PS/AA/JPR/ip
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AA Long Term Note 3

Summary of the meeting of March 9, 1982

Present : G. Brianti, V. Chohan, L. Evans, F. Ferger, J. Gareyte, W. Hardt, L. Henny, C. Johnson, R. Johnson, E. Jones, H. Koziol, P. Lefèvre, S. Maury, C. Metzger, S. Milner, D. Möhl, P. Pearce, F. Pedersen, W. Pirkl, A. Poncet, K.H. Reich, L. Rinolfi, J.P. Riunaud, C. Rubbia, K. Schindl, J.C. Schnuriger, R. Sherwood, P. Sievers, A. Sullivan, C. Taylor, L. Thorndahl, H.H. Umstätter, S. van der Meer, E.J.N. Wilson

Absent : B. Autin, R. Billinge, G. Carron, B. Szeless

Basic limitations in the cooling of the present Antiproton Accumulator, by S. van der Meer, was the only topic on the agenda of the meeting.

S. van der Meer mentioned the main limitations which may affect any cooling system, indicated which of them is preponderant in each of the 7 cooling systems of the AA and, whenever possible, how to overcome them.

1. Cooling is a rather complicated subject, and in the several cooling systems of the AA many parameters interfere with each other.

   In the basic principle of cooling, a single particle is detected in a PU and corrected later-on through a kicker. Cooling speed increases with the gain of the system, but in practice there are several limitations:

   - Not only one particle generates a signal, but all other surrounding particles do so and generate a Schottky noise proportional to the particle density.

   - Electronics in the amplification chain introduces thermal noise (usually called amplifier noise, although other sources may contribute) which leads to a noise density at the frequency one wants to cool.

- Both noise sources may directly limit the cooling rate; an additional lower limit may also come from the finite power available at the correctors (kickers).
- Many other effects can also act on the cooling speed: bad mixing, intrabeam scattering, mixing between PU and kickers, etc.

2. Respective limitations of the 7 cooling systems of the AA were presented:

2.1 Precooling

As beam (and Schottky noise) density increases during precooling, the gain of the system has to be lower at the end than at the beginning. Therefore, precooling is split in 2 consecutive phases. Both of which are limited by the power amplifier noise, but at the end of phase 2, as the density has significantly increased, cooling Schottky noise starts to become important.

Better ferrite in the precooling pick-ups and kickers could improve the signal response and therefore reduce this power amplifier noise. Cryogenic cooling of the pick-up might perhaps also help.

2.2 Stack Tail Cooling

The stack tail cooling doesn't seem to be worse than expected. But as the precooled beam is still wide in energy spread, a rather large RF bucket area is needed to trap it and during deposit some particles of the stack tail are phase-displaced and swept away from the stack tail cooling range.

The stack tail Δp cooling is limited by the Schottky noise (fundamental limitation) but 2 other effects introduce interference with the stack core system.

(i) the output of the stack tail system contains a wide spread of frequencies, and even frequencies in the stack core range. Therefore, a filter is introduced to attenuate the noise within this range;

(ii) in the centre of the stack tail cooling range the phase is right, but gets worse on both ends, in particular in the region where it overlaps with the stack core system. If the gain of the stack tail cooling is too high, cooling can be cancelled in the overlap region and can even turn to heating.

- Transverse stack tail cooling is limited by cooling amplifier noise.

2.3 Stack Core Cooling

The stack core cooling is limited by the cooling Schottky noise (fundamental limitations).

For the stack core Δp cooling it is difficult to have a good phase response and constant loop gain over the whole frequency range. The problem is aggravated by a filter that is needed to suppress interference from the stack tail and precooling systems.

Moreover, differences in flight time dueto differences in momentum give rise to phase differences which are difficult to compensate.

- In the vertical stack core cooling a 45^0 error in betatron phase shift between PU and kicker has been noticed. This has been partly compensated by a special filter designed by L. Thorndahl.
- In the horizontal stack core cooling the betatron phase shift appears to be right, but the PU is not in place where $\alpha_p = 0$. This results in interference from longitudinal Schottky signals coming from particles in the stack tail. The pick-up could be placed in a region where $\alpha_p = 0$, but in this case the phase shift would be wrong and would also have to be compensated by a special filter.

Limitations acting on the different cooling systems are summarized in the table below:

Limitations on the gain		Precooling		stack tail			stack tail		
		1	2	Δp	V	H	Δp	V	H
Effect on cooling	Schottky noise		X	X			X	X	X
	amplifier noise				X	X			
Power Limitation	Schottky noise								
	amplifier noise	X	X			X			

3. Discussions following the talk led to the conclusion that improvements could be made in two directions:

   (i) Improve the precooling by either using a better and less lossy ferrite or a new type developed by Philips, cooled in liquid nitrogen (cost $\sim$ 1.8 MFS).

   (ii) Improve the stack tail cooling to cope with the precooling as it is: shift its frequency range to 1-2 GHz, but then mixing between PU and kicker would become important, due to the long transit time, and the PU should be split in several parts and treated in independent chains.

   With such a system a gain of a factor 16 in the stack tail cooling may be expected, but there are several aspects that need more study (e.g. how to make the filter lines good enough for this frequency range).

These improvements could lead to faster stacking rates (rather than bigger stacks) and therefore to a higher integrated luminosity in the SPS, provided that higher pulses of antiprotons could be supplied.

S. van der Meer pointed out that although he is optimistic in increasing cooling efficiency with these improvements, none of them can be implemented without money and manpower.

J.P. Riunaud

<u>Distribution:</u> Persons present + absent
PS Group Leaders
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