

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

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y Tecnológicas



Identifying the start of the shower to filter events

We have two options:

- 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 $i, j(\text{path})$ plane of each hit would be enough?
- As you can see in the list of available variables the most promising variables: $\text{rcmo}(x, y, z)[\text{nrec}]$

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

- This presentation is a follow up of our previous report
<https://agenda.linearcollider.org/event/8559/>
- 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 particles
- For the first test production we presented results using high level objects (Physics objects). Now we have a working recipe that give us access to the low level objects (SDHCAL hits).

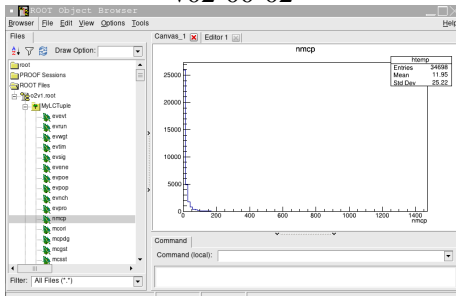
First look at the second test-dataset for the SDHCAL validation and AHCAL comparison, K_L^0

- **o2** Energy range: (1,2,5,10,20,30,40,50,60,70,80,90,100,110) GeV.
/ilc/prod/ilc/mc-opt/ild/dst-merged/1-calib/single/ILD_15_o2_v02_nobg/v02-01-02
- **o1** Energy range: (1,2,5,10,20,30,40,50,**60,70,80,90,100,110**) GeV.
(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-**01**-02 → /cvmfs/ilc.desy.de/sw/x86_64_gcc82_sl6/v02-01-02/init_ilcsoft.sh as for the central production we have produced the corresponding LCTuples.
- /pool/calice3/data/MonteCarlo/sdhcal_validation/second_test_production/o1/dstm

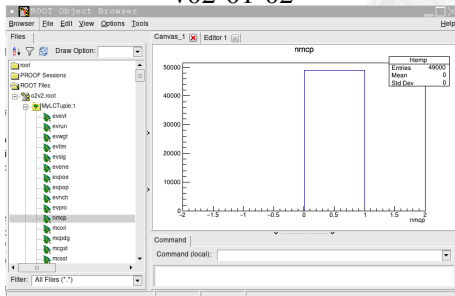
DST-merged datasets look different

First a remark about the LCTuples:

v02-00-02



v02-01-02



The nmcp variable accounts for the number of MC particles in a given event. In the default LCTuple this variable appears always at zero in this second test-production.

links with all results, please explore yourself:

- first test production

- `http://wwvae.ciemat.es/~carrillo/calice/indexk0o1.html`
- `http://wwvae.ciemat.es/~carrillo/calice/indexk0o2.html`

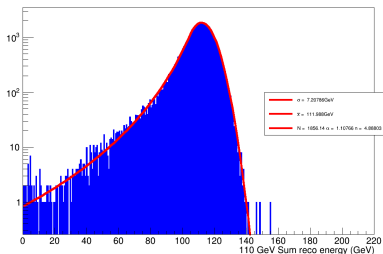
- second test production

- `http://wwvae.ciemat.es/~carrillo/calice/indexk0o1v2.html`
- `http://wwvae.ciemat.es/~carrillo/calice/indexk0o2v2.html`

Comparison o1/o2 \otimes 1st/2nd Test Production, K_L^0 110 GeV2ndTP

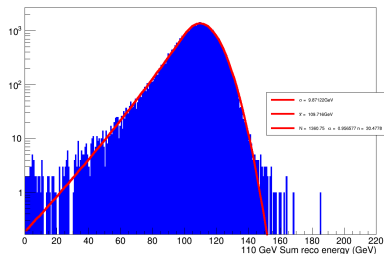
AHCAL(o1)

110 GeV Sum reco energy(GeV)



SDHCAL(o2)

110 GeV Sum reco energy(GeV)

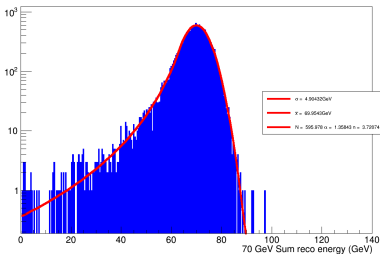


Comparison o1/o2 \otimes 1st/2nd Test Production, K_L^0 70 GeV

1stTP

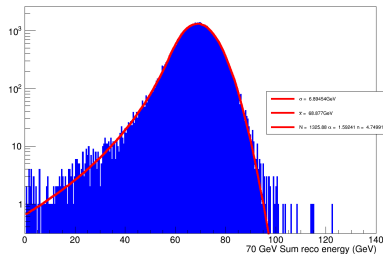
AHCAL(o1)

70 GeV Sum reco energy(GeV)



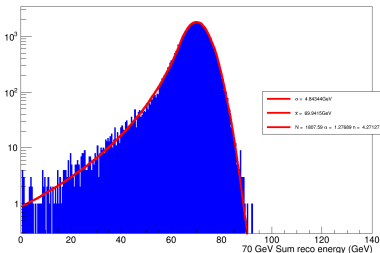
SDHCAL(o2)

