Muon phase rotation with magnetic compression

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1 Introduction

Solenoidal channel - large transverse acceptance, but large chromatic aberrations

$$1/f_s = 1/4(e/cp)^2 B^2 L$$

AG channel - smaller transverse acceptance, less chromatic aberrations.

$$1/f_q = (e/cp) g L$$

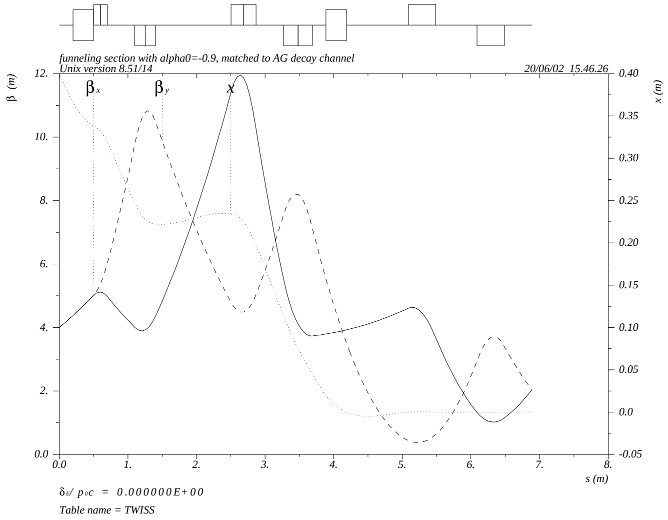
In addition AG lattices offer several benefits like: simpler optics, introduction of bending (proton beam dump, beam cleaning, lengthening for off-momentum trajectories).

Recently studies of an AG decay channel (see F. Meot's talk) show interesting alternative for a solenoidal decay channel.

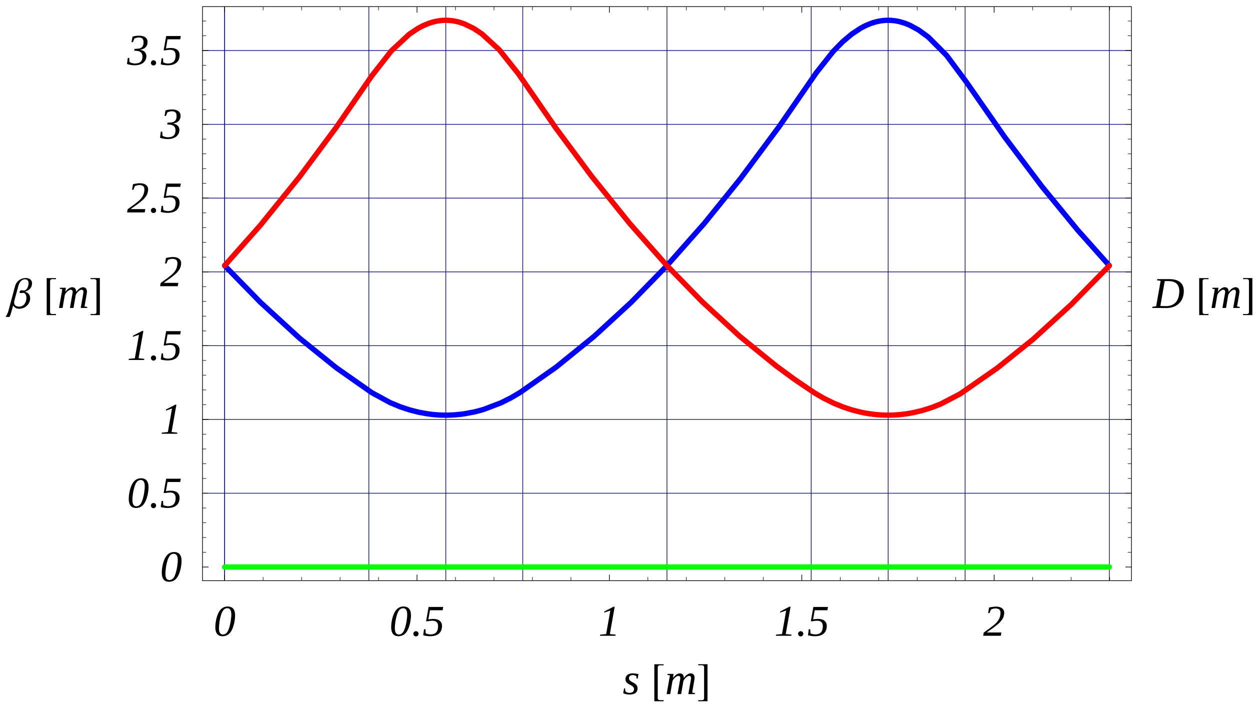
We assume that 1 cm rad physical transverse emittance can be accepted by a muon accelerator (RLA or FFAG).

Let's try to design a AG muon front end for the Neutrino Factory.

