LICH : A CHARGED PID PROCESSOR

CEPC Physics Software Meeting

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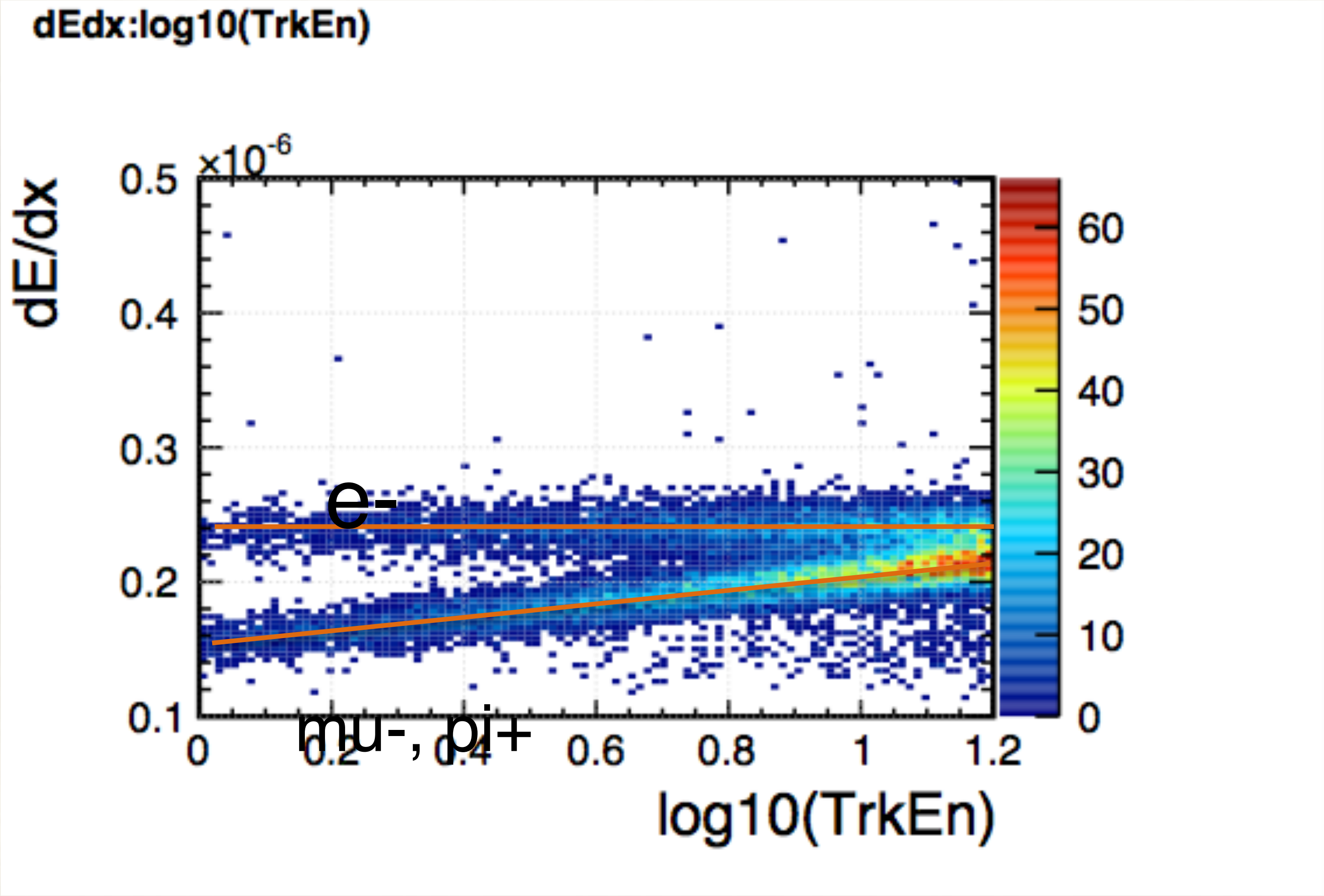
Intro

- Use of very high granularity (SiW-ECAL+SDHCAL, cepc_v1 ~ ILD_o2_v05) + ARBOR
- on final charged PFO's
- internally to identify more charged particles
- Simultaneous PID

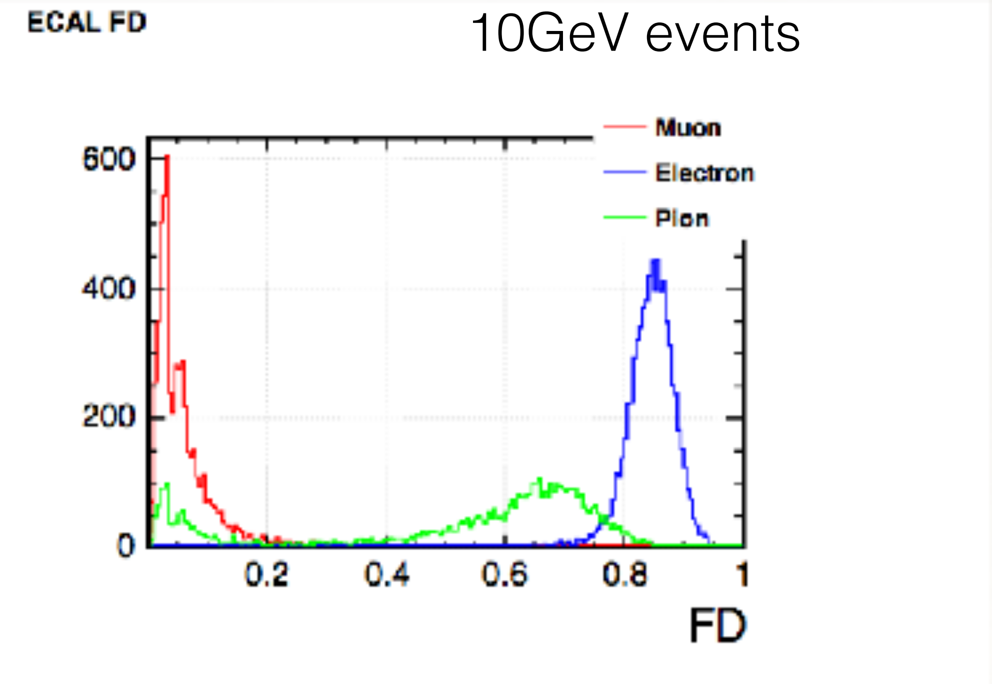
PID Variables: tracks

- **dE/dx**: For a track in TPC, the distribution of energy loss per unit of depth follows the **Landau distribution**.
- The dE/dx of a track used here is actually the **average** of this value but after **vetoing tails** at the two edges of Landau distribution [10%–70%]



PID Variables: Fractal Dim.

- reveals detailed information of the spatial configuration of the shower
  - α: scale at which the shower is analysed (by grouping hits)
  - N_α: the number of hits at scale α
  - $R_{\alpha,\beta} = N_\beta / N_\alpha$: ratio of the number of hits at different scales
  - $FD_\beta = \langle \log(R_{\alpha,\beta}) / \log(\alpha) \rangle_{\beta-150} + 1$ (or FD-1)
    - here: FD_10mm
- Used: FD_ECAL, FD_HCAL, FD_all