70 GeV Sum reco energy(GeV)

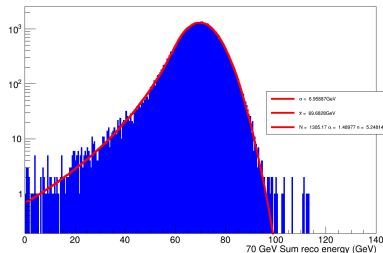


2ndTP

70 GeV Sum reco energy(GeV)



70 GeV Sum reco energy(GeV)

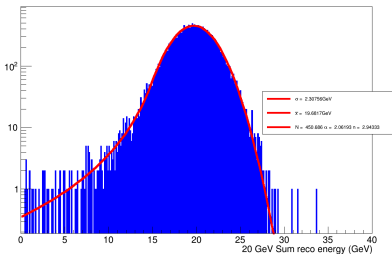


Comparison $\alpha_1/\alpha_2 \otimes 1^{st}/2^{nd}$ Test Production, K_L^0 20 GeV

1stTP

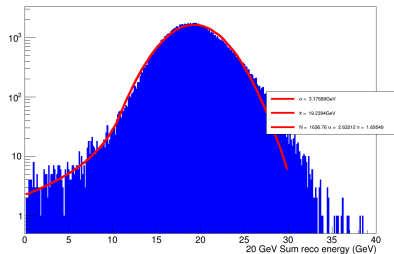
AHCAL(α_1)

20 GeV Sum reco energy(GeV)



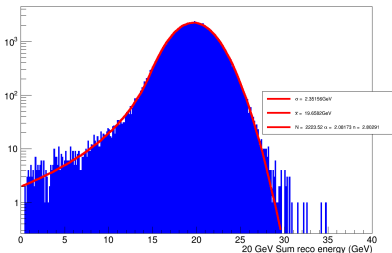
SDHCAL(α_2)

20 GeV Sum reco energy(GeV)

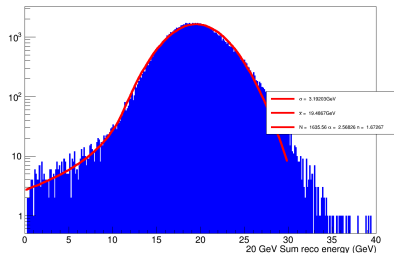


2ndTP

20 GeV Sum reco energy(GeV)



20 GeV Sum reco energy(GeV)



resolution and discrepancy for o1 and o2, fit results

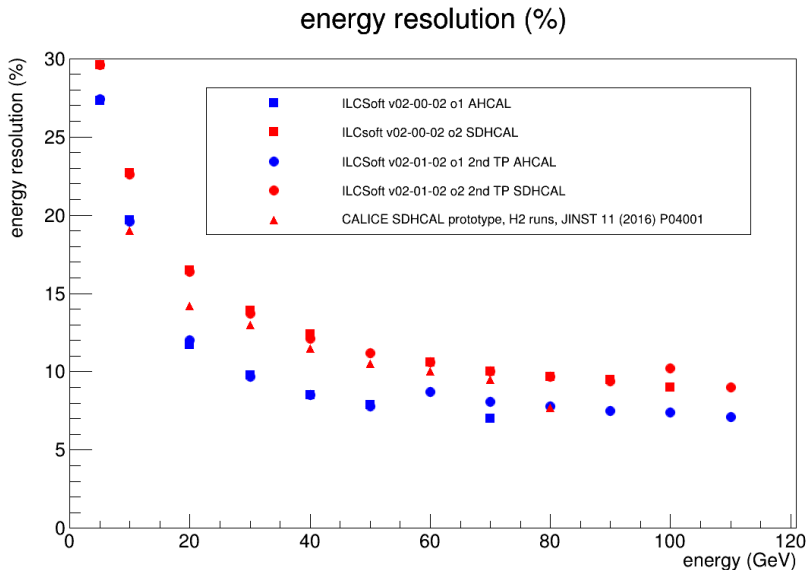
1stTP

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%

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

2ndTP

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%
110	109.70	9.87	9.0%	0.3%

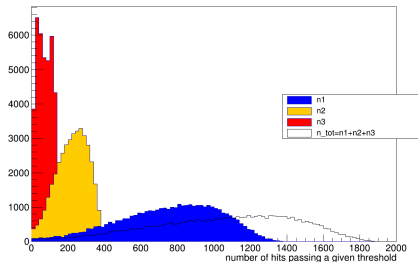
Resolution for the four scenarios: o1/o2 \otimes 1st/2nd TP

SDHCAL Hit Level Analysis

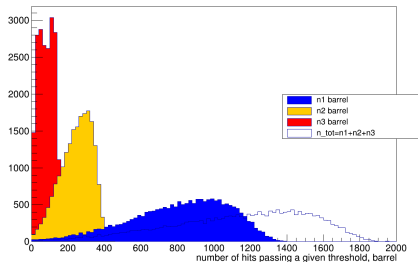
- For the single-hit level analysis, the dst datasets are not enough. The hit information is skimmed.
- An analysis of the rec dataset was needed.
- A copy of the rec dataset to CIEMAT was done.
- `/pool/calice3/data/MonteCarlo/sdhcal_validation/second_test_production/rec/o2v2`
- A customized LCTuple was produced out of rec dataset including the single hit information.
- As a reminder each hit in the SDHCAL tell us if the read energy on a given pad has passed one, two or three pre-set threshold.

