A detailed wireframe model of a heavy ion synchrotron is shown in the background. It features a large, circular ring structure with various internal components and a smaller, more complex structure extending from the top of the ring.

Charge Exchange Beam Loss in Heavy Ion Synchrotrons: Simulations and Measurements

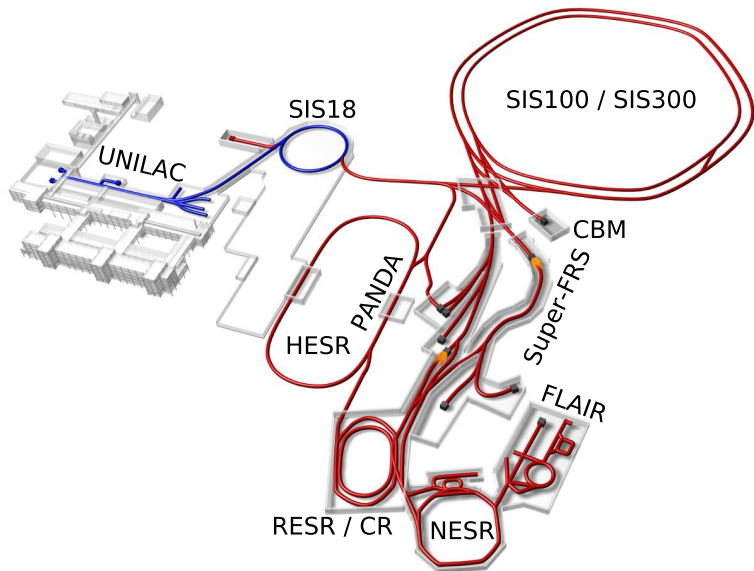
Patrick Puppel

Frankfurt, 18. November 2011

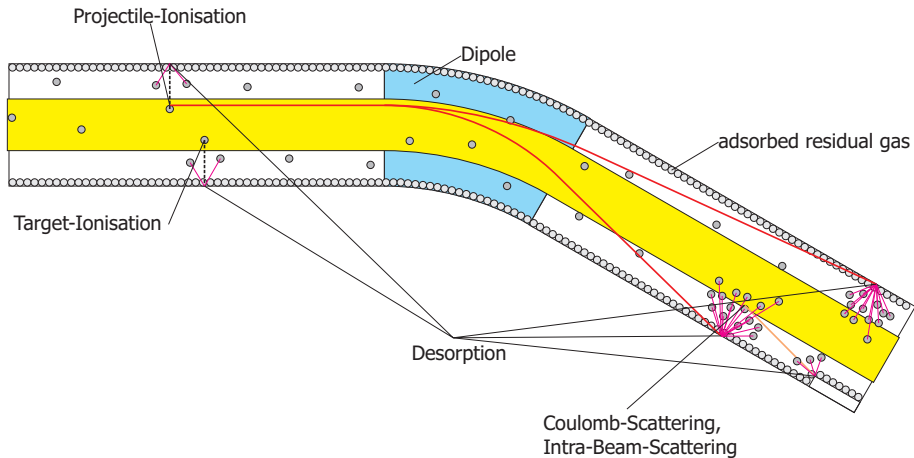
- 1 Beam Loss and Dynamic Vacuum
- 2 Benchmarking of the Strahlsim Code
- 3 Simulations for SIS100
- 4 Summary

