AUSTRALIAN NATIONAL UNIVERSITY
DEPARTMENT OF NUCLEAR PHYSICS

14UD TANK OPENING REPORT No. 50

Three Openings:
24th to 28th May 1985 (4 days open; 2 working days).
3rd. to 8th July (6 days open; 4 working days).
5th to 8th August (3 days open).

REFERENCES: Earlier Tank Opening Reports are referred to by the notation (38/4) etc, meaning Report No. 38, page 4.

This is the 50th Tank Opening Report. For several months we have been excitedly planning to make it a gala issue with an index of earlier reports and perhaps a collection of notable snippets from the past; maybe even an illustrated cover. Somehow or other the material has not been assembled in time; this means that either we shall get the report off promptly, as usual, or delay it while we try to think of something special to illuminate it with. However, this is only the opening paragraph and we have a long way to go before we have to make up our minds. Whatever we decide, we accord very first place to the following:

An apology to N.E.C.

We said (49/5) that our old friends had caught us out with yet another variation of their evergreen starheaded screw trick by making the captive nuts in our new posts incompatible with the corona assembly screws. No such trick was played on us and the threads in the new posts are all consistent. The mistake arose from the fact that a damaged post bracket had been drilled out and a non-standard screw and nut used to fix a stringer onto the post. When a new post was put in that position the existing screw failed to fit the captive nut. The authors support each other fervently that neither was responsible for this ridiculous mistake; with equal fervour each is emphatic that it was inexcusable of the other not to have checked on the information handed in to us before rushing into print. N.E.C. are quite innocent of the subtle trick we suspected them of; even so, remembering the undeniable lapses of innocence in the past, we wonder a little if this particular idea has ever crossed their affectionate, impish minds.

REASON FOR THE FIRST TANK OPENING (24th May).

The Tank Cup failed in its 'in' position.

PREAMBLE

The 14UD was last closed on 4th April 1985. There were very stable charging currents after we had machined the pulleys to improve contact of the bands to the pellets (49/11). The machine was required at middle voltages until the end of April when it was conditioned for a high voltage run. On May 2nd it held 13.9 MV, which we felt to be remarkably good, considering how much of the column was shorted (49/5), in addition to the third of a unit in the H.E. column which houses the second stripper.

Unfortunately, the tank cup continued to give trouble after our repair, (49/11) and we were obliged to to keep it in the out position where it was known to intercept at least a small amount of beam.

Some good high voltage runs included a 6-day continuous one at 13.63 MV. On 24th May the tank cup commemorated dear old Queen Victoria's birthday by making a royal progress into the beam path and staying there, beyond deposing. We were not amused and began to take out the gas that same day.

OPERATIONAL TIME.

During the 49 days since the last closure, the 14UD operated for 811 hours. This was 77% of elapsed time, excluding the days for gas transfer (42/2), also the 4 days of Easter when the 14UD was not gassed up.

THE FIRST TANK OPENING. (24th to 28th May)

The initial sniff was made by the younger author who wrote in the logbook: "A fine bouquet with the fragrance of a north slope fluoride".

Exploratory tour.

The column was once again dusty and gritty, but there was no corresponding dust at the recirculator port and baffle. All the post ceramics which had been shorted out by hoseclamp bands across the electrodes (48/4; 49/5) were uncovered and re-inspected. There were 4 categories of marks on these ceramics: 1) - "Beyond doubt" cracks which tend to be light in colour and immediately stain with dye-check; 2) - Black lines, vertically across the ceramic, which do NOT show a crack when dye-checked and exhibit resistance indistinguishable from that of unmarked ceramics; 3) - "Nibbled" ceramics. There was one example of a ceramic appearing nibbled away about 1 mm deep and 4 mm along the circumference and a quarter of the way across the gap. Under dye-check this ceramic was indicated as not cracked. 4) - Just plain dirty, with black, smudgy marks which are often, but not always, removed with alcohol.

As to the hose clamp shorting bands themselves, there was spark erosion under every one.

And so to work!

Shorting bands were put back on some of the post electrodes after the latter had been polished back to clean metal. The shorting bands were "taped" with 0.008 inch thick copper shim to obtain better contact to the electrodes. The ceramics with vertical black lines which did not show a crack when dye-checked, were not rebanded, but were left live. The single instance of "nibbling", yet without a crack indicated, was nevertheless rebanded.

Tank Cup.

After letting the tube up to atmospheric pressure the recalcitrant tank cup was removed from its housing and it was found that both its ceramic insulators were broken. As this has happened before, (31/3), we decided to keep the cup out of the machine pending a reliable design.

In that region of the tube, we now had an empty beam profile monitor and empty tank cup, but still the entrance slits which were checked and found to be working, if rarely used.

Nothing else was done in the machine; no chains or idlers were examined and no terminal spinnings were moved.

Initial performance.

