Imaging TopoClustering on ScFi

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July 22,2025

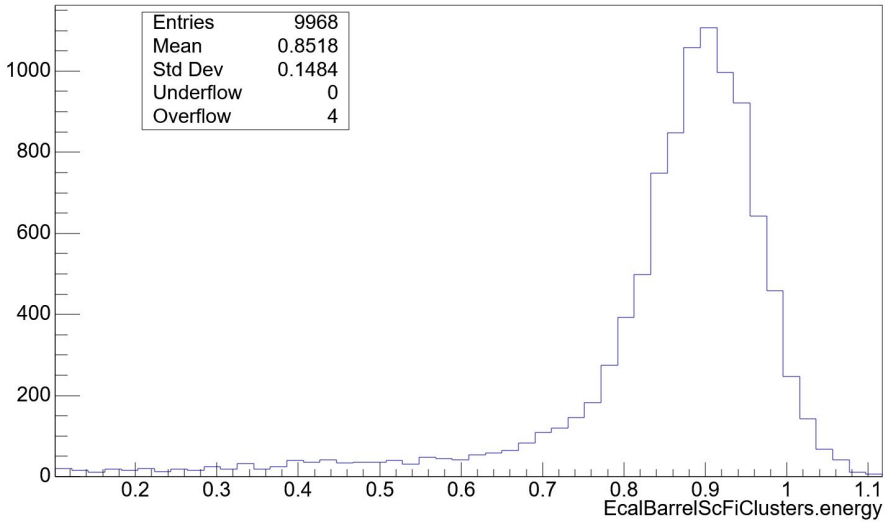
Topological Clustering - 2D (without Z information)

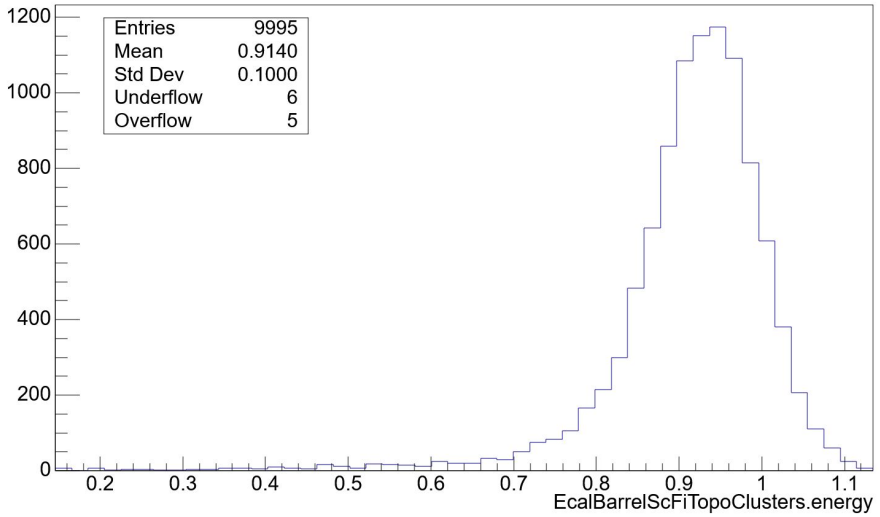
```cpp
// helper function to group hits
bool ImagingTopoCluster::is_neighbour(const edm4eic::CalorimeterHit& h1,
                                      const edm4eic::CalorimeterHit& h2) const {
  // different sectors, simple distance check
  if (h1.getSector() != h2.getSector()) {
    return std::hypot((h1.getPosition().x - h2.getPosition().x),
                      (h1.getPosition().y - h2.getPosition().y),
                      (h1.getPosition().z - h2.getPosition().z)) <= sectorDist;
  }

  // layer check
  int ldiff = std::abs(h1.getLayer() - h2.getLayer());
  same layer, check local positions
  if (ldiff == 0) {
    return (std::abs(h1.getLocal().x - h2.getLocal().x) <= localDistXY[0]) &&
           (std::abs(h1.getLocal().y - h2.getLocal().y) <= localDistXY[1]);
  }
```

```cpp
app->Add(new JOmniFactoryGeneratorT<ImagingTopoCluster_factory>(
"EcalBarrelScFiProtoClusters_Topo", {"EcalBarrelScFiRecHits"},
{"EcalBarrelScFiProtoClusters_Topo"},
{

.neighbourLayersRange = 2,
.localDistXY          = {2.0 * dd4hep::mm, 2.0 * dd4hep::mm},
.layerDistEtaPhi      = {10 * dd4hep::mrad, 10 * dd4hep::mrad},
.sectorDist           = 3.0 * dd4hep::cm,
.minClusterHitEdep    = 0,
.minClusterCenterEdep = 0,
.minClusterEdep       = 100 * dd4hep::MeV,
.minClusterNhits      = 10,
},
app // TODO: Remove me once fixed
));
```

