Geant-level hits in tracking detectors

Barak Schmookler

Tracker hits in Geant (DD4Hep) output

VertexBarrelHits = (vector<edm4hep::SimTrackerHitData>)0x393a8f0

VertexBarrelHits.cellID = 1740106435056286543, 1705175386151526863, 1495786141957038595, 1740106434626789814, 1747368519520192131, 1742724194859871055, 1743906370864200118, 1744413049444599017, 1745989302871728156, 1743512326942144540, 1621126990317978857, 1619775894108891983, 1619072194211710185

VertexBarrelHits.EDep = 0.000050, 0.000011, 0.000018, 0.000011, 0.000106, 0.000013, 0.000025, 0.000037, 0.000023, 0.000078, 0.000010, 0.000014, 0.000085

VertexBarrelHits.time = 0.172631, 0.230277, 0.575604, 0.172684, 0.198817, 0.222128, 0.233706, 0.249430, 0.262780, 0.276989, 0.534295, 0.538136, 0.540672

VertexBarrelHits.pathLength = 0.057513, 0.057520, 0.057511, 0.041903, 0.278637, 0.044581, 0.038396, 0.041919, 0.043550, 0.143896, 0.016068, 0.007537, 0.051001

VertexBarrelHits.quality = 0, 0, 0, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824

VertexBarrelHits.position.x = -30.1701, -40.2047, -100.186, -30.1782, -28.8245, -27.4767, -28.8427, -27.407, -28.6091, -27.4422, -27.6744, -27.9173, -28.1112

VertexBarrelHits.position.y = 19.6455, 26.2272, 66.0554, 19.6389, 21.6014, 23.2667, 21.5396, 23.3516, 21.8583, 23.3087, 22.9942, 22.6983, 22.4739

VertexBarrelHits.position.z = 37.1742, 49.5744, 123.963, 37.1548, 34.5338, 36.2218, 35.8026, 35.616, 35.0633, 35.9978, 79.4242, 79.9155, 80.156

VertexBarrelHits.momentum.x = -3.186112, -3.182194, -3.162133, -0.000774, -0.000237, 0.000247, -0.000520, 0.000420, -0.000402, 0.000224, -0.000031, -0.000141, -0.000099

VertexBarrelHits.momentum.y = 2.085773, 2.090894, 2.121809, 0.000138, -0.000261, -0.000596, 0.000243, -0.000375, 0.000280, -0.000111, -0.000036, -0.000159, -0.000061

VertexBarrelHits.momentum.z = 3.934102, 3.934191, 3.933759, -0.000174, -0.000110, 0.000081, -0.000105, -0.000062, -0.000001, 0.000263, 0.000295, 0.000229, 0.000103

VertexBarrelHits#0 = (vector<podio::ObjectID>)0x39835b0

VertexBarrelHits#0.index = 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0

VertexBarrelHits#0.collectionID = 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1

Commas delimit the hits in detector

Tracker hits in Geant (DD4Hep) output

VertexBarrelHits = (vector<edm4hep::SimTrackerHitData>)0x393a8f0

VertexBarrelHits.cellID = 1740106435056286543, 1705175386151526863, 14
1742724194859871055, 1743906370864200118, 1744413049444599017, 1
1619775894108891983, 1619072194211710185

VertexBarrelHits.EDep = 0.000050, 0.000011, 0.000018, 0.000011, 0.000106, 0.

VertexBarrelHits.time = 0.172631, 0.230277, 0.575604, 0.172684, 0.198817, 0.2

VertexBarrelHits.pathLength = 0.057513, 0.057520, 0.057511, 0.041903, 0.2786

VertexBarrelHits.quality = 0, 0, 0, 1073741824, 1073741824, 1073741824, 1073

VertexBarrelHits.position.x = -30.1701, -40.2047, -100.186, -30.1782, -28.8245,

VertexBarrelHits.position.y = 19.6455, 26.2272, 66.0554, 19.6389, 21.6014, 23.2

VertexBarrelHits.position.z = 37.1742, 49.5744, 123.963, 37.1548, 34.5338, 36.2

VertexBarrelHits.momentum.x = -3.186112, -3.182194, -3.162133, -0.000774, -0

VertexBarrelHits.momentum.y = 2.085773, 2.090894, 2.121809, 0.000138, -0.000261, -0.000596, 0.000243, -0.000375, 0.000280, -0.000111, -0.000036, -0.000159, -0.000061

VertexBarrelHits.momentum.z = 3.934102, 3.934191, 3.933758, -0.000174, -0.000110, 0.000081, -0.000105, -0.000062, -0.000001, 0.000263, 0.000295, 0.000229, 0.000103

VertexBarrelHits#0 = (vector<podio::ObjectID>)0x39835b0

VertexBarrelHits#0.index = 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0

VertexBarrelHits#0.collectionID = 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1

MCParticles = (vector<edm4hep::MCParticleData>)0x340c710
MCParticles.PDG = 11, 11, 22, 11
MCParticles.generatorStatus = 1, 0, 0, 0
MCParticles.simulatorStatus = 16777216, 1493172224, 1358954496, 1493172224
MCParticles.charge = -1.000000, -1.000000, 0.000000, -1.000000
MCParticles.time = 0.000000, 2.127509, 3.376798, 3.537263
MCParticles.mass = 0.000510999, 0.000510999, 0, 0.000510999
MCParticles.vertex.x = 0, -364.581, -571.663, -597.841
MCParticles.vertex.y = 0, 252.174, 409.991, 430.794
MCParticles.vertex.z = 0, 458.511, 727.721, 762.307
MCParticles.endpoint.x = -702.893, -353.818, -671.82, -597.654
MCParticles.endpoint.y = 543.874, 269.065, 489.223, 431.325
MCParticles.endpoint.z = 953.056, 466.876, 859.89, 763.511
MCParticles.momentum.x = -3.197403, -0.001730, -0.027344, -0.000472
MCParticles.momentum.y = 2.071061, 0.003967, 0.021631, -0.000350
MCParticles.momentum.z = 3.933372, 0.003131, 0.036083, 0.001524

https://github.com/key4hep/EDM4hep/blob/master/edm4hep.yaml#L191

Tracker hits in Geant (DD4Hep) output

VertexBarrelHits = (vector<edm4hep::SimTrackerHitData>)0x393a8f0

VertexBarrelHits.cellID = 1740106435056286543, 1705175386151526863, 1495786141957038595, 1740106434626789814, 1747368519520192131, 1742724194859871055, 1743906370864200118, 1744413049444599017, 1745989302871728156, 1743512326942144540, 1621126990317978857, 1619775894108891983, 1619072194211710185

VertexBarrelHits.EDep = 0.000050, 0.000011, 0.000018, 0.000011, 0.000106, 0.000013, 0.000025, 0.000037, 0.000023, 0.000078, 0.000010, 0.000014, 0.000085

VertexBarrelHits.time = 0.172631, 0.230277, 0.575604, 0.172684, 0.198817, 0.222128, 0.233706, 0.249430, 0.262780, 0.276989, 0.534295, 0.538136, 0.540672

VertexBarrelHits.pathLength = 0.057513, 0.057520, 0.057511, 0.041903, 0.278637, 0.044581, 0.038396, 0.041919, 0.043550, 0.143896, 0.016068, 0.007537, 0.051001

VertexBarrelHits.quality = 0, 0, 0, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824

