ALEPH 93-08
PHYSIC 93-05
J. Proriol
18.01.1993

COMPARISON OF 3 METHODS TO CLASSIFY HADRONIC EVENTS IN E^+E^- COLLISIONS: CUT ON THE MOST DISCRIMINATING VARIABLE, DISCRIMINANT ANALYSIS, NEURAL NETWORK

J. PRORIOL
Laboratoire de physique corpusculaire
Clermont-Ferrand

Abstract.

We compare 3 methods of classification used in High Energy physics:cut on the most discriminating variable,discriminant analysis,neural network.We apply these methods to 2 problems:the classification of an hadronic event according to the primary quark,when considering the variables computed from the tracks of the entire event or from only the most energetic jet.

1-Introduction

Some works have been devoted to the comparison of discriminant analysis and neural networks[1],but the application was not a problem of high energy physics where the data are noisy and where the different classes overlap strongly.

A first attempt was done for the classification of b quark events[2],but the variables connected with the vertex detector were not used,and only one class was considered.

In this paper,we'll use variables extracted from the vertex detector of ALEPH and we'll consider b and c quark events.

In a first part of this paper,we recall the different methods used to classify hadronic events,in a second part,we present the different results.

2-Methods

With a detector equiped with a detector of vertex,the most discrimininating variable to classify b quark events is the variable connected to the outputs of this detector.When the detector of vertex is absent,the sphericity product is the most discriminating variable[2].

For the 3 methods,we proceed the same way to get our results.The ouputs of the 3 methods are presented in histograms for the different classes(figures 1 to 4).From these histograms,with a moving cut,we can get samples with increasing purity.For each position of the cut we define the following parameters for the events above the cut:

-purity for one class=(# of true events of the class)/(# of events classified in this class)

-efficiency for one class=(# of true events of the class)/(total # of events of the class)

Then for every method and different classes,we can draw the curves purity/efficiency.

In the first method we use the variables connected to the impact parameter defined for the entire event and for one jet[3].

For the study of the 2 other methods,we have generated 150 variables with the ALEPH Monte-Carlo.The detector is then fully simulated:the variables are very noisy and the different classes overlap strongly.These variables are diveded into 2 groups:the first group is the group of the variables which consider all the tracks of one event;the second group the variables are computed with the tracks of the 2 most energetic jets[4-6].

We choose the same set of selected variables for the discriminant analysis and for the MLP neural network.To select the variables we use the method called F-test,this method is presented in reference [2].

For the study of the entire event,the first variable is the variable connected with the impact parameter.We find then variables connected with all the tracks as the sphericity product or 3-D invariants and variables connected with the jets or groups of tracks as Wisconsin variables[5].

We have selected 20 of these variables.

When we consider only the 2 most energetic jets,the number of variables is more limited.Using The same F-test method,we have also selected 20 variables.

These 2 sets of variables are computed on 10000 events of each of the 3 classes:b quark events,c quark events and light quark envents have feeded the learning of a discriminant analysis and the learning of a MLP neural network with 2 hidden layers.This network has 20 inputs,2 layers of 20 and 8 neurons and a layer with 3 outputs.

The test was done with a different sample of 73376 events.

3-Results

We have classified the test set of the 2 cases with discriminant analysis and neural network.

For the entire event case the percentage of well classified events is 67.2 for discriminant analysis and 71.2 for neural network.

For the classication from one jet the percentage is 62.4 for discriminant analysis and 66.6 for neural network.

In figures 5-8,we give the comparisons of the curves purity/efficiency for the differents cases and the b and c quark events classes.We can see that the multivariate methods are more powerful than the single variable method.In the b quark events classes,the discriminant analysis is almost as powerful than the neural network:this class is almost linearly separable from the other classes because the impact parameter variable is very powerful.The conclusion was different when the impact variable was not used[2].

But in the c quark events class,the conclusion is different.The single variable method does not give a result;discriminant analysis gives a result inferior to the neural network result:it is more difficult to separate,with a simple classification,the c quark events from the others.

4-Conclusion

We have compared 3 methods of classification.The most efficient one is the neural network;but when one variable is strongly discriminating,the discriminant analysis gives a good result.Only these 2 methods allows a separation of c quark events from b quark events.

5-Aknowlegments

These results were obtained with the full Monte-Carlo simulation of ALEPH.I would like to thank all the physicists of the ALEPH collaboration for their help and their support.

