Beam Intensity Bottlenecks Specification and 100 mA Operation of J-PARC Cesiated RF-Driven H^- Ion Source

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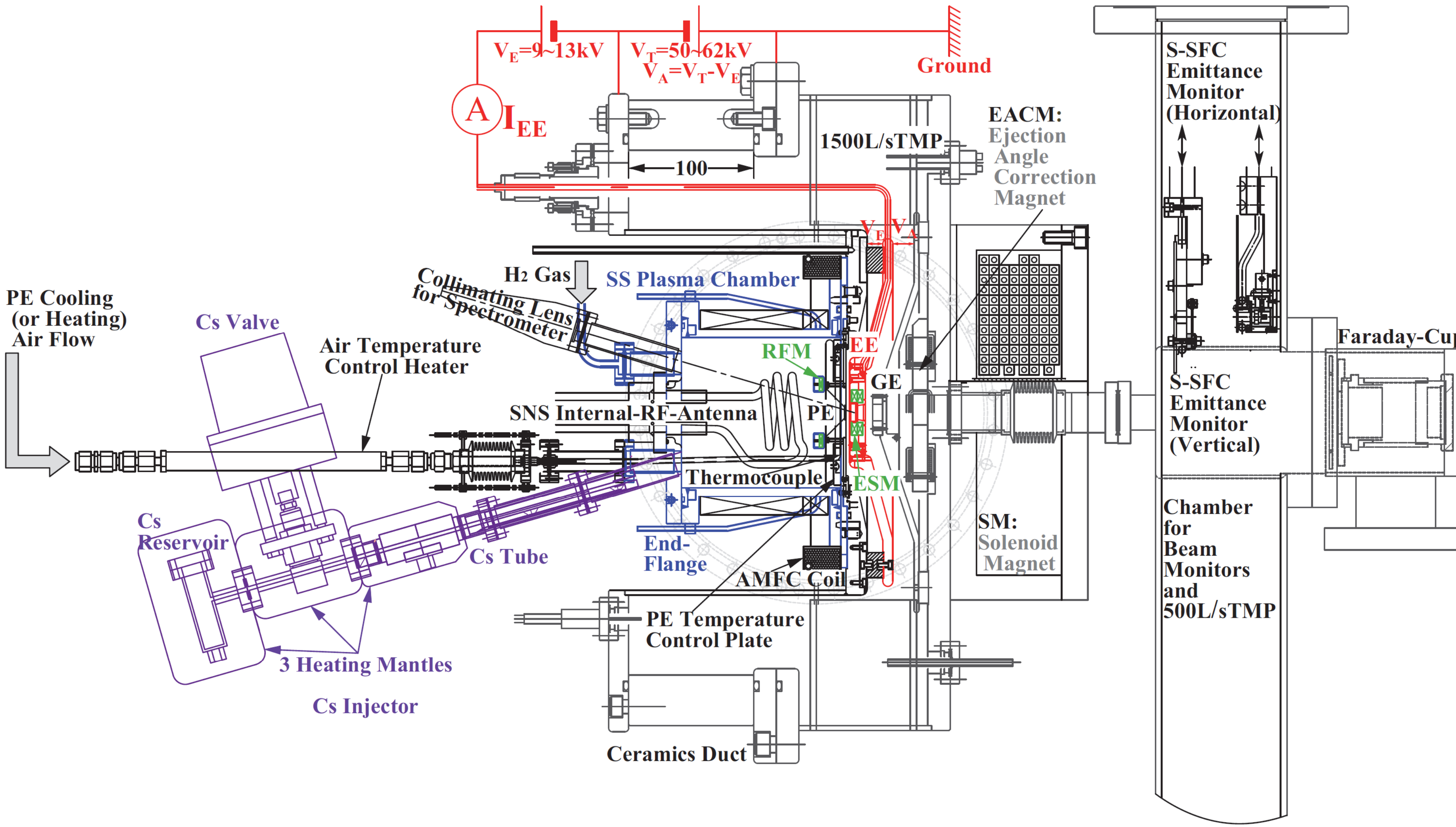
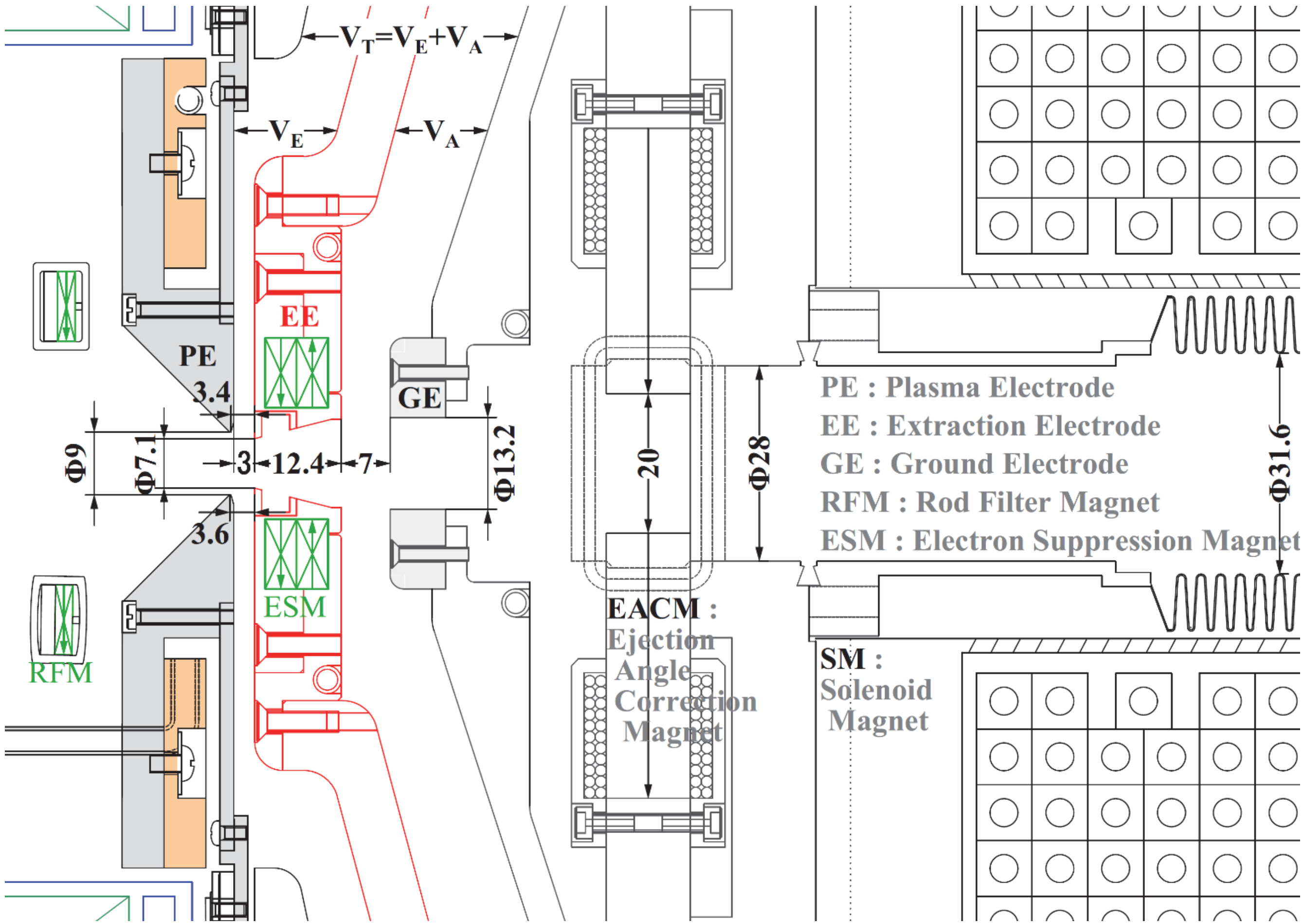
J-PARC RF-Driven H⁻ Ion Source Test-Stand



