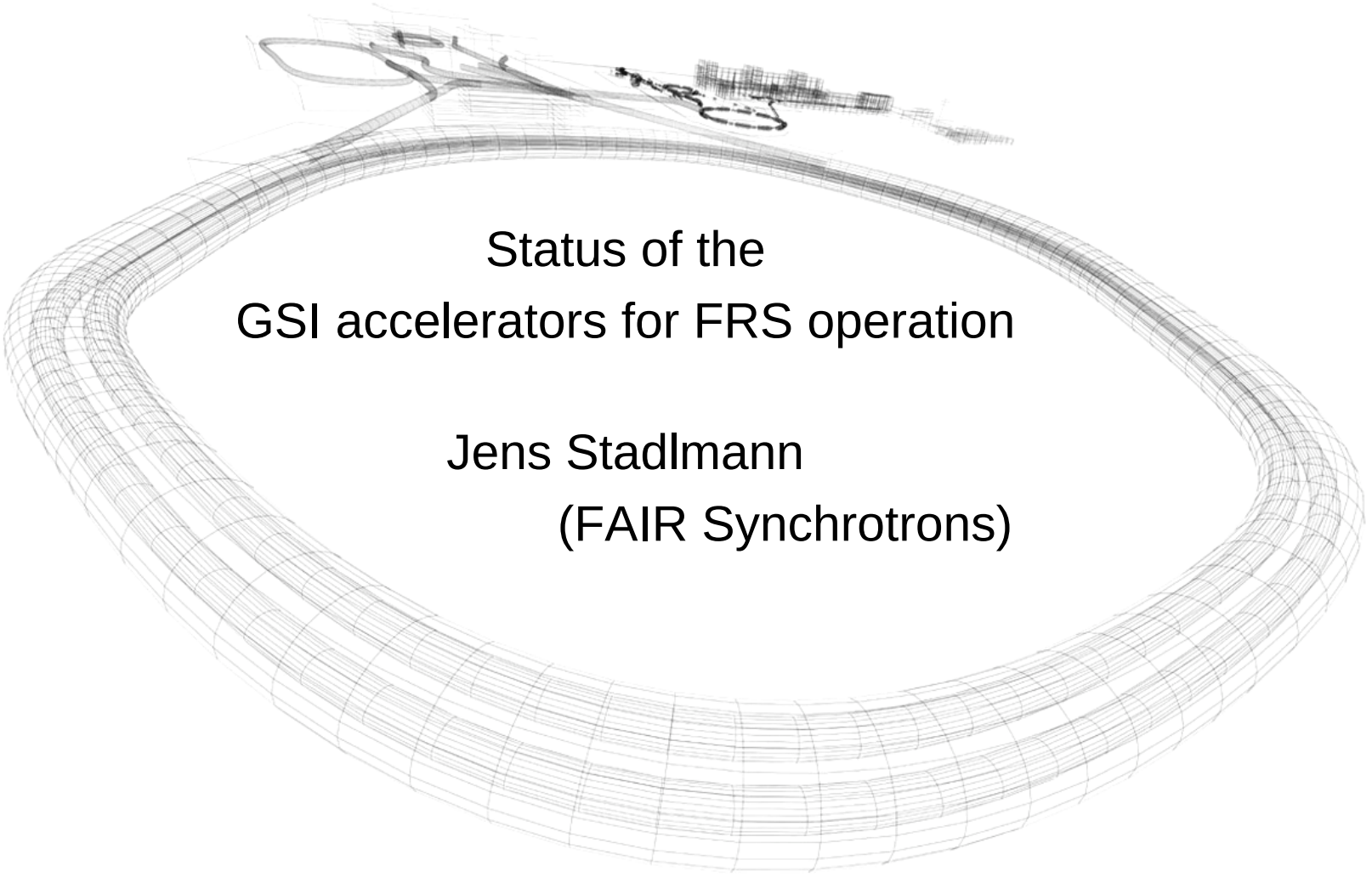
Statusreport



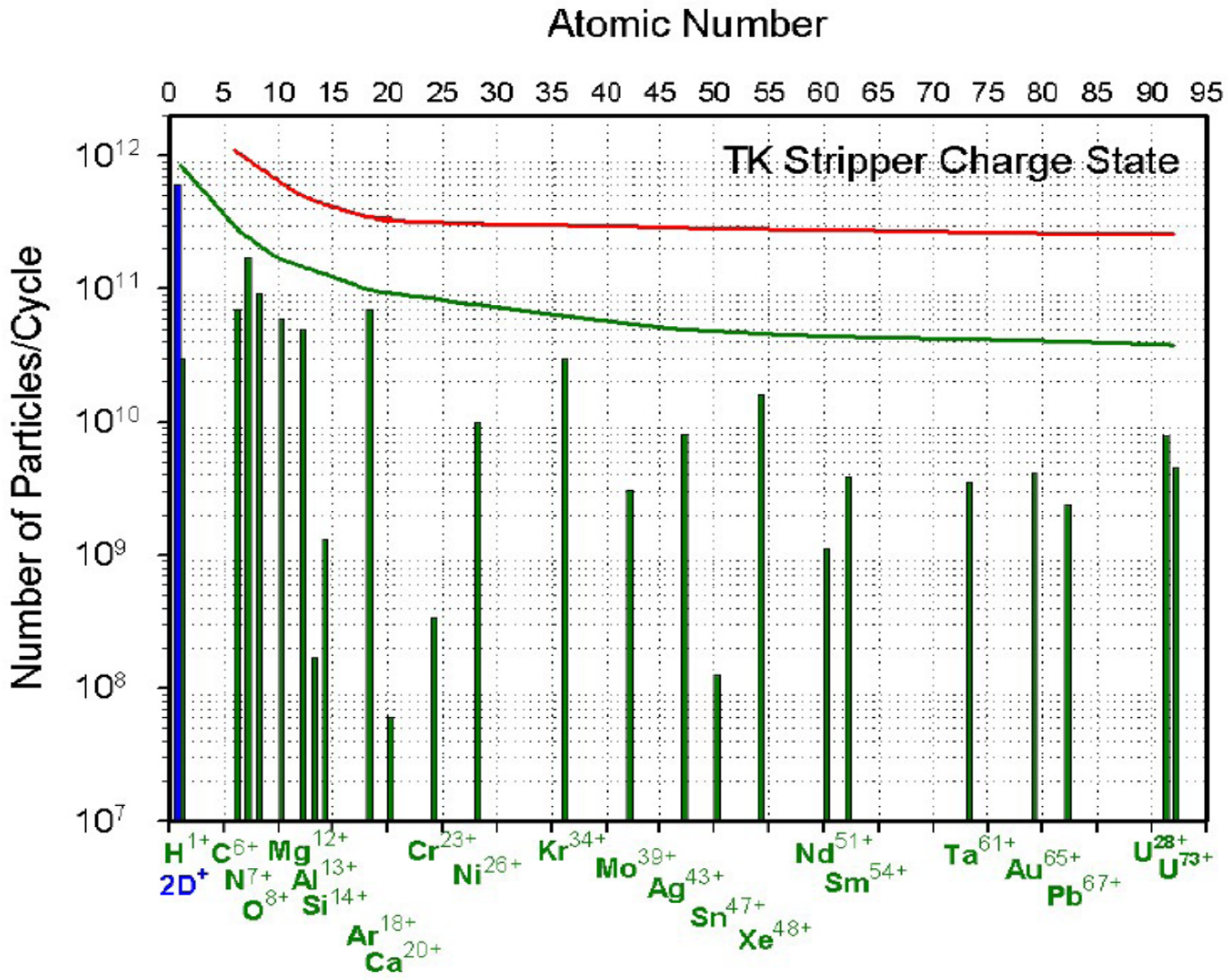
Status of the
GSI accelerators for FRS operation

Jens Stadlmann
(FAIR Synchrotrons)

Overview

- Intensities reached and "candidates" for experiments.
- Uranium?
- Upgrade program
- New developments:
  - Fast ramping
  - Hardt condition for lower extraction losses
- Conclusion and Outlook

Present intensities at SIS18



Lower Z:
close to space charge limit.

Higher Z:
lacking intensity due to source and UNILAC problems and dynamic vacuum effects.

More machine development time needed.

