H1-08/98-550

Status of the BDC analysis

and a proposal for the future data treatment

N. Keller, J. Marks, P. Sievers, U. Straumann, R. Wallny, T. Wengler

August 24, 1998

Abstract

The present status of the BDC analysis of track finding and its use as a preshower detector is summarised. The available standard software tools are mentioned and a proposal for a possible new data storage scheme is sketched. In view of the ongoing studies we propose to stay for 1998 with the present scheme of data storage on the DST (raw data plus track cluster match in DELE bank).

1 BDC data analysis

The BDC was originally designed to measure exact positions of the charged particles entering the backward region. It was also supposed to help identifying fake electron clusters in the SPACAL originating from photons. However, there is a lot of dead material in front of this chamber. In some areas it amounts to more than one radiation length (endwalls, electronics and cables of the CJC, CIP/CIZ, COP/COZ and BST). Electromagnetic showering of electrons and photons does not allow to determine uniquely the original electron track in the BDC and since most photons shower as well, they can not be identified. At the time, when this chamber was designed, a much more optimistic material distribution was assumed.

In the meanwhile the inclusive analysis of DIS in the low Q^2 region has reached higher and higher precision. It turns out, that the largest contribution to the errors of the structure functions is in fact still the energy measurement of the scattered electron. This resolution is significantly affected by the fluctuations of the showering in front of the backward detectors. In contrast to that, the position and polar angle resolution becomes important at very large angles, affecting the lowest Q^2 bins only.

Since 1997 the BST is available, which can measure the polar angles much better, since it is installed in front of most of the dead material (apart from the beampipe). However, it does not cover the full BDC acceptance, so the BDC must still be used.

It is natural trying to use the BDC as a preshower detector and to correct the SPACAL energy accordingly. Recently new preliminary results on this subject became available and are summarised shortly below.

For charged hadrons a more precise angular measurement is easily possible. However, in most physics analyses a very high precision is not needed, since the errors are dominated by many other sources.

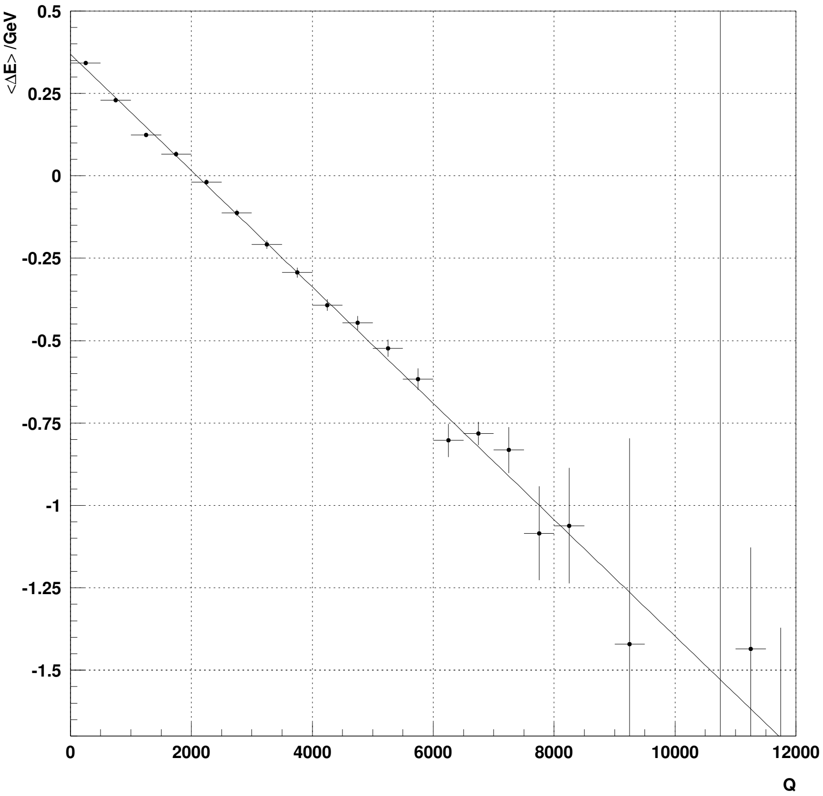

Figure 1: Statistical correlation between the missing energy in the SPACAL (calculated as the difference between the SPACAL cluster energy and the electron energy determination from the double angle method) and the truncated mean of the summed BDC charge in the neighbourhood of the track (arbitrary units).

