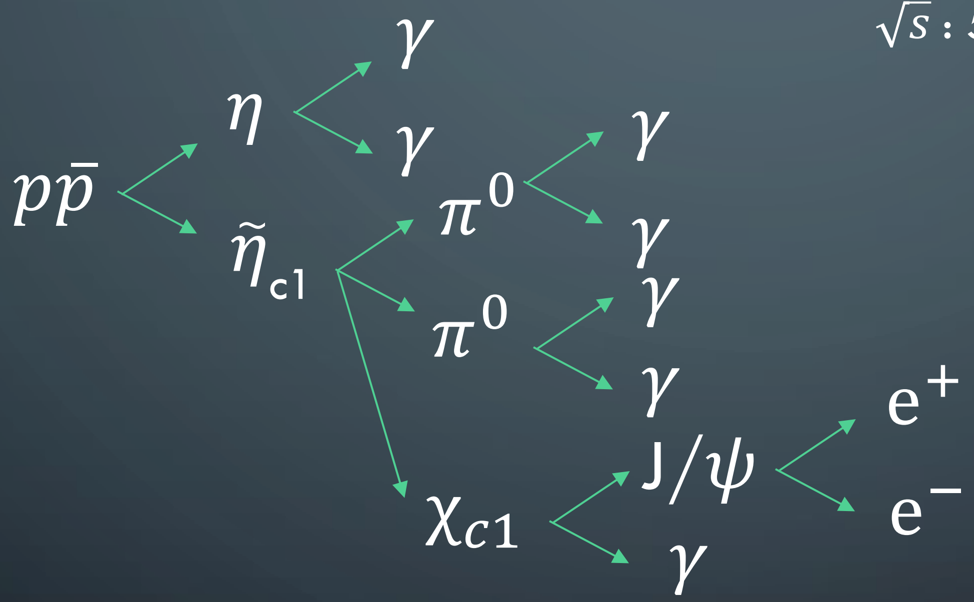
ANALYZING A COMPLEX DECAY CHANNEL BY USING GENETIC ALGORITHM

ÁRON KRIPKÓ FOR THE PANDA COLLABORATION

A. G. BRINKMANN

THE DECAY

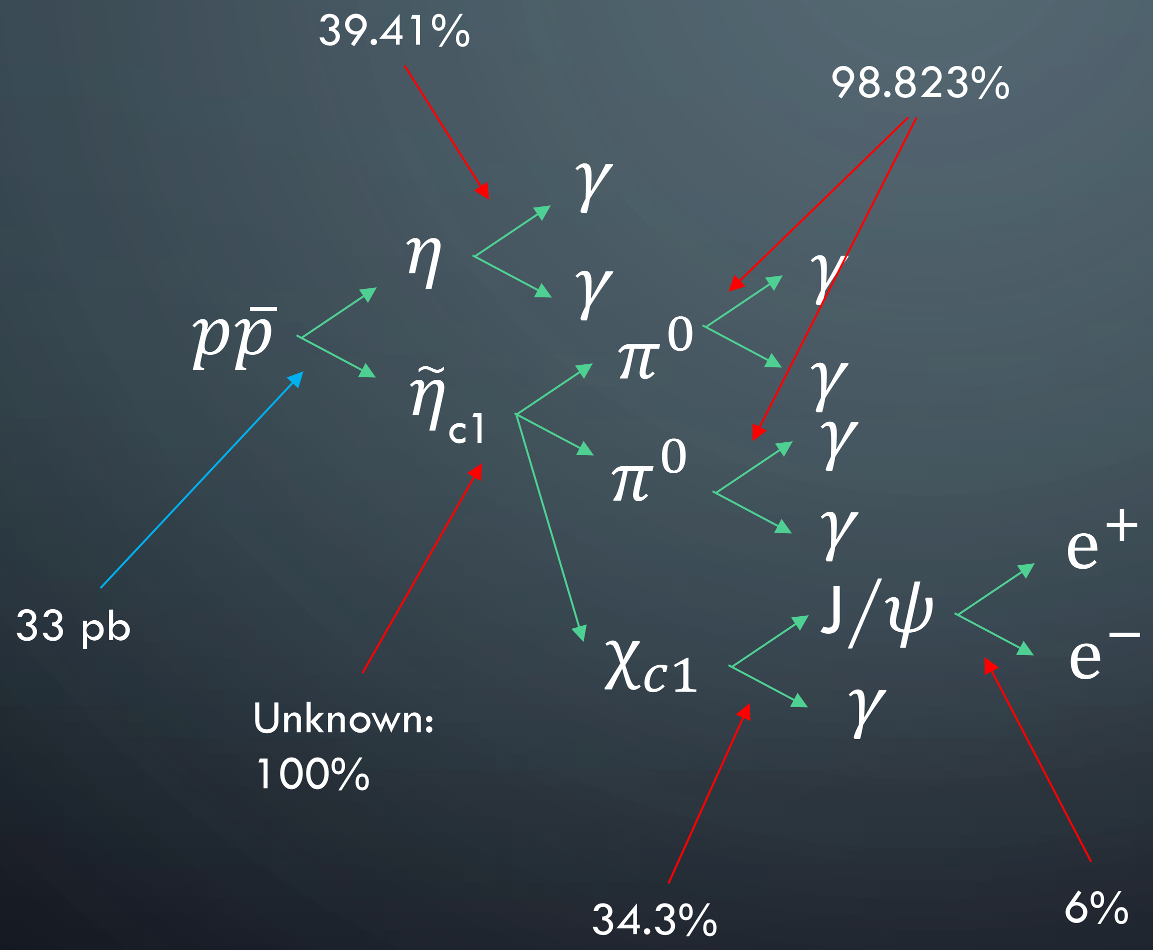


$\sqrt{s}$: 5 GeV

BACKGROUND

```
0.2110  pi+ pi+ pi- pi- pi0 pi0 pi0 pi0              PHSP; # x-sec =   571.565 mub
0.0994  pi+ pi+ pi- pi- pi0 pi0 pi0 eta              PHSP; # x-sec =   269.277 mub
0.0697  pi- p+ anti-n0 pi0 pi0 pi0                   PHSP; # x-sec =   188.941 mub
0.0692  pi+ anti-p- n0 pi0 pi0 pi0                   PHSP; # x-sec =   187.574 mub
0.0463  pi+ pi- n0 anti-n0 pi0 pi0 pi0               PHSP; # x-sec =   125.389 mub
0.0387  pi+ pi- pi0 pi0 pi0 pi0                      PHSP; # x-sec =   104.942 mub
0.0379  pi+ pi- pi- p+ anti-n0 pi0 pi0 pi0           PHSP; # x-sec =   102.683 mub
0.0367  pi+ pi+ pi- anti-p- n0 pi0 pi0 pi0           PHSP; # x-sec =    99.497 mub
0.0231  pi+ anti-p- n0 pi0 pi0 eta                   PHSP; # x-sec =    62.563 mub
0.0227  pi- p+ anti-n0 pi0 pi0 eta                   PHSP; # x-sec =    61.542 mub
0.0227  pi+ pi- p+ anti-p- pi0 pi0 pi0 pi0           PHSP; # x-sec =    61.541 mub
0.0204  pi+ pi- pi0 pi0 pi0 eta                      PHSP; # x-sec =    55.196 mub
0.0179  p+ anti-p- pi0 pi0 pi0 pi0                   PHSP; # x-sec =    48.600 mub
0.0151  pi+ pi+ pi- pi- pi0 pi0 eta eta              PHSP; # x-sec =    40.853 mub
0.0147  pi- p+ anti-n0 pi0 pi0 pi0 pi0               PHSP; # x-sec =    39.750 mub
0.0142  pi+ anti-p- n0 pi0 pi0 pi0 pi0               PHSP; # x-sec =    38.384 mub
0.0140  pi+ pi+ pi- pi- pi0 pi0 pi0 gamma            PHSP; # x-sec =    37.962 mub
0.0140  pi+ pi- p+ anti-p- pi0 pi0 pi0 eta           PHSP; # x-sec =    37.943 mub
0.0135  p+ anti-p- pi0 pi0 pi0 eta                   PHSP; # x-sec =    36.442 mub
0.0133  pi+ pi- n0 anti-n0 pi0 pi0 eta               PHSP; # x-sec =    35.934 mub
0.0124  pi+ pi+ pi- pi- pi0 pi0 pi0 pi0 gamma        PHSP; # x-sec =    33.476 mub
0.0106  pi+ pi+ pi- anti-p- n0 pi0 pi0 eta           PHSP; # x-sec =    28.786 mub
0.0104  pi+ pi- pi- p+ anti-n0 pi0 pi0 eta           PHSP; # x-sec =    28.252 mub
0.0091  pi- p+ anti-n0 pi0 pi0 pi0 eta               PHSP; # x-sec =    24.763 mub
0.0088  pi+ anti-p- n0 pi0 pi0 pi0 eta               PHSP; # x-sec =    23.759 mub
0.0086  pi+ pi- K+ K- pi0 pi0 pi0 pi0                PHSP; # x-sec =    23.251 mub
0.0084  pi+ pi+ pi- K- pi0 pi0 pi0 K_L0              PHSP; # x-sec =    22.728 mub
0.0084  pi+ pi- pi- K+ pi0 pi0 pi0 K_L0              PHSP; # x-sec =    22.671 mub
0.0079  pi+ pi+ pi- pi- n0 anti-n0 pi0 pi0 pi0       PHSP; # x-sec =    21.409 mub
0.0064  pi+ pi- n0 anti-n0 pi0 pi0 K_L0              PHSP; # x-sec =    17.336 mub
0.0051  pi+ pi- K+ K- pi0 pi0 pi0 eta                PHSP; # x-sec =    13.869 mub
0.0046  pi+ pi+ pi- pi- pi0 pi0 pi0 gamma eta        PHSP; # x-sec =    12.459 mub
0.0045  pi+ pi- pi- p+ anti-n0 pi0 pi0 pi0 pi0       PHSP; # x-sec =    12.059 mub
