

# PANDORA, ARBOR and GARLIC separation power for two overlapping electromagnetic or electromagnetic-hadronic showers

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# Introduction

- Task: Compare particle separation in PFA between ECAL physics prototype data and MC
- "photon"-"photon" separation
  - "photon"= $e^+$ , track removed (phys prot FNAL'11 TB and MC) or  $\gamma$  (MC)
  - energies: 4+4GeV, 12+4GeV, 25+4GeV, 32+25GeV
- hadron-"photon" separation
  - hadron: 50GeV  $\pi^+$  (only ECAL, phys prot FNAL'11 TB and MC)
  - "photon"= $e^+$ , track removed (phys prot FNAL'11 TB and MC)
  - energies: 50+4GeV, 50+12GeV, 50+25GeV, 50+32GeV

PFA:

- PANDORA v00-12
- GARLIC 2.11, december edition from Daniel
- ARBOR from Manqi

# Event creation and reconstruction

- TB data:
  - ECAL physics prototype FNAL'11 TB data
  - Particles: 4, 12, 25, 32GeV  $e^+$  & 50GeV  $\pi^+$  runs
  - FNAL'11 detector: tracker+ECAL+DHCAL, only ECAL was used (same in MC)
- MC data:
  - MC in TB geometry
  - Particles: 4, 12, 25, 32 GeV  $e^+$ ,  $\gamma$  & 50 GeV  $\pi^+$  runs
  - detector model: TBFnal0508\_p1211
  - GEANT4: geant4-09-05-patch-01
  - Mokka: mokka-08-00-03
  - Physics list: QGSP\_BERT

# Event creation and reconstruction

- Event creation:
  - no standard tool to run PFA for TB geom: for both data and MC  $\rightarrow$  hits transition TB geometry  $\rightarrow$  ILD geometry (ILD\_v05\_o1\_forCalice)
  - $e^+$  no track  $\rightarrow$   $\gamma$  emulation, no problems with magnetic field
  - $\pi^+$   $\rightarrow$  for both TB and MC events tracks were created in ILD geometry ( $10^4$  tracks were generated, the closest was taken)
  - event selection cuts (see later): only events from central cells area  $4 \times 4 \text{ cm}^2$  were selected (physprot size  $18 \times 18 \text{ cm}^2$ )
  - **overlay**: particle + shifted particle (by 0,1,...,11 cells, if a cell is hit in both events, energies summed)
- Definition of "correct" separation:
  - $\gamma - \gamma$  case: 2 reconstructed  $\gamma$
  - $\pi^+ - \gamma$  case: 1 reconstructed  $\gamma$  & no requirements for  $\pi^+$
  - Reconstructed Energy = Initial Energy  $\pm 20\%$
  - Reconstructed Barycentre = Initial Barycentre  $\pm 5 \text{ mm}$

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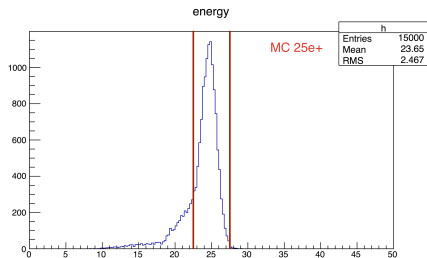
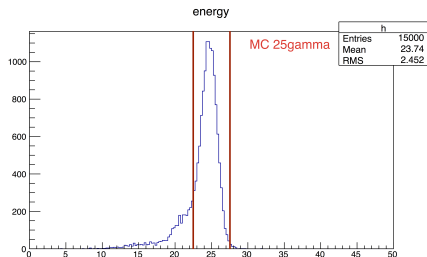
# Cuts for "photons"

Particle/Cuts	TB 4GeV e+	MC 4GeV e+	MC 4GeV gamma	Particle/Cuts	TB 12GeV e+	MC 12GeV e+	MC 12GeV gamma
<b>Vetoed Layers</b>	layers #27, 28, 29	layers #27, 28, 29		<b>Vetoed Layers</b>	layers #27, 28, 29	layers #27, 28, 29	
<b>Calibration MIP-&gt;GeV</b>	0.0050	0.00505	0.00491	<b>Calibration MIP-&gt;GeV</b>	0.0048	0.00495	0.00489
<b># Hits in 1st Layer</b>	1 hit	1 hit	0,1 hit	<b># Hits in 1st Layer</b>	1 hit	1 hit	0,1 hit
<b>1st Layer Energy</b>	<2.0 MIP	<2.0 MIP	<4.0 MIP	<b>1st Layer Energy</b>	<2.0 MIP	<2.0 MIP	<4.0 MIP
<b>Barycentre position X</b>	-16...24 mm	10...50 mm	10...50 mm	<b>Barycentre position X</b>	-16...24 mm	10...50 mm	10...50 mm
<b>Barycentre position Y</b>	-20...20 mm	-20...20 mm	-20...20 mm	<b>Barycentre position Y</b>	-20...20 mm	-20...20 mm	-20...20 mm
<b>Layer Max Energy</b>	layers #4...20	layers #4...20	layers #4...20	<b>Layer Max Energy</b>	layers #4...20	layers #4...20	layers #4...20
<b>Energy Layer Max En</b>	30...120 MIP	30...120 MIP	30...120 MIP	<b>Energy Layer Max En</b>	40...400 MIP	40...400 MIP	40...400 MIP
<b>Energy cut</b>	3.0...5.0 GeV	3.0...5.0 GeV	3.0...5.0 GeV	<b>Energy cut</b>	10.0...14.0 GeV	10.0...14.0 GeV	10.0...14.0 GeV
<b>Runs, #events</b>	run630065, #evt 3455 run630067, #evt 8004	#evt 3905	#evt 6248	<b>Runs, #events</b>	run630061, #evt 701 run630062, #evt 471	#evt 3320	#evt 6042

