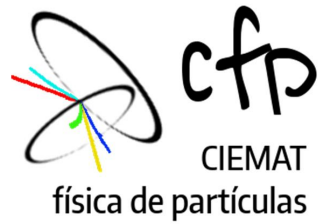
Validation of single-particle test samples with SDHCal and comparison with AHCaL

CIEMAT SDHCAL group meeting

16/04/21

Camilo

Centro de Investigaciones
Energéticas, Medioambientales
y Tecnológicas



Introduction

- A bug in ILCSoft concerning the managing of the overlay for the SDHCAL has been identified and solved by Hector on the first of March..
- Link to the PR → `https://github.com/iLCSoft/Overlay/pull/21`
- The pull request has been merged in ILCSoft and a new MC production for the o2 has been produced on the 30th of march.
  - single particle of muon and K_0^L `https://ild.ngt.ndu.ac.jp/elog/dbd-prod/467`
  - inclusive H → qqh, which was requested in January.`https://ild.ngt.ndu.ac.jp/elog/dbd-prod/468`
- In this presentation we are showing our SDHCAL hit and energy validation for this new MC production.

Wofkflow

- We focus for the moment only in the K_0^L sample.
  o2 Energy range: (1,2,5,10,20,30,40,50,60,70,80,90,100,110) GeV.
- A copy of the *dstm* dataset to our SDHCAL-cluster in CIEMAT has been done and it is available (for those with access) here: `/pool/calice3/data/MonteCarlo/sdhcal_validation/k0_long_v02-02`
- A copy of the *rec* dataset to our SDHCAL-cluster in CIEMAT has been done and it is available (for those with access) here: `/pool/calice3/data/MonteCarlo/sdhcal_validation/k0_long_v02-02/rec`
- Out of this dataset, two LCTuples have been produced for every single energy point:
  - LCTuple by default. `/pool/calice3/data/MonteCarlo/sdhcal_validation/k0_long_v02-02/lctuples/`
  - Customized LCTuple including the ECAL hits (to correctly identify the parton showers startin in our subdetector, explained in next slides) `/pool/calice3/data/MonteCarlo/sdhcal_validation/k0_long_v02-02/rec/lctuples/with_ecal`

Identifying the start of the shower to filter events

We had 3 options we use the ECAL one:

- The parameter should be in ilcSoft (maybe stored in the LCTuple may be not (if not we can add it and produce again the ntuples).
- As another option we can try to identify the position where the shower starts using the test beam analysis tools (Hector)
  - What information would be needed?
  - x, y, z or i, j(path) plane of each hit would be enough?
- As you can see in the list of available variables the most promising variables: rcmo(x, y, z)[nrec]
- **As a 3rd option, selecting events without ECAL activity**

The Standard LCTuple xml Marling, no ECAL hits

```
<processor name="MergeSimCaloHits" type="MergeCollections">
  <!--MergeCollections creates a transient subset collection that merges all input collections -->
  <!--Names of all input collections-->
  <parameter name="InputCollections" type="StringVec">
    BeamCalCollection
    EcalBarrelCollection
    EcalEndcapRingCollection
    EcalEndcapsCollection
    HcalBarrelRegCollection
    HcalEndcapRingCollection
    HcalEndcapsCollection
    LumiCalCollection
    YokeBarrelCollection
    YokeEndcapsCollection
    LHCalCollection
  </parameter>
 <!--Optional IDs for input collections - if given id will be added to all objects in merged collections as ext<CollID>()-->
  <parameter name="InputCollectionIDs" type="IntVec">
    25 20 21 29 22 23 30 24 27 31
  </parameter>
  <parameter name="OutputCollection" type="string">SimCalorimeterHits </parameter>
  <!--verbosity level of this processor ("DEBUG0-4,MESSAGE0-4,WARNING0-4,ERROR0-4,SILENT")-->
  <parameter name="Verbosity" type="string">DEBUG </parameter>
</processor>


<processor name="MergeCaloHits" type="MergeCollections">
  <!--MergeCollections creates a transient subset collection that merges all input collections -->
  <!--Names of all input collections-->
  <parameter name="InputCollections" type="StringVec">
    HcalBarrelCollectionDigi
    HcalEndcapRingCollectionDigi
    HcalEndcapsCollectionDigi
  </parameter>
 <!--Optional IDs for input collections - if given id will be added to all objects in merged collections as ext<CollID>()-->
  <parameter name="InputCollectionIDs" type="IntVec">
    29 22 23
  </parameter>
  <parameter name="OutputCollection" type="string">CaloHits </parameter>
  <!--verbosity level of this processor ("DEBUG0-4,MESSAGE0-4,WARNING0-4,ERROR0-4,SILENT")-->
  <parameter name="Verbosity" type="string">DEBUG </parameter>
</processor>
```