Beam Loss and Dynamic Vacuum

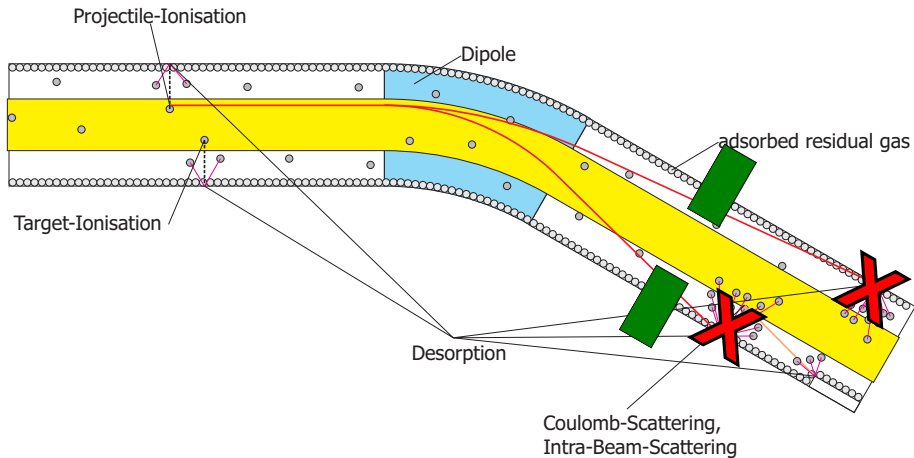
The FAIR Project



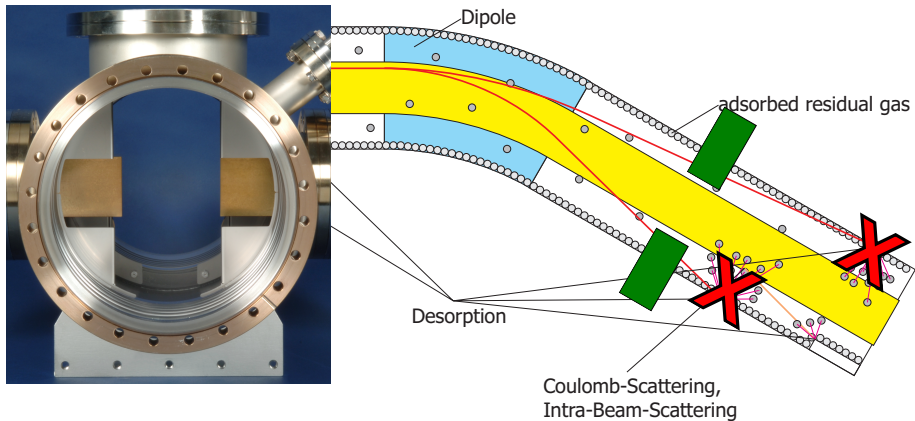
Charge Exchange Beam Loss



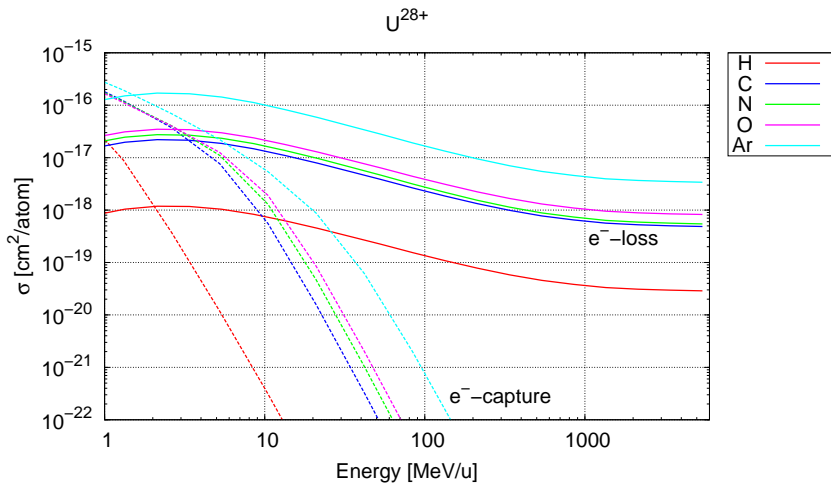
Charge Exchange Beam Loss



Charge Exchange Beam Loss



Charge Exchange Cross Sections



V. Shevelko, private communication

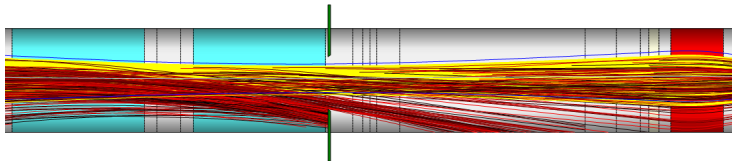
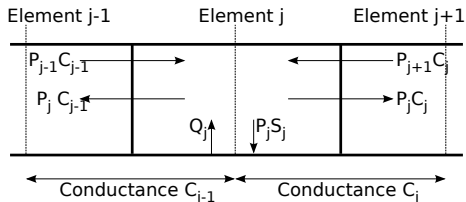
Dynamic Vacuum and Beam Loss Simulations

Time and Space Resolved Pressure Profiles

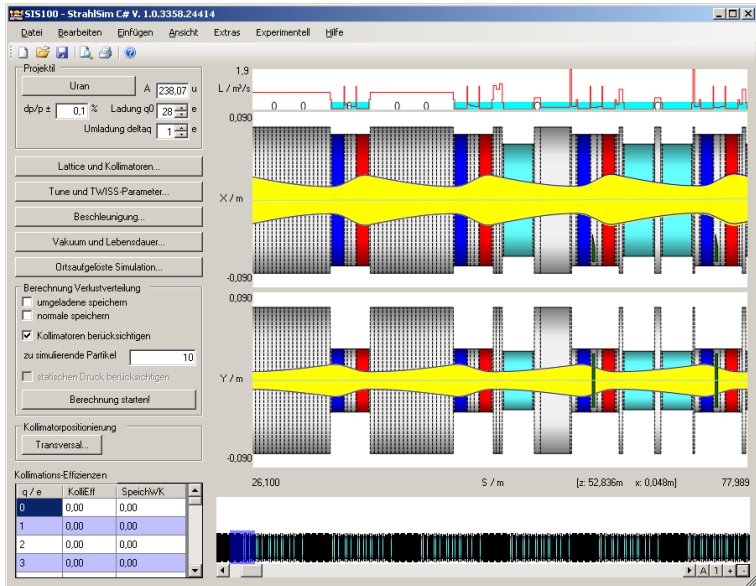


In order to simulate the dynamic vacuum and beam loss over a synchrotron cycle, one has to account for