Particle/Cuts	TB 25GeV e+	MC 25GeV e+	MC 25GeV gamma	Particle/Cuts	TB 32GeV e+	MC 32GeV e+	MC 32GeV gamma
<b>Vetoed Layers</b>	layers #27, 28, 29	layers #27, 28, 29		<b>Vetoed Layers</b>	layers #27, 28, 29	layers #27, 28, 29	
<b>Calibration MIP-&gt;GeV</b>	0.00475	0.00492	0.00486	<b>Calibration MIP-&gt;GeV</b>	0.00475	0.00491	0.00484
<b># Hits in 1st Layer</b>	1 hit	1 hit	0,1 hit	<b># Hits in 1st Layer</b>	1 hit	1 hit	0,1 hit
<b>1st Layer Energy</b>	<2.0 MIP	<2.0 MIP	<4.0 MIP	<b>1st Layer Energy</b>	<2.0 MIP	<2.0 MIP	<4.0 MIP
<b>Barycentre position X</b>	-16...24 mm	10...50 mm	10...50 mm	<b>Barycentre position X</b>	-16...24 mm	10...50 mm	10...50 mm
<b>Barycentre position Y</b>	-20...20 mm	-20...20 mm	-20...20 mm	<b>Barycentre position Y</b>	-20...20 mm	-20...20 mm	-20...20 mm
<b>Layer Max Energy</b>	layers #4...20	layers #4...20	layers #4...20	<b>Layer Max Energy</b>	layers #4...20	layers #4...20	layers #4...20
<b>Energy Layer Max En</b>	100...800 MIP	100...800 MIP	100...800 MIP	<b>Energy Layer Max En</b>	100...1000 MIP	100...1000 MIP	100...1000 MIP
<b>Energy cut</b>	22.5...27.5 GeV	22.5...27.5 GeV	22.5...27.5 GeV	<b>Energy cut</b>	29.0...35.0 GeV	29.0...35.0 GeV	29.0...35.0 GeV
<b>Runs, #events</b>	run630037, #evt 512 run630038, #evt 995 run630039, #evt 187	#evt 2715	#evt 5655	<b>Runs, #events</b>	run630033, #evt 186 run630034, #evt 511 run630036, #evt 337	#evt 2623	#evt 5644

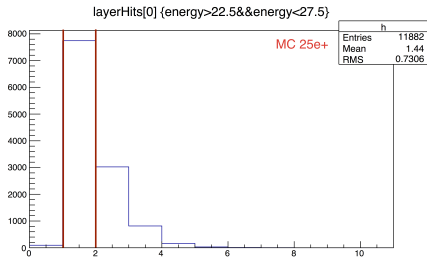
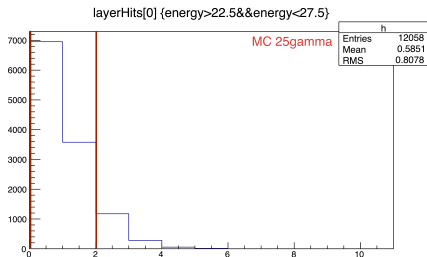
# Ex. 25 GeV photons spectra: ECAL energy before cuts

Particle/Cuts	TB 25GeV e+	MC 25GeV e+	MC 25GeV gamma
<b>Vetoed Layers</b>	layers #27, 28, 29	layers #27, 28, 29	
<b>Calibration MIP-&gt;GeV</b>	0.00475	0.00492	0.00486
<b># Hits in 1st Layer</b>	1 hit	1 hit	0,1 hit
<b>1st Layer Energy</b>	<2.0 MIP	<2.0 MIP	<4.0 MIP
<b>Barycentre position X</b>	-16...24 mm	10...50 mm	10...50 mm
<b>Barycentre position Y</b>	-20...20 mm	-20...20 mm	-20...20 mm
<b>Layer Max Energy</b>	layers #4...20	layers #4...20	layers #4...20
<b>Energy Layer Max En</b>	100...800 MIP	100...800 MIP	100...800 MIP
<b>Energy cut</b>	22.5...27.5 GeV	22.5...27.5 GeV	22.5...27.5 GeV
<b>Runs, #events</b>	run630037, #evt 512 run630038, #evt 995 run630039, #evt 187	#evt 2715	#evt 5655



# Ex. 25 GeV photons spectra: # hits in 1st layer

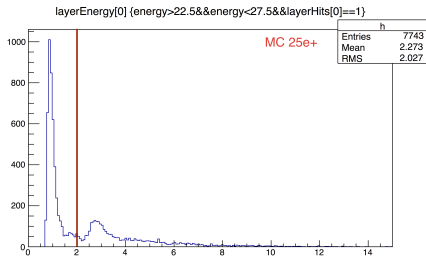
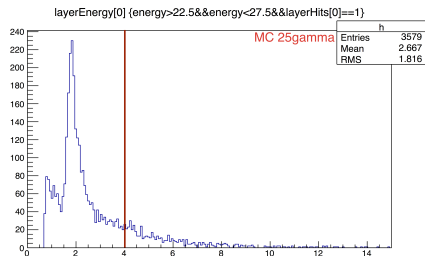
Particle/Cuts	TB 25GeV e+	MC 25GeV e+	MC 25GeV gamma
<b>Vetoed Layers</b>	layers #27, 28, 29	layers #27, 28, 29	
<b>Calibration MIP-&gt;GeV</b>	0.00475	0.00492	0.00486
<b># Hits in 1st Layer</b>	1 hit	1 hit	0,1 hit
<b>1st Layer Energy</b>	<2.0 MIP	<2.0 MIP	<4.0 MIP
<b>Barycentre position X</b>	-16...24 mm	10...50 mm	10...50 mm
<b>Barycentre position Y</b>	-20...20 mm	-20...20 mm	-20...20 mm
<b>Layer Max Energy</b>	layers #4...20	layers #4...20	layers #4...20
<b>Energy Layer Max En</b>	100...800 MIP	100...800 MIP	100...800 MIP
<b>Energy cut</b>	22.5...27.5 GeV	22.5...27.5 GeV	22.5...27.5 GeV
<b>Runs, #events</b>	run630037, #evt 512 run630038, #evt 995 run630039, #evt 187	#evt 2715	#evt 5655





