π^0 background to DVCS

Update by S. Fazio (BNL) – Exclusive Processes W.G. – April 3nd, 2020

❑ Why we worry about a background from "$\pi^0 \rightarrow \gamma\gamma$" ?

    1) The two decay photons could merge into one

    2) One of the photons could go out of the acceptance

❑ Our quick (short term) goal

- Evaluate the angular spread of the two decay photons
- study their distribution in pseudo-rapidity

❑ Context

- Cross section of exclusive π^0 still to be evaluated (PARTON group working on this…)
- Assumption: π^0 decay kinematics are the same as in the inclusive

THIS ANALYSIS:

Beam Energy: 18x275 GeV

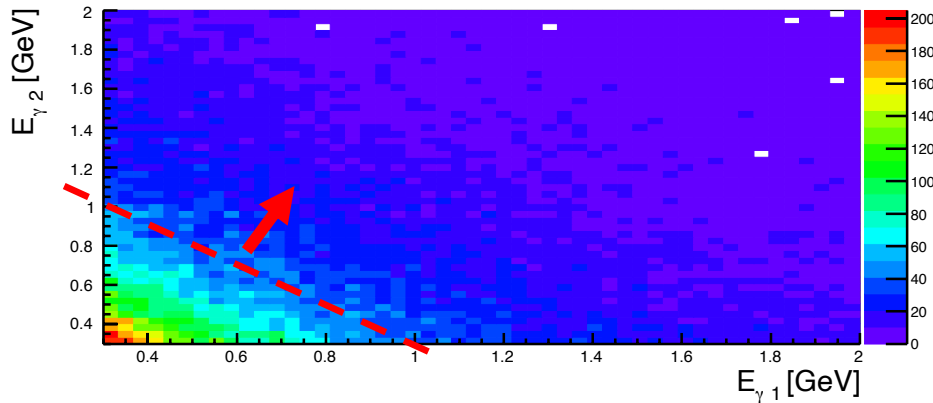PYTHIA min bias - tree: /eicdata/eic0009/PYTHIA/ep/TREES/pythia.ep.18x275.5Mevents.1.RadCor=0.Q2.all.root

Kinematical acceptance cuts
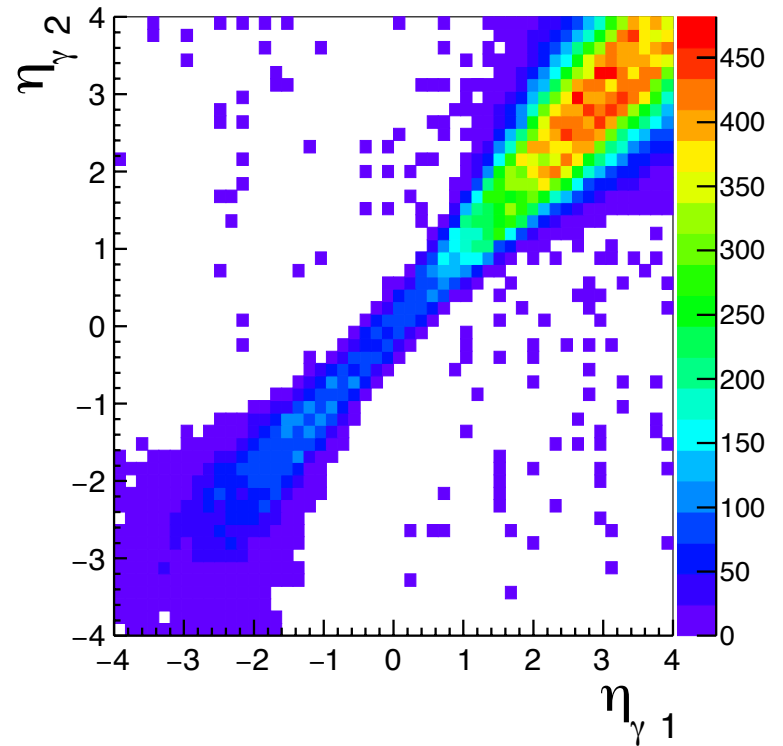
    $1 < Q^2 < 100$ GeV^2