1.1 The BDC as a preshower detector of the SPACAL

Already in 1995 it could be shown with data, that there is a statistical correlation between the charge deposited in the BDC and the energy deviation in the SPACAL [1].

In order to use this information to correct the SPACAL energy a much better charge calibration of the BDC is needed. Such an analysis was recently performed, using 1997 data. A sample of charged pions was selected based on e.m. and hadronic SPACAL cluster information and an isolation criterium for the BDC track. The charge distributions of the hits of these tracks show a Landau type distribution, which was fitted to obtain charge calibration constants. This procedure requires very large statistics to reach good accuracy.

From a DIS sample events are selected, which allow a reliable determination of the electron energy not only by the SPACAL cluster energy but also by the double angle method. This includes a cut on the hadronic angle ($15° \ldots 140°$) and $y < 0.05$ (kinematical peak events). Now the calibrated BDC charge in a limited region around the selected electron is summed. The SPACAL energy offset is obtained by comparing the electron energy determined by the double angle method with the direct SPACAL measurement. The statistical correlation between this energy offset and the BDC charge is shown in figure 1.

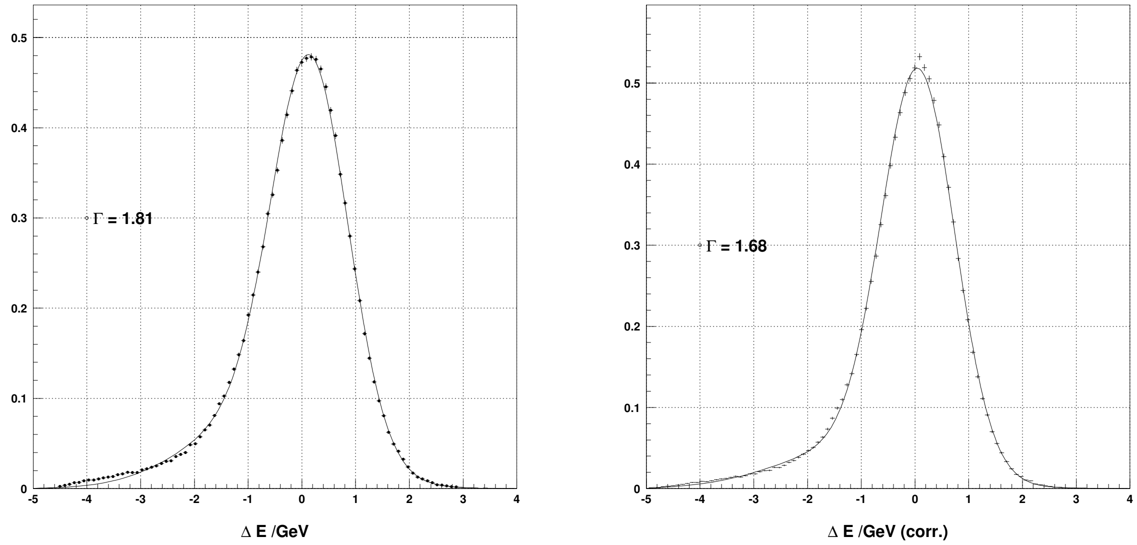

Figure 2: Energy resolution of the SPACAL before (left) and after (right) applying the presampling correction from the BDC charge. VERY PRELIMINARY!

This correlation allows to obtain correction functions, which are applied on an event by event basis to the SPACAL energy measurements after all state of the art ELAN energy calibrations. Figure 2 shows the resulting energy distributions before and after the BDC correction. The resolution, defined as FWHM / 2.77, is measured to be 0.652 GeV before and 0.603 GeV after the correction. The squared difference of these two numbers is a measure for the effect of the event by event fluctuations of the showering in the dead material and evaluates to 0.25 GeV. (Geometrical variations of the material thickness change the average energy calibration of each SPACAL cell. This is taken into account in the standard ELAN correction already).