Topological Clustering on ScFi - 2D (without Z information)

Plots based on 1 GeV photon single particle simulation

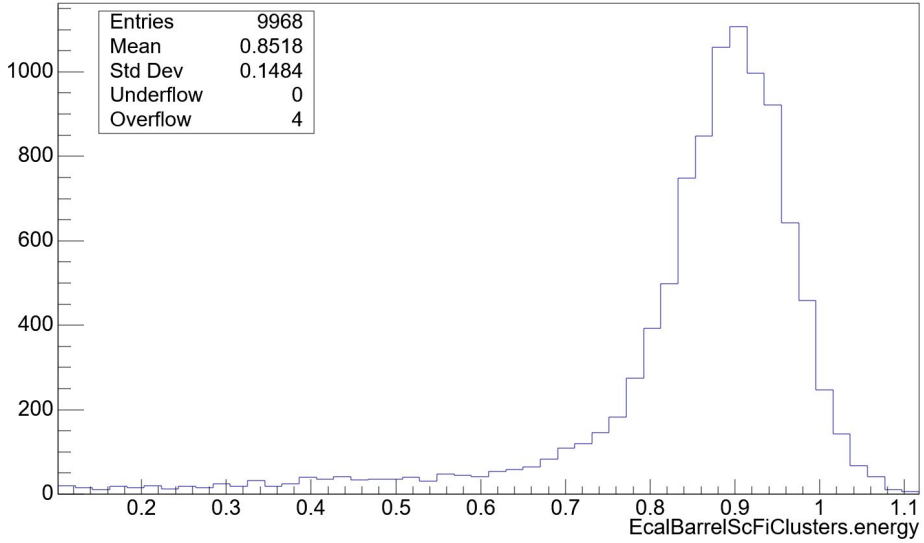


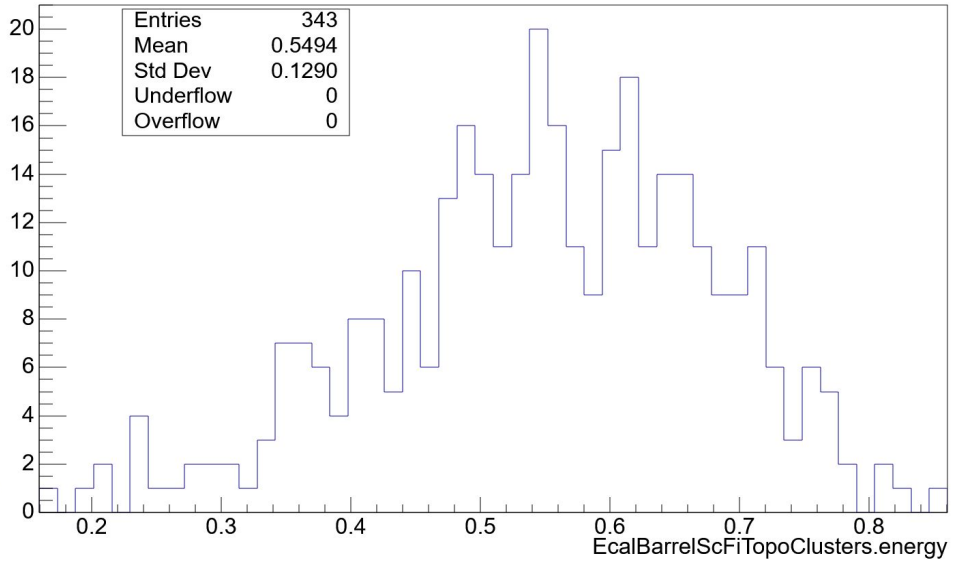


Topological Clustering on ScFi - 3D (Cluster Grouping based based on new parameter : locDistXYZ)

```cpp
// helper function to group hits
bool ImagingTopoCluster::is_neighbour(const edm4eic::CalorimeterHit& h1,
                                      const edm4eic::CalorimeterHit& h2) const {
  // different sectors, simple distance check
  if (h1.getSector() != h2.getSector()) {
    return std::hypot((h1.getPosition().x - h2.getPosition().x),
                      (h1.getPosition().y - h2.getPosition().y),
                      (h1.getPosition().z - h2.getPosition().z)) <= sectorDist;
  }

  // layer check
  int ldiff = std::abs(h1.getLayer() - h2.getLayer());
  // same layer, check local positions
  // if (ldiff == 0) {
  //   return (std::abs(h1.getLocal().x - h2.getLocal().x) <= localDistXY[0]) &&
  //          (std::abs(h1.getLocal().y - h2.getLocal().y) <= localDistXY[1]);
  // }

  // // check based on locDistXYZ
  if (ldiff == 0) {
  return (std::abs(h1.getLocal().x - h2.getLocal().x) <= locDistXYZ[0]) &&
         (std::abs(h1.getLocal().y - h2.getLocal().y) <= locDistXYZ[1]) &&
         (std::abs(h1.getLocal().z - h2.getLocal().z) <= locDistXYZ[2]);
  }
```

```cpp
app->Add(new JOmniFactoryGeneratorT<ImagingTopoCluster_factory>(
"EcalBarrelScFiProtoClusters_Topo", {"EcalBarrelScFiRecHits"},
{"EcalBarrelScFiProtoClusters_Topo"},
{

.neighbourLayersRange = 2,
.localDistXY          = {2.0 * dd4hep::mm, 2.0 * dd4hep::mm},
.layerDistEtaPhi      = {10 * dd4hep::mrad, 10 * dd4hep::mrad},
.locDistXYZ           = {2.0 * dd4hep::mm, 2.0 * dd4hep::mm, 200.0 * dd4hep::mm},
.sectorDist           = 3.0 * dd4hep::cm,
.minClusterHitEdep    = 0,
.minClusterCenterEdep = 0,
.minClusterEdep       = 100 * dd4hep::MeV,
.minClusterNhits      = 10,
},
app // TODO: Remove me once fixed
));
```






```
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] A single maximum found, added one ProtoCluster
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hits in a group: 23, local maxima: 1
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] No maxima found, not building any clusters
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hits in a group: 1, local maxima: 0
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] No maxima found, not building any clusters
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hits in a group: 1, local maxima: 0
```

```
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] found 19 potential clusters (groups of hits)
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 0: 5 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 1: 5 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 2: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 3: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 4: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 5: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 6: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 7: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 8: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 9: 2 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 10: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 11: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 12: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 13: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 14: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 15: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 16: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 17: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 18: 1 hits
```

Debug : EcalBarrelScFiProtoClsuters_Topo

```
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] hit 14: local position = (-582.6208, 630.2359, -52.5), global position = (-582.6208, 630.2359, -52.5), energy = 0.009859483
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] self hit skipped
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 17 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 18 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 19 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 23 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 4 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 5 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 9 is neighbour of 14 - adding to group
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 0 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 3 is neighbour of 14 - adding to group
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 6 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 7 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 2 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 15 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 21 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 24 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 27 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 10 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 12 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 13 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 16 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 20 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 26 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 8 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 11 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 1 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 25 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug]   hit 22 is NOT neighbour of 14 - skipping
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] self hit skipped
```

