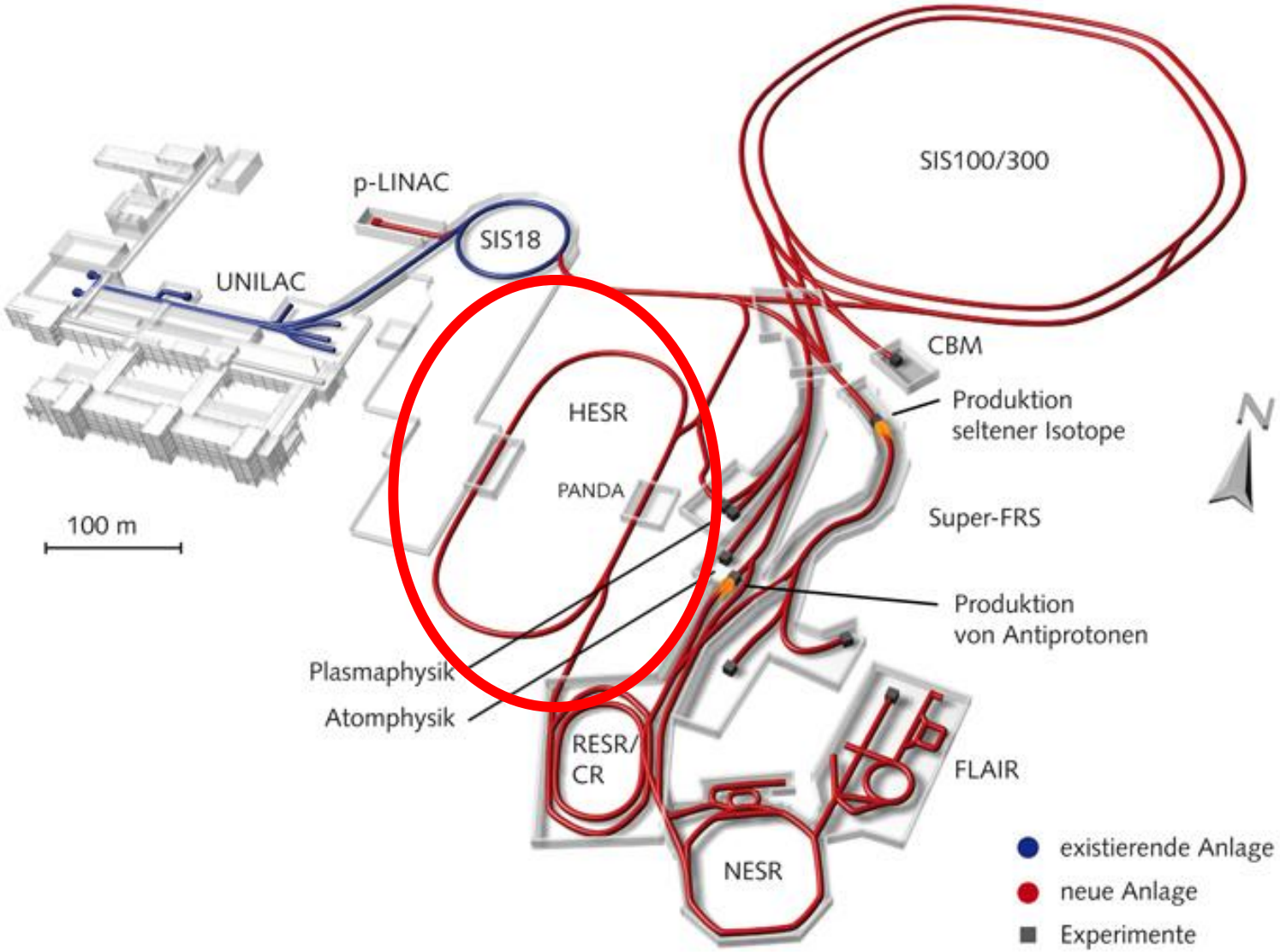
JÜLICH
FORSCHUNGSZENTRUM

Overview over the HESR

13th June 2013 COOL´13

The FAIR facility (introduced by Markus Steck)