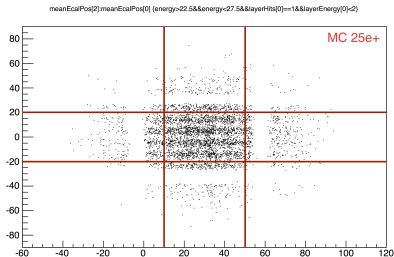
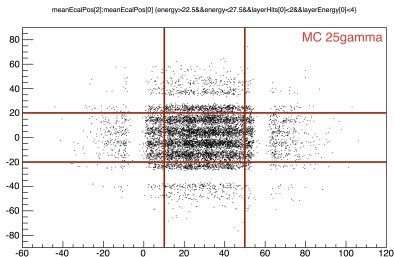
# Ex. 25 GeV photons spectra: energy in 1st layer

Particle/Cuts	TB 25GeV e+	MC 25GeV e+	MC 25GeV gamma
<b>Vetoed Layers</b>	layers #27, 28, 29	layers #27, 28, 29	
<b>Calibration MIP-&gt;GeV</b>	0.00475	0.00492	0.00486
<b># Hits in 1st Layer</b>	1 hit	1 hit	0,1 hit
<b>1st Layer Energy</b>	<2.0 MIP	<2.0 MIP	<4.0 MIP
<b>Barycentre position X</b>	-16...24 mm	10...50 mm	10...50 mm
<b>Barycentre position Y</b>	-20...20 mm	-20...20 mm	-20...20 mm
<b>Layer Max Energy</b>	layers #4...20	layers #4...20	layers #4...20
<b>Energy Layer Max En</b>	100...800 MIP	100...800 MIP	100...800 MIP
<b>Energy cut</b>	22.5...27.5 GeV	22.5...27.5 GeV	22.5...27.5 GeV
<b>Runs, #events</b>	run630037, #evt 512 run630038, #evt 995 run630039, #evt 187	#evt 2715	#evt 5655



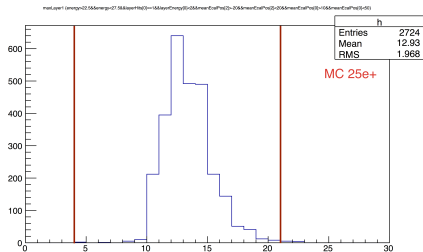
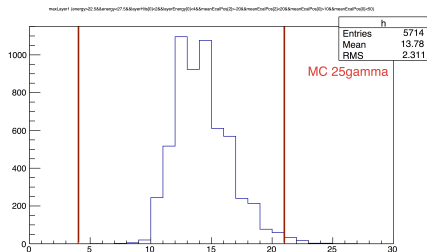
# Ex. 25 GeV photons spectra: shower barycentre position

Particle/Cuts	TB 25GeV e+	MC 25GeV e+	MC 25GeV gamma
Vetoed Layers	layers #27, 28, 29	layers #27, 28, 29	
Calibration MIP->GeV	0.00475	0.00492	0.00486
# Hits in 1st Layer	1 hit	1 hit	0,1 hit
1st Layer Energy	<2.0 MIP	<2.0 MIP	<4.0 MIP
Barycentre position X	-16...24 mm	10...50 mm	10...50 mm
Barycentre position Y	-20...20 mm	-20...20 mm	-20...20 mm
Layer Max Energy	layers #4...20	layers #4...20	layers #4...20
Energy Layer Max En	100...800 MIP	100...800 MIP	100...800 MIP
Energy cut	22.5...27.5 GeV	22.5...27.5 GeV	22.5...27.5 GeV
Runs, #events	run630037, #evt 512 run630038, #evt 995 run630039, #evt 187	#evt 2715	#evt 5655



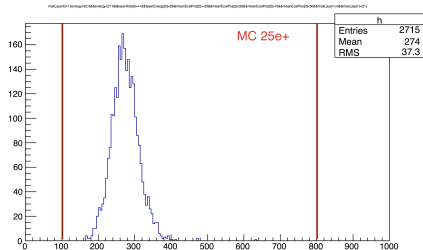
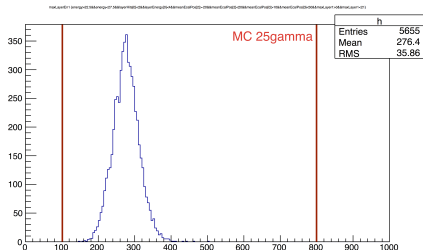
# Ex. 25 GeV photons spectra: layer with max energy

Particle/Cuts	TB 25GeV e+	MC 25GeV e+	MC 25GeV gamma
<b>Vetoed Layers</b>	layers #27, 28, 29	layers #27, 28, 29	
<b>Calibration MIP-&gt;GeV</b>	0.00475	0.00492	0.00486
<b># Hits in 1st Layer</b>	1 hit	1 hit	0,1 hit
<b>1st Layer Energy</b>	<2.0 MIP	<2.0 MIP	<4.0 MIP
<b>Barycentre position X</b>	-16...24 mm	10...50 mm	10...50 mm
<b>Barycentre position Y</b>	-20...20 mm	-20...20 mm	-20...20 mm
<b>Layer Max Energy</b>	layers #4...20	layers #4...20	layers #4...20
<b>Energy Layer Max En</b>	100...800 MIP	100...800 MIP	100...800 MIP
<b>Energy cut</b>	22.5...27.5 GeV	22.5...27.5 GeV	22.5...27.5 GeV
<b>Runs, #events</b>	run630037, #evt 512 run630038, #evt 995 run630039, #evt 187	#evt 2715	#evt 5655



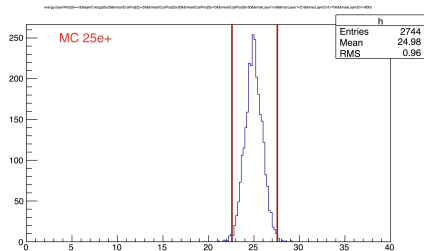
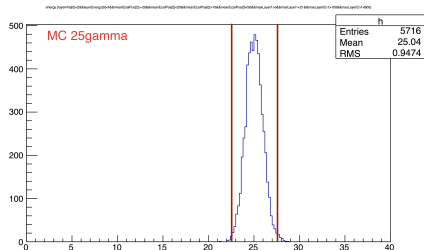
# Ex. 25 GeV photons spectra: energy of layer max energy

