Heavy Ion Induced Desorption Measurements on Cryogenic Targets

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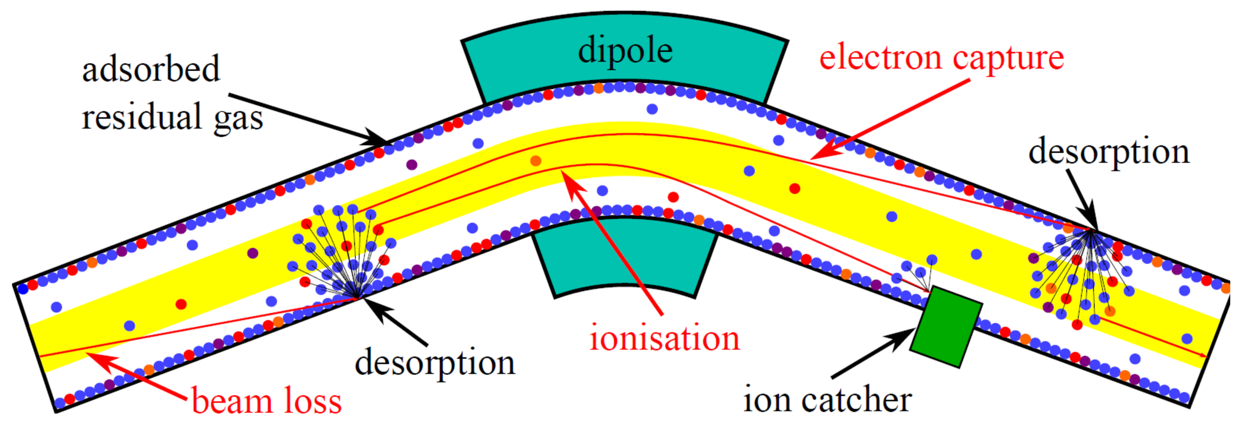
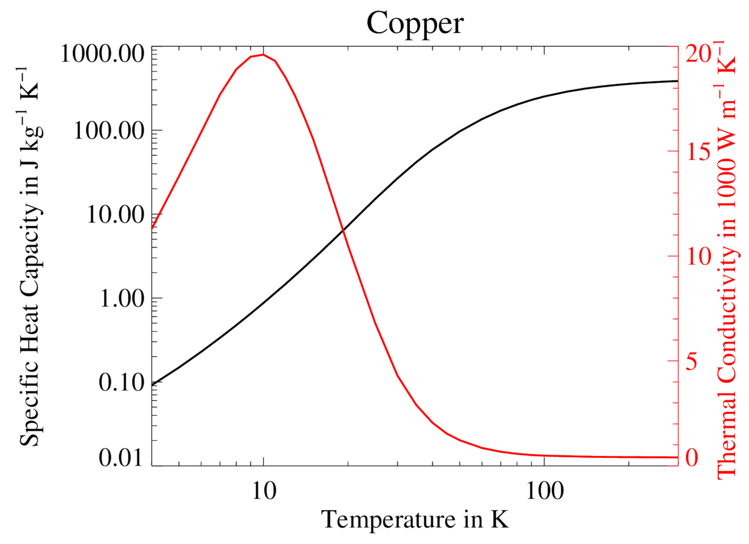
Heavy Ion Induced Desorption

