

Validation of single-particle test samples with SDHCAL and comparison with AHCaL ILD software & analysis meeting

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Centro de Investigaciones
Energéticas, Medioambientales
y Tecnológicas



The second test-dataset for the SDHCAL validation and AHCAL comparison

- Details about the ILD confluence production for the **second** test production with the latest ilcsoft v02-01-02.
<https://ild.ngt.ndu.ac.jp/eelog/dbd-prod/323>
- We are interested again in K_L^0 and μ particles
- For the first test production we presented results using high level objects in this dataset.
- Now we have a working recipe that give us access to the low level objects.

First look at the second test-dataset for the SDHCAL validation and AHCAL comparison, K_L^0

- Energy range: (1,2,5,10,20,30,40,50,60,70,80,90,100,110) GeV. **o2**
/ilc/prod/ilc/mc-opt/ild/dst-merged/1-calib/single/ILD_15_o2_v02_nobg/v02-01-02
- Energy range: (1,2,5,10,20,30,40,50,**60,70,80,90,100,110**) GeV. **o1**
(single particle dataset, in blue new datasets wrt first test sample)
/ilc/prod/ilc/mc-opt/ild/dst-merged/1-calib/single/ILD_15_o1_v02_nobg/v02-01-02
- We made a full copy of both datasets to our local cluster in CIEMAT dedicated to CALICE/ILD analysis by accessing the dataset via DIRAC.
- Using the same ilcsoft version (v02-**00**-02 → /cvmfs/ilc.desy.de/sw/x86_64/gcc82_sl6/v02-\protect\unhbox\voidb@x{\color{blue}\protect\protect\protect\edefT1{T1}\let\enc@update\relax\edefptm{ptm}\edefm{m}\edefn{n}\protect\xdef\T1/ptm/b/n/10.95{\T1/ptm/m/n/10.95}\T1/ptm/b/n/10.95\size@

Backup

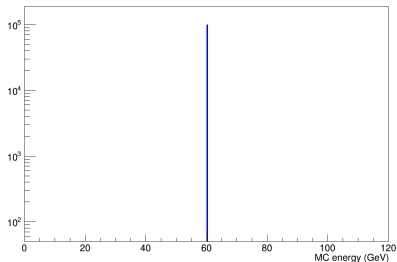
Copy is ongoing..... In back up previous slides.

Backup

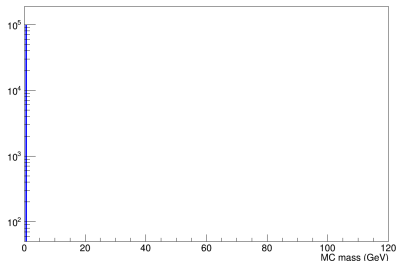


SDHCAL validation, K_L^0 p=60 GeV

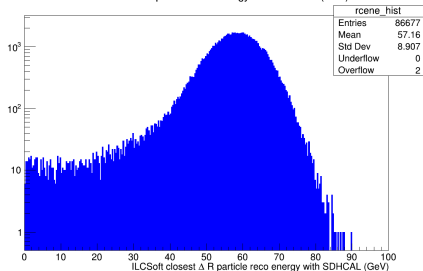
MC energy 60 GeV



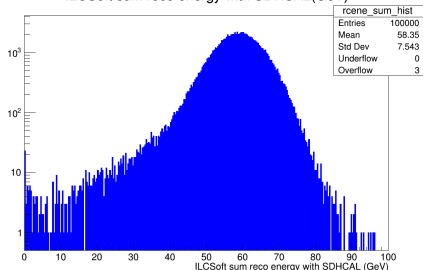
MC mass 60 GeV



ILCSofT closest ΔR particle reco energy with SDHCAL (GeV)



ILCSofT sum reco energy with SDHCAL(GeV)



