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Testing the New FEB Bumps

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Study Period:	11 May, 15 June 1995
Participants:	L. Ahrens, A. Dunbar, J.W. Glenn and M. Tanaka
Reported by :	M. (Sanki) Tanaka
Machine:	AGS SBE Setup @ SBE flattop
Beam:	2 x 10^{12} protons/pulse at p = 24 GeV/c on flattop, 8 bunches
Tools:	AGSOrbitDisplay, RLRM, TuneMeter, MAD
Aim:	***To test new FEB Extraction Bumps (BLWG09 and BLWH11) with beam***

§ Introduction

The new FEB extraction system [1], which is scheduled to be commissioned in October 1995, consists of a fast multi-pulsing C-type ferrite kicker at ssG10 [FKG10] followed by a thick septum ejector at ssH10 [SMH10], and two local extraction orbit bumps [BLWG09 and BLWH10] with three independent power supplies[A,B,&C(trim)]. A few ms before firing the kicker, the FEB extraction bumps are excited by powering backleg windings on selected main magnets to bring the beam into the aperture of the kicker (~60 mm from R_0) and adjacent to the septum of the ejector (~50 mm) as shown in the following figure.

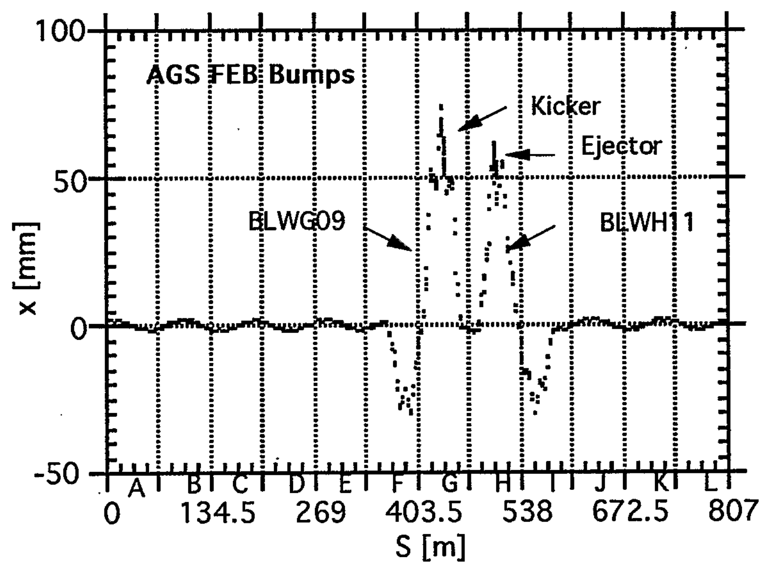

Fig.1.

During the FY1995 HEP/SBE test-beam run (14-15 March & 15-17 June), the FKG10 and BLWG09 with two power supplies, "A" and "B", were tested and used to extract proton single bunch beam to the B target at 24 GeV/c [2]. The devices were temporarily controlled by the old Datacon II system. At one AGS studies session (11 May), we managed to test the BLWH11 bumps using the BLWG09 power supplies. In this report, we present the measured BLWG09 and BLWH11 orbit bumps separately with predictions from MAD for the same machine conditions and bump parameters.

§ Setup and Data Taking

We used the following AGS setup for the HEP/SBE test beam run:

- SBE flattop at p =24.0 GeV/c.
- N_{bunch} = 8.
- Intensity = $2\text{-}3\cdot 10^{12}$ ppp.
- Mean beam radius <dRo> = 0.
- $\{Q_h, Q_v\} = \{8.61, 8.75\}$.

The FEB extraction bump configuration and parameters are listed in Table 1 (excluding the trim bumps, BLWG09C and BLWH11C, which are not yet available).

Table 1. FEB Extraction Bump Configuration and Parameters

	BLWG09A	**BLWG09B**	**BLWH11B**	**BLWH11A**
Magnet	F08,F09,G02,G03	G16, G17	H04, H05	H18,H19,I12,I13
Polarity/kick	- - + +	++ ++	++ ++	- - + +
N_{turns}	5 6 6 5	10 10	10 10	5 6 6 5
I_{max} [A]	800	1200	1200	800
$V_{discharge}$[V]	720	1100	1100	720
Type	a & b = 1λ†		a & b = 1λ†	
Pulse mode	half-sine (8 ms base)	half-sine (8 ms base)	half-sine (8 ms base)	half-sine (8 ms base)

† With a combination of two *standard* 3/2 λ bumps[3], the kicked beam might hit the inside wall of the vacuum chamber around ssG17.

