

Report on ANN for NC - v_e CC (all) 2 classification

- **Methods for ANN classification :**
 - Construct two Neural Networks : a) v_μ CC - All the rest
 - b) All the rest - NC
 - Construct one Neural Network : a) NC - v_e CC

The first network performs classification of v_μ CC from all the rest
(all the rest = NC + v_e CC + v_τ CC)

The second network performs classification of NC from “all the rest”
from the previous network.

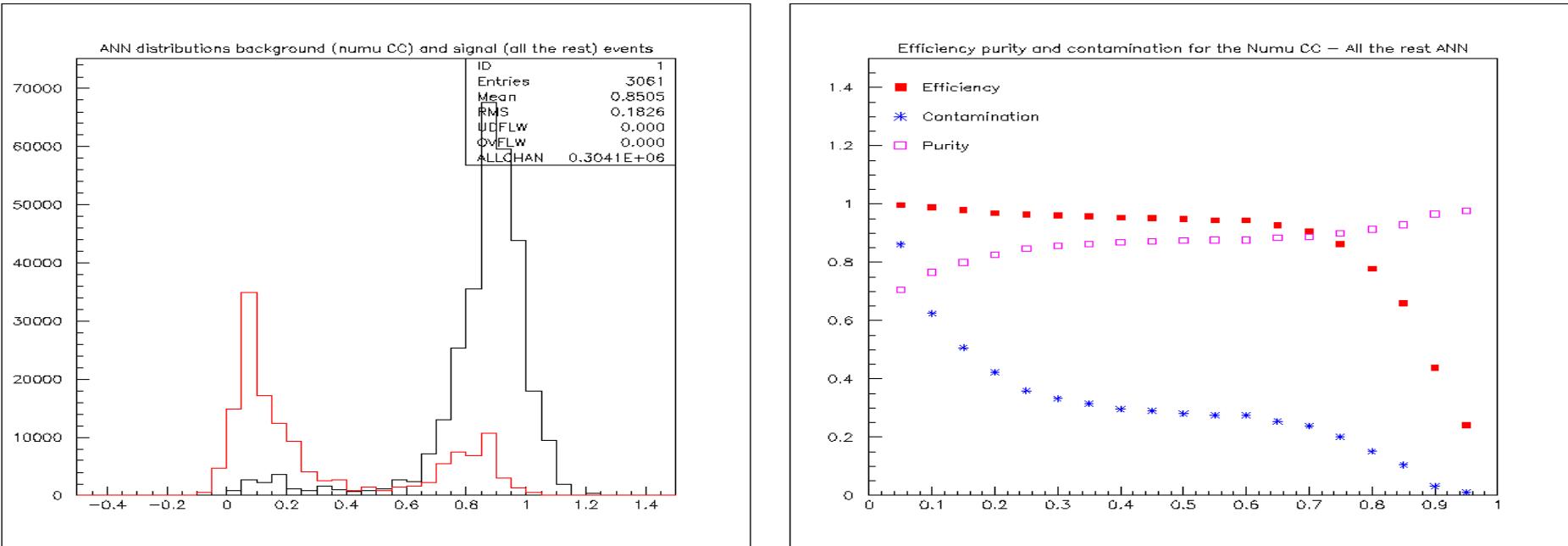
**(“all the rest” = v_μ CC (that have been missed from the first
network) + v_e CC + v_τ CC)**

The third network simply distinguishes NC from v_e CC interactions

Results on ANN for NC - v_e CC (all) classification

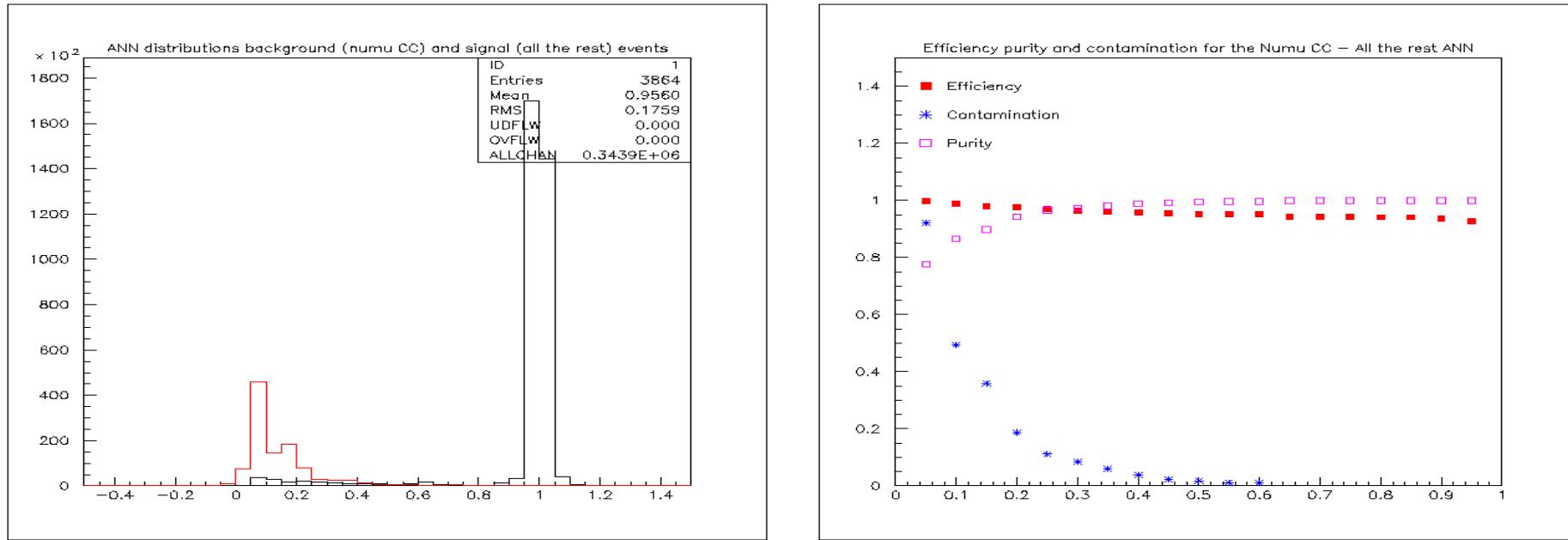
- We present results on all the previous networks for period 2 - period 3 and period 4 data.
- We have performed studies on the best network structure (number of hidden layers - number of neurons - “test samples”) which are not presented in this report but lead us to different network structures with very similar results with the previous ones but less time consuming.
- Since we do not have (yet) a different set of MC events (~ 5000) to test our networks, we have used half events (2500) as a test set and the other half as a training set in order to see in what epoch the network starts to become “over-trained ”. With that information (maximum number of epochs) we then used all 5000 events as a training set.
- We also present results (tables of events) with the ANN implementation on the 203 data set for period 4 (period 3 and period 2 tables exist but not presented).

