Muon Collaboration Meeting -- BNL January 30, 2001

1.5-GeV Superconducting Proton Linac

as the Injector to the 1-MW Average Power AGS

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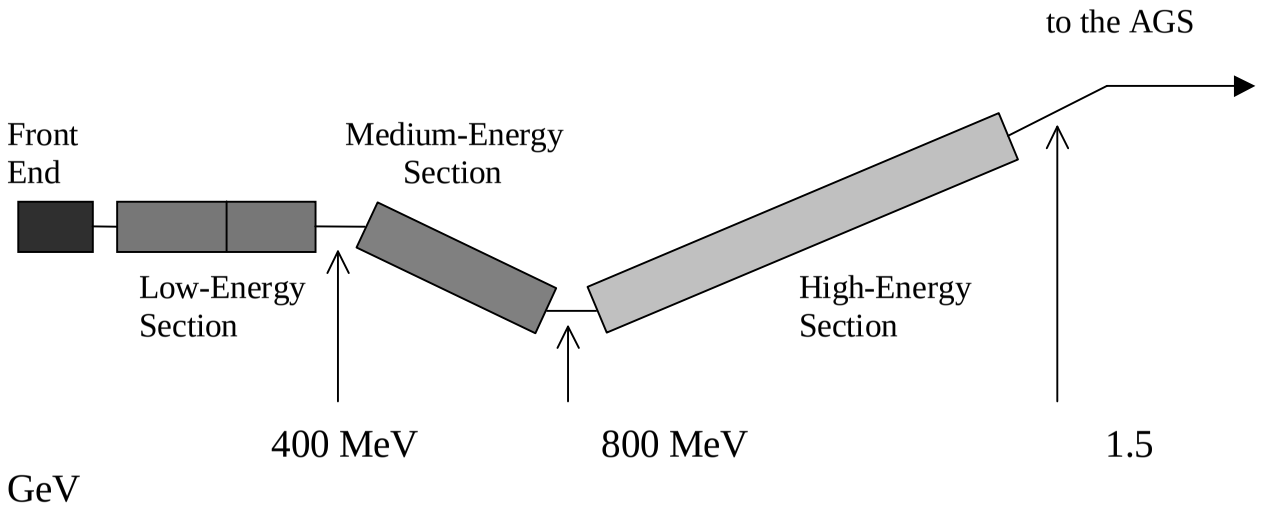
References

- Alessandro G. Ruggiero, “Design Considerations on a Proton Superconducting Linac”, BNL 62312 Informal report, August 1995.
- D.Raparia and A.G. Ruggiero, “A Super-Conducting Linac Injector to the BNL-AGS”, BNL xxxxx Informal report, July 2000.
- D.Raparia and A.G. Ruggiero, “A Super-Conducting Linac Injector for the BNL-AGS”, presented to the XX International Linac Conference, Monterey, California, BNL 67427, August 21-25, 2000.
- Alessandro G. Ruggiero, “SCL-Template”, A Design Tool written for EXCEL with VisualBasic.

Layout of the 1.5-GeV Linac



Front End

- **Negative Ion Source**

Current (H^-)	37.5 mA
Platform	30-50 kV
Rep Rate	2.5 Hz
Pulse Length	1 ms
Duty Cycle	0.25 %
Emittance, norm. rms	0.3 • mm mrad

- **RFQ**

Frequency	201.25 MHz
Output Energy	750 keV
Capture Efficiency	80%
Output Current	30 mA

