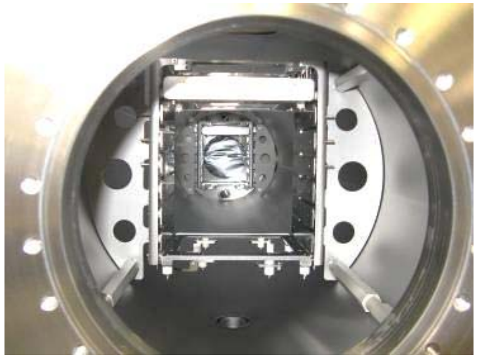
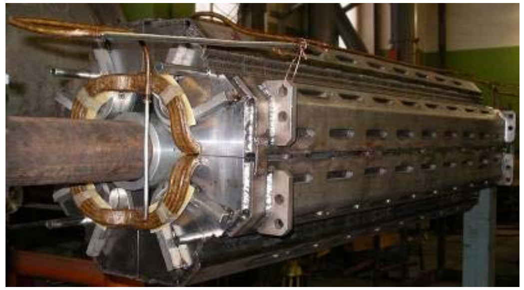
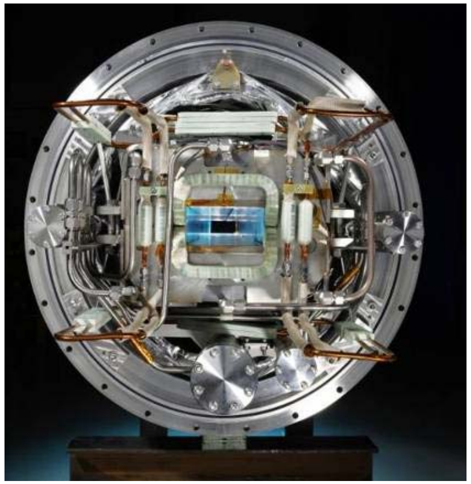
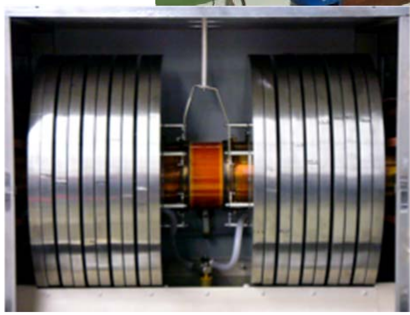
Themenschwerpunkte Kooperationen Beschleunigerphysik



