AGS Intensity Upgrades

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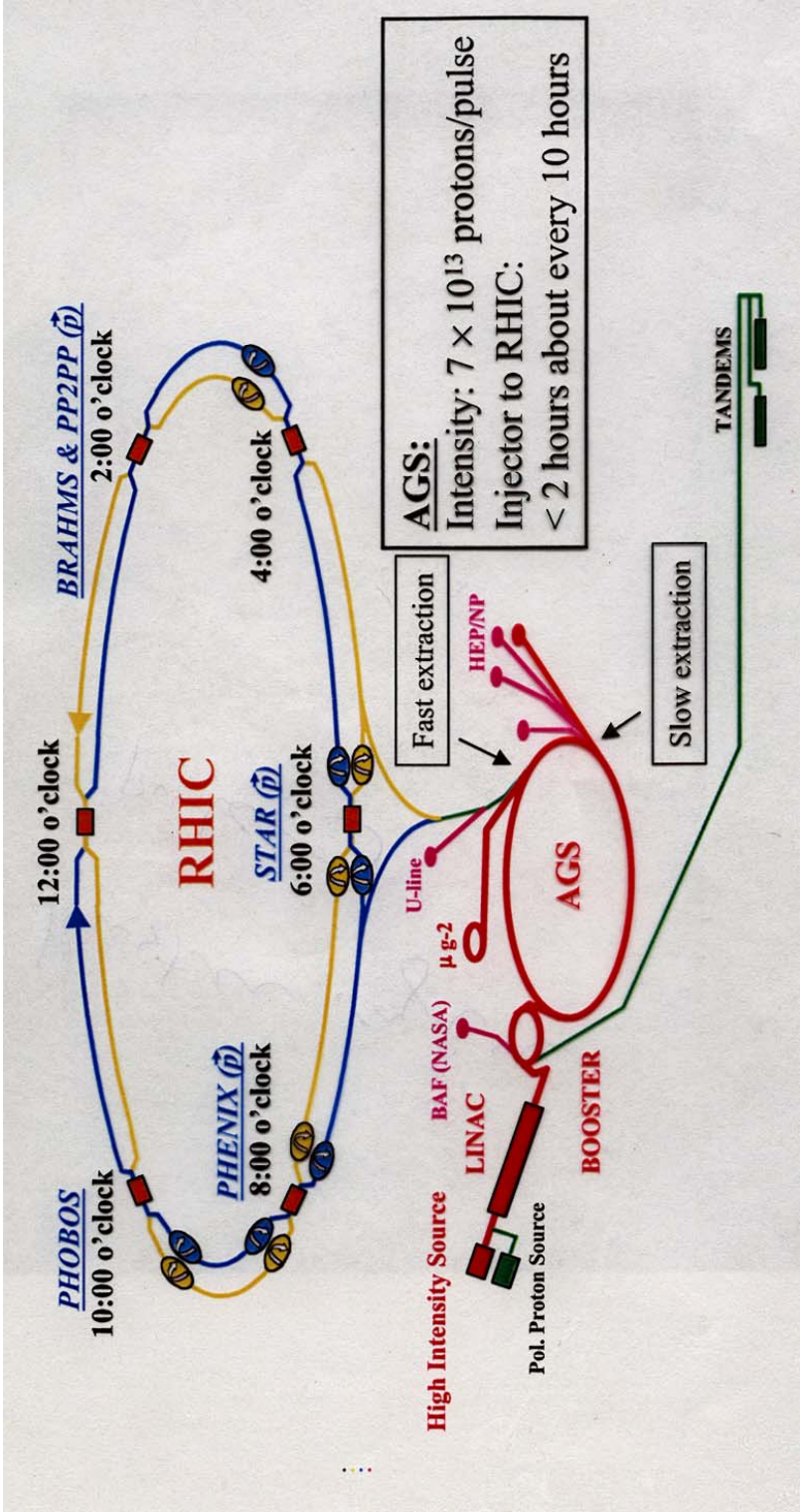
