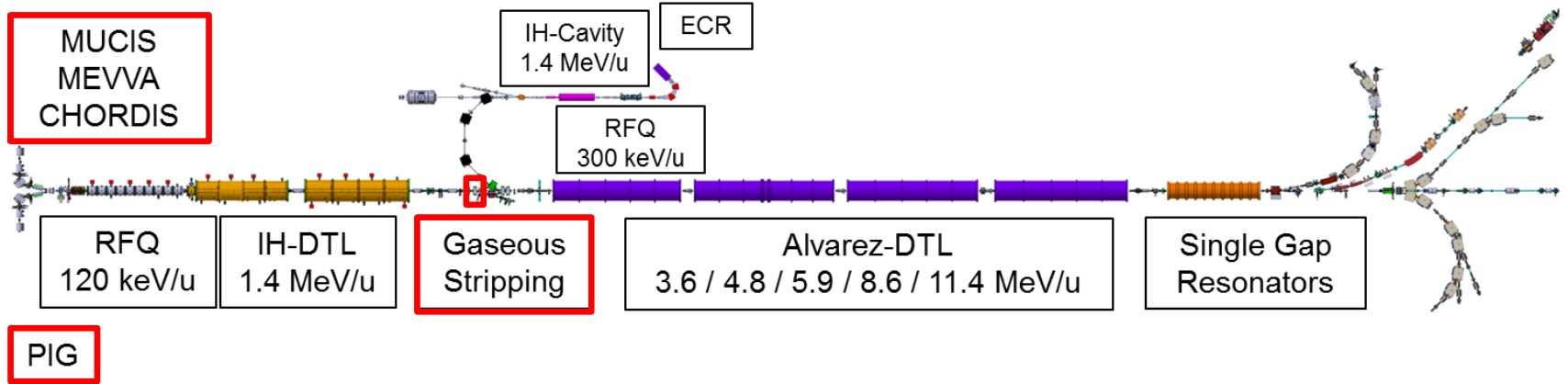


UNILAC

Pulsed Hydrogen Gas Stripper

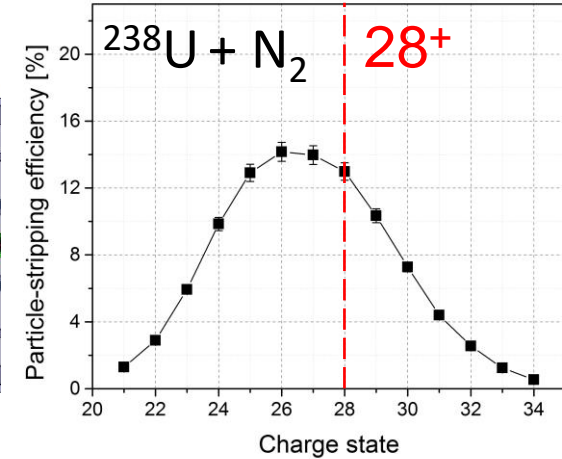
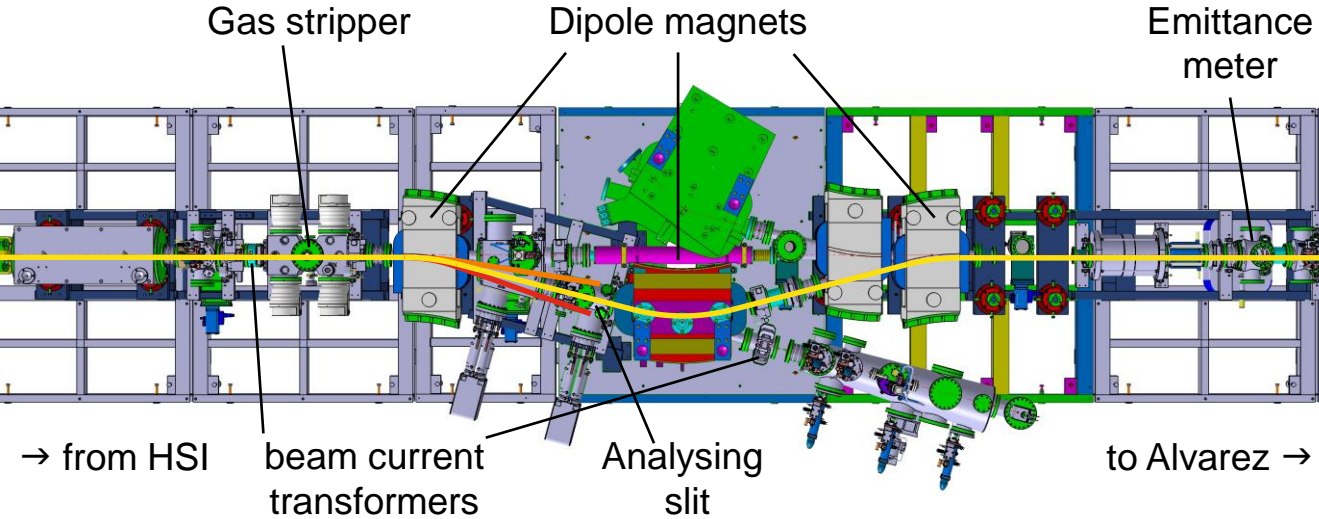
11th BGC Collaboration Meeting
Liverpool University, 02.12.2024
P. Gerhard / PSU, GSI, Darmstadt
on behalf of Pulsed Gas Stripper team

- Heavy ion stripping at UNILAC
- Pulsed hydrogen gas stripper: Why are we doing this?
- Link to Beam Gas Curtain (BGC) profile monitor
- Performance of our gas target and some experience
- Conclusions