References

[1]P.GALLINARI,S.THIRIA,F.FOGELMAN-SOULIE
Proc of IEEE 2nd ICNN,San-Diego,Vol I,pp391-401 (1988)
P.GALLINARI,S.THIRIA,F.BADRAN,F.FOGELMAN-SOULIE
Neural Networks 4(1991)349
M. de BOLLIVIER
Thesis LRI ORSAY (1992)

[2]J.PRORIOL,J.JOUSSET,C.GUICHENEY,A.FALVARD,P.HENRARD,
D.PALLIN,P.PERRET,B.BRANDL
Proc of the 1st workshop on neural networks:from biology high to energy physics.Isola d'Elba
Editors:O.Benhar,L.Bosio,P.del Giudice,E.Tabet
ETS EDITRICE PISA(1991)pp419-444
B.BRANDL,A.FALVARD,C.GUICHENEY,P.HENRARD,J.JOUSSET,J.PRORIOL
Nuclear Instr and Methods **A234**(1992)307

[3]D.BROWN,M.FRANK
ALEPH 92-135 (1992)

[4]A. de RUJULA,J.ELLIS,E.G.FLORATOS,M.K.GAILLARD
Nuclear Physics **B138**(1978)37
G.C.FOX,S.WOLFRAM
Nuclear Physics **B149**(1979)413
S.BRANDT,U.D.DAHMEN
Z. Phys **C1**(1979)61
J.B.BABCOCK,R.E.CUTKOWSKI
Nuclear Physics **B179**(1980)113
F.BARRIERO,S.BRANDT,M.GEBNER
Nucl Inst and Meth **A240**(1985)237
SAU LAN WU
Nuclear Physics(Proc supp)(1988)102

[5]L.BELLANTONI,J.S.CONWAY,J.E.JACOBSON,Y.B.PAN,SAU LAN WU
Nucl Inst Meth **A310**(1991)675

[6]J.PRORIOL
Preprint

figure captions

Figure 1-Histograms of the impact parameter variable of the entire event for the 3 classes:b quark events,c quark events,light quark events.

Figure 2-Histograms of the impact parameter variable of the most energetic jet.

Figure 3-Outputs of the disriminant analysis.

-1:b quark
-2:c quark
-3:light quark
-4:not b quark
-5:not c quark
-6:not light quark

