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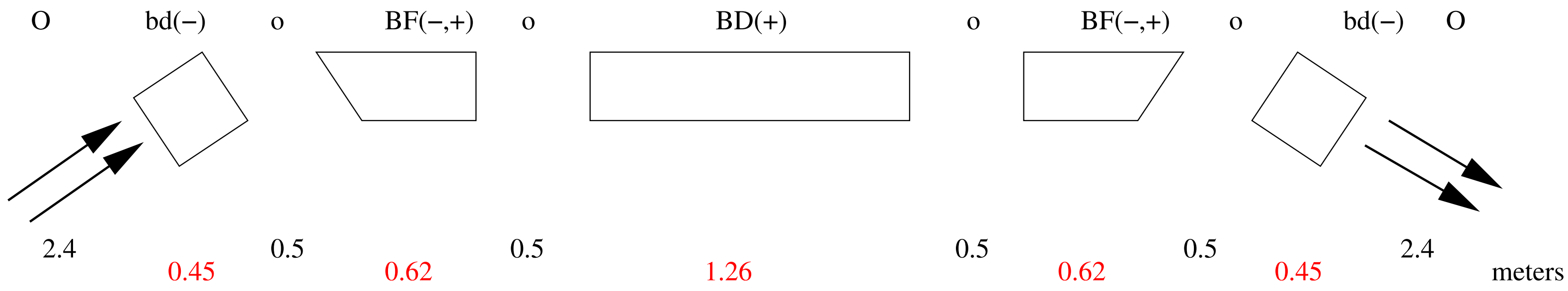
Beam transmission in isochronous FFAG lattices (! μ, here)

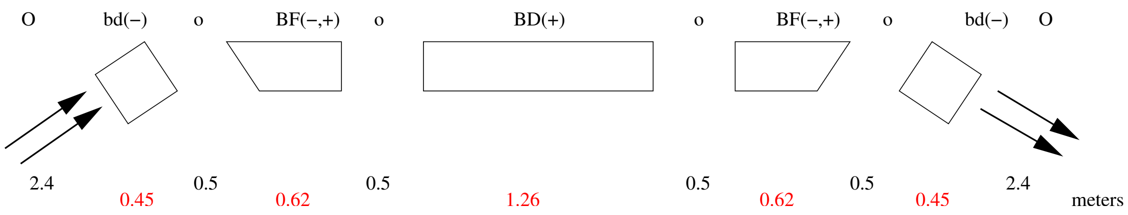
Contents

1 Isochronous cell, ring parameters

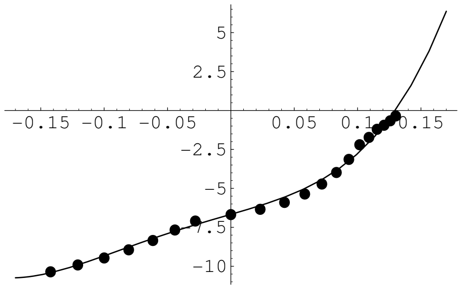


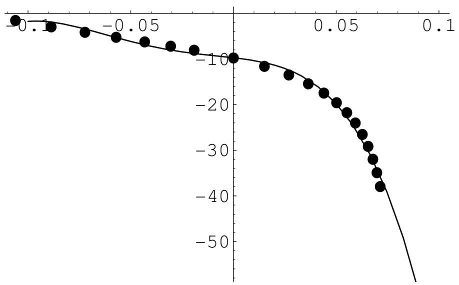
E	GeV	8 - 20	
$\mathcal{C}$	m	1254.6	
num. turns		16	
num. cells		123	3×41, provision for resonant D_x excitation (?)
cell length	m	10.2	
cell type		$\overline{dF}$B$\overline{Fd}$	at low E
		$\bar{b}FDF\bar{b}$	at highest E
f_{RF}	Hz	201.20	
η		0	$\forall\gamma$
E gain	MeV/turn	750	
ξ		> 0	

