Studies for measurement of top-pair cross section in fully hadronic channel at CMS

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Contents

- 연구 목적 & Motivation
- Fully Hadronic channel의 특징
- Framework & Data samples
- Event selection cuts & performance
- Statistical uncertainty on ttbar cross section mearuement
- Summary & plans

연구 목적

SUSY 그룹의 2008년도 Topics 중

- SM Background to SUSY : t-tbar

https://twiki.cern.ch/twiki/bin/view/CMS/SusyTopics#Table_of_commitments_for_the_Bac

우선적으로 t-tbar에 대한 연구를 선행

- Cross section expectation
- Top & W mass measurement

차후에 t-tbar가 background가 되는 SUSY signal 연구

Motivation

P-TDR을 참고로 하여 CMS 실험에서 이루어지는 SUSY와 t-tbar 이벤트를 이해하고자 함

t-tbar에 대한 연구 방향은 세가지 channel들로 가능

- Di-leptonic channel
- Semi-leptonic channel
- Fully hadronic channel

MET가 고려되지 않는 Fully hadronic channel을 선택

P-TDR에 수록되어 있는 t-tbar에 관련된 Analysis Plot들을 직접 만들어 보고 그 결과들을 비교하고 분석

- " Measurement of top-pair cross section and top-quark mass in the di-lepton and full-hadronic channels with CMS "
  - CMS Note 2006/077

Fully Hadronic Channel

Branching Ratio ~ 46 %

Huge QCD background ~ 1M

Final State

- No lepton
- No Missing Transverse Energy
- 4 quark jets and 2 B-quark jets

Framework

CMSSW_1_5_2 -> CMSSW_1_6_7

SusyAnalyzer v01-01-00 -> v01-02-00

- ParticleType Identification
  - electron, muon, jet, b-jet, …
- MatchObject module
- Jet Energy Correction module :
  - Jet Corrector (by JetMET Group)

CRAB & CERN Batch Services

Signal Samples

t-tbar + multijets

CSA07 samples

- GEN-SIM : Alpgen + PYTHIA at CMSSW_1_4_6
- DIGI-RECO : at CMSSW_1_5_2
- /ttNj_mT_70_alpgen/CMSSW_1_5_2-CSA07-2231/GEN-SIM-DIGI-RECO

Cross sections at GEN level

	tt + 0jet	tt + 1jet	tt + 2jets	tt + 3jets	tt + 4jets
Cross Section	619 Pb	176 Pb	34 Pb	6 Pb	1.5 Pb
Running Information	CRAB	CERN Batch Services			
Number of Event (L = 1 fb^{-1})	619000	176000	34000	6000	1500

Background Samples

QCD + dijets : 30 GeV < Pt < 600 GeV

CSA07 samples

- GEN-SIM : at CMSSW_1_4_4 with PYTHIA
- DIGI-RECO : at CMSSW_1_5_2
- /QCD_Pt_30_50 ~ 470_600/CMSSW_1_5_2-CSA07-2048/GEN-SIM-DIGI-RECO

Running Information

- CRAB + CASTOR

Background Samples

Cross section at GEN level

	Cross section	Number of Event	Luminosity
CSA07QCD_Pt_30_50_GEN_SIM	0.163 mb	163 x 10^6	1 pb^{-1}
CSA07QCD_Pt_50_80_GEN_SIM	21.6 μb	21.6 x 10^6	
CSA07QCD_Pt_80_120_GEN_SIM	3.08 μb	3.08 x 10^9	1 fb^{-1}
CSA07QCD_Pt_120_170_GEN_SIM	494 nb	494 x 10^6	
CSA07QCD_Pt_170_230_GEN_SIM	101 nb	101 x 10^6	
CSA07QCD_Pt_230_300_GEN_SIM	24.5 nb	24.5 x 10^6	
CSA07QCD_Pt_300_380_GEN_SIM	6.24 nb	6.24 x 10^6	
CSA07QCD_Pt_380_470_GEN_SIM	1.78 nb	1.78 x 10^6	
CSA07QCD_Pt_470_600_GEN_SIM	683 pb	683 x 10^3	

