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Comparison of computational methods and results concerning the simulation of IH structures with the codes LORAS and DYNAC.

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Introduction

The differences in results between the codes LORAS and DYNAC could be explained by differences in methods of computation, and by differences in the adjustment of energy and phase of the "reference" particle along the structure.

Adjustment of the structure

The IH structure is generated using a set of "reference" particles, one per section of the structure. LORAS output gives the energy of the reference particle after each gap. Its phase is always given in the gap centre. DYNAC input data are made such as to have identical energy and phase evolution for the reference particle as in LORAS (i.e. same phase at the gap centre and same energy gain).
The energy and phase of the beam at the input of the IH structure does not coincide with the reference, and have their own evolution along the structure. Therefore a check was made on DYNAC over a section of 13 gaps, using a small beam with the same input energy and phase as the reference particle. As the beam evolves indepedently of the reference, but now having the same starting conditions, both beam and reference particle should behave the same way.

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E_{in}	50.4	MeV
$E_{out,refer}$	135.100	MeV
$E_{out,beam}$	135.104	MeV
$\Phi_{beam,out}-\Phi_{ref,out}$	0.0	deg
$\Phi_{out}-\Phi_{in}$	3079.3	deg

Table 1:DYNAC results

From the above one can see that the procedure used for the setting up of the machine is correct. Similar results are found with LORAS.

Beam simulation

Now consider a complete accelerating structure (we used the GSI IH design), with normal input conditions (N.B. both in LORAS and in DYNAC simulations a total of 500 particles were used). Simplifying the simulation of this structure by having zero transverse coordinates gave us the following LORAS and DYNAC results :

	DYNAC	LORAS	
E_{in}	71.4	71.4	MeV
$E_{out,refer}$	332.676	332.676	MeV
$E_{out,beam}$	333.676	333.519	MeV
$\Phi_{beam,out}-\Phi_{ref,out}$	-3.01	-4.23	deg
$\Phi_{out}-\Phi_{in}$	19478.		deg
$Emit_{out,lon}/Emit_{in,lon}$	1.07	1.06	

Table 2:IH simulation with longitudinal motion only

Table 2 shows a good agreement between LORAS and DYNAC when simulating with longitudinal movement only, though there is some difference in the output beam energy. The next step is to include radial motion (i.e. beam has nominal transverse input emittances):

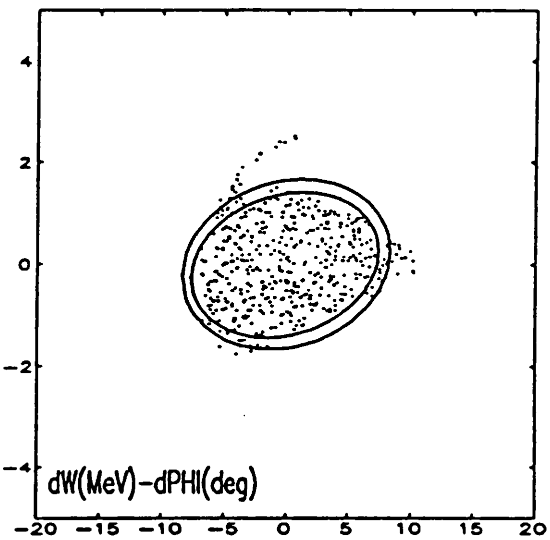
	DYNAC	LORAS	
E_{in}	71.4	71.4	MeV
$E_{out,refer}$	332.676	332.676	MeV
$E_{out,beam}$	333.090	333.151	MeV
$\Phi_{beam,out}-\Phi_{ref,out}$	-3.32	-4.73	deg
$\Phi_{out}-\Phi_{in}$	19477.		deg
$Emit_{out,lon}/Emit_{in,lon}$	1.20	1.08	

Table 3:IH simulation with longitudinal and transverse motion

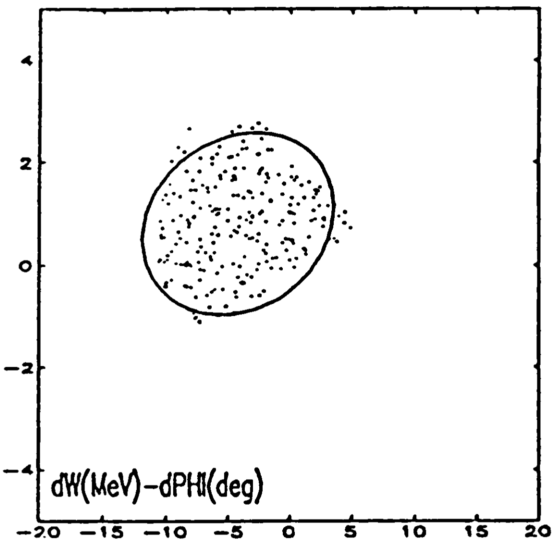
From table 3 it can be seen that including radial motion does not affect the longitudinal emittance growth when looking at LORAS results. DYNAC results (analytical as well as numerical), however, give an increase in longitudinal emittance. The emittance growth in the transverse planes is of the order of 10% in LORAS. In DYNAC values of 11% (horizontal plane) and 21% (vertical plane) are found. Table 4 shows the beam characteristics in the transverse planes at the output of the structure.

