Prospective upgrade programme at the UNILAC for the super-heavy elements research

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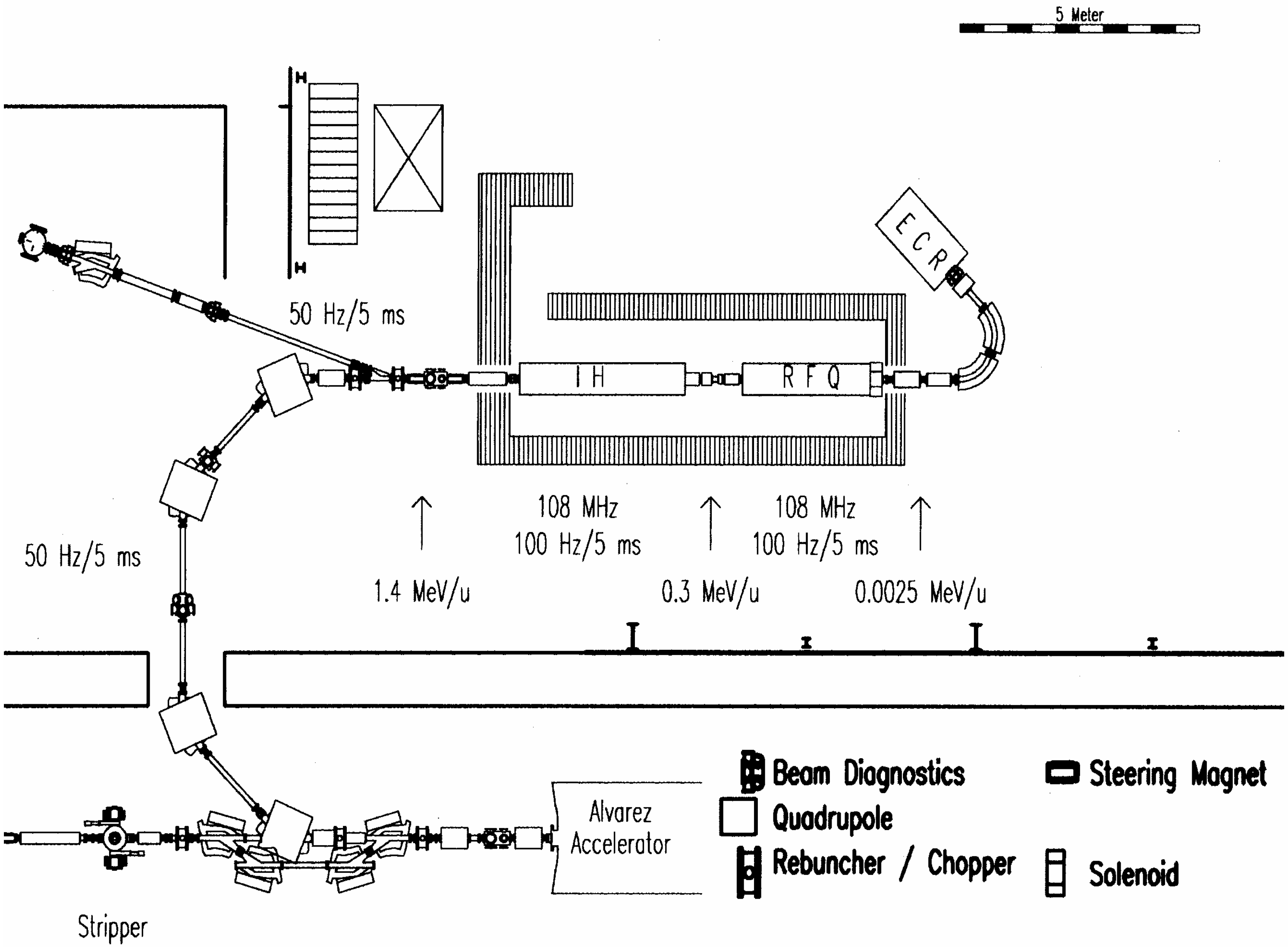
GSI

High Charge State Injector (HLI)



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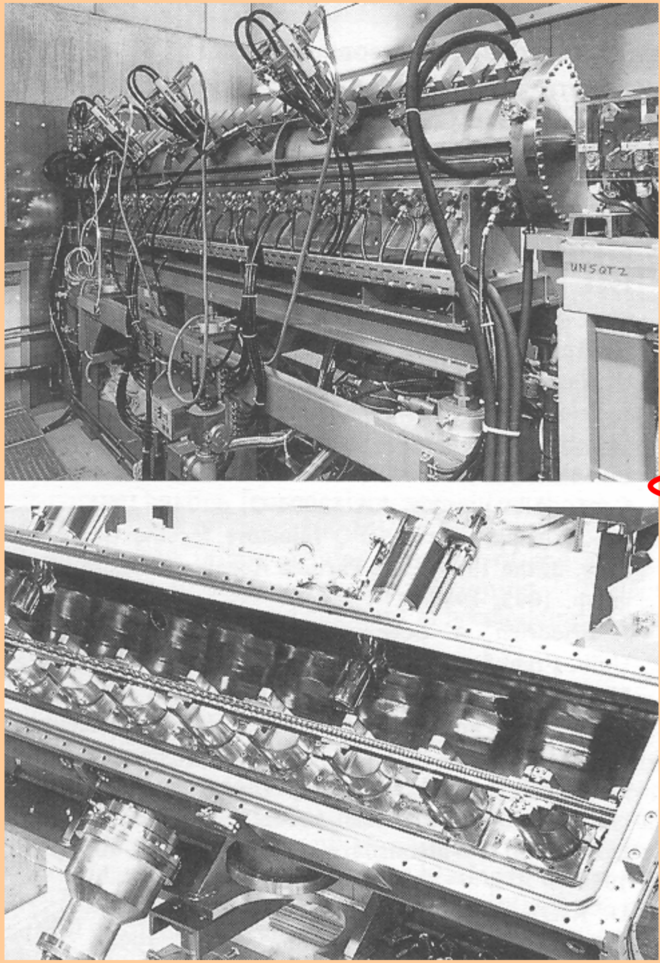
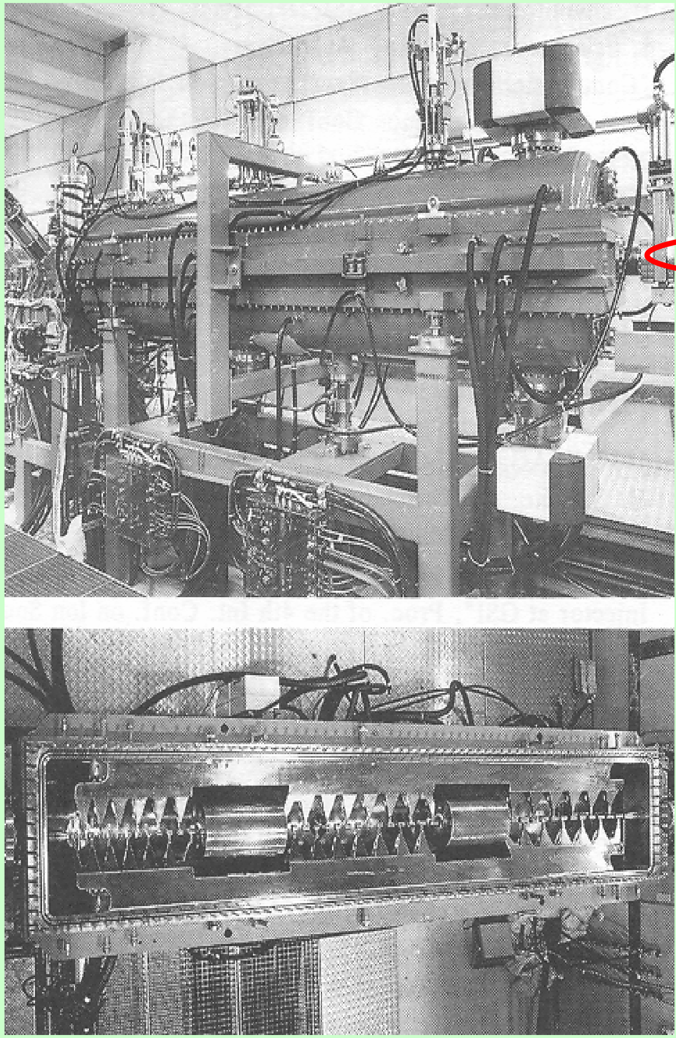


