Updates on $\eta \to \gamma\gamma\pi^0$

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GEMTRD

Simulation sets with

- Standard JEF geometry i.e. with DIRC
- Standard JEF geometry + GEMTRD (all four panels)
  - GEMTRD PAC proposal asks to add only one panel for 10 PAC days or 10% of JEF's allocated PAC days
  - GEMTRD is expected to stop γ with momentum below 200 MeV/c
- Standard JEF geometry without DIRC

Photon selection criteria

Events with 4 FCAL clusters

- FCAL, 3 ns within RF and cluster energy above 250 MeV
- CCAL not used
- TOF & BCAL veto
  - TOF, 0.5 ns within RF to avoid removing events backsplashing
  - $|\mathrm{x_{TOF}} - \mathrm{x_{FCAL}}| > 6$ cm and $|\mathrm{y_{TOF}} - \mathrm{y_{FCAL}}| > 6$ cm
  - BCAL, 6 ns within RF, if not matched with a track

Without discarding events with out of sync photons/tracks but still be able to veto if needed non-recontructed tracks creating a cluster in BCAL

Proton selection criteria

Events with one track, no PID and no timing selection criteria applied

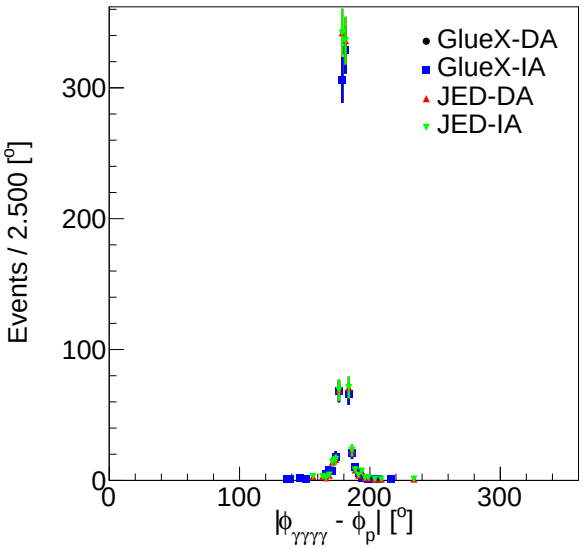
$\gamma\gamma\pi^0$ selection criteria

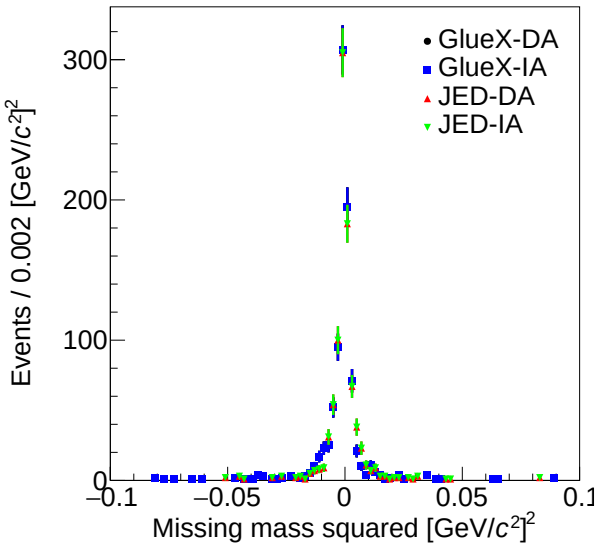
Out of 4 photons, there are 6 combinations to reconstruct $\gamma\gamma\pi^0$ final state