2 AG decay channel.

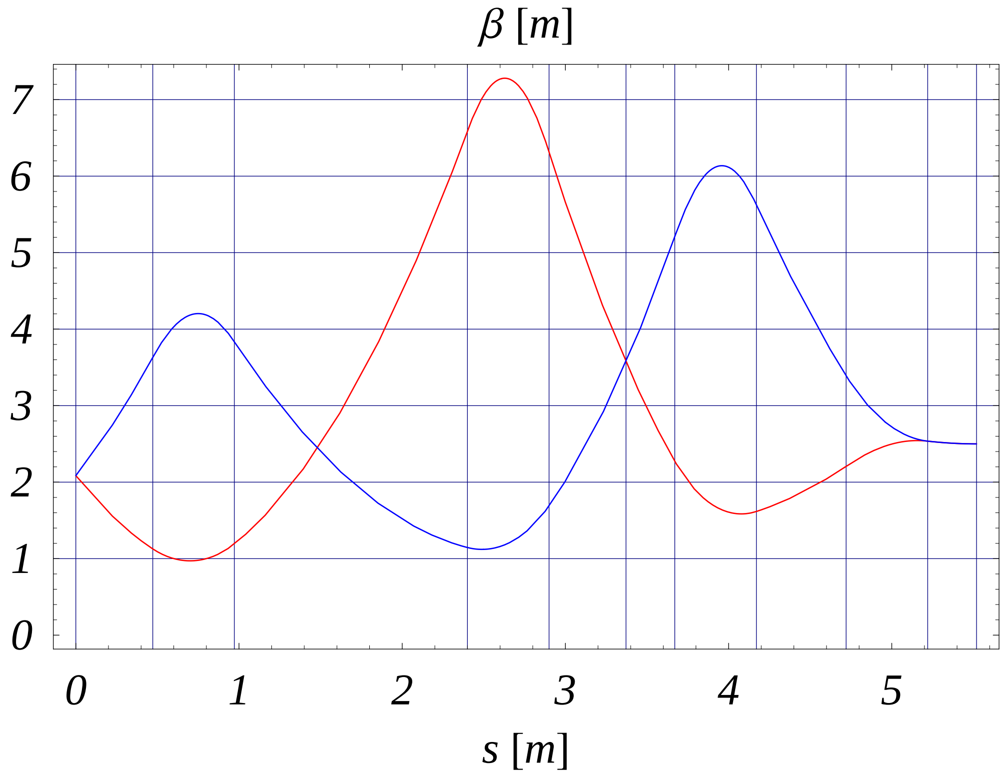


Optical functions in the funnel (to combine several pion beams from different collection horns and match to the decay FODO). Courtesy of A. Verdier.

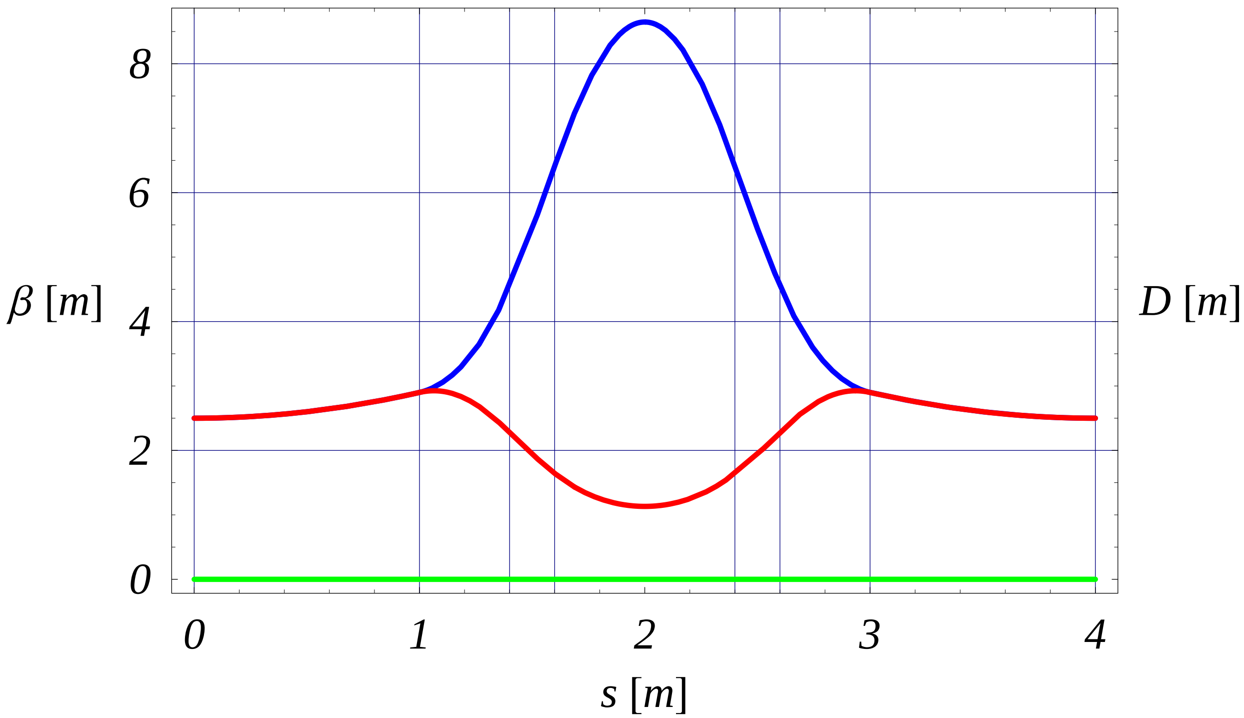


Single FODO cell of AG decay channel. For more details I refer to F. Meot.

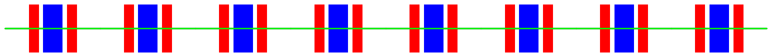
2 Phase rotation



Matching section from AG decay channel to a triplet lattice.

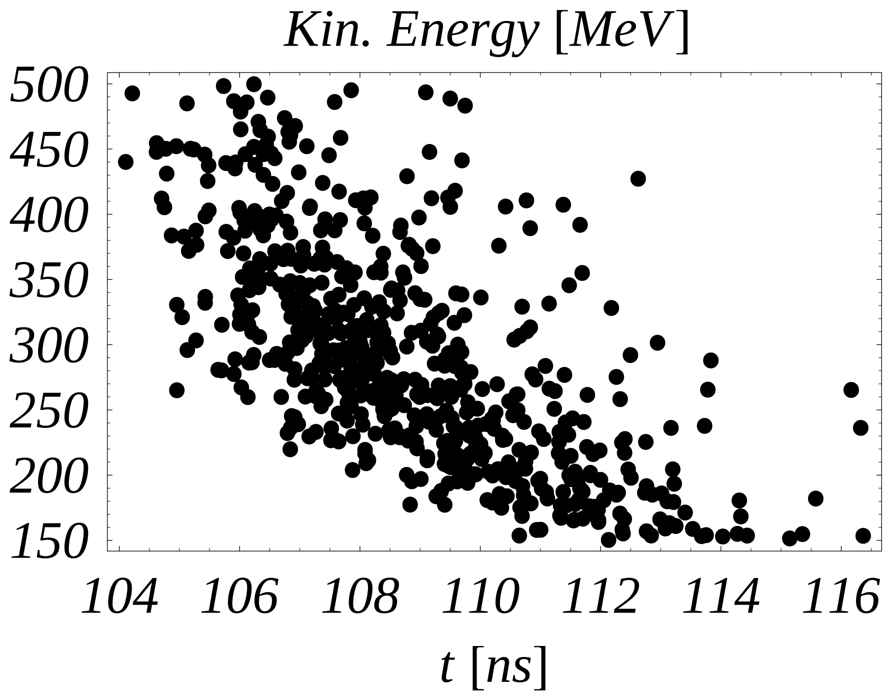


Triplet lattice for phase rotation. On both sides enough drift with low β for 44 MHz cavity. Packing factor 1/2.