Event Selection

Number of jets without leptons

- $6 \leq \text{Njets} \leq 8$ & $\text{Nlepton} = 0$

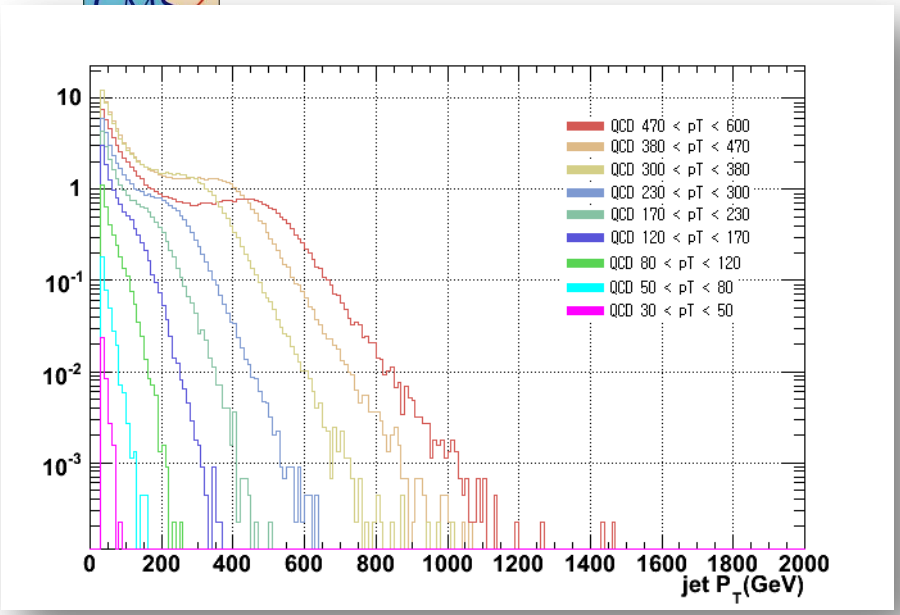
Transverse momentum and pseudorapidity thresholds