The machine started up well, and straight away embarked on a 10 day high voltage spree between 13 and 13.6 MV which only came to an end because of a minor disaster with the lithex source heat exchanger, in which circulated freon is cooled by the same chilled, demineralized water which cools the sputter source directly. The freon/water interface sprang a leak so that the two got into each other. Though, in their respective circuits, the freon and demineralized water are individually happy at 200 kV, as a mixture, helped by a little handy electricity, they form corrosive products and become most hostile to their intended purposes. We had more work to do, and repairs to make, than we care to confess.

On 17th June the generating voltmeter stopped. We took the gas out until a mercury manometer indicated that the port was within 1 mm of atmospheric pressure, then we whipped out the G.V.M. and put on a blanking plate. Finding the bearings had failed we fitted a replacement motor and then deftly slid off the plate and popped back the assembly. We have done this before (40/7) and the interchanges can be performed in about one second if the performers are completely ready, at the right height and don't start arguing at the last minute.

PREAMBLE TO THE SECOND TANK OPENING (3rd to 8th July).

Since the terminal foils were last renewed at the end of March, there were twelve days of nickel operation and two of Br, together with sundry other beams up to sulphur 32 for an additional 66 days. It came as no surprise that after the last six days of nickel 58, the foil changer went completely through the full set for the fourth time and there appeared to be no more usable terminal stripper foils. In addition, the charging current on Chain 2 was lurching between 30 and 50 microamps.

Operation time since the closure on 28th May

Of the 36 days since that closure, the 14UD operated for 660 hours. This was 83% of elapsed time, excluding the days of gas transfer and the day when gas was taken to atmospheric because of the G.V.M.

THE SECOND TANK OPENING (3rd to 8th July).

Exploratory tour.

There was grey dust on the column and some grittiness. Small lumps of oily 'chain mud' were on castings near idlers and rubbery-looking lumps on the lowest idler casting. Apart from these observations there was nothing else to comment on and we began work.

And so to work for the Second Opening.

Stripper.

The terminal stripper was taken out and it was found that the foil chain must have jammed (frequently, at some time in the past) since the empty space on the chain, appropriate for the operation of the isolation valve, was at least 100 positions from the indicated number. The mechanism operated freely after removal. Because of the erroneous position of the foil chain, four foil clips were spread by the closure of the valve; in addition to these four foil frames found in the stripper well, there were two found in the stripper unit itself; one of these was badly bent. There was a continuous string of about 100 good foils, but the broken state of the foils in the region of the current position was clearly the cause of the bad transmission. We conclude that for about 100 operations the foil chain had been prevented from advancing by a displaced foil frame. As most of the foils were "known" to be broken, changes in beam intensity could not be relied on as a diagnostic of foil change.

Our 'new' stripper, started five years ago, on which Bob Turkentine has worked whenever he had the time, was sufficiently advanced to be tried in position and tested for general fit while there was the opportunity. All was well. It was then removed for bench testing.

Chain stabilizing idlers.

In the last report we said that (49/11) the casting idler bearings for Chains 1 and 2, which had done so remarkably well since they were put in in November 1983, were getting noisy. The noise and roughness were now worse and the rubber tyre deposits on the chain convinced us to change all the casting idler bearings on chains 1 and 2. In addition, 13 idler wheels were also replaced because of worn tyres. Although there were deposits of tyre rubber on the chains, no one tyre was in very bad condition.

Total operating hours were 8,342 and 8,411 for the idlers of chain positions 1 and 2 respectively.

No idler bearing changes were needed in Chain 3 since they had only operated for 1,765 hours and they sounded fine.

The terminal pulley for Chain 2 had a failed inner bearing housing. A new block was put in. The lurching of Chain 2 current was ascribed to "improper," too loose, a setting of the terminal d.c. idlers. This was now reset superbly by the younger author. (Stay tuned for the fall of youth).

Chain links.

No chain links were inspected at this opening. We have not fully inspected links in any chain since last November, when all links of the then only two chains were fully examined (48/4); In February 100 links in each chain were checked (49/4). However, gas tests have been made at appropriate intervals. Chains 1 and 2 have now operated for 7,728 and 12,972 hours respectively. In part, this absence of inspection reflects staff and time shortages.

Button-up.

After the usual column cleaning and charging tests, the machine was closed on 8th July.

This opening had extended over the weekend, not because of workload, but because of delay in getting enough bearings for the idler repairs. It turned out that a whole bunch were not enough. A metric bunch was ordered for next time.

Initial performance.

First tests after gassing up revealed that there was a large sinusoidal component on the pickup trace from Chain 1 and oiling that chain made no difference. The upcharge on Chain 2 displayed low frequency pulsing and the trace of the downcharge of Chain 3 was dreadful. Fortunately 1 and 2 settled down and after a couple of days, Chain 2 was left off and the machine ran reasonably well at 13.59 MV. (The fall of youth!).

