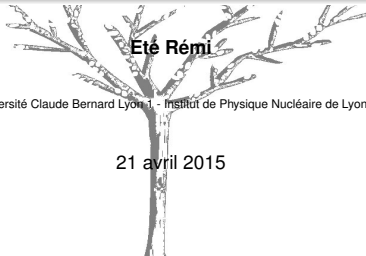


# Arbor PFA

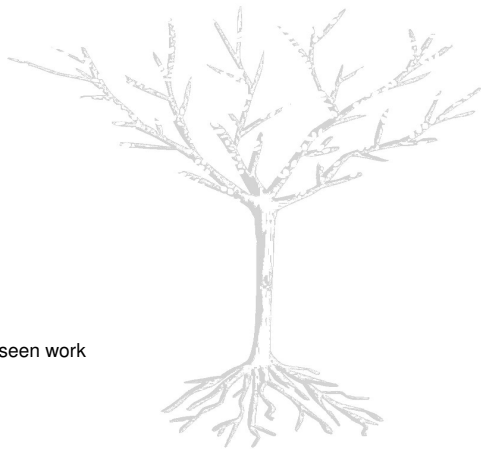
## Update Separation of overlaid shower studies



Université Claude Bernard  Lyon 1



# Summary



1 Package review

2 Analysis updates

3 Conclusion and forseen work

# Package review

Software package

Package currently under refactorization.

Current is ArborPFA package v01-04-00 available at <https://github.com/SDHCAL/ArborPFA>

Package based on PandoraSDK framework.

Currently working with J. Marshall to make the PandoraSDK framework extensible for base objects : CaloHit, Clusters, Tracks, Pfo, Vertex and MCParticle (CaloHit -> ArborCaloHit)

The whole code will be refactorized in new packages :

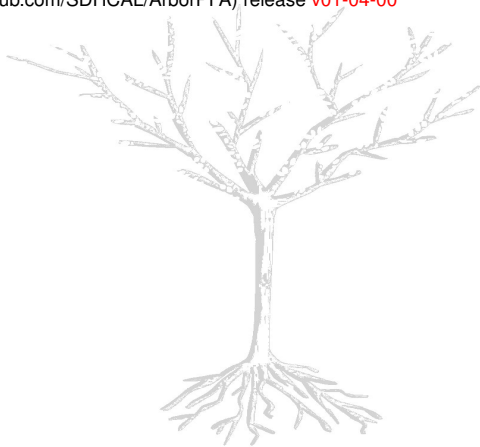
- 1 ArborContent : Algorithm content (<https://github.com/rete/ArborContent>)
- 2 MarlinArbor : Marlin interface to ArborPFA (<https://github.com/rete/MarlinArbor>)

Interface is (already the case) the same as MarlinPandora with the same inputs that Pandora asks.  
Current documentation is only Doxygen.

