SPACE CHARGE COMPENSATION IN THE LINAC4 LEBT FOR THREE INJECTED GAS TYPES

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ABSTRACT

The space charge of unbunched, high intensity beams can be compensated by the trapping opposite charged particles in the potential well of the beam. The source of these secondaries is ionization of the residual gas in the beam line. The effect is important in the Low energy beam transport (LEBT) regions. At CERN's Linac4, the LEBT transports a pulsed 45 keV H^- beam, which is compensated by the positive ions, created by collision of the beam with the neutral gas in the beam pipe. The rise time and amount of compensation may be varied by the density of neutral gas and the type of gas used (through the cross-section for ion production and the mass of the resulting ion). In this paper we present measurement results for the transport of the beam at the Linac4 LEBT with the addition of hydrogen, nitrogen and krypton gases into the line, and compare them with simulations of the beam dynamics including the effect of compensating positive ions. The H^- beam is provided by a cesiated 2 MHz RF ion source with an external solenoidal antenna, operating with 600 μs pulses at 0.8 Hz repetition rate.

Introduction

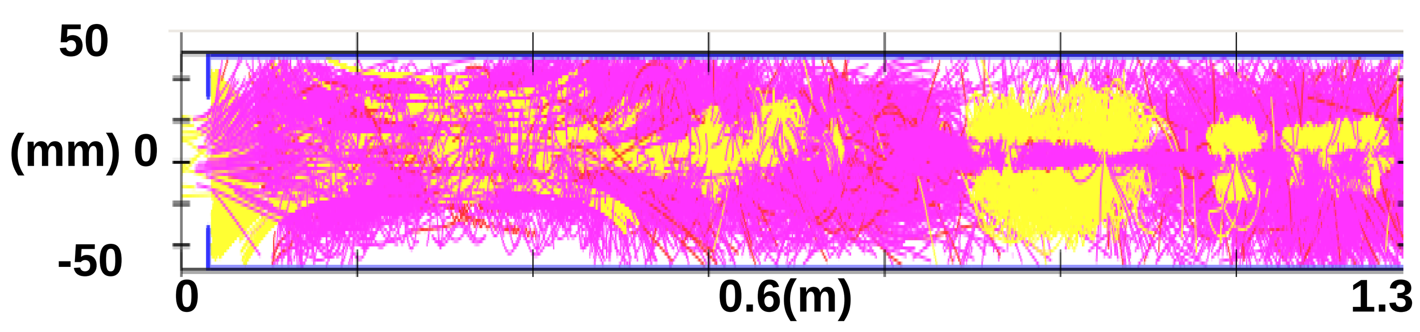
The Linac4 LEBT transports a high intensity H^- beam at 45 keV, extracted from the source, to match the RFQ under strong space charge conditions. It is necessary to reduce the space charge using the Space charge compensation effect(SCC) to decrease the overall beam potential.

R. Gobin et al [1] experiments have shown that the rms beam emittance is improved by using this technique; we investigate wether changing the type of gas affects the dynamics of the SCC.

Measurements were done at the Linac4 Ion Source Test Stand, using the first section of the Linac4 LEBT with a solenoid and emittance meter.The pressure inside the LEBT was varied by the injection of different gases, and compared to IBsimu [2] beam simulations of the region including the SCC.