Crystalball fit

$$f(x; \alpha, n, \bar{x}, \sigma) = N \cdot \begin{cases} \exp\left(-\frac{(x-\bar{x})^2}{2\sigma^2}\right), & \text{for } \frac{x-\bar{x}}{\sigma} > -\alpha \\ A \cdot \left(B - \frac{x-\bar{x}}{\sigma}\right)^{-n}, & \text{for } \frac{x-\bar{x}}{\sigma} \leq -\alpha \end{cases}$$

$$A = \left(\frac{n}{|\alpha|}\right)^n \cdot \exp\left(-\frac{|\alpha|^2}{2}\right),$$

$$B = \frac{n}{|\alpha|} - |\alpha|,$$

$$N = \frac{1}{\sigma(C+D)},$$

$$C = \frac{n}{|\alpha|} \cdot \frac{1}{n-1} \cdot \exp\left(-\frac{|\alpha|^2}{2}\right),$$

$$D = \sqrt{\frac{\pi}{2}} \left(1 + \operatorname{erf}\left(\frac{|\alpha|}{\sqrt{2}}\right)\right).$$

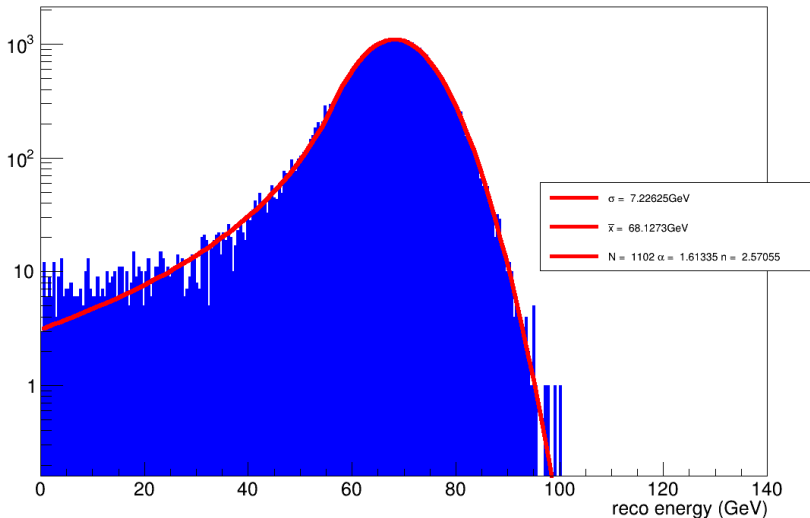
```
FCN=342.074 FROM MIGRAD      STATUS=CONVERGED      184 CALLS      185 TOTAL
                        EDM=2.61519e-08  STRATEGY= 1  ERROR MATRIX UNCERTAINTY
EXT PARAMETER              STEP          FIRST
NO.  NAME      VALUE      ERROR      SIZE      DERIVATIVE
1    N          2.00731e+03  9.14867e+00 -2.32131e-02  2.47481e-05
2  mean         5.83022e+01  2.70121e-02  2.65898e-05 -4.92050e-03
3  sigma        6.59899e+00  2.21181e-02  1.22279e-04  1.43070e-02
4  alpha        1.80238e+00  2.83231e-02  7.01543e-05 -6.05402e-03
5    n          1.97606e+00  1.01879e-01 -9.94635e-05  1.27298e-03
50 GeV thismax2.1e+03 mean=58 sigma=6.6 error=11%
```

0.3 per cent	
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https://en.wikipedia.org/wiki/Crystal_Ball_function

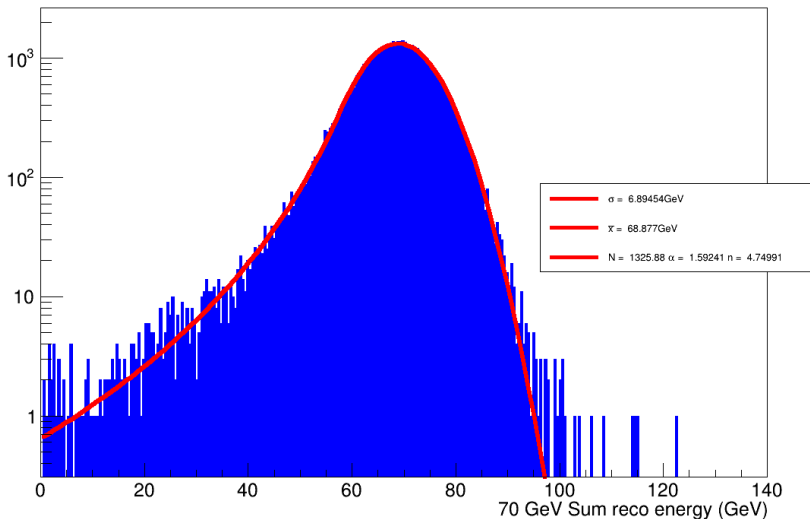
Crystalball fit, K_L^0 p=70 GeV, closest ΔR match, o2

