H.E. Mills JADE Computer Note 82 June 6, 1985

MUTANA — A Simple Algorithm to find Tracks in the Muon Filter

Introduction.

The algorithm described here finds tracks in the muon filter. It is based upon the scheme used by the hardware of the T3 level trigger. It operates independently of other detector parts. The motivation to produce the algorithm was for the fast online filtering of cosmic background events in certain trigger sources.

The algorithm is implemented in the Nord-50 computer as part of JDAS and the results stored in the N50S bank. During offline analysis one may use the information in the N50S bank to select events with a track in the muon filter such as when looking for multihadronic events with a muon candidate. The algorithm may be run on the IBM computer for data taken before it was adopted online.

Early Developments.

The history of development is given here since it explains why certain decisions were taken.

The initial idea was to analyse by software the information available in the streets and groups of the T3 level trigger. The trigger hardware ORs together chambers in the barrel and endwalls of the muon filter and then the streets are ANDed. The streets point towards the interaction region and overlap so as not to lose efficiency. Thus a chamber may belong to one, two or even three groups. The layout of the T3 streets in the barrel of the muon filter is shown in Figure 1; that for the endwalls in Figure 2. The hardware of the T3 level trigger permits one of the five groups within a street to be inefficient.

Development started when the low energy neutral ("J.O.") trigger was installed. This trigger requires two low energy deposits in the lead glass barrel with TOF veto. The main background consists of cosmic particles outside the TOF timing gate but within that of the leadglass system. For this trigger (if no other trigger bits are on) it is possible to filter out events if there is a track in the muon filter. When scanning events triggered by this source it was clear that many cosmic particles do not go near the interaction region i.e. they slant across the detector. Such tracks would not be picked up by the T3 hardware. Thus the algorithm allows some overlapping between adjacent groups. Group 1 (the innermost layer) is excluded due to the fact that the chambers register additional hits due to other causes.

Tests showed that although the algorithm worked in general there were some problems. Tracks were being found where they did not exist due to some groups within the trigger being permanently set "ON" (due to known dead chambers). This is perfectly acceptable for a trigger but disastrous for a filtering algorithm where a few spurious hits could cause the event to be rejected.

The algorithm was also missing good tracks due to the fact that the T3 gate is shorter than the muon digitiser gate. Hits can be present in the muon filter chambers but not in the T3 trigger. This does not cause problems for in-time beam–beam events, such as muon pairs where the T3 level trigger is fully efficient, but for out–of–time cosmic particles (which we wish to filter out) the T3 trigger is inefficient — which again is reasonable for a hardware trigger.

The Current Algorithm.

It was decided to use chamber hits to reconstruct the T3 level trigger information and then search for tracks. This avoids the problems mentioned above. Block data statements supplied by Austin Ball specify which group(s) and street each chamber belongs to.

For each track found the street position is recorded (1—20 in the barrel; 21—28 and 29—36 in the endwalls). The track quality is also recorded:—

1	clean track	4/4 efficiency	
2	clean track	3/4 efficiency	
11	slant track	4/4 efficiency	not for endwalls
12	slant track	3/4 efficiency	

Figure 3 shows an event caused by the "J.O." trigger together with the MUTANA results. The algorithm is fairly simple and does not require significant computer resources.

Use of MUTANA Online.

MUTANA is applied to each event by the Nord-50 analysis program. The N50S bank (see supplement 1 to JADE Computer Note 78) contains the total number of muon tracks, the number in the barrel and up to five track position/quality pairs. MUTANA is currently used for online event filtering for three trigger sources. The complete online event filtering scheme is described elsewhere[1]. If the low energy neutral "J.O." trigger (T1 accept bit 13 — installed from run 10493) is set, and no other trigger bit, then if MUTANA has found a track the event will be a candidate for rejection. Around 85% of events caused by this trigger are rejected online. It is realised that a cosmic particle passing through the detector at the same time as a genuine 2-photon event could cause that event to be rejected. This is acceptable to the physicist since it occurs at a low rate and can be corrected for. The online filtering has been active since run 13762 on 16/6/1983. From run 20000 onwards (1985 data) it was changed to filter events only if a track was found in the muon filter barrel (ignore endwalls due to worries about extra hits there faking tracks and hence rejecting genuine events). The change in rejection percentage was negligible.

The same algorithm is applied to the "Zorn" trigger (T1 accept bit 14) since run 14953 on 21/10/1983.

