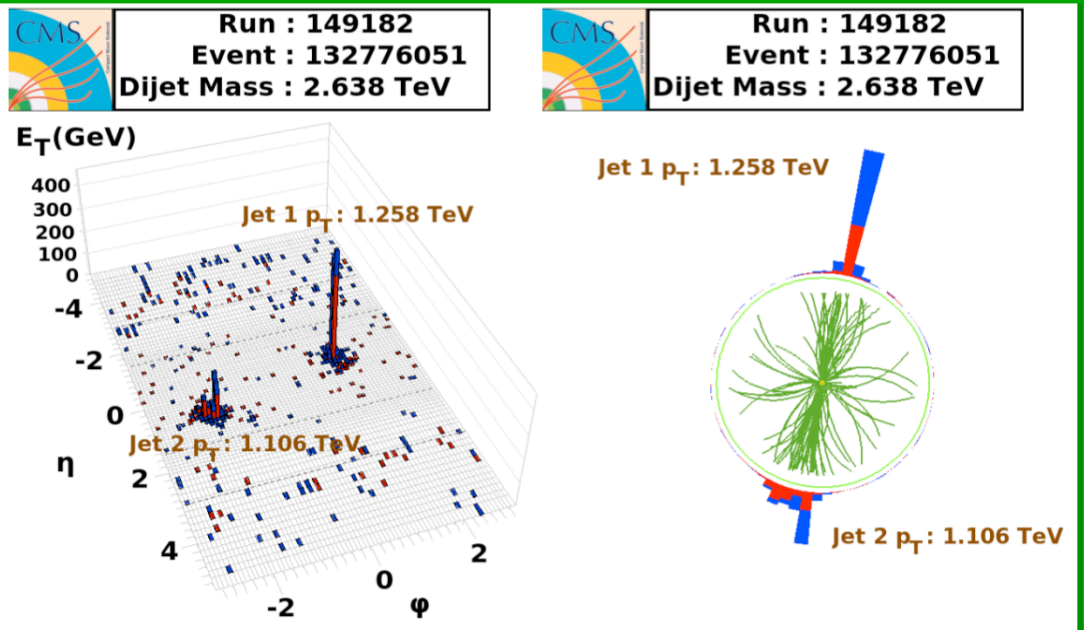


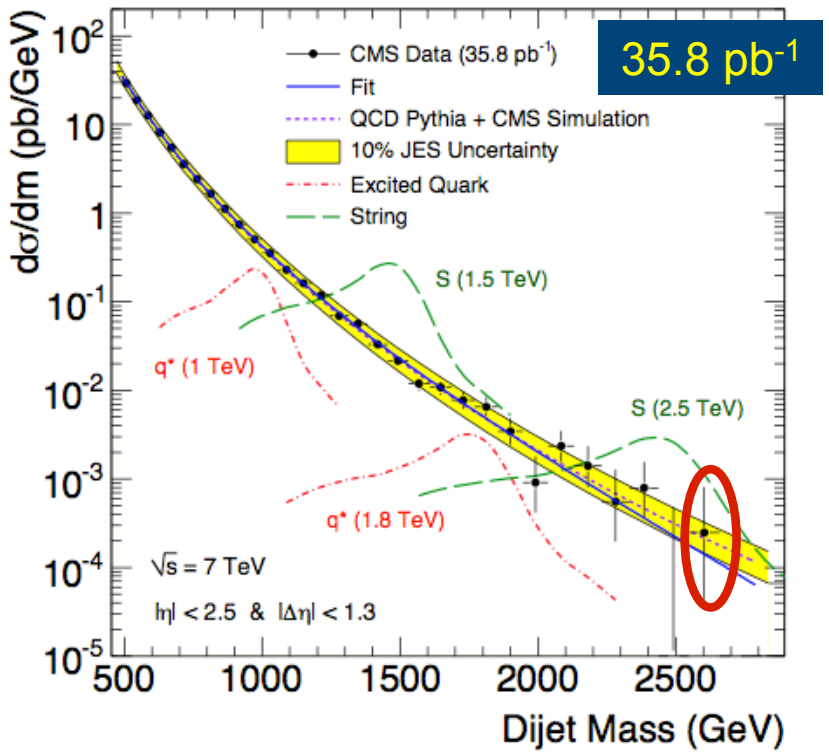


No new physics yet, set 95% C.L. mass limits for new particles decaying to parton pairs: String resonances >2.5TeV; Excited quarks >1.58TeV: "the world's most stringent limits"

