核物理与核技术国家重点实验室（北京大学）
State Key Laboratory of Nuclear Physics and Technology (Peking University)

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Beam dynamics design of a 162.5MHz superconducting RFQ accelerator

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Abstract

Superconducting(SC) RFQ has lower power consumption, larger aperture and higher accelerating gradient than room temperature RFQ. We plan to design a 162.5MHz SC RFQ to accelerate the 30 mA proton beams from 35 keV to 2.5 MeV, which will be used as a neutron source for BNCT and neutron imaging project. At an inter-vane voltage of 180kV, the beam dynamics design was carried out with acceptable peak surface electric field, high transmission efficiency, and relatively short cavity length.

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Design considerations

- **Goal**: very high accelerating efficiency and very high beam transmission efficiency
- **Acceleration gradient**: the lowest possible peak electric field and magnetic field should be used to obtain the highest possible acceleration effect
- **Beam focusing force**: proportional to the inter-vane voltage, inversely proportional to the aperture

appropriate values of a, m, and φ

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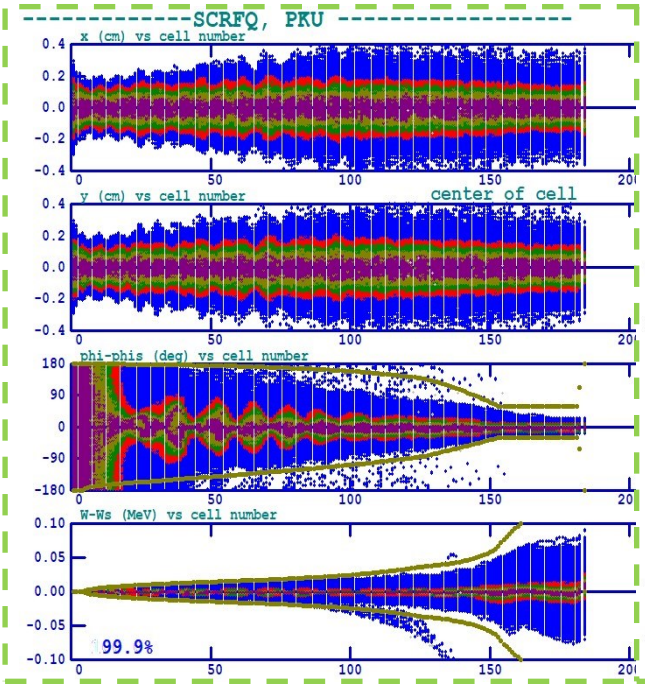
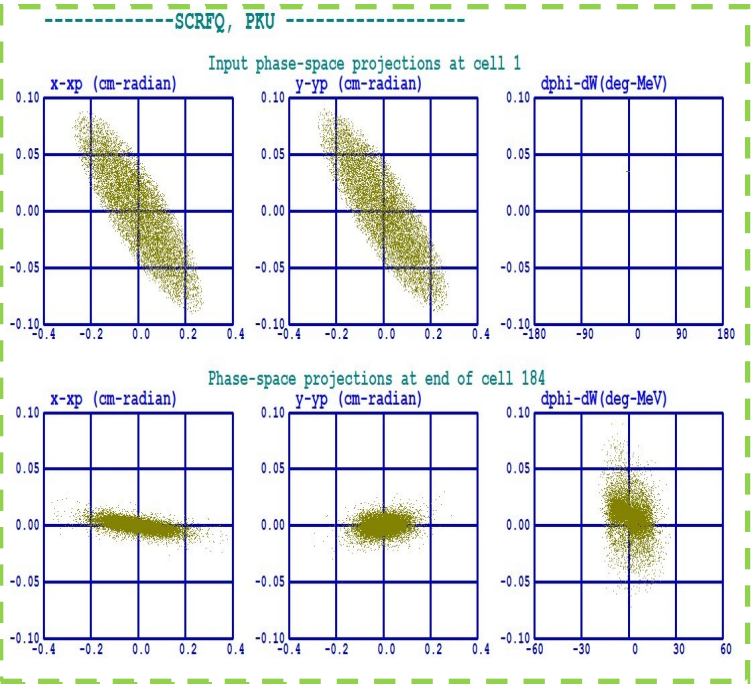
Beam dynamics design