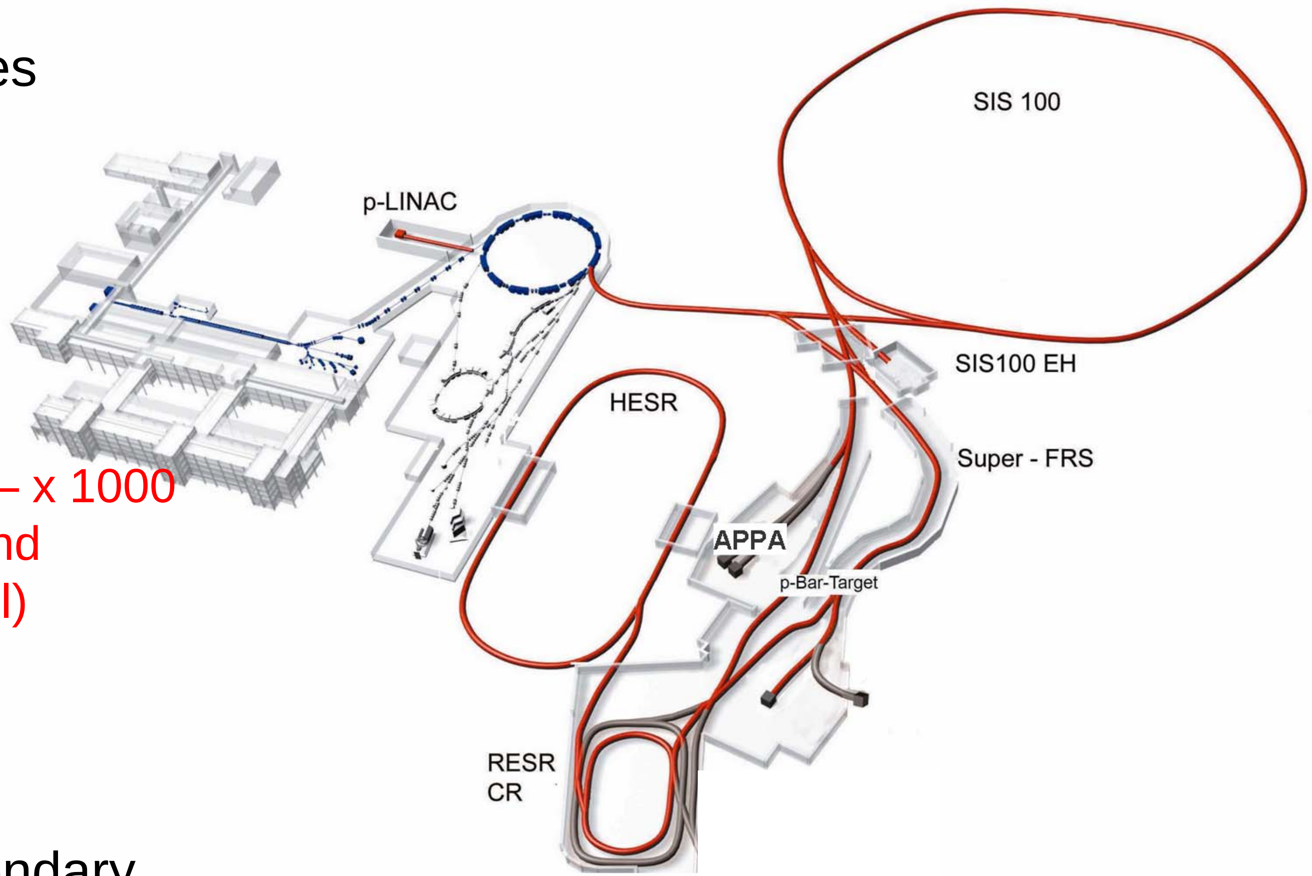






FAIR Accelerators

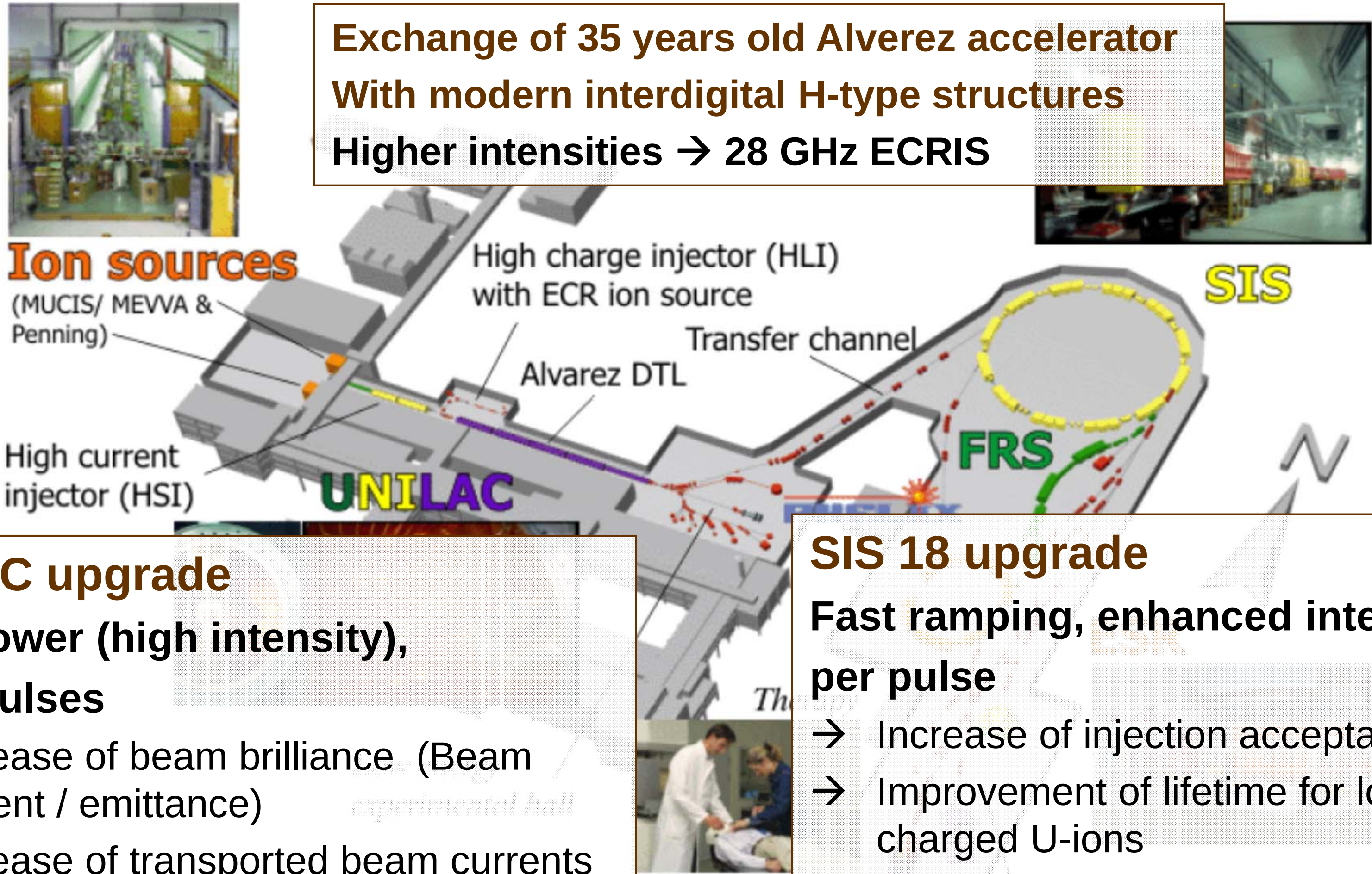
- Injectors:
  High current ion soures and linacs
- Synchrotrons
  → Primary beam driver accelerators
  - Primary beams: x 100 – x 1000 (4*10^11 uranium ions and 2*10^13 protons per spill)
  - Secondary beams: x 10.000
- Storage rings for secondary beam preparation and experiments



Modularized start version

Ertüchtigung der Injektorkette

Exchange of 35 years old Alverez accelerator
With modern interdigital H-type structures
Higher intensities → 28 GHz ECRIS



UNILAC upgrade

High power (high intensity), short pulses

- → Increase of beam brilliance (Beam current / emittance)
- → Increase of transported beam currents
- → Improvements of high current beam diagnostics / operation

SIS 18 upgrade

Fast ramping, enhanced intensity per pulse

- → Increase of injection acceptance
- → Improvement of lifetime for low-charged U-ions
- → Increase of beam-intensity per time due to reduction of SIS18- cycle time