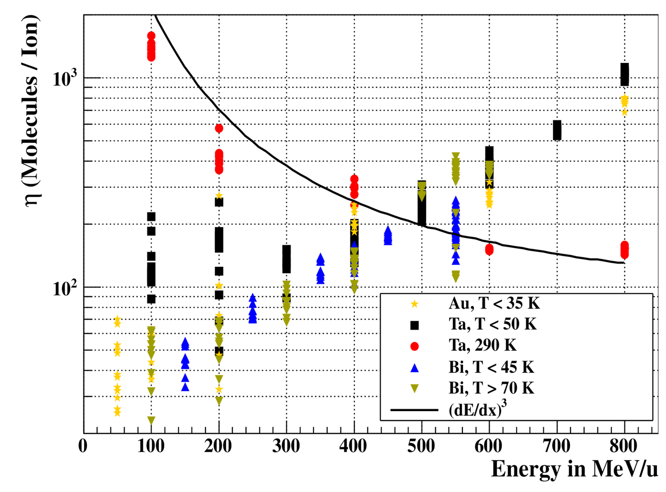


- Collisions with residual gas particles cause charge exchange of beam ions.
- These ions deviate from their projected paths and collide with the wall.
- Previously adsorbed gas particles are released, pressure rises.
- Self-amplifying process resulting in beam loss → Beam intensity limiting factor.
- Solution: low desorbing surface (ion catcher) at loss positions.
- Ion catcher's desorption yield critical for accelerator's maximum beam intensity!

Desorption: Room Temperature vs. Cryogenic Environment

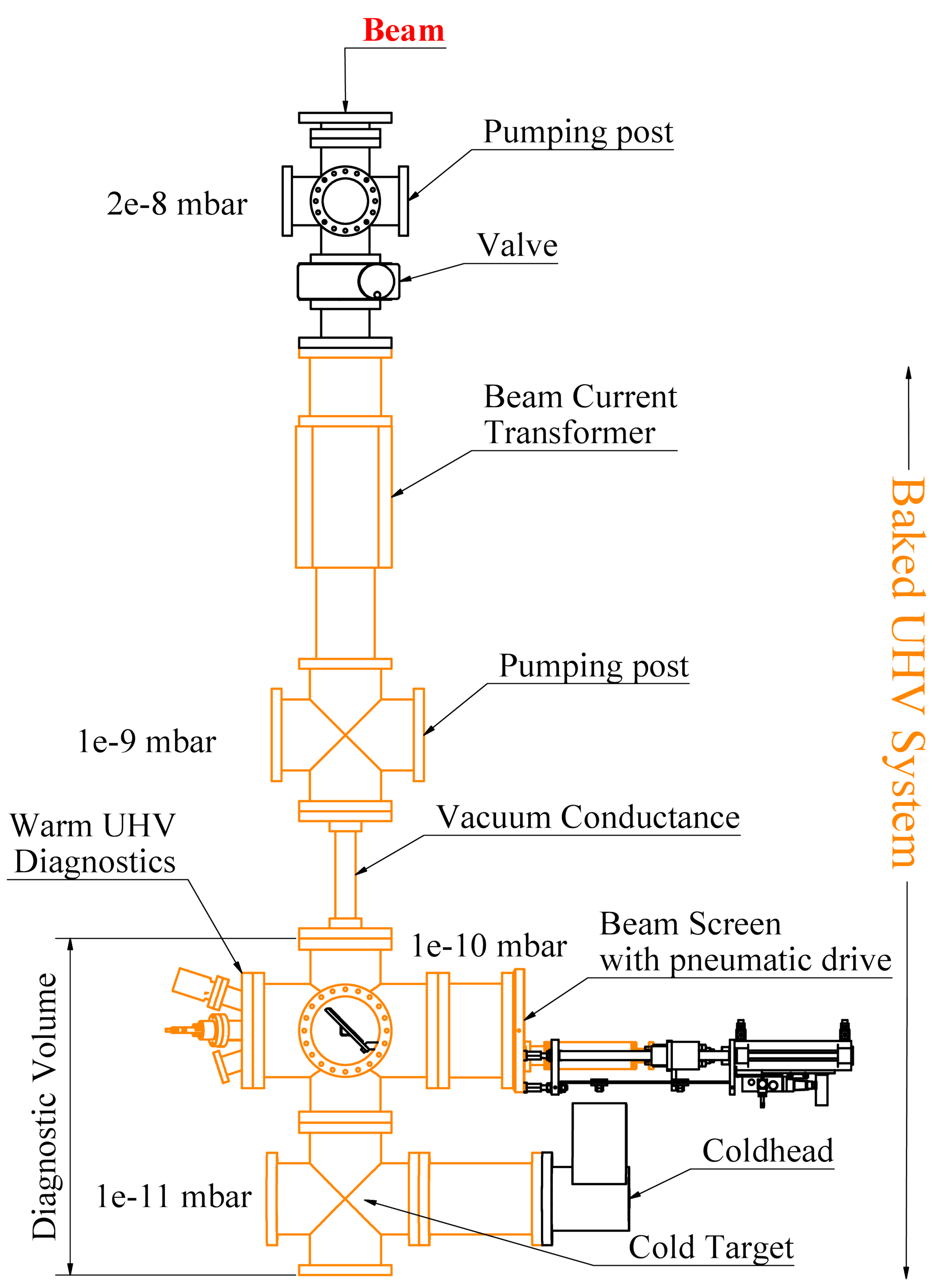
- Room temperature desorption was systematically investigated, optimized material was found[1].
- Room temperature desorption yield scales with the ion's electronic energy loss at the surface $(dE/dx)^n$[1,2].
- SIS100 will feature superconducting magnets → cold walls → bind even more gas → desorption must be suppressed.
- A cryocatcher prototype has been developed and cryogenic desorption was measured.
- New scaling of η at cryogenic temperatures has been found[3].
- Possible explanation: Dependance of η on heat capacity and thermal conductivity.