The Standard LCTuple xml Marling, with ECAL hits

```
<processor name="MergeSimCaloHits" type="MergeCollections">
  <!--MergeCollections creates a transient subset collection that merges all input collections -->
  <!--Names of all input collections-->
  <parameter name="InputCollections" type="StringVec">
    BeamCalCollection
    EcalBarrelCollection
    EcalEndcapRingCollection
    EcalEndcapsCollection
    HcalBarrelRegCollection
    HcalEndcapRingCollection
    HcalEndcapsCollection
    LumiCalCollection
    YokeBarrelCollection
    YokeEndcapsCollection
    LHCalCollection
  </parameter>
 <!--Optional IDs for input collections - if given id will be added to all objects in merged collections as ext<CollID>()-->
  <parameter name="InputCollectionIDs" type="IntVec">
    25 20 21 29 22 23 30 24 27 31
  </parameter>
  <parameter name="OutputCollection" type="string">SimCalorimeterHits </parameter>
  <!--verbosity level of this processor ("DEBUG0-4,MESSAGE0-4,WARNING0-4,ERROR0-4,SILENT")-->
  <parameter name="Verbosity" type="string">DEBUG </parameter>
</processor>


<processor name="MergeCaloHits" type="MergeCollections">
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    HcalBarrelCollectionDigi
    HcalEndcapRingCollectionDigi
    HcalEndcapsCollectionDigi
  </parameter>
 <!--Optional IDs for input collections - if given id will be added to all objects in merged collections as ext<CollID>()-->
  <parameter name="InputCollectionIDs" type="IntVec">
    25 20 21 29 22 23
  </parameter>
  <parameter name="OutputCollection" type="string">CaloHits </parameter>
  <!--verbosity level of this processor ("DEBUG0-4,MESSAGE0-4,WARNING0-4,ERROR0-4,SILENT")-->
  <parameter name="Verbosity" type="string">DEBUG </parameter>
</processor>
```
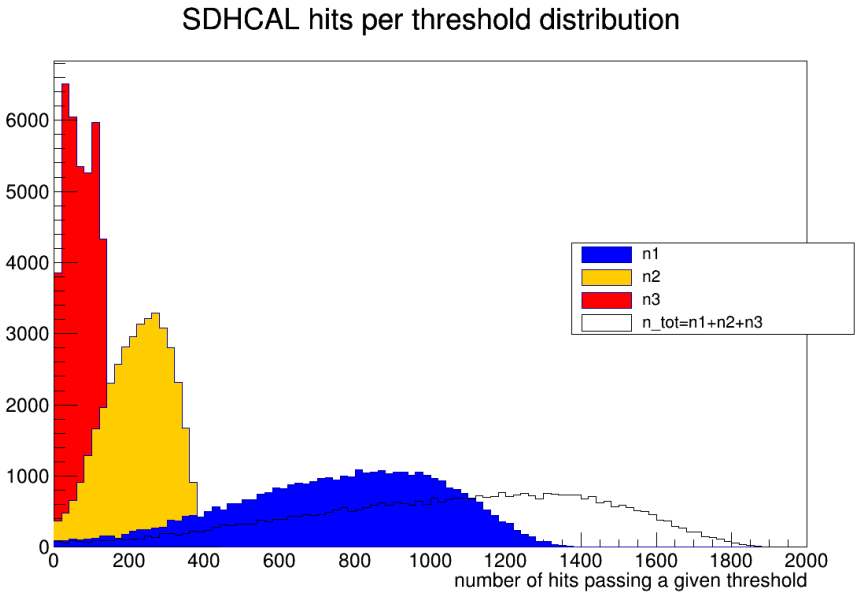
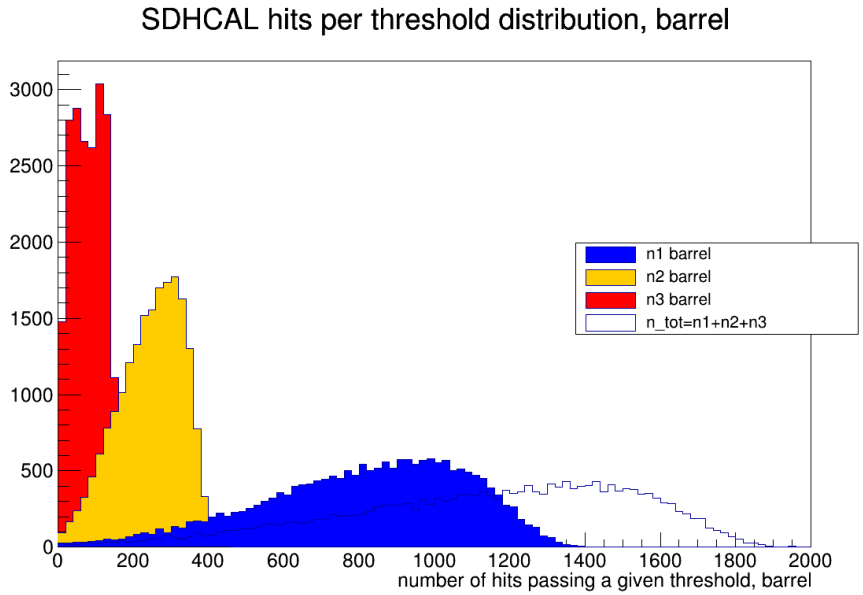
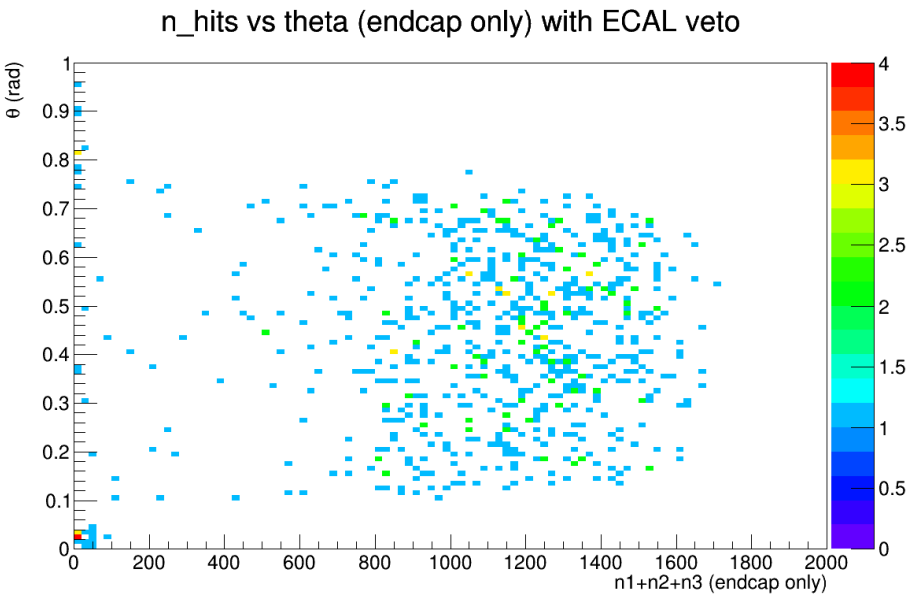
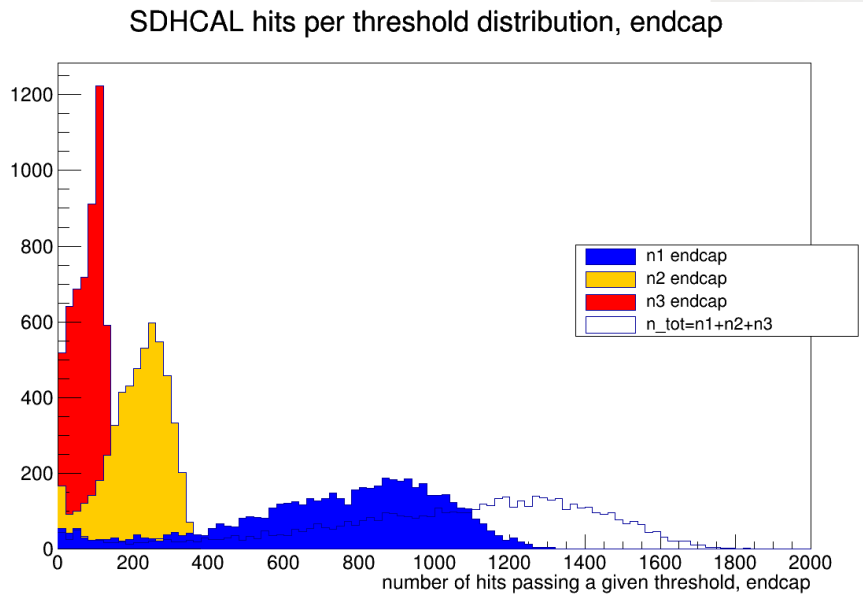

