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1 GeV リニアック検討資料

1 GeV LINAC DESIGN NOTE

題目 (TITLE) Comparison among four RFQ designs by DTL simulation

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概要 (ABSTRACT)

There are three designs and one simple trial for the RFQ linac of JHP. The first, QKEK1, and the second, QKEK2, have been obtained by Ueno with the optimization of focusing force under the appropriate current limit. The third design, QINS by Tokuda, was optimized at a current of 20 mA. The fourth design, PAQ461 by Kato, was converted from the design of 200 MHz- 750 keV RFQ linac.The beam simulation was done for four kinds of RFQ designs mentioned above. The transverse emittances of the injected beam (5000 particles) were assumed to be a 1.0 (90%) and 1.5 (100%) pmm.mrad at a beam current of 20 mA. The calculated results are shown.

KEY WORDS:

Ion source, RFQ, DTL, CCL, Magnet, Monitor, Beam Dynamics,
Transport, Vacuum, Cooling
Klystron, Low level rf, High power rf, Modulator
Control, Operation, Radiation, Others

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Comparison among four RFQ designs by DTL simulation

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There are three designs and one simple trial for the RFQ linac of JHP. The first, QKEK1, and the second, QKEK2, have been obtained by Ueno with the optimization of focusing force under the appropriate current limit. It was pointed out that the longitudinal emittance of QKEK1 was larger than those of others. Thus, QKEK2 was newly designed in order to obtain smaller longitudinal emittance. The third design, QINS by Tokuda, was optimized at a current of 20 mA. The fourth design, PAQ461 by Kato, was converted from the design of 200 MHz- 750 keV RFQ linac by changing a few parameters such as the frequency, the injection and final energies, and so on. Therefore, the optimization has not been performed yet.

The beam simulation was done for four kinds of RFQ designs mentioned above. The transverse emittances of the injected beam (5000 particles) were assumed to be a 1.0 (90%) and 1.5 (100%) πmm·mrad at a beam current of 20 mA. The calculated results are shown in Figs. 1- 8 and the following tables.

Fig.1 Longitudinal emittance at RFQ exit.
Fig.2 Energy spread at RFQ exit.
Fig.3 Phase spread at RFQ exit.
Fig.4 Longitudinal emittance after DTL acceleration.
Fig.5 Comparison of output emittances among four designs.
Fig.6 Comparison of transmission efficiency among four designs.
Fig.7 Comparison of mechanical parameters among four designs.
Fig.8 Comparison of relative field strength among four designs.

The length of the beam line (3.4 m) between the RFQ and the DTL is so long that the the spiral parts are observed in the longitudinal emittances at the exit of the DTL. It means that the tolerance of the longitudinal emittance is small. Therefore, it had better shorten the length of the beam line.

The transmission efficiencies for different types of the injected beam are shown in Table 2. Results of DTL simulation is shown in Table 3.

Table 1 Results of RFQ simulation - 1

	PAQ461	QKEK1	QINS	QKEK2	
Number of particle after RFQ	4477	4683	4682	4530	
Longitudinal emittance					
rms	0.061	0.1282	0.0569	0.0754	MeV deg
90 %	0.296	0.5887	0.2779	0.3543	
rms phase spread	6.06	7.55	6.0	6.06	degree
90% energy width	32	60	28	40	keV
Transverse emittance					
X rms	0.0308	0.0250	0.0273	0.0262	πcm·mrad
90 %	0.130	0.106	0.1095	0.1086	
Y rms	0.0304	0.0242	0.0273	0.0258	
90%	0.1289	0.1010	0.1123	0.1060	

Table 2 Results of RFQ simulation - 2
-transmission efficiency for different distribution-

	PAQ461	QKEK1	QINS	QKEK2
(πmm·mrad(90%))				
20 mA-0.1	89.8	93.5	93.8	90.6
20 mA-0.2	69.0	72.7	76.4	67.9
40 mA-0.1	77.6	84.6	78.6	81.6
Length	276	263	266	269
No. of cell	325	297	295	334
Voltage (kV)	90	87	90	90
Min. radius (mm)	2.21	2.07	2.35	2.17
Modulation	1.8	2.03	1.83	2.0
B	4.5	4.1	4.0	4.0
Voltage/radius	40.7	42.0	38.3	41.5

