

Workshop Goals

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July 1988

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U.S. Department of Energy

USDOE Office of Science (SC)

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Workshop Goals

(Mini-Workshop on RHIC RF Systems)

*July 11-15, 1988
Collider Center*

H. Hahn
BNL

MINI-WORKSHOP ON RHIC RF SYSTEM

JULY 11, 1988

REASON

- A HIGH-FREQUENCY 160 MHz RF SYSTEM WAS ADDED TO ASSURE SHORT BUNCHES AND SHORT DIAMOND LENGTH DURING STORAGE MODE
- CO-EXISTENCE OF TWO RF SYSTEMS POSES NEW PROBLEMS

OBJECTIVES

- REVIEW RF SYSTEMS REQUIREMENT
DURING INJECTION, ACCELERATION, CROSSING OF TRANSITION ENERGY,
TRANSFER FROM LOW-F TO HIGH-F SYSTEM, STORAGE OF BEAMS
- REVIEW CAVITY AND AMPLIFIER HARDWARE
VOLTAGE RANGES, NUMBER OF 160 MHz CAVITIES,
FEEDBACK REQUIREMENTS, INTERACTION OF TWO SYSTEMS,
COUPLING IMPEDANCE REQUIREMENTS, INSTABILITIES
- ESTABLISH BASIS FOR REVISED CDR TEXT AND COST ESTIMATE
- WRITTEN SUMMARY AND TECH NOTES

RELATIVISTIC HEAVY ION FACILITIES AT BNL

1986 BEGIN AGS FIXED TARGET EXPERIMENTS

ION SPECIES: ^1H TO ^{28}S :

BEAM ENERGY: UP TO $29 \left[\frac{Z}{A} \right] \text{GeV} \cdot c^1/\text{U}$

FLUX: $\approx 10^9$ IONS/PULSE

RUNNING TIME: 5 - 10 WEEKS/YEAR

1991 AGS EXPERIMENTS WITH BOOSTER SYNCHROTRON

EXTEND ION MASS TO $A \approx 200$ (^{197}Au)

(1994) [?] BEGIN RHIC COLLIDER EXPERIMENTS

ION SPECIES: ^1H TO ^{197}Au

ENERGY/BEAM: UP TO $250 \left[\frac{Z}{A} \right] \text{GeV}/\text{U}$

C.M. ENERGY: 250 + 250 GeV (P) 100 + 100 GeV/U (Au)

LUMINOSITY: $10^{31} \text{cm}^{-2} \text{SEC}^{-1}$ $5 \times 10^{26} \text{cm}^{-2} \text{SEC}^{-1}$

RHIC MAJOR PARAMETERS

ENERGY RANGE (EACH BEAM), Au
PROTONS

(7) 10.7-100 GeV/u
28-250⁺ GeV

LUMINOSITY, Au-Au @ 100 GeV/u HEAD-ON & 10 H AV.

$4.4 \times 10^{26} \text{ cm}^{-2} \text{ sec}^{-1}$

OPERATIONAL LIFETIME Au @ >30 GeV/u

>10 H

DIAMOND LENGTH @ 100 GeV/u, (2 MRAD)

$\pm 27 \text{ cm RMS} \quad \pm 20$

CIRCUMFERENCE, $4\frac{3}{4} \text{ C}_{\text{AGS}}$

3833.845 M

NUMBER OF CROSSING POINTS

6

FREE SPACE AT CROSSING POINT

$\pm 9 \text{ M}$

BETA @ CROSSING, HORIZONTAL/VERTICAL

6 M

LOW-BETA INSERTION

3 M

BETATRON TUNE, HORIZONTAL/VERTICAL

28.82

TRANSITION ENERGY, γ_T

24.8

FILLING MODE

Box-Car

NO. OF BUNCHES/RING

57

NO. OF Au-IONS/BUNCH

1.1×10^9

FILLING TIME (EACH RING)

~1 MIN

MAGNETIC RIGIDITY, Bp: @ INJECTION

96.74 T·M

@ TOP ENERGY

839.5 T·M

NO. OF DIPOLES (180/RING + 12 COMMON)