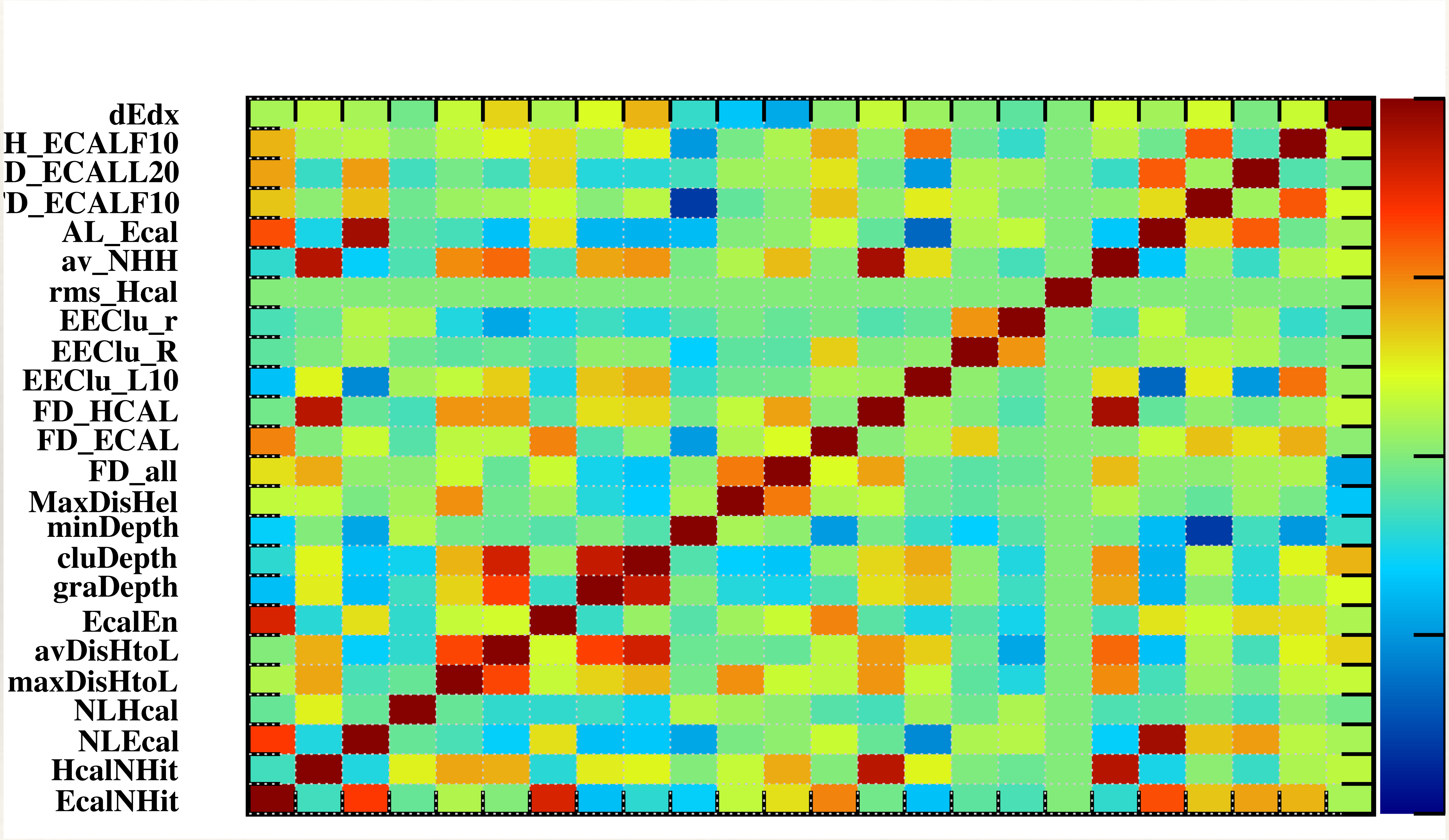


PID Variables: Other Calo

- **Energy Distribution**:
  - the proportion of energy deposit **in ECAL**: **EcalEn**
  - energy deposit in the **first 10 layers** in ECAL: **EEClu_L10**
  - energy deposit in a cylinder around the incident direction within a **radius of 1 R_M** and **1.5 R_M** : **EEClu_r, EEClu_R**
- Spatial **Hits Information**:
  - **number of layers** hit by the shower: **ECALHit, HCALHit**
  - **number of hits** in the **first 10 layers** of ECAL: **NH_ECALF10**
  - the **maximum distance** between a **hit** and the **helix**: **MaxDisHel**
  - the **maximum** and **average distance** between a **hit** and **axis of the shower** (defined by the 1st hit and the COG): **maxDisHtoL, avDisHtoL**
  - the **depth of COG**, and the **depth of shower** defined as the **depth** of the **inner most** hit and the **outer most** hit: **graDepth, CluDepth, MinDepth**

TMVA Correlation Matrix

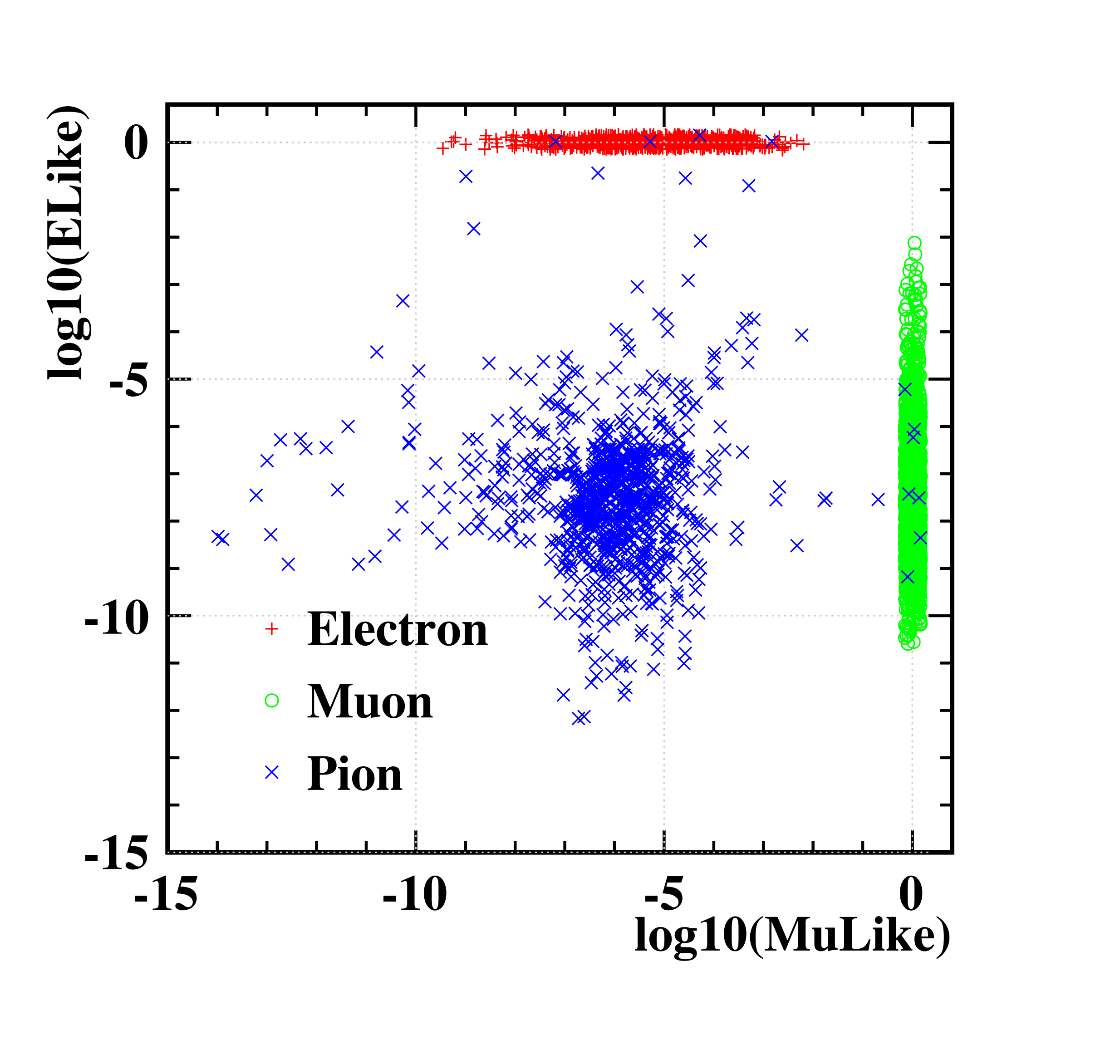
10GeV Muon(root-6.04)



TMVA BDTG

- Samples: (e, mu, pi) x (1, 2, 3, 5, 7, 10, 20, 30, 40, 50, 70 GeV) x (10000 events)
- Method: TMVA BDTG selected as "best" (vs likelihood, etc.)
- Catalog : TMVA Value for three catalogs: e, mu, pi
    - Classification :
        - mvaVal_*>0.5
        - otherwise"undefined pid" (very rare)

