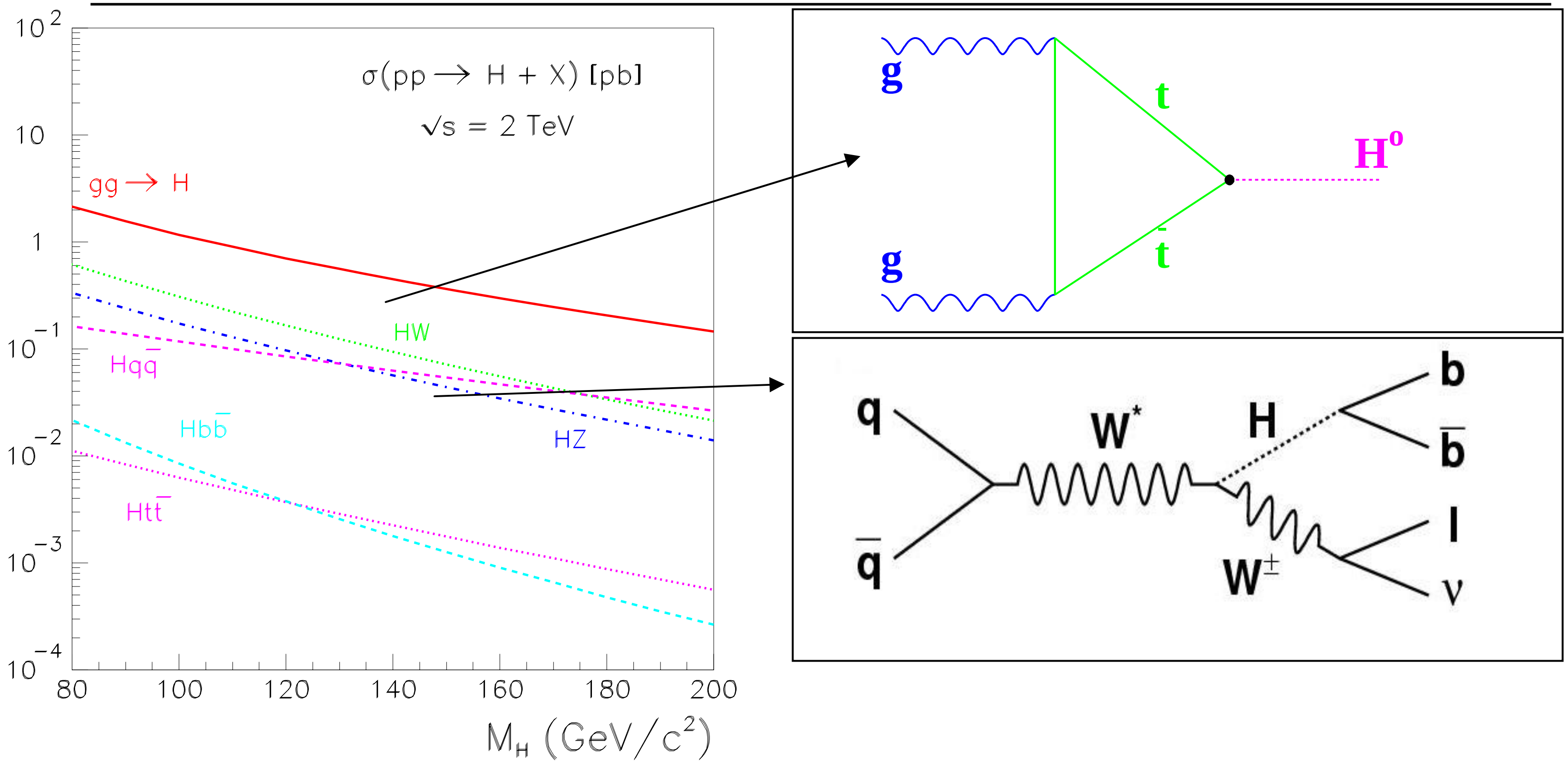
A Search for WH/W$b\bar{b}$ Production with 1.2 fb^{-1} of data at the DØ Experiment

Venkat Kaushik, Jae Yu
University of Texas at Arlington

Physics Motivation

- Existence of Higgs has major consequences
  - W and Z bosons *acquire mass* in the ratio $M_W/M_Z = \cos\theta_W$
  - neutral Higgs bosons H° *must exist* !
  - Interactions with the Higgs field can *generate* fermion masses
- SM Predicts neutral Higgs Boson which has not been verified experimentally
  - Since H° couples strongly to W and Z the best places to search for it are at Tevatron and LHC!
  - Does *not predict* the mass of the Higgs boson
  - Does predict its couplings to other particles e.g. *coupling to fermions* gffH ~ mf
  - $H^\circ \rightarrow b\underline{b}$ is likely to be the decay mode for Higgs *discovery*

