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BROOKHAVEN NATIONAL LABORATORY
Associated Universities, Inc.
Upton, New York

ACCELERATOR DEPARTMENT
Informal Report

AGS Secondary Beams and Parameters - FY 73

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C.L. Wang and D. Berley
October 19, 1972

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ABSTRACT

A compilation is presented of the AGS secondary beam parameters and fluxes.

A compilation is presented of the AGS secondary beam parameters and particle fluxes. Fig. 1 and 2 show the layout of the secondary beams at the AGS for the second half of 1972 and for the first half of 1973 respectively. Some details of the beams from G10, A, B, and C target stations are given in Fig. 3 and 4. References are those available on hand and no effort is made for completeness. The compilation will be revised when new beams and more information become available. We welcome comments and contributions from experimenters, especially with respect to measured beam fluxes.

Beam 2 - Low Energy Separated Beam for 30-in. Bubble Chamber

Particles	K^{\pm}, \bar{p}
Maximum momentum	1.2 GeV/c
Momentum bite	$\pm 0.5\%$
Target location	F20
Target material	Be
Target size	0.5 in. diameter, 0.75 in. length
Production angle	12°
Solid angle	1 msr
Separators	2-stage electrostatic separators
Length	850 in. to chamber
Purity	$K/\text{other} \geq 0.9$ at 750 MeV/c

Beam 2 (continued)

Flux/burst	Momentum (MeV/c)	Particles/10 ¹¹ circulating protons			
		π^\pm	K^-	K^+	\bar{p}
	0		10	40	4
	600		35	140	6
	800	$\sim 10^5$	180	700	12
	1000		750	3000	50

Reference: D. Berley, AGS Division Technical Note No. 25 (1965).

Beam 4 - High Energy Separated Beam for 80-in. Bubble Chamber

Particles K^\pm , p^\pm , π^\pm , d

Momentum range	K, 3.5 to 15 GeV/c (flux limited below 3.5 GeV/c) \bar{p} , 3 to 15 GeV/c (flux limited above 15 GeV/c) π^\pm , to 24 GeV/c (focal strength limited above 24 GeV/c) π^- , to 25 GeV/c (unseparated) P, to 29 GeV/c (unseparated) d, 20 to 29 GeV/c (momentum separated)
Momentum bite	1%
Target location	External target near I 13
Target material	Be
Target size	0.2 in. wide, 0.15 in. wide, 10 in. long
Production angle	0°
Solid angle	0.0066 msr
Separator	three deflectors
Length	129m
Purity	$\geq 90\%$

Flux/burst (A)	Momentum (GeV/c)	Particles/10 ¹¹ incident protons (at 25 GeV/c)				
		π^+	π^-	K^+	K^-	\bar{p}
	8	5000	2300	70	17	18
	10	4700	2000	85	16	10
	12	4000	1500	80	11	5
	15			60	4	2
(B)		Particles/10 ¹² incident protons (at 27 GeV/c)				
	4			30	20	200
	6			250	100	250

PHYSICS

Beam 4 (continued)

References: H.W.J. Foelsche, V.D. Vander Burg, T. Ferbel and P. Yamin, in
 Summer Study on AGS utilization (Ed. T.E. Toohig), BNL 1600 (1970).
 H.W.J. Foelsche, private communication.

Beam 5A - Medium Energy Partially Separated Beam

Particles	K^{\pm}, \bar{p}			
Momentum range	1.3 to 2.6 GeV/c			
Momentum bite	$\pm 2\%$			
Target location	G10			
Target material	BeO			
Target size	0.04 in. diameter, 0.6 in. length			
Production angle	10°			
Solid angle	0.47 msr			
Length	1788 in.			
Separators	2 electrostatic separators			
Purity	K^+ /other ≈ 0.5			
Flux/burst	Momentum	Particles/ 10^{12} circulating protons		
	(GeV/c)	K^+	K^-	\bar{p}
	1.3	3500		
	1.6	15000		8200
	1.8	28000	13000	17000
	2.0	50000	22000	29000
	2.2	68000	33000	42000
	2.4	85000		58000
2.6	103000		70000	

References: B. Barish and T.F. Kycia (preprint).
 S. Mori, private communication.