K0long 70 GeV



Crystalball fit, K_L^0 p=70 GeV, sum energy, o2

70 GeV Sum reco energy(GeV)



links with all results, please explore yourself:

http:

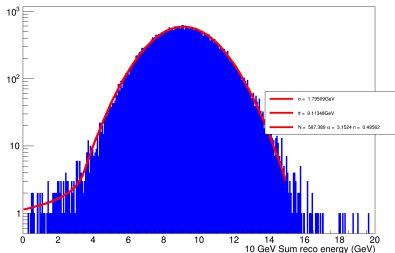
[//wwwae.ciemat.es/~carrillo/calice/indexk0o1.html](http://wwwae.ciemat.es/~carrillo/calice/indexk0o1.html)

http:

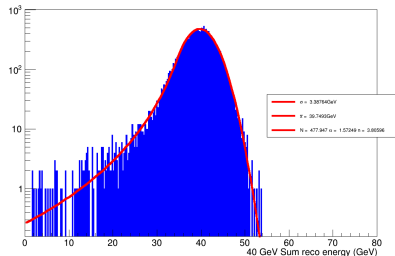
[//wwwae.ciemat.es/~carrillo/calice/indexk0o2.html](http://wwwae.ciemat.es/~carrillo/calice/indexk0o2.html)

Crystalball fit, K_L^0 , o1 sum reco energy

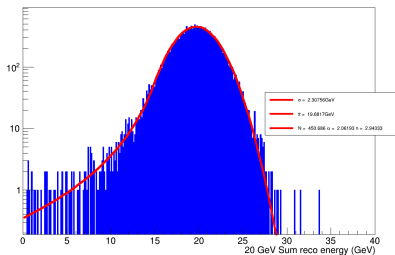
10 GeV Sum reco energy(GeV)



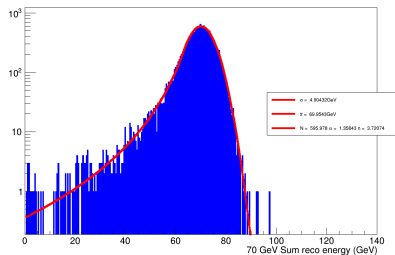
40 GeV Sum reco energy(GeV)



20 GeV Sum reco energy(GeV)

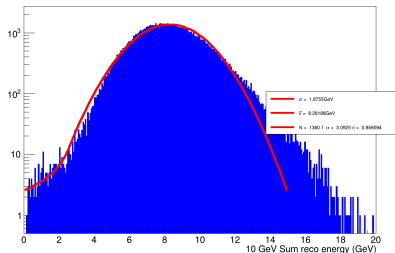


70 GeV Sum reco energy(GeV)

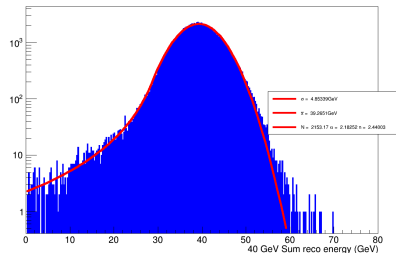


Crystalball fit, K_L^0 , o2 sum reco energy

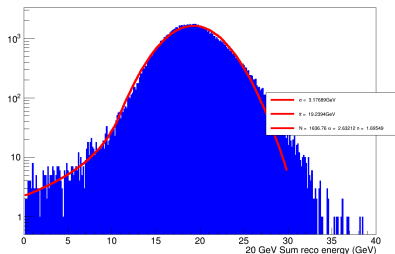
10 GeV Sum reco energy(GeV)