# Package review

Arbor algorithms + updates

ArborPFA (<https://github.com/SDHCAL/ArborPFA>) release **v01-04-00**

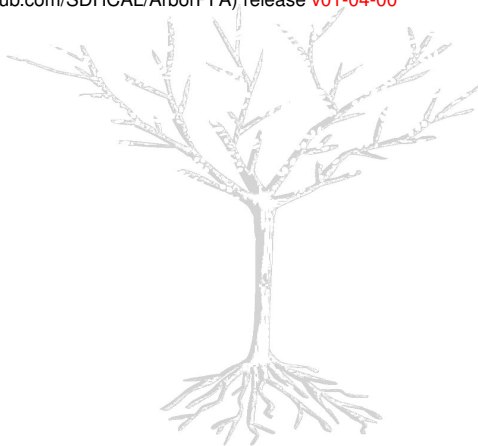


# Package review

Arbor algorithms + updates

ArborPFA (<https://github.com/SDHCAL/ArborPFA>) release **v01-04-00**

## 1 Object Creation



# Package review

Arbor algorithms + updates

ArborPFA (<https://github.com/SDHCAL/ArborPFA>) release **v01-04-00**

- 1 Object Creation
- 2 Isolation Tagging
- 3 Mip track Candidate Tagging

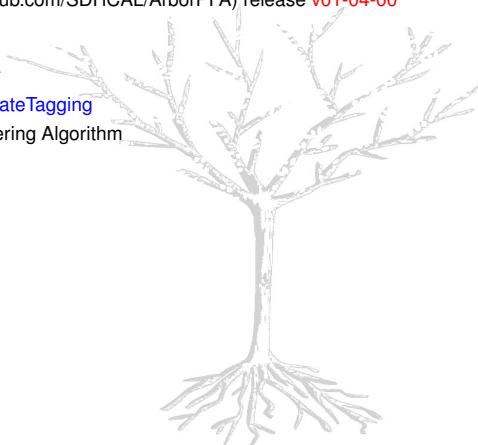


# Package review

Arbor algorithms + updates

ArborPFA (<https://github.com/SDHCAL/ArborPFA>) release **v01-04-00**

- 1 Object Creation
- 2 Isolation Tagging
- 3 Mip track Candidate Tagging
- 4 Connector Clustering Algorithm



# Package review

Arbor algorithms + updates

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- 1 Object Creation
- 2 Isolation Tagging
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- 4 Connector Clustering Algorithm
  - 1 Connector Iteration Algorithms





# Package review

Arbor algorithms + updates

ArborPFA (<https://github.com/SDHCAL/ArborPFA>) release **v01-04-00**

- 1 Object Creation
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    - 1 Primary Track Finder (local seeding and cleaning)

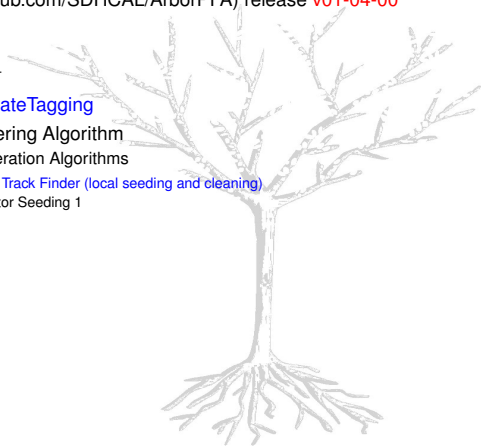


# Package review

Arbor algorithms + updates

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  - 1 Connector Iteration Algorithms
    - 1 Primary Track Finder (local seeding and cleaning)
    - 2 Connector Seeding 1



# Package review

Arbor algorithms + updates

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    - 3 Connector Cleaning 1



# Package review

Arbor algorithms + updates

ArborPFA (<https://github.com/SDHCAL/ArborPFA>) release **v01-04-00**

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    - 3 Connector Cleaning 1
    - 4 Connector Seeding 2

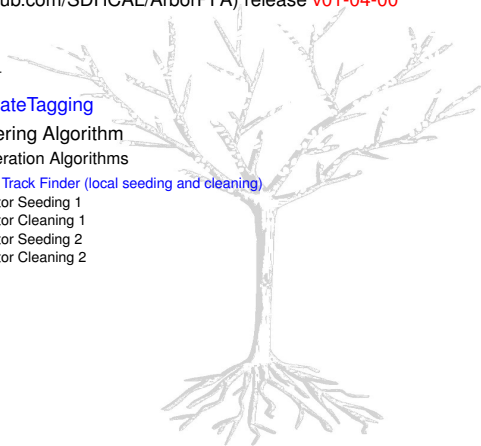


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    - 5 Connector Cleaning 2

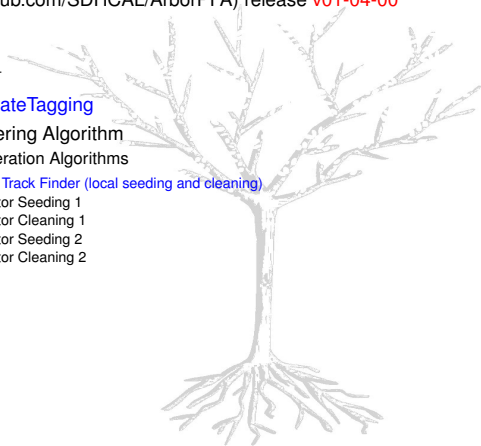


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    - 4 Connector Seeding 2
    - 5 Connector Cleaning 2
  - 2 Tree Building