SDHCAL Hit Level Analysis 110 GeV, with overlay bug

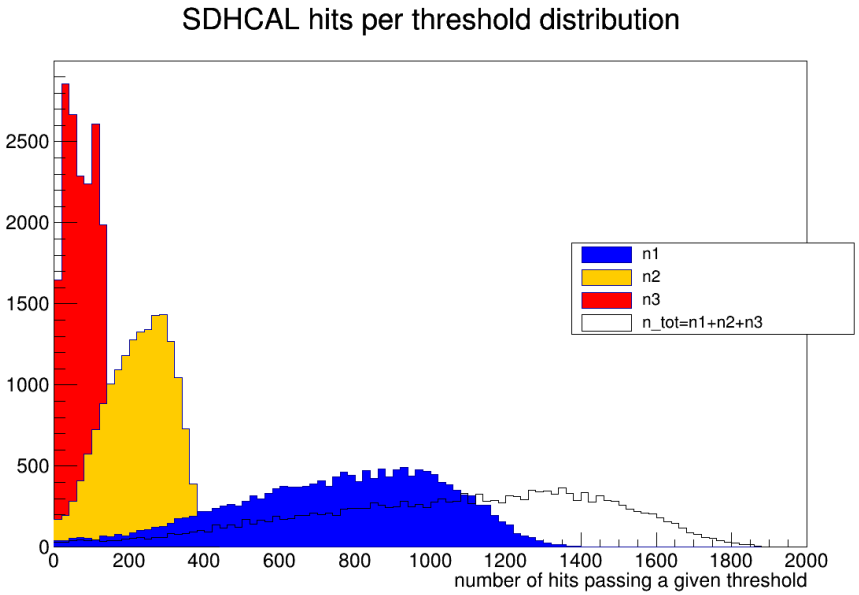


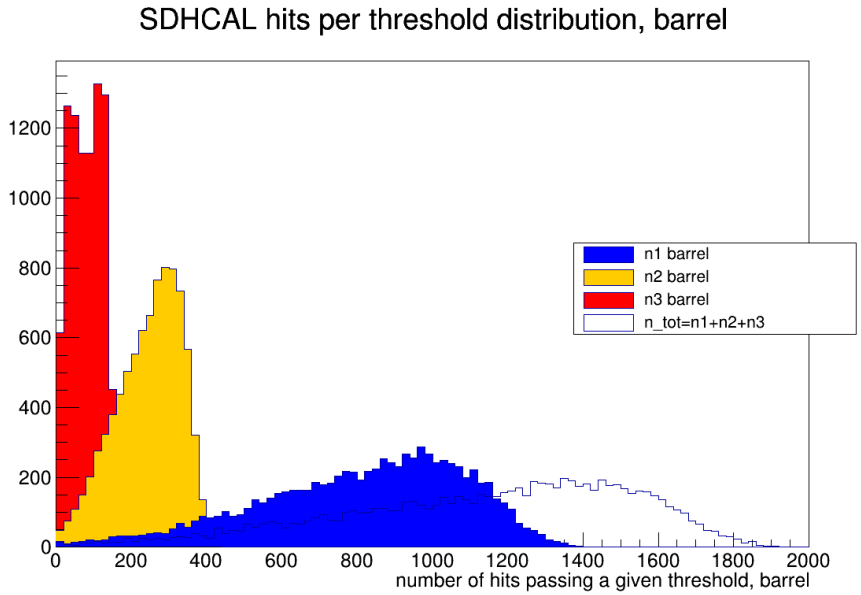


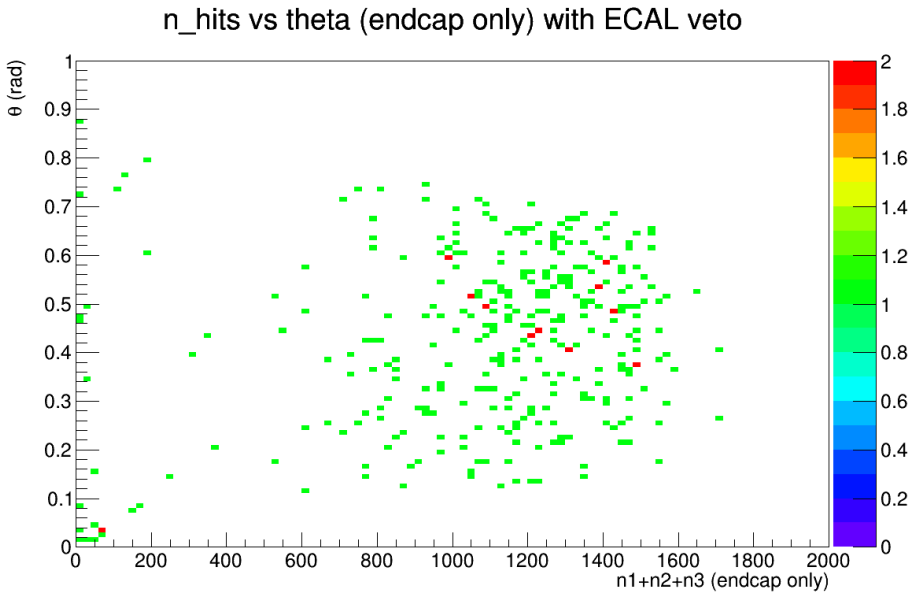


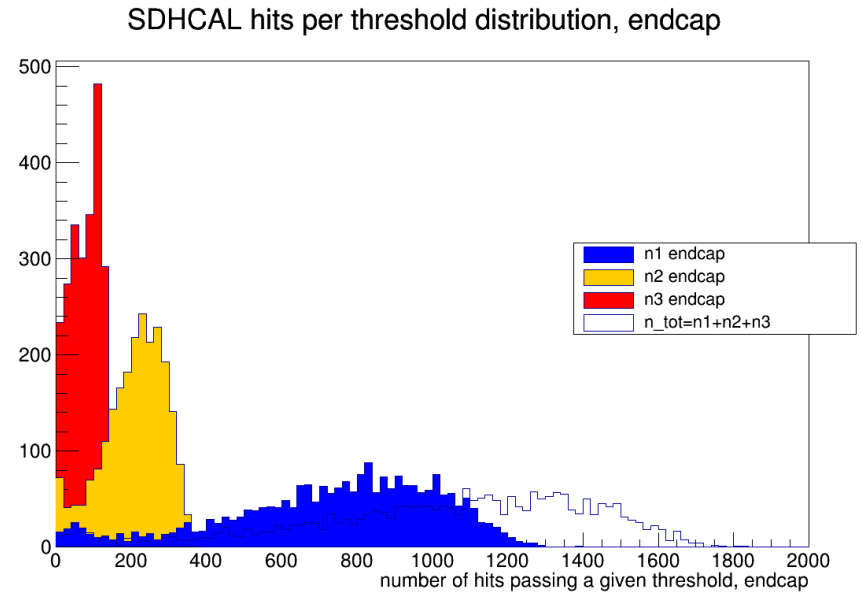


SDHCAL Hit Level Analysis 110 GeV, without overlay bug









SDHCAL pythia simulation of prototype:

Discussing with Guillaume....

Backup

Backup

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]
   Float_t         mcvtz[807];   //[nmcp]
   Float_t         mcepx[807];   //[nmcp]
   Float_t         mcepy[807];   //[nmcp]
   Float_t         mcepz[807];   //[nmcp]
   Float_t         mcmox[807];   //[nmcp]
   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]
   Float_t         mctim[807];   //[nmcp]
   Float_t         mcspx[807];   //[nmcp]
   Float_t         mcspy[807];   //[nmcp]
   Float_t         mcspz[807];   //[nmcp]
   Int_t           mccf0[807];   //[nmcp]
   Int_t           mccf1[807];   //[nmcp]
   Int_t           mcpa0[807];   //[nmcp]
   Int_t           mcpa1[807];   //[nmcp]
   Int_t           mcda0[807];   //[nmcp]
