ICIS2017
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How to Make Extraction Electrode Current (I_{EE}) Lower than Beam (I_{H^-}) and Corresponding Beam Qualities in J-PARC Cesiated RF-Driven H^- Ion Source 66 mA Operation

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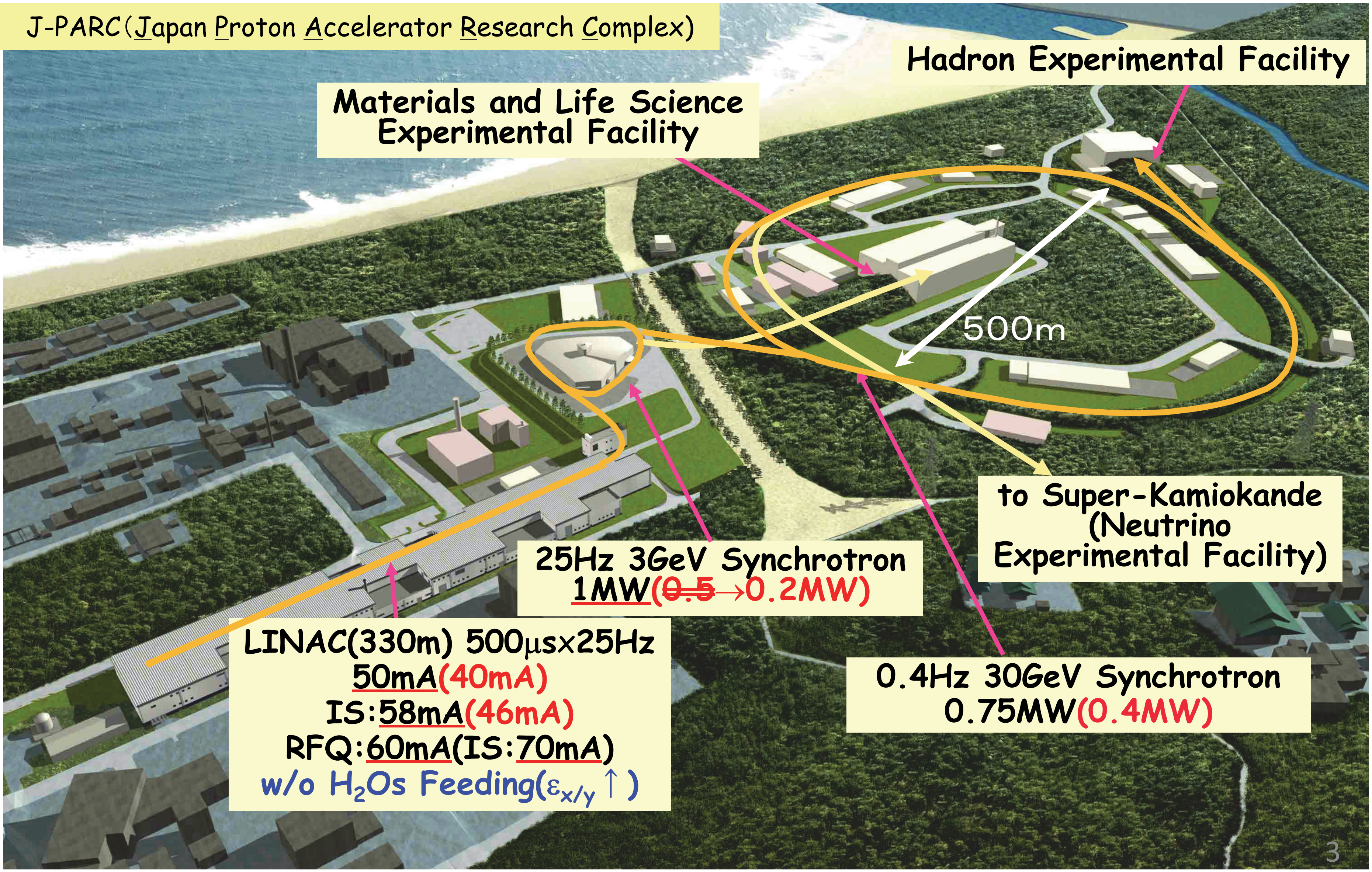
- Summary

