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

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for the GlueX Collaboration

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Introduction

Reaction filter: $\gamma p \to \gamma\gamma\gamma\gamma p$
Events with two photon pairs with invariant masses, $m_{\gamma\gamma}$, with

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

are discarded
Events with

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

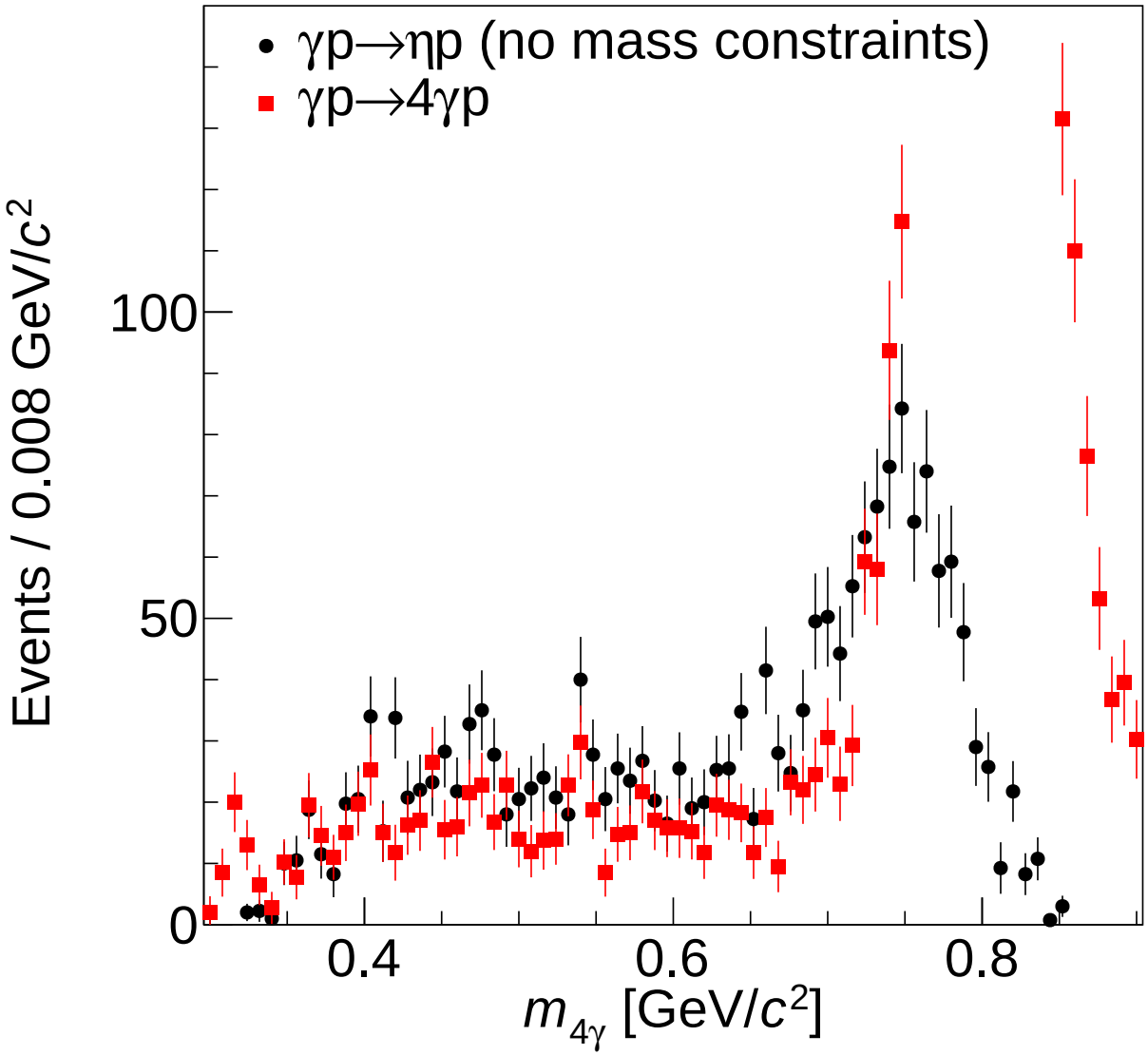
are selected. Best surviving combination is selected by a χ^2 test (solely based on final state photons)
Addition (loose) selection criteria

- Extra energy
- Extra tracks
- Kinematic fit χ^2
- Coplanarity
- Missing mass squared
- Elasticity

2017 "Winter" data set

All photons are in FCAL and at least 3 photons with polar angle below 4.5^o

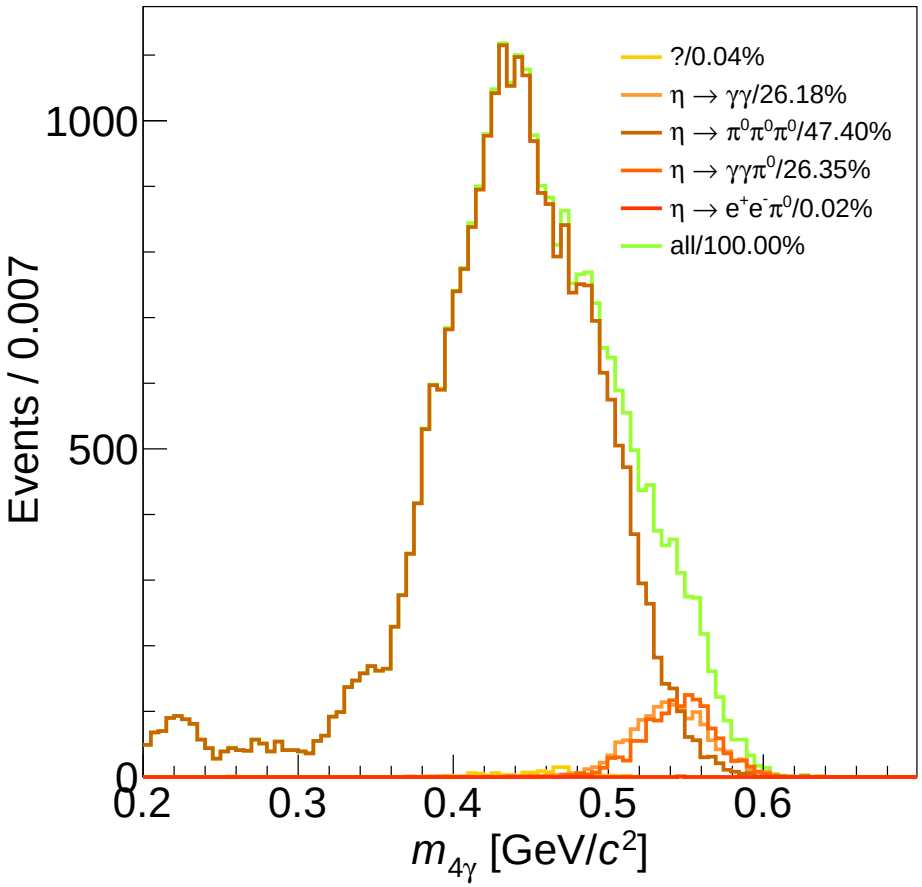
(1_14__17_14 with 17__7__1 and M7/M17 has a fiducial cut)

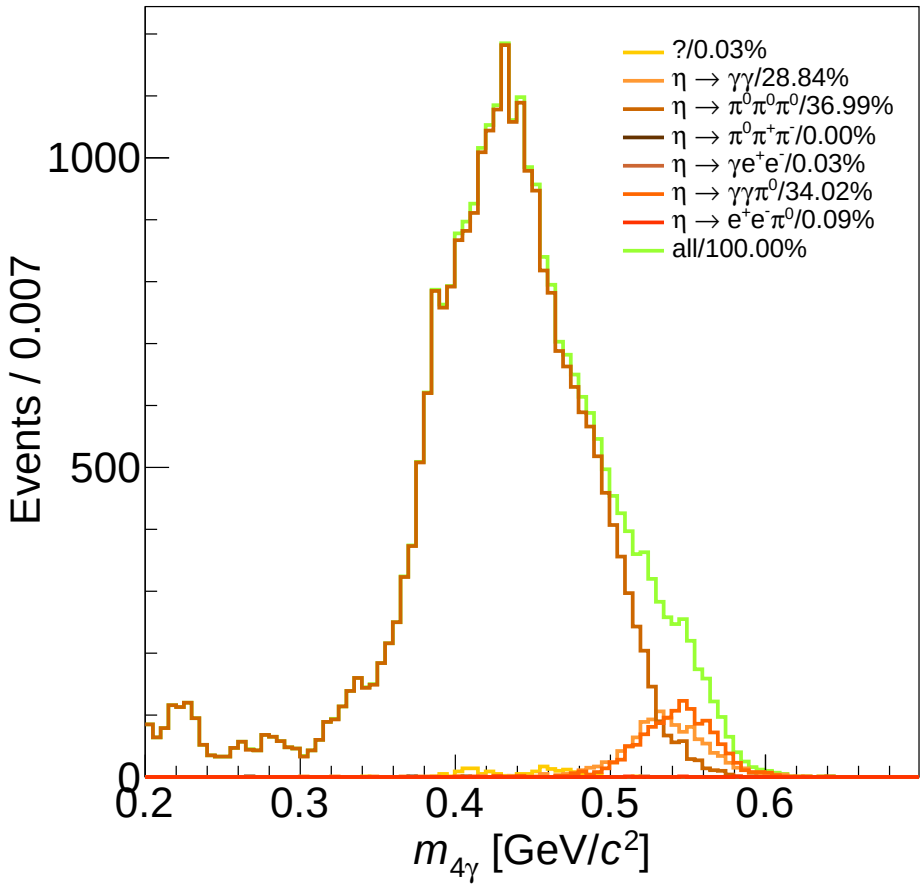


η simulation samples

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 MeV/c^2, peaking background!

