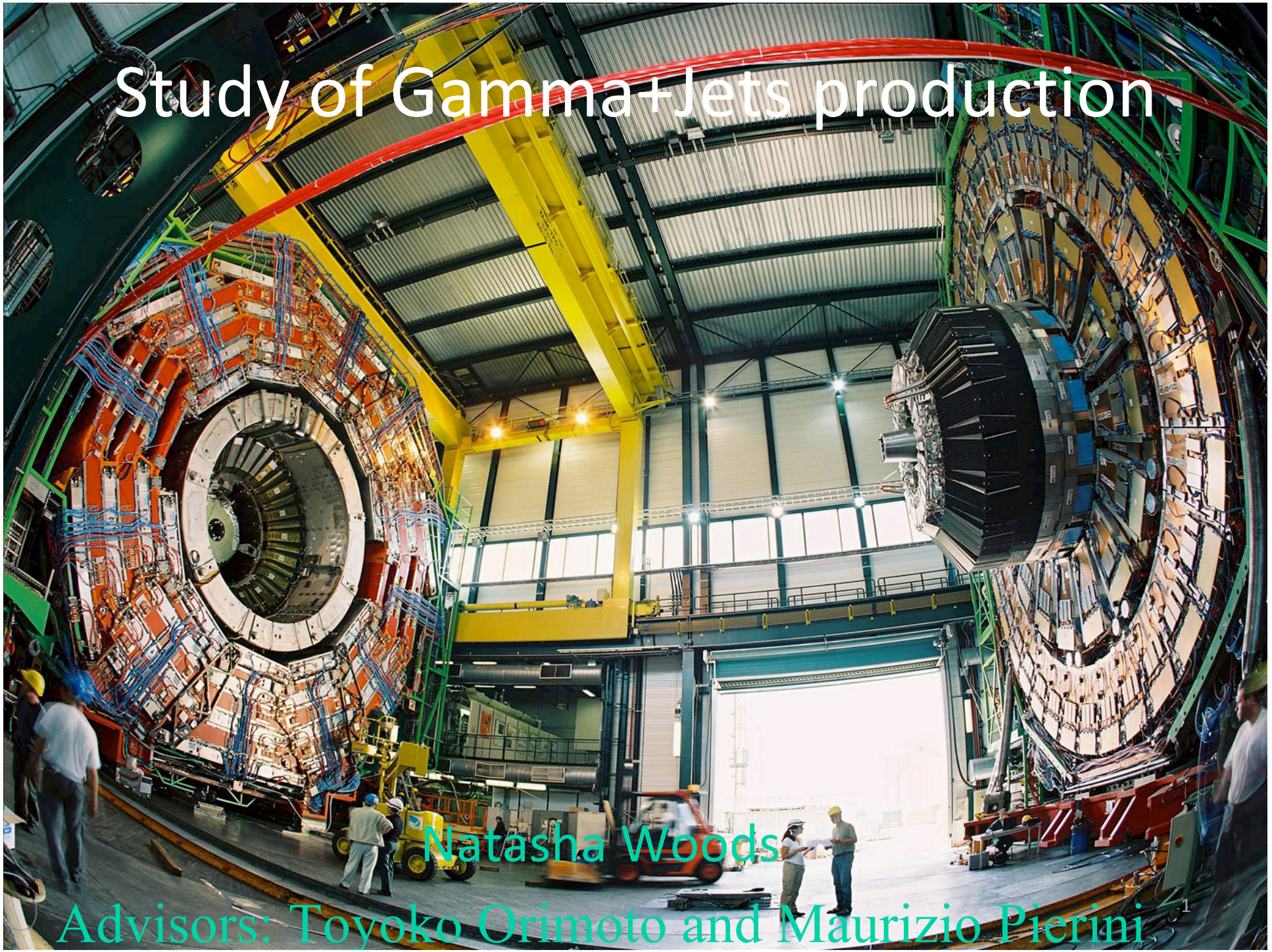
Study of Gamma+Jets production



Natasha Woods

Advisors: Toyoko Orimoto and Maurizio Pierini

Outline

1. CMS

2. Gamma+Jet Events
   -Jet Production
   -Backgrounds
   -Photon Isolation

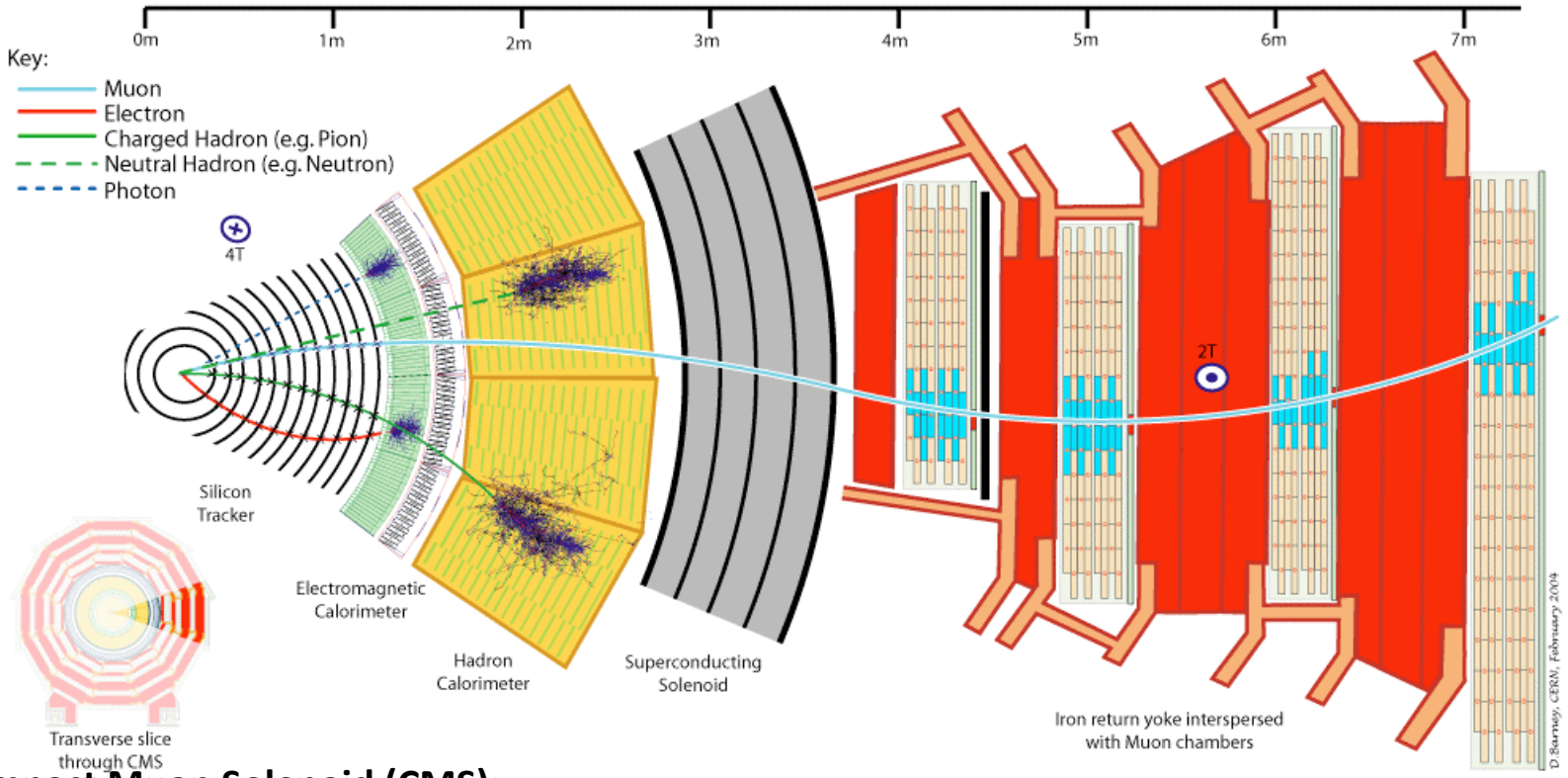
3. Discriminating Variables

4. TMVA

5. Conclusions

6. Fun

1. CMS: Detector



Compact Muon Solenoid (CMS):

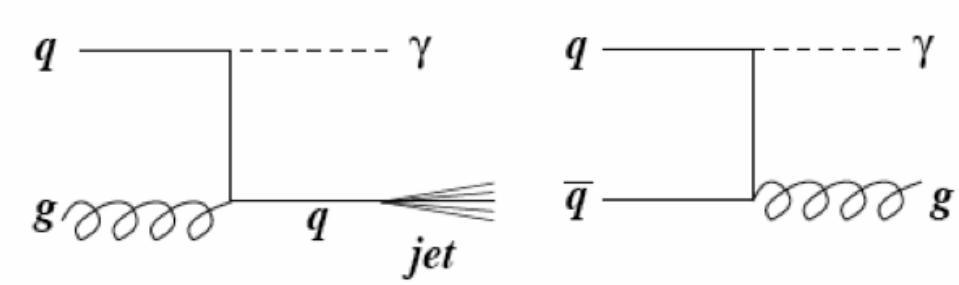
-isolates different types of particles α their interactions with components of CMS
-superconducting solenoid (6m internal diameter)
-silicon pixel and strip tracker
-crystal electromagnetic calorimeter (ECAL) – electrons, photons
-brass-scintillator hadronic calorimeter (HCAL) – neutral and charged hadrons
-gas chambers embedded in iron return yoke (to measure muons)