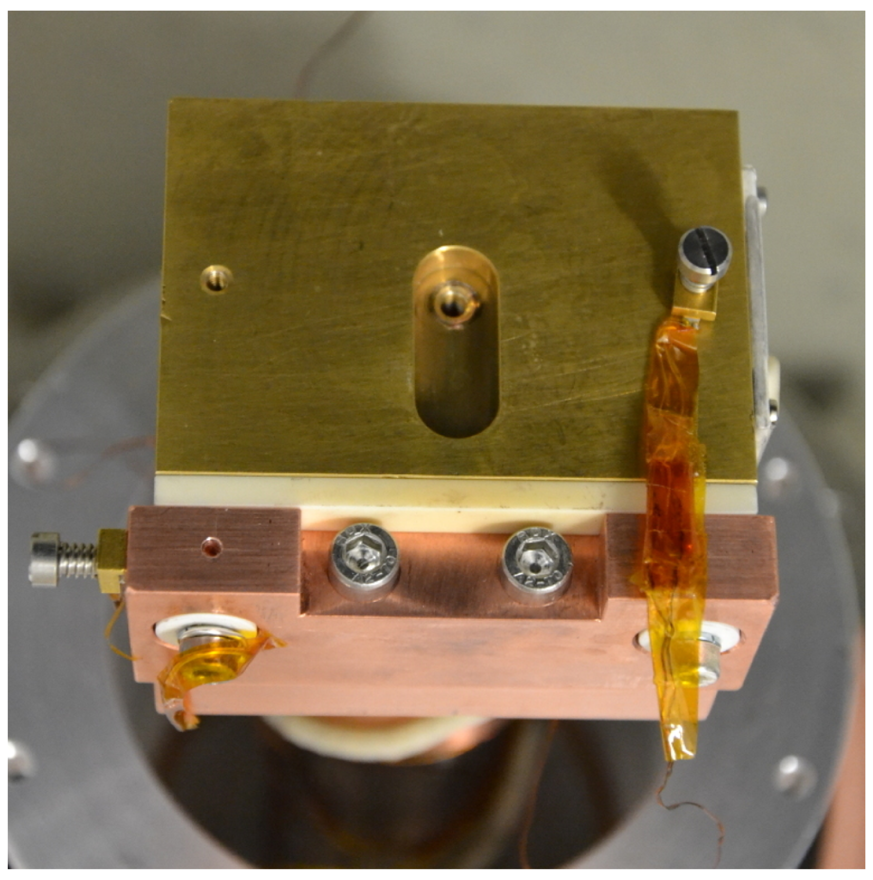




Cryogenic η-scaling has to be investigated!

