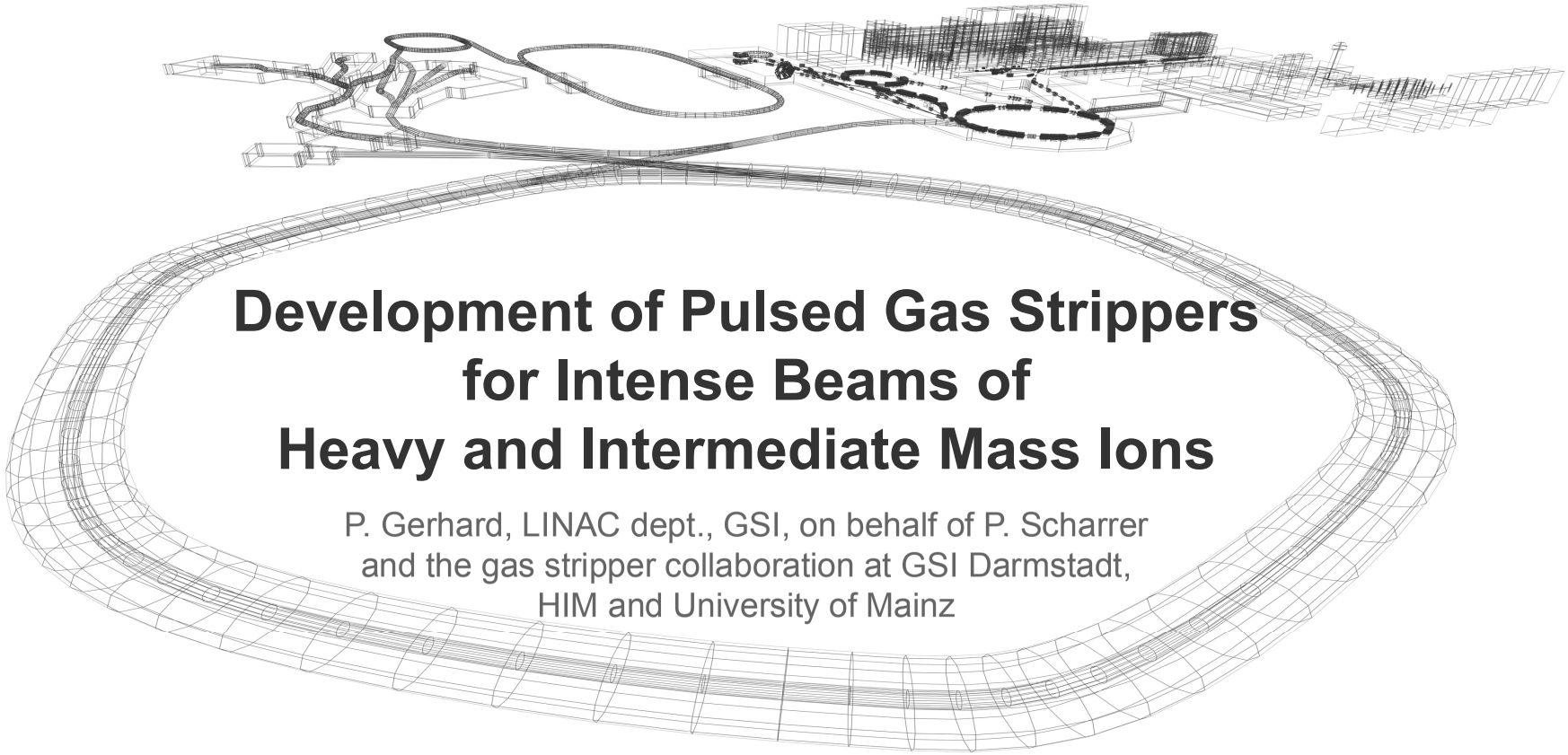
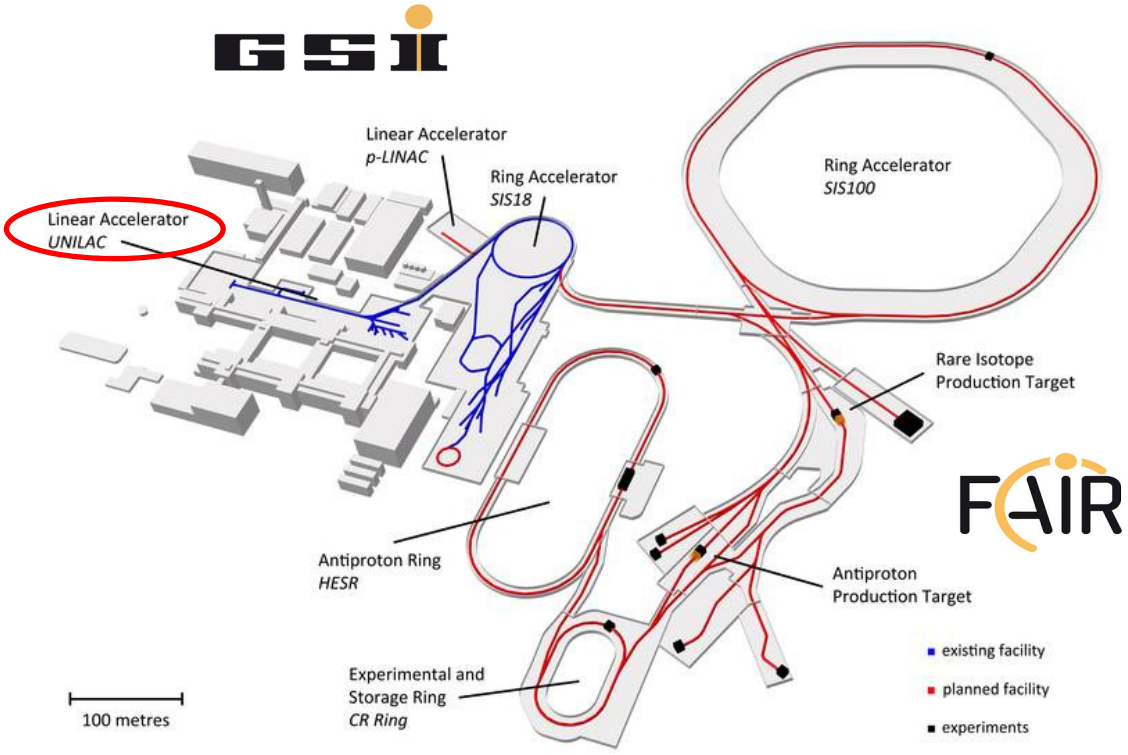