Local and Global positions of the hits

ΔX = 52.9 mm , ΔY = 57mm, ΔZ = 10mm

ΔX = 26.5 mm , ΔY = 28.6 mm, ΔZ =10mm

```
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 0: energy = 6.9016 MeV, local = (-719.8444, 598.6500) mm, global=(-719.8444, 598.6500, -82.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 1: energy = 6.9016 MeV, local = (-803.8329, 743.1024) mm, global=(-803.8329, 743.1024, -132.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 2: energy = 11.8314 MeV, local = (-716.1125, 662.0093) mm, global=(-716.1125, 662.0093, -142.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 3: energy = 155.7798 MeV, local = (-635.5465, 687.4870) mm, global=(-635.5465, 687.4870, -62.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 4: energy = 4.9297 MeV, local = (-643.3564, 626.7638) mm, global=(-643.3564, 626.7638, -92.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 5: energy = 198.1756 MeV, local = (-626.7638, 643.3564) mm, global=(-626.7638, 643.3564, -62.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 6: energy = 12.8173 MeV, local = (-671.3083, 653.9948) mm, global=(-671.3083, 653.9948, -72.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 7: energy = 66.0585 MeV, local = (-653.9948, 671.3083) mm, global=(-653.9948, 671.3083, -72.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 8: energy = 14.7892 MeV, local = (-729.0187, 788.5983) mm, global=(-729.0187, 788.5983, -92.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 9: energy = 27.6066 MeV, local = (-609.0837, 658.8615) mm, global=(-609.0837, 658.8615, -62.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 10: energy = 25.6347 MeV, local = (-727.2121, 708.4568) mm, global=(-727.2121, 708.4568, -62.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 11: energy = 11.8314 MeV, local = (-707.8572, 807.1564) mm, global=(-707.8572, 807.1564, -52.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 12: energy = 27.6066 MeV, local = (-668.4877, 762.2640) mm, global=(-668.4877, 762.2640, -72.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 13: energy = 42.3958 MeV, local = (-688.4722, 744.7381) mm, global=(-688.4722, 744.7381, -2.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 14: energy = 9.8595 MeV, local = (-582.6208, 630.2359) mm, global=(-582.6208, 630.2359, -52.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 15: energy = 7.8876 MeV, local = (-699.2602, 681.2258) mm, global=(-699.2602, 681.2258, -72.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 16: energy = 4.9297 MeV, local = (-648.5031, 779.7900) mm, global=(-648.5031, 779.7900, -152.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 17: energy = 47.3255 MeV, local = (-599.5328, 615.4045) mm, global=(-599.5328, 615.4045, -52.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 18: energy = 4.9297 MeV, local = (-674.7301, 531.8849) mm, global=(-674.7301, 531.8849, -162.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 19: energy = 7.8876 MeV, local = (-565.7088, 645.0673) mm, global=(-565.7088, 645.0673, -142.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 20: energy = 36.4801 MeV, local = (-630.8252, 844.7300) mm, global=(-630.8252, 844.7300, -82.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 21: energy = 129.1592 MeV, local = (-662.0093, 716.1125) mm, global=(-662.0093, 716.1125, -72.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 22: energy = 10.8454 MeV, local = (-853.9359, 748.8817) mm, global=(-853.9359, 748.8817, -12.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 23: energy = 7.8876 MeV, local = (688.3943, -514.0773) mm, global=(688.3943, -514.0773, -52.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 24: energy = 29.5784 MeV, local = (-681.2258, 699.2602) mm, global=(-681.2258, 699.2602, -102.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 25: energy = 5.9157 MeV, local = (-857.6179, 713.2277) mm, global=(-857.6179, 713.2277, -92.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 26: energy = 7.8876 MeV, local = (-714.9351, 773.3636) mm, global=(-714.9351, 773.3636, -72.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hit 27: energy = 46.3396 MeV, local = (-642.7930, 732.9648) mm, global=(-642.7930, 732.9648, -72.5000) mm
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] A single maximum found, added one ProtoCluster
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hits in a group: 23, local maxima: 1
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] No maxima found, not building any clusters
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hits in a group: 1, local maxima: 0
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] No maxima found, not building any clusters
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hits in a group: 1, local maxima: 0
```