- ▶ Distribution of the charge exchanged ions
- ▶ Initial static pressure profile and pressure evolution
- ▶ Dynamic and systematic beam losses
- ▶ Properties of the synchrotron cycle

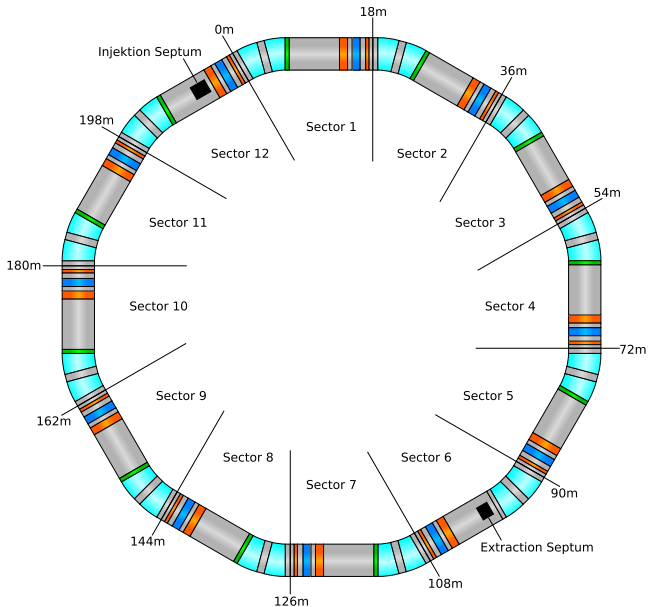


The StrahlSim Program

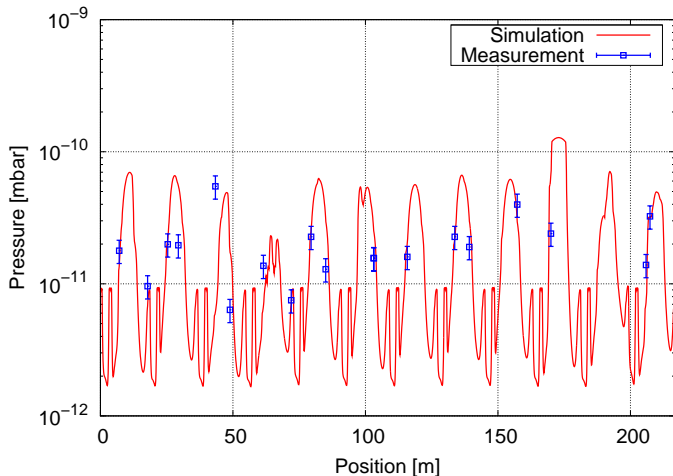


Benchmarking of the StrahISim Code

Design of SIS18



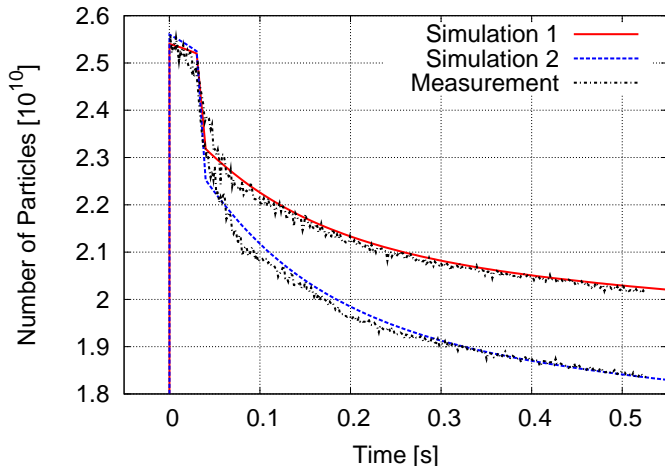
Simulated and Measured Static Pressure Profile of SIS18