0.0043  pi+ pi+ pi- anti-p- n0 pi0 pi0 pi0 pi0       PHSP; # x-sec =    11.784 mub
0.0042  n0 anti-n0 pi0 pi0 gamma K_S0                PHSP; # x-sec =    11.344 mub
0.0041  pi+ pi- pi0 pi0 pi0 K_S0 K_L0                PHSP; # x-sec =    11.117 mub
0.0041  pi+ pi- n0 anti-n0 pi0 pi0 gamma             PHSP; # x-sec =    11.090 mub
0.0037  pi+ pi+ pi- pi- pi0 pi0 gamma eta            PHSP; # x-sec =     9.941 mub
0.0036  pi+ pi- pi0 pi0 eta eta                      PHSP; # x-sec =     9.862 mub
0.0035  pi+ pi- pi- K+ pi0 pi0 pi0 pi0 K_L0          PHSP; # x-sec =     9.434 mub
0.0035  pi+ pi+ pi- K- pi0 pi0 pi0 pi0 K_L0          PHSP; # x-sec =     9.350 mub
0.0034  pi+ pi+ pi- pi- pi0 pi0 pi0 gamma gamma      PHSP; # x-sec =     9.124 mub
0.0033  pi+ pi- pi- K+ pi0 pi0 eta K_L0              PHSP; # x-sec =     8.867 mub
0.0032  pi+ anti-p- n0 pi0 pi0 gamma K_L0            PHSP; # x-sec =     8.592 mub
0.0030  pi- p+ anti-n0 pi0 pi0 gamma K_L0            PHSP; # x-sec =     8.148 mub
0.0029  pi+ pi- n0 anti-n0 pi0 pi0 gamma K_S0        PHSP; # x-sec =     7.879 mub
0.0028  pi+ pi+ pi- pi- pi0 pi0 pi0 K_L0 K_L0        PHSP; # x-sec =     7.634 mub
0.0027  pi+ pi- p+ anti-p- pi0 pi0 pi0 gamma         PHSP; # x-sec =     7.437 mub
0.0026  pi- p+ anti-n0 pi0 pi0 pi0 K_S0              PHSP; # x-sec =     6.909 mub
0.0025  pi+ pi+ pi- anti-p- n0 pi0 pi0 pi0 eta       PHSP; # x-sec =     6.829 mub
0.0025  pi+ anti-p- n0 pi0 pi0 pi0 K_L0              PHSP; # x-sec =     6.773 mub
0.0025  pi- p+ anti-n0 pi0 pi0 pi0 K_L0              PHSP; # x-sec =     6.727 mub
0.0025  pi+ anti-p- n0 pi0 pi0 pi0 K_S0              PHSP; # x-sec =     6.704 mub
0.0024  K+ anti-p- n0 pi0 pi0 pi0                    PHSP; # x-sec =     6.560 mub
0.0023  pi+ pi- pi- p+ anti-n0 pi0 pi0 pi0 eta       PHSP; # x-sec =     6.185 mub
0.0023  pi+ pi- pi0 pi0 pi0 pi0 gamma                PHSP; # x-sec =     6.168 mub
0.0022  K- p+ anti-n0 pi0 pi0 pi0                    PHSP; # x-sec =     6.092 mub
0.0021  pi+ pi- p+ anti-p- pi0 pi0 pi0 K_L0          PHSP; # x-sec =     5.781 mub
0.0021  pi+ pi+ pi- pi- n0 anti-n0 pi0 pi0 eta       PHSP; # x-sec =     5.770 mub
0.0021  p+ anti-p- pi0 pi0 pi0 K_L0                  PHSP; # x-sec =     5.716 mub
```

CROSS-SECTION AND BRANCHING FRACTIONS



60000 signal – 6 10^{14} background

CUTS

- 60000 signal
- 60000 background
- The background was scaled for the significance calculation
- The new clustering algorithm was used
  - Better neutral reconstruction
  - Available in the PandaRoot dev

GENETIC ALGORTIHM

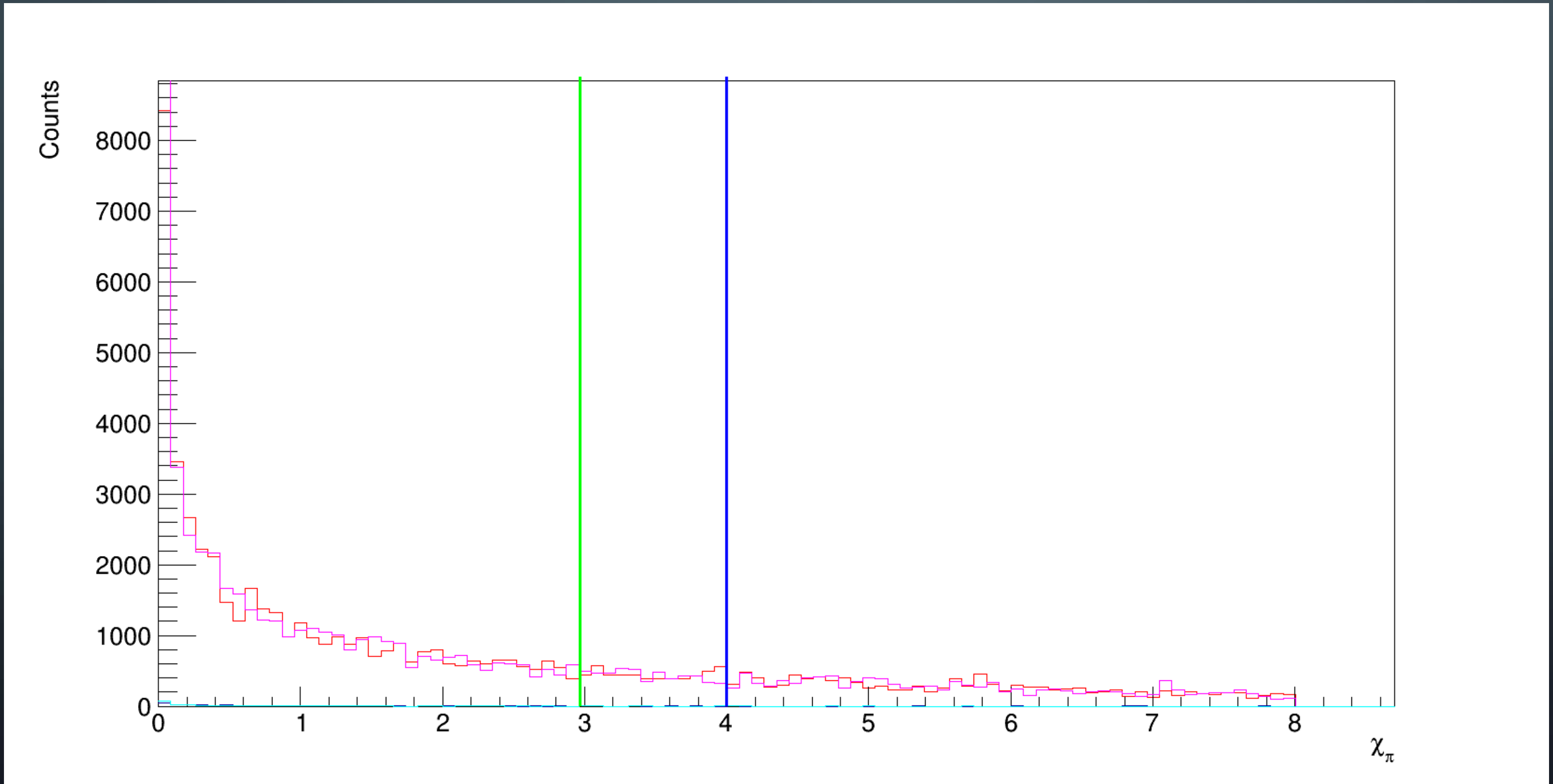
- Continued the work of Christian Will
- Inspired by natural selection
- Used when the evaluation of the fitness function takes many time
- Mutation: randomly modify a parameter with a few percent
- Cross-over: generate new individulas by taking parameters from 2 or more individuals
- Selection: Delete the worst individuals
- Drawback: not scale well with complexity