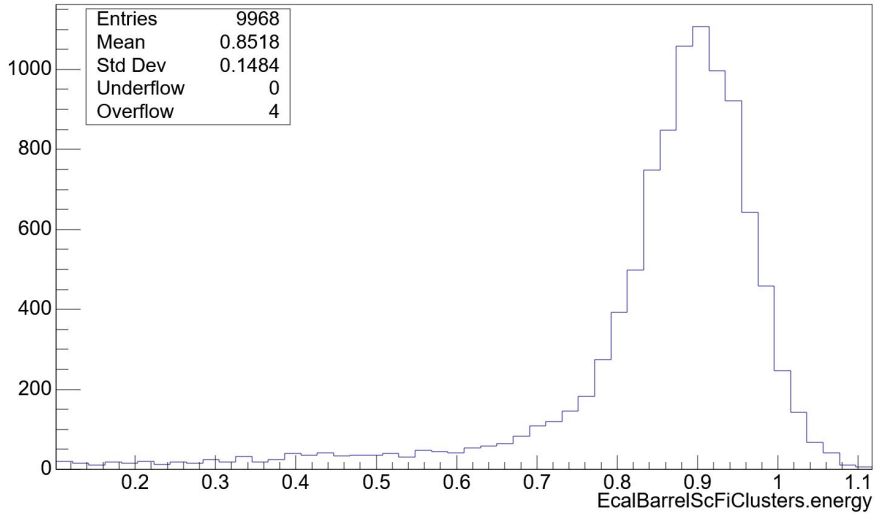
```cpp
// helper function to group hits
bool ImagingTopoCluster::is_neighbour(const edm4eic::CalorimeterHit& h1,
                                      const edm4eic::CalorimeterHit& h2) const {
  // different sectors, simple distance check
  if (h1.getSector() != h2.getSector()) {
    return std::hypot((h1.getPosition().x - h2.getPosition().x),
                      (h1.getPosition().y - h2.getPosition().y),
                      (h1.getPosition().z - h2.getPosition().z)) <= sectorDist;
  }

  // layer check
  int ldiff = std::abs(h1.getLayer() - h2.getLayer());
  // same layer, check local positions
  // if (ldiff == 0) {
  //   return (std::abs(h1.getLocal().x - h2.getLocal().x) <= localDistXY[0]) &&
  //          (std::abs(h1.getLocal().y - h2.getLocal().y) <= localDistXY[1]);
  // }

  // // check based on locDistXYZ
  if (ldiff == 0) {
  return (std::abs(h1.getLocal().x - h2.getLocal().x) <= locDistXYZ[0]) &&
         (std::abs(h1.getLocal().y - h2.getLocal().y) <= locDistXYZ[1]) &&
         (std::abs(h1.getLocal().z - h2.getLocal().z) <= locDistXYZ[2]);
  }
```