Development of Pulsed Gas Strippers for Intense Beams of Heavy and Intermediate Mass Ions

P. Gerhard, LINAC dept., GSI, on behalf of P. Scharrer
and the gas stripper collaboration at GSI Darmstadt,
HIM and University of Mainz

Introduction



- GSI UNILAC and SIS18 will serve as heavy ion injector for FAIR
- UNILAC reference for FAIR operation:
  ≥ 15 mA $^{238}U^{28+}$
  ≤ 100 µs pulse length
  ~ $3 \cdot 10^{11}$ U^{28+} / SIS18-pulse
- $^{238}U^{28+}$ achieved until 2012 with operating setup:
  6 mA behind UNILAC
  $3 \cdot 10^{10}$ extracted from SIS18
  (2.5 mA injected from UNILAC)

Introduction

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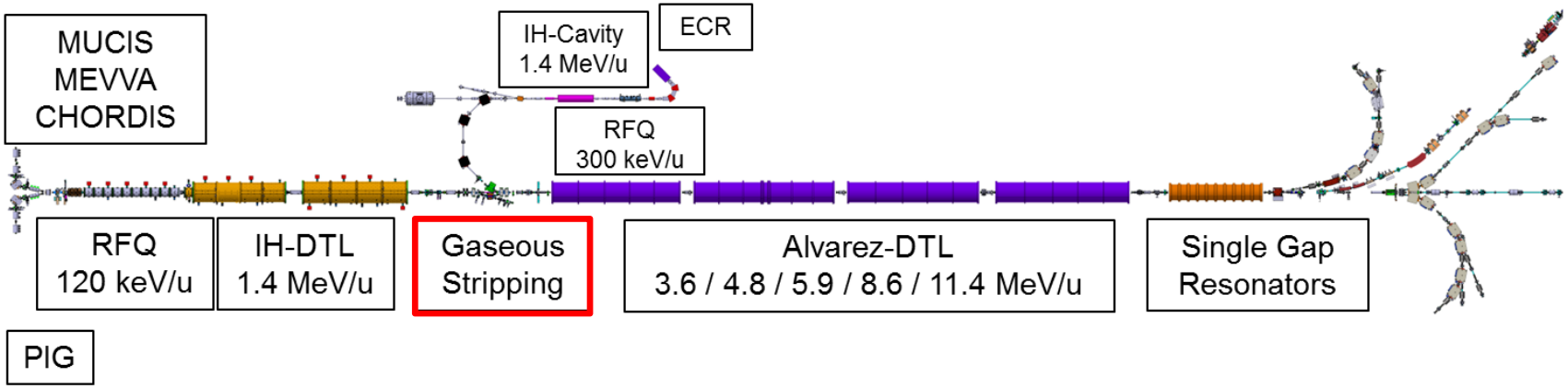
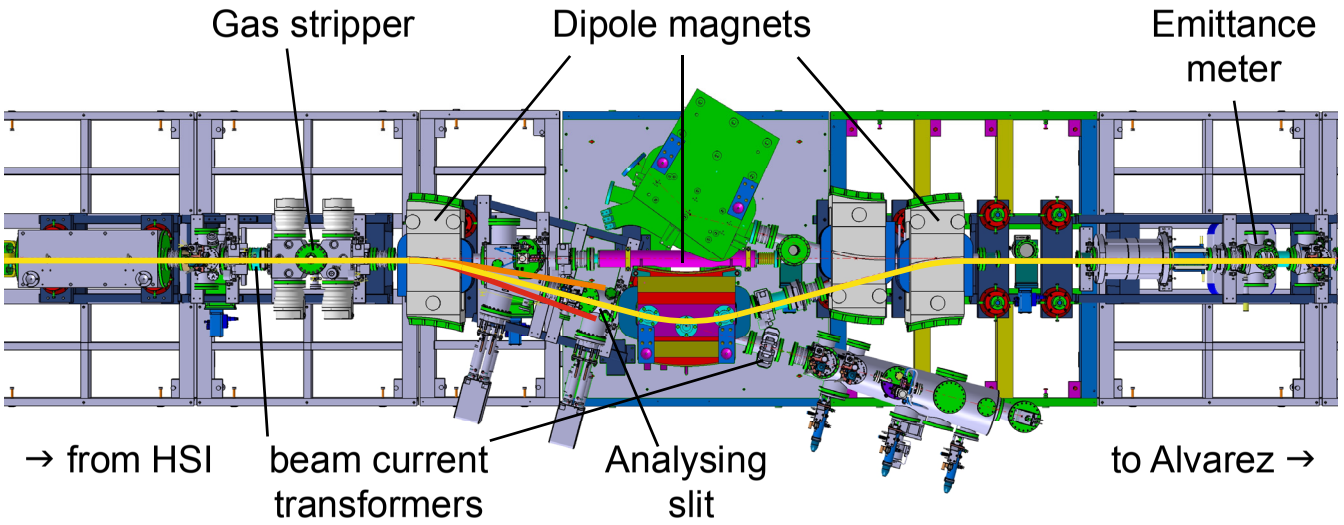
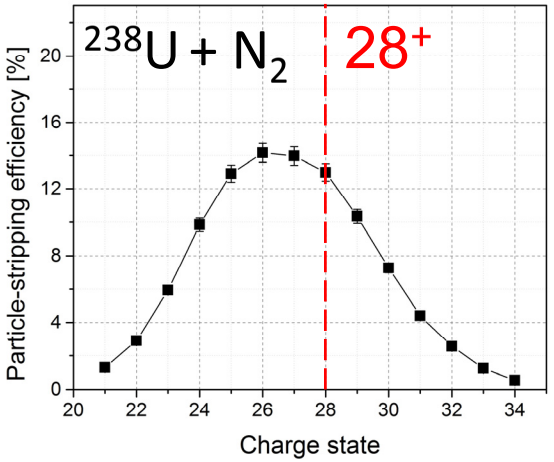
UNIversal Linear ACcelerator