Table 3 Results of DTL simulation

	PAQ461	QKEK1	QKEK2	
Before injection				
Longitudinal				
rms	0.1036	0.2671	0.1315	MeV deg
90 %	0.3812	1.0214	0.4956	
Transverse				
X rms	0.0305	0.0251	0.0261	πcm·mrad
90 %	0.1287	0.1067	0.1082	
Y rms	0.0301	0.0243	0.0257	
90%	0.1277	0.1010	0.1056	
After DTL Acceleration				
Number of particles after DTL	4469	4629	4517	
transmission	99.8%	98.9%	99.7%	
Longitudinal				
rms	0.1443	0.2671	0.1583	MeV deg
90 %	0.4872	1.0214	0.5446	
rms phase	1.98	2.47	2.18	degree
full phase	14.61	20.67	19.09	
90% energy width	180	300	180	keV
Transverse				
X rms	0.0306	0.0254	0.0265	πcm·mrad
90 %	0.1274	0.1079	0.1126	
Y rms	0.0311	0.0247	0.0264	
90%	0.1349	0.1032	0.1087	

The beam line between the RFQ and the DTL consists of a 2 m drift-space, buncher, and a 1.4 m drift -space.

An injection phase into the DTL is optimized so that the output longitudinal emittance becomes the smallest.