   Int_t           mcda1[807];   //[nmcp]
   Int_t           mcda2[807];   //[nmcp]
   Int_t           mcda3[807];   //[nmcp]
   Int_t           mcda4[807];   //[nmcp]
   Int_t           nrec;
   Int_t           rcori[41];   //[nrec]
   Int_t           rccid[41];   //[nrec]
   Int_t           rctyp[41];   //[nrec]
   Float_t         rccov[41][10];   //[nrec]
   Float_t         rcrpx[41];   //[nrec]
   Float_t         rcrpy[41];   //[nrec]
   Float_t         rcrpz[41];   //[nrec]
   Float_t         rcgpi[41];   //[nrec]
   Int_t           rcpiu[41];   //[nrec]
   Int_t           rcnpi[41];   //[nrec]
   Int_t           rcfpi[41];   //[nrec]
   Float_t         rcmox[41];   //[nrec]
   Float_t         rcmoy[41];   //[nrec]
   Float_t         rcmoz[41];   //[nrec]
   Float_t         rcmas[41];   //[nrec]
   Float_t         rcene[41];   //[nrec]
   Float_t         rccha[41];   //[nrec]
   Int_t           rcntr[41];   //[nrec]
   Int_t           rcncl[41];   //[nrec]
   Int_t           rcnrp[41];   //[nrec]
   Int_t           rcftr[41];   //[nrec]
```

No ECAL hits!

