Study of Z/W + nJets Events in CMS

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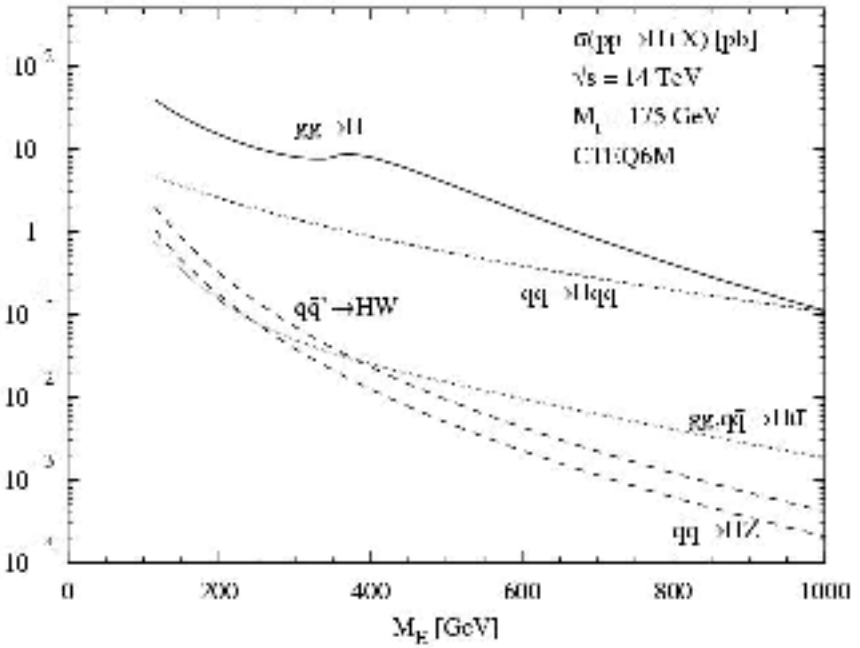
Outlines

- Features of Weak Boson Fusion
- Importance of Z/W + nJets processes as Background
- CSA06 Exercise
- Job submission using CRAB
- Overview of Analysis steps
- Events Statistics
- Conclusions

Weak Boson Fusion : Discovery mode for higgs Production

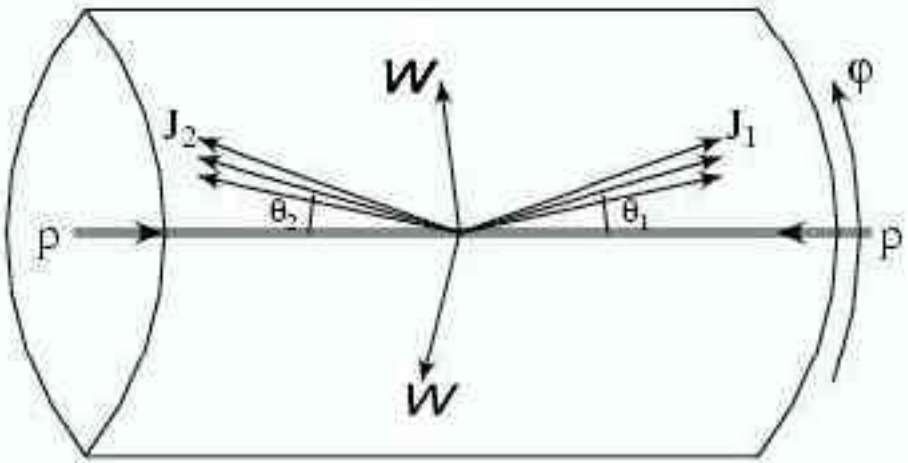
For *mH* 120 GeV & *Mt* = 175GeV
Gluon Fusion (*gg* -> *h*) = 36.4pb
Weak Boson Fusion(*VV* -> *h*) = 4.5pb
For *mH* 800 GeV & *Mt* = 175 GeV
Gluon Fusion (*gg* -> *h*) = 0.397pb
Weak Boson Fusion(*VV* -> *h*)= 0.196pb



