Particle Identification using BDT in SDHCAL

CALICE Meeting –Mainz University

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Outline

- Particle Identification using BDT
  - BDT using MC training
  - BDT using DATA training
- Conclusion

Particle identification using BDT in SDHCAL

MC samples training

- PID
  - Application
    - Event selection
    - Better estimation in energy reconstruction
- Tool: Traditional cuts, BDT
- TMVA of root, Methods: BDT 6var
- BDT 6 var Input:

1. First layer of the shower(Begin)
2. Number of tracks in the shower (TrackMultiplicity)
3. Ratio of shower layers over total fired layers(NInteractinglayer/Nlayers)
4. Shower density(Density)
5. Shower radius(Radius)
6. Maximum shower position(Length)

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---------------------------------------------------
Rank : Variable          : Variable Importance
---------------------------------------------------
   1 : Density           : 2.176e-01
   2 : Length            : 2.121e-01
   3 : Radius            : 1.710e-01
   4 : MuonR2            : 1.688e-01
   5 : Begin             : 1.457e-01
   6 : TrackMultiplicity : 8.472e-02
---------------------------------------------------
```

Pion vs muon

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---------------------------------------------------
Rank : Variable          : Variable Importance
---------------------------------------------------
   1 : Radius            : 2.160e-01
   2 : Density           : 1.989e-01
   3 : MuonR2            : 1.911e-01
   4 : Length            : 1.452e-01
   5 : Begin             : 1.375e-01
   6 : TrackMultiplicity : 1.114e-01
---------------------------------------------------
```
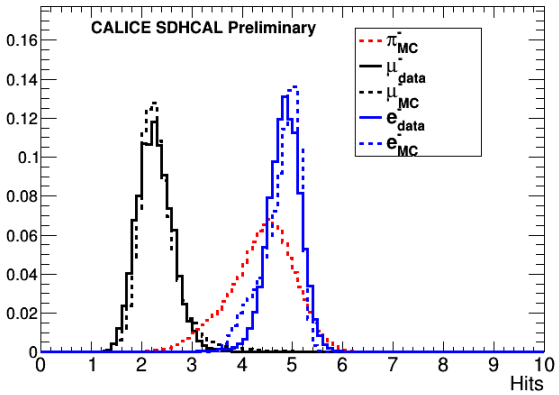
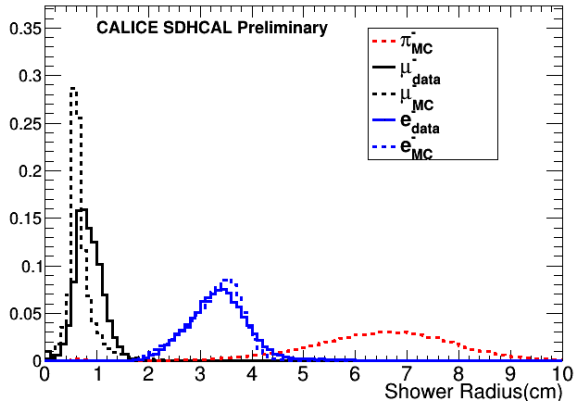