BDTG Value mvaVal_pi
for 10GeV pi, e, mu



Migration Matrix

- Probability of * particle tagged as * catalog

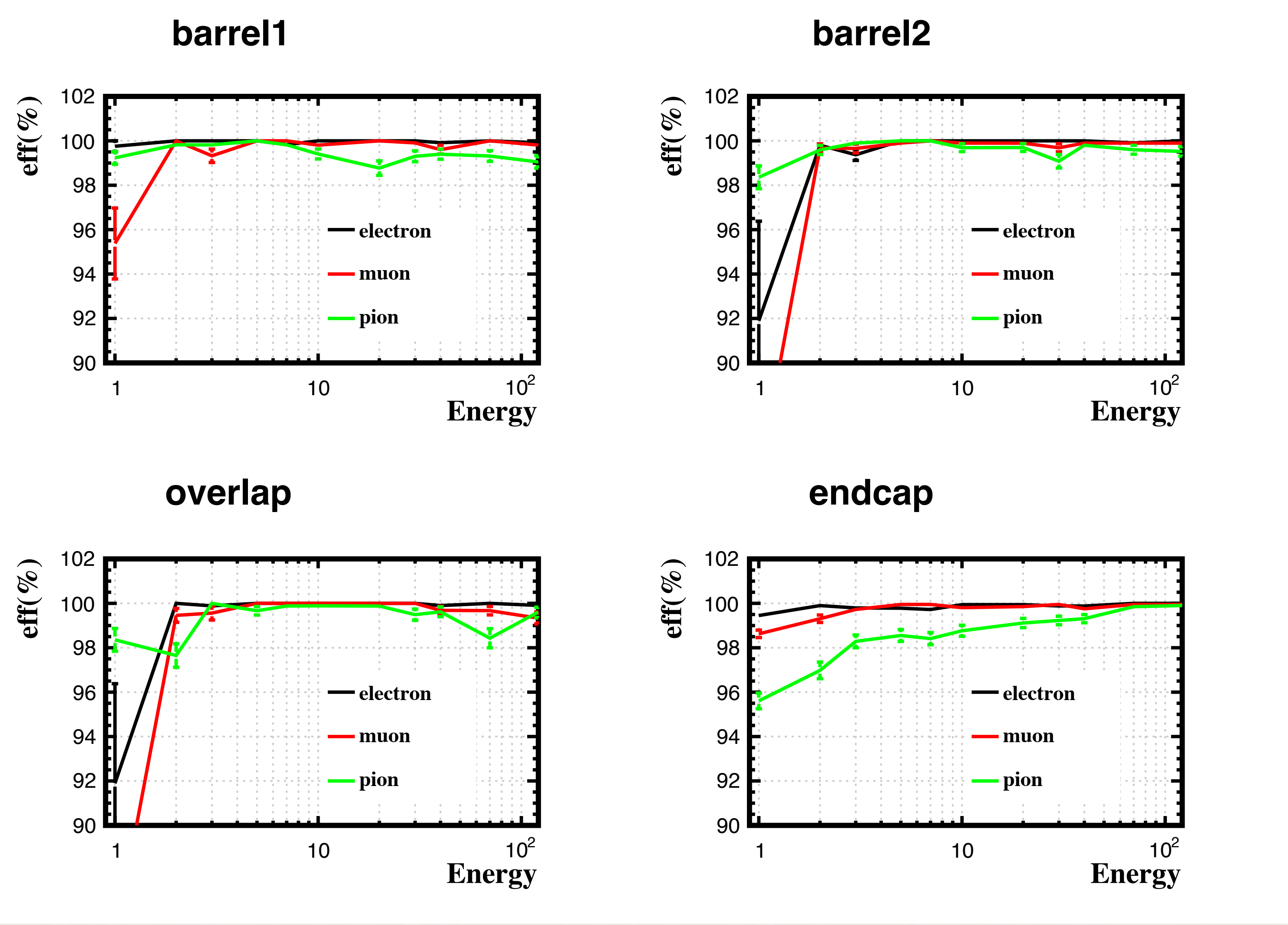
	e^- like	μ^- like	π^+ like	undefined
e^-	ε_e^e	P_μ^e	P_π^e	P_{und}^e
μ^-	P_e^μ	ε_μ^μ	P_π^μ	P_{und}^μ
π^+	P_e^π	P_μ^π	ε_π^π	P_{und}^π

- An example of MM

	e^-	μ^-	π^+
e^-	99.91 ± 0.08	0.08 ± 0.03	0
μ^-	0	99.60 ± 0.19	0.39 ± 0.19
π^+	0.34 ± 0.17	0.25 ± 0.14	99.39 ± 0.22

Efficiency & Mis-tagging

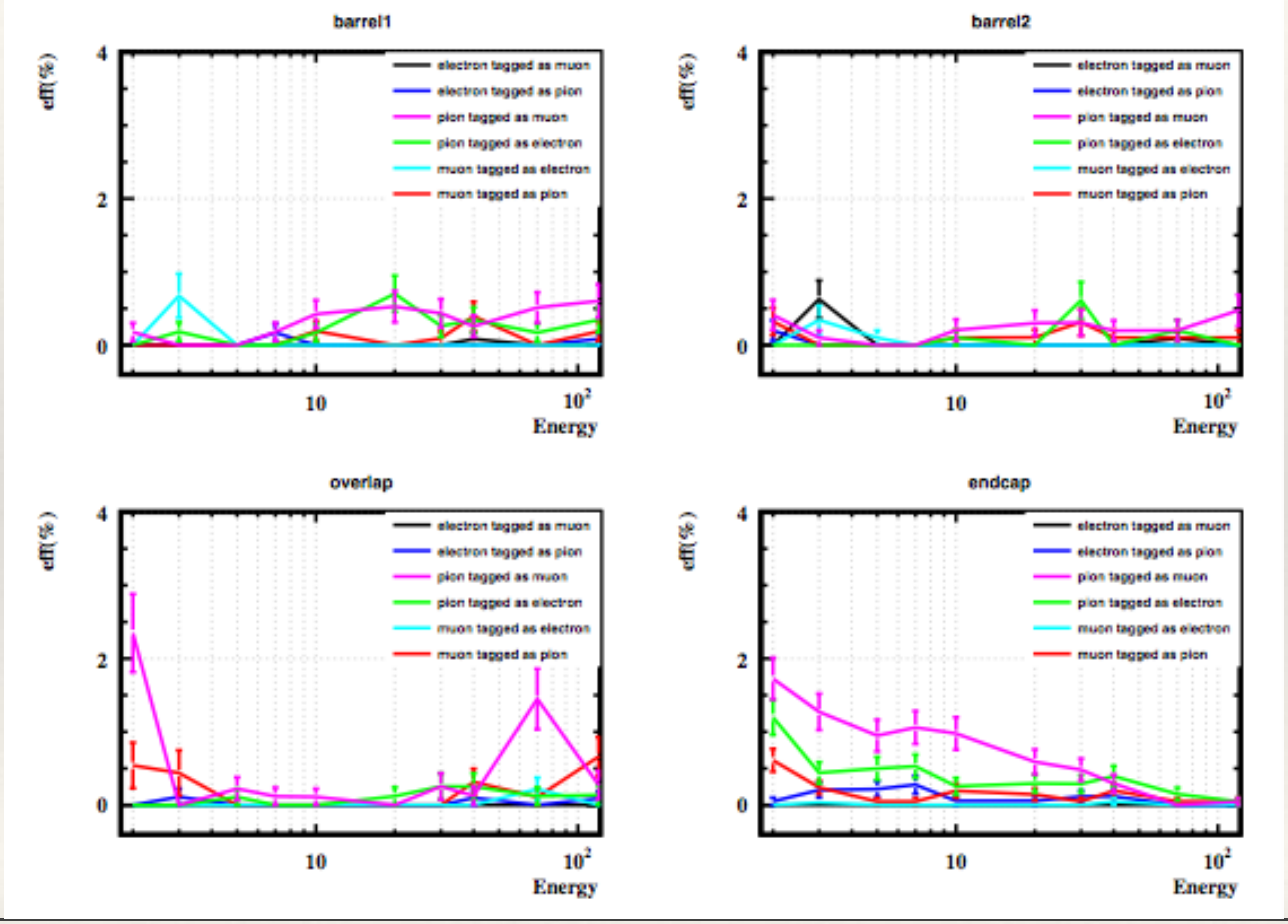
- PID efficiency for e, mu, pi at different detector regions



- endcap is the best region (more statistics for low energy)
- combined efficiency: about 98% for pion higher than 3GeV
- muon & electron: even better

Efficiency & Mis-tagging

- PID efficiency for e, mu, pi at different detector regions



Marlin Processor

- **L**epton **I**dentification for **C**alorimeter with **H**igh-granular

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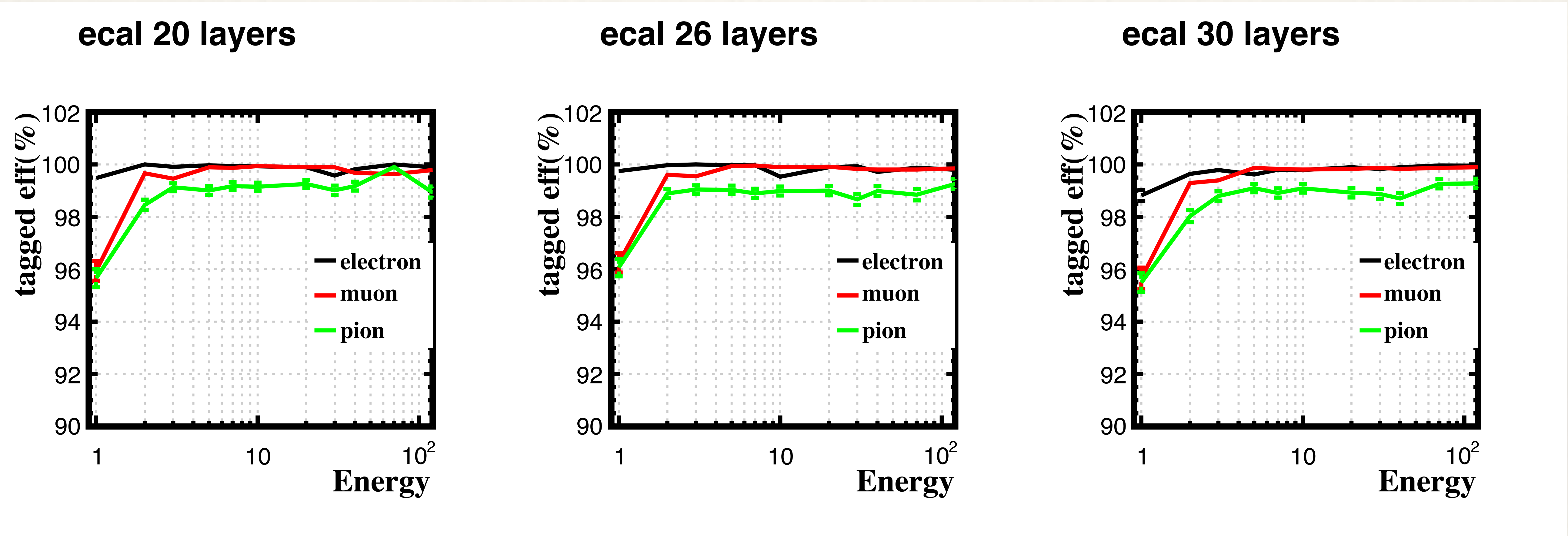
- Parameters: InputDectorModules, TrainingFlag, InputEnergyPoints, InputPFO, OutputPFO(TrainingFlag==0), mvacut(TrainingFlag==0), weightDir (TrainingFlag==0), TrainingEn(TrainingFlag==1)
- Step (the first two steps need to be run only once for one PFA and one Geometry):
  - Put TrainingFlag to 1 to produce root samples at each energy point
  - run TMVA to get weight files
  - Put TrainingFlag to 0 and put weightDir as the path of weight files, get identified ReconstructedParticle