SDHCAL Hit Level Analysis 110 GeV

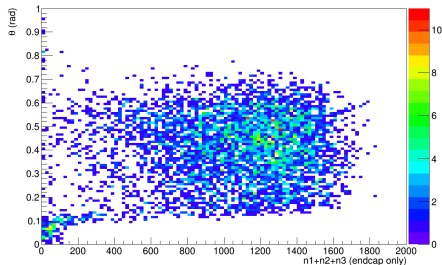
SDHCAL hits per threshold distribution



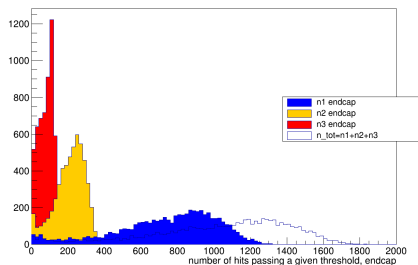
SDHCAL hits per threshold distribution, barrel



n_hits vs theta (endcap only)

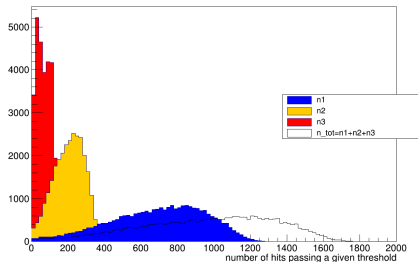


SDHCAL hits per threshold distribution, endcap

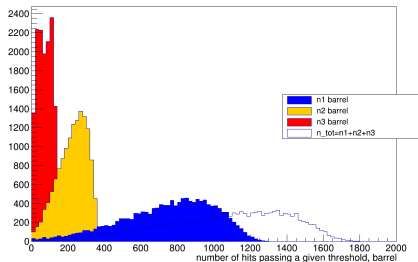


SDHCAL Hit Level Analysis 100 GeV

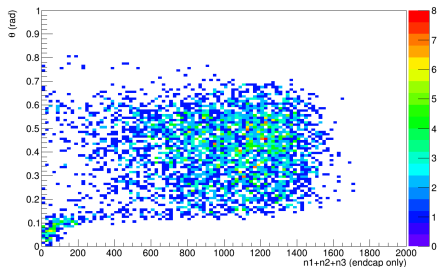
SDHCAL hits per threshold distribution



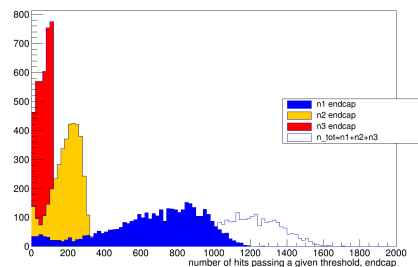
SDHCAL hits per threshold distribution, barrel



n_hits vs theta (endcap only)

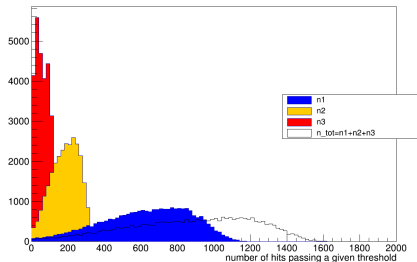


SDHCAL hits per threshold distribution, endcap

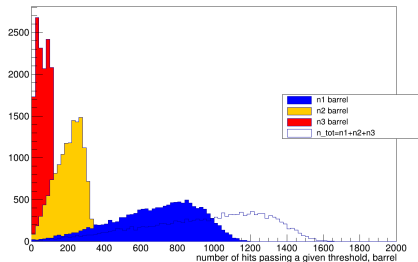
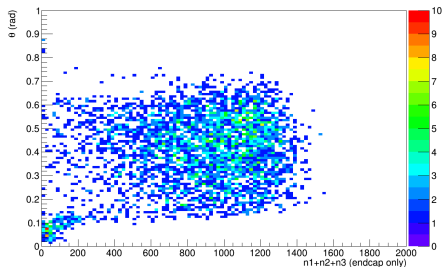


SDHCAL Hit Level Analysis 090 GeV

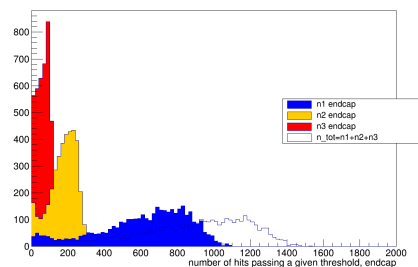
SDHCAL hits per threshold distribution



SDHCAL hits per threshold distribution, barrel

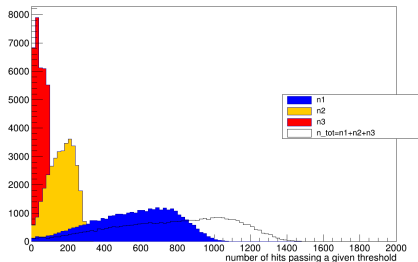
 n_{hits} vs θ (endcap only)