Pion vs electron

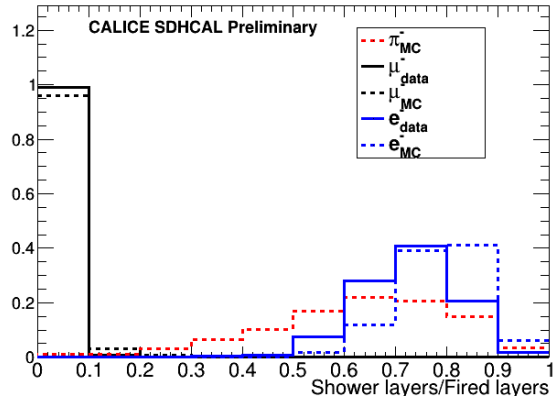
BDT Input variables



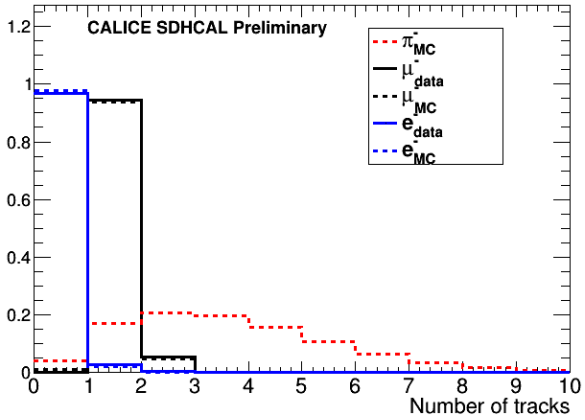
Density



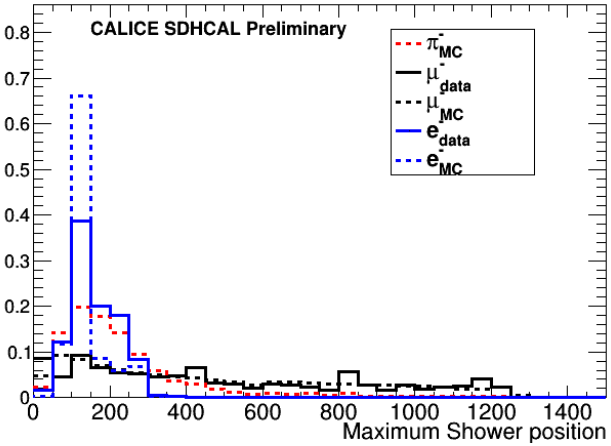
Radius



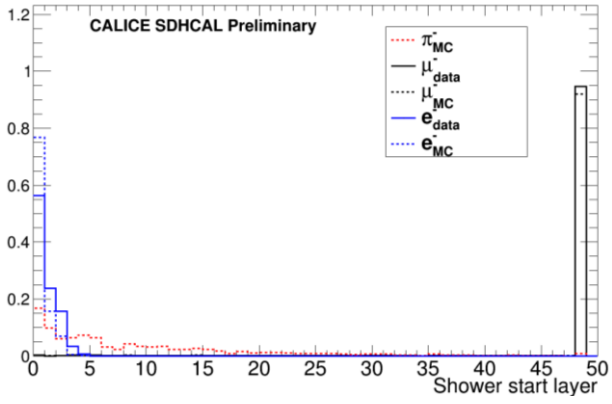
Shower layers / fired layers



Trackmultiplicty



Shower Length



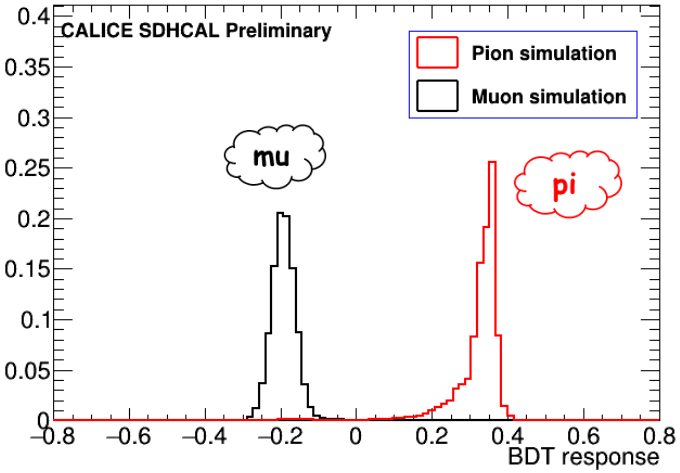
Begin

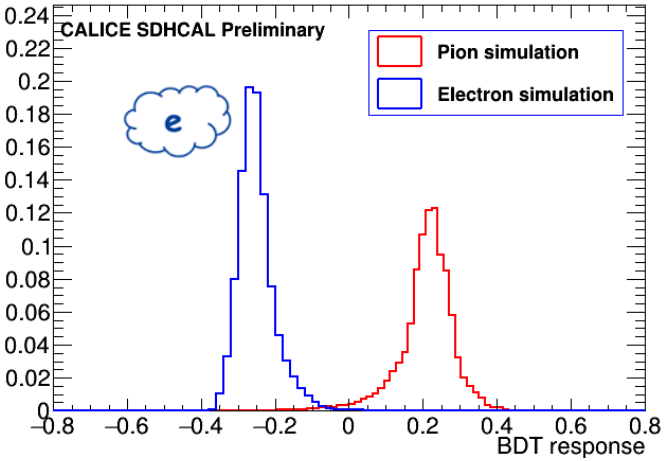
Training and Test

MC samples training

- TMVA of root, Methods: BDT 6var
- Training and Test
  - Signal: 160000 pion events with energy 10,20,30,40,50,60,70 and 80GeV
  - Background:160000 electron events with energy 10,20,30,40,50,60,70 and 80GeV
  - Background: ≈120000 muon events with energy 10,20,30,40,50,60,70 and 80GeV