VertexBarrelHits.position.x = -30.1701, -40.2047, -100.186, -30.1782, -28.8245, -27.4767, -28.8427, -27.407, -28.6091, -27.4422, -27.6744, -27.9173, -28.1112

VertexBarrelHits.position.y = 19.6455, 26.2272, 66.0554, 19.6389, 21.6014, 23.2667, 21.5396, 23.3516, 21.8583, 23.3087, 22.9942, 22.6983, 22.4739

VertexBarrelHits.position.z = 37.1742, 49.5744, 123.963, 37.1548, 34.5338, 36.2218, 35.8026, 35.616, 35.0633, 35.9978, 79.4242, 79.9155, 80.156

VertexBarrelHits.momentum.x = -3.186112, -3.182194, -3.162133, -0.000774, -0.000237, 0.000247, -0.000520, 0.000420, -0.000402, 0.000224, -0.000031, -0.000141, -0.000099

VertexBarrelHits.momentum.y = 2.085773, 2.090894, 2.121809, 0.000138, -0.000261, -0.000596, 0.000243, -0.000375, 0.000280, -0.000111, -0.000036, -0.000159, -0.000061

VertexBarrelHits.momentum.z = 3.934102, 3.934191, 3.933759, -0.000174, -0.000110, 0.000081, -0.000105, -0.000062, -0.000001, 0.000263, 0.000295, 0.000229, 0.000103

VertexBarrelHits#0 = (vector<podio::ObjectID>)0x39835b0

VertexBarrelHits#0.index = 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0

VertexBarrelHits#0.collectionID = 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1

Indicates with which MC particle the hit is associated. All hits here are associated with the primary particle.

Tracker hits in Geant (DD4Hep) output

https://github.com/AIDASoft/DD4hep/issues/126
https://github.com/AIDASoft/DD4hep/pull/145

VertexBarrelHits = (vector<edm4hep::SimTrackerHitData>)0x393a8f0

VertexBarrelHits.cellID = 1740106435056286543, 1705175386151526863, 1495786141957038595, 1740106434626789814, 1747368519520192131, 1742724194859871055, 1743906370864200118, 1744413049444599017, 1745989302871728156, 1743512326942144540, 1621126990317978857, 1619775894108891983, 1619072194211710185

VertexBarrelHits.EDep = 0.000050, 0.000011, 0.000018, 0.000011, 0.000106, 0.000013, 0.000025, 0.000037, 0.000023, 0.000078, 0.000010, 0.000014, 0.000085

VertexBarrelHits.time = 0.172631, 0.230277, 0.575604, 0.172684, 0.198817, 0.222128, 0.233706, 0.249430, 0.262780, 0.276989, 0.534295, 0.538136, 0.540672

VertexBarrelHits.pathLength = 0.057513, 0.057520, 0.057511, 0.041903, 0.278637, 0.044581, 0.038396, 0.041919, 0.043550, 0.143896, 0.016068, 0.007537, 0.051001

VertexBarrelHits.quality = 0, 0, 0, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824

VertexBarrelHits.position.x = -30.1701, -40.2047, -100.186, -30.1782, -28.8245, -27.4767, -28.8427, -27.407, -28.6091, -27.4422, -27.6744, -27.9173, -28.1112

VertexBarrelHits.position.y = 19.6455, 26.2272, 66.0554, 19.6389, 21.6014, 23.2667, 21.5396, 23.3516, 21.8583, 23.3087, 22.9942, 22.6983, 22.4739

VertexBarrelHits.position.z = 37.1742, 49.5744, 123.963, 37.1548, 34.5338, 36.2218, 35.8026, 35.616, 35.0633, 35.9978, 79.4242, 79.9155, 80.156

VertexBarrelHits.momentum.x = -3.186112, -3.182194, -3.162133, -0.000774, -0.000237, 0.000247, -0.000520, 0.000420, -0.000402, 0.000224, -0.000031, -0.000141, -0.000099

VertexBarrelHits.momentum.y = 2.085773, 2.090894, 2.121809, 0.000138, -0.000261, -0.000596, 0.000243, -0.000375, 0.000280, -0.000111, -0.000036, -0.000159, -0.000061

VertexBarrelHits.momentum.z = 3.934102, 3.934191, 3.933759, -0.000174, -0.000110, 0.000081, -0.000105, -0.000062, -0.000001, 0.000263, 0.000295, 0.000229, 0.000103

VertexBarrelHits#0 = (vector<podio::ObjectID>)0x39835b0

VertexBarrelHits#0.index = 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0

VertexBarrelHits#0.collectionID = 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1

Indicates with which MC particle the hit is associated. All hits here are associated with the primary particle. However, non-zero 'quality' means hit is actually associated with a secondary which was not saved to MC Particle list – due to energy threshold for produced secondary (governed by RangeCut) to be saved to MC Particle list.

Tracker hits in Geant (DD4Hep) output

VertexBarrelHits = (vector<edm4hep::SimTrackerHitData>)0x393a8f0

VertexBarrelHits.cellID = 1740106435056286543, 1705175386151526863, 1495786141957038595, 1740106434626789814, 1747368519520192131, 1742724194859871055, 1743906370864200118, 1744413049444599017, 1745989302871728156, 1743512326942144540, 1621126990317978857, 1619775894108891983, 1619072194211710185

VertexBarrelHits.EDep = 0.000050, 0.000011, 0.000018, 0.000011, 0.000106, 0.000013, 0.000025, 0.000037, 0.000023, 0.000078, 0.000010, 0.000014, 0.000085

VertexBarrelHits.time = 0.172631, 0.230277, 0.575604, 0.172684, 0.198817, 0.222128, 0.233706, 0.249430, 0.262780, 0.276989, 0.534295, 0.538136, 0.540672

VertexBarrelHits.pathLength = 0.057513, 0.057520, 0.057511, 0.041903, 0.278637, 0.044581, 0.038396, 0.041919, 0.043550, 0.143896, 0.016068, 0.007537, 0.051001

VertexBarrelHits.quality = 0, 0, 0, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824

VertexBarrelHits.position.x = -30.1701, -40.2047, -100.186, -30.1782, -28.8245, -27.4767, -28.8427, -27.407, -28.6091, -27.4422, -27.6744, -27.9173, -28.1112

VertexBarrelHits.position.y = 19.6455, 26.2272, 66.0554, 19.6389, 21.6014, 23.2667, 21.5396, 23.3516, 21.8583, 23.3087, 22.9942, 22.6983, 22.4739

VertexBarrelHits.position.z = 37.1742, 49.5744, 123.963, 37.1548, 34.5338, 36.2218, 35.8026, 35.616, 35.0633, 35.9978, 79.4242, 79.9155, 80.156

VertexBarrelHits.momentum.x = -3.186112, -3.182194, -3.162133, -0.000774, -0.000237, 0.000247, -0.000520, 0.000420, -0.000402, 0.000224, -0.000031, -0.000141, -0.000099

VertexBarrelHits.momentum.y = 2.085773, 2.090894, 2.121809, 0.000138, -0.000261, -0.000596, 0.000243, -0.000375, 0.000280, -0.000111, -0.000036, -0.000159, -0.000061

VertexBarrelHits.momentum.z = 3.934102, 3.934191, 3.933759, -0.000174, -0.000110, 0.000081, -0.000105, -0.000062, -0.000001, 0.000263, 0.000295, 0.000229, 0.000103

VertexBarrelHits#0 = (vector<podio::ObjectID>)0x39835b0

VertexBarrelHits#0.index = 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0

VertexBarrelHits#0.collectionID = 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1

First 3 hits – with ‘quality’ 0 – are at layer 1, 2, and 3 of the inner vertex detector, respectively.

