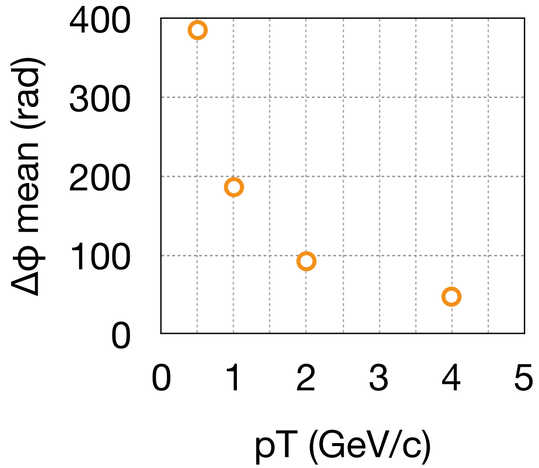
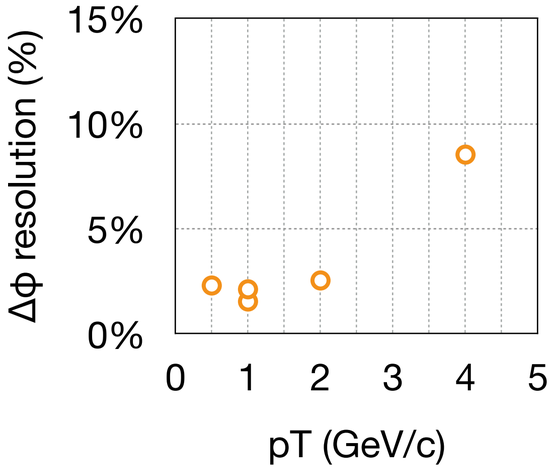
φ resolution study by MC

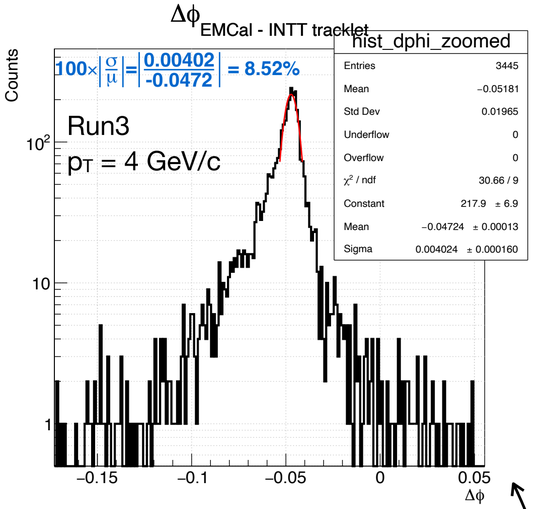
2nd report

Genki Nukazuka (RIKEN)

Summary of the 1st report







Run	#event	Beam	Momentum (GeV/c)	ϕ dist (rad)	η dist	vertex (cm)	Δφ mean (mrad)	Δφ std. dev. (mrad)	Δφ resolution (%)
Pilot	2k	μ⁻	1	fixed at π/2	fixed at 0	fixed at (0, 0, 0)	186	2.87	1.54%
1	50k	μ⁻	1	[-π, π]	fixed at 0	fixed at (0, 0, 0)	186	3.95	2.12%
2	50k	μ⁻	2	[-π, π]	fixed at 0	fixed at (0, 0, 0)	92.1	2.34	2.54%
3	50k	μ⁻	4	[-π, π]	fixed at 0	fixed at (0, 0, 0)	47.2	4.02	8.52%
4	50k	μ⁻	0.5	[-π, π]	fixed at 0	fixed at (0, 0, 0)	385	8.85	2.30%

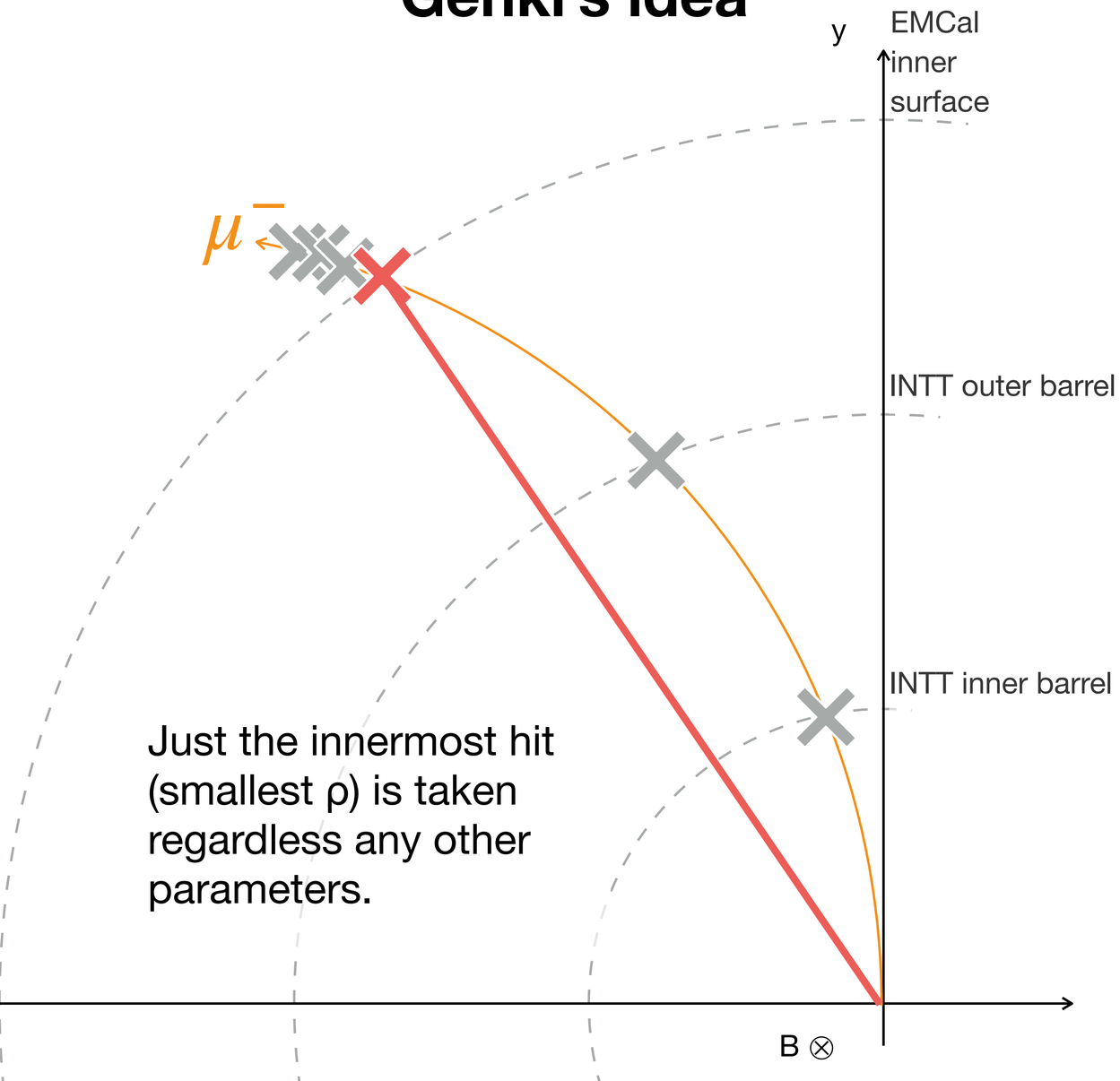
←!?

Topics

- New selection method of EMCal truth hit. Thank you, Jingyu!
- Single electron simulations

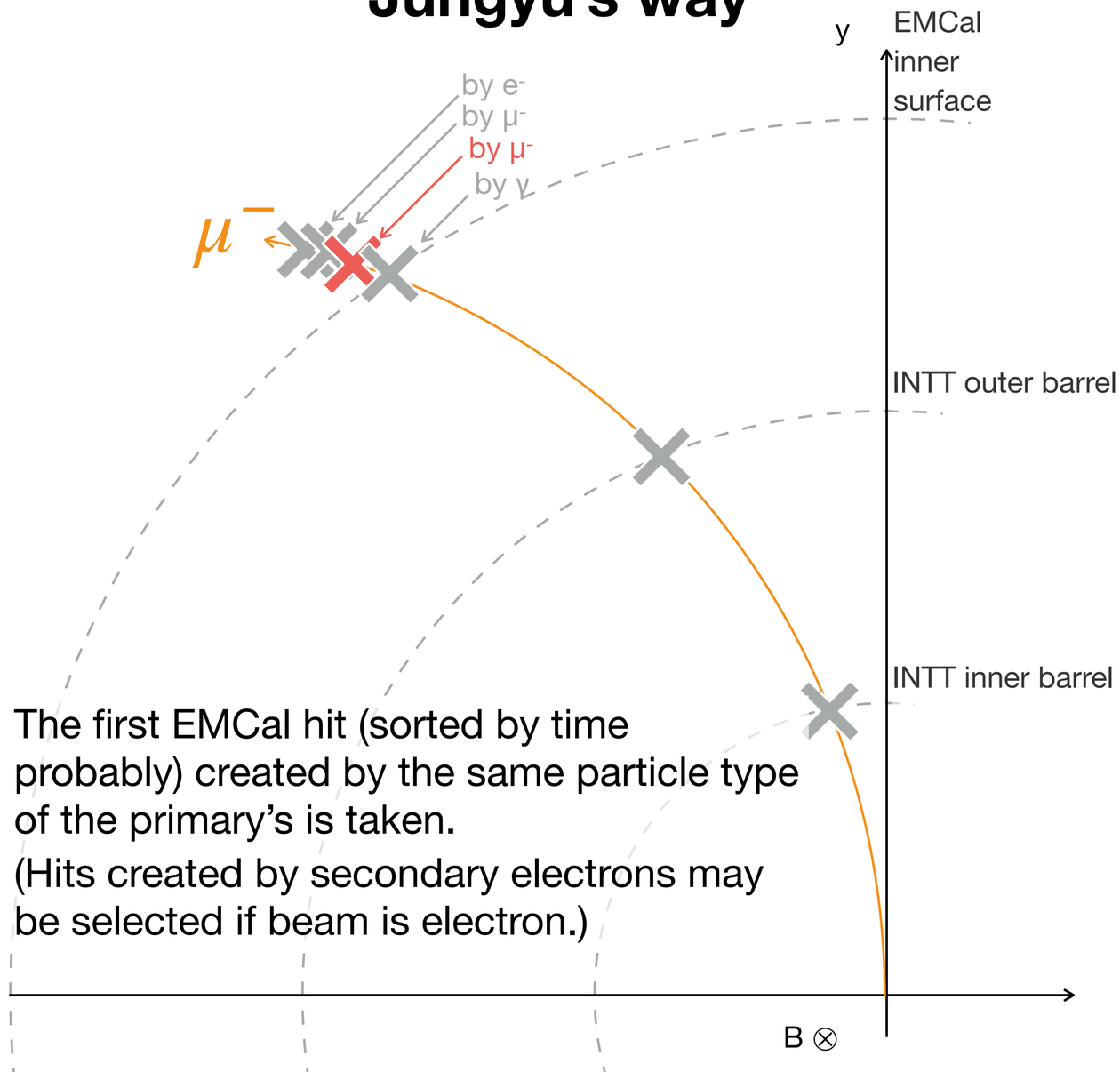
Topic1: Selection of EMCal truth hit

Genki's idea



Just the innermost hit (smallest ρ) is taken regardless any other parameters.

Jungyu's way

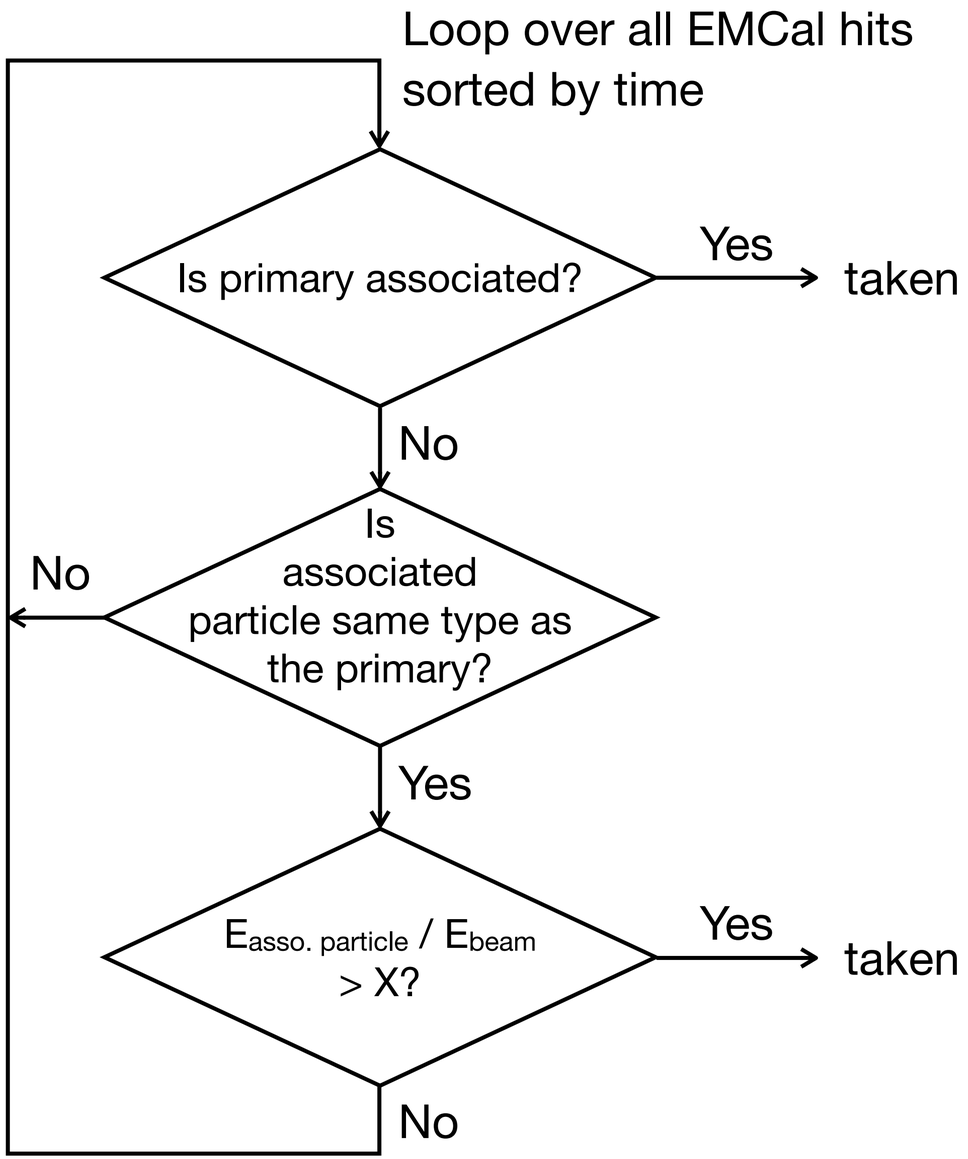


The first EMCal hit (sorted by time probably) created by the same particle type of the primary's is taken.

(Hits created by secondary electrons may be selected if beam is electron.)