ΔX = 52.9 mm , ΔY = 57mm, ΔZ =10mm
ΔX = 26.5 mm , ΔY = 28.6 mm, ΔZ =10mm

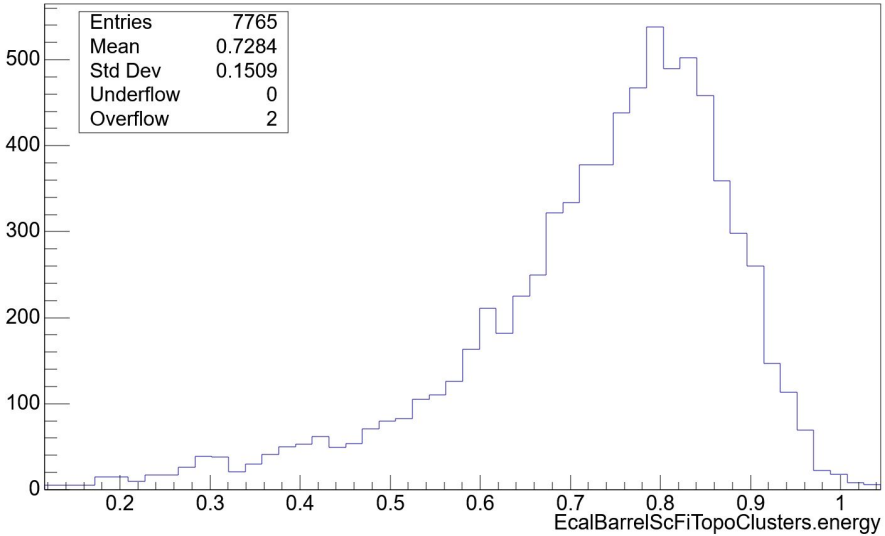
locDistXYZ = {2.0 * dd4hep::mm, 2.0 * dd4hep::mm, 200.0 * dd4hep::mm}

So, the Grouping is not based on the layer check but Sector distance check (3.0 * dd4hep::cm)

Thus, Improving the locDistXYZ to {30.0 * dd4hep::mm, 30.0 * dd4hep::mm, 120.0 * dd4hep::mm},



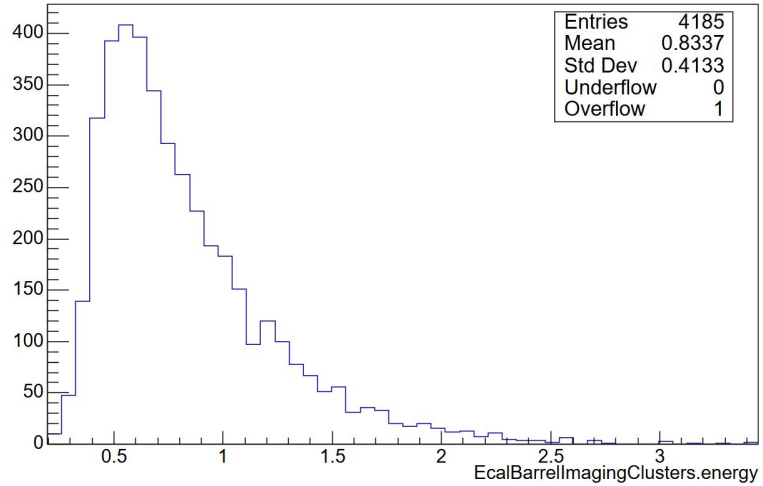

```
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] A single maximum found, added one ProtoCluster
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hits in a group: 23, local maxima: 1
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] No maxima found, not building any clusters
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hits in a group: 1, local maxima: 0
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] No maxima found, not building any clusters
[e:100] [BEMC:EcalBarrelScFiProtoClusters] [debug] hits in a group: 1, local maxima: 0
```




```
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] found 12 potential clusters (groups of hits)
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 0: 16 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 1: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 2: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 3: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 4: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 5: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 6: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 7: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 8: 2 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 9: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 10: 1 hits
[e:100] [BEMC:EcalBarrelScFiProtoClusters_Topo] [debug] group 11: 1 hits
```