Tracker hits in Geant (DD4Hep) output

VertexBarrelHits = (vector<edm4hep::SimTrackerHitData>)0x393a8f0

VertexBarrelHits.cellID = 1740106435056286543, 1705175386151526863, 1495786141957038595, 1740106434626789814, 1747368519520192131, 1742724194859871055, 1743906370864200118, 1744413049444599017, 1745989302871728156, 1743512326942144540, 1621126990317978857, 1619775894108891983, 1619072194211710185

VertexBarrelHits.EDep = 0.000050, 0.000011, 0.000018, 0.000011, 0.000106, 0.000013, 0.000025, 0.000037, 0.000023, 0.000078, 0.000010, 0.000014, 0.000085

VertexBarrelHits.time = 0.172631, 0.230277, 0.575604, 0.172684, 0.198817, 0.222128, 0.233706, 0.249430, 0.262780, 0.276989, 0.534295, 0.538136, 0.540672

VertexBarrelHits.pathLength = 0.057513, 0.057520, 0.057511, 0.041903, 0.278637, 0.044581, 0.038396, 0.041919, 0.043550, 0.143896, 0.016068, 0.007537, 0.051001

VertexBarrelHits.quality = 0, 0, 0, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824

VertexBarrelHits.position.x = -30.1701, -40.2047, -100.186, -30.1782, -28.8245, -27.4767, -28.8427, -27.407, -28.6091, -27.4422, -27.6744, -27.9173, -28.1112

VertexBarrelHits.position.y = 19.6455, 26.2272, 66.0554, 19.6389, 21.6014, 23.2667, 21.5396, 23.3516, 21.8583, 23.3087, 22.9942, 22.6983, 22.4739

VertexBarrelHits.position.z = 37.1742, 49.5744, 123.963, 37.1548, 34.5338, 36.2218, 35.8026, 35.616, 35.0633, 35.9978, 79.4242, 79.9155, 80.156

VertexBarrelHits.momentum.x = -3.186112, -3.182194, -3.162133, -0.000774, -0.000237, 0.000247, -0.000520, 0.000420, -0.000402, 0.000224, -0.000031, -0.000141, -0.000099

VertexBarrelHits.momentum.y = 2.085773, 2.090894, 2.121809, 0.000138, -0.000261, -0.000596, 0.000243, -0.000375, 0.000280, -0.000111, -0.000036, -0.000159, -0.000061

VertexBarrelHits.momentum.z = 3.934102, 3.934191, 3.933759, -0.000174, -0.000110, 0.000081, -0.000105, -0.000062, -0.000001, 0.000263, 0.000295, 0.000229, 0.000103

VertexBarrelHits#0 = (vector<podio::ObjectID>)0x39835b0

VertexBarrelHits#0.index = 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0

VertexBarrelHits#0.collectionID = 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1

First 3 hits – with ‘quality’ 0 – are at layer 1, 2, and 3 of the inner vertex detector, respectively.
In this event, other hits seem to be at first layer (r = 36mm).
Some hits are close to primary hit; some are farther away.

Tracker hits in Geant (DD4Hep) output

VertexBarrelHits = (vector<edm4hep::SimTrackerHitData>)0x393a8f0

VertexBarrelHits.cellID = 1740106435056286543, 1705175386151526863, 1495786141957038595, 1740106434626789814, 1747368519520192131, 1742724194859871055, 1743906370864200118, 1744413049444599017, 1745989302871728156, 1743512326942144540, 1621126990317978857, 1619775894108891983, 1619072194211710185

VertexBarrelHits.EDep = 0.000050, 0.000011, 0.000018, 0.000011, 0.000106, 0.000013, 0.000025, 0.000037, 0.000023, 0.000078, 0.000010, 0.000014, 0.000085

VertexBarrelHits.time = 0.172631, 0.230277, 0.575604, 0.172684, 0.198817, 0.222128, 0.233706, 0.249430, 0.262780, 0.276989, 0.534295, 0.538136, 0.540672

VertexBarrelHits.pathLength = 0.057513, 0.057520, 0.057511, 0.041903, 0.278637, 0.044581, 0.038396, 0.041919, 0.043550, 0.143896, 0.016068, 0.007537, 0.051001

VertexBarrelHits.quality = 0, 0, 0, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824, 1073741824

VertexBarrelHits.position.x = -30.1701, -40.2047, -100.186, -30.1782, -28.8245, -27.4767, -28.8427, -27.407, -28.6091, -27.4422, -27.6744, -27.9173, -28.1112

VertexBarrelHits.position.y = 19.6455, 26.2272, 66.0554, 19.6389, 21.6014, 23.2667, 21.5396, 23.3516, 21.8583, 23.3087, 22.9942, 22.6983, 22.4739

VertexBarrelHits.position.z = 37.1742, 49.5744, 123.963, 37.1548, 34.5338, 36.2218, 35.8026, 35.616, 35.0633, 35.9978, 79.4242, 79.9155, 80.156

VertexBarrelHits.momentum.x = -3.186112, -3.182194, -3.162133, -0.000774, -0.000237, 0.000247, -0.000520, 0.000420, -0.000402, 0.000224, -0.000031, -0.000141, -0.000099

VertexBarrelHits.momentum.y = 2.085773, 2.090894, 2.121809, 0.000138, -0.000261, -0.000596, 0.000243, -0.000375, 0.000280, -0.000111, -0.000036, -0.000159, -0.000061

VertexBarrelHits.momentum.z = 3.934102, 3.934191, 3.933759, -0.000174, -0.000110, 0.000081, -0.000105, -0.000062, -0.000001, 0.000263, 0.000295, 0.000229, 0.000103