Figure 4-Outputs of the MLP neural network

Figure 5-Pur/eff for b quark,all the tracks

star:single variable
lozenge:discriminant analysis
circle:MLP neural network

Figure 6-Pur/eff for c quark,all the tracks

Figure 7-Pur/eff for b quark,one jet

Figure 8-Pur/eff for c quark,one jet

Figure 1

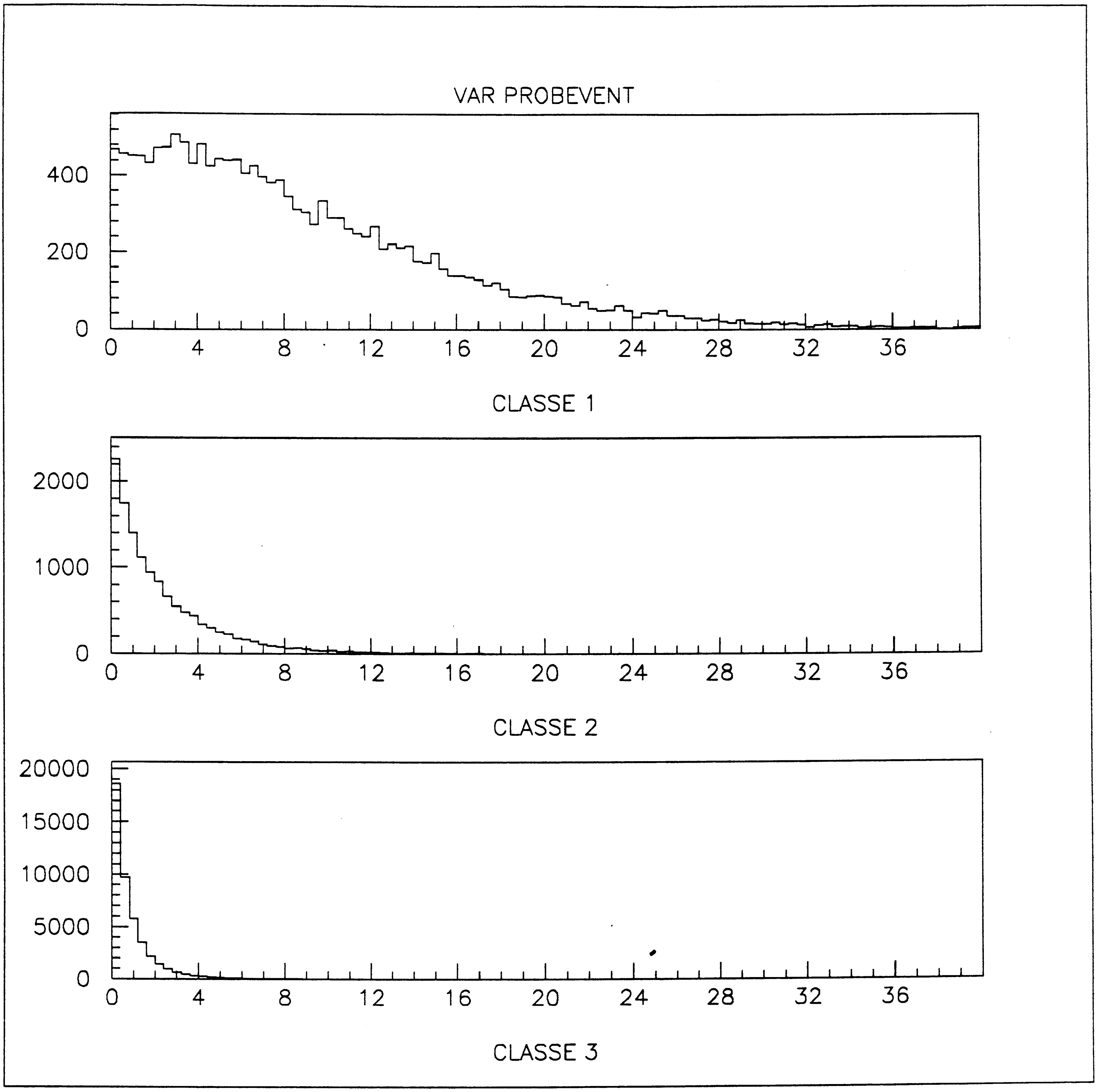

VAR PROBEVENT
400
200
0
0