    Mixed Background
  - Ntraining : Ntest=1 : 1



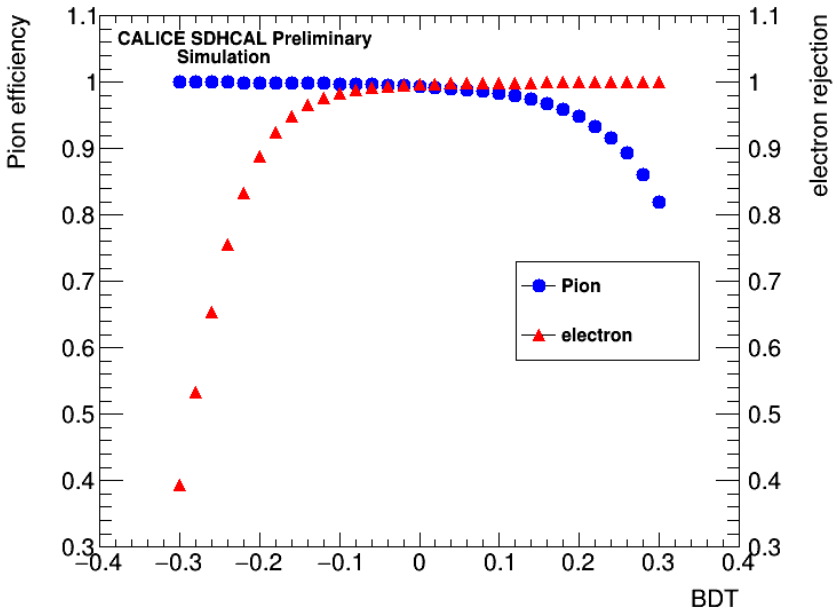


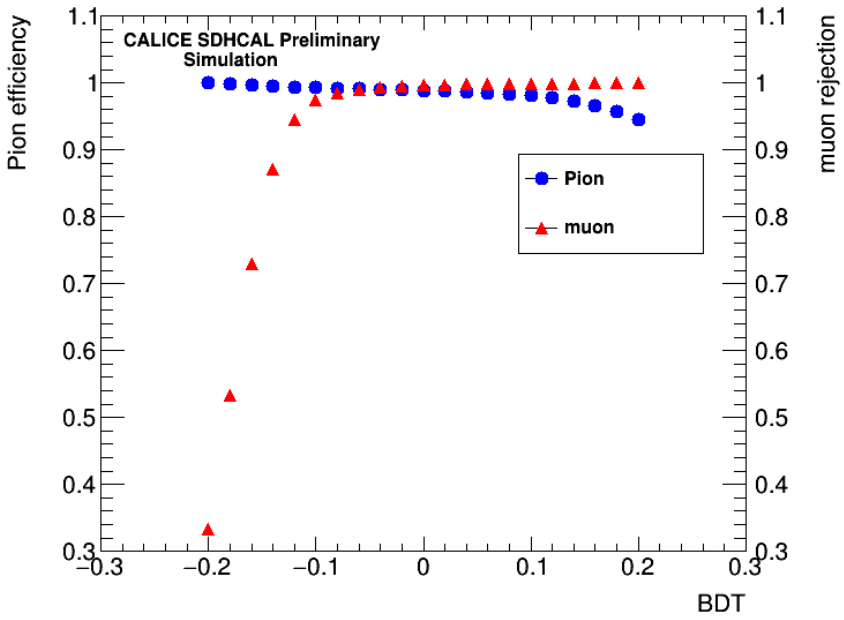
Strong separation power in pi/e and pi/muon

Pion eff vs Bkg rejection rate

MC samples training

- Good pi/e and pi/muon separation
- High pion efficiency exceeding 99% with electron and muon rejection of the same level (>99%)

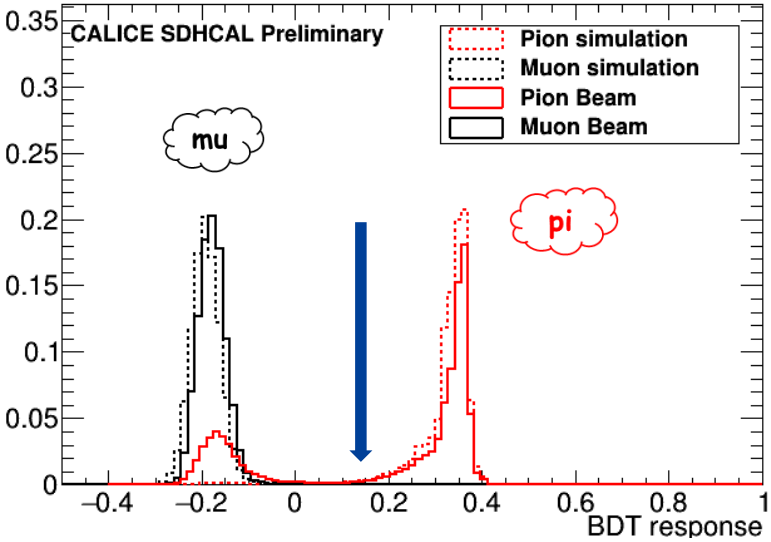


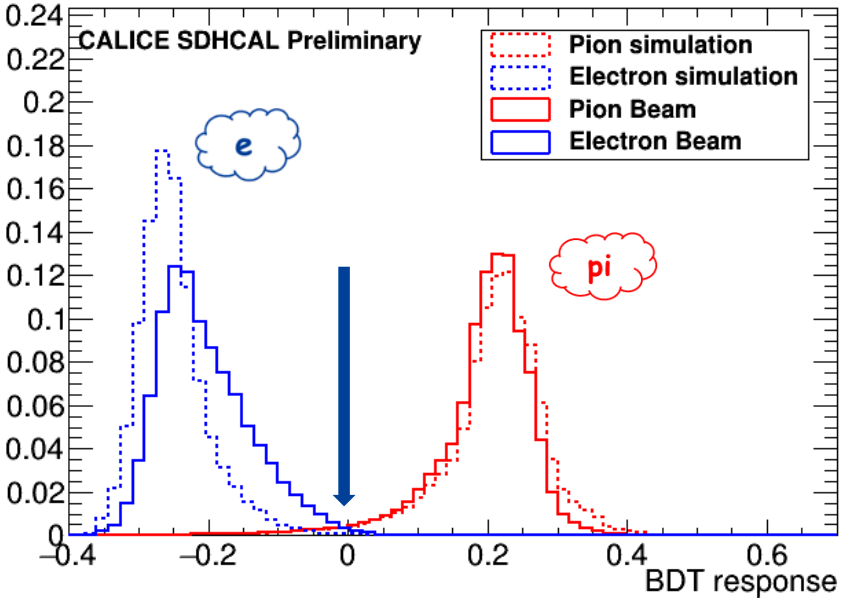


Particle identification using BDT

@Beam data validation

- **Beam data**
  - SPS 2015
    - electron 10,20,30,40 and 50 GeV
    - Pion 10,20,30,40,50,60,70,80GeV
    - Muon 110 GeV