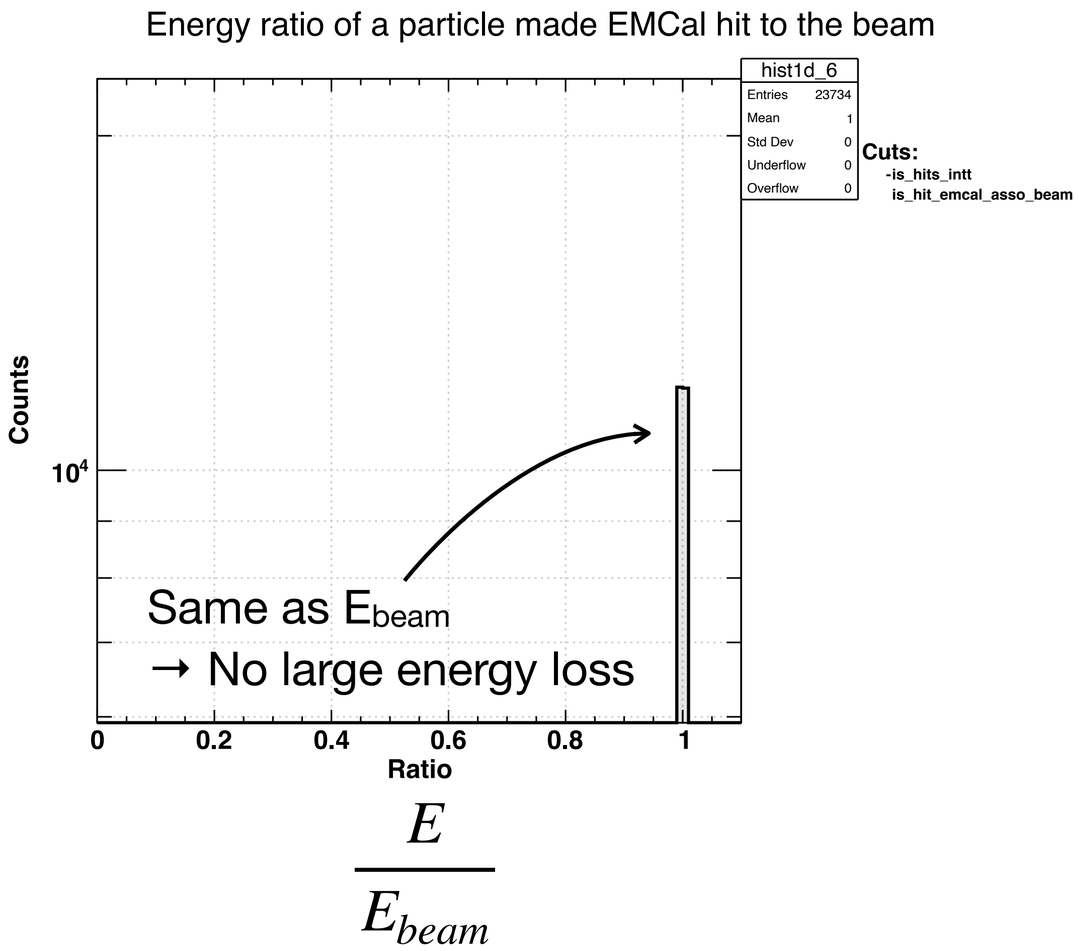
EMCal hit produced by primary particle

- Jingyu's method is better than mine as association with the beam is required.
- New method I made:
  - Hits associated with the primary particles are taken.
  - If not, the first hits associated with the same particle type as the primary are taken.
  - Who made the hit is important. A ratio of energy of the associated particle to that of the primary is a good indicator to know how much close the particle which made the hit to the primary (we may call it primarity).

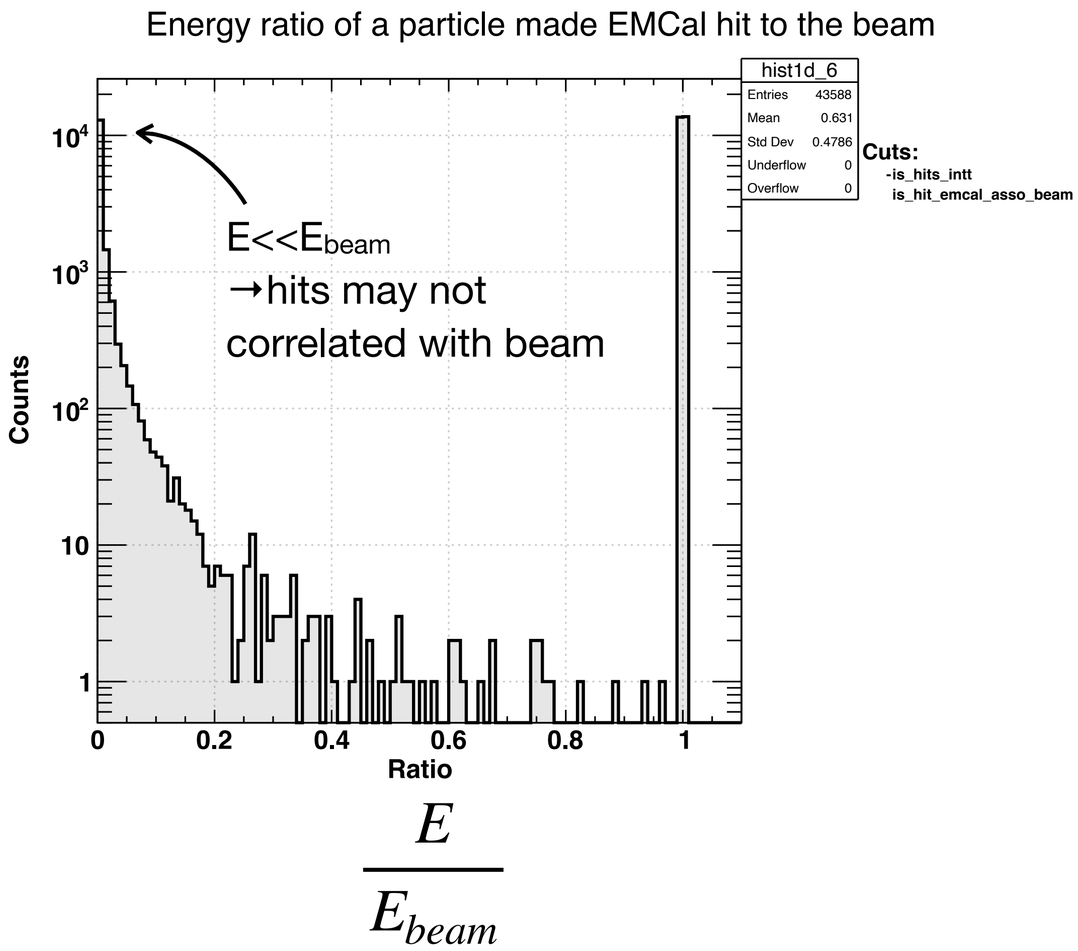


Energy ratio of EMCal hit particle to the beam

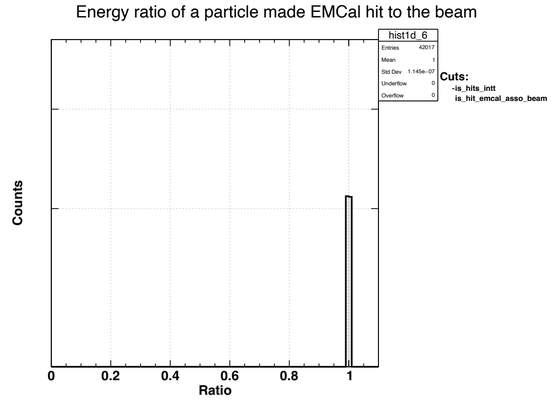
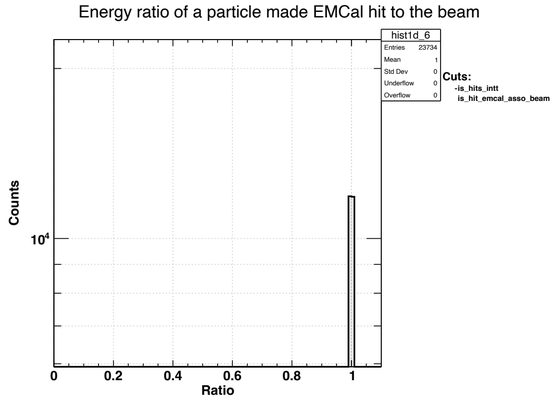
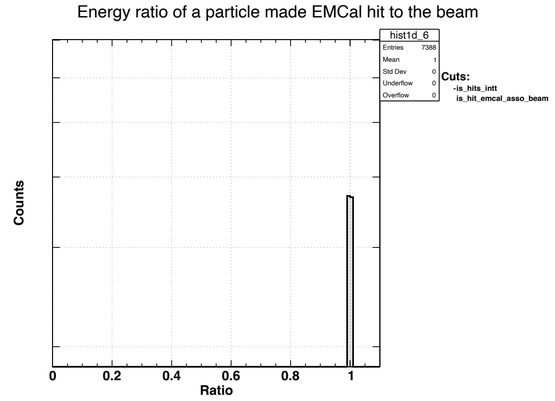
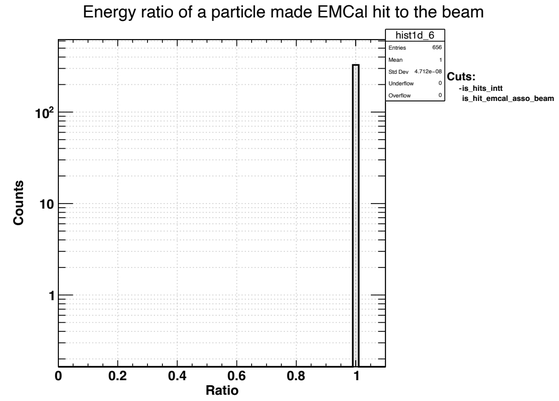
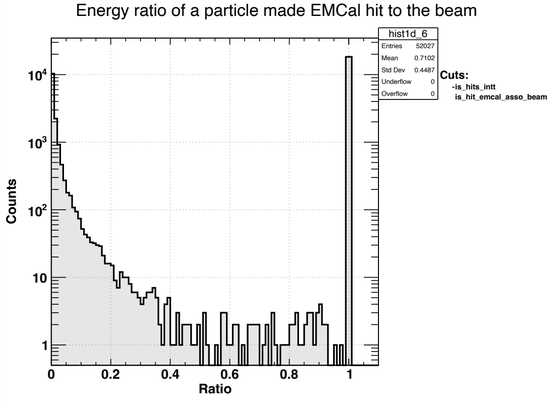
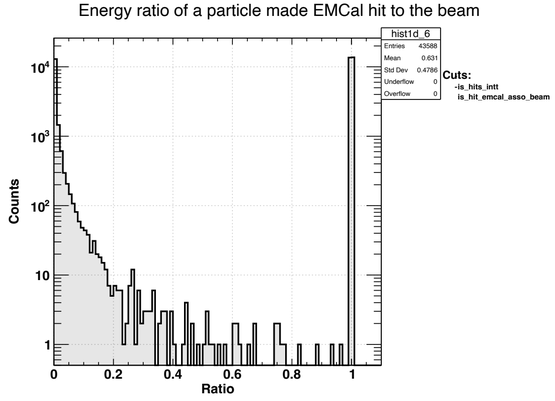
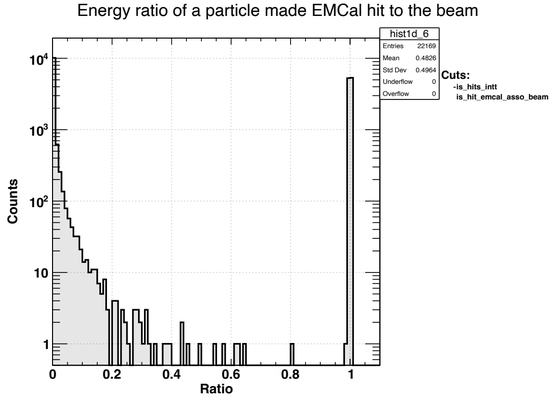
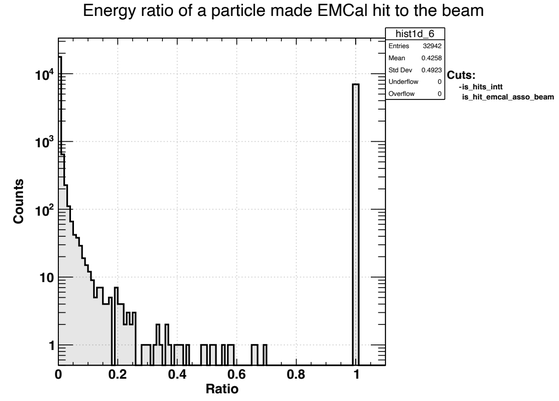
μ^-, p_T = 1 GeV/c



e^-, p_T = 1 GeV/c



Energy ratio of EMCal hit particle to the beam

	0.5 GeV/c	1 GeV/c	2 GeV/c	4 GeV/c
μ^-				
e^-				

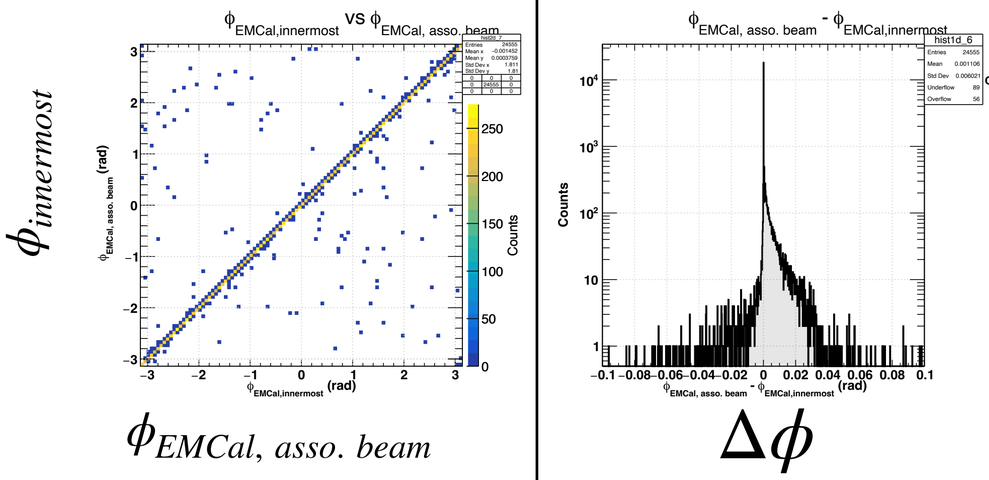
$$\frac{E}{E_{beam}}$$

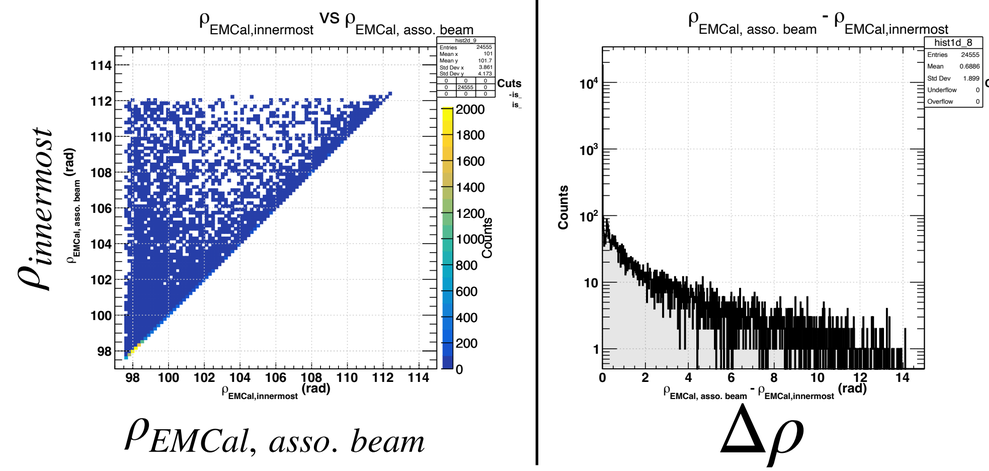
The energy ratio selection is useful for electron MC.