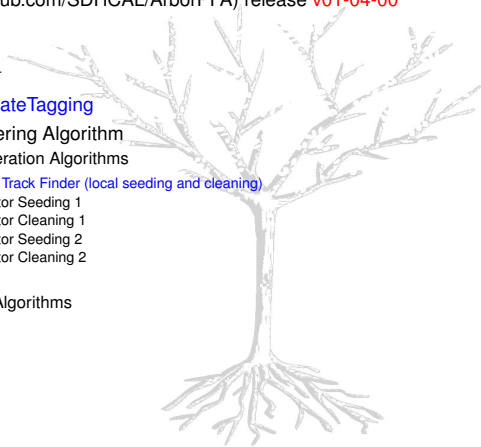


# Package review

Arbor algorithms + updates

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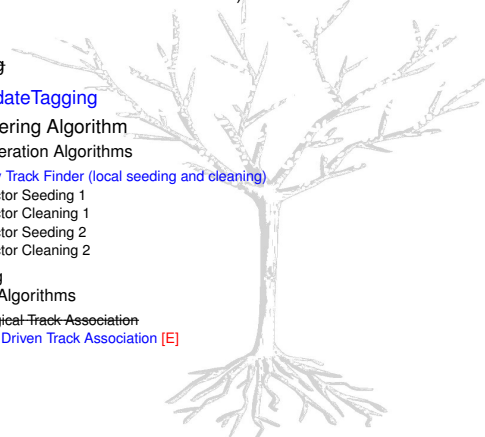
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    - 3 Connector Cleaning 1
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  - 2 Tree Building
  - 3 Association Algorithms



# Package review

Arbor algorithms + updates

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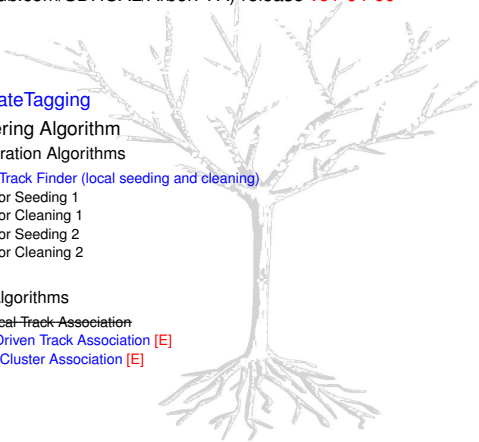
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      - 5 Connector Cleaning 2
    - 2 Tree Building
    - 3 Association Algorithms
      - 1 Topological Track Association
      - 2 Energy Driven Track Association [E]



# Package review

Arbor algorithms + updates

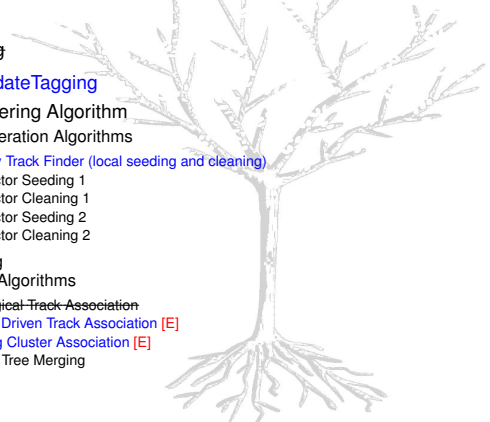
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      - 2 Energy Driven Track Association [E]
      - 3 Pointing Cluster Association [E]

# Package review

Arbor algorithms + updates

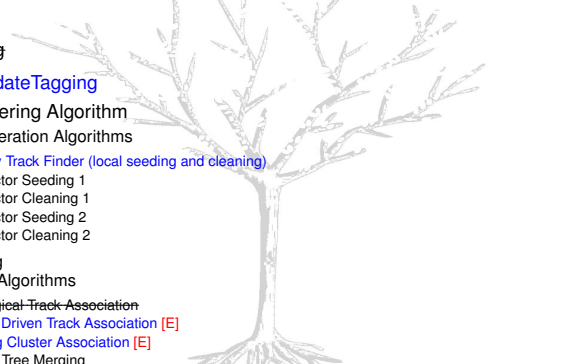
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      - 4 Neutral Tree Merging

# Package review

Arbor algorithms + updates

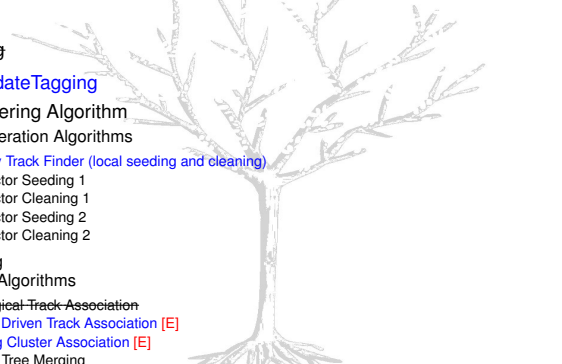
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      - 3 Pointing Cluster Association [E]
      - 4 Neutral Tree Merging
      - 5 Small Neutral Merging