Beam 5B - Medium Energy Partially Separated Beam

Particles	K^{\pm}, \bar{p}
Momentum range	1 to 2.5 GeV/c
Momentum bite	± 1 to $\pm 3\%$
Target location	G10
Target material	BeO
Target size	0.04 in. diameter, 0.6 in. length
Production angle	10°
Solid angle	0.47 msr
Length	1522 in.
Separators	2 electrostatic separators

Beam 5B (continued)

Purity	π^+/K^+	1-4		
	π^-/K^-	1-4		
	π^-/\bar{p}	1-15		
Flux/burst	Momentum	Particles/ 10^{12} circulating protons		
	(GeV/c)	K^+	K^-	\bar{p}
	0.8			500
	1.0	950		1700
	1.5	11000	7500	12000
	2.0	30000	20000	25000
2.4	50000	27000	40000	

References: B. Berish and T.F. Kycia (preprint).

J.K. Yeh et al, Phys. Rev. Letters 23, 506 (1969);

Y. Nagashima, private communication.

Beam 6A - G10 4.7° Neutral Beam

Particles	K_L^0		
Momentum range	3 to 10 GeV/c		
Target location	G10		
Target material	BeO		
Target size	0.03 in. diameter, 0.5 in. length		
Production angle	4.7°		
Solid angle	0.015 msr		
Length	190 ft		
Yield	Momentum	K_L /sr/GeV/c/proton	$K_L/10^{12}$ protons
	(GeV/c)		at detector
	3	0.025	39000
	4	0.026	48000
	5	0.023	46000
	6	0.020	42000
	7	0.013	28000
	8	0.008	18000
	9	0.005	11000
	10	0.003	7000

References: J.W. Cronin, in Possible Beams and Experiments for a High Intensity AGS (Ed. L.C.L. Yuan), BNL 7957 (1964), p. 44, also private communication.

E. Engels, private communication.

Beam 6B - Medium Energy Test Beam

Particles	π^{\pm}, p (unseparated)	
Momentum range	2 to 17 GeV/c	
Momentum bite	$\pm 2\%^*$	
Target location	G10	
Target material	BeO	
Target size	0.02 in. high, 0.04 in. wide, 0.6 in. long	
Production angle	4.7°	
Solid angle	$9\mu\text{sr}^{**}$	
Beam size	3-4 in. horizontal, 2-3 in. vertical	
Flux/burst	Momentum	Particles/ 10^{12} circulating protons
	(GeV/c)	π^{\pm} p
	6	10^6 9×10^5
	12	2.5×10^5 7×10^5
17	2×10^4 2×10^5	

Remarks: *This is the maximum momentum band transmitted. Under normal conditions the momentum defining aperture C_2 will be reduced so that the beam flux corresponds to the requirements of the Radiation Safety Committee.

**This is dependent upon the collimator C_1 at the input to quadrupole Q_1 . The figure given here is for the collimator installed for Exp. 556 in the neutral beam. An acceptance of $150 \mu\text{sr}$ is attainable with no collimator.

References: T. Blair and D. Lazarus, EP&S Tech Note. 48 (1972).
D. Lazarus, private communication.

Beam 7A - G10 20° Neutral Beam

Particles	K_L^0	
Momentum range	1 to 4 GeV/c	
Target location	G10	
Target material	BeO	
Target size	0.02 in. high, 0.04 in. wide, 0.6 in. long	
Production angle	20°	
Solid angle	$\sim 0.0784 \mu\text{sr}$	
Flux	Momentum	$K_L^0/\text{sr}/100 \text{ MeV/c}$ per 10^4
	(GeV/c)	circulating protons
	1.0	0.63
	1.2	1.55
	1.4	2.12
1.6	2.07	

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Beam 7A - G10 20° Neutral Beam (continued)

2.0	1.55
2.4	1.01
2.8	0.63
3.3	0.27
3.8	0.14

Reference: D. Nygren, private communication.