    $0.01 < y < 0.95$

    $E_\gamma^{min} = 300$ MeV -> emc noise threshold

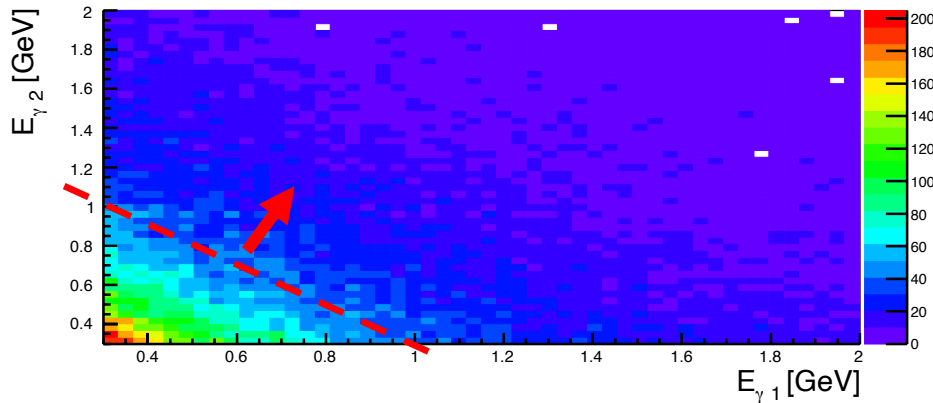# Kinematics of decay-photons

Things to keep in mind:

- DVCS has usually a selection cut at ~ $E\gamma$ > 1 GeV
- Most of the photon pairs from π^0 have much lower energy
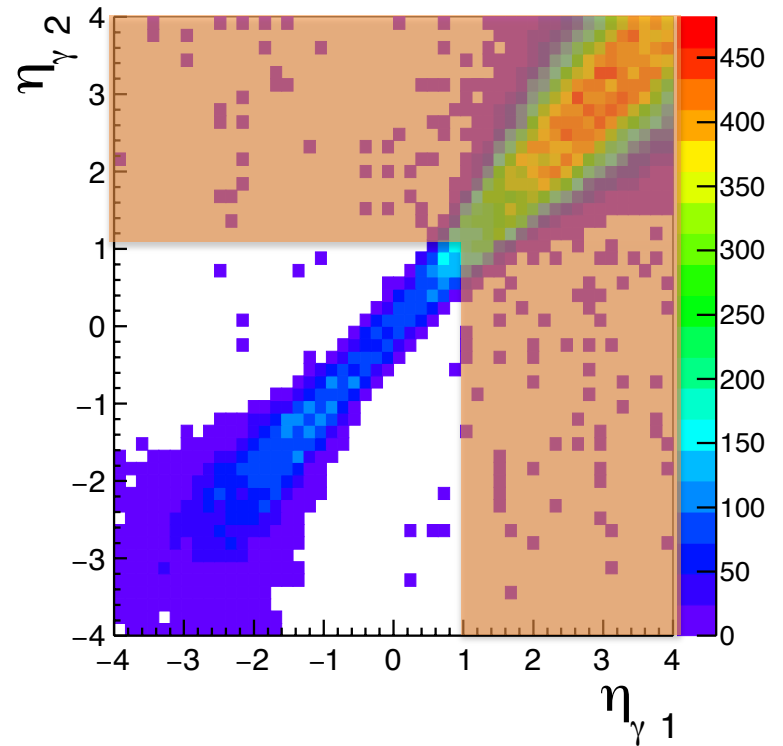

Things to keep in mind:

- DVCS has a veto on the FORWARD endcap (γ tend to go BACKWARDS)