High Brightness & RF power efficiency by Thick PE(16mm-45°:1.5I_{H^-}), AMFC(1.1I_{H^-}), 50W-CW-30MHzRF igniter(17SCCMforϕ_{PE}=9mm),T_{PE}~70 °C(0.75$\varepsilon_{nrmsx/y}$), H_2Os Feeding(0.5$\varepsilon_{nrsmx/y}$)

Detailed dimensions of beam extraction region

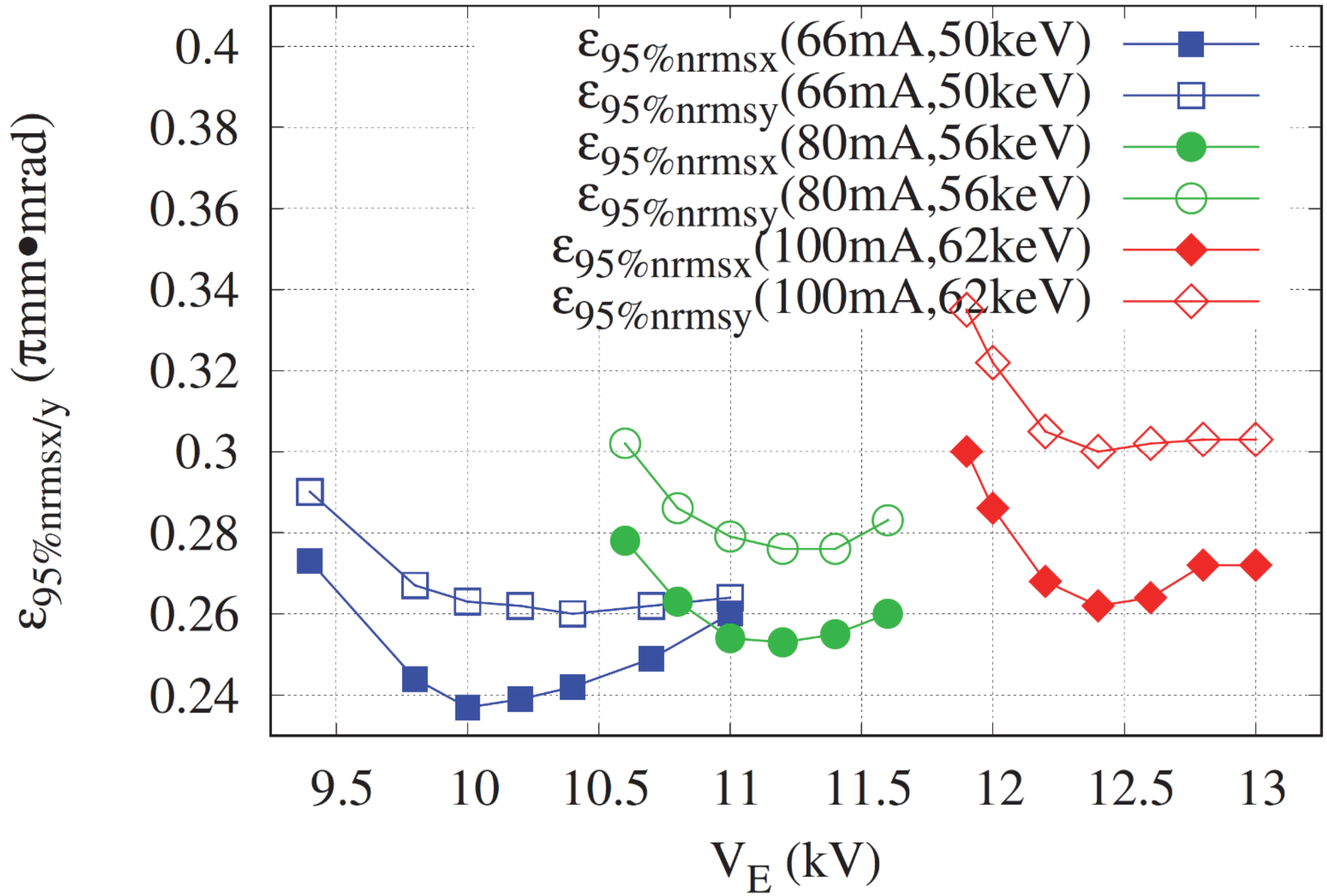


ϕ_{PE}=9mm, ϕ_{EE}=7.1mm , ϕ_{GE}=13.2mm

Extraction gap=3(+0.4+0.2)mm for V_E=10~13kV

Acceleration gap=7 mm for V_A=40~51kV

V_E vs $\varepsilon_{95\%nrmsx/y}$ showing beam intensity bottlenecks in extraction & acceleration gaps

