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

ILD software & analysis meeting

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cfp CIEMAT física de partículas

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/elog/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.

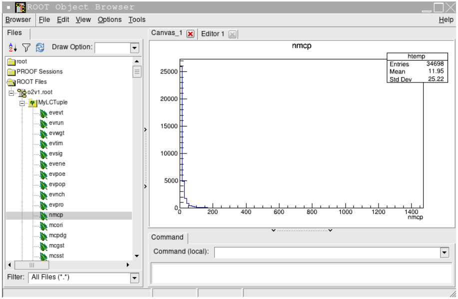
First look at the second test-dataset for the SDHCAL validation and AHCal comparison, K_L^0

- 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_l5_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_l5_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`

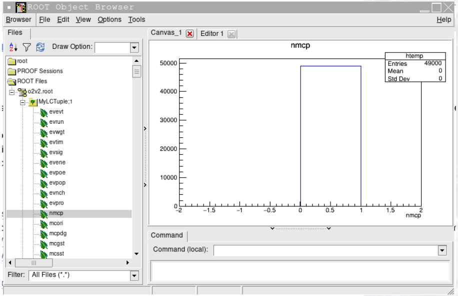
DST-merged datasets look different

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.

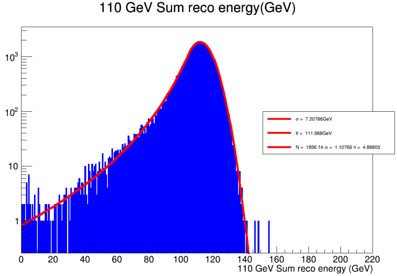
links with all results, please explore yourself:

- first test production
  - http://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

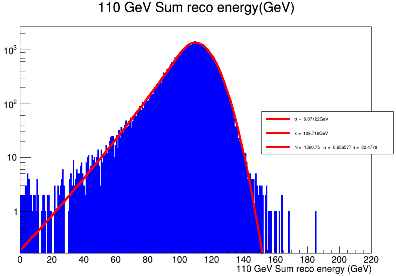
Comparison o1/o2 ⊗ $1^{st}/2^{nd}$ Test Production, K_L^0 110 GeV

2^{nd}TP

AHCAL(o1)



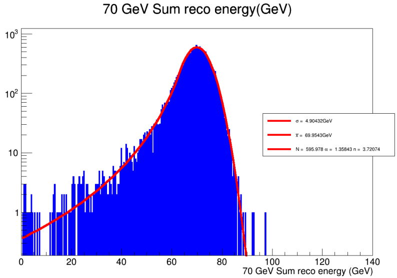
SDHCAL(o2)

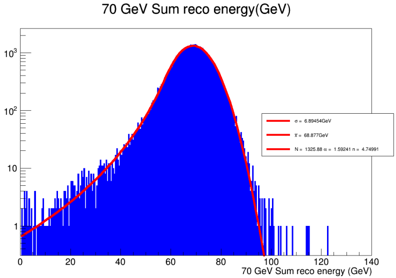


Comparison o1/o2 ⊗ $1^{st}/2^{nd}$ Test Production, K_L^0 70 GeV

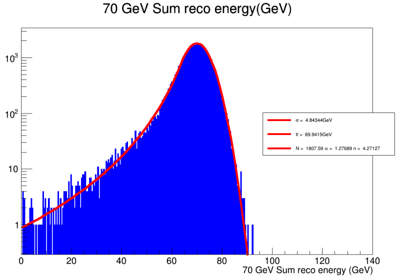
AHCAL(o1) | SDHCAL(o2)

