Energy reconstruction of hadronic showers in SDHCAL for 2015 TB data

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Outline

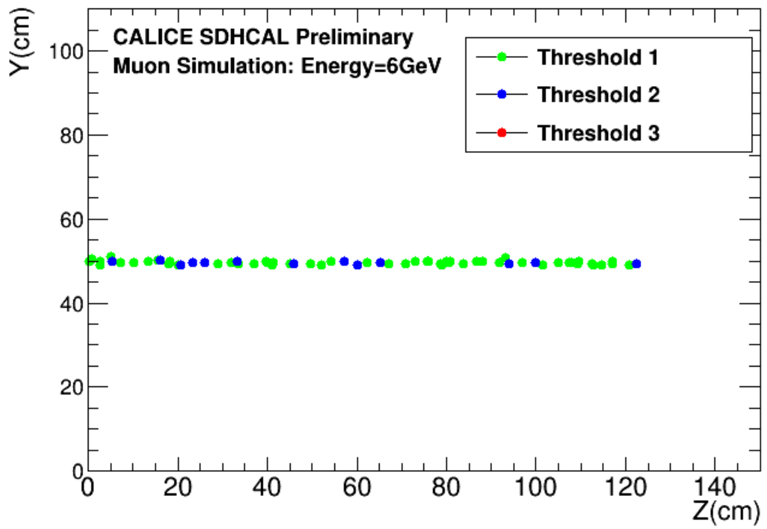
- Introduction for combined beam data
- Event selection
  - Muon rejection
  - Electron background check & rejection
- Linearity and resolution
- Conclusion

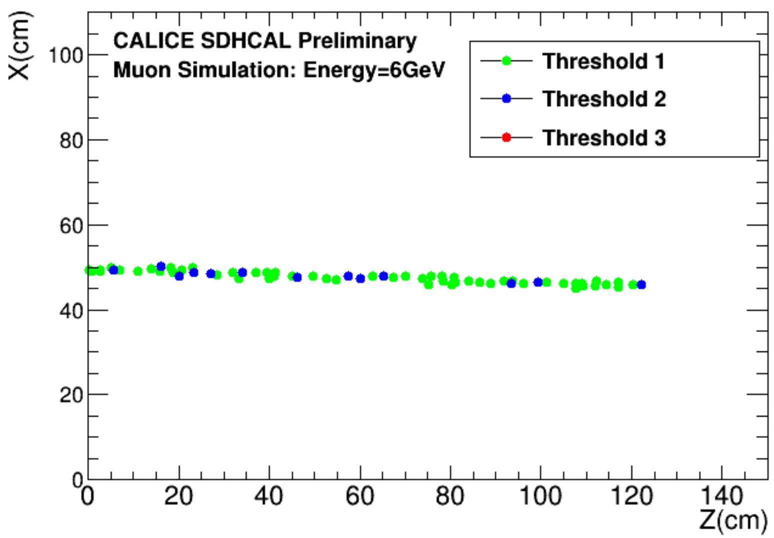
Combined beam data analysis

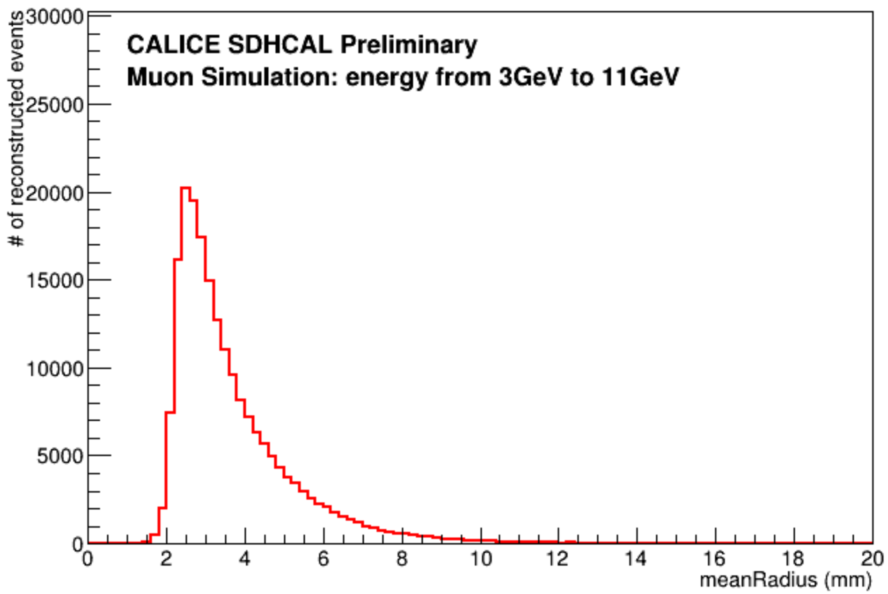
- Data samples were taken at PS(3 -11 GeV), May 2015 SPS data (10-80GeV) taken at SPS.
- Contamination :
  - PS: muons , electrons(since using electron eliminator in test beam period, the electron contamination is negligible except 3-5GeV samples)
- Simulation: FTF_BIC , geant4.9.6

