



FCAL Detector Validation

OUTLINE

- Software
- Data Samples
- Results
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Software

- Event generation Whizard 2.3.1
- Event simulation and reconstruction
Software: ILCSoft-2017-07-27_gcc62

Detector: CLIC_o3_v12

Andre has implemented BeamcalReco and LumicalReco processors reconstructing the Beamcal and Lumical clusters providing Beamcal and Lumical pfos.

To test the software no pair background was overlaid.



Processes

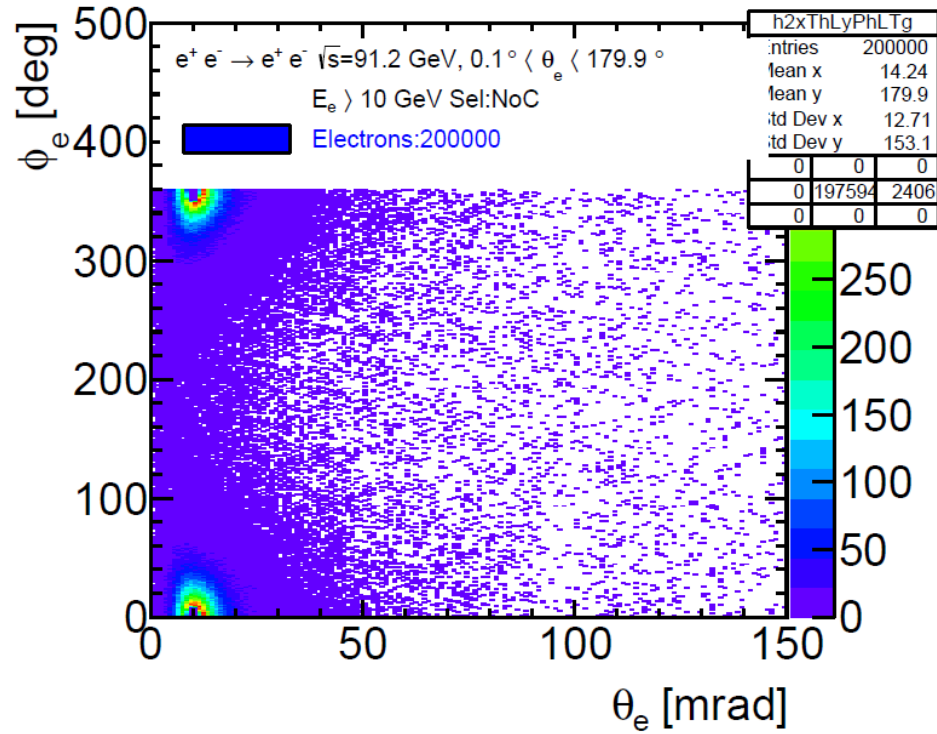
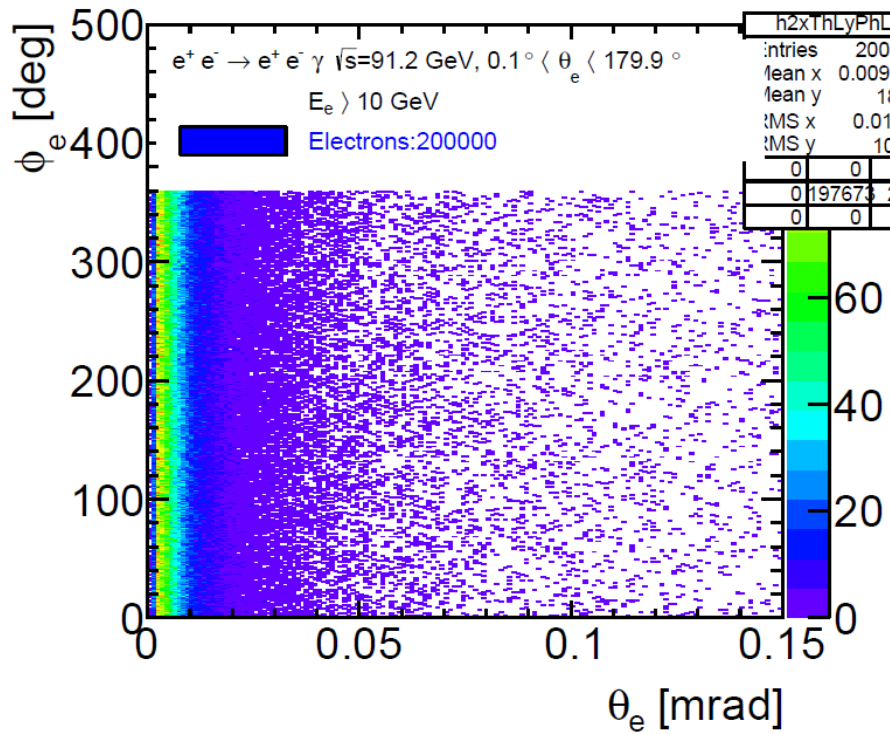
| Process | \sqrt{s} [GeV] | Cuts | σ [fb] |
|--------------------------------------|------------------|--|------------------|
| $e^+ e^- \rightarrow e^+ e^- \gamma$ | 91.2 | $0.1^\circ < \theta_e < 179.9^\circ$ $E_\gamma > 10$ GeV | $5.6 \cdot 10^9$ |
| $e^+ e^- \rightarrow e^+ e^- \gamma$ | 91.2 | $0.5^\circ < \theta_e < 179.5^\circ$ $E_\gamma > 10$ GeV | $9.3 \cdot 10^8$ |
| $e^+ e^- \rightarrow e^+ e^- \gamma$ | 91.2 | $10^\circ < \theta_\gamma < 170^\circ$, $E_\gamma > 10$ GeV | $6.7 \cdot 10^5$ |

- Data samples created for the validation studies:
Process $e^+ e^- \rightarrow e^+ e^- \gamma$
100 k events for each set of cut
The last sample is the one which is the main background for DM searches.



