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IEAP
Extraterrestrische Physik

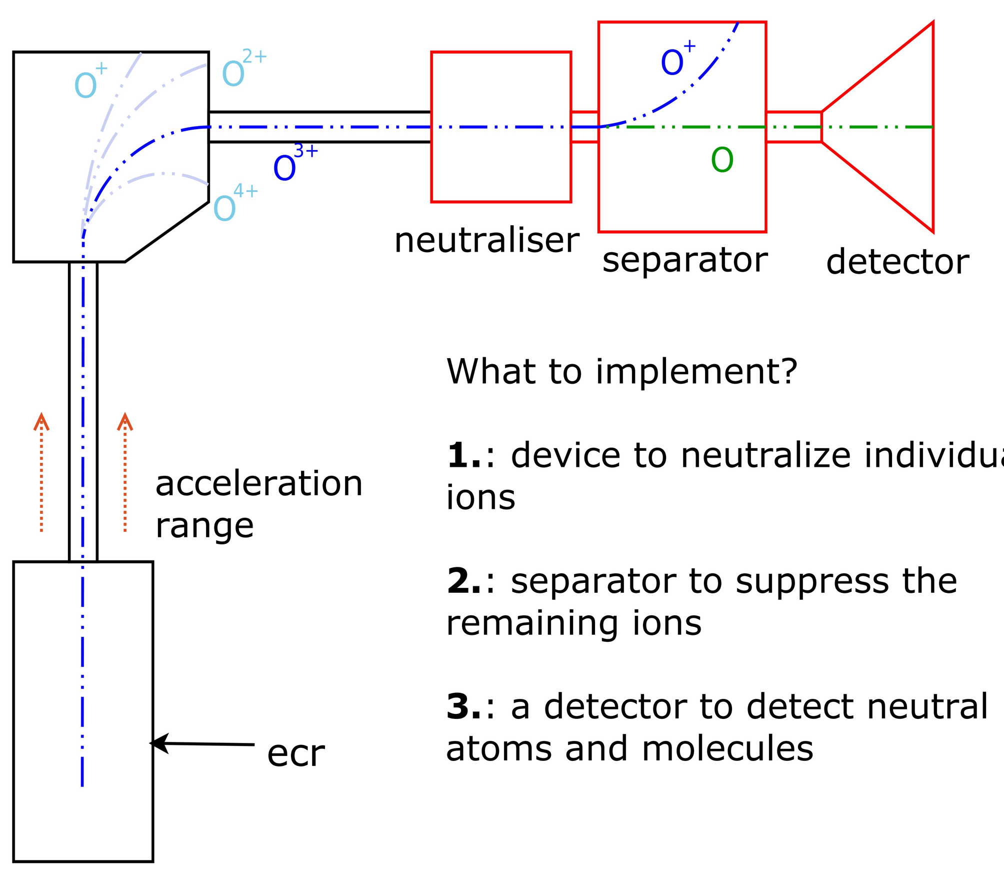
Neutralizing an ion beam

Expanding the spectrum of the solar wind laboratory

Thies Peleikis, Michael Stalder, Lauri Panitzsch, Stefan Kolbe,
Robert Wimmer-Schweingruber
IEAP, Christian-Albrechts-Universität zu Kiel

Abstract:
At the University of Kiel, the Department of Experimental and Applied Physics is running an ECR ion source in order to, amongst others, calibrate space instruments designed to measure solar wind properties and suprathermal particles.
The ion source is able to produce medium to highly charged ions which are then accelerated by an electrostatic field up to 450keV per charge.
In order to extend the particle spectrum from ions to neutral atoms we are planning to install a device for the beam particle neutralisation.
Neutralisation can be achieved either by passing the ions through a thin carbon foil or through a gastarget where charge-exchange occurs. The remaining ions behind the neutraliser will be suppressed by an electrostatic separator.
Both methods will alter the beam properties and lead to a divergence in energy and an angular spread of the beam.
The actual progress of this project will be presented in this poster.

