Power limitations in the travelling wave RF system - implications for high intensity.

1) The cavities.

2) The power limitations.

3) Use of cavities for high intensities

4) Emittance as a function of voltage

5) Power requirements

Power limitations.

1) Power amplifiers. Each amplifier 1MW maximum.

2) Feeder lines. 750kW thermal limit. Can pulse to 1MW for e.g. 2-3s and then run lower to keep mean at 750kW. By applying air-cooling, relatively easy, could go to 1MW continuous.

3) Couplers. After SPS for LHC modification will be able to take 1.5MW peak and 750kW average. (1MW at 2s OK). Difficult to cool and expensive but might make 1MW continuous.

Conclusion. 1MW for 2-3s OK. 750kW average.

Use of TW cavities for high intensity beams.

Optimum cavity length.

Short filling time - local intensity ~1μs important

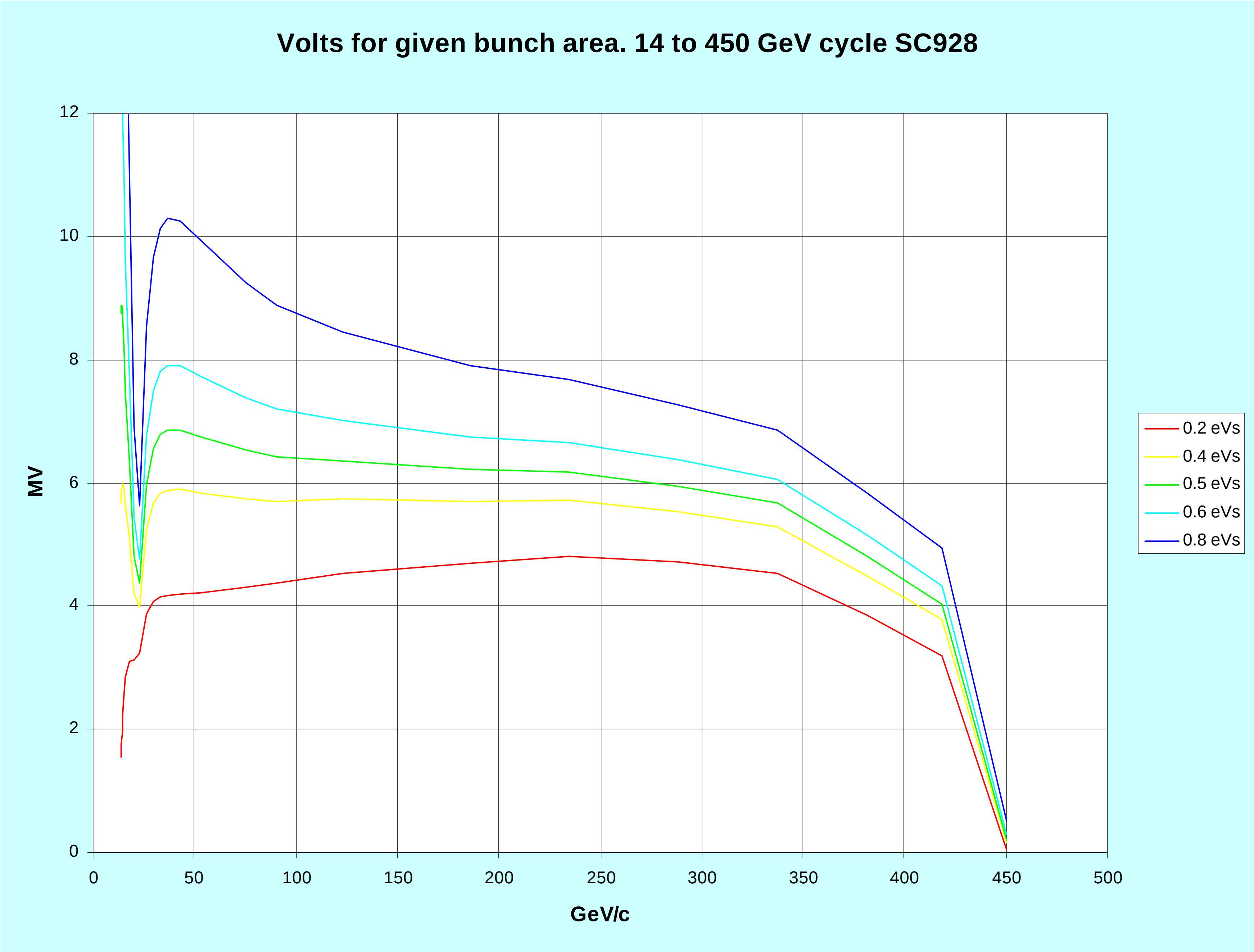
Optimum length given by:

For ultimate LHC beam, $I_{brfcomp.}$ ~ 2.2A, ($1.4*10^{13}$ in 2μs).