Kinematics of decay-photons

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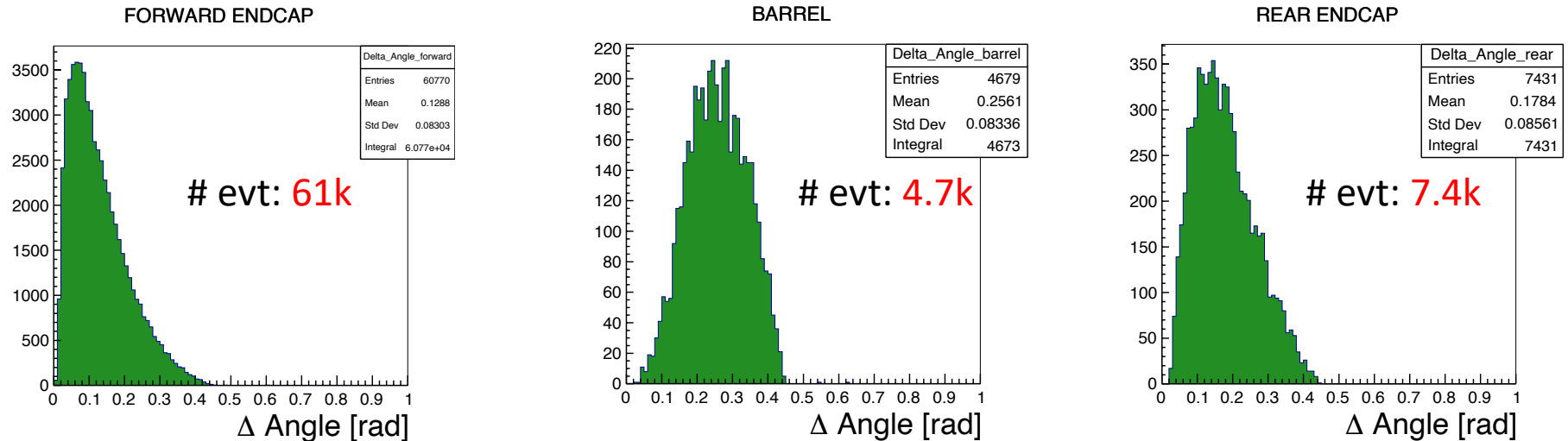- Most of the photon pairs from π^0 have much lower energy

Things to keep in mind:

- DVCS has a veto on the FORWARD endcap (γ tend to go BACKWARDS)
- Most of the photon pairs from π^0 go in the FORWARD endcap

Difference between angles of decay-photons

generated events: 5M

FORWARD ENDCAP

Delta_Angle_forward	
Entries	60770
Mean	0.1288
Std Dev	0.08303
Integral	6.077e+04

evt: 61k

Δ Angle [rad]

BARREL

Delta_Angle_barrel	
Entries	4679
Mean	0.2561
Std Dev	0.08336
Integral	4673

evt: 4.7k

Δ Angle [rad]

REAR ENDCAP

Delta_Angle_rear	
Entries	7431
Mean	0.1784
Std Dev	0.08561
Integral	7431

evt: 7.4k

Δ Angle [rad]

- Most of the π^0 events are below noise threshold
- Large majority that survives the cuts go FORWARD (i.e. into the vetoes endcap)
- In the barrel: significantly larger angular spread! (easier to discriminate)