Particle/Cuts	TB 25GeV e+	MC 25GeV e+	MC 25GeV gamma
<b>Vetoed Layers</b>	layers #27, 28, 29	layers #27, 28, 29	
<b>Calibration MIP-&gt;GeV</b>	0.00475	0.00492	0.00486
<b># Hits in 1st Layer</b>	1 hit	1 hit	0,1 hit
<b>1st Layer Energy</b>	<2.0 MIP	<2.0 MIP	<4.0 MIP
<b>Barycentre position X</b>	-16...24 mm	10...50 mm	10...50 mm
<b>Barycentre position Y</b>	-20...20 mm	-20...20 mm	-20...20 mm
<b>Layer Max Energy</b>	layers #4...20	layers #4...20	layers #4...20
<b>Energy Layer Max En</b>	100...800 MIP	100...800 MIP	100...800 MIP
<b>Energy cut</b>	22.5...27.5 GeV	22.5...27.5 GeV	22.5...27.5 GeV
<b>Runs, #events</b>	run630037, #evt 512 run630038, #evt 995 run630039, #evt 187	#evt 2715	#evt 5655



# Ex. 25 GeV photons spectra: ECAL energy after cuts

Particle/Cuts	TB 25GeV e+	MC 25GeV e+	MC 25GeV gamma
<b>Vetoed Layers</b>	layers #27, 28, 29	layers #27, 28, 29	
<b>Calibration MIP-&gt;GeV</b>	0.00475	0.00492	0.00486
<b># Hits in 1st Layer</b>	1 hit	1 hit	0,1 hit
<b>1st Layer Energy</b>	<2.0 MIP	<2.0 MIP	<4.0 MIP
<b>Barycentre position X</b>	-16...24 mm	10...50 mm	10...50 mm
<b>Barycentre position Y</b>	-20...20 mm	-20...20 mm	-20...20 mm
<b>Layer Max Energy</b>	layers #4...20	layers #4...20	layers #4...20
<b>Energy Layer Max En</b>	100...800 MIP	100...800 MIP	100...800 MIP
<b>Energy cut</b>	22.5...27.5 GeV	22.5...27.5 GeV	22.5...27.5 GeV
<b>Runs, #events</b>	run630037, #evt 512 run630038, #evt 995 run630039, #evt 187	#evt 2715	#evt 5655



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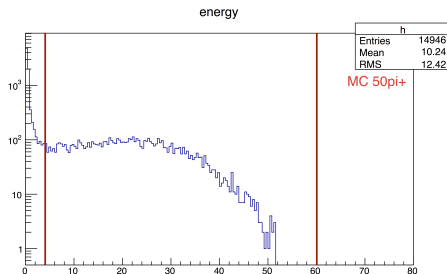
## 4 Conclusions

# Cuts for hadrons (ECAL)

Particle/Cuts	TB 50GeV pi+ ECAL	MC 50GeV pi+ ECAL
Vetoed Layers	layers #27, 28, 29	layers #27, 28, 29
Calibration MIP->GeV	0.0050	0.0050
# Hits in 1st Layer	1...4 hits	1...4 hits
1st Layer Energy	<5.0 MIP	<5.0 MIP
Barycentre position X	-16...24 mm	10...50 mm
Barycentre position Y	-20...20 mm	-20...20 mm
Layer Max Energy	layers #4...20	layers #4...20
Energy Layer Max En	100...1000 MIP	100...1000 MIP
Energy cut	4.0...60.0 GeV	4.0...60.0 GeV
Runs, #events	run630084, #evt 5399	#evt 2820

# Ex. 50 GeV hadrons spectra: ECAL energy before cuts

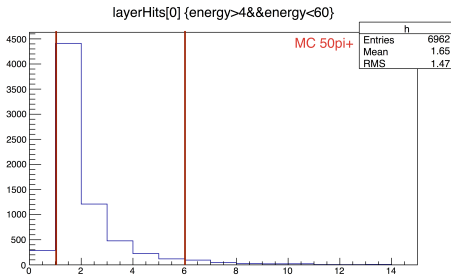
Particle/Cuts	TB 50GeV pi+ ECAL	MC 50GeV pi+ ECAL
Vetoed Layers	layers #27, 28, 29	layers #27, 28, 29
Calibration MIP->GeV	0.0050	0.0050
# Hits in 1st Layer	1...4 hits	1...4 hits
1st Layer Energy	<5.0 MIP	<5.0 MIP
Barycentre position X	-16...24 mm	10...50 mm
Barycentre position Y	-20...20 mm	-20...20 mm
Layer Max Energy	layers #4...20	layers #4...20
Energy Layer Max En	100...1000 MIP	100...1000 MIP
Energy cut	4.0...60.0 GeV	4.0...60.0 GeV
Runs, #events	run630084, #evt 5399	#evt 2820





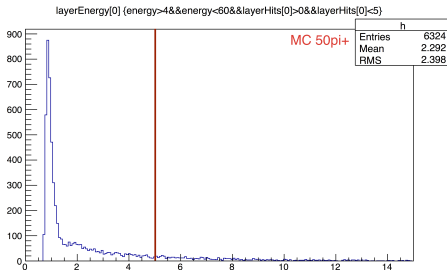
# Ex. 50 GeV hadron spectra: # hits in 1st layer

Particle/Cuts	TB 50GeV pi+ ECAL	MC 50GeV pi+ ECAL
<b>Vetoed Layers</b>	layers #27, 28, 29	layers #27, 28, 29
<b>Calibration MIP-&gt;GeV</b>	0.0050	0.0050
<b># Hits in 1st Layer</b>	1...4 hits	1...4 hits
<b>1st Layer Energy</b>	<5.0 MIP	<5.0 MIP
<b>Barycentre position X</b>	-16...24 mm	10...50 mm
<b>Barycentre position Y</b>	-20...20 mm	-20...20 mm
<b>Layer Max Energy</b>	layers #4...20	layers #4...20
<b>Energy Layer Max En</b>	100...1000 MIP	100...1000 MIP
<b>Energy cut</b>	4.0...60.0 GeV	4.0...60.0 GeV
<b>Runs, #events</b>	run630084, #evt 5399	#evt 2820