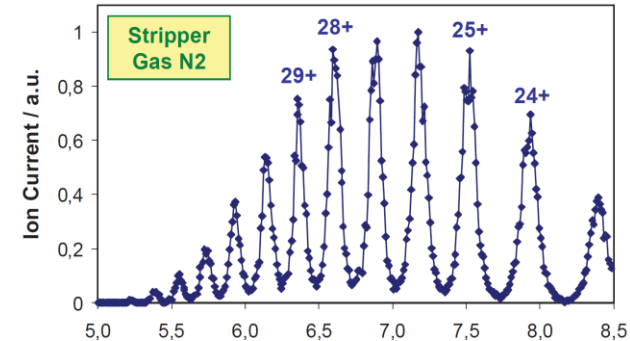


- UNILAC: Heavy ion accelerator
- High current ion sources deliver low charge states
- Increase of charge state highly desirable to facilitate acceleration
- Use gas stripper after injector linac at (RFQ + IH-DTL) 1.4 MeV/u

Increase Charge State: The Gas Stripper Section

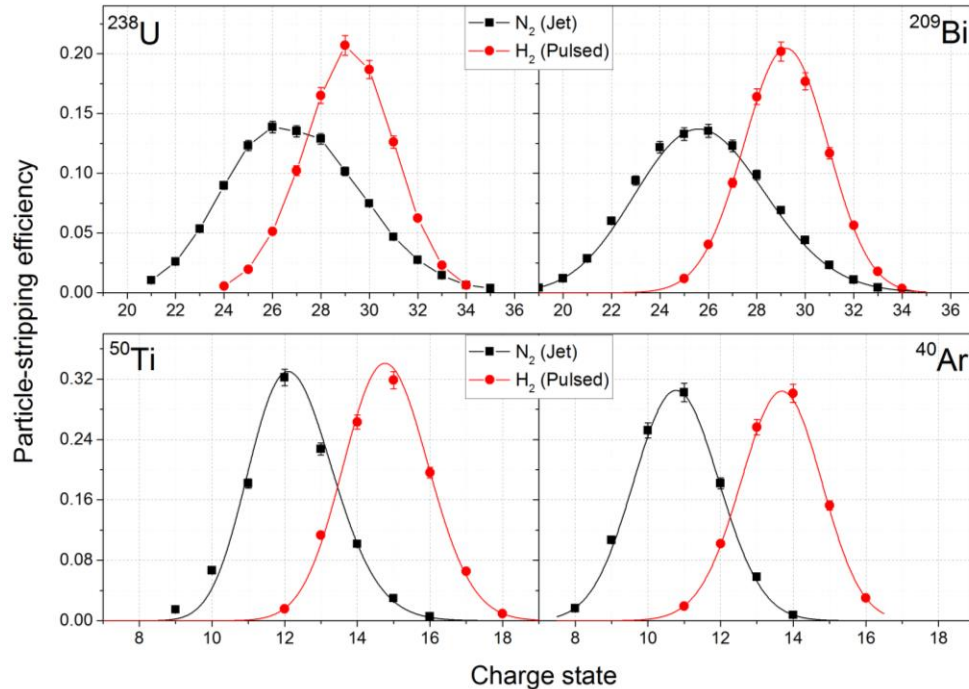


- Stripping due to collisions of ions with target particles
- Increased charge state(s), distribution ⇒ **loss of up to 85% of beam**
- Figure of merit: Stripping efficiency into desired charge state
- Separation and selection of desired charge state, e.g. U^{28+}



Increase Stripping Efficiency: Use Hydrogen

Measured charge state distributions with highest $\langle q \rangle$

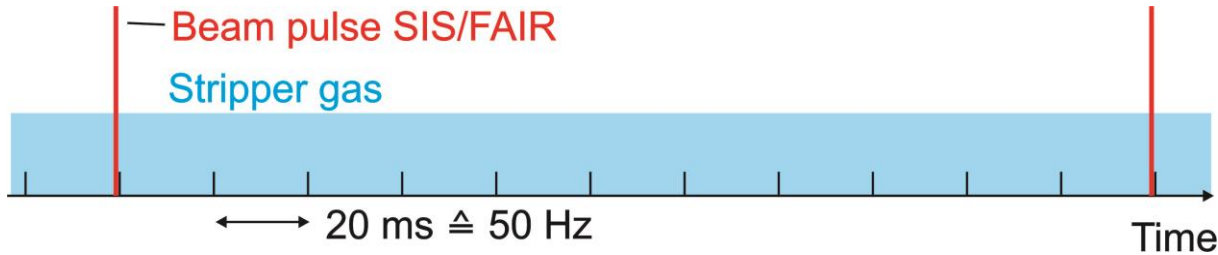


- All ions:
 - higher average charge state
 - less rf power
 - higher energy in SIS18
 - increased space charge effects

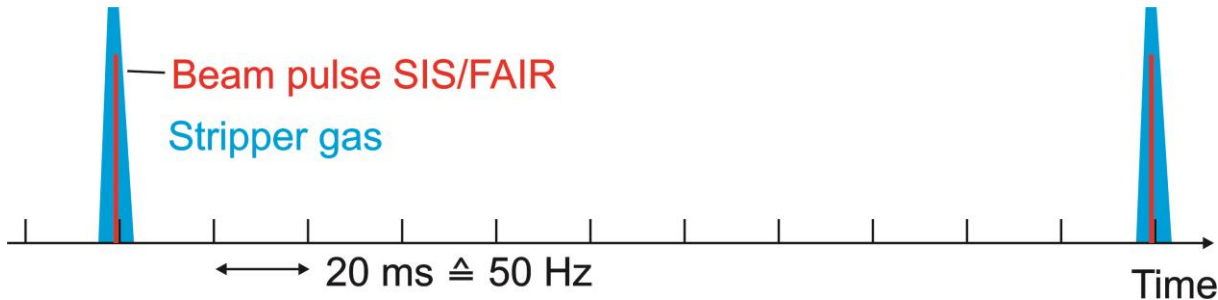
- **Heavy ions (U, Bi):**
 - **more narrow distribution**
 - **increased stripping efficiency**
 - **higher beam intensity**

H_2 : need to reduce gas load!