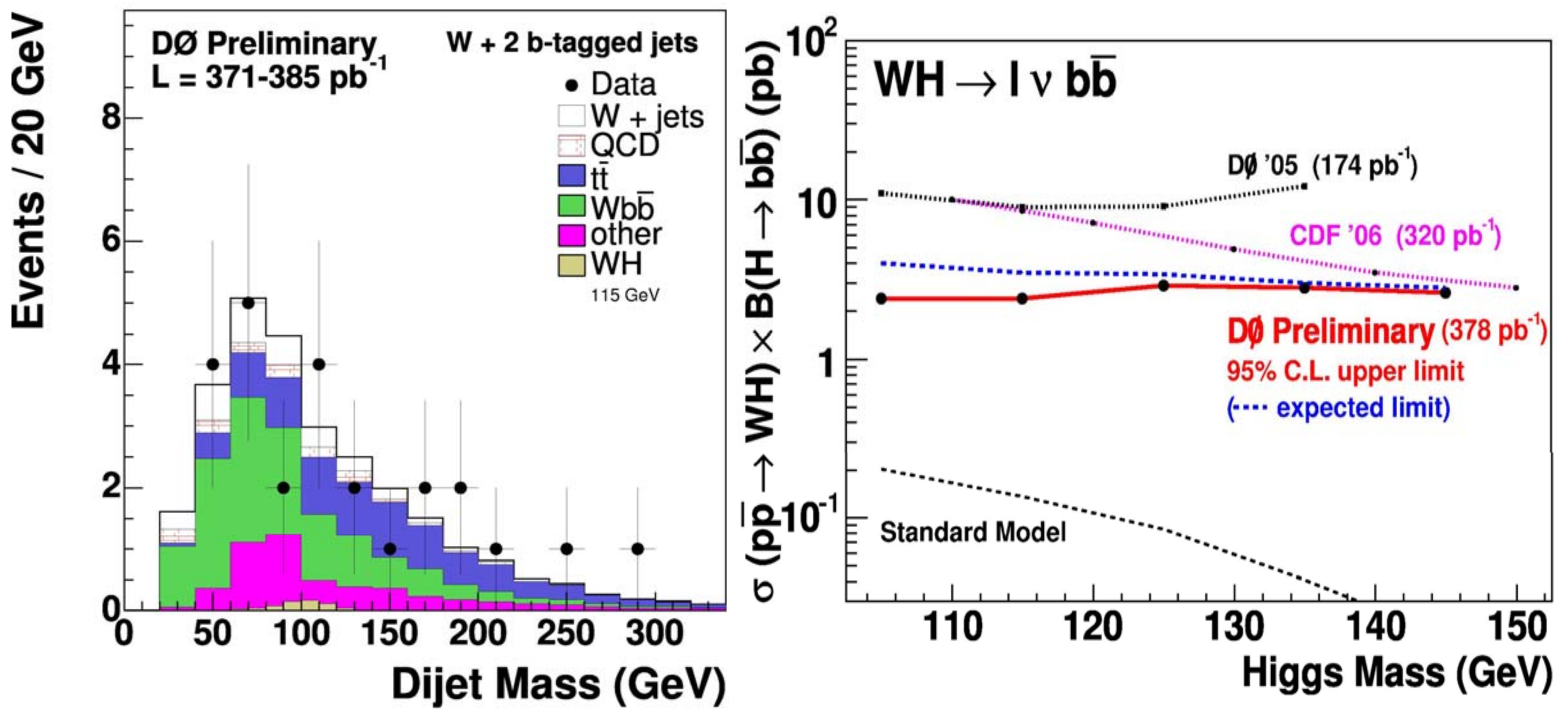
Higgs Search at Tevatron



Gluon fusion dominates but WH/ZH more accessible
(gg→bb channel has huge QCD background !)

Event signature with 2 b-tagged jets, missing transverse energy and an isolated lepton (electron/muon)

W(lv) H(b$\underline{\text{b}}$) Results with 378 pb^{-1}

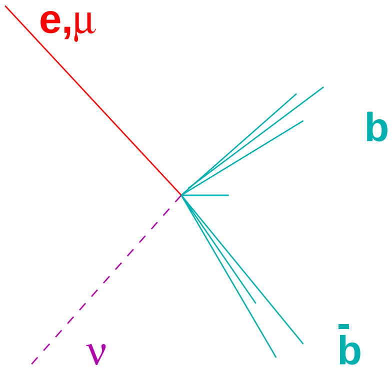


Analysis by Hyunwoo (UTA) and Lars (IN2P3) on electron and muon channels respectively

The goal is to extend the analysis to 1.2 fb^{-1} with significant improvements to b-tagging,

Identifying Physical Objects

- Isolated Electron
  - p_T > 20 GeV/c
  - $|\eta|$ < 1.1
  - Fractional Energy in EM Calorimeter > 90%
  - Isolation Fraction < 0.2
  - Tight Shower shape
    - $\Rightarrow \chi^2$ of HMx(7) < 75
  - Electron Likelihood > 0.85
  - Event should have fired at least one of the single EM Triggers



