AUSTRALIAN NATIONAL UNIVERSITY

DEPARTMENT OF NUCLEAR PHYSICS

14UD TANK OPENING REPORT No. 52

11th to 25th March 1986
(14 days open; 9 working days)

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

REASON FOR TANK OPENING

We had to renew foils, but were glad of the opportunity to carry out several other jobs.

PREAMBLE

The 14UD was last closed on 10th December 1985 and presented no problems with the early runs, settling into higher voltages when they were required. On January 9th, lost charge caused us to think about the overall situation with regard to the gas quality.

Breakdown products.

Lost charge of 23 microamps at 14 MV and 15 microamps at 12.8 MV were observed. The moisture level in the SF6 was found to be 21 p.p.m. at atmospheric pressure. While this is somewhat higher than the usual base of less than 10 p.p.m. it was thought not to be too high. The small recirculator had not been reactivated since the tank opening, so, more from superstition than science, it was valved off to be reactivated. By 11th January the lost charge at 12.8 MV increased from 15 microamps to 36 microamps; this with the small dryer still valved off. Unfortunately, the hydrolyzable fluoride detector detected NIL hydrolyzable fluorides.

Three and a quarter hours after the small recirculator was put back on line, the lost charge at 12.8 MV reduced to 13 microamps. After 44 hours it had reduced to 5 microamps. We concluded that the Vivalyme had lost its purification ability and we resolved to change it at the next tank opening. The freshly reactivated alumina would have to continue to bear the burden of purifying the gas until then. On 20th January lost chrge at 13.6 MV was 90 microamps. Now the classical poltergeist symptom was manifest; that is, the sum of the triode current plus the lost charge was a constant. Under these conditions, triode control of the terminal is impossible. One should expect, (and we later found), a substantial dark stain on the triode mushroom, a sure footprint of the poltergeist. The 6 atmospheres of SF6 in the large recirculator loop were discharged and the Vivalyme replaced with fresh material. The used Vivalyme had a very slight bluish tinge which should indicate it was exhausted. After 16 hours of recirculation and 12 hours of continued beam operation near 14 MV, the lost charge reduced to less than 4 microamps. The enclosed photographs show symmetric spit-soluble brown stains on both the terminal opposite the triode and on the triode mushroom. The terminal stain is the normal result of negative ion current to the terminal; the mushroom stain is due to b.d.p. positive ions: the poltergeist.

It is clear, as to be expected, that any purifying agent of b.d.ps has a finite lifetime. The charge of Vivalyme just removed gave us the first unambiguous measure of Vivalyme lifetime because the previous changes of Vivalyme were premature. A total of 65 kg of dry Vivalyme was exhausted by 440 milliampere hours of corona currents from the 14UD, or 6.8 ma.hrs/kg (dry Vivalyme), an amount which is 92% of the theoretical maximum of 7.4 plus or minus 1.05 ma.hrs/kg and well confirms the theoretical estimate. The Vivalyme charge was in use for 18 months during which time volts were on terminal for 7.7k hours.

When all is said and done, a machine operating like the 14UD should discard its purifying medium annually, whether it is needed it or not, just like Queen Elizabeth the First's bath. The concept is consistent with the recommendation of SF6 manufacturers, e.g. Allied Chemicals.

The figure quoted for integrated corona current per kilogram of dry Vivalyme is specific to the ANU 14UD. To apply it to other accelerators one must take into account that twice as much current flows through the 33 accelerator tube corona points than through the 18 column corona assemblies in each unit. The lifetime of a kilogram of dry Vivalyme for a single point is then (5.7 ampere hours)/kg.pt

It might be of some interest to know how much SF6 is broken down by corona. In the ANU 14UD, the rate of production of "active" fluorine is 0.045 gm/microampere hour. Over the 18 month, 440 milliampere hour life of the Vivalyme, 20 kg of "active" fluorine were produced. If each active fluorine comes from a different SF6 molecule, then

$[(32 + (19 \times 6))/19] \times 20 = 154$ kg is consumed, (3 bottles).

While this is a trivial fraction of our 30 tonne inventory, machines with enclosed corona systems could consume all the SF6 in such small volumes in a couple of days. The only way an enclosed corona system might reliably operate on SF6, and not a mixture whose properties are dominated by breakdown products, would be for it to employ many kilograms of a purifier such as Vivalyme and continuously top up with SF6.