- Commissioned 1975, all ion species from H^+ to U^{73+}
- Pulsed operation, different beams „in parallel“
- Max. 5 ms pulses at 50 Hz for UNILAC users
- Max. 200 µs pulses at 5 Hz for SIS18 / FAIR injection

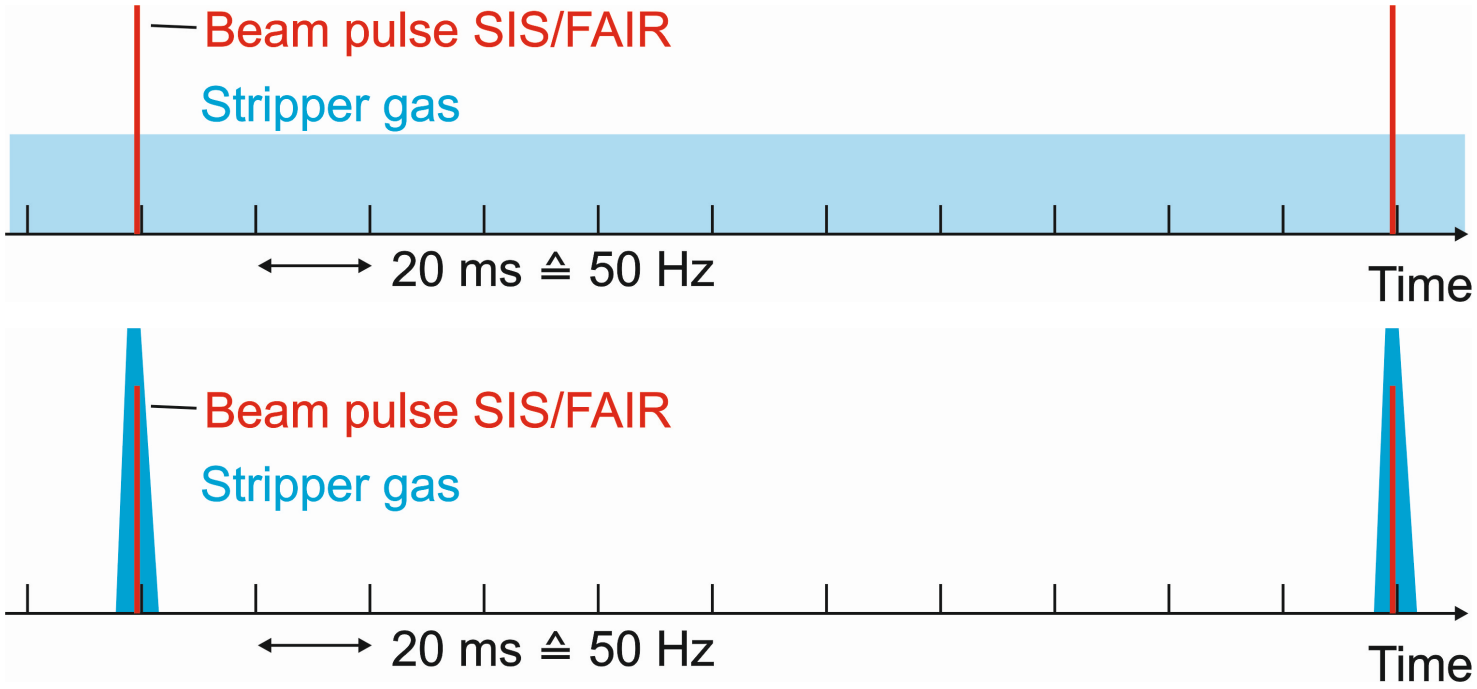
Gas Stripper Section





- Stripping due to collisions of ions with target particles
- Increased charge state, but distribution
- Figure of merit: Stripping efficiency into desired charge state
- Separation and selection of desired charge state, e.g. U^{28+}

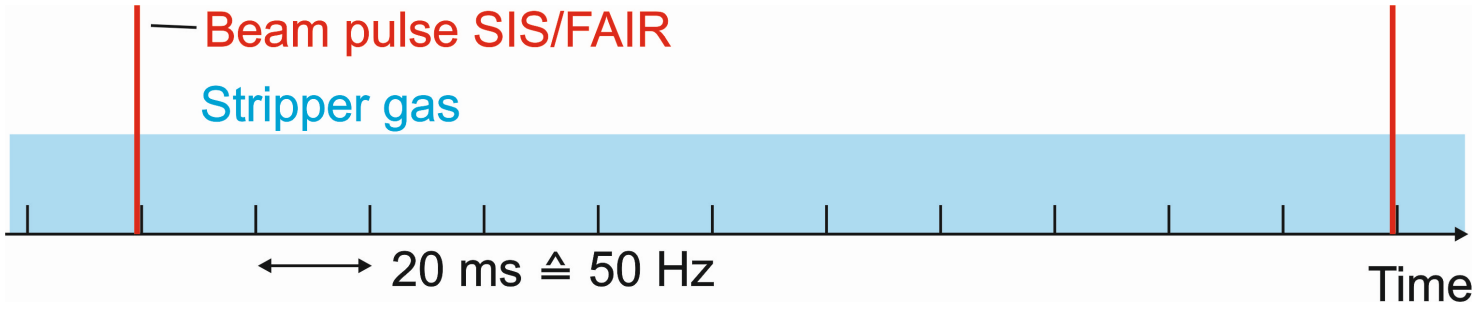
How to Improve the Gas Stripper?