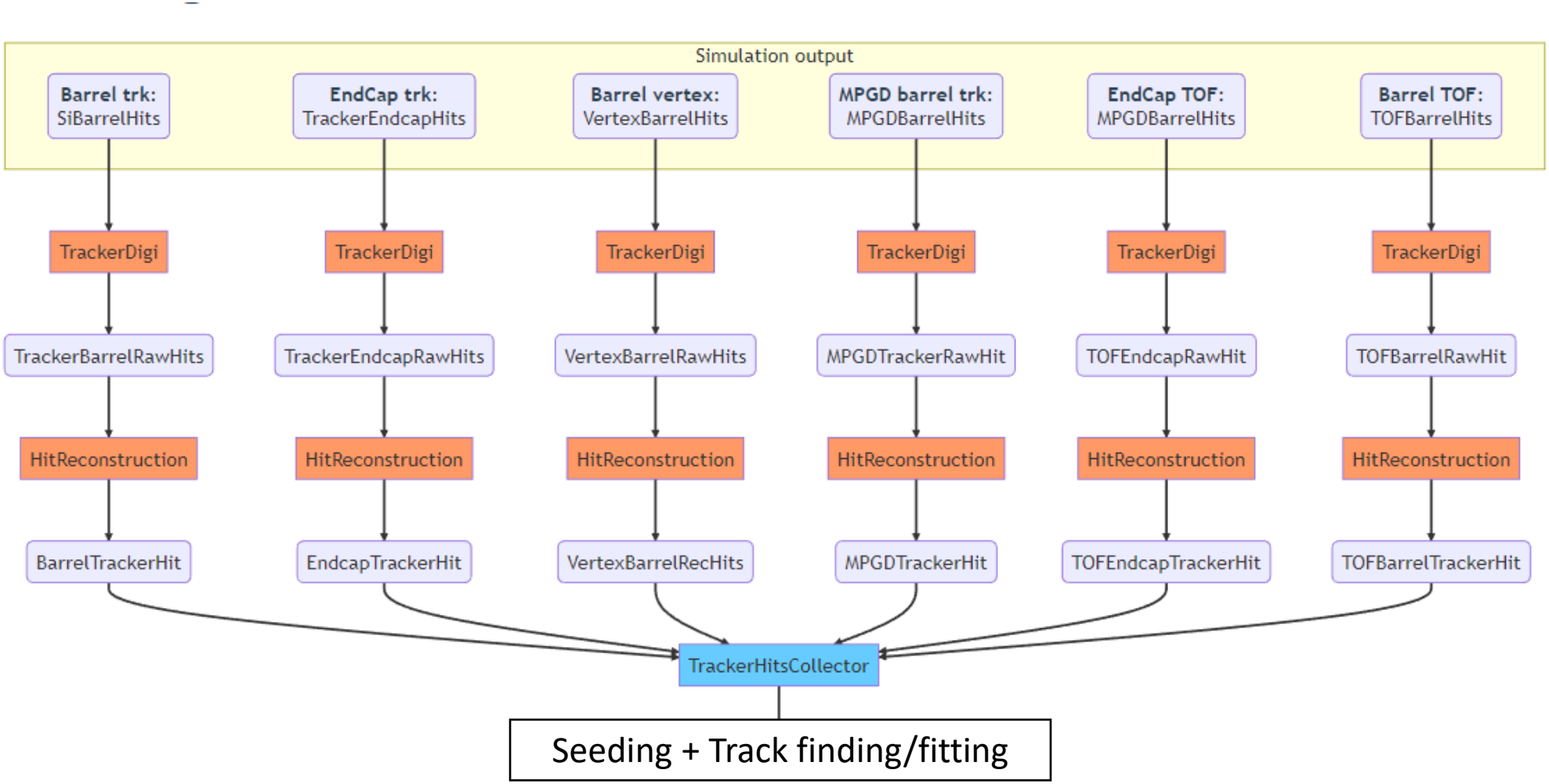
VertexBarrelHits#0 = (vector<podio::ObjectID>)0x39835b0

VertexBarrelHits#0.index = 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0

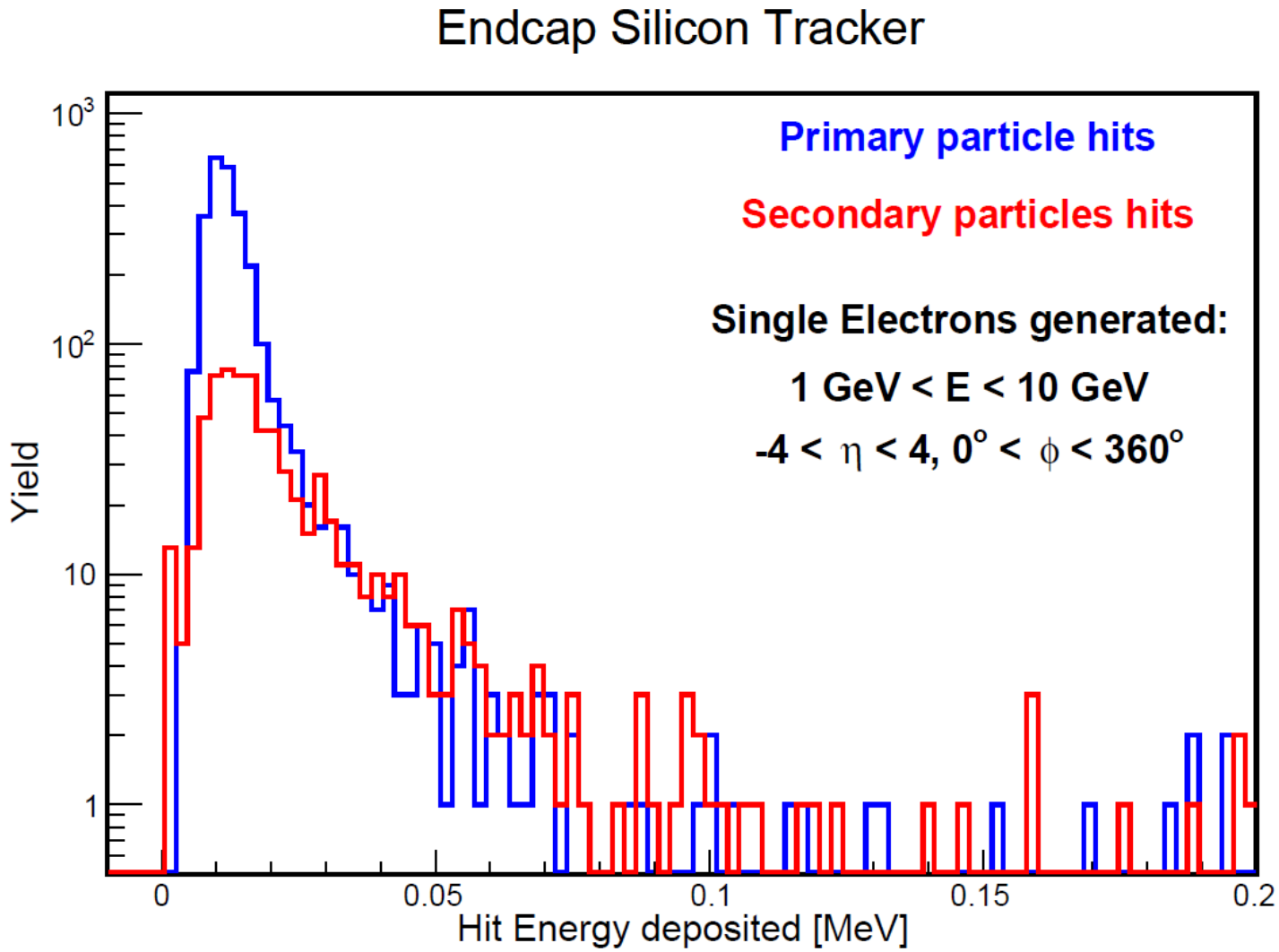
VertexBarrelHits#0.collectionID = 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1

Deposited energy is similar order of magnitude for all hits.