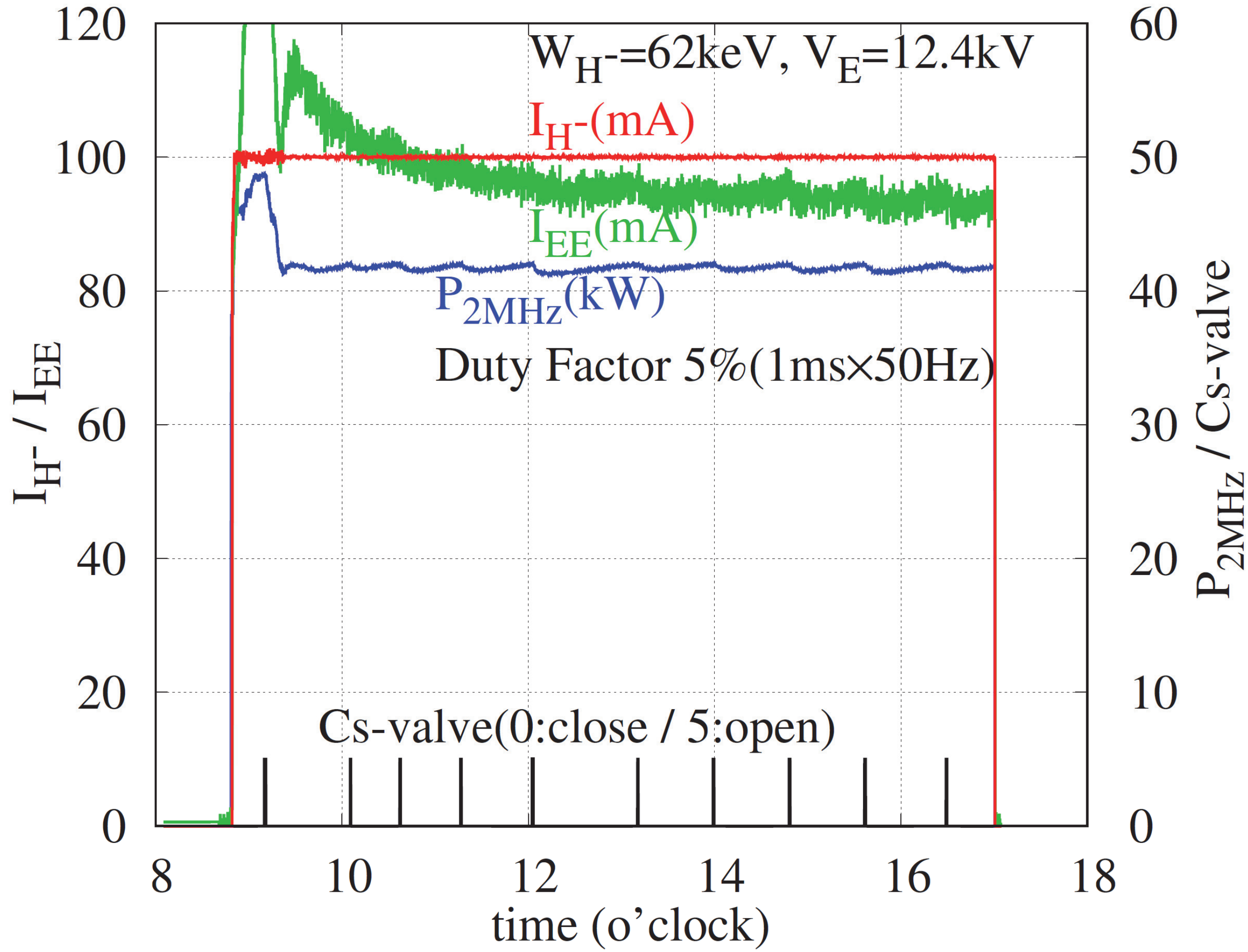


Measured relationships between and V_E and $\varepsilon_{95\%nrmsx/y}$ for conditions of (W_{H^-}, I_{H^-}) = (50 keV, 66 mA), (56 keV, 80 mA) and (62 keV, 100 mA).

$\varepsilon_{95\%nrmsx\_min}$ (W_{H^-}) $\propto$ relativistic/ $\beta\gamma$(W_{H^-})