SDHCAL hits per threshold distribution, endcap

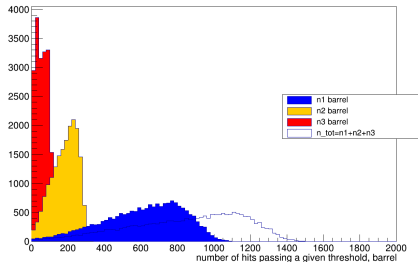


SDHCAL Hit Level Analysis 080 GeV

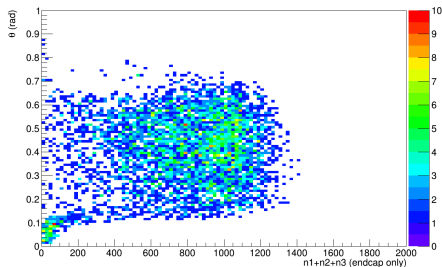
SDHCAL hits per threshold distribution



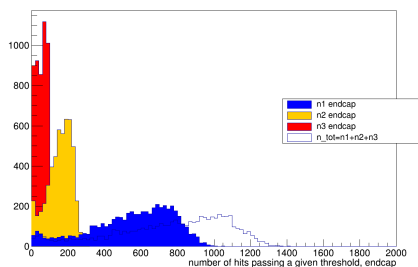
SDHCAL hits per threshold distribution, barrel



n_hits vs theta (endcap only)

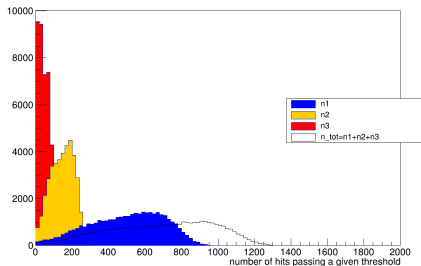


SDHCAL hits per threshold distribution, endcap

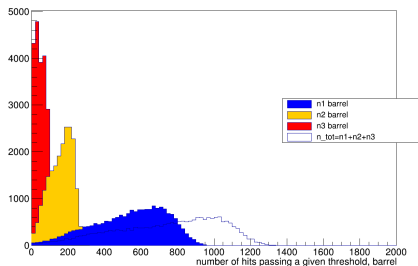


SDHCAL Hit Level Analysis 070 GeV

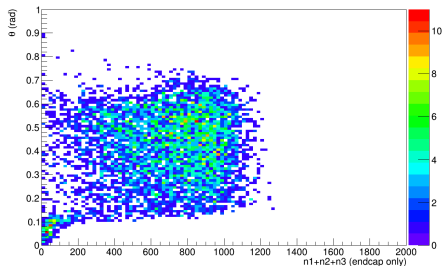
SDHCAL hits per threshold distribution



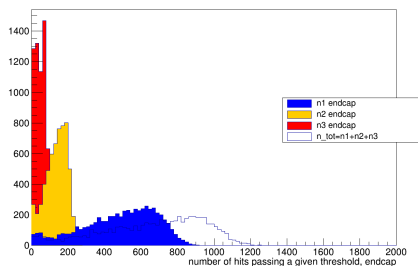
SDHCAL hits per threshold distribution, barrel



n_hits vs theta (endcap only)

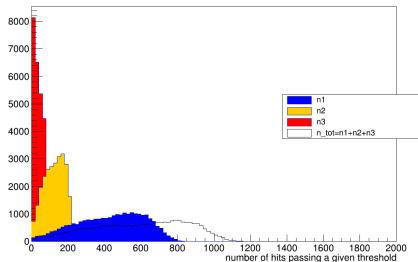


SDHCAL hits per threshold distribution, endcap

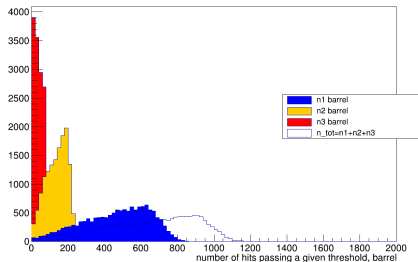


SDHCAL Hit Level Analysis 060 GeV

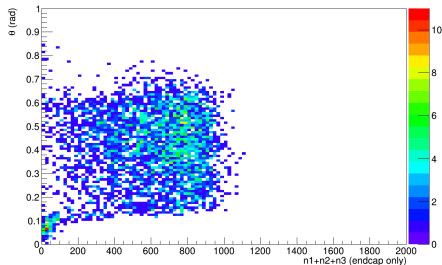
SDHCAL hits per threshold distribution



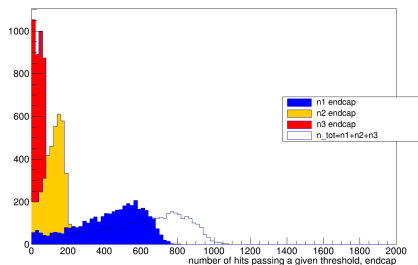
SDHCAL hits per threshold distribution, barrel



n_hits vs theta (endcap only)