RFQ

Structure type	four-rod
Input energy	2.5 keV/u ($\beta = 0.0023$)
Output energy	300 keV/u ($\beta = 0.025$)
Radio frequency	108 MHz
Repetition frequency	100 Hz
Duty cycle	50 %
Max. RF power(U^{25+})	125 kW
Max. voltage	90 kV
Length	3 m
Tank diameter	0.5 m
Radial acceptance (norm.)	≥ 0.8 π•mm•mrad
Longitud. emittance	30 π•keV/u•deg
Energy spread	± 1.0 %
Bunch width	± 0.3 ns (± 10 deg)

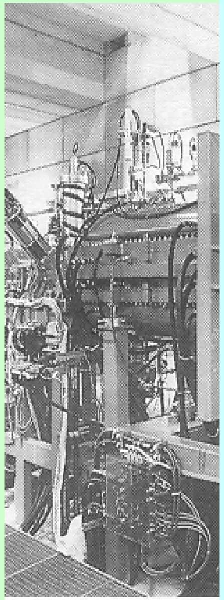
High Charge State Injector (HLI)

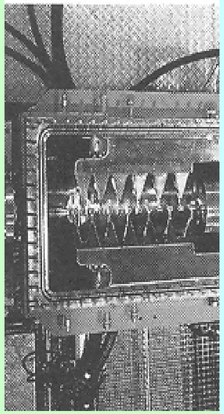


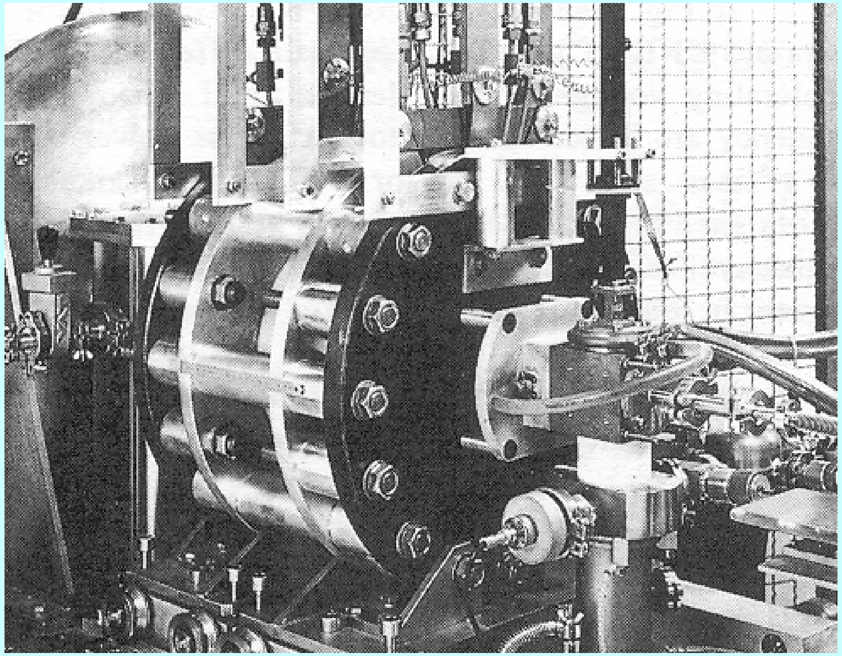
IH

Input energy	300 keV/u (β=0.025)
Output energy	1.4 MeV/u (β=0.055)
Radio frequency	108 MHz
Repetition frequency	100 Hz
Duty cycle	50 %
Max. RF power(U^{26+})	100 kW
Max. field strength	150 kV/cm
Length	3.55 m
Shunt impedance	310 MΩ/m
Radial acceptance	
(norm.)	1.5 π•mm•mrad
(unnorm.)	60 π•mm•mrad
Longitudinal	
acceptance	150 π•keV/u•deg
emittance	70 π•keV/u•deg
Energy spread	± 0.5 %
Bunch width	± 0.3 ns (± 10 deg)

High Charge State Injector (HLI)