Beam 7B - G10 18° Test Beam

Particles	$\pi^\pm, K^\pm, p^\pm, D, T, H_e^3, H_e^4$						
Momentum range	0.8 to 3.3 GeV/c						
Momentum bite	$\pm 1\%$						
Target location	G10						
Target material	BeO						
Target size	0.02 in. high, 0.04 in. wide, 0.6 in. long						
Production angle	18°						
Solid angle	9.1×10^{-8} sr						
Flux/burst	Momentum (GeV/c)	Particles/ 1.5×10^{12} circulating protons					
		p	π^+	π^-	K^+	K^-	
	1.5	57000	54000	50000	8300	1700	
	2.5	22000	18000	14000	3600	1100	
	3.3	9000	6500	5000	1700	370	
		Ratios					
	(GeV/c)	p/π^+	\bar{p}/π^-	D/π^+	T/π^+	H_e^3/π^+	H_e^4/D
	1.5	1.0	0.003	0.02	0.001	0.0002	0.02
	2.5	1.2	0.006	0.03	0.001		0.003
	3.3	1.5		0.04	0.0005		

References: A.S. Carroll, et al., Phys. Rev. Letters 20, 607 (1968).
C.L. Wang, Phys. Rev. Letters 22, 1011 (1969).

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Beam 8 Neutrino Beam

Particles	$\nu, \bar{\nu}$	
Energy	peaked at ~ 1.5 GeV	
Target location	U station	
Target material	sapphire	
Target size	diameter 0.5 cm, length 45 cm	
Length	π, K decay region	208 ft
	ν filter	96 ft iron
	from target to bubble chamber	336 ft
Optics	3 magnetic fingers focusing pions and kaons toward the bubble chamber	
Flux/burst	Energy (GeV)	Neutrinos/(interacting proton-meter ² ·GeV) (averaged over 70 cm radius area)
	.5	3.5×10^{-4}
	1	9.5×10^{-4}
	1.5	1.4×10^{-3}
	2	1.1×10^{-3}
	4	2.2×10^{-4}
	6	3.7×10^{-5}
	8	1.3×10^{-5}
	10	6.8×10^{-6}
	12	3.6×10^{-6}
Expected completion date	Summer 1973	

Reference: N.P. Samios, R.B. Palmer, W.B. Fowler, and R.I. Louttit;
 AGS Proposal #A-427 (1967).
 BNL neutrino beam working group, private communication.

Note added in proof: Recent estimate shows that approximately 1.5 times more flux than given above can be expected.

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Beam A 1 - High Energy Charged Beam

Particles	$\pi^\pm, K^\pm, p, \bar{p}$
Momentum range	6 to 25 GeV/c
Momentum bite	$\sim \pm 1\%$ (without collimators)
Target location	Target Station A
Target material	Cu
Target size	0.1 in. x 0.2 in. x 6 in.
Production angle	0°
Solid angle	0.23 msr (without collimators)
Length	4154 in.
Flux/burst	At 10 GeV/c, π^- flux $\approx 500,000/3 \times 10^{11}$ incident protons. Flux for different momenta and particles can be obtained by scaling with yield curves of Sanford and Wang (BNL 11299 and BNL 11479).

References: E.H. Willen, private communication.

J. Detweiler and T. Toohig, EP&S Division Tech. Note 32 (1970).

Beam B 2 - Medium Energy Separated Beam

Particles	K^\pm, \bar{p}, π^\pm	
Target location	B station	
Target material	Cu (tentative)	
Target size	0.04 in. high, 0.1 in. wide, 3 in. long (tentative)	
Production angle	6° (phase 1) 3° (phase 2. For this later phase, particle fluxes at higher momentum will be increased).	
Separator	2 electrostatic separators	
Length	3182 in.	
	<u>Mode 1</u>	<u>Mode 3</u>
Momentum range	1.5 - 4 GeV/c	2 - 6 GeV/c
Momentum bite	$\pm 3\%$	$\pm 2.2\%$
Solid angle	320 μ sr	93 μ sr

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Beam B 2 - Medium Energy Separated Beam (cont.)