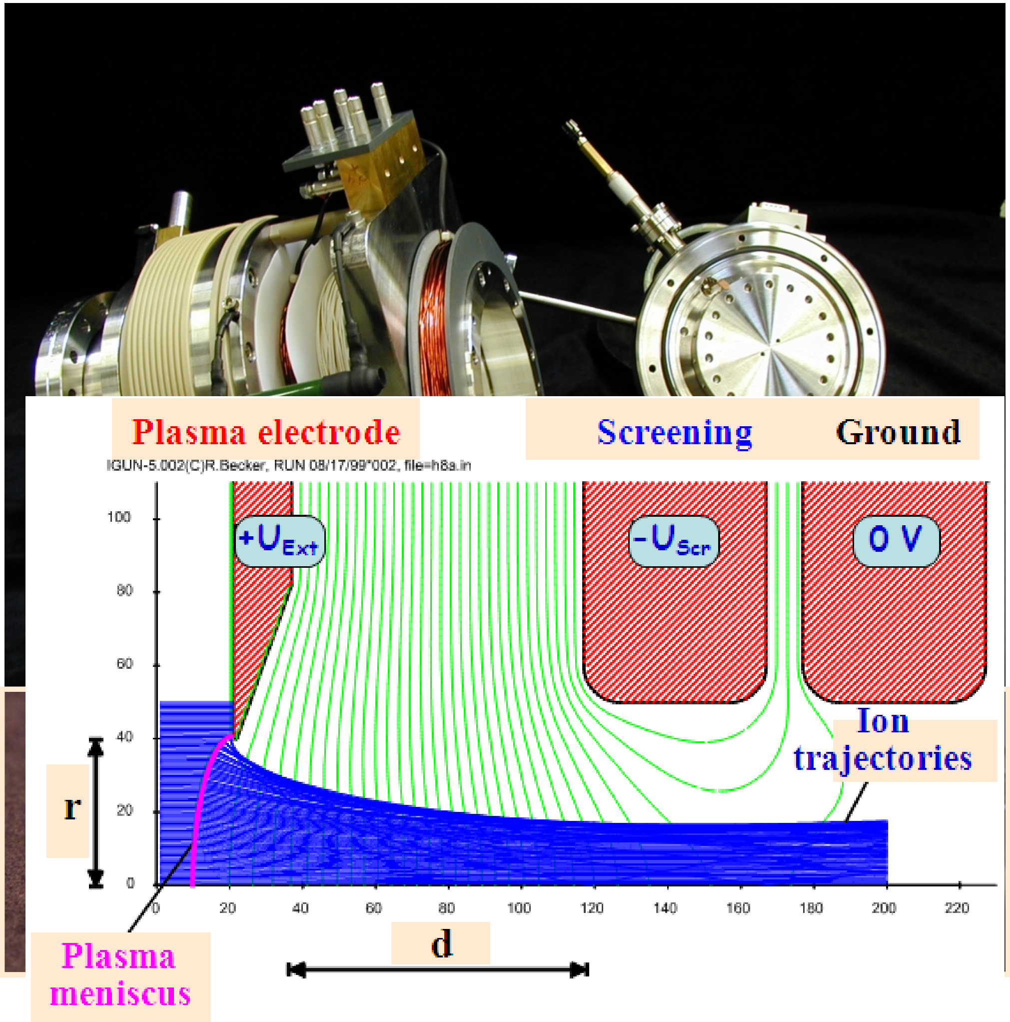
Ion sources and linacs

R&D areas and topics

- Ion source development:
  Extraction and beam transport – correction, collimation,
  intense rf-proton sources, MeVVA with high rep rate
- rf cavity development (low beta cavities):
  H-type structures, buncher cavities, SC- cavities
- Charge state strippers
  Investigation of C-stripper foils, alternative scenarios (high pressure gas stripper,
  plasma stripper systems, liquid metal stripper)
- Beam dynamics
  Space charge dominated HI beams in linacs, beam halo formation,
  brilliance optimization
- Beam diagnostics
  Day zero diagnostics – scintillator screens
  Non intercepting diagnostics

VARIS and beam transport

VARIS (Vacuum Arc Ion Source)



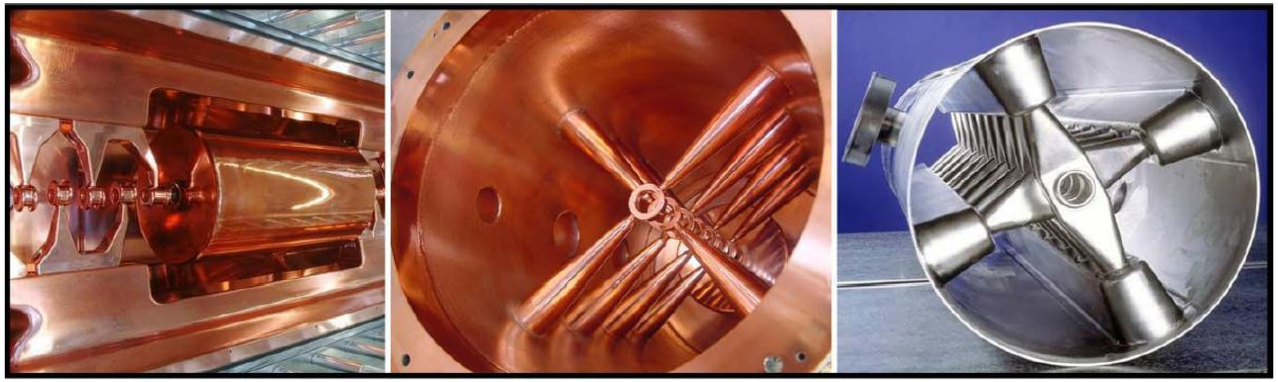
- Optimized for Uranium (67% of 238U^{4+})
- Emission current density 170 mA/cm^2
  - → 156 mA @ 32 kV
    55 mA @ 131 kV
    20 mA in front of the RFQ
    9 mA behind the RFQ