Clustering on AstroPix

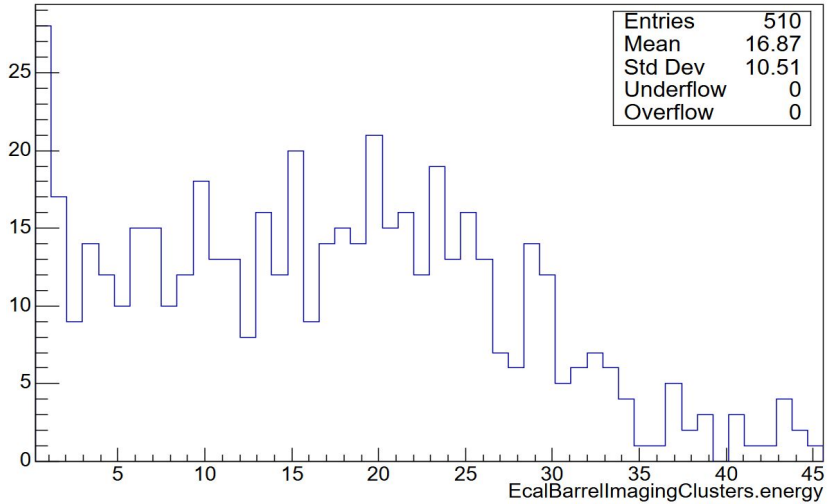
```
// helper function to group hits
bool ImagingTopoCluster::is_neighbour(const edm4eic::CalorimeterHit& h1,
                                      const edm4eic::CalorimeterHit& h2) const {
  // different sectors, simple distance check
  if (h1.getSector() != h2.getSector()) {
    return std::hypot((h1.getPosition().x - h2.getPosition().x),
                      (h1.getPosition().y - h2.getPosition().y),
                      (h1.getPosition().z - h2.getPosition().z)) <= sectorDist;
  }

  // layer check
  int ldiff = std::abs(h1.getLayer() - h2.getLayer());
  // same layer, check local positions
  if (ldiff == 0) {
    return (std::abs(h1.getLocal().x - h2.getLocal().x) <= localDistXY[0]) &&
           (std::abs(h1.getLocal().y - h2.getLocal().y) <= localDistXY[1]);
  } else if (ldiff <= m_cfg.neighbourLayersRange) {
    switch (m_cfg.layerMode) {
    case eicrecon::ImagingTopoClusterConfig::ELayerMode::etaphi:
      return (std::abs(edm4hep::utils::eta(h1.getPosition()) -
                       edm4hep::utils::eta(h2.getPosition())) <= layerDistEtaPhi[0]) &&
             (std::abs(edm4hep::utils::angleAzimuthal(h1.getPosition()) -
                       edm4hep::utils::angleAzimuthal(h2.getPosition())) <= layerDistEtaPhi[1]);
    case eicrecon::ImagingTopoClusterConfig::ELayerMode::xy:
      return (std::abs(h1.getPosition().x - h2.getPosition().x) <= layerDistXY[0]) &&
             (std::abs(h1.getPosition().y - h2.getPosition().y) <= layerDistXY[1]);
    }
  }
```



Even after changing the layer check based on the locDistXYZ, the imaging Clusters (initially based on the localDistXY) are not affected.