Muon background rejection

MeanRadius of muon track

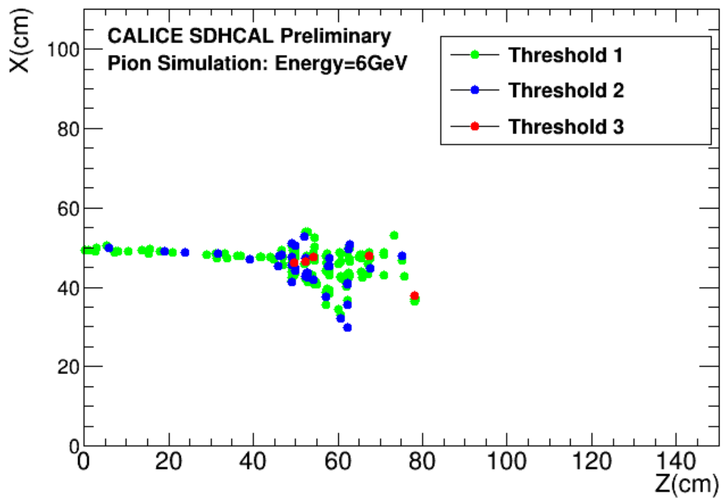


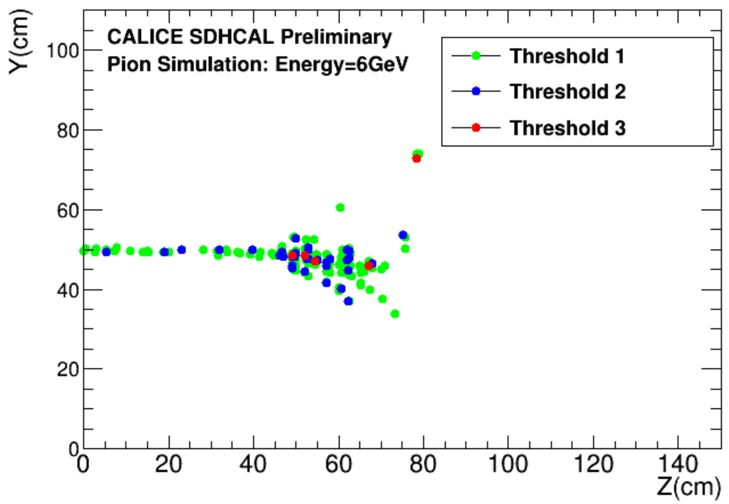


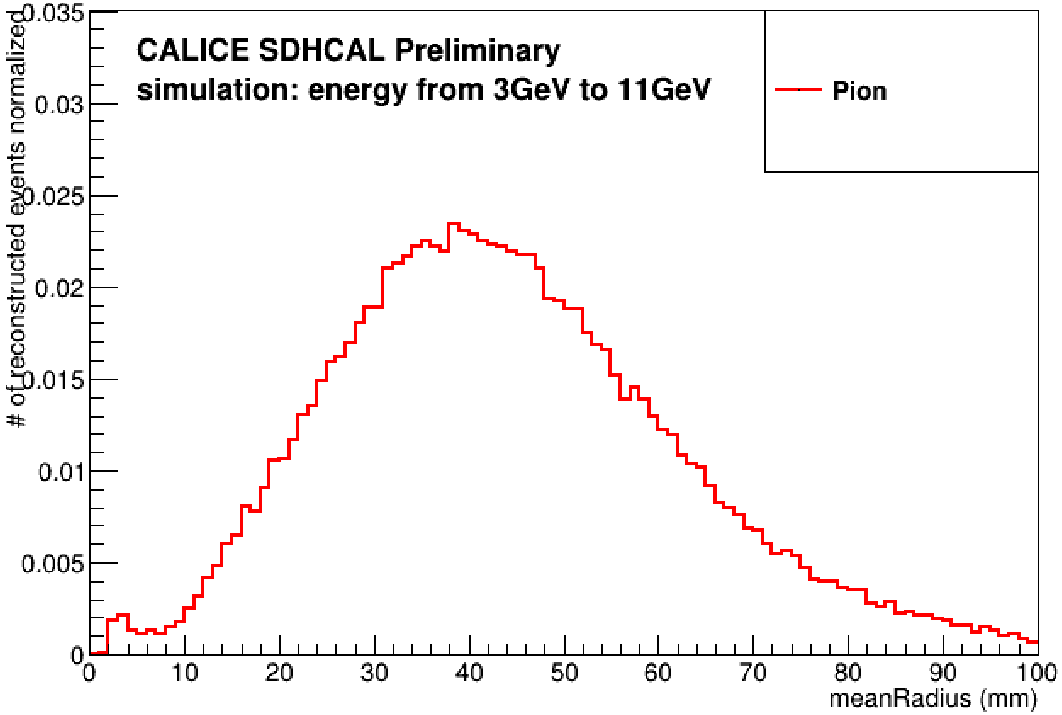


The shower radius is very small < 15mm(≈1.5pad size)