$e^+ e^- \rightarrow e^+ e^- \gamma$

$0.1^\circ < \theta_e < 179.9^\circ$



Left: $dN/d\theta d\phi$ at generator level no beam crossing boost.

Events with $\theta_e > 90^\circ$; $\theta = \pi - \theta$.

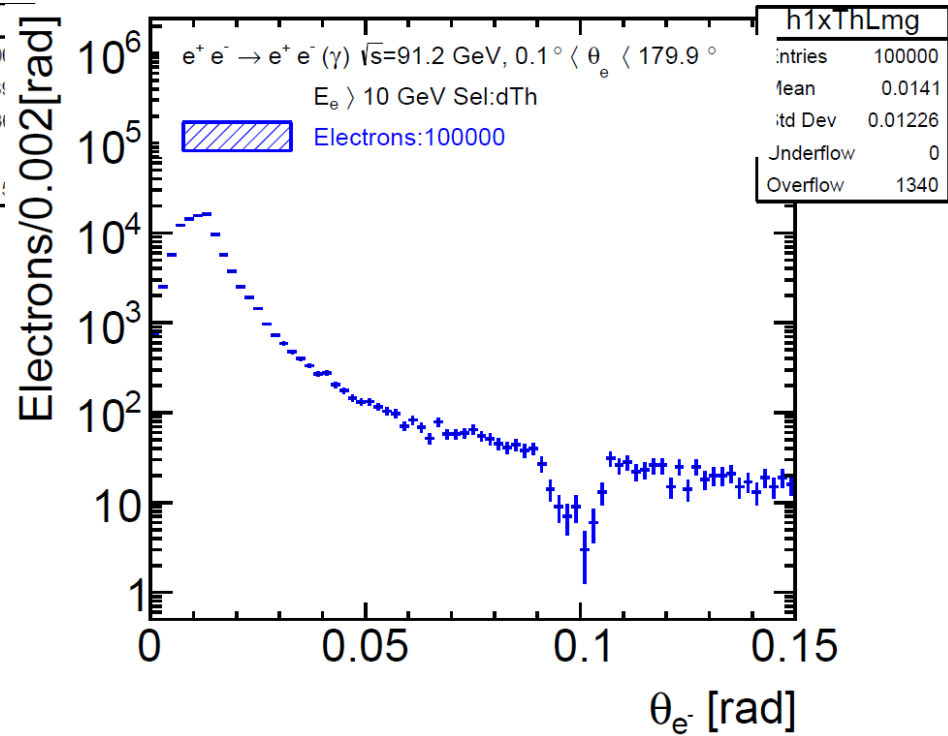
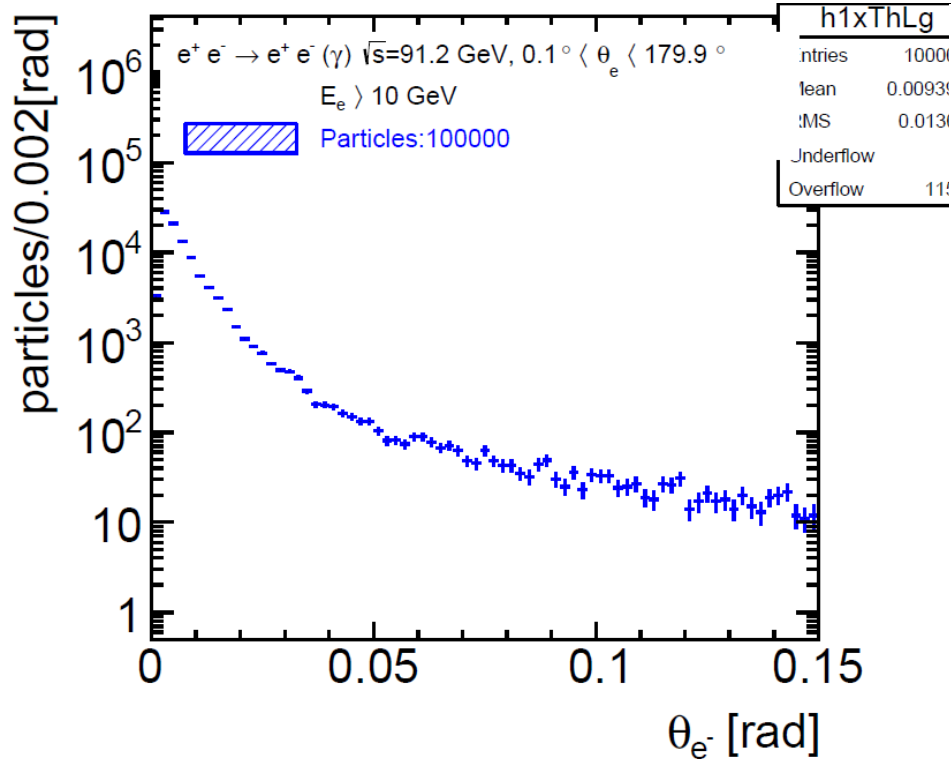
Right: $dN/d\theta d\phi$ (T) after simulation, with beam crossing boost;