4
8
12
16
20
24
28
32
36
CLASSE 1
2000
1000
0
CLASSE 2
20000
15000
10000
5000
CLASSE 3

Figure 2

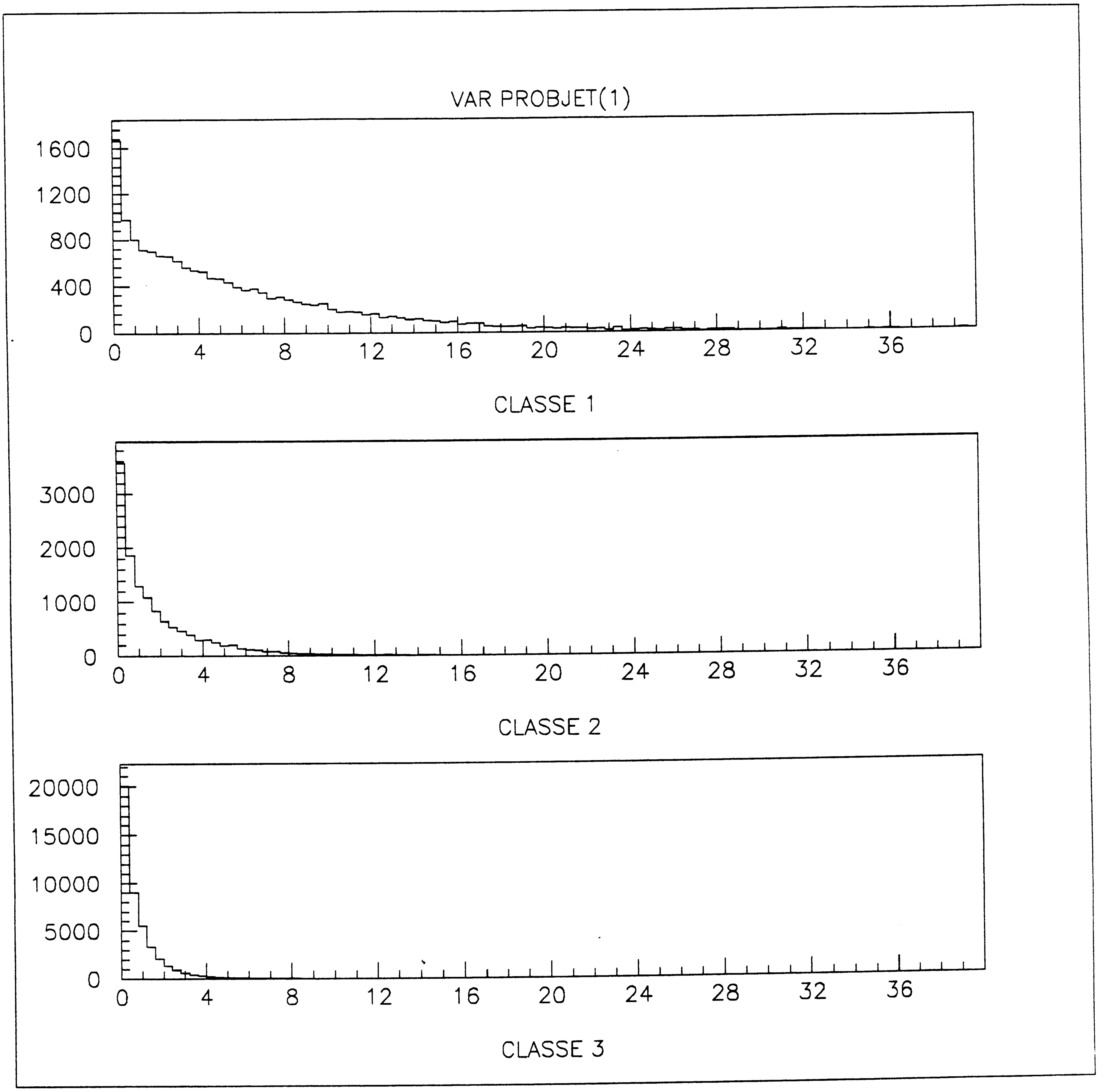
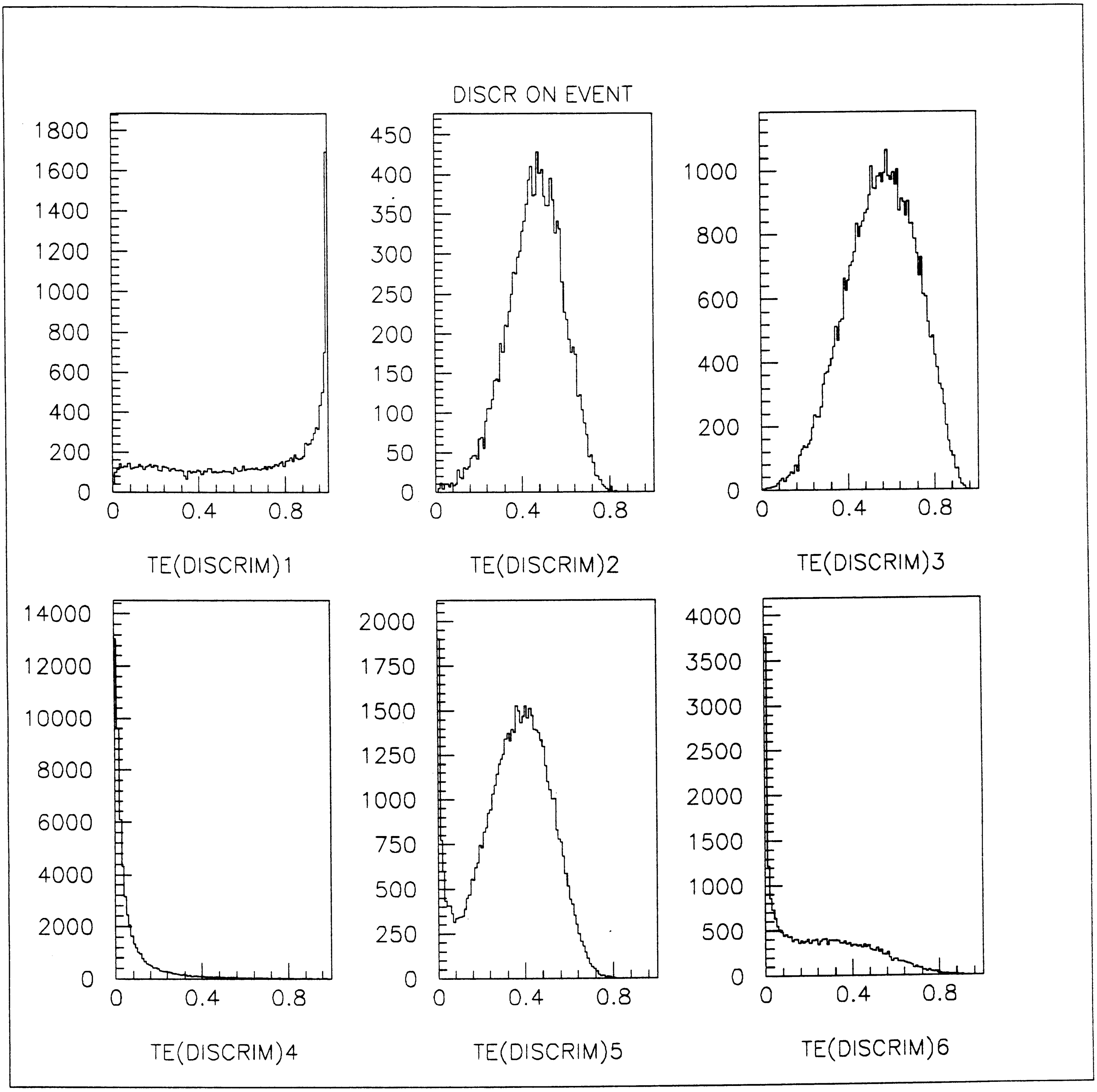

VAR PROBJET(1)
1600
1200
800
400
0
0
4
8
12
16
20
24
28
32
36
CLASSE 1
3000
2000
1000
0
0
4
8
12
16
20
24
28
32
36
CLASSE 2
20000
15000
10000
5000
0
0
4
8
12
16
20
24
28
32
36
CLASSE 3