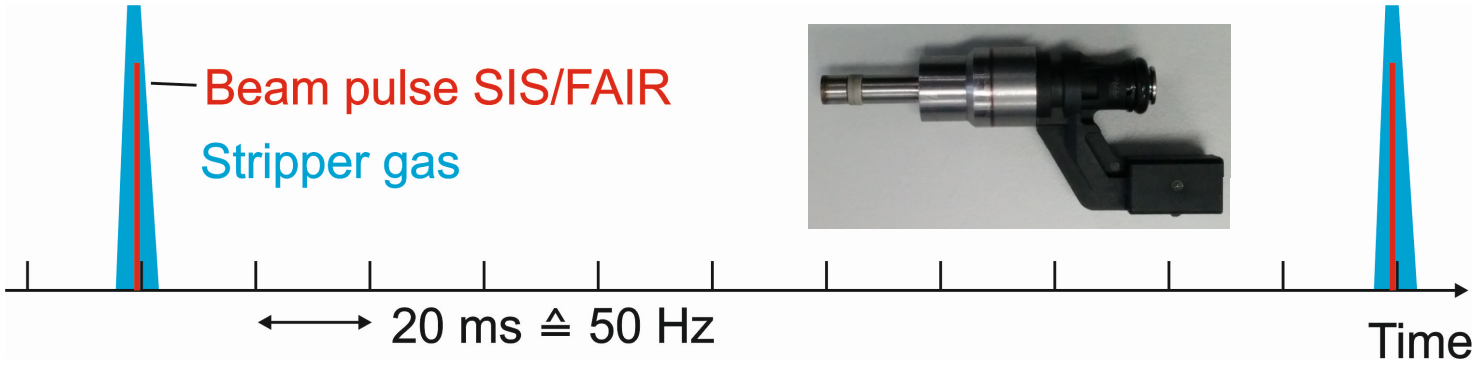
N_2 jet stripper

New pulsed stripper

How to Improve the Gas Stripper?

