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UNEXPLOITED FEATURES OF THE CALORIMETER

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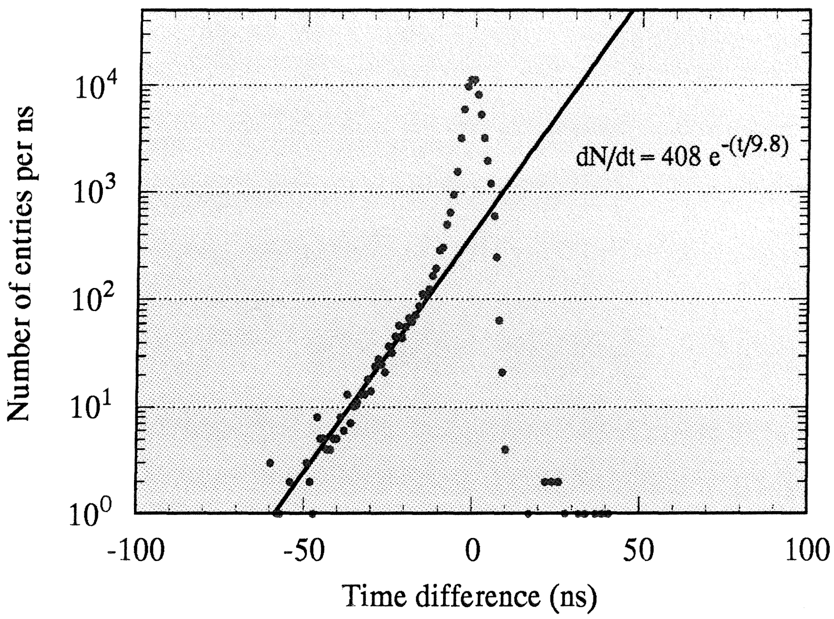


1. INTRODUCTION

The **Forward Calorimeter** of the JETSET experiment currently installed at LEAR is somewhat underexploited when it comes to the detection and analysis of the present experiment, viz. the "$\phi\phi$" study. In this note we propose that for the forthcoming series of runs a **TDC read-out** of each module be installed, the purpose of which will be to provide a powerful handle on the sign attribution of the four tracks. This should considerably benefit the $\phi\phi$ analysis by reducing the combinatorial ambiguity in the population of the effective-mass plot.

The same result can, of course, be achieved with a magnet. What we propose should cost in the region of 30 to 50 KSF: it surely beats the cost of a magnet any time !

In what follows we shall present simple arguments supporting our proposal. It is hoped that a better justification will come from test-beam studies which we plan to perform in the near future.

2. MOTIVATION

The four tracks of the events selected by our trigger conditions are supposed to be kaons, two of each sign. Their momenta are in the region of a few hundred MeV/c. The range of most of them should be contained inside the calorimeter. The positive kaons, as is their wont, will mainly stop and decay whereas the negative kaons will mainly interact. The stopping process occurs very quickly; the decay process takes place more leisurely with an exponential distribution corresponding to the 12.4 ns lifetime of the charged kaons. As a result we can expect that those tracks which are accompanied by **delayed signals** in the calorimeter will be positive. If two such tracks can be identified in an event then we will not plot the corresponding effective-mass of these two, thus reducing the number of entries in the mass plot from 3 to 2. The fraction of events where this will be possible depends of course on the detailed calorimeter configuration, on the specific momentum distributions of the kaons and on the timing accuracies of the proposed TDC system. We are not yet in a position to give a reliable estimate of this fraction. Notice also that the detection of the decay will turn out to be quite valuable in the identification of ambiguous events (and we have quite a few of these at the moment ...).

More specifically, the calorimeter modules are 20 cm long, with an average effective density of 4.58 g cm^{-3} [1]. This corresponds to a total range of 91.6 g cm^{-2} which should be sufficient to stop kaons up to 500 MeV/c (using the range-energy relation valid for lead). The decay product (two thirds of the time a 236 MeV/c muon with an approximate 22 cm range in the calorimeter) has a good chance of entering one of the adjacent modules thus generating the tell-tale delayed signal.

Notice that this same signal will also occur in the same module where the track stops. An elegant way to deal with this delayed signal would be to introduce a wave-form analyser with a resolution in the nanosecond range on each of the ≈ 300 modules of the calorimeter so as to detect both signals from the same photomultiplier (but this may well be outside the financial capabilities of our collaboration).

The method we advocate at the moment is simply to examine (off-line) all the modules adjacent to the one where the track-reconstruction points as entry module and make a simple time difference of the signals between them. The decay should be noticeable at the level of the precision of the element-to-element relative calibration. Notice that — if one so wishes — it is also possible to envisage a more sophisticated procedure (based for instance on the presently inert *transputers*) to select at the trigger level the events with signed decays.

3. BARREL GAMMA-VETO RESULTS

Barring beam tests with the Forward Calorimeter modules, which in any case cannot be made before the restart of the accelerators in April, the above arguments would remain at the conjectural stage were it not for the existence of a providential TDC system already present on the elements of the Barrel Gamma Veto. The configuration of these elements is not as advantageous as that of the Forward Calorimeter elements; still they can be used as a real-life testing ground of our hypotheses. We have analysed these data and have found convincing evidence for the validity of our proposal. The story goes as follows.

For reasons of convenience we have used the data from the July 1991 runs at the following momenta: 1.2, 1.3, 1.4, 1.5, 1.6 and 1.8 GeV/c. For these momenta we have looked into the collection of *"1-barrel 3-forward"* triggers selected as the first-level data for the study of ref. [2]. The selection consisted of having made sure that tracks existed in the barrel and forward tracker and their number was within the allowed range. No 4K-event reconstruction was requested and no criteria imposed on the Cherenkov and Silicon conditions. Notice however that a loose restriction had already been made at an earlier stage over the total number of elements hit in the Gamma Veto and in the Julich Scintillator Barrel; this selection was deemed not to affect the four-kaon identification; in practice it may well be the cause for the removal of some of the events we are looking for (in particular those that we don't find among the adjacent hits — see below).

In any case we can safely assume that an undetermined, but not negligible, fraction of kaons should be present among these events. We realise that the best way of dealing with this approach would have been to look into the final collection of well identified four-kaon events. But (a) this collection is quite small and the effects searched for may not be so visible and (b) this operation would have required a much larger effort from our side in data collection and analysis which we did not feel like doing at this moment[1].

3.1 Time equalisation of the modules

In order to make sense of the time information from the barrel elements we must first equalise the TDC scales of all the modules. Not knowing of a better way (unknown cable lengths, unknown inner TDC delay, etc..) we did this iteratively by producing time spectra for each module, determining its average and then using it to correct the next step.

It should be stressed that these results are somewhat approximative but precise enough to detect a gross effect and this is what we wanted. Notice for example that we have not made use of the individual pipe-scintillators delays which enter the time spread of the observed signals; this can and should be done in the future if one wants to improve the level of precision that can be reached in the type of analysis proposed here. The numbers in Table 1 and the plots in figs 1 to 24 show the results of the time equalisation for each module.

Table 1

Delay settings (calculated at 1.3 GeV/c)
used at all momenta in this analysis[2]

module (no.)	delay (channels)	module (no.)	delay (channels)
1	1290	13	1225
2	870	14	750
3	1265	15	1230
4	780	16	730
5	1280	17	1140
6	815	18	590
7	1190	19	1130
8	800	20	560
9	1240	21	1050
10	710	22	545
11	1235	23	1055
12	740	24	560

[1] We encourage people to attempt this analysis using their own samples of four-kaon reactions and to let us know of their observations.

[2] Please notice that these parameters seem to vary somewhat with time and run number. The variation is not very large and — mostly for simplifying our task — we have ignored it. For any further more reliable study it is recommended that this variation be taken into account.

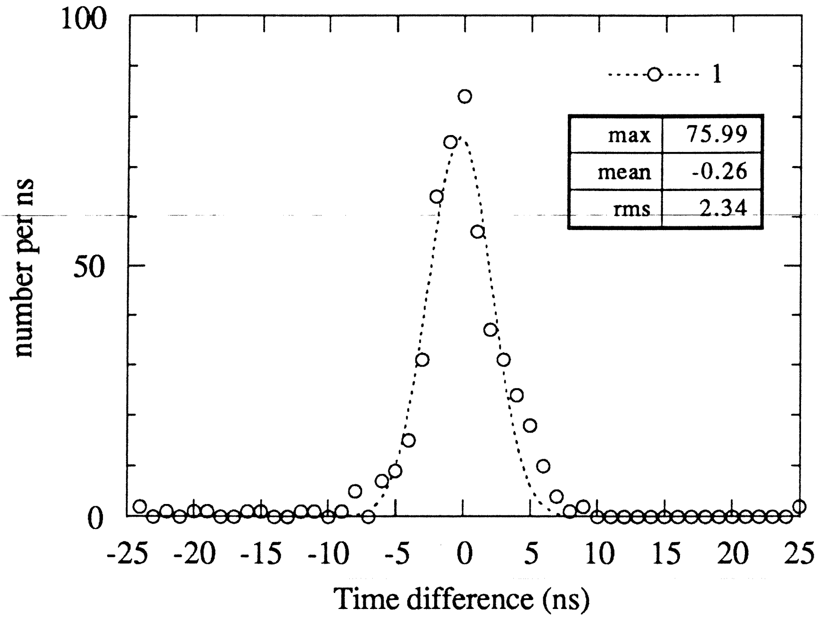


Fig. 1 Time distribution in module number 1 after delay correction (at 1.3 GeV/c)

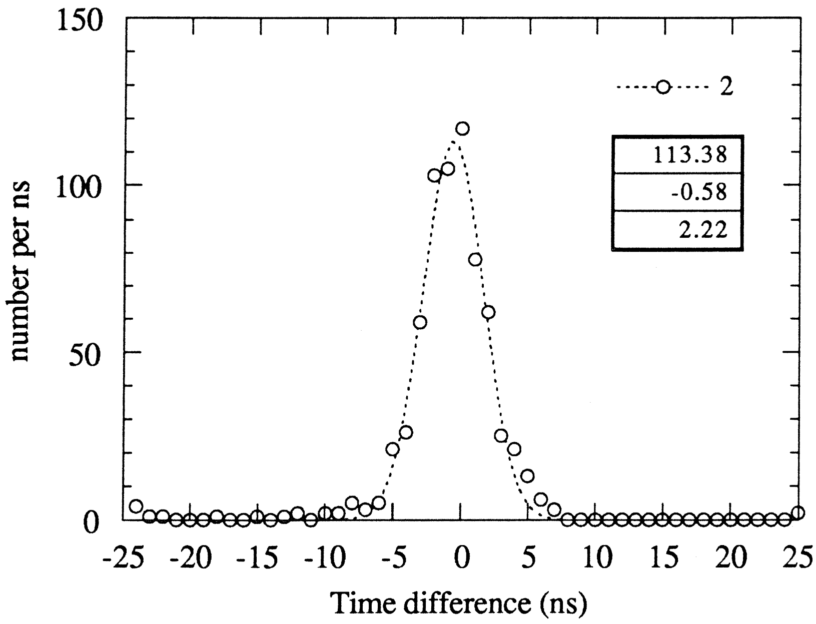


Fig. 2 Time distribution in module number 2 after delay correction (at 1.3 GeV/c)