There then followed a period of unusual idleness for the 14UD. The January long weekend, traditionally a holiday period, found no takers for the machine. There were three days of buncher tests, then the next week most of the experimenters defected to the AINSE conference. However, on 25th February there was an entry in the logbook which read: "Machine has run for a week at 13.5 MV". In the following week the lithex source was scheduled for one of our groups which continues to indulge its whimsical interest in the oldfashioned alpha particle; however, after fighting the lithex source for two days because of poor output, it was opened up to reveal a general mess and inadequate melting of the lithium which had not been properly washed free of paraffin. By the time the source was cleaned, reassembled and made useful again, the 5 scheduled days were at an end.

OPERATIONAL TIME.

During the 90 days since the last closure, the 14UD operated for 921 hours. Excluding the days for gas transfer (42/2) this was 43% of elapsed time, an abysmal all-time low for us which is explained, if not justified, in the preceding paragraph.

THE TANK OPENING.

The critical sniff, immediately on opening the doors, was made by the younger author, the older being disinclined to abandon other sampling tests which had begun in the darkroom. The atmosphere in the tank was pronounced to be quite acceptable.

Exploratory tour.

It was dirty inside the tank; there was considerable encrusted material on the backs of the column corona assemblies. For the first time we observed on the stabilizing triode mushroom a dusty brown stain heavy enough to scribble on with one's finger tip. This effect was accounted for by the lost charge problems reported in the preamble and is associated with stable positive ions in the SF6 which apparently do not show up as hydrolyzable fluorides. There was a white, powdery deposit on rings opposite the recirculator input. The filters on this system were checked and found to be leak free; however, they do not have sufficiently small pore size to eliminate dust associated with new Vivalyme. We promised ourselves to worry about finer filters, but we probably shall never get round to it.

And so to work!

CHARGING SYSTEM:

Chains:

Chain 2, in which cracks were found last time, was examined carefully, revealing a total of 8 new cracks in the nylon links, though all were contained in a length of about 6 feet. This phenomenon, of a string of cracks being confined to one section of a chain, has happened before when 16 cracks were found in a length of 58 pellets, (42/4). For the convenience of using removable links, rather than grinding off rivets, we replaced a length of 216 pellets with the same length from a chain retired because it had 3 cracked links.

New bearings were fitted on all charging pulleys, in the terminal and in the bottom of the tank.

We had received from NEC new "conducting and self-lubricating" tyres made of high molecular weight plastic. An earlier version of these was reported at SNEAP '85' by J. W. Stark of McMaster as already in use in their machine, persuading us to order a set. We took out all our 6 charging pulleys, fitted the new tyres and machined them, with the traditional groove in the centre. The pulleys were put back, without shimstock contact bands and all were aligned according to our recently established routine, (49/3,4). This time, however, we made a special jig which could be held across the steel column posts to pinpoint centres of the pulleys for precise chain position. With the new, sleek tyres on all pulleys, we descended on the chain oilers, a longstanding source of oil spattered over much of the H.E. column; they were dismantled and dumped gleefully outside the tank.

Howard Wallace, who had put a multimeter on the new tyres, said that he wasn't impressed with their conductivity. It was pointed out to him that a variety of things, such as contact area, had to be taken into account; the new tyres were known to work and he would be convinced when he saw the final charging tests. He had cleaned many an oily column post in the past and he would come to love the new tyres, which did away with oil. Next day the chains were run to see how they behaved on the new tyres. They looked good and there was certainly none of the undesirable selfcharge which the new tyres were intended to eliminate. Even more striking, perhaps, at the highest inductor volts we could push in air, there was no charging current at all!

With barely an instant's hesitation, the younger author raced through drawer after drawer of his well-known filing system for the notes he took at SNEAP '85. J. W. Stark had reported in his paper that McMaster's new black pulleys were conductive and required no oil for operation; but there was no clear statement that the new material eliminated shimstock contact bands. Scribbles about discussions with Robert Rathmell, of NEC, revealed that he had said the new pulleys gave no static charging and did not need oil; again, there was no reference to discontinuing contact bands.

After establishing for himself that the new tyres resolutely withstood 10 kV on the insulation tester, the younger author took full responsibility for interpreting that the new material did away with contact bands. He wrote in the logbook a handsome acknowledgement of his mistake, then he very politely asked the three technicians if they would mind taking all the pulleys out again, machining them and fitting shimstock. This was accordingly done and a quick test showed that normal charging currents had returned. Within only a couple of days everyone was speaking to everyone else again.