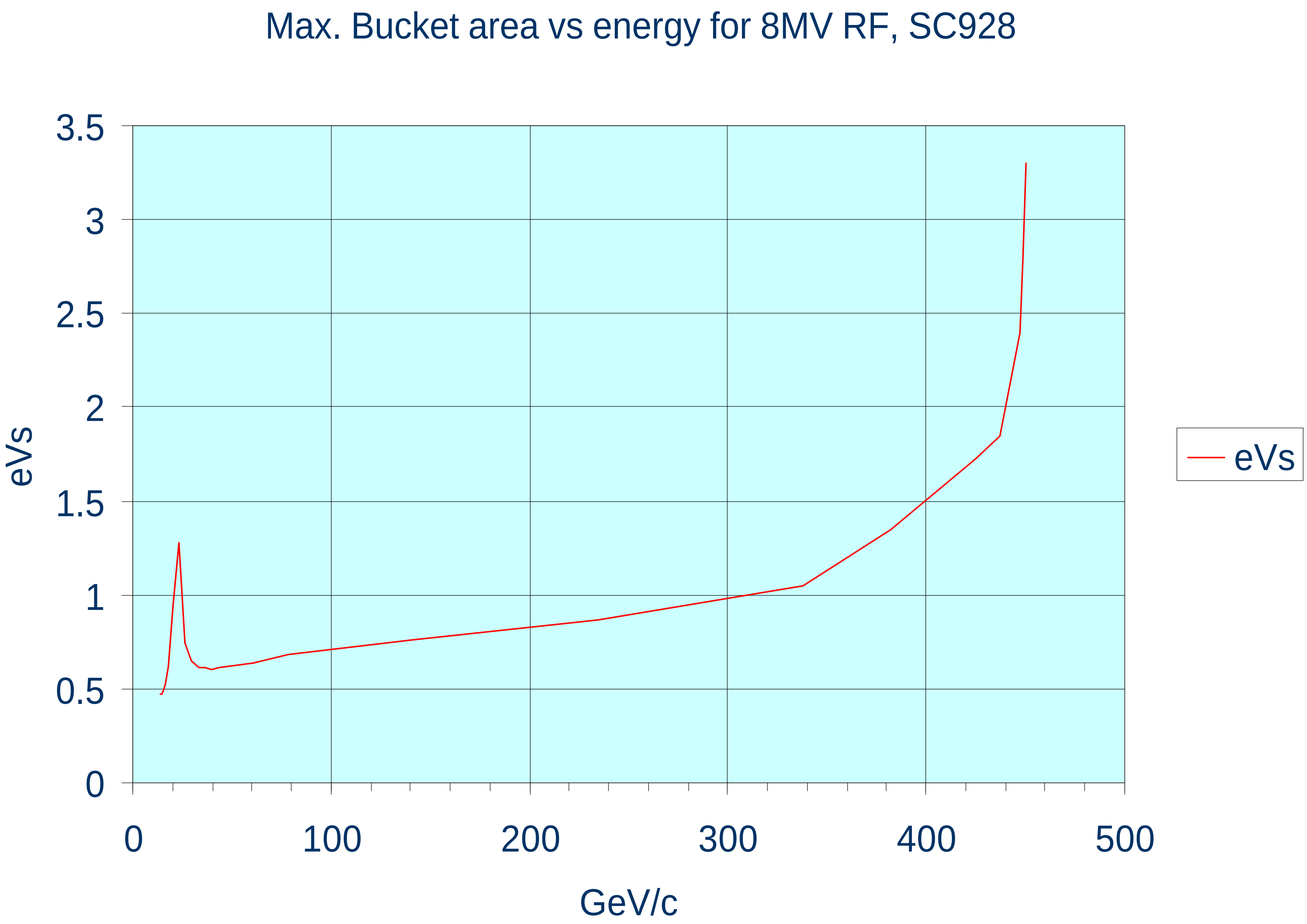
Vrf = 2MV gives l=16.46m or 4 sections.

N.B Using 4 sections for intensities where 5 sections is optimum gives a penalty of ~ 10% in power.

