STATUS OF THE ETA_C1-TILDE ANALYSIS

ÁRON KRIPKÓ FOR THE PANDA COLLABORATION

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THE DECAY

$\sqrt{s}$: 5 GeV

$$p\bar{p} \to \eta + \tilde{\eta}_{c1}$$

$\eta \to \gamma\ \gamma$

$\tilde{\eta}_{c1} \to \pi^0\ \pi^0\ \chi_{c1}$

$\pi^0 \to \gamma\ \gamma$

$\pi^0 \to \gamma\ \gamma$

$\chi_{c1} \to J/\psi\ \gamma$

$J/\psi \to e^+\ e^-$
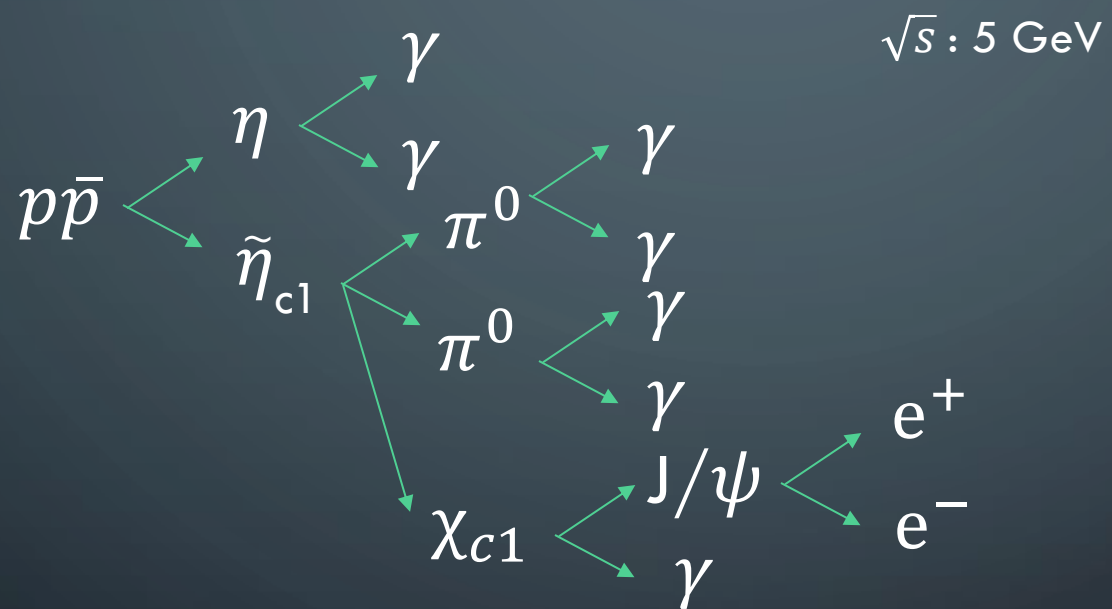
BACKGROUND

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

CROSS-SECTION AND BRANCHING FRACTIONS

39.41%

98.823%

γ

η

γ

γ

$p\bar{p}$

π^0

γ

$\tilde{\eta}_{c1}$

γ

π^0

γ

γ
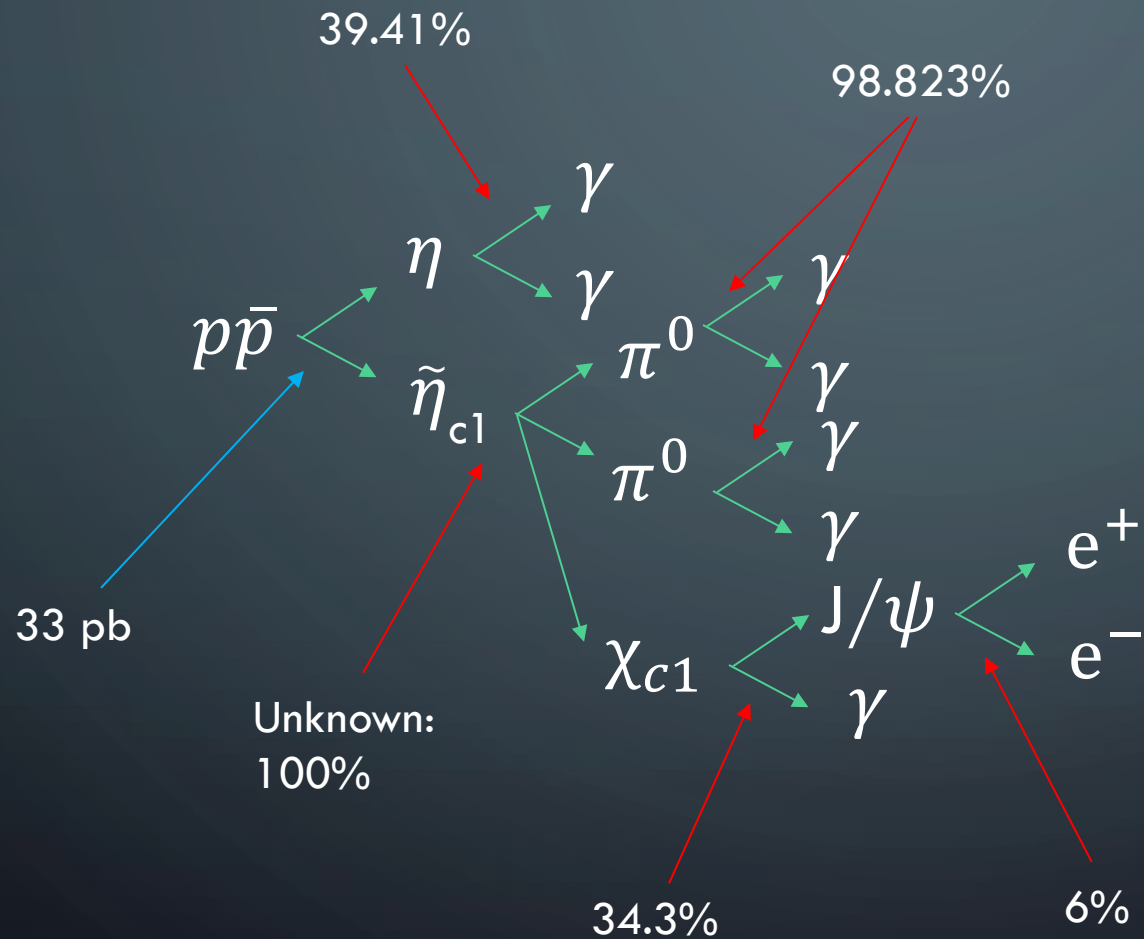
60000 signal $-$ 6 10^{14} background

33 pb

e^+

J/ψ

Unknown:
100%

χ_{c1}

e^-

γ

34.3%

6%

SIMULATION AND RECONSTRUCTION

- 60000 signal

- 60000 background

- The background was scaled for the significance calculation

- The reworked EMC clustering algorithm was used for the reconstruction

  - Better neutral reconstruction

  - Available in the new PandaRoot release

  - Detailed comparison:

    - PANDA Collaboration Meeting 19/1: Optimization of the Photon Reconstruction of the PANDA Target Calorimeter - Markus Moritz

GENETIC ALGORTIHM

- Inspired by natural selection

- Used when the evaluation of the fitness function takes many time

- Individual: represents a parameter set

- Mutation: randomly modify a parameter with a few percent

- Cross-over: generate new individuals 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