372

NO. OF QUADRUPOLES (276 ARC + 216 INSERTION)

492

DIPOLE FIELD @ 100 GeV/u, Au

3.45 T

DIPOLE MAGNETIC LENGTH

9.46 M

DIPOLE YOKE LENGTH

9.7 M

COIL I.D. ARC MAGNETS

8 CM

BEAM SEPARATION IN ARCS

90 CM

RF FREQUENCY

26.7 MHz

RF VOLTAGE

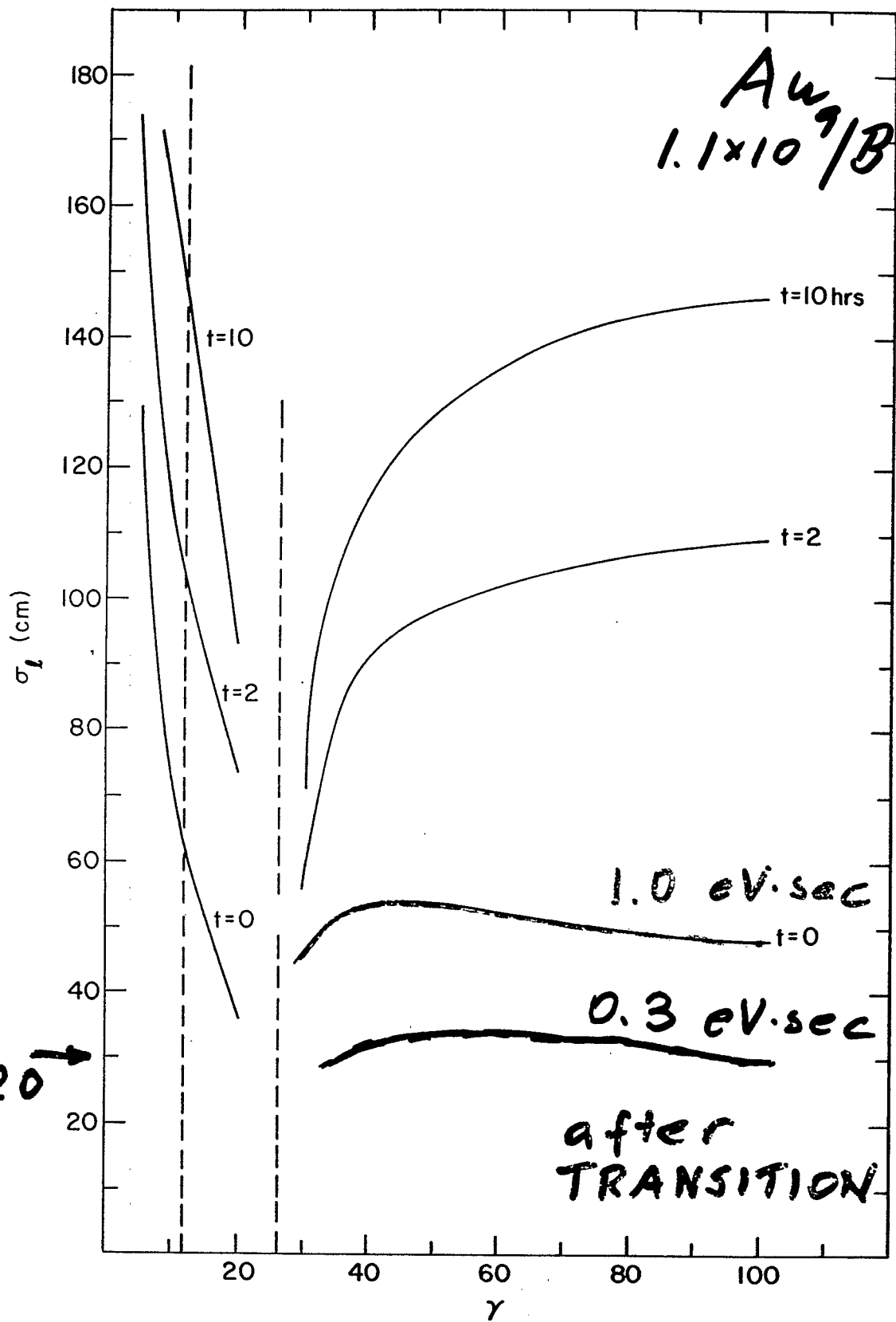
1.2 MV

ACCELERATION TIME

1 MIN

HEAD-ON TMO diamond length $\sigma_z = \sigma_0 / \sqrt{2}$

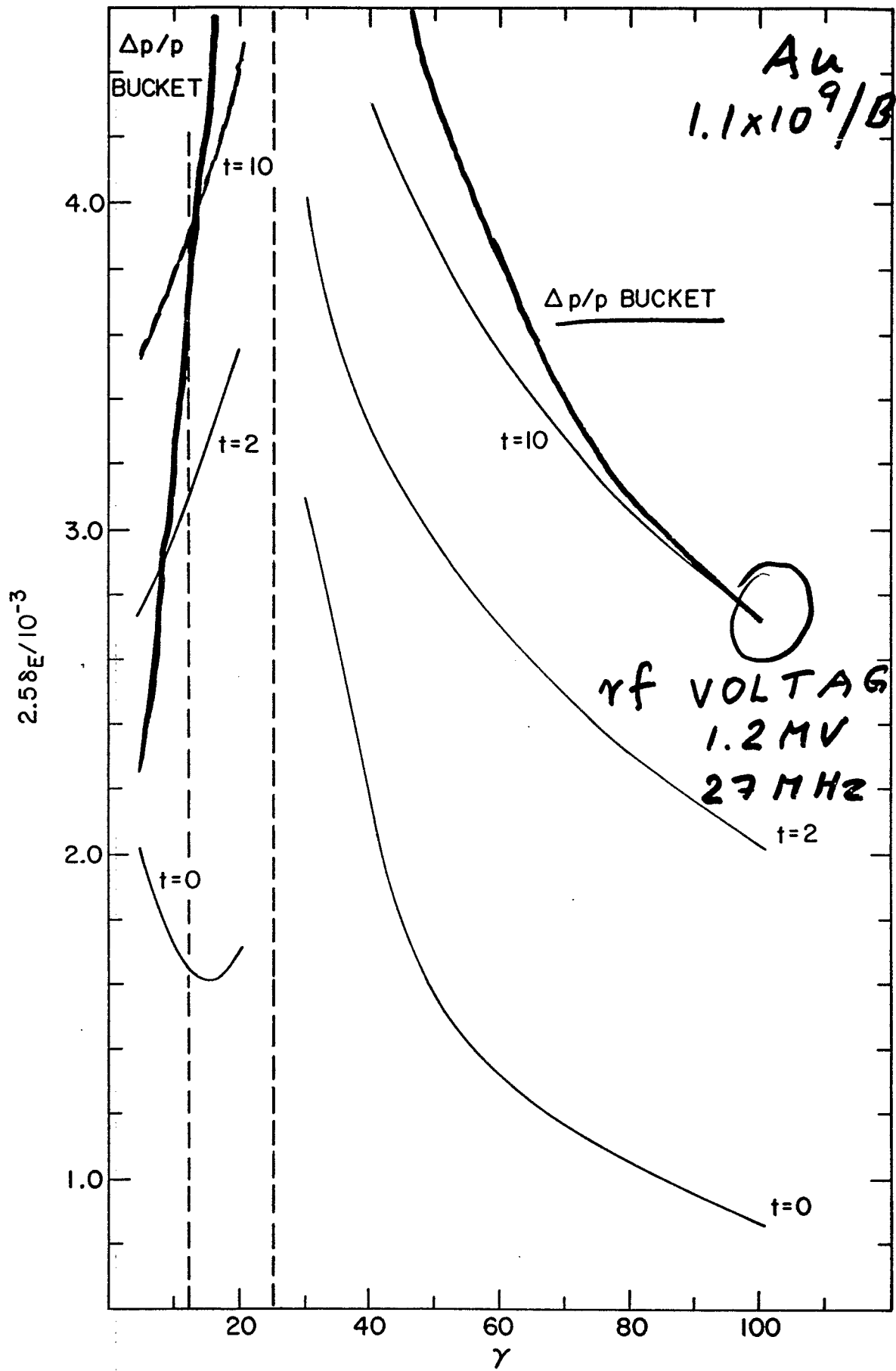
20



W.O.