Reduce Gas Load: Make Use of Low Duty Cycle! ⇒ Pulsed Gas Injection

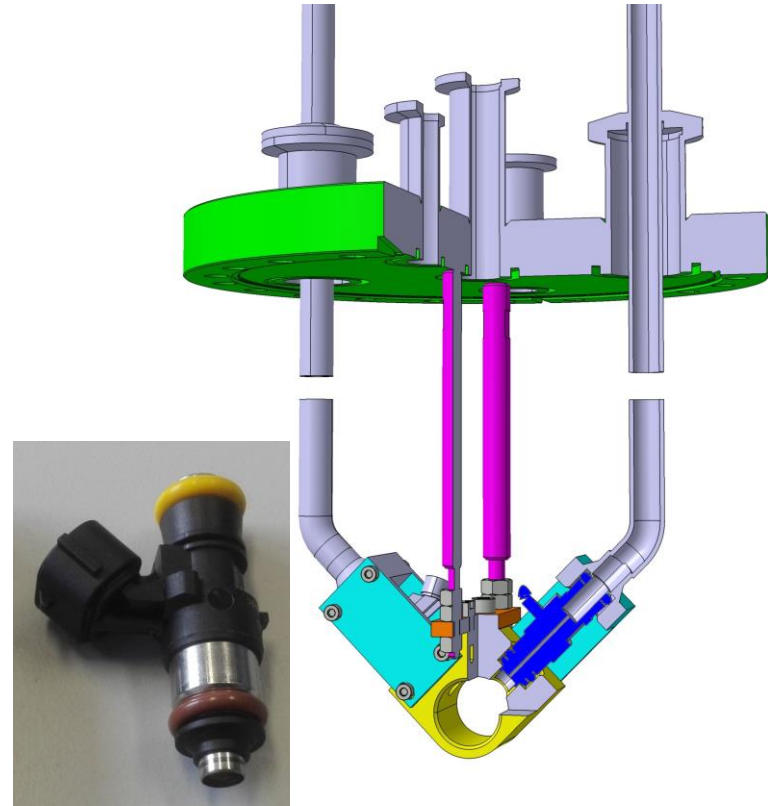
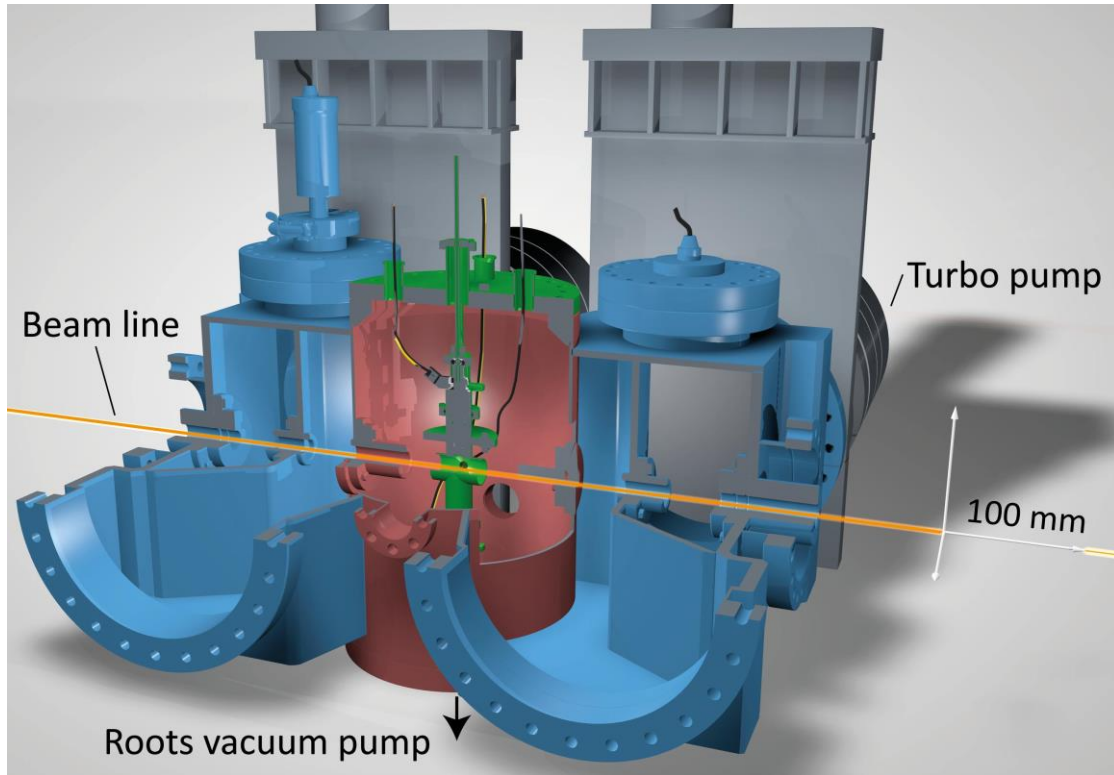