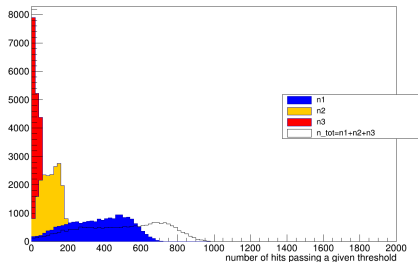


SDHCAL hits per threshold distribution, endcap

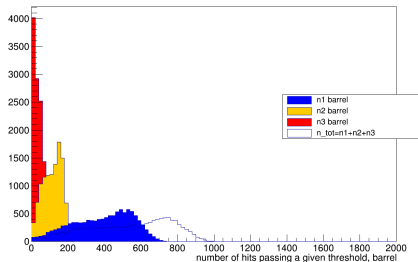


SDHCAL Hit Level Analysis 050 GeV

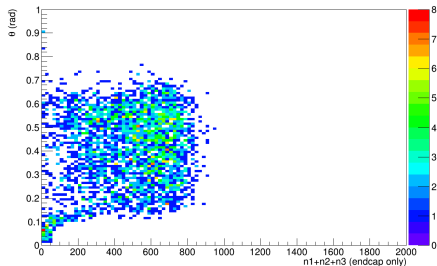
SDHCAL hits per threshold distribution



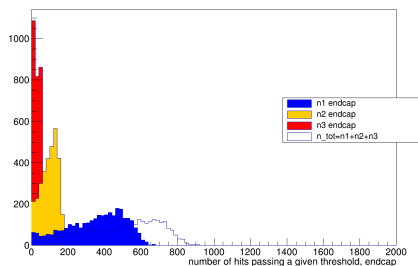
SDHCAL hits per threshold distribution, barrel



n_hits vs theta (endcap only)

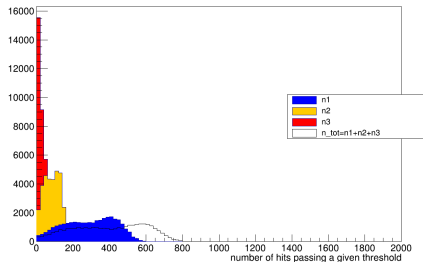


SDHCAL hits per threshold distribution, endcap

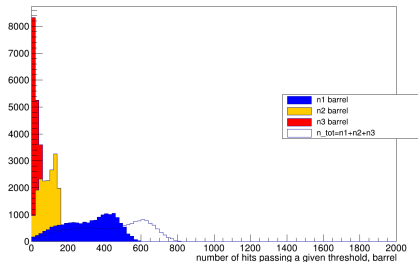
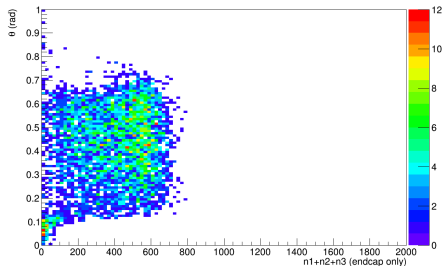


SDHCAL Hit Level Analysis 040 GeV

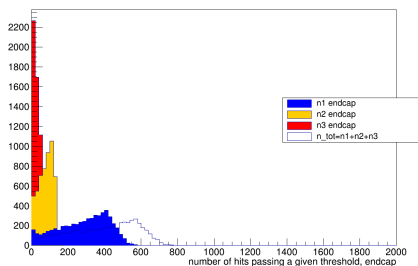
SDHCAL hits per threshold distribution



SDHCAL hits per threshold distribution, barrel

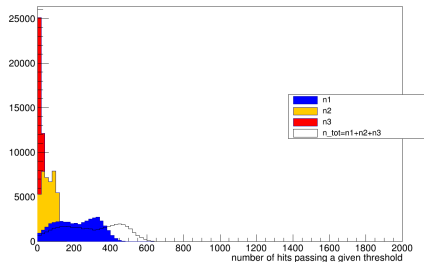
 n_{hits} vs theta (endcap only)

SDHCAL hits per threshold distribution, endcap

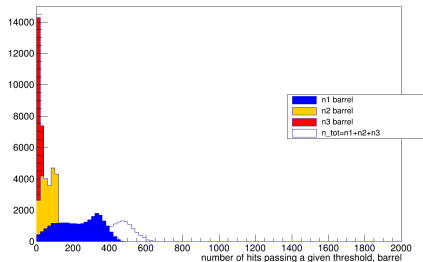


SDHCAL Hit Level Analysis 030 GeV

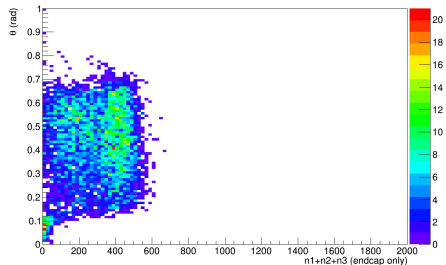
SDHCAL hits per threshold distribution



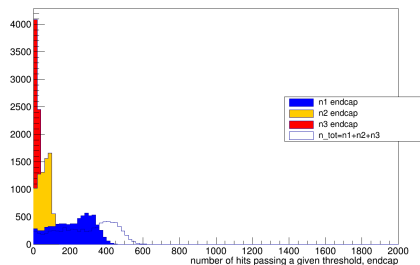
SDHCAL hits per threshold distribution, barrel



n_hits vs theta (endcap only)