with
P_T JUMP

ENERGY SPREAD



Au
 $1.1 \times 10^9 / \text{BUNCH}$

$\Delta p/p$ BUCKET

γf VOLTAGE
1.2 MV
27 MHz

INTRABEAM SCATTERING ABOVE TRANSITION*

$$\tau_E^{-1} = \frac{1}{\delta_E} \frac{d\delta_E}{dt} = \left[\frac{\langle \sigma_H \rangle}{\langle X_p \rangle \delta_E} \right]^2 \tau_H^{-1}$$

with

$$\tau_H^{-1} = \frac{27\pi}{2} L_g r_p^2 E_o \frac{N_B}{S \epsilon_H \epsilon_v} \frac{\langle X_p \rangle}{\langle \beta \rangle} \frac{1}{\left[1 + \left[\frac{\langle \sigma_H \rangle}{\langle X_p \rangle \delta_E} \right]^2 \right]^{1/2}} \left[\frac{Q^2}{A} \right]^2$$

where

$$L_g \approx 20$$

$$r_p = \frac{\mu_o e^2 c^2}{4\pi E_o}$$

$$\langle \sigma_H \rangle = \left[\frac{\epsilon_H}{6\pi} \frac{\langle \beta \rangle}{\gamma} \right]^{1/2}$$

$$S = 6\pi \sigma_\ell \delta_E \gamma E_o / c$$

$\epsilon_{H,v}$ = normalized transverse emittance

$\langle X_p \rangle$ = averaged dispersion

$\langle \beta \rangle$ = averaged betatron function

*G. Parzen, Nucl. Instr. Meth. A251, p. 220 (1986), A256, p. 231 (1987).

DIAMOND LENGTH

REQUIREMENT

$$\sigma_I \leq 20 \text{ CM RMS}$$

BUNCH RMS LENGTH

$$\sigma_l = \sqrt{2} \sigma_I \approx 28 \text{ CM RMS}$$

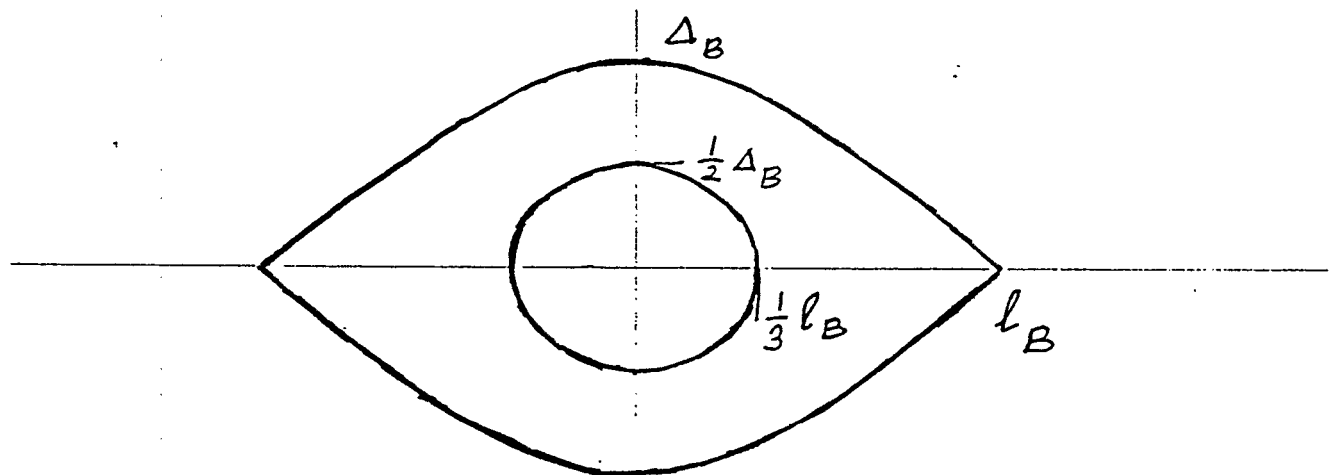
BUCKET HALF LENGTH

$$160 \text{ MHz } (h = 2052)$$

$$l_B = \pi R/h = 0.934 \text{ M}$$

DUE TO BUCKET NONLINEARITY

$$\sigma_l < l_B / \sqrt{6} = 38 \text{ CM RMS}$$



$$\sigma_E = \Delta_B / \sqrt{6} \text{ YIELDS } \sigma_l = 0.268 \times l_B = 25 \text{ CM RMS}$$