The new T2 accept "J.O.2" trigger (T1 postpone bit 10), if it is the sole cause of a T2 accept event, is cleaned up by MUTANA in the same way. This was active as soon as the trigger was installed (run 20300 onwards on 18/4/1985).

Use of MUTANA offline.

Often there is a requirement to find which events in a sample contain a muon candidate. For data since May 1983 one can use the stored results in the N50S bank. For other data it is possible to run MUTANA on the DESY IBM computer. Assuming the program has the BOS common, the MUEV bank must be located, the chamber data converted into Nord-50 format, then to T3 trigger format and then analysed thus:—

```
COMMON /CT3MU/ NMU,NMC(3),MUDEV,MUPOSN(5),MUQUAL(5)
        .
        .
CALL CLOC(IPMU,'MUEV',0)
IF(IPMU.LE.0) GOTO 999
LEN=IDATA(IPMU)*2 - 2
CALL MUNPK(IPMU,LEN)
CALL MU2T3
CALL MUTANA
```

The /CT3MU/ common block contains the results :—

NMU	total tracks found
NMC(1)	tracks found in barrel
NMC(2)	tracks found in −z endwall
NMC(3)	tracks found in +z endwall
MUDEV	not used
MUPOSN	position of up to 5 tracks
MUQUAL	quality of up to 5 tracks

The routines are written in FORTRAN 77 and are available in compiled form on library F22HEM.N50RED.L. If the calling program is written in FORTRAN then two FORTRAN 77 libraries must be included (SYS1.FT77LNKL and SYS1.FT77LIB).

Limitations of MUTANA.

The algorithm may fail to find a muon track in an event because of :—

1) A missing muon crate.

2) Dead chambers — no notice is taken of calibration information which specifies if a chamber is dead. Such chambers will just not have any hits. This is at least safe for online event filtering purposes.

3) Low energy tracks — if a muon track does not fully penetrate the filter then there may be insufficient hits for a track to be found in this way.

Since no attempt is made to ensure that any hits within a T3 street actually belong to a track, it is possible that a large number of random hits could satisfy the logic and hence cause a spurious track to be found.

Summary.

This algorithm is a fast way of counting tracks within the muon filter. It has performed well for several years as part of the Nord-50 online event filtering scheme and has been used offline during analysis of the width of the Eta decay[2].

References.