- Neutrino (Missing E_T)
  - Require $\not{E}_T$ > 25 GeV
  - Corrected for the presence of Muons
  - Corrected for the jet energy scales

- Two Jets (Missing E_T)
  - Exactly 2 jets required
  - Reconstructed with cone algorithm

$$\Delta R = \sqrt{\Delta\eta^2 + \Delta\varphi^2} = 0.5$$

  - $|\eta|$ < 2.5
  - p_T > 20 GeV/c
  - B Tagging

Analysis Approach

- Apply selection criteria to the data to select the candidate signal events. (S)
  - Split the selection into loose/tight samples based on electron quality (likelihood requirement)
- Estimate the background sources (B)
  - Physics Backgrounds (from simulated data)
  - Instrumental Background multi-jet/QCD
  - Determine the efficiency corrections to be applied to simulated data (Monte Carlo/MC) from data
  - Determine the Luminosity for MC
- Optimize selection for $S/\sqrt{B}$
- Estimate the Systematic Uncertainties
- To minimize Wbb contributions to a potential Higgs signal
  - Apply additional selection on $b\underline{b}$ invariant mass, using a sliding mass window for Higgs (115 – 145)GeV/c^2.
  - Hope to observe an excess of signal over estimated background!!

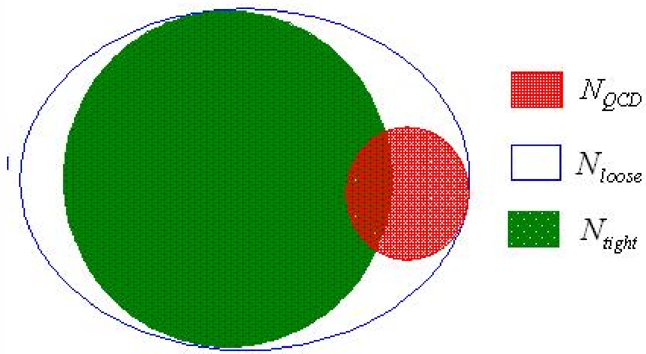
Dataset and Sub-skimming Status

a) Data - def:CSG_CAF_EMinclusive_p17refix - 29.53M Events $\approx 800\ pb^{-1}$

- (SKIM_TOP_ETRACK && HAS_JCCB && EM pT > 15 && |eta| < 2.5 and emfrac > 0.9 and iso < 0.2 and chi2 > 0.0) || HAS_2ELE_5

b) Subskims - Require $\geq$ 1 e with Loose_trk or Tight_trk Ver.2 (emid_cuts)

Loose_trk	Tight_trk
emfrac ≥ 0.9	emfrac ≥ 0.9
iso ≤ 0.2	iso ≤ 0.2
pT $\geq$ 3 GeV/c lhood ≥ 0.2	pT $\geq$ 3 GeV/c lhood ≥ 0.85



$$N_{loose} = N_e + N_{QCD}$$

$$N_{tight} = \varepsilon_{lk} N_e + p_{fake} N_{QCD}$$

c) Still to Process ~ 300 pb^{-1} of data

d) Standard Data/MC scale factors: 1D binned vs DetEta ver.2 loose_trk/ tight_trk

Summary of Event Selection

Selection	Events	Relative %	Absolute %
Proc "dq" (input)	29528499	100	100
Data Quality	27663515	82.82	82.82
Object ID = 10, 11	27614353	99.82	82.67
Calorimeter isolation ≤ 0.2	27614261	99.99	82.67
EM fraction ≥ 0.9	27593237	99.92	82.60
Electron pT ≥ 3	27570345	99.91	82.54
Likelihood7 ≥ 0.2	6418061	24.74	20.44
N electrons ≥ 1	6418061	24.74	20.44
Loose: Proc "selected" (input)	6418061	24.74	20.44
Likelihood7 ≥ 0.85	3309472	12.00	9.91
N electrons ≥ 1	3309472	12.00	9.91
Proc "electronCorr" (input)	3309472	12.00	9.91
Tight: Proc "selected" (input)	3309472	12.00	9.91

Single EM-Trigger Suite

- Trigger V11(*i.e.*, all versions before 12) are represented by EM_MX and EM_HI
- Ex_SHT20 (x=1,4) belong exclusively to V12
- Ex_SHT22 and Ex_T13SH15 (x=1,4,6) belong exclusively to V13
- Ex_SH30 (x=1,4), Ex_SHT15_TK13 (x=1,4,6), and Ex_T13L15 (x=1,4,6) are common to V12 and V13
- Ex_SHT25, Ex_ISH30, Ex_ISHT22, Ex_T15SH20, Ex_ISHT15_TK13 (x=1,3,4) are exclusive to V14
- E1_SH30 and E1_ISH30 are unprescaled
- Used tag-probe method. Restricted to CC region. Determined the trigger "turn-ons"

$$y = \frac{p_2}{2}\left[1 + ERF\left(\frac{x - p_0}{p_1\sqrt{x}}\right) + ERF\left(\frac{x - p_3}{p_4\sqrt{2}}\right)\right]$$