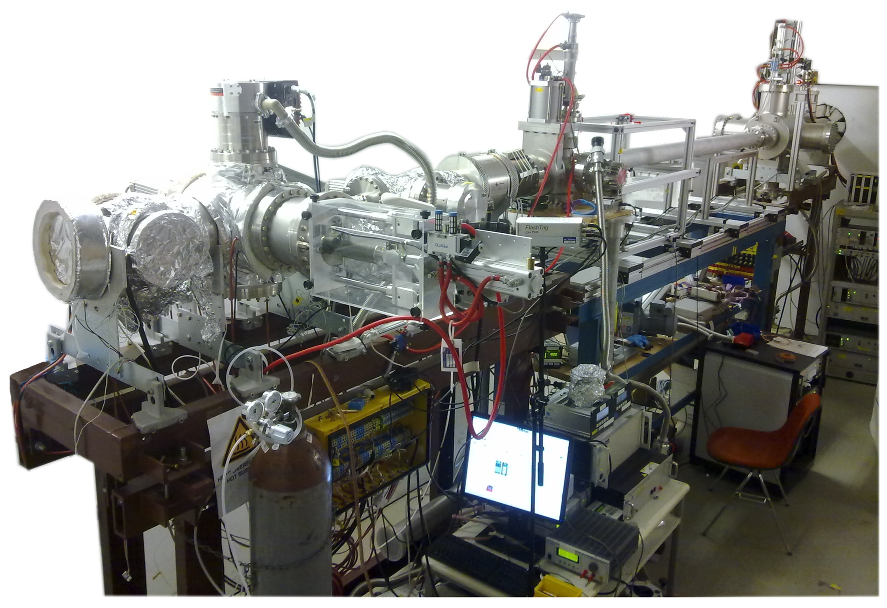
Experimental Setup and Methodology





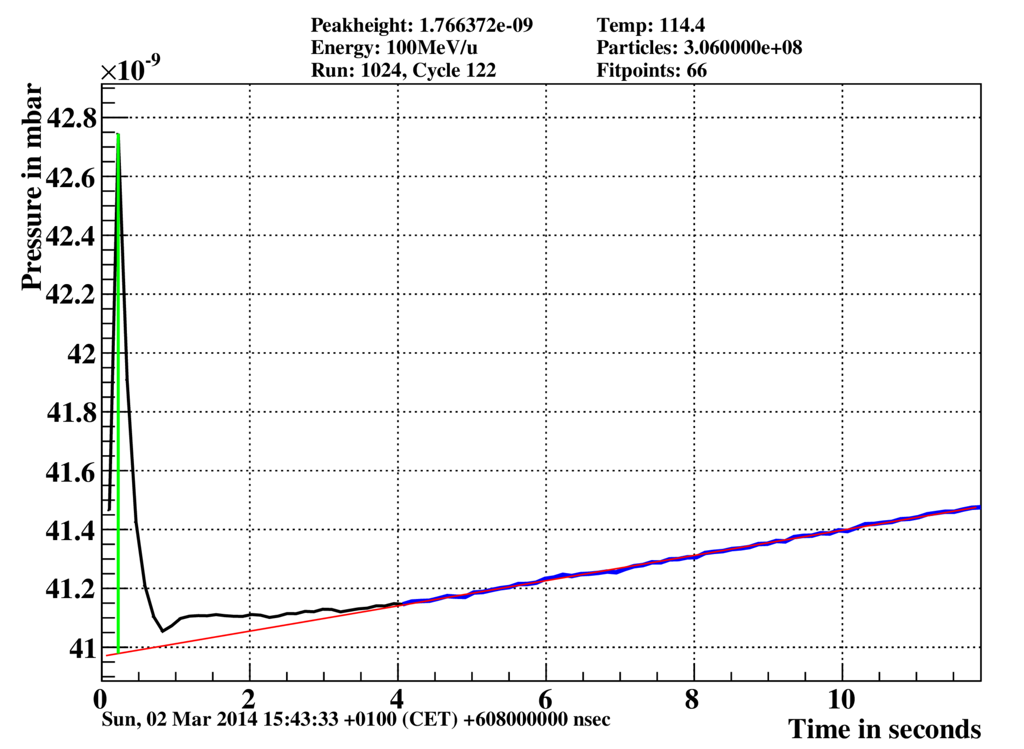
- Warm UHV Diagnostics: carries extractor ion pressure gauge and fast residual gas analyzer.
- Differential pumping line and bakeout procedure ensure a sufficiently low pressure to measure a desorption peak.
- A coldhead and a thermal shield provide the cryogenic environment.
- Diagnostic volume "closed" by vacuum conductance.
- Target assembly equipped with:
  - Temperature sensors – measure thermal reaction.
  - Insulating tile – necessary to measure deposited charge.
  - Ceramic heater – acceleration of warmup.