This might be compared to the "official" pure SPACAL resolution of $7\%/\sqrt{E} \oplus 1\% = 0.46$ GeV at 27.5 GeV determined in test beam measurements.

Although the overall improvement seems to be marginal, we expect, that the effect is more sizeable in certain geometrical regions. Also work is in progress to improve the accuracy and the energy dependence of the correction factors using QED compton events, as well as the π^0 invariant mass peak.

As it is well known, an exact Monte Carlo description of such showering phenomena in a wire chamber is very difficult, since showering has to be simulated with a very low cutoff energy (order 1 MeV, so called δ-rays). It is probably better to smear the simulated electron energy cluster in the SPACAL using the measured resolution function as described above as a function of the cluster position in R.

More detailed information on this work by Phillip Sievers and Rainer Wallny will be presented in the near future to the collaboration.

1.2 Backward track reconstruction

The standard reconstruction code of the BDC tries to find tracks, making use of the BDC information only. It was developped in 1995 [1] and has overgone only small technical corrections and an adaption to the minimum number of planes required, according to the reduced number of dead sectors since then.

It gives typical resolutions of 0.65 mrad for weakly showering particles, corresponding to a position resolution of about 800 μm. This is not so bad for a single cell type of drift chamber trying to work behind one radiation length of dead material.

A first attempt was made by Judith Katzy [2] to improve the situation for strongly showering electrons. The standard reconstruction code delivers in such a case a lot of track candidates. She tried various methods using direction information of these tracks to improve on the selection of the best candidate. Although she was able to make significant improvements, this method was not widely accepted by the collaboration, because the Monte Carlo description of this algorithms turns out to be very difficult (same reasons as mentioned in the last section).

A new method was recently developed within the ELAN group (S. Glazov and R. Wallny)[3]. The so called BDCLEV algorithm starts from a first prediction of the track position, using the SPACAL cluster and the event vertex position. The BDC hits, which fit this predictions best, are combined to a track candidate. This method improves the average resolution from 0.77 mrad to 0.57 mrad [4]. Figure 3 compares standard resolution with BDCLEV for weakly and strongly showering electrons. More important, the distributions are well described by the Monte Carlo simulation, because this algorithm does not depend so much on the details of the shower particles.

This method is being used within ELAN for inclusive structure function analyses. The code can be obtained from R. Wallny or S. Galzov directly. Its performance is so far studied for electromagnetic clusters only. For hadrons an independent method might give better results.

Note, that for all this the SPACAL cluster banks SCLR and SCLP are regenerated from the DCLU bank. The DELE bank is not used.

We believe that we are in general rather close to the best possible resolution. There is however one serious unsolved problem: we observe a systematic shift of the BDC hits and tracks in the region around $R = 25$ cm of sometimes more than 1 cm[5], where both the material distribution in front of the BDC has a strong discontinuity and the BDC changes its internal segmentation size. This problem is presently being studied intensively.

2 Presently available standard information

For efficient analysis the amount of CPU time used by the average user should be minimised. The same time the DST data volume should be kept small and all information, which is needed to improve the BDC analysis further should be kept on the DST.

These contradicting requirements are presently resolved by writing only the raw data information (HDBD, HRDE) of the BDC onto the DST.

The same time the distance between a SPACAL electron cluster and the nearest BDC track, obtained by the standard reconstruction code, is written to the DELE bank. This information is sufficient for the big majority of H1 analyses.

H1REC and H1PHAN: H1REC contains presently only code for the standard (independent) track reconstruction method. In order to obtain the BDC track segments this BDC reconstruction has to be performed on the analysis level. Two possibilities exist, either the BDC reconstruction module HDREC is called as a module before any analysis module with all technical consequences of the module steering or an interface routine is called which does not provide module steering.