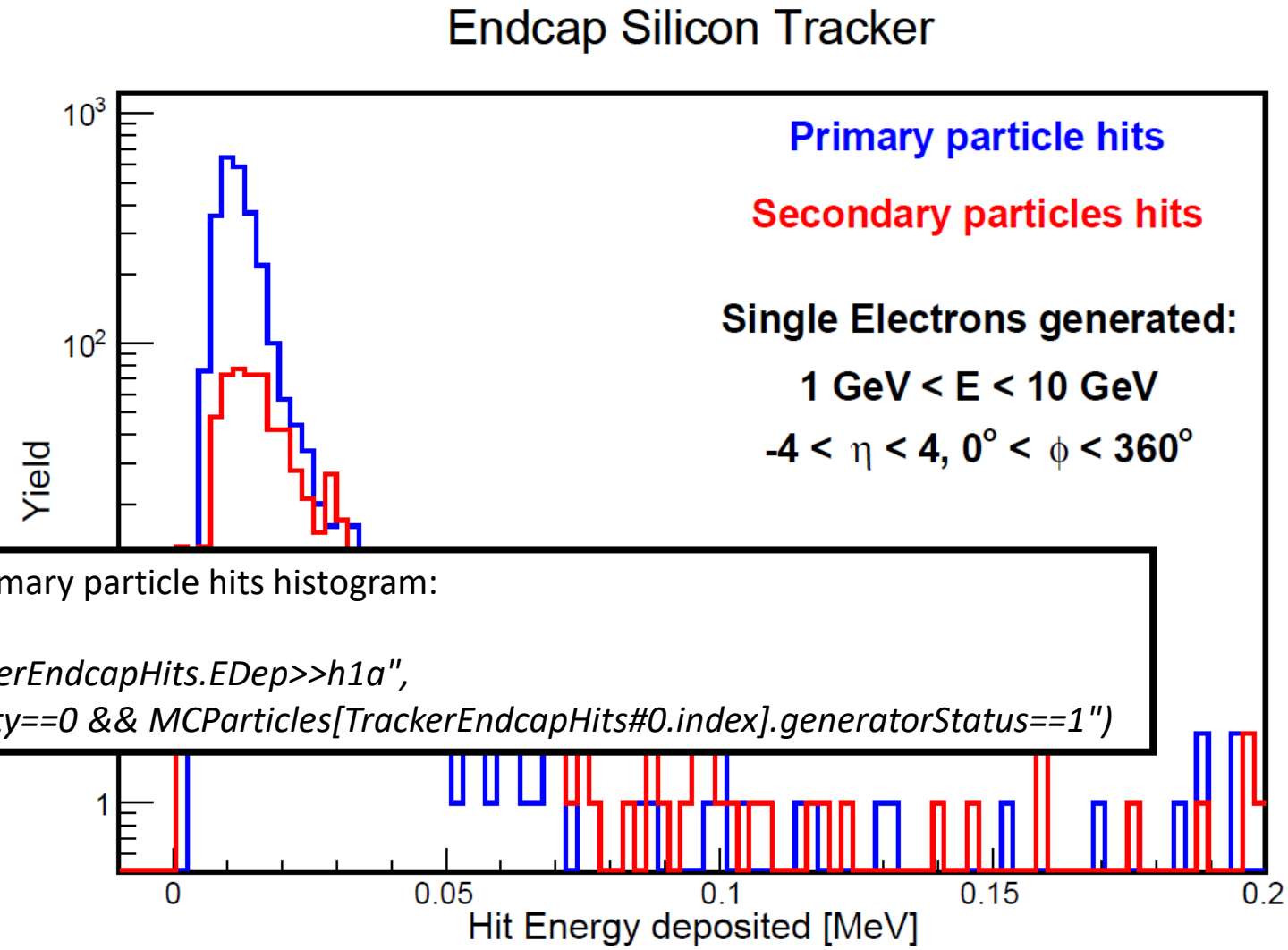
Tracking detectors in simulation



Hit energy deposition



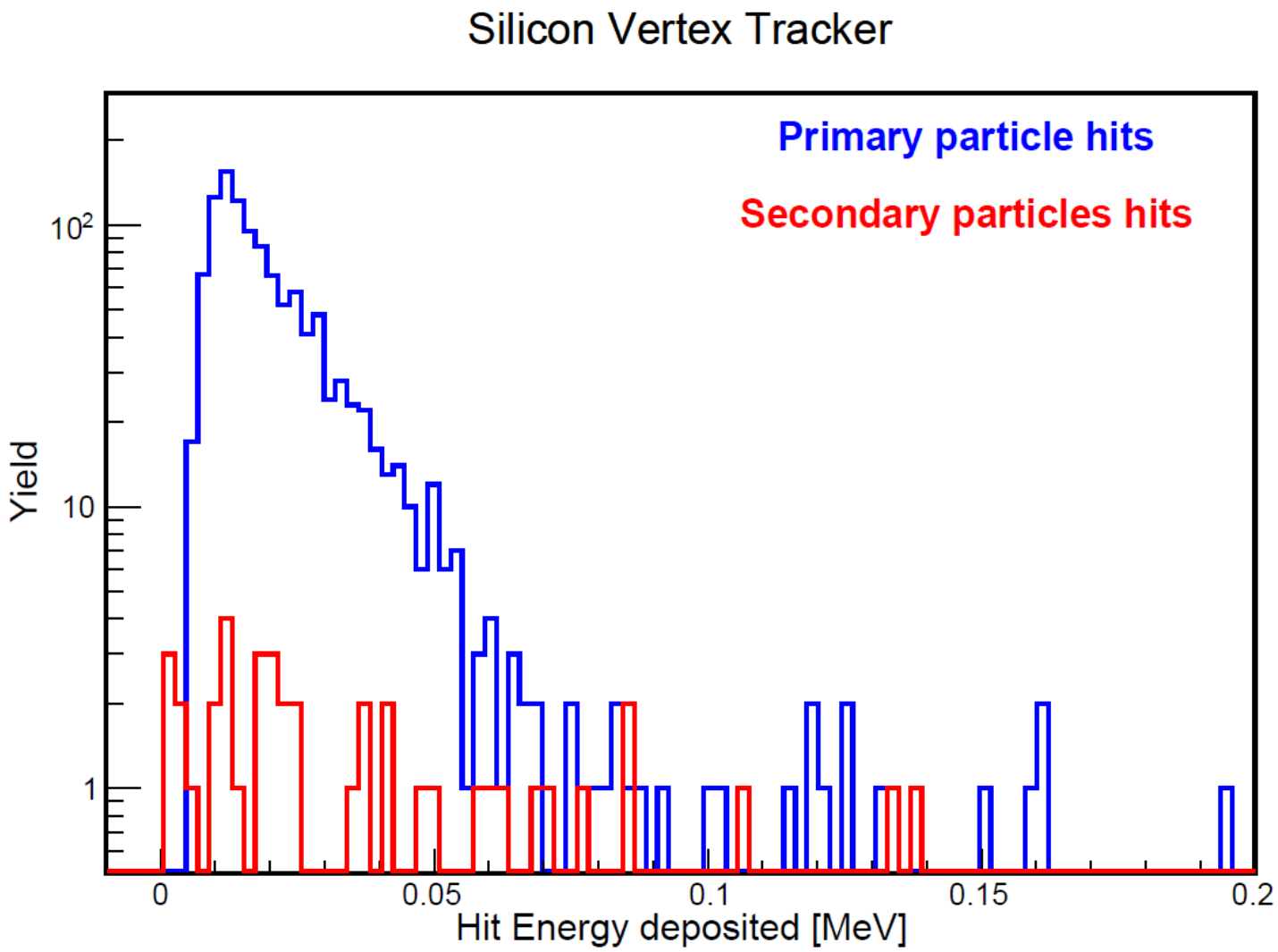
Hit energy deposition



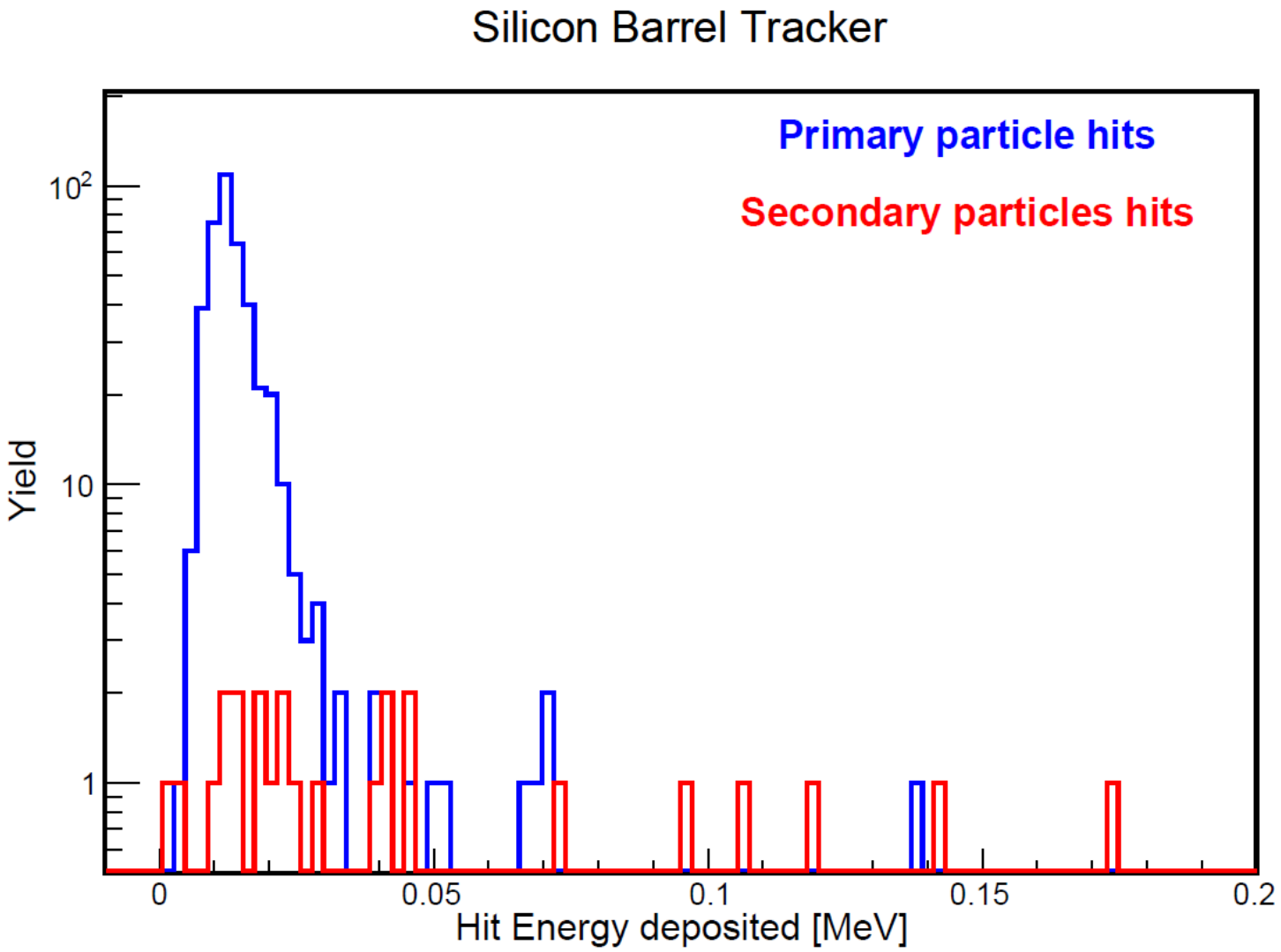
Line used to draw this primary particle hits histogram:

*tree->Draw("1000.*TrackerEndcapHits.EDep>>h1a",*
"TrackerEndcapHits.quality==0 && MCParticles[TrackerEndcapHits#0.index].generatorStatus==1")