Figure 3



DISCR ON EVENT
TE(DISCRIM)1
TE(DISCRIM)2
TE(DISCRIM)3
TE(DISCRIM)4
TE(DISCRIM)5
TE(DISCRIM)6

Figure 4

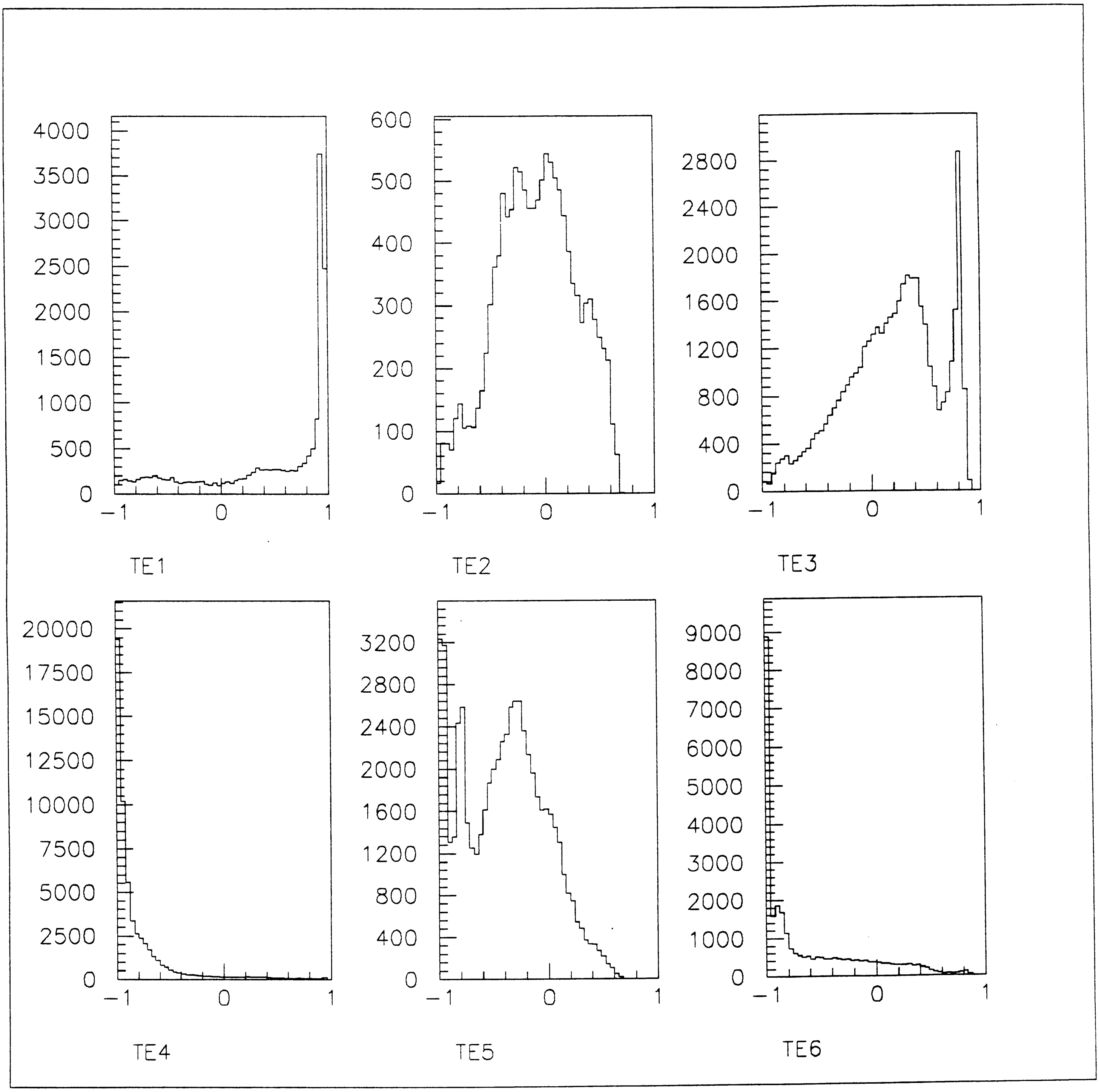


Figure 5

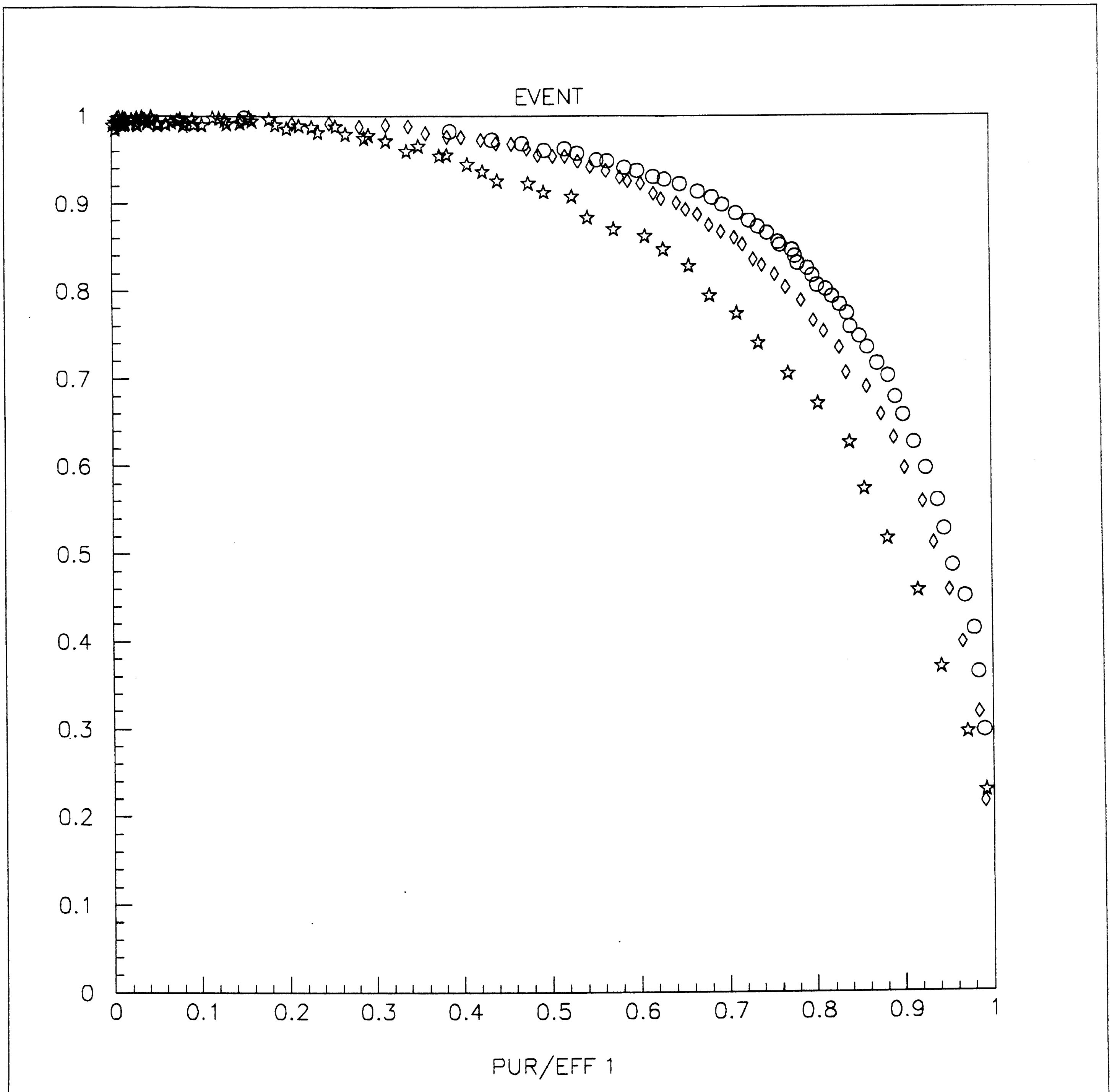