MeanRadius of pion shower

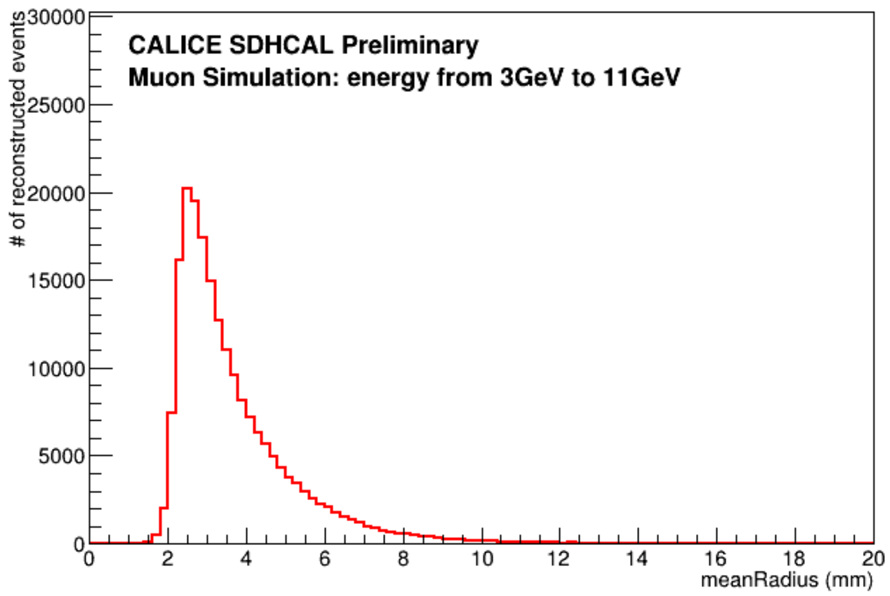




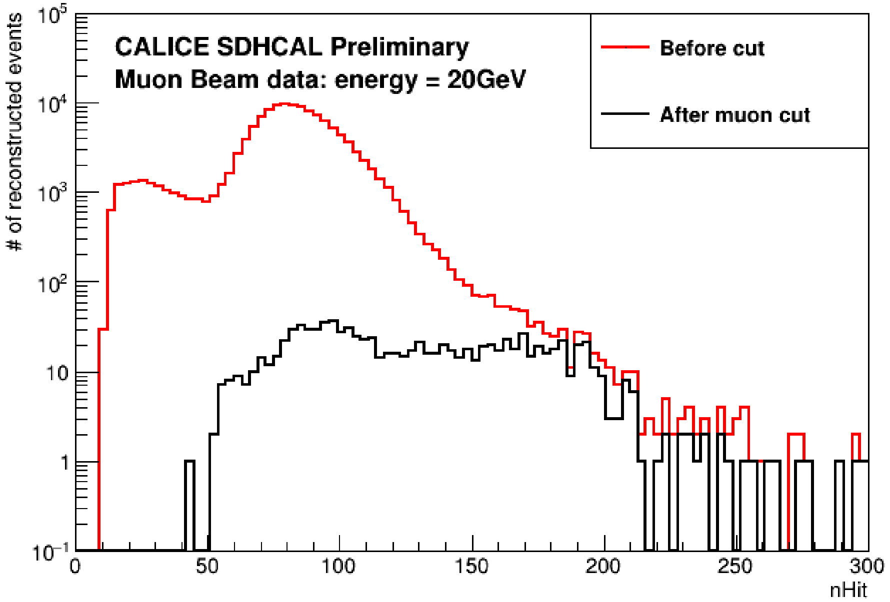


Larger shower radius than muon

Event selection: muon rejection



MeanRadius > 15mm



Muon beam data validation
99% background rejection rate achieved

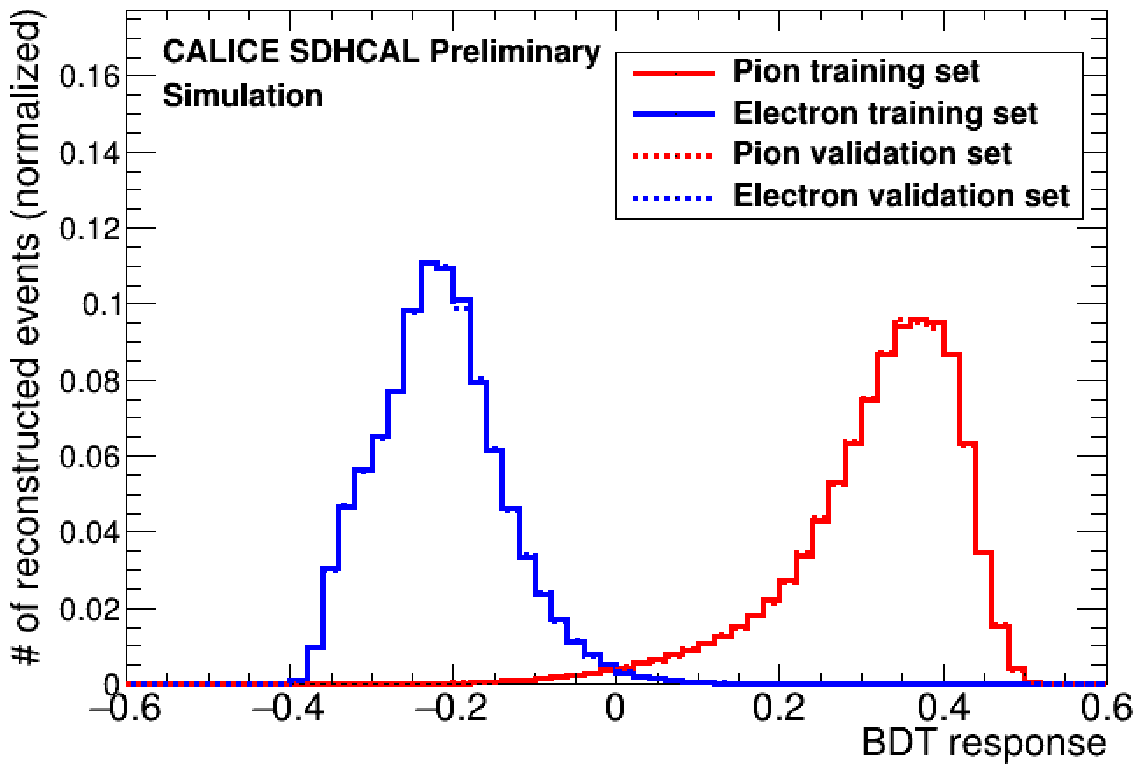
Electron background

- Method: Boosted decision tree (BDT)

- Training set:
  - Electron 1-80GeV, 10000 events per GeV
  - Pion 1-80GeV, 10000 events per GeV
- Test set: the same size

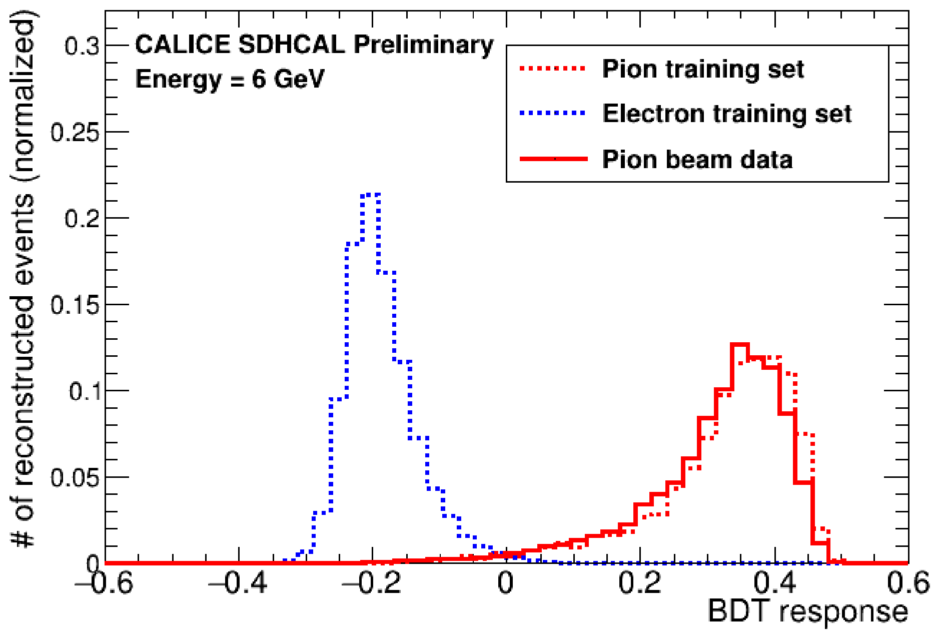
- Input variables: Begin, nTrack, nCluster, radius, nHit/nLayer, density, nHit1/nHit, nHit3/nHit, nShowerlayer/nLayer