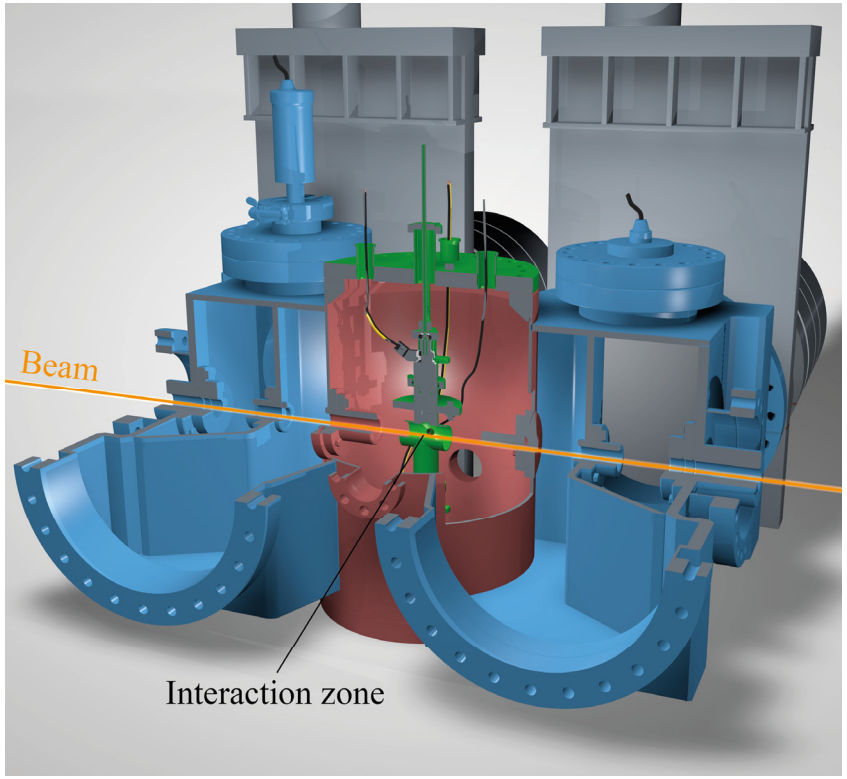


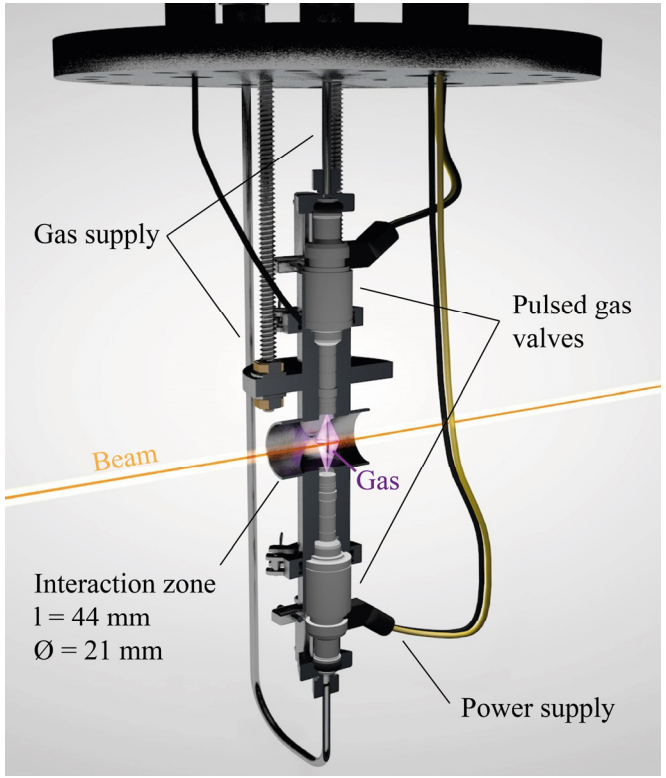
N_2 jet stripper



New pulsed stripper

Gas Stripper Chamber and Pulsed Setup



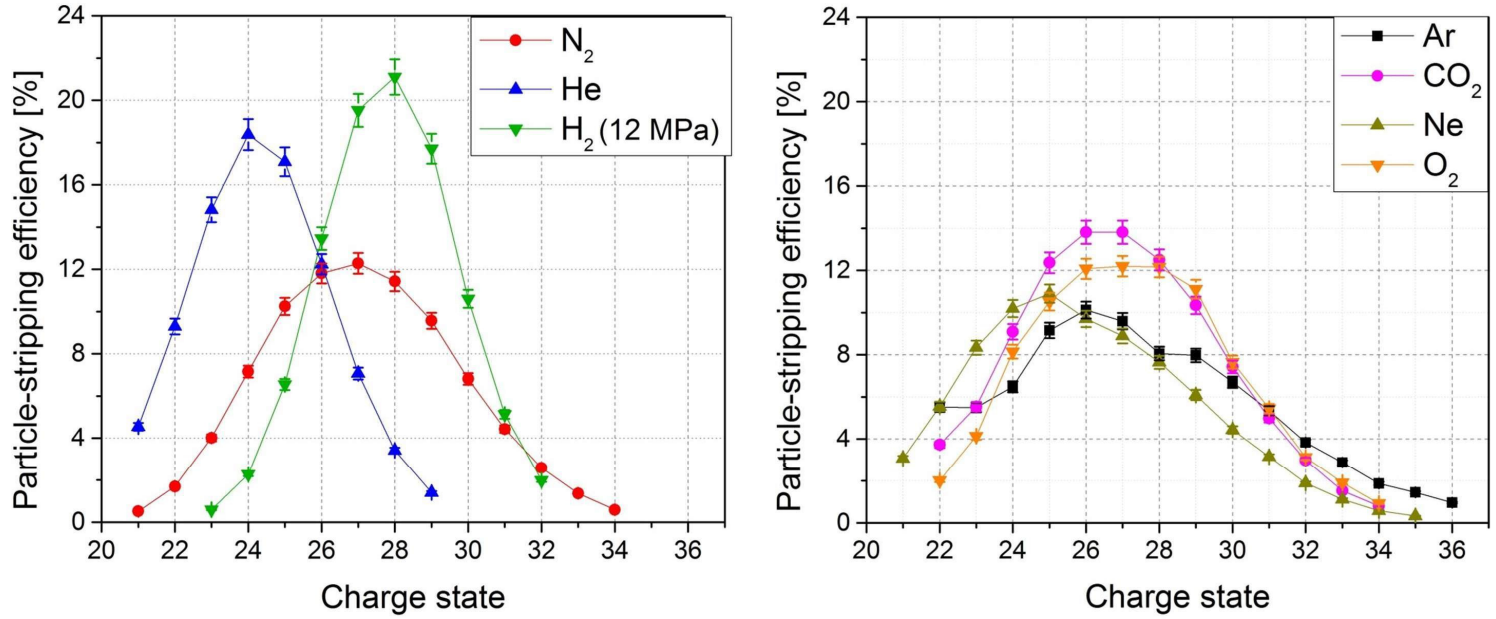


Automotive Gasoline Injector

Status 2016

Gas Target Investigations

Uranium equilibrated* charge state distributions



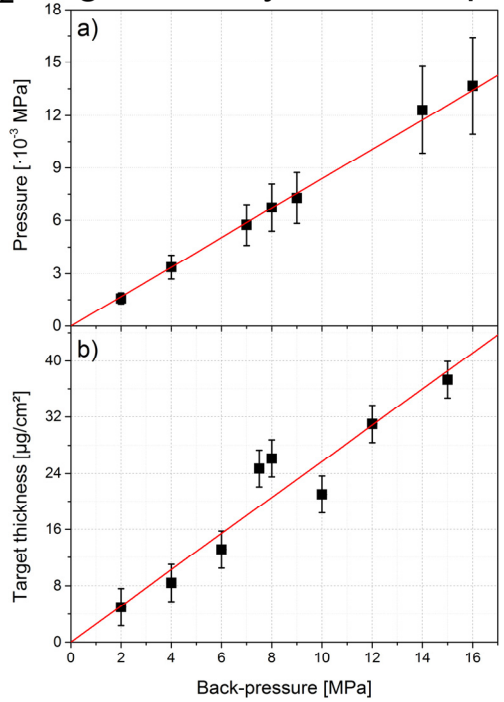
P. Scharrer et al., Proc. HIAT15, TUA1C01