Parameter	Simulated	NTuple	Hand	Genetic
Pion mass	-	0.132-0.138	0.1349-0.1354	0.107-0.169
Eta mass	-	0.048-1.048	0.5477-0.5494	0.046-1.047
Muon mass	-	0-0.3	0-1.1	0.045-0.231
J/psi mass	-	0.09-6.09	3.0965-3.106	2.241-3.249
Chi_c mass	-	0.51-6.51	3.48-3.55	3.497-3.707
Eta_c1 mass	-	3.3-5.3	4.1-4.5	3.948-4.604
Pbarp mass	-	3.9-6.2	4.939-5.058	4.992-5.37
Pion chi	-	8	4	2.971
Eta chi	-	8	5	2.971
J/psi chi	-	-	7	12.941
J/psi vertex chi	-	40	4	23.286
Pbarp chi	-	20	3	3.356
Significance	0	0	0.01397	4.82759
FTM	467	292	179	133

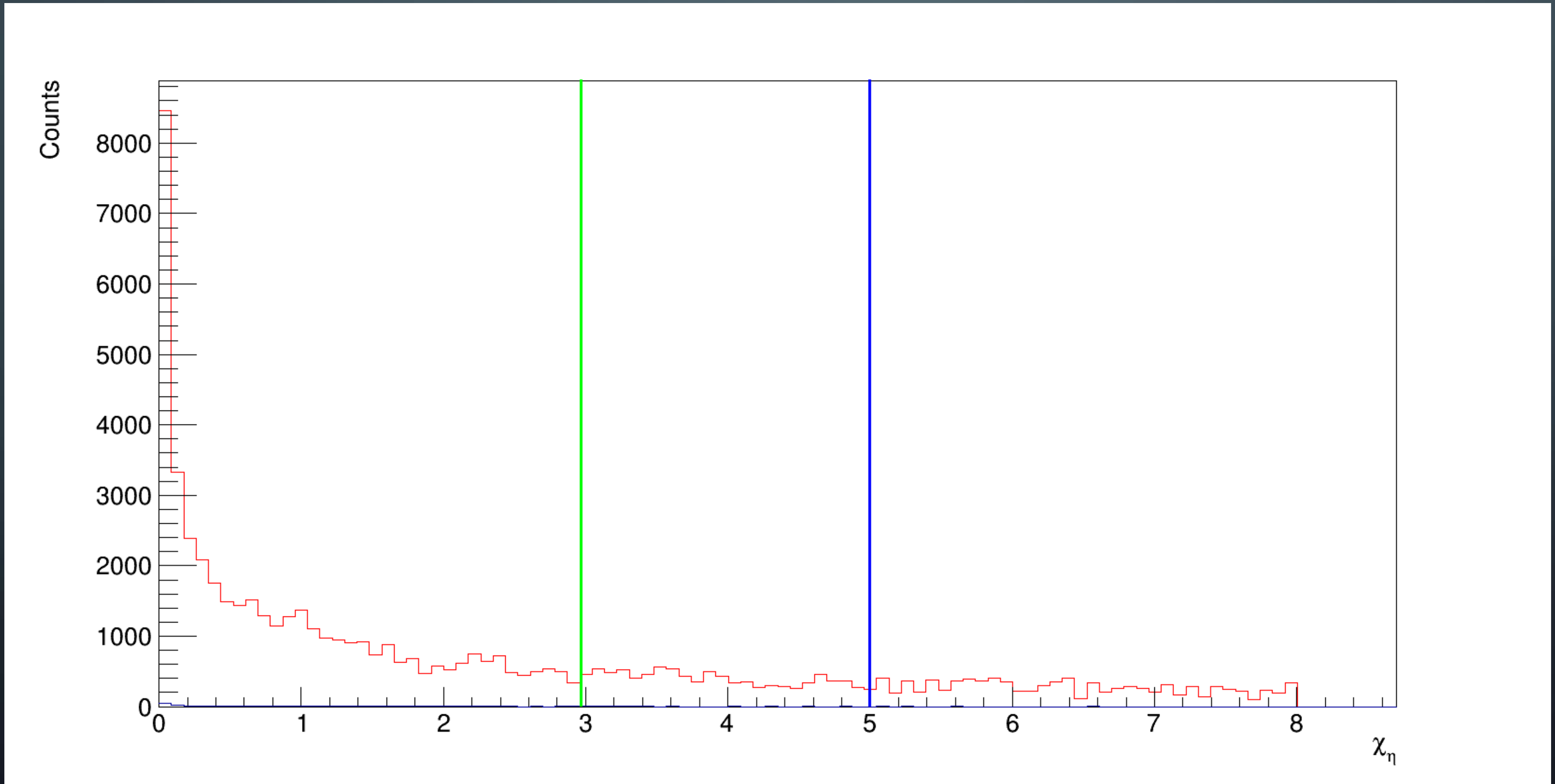
LEGEND

- Red – simulated signal event
- Blue – FTM simulated signal event
- Blue line – cuts placed by hand
- Green line – cuts placed by genetic algorythm

