

# $\eta \rightarrow \pi^0 \gamma \gamma$ with FCAL(2)

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13.08.2021



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# Introduction

Reaction filter:  $\gamma p \rightarrow \gamma\gamma\gamma\gamma p$

Events with two photon pairs with invariant masses,  $m_{\gamma\gamma}$ , with

- $m_{\pi^0} - 3\sigma \leq m_{\gamma\gamma}^{a/b} \leq m_{\pi^0} + 3\sigma$  ( $2\pi^0$  events)
- $m_{\pi^0} - 3\sigma \leq m_{\gamma\gamma}^a \leq m_{\pi^0} + 3\sigma$  and  $m_\eta - 3\sigma \leq m_{\gamma\gamma}^b \leq m_\eta + 3\sigma$  ( $\pi^0\eta$  events)
- $m_\eta - 3\sigma \leq m_{\gamma\gamma}^{a/b} \leq m_\eta + 3\sigma$  ( $2\eta$  events)

are discarded

Events with

- $m_{\pi^0} - 3\sigma \leq m_{\gamma\gamma}^a \leq m_{\pi^0} + 3\sigma$
- $m_{\gamma\gamma}^b \leq m_{\pi^0} - 5\sigma$  or  $m_{\gamma\gamma}^b \geq m_{\pi^0} + 5\sigma$  ( $2\pi^0$  veto)

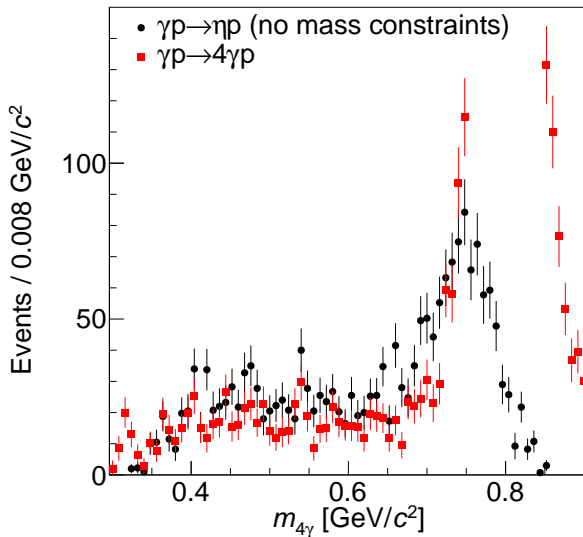
are selected. Best surviving combination is selected by a  $\chi^2$  test (solely based on final state photons)

Addition (loose) selection criteria

- Extra energy
- Extra tracks
- Kinematic fit  $\chi^2$
- Coplanarity
- Missing mass squared
- Elasticity

# 2017 “Winter” data set

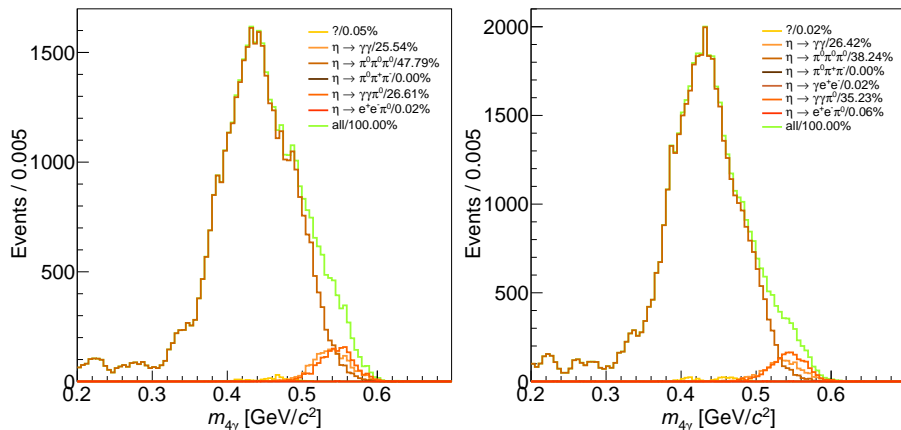
All photons are in FCAL



# $\eta$ simulation samples

EtaRegge + post processing via evtgen

- 50M w/o  $2\gamma\pi^0$  and  $e^+e^-\pi^0$  decays (background training sample)
- 1M  $2\gamma\pi^0$  decay (signal training sample)
- 50M with all decays (testing sample), figure below, left-GlueX and right-JEF, invariant mass from measured P4