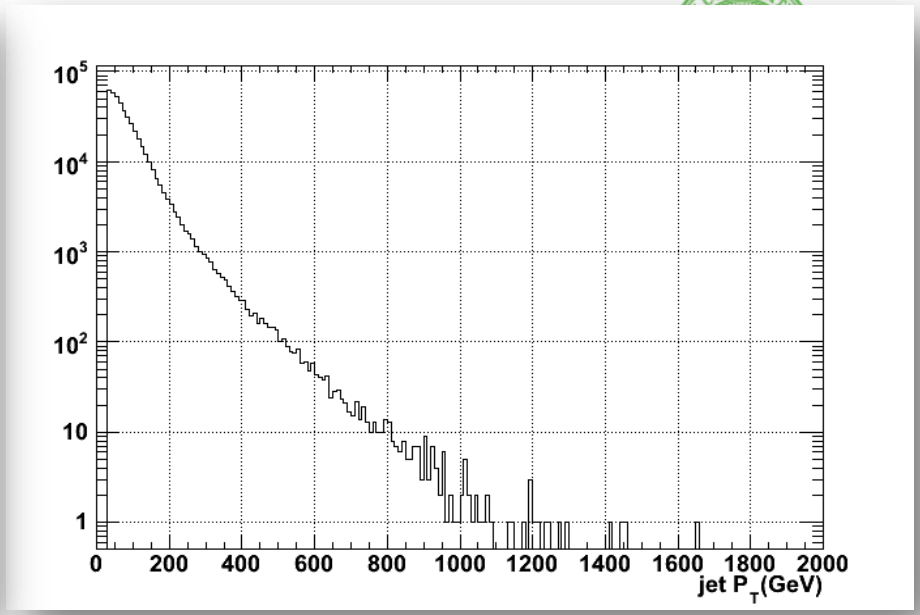
- $P_T > 30$ GeV & $|\eta| < 2.4$

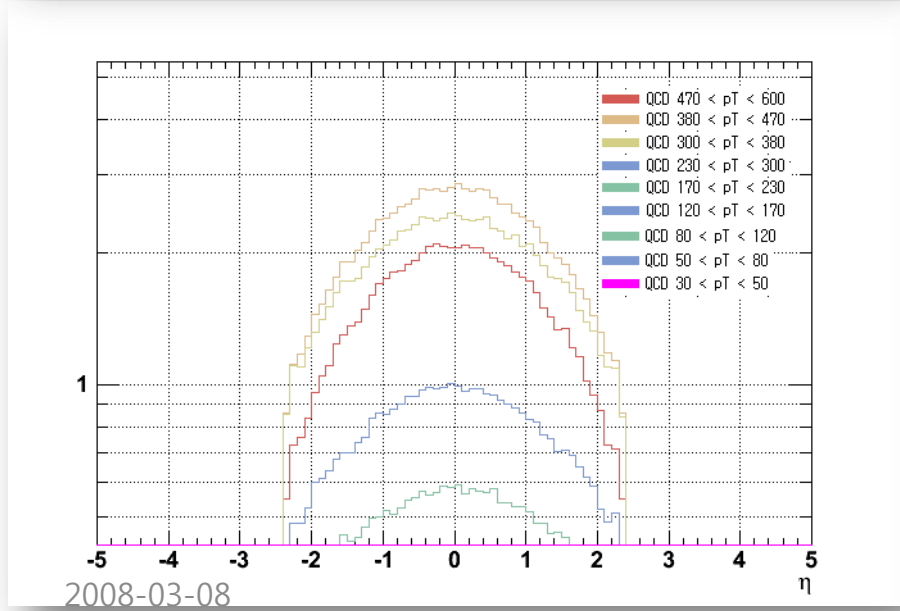
Event Selection

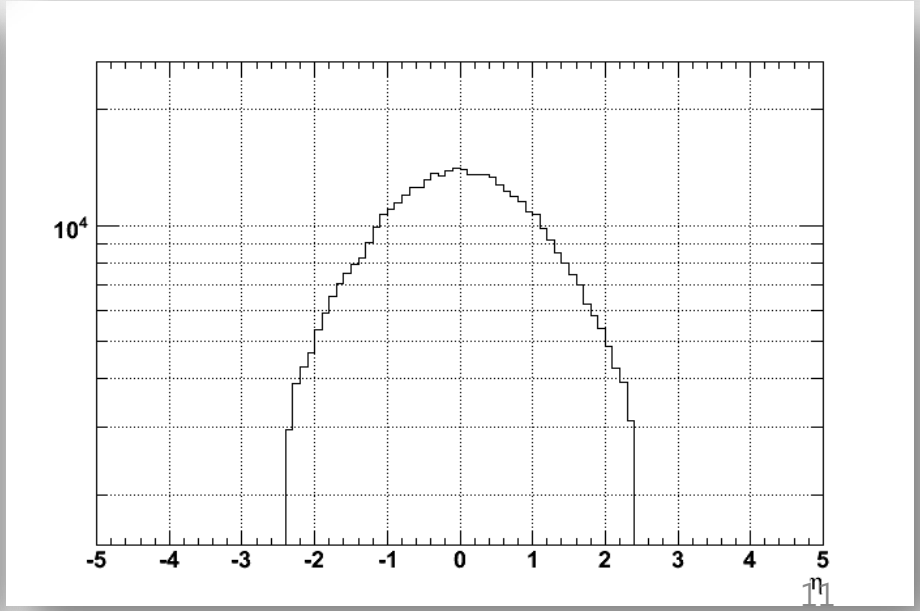
- Centrality ≥ 0.68
- Aplanarity ≥ 0.024
- Sum $P_T(E_T)$ of non-leading jets ≥ 148 GeV