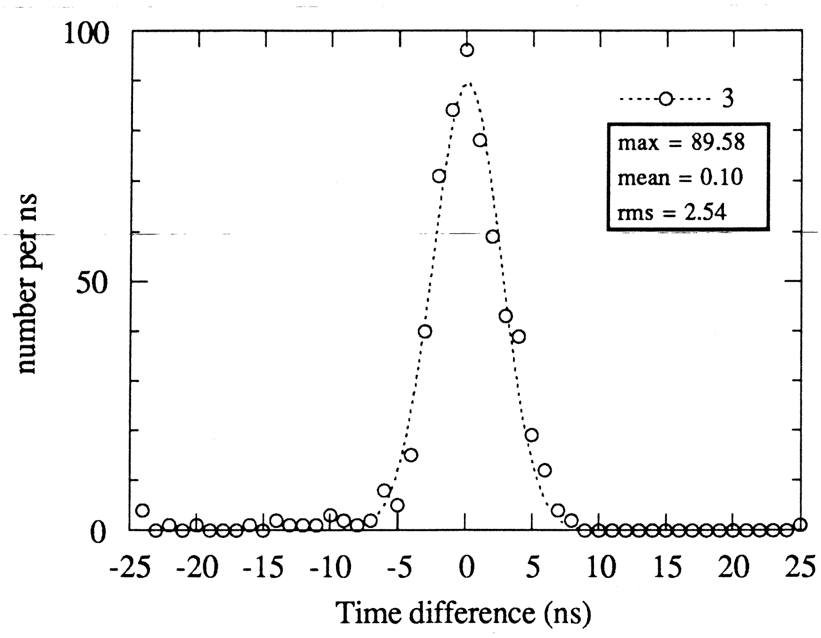


Fig. 3 Time distribution in module number 3 after delay correction (at 1.3 GeV/c)

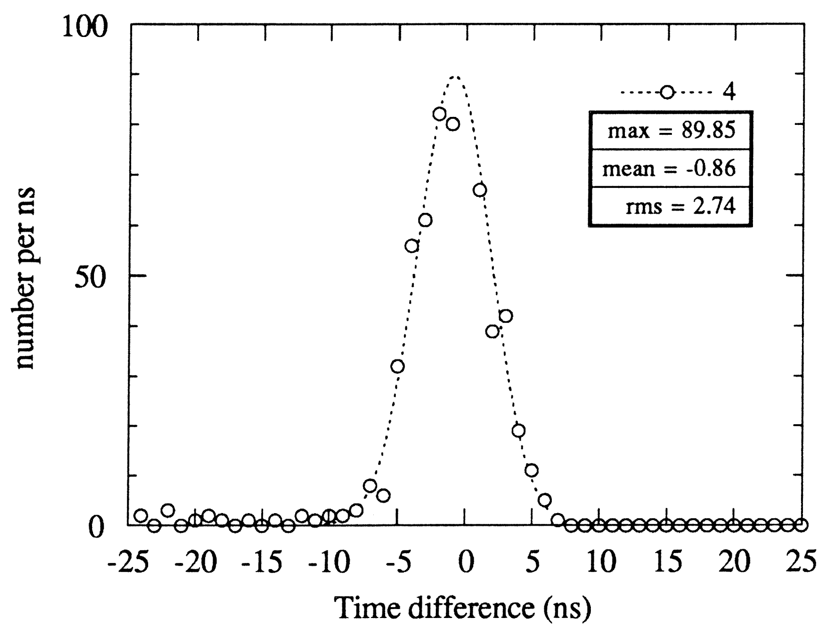


Fig. 4 Time distribution in module number 4 after delay correction (at 1.3 GeV/c)

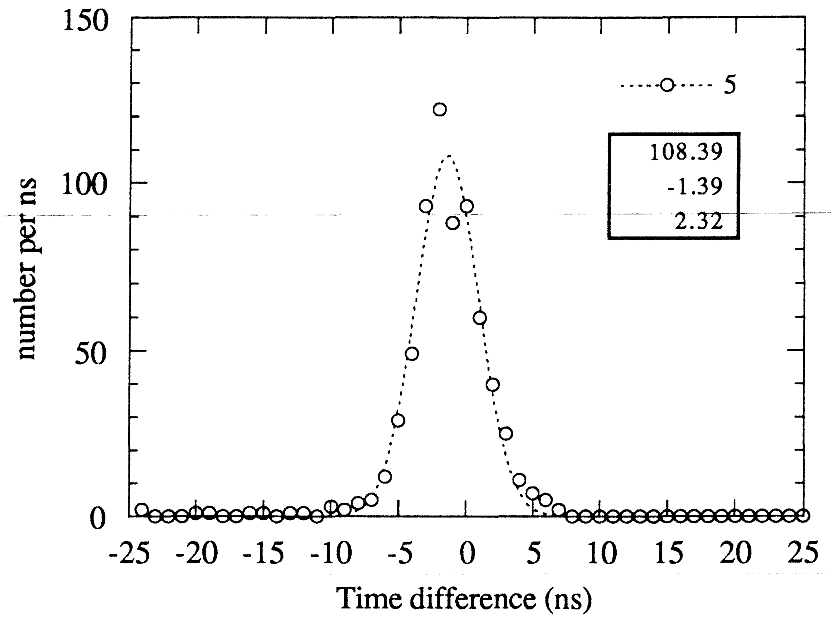


Fig. 5 Time distribution in module number 5 after delay correction (at 1.3 GeV/c)

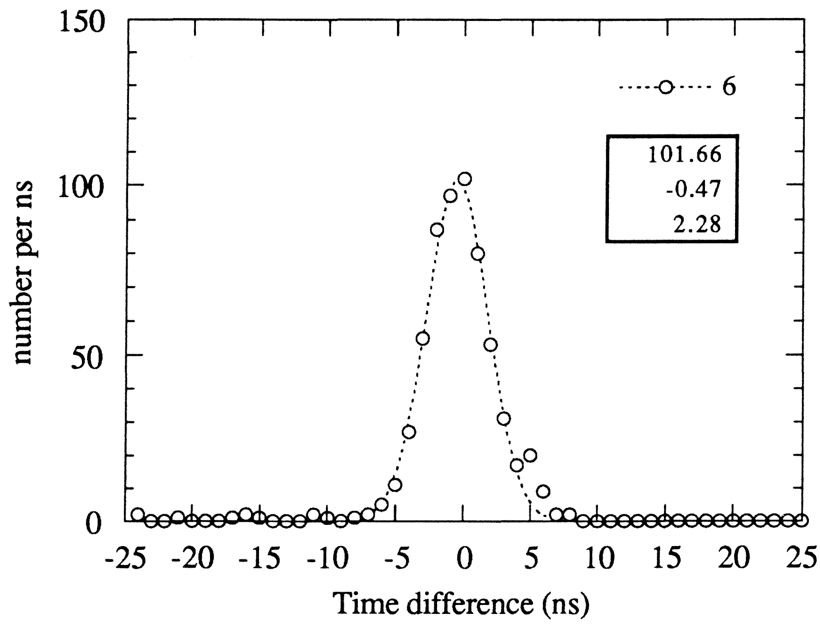


Fig. 6 Time distribution in module number 6 after delay correction (at 1.3 GeV/c)

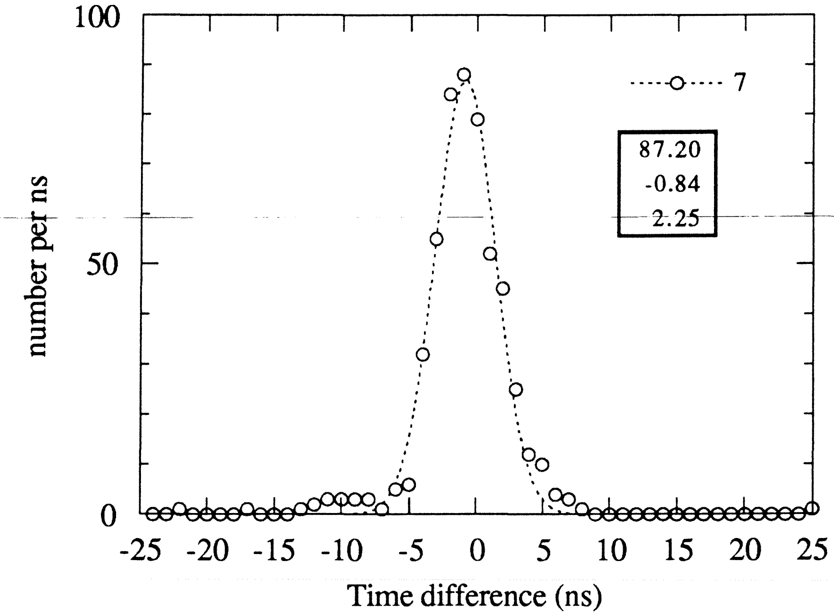


Fig. 7 Time distribution in module number 7 after delay correction (at 1.3 GeV/c)

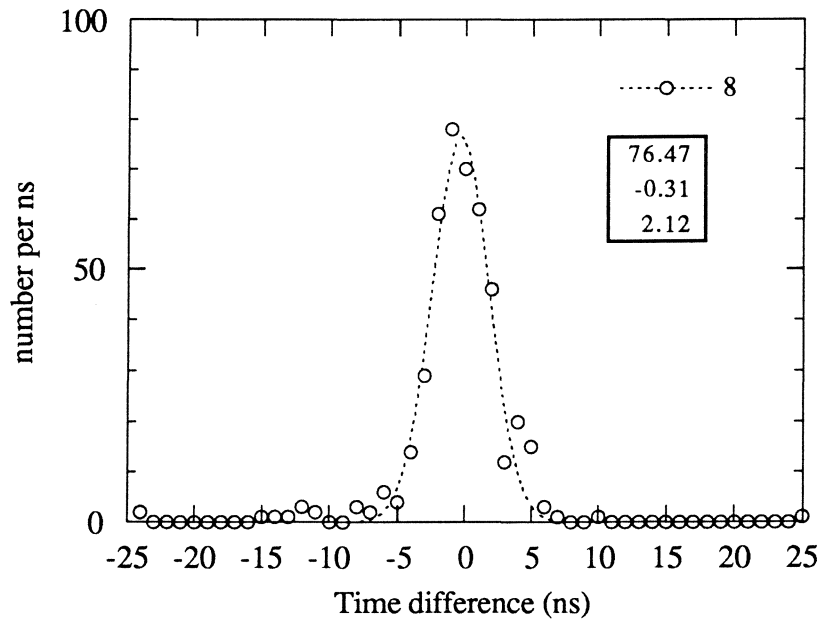


Fig. 8 Time distribution in module number 8 after delay correction (at 1.3 GeV/c)