LETS LOOK IN BINS OF MESON'S P_T ....>

Difference between angles of decay-photons
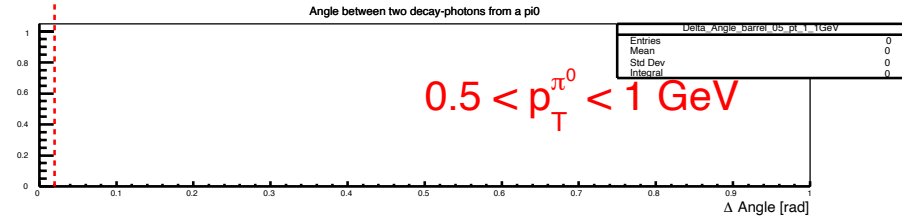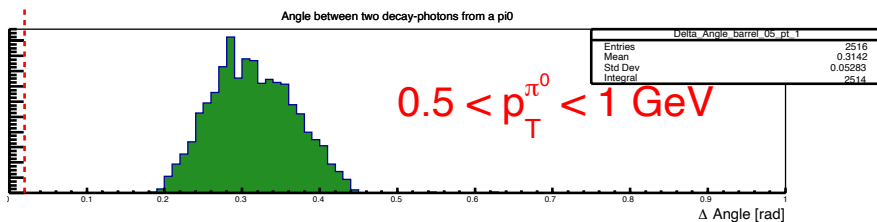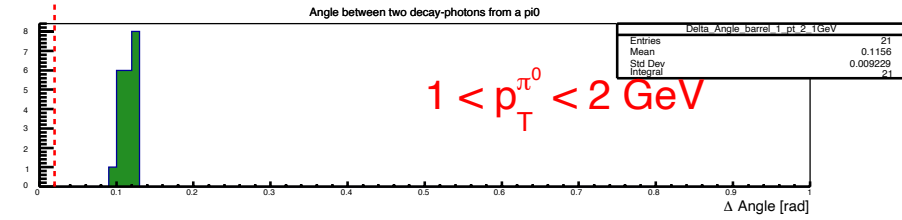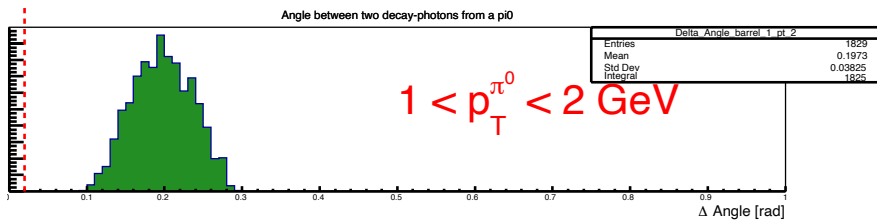## BARREL
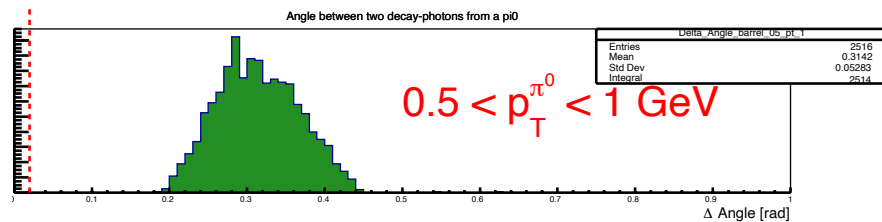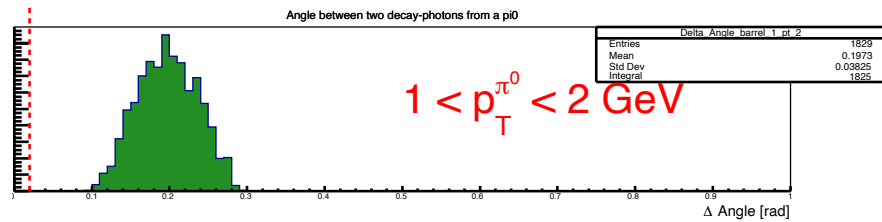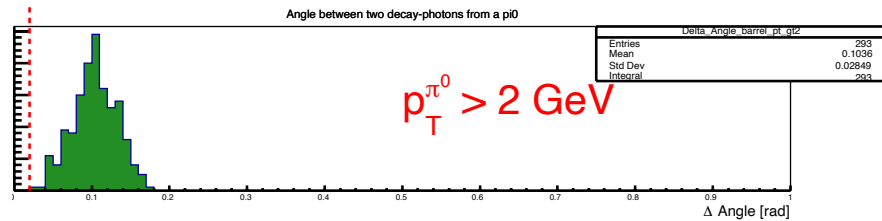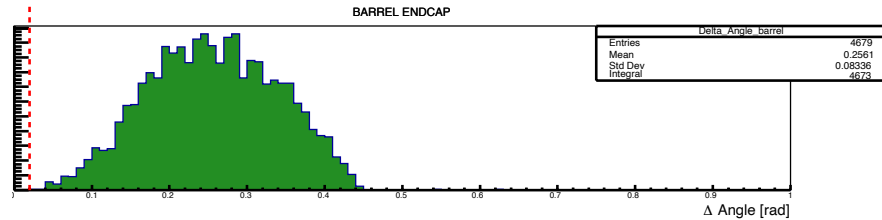
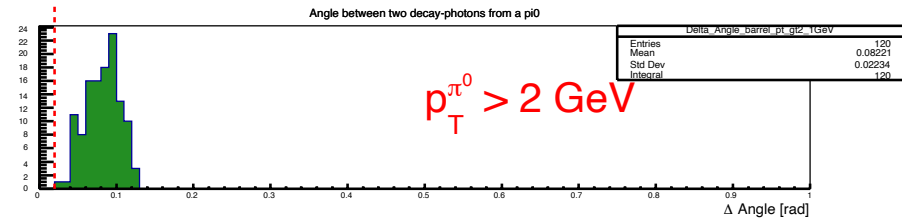**Min photon energy = 200 MeV**