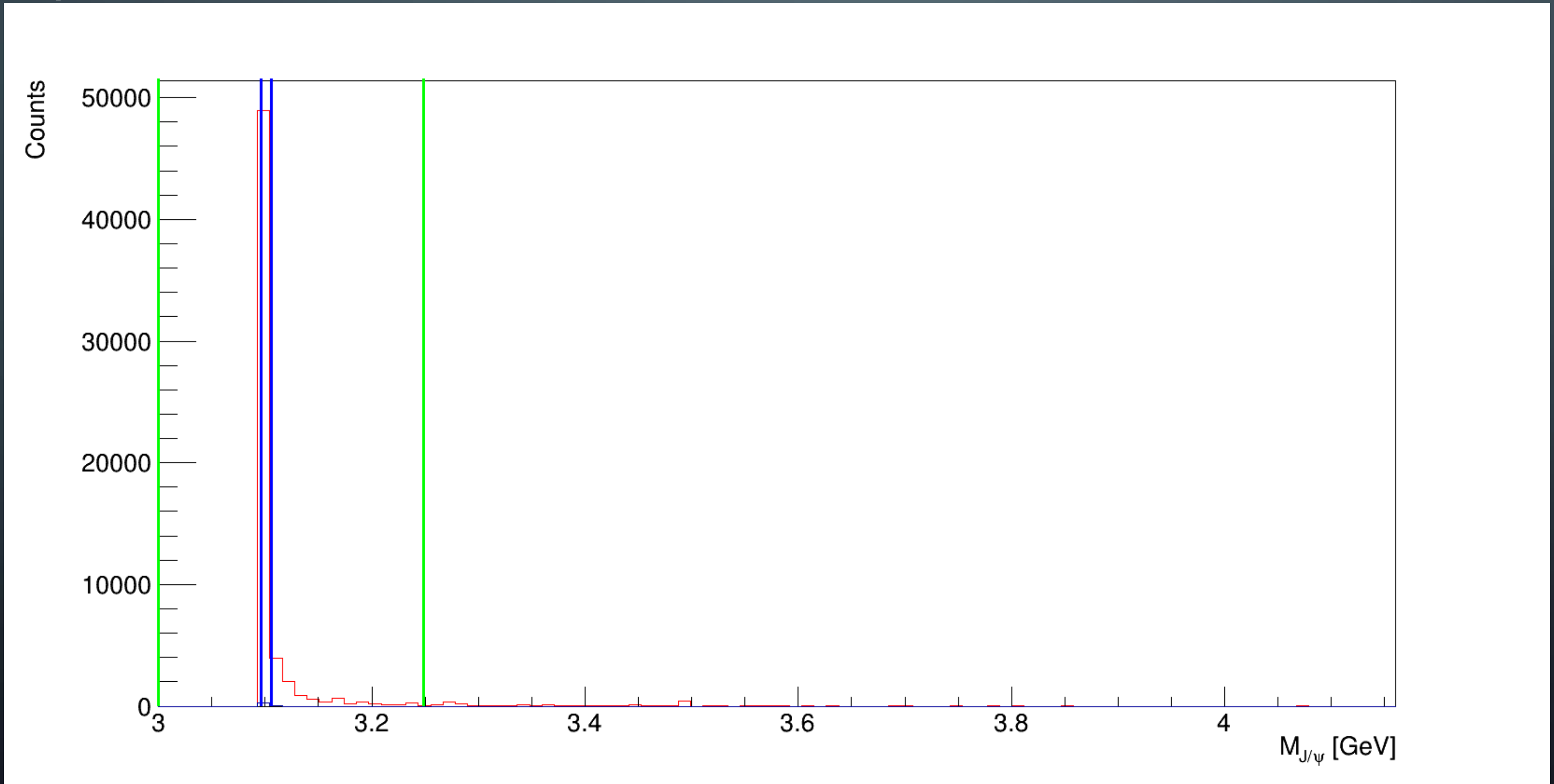
PION MASS CONSTRAINT FIT



ETA MASS CONSTRAINT FIT

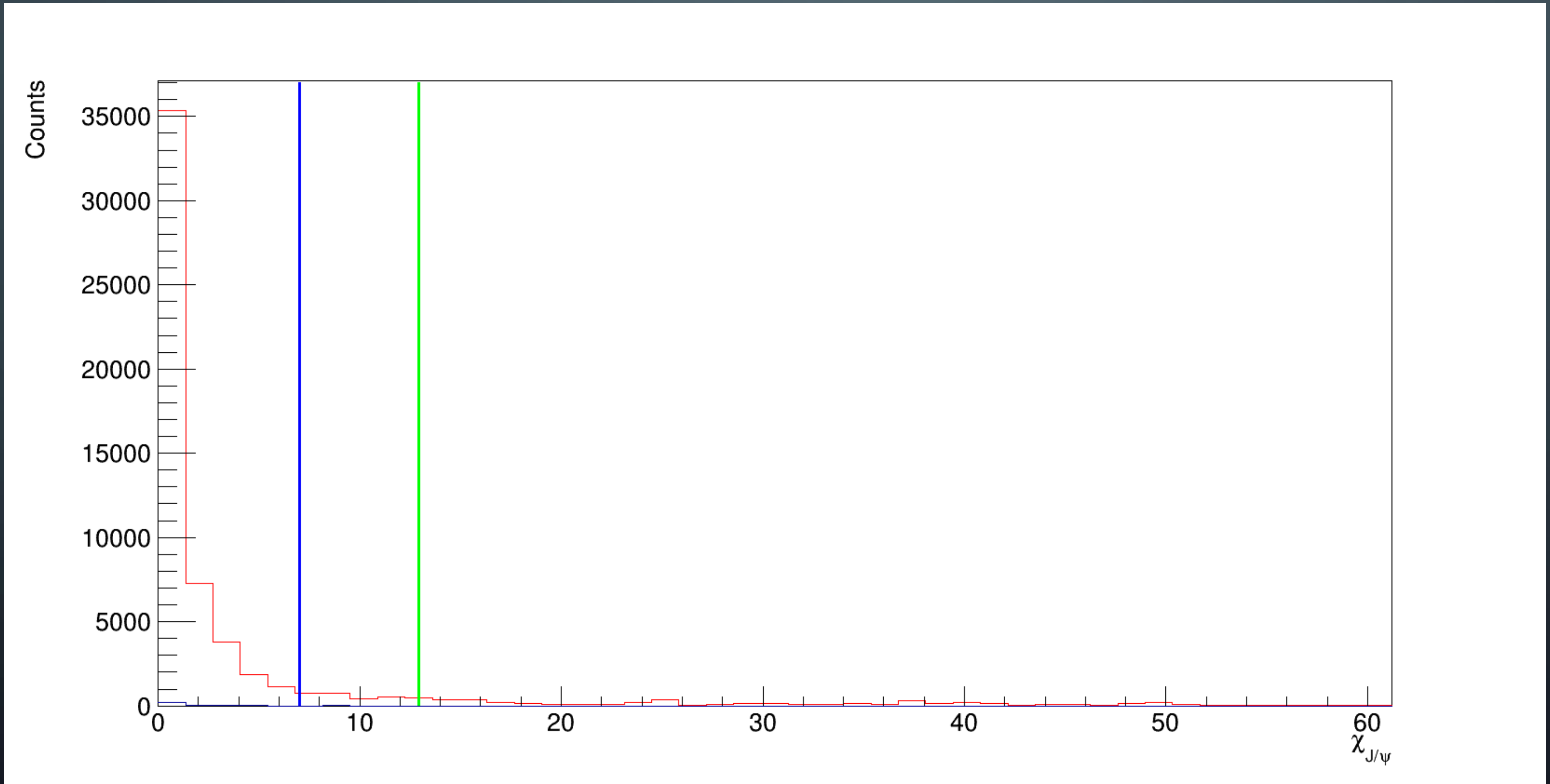


J/PSI MASS

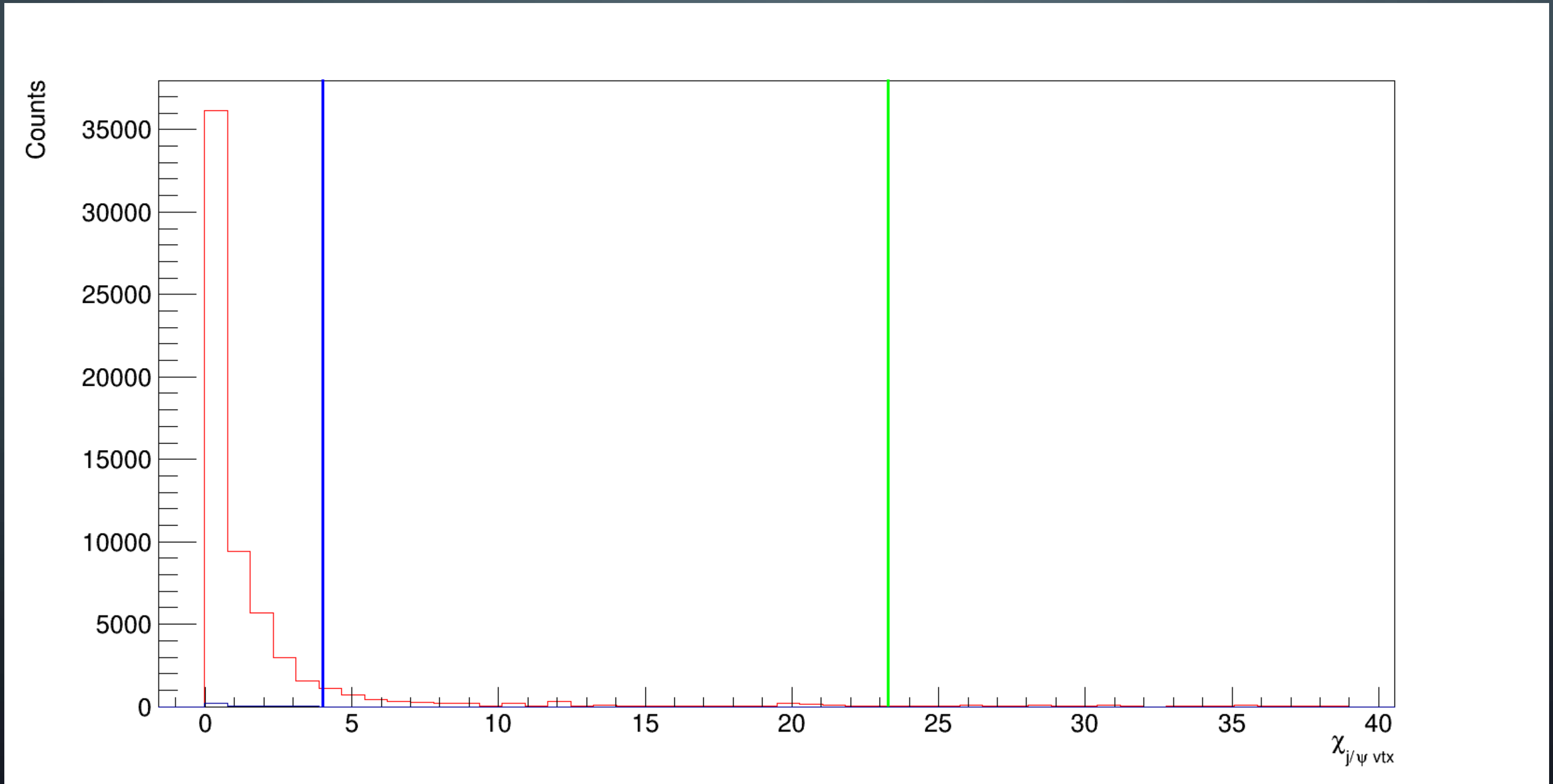


Counts
50000
40000
30000
20000
10000
0
3
3.2
3.4
3.6
3.8
4
$M_{J/\psi}$ [GeV]