1. H.E. Mills, Online Event Filtering in the JADE Data Acquisition System, to be submitted to Nucl. Instr. Methods.

2. JADE Collaboration, A measurement of the η radiative width $\Gamma_{\eta\to\gamma\gamma}$, DESY 85-033.

18|6|80

T3 TRIGGER BARREL STREETMAP

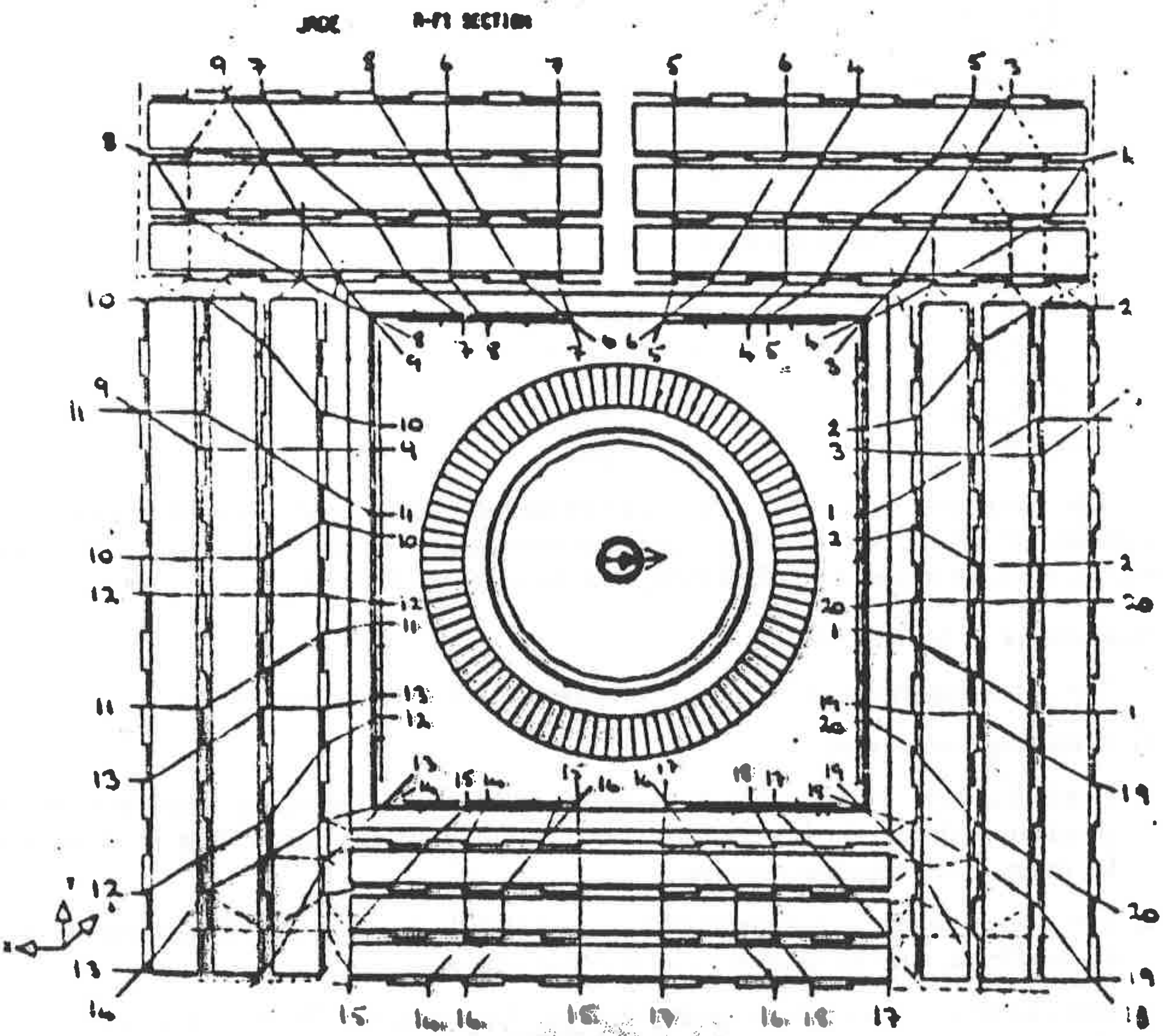


Figure 1

29/4/80

T3 TRIGGER

ENDWALL STREET-MAP

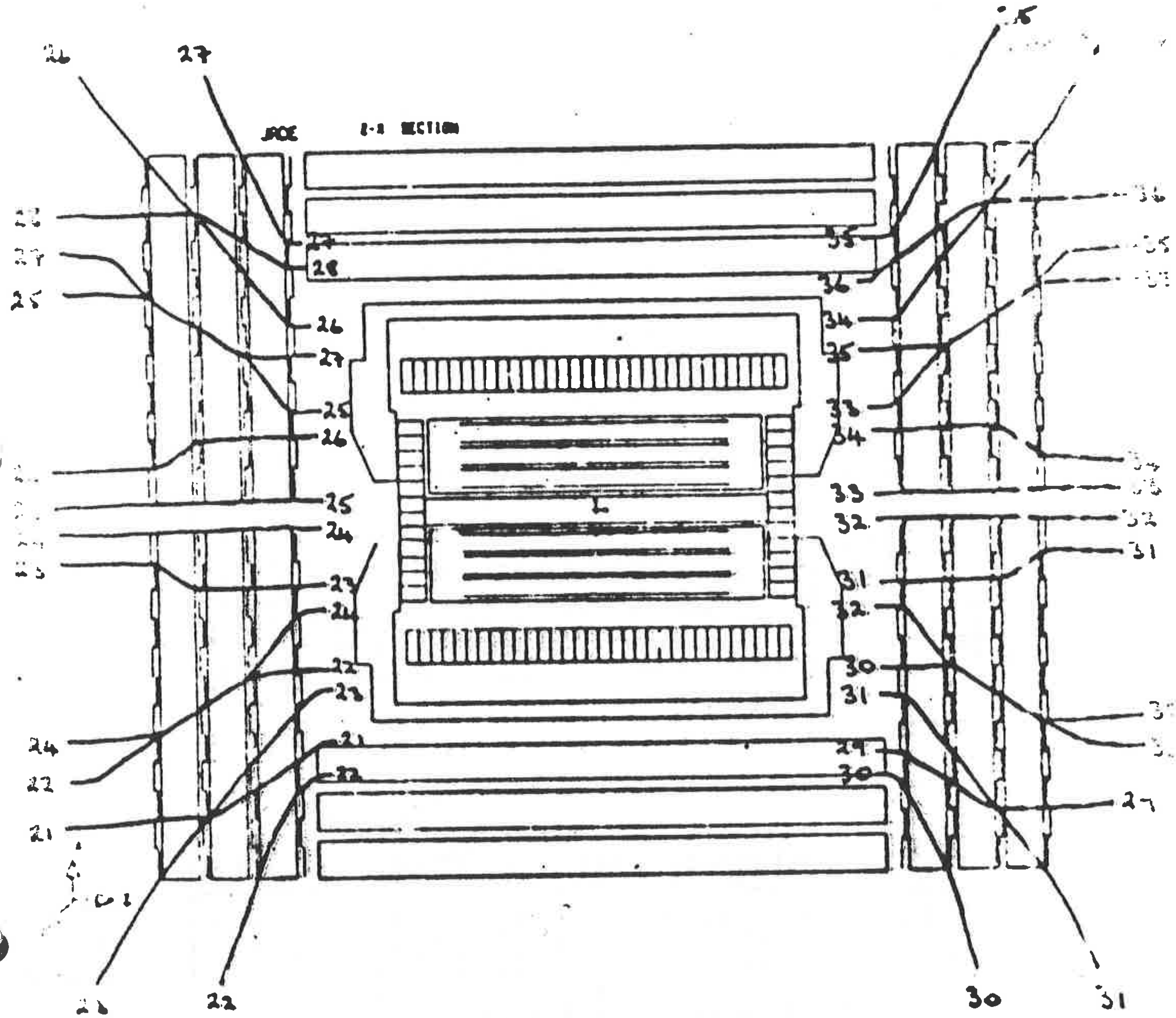
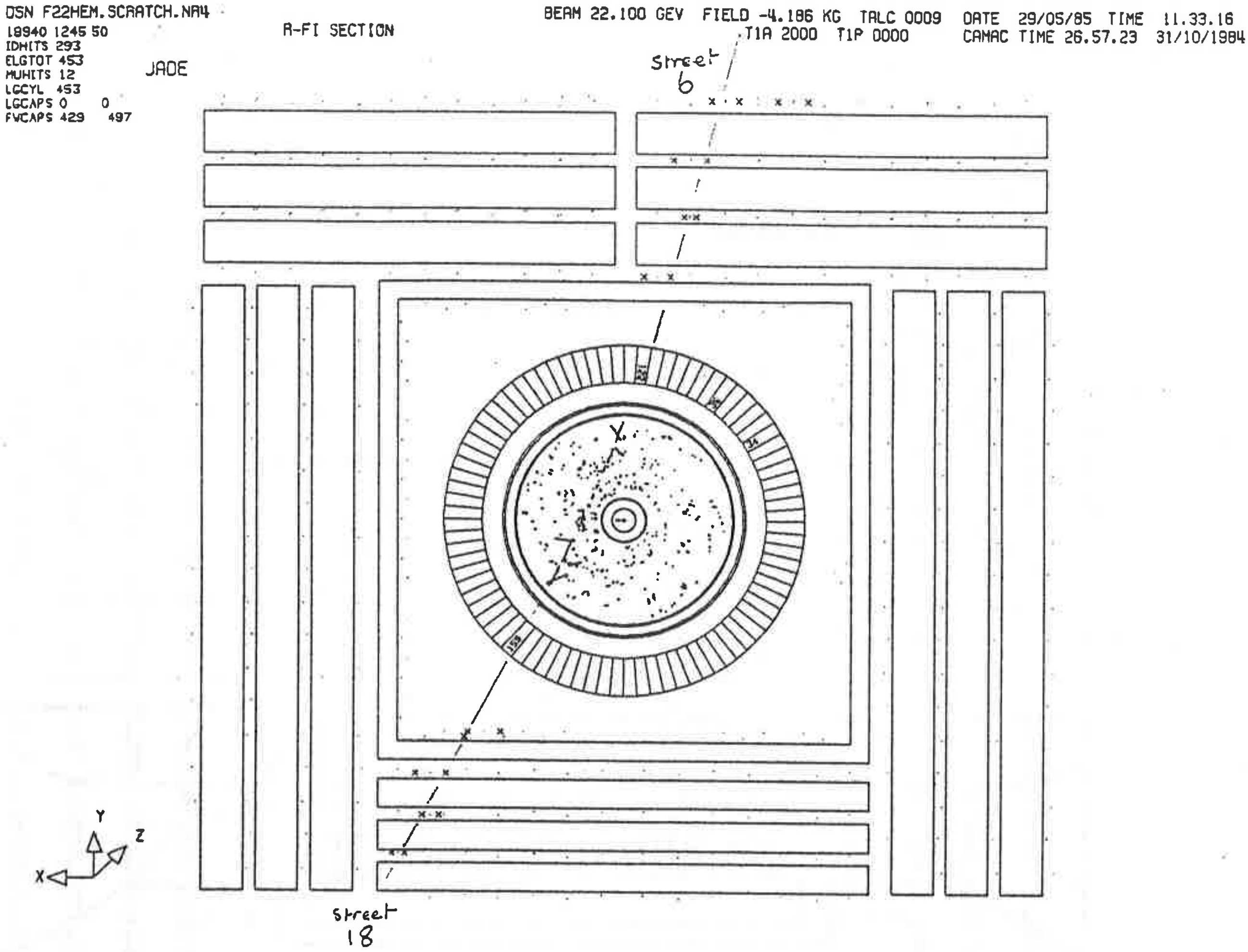
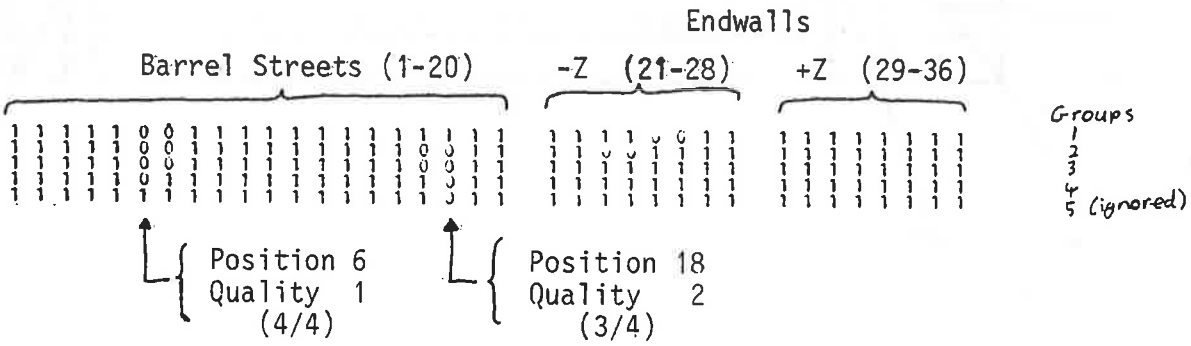