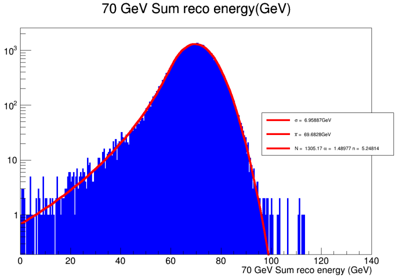
1^{st}TP





2^{nd}TP

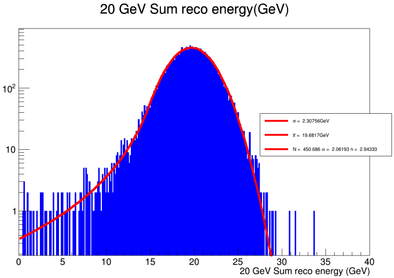


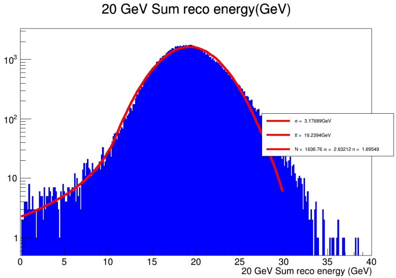


Comparison o1/o2 $\otimes$ $1^{st}/2^{nd}$ Test Production, K_L^0 20 GeV

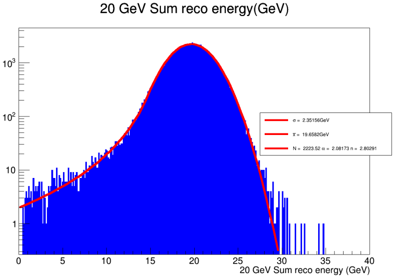
AHCAL(o1) | SDHCAL(o2)

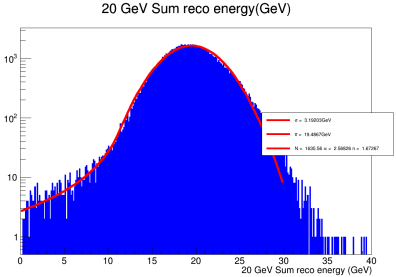
1^{st}TP





2^{nd}TP





resolution and discrepancy for o1 and o2, fit results

1^{st}TP

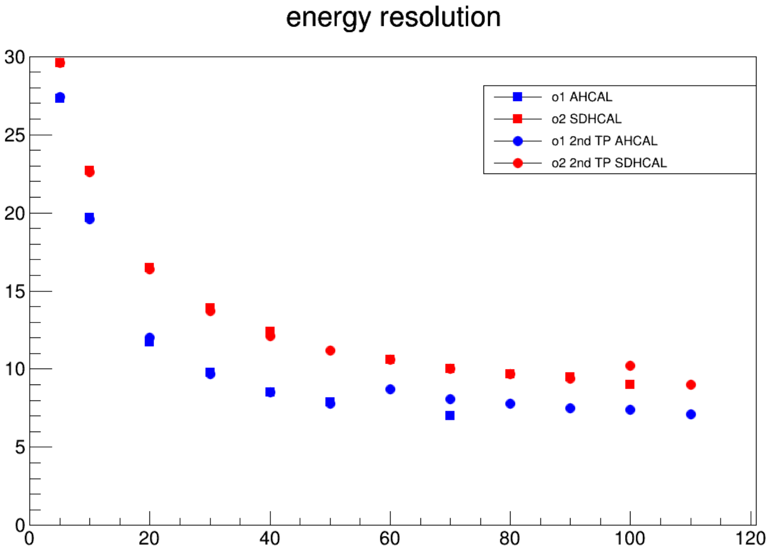
sim p (GeV)	mean (GeV)	sigma (GeV)	resolution (%)	discrepancy(%)
		o1		
1	0.85	0.34	**39.6%**	**15.1%**
2	1.64	0.61	**37.2%**	**18.3%**
5	4.37	1.19	**27.3%**	**12.5%**
10	9.11	1.80	**19.7%**	**8.9%**
20	19.68	2.31	**11.7%**	**1.6%**
30	29.75	2.91	**9.8%**	**0.8%**
40	39.75	3.39	**8.5%**	**0.6%**
50	49.50	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%**

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

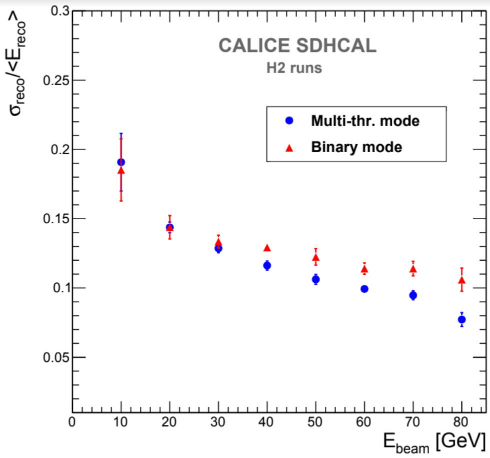
2^{nd}TP

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%**
110	109.70	9.87	**9.0%**	**0.3%**

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



Only SDHCAL resolution observed in test-beams K_L^0



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

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 is 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.