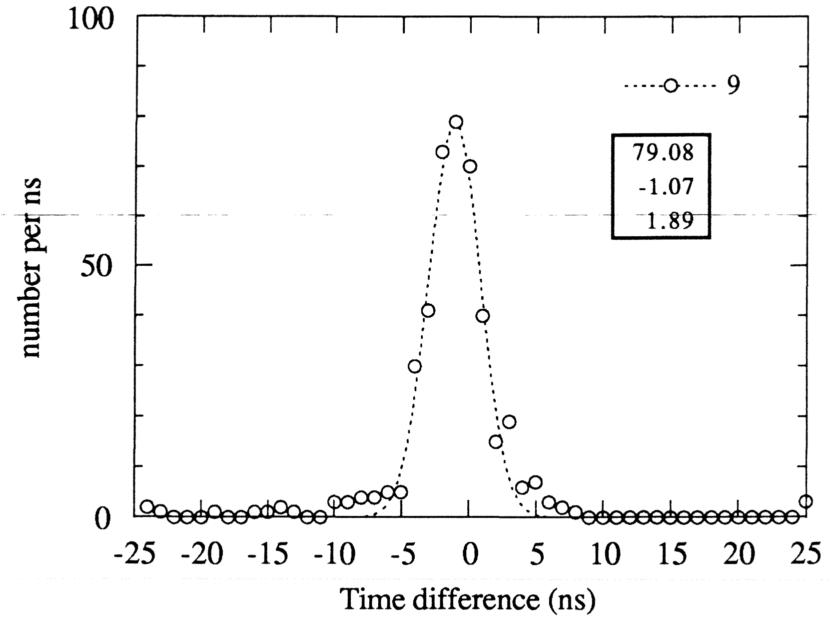


Fig. 9 Time distribution in module number 9 after delay correction (at 1.3 GeV/c)

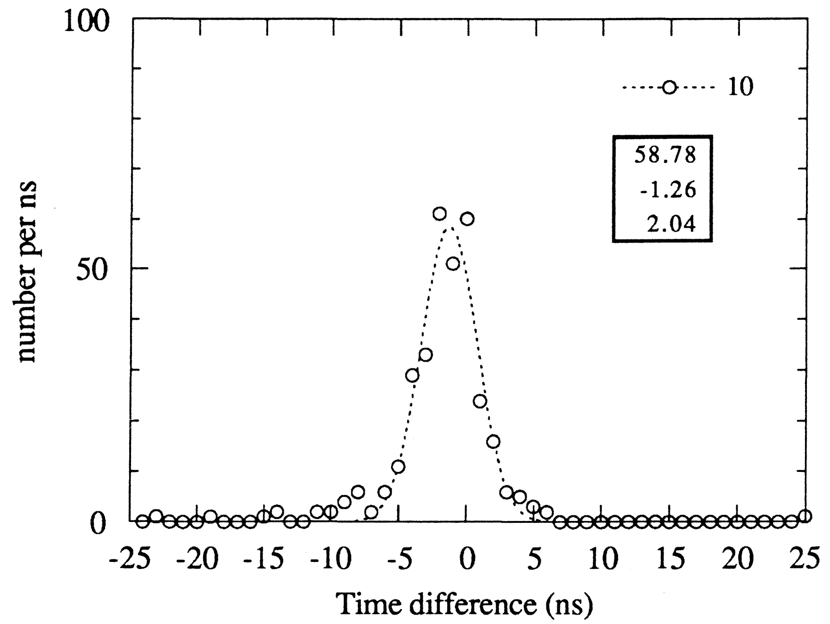


Fig. 10 Time distribution in module number 10 after delay correction (at 1.3 GeV/c)

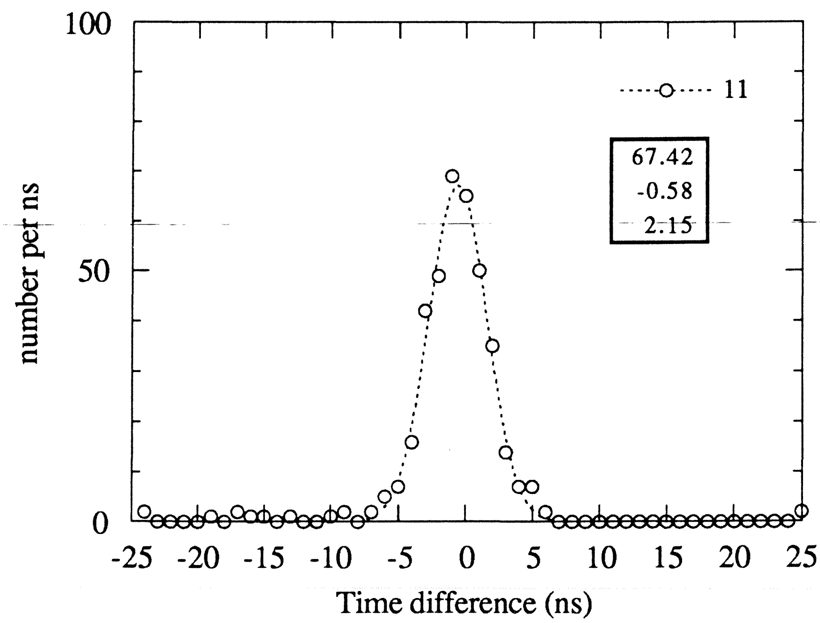


Fig. 11 Time distribution in module number 11 after delay correction (at 1.3 GeV/c)

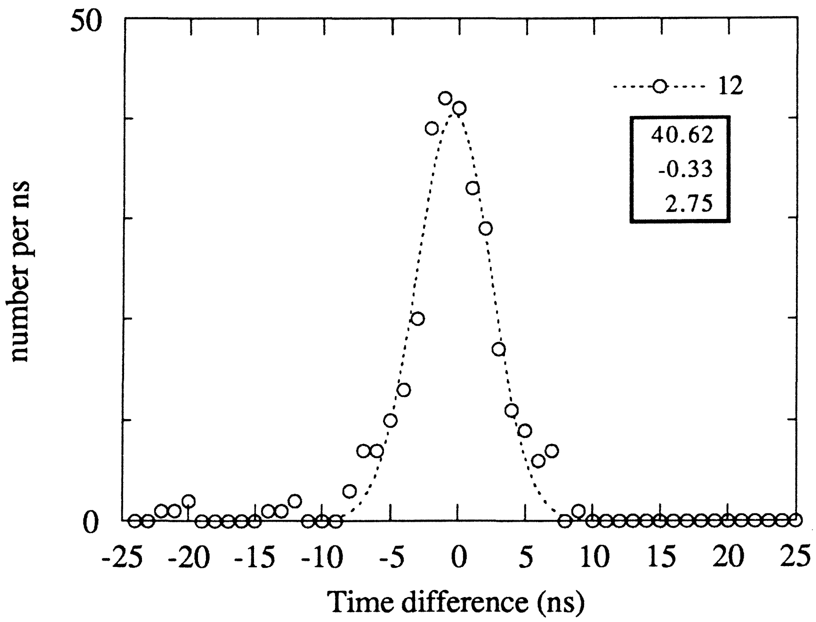


Fig. 12 Time distribution in module number 12 after delay correction (at 1.3 GeV/c)

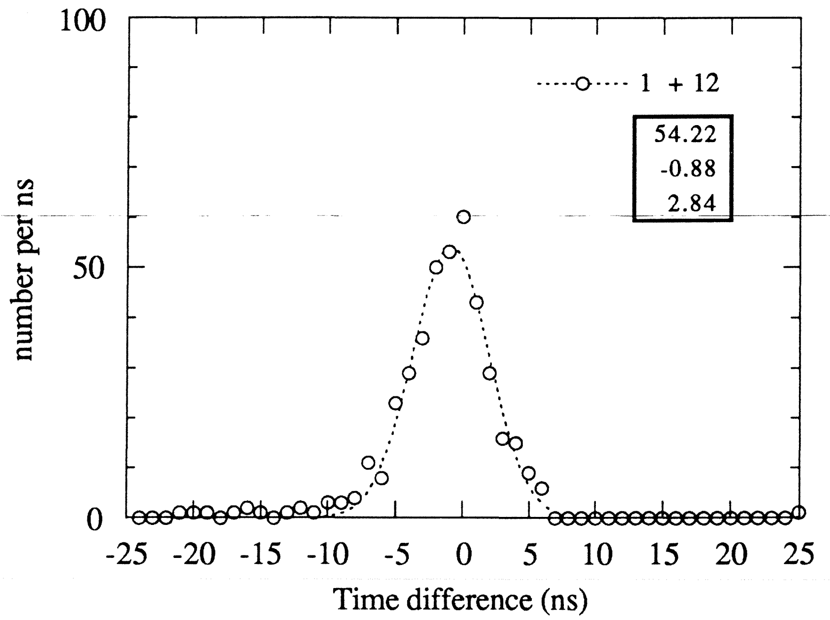


Fig. 13 Time distribution in module number 13 after delay correction (at 1.3 GeV/c)

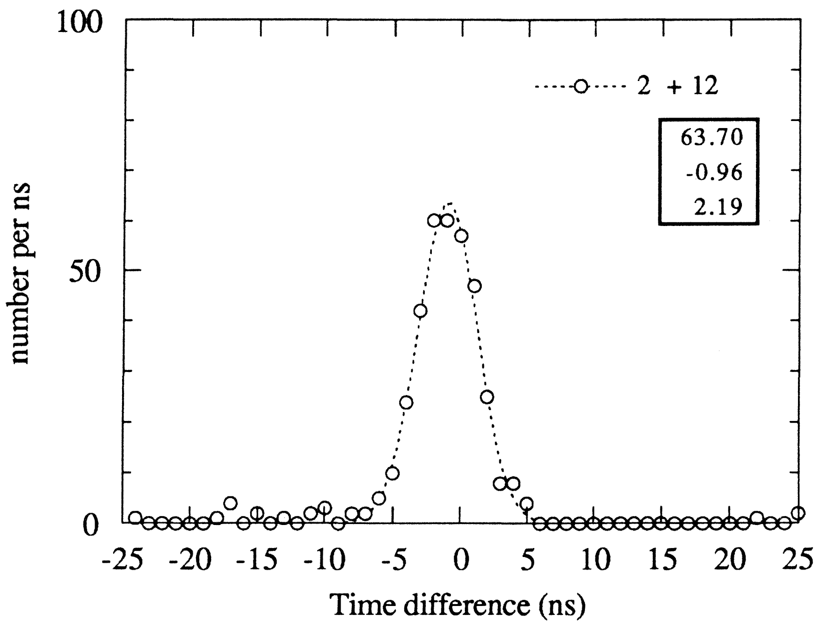


Fig. 14 Time distribution in module number 14 after delay correction (at 1.3 GeV/c)

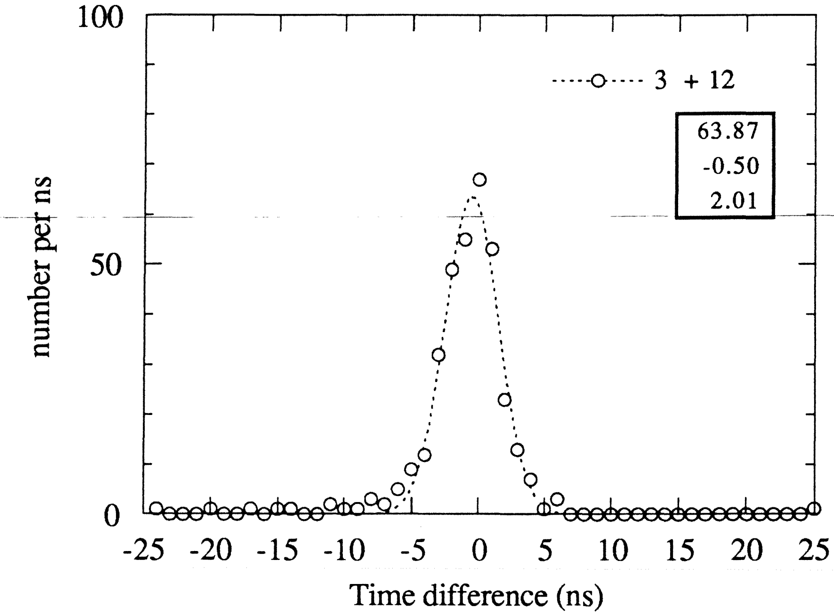


Fig. 15 Time distribution in module number 15 after delay correction (at 1.3 GeV/c)

