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The AGS Gauss Clock Reproducibility Test

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Reported by W. Weng

Subject The AGS Gauss Clock Reproducibility Test

OBSERVATIONS AND CONCLUSION

Purpose: To monitor the AGS Gauss Clock reproducibility from pulse to-pulse, calibrated by a high precision Direct Current Current Transformer.

Concept and Equipment Review

For ISABELLE injection, it is required that the beam energy from the AGS from pulse to pulse stays within one part in 10^4. In a synchrotron, the beam energy is determined by any two of the following parameters, average radius, revolution frequency, or the magnetic field. We choose to use the field and frequency as independent variables, then the uncertainty of momentum can be related to that of field and frequency in the following way:

$$\frac{\delta P}{P} = -\frac{1}{\eta}\frac{\delta f}{f} + \frac{1}{\eta\gamma_{tr}^2}\frac{\delta B}{B} \approx -78.43\frac{\delta f}{f} + \frac{\delta B}{B}$$

Before extraction, the AGS rf frequency will be locked to an outside oscillator. Assuming perfect frequency control, then the 10^{-4} momentum reproducibility turns into a 10^{-4} field reproducibility requirement in the AGS.

The field of the AGS main magnet is monitored by a pick-up coil inside the gap of Magnet 242 and then through a voltage-to-frequency converter (VFC) sending out digital counts--so called Gauss Clock. Whenever the Gauss Clock reads a preassigned number, it triggers the reading of current through the bus bar by a Direct Current Current Transformer (DCCT) which reproducibility is calibrated to be 5 ppm.

Inside the DCCT, a secondary calibration current is produced to counteract the main current until they give out zero flux at a coil, then the secondary current is measured through a precision burden resistor.

The readings from the DCCT were recorded from pulse to pulse over a period of about 50 to 100 pulses. The standard deviation and the peak-to-peak variation were derived from the sample recorded. Thus, the reproducibility measured is for short term only, typically for less than 30 minutes.

Results and Discussions

Referring to Figure 1, there are three measurements performed: 1) on February 19, 1981 with the old Gauss Clock system triggered at t_f, 2) on April 20, 1981 with the new Gauss Clock system triggered at t_p, and 3) on July 16, 1981 with the new Gauss Clock system triggered at t_f.

The results obtained can be summarized in the following table.

		No. of Pulses	Peak-Peak	σ
1	Old Gauss Clock (t_f)	116	6×10^{-4}	1.3×10^{-4}
2	New Gauss Clock (t_p)	80	6×10^{-5}	1.3×10^{-5}
3	New Gauss Clock (t_f)	150	1.1×10^{-4}	2.6×10^{-5}

It is clear that the new Gauss Clock's reproducibility is better by a factor of five over that of the old Gauss Clock and it is well within the 1.0×10^{-4} requirement for ISABELLE injection. Further tests on long term stability over a few hour period should be carried out later.

There are three improvement programs to extend the new Gauss Clock system: 1) installation of a NMR device to measure the absolute field in the gap, 2) installation of a DCCT device operational at 6 kA in the AGS for permanent reference, and 3) extend the field identification over a few hundred msec flat top.

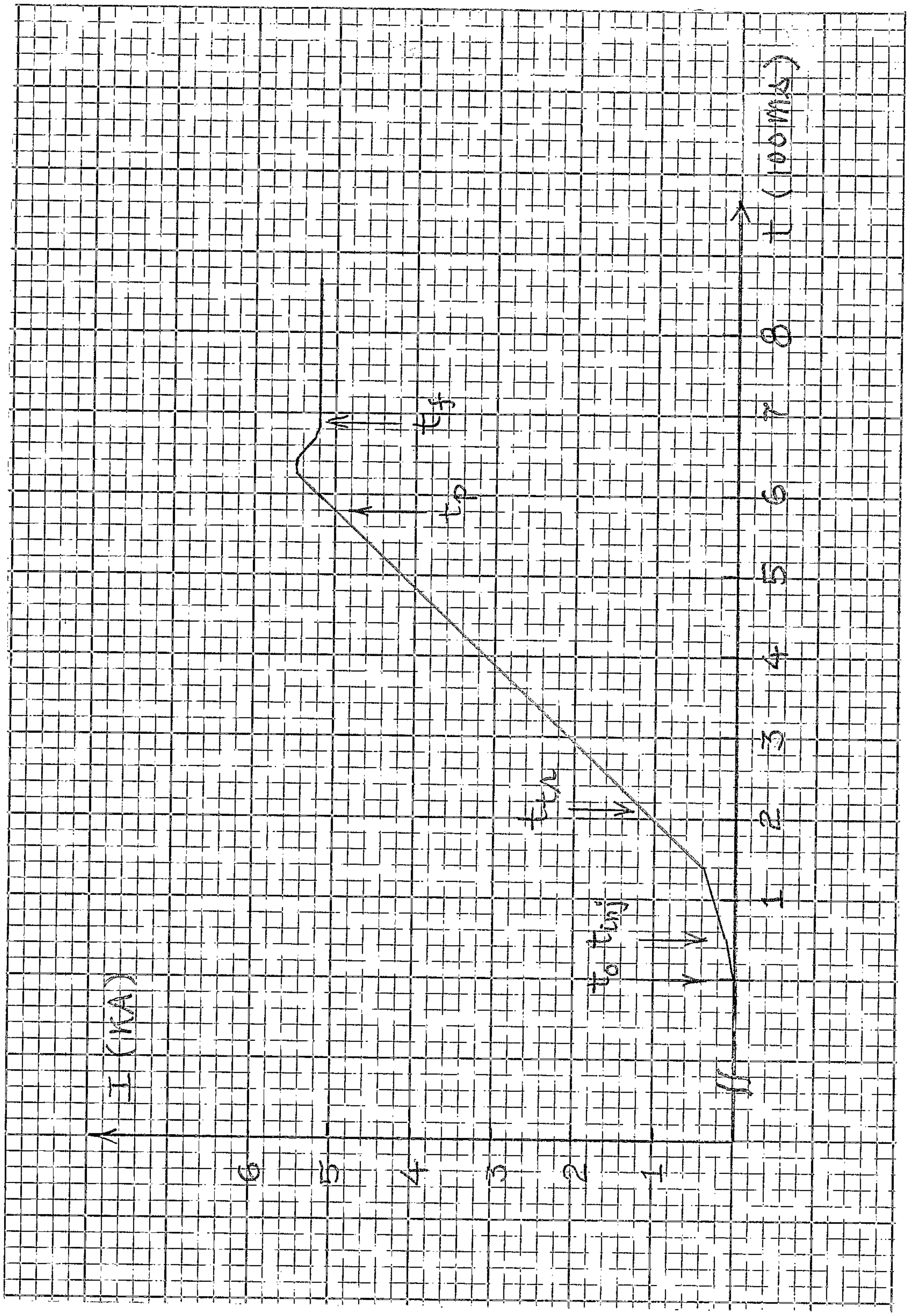

Fig. 1 - The AGS Main Magnet Excitation Curve
(During the test, due to the limitation of the DCCT, the flat top current is at 4 kA)