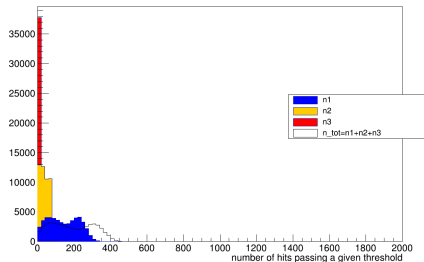


SDHCAL hits per threshold distribution, endcap

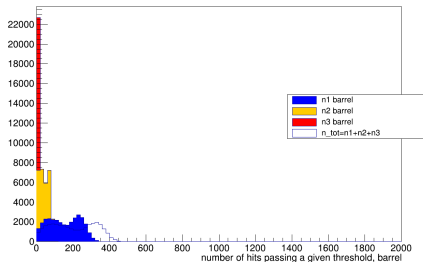


SDHCAL Hit Level Analysis 020 GeV

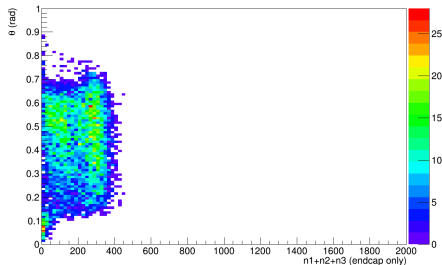
SDHCAL hits per threshold distribution



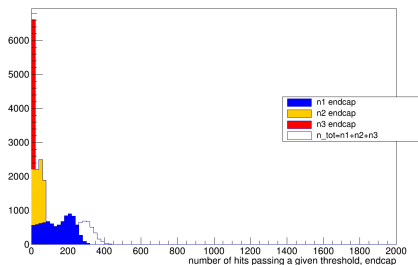
SDHCAL hits per threshold distribution, barrel



n_hits vs theta (endcap only)

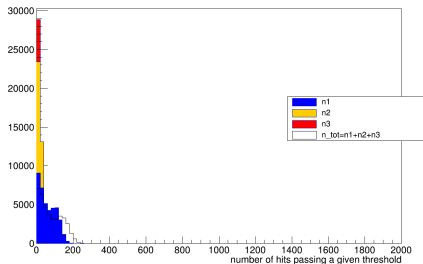


SDHCAL hits per threshold distribution, endcap

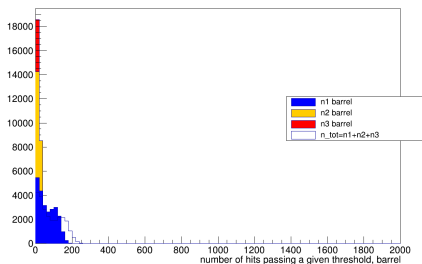


SDHCAL Hit Level Analysis 010 GeV

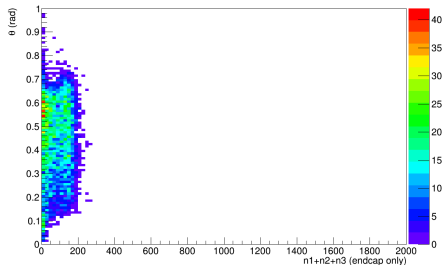
SDHCAL hits per threshold distribution



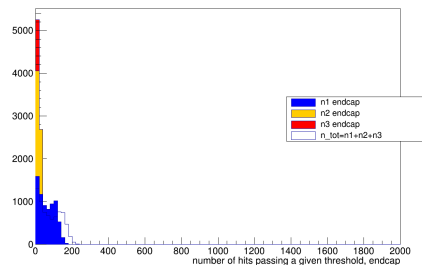
SDHCAL hits per threshold distribution, barrel



n_hits vs theta (endcap only)

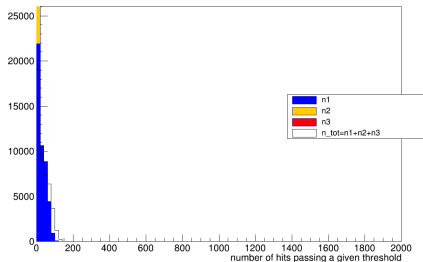


SDHCAL hits per threshold distribution, endcap

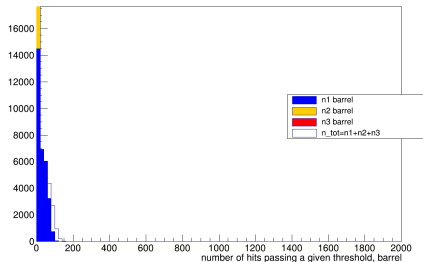


SDHCAL Hit Level Analysis 005 GeV

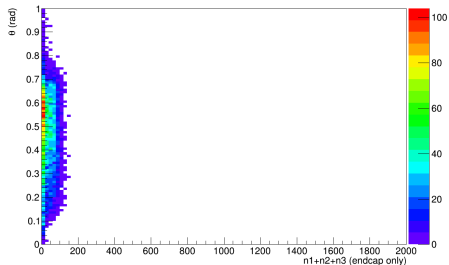
SDHCAL hits per threshold distribution



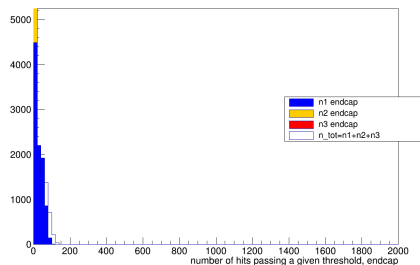
SDHCAL hits per threshold distribution, barrel



n_hits vs theta (endcap only)