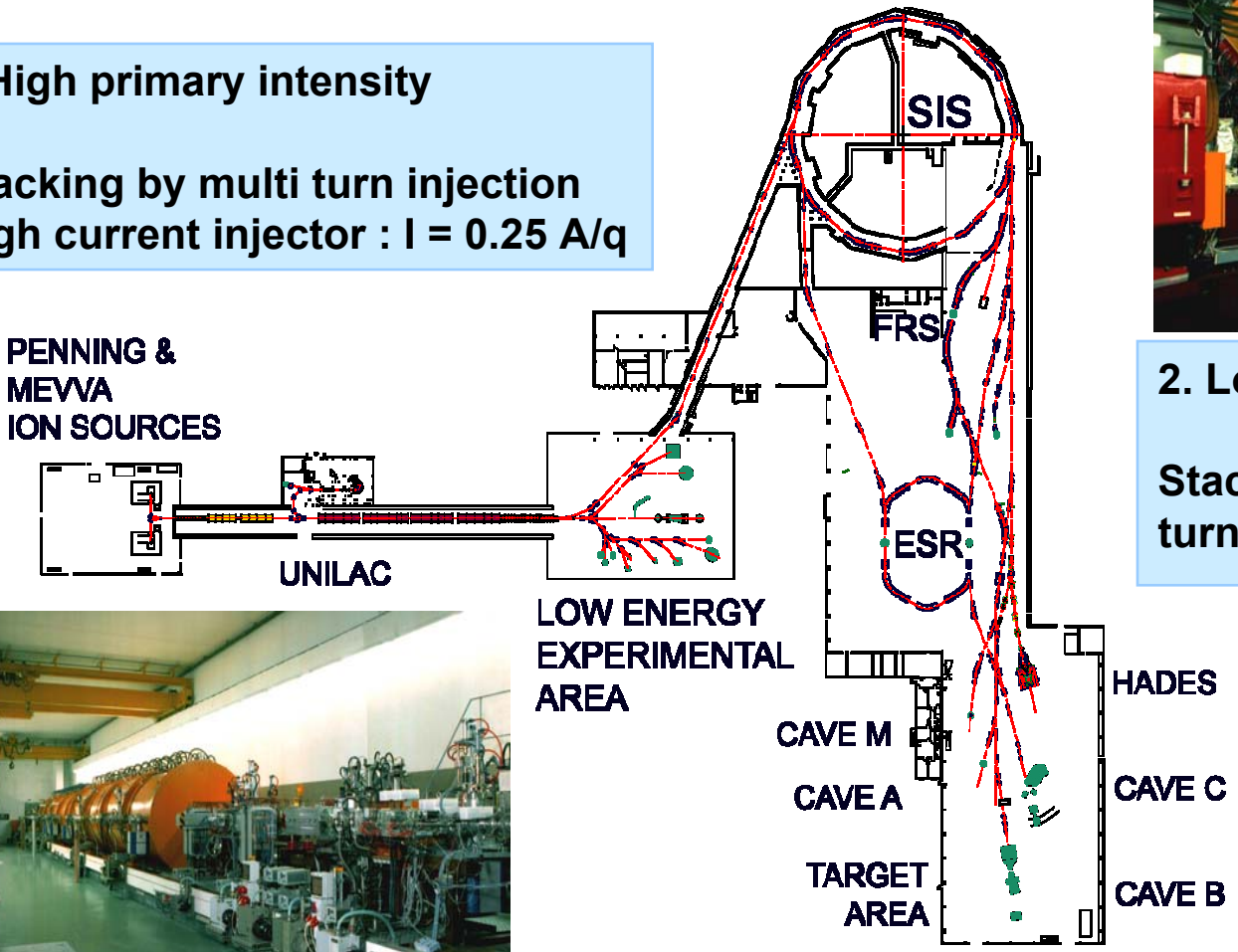
(Status: early 2008)

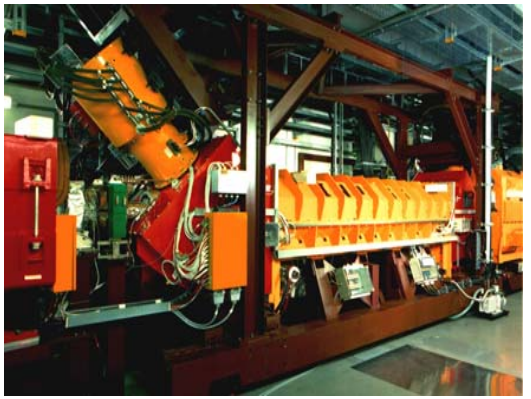
SIS Intensity Accumulation

Two ways to gain intensity

1. High primary intensity

Stacking by multi turn injection
High current injector : I = 0.25 A/q





2. Low primary intensity

Stacking by multi-multi turn injection (e-cooling)

The present currents reached from the high current injector and sources need no stacking by the electron-cooler.