Results ν_μ CC - All the rest (period 2)



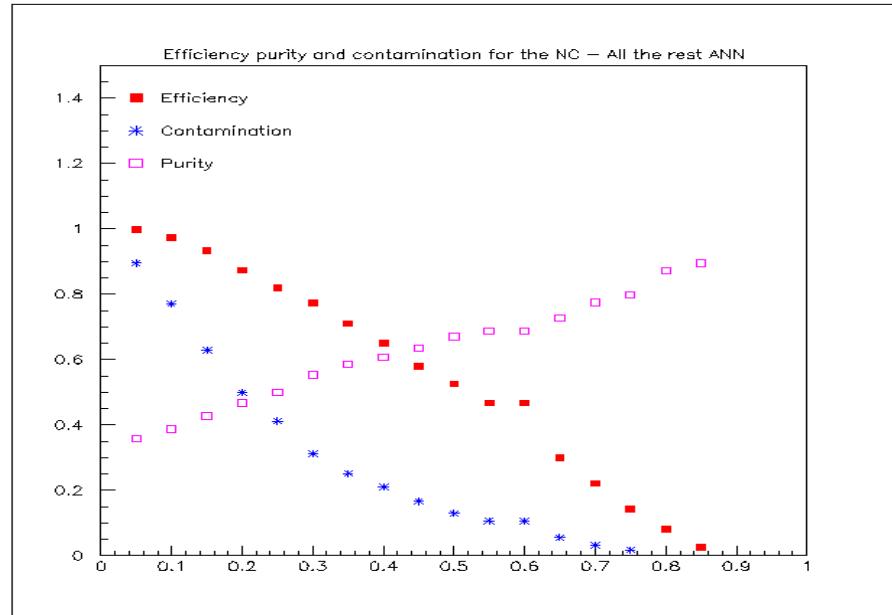
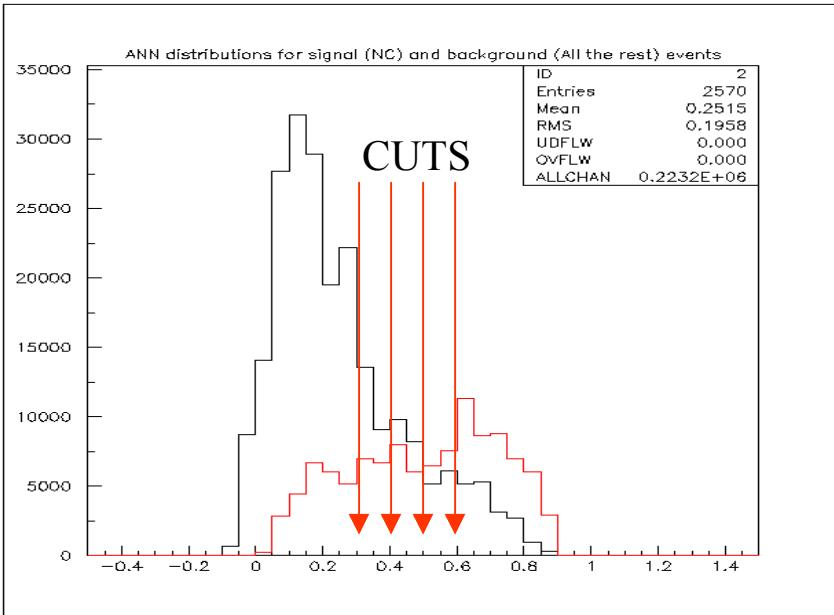
- We use a cut at 0.5 in order to select events that are not ν_μ CC.
- efficiency 94.8 % - purity 87.4 % - contamination 28.1 %**

Results v_μ CC (with hits in the MID) - All the rest (period 2)



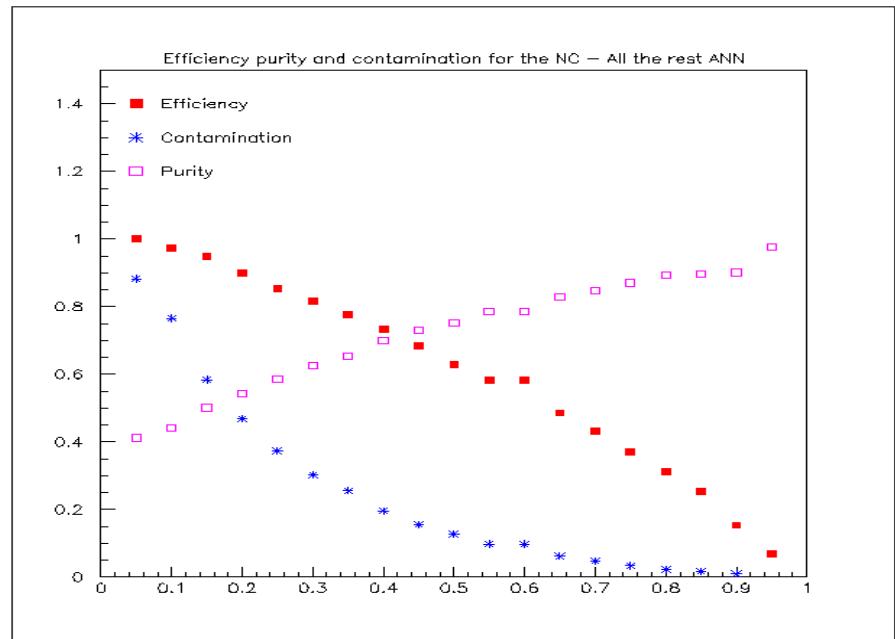
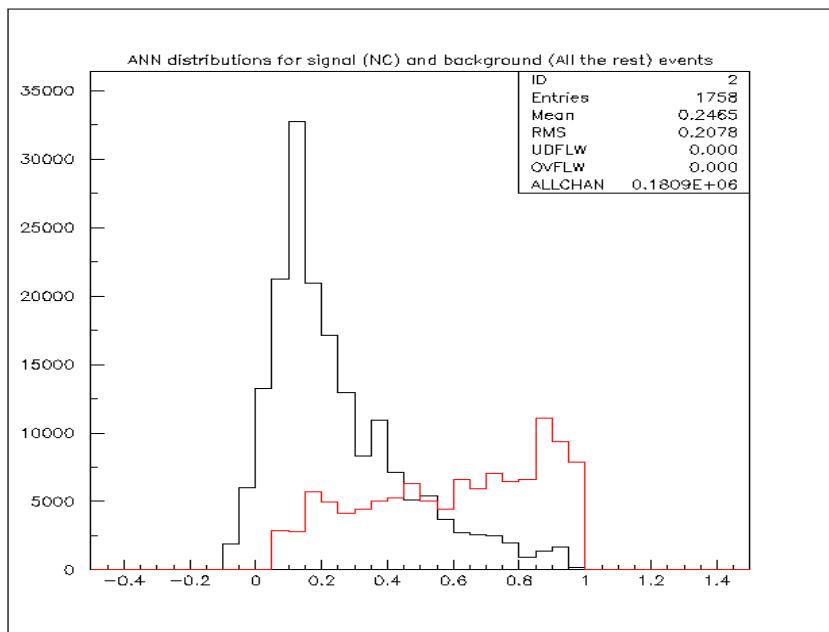
- The network has an extremely good behavior when we limit our “background” set to v_μ CC events that have a muon passing through the MID system (more than 3 hits)
- For the rest periods (3 and 4) we have such a behavior for that network