The particles are focused in the h plane $\sim -40^\circ < \phi < 40^\circ$



$$e^+ e^- \rightarrow e^+ e^- \gamma$$

$$0.1^\circ < \theta_e < 179.9^\circ$$



Left: $dN/d\theta$ (T) at generator, no boost

Right: $dN/d\theta$ (T) after simulation, with boost

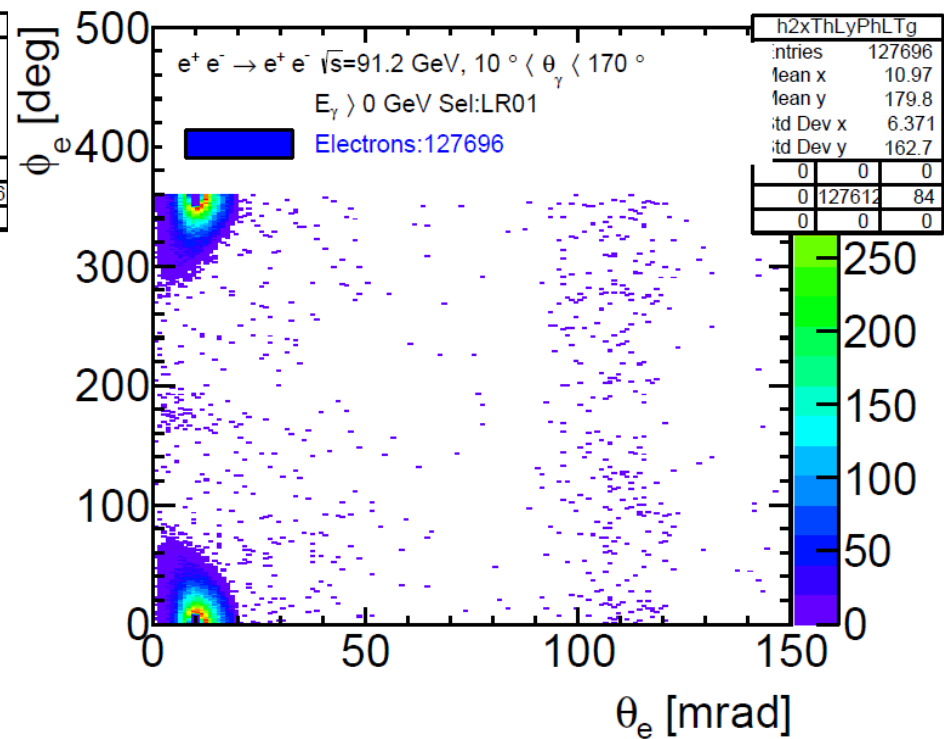
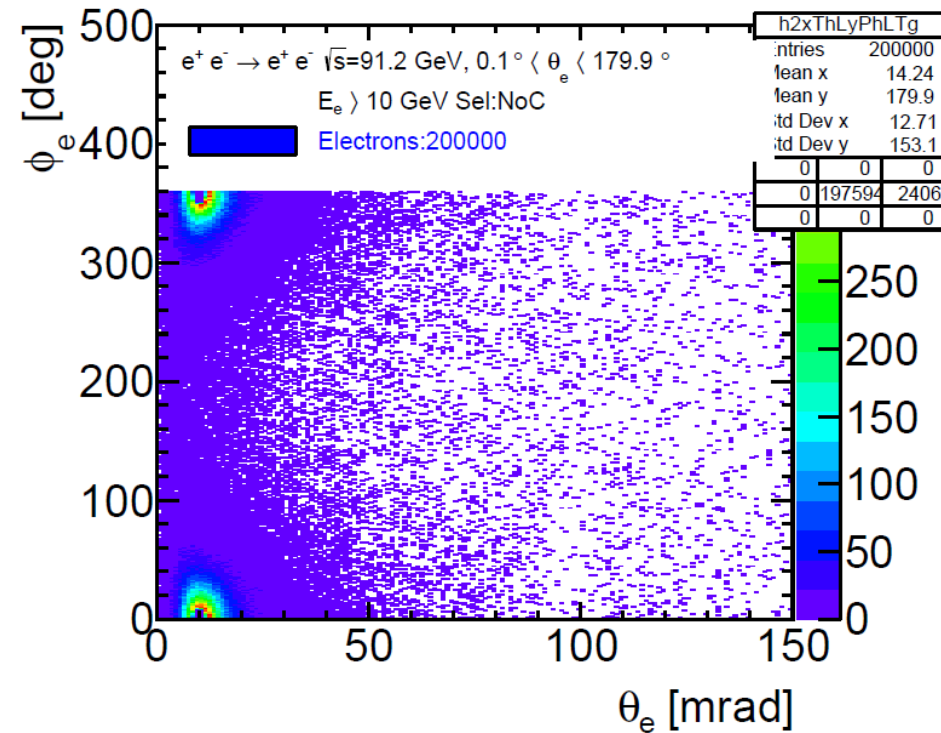
Particles are boosted towards larger θ values

Dip ~ 0.1 rad ??