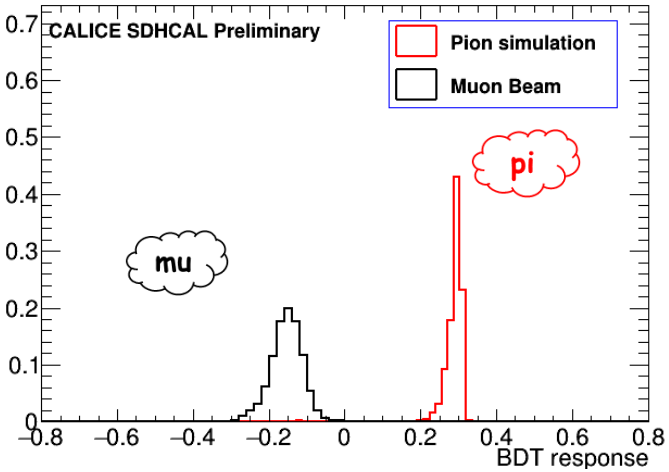


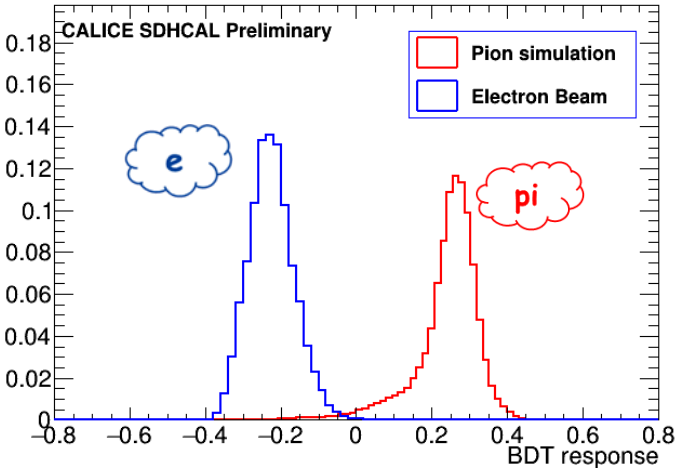
The beam data also show the performance of pi-e and pi-mu separation are good .

Particle identification using BDT in SDHCAL

DATA samples training

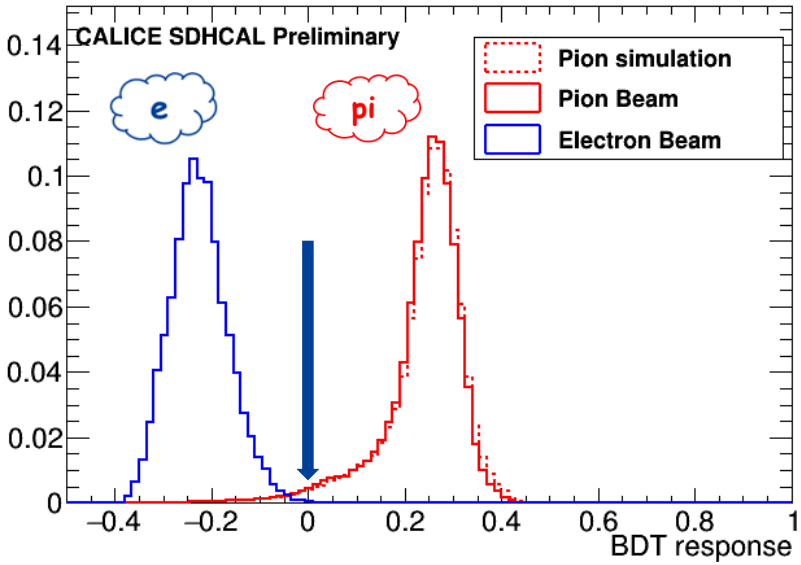
- **Training and Test**
  - **Signal**: 160000 pion events with energy 10,20,30,40,50,60,70 and 80GeV
  - **Background**:50000 beam electron events with energy 10,20,30,40,50GeV
  - **Background**: ≈50000 beam muon events with energy 110 GeV
  - **Ntraining : Ntest=1 : 1**