Unfortunately, with contact bands on, the new tyres displayed 6 to 8 microamps of self-charge and oscilloscope traces were consistent with need for oil. Not daring to pretend this wasn't really happening to us, there was a scramble for the rubbish heap to retrieve the cast out oilers. They were soothed, cleaned nicely and put back. We were roughly where we had started, with contact bands and oilers, following an amusing little week of discovery, involving scarcely more than three technicians full time on the pulleys. This, following the humiliation of having to put back the shimstock contact bands, led the younger author to telephone N.E.C. from whom he learned that the new tyres were certainly supposed not only to be self-lubricating to eliminate self-charge, but to have low resistance and conduct well enough to eliminate the need for contact bands. NEC said we were the first users to report these effects and it was clear that something was decidedly amiss with the latest batch of black plastic. The younger author then exultantly cancelled the record of his former contrition in the logbook.

Posts.

During the 'Post Mortem', (49/9), spark erosion had been found between the end electrode contact surfaces of various posts examined. This led to Alan Cooper's process of bonding these electrodes (51/2) on the four new posts put in last December (51/3). A further 8 new posts had arrived. We were ready to use these as the start of a systematic reconditioning of the entire column support system. The ends of the new posts would be removed and contact surfaces prepared; immediately before installing the bond would be coated on, the flanges pressed hard down on the ceramic and the post would be held in compression by the castings

before the bond began to cure. Unfortunately, this procedure could not be carried out; once the flanges had been unlocked and removed there was no means of applying sufficient force to get them fully down onto the ceramic. When interchanging posts, the castings can not be eased up nearly enough to allow installation of posts not fully "compressed". Happily, we had not bonded the first post before trying to get it in, but compared it with a fixed gauge of precisely the length of a post. The discrepancy was a matter of millimetres, obviously far too much to be accommodated by raising the casting so that the post could be slipped in. We left the old post where it was and abandoned plans for changing any posts at this tank opening.

We made a press (photograph) in which newly bonded posts can be "bottomed" and left under heat to cure. Old posts removed will be shotblasted, have ring seats repaired and be bonded, cured and returned to service. Eventually, the entire column will have posts which are electrically and mechanically sound and we shall have a small standby supply of posts to put in when the need arises. Lack of such replacements has often made us close the machine in the past with part, or even whole units shorted out.

Idlers:

Nothing seemed wrong with any of the stabilizing idlers and all were left as they were, without adjustment. The contact springs on the d.c. idlers in the terminal were replaced, where they had failed, with a new type of spring which we believe will last longer as it has no sharp bend to weaken it during manufacture.

Foils.

Foils were changed in both terminal and second strippers. So far as the one in the terminal was concerned, the inviolable, definitive number of positions somehow was misinterpreted. The number was checked once more and found to disagree by two positions with the spaces on the foil chain. A new number, denoting the number of foil positions as 280 frames plus 4 empty positions, was accepted absolutely and finally, for the time being.

Shafts.

All the remaining original perspex shaft sections were removed from the H.E. column and replaced by new ones made from perspex supplied by N.E.C. and machined at A.N.U.

Points.

As mentioned earlier, heavy, solid deposits were noticed on the backs of the column assemblies. Beyond noting this, all we did to the point assemblies was to straighten one or two which had drooped.

MISCELLANEOUS

Level 5 isolation valve.

This is a pneumatically operated flap valve which is triggered by a variety of trips and protects the accelerator from all sorts of vacuum disasters which occur in the source room. For a very long time, this has leaked badly, in spite of being dismantled and serviced many times. With the machine off for the tank opening we took the opportunity to have yet another try. This time the younger author contemplated the inner workings of the valve as some contemplate eternity. He exclaimed: (older author quotes) "But the @#%$&"*! flap hasn't been fully opening!" The @#%$&"*! flap was, accordingly, set properly and the valve put back into position.

Inside nylon insulators.

Two years ago we reported internal failure of nylon inductor insulators, deep enough for the damage not to be visible from outside, (43/5,6; 44/3). The photographs enclosed with Report 43 showed the effect dramatically. Recently we needed a half inch nylon stud and set about making it in the lathe from an old, retired shorting rod. When the three-quarter inch rod was turned down to half an inch we could plainly see blackening deep in the rod. When cut open, a distinct black line, characteristic of electrical breakdown, ran straight through the rod. The mark occurred two and a half inches from the end of the rod and was an inch and a half from the bottom of the tapped hole into which the next rod screws. We no longer trust nylon insulators further than we can see into them.