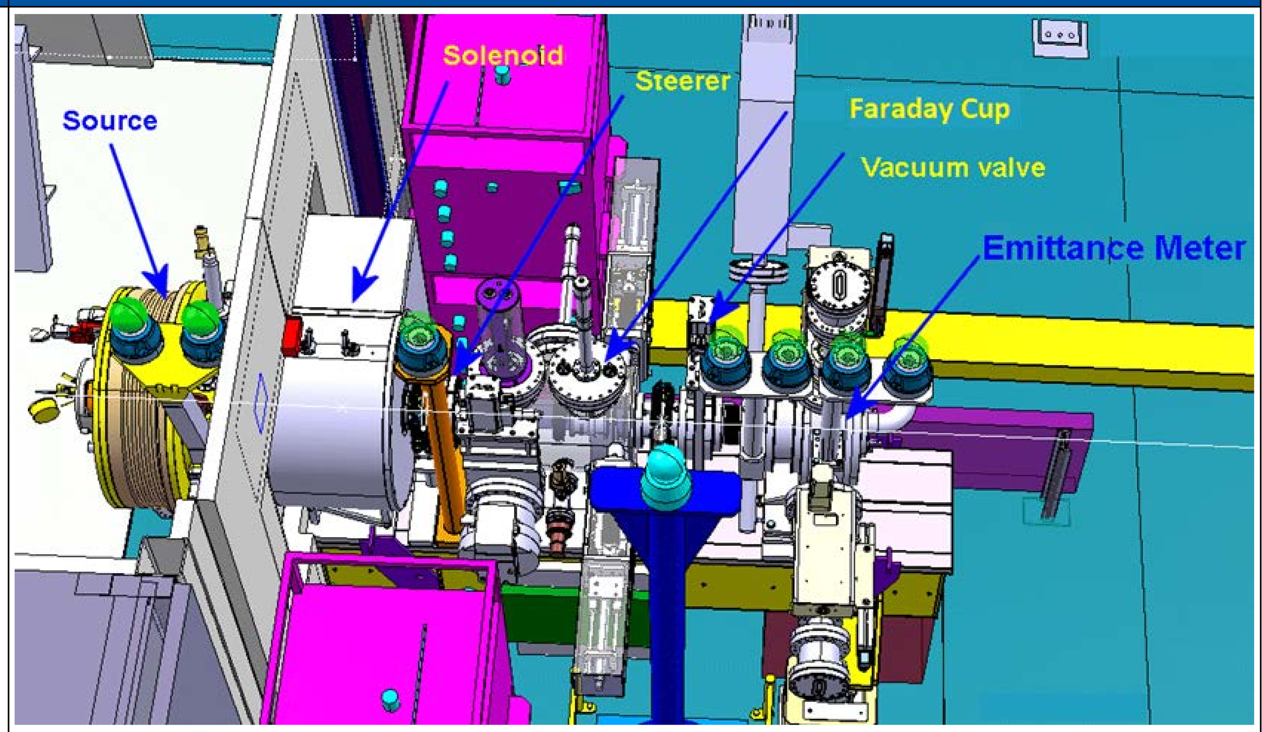
H^- beam Simulations with Secondaries

H^- beam transport includes the SCC; for each residual gases the secondary ions and electrons generated by ionization of the gases are included



Tracking of secondaries: H_2^+ (Red) Kr^+ (pink) and electrons (yellow) inside the Linac4 LEBT beam pipe