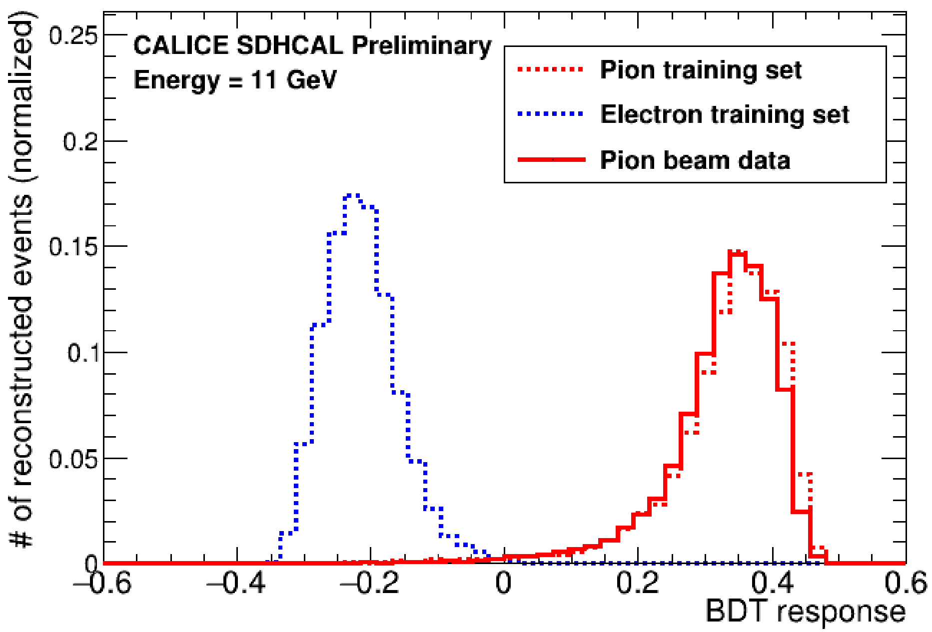
Model Performance



A good agreement between training and validation sets.

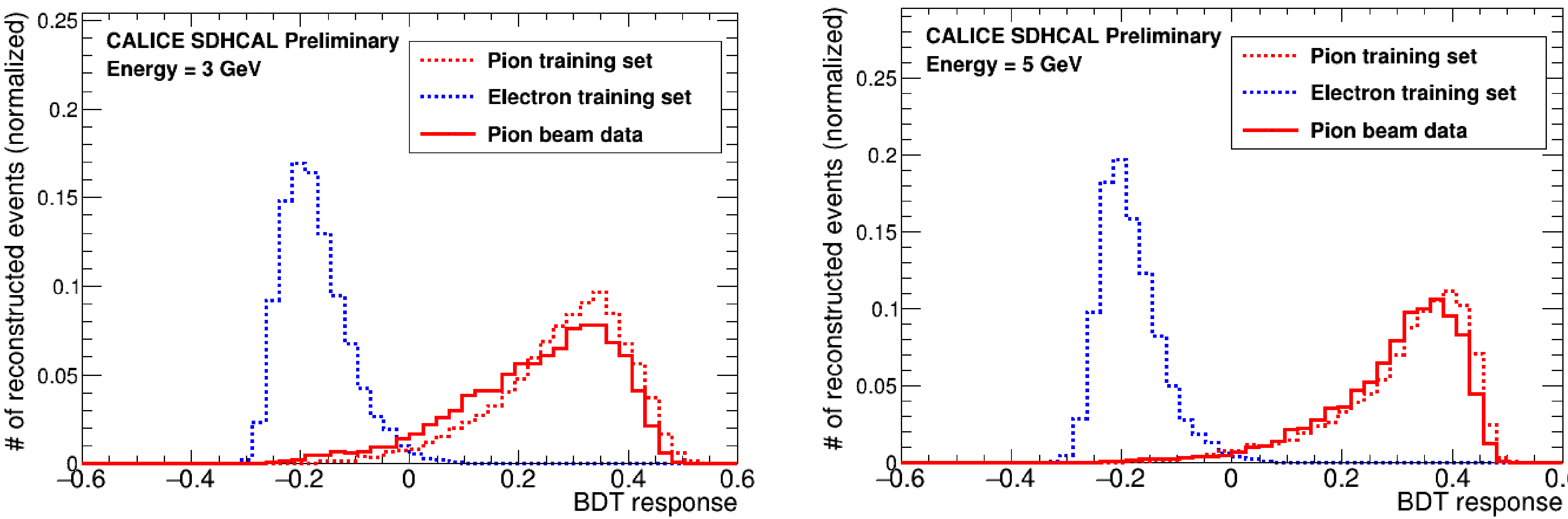
Pion beam validation for 6-11GeV





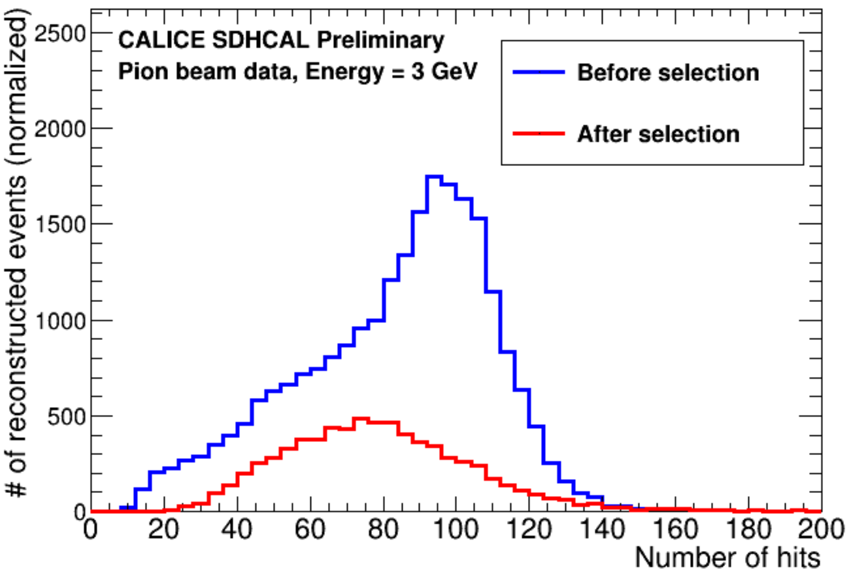
We know there is no electron for 6-11GeV pion beam. These two results confirm it.