Conclusions

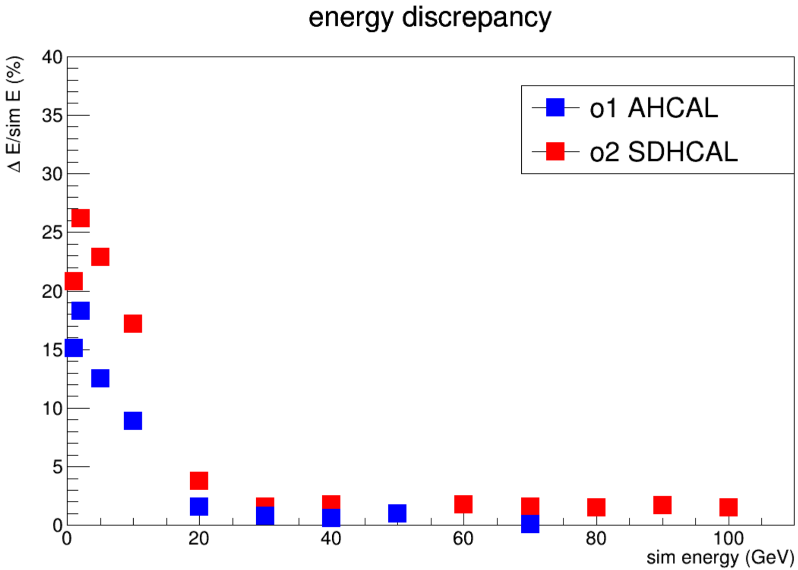
- No relevant difference has been observed with the new test-sample for the SDHCAL/AHCAL performance.
- Hector: We would like to implement “Imad’s algorithm” for energy reconstruction but so far we haven’t dig into the problem with the simulated data.
- Next steps:
  - Produce the full ntuples with SDHCAL hits.
  - extra variables to check the SDHCAL calibration are under scrutiny.
  - study the SDHCAL local reconstructed objects (cluster performance).
- key point about SDHCAL in ilcsoft[1]:
  - 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

Comparison for the two scenarions, discrepancy.



Crystalball fit

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

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

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

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

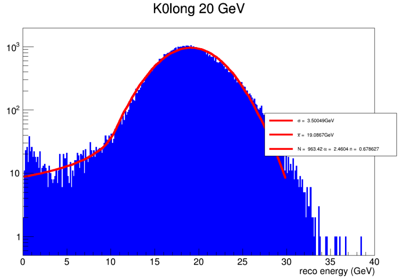
$$C = \frac{n}{|\alpha|} \cdot \frac{1}{n-1} \cdot \exp\left(-\frac{|\alpha|^2}{2}\right),$$

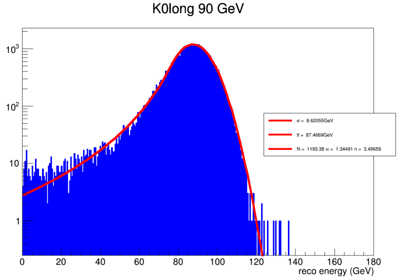
$$D = \sqrt{\frac{\pi}{2}}\left(1 + \operatorname{erf}\left(\frac{|\alpha|}{\sqrt{2}}\right)\right).$$

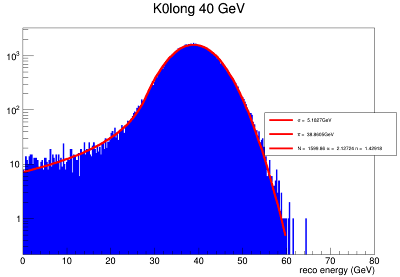
```
FCN=342.074 FROM MIGRAD    STATUS=CONVERGED     184 CALLS        185 TOTAL
                     EDM=2.61519e-08    STRATEGY= 1  ERROR MATRIX UNCERTAINTY   0.3 per cent
 EXT PARAMETER                                  STEP         FIRST
 NO.   NAME        VALUE            ERROR          SIZE      DERIVATIVE
  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%
```