On 23rd July an efficiency test, carried out by the younger author, showed an apparent correlation between loss of efficiency above 20 kV charging voltage and occasional instability of chains 1 and 2. Chain 3, the youngest of the trio, was linear up to 122 microamps at 40 kV inductor voltage. So, look for "age" effects in Chains 1 and 2. Some respectable voltages from 13 to 13.5 MV were used solidly after this, though something was intermittently amiss along the column. On Friday, 2nd August, there were frequent sparks at 13.5 MV followed by sparks up to 12 MV with no vacuum or x-ray precursors. Clearly this was due to some trouble in the column. Using our standard alpine technique of hanging by the teeth to various view ports on the tank, sparking in Unit 4 was confirmed in 3 out of 5 thunderous sparks, at the near cost of physiological responses by the intrepid younger author. With Unit 4 shorted, the machine temporarily achieved 13.5 MV, or 1.04 MV/unit in the L.E. end before random 12 MV sparking recurred. It was decided to open up on Monday.

THE THIRD TANK OPENING. (5th to 8th August).

Exploratory tour.

There were badly charred rotating shaft sections in Units 1 and 2 (Photos 1 and 2) and various other instances of shaft damage, including severe "snail tracks" on the shaft in Unit 4. In all, 7 shafts needed to be replaced.

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INTERLUDE: "Snail Tracks Revisited".

In April 1978, when examining a unit which had been shorted because of a discharge problem, we reported (11/6) finding marks in the deposit which is seen easily on the perspex shaft sections and control rods. We called these marks "snail tracks" and said that they wiped off easily with alcohol and elbow grease.

In the very next paragraph we said that the shaft in Unit 15 had a faint pattern of tracking marks over most of its surface and that these marks did not respond to cleaning, as similar marks did elsewhere. We added that no such indelible marks occurred on any other shaft or control rod in the machine. (The older author's diary for this occasion has a small sketch of a winding river and the comment: "Shaft in unit 15 had river patterns which did not wash off. They were not burn marks, but were etched into the skin of the shaft, yet not detectable by touch. It was the only shaft in the machine to have this effect"). All shafts and control rods had just been cleaned with alcohol and a dry rag, therefore all had been well looked at. It is significant that the diary entry made no reference to snail tracks, possibly because, if seen, they had washed off easily.

Three months later (13/2) we said that Unit 22, which had resisted conditioning, appeared to have nothing wrong with it until we saw "riverlike" tracks in the dusty deposit on the surface, adding that the tracks corresponded roughly to the ones seen earlier (11/6, above). In this new case we said nothing about attempting to clean the marks. In the control room logbook the younger author had written: "Discharge marks on shaft in U22. Similar marks on other shafts, but not as severe". Either these marks had all formed since our declaration, three months earlier, that only one shaft section was indelibly marked, or they had begun, and were very weak, and we missed them.

The dusty deposit on the shafts serves to render these marks visible, even if perhaps it doesn't contribute to their formation. Cleaning off the deposit makes the marks more difficult to see, or rather, their observation becomes very dependent on how the shafts are illuminated.

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Returning from that glimpse into the past, over almost 40 reports, it appears from what was written down that we believed "snail tracks" were in the deposit on the shafts, and washed off, whereas "rivers" were beneath the surface of the perspex and could not be cleaned. It might be that snail tracks, allowed to stay in the grime on shafts, triggered the rivers. At all events, we came to accept that some marks were permanent. They wander rather vaguely down (or up) the shaft; their appearance suggests that they are drawn by a pair of very fine plotter pens, fixed about 2 mm apart, drifting to right and left, but always with an unmarked path between the lines. Rubbing vigorously with a rag, damp with water or alcohol, fails to remove the tracks, or even change their appearance. Scraping them with a fingernail fails to detect any surface roughness. Examined with a low power microscope the fine structures of the two "pen" lines have their individual excursions in the form of cracks which seem to be just below the surface. (Photo 2). Whatever the appearance of these shafts, snail tracks and all, the machine operated over this period above 1 MV/unit. We therefore concluded that snail tracks and deposits on the shafts were benign.

Samples of the grey, powdery deposit on the shafts were collected using a camel hair artist's brush dipped and rinsed in a test tube of de-ionized water. It was confidently expected that the powder was SF6 breakdown products, Devil no. 1, and so would readily dissolve, resulting in a clear, vile, acidic liquid. Our surprise can be imagined when we found the powder to be, in the main, insoluble and to settle out on the bottom of the test tube. Devil number 2 was now put up to blame. As reported (49/9), a fine grey powder is continuously produced by arc erosion of the aluminium flanges at the ends of the column posts. As a normal part of pre-closure cleaning, a compressed nitrogen jet blows off surfaces, and, in particular, is inserted into the split in these post flanges to blow out any loose dust. In about 10% of cases, a fine powder cloud is produced. The rationale for pursuing this "cleaning" is that this process leaves less powder in the machine for later contamination and is probably more psychologically comforting than actually effective. The evidence for the impotence of this reduction in the amount of loose aluminium dust is that disassembled posts, presumably blown in the past, nevertheless contain the order of 1 cc of aluminium powder.