Sketch of the ion source and the additional parts.



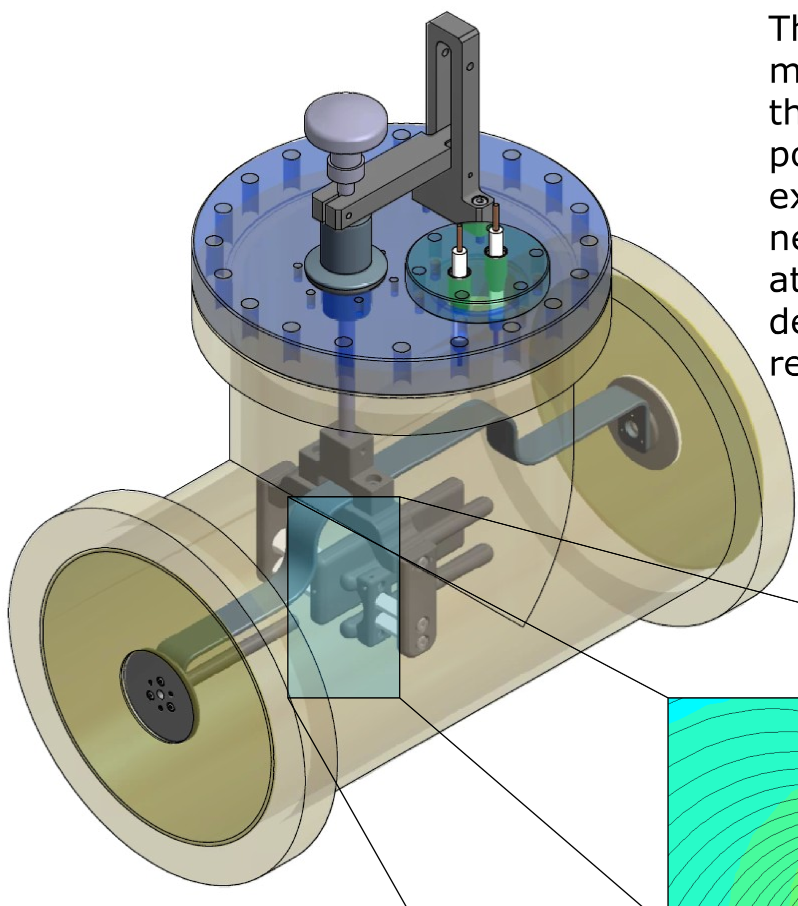
What to implement?

1.: device to neutralize individual ions

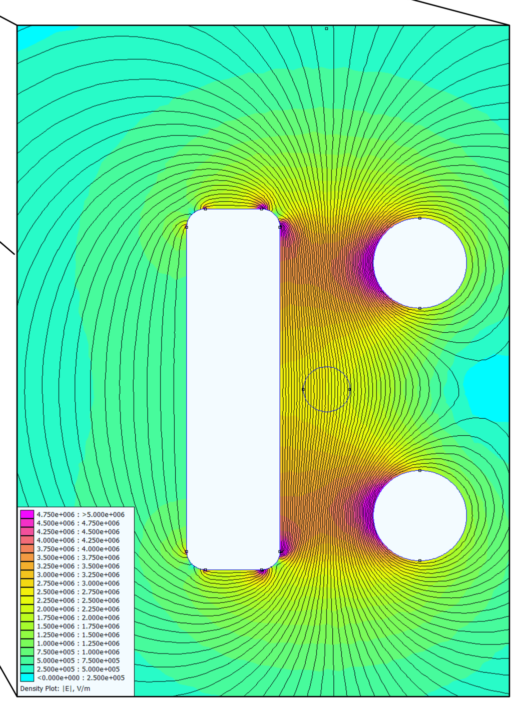
2.: separator to suppress the remaining ions

3.: a detector to detect neutral atoms and molecules

Separation of remaining ions
Since none of the ways to neutralize the ions has an efficiency of 100%, there are still ions inside the beam after passing through the neutraliser.
Those remnants need to be suppressed, either by a magnetic or an electrostatic system.
We chose an electrostatic system in form of a plate capacitor. The electric field was simulated with FEMM4.2.