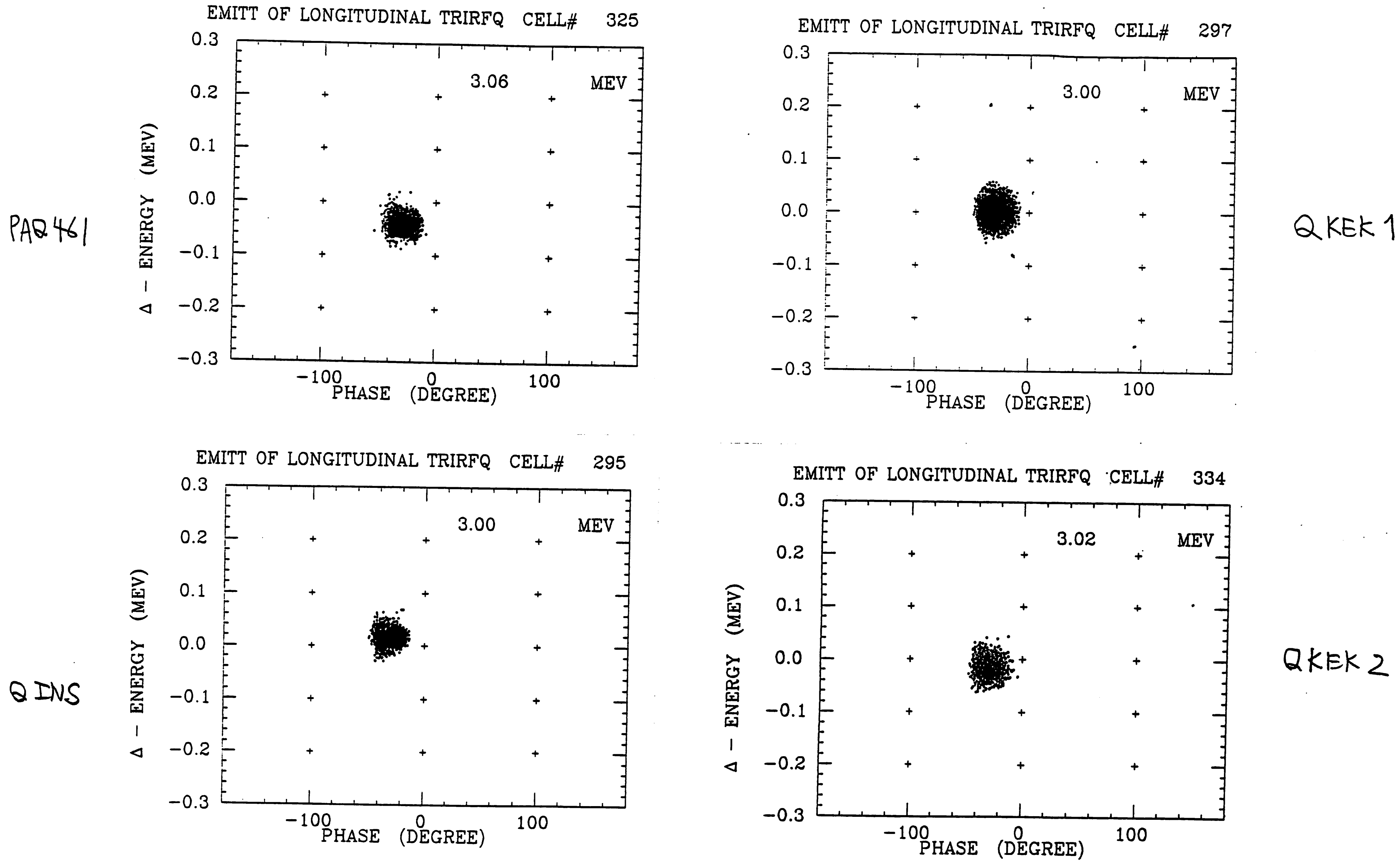


Fig. 1 Longitudinal emittances at RFQ exit.