Devil number 3 is dust from the high throughput SF6 purifying system. While it would be extremely difficult to distinguish between aluminium oxide from the dryer and aluminium spark eroded in an SF6 atmosphere, one should be able to detect Na or K from the sodalime. This has not yet been tested, but there is no evidence of greater dust near the purifier gas input to the tank. Finally, if the sodalime were the chief constituent of the dust, then the water solution should have a basic pH. It doesn't; the pH is between 3.8 and 4.2. This evidence revitalizes devil number 1, acidic SF6 breakdown products.

We conclude that the deposits are chiefly aluminium powder, spark eroded in SF6 together with SF6 breakdown products, co-produced in the spark erosion, and/or independently produced by normal corona currents. Further, the rate of buildup on the perspex has accelerated over the life of th 14UD, pointing to an acceleration of the degradation of the posts as the eroded aluminium-titanium interface worsens. The high throughput SF6 purifier demonstrably reduces the SF6 breakdown products in the gas due to corona.

We removed the most badly damaged and tracked shaft sections which were in units 1, 2, 3 and 4 of the L.E. column and units 22 nd 27 of the H.E. column. Alan Cooper pointed out that the failed shaft sections were predominantly at positions of greatest torsional stress on the shaft. This idea was borne out to some extent by noticeable helicity exhibited by the tracks. The shaft in Unit 14 was removed because of damage caused by a wandering stringer and NOT by vicious snail tracks.

There are two ironic points. One, the machine instabilities were associated with particles of charred perspex on the rings of Unit 4 and elsewhere. Two, the charring of the shafts themselves did not lead to noticeable sparking in the damaged units. (Photo 1).

Having no spare shaft sections we elected to leave the upper (L.E.) shaft inactive and borrow "good" shaft sections from it to replace the damaged ones in the lower shaft, the significant function of which is to power the terminal lens, terminal pumps and foil changer lights.

Charging system.

We began investigation of the charging problems by observing the

performance of the charging system before we did anything to it. After lowering the bottom terminal spinning we ran the chains. The d.c. idlers for Chain 3 ran nicely, but the 'up' idler for Chain 1 did not get up to speed and that for Chain 2 did not spin at all; they were both adjusted closer and closer to the chain until they finally performed correctly. Clearly, setting them to just touch a just stationary chain is not sufficient, since the position of the chain changes when it is running.

All inductor and cross-over insulators stood 10 kV in air without drawing current. Samples of the three chains passed the same test between pellets. In the bottom of the tank the charging pulley of Chain 3 had a wobble; it was removed and its axle flange was machined. It is a source of some chagrin that this mechanical defect escaped our previous efforts. The chains were run again and observed mechanically; charging tests were carried out satisfactorily.

Tank cup.

The tube was let up to atmospheric pressure and we put back the tank cup removed during the first of these openings for modification. In order to improve its reliability we had altered the mechanism is three significant ways. 1), the tiny weeny insulating washers between the "cup" electrode and its rotating support rod were replaced by a block of maycor. 2), the current feedthrough was incorporated in the flange to avoid the spring effect of the previous body connection. 3), the pneumatic actuator was modified so that it could be mounted on the flange before the vacuum seal was made, allowing reliable alignment. In addition, the ball bearing within the magnet polepiece was replaced by bronze bushes above the magnet, eliminating a magnetic short and so improving the magnetic coupling. (Photo 3).

Analyzing magnet.

While the machine was off the air we investigated the troublesome instability in the field of the energy analyzing magnet. For the past year or so, we have been successful in ignoring complaints about its performance ,but now gave in. Four defective coils had been shorted out on one set of coils and a complementary four out of six on the other side. These shorts were mainly to avoid high voltages during a field collapse and were made with large alligator clips. It was some surprise that poor contact in these unused groups of four caused field jumps of several gauss in 4 kgauss. Improving the contact with screwed clamps returned the field stability to 6 parts in one million.

Platform carpet.

Removable indoor/outdoor carpet was first used in the 14UD in July 1976 (4/5) to reduce the din caused by dropping pins and lessen the pattern of steel checker plate on various parts of the body. Its removal at each button-up was believed to reduce the amount of dust and debris left in the machine. Unfortunately, years of use and dry cleaning gave the carpet terminal dermatitis, leaving more junk in the machine than it prevented. Various styles and materials have been brought to the younger author and displayed for consideration as a replacement, only to be rejected after tests which usually included saturation with acetone and biting. The closest contestant was very similar in texture and appearance to the original carpet, which was

chosen by the younger author himself. It was comfortable to kneel on, when praying for guidance and it absorbed dirt, fragments of this and that, and very small screws which one wouldn't be able to find anyway. The new improved version flaked adhesive when folded, and was rejected.

Button-up

The column was cleaned with nitrogen and tacrags and then the tank was closed.

Initial performance.

During gassing up, volts were run up appropriately. At the first spark, metering on Chain 2 failed. Once at 85 p.s.i.a. the machine ran steadily at 13 MV, the shorting rods were put in for a low voltage run.

D. C. Weisser.

T. A. Brinkley

28th August 1985.

Enclosures:

Plots of particle masses accelerated, and operating terminal voltages.

NOTE: On the plot of terminal voltages we have drawn a horizontal line at 14 MV for easy reference to performance near the nominal voltage limit of the 14UD.