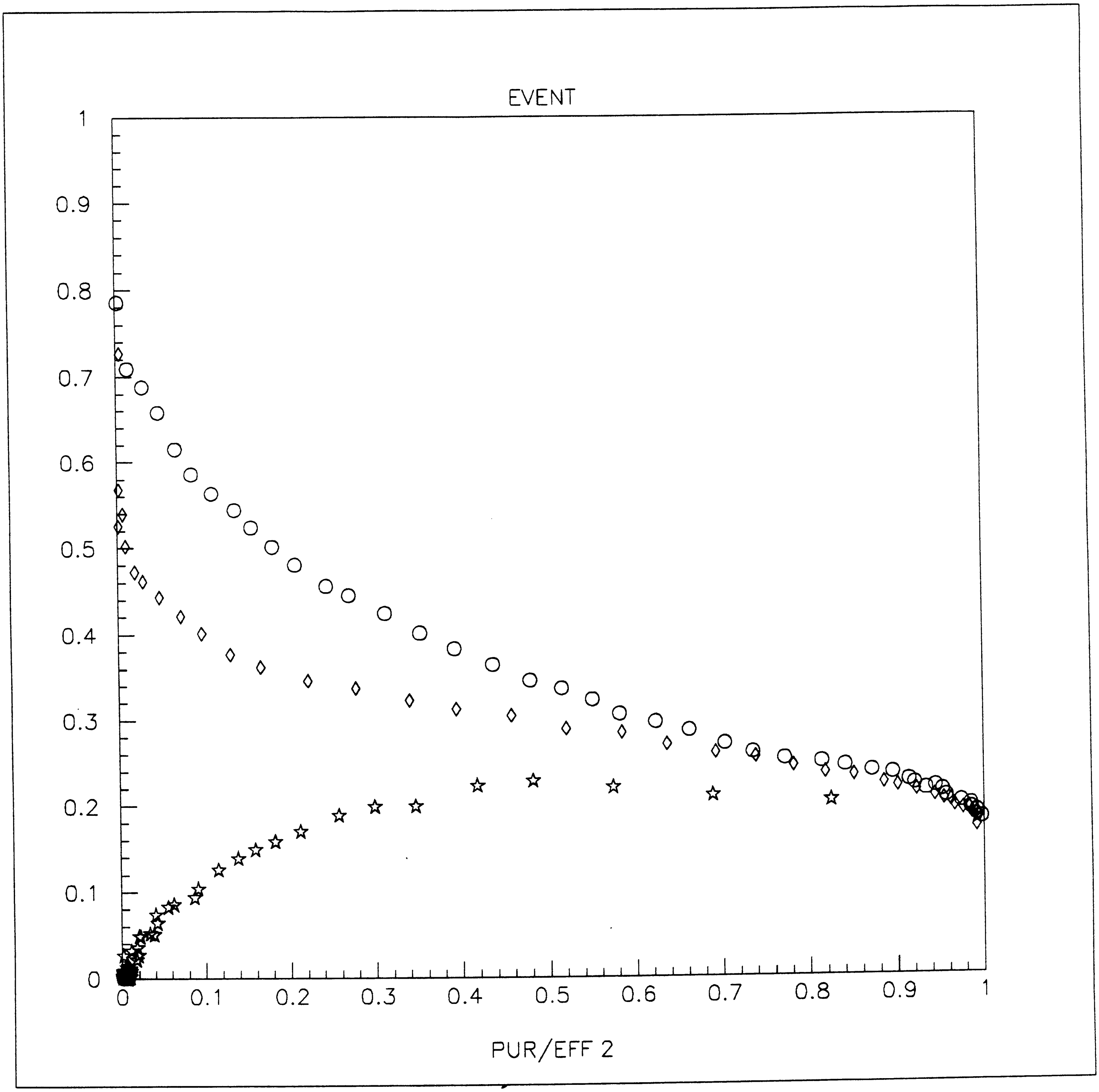
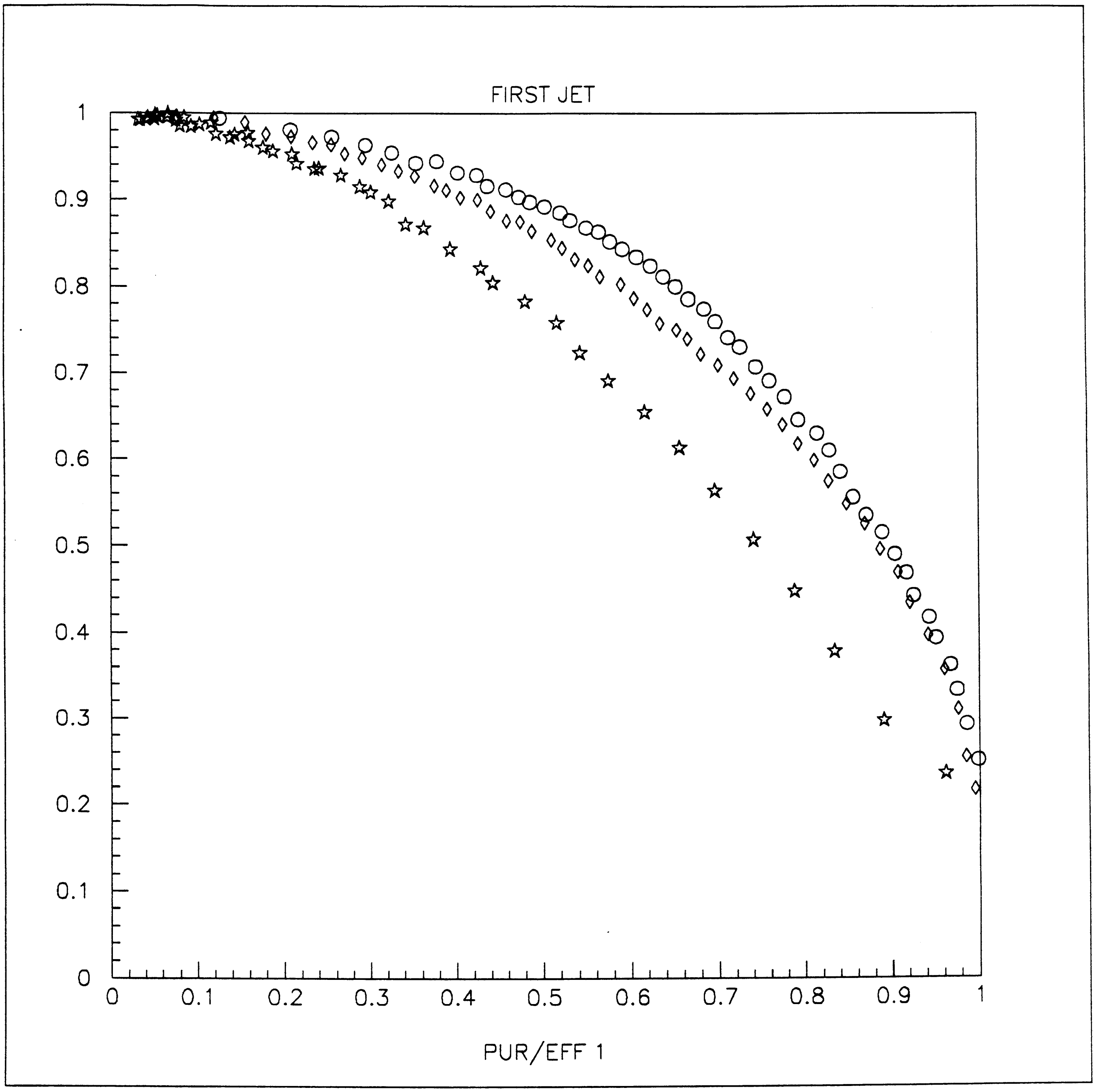