Light gas targets → narrow distribution → increased stripping efficiency

*: First setup, non-equilibrium distribution for H_2

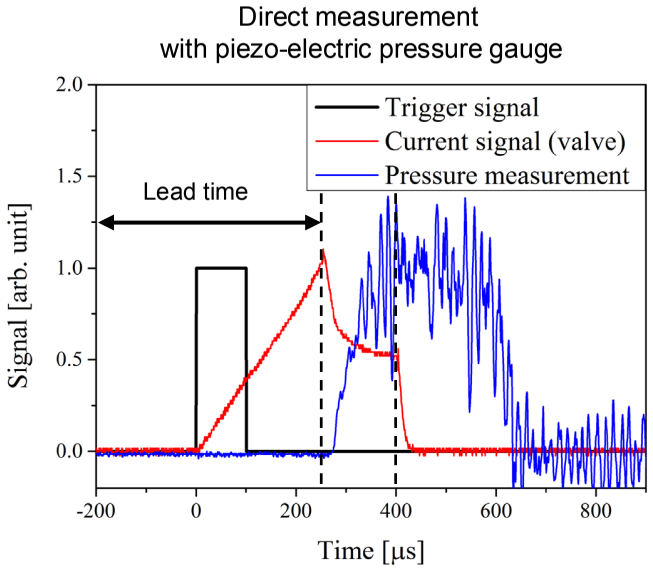
Target Characterization

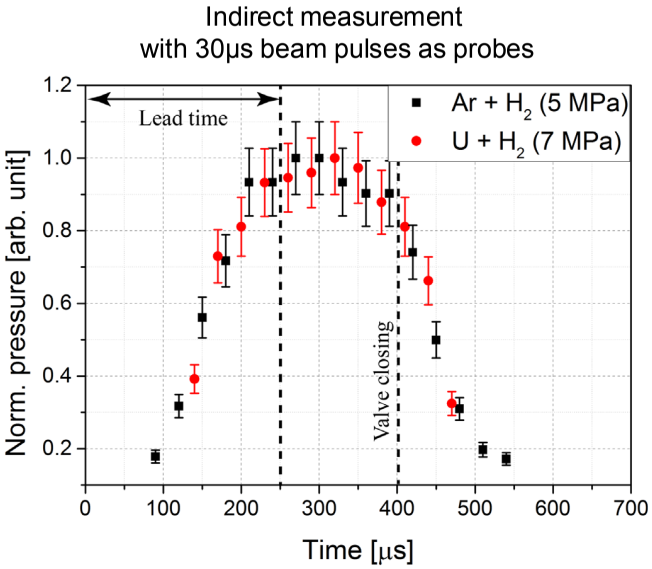
H_2 target density vs. back-pressure



P.Scharrer et al., Proc. IPAC 2016, TUPMR058

H_2 target density build up and drain-off

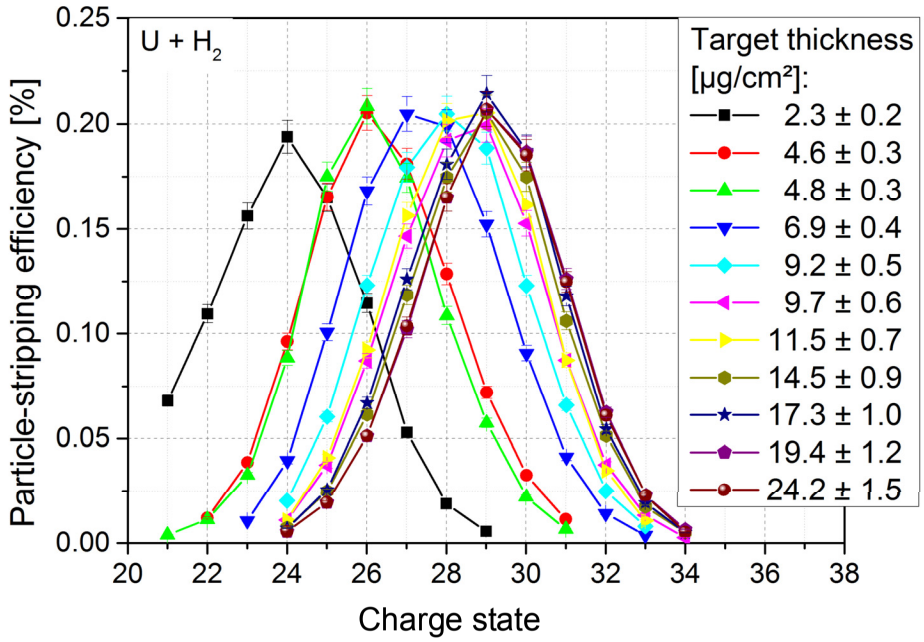




Target thickness derived from energy loss of U,
Upgraded setup, increased thickness wrt. back pressure

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

Charge State Distributions and Saturation



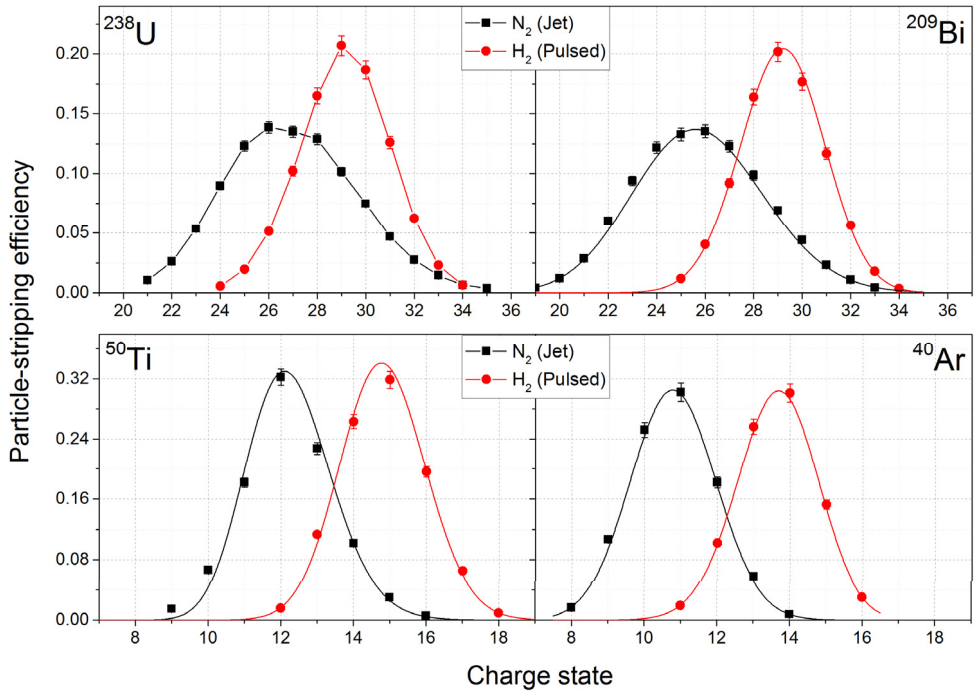
- Avg. charge state increases with target thickness, max. 29+
- Saturation around 19 µg/cm² target thickness
- Distribution remains similar
- Stripping efficiency stays constant at 21%