Figure 2



DSN F22HEM.SCRATCH.NA4
18940 1245 50
IDHITS 293
ELGTOT 453
MUHITS 12
LGCYL 453
LGCAPS 0 0
FWCAPS 429 497
R-FI SECTION
JADE
BEAM 22.100 GEV FIELD -4.186 KG TALC 0009 DATE 29/05/85 TIME 11.33.16
T1A 2000 T1P 0000 CAMAC TIME 26.57.23 31/10/1984
Street 6
Street 18
Y
Z
X



Endwalls
Barrel Streets (1-20)
-Z (21-28)
+Z (29-36)
Groups
1
2
3
4
5 (ignored)
Position 6
Quality 1
(4/4)
Position 18
Quality 2
(3/4)

Figure 3

Olsson

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JADE COMPUTER NOTE No 83
Re-Analysis of Multihadronic Events

E.Elsen and K.H.Hellenbrand

The hadronic events taken up to the end of 1984 have been reTPed on the Heidelberg computer. The objective was to create uniform event result banks for the entire datataking of JADE. The so-called standard MH-datasets were processed and partly reanalysed over the years so that different and sometimes irreproducable result bank versions were available. This is usually of minor importance for the standard MH-user but hampers the detailed understanding that is needed for dE/dx and other purposes.

The list of datasets available is given at the end. The input to the analysis were MH-event candidates before E_{vis} and p_{bal}-cut. This was felt neccessary not to bias the event selection. It also makes the data usable for people looking for exotics. People interested in standard MH-events should call routine MCREDU to perform the neccessary reduction.

There is not always a one to one correspondance between the input datasets and the ones given in the TPSTATUS-list. The reason is that the origin of the event samples in the TPSTATUS-list sometimes is not very clear and some of the later occuring rearranging of event samples did not propagate into the TP-datasets. To the best of our knowledge the list below gives the complete sample of hadronic event candidates.

Before reanalysing the data were basically reduced to their original NORD format. The only banks kept were the ones created on the NORD: uncalibrated JETC etc. This made sure that no half-old information was used.