$\varepsilon_{95\%nrmsx\_min}$ $/\beta_r\gamma_r$ (50,56,62) = (0.237/0.01032,0.253/0.01093,0.262/0.01150) = (23.0,23.2,22.8) : Same beam optics.

8 hours operation with (I_{H^-}, W_{H^-}, V_E, duty factor) of (100mA, 62keV, 12.4kV, 5%)



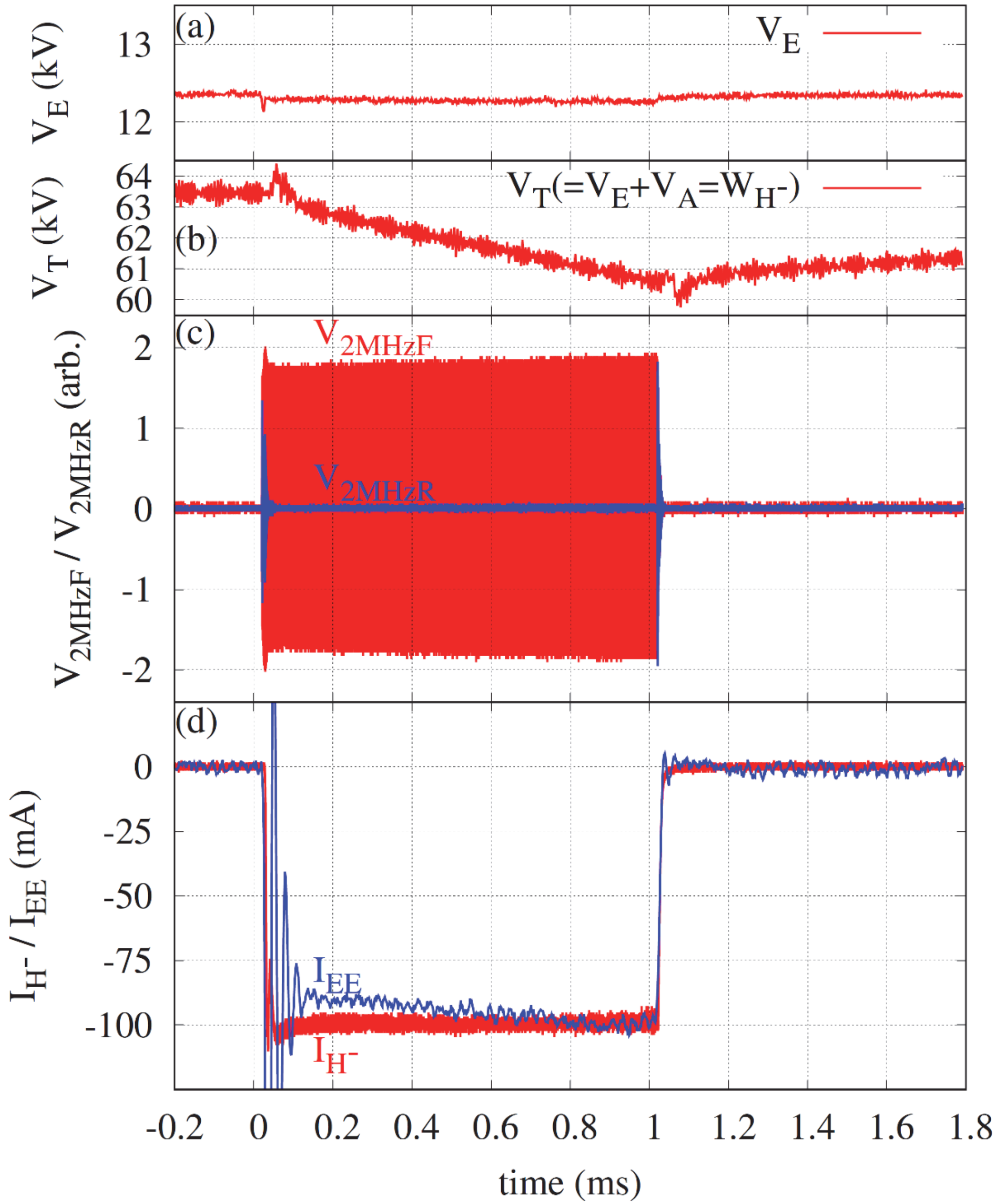
I_{H^-} was controlled to 100±1mA by P_{2MHz} feedback

