

Energy resolution of single hadron

Single hadron: π^+ (1GeV ~ 50GeV)

Geometry:

Si-W ECAL + SDHCAL

Crystal ECAL + SDHCAL

Stand-alone SDHCAL

ECAL Longitudinal thickness: $24 X_0$

ECAL calibration (coefficient, C_{ECAL}):

Si-W ECAL + SDHCAL

48.16 for first 20 layers; 96.32 for later 10 layers (used in baseline reconstruction)

Crystal ECAL: $C_{ECAL} = 1$

HCAL calibration (coefficient, C_{HCAL}):

Digital mode: hit number $\times C_{HCAL}$

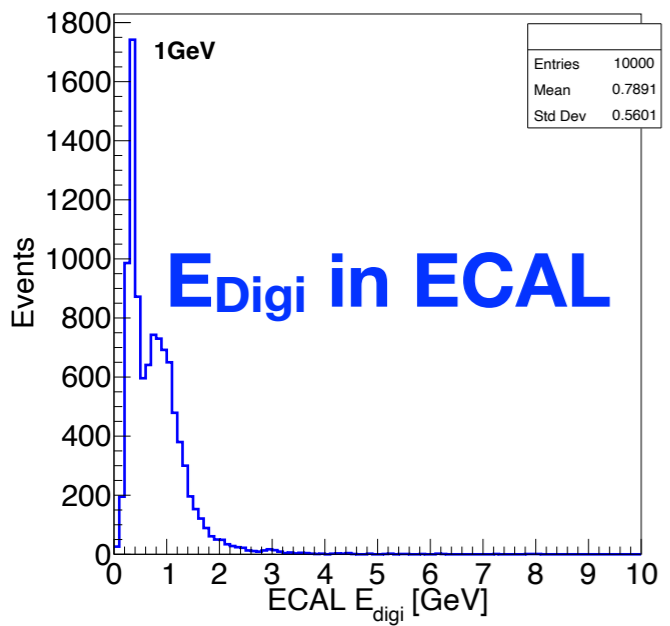
$$E_{Reco} = E_{Simu} \text{ in ECAL} \times C_{ECAL} + N_{Hit} \text{ in HCAL} \times C_{HCAL}$$

Parameters of calorimeter materials

	W	BGO	PWO	BaF2	CsI	LYSO
X_0 (mm)	3.5	11.2	8.9	20.3	18.6	11.4
λ l (mm)	99	228	207	307	393	209
$24X_0 \rightarrow n\lambda$	0.85	1.18	1.03	1.59	1.14	1.31

Si-W ECAL + SDHCAL

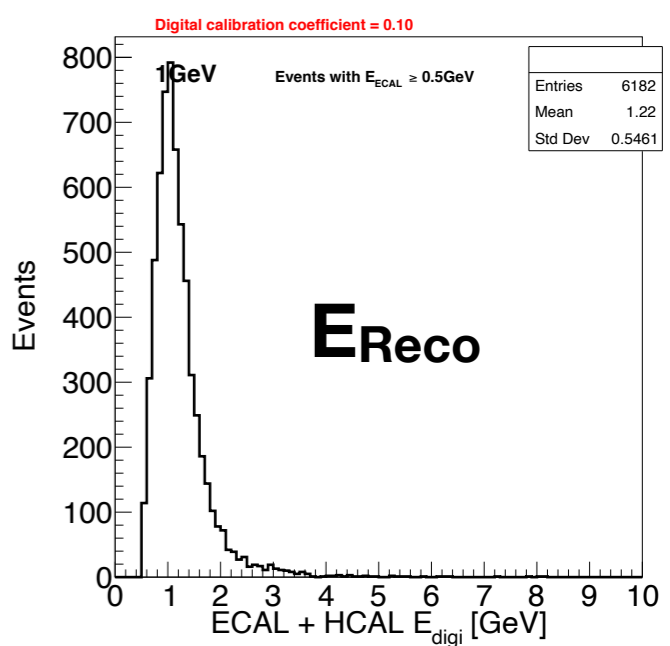
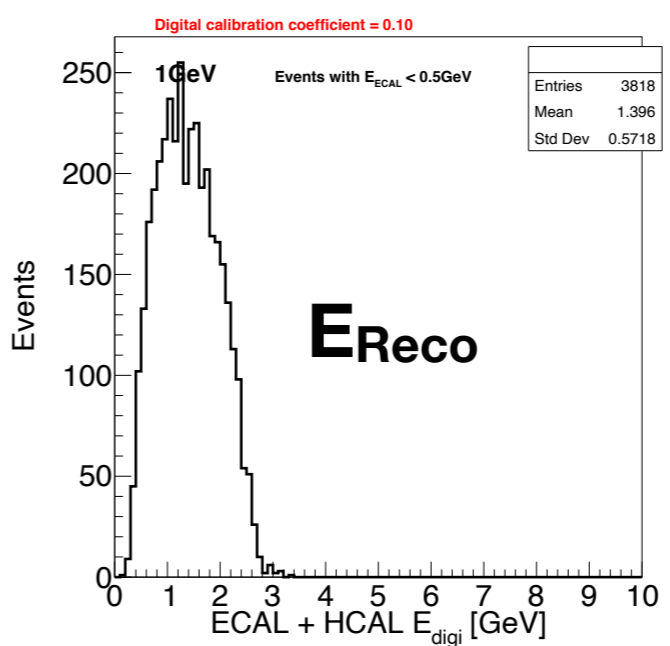
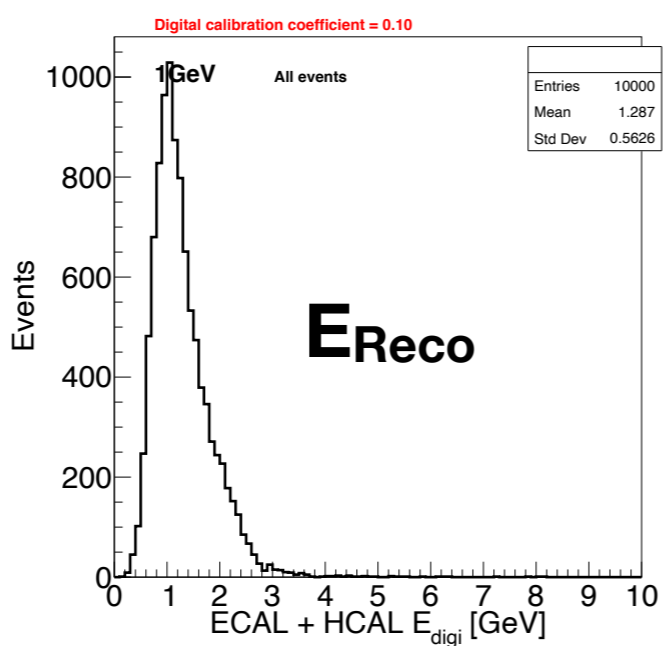
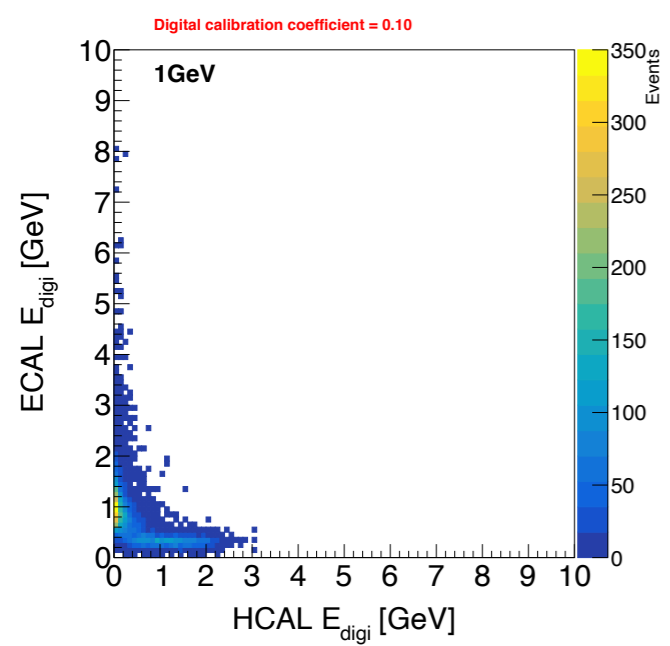
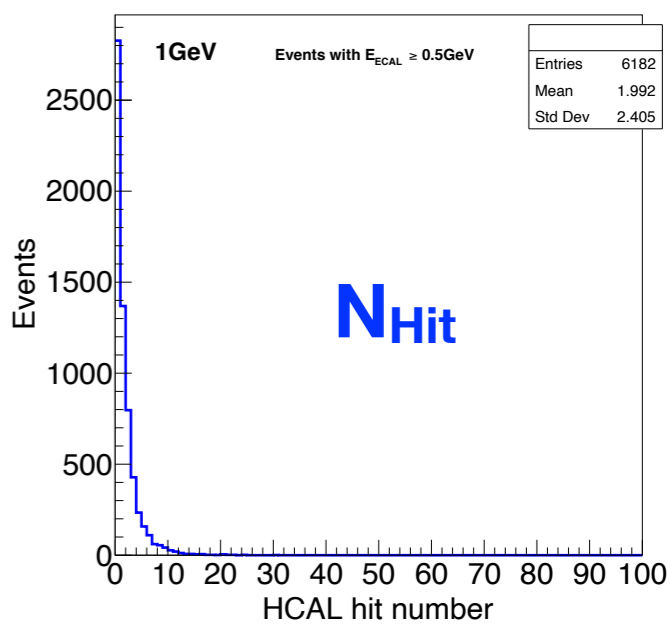
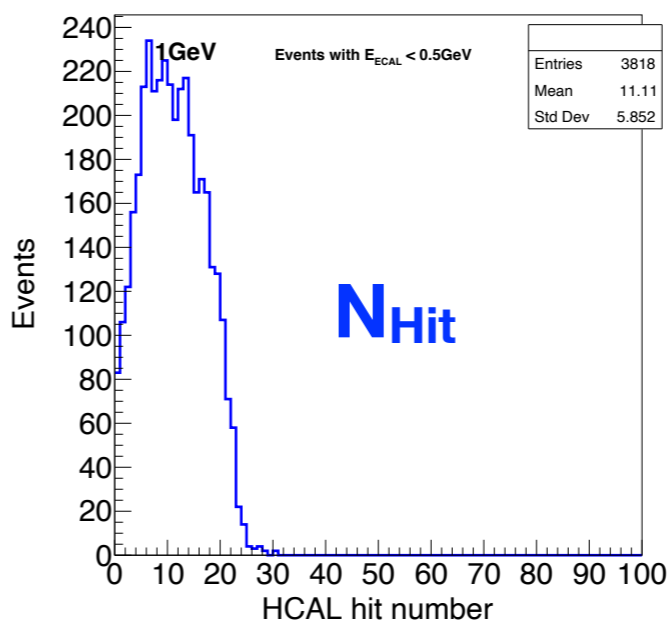
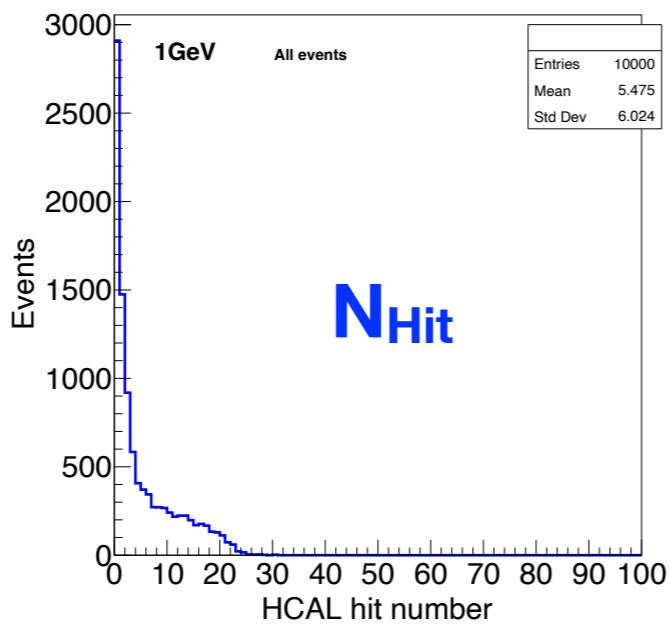
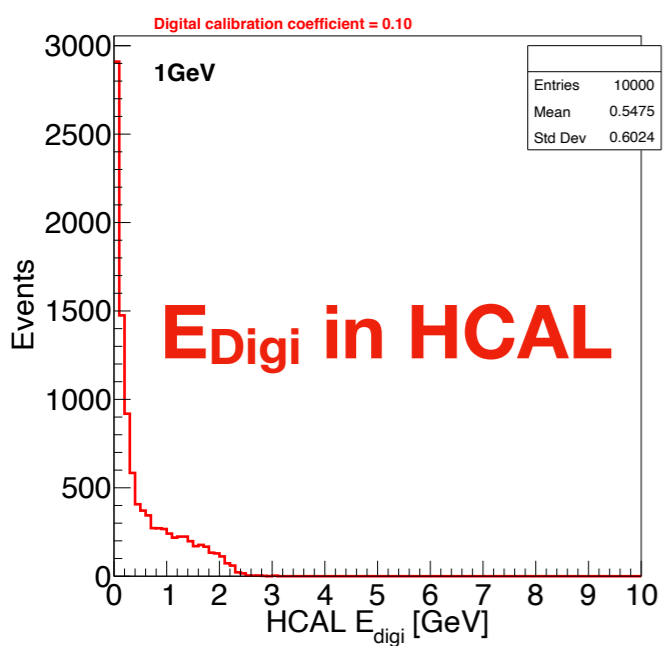
1GeV π^+



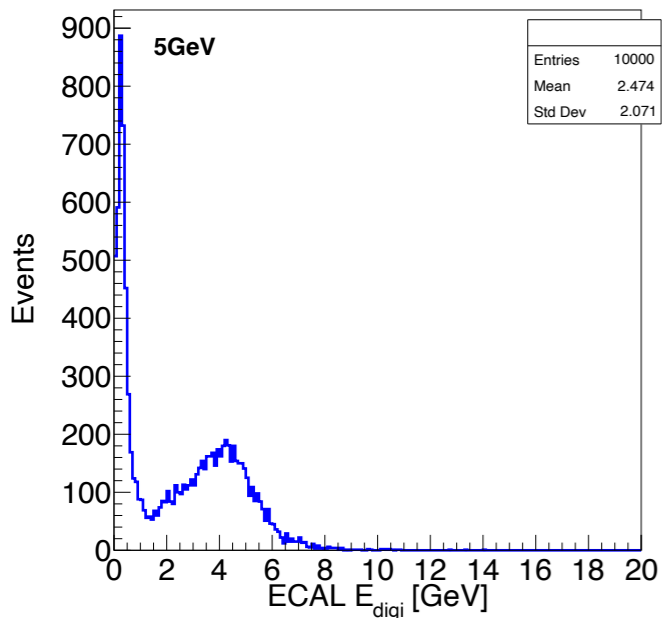
All events

Events with $E_{ECAL} < \text{threshold}$

Events with $E_{ECAL} > \text{threshold}$



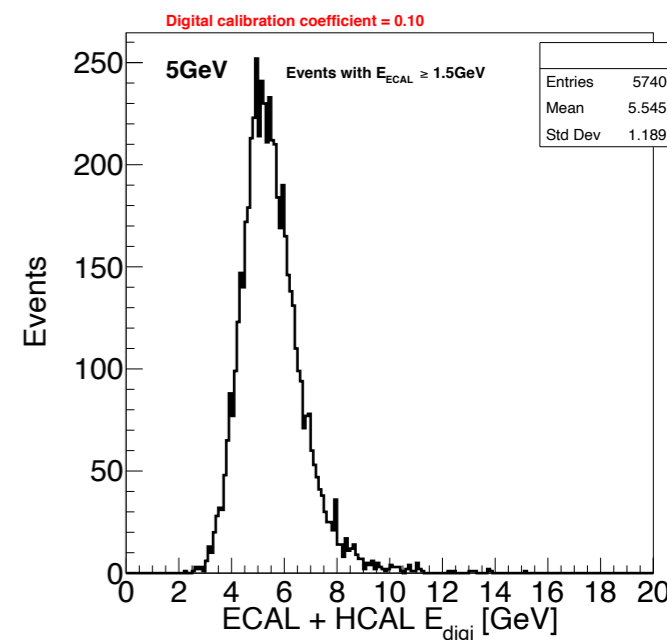
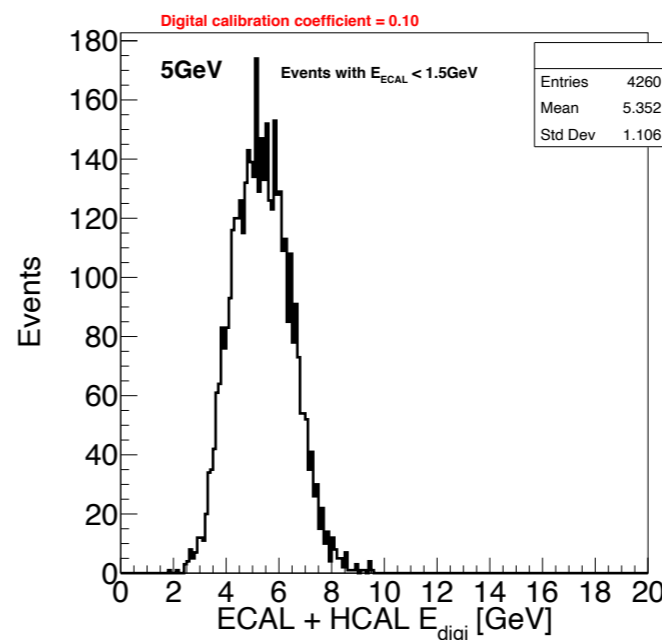
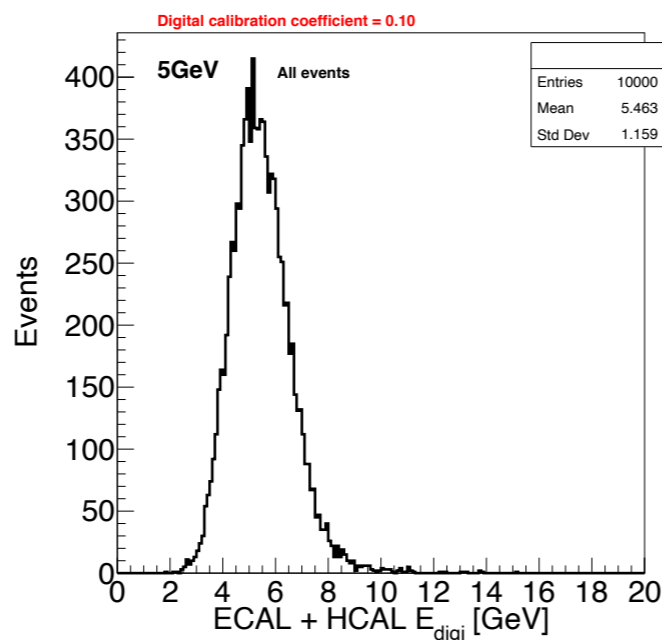
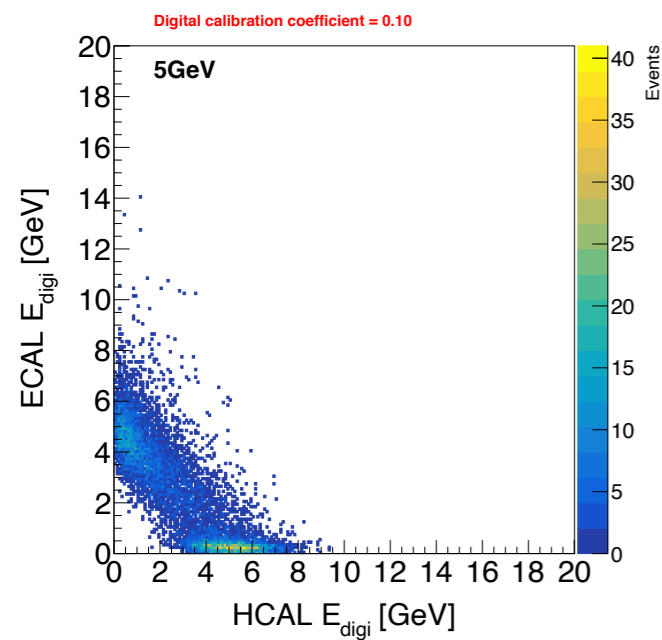
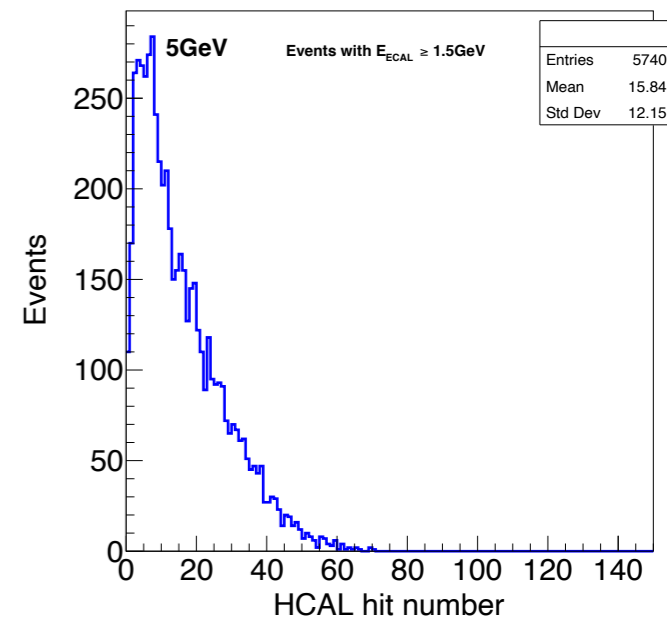
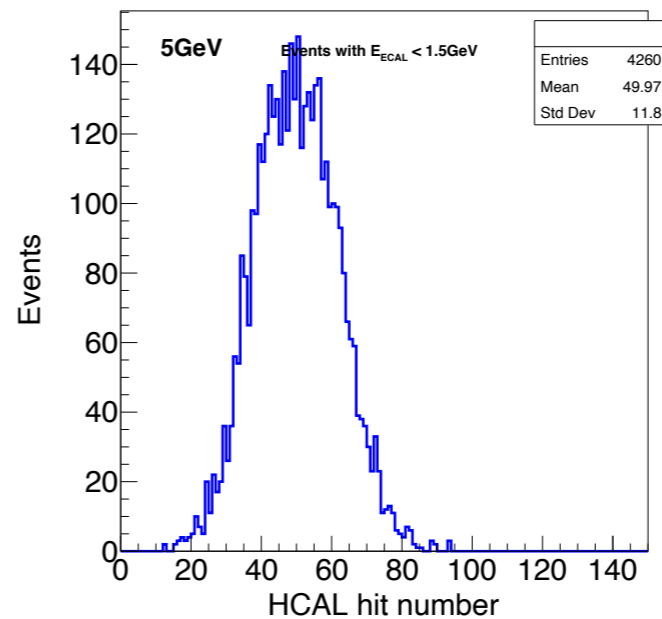
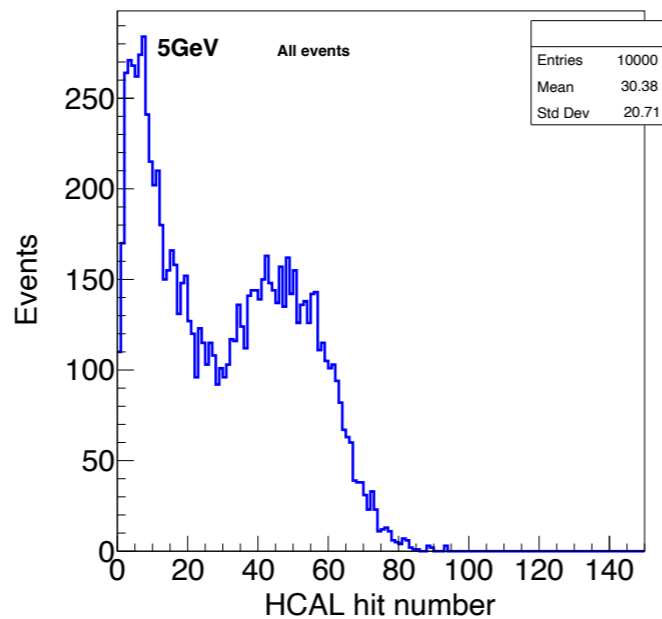
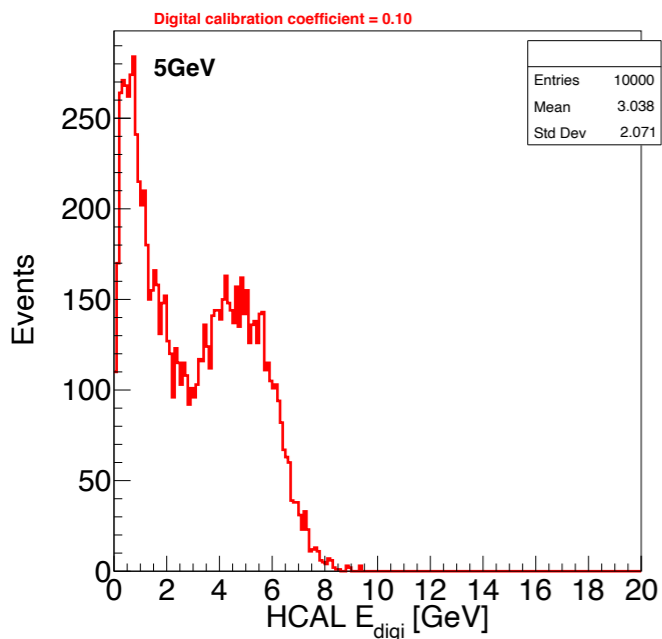
5GeV π^+



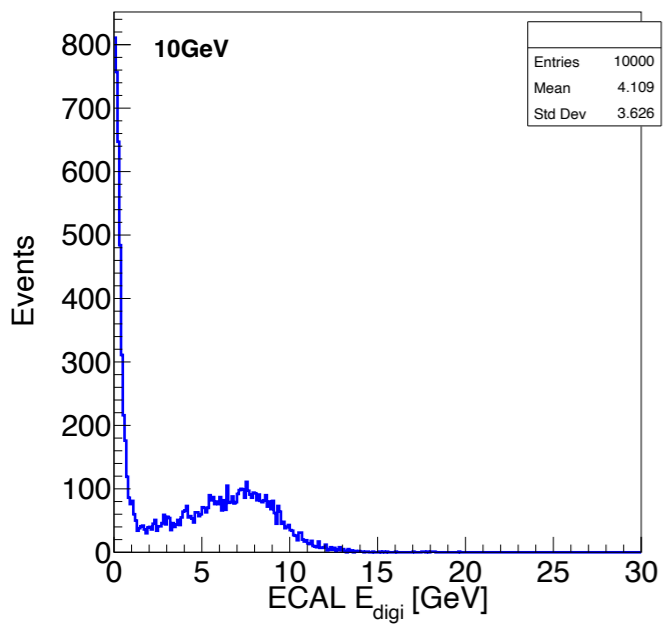
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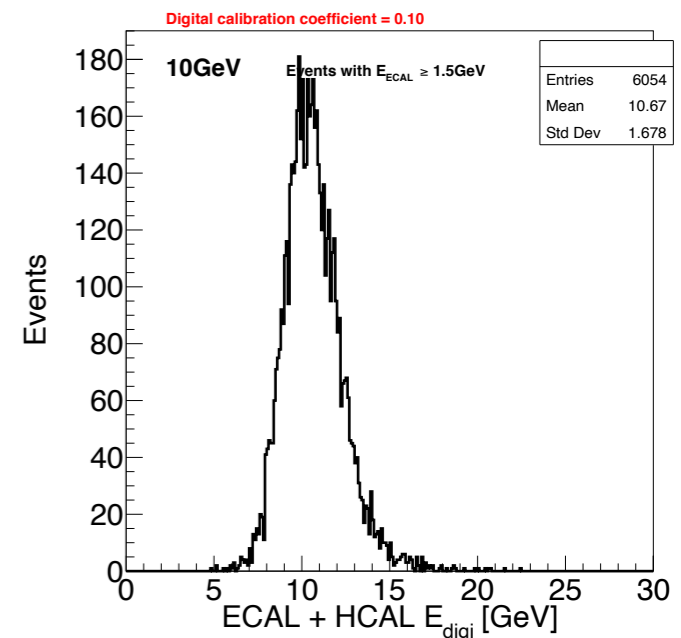
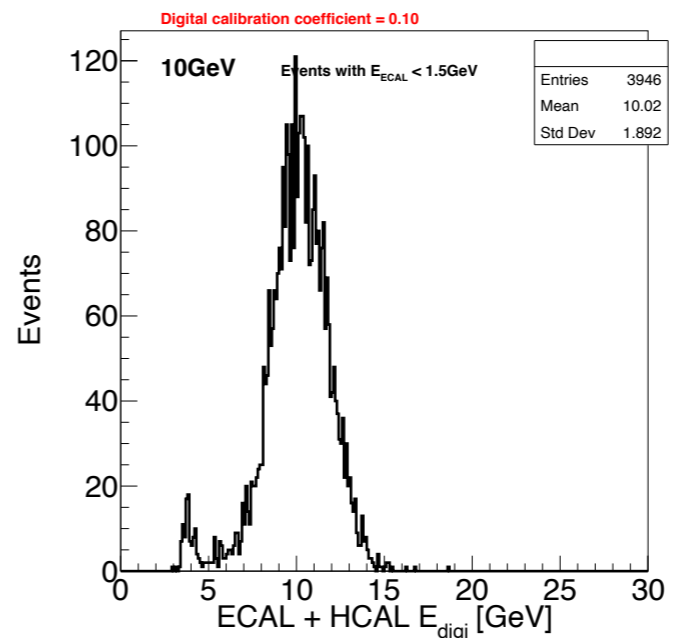
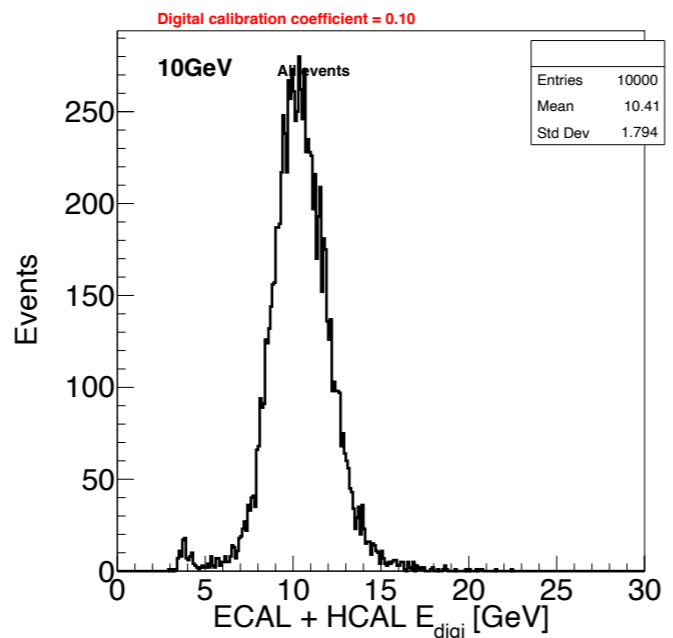
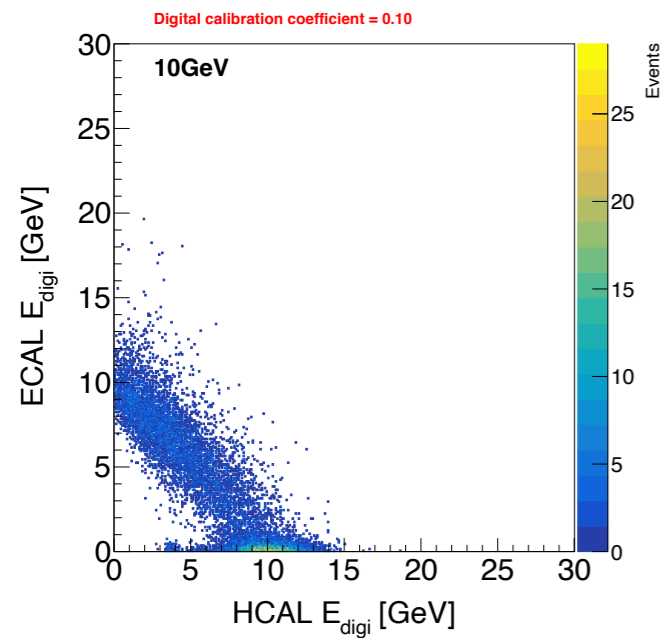
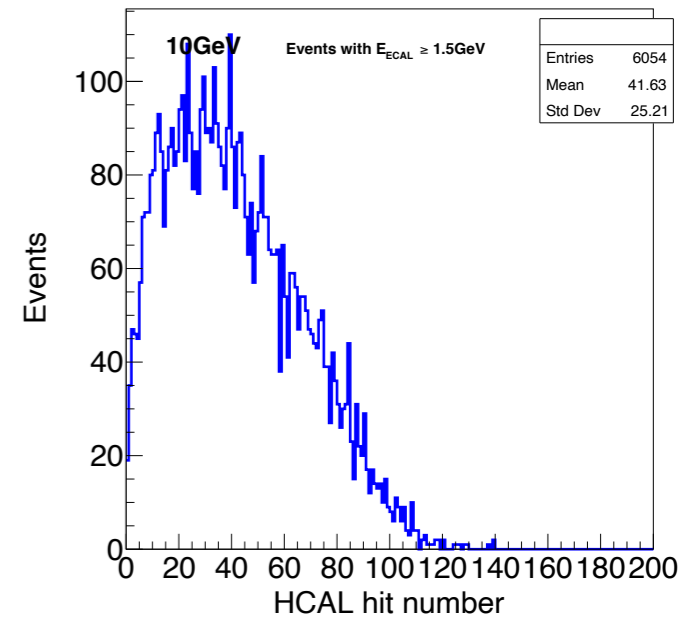
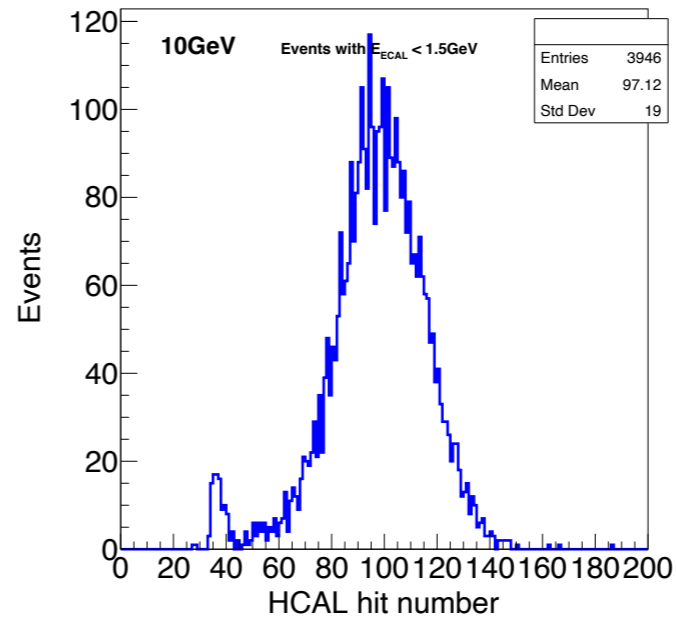
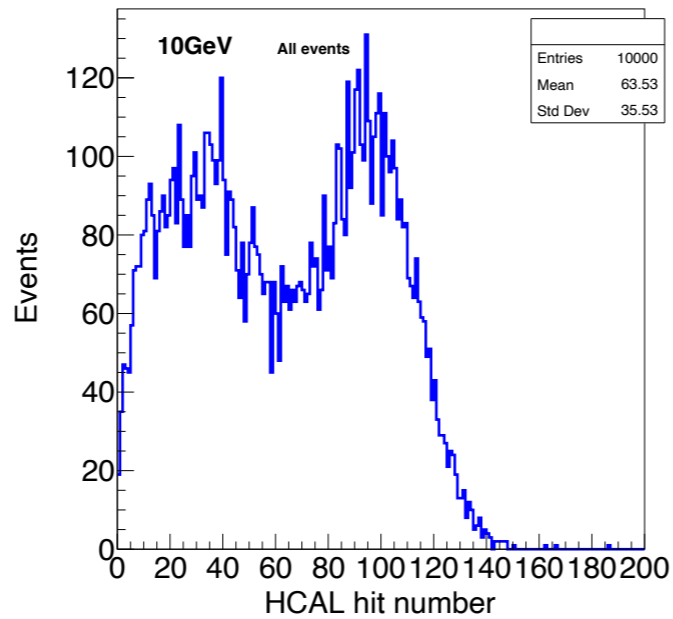
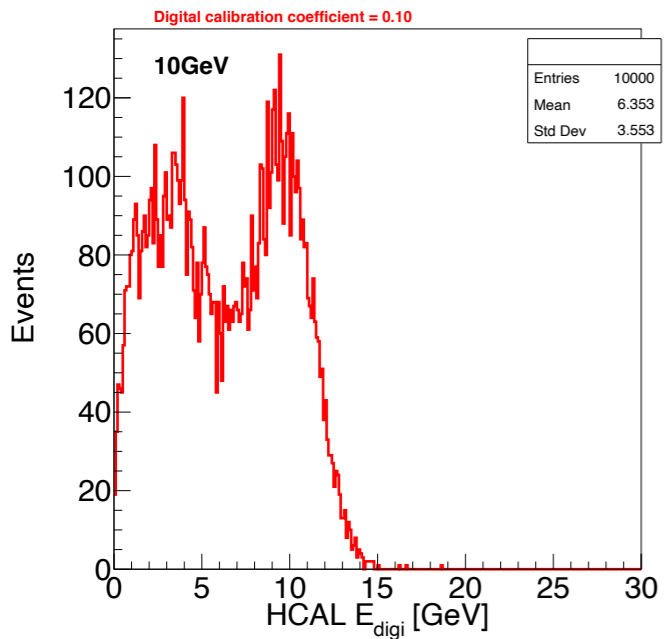
10GeV π^+



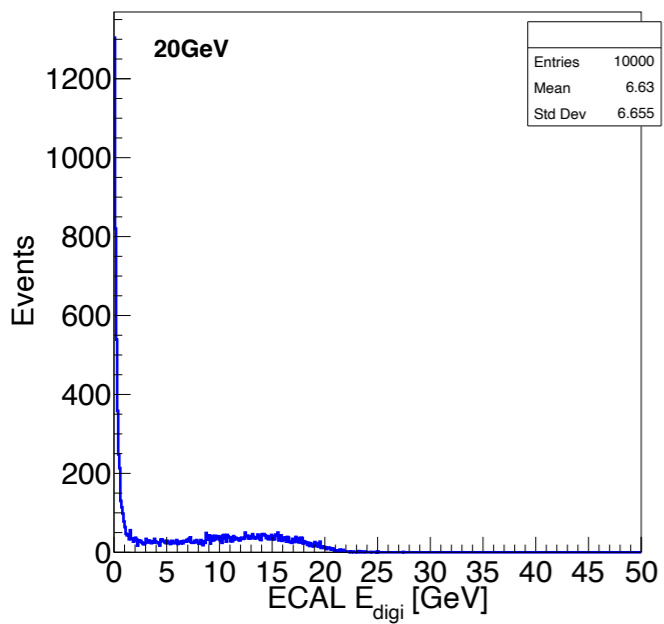
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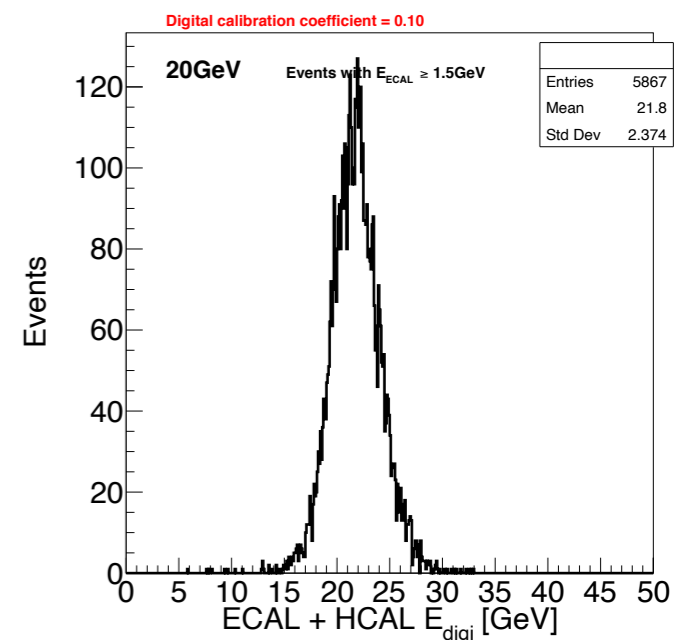
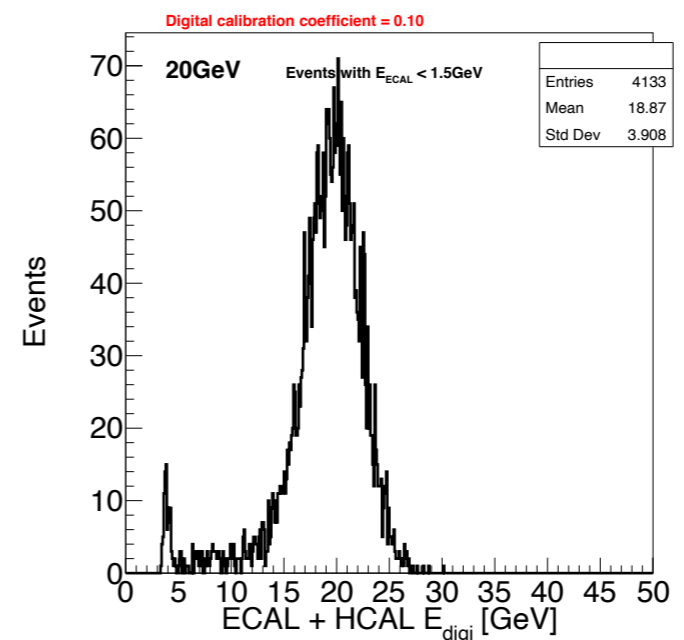
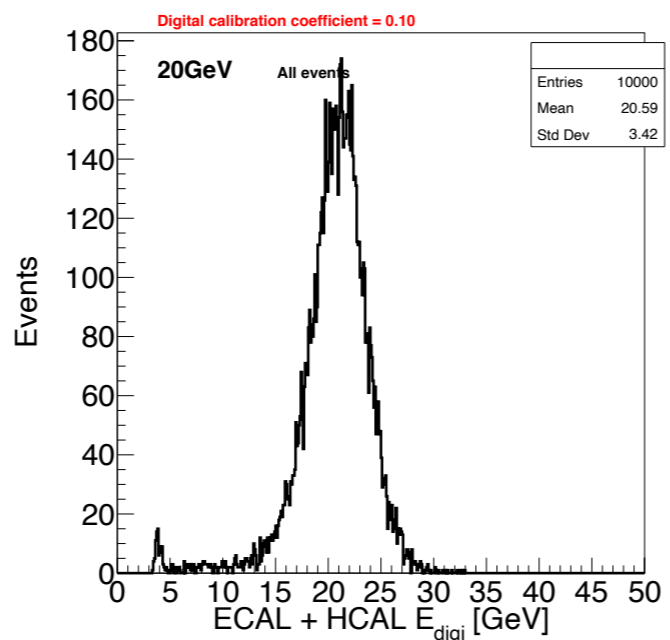
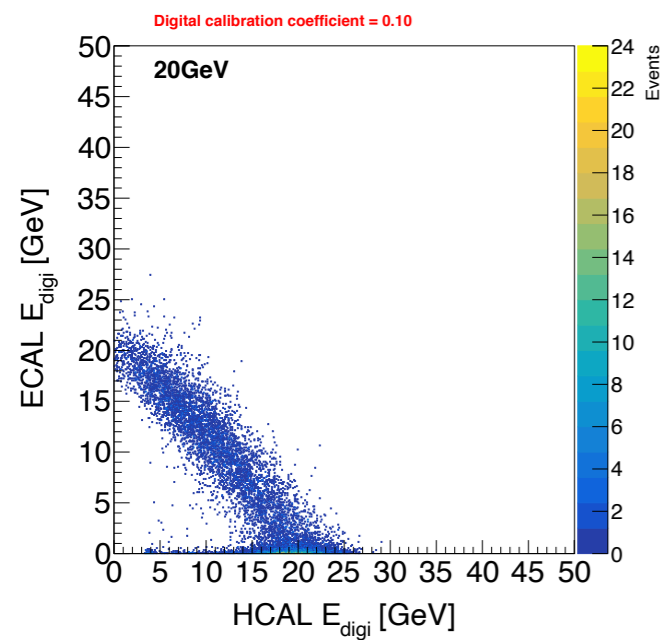
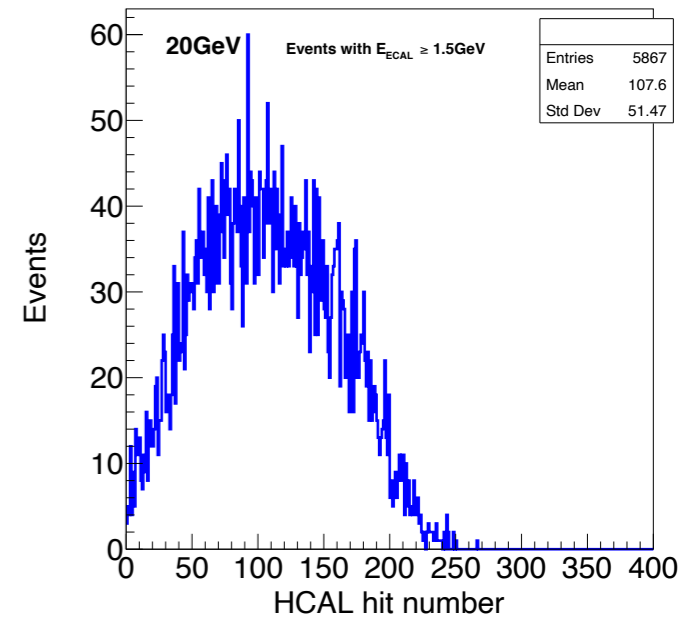
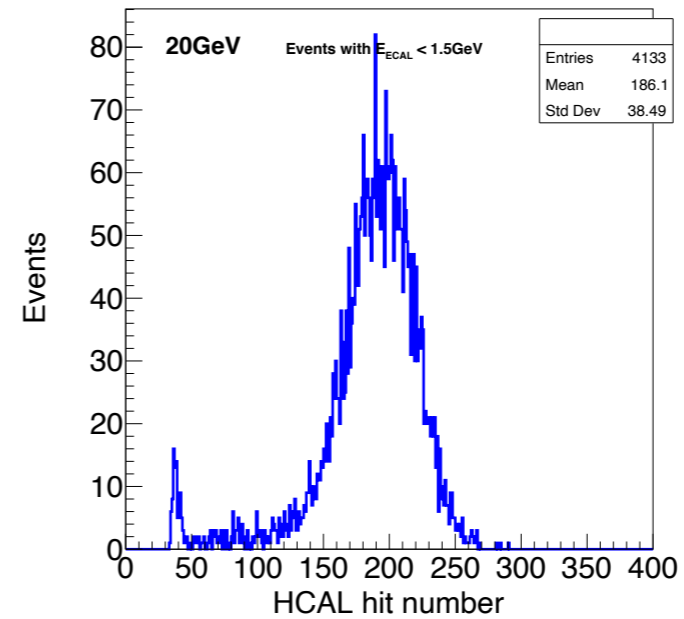
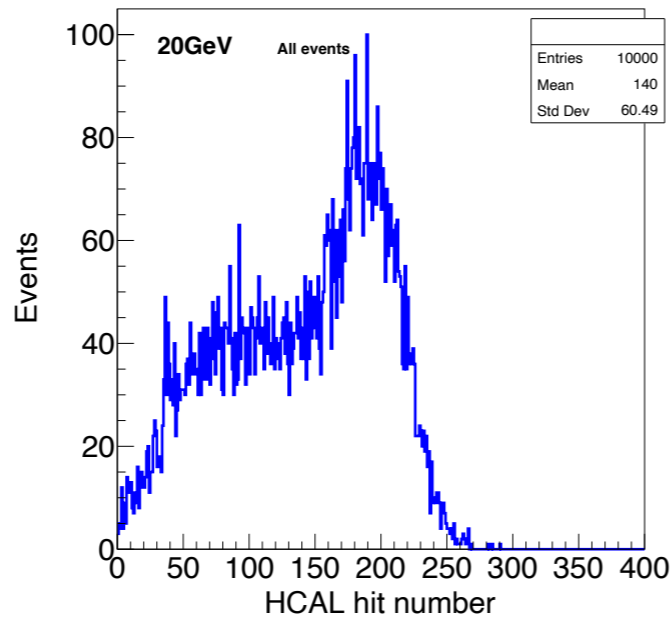
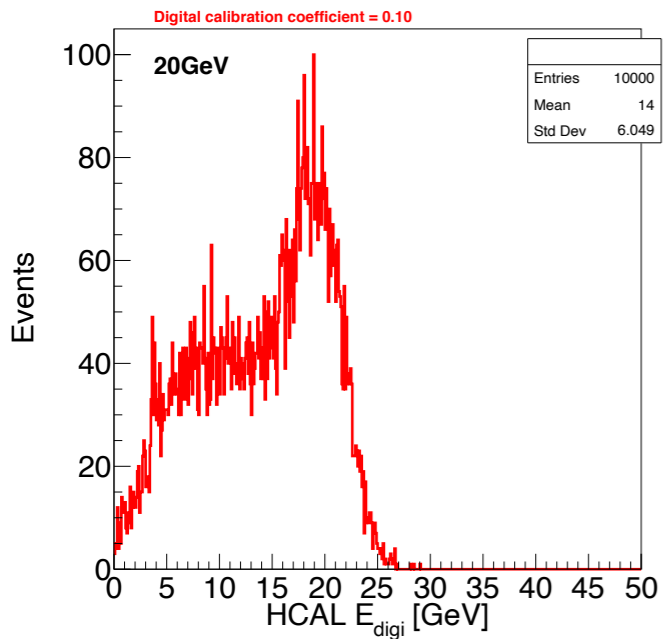
20GeV π^+