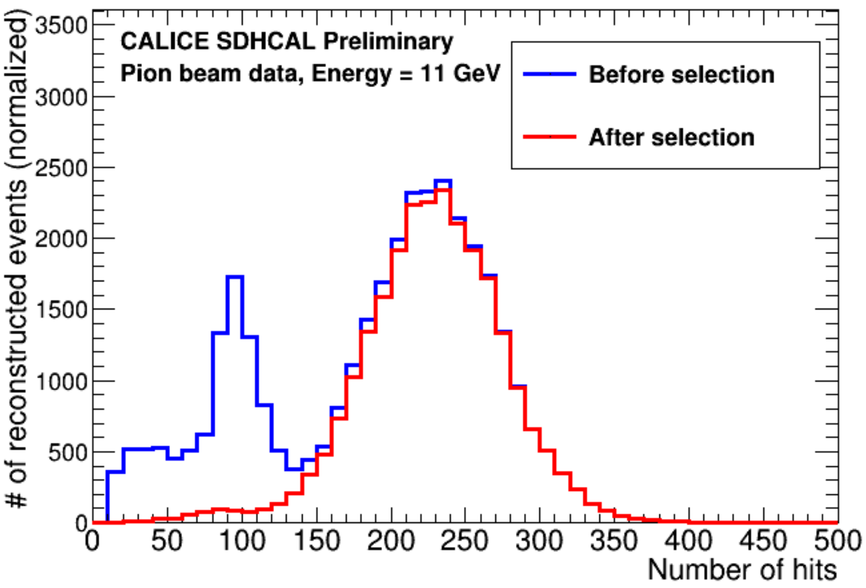
Electron check for pion beam 3-5GeV



The electron contamination is almost negligible. Applying BDT value cut > 0.0 is enough to reject electron-like events

Apply the muon rejection and electron rejection





The number of hits before and after selection

Energy reconstruction

- Feeding combined data, PS (3-11GeV) + SPS (20-80GeV).

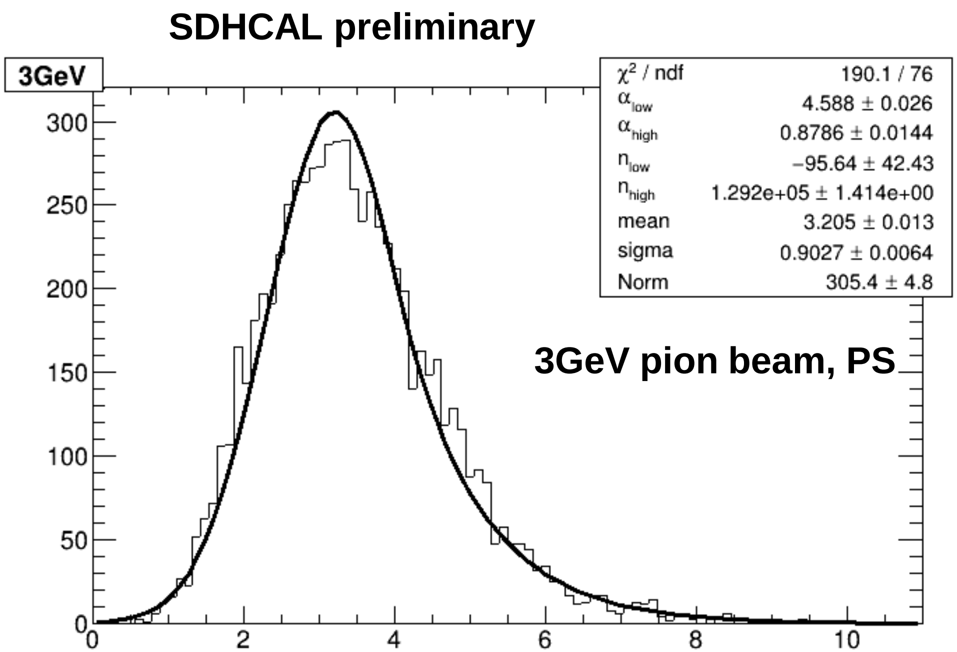
$$E_{reco} = \alpha N_1 + \beta N_2 + \gamma N_3$$

→N_1 = Nb. of hits with 1st threshold < signal < 2nd threshold
→N_2 = Nb. of hits with 2st threshold < signal < 3nd threshold
→N_3 = Nb. of hits with signal > 3rd threshold
N_{tot} = N_1 + N_2 + N_3

α, β, γ are parameterized as quadratic functions of N_{tot}
→They can be determined by minimizing a χ^2

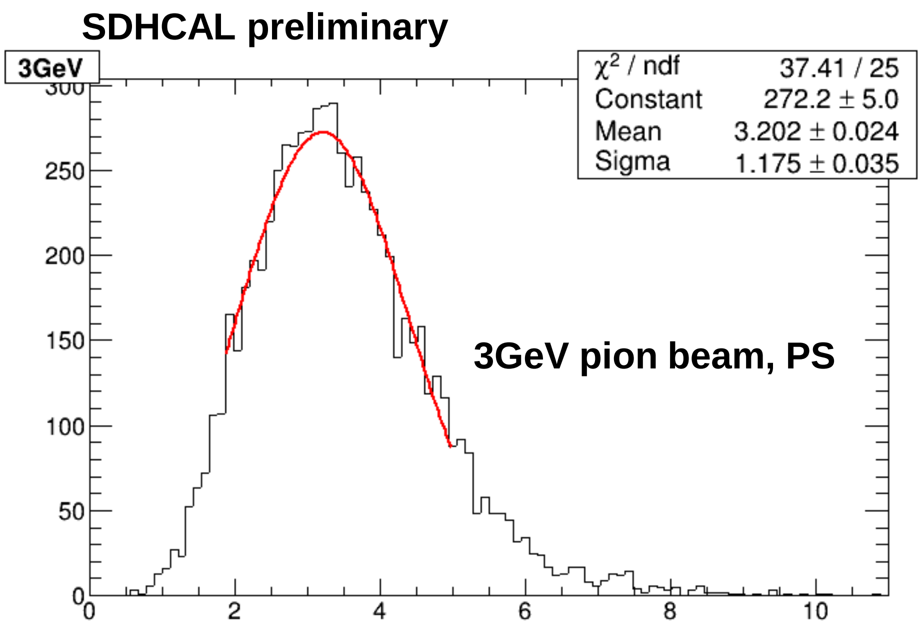
$$\chi^2 = \sum_{i=1}^{N} \frac{(E^i_{beam} - E^i_{reco})^2}{\sigma_i^2} \qquad \sigma_i = \sqrt{E^i_{beam}}$$