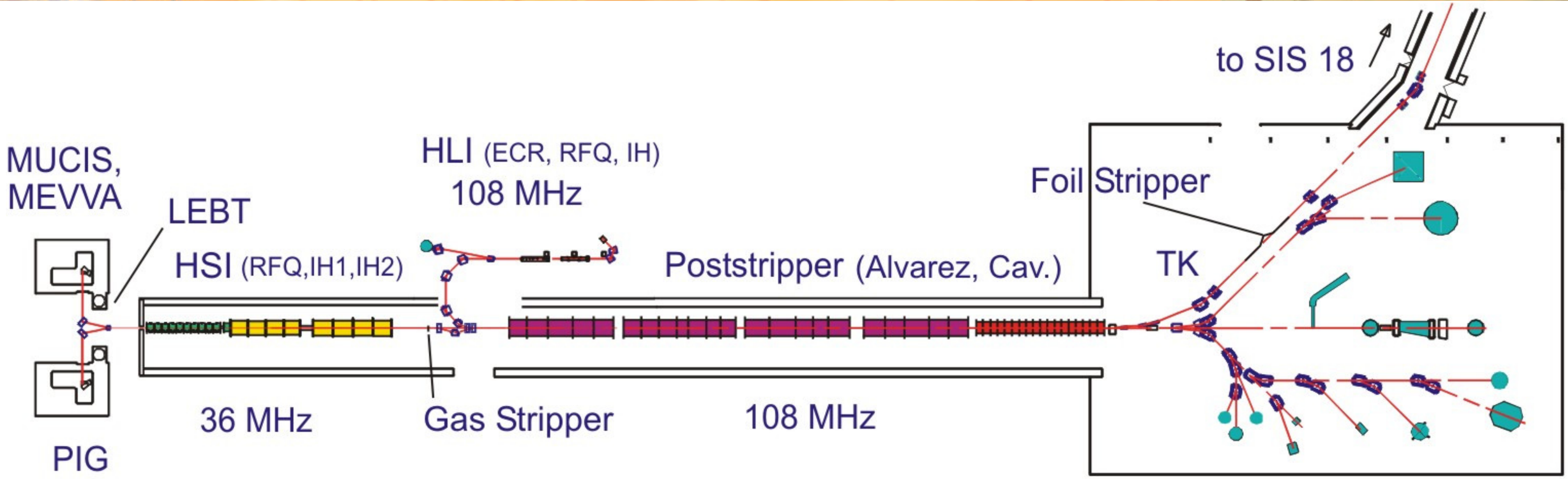




Ion Source	EZR (CAPRICE-Typ)
m/q	8.5
Extraction Voltage	2.5· (m/q)
Beam Energy	2.5 keV/u (β = 0.23 %)
Beam Emittance	0.46 π· mm· mrad (norm.) 200 π· mm· mrad (unnorm.)
Mass Resolution	$\Delta m/m = 3 \cdot 10^3$

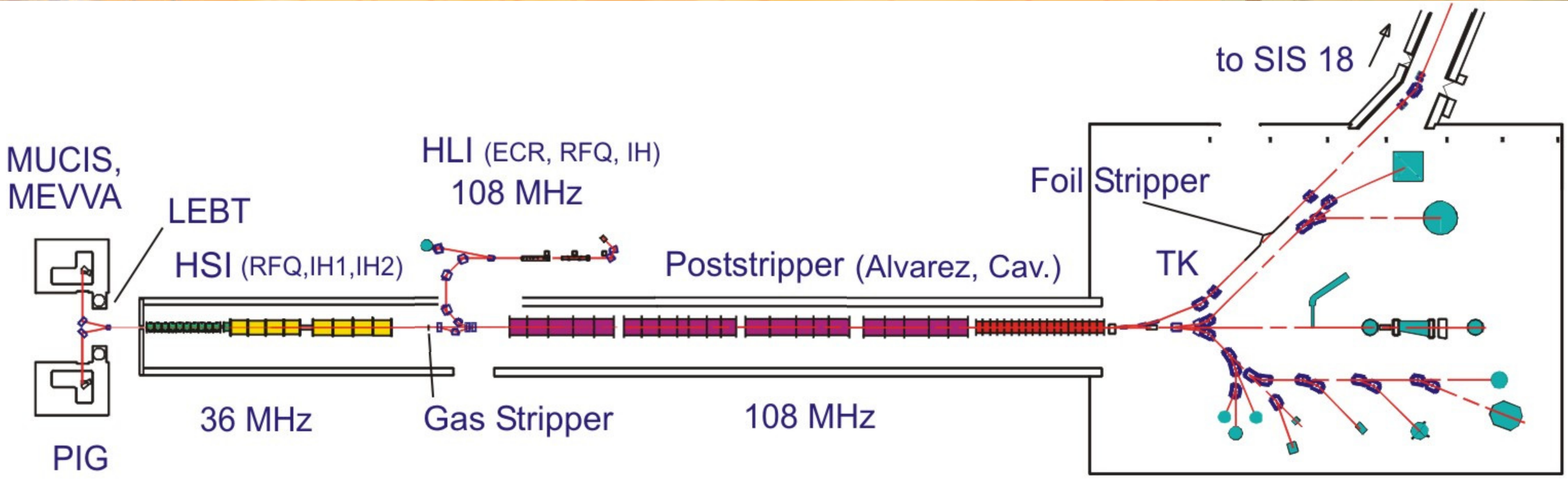
V/u (β=0.025)
V/u (β=0.055)
Hz
V
/cm
Ω/m
mm•mrad
nm•mrad
keV/u•deg
eV/u•deg
%
ns (± 10 deg)