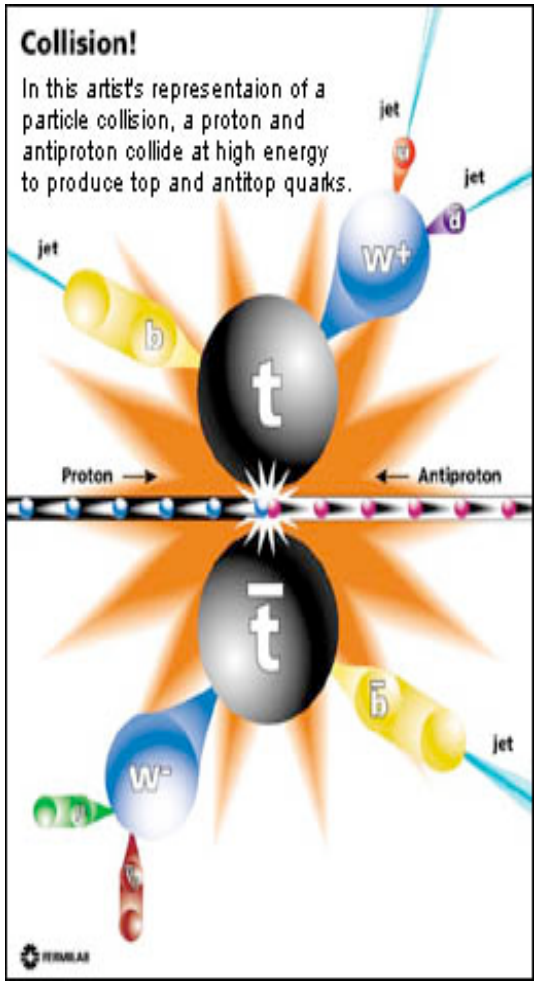
2. Gamma+Jet Events: Jet Production

1. Proton-Proton collisions

2. QCD -> Color Charge (quarks & gluons)
   ->Color Confinement
   ->Hadronization->Jets

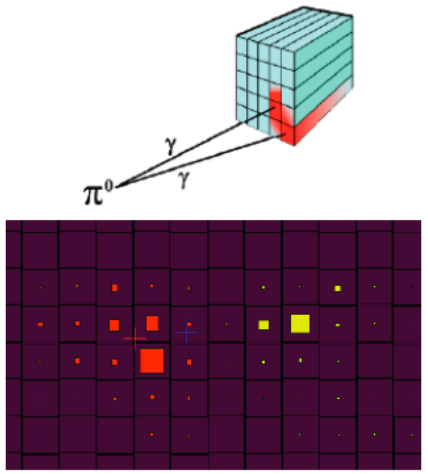
3. Photon production





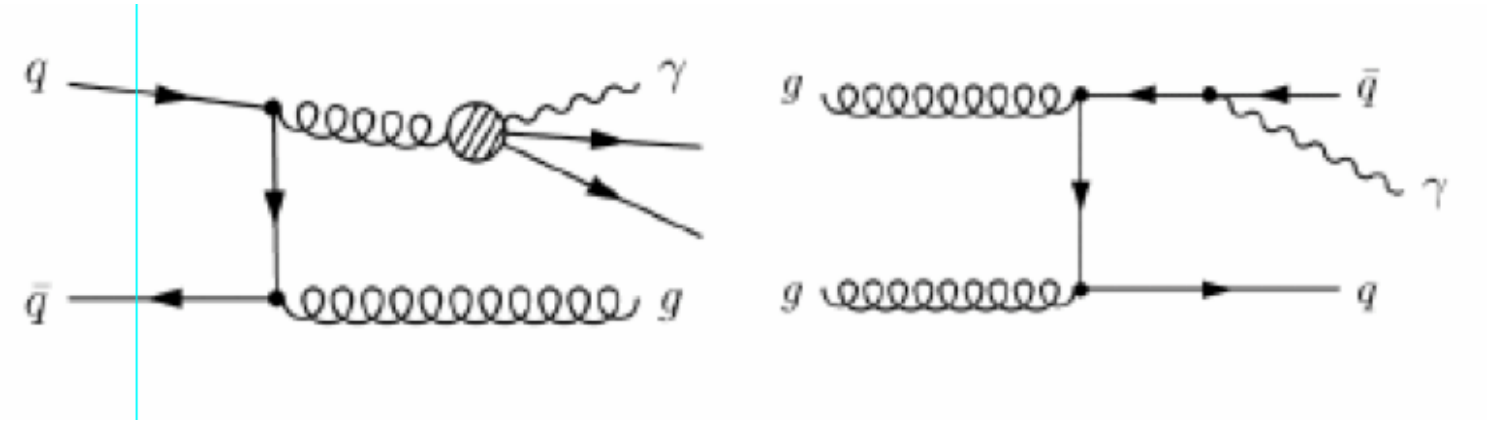
2. Gamma+Jet Events: Backgrounds

Primary background comes from QCD jet events…



1. Real photons:
    - From neutral hadron decays inside jets
    - Photons from bremsstrahlung

2. Fake photons from jets



2. Gamma+Jet Events: Photon Isolation

ECAL

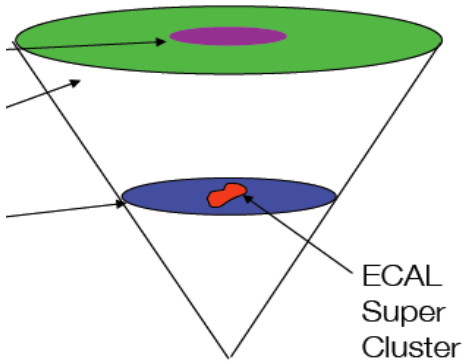
- Clean shower shape compared to jets
- Isolated energy deposition

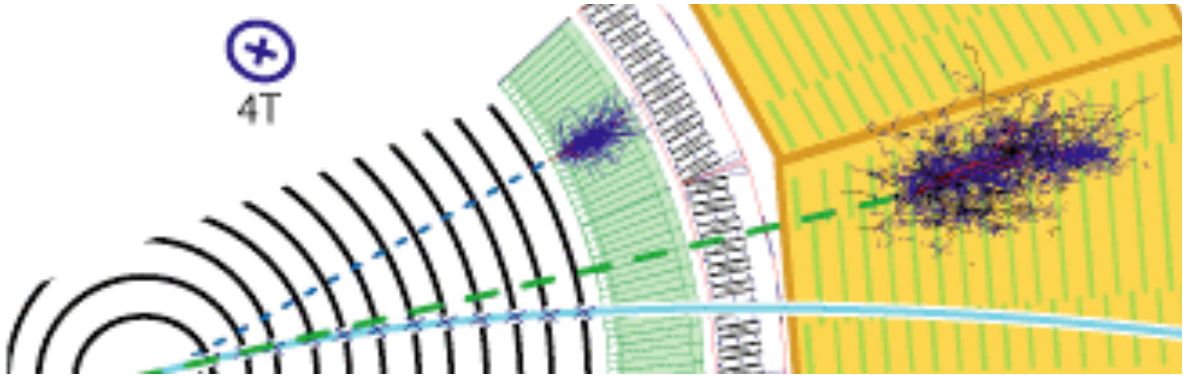
HCAL

- Isolation: Little if any energy deposit in HCAL
- H/E: ratio of hadronic to electromagnetic depositions small

Tracker

- Straight path
- Sum pT of tracks around cluster low





2. Gamma+Jet Events: Photon Isolation

Variables to discriminate against backgrounds

- ECAL isolation, HCAL isolation, H/E, Tracker isolation
- Covariance η, η and ϕ, ϕ

Kinematic requirements on photons:

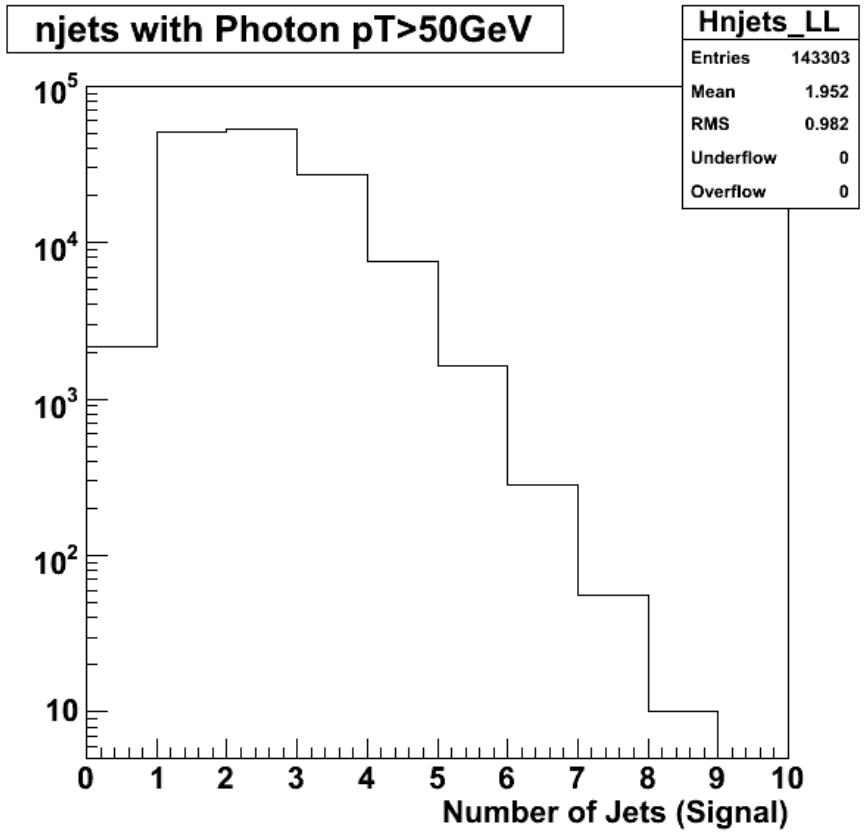
- $p_T > 50$ GeV, $|\eta| < 3$

2. Gamma+Jet Events: Results

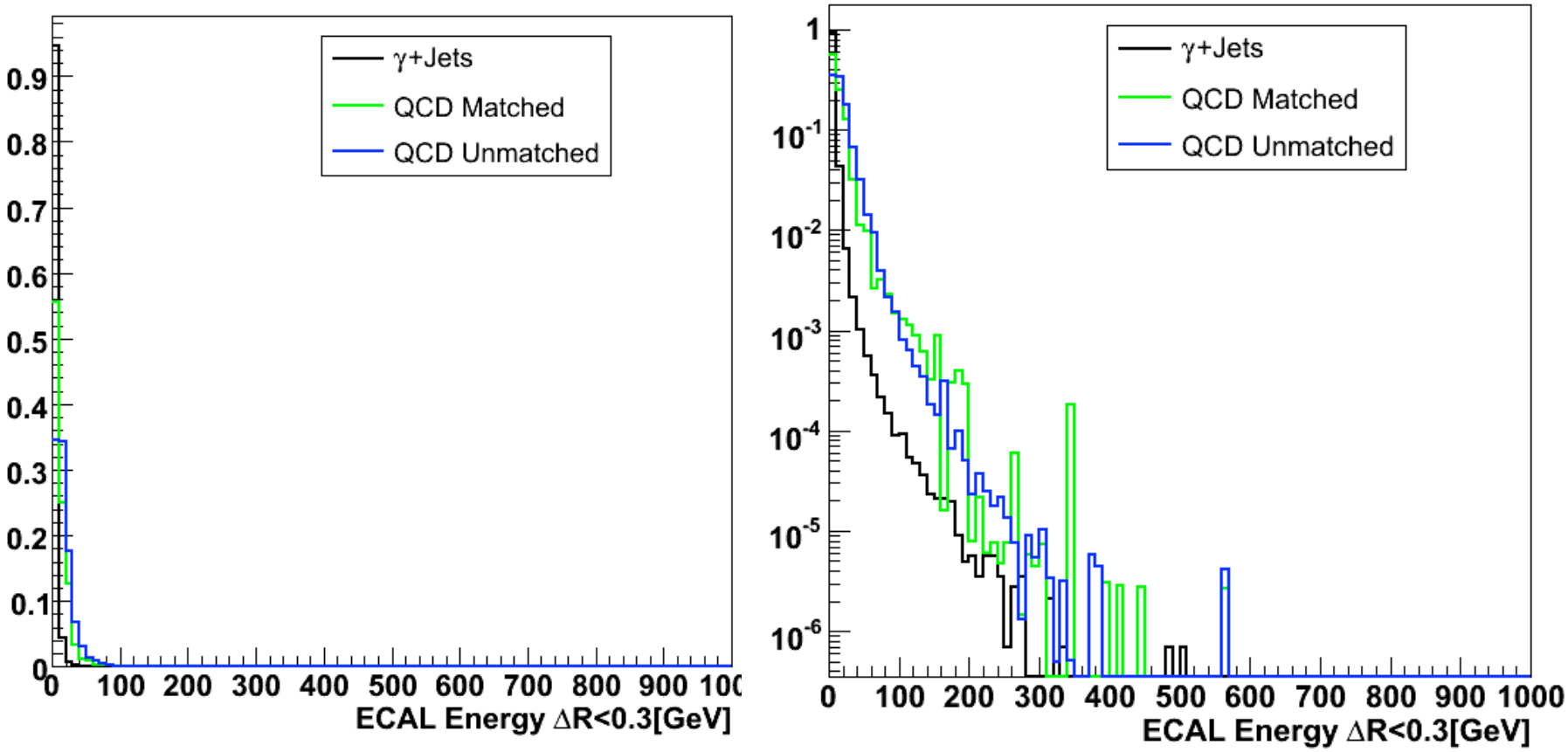
- Ratio of γ+njets/γ+(n+1)jets

  Expect exponential decrease, if there is a new mechanism to produce photon+jets events there should be an excess at large jet multiplicities

- SUSY, Detector Issues

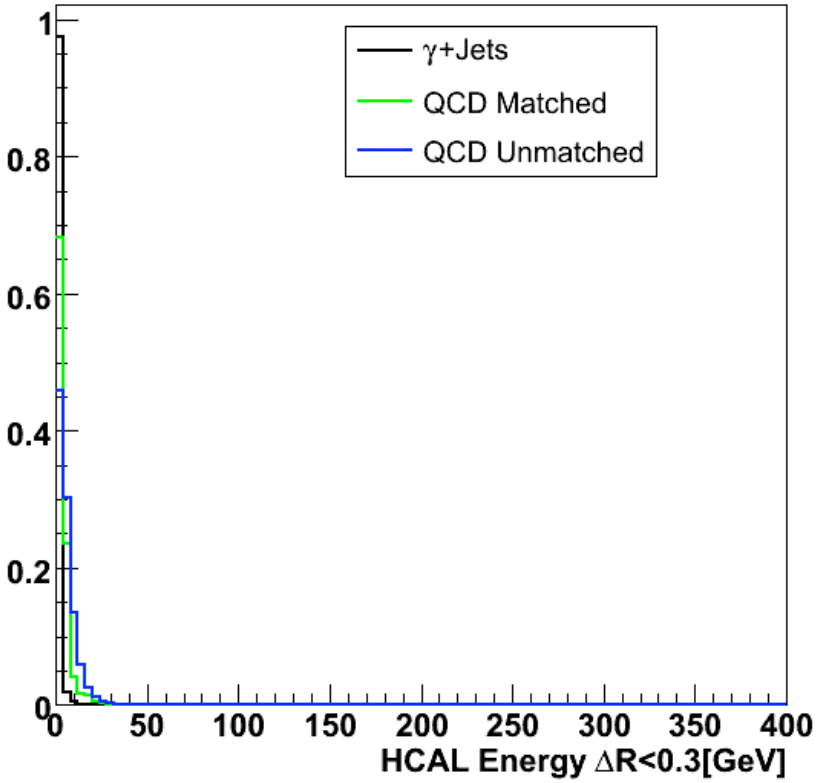


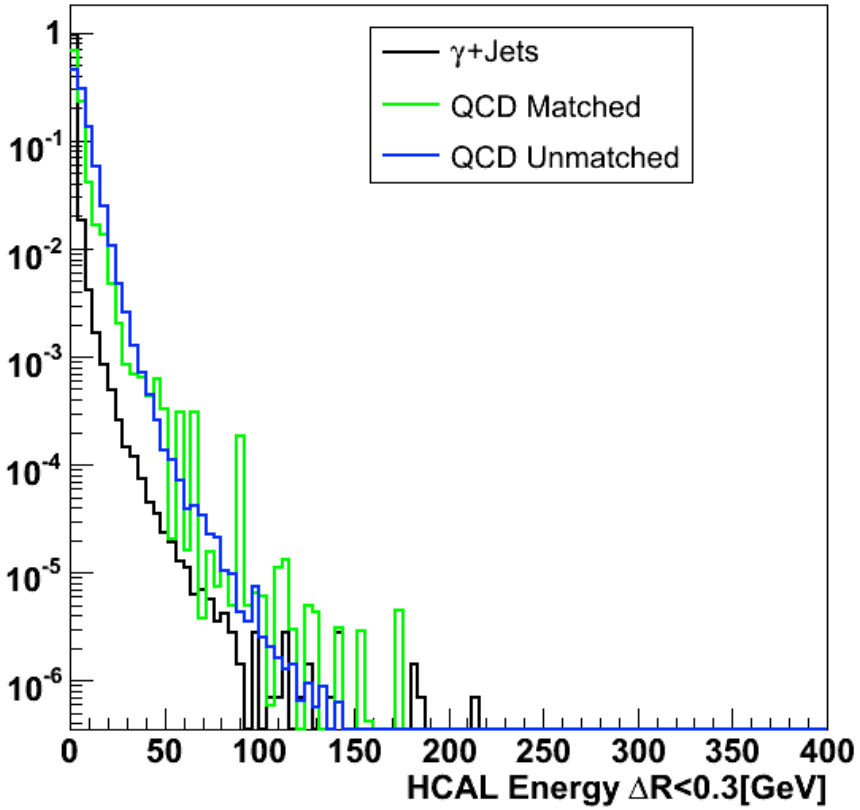
3. Discriminating Variables: ECAL Isolation



Σ Energy in ECAL in cone ΔR < 0.3

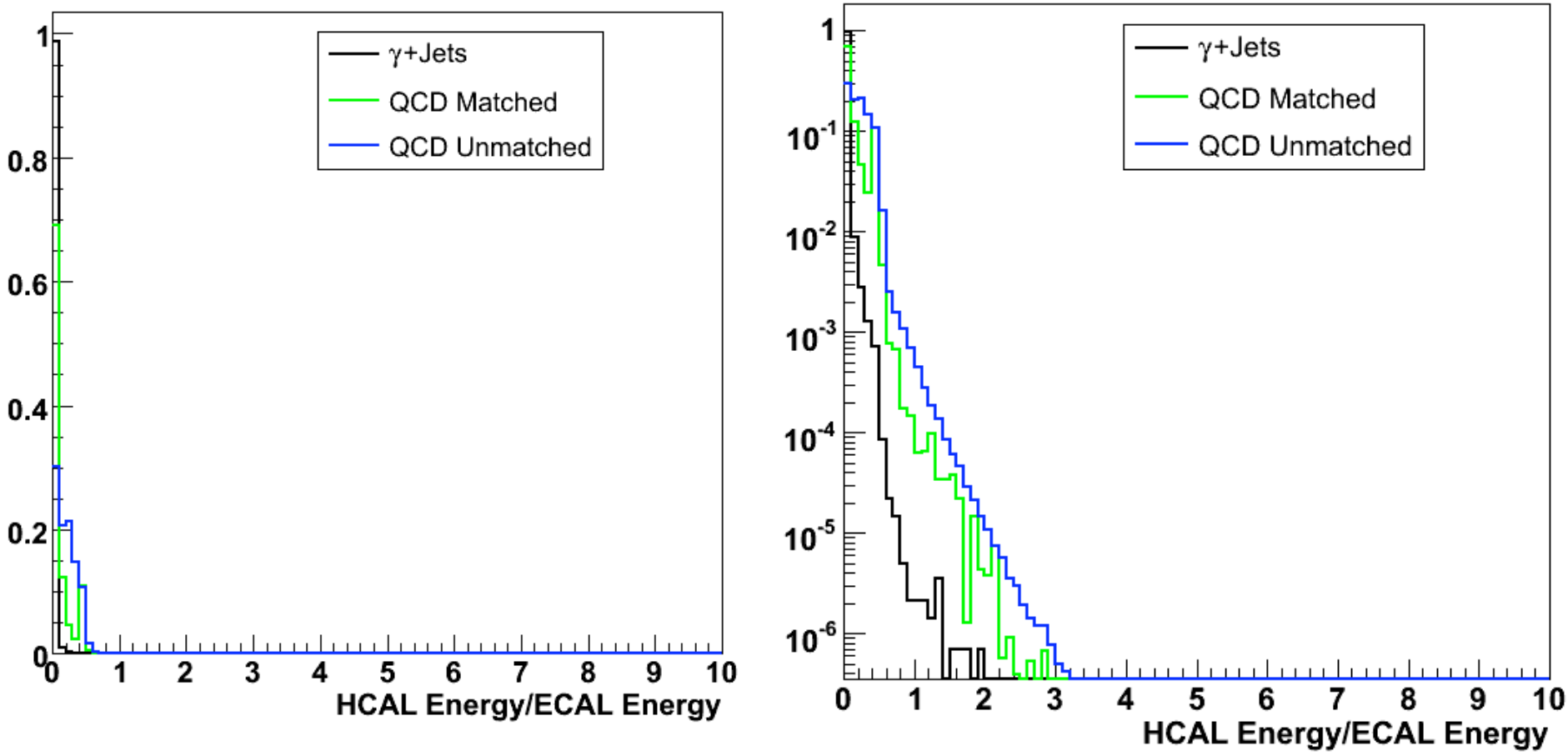
3. Discriminating Variables: HCAL Isolation