HESR Consortium

JÜLICH FORSCHUNGSZENTRUM

JÜLICH FORSCHUNGSZENTRUM

GSI

HELMHOLTZ Institut Mainz

universitätbonn

ICPE-CA, Bukarest, Rumania

Rumania

Instrumentation Technologies

Outline

- Design requirements for the HESR
- p-bar injection and accumulation
- Ions in the HESR
- Status of the HESR
- Summary

Design criteria for the HESR

The HESR was originally designed as a synchrotron and storage ring for anti-proton physics with one internal user:

PANDA

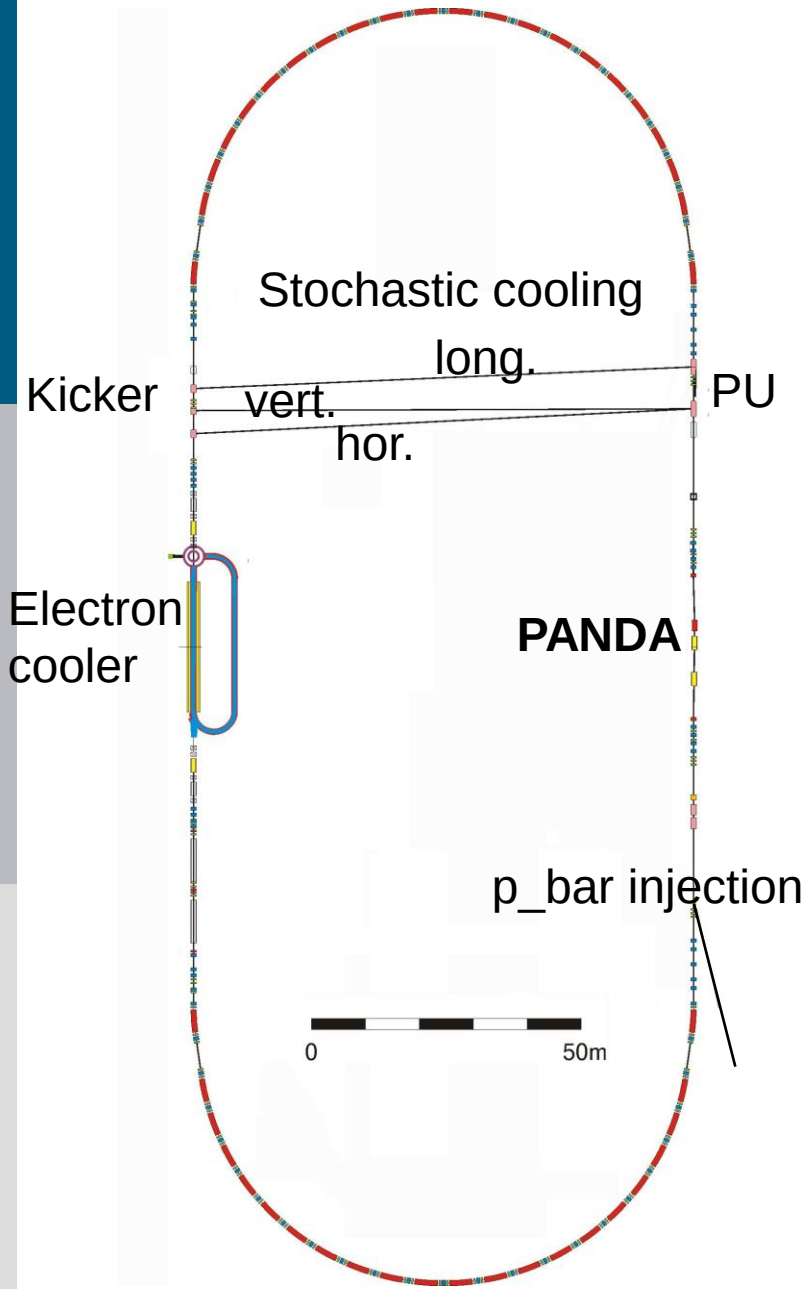
So, PANDA defined the basic design criteria.