Cleaning.

There was a massive cleanup of H.E. castings, using acetone and alcohol to get rid of the oil from casting surfaces and post electrodes and ceramics. So much was involved that, on this occasion, the students who are traditionally rounded up as willing volunteers were allowed to hide in their corners and believe they had escaped by their own initiatives. The column was cleaned and closed by technicians. The younger author, whose skill and style with a nitrogen jet have long been admired in action, blew and checked the column for two hours himself; he found only one ring screw badly set on its post. This was a very good score.

Initial performance.

The machine went easily to high voltage and we found that eerie stability was back with us. We wondered if this was related to the fact that only technicians had worked on cleaning and closing the column.

We were soon up to full volts and the machine ran steadily at 13.6 MV for 9 days on end.

Transmission was seen to be distinctly improved since our adjustment of the gate on the Level 5 isolation valve; in addition, low energy

steering was now nearly neutral after 5 years of excessive bias.

D. C. Weisser.

T. A. Brinkley

14th April 1986

FREE GIFT
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We mentioned in TOR 50 that we had planned to include an index as a special commemoration of the 50th report, but it was not finished in time. An index covering most of the matters of special interest has been prepared since then and is included separately with this report.

Enclosures:

Index for reports 1 to 51 inclusive.

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). Stain on terminal.
2). Stain on triode mushroom.
3). Ball-Cooper device for compressing post electrodes.