N_2 jet stripper



New pulsed
stripper

UNILAC Pulsed Gas Stripper



Some Technical Details

Valves: automotive magnetic injector valves

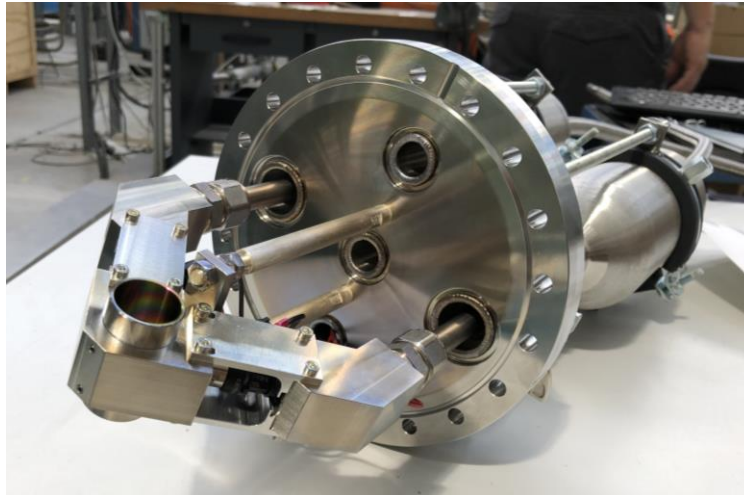
- 1. Direct liquid injection valve, not compatible with gas operation, fast ($< \text{ms}$), directed spray, high pressure (250 bar)
- 2. Intake-manifold gas injection valve, slower ($\sim \text{ms}$), low pressure (max. 12 bar)
- no (intended) super-sonic expansion/jet, simple annular outlet, containment by “stripping cell” (pipe)
- no theoretical investigations so far
- cooling by medium
- $\sim 200 \text{ €}$

Controller: automotive test stand and development equipment

- flexible programming, current profiles
- $\sim 15 \text{ k€}$



Liquid and gaseous media valves



Link to BGC

- Injection of a 2-dim. gas curtain similar to our former gas jet
- Possible reduction of gas load by pulsed injection?

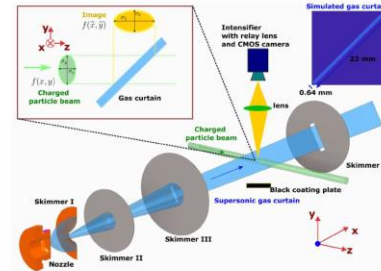
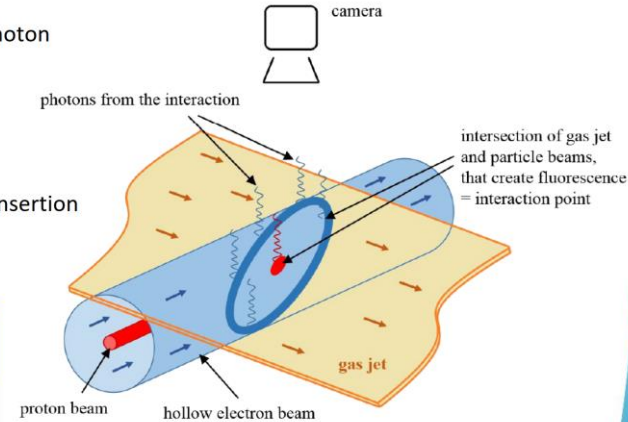
Principle of Fluorescence Gas Curtain Monitor

The 2-dim transverse profile Beam Gas Curtain Monitor features are:

- Sheet of gas
- Observation of the fluorescence photon
- Gas curtain at 45° angle
⇒ 2-dim transverse distribution

Advantage:

- Non-invasive to particle beam
- Compact installation due to short insertion



P. Forck et al., Fluorescence Profile Monitor

12th ARD-ST3 meeting, 4th July 2024

Stripping target characterization

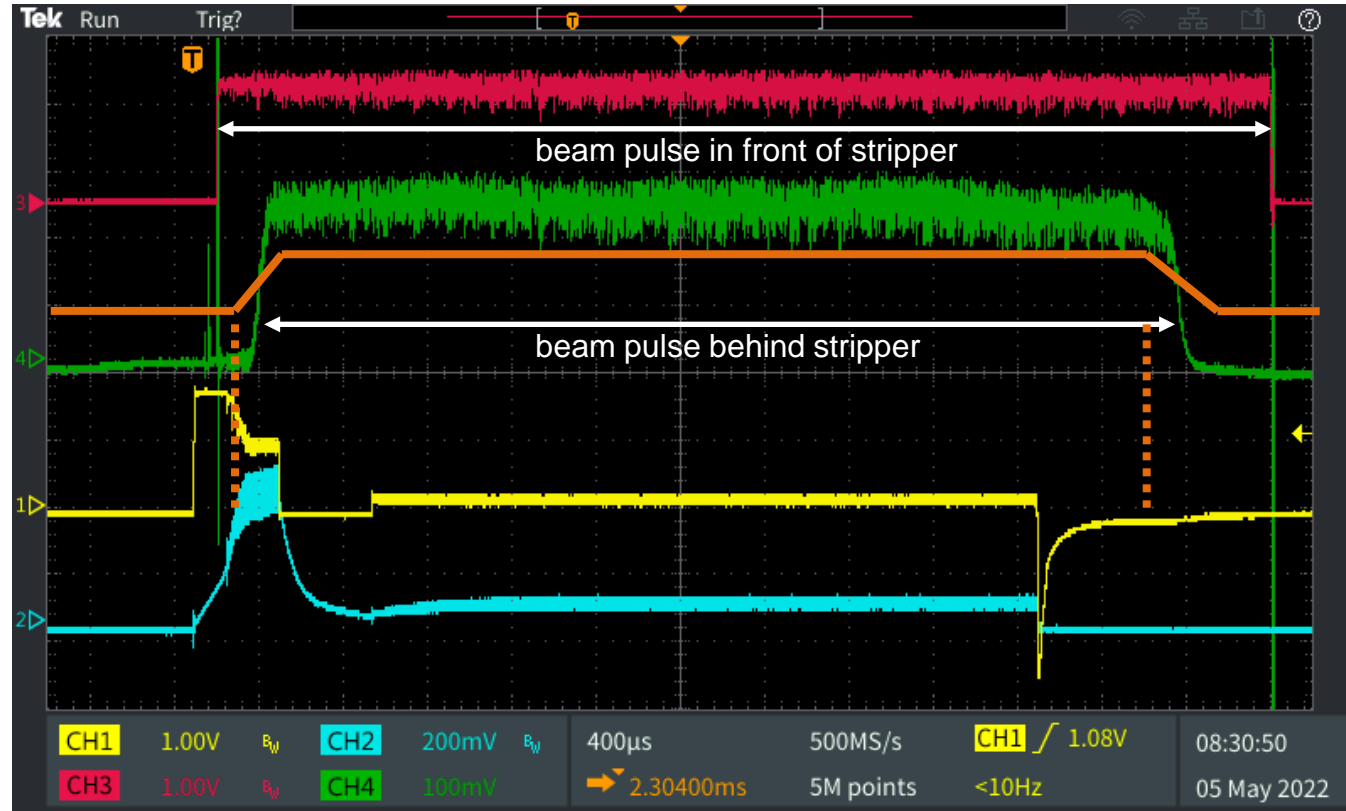
Beam current unstripped

Valve opening /
stripping target build up
and dissipation

Beam current stripped

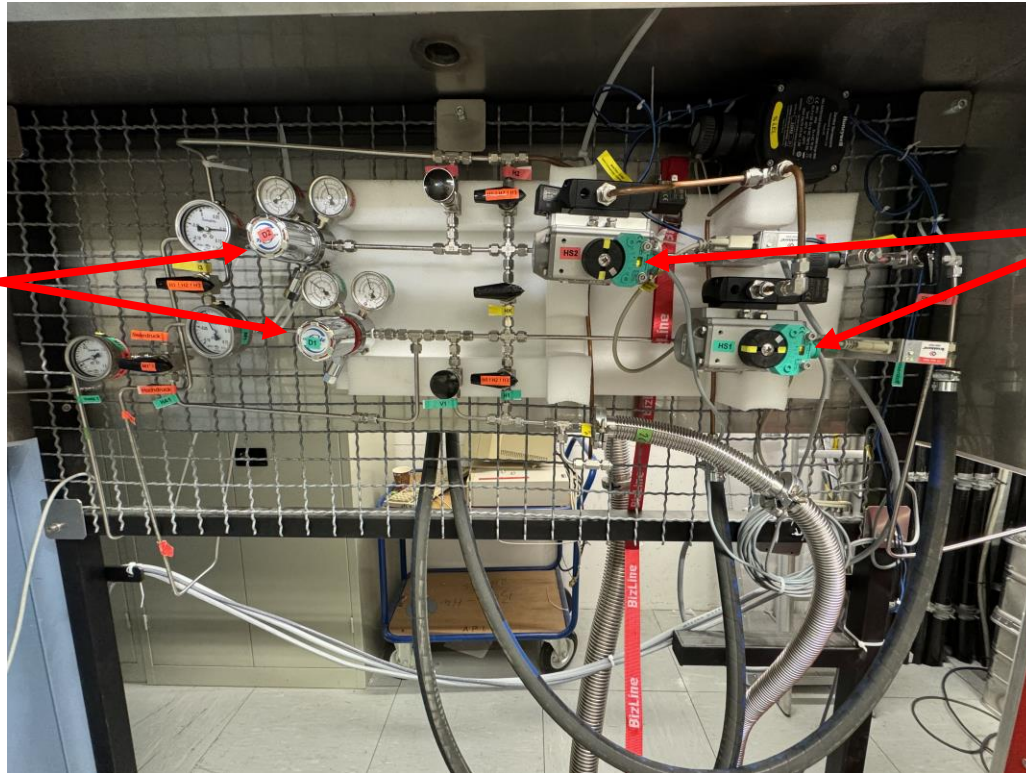
Valve coil voltage

Valve coil current



- Switch gas target on/off within ~ 100 s of μ s
- Gas target reasonably stable for \sim ms
- $p_{\text{gas}} \sim 10$ mbar
- Operating parameters of BGC (type of gas, pressure) are generally compatible
- Service life of valves?
From our experience $50\text{-}80 \cdot 10^6$ cycles @50Hz operation,
nominal $380 \cdot 10^6$ cycles
- Maybe not what you are looking for ...

Our Gas Control Setup: More Standard Valves ...