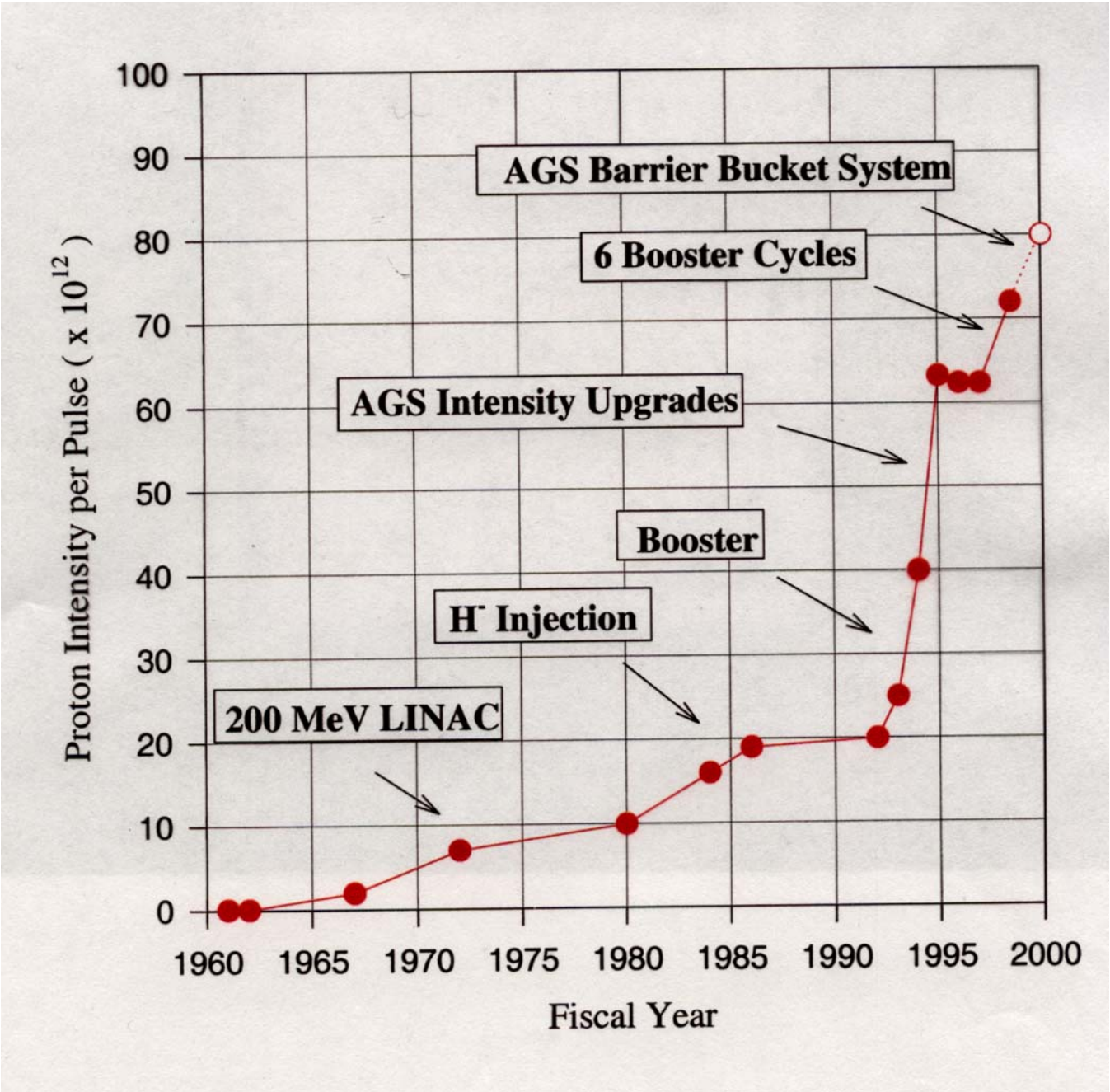
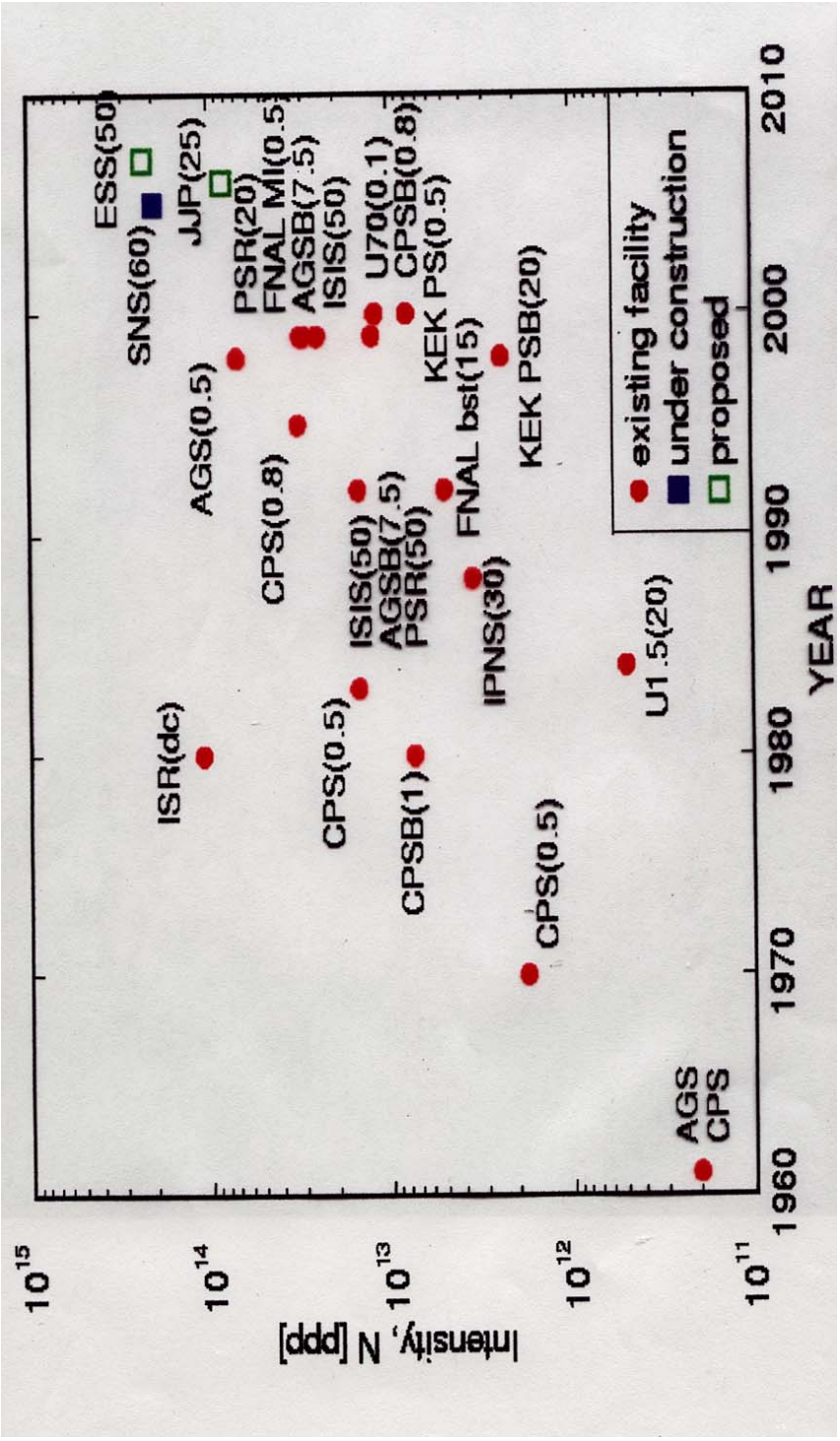
AGS/RHIC Accelerator Complex