The FEB/SBE bump timings were started by the FEB/SBE real-time trigger event and Tstart_charge and Tdischarge times were set through autodets. Typical discharge current waveforms are shown in Fig. 2 with peak currents, $\{I_A, I_B\} = \{450, 900\}$ A. Since the "B" bump is connected in parallel, the required current I_B is two times larger than the "A" bump current I_A for the same kick strength.

AGS OrbitDisplay code was set for low intensity measurements. The orbits were measured just before turning on the bumps as a reference and at SBE time for each bump. The results shown in Fig. 4 - 6 are difference orbits together with MAD predictions. For BLWH11 bump testing, the data were taken at $\{Q_h, Q_v\} = \{8.77, 877\}$[4] for different high field horizontal sextupole current settings, IS_h =0, 160, 300 A, to study the its effects on the bump amplitude.

To model orbits using this type of orbit bump, J. Niederer has modified the MAD program so that the effects of backleg windings on selected main magnets can be realistically simulated as relative excitation field errors affecting all field components (dipole, quadrupole, sextupoles) in a combined function main magnet. MAD also fully cooperated with AGS high field quadulpoles for tune controls and sextupoles for chromaticity controls. The required currents $I_{A,B}$ [A] are estimated by using $(dB/B)*B*g/\mu_o/N_{turn}$ where $B=p/(0.2998*\rho)$.

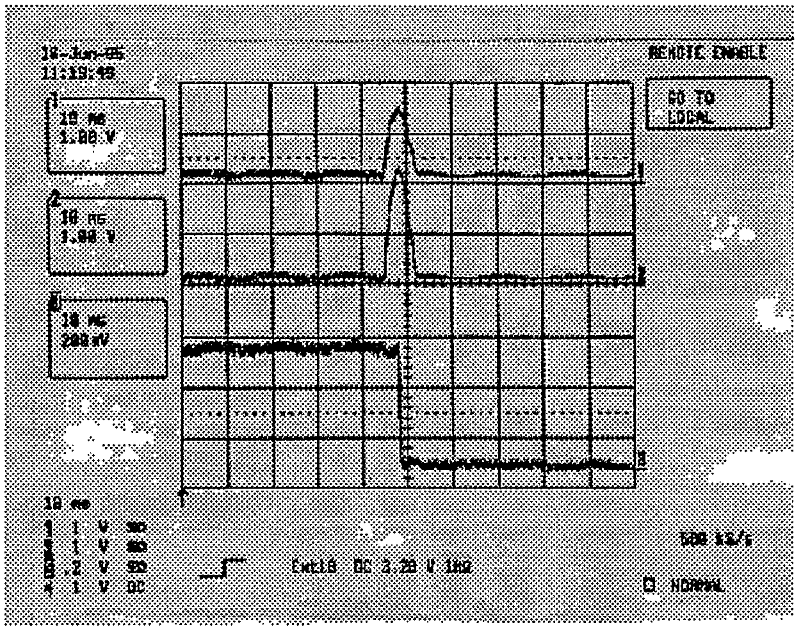

Fig. 2. 1 = BLWG09A_I, 2 = BLWG09B_I and 3 = F15CT during the SBE run.

§ Results and Analysis

It should be noted that PUEs are located at straight sections 2,4,8,12,14,18 except at ssF08, H08. Data points (o) from some PUEs (*e.g.*, ssH02, H04 etc.) are missing while MAD points (+) are not.

A. BLWG09

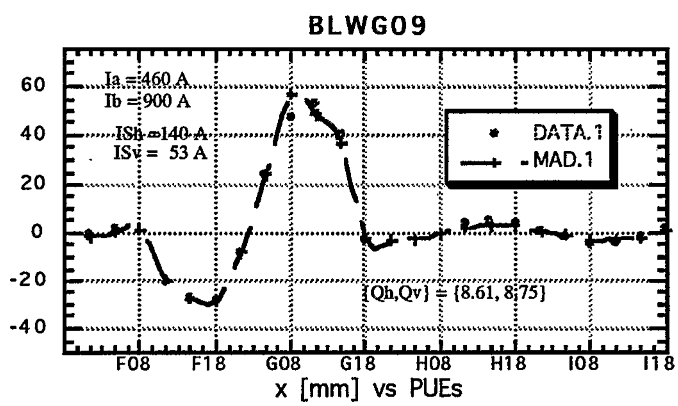

Fig.3.