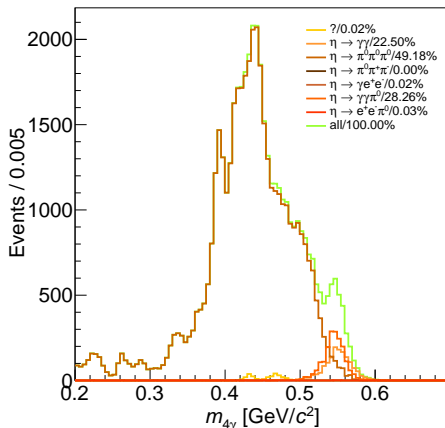
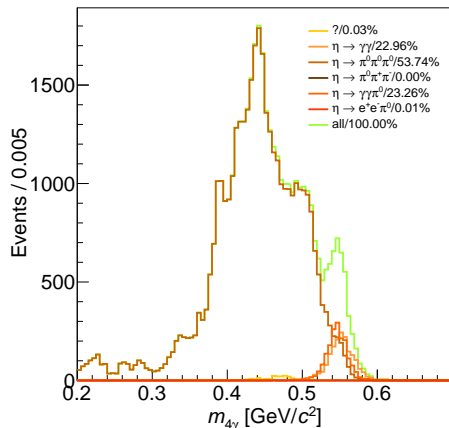


Percentage calculated between 510 and 590  $\text{MeV}/c^2$

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- 50M with all decays (testing sample), figure below, left-GlueX and right-JEF, invariant mass from fitted P4



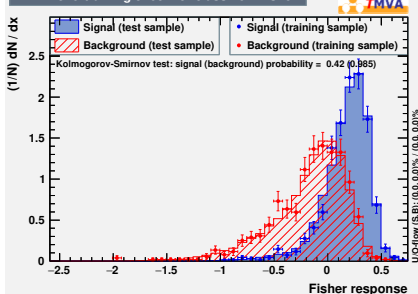
Percentage calculated between 510 and 590  $\text{MeV}/c^2$

## List of variables increased

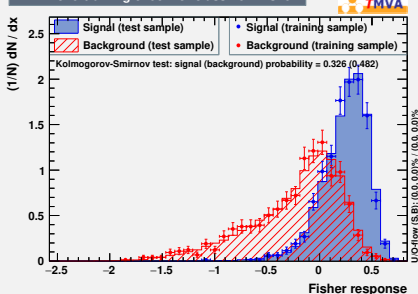
<i>m_gambeam_energy</i>	<i>m_vetofakepi0</i>
<i>m_chi2</i>	<i>m_mandelstam_t</i>
<i>m_weight</i>	<i>m_transversemomentum_eta</i>
<i>m_extraE</i>	<i>m_transversemomentum_pi0</i>
<i>m_elasticity_meas</i>	<i>m_transversemomentum_2g</i>
<i>m_elasticity_cons</i>	<i>m_shower_x0</i>
<i>m_signal</i>	<i>m_shower_y0</i>
<i>m_background</i>	<i>m_shower_z0</i>
<i>m_invariantmass2g</i>	<i>m_shower_e0</i>
<i>m_invariantmass4g</i>	<i>m_shower_x1</i>
<i>m_invariantmass2gpi0</i>	<i>m_shower_y1</i>
<i>m_rawinvariantmass4g</i>	<i>m_shower_z1</i>
<i>m_rawinvariantmass2gpi0</i>	<i>m_shower_e1</i>
<i>m_missingmasssquare</i>	<i>m_shower_x2</i>
<i>m_coplanarity</i>	<i>m_shower_y2</i>
<i>m_helicity</i>	<i>m_shower_z2</i>
<i>m_insertnumber</i>	<i>m_shower_e2</i>
<i>m_fcnumber</i>	<i>m_shower_x3</i>
<i>m_veto2pi0</i>	<i>m_shower_y3</i>
<i>m_vetopi0eta</i>	<i>m_shower_z3</i>
<i>m_veto2eta</i>	<i>m_shower_e3</i>