Modes of Operation with PANDA

JÜLICH FORSCHUNGSZENTRUM

Experiment Mode	High Resolution Mode	High Luminosity Mode (not achievable in MSV)
Target	Hydrogen Pellet target with $4*10^{15}$ cm^{-2}	
rms-emittance	1 mm mrad	
Momentum range	1.5 – 8.9 GeV/c	1.5 – 15.0 GeV/c
Intensity	$1*10^{10}$	$1*10^{11}$
Luminosity	$2*10^{31}$ cm^{-2} s^{-1}	$2*10^{32}$ cm^{-2} s^{-1}
rms-momentum resolution	$5*10^{-5}$	$1*10^{-4}$

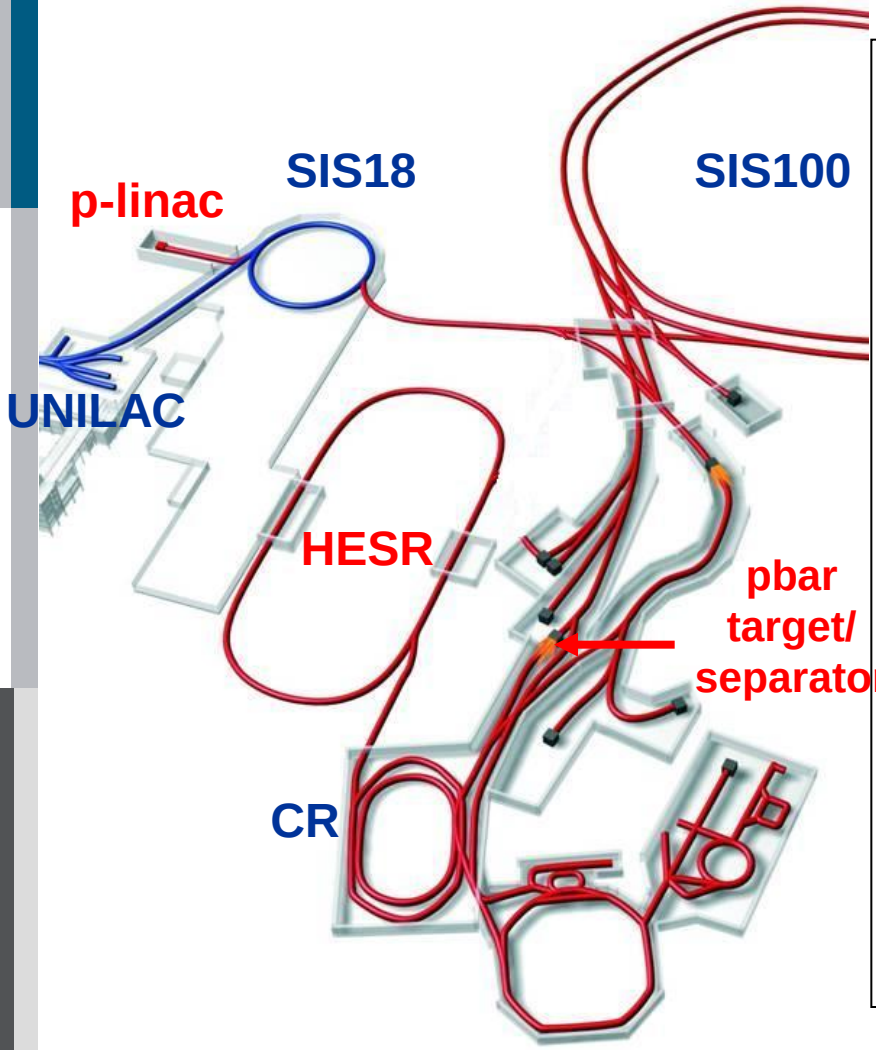
Basic Data of HESR



- Circumference 574 m
- Momentum (energy) range
  1.5 to 15 GeV/c (0.8-14.1 GeV)
- Injection of (anti-)protons from CR / RESR at 3.8 GeV/c
- Maximum dipole field: 1.7 T
- Dipole field at injection: 0.4 T
- Dipole field ramp: 0.025 T/s
- Acceleration rate 0.2 (GeV/c)/s

The Modularized Start Version made a new scheme of injection and accumulation necessary, which reduces the achievable intensity of anti-protons in the HESR.

Antiproton Chain (Modularised Start Version)



- acceleration in p-linac to 70 MeV
- multiturn injection into SIS18, acceleration to 4 GeV
- transfer of 4 SIS pulses to SIS100
- acceleration to 29 GeV and extraction of single bunch
- antiproton target and separator for 3 GeV antiprotons
- collection and pre-cooling of 10^8 p-bars in the Collector Ring CR
- transfer of 10^8 p-bars at 3 GeV to HESR
- accumulation and storage of antiprotons in the HESR