The separator will be moveable like the foil and the gas-cell. This way it is possible to run the experiment as a source of neutral atoms, ions and atoms or only ions, depending on the requirements.



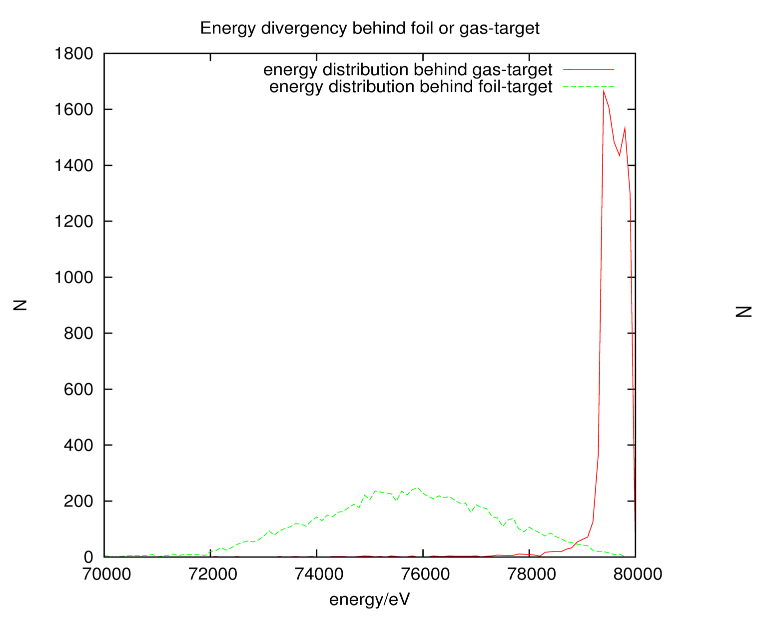
Simulation of the electric field produced by the separator. The remaining ions will accelerated by the field and leave the former beam axis.

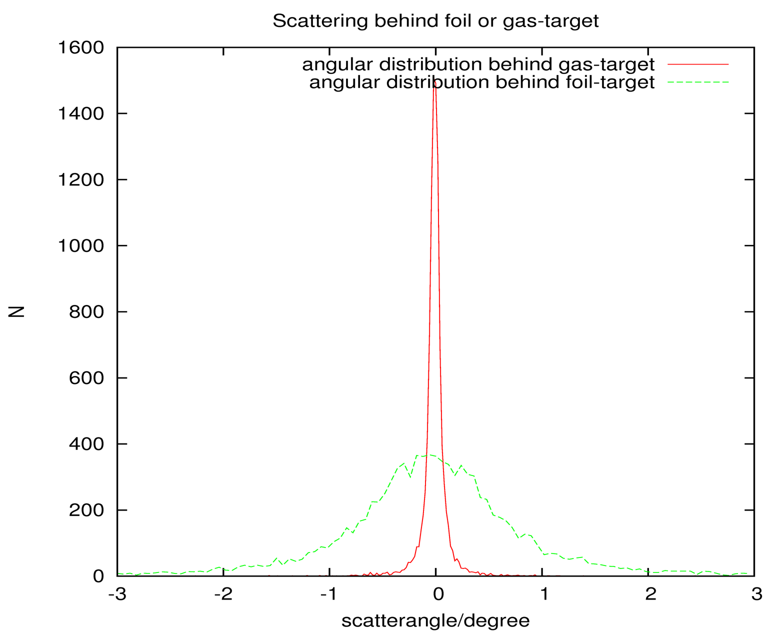
How to neutralize ions?

In generell, the ions have to interact with matter. So charge-changing collisions can occur and the ions can gain missing electrons. The matter can either be a gaseous media or solid matter, for example an ultra thin carbon foil.