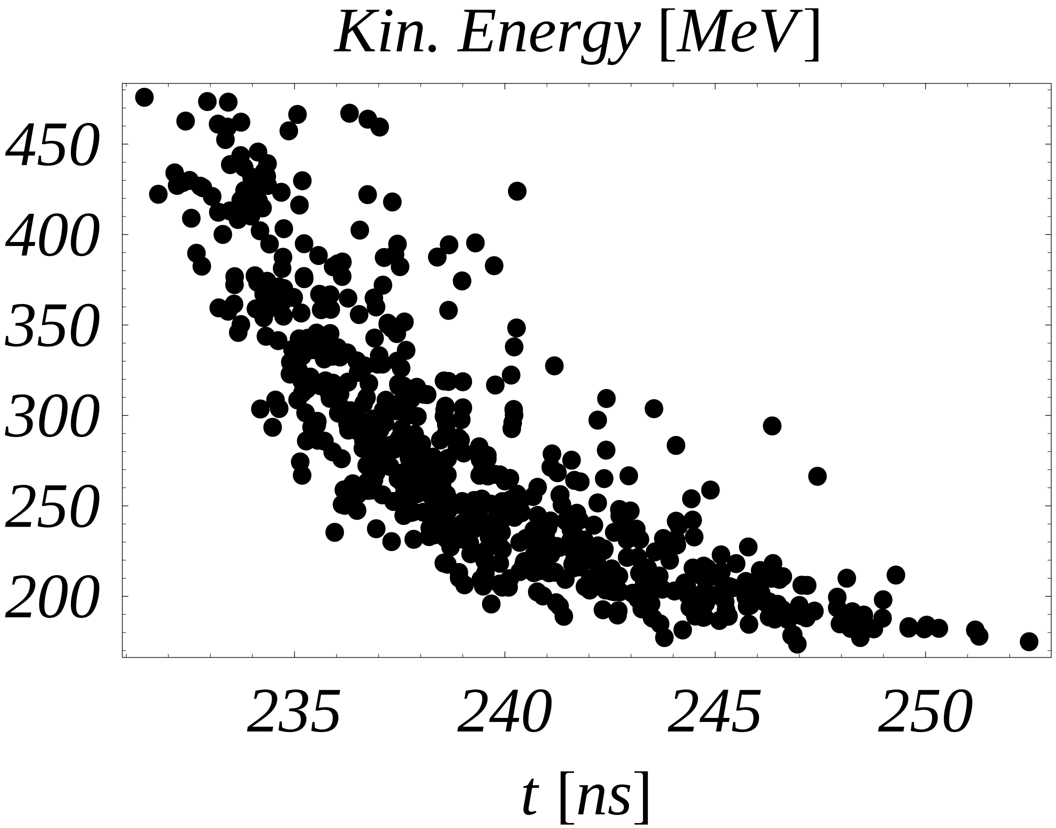


Layout of phase rotation with 8 triplet cells
(16 cavities - 44 MHz 2 MV).

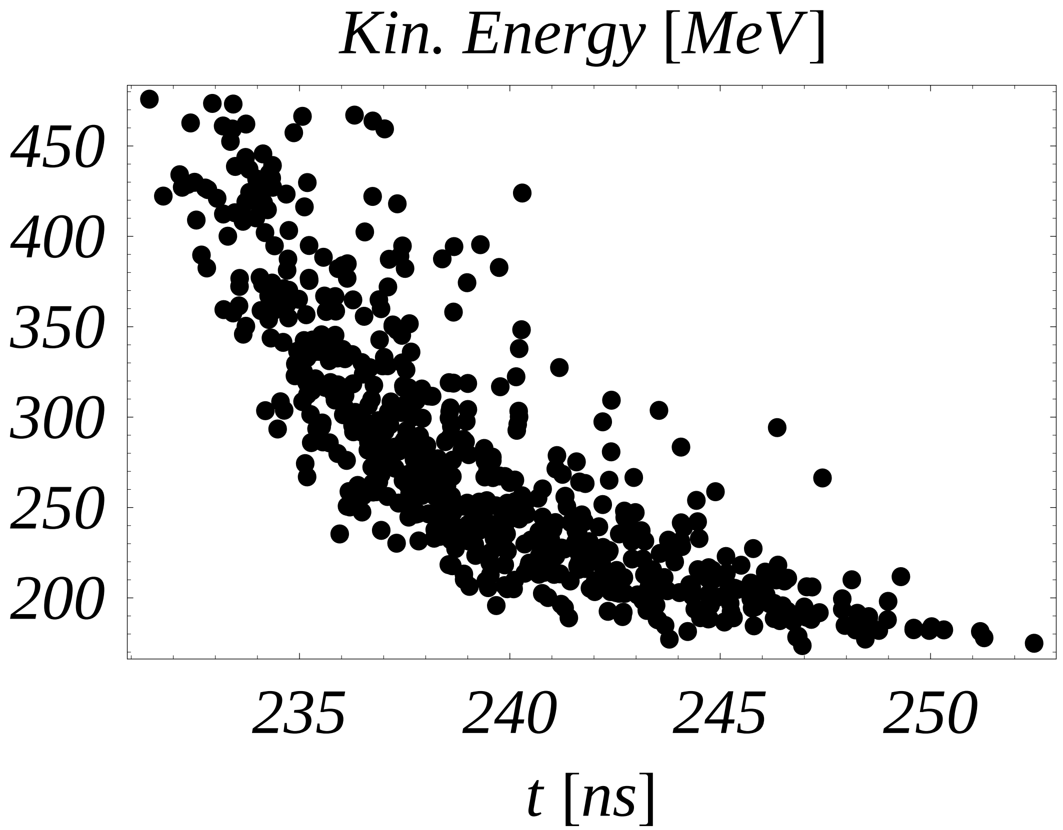
How does it work?



Longitudinal muon distribution after decay channel.