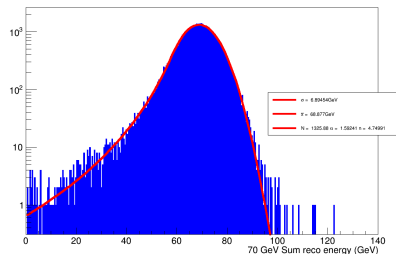
40 GeV Sum reco energy(GeV)



20 GeV Sum reco energy(GeV)



70 GeV Sum reco energy(GeV)



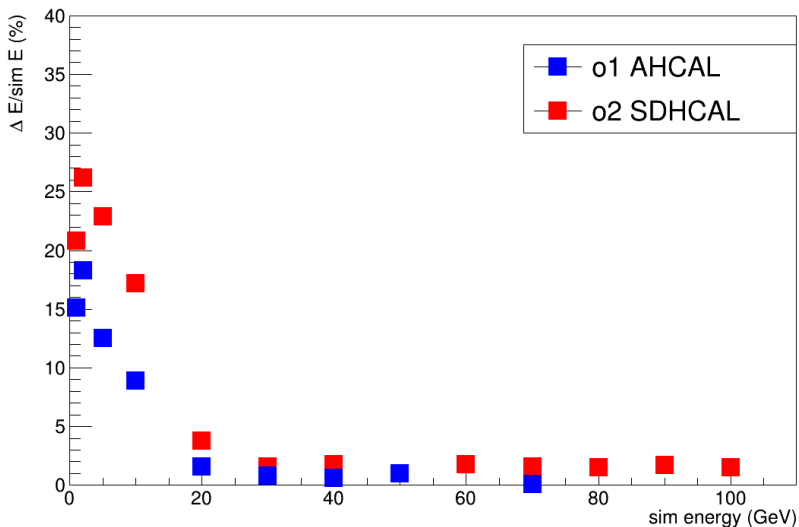
resolution and discrepancy for o1 and o2, fit results

sim p (GeV)	mean (GeV)	sigma (GeV)	resolution (%)	discrepancy(%)
o1				
1	0.85	0.34	39.6%	15.1%
2	1.64	0.61	37.2%	18.3%
5	4.37	1.19	27.3%	12.5%
10	9.11	1.80	19.7%	8.9%
20	19.68	2.31	11.7%	1.6%
30	29.75	2.91	9.8%	0.8%
40	39.75	3.39	8.5%	0.6%
50	49.50	3.94	7.9%	1.0%
70	69.95	4.90	7.0%	0.1%
o2				
1	0.79	0.31	38.6%	20.8%
2	1.48	0.56	38.2%	26.2%
5	3.86	1.14	29.6%	22.9%
10	8.28	1.88	22.7%	17.2%
20	19.24	3.18	16.5%	3.8%
30	29.51	4.11	13.9%	1.6%
40	39.27	4.85	12.4%	1.8%
60	58.95	6.27	10.6%	1.8%
70	68.88	6.90	10.0%	1.6%
80	78.77	7.62	9.7%	1.5%
90	88.45	8.40	9.5%	1.7%
100	98.50	8.91	9.0%	1.5%

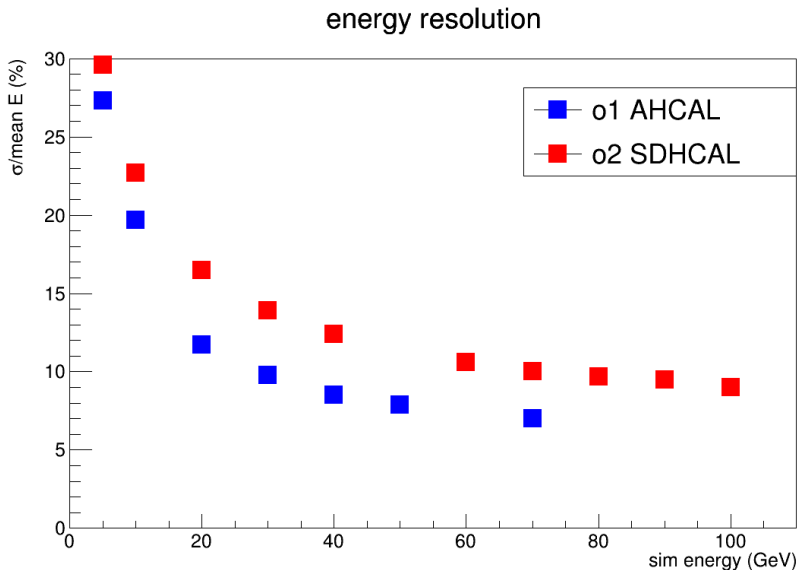
$$\text{resolution} = \frac{\text{sigma}}{\text{mean}}, \text{discrepancy} = \frac{\text{sim } p - \text{mean}}{\text{sim } p}$$

Comparison for the two scenarios, discrepancy.