$$P_{\text{simulated}} = 2.0 \times 10^{-11} \text{ mbar}$$

$$P_{\text{measured}} = 2.6 \times 10^{-11} \text{ mbar}$$

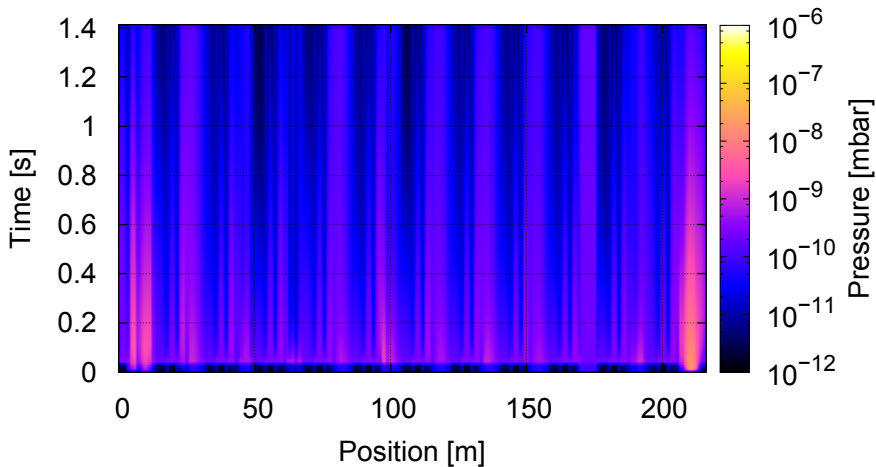
Beam Loss of U^{28+} in SIS18



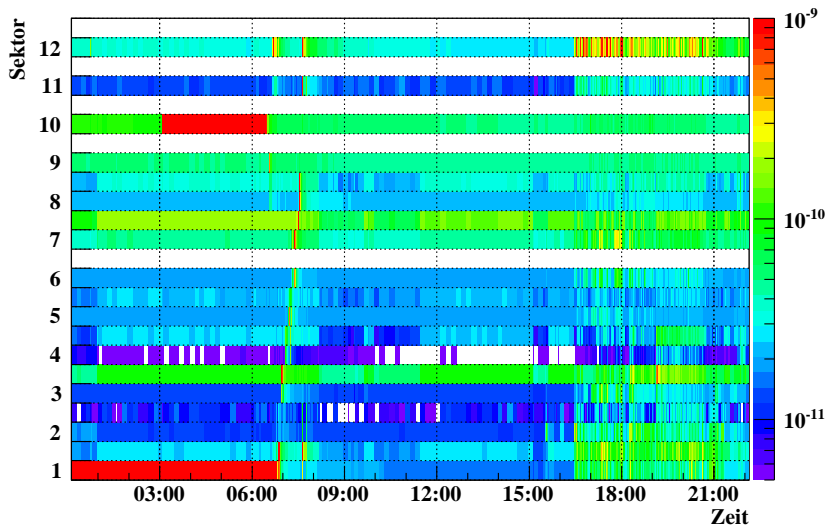
Simulation 1: 2.9×10^{10} U^{28+} ions, 12.4 % injection and 7.5 % rf-capture losses

Simulation 2: 3.2×10^{10} U^{28+} ions, 20.0 % injection and 10.0 % rf-capture losses

