national accelerator laboratory

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NEUTRINO AREA - DESIGN REPORT - MUON BEAM: N-1

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Muon beam, N-1, was designed as a low-cost muon channel to make use of muons produced along with neutrinos in the decay of π- and K- mesons from the Neutrino Area primary production target. The design energy of the beam was $\leq$ 300 GeV with $\Delta E/E \approx \pm 5\%$. Under the assumption of a simple quadrupole doublet front end, using Main Ring type 3Q84 quadrupoles, the design flux was $10^6 - 10^7$ μ/pulse into a 4-inch by 4-inch spot at the Muon Laboratory for 5×10^{13} p/pulse on the target. The beam is a dipole beam with a pair of 3Q84 quadrupoles at Enclosure 101 to cancel the angular spread of the beam due to Δp and π-μ decay, and a second pair of 3Q84 quadrupoles at Enclosure 103 to cancel the multiple scattering in the 40-foot CH_2 absorber at Enclosure 102. The Muon Laboratory, which is the experimental station fed by the N-1 beam, is located half way along the Neutrino Area shielding berm. After passing through the Muon Laboratory the residual muon beam is dumped into the shielding berm and ranged out short of the 15-foot bubble chamber.

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Subsequent to the original design and prior to the completion of the construction of the beam enclosures a substitution was made in Enclosure 103 of six 12-inch diameter, 12Q48, quadrupoles for the two 3-inch by 5-inch, 3Q84, main ring quadrupoles. This change was based on a calculated 5-fold increase in flux and an 8-fold reduction in the halo-to-beam ratio at 100 GeV. The cost was a reduction in focussing capability from 300 GeV to 200 GeV and an increase in required power from 125 kw to 825 kw at the 200 GeV level. The measured μ^+/p at 120 GeV/c ratio with this configuration, but using the narrow-band Prototype Target Load is:

$$\frac{\mu^+}{p} \approx 5 \times 10^{-9}$$

A further change in the beam is the substitution of 4-inch aperture dipoles in Enclosure 104 in place of the 2-inch aperture main ring B2 dipoles. The calculated gains from this opening up of the aperture are a 30% increase in intensity and a further factor of two reduction in the halo to berm ratio at 100 GeV/c to 1:8. The maximum beam energy is reduced to 160 GeV with an upper limit of 200 GeV by use of an additional power supply and then ramping the two supplies together. The power required at 200 GeV is increased from 209 kw to 772 kw. The measured μ^+/p ratio at 150 GeV/c with this modified configuration and using the modified narrow band target load of Stefanski, Teng, Yamanouchi, et al. is:

$$\frac{\mu^+}{p} \approx 2.5 \times 10^{-8}$$

To achieve the design intensity of 10^6 $\mu/10^{13}$p in the absence of the high-acceptance quadrupole target load, a basic change in design philosophy has been initiated in the Mark II beam shown in Figure 1. The beam will be opened up at Enclosure 100 to a 4-inch dipole aperture and 5-inch aperture quadrupoles will be added. The function of the quadrupoles will be to capture muon flux and not simply to cancel out the multiple scattering in the absorbers. This is calculated to result in an additional factor of two in intensity at the Muon Laboratory.

Table I lists the parameters of the Mark II version of the N-1 beam. Table II lists the beam elements together with their coordinates.

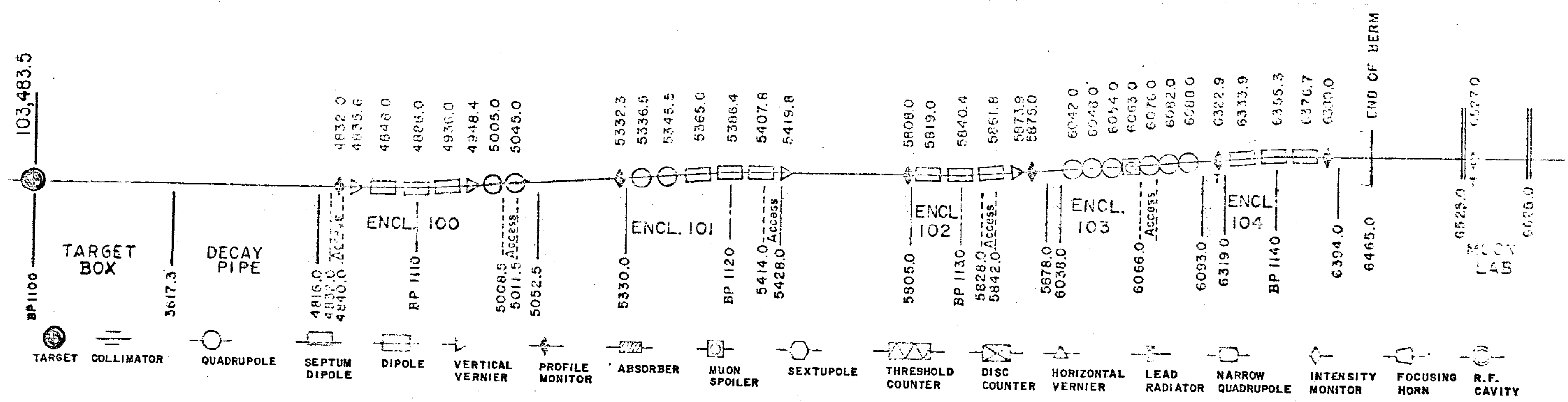

Figure 1. Muon Beam N-1, Mark II

TABLE I.