The important steps in the TP-program were

- JETC calibration
- Pattern Recognition (creates PATR 10,JHTL 10)
- JETC z-calibration (CALL ZSFIT(1))
- Helix fit (CALL RFEVFT) (creates PATR 9, JHTL 9)
- Refit of track with soft origin constraint (CALL PATRCO) using as input PATR 10, JHTL 10. Step creates PATR 8, JHTL 8. Note, however, that JHTL 8 is a mere copy of JHTL 10. The refit does not properly set the hit labels so that the input bank JHTL 10 is the best one has. Note also that with this fit it is perfectly possible that a track has more $r-z-$ than $r-\phi-$hits. (Ask P.Steffen for details).
- LG-calibration
- LG-clusterfinding
- Thrust calculation

In addition to the standard TP-banks the event records also contains a PHOT-bank, created with options LPAT=0, LZF=1 and LFIT=1 (see JADE Computer Note 75 by M.Kuhlen). This bank holds the information about candidates for converted photons.

All banks are kept on tape (The event length increases by a factor 6 from the raw format).

Typeset by $\mathcal{A}_{\mathcal{M}}\mathcal{S}$-TeX

INPUT TAPES	FIRST- LAST RUN NUMBER	EVENTS	ECM	DSNAME TPED DATA
1979-1980 DATA				
F22ELS.TAPE.TPMH612	2307- 2520	314	12	F11HEL.URZ.TPMH612
F22ELS.TAPE.TPMH622	1083- 1162	21	22	F11HEL.URZ.TPMH622
F22ELS.TAPE.TPMH630	540- 3605	1363	27-31	F11HEL.URZ.TPMH630
1980-1981 DATA				
F22PWA.MERGORD.TPMH714	7969- 8629	3467	14	F11HEL.URZ.TPMH714
F22PWA.MERGORD.TPMH722A	7181- 7962	3098	22-25	F11HEL.URZ.TPMH722A
F22PWA.MERGORD.TPMH734A	6196- 7588	6199	30-34	F11HEL.URZ.TPMH734A
F22PWA.MERGORD.TPMH735A	2750- 5665	4605	33-36	F11HEL.URZ.TPMH735A
F22PWA.MERGORD.TPMH735F	8716- 9724	9479	35	F11HEL.URZ.TPMH735F
1982 DATA				
F22PWA.MERGORD.TPMA735G	10055-10601	4776	35	F11HEL.URZ.TPMA735G
F22PWA.MERGORD.TPMA735L	10602-10973	4827	35	F11HEL.URZ.TPMA735L
F22PWA.MERGORD.TPMA735Q	11039-11656	5888	35	F11HEL.URZ.TPMA735Q
F22PWA.MERGORD.TPMA735W	11656-12518	6496	35	F11HEL.URZ.TPMA735W
F22ELS.TAPE.TPMA717A	12446-12462	50	17	F11HEL.URZ.TPMA717A
F22ELS.TAPE.TPMB738A	12560-12948	1216	36-39	F11HEL.URZ.TPMB738A
1983 DATA				
F22ELS.TAPE.TPMD840A	12950-13581	1000	40	F11HEL.URZ.TPMD840A
F22ELS.TAPE.TPMD840B	13581-13879	1000	.	F11HEL.URZ.TPMD840B
F22ELS.TAPE.TPMD840C	13879-14225	1000	.	F11HEL.URZ.TPMD840C
F22ELS.TAPE.TPMD840D	14228-14582	994	.	F11HEL.URZ.TPMD840D
F22ELS.TAPE.TPMD844A	14611-15046	820	.	F11HEL.URZ.TPMD844A
F22ELS.TAPE.TPMD844B	15047-15688	1269	45	F11HEL.URZ.TPMD844B
1984 DATA				
F22ELS.TAPE.TPME846A	15699-16736	1865	46	F11HEL.URZ.TPME846A
F22ELS.TAPE.TPME844A	16806-17549	1804	44	F11HEL.URZ.TPME844A
F22ELS.TAPE.TPME844B	17550-17962	1090	44	F11HEL.URZ.TPME844B
>>>>> FROM RUN 17990 ON NO VALID DE/DX CALIBRATION <<<<<				
F22ELS.TAPE.TPME844C	17963-18275	684	44	F11HEL.URZ.TPME844C
F22RAM.TAPE. REDUCONE.G892T904	18276-18433	323	44	F11HEL.URZ.G892T904
F22RAM.TAPE. REDUCONE.G905T956	18434-19018	1528	44	F11HEL.URZ.G905T956