New Uranium service area

Due to a necessary upgrade of the service area for all types of uranium sources there is no Uranium beam available at present.

The revision will be finished in Summer 2009. The first Uranium experiments are expected to be possible in July (KW 29).

Another possible candidate for high current SIS operation with high Z is Ta. Machine experiments using Ta^{3+} from the MEVVA source have reached several 10^9 particles per spill.

SIS18 upgrade program

Supported by EU Construction contract:

- **Task 1: RF System**
  New h=2 acceleration cavity and bunch compression system for FAIR stage 0, 1
  (2010)
- **Task 2: UHV System**
  New, NEG coated dipol- and quadrupole chambers
  (2006-2009)
- **Task 3: Insertions**
  Set-up of a „low-desorption“ scraper system
  (2007-2009)
- **Task 4: Injection / Extraction Systems**
  New, large acceptance injection system plus HV power suppy
  (2007)
- **Task 5: Beam Diagnostics Systems**
  Fast residual gas profile monitor and high current transformer
  (2008)
- **Task 6: Injector**
  Set-up of a TK charge separator
  (2007)

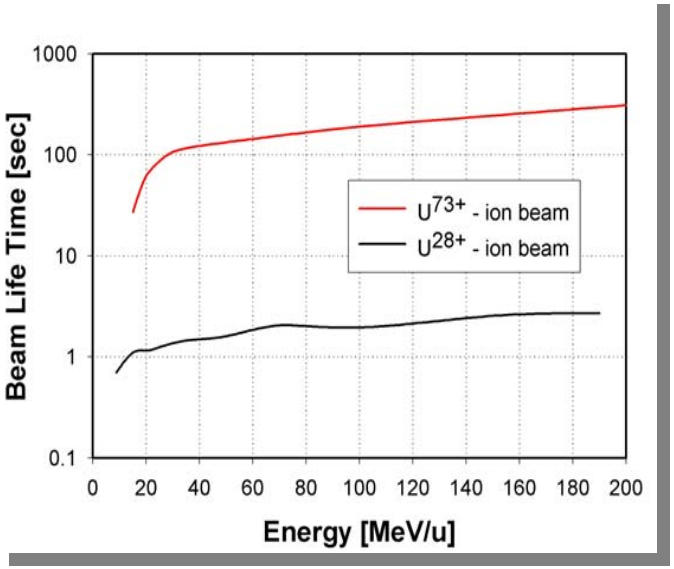
SIS18 upgrade program

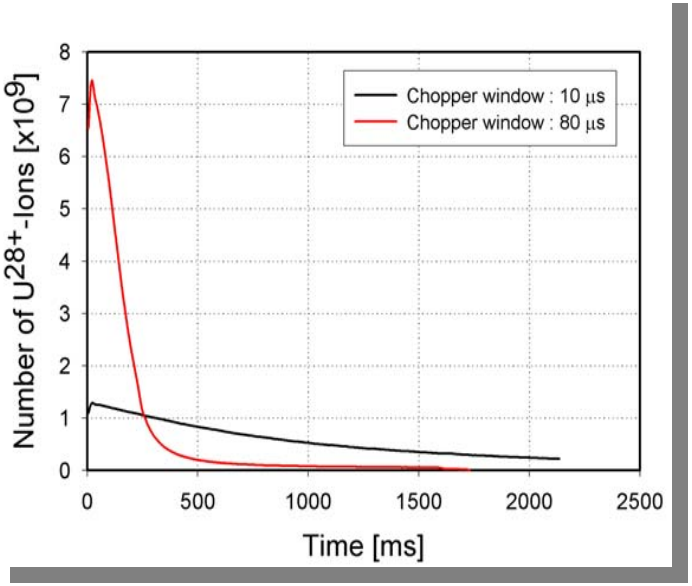
Not supported by EU construction program:

- **Pulse Power Connection**
  Dedicated 110 kV power connection and transformer for fast ramping
  (2006 and 2010)
- **Replacement of Main Dipole Power Supplies**
  Operation with 10 T/s up to 18 Tm
  (2010)
- **Longitudinal and Transverse Feed Back Systems**
  Damping of coherent oscillations, coupled bunch modes and phase stabilization
- **Beam Diagnostics upgrade**
  New digital front end electronics for BPMs (2007)
  New high current transformer (2006)
- **Machine Protection and Interlock Systems**
  Halo collimators, local shielding, transmission interlock etc.
- **Development of High Current Operation**
  Compensation of resonances, impedance issues etc.
  (2008-2010)

Life Time and Beam Loss:

XHV is the key to heavy ion acceleration





- Life time of U^{28+} is significantly lower than of U^{73+}
- Life time of U^{28+} depends strongly on the residual gas pressure and composition

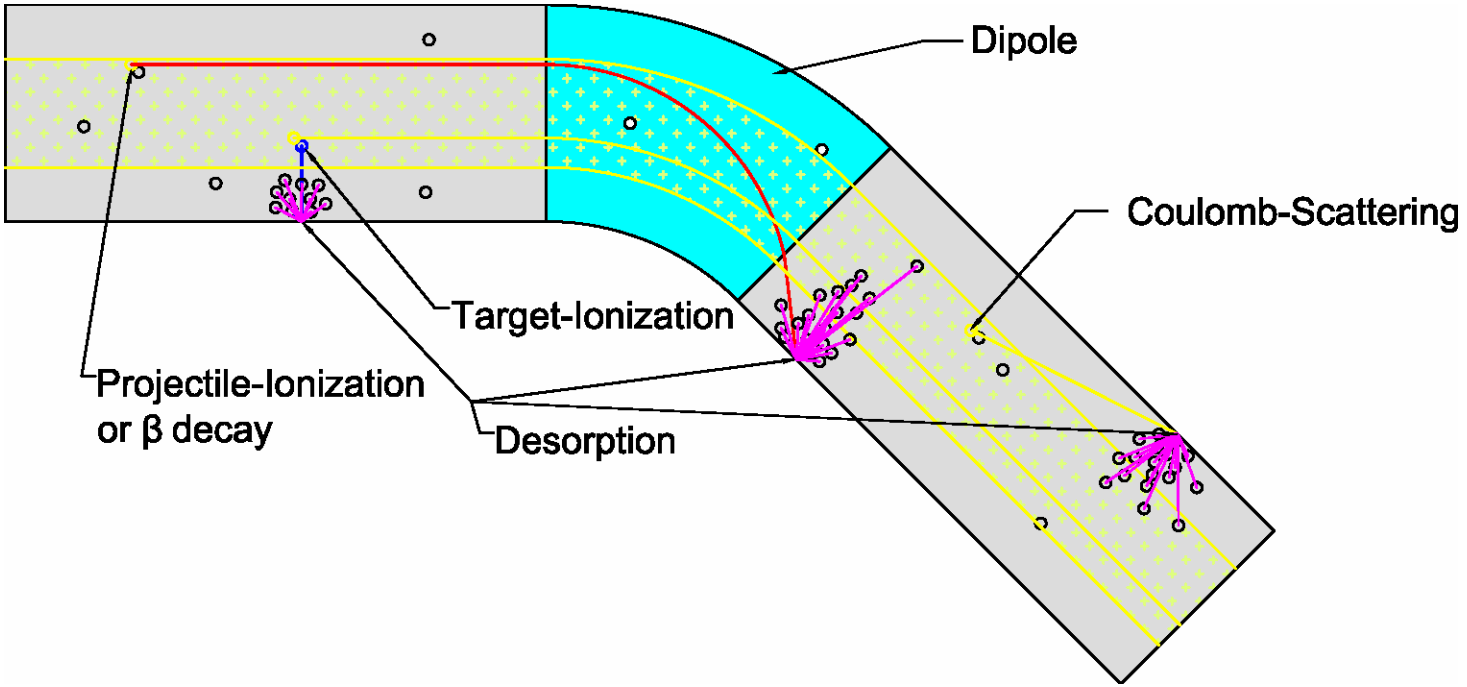
- Ion induced gas desorption ($\eta \approx 10\,000$) increases the local pressure
- Beam loss increases with intensity

(dynamics vacuum, vacuum instability)

