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COSTS OF RUNNING FEB AND SEB PROGRAMS-COMBINED AND ALTERNATING

INTRODUCTION

Since 1973, we have run the Slow Extracted Beam (SEB) and Fast Extracted Beam (FEB) programs at the AGS in an alternating manner. That is, so many weeks are given to FEB and to SEB as separate operations. Apparently, the reasons for this mode of operation have never been formally documented, and in view of the rapidly escalating electrical power costs and changes in the experimental program, it seems worthwhile to review this decision.

ELECTRICAL POWER AND NUMBER OF PROTONS

On purely economic grounds, we should run the program in such a way that we deliver the required number of protons for the minimum electrical power cost. Since the parameters involved in calculating this cost vary, we shall develop formulae into which the reader may insert her own values.

T = Total power for the year (assumed fixed by budget).

E_S = Electrical usage per hour of SEB running.

E_F = Electrical power usage per hour of FEB running.

E_I = Increment of power usage per hour for combined FEB and SEB operations.

n_S = Number of pulses per hour for SEB or FEB combined with SEB.

n_F = Number of pulses per hour for FEB.

p = Number of protons/pulse. Assumed the same for SEB and FEB running.

f_F = Fractions of protons given to FEB for combined operation.

q_F = Fraction of time alloted to FEB for separate operation.

H_a = Number of hours of operation per year in alternating operations.

H_c = Number of hours of operation per year of combined operation.

P_a = Number of protons delivered, alternating operation.

P_c = Number of protons delivered, combined operation.

Power usage per year:

Alternating

$$[\, E_F\, q_f + E_S\, (1 - q_F)]\, H_a = T \qquad (1)$$

Combined

$$[E_S + E_I]\, H_c = T \qquad (2)$$

Number of protons delivered:

Alternating

$$P_a = p\, H_a [\underbrace{q_F\, n_f}_{\text{To FEB}} + \underbrace{(1-q_F)\, n_s}_{\text{To SEB}}] \qquad (3)$$

Combined

$$P_c = p\, H_c\, n_S \qquad (4)$$

fraction to FEB: $f_F\, P_c$ (4a)

fraction to SEB: $(1-f_F)\, P_c$ (4b)

Now let us put some values into these formulae;

T = 5.2×10^4 MWH which corresponds to approximately 15 weeks of SEB and 10 weeks of FEB operation for 120 hours/week, which provides about 100 hours/week to experiments (83% efficiency).

E_S = 22 MW at 28.5 GeV/c

E_F = 10 MW at 28.5 GeV/c

E_I = 1 MW

n_S = 1500 pulses/hr (repetition rate 2.4 sec)

n_F = 3000 pulses/hr (repetition rate 1.2 sec)

p = 10^{13} protons/pulse = 10 TP (tera protons).

f_F = 0.5, This is one possible value.

q_F = 0.4 = 10 out of 25 weeks.

Using equation (1)

H_a = 3023 hours => ~ 25 weeks.

Using equation (2) for combined operation throughout year:

H_c = 2261 hours => ~ 19 weeks.

Using equation (3)

to FEB:	3.00×10^7 TP	at 83% efficiency.
to SEB:	2.26×10^7 TP	at 83% efficiency.
Total:	5.26×10^7 TP	at 83% efficiency.

Using equation (4)

to FEB:	1.41×10^7 TP	at 83% efficiency.
to SEB:	1.41×10^7 TP	at 83% efficiency.
Total:	2.82×10^7 TP	at 83% efficiency.

Number of protons delivered for total power cost T is 54% for combined running with respect to alternating operation. So there is a very clear economic benefit to this mode of operation.

Other Considerations

The complexity of operation and number of technicians required to maintain the beam transport equipment is more for combined operation.

Recommendations

1. We continue alternating FEB and SEB operation.
2. The AGS intensity and repetition rate be made as high as possible for FEB operations since the neutrino experiments are never intensity limited. Running time for the neutrino experiments should be in terms of numbers of protons, and then be run off as quickly as possible.
3. The SEB program is not necessarily intensity limited and we should consider trading machine energy for an extended running period.
4. The base load for the Accelerator Department is ~ 4.4×10^4 MWH per year (85% of the electrical power needed to run the AGS program) and so significant reductions in this load could be translated into running weeks.
5. The "standby" power of about 4 MW should be reduced and/or this equipment should be modified to allow shedding this load for shorter shutdowns.

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