Photographs:
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1). Spark damaged shaft from Unit 2.

2). Snail tracks on shaft from Unit 22.

3). Redesigned tank cup.

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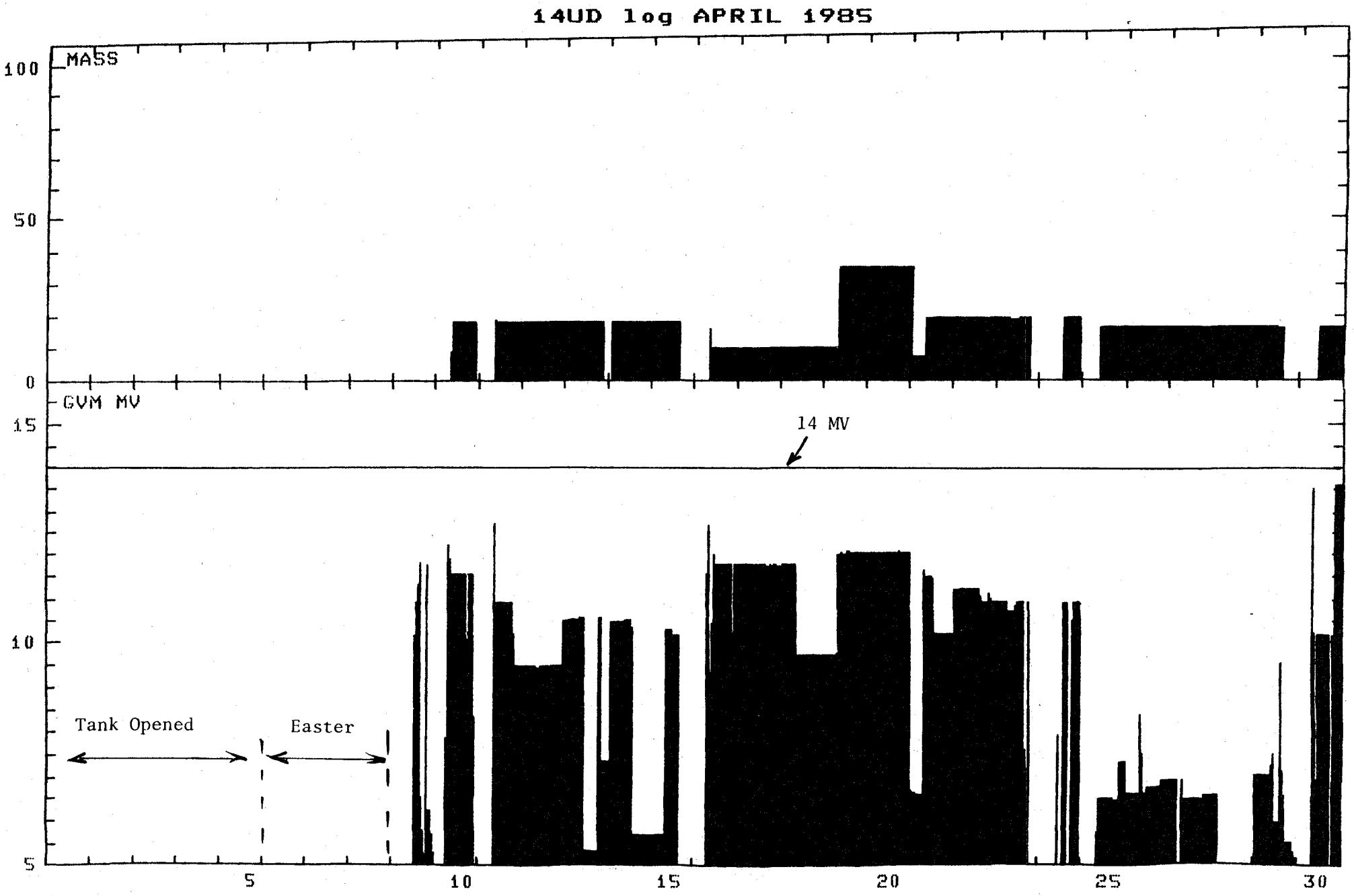
14UD log APRIL 1985
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14 MV