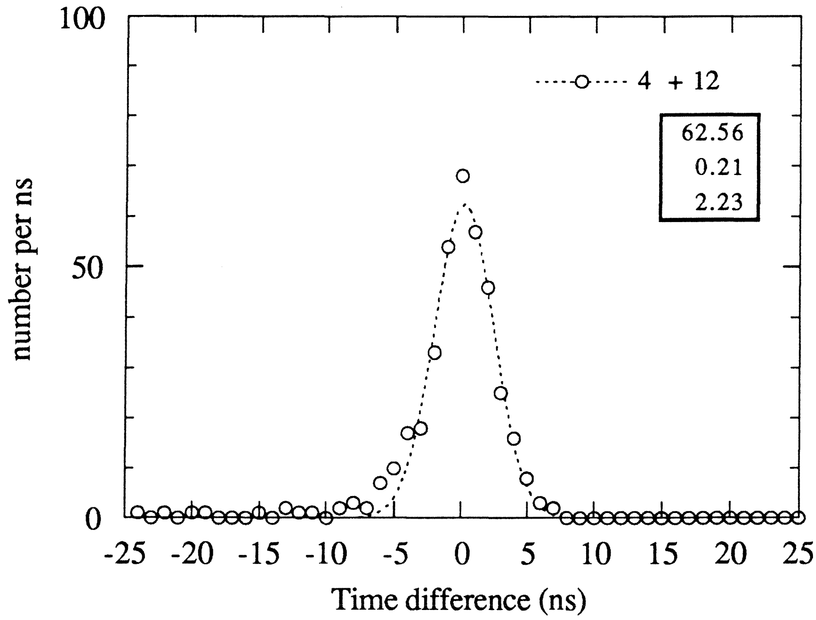


Fig. 16 Time distribution in module number 16 after delay correction (at 1.3 GeV/c)

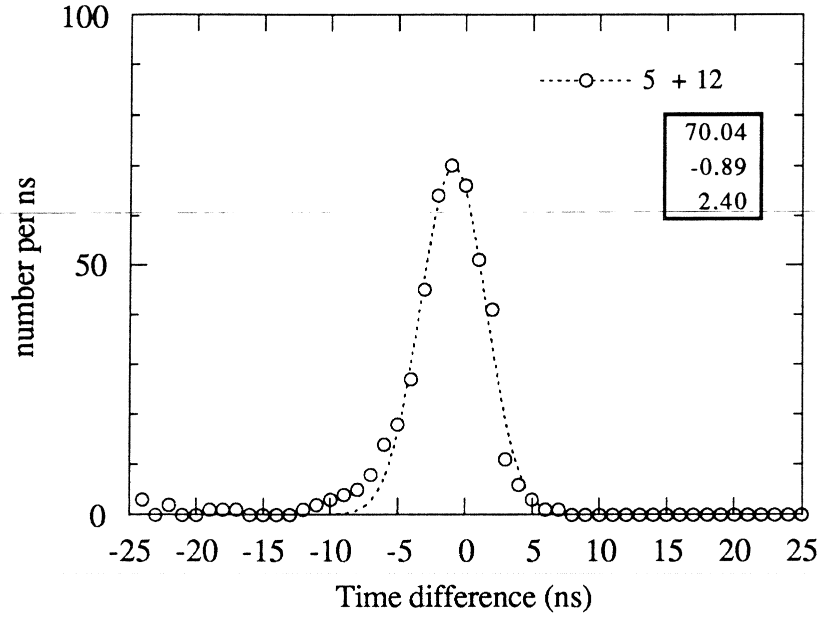


Fig. 17 Time distribution in module number 17 after delay correction (at 1.3 GeV/c)

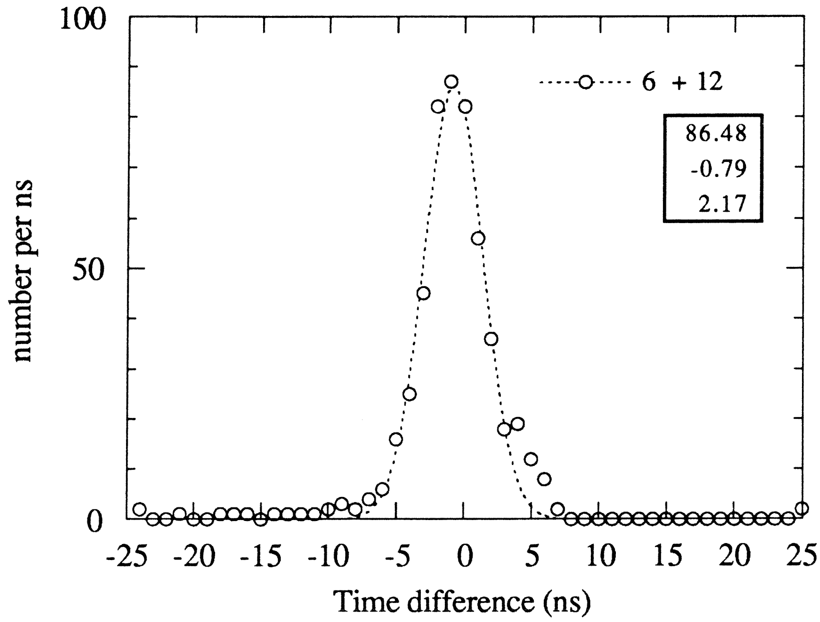


Fig. 18 Time distribution in module number 18 after delay correction (at 1.3 GeV/c)

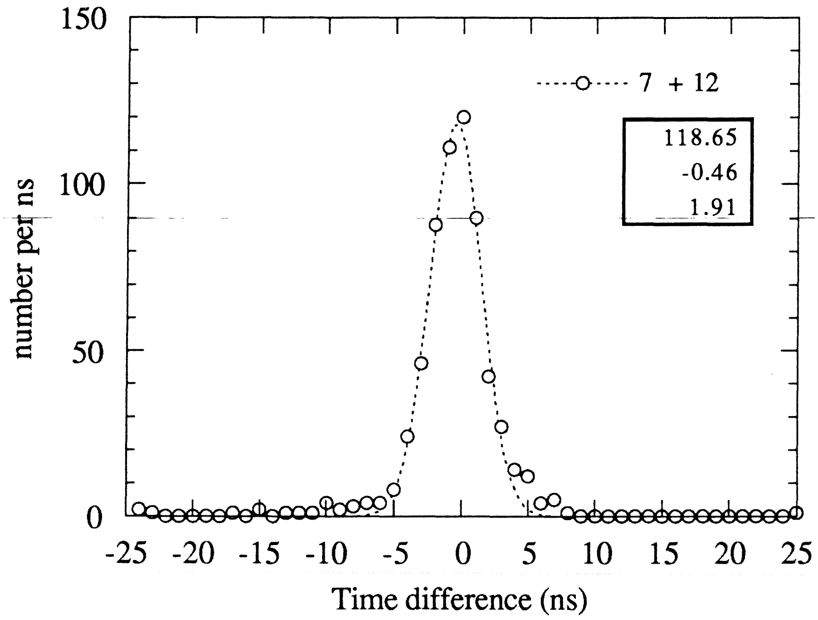


Fig. 19 Time distribution in module number 19 after delay correction (at 1.3 GeV/c)

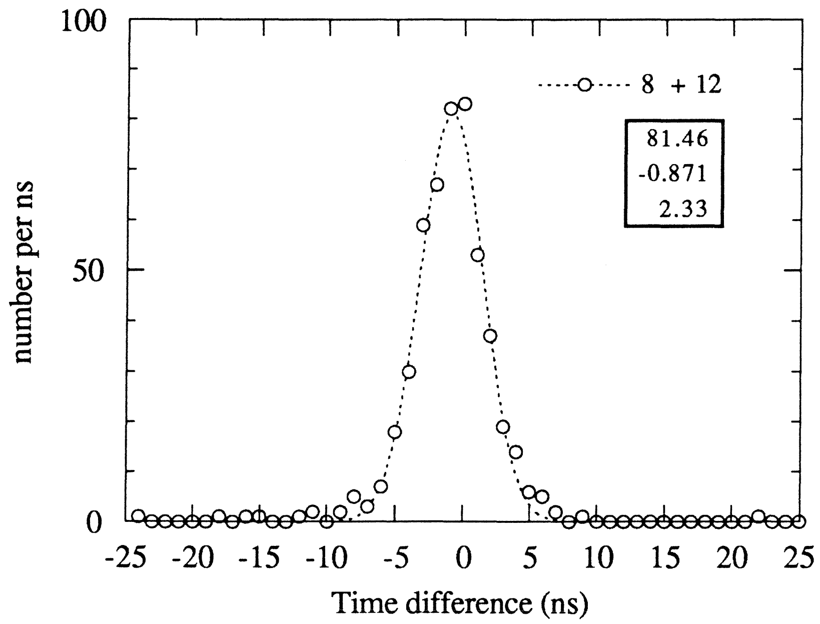


Fig. 20 Time distribution in module number 20 after delay correction (at 1.3 GeV/c)

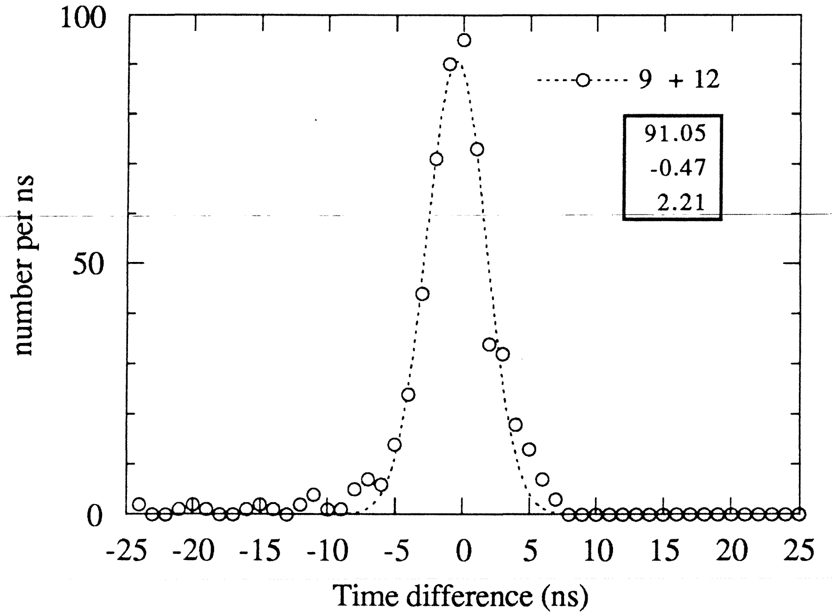


Fig. 21 Time distribution in module number 21 after delay correction (at 1.3 GeV/c)

