ENHANCEMENT OF TRANSVERSE BEAM PHASE SPACE ANALYSIS BY TOMOGRAPHY METHOD AT INR LINAC

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Abstract

The investigation of transverse beam phase space parameters behavior along the accelerator is important for proper accelerator tuning. At INR RAS linac transverse emittance and Twiss parameters are reconstructed from beam profile measurements with quadrupole scan technique at several measurement points along the accelerator. Profile treatment is performed with ordinary transverse profiles method and tomographic reconstruction method. Various experimental data is presented. The comparison of the results obtained by the two methods is done. Features of beam dynamics simulation based on the data from these methods are discussed.

Introduction

At INR linac the main method for measuring phase ellipse parameters is a typical quadrupole scan technique (QST) realization – transverse profiles method (TPM). Also a tomographic reconstruction is implemented as an alternative and enhancement to the TPM.

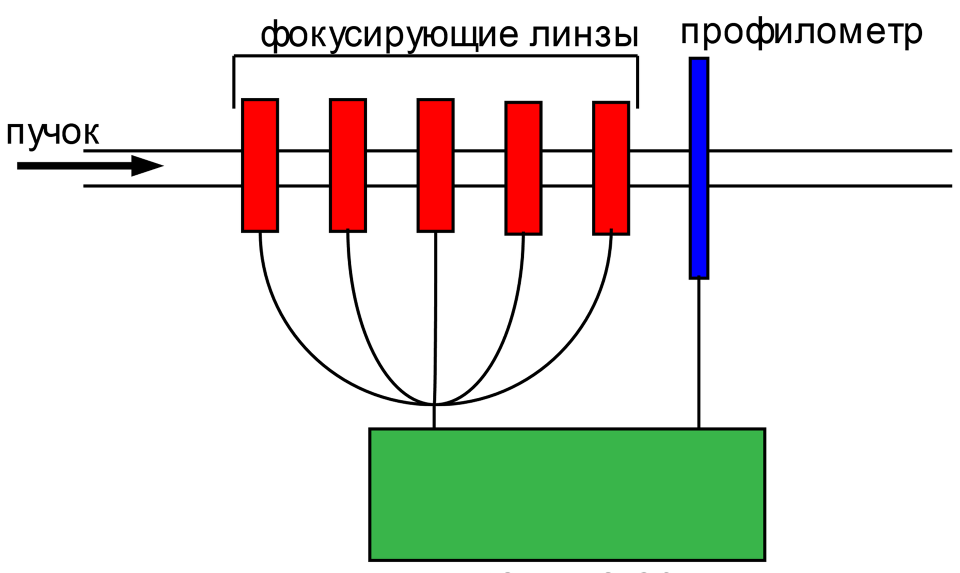

Fig. 1. Typical layout of components required for QST measurements.

Experimental results

Measurements were made with SEM-grid (SEM) located after first DTL tank, two wire scanners (WS1 and WS2) located near the matching cavity (MC) and Beam Cross-section monitor (BCSM) located at the exit of the linac. Normalized transverse emittance values for all measurements are presented in Table 1. Data from wire scanners was treated by TPM simultaneously. Underlined values for tomography measurements mean that phase portraits cannot be treated as elliptical. Phase ellipses and phase portraits are presented in figure 4.

Param.	Tomography					TPM			
	SEM	WS1	WS2	BCSM 32 μs	BCSM 100 μs	SEM	WS	BCSM 32 μs	BCSM 100 μs
$\varepsilon_{x\ norm}$, mm∗mrad	2.48	2.43	2.60	2.14	2.41	0.52	0.41	0.38	0.77
$\varepsilon_{y\ norm}$, mm∗mrad	3.40	2.81	3.63	3.2	4.16	0.62	0.52	0.57	0.85

Table 1. Values of normalized emittance in different measurement points.