10
5
Tank Opened
Easter
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10
15
20
25
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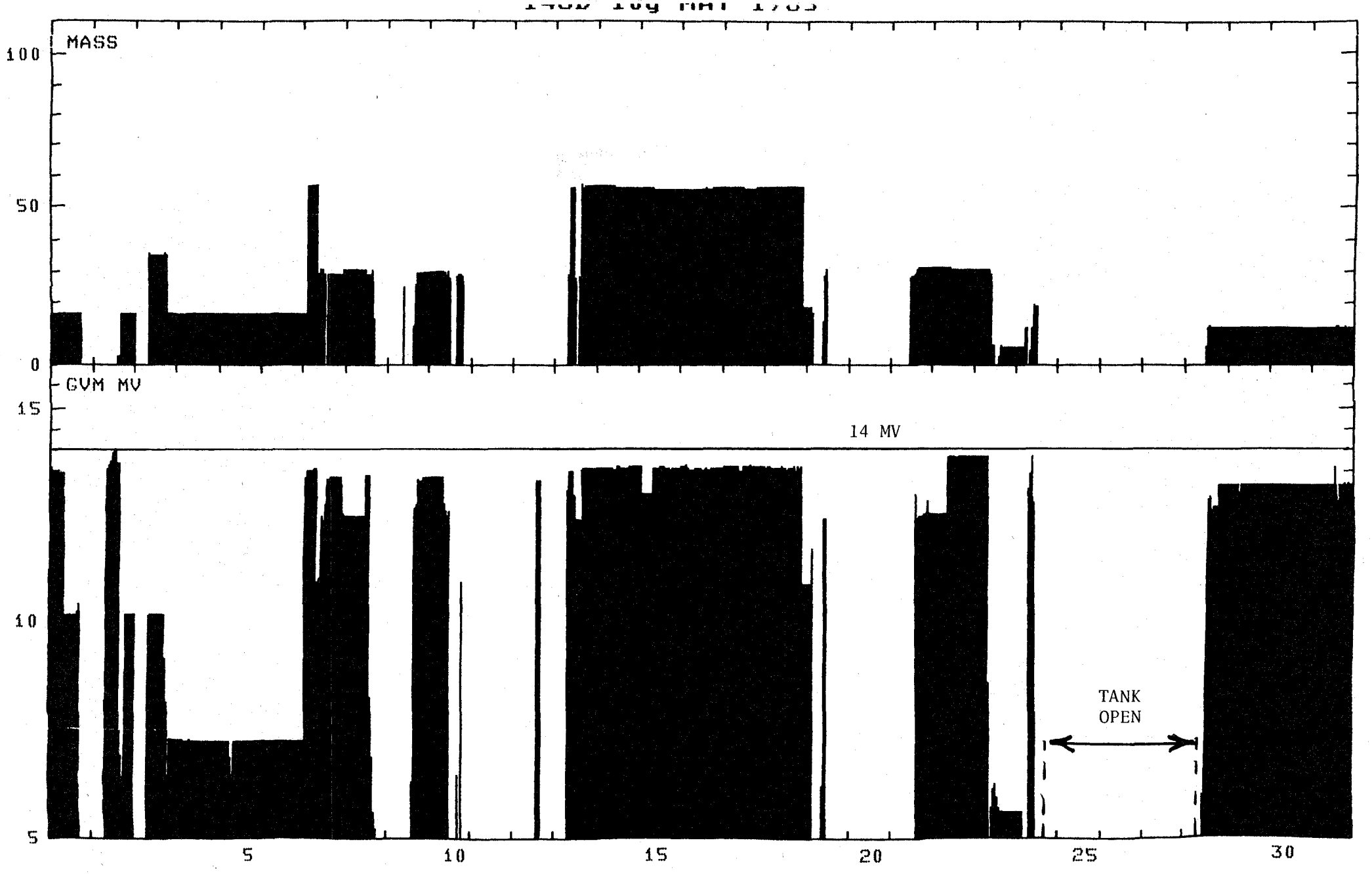
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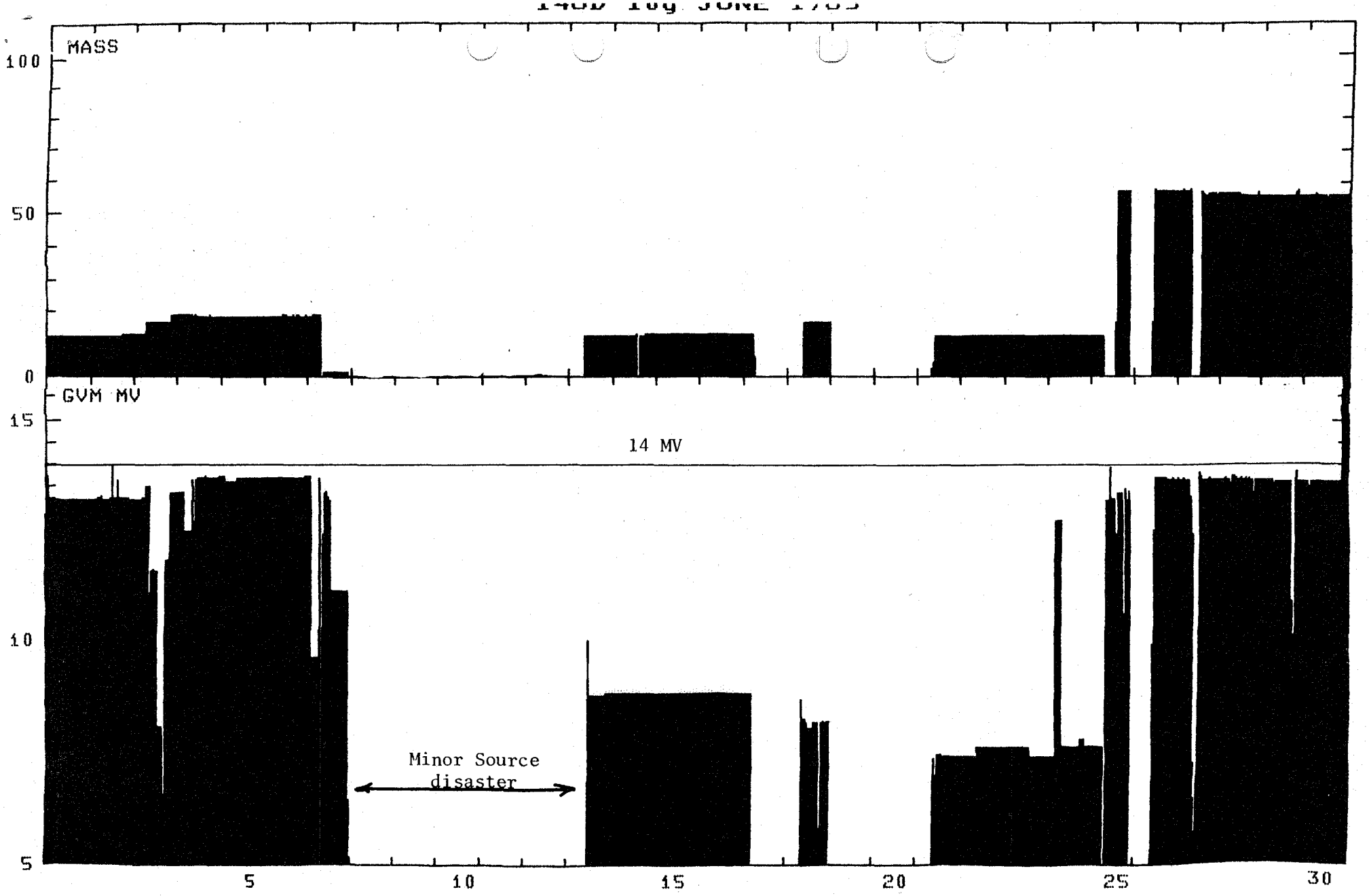