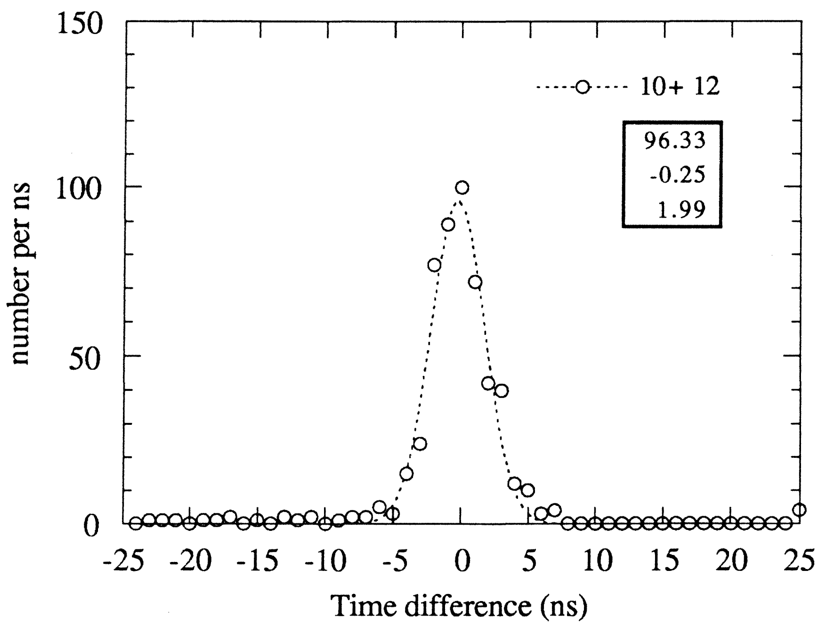


Fig. 22 Time distribution in module number 22 after delay correction (at 1.3 GeV/c)

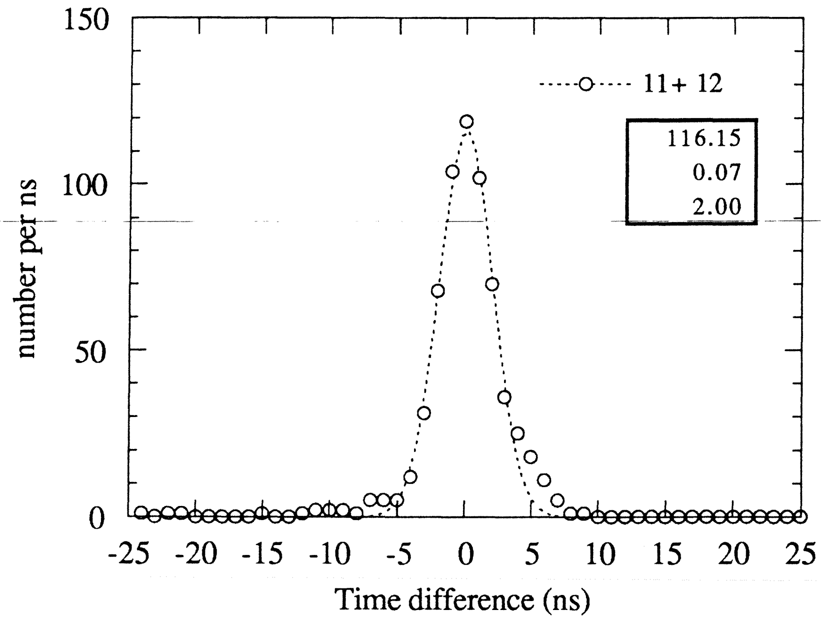


Fig. 23 Time distribution in module number 23 after delay correction (at 1.3 GeV/c)

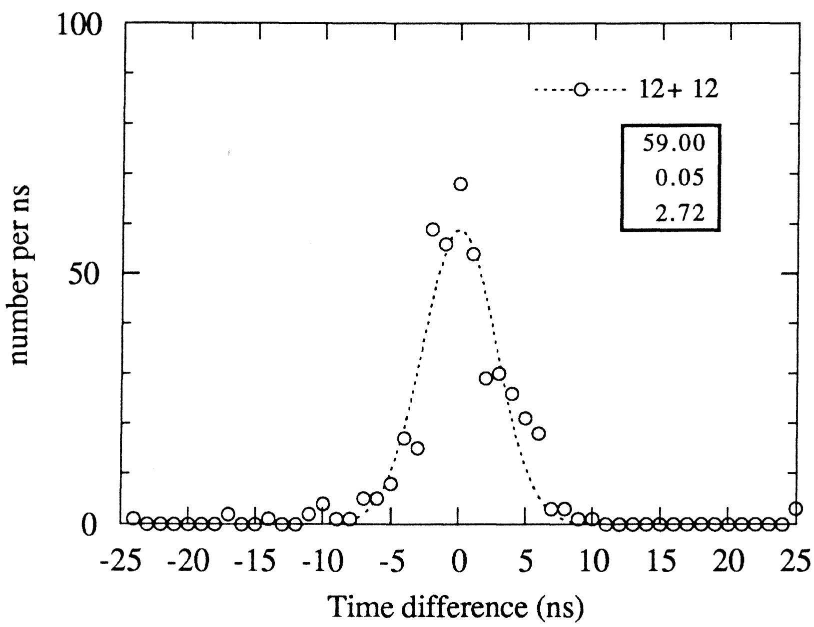


Fig. 24 Time distribution in module number 24 after delay correction (at 1.3 GeV/c)

3.2 Evidence for decays

Having calibrated the TDC scales we then measured the time spreads observed at each momentum irrelevant of the module and the hit-multiplicity of the event. As far as the latter is concerned the great majority of hit-multiplicities is between 1 and 2. Fig. 25 shows these distributions for the momenta used in the analysis.

The TDC spectra integrated over all modules are shown separately for each momentum setting in figs 26 to 31. On the same figures we have also plotted the spectra of the adjacent modules and of those events having a total of two hits. We do not find much difference between these three types of spectra. We have not understood why. Perhaps the reason for this similarity between the three selected configurations has to do with the cuts done on the raw data of the first reduction stage. Suppose in fact that for one reason or another our sample had been deliberately depopulated of events with <u>three</u> contiguous hits. Then our *adjacent-hits* population would be a distorted subsample of a larger set containing the true stop-and-decay events. This and similar arguments can be invented *ad libitum* and we leave the solution to this question to a future better study.

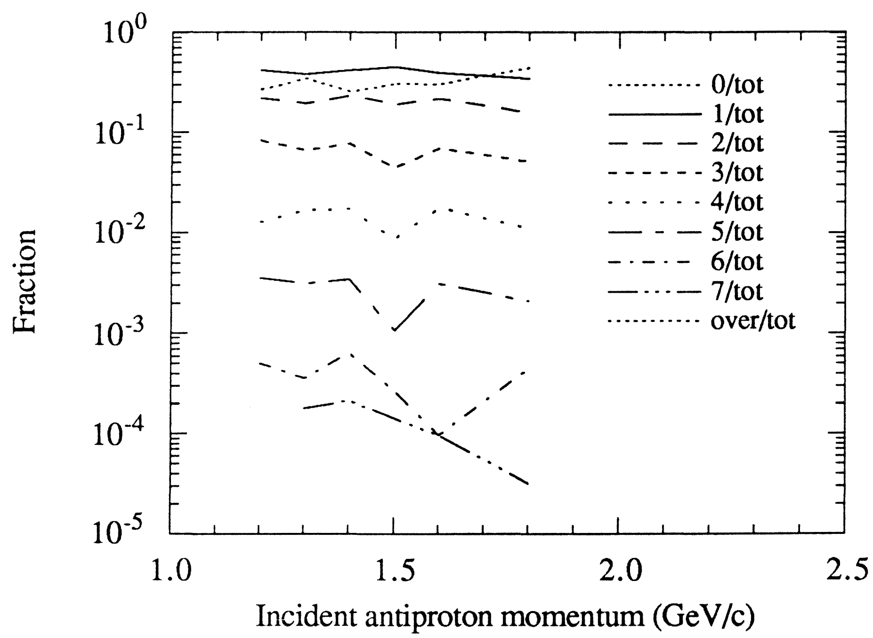


Fig. 25 Hit multiplicity of the barrel elements as a function of the incident momentum.