Overview of the upgrade programme for the GSI UNIversal Linear ACcelerator



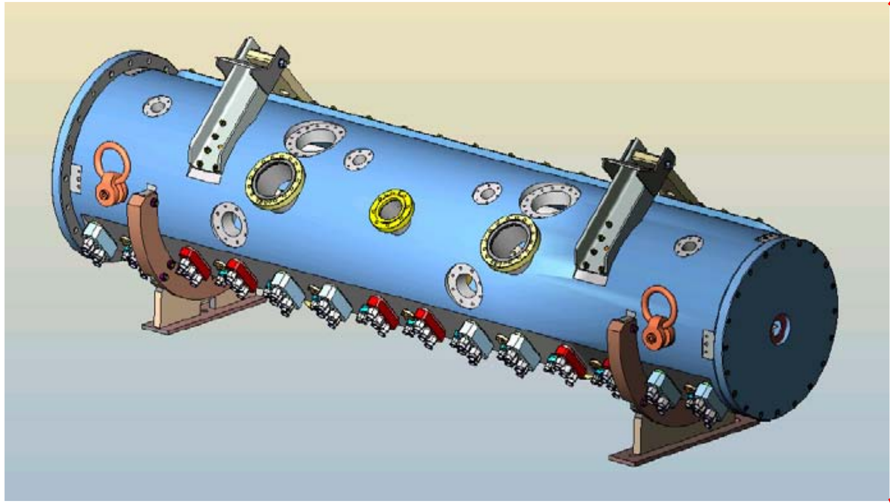
- **In Progress: New radio frequency quadrupole (RFQ) at the high charge state injector (HLI) in 2009**
- **In development: New ion source, commissioning planned 2011**
- **In design: Low energy transport line (LEBT) for new ion source**
- **Kick off: Development, setup and beam commissioning of superconducting CH test cavity in preparation for cw linac (see below) 2012**
- **Proposed: Complete new cw linac (2015?)**

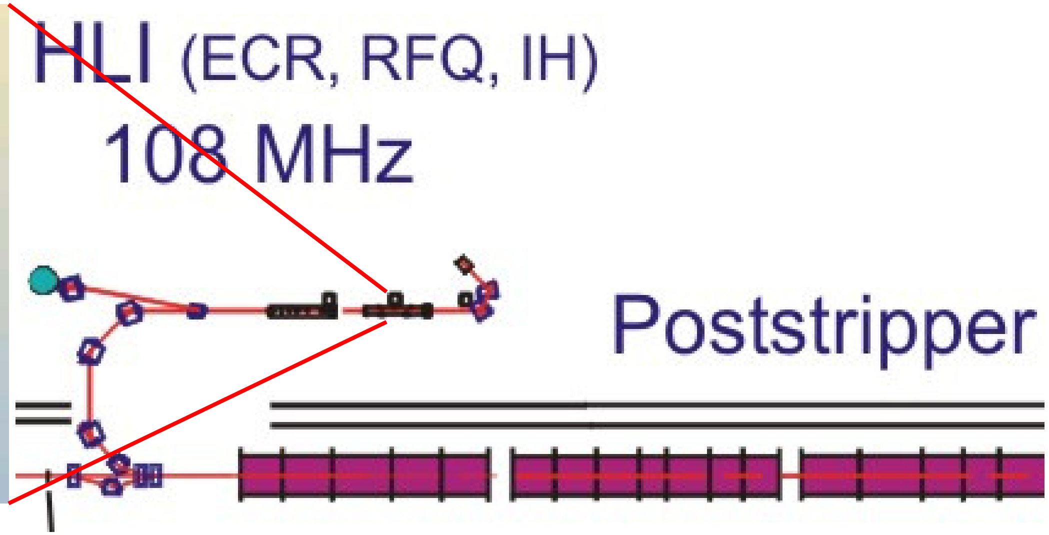
Overview of the upgrade programme for the GSI UNIversal Linear ACcelerator



	Luminosity gain
• **New RFQ: Duty cycle 25 -> 40%, available in spring 2009**	*1.6
• **New MS-ECRIS: higher beam currents, availability planned 2012** • **LEBT for new ion source at UNILAC**	*5
• **Cw linac, 100% duty cycle + independent operation, available approx. 5 years after approval (2015?)**	*(2.5 + 2)

