Experience with a Pulsed Gas Stripper from First User Beam Times at GSI

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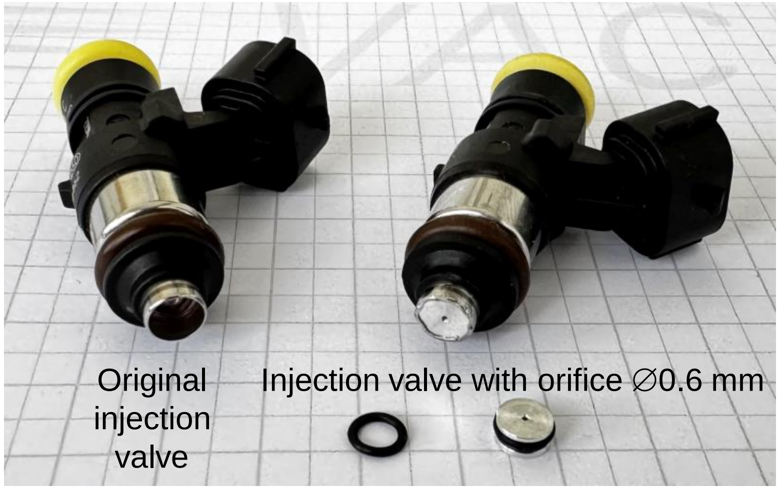
Pulsed gas stripper for hydrogen