AGS Proton Intensity Evolution



Intensity evolution

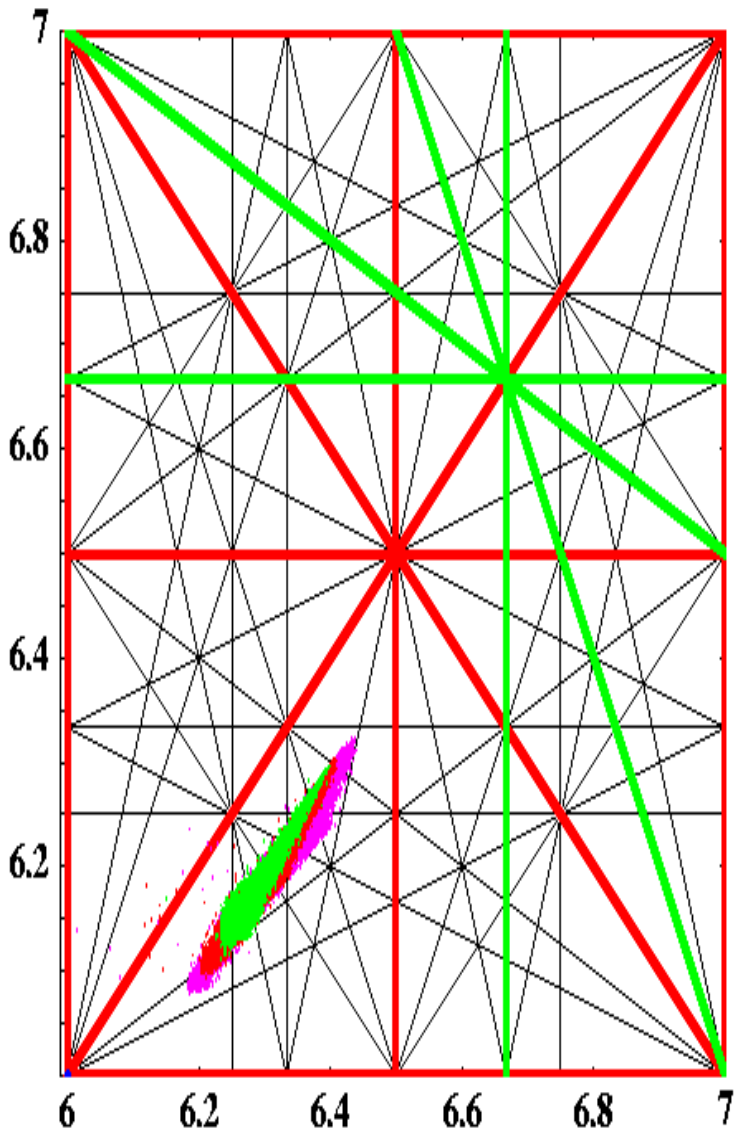


Incoherent and Coherent Space Charge Limit

$$\Delta Q_{inc} = \frac{3 r_p N}{2\beta\gamma^2 \varepsilon_N B_f}$$

	E (MeV)	N (10^{12})	Qx/Qy	ΔQ_{inc}	ΔQ_{exp}	ΔQ_{coh}
KEK-B	40	2.5	2.17/2.3	0.17	0.23	0.27
FNAL-B	400	8	6.7/6.8	0.2	0.4	0.32
ISIS	70	25	3.7/4.2	0.25	0.4	0.4
CERN-PS	1000	28	6.22/6.22	0.22	0.27	0.29
AGS-B	200	15	4.8/4.9	0.35	0.5	0.48
AGS-B	400	20	4.8/4.9	0.21		
AGS	1900	60	8.8/8.9	0.20		
AGS	2500	100	8.8/8.9	0.1.5		
AGS	2500	200	8.8/8.9	0.30		

Space Charge Tune Shift Causes Nonlinear Resonances



Example of tune space region free from structure resonances.

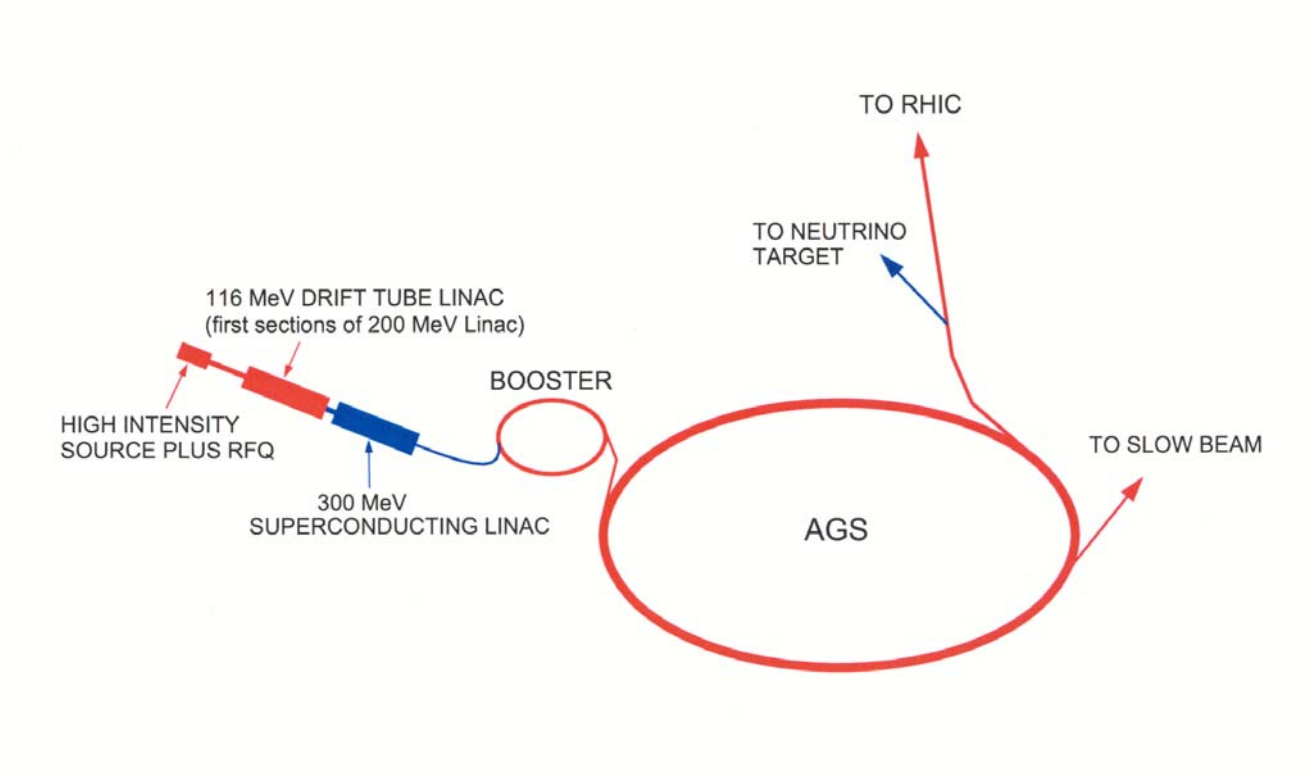
Tune foot-print of 2MW beam:

Green – space-charge spread

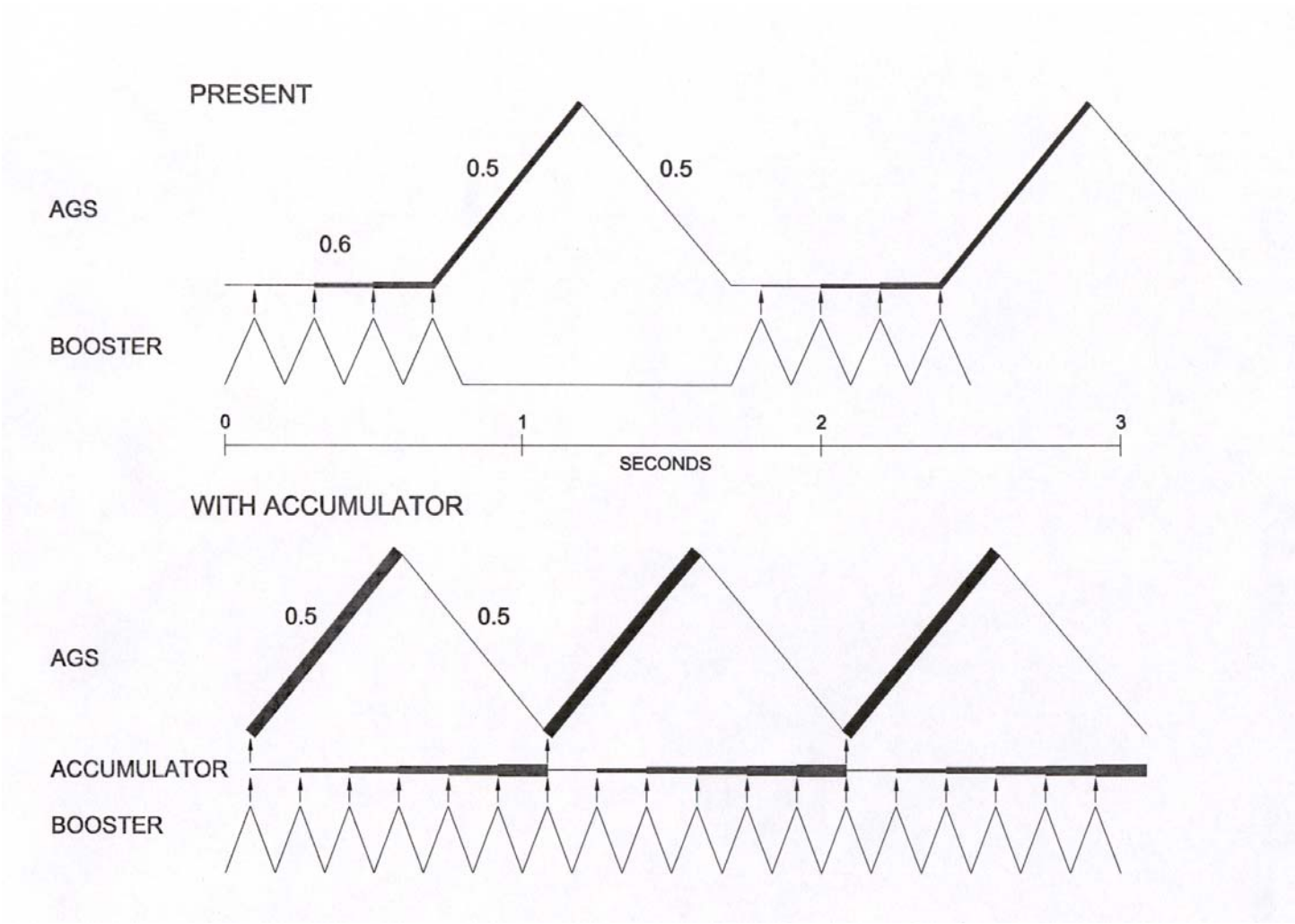
Red – space-charge and dp/p=0.7% spread

Pink – space-charge and dp/p=1% spread

AGS with SCL Addition



AGS Injection Modes



AGS Intensity Upgrades

		Phase I		Phase II
	Now Mar/02	**2.5 GeV Accumulator New 300 MeV Linac**		**AGS 2.5 Hz**
Linac Energy (MeV)	200	**200**	**400**	**400**
Booster Intensity (ppp)	1.5×10^{13}	$\mathbf{1.5 \times 10^{13}}$	$\mathbf{2.0 \times 10^{13}}$	$\mathbf{2.0 \times 10^{13}}$
Booster Energy (GeV)	1.8	**2.5**	**2.5**	**2.5**
Booster Cycles	4	**6**	**6**	**6**
AGS Energy (GeV)	24	**28**	**28**	**28**
AGS Intensity (Tp/sec)	36	**90**	**120**	**300**
AGS Rep Rate (Hz)	0.6	**1.0**	**1.0**	**2.5**
AGS Current (μA)	5.6	**14**	**19**	**48**
AGS Intensity (ppp)	6×10^{13}	$\mathbf{9 \times 10^{13}}$	$\mathbf{12 \times 10^{13}}$	$\mathbf{12 \times 10^{13}}$
AGS Power (kW)	140	**390**	**530**	**1300**

Accumulator Parameters

Max. Kinetic Beam Energy	2.5 GeV
Rigidity	13 Tm
Circumference	819.07 m
Number of Superperiods	25
Number of FODO Cells	50
Number of (Combined-Function) Dipoles	100
Dipoles Length / Field	3.25 m / 0.25 T
Length of FODO Cell	16.45 m
Length of straight sections	8.22 m
Phase Advance per FODO Cell	72 degrees
Vacuum Chamber x / y	150 mm / 75 mm
Acceptance Geometric x / y	234 / 58 π mm mrad
Acceptance Normalized @ 2.5 GeV x / y	744 / 184 π mm mrad
Space Charge limit:	
(100 π mm mrad, $\Delta\nu$ = 0.3, 2.5 GeV, debunched)	3.5×10^{14} ppp
Betatron Tunes x / y	10.3 / 10.5
Chromaticities x / y	-11.7 / -12.7
Beta Max. x / y	24.7 m / 24.3 m
Beta Min. x / y	7.8 m / 7.5 m
Dispersion Max.	1.8 m
Transition Gamma	9.6