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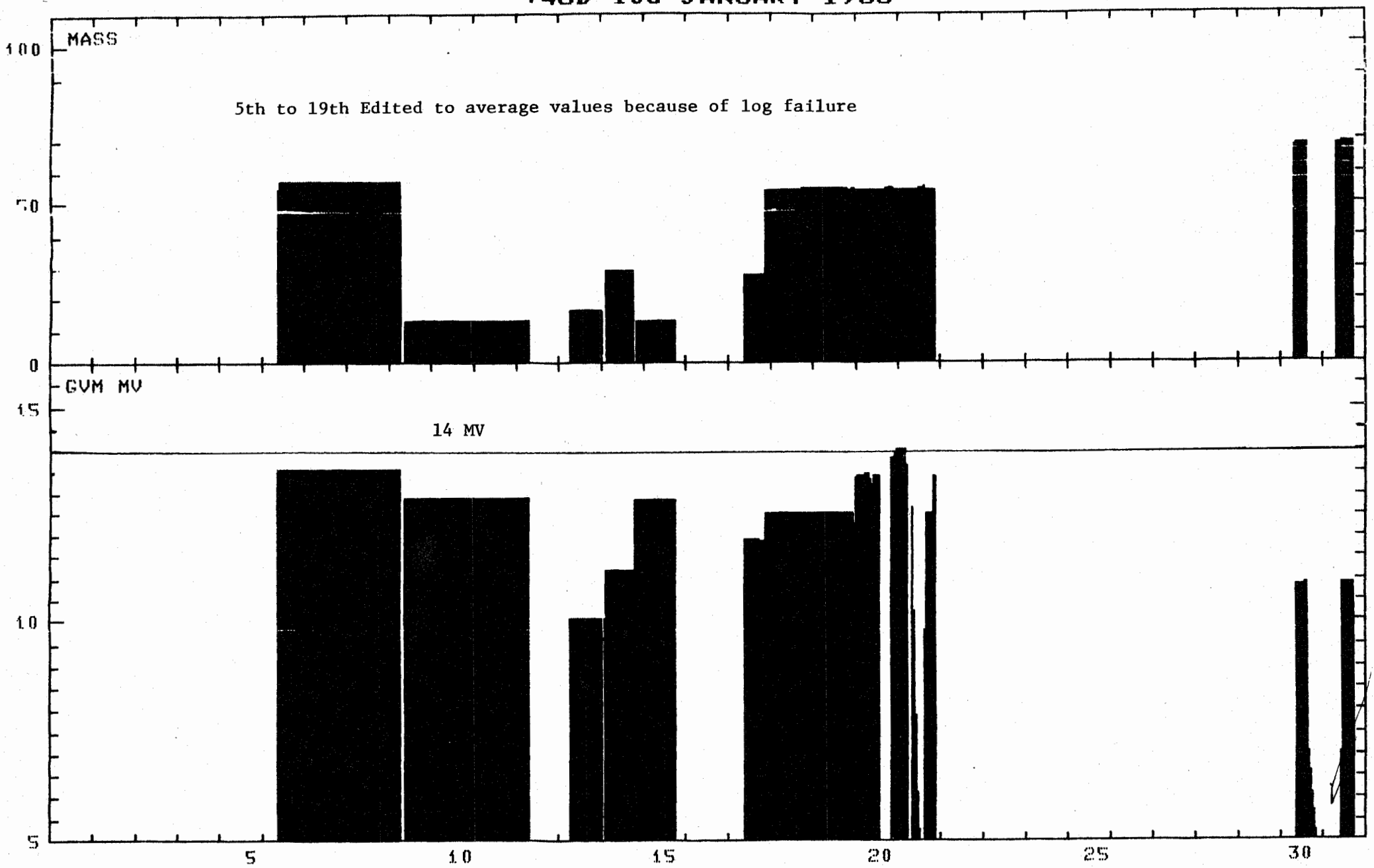
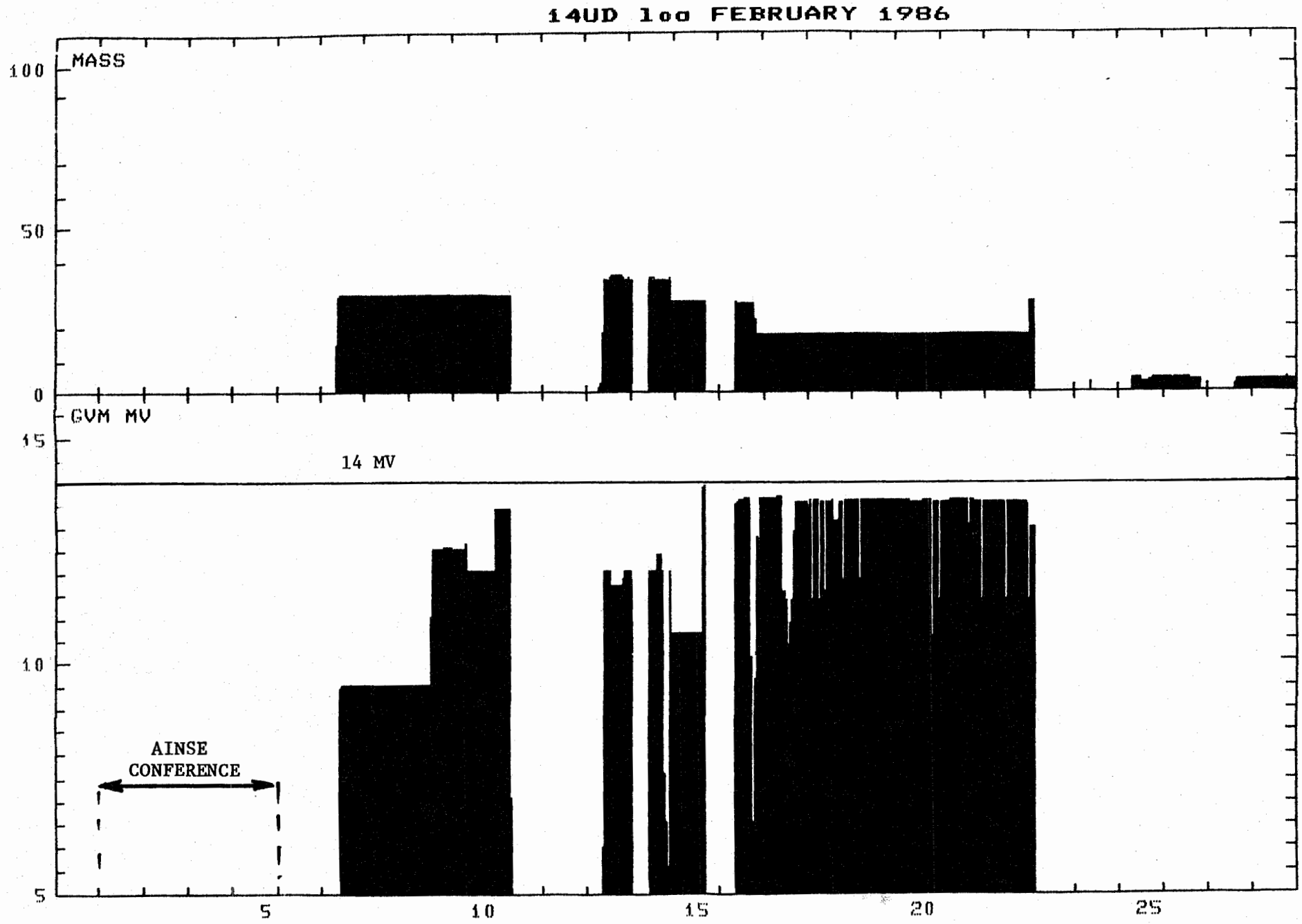
14UD 1oa JANUARY 1986