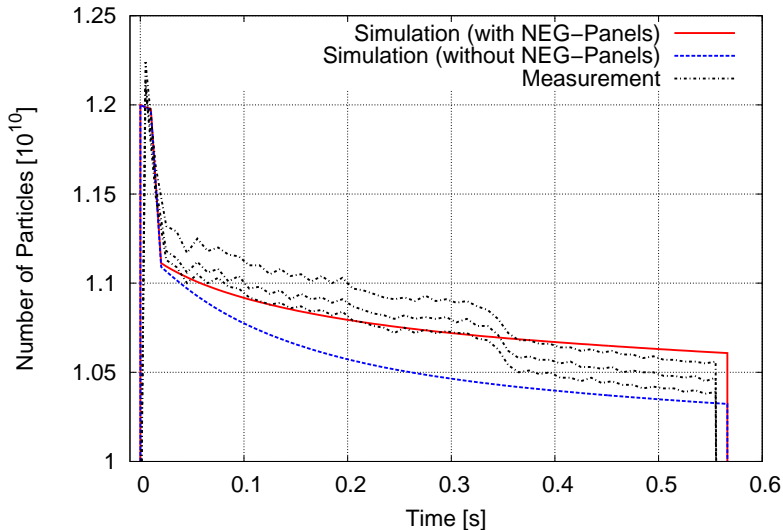
Simulated Pressure Evolution



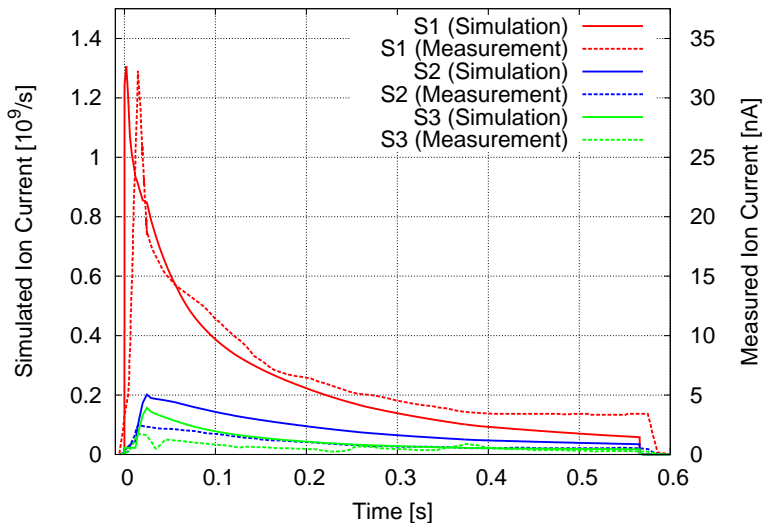
Systematic Pressure Rise during High Current Operation



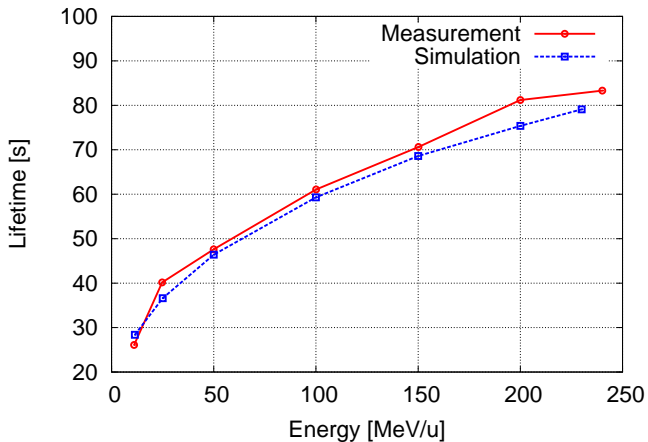
Beam Loss of Ta²⁴⁺ in SIS18



Currents on Ion Catchers

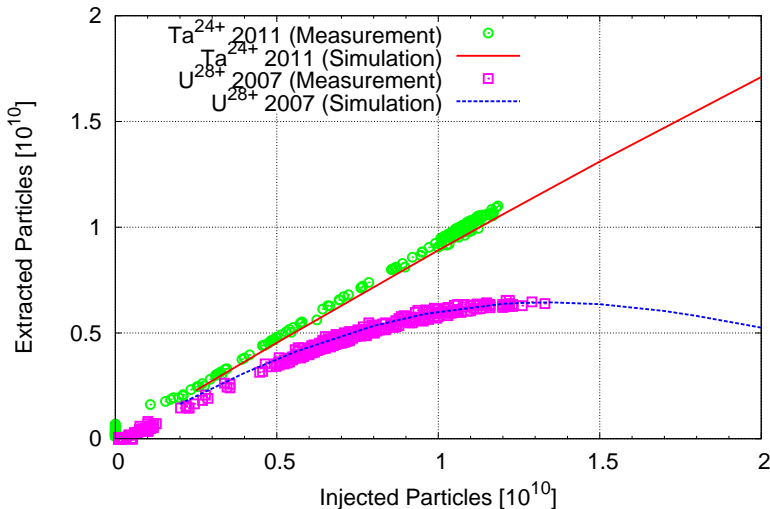


Beam Lifetime for Ta^{24+}



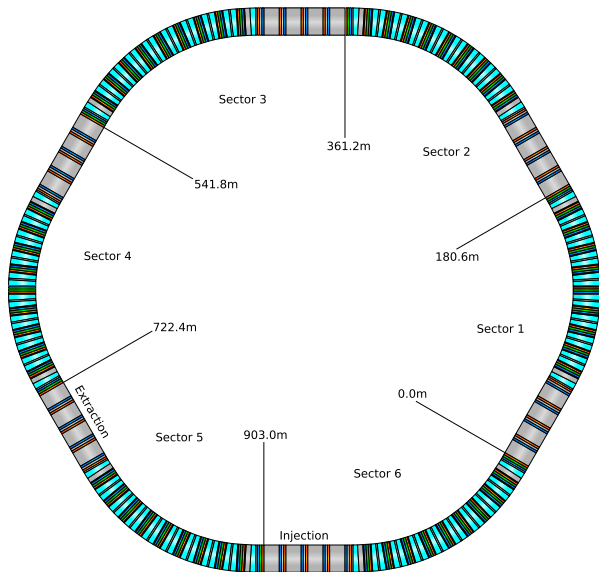
$$P_{\text{sim}} = 7 \times 10^{-11} \text{ mbar}$$