While the first method is obvious the second method is implemented within H1PHAN (available since version 2.03/08). The BDC reconstruction is enabled by adding the bank QHDR to your H1PHAN steering file (/h1/h1phan/bin/h1phan30002.qhdr) and setting the card HRON. Processing the BDC reconstruction within H1PHAN gives not only access to the DST banks (track segments) but to the full reconstruction information.

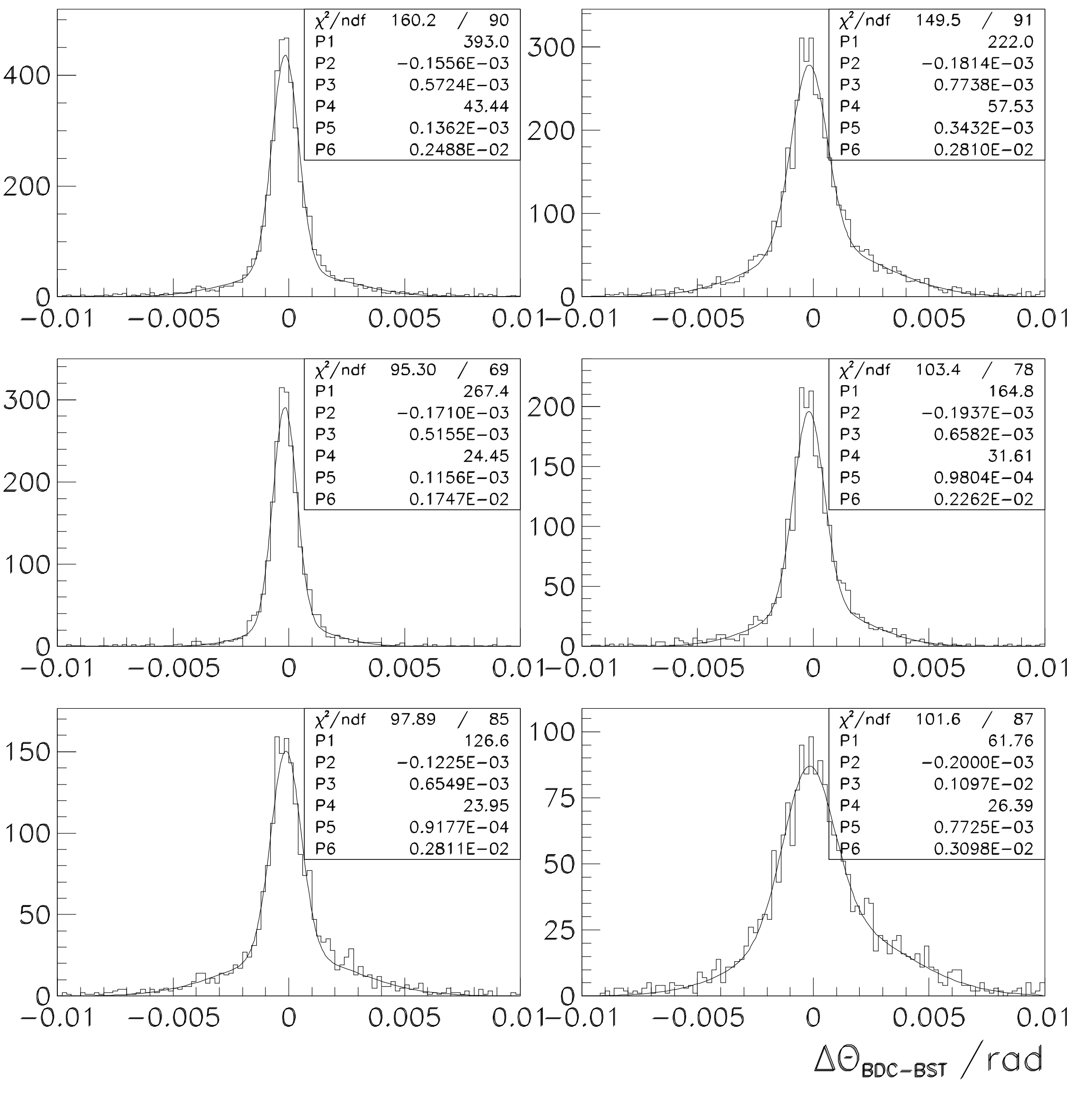

Figure 3: Distributions of the difference between BDC and BST angular resolution in the region, where the acceptances overlap. The right column is for standard reconstruction, the left column for BDCLEV algorithm. All (top), weekly showering (middle) and heavily showering electrons (bottom) are compared.