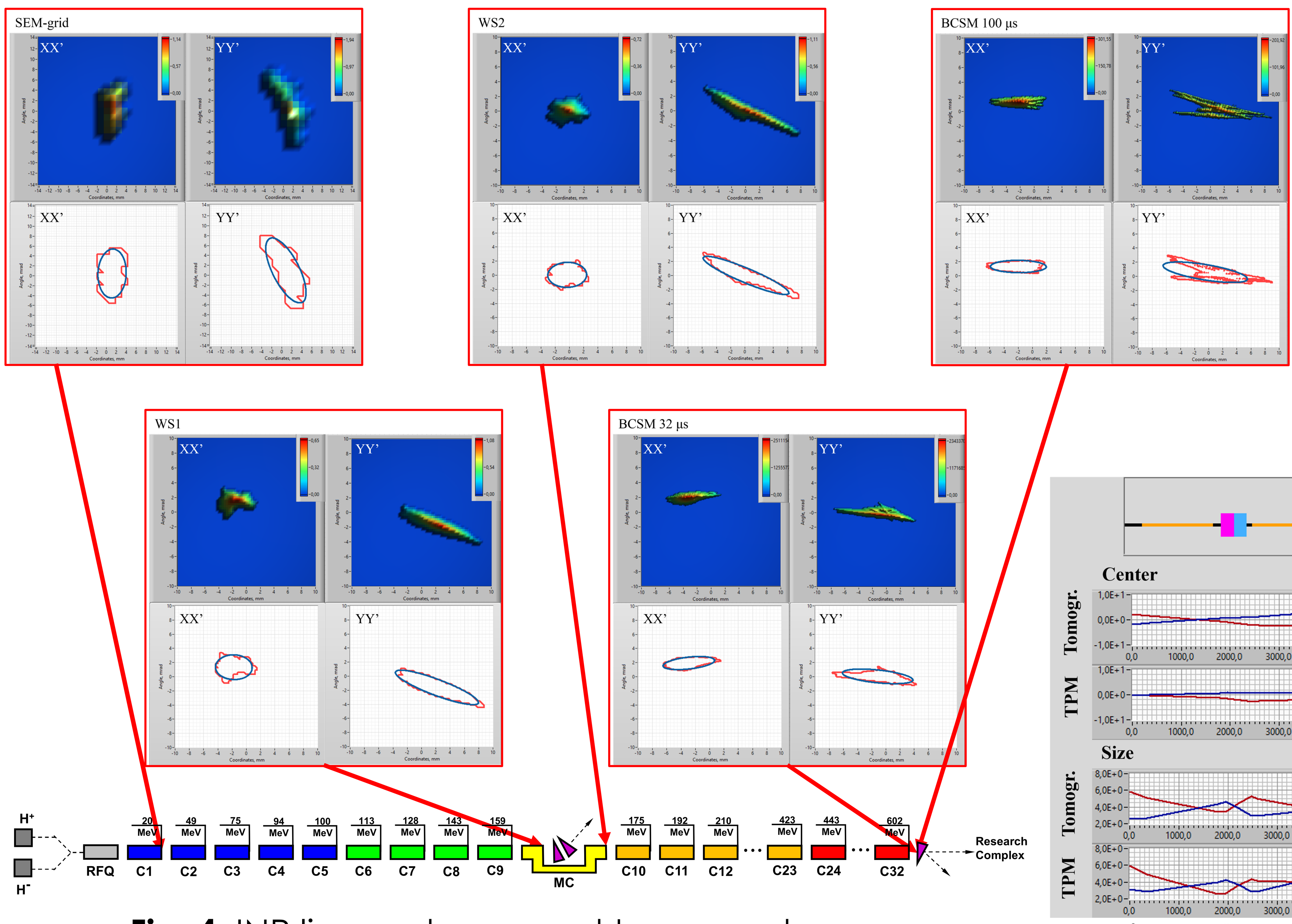

Fig. 4. INR linac scheme and tomography results for different points.

Transverse profiles method

TPM requires rms beam size and beam centre measured for its operation. These values are transferred to the arbitrary point of measuring area by transfer matrix method. Results of the measurement represent a set of lines. The phase ellipse is inscribed in these lines with the iteration algorithm (figure 2).