Σ Energy in HCAL in cone $\Delta R < 0.3$

3. Discriminating Variables: H/E

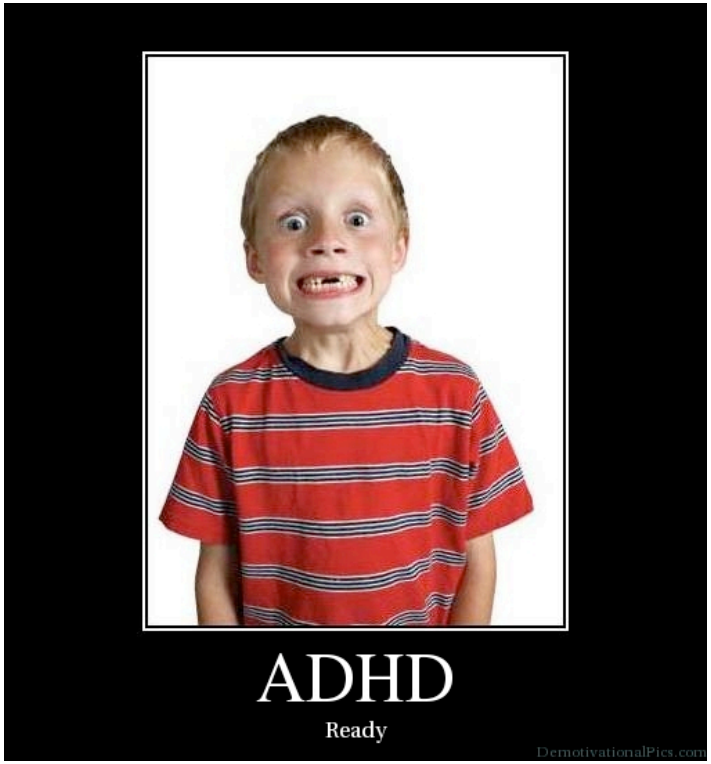


Σ Energy in HCAL in cone ΔR < 0.3 /Σ Energy in ECAL in cone ΔR < 0.3

4. TMVA

- Correlations between variables (heart rate)