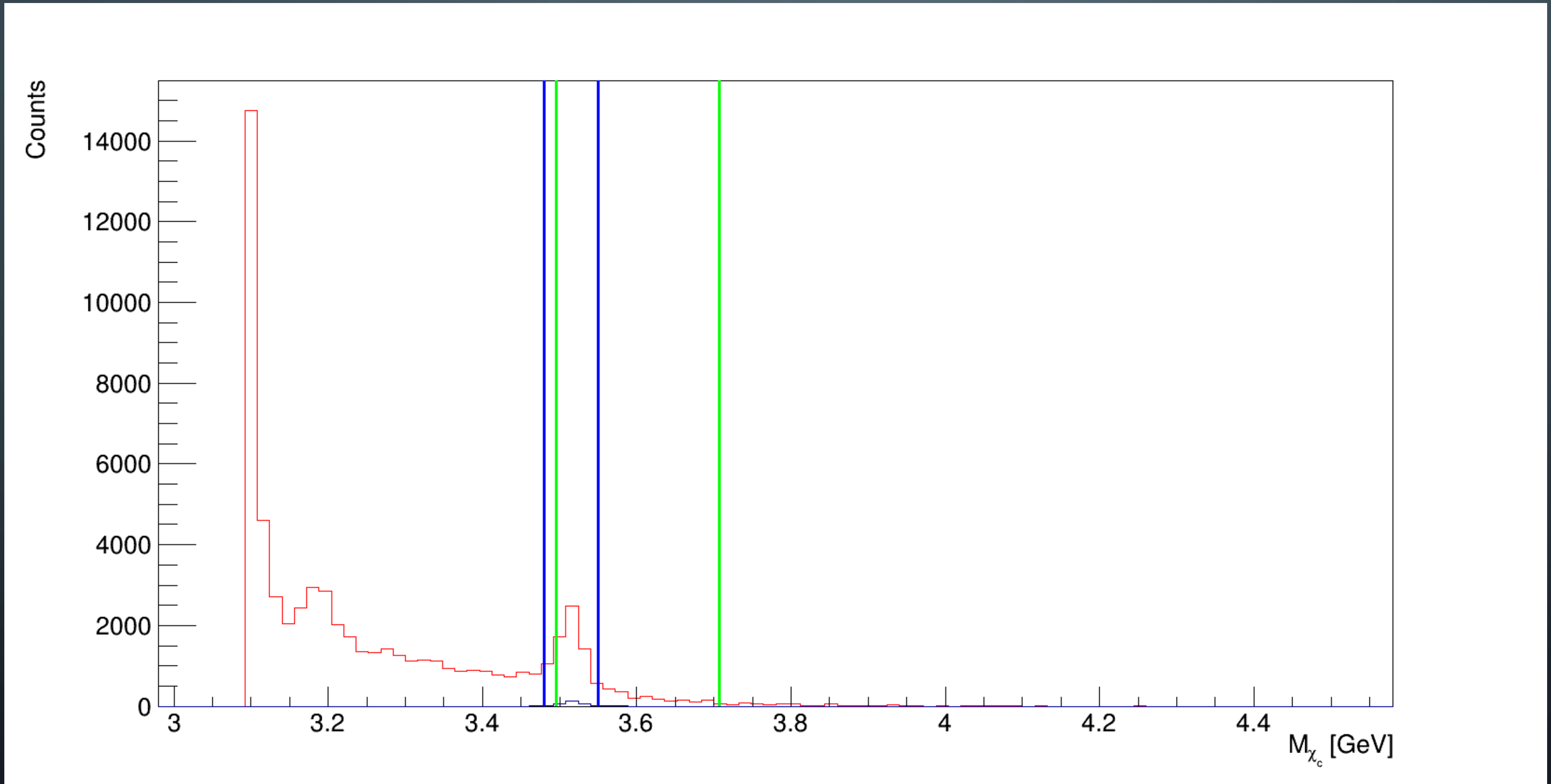
J/PSI MASS CONSTRAINT FIT



J/PSI VERTEX FIT

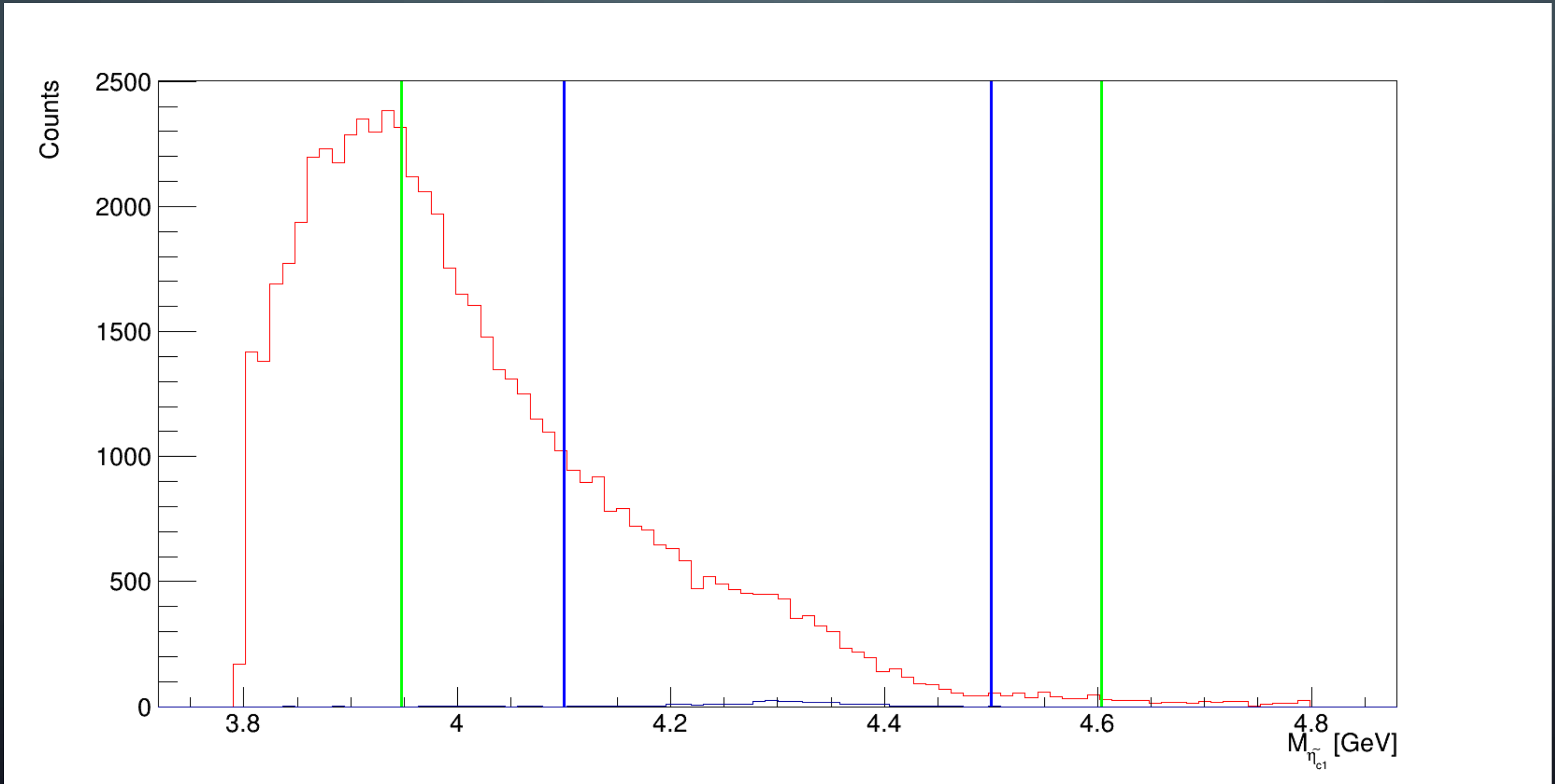


CHIC1 MASS