→ Improving the beam quality at plasma extraction

→ Improvement of beam transport
→ Lifetime of cathodes
→ 3 Hz operation

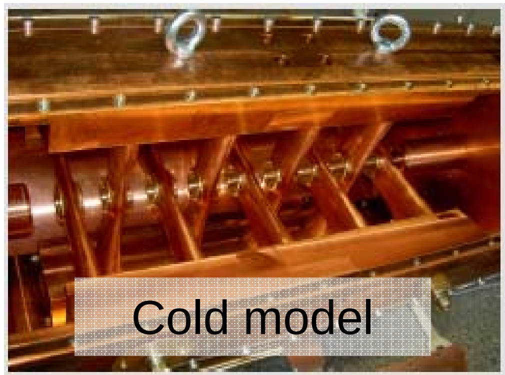
H-type structures for FAIR – acc. gradients

- FAIR-p-linac → 325 MHz-CH-prototype, room temperature
- ALVAREZ replacement → IH-structures (108 MHz)

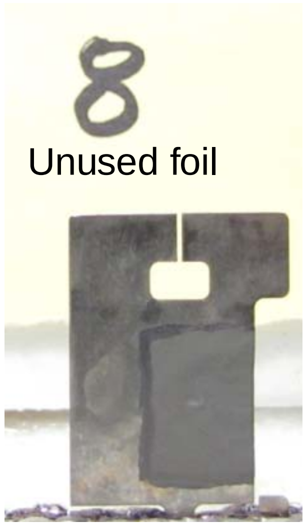


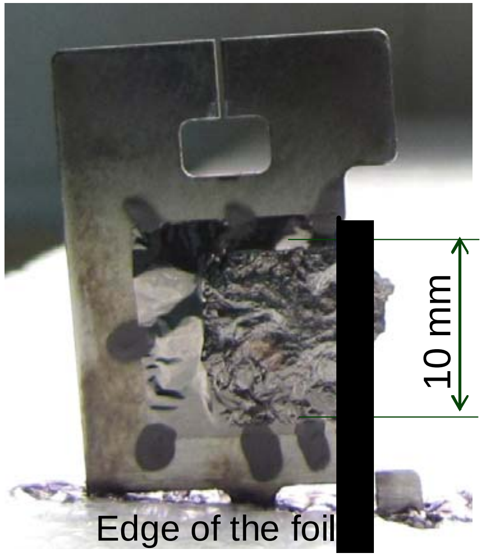
Room Temp. IH-DTL | Room Temp. CH-DTL | Supercond. CH-DTL

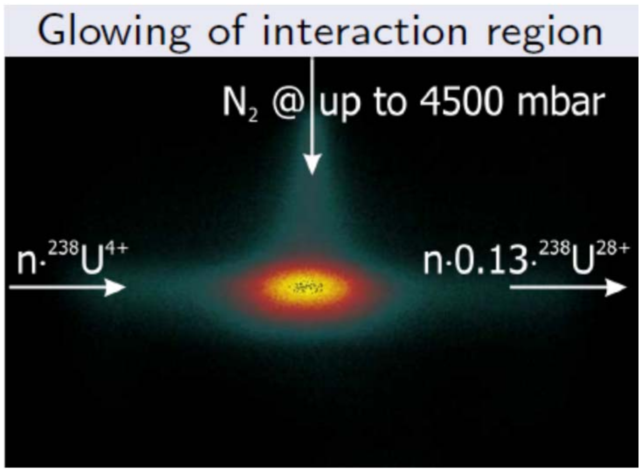
- Prototyping of a SC 325 MHz-CH structure @ Frankfurt



Charge state stripper for intense heavy ion beams?