2 Magnet fields

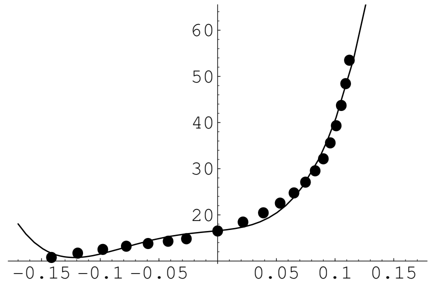


Strength (m^{-2}) in bd and BF multipoles :





Field (T) in BF sector magnet :



Polynomial representation (and modeling) :

Straight multipoles, bd and BD : get strengths that ensure tunes on closed orbits sticking to design data :

$$
\begin{aligned}
K_{bd}(x) &= -1.16096 + 52.7949\,x + 3349.85\,x^2 + 24707.2\,x^3 - 5.7728410^6\,x^4 \\
K_{BD}(x) &= -1.92981 - 168.352\,x - 10056.6\,x^2 - 2.108410^6\,x^3 - 1.7228210^8\,x^4
\end{aligned}
$$

then, integration yields the series expansions

$$B_{bd}(x) = \mathbf{b_{bd0}} - 1.16096\,x + 26.3975\,x^2 + 1116.62\,x^3 + 6176.79\,x^4 - 1.154710^6\,x^5 \quad (1)$$

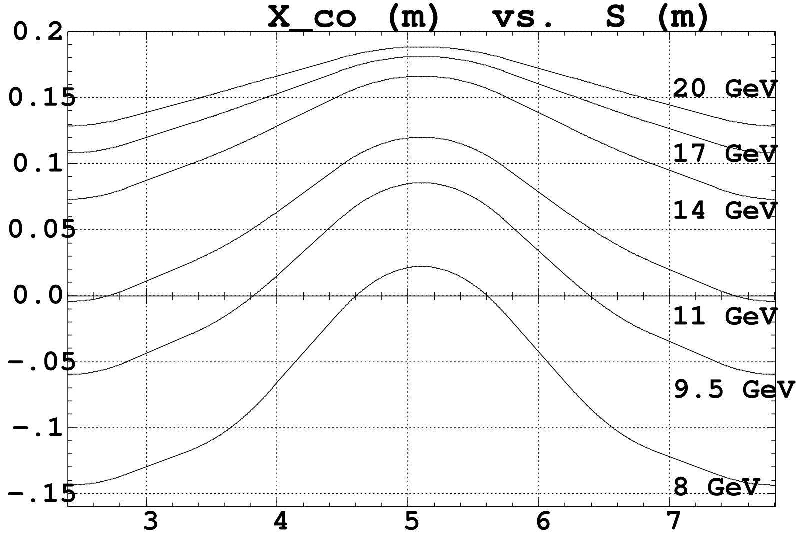
$$B_{BD}(x) = \mathbf{b_{BD0}} - 1.92981\,x - 84.1762\,x^2 - 3352.2\,x^3 - 527101.\,x^4 - 3.4456510^6\,x^5 \quad (2)$$