$$e^+ e^- \rightarrow e^+ e^- \gamma$$

$$0.1^\circ < \theta_e < 179.9^\circ$$



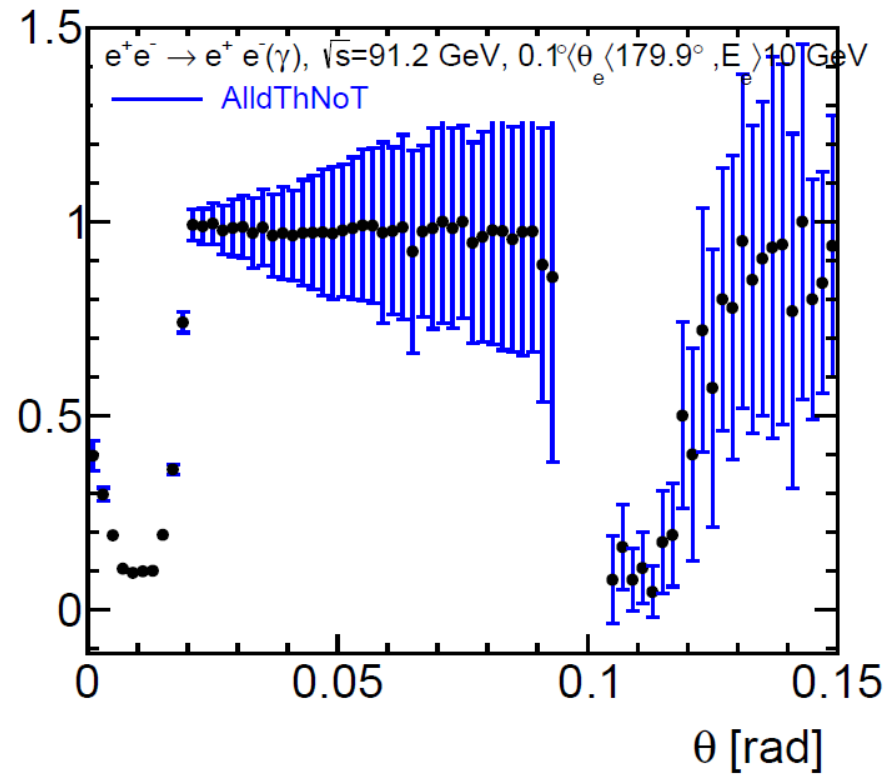
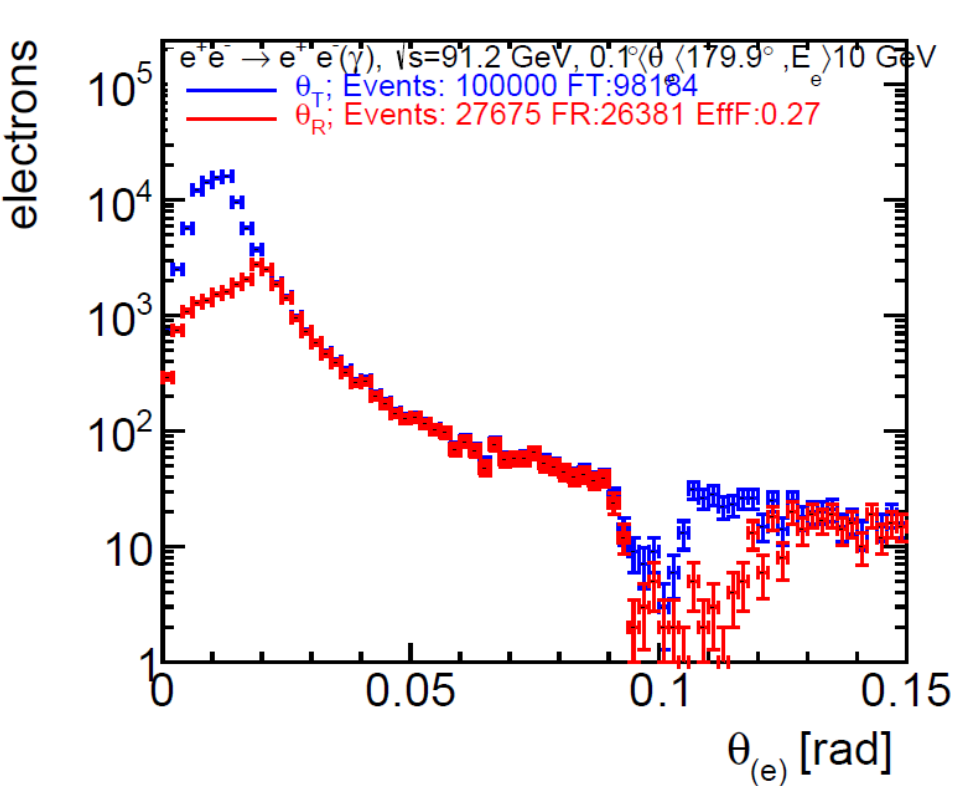
Left: $dN/d\theta d\phi$ (T) after simulation, no selection

Right: $dN/d\theta d\phi$ (T) for events without e or γ in Beamcal, Lumical or Ecal; inefficiency for $\theta < 20 \text{ mrad}$ and $-60^\circ < \phi < 60^\circ$ and $\theta \sim 110 \text{ mrad}$.