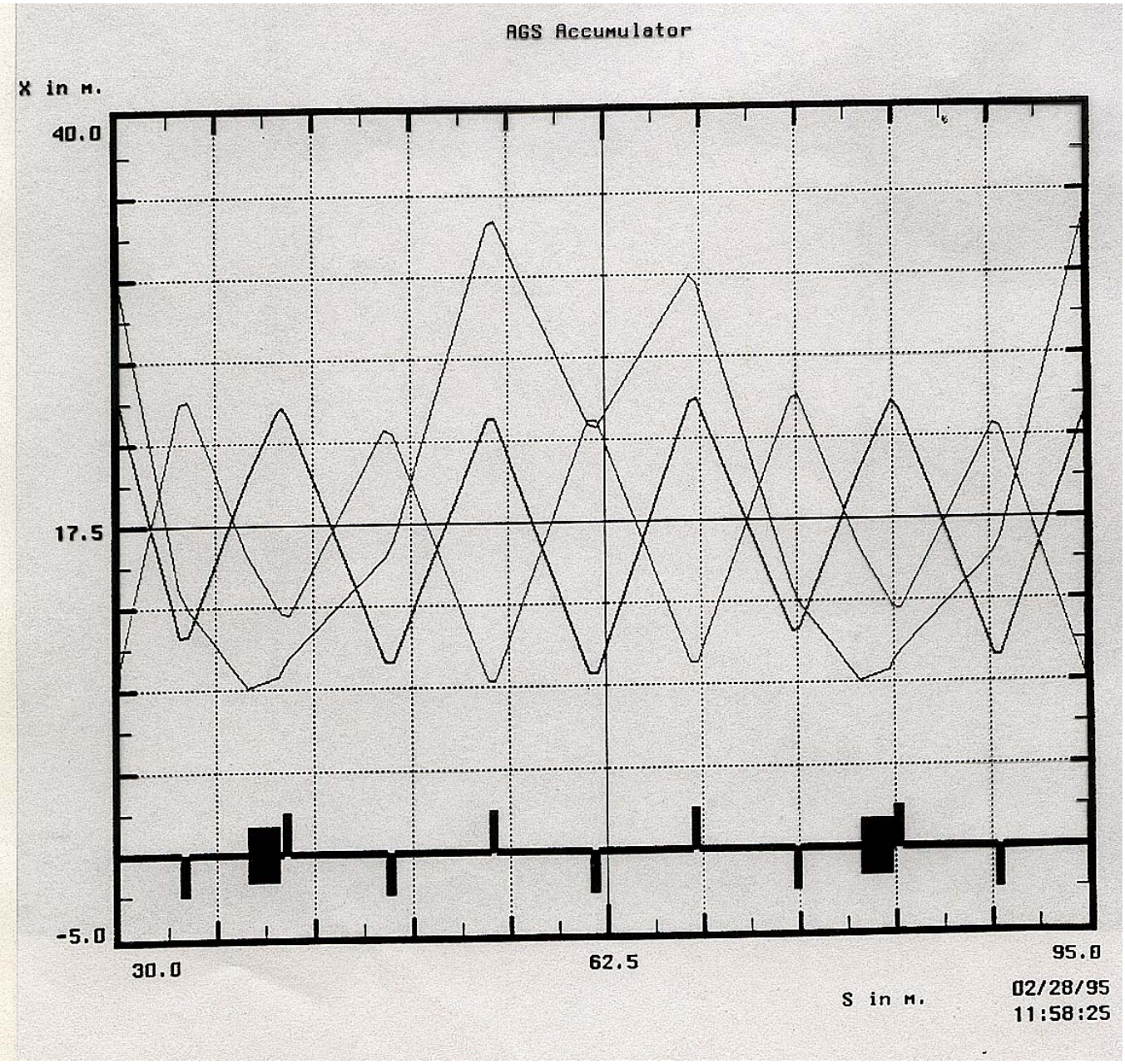
100 DIPOLES $\int B dl \approx 0.5\,Tm$, $B_0 \approx 0.25\,T$

COMBINED FUNCTION!

POS. NO.	ELEMENT SEQUENCE ELEMENT NAME	OCC. NO.	DIST [M]	I I	BETAX [M]	ALFAX [1]	HORIZONTAL MUX [2PI]	X(CO) [MM]	PX(CO) [.001]	DX [M]	DPX [1]	I I	BETAY [M]	ALFAY [1]	VERTICAL MUY [2PI]	Y(CO) [MM]	PY(CO) [.001]	DY [M]	DPY [1]
BEGIN	ACCUM	1	0.000		24.676	-1.991	0.000	0.000	0.000	1.778	0.114		7.481	0.719	0.000	0.000	0.000	0.000	0.000
BEGIN	SUPER	1	0.000		24.676	-1.991	0.000	0.000	0.000	1.778	0.114		7.481	0.719	0.000	0.000	0.000	0.000	0.000
1	BF	1	2.000		24.676	1.991	0.012	0.000	0.000	1.778	-0.114		7.481	-0.719	0.045	0.000	0.000	0.000	0.000
2	LDDEFF	1	8.224		7.683	0.739	0.087	0.000	0.000	1.069	-0.114		24.295	-1.982	0.122	0.000	0.000	0.000	0.000
3	BD	1	10.224		7.683	-0.739	0.131	0.000	0.000	1.069	0.114		24.295	1.982	0.134	0.000	0.000	0.000	0.000
4	LDDEFF	2	16.448		24.676	-1.991	0.206	0.000	0.000	1.778	0.114		7.481	0.719	0.211	0.000	0.000	0.000	0.000
END	SUPER	1	16.448		24.676	-1.991	0.206	0.000	0.000	1.778	0.114		7.481	0.719	0.211	0.000	0.000	0.000	0.000
END	ACCUM	1	822.400		24.676	-1.991	10.287	0.000	0.000	1.778	0.114		7.481	0.719	10.532	0.000	0.000	0.000	0.000

TOTAL LENGTH =	822.400000	QX =	10.287348	QY =	10.532447
DELTA(S) =	0.000000 mm	QX' =	-11.699115	QY' =	-12.717829
ALFA =	0.108781E-01	BETAX(MAX) =	24.676133	BETAY(MAX) =	24.295253
GAMMA(TR) =	9.587895	DX(MAX) =	1.777746	DY(MAX) =	0.000000
		XCO(MAX) =	0.000000	YCO(MAX) =	0.000000
		XCO(R.M.S.) =	0.000000	YCO(R.M.S.) =	0.000000