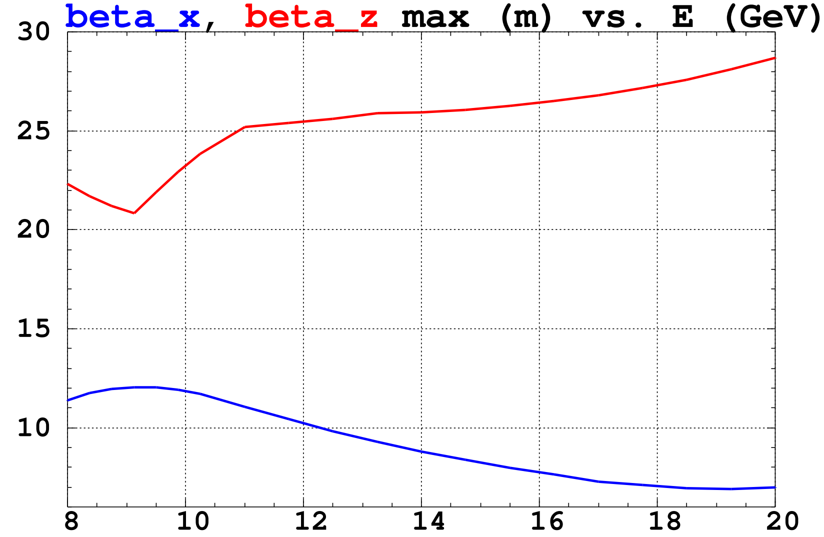
BF sector magnet :

$$B_{BF}(r) = \mathbf{b_{BF0}} + 16.5655\,r + 12.612\,r^2 + 86.4359\,r^3 + 2987.43\,r^4 + 13647.1\,r^5$$

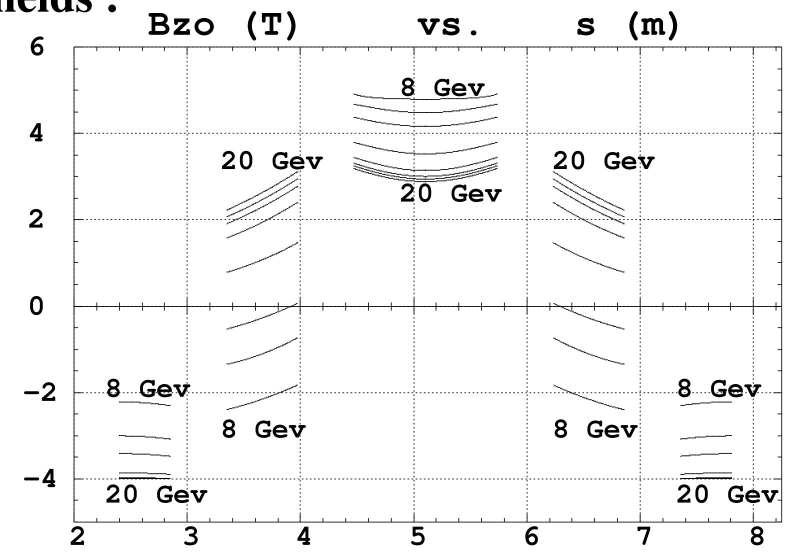
3 Ring parameters

closed orbits along cell :

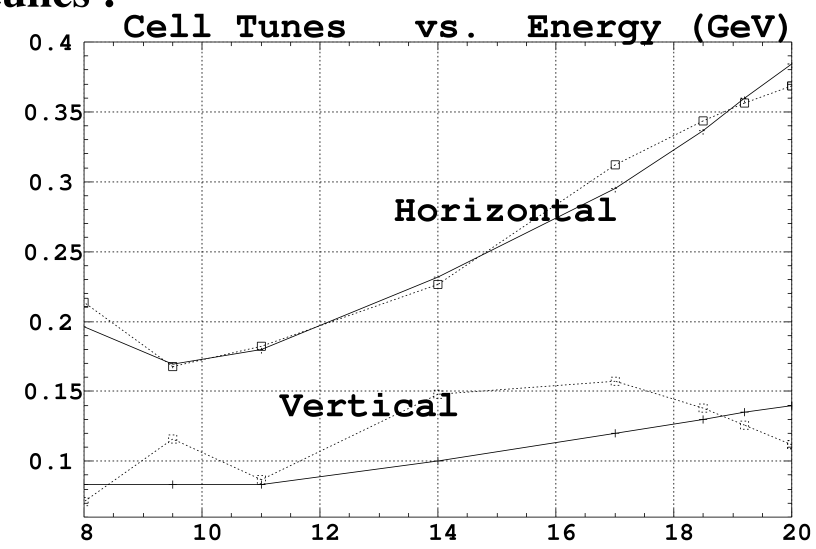




fields :



tunes :



4 Stability limits

Goal 1. Check symplecticity of the motion over the all energy span, at largest transverse amplitudes. This will guarantee correct 6-D simulation of 8-20 GeV acceleration.

