The Neutrino Superbeam from the AGS

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1. Introduction

We have examined [1] possible upgrades to the AGS complex that would meet the requirements for the proton beam for a 1 MW neutrino super beam facility. Those requirements are summarized in Table 1 and a layout of the upgraded AGS is shown in Figure 1.

We are proposing here to build a superconducting upgrade to the existing 200 MeV Linac to an energy of 1.2 GeV for direct H^- injection into the AGS. This will be discussed in the next section. The required upgrade of the AGS power supply and the AGS rf system can be found in reference [1]. The target design and the decay channel will be described in third section and the upgrade to 4 MW will be covered in the fourth section.

Table 1. AGS Proton Driver Parameters.

Total beam power	1 MW	Protons per bunch	0.4×10^{13}
Beam energy	28 GeV	Injection turns	230
Average beam current	42 μA	Repetition rate	2.5 Hz
Cycle time	400 ms	Pulse length	0.72 ms
Number of protons per fill	9×10^{13}	Chopping rate	0.75
Number of bunches per fill	24	Linac average/peak current	20/30 mA

2. Superconducting Linac

The superconducting linacs accelerate the proton beam from 200 MeV to 1.2 GeV. The presented configuration follows a similar design described in detail [2]. All three linacs are built up from a sequence of identical periods. The major parameters of the three sections of the SCL are given in Table 2. The low energy section operates at 805 MHz and accelerates proton from 200 to 400 MeV. The following two sections, accelerating to 800 MeV and 1.2 GeV respectively, operate at 1.61 GHz. A higher frequency is desirable for obtaining a larger accelerating gradient with a more compact structure and reduced cost. The SCL will be operated at 2^oK for the assurance of reaching the desired gradient.

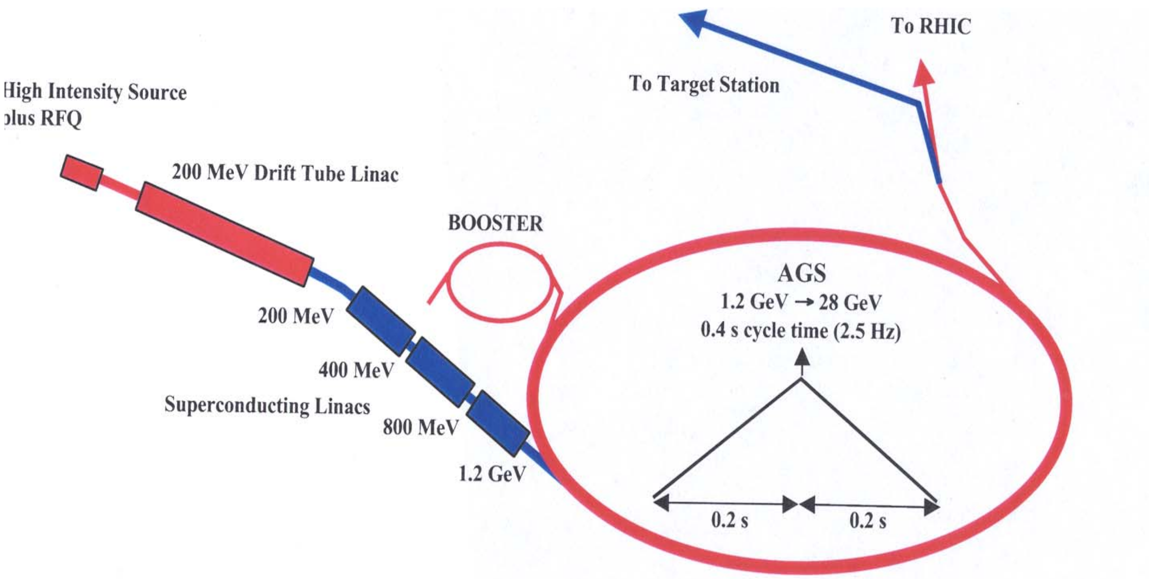

Figure 1. AGS Proton Driver Layout.