P_{2MHz} was controlled to 41.5~42kW by Cs density feedback (38.8 μg / 1 open)

*No high-voltage sparking in this operation

Sparking rate 1 / 2~3 days for well-conditioned source (after 5 days operation)

Measured waveforms of V_E (a), V_T (b), V_{2MHzF} & V_{2MHzR} (c) and I_{H^-} & I_{EE} (d) of one beam pulse



(a) Droop of V_E is negligibly small (-0.1kV).

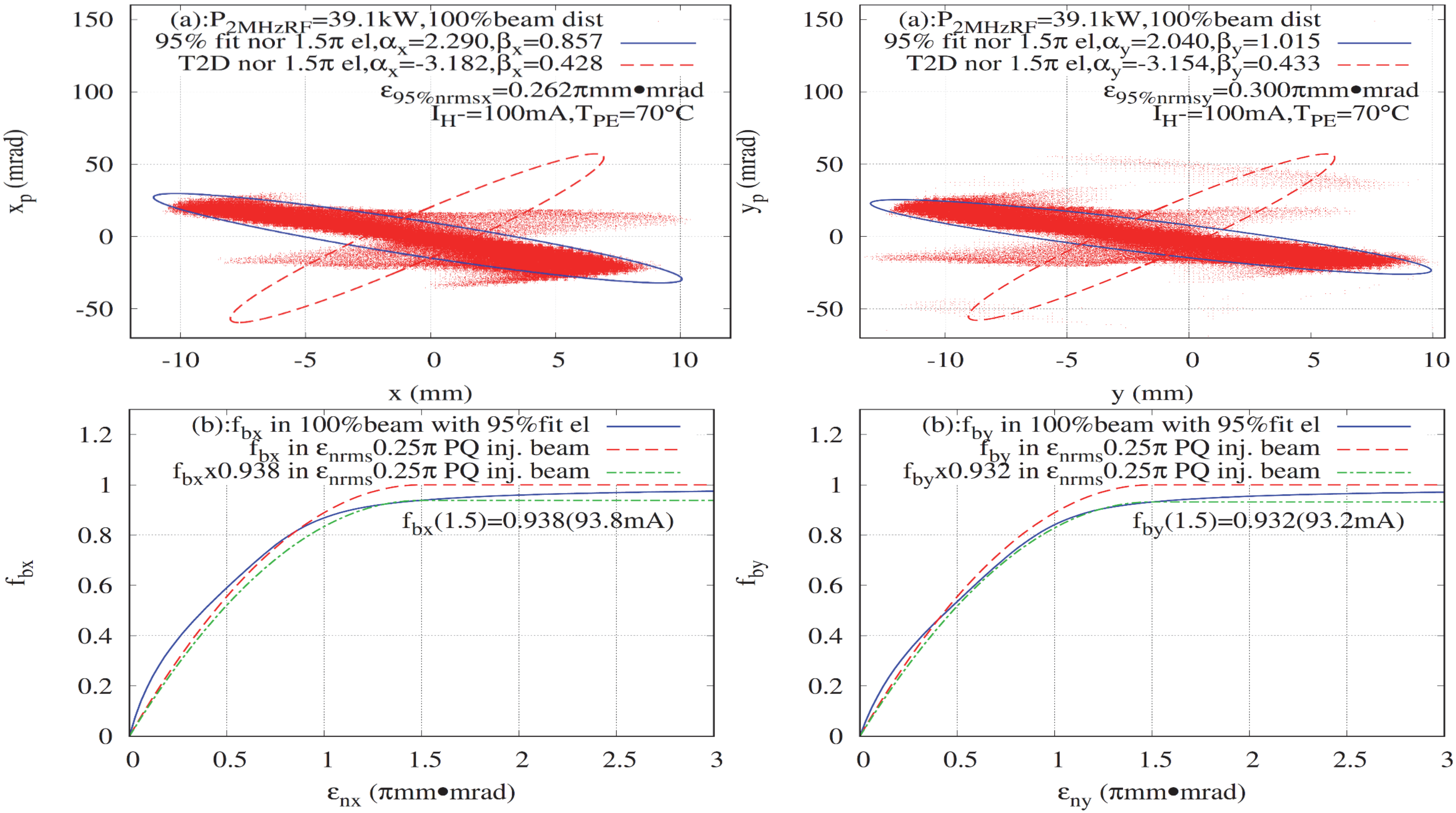
(b) Droop of V_T is significantly large (from 63.4 to 60.7 kV by -2.7 kV).