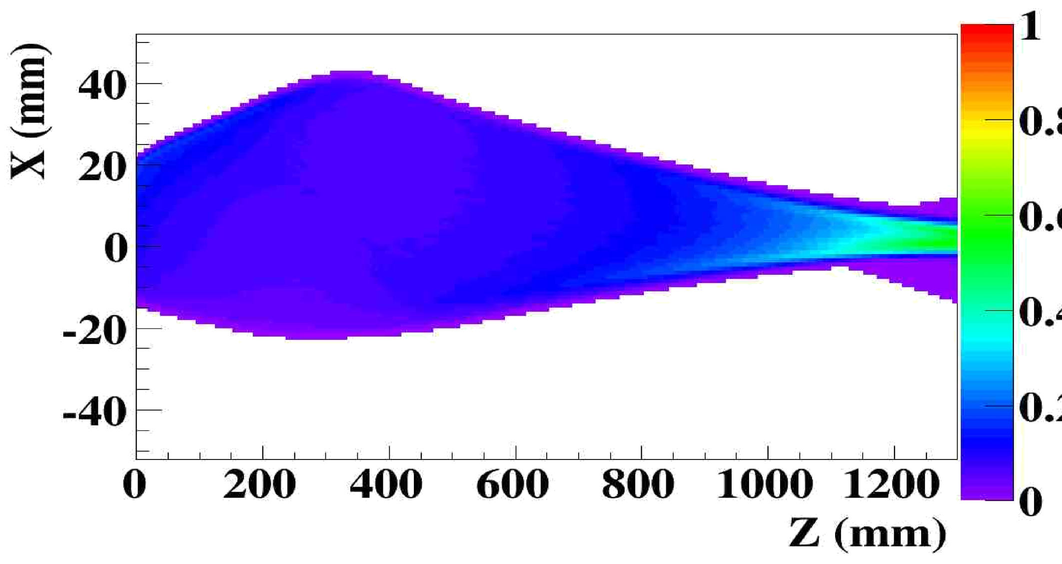
Experimental Setup



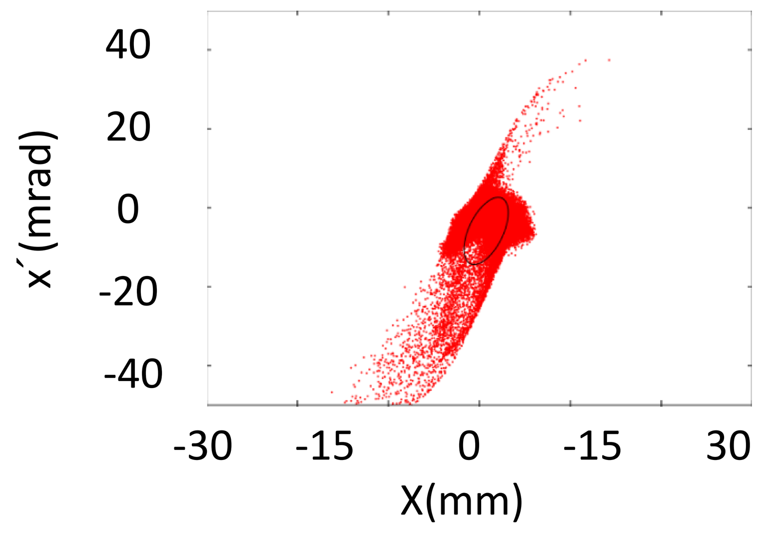
Beam Density in the LEBT

Phase Space

a) Constant SCC set to 20% (no secondaries)