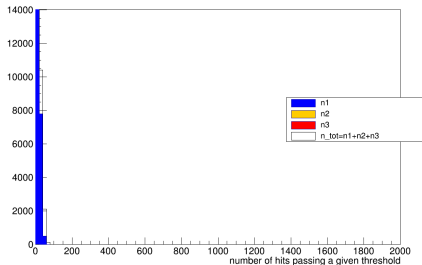


SDHCAL hits per threshold distribution, endcap

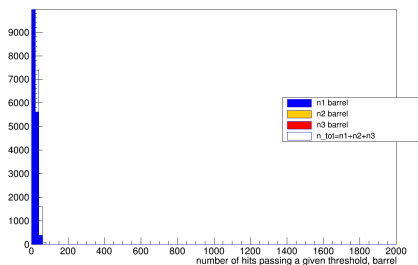


SDHCAL Hit Level Analysis 002 GeV

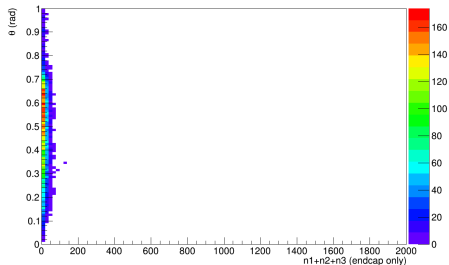
SDHCAL hits per threshold distribution



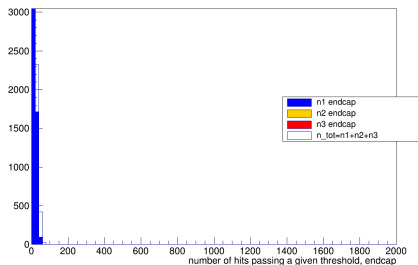
SDHCAL hits per threshold distribution, barrel



n_hits vs theta (endcap only)

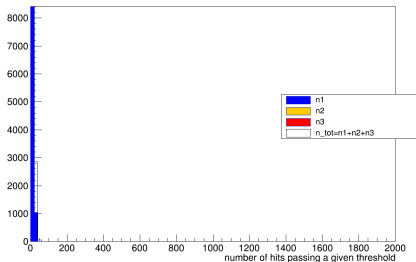


SDHCAL hits per threshold distribution, endcap

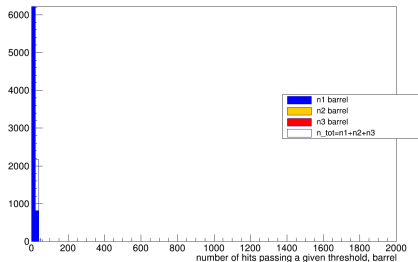


SDHCAL Hit Level Analysis 001 GeV

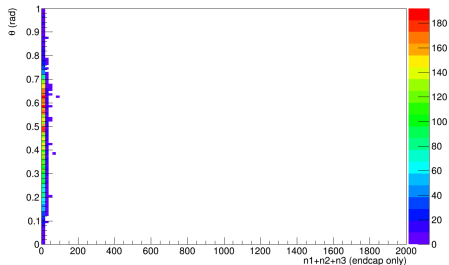
SDHCAL hits per threshold distribution



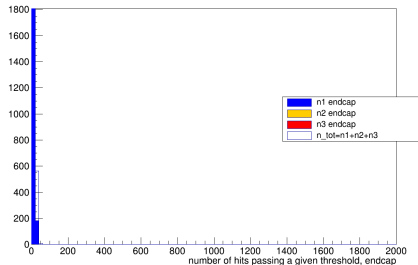
SDHCAL hits per threshold distribution, barrel



n_hits vs theta (endcap only)



SDHCAL hits per threshold distribution, endcap



Conclusions

- No relevant difference has been observed with the new test-sample for the SDHCAL/AHCAL performance.
- 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.

