Validation of single-particle test samples with SDHCal

ILD software & analysis meeting

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cfp
CIEMAT física de partículas

First look at the datasets for the SDHCAL validation

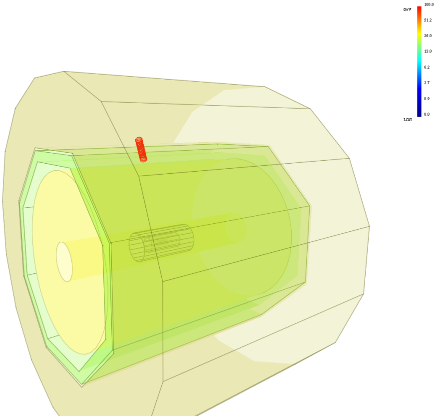
- Details about the ILD confluence production for the recent test production with the latest ilcsoft v02-01. `https://confluence.desy.de/display/ILD/Production+with+v02-01`
- For the moment the data (mostly single particles) are reconstructed with the AHCAL (scintillator) option ILD-l5-o1-v02.
- We requested to start two samples, muons and K_L^0, as suggested by D. Jeans, to be reconstructed with the "option 2" ILD-l5-**o2**-v02. or with the SDHCAL.
- The production is finished, here the details: `https://ild.ngt.ndu.ac.jp/elog/dbd-prod/311`
- We have access to the high level objects in this dataset.

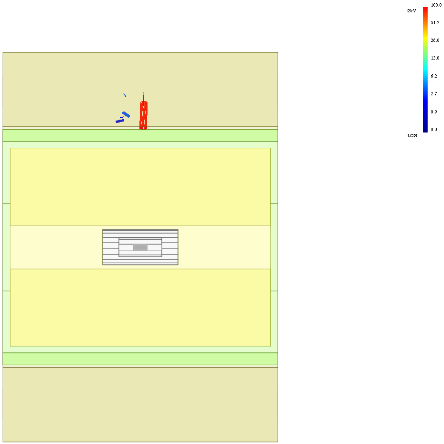
First look at the datasets for the SDHCAL validation, K_L^0

- Energy range: (1,2,5,10,20,30,40,50,60,70,80,90,100,110) GeV.
- We made a full copy of the dataset to our local cluster in CIEMAT dedicated to CALICE/ILD analysis by accessing the dataset via DIRAC[1]
- Using the same ilcsoft version (v02-01 $\rightarrow$ `/cvmfs/ilc.desy.de/sw/x86_64_gcc82_sl6/v02-01/init_ilcsoft.sh`) as for the central production we have produced the corresponding LCTuples.
- In the root ntuple we have access to the reconstructed high level objects:

[1] We have got certificate issues, help appreciated

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





List of variables available in the standard LCTuple

```
// Fixed size dimensions of array or collections stored in the TTree if any.

   // Declaration of leaf types
   Int_t           evevt;
   Int_t           evrun;
   Float_t         evwgt;
   Long64_t        evtim;
   Float_t         evsig;
   Float_t         evene;
   Float_t         evpoe;
   Float_t         evpop;
   Int_t           evnch;
   Char_t          evpro[1];   //[evnch]
   Int_t           nmcp;
   Int_t           mcori[807];   //[nmcp]
   Int_t           mcpdg[807];   //[nmcp]
   Int_t           mcgst[807];   //[nmcp]
   Int_t           mcsst[807];   //[nmcp]
   Float_t         mcvtx[807];   //[nmcp]
   Float_t         mcvty[807];   //[nmcp]
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   Float_t         mcmoy[807];   //[nmcp]
   Float_t         mcmoz[807];   //[nmcp]
   Float_t         mcmas[807];   //[nmcp]
   Float_t         mcene[807];   //[nmcp]
   Float_t         mccha[807];   //[nmcp]
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   Int_t           mcda2[807];   //[nmcp]
   Int_t           mcda3[807];   //[nmcp]
   Int_t           mcda4[807];   //[nmcp]
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   Int_t           rcori[41];   //[nrec]
   Int_t           rccid[41];   //[nrec]
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   Float_t         rccov[41][10];   //[nrec]
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   Int_t           rcncl[41];   //[nrec]
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   Int_t           rcftr[41];   //[nrec]
```

```
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   Int_t           rcvts[41];   //[nrec]
   Int_t           rcvte[41];   //[nrec]
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   Int_t           pialg[212];   //[npid]
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   Int_t           trtyp[36];   //[ntrk]
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   Int_t           trndf[36];   //[ntrk]