Comparison: Innermost hit & hit by primary particle

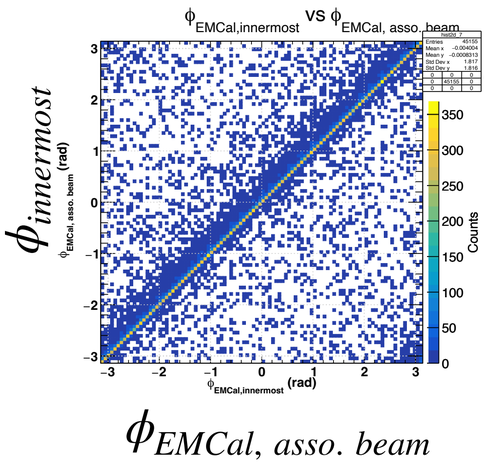
$\Delta\phi \equiv \phi_{EMCal,\ asso.\ beam} - \phi_{innermost}$ $\Delta\rho \equiv \rho_{EMCal,\ asso.\ beam} - \rho_{innermost}$

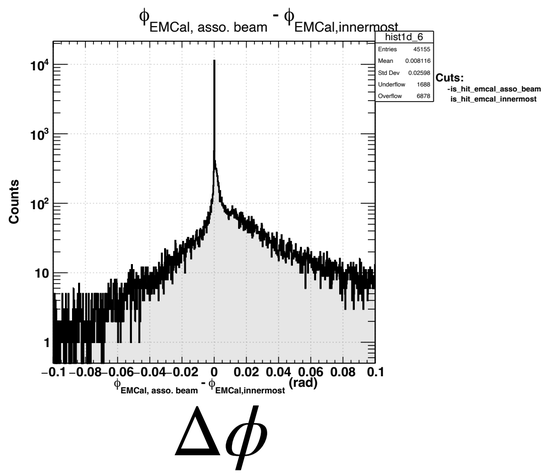
μ^-, p_T = 1 GeV/c

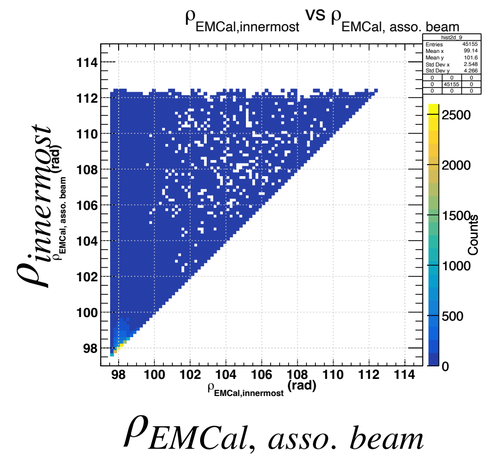


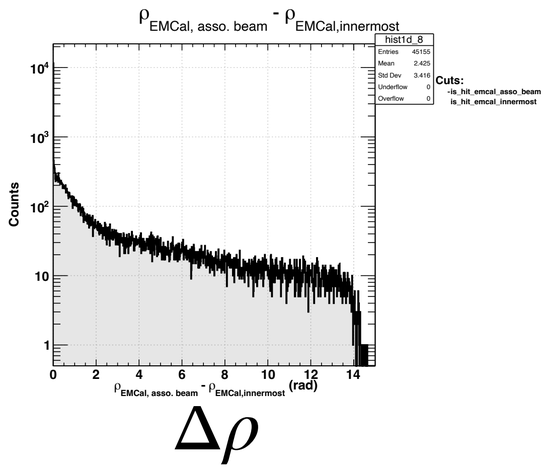


e^-, p_T = 1 GeV/c







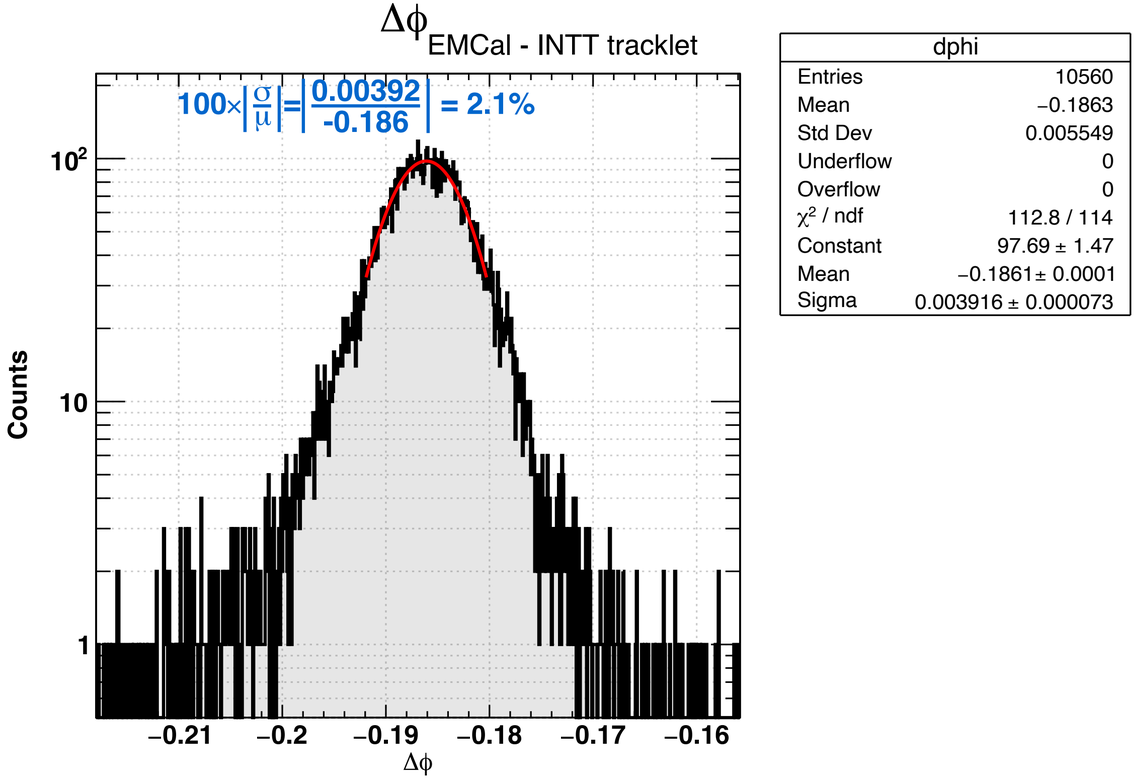


There are some differences in ϕ angle and ρ. The differences in the electron case are larger.

ϕ angle resolution μ^-, p_T = 1 GeV/c

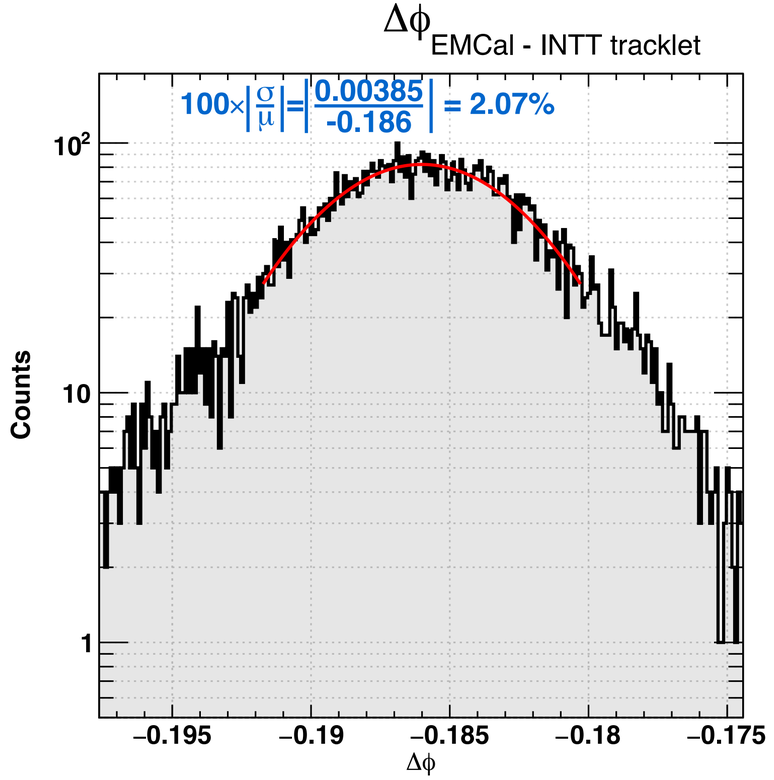
Cuts:
- a hit on each INTT barrel
- EMCal hit asso. with beam found
- Primarity > 0.9
- $\left|\Delta\phi_{INTT\ tracklet\ -\ beam}\right| \leq \mu \pm 2\sigma$

EMCal hit: innermost



dphi	
Entries	10560
Mean	−0.1863
Std Dev	0.005549
Underflow	0
Overflow	0
χ^2 / ndf	112.8 / 114
Constant	97.69 ± 1.47
Mean	−0.1861± 0.0001
Sigma	0.003916 ± 0.000073

EMCal hit: associated with beam



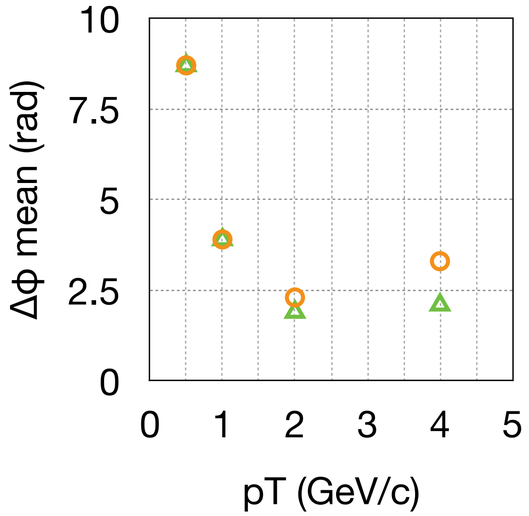
dphi	
Entries	8597
Mean	−0.186
Std Dev	0.004135
Underflow	57
Overflow	52
χ^2 / ndf	118.9 / 113
Constant	82.08 ± 1.36
Mean	−0.186 ± 0.000
Sigma	0.003851± 0.000079

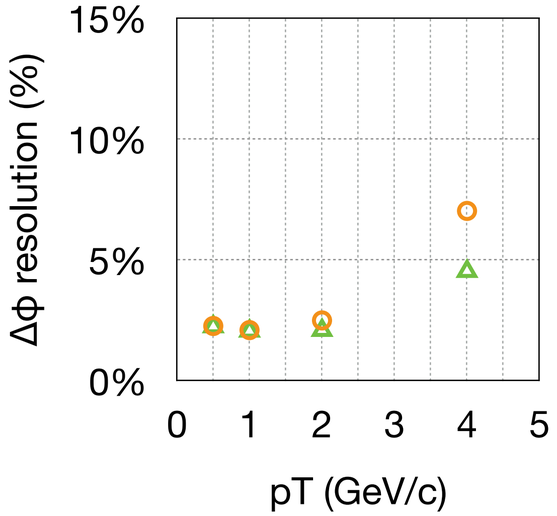
ϕ angle resolution with EMCal hits associated with beam gets slightly better than that with innermost EMCal hits.

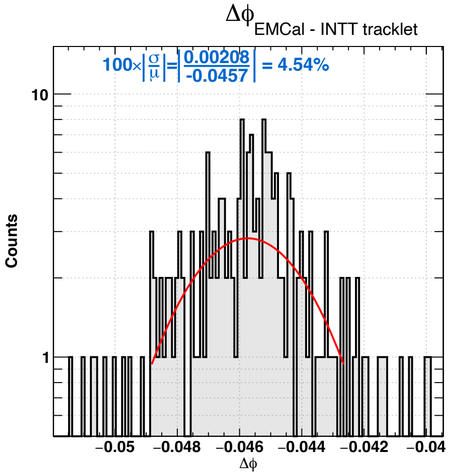
Comparison

◯ innermost EMCal hits

△ EMCal hits asso. with beam







dphi	
Entries	193
Mean	−0.04568
Std Dev	0.002083
Underflow	2
Overflow	3
χ^2 / ndf	41.44 / 54
Constant	2.828 ± 0.378
Mean	−0.04574 ± 0.00027
Sigma	0.002076 ± 0.000385

too low stats

Run	#event	Beam	Momentum (GeV/c)	ϕ dist (rad)	η dist	vertex (cm)	with innermost EMCal hits			with EMCal hits asso. with beam		
							Δϕ mean (mrad)	Δϕ std. dev. (mrad)	Δϕ resolution (%)	Δϕ mean (mrad)	Δϕ std. dev. (mrad)	Δϕ resolution (%)
4	50k	μ^-	0.5	[-π, π]	fixed at 0	fixed at (0, 0, 0)	-385.3	8.7	2.27%	-385.3	8.7	2.25%
1	50k	μ^-	1	[-π, π]	fixed at 0	fixed at (0, 0, 0)	-186.1	3.9	2.10%	-186.0	3.9	2.07%
2	50k	μ^-	2	[-π, π]	fixed at 0	fixed at (0, 0, 0)	-92.2	2.3	2.50%	-91.9	1.9	2.10%
3	50k	μ^-	4	[-π, π]	fixed at 0	fixed at (0, 0, 0)	-47.3	3.3	7.03%	-45.7	2.1	4.54%

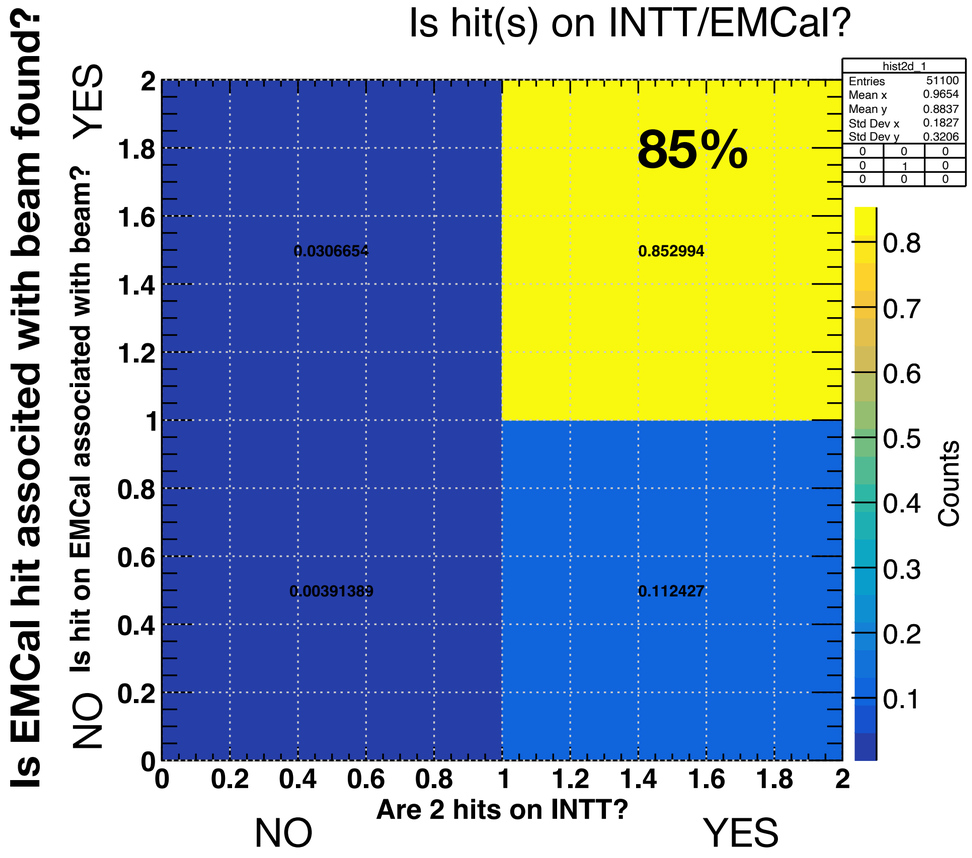
Topic2: Single electron simulation

Setup:

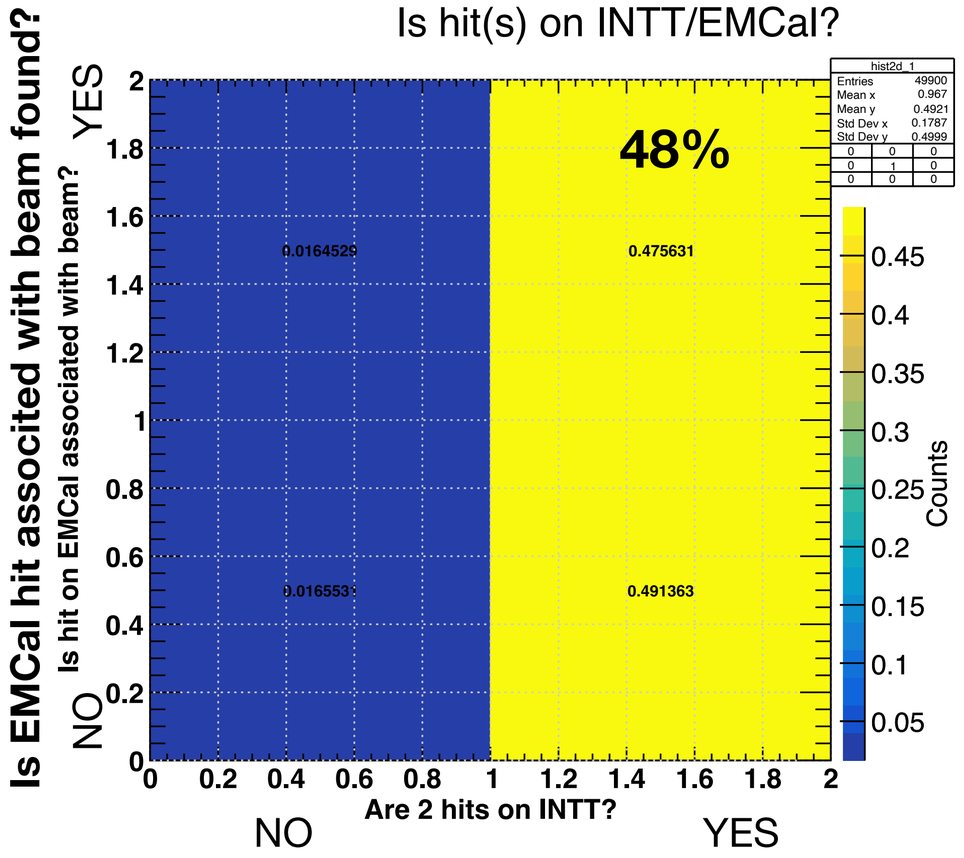
- Single e^- MC with $p_T = 1\ \mathrm{GeV/c}$
- $\phi = [-\pi, \pi]$
- $\eta = 0$
- $\vec{r}_{\mathrm{vertex}} = (0,0,0)\ \mathrm{cm}$
- Beam pipe, MVTX, INTT, TPC, TPOT, and EMCal are in the simulation.
- ~50k events