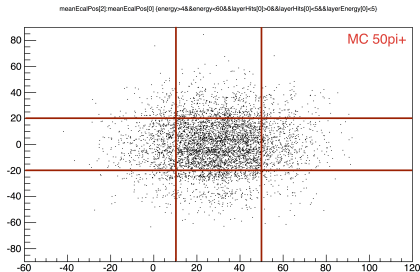
# Ex. 50 GeV hadron spectra: energy in 1st layer

Particle/Cuts	TB 50GeV pi+ ECAL	MC 50GeV pi+ ECAL
Vetoed Layers	layers #27, 28, 29	layers #27, 28, 29
Calibration MIP->GeV	0.0050	0.0050
# Hits in 1st Layer	1...4 hits	1...4 hits
1st Layer Energy	<5.0 MIP	<5.0 MIP
Barycentre position X	-16...24 mm	10...50 mm
Barycentre position Y	-20...20 mm	-20...20 mm
Layer Max Energy	layers #4...20	layers #4...20
Energy Layer Max En	100...1000 MIP	100...1000 MIP
Energy cut	4.0...60.0 GeV	4.0...60.0 GeV
Runs, #events	run630084, #evt 5399	#evt 2820



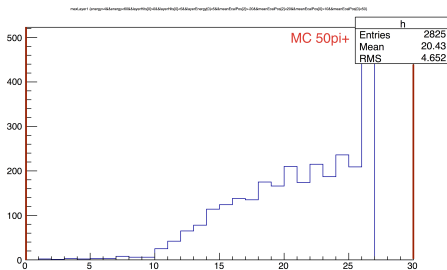
# Ex. 50 GeV hadrons spectra: shower barycentre position

Particle/Cuts	TB 50GeV pi+ ECAL	MC 50GeV pi+ ECAL
Vetoed Layers	layers #27, 28, 29	layers #27, 28, 29
Calibration MIP->GeV	0.0050	0.0050
# Hits in 1st Layer	1...4 hits	1...4 hits
1st Layer Energy	<5.0 MIP	<5.0 MIP
<u>Barycentre position X</u>	-16...24 mm	10...50 mm
<u>Barycentre position Y</u>	-20...20 mm	-20...20 mm
Layer Max Energy	layers #4...20	layers #4...20
Energy Layer Max En	100...1000 MIP	100...1000 MIP
Energy cut	4.0...60.0 GeV	4.0...60.0 GeV
Runs, #events	run630084, #evt 5399	#evt 2820



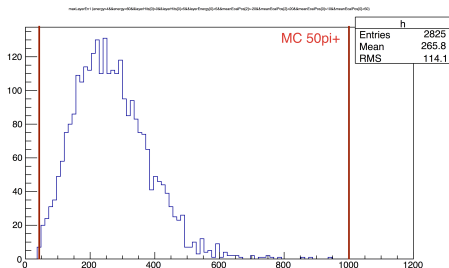
# Ex. 50 GeV hadrons spectra: layer with max energy

Particle/Cuts	TB 50GeV pi+ ECAL	MC 50GeV pi+ ECAL
<b>Vetoed Layers</b>	layers #27, 28, 29	layers #27, 28, 29
<b>Calibration MIP-&gt;GeV</b>	0.0050	0.0050
<b># Hits in 1st Layer</b>	1...4 hits	1...4 hits
<b>1st Layer Energy</b>	<5.0 MIP	<5.0 MIP
<b>Barycentre position X</b>	-16...24 mm	10...50 mm
<b>Barycentre position Y</b>	-20...20 mm	-20...20 mm
<b>Layer Max Energy</b>	layers #4...20	layers #4...20
<b>Energy Layer Max En</b>	100...1000 MIP	100...1000 MIP
<b>Energy cut</b>	4.0...60.0 GeV	4.0...60.0 GeV
<b>Runs, #events</b>	run630084, #evt 5399	#evt 2820



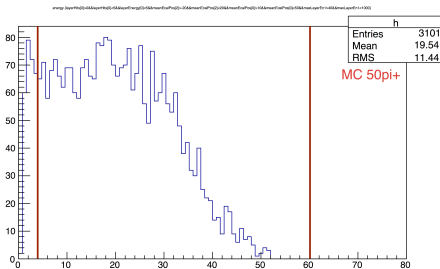
# Ex. 50 GeV hadrons spectra: energy of layer max energy

Particle/Cuts	TB 50GeV pi+ ECAL	MC 50GeV pi+ ECAL
Vetoed Layers	layers #27, 28, 29	layers #27, 28, 29
Calibration MIP->GeV	0.0050	0.0050
# Hits in 1st Layer	1...4 hits	1...4 hits
1st Layer Energy	<5.0 MIP	<5.0 MIP
Barycentre position X	-16...24 mm	10...50 mm
Barycentre position Y	-20...20 mm	-20...20 mm
Layer Max Energy	layers #4...20	layers #4...20
<u>Energy Layer Max En</u>	100...1000 MIP	100...1000 MIP
Energy cut	4.0...60.0 GeV	4.0...60.0 GeV
Runs, #events	run630084, #evt 5399	#evt 2820



# Ex. 50 GeV hadrons spectra: ECAL energy after cuts

Particle/Cuts	TB 50GeV pi+ ECAL	MC 50GeV pi+ ECAL
Vetoed Layers	layers #27, 28, 29	layers #27, 28, 29
Calibration MIP->GeV	0.0050	0.0050
# Hits in 1st Layer	1...4 hits	1...4 hits
1st Layer Energy	<5.0 MIP	<5.0 MIP
Barycentre position X	-16...24 mm	10...50 mm
Barycentre position Y	-20...20 mm	-20...20 mm
Layer Max Energy	layers #4...20	layers #4...20
Energy Layer Max En	100...1000 MIP	100...1000 MIP
Energy cut	4.0...60.0 GeV	4.0...60.0 GeV
Runs, #events	run630084, #evt 5399	#evt 2820



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# Event display: Photon 4GeV + Photon 4GeV, shift=0cm