Table 2. General Parameters of the SCL.

Linac Section	LE	ME	HE
Average Beam Power, kW	7.14	14.0	14.0
Average Beam Current, μA	35.7	35.7	35.7
Initial Kinetic Energy, MeV	200	400	800
Final Kinetic Energy, MeV	400	800	1200
Cell Reference β_0	0.615	0.755	0.887
Frequency, MHz	805	1610	1610
Cells/Cavity	8	8	8
Cavities/Cryo-Module	4	4	4
Cavity Internal Diameter, cm	10	5	5
Total Length, m	37.82	41.40	38.32
Accelerating Gradient, MeV/m	10.8	23.5	23.4
Cavities/Klystron	1	1	1
Norm. rms Emittance, πmm-mrad	2.0	2.0	2.0
Rms Bunch Area, π^oMeV (805 MHz)	0.5	0.5	0.5

3. Target Station and Neutrino Beam [3]

To achieve the 1 MW upgrade option of the proton driver at BNL, serious consideration must be given to the target selection. In evaluating the various choices of target materials and of target/horn configurations, the following concerns are being addressed:

- Optimization of neutrino flux,
- Heat removal from the target and horn,
- Survivability of the target intercepting energetic, high intensity proton bunches,
- Irradiation and integration issues.

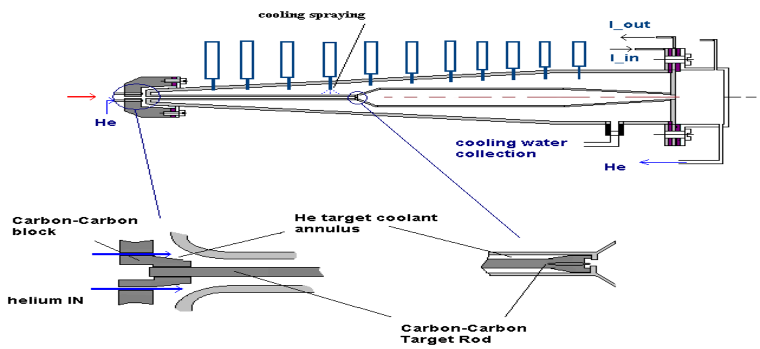

Figure 2. Proposed graphite target and horn configuration.

The design of the target/horn configuration is shown in Fig. 2. The material selected for the superbeam experiment is a Carbon-Carbon composite. It is 3-D weaved material and exhibits extremely low thermal expension for the temperatures up to 1000° C while for the higher temperatures it responds like graphite. This property is significant in the sense that the thermoelastic stresses induced by intercepting the beam will be quite small thus extending the life of the target.

In the current option the target is an 80-cm long cylindrical rod with 12 mm diameter sizes. The 12 mm diameter target is chosen to intercept 100 TP, 2 mm rms proton beam. With this beam size, the total energy deposited as heat in the target is 7.3 kJ with peak temperature rise of about 280°C. Heat will be removed from the target through forced convection of helium through the outside surface.The resultant ν_μ spectrum is shown in Fig. 3. Which is used to study various neutrino proceses and event rates at distant target.

The extracted beam will come into the existing U-line at the AGS, but it has to climb to a high hill for the target and decay channel. The hill arrangement is to keep the target and hadronic decay well above the water table in Long Island. The 11 deg incline is suitable for aiming at Homestake site in South Dakota. A sketch of the hill is shown in Fig. 4.

4. Upgrade to 4 MW

The AGS-based neutrino superbeam can be further upgraded to 4 MW by 1) increase the linac energy to 1.5 GeV; 2) increase the AGS intensity to 1.8×10^{14} ppp, and 3) increase the AGS rep rate to 5.0 Hz. The associated problem in beam dynamics, power supply, rf system, beam losses and radiation protection are under study and shown to be feasible if such a capability is required by the physics experiments.