Results NC- “All the rest” (period 2)



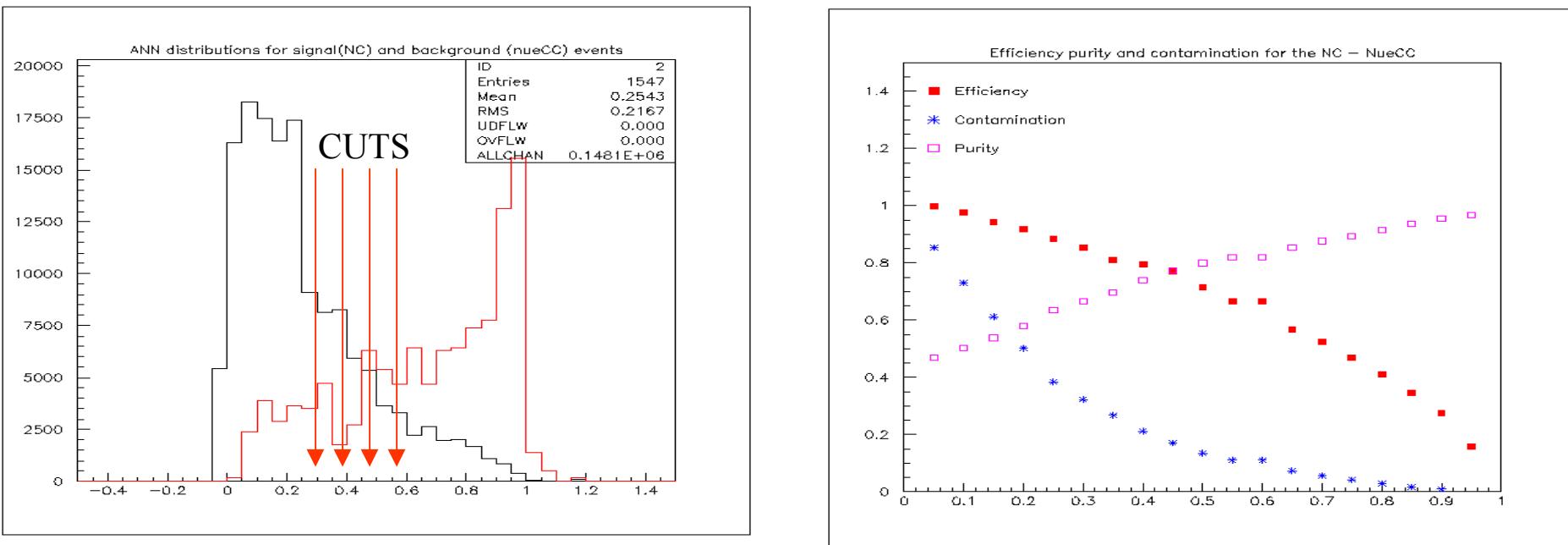
- We used cuts at **0.3 0.4 0.5 0.6** to obtain the selection functions for real data.
- CUT 0.3 : **eff 77.3 % pur 55.4 % cont 31.2 %**
- CUT 0.4 : **eff 65.0 % pur 60.8 % cont 21.0 %**
- CUT 0.5 : **eff 52.5 % pur 67.0 % cont 13.0 %**
- CUT 0.6 : **eff 46.8 % pur 68.8 % cont 10.6 %**

Results NC- “All the rest_(without ν_μ CC) ” (period 2)



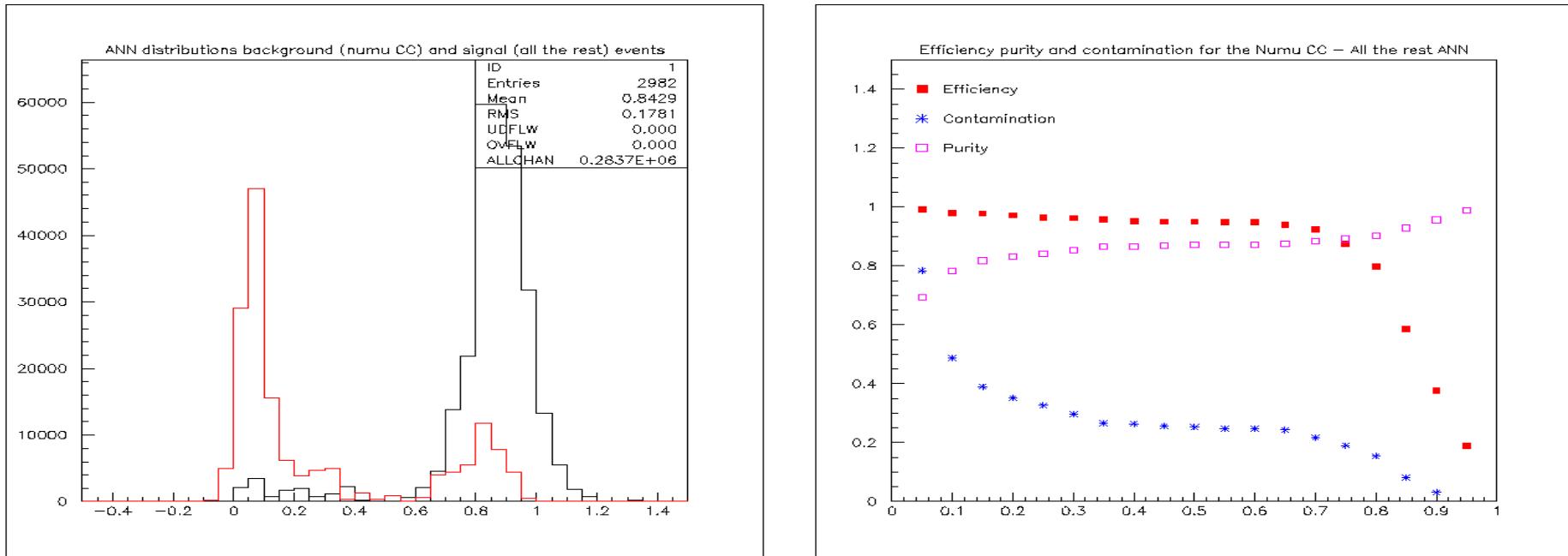
- In this network we have used as “background” events ν_e CC and ν_τ CC.
- It is quite clear that its performance is much better than the previous one and comparable to that of NC - ν_e CC

Results NC- v_e CC (period 2)



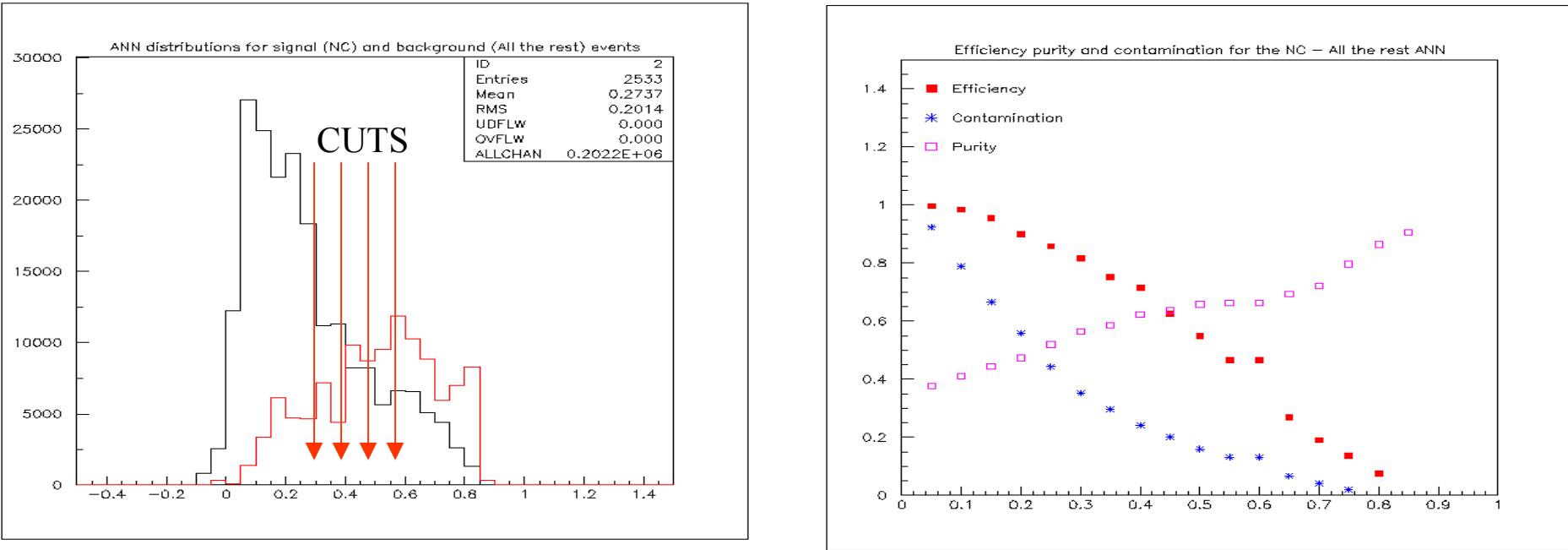
- We used cuts at **0.3 0.4 0.5 0.6** to obtain the selection functions for real data.
- CUT 0.3 : **eff 85.2 % pur 66.6 % cont 32.2 %**
- CUT 0.4 : **eff 79.4 % pur 74.0 % cont 21.1 %**
- CUT 0.5 : **eff 71.4 % pur 78.0 % cont 13.5 %**
- CUT 0.6 : **eff 66.6 % pur 82.0 % cont 11.0 %**

Results v_μ CC - All the rest (period 3)



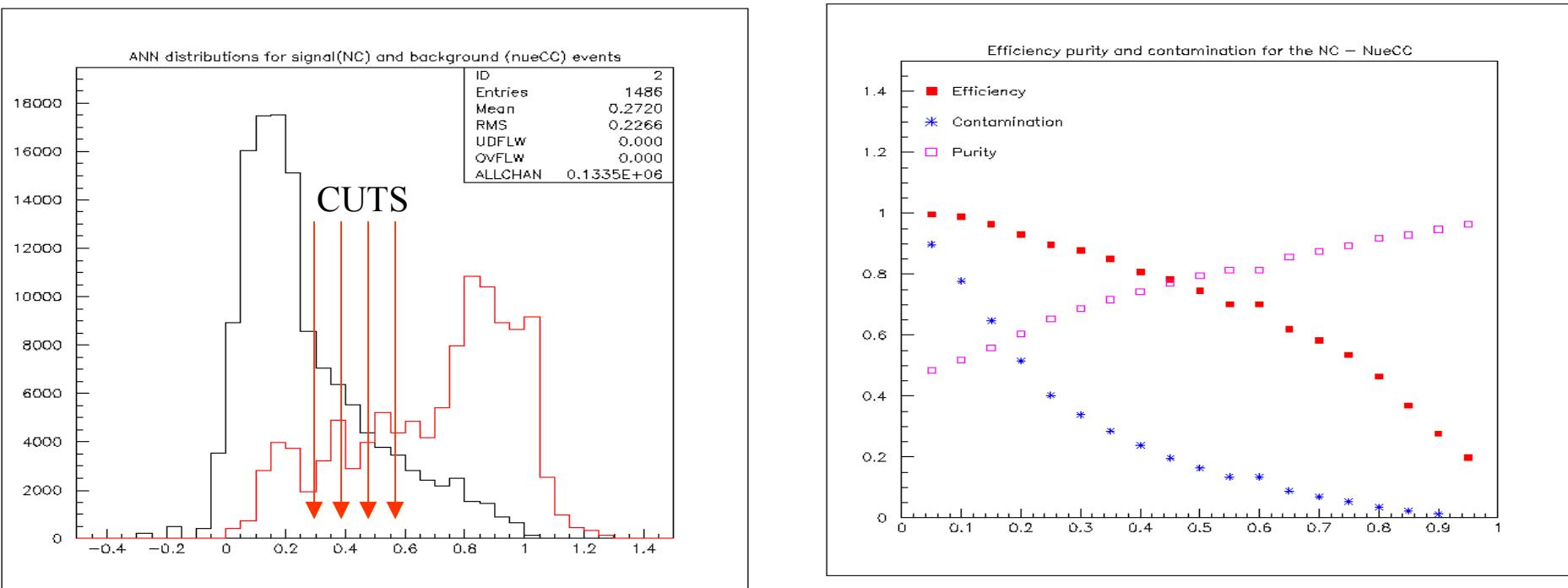
- We use a cut at 0.5 in order to select events that are not v_μ CC.
- efficiency 95.0 % - purity 87.0 % - contamination 25.0 %**

Results NC- “All the rest” (period 3)



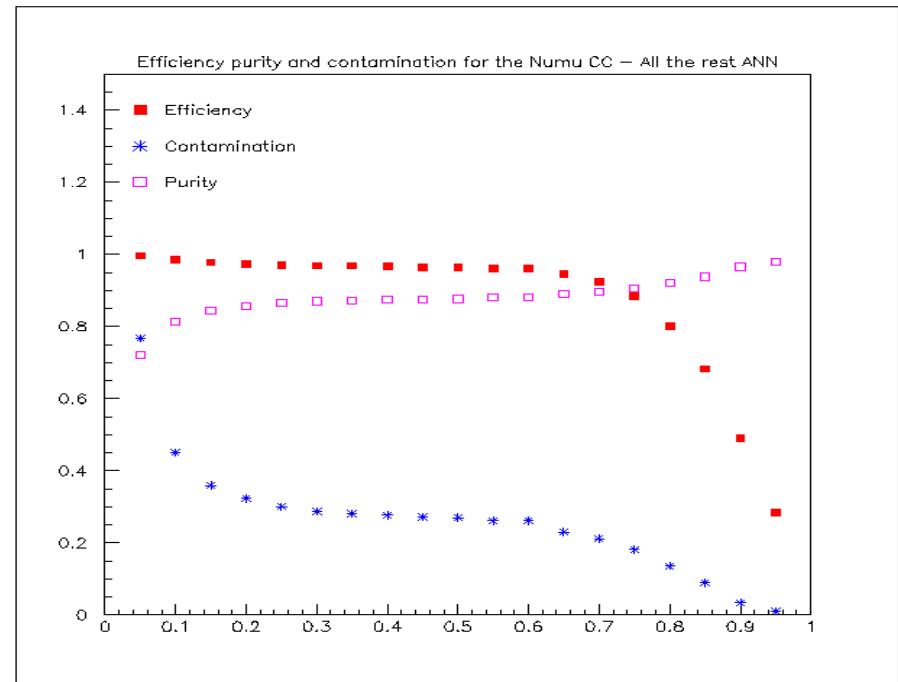
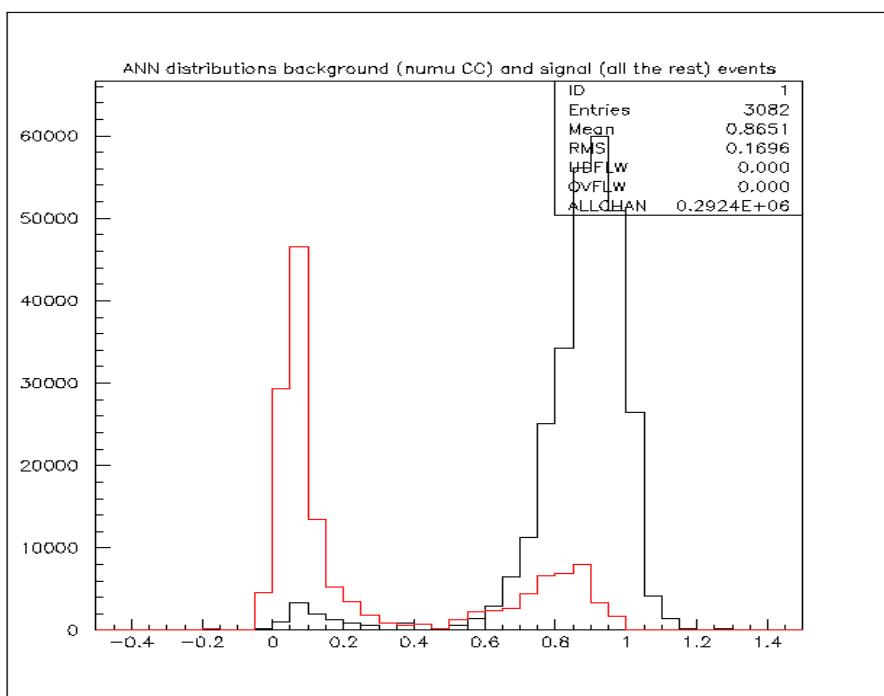
- We used cuts at **0.3 0.4 0.5 0.6** to obtain the selection functions for real data.
- CUT 0.3 : **eff 81.7 % pur 56.4 % cont 35.2 %**
- CUT 0.4 : **eff 71.4 % pur 62.3 % cont 24.1 %**
- CUT 0.5 : **eff 55.0 % pur 65.8 % cont 16.0 %**
- CUT 0.6 : **eff 46.5 % pur 66.3 % cont 13.2 %**

Results NC- ν_e CC (period 3)



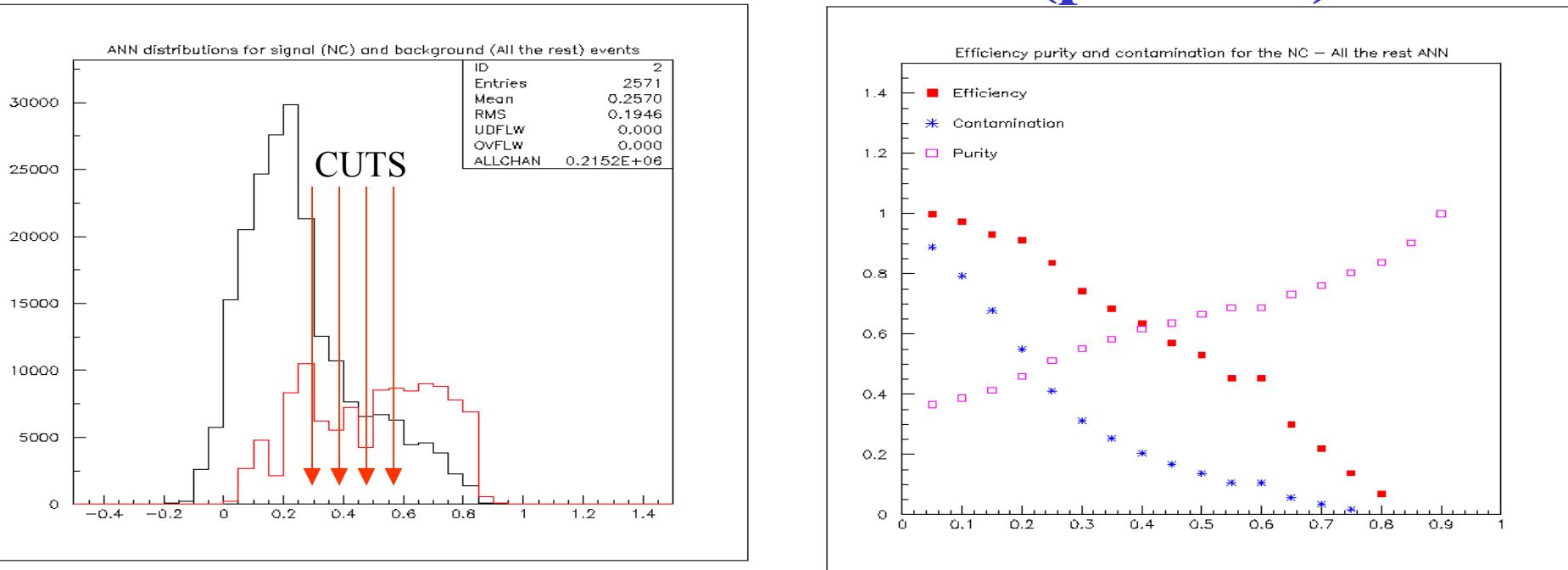
- We used cuts at **0.3 0.4 0.5 0.6** to obtain the selection functions for real data.
- CUT 0.3 : **eff 87.9 % pur 68.7 % cont 33.8 %**
- CUT 0.4 : **eff 80.7 % pur 74.2 % cont 23.8 %**
- CUT 0.5 : **eff 74.7 % pur 79.4 % cont 16.4 %**
- CUT 0.6 : **eff 70.0 % pur 81.4 % cont 13.5 %**

Results v_μ CC - All the rest (period 4)



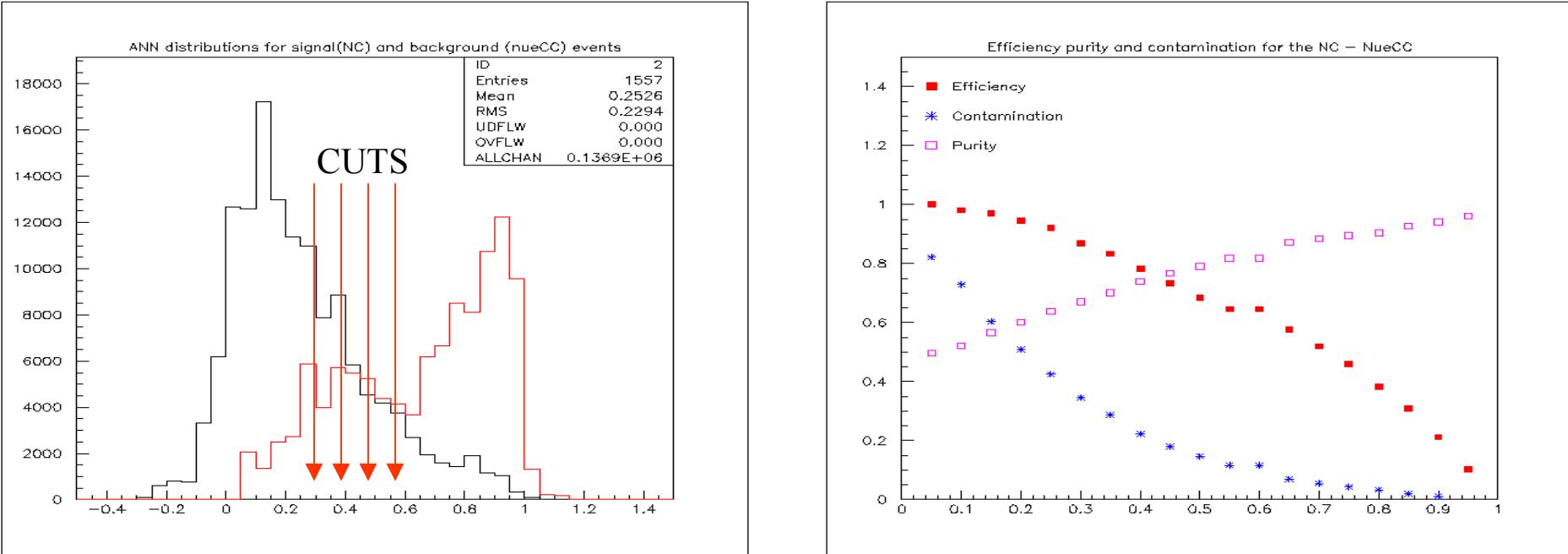
- We use a cut at 0.5 in order to select events that are not v_μ CC.
- efficiency 96.3 % - purity 87.6 % - contamination 27.0 %**

Results NC- “All the rest” (period 4)



- We used cuts at **0.3 0.4 0.5 0.6** to obtain the selection functions for real data.
- CUT 0.3 : **eff 74.1 % pur 55.0 % cont 31.2 %**
- CUT 0.4 : **eff 63.5 % pur 61.6 % cont 20.4 %**
- CUT 0.5 : **eff 53.1 % pur 66.5 % cont 13.8 %**
- CUT 0.6 : **eff 45.4 % pur 68.7 % cont 10.6 %**

Results NC- ν_e CC (period 4)



- We used cuts at **0.3 0.4 0.5 0.6** to obtain the selection functions for real data.
- CUT 0.3 : **eff 86.9 % pur 67.1 % cont 34.5 %**
- CUT 0.4 : **eff 78.2 % pur 74.0 % cont 22.3 %**
- CUT 0.5 : **eff 68.5 % pur 79.0 % cont 14.7 %**
- CUT 0.6 : **eff 64.5 % pur 81.8 % cont 11.6 %**

Results on 203 data set

- We used the output functions of ANN 1 (v_μ CC - All) and 2 (NC - “All”) as selection functions in the 203 events (period 2 - period 3 - period 4)
- We used the output function of ANN 3 (NC - v_e CC) as selection function in the “NC- v_e CC” data set obtained from Byron.
- For ANN 1 the cut is always 0.5. For networks 2 and 3 the cuts are 0.3 0.4 0.5 0.6.

Results of ANN1 on 203 data set p4

Events from p4 that have been selected as NOT ν_μ CC interactions

3222_53313	3223_41138	3223_46736	3224_13443	3225_14772	3225_21089	3228_15365
3230_13227	3231_00431	3232_18635	3235_06686	3235_11264	3235_17215	3240_09118
3244_19107	3245_16327	3245_25887	3246_16223	3247_24351	3250_00470	3253_08684
3253_12208	3255_03664	3257_13542	3258_13907	3260_11519	3261_13539	3261_18428
3261_22883	3261_24198	3262_24891	3263_25102	3267_16322	3267_22046	3278_17752
3284_00315	3286_26982	3288_22591	3289_11309	3291_18579	3297_16057	3298_17712
3299_09529	3300_21994	3317_00693	3330_19742	3331_09076	3331_10854	3331_11197
3333_05853	3333_17665	3335_02658	3335_22286	3337_05189	3339_28485	3340_20988
3343_13963	3345_00880	3345_11919	3349_06094	3350_08796	3352_23387	3352_31223
3355_13568	3356_17099	3358_07808	3358_11268	3359_08038		

Events of p4 that have been selected as ν_μ CC interactions

3276_03366	3232_03434	3352_03466	3290_03529	3249_03536	3230_03860	3285_04113
3284_04224	3339_04355	3331_04888	3230_05603	3352_05679	3244_07138	3287_07185
3351_10406	3296_10500	3301_11619	3242_11719	3291_13369	3358_13933	3244_14018
3350_14131	3349_15212	3296_16049	3340_16083	3245_17107	3315_17199	3264_17219
3292_21438	3356_21575	3299_21922	3345_21951	3245_22786	3345_23003	3262_23218
3261_23533	3267_24207	3297_25222	3353_25590	3278_25763	3336_26486	3352_30567

Results of ANN2 on 203 data set p4 0.3 cut

Events of p4 that have been selected as NC interactions with a cut at 0.3 in the selection function

3284_00315 3358_07808 3350_08796 3331_09076 3331_11197 3289_11309
3260_11519 3345_11919 3230_13227 3343_13963 3267_16322 3330_19742
3267_22046 3288_22591 3261_22883 3247_24351 3262_24891

Events of p4 that have been selected as not NC interactions with a 0.3 cut in the selection function

3222_53313 3223_41138 3223_46736 3224_13443 3225_14772 3225_21089
3228_15365 3230_13227 3231_00431 3232_18635 3235_06686 3235_11264
3235_17215 3240_09118 3244_19107 3245_16327 3245_25887 3246_16223
3250_00470 3253_08684 3253_12208 3255_03664 3257_13542 3258_13907
3261_13539 3261_18428 3261_24198 3263_25102 3278_17752 3286_26982
3291_18579 3297_16057 3298_17712 3299_09529 3300_21994 3317_00693
3331_10854 3333_05853 3333_17665 3335_02658 3335_22286 3337_05189
3339_28485 3340_20988 3345_00880 3349_06094 3352_23387 3352_31223
3355_13568 3356_17099 3358_11268 3359_08038

Results of ANN2 on 203 data set p4 0.4 cut

Events of p4 that have been selected as NC interactions with a cut at 0.4 in the selection function

3358_07808 3331_09076 3289_11309 3260_11519 3230_13227 3343_13963 3267_16322
3288_22591 3261_22883 3262_24891

Events of p4 that have been selected as not NC interactions with a 0.4 cut in the selection function

3247_24351 3330_19742 3267_22046 3345_11919 3331_11197 3350_08796
3284_00315 3222_53313 3223_41138 3223_46736 3224_13443 3225_14772
3225_21089 3228_15365 3230_13227 3231_00431 3232_18635 3235_06686
3235_11264 3235_17215 3240_09118 3244_19107 3245_16327 3245_25887
3246_16223 3250_00470 3253_08684 3253_12208 3255_03664 3257_13542
3258_13907 3261_13539 3261_18428 3261_24198 3263_25102 3278_17752
3286_26982 3291_18579 3297_16057 3298_17712 3299_09529 3300_21994
3317_00693 3331_10854 3333_05853 3333_17665 3335_02658 3335_22286
3337_05189 3339_28485 3340_20988 3345_00880 3349_06094 3352_23387
3352_31223 3355_13568 3356_17099 3358_11268 3359_08038

Results of ANN2 on 203 data set p4 0.5 cut

Events of p4 that have been selected as NC interactions with a cut at 0.5 in the selection function

3358_07808 3331_09076 3260_11519 3343_13963 3267_16322 3261_22883 3262_24891

Events of p4 that have been selected as not NC interactions with a 0.5 cut in the selection function

3247_24351 3330_19742 3267_22046 3345_11919 3331_11197 3350_08796
3284_00315 3222_53313 3223_41138 3223_46736 3224_13443 3225_14772
3225_21089 3228_15365 3230_13227 3231_00431 3232_18635 3235_06686
3235_11264 3235_17215 3240_09118 3244_19107 3245_16327 3245_25887
3246_16223 3250_00470 3253_08684 3253_12208 3255_03664 3257_13542
3258_13907 3261_13539 3261_18428 3261_24198 3263_25102 3278_17752
3286_26982 3291_18579 3297_16057 3298_17712 3299_09529 3300_21994
3317_00693 3331_10854 3333_05853 3333_17665 3335_02658 3335_22286
3337_05189 3339_28485 3340_20988 3345_00880 3349_06094 3352_23387
3352_31223 3355_13568 3356_17099 3358_11268 3359_08038 3230_13227
3289_11309 3288_22591

Results of ANN2 on 203 data set p4 0.6 cut

Events of p4 that have been selected as NC interactions with a cut at 0.6 in the selection function

3358_07808 3331_09076 3260_11519 3343_13963 3267_16322 3262_24891

Events of p4 that have been selected as not NC interactions with a 0.6 cut in the selection function

3247_24351 3330_19742 3267_22046 3345_11919 3331_11197 3350_08796
3284_00315 3222_53313 3223_41138 3223_46736 3224_13443 3225_14772
3225_21089 3228_15365 3230_13227 3231_00431 3232_18635 3235_06686
3235_11264 3235_17215 3240_09118 3244_19107 3245_16327 3245_25887
3246_16223 3250_00470 3253_08684 3253_12208 3255_03664 3257_13542
3258_13907 3261_13539 3261_18428 3261_24198 3263_25102 3278_17752
3286_26982 3291_18579 3297_16057 3298_17712 3299_09529 3300_21994
3317_00693 3331_10854 3333_05853 3333_17665 3335_02658 3335_22286
3337_05189 3339_28485 3340_20988 3345_00880 3349_06094 3352_23387
3352_31223 3355_13568 3356_17099 3358_11268 3359_08038 3230_13227
3289_11309 3288_22591 3261_22883

Results of ANN3 on “NC- v_e CC” data set

p4 0.3 cut

Events of p4 that have been selected NC interactions with a cut at 0.3 in the selection function

3223_46736	3225_14772	3228_15365	3230_13227	3231_00431	3235_11264
3235_17215	3245_17107	3246_16223	3247_24351	3257_13542	3260_11519
3261_22883	3261_24198	3262_24891	3263_25102	3267_16322	3267_22046
3284_00315	3286_09110	3286_26982	3288_22591	3289_11309	3297_13984
3297_16057	3299_12702	3300_21994	3315_17199	3331_09076	3331_10854
3331_11197	3333_05853	3336_26486	3339_04355	3339_28485	3340_16083
3340_20988	3345_11919	3349_06094	3350_08796	3352_31223	3355_13568
3356_21575	3358_07808	3359_08038			

Events of p4 that have been selected as nue CC interactions with a cut at 0.3 in the selection function

3250_00470	3345_00880	3255_03664	3337_05189	3253_08684	3240_09118
3299_09529	3358_11268	3224_13443	3261_13539	3258_13907	3245_16327
3356_17099	3333_17665	3298_17712	3278_17752	3261_18428	3291_18579
3232_18635	3244_19107	3225_21089	3335_22286	3353_25590	3245_25887
3223_41138	3222_53313				

Results of ANN3 on “NC- v_e CC” data set p4 0.4 cut

Events of p4 that have been selected NC interactions with a cut at 0.4 in the selection function

3223_46736	3225_14772	3230_13227	3231_00431	3235_11264	3235_17215
3246_16223	3247_24351	3257_13542	3260_11519	3261_22883	3261_24198
3262_24891	3263_25102	3267_16322	3267_22046	3284_00315	3286_09110
3288_22591	3289_11309	3299_12702	3300_21994	3331_09076	3331_10854
3331_11197	3333_05853	3339_04355	3339_28485	3340_16083	3345_11919
3349_06094	3350_08796	3352_31223	3355_13568	3356_21575	3358_07808
3359_08038					

Events of p4 that have been selected as nue CC interactions with a cut at 0.4 in the selection function

3250_00470	3345_00880	3255_03664	3337_05189	3253_08684	3240_09118
3299_09529	3358_11268	3224_13443	3261_13539	3258_13907	3245_16327
3356_17099	3333_17665	3298_17712	3278_17752	3261_18428	3291_18579
3232_18635	3244_19107	3225_21089	3335_22286	3353_25590	3245_25887
3223_41138	3222_53313	3297_13984	3228_15365	3297_16057	3245_17107
3315_17199	3340_20988	3336_26486	3286_26982		

Results of ANN3 on “NC- v_e CC” data set

p4 0.5 cut

Events of p4 that have been selected NC interactions with a cut at 0.5 in the selection function

3225_14772	3230_13227	3235_11264	3235_17215	3246_16223	3247_24351
3260_11519	3261_22883	3261_24198	3262_24891	3267_16322	3284_00315
3286_09110	3288_22591	3289_11309	3300_21994	3331_09076	3331_10854
3331_11197	3333_05853	3339_04355	3339_28485	3340_16083	3345_11919
3349_06094	3350_08796	3352_31223	3355_13568	3356_21575	3358_07808

Events of p4 that have been selected as nue CC interactions with a cut at 0.5 in the selection function

3250_00470	3345_00880	3255_03664	3337_05189	3253_08684	3240_09118
3299_09529	3358_11268	3224_13443	3261_13539	3258_13907	3245_16327
3356_17099	3333_17665	3298_17712	3278_17752	3261_18428	3291_18579
3232_18635	3244_19107	3225_21089	3335_22286	3353_25590	3245_25887
3223_41138	3222_53313	3297_13984	3228_15365	3297_16057	3245_17107
3315_17199	3340_20988	3336_26486	3286_26982	3231_00431	3359_08038
3299_12702	3257_13542	3267_22046	3263_25102	3223_46736	

Results of ANN3 on “NC- v_e CC” data set p4 0.6 cut

Events of p4 that have been selected NC interactions with a cut at 0.6 in the selection function

3225_14772	3230_13227	3235_11264	3246_16223	3247_24351	3260_11519
3261_22883	3261_24198	3262_24891	3267_16322	3284_00315	3288_22591
3289_11309	3300_21994	3331_09076	3331_10854	3331_11197	3333_05853
3339_04355	3340_16083	3345_11919	3349_06094	3352_31223	3355_13568
3356_21575	3358_07808				

Events of p4 that have been selected as nue CC interactions with a cut at 0.6 in the selection function

3250_00470	3345_00880	3255_03664	3337_05189	3253_08684	3240_09118
3299_09529	3358_11268	3224_13443	3261_13539	3258_13907	3245_16327
3356_17099	3333_17665	3298_17712	3278_17752	3261_18428	3291_18579
3232_18635	3244_19107	3225_21089	3335_22286	3353_25590	3245_25887
3223_41138	3222_53313	3297_13984	3228_15365	3297_16057	3245_17107
3315_17199	3340_20988	3336_26486	3286_26982	3231_00431	3359_08038
3299_12702	3257_13542	3267_22046	3263_25102	3223_46736	3350_08796
3235_17215	3339_28485	3286_09110			

Conclusions

- In order to test the quality of our ANN's we need to obtain additional sets of 5000 similar to the training ones and see their performance.
- With the existent ANN's we need to study their results on the real data sets .
- A thorough debugging cycle will be performed on the whole procedure (which includes a fairly large amount of complexity).