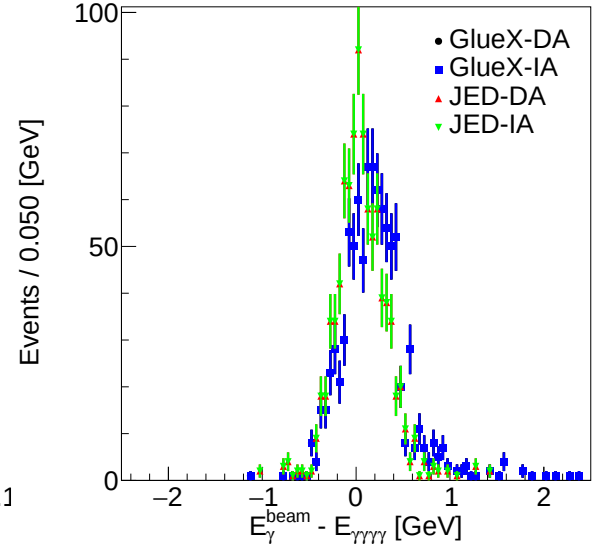
- For each combination, up to 7 different final states are reconstructed
  - $\pi^0\pi^0$
  - $\pi^0\eta$
  - $\pi^0\eta'$
  - $\eta\eta$
  - $\eta\eta'$
  - $\eta'\eta'$
  - $\gamma\gamma\pi^0$
- All final states passing the "mass" selection criteria are selected and their corresponding $\chi^2 = \sum(\frac{m_{th}-m_{exp}}{\Delta m_{exp}})^2$ is calculated
- For each event, the final state with the best χ^2 is selected
- $\pi^0\pi^0$ veto applied i.e. cut in $m_{\gamma\gamma}$

$\gamma p \to \eta(\to \gamma\gamma\pi^0)p$ selection criteria

- Coplanarity fullfilled
- Missing mass squared consistent with zero
- Elasticity fullfilled