Goal 2. Find the maximum stable amplitudes.

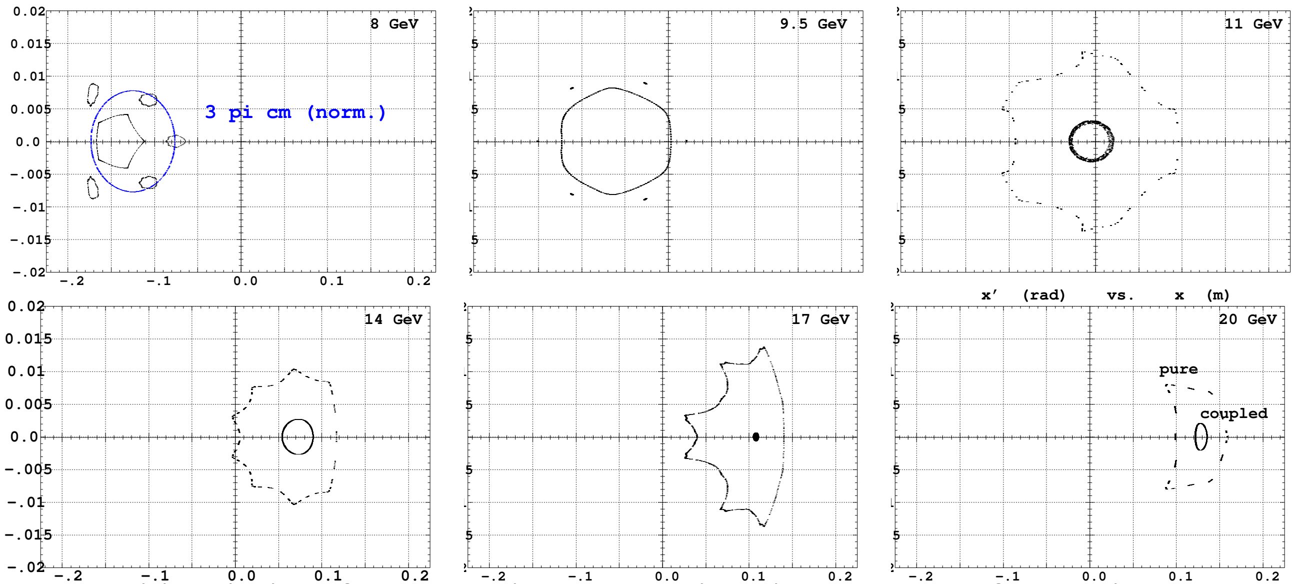


Figure 1: **1000-cell, stability limits of pure horizontal motion, in presence of paraxial z component. Precision beyond 0.1 cm.**