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   Float_t         tsphi[144];   //[ntrst]
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   Float_t         tsrpz[144];   //[ntrst]
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   Int_t           stori[1];   //[nsth]
   Int_t           stci0[1];   //[nsth]
   Int_t           stci1[1];   //[nsth]
   Double_t        stpox[1];   //[nsth]
   Double_t        stpoy[1];   //[nsth]
   Double_t        stpoz[1];   //[nsth]
   Float_t         stedp[1];   //[nsth]
   Float_t         sttim[1];   //[nsth]
   Float_t         stmox[1];   //[nsth]
   Float_t         stmoy[1];   //[nsth]
   Float_t         stmoz[1];   //[nsth]
   Float_t         stptl[1];   //[nsth]
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   Int_t           scori[1];   //[nsch]
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   Int_t           scci1[1];   //[nsch]
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   Float_t         scpoy[1];   //[nsch]
   Float_t         scpoz[1];   //[nsch]
   Float_t         scene[1];   //[nsch]
   Int_t           r2mnrel;
   Int_t           r2mf[169];   //[r2mnrel]
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```
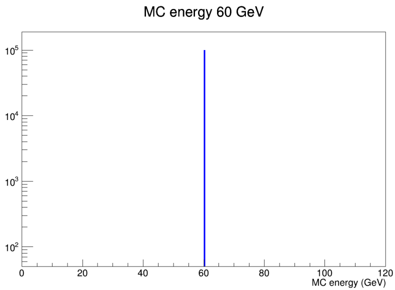
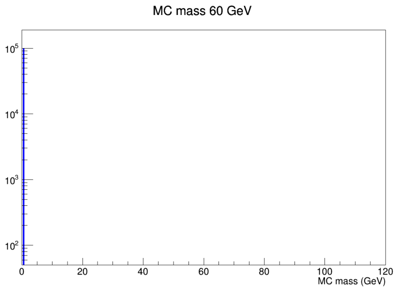
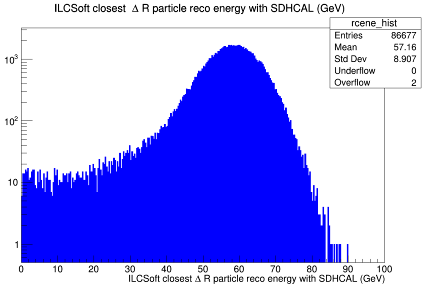

SDHCAL validation, K_L^0 m=60 GeV





LCTuples reconstructed energy (full ILD detector)



Among the gen particles we found few extra K_L^0 with $m \neq 60GeV$. They were removed by requiring the energy of the mc-particle to actually match the energy quoted in the dataset name.

Crystalball fit, K_L^0 m=60 GeV

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

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

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

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

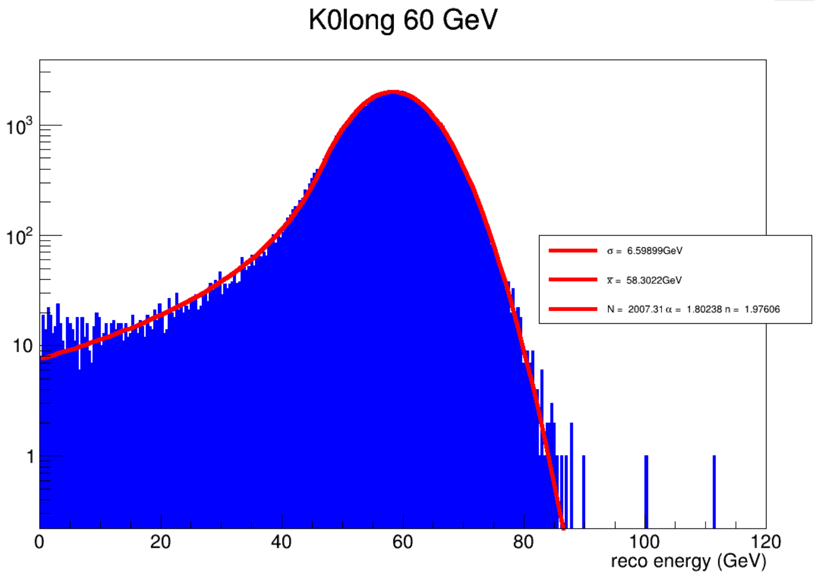
$$C = \frac{n}{|\alpha|} \cdot \frac{1}{n-1} \cdot \exp\left(-\frac{|\alpha|^2}{2}\right),$$

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