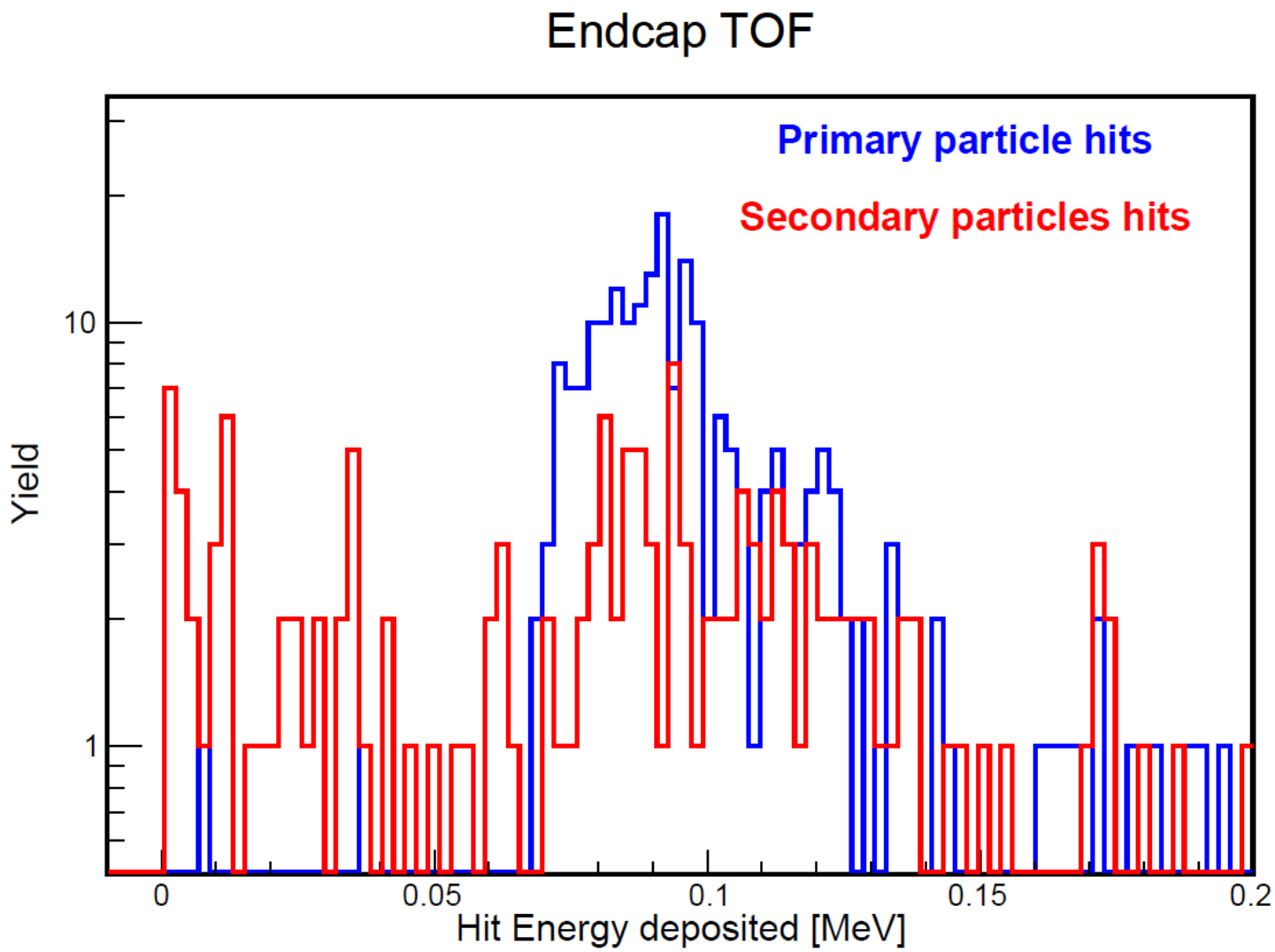
Hit energy deposition



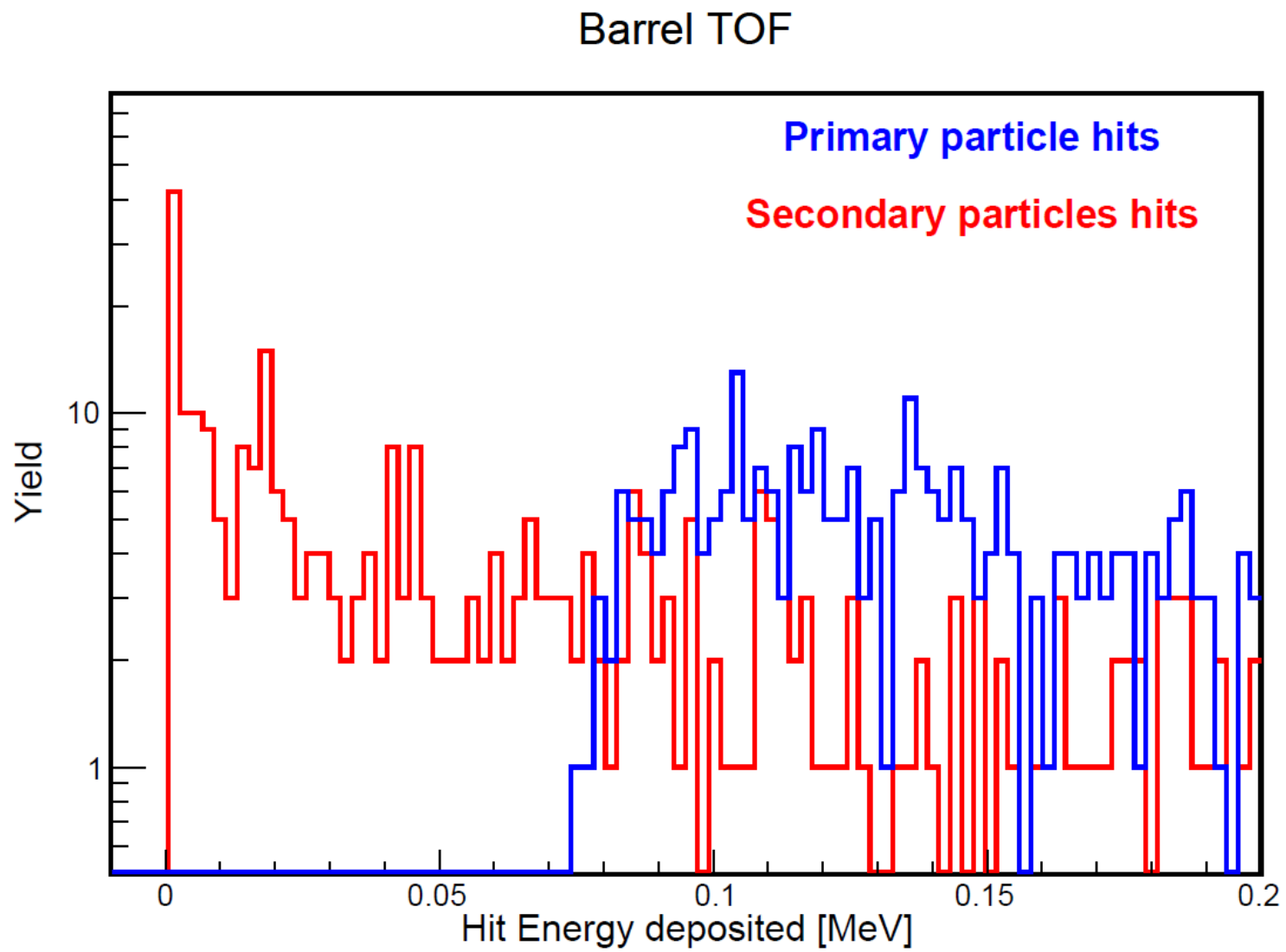
Hit energy deposition



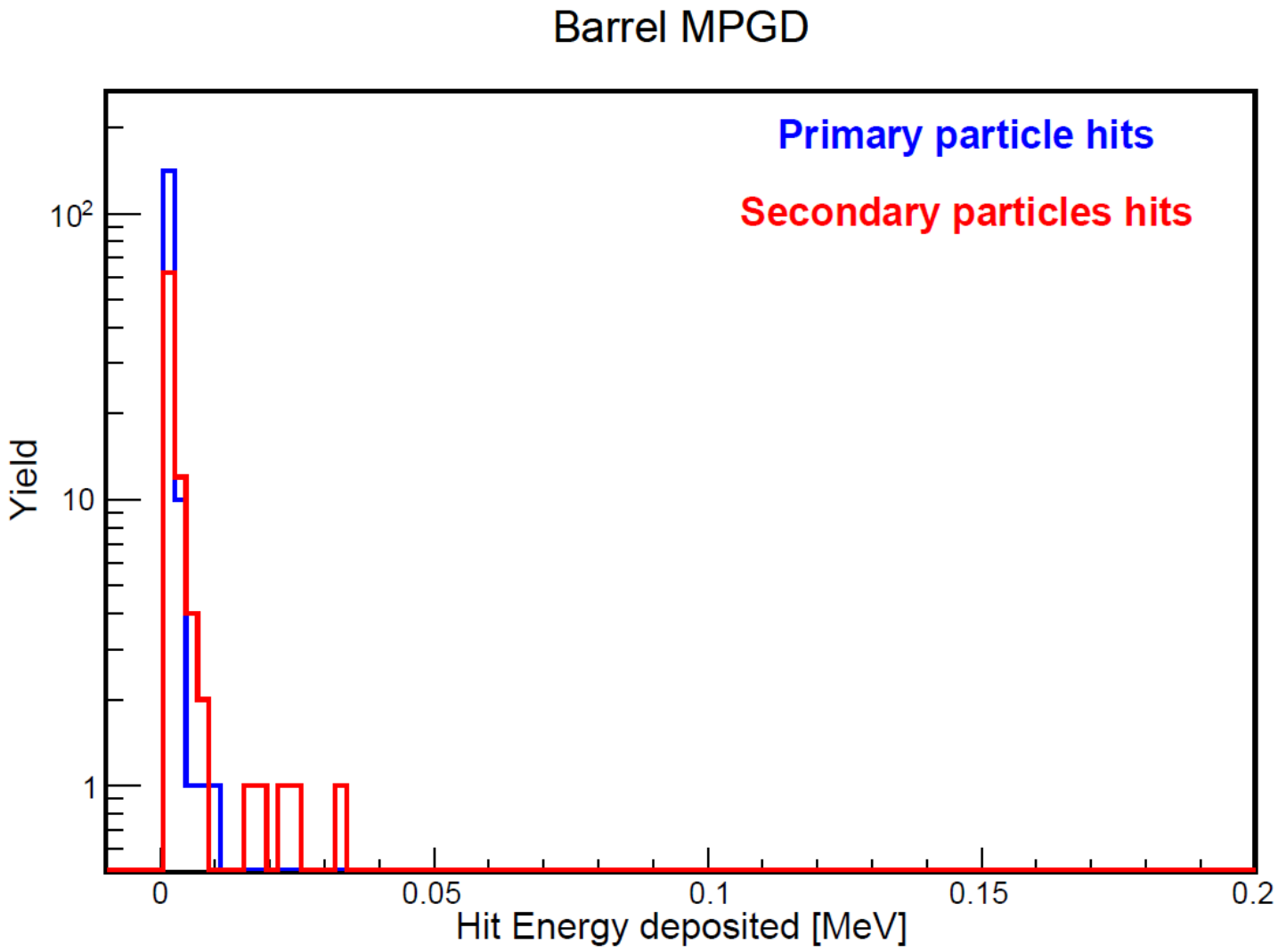
Hit energy deposition