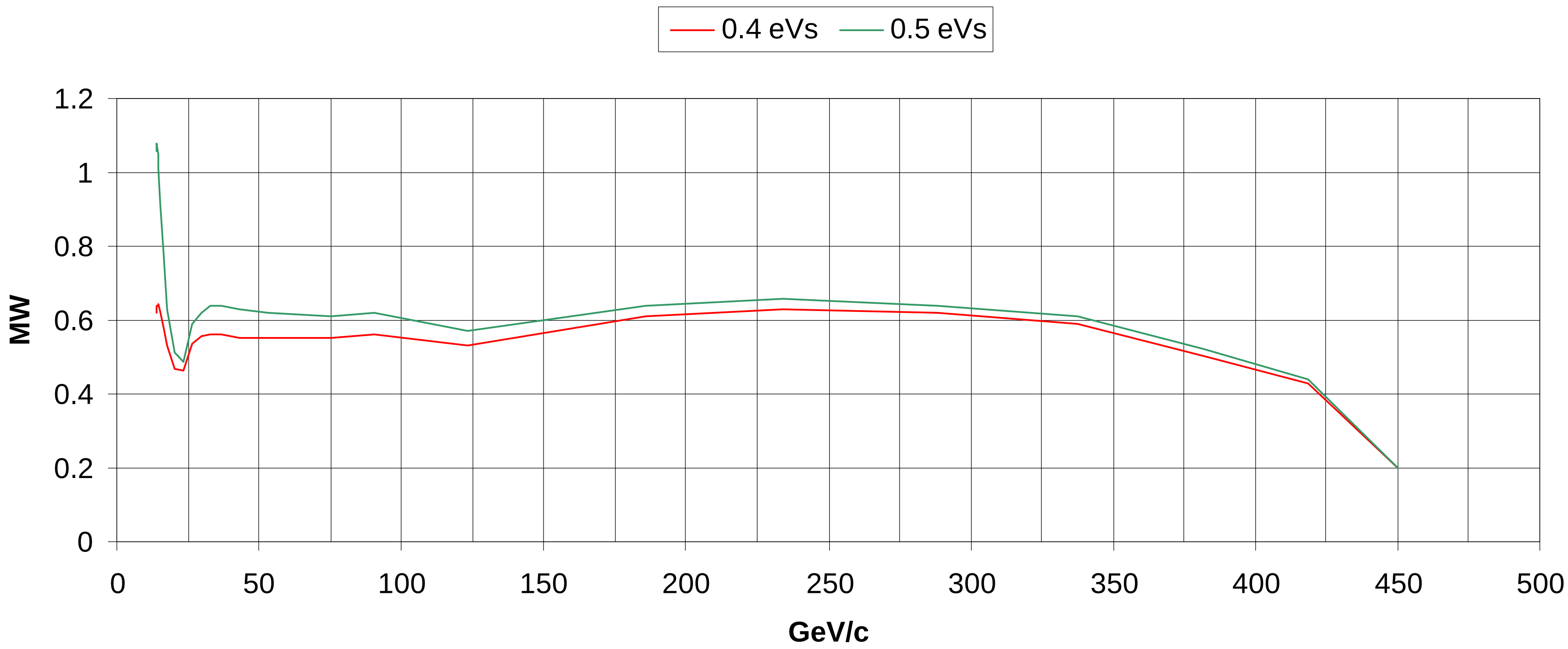
Calculation of voltage required. (hence power)