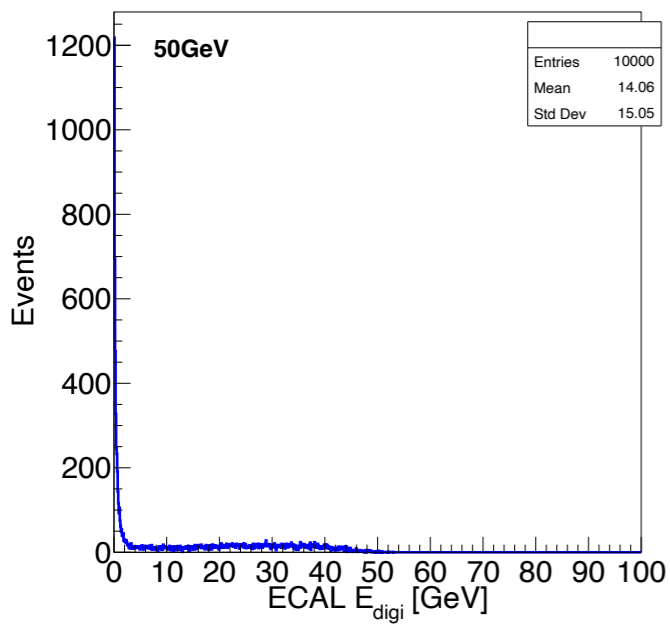
All events

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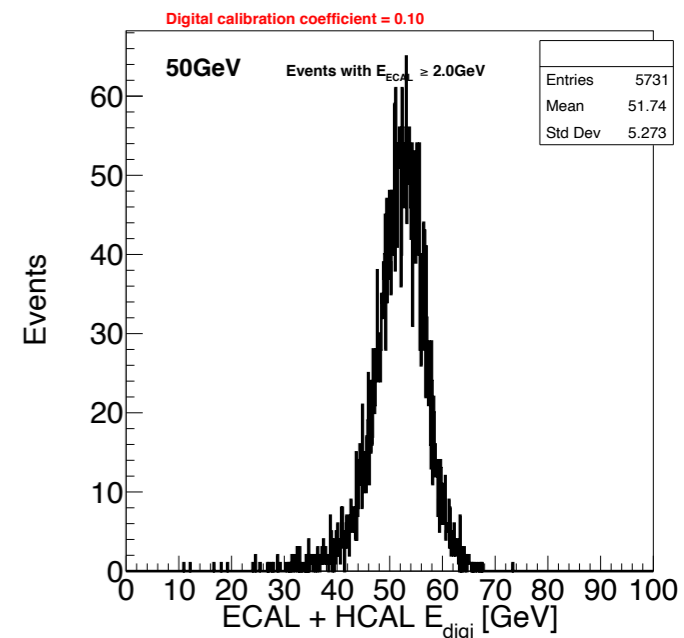
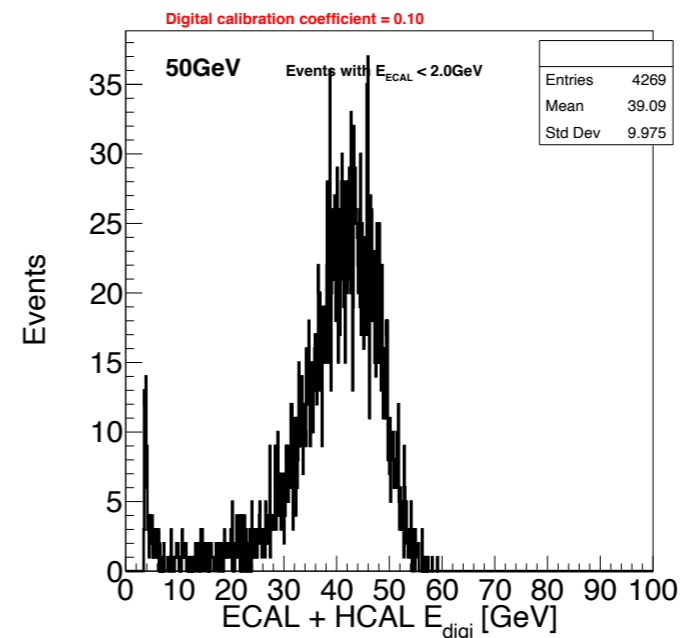
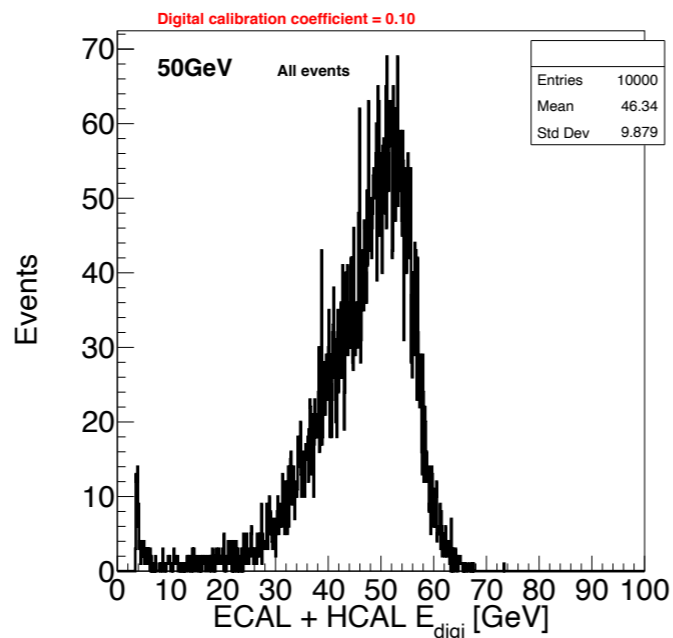
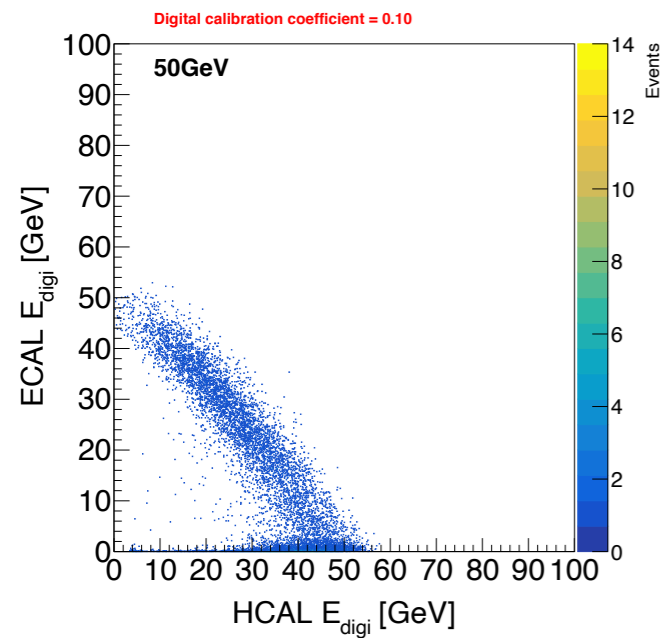
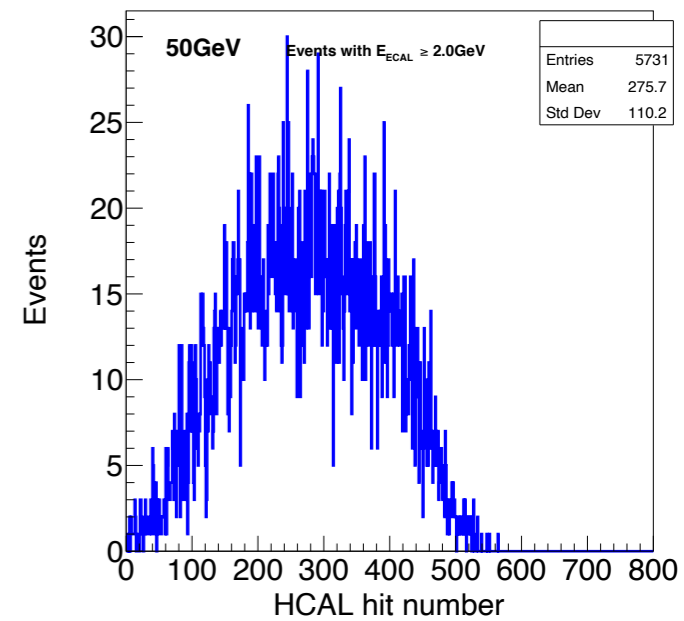
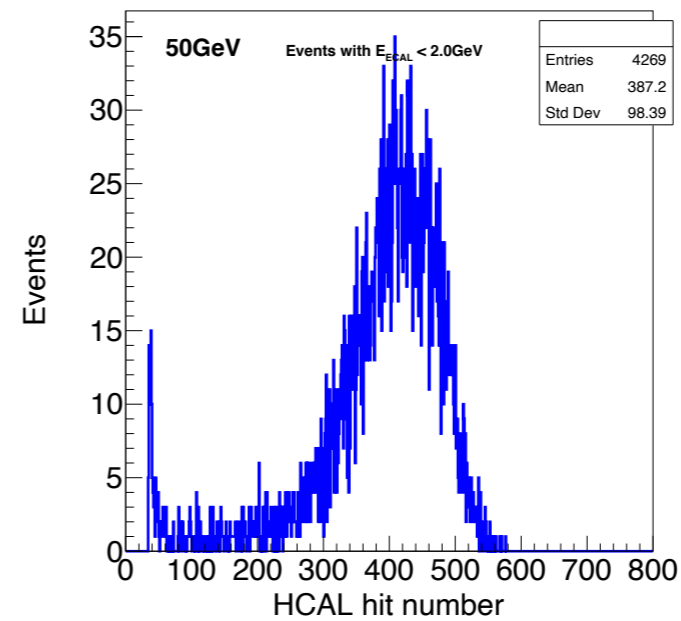
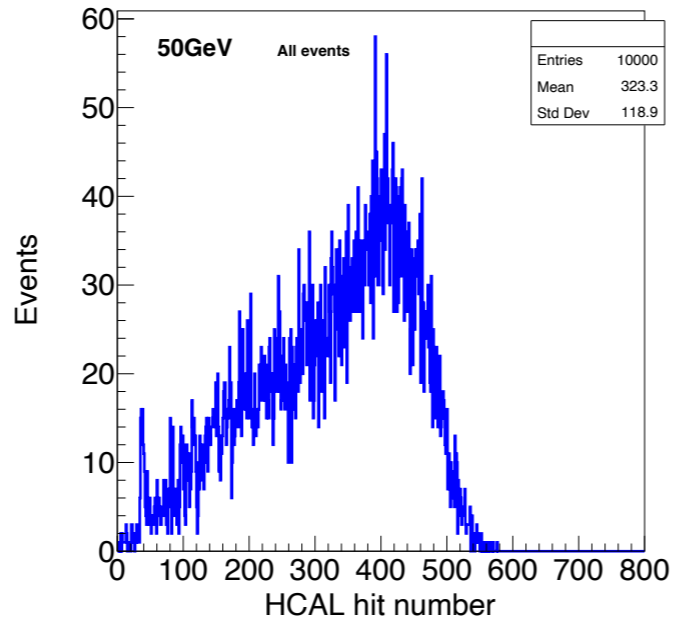
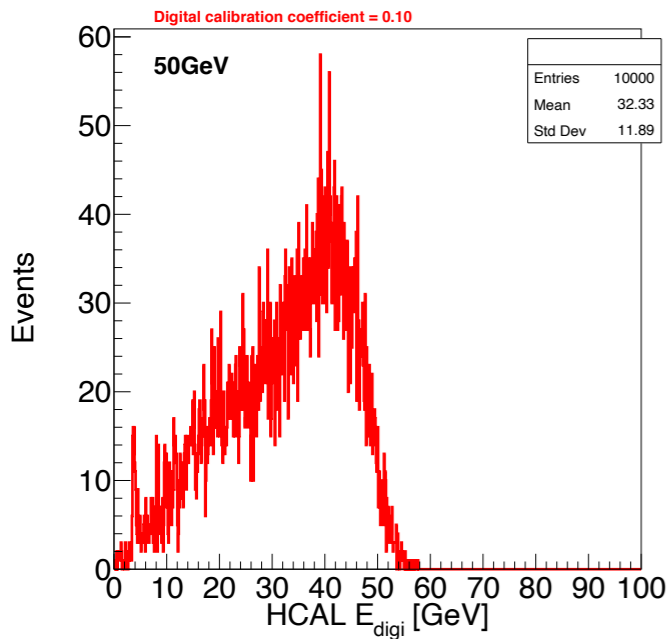
50GeV π^+



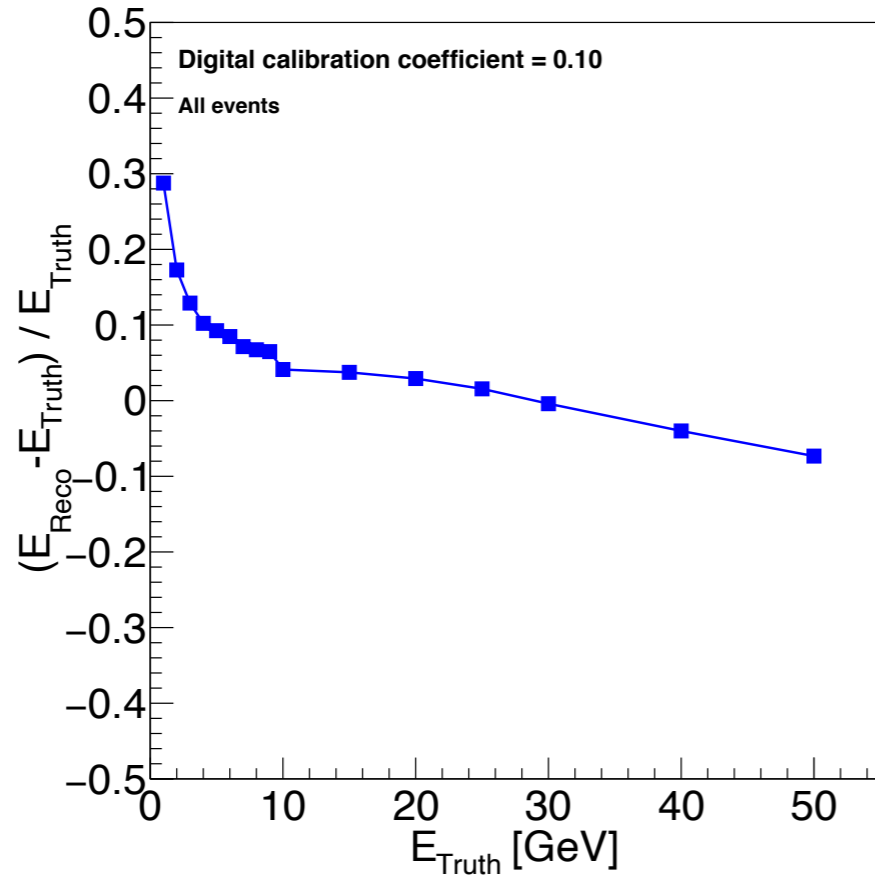
All events

Events with $E_{ECAL} < \text{threshold}$

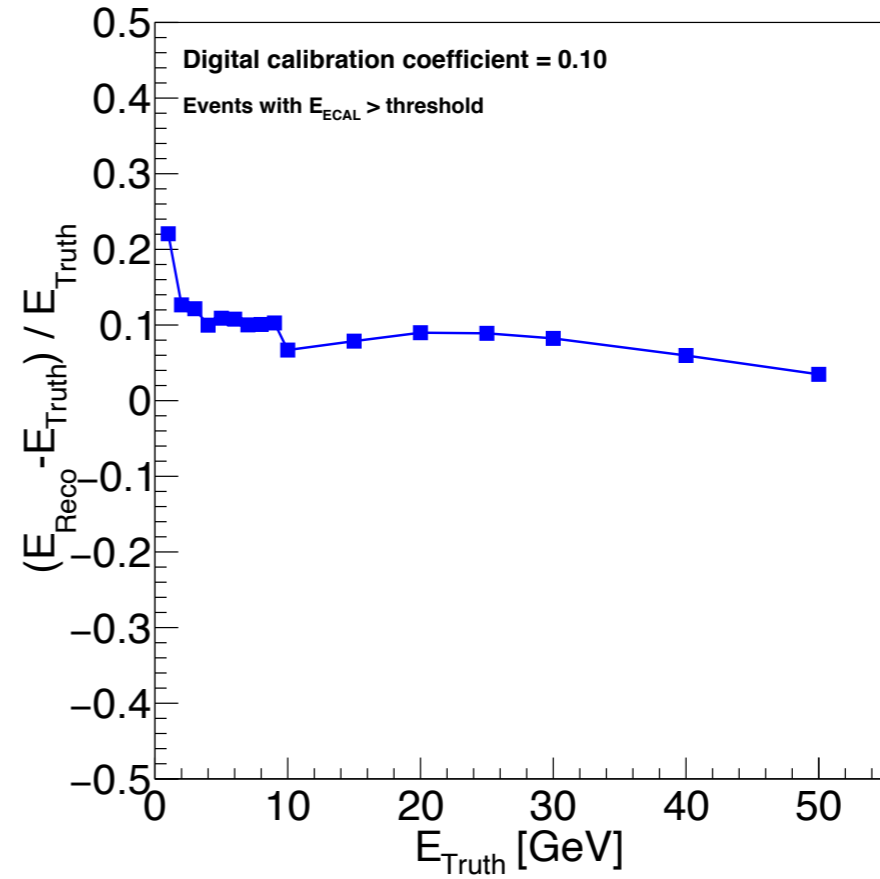
Events with $E_{ECAL} > \text{threshold}$



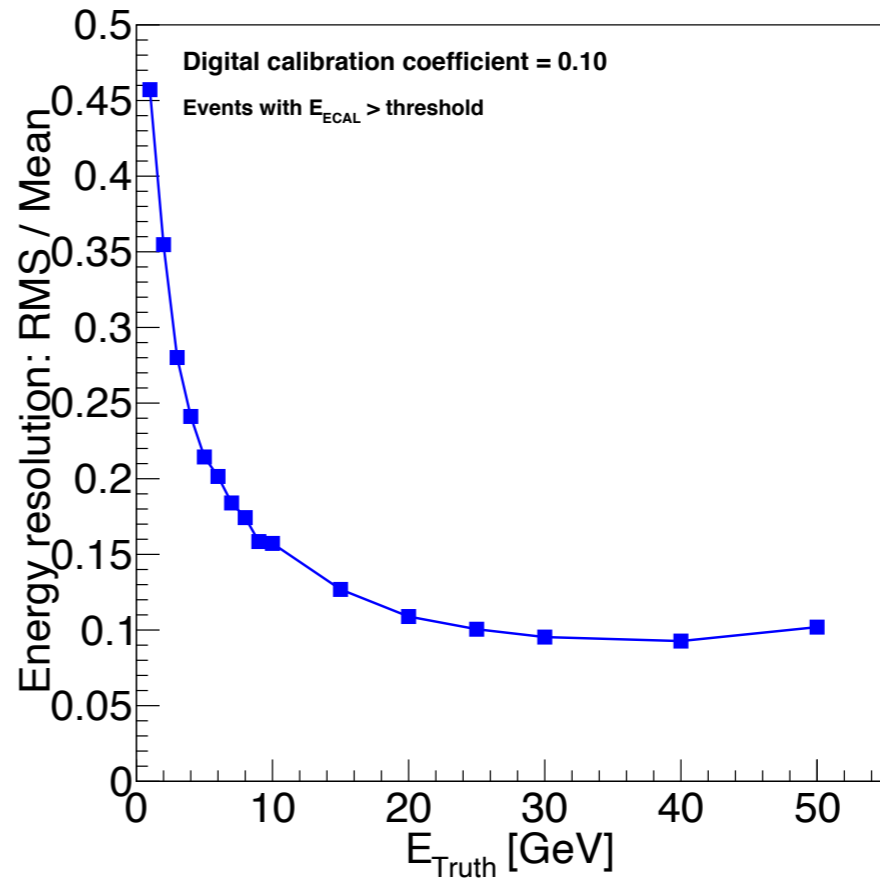
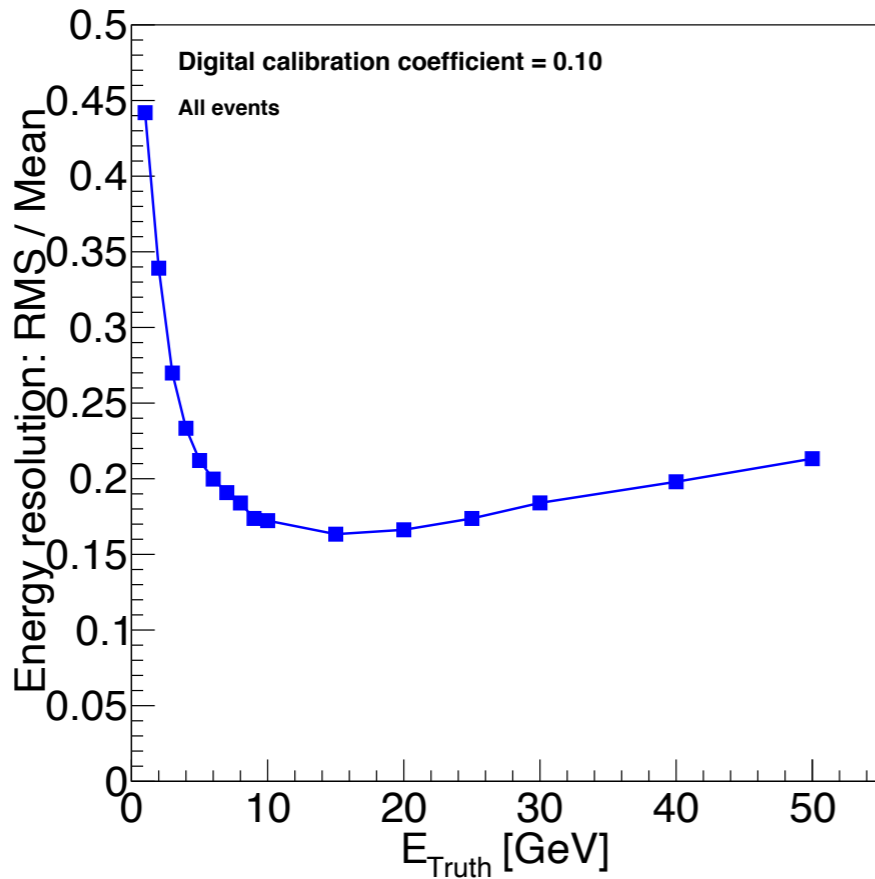
All events



Events with $E_{\text{ECAL}} > \text{threshold}$



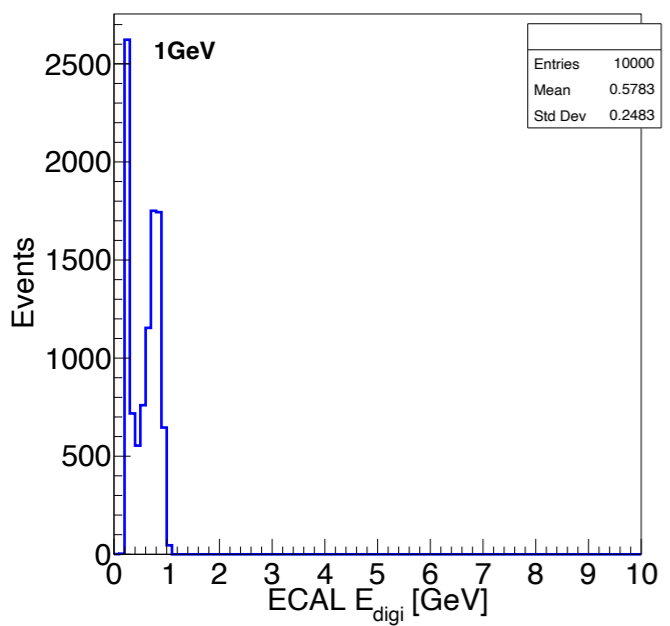
Linearity



Resolution
(RMS / Mean)

BGO ECAL + SDHCAL

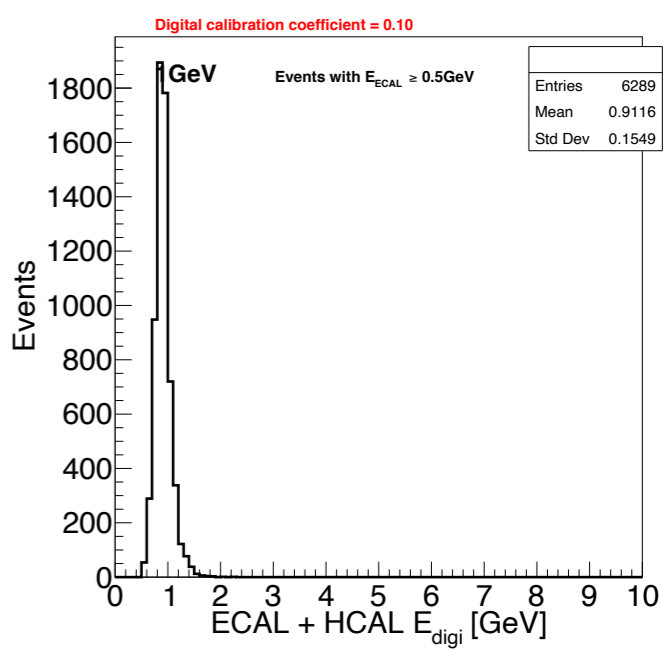
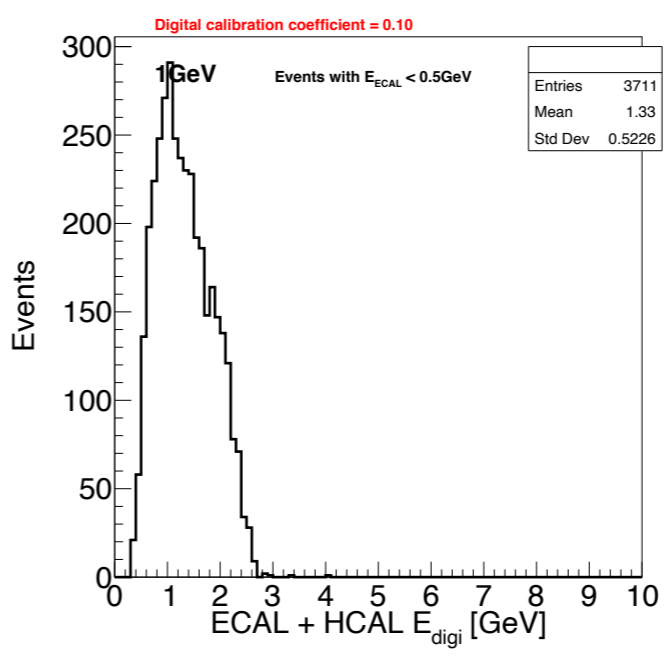
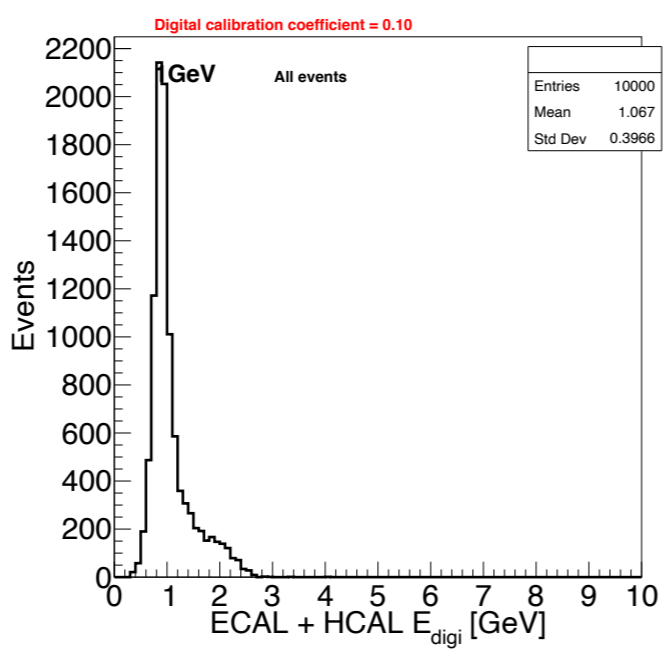
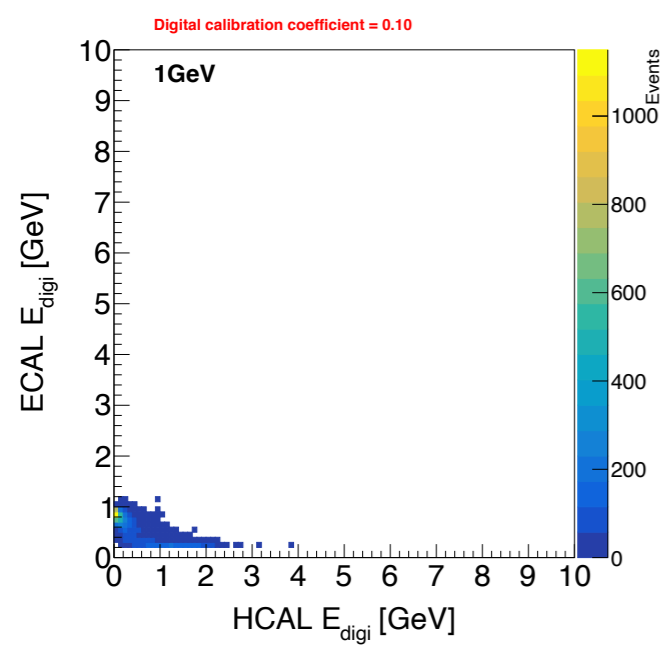
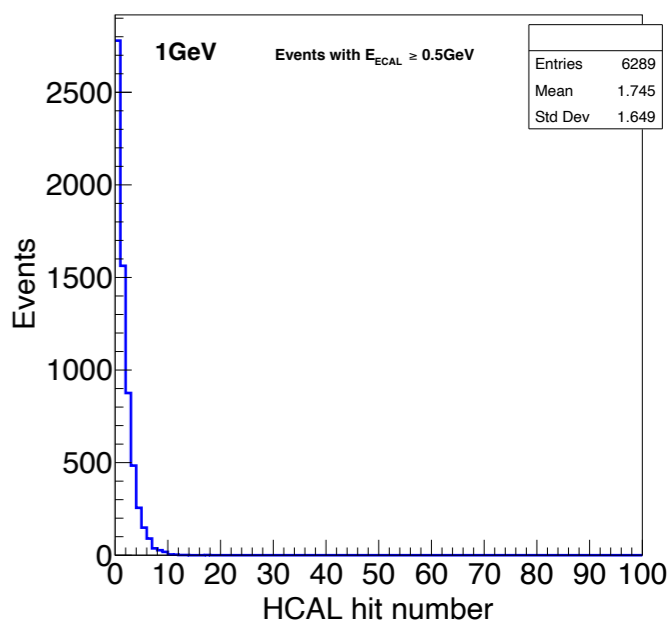
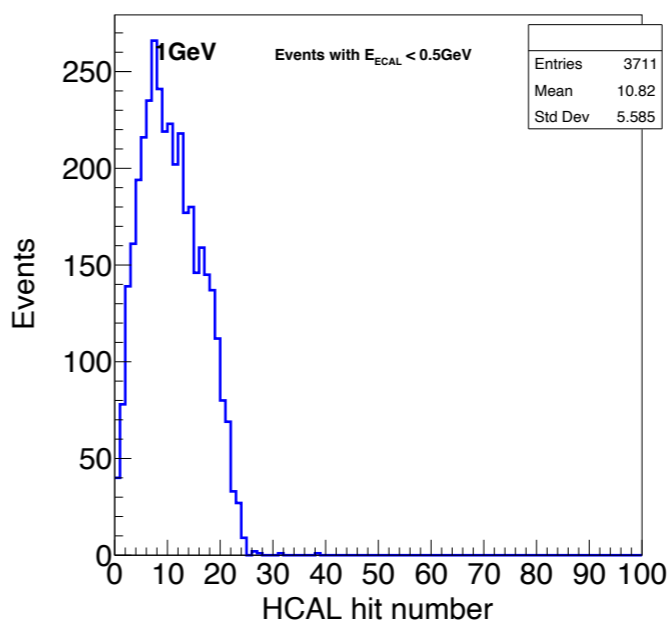
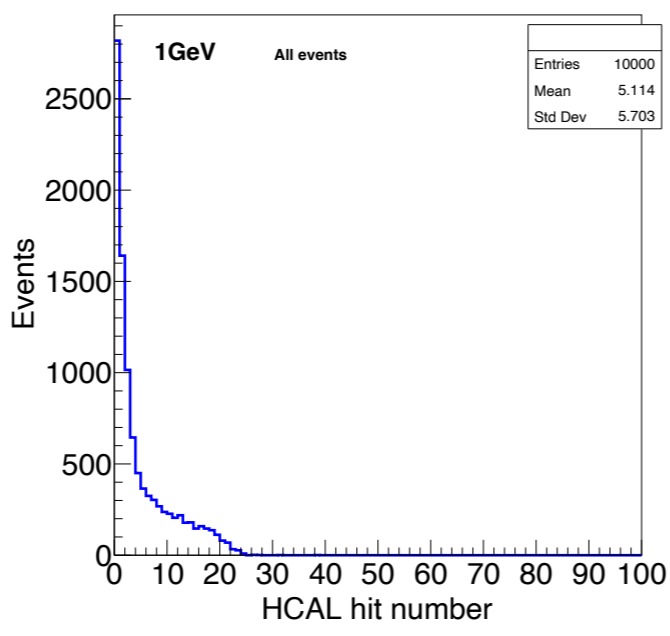
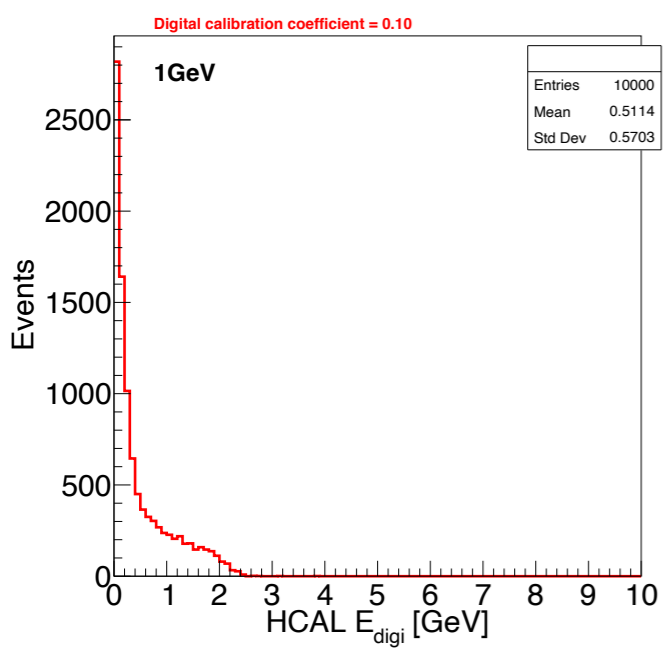
1GeV π^+



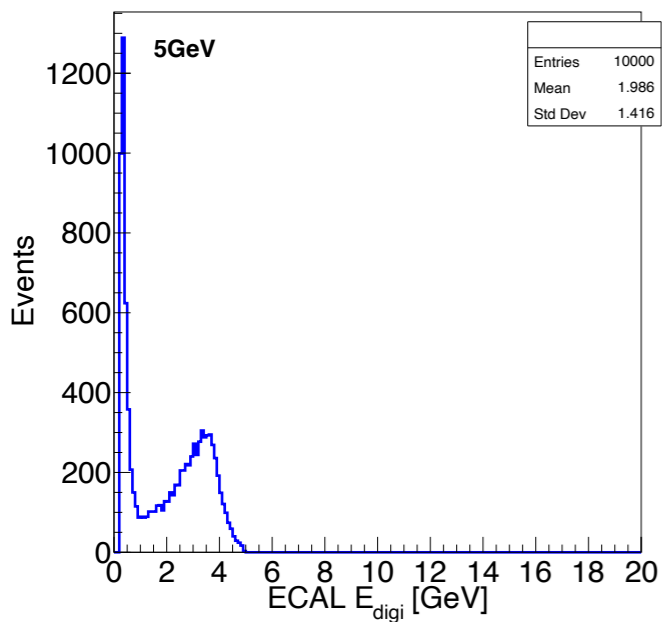
All events

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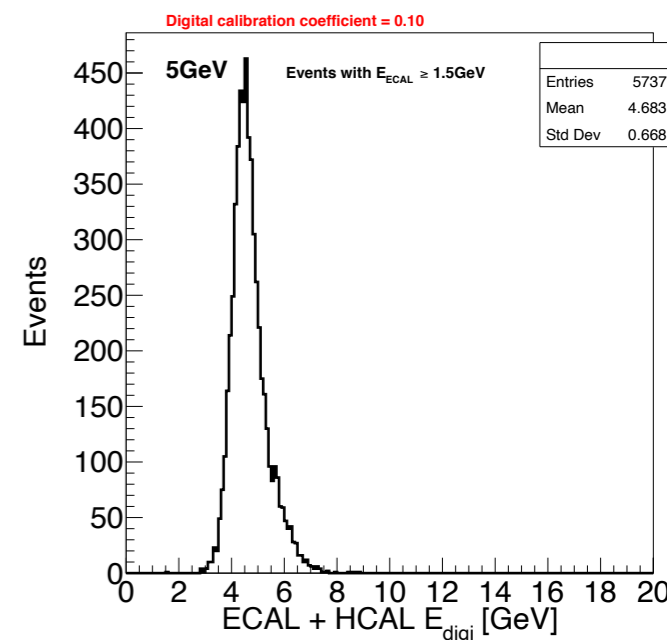
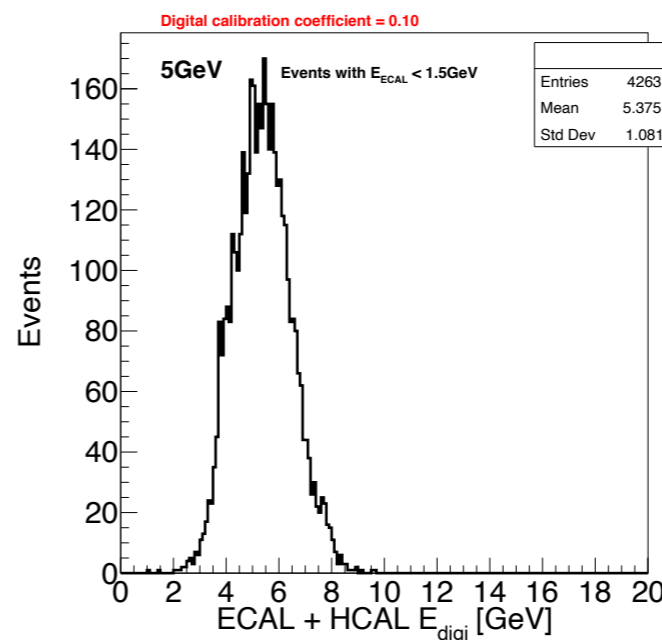
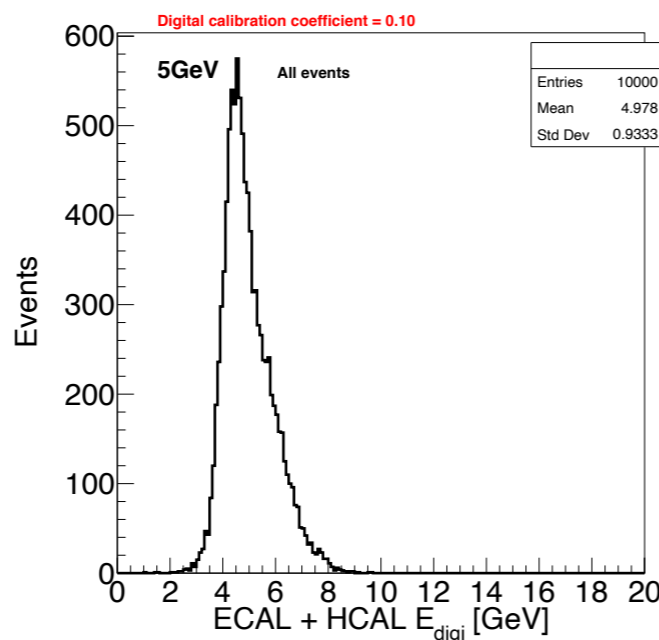
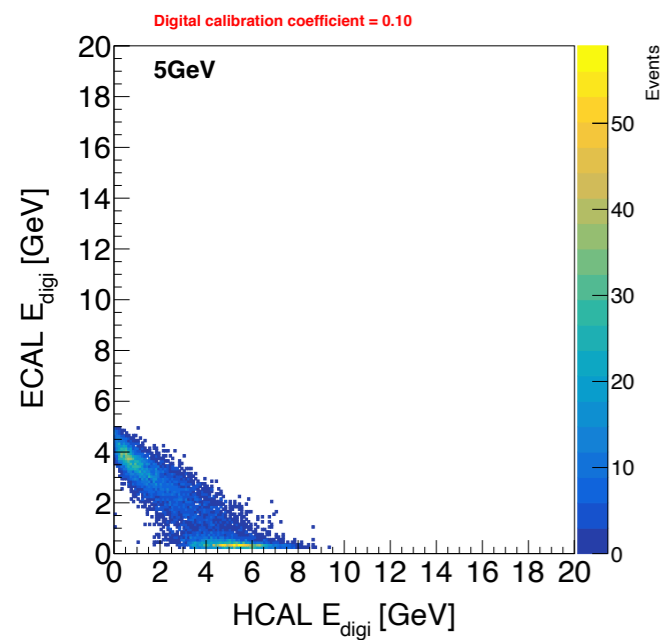
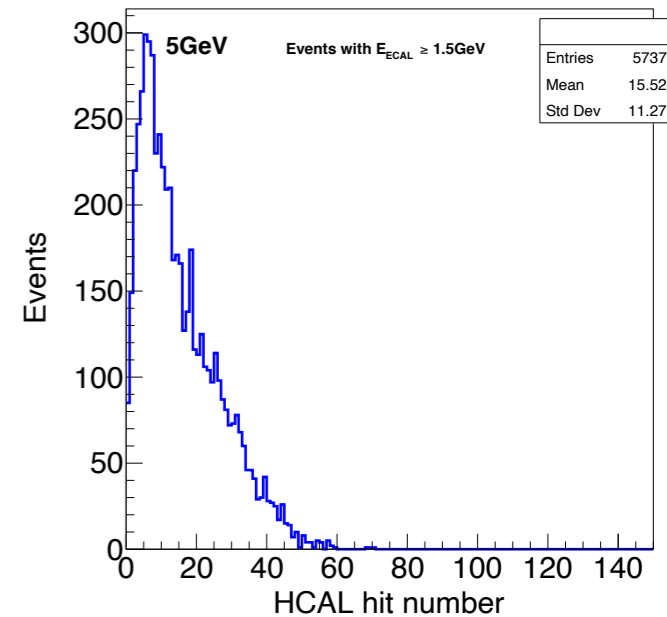
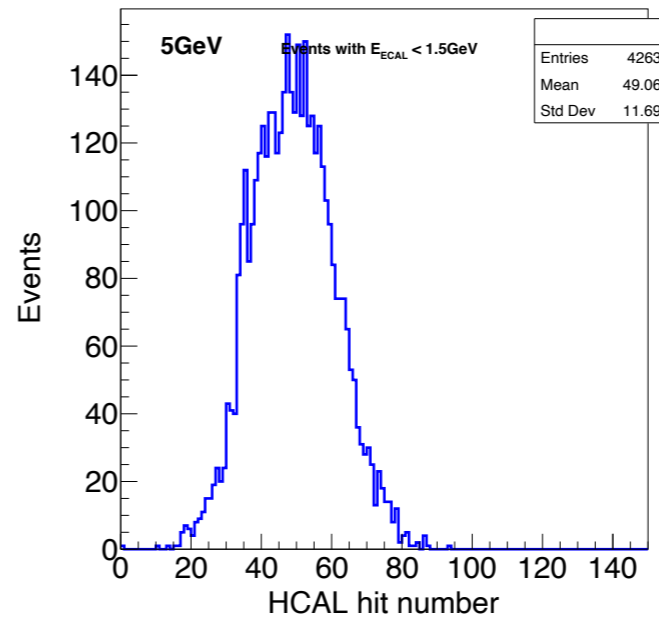
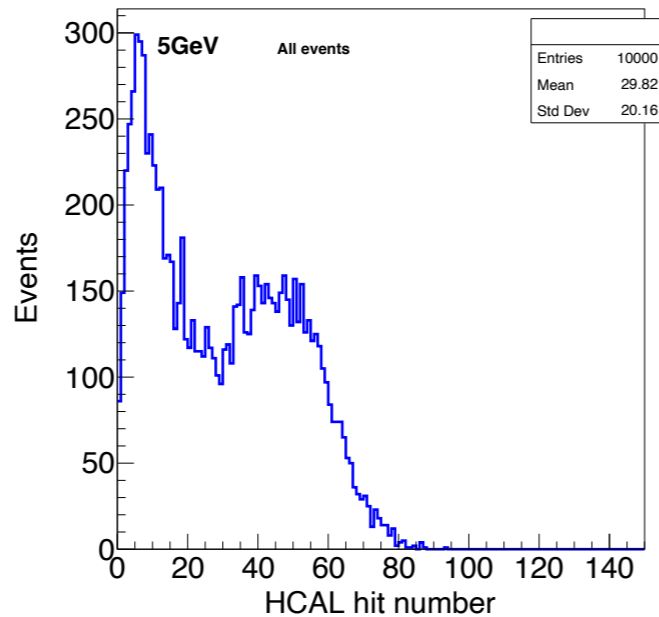
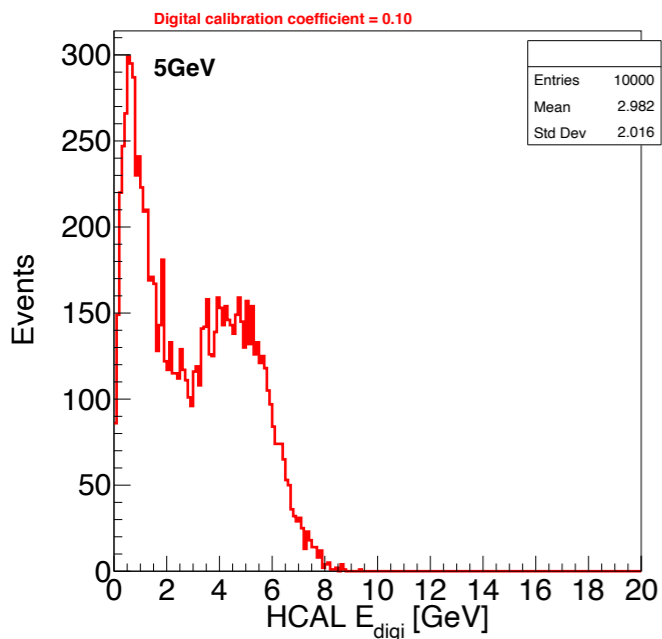
5GeV π^+