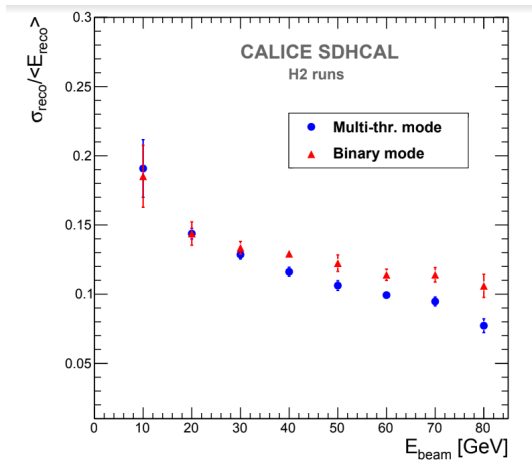
energy discrepancy



Comparison for the two scenarios, resolution.



Only SDHCAL resolution observed in test-beams K_L^0



CALICE collaboration, First results of the CALICE SDHCAL technological prototype, JINST **11** (2016) P04001.

Rerunning the ILCSoft Reconstruction

we had two ideas:

- Get the SDHCAL hits out of the corresponding datasets in an ntuple for some of the masses. And forward the information to Imad's algorithm.
- Rerun the ILCSoft changing the parameters so we can improve the algorithm by changing the alpha beta gamma parameters.

```
https://github.com/iLCSoft/ILDConfig/blob/master/StandardConfig/production/Calibration/Calibration\_ILD\_15\_o2\_v02.xml
```


SDHCAL hits out of corresponding dataset

- Identify the correct dataset.
- To Run the standard LCTuple production with SDHCAL Calorimeter Hit collection only, to get this info:
`https://github.com/iLCSoft/LCTuple/blob/master/src/CalorimeterHitBranches.cc`
- The number of hits will be the variable "ncah", the variable "caene" will contain the energy for each hit.
- For SDHCAL, there will be 3 values.
- It would be easy to compute N1, N2 and N3 from this ntuple.

SDHCAL hits out of corresponding dataset

- The Marlin parameters to get calorimeter hit in the standard ntuple are:
`https://github.com/iLCSoft/LCTuple/blob/master/src/LCTuple.cc`
 - — `WriteCalorimeterHitCollectionParameters` to set to true
 - — `CalorimeterHitCollection` to set to the collection name containing the SDHCAL calorimeterHit.
- An example Marlin config to produce the LCTuple is here:
`https://github.com/iLCSoft/ILDConfig/blob/master/StandardConfig/production/MarlinStdRecoLCTuple.xml`
- We have to add a `MergeCollections` processor to merge the SDHCAL calo Hit collections into one and then set correctly the 2 parameters above

Rerun the ILCSoft changing the parameters so we can improve the algorithm

- This option is not yet clear to me. This week we are planing a short meeting with Gerald.
- This second step will be needed as well according to Gerald(?).
- As a first step, it can be done by giving flags options to the Marlin executable.

Conclusions

- Observed reconstructed p for the K_L^0 samples in **ilcsoft v02-01** test samples behave as expected with SDHCAL \rightarrow ILD-15-**o2**-v02.
- Studies with muon samples still to be done.
- Next steps:
 - extra variables to check the SDHCAL calibration are under scrutiny.
 - study the SDHCAL local reconstructed objects (cluster performance).
- key point about SDHCAL in ilcsoft¹:
 - Geant4 physics model used in ilcsoft is QGSP-Bert which is not ideal to simulate SDHCAL.
 - FTF-BIC is the more appropriate for SDHCAL.