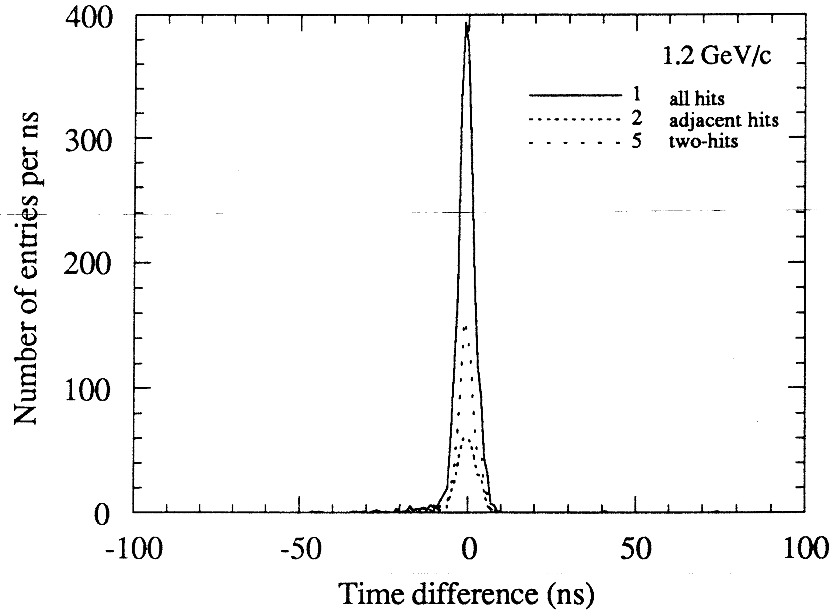


Fig. 26 Time spectrum of all hits at 1.2 GeV/c

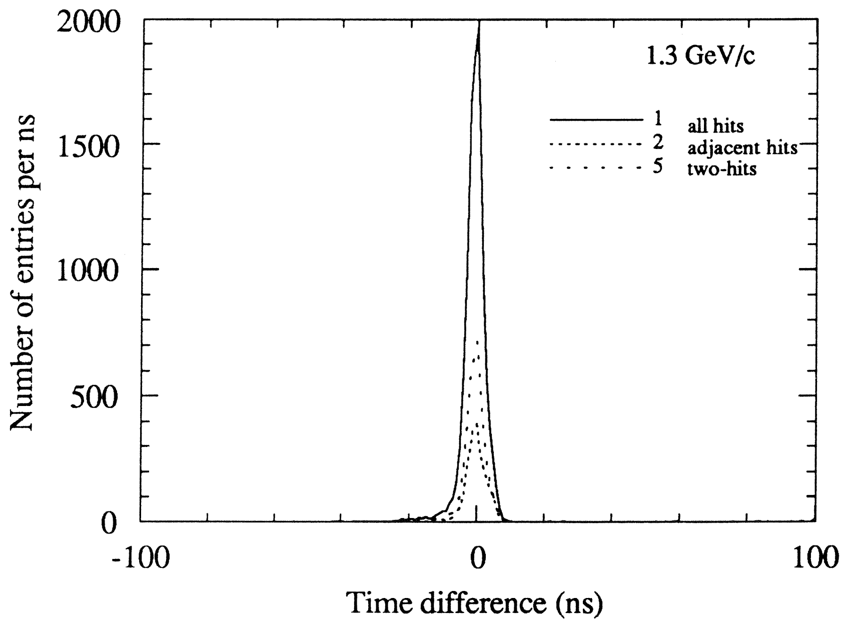


Fig. 27 Time spectrum of all hits at 1.3 GeV/c

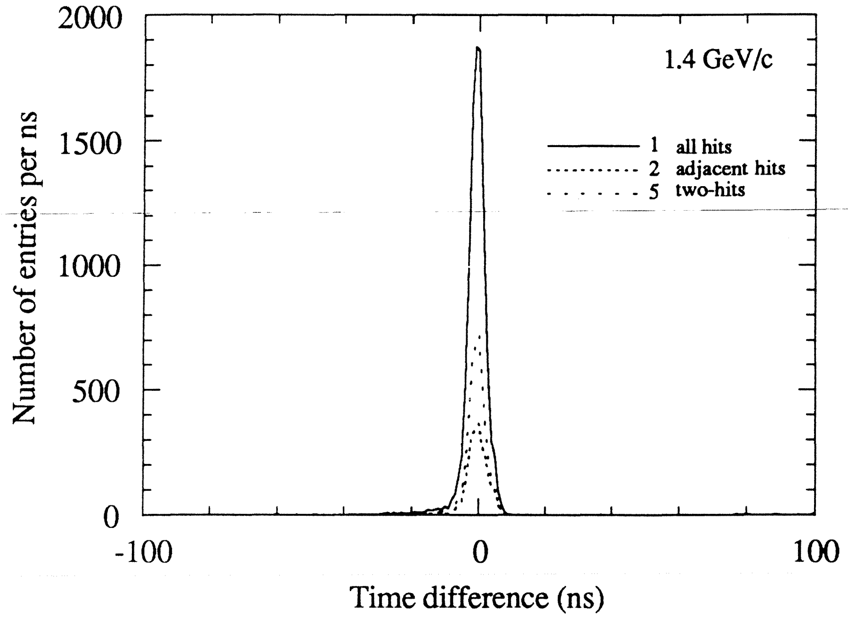


Fig. 28 Time spectrum of all hits at 1.4 GeV/c

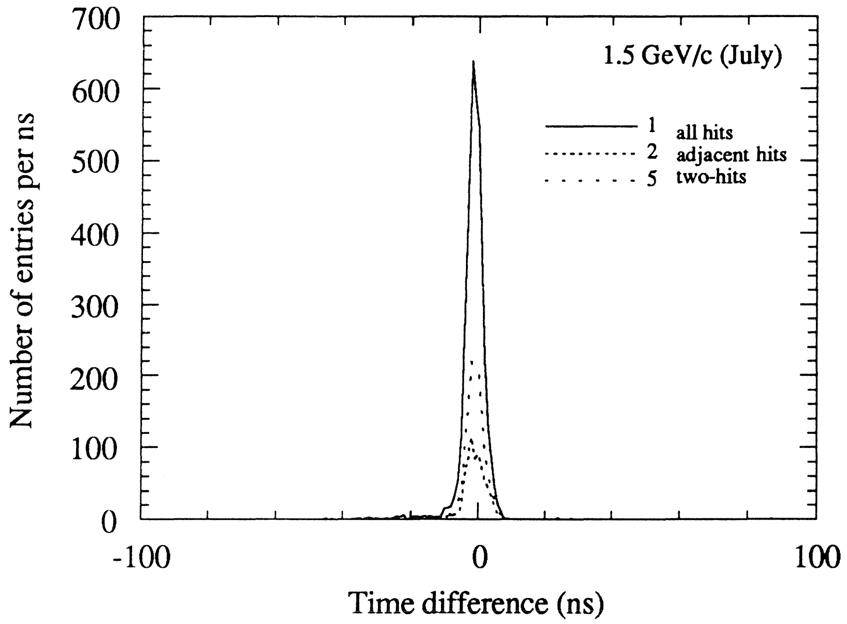


Fig. 29 Time spectrum of all hits at 1.5 GeV/c (July runs)

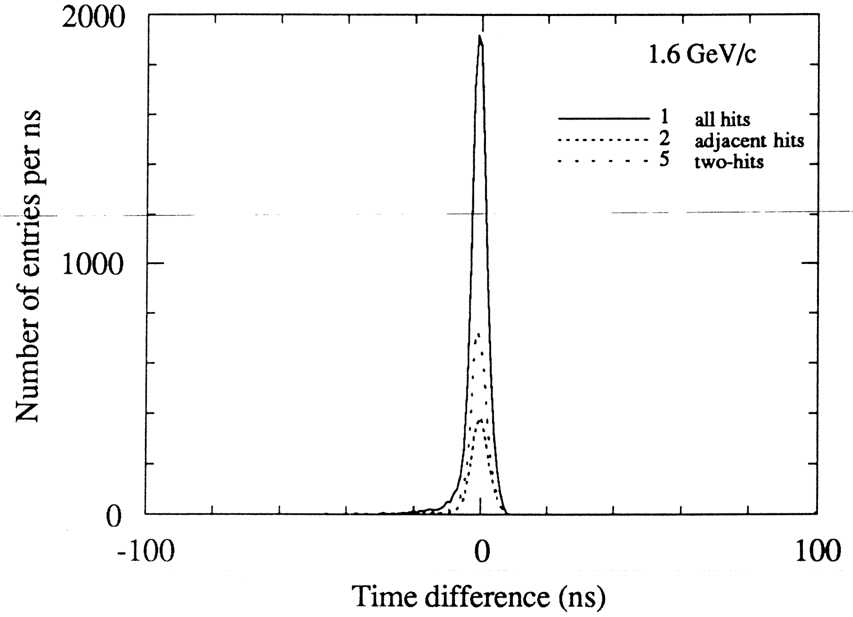


Fig. 30 Time spectrum of all hits at 1.6 GeV/c

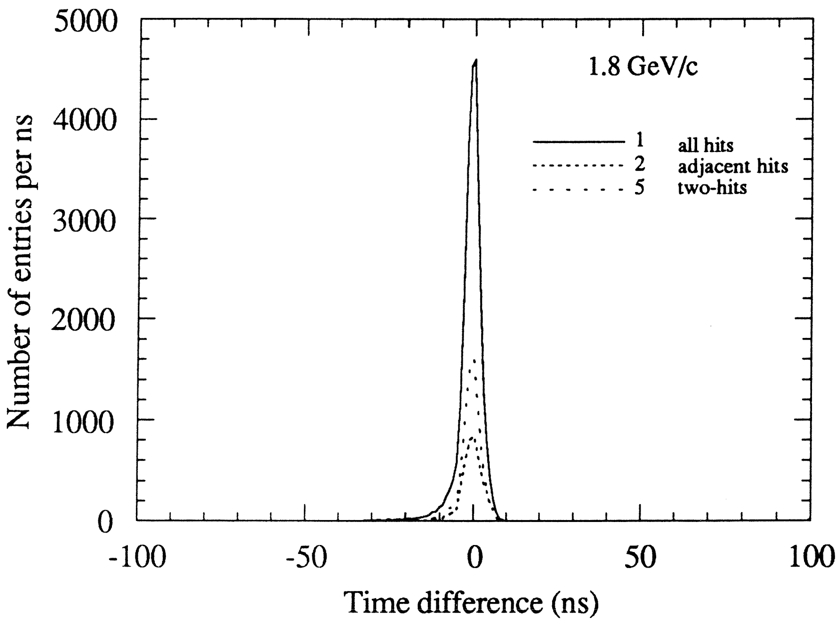


Fig. 31 Time spectrum of all hits at 1.8 GeV/c

The spectra of the above figures are all very similar to each other. Therefore we felt justified to add them up to produce the combined plot of fig. 32. The slight skewness already noticeable in the separate spectra is now clearly observable as a tail on the negative side of the time scale. With our TDC running convention (time is stopped when the signal arrives) the signals on the negative side mean signals arriving late, hence possible decays.

If we observe more carefully this spectrum (figs 33 and 34) it becomes apparent that the shape in this region is strongly reminiscent of an exponential decay. In fig. 35 we have fitted the time region between -10 and -50 ns and find that it agrees with a decay lifetime equal to 9.8 ns. This is not quite the 12.4 ns expected for the charged kaon but is close enough to support our conjecture that we are indeed in the presence of kaon-decays. Notice that we have not made any background subtraction (this would lower the spectrum at small values of time more than at high values hence increasing the lifetime) nor have we bothered to accurately align the component spectra (the superposition of spectra horizontally shifted in the appropriate direction may also distort the lifetime). The figure on the frontispiece shows the spectrum over the full time-scale together with the result of our fit. The K-decays seem to represent a fraction of $\approx 4\%$ of the peak.

A very simplistic consideration that can be done on this observed rate is the following. Let us assume that the acceptance of the barrel system for a kaon to stop in one module and emit its decay product into another module is somewhere in the region of 50% (take the middle of each element thickness as the stopping point and look at the solid angle covered by the other elements whether they are contiguous or further along the ring circumference). With this value of the acceptance we then expect $\approx 8\%$ of the incoming tracks to be positive kaons. If we also assume that for each positive kaon there should be a negative one (no reason to emit positive rather than negative particles in the barrel), this means that in fact about 16% of the incoming tracks were kaons. Compare this figure with the data in the table "*Analysis accounting*" of ref. [2]: the ratio of the columns "output 3 (1B3F)" to "output 1" for the momenta examined in the present report is 9%. We find twice that, which is surprisingly close particularly if one remembers that the 1B3F part of the analysis of ref. [1] is now known to have been particularly inefficient.