Low T_{PE}&H_2Os and so on caused many unheralded results

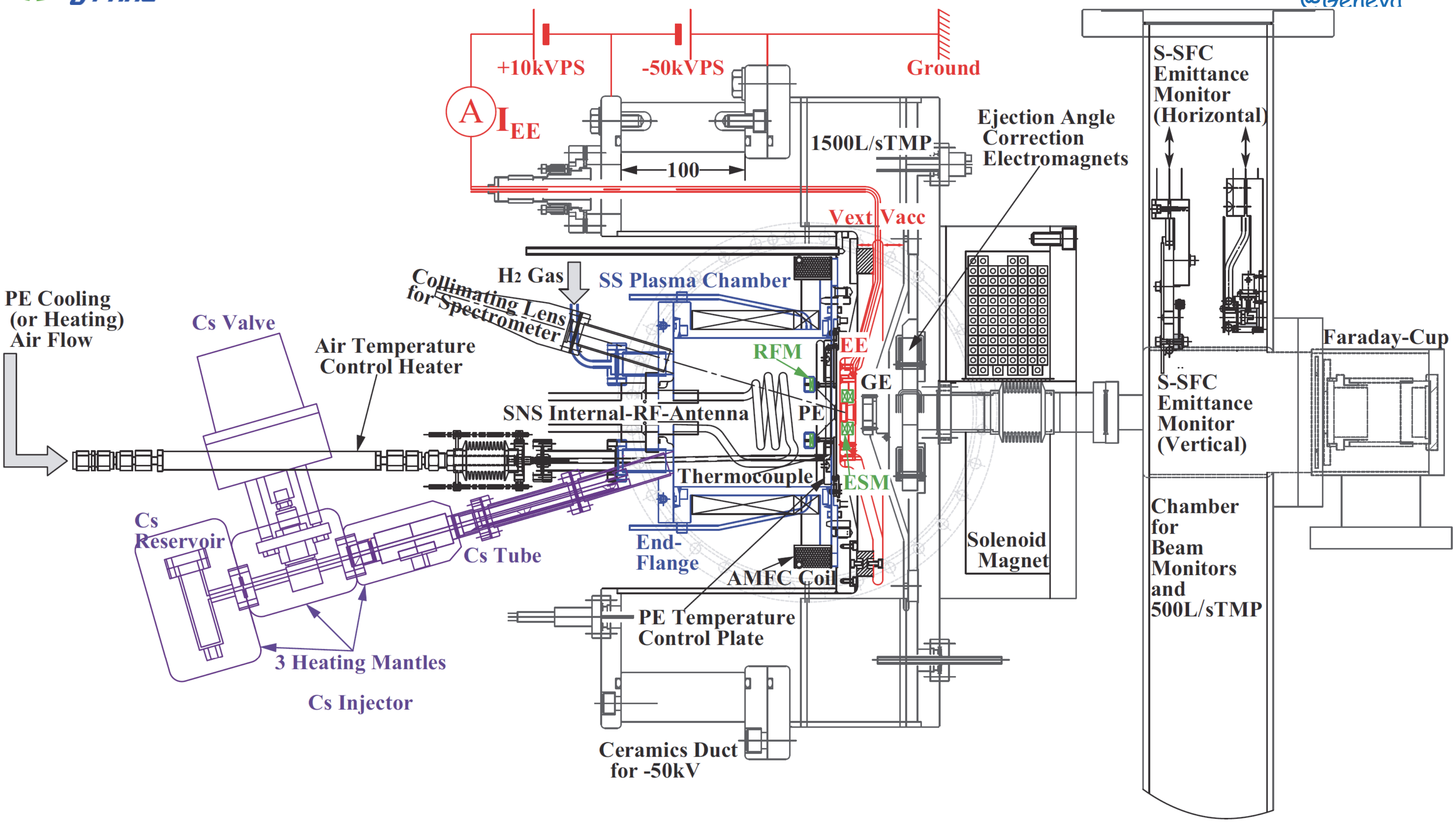
→We need plasma & beam simulation specialist collaborator.

＊ICIS2017 Poster Presentation on J-PARC-IS
"Present Status of the J-PARC Cesiated RF-driven H- Ion Source"

J-PARC (routine operationstatus)