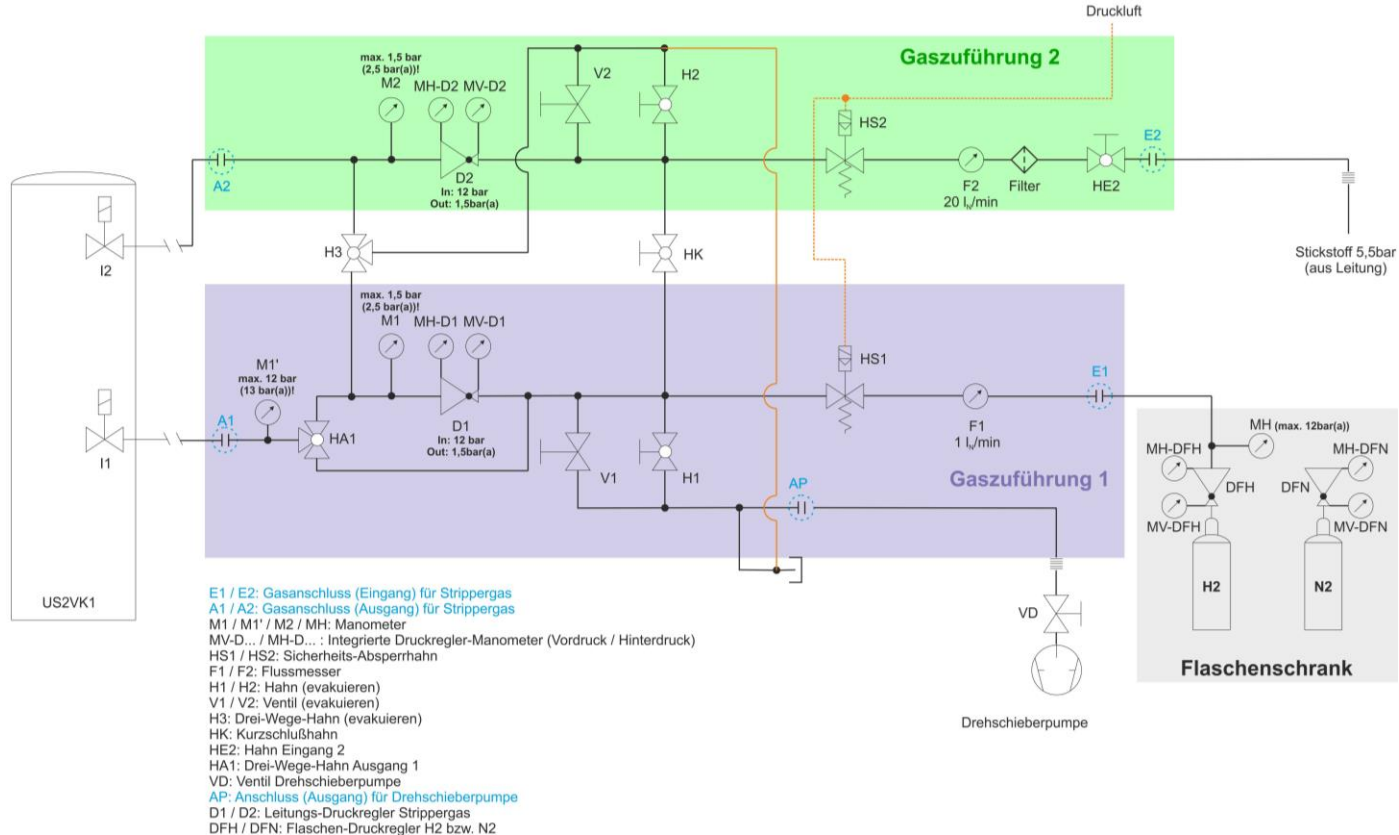


low pressure regulators

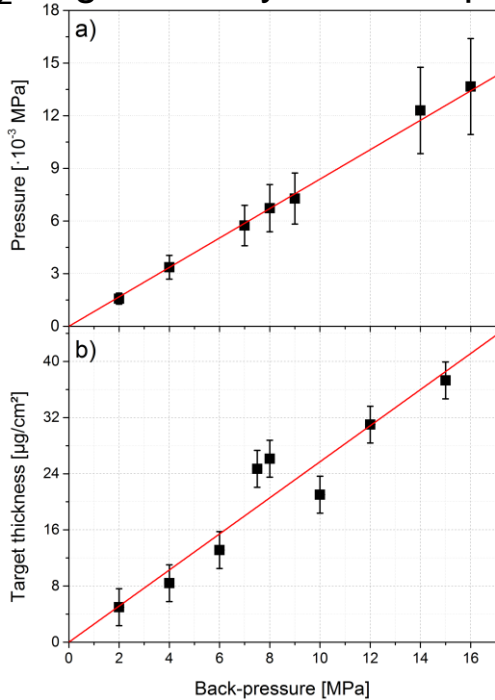
“fast” safety valves

Thank you for your attention!

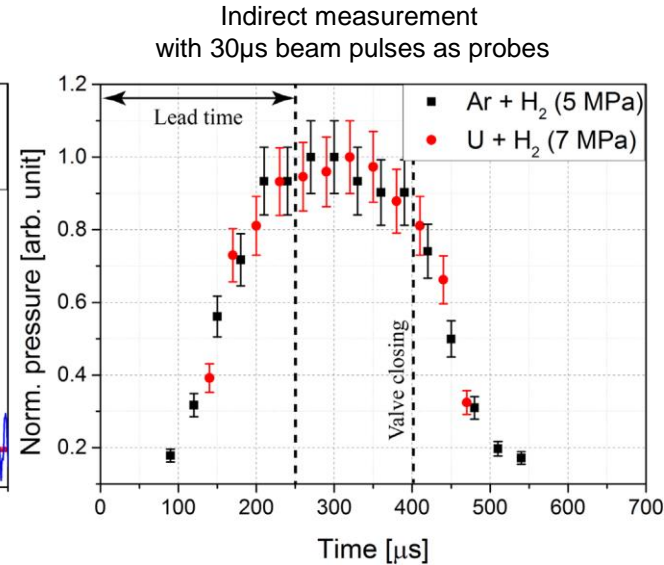
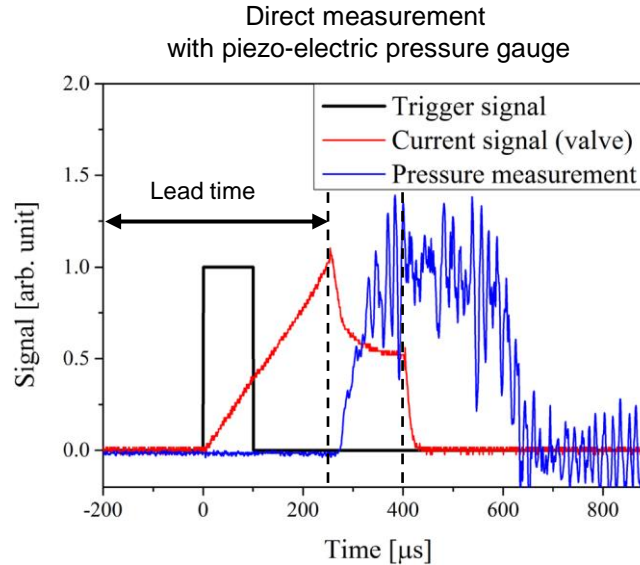
Gas Handling Schematics