C-foil stripper

- short lifetime at highest intensities, but highest charge states

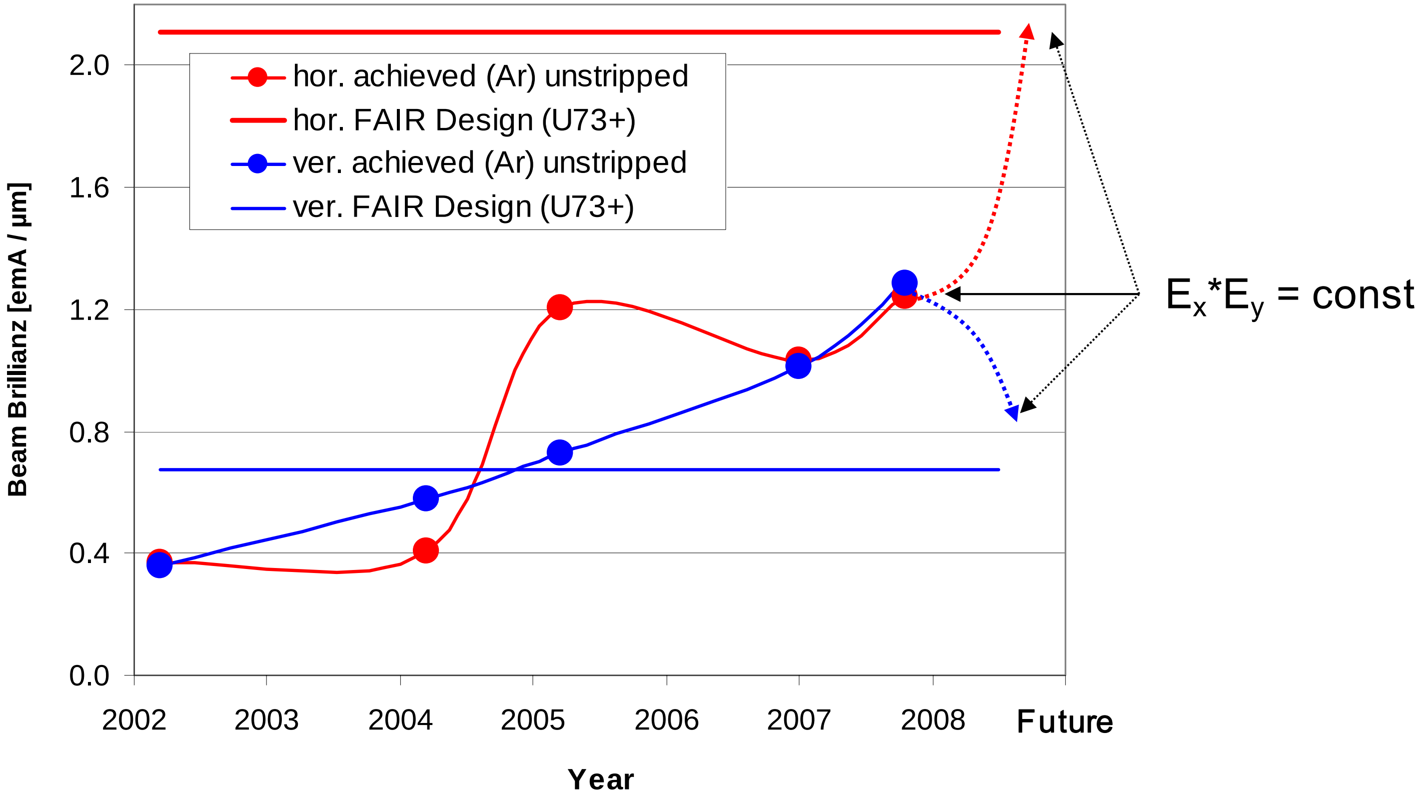
gas stripper

- High intensity capabilities, but lower charge states
- Equilibrium charge state (efficiency)

What is the right choice?

Higher charge states at 1.4 MeV/u stripping energy?

Beam dynamics



Emittance transfer → brilliance matching

KONUS beam dynamics → high intensity beams, Beam halo formation

Heavy Ion Synchrotrons SIS18 and SIS100 and storage rings

R&D areas and topics

- Superconducting magnets (Superferric magnets)
  cryostat technology
- Beam collimation in high current machines
  Concepts (cryogenic systems), materials, dynamic vacuum degradation
  – desorption
- rf-cavities and rf-systems
  Magnetic alloy ring core cavities, barrier bucket systems,
  bunch to bucket transfer between synchrotrons, bunch merging
- Beam dynamics
  Effects of electron clouds in HI machines, instabilities, impedances (impedance library), beam losses → Code development
- HV-kicker and pulsed beam optics elements (injection, extraction and beam transfer between ring machines)
- Activation and damages of materials by heavy ion irradiation

Space charge effects in the FAIR rings

Resonances:

* Tune shift and higher order resonance crossing

→ Resonance compensation?

Impedances:

* image currents in the beam pipe
* magnetic/resistive materials: ferrite, magnetic alloy

→ coherent instabilities and feedback requirements

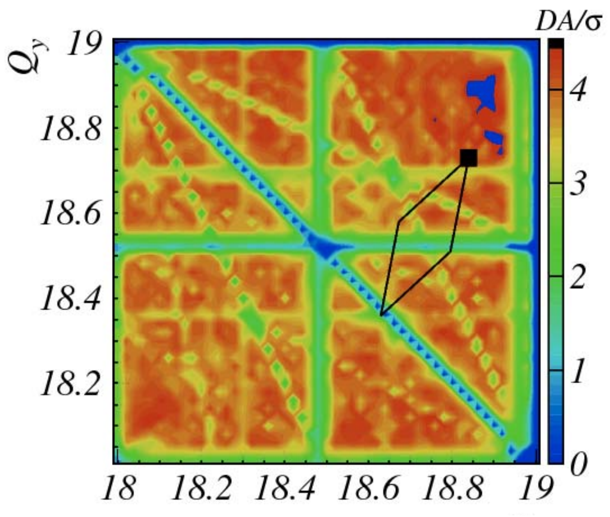
Secondary particles:

* electron clouds created by residual gas ionization and secondary electron emission
* trapping of electrons during slow extraction, two-stream instability

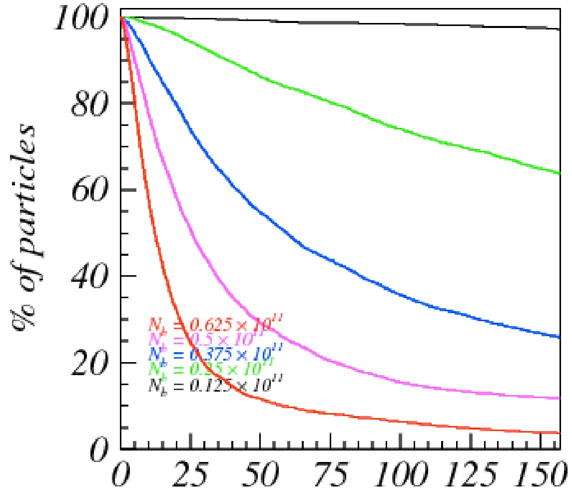
Numerical models are essential!