Dijet Mass Search, Status & Plans

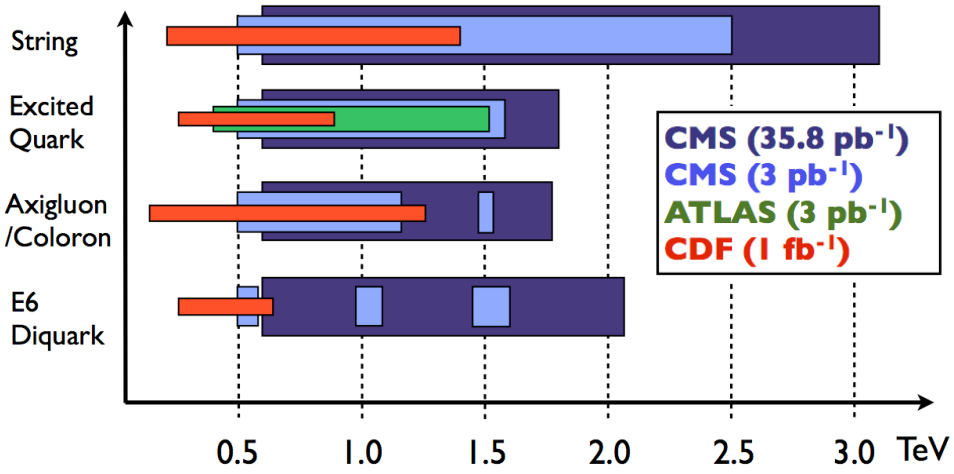
Highest Mass Dijet Event: 2.6 TeV





- **Status & Plans**
  - updating analysis on a weekly basis.
  - Moving to next publication with full statistics, better statistical methods & (possibly) adding PF

Also, contributed to Dijet centrality ratio analysis recently, accepted by PRL in Nov.



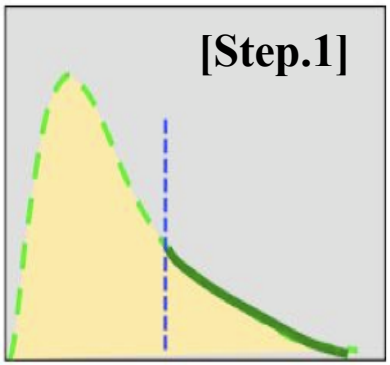
Hadronic W Decays in Jet+MET

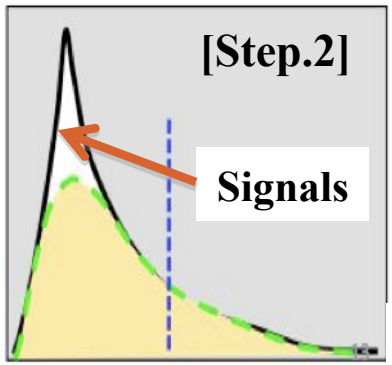
Experimental question leads to detection of the SM W bosons in the Jets+MET final state. We developed a data-driven method to extract hadronic W decays in the Jets+MET final state to characterize the signals (ttbar, SUSY) @ LHC.