Hydrogen difficult to pump ⇒ need to reduce gas load ⇒ pulsed stripping

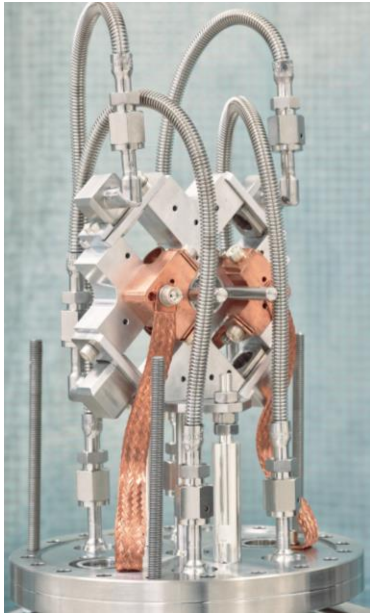
Fast injection valves

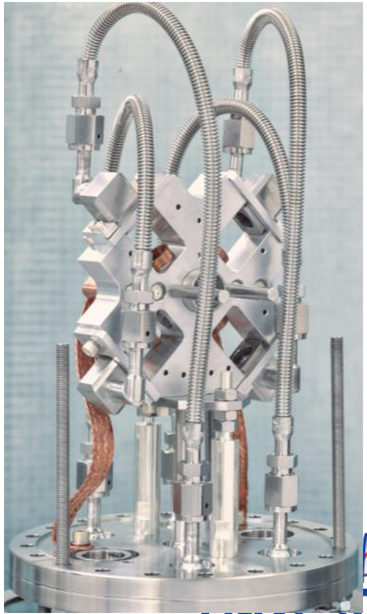


Restrict gasflow ⇒ increase system pressure

see poster for more details

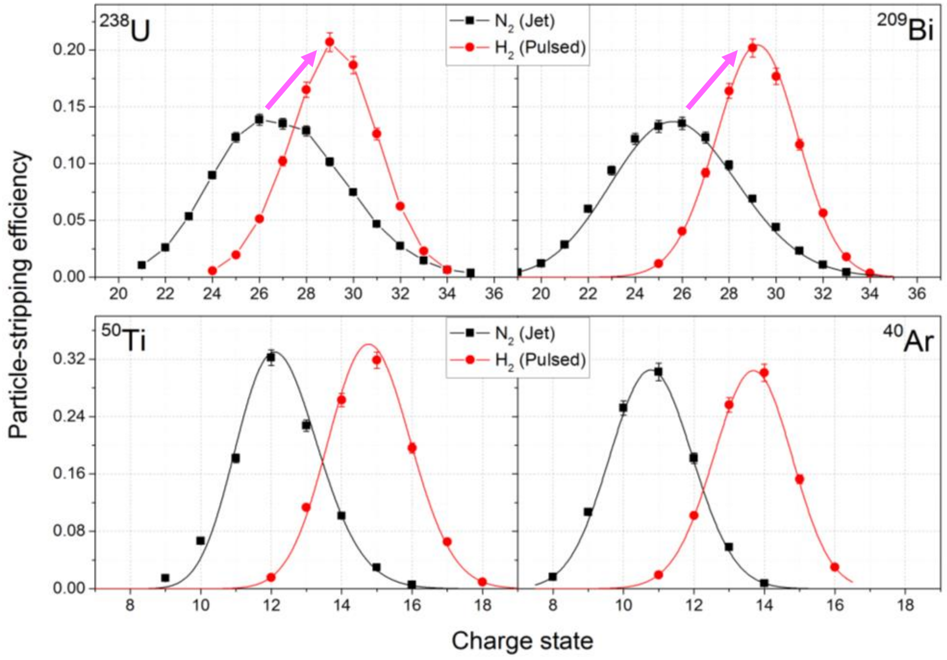
New stripper setup with 4 gas valves