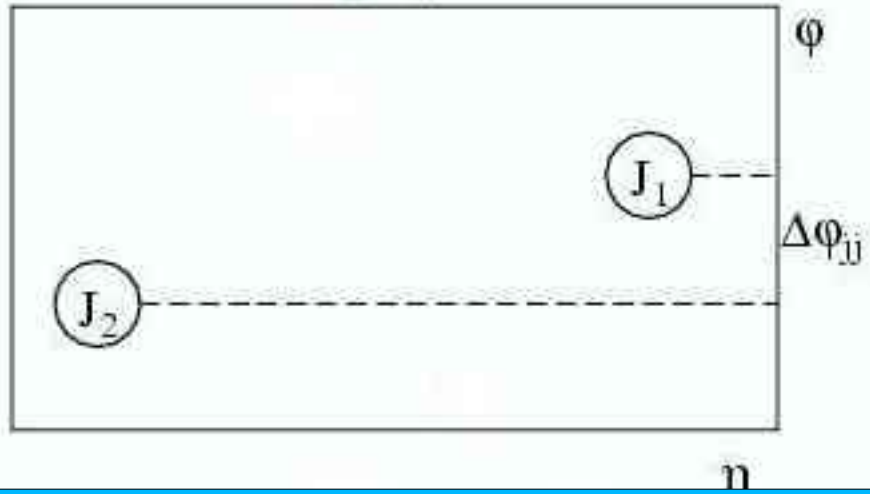
Higgs production rate by Weak Boson Fusion is large, over wide range of higgs mass.

WEAK BOSON FUSION

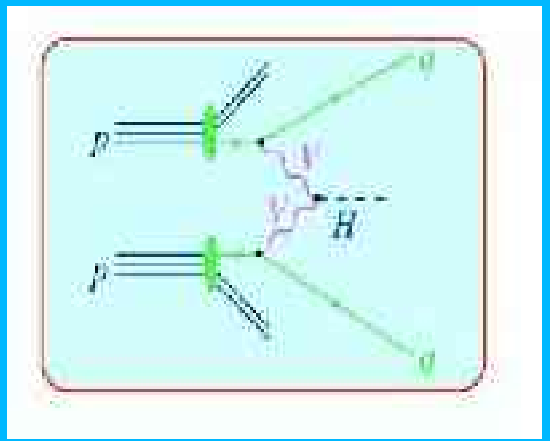
WBF event



Lego plot



- Energetic jets in the forward and backward direction (large dijet invariant mass).
- Large eta difference between jets.
- Small opening angle between jets in φ-plane.
- Higgs decay products in between the tagging jets.
- Absence of gluon radiation in central rapidity region, due to colorless exchange of W/Z.



Cont . . .

Zeppenfied Variable:

$$\eta_3 - (\eta_1 + \eta_2)/2$$

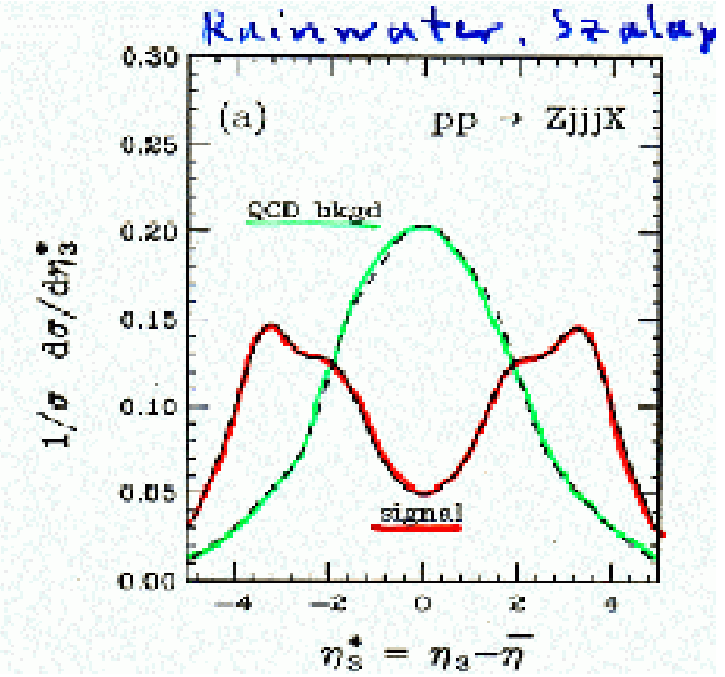
- Large value of Zeppenfied variable for 3rd jet.