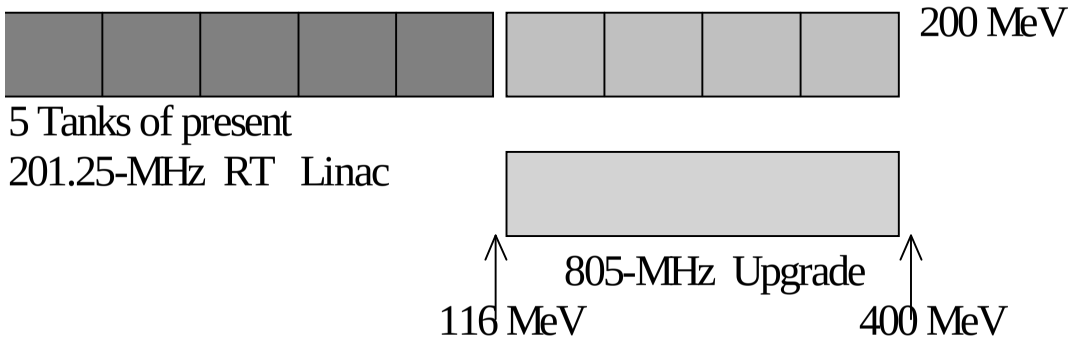
- **Chopper**

Frequency	2.057 MHz (h = 6 AGS rf frequency)
Chopping Ratio	60 %

- **Buncher**

Frequency	201.25 MHz

Low-Energy Section



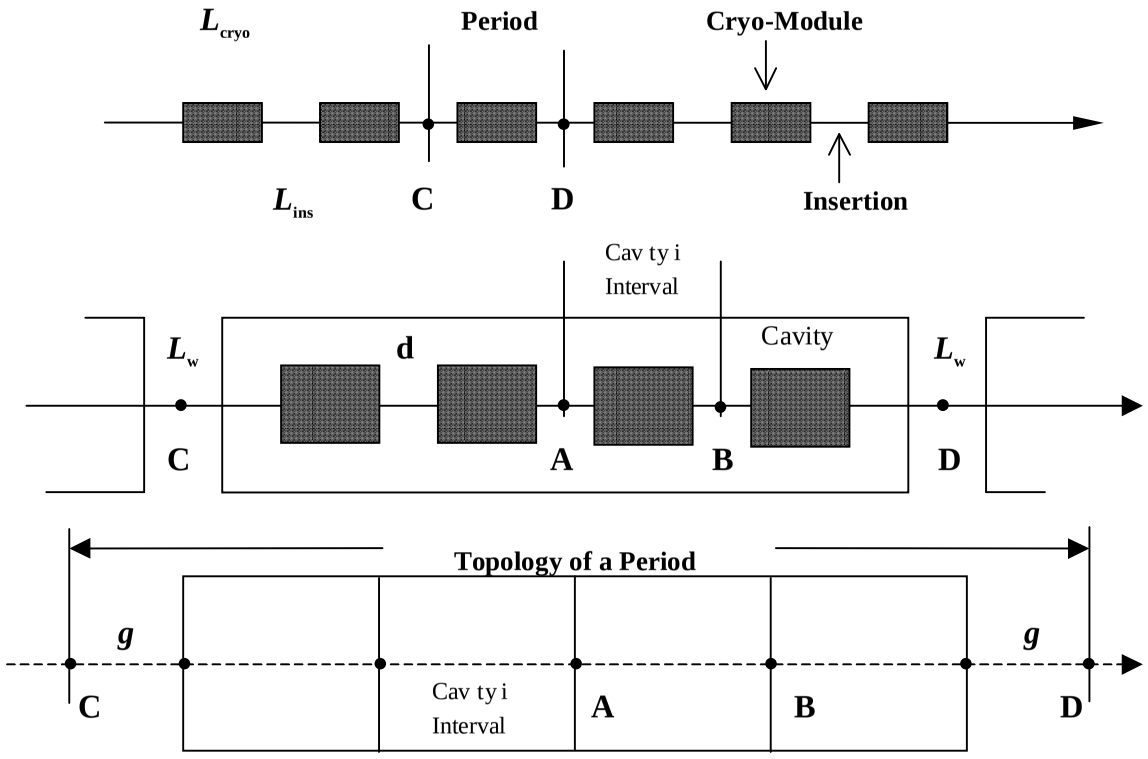
- Upgrade can be at RT as done for Fermilab
- Or it can be Superconducting
- In both cases the length is about the same (~75 m)
- The average Accelerating Gradient ~ 3.8 MeV/m
- Cost also about the same (~ 40 M$)