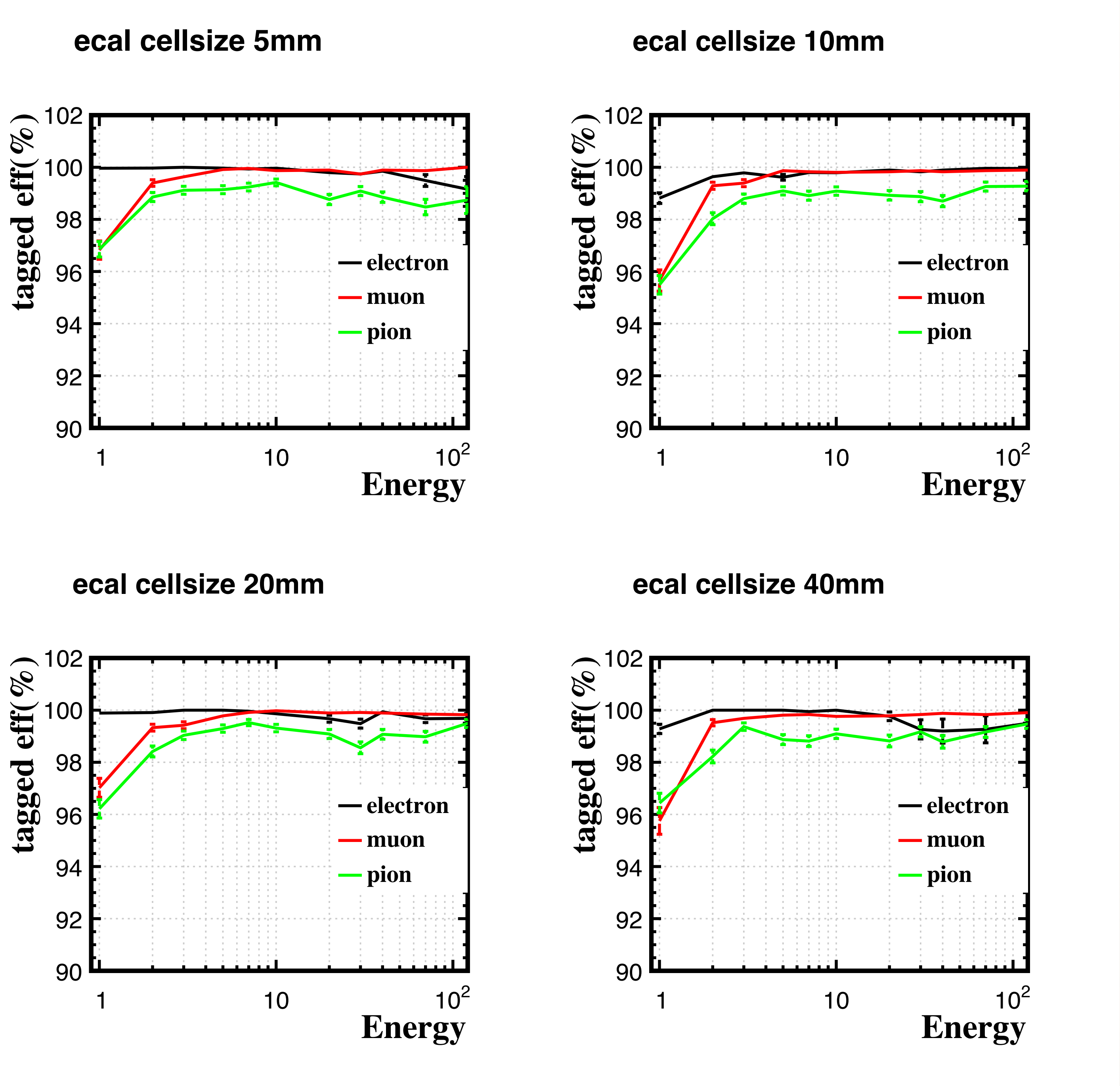
Tests on different geometries

- PID efficiency for e, mu, pi at different Ecal N layers



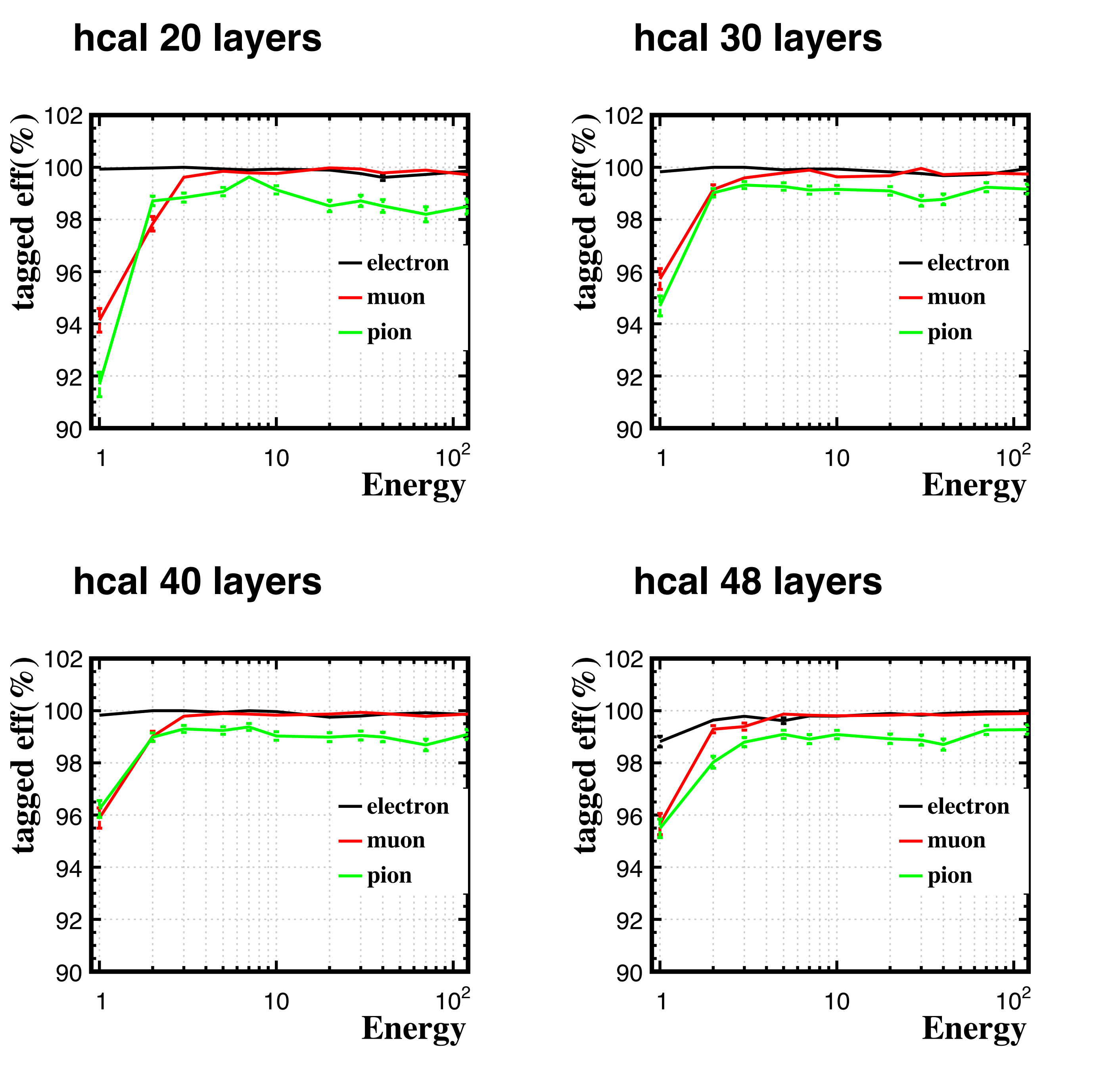
Tests on different geometries

- PID efficiency for e, mu, pi at different Ecal Cell Size



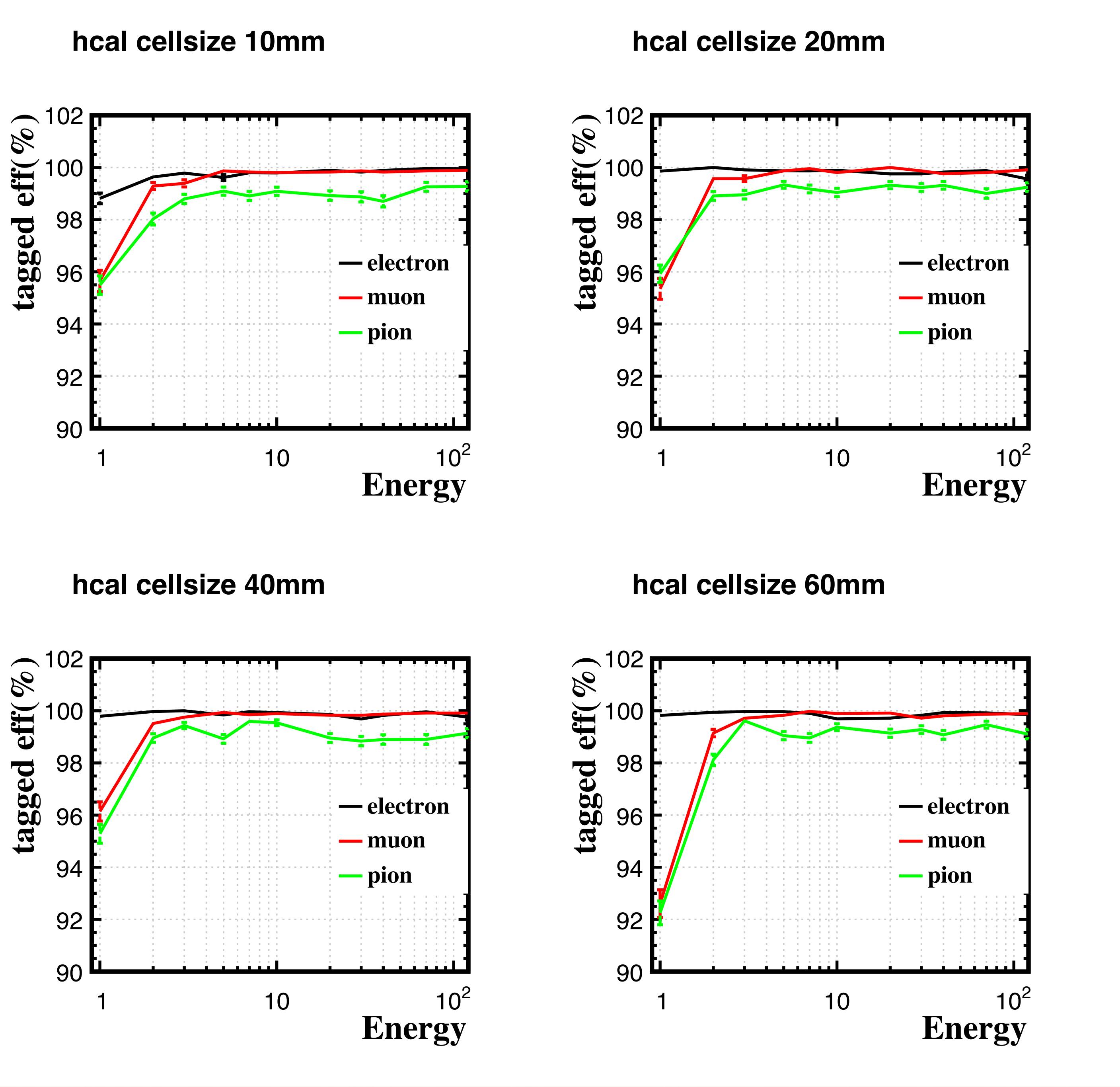
Tests on different geometries

- PID efficiency for e, mu, pi at different Hcal N layers



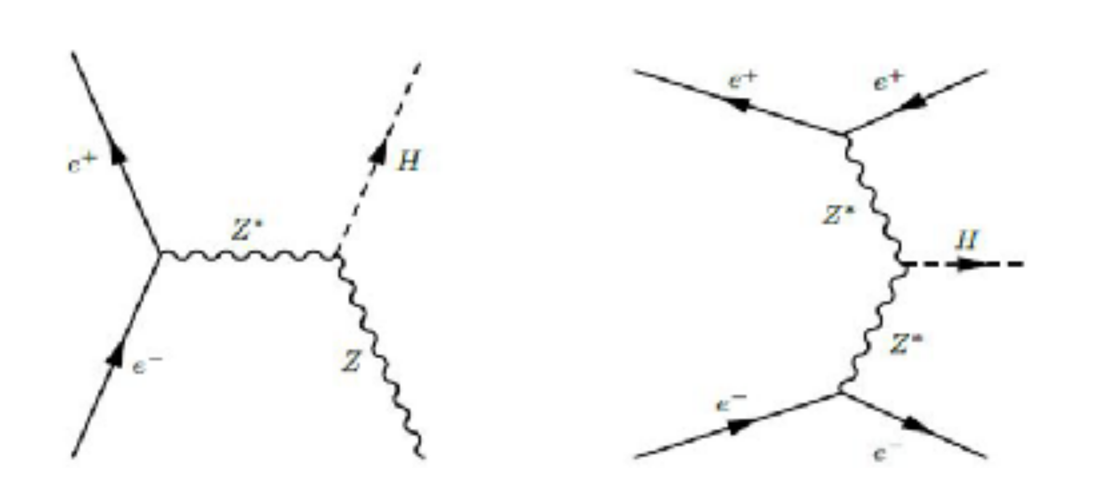
Tests on different geometries

- PID efficiency for e, mu, pi at different Hcal Cell Size

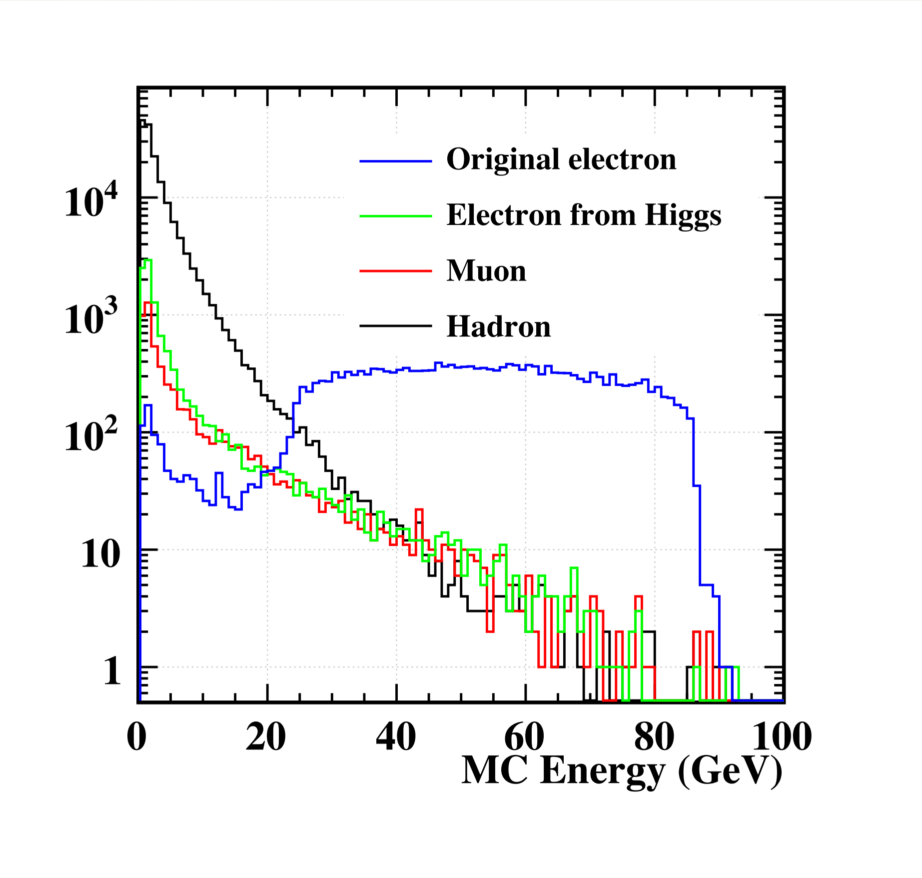


Physics Events :   eeH / μμH

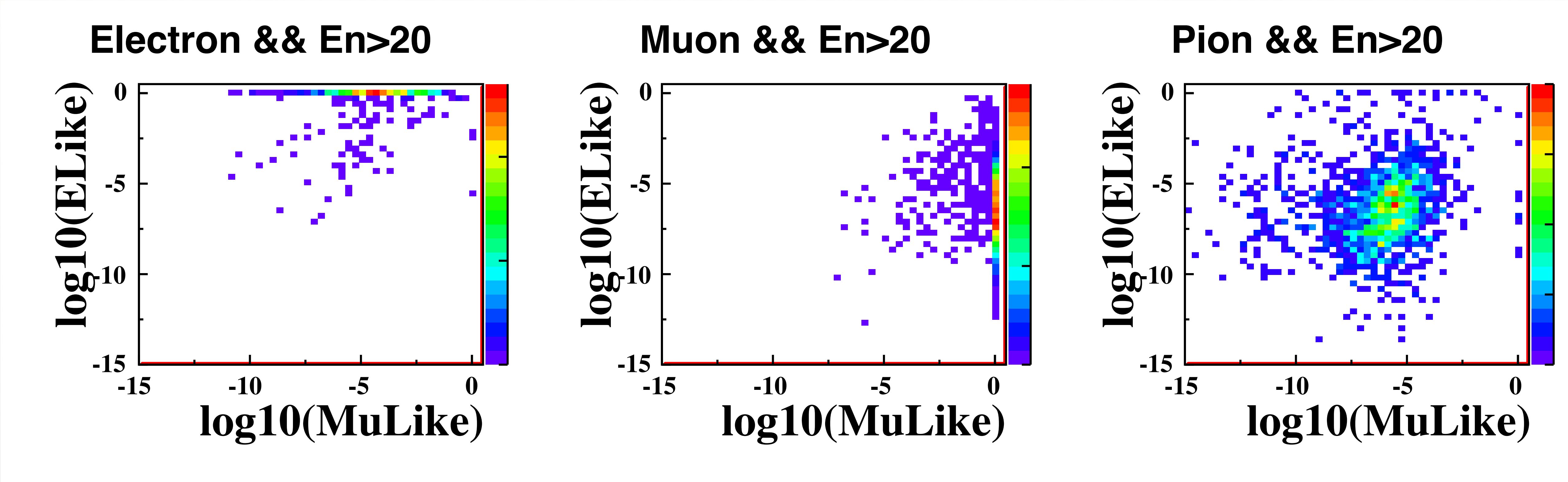
❖ Feynman Diagram



❖ Energy Spectrum



Physics Events



	Geom 1		Geom 2	
	$\mu\mu$H	eeH	$\mu\mu$H	eeH
Cut_μ	0.1	0.1	0.1	0.1
Cut_e	0.01	0.001	0.01	0.001
ε_E	93.41 ± 0.92	$\mathbf{98.64 \pm 0.08}$	91.60 ± 1.02	$\mathbf{97.89 \pm 0.11}$
η_E	92.02 ± 1.00	$\mathbf{99.74 \pm 0.04}$	89.89 ± 1.10	$\mathbf{99.67 \pm 0.04}$
ε_μ	$\mathbf{99.54 \pm 0.05}$	95.53 ± 0.76	$\mathbf{99.19 \pm 0.06}$	86.48 ± 1.26
η_μ	$\mathbf{99.60 \pm 0.04}$	96.31 ± 0.70	$\mathbf{99.83 \pm 0.03}$	95.38 ± 0.81
ε_{event}	98.53 ± 0.13	97.06 ± 0.19	97.24 ± 0.18	95.40 ± 0.24

Summary

- LICH:
  - An PFA independent PID processor combining tracking & calo informations
- PID efficiency improved with Arbor PFA:
  - about 98% for pions higher than 3GeV
  - higher than 99% for lepton identification
  - Geometry independent
- Potential:
  - Add more charged particle catalog
  - efficiency varies while tmva cut change depending on physics objective

Thank you

for

your attention!

BACKUP

e2e2h/E30L_E10mm_H48L_H10mm

	1-5	5-20	>20
cut_mu	0.1	0.1	0.01
cut_e	1E-05	0.01	0.01
eff_mu	52.2399+/-0.9732	85.4064+/-0.8760	99.5359+/-0.0485
pur_mu	29.3015+/-0.6641	80.7334+/-0.9515	99.6019+/-0.0449
eff_E	93.1083+/-0.3358	89.3536+/-0.0071	93.4066+/-0.9197
pur_E	82.7112+/-0.4725	76.228+/-0.9163	92.0162+/-0.9970

e2e2h/E30L_E20mm_H48L_H20mm

	1-5	5-20	>20
cut_mu	0.1	0.1	0.01
cut_e	1E-05	0.01	0.01
eff_mu	53.1617+/-0.9709	76.4994+/-1.0489	99.1866+/-0.0636
pur_mu	29.1649+/-0.6550	82.021+/-0.98367	99.8282+/-0.0294
eff_E	86.3915+/-0.4534	78.6056+/-0.0094	91.5989+/-1.0211
pur_E	83.4009+/-0.4834	84.1116+/-0.8723	89.8936+/-1.0994

e2e2h/E20L_E20mm_H20L_H20mm

	1-5	5-20	>20
cut_mu	0.1	0.1	0.01
cut_e	1E-05	0.01	0.01
eff_mu	23.3028+/-0.8256	56.3779+/-1.2164	98.8029+/-0.0771
pur_mu	30.0985+/-1.0180	82.7008+/-1.1237	99.6247+/-0.0435
eff_E	84.5979+/-0.4772	77.0022+/-0.0097	92.7577+/-0.9672
pur_E	79.8383+/-0.5153	74.4247+/-0.9977	68.5891+/-1.4895

e1e1h/E30L_E10mm_H48L_H10mm

	1-5	5-20	>20
cut_e	1E-05	0.001	0.001
cut_mu	0.1	0.1	0.1
eff_E	95.3145+/-0.270488	92.5227+/-0.521467	98.6419+/-0.0836536
pur_E	79.2751+/-0.473147	80.2278+/-0.651185	99.7439+/-0.0369169
eff_mu	61.1156+/-0.980085	79.8962+/-1.02061	95.5345+/-0.759788
pur_mu	22.4233+/-0.507912	81.6976+/-0.995767	96.3165+/-0.69571