Parameters	Value
Frequency [MHz]	162.5
Input beam energy [MeV/u]	0.035
Output beam energy [MeV/u]	2.54
Focusing parameter B	9.0
Average aperture r_0 [mm]	8.5
Minimum aperture a [mm]	5.4
Modulation m	1~2.069
Synchronous phase φ [°]	-90~-30
Number of cells	184
Peak beam current [mA]	30

Parameters	Value
Inter-vane voltage [kV]	180
Peak surface electric field[MV/m]	30.4
Kilpatrick coefficient	2.24
Acceleration gradient [MV/m]	0.77
Input transverse normalized RMS emittance [mm·mrad]	0.200
Output longitudinal normalized RMS emittance [MeV·deg]	0.12
Transmission efficiency [%]	99.9
Length[m]	3.27

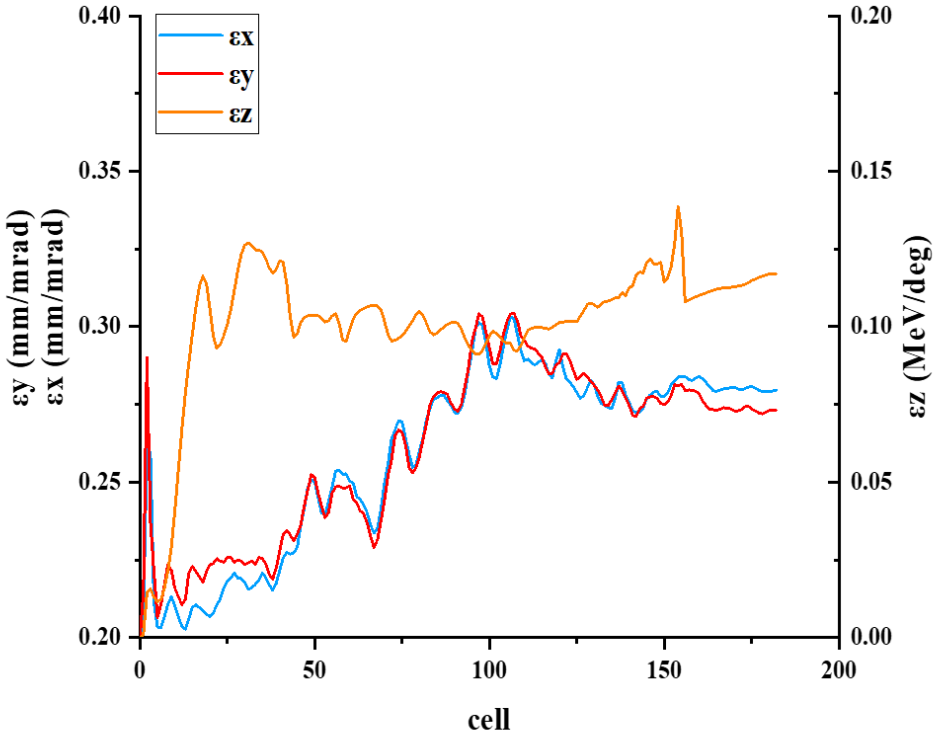
Beam dynamics design (PARMTEQM results)