Medium - & High - Energy Sections

- Both are Superconducting
- Operate at 805 MHz (λ = 37.24 cm)
- Each have the same geometry ad size of a cavity cell adjusted in length to an intermediate value β_0

$$L_{cell} = \lambda \beta_0 / 2$$

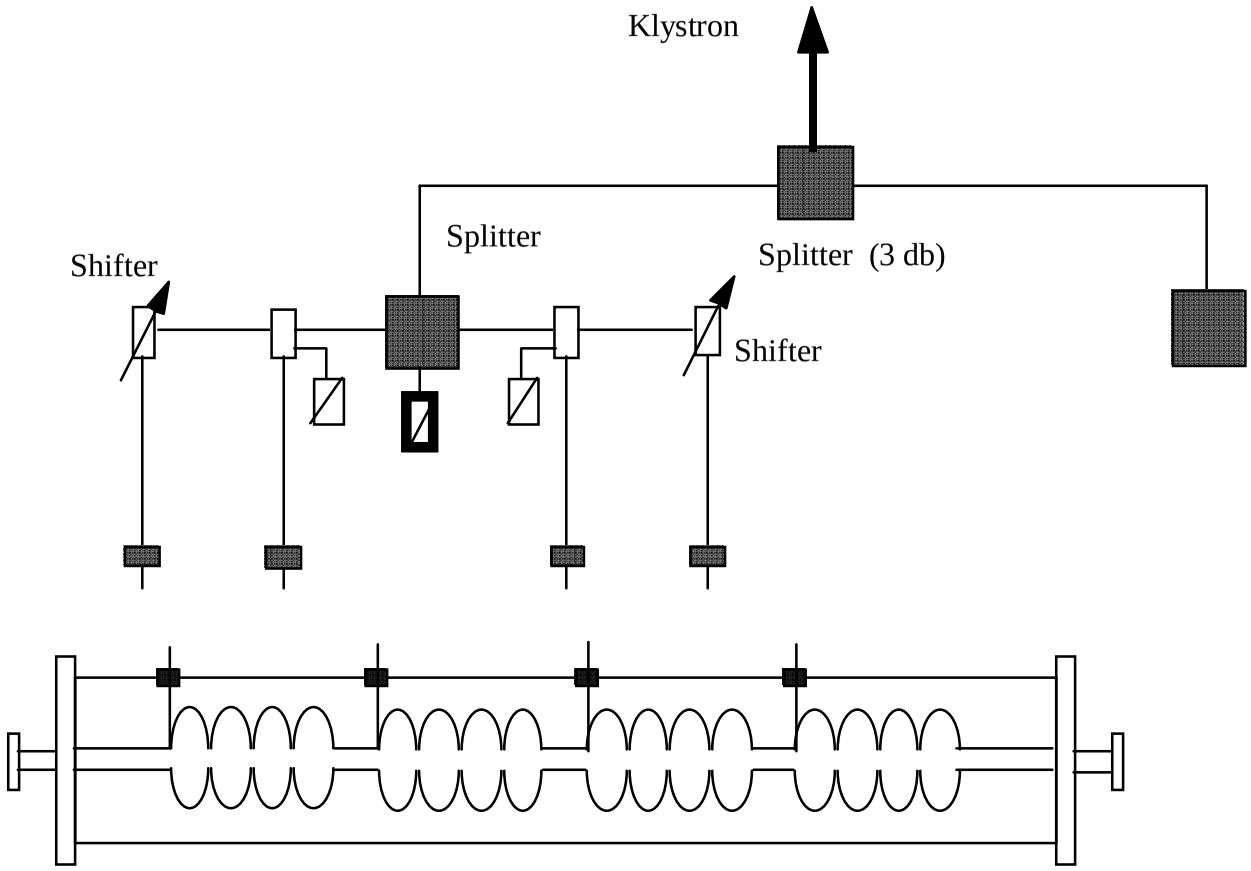
Configuration of a SC Linac Section



General Parameters of SC Sections

Linac Section	Low	Medium	High
Average Beam Power, kW	18	36	67.5
Average Beam Current, µA	45	45	45
Initial Kinetic Energy, MeV	116	400	800
Final Kinetic Energy, MeV	400	800	1500
Frequency, MHz	805	805	805
No. of Protons / µBunch x 10^8	2.33	2.33	2.33
Temperature, ^oK	2.0	2.0	2.0
Cells / Cavity	4	4	4
Cavities / Cryo-Module	4	8	8
Cavity Separation, cm	32	32	32
Cold-Warm Transition, cm	30	30	30
Cavity Internal Diameter, cm	10	10	10
Length of Warm Insertion, m	1.079	1.079	1.079
Accelerating Gradient, MeV/m	11.9	14.4	15.0
Cavities / Klystron	4	4	4
No. of rf Couplers / Cavity	1	1	1
Rf Phase Angle	30^o	30^o	30^o
Method of Transverse Focussing	FODO	FODO	FODO
Betatron Phase Adv. / FODO cell	90^o	90^o	90^o
Norm. rms Emittance, p mm-mrad	0.30	0.30	0.30
Rms Bunch Area, p ^{o}MeV	0.5	0.5	0.5