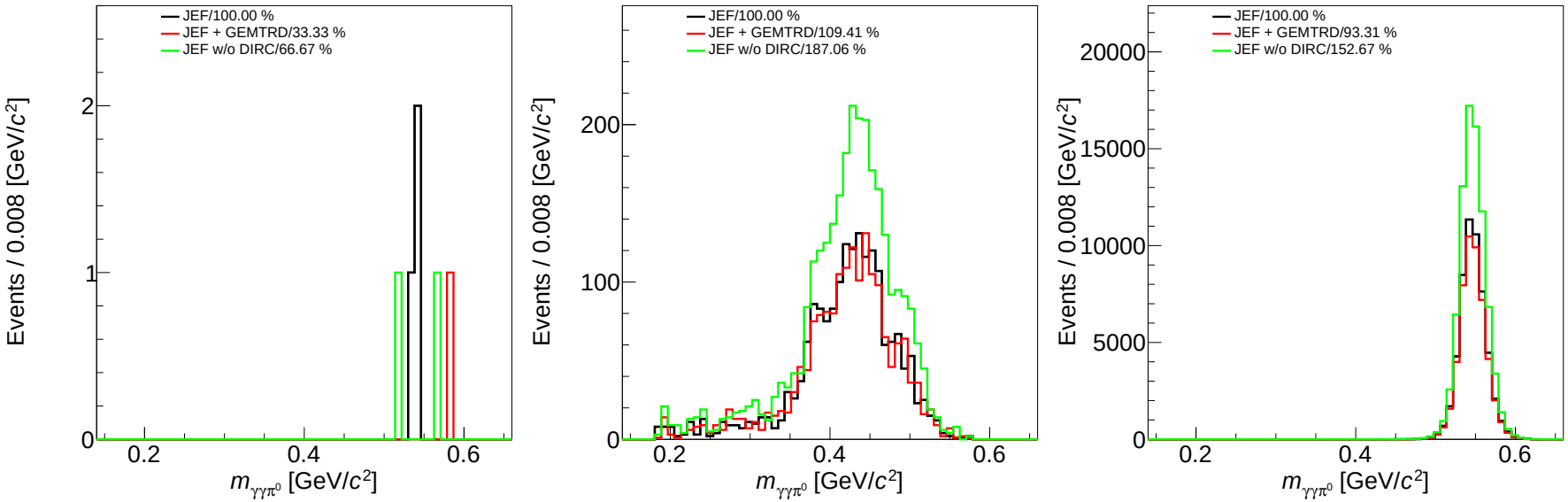




Resulting invariant mass distribution

After all selection criteria are applied

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



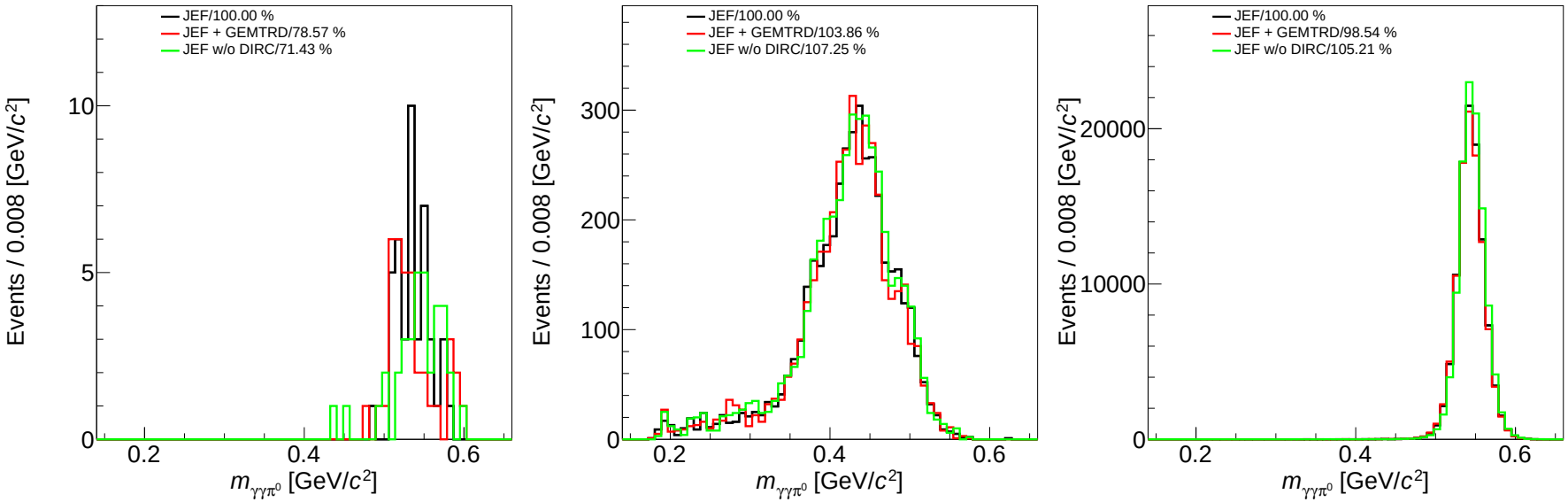
- One quadrant will decrease the $\eta \to \gamma\gamma$-background by 17%
- One quadrant will increase the $\eta \to \pi^0\pi^0\pi^0$-background by 2.3%
- One quadrant will decrease the signal by 1.6%

- DIRC is detrimental to this decay by comparison GEMTRD negative effect is negligible
- GEMTRD positive effect should also be investigated particularly for rare η decays with electron/positron in the final states
- Power separation between π and e improved by 50% by GEMTRD

Resulting invariant mass distribution

After all selection criteria are applied without TOF veto

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



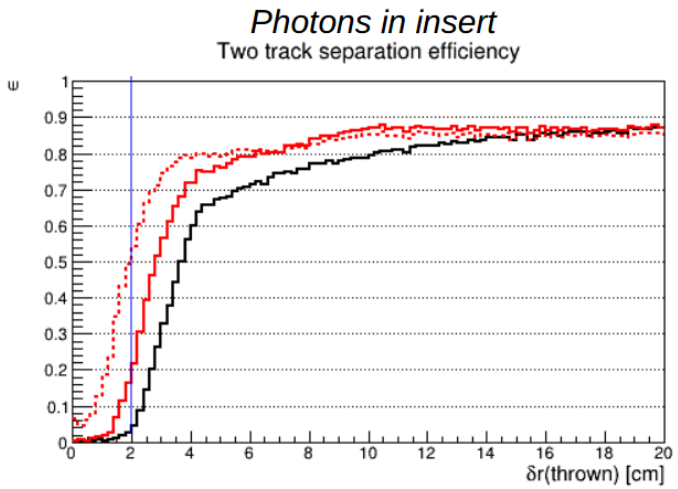
- $\eta \to \gamma\gamma$ background is peaking at 548 MeV/c^2
- Produce a signal signature undisguisable from the the real signal
- If not veto, more than 50% of the "signal" yield would $\eta \to \gamma\gamma$