P.Scharrer et al., Proc. IPAC 2016, TUPMR058

Projectile Investigations

Measured charge state distributions with highest <q>

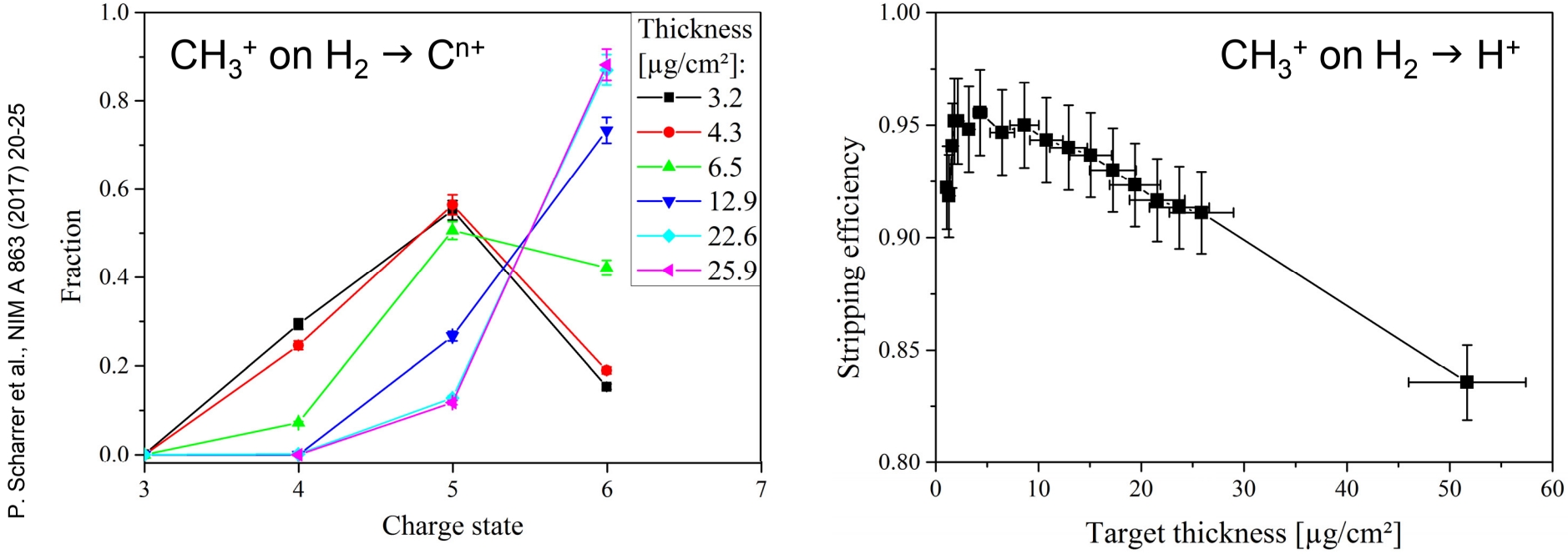
P. Scharrer et al., Proc. LINAC16, TUOP03



- 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

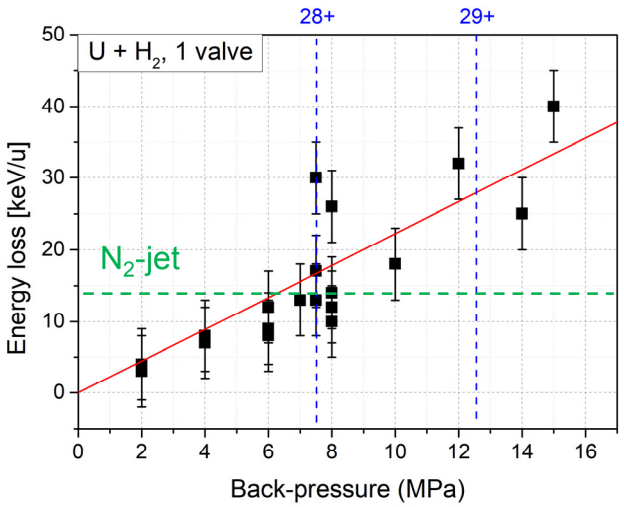
Projectile Investigations

High current carbon and proton beams from molecular CH_3^+-ions



Beam characterization

Energy loss



Energy loss relevant for matching to Alvarez DTL

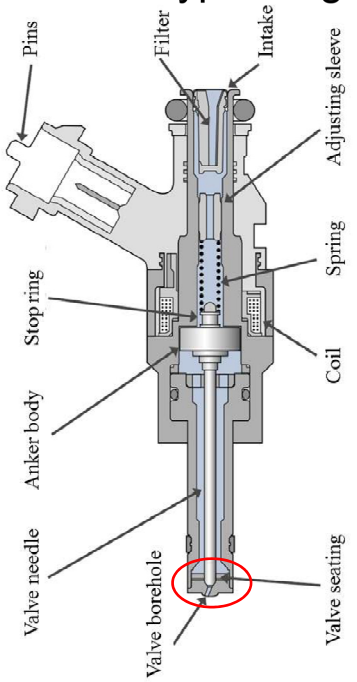
Exemplary measured beam parameters

Ion	Stripper	X [µg/cm²]	dE [keV/u]	I_{Beam} [mA]	$\varepsilon_{tot,norm}(x)$ [mm mrad]	$\varepsilon_{tot,norm}(y)$ [mm mrad]
$^{238}U^{28+}$	N_2 (jet)	8	14±5	3.7	0.76	0.84
$^{238}U^{29+}$	H_2 (pulsed)	21	40±5	6.1	0.56	1.07
$^{209}Bi^{26+}$	N_2 (jet)	8	-	1.8	0.61	0.72
$^{209}Bi^{29+}$	H_2 (pulsed)	37	80±5	2.8	0.82	0.82
$^{40}Ar^{11+}$	N_2 (jet)	8	-	0.10	0.39	0.42
$^{40}Ar^{14+}$	H_2 (pulsed)	37	100±5	0.13	0.83	0.72