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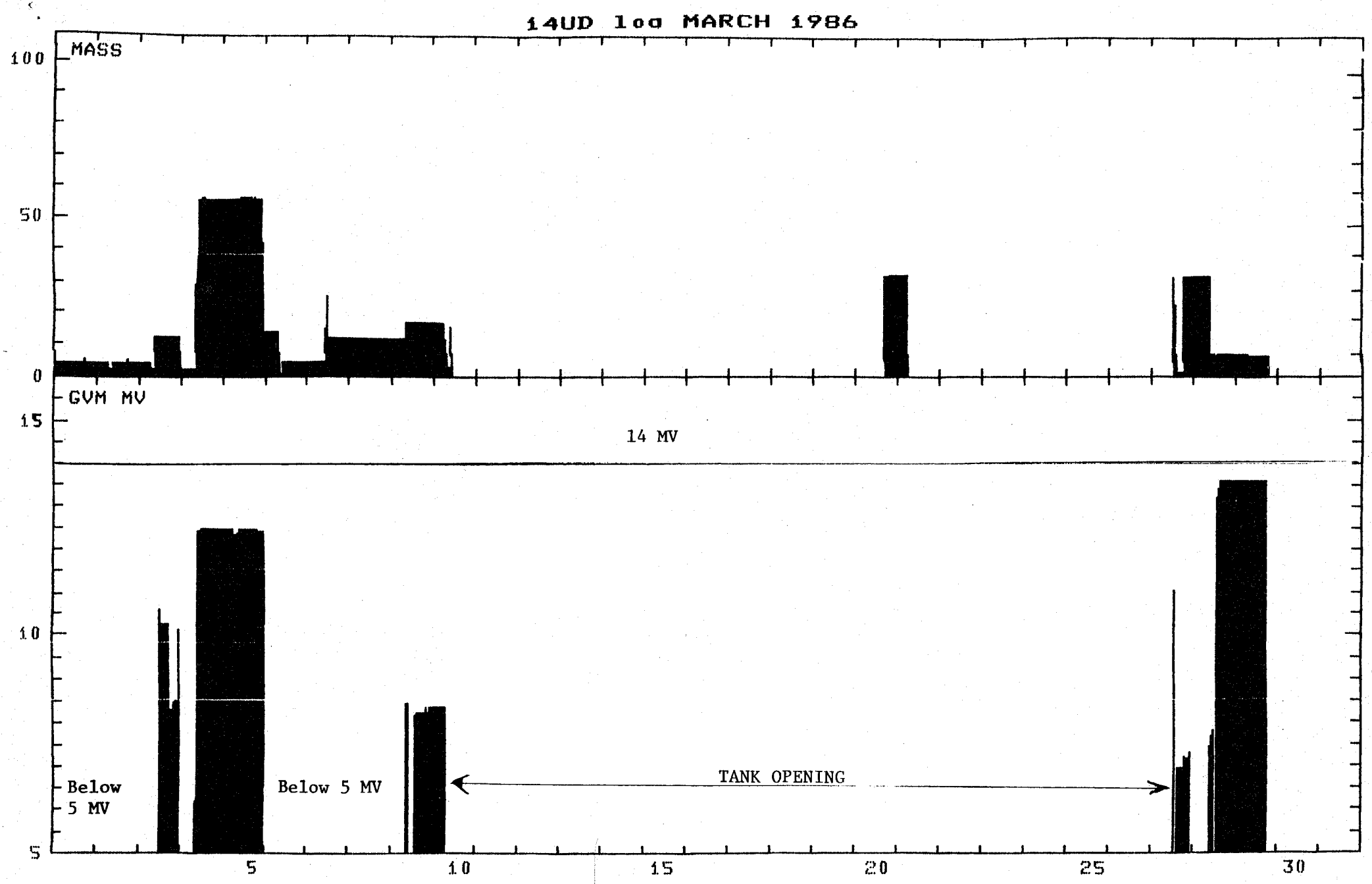
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