Fig. 3 shows PUE orbit measurements for the full BLWG09 bump with $\{I_A, I_B\}$ = {460, 900}A and $\{IS_h, IS_v\}$ = {140, 50}A at $\{Q_h, Q_v\}$ ={8.61, 8.75} during the SBE setup period. Only 6 horizontal sextupoles were available at ss A13, C13,.., K13 at that time due to some bad ones. The noticeable difference between DATA.1 and MAD.1 at PUEG08 and G12 positions could be attributed to PUE calibration errors. Otherwise, they are in good agreement, including residuals outside the BLWG09 bump.

B. BLWH11

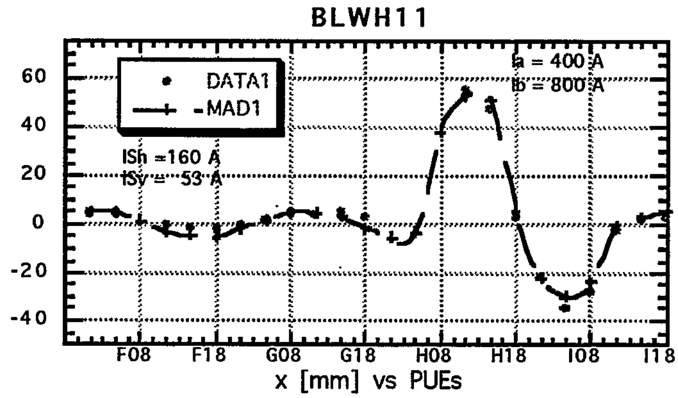

Fig. 4.1.

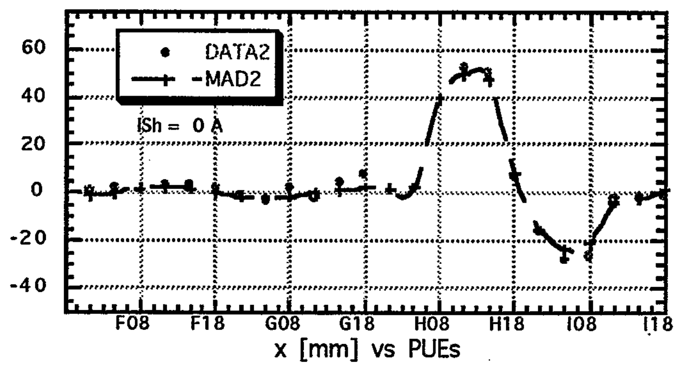

Fig. 4.2.

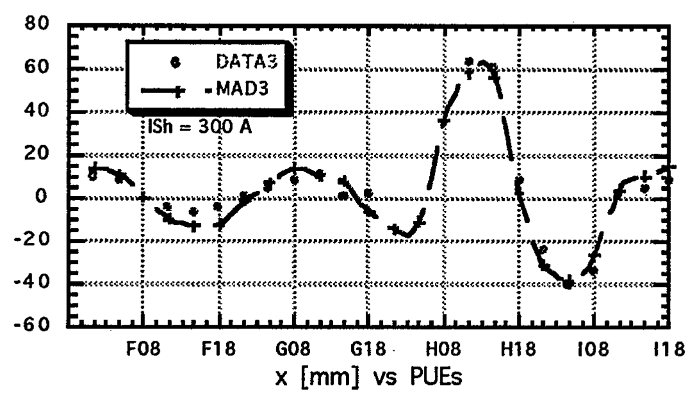

Fig. 4.3

For each case, IS_h =160, 0, 300 A with fixed $\{I_A, I_B\} = \{400, 800\}$ A, there is a good agreement between data and MAD though the measured residuals are smaller than MAD predictions. It should be noted that as IS_h increases, not just the residuals but also the bump amplitude increases significantly as one horizontal sextupole is located on the bump at ssH13.

Fig. 5.1 is the same to Fig. 4.3 but plotted for the whole AGS ring. Fig. 5.2 shows the difference, dx, between DATA3 and MAD3. The values of dx = ± 5-7 mm are higher than the expected |dx| ≤~ a few mm. We learned later that some (two) sextupoles out of 12 have been shorted. This could explain the rather large differences.