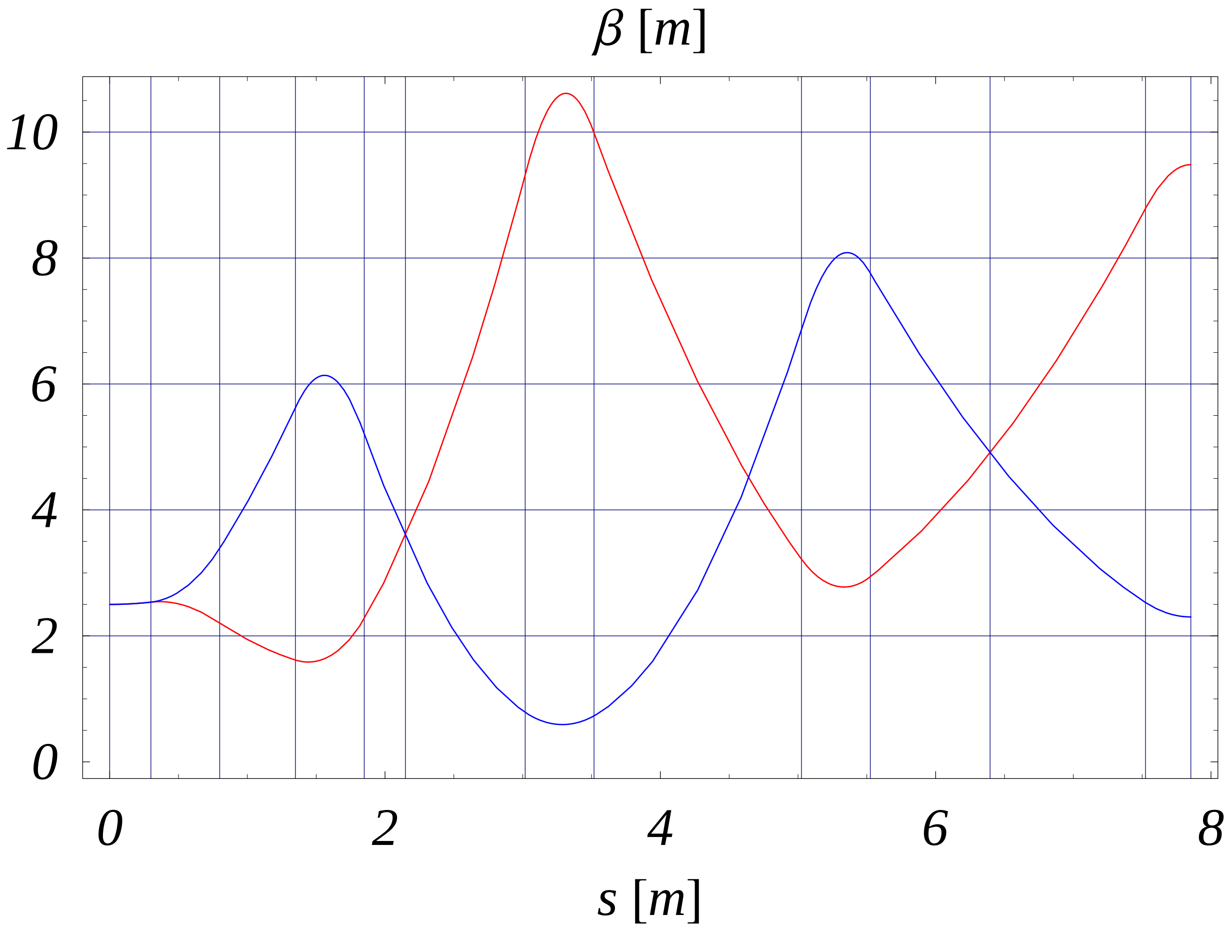


Phase rotation in 8 triplet cells. Can we do better?