	DYNAC	LORAS	
X max	4.99	5.05	mm
X'max	4.27	4.04	mrad
$Emit_{out,xx'}$ (normalized)	.895	.843	π mm.mrad
Y max	4.89	5.21	mm
Y'max	6.15	5.94	mrad
$Emit_{out,yy'}$ (normalized)	.981	.871	π mm.mrad

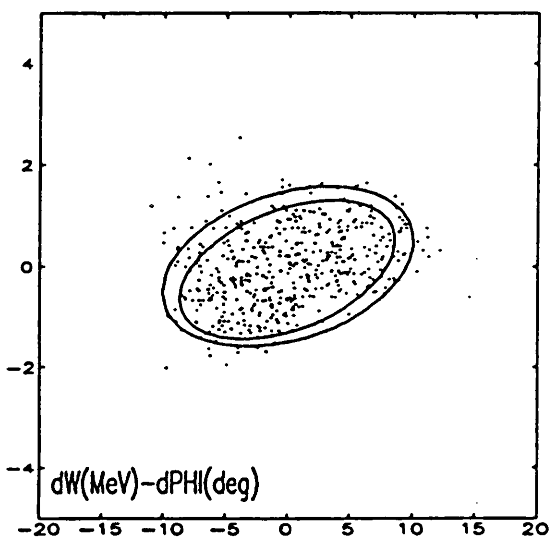
Table 4: Transverse output emittances



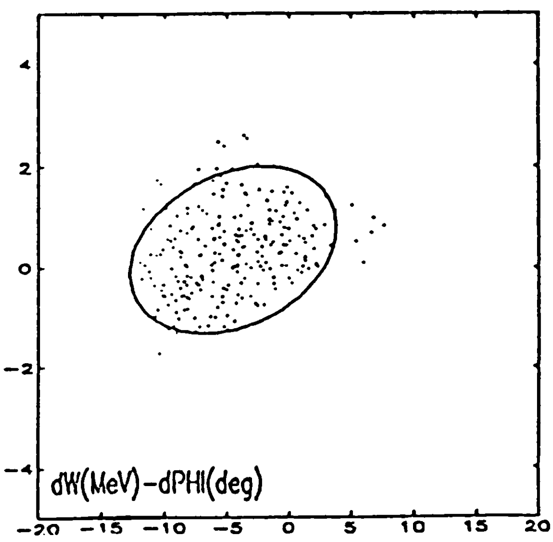
DYNAC, without radial movement



LORAS, without radial movement

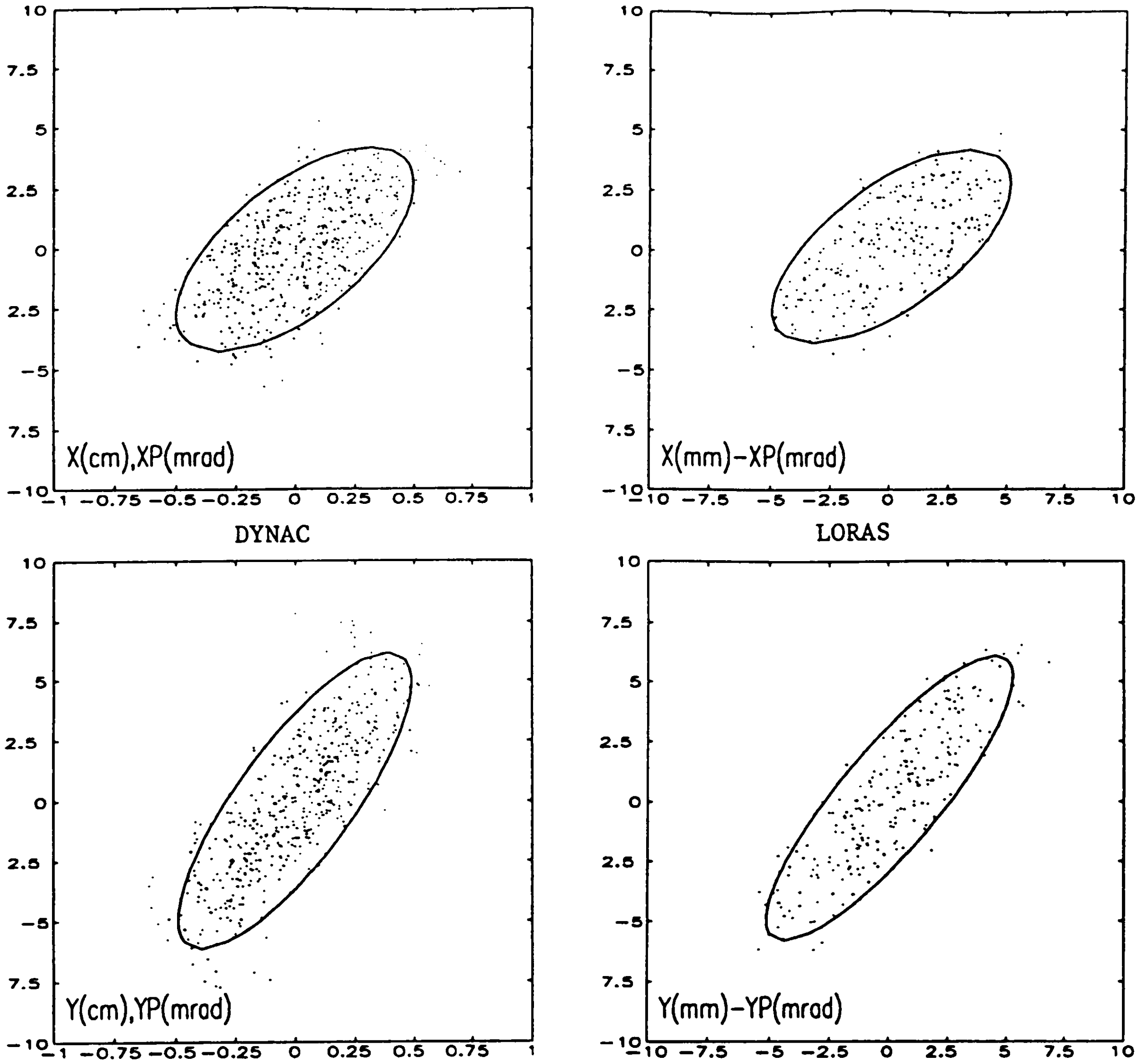


DYNAC, nominal case



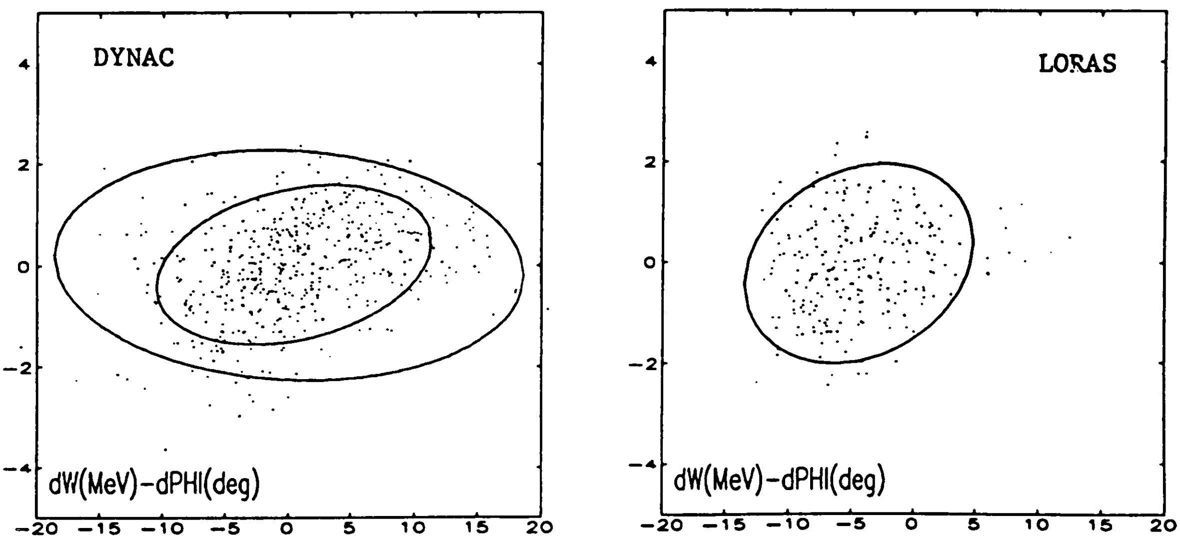
LORAS, nominal case

Output emittances in the longitudinal plane



Output emittances in the transverse planes

Increasing the transverse emittances by a factor two, LORAS gives a longitudinal emittance growth of 30 %, whereas DYNAC gives 300 % (both in analytical and numerical results). However, taking 85% of the DYNAC output beam, a longitudinal emittance growth of some 50% is found.



Longitudinal output emittances containing 85% and 100% of beam (DYNAC) and 100% of beam (LORAS) for doubled transeverse input emittances.