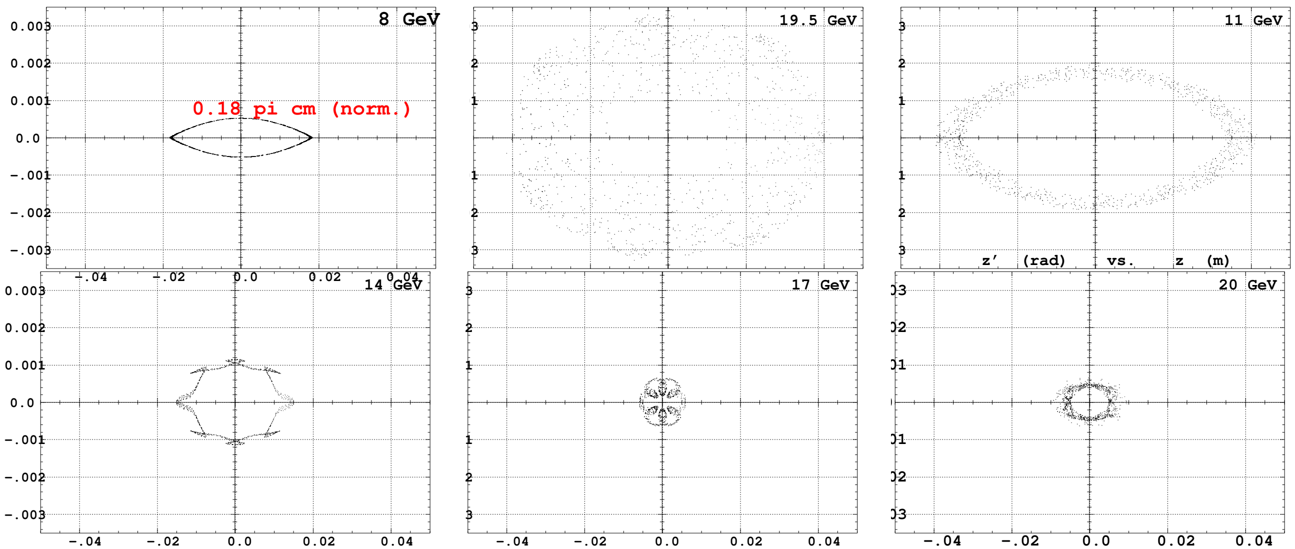


Figure 2: **1000-cell or more, vertical motion stability limits. Precision 0.1 cm.**

5 Amplitude detuning

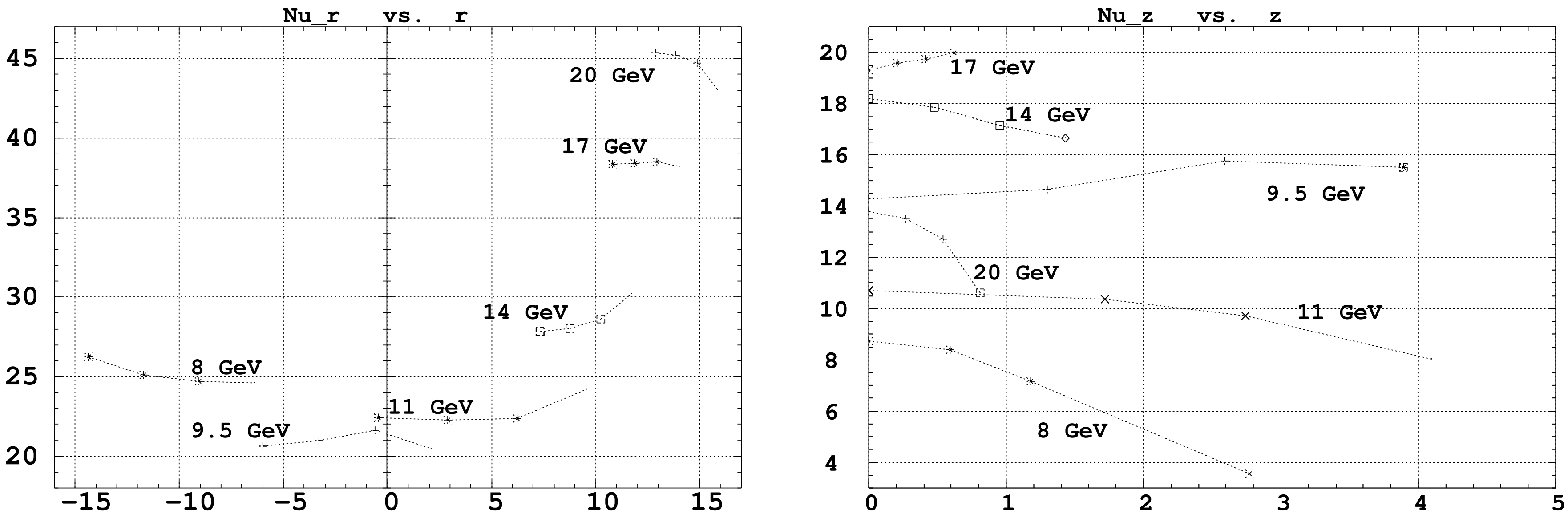


Figure 3: Amplitude detuning.