PRODUCTION TARGET			Same as monochromatic ν beam
Material			
Width			
Height			
Length			
PRODUCTION ANGLE		θ_p	
LAB ANGLE		θ_v	
		θ_h	
MOMENTUM RANGE			
Minimum	(1)	$P_{o_{min.}}$	∿50
Maximum	(2)	$P_{o_{max.}}$	200
SOLID ANGLE		$\Delta\Omega$	
ANGULAR ACCEPTANCE	(2)		
Horizontal		$\Delta\Omega_h$	
Vertical		$\Delta\Omega_v$	
MOMENTUM BITE			
Minimum	(3)	$\Delta P/P$	±2%
Maximum	(4)	$\Delta P/P$	
DISPERSION AT MOM.		$\frac{\Delta X}{\Delta P/P}$	
BEAM PROPERTIES AT EXPERIMENT			
Beam Width	(5)	ΔX_f	4"x4"
Horiz. Diverg.	(6)	ΔX_f	
Beam Height	(5)	ΔY_f	
Vert.Diverg.	(6)	ΔY_f	
NOMINAL BEAM LENGTH		L 3000	

TABLE I: Muon Beam N-1, Mark II

TABLE II.

Z Cent.	Y Cent.	Position Code	Element Code	B/G (kG) (kG/in)	I (Amp.)	P ([illegible])
4832.0	-0.669	N1M1	Profile Monitor			
4835.6	-0.667	N1V1	Vert.Vern. 4-4-30	±4.0	±224.1	9.0
4848.0	-0.620	N1B1	BEND 4-4-240	15.69	4062.1	[illegible]
4886.0	-0.260	N1B2	BEND 4-4-240	15.69	4062.1	550
4936.0	+0.700	N1B3	BEND 4-4-240	15.69	4062.1	550
4940.4	+1.008	N1V2	Vert.Vern. 4-4-30	±4.0	±224.1	9.0
5005.0		N1Q1	Quad 5Q36	5.0	1200	150
5045.0		N1Q2	Quad 5Q36	5.0	1200	150
5336.5	12.14	N1Q3	Quad 3Q84	6.52	4753.7	161.7
5345.5	12.40	N1Q4	Quad 3Q84	6.52	4753.7	161.7
5365.0	12.91	N1B4	BEND 4-2-240	-15.69	-4062.1	117.
5386.4	13.32	N1B5	BEND 4-2-240	-15.69	-4062.1	117.
5407.8	13.52	N1B6	BEND 4-2-240	-15.69	-4062.1	117.
5410.0	13.57	N1V3	Vert.Vern. 4-4-30	±4.0	±224.1	9.0
5819.0	13.62	N1B7	BEND 4-2-240	15.69	4062.1	117.
5840.4	13.82	N1B8	BEND 4-2-240	15.69	4062.1	117.
5861.8	14.23	N1B9	BEND 4-2-240	15.69	4062.1	[illegible]
5873.9	14.53	N1V4	Vert.Vern. 4-4-30	±4.0	±224.1	[illegible]
5875.0	14.60	N1M2	Profile Monitor			
6042.0	19.36	N1Q5	Quad 12Q48	2.3	450.	[illegible]
6048.0	19.53	N1Q6	Quad 12Q48	2.3	450.	[illegible]
6054.0	19.70	N1Q7	Quad 12Q48	2.3	450.	[illegible]
6076.0	20.33	N1Q8	Quad 12Q48	2.3	450.	[illegible]
6082.0	20.50	N1Q9	Quad 12Q48	2.3	450.	[illegible]
6088.0	20.67	N1Q10	Quad 12Q48	2.3	450.	[illegible]
6322.9	27.41	N1M3	Profile Monitor (temporary)			
6333.9	27.68	N1B10	BEND 4-4-240	-15.69	-4062.1	[illegible]
6355.3	28.09	N1B11	BEND 4-4-240	-15.69	-4062.1	[illegible]
6375.7	28.30	N1B12	BEND 4-4-240	-15.69	-4062.1	550
[illegible]	28.32	N1M4	Profile Monitor			
6465.0	28.34		End of Berm			
6525.0	28.34		Muon Laboratory (start)			
6527.0	28.34	N1M5	Profile Monitor (temporary)			

BEND POINT	Z Cent.	X Cent	ANGLE	TOTAL ANGLE
1100	3483.5	-0.6670	0	0
1110	4890.0042	-0.6670	+28.68	+28.68
1120	5386.3668	13.5724	-28.68	0
1130	5840.3714	13.5724	-28.68	+28.68
1140	6355.2642	28.3434	-28.68	0

TABLE II: Muon Beam N-1, Mark II