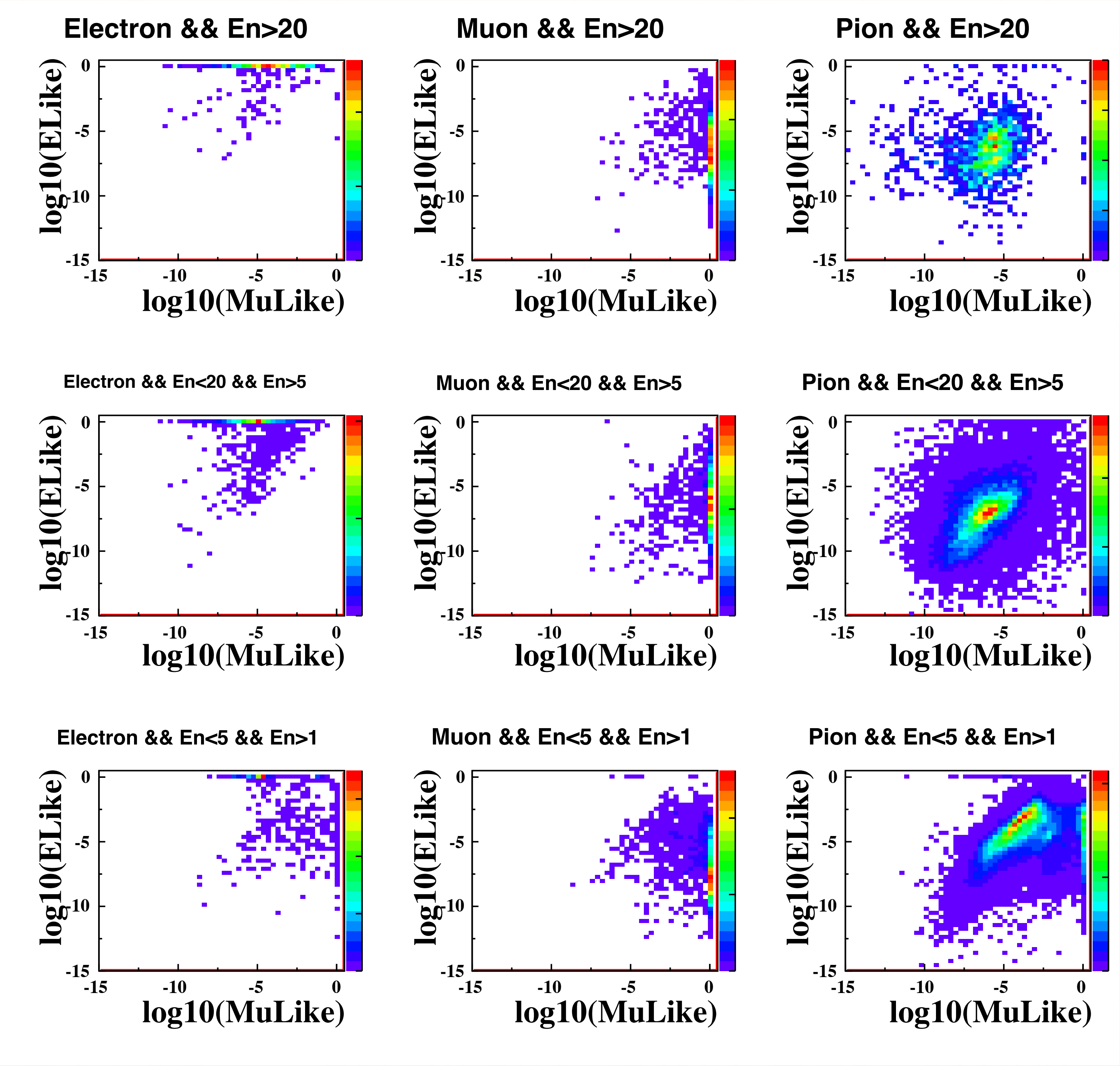
e1e1h/E30L_E20mm_H48L_H20mm

	1-5	5-20	>20
cut_e	1E-05	0.001	0.001
cut_mu	0.1	0.1	0.1
eff_E	92.5781+/-0.334415	83.1634+/-0.69946	97.8946+/-0.105212
pur_E	80.1014+/-0.473774	85.9912+/-0.604523	99.6702+/-0.0428622
eff_mu	59.4927+/-0.977327	68.9928+/-1.18674	86.4865+/-1.25673
pur_mu	22.333+/-0.508013	82.9114+/-1.05873	95.38+/-0.810377

e1e1h/E20L_E20mm_H20L_H20mm

	1-5	5-20	>20
cut_e	1E-05	0.001	0.001
cut_mu	0.1	0.1	0.1