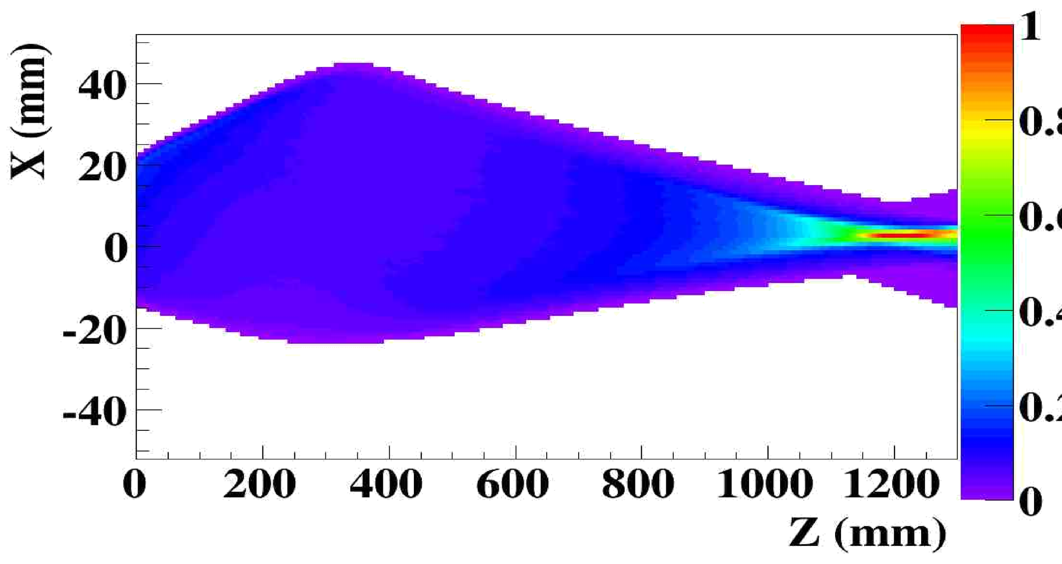


Simulation

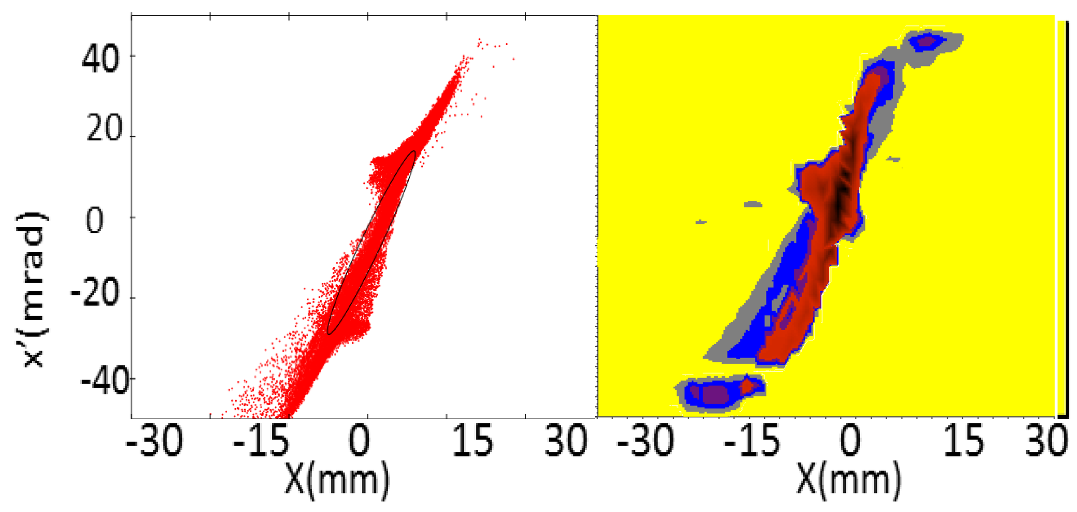


Emittance norm 1rms 0.29 mm.mrad

b) Kr or N_2 pressure at 0.5×10^{-6} mbar and 1×10^{-6} mbar

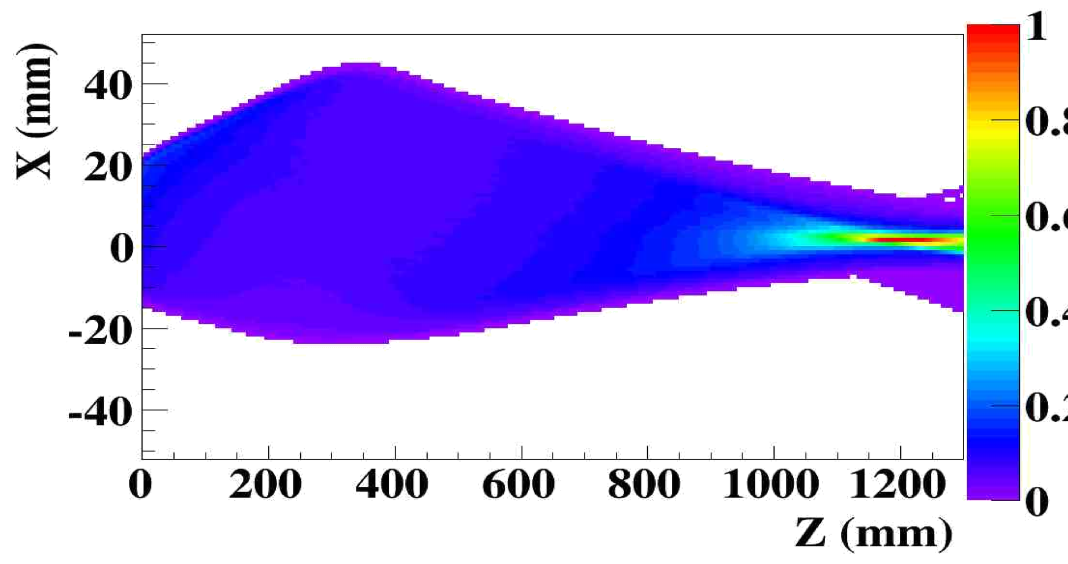


Simulation Measurement

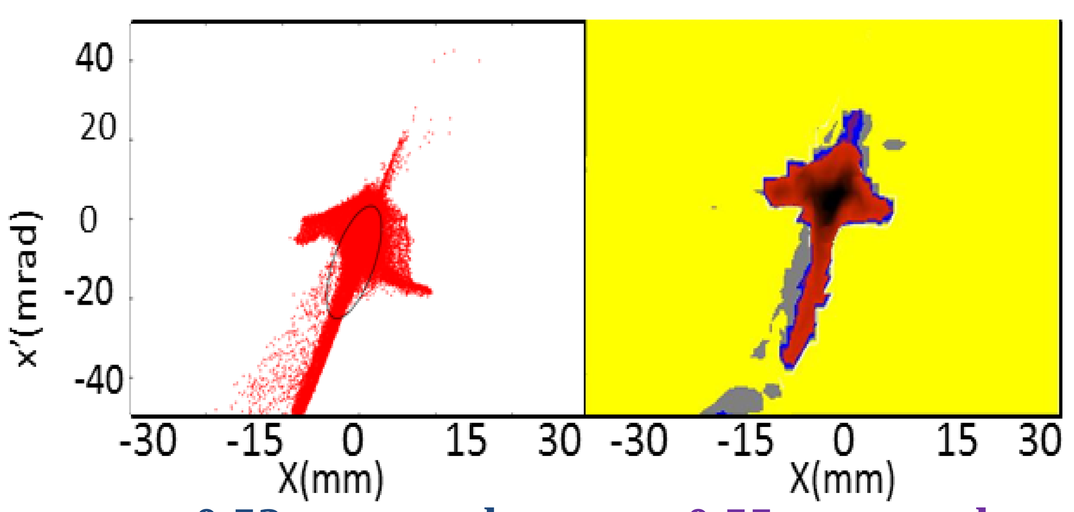


0.45mm.mrad 0.61mm.mrad

c) H_2 pressure at 2.5×10^{-6} mbar

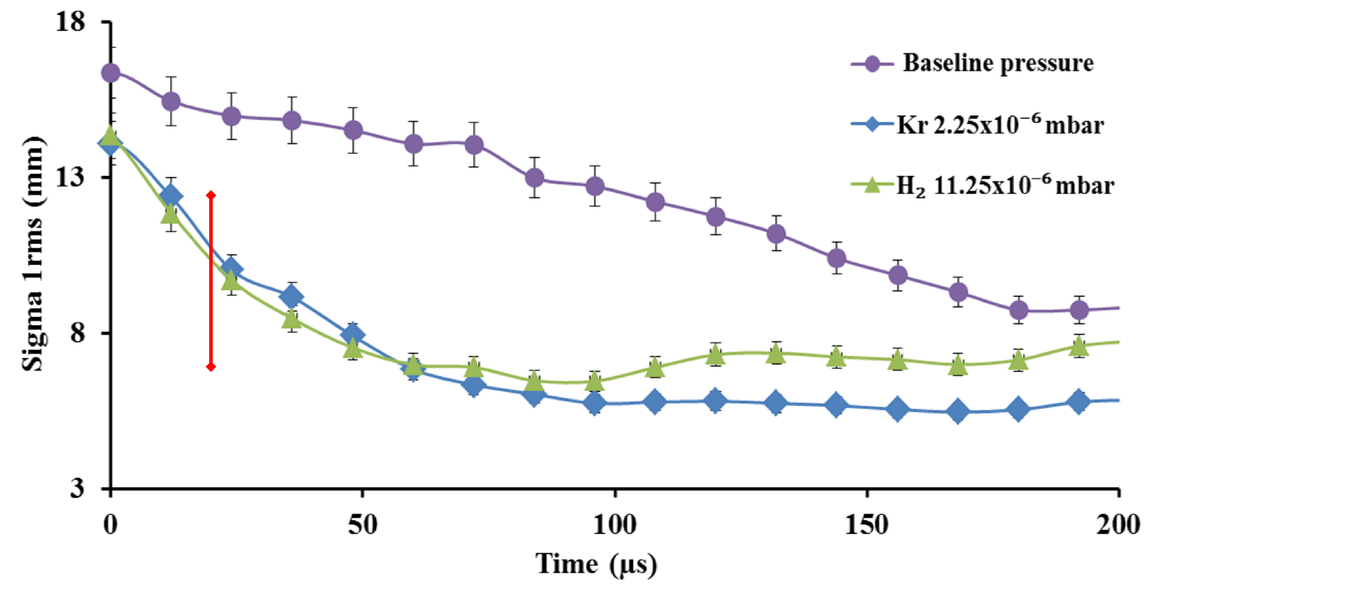


Simulation Measurement



