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AA MACHINE EXPERIMENT NEWS

Summary of Period 4 : 13th September to 7th October 1983 and ME Meeting on 4th October.

This period started with a 14-day ME session broken only, at least in the planning, by a 36-hour PS MD around the 22nd September. In practice an additional 48 hours were lost as a consequence of the 18kV supply failure during the afternoon of the 19th September. Nevertheless, a total of ten experiments were performed including five major ones, namely: trials of the Fermilab lithium lens and a CERN pulsed-current target, precooling with new ferrites, HF cooling with a new filter arrangement and studies on an intense proton stack.

Fermilab lithium lens

The standard copper target and horn arrangement was replaced for this test by the combination of a shorter tungsten target and a 15cm long, 1cm radius lithium lens, which was described and explained in excellent fashion by G. Dugan at the PS Seminar on the 14th September (copies of transparancies from E.Jones). The purpose was to try out the Fermilab lens under full operating conditions and to compare calculated predictions of the antiproton yield into the AA with measured performance. Due to heavy rain infiltrating into the target area during the tests, the lens was subjected to particularly severe conditions of operation.

The result on performance was a maximum measured yield of 8.9 E-7 antiprotons per incident proton; 1.4 times the best yield with the standard target and horn - measured at the end of the same ME period. The absolute yield into a reduced acceptance of 40 pi mm mrad in each transverse plane was within 12% of the predictions, whereas into full acceptance the measured yield was 40% down on the estimates, a reflection of the previously observed depletion in our antiproton distributions at large betatron amplitudes.

The lens withstood repeated pulsing every 12 s for short periods with up to 6 E12 protons on target, but the coaxial transformer failed during tests prior to a scheduled run at full repetition rate. This is now attributed to a combination of humidity and slight over-voltage. The experiment was thus curtailed before the full optimisation, including tests with a copper target, had been completed. An ME Note is in preparation.

Pulsed-current target

This was the third test in the experimental program to optimise the yield from a conducting target placed upstream of the horn and connected electrically in series with it. On this occasion the copper target diameter had been reduced to 3mm and its position with respect to the horn optimised by computation. The target had an overall length of 100 mm with an effective length (region of high current density) of 88 mm. It was contained by concentric graphite and alumina cylinders, which incorporated nitrogen gas-cooling channels.

After some preliminary tests to set the best target/horn current, a fairly long session was devoted to optimising injection conditions into the AA, including varying the injection line matching downstream of the target. This eventually gave yields of 9.2 E-7 antiprotons per incident proton, 1.5 times the standard yield. Yields were higher at low proton intensities (corresponding to one Booster ring only) and lower at full intensity from all four Booster rings. The quoted result was for primary beams in the range 5 E12 to 9 E12.

Changing to air for cooling instead of nitrogen, with the consequent risk of problems from oxidation, the pulsed target was used for production with a PS supercycle giving 3/6 cycles to the AA. A stack of 2 E9 antiprotons was produced before the target/horn failed. The cause of the failure has not yet been investigated.

Future target area developments

These gains in yield cannot be immediately applied to AA operation. The two main reasons are that the devices have not yet stood up to prolonged tests and, being designed for a much more limited operational program, our target area is not suitably equipped to handle them, particularly the difficulties caused by induced radioactivity. We are now proposing to make provisions for a lithium lens and conducting target to become operational in January 1985.

Precooling with new ferrites

During the shut-down preceeding this ME period, all of the type 4E2 ferrites in the precoolong pick-ups were replaced by type 4E3 material, which has a higher Q and lower relative permeability. This gave a gain in signal to noise in the 300 to 500 MHz band and a loss below 300 MHz. After some correction to the phase response over the whole band, the precooling performance was seen to be significantly improved, permitting capture into a 420 Hz bucket instead of the previous 600 Hz.

Some parasitic signals fom the stack were subsequently observed on one third of the pick-up structure. These could possibly limit stack intensity but a remedy is in hand. A discussion on the replacement of the precooling kicker ferrites, which would be redundant if the ACOL project were accepted, led to a postponement of the decision until the end of this year by which time the choice may be clearer.