Why hydrogen?

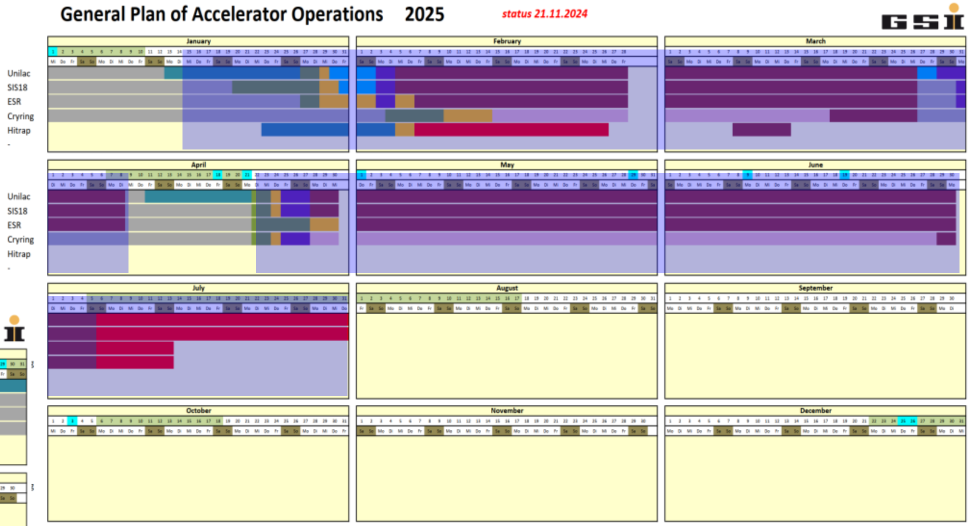
Comparison of **nitrogen** and **hydrogen** stripping



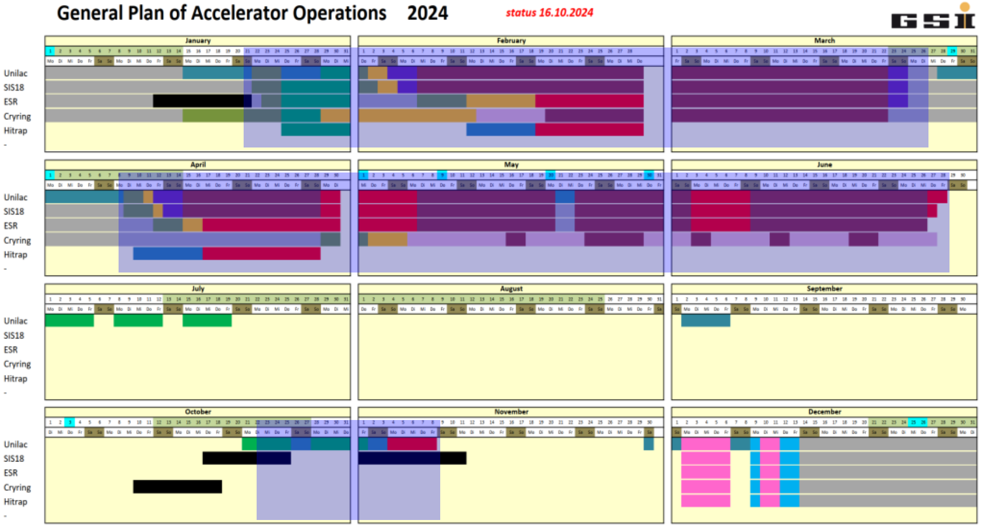
- Heavy ions (like U, Bi, ...):
  - narrower distribution
  - **higher beam intensity**
- All ions:
  - higher charge state
  - less need for second stripping