AGS Accumulator Lattice



AGS Accumulator with Permanent Magnets

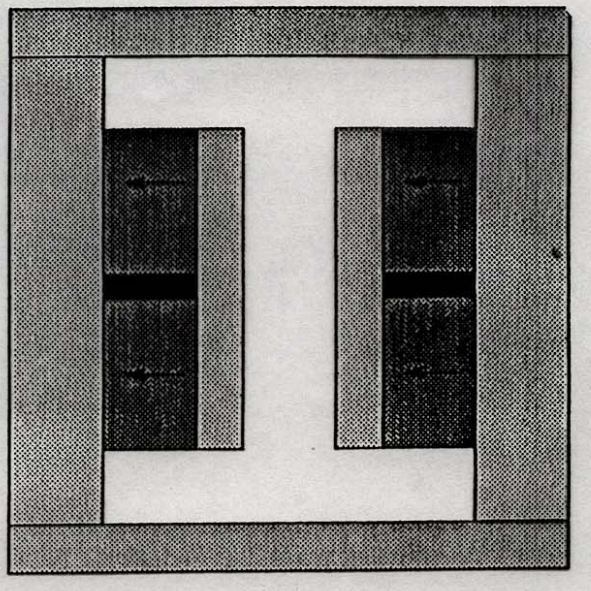
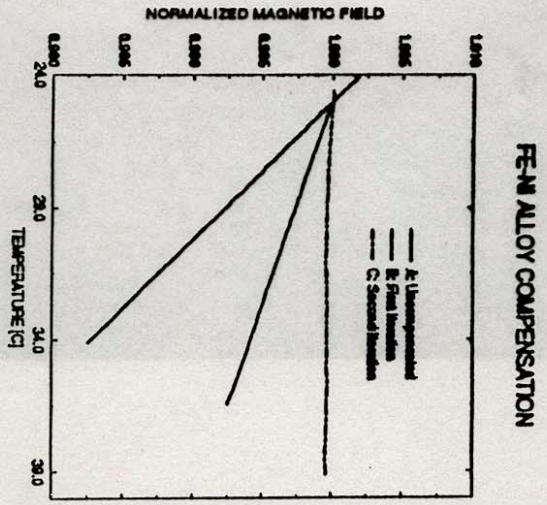
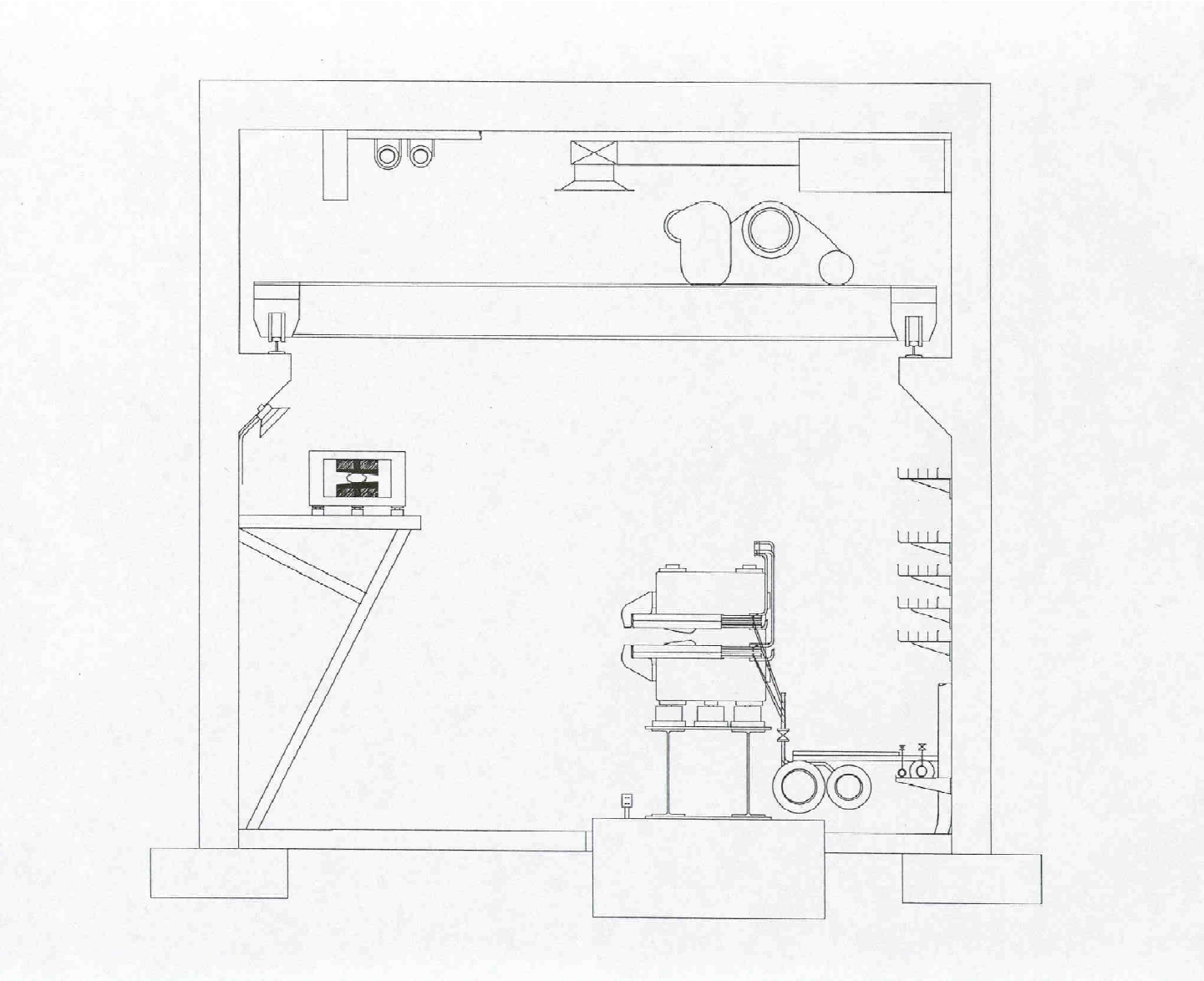


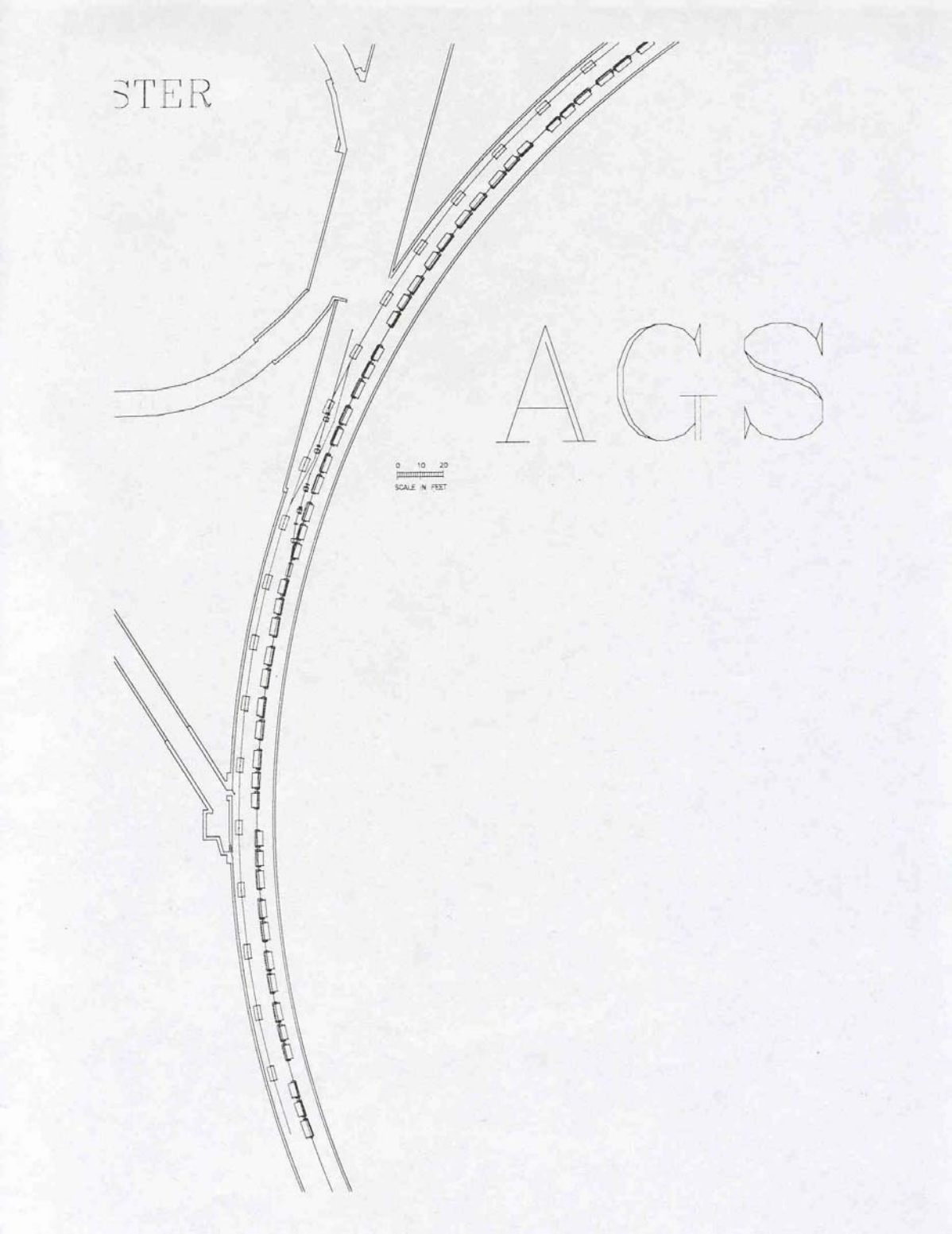
Figure. 1. Cross section of a dipole magnet. Temperature compensating strips are placed symmetrically between blocks of ferrite material.