$$e^+ e^- \rightarrow e^+ e^- \gamma$$

$$0.1^\circ < \theta_e < 179.9^\circ$$

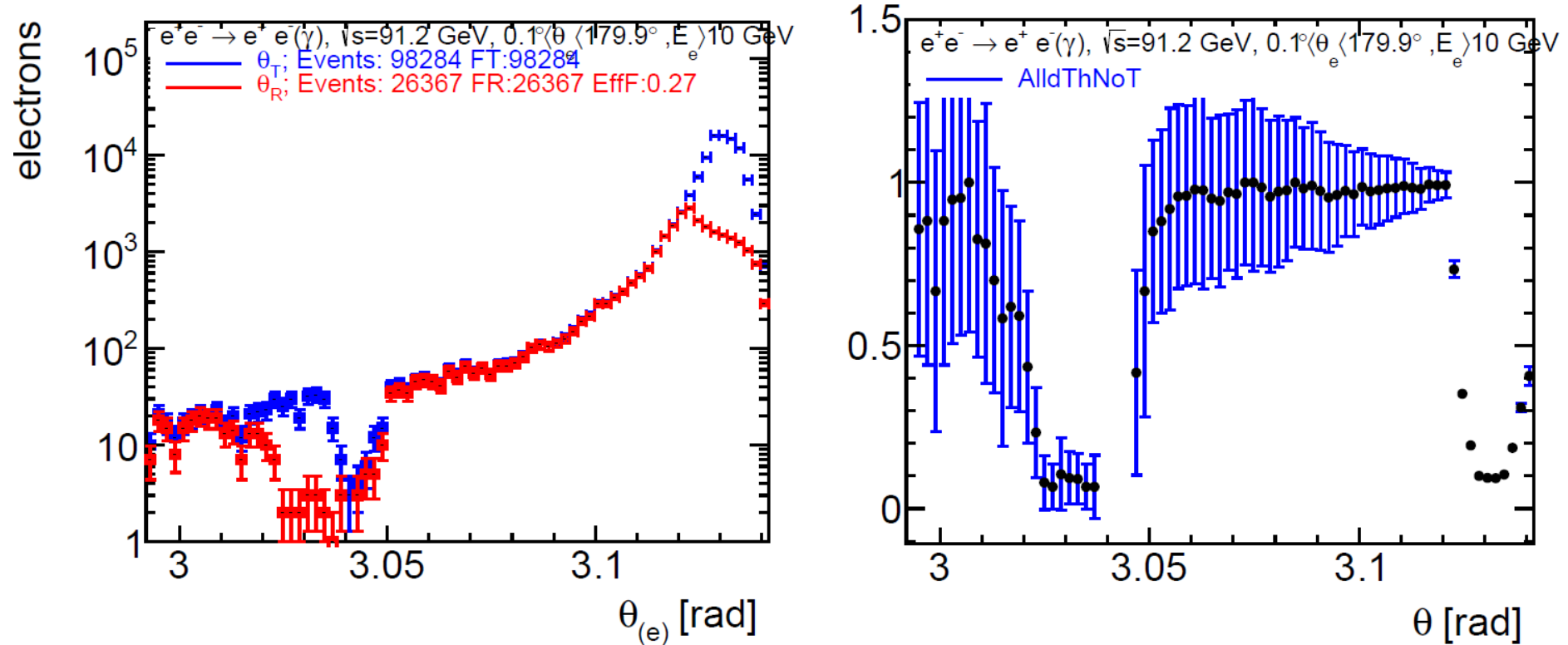


Left: $dN/d\theta_{e^-}$ (T) after simulation; without selection (blue);
 Selecting particles with pfo (e or γ) in Beamcal, Lumical or
 Ecal (red). Right: ratio; low efficiency for $\theta < 20$ mrad
 and $\theta \sim 0.11$ rad Lumical, EcalEndcap transition and B.Pipe



$$e^+ e^- \rightarrow e^+ e^- \gamma$$

$$0.1^\circ < \theta_e < 179.9^\circ$$

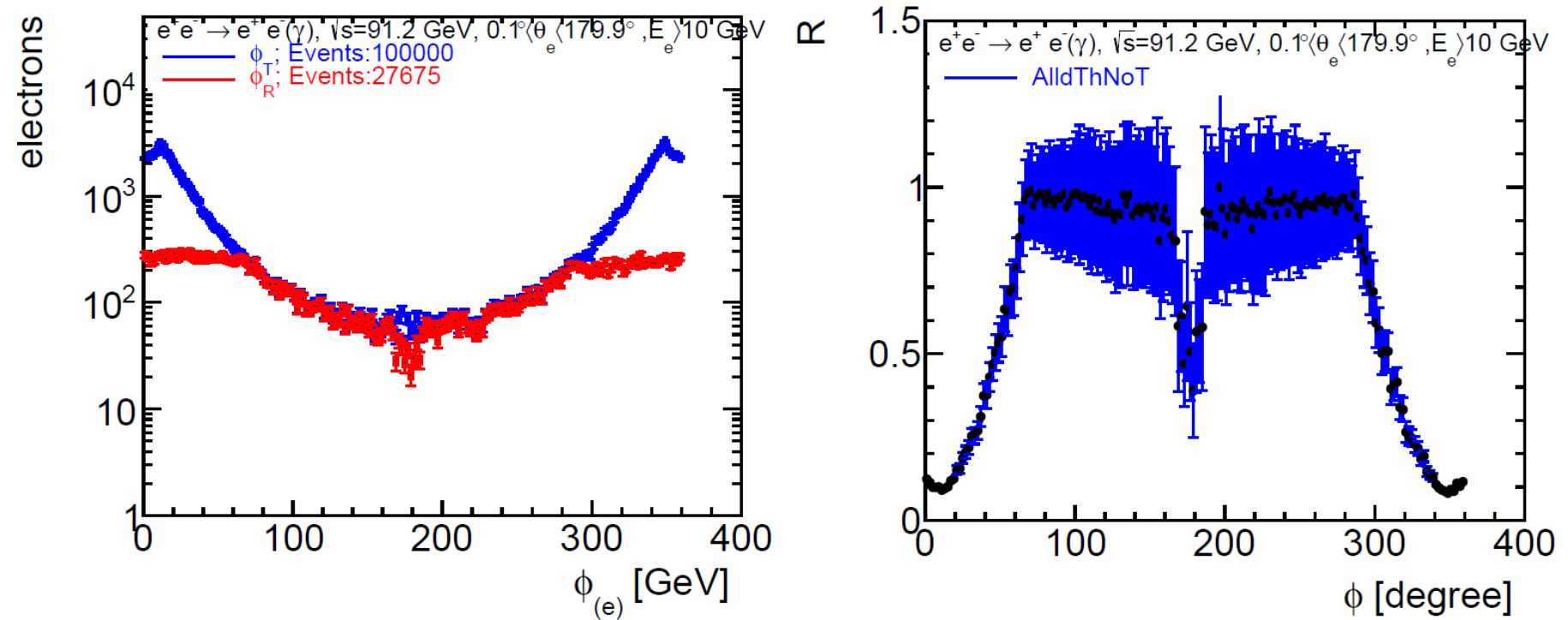


Left: $dN/d\theta_{e^+}$ (T) after simulation; without selection (blue);
 Selecting particles with pfo (e or γ) in Beamcal, Lumical or
 Ecal (red). Right: ratio; low efficiency for $\pi - \theta < 20$ mrad
 and $\theta \sim 3.03$ rad; Lumica; Ecal Endcap transition, B.Pipe