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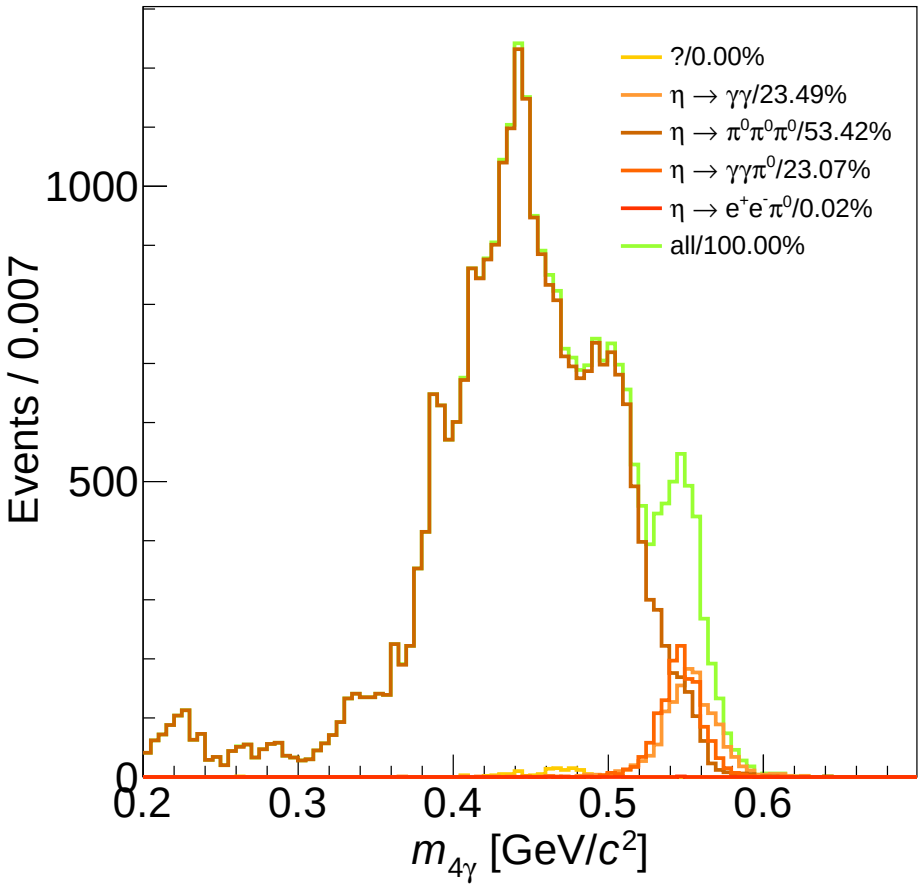
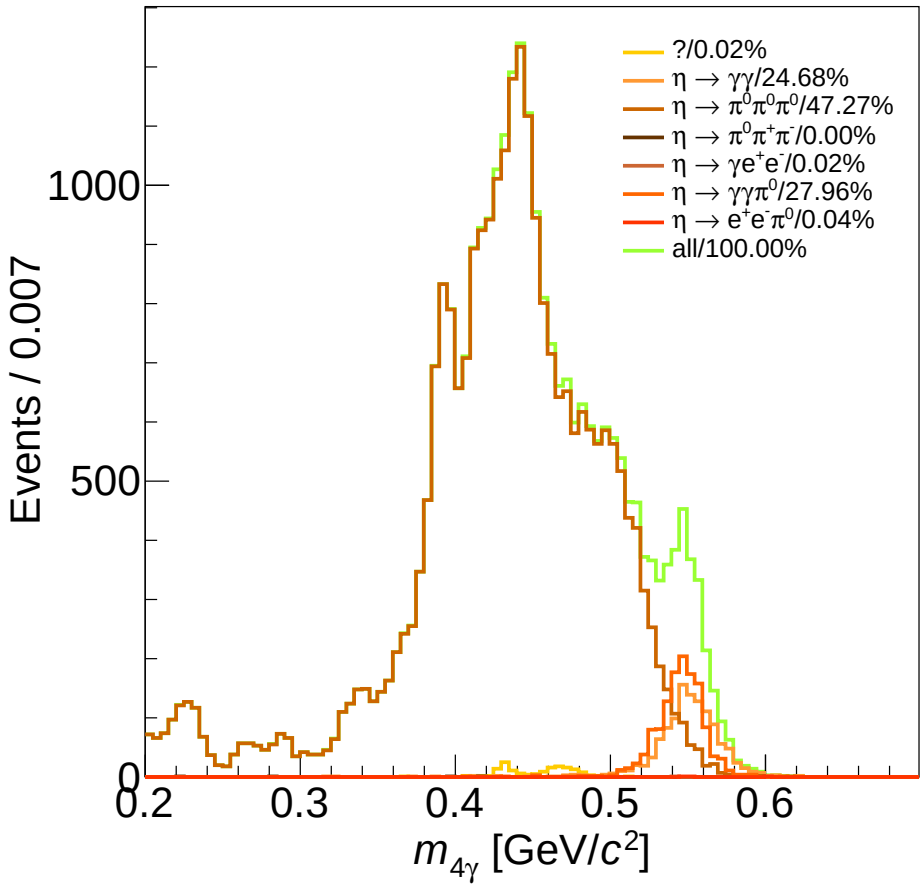