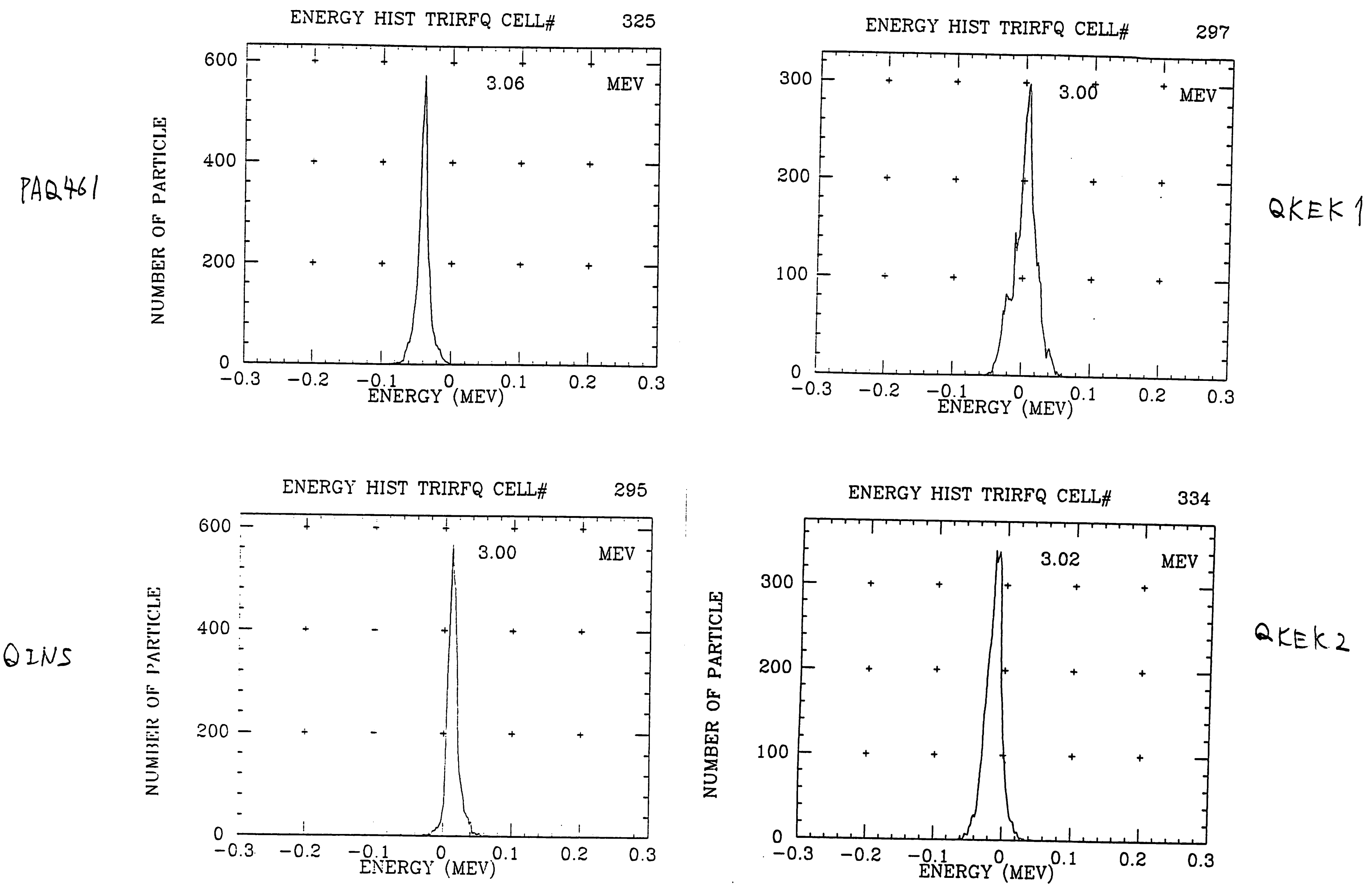


Fig. 2 Energy spread at RFQ exit.

