



BNL-104527-2014-TECH

AGS/AD/Tech Note No. 94;BNL-104527-2014-IR

A NOTE ON DEUTERON ACCELERATION IN LINAC AND AGS

T. Sluyters

June 1972

Collider Accelerator Department
Brookhaven National Laboratory

U.S. Department of Energy

USDOE Office of Science (SC)

Notice: This technical note has been authored by employees of Brookhaven Science Associates, LLC under Contract No.AT(30-1)-16 with the U.S. Department of Energy. The publisher by accepting the technical note for publication acknowledges that the United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this technical note, or allow others to do so, for United States Government purposes.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or any third party's use or the results of such use of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof or its contractors or subcontractors. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

Accelerator Department
BROOKHAVEN NATIONAL LABORATORY
Associated Universities, Inc.
Upton, New York

AGS DIVISION TECHNICAL NOTE

No. 94

Th. Sluyters
June 8, 1972

A NOTE ON DEUTERON ACCELERATION IN LINAC AND AGS

E. Courant recently brought to my attention that deuterons accelerated in the new 200-MeV linac, perhaps do not reach its final relativistic energy of 80 MeV due to unfavorable energy gains across the accelerating gaps in the later linac tanks.

With the formula for the transit time factor¹:

$$T \times R = \frac{\sin n\pi g/L}{ng/L} \times I_0 (k_n a)$$

the energy gains of protons and deuterons were compared at the entrance and exit of each tank. Table I shows the results.

For proper acceleration of deuterons the (T x R) for deuterons should be half or more than (T x R) for protons. These ratios are summarized in Table I.

The following general conclusions seem to be valid.

a) Acceleration of deuterons up to 30 MeV will not impose a significant change from the procedures of proton acceleration.

b) Acceleration of deuterons from 30 to 80 MeV is limited by the available rf power in each tank; acceleration "off" stable phase is quite possible, but it might affect the final energy spread. The practical limit of deuteron acceleration in this energy range has to be measured. The quadrupole fields and bending magnets have to be reduced accordingly.

How will this lower final energy of the deuterons affect acceleration in the AGS? The maximum frequency range of the new rf cavities is 2.3 to 4.8 MHz.

In this frequency range the lower energy limit of the deuterons seems to be 67 MeV ($\beta = 0.26$, see Table I). Hereby we assume to accelerate deuterons using the 24th harmonic to 4.8 MHz and then the 12th harmonic to the final energy.^{2,3} It is, however, unlikely that we can reach this energy!

What will happen if we can only accelerate up to 40 MeV deuterons? A possible procedure is to leave one "old" rf cavity in the ring (operational frequency range 1.4 to 4.5 Mc). The 24th harmonic of this cavity will accelerate deuterons of 40 MeV energy until they reach the lower frequency range of the new system. If the frequency range of the "old" cavity reaches indeed 4.6 or 4.8 Mc, the deuteron beam can be recaptured by the 12th harmonic ($f = 2.3$ Mc) of the new cavity.

Another possibility is to start with the 36th harmonic of the new cavities until the deuterons reach the frequency limit of $f = 4.8$ Mc ($\beta_D = .364$). Then it jumps back to the 24th harmonic until the deuterons reaches again the frequency limit of 4.8 Mc after which a third tuning back to the 12th harmonic will finally accelerate the deuterons to the energy of 30 BeV/c. Though this procedure seems to be more complicated compared with the first solution, it has the advantage that it needs only one tuning system.

-
1. E. Courant, Linear Accelerator Conf., 1962.
 2. J.G. Cottingham, AGS Div. Tech. Note No. 86, 1971.
 3. A.M. Baldin, et al., Dubna, p. 9-5442, 1971.

Distr: Dept. Admin.
Accel. Dept. Scientific Staff

(transit time factors for protons and deuterons)

Tank		g/l	a (cm)	$T_{H^+} \times R_{H^+}$	$T_{D^+} \times R_{D^+}$	$\frac{T_{D^+} \times R_{D^+}}{T_{H^+} \times R_{H^+}}$	H ⁺ Energy (MeV)	D ⁺ Energy (MeV)	β_{Deuteron}
T ₁	in	.21	2.0	0.73	0.31	0.42	.75	.37	
	out	.31	2.5	0.83	0.42	0.50	10.42	5	
T ₂	in	.20	3.0	0.87	0.62	0.70	10.42	5	
	out	.31		0.84	0.45	0.53	37.54	18	
T ₃	in	.30	3.0	0.84	0.48	0.57	37.54	18	
	out	.36		0.79	0.33	0.41	66.18	30	
T ₄	in	.37	3.0	0.78	0.30	0.38	66.18	30	
	out	.41		0.74	0.21	0.28	92.55	41.5	0.207
T ₅	in	.37	4.0	0.78	0.30	0.38	92.55	41.5	
	out	.40		0.75	0.23	0.31	116.54	50	0.227
T ₆	in	.40	4.0	0.75	0.23	0.30	116.54	50	
	out	.42		0.73	0.18	0.25	138.98	58	0.245
T ₇	in	.42	4.0	0.73	0.18	0.25	138.98	58	
	out	.44		0.70	0.13	0.18	160.53	66	0.259 (f=1.14Mc)
T ₈	in	.44	4.0	0.07	0.13	0.18	160.53	66	
	out	.46		0.68	0.084	0.12	181.01	73	0.271
T ₉	in	.46	4.0	0.68	0.084	0.12	181.01	73	
	out	.47		0.67	0.061	0.09	200.30	80	0.283

$$T_{H^+} = \frac{\sin \pi g/L}{\pi g/L}$$

$$T_{D^+} = \frac{\sin 2\pi g/L}{2\pi g/L}$$

$$R_{H^+} = \frac{1}{I_0(k_1 a)}$$

$$R_{D^+} = \frac{1}{I_0(k_2 a)}$$