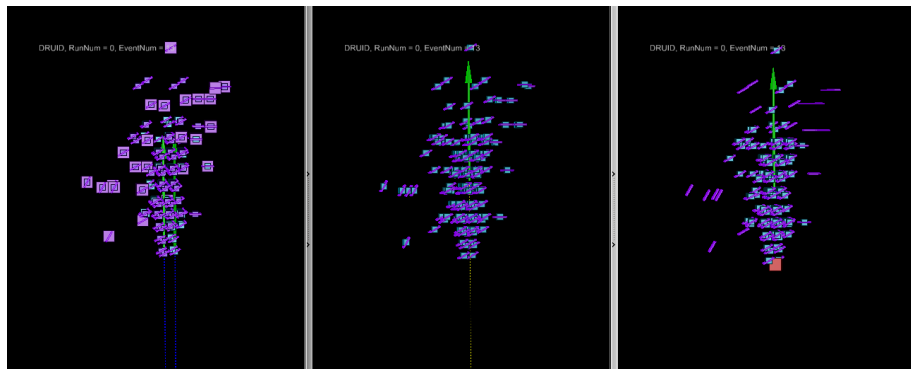


Figure : Reconstruction: ARBOR (left), PANDORA (middle), GARLIC (right)



# Event display: Photon 4GeV + Photon 4GeV, shift=2cm

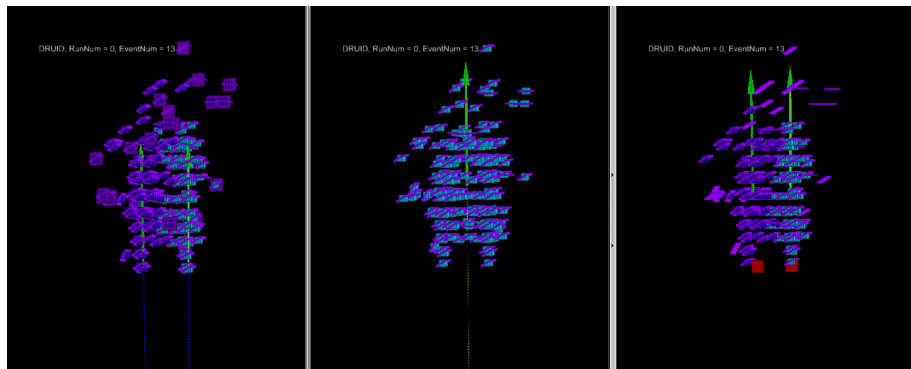


Figure : Reconstruction: ARBOR (left), PANDORA (middle), GARLIC (right)

# Event display: Photon 4GeV + Photon 4GeV, shift=6cm

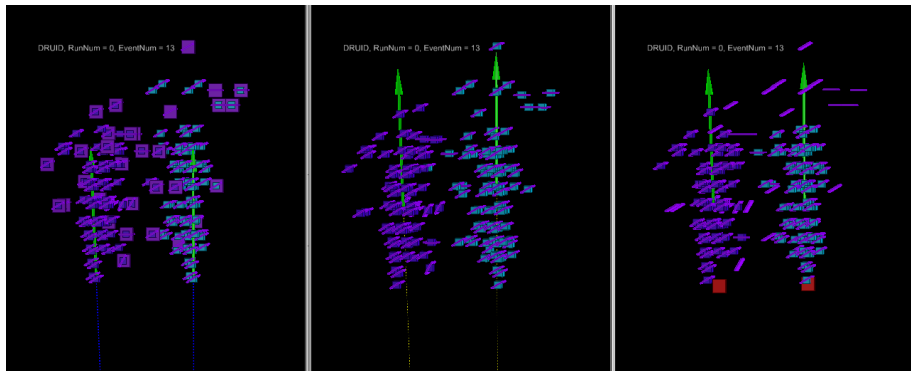
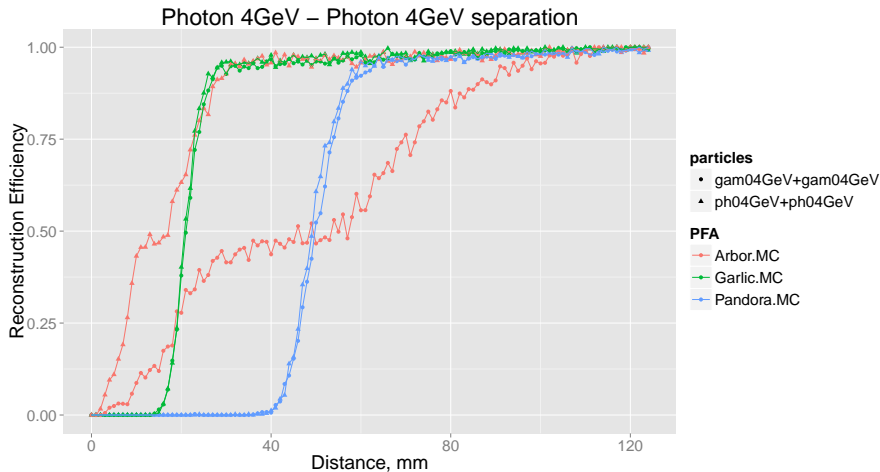


Figure : Reconstruction: ARBOR (left), PANDORA (middle), GARLIC (right)

# Photon-Photon separation



Distance = between shower barycentres (not integer) with shifts (integer)

Reconstruction efficiency = probability of "correct" separation

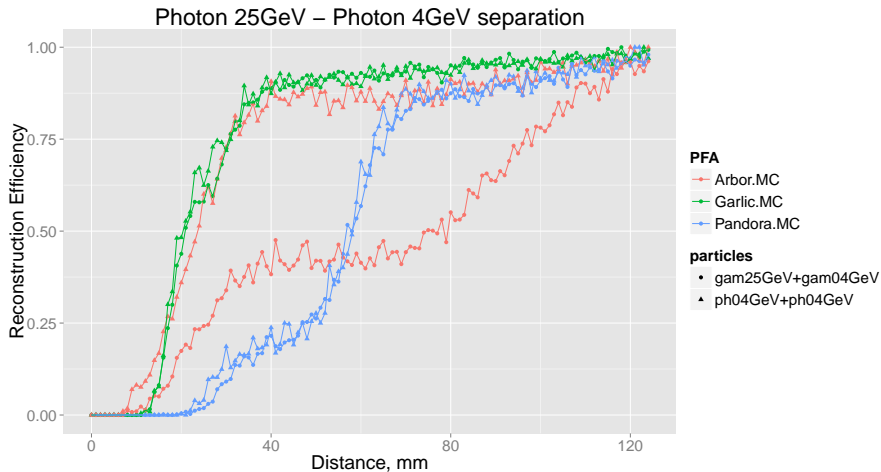
# Photon-Photon separation



Distance = between shower barycentres (not integer) with shifts (integer)

