

## AGS Working Points for AtR, MS I

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AGS Complex Machine Studies (AGS Studies Report No. 318 ) <u>AGS Working Points for AtR, MS L</u>	
<b>Study Period:</b>	12 October 1994, 12:45 - 14:30 pm
<b>Participants:</b>	L. Ahrens, K. Brown, E. Gill, W. van Asselt, M. Tanaka
<b>Reported by :</b>	M. Tanaka
<b>Machine:</b>	AGS @ extraction flattop
<b>Beam:</b>	Bunched Au <sup>77+</sup> beam @ p = 11.23 GeV/c/N
<b>Instruments:</b>	IPM, Tune Meter, CT, Frequency Analyzer, WCM
<b>Aim:</b>	<i>To explore the optimal working point for AtR transfer.</i>

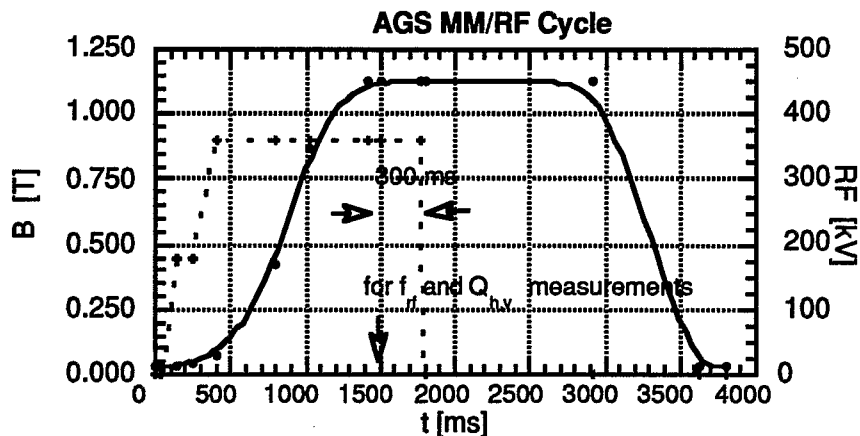
### Introduction:

This study is the first attempt to get some real data in order to specify the basic AGS NewFEB operation parameters for AtR beam transfer[1].

### Setup and Data Taking:

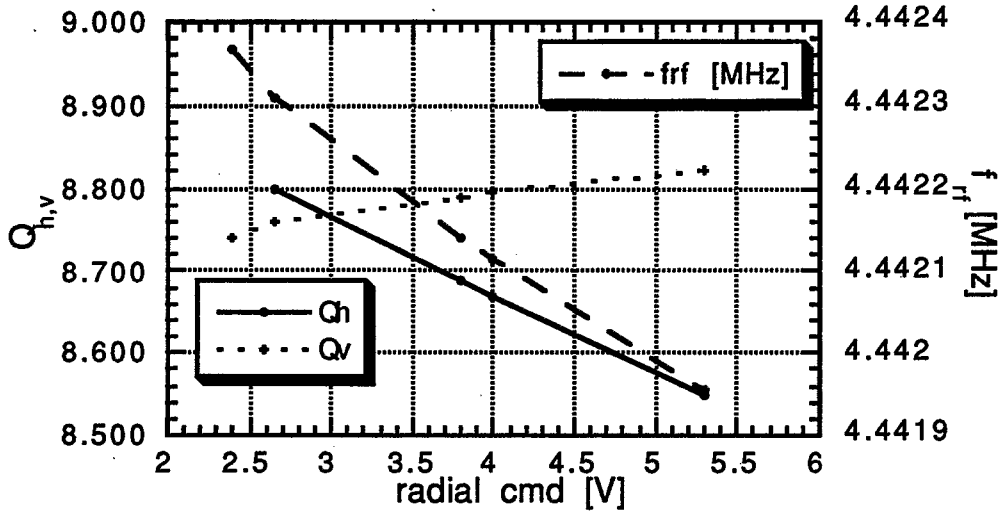
We used the current machine setup for the FY95 HIP/Au<sup>77+</sup> SEB run except for the following changes:

- the rf turnoff time was delayed 300 ms from 1467 ms to 1767 ms from  $t_0$  and the rf voltage was flattened at 360 kV during this period.
- the SEB flattop in the main magnet cycle was flattened at 1.1250 T.  
 $p = 11.23 \text{ GeV/c/N}$  or  $28.725 \text{ GeV/c/Charge}$  or  $B\rho = 95.82 \text{ T-m}$ .
- SMF05, SMF10 and DSX's were turned off.