Trigger Efficiency using $Z \rightarrow ee$ events

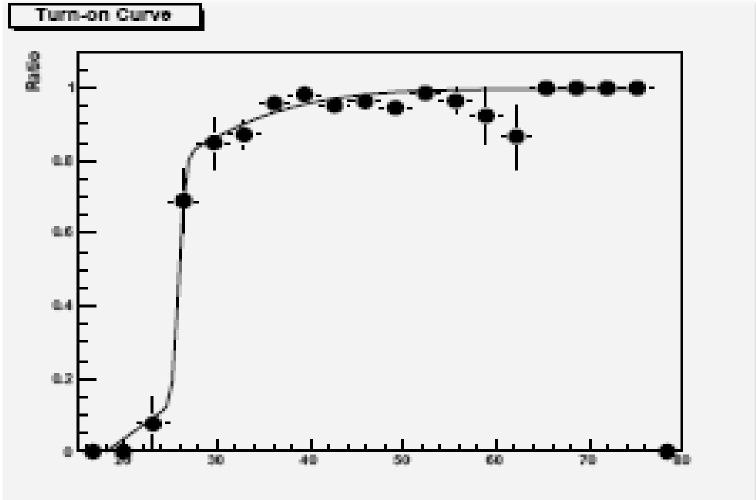
- Require two reconstructed em objects with
  - emfrac > 0.9
  - has_track_match(χ^2 prob $> 1\%$)
  - $|\eta_{cal}^{det}| < 1.2$
  - is_in_fiducial
  - HMx8 < 20
  - isolation < 0.15
  - $|$ typeID $| = 10, 11$
- 65 GeV $<$ Z invariant mass $<$ 110 GeV

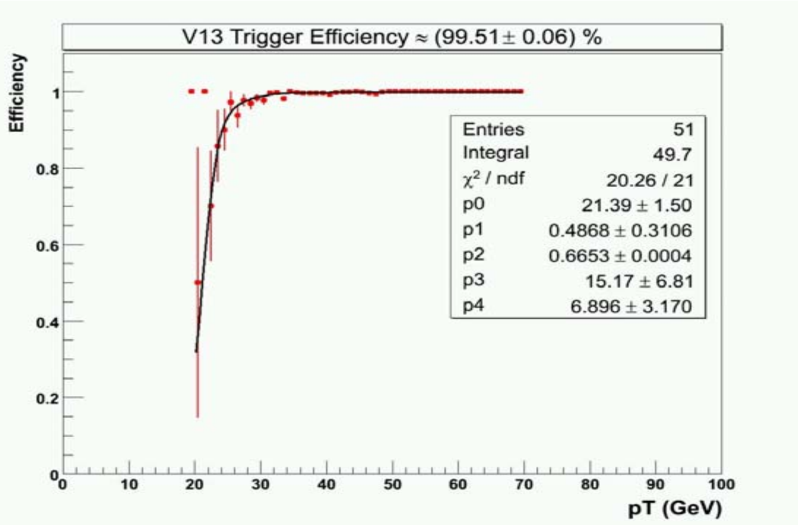
Probe- Test if it passed all the trigger requirements

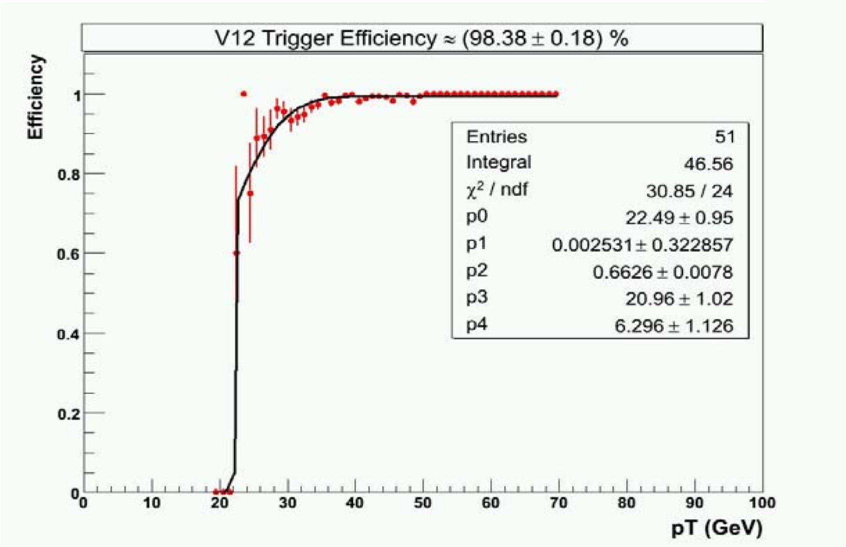
Tag - Must be matched to a single EM trigger