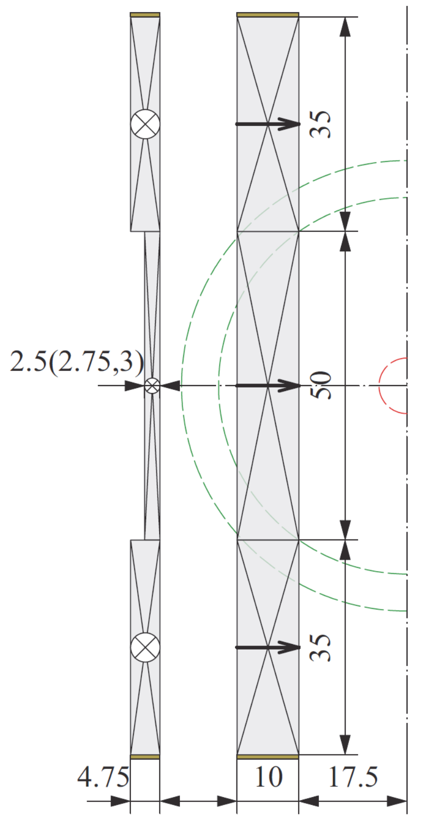


J-PARC RF-Driven H^- Ion Source Test-Stand



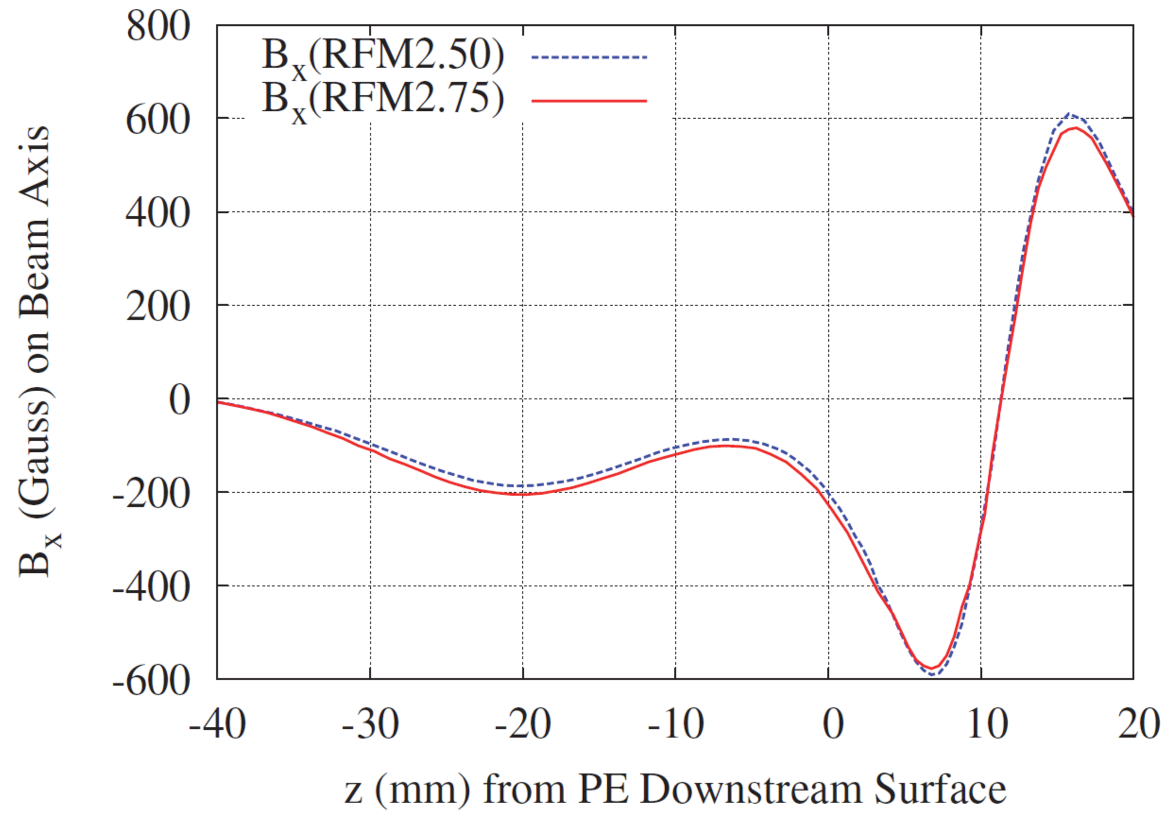
High Brightness & RF power efficiency by Thick PE(16mm-45°:1.5I_{H^-}), AMFC(1.1I_{H^-}), 50W-CW-30MHzRF igniter(17SCCMforϕ_{PE}=9mm),T_{PE}~60 °C(0.75$\varepsilon_{nrmsx/y}$), H_2Os Feeding(0.5$\varepsilon_{nrsmx/y}$)→I_H-66mA&$\varepsilon_{95\%nrmsx/y}$0.23πmm·mradby$P_{RF}$=29kW($I_{EE}$~150mA)

How to Make I_{EE} Lower than I_{H^-}(66mA)



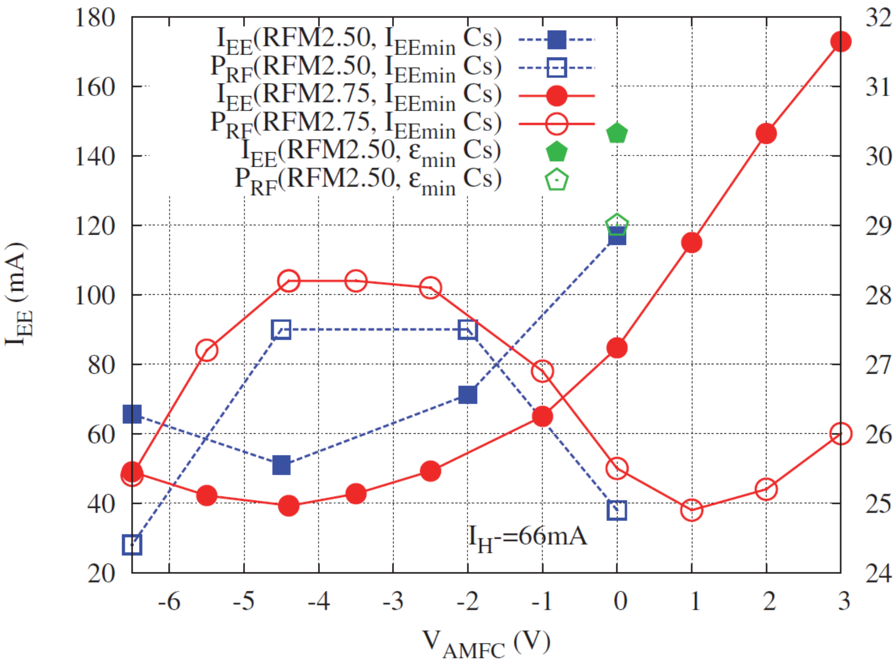
Schematic of half set of rod-filter-magnets (RFMs) with half RF-antenna and half PE aperture.