Flux/burst (particles/10 ¹² interacting protons)	Momentum (Gev/c)	Mode 1		\bar{p}	Mode 3			K^-	\bar{p}
		K^+	K^-		π^+	π^-	K^+		
1				6.2×10^4	1.7×10^5	1.4×10^5			1.3×10^4
2		1.7×10^4	5×10^3	2.5×10^5	6.7×10^5	5.2×10^5	3.5×10^3	1×10^3	5.3×10^4
3		1.4×10^5	4.8×10^4	4.3×10^5	9.2×10^5	7.0×10^5	3.2×10^4	1×10^4	9.2×10^4
4		3.7×10^5	1.3×10^5	4.8×10^5	9.2×10^5	6.8×10^5	7.7×10^4	2.7×10^4	1×10^5
5				4.2×10^5	7.6×10^5	5.5×10^5	1.2×10^5	4.1×10^4	8.9×10^4
6				3.1×10^5	5.6×10^5	4.0×10^5	1.4×10^5	4.4×10^4	6.4×10^4
8					2.7×10^5	1.7×10^5			2.5×10^4
10					1.0×10^5	7.0×10^5			6.5×10^3

Expected completion date Summer 1973

References: A.S. Carroll, in Summer Study on AGS Utilization (Ed. T.E. Toohig),
BNL 16000 (1970).
J.D. Fox and C.T. Murphy, Accelerator Department Informal Report
EP&S 72-1 (1972), also private communication.

Beam C 1 Muon Beam

Particles	μ^\pm	
Central momentum	7.3 GeV/c	(Momentum range 5-9.5 GeV/c)
Momentum width (at half max.)		+ 900 MeV/c - 700 MeV/c
Angular spread (at half max.)		± 7 mrad.
	($\geq 90\%$)	± 15 mrad.
Profile	vertical	± 2.25 in. ($\geq 90\%$)
	horizontal	± 1.25 in. (half max.)
		± 2.25 ($\geq 90\%$)
Target location	C Station	
Target material	Cu	
Target size	0.1 in. high, 0.2 in. wide, 1.5 in. long	
Flux/burst	10^8 muons/10 ¹² incident protons	
Purity	$\pi/\mu \approx 10^{-8}$	(with 21 ft. Be + 4 ft. carbon filter)
Halo/beam	≈ 1	

Reference: Columbia-Harvard-NAL-Rochester Muon Group, private communication.

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Beam C 3 - Hyperon Beam

Particles	Σ^-, Ξ^-
Momentum range	17 to 26 GeV/c
Momentum bite	$\pm 0.5\%$
Target location	C' station
Target material	Be
Target size	0.1 in. high, 0.2 in. wide, 10 in. long
Production angle	0°
Solid angle	22 μ sr
Length	172 in.

Flux detected/burst	Momentum (GeV/c)	Σ -trigger/ 10^{11} incident protons	(Σ/π) trigger	(Ξ/Σ) detected
	19	12	7.4×10^{-5}	
	20	28	2.5×10^{-4}	
	20.5			2.85×10^{-2}
	21	56	6.9×10^{-4}	
	22	88	1.4×10^{-3}	
	23	121	3.1×10^{-3}	
	24	180	9.4×10^{-3}	
	25	160	1.4×10^{-2}	
	26	105	1.6×10^{-2}	

Reference: Yale-NAL-BNL Hyperon Group, private communication.

Beam C 4 - Low Energy Separated Beam

Particles	K^\pm, \bar{p}, π^\pm
Maximum momentum	1.1 GeV/c
Momentum bite	$\pm 1\%$
Target location	Target Station "C"
Target material	Cu
Target size	0.1 in. high, 0.2 in. wide, 4.1 in. long
Production angle	10.5°
Solid angle	2.64 msr
Separator	1 electrostatic separator
Length	580 in.

Beam C 4 - Low Energy Separated Beam (cont)

Purity	π/K is a function of the momentum and mass slit opening, e.g.			
	K^+ Momentum (MeV/c)	550	900	800 800
	Mass slit (in.)	0.2	0.2	.05 .25
	π/K	40	5	3.0 7.5
Flux/burst	Momentum (GeV/c)	Particles/10 ¹²		incident protons
		K^+	K^-	\bar{p}
	0.55	3.5x10 ³		
	0.65	1.5x10 ⁴		
	0.75	3.5x10 ⁴	1.4x10 ⁴	900
	0.9	9x10 ⁴		

References: J.D. Fox, EP&S Division Technical Note No. 7 (1967) and No. 20 (1968).
M. Zeller, L. Rosenson and R.E. Lanou, Jr., in Summer Study on AGS Utilization (Ed. T.E. Toohig), BNL 16000 (1970).
A.S. Carroll et al., EP&S Division Technical Note No. 54 (1972).
R. Rubinstein, private communication.