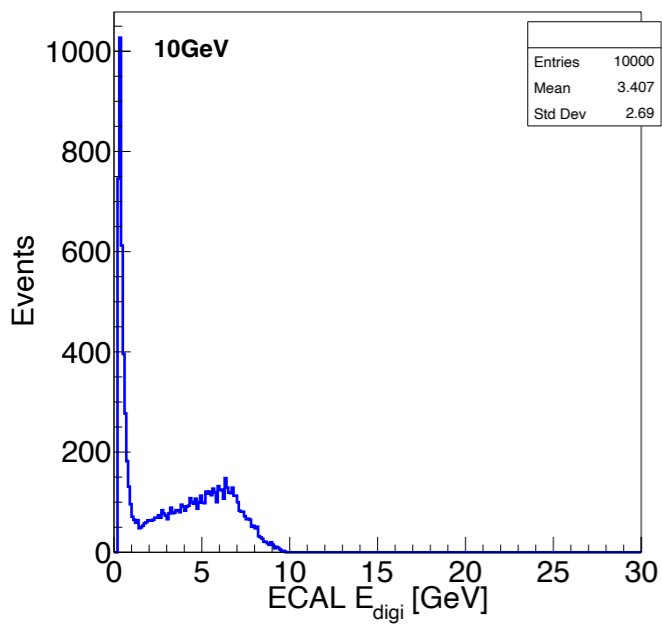
All events

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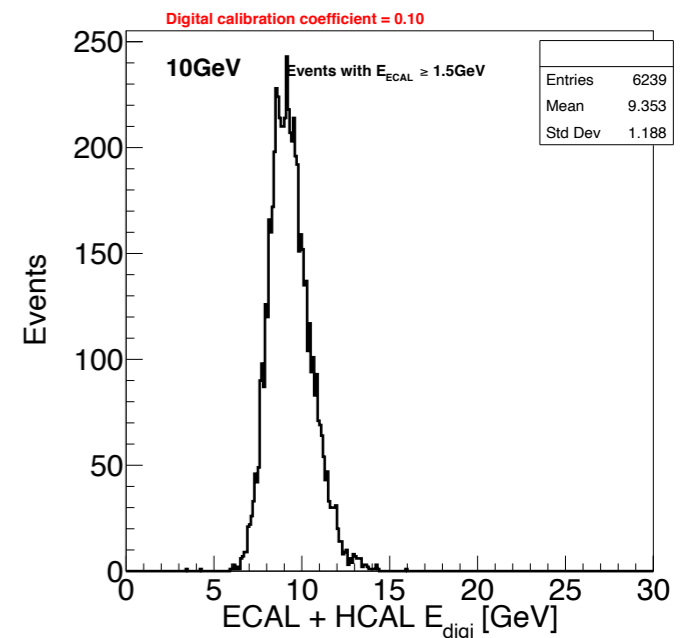
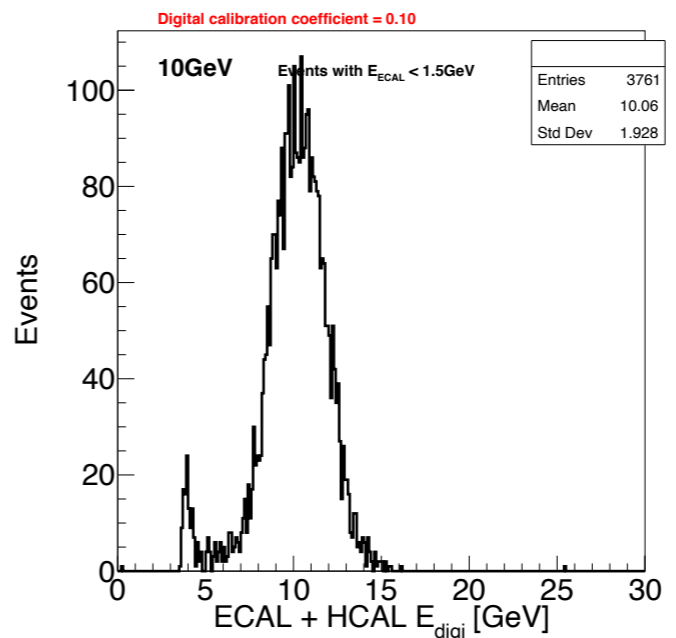
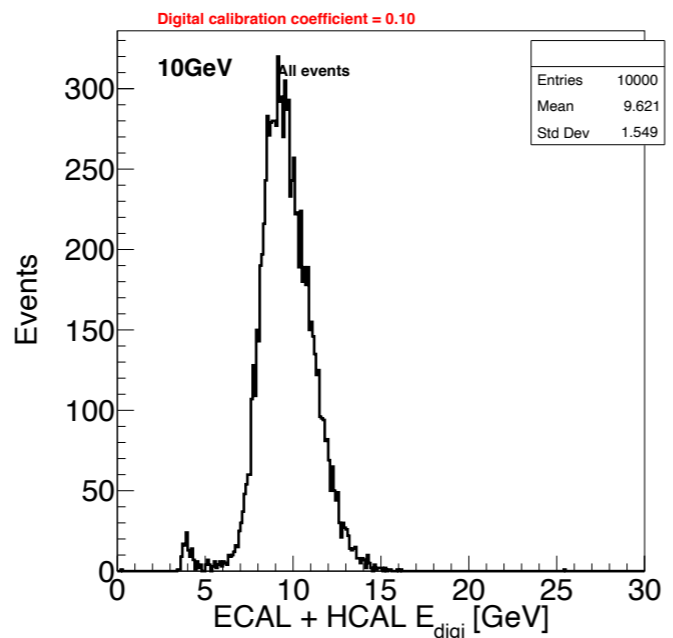
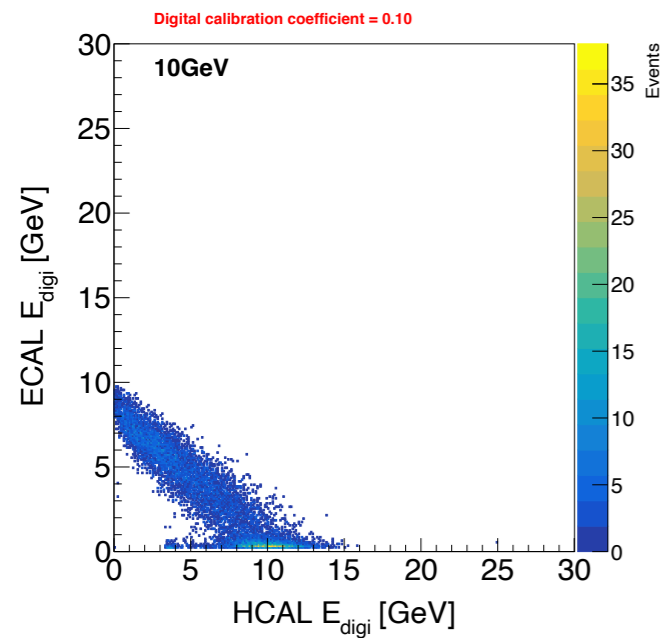
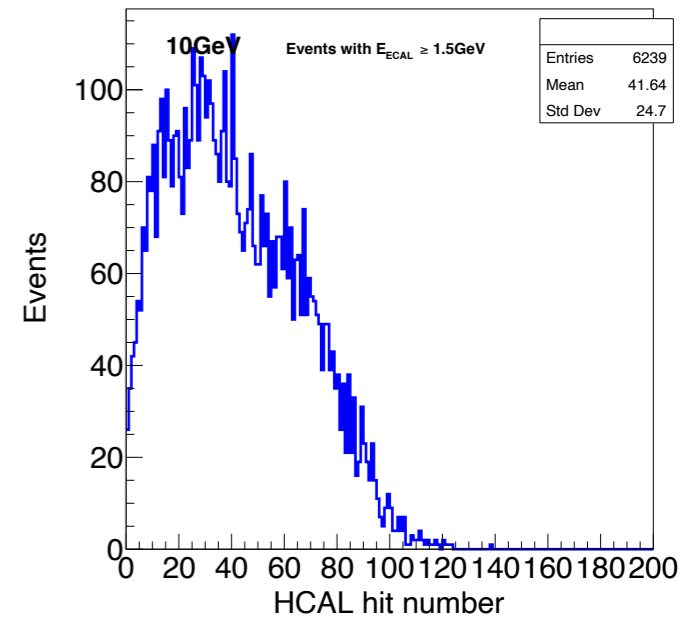
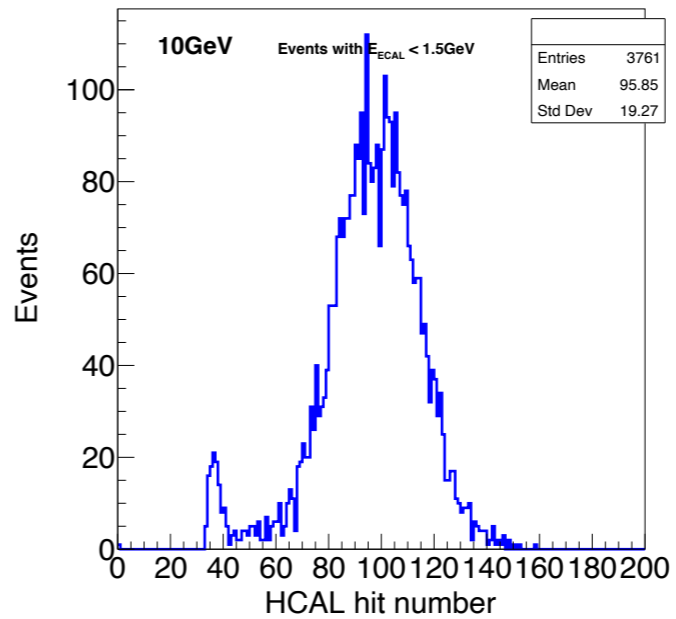
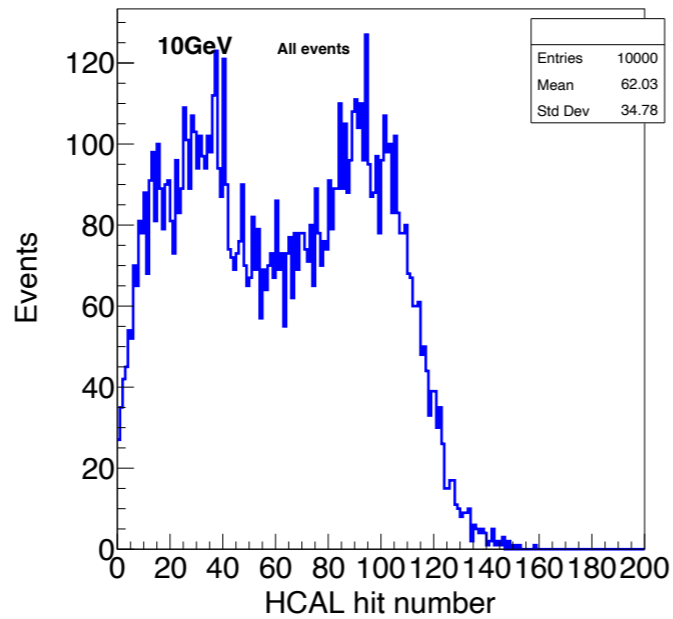
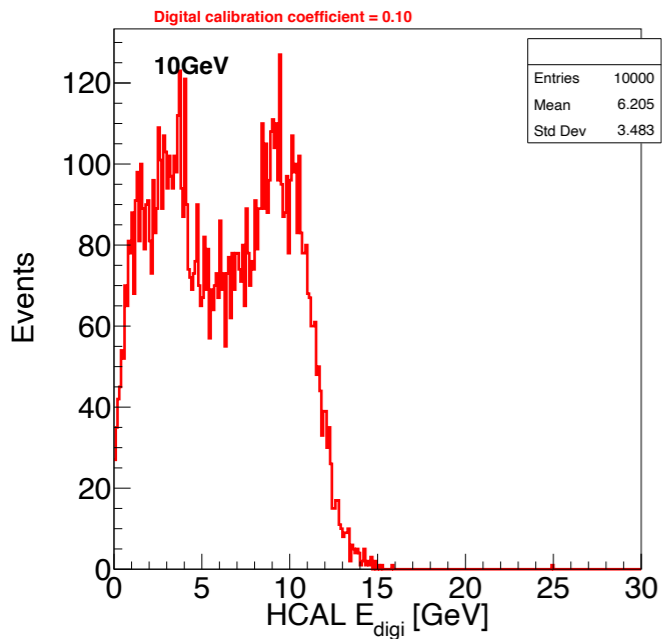
10GeV π^+



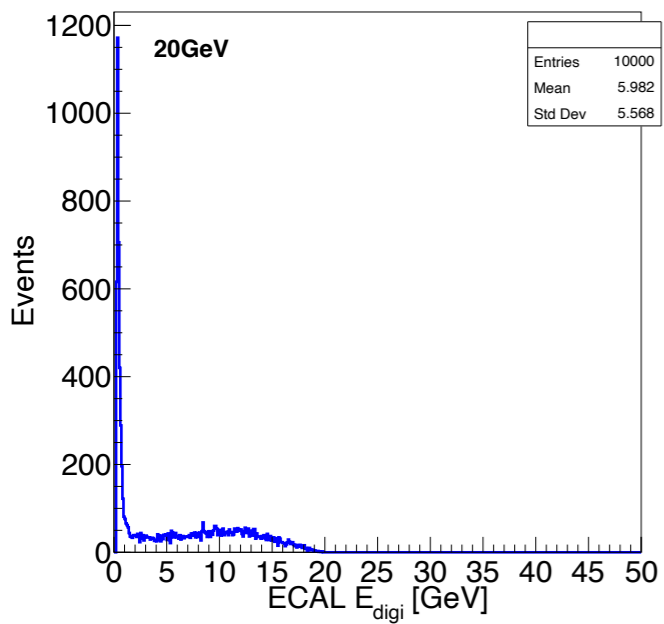
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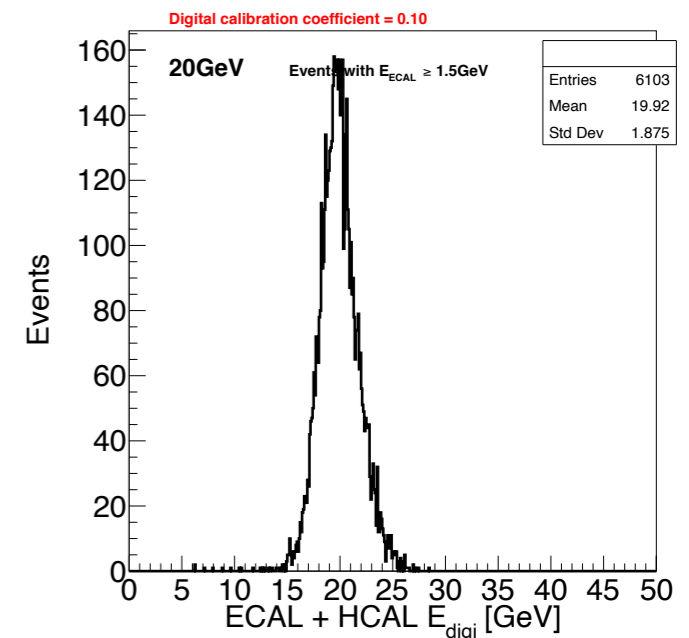
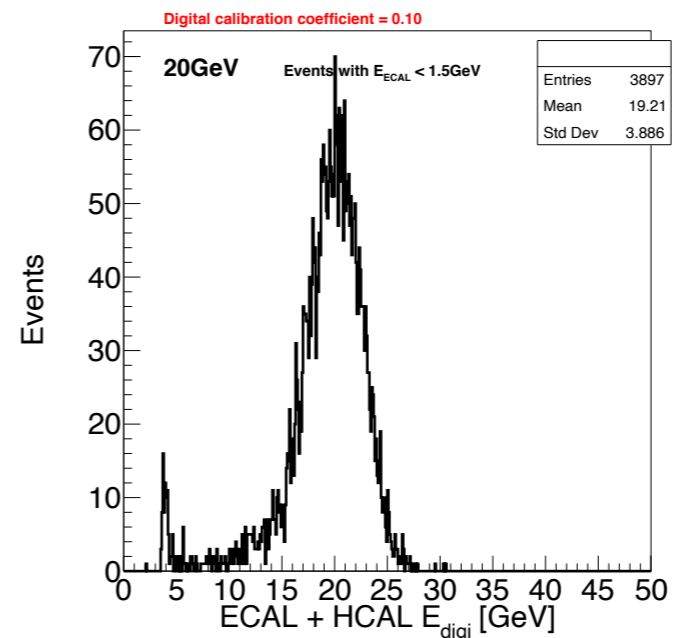
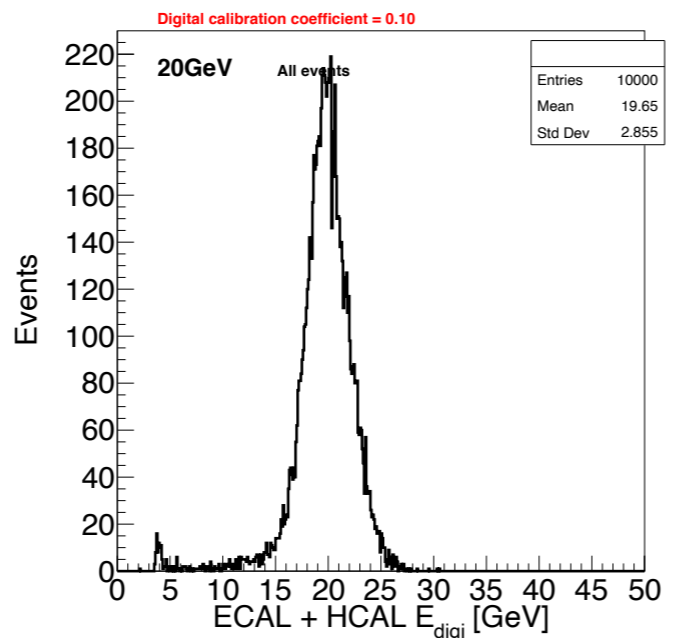
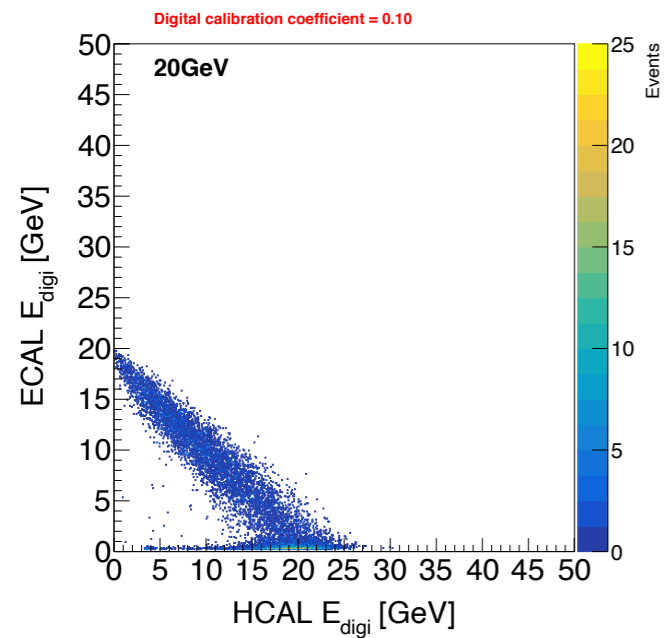
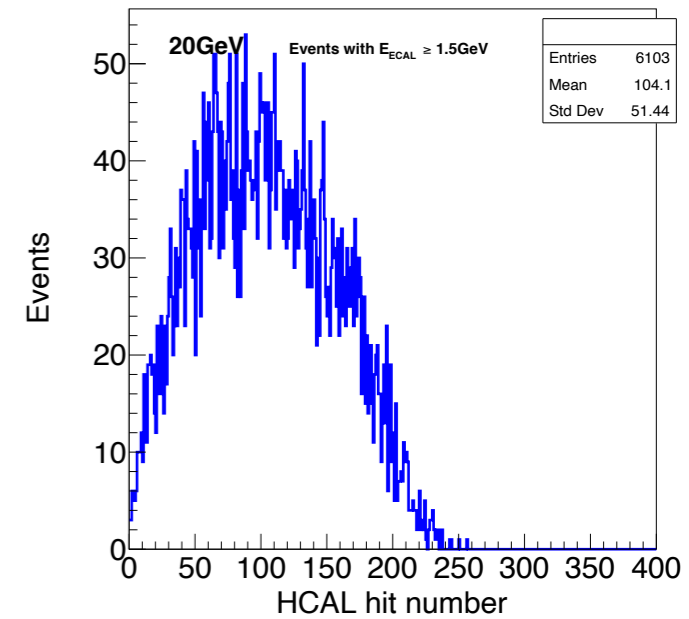
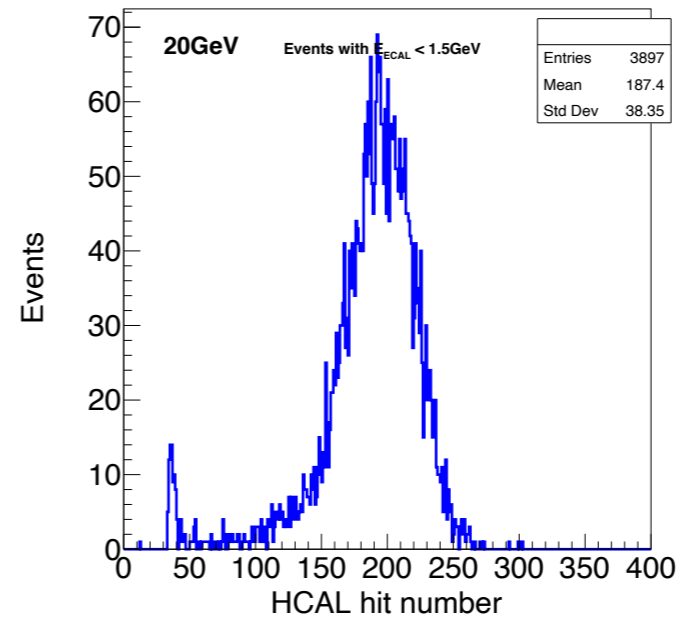
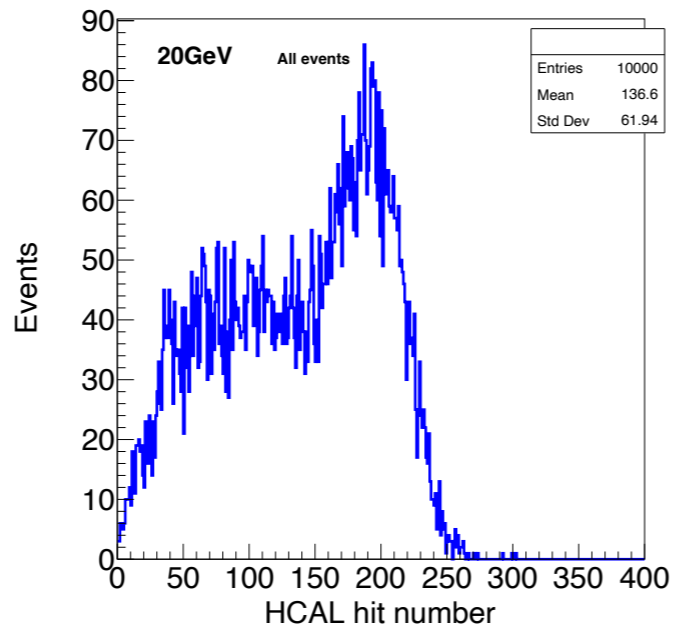
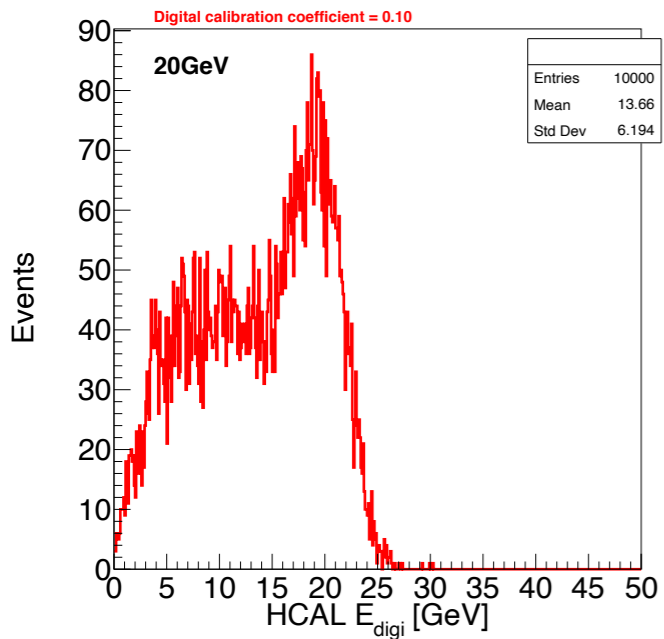
20GeV π^+



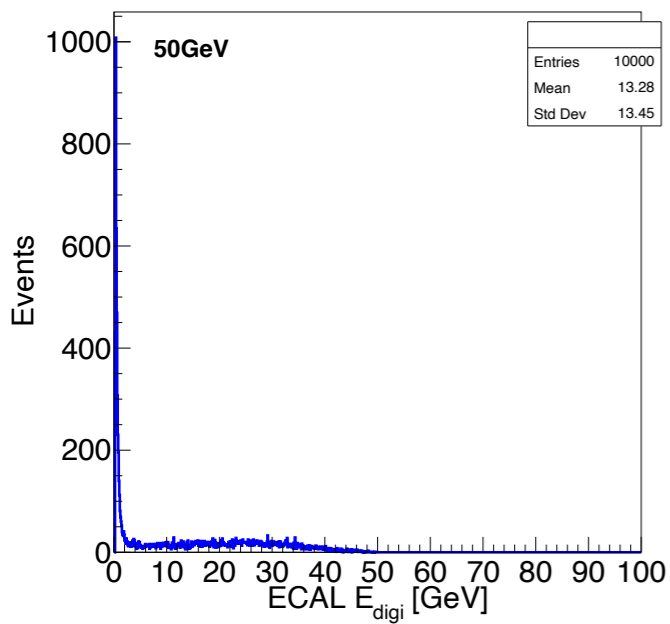
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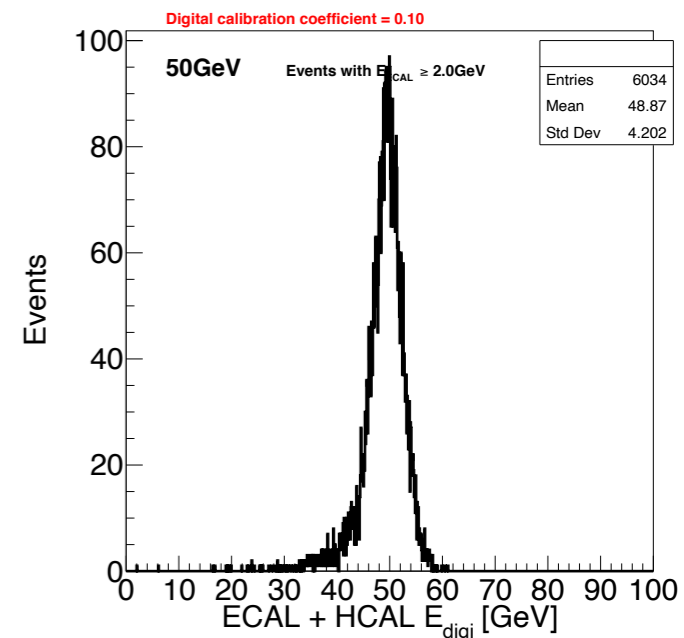
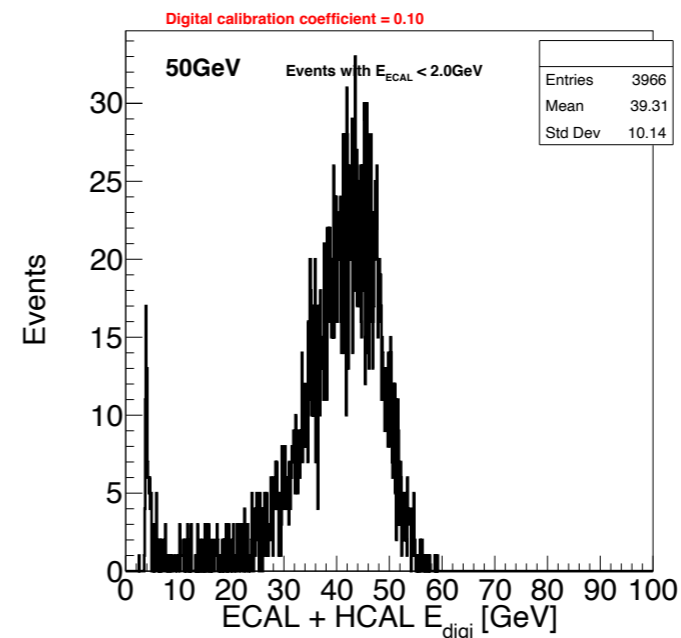
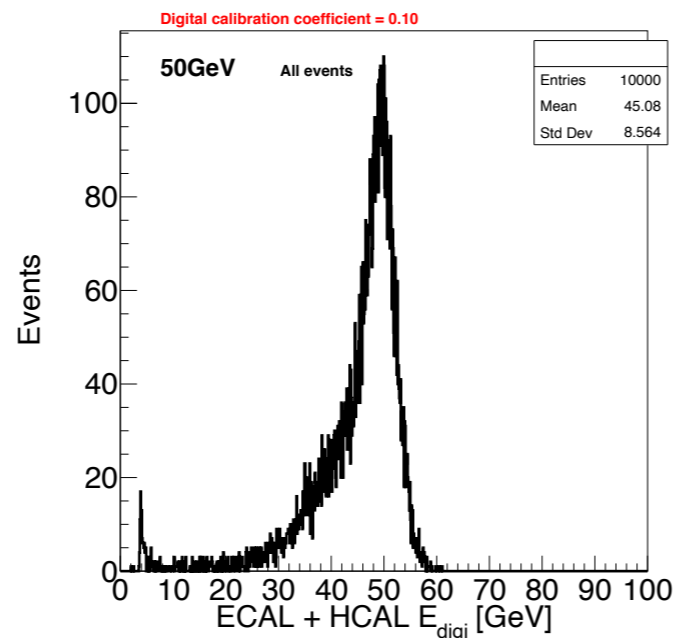
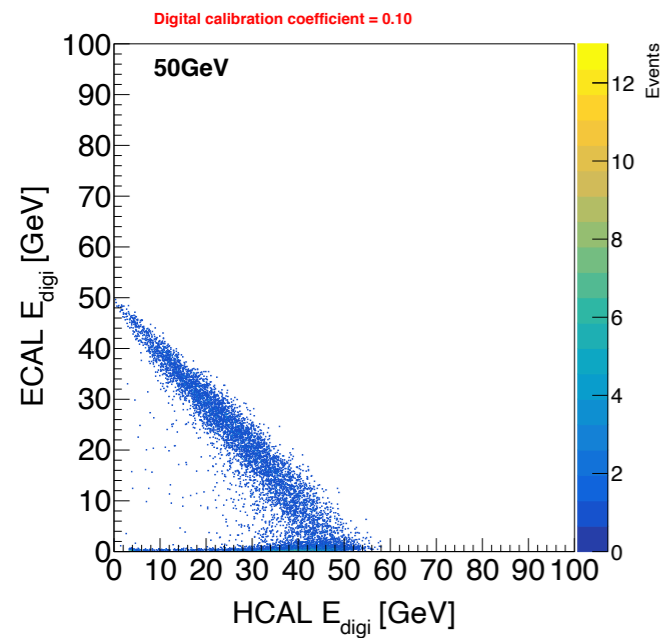
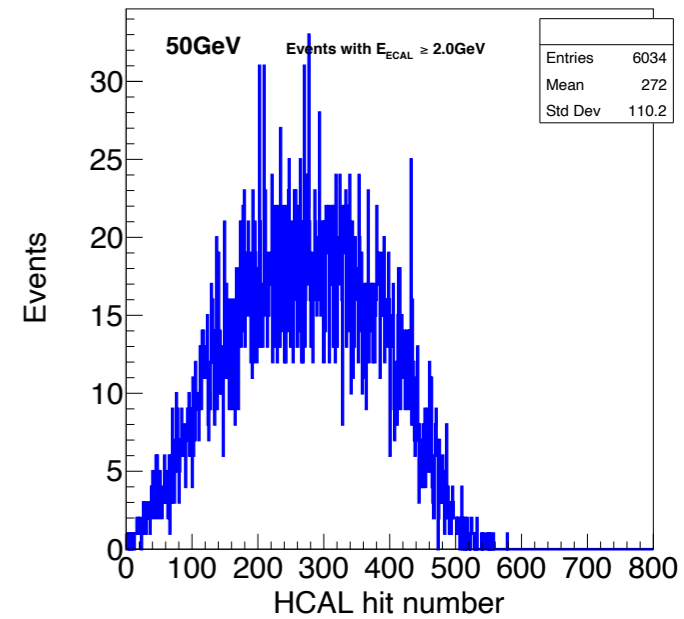
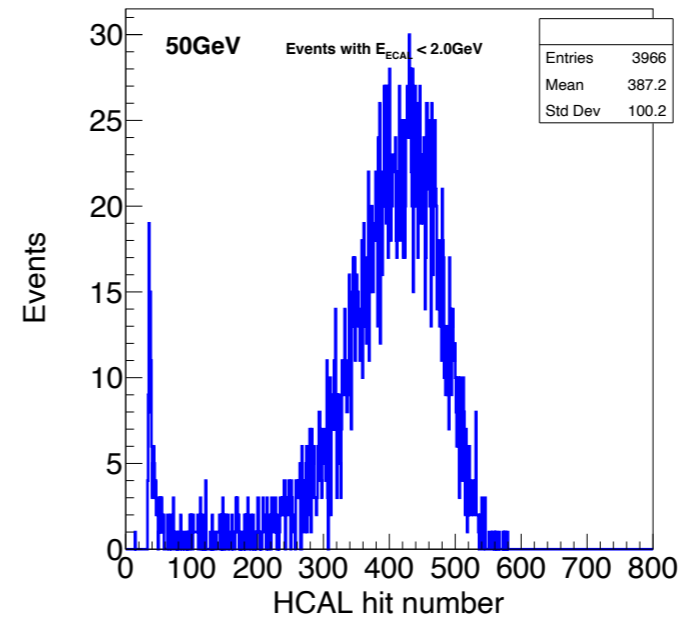
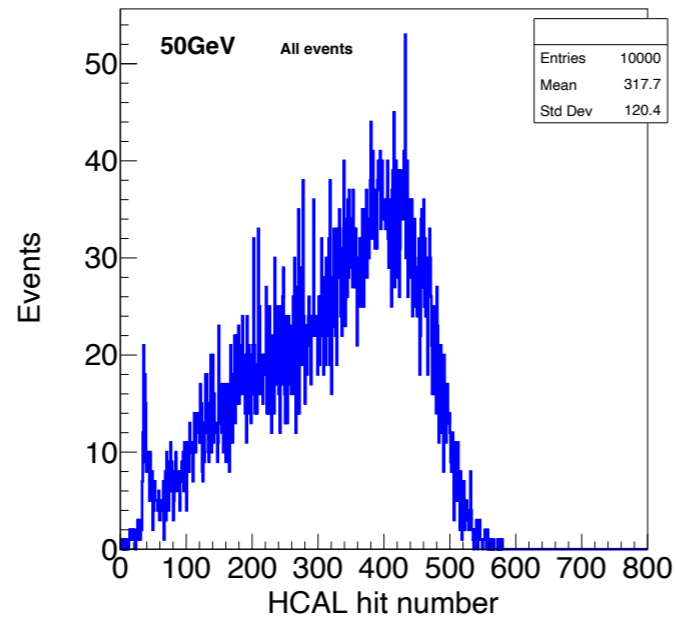
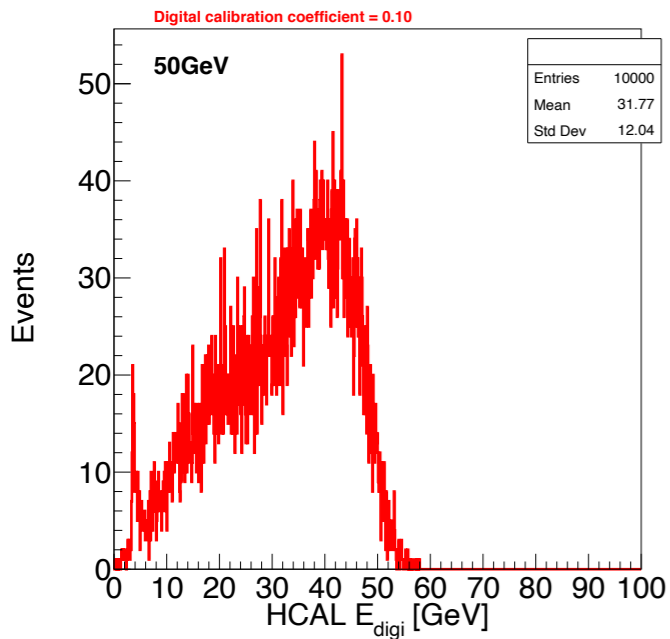
50GeV π^+



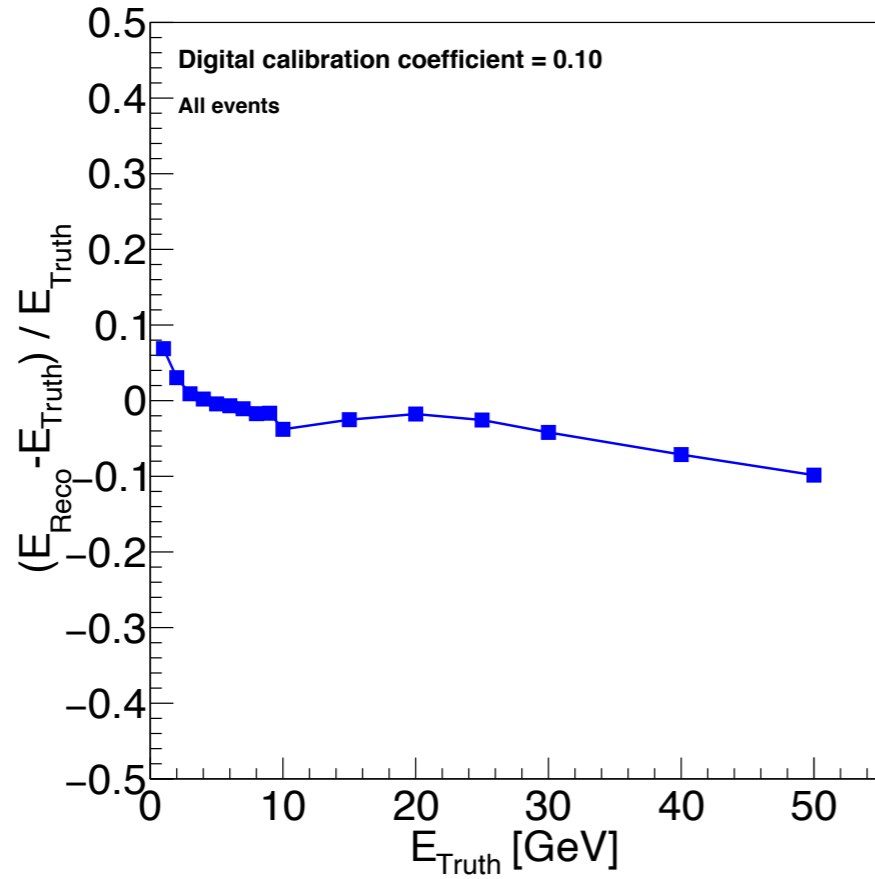
All events

Events with $E_{ECAL} < \text{threshold}$

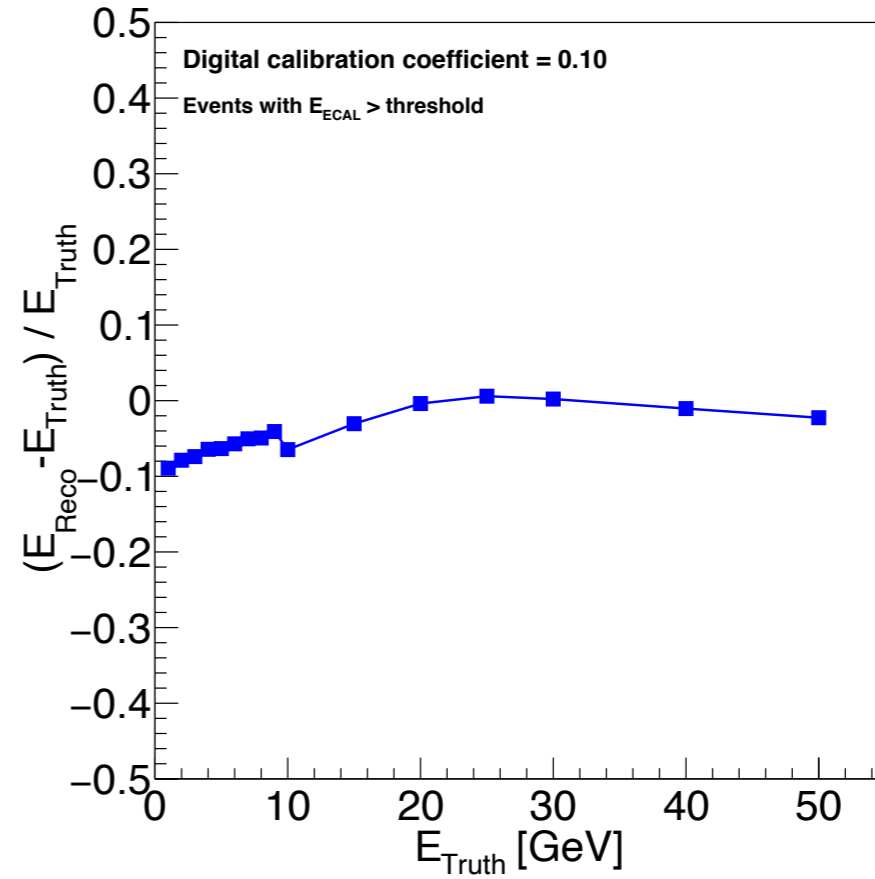
Events with $E_{ECAL} > \text{threshold}$