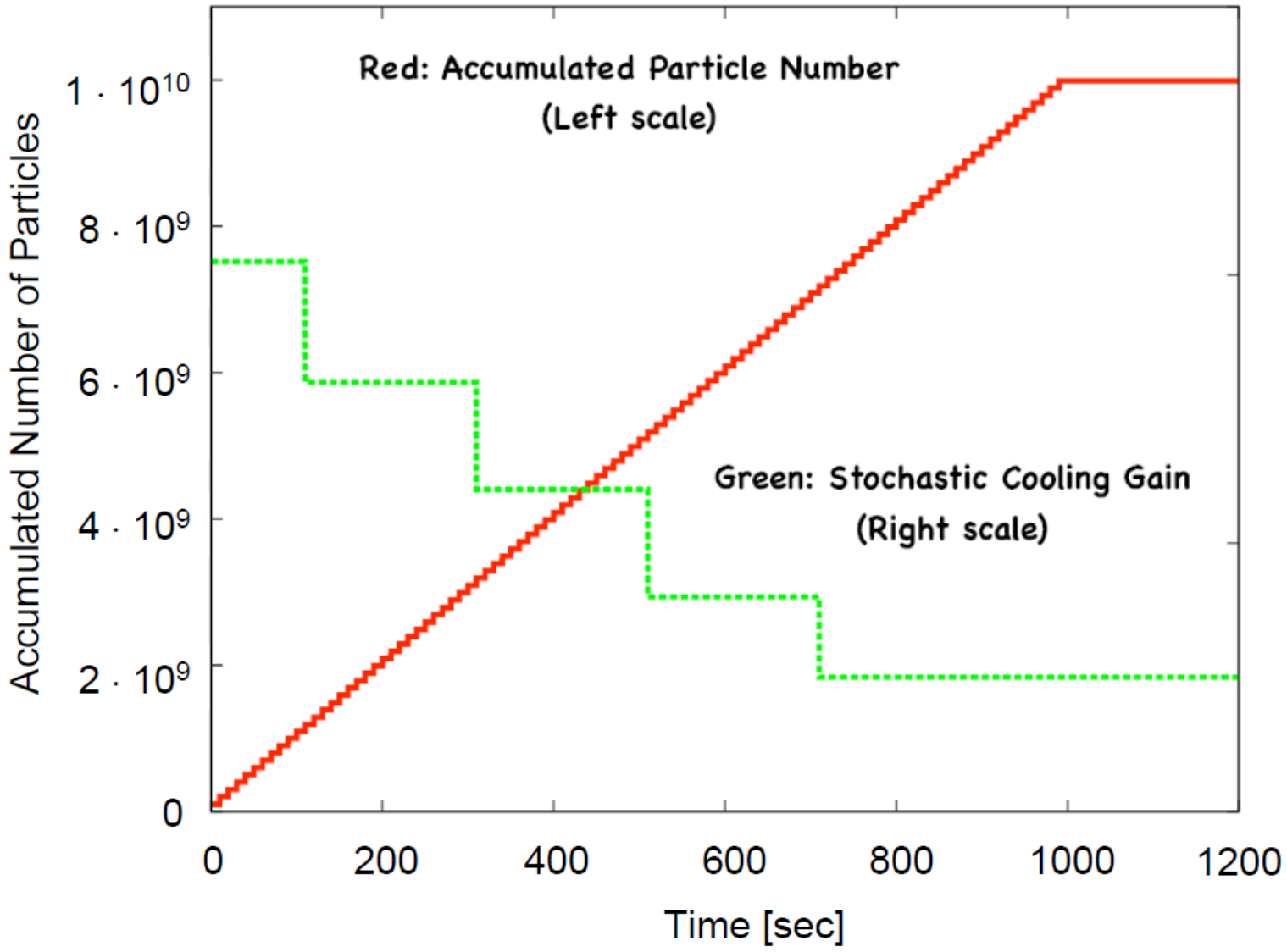
The p-bar accumulation without RESR

- 10^8 p-bars collected in the CR
- 10 s cooling time in CR
- Transfer of 10^8 p-bars to HESR
- In parallel:
  - Cooling of 10^8 p-bars in CR
  - Cooling of 10^8 p-bars in HESR
- Transfer of 2nd CR-stack into HESR