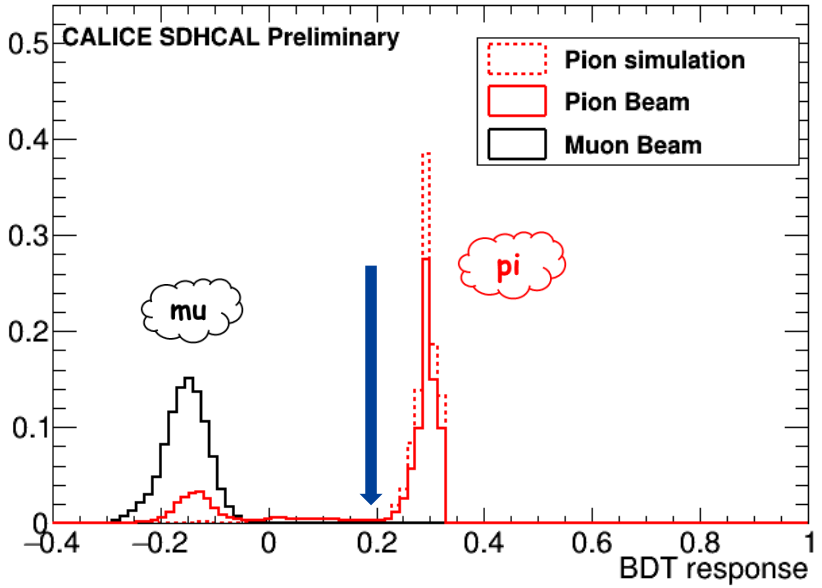




Particle identification using BDT

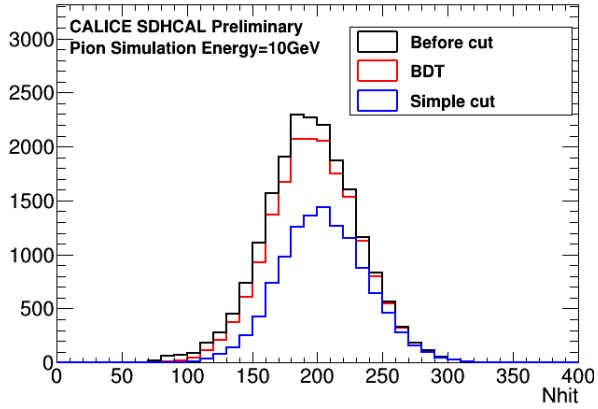
@Beam data validation

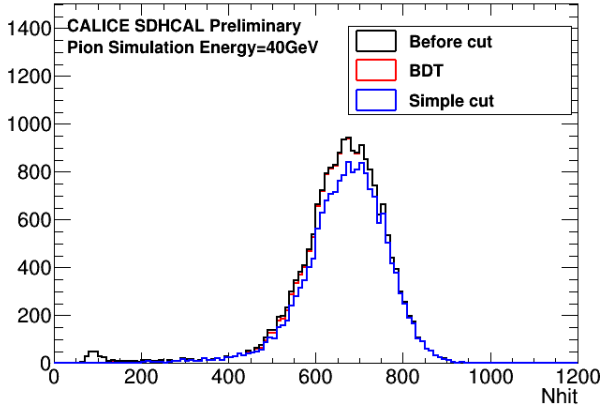


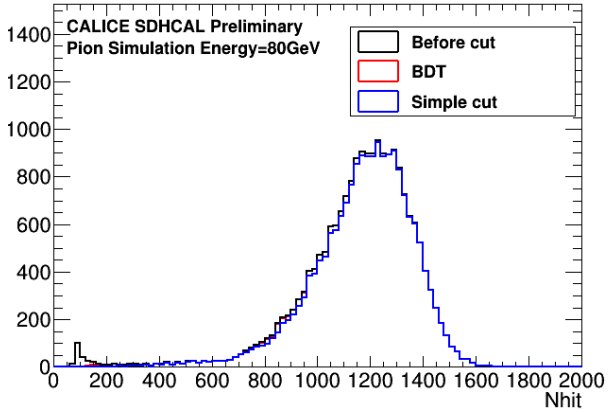


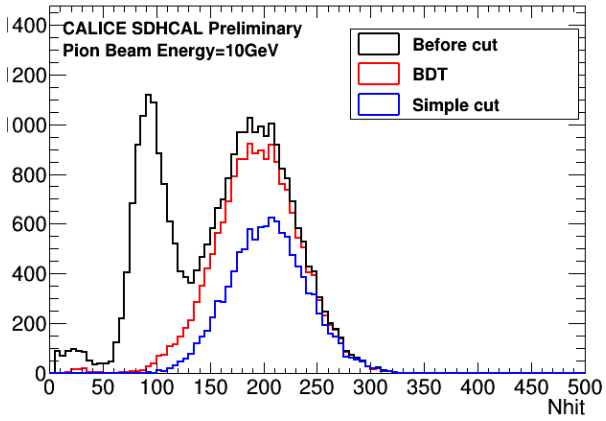
Good separation power and in agreement with previous MC training process