Power Distribution



Cost (‘00 $) and other Parameters

AC-to-rf Efficiency	0.45	For pulsed mode
Cryogenic Efficiency	0.004	At 2.0 ^{o}K
Electricity Cost	0.05	$ / kWh
Linac Availability	75	% of yearly time
Normal Conducting Cost	150	k$ / m
Superconducting Cost	500	k$ / m
Tunnel Cost	100	k$ / m
Cost of Klystron	2.50	$ / W of rf Power
Cost of Refrigeration Plant	2	k$ / W of Power @ 2.0 ^{o}K
Cost of Electrical Distribution	0.14	$ / W of AC Power

Dimensions

Linac Section	**Low**	**Medium**	**High**
Energy: in - out, GeV	0.116 -0.40	0.40 - 0.80	0.80 - 1.50
Velocity, β: in out	0.4560 0.7131	0.7131 0.8418	0.8418 0.9230
Cell Reference β_0	0.520	0.717	0.860
Cell Length, cm	9.68	13.35	16.01
Total No. of Periods	18	8	11
Length of a period, m	4.188	8.191	9.043
FODO-Cell ampl. func., β_Q, m	14.30	27.97	30.88
Total Length, m	75.39	65.53	99.48

RF Parameters

Linac Section	Low	Medium	High
Coupler rf Power, kW (*)	120	200	250
Energy Gain/Period, MeV	16.00	53.33	66.67
Total No. of Klystrons	18	16	22
Klystron Power, kW (*)	720	1200	1500
$Z_0T_0^2$, ohm/m	261.6	497.4	715.5
Q_0 x 10^9	5.35	7.38	8.85
Ave. Filling Time, ms	0.593	0.297	0.216

(*) Including 50% rf power contingency.

RF Power Breakdown

Linac Section	Low	Medium	High
Ave. Dissipated Power, kW	0.014	0.006	0.006
Ave. HOM-Power, kW	0.0005	0.0005	0.0007
Ave. Cryogenic Power, kW	0.294	0.291	0.445
Ave. Beam Power, MW	0.013	0.018	0.032
Total Ave. rf Power, MW (*)	0.031	0.035	0.057
Ave. AC Power for rf, MW (*)	0.068	0.078	0.128
Ave. AC Power for Cryo., MW	0.074	0.073	0.111
Total Ave. AC Power, MW (*)	0.142	0.151	0.239
Efficiency, % (*)	9.03	11.95	13.19