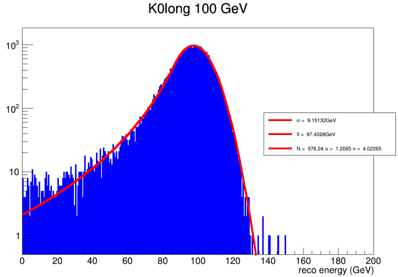
https://en.wikipedia.org/wiki/Crystal_Ball_function

Crystalball fit, K_L^0, o2





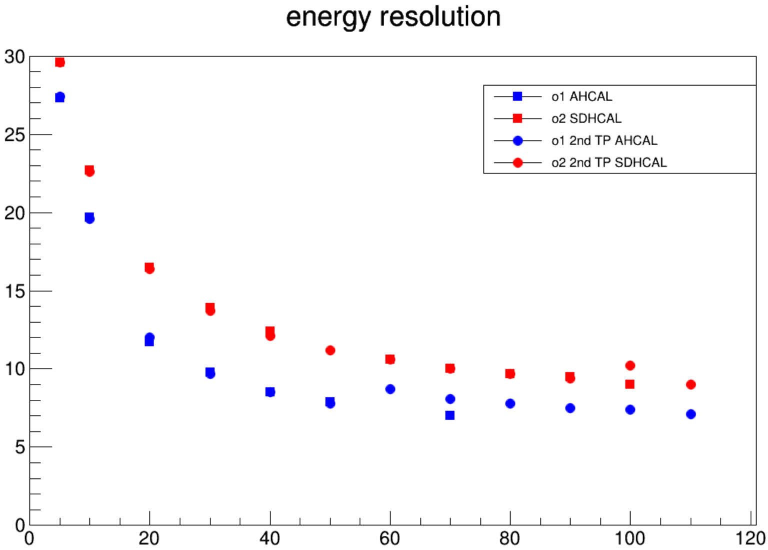




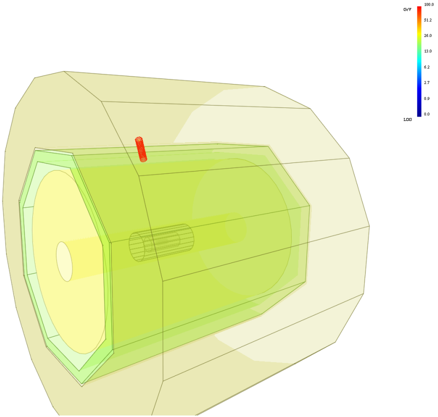
Summary, K_L^0, o2

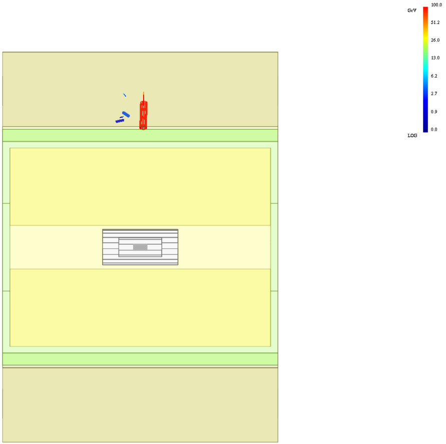
sim energy (GeV)	CB $\bar{x}$ (GeV)	CB σ (GeV)	$\frac{\sigma}{E}$ (%)
1	0.79	0.3	30
2	1.4	0.53	26
5	3.5	1.2	25
10	7.8	2.1	21
20	19	3.5	18
30	29	4.4	15
40	39	5.2	13
60	58	6.6	11
70	68	7.2	10
80	78	7.9	9.8
90	87	8.6	9.6
100	97	9.2	9.2

Summary Resolution, K_L^0



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         mcepz[807];   //[nmcp]
   Float_t         mcmox[807];   //[nmcp]
   Float_t         mcmoy[807];   //[nmcp]
   Float_t         mcmoz[807];   //[nmcp]
   Float_t         mcmas[807];   //[nmcp]
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   Float_t         mcspx[807];   //[nmcp]
   Float_t         mcspy[807];   //[nmcp]
   Float_t         mcspz[807];   //[nmcp]
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   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]
```

```
   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         stptl[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]
```