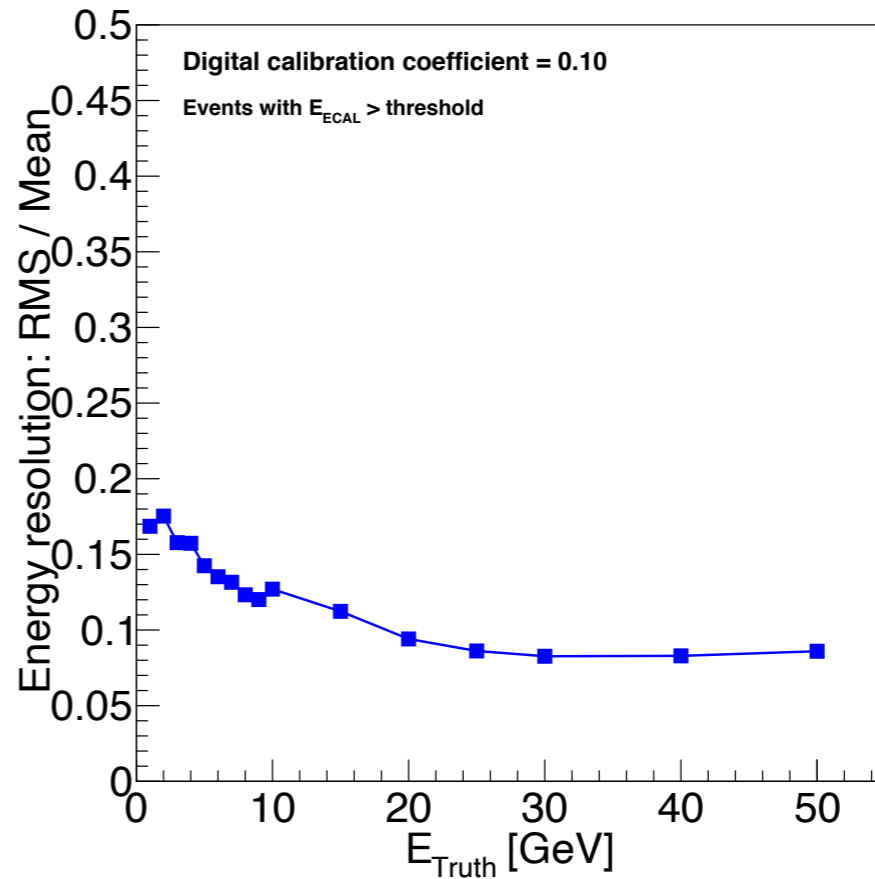
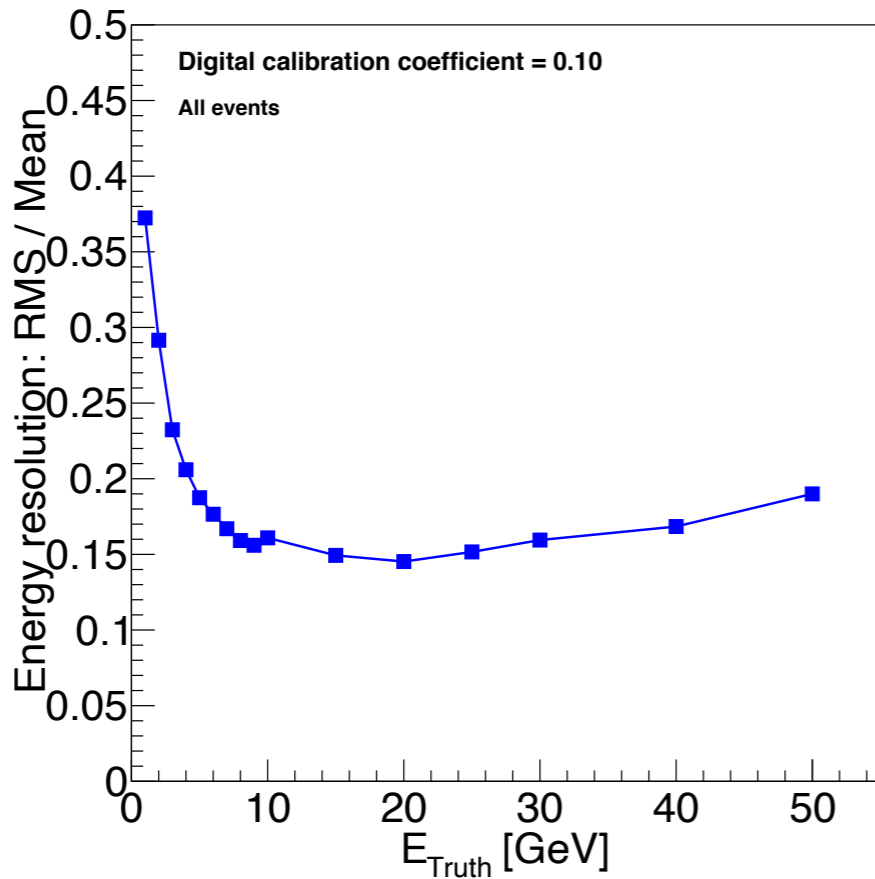
All events



Events with $E_{\text{ECAL}} > \text{threshold}$



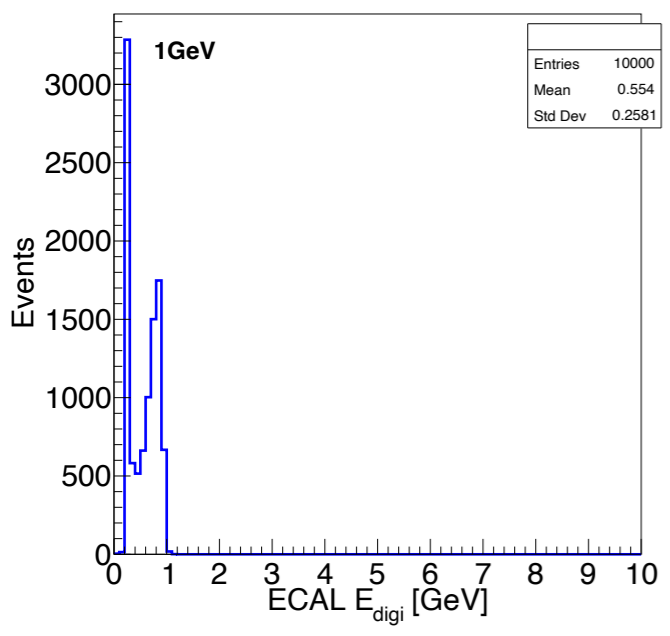
Linearity



Resolution (RMS / Mean)

PbWO₄ ECAL + SDHCAL

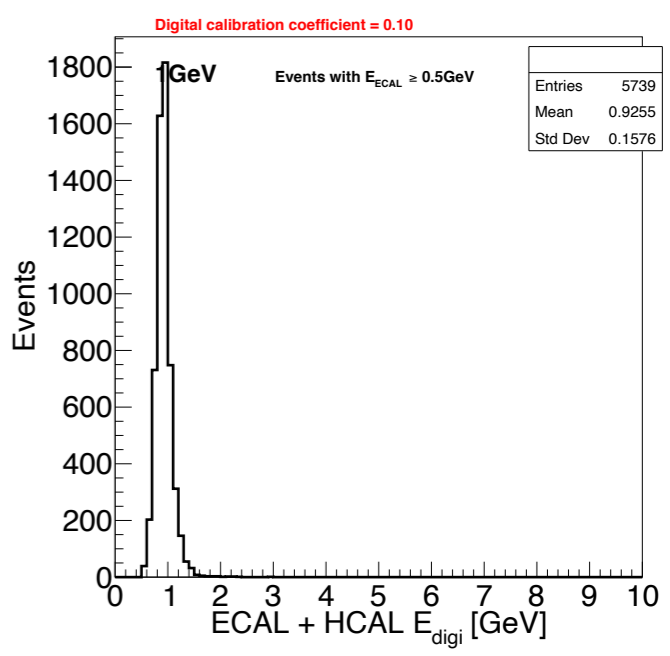
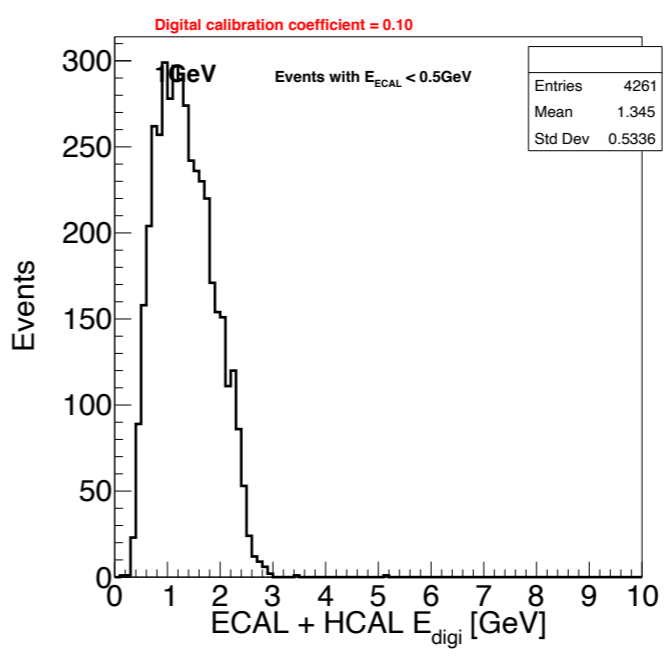
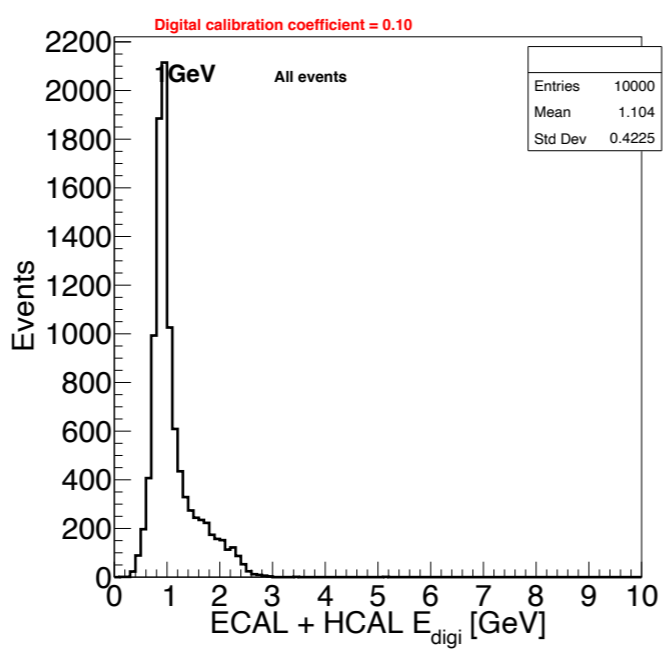
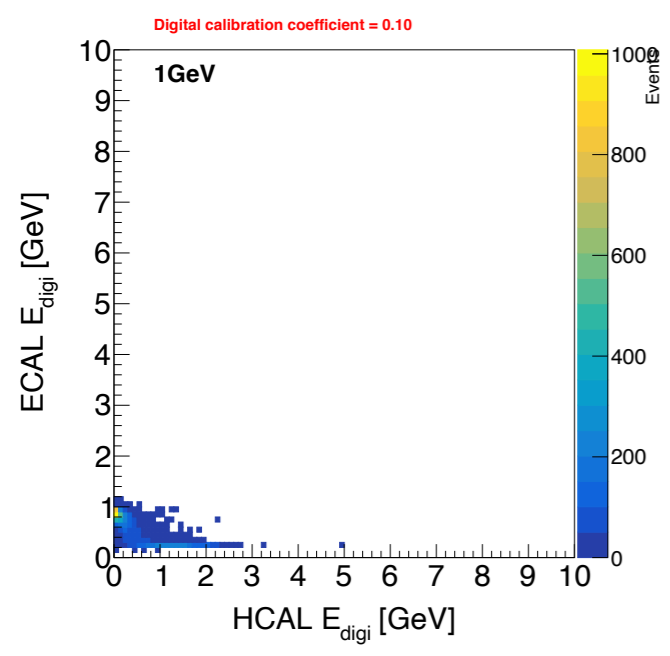
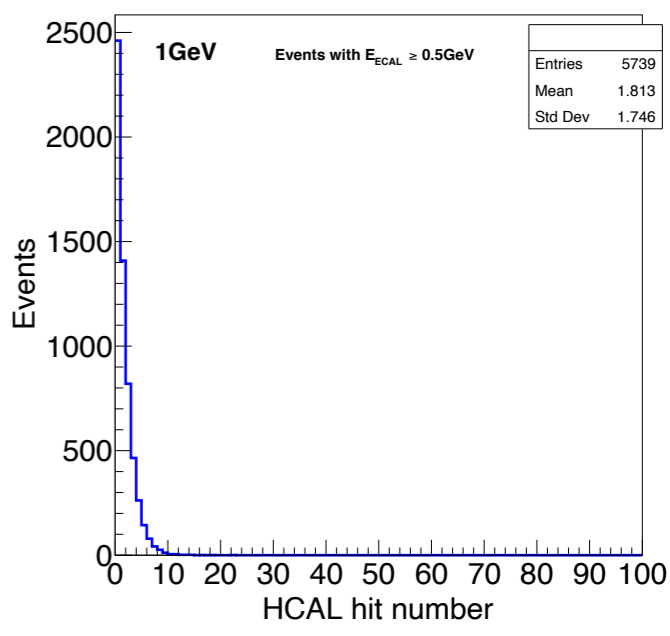
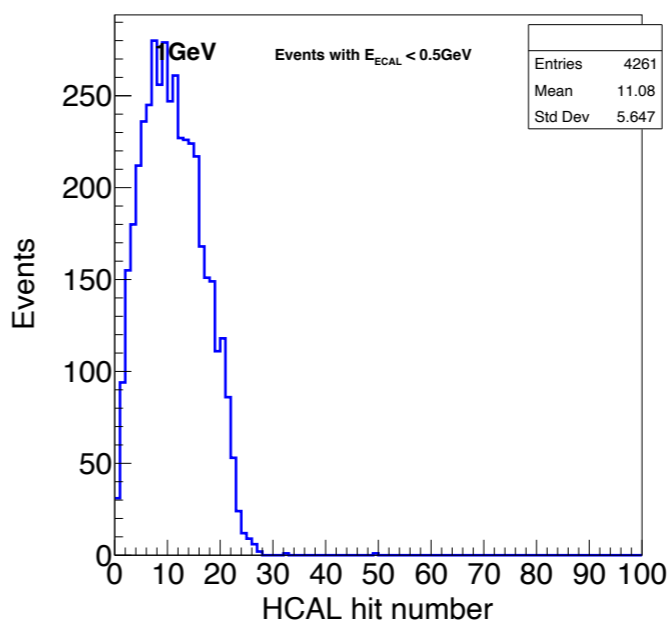
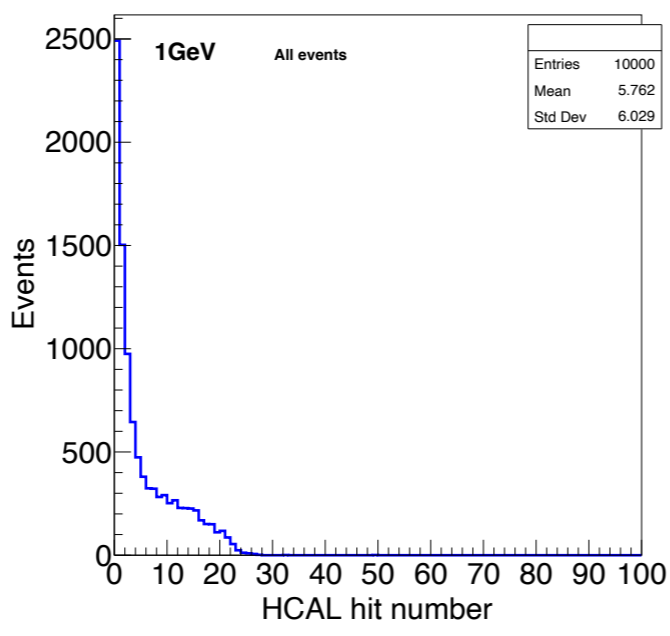
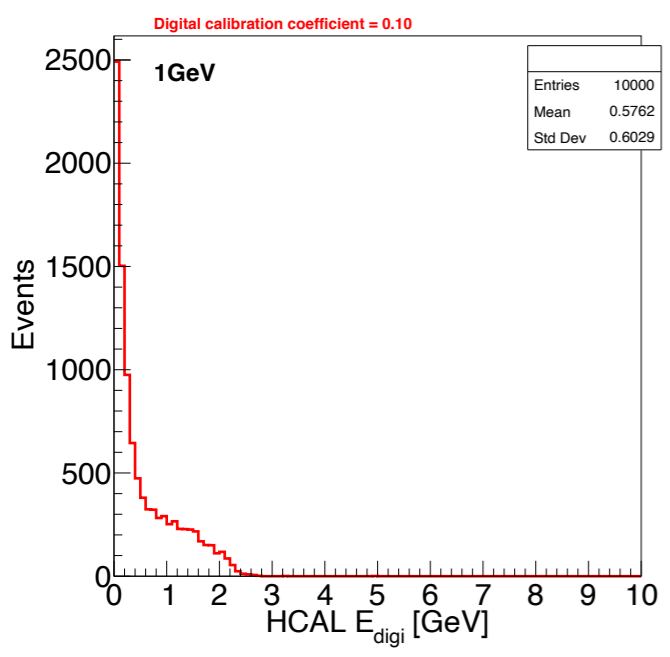
1GeV π^+



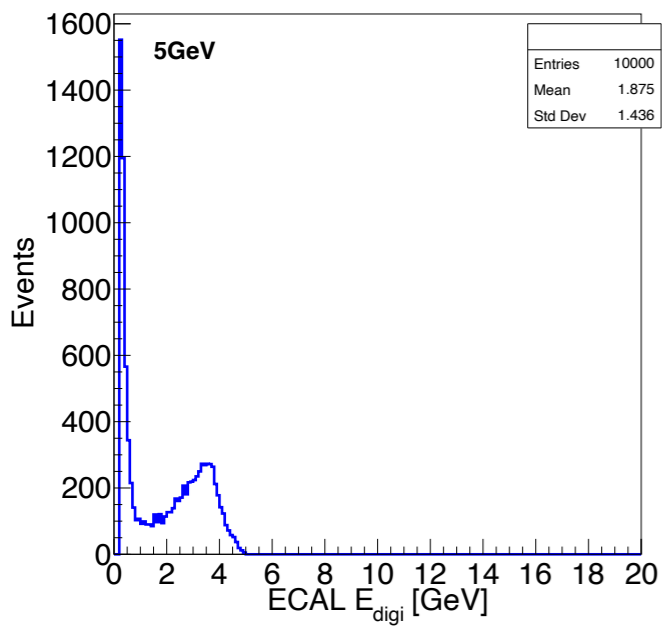
All events

Events with $E_{ECAL} < \text{threshold}$

Events with $E_{ECAL} > \text{threshold}$



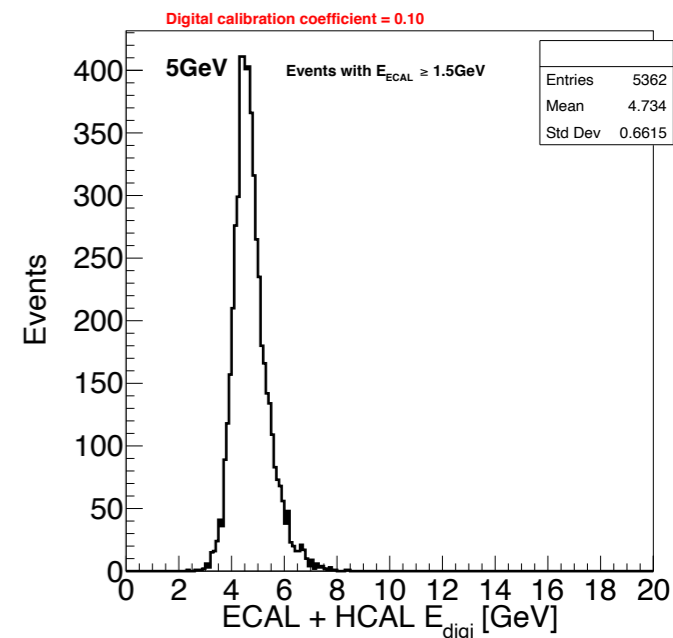
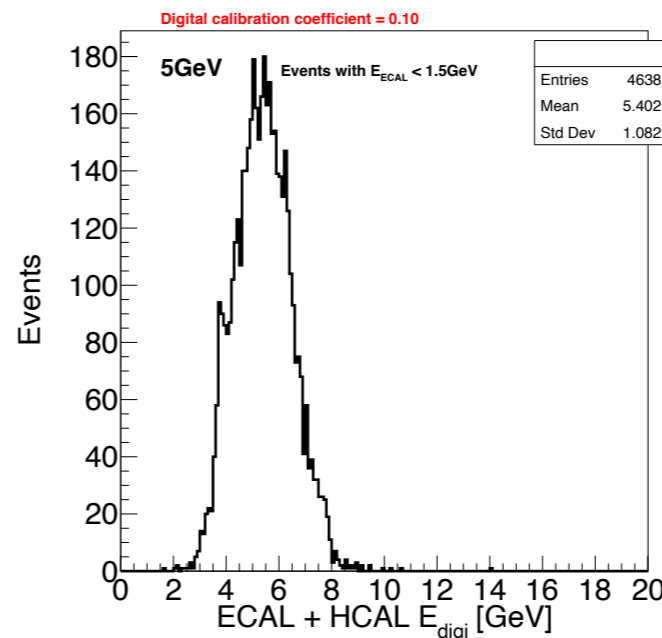
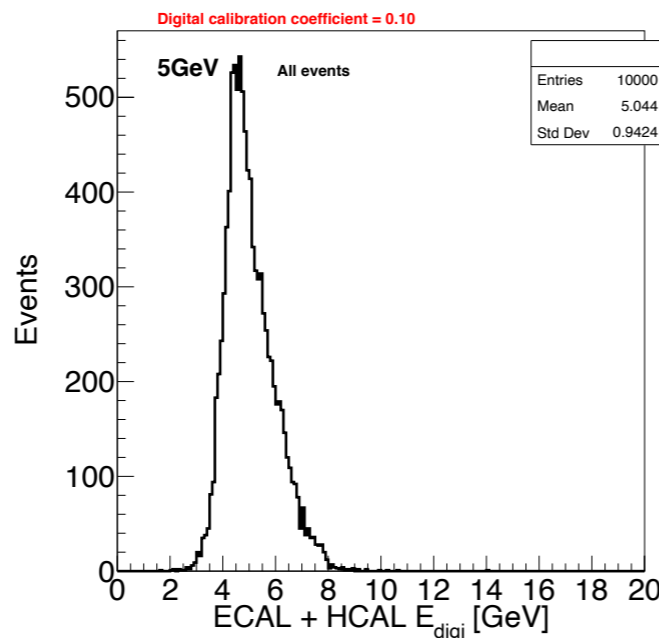
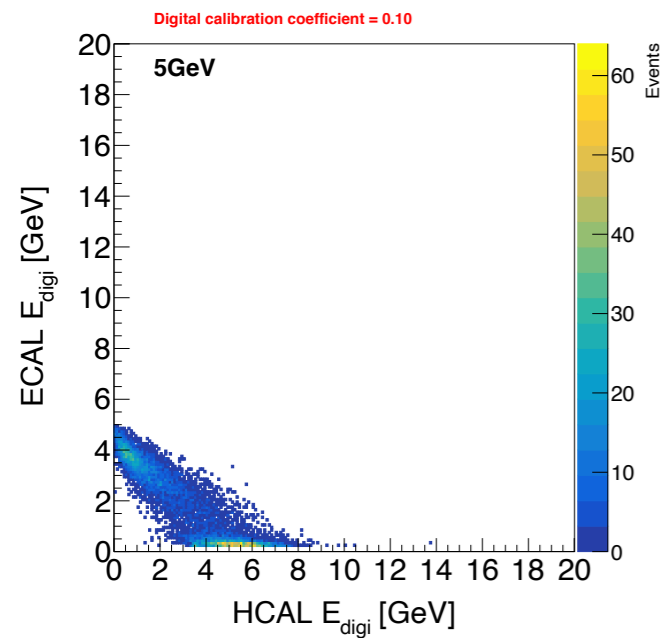
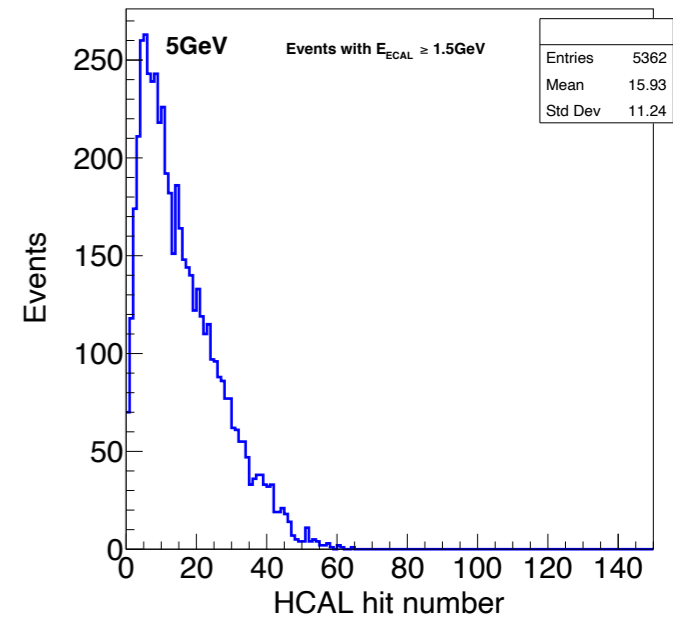
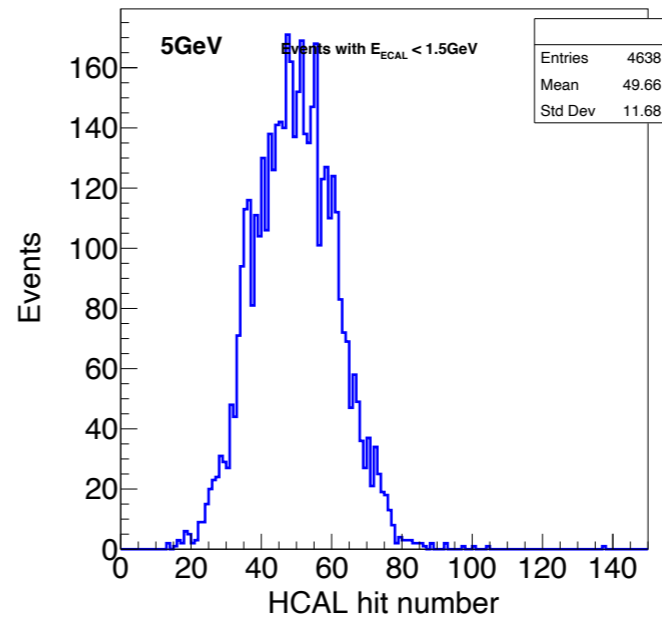
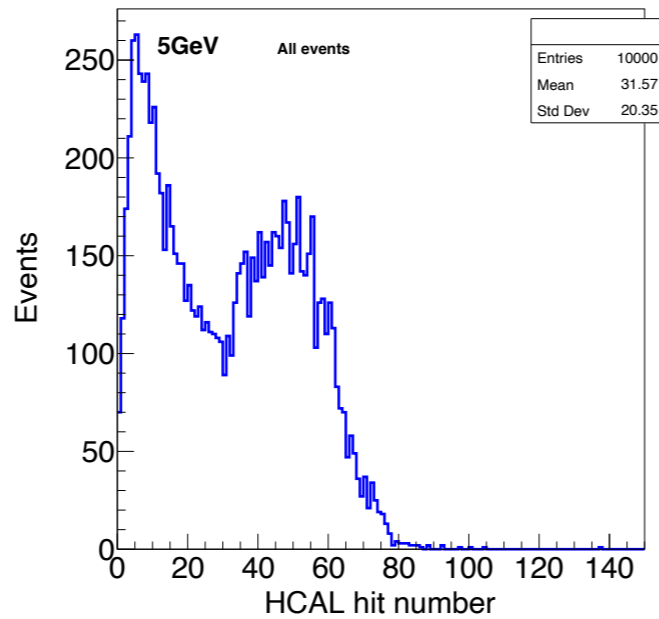
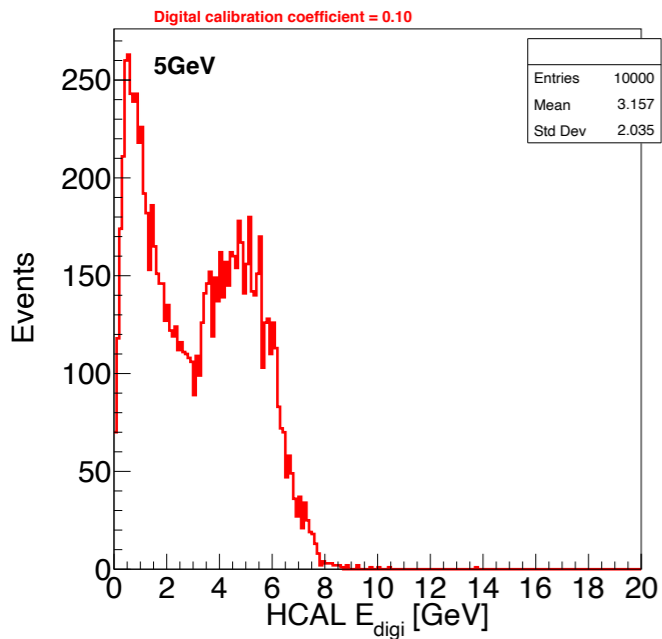
5GeV π^+



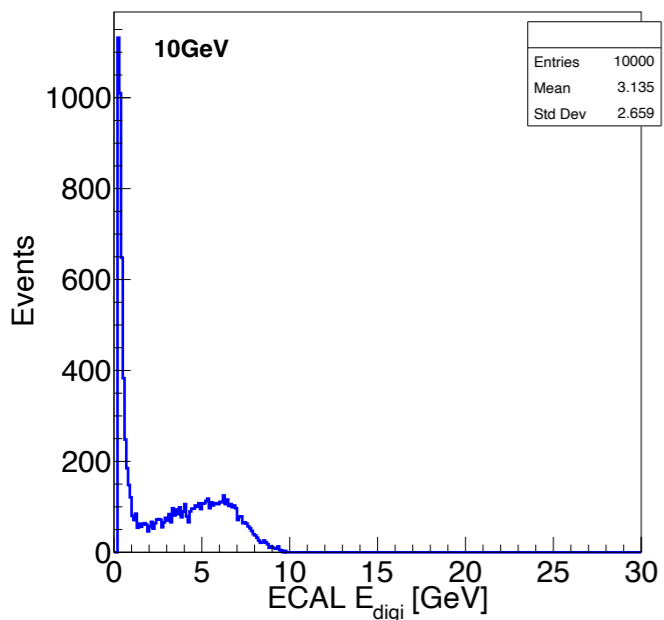
All events

Events with $E_{ECAL} < \text{threshold}$

Events with $E_{ECAL} > \text{threshold}$



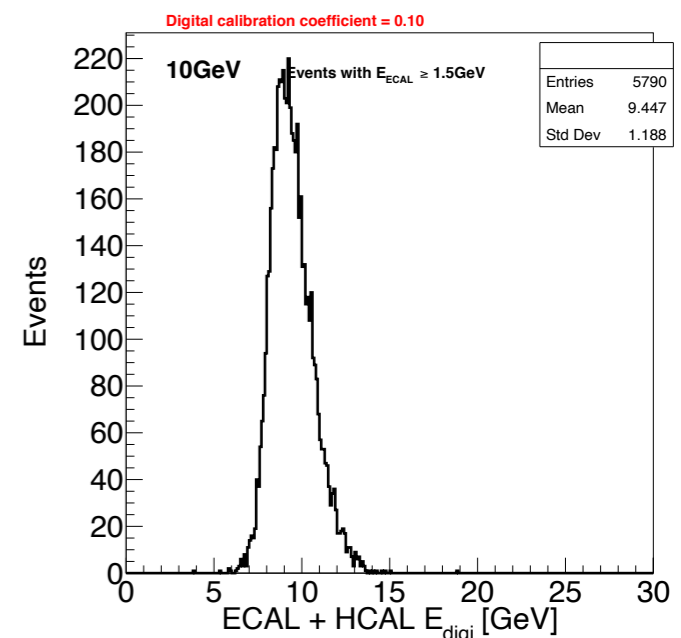
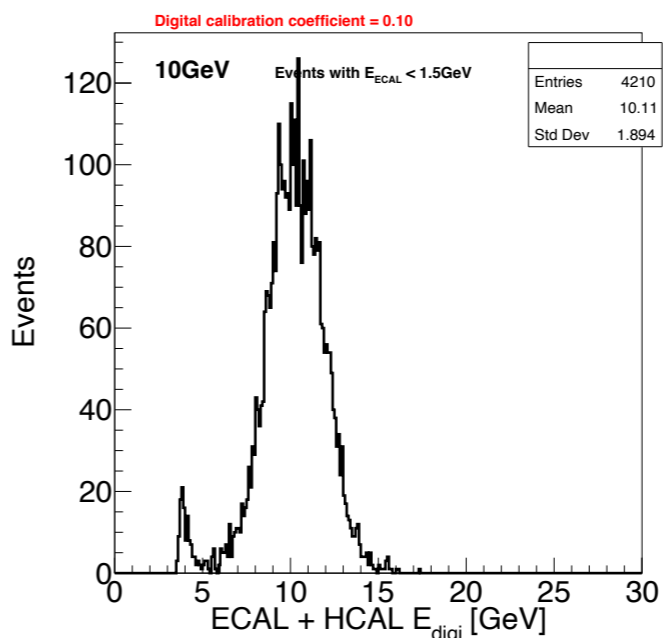
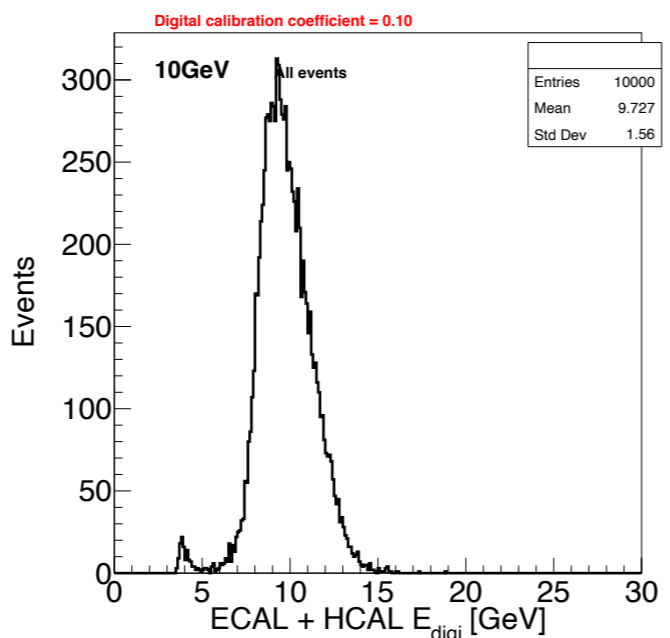
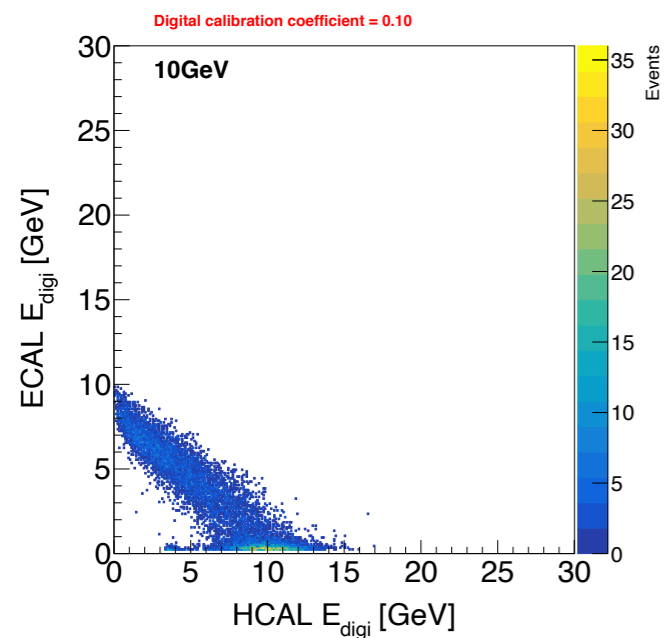
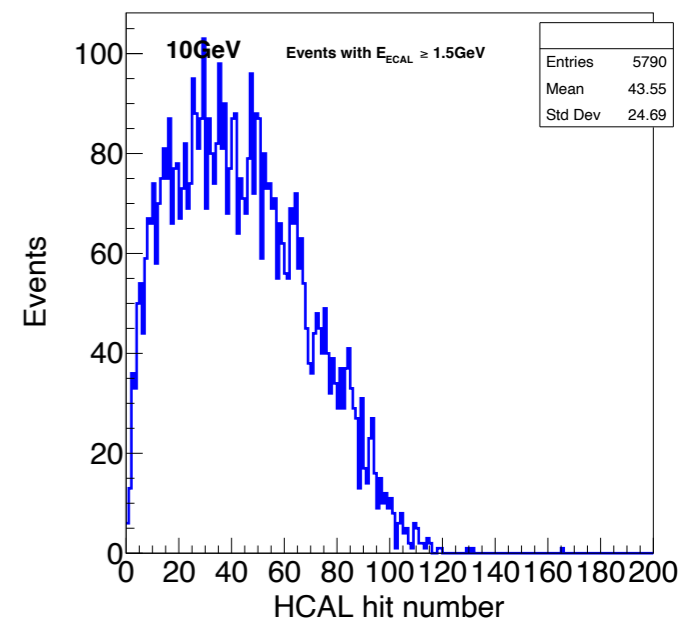
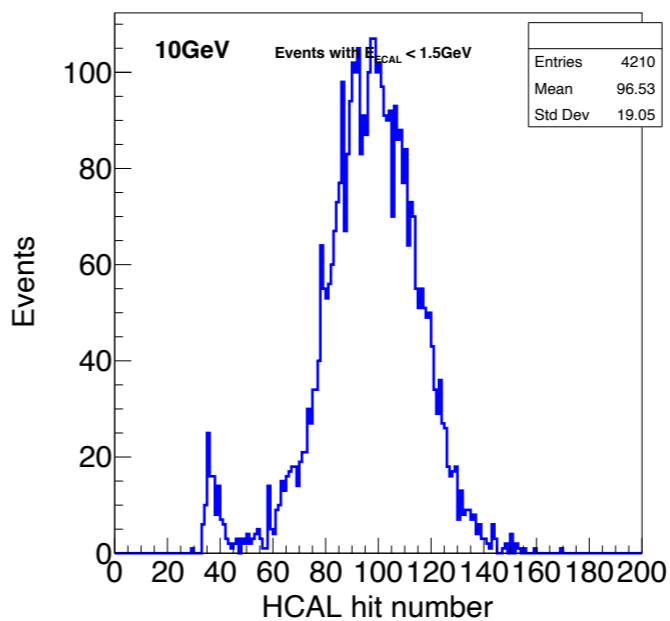
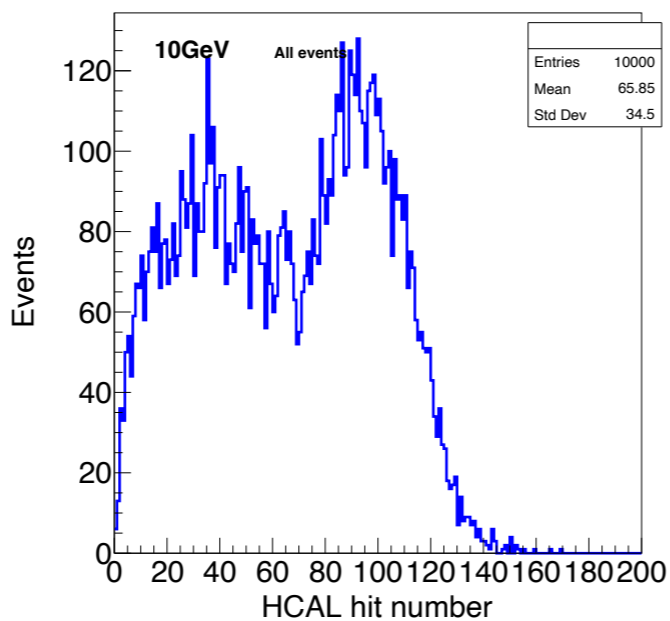
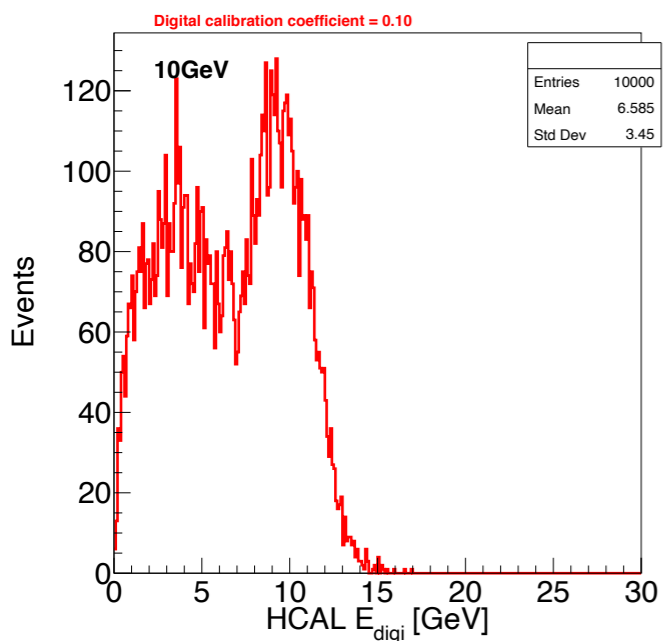
10GeV π^+



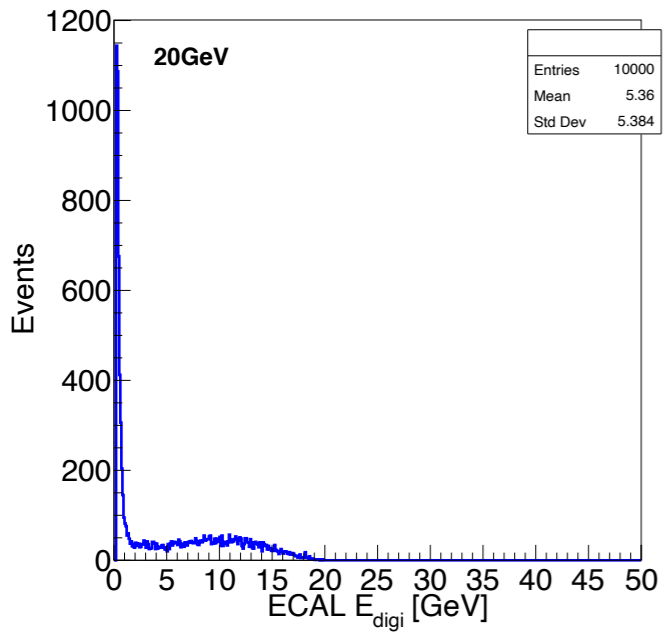
All events

Events with $E_{ECAL} < \text{threshold}$

Events with $E_{ECAL} > \text{threshold}$



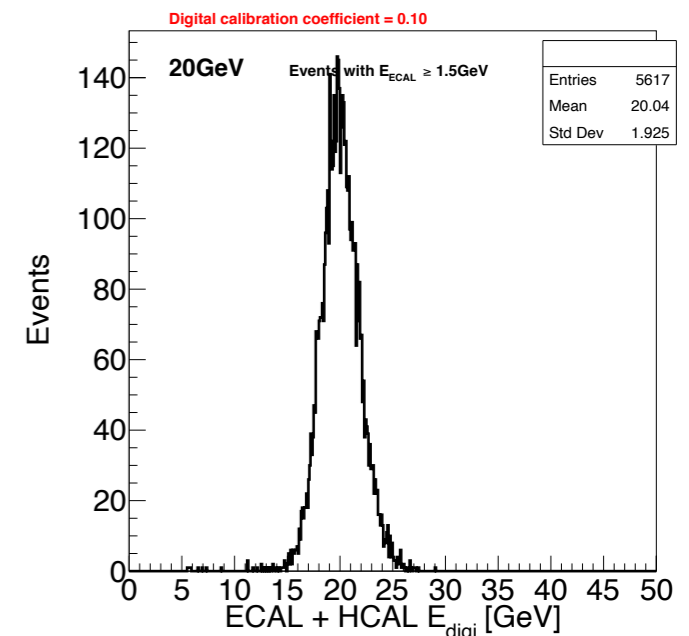
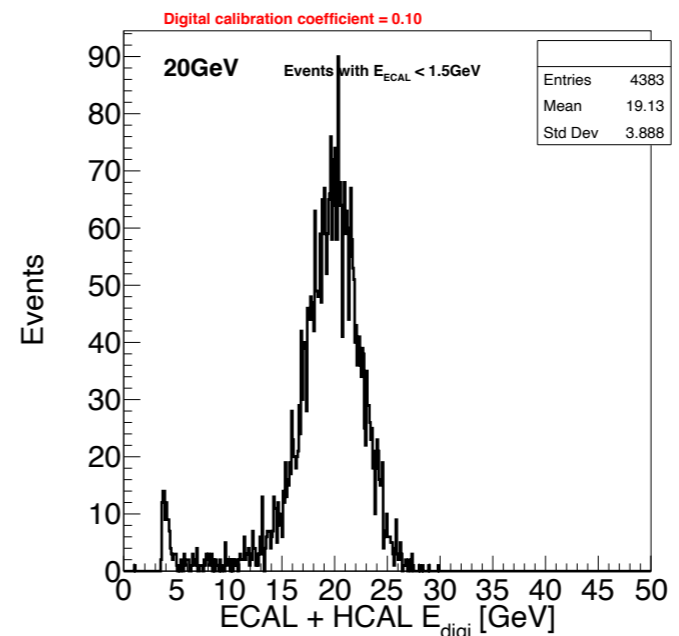
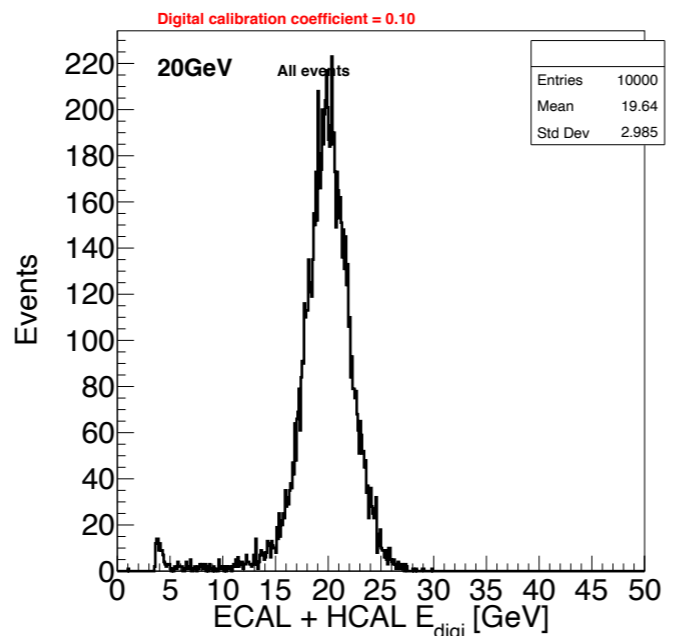
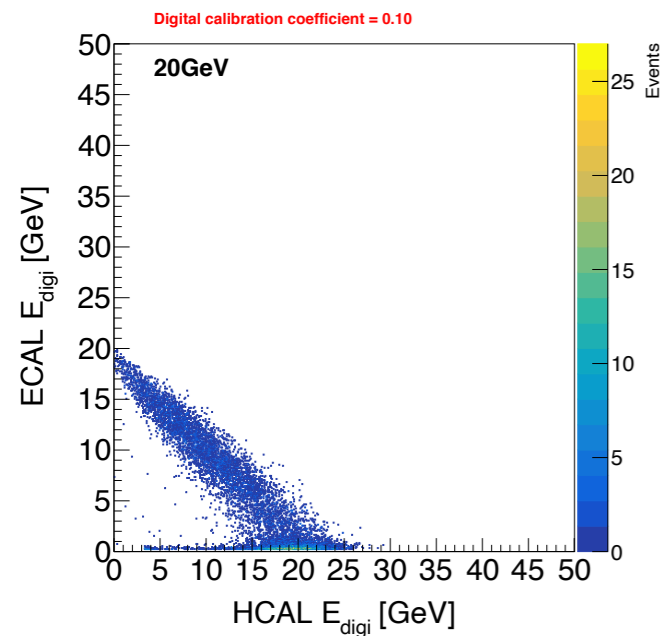
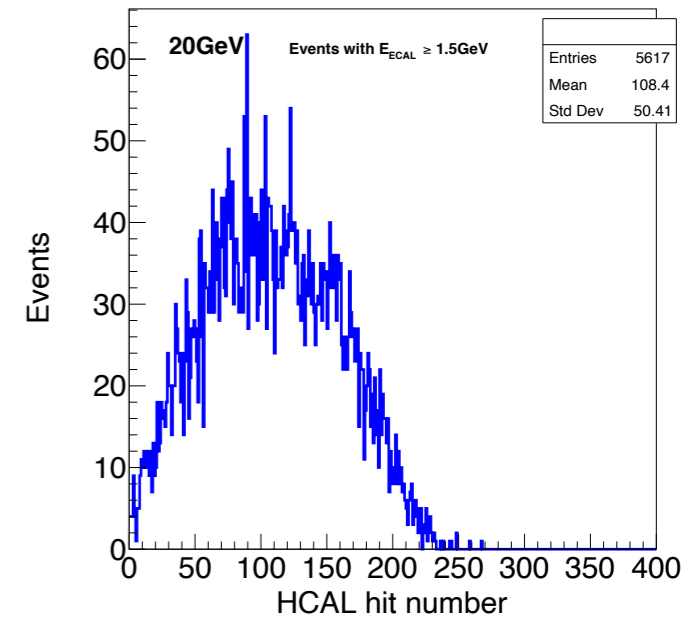
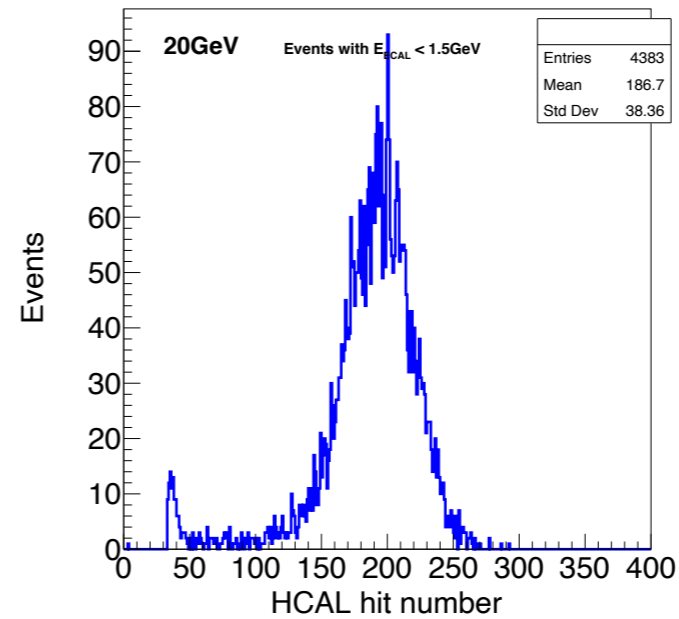
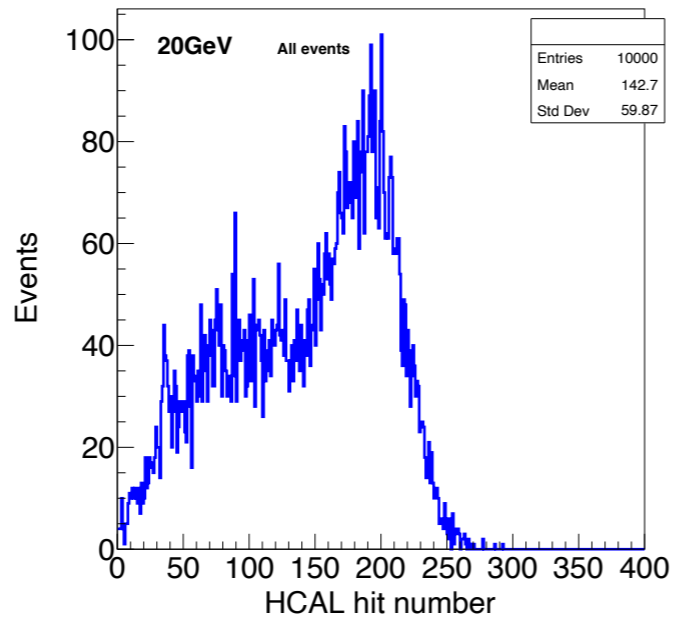
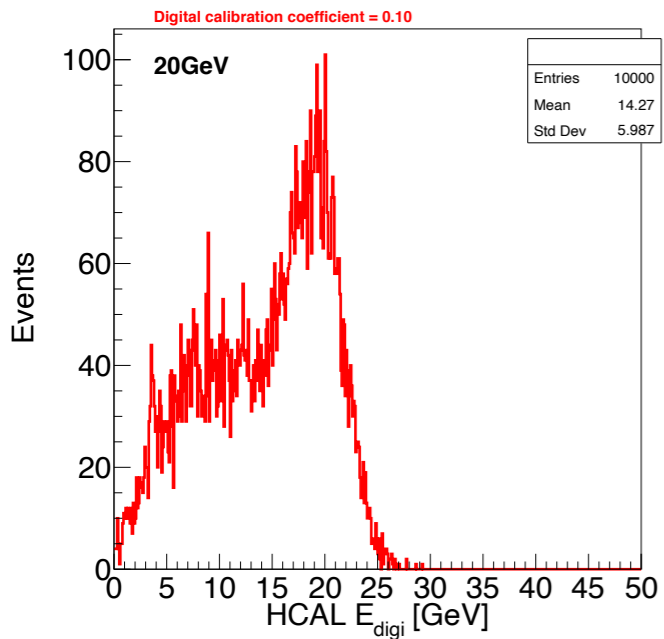
20GeV π^+