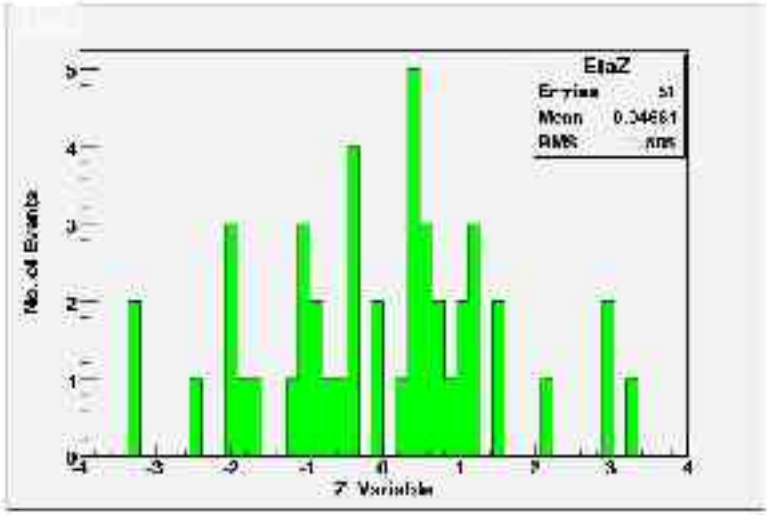
Cuts :

- $|\eta_1 - \eta_2| > 4.2$.
- $\eta_1 \times \eta_2 < 0$
- Dijet invariant mass ~ 1 TeV.

These are WBF criterion

- $\Delta\varphi < 1.$ radian
- Cut on Zeppenfied variable .





Z/W + nJets processes as Background to Higgs

topology	Background for Higgs channel (one example)
W+1j+X	gg->h->WW*->2l
W+2j+X	MSSM gg->bbH, H->ττ->*l*+jet (one b-tag)
W+3j+X	VBF qq->qqh, h->ττ->*l*+jet + 2 tag. jets
W+4j+X	VBF qq->qqh, h->WW->*l*νjj + 2 tag jets
Z+1j+X	MSSM gg->bbH, H->ττ->l+jet (one b-tag)
Z+2j+X	VBF qq->qqh, h->ττ->*l*+jet + 2 tag jets
Z+4j+X	VBF qq->qqh, h->ZZ->*ll*jj + 2 tag jets

channel, NLO σ x Br	Level-1 + HLT efficiency	events for10 fb^{-1}
W->e ν, 20.3 nb	0.25	5.1×10^7
W->μν, 20.3 nb	0.35	7.1×10^7
Z->ee, 1.87 nb	0.53	1.0×10^7
Z->μμ, 1.87 nb	0.65	1.2×10^7
tt~->μ+X, 187 pb	0.62	1.2×10^6

Invisble Decay of Higgs :

2 tag. Jet + Large MET

- Z -> invisible (B.R. 20 %)
- W -> 1 ν (B.R. ~ 10%)