H₂ target density vs. back-pressure



H₂ target density build up and drain-off



Target thickness derived from energy loss of U, Upgraded setup, increased thickness wrt. back pressure

P. Scharrer et al., NIM A 863 (2017) 20-25

Fast valve operation

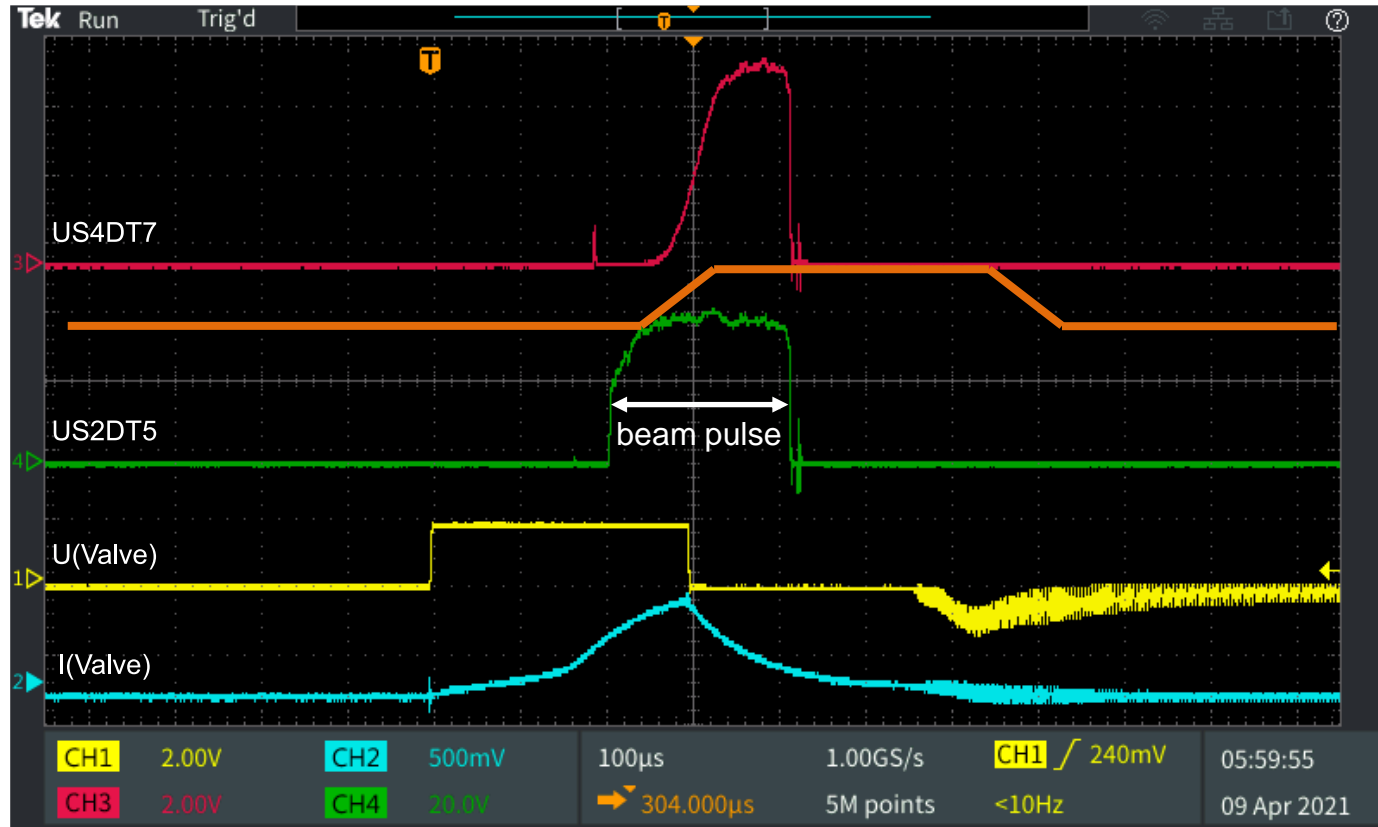
Beam current stripped

Valve opening /
stripping target build up

Beam current unstripped

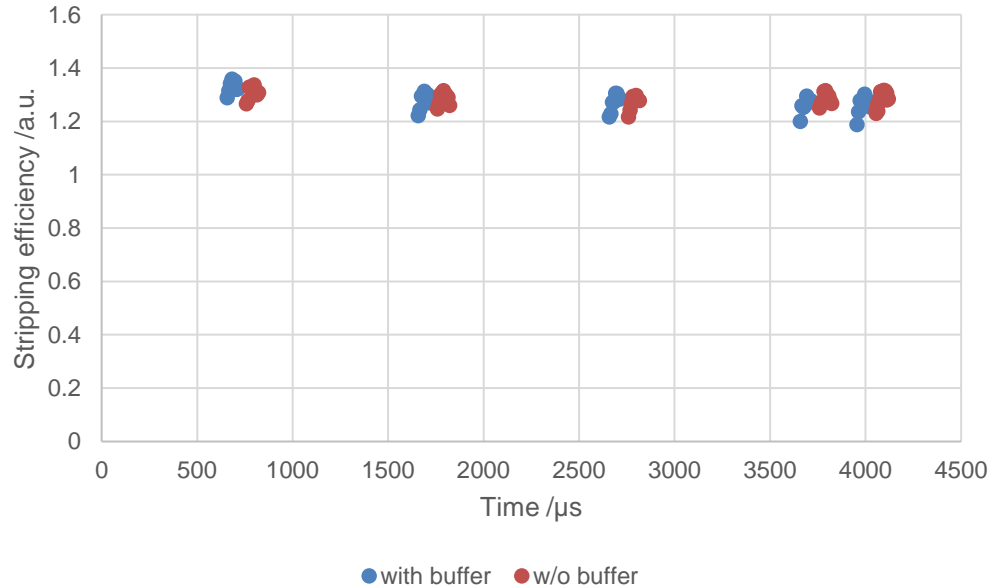
Valve coil voltage

Valve coil current