- Train, test, evaluate



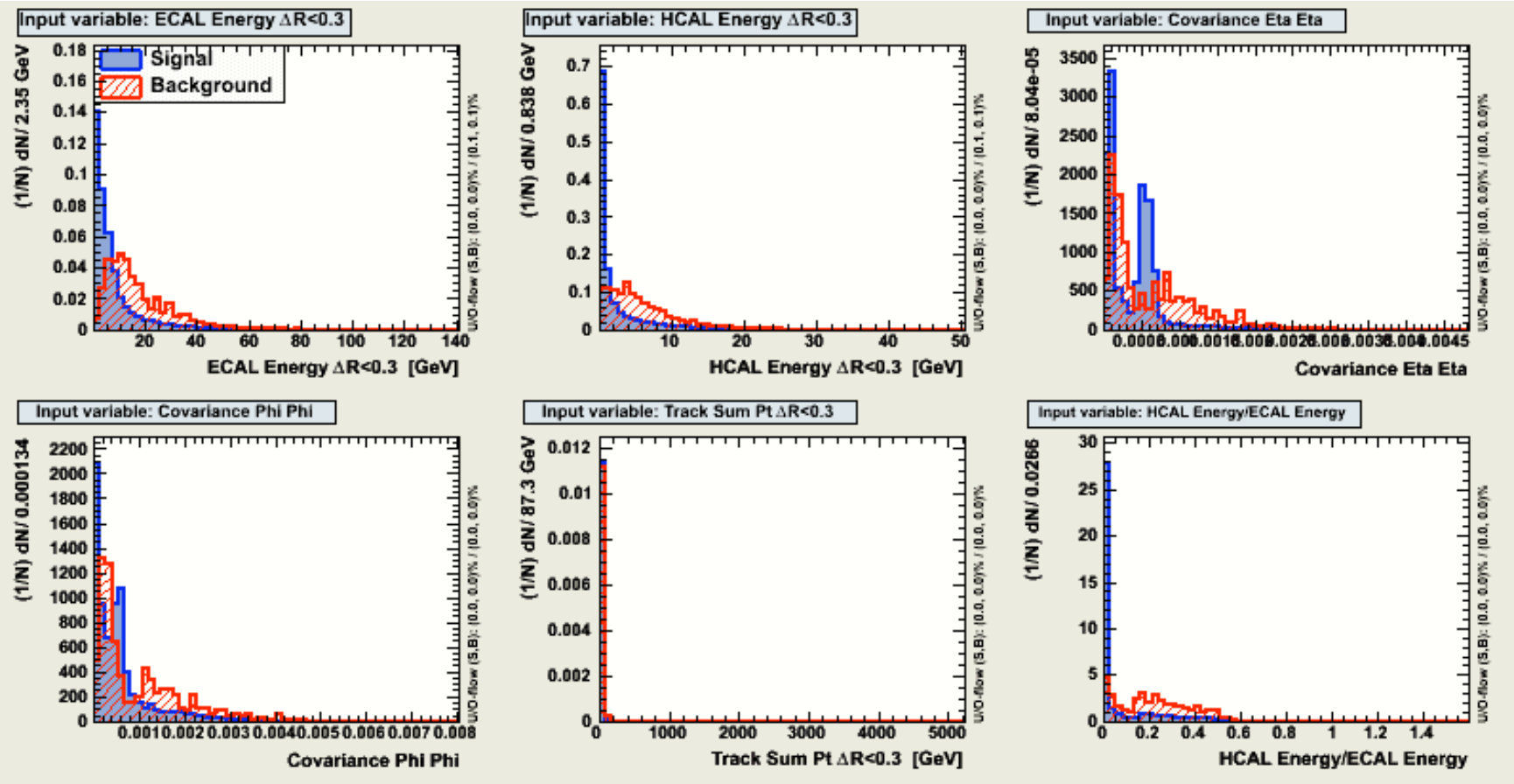
4. TMVA

Optimized discriminating power with TMVA…

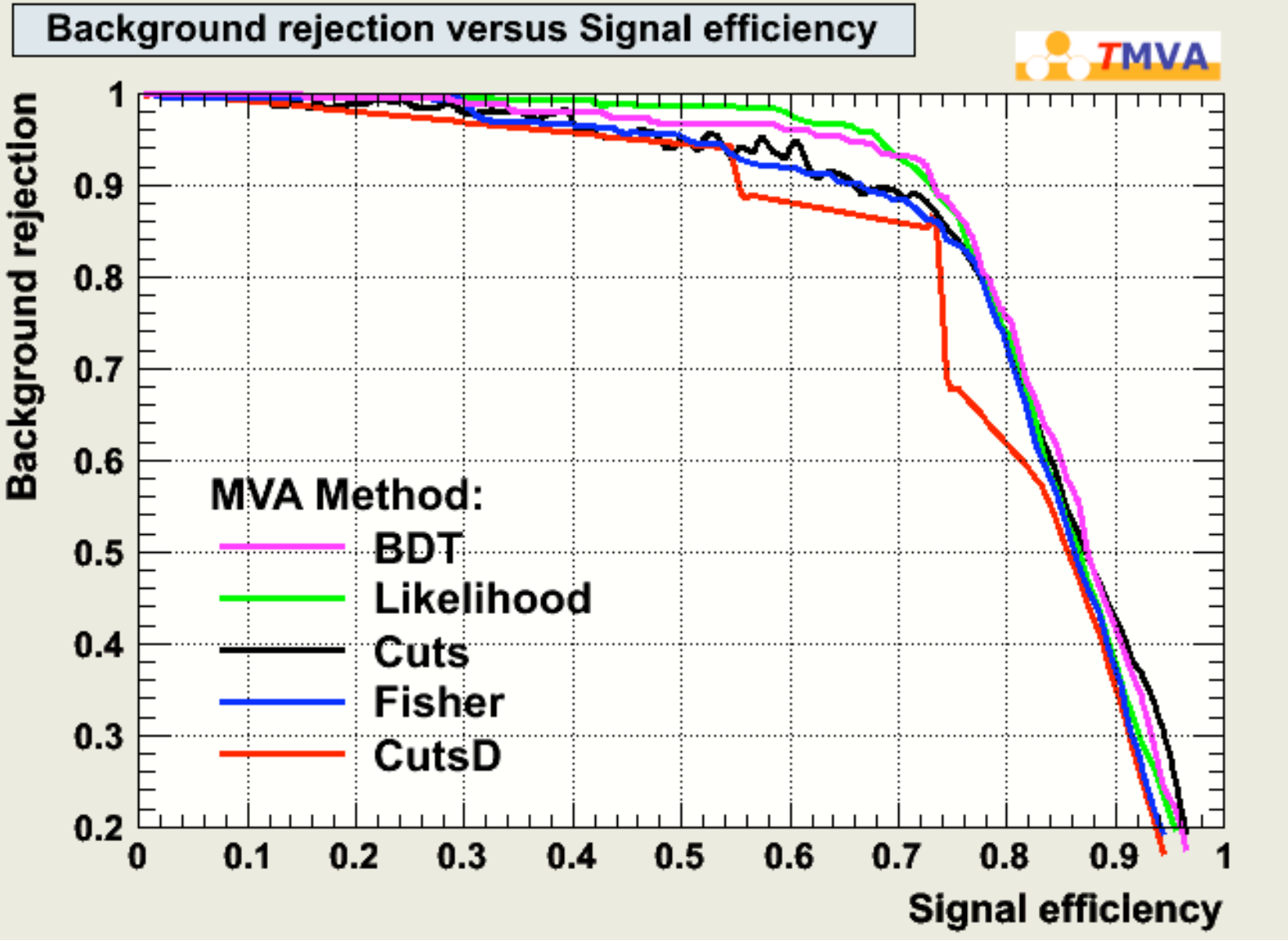
-Num signal = 203,851

-Num background = 416,970

-Divided equally between training and testing samples



4. TMVA: Efficiencies

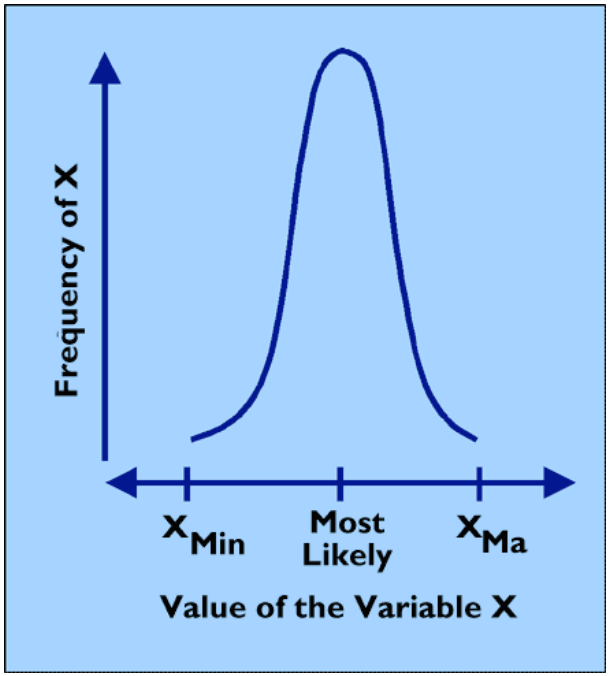


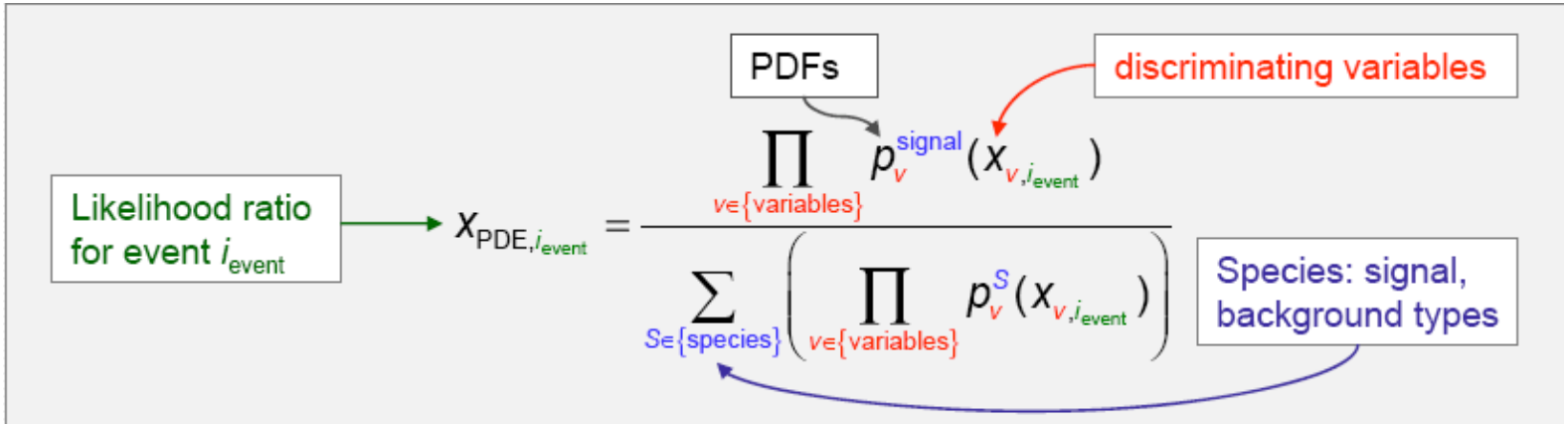
4. TMVA: Likelihood MVA

-Likelihood: probability of specific outcome given set of parameter values

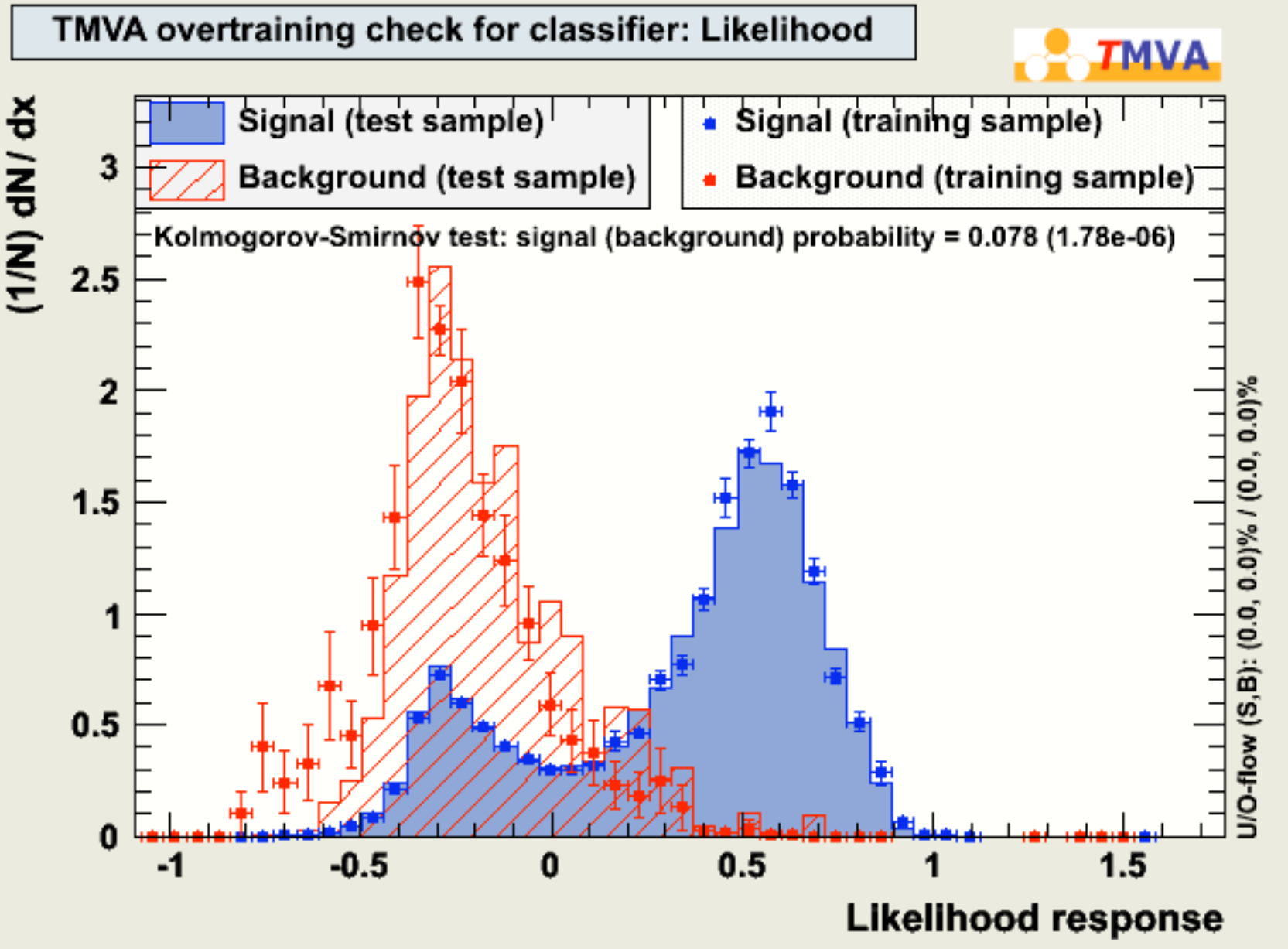
-Probability Distribution Functions

-Maximum Likelihood MVA
- -model based on PDFs of input variables for signal and background
- -Maximize likelihoods





4. TMVA


TMVA overtraining check for classifier: Likelihood
TMVA
Signal (test sample)
Background (test sample)
Signal (training sample)
Background (training sample)
Kolmogorov-Smirnov test: signal (background) probability = 0.078 (1.78e-06)
(1/N) dN / dx
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
Likelihood response
0
0.5
1
1.5
2
2.5
3
-1
-0.5
0
0.5
1
1.5

4. TMVA

- "optimal" cut of 0.1506
- signal efficiency of 73.21%
- background efficiency of 9.7%

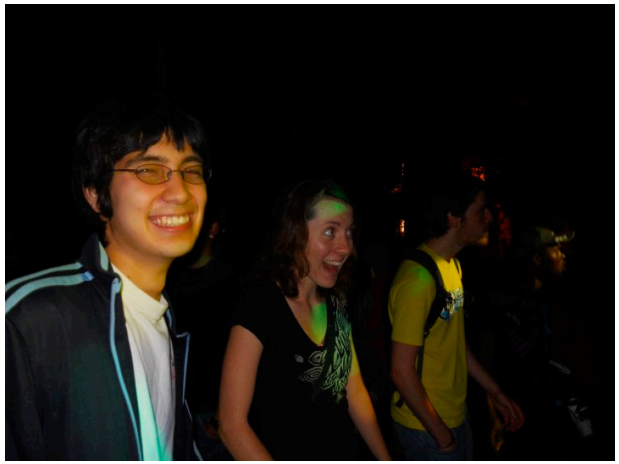
5. Conclusions

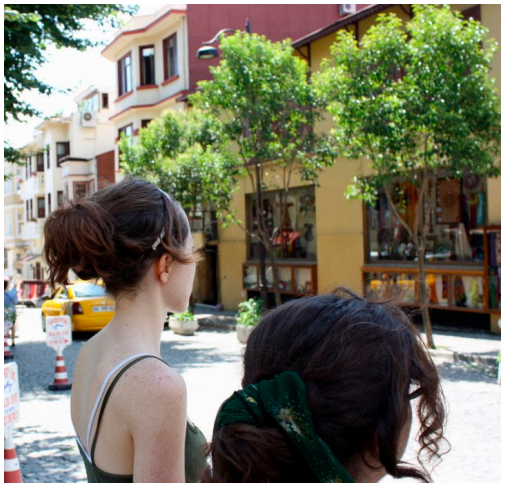
- Apply TMVA selection to get njets ratio plot from real data