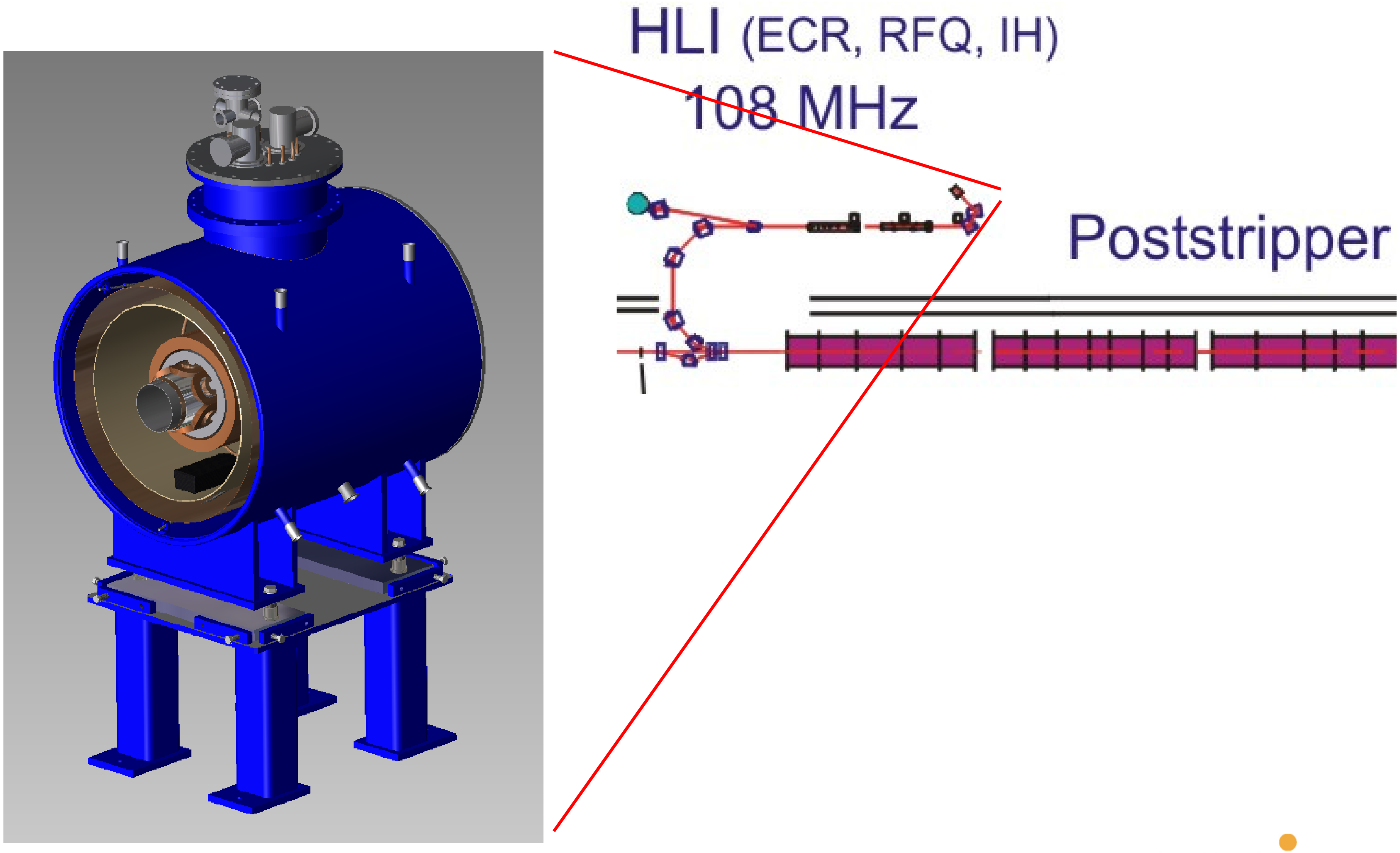
RFQ upgrade



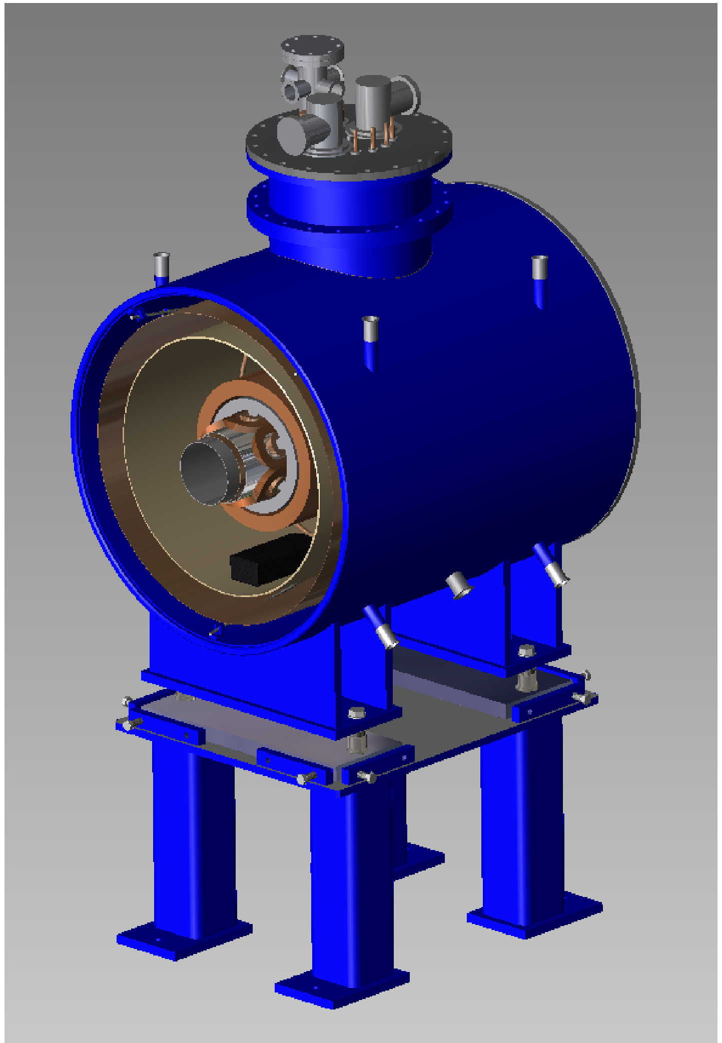


- **Status quo: Same RFQ in operation since 1991, first RFQ-IH-LINAC, RFQ with highest operation time in the world**
- **Design parameters: acceleration 2.5 to 300keV/u; operating frequency 108MHz; duty cycle 25-50%, repetition rate 50-100Hz; electrode voltage 80kV; tank length 3m**
- **Problems: Transmission less than expected, operational stability; after more than 15 years of operation (with exchange of electrodes in 1999?) 25% duty cycle hard to reach**
- **New RFQ: Design for 100% duty cycle, increased acceptance, better transmission, revised construction for stable operation; only 2m long, electrode voltage 55kV to keep max. avg. rf power; rf power amplifier will remain the same**