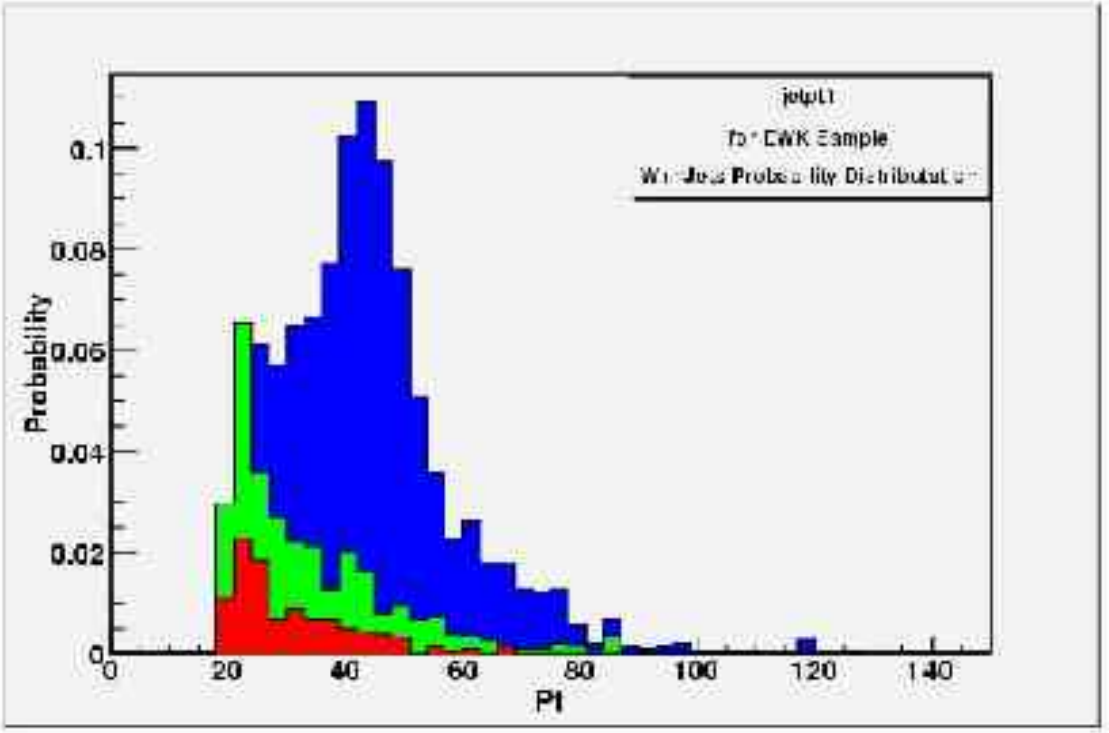
lepton may pass undetected.

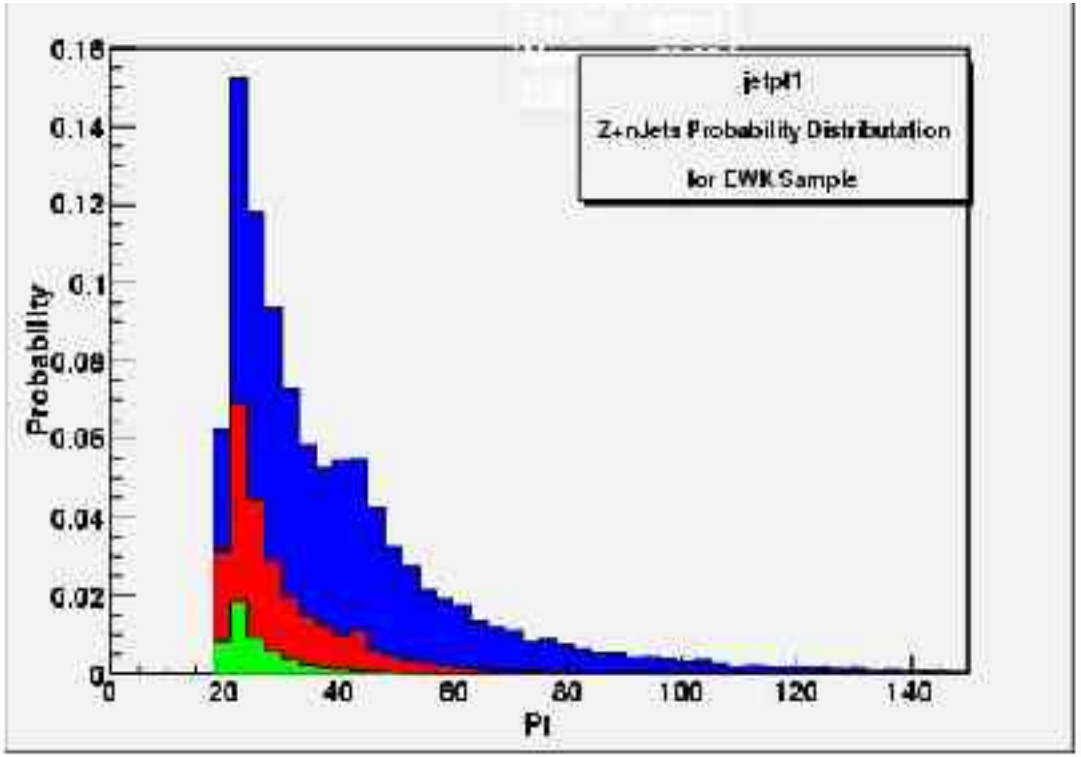
Cont . . .