¹<https://geant4.web.cern.ch/node/155>

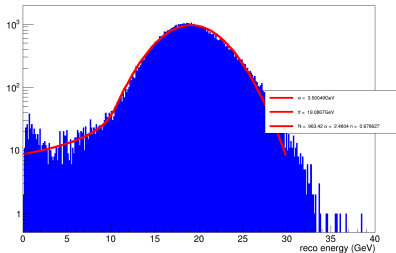
Backup

Backup

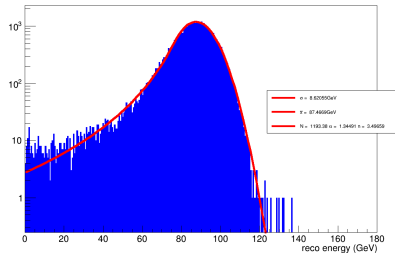


Crystalball fit, K_L^0 , o2

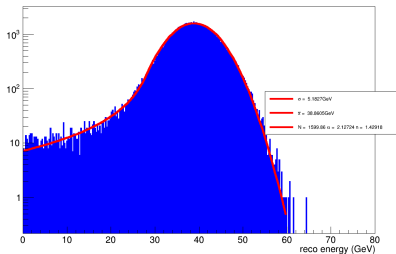
K0long 20 GeV



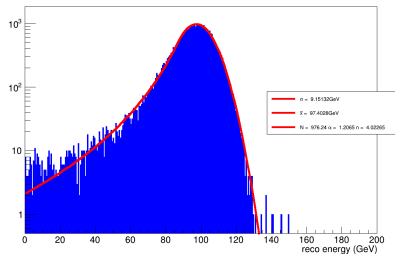
K0long 90 GeV



K0long 40 GeV



K0long 100 GeV

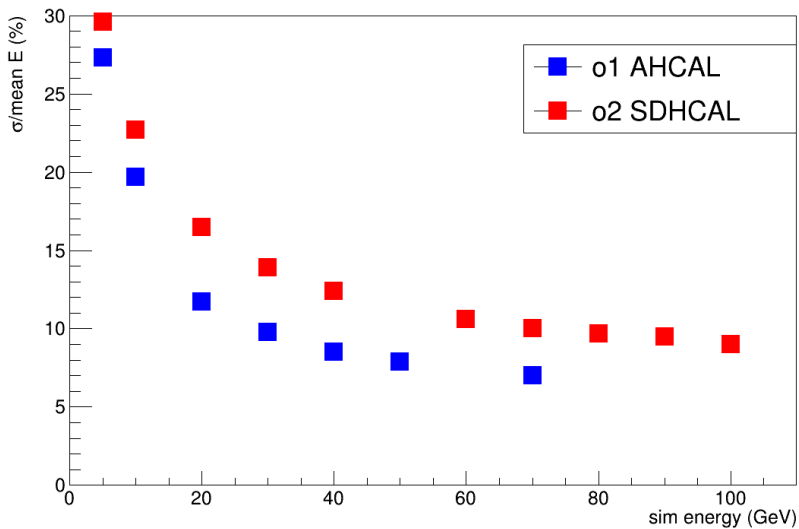


Summary, K_L^0 , o2

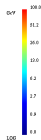
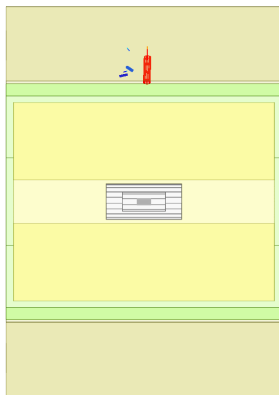
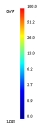
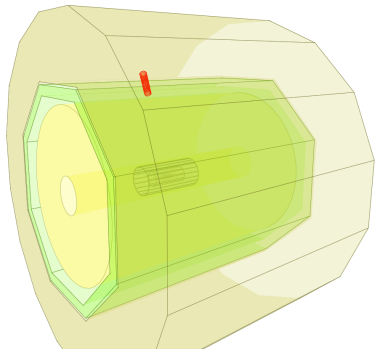
sim energy (GeV)	CB \bar{x} (GeV)	CB σ (GeV)	$\frac{\sigma}{E}$ (%)
1	0.79	0.3	30
2	1.4	0.53	26
5	3.5	1.2	25
10	7.8	2.1	21
20	19	3.5	18
30	29	4.4	15
40	39	5.2	13
60	58	6.6	11
70	68	7.2	10
80	78	7.9	9.8
90	87	8.6	9.6
100	97	9.2	9.2