Difference between angles of decay-photons
BARREL

Min photon energy = 200 MeV ⟶ **Min photon energy = 1 GeV**

$p_T^{\pi^0} > 2$ GeV

$1 < p_T^{\pi^0} < 2$ GeV

$0.5 < p_T^{\pi^0} < 1$ GeV

$p_T^{\pi^0} > 2$ GeV

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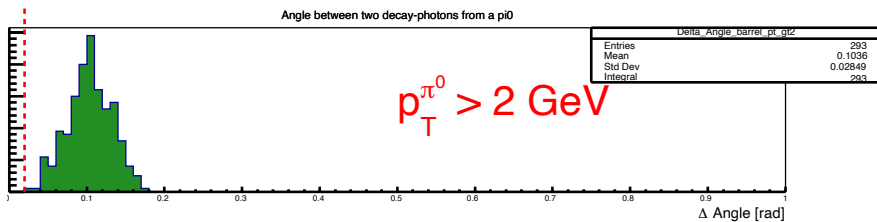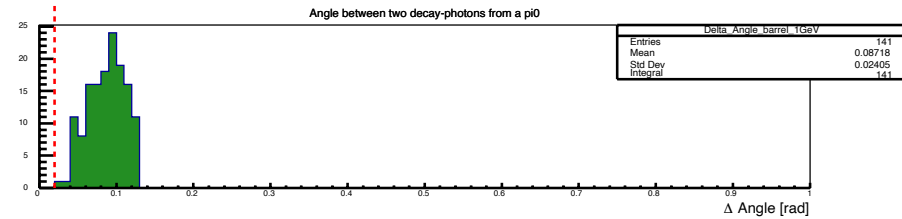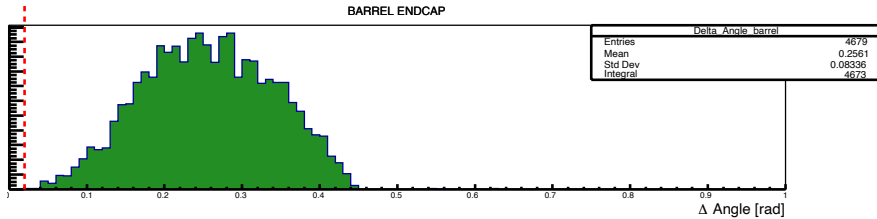
- Red line: ~ min **Δ** Angle that can be resolved with a barrel rad. ~1200mm and 25.4 cell size (A. Kiselev) → This configuration works well to fully suppress π^0 in the BARREL
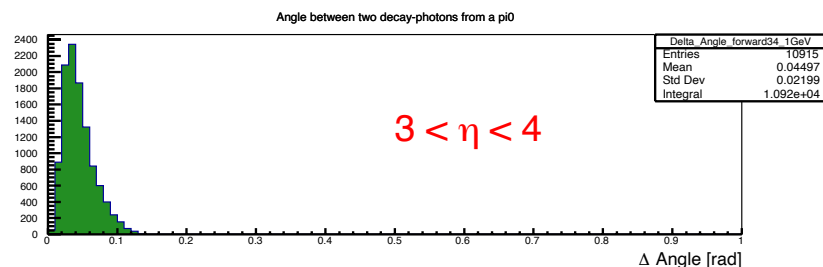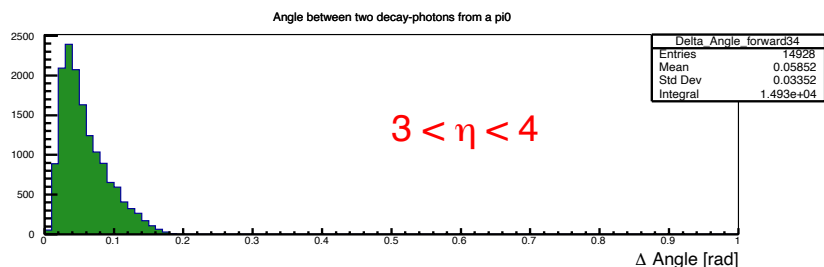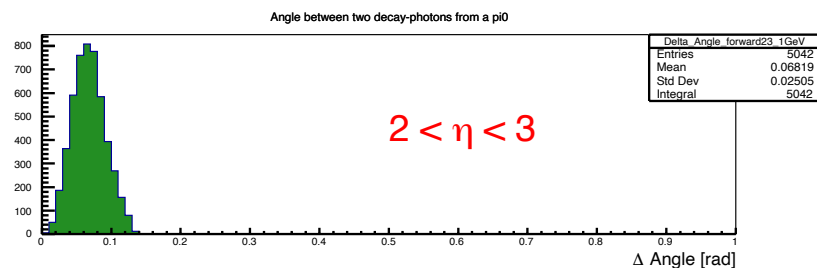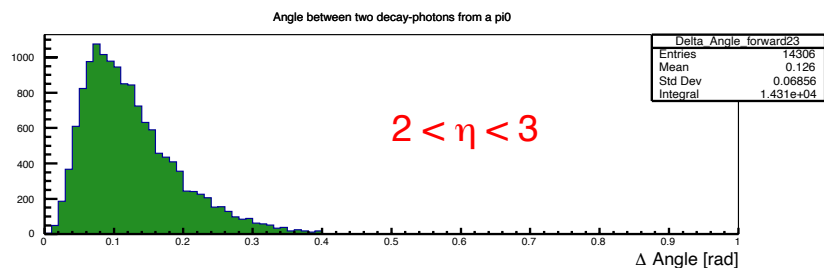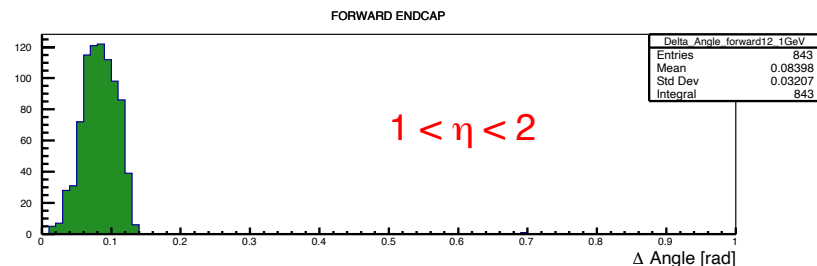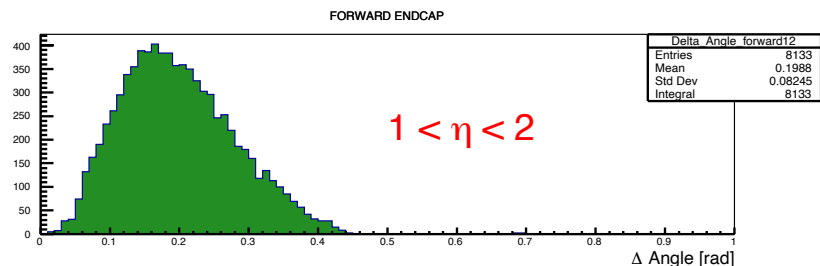
Difference between angles of decay-photons