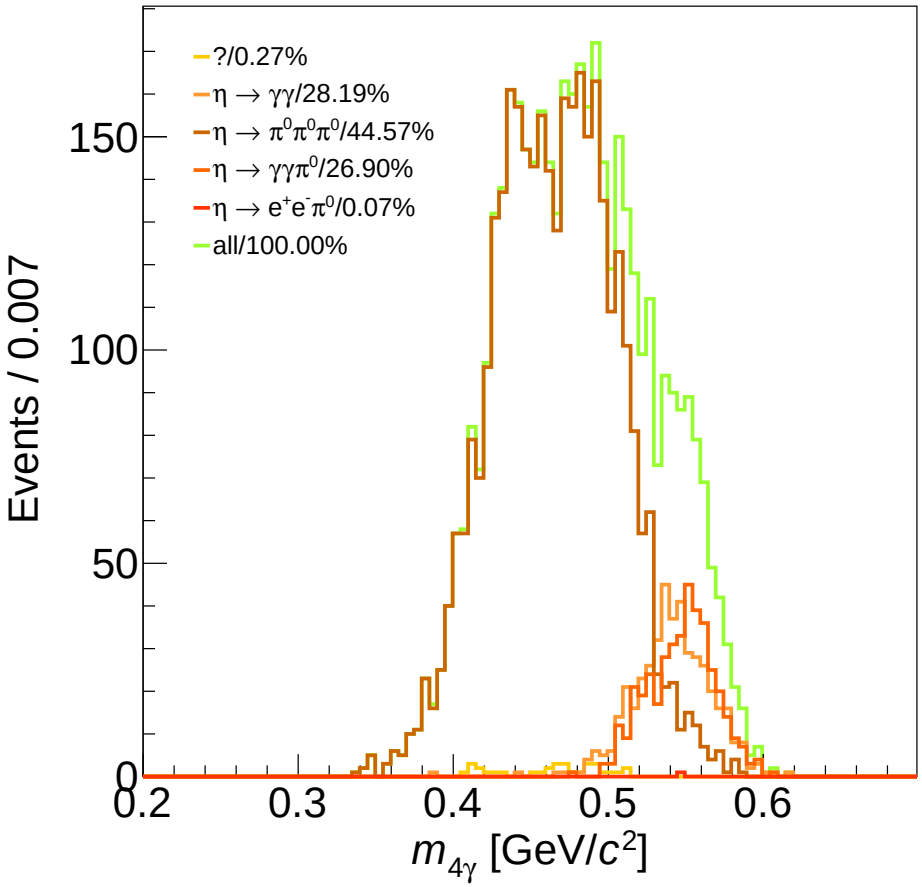


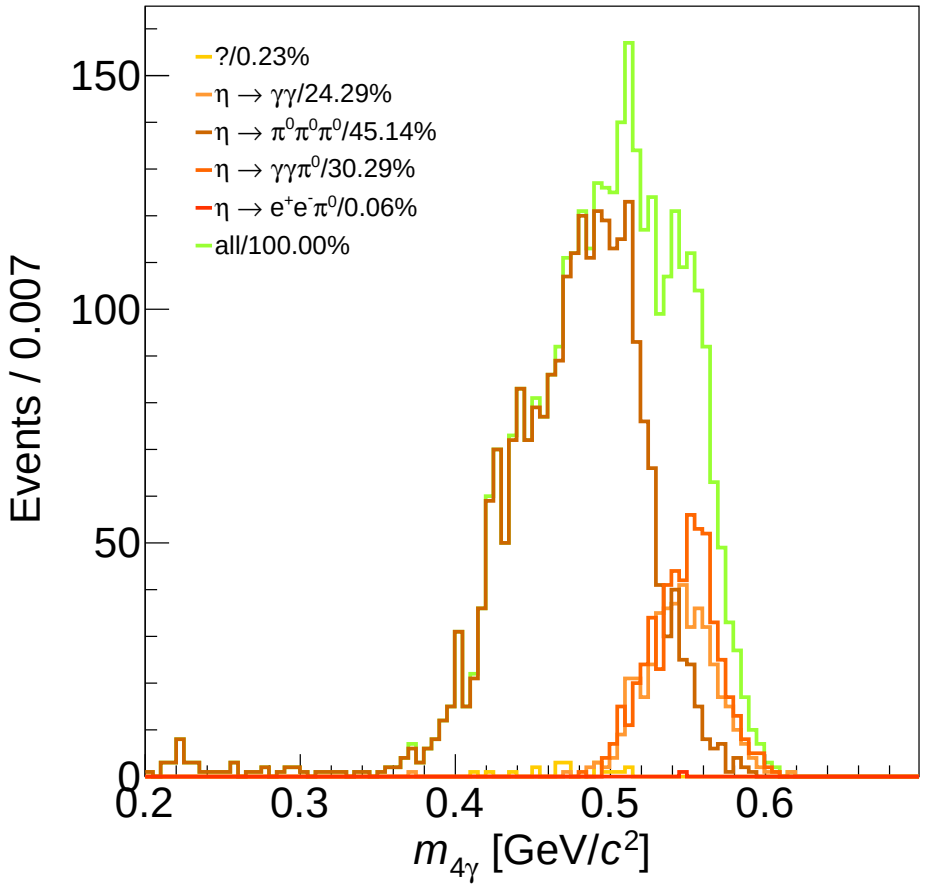
Percentage calculated between 510 and 590 MeV/c^2, peaking background!

TMVA, GlueX

All photons in FCAL + 1 or more photons below 4.5^o, ring > 4, rejec > 0.7

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





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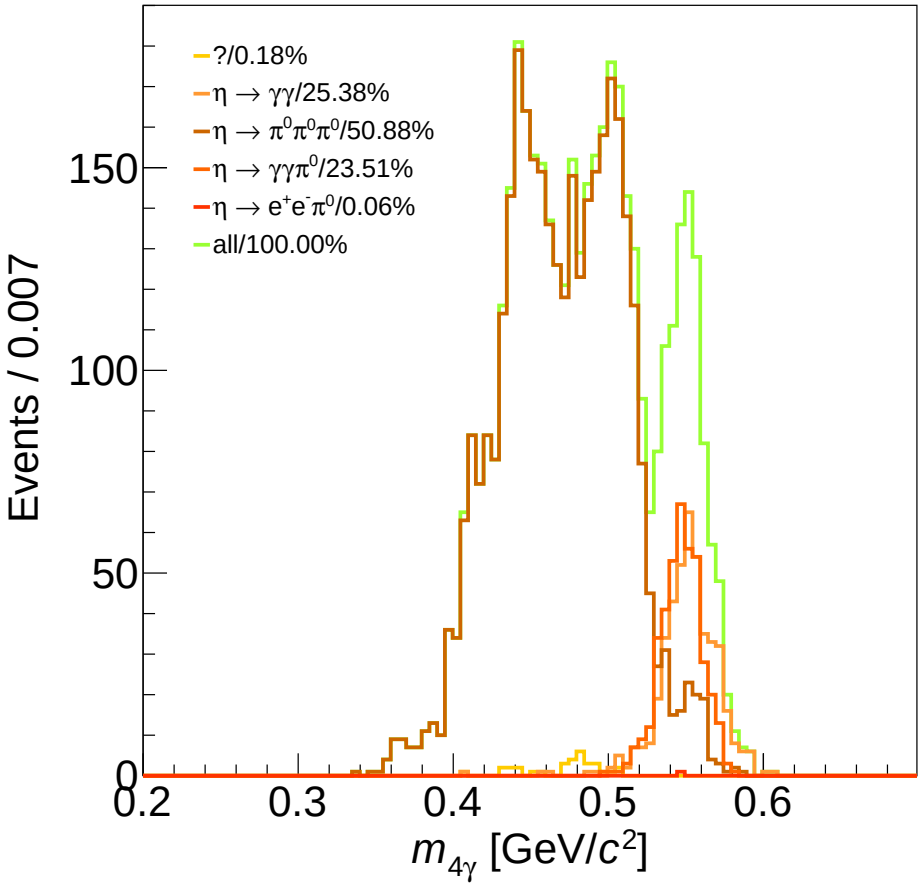

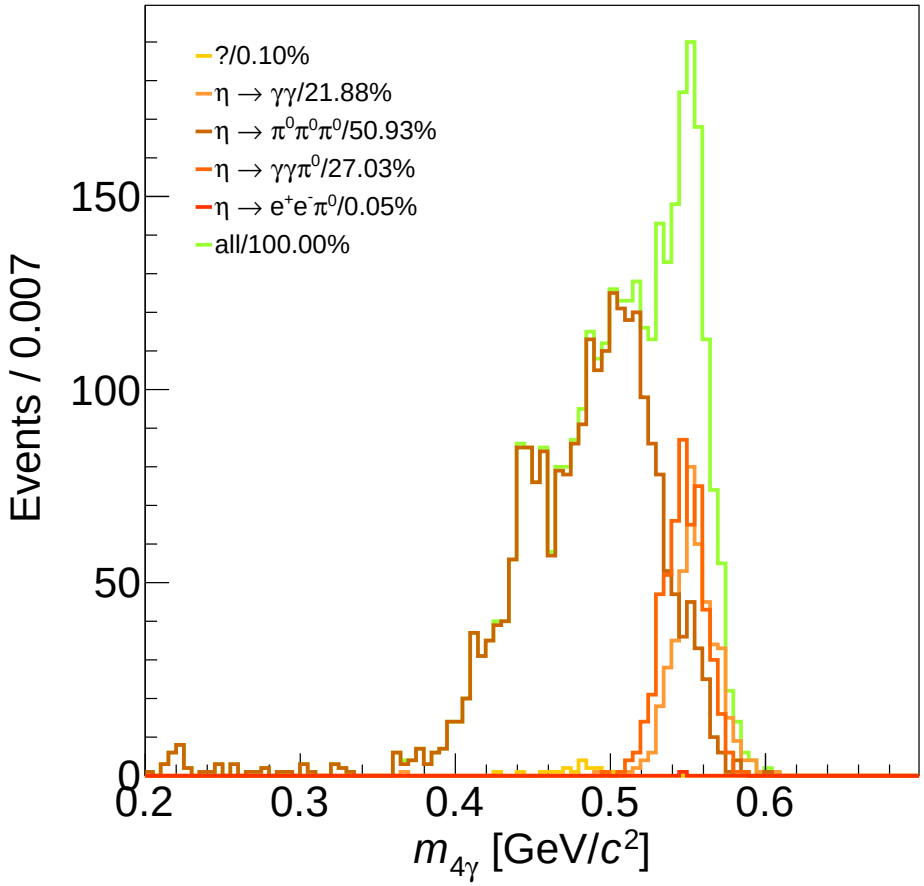

Peaking background, if fitted P4 used in $3\pi^0$ also (depending of selection critiria)!

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All photons in FCAL + 1 or more photons in insert, ring > 4, rejec > 0.7

- Left, Fisher
- Right, BDT
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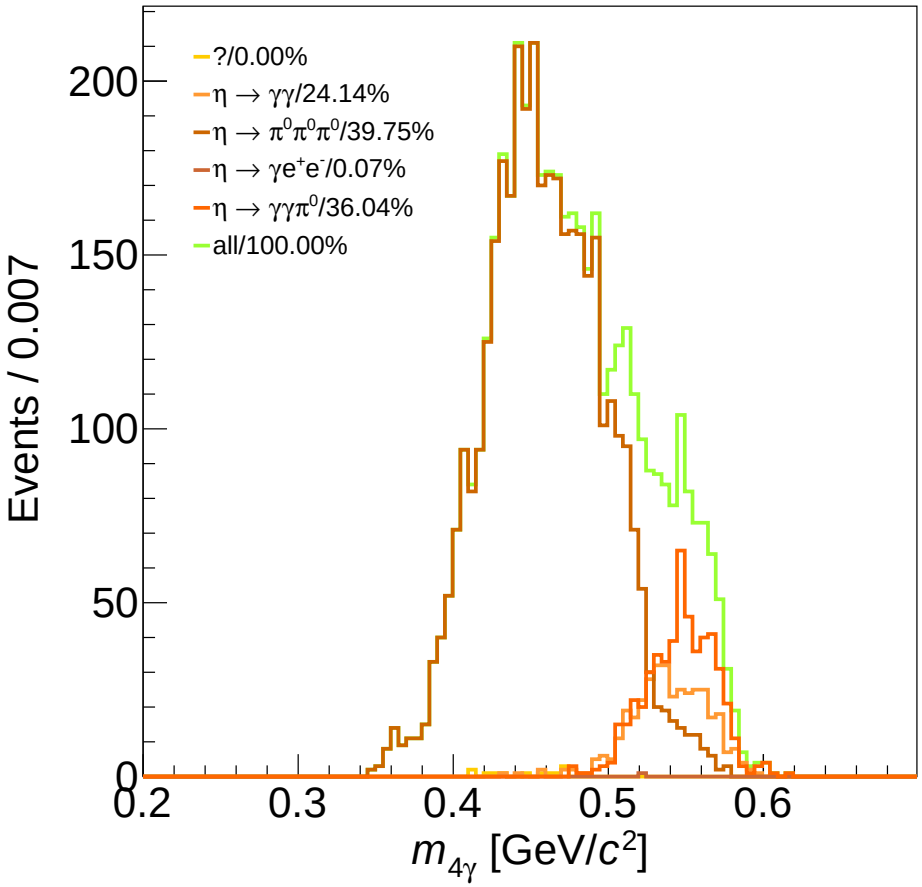