Summary Resolution, K_L^0

energy resolution

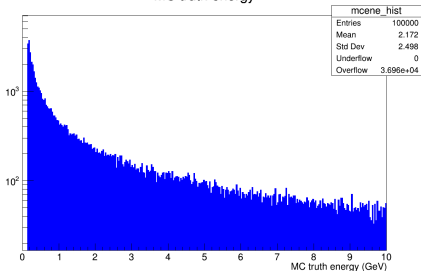


First look at the datasets for the SDHCAL validation, event display K_L^0 110 GeV, energy deposit in SDHCAL

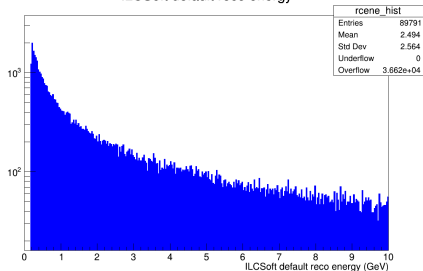


SDHCAL validation, μ sample

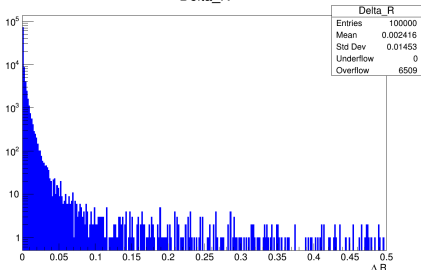
MC truth energy



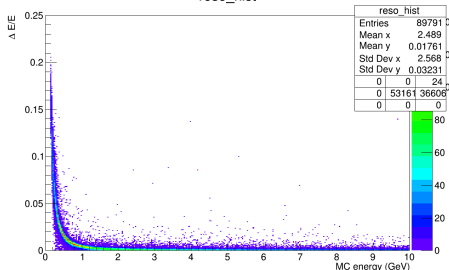
ILCSoft default reco energy



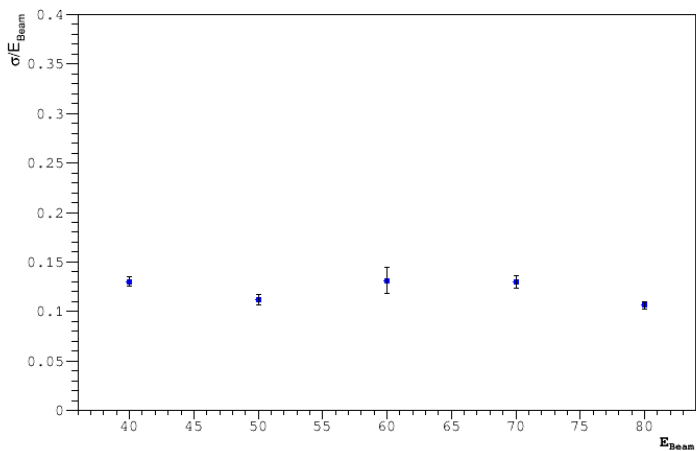
Delta_R



reso_hist



SDHCAL validation, TB2018



The tools we have learned.

In the framework of the SDHCAL test-beams data analysis we have learned:

- How to work in the ILCSoft analysis framework. (Installed in CIEMAT running in dedicated nodes)
- Run from scratch a simulation using the standard sequences in the framework and switching from one scenario to another (large \rightarrow small), (AHCAL \rightarrow SDHCAL), etc.
- Navigate and run over the centrally produced datasets (DIRAC)
- Produce ntuples out of the samples for detector/physics analysis. (AIDA,REC,SIM)
- Use reconstructed physics objects and produce event cut flows for analysis.
- Event display, etc.

The tools we have learned

Private CIEMAT-SDHCAL pion gun simulation for comparison with TB-2018.