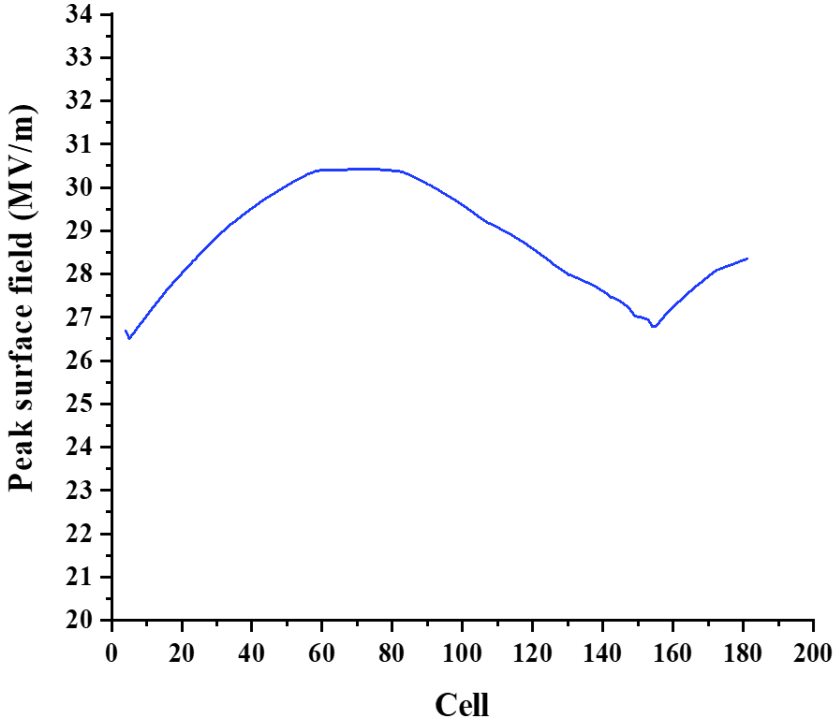


Beam dynamics design (PARMTEQM results)