$$\text{Significance} = \text{Full truth match} / \sqrt{\text{Reconstructed}}$$

EFFECT OF THE CUTS

Simulated:
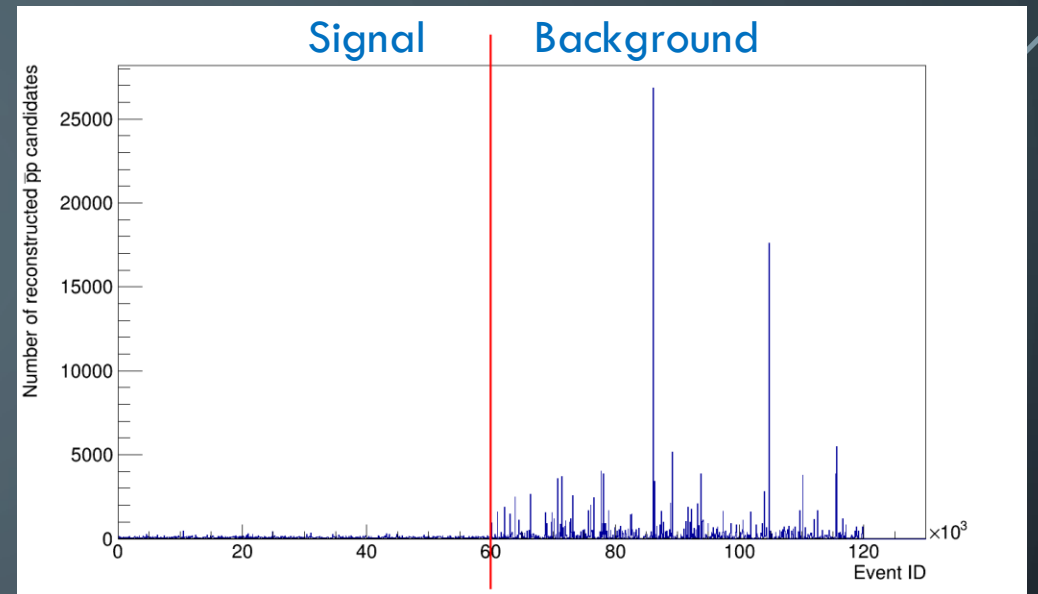
