National Electrostatics Corp.
7540 Graber Rd., P.O. Box 620310, Middleton, WI 53562-0310 USA

02/17

Alphatross Source
RF-Charge Exchange Ion Source

The NEC RF-charge exchange ion source, henceforth referred to as the Alphatross source, was designed primarily for the production of He^- beams for injection into tandem accelerators. Its use has been expanded to include H^-, NH^- and O^- beams. The source design was patterned after the RF-charge exchange ion source built and in regular use by Professor H.T. Richards at the University of Wisconsin - Madison, Department of Physics. The design has been continuously improved since its introduction on the S-Series tandem Pelletrons® in 1979. There are now more than one hundred Alphatross sources in use on tandem accelerators worldwide.

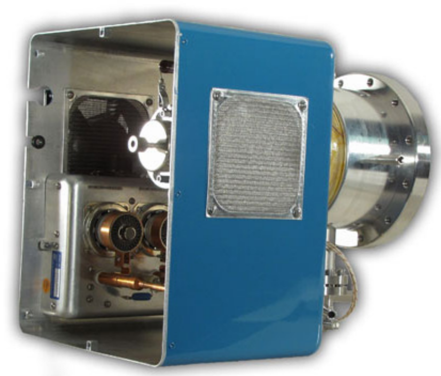
APPLICATIONS

Modern, MeV ion beam analytical instruments require a long lived and simple to operate source of He^-, H^- and NH^- beams. The Alphatross source satisfies these requirements.

The entire source is designed for a simple, straightforward operation. On initial start up, the source can be expected to provide 2μA of He^- and can be tuned to beyond 4μA. In addition, factory tests and customer reports have shown that this source demonstrates a beam lifetime between routine maintenance in excess of 1000 hours while producing 2μA of He^-.

Other ion species are also available such as H^- in excess of 10μA and NH^- in the 2-3μA range. H^- is used in PIXE applications while the NH^- is used for Nuclear Reaction Analysis (NRA). The NH^- beam is used primarily to produce a positive nitrogen beam for hydrogen profiling.

The Alphatross source is a compact, reliable source of light negative ions. A positive RF source injects immediately into a compact rubidium charge exchange cell.



The Alphatross source and oscillator are housed in an RF shielded box. The RF plasma bottle is easily demounted for rapid servicing.

DESIGN

The only way that the He^- ion can be formed is by a two step process which involves the production of the He^+ ion followed by charge exchange using an alkali metal vapor.

[Alphatross v1]

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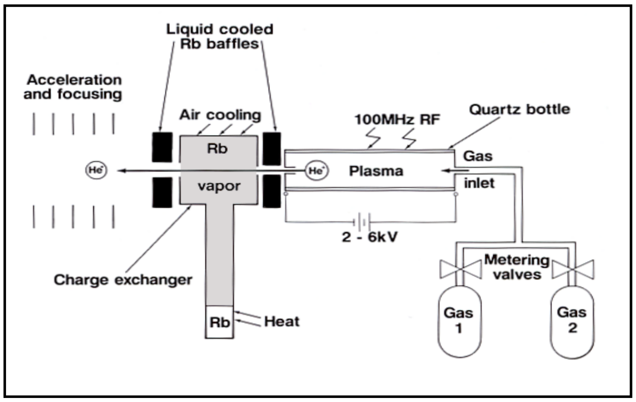
Alphatross Source



Helium gas (for He^-) or a gas mixture ($N_2 + H_2$) for NH^- is bled into a quartz bottle. An RF oscillator is connected to the quartz bottle to disassociate the neutral gas. The potential difference across the bottle is typically 2-6kV. The beam exiting the quartz bottle is immediately injected into a rubidium vapor charge exchange cell.

Rubidium is chosen because it has a higher charge exchange efficiency than other alkali metals. The rubidium is heated to form a vapor in the beam path. The vapor condenses on the cell walls and returns to the oven for reuse.

For long ion source lifetime, it is essential that the rubidium vapor remain trapped in the charge exchange cell. This is accomplished by air cooling to the cell body and liquid cooling to baffles at the entrance and exit to the charge exchange cell.

The entire RF source is housed in an RF sealed enclosure. The source uses a quartz bottle which is o-ring sealed to the source flange. The quartz bottle can be cleaned and reused.