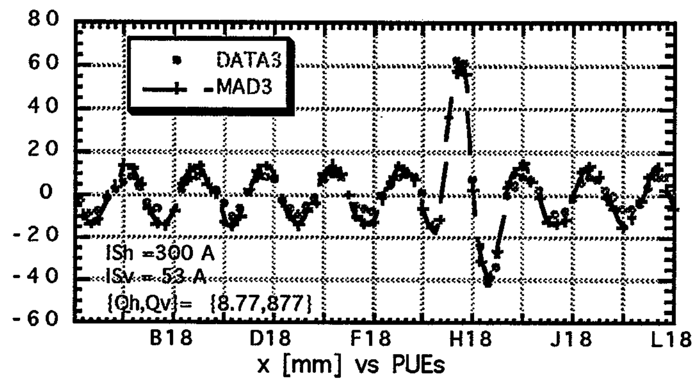

Fig. 5.1

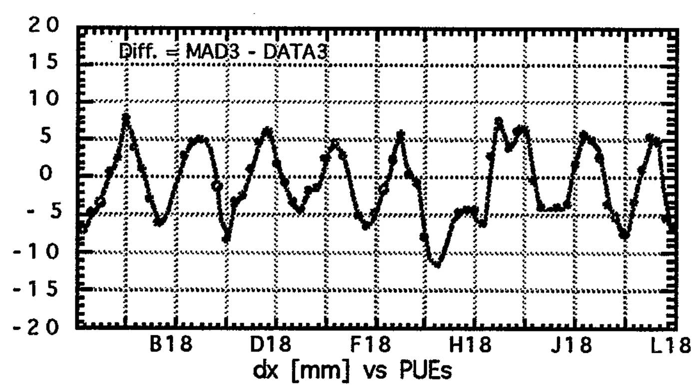

Fig. 5.2

C. Double pulsing:

The BLWH11A&B power supplies were double pulsed about 70 ms apart to check if the first and second bumps were identical. In Fig.6, we show the bump orbit for single pulse (DATA1), orbits for the first (DATA1.1) and for the second (DATA1.2) in the case of double pulsing. They are identical within a few mm for one shot measurement.

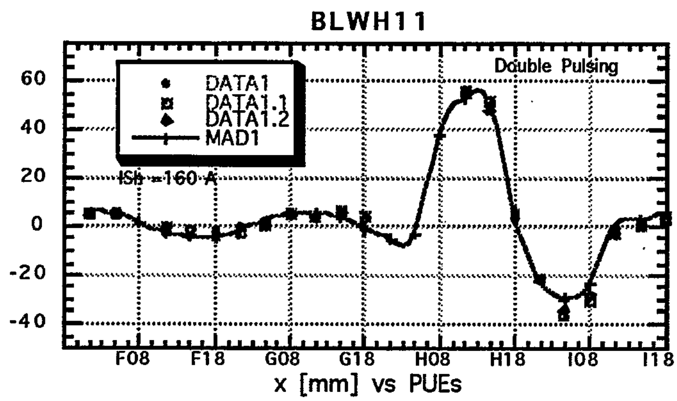

Fig. 6.

§ Conclusions

- The FEB extraction bumps, both BLWG09 and BLWH11, were tested separately on flattop at 24 GeV/c with two power supplies (A & B) using the Datacon II control system. The measured orbit deformations and amplitudes are in agreement with the MAD predictions, including the high field sextupole effects.
- We made a quick test of double pulsing at about 70 ms apart.
- We could *not* have a chance to test:
  - both BLWG09 and BLWH11 at the same time (full FEB bumps),
  - at 28.73 GeV/c (or 28.73*(77/197) for Au^{77+}),
  - with trim, "C", power supplies,
  - with the new controls system,
  - for triple or quadruple pulsing at 33.3 ms apart,
  - with selected PUEs connected to the high sensitive readout system.
- *However, we have some FEB bump data at 24 GeV/c and confidence in MAD simulations that are vital for the coming FEB-AtR commissioning at 28.73*(Z/A) GeV/c with Au^{77+} beam.*

References

[1] M. Tanaka et al, BNL-61097, *The AGS Accelerator Complex with the New Fast Extraction System.*
[2] M. Tanaka, AGS/AD/Tech Note No. 393, *NewFEB: SBE to the SEB line using FKG10.*
[3] M.Q. Barton and F. Faure, AADD-131(1967), Appendex, *Use of Backleg Windings for Generating Local orbit Bumps.*
[4] M. Tanaka, AGS Studies Report No. 318, *AGS Working Point for AtR.*