Genetic:
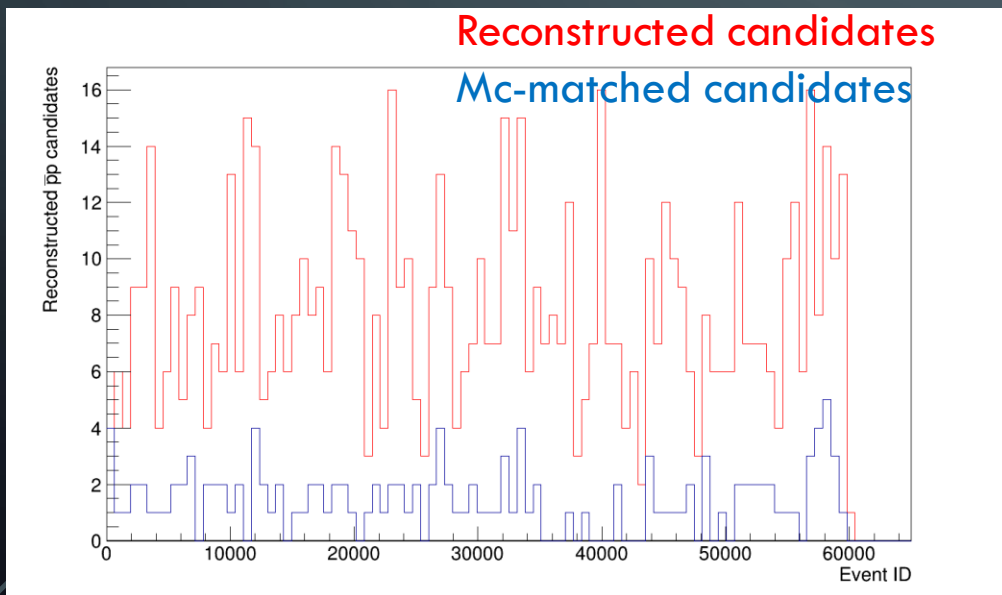
Hand:
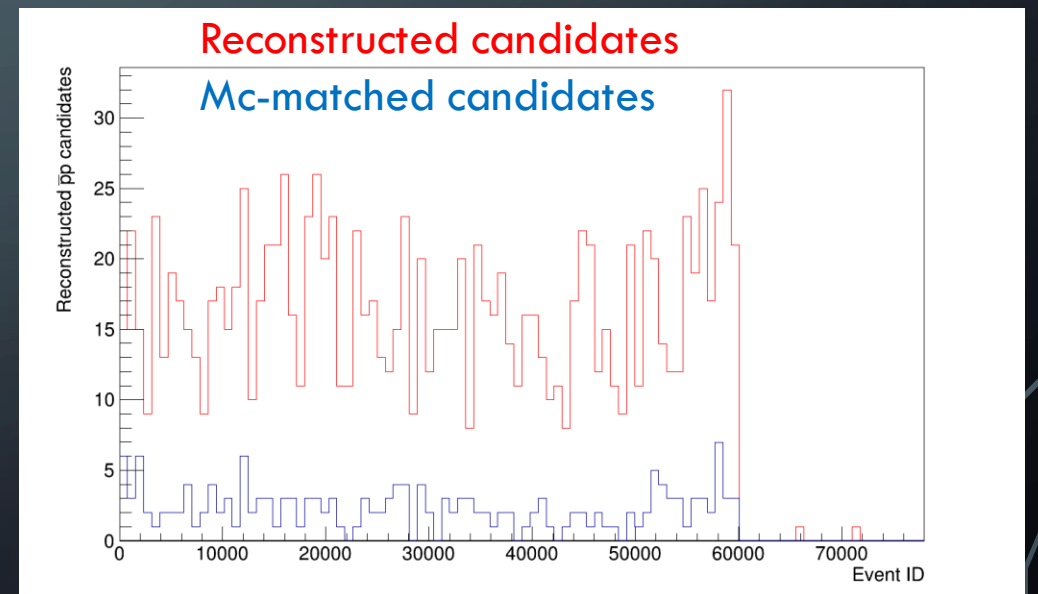
MUCH MORE BACKGROUND EVENTS