FORWARD ENDCAP

Min photon energy = 200 MeV ⟶ **Min photon energy = 1 GeV**
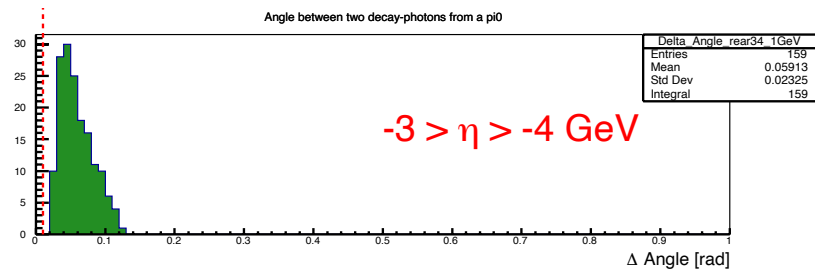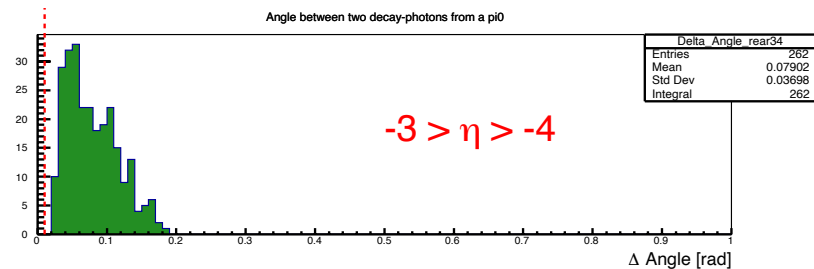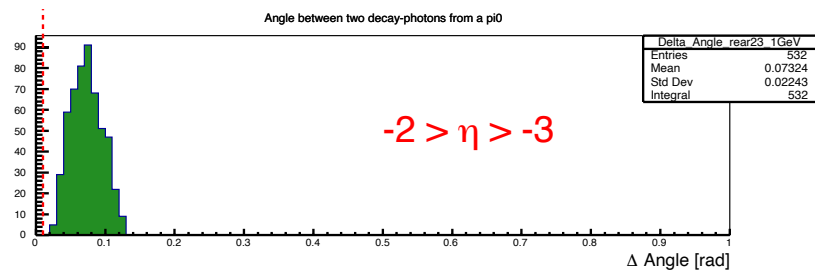