Reconstruction efficiency = probability of "correct" separation

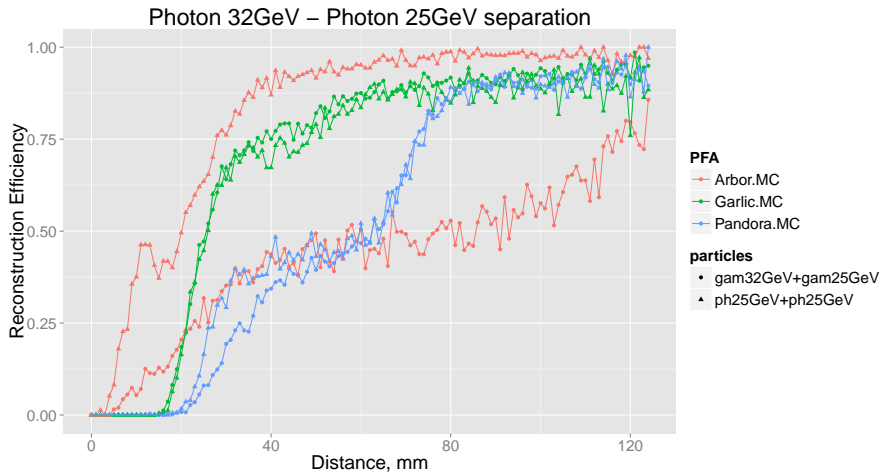
# Photon-Photon separation



Distance = between shower barycentres (not integer) with shifts (integer)

Reconstruction efficiency = probability of "correct" separation

# Photon-Photon separation



Distance = between shower barycentres (not integer) with shifts (integer)

Reconstruction efficiency = probability of "correct" separation

## Problems:

- GARLIC is optimized for photons, typical problems: to pass inner selection criteria, fake photons
- PANDORA's problems: SEPARATION, fake PID, fake photons
- ARBOR is biased, for  $2-e^+$  it has hint (1 hit in 1st layer), for  $2-\gamma$  case typical problems are fake photons and distribution of energy between clusters

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- Photon-Photon separation
- **Hadron-Photon separation**

## 4 Conclusions



# Event display: Hadron 50GeV + Photon 4GeV, shift=0cm

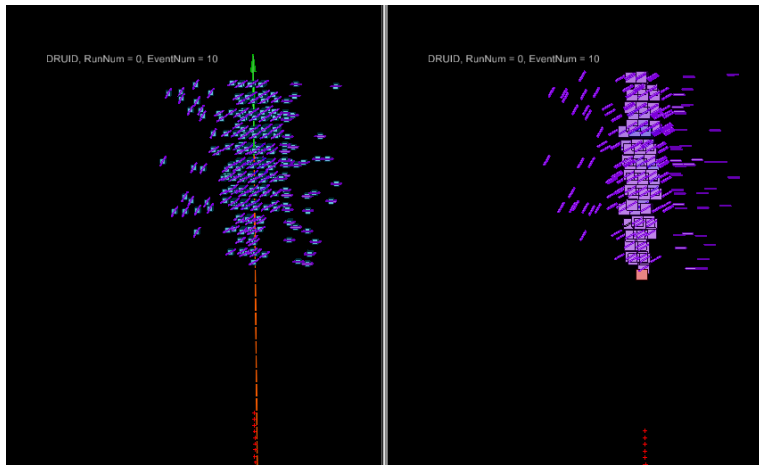


Figure : Reconstruction: PANDORA (left), GARLIC (right)

# Event display: Hadron 50GeV + Photon 4GeV, shift=10cm

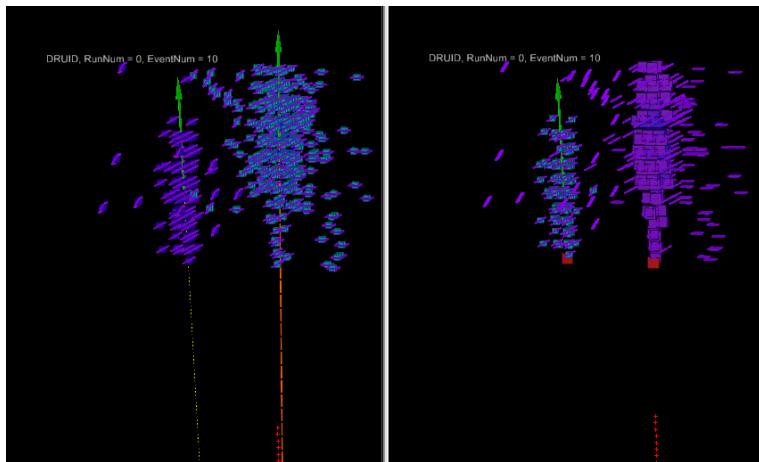
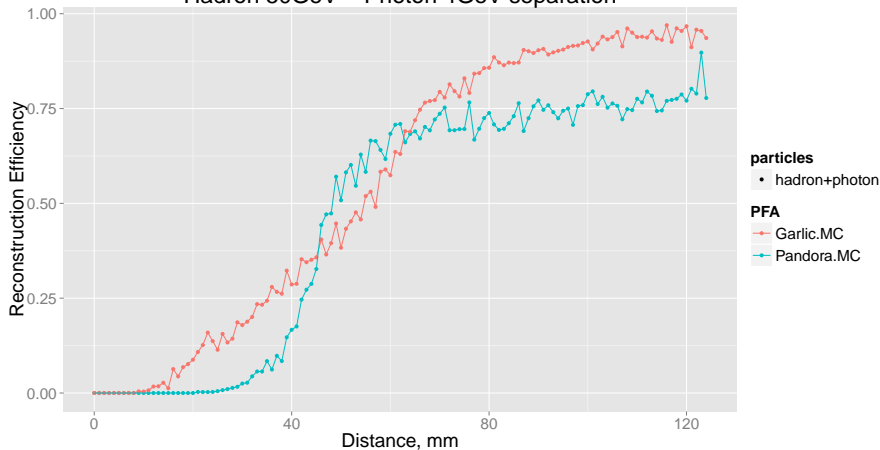