References

[1] Neutrino Factory Feasibility Study II, http://server.cap.bnl.gov/mumu/studyii/
[2] Ruggiero, A.G., A Superconducting Linac as a New Injector to the BNL AGS, BNL Internal Report, C-A/AP/40, February 2001.

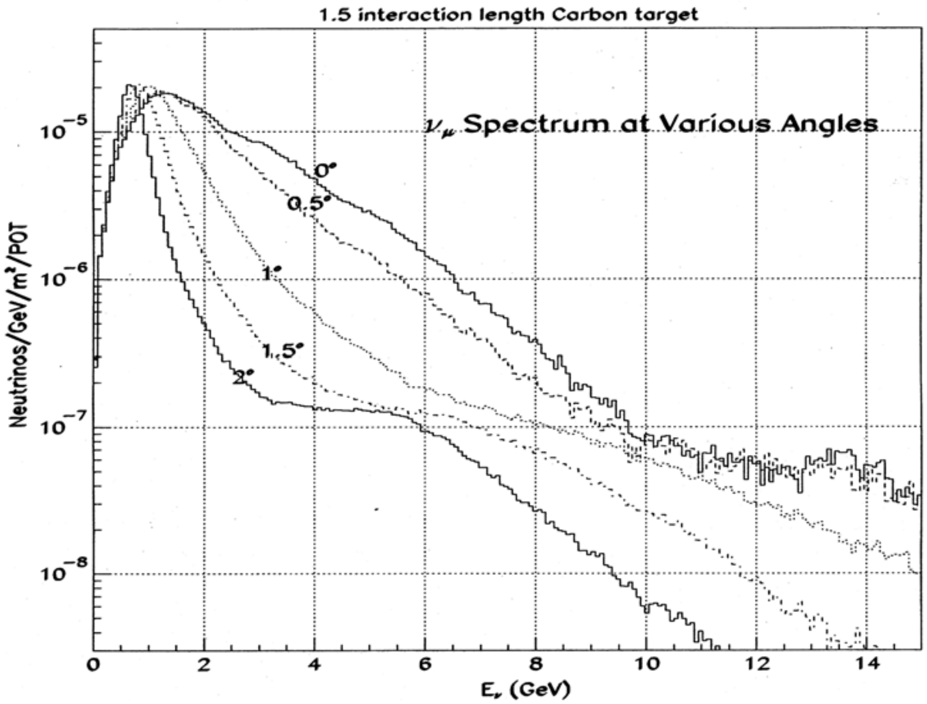

Figure 3. Wide band horn focused muon neutrino spectrum for 28 GeV protons on a Carbon target. Spectrum of neutrinos are calculated at various angles with respect to the 200 m decay tunnel axis at the AGS and at a distance of 1 km from the target.

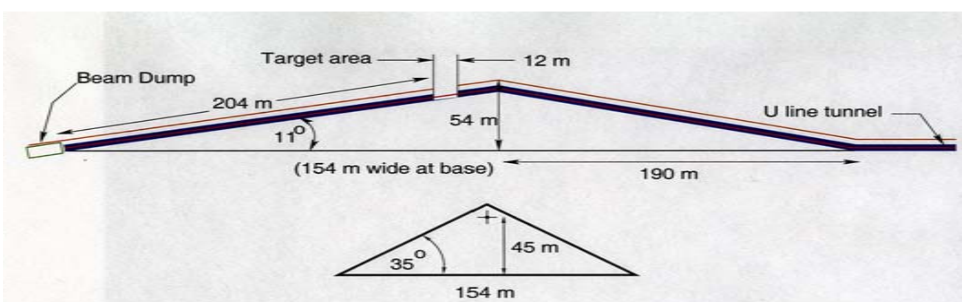

Figure 4. Elevation view of the neutrino beam line to Homestake, South Dakota.

[3] Very Long Baseline Neutrino Oscillation Experiments, Letter of Intent to BNL PAC, D. Beavis, M. Diwan, *et al* October 2002.

Acknowledgments

This work was performed under the auspices of the U.S. Department of Energy.