REMEMBER: this endcap is **vetoed** in a DVCS analysis
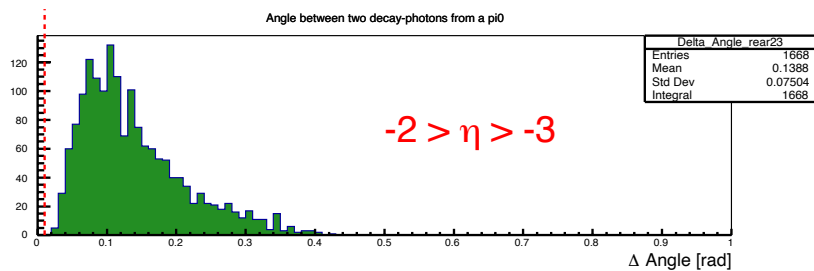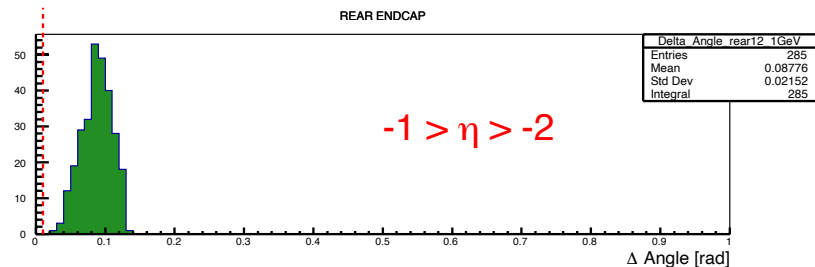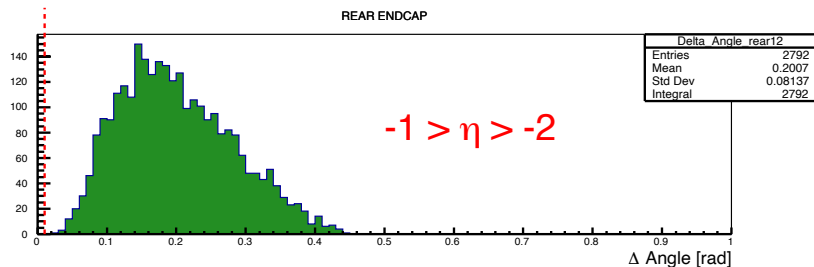
Difference between angles of decay-photons

REAR ENDCAP

Min photon energy = 200 MeV ⟶ **Min photon energy = 1 GeV**

- We would need to discriminate ~0.03(4) rad in the (rear) endcap
- Red line: ~ min Δ Angle that can be resolved with EmCal at 2500mm and 25.4 cell size (A. Kiselev) → This configuration works well to fully suppress π^0 in the REAR ENDCAP

Summary

- Simulation is for beam energy: 18x275 GeV

- Most of π^0 events do not survive selection criteria

    - Very low $E\gamma$

    - Photons going in the forward endcap

- To avoid 2γ merging into one

    - Discriminate down to **Δ**Angle ~<0.03(4) rad

    - If this is doable: bkgd. from π^0 can be suppressed to negligible (at the explored energy)

    - Current baseline configuration with a barrel rad. ~1200mm, rear endcap at 2500mm from I.P. and a 25.4 cell size **achieves this goal!**

- Only a very very small fraction of events in the backwards region goes close enough to the beam pipe that missing one photon can be a risk

TO BE STUDIED

- In case of particular detector configurations where full γ/π^0 cannot be achieved: we need a reliable cross section for exclusive $\pi^0 \rightarrow \gamma\gamma$ in order to correctly normalize the surviving background (if any)

- We need to study lower energies