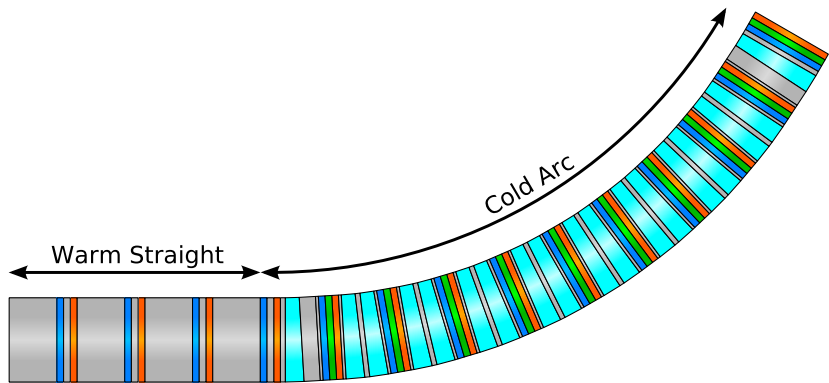
Injected vs. Extracted Particle Numbers



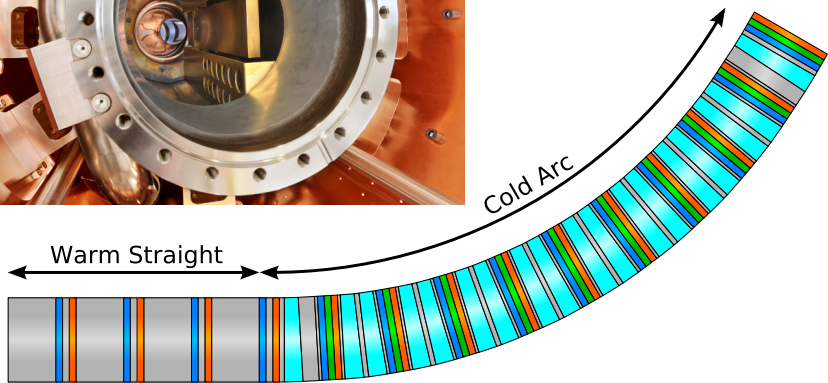
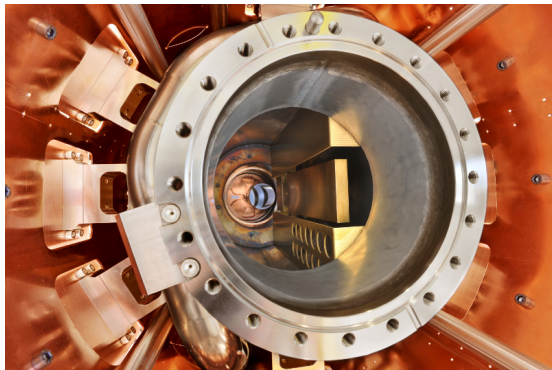
SIS100 Simulations

Design of SIS100

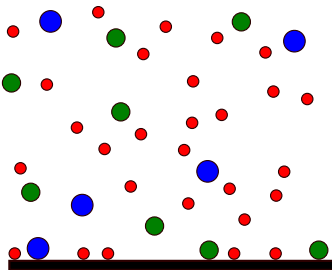
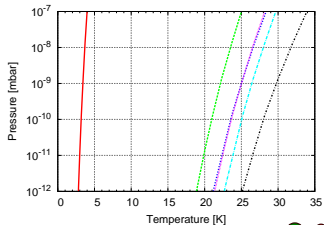
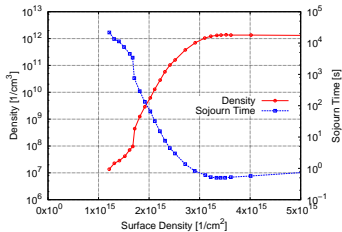