- Heavy ion beam impact on target → Desorption of gas.
- Pressure relaxation between measurements define maximum repetition rate.
- Fast pressure measurement, triggered by beam impact resolves desorption peak.
- Measurements at different temperatures are taken during warmup, cooldown, at room temperature and at T_{min}=38 K.
- Pressure bumps at critical temperatures during T-ramp → Background slope is eliminated by fitting a first degree polynomial to the relaxed part of the pressure curve (t>4s).
- Peakheight Δp is calculated based on this polynomial.



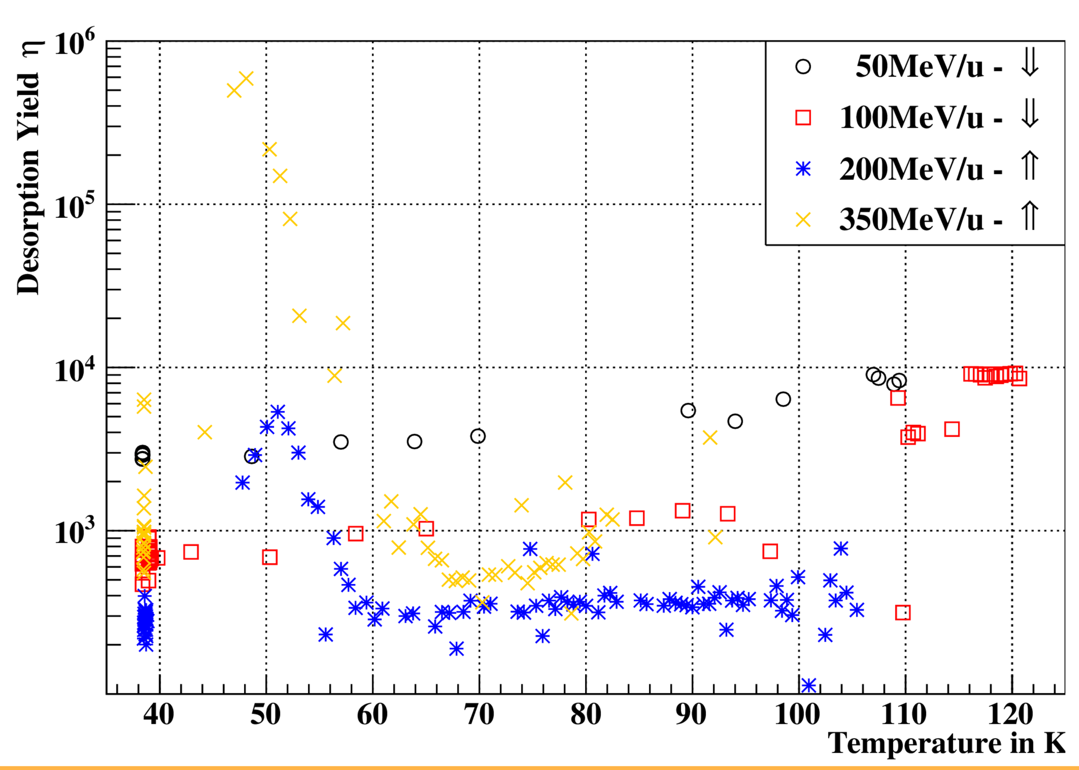
Desorption Yield:

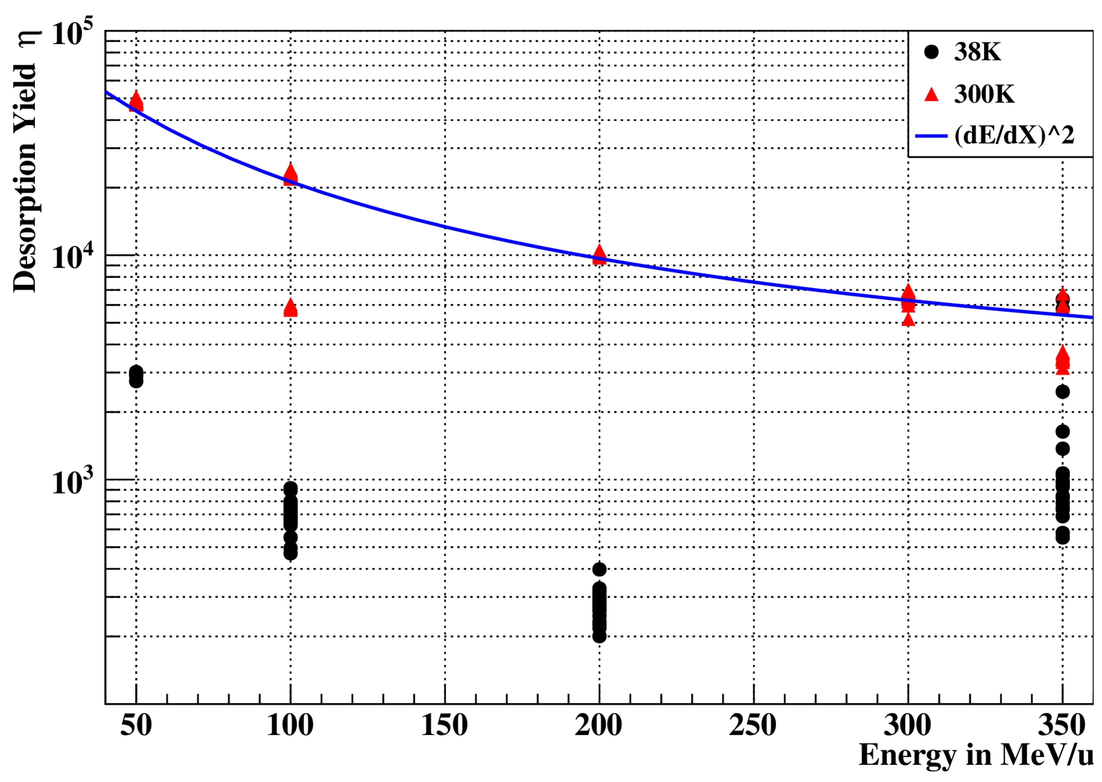
$$\eta = \frac{N_{des}}{N_{beam}} = \frac{\Delta p \cdot V}{N_{beam} k_B T}$$



First Results

- Beamtime with U^{73+} and intensities of the order of 10^8 particles per pulse.
- The peak at T=50 K only occurs with rising T. Raw data has been inspected manually in these regions to check for a possible fault in the analyzing algorithm, but none has been found.
  The temperature slope's direction has a strong influence on the desorption yield.
- Possible explanation: radial T-gradient steeper with activated coldhead → More energy from beam impact dissipates into the inside of the target → Heating the surface above a critical gas release temperature is largely avoided.
- Accuracy of measurement visible in point scattering at T_{min}.
- The falling T-slope is steeper than the rising one, so data is less abundant in the cooldown cycle.