Energy reconstruction



Mean:3.20 sigma: 0.90

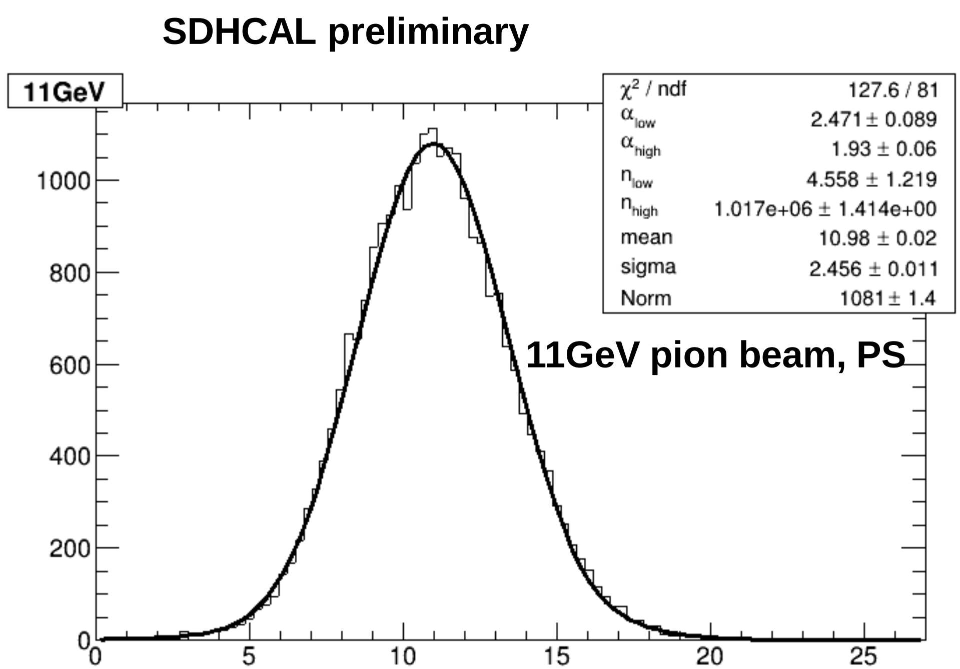
The double sided Crystal ball are applied.



Mean:3.20 sigma: 1.18

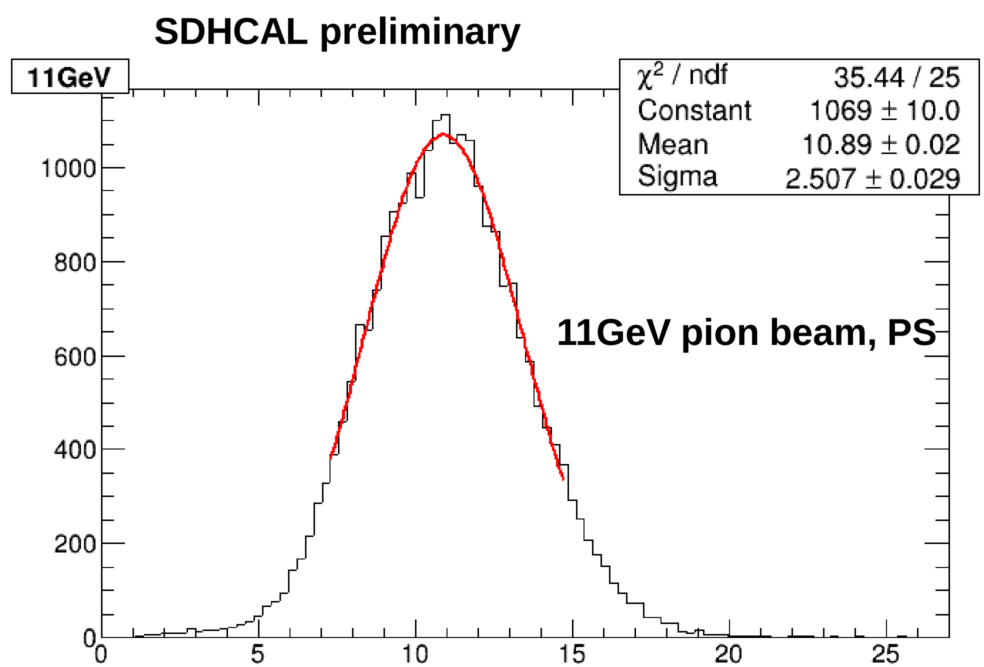
The double-step Gaussian applied.