While the ion beam passes through the target, the ions will lose part of their kinetic energy. Also they will scatter because of collisions with the target atoms.

Therefore there are three major criteria to consider when chosing a target:
- the efficiency in neutralisation
- the scattering of the particles
- the energy-divergency of the particles

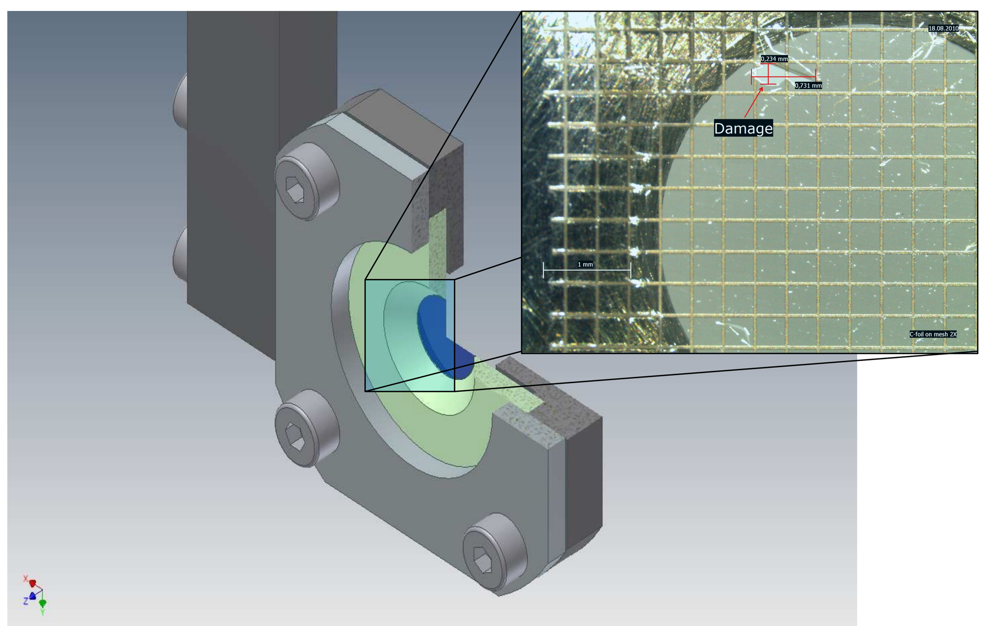




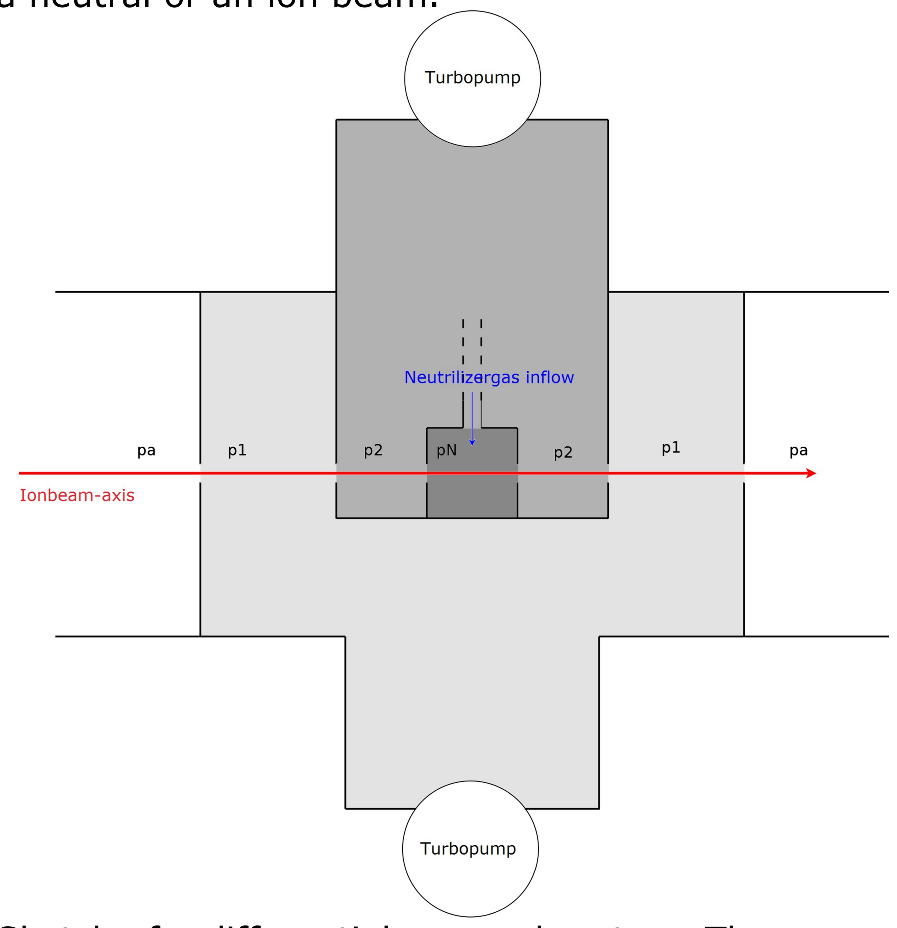
Simulation of 10000 ions passing through a gas-target and a thin foil. Shown is the comparison between the energy divergency and the scattering behind the target.