- the local oscilloscope time window was set such that we could monitor the current transformer(CT) reading during the flattop.
- the time of the rf frequency,  $f_{rf}$  measurements was set at  $t = 1500$  ms with a 20 ms window.

First, we systematically varied the mean beam radius  $\langle dR \rangle$  by changing the voltage of the radial shifter(RS) and measured  $f_{rf}$  and  $Q_{h,v}$  at  $t = 1500$  ms for each setting to find out the value corresponding to  $\langle dR \rangle = -0.0$  as shown in the following figure.



- the beam was lost at RS = 2.2 and 5.5 V.
- we set RS = 3.8 V for  $\langle dR \rangle = -0.0$ .
- on the flattop,
  - Au<sup>77+</sup> intensity =  $\sim 1 \cdot 10^9$  ions/cycle.
  - tune control quadrupole currents,  $IQ_{h,v} = \{275A, -430A\}$  (on from 1250 - 2920 ms)
  - chromaticity control sextupole currents,  $IS_{h,v} = \{340A, 0A\}$ .
  - skew quadrupole current  $ISKQ = 50$  A.

Then, sitting at  $\langle dR \rangle = -0.0$  mm, we turned on/off the chromaticity sextupoles, the skew quadrupoles and the tune quadrupoles to see whether there were any changes in beam intensity or in bunch shape.

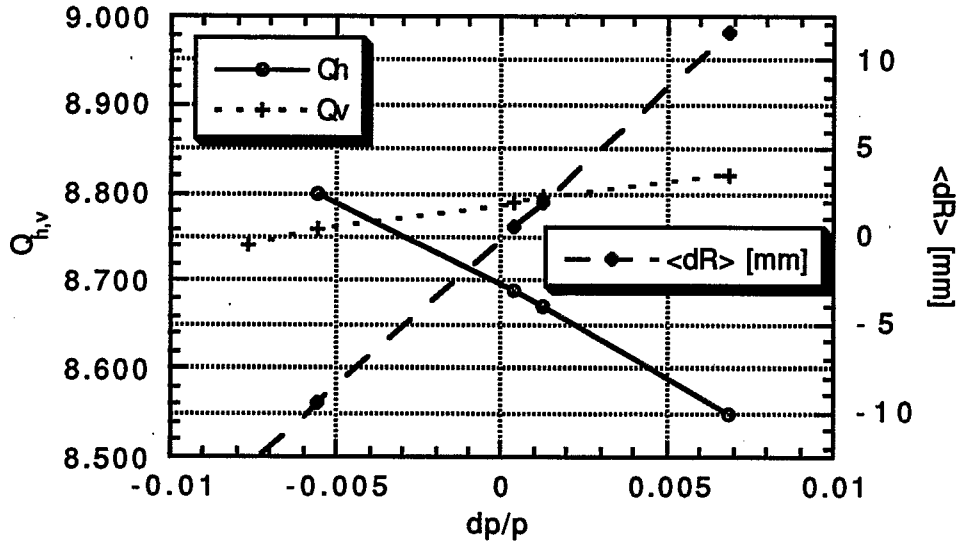
## Results:

- The measured  $f_{rf}$  values are converted to  $dp/p_0$  and to  $\langle dR \rangle$  using the formula:

$$\langle dR \rangle = \alpha_p \cdot R_0 \cdot (dp/p_0) \text{ and } f_{rf} = h \cdot f_{rev} = hc \cdot (p/E) / (2\pi \cdot (R_0 + \langle dR \rangle))$$

where  $\alpha_p = -0.0132$ ,  $R_0 = 128.452$  m,  $p_0 = 11.228$  GeV/c/N,  $h = 12$ ,  $c$  = speed of light and  $p/E = \beta_{rel}$ .