AGS Tunnel with Accumulator Ring



AGS Tunnel with AR

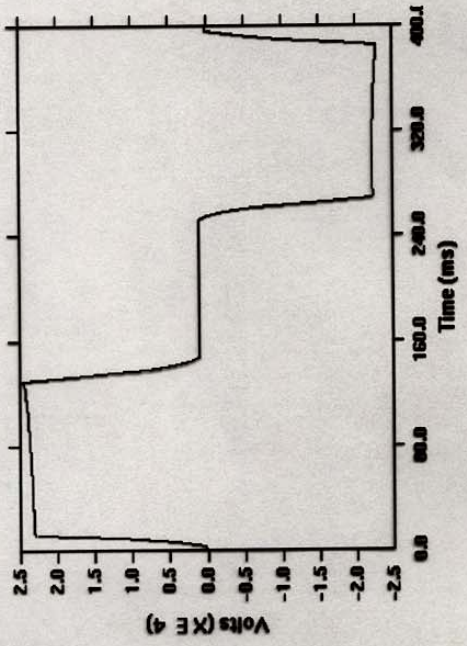


Summary of Preliminary Cost Estimate

Phase-I (AGS at 1 Hz)		
300 MeV SRT (116 -> 416)	$	35 M
2.5 GeV AGS Accumulator Ring	$	25 M
AGS Injection at 2.5 GeV	$	5 M
Initial 65 M$ (for 0.53 MW)		
Phase-II (AGS at 2.5 Hz)		
AGS power supply	$	32.0 M
AGS rf upgrade	$	8.6 M
Booster Power Supply	$	8.6 M
AGS Collimation and Shielding	$	8.0 M
Additional 54.1 M$ (for 1.3 MW)		
Material & Labor only, no contingency		

New AGS Main Magnet Power Supply

		presently:
• Repetition rate	2.5 Hz	1 Hz
• Peak power	110 MW	50 MW
• Average power	4 MW	4 MW
• Peak current	4.2 kA	5 kA
• Peak total voltage	± 25 kV	± 10 kV
• Number of power converters / feeds	6	2



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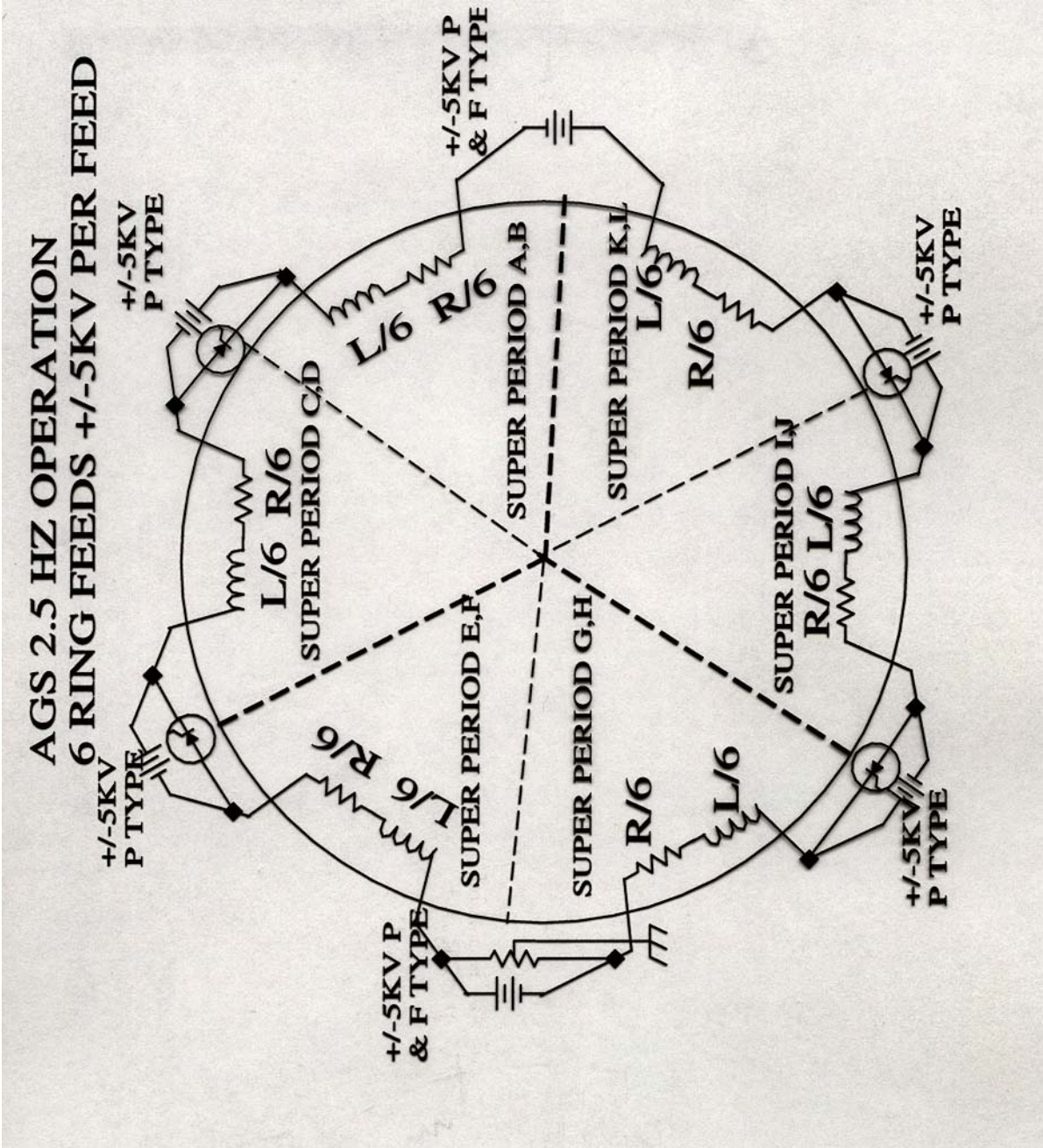
Distribution of Current Feeds