As n increases Z/W + nJets, rate goes down roughly by factor of α^n.

So Z/W + 3 jets rate can be scaled using Z/W +2 jets rate.

Calculation will be done using data so theoretical uncertainties will be absent.





CSA06 EXERCISE

- Testing of work flow and data flow associated with CMS
- 50 millions events are generated (*Minimum Bias,Z->$\mu\mu$, W->lν, EWK soup, t-tbar etc*.)

Tier-0 :

Prompt reconstruction, determination of calibration constant and creation AOD samples.

Tier-1 :

Testing of calibration, analysis of AOD samples and skim jobs.

Tier-2 :

Physics jobs on skimmed data.

Sample of Interest :

EWK soup (5M events) : Drell-Yan + W->lν + H->WW where W decay leptonically.

t-tbar (5M events) : all decay channels are open.

http://indico.cern.ch/conferenceDisplay.py?confId=6487.

CRAB

/afs/cern.ch/cms/ccs/wm/scripts/Crab/CRAB_1_4_0/configureBoss

```
eval `scramv1 runtime -sh`
source /afs/cern.ch/cms/ccs/wm/scripts/Crab/crab.sh
source /afs/cern.ch/cms/LCG/LCG-2/UI/cms_ui_env.sh

voms-proxy-init -voms cms
rfmkdir  /castor/cern.ch/user/s/sunil/csa06
rfchmod  775  /castor/cern.ch/user/s/sunil/csa06
```

Crab.cfg :

```
        jobtype = cmssw
        scheduler = edg, glite
        datasetpath = /CSA06-106-os-EWKSoup0-0/RECOSIM/
                      CMSSW_1_0_6-hg_HiggsTau_1lFilter-1164299525
```

Cont . . .

pset = analysis.cfg
Total no of events = -1
No. of events per job = 5000
output_file = analysis.root
storage_path = /castor/cern.ch/user/s/sunil/csa06
se_black_list = exclude storage element
se_white_list = preference to particular storage element
ce_black_list = exclude computing element
ce_white_list = preference to particular computing element

- crab -create
- crab -submit N -c
- crab -status
- crab -getoutput

http://www.uscms.org/SoftwareComputing/UserComputing/Tutorials/Crab.html

Analysis Steps

Muons (Pt > 15 GeV) : (i) *Global muons* used.

(ii) Muon isolation is not implemented in CMSSW_1_0_6.

(iii) Z events are selected usingtwo highest Pt muons and then putting mass window around Z mass.

(iv) For W events and MET is taken to be greater than 40 GeV. Using mass window around W mass W events being selected.

Jets (Pt > 20 GeV) : (i) " *midPointCone5"* algorithm used.

(ii) skimmed sample JetPt is uncorrected, correction has been done using "GammaJet" module.

module corJetMCone5 = GammaJet {

string src = "midPointCone5CaloJets"

}

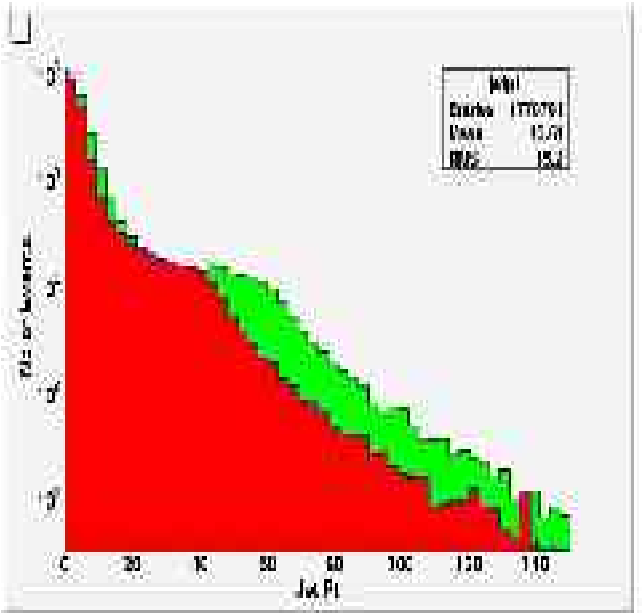
(iii) GammaJet procedure make use of processes like