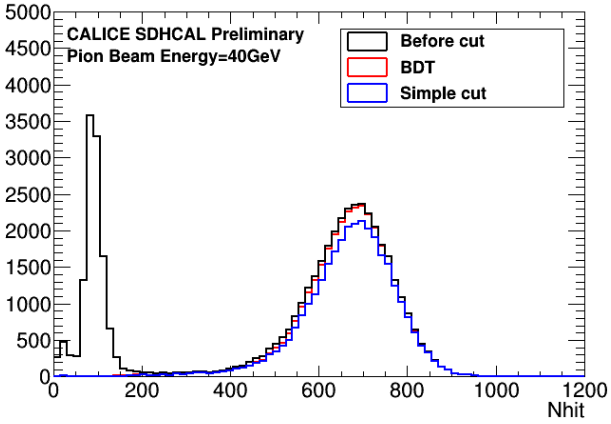
Comparison with simple cut

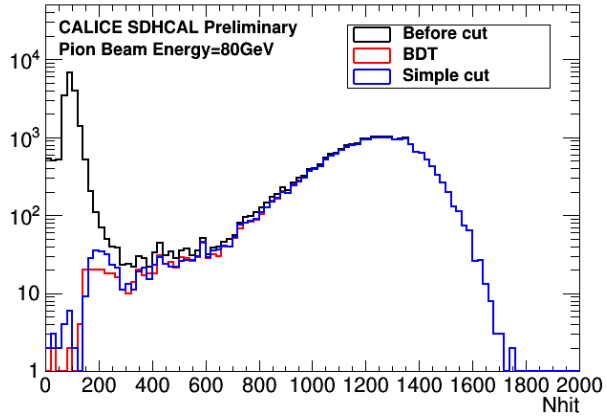








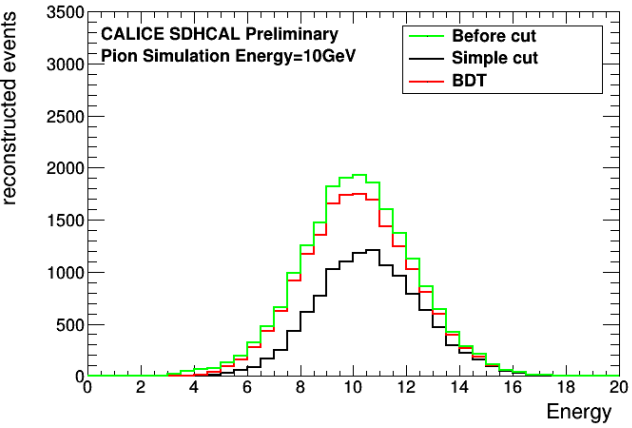


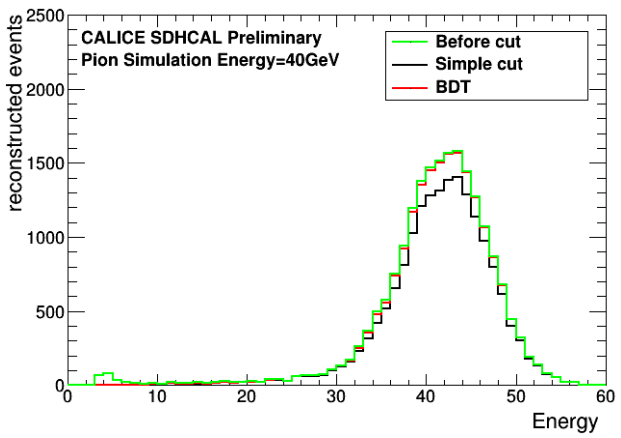


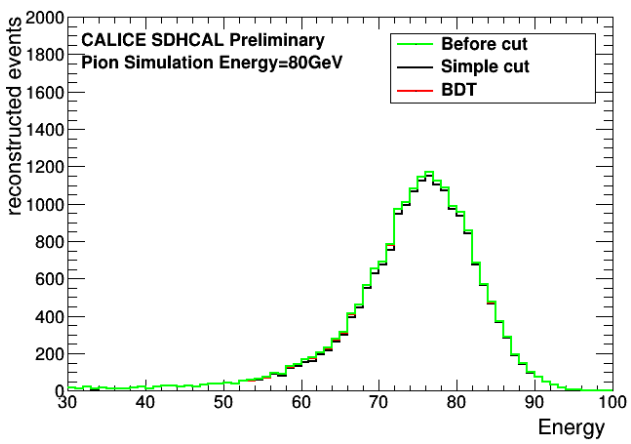
In the low energy, Using BDT save many events.