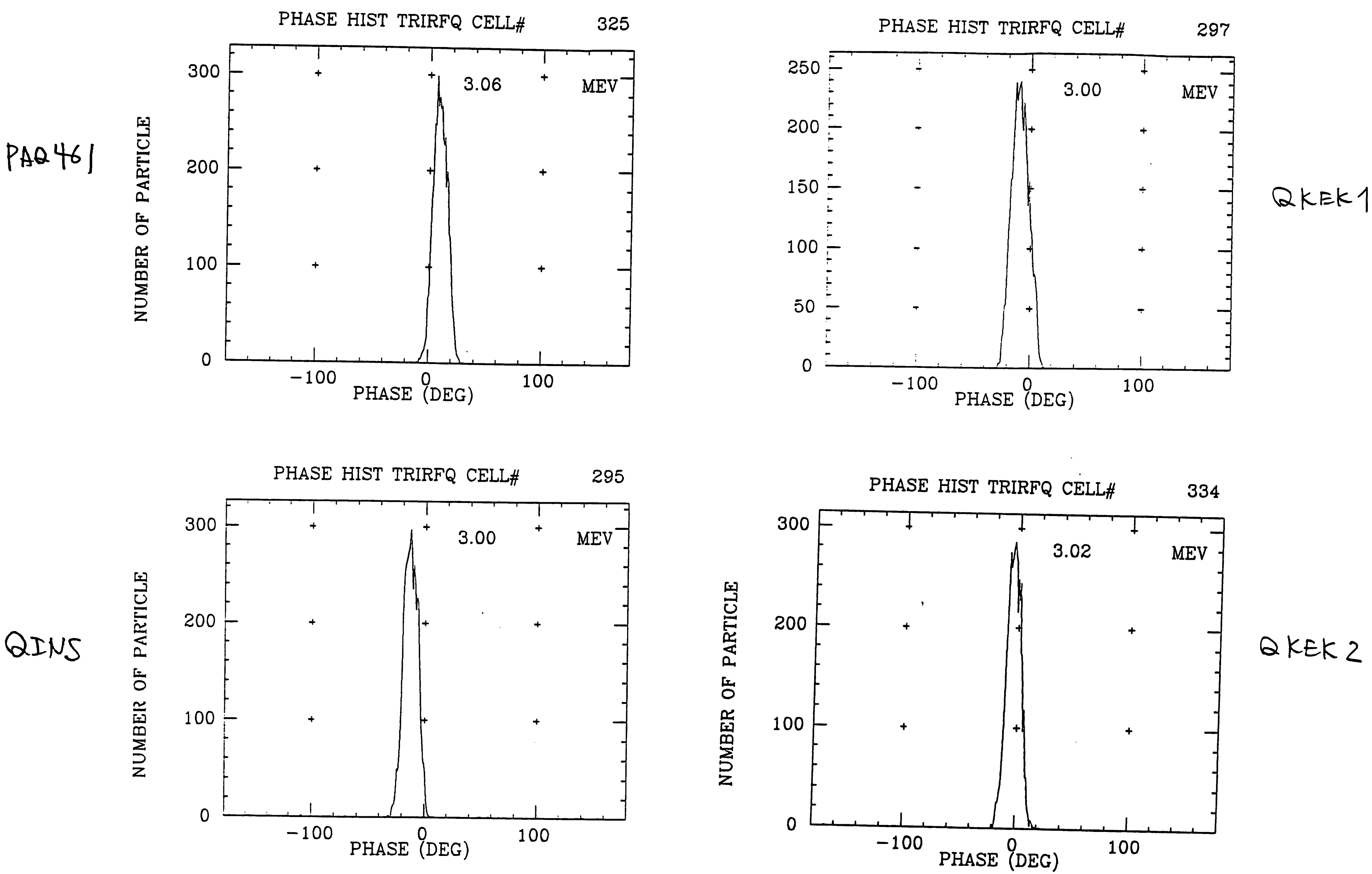
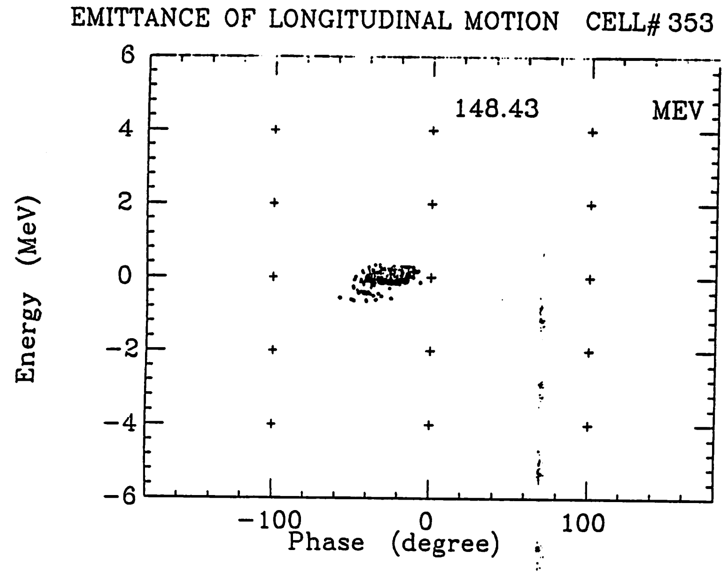
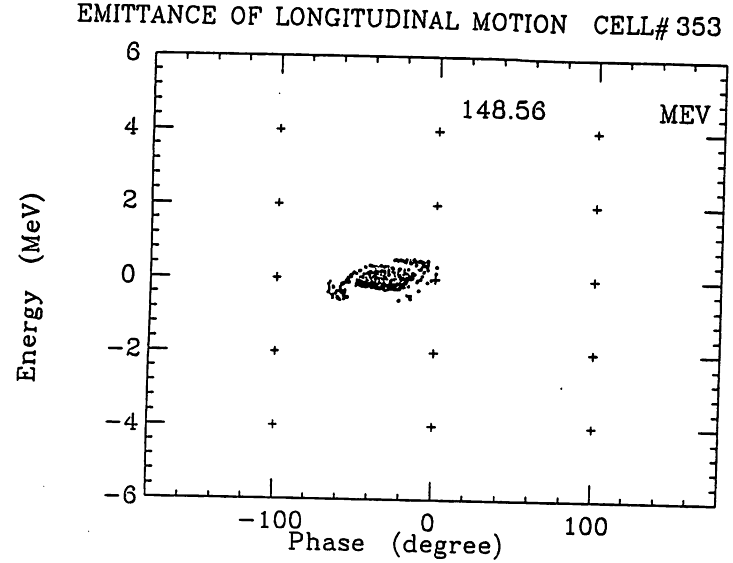


Fig. 3 Phase spread at RFQ exit.