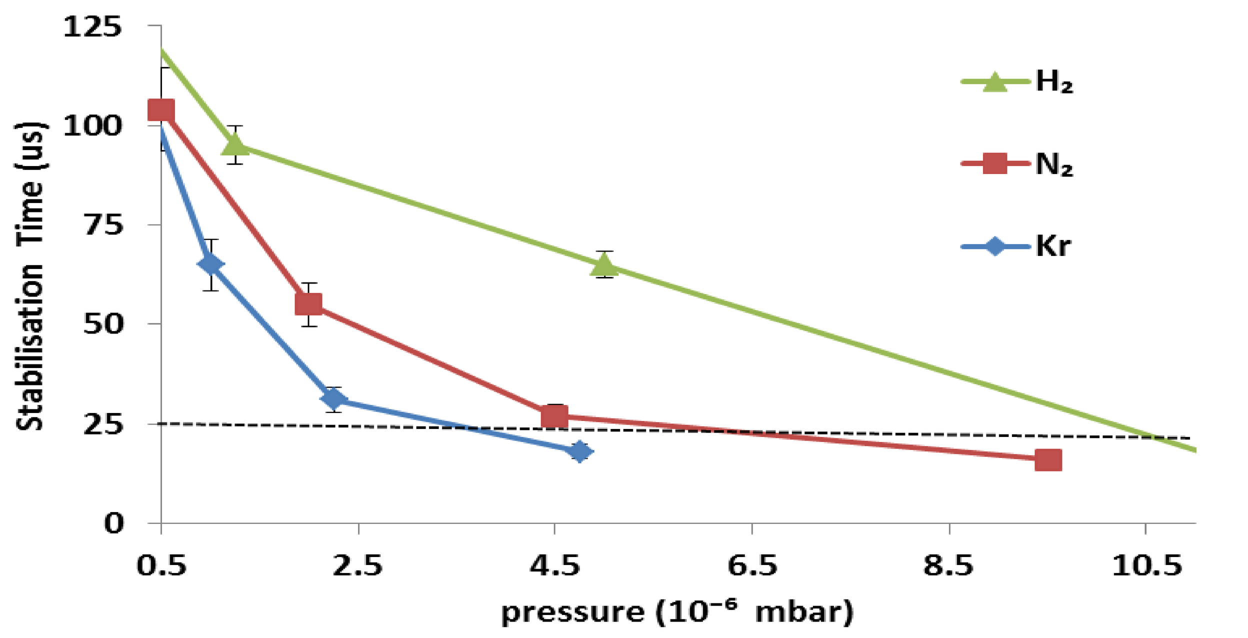
0.52mm.mrad 0.55mm.mrad

SCC Dynamics Results

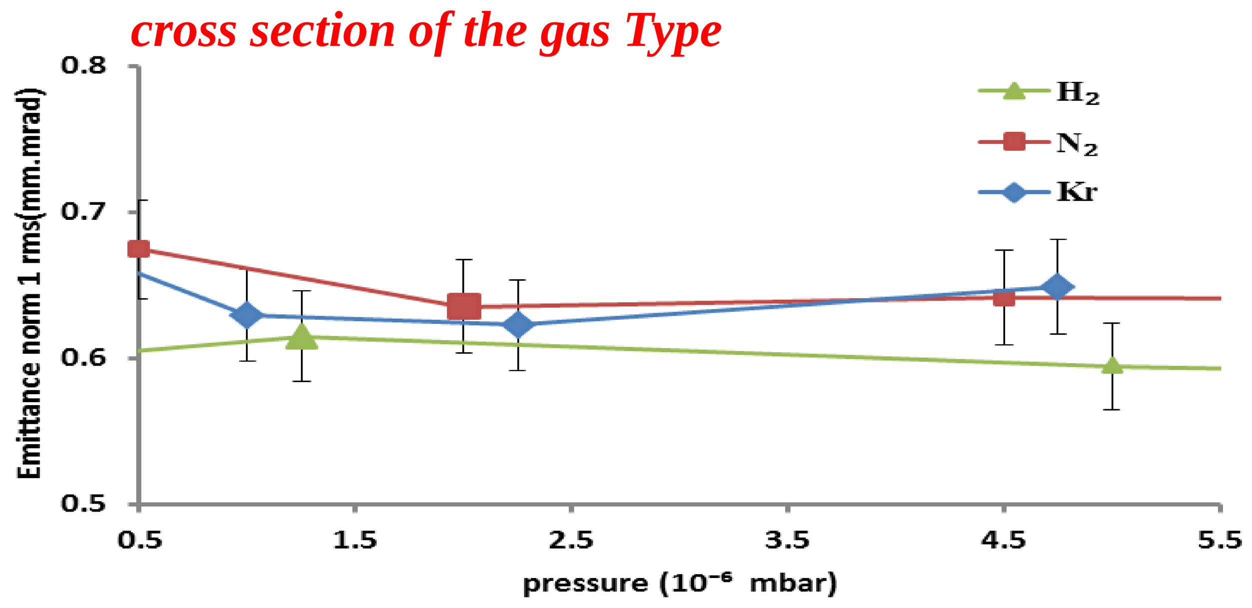


Beam size evolution measured in the emittance meter, the stabilization H_2 and Kr is indicated.

Baseline pressure : 0 mbar of gas injected and 1×10^{-6} mbar H_2



✓ *Stabilisation Time: is proportional to the pressure and cross section of the gas Type*



✓ *No relation between emittance, pressure and gas Types*

CONCLUSIONS AND OUTLOOK

Measurements and simulations have been made of the transport of a 45keV 35mA H^- ion beam under space charge compensation conditions, using three different gases as the source of secondary ions.

✓ The simulations show a very good correspondence to the measured phase space.
✓ In order to stabilise the beam (with a 1/e time of 25us), it is necessary to reach pressures of H_2: 1×10^{-5} mbar, N_2: 6×10^{-6} mbar, Kr: 2×10^{-6} mbar.

The maximum pressure is limited to 1×10^{-5} mbar in the LEBT; the choice of SCC-gas is also driven by pumping efficiency considerations.

➢ Therefore N_2 is a good alternative as it leads to lower pressure in the RFQ, and increases the pump lifetime; It will be tested in Linac4.

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REFERENCES

1) R. Gobin et al, Rev. Sci. Instrum. 70, 2652 (1999)
2) T. Kalvas et al, Rev. Sci. Instrum. 81, 02B703, (2010).