Mitigation strategy (resonances)

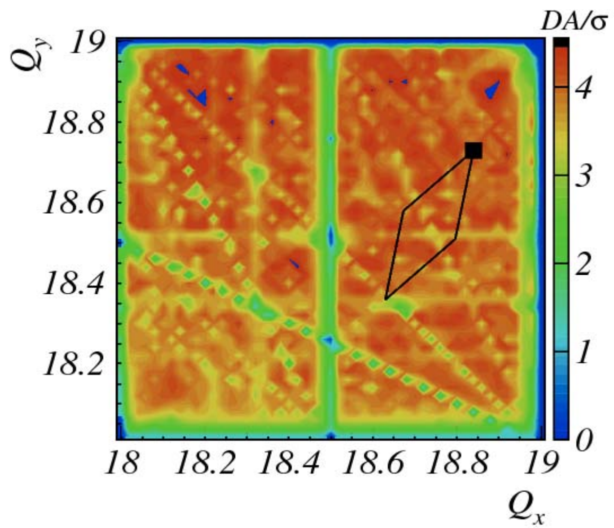
without resonance compensation



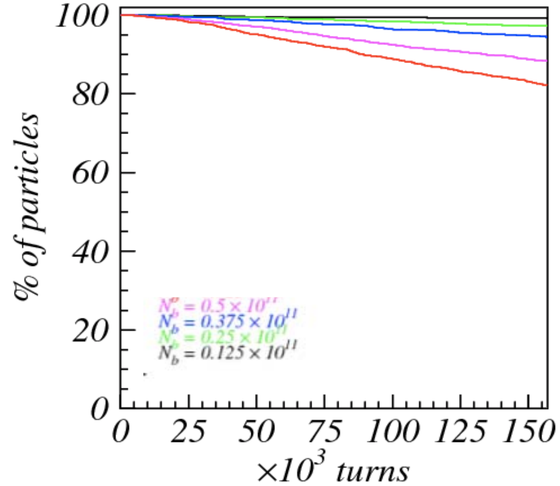
first bunch



compensating the lattice resonances

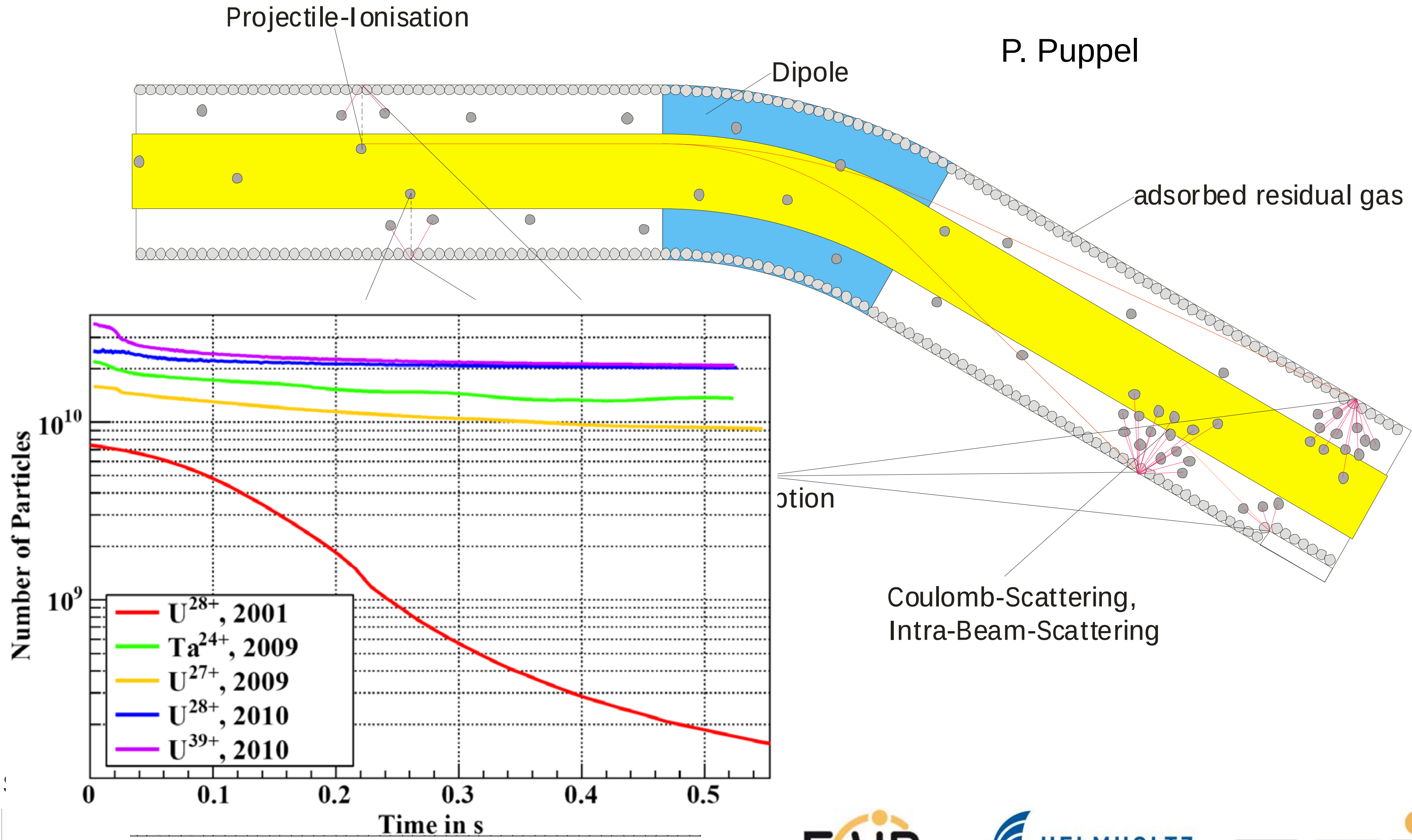


first bunch



Ongoing effort for including self-consistency

Dynamic Vacuum effect and collimation

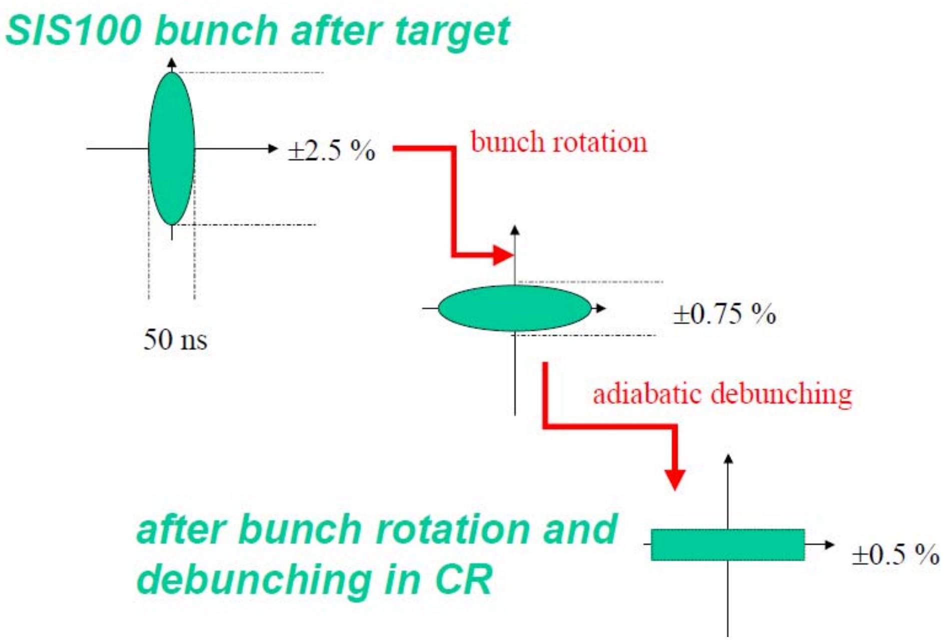


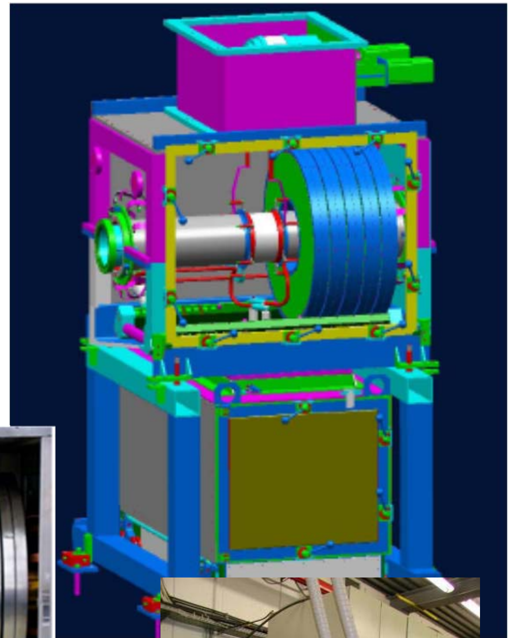
MA ring core cavities

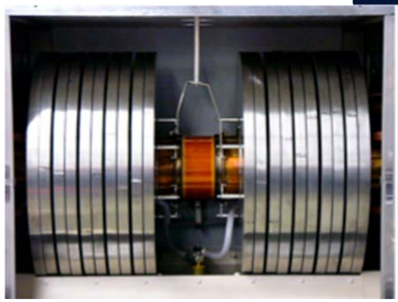
Examples:

- Short bunch from SIS100 (50 ns)