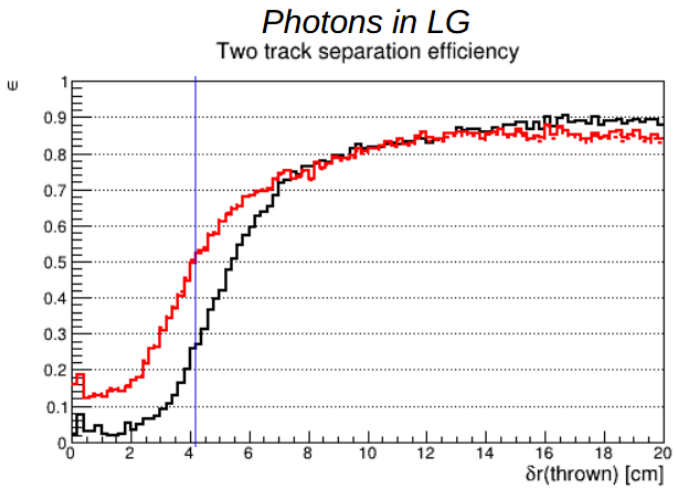
Simon's GlueX Collaboration talk, DocDB-5888

Two-cluster separation efficiency

- Require 2 reconstructed showers

DA
IA: solid (mass cut=5x10^{-5} GeV^2)
IA: dashed (mass cut=1x10^{-5} GeV^2)





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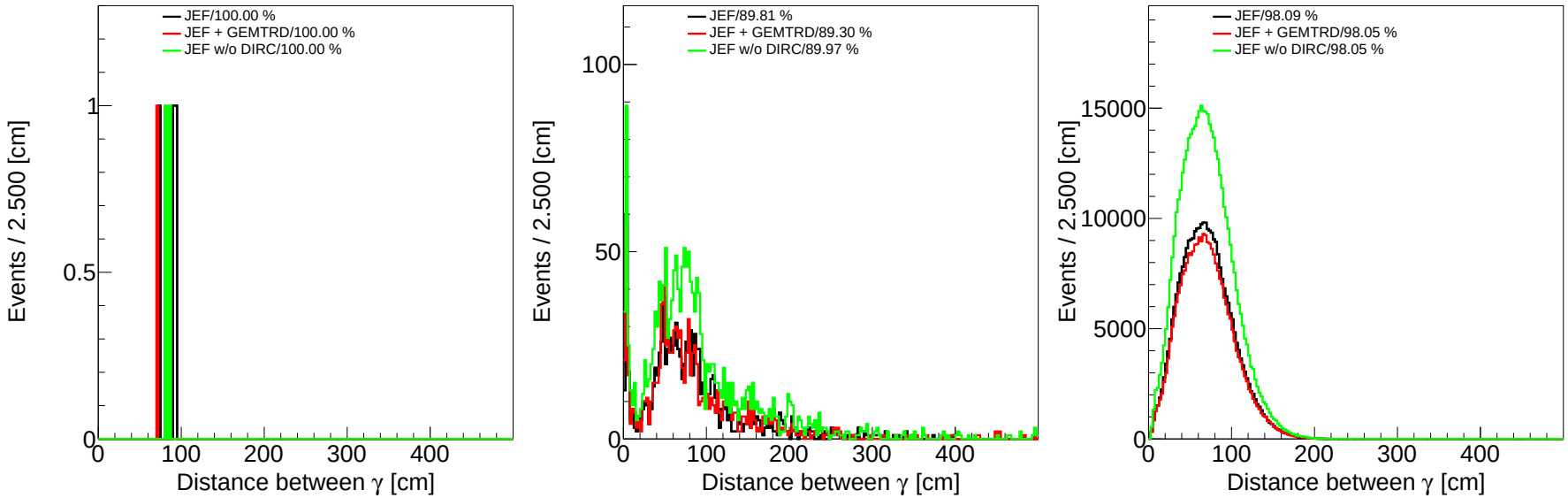
Jefferson Lab