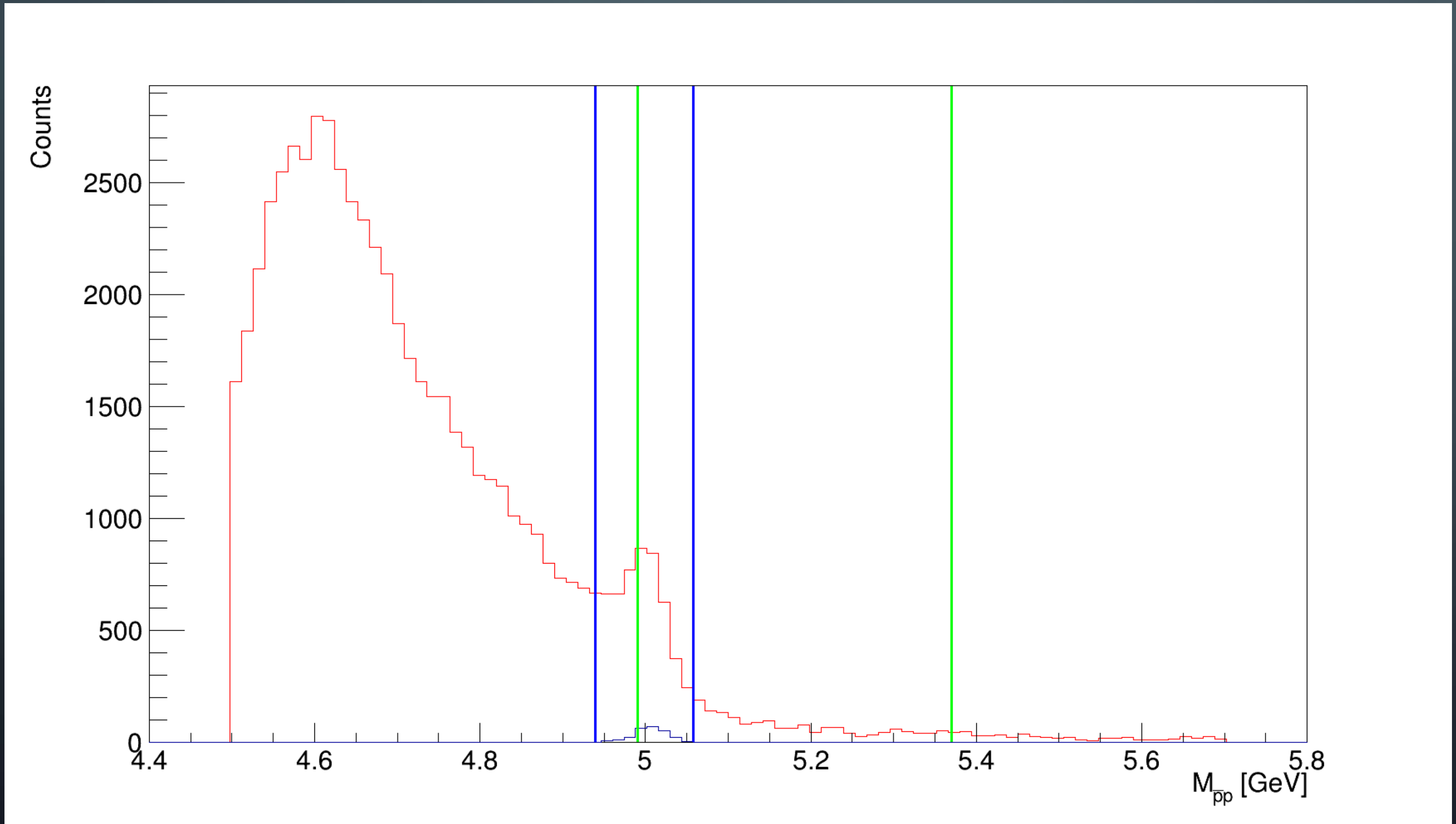


Counts
14000
12000
10000
8000
6000
4000
2000
0
3
3.2
3.4
3.6
3.8
4
4.2
4.4
M_{χ_c} [GeV]