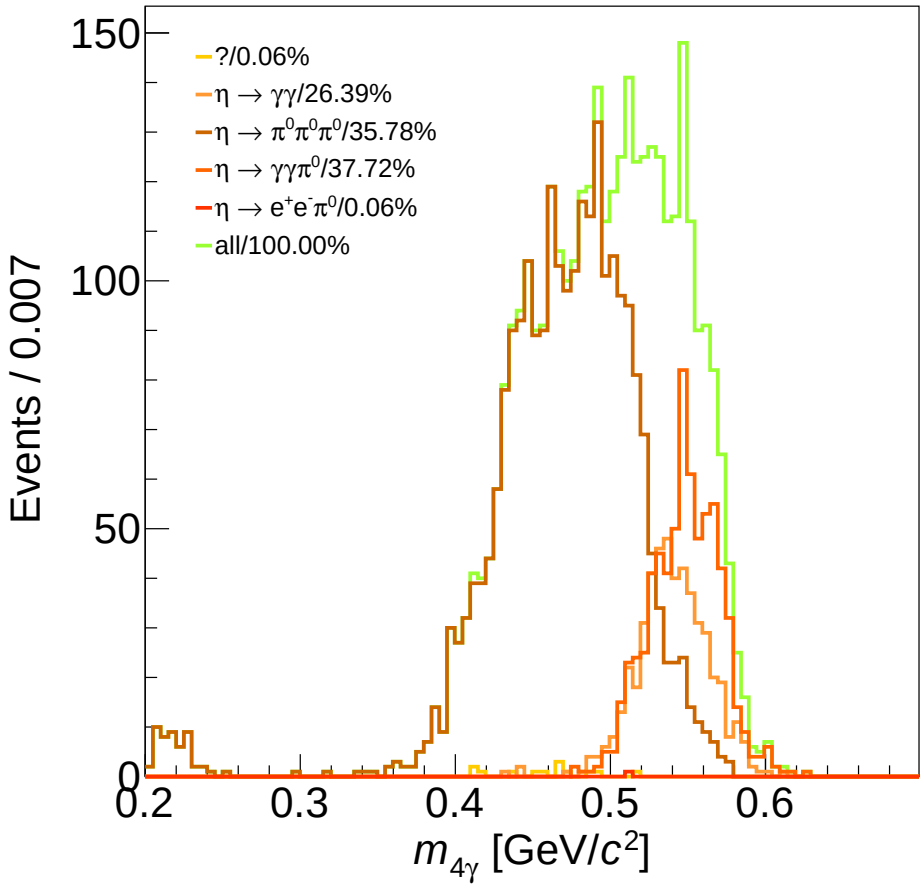

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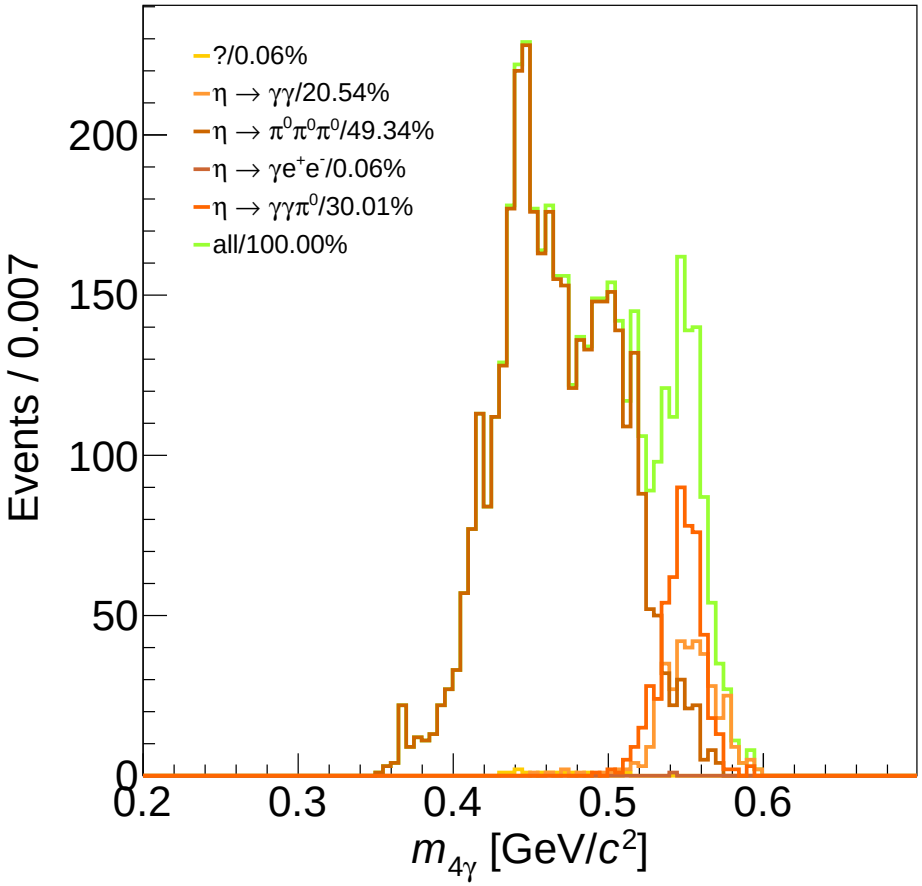
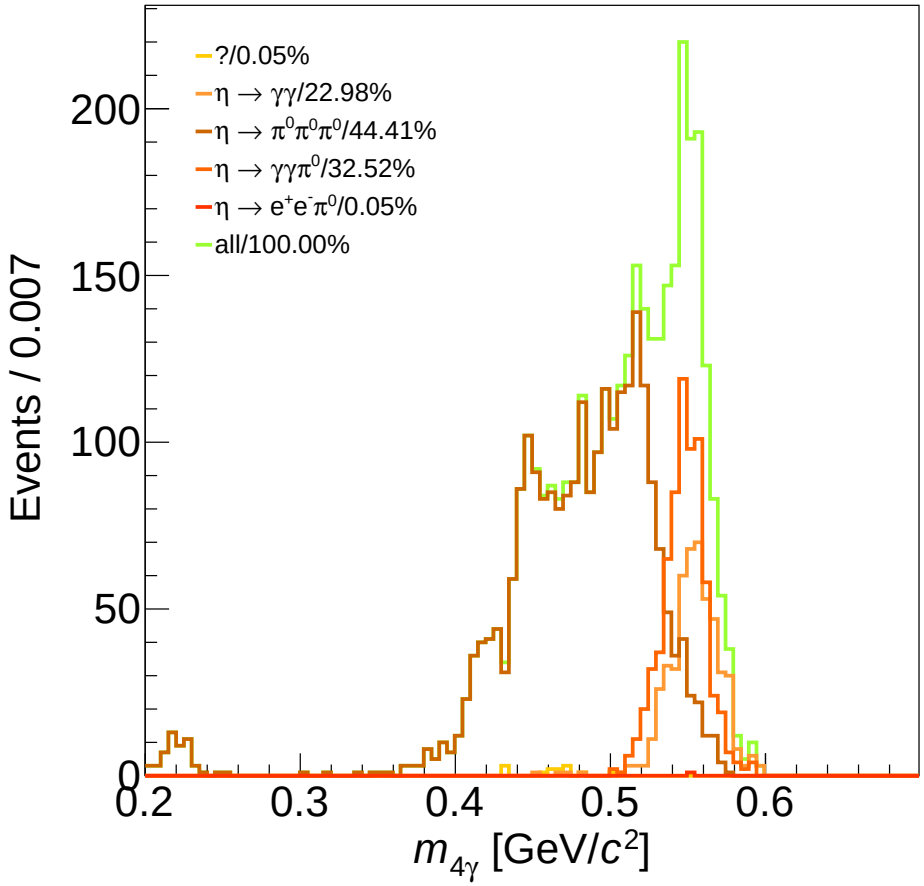




Peaking background, if fitted P4 used in $3\pi^0$ also (depending of selection critiria)!