EVENT
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
PUR/EFF 1

Figure 6



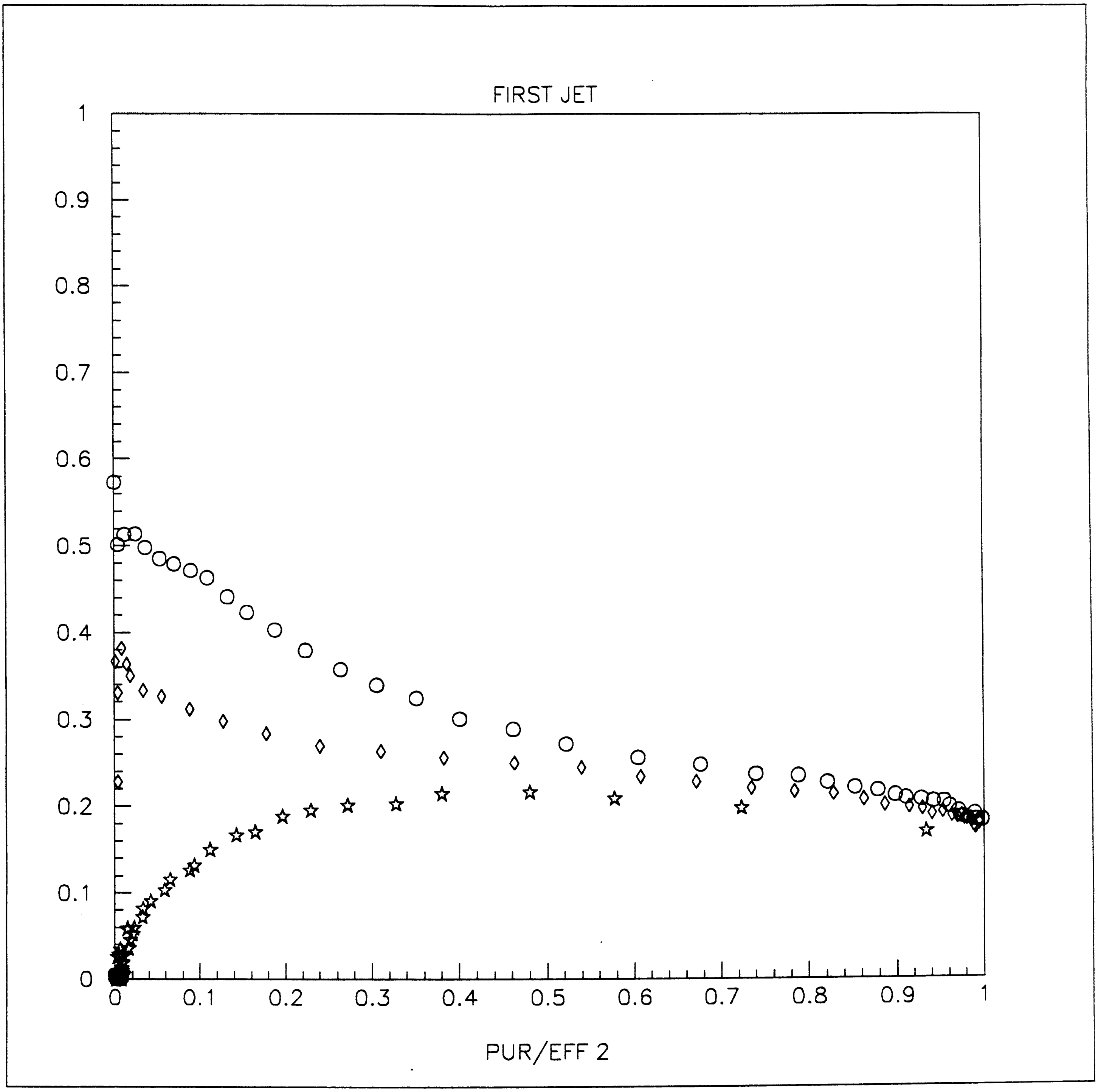
EVENT
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
PUR/EFF 2

Figure 7



FIRST JET
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
PUR/EFF 1

Figure 8



FIRST JET
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
PUR/EFF 2