P. Scharrer et al., Proc. LINAC16, TUOP03

Beam times 2024 and 2025



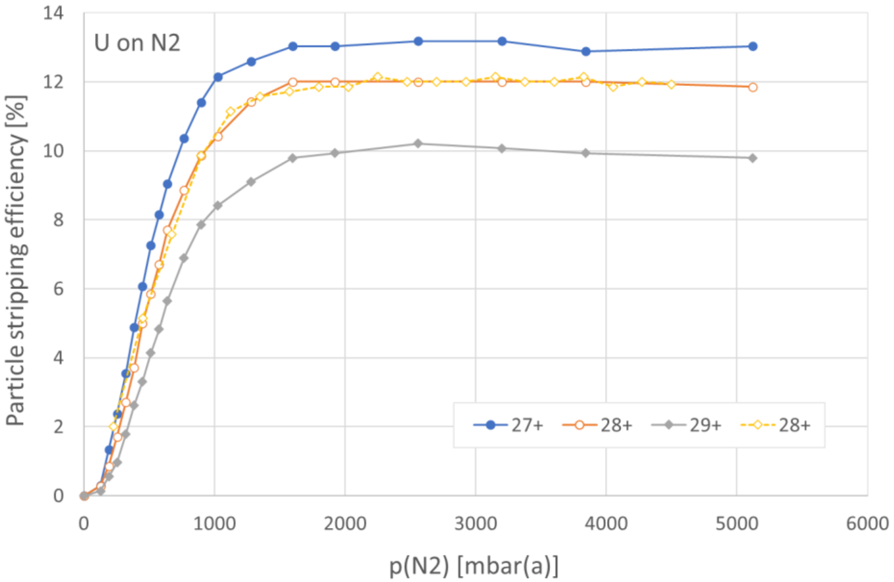
Pulsed stripper operation
2x 6 months

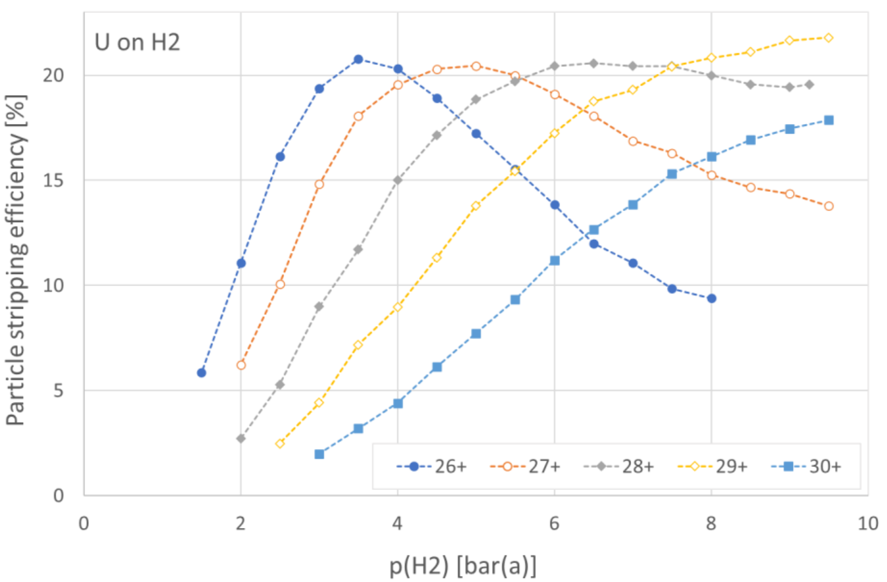


15 Ions stripped by N_2:
CH_3, O_2, Ar, Ti, Cr, Fe, Ni, Kr, Mo, Ag, Er, Au, Pb, Bi, U

U also stripped by H_2

Exemplary data: stripping Uranium by N_2 and H_2



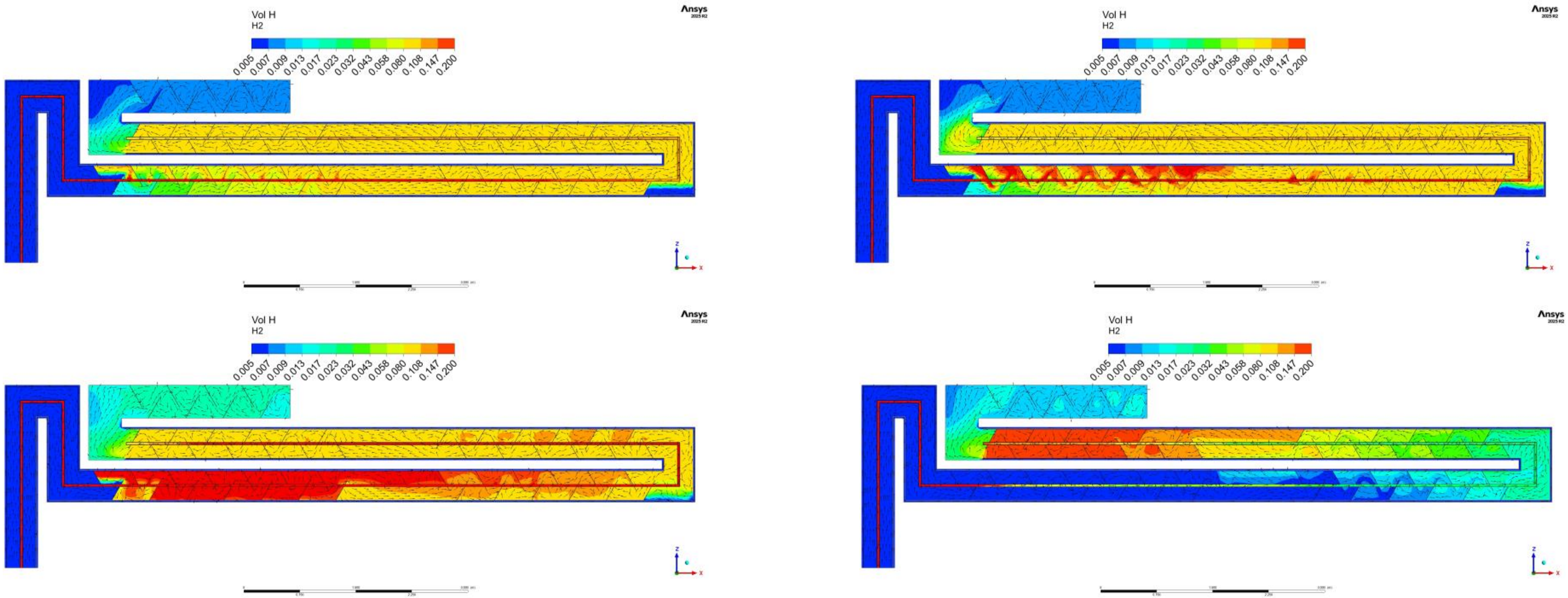


stripping by nitrogen: equilibrium charge state distribution reached
solid line: valve with orifice
dashed line: original valve, pressure scaled by 4.5