- The genetic algorithm seems to work so far

- But what if we simulate much more background events - $3 \cdot 10^8$

	Hand	Genetic
signal	89	38
Background (not scaled)	358	6423
Significance	0.00326	0.000329

- Running the genetic algorithm on this much bigger dataset – new cuts

Parameter	Hand	Genetic
Pion mass	0.1349 - 0.1354	0.1 - 0.16
Eta mass	0.5477 - 0.5494	0.04 - 1.04
Muon mass	0 - 1.1	0 - 0.12
J/psi mass	3.0965 - 3.106	1,18- 3.12
Chi_c mass	3.48 - 3.55	3.51 - 3.58
Eta_c1 mass	4.1 - 4.5	4.18 - 4.56
Pbarp mass	4.939 - 5.058	4.939 - 5.058
Pion chi	4	5.11
Eta chi	5	5.11
J/psi chi	7	7.95
J/psi vertex chi	4	1.14
Pbarp chi	3	3.83
Significance	0.00326	0.00334
FTM	89	75
Background	358	243

$$\text{Significance} = \text{Full truth match} / \sqrt{\text{Reconstructed}}$$

MISSING RESONANCES

- Only a few hundred resonances were detected out of 60000

- Almost all leptons were detected -> the problem is with the photons

- Studies with eta, pion and gamma guns

eta	2 x pion	7 x gamma
39 %	44 %	95 %

7 PHOTONS FROM THE ETA_C1-TILDE
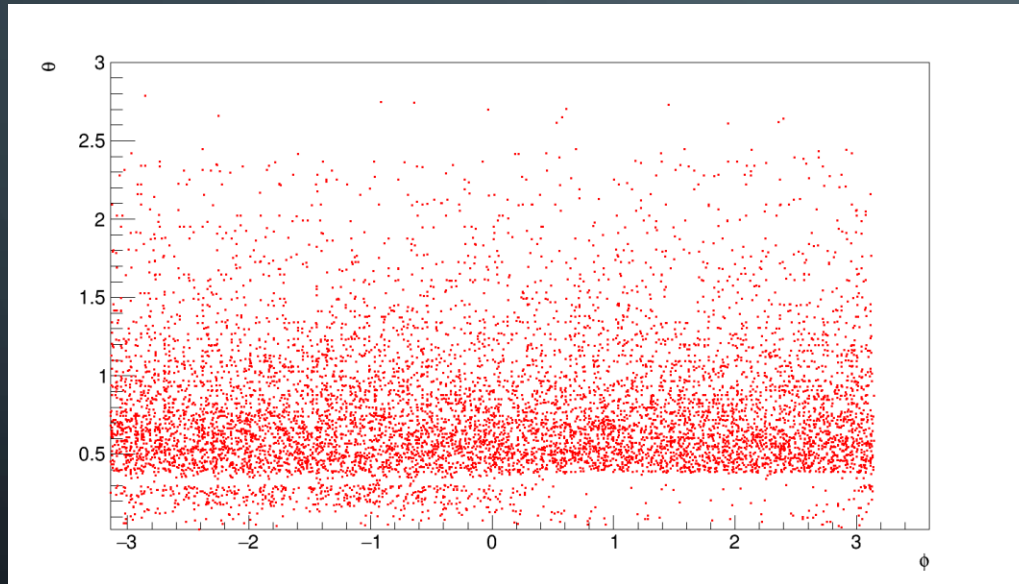
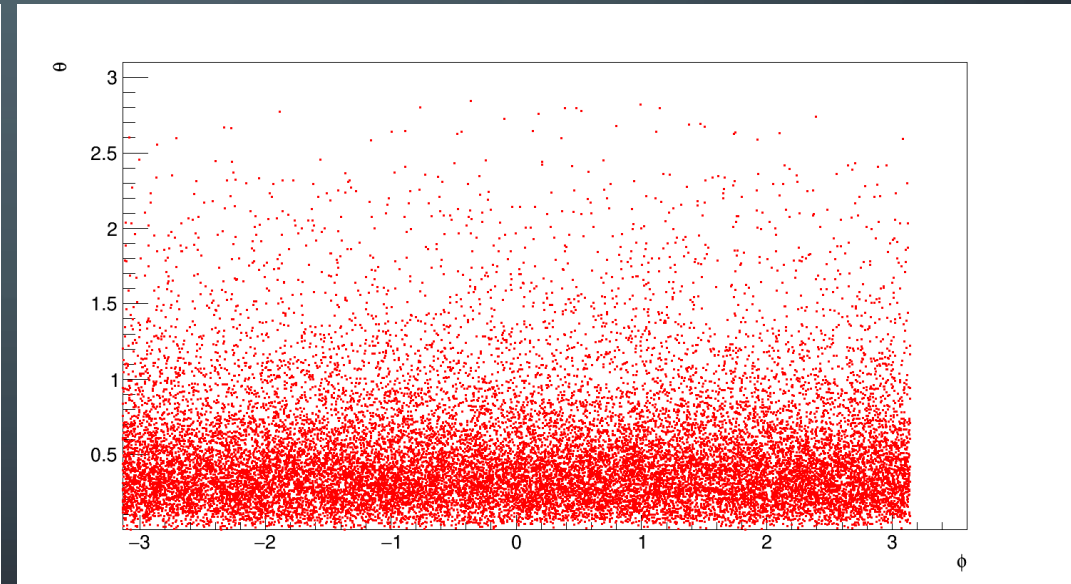From the mc-matched reconstructed resonance
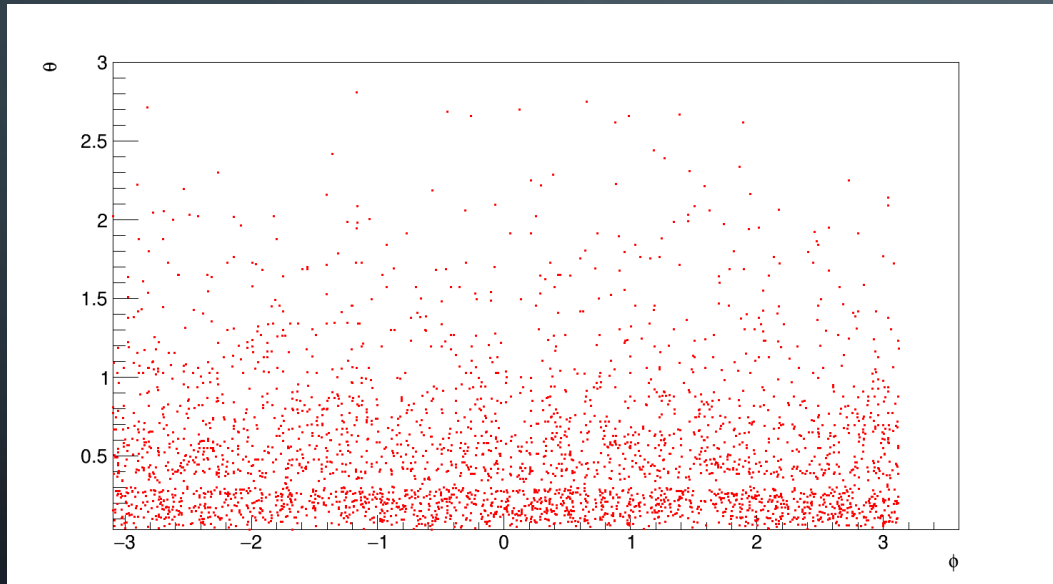
From the generated resonance
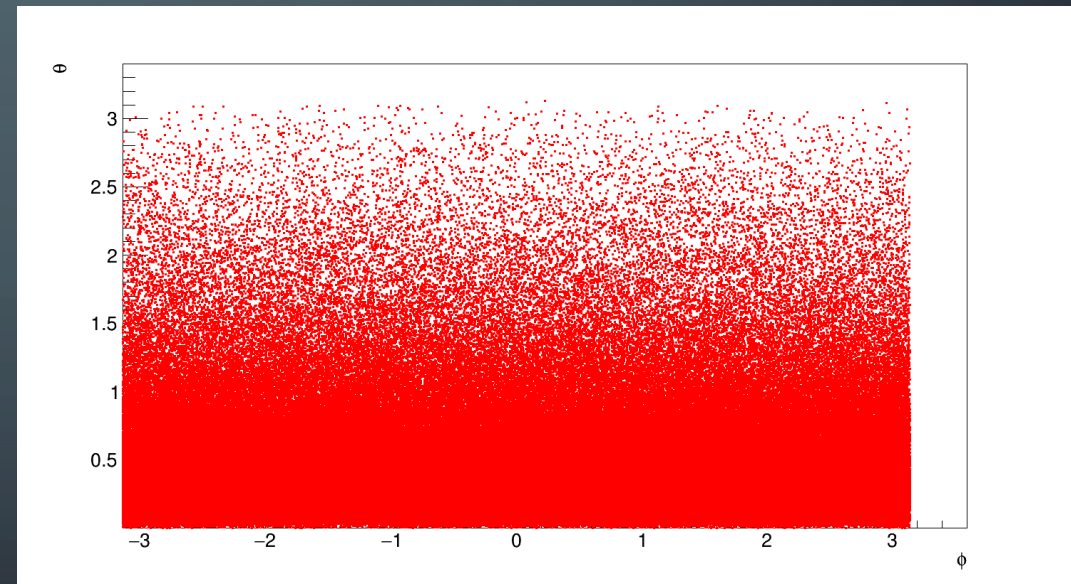
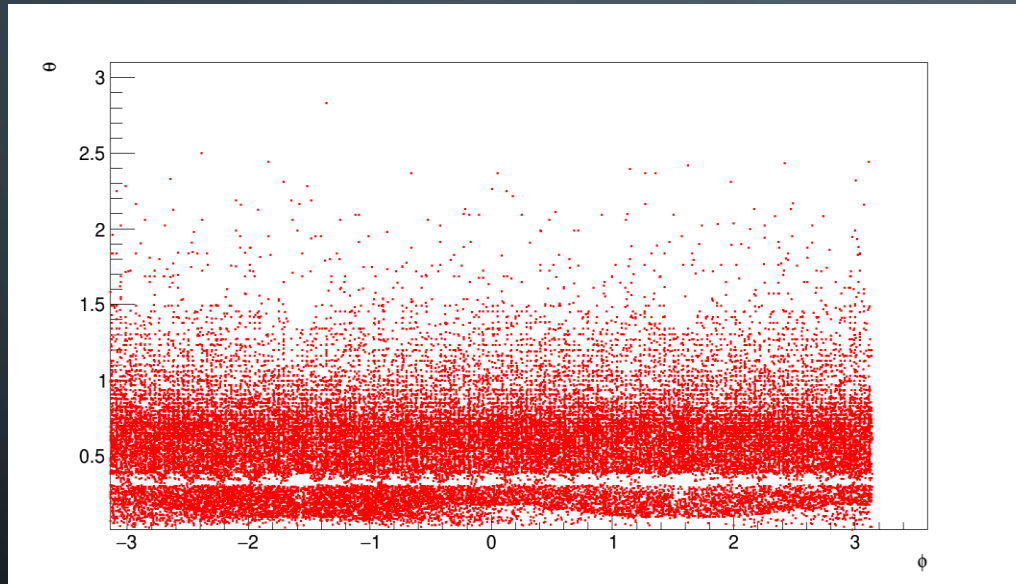# 2 PHOTONS FROM THE ETA GUN