Left : pure radial motion, with for each energy, x_0 varied from closed orbit position to maximum stable amplitude.

Right : axial motion, with for each energy, z_0 varied from zero to maximum stable amplitude while $x_{initial} \equiv x_{c.o.}$ always.

6 Beam transmission

A 10000 particles beam is launched for 16 turn acceleration (123 cells/turn), from 8 to 20 GeV.
18.3 MV per cavity, no synchroton motion. Cavities are put every three cells at the center of the long drift.

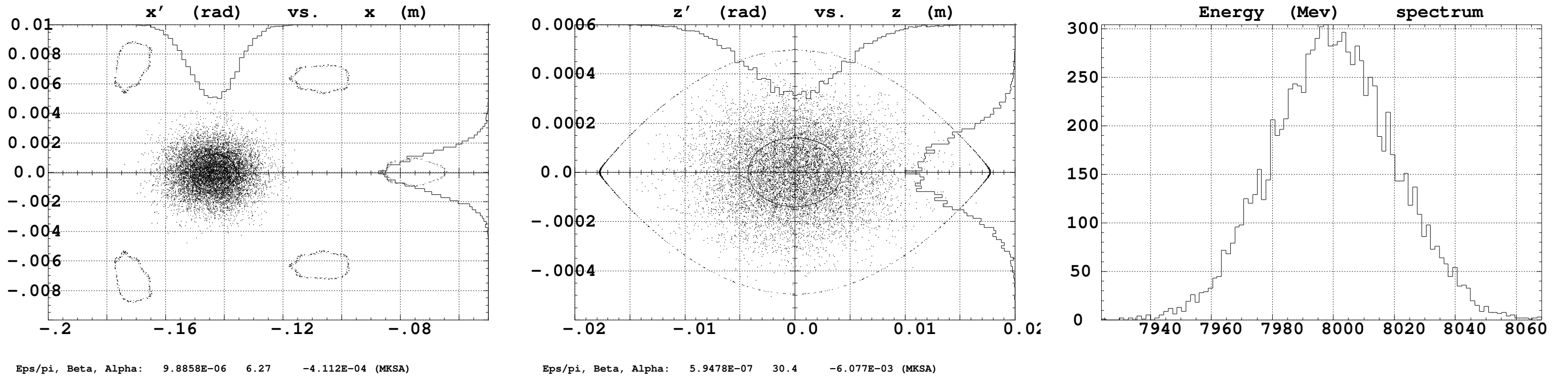


Figure 4: **Initial phase spaces**

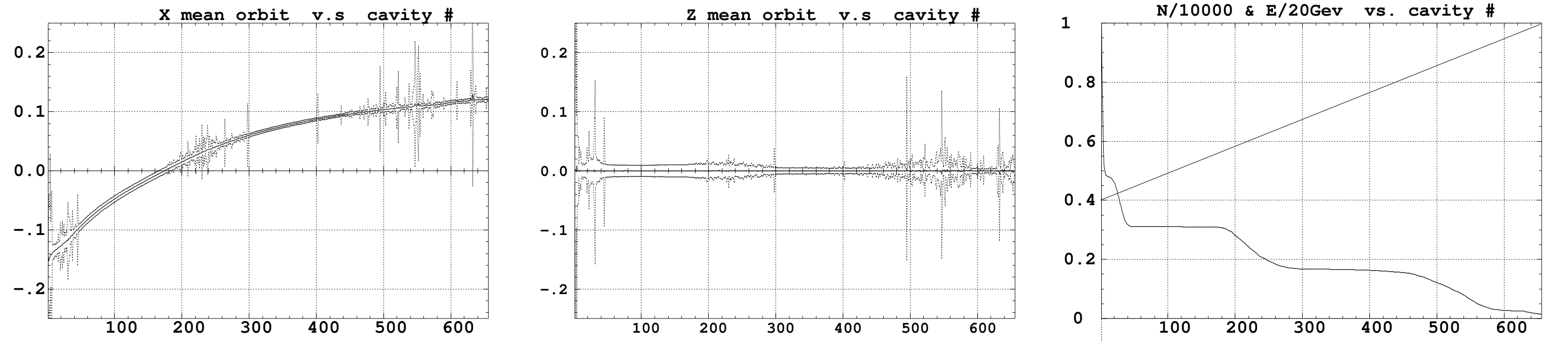


Figure 5: **Left : Envelopes. Right : transmission.**

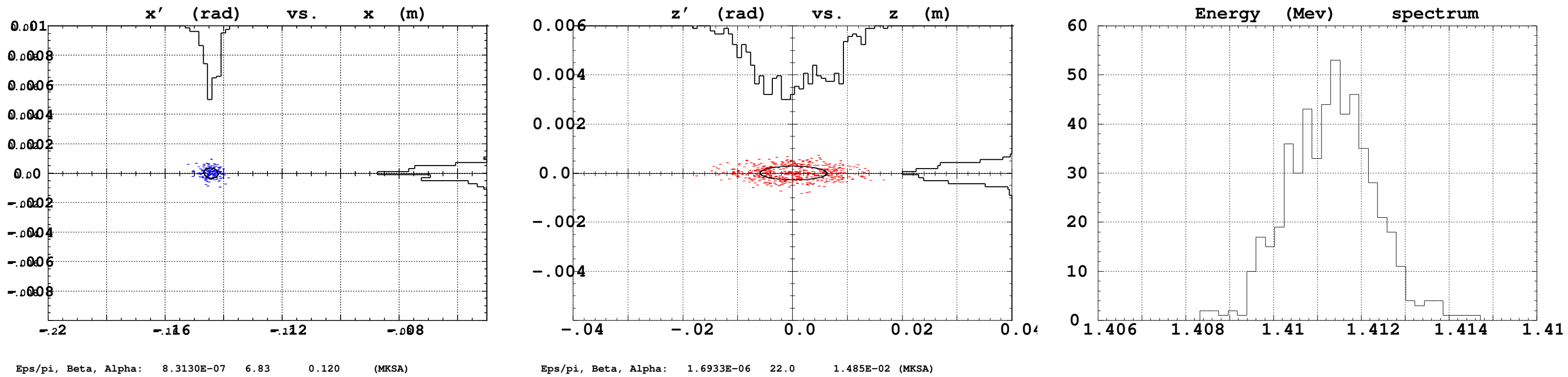


Figure 6: **Initial phase spaces of transmited particles after the acceleration cycle.**

Beam transmission, after iterating

A 10000 particles beam is launched for 16 turn acceleration, from 8 to 20 GeV.
Initial coordinates fill the previous acceptance.