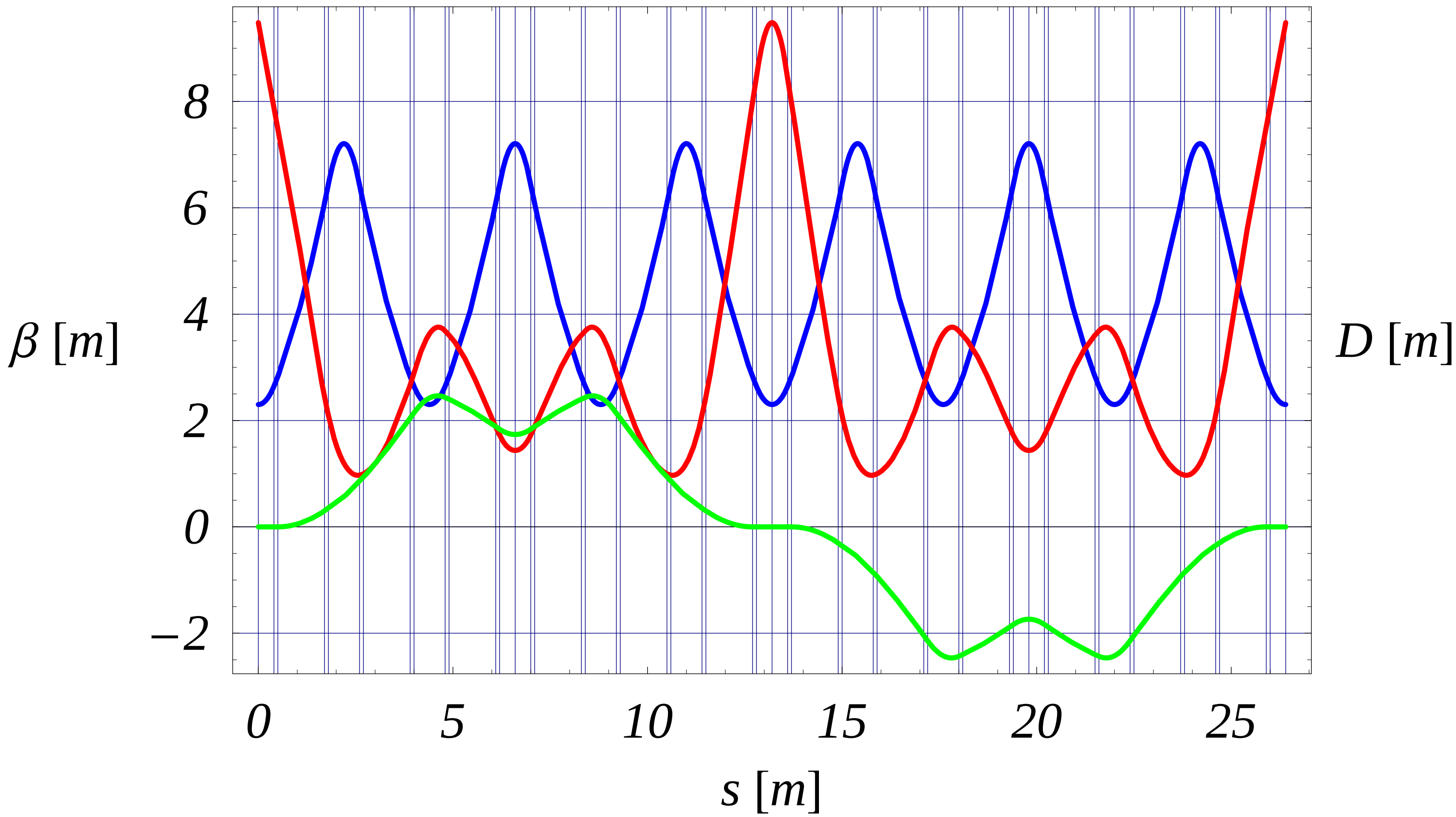


Phase rotation in 11 cells (22 cavities). Better rotation, but beam is longer.

2 Magnetic compression

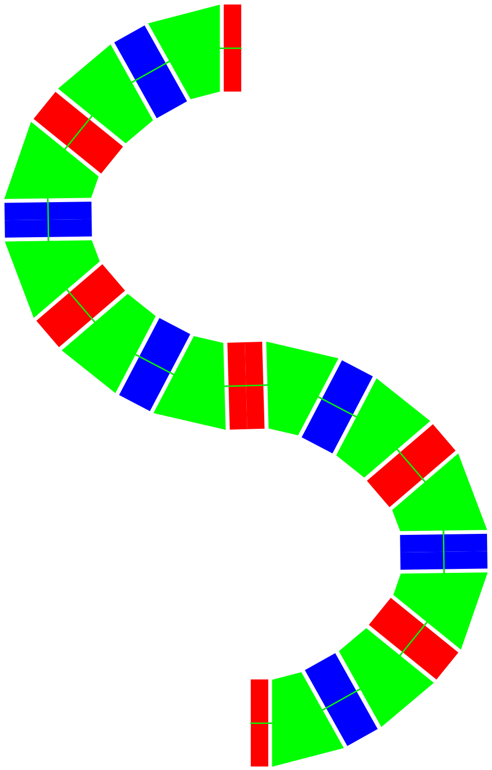


Matching between the triplet and a magnetic compressor.