# TMVA, Fisher

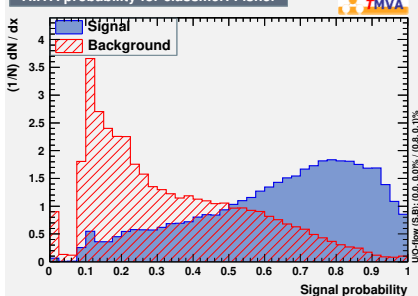
TMVA overtraining check for classifier: Fisher



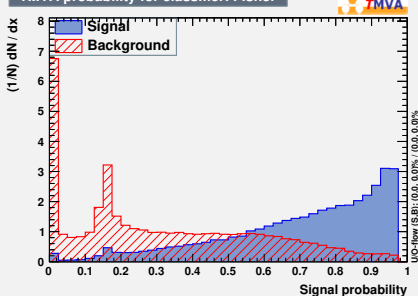
TMVA overtraining check for classifier: Fisher



TMVA probability for classifier: Fisher

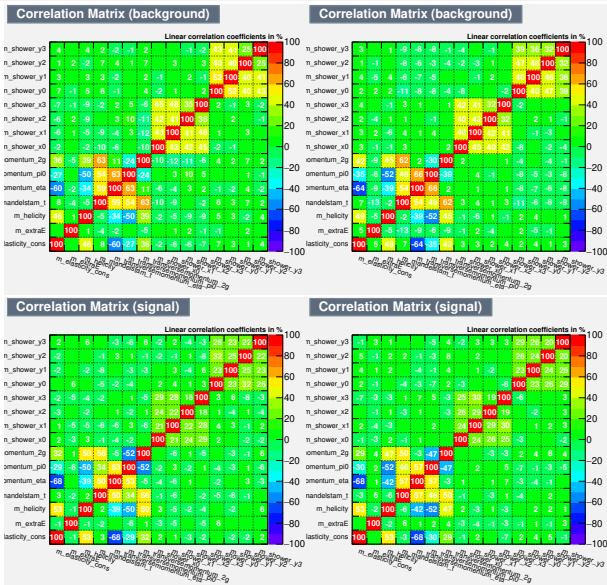


TMVA probability for classifier: Fisher

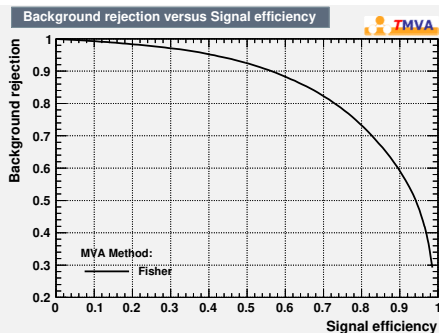
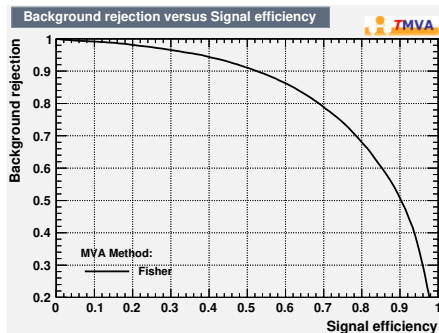