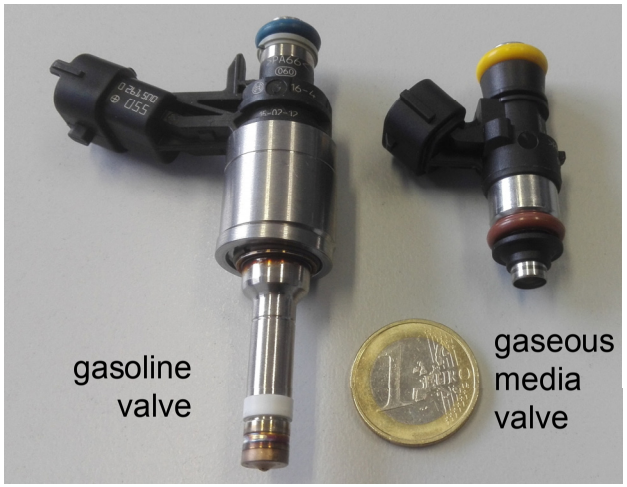
P. Scharrer, Dissertation

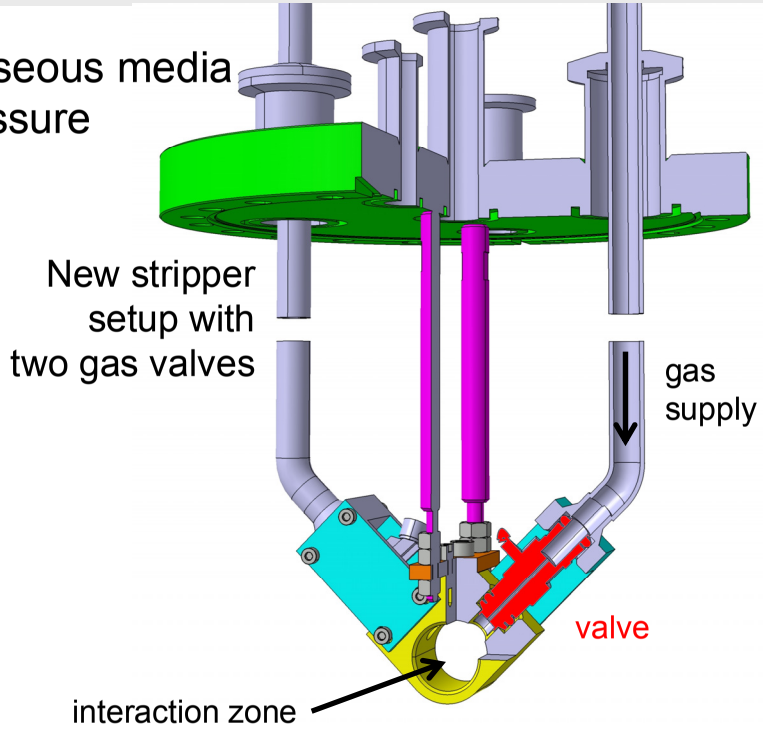
Pulsed Gas Stripper for Routine Operation

Gasoline valve not suitable for long term operation with gaseous media
New valve type for gaseous media, requires less back pressure



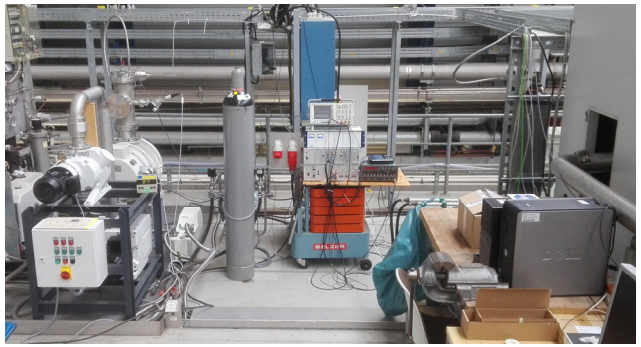
BOSCH Automotive Berufsschulinfo, 2003/4

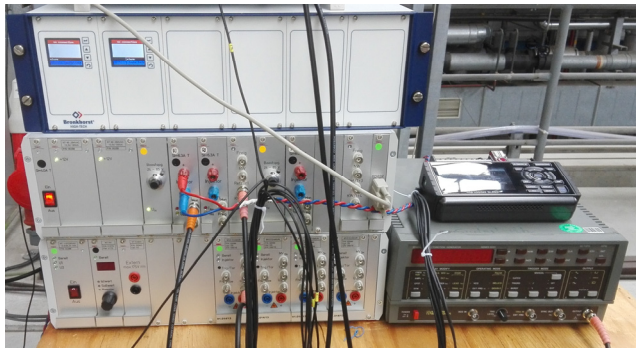




Pulsed Gas Stripper for Routine Operation

Evaluation of new valve type and new valve controller at test stand:





Some of the infrastructure needed for routine operation:

High pressure hydrogen compressor (ATEX, 600 bar)

Gas supply station for cylinder bundles

Linde ZGV Katalog

Summary

- Exploiting the low beam duty factor for the gas injection enables the use of hydrogen and increased stripper target densities
- Beam intensities increased by ~60%, this is a big step towards FAIR requirements
- Making it available for routine operation is more difficult than expected, mostly due to safety requirements
- New setup with gas qualified valves is waiting for evaluation

Thank you

... for your attention!

Special thanks to:

P. Scharrer[1], E. Jäger[1], W. Barth[1], M. Bevcic[1], Ch. E. Düllmann[1,2,3], L. Groening[1], K. P. Horn[1], J. Khuyagbaatar[2], J. Krier[1], M. Maier[1], A. Yakushev[1]

[1]GSI Darmstadt, [2]HI Mainz, [3]University Mainz