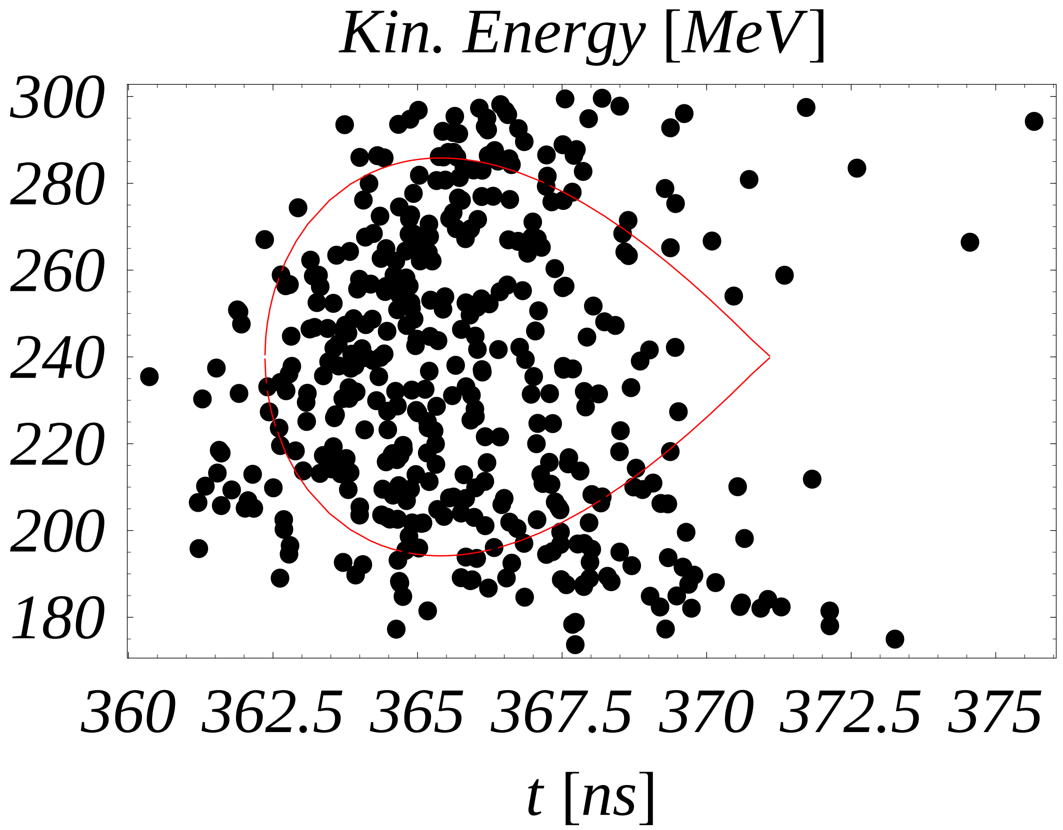


Optical function in the magnetic compressor

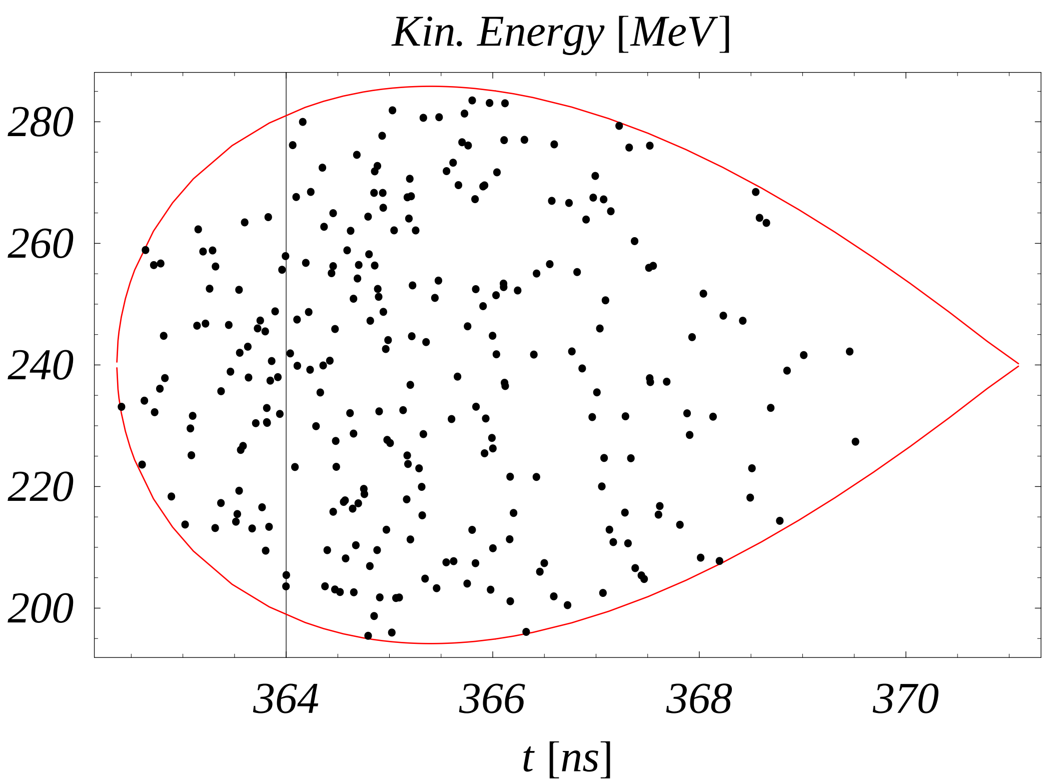
$$\eta = 1/\gamma_T^2 - 1/\gamma^2 > 0$$



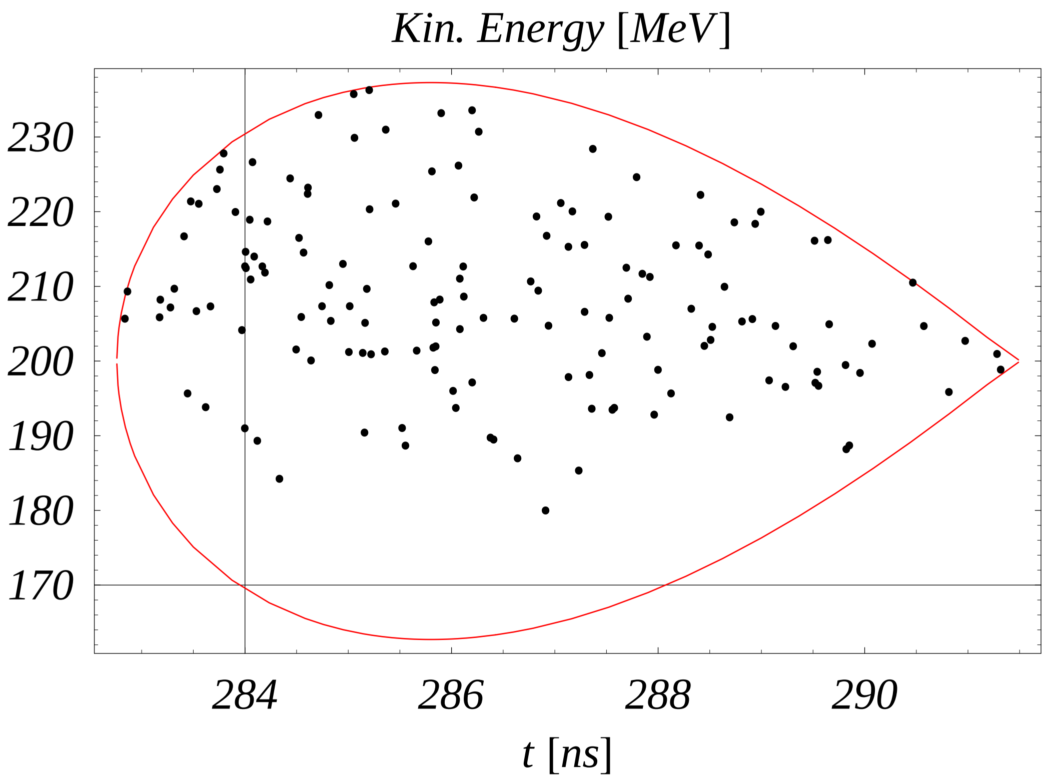
Compressor@work



Reduction of the bunch length with a constant energy spread.