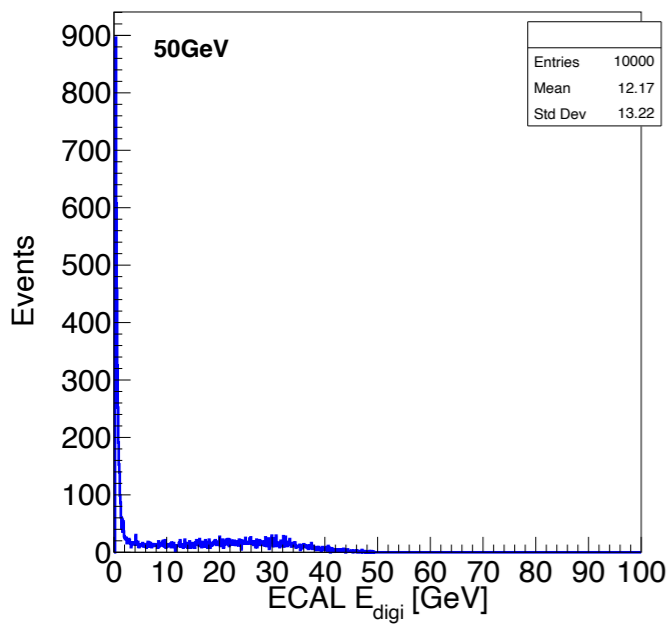
All events

Events with $E_{ECAL} < \text{threshold}$

Events with $E_{ECAL} > \text{threshold}$



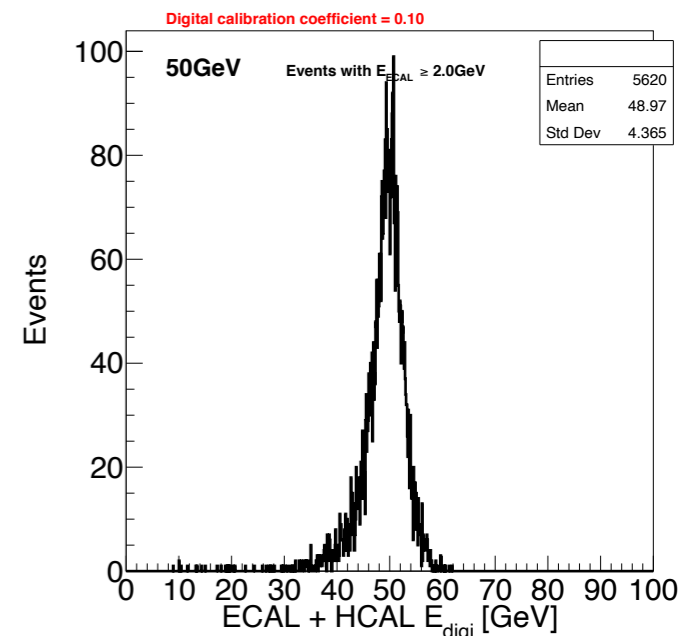
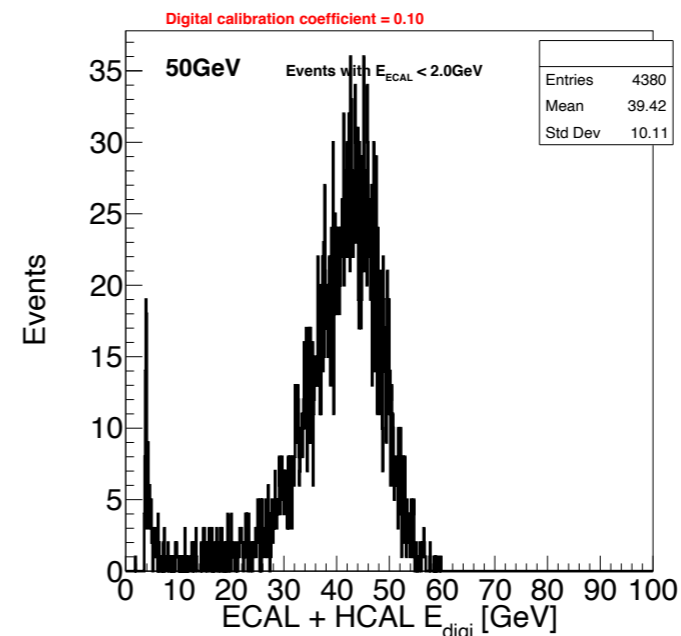
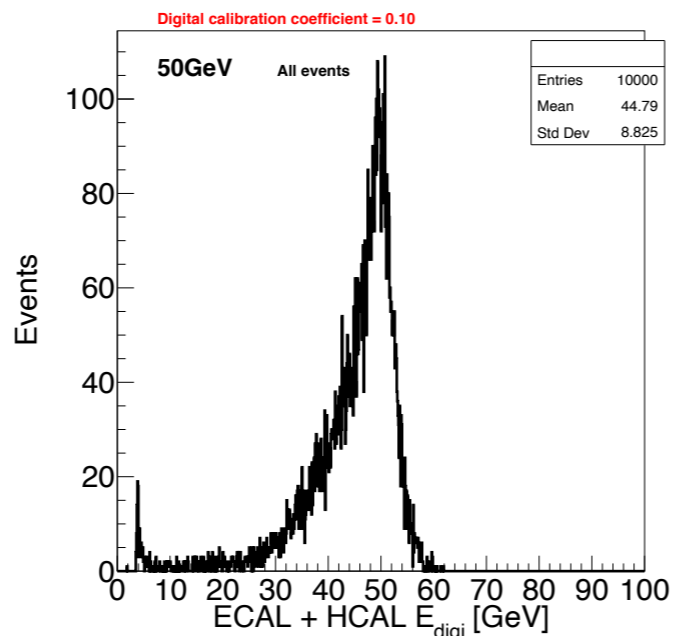
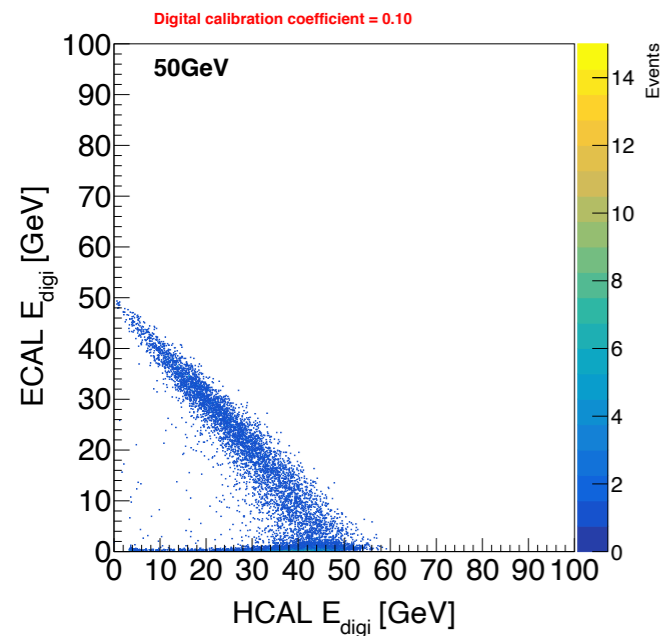
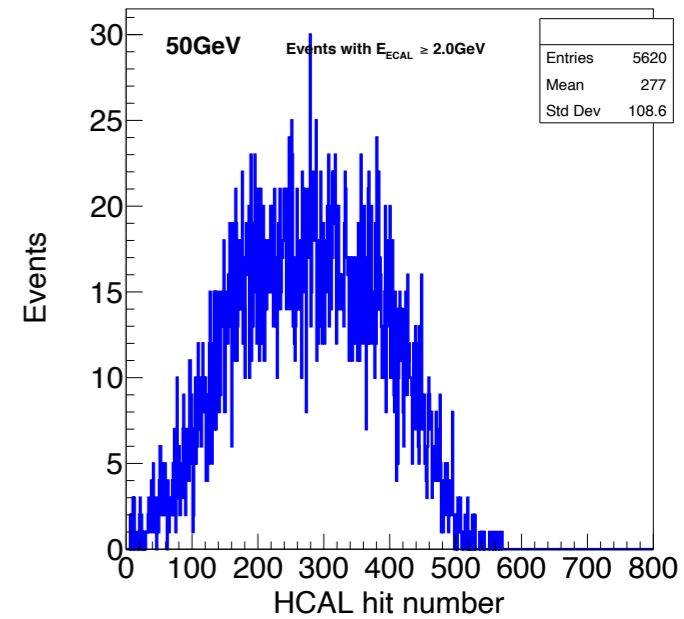
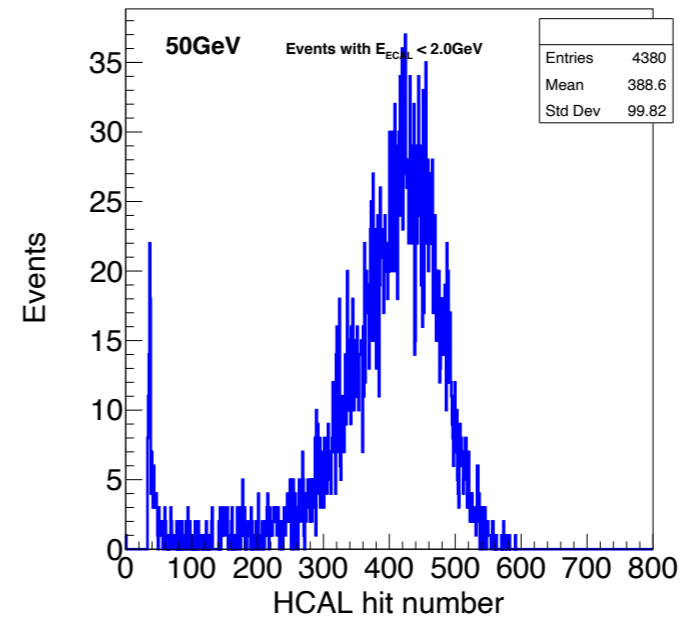
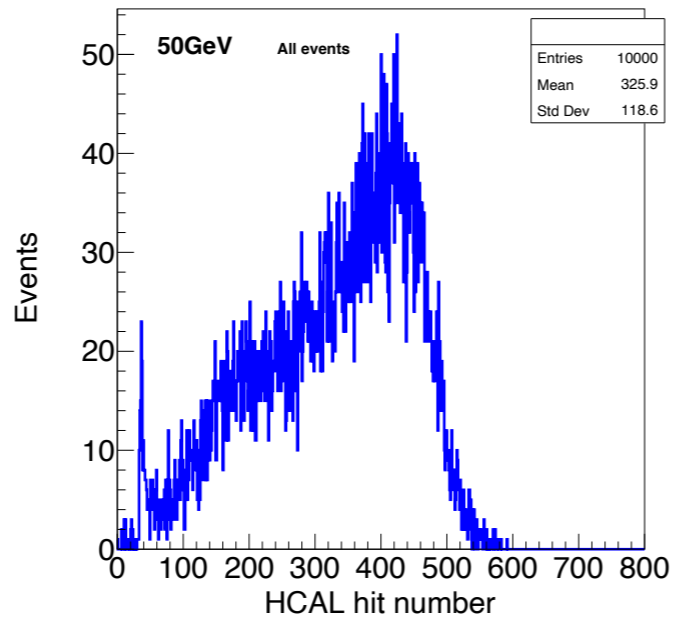
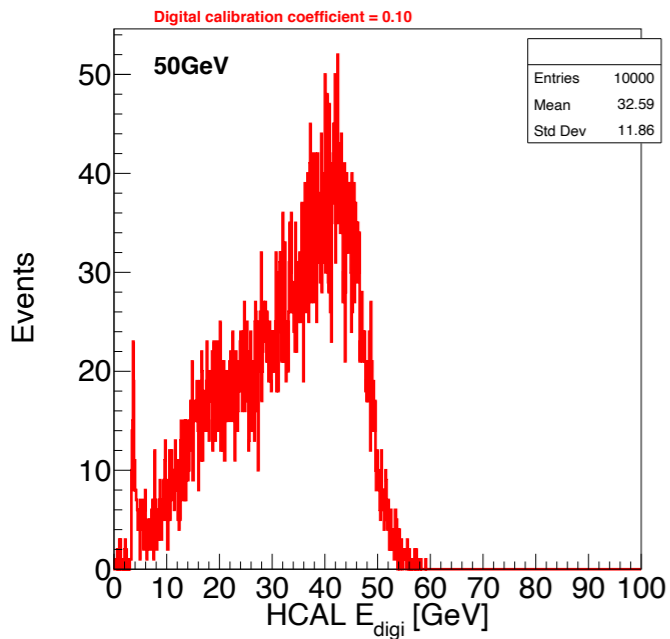
50GeV π^+



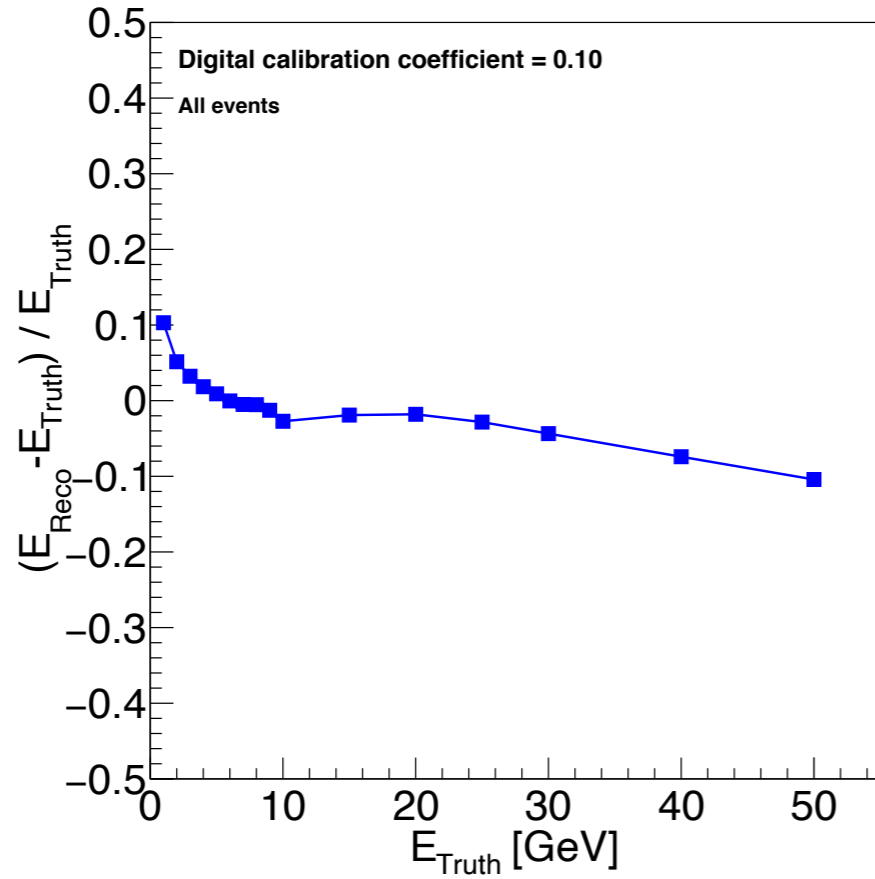
All events

Events with $E_{ECAL} < \text{threshold}$

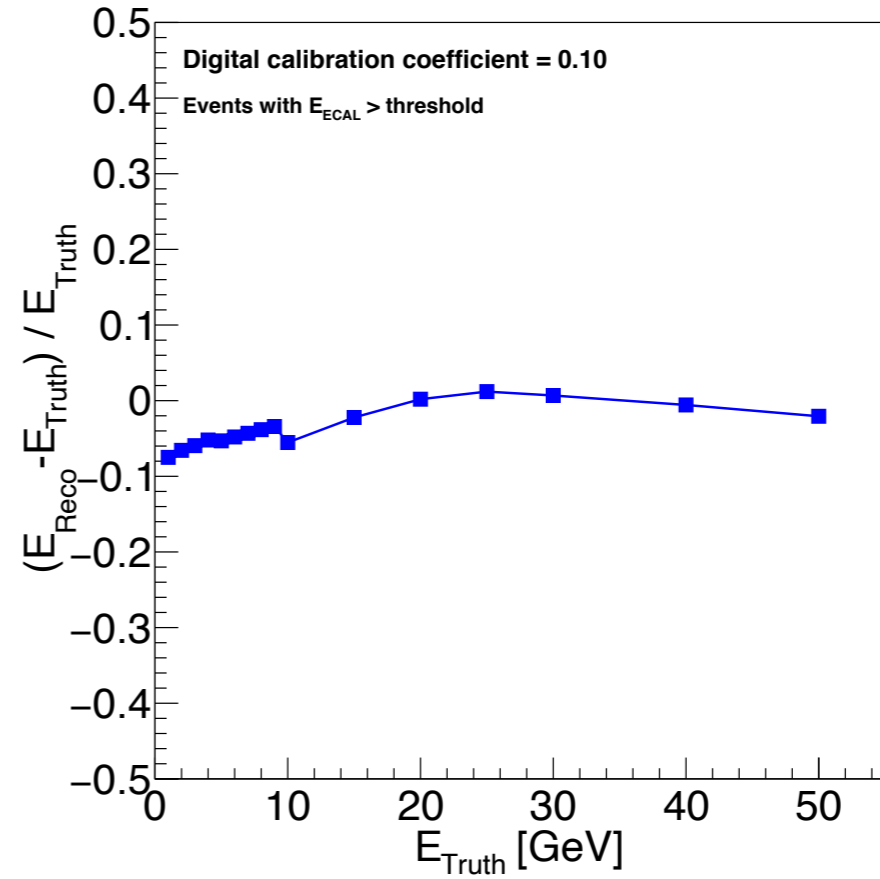
Events with $E_{ECAL} > \text{threshold}$



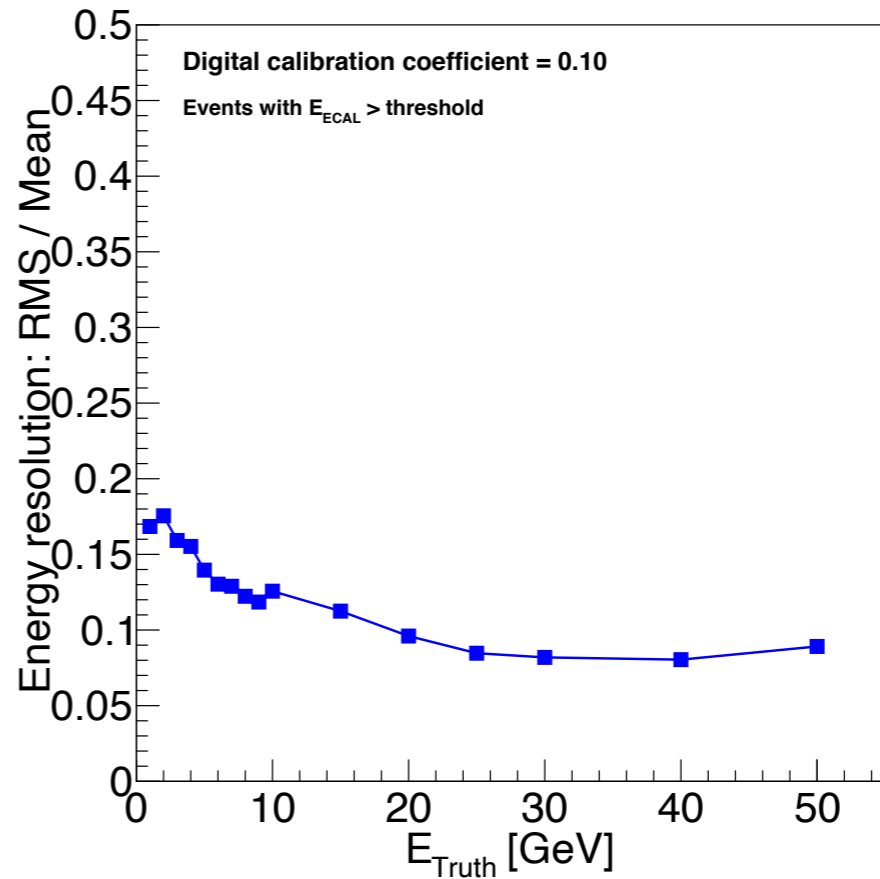
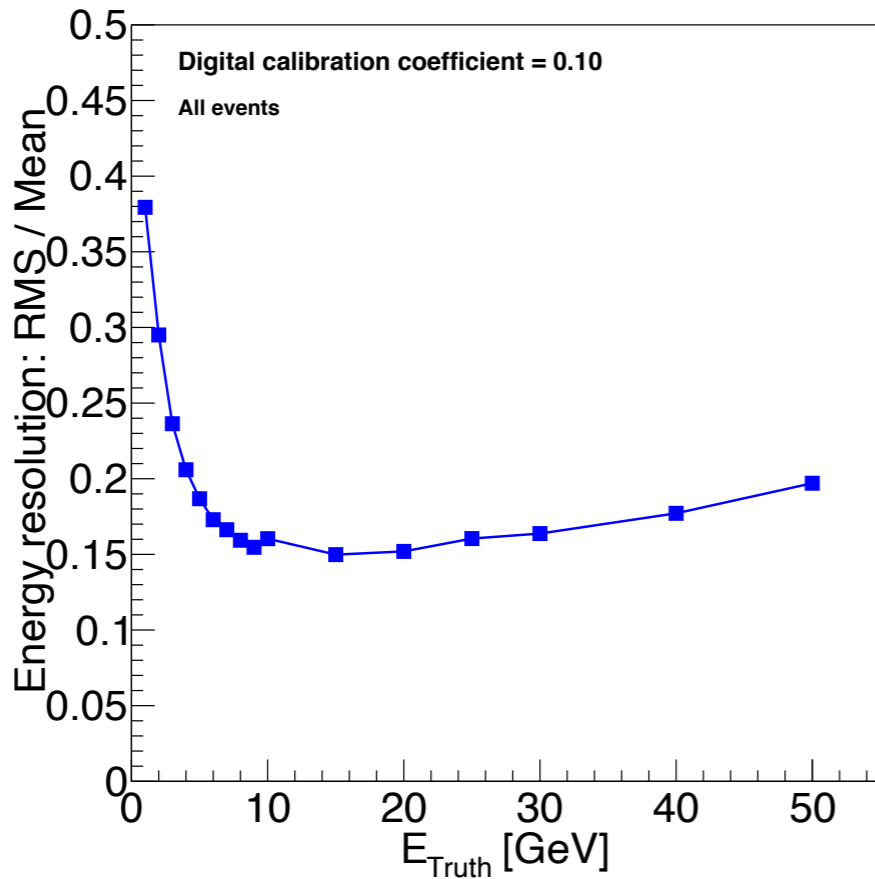
All events



Events with $E_{\text{ECAL}} > \text{threshold}$



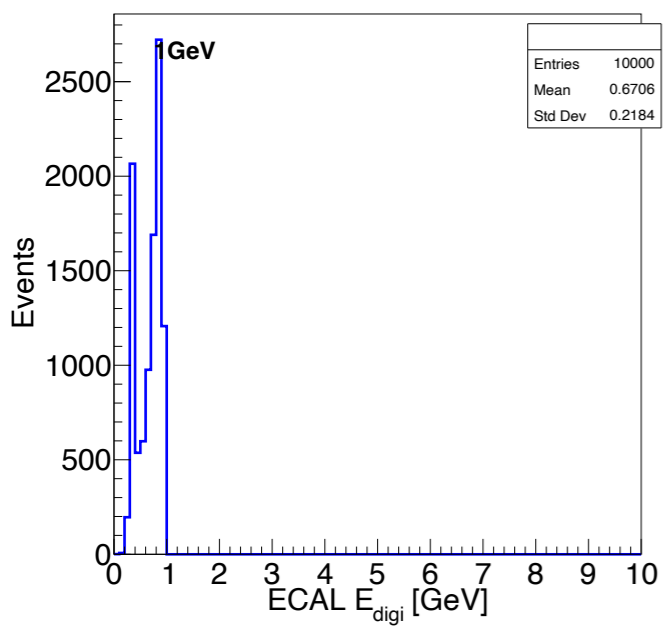
Linearity



Resolution
(RMS / Mean)

BaF2 ECAL + SDHCAL

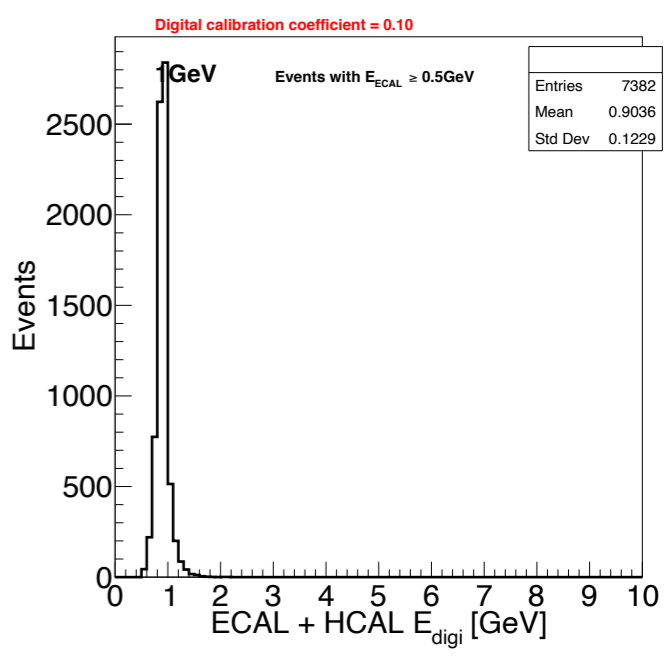
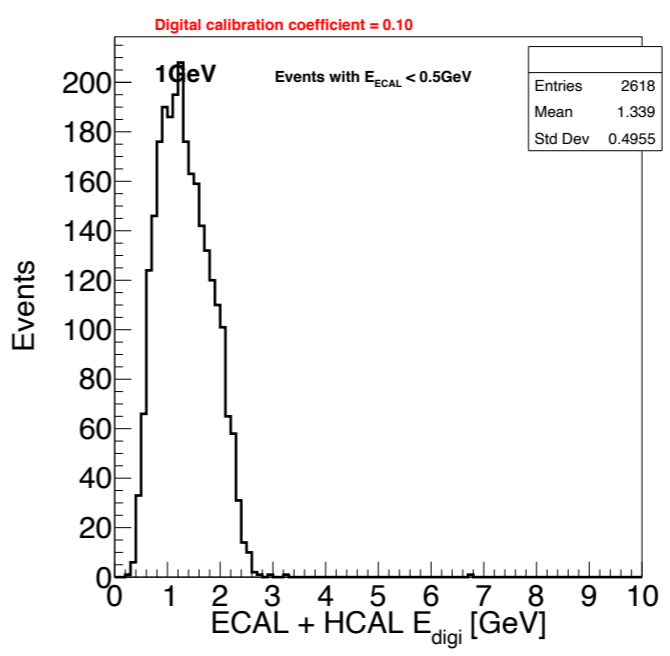
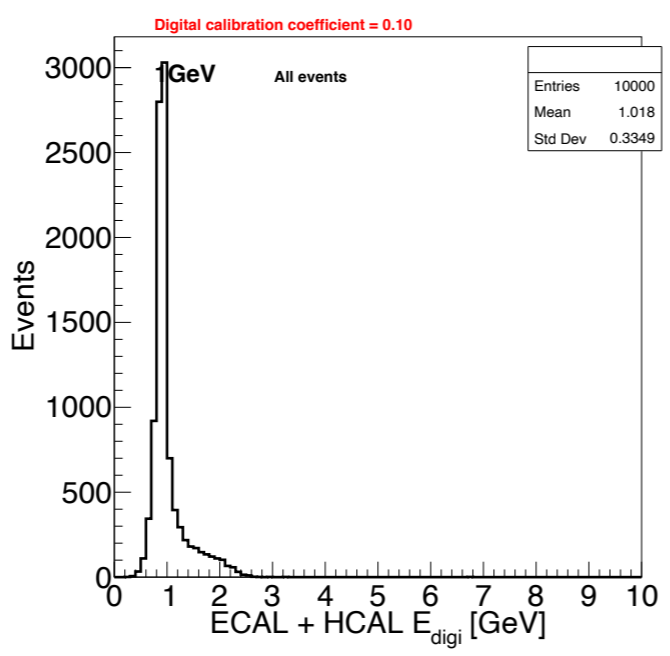
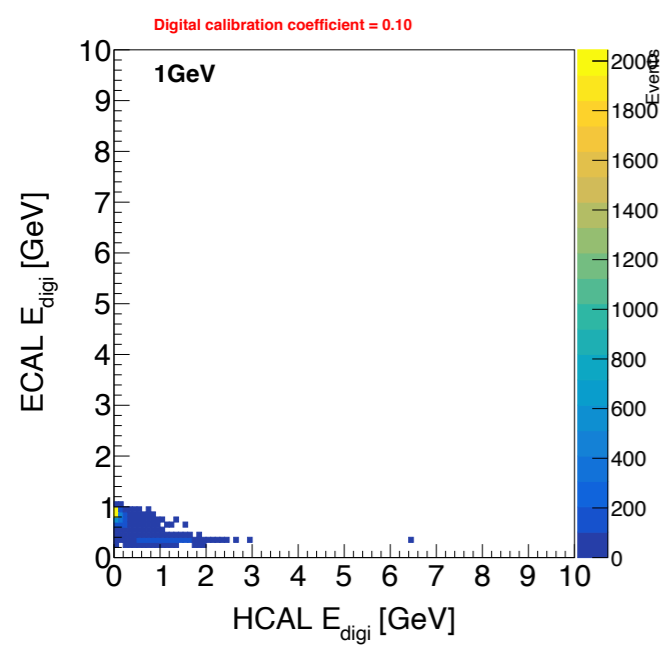
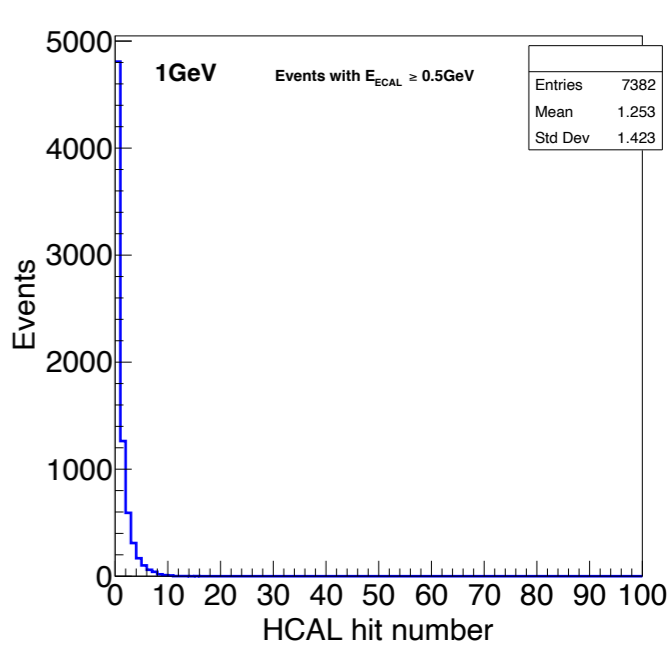
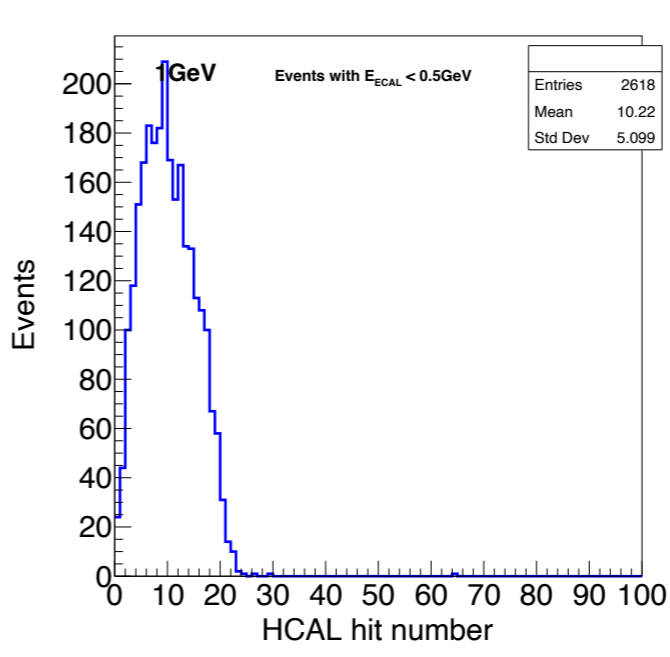
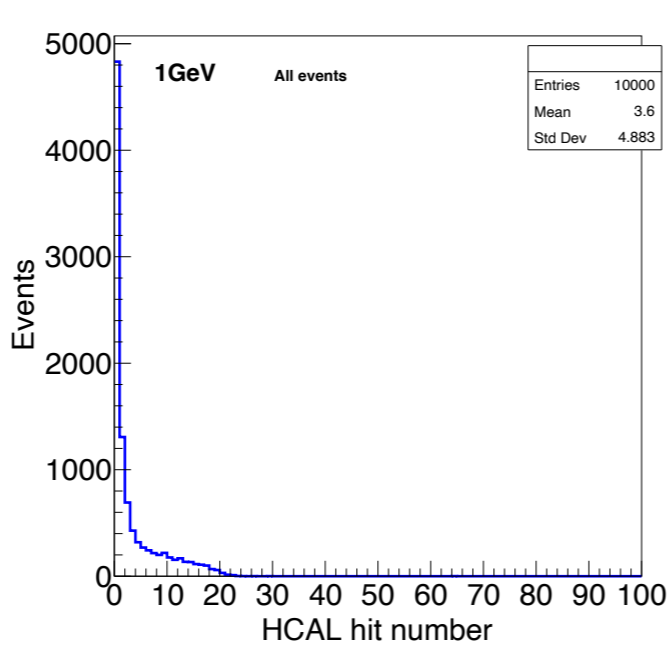
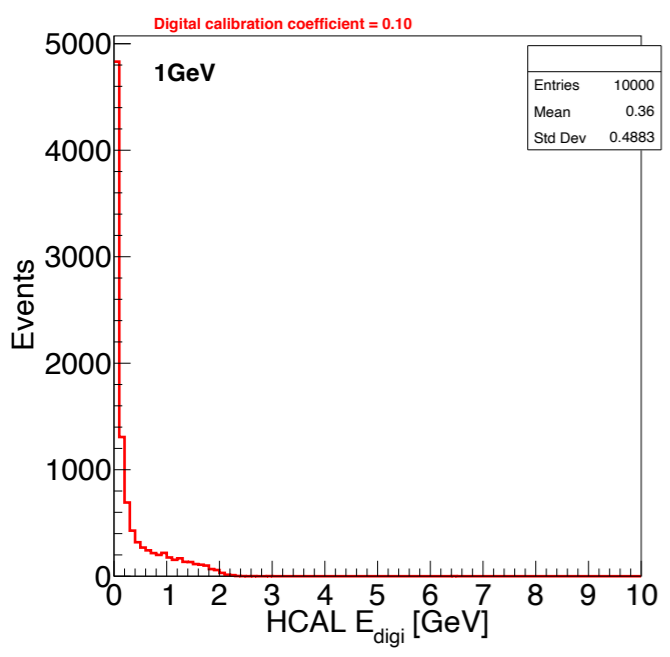
1GeV π^+