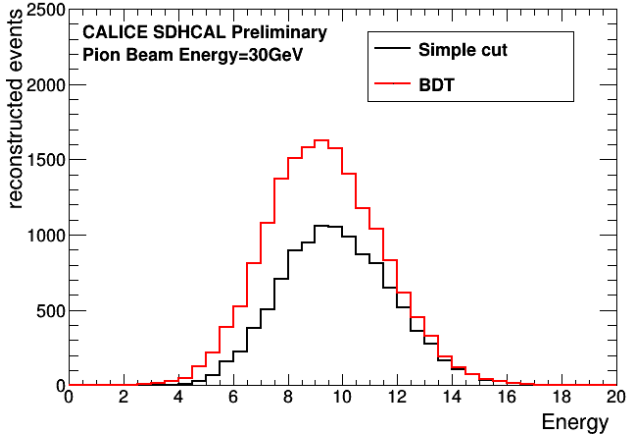
Comparison with simple cut

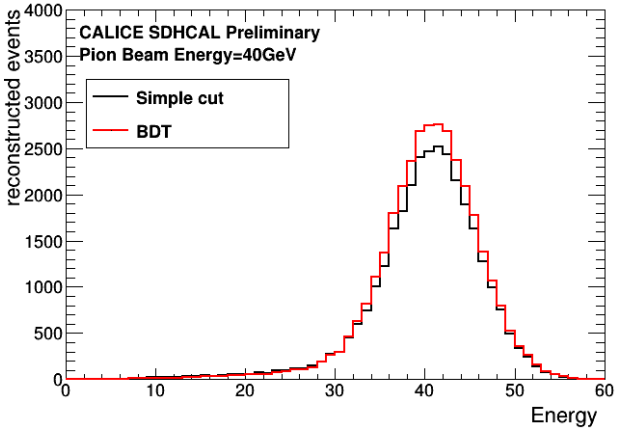
energy reconstruction

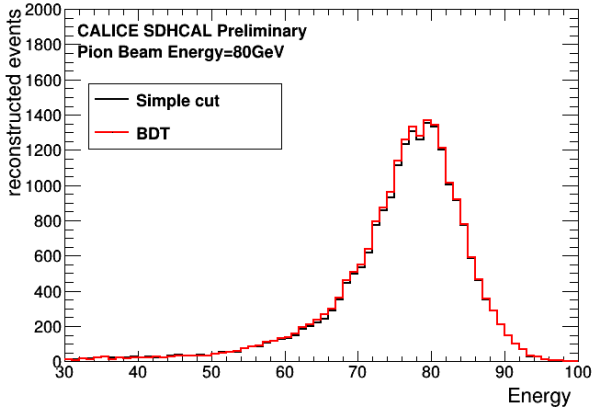












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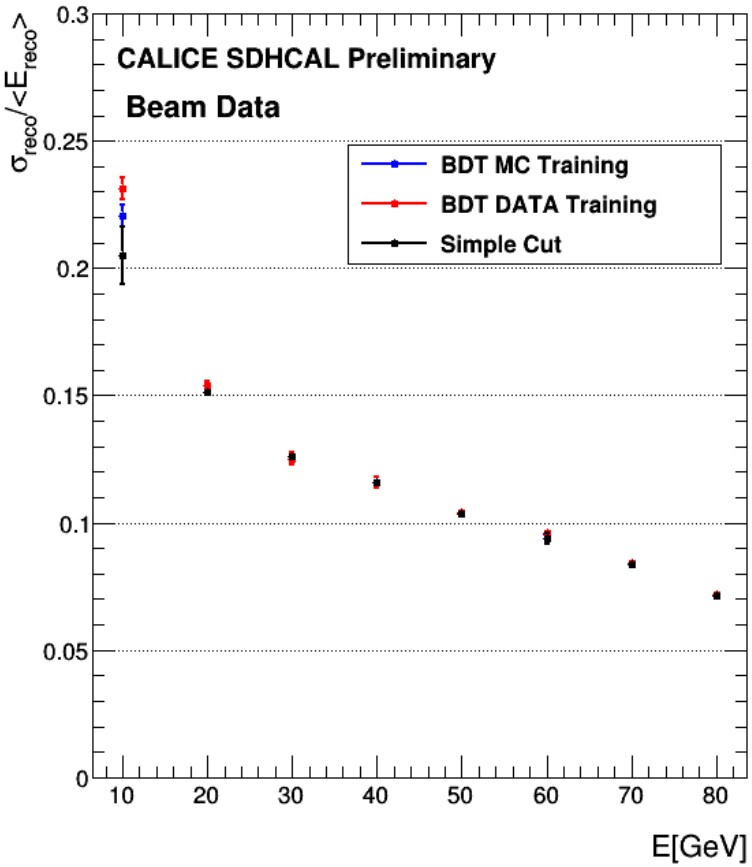
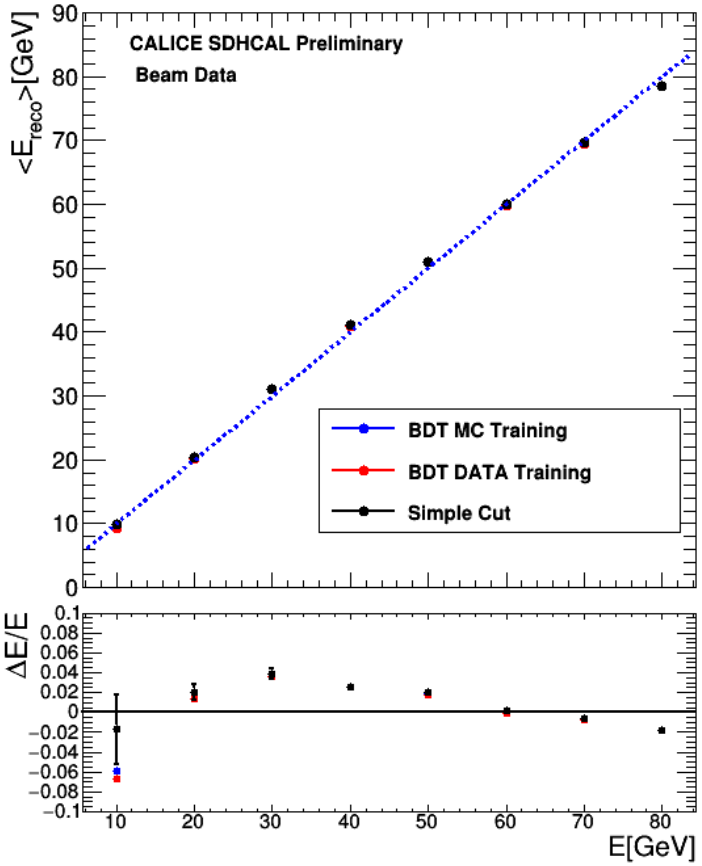




Conclusion & Next Plan

- Particle identification using BDT in SDHCAL
  - PID with BDT is reliable: Good pion efficiency with high electron and muon rejection rate
  - Good resolution and linearity in agreement with standard method, and we got the improvement at 10GeV
  - Systematic uncertainty study
  - Energy reconstruction using BDT