PAQ461



QKEK1



QKEK2

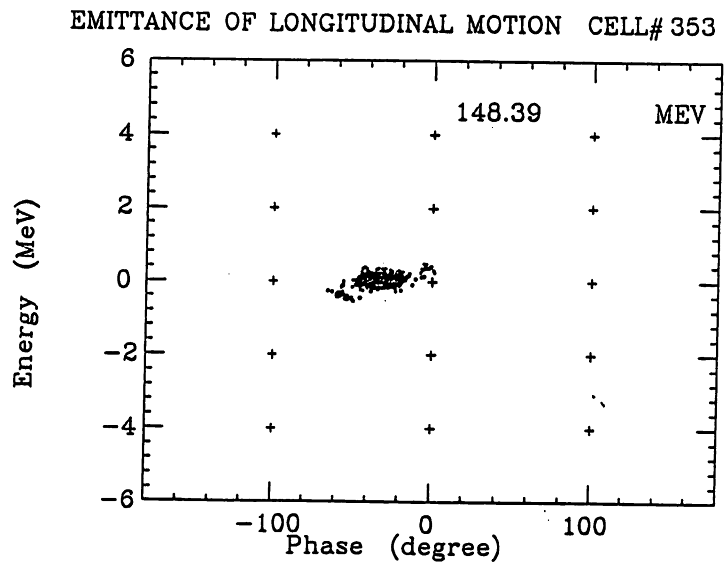


Fig. 4 Longitudinal emittances after DTL acceleration.

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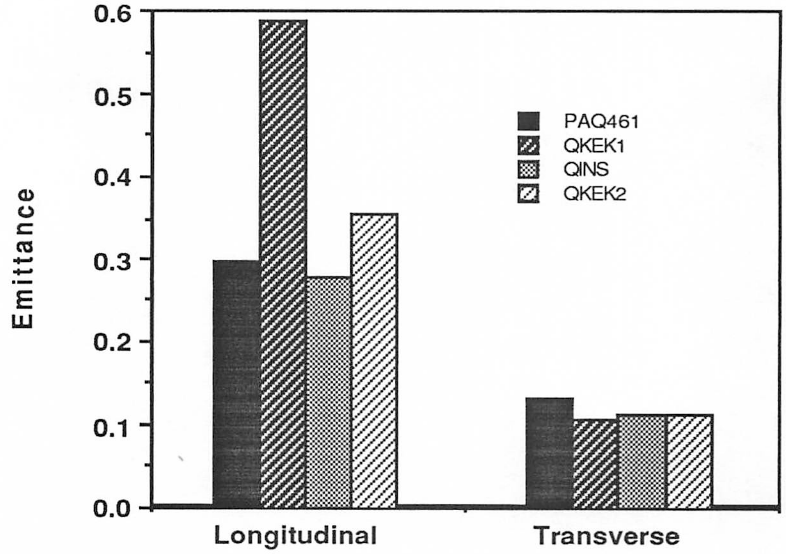

Fig. 5 Comparison of output emittances among four designs.