Topic2: Single electron simulation

e^-, p_T = 1 GeV/c



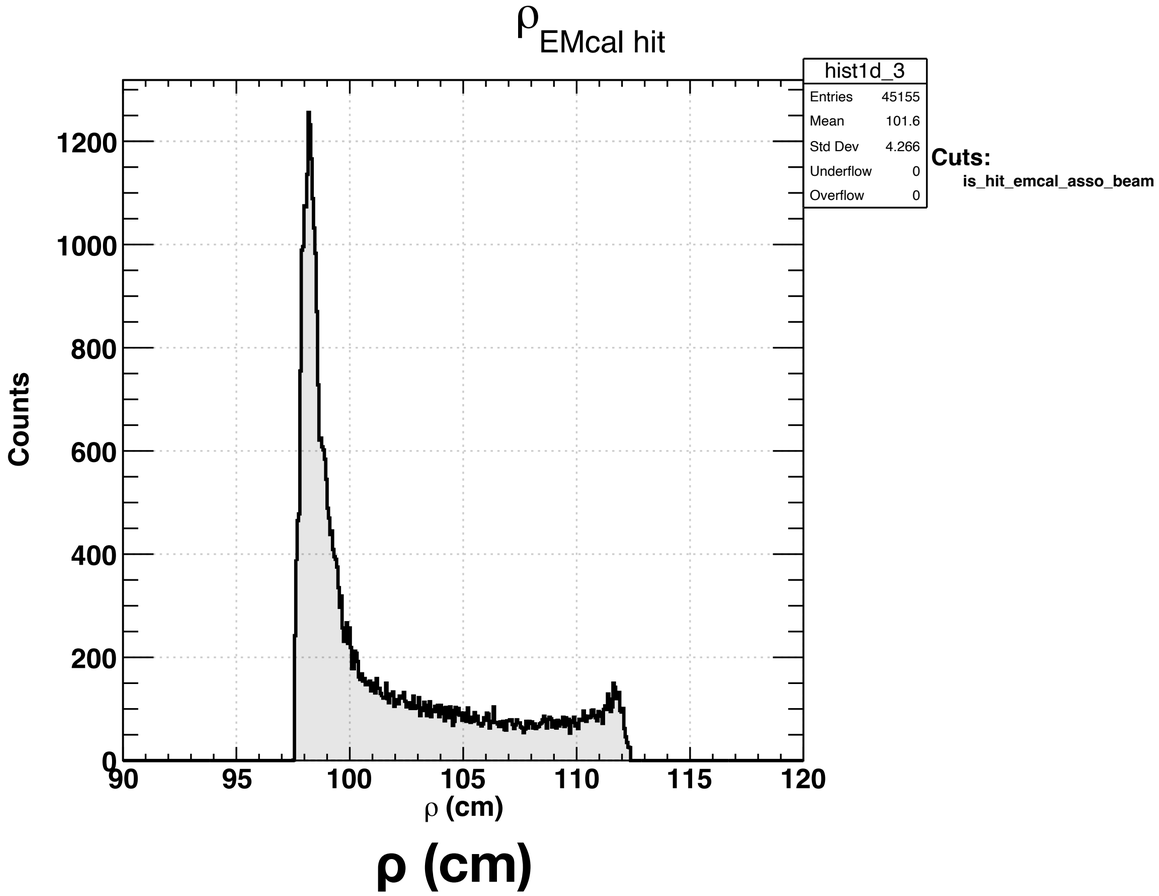
μ^-, p_T = 1 GeV/c



Topic2: Single electron simulation

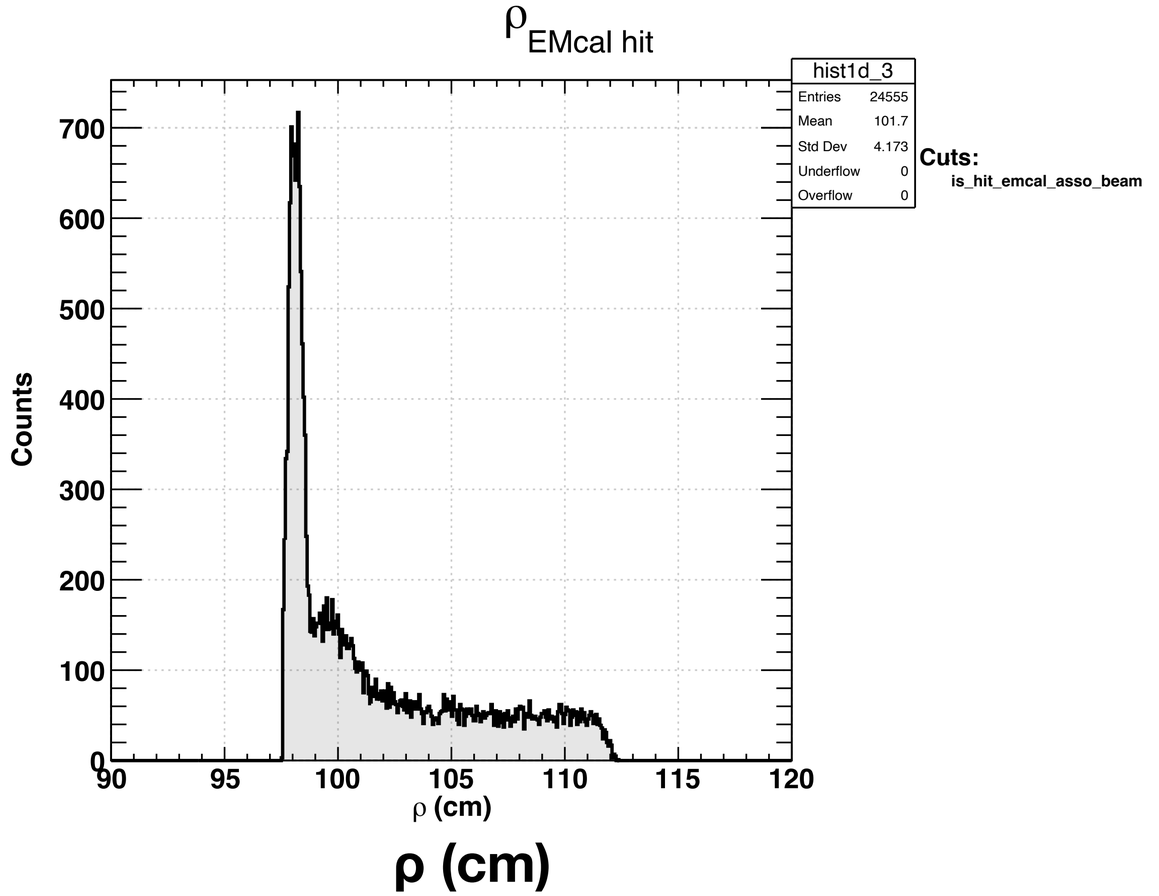
Cuts:
- EMCal hit asso. with beam found

e^-, p_T = 1 GeV/c



ρ (cm)

μ^-, p_T = 1 GeV/c

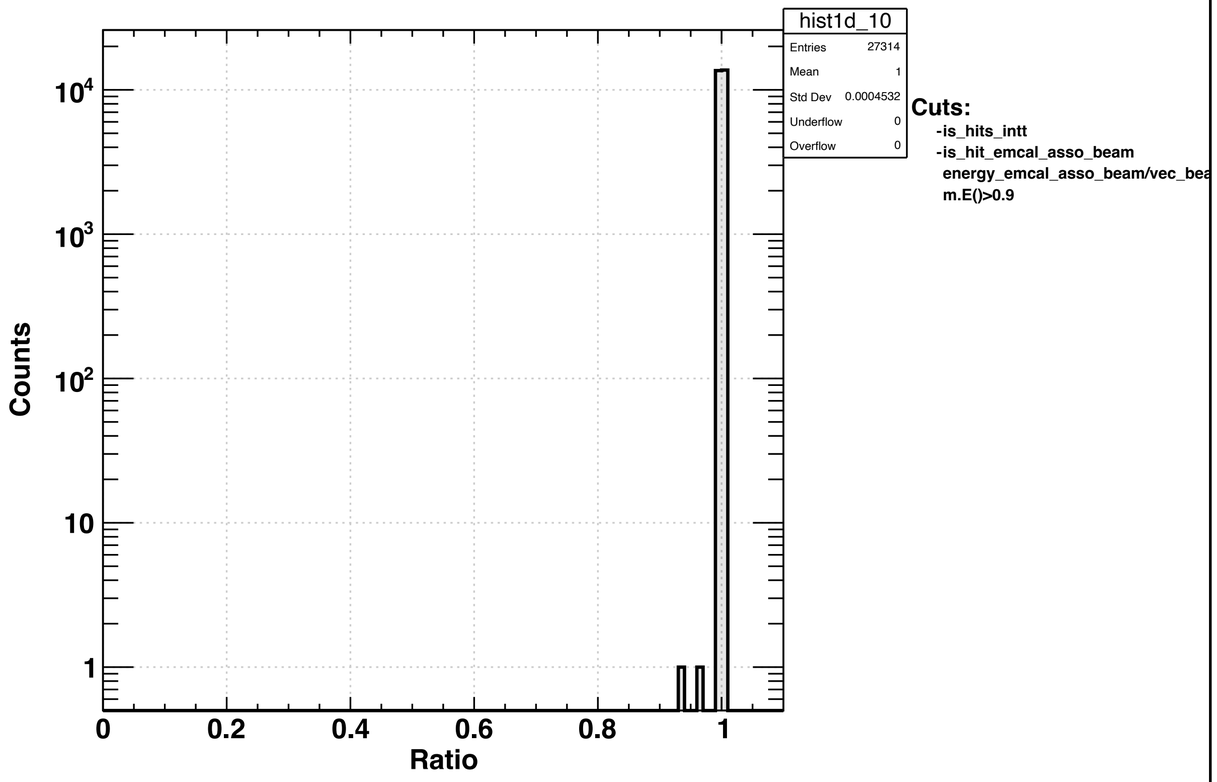


ρ (cm)

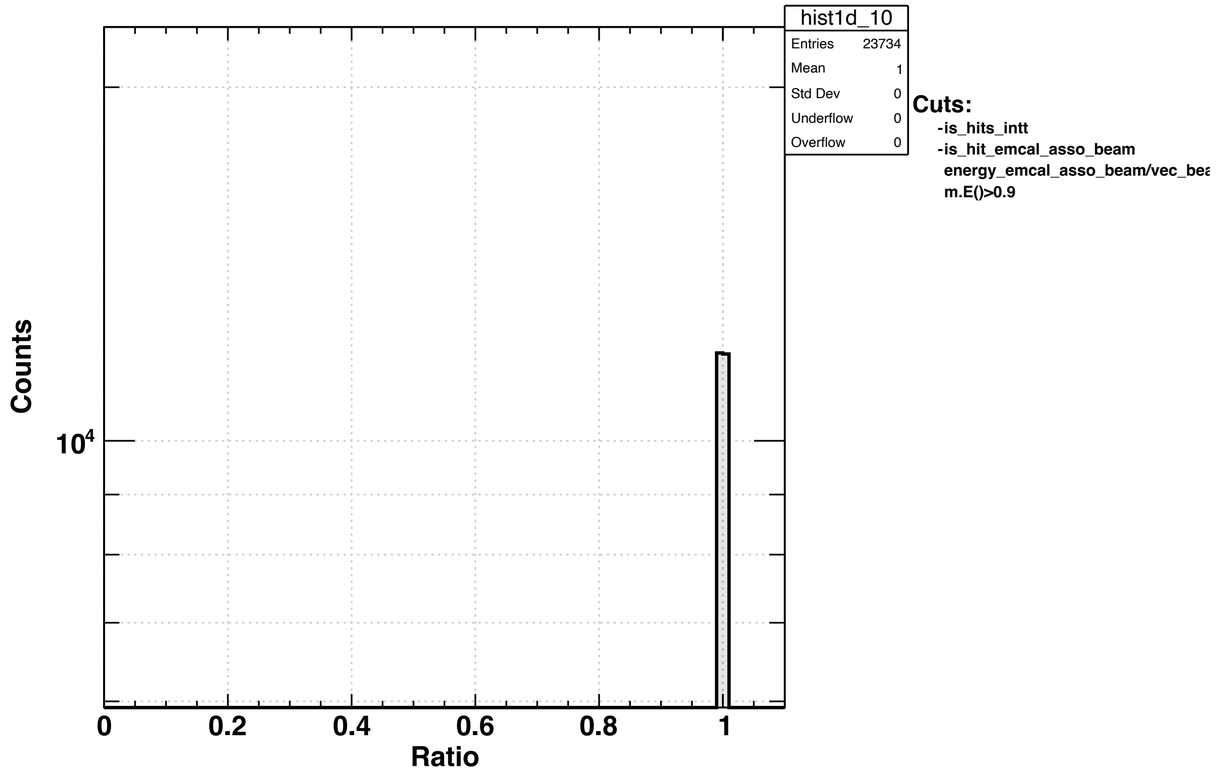
Topic2: Single electron simulation

Cuts:
- a hit on each INTT barrel
- EMCal hit asso. with beam found
- Primarity > 0.9