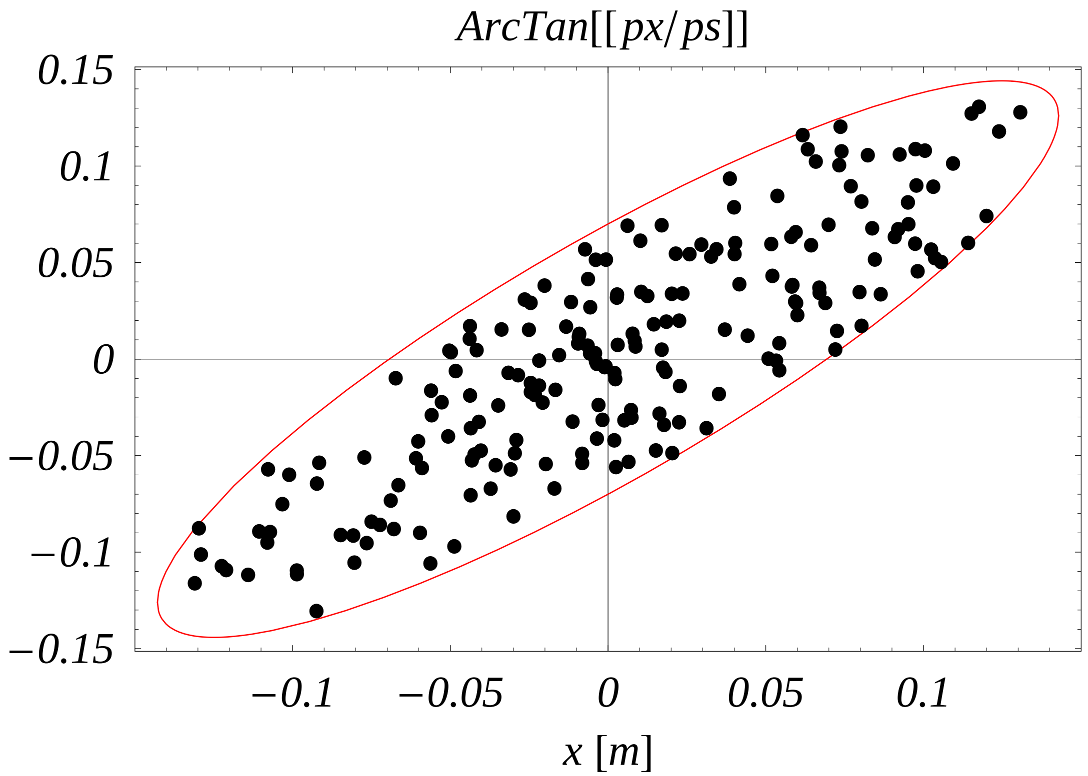


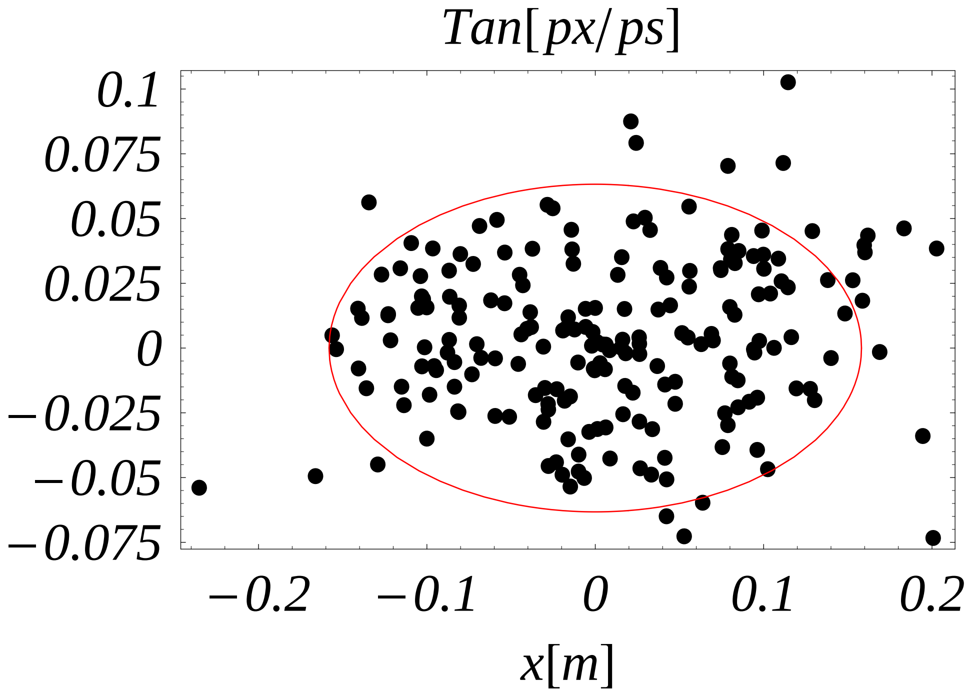
Kin. Energy [MeV]
280
260
240
220
200
364
366
368
370
t [ns]

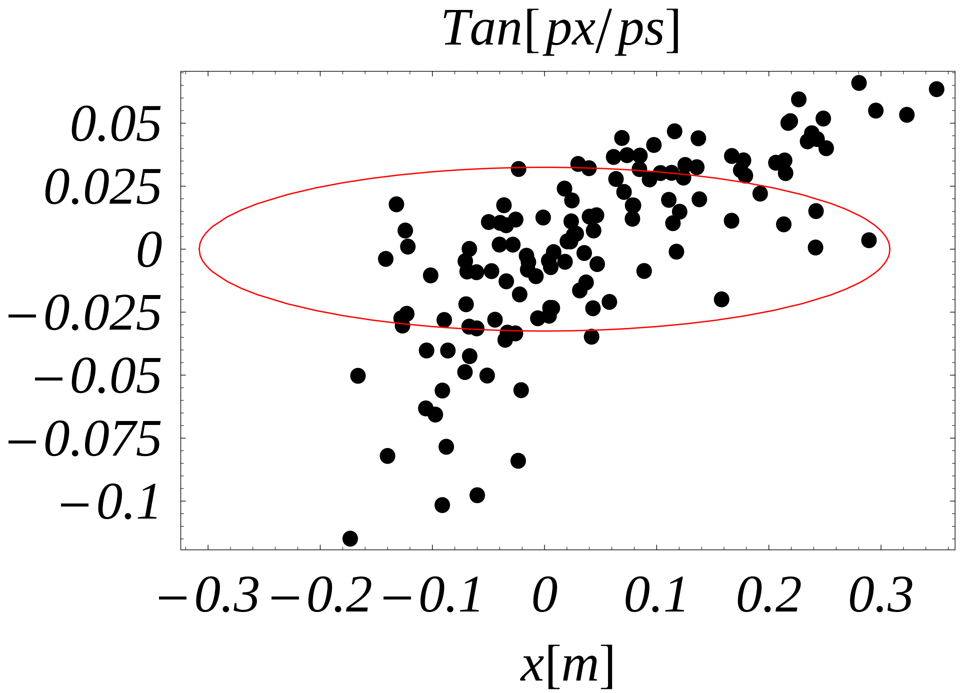


Comparison with 11 cell case shows,that separatrix contains more particles by factor 1.8.

What about transverse phase spaces?




Tan[px/ps]
0.1
0.075
0.05
0.025
0
−0.025
−0.05
−0.075
−0.2
−0.1
0
0.1
0.2
x[m]