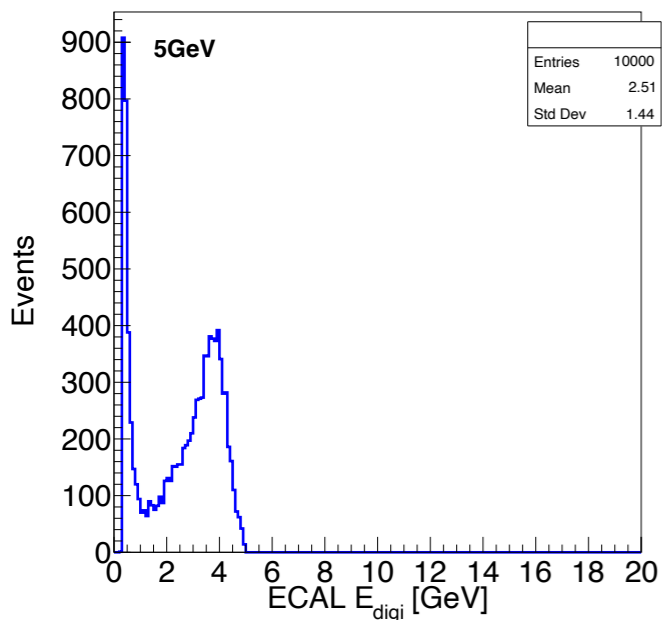
All events

Events with $E_{ECAL} < \text{threshold}$

Events with $E_{ECAL} > \text{threshold}$



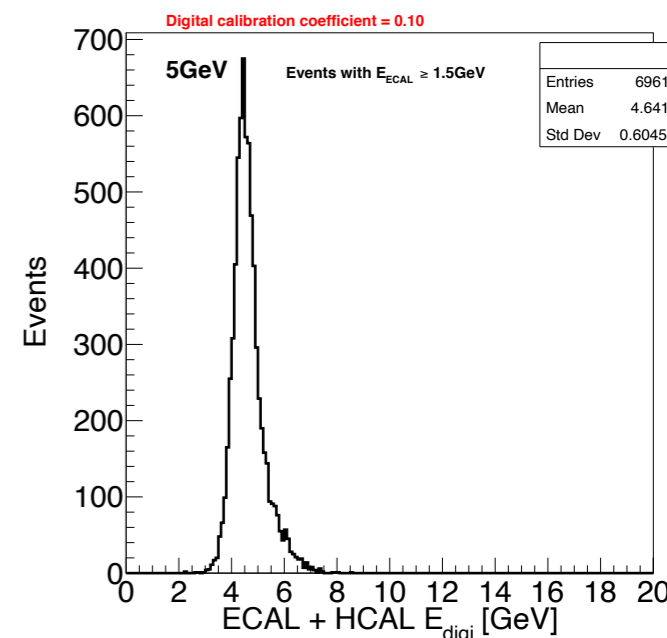
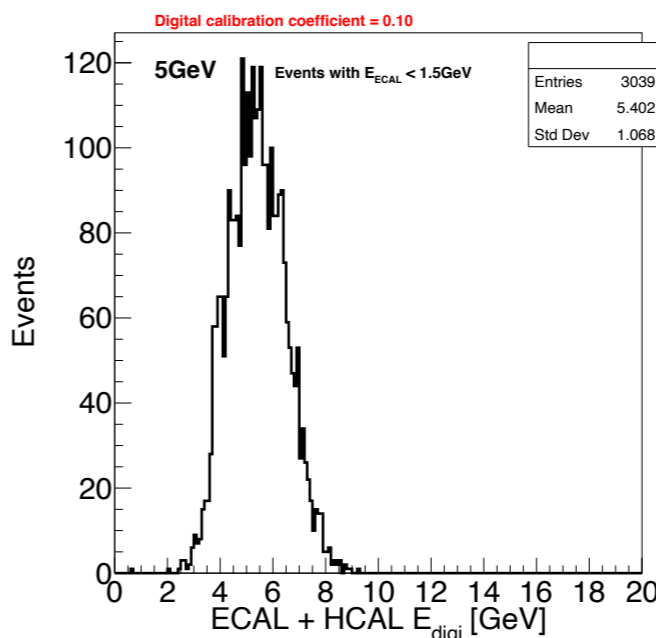
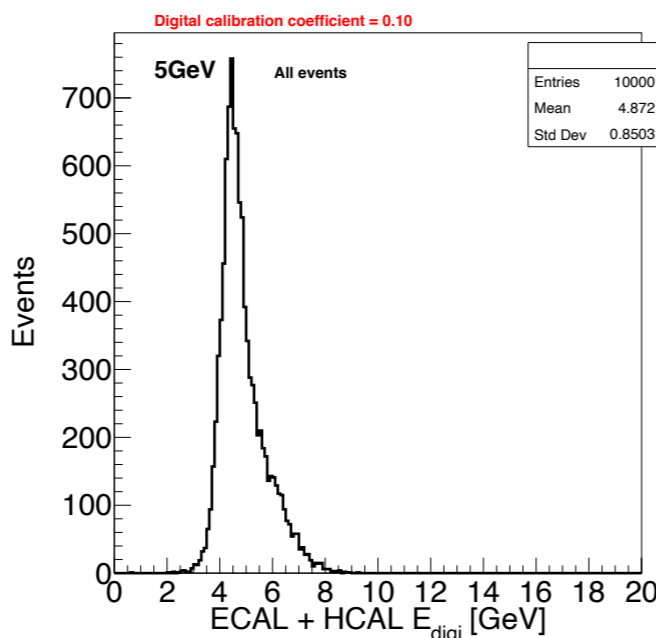
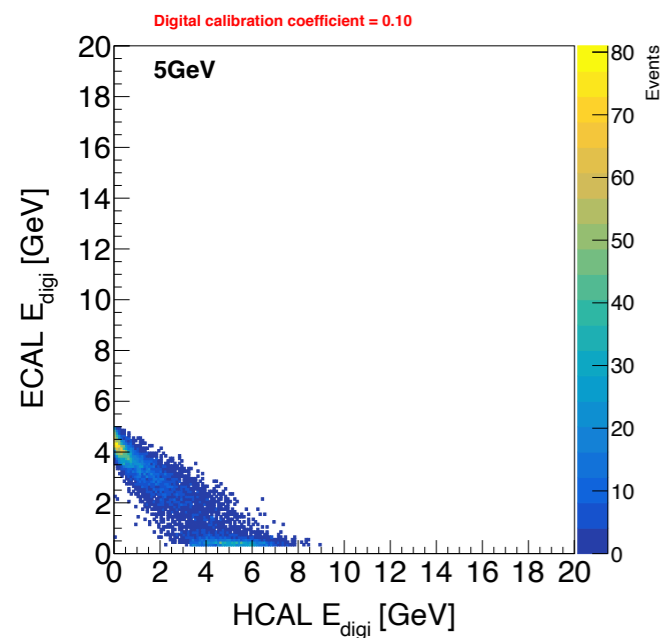
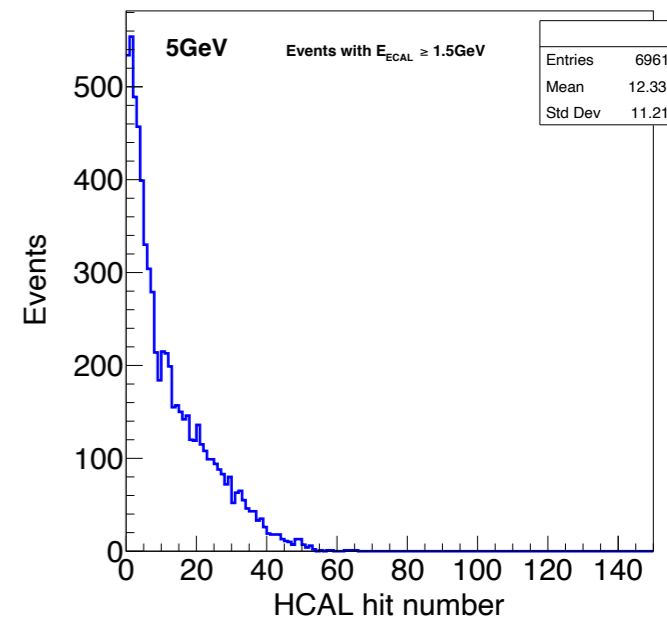
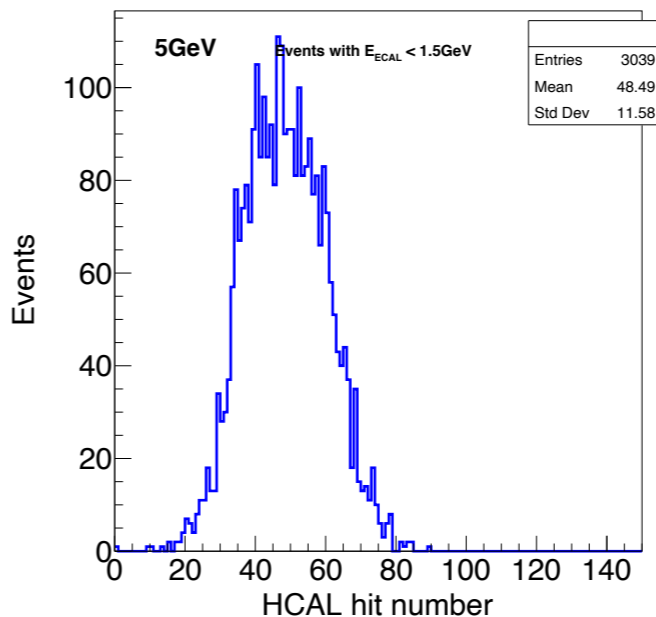
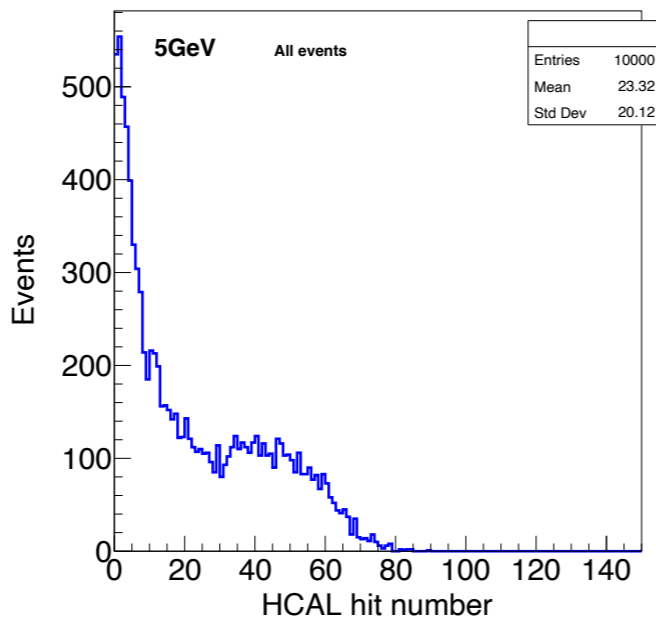
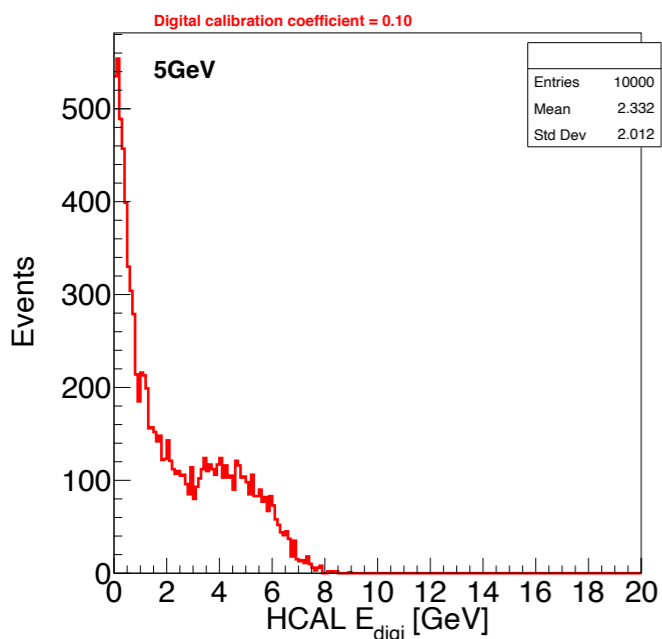
5GeV π^+



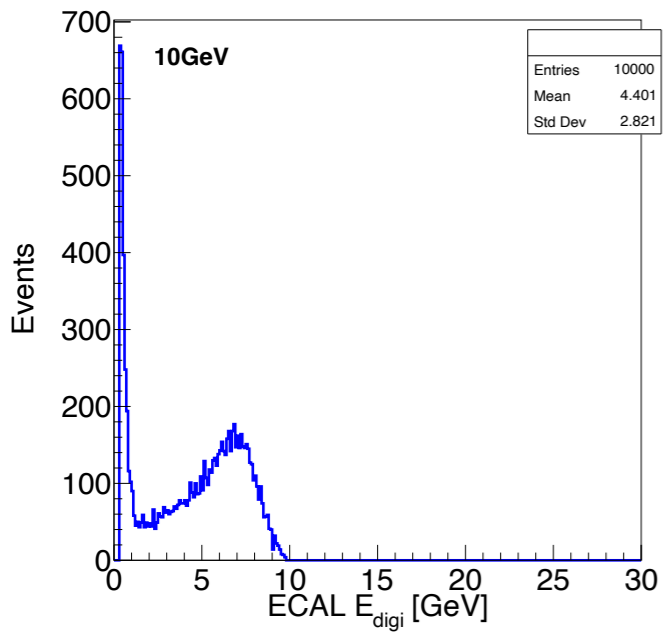
All events

Events with $E_{ECAL} < \text{threshold}$

Events with $E_{ECAL} > \text{threshold}$



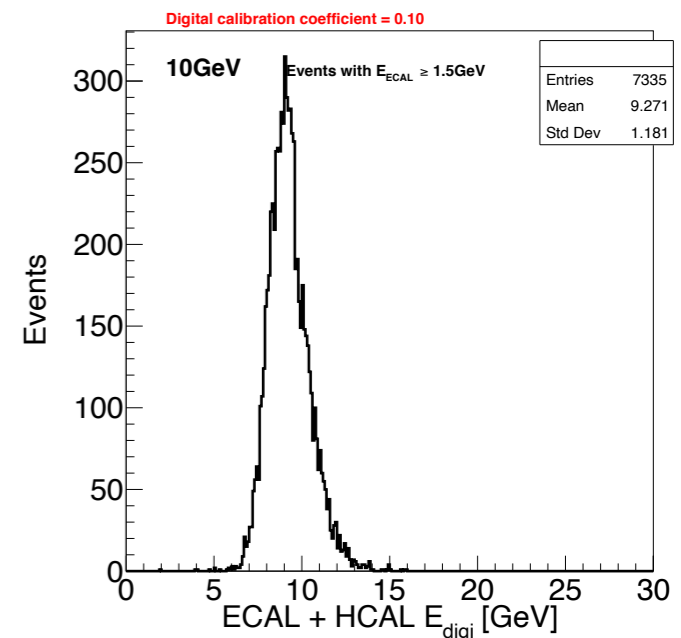
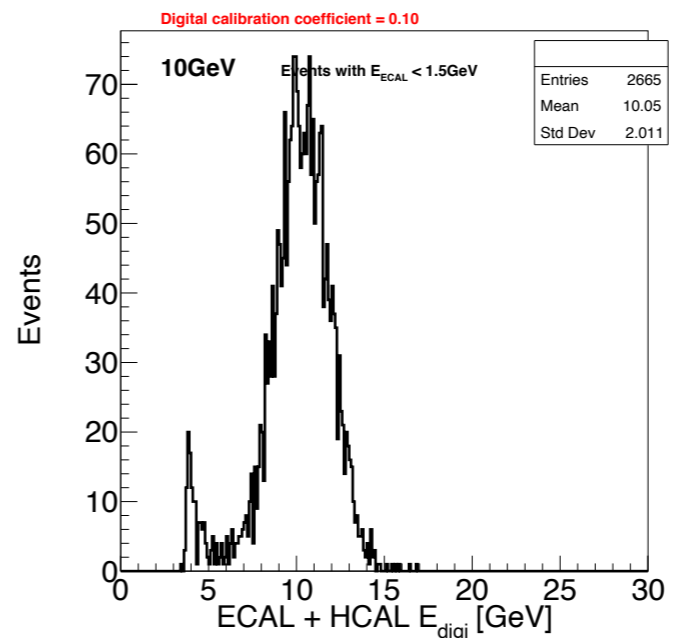
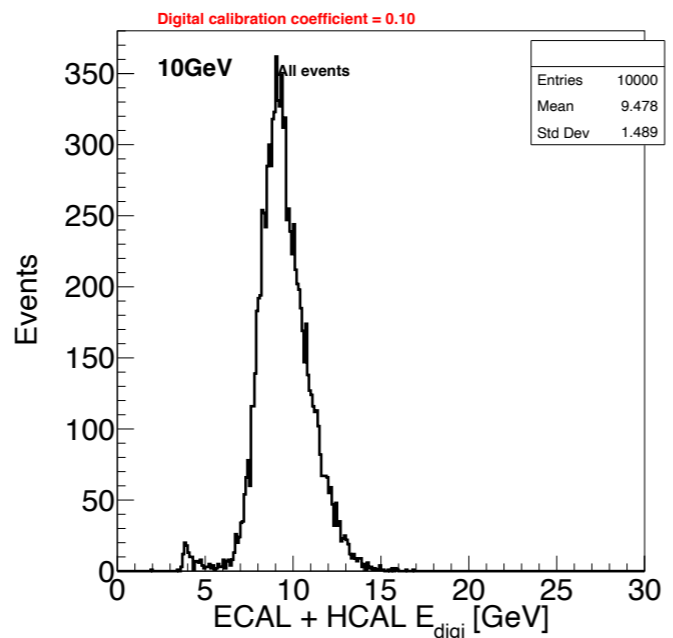
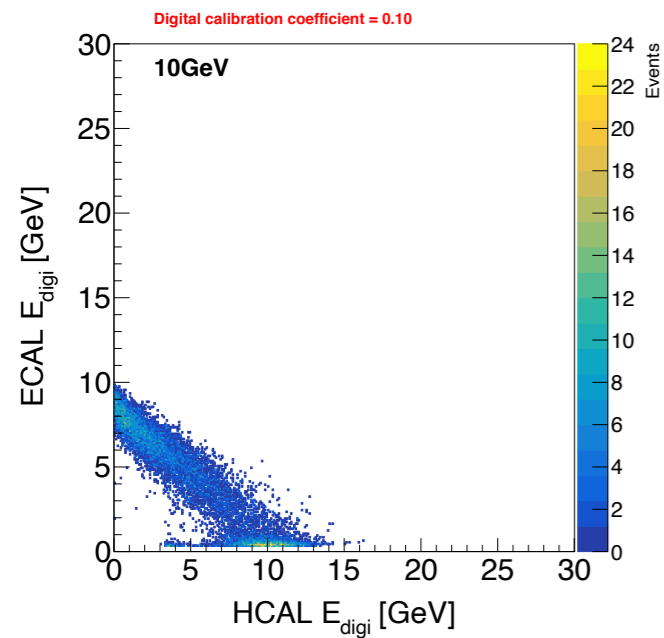
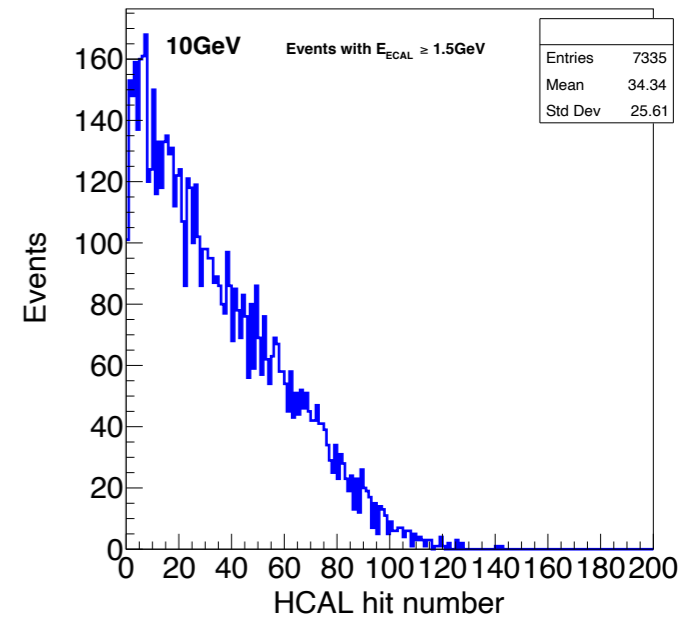
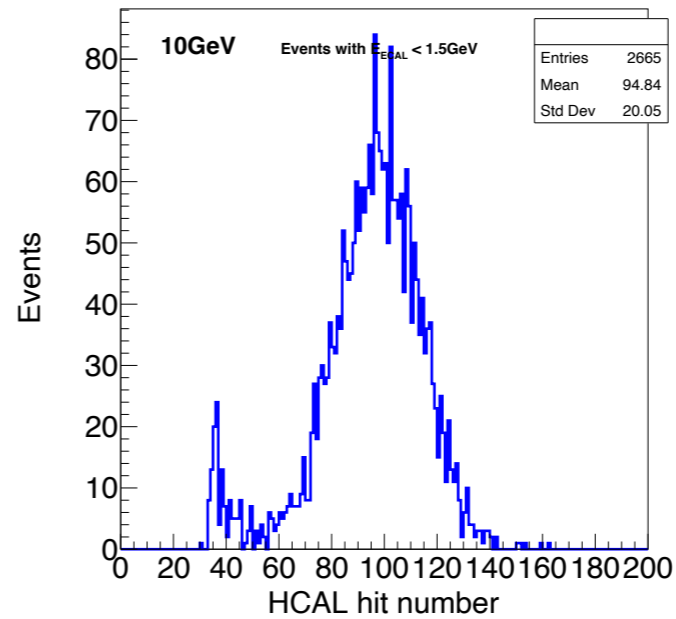
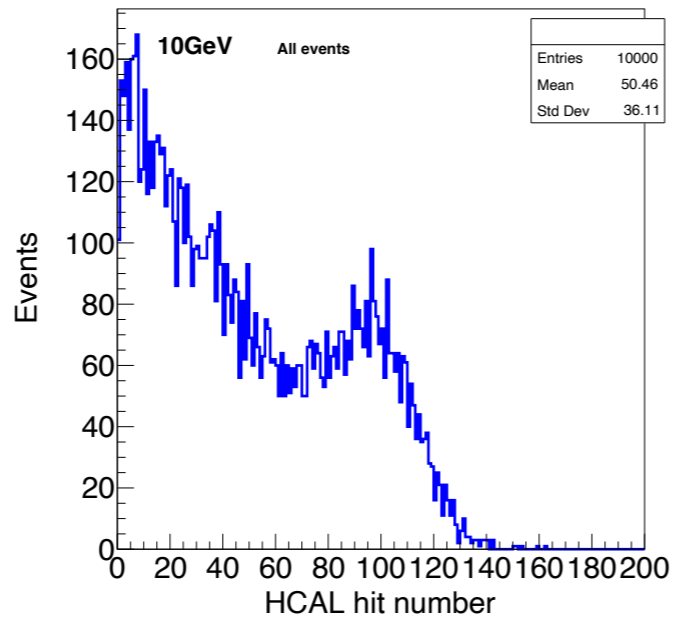
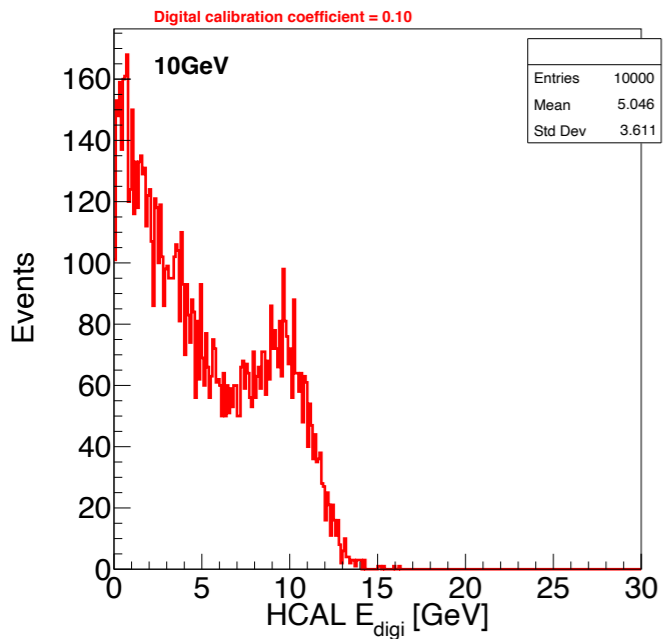
10GeV π^+



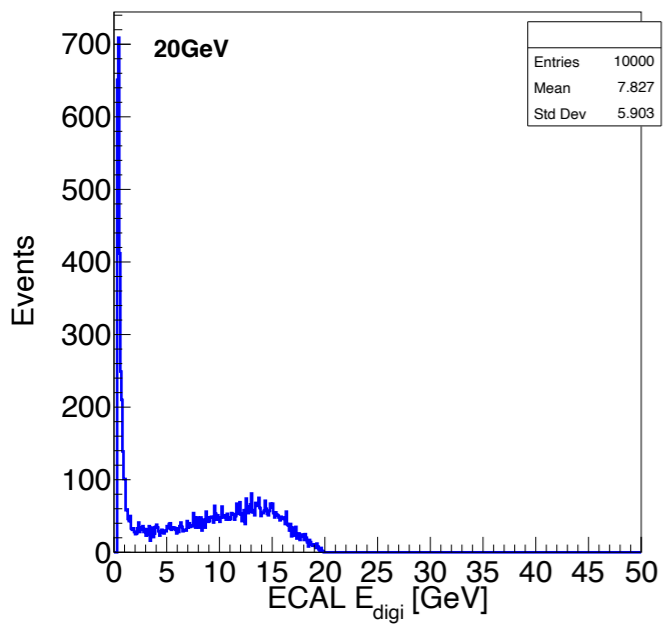
All events

Events with $E_{ECAL} < \text{threshold}$

Events with $E_{ECAL} > \text{threshold}$



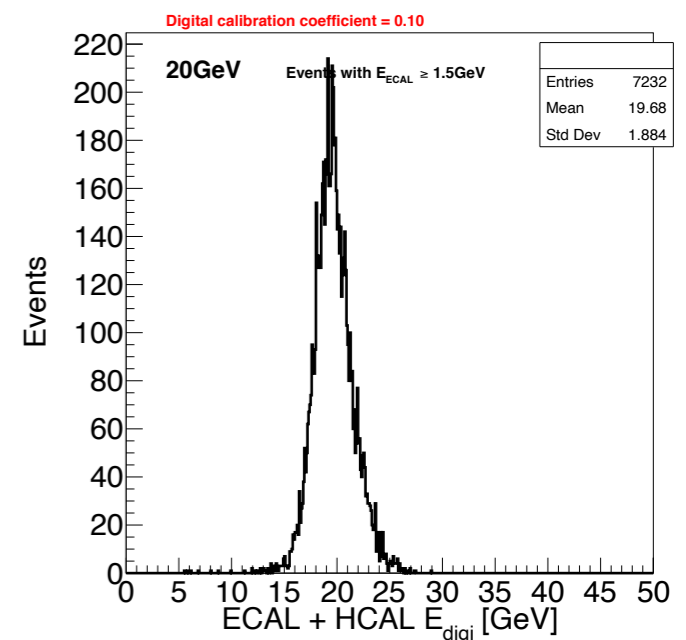
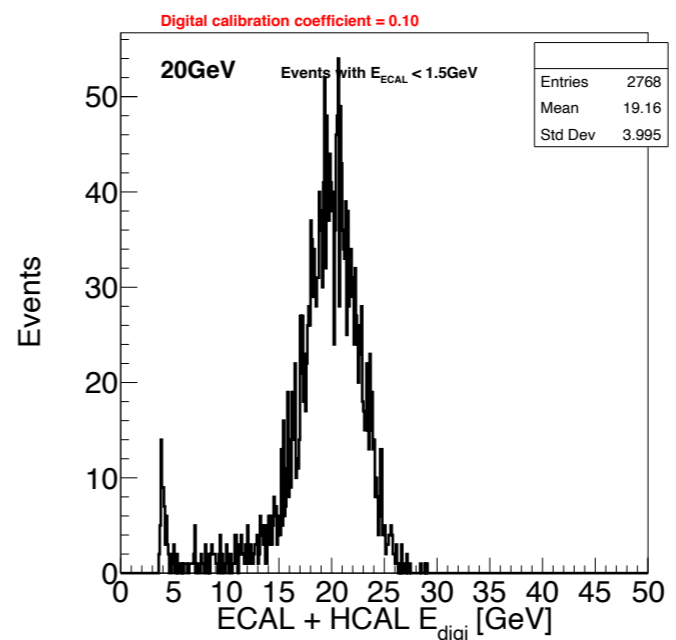
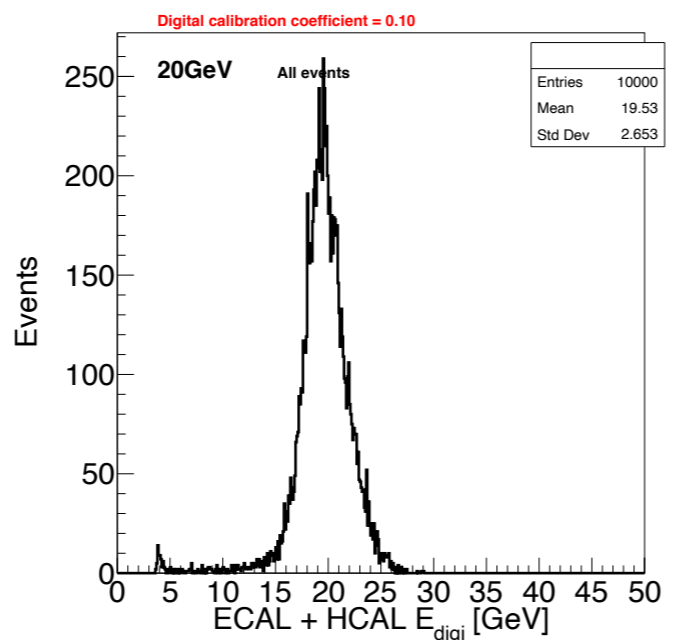
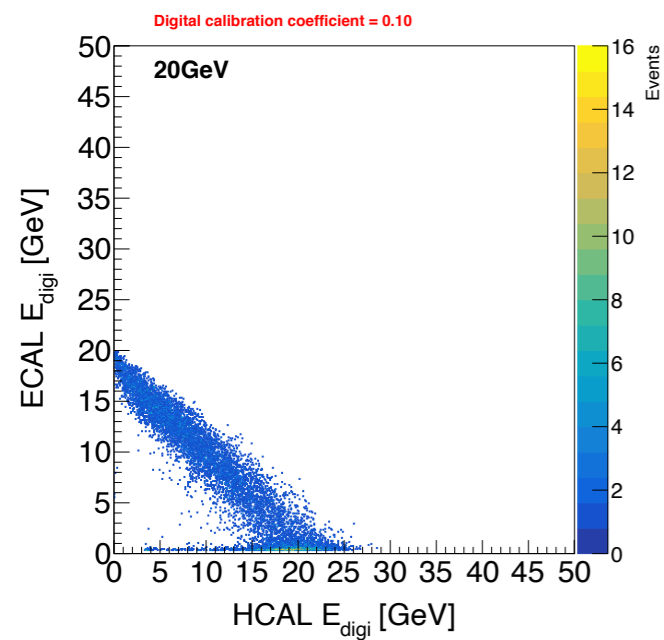
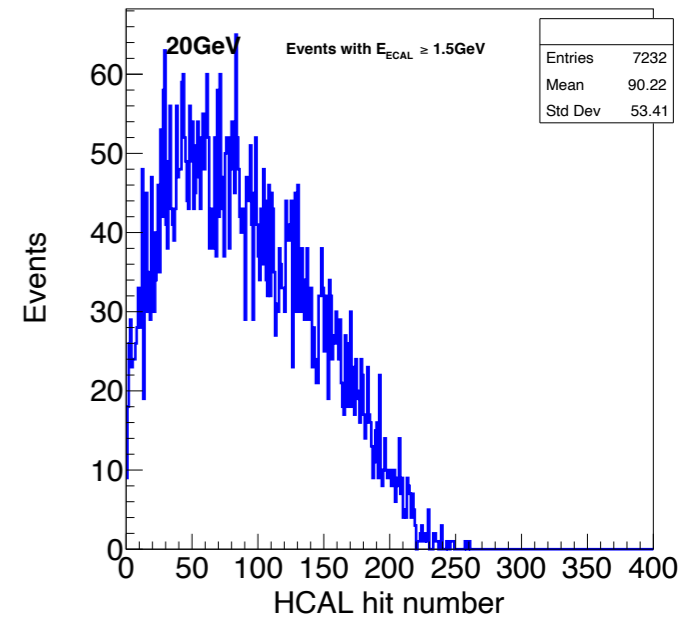
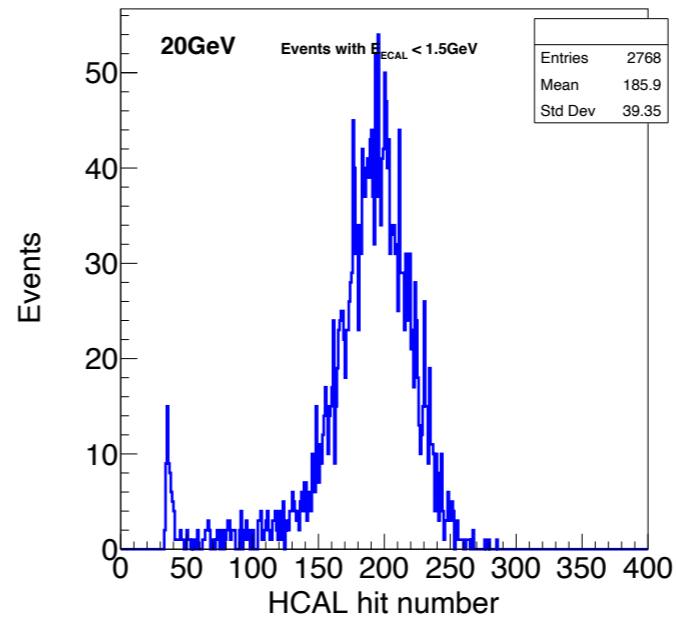
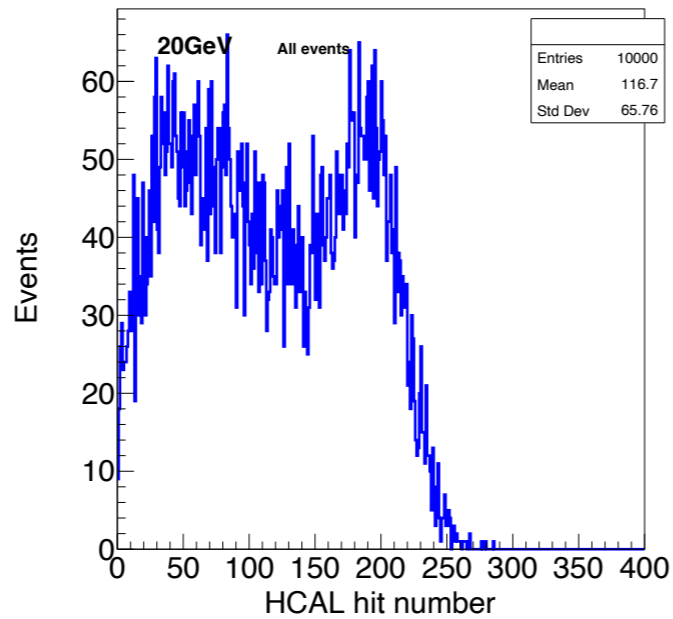
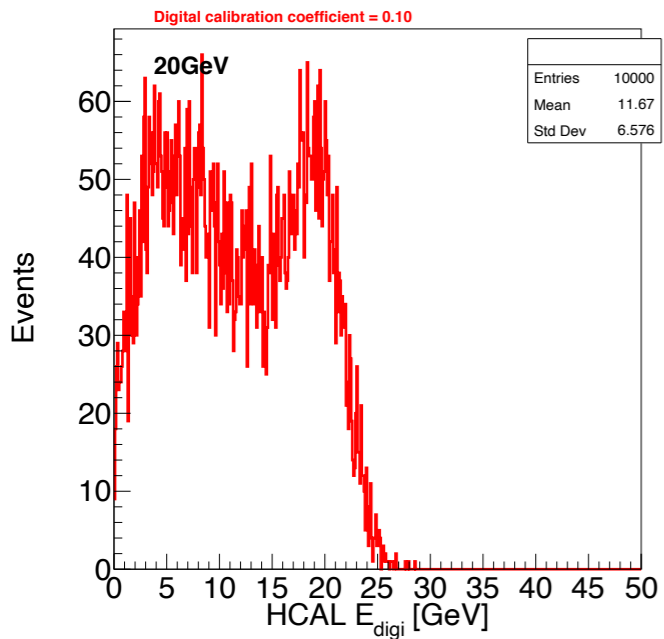
20GeV π^+



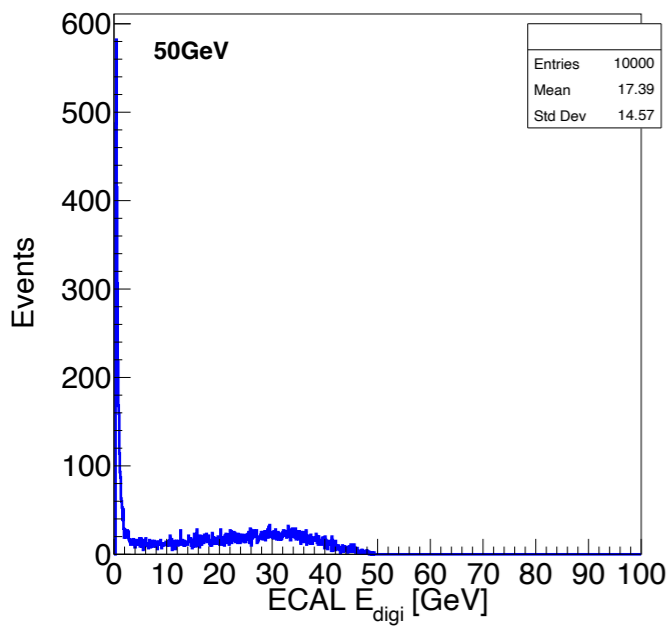
All events

Events with $E_{ECAL} < \text{threshold}$

Events with $E_{ECAL} > \text{threshold}$



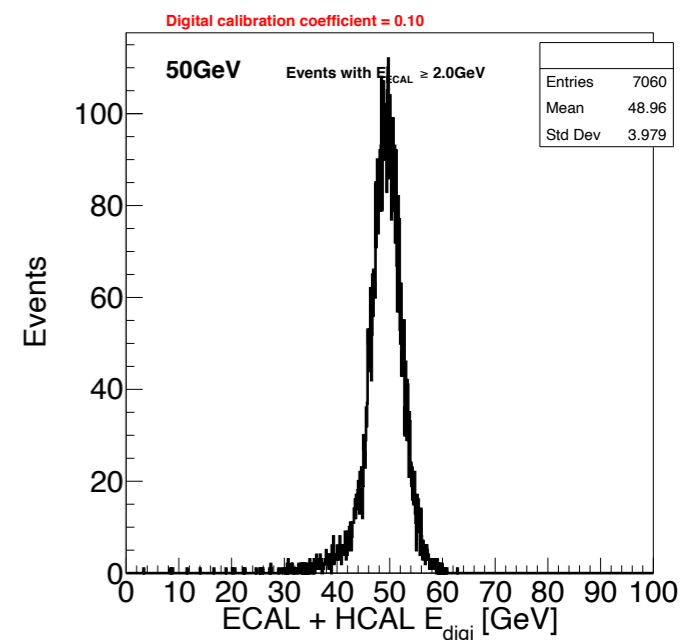
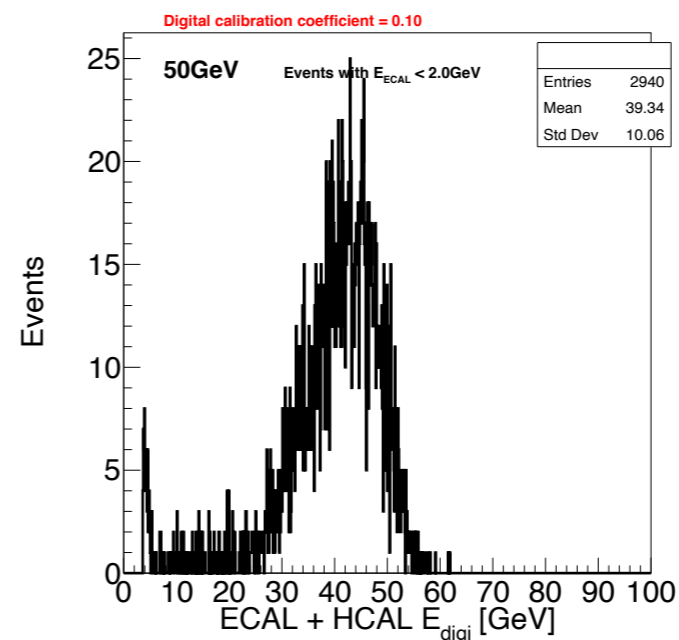
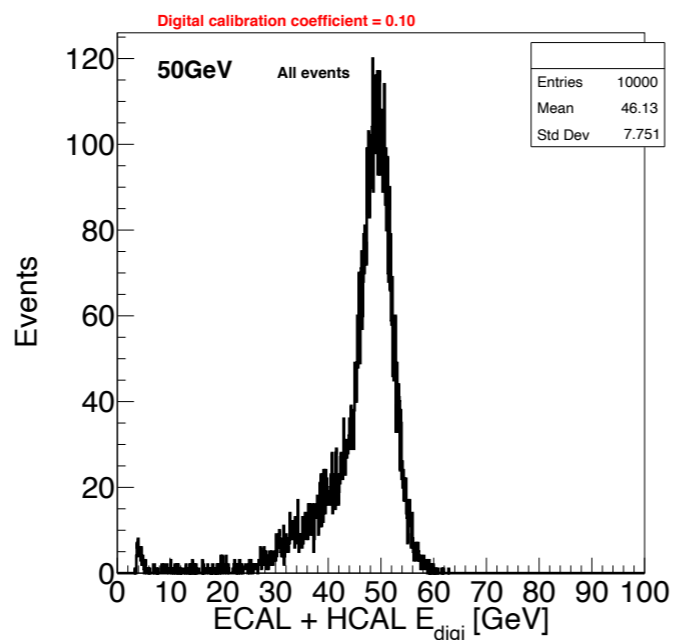
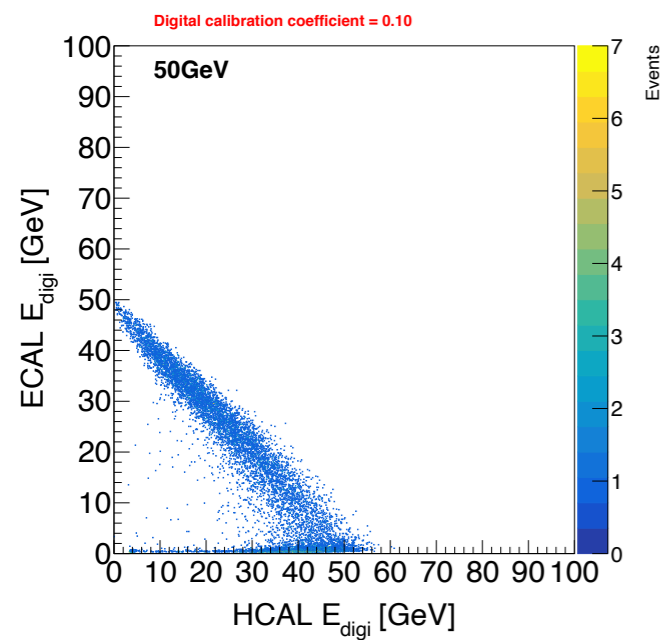
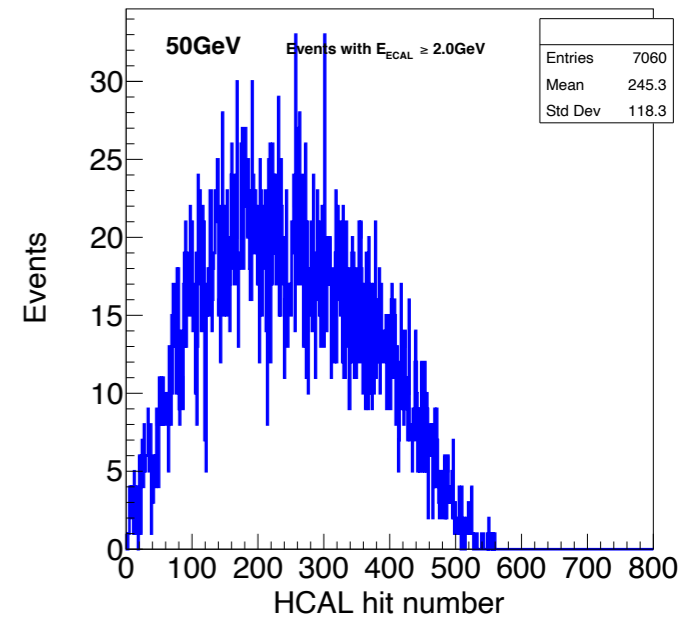
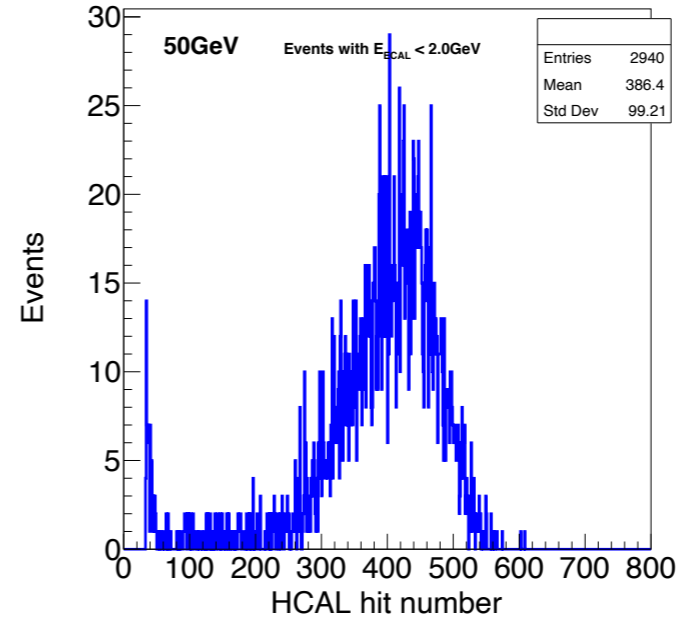
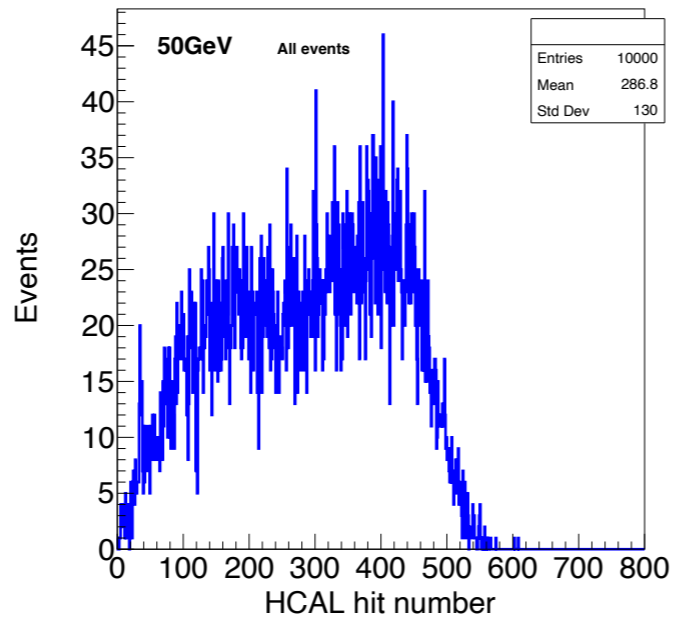
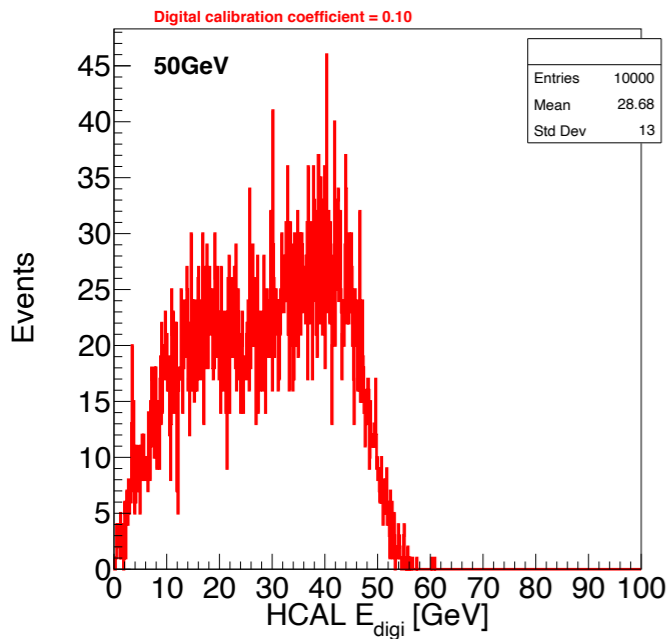
50GeV π^+



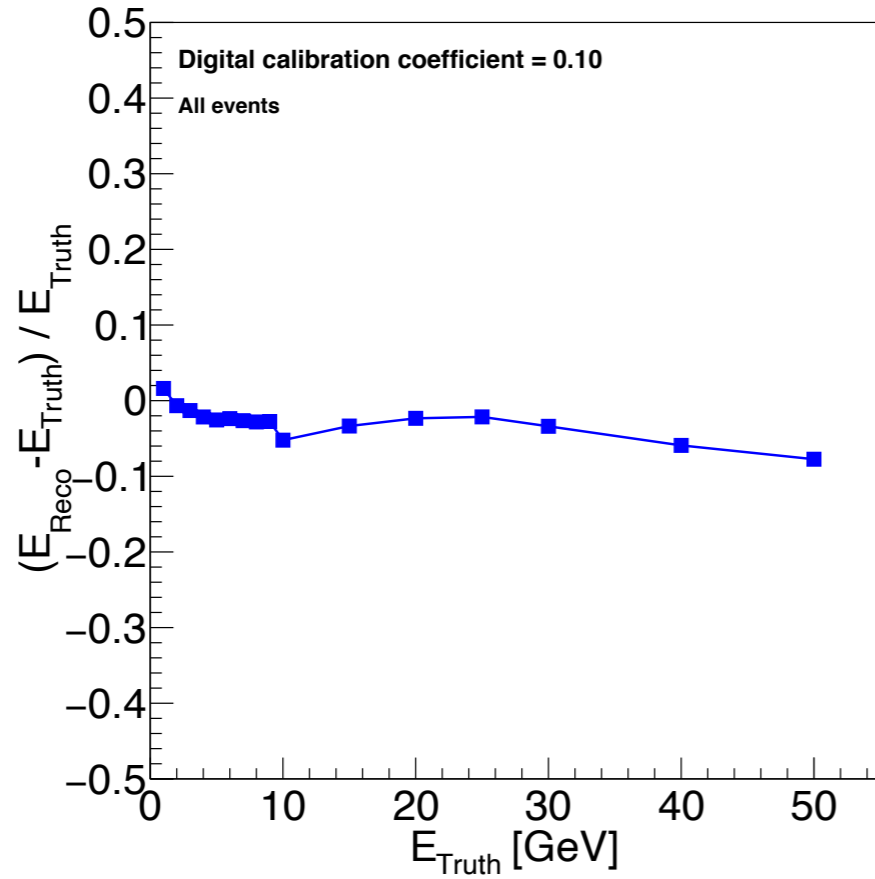
All events

Events with $E_{ECAL} < \text{threshold}$

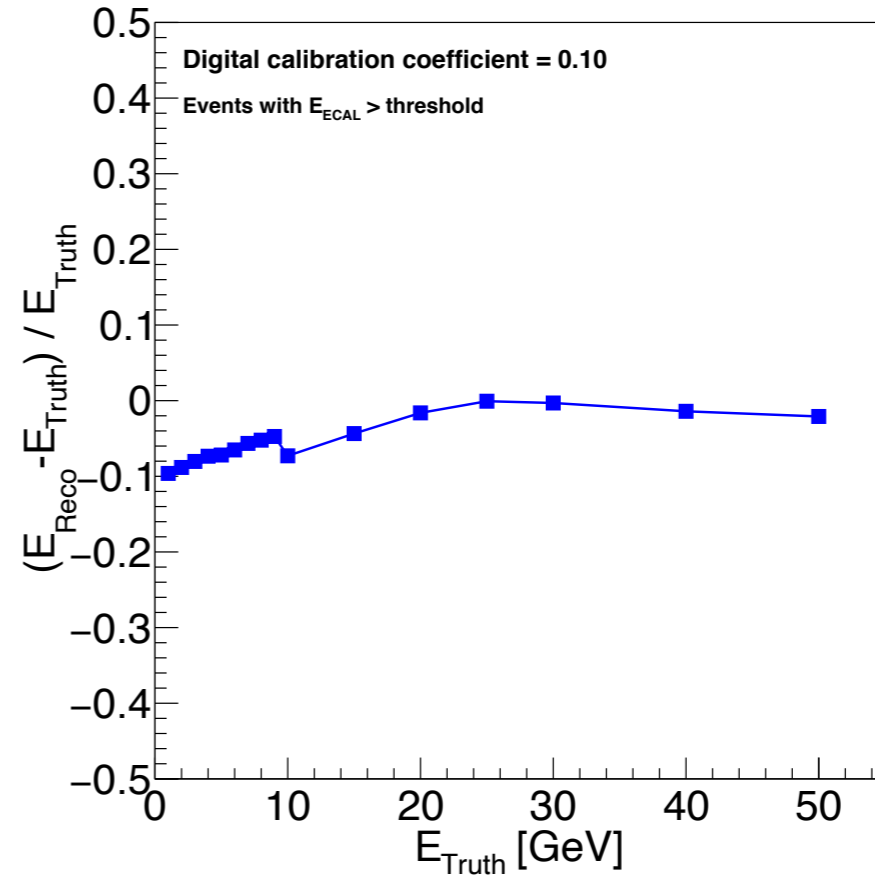
Events with $E_{ECAL} > \text{threshold}$