- De-bunching in CR→ High voltage (200 kV) required for fast bunch rotation

→ **Cooling of ring cores and power coupling**







Gap voltage 40 kV
Length 1 m
Rotation time ~ 100 μs

FAIR ‘materials’

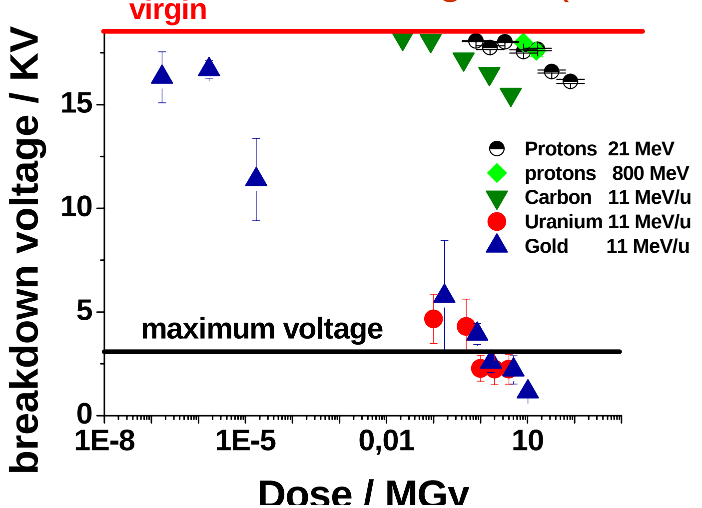
Carbon materials for Super-FRS:

- Mechanism of radiation damage, critical dose
- Structural and thermo-mechanical properties degradation

Insulators:

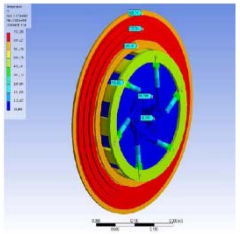
- critical dose determined
- break down voltage of insulating material after irradiation

Insulators - SC magnets (SIS100)