(*) Including 50% rf power contingency

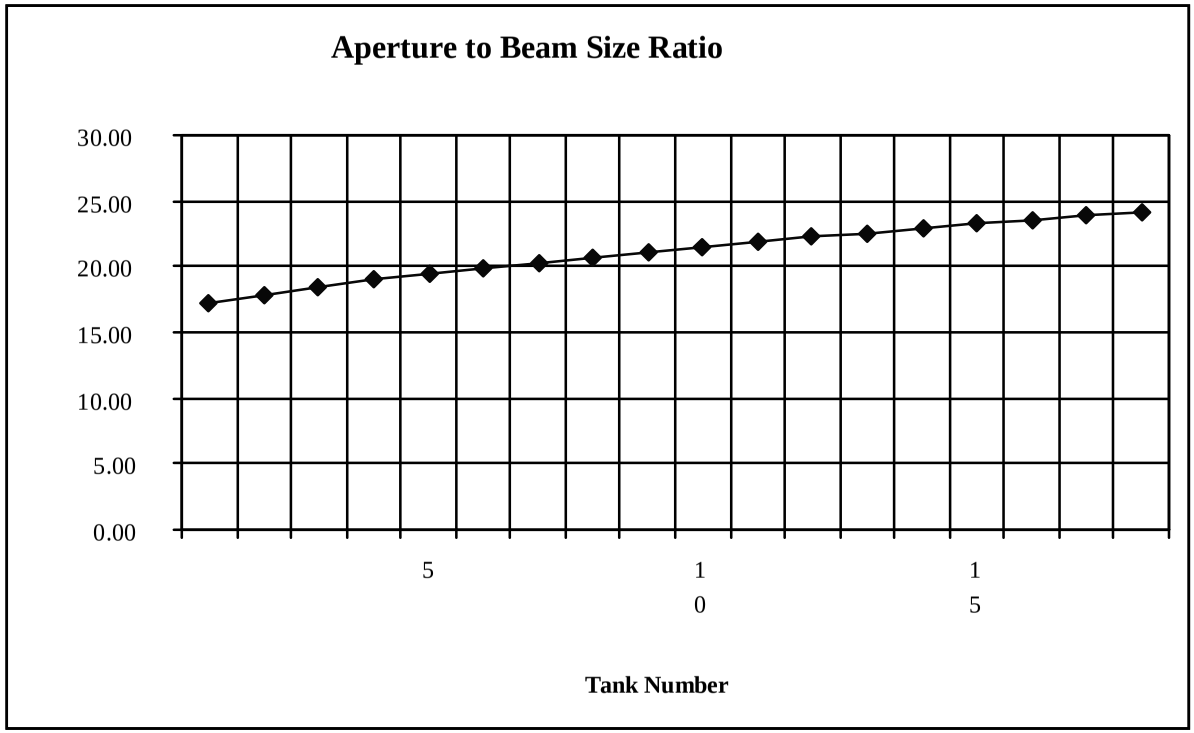
Cost

Linac Section	Low	Medium	High
Capital Cost, '00 M$:	67.5		
RF Klystron (*)	0.076	0.088	0.144
Elect. Distr. (*)	0.020	0.021	0.033
Refrig. Plant	0.589	0.582	0.889
Warm Structure	3.075	1.457	1.942
Cold Structure	27.983	28.449	43.804
Tunnel	7.647	6.661	10.056
Total Cost, '00 M$ (*)	39.390	37.258	56.968
Operation Cost, '00 M$/y (*)	0.046	0.088	0.078