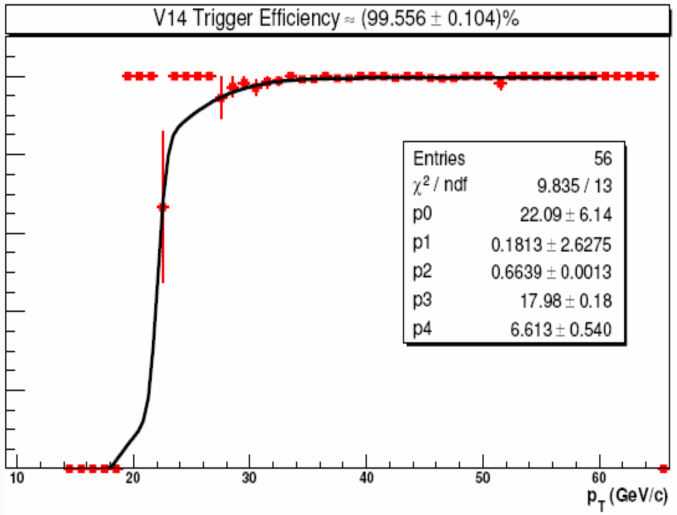
1. Plot the efficiencies as a function of pT of the electron
2. This method can also be used to measure electron ID efficiencies and examine differences between data & MC.

Trigger Efficiency vs. p_T







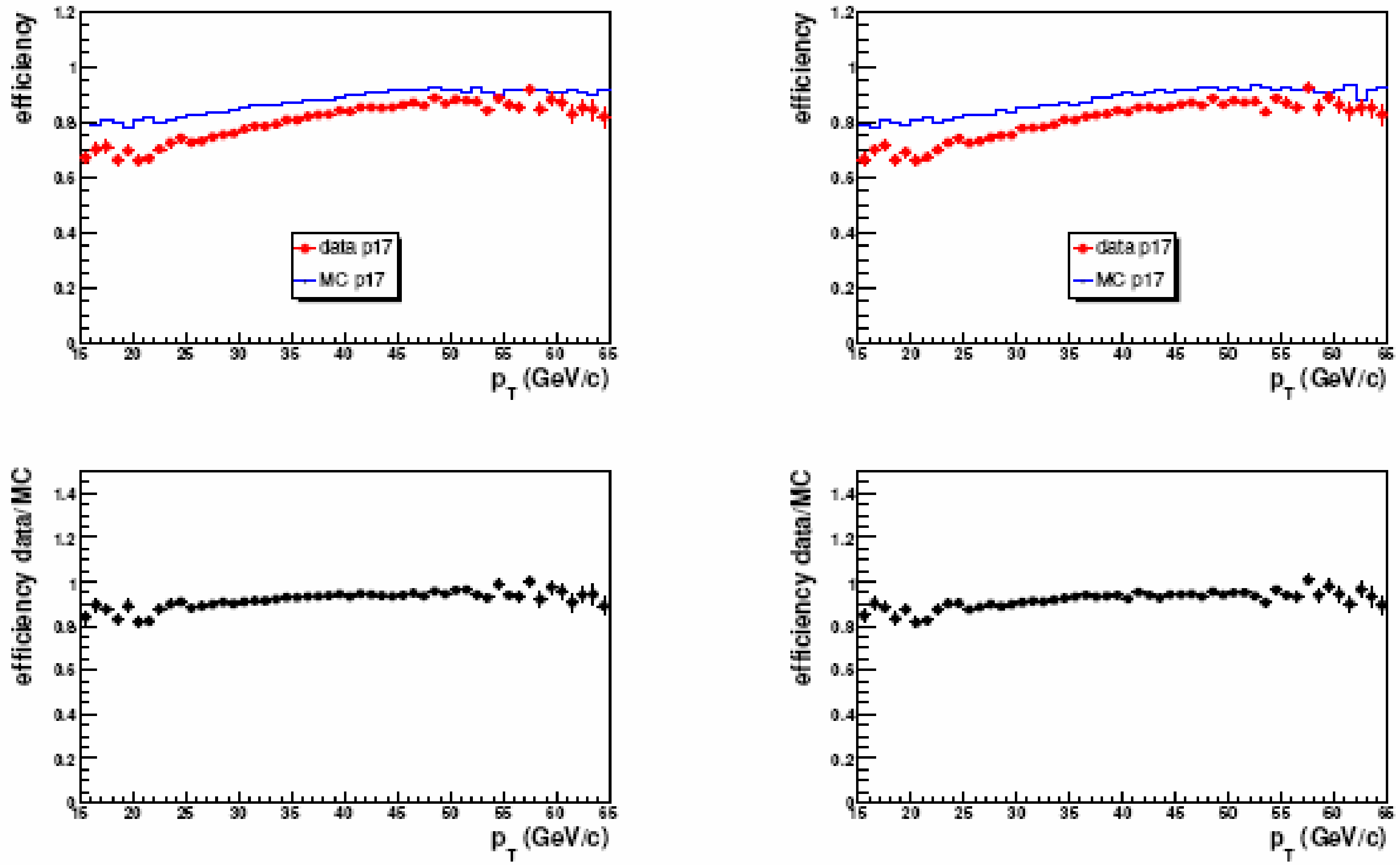


Electron ID Efficiency

- Using a similar Tag-Probe method, we can measure the electron reconstruction and identification efficiency
  - HMx(7) efficiency
  - Track Match Efficiency
  - Likelihood Efficiency

CC Eff	Loose		Tight	
	Data	MC	Data	MC
HMx	98.514 ± 0.053	99.216 ± 0.020	98.205 ± 0.059	99.237 ± 0.027
Track	89.457 ± 0.123	93.574 ± 0.057	89.384 ± 0.120	82.353 ± 0.253
Track + pT	89.280 ± 0.124	93.396 ± 0.058	89.205 ± 0.121	93.450 ± 0.058
Lhood	96.020 ± 0.083	97.603 ± 0.037	86.038 ± 0.139	91.639 ± 0.091
Total	84.620± 0.158	90.615 ± 0,071	75.524 ± 0.193	74.892 ± 0.270

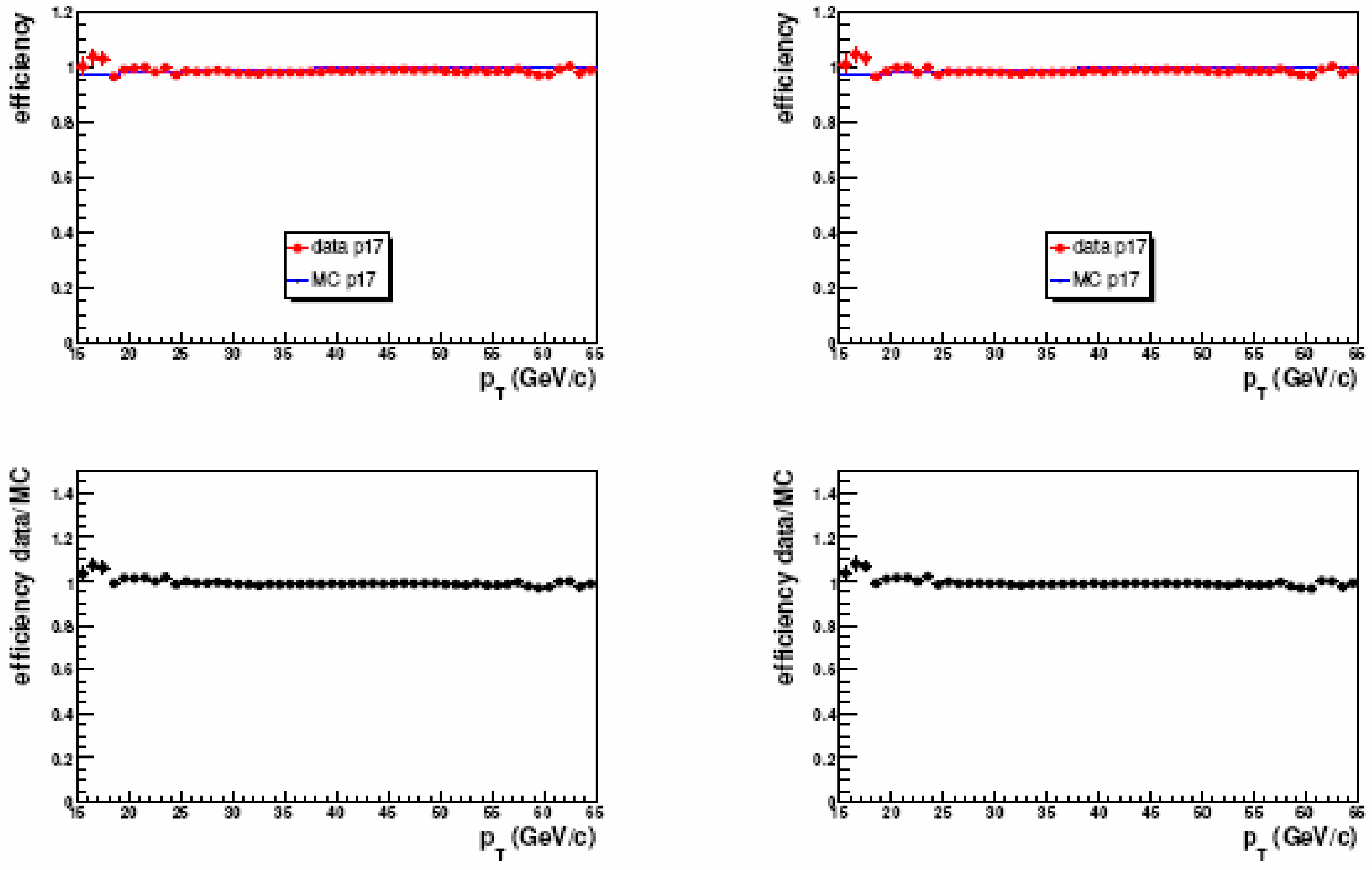
Track Match Efficiency vs. p_T



LOOSE

TIGHT

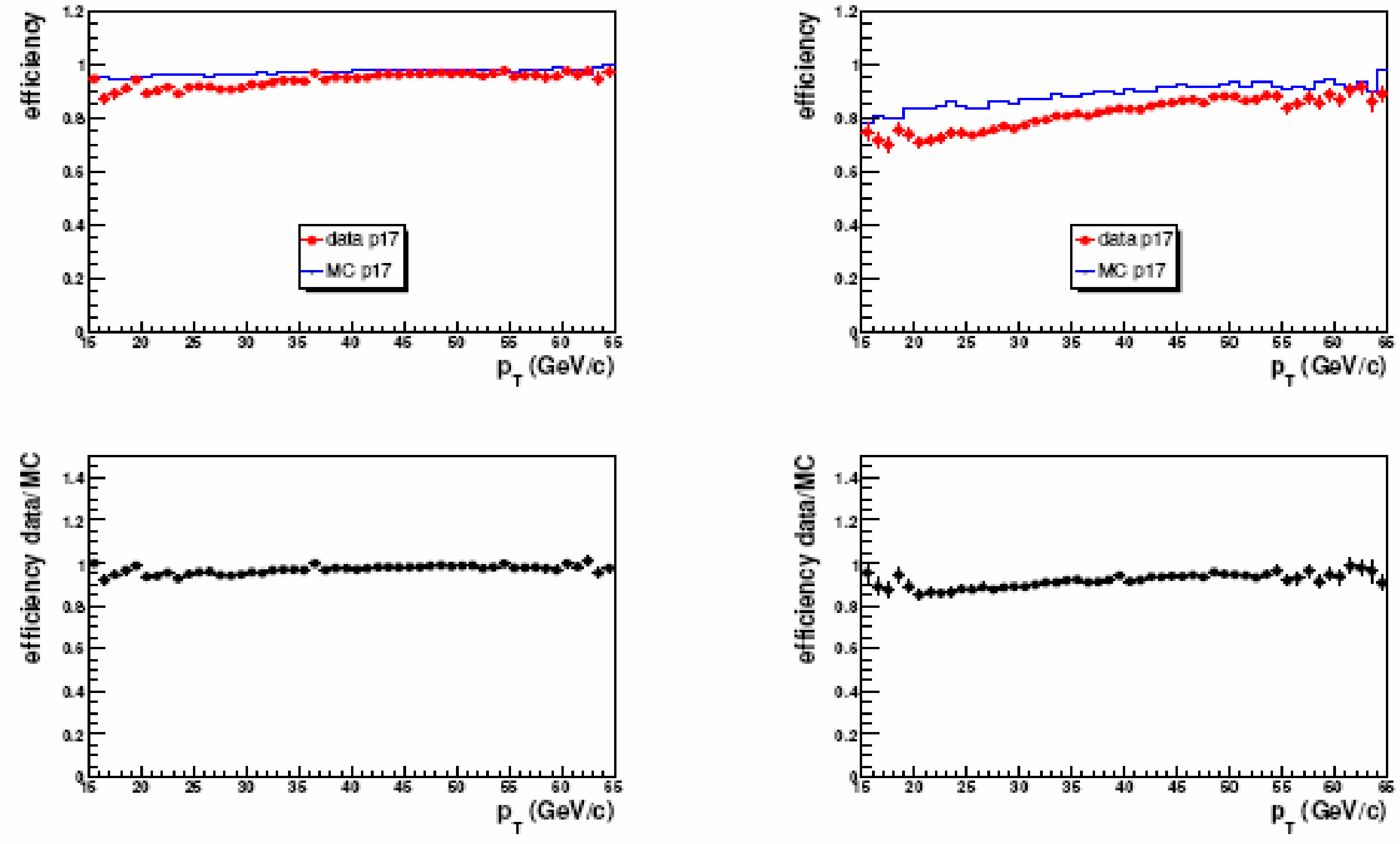
HMx Efficiency vs. p_T



LOOSE

TIGHT

Likelihood Efficiency vs. p_T

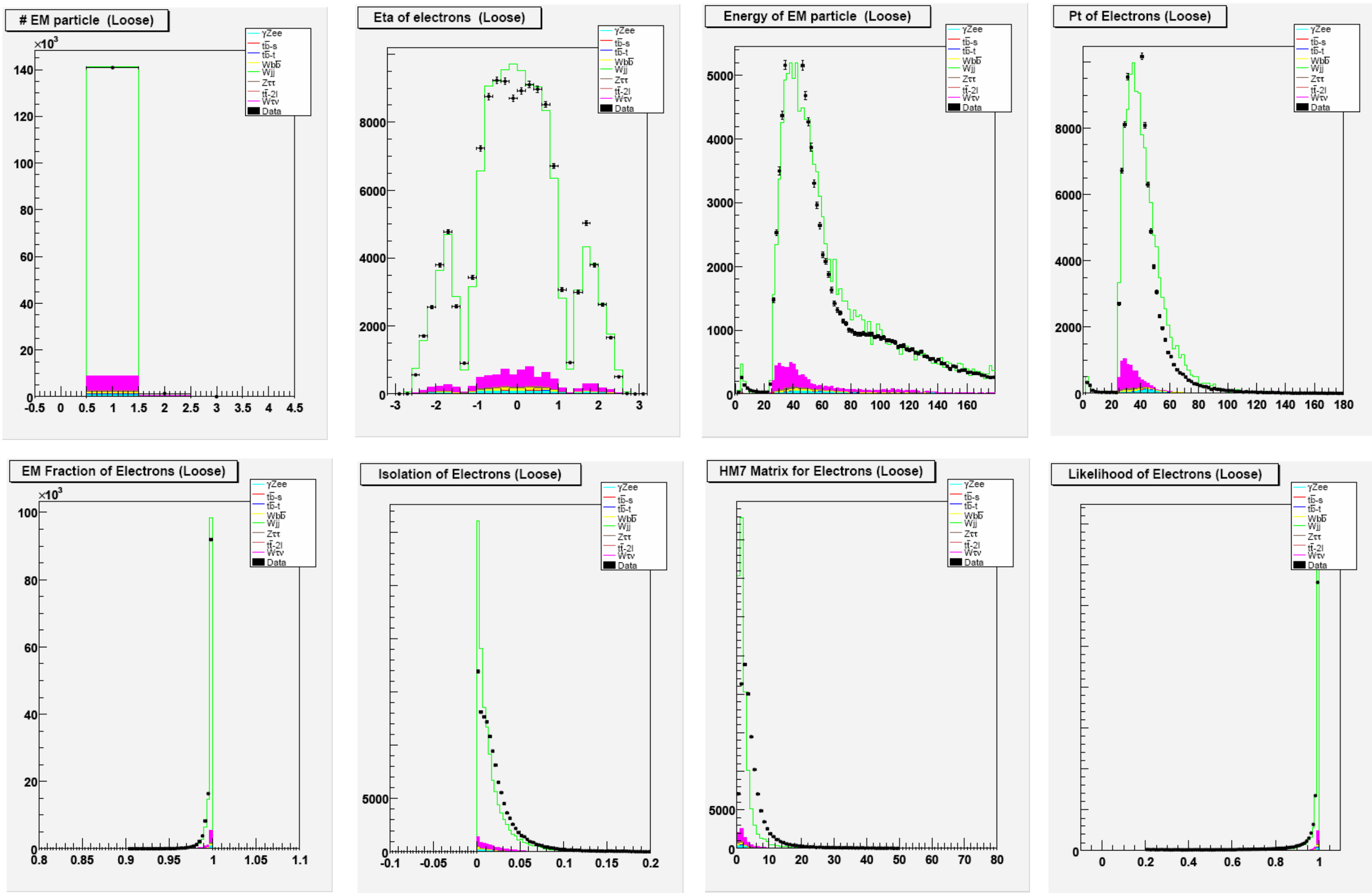


LOOSE TIGHT

Simulated Data for various processes

Process	Release	# Events	Generator/Comment
$\gamma Z - ee$ incl	p170901	663000	CSMC Pythia gam-z(+jets)→ee(+jets)
$\gamma Z - \tau\tau$ (incl?)	p170901	447500	CSMC Pythia gam-z→tautau m=60-130
$t\bar{t}$-dileptons	p170901	253750	Alpgen t+t+0lp→2l+2nu+2b+0lp excl
$t\bar{t}$-l+jets			
Single Top -s	p170602	146500	Comphep SingleTop S
Single Top -t	p170602	147000	Comphep SingleTop T
$Wb\bar{b}$	p170602	99000	Alpgen(1.2) + Pythia-6.202(fix) W(enu)bb
Wjj	p170602	64550	Alpgen w+2j→e+met+2j
$W - \tau\nu$ (incl?)	p170901	977250	CSMC Pythia W→taunu
W(e)H, W($\tau \to e$)H			
WZ($\to b\bar{b}$)			

Preliminary Data/MC comparisons



Action Items / Conclusions

- Estimate the QCD Background
- Apply efficiency corrections to MC
- Determine the Jet Reconstruction Efficiency
- b – Tagging using NN algorithm
- Estimate b – tagging efficiency
- Systematic Uncertainties have to be estimated

- Plan to complete most of the items above by end of June 2006.
- Current analysis can be improved in many ways
  - Extend the analysis to forward region
  - Increase b-quark jet tagging performance
  - Improve the mass resolution of reconstructed bb jets