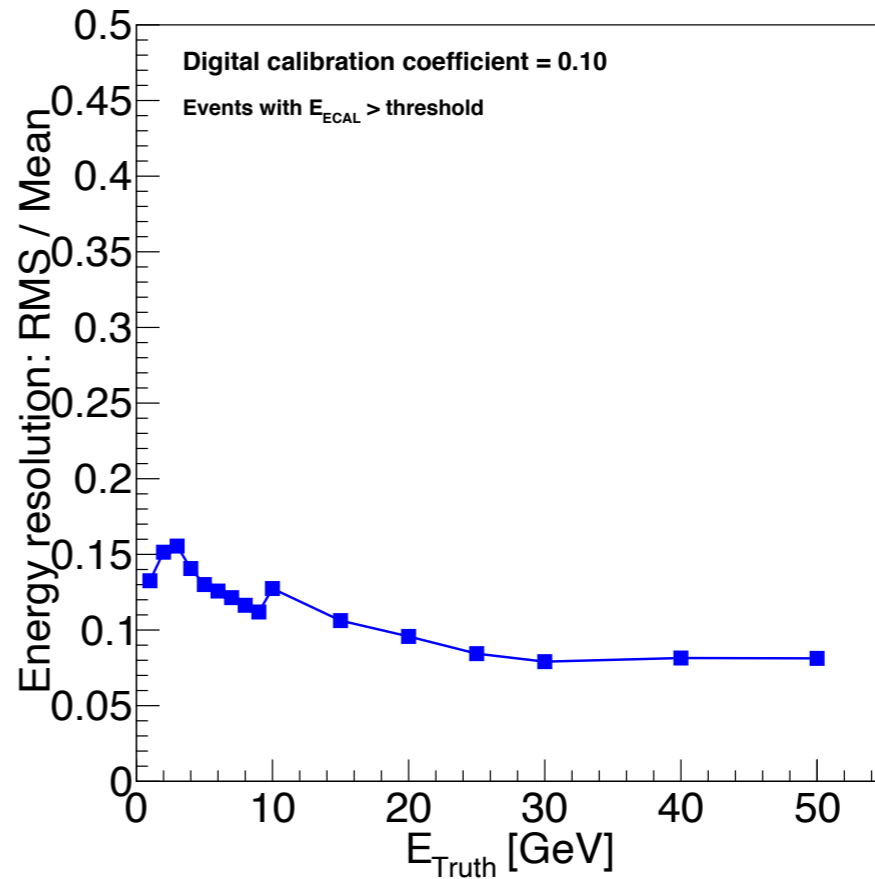
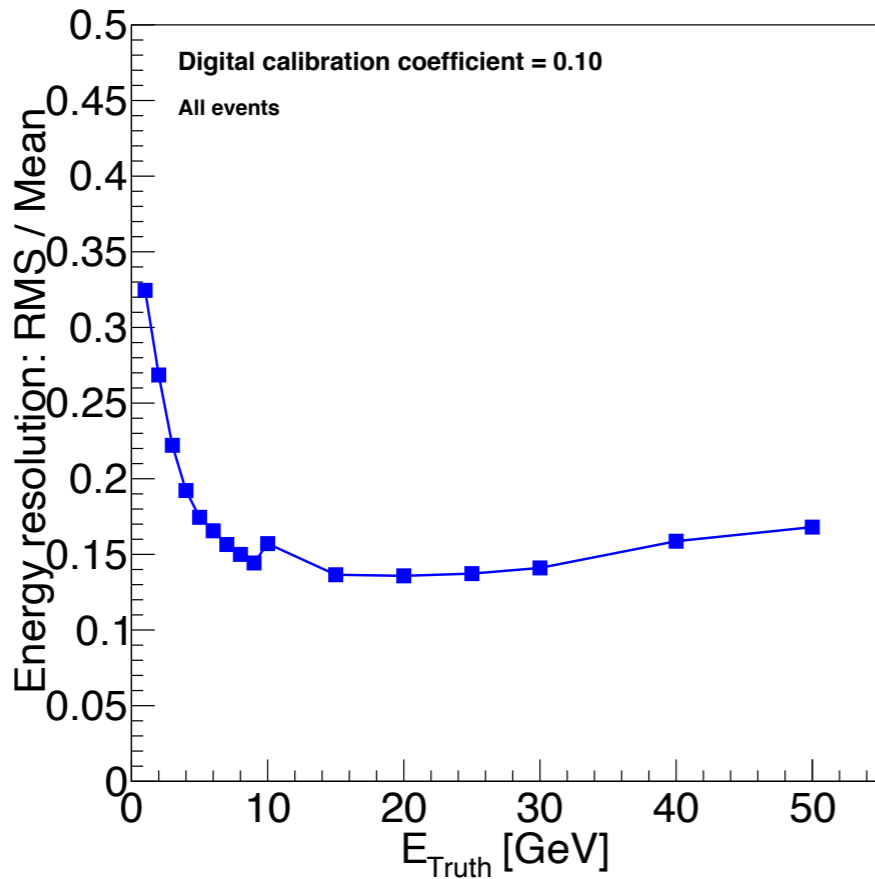
All events



Events with $E_{\text{ECAL}} > \text{threshold}$



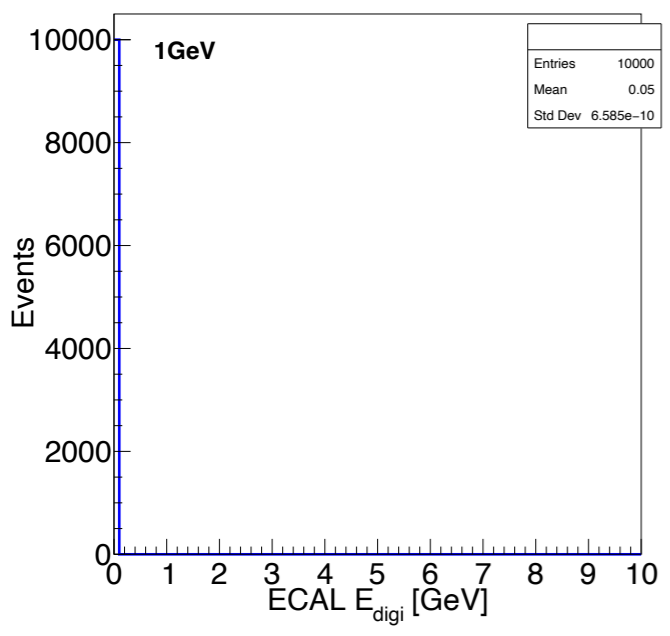
Linearity



Resolution (RMS / Mean)

Stand-alone SDHCAL

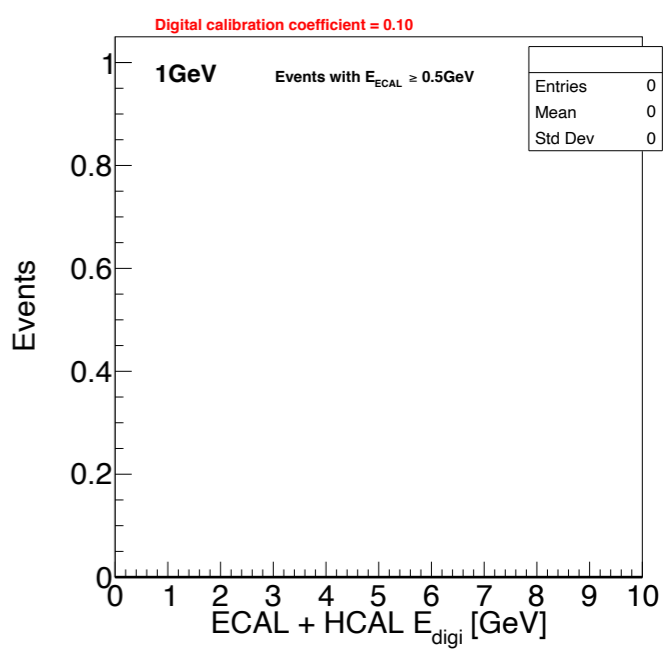
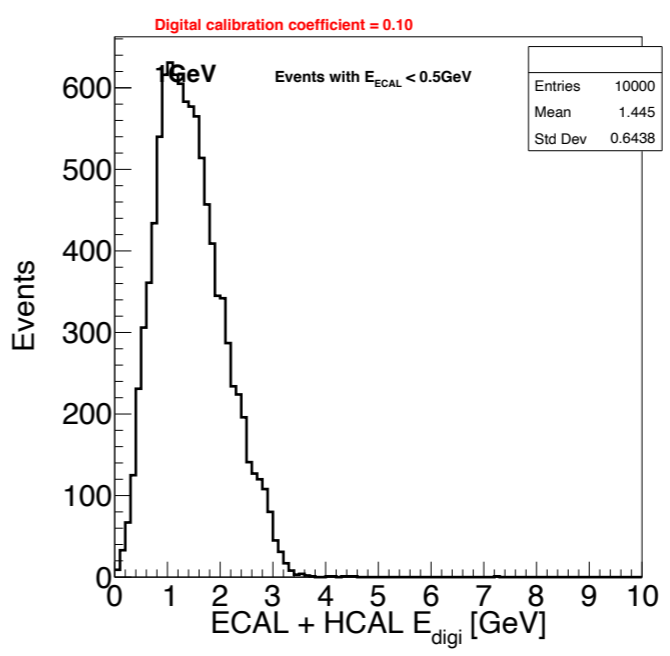
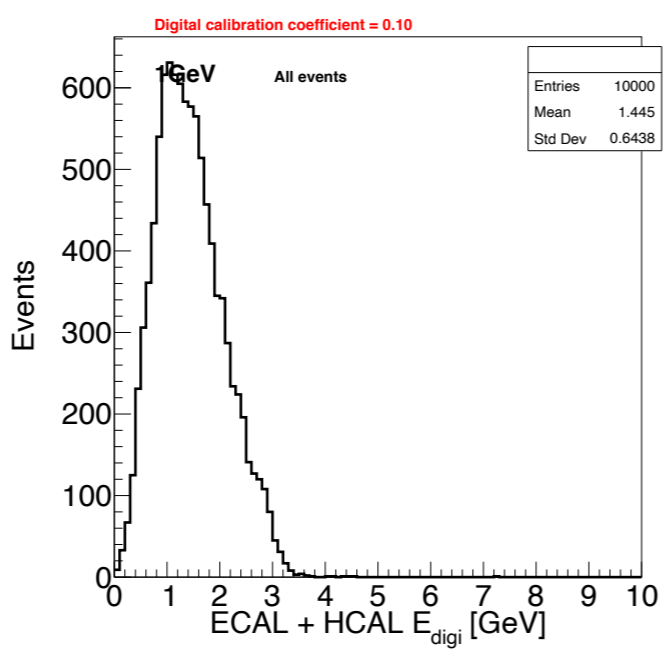
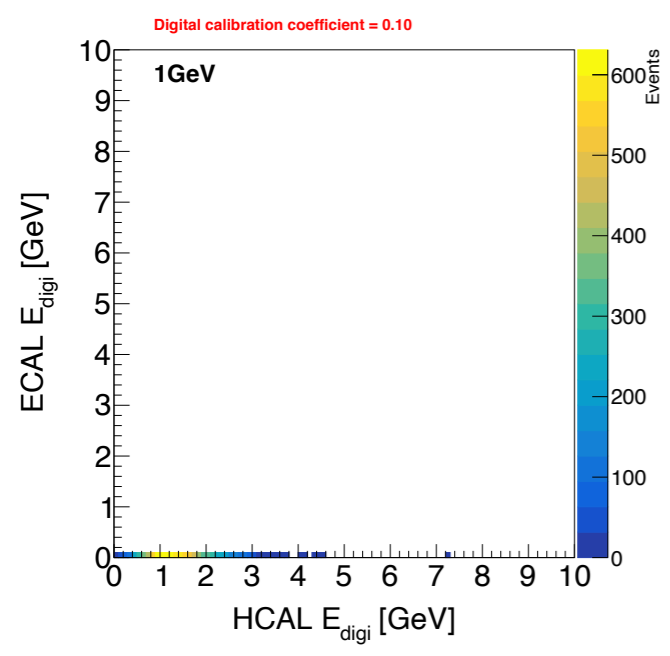
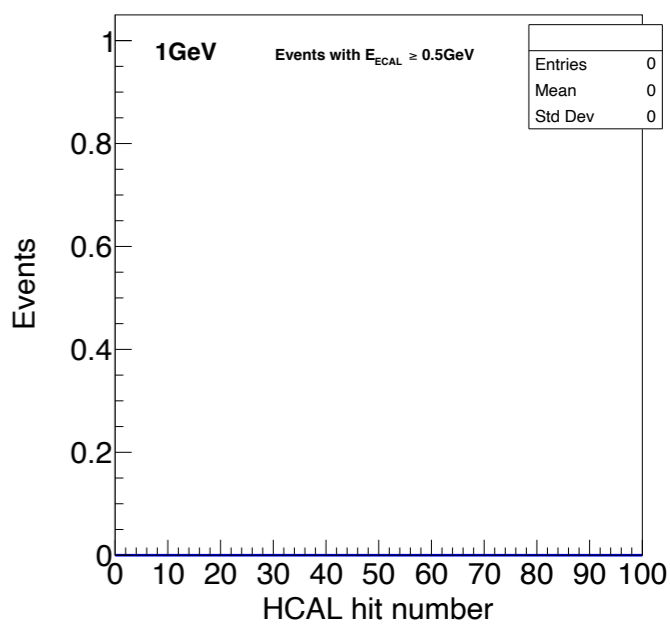
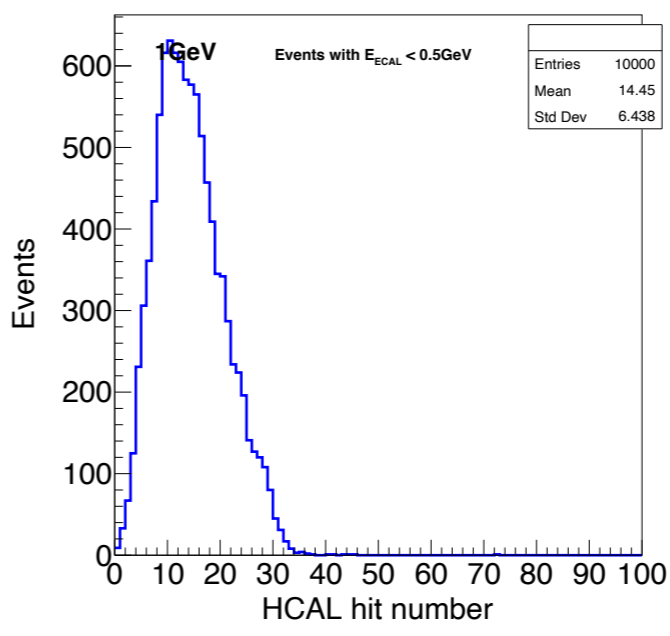
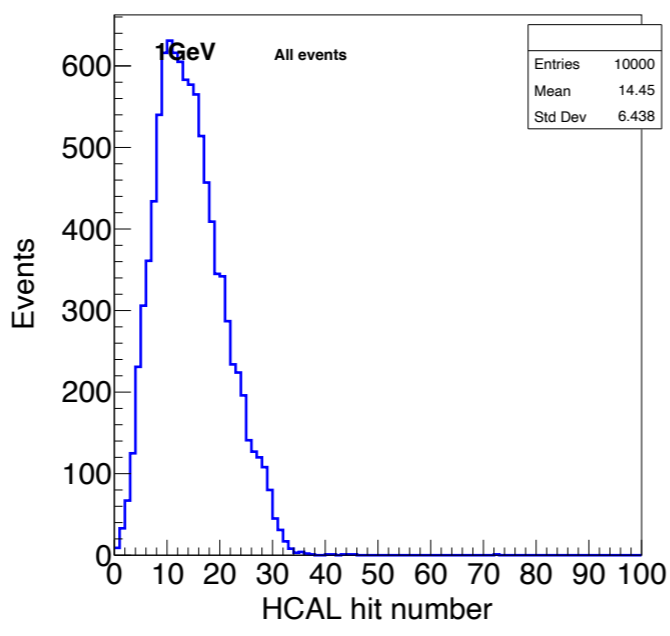
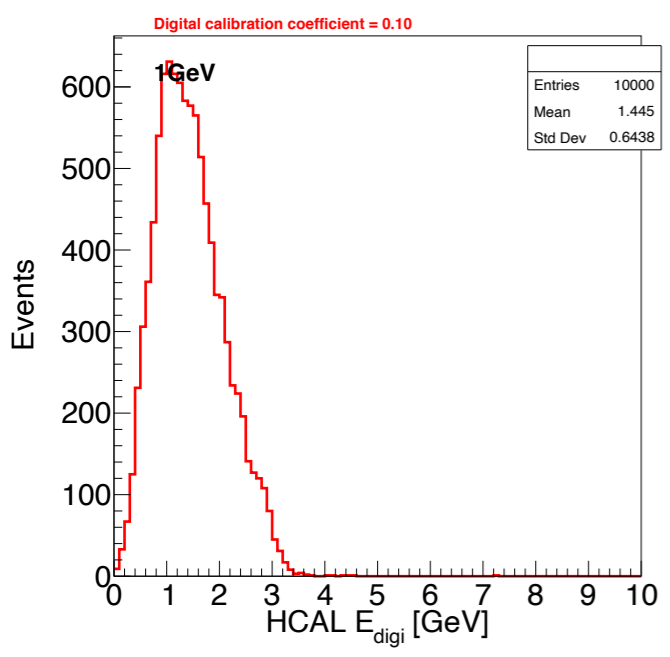
1GeV π^+



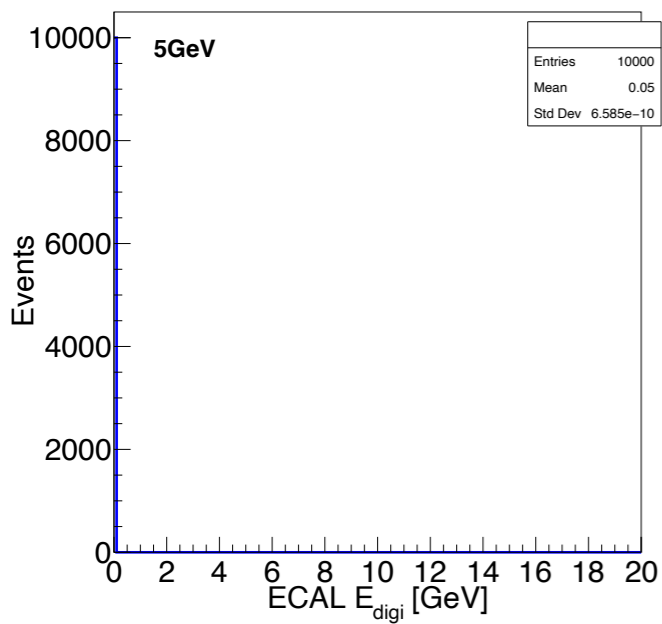
All events

Events with $E_{ECAL} < \text{threshold}$

Events with $E_{ECAL} > \text{threshold}$



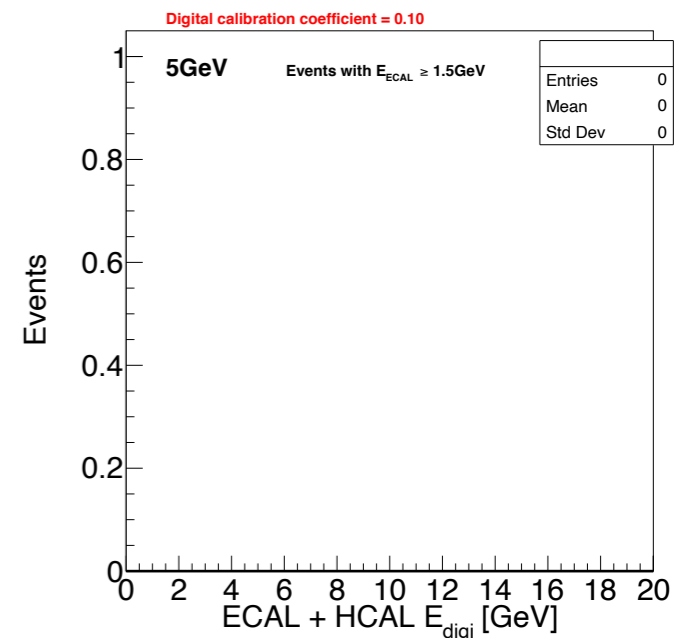
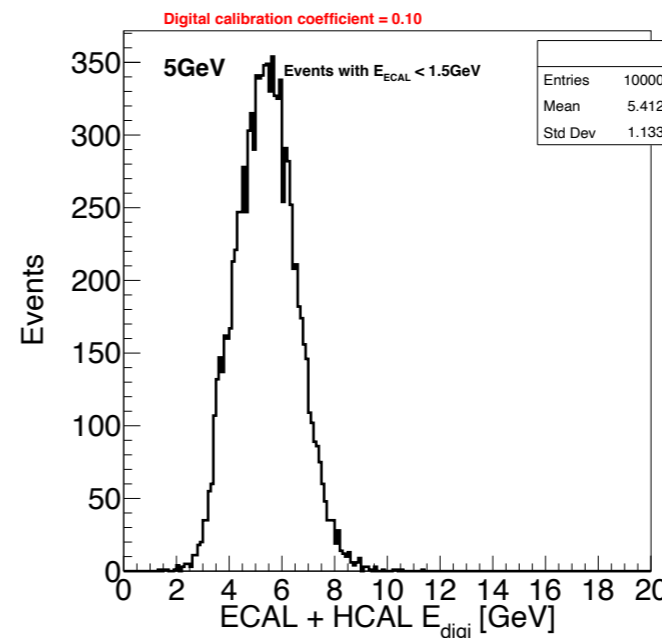
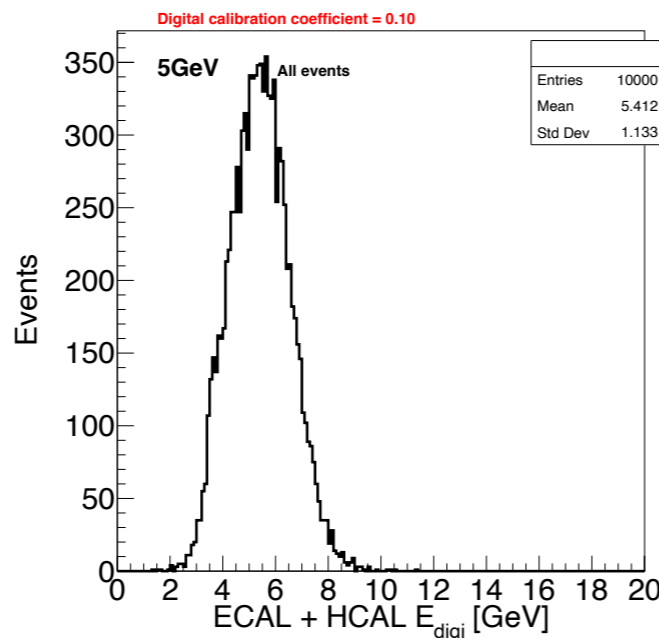
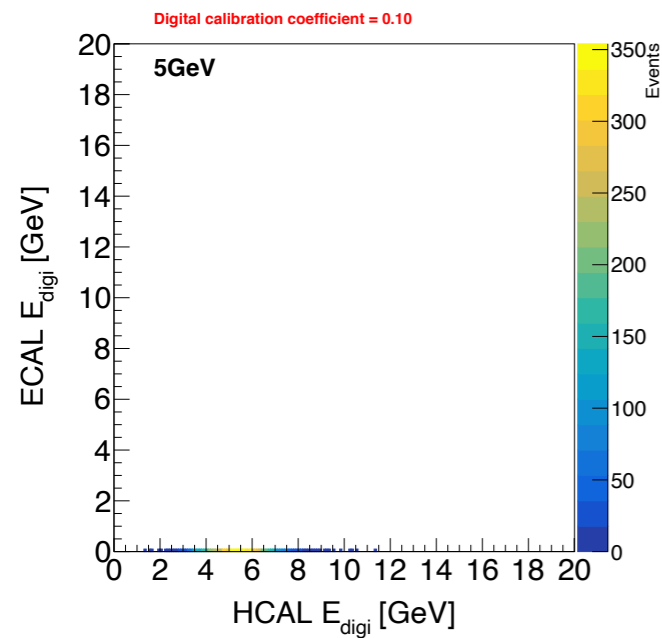
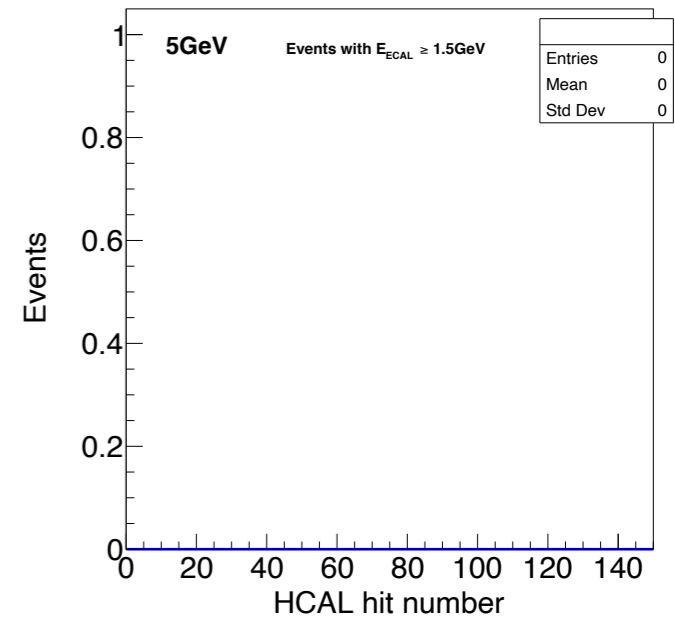
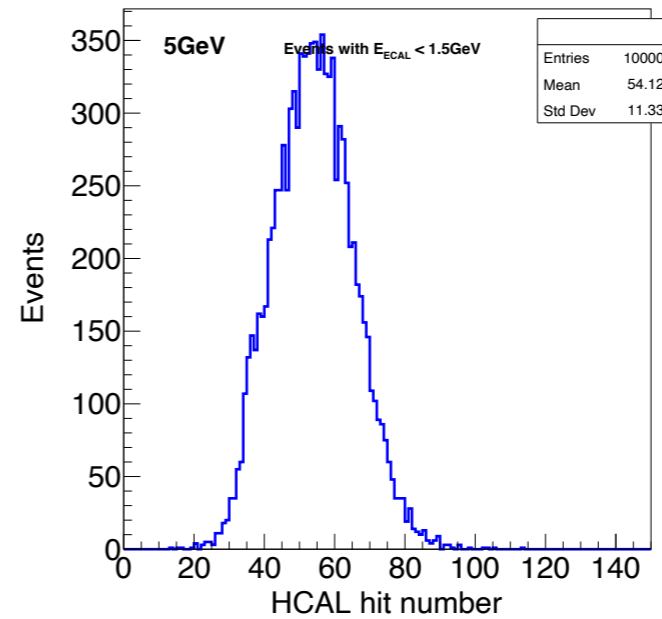
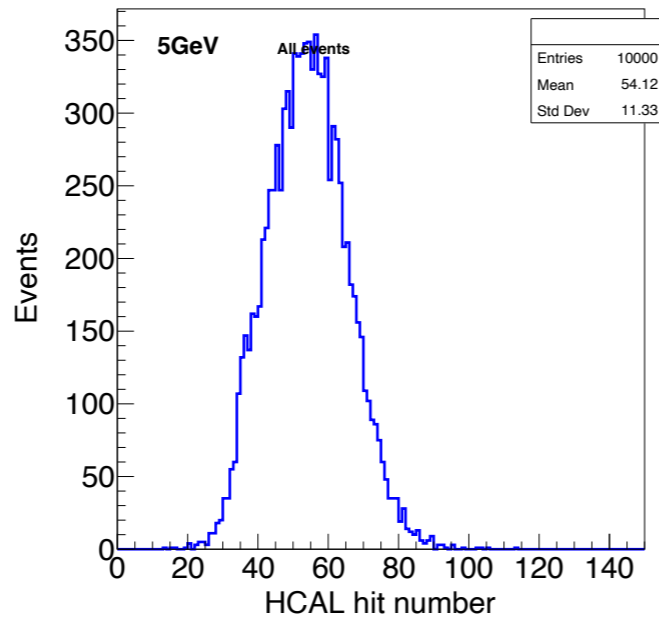
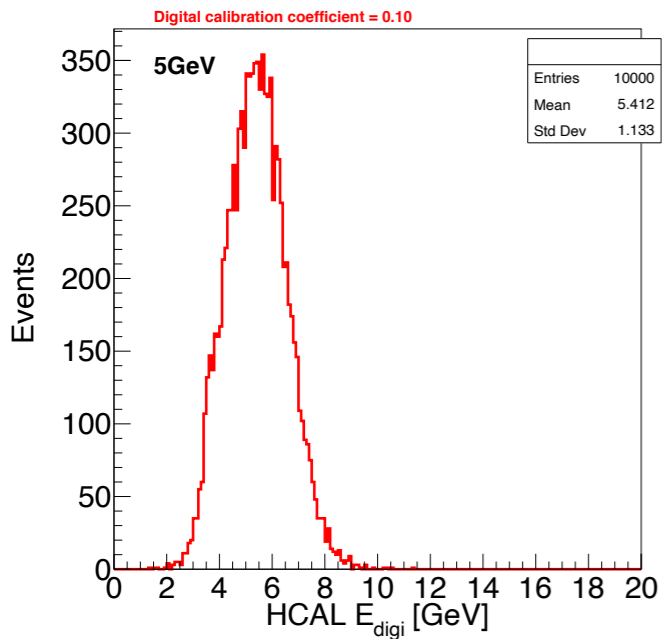
5GeV π^+



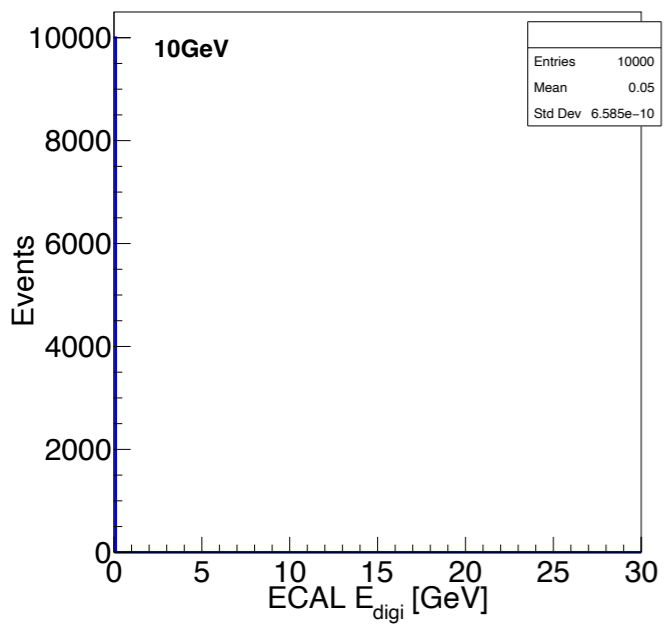
All events

Events with $E_{ECAL} < \text{threshold}$

Events with $E_{ECAL} > \text{threshold}$



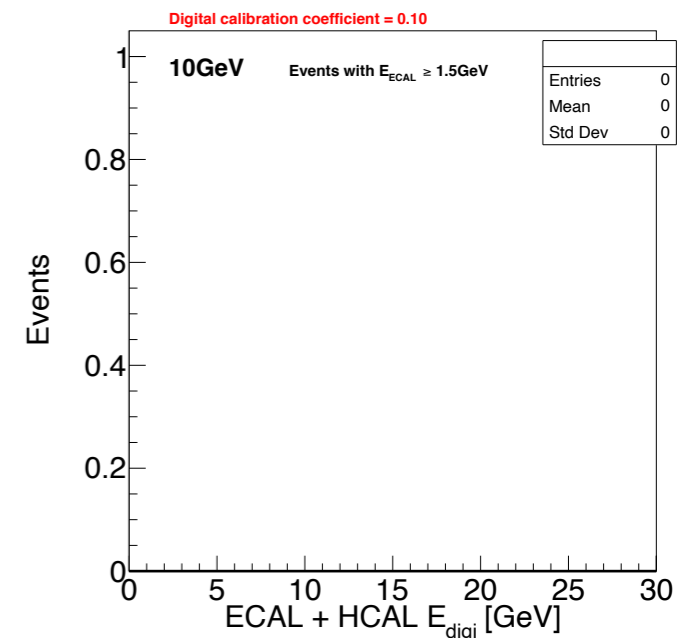
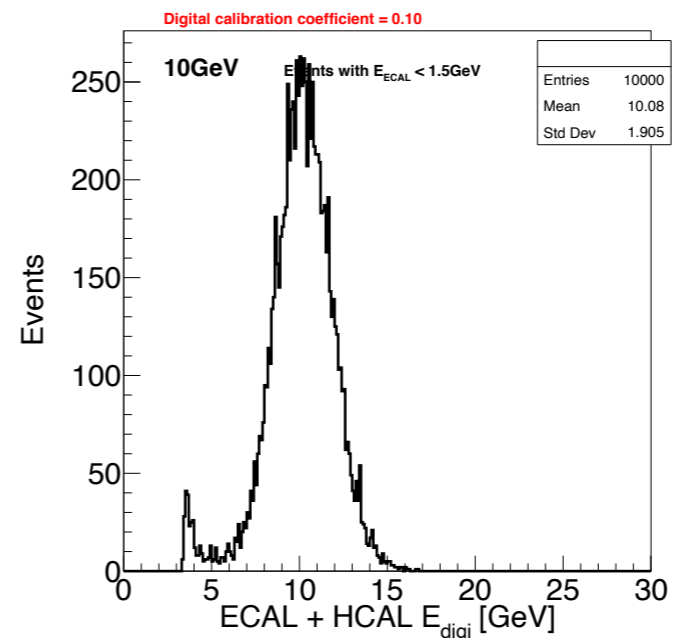
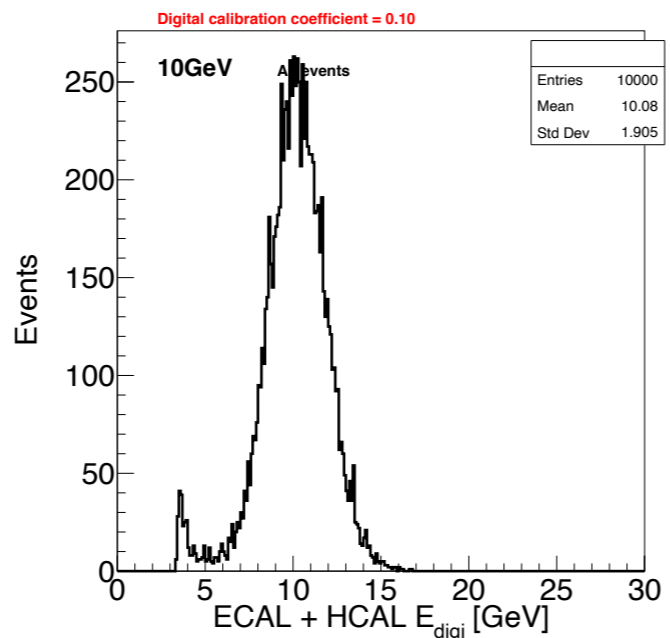
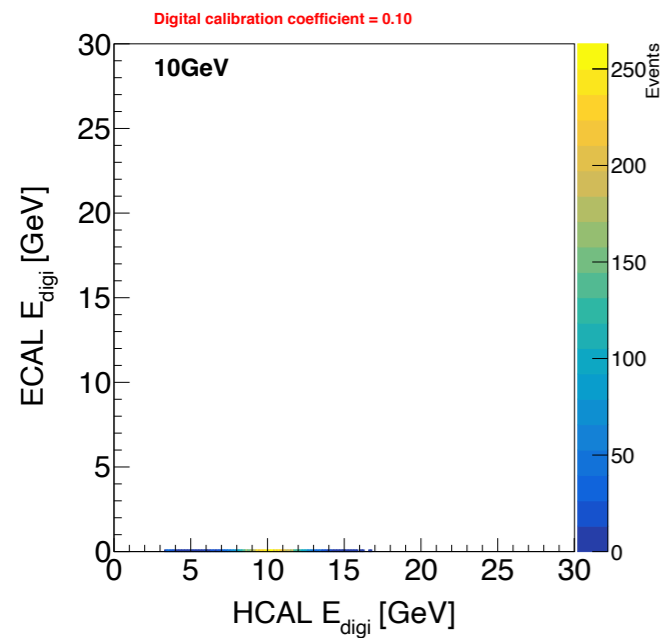
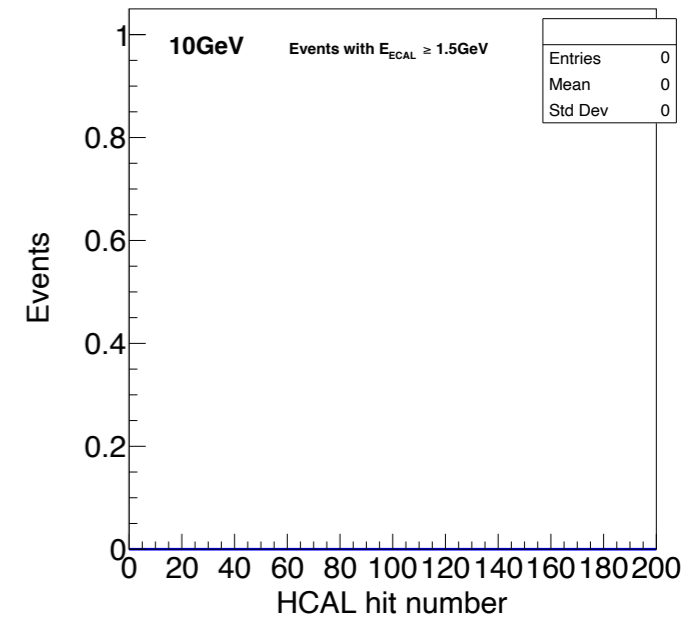
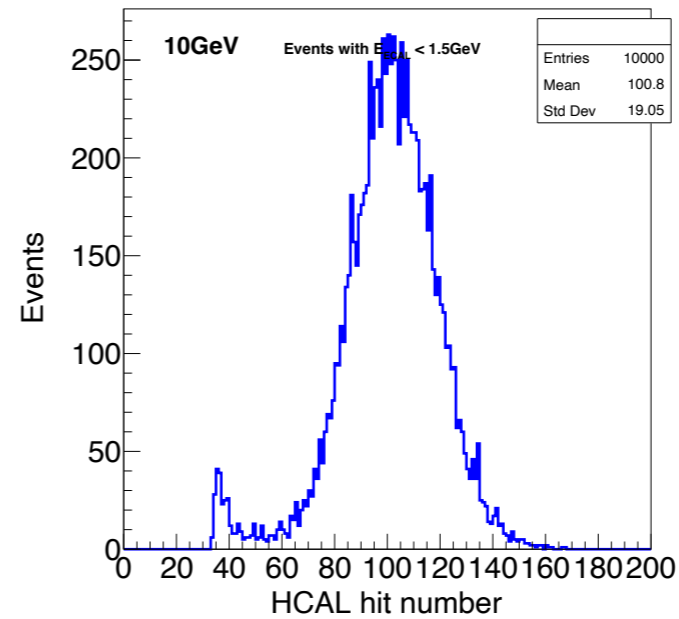
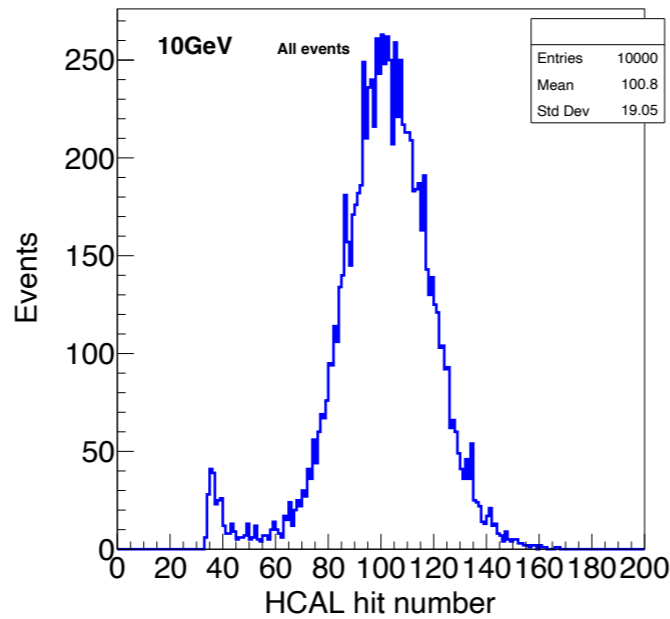
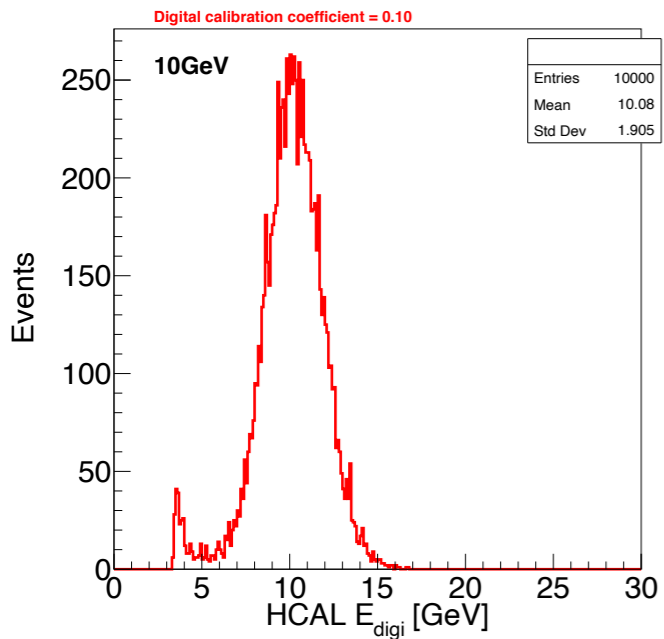
10GeV π^+