Some numbers

For 50M η, we expect 13500 $\eta \to \gamma\gamma\pi^0$

Version	Acceptance	Counts w/o cuts	Detection efficiency	Counts w/ cuts
FCAL	0.0987	1333	0.039	536
FCAL2	0.0948	1281	0.051	695

w/o cuts:

- If photons in FCAL, ring > 4

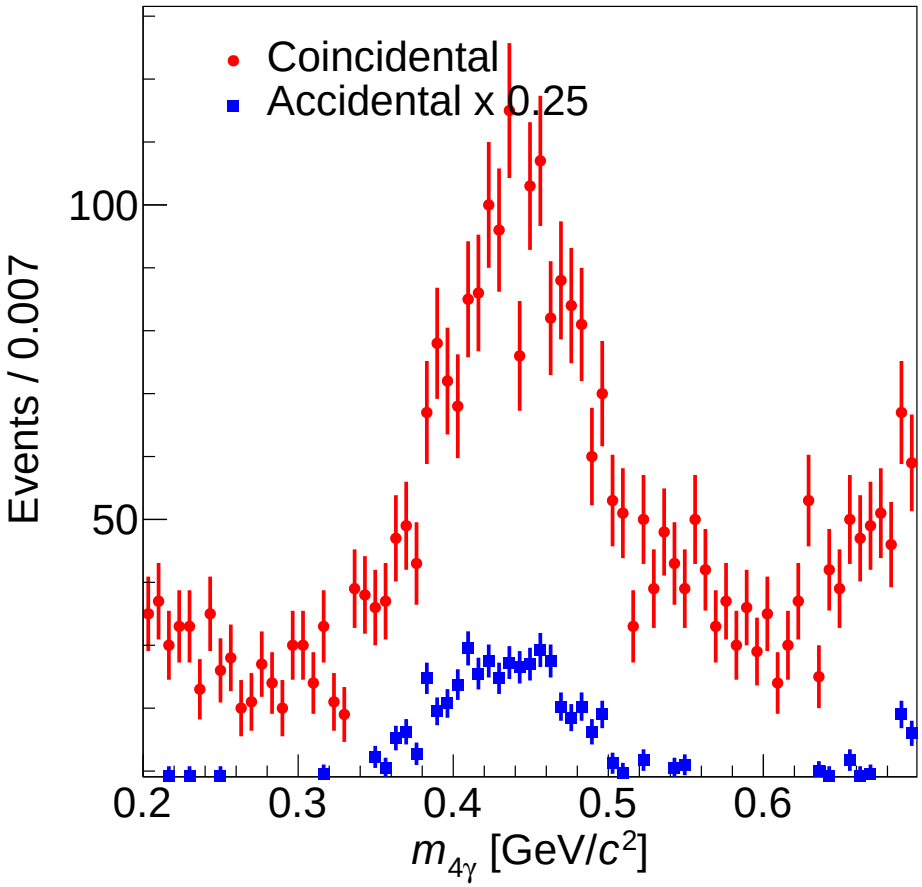
w/ cuts:

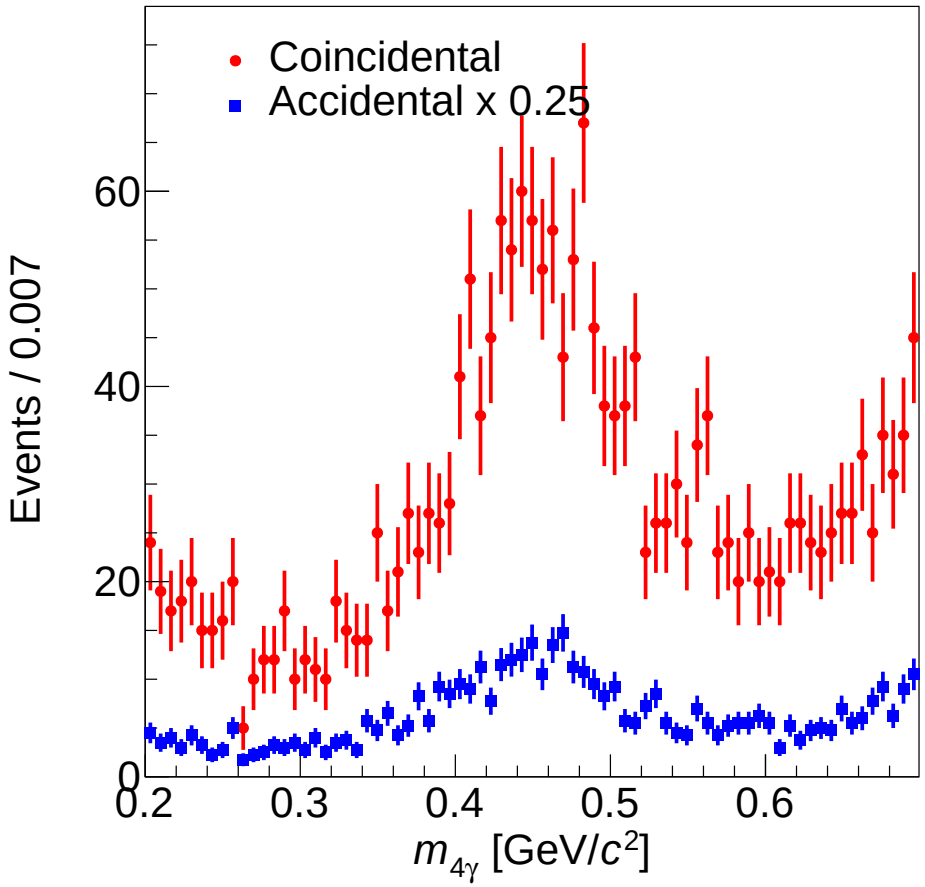
- All photons in FCAL, ring > 4
- 1 or more photons in insert or below 4.5^o
- BDT, rejec > 0.7

2017 "Winter" data set

Selection critiria (1_14___1_1_1_1_14):

- All photons in FCAL, ring > 4
- 1 or more photons below 4.5^o
- Left, measured P4 / Right, fitted P4





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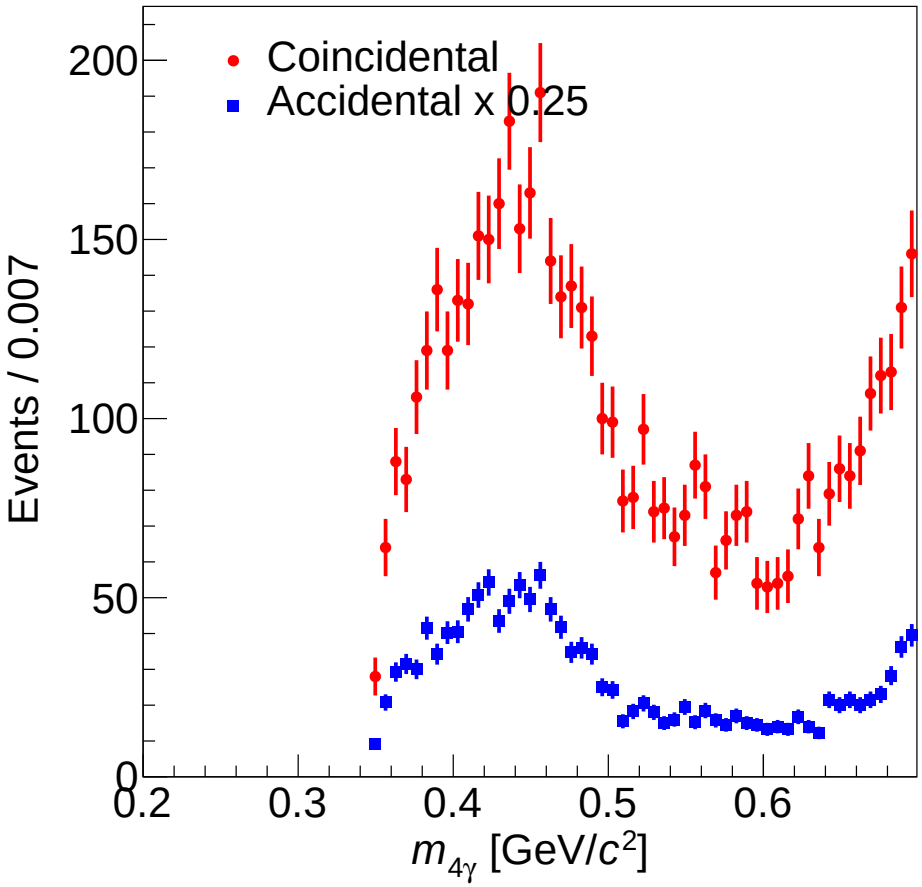
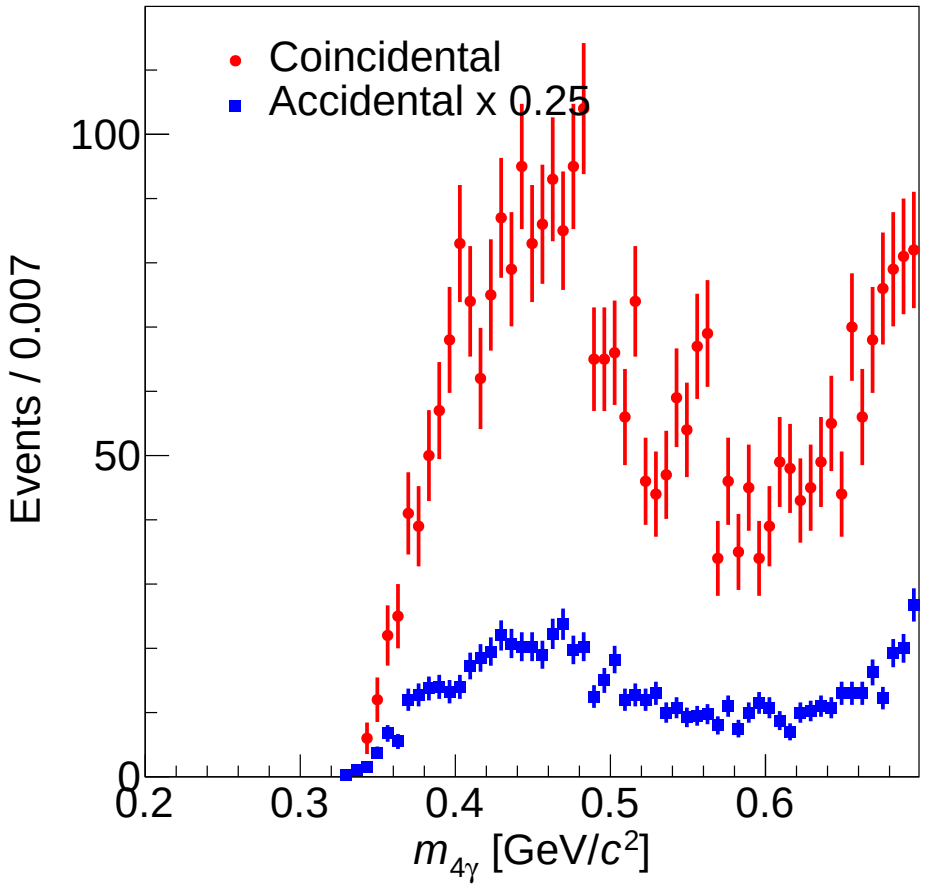
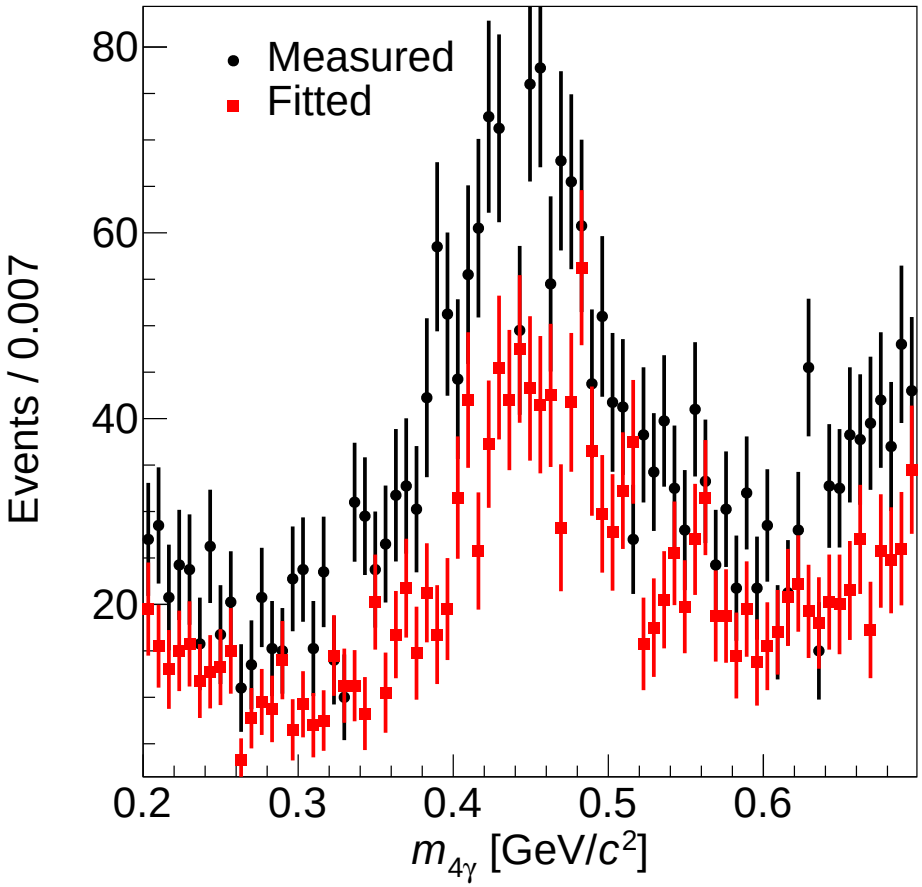