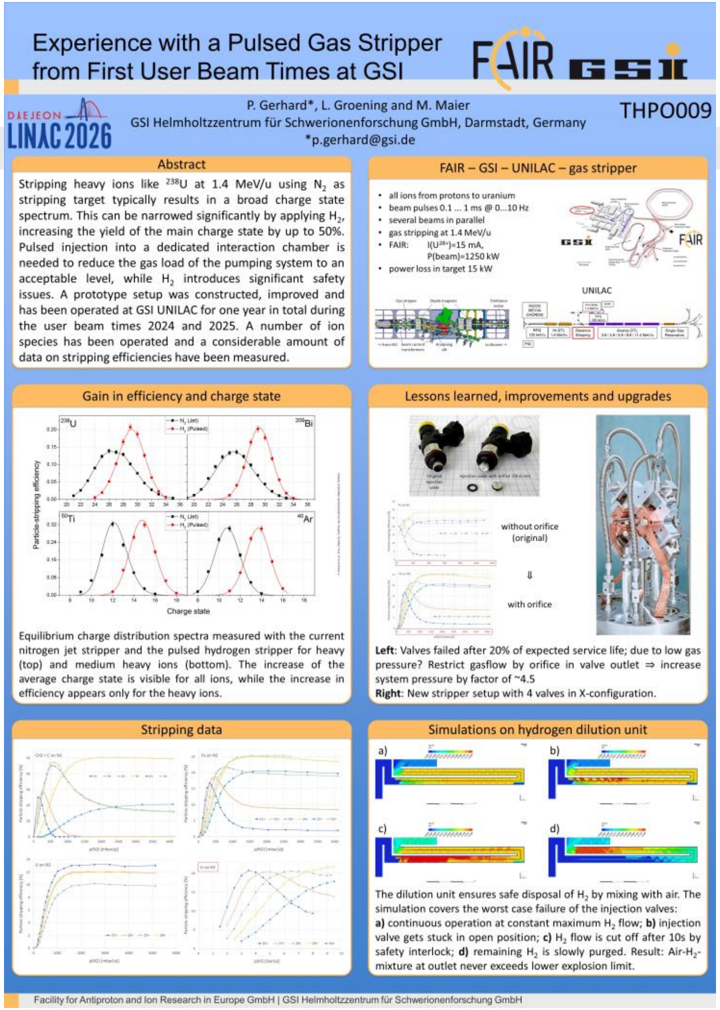
stripping by hydrogen: equilibrium charge state distribution not reached
original valve
(data taken in 2024)

Disclaimer: significant systematic and random errors should be considered

Simulation of safe hydrogen disposal



The safe disposal of H_2 under regular operation and worst case failure conditions was investigated by simulations.


Experience with a Pulsed Gas Stripper from First User Beam Times at GSI

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THPO009

Abstract

Stripping heavy ions like ^{238}U at 1.4 MeV/u using N_2 as stripping target typically results in a broad charge state spectrum. This can be narrowed significantly by applying H_2, increasing the yield of the main charge state by up to 50%. Pulsed injection into a dedicated interaction chamber is needed to reduce the gas load of the pumping system to an acceptable level, while H_2 introduces significant safety issues. A prototype setup was constructed, improved and has been operated at GSI UNILAC for one year in total during the user beam times 2024 and 2025. A number of ion species has been operated and a considerable amount of data on stripping efficiencies have been measured.

FAIR – GSI – UNILAC – gas stripper

- all ions from protons to uranium
- beam pulses 0.1 ... 1 ms @ 0...10 Hz
- several beams in parallel
- gas stripping at 1.4 MeV/u
- FAIR: $I(U^{28+})$=15 mA, P(beam)=1250 kW
- power loss in target 15 kW

UNILAC

Gain in efficiency and charge state

Equilibrium charge distribution spectra measured with the current nitrogen jet stripper and the pulsed hydrogen stripper for heavy (top) and medium heavy ions (bottom). The increase of the average charge state is visible for all ions, while the increase in efficiency appears only for the heavy ions.

Lessons learned, improvements and upgrades

without orifice (original)

⇓

with orifice

Left: Valves failed after 20% of expected service life; due to low gas pressure? Restrict gasflow by orifice in valve outlet ⇒ increase system pressure by factor of ~4.5
Right: New stripper setup with 4 valves in X-configuration.

Stripping data

Simulations on hydrogen dilution unit

a) b) c) d)

The dilution unit ensures safe disposal of H_2 by mixing with air. The simulation covers the worst case failure of the injection valves: **a)** continuous operation at constant maximum H_2 flow; **b)** injection valve gets stuck in open position; **c)** H_2 flow is cut off after 10s by safety interlock; **d)** remaining H_2 is slowly purged. Result: Air-H_2-mixture at outlet never exceeds lower explosion limit.

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Thank you for your attention

and

looking forward to seeing you at

my poster THPO009