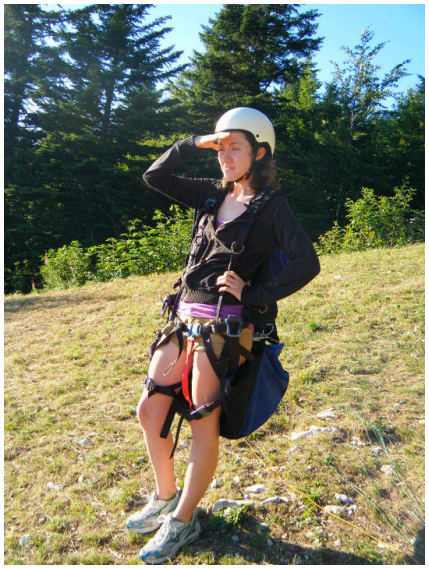
- Better TMVA classification

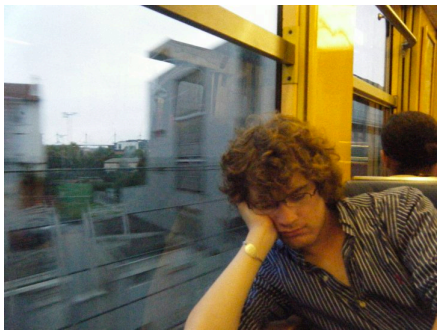
6. FUN

- Fete de la Musique
- Wine and Cheese
- Montreaux Jazz
- Istanbul
- Paris
- Paragliding









Acknowledgements

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Works Cited

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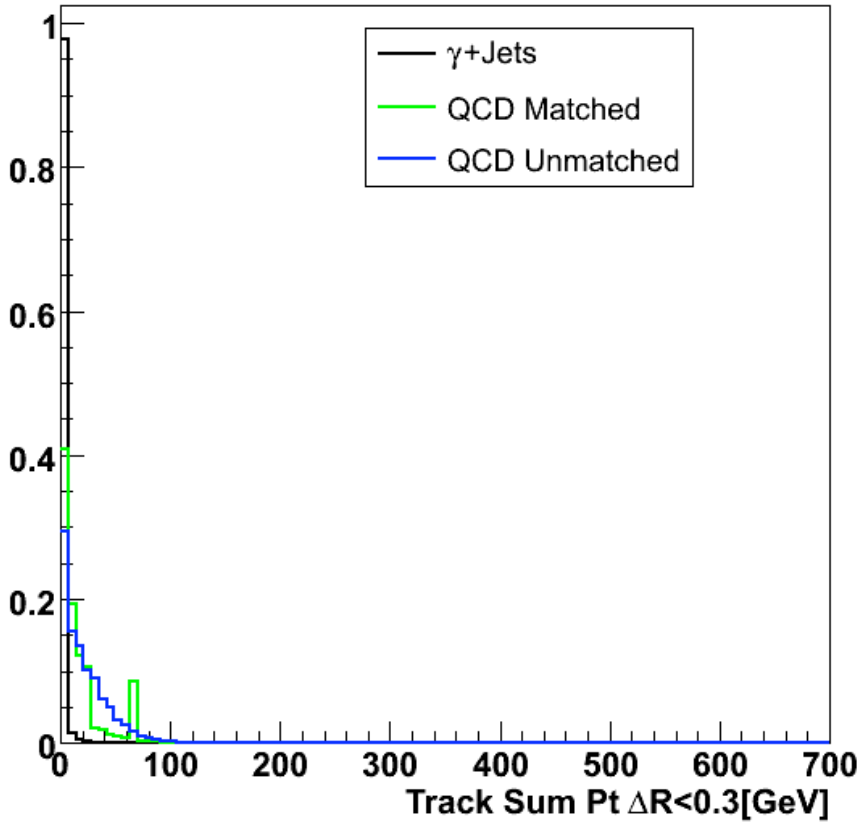
- http://cdsweb.cern.ch/record/1202800/files/EWK-08-006-pas.pdf
- cdsweb.cern.ch/record/1202801/files/EWK-09-006-pas.pdf
- Pdf: http://www.information-management.com/specialreports/20030624/6935-1.html

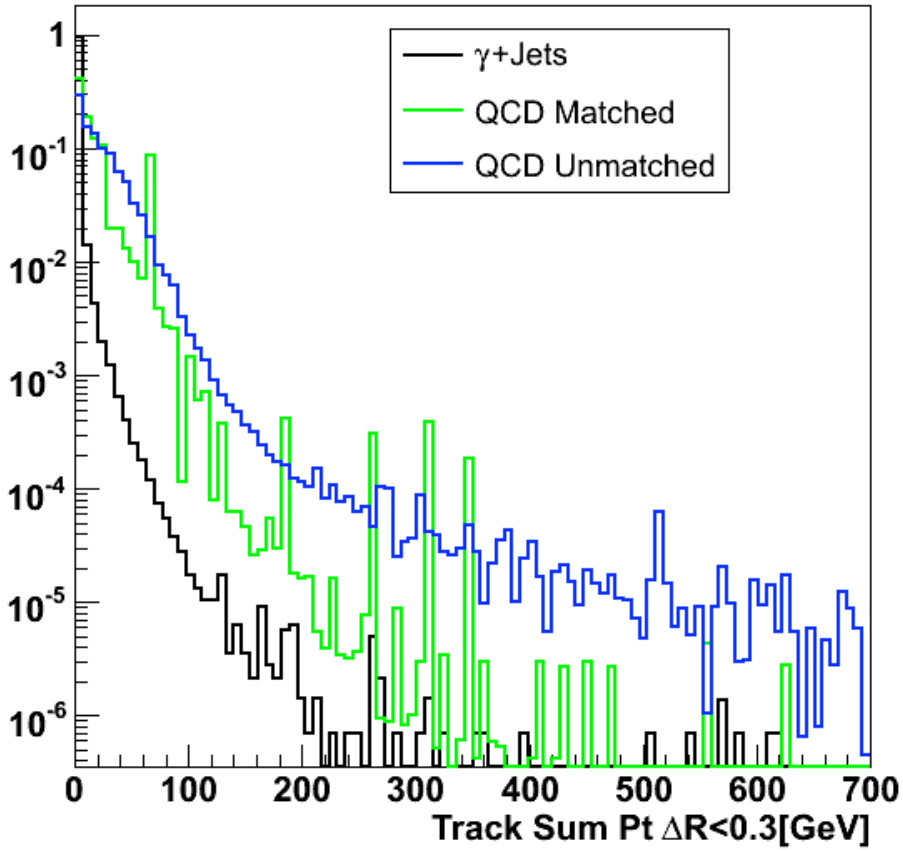
Back-up Slides

3. Discriminating Variables

- ECAL $\Delta R<0.3$
- HCAL $\Delta R<0.3$
- H/E
- Cov Eta Eta
- Cov Phi Phi
- Track Sum Pt $\Delta R<0.3$