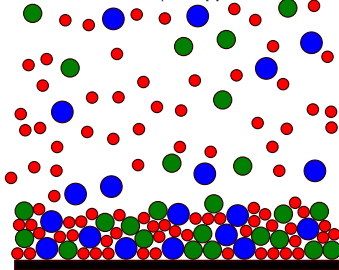
Design of SIS100



Simulation of Cryogenic Surfaces

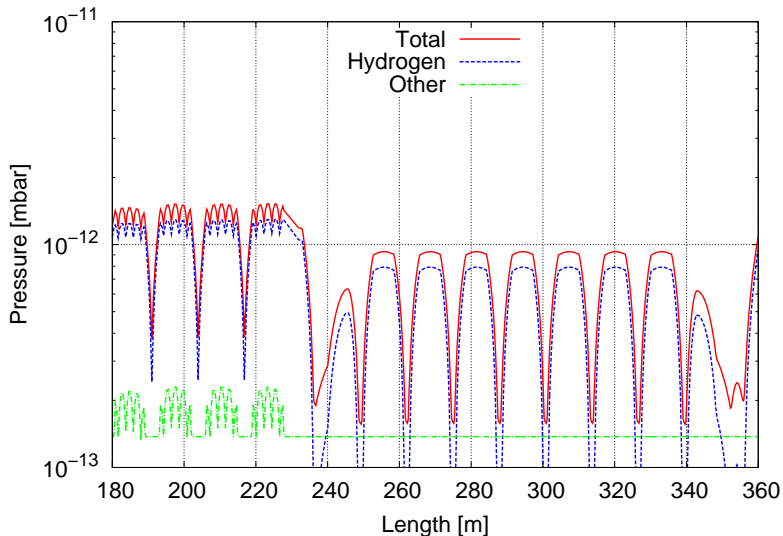


Cryoadsorption

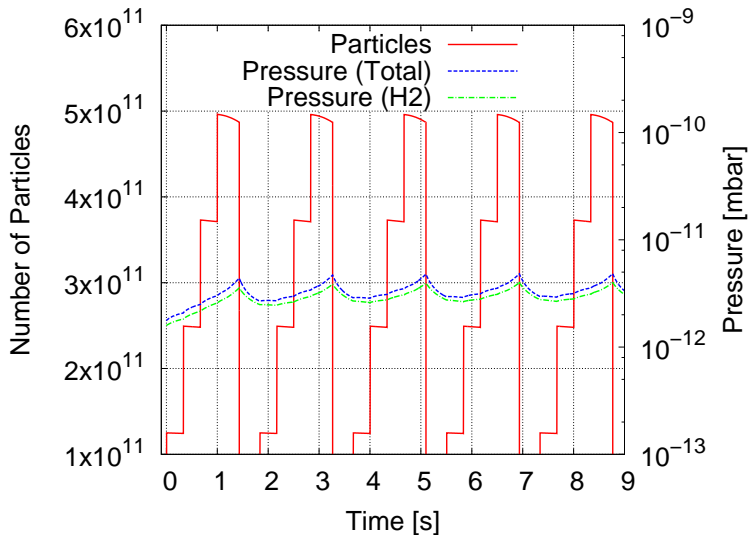


Cryocondensation

Simulated Static Pressure Profile of SIS100

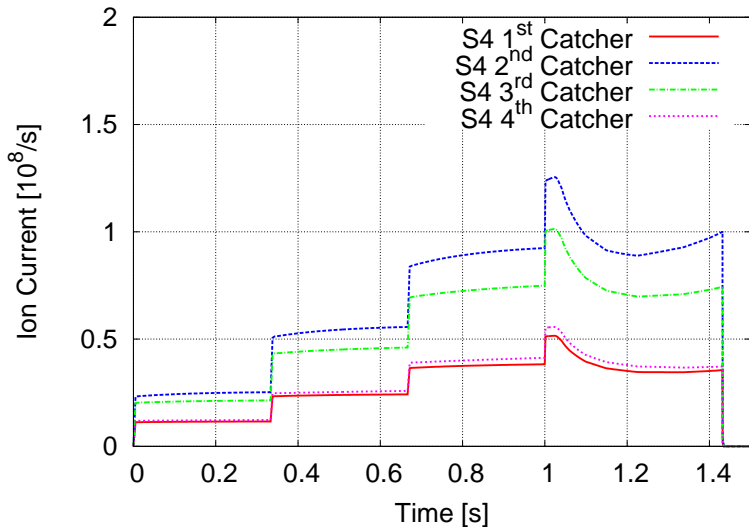


Simulated Beam Loss for U²⁸⁺ Fast Extraction



Current on Ion Catchers

Fast Extraction



Beam Energy Deposition

Fast Extraction

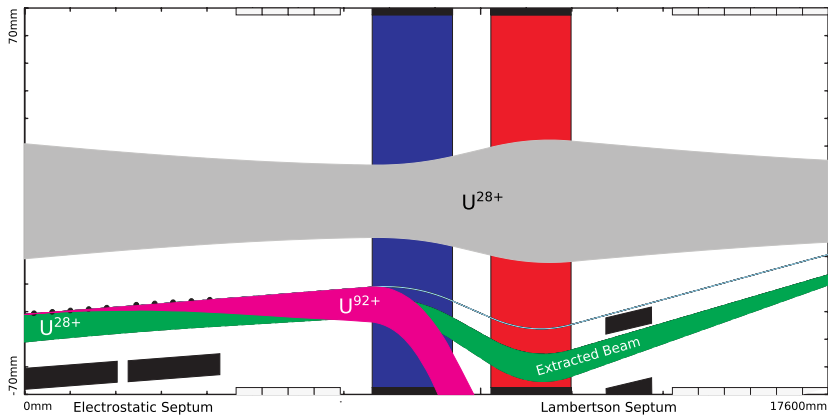


Beam energy deposition on the ion catchers within one sector of SIS100 during a cycle with fast extraction.