TABLE I. Momenta available in bubble chamber beams at the AGS

Particle	Beam 2	Beam 4
	$P_{min} - P_{max}$ GeV/c	GeV/c
π^+	~0.4 to 1.1	4 - 24
π^-	~0.4 to 1.1	4 to 25 (unseparated)
K^\pm	0 to 0.9	3.5 - 15
p		4 - 24
p	0 to 1.1	~9 to 29 (diffracted)
\bar{p}	0 to 1.1	3 - 15
d		20 - 29

BROOKHAVEN NATIONAL LABORATORY
 ALTERNATING GRADIENT SYNCHROTRON
 SECOND HALF 1972
 *PRIMARY PROTON TARGET

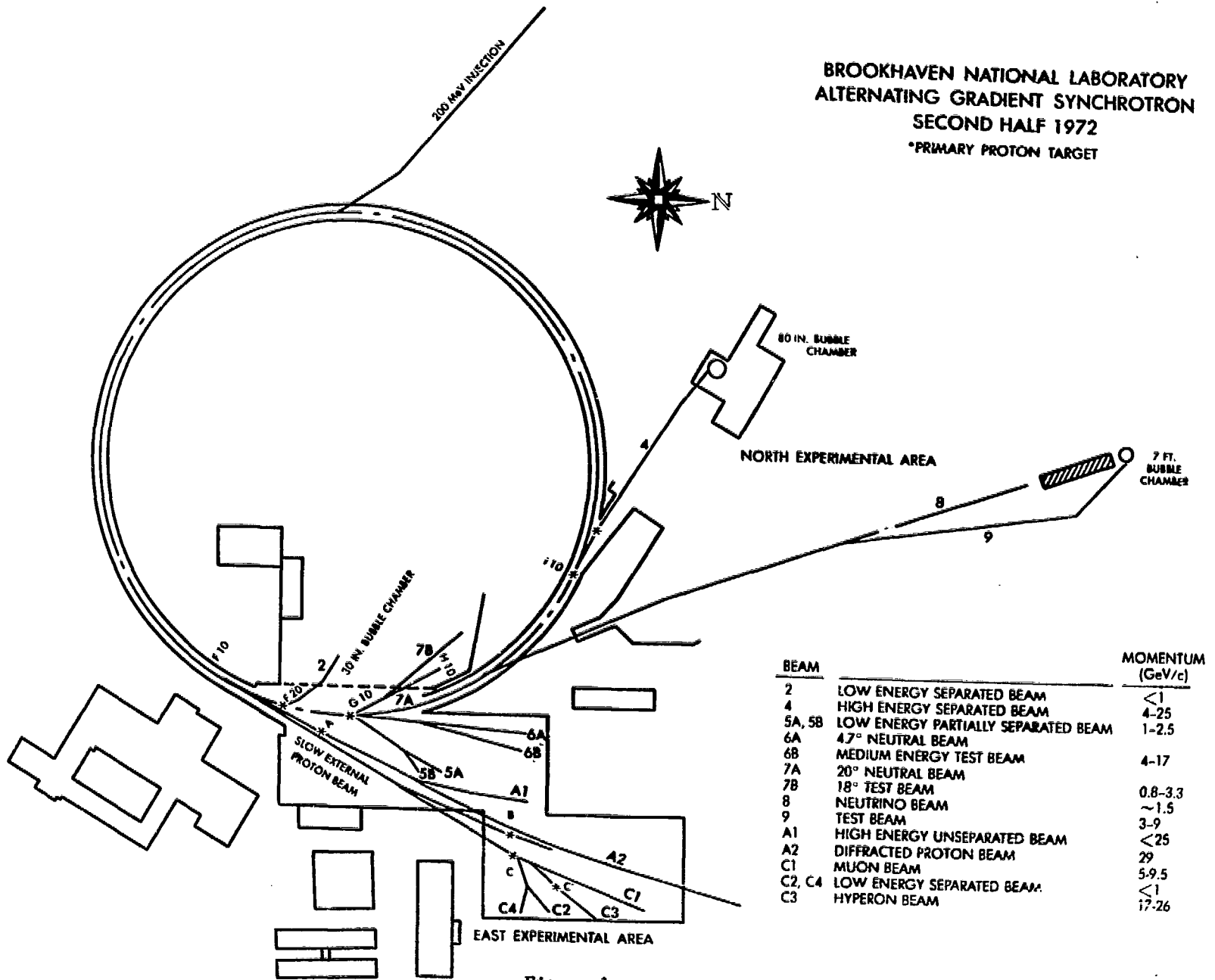


Figure 1

BROOKHAVEN NATIONAL LABORATORY
ALTERNATING GRADIENT SYNCHROTRON
FIRST HALF 1973