```
Int_t           rcftr[41];   //[nrec]
Int_t           rcvts[41];   //[nrec]
Int_t           rcvte[41];   //[nrec]
Int_t           rccom[41];   //[nrec]
Int_t           npid;
Int_t           pityp[212];   //[npid]
Int_t           pipdg[212];   //[npid]
Float_t         pillh[212];   //[npid]
Int_t           pialg[212];   //[npid]
Int_t           ntrk;
Int_t           trori[36];   //[ntrk]
Int_t           trtyp[36];   //[ntrk]
Float_t         trch2[36];   //[ntrk]
Int_t           trndf[36];   //[ntrk]
Float_t         tredx[36];   //[ntrk]
Float_t         trede[36];   //[ntrk]
Float_t         trrih[36];   //[ntrk]
Int_t           trshn[36][12];   //[ntrk]
Int_t           trnts[36];   //[ntrk]
Int_t           trfts[36];   //[ntrk]
Int_t           trsip[36];   //[ntrk]
Int_t           trsfh[36];   //[ntrk]
Int_t           trslh[36];   //[ntrk]
Int_t           trsca[36];   //[ntrk]
Int_t           ntrst;
Int_t           tsloc[144];   //[ntrst]
Float_t         tsdze[144];   //[ntrst]
Float_t         tsphi[144];   //[ntrst]
Float_t         tsome[144];   //[ntrst]