Center RFMs with thicknesses of 2.50. 2.75 and 3.00mm were examined.



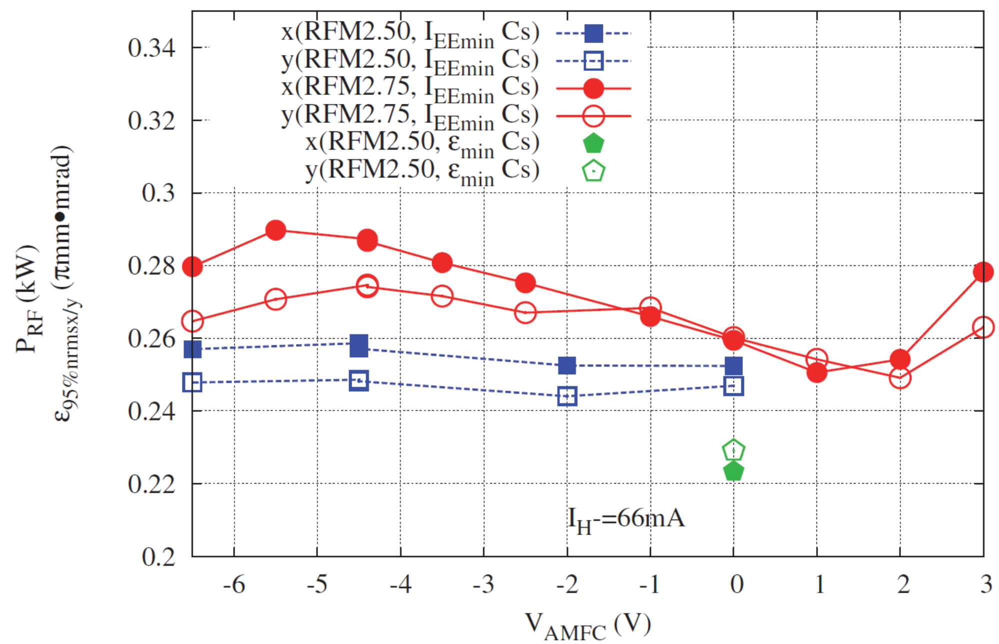
Measured horizontal magnetic field (B_x) on beam axis around RFMs (at z=-20mm) and electron-suplession-magnets (ESMs, at z=6.75 and 11.25mm) for center RFMs with thicknesses of 2.50 mm (RFM2.50) and 2.75 mm (RFM2.75).

How to Make I_{EE} Lower than I_{H^-}(66mA)



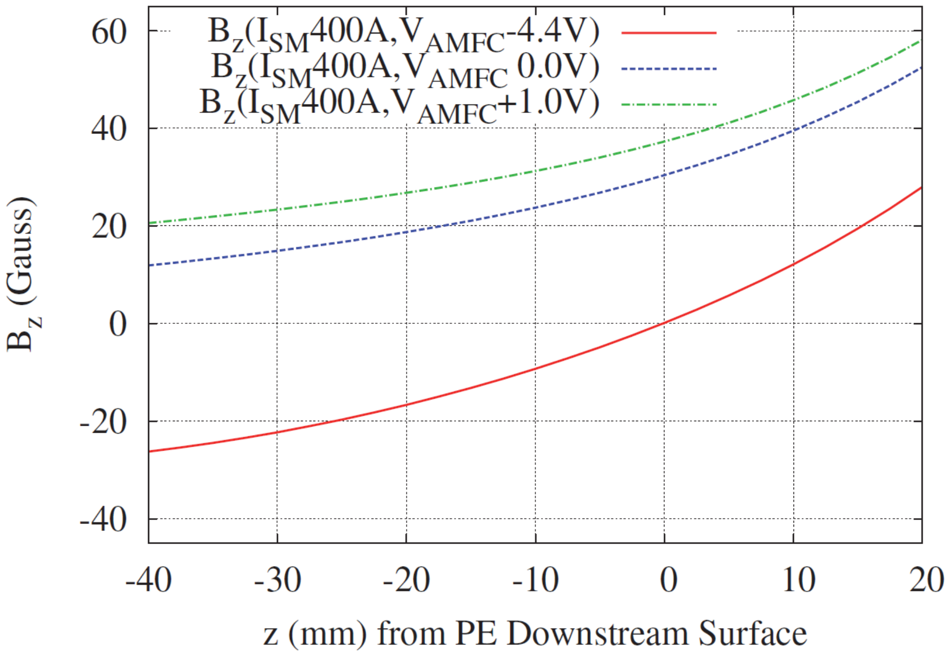
Measured relationships of I_{EE} and P_{RF} on V_{AMFC} for center RFMs with thicknesses of 2.50 mm (RFM2.50) with blue closed and open rectangles and 2.75 mm (RFM2.75) with red closed and open circles for Cs density minimizing I_{EE}. For center RFMs with 2.50 mm thickness, Cs density minimizing $e_{95\%nrmsx/y}$ and V_{AMFC}=0.0, measured I_{EE} and P_{RF} are also shown with green closed and open pentagons.