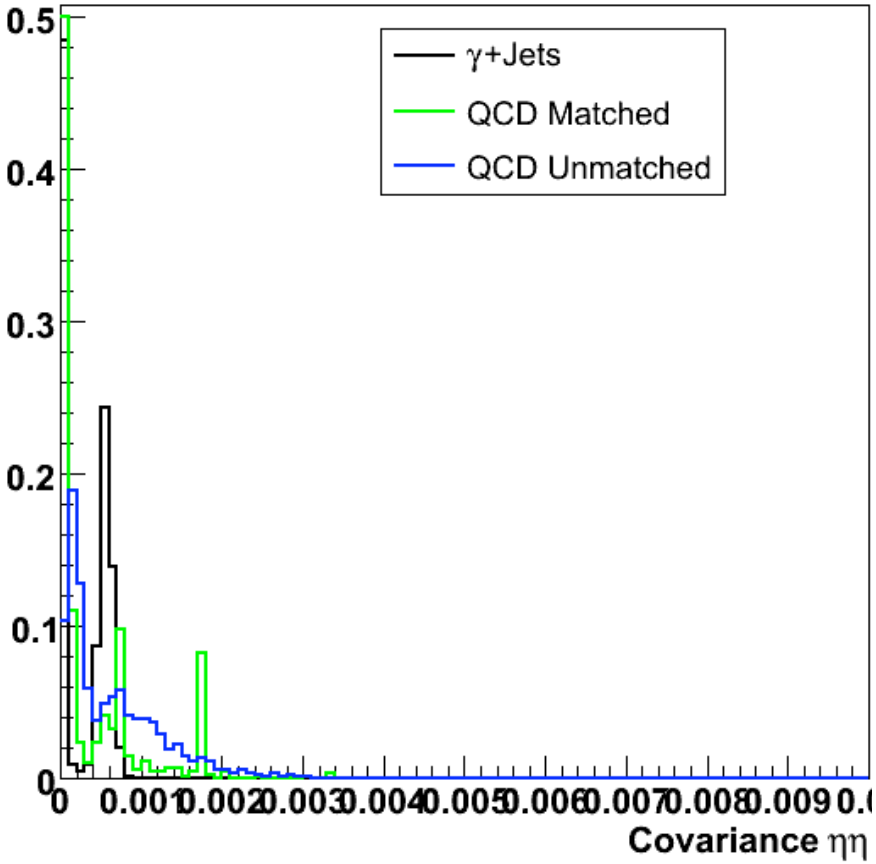
Tracker Isolation

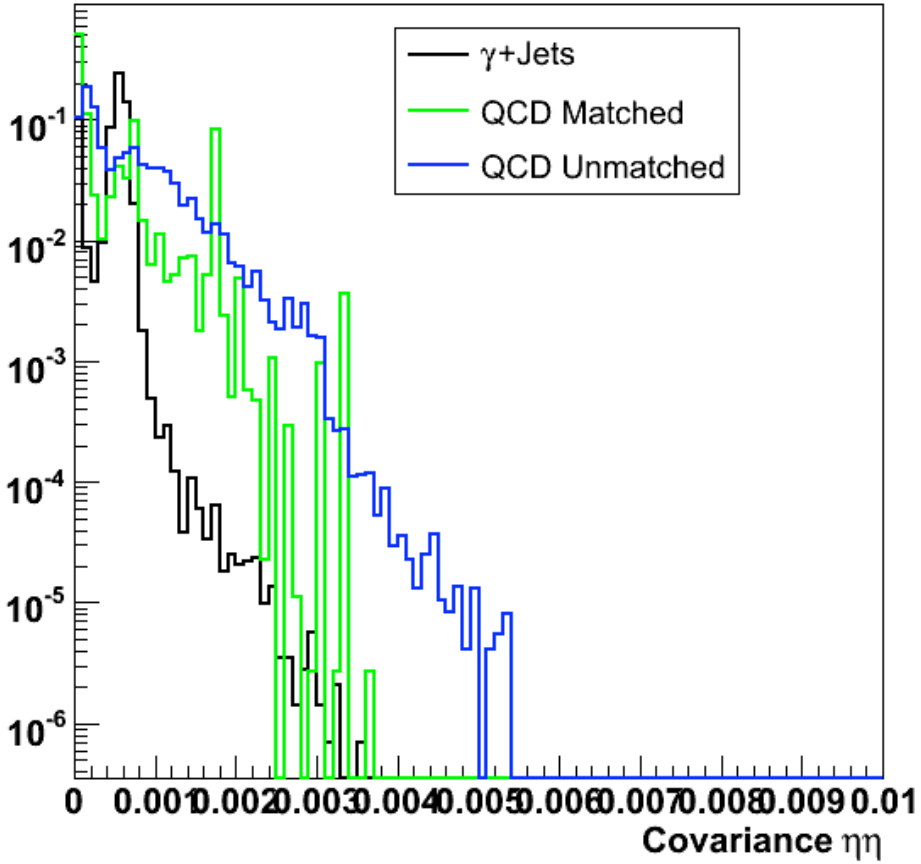




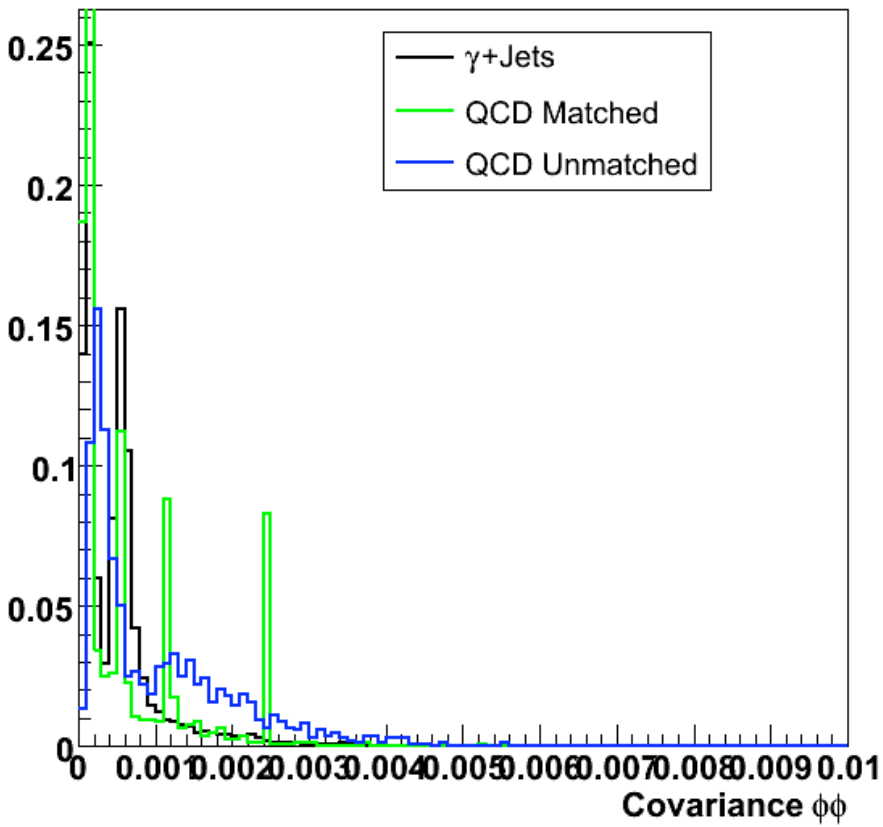
Σ Momentum Tracks in cone ΔR < 0.3

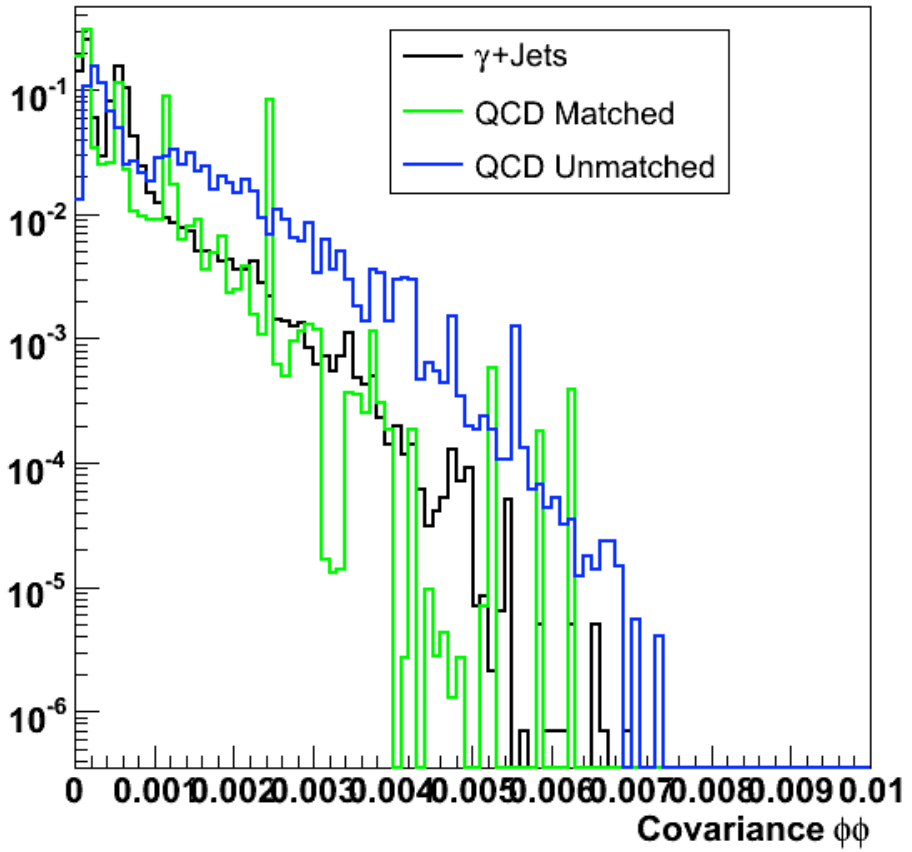
Covariance η,η





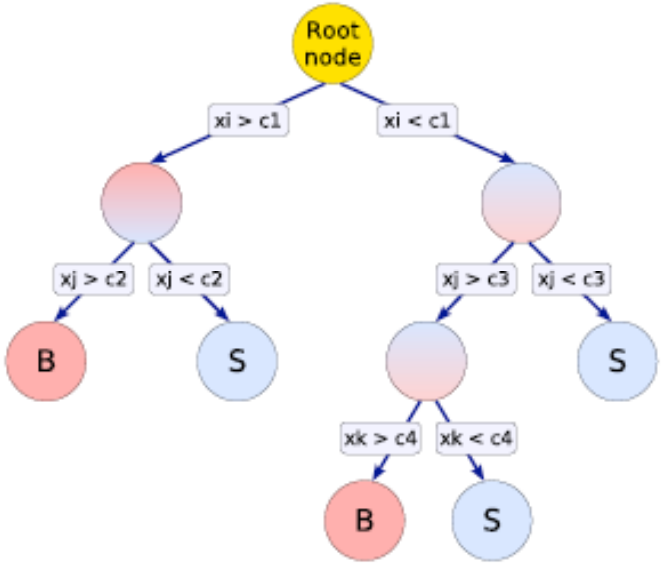
Covariance ϕ,ϕ



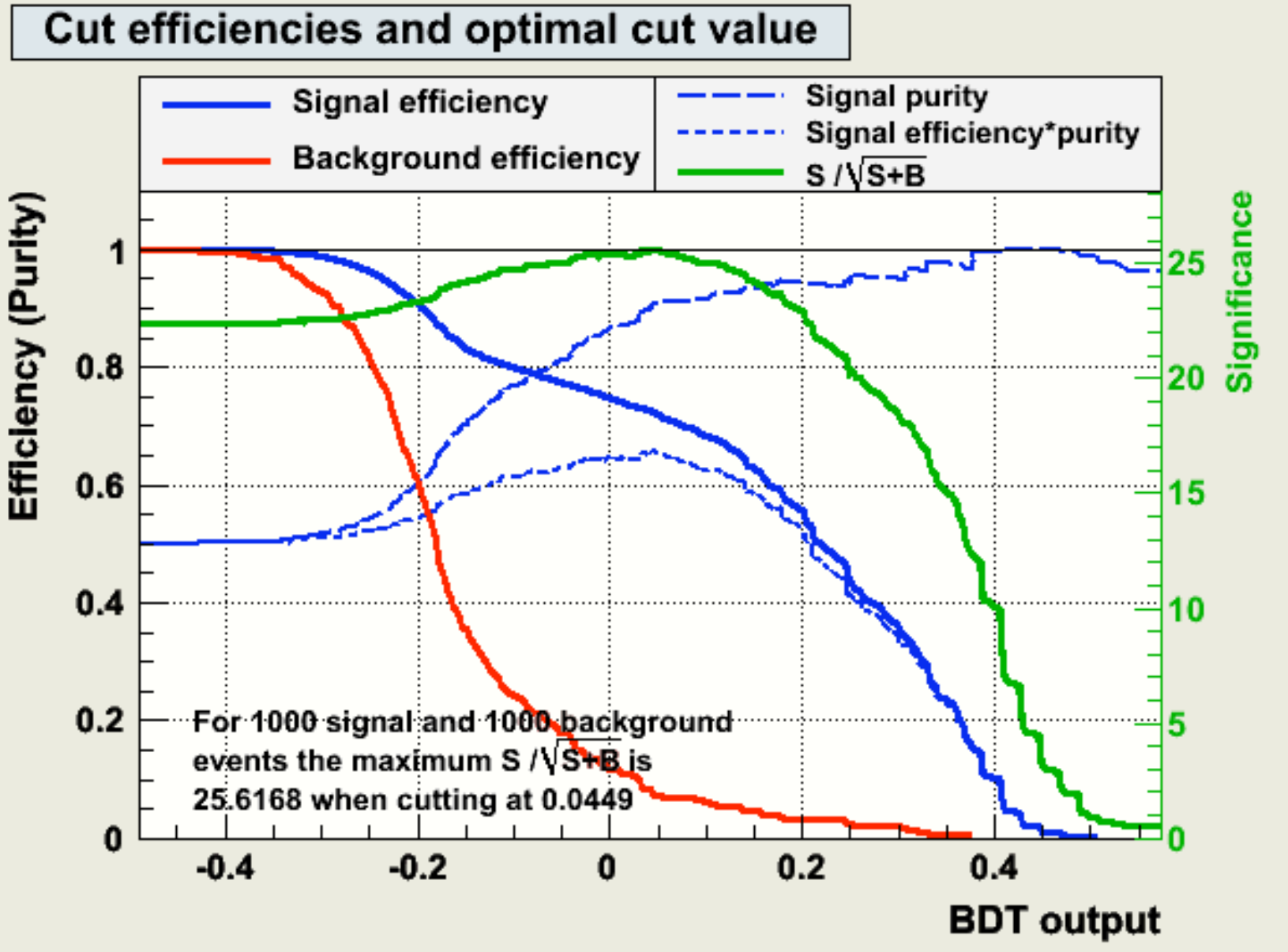


TMVA: BDT

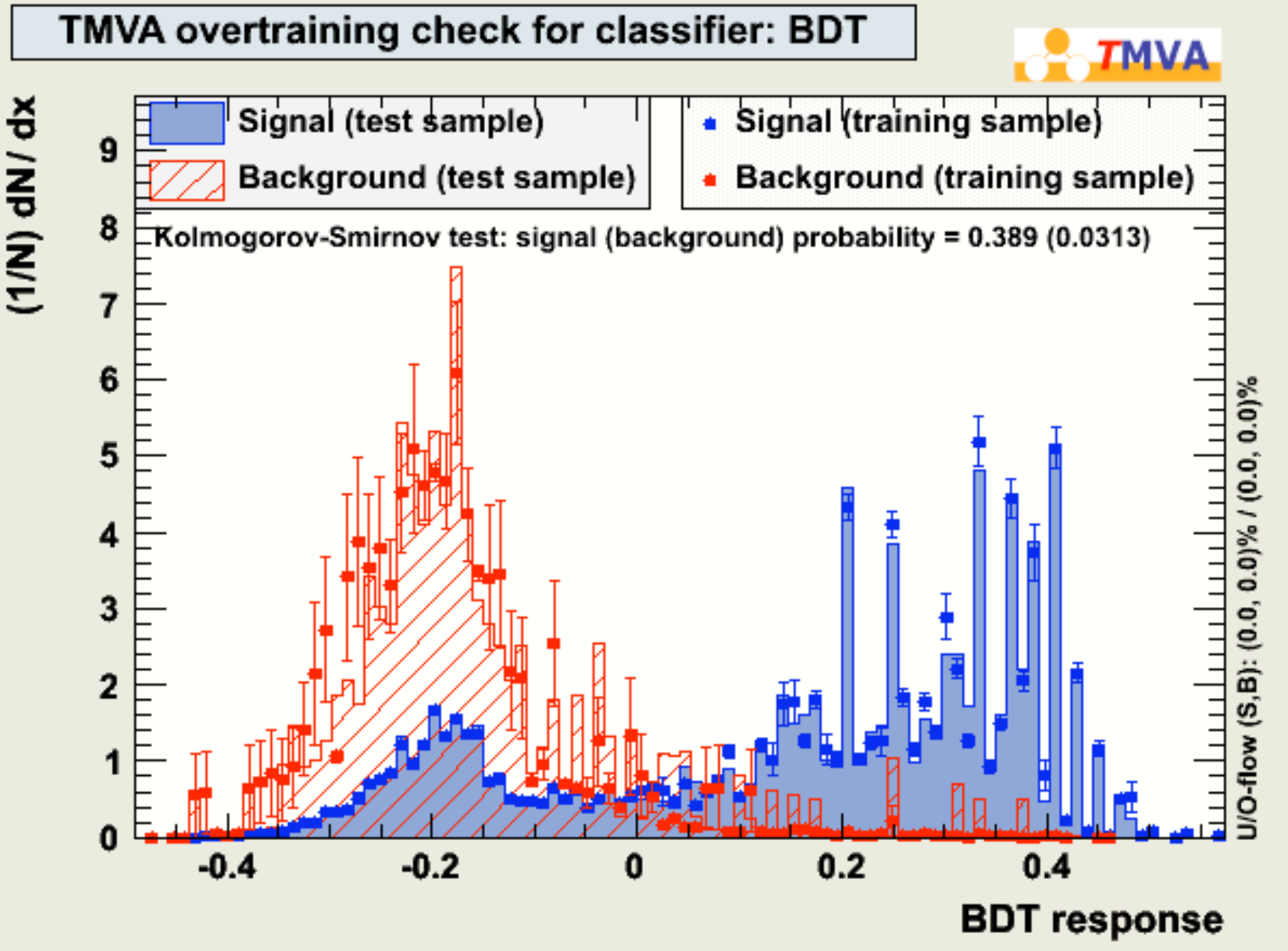
- "optimal" cut of 0.0449
- S/sqrt(S+B) of 25.6168
- signal efficiency of 72.28%
- background efficiency of 7.336%



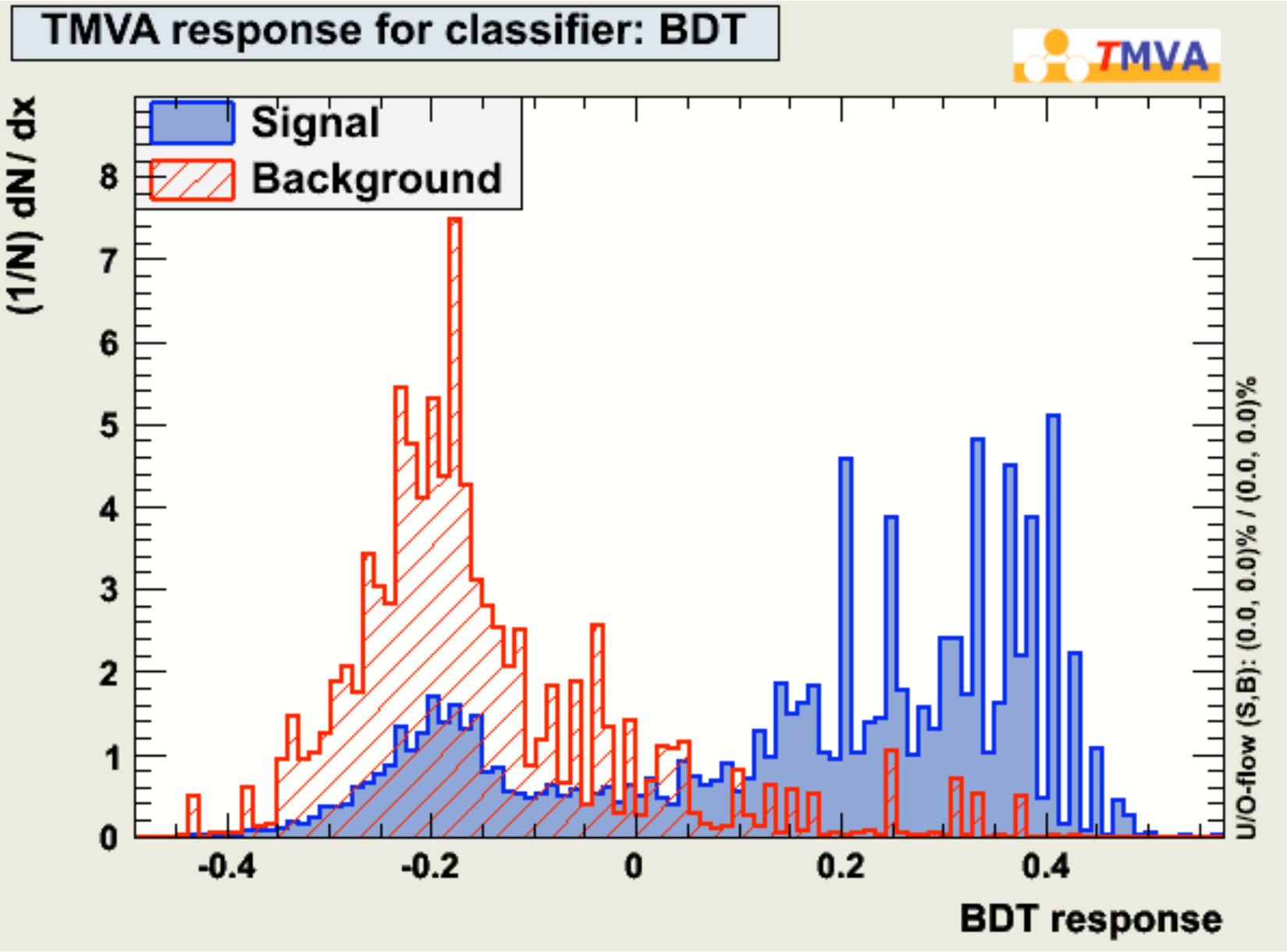
TMVA


Cut efficiencies and optimal cut value
Signal efficiency
Background efficiency
Signal purity
Signal efficiency*purity
S /√S+B
Efficiency (Purity)
Significance
1
0.8
0.6
0.4
0.2
0
25
20
15
10
5
0
-0.4
-0.2
0
0.2
0.4
BDT output
For 1000 signal and 1000 background
events the maximum S /√S+B is
25.6168 when cutting at 0.0449

TMVA


TMVA overtraining check for classifier: BDT
TMVA
Signal (test sample)
Background (test sample)
Signal (training sample)
Background (training sample)
Kolmogorov-Smirnov test: signal (background) probability = 0.389 (0.0313)
(1/N) dN / dx
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
BDT response
0
1
2
3
4
5
6
7
8
9
-0.4
-0.2
0
0.2
0.4

TMVA


TMVA response for classifier: BDT
TMVA
Signal
Background
(1/N) dN / dx
0
1
2
3
4
5
6
7
8
-0.4
-0.2
0
0.2
0.4
BDT response
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%