$qg \rightarrow q\,\gamma$ & $q\text{-}qbar \rightarrow g\,\gamma$

Jet Pt is calibrated using γ Pt.

Cont . . .

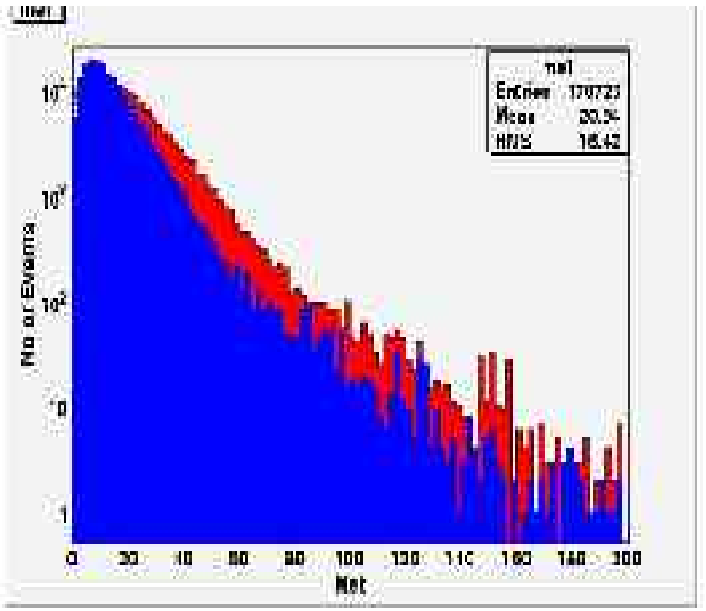
(iv) Highest Pt Jets (Pt > 40 GeV) are passed through WBF criterion.
(v) Small opening angle cut ($\Delta\varphi < 1.$ radian) is applied.



MET :

It is the negative of total energy deposited in calorimeter towers.

MET is corrected using “Type1MET” module. It uses the corrected Jet Pt and energy of towers, not belonging to any jet ..



Cont . .

```
module corMET        =              Type1MET   {
        string inputCorJetLabel    =  "corJetMcone5"

        string inputUnCorJetLabel = "midPointCone5CaloJets"

        string  metType                 =  "CaloMET"

        string  inputUncorMetLabel  =  "met"
      }
```

- Muon Pt added to intrinsic MET in the events to resemble the process with Z ->$\nu\nu$.
- MET > 100 GeV , Cut

Event Statistics :

Z + nJets process :

Selection Cut	EWK Sample	t-tbar Sample
Total Skimmed Events.	1803128	1858951
Z events.	114894	8662
Z + Jets >=2 (Pt > 40 GeV).	1787	5794
Z + VBF Jets.	21	40
Z + VBF Jets and MET.	17	21
Z + VBF Jets ,MET and $\Delta\varphi$ cut.	4	6

Cont . . .

W + nJets process :

Selection	EWK Soup	t-tbar
Total skimmed Events	2240144	_
W Events	7920	_
W + Jets >= 2 (Pt > 40 GeV)	1922	_
W + WBF Jets	107	_
W + WBF Jets and MET cut	69	_
W + WBF Jets,MET and $\Delta\varphi$ cut	18	_

Conclusions

- W/Z + nJets are very important standard model events which will be studied for their own credit (determination of α etc.).
- We are studying W/Z + 2Jets events,
  - (i) W/Z decay in leptonic modes
  - (ii) Jets satisfy WBF criterion.

- Estimation of background rates ,for higgs search by rate measurement for above processes

Study of such processes is one of the main physics items this year in CMS. We shall be participating in studying experimental and theoretical issues and the estimation of limiting factor for absolute rate.