$$e^+ e^- \rightarrow e^+ e^- \gamma$$

$$0.1^\circ < \theta_e < 179.9^\circ$$

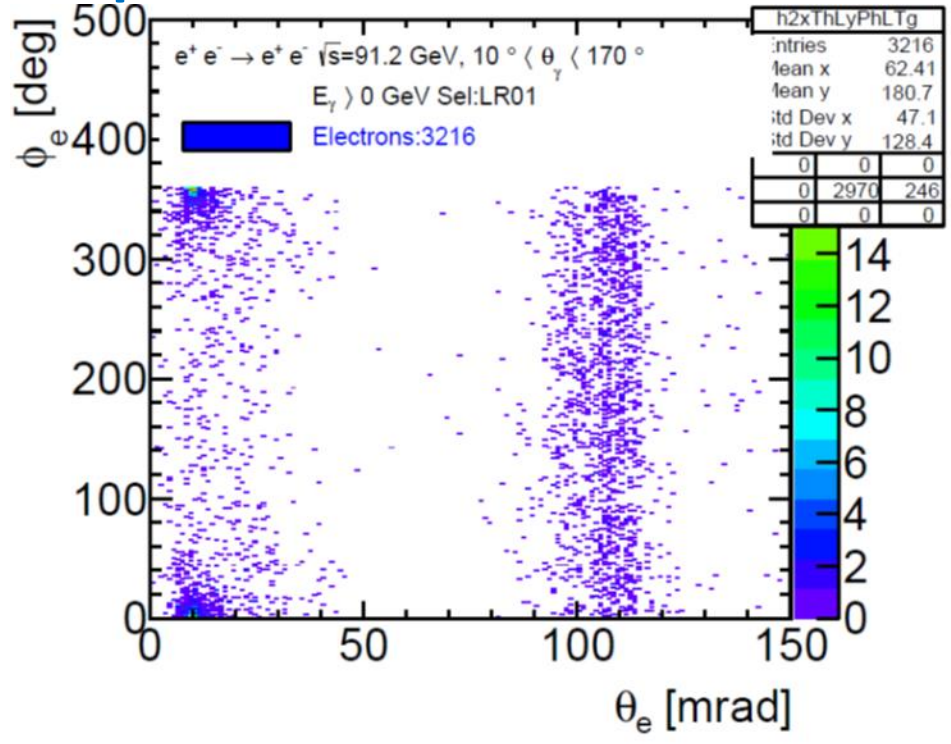
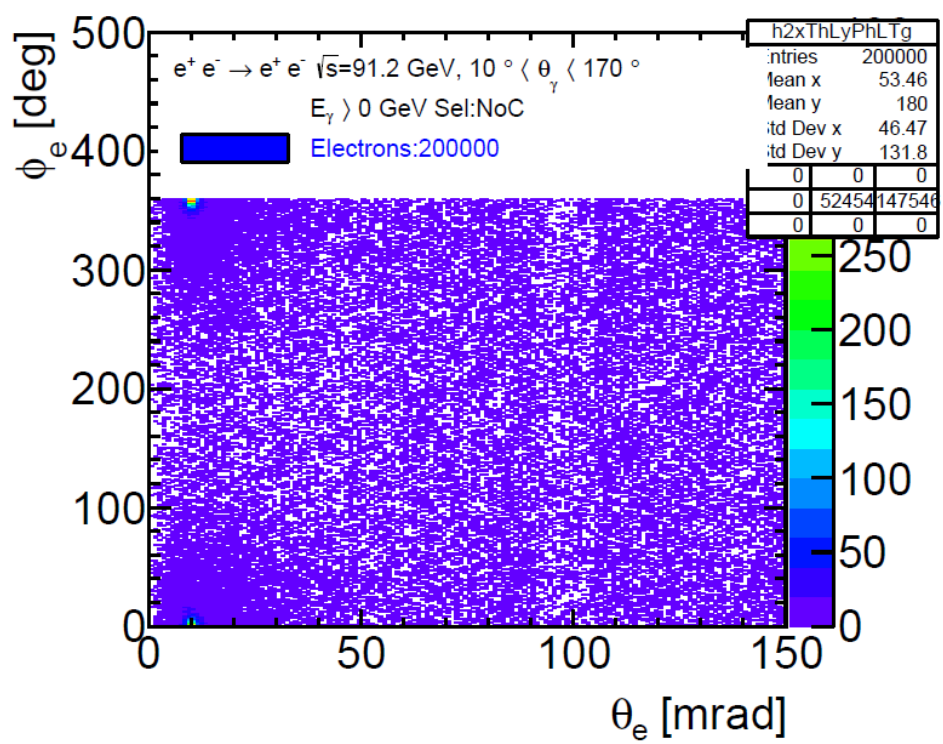