*For 3.00mm center RFMs, transiently I_{EE}=30mA but stable operation was impossible.

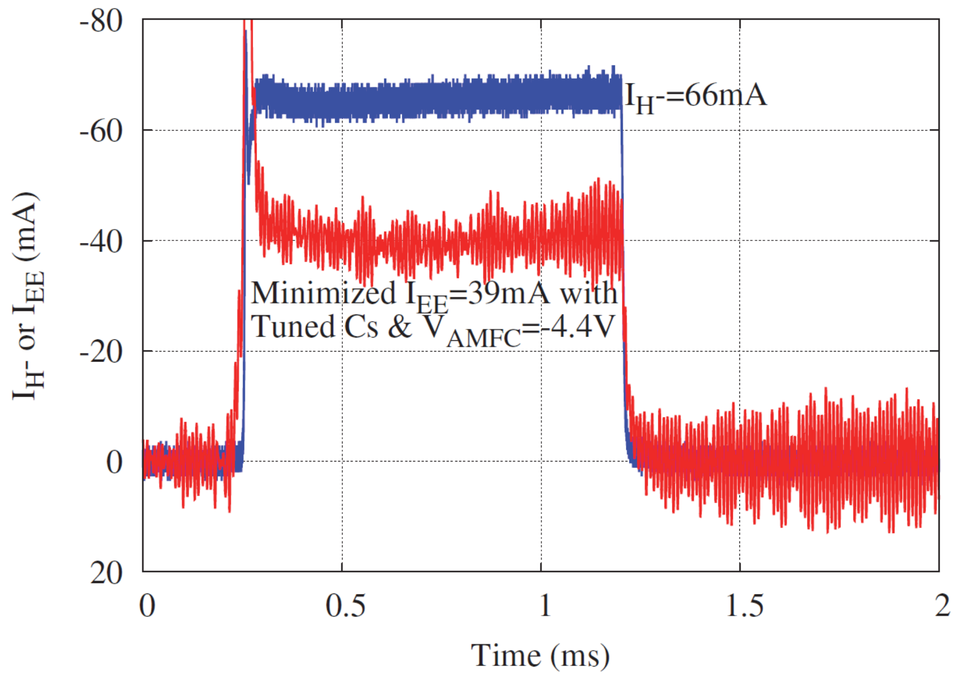


Measured relationships of $\varepsilon_{95\%nrmsx/y}$ on V_{AMFC} for center RFMs with thicknesses of 2.50 mm (RFM2.50) with blue closed and open rectangles and 2.75 mm (RFM2.75) with red closed and open circles for Cs density minimizing I_{EE}. For center RFMs with 2.50 mm thickness, Cs density minimizing $\varepsilon_{95\%nrmsx/y}$ and V_{AMFC}=0.0, measured $\varepsilon_{95\%nrmsx/y}$ are also shown with green closed and open pentagons.

How to Make I_{EE} Lower than I_{H^-}(66mA)