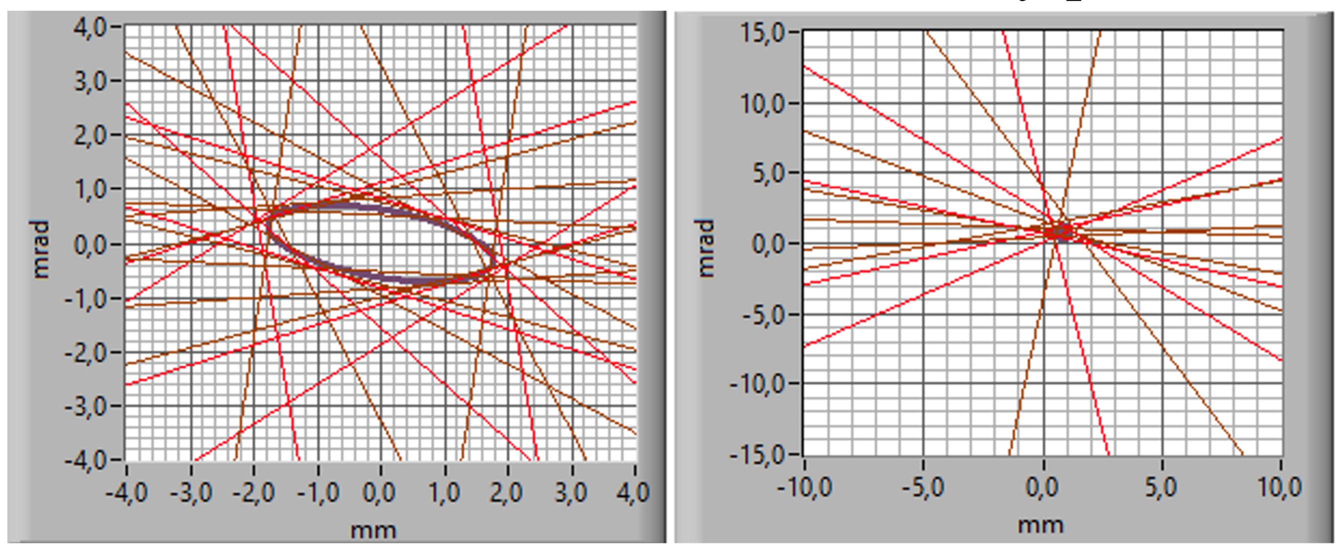

Fig. 2. Results of TPM reconstruction. Phase ellipse (on the left) and phase ellipse center (on the right).

Tomographic reconstruction

Tomographic reconstruction requires all information about beam profiles for its operation. Profiles are transformed with use of the transfer matrixes and converted into a sinogram. Tomography kernel is based on the SART algorithm. Result of the tomography is post-processed so it can be used for beam dynamics simulation (figure 3). Tomography reconstructs full-beam emittance and determine if the result can be treated as an ellipse or not.

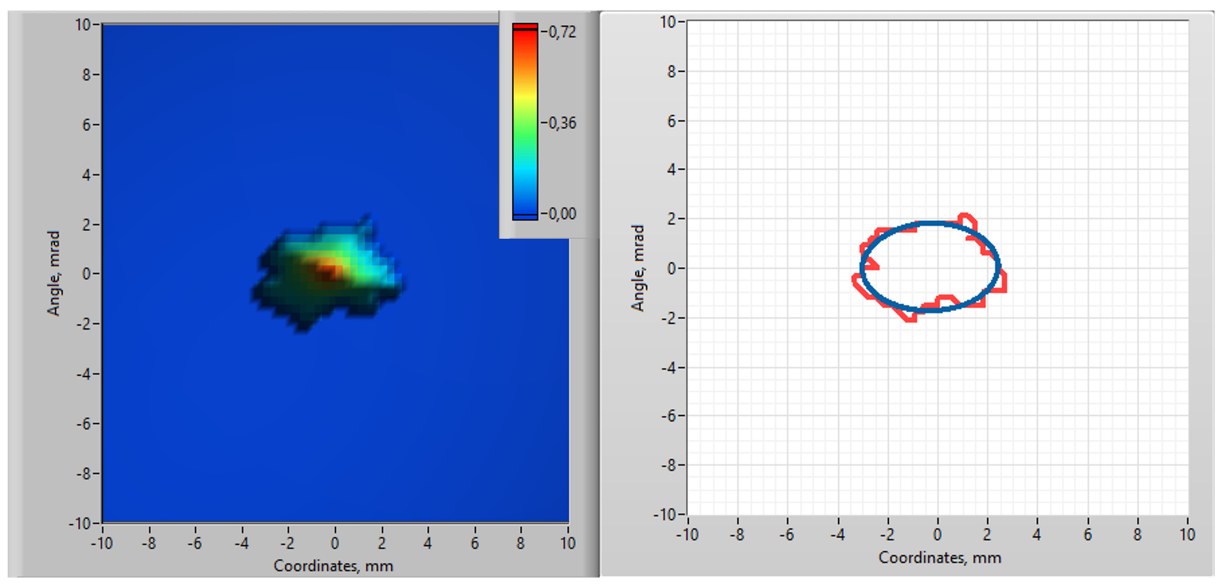

Fig. 3. Results of the tomography. Phase portrait (on the left). Portrait envelope (red) and phase ellipse (blue) (on the right).