e^-, p_T = 1 GeV/c



μ^-, p_T = 1 GeV/c



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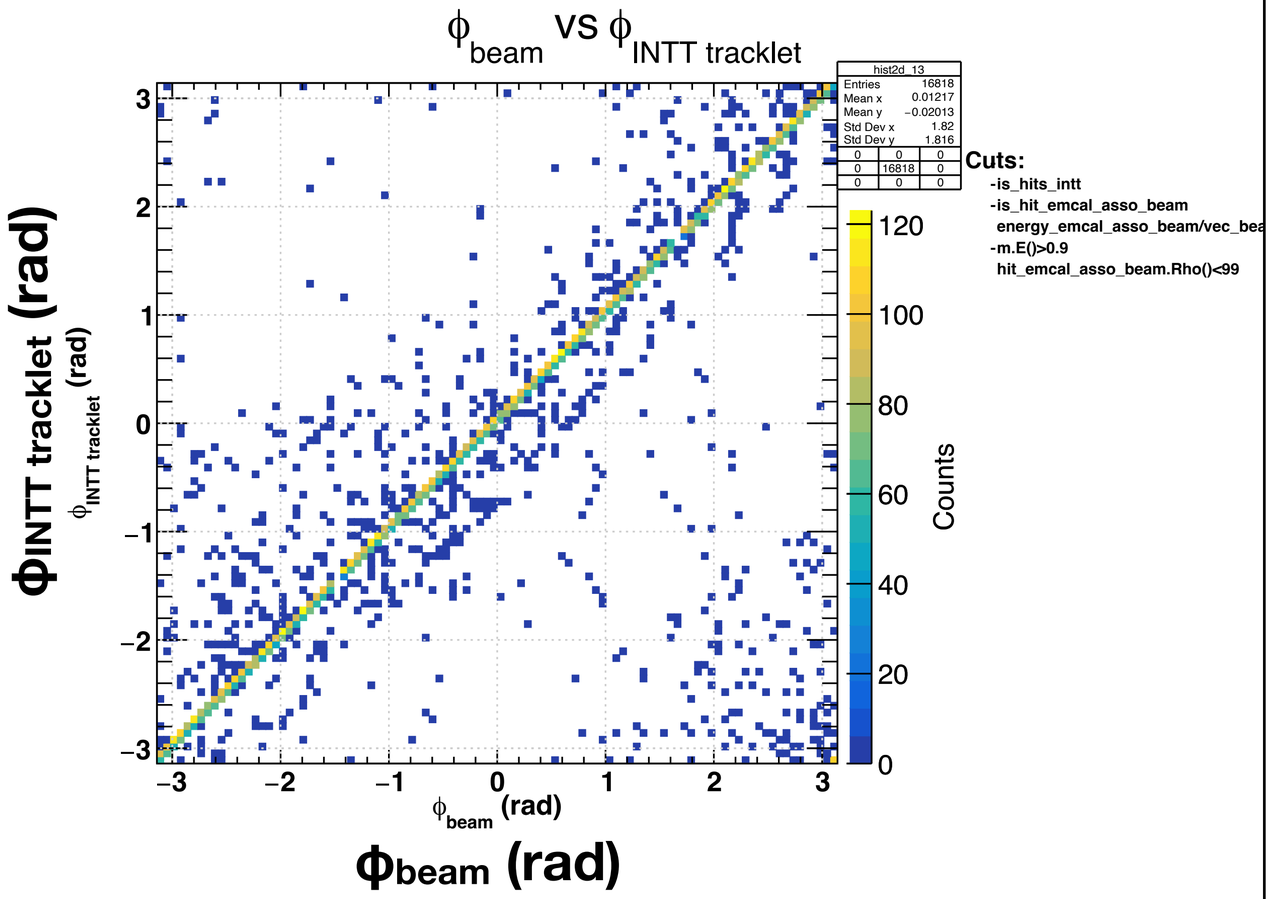
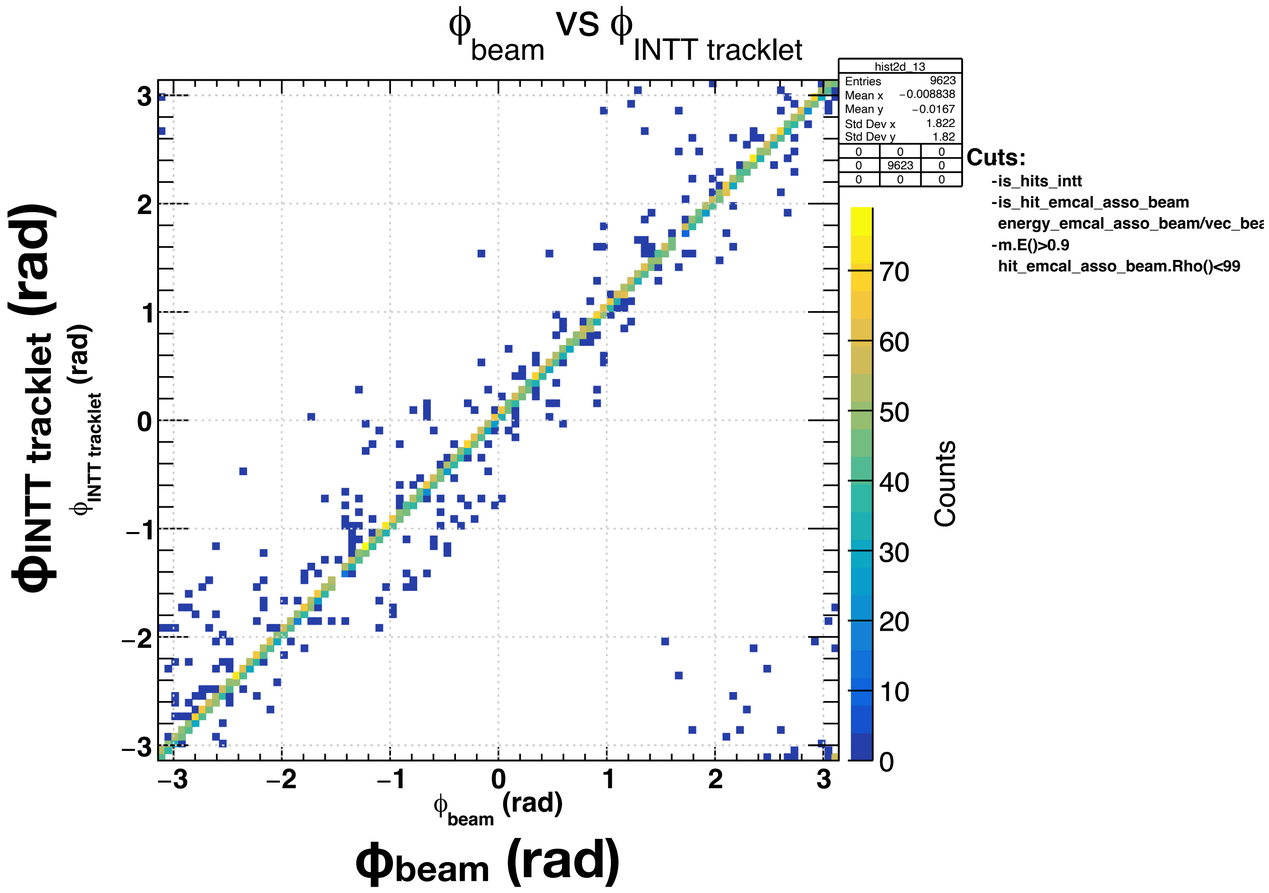
e^-, p_T = 1 GeV/c



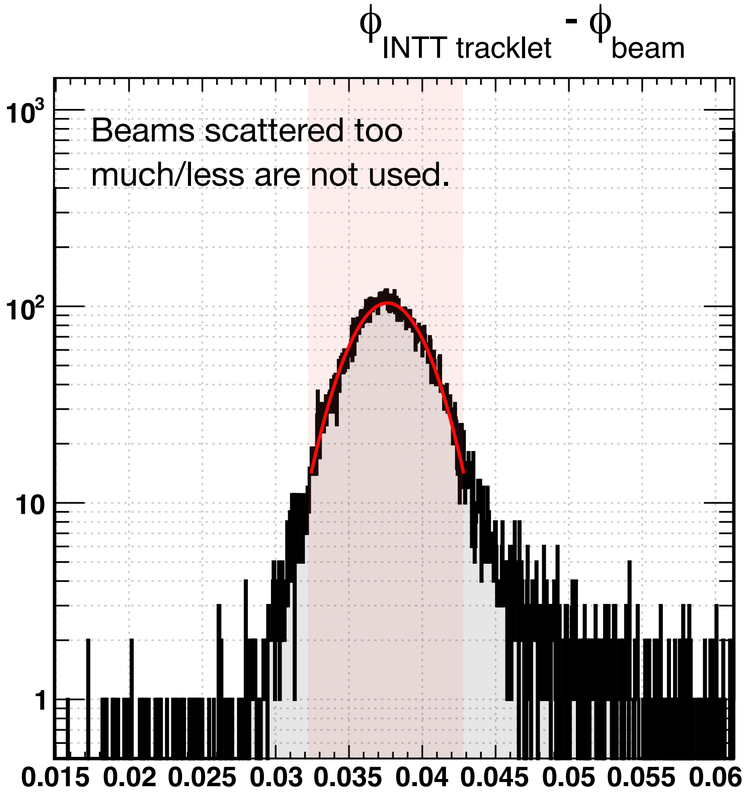
μ^-, p_T = 1 GeV/c



Topic2: Single electron simulation

Cuts:
- a hit on each INTT barrel
- EMCal hit asso. with beam found
- Primarity > 0.9

e^-, p_T = 1 GeV/c

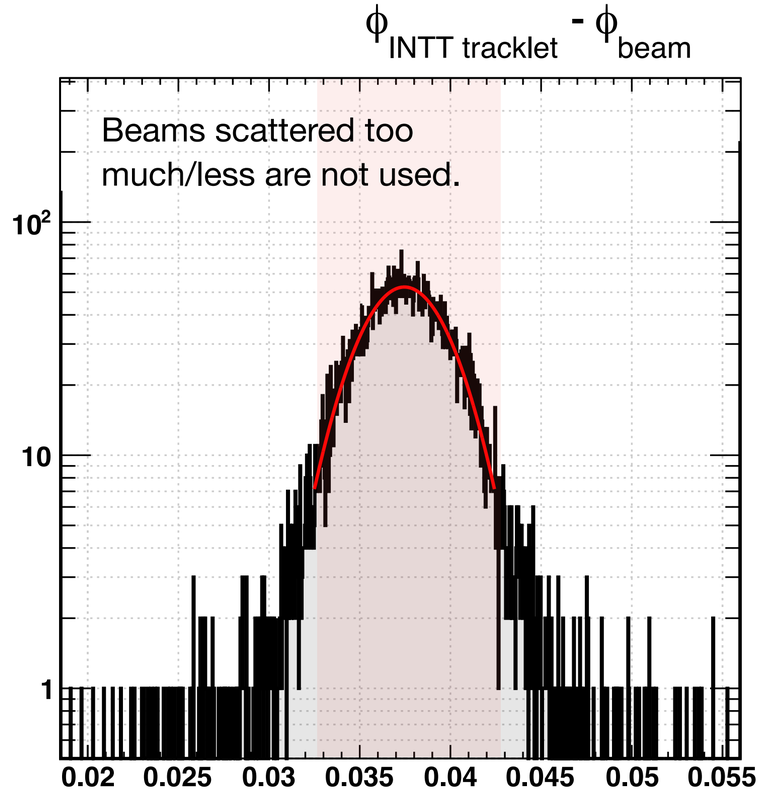


hist_dphi_intt_beam	
Entries	16818
Mean	0.03851
Std Dev	0.007057
Underflow	397
Overflow	766
χ^2 / ndf	223.6 / 225
Constant	103.9 ± 1.2
Mean	0.03762 ± 0.00002
Sigma	0.002605 ± 0.000024

ϕ resolution with INTT tracklet:

$$100 \times \left| \frac{\sigma}{\mu} \right| = 6.9\,\%$$

μ^-, p_T = 1 GeV/c



hist_dphi_intt_beam	
Entries	9623
Mean	0.03761
Std Dev	0.004607
Underflow	134
Overflow	219
χ^2 / ndf	235.1 / 258
Constant	52.66 ± 0.76
Mean	0.03746 ± 0.00003
Sigma	0.002484 ± 0.000031

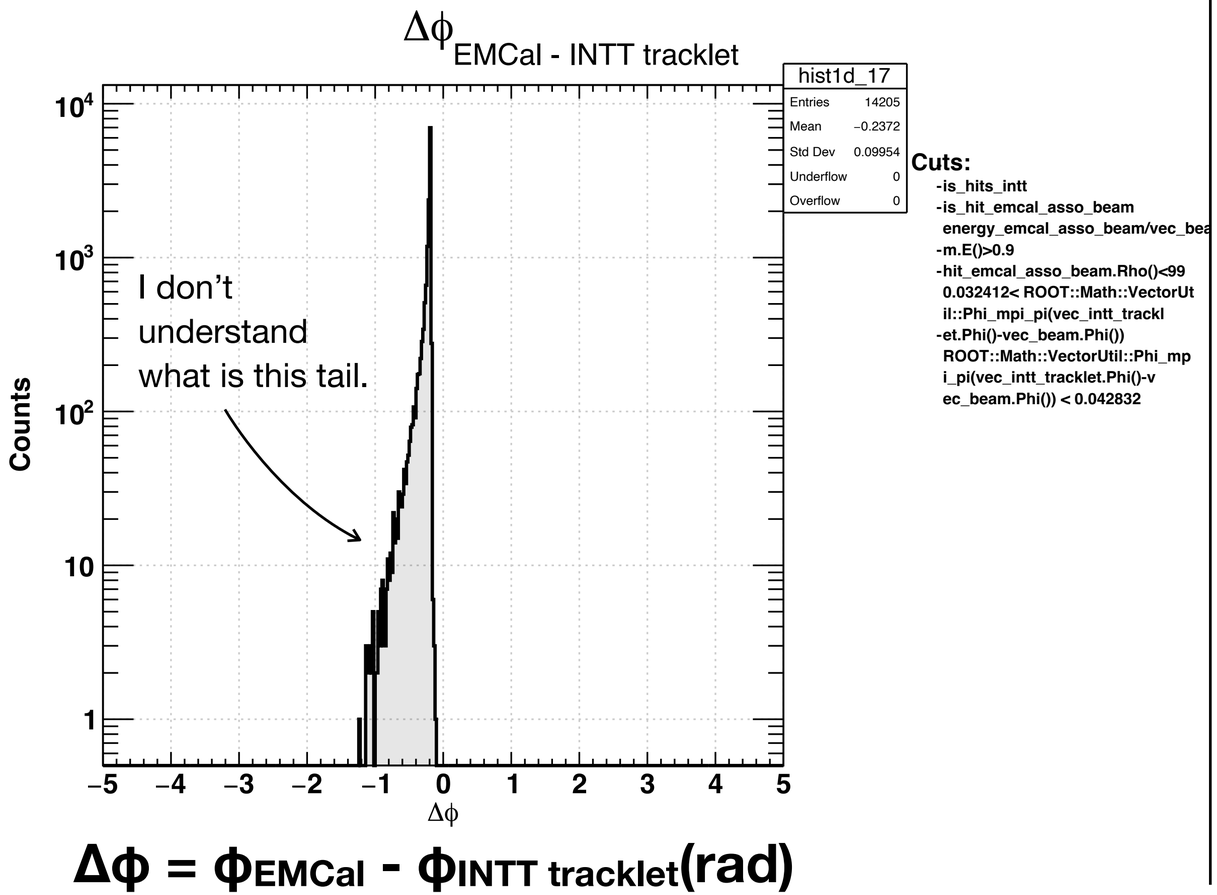
ϕ resolution with INTT tracklet:

$$100 \times \left| \frac{\sigma}{\mu} \right| = 6.6\,\%$$

Topic2: Single electron simulation

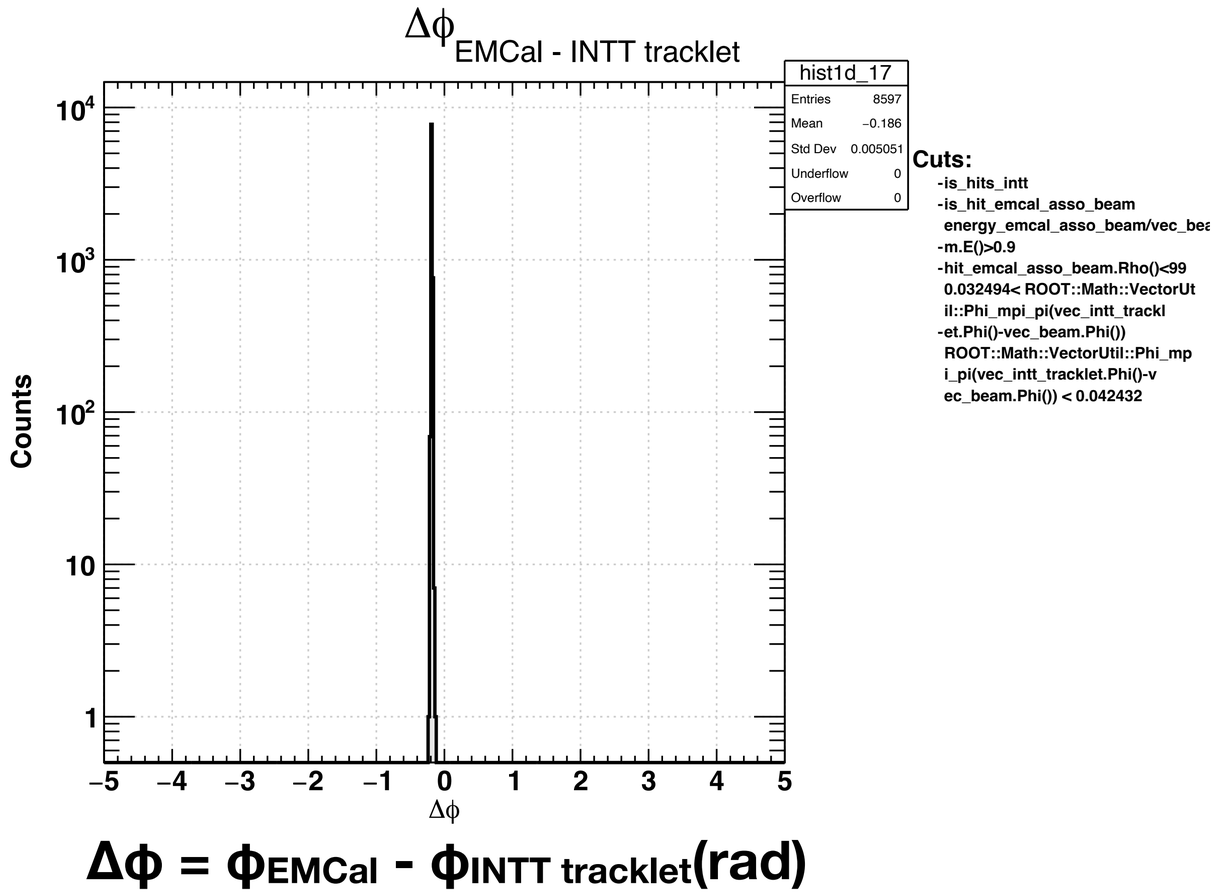
Cuts:
- a hit on each INTT barrel
- EMCal hit asso. with beam found
- Primarity > 0.9
- $\left|\Delta\phi_{INTT\ tracklet\ -\ beam}\right| \leq \mu \pm 2\sigma$

e^-, p_T = 1 GeV/c



Δϕ = ϕEMCal - ϕINTT tracklet(rad)