Transverse momentum & pseudorapidity distribution

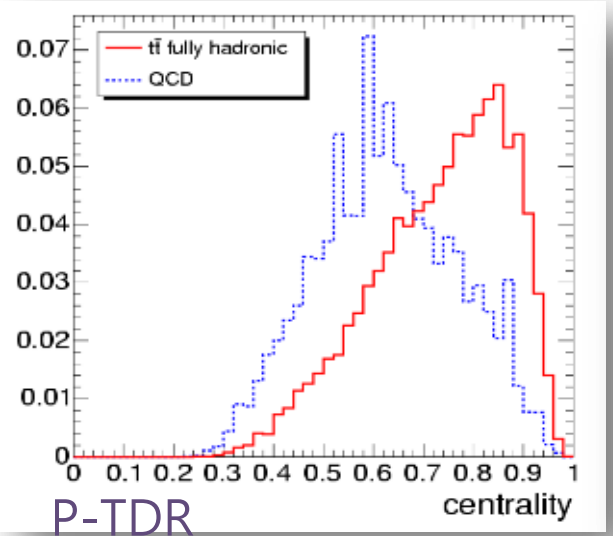




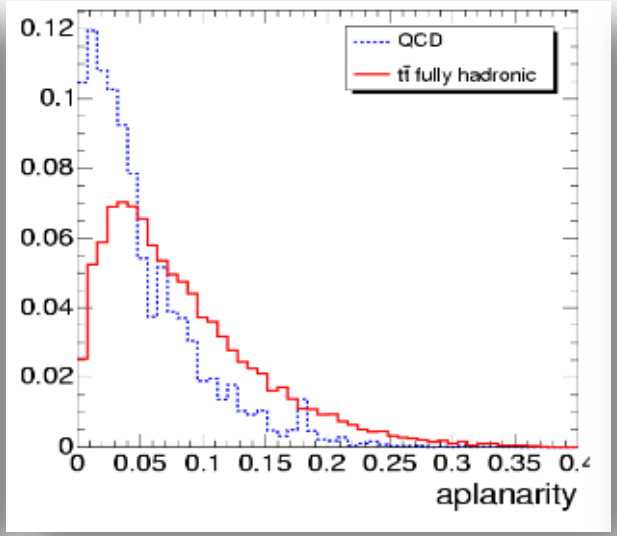


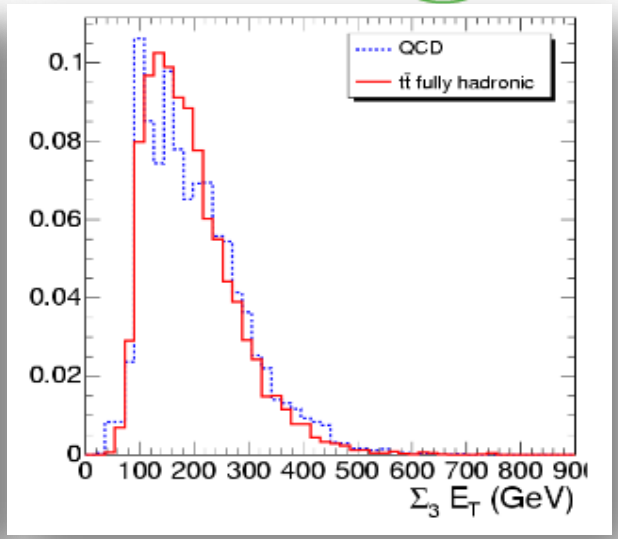


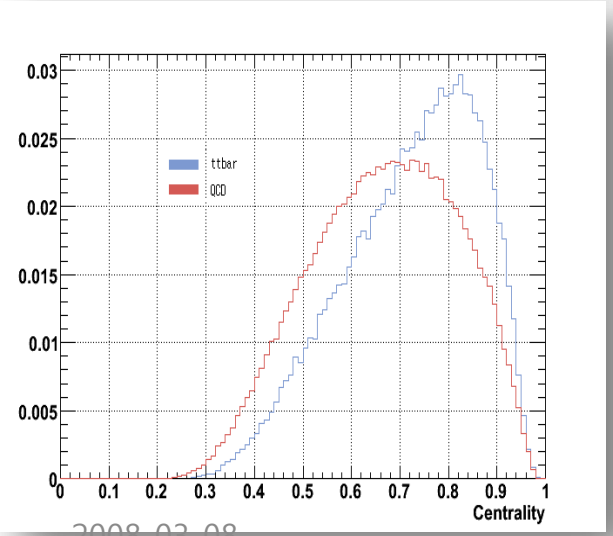
Centrality, Aplanarity and Sum $P_T(E_T)$ of non-leading Jets