New superconducting ECR ion source



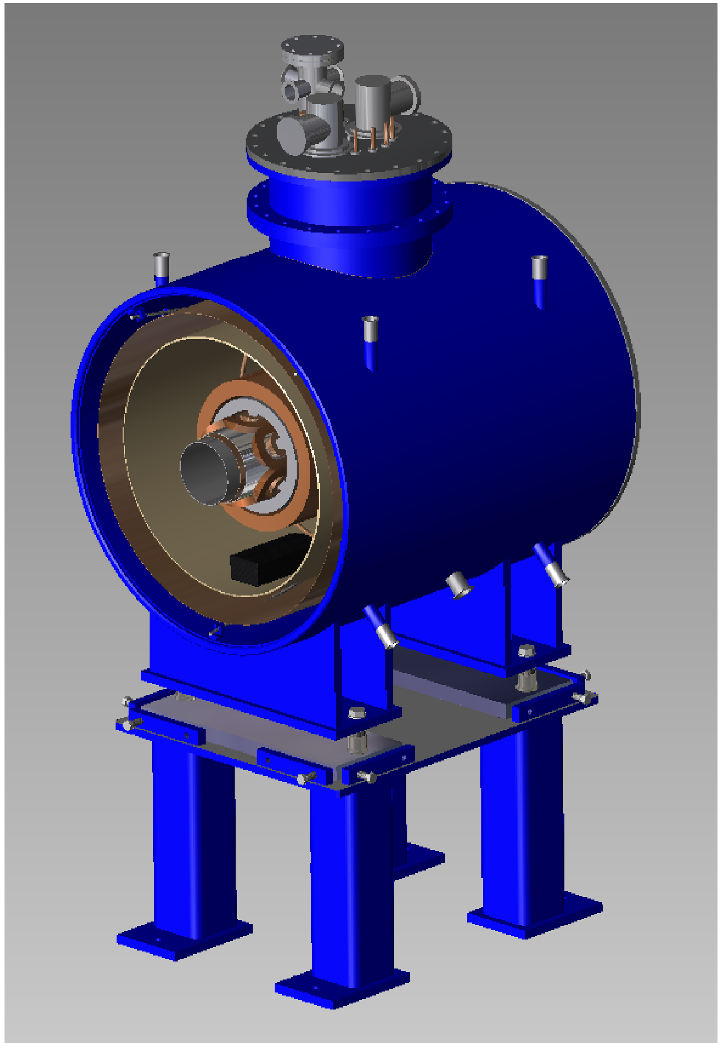
New superconducting ECR ion source



First Layout and Design Parameters

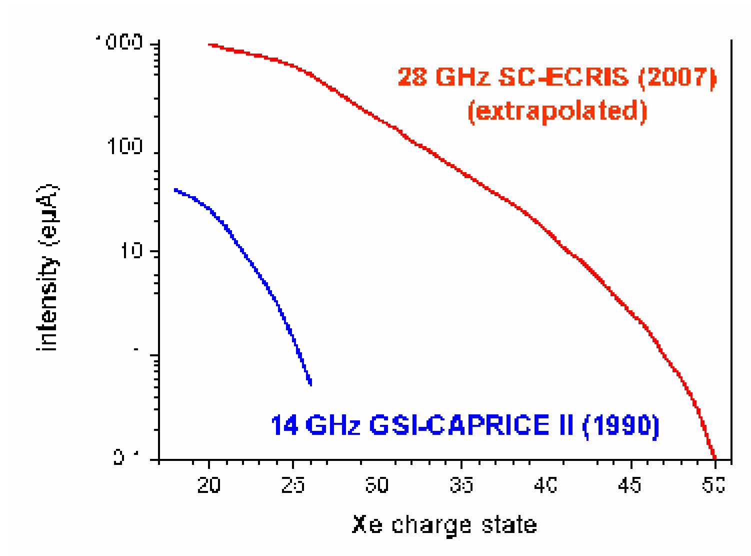
Microwave Frequency	28 GHz
Maximum RF power	10 kW
B (radial) at r = 90 mm	2.7 T
B_1 (injection)	4.5 T
B_2(extraction)	3.5 T
Diameter of Plasma chamber	180 mm
Diameter of Cryostat	1200 mm
Length of Cryostat	1350 mm
Extraction Voltage	up to 40 kV
LHe consumption	0

New superconducting ECR ion source



Major steps:

- Completion of sc magnet system and cryostat
- Delivery to GSI/IQ
- Completion of ion source
- Commissioning on test bench
- Installation and commissioning at HLI