# TMVA, Fisher

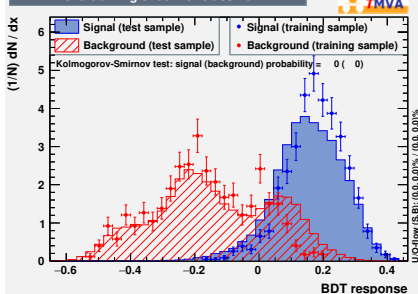


# TMVA, Fisher

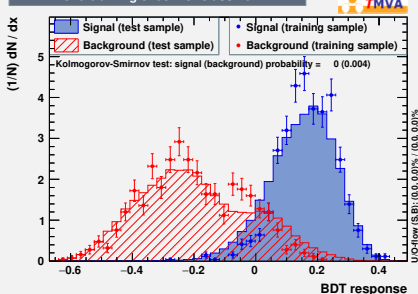


# TMVA, BDT

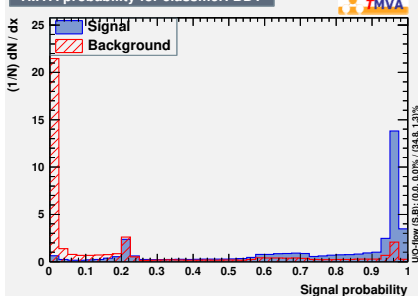
TMVA overtraining check for classifier: BDT



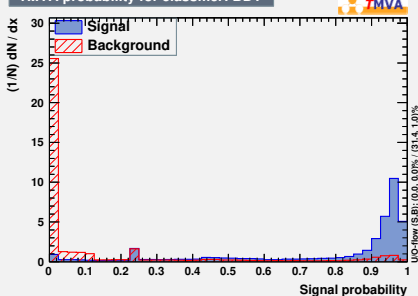
TMVA overtraining check for classifier: BDT

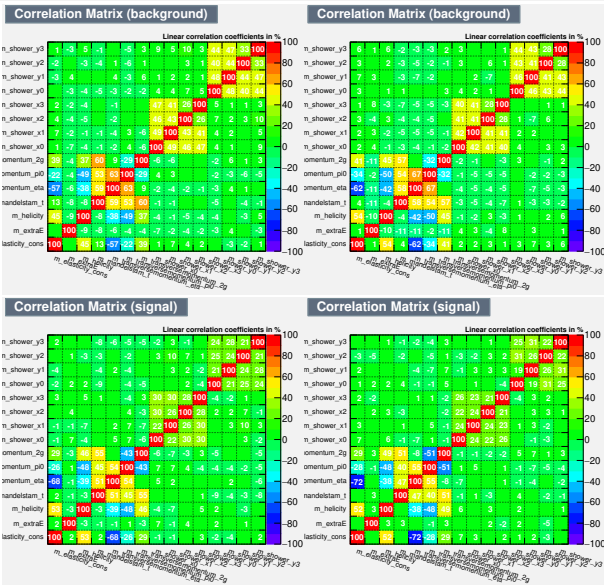


TMVA probability for classifier: BDT

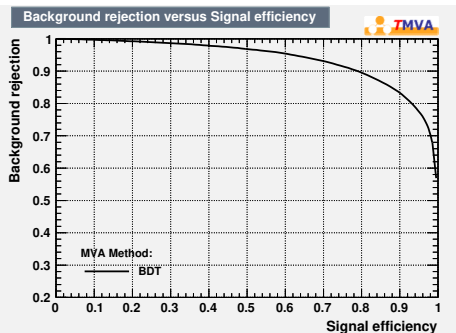
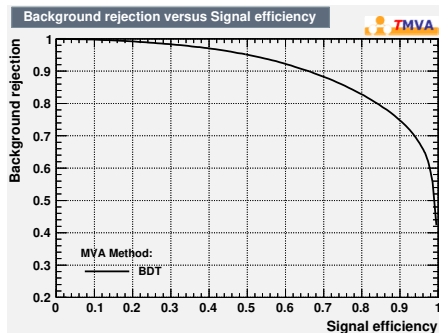