- 100 times repetition of that procedure

$\Rightarrow$ Accumulation of 10^{10} p-bars in HESR in 1000 s

- Acceleration, cooling, experiment

The accumulation process in HESR



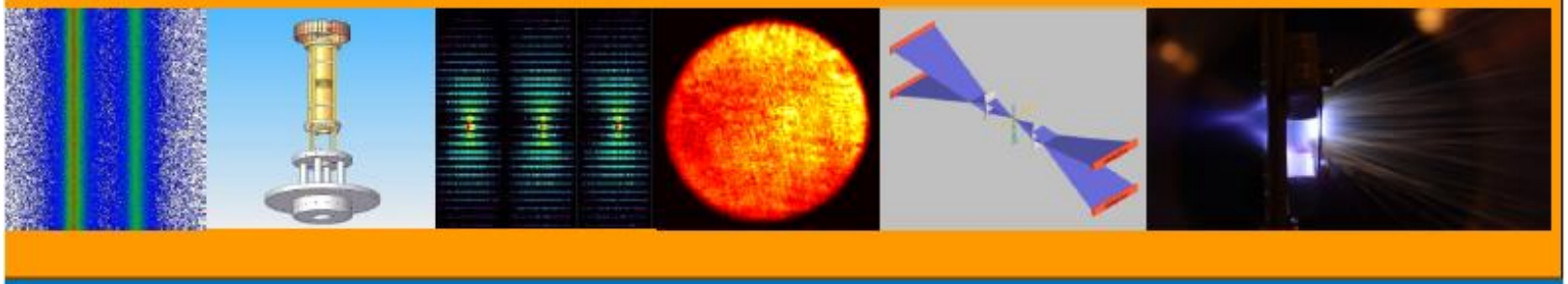
JÜLICH
FORSCHUNGSZENTRUM

New customers:

Heavy Ions in the HESR

A presentation by Thomas Stöhlker

JÜLICH FORSCHUNGSZENTRUM



The SPARC Collaboration –

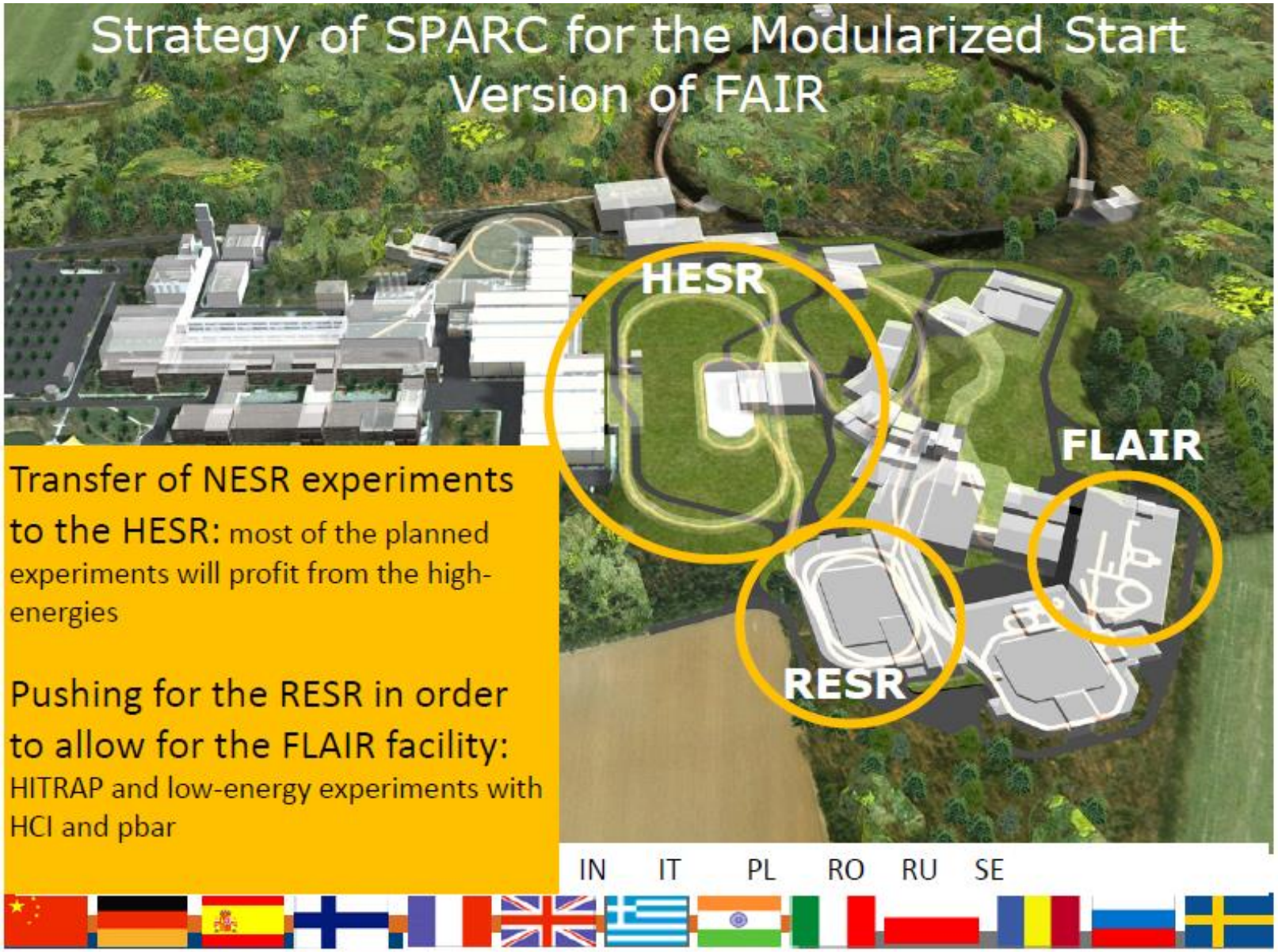
Atomic Physics Research with Highly Charged Ions and Exotic Nuclei at the Future FAIR Facility