ETAC1TILDE MASS

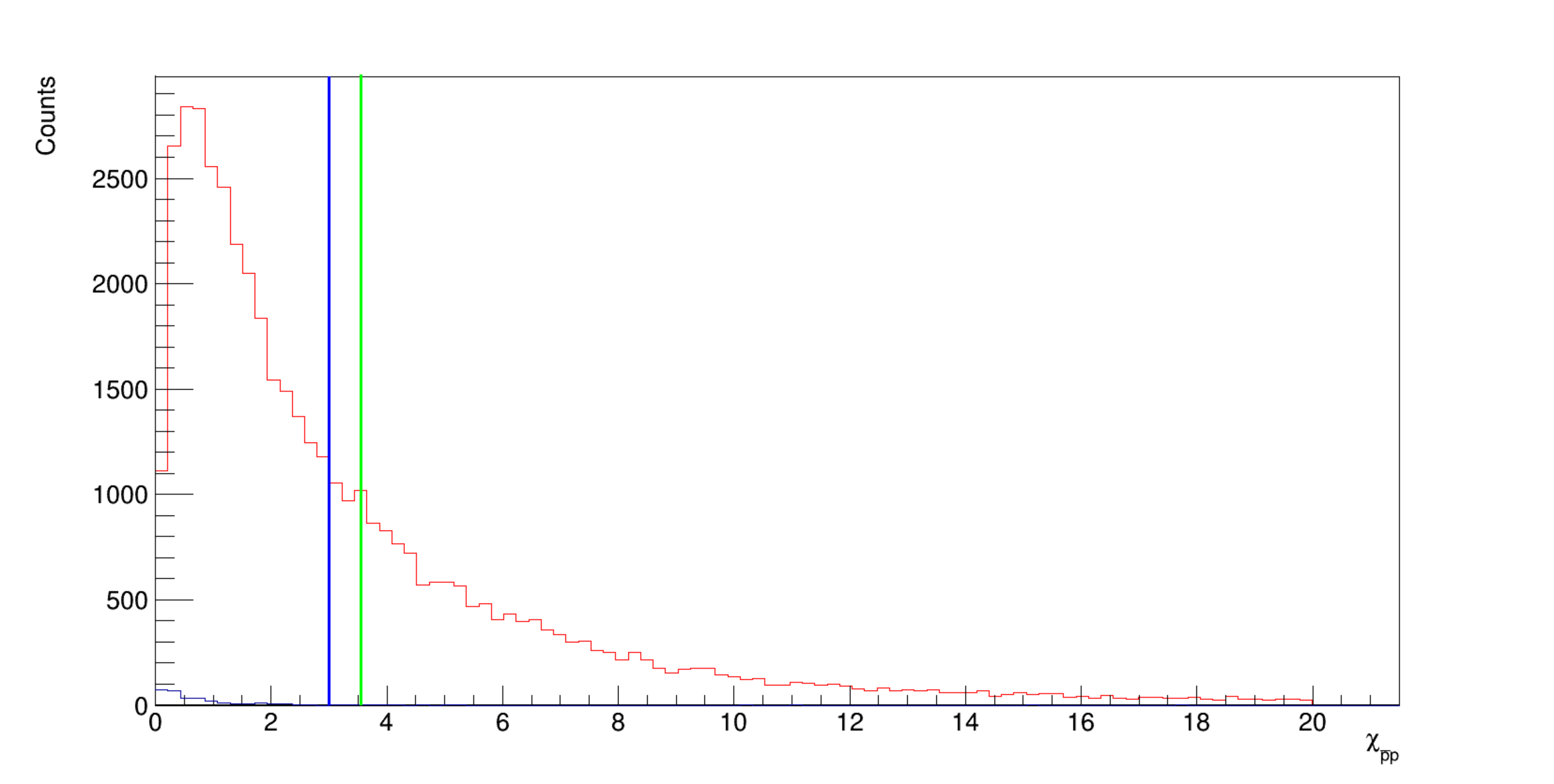


PBARP MASS



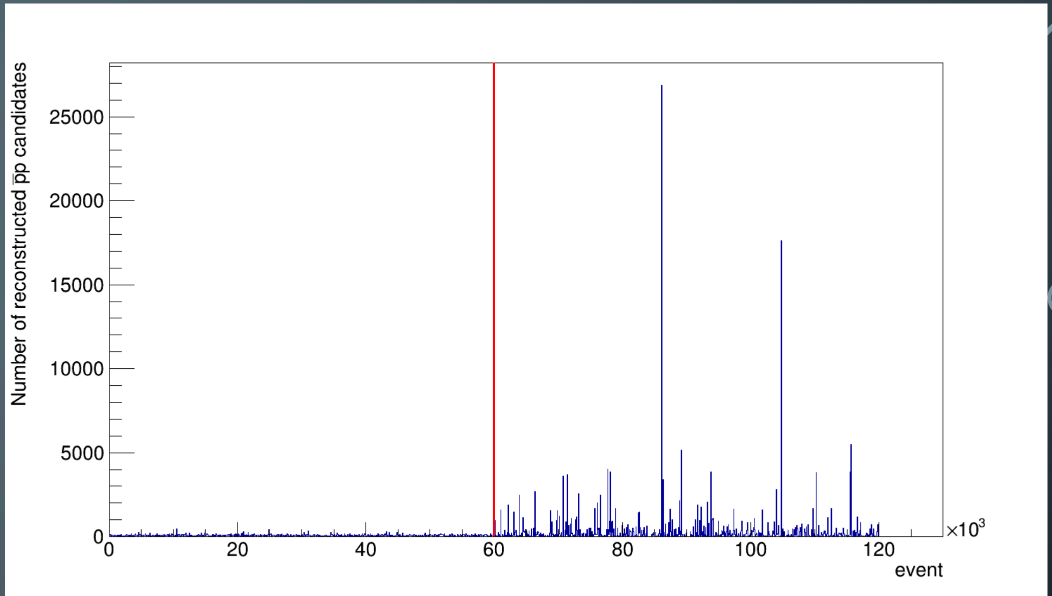
Counts
2500
2000
1500
1000
500
0
4.4
4.6
4.8
5
5.2
5.4
5.6
5.8
$M_{\bar{p}p}$ [GeV]

PBARP 4 CONSTRAINT FIT

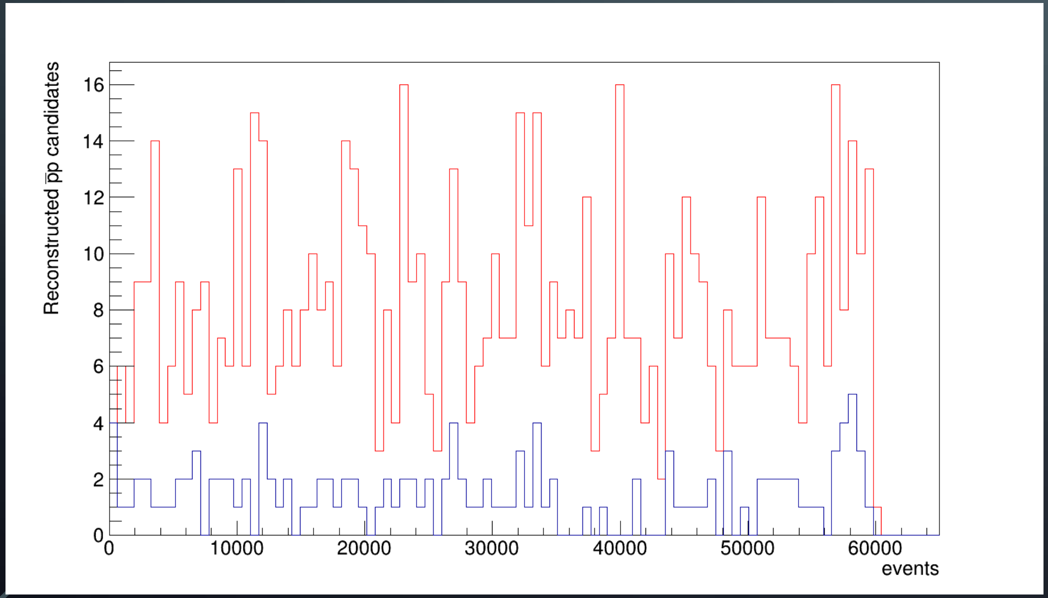


EFFECT OF THE CUTS

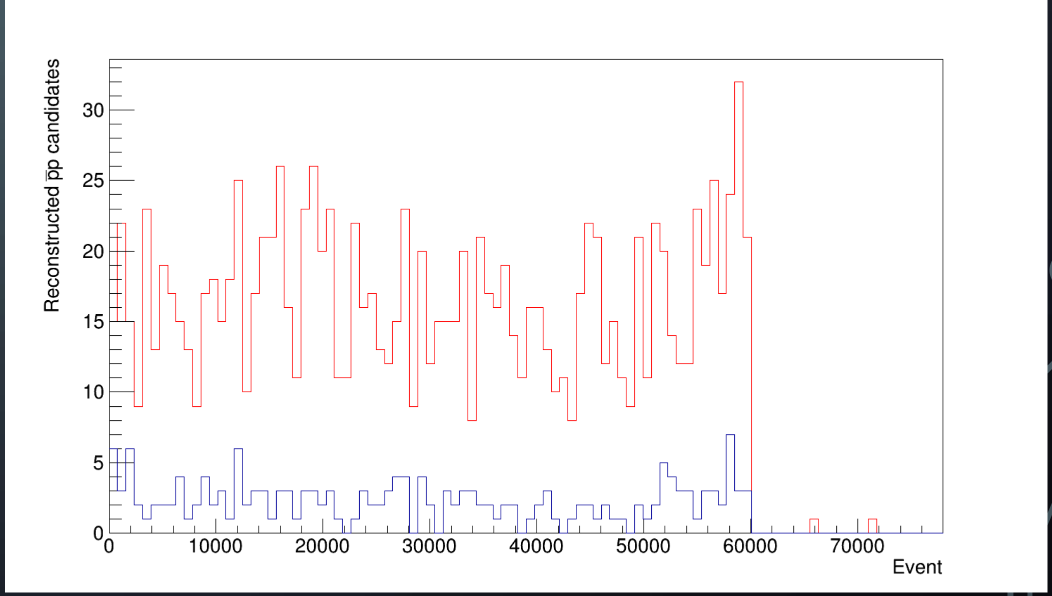
Simulated:



Genetic:



Hand:



MUCH MORE BACKGROUND EVENTS

- The genetic algorithm seems to work so far
- But what if we simulate much more background events - $3\ 10^8$