Left: $dN/d\theta_e$ (T) after simulation; without selection (blue)
 Selecting particles with pfo(e or γ) in Beamcal, Lumical or
 Ecal Endcap (red). Right: ratio, low efficiency for $60^\circ < \phi < 120^\circ$;
 outgoing beam pipe, smaller inefficiency for $\phi \sim 180^\circ$
 incoming B.P



$$e^+ e^- \rightarrow e^+ e^- \gamma$$

$$10^\circ < \theta_\gamma < 170^\circ$$

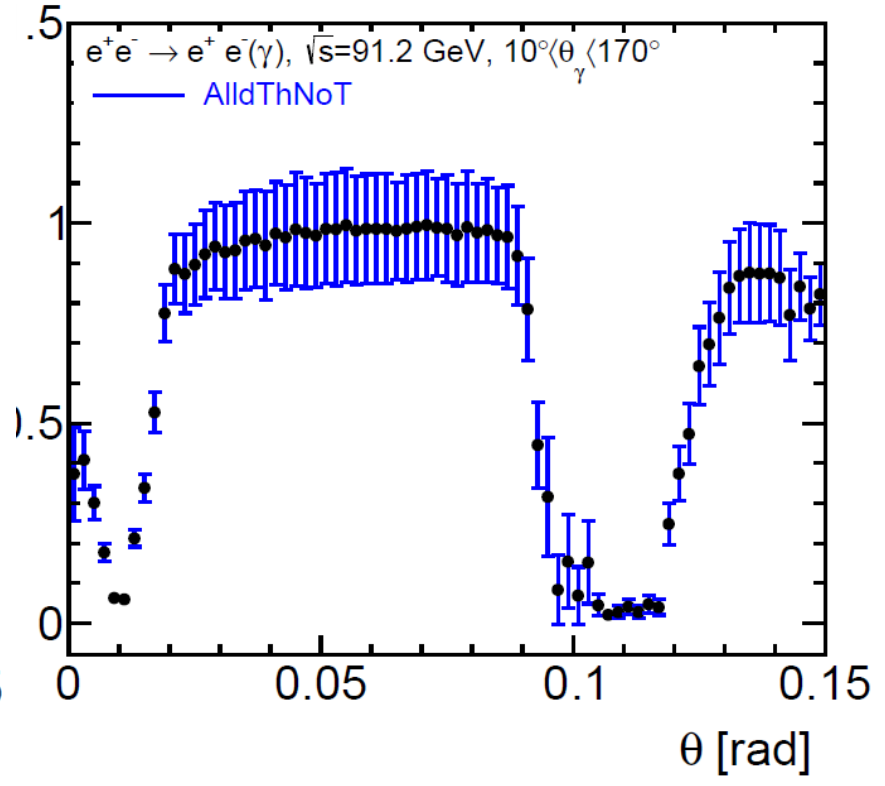
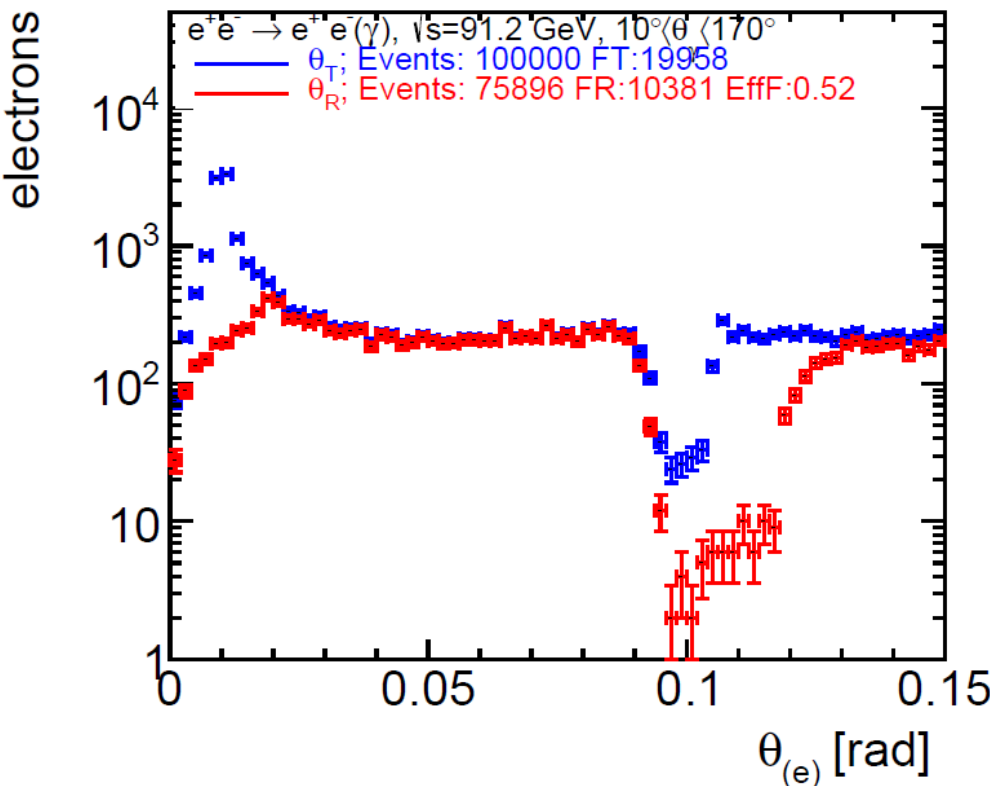