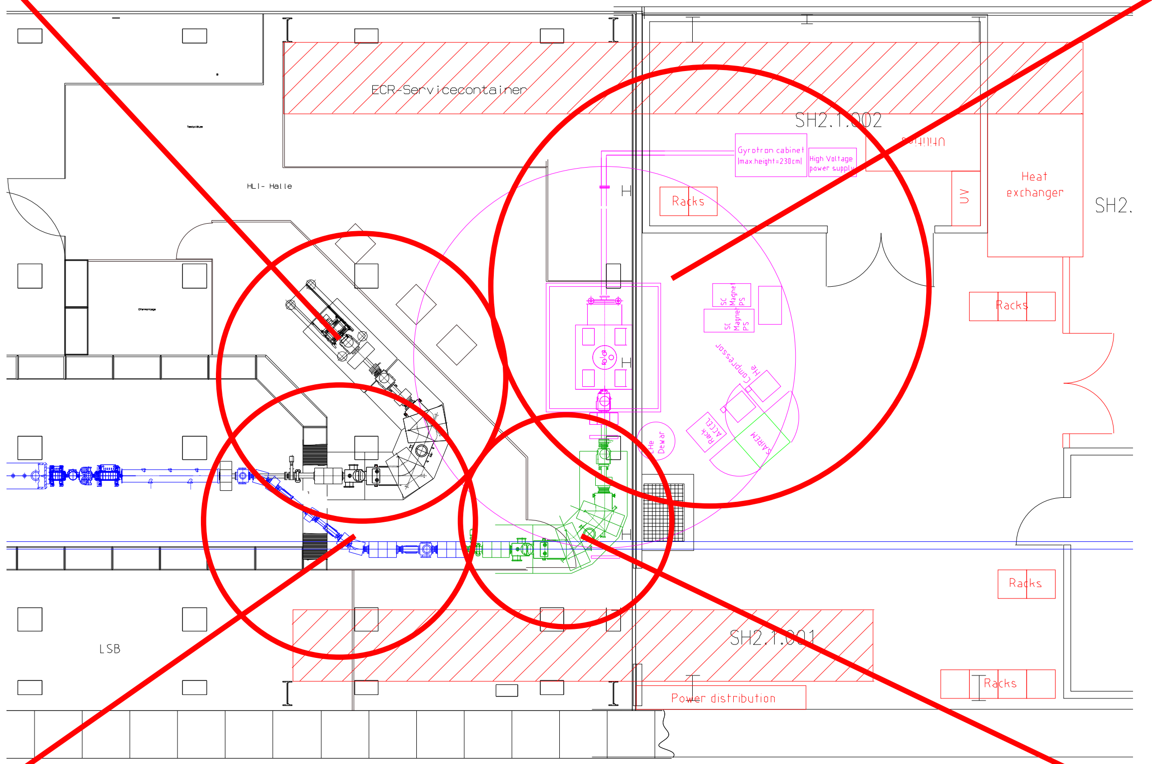


New LEBT for MS-ECRIS

Existing ECR ion source (CAPRICE) with LEBT

New MS-ECRIS with supply

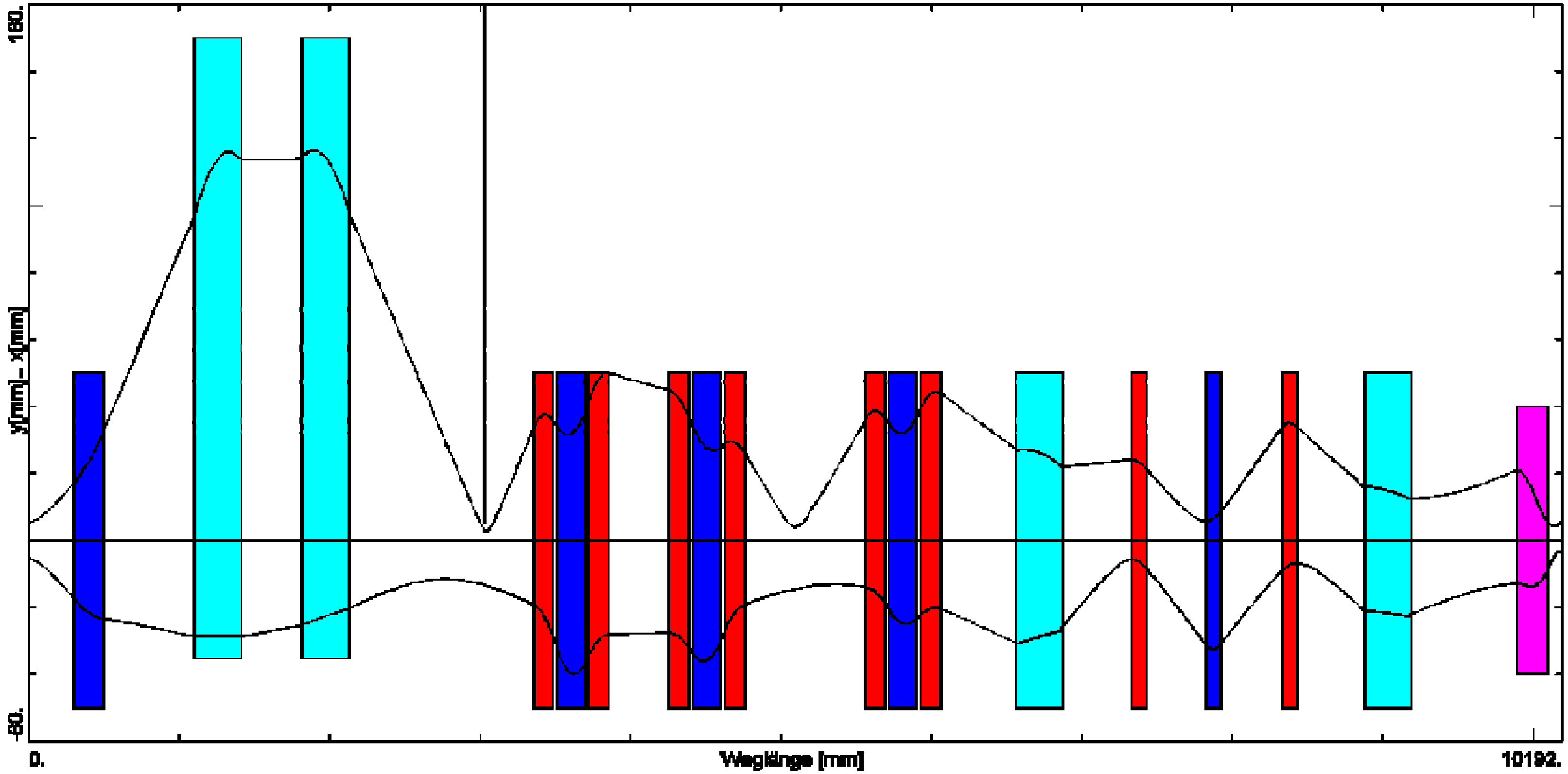
HLI linac



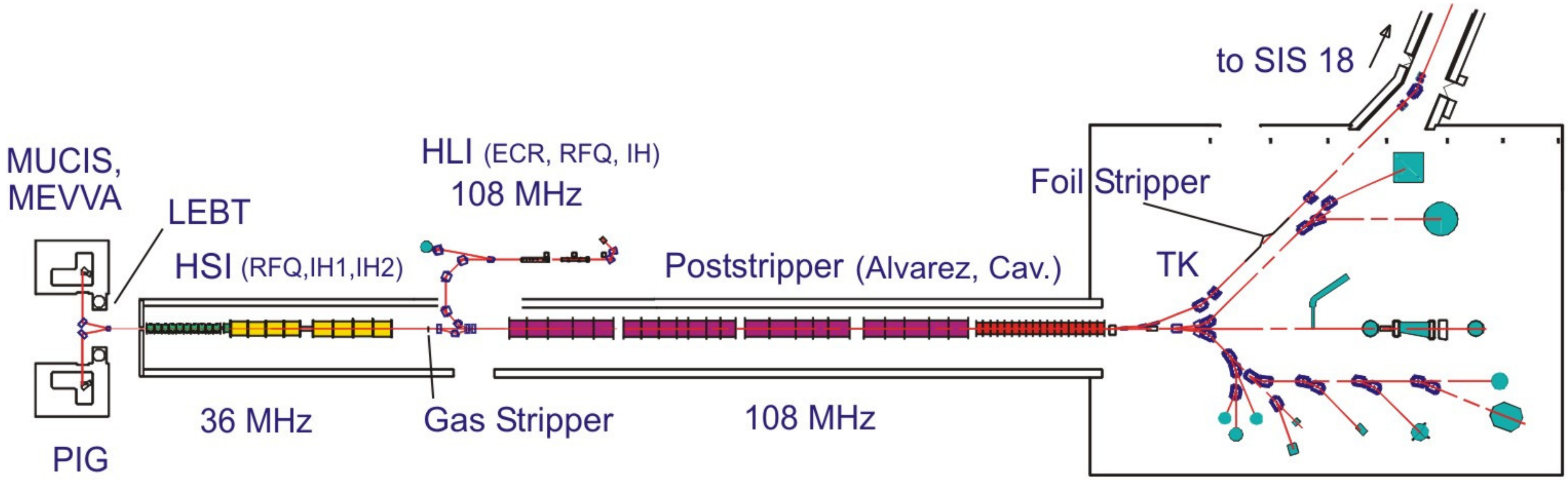
New LEBT for beam transport to linac

New LEBT with analyzing system

New LEBT for MS-ECRIS

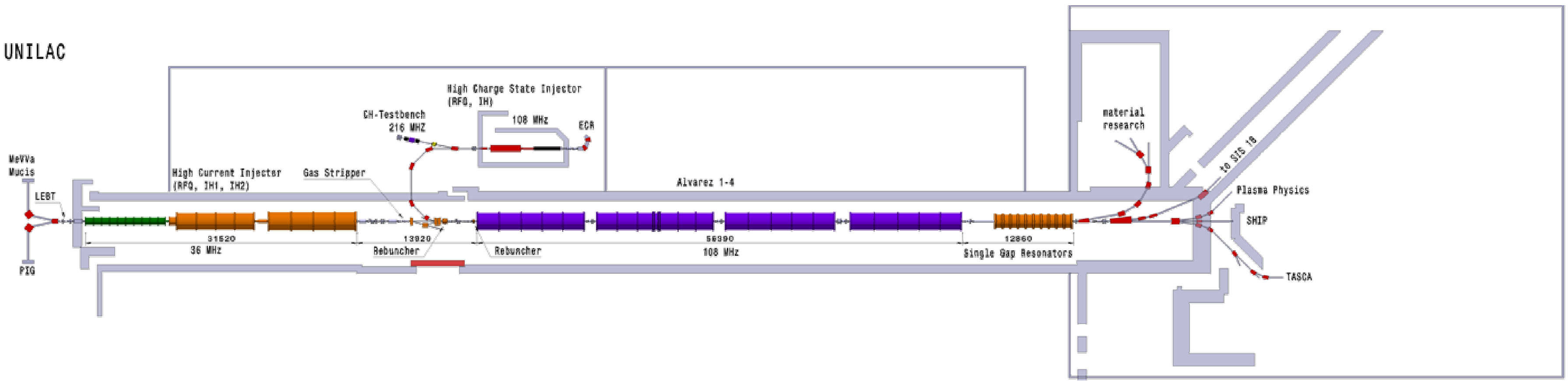


Superconducting cw-linac

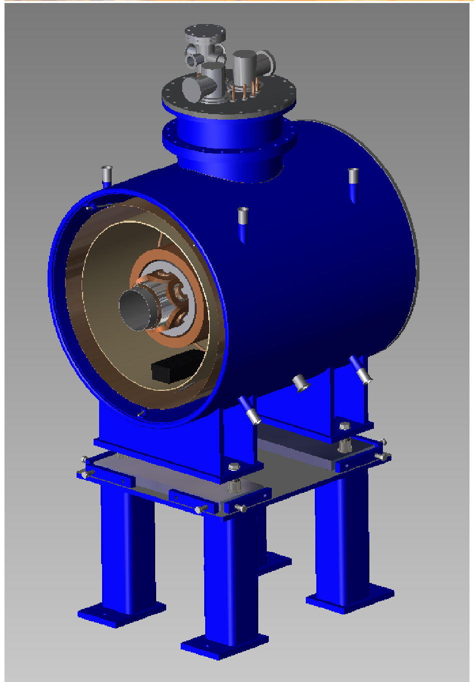


Superconducting cw-linac

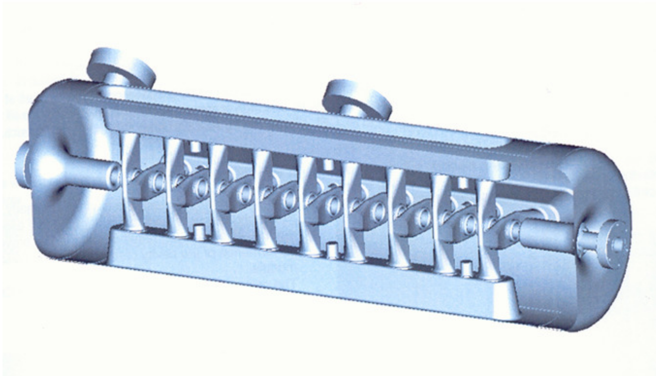
A. GSI - UNILAC

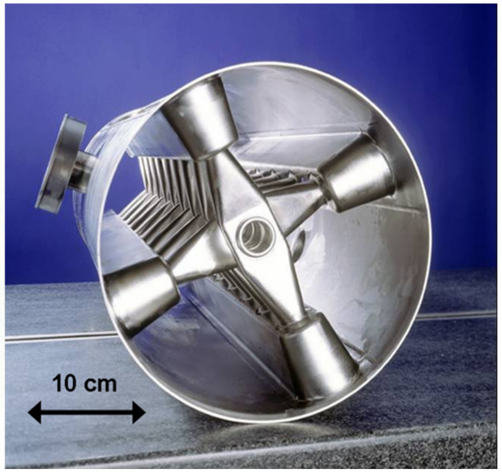