(c) V_{2MHzF} is tilted up 4% (from 42 to 43.7 kW) during the pulse.

(d) Flat I_{H^-} pulse is produced. Tilted up V_{2MHZF} causes tilted up I_{EE}.

*If V_T was well-compensated against beam & electron loading and operated at 63.4 kV, I_{H^-} of 110mA with the similar stability was expected.

Particle distributions in horizontal & vertical phase-planes for (I_{H^-},W_{H^-},V_E,duty)=(100mA,62keV,12.4kV,5%)



Horizontal emittance of 93.2mA ~ PARMTEQ(PQ) inj. Beam with 0.25πmm·mrad

Acceleration efficiency simulated with PQ is expected for 93.2 mA.

CONCLUSIONS

(1) $\varepsilon_{95\%nrmsx/y}$ dependences on V_E (tunable range ~1kV) were measured for (W_{H^-}, I_{H^-}) of (50keV,66mA), (56 keV,80mA) and (62 keV,100mA). There was optimum V_E for each condition with same beam optics. Focusing force is insufficient (bottleneck) in extraction or acceleration gaps for V_E lower or higher than optimum.

(2) Stability of operation with (I_{H^-}, W_{H^-}, V_E, duty factor) of (100mA, 62keV, 12.4kV, 5%) was confirmed (No high voltage sparking in 8 h operation). *Bottlenecks were enlarged.

(3) I_{H^-} droop due to significant droop of V_T caused by beam & electron loading was compensated by 4% tilting up P_{2MHz} (from 42 to 43.7kW). If V_T was well-compensated and source was operated with V_T of 63.4kV, higher I_{H^-} of about 110 mA was expected with same stability.

(4) 93.2 mA of measured beam distribution in vertical phase-plane has almost same distribution with PARMTEQ(PQ) injection beam. Therefore, 93.2 mA of measured beam is expected to be accelerated with acceleration efficiency of PQ simulation.

Thank you for your attention.

ACKNOWLEDGMENT

The authors wish to express their sincere thanks to Dr. Martin P. Stockli and SNS ion-source group members for their support to purchase internal-RF-antennas and their information on the SNS RF-driven H^- ion-source. One SNS-antenna will survive for a year in J-PARC by halved P_{2MHz}.

