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ERROR STUDY OF CPHS DTL AFTER ASSEMBLY

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ABSTRACT

The Compact Pulsed Hadron Source (CPHS) at Tsinghua University is one multi-purpose pulsed neutron source. The injector of the CPHS is a linac, which mainly consists of a source, a low-energy beam transport line (LEBT), a radio frequency quadrupole (RFQ) and a drift tube linac (DTL). The error study of the DTL for CPHS is presented in this paper. The error study can provide the field tolerances in the DTL cavity and the alignment tolerance between the RFQ and DTL.

INTRODUCTION

Compact Pulsed Hadron Source (CPHS) at Tsinghua University is a pulsed hadron-source scientific facility based on one high-intensity proton linac. The construction was launched in 2009. In July 2013, the 3 MeV RFQ was built, the proton beam was accelerated to 3 MeV and the neutron beam was produced. So far, the 13 MeV DTL cavity is assembled. The DTL will be commissioned and the neutron beam will be produced by the 13 MeV proton beam bombarding the Beryllium target.

PARAMETERS OF DTL

- The PMQs are mounted in the drift tubes with an FD lattice;
- No MEBT;

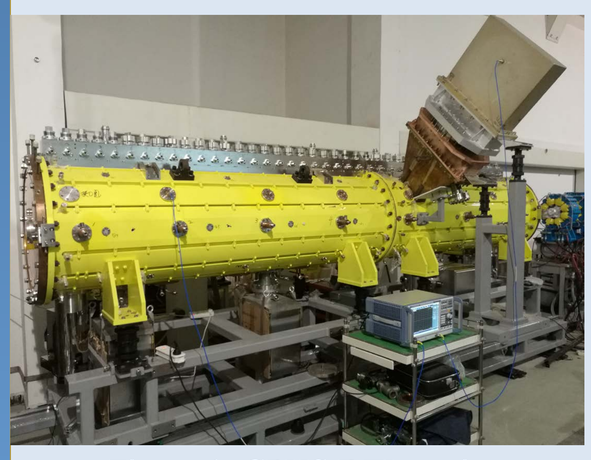

Figure 1: CPHS DTL cavity.

Table 1: DTL Parameters

Ion type	Proton
Input beam energy	3 MeV
Output beam energy	13 MeV
Input Norm. RMS emit.	0.25π mm·mrad
Peak current	50 mA
RF frequency	325 MHz
Pulse length	0.5 ms
Pulse repetition rate	50 Hz
Cell number	40
Accelerating field	2.2 to 3.8MV/m
Total RF peak power	1.2 MW
Total length	4.4 m

BEAM DYNAMICS

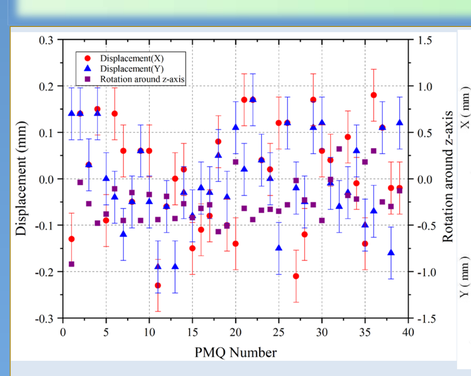

Figure 2: Alignment result

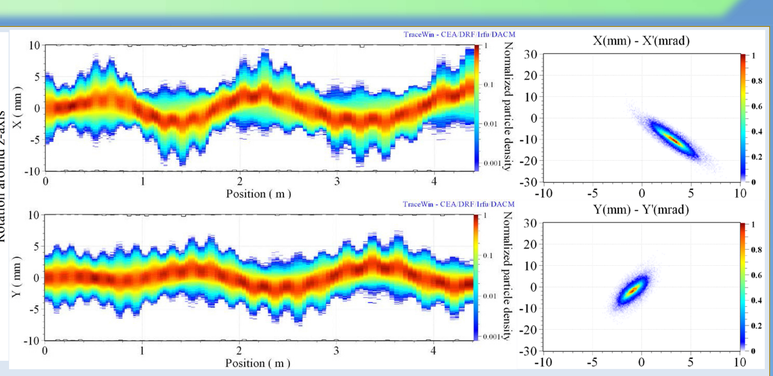

Figure 3: Beam dynamics of the DTL

- The RMS value of the displacements of the PMQs is 0.13 mm (x)/ 0.10 mm (y), which is slightly larger than the required value (0.1 mm).
- According to the result of the emittance meter at the downstream of the RFQ, the normalized RMS emittance is 0.34 π mm·mrad (x)/ 0.35 π mm·mrad (y), which is different from the designed value.

As the PMQs are difficult to rectify in the drift tubes, it is necessary to figure out the tolerances of other parameters after the alignment.