Energy reconstruction



Mean:10.98 sigma: 2.46

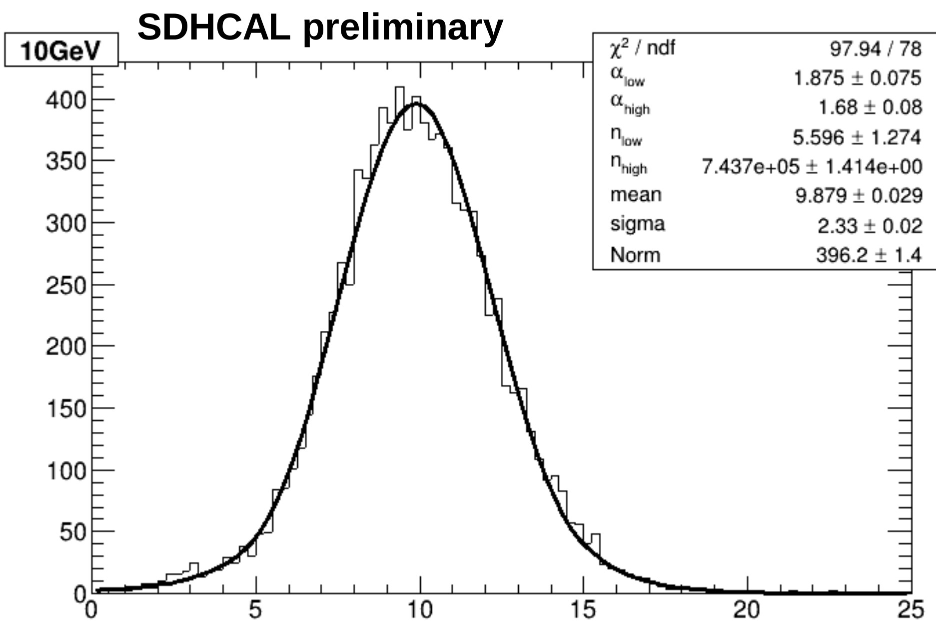
The double sided Crystal ball are applied.



Mean:10.89 sigma: 2.50

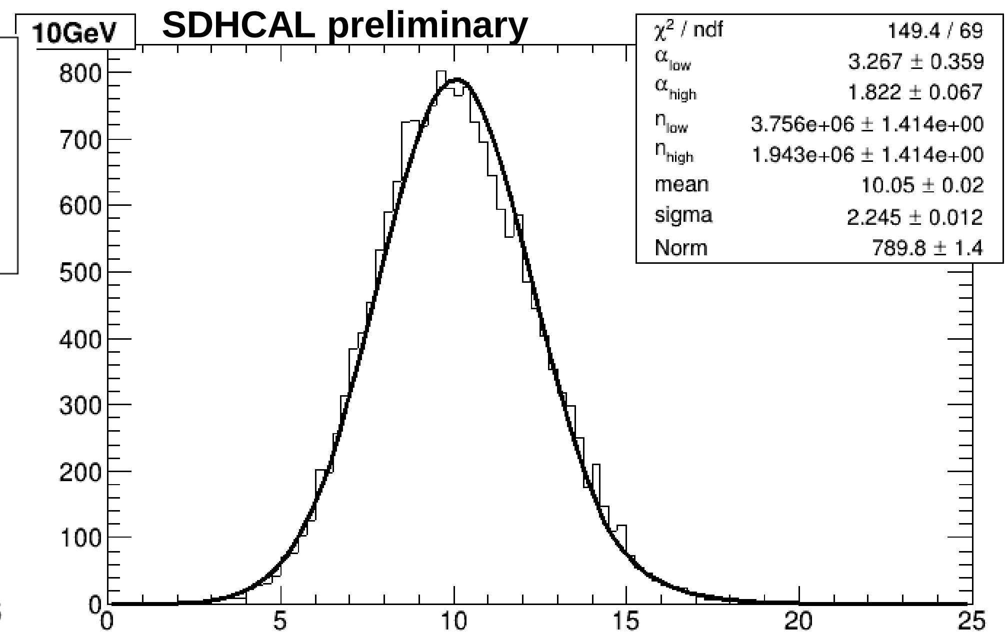
The double-step Gaussian applied.