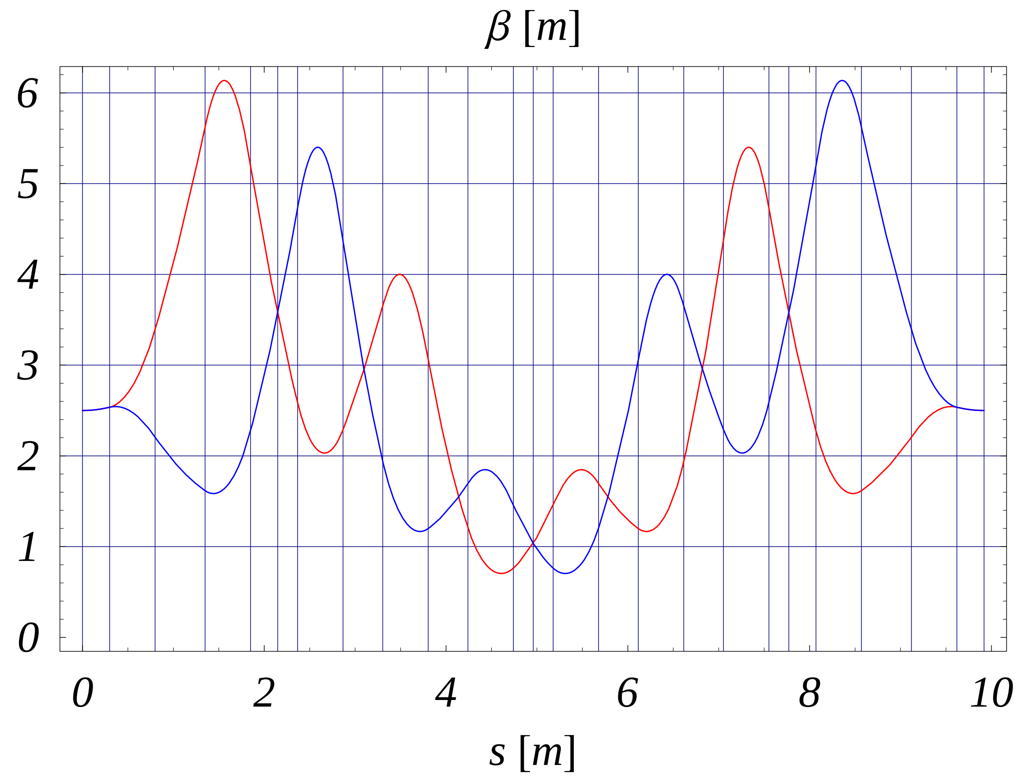


Horizontal phase space after the decay channel, the phase rotation and the compressor respectively. Aberrations mostly due to not matched dispersion- compressor is only a first order achromat.

5 Parameters

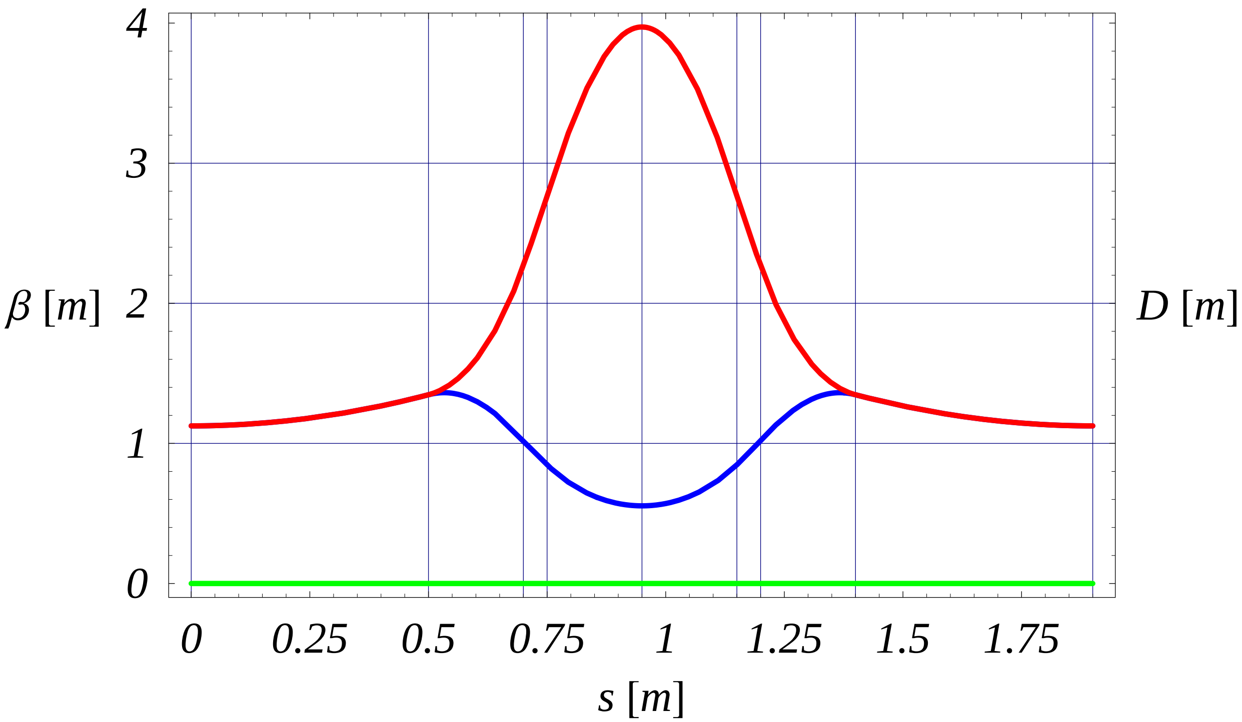
	k $[m^{-}2]$	β [m]	g [T/m]	r [m]	B [T]
Triplet	2.25	4.5	1.91	0.3	0.57
	-1.79	8.5	1.52	0.41	0.63
Matching	1.94	7	1.65	0.37	0.62
sections	1.4	10.5	1.34	0.45	0.61
Compressor	0.7	3.9	0.74	0.88	0.66
Bending	-	-	-	-	0.55

Examples of magnet parameters in the line for 0.02 cm rad acceptance.



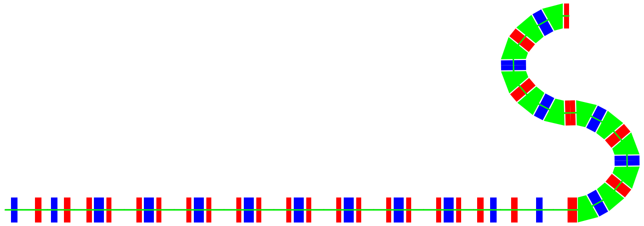
6 Cooling?

After the compressor we could come to triplet acceleration or cooling with a matching to low beta at the position of an absorber given above.



Solution with a special cooling triplet lattice
(B field up to 2.3 T).

7 Summary



AG muon front end offers an interesting and a cost effective alternative, which final performance should be calculated with and without cooling.

Transverse losses remain to be estimated and mismatch to be carefully studied and corrected.

Phase rotation together with magnetic compression helps to achieve better longitudinal transmission.