2 photon simulation details to check the clustering in AstroPix :

```
// Two photons in the final state
auto [id, mass] = extract_particle_parameters(particle_name);
double theta1 = theta;
double theta2 = theta + TMath::DegToRad()*1.0; // 1 degree difference

// Photon 1
double px1 = p * cos(phi) * sin(theta1);
double py1 = p * sin(phi) * sin(theta1);
double pz1 = p * cos(theta1);
GenParticlePtr photon1 = std::make_shared<GenParticle>(FourVector(px1, py1, pz1, sqrt(px1*px1 + py1*py1 + pz1*pz1)), id, 1);

// Photon 2
double px2 = p * cos(phi) * sin(theta2);
double py2 = p * sin(phi) * sin(theta2);
double pz2 = p * cos(theta2);
GenParticlePtr photon2 = std::make_shared<GenParticle>(FourVector(px2, py2, pz2, sqrt(px2*px2 + py2*py2 + pz2*pz2)), id, 1);
```



```
[e:50] [BEMC:EcalBarrelImagingProtoClusters] [debug]   hit 122 -> energy = 0.029419, layer = 4, sector = 28, local = (-6.50, 3.50, -0.00), global = (361.78, 884.67, -732.20)
[e:50] [BEMC:EcalBarrelImagingProtoClusters] [debug]   hit 128 -> energy = 0.023024, layer = 4, sector = 28, local = (-6.50, 4.00, -0.00), global = (361.78, 884.67, -731.70)
[e:50] [BEMC:EcalBarrelImagingProtoClusters] [debug]   hit 227 -> energy = 0.034110, layer = 6, sector = 28, local = (-7.50, 5.00, -0.00), global = (393.48, 958.78, -670.10)
[e:50] [BEMC:EcalBarrelImagingProtoClusters] [debug]   hit 85 -> energy = 0.021318, layer = 4, sector = 28, local = (2.50, 7.50, -0.00), global = (334.25, 895.67, -546.40)
[e:50] [BEMC:EcalBarrelImagingProtoClusters] [debug]   hit 17 -> energy = 0.064552, layer = 6, sector = 28, local = (-7.00, 9.50, -0.00), global = (375.00, 964.96, -706.00)
[e:50] [BEMC:EcalBarrelImagingProtoClusters] [debug]   hit 195 -> energy = 0.015008, layer = 4, sector = 28, local = (-9.00, -2.00, 0.00), global = (363.98, 883.47, -697.30)
[e:50] [BEMC:EcalBarrelImagingProtoClusters] [debug]   hit 26 -> energy = 0.035900, layer = 4, sector = 28, local = (-2.50, 5.00, 0.00), global = (338.63, 893.26, -569.10)
[e:50] [BEMC:EcalBarrelImagingProtoClusters] [debug]   hit 28 -> energy = 0.026605, layer = 4, sector = 28, local = (-2.00, 4.00, -0.00), global = (338.19, 893.50, -570.10)
[e:50] [BEMC:EcalBarrelImagingProtoClusters] [debug]   hit 102 -> energy = 0.041869, layer = 4, sector = 28, local = (-2.00, 5.00, -0.00), global = (338.19, 893.50, -569.10)

[e:50] [BEMC:EcalBarrelImagingProtoClusters] [debug]   hit 7 -> energy = 0.072568, layer = 6, sector = 28, local = (5.50, 6.50, 0.00), global = (344.66, 972.97, -648.40)
[e:50] [BEMC:EcalBarrelImagingProtoClusters] [debug]   hit 11 -> energy = 0.005884, layer = 6, sector = 28, local = (4.00, 5.50, -0.00), global = (346.15, 972.74, -649.40)
[e:50] [BEMC:EcalBarrelImagingProtoClusters] [debug]   hit 274 -> energy = 0.031210, layer = 6, sector = 28, local = (7.00, 7.00, 0.00), global = (361.16, 967.09, -748.90)
[e:50] [BEMC:EcalBarrelImagingProtoClusters] [debug]   hit 62 -> energy = 0.108212, layer = 6, sector = 28, local = (6.50, 1.50, 0.00), global = (361.66, 967.02, -714.00)

[e:50] [BEMC:EcalBarrelImagingProtoClusters] [debug]   hit 245 -> energy = 0.037520, layer = 6, sector = 28, local = (4.50, -1.00, -0.00), global = (363.64, 966.71, -676.10)
[e:50] [BEMC:EcalBarrelImagingProtoClusters] [debug]   hit 47 -> energy = 0.048350, layer = 6, sector = 28, local = (5.00, -2.00, -0.00), global = (363.14, 966.79, -717.50)
[e:50] [BEMC:EcalBarrelImagingProtoClusters] [debug]   hit 214 -> energy = 0.043916, layer = 6, sector = 28, local = (5.00, -1.50, -0.00), global = (363.14, 966.79, -717.00)
[e:50] [BEMC:EcalBarrelImagingProtoClusters] [debug]   hit 16 -> energy = 0.012109, layer = 6, sector = 28, local = (6.00, -3.50, 0.00), global = (344.17, 973.05, -658.40)
[e:50] [BEMC:EcalBarrelImagingProtoClusters] [debug]   hit 29 -> energy = 0.056963, layer = 6, sector = 28, local = (5.00, -4.00, -0.00), global = (363.14, 966.79, -699.30)
```

Imaging hits in the same layer which are far in global distance are grouped