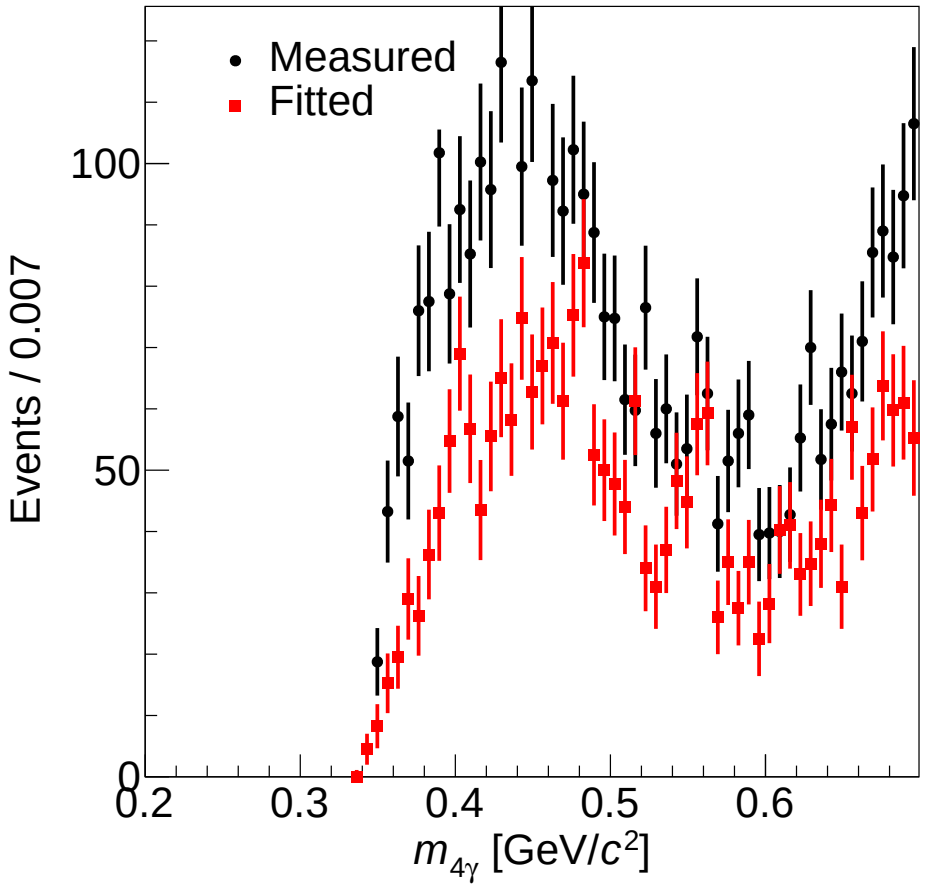


2017 "Winter" data set

Comparison between the 2 RF and measured/fitted

- All photons in FCAL, ring > 4
- 1 or more photons below 4.5^o
- Left, 1_14___1_1_1_1_14/ Right, 1_14__17_14 with 17__7__1 and M7/M17





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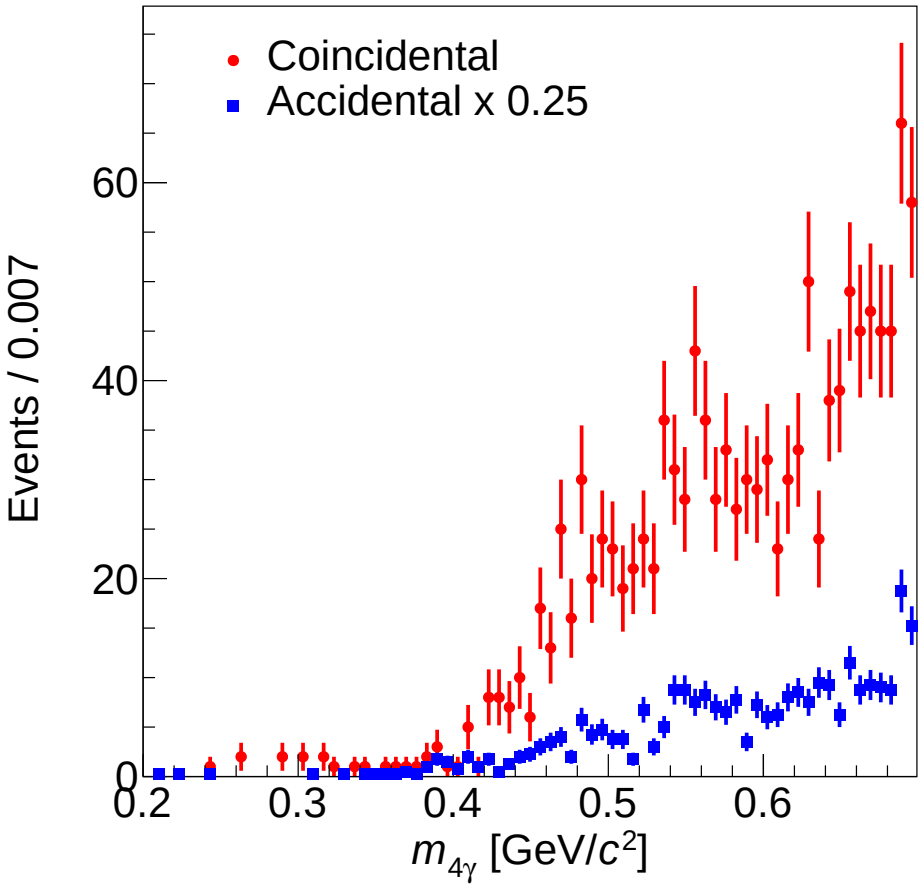