Methods comparison

Not all measurements can be selected for further beam dynamics simulation because they have non-elliptical phase portraits. Elliptical results were used for dynamics simulation through the transport line (figure 5).

Results show a similar behaviour of the normalized emittance values for both methods: it decreases from SEM-grid to WS and then grow from WS to BCSM in case of 100 μs beam (for tomography growth starts from WS1 to WS2). For 32 μs beam there is no significant growth from WS to BCSM. There is a possible explanation for this phenomenon, connected with a problem with beam loading compensation system.

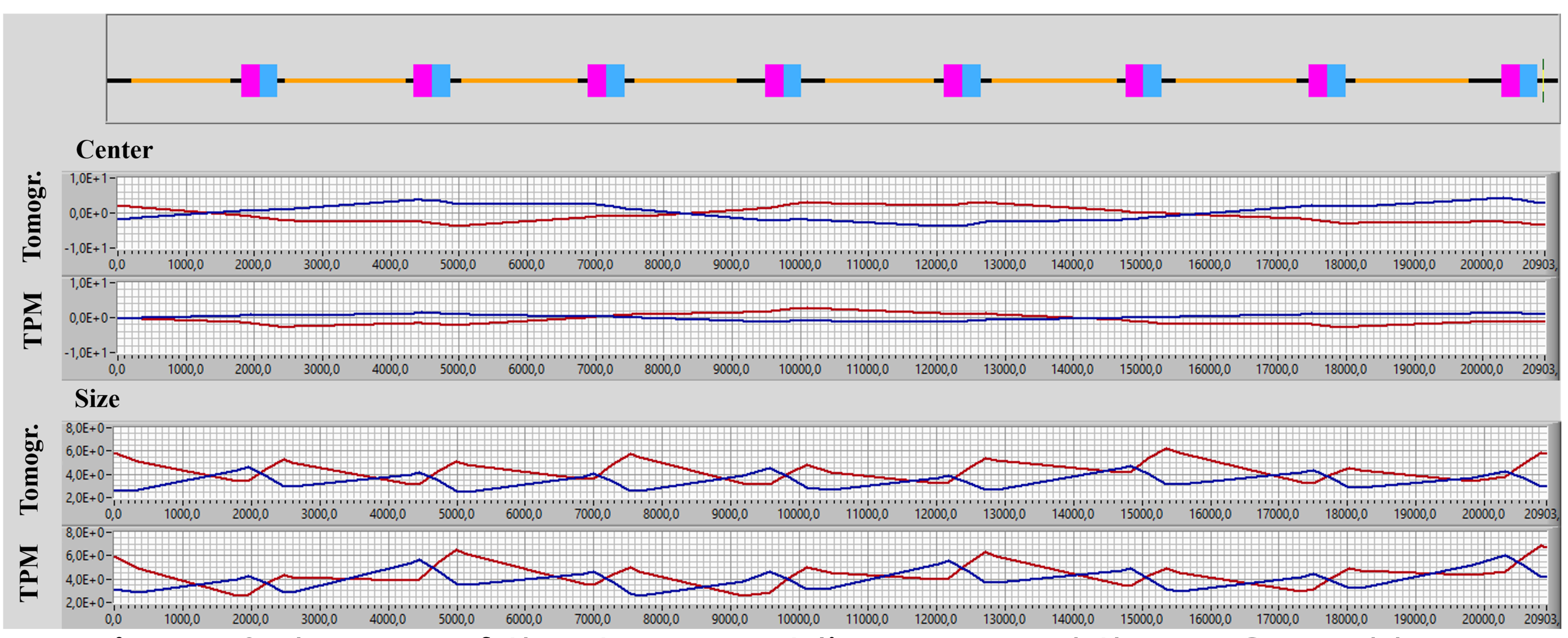

Fig. 5. Scheme of the transport line around the MC and beam position and size dynamics through the simulated transport line.