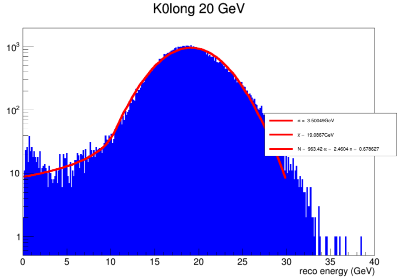
```
 FCN=342.074 FROM MIGRAD    STATUS=CONVERGED     184 CALLS         185 TOTAL
                     EDM=2.61519e-08    STRATEGY= 1  ERROR MATRIX UNCERTAINTY   0.3 per cent
  EXT PARAMETER                                   STEP         FIRST
  NO.   NAME      VALUE            ERROR          SIZE      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
60 GeV thismax2.1e+03 mean=58 sigma=6.6 error=11%
```

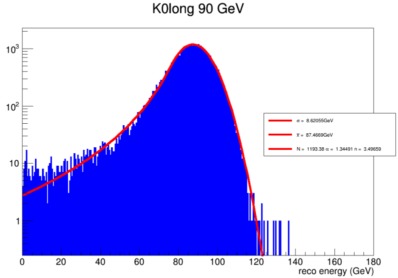
https://en.wikipedia.org/wiki/Crystal_Ball_function

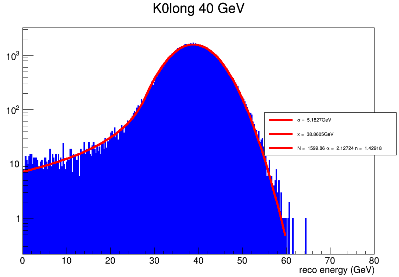
Crystalball fit, K_L^0 m=60 GeV

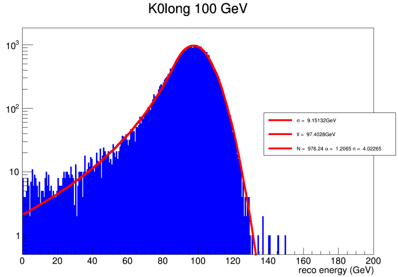


Crystalball fit, K_L^0





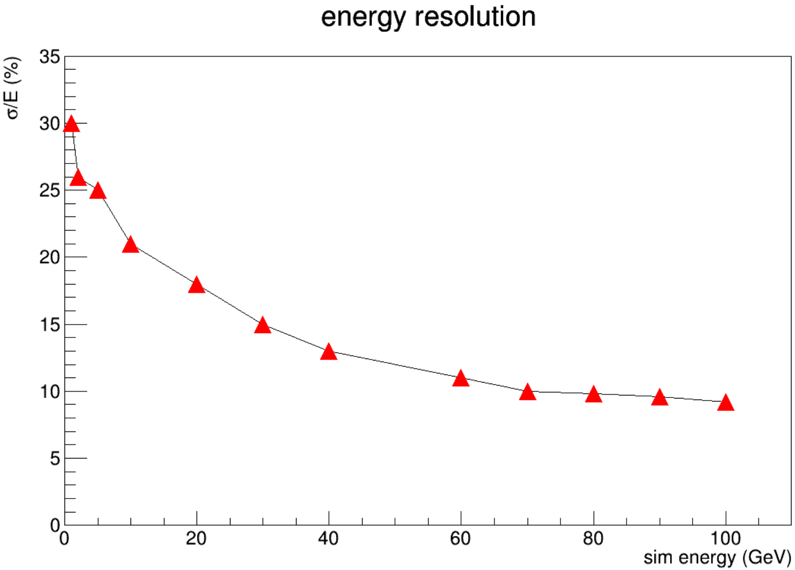




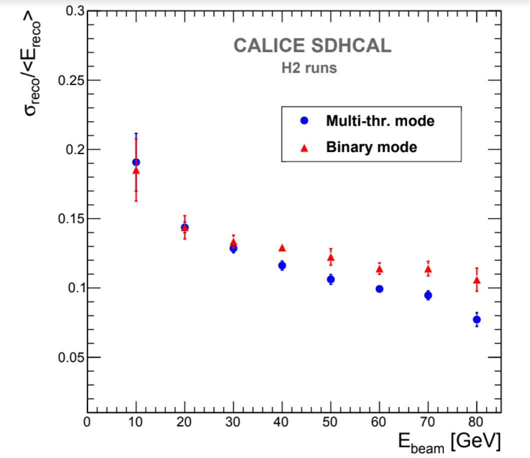
Summary, K_L^0

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



Only SDHCAL resolution observed in test-beams K_L^0



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

links:

http:
//wwwae.ciemat.es/~carrillo/calice/indexk0o1.html
http:
//wwwae.ciemat.es/~carrillo/calice/indexk0o2.html

Conclusions

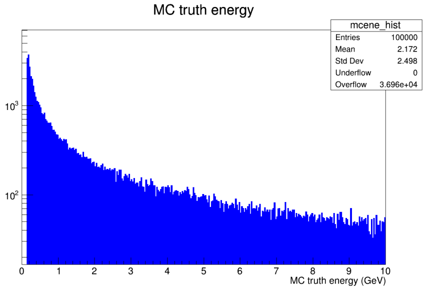
- Observed reconstructed energy for the K_L^0 samples in **ilcsoft v02-01** test samples behave as expected with SDHCAL → ILD-l5-**o2**-v02.
- Studies with muon samples still to be done.
- Next steps:
  - extra variables to check the SDHCAL calibration are under scrutiny.
  - study the SDHCAL local reconstructed objects (cluster performance).
- key point about SDHCAL in ilcsoft[2]:
  - Geant4 physics model used in ilcsoft is QGSP-Bert which is not ideal to simulate SDHCAL.
  - FTF-BIC is the more appropriate for SDHCAL.

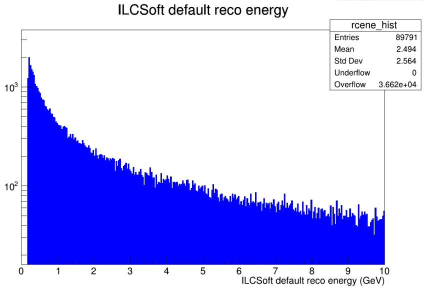
[2] https://geant4.web.cern.ch/node/155

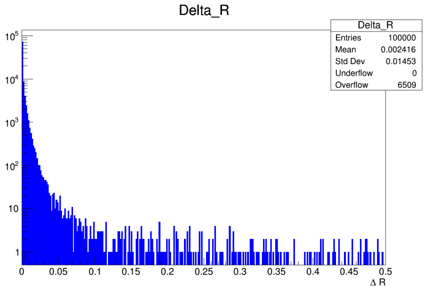
Backup

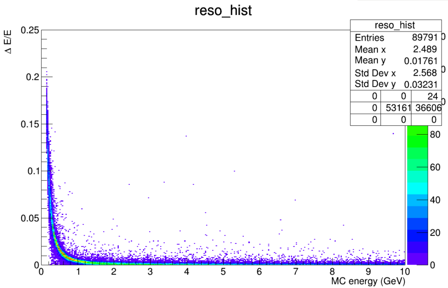
Backup

SDHCAL validation, μ sample

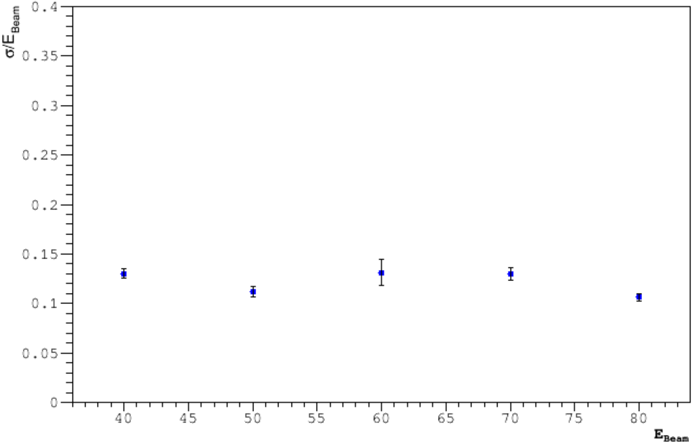








SDHCAL validation, TB2018



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 scneario 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.