* PRIMARY PROTON TARGET

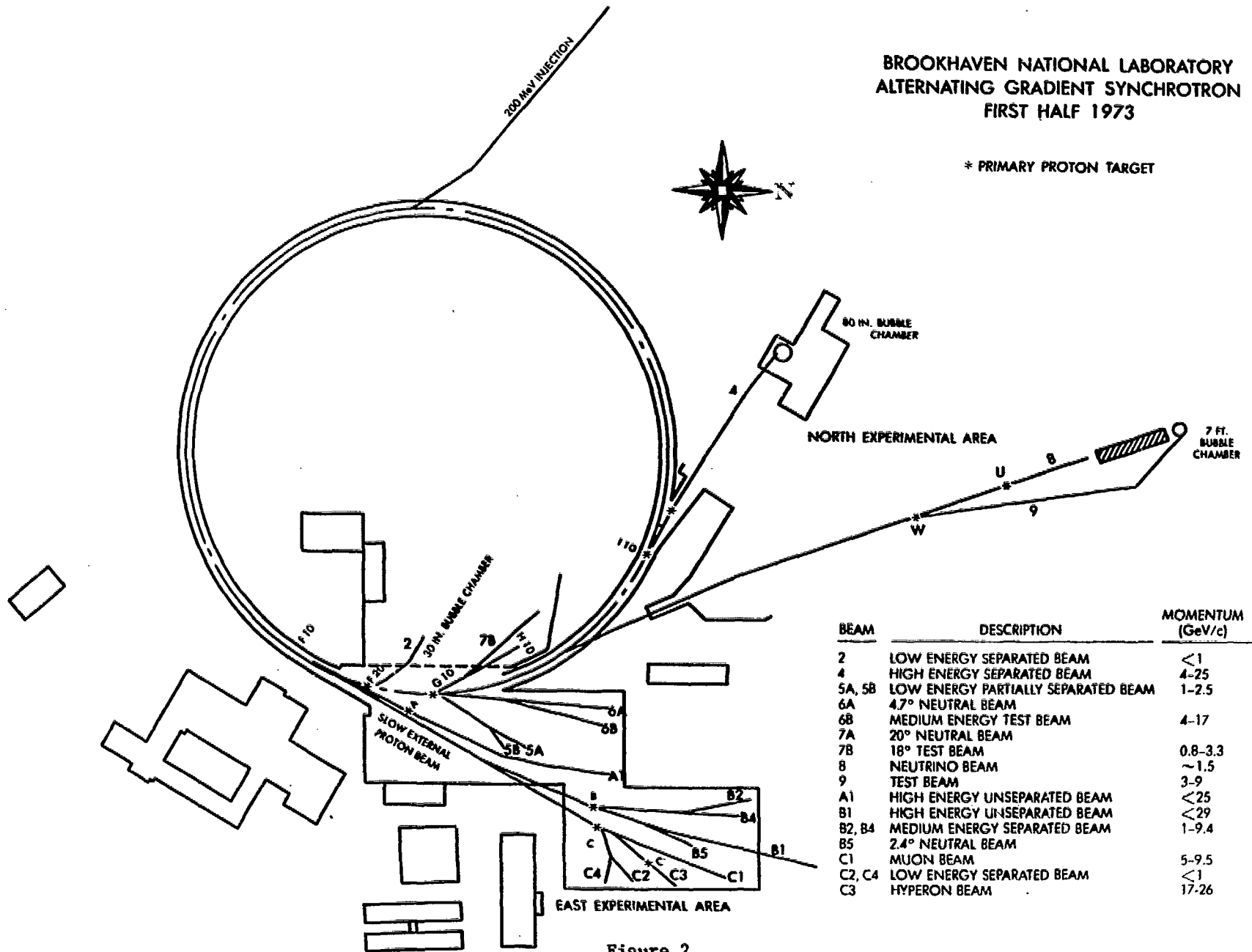


Figure 2

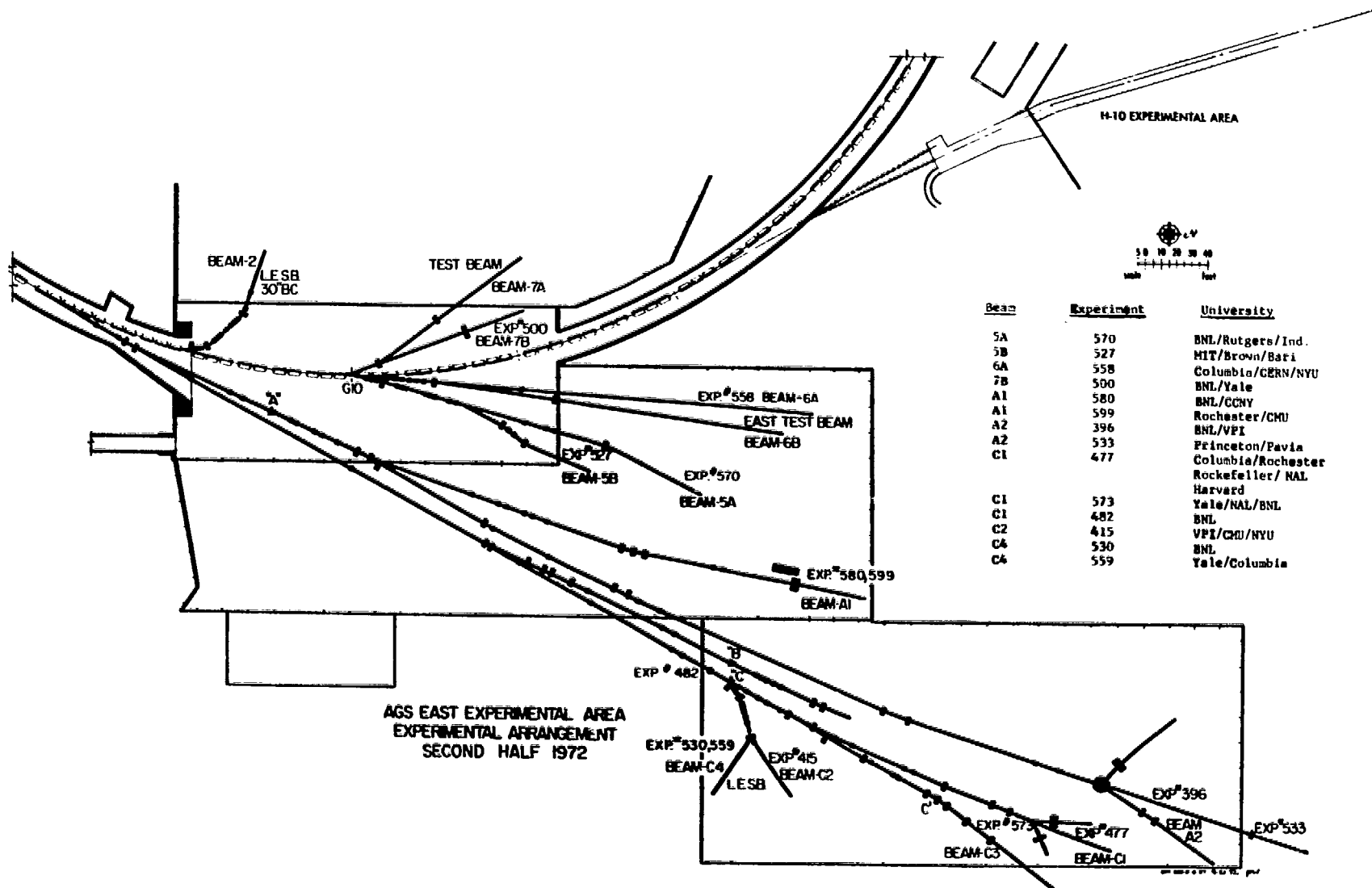


Figure 3

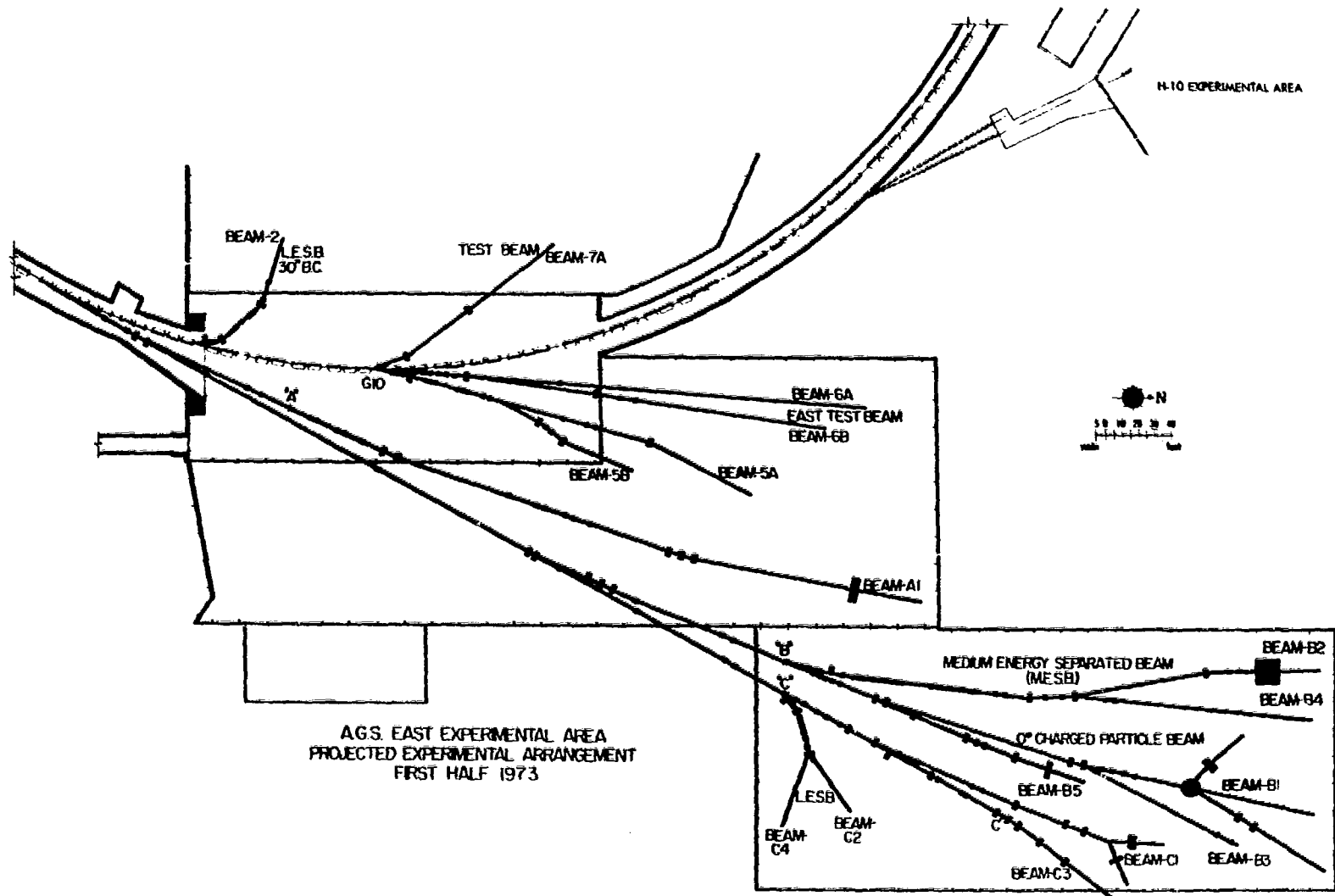


Figure 4