μ^-, p_T = 1 GeV/c



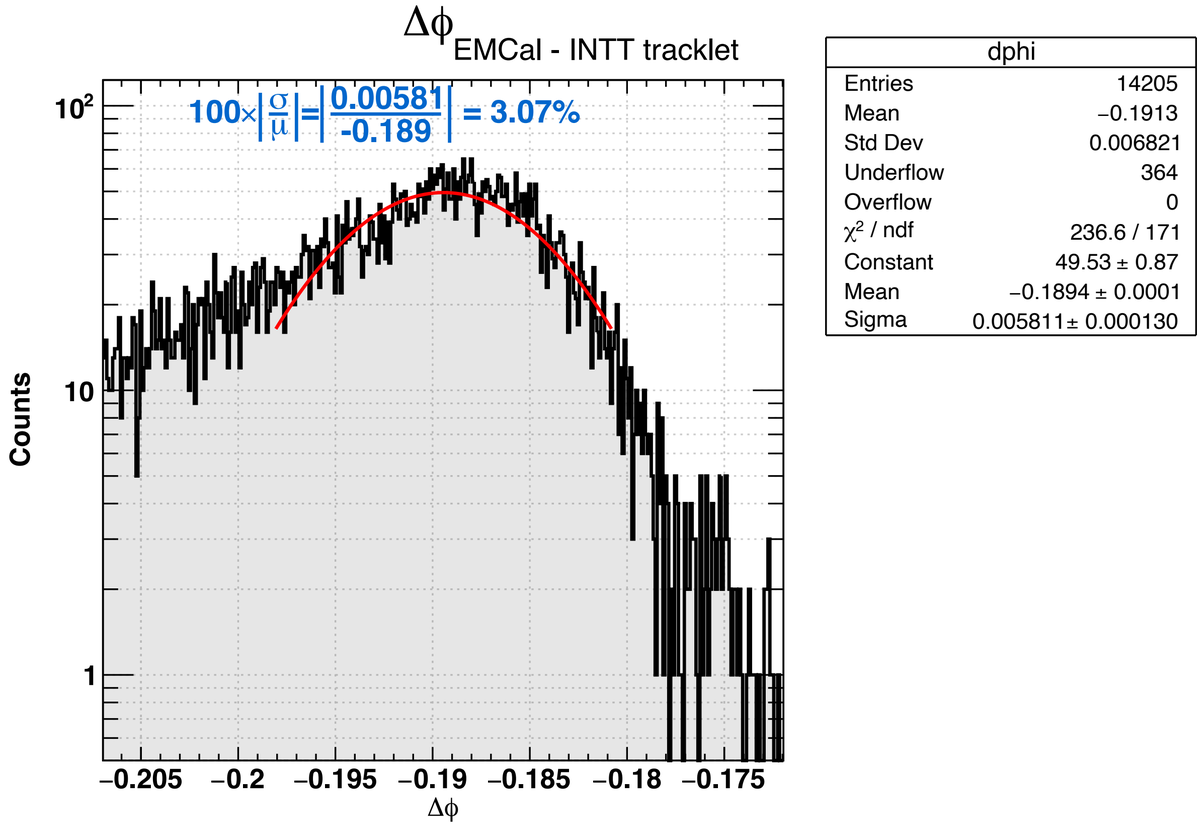
Δϕ = ϕEMCal - ϕINTT tracklet(rad)

Δϕ distributions are different.

Topic2: Single electron simulation

Cuts:
- a hit on each INTT barrel
- EMCal hit asso. with beam found
- Primarity > 0.9
- $\left|\Delta\phi_{INTT\ tracklet\ -\ beam}\right| \leq \mu \pm 2\sigma$

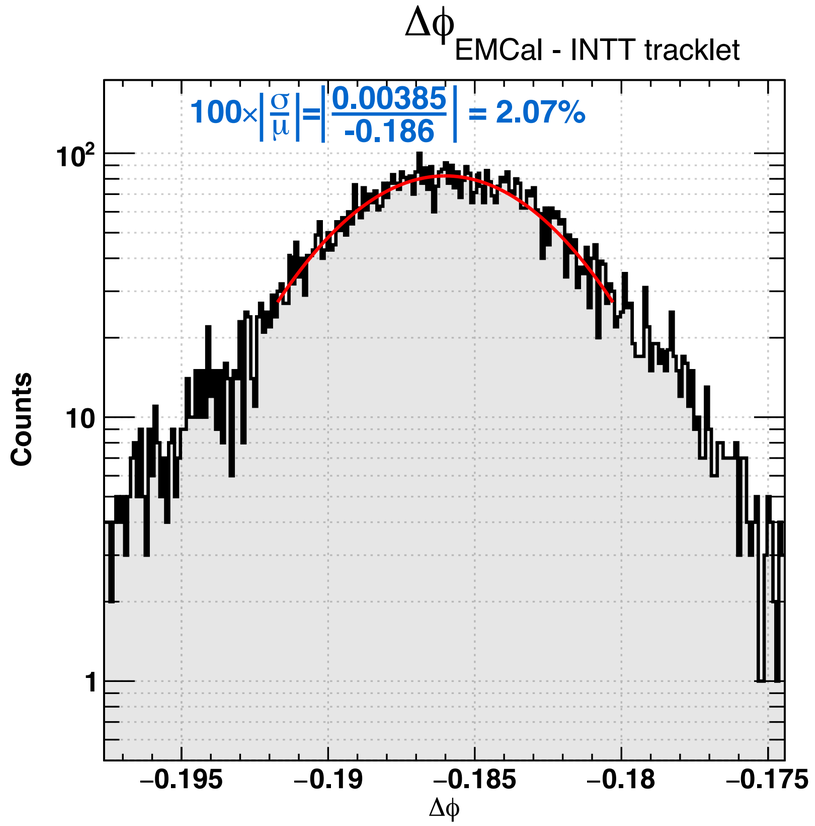
e^-, p_T = 1 GeV/c



dphi	
Entries	14205
Mean	−0.1913
Std Dev	0.006821
Underflow	364
Overflow	0
χ^2 / ndf	236.6 / 171
Constant	49.53 ± 0.87
Mean	−0.1894 ± 0.0001
Sigma	0.005811± 0.000130

Δϕ = ϕEMCal - ϕINTT tracklet(rad)

μ^-, p_T = 1 GeV/c



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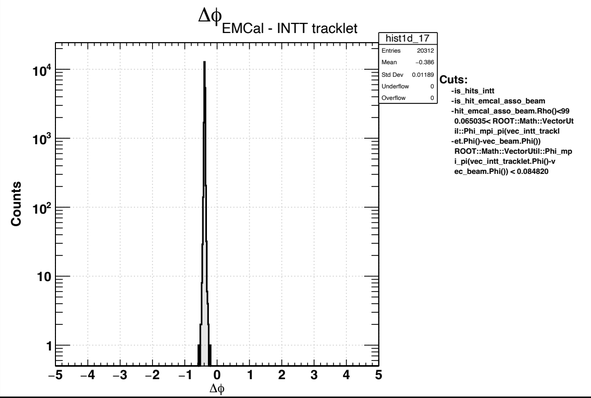
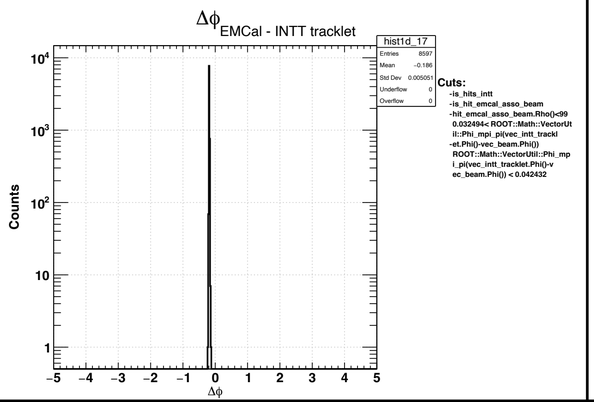
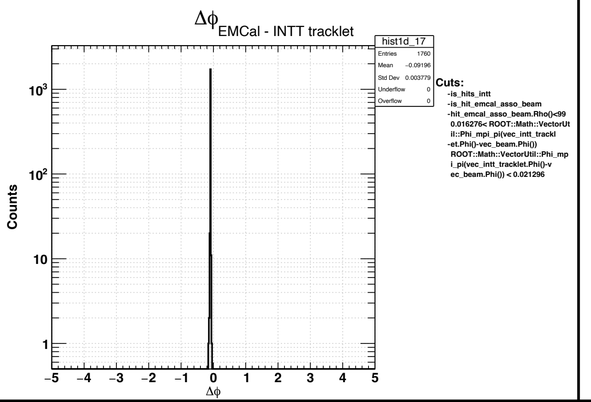
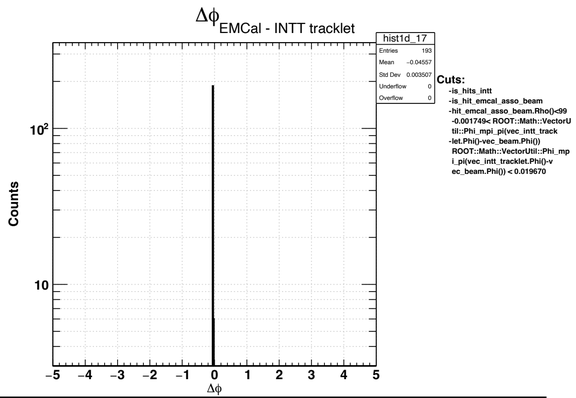
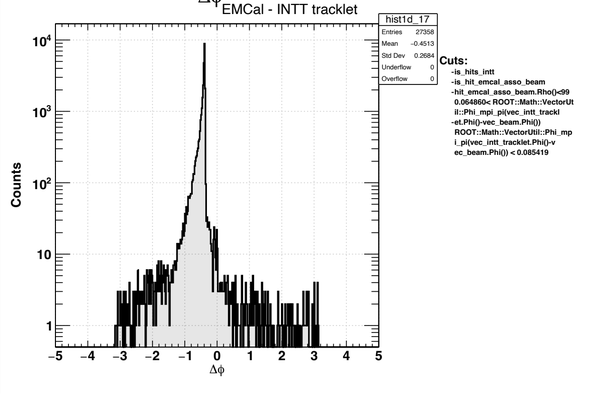
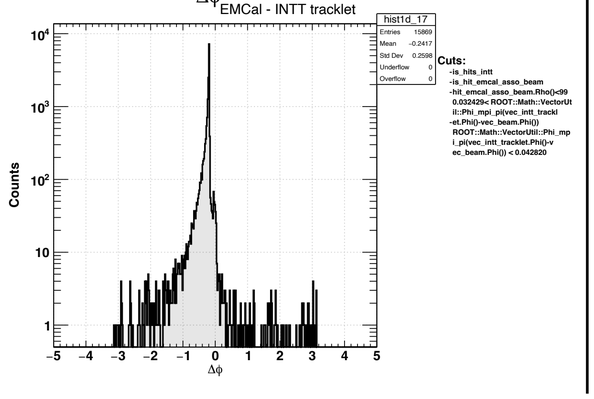
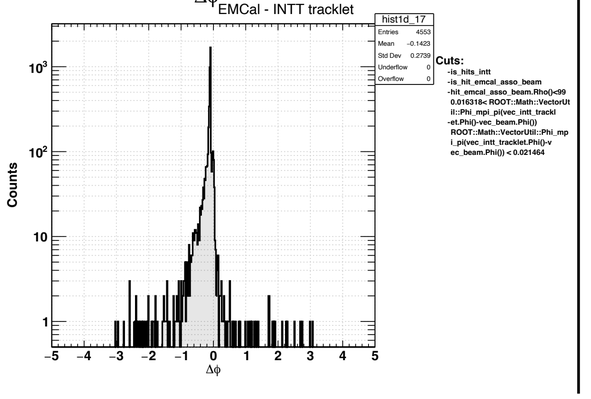
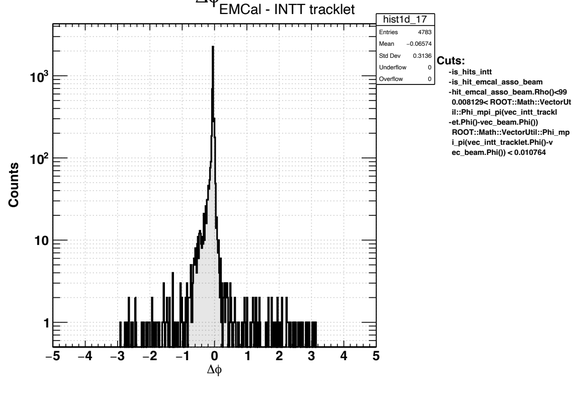
Constant	82.08 ± 1.36
Mean	−0.186 ± 0.000
Sigma	0.003851± 0.000079

Δϕ = ϕEMCal - ϕINTT tracklet(rad)

Δϕ distributions are different.