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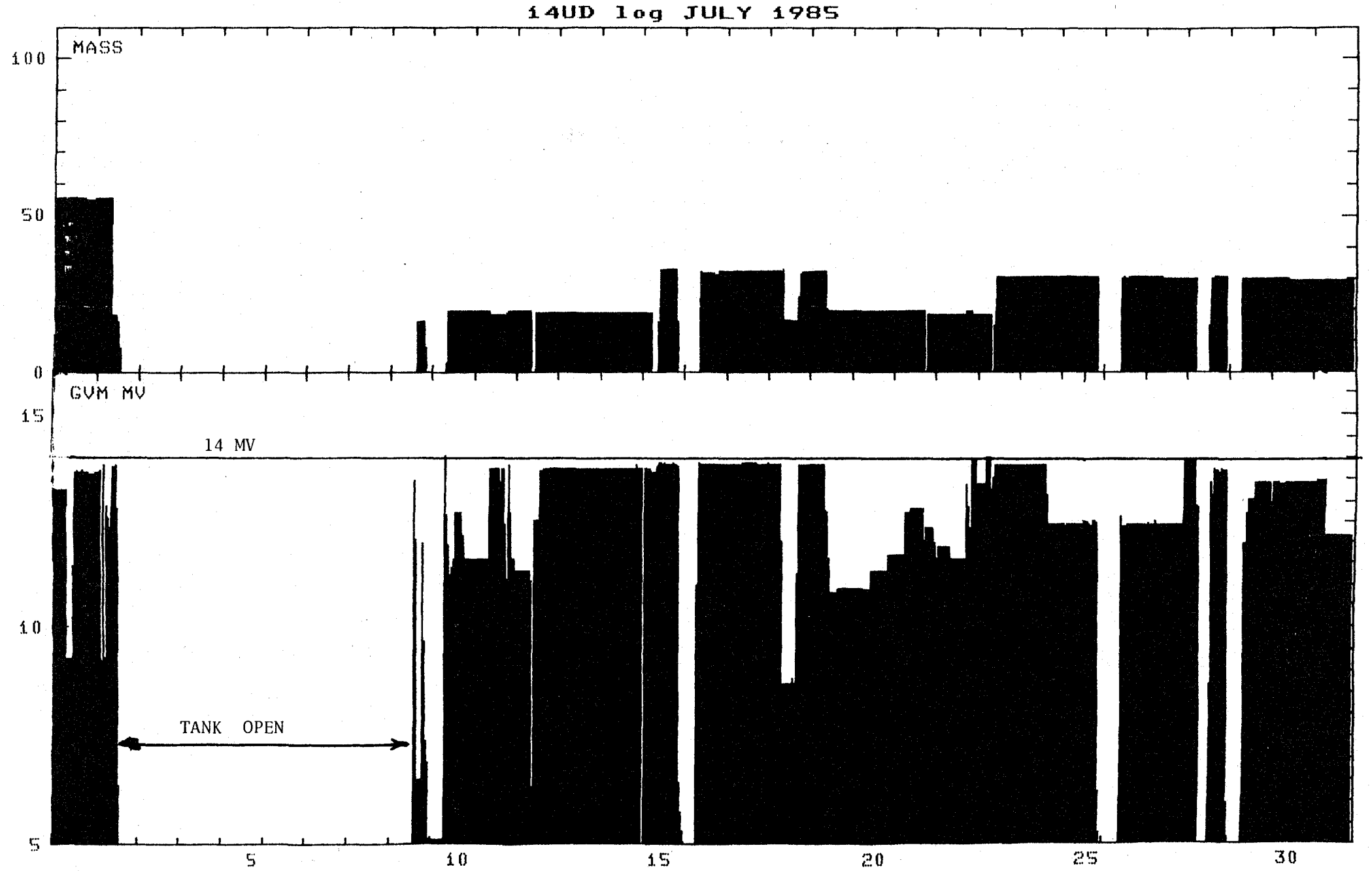
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GVM MV
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14 MV
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TANK OPEN
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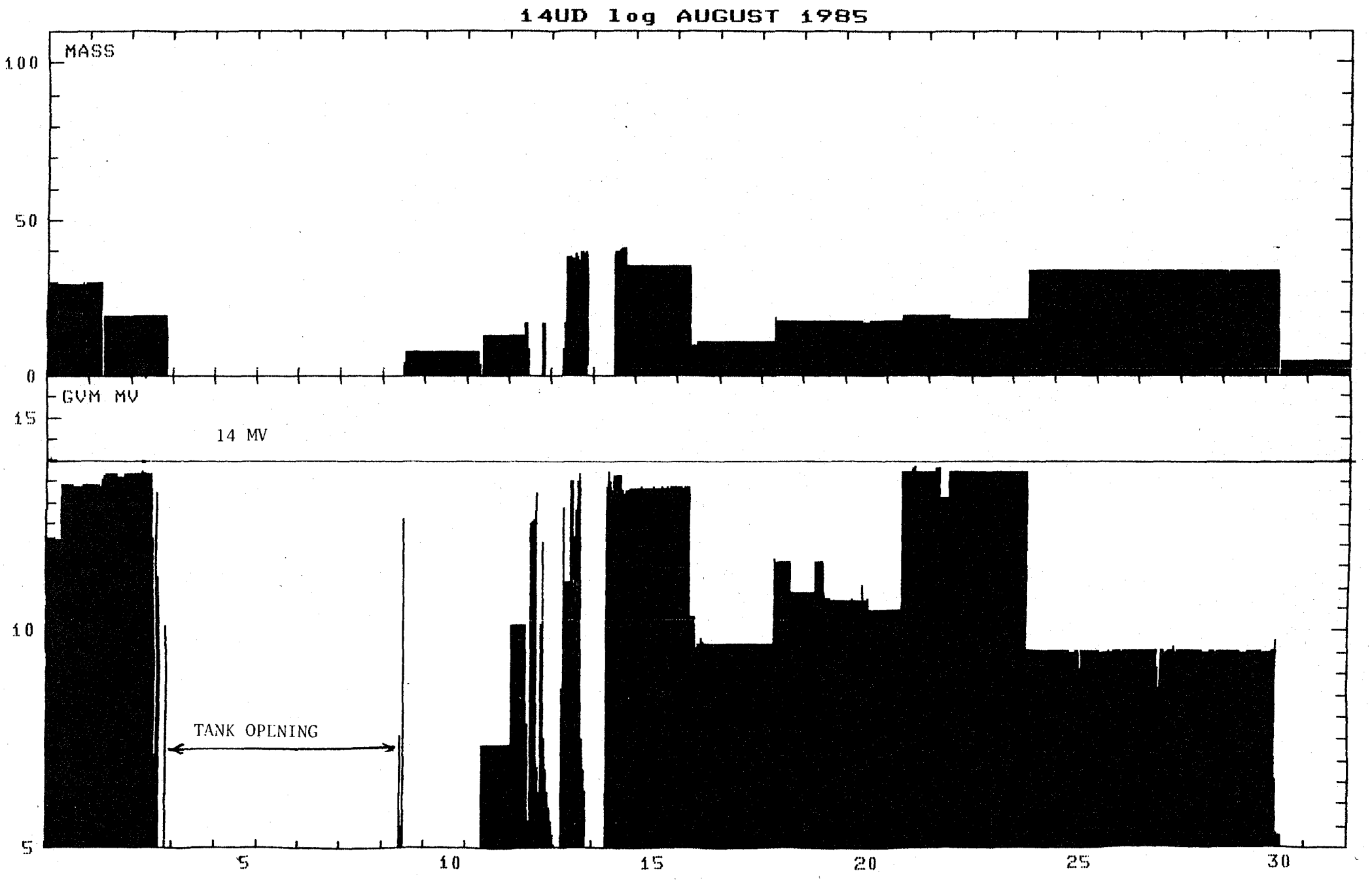
14UD log AUGUST 1985
MASS
100
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GVM MV
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14 MV
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TANK OPENING
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