Beam Loss due to Charge Change

$U^{28+} \rightarrow U^{29+}$ $U^{73+} \rightarrow U^{72+}$

Ionization dominated Capture dominated



SIS18 upgrade - Pressure Stabilization

- Short cycle times and short sequences

  SIS18: 10 T/s - four cycle sequence for injection

  (new power connection, power converters and Rf system)

- Enhance pumping power (UHV upgrade)

  (NEG-coating, cryo panels - local and distributed)

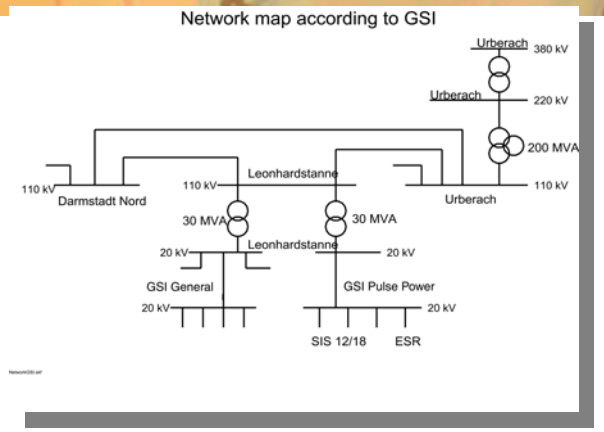
  (new magnet chambers, improved bake out system)

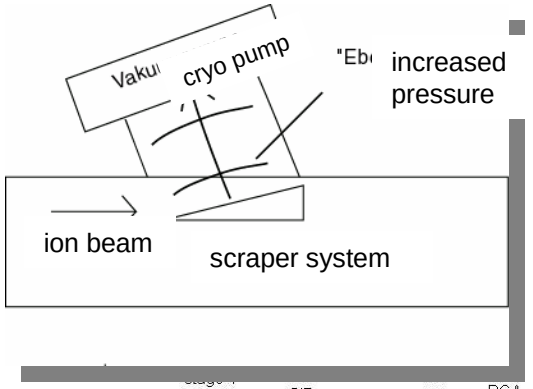
- Localizing beam loss and control/suppression of desorption gases

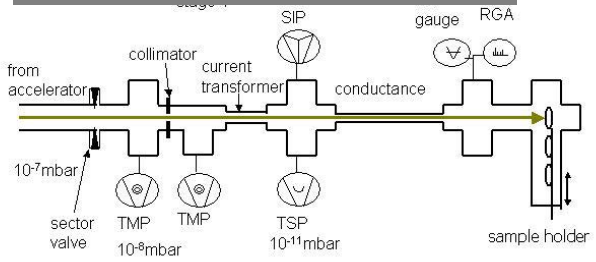
  (Scraper system)

- Materials with low desorption yields

  η-Teststand, ERDA measurements,





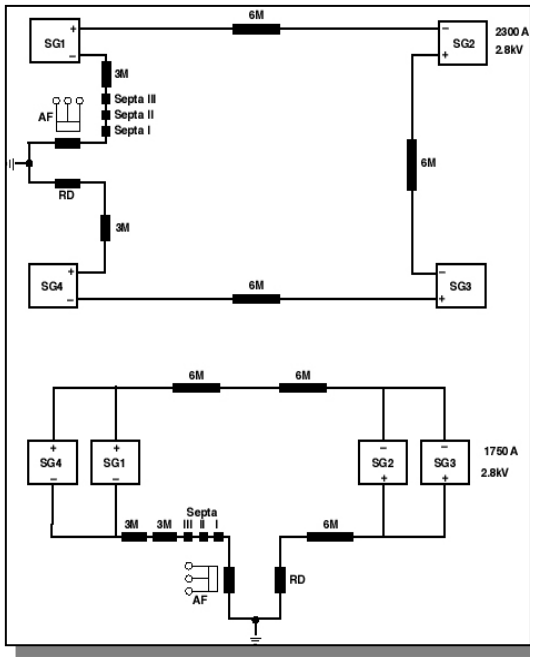


Fast Ramping

High average beam intensity requires fast short cycle times with fast ramping.