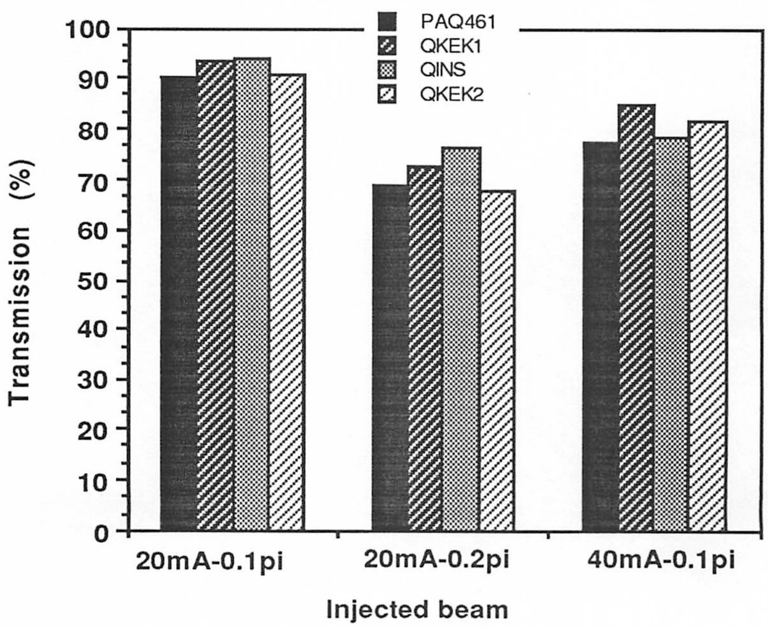

Fig. 6 Comparison of transmission efficiency among four designs.

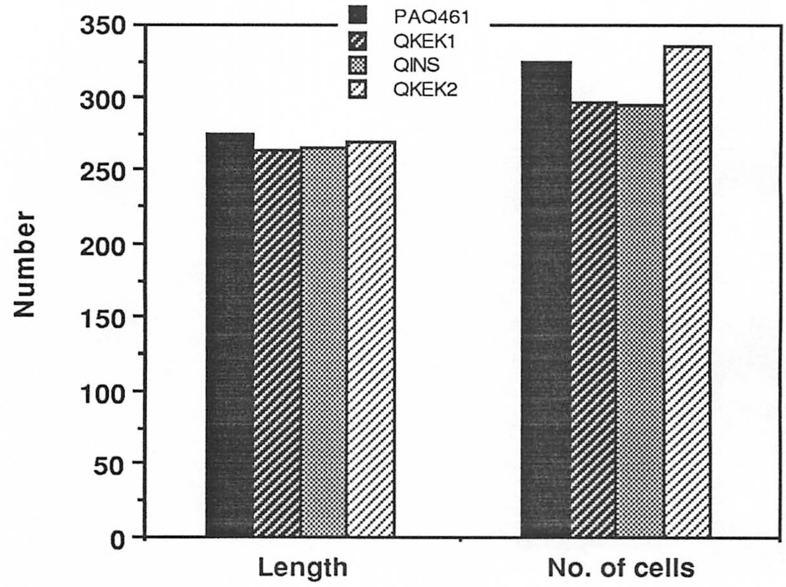

Fig. 7 Comparison of mechanical parameters among four designs.

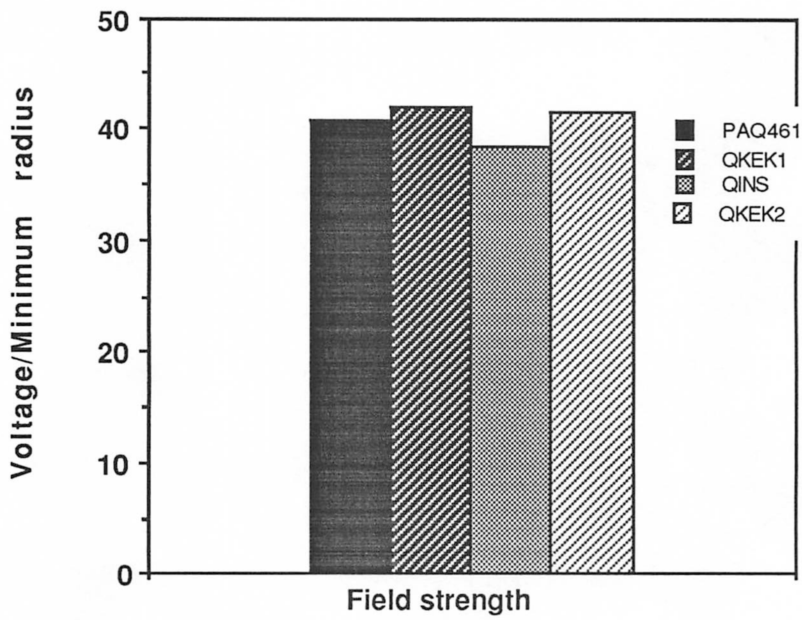

Fig. 8 Comparison of relative field strength among four designs.