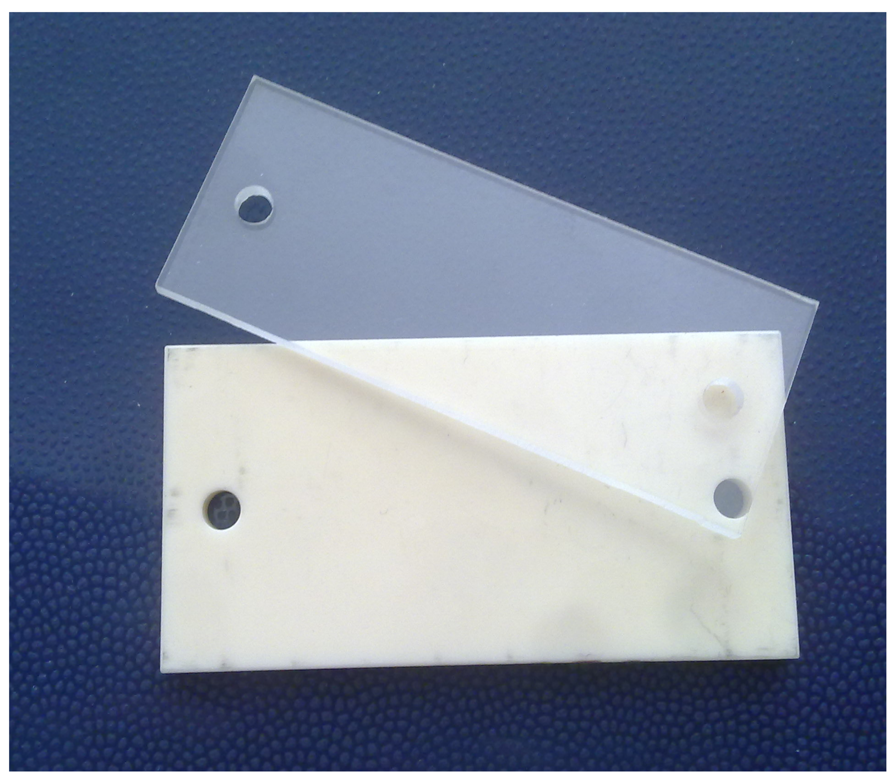




- At room temperature, η exhibits the previously observed $(dE/dX)^n$-scaling.
- Reproducing it is evidence for the setup's performance.
- In a cryogenic environment, this scaling seems to break down: above a critical energy around 200 MeV/u, η starts to rise again.
- New measured cryodesorption yields higher than in previous experiments:
  - Here: Target coldest spot, chamber at room temperature.
  - [3]: Target warmest spot in cold chamber.

Outlook

- Another target made of stainless steel is already prepared. Its heat capacity is comparable to copper, while it's thermal conductivity is lower.
- This target is uncoated, so the coating's influence will also be investigated.
- The current insulation tile is made of Al_2O_3-ceramics and constitutes a major heat barrier. Another tile made of monocrystalline Al_2O_3 has been procured and its influence on T_{min} and η will be examined.
- The influence of the T-slopes direction will be further examined by conducting two measurements which are identical except for the T-slope.
- Different ion species will be used and their influence will be analyzed.



References:
[1] H. Kollmus et. al, AIP Conf. Proc. **773**, 207 (2005)
[2] E. Mahner et. al, Phys. Rev. ST Accel. Beams **14**, 050102 (2011)
[3] L.H.J. Bozyk, Dissertation

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