Ion Catcher	Peak Load [W]	Average Load [W]
1	3.6	0.5
2	10.3	1.4
3	7.7	1.1
4 – 10	3.9	0.6

The total average load is about 43 W.

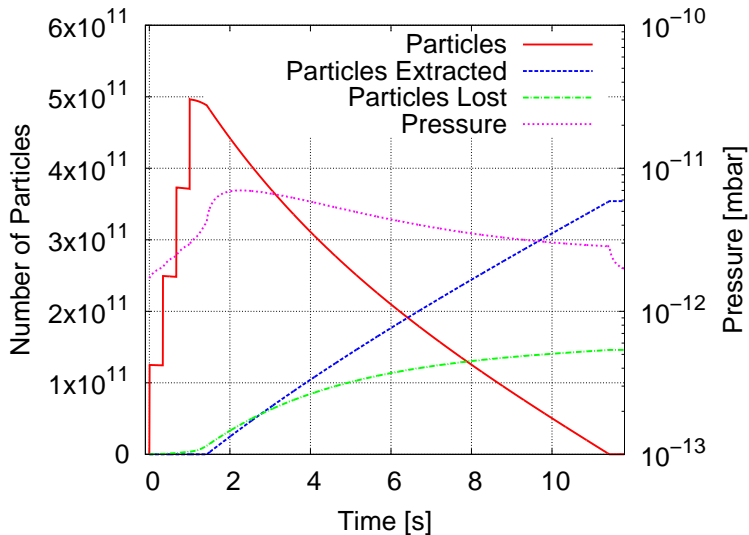
Slow Extraction of U^{28+}



Technical Design Report SIS100

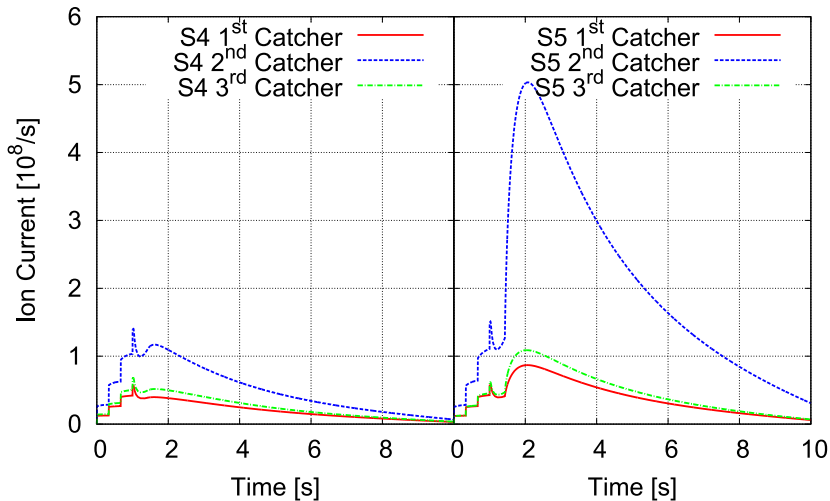
Simulated Beam Loss for U²⁸⁺

Slow Extraction



Current on Ion Catchers

Slow Extraction



Beam Energy Deposition

Slow Extraction

Beam energy deposition on the ion catchers within one sector of SIS100 during a cycle with slow extraction.

The differing numbers for the ion catchers in sector 5 are given in brackets.

Ion Catcher	Peak Load [W]		Average Load [W]	
1	4.1	(9.0)	1.5	(3.1)
2	12.1	(52.0)	3.8	(16.7)
3	5.3	(11.3)	1.9	(3.7)
4	3.1	(3.8)	1.2	(1.4)
5 – 10		3.1		1.2

The total average load is about 110 W.

Summary

- ▶ Beam loss simulations with time and space resolved pressure profiles have been implemented.
- ▶ The simulations for U^{28+} and Ta^{24+} show a good agreement with measurements.
- ▶ Simulation results for U^{39+} are too optimistic compared to the measurements. Further investigations are necessary.
- ▶ It was shown, that a stable operation of SIS100 with high intensity U^{28+} beams is possible.
- ▶ The beam energy deposition on the ion catchers has been calculated (110 W for SX and 43 W for FX).

Thank you for your attention!

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