# Package review

Arbor algorithms + updates

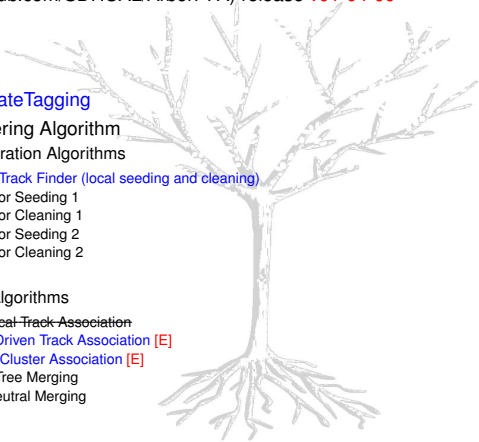
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      - 2 Energy Driven Track Association [E]
      - 3 Pointing Cluster Association [E]
      - 4 Neutral Tree Merging
      - 5 Small Neutral Merging
  - 5 Pfo Creation

# Package review

Arbor algorithms + updates

ArborPFA (<https://github.com/SDHCAL/ArborPFA>) release **v01-04-00**

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      - 2 Energy Driven Track Association [E]
      - 3 Pointing Cluster Association [E]
      - 4 Neutral Tree Merging
      - 5 Small Neutral Merging
  - 5 Pfo Creation

Parameters returned to reduce connection distance ...

→ More pfo splitting (-)

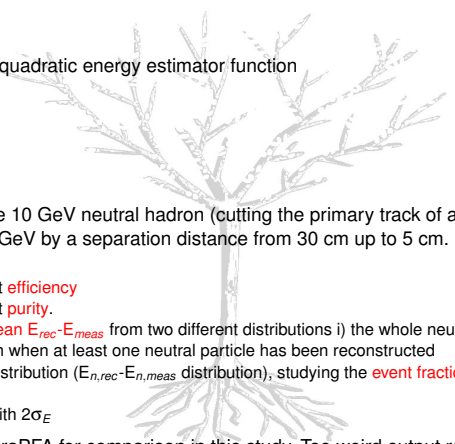
→ Separation more powerful (+)

... BUT !! additional cluster association offsets this pfo splitting (reassociation) (+)

# Analysis updates

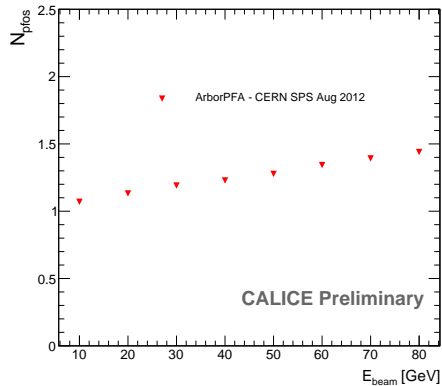
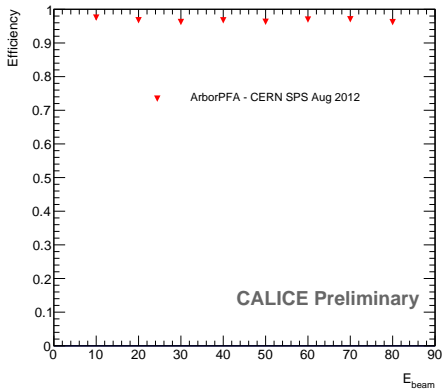
## Overview

- Using SDHCAL with quadratic energy estimator function
- Single particle
  - Efficiency
  - $N_{pfs}$
  - $E_{rec}$
  - $E_{resol}$
- Overlay event : a fake 10 GeV neutral hadron (cutting the primary track of a  $\pi^-$ ) overlaid with a charged  $\pi^-$  from 10 up to 50 GeV by a separation distance from 30 cm up to 5 cm.
  - $N_{pfs}$
  - Neutral particle hit **efficiency**
  - Neutral particle hit **purity**.
  - **Mean  $E_{rec}$**  and **mean  $E_{rec}-E_{meas}$**  from two different distributions i) the whole neutral energy distribution, ii) neutral energy distribution when at least one neutral particle has been reconstructed
  - Using the  $E_{n,rec}$  distribution ( $E_{n,rec}-E_{n,meas}$  distribution), studying the **event fraction** contained in  $E_{rec} \pm 1\sigma_E$  (resp.  $0 \pm 1\sigma_E$ )
  - Same variables with  $2\sigma_E$
- No longer use PandoraPFA for comparison in this study. Too weird output results shown at HCG4ILD for TPC+SDHCAL only system (ConeClusteringAlgorithm not adapted).