Next Bottleneck for I_{H^-} > 110 mA

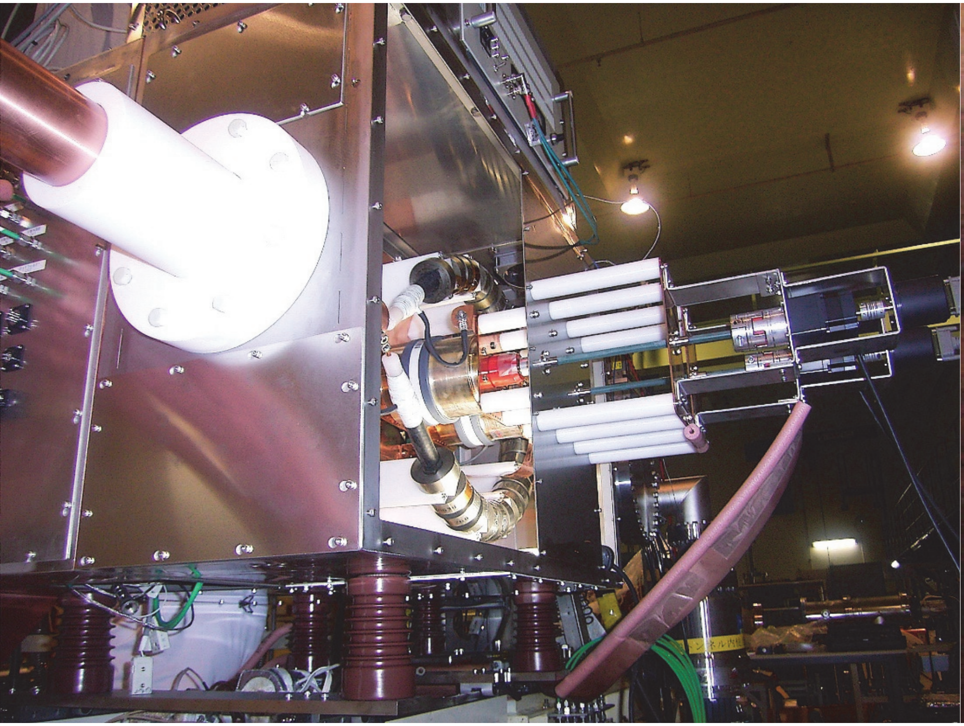


Photo of 2 MHz RF matching circuit including one turn isolation transformer.

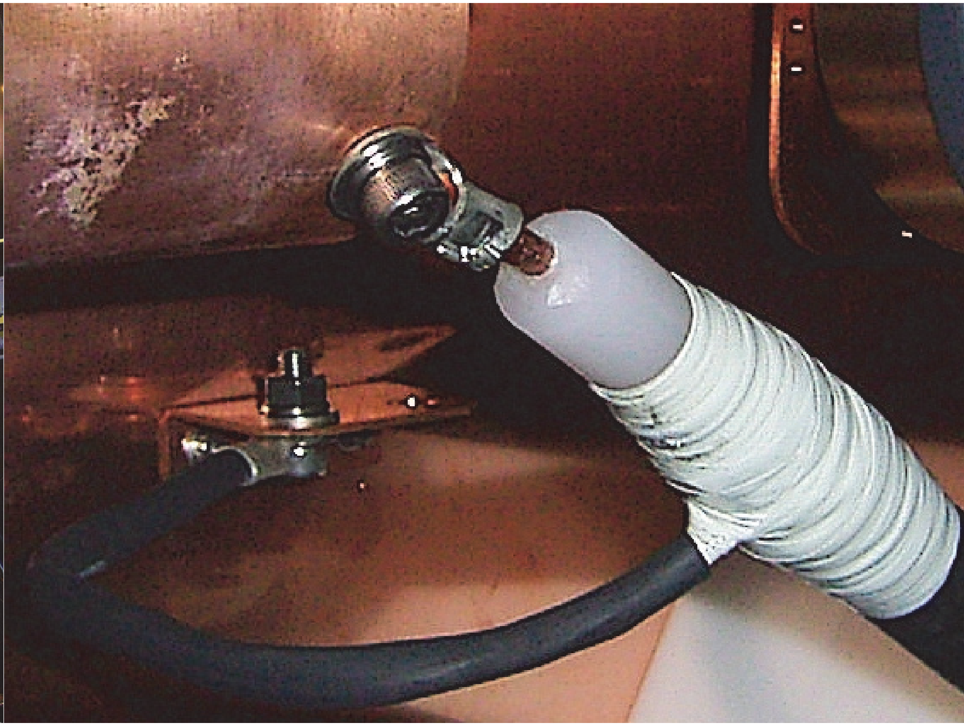


Photo of high voltage sparking at a terminal of one turn isolation transformer.