Atomic Physics at the HESR

Thomas Stöhlker *on behalf of the SPARC-Collaboration*
GSI-Darmstadt, Helmholtz-Institute Jena

Special thanks to:
Christina Dimopoulou, Fritz Nolden, Markus Steck

Strategy of SPARC for the Modularized Start Version of FAIR

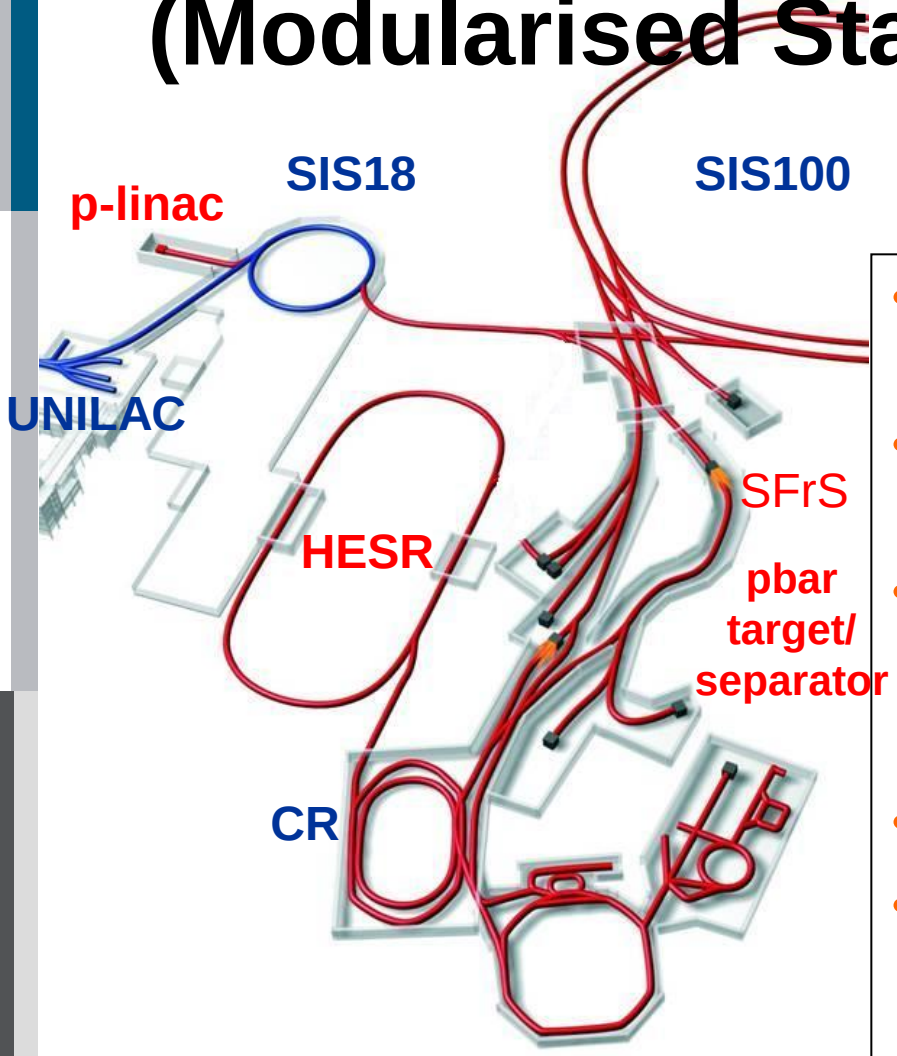


Transfer of NESR experiments to the HESR: most of the planned experiments will profit from the high-energies

Pushing for the RESR in order to allow for the FLAIR facility: HITRAP and low-energy experiments with HCI and pbar

IN IT PL RO RU SE

Possible ways for ions into the HESR (Modularised Start Version)



- acceleration in UNILAC, SIS18 and SIS100
- Bypass the antiproton target or SFrS Target
- collection and pre-cooling of ions in the Collector Ring CR