PERFORMANCE

The chart below is a guide to those beams which have been demonstrated. However, they do not represent the limit in capabilities of the ion source. All elements which can exist in the gaseous form and form negative ions (either atomic or molecular) could be considered candidates for ion production in the Alphatross source.

NEC has not done a detailed study of the ion source emittance. However, customers have reported emittances both for He^- and H^- beams. The group at Los Alamos[1] has reported a best emittance of ~1.2 πmmmrad $(MeV)^{1/2}$ for 80% of the He^- beam. For H^- beams, this same group reported a 3 πmmmrad $(MeV)^{1/2}$. These measurements were taken on the injector to their 3MV tandem Pelletron®.

Source lifetime is dependent on ion species mass. Customer reports and factory tests have demonstrated a beam time between maintenance of over 1000 hours while producing 2µA of He^-. However, heavier ions will sputter away the canal faster than light ions, resulting in shorter source life.

Beam Current	Canal Type	Gas
2-3µA He^-	Tantalum	Helium
>10µA H^-	Aluminum	Hydrogen
> 10µA O^-	Tantalum	He and O_2 controlled independently
2-3µA NH^-	Aluminum	H_2 and N_2 controlled independently
1-2µA NH^-	Aluminum	99% H_2 + 1% N_2 premixed
1µA He^- } 2µA H^-	Tantalum	99% He + 1% H_2 premixed

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OPTIONS AND ACCESSORIES

The ion source is normally supplied with two (2) quartz bottles, two (2) sets of boron nitride insulators and two (2) extractor canals.

Tantalum extractor canals are recommended for He^- beams and aluminum extractor canals are recommended for H^- beams.

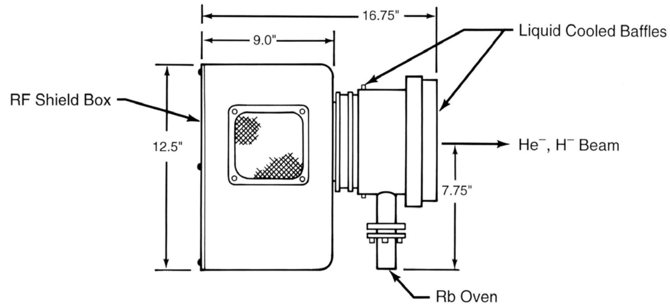
The NEC rack-mountable liquid cooling system is required and a separate simple air cooling system is highly recommended. These systems are designed to provide coolant at the proper temperature and flow rate for optimum source life.

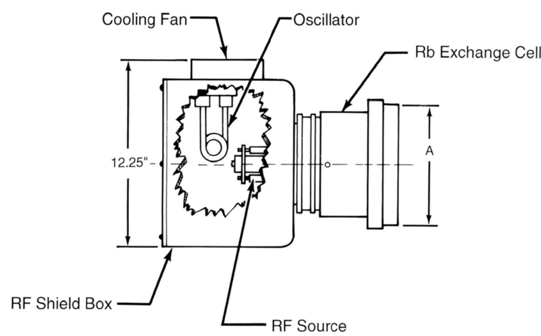
Source gas bottle assemblies with mass flow controllers are available in single, double and triple unit sizes. Double or triple unit assemblies are recommended when a gas mixture is required. Separate source gas metering units allow the precise mixing of the gases in the RF plasma.

Below is a list of the recommended power supplies. These power supplies are available in an insulated cabinet to allow operation at source potential. Focus and extractor power supplies will vary, depending on final configuration.

Recommended Power Supplies

Probe	+10kV, 12mA	Voltage regulated
Magnet	80V, 4.5A	Current regulated
Extractor	10kV, 12mA	Voltage regulated
Focus	15kV, 5mA	Voltage regulated
Rb oven	160 VDC, 2A	Voltage regulated





Exit Flanges Available (A):
8” O.D. NEC
8” O.D. ConFlat
6” ASA
Other flanges may be available upon request

[1]J.R. Tesmer, C.J. Maggiore and D.M. Parkin, Nucl. Instr. and Meth. B40/41 (1989) 718.
J.R. Tesmer, C.R. Evans and M.G. Hollander, proceeding of the
Symposium of Northeastern Accelerator Personnel, (1987), World Scientific, 77.

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