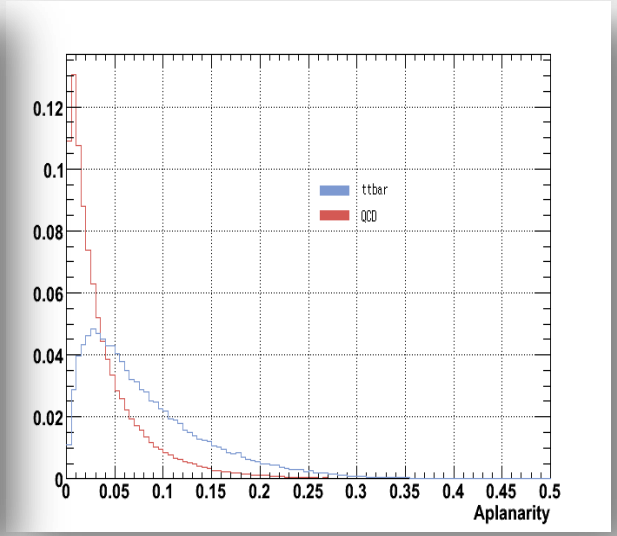


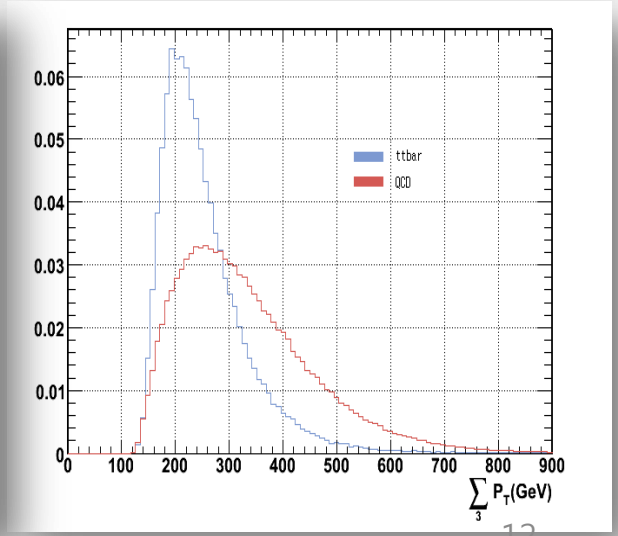
P-TDR











Cut efficiency at each step of event selection

Initial number of events = 2360449 (t-tbar) , 18780060 (QCD)

Selection	Requirement	Survived Events	Rejected Events	Efficiency
Kinematical (t-tbar)	Pt ≥ 30 GeV & |η| < 2.4	2083043	277406	11.8 %
	6 ≤ Njets ≤ 8	443742	1639301	78.7 %
	Centrality ≥ 0.68	287394	156348	35.2 %
	Aplanarity ≥ 0.024	373098	70644	15.9 %
	$\Sigma_3 P_T \geq 148$ GeV	438294	5448	1.2 %

$$\epsilon = \frac{\text{Initial Number of Event} - \text{Survived Number of Event}}{\text{Initial Number of of Event}} = \frac{\text{Rejected Number of Event}}{\text{Initial Number of of Event}}$$

Selection	Requirement	Survived Events	Rejected Events	Efficiency
Kinematical (QCD)	Pt ≥ 30 GeV & |η| < 2.4	15927480	2852580	15.2 %
	6 ≤ Njets ≤ 8	1496280	14431200	90.6 %
	Centrality ≥ 0.68	730542	765738	51.2 %
	Aplanarity ≥ 0.024	754746	741534	49.6 %
	$\Sigma_3 P_T \geq 148$ GeV	1480920	15360	1.0 %

Statistical uncertainty on cross section measurement

$$\sigma = \frac{n - b}{\epsilon \mathcal{L}}$$

n = candidate events = N(t-tbar) + N(QCD)
b = expected background = N(QCD)
n – b = surviving events = N(t-tbar)
ϵ = total signal efficiency
$\mathcal{L}$ = integrated luminosity

$$(\Delta\sigma)_{stat} \approx \frac{(\Delta n)_{stat}}{\epsilon \mathcal{L}} = \frac{\sqrt{n}}{\epsilon \mathcal{L}} = \sigma \frac{\sqrt{n}}{n - b}$$

현재 위의 주어진 수식에 대한 공부를 하고 있고, 앞선 cut performance부분에서 각 step에 따른 signal efficiency를 계산하는 방법을 연구해야 함

그 후, 계산된 값들을 도표로 만들고 이를 P-TDR의 결과와 비교/분석

Summary

SUSY에 대한 Background로서의 ttbar 연구

Fully hadronic channel을 이용한 ttbar 연구를 시작

❖ Physics TDR을 참고

P-TDR에서 사용된 Event selection 을 수행해 보고, P-TDR 의 결과와 비교/분석

위의 결과를 토대로 ttbar의 cross section에 대한 statistical uncertainty 를 계산하고 P-TDR과 비교/분석 할 계획

Future plan

남은 과제/계산들을 마무리

- Trigger & B-tag cut performance and efficiency measurement
- Signal efficiency & Effective cross section meaurement
- Systemic uncertainty & Luminosity uncertainty 에 대한 연구

지금까지의 연구 과정을 Semi/Di-Leptonic channel 에서도 수행하고 ttbar를 background로 하는 SUSY signal에 대한 연구

LHC에서의 Z+jets 이벤트를 통한 Luminosity 측정 연구

- "Towards a precise parton luminosity determination at the CERN LHC"
  - M. Dittmar, F. Pauss and D. Zuercher