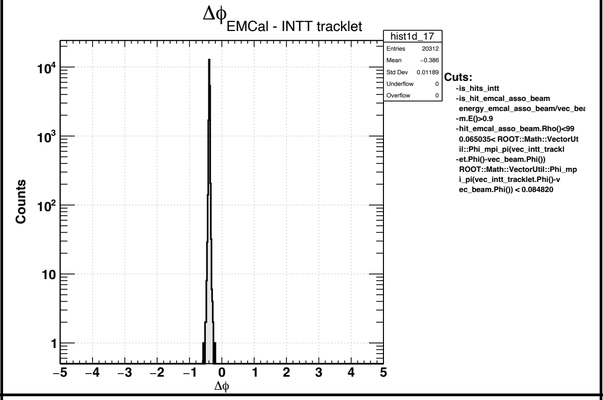
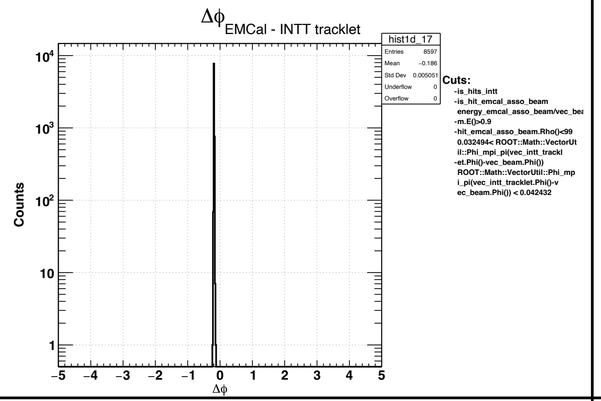
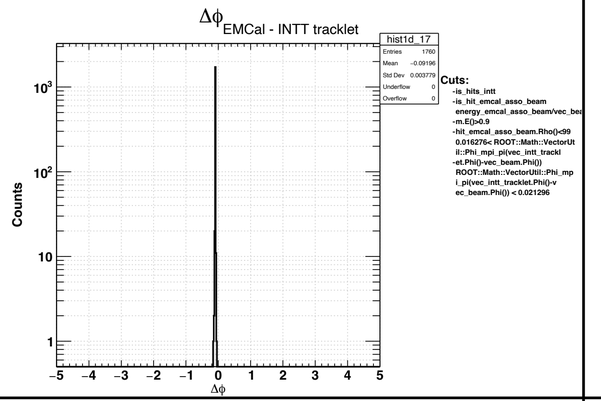
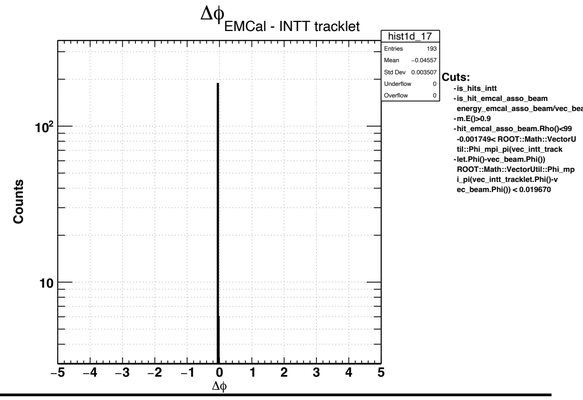
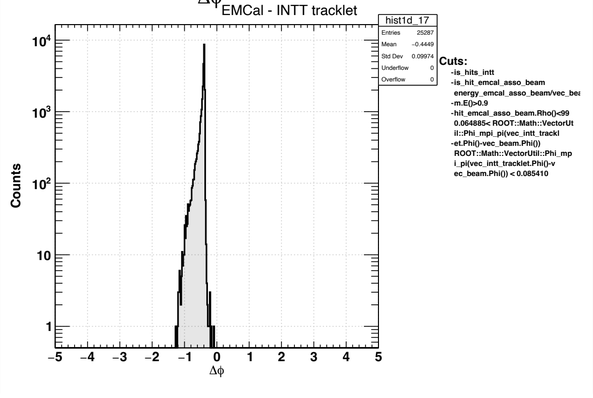
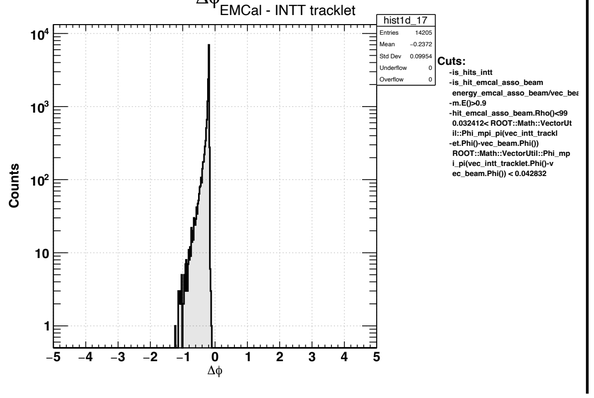
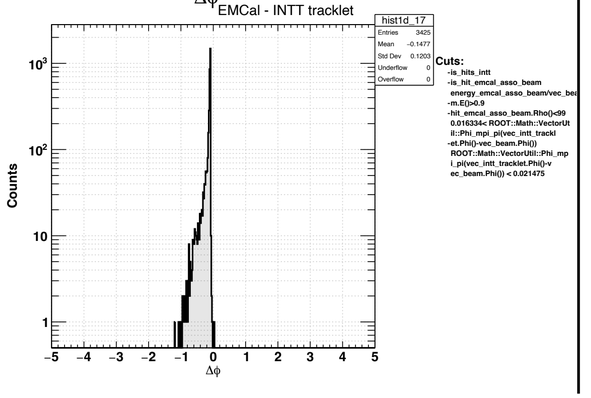
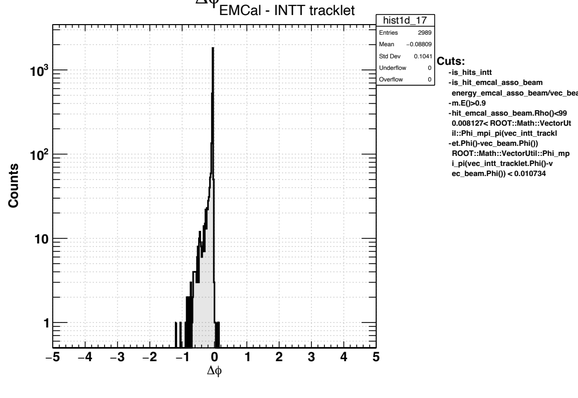
Topic2: ϕ angle resolution of various setup

Cuts:
- a hit on each INTT barrel
- EMCal hit asso. with beam found
- $\left|\Delta\phi_{INTT\ tracklet\ -\ beam}\right| \leq \mu \pm 2\sigma$

	0.5 GeV/c	1 GeV/c	2 GeV/c	4 GeV/c
μ^-				
e^-				

Topic2: ϕ angle resolution of various setup

Cuts:
- a hit on each INTT barrel
- EMCal hit asso. with beam found
- Primarity > 0.9
- $\left|\Delta\phi_{INTT\ tracklet\ -\ beam}\right| \leq \mu \pm 2\sigma$

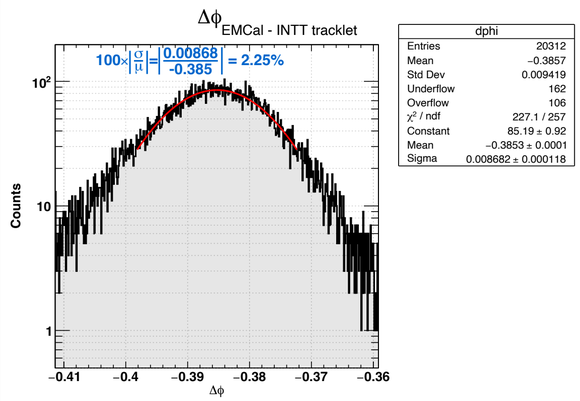
	0.5 GeV/c	1 GeV/c	2 GeV/c	4 GeV/c
μ^-				
e^-				

Topic2: ϕ angle resolution of various setup

Cuts:
- a hit on each INTT barrel
- EMCal hit asso. with beam found
- Primarity > 0.9
- $\left|\Delta\phi_{INTT\ tracklet\ -\ beam}\right| \leq \mu \pm 2\sigma$

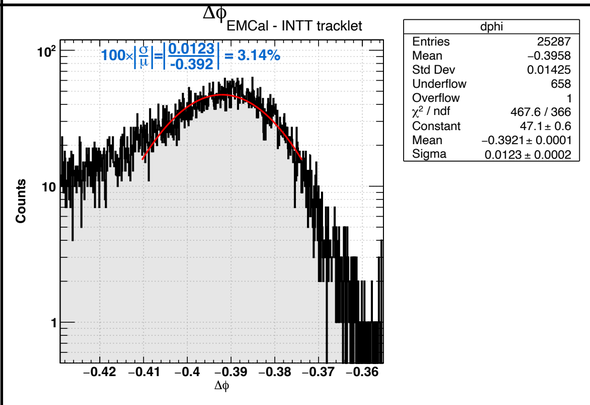
0.5 GeV/c

μ^-



dphi	
Entries	20312
Mean	−0.3857
Std Dev	0.009419
Underflow	162
Overflow	106
χ^2 / ndf	227.1 / 257
Constant	85.19 ± 0.92
Mean	−0.3853 ± 0.0001
Sigma	0.008682 ± 0.000118

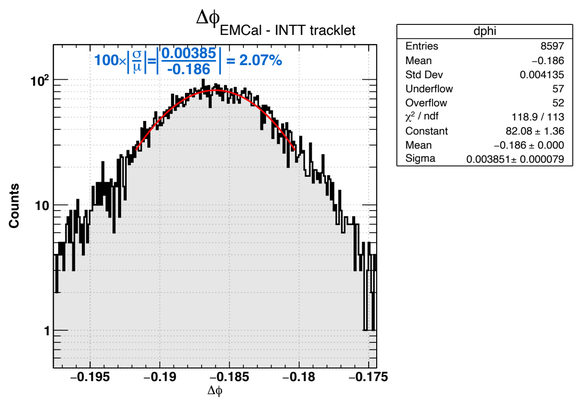
e^-



dphi	
Entries	25287
Mean	−0.3958
Std Dev	0.01425
Underflow	658
Overflow	1
χ^2 / ndf	467.6 / 366
Constant	47.1 ± 0.6
Mean	−0.3921 ± 0.0001
Sigma	0.0123 ± 0.0002

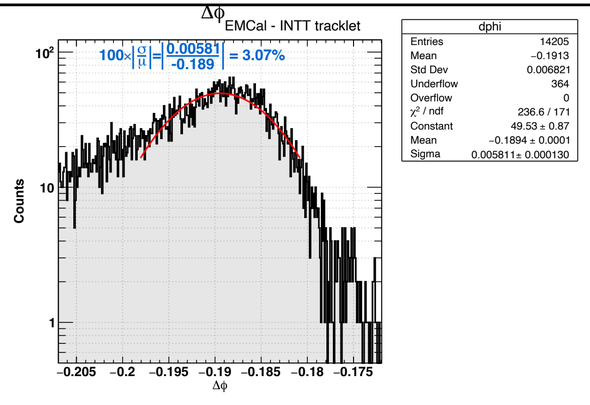
1 GeV/c

μ^-



dphi	
Entries	8597
Mean	−0.186
Std Dev	0.004135
Underflow	57
Overflow	52
χ^2 / ndf	118.9 / 113
Constant	82.08 ± 1.36
Mean	−0.186 ± 0.000
Sigma	0.003851 ± 0.000079

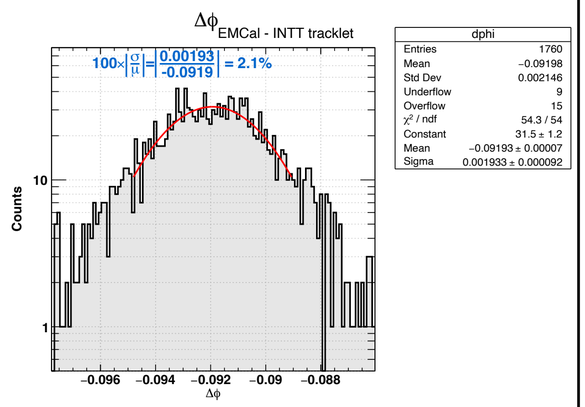
e^-



dphi	
Entries	14205
Mean	−0.1913
Std Dev	0.006821
Underflow	364
Overflow	0
χ^2 / ndf	236.6 / 171
Constant	49.53 ± 0.87
Mean	−0.1894 ± 0.0001
Sigma	0.005811 ± 0.000130

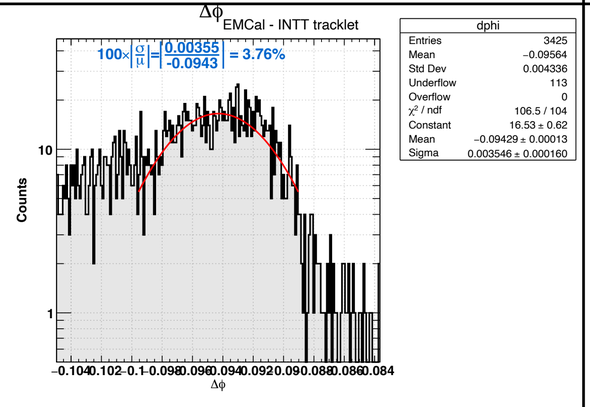
2 GeV/c

μ^-



dphi	
Entries	1760
Mean	−0.09198
Std Dev	0.002146
Underflow	9
Overflow	15
χ^2 / ndf	54.3 / 54
Constant	31.5 ± 1.2
Mean	−0.09193 ± 0.00007
Sigma	0.001933 ± 0.000092

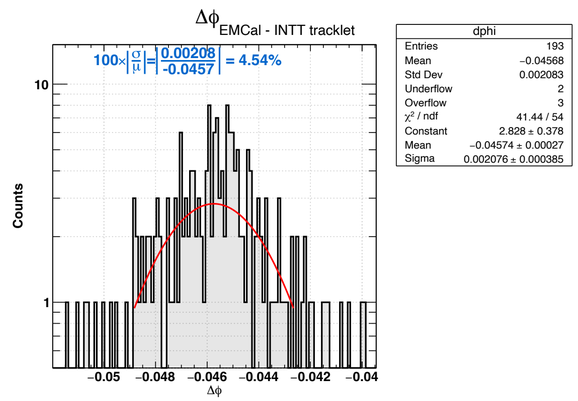
e^-



dphi	
Entries	3425
Mean	−0.09564
Std Dev	0.004336
Underflow	113
Overflow	0
χ^2 / ndf	106.5 / 104
Constant	16.53 ± 0.62
Mean	−0.09429 ± 0.00013
Sigma	0.003546 ± 0.000160

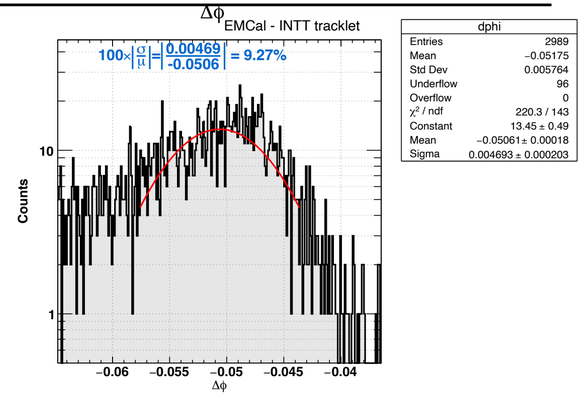
4 GeV/c

μ^-



dphi	
Entries	193
Mean	−0.04568
Std Dev	0.002083
Underflow	2
Overflow	3
χ^2 / ndf	41.44 / 54
Constant	2.828 ± 0.378
Mean	−0.04574 ± 0.00027
Sigma	0.002076 ± 0.000385