True distance between two photons on FCAL2 face

After all selection criteria are applied with TOF veto and a cut around the η mass

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

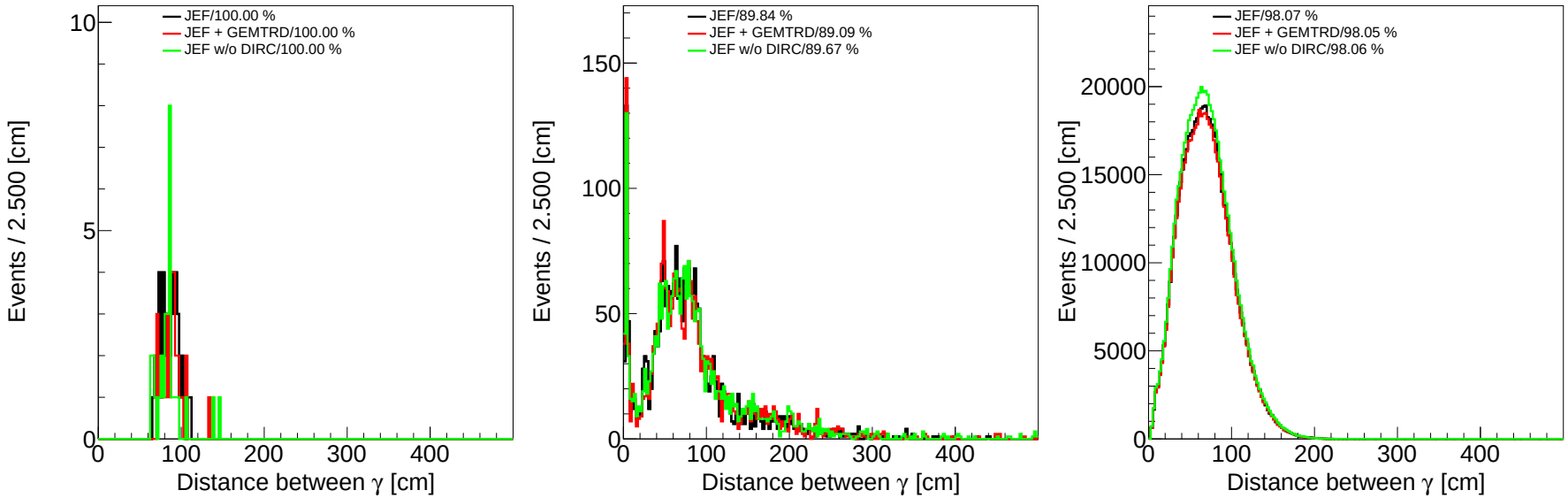


Backgrounds and signals are dominantly producing photons with more than 15 cm distance on FCAL2 where the two-cluster separation efficiency is closed to 90% for both algorithm
NB: Percentages in FIGs represent the fraction of photons with a distance larger than 15 cm

True distance between two photons on FCAL2 face

After all selection criteria are applied without TOF veto and a cut around the η mass

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



Backgrounds and signals are dominantly producing photons with more than 15 cm distance on FCAL2 where the two-cluster separation efficiency is closed to 90% for both algorithm
TOF veto is not changing that
NB: Percentages in FIGs represent the fraction of photons with a distance larger than 15 cm

Improving effiency below 15 cm will not yield dramatic improvements
But we still have to implemente correctly LOG position and clustering for border between insert and GLASS