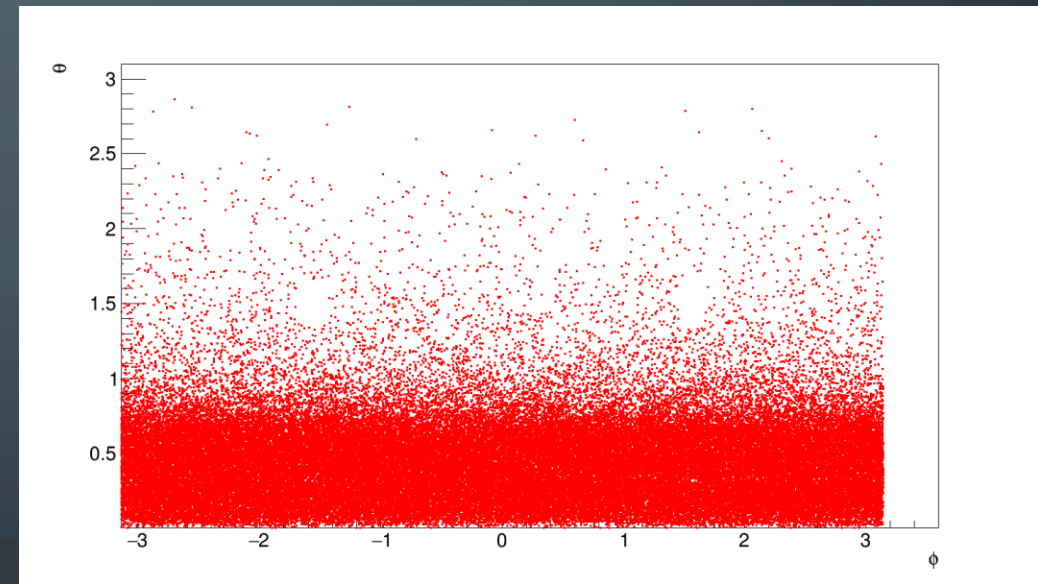From the mc-matched reconstructed eta

From the generated eta

2 X 2 PHOTONS FROM THE PION GUN
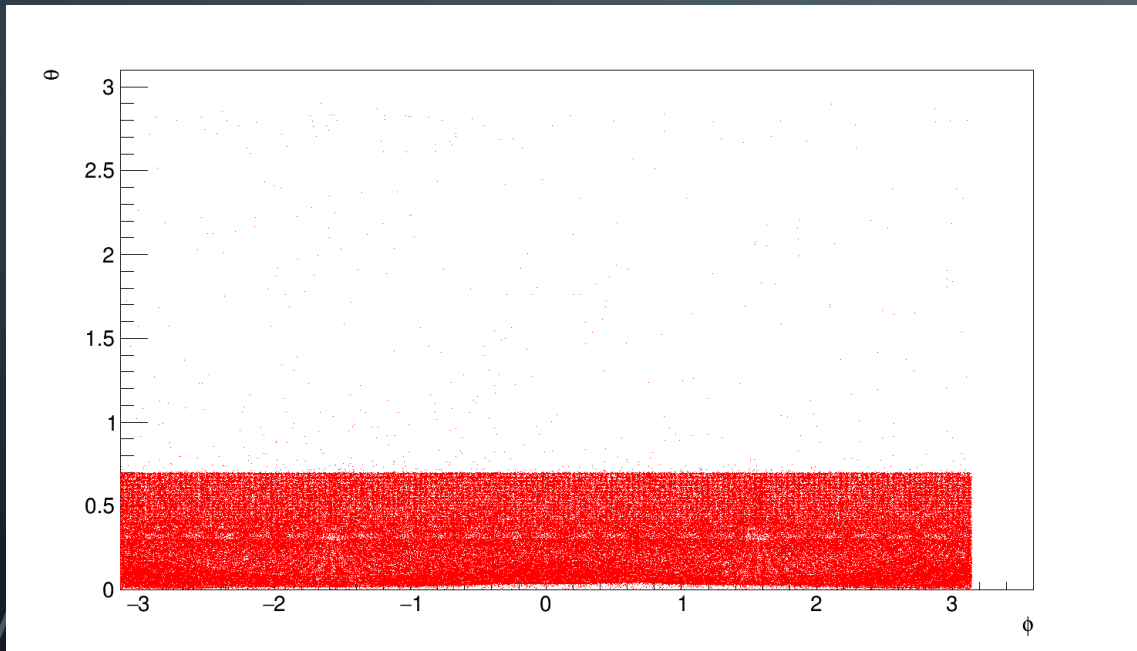
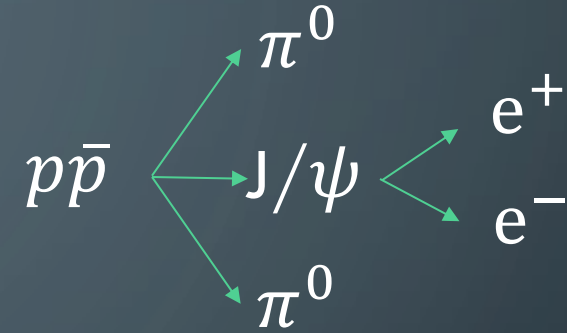From the mc-matched reconstructed 2 pions

From the generated 2 pions

7 PHOTONS FROM THE GUN

Mc-matched reconstructed photons

- A gap can be seen in theta aroung 0.3
- It can be the GEM detector or a holding structure
- It is only responsible for 5-10%
- All other distributions look similar

TEST THE GENETIC ALGORYTHM WITH A SIMPLER CHANNEL

$$p\bar{p} \begin{cases} \pi^0 \\ J/\psi \begin{cases} e^+ \\ e^- \end{cases} \\ \pi^0 \end{cases}$$

- The significance increases

- The signal is not destroyed

- Seems to work

- But there are only 15 mcmatches reconstructed out of 60000

- Probably the problem is with the mcmatching in both cases

SUMMARY

- The signal-background ratio is very small – challenging channel

- Using the new clustering algorythm – major improvement for this channel

- Using genetic algorythm to optimize the cuts

- The reconstruction is poor (problem with mcmatching)
  - There could be a problem with the mcmatching for composite particles
  - If this is the case, the genetic algorithm uses a wrong significance
  - This problem should be investigated in details and fixed