(*) Including 5% rf power contingency

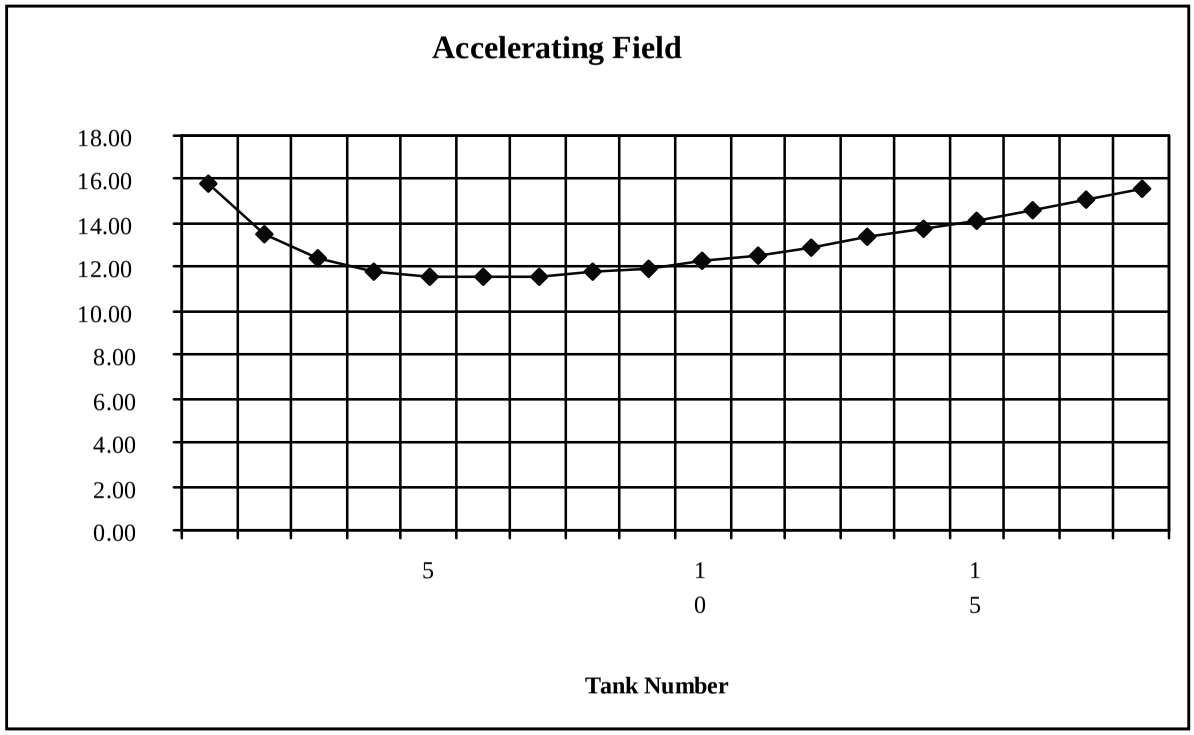
Aperture to Beam Size Ratio

Low-Energy Section



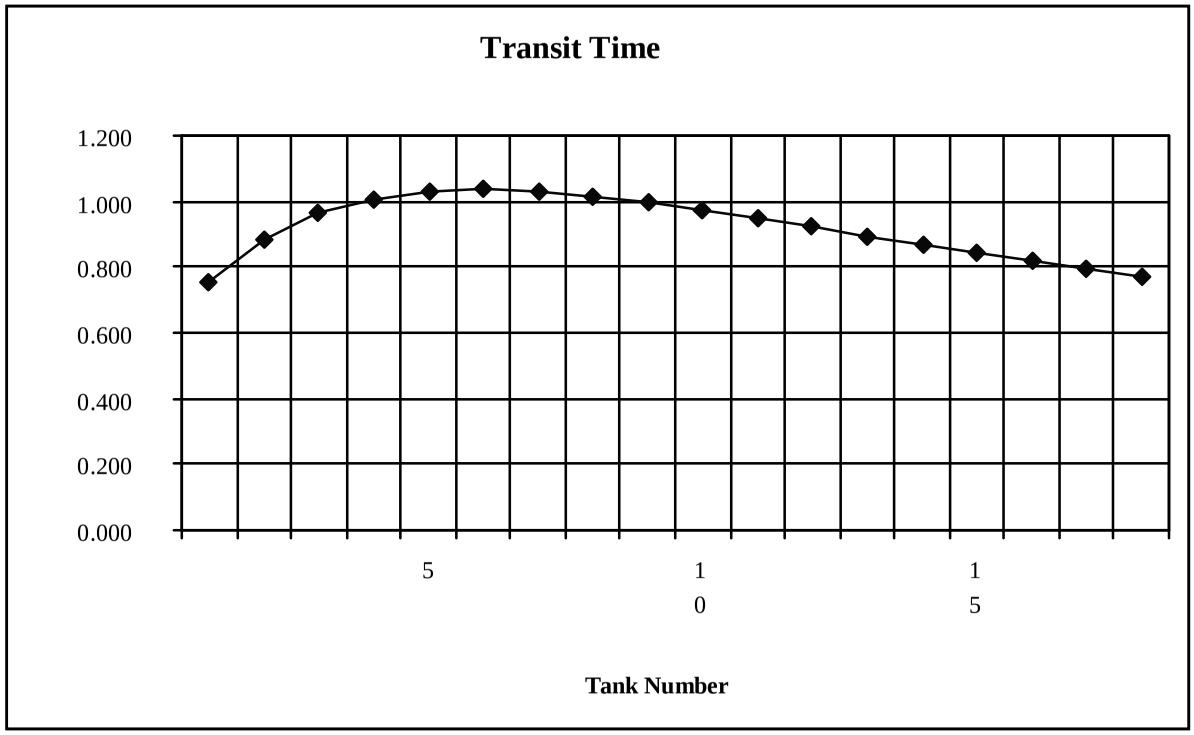
Axial Accelerating Field

Low-Energy Section



Transit Time Factor

Low-Energy Section



Longitudinal Tune / Cryostat

Low-Energy Section