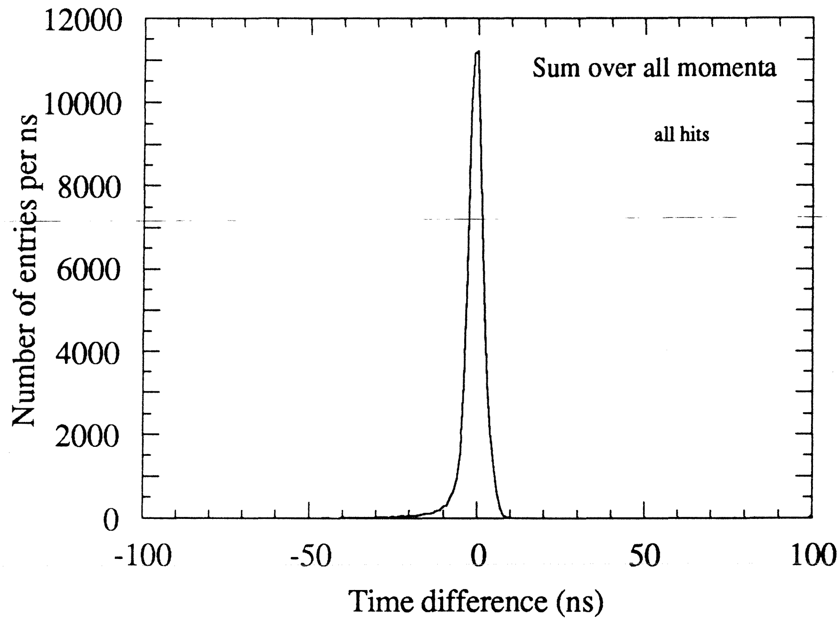


Fig. 32 Time spectrum of all hits summed over all momenta

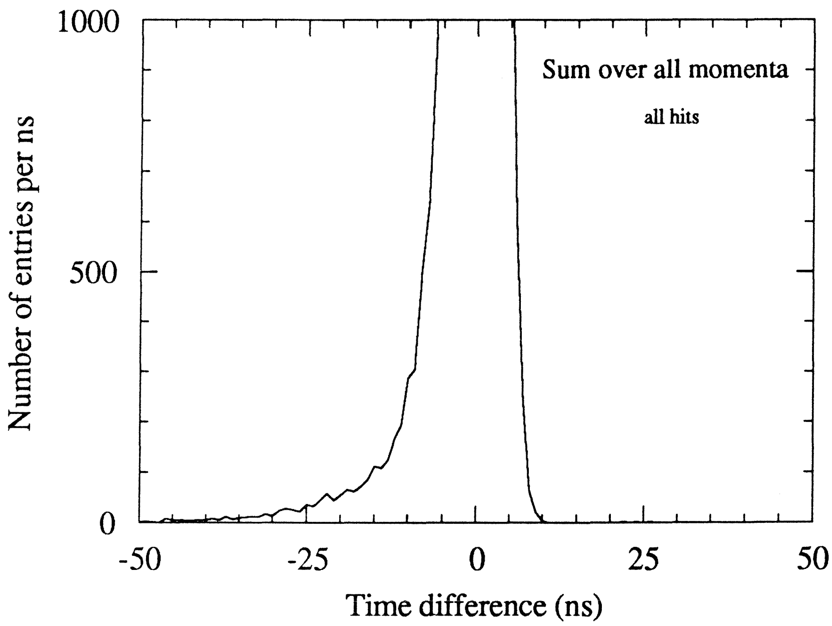


Fig. 33 Detail of the combined spectrum in fig. 32

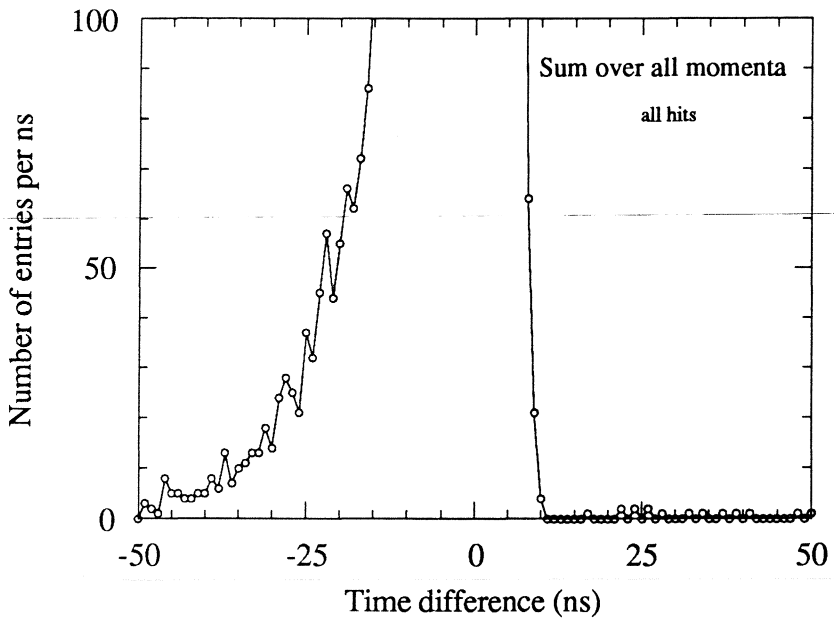


Fig. 34 Further details of the spectrum in fig. 32

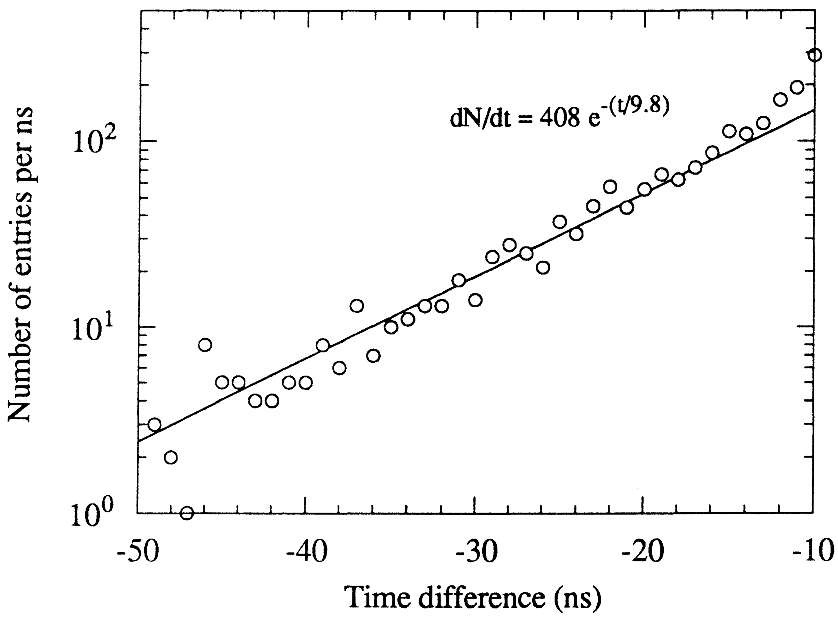


Fig. 35 Exponential fit of the spectrum in fig. 32 in the region between - 10 and - 50 ns

Finally a word of caution. Here again (as in our analysis of the "Forward Silicon") we are walking on thin ice: we have again analysed data from a detector for which we have not been directly responsible and with which we are not familiar at all. It may well be that we have been naive or utterly wrong in some or all of our assumptions. On the other hand we are not aware of a similar analysis on these data performed by anybody else in the Collaboration. Our considerations may turn out to be useful for those who haven't thought about the subject.

Please let us know of possible omissions, mistakes or misconceptions.

APPENDIX 1

Following our customary candid approach we offer herewith the listing of the routines used for this study. They are simple and straightforward. They are given, once again, for checking purposes and to encourage external usage. Of course there is a lot going on behind them; they are incorporated as usual in the much more complex framework of our "Display" program. See the appendix of ref. [2] for some of the listings.

The computer system was the one running on our Macintosh IIci and Macintosh fx machines. The computing time in this case was very small (a few hours).

```
      options mix=off ! on
      Public UserStart,User,UserSpit
      Include '*F:Source:CDE1.For'
      common/locUser/hisTDC(24,50),hisADC(24,50)
     *,    hisTDC_tot(200),hisTDC_adj_tot(200),hisADC_tot(200),hisADC_adj_tot(200)
     *,    TDC_delay(24),Nb_multihits(10),hisTDC_twohits(200),hisTDC_adj_dif(200)
     *,    MaxFile
      integer*4 hisTDC,hisADC,hisTDC_tot,hisTDC_adj_tot,hisADC_tot,hisADC_adj_tot
     *,    TDC_delay,hisTDC_twohits,hisTDC_adj_dif
      data TDC_delay/1290, 870, 1265, 780, 1280, 815, 1190, 800, 1240, 710, 1235, 740
     *,          1225, 750, 1230, 730, 1140, 590, 1130, 560, 1050, 545, 1055, 560/
c___________________________________________________________________________
      subroutine UserStart
      call vzero(hisTDC,24*50)
      call vzero(hisADC,24*50)
      call vzero(hisTDC_tot,200)
      call vzero(hisTDC_adj_tot,200)
      call vzero(hisADC_tot,200)
      call vzero(hisADC_adj_tot,200)
      call vzero(Nb_multihits,10)
      call vzero(hisTDC_twohits,200)
      call vzero(hisTDC_adj_dif,200)
      call SelectDlg
c      call PrintSelectParam  ! print conditions
      print '(1x,'TDC delays (channels) =',2(/,20x,12i6))',TDC_delay
      MaxFile = 31 ; open(MaxFile,file='',access='Write')
         write(MaxFile,'(1x,'bin',1x,'1',1x,'2',1x,'3',1x,'4',1x,'5'
     *     ,1x,'6',1x,'7',1x,'8',1x,'9',1x,'10',1x,'11',1x,'12')')

      END
c___________________________________________________________________________
      subroutine User
c     plot TDC in 1-ns bins (1 channel = 50 ps)
      if(NbBarGamVetoTDC.le.9)
     * Nb_multihits(NbBarGamVetoTDC+1)=Nb_multihits(NbBarGamVetoTDC+1)+1
      if(NbBarGamVetoTDC.eq.0)return
      ilast=-999
      do i=1,24
         j=BarGamVetoTDC(i)-TDC_delay(i) ; jj=BarGamVetoADC(i)
         if(BarGamVetoTDC(i).gt.0) then

c            50 bins: from -25 to +25 ns in steps of 1 ns
            ibin=(0.05*j)+25.0 ; if(ibin.le.0)ibin=1; if(ibin.gt.50)ibin=50
            hisTDC(i,ibin)=hisTDC(i,ibin)+1

c            200 bins: from -100 to +100 ns in steps of 1 ns
            ibin=(0.05*j)+100.0 ; if(ibin.le.0)ibin=1; if(ibin.gt.200)ibin=200
            hisTDC_tot(ibin)=hisTDC_tot(ibin)+1

c            50 bins: from 0 to +4000 ns in steps of 80 ch
            ibin=0.0125*jj+.5 ; if(ibin.le.0)ibin=1; if(ibin.gt.50)ibin=50
            hisADC(i,ibin)=hisADC(i,ibin)+1

c            200 bins: from 0 to +4000 ns in steps of 20 ch
            ibin=0.05*jj+.5 ; if(ibin.le.0)ibin=1; if(ibin.gt.200)ibin=200
            hisADC_tot(ibin)=hisADC_tot(ibin)+1

            if(NbBarGamVetoTDC.eq.2)then
c            200 bins: from -100 to +100 ns in steps of 1 ns
               ibin=(0.05*j)+100.0 ; if(ibin.le.0)ibin=1; if(ibin.gt.200)ibin=200
               hisTDC_twohits(ibin)=hisTDC_twohits(ibin)+1
            endif
```