- Shortening of cycle time (low charge state operation)
- Higher repetition rate (booster operation 2.7 – 4 Hz)
- Increased average intensity (x 2-9)

Standard operation:
dB/dt = 1.3 T/s , 1/3 Hz



A. SIS18 Modus

B_{max}= 1.8 T , dB/dt = 4 T/s

I_{max} = 3500 A , V_{max} = 5.5 kV

2 groups each 2 parallel power converters

2 groups each 12 dipoles

P_{max} = +19/-17 MW

B. SIS12 Modus

B_{max} = 1.2 T , dB/dt = 10 T/s , I_{max} = 2300 A , V_{max} = 11.2 kV

4 power converters in series supply 4 groups of each 6 dipoles

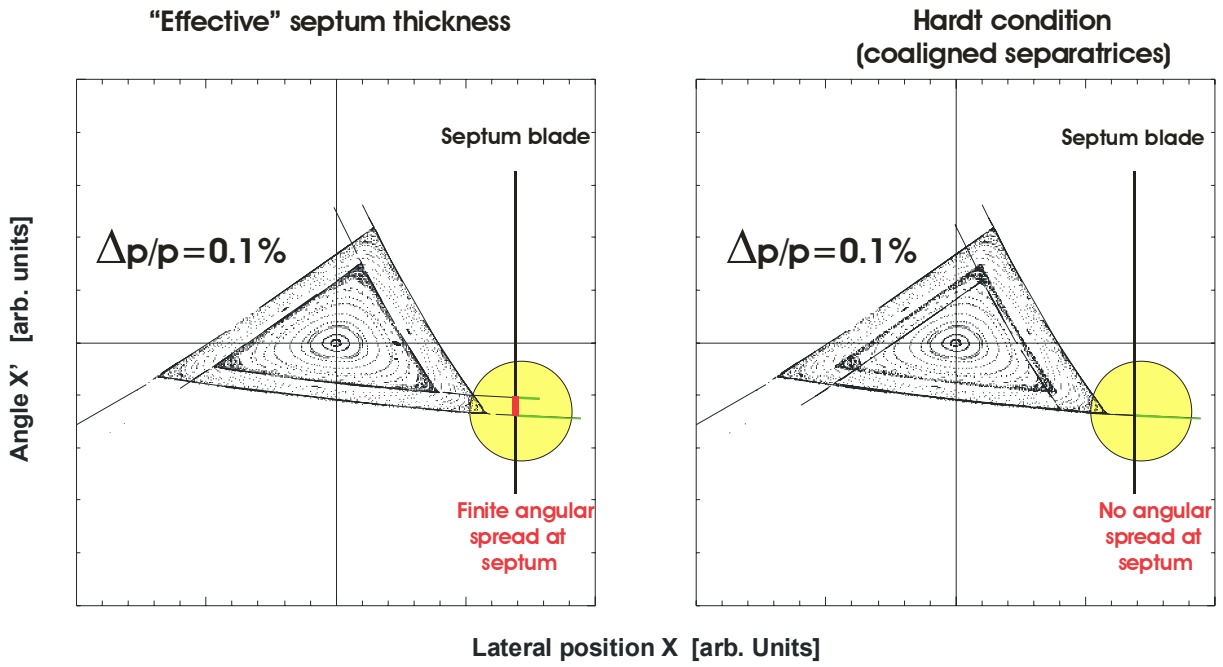
P_{max} = +26/-23 MW

(U^{73+} : E_{max} = 512 MeV/u)

Power converter upgrade for 10 T/s up to 18 Tm (project start 2008)

Beam loss due to momentum spread. (slow extraction)

Hardt condition: $D_n \cos(\alpha - \Delta\mu) + D_{n'} \sin(\alpha - \Delta\mu) = -4\pi (Q' / S)$



D_n	Dispersion at ES
$D_{n'}$	Derivative of dispers.
α	Orientation separatrix at sextupole
$\Delta\mu$	Phase advance sextupole - ES
Q'	Chromaticity
S	Sextupole strength

Hardt condition realized

(via chromaticity control)

thus minimum beam loss

First experiment at SIS18

Extraction efficiency raise

from 83 to 93%

Outlook

- The upgrade program aimed at the operation of SIS18 and UNILAC for FAIR delivers higher beam intensities already now.
- Only the combination of all planned improvements will lead to the desired "FAIR intensities".
- The upgrade program needs long shutdowns and extended time for machine development.
- New benefits are introduced into normal operation as fast as possible.