eff_E	91.7082+/-0.349566	81.8572+/-0.715548	97.166+/-0.12146
pur_E	78.3176+/-0.482736	75.1517+/-0.734405	98.6953+/-0.0845513
eff_mu	37.9619+/-0.957089	35.0616+/-1.21474	58.9744+/-1.80697
pur_mu	21.8981+/-0.61946	85.6013+/-1.39651	91.6143+/-1.26909

e2e2h/E30L_E10mm_H48L_H10mm



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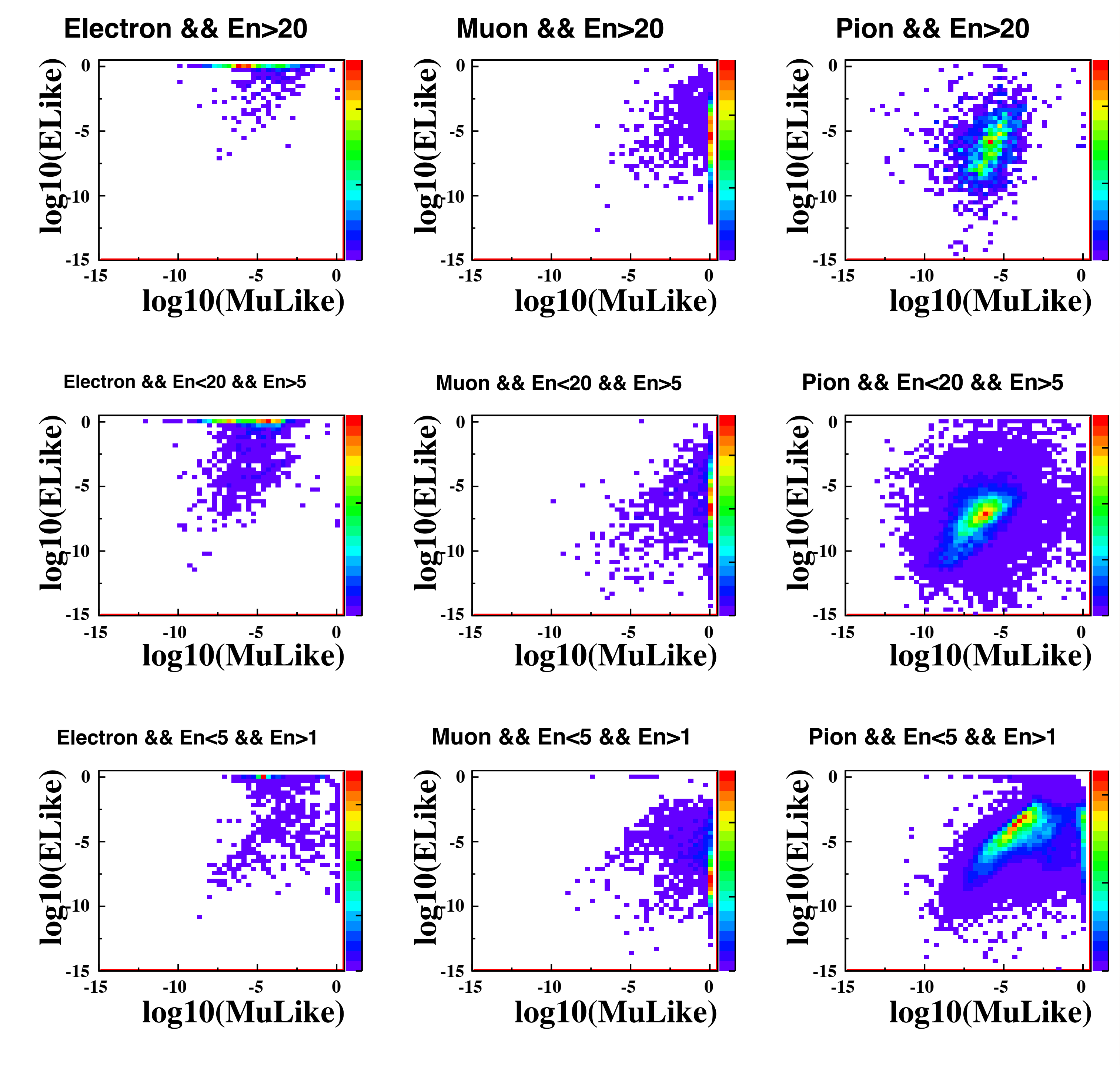
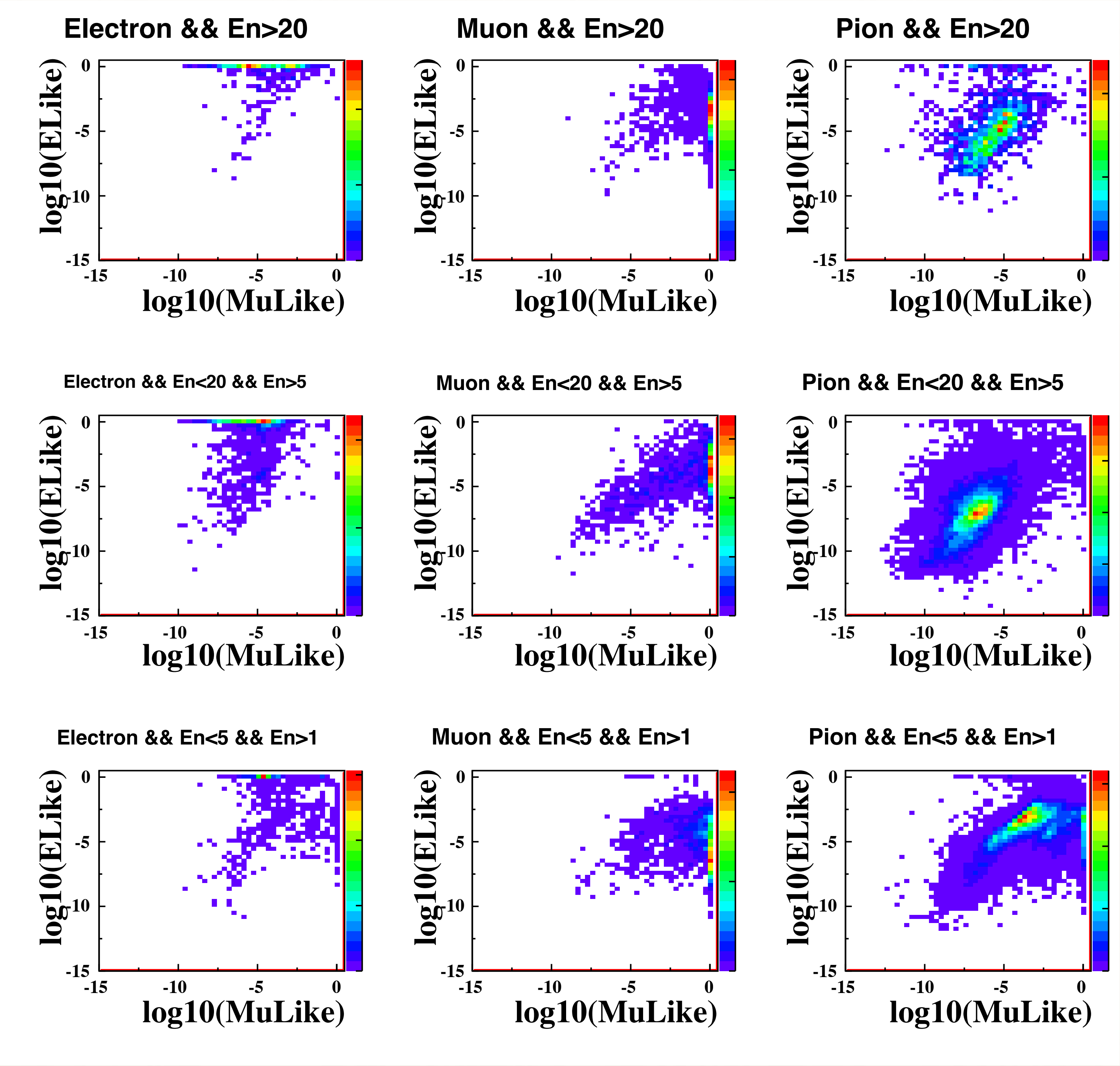
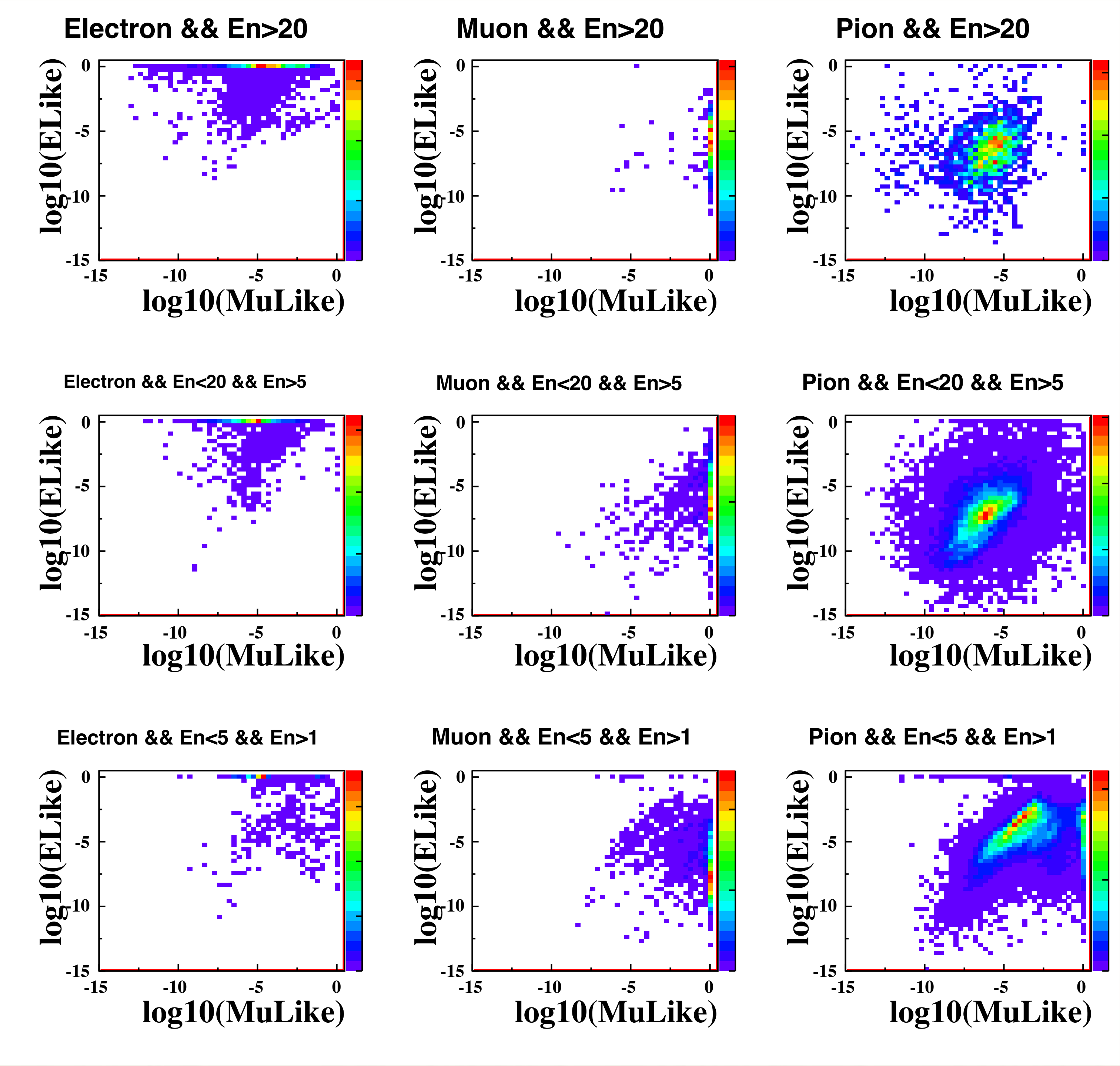