Float_t         tszze[144];   //[ntrst]
Float_t         tstnl[144];   //[ntrst]
Float_t         tscov[144][15];   //[ntrst]
Float_t         tsrpx[144];   //[ntrst]
Float_t         tsrpy[144];   //[ntrst]
Float_t         tsrpz[144];   //[ntrst]
Int_t           nsth;
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         stpt1[1];   //[nsth]
Int_t           stmcp[1];   //[nsth]
Int_t           nsch;
Int_t           scori[1];   //[nsch]
Int_t           scci0[1];   //[nsch]
Int_t           scci1[1];   //[nsch]
Float_t         scpox[1];   //[nsch]
Float_t         scpoy[1];   //[nsch]
Float_t         scpoz[1];   //[nsch]
Float_t         scene[1];   //[nsch]
Int_t           r2mnrel;
Int_t           r2mf[169];   //[r2mnrel]
Int_t           r2mt[169];   //[r2mnrel]
Float_t         r2mw[169];   //[r2mnrel]
```

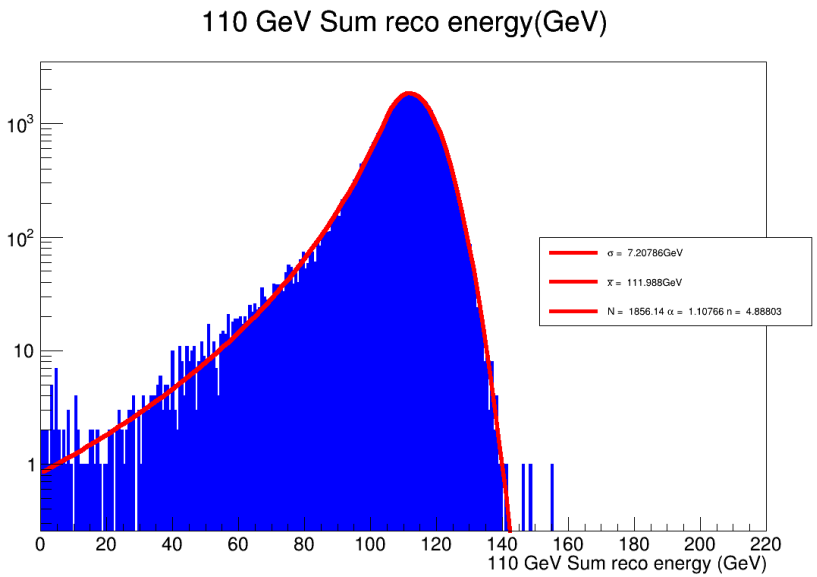
Previous results: links with all results, please explore yourself:

- first test production
  - `http://wwwae.ciemat.es/~carrillo/calice/indexk0o1.html`
  - `http://wwwae.ciemat.es/~carrillo/calice/indexk0o2.html`