Further information is available via the file http://www-h1.desy.de/~marks/bdc/bdc.html

Data volume and CPU time: The reconstruction of the BDC consists of two major steps. First the hit banks HDHH are generated from the raw data banks HDBD, HRDE. This includes resolving the sector ambiguities and forming hits, and uses about 90% of the total CPU time. The second step produces the track banks HDTF, using about 10% of the CPU time. The total CPU time spent in the BDC is on average 317 ms, evaluated in a run of last years low Q^2 special run period. The same run showed the following average banksizes:

	bank name	size [kB]
raw data	HDBD, HRDE	2.3
hit bank	HDHH	3.3
track bank	HDTF	2.4

This depends obviously on the trigger mix, and it is expected, that for standard runs the banks get smaller. Note that the smallest data volume is obtained by the present method, writing only raw data to DST.

3 Proposal for a new data storage scheme

In longer term we plan to provide for each SPACAL cluster stored on the DST the parameters of the best track candidates obtained both by the independent standard method and by the BDCLEV algorithm, the number of hits and the total calibrated charge deposited in the BDC in a region around the cluster allowing to do energy corrections. This information should be linked to the DCLU clusters.

For this the analysis described above needs to be finished and some further questions have to be answered, for example how large the region around the clusters should be, and what to do, if the regions of two neighbouring clusters overlap.

If all this works satisfactory, the raw data does not need to be stored on DST anymore. The timescale for this work is typically a few months.

4 Proposal for 1998 DST production

The analysis of the energy corrections should be followed further as discussed above. The systematic effects at $R = 25$ cm are being investigated. The behaviour of the two track finding algorithms available should be studied also for charged hadrons. For all this work the raw data is still needed.

For the immediate future we propose therefore to stay with the present version, writing only the raw data banks to DST and support the information in the DELE bank. This scheme fullfills in an optimal way the contradicting requirements:

1. Gives reliable information for standard H1 users within DELE bank. In this case no CPU time is wasted in the analysis steps.
2. Keeps complete information for further improvement of the energy correction algorithm, to work on the 25 cm problem and to run the BDCLEV algorithm to determine the electron angle precisely for low Q^2 inclusive precision studies.
3. Allows access to the full standard BDC reconstruction information by rerunning the reconstruction code as described above.

4. Keeps data volume on DST small.

5. Does not enlarge the manpower requirements by generating new service jobs.

In particular we think, that it would not be wise to put BDCLEV information to the present DELE bank since

- the improved accuracy is not really needed except for low Q^2 inclusive precision studies.
- we do not want to generate more discontinuities in the H1 analysis than necessary by introducing an intermediate DST scheme.
- the BDCLEV algorithm depends on the clustering algorithm in the SPACAL, but the clustering version used presently in ELAN for the BDCLEV studies is not identical to the clustering used for the DELE bank. This could produce unknown new systematical effects.

References

[1] B. Schwab, *Das Rückwärtskammersystem des H1 Experimentes* Dissertation Universität Heidelberg, 1996.

[2] J. Katzy, *Messung der Strukturfunktion F_2 bei kleinen Bjorken - x und kleinen Impulsüberträgen am H1 Experiment bei HERA* Dissertation Universität Heidelberg, 1997

[3] S. Glazov, Talk given in the H1 group meeting at DESY, Jan 22, 1998.

[4] R. Wallny, Talk given in the H1 data quality meeting, May 19, 1998.

[5] R. Wallny, *The 25 cm problem*, talk given in the H1 data quality meeting, Feb 3., 1998.