Left: $dN/d\theta d\phi_{e^-}$ (T) after simulation; without selection.
 Right: Events without e or γ and $E < 10 \text{ GeV}$ in Beamcal, Lumical or Ecal Endcap. Inefficiency for $\theta < 20 \text{ mrad}$ and $\theta \sim 0.11 \text{ rad}$ Lumical, EcalEndcap transition, B.Pipe



$$e^+ e^- \rightarrow e^+ e^- \gamma$$

$$10^\circ < \theta_\gamma < 170^\circ$$

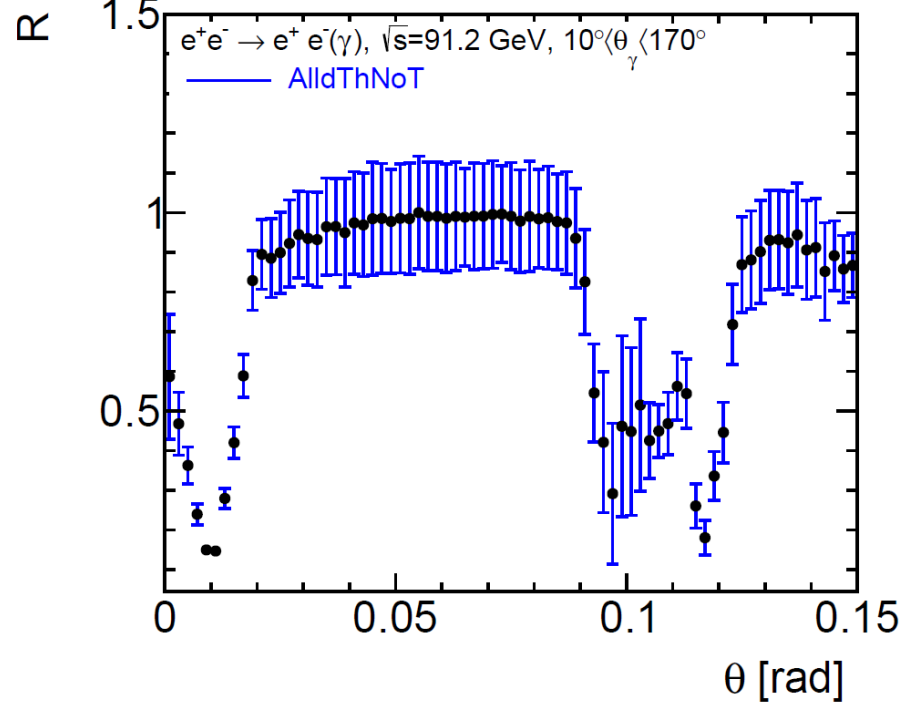
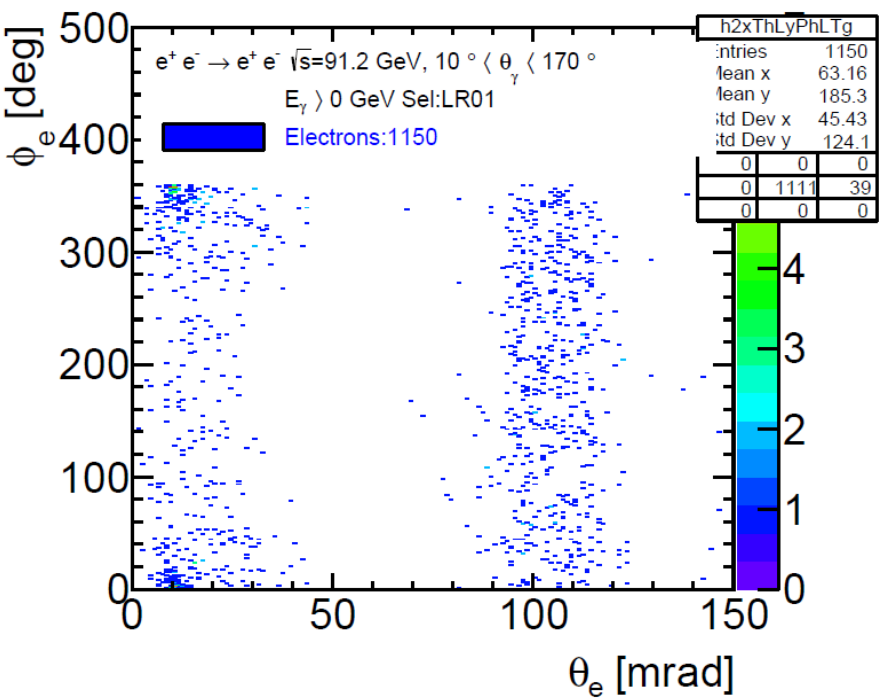


Left: $dN/d\theta_{e^-}$ (T) after simulation; without selection (blue);
 Select particles with pfo (e or γ) in Beamcal, Lumical or Ecal
 (red). Right: ratio=efficiency, low for $\theta < 20$ mrad
 and $\theta \sim 0.11$ rad Lumical, EcalEndcap transition, B.Pipe



$$e^+ e^- \rightarrow e^+ e^- \gamma$$

$$10^\circ < \theta_\gamma < 170^\circ$$



Left: $dN/d\theta d\phi_{e^-}$ (T) after simulation selecting events without e or γ or N in Beamcal, Lumical or Ecal. The veto inefficiency is reduced. In the region $5 < \theta < 7^\circ$ The energy measurement is bad, but it should allow vetoing radiative bhabha events.



Summary

BeamcalReco and LumicalReco processors are reconstructing Beamcal and Lumical clusters allowing to test the detector hermeticity.

At 91.2 GeV, without pair background overlaid the reconstruction efficiency looks as expected except in the Lumical Ecal Endcap transition region $5^\circ < \theta < 7^\circ$.

This is the angle at which the conical beam pipe is located. Some inefficiency is due to electrons showering in the conical beam pipe. For a significant fraction of events Pandora identifies the electron as a N instead a Photon.



Outlook

The origin of the inefficiency in the Lumical to Ecal Endcap transition region $5^\circ < \theta < 7^\circ$ is due to:

- Showering in beam pipe.
- γ misidentification

Fixing the γ misidentification should allow to reduce the veto inefficiency.

Perform the same study at 380 GeV with pair background overlaid.



Backup