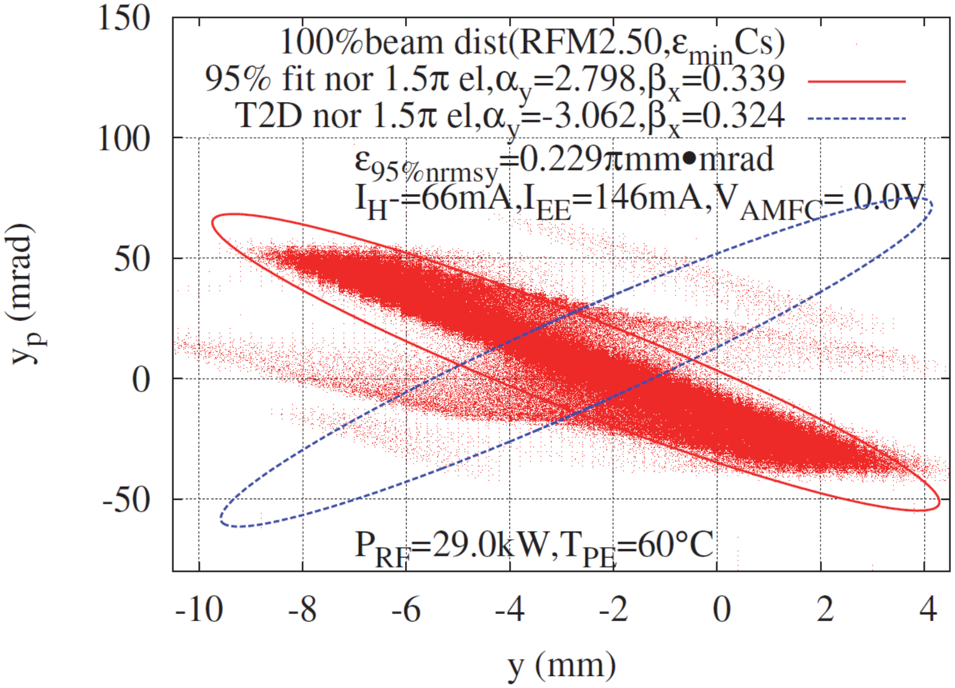


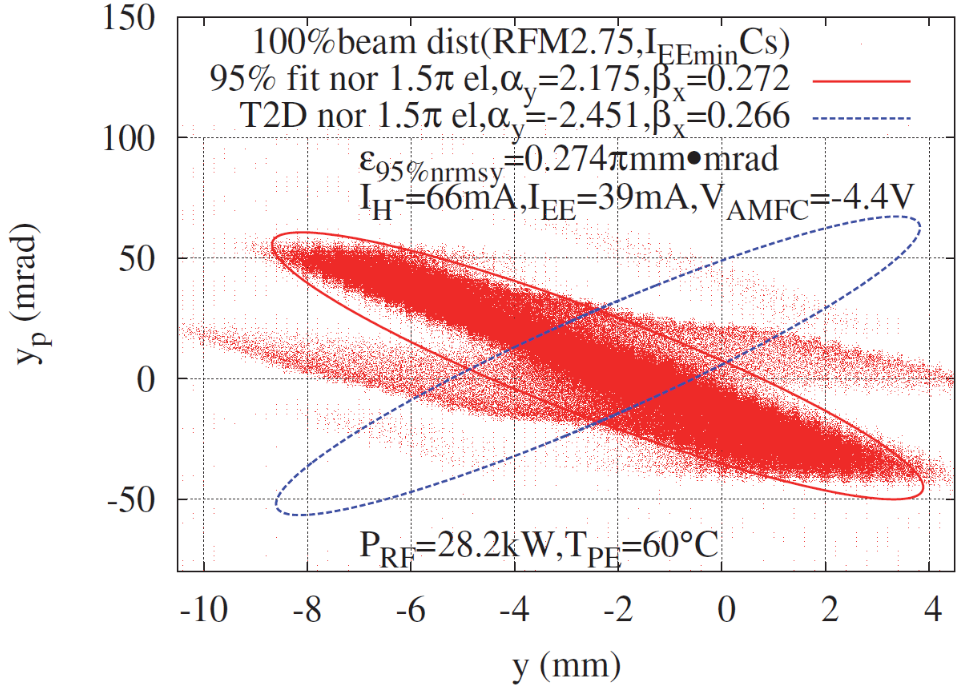
Axial magnetic field (B_z) distribution around RFMs (z=-20) and ESMs (z=6.75 and 11.25) on beam axis simulated with POISSON for I_{SM}=400A (56000AT) and V_{AMFC}=-4.4 (minimizing I_{EE} for optimum Cs density), 0.0 (I_{SM} only) or +1.0 (minnimizinng $\varepsilon_{95\%nrmsx/y}$) V.

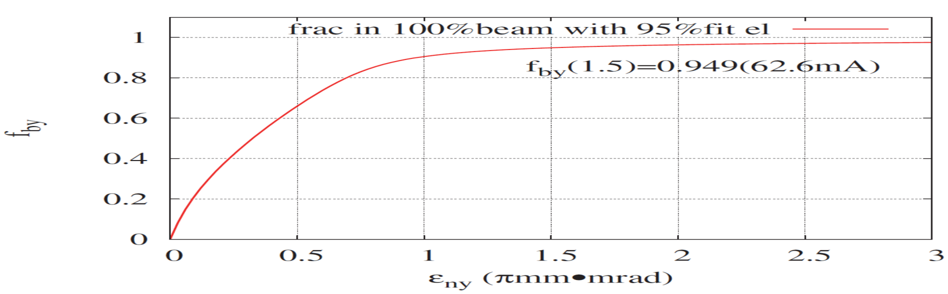


Measured waveforms of I_{H^-} (blue upper pulse) and I_{EE} (red lower pulse).

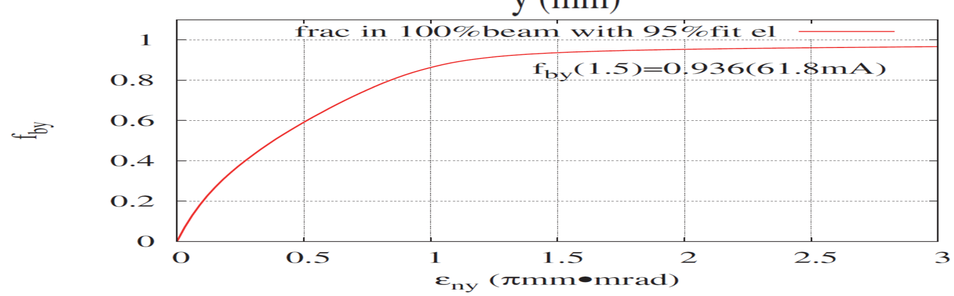
How to Make I_{EE} Lower than I_{H^-}(66mA)







(a)



(b)

Top figures showing 100% beam H^- ion distributions in vertical phase plane (red dots), fitted normalized 1.5 πmm·mrad ellipse fitting 95% beam (red solid line) and ellipse backward-traced to GE downstream surface with TRACE2D (blue dash line) and bottom figures showing relationships between normalized emittance ε_{ny} and included beam fraction f_{by} in 100% beam with ellipses fitting 95% beam measured for conditions to minimizing $\varepsilon_{95\%nrmsx/y}$ (a) and I_{EE} (b).