Idea:

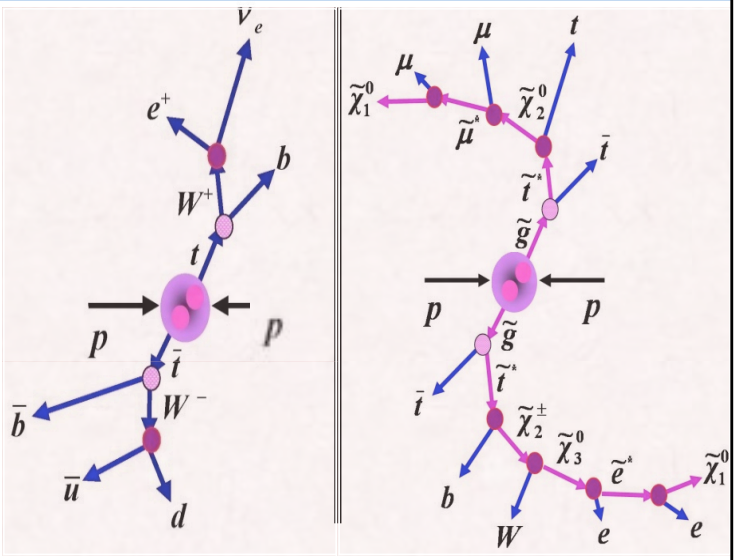
① mix jets from different events to estimate the W combinatorial background shape.

② get the normalization from the tail for subtraction





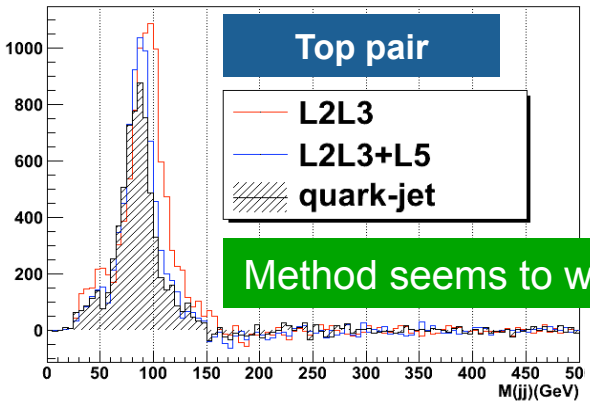
$$\frac{\int_{300}^{500} \mathrm{M}_{jj}^{same} dM}{\int_{300}^{500} \mathrm{M}_{jj}^{mix} dM}$$

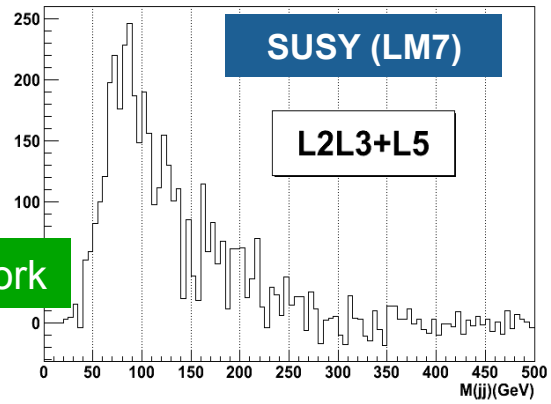


This method is used to reconstruct **M(jj)** on the **ttbar** and **SUSY** samples

$$p\bar{p} \rightarrow t\,\bar{t} \rightarrow (W^+b)\ \ (W^-\bar{b})$$
$$\hookrightarrow jj \quad \hookrightarrow l^+\nu$$
$$\tilde{g} \rightarrow t\,\bar{t}\,\tilde{\chi}_2^0 \rightarrow (W^+b)(W^-\bar{b})(\ell^+\ell^-\tilde{\chi}_1^0)$$