Figure : Reconstruction: PANDORA (left), GARLIC (right)

# Hadron(ECAL)-Photon separation

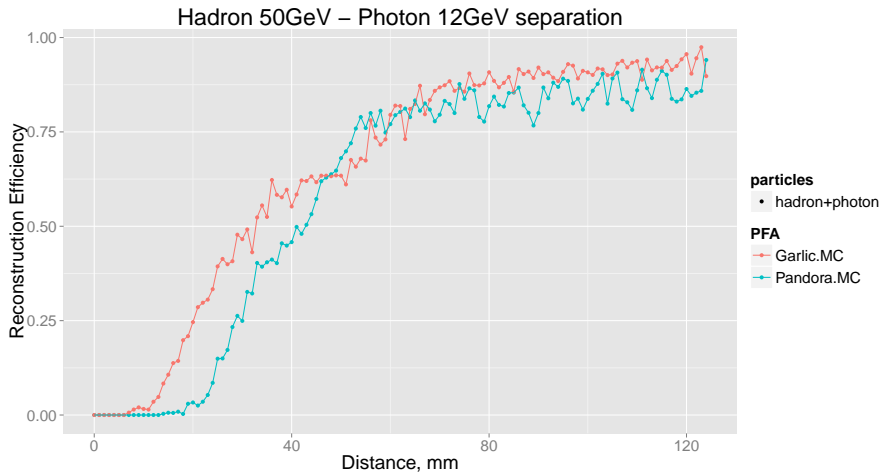
## Hadron 50GeV – Photon 4GeV separation



Distance = between shower barycentres (not integer) with shifts (integer)

Reconstruction efficiency = probability of "correct" separation

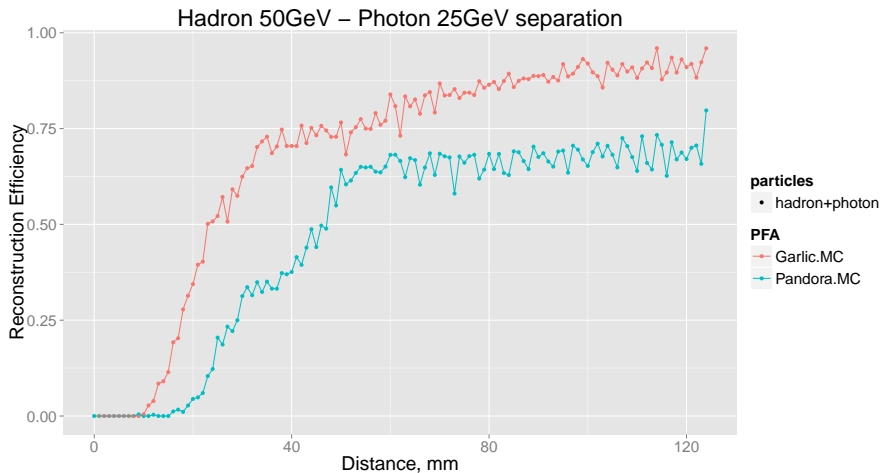
# Hadron(ECAL)-Photon separation



Distance = between shower barycentres (not integer) with shifts (integer)

Reconstruction efficiency = probability of "correct" separation

# Hadron(ECAL)-Photon separation

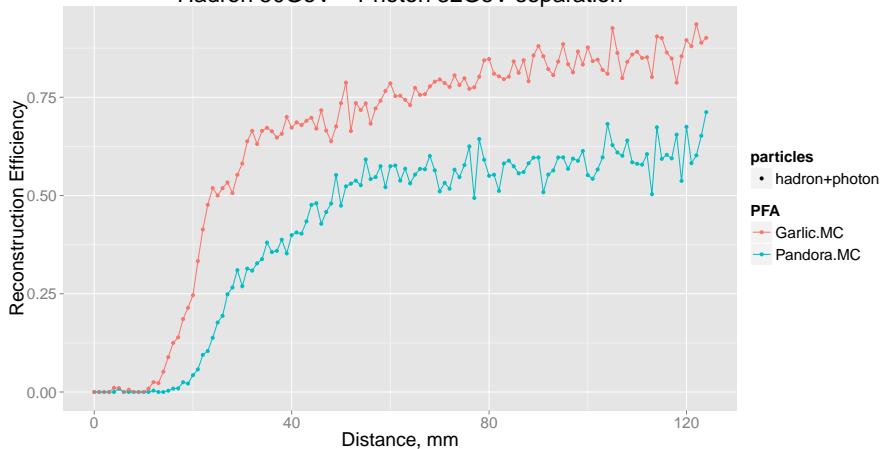


Distance = between shower barycentres (not integer) with shifts (integer)

Reconstruction efficiency = probability of "correct" separation

# Hadron(ECAL)-Photon separation

## Hadron 50GeV – Photon 32GeV separation



Distance = between shower barycentres (not integer) with shifts (integer)

Reconstruction efficiency = probability of "correct" separation

## Problems:

- Absence of HCAL data to make full analysis
- GARLIC's problems: to pass inner selection criteria, fake photons
- PANDORA's situation: 2 clearly separated by eye cluster can be merged in 1 cluster during clustering procedure → but merged Cluster Energy  $<$  Track Energy → impossible to start reclustering

# Problems and Conclusions

- Separation on data is reproduced on MC
- GARLIC (specialized on  $\gamma$  reconstruction) is better than PANDORA, but GARLIC is slow
- ARBOR: problems with MC gamma separation