Measurements of Linac4 H⁻ Ion Source Beam with a Magnetized Einzel Lens Electron Dump

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This presentation compares H⁻ measurements and simulations with a new extraction system.

Motivation for designing a new extraction system

Two sets of beam measurements compared with simulations

Method to reduce the e/H ratio
The motivation for a new beam extraction system was linked to the high energy co-extracted electron beam.

The sublimated metal traveled to the extraction gap and made it impossible to hold the voltage -> no beam was extracted.
Two courses of action were taken to prevent high voltage breakdowns

Pulsed high voltage converters – avoid breakdowns between beam pulses

New beam extraction system where electrons are dumped with lower energy
The new extraction system uses a magnetized Einzel lens to dump co-extracted electrons.

The electrons are dumped with an energy of 10 keV, and spread over a large surface to reduce the power density.
The ion source consists of two independent parts: the plasma generator and the front end.

These two parts are exchangeable, so the ion source can host plasma generators based on different ion production modes.
Motivation for designing a new extraction system

Two sets of beam measurements compared with simulations

Method to reduce the e/H ratio
The comparison to simulations has been made by using the currents measured on four electrodes.
Measurement 1: RF-power
Changes the H\(^{-}\) density in the plasma, thus the extracted beam current

Linear scaling between
- RF-power (measurement)
- H\(^{-}\) density (simulation)
The simulations of the puller and electron dump current do not correspond to the measured values

Secondary electrons emitted from the electron dump
  • Reduce the current measured on the electron dump
  • Increase the current on the puller
The simulations fit the measurement data when secondary electron emission from the electron dump is considered.

Secondary electrons emitted from the electron dump:
- Reduce the current measured on the electron dump
- Increase the current on the puller
The $\text{H}^-$ beam extraction has been reproduced for a varying RF-power when measuring the current on four electrodes

Linear scaling between
- RF-power (measurement)
- $\text{H}^-$ density (simulation)
Measurement 2: Puller voltage
Defines the electric extraction field, tunes the beam optics

Plasma generator current increases with higher extraction voltage
- Increased plasma meniscus surface

Measured current increases slightly more than the simulated one
- Density varies as a function of the depth of the plasma
Measurement 2: Puller voltage
Defines the electric extraction field, tunes the beam optics
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- Plasma generator
- Einzel e-dump
- Ground
- Einzel lens
- LEBT
- Faraday cup

Graph showing the relationship between plasma generator, puller, electron dump current, and faraday cup current with varying Vext (kV) (Vpuller - Vsource).
Measurement 2: Puller voltage
Defines the electric extraction field, tunes the beam optics

[Graph showing the relationship between plasma generator, puller, electron dump current, and Faraday cup current with respect to Vext (puller - source voltage)].

Plasma generator Meas, Plasma generator Sim, Puller Meas, Puller Sim, Electron dump Meas, Electron dump Sim, Faraday cup Meas, Faraday cup Sim.
Measurement 2: Puller voltage
Defines the electric extraction field, tunes the beam optics
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![Diagram showing electric field lines with labels for Plasma generator, Einzel e-dump, Ground, Einzel lens, LEBT, Faraday cup, Puller, Einzel lens, LEBT, and Faraday cup.]

![Graph showing a plot of Plasma generator, Puller, Electron dump, and Faraday cup current against Vext (Vpuller - Vsource). The graph includes data points for Plasma generator Meas, Plasma generator Sim, Puller Meas, Puller Sim, Electron dump Meas, Electron dump Sim, and Faraday cup Meas, Faraday cup Sim. The x-axis represents Vext in kV, and the y-axis represents current in mA. The graph ranges from 0 to 15 Vext and 8 to 16 Faraday cup current.]
Motivation for designing a new extraction system

Two sets of beam measurements compared with simulations

Method to reduce the e/H ratio
The electron to $\text{H}^-$ ($\text{e/H}$) ratio is affected by the potential on the plasma aperture voltage.

With a negative bias on the plasma aperture, negative charges ($\text{H}^-$ and electrons) are repelled away from the extraction hole.

With a voltage difference of -30 V between the plasma aperture and the collar, the $\text{e/H}$ ratio is reduced by 20 %.
The new H\textsuperscript{−} beam extraction system has been implemented with success

The beam extraction has been reproduced in simulations

The plasma aperture voltage can be used to lower the e/H ratio