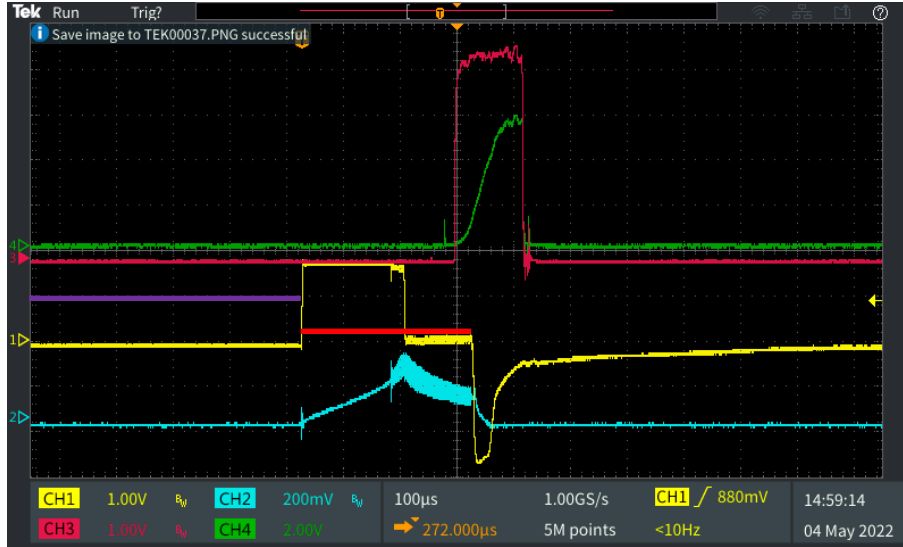
Stripping target stability

U 28+, H2 6bar

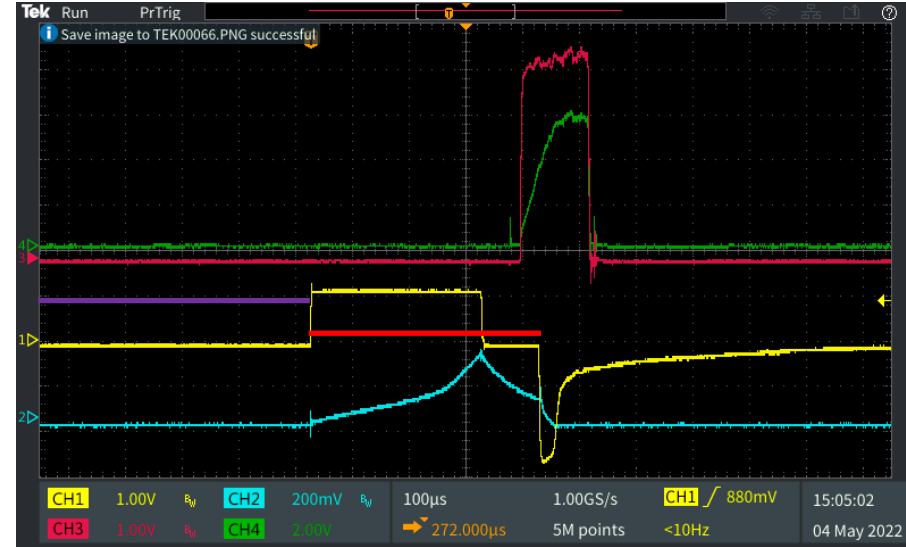


Data: TEK00068-78

Valve profile verification

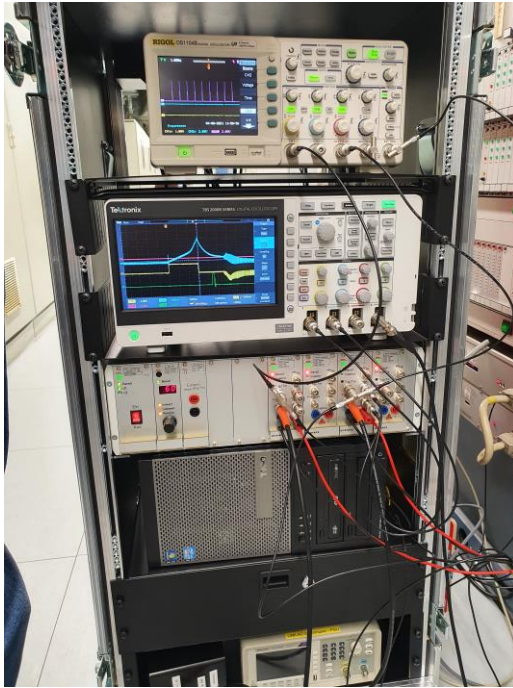


90V, impulse 300 μs



60V, impulse 400 μs

Measurement Equipment



Timing monitoring

Valve monitoring
Beam currents

Valve controller

Operation:
Valve controller
Gate pulse generator

Local timing generation



Flow meter



Flight case for electronics
on its way to the ESR roof