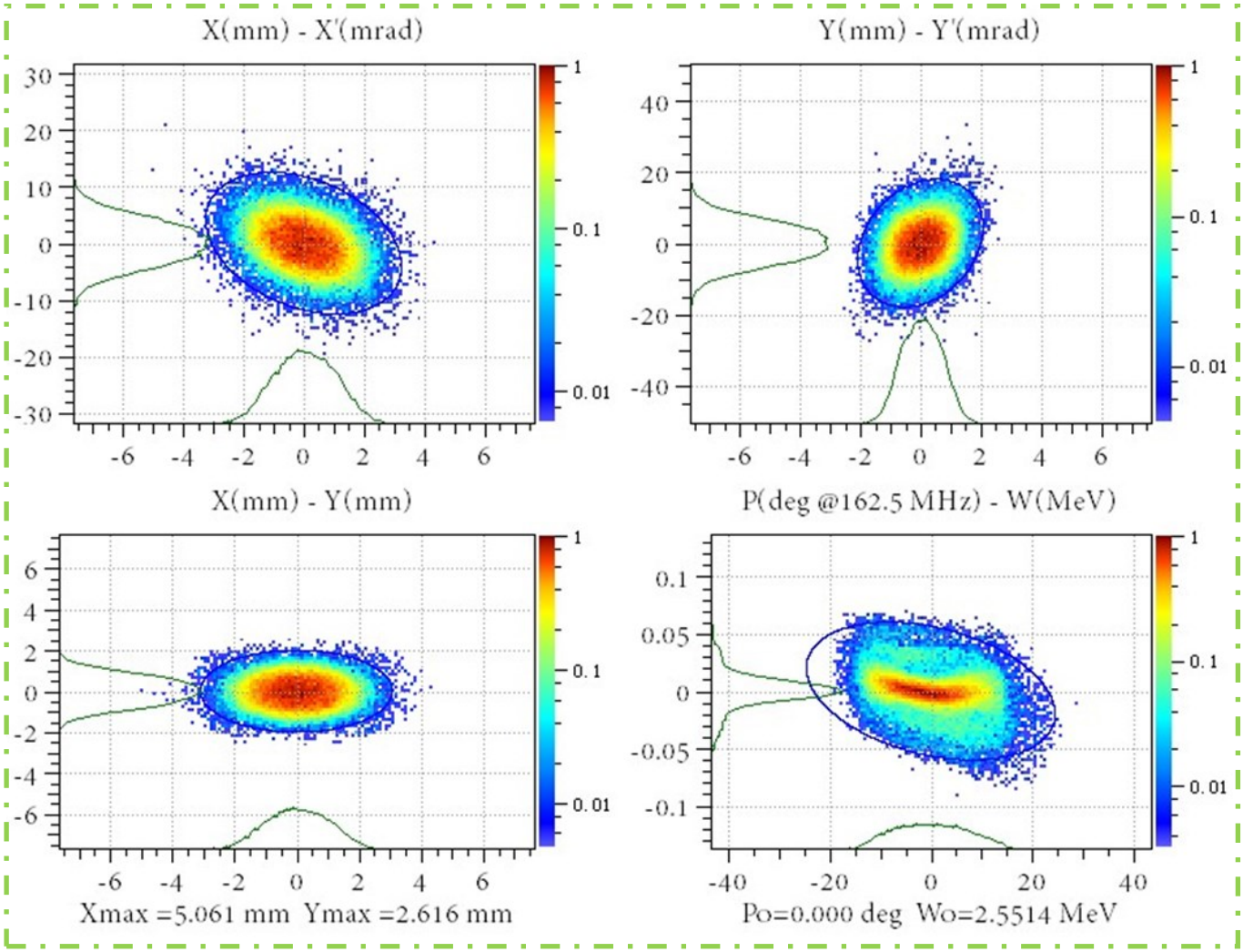
Emittance growth along RFQ



Peak surface field distribution

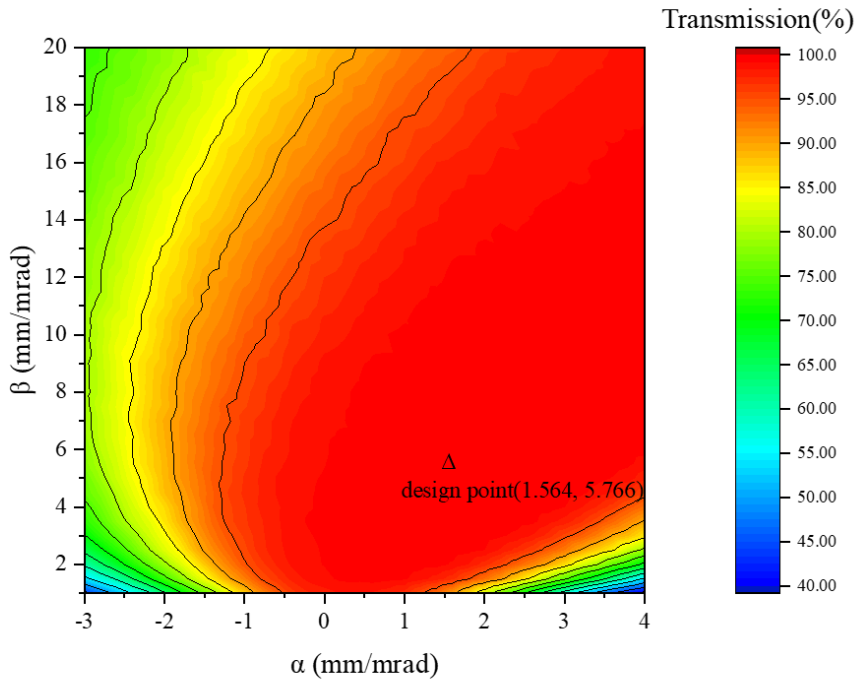


Beam dynamics design (IMPACT-T results)

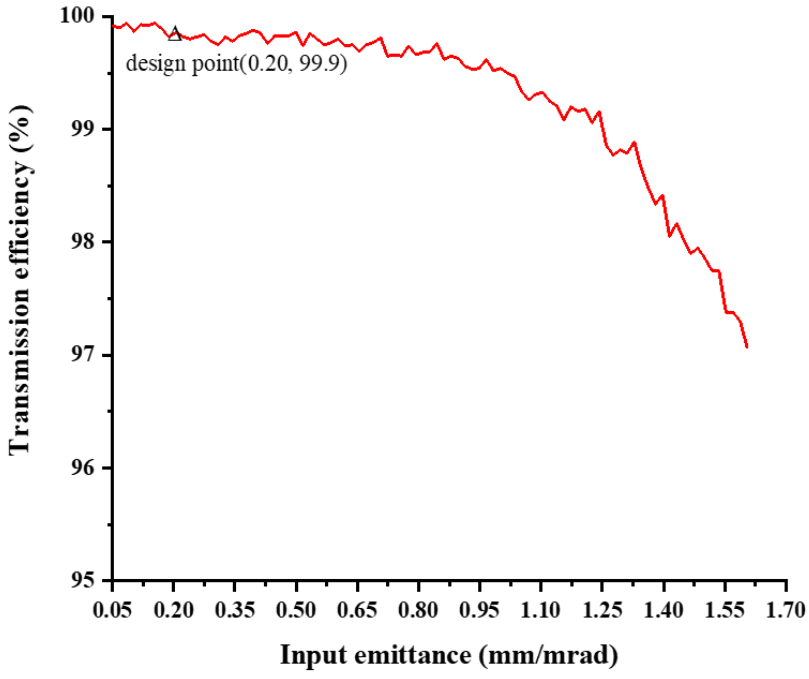


Particles phase-space distribution at the exit of RFQ

Redundancy Study



Transmission efficiency of the RFQ versus the input beam Twiss parameters



Transmission efficiency of the RFQ versus the input transverse emittance