e^-

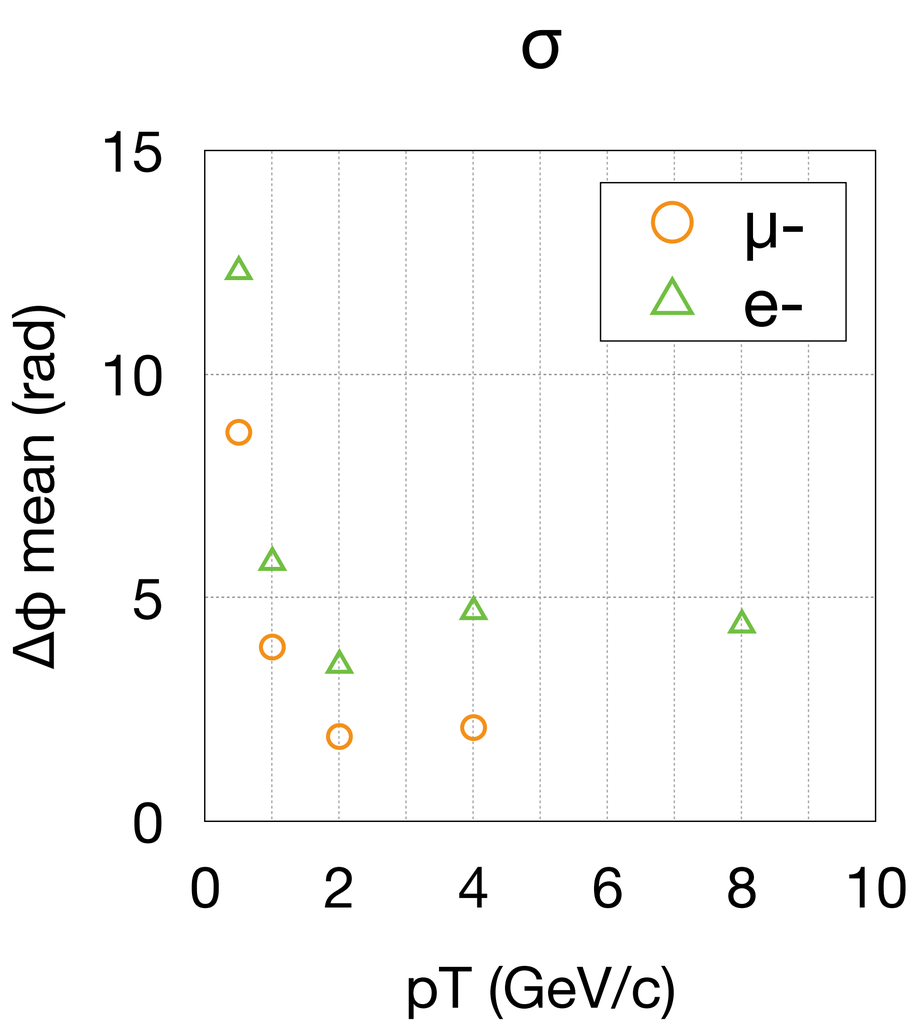


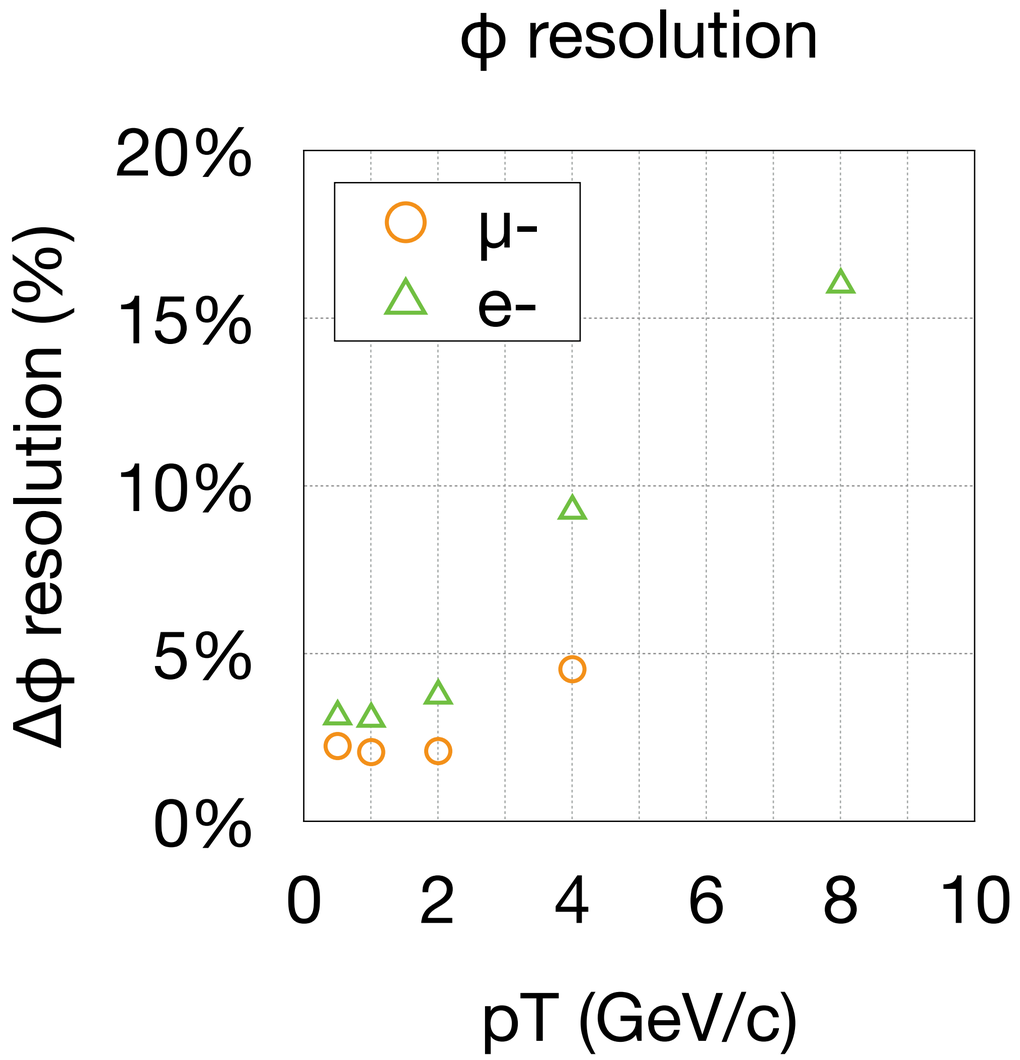
dphi	
Entries	2989
Mean	−0.05175
Std Dev	0.005764
Underflow	96
Overflow	0
χ^2 / ndf	220.3 / 143
Constant	13.45 ± 0.49
Mean	−0.05061 ± 0.00018
Sigma	0.004693 ± 0.000203

Topic2: Summary

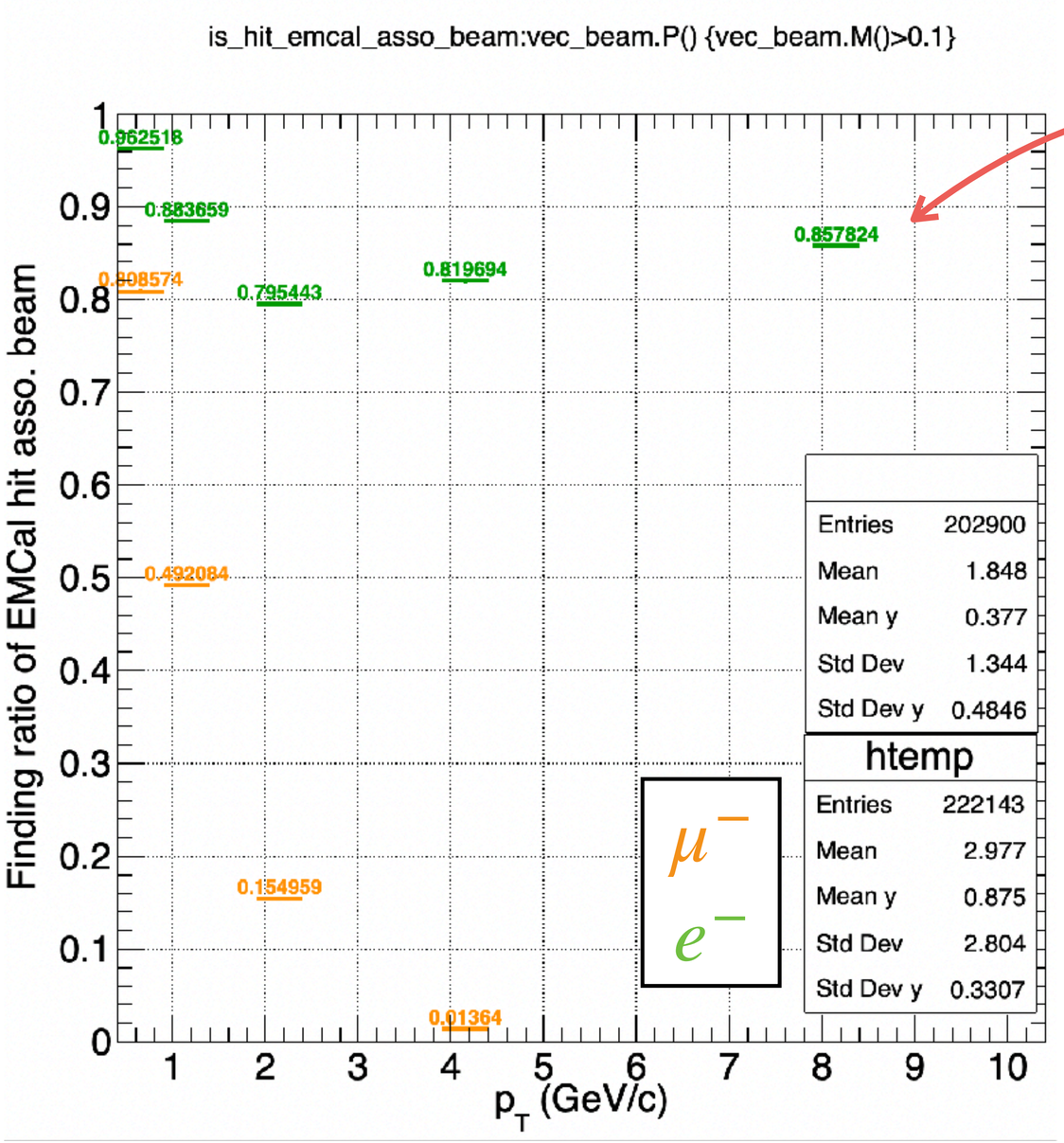
Run	#event	Beam	Momentum (GeV/c)	ϕ dist (rad)	η dist	vertex (cm)	with EMCal hits asso. with beam Δϕ mean (mrad)	Δϕ std. dev. (mrad)	Δϕ resolution (%)
4	5.4E+04	μ^-	0.5	[-π, π]	fixed at 0	fixed at (0, 0, 0)	-385.3	8.7	2.25%
1	5.0E+04	μ^-	1	[-π, π]	fixed at 0	fixed at (0, 0, 0)	-186.0	3.9	2.07%
2	4.9E+04	μ^-	2	[-π, π]	fixed at 0	fixed at (0, 0, 0)	-91.9	1.9	2.10%
3	5.0E+04	μ^-	4	[-π, π]	fixed at 0	fixed at (0, 0, 0)	-45.7	2.1	4.54%
9	5.6E+04	e^-	0.5	[-π, π]	fixed at 0	fixed at (0, 0, 0)	-392.1	12.3	3.14%
5	5.1E+04	e^-	1	[-π, π]	fixed at 0	fixed at (0, 0, 0)	-189.4	5.8	3.07%
6	2.9E+04	e^-	2	[-π, π]	fixed at 0	fixed at (0, 0, 0)	-94.3	3.5	3.76%
7	4.1E+04	e^-	4	[-π, π]	fixed at 0	fixed at (0, 0, 0)	-50.6	4.7	9.27%
8	4.5E+04	e^-	8	[-π, π]	fixed at 0	fixed at (0, 0, 0)	-27.4	4.4	16.01%

Topic2: Summary

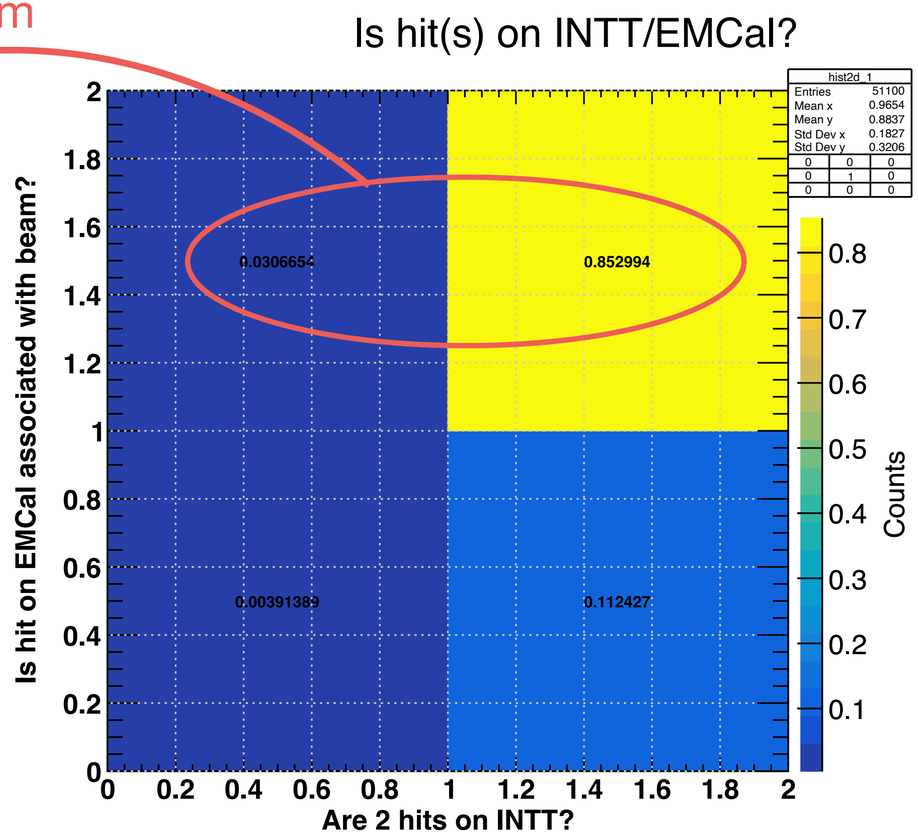




How often are EMCal hits associated with beam created?

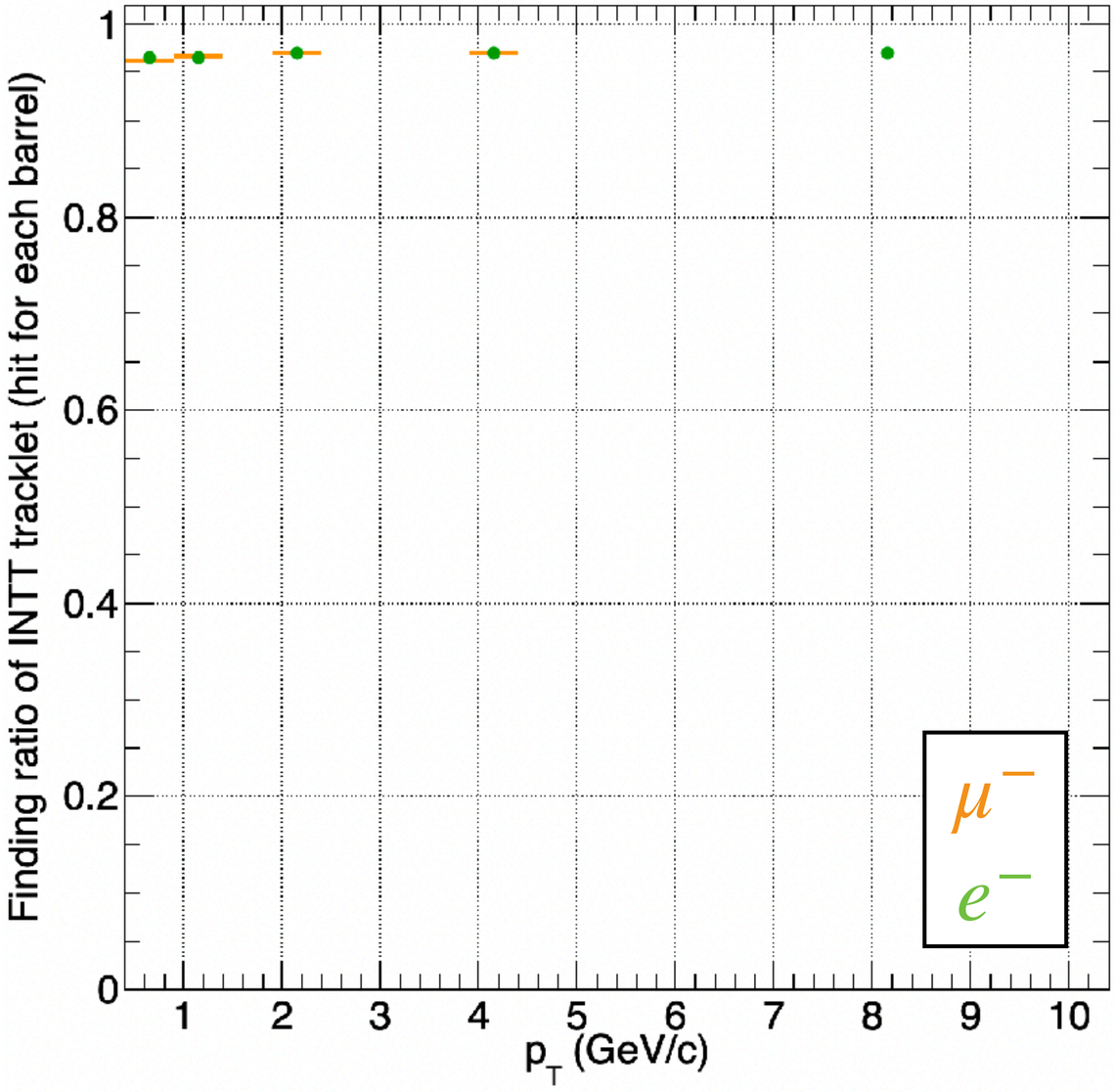


sum



- μ^-: EMCal hit is made for up to 80% of events
- e^-: More than 80%, p_T dependence can be seen.
- It's good to understand why…

How often is INTT tracklet found?



- INTT tracklet: a hit on each INTT barrel
- The finding ratio is constant for p_T and μ/e.

Summary

- New selection method of EMCal truth hit was introduced. It's more reasonable than just selecting the innermost EMCal hit. ϕ resolution is slightly improved.
- Single electron MC were carried out.
  - EMCal hits are generated in higher probability than single μ MC but not 100%.
  - Energy ratio of particles which created the EMCal hits to beam energy is a good parameter to select EMCal hits closer to the beam particle for electron MC case.
  - Electrons are scattered more than μ so that ϕ resolution gets worse.
  - The tail on the low side of Δϕ distribution needs to be understood.
- Events without a EMCal hit are interesting. I need to check the stepping action to understand it.