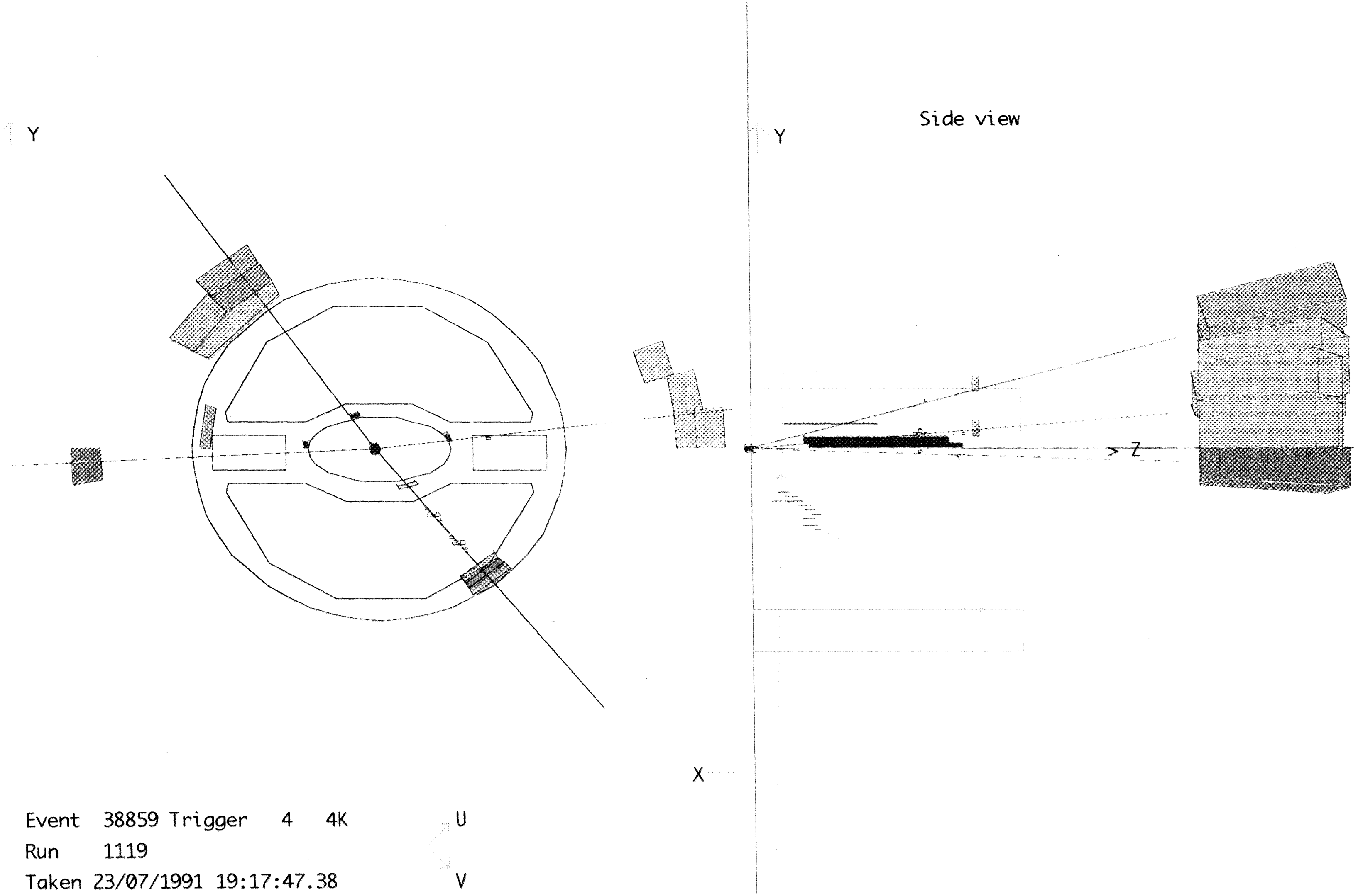
```
c            adjacent hits
             if(i.eq.ilast+1) then
             jlast=BarGamVetoTDC(ilast)-TDC_delay(ilast) ; jjlast=BarGamVetoADC(ilast)
c            200 bins: from -100 to +100 ns in steps of 1 ns
                ibin=(0.05*j)+100.0 ; if(ibin.le.0)ibin=1; if(ibin.gt.200)ibin=200
                hisTDC_adj_tot(ibin)=hisTDC_adj_tot(ibin)+1
                ibin=(0.05*jlast)+100.0 ; if(ibin.le.0)ibin=1; if(ibin.gt.200)ibin=200
                hisTDC_adj_tot(ibin)=hisTDC_adj_tot(ibin)+1
                ibin=0.05*(j-jlast)+100
                hisTDC_adj_dif(ibin)=hisTDC_adj_dif(ibin)+1

c            200 bins: from 0 to +4000 ns in steps of 20 ch
                ibin=0.05*jj+.5 ; if(ibin.le.0)ibin=1; if(ibin.gt.200)ibin=200
                hisADC_adj_tot(ibin)=hisADC_adj_tot(ibin)+1
                ibin=0.05*jjlast+.5 ; if(ibin.le.0)ibin=1; if(ibin.gt.200)ibin=200
                hisADC_adj_tot(ibin)=hisADC_adj_tot(ibin)+1
             endif
             ilast=i
          endif
       enddo
       if(ipriUser.ge.1)print'(1x,12i6.0)',(i,BarGamVetoTDC(i),i=1,24)
       END


c_____________________________________________________________________
       subroutine UserSpit
c      -------
       print '(/,1x,'Hits ='
     *,t10,'0',t20,'1',t30,'2',t40,'3',t50,'4',t60,'5',t70,'6',t80,'7',t90,'8',t100,'9'
     *,/,10i10)',Nb_multihits
c      -------
       print'(/,1x,'Time: from -100 to +100 ns in steps of 1 ns',/
     *      ,1x,'ADC:  from 0 to +4000 ns in steps of 20 ch',/
     *      ,11x,'TDC  TDC-adj    ADC   ADC-adj  TDC-twohit',)'
       do j=1,200
         print '(1x,i5,12i8)',j,hisTDC_tot(j),hisTDC_adj_tot(j),hisADC_tot(j)
     *      ,hisADC_adj_tot(j),hisTDC_twohits(j),hisTDC_adj_dif(j)
       enddo
c      -------
       print'(/,1x,'Barrel-Gamma-Veto TDC from -25 to +25 ns in steps of 1 ns for counters number 1-12')'
       do j=1,50
         print '(1x,i5,12i8)',j,(hisTDC(i,j),i=1,12)
       enddo
       print'(1x,'Barrel-Gamma-Veto TDC from -25 to +25 ns in steps of 1 ns for counters number 13-24')'
       do j=1,50
         print '(1x,i5,12i8)',j,(hisTDC(i,j),i=13,24)
       enddo
c      -------
       print'(/,1x,'Barrel-Gamma-Veto ADC from 0 to +4000 ns in steps of 80 ch for counters number 1-12')'
       do j=1,50
         print '(1x,i5,12i8)',j,(hisADC(i,j),i=1,12)
       enddo
       print'(1x,'Barrel-Gamma-Veto ADC from 0 to +4000 ns in steps of 80 ch for counters number 13-24')'
       do j=1,50
         print '(1x,i5,12i8)',j,(hisADC(i,j),i=13,24)
       enddo
c      -------
       do j=1,200
         write (MaxFile, '(1x,i5,12i8)') j,hisTDC_tot(j),hisTDC_adj_tot(j),hisADC_tot(j)
     *      ,hisADC_adj_tot(j),hisTDC_twohits(j),hisTDC_adj_dif(j)
       enddo
       do j=1,50
         write (MaxFile, '(1x,i5,12i8)') j,(hisTDC(i,j),i=1,12)
       enddo
       do j=1,50
         write (MaxFile, '(1x,i5,12i8)') j,(hisTDC(i,j),i=13,24)
       enddo
       do j=1,50
         write (MaxFile, '(1x,i5,12i8)') j,(hisADC(i,j),i=1,12)
       enddo
       do j=1,50
         write (MaxFile, '(1x,i5,12i8)') j,(hisADC(i,j),i=13,24)
       enddo
       END
```

APPENDIX 2

This is an example of a $\phi\phi$ event (carefully chosen for public relation purposes) where two of the tracks which our kinematical reconstruction attributes to separate ϕ's are both seen to "decay" (i.e. there are several adjoining forward calorimeter modules linking in a manner suggestive of the traversal of a decay product) therefore making them candidates for the positive charge assignment. The remaining two tracks (the negative kaons) don't do anything comparable in the forward and in the barrel modules. If our conjectures are correct then the TDC output of the trailing modules should be shifted in time with respect to that of the elements along the tracks trajectories. The fact that the decay particles cross several modules should make the time-shift determination more reliable (one could devise a chi-square procedure of some sort or another).

In what follows we first give the information produced by the series of routines of our standard program (see ref. [2] for listings) about the track-matching and the four-K reconstruction, then the color picture of the event as represented by the "Display" program.

```
------------------------------ EVENT No. 38859 ------------------------------
                               entry no   12
                                1.400 GeV/c
                               1B3F

 11 PIXELS of which  6 validated
     forw.scint  sci.azim       pixel   pix.azim  deltazim  wedge   Cher    assoc.
       1   176.7  +-  3.3        11      182.8      6.1       48      24      1
       8   122.5  +-  5.7         2      123.2      0.7        8       4      1
      19     9.9  +-  3.2         9        5.4     -4.5       24      12      1

     barr.scint   sci.azim
      14   307.4  +-  10.6
TRACK MATCH finds  1 sets with flag = 0
set number  1      chisquare  =  7.0          4.2          2.7
                probability =  3.7369E-01 pipes      4.3809E-01 pixels
tracks of set 1                 1       2       3       4
              azimuth    =    7.02  124.94  182.68  308.73
              polar ang =    36.74   19.22   31.89   51.94
  1 BARREL tracks               1             2             3             4
              azimuth    =  308.81[1]
              polar ang =    51.94
RECONSTRUCTION yields  2 solutions
 of which 1 retained [ 3 & 3 ] with energy unbalance =   0.017

KIN.SOL. no.  1
track  1     theta =  36.7  azim =   7.0 old mom. = 0.370
           mom.loss =   0.013 new mom. = 0.357   rej 0
           silic =  1   plane = 1   azim =  7.73   dE =  70   theta =  36.1
           silic =  3   plane = 2   azim =  5.47   dE =  47   theta =  38.4
           min. dE =     47.  expected dE (GeV) =   0.239  expected dE (chan)=  31.362
           norm. factor =   157.4 Sil. chisquare =  1.1116E+01
            Cher. test with mom = 0.357   beta = 0.586   3etactau =    802.
           Cher no. 12   dist =  12.2    meas ADC =  0.    exp ADC =  0.   calib =  0.00   rej 0
           Cher chisquare =  0.0000E+00
           warning: this Cherenkov was dead !
track  2     theta =  19.2  azim = 124.9 old mom. = 0.554
           mom.loss =   0.007 new mom. = 0.547   rej 0
           silic =  2   plane = 1   azim =123.97   dE =  22   theta =  20.3
           silic =  4   plane = 2   azim =130.80   dE =  13   theta =  21.2
           min. dE =     13.  expected dE (GeV) =   0.162  expected dE (chan)=  17.965
           norm. factor =    76.0 Sil. chisquare =  1.1203E+00
            Cher. test with mom = 0.547   beta = 0.742   3etactau =   1229.
           Cher no.  4   dist =  33.5    meas ADC =  5.    exp ADC =  0.   calib =  0.00   rej 0
           Cher chisquare =  2.0883E+00
track  3     theta =  31.9  azim = 182.7 old mom. = 0.469
           mom.loss =   0.009 new mom. = 0.460   rej 0
            unsuccessful sil.assoc. in plane  2 ... closest element follows
           sil ? =  5    azim = 349.1   dE = -34   theta =  14.9
            Cher. test with mom = 0.460   beta = 0.682   3etactau =   1034.
           Cher no. 24   dist =  18.8    meas ADC =  0.    exp ADC =  0.   calib =  0.00   rej 0
           Cher chisquare =  0.0000E+00
           warning: this Cherenkov was dead !
track  4     theta =  49.1  azim = 308.7 old mom. = 0.279
           mom.loss =   0.016 new mom. = 0.264   rej 0
           barrel track mom = 0.264   beta = 0.471   3*ect =    593.   rej 0
     Total Cher. prob.     =  0.1484
     Total Silicon prob.  =  0.0022
     Cher&Sil comb. prob. =  0.0025

---> THIS SOLUTION PASSES PRESENT TESTS
     Track momenta in sol. 1 =    0.370   0.554   0.469   0.279

    EFFECTIVE MASSES =      1.063(1+2)  1.096(1+3)  1.015(1+4)  1.016(2+3)  1.102(2+4)  1.084(3+4)
     cosine(cm angle) =          0.467       0.072      -0.431       0.431      -0.072      -0.467
     combination 4 & 3 with mass  1.016 & 1.015 closest to phi-phi
```



Event 38859 Trigger 4 4K
Run 1119
Taken 23/07/1991 19:17:47.38

REFERENCES

[1] A high-resolution lead/scintillating-fiber electromagnetic calorimeter.
D.W. Hertzog et al. Jetset Note 90-11 (26 June 1990)

[2] Analysis of the data from December 1990 to July 1991.
CERN Jetset Group. Jetset Note 91-11 (2 October 1991)
(don't forget that the appendix containing the listings is bound separately)