New HF filter

In ME Note 68 we explained that despite some important gains in the performance of the HF cooling systems, the horizontal system interfered with the stack tail and had to be switched out during stacking. The differences between vertical and horizontal systems remain a bit of a mystery but the latter has now been considerably improved by the use of a new composite transmission-line filter designed by C.Metzger. This permits the phase to be correctly adjusted in the regions of the sidebands at 1.5 GHz with some remaining mismatch at the limits of the band.

The horizontal emittance now cools faster than the vertical and we have seen a 95% emittance of just over 1 pi mm mrad after 1.5 h cooling of a stack of 6 E10 antiprotons. Further work on improving the quality of the coaxial cables used in the filter or simply adding delay equalizers plus a temperature controlled environment will improve this performance even further. The possibility of using superconducting cable is also being considered.

Intense proton stack

S. Van der Meer devised a novel method to produce a record stack of 1 E12 protons by adding to the low frequency side of a modest proton stack, monitoring the HF momentum cooling power and, on the spectrum analyser, the stack intensity at the deposit frequency, adding more protons (with the cooling temporarily off) whenever the power and the local intensity fell below a set level. The loss rate was less than 3 E8 p/h for a stack of 5 E11 protons rising to 2 E11 p/h with 1 E12 in the stack. Emittances of the intense stack were around 7 pi mm mrad in both planes after one hour of cooling and still decreasing. A 300 Hz bucket captured 2.6 E11 from the core of the 5 E11 stack and 4 E11 from the final stack. This corresponds to a performance beyond that given in the AA Design Report. Unstacking and restacking three times gave little loss with nothing remaining on the injection orbit at the end and only slight dilution of the stack density.

However, all this was done with the LF stack tail system off. When switched on with maximum attenuation the tail system was just stable, but it became irreversibly unstable when the attenuation was reduced by 1dB. The stack tail system presently limits us to stacks of 5 E11.

Another observation was a transverse instability attributed to trapped electrons on account of the appearance of the f(n-q) lines in the range 32 to 34 MHz, the frequency jumping down as the stack intensity increased. The transverse damper bandwidth should be increased to deal with this instability. It would not occur for antiproton stacks.

With the cooling off, intrabeam scattering was observed to give blow-up longitudinally and horizontally but not vertically. This accords with the theory but the rates appear to be in disagreement with the Piwinski theory by a factor of about two

Amplitude distributions and linear coupling

Using an injected beam of 5 E8 protons (reverse polarity), proton amplitude distributions measured by the scrapers 1302 and the counters (the method employed for antiprotons) were compared with distributions obtained using the same scrapers and differential measurements of the circulating beam as seen by the beam current transformer. The two were found to agree rather well. Some preliminary distributions in x and y simultaneously were attempted using the scrapers in the dispersion region 2102. The dispersion is a handicap but these are the only scrapers that allow this type of measurement. Done on a precooled antiproton beam they could give useful information on the particle population of the corners of the aperture.

Linear coupling was studied by the beam transfer function and adjusted using the skew quadrupole and the tilt of the normal quadrupole QFN24. Although not entirely eliminated, the coupling was reduced more than can be achieved by the skew quadrupole alone. This was done on the injection orbit and a gain in yield of 12% seemed to result. However, the setting of the skew quadrupole is usually found to be different during stacking, when it is optimised with respect to Missing Factor. Correction over the whole momentum aperture will require some higher order multipole.

Unstacking for LEAR

Durind the LEAR production run unstacking in 10 Hz buckets was attempted and gave some initial difficulties. These were later overcome and unstacking in a 10 Hz bucket immediately after stopping stacking was found to give a beam of 2.6 E8 from a stack of 1.4 E10 antiprotons. Transverse 95% emittances of the unstacked beam, measured on the ejection orbit, were 1.5 to 2 pi mm mrad.

Reported by C.D. Johnson