# Analysis updates

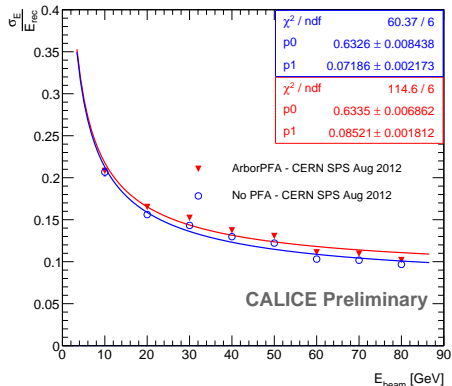
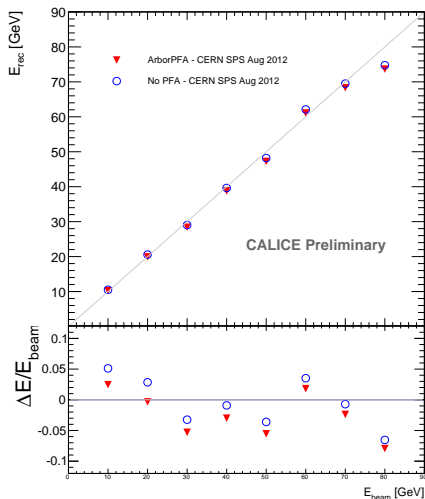
Single particle



Efficiency  $\rightarrow$  OK. NPfos  $\rightarrow$  Still a bit of splitting but OK.

## Analysis updates

Single particle



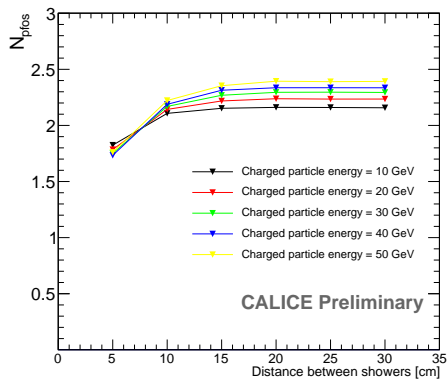
$E_{Rec}$  → Effect of pfo splitting visible in deviation (rather small).

$E_{Resol}$  → Effect of deviation visible in  $E_{Resol}$  (Gaussian width remains the same)



# Analysis updates

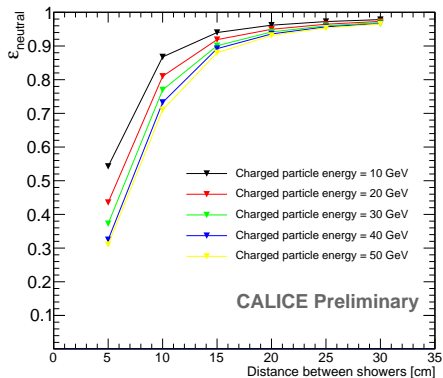
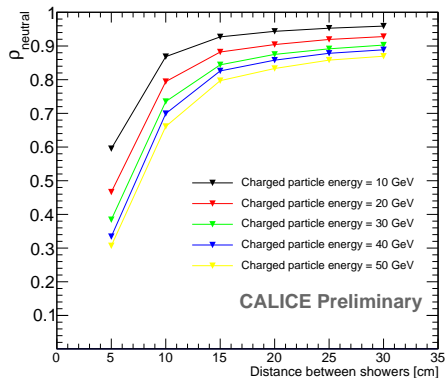
Overlay events



Compatible with  $N_{pto,n,single} + N_{pto,ch,single}$  at large distance.  
As expected decreasing with the separation distance