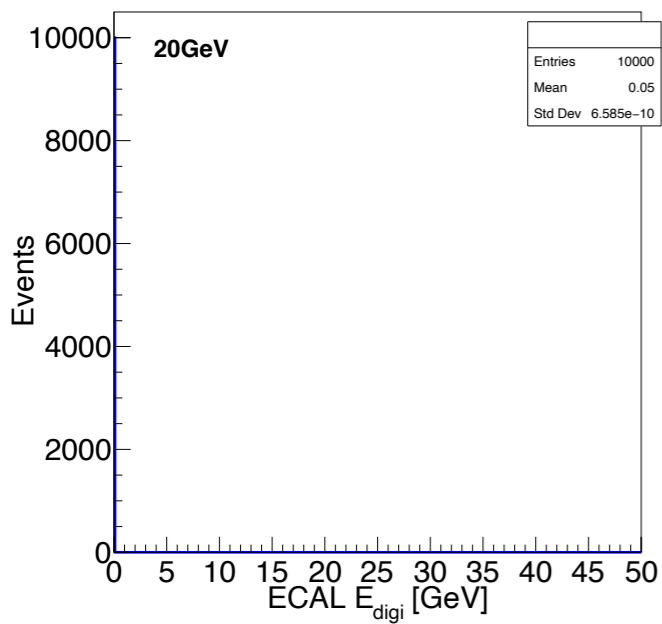
All events

Events with $E_{ECAL} < \text{threshold}$

Events with $E_{ECAL} > \text{threshold}$



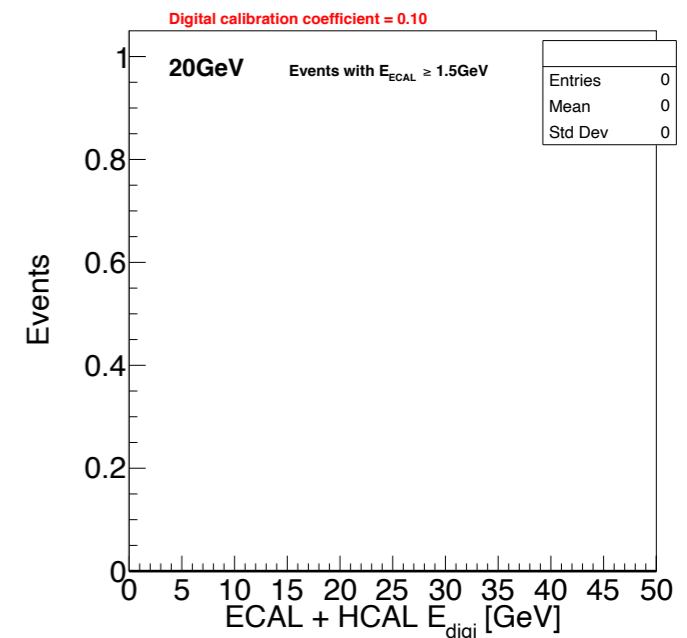
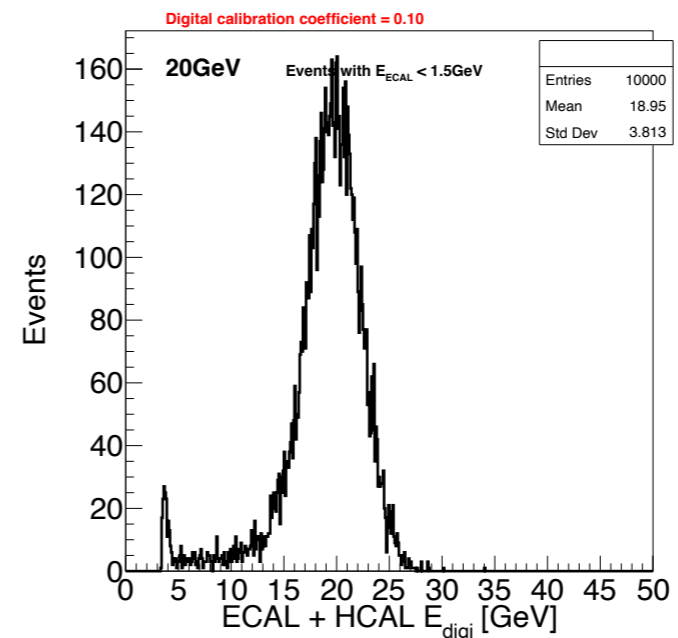
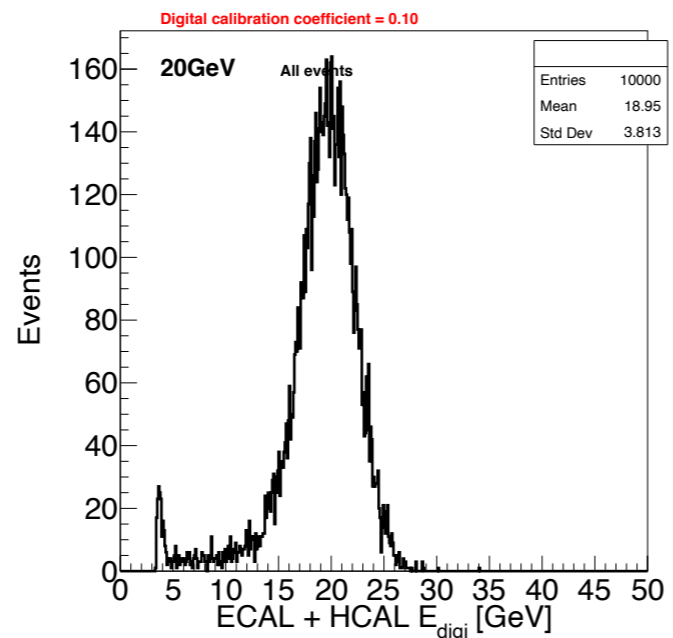
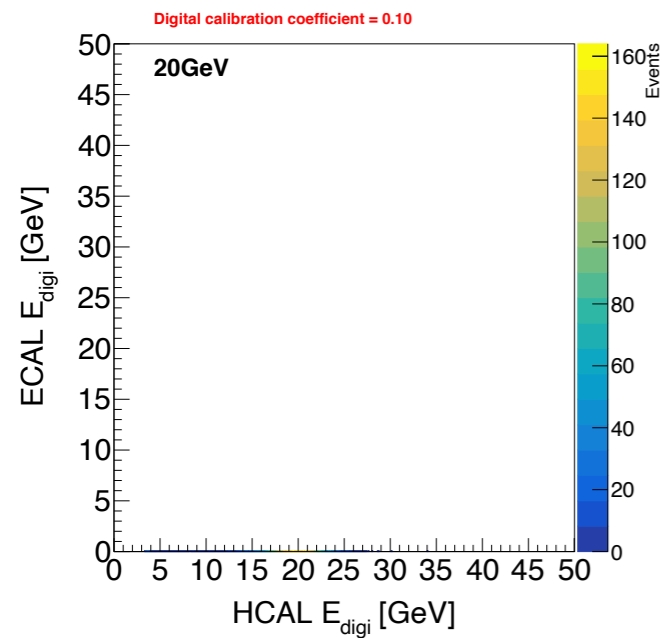
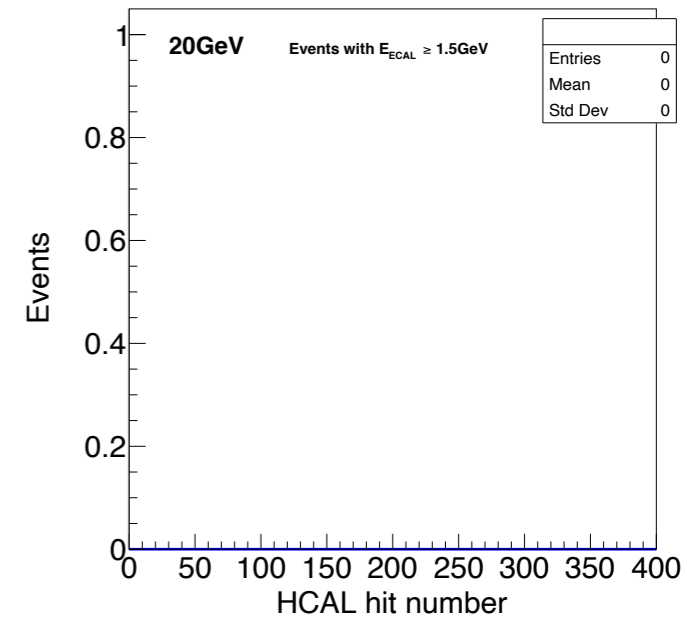
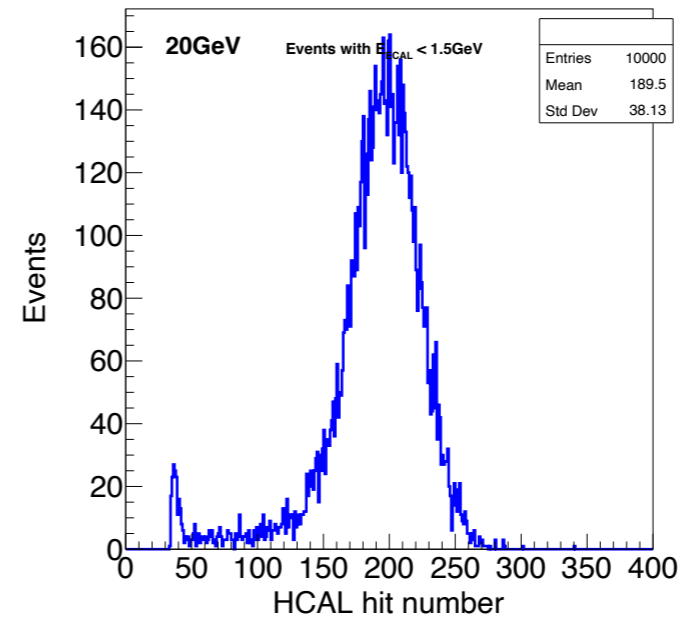
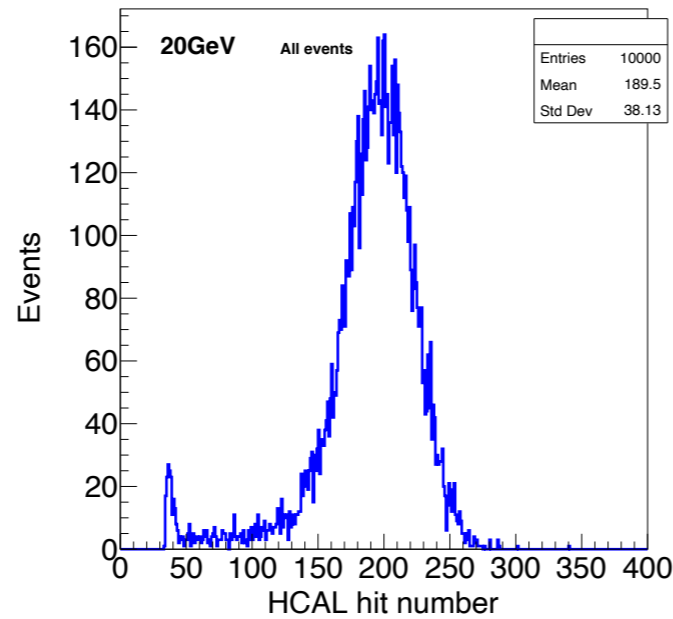
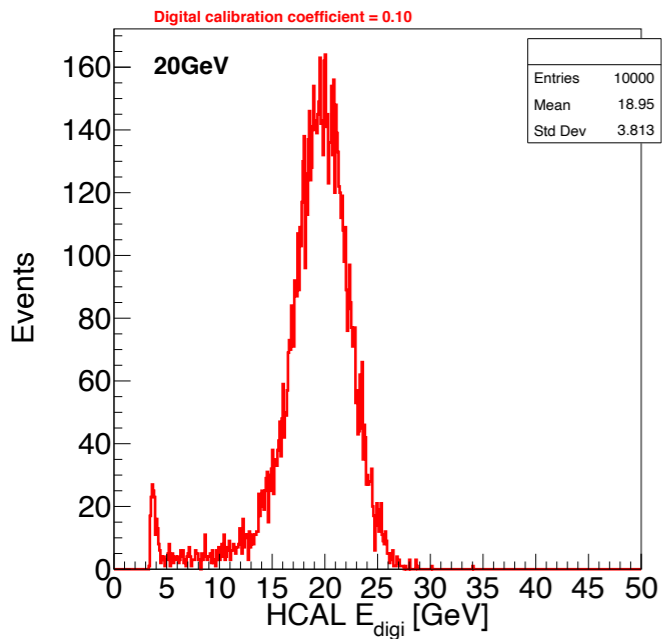
20GeV π^+



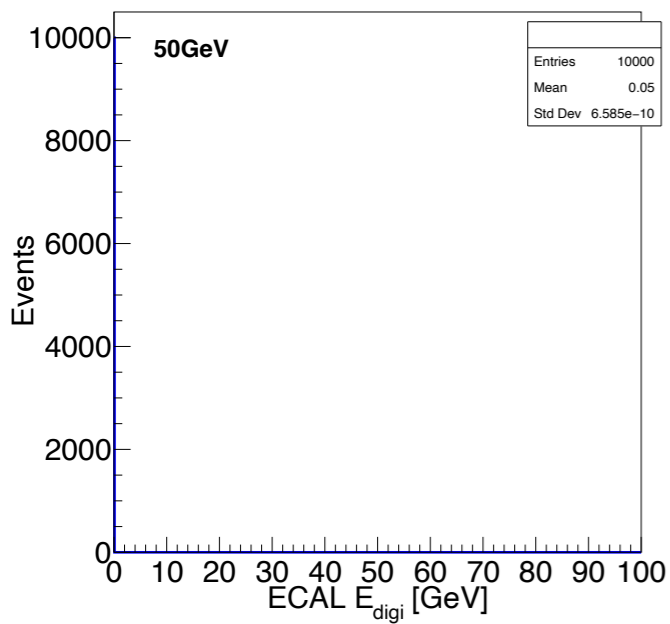
All events

Events with $E_{ECAL} < \text{threshold}$

Events with $E_{ECAL} > \text{threshold}$



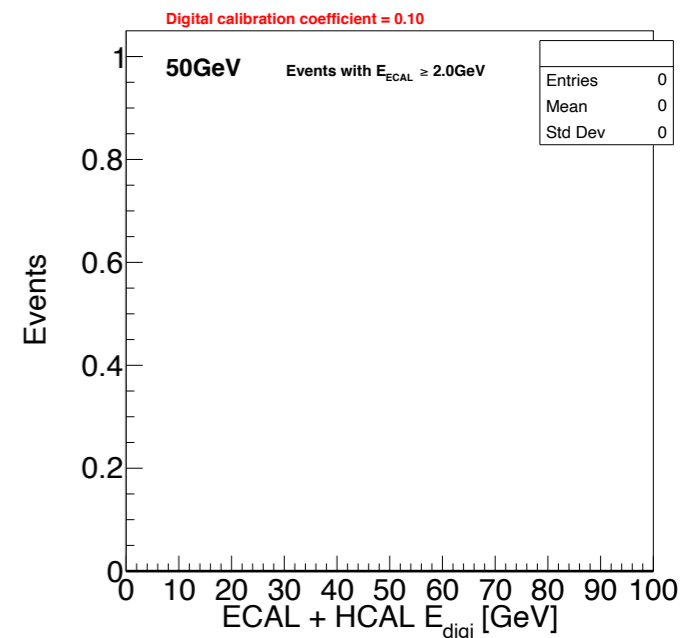
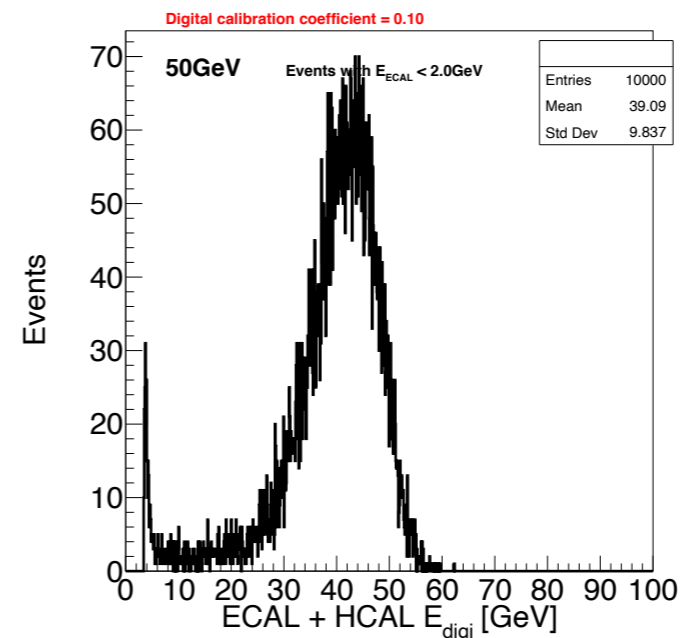
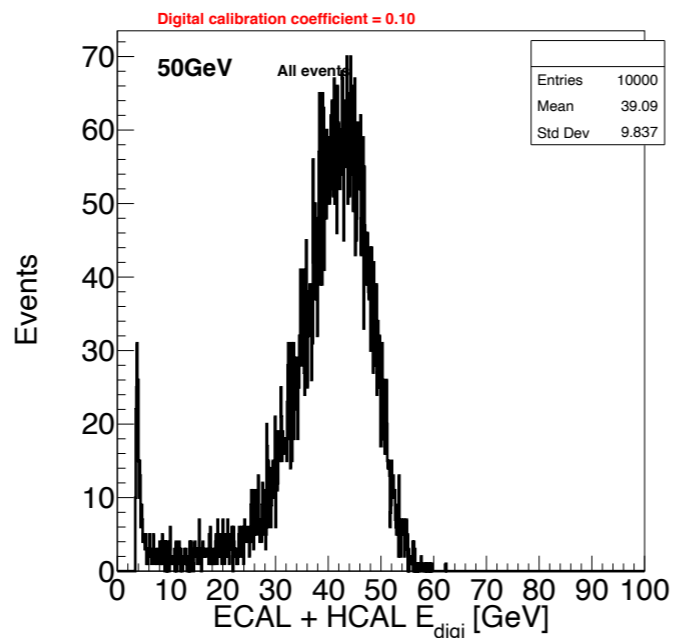
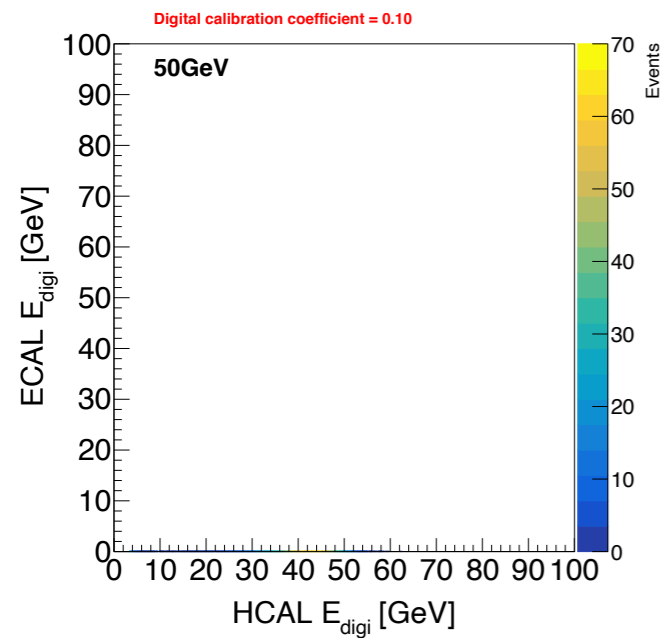
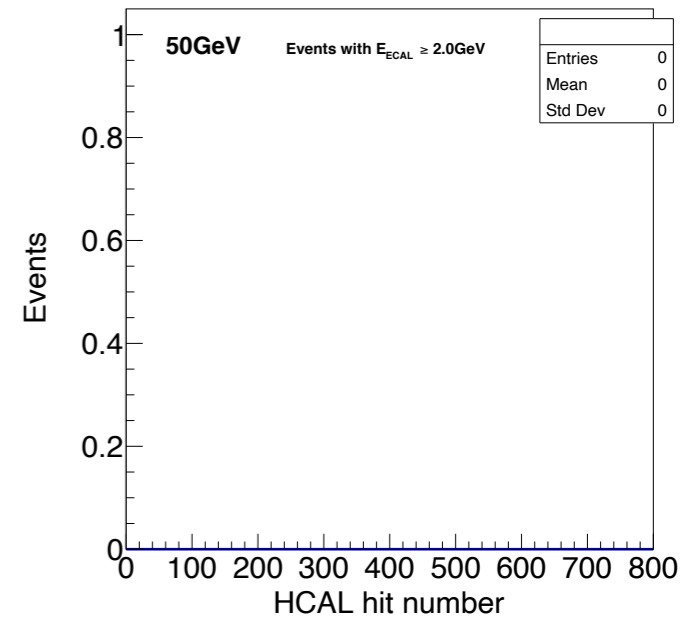
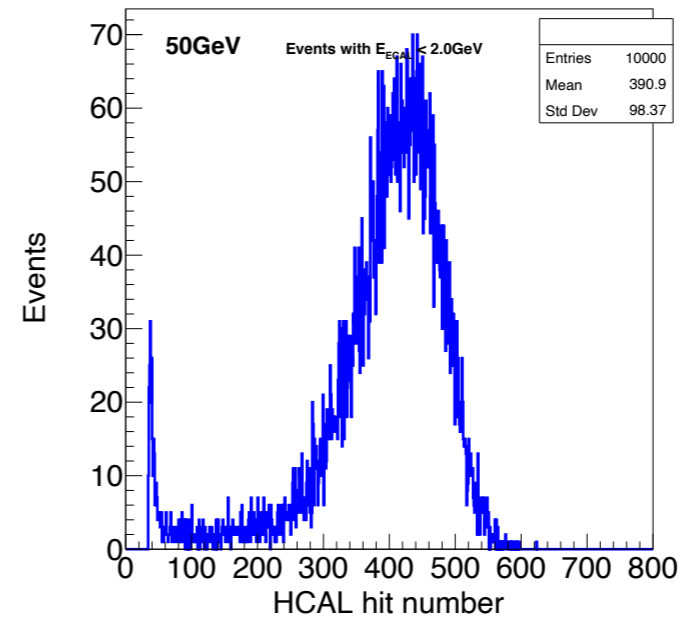
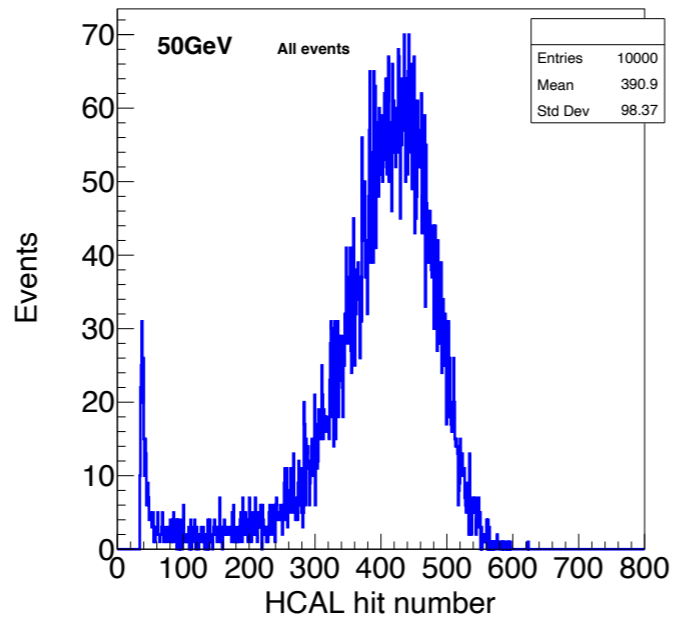
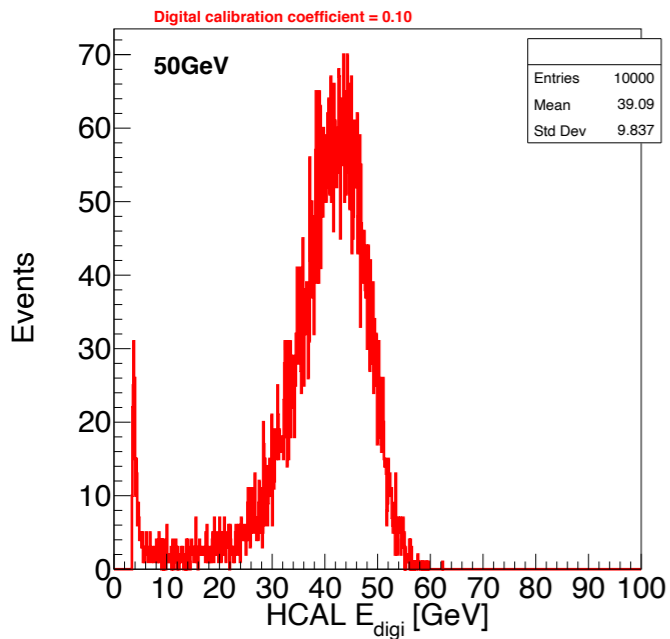
50GeV π^+



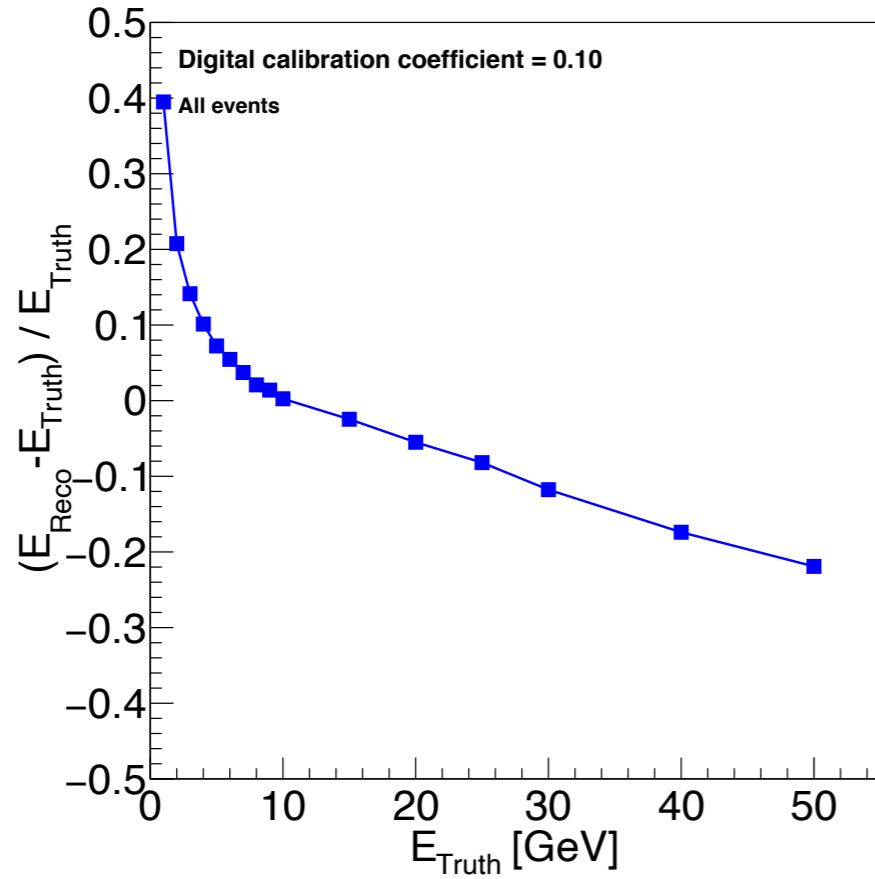
All events

Events with $E_{ECAL} < \text{threshold}$

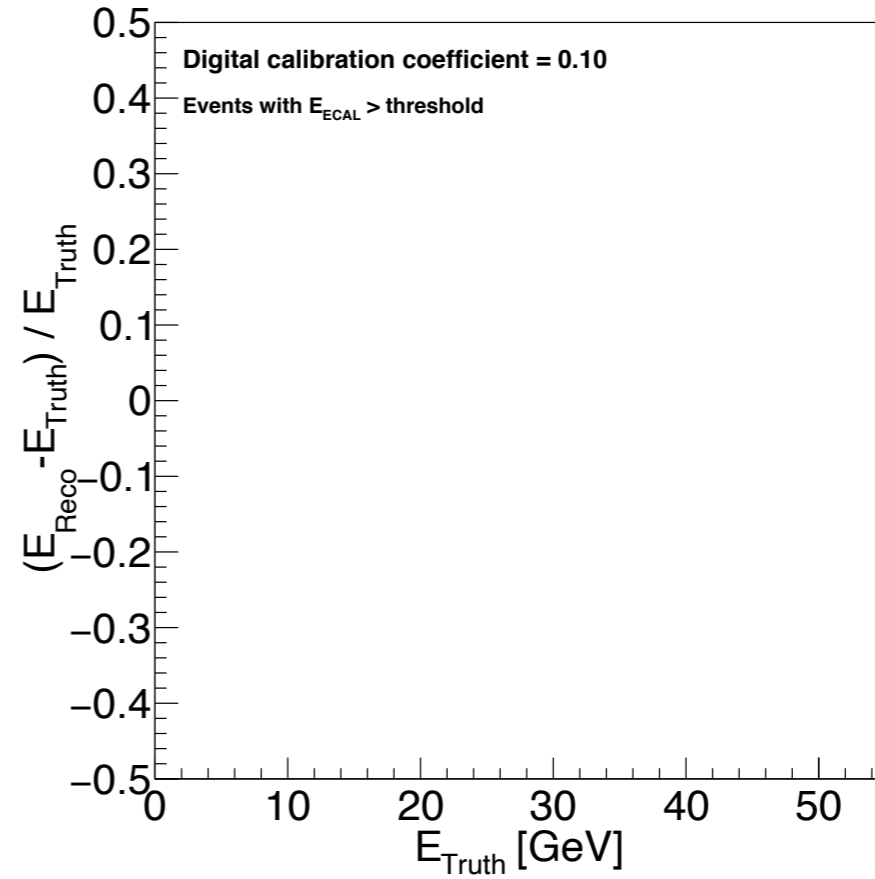
Events with $E_{ECAL} > \text{threshold}$



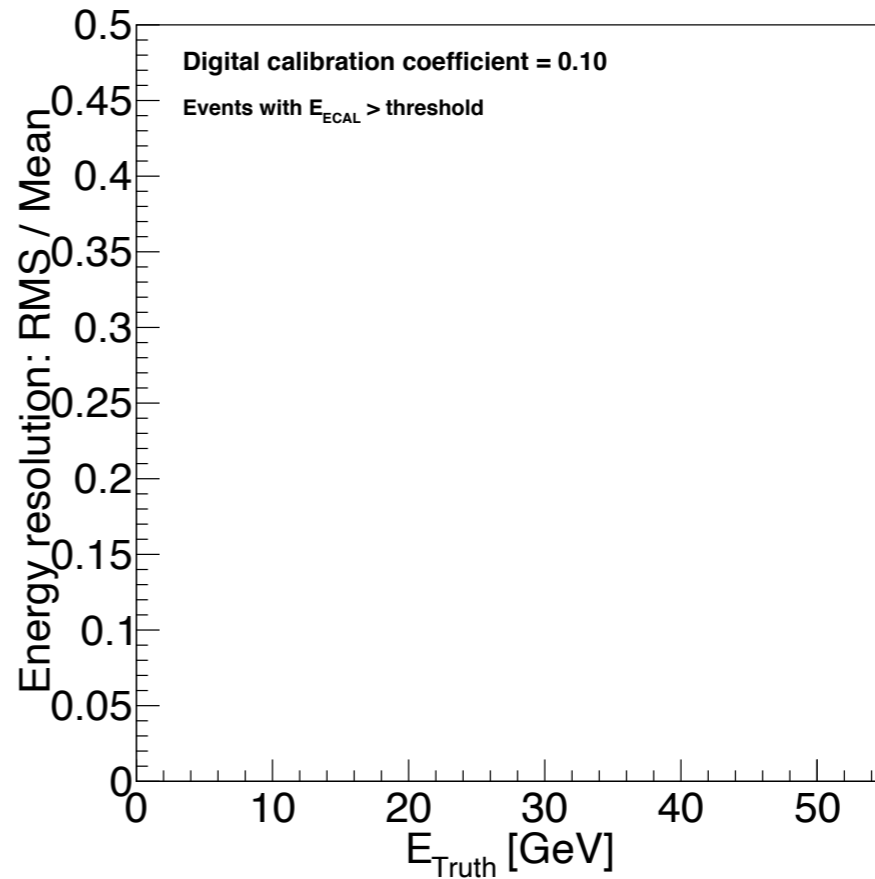
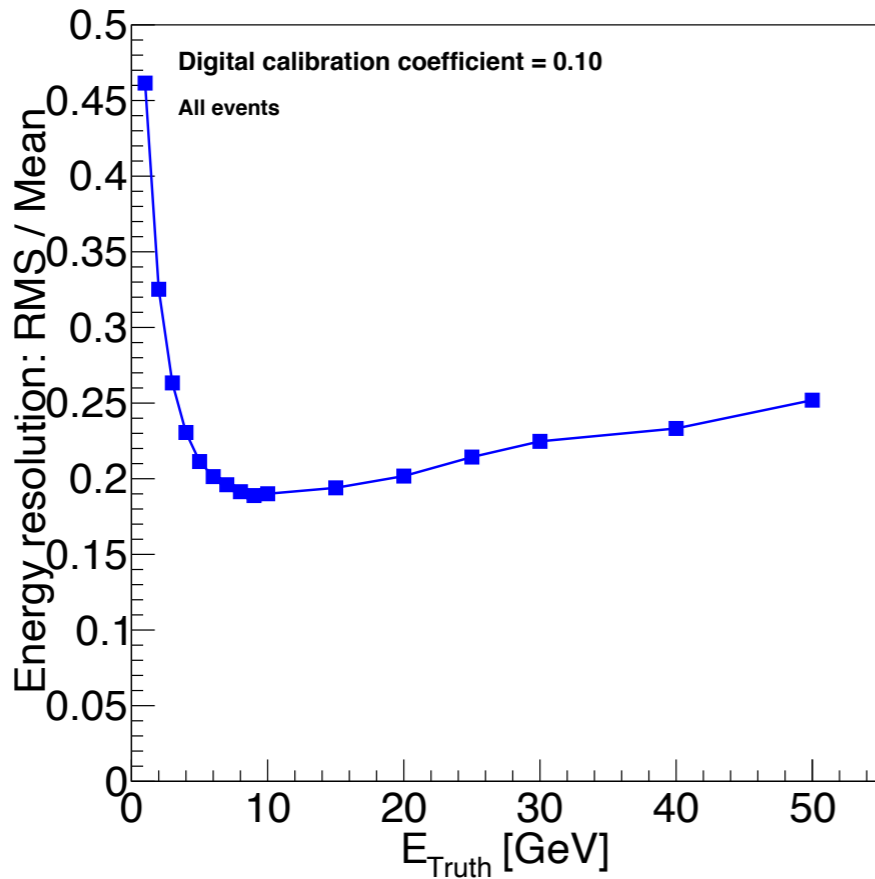
All events



Events with $E_{\text{ECAL}} > \text{threshold}$



Linearity



Resolution
(RMS / Mean)

Energy resolution

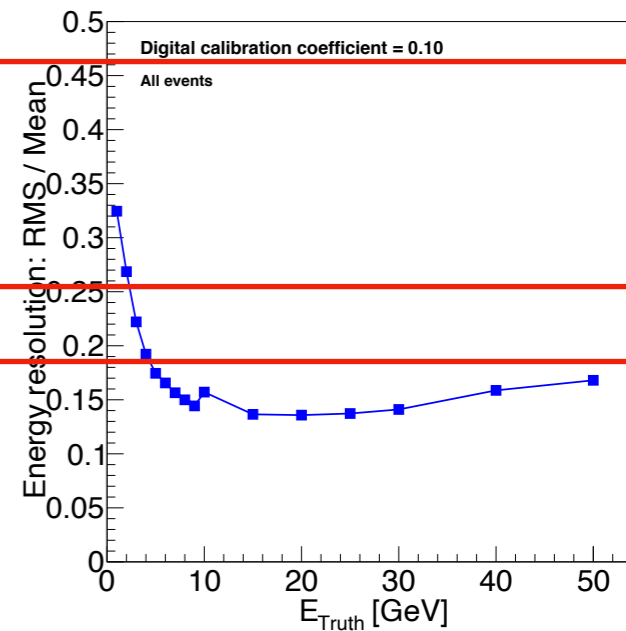
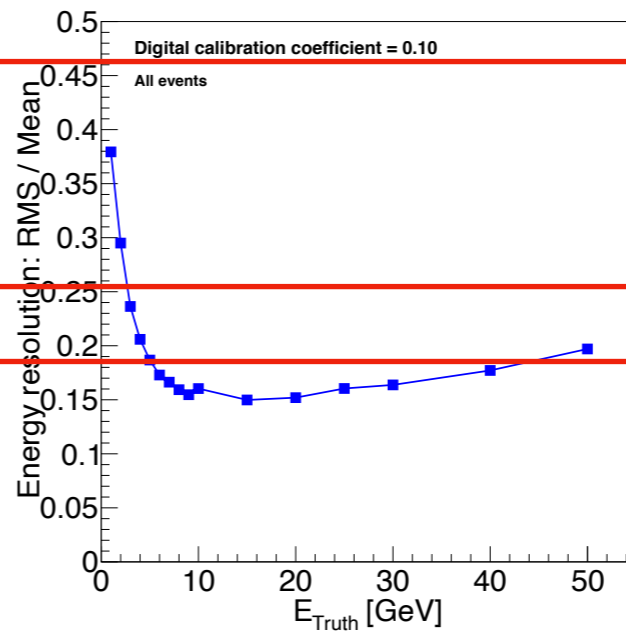
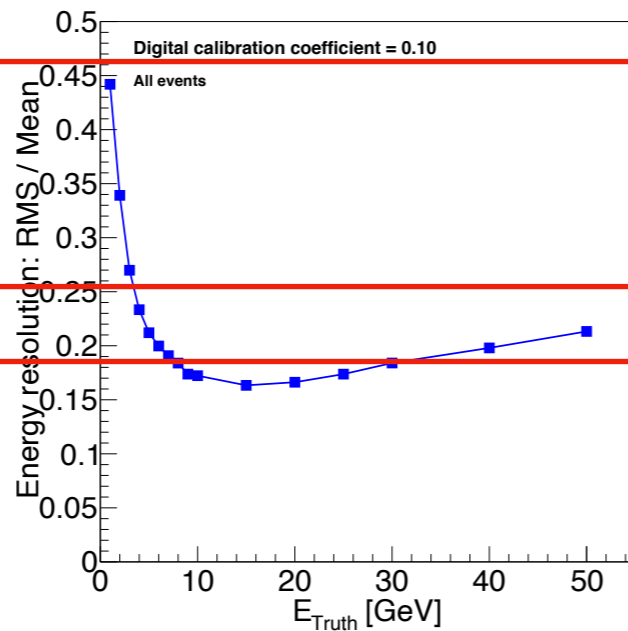
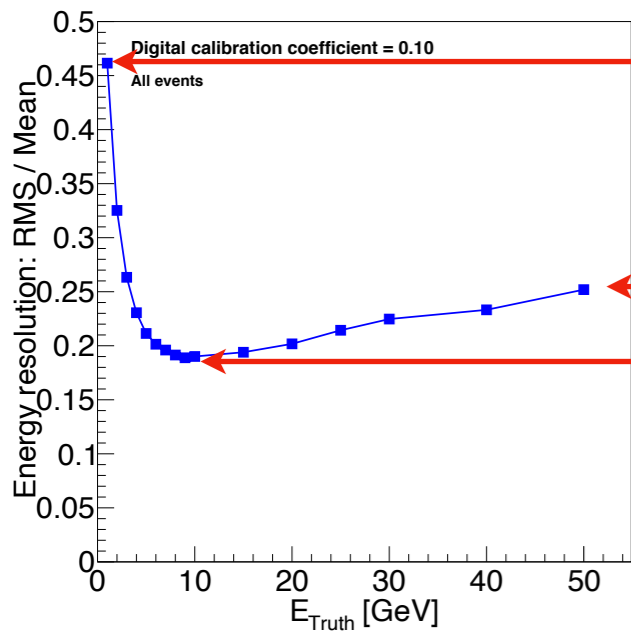
**Stand-alone
SDHCAL**

Si-W

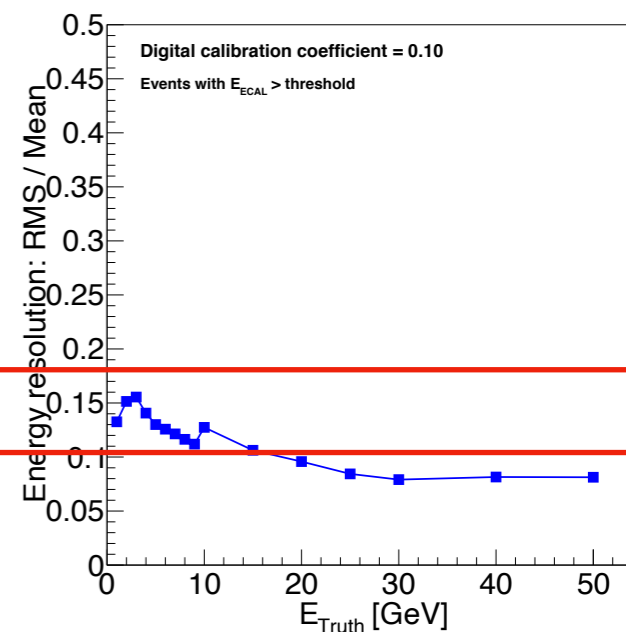
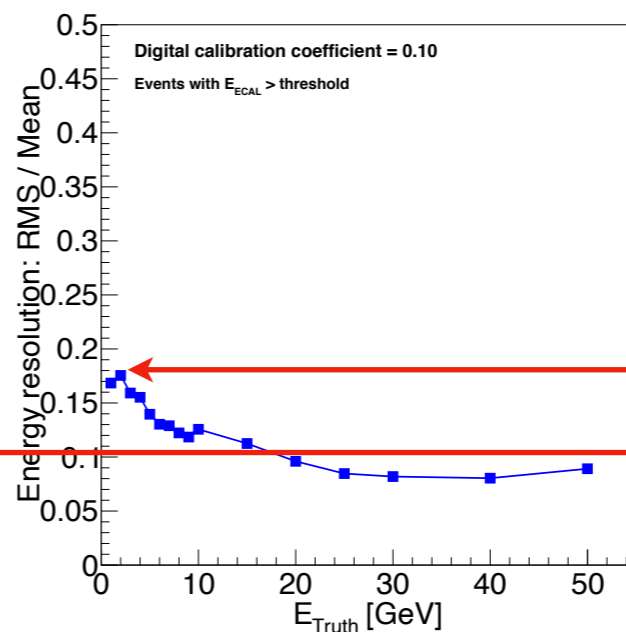
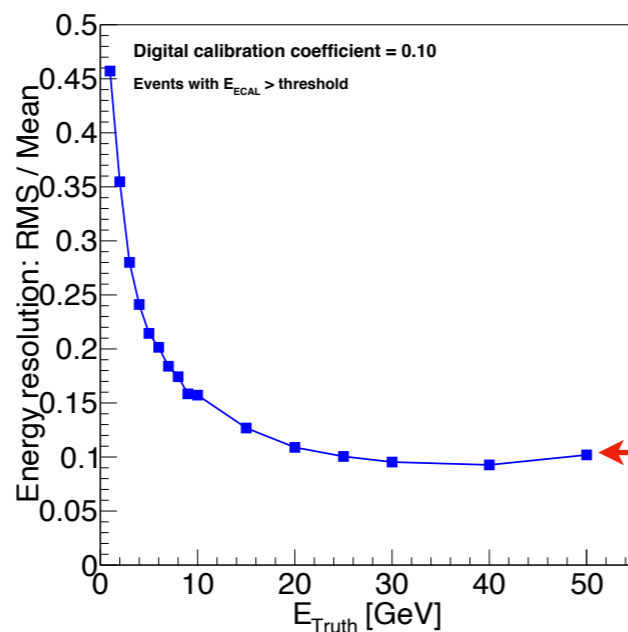
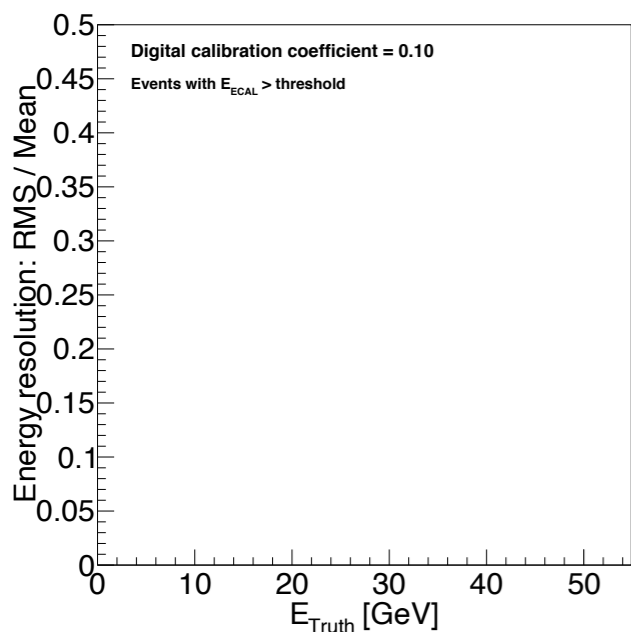
PWO

BaF2

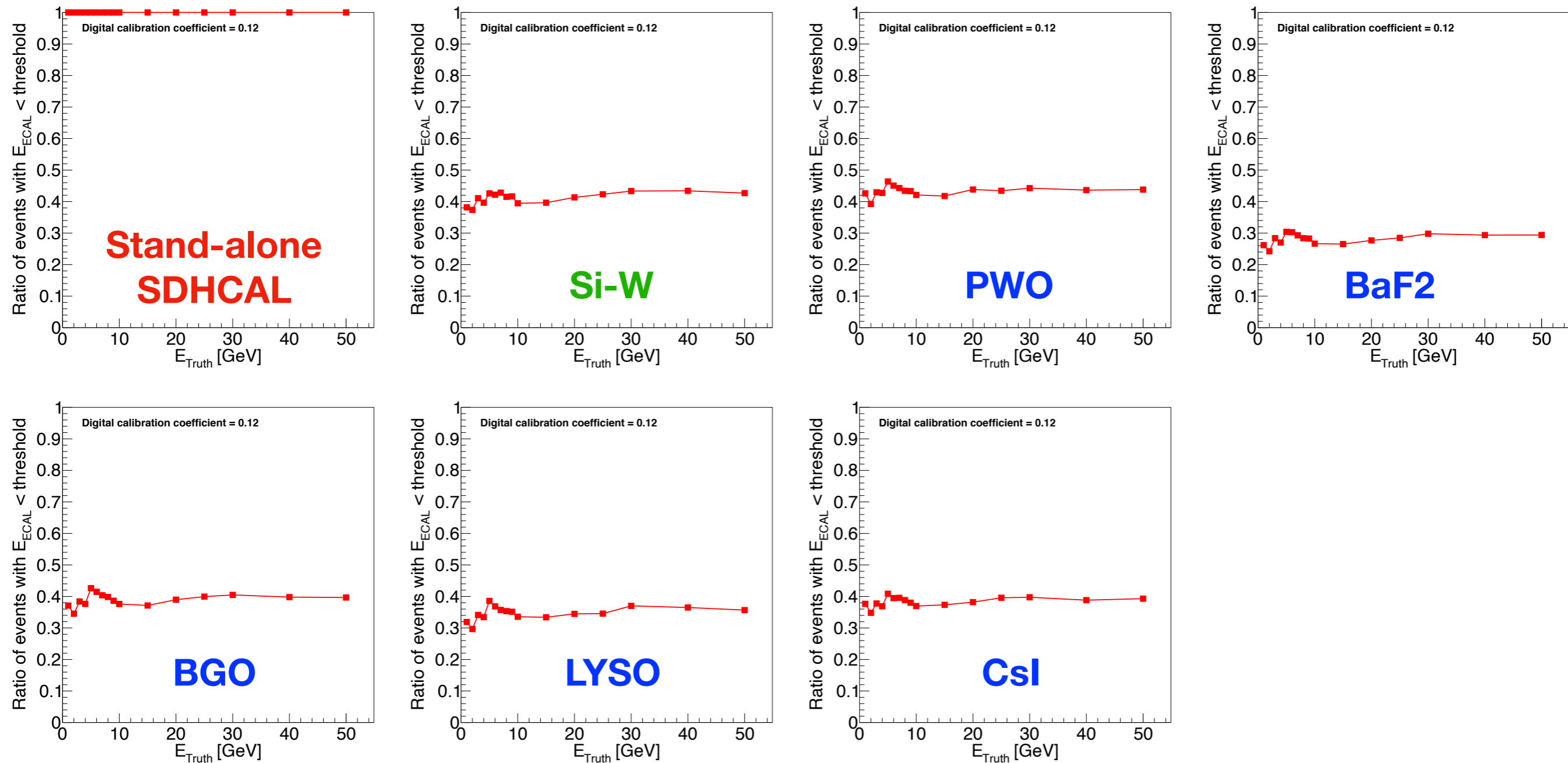
All events



Events with $E_{\text{ECAL}} > \text{threshold}$



Proportion of events with $E_{\text{ECAL}} < \text{threshold}$



	W	BGO	PWO	BaF2	Csl	LYSO
X0 (mm)	3.5	11.2	8.9	20.3	18.6	11.4
λ (mm)	99	228	207	307	393	209
24X0 -> $n\lambda$	0.85	1.18	1.03	1.59	1.14	1.31