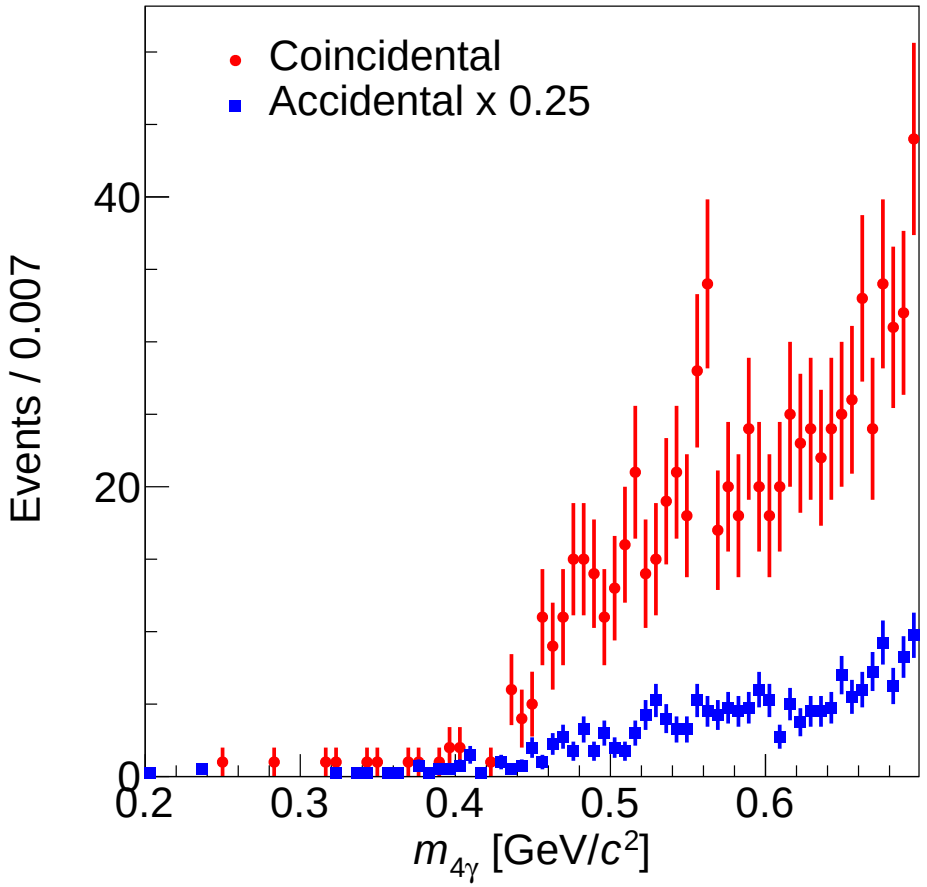

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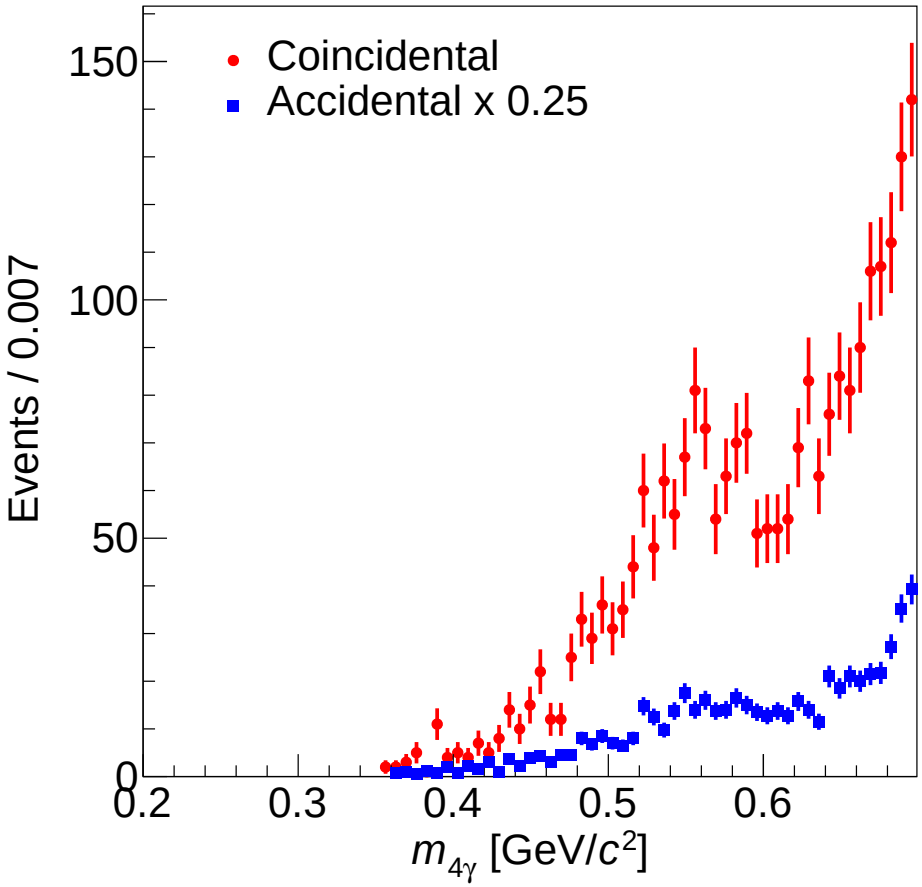
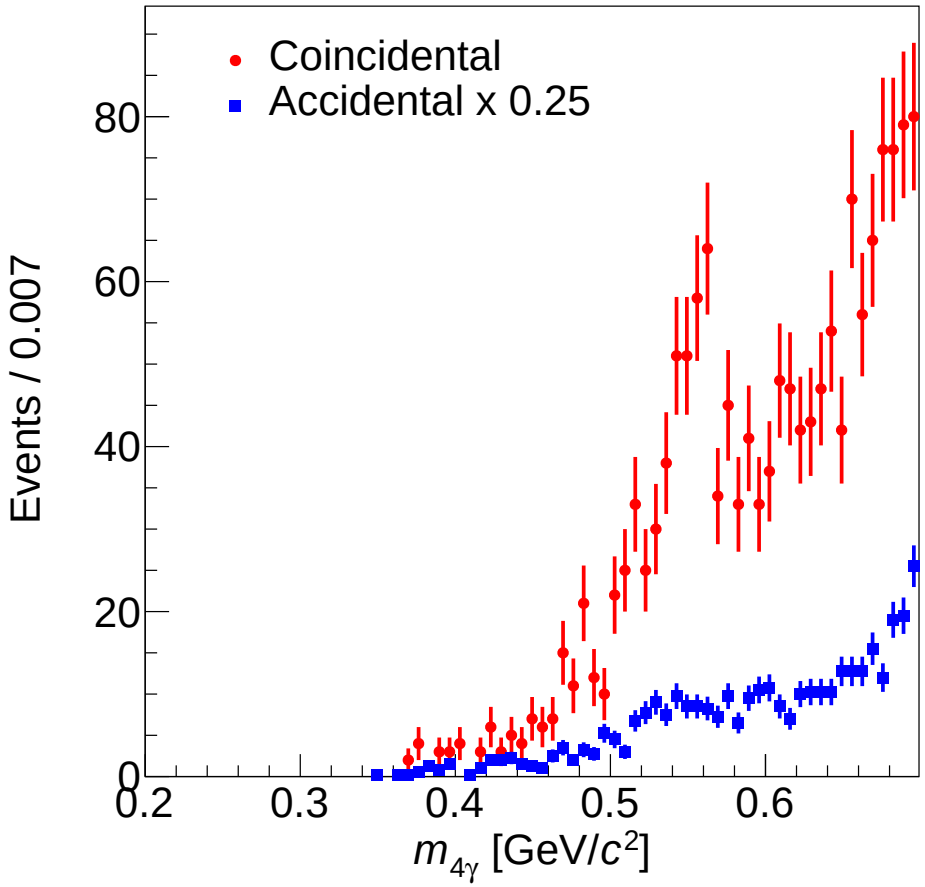
- BDT > 0.7
- Left, measured P4 / Right, fitted P4