# Analysis updates

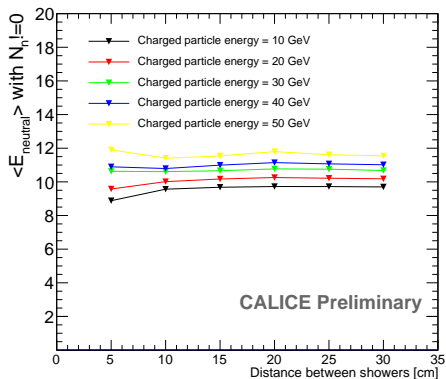
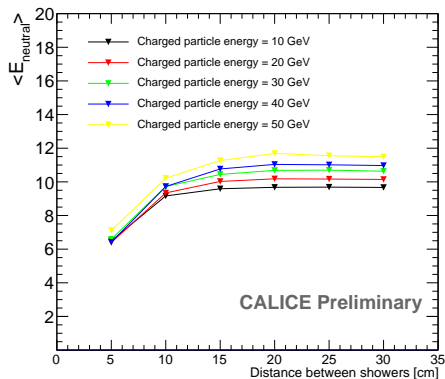
## Overlay events



SmallNeutralTreeMerging effect on purity. Using the distance between parent and daughter trees, no energy information (that should be used here !)

# Analysis updates

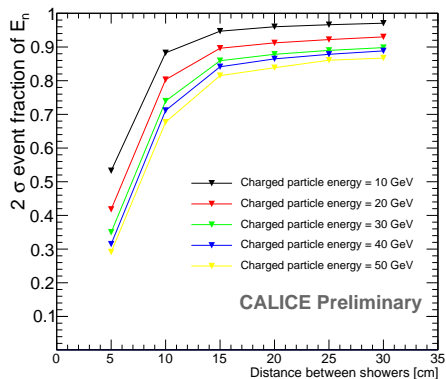
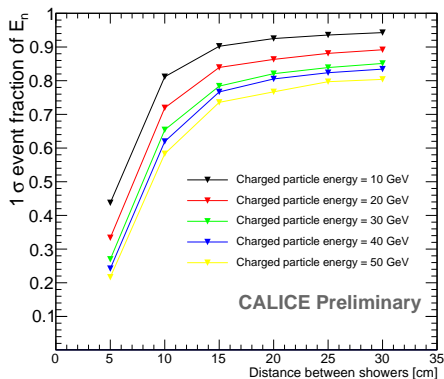
## Overlay events



- Again the effect of the SmallNeutralTreeMerging can be seen
- Binary-like behavior at small separation distances : good separation or complete merging (event topology)

# Analysis updates

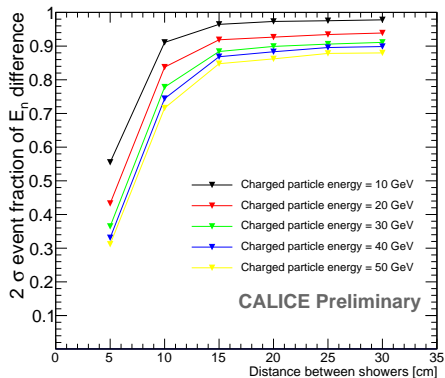
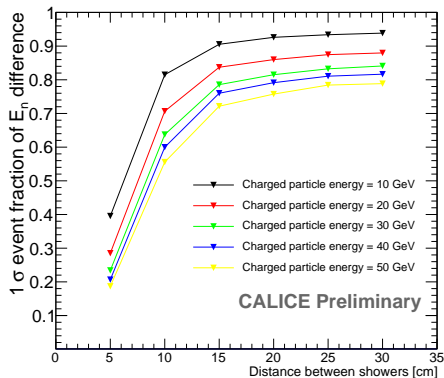
## Overlay events



Effect of PFA (confusion) + detector (energy resolution)

# Analysis updates

## Overlay events



Effect of PFA only (confusion)

# Conclusion and forseen work

## Conclusion

- Single particle understood and shown very good result
- Overlaid particle separation understood and shown good results until 5 cm. At this distance the separation power is binary-like (weel separated or completely merged). Need improvement again ...

## Current and forseen work

- Currently working on PandoraSDK development with J. Marshall to make the framework extensible (CaloHit -> ArborCaloHit). This will also make ArborPFA fully compatible with PandoraSDK functionalities (reclustering, cluster fragmentation).
- Finalize the note on the single particle / hadron separation
- Correct the isolated tree merging to take into account the main "tree" energy
- Finish to rewrite the algorithms in the new SDK framework (almost done)
- Implements a reclustering :
  - Statistical loop (a la Pandora)
  - Branch cutting and switching (a la Arbor)
- Starting to look ILD model (ILD\_02\_v05) :
  - Implementation in ECal for hadronic interactions
  - Connection between ECal-HCal
- Garlic in ECal and ArborPFA in ECal+HCal looks promising
- Start thinking about combined ECal+SDHCAL energy estimator functions