- second test production
  - `http://wwwae.ciemat.es/~carrillo/calice/indexk0o1v2.html`
  - `http://wwwae.ciemat.es/~carrillo/calice/indexk0o2v2.html`

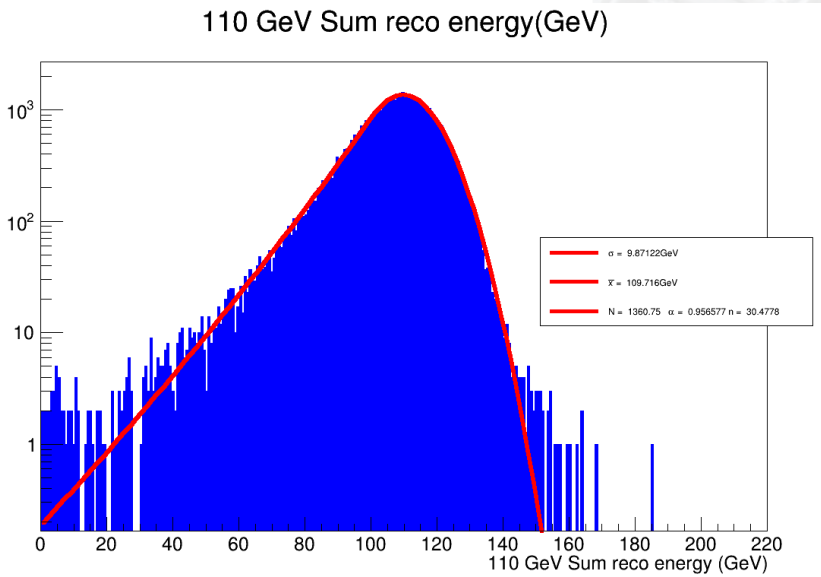
Comparison o1/o2 $\otimes$ $1^{st}/2^{nd}$ Test Production, K_L^0 110 GeV

2^{nd}TP

AHCAL(o1)



SDHCAL(o2)

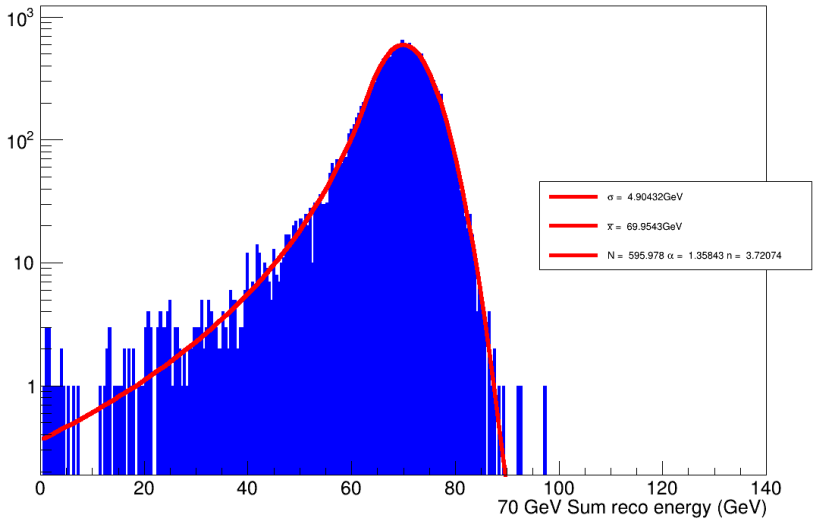


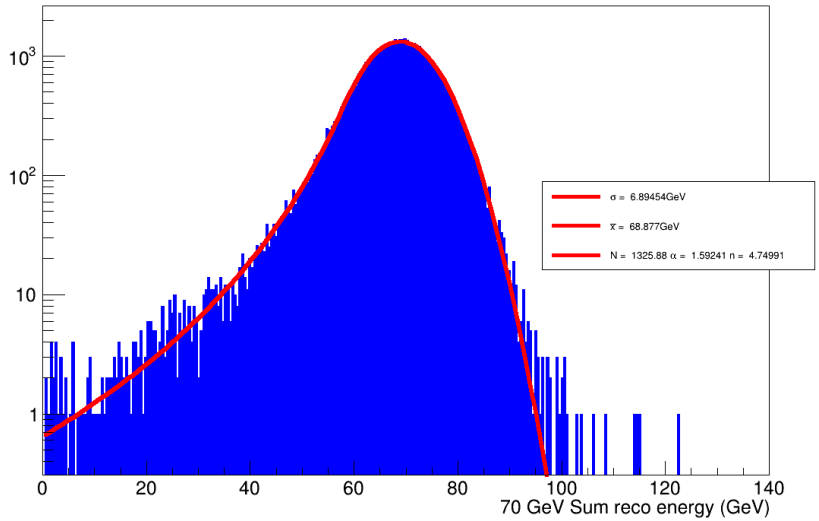
Comparison o1/o2 ⊗ $1^{st}/2^{nd}$ Test Production, K_L^0 70 GeV

AHCAL(o1)

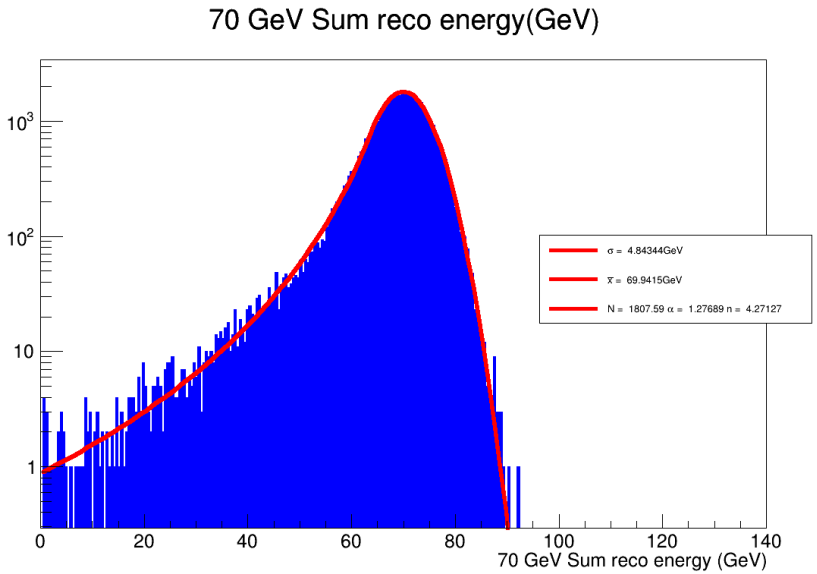
SDHCAL(o2)

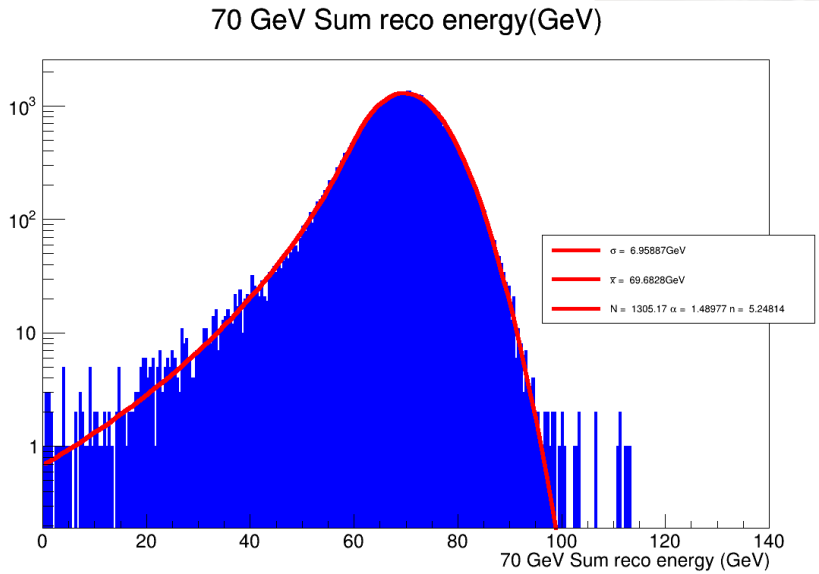
1^{st}TP





2^{nd}TP



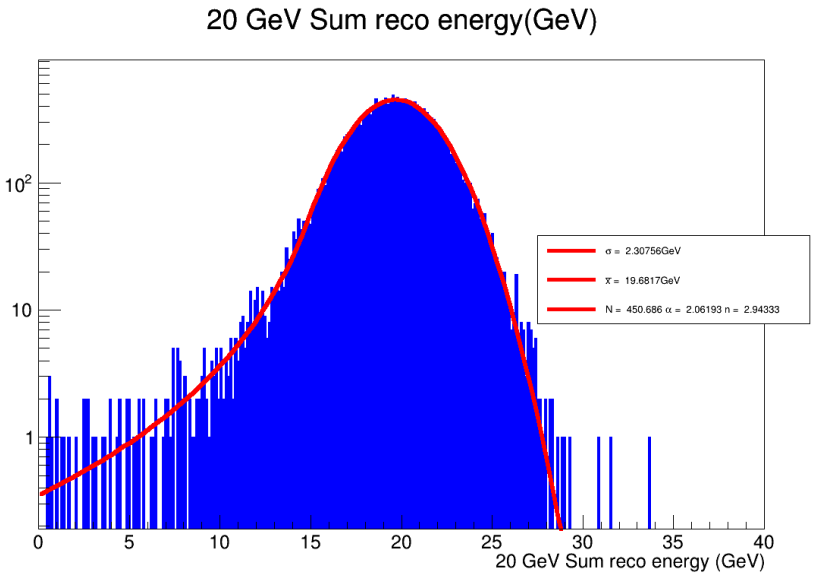


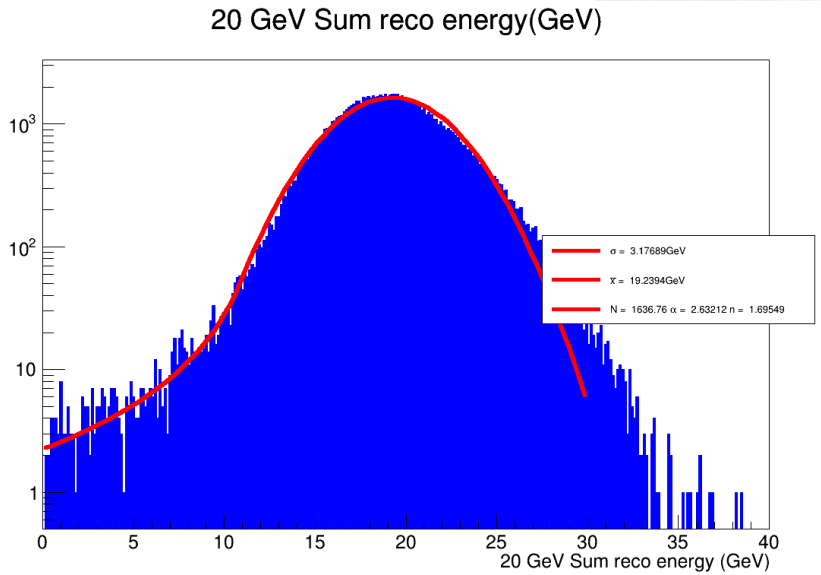
Comparison o1/o2 ⊗ $1^{st}/2^{nd}$ Test Production, K_L^0 20 GeV

AHCAL(o1)

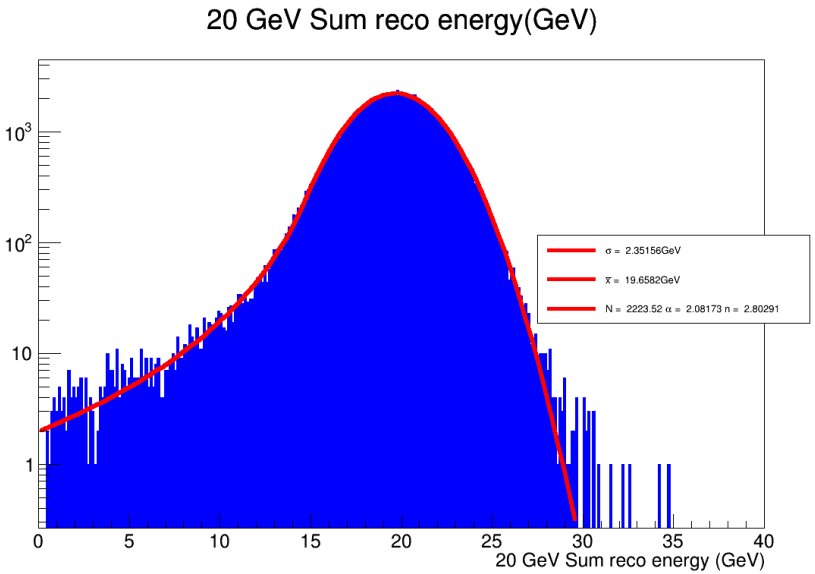
SDHCAL(o2)

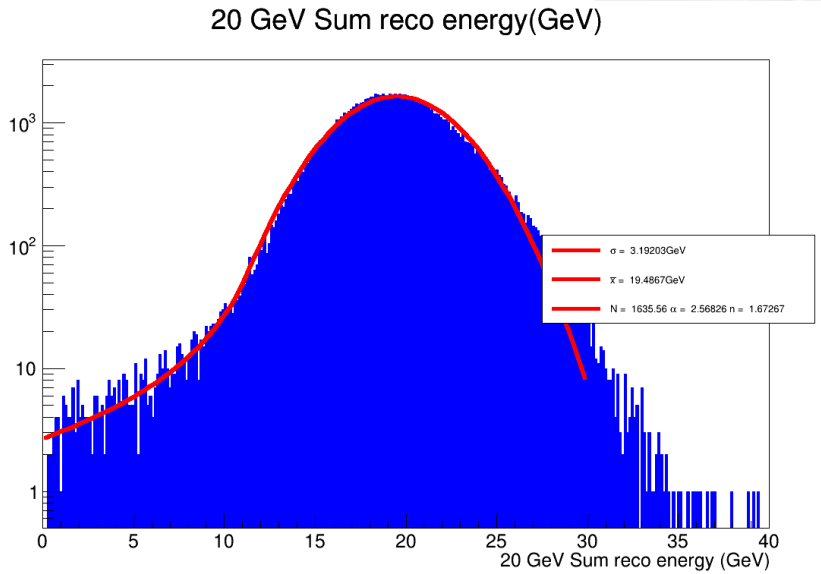
1^{st}TP





2^{nd}TP





Previous results: resolution and discrepancy for o1 and o2, fit results

1^{st}TP

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%**

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