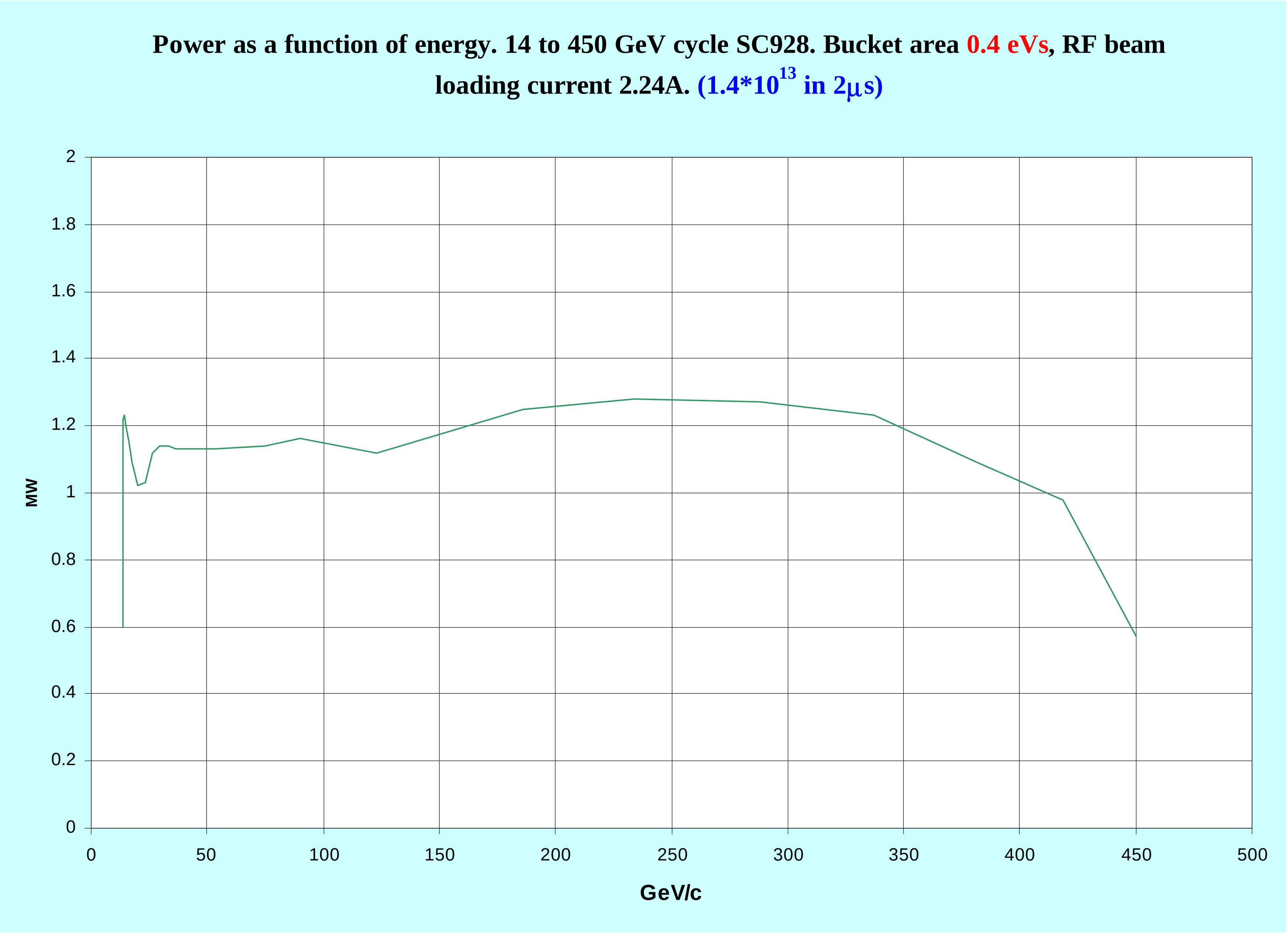
Volts for given bunch area. 14 to 450 GeV cycle SC928
MV
GeV/c
0
2
4
6
8
10
12
0
50
100
150
200
250
300
350
400
450
500
0.2 eVs
0.4 eVs
0.5 eVs
0.6 eVs
0.8 eVs


Max. Bucket area vs energy for 8MV RF, SC928
3.5
3
2.5
2
1.5
1
0.5
0
eVs
0
100
200
300
400
500
GeV/c
eVs

Power / cavity as a function of energy for 0.4 eVs and 0.5 eVs.



- 14 - 450 GeV/c cycle (SC 928).
- RF current =1,12A, **(7*10^{12} protons in a 2µs batch).**
- 2 TW cavities of 5 sections and 2 of 4 sections are assumed.
- The power increase with 4 cavities of 4 sections is ~50kW/cavity.


Power as a function of energy. 14 to 450 GeV cycle SC928. Bucket area 0.4 eVs, RF beam loading current 2.24A. (1.4*10^13 in 2μs)
MW
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
0
50
100
150
200
250
300
350
400
450
500
GeV/c

Conclusions.

Local intensity is important.

For $7*10^{13}$ in 10/11 of ring, (1.12A locally), we are limited to 0.4 (5) eVs in the front porch. (2x5 turn CT extraction from the PS) Playing with the cycle may help a bit. This beam can blow up on the ramp.

For $1.4*10^{13}$ in 2μs, (2.24A locally), we are limited to ~0.35eVs up to ~400GeV. (5 fast extractions from the PS)

Each cycle and case has to be calculated separately.

We do not consider here the problems of high intensity operation on loops, feedbacks and stability.