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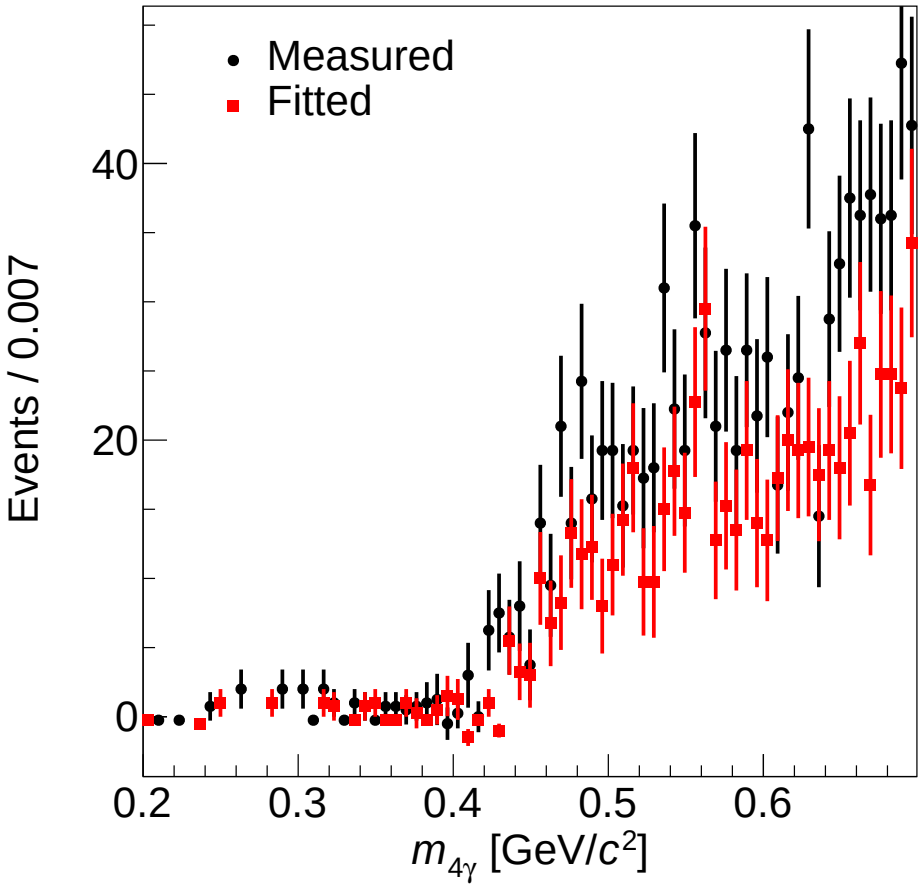
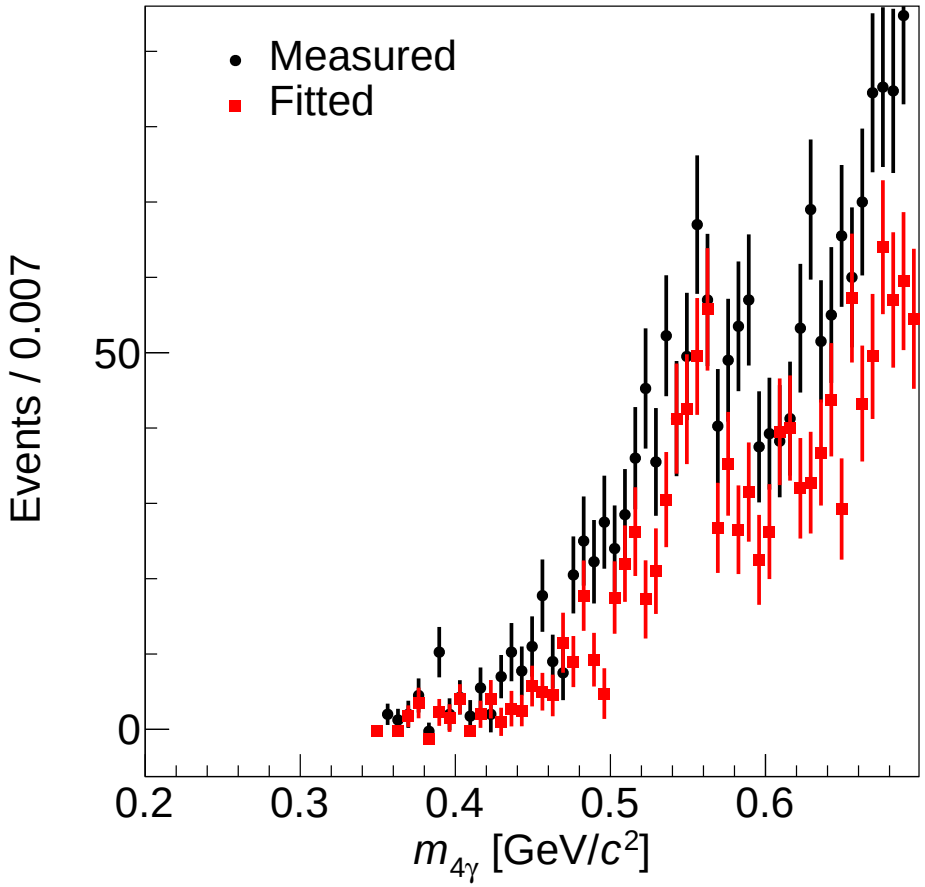
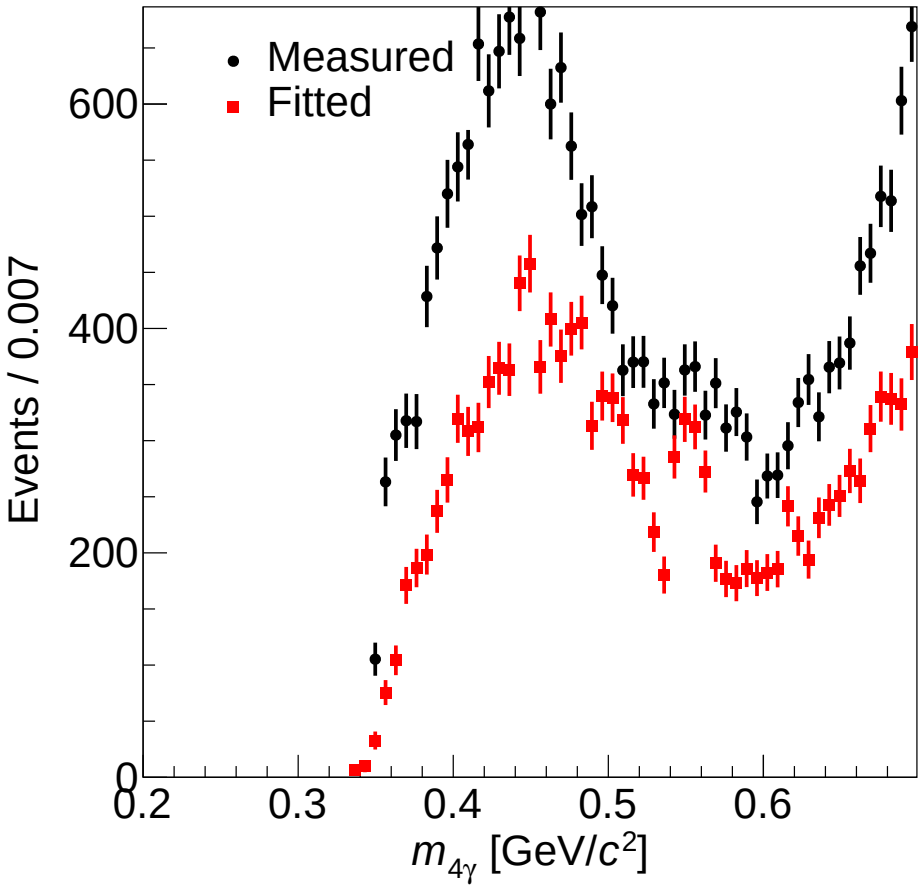


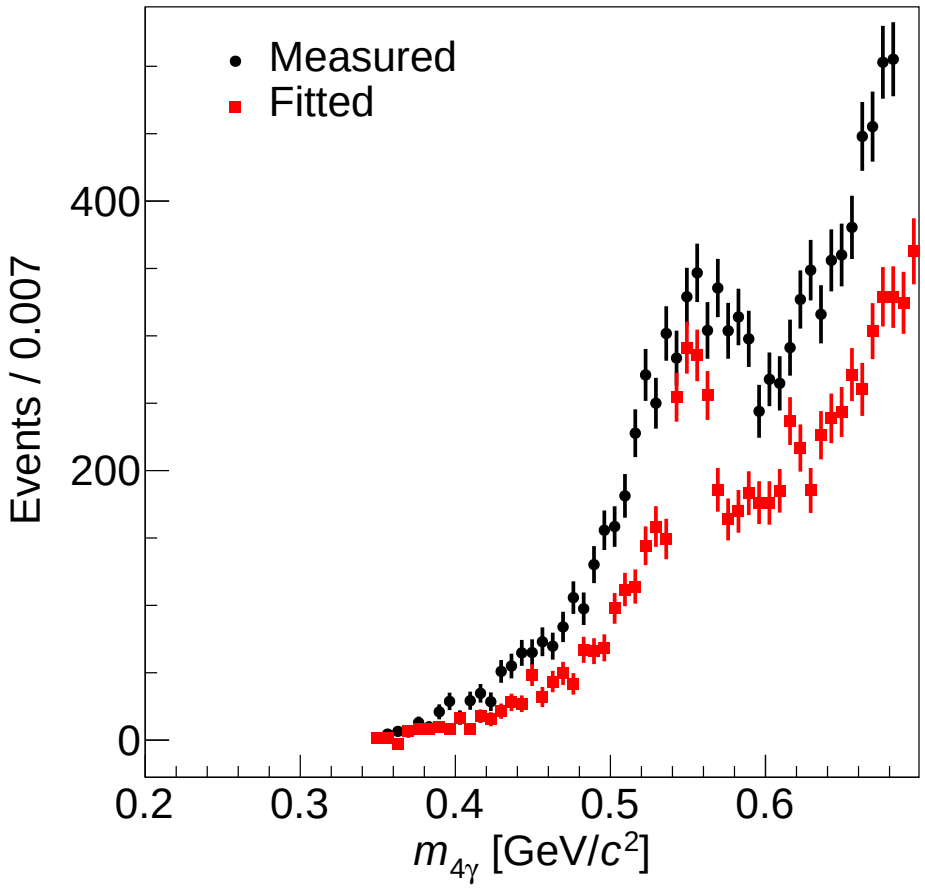


2017/2018 data sets

1_14__17_14 with 17__7__1 and M7/M17

- All photons in FCAL, ring > 4
- 1 or more photons below 4.5^o
- Left, no BDT cut/ Right, BDT > 0.7





Conclusion

In progress but selection critiria/MVA might enhance an already existing peaking background!