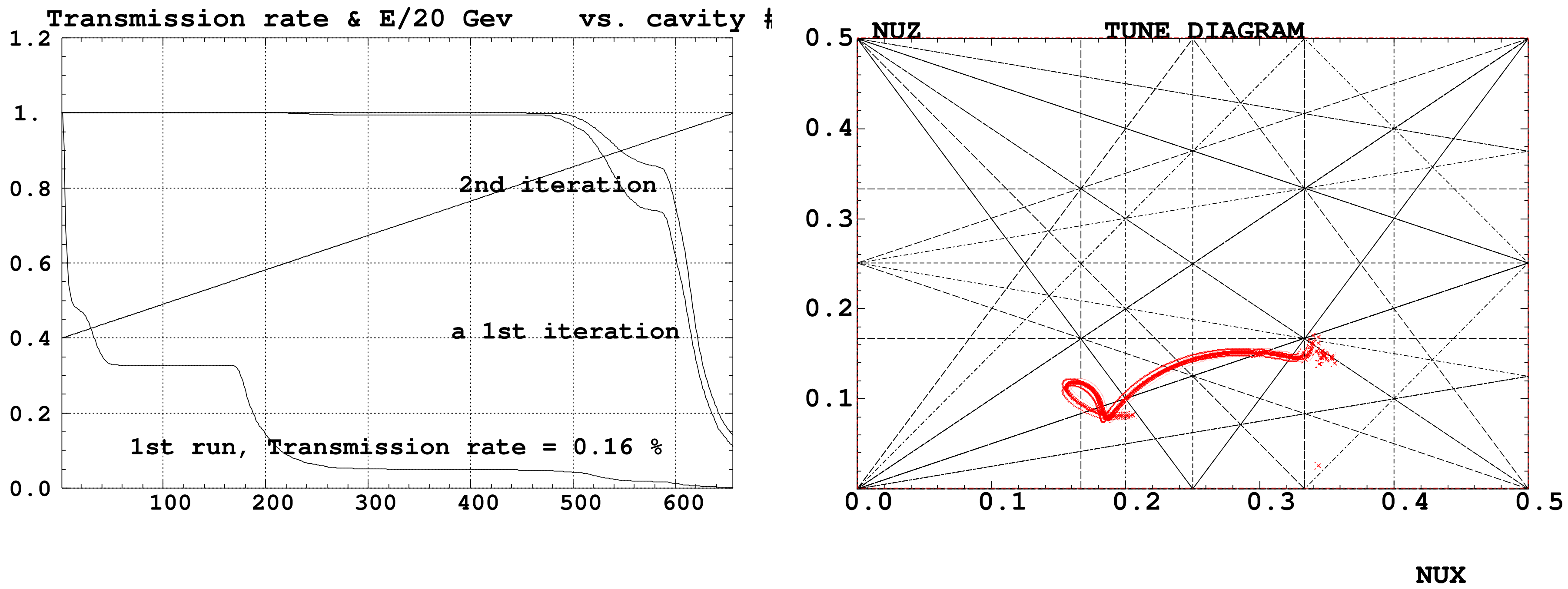


Figure 7: **Left : transmission. Right : beam trajectory in tune diagram.**

Acceptance, for 8-17 GeV acceleration range :

$\epsilon_x = 0.08\,\pi$ **cm (norm.),** $\epsilon_z = 0.12\,\pi$ **cm (norm.).**

7 Don't give up ! : lattice with insertions

• It is possible to design matched cell insertions over the full energy range.
• Similar pumplet cells may be considered for both the arcs and insertions, but with shorter straight sections and changed non-linear fields in the arc cells.

As an example :
- ring composed of 4 superperiods, = 4 $\times$ (21 arc cells + 9 insertion cells),
- total of 120 cells (compared to the 123 identical cells of the 1254.6 m ring).

Assuming cells of length 10.2 m (as before) for the insertion, but cells of length 6.4 m in the arcs, the circumference reduces to 904.8m.

There are the benefits of the reduced ring size and of localising the rf systems, but the possible disadvantage of the reduced ring periodicity with more dangerous resonance crossing.

Tunes

	μ_z	μ_x
	$\forall$ **E**	**9.5 GeV $\rightarrow$ 20 GeV**
Insertion cell	**0.16**	**0.12 $\rightarrow$ 0.32**
Normal cell	**0.10**	**0.09 $\rightarrow$ 0.25**

ν_x **will not reach 1/3**