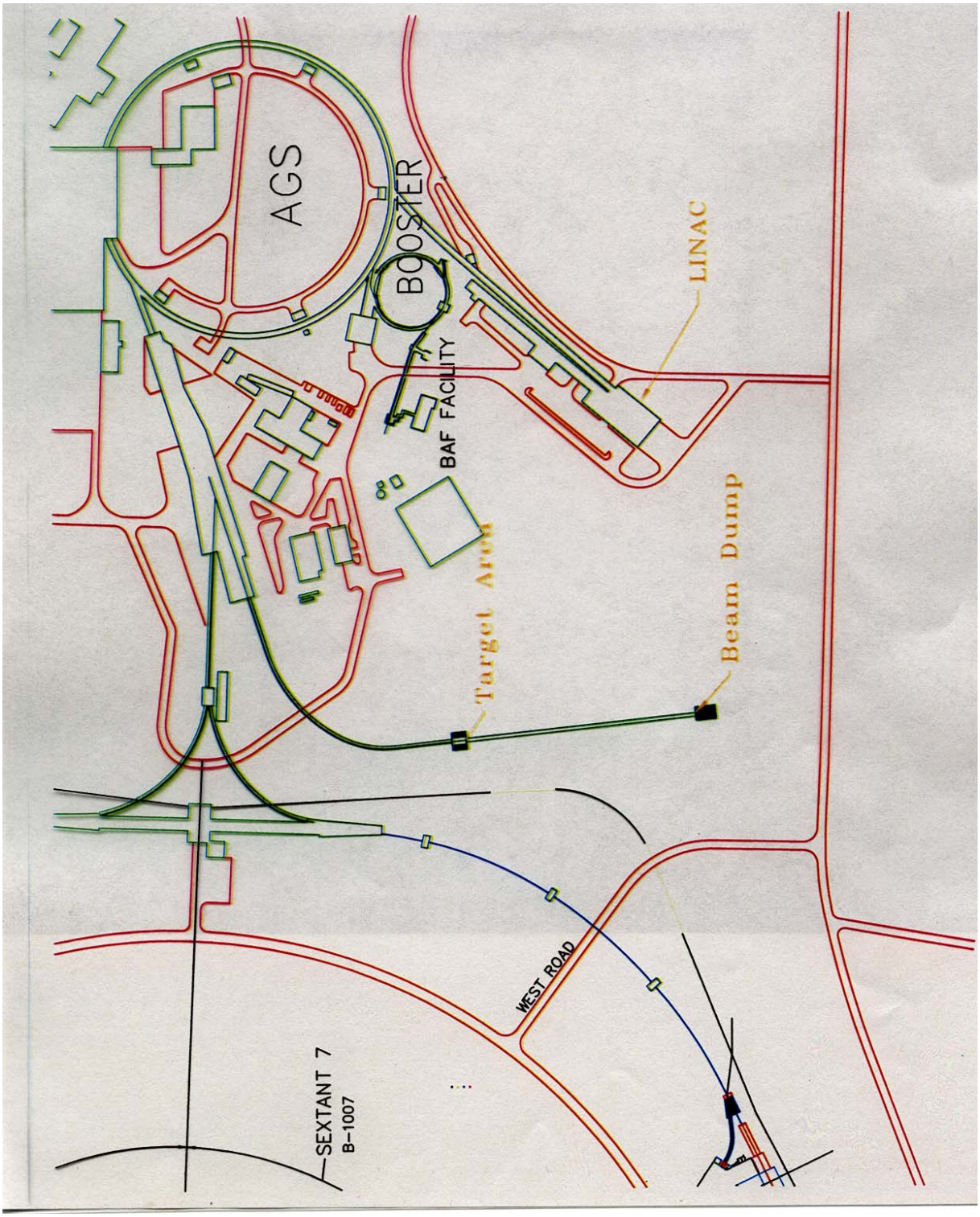


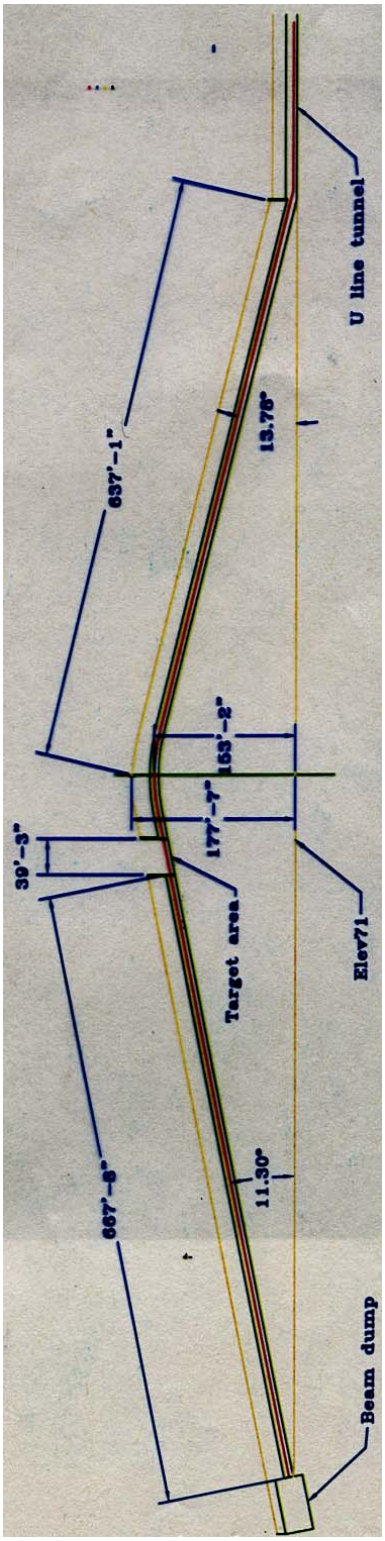
Associated Accelerator Improvements

1. AGS injection improvements

2. AGS machine improvements
   - Resonace corrections
   - RF feedbacks
   - Transition crossing
   - Beam collimation and shielding

3. AGS extraction and Beam Transport to Target


AGS
BOOSTER
BAF FACILITY
LINAC
Target Area
Beam Dump
WEST ROAD
SEXTANT 7
B-1007


667'-8"
39'-3"
657'-1"
11.30°
177'-7"
153'-2"
13.75°
Beam dump
Target area
Elev71
U line tunnel