2^{nd}TP

sim p (GeV)	mean (GeV)	sigma (GeV)	resolution (%)	discrepancy(%)
o1				
1	0.66	0.23	**34.9%**	**34.0%**
2	1.63	0.62	**37.9%**	**18.5%**
5	4.37	1.19	**27.4%**	**12.7%**
10	9.12	1.79	**19.6%**	**8.9%**
20	19.66	2.35	**12.0%**	**1.7%**
30	29.73	2.90	**9.7%**	**0.9%**
40	39.76	3.37	**8.5%**	**0.6%**
50	49.71	3.90	**7.8%**	**0.6%**
60	59.82	4.33	**8.7%**	**17.2%**
70	69.94	4.84	**8.1%**	**14.5%**
80	80.13	5.46	**7.8%**	**12.6%**
90	90.63	6.02	**7.5%**	**11.0%**
100	101.20	6.71	**7.4%**	**9.4%**
110	112.00	7.21	**7.1%**	**8.0%**
o2				
1	0.81	0.31	**38.4%**	**19.1%**
2	1.51	0.56	**37.2%**	**24.5%**
5	3.92	1.16	**29.6%**	**21.7%**
10	8.40	1.90	**22.6%**	**16.0%**
20	19.49	3.19	**16.4%**	**2.6%**
30	29.86	4.09	**13.7%**	**0.5%**
40	39.74	4.80	**12.1%**	**0.6%**
50	49.64	5.56	**11.2%**	**0.7%**
60	59.63	6.31	**10.6%**	**0.6%**
70	69.68	6.96	**10.0%**	**0.5%**
80	79.63	7.70	**9.7%**	**0.5%**
90	89.66	8.40	**9.4%**	**0.4%**
100	98.50	10.09	**10.2%**	**1.5%**

Previous results: Resolution for the four scenarions: o1/o2 ⊗ $1^{st}/2^{nd}$ TP