Test on SM (ttbar) & SUSY





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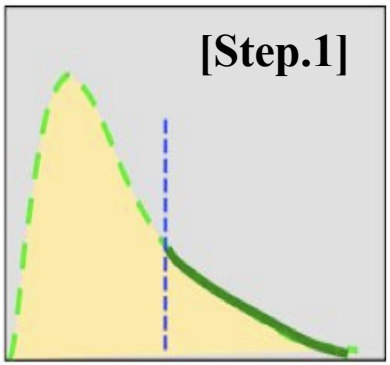
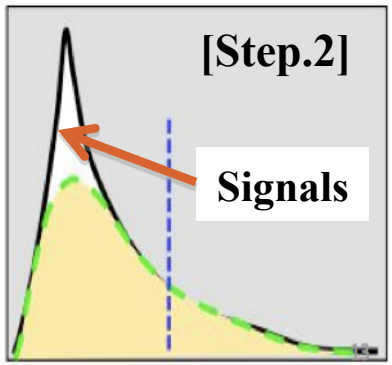
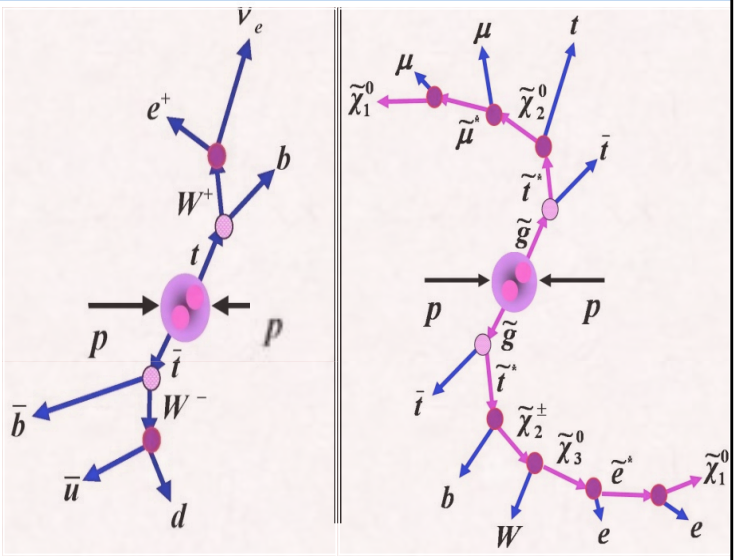




$$\frac{\int_{300}^{500} \mathrm{M}_{jj}^{\mathrm{same}} d\mathrm{M}}{\int_{300}^{500} \mathrm{M}_{jj}^{\mathrm{mix}} d\mathrm{M}}$$



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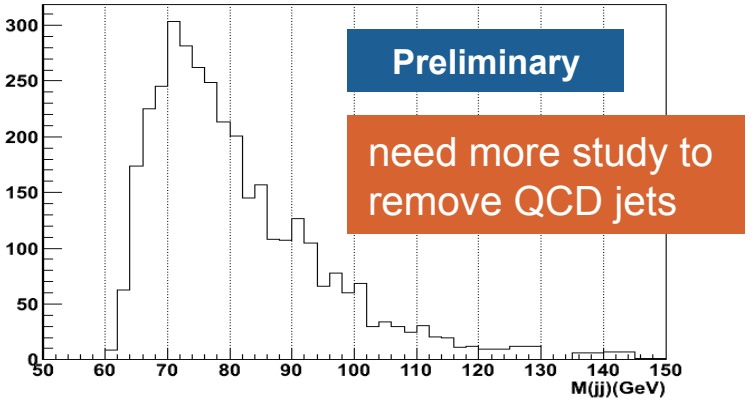
$$p\bar{p} \to t\,\bar{t} \to (W^{+}b)\ \ (W^{-}\bar{b})$$
$$\hookrightarrow jj \quad \hookrightarrow l^{+}\nu$$
$$\tilde{g} \to t\,\bar{t}\,\tilde{\chi}_2^0 \to (W^{+}b)(W^{-}\bar{b})(\ell^{+}\ell^{-}\tilde{\chi}_1^0)$$

Test on LHC Collision Data



TTU Contribution to CMS

Part.2 Summary

- TTU contributions cover many aspects of Jet/MET & BSM physics (coherent effort)
  - Jet
    - provided steady contributions to the Jet DQM & Validation
    - developed the method to determine a new Jet Energy Scale
  - MET
    - important/major contribution to the MET performances
    - Major contributor to MET JINIST paper, to be submitted soon
  - BSM Physics
    - Leadership role (Exotica-Multijet co-convener)
    - main contributor to the dijet resonance analysis (PRL 105)
    - developed data-driven method to reconstruct hadronic W (for SUSY/EW/Top)
- Results presented at major conferences (PLHC, ICHEP, HCP, SUSY)
- Work shown here (already) published or to be submitted for publication