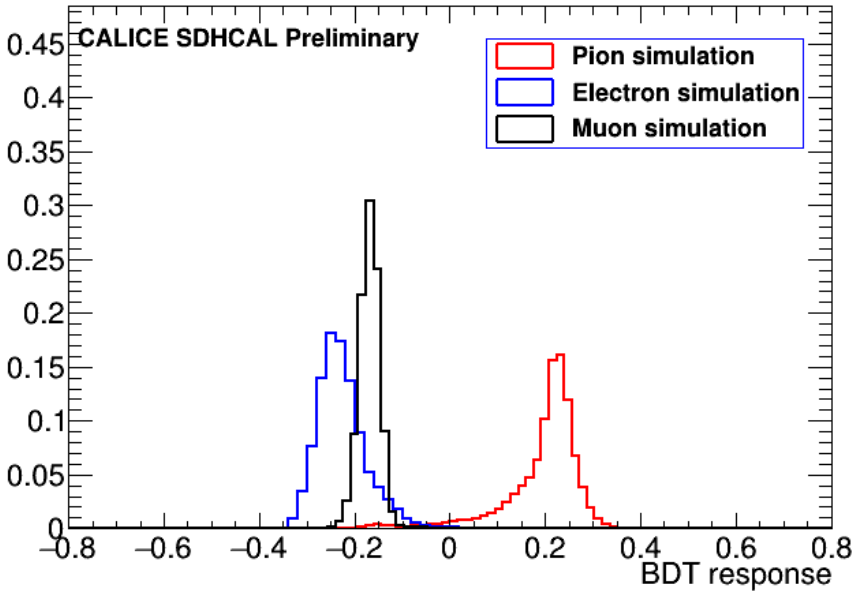
Back up

Training and Test

MC samples training @ Mixed

- Training and Test
  - Signal: 160000 pion events with energy 10,20,30,40,50,60,70 and 80GeV
  - Background:160000 electron events with energy 10,20,30,40,50,60,70 and 80GeV
  - Background: ≈120000 muon events with energy 10,20,30,40,50,60,70 and 80GeV

  Mixed Background
  - Ntraining : Ntest=1 : 1



Particle identification using BDT
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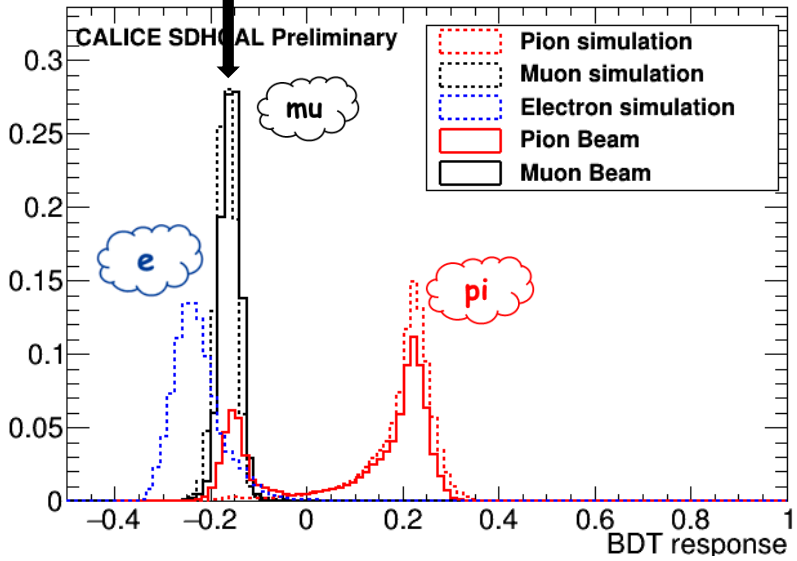
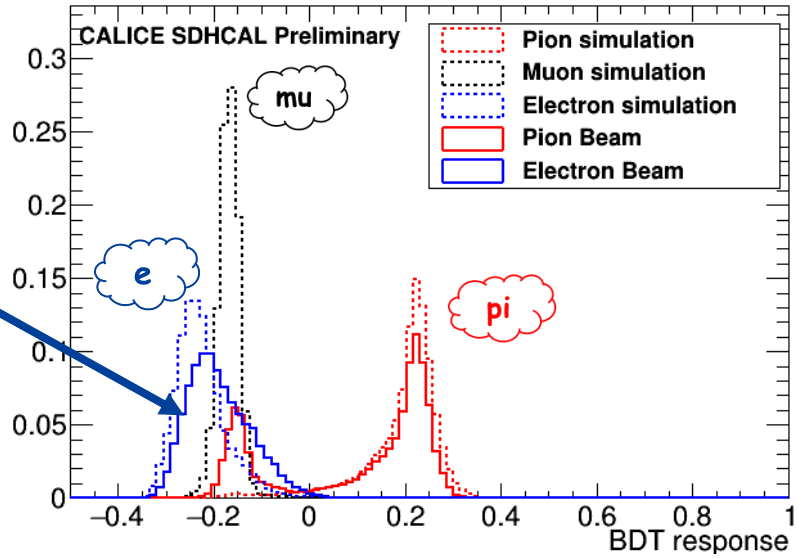
  - Pion 10,20,30,40,50,60,70,80GeV
  - Muon 110 GeV





the performance between pi- and (e-+mu)separation are good .