Summary

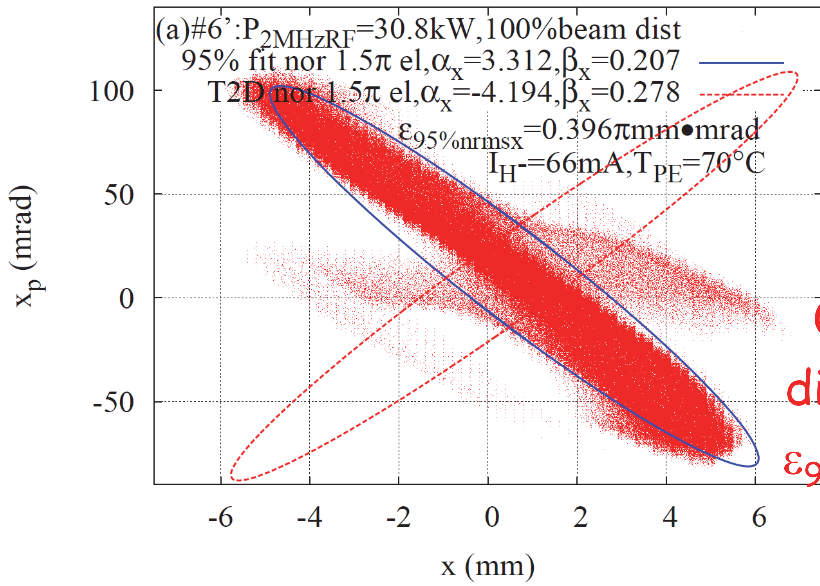
(1) I_{EE}=39mA (cf. I_{H^-}=66mA) by center RFMs thickness 2.50mm→2.75mm, optimum Cs density & V_{AMFC}=-4.4V (B_z=0 Gauss@PE aperture)

(2) $\varepsilon_{95\%nrmsx/y}$: 0.23→0.27πmm·mrad by high Cs density & high RFF
60mA @ high energy LINACs will be possible by increasing a few mA.
∵ I_{RFQ}=60mA with 0.4πmm·mrad, 70mA beam

(3) Large I_{EE} dependence (39~115mA) on Bz (0~37 Gauss)

(4) Sinusoidal dependence of P_{RF} or $\varepsilon_{95\%nrmsx/y}$ on V_{AMFC}

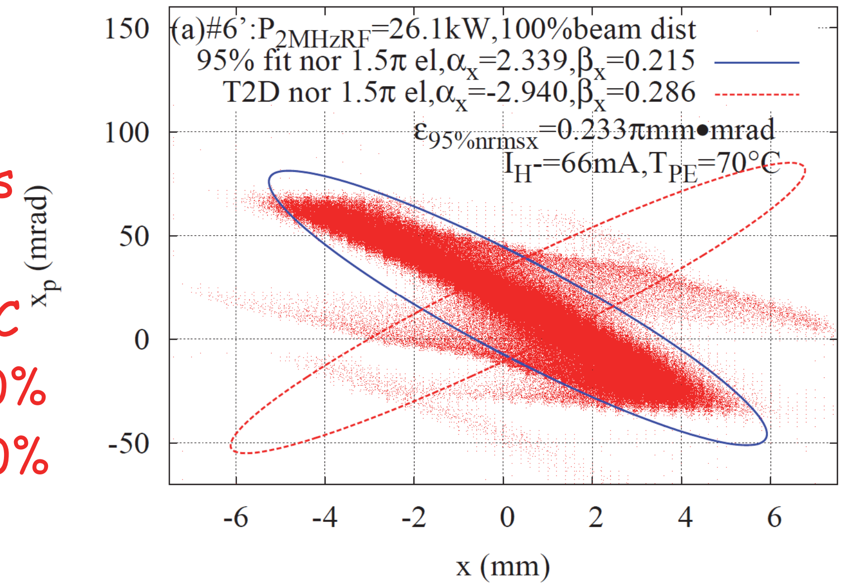
Slight H_2Os Feeding in Hydrogen Plasma Reported in NIBS2016