TMVA probability for classifier: BDT





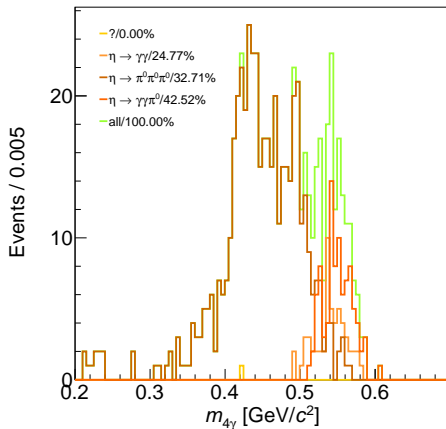
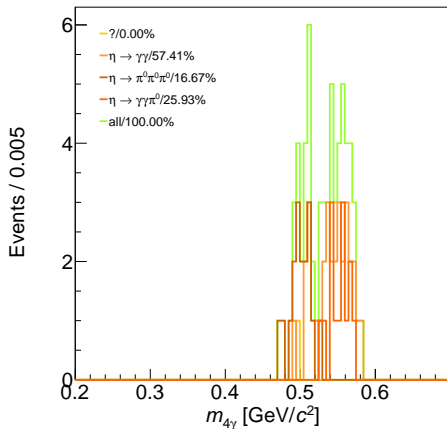
# TMVA, BDT



# TMVA, GlueX

All photons in FCAL + 3 or more photons in insert, reject  $\zeta$  0.9

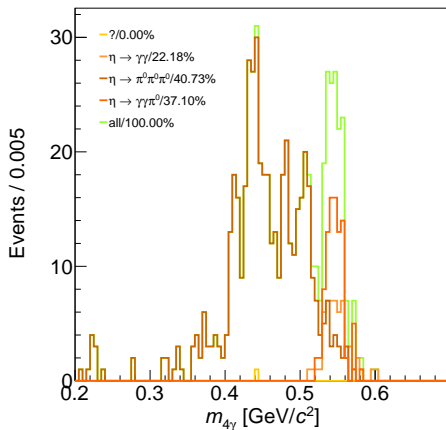
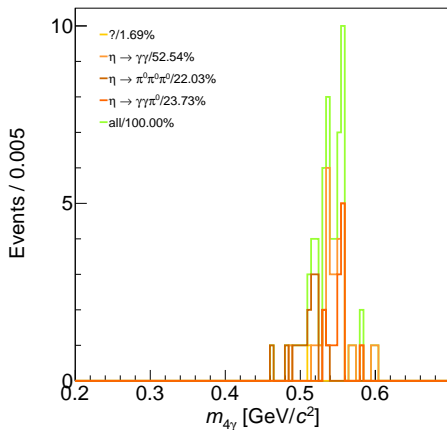
- Left, Fisher
- Right, BDT
- Invariant mass from measured P4



# TMVA, GlueX

All photons in FCAL + 3 or more photons in insert,  $\text{rejec } \bar{z} < 0.9$

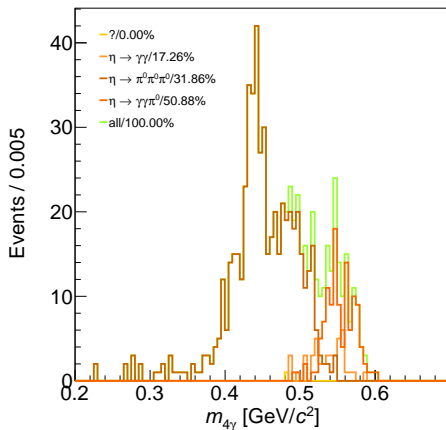
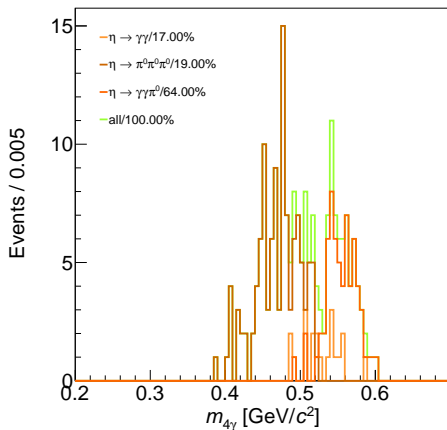
- Left, Fisher
- Right, BDT
- Invariant mass from fitted P4



# TMVA, JEF

All photons in FCAL + 3 or more photons in insert,  $\text{rejec } \bar{z} < 0.9$

- Left, Fisher
- Right, BDT
- Invariant mass from measured P4





# TMVA, JEF

All photons in FCAL + 3 or more photons in insert,  $\text{rejec } \bar{z} < 0.9$

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- Right, BDT
- Invariant mass from fitted P4