Conclusion
The ion beam suffers much less scattering and energy-loss while passing a gaseous media than while passing a thin carbon foil (see left). On the other hand, the neutralisation-effctiveness of a gas-neutraliser and a foil-neutraliser are nearly equal.
Therefore a gas-neutralizer will be superior but much more challenging to implent. One has to assure that the pressure inside the ECRIS will not rise above a certain level if implementing a gas-cell into the beamline.

Technical implementation of the neutraliser
Implementation of a foil-neutralizer: Relatively easy. The foil needs to be mounted and brought into the beam.
Implementation of a gas-neutralizer: One needs a central gas-cell filled with a neutral gas (e.g. Hydrogen). This cell must be separated from the rest of the arrangement by a differential pumped system.
The pressure inside the central cell should be around 0.6 Pa, while the pressure inside the rest of the experiment is around $1*10^{-5}$ Pa.



CAD-drawing of a mounted carbon foil(blue). The foil can be moved in and out of the bea, whether one wants a neutral or an ion beam.



Sketch of a differential pumped system. The pressure decreases from pN to pa. Inside the central cell the pressure pN will be kept constant. Two turbopumps assure the decrease in pressure from one cell to the next.
The central cell can be moved out of the beam axis and the gas-inflow can be closed if neutrals are not required.

Detector
After the neutralisation and the separation of the remaining ions inside the beam one wants to detect the neutral atoms. A particle detector will be placed downstream behind the separator.
A suitable detector will be most likely a semiconductive detector or a micro-channel-plate.

Requirements for the detector: -wide energy-range
-single particle detection

The ions (and therefore the neutralized atoms) can have kinetic energies up to 450keV per charge.
The particle current will be reduced in order to enable single particle counting.

Kontakt:
Thies Peleikis
Extraterrestrische Physik
Institut für Experimentelle und Angewandte Physik
Christian-Albrechts-Universität zu Kiel
Olshausenstr. 40-60, 24098 Kiel
Tel.: +49-431-880-3799
Fax: +49-431-880-3968
peleikis@physik.uni-kiel.de
www.ieap.uni-kiel.de/et

Outlook
The conception stage is nearly complete. The physical calculations for the separator, the gas-neutraliser and the foil-neutraliser are finished. The concept of the gas-neutraliser must be completed and a suitable detector-system must be found. Thin carbon foils have been ordered and recived and the separator is under construction.
The first measurment with the carbon foils have been made. We expect the whole sytem to be completed within four months.