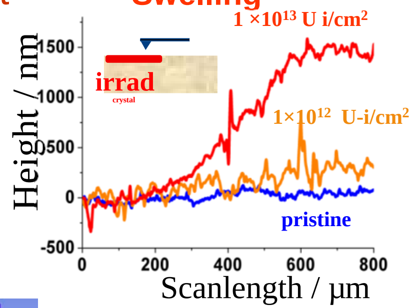


Targets and Beam Catchers - Super-FRS

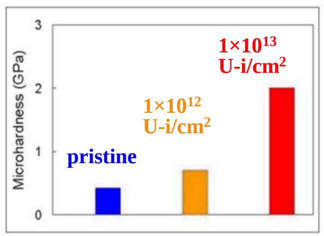
Production target



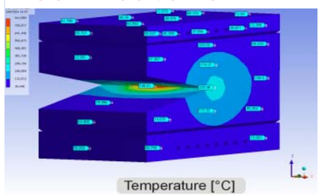
Swelling

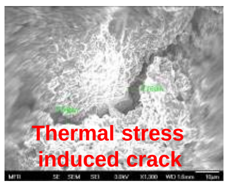


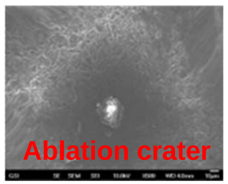
Hardening



Beam catcher







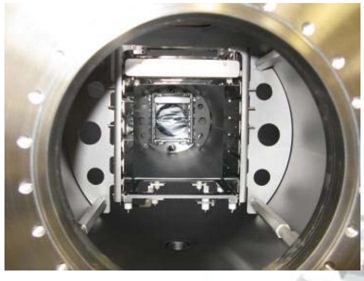
- Investigate radiation damage and failure mechanism of FAIR accelerators materials
- Lifetime estimations for FAIR components
- Innovative materials for extreme conditions

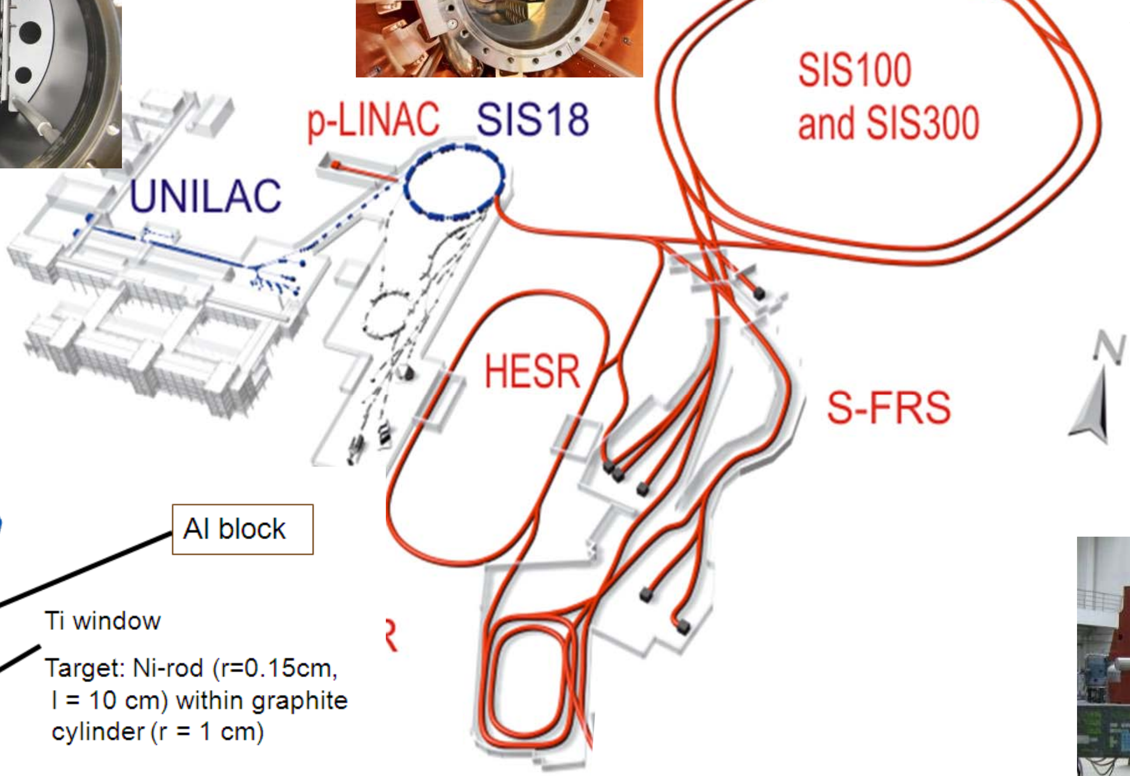
Summary FAIR accelerator topics

- Ion sources
- Rf-Cavities
- Beam transport and collimation
- Beam dynamics investigations
- RF-controls and feedback systems, timing
- Beam Diagnostics
- Superconducting magnets
- Cryogenic systems
- Targets and charge state strippers - materials
- Activation and radiation damage of accelerator components
- Pulse power techniques – kicker systems
- Injection-, extraction systems

Global R&D issues

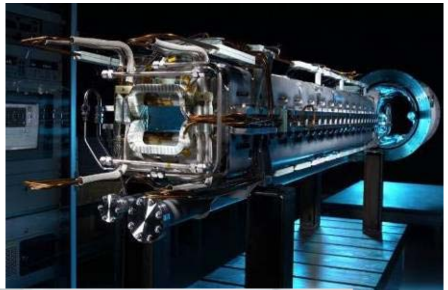
XHV – vacuum systems

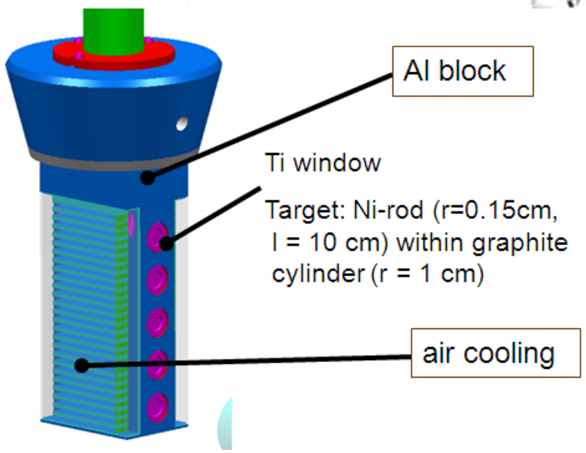




Superconducting magnets

→ energy efficiency!





Production-targets

→ radiation protection