ERROR ANALYSIS

- The normalized RMS acceptance of the DTL is 2.19 π mm·mrad (x)/ 2.78 π mm·mrad (y).
- The center of the acceptance is (1.15 mm, 6.29 mrad) and (-0.53 mm, 3.06 mrad) in x-x' plane and y-y' plane separately.
- The acceptance is large enough even though the PMQs are misaligned and the real emittance is larger.
- As the beam center out from the RFQ is measured by the emittance meter, with an accuracy of ±0.2mm, the beam position tolerances should be larger.
- The displacement values of the PMQs are the alignment results with an error bar of ±0.056mm.
- The measured value of emittance is used as the emittance at the entrance of the DTL.
- The beam center is in the center of the pipe.
- 3000 times with 50000 macro-particles in each run

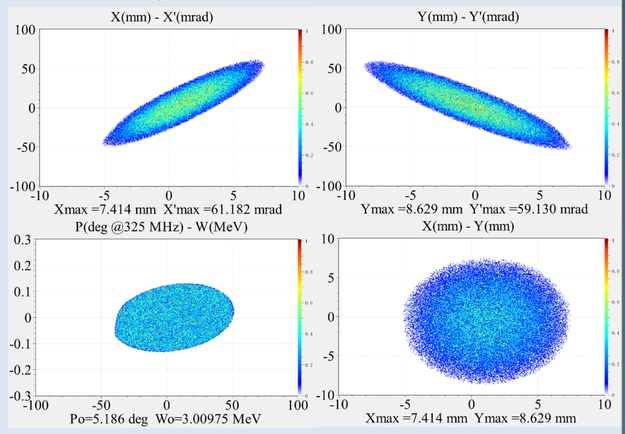

Figure 4: Acceptance of the DTL

Table 2: The main error tolerances of the DTL

Input beam tolerances		Field tolerances	
Position	±0.55 mm	Amplitude (uncoupled)	±3%
Divergence	±5.5 mrad		
Mismatch	15%	Phase (uncoupled)	±3°
Energy jitter	±0.04 MeV		
Phase jitter	±2°	Amplitude (coupled)	±2%
PMQ tolerances			
Gradient	±3%	Phase (coupled)	±2°
Rotation around x,y	±3°		
		Amplitude tilt	±3%

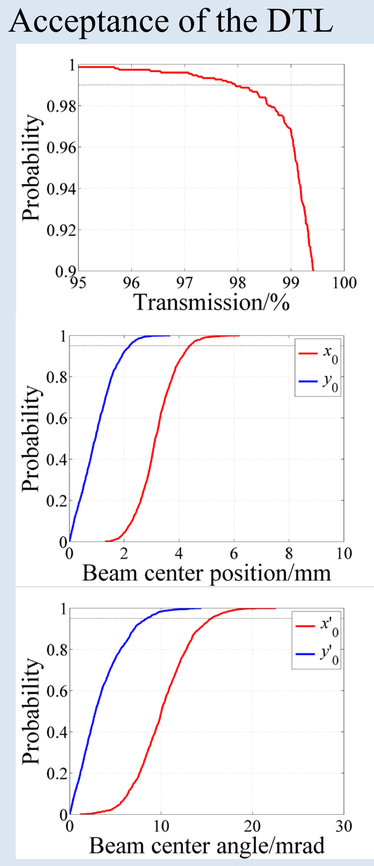

Figure 5: Combined errors result

FIELD AND BEAM REQUIREMENTS

- ✓ Field distribution error ≤ ±3%
- ✓ Tilt sensitivity ≤ ±150%/MHz (20 kHz perturbation)
- ✓ Beam center (1.15 mm, 6.29 mrad)(x)/(-0.53 mm, 3.06 mrad)(y)
- ✓ Steerers are needed in the HEBT

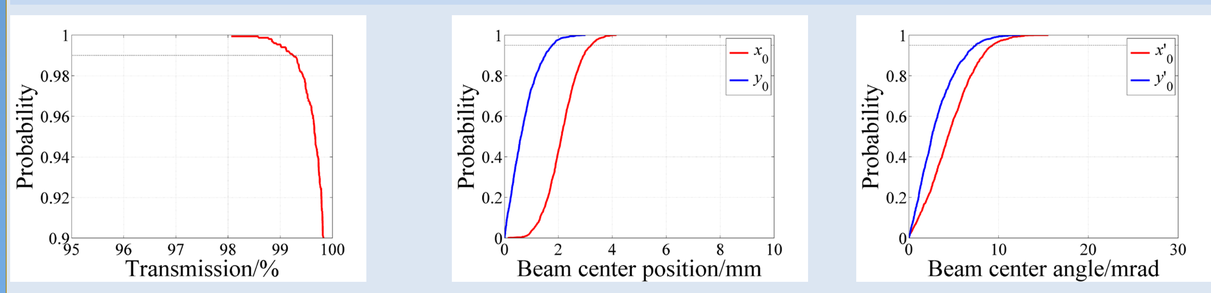

Figure 6: Error study after changing the input beam

CONCLUSION AND FUTURE WORK

The error study of the CPHS DTL after collimating has been presented. The error study provides the field tolerances in the DTL cavity and the alignment tolerance between the RFQ and DTL.

The tuning of the DTL has been finished, which meets the demand of the above field tolerances. The DTL will be aligned downstream the RFQ and the beam test of the DTL is expected.

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