Energy reconstruction



10GeV pion beam, PS

Mean:9.88, sigma:2.33

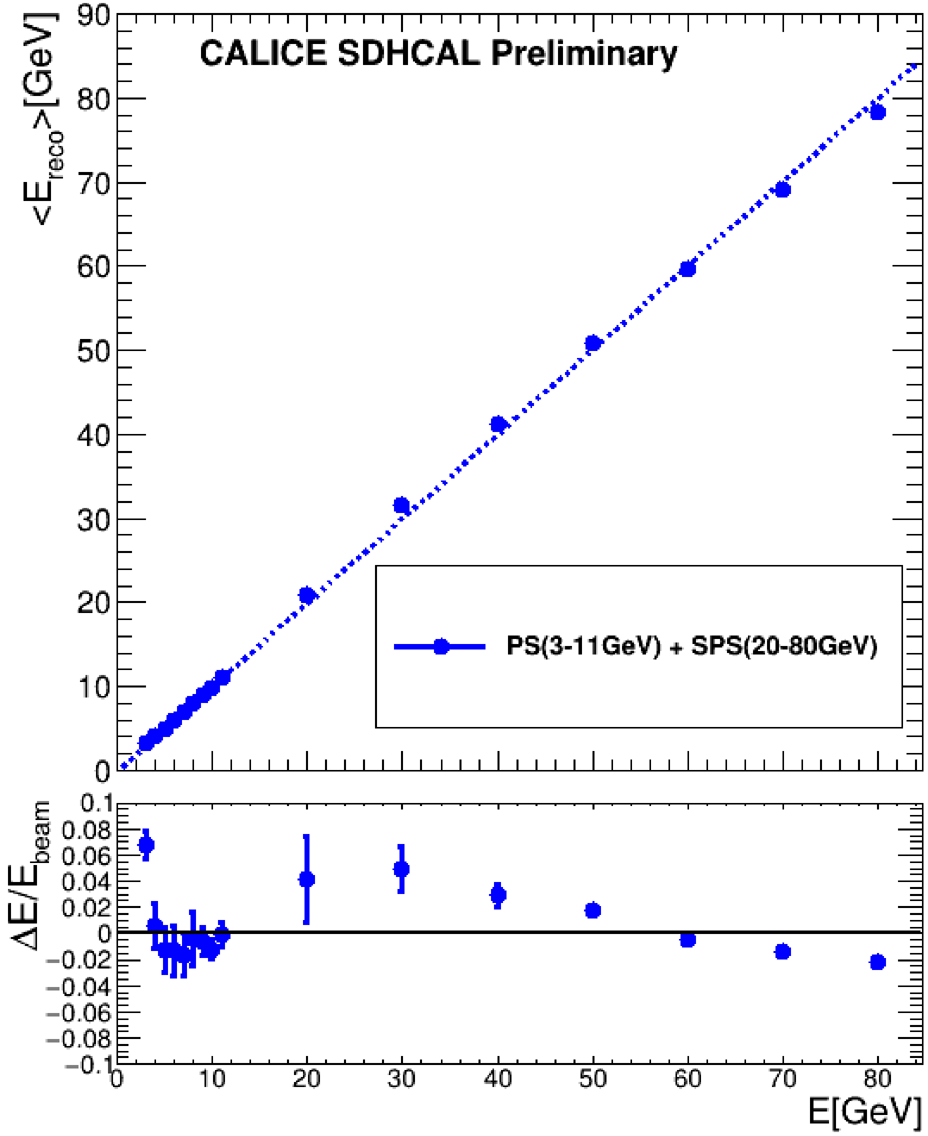


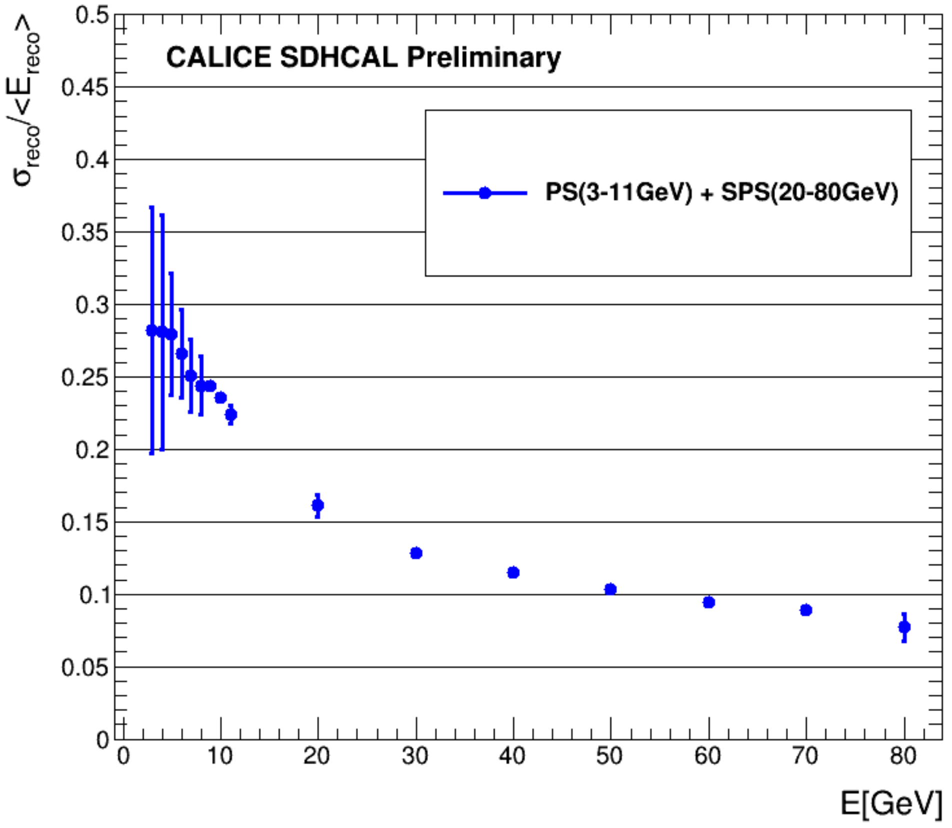
10GeV pion beam, SPS

Mean:10.05, sigma:2.24

The common energy point 10GeV, for both PS and SPS.

Linearity and resolution

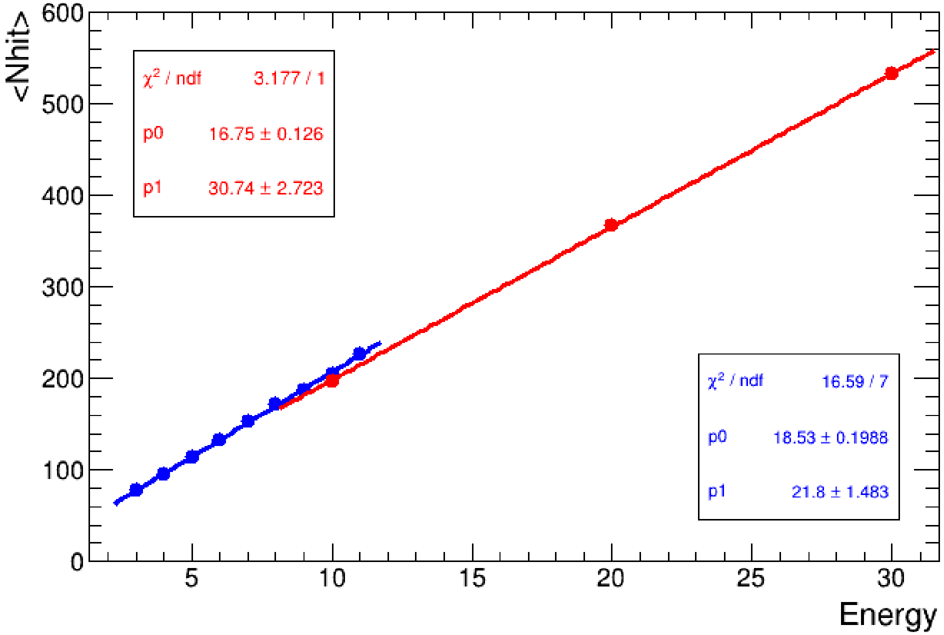




Conclusions & Next

- The BDT model is robust and it can separate electron and pion events of beam data.
- The resolution of combined beam data is in agreement with SPS data.
- Systematic uncertainty studied.

Backup



$$N \cdot \begin{cases} e^{-0.5t^2} & \text{if } -\alpha_{\text{low}} \leq t \leq \alpha_{\text{high}} \\ e^{-0.5\alpha_{\text{low}}^2} \left[\frac{\alpha_{\text{low}}}{n_{\text{low}}} \left(\frac{n_{\text{low}}}{\alpha_{\text{low}}} - \alpha_{\text{low}} - t \right) \right]^{-n_{\text{low}}} & \text{if } t < -\alpha_{\text{low}} \\ e^{-0.5\alpha_{\text{high}}^2} \left[\frac{\alpha_{\text{high}}}{n_{\text{high}}} \left(\frac{n_{\text{high}}}{\alpha_{\text{high}}} - \alpha_{\text{high}} + t \right) \right]^{-n_{\text{high}}} & \text{if } t > \alpha_{\text{high}}, \end{cases}$$