Superconducting cw-linac

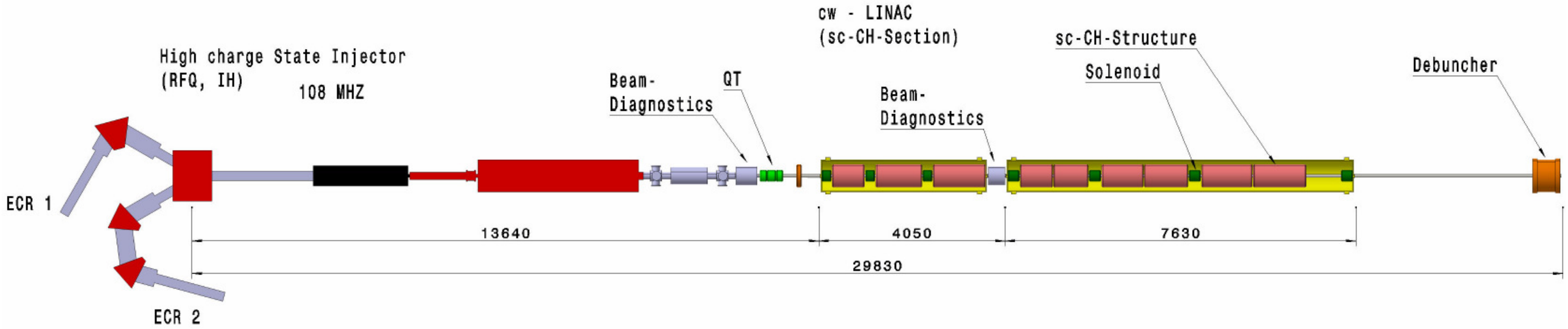


CH-prototype cavity





Superconducting cw-linac



- Compact linac: 12.7 m acceleration and 5.8 m debunching section (ΔE=3 keV/u)
- Injection parameters: E=1.4 MeV/u, max. A/q=6, I=1 mA
- 2 cryostats with 9 superconducting CH-cavities operated at 217MHz: cw operation, high gradients, cost saving rf power amplifiers, but expensive cryo equipment
- Lower operating costs
- High beam availability, independent operation from UNILAC/SIS18
- Energy variable from 3.5 to 7.3 MeV/u without single gab resonators