- transfer of ions at 12 Tm to HESR
- (accumulation and) storage, acceleration and cooling of ions in the HESR

The storage ring group at GSI (Markus Steck, Christina Dimopoulou and Alexej Dolinskii)

and the beam dynamic group in Jülich (Hans Stockhorst, in coll. with Takeshi Katayama) are working on the related topics:

- Improvements of optics
- Cooling of Heavy Ions
- Interaction region

Experimental conditions for ions in the HESR

Requirements:

- Ions: $^{238}U^{92+}$
- Proposed experiments use 10^8 ions

Simulations were carried out for different modes:

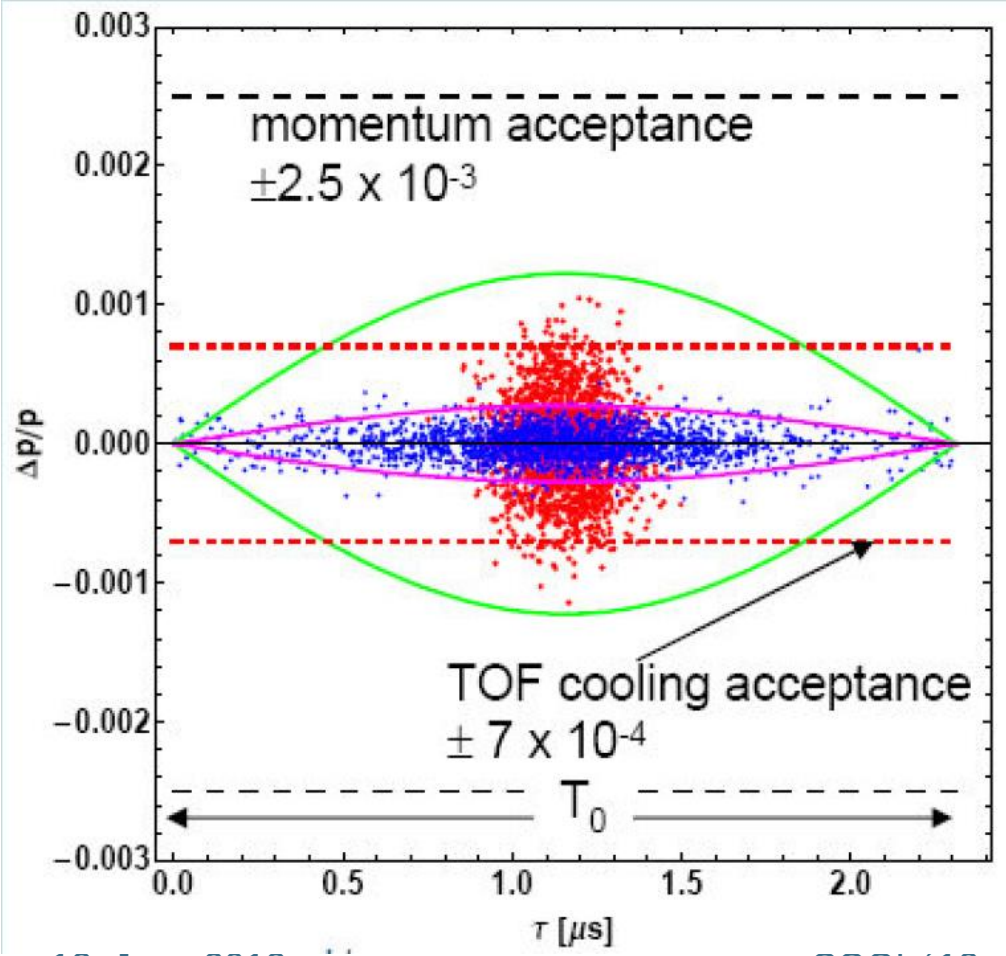
- Experiments at injