Search for the Standard Model Higgs Boson in the Channel

$ZH \to \nu\bar{\nu}b\bar{b}$

at the DØ Experiment

Weigang Geng

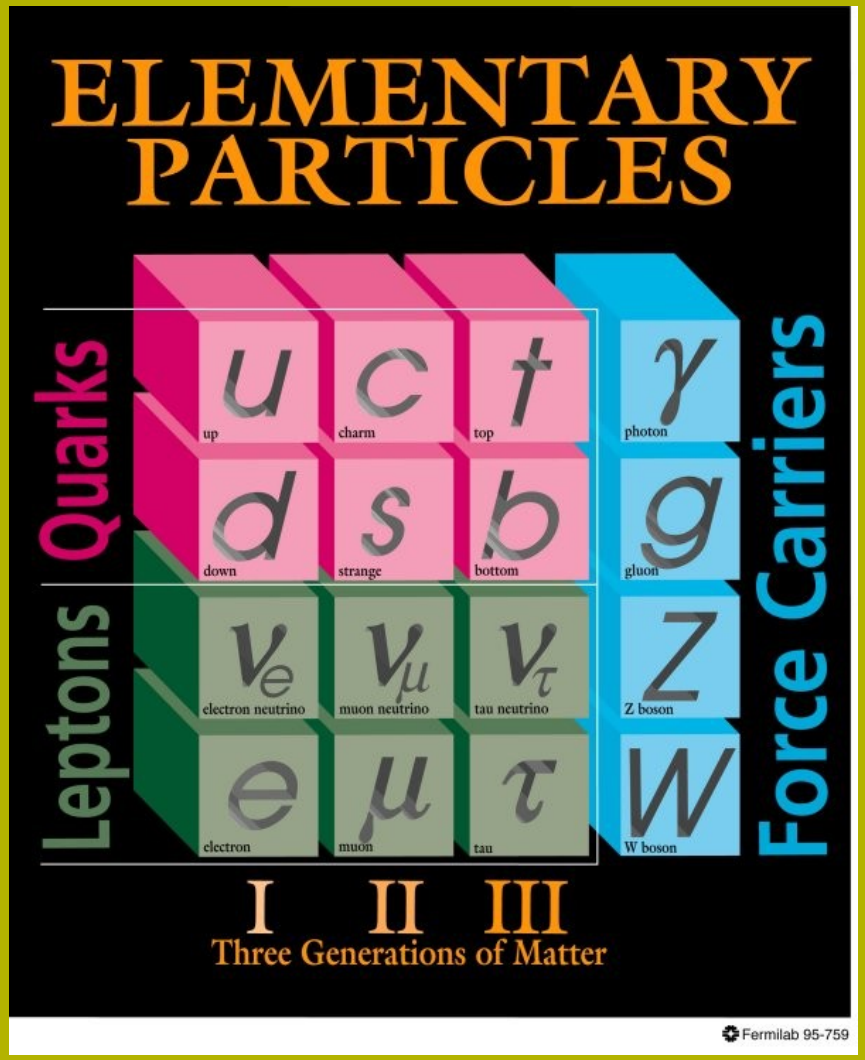
Advisers:
Arnaud Duperrin, Reinhard Schwienhorst

Centre de physique des particules de Marseille
Michigan State University

Outline

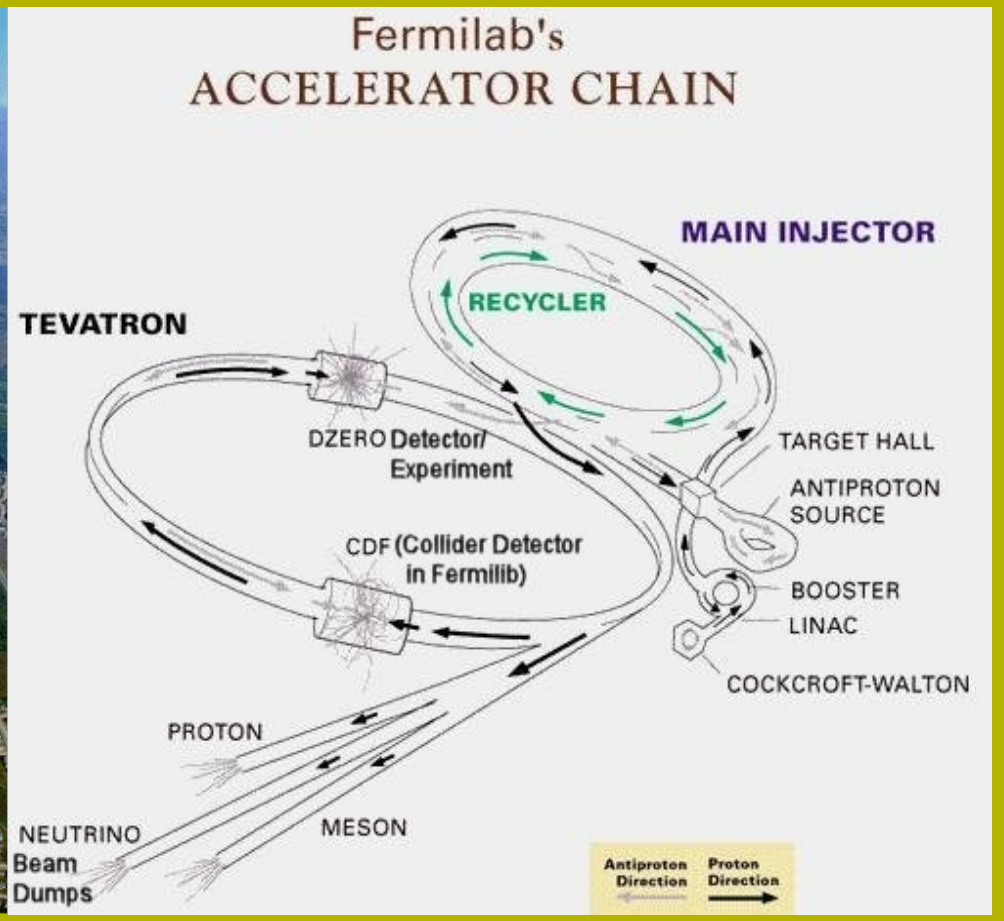
- Introduction
- Trigger Studies
- Higgs
- Outlook

Standard Model Higgs



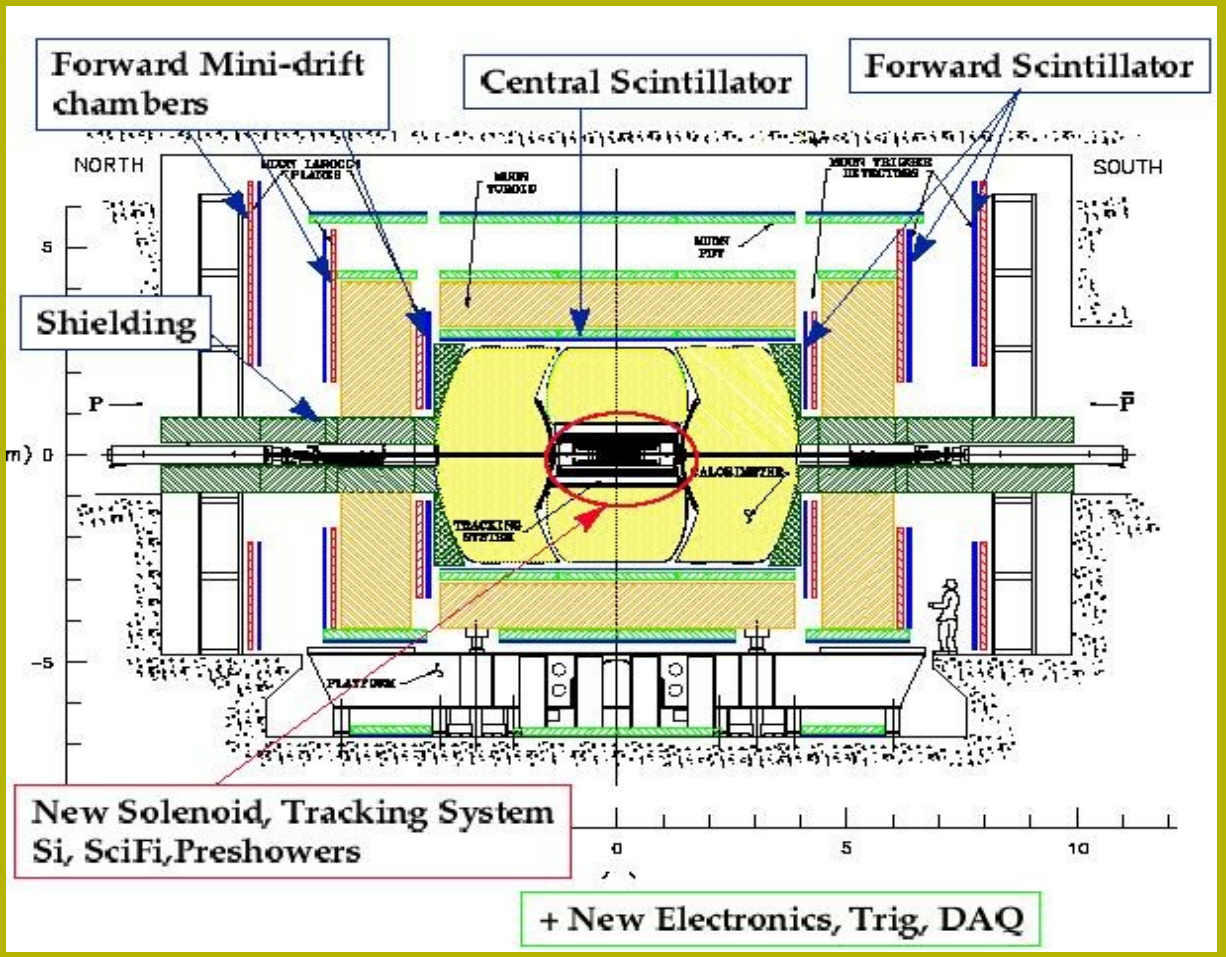
- Higgs is the only missing piece in the Standard Model.
- Higgs Mechanism explains electroweak symmetry breaking.
- It gives mass to all elementary particles.
- Current measurement favors light Higgs.

The Tevatron accelerator



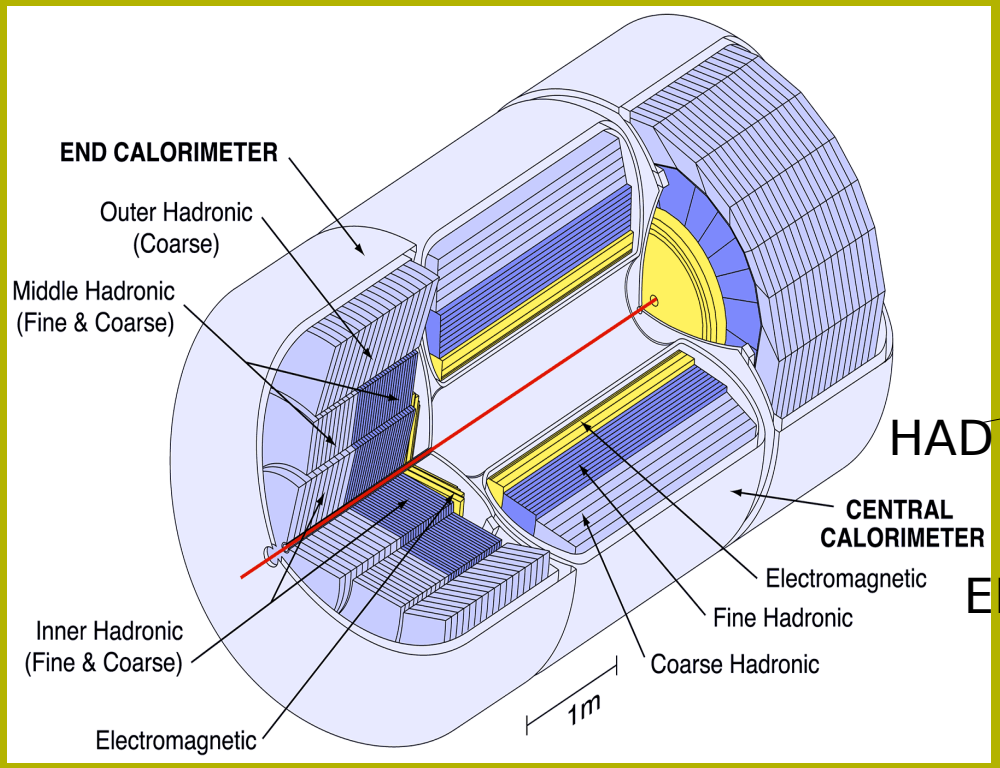
The Tevatron accelerates protons and antiprotons in a 6.3 km ring to energies of up to 1 TeV each.

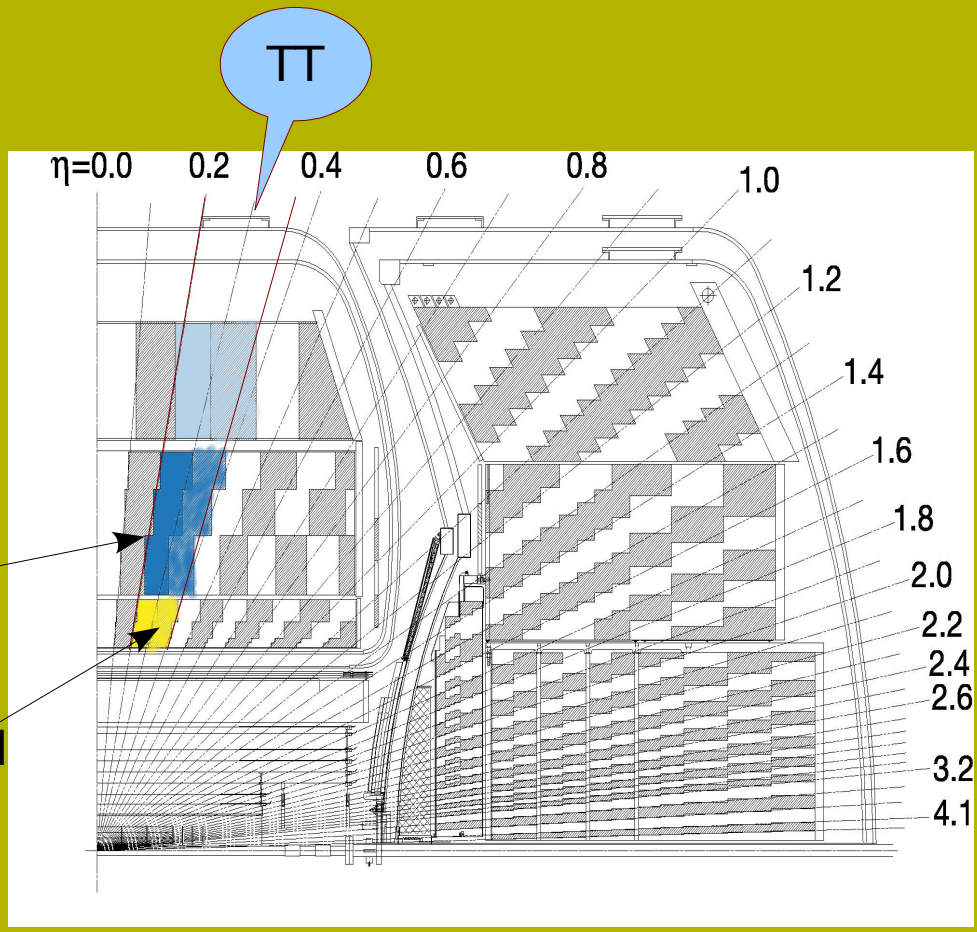
The D0 detector



The D0 experiment is focused on precise studies of interactions of protons and antiprotons at the high energies. It is comprised of three major parts: the tracking system, the calorimeter, and the muon system.

Calorimeter and trigger towers (TT)





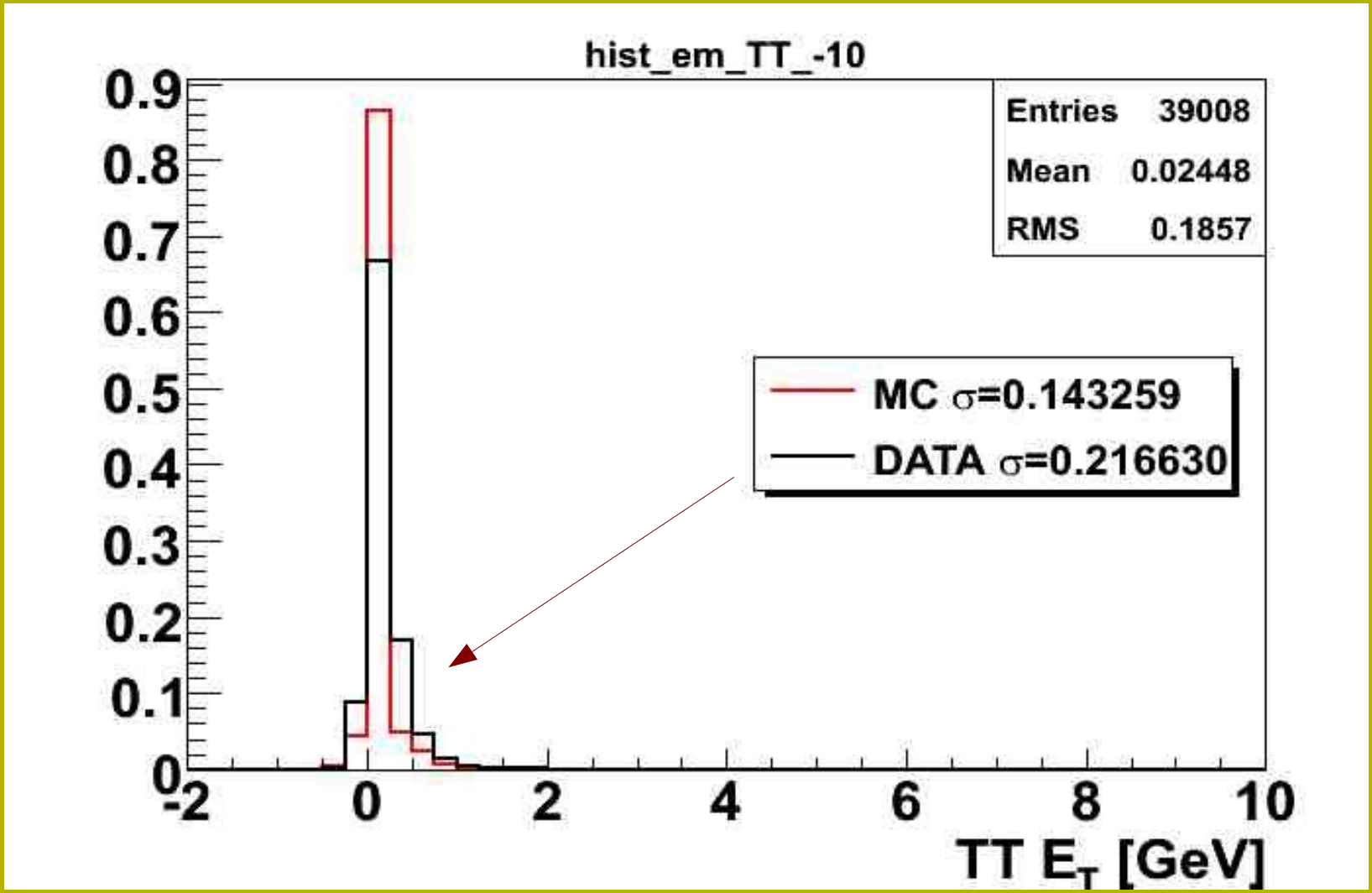
The liquid argon calorimeter consists of 3 units: the Center Calorimeter (CC), and the two End-cap Calorimeters (EC).

D0 Trigger system

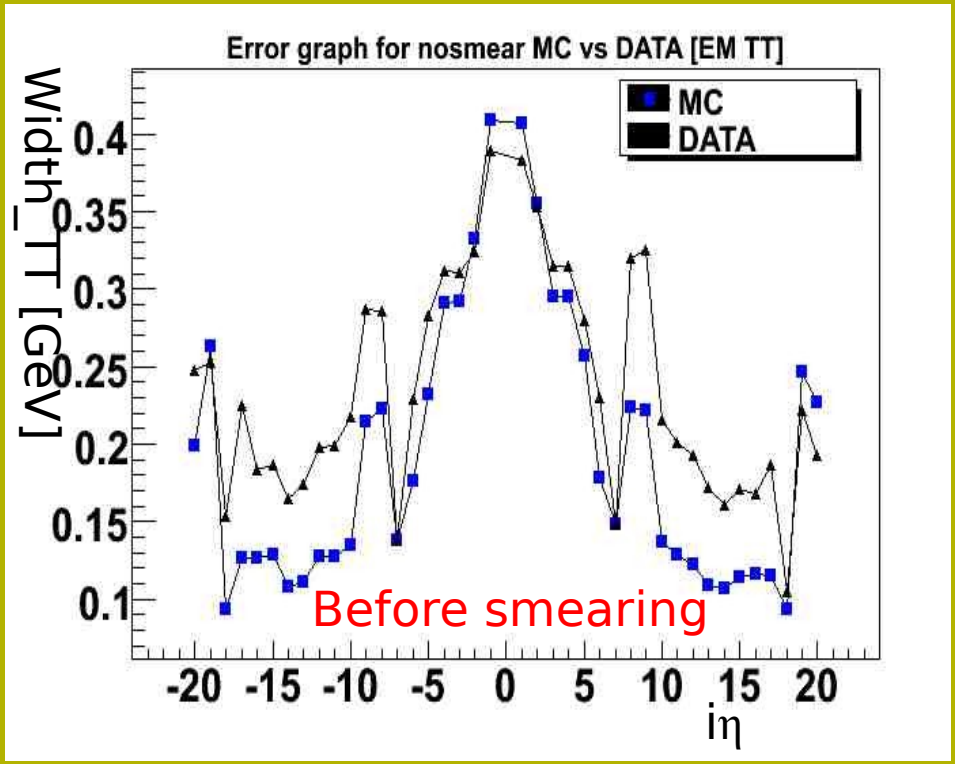
Level 1	Level 2	Level 3
Hardware Firmware (~ 4.2 µs)	Firmware Software (~ 100 µs)	Software (~ 50 ms)

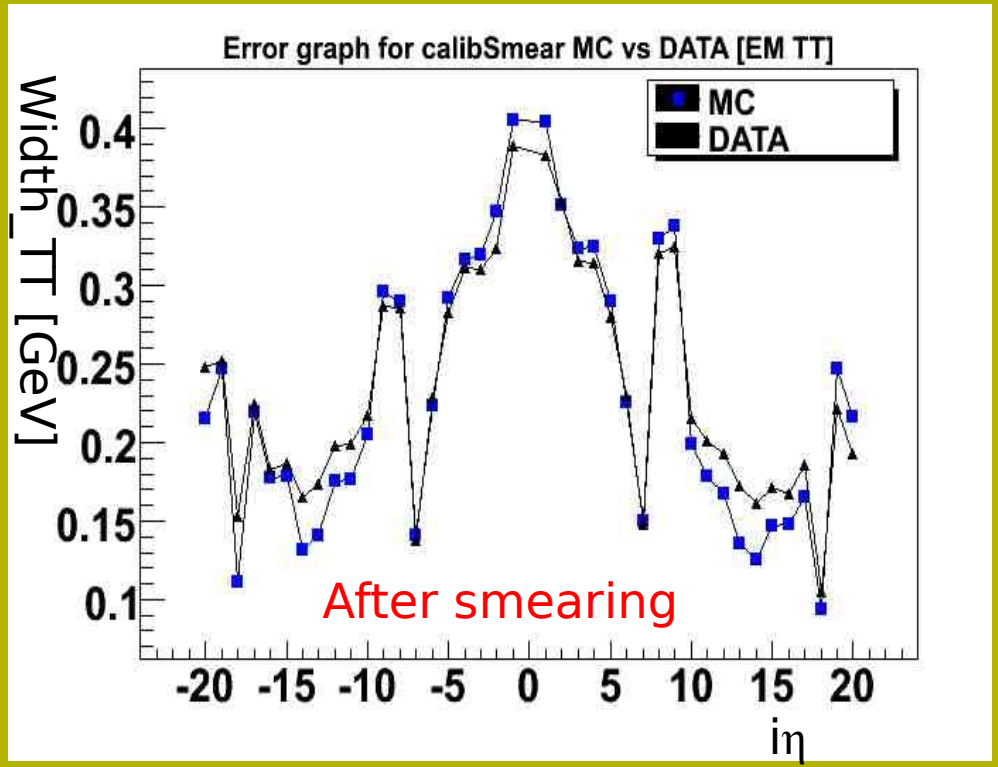
The D0 trigger system consists of 3 levels:
- Level 1 comprises hardwares that make decision 4.2 µs after the beam collision.
- Level 2 is software. Information from L2 is used to form simple physics objects.
- Level 3 is purely software-based. It uses full detector readout and performs partial event reconstruction on a farm of microprocessors within ~50 ms.

Trigger Tower Pedestal



L1Cal Pedestal Smear

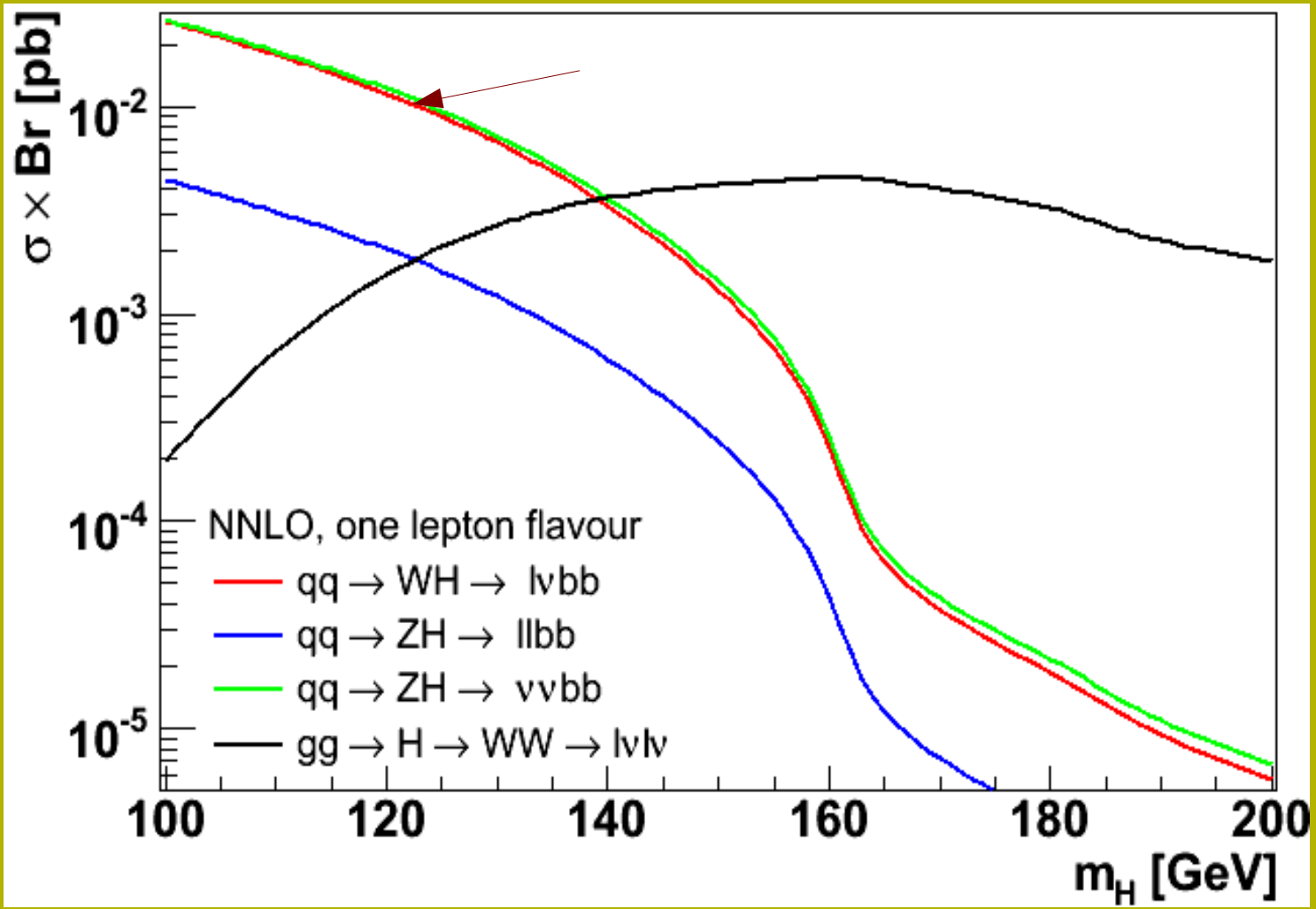




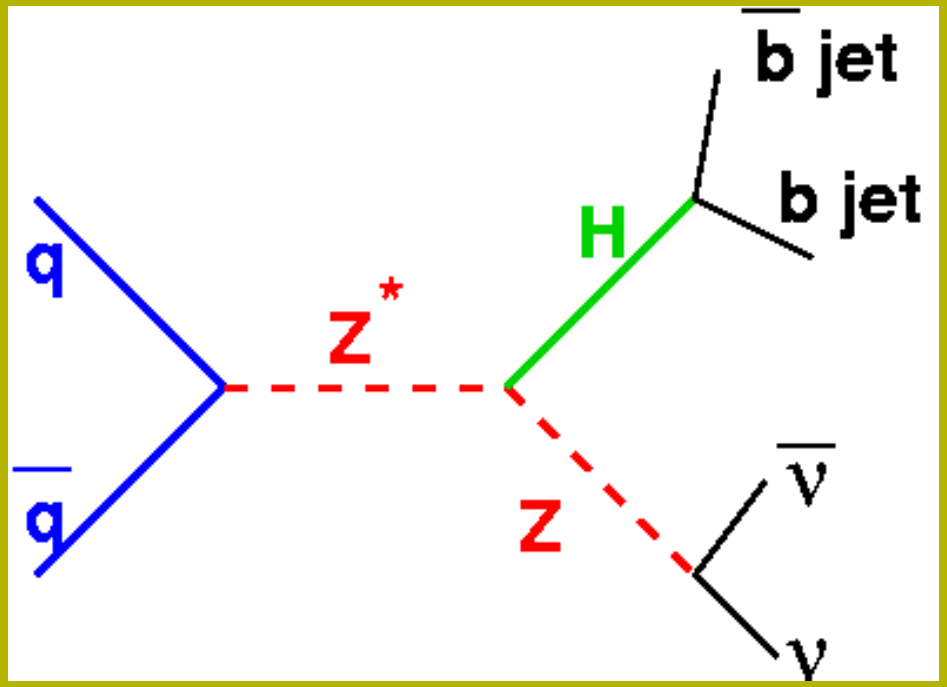
Calculated the smearing parameters from the nosmear samples (left), then input them to TrigSim to produce the smeared samples (right).

* This work was done in collaboration with Mr. Marc Escalier from CPPM.

Higgs Production at Tevatron



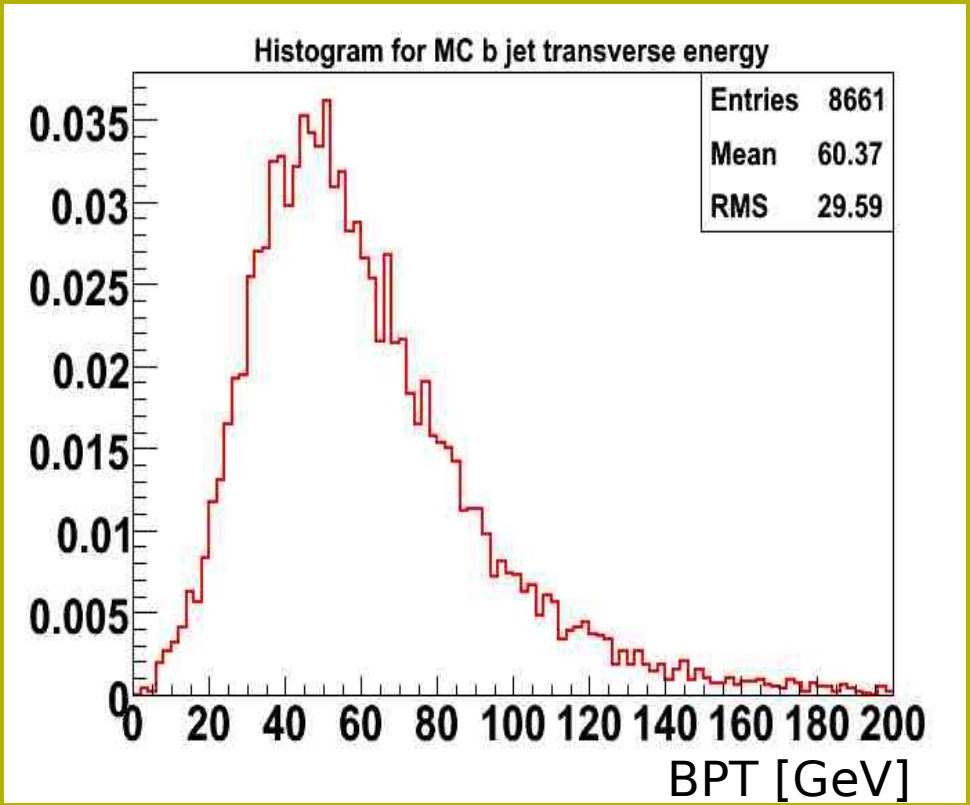
Higgs Search Channel



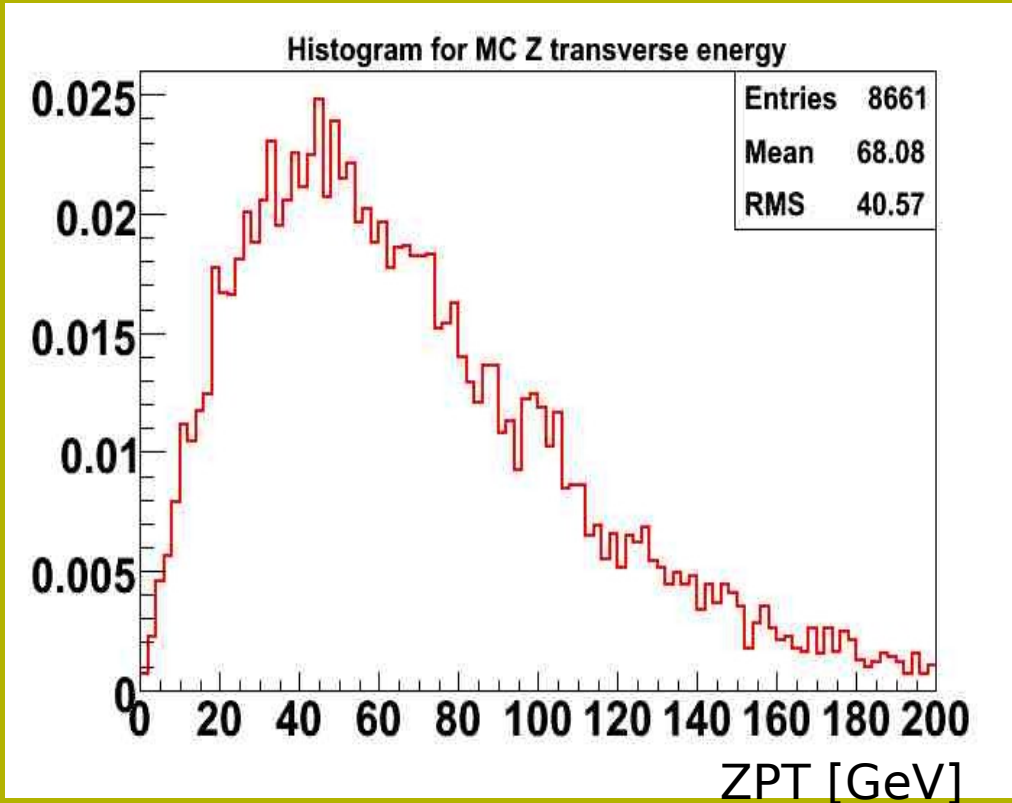
- Cross section for Higgs mass of 115GeV: ~ 0.015 pb.
- Current Tevatron luminosity: ~ 4fb^{-1}.
- Events produced so far: ~ 60.

Parton Level Information

Transverse Energy for b jets

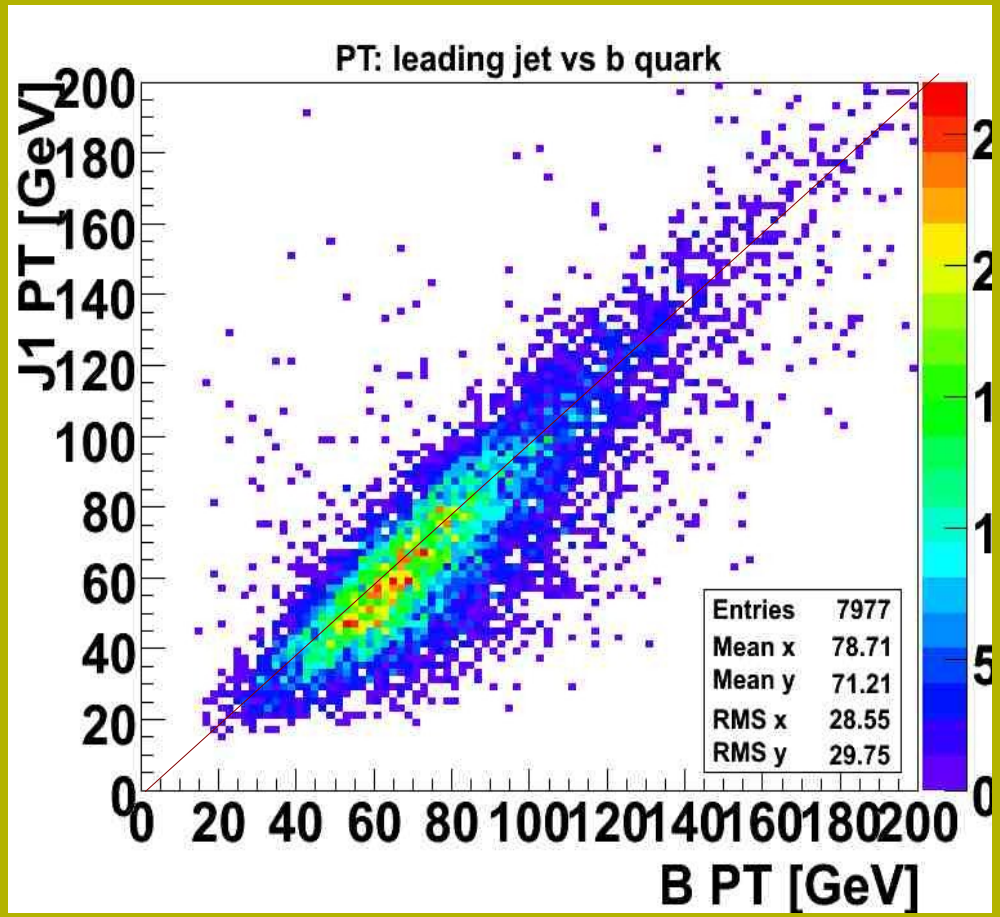


Transverse Energy for Z/MET

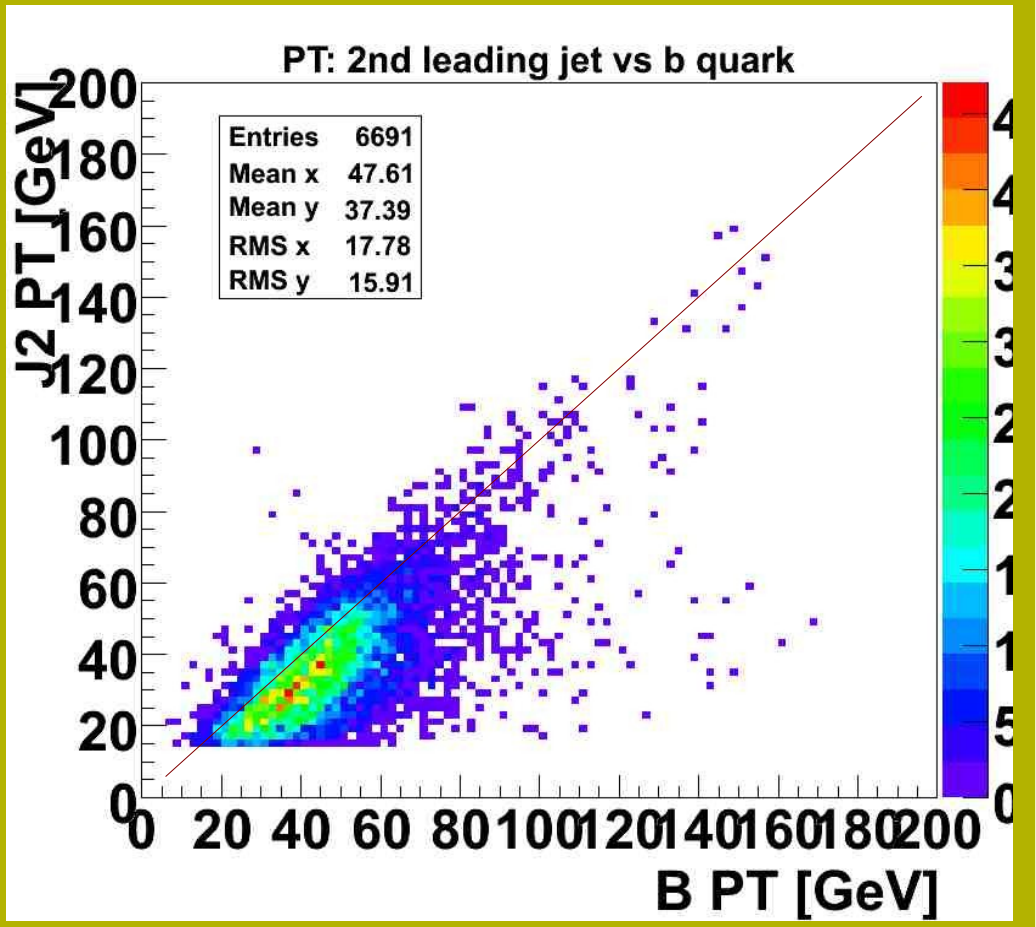


Parton level vs Reconstruction (1)

PT: Leading jet vs B jet

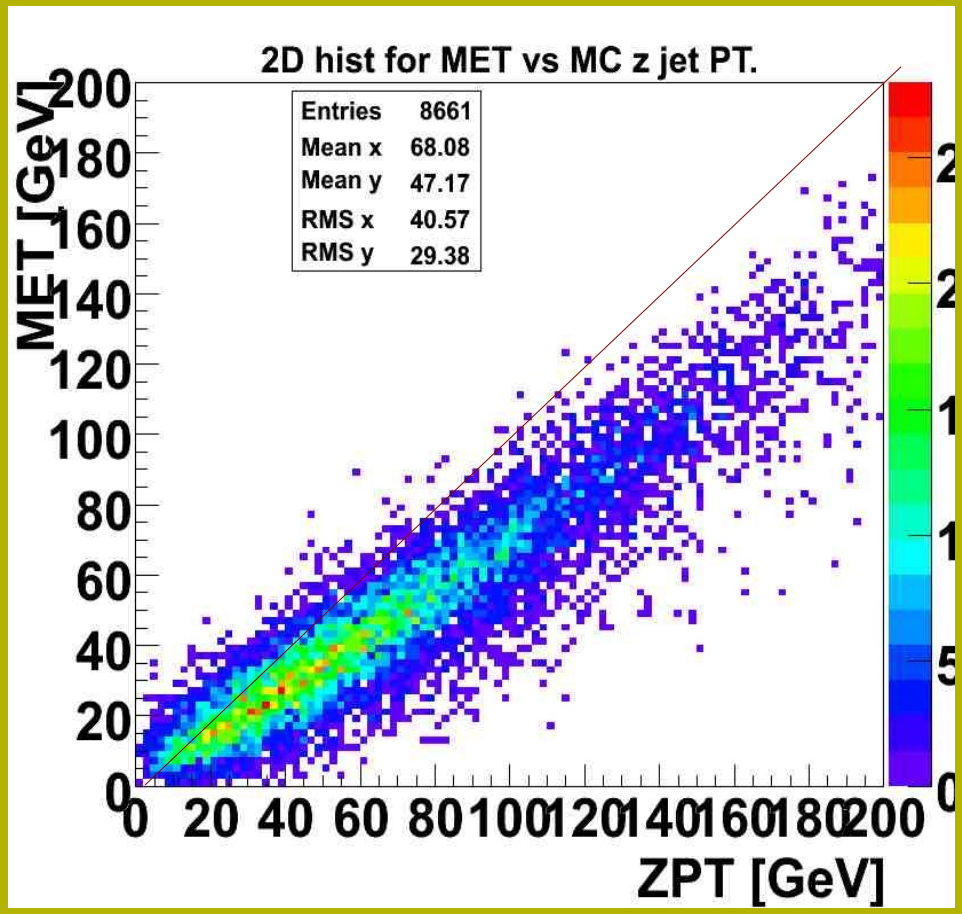


PT: 2nd leading jet vs B jet

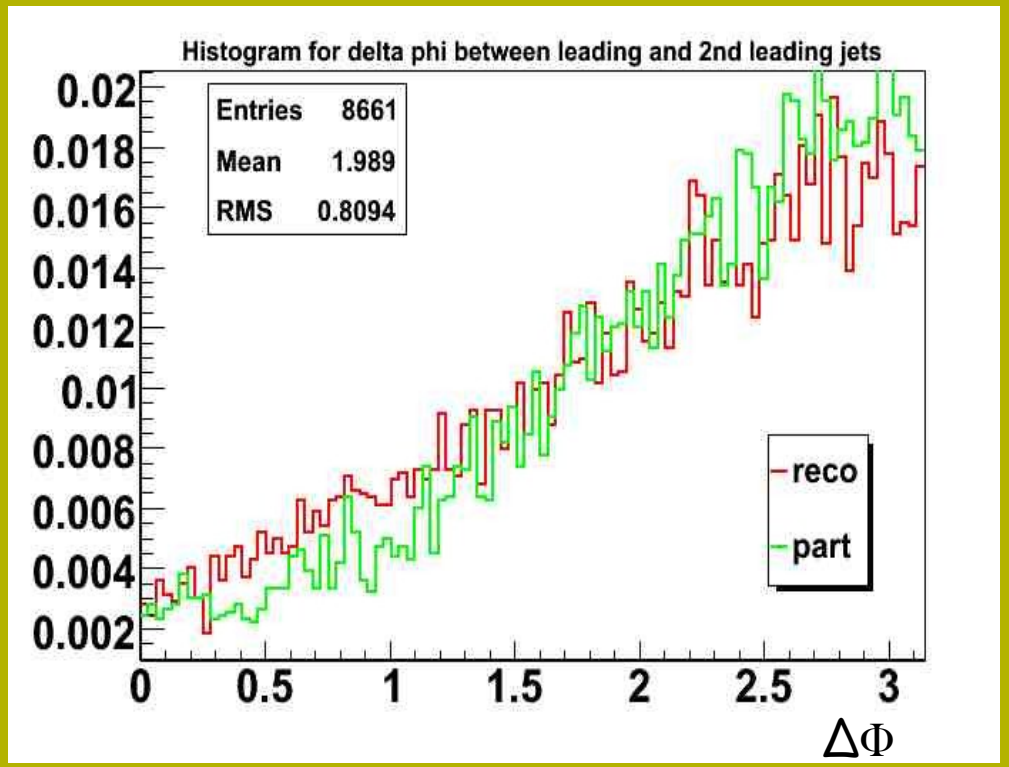


Parton level vs Reconstruction (2)

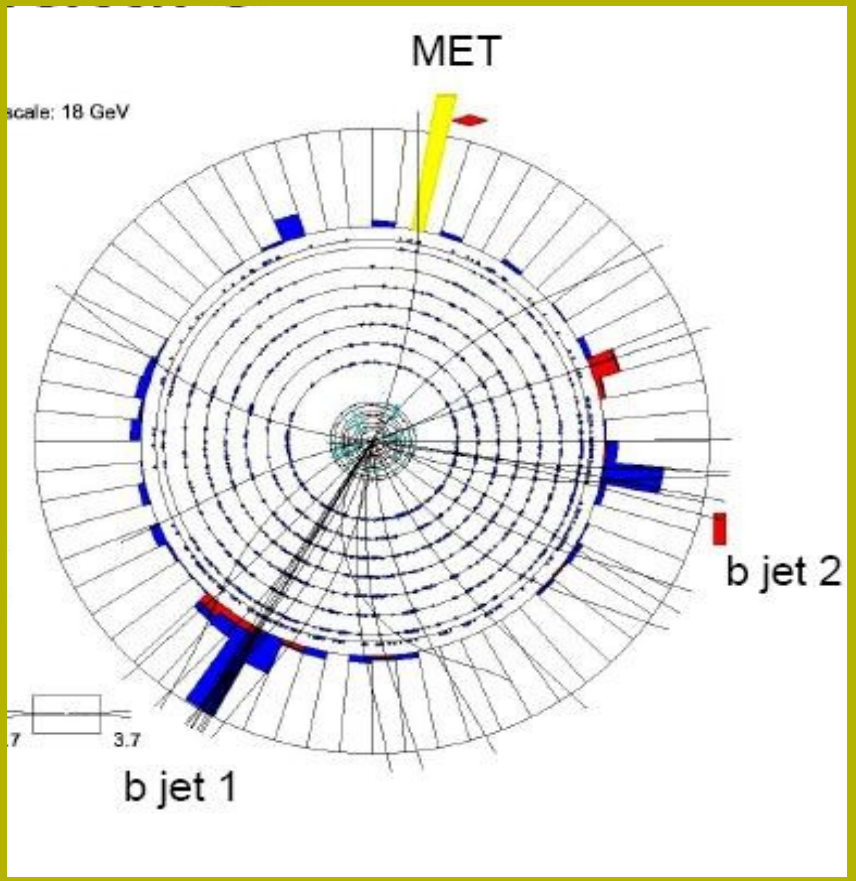
MET vs ZPT



ΔΦ (jet1, jet2) vs ΔΦ (b, bbar)



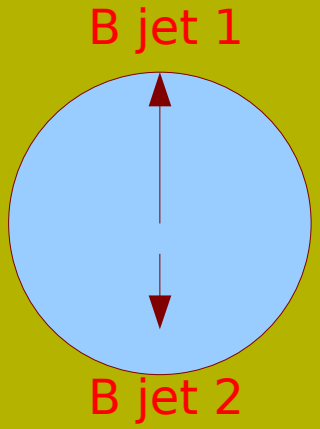
Signature

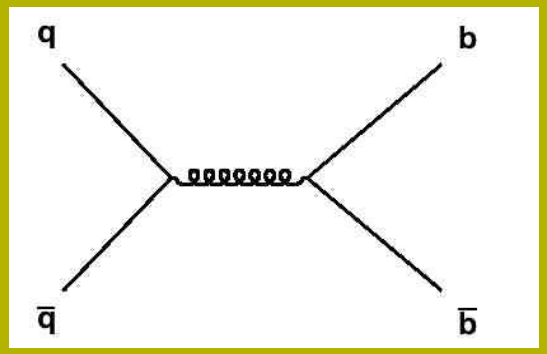


- Two acoplanar jets with ET > 25 GeV.
- At least one of them has to be b-tagged.
- MET > 40 GeV (2 neutrinos).

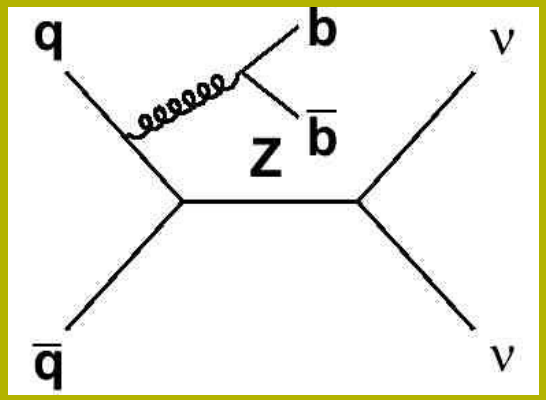
Backgrounds

- Multi-jet production





- W/Z production associated with heavy flavor jets



- Di-boson production
- ttbar production

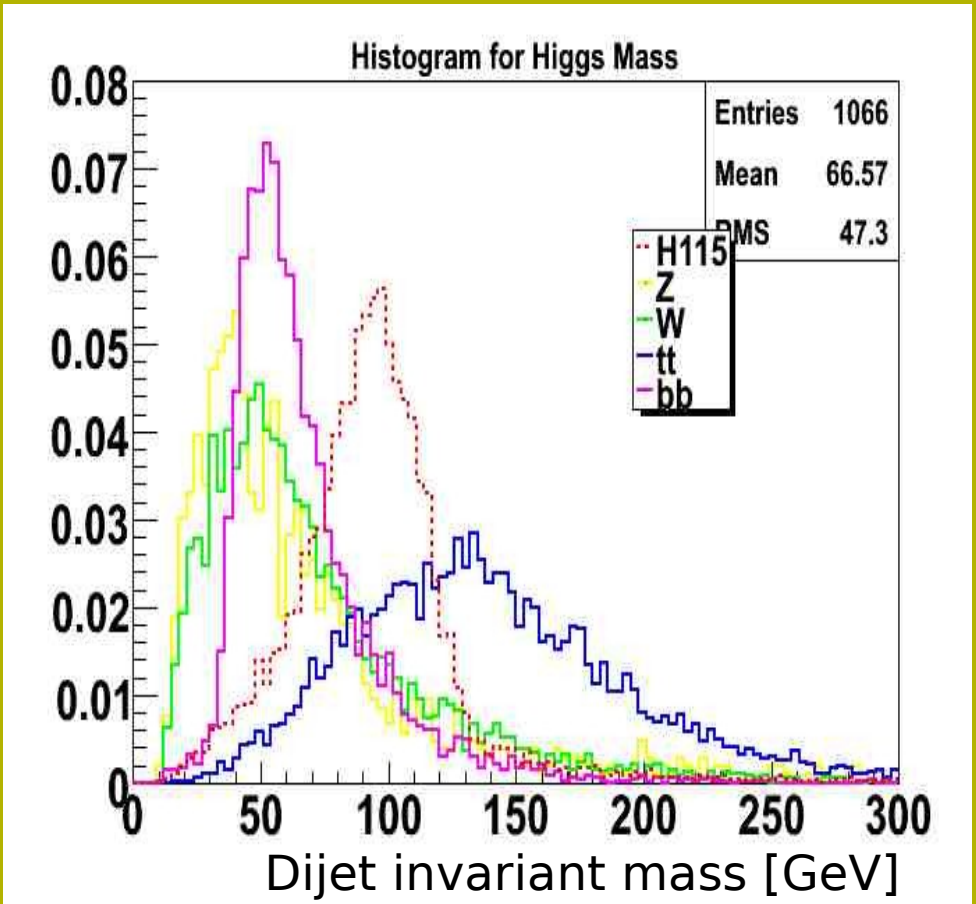
Sample Components & Cuts

		Higgs (m=115 GeV)	QCD (pt>20 Gev)	Top pair	W+2lp	Z+2b	
	x section (pb)	0.0152	50478	1.31	305	2.51	
	# of events	60	201912000	5240	1220000	10040	
Cut 1 (# of jets >= 2 jets ET>15 GeV)	# of events	48	102167472	4036	429440	1080	

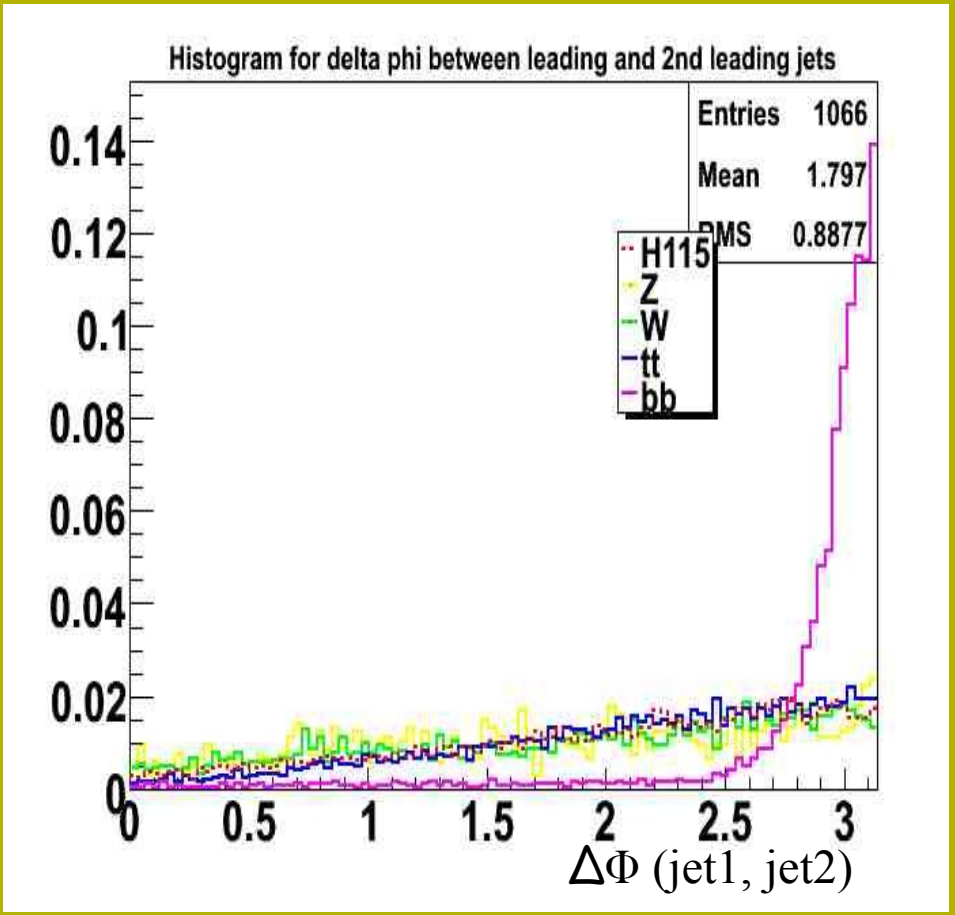
We are adding more cuts next.

Signal and Backgrounds

Invariant mass of the 2 leading jets



Angle difference between the 2 jets



Outlook

- Multi variate techniques
- Boosted decision trees to identify signals from backgrounds.
- M_H, $\Delta\Phi$(J1, J2), MET, HT, $\Delta\Phi$(MET, J1), $\Delta\Phi$(MET, J2), min $\Delta\Phi$(MET, Jets), ...

Summary

- L1Cal pedestal smearing improved MC modeling of trigger towers.
- We are looking at signal and background samples.
- We are comparing reconstructed quantities with parton level information.
- Next apply simple cuts to isolate signal.
- Combine variables in multivariate classifiers.

Merci!

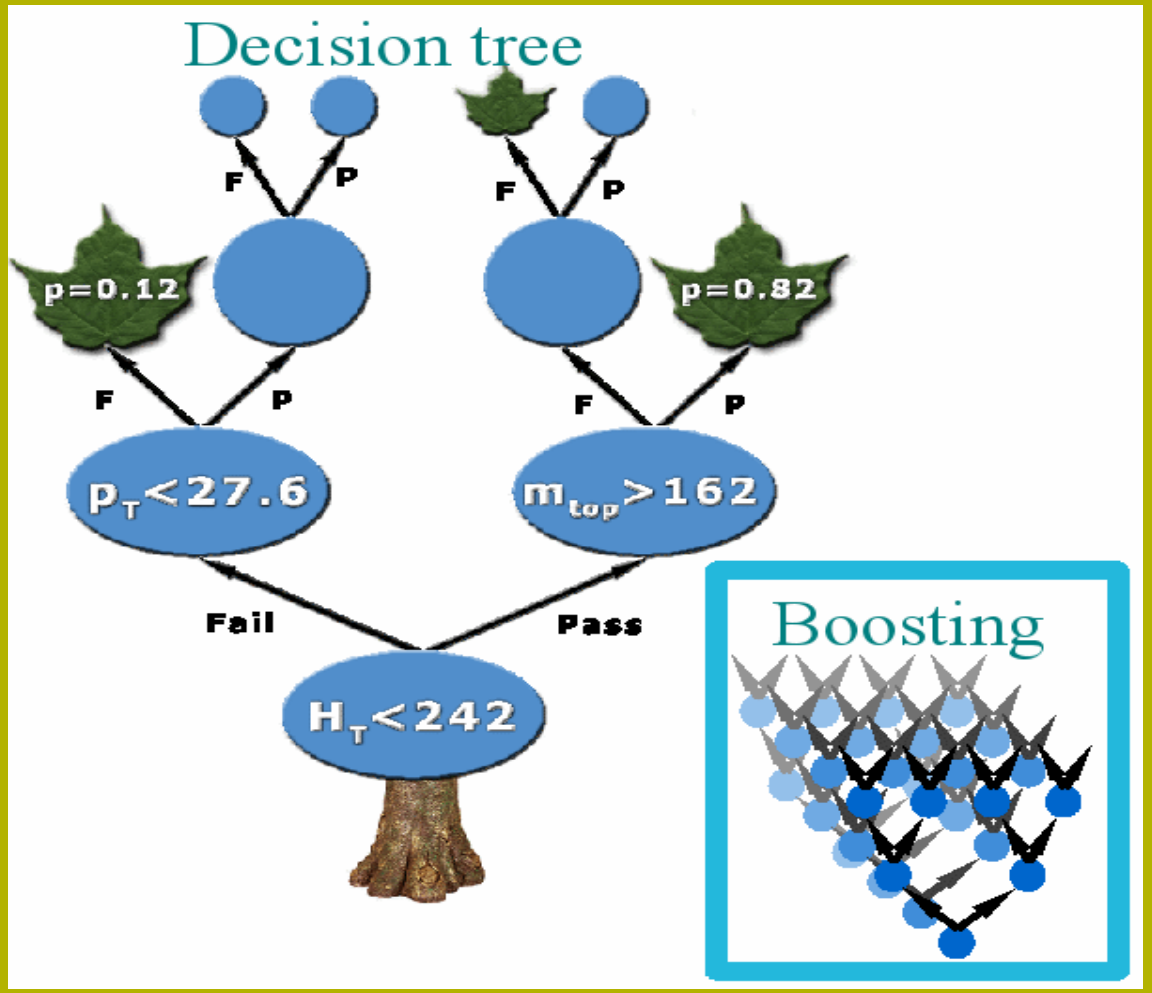
Samples used

- Higgs Sample
  - CAF-MCv3-87450-MERGE_p20.09.03_NumEv-12500_hl+z-2b+2nu_sm.n_higgs_mcp20_ccin2p3_87450_1341581732331952808123035007_p21.11.00.root

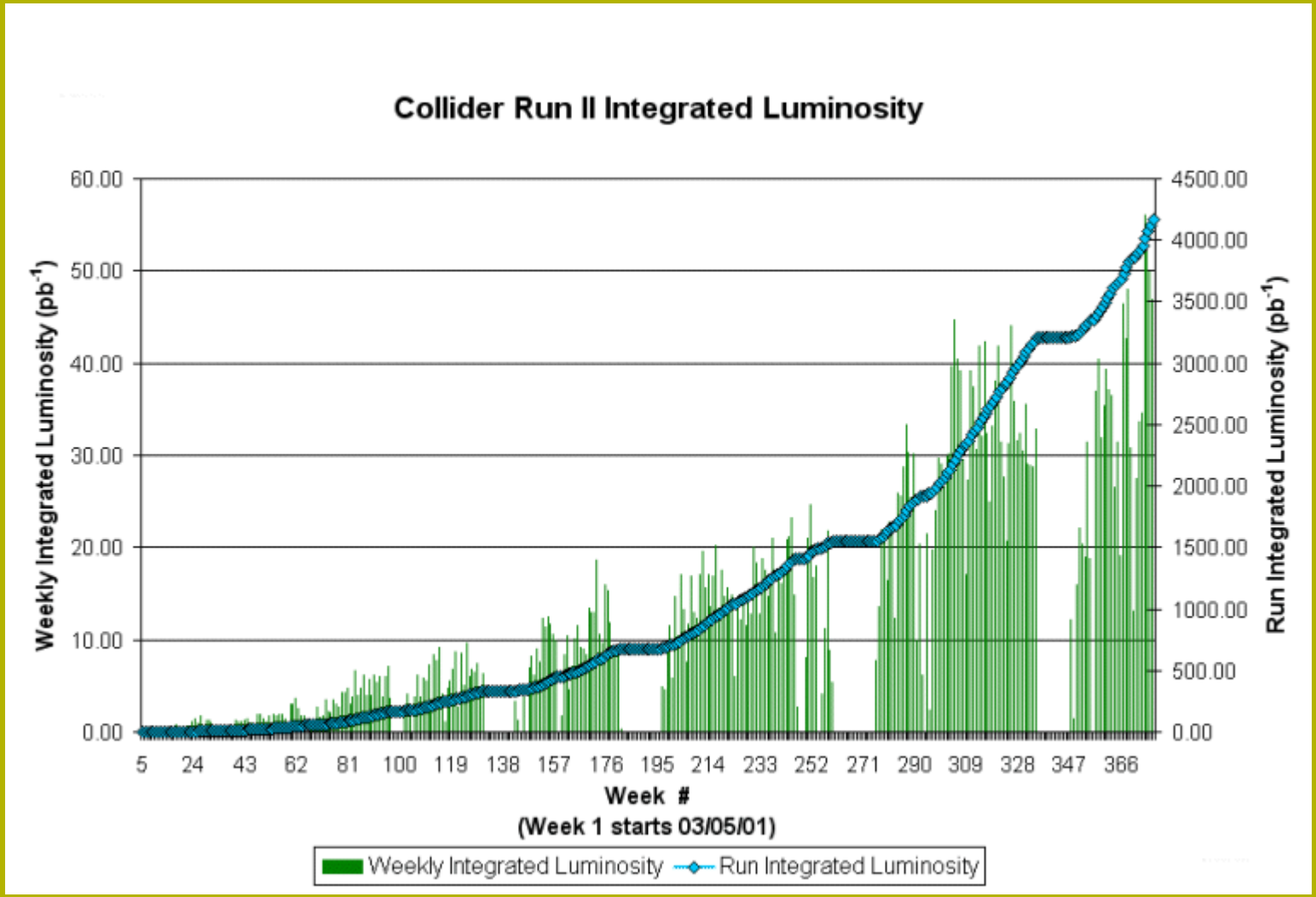
Background samples

- CAF-MCv3-87013-MERGE_p20.09.03_NumEv-12500_w+2lp-lnu+2lp_n.unw_dzero_mcp20_ccin2p3_87013_13415817311823460081080325 26_p21.11.00.root
- CAF-MCv4-70999-tmb_p20.08.02_NumEv-10000_z+2b+0lp-nunu+2b+0lp_n.unw_mcc99_mcp20_Tata_70999-118400811012250_p21.11.00.root
- CAF-MCv4-87351-tmb_p20.09.03_NumEv-10000_t+t+0lp-lnu+2b+2lpc_n.unw_dzero_mcp20_87351-12094321928718_p21.11.00.root
- CAF-MCv4-88529-MERGE_p20.09.03_NumEv-12500_2b+0lp-2b+0lp_n.unw_higgs_mcp20_ccin2p3_88529_13415817319511477081431346 42_p21.11.00.root

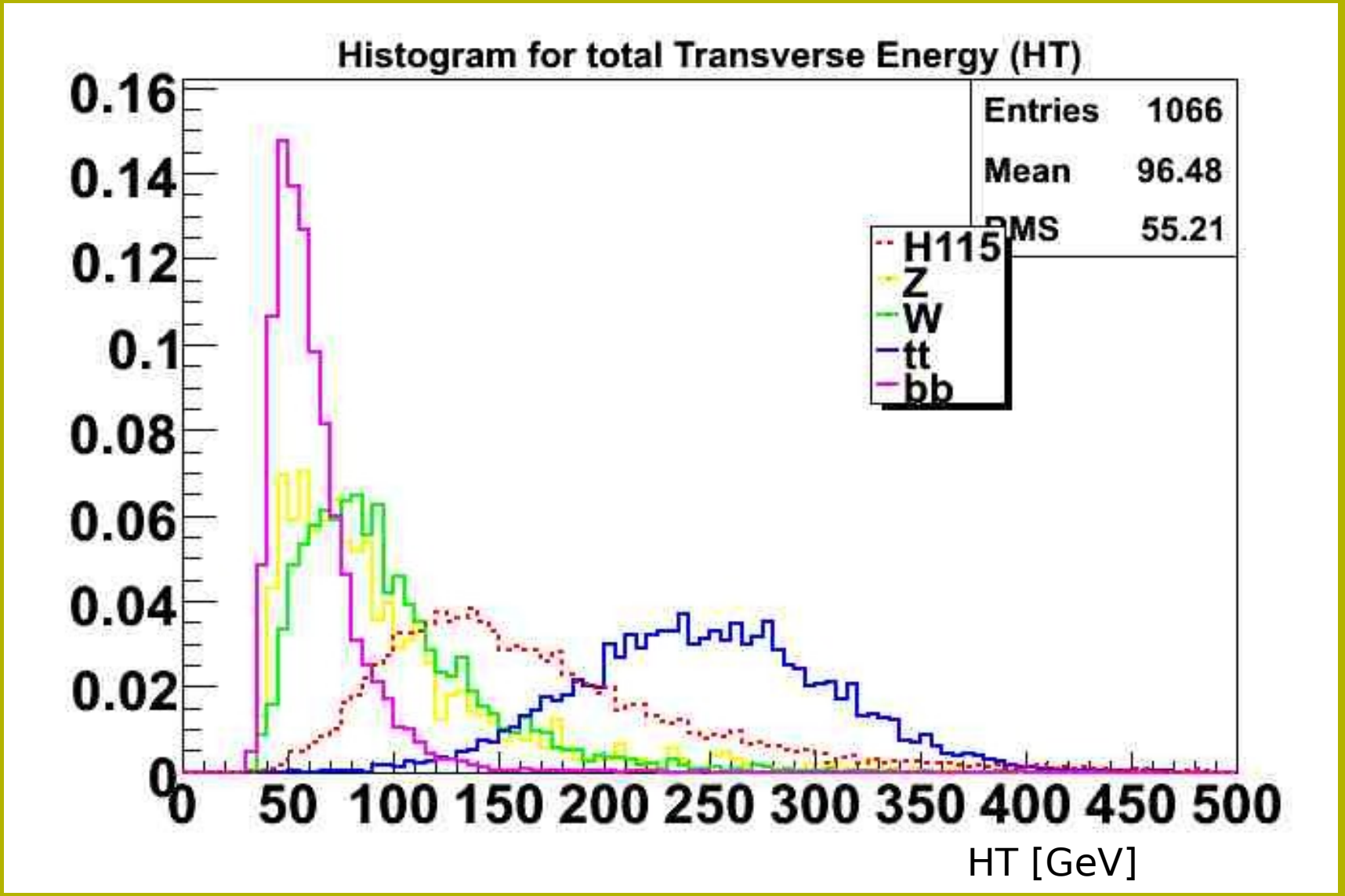
Boost decision tree

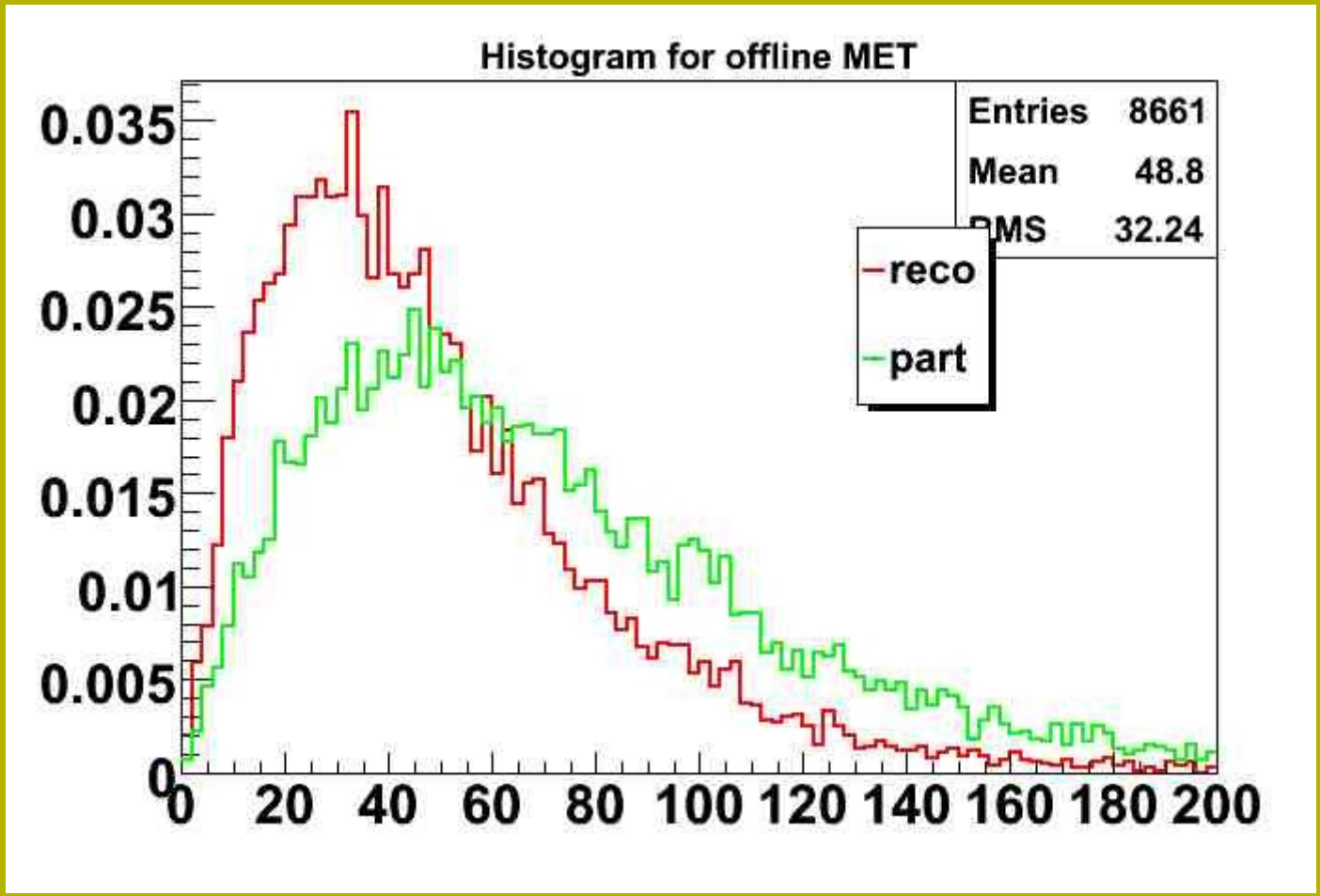


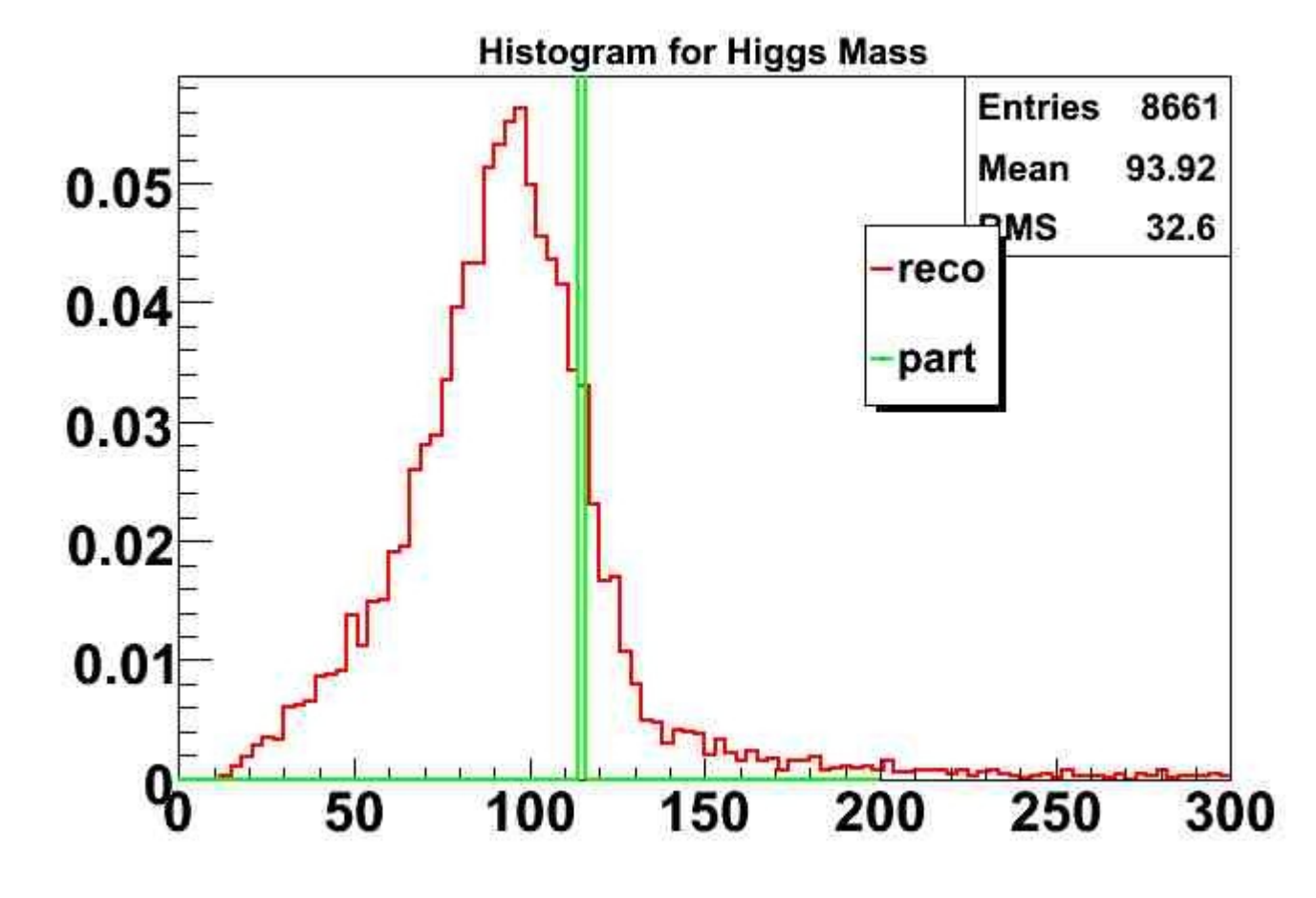
Tevatron Run II integrated luminosity



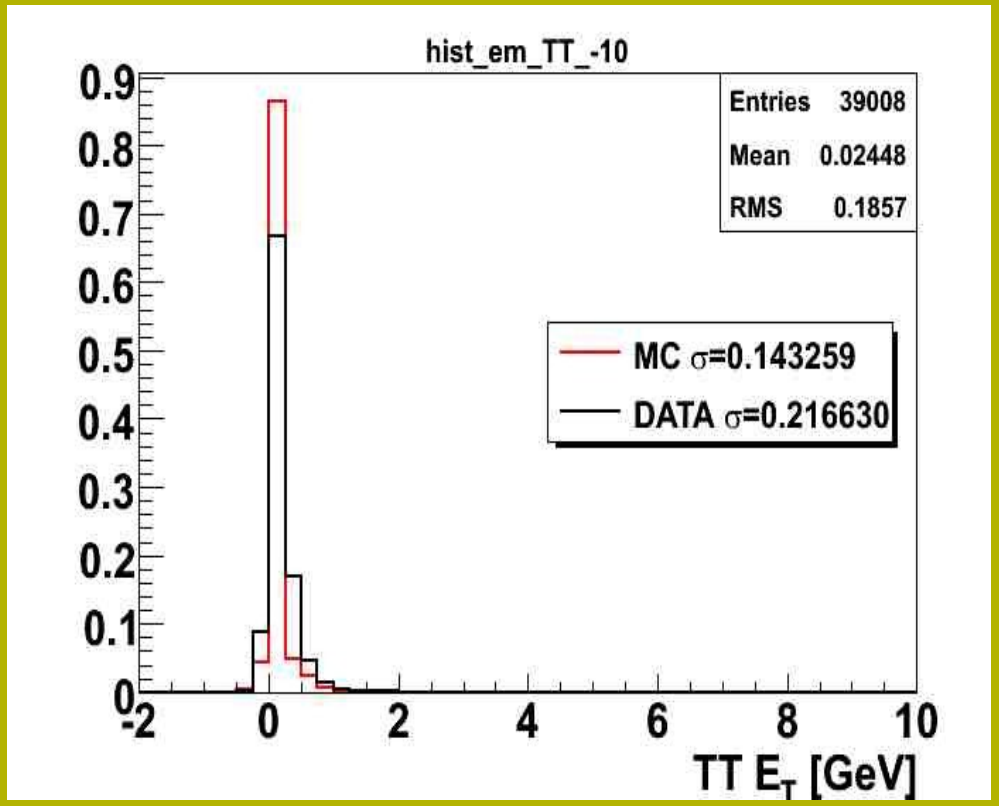
Total Transverse Energy (HT)



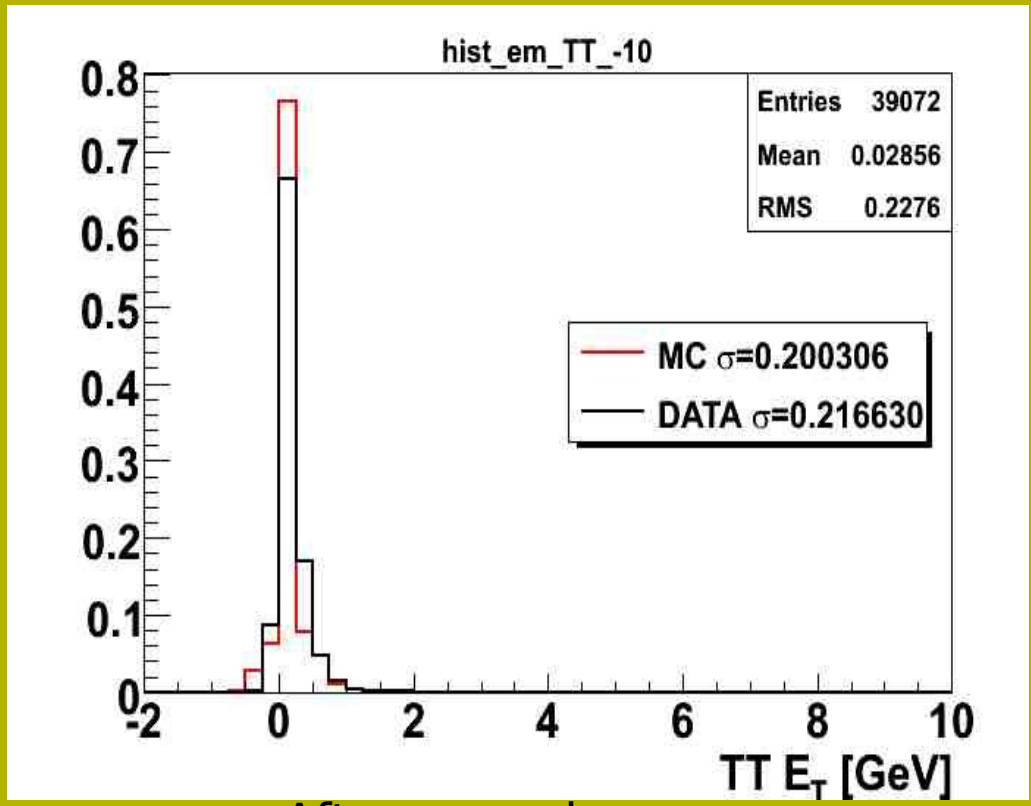

Histogram for offline MET
Entries 8661
Mean 48.8
RMS 32.24
reco
part
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
0 20 40 60 80 100 120 140 160 180 200


Histogram for Higgs Mass
Entries 8661
Mean 93.92
RMS 32.6
reco
part
0.05
0.04
0.03
0.02
0.01
0
0
50
100
150
200
250
300

Pedestal smearing for each trigger tower (TT) Ring



Before smearing



After smearing

$$\sigma_{diff} = \sqrt{\sigma^2_{DATA} - \sigma^2_{MC}}$$