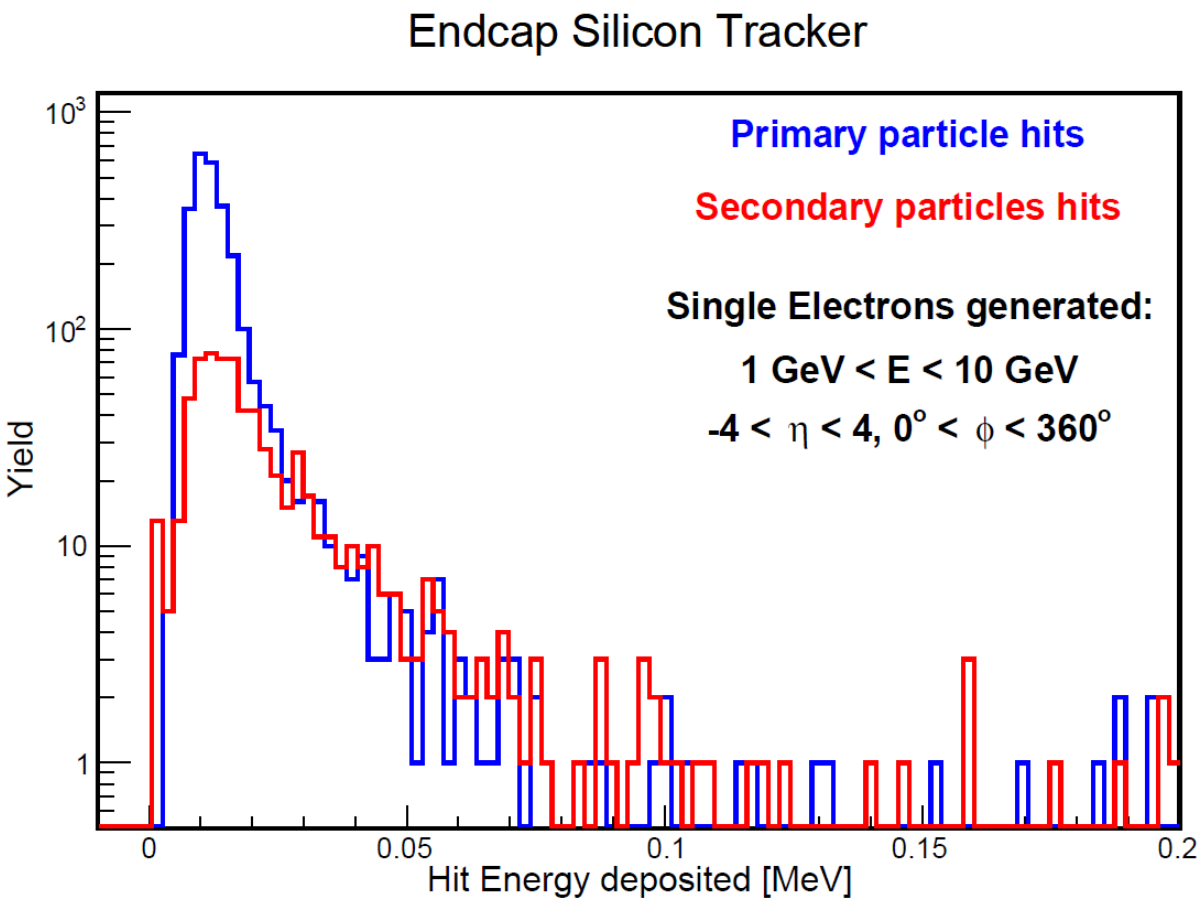
Hit energy deposition

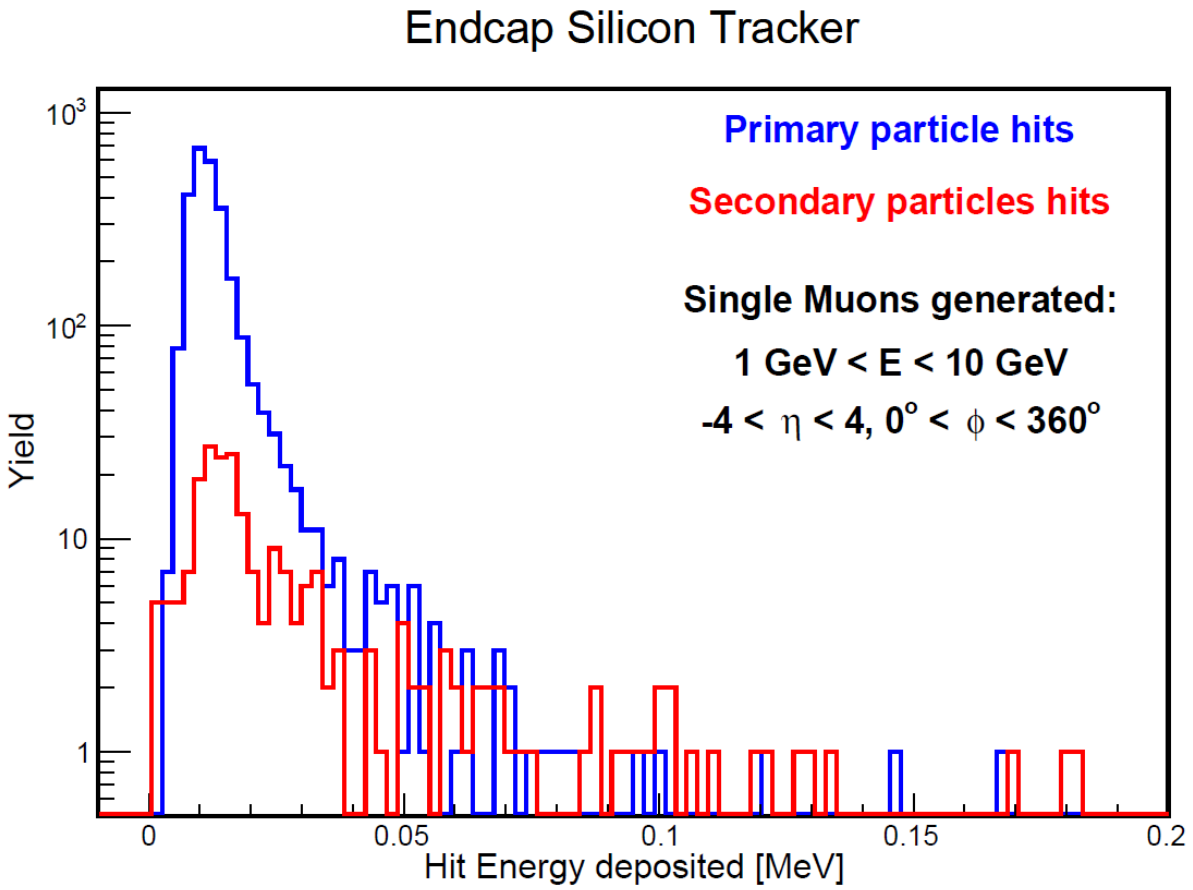


Hit energy deposition



Hit energy deposition – comparison





Hit energy deposition – comparison