ECONOMY CONDITION:

$$\sigma_E = \Delta_B / 2$$

$$\sigma_l = l_B / 3 = 31 \text{ CM RMS}$$

RF BUCKET AND LONGITUDINAL BUNCH PARAMETERS

BUCKET HALF HEIGHT $\Delta_B = \left[\frac{2. e V}{\pi h |\eta| \gamma E_o} \frac{Q}{A} \right]^{1/2}$

BUCKET AREA/AMU $A_B = 8 \Delta_B \frac{\gamma E_o}{h \omega_o}$

BUNCH PHASE HALF WIDTH $0 < \phi < \pi$

COLE-MORTON: $N = \sin^2 \phi/2$

RMS BUNCH LENGTH $\sigma_\ell = \frac{1}{\sqrt{6}} \frac{R}{h} \phi$

RMS BUNCH HEIGHT $\delta_E = \frac{1}{\sqrt{6}} \Delta_B \sin \phi/2$

BUNCH AREA/AMU $S = A_B \left\{ (N-1) K(N) + E(N) \right\}$

$$\approx 6 \pi \sigma_\ell \delta_E \gamma E_o / c$$

RHIC RF SYSTEMS PARAMETER

■ BEAM PARAMETERS FROM AGS

$$\left. \begin{array}{l} \text{P} \quad 10^{11} / \text{BUNCH} \\ \text{AU} \quad 10^9 / \text{BUNCH} \end{array} \right\} \begin{array}{l} 0.3 \text{ EV} \cdot \text{SEC} / \text{U} \\ 10 \pi \text{ MM} \cdot \text{MRAD} \end{array}$$

■ ASSUME ESSENTIALLY NO GROWTH OF BUNCH AREA AT INJECTION AND DURING TRANSITION

■ ACCELERATION RF SYSTEM	26.7 MHz
2 CAVITIES (CDR-TYPE)	300 kV
TUNING RANGE	1% (> 7 GeV/U)

■ STORAGE RF SYSTEM	160 MHz
TUNING RANGE	0.1% - (> 30 GeV/U)
VOLTAGE @ 10 HR	11.4 MV - AU ($\Delta_B = 2 \sigma_E$)
	17.7 MV - AU ($\Delta_B = \sqrt{6} \sigma_E$)
	2.3 MV - P ($\Delta_B = \sqrt{6} \sigma_E$)

SCALED CERN-TYPE CAVITY

NUMBER OF CAVITIES, VOLTAGE/CAVITY ?

SUPERCONDUCTING CAVITIES ?

■ DESIGN FOR FUTURE UPGRADE

2×57 BUNCHES, $2 \times$ NUMBER IONS/BUNCH

■ DESIGN FOR 2 - 3 MISSING BUNCHES (BEAM DUMP GAP)

MINI WORKSHOP ON RHIC RF SYSTEMS

MONDAY, JULY 11 -- 2:30 PM

BLDG. 1005 CONFERENCE ROOM 4TH FLOOR

WELCOME & WORKSHOP GOALS

H. HAHN

RF SYSTEMS OVERVIEW

A.G. RUGGIERO

INTRABEAM SCATTERING RESULTS

G. PARZEN

**BEAM TRANSFER AGS/RHIC,
LOW F - HIGH F**

E.C. RAKA

PASSAGE THROUGH TRANSITION

S.Y. LEE

**SIMULATION OF TRANSITION
& TRANSFER**

J. WEI

RF CAVITIES AND AMPLIFIERS

J.G. COTTINGHAM

GAMMA-TRANSITION QUADRUPOLES

P.A. THOMPSON