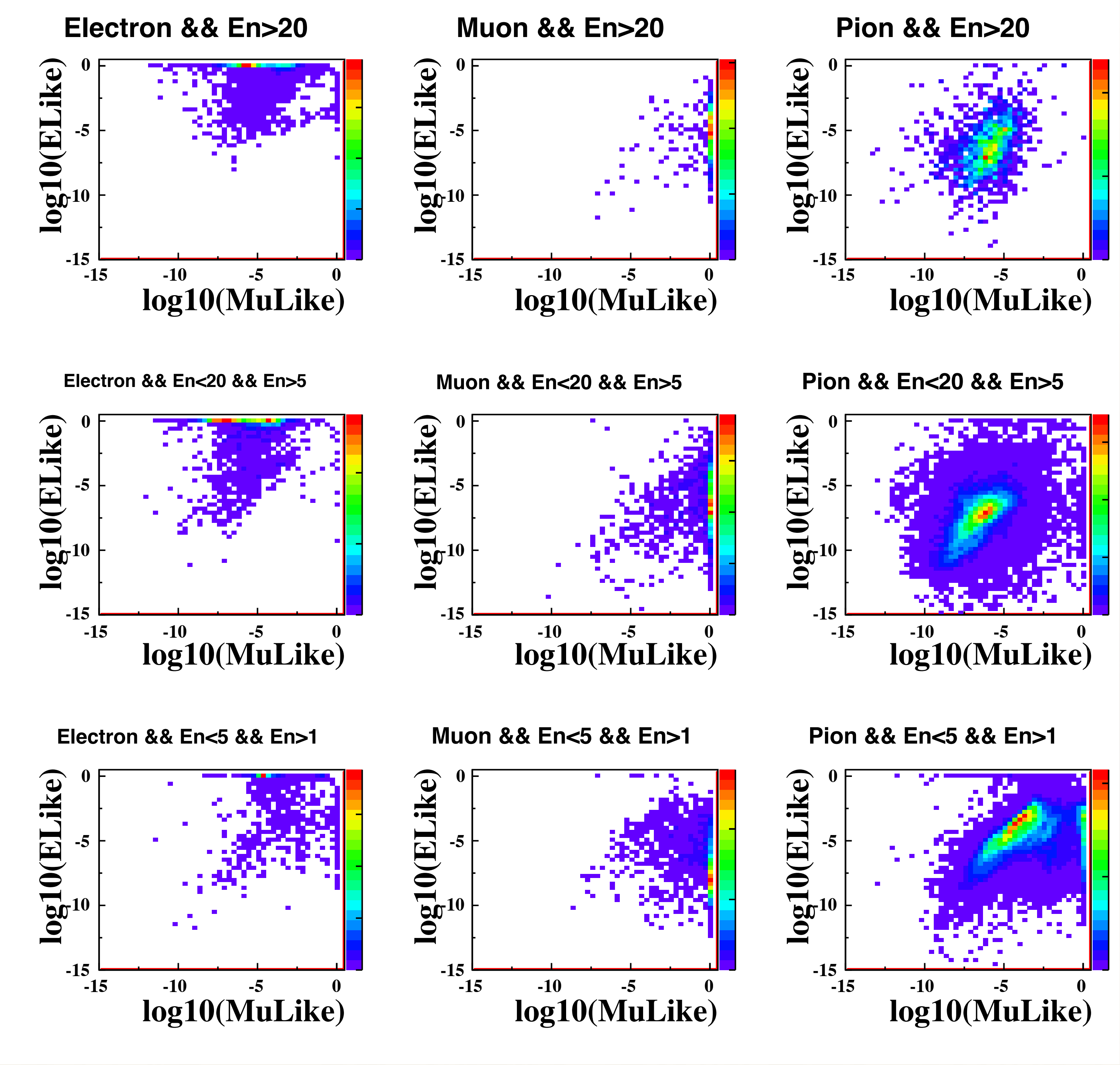
e2e2h/E20L_E20mm_H20L_H20mm



e1e1h/E30L_E10mm_H48L_H10mm



e1e1h/E30L_E20mm_H48L_H20mm



e1e1h/E20L_E20mm_H20L_H20mm