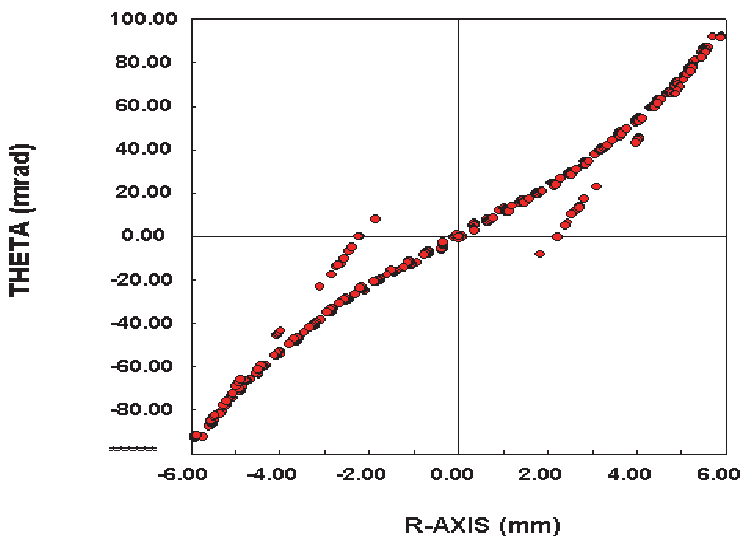


→ Slight H_2Os feeding in @T_{PE}~60° C

div. angle↓30%

$\varepsilon_{95\%nrmsx/y}$↓40%





Backward traced emittance (top red ellipse) agrees with BEAMORBT simulation (bottom)

We need plasma & beam simulation specialist collaborator.

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 one year in J-PARC by half P_{RF}.

EFFECTS OF IMPURITY ELEMENTS
H_2Os feeder & summary plot

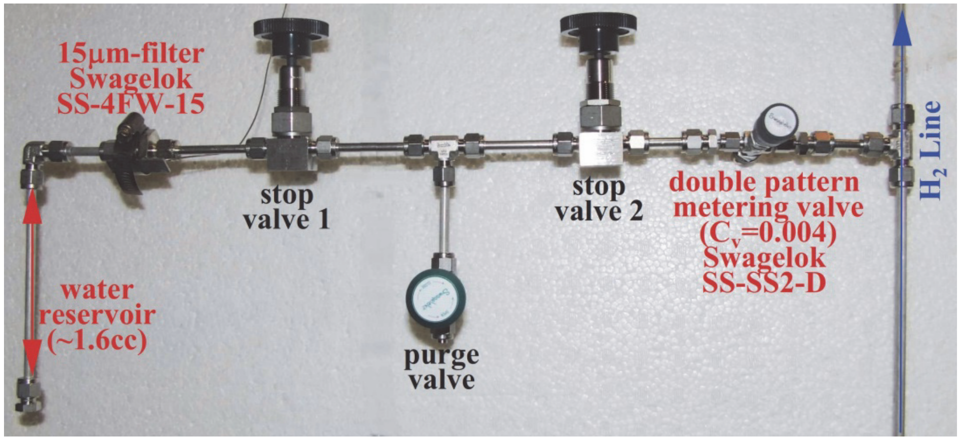
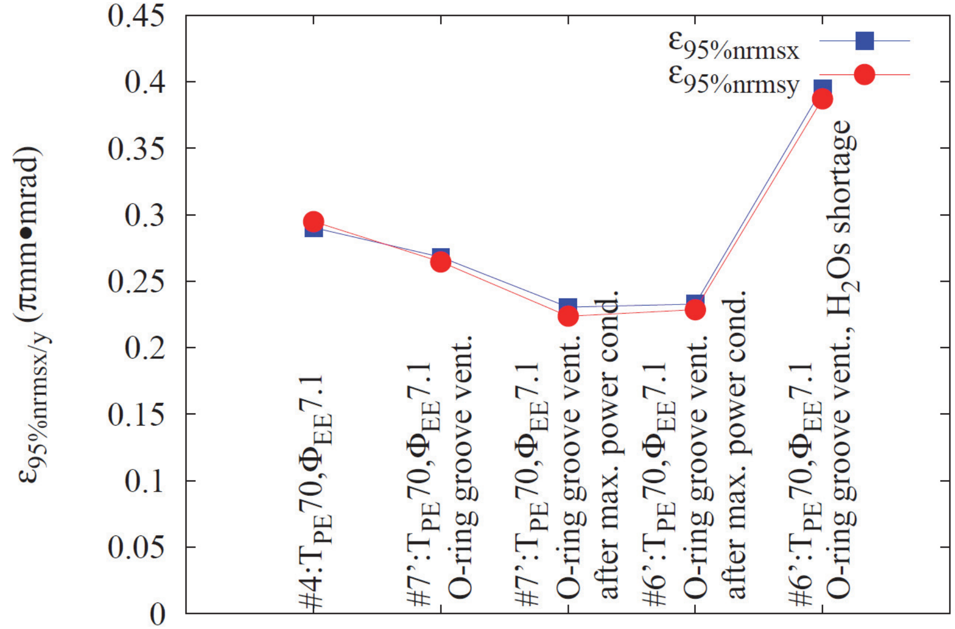


Photo of H_2Os feeder composed with 13 cm pipe as H_2O reservoir of 1.6 cc, 15μm-filter (Swagelok SS-4FW-15), two stop valves, purge valve and double pattern metering valve (Swagelok SS-SS2-D) with C_v-value of 0.0004.

→no emittance expansion



Relationship between principal parameters effective to H^- ion emittances and measured emittances ($\varepsilon_{95\%nrmsx}$ and $\varepsilon_{95\%nrmsy}$).