Faraday-cup & W-slits sputtered by focused 100 mA I_{H^-} beam

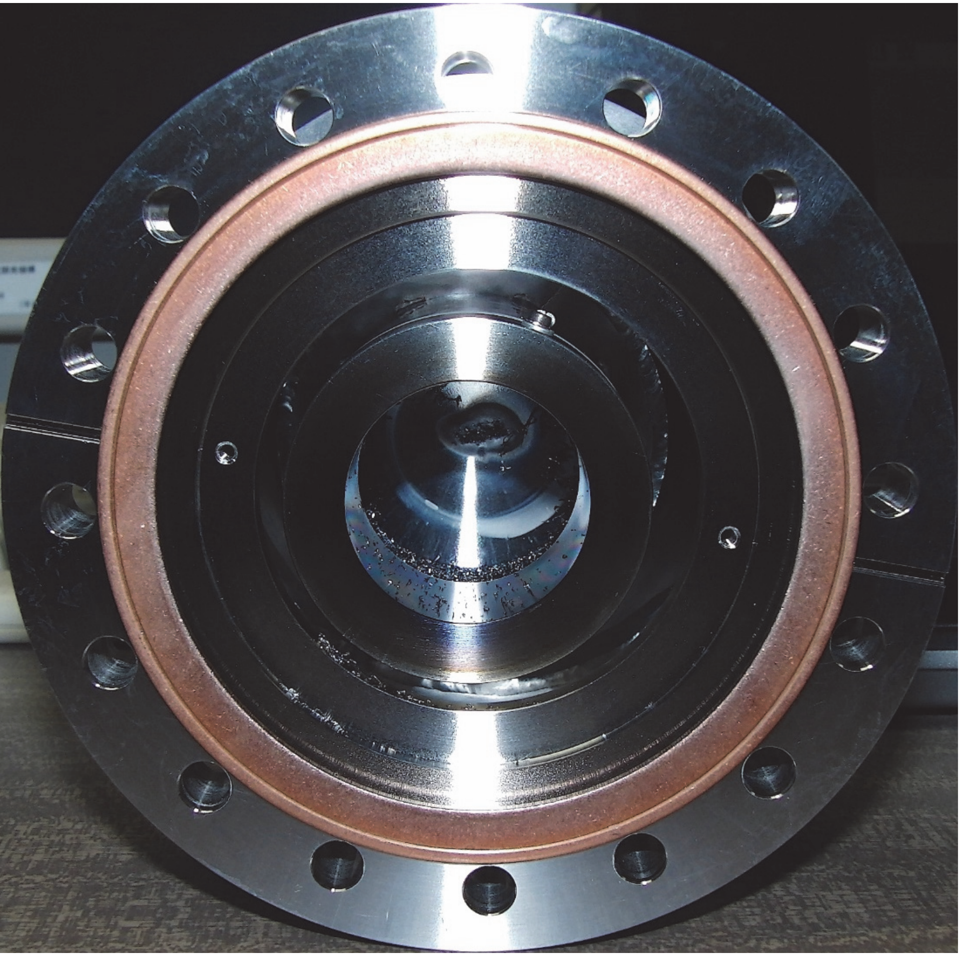


Photo of SS Faraday-cup sputtered by 100mA I_{H^-} beam with rms beam size of about 2.5mm.

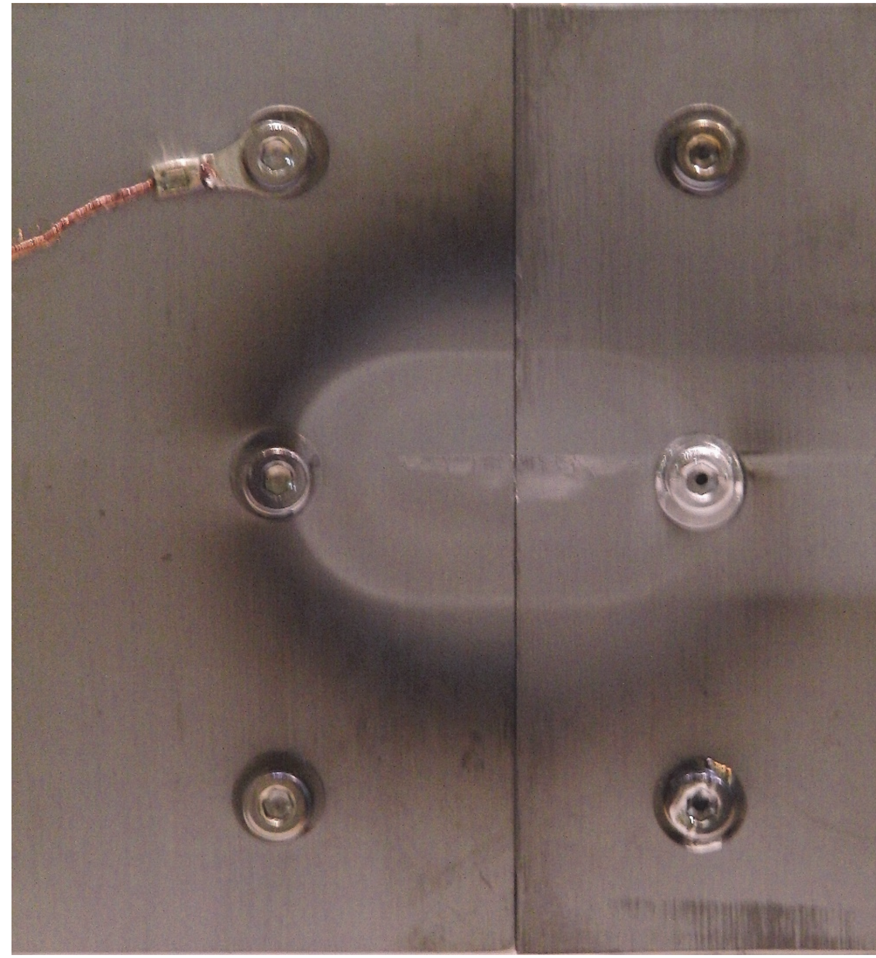


Photo of W-slits sputtered by 100mA I_{H^-} beam with rms beam size of about 1mm.