The results are shown in the following figure. For  $dp/p_0 = 0$  at  $\langle dR \rangle = 0$ , we should have  $f_{rf} = 4.442146$  MHz which is very close to the measured value  $f_{rf} = 4.442139 (\pm 35)$  MHz at RS = 3.8 V, corresponding to  $dp/p_0 = 0.00039$  or  $\langle dR \rangle = 0.66$  mm. From the figure, we have  $Q_{h,v} = \{8.69, 8.79\}$  at  $dp/p = 0$  and  $\xi_{h,v} = dQ_{h,v}/(dp/p) = \{-20, +4.8\}$ . These values are consistent with the MAD predictions of  $Q_{h,v} = \{8.668, 8.793\}$  and  $\xi_{h,v} = \{-22.6, +7.7\}$  with  $IQ_{h,v} = \{275A, -430A\}$  and  $IS_{h,v} = \{340A, 0A\}$



• At  $RS = 3.8V$  (i.e.,  $\langle dR \rangle = \sim 0.0$  mm)

action	$f_{rf}$ [MHz]	$\{Q_h, Q_v\}$	MAD $Q_{h,v}$ , and $\xi_{h,v}$
- startup point	$4.442139 \pm 35$	$\{8.69 \pm 0.01, 8.79\}$	$\{8.668, 8.793\} \{-22.6, 7.7\}$
② turned off the chro. sexts	$4.442136 \pm 37$	$\{8.67, 8.795\}$	$\{8.668, 8.793\} \{-36.0, 15.0\}$
- turned off the skew quads	$4.442134 \pm 33$	$\{8.67, 8.795\}$	-----
③ turned off the tune quads	$4.442141 \pm 51$	$\{8.65, 8.685\}$	$\{8.639, 8.677\} \{-36.0, 16.0\}$
⚡ the beam survived but it appeared very tight.			
④ $IQ_{h,v} = \{550A, -480A\}$	$4.442143 \pm 33$	$\{8.79?, 8.758\}$	$\{8.765, 8.763\}$
⑤ $IQ_{h,v} = \{475A, -480A\}$	$4.442143$	$\{8.735, 8.775\}$	$\{8.736, 8.777\}$

• Other data during the 300 ms period

a) CT data:

⚡ throughout the study, we watched CT readings on the oscilloscope for any beam losses and did not see any significant changes except it appeared that there was a steady decrease in intensity by 3-4 % ( $\sim 18$  % loss over the 1.5 sec flattop).

b) IPM data:

⚡ it did not reveal any clear beam losses.

⚡  $\epsilon_{h,v}^*(95\%)$  stayed constant at  $\{10, 7\} \pi$  mm-mrad.

c) WC M mountain range display:

⚡ the bunch shape stayed constant with the full bunch length =  $\sim 22$  ns.

• Miscellaneous

⚡ we turned on/off DSX's and BLWF07 (a bump for SMF05&F10) and saw no effects. However, it turned out that these devices started at  $t = 1580$  ms while  $f_{rf}$  and  $Q_{h,v}$  measurements were done at  $t = 1500$  ms.

⚡ we did not see any changes in the CT reading when we set  $\xi_h = 20$  and 16 by turning back the chromaticity sextupoles.

## Conclusions:

✎ The Au<sup>77+</sup> bunched beam at  $\langle dR \rangle = 0$  could survive without any chromaticity and tune corrections for the 300 ms flat-top at  $B\rho = 95.83$  T-m (AGS proposed maximum  $B\rho$ ) though it was very tight and no extraction bumps existed.

✎ We prefer the working point  $Q_{h,v} = \{\sim 8.735, \sim 8.775\}$  to  $\{\sim 8.775, \sim 8.735\}$  since it requires less current for the tune control quadrupoles. It should be noted that the NewFEB bumps will cause a tune shift  $\Delta Q_h \approx -0.02$ .

✎ For the next study, we propose

- while maintaining  $Q_{h,v} = \{8.735, 8.775\}$  at  $\langle dR \rangle = 0$ ,
- study chromaticity effects,
- study bump effects (using BLWF07 and/or BLWH20),

by measuring CT readings quantitatively, and taking more complete TM, IPM and WCM data.

## References:

- [1] BNL-48230, M. Tanaka and Y.Y. Lee, *The AGS-Booster Complex for the g-2 Experiment and RHIC Injection*.