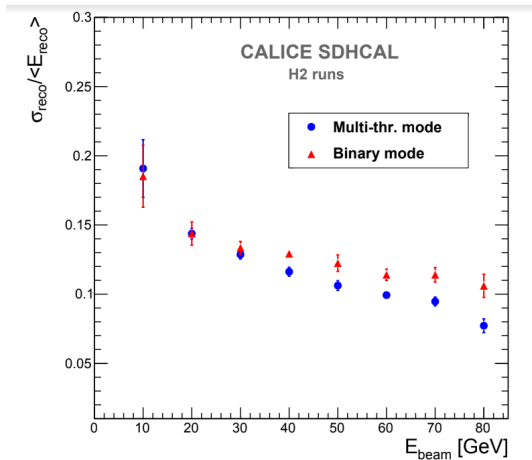
¹<https://geant4.web.cern.ch/node/155>

Backup

Backup



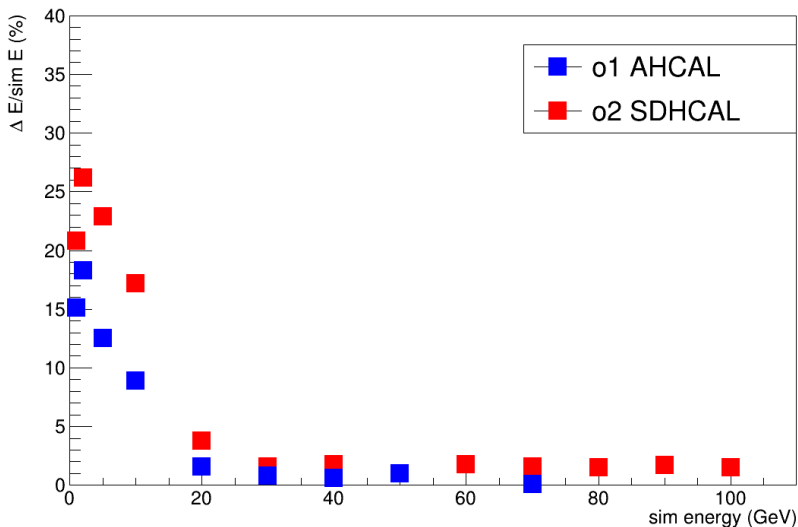
Only SDHCAL resolution observed in test-beams



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

Comparison for the two scenarios, discrepancy.

energy discrepancy



Crystalball fit

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

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

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

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

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

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

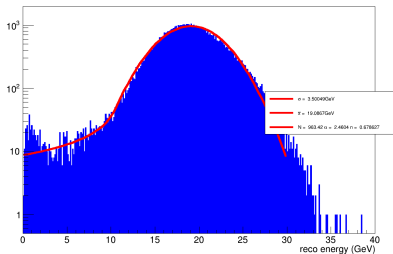
EXT PARAMETER		STEP		FIRST	
NO.	NAME	VALUE	ERROR	SIZE	DERIVATIVE
1	N	2.00731e+03	9.14867e+00	-2.32131e-02	2.47481e-05
2	mean	5.83022e+01	2.70121e-02	2.65898e-05	-4.92050e-03
3	sigma	6.59899e+00	2.21181e-02	1.22279e-04	1.43070e-02
4	alpha	1.80238e+00	2.83231e-02	7.01543e-05	-6.05402e-03
5	n	1.97606e+00	1.01879e-01	-9.94635e-05	1.27298e-03

FCN=342.074 FROM MIGRAD STATUS=CONVERGED 184 CALLS 185 TOTAL
EDM=2.61519e-08 STRATEGY= 1 ERROR MATRIX UNCERTAINTY 0.3 per cent
50 GeV thismax2.1e+03 mean=58 sigma=6.6 error=11%

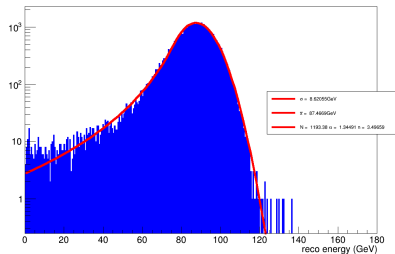
https://en.wikipedia.org/wiki/Crystal_Ball_function

Crystalball fit, K_L^0 , o2

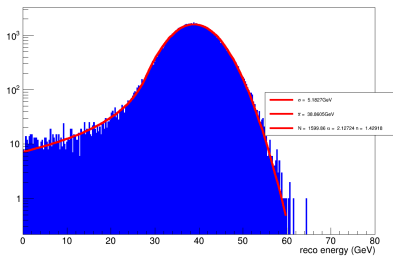
K0long 20 GeV



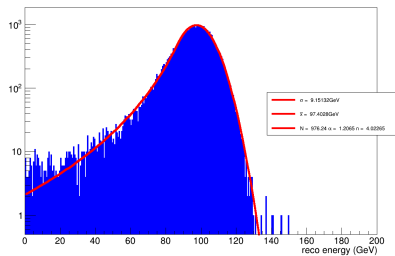
K0long 90 GeV



K0long 40 GeV



K0long 100 GeV

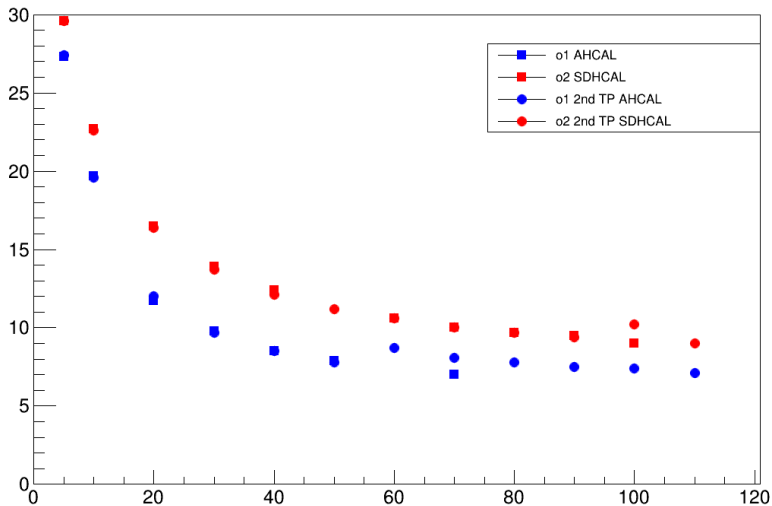


Summary, K_L^0 , o2

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