Hand	Genetic
0.00326	0.000329

- Running the genetic algorithm on this much bigger dataset

MISSING RESONANCES

- Investigate, what happened to the 55000 not detected resonance
- Almost all leptons were detected -> the problem is with the photons
- How to find the missing photons?
  - Compare the generated tracks 'theAnalysis->FillList(mctruth, "McTruth");' with the reconstructed ones '(PndEmcHit->GetMcList();)'
  - Check if a track entered a sensitive detector 'PndMCTrack->GetNPoints(kEMC);'
  - Compare the generated distributions of the detected and non-detected photons (E, p, theta, phi, ...) - there is no difference between them

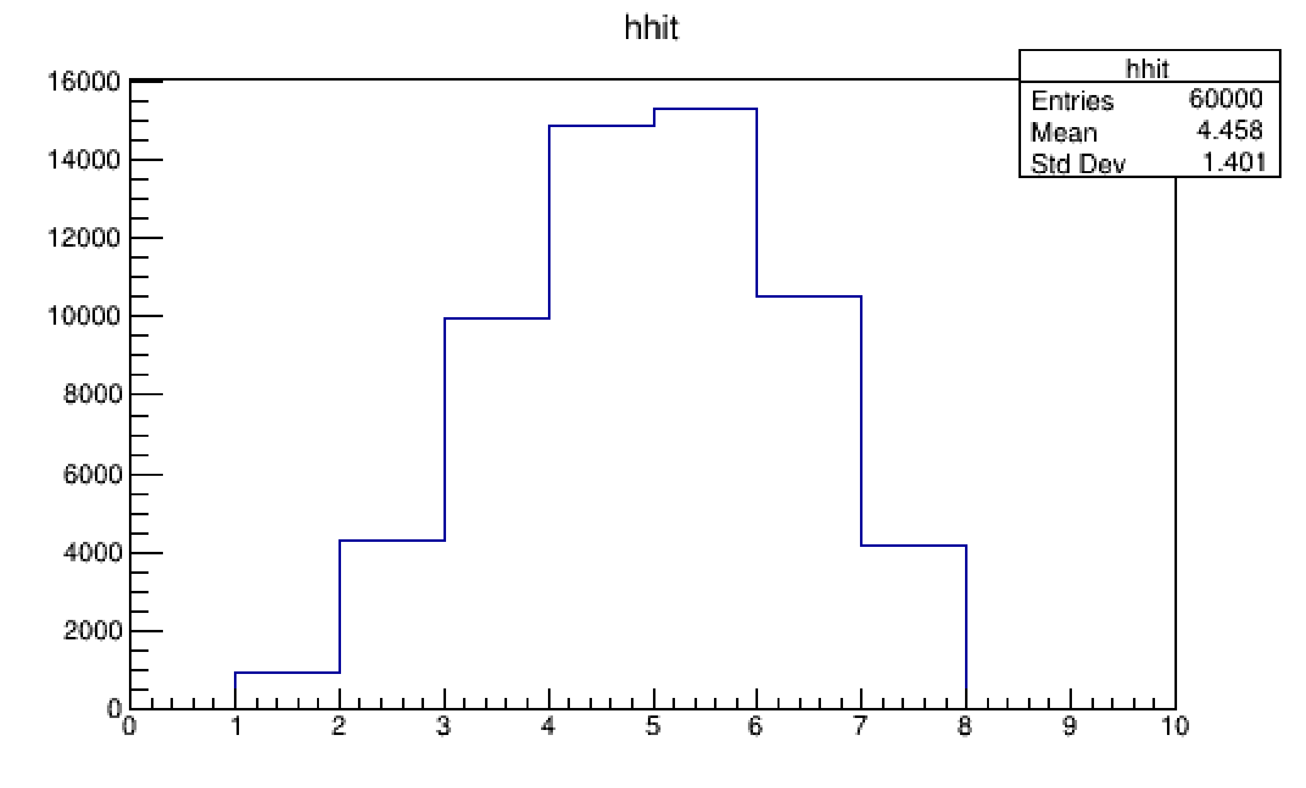
SENSITIVE DETECTOR HIT

- Percent of the primary gamma tracks which created a signal in a sensitive detector part
- If a pair production is allowed 63% is detected in the EMC
- This means, that all photons were detected approx. in 2400/60000 events

```
Percent of gammas detected in DRC: 36.2148
Percent of gammas detected in MDT: 0.0216667
Percent of gammas detected in MVD: 0.307857
Percent of gammas detected in RICH: 0
Percent of gammas detected in EMC: 61.9819
Percent of gammas detected in STT: 0.344048
Percent of gammas detected in FTOF: 0.0942857
Percent of gammas detected in TOF: 0.410952
Percent of gammas detected in GEM: 0.392143
Percent of gammas detected in DSK: 0.517381
Percent of gammas detected in HYP: 0
Percent of gammas detected in RPC: 0
Percent of gammas detected in LUMI: 0
Percent of gammas detected in HYPG: 0
Percent of gammas detected in FTS: 0.132619
```

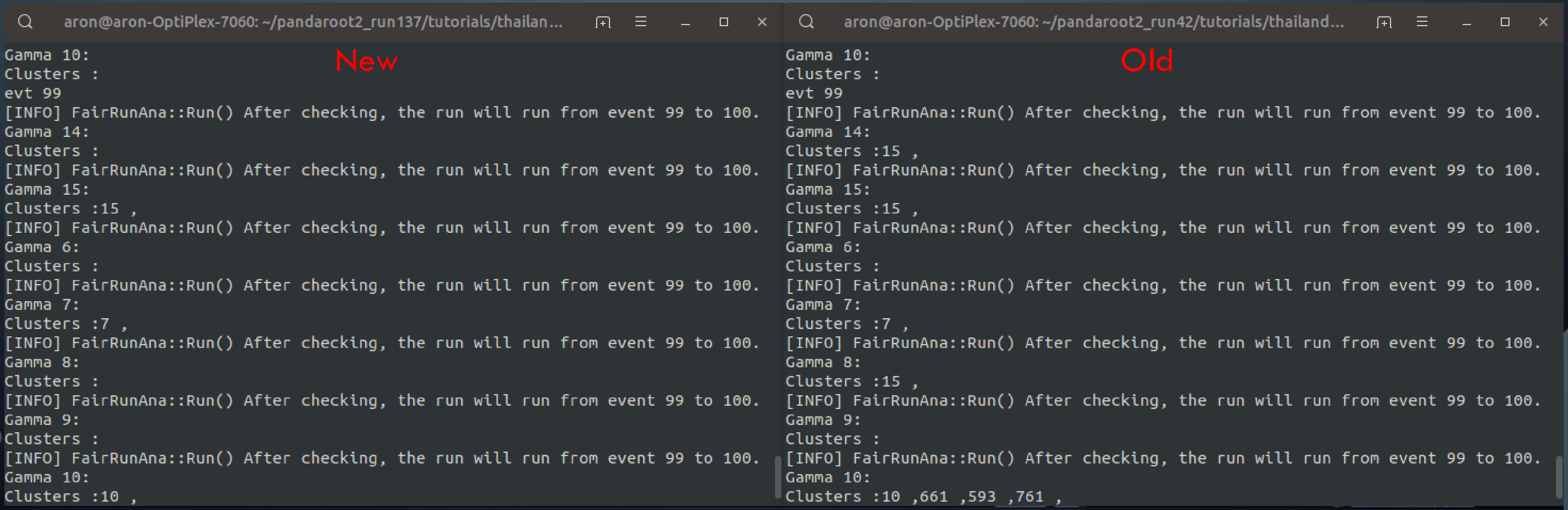
CREATED HITS

- Number of events when a hit is created from a gamma or any of its daughter tracks



CLUSTERS

- After the clustering this 4000 is reduced
- A comparison between the 2 clustering algorithms:
  - MC number of the clusters which have a contribution from the gamma



SUMMARY

- The signal-background ratio is very small – challanging channel
- Using the new clustering algorythm – mayor improvement for this channel
- Using genetic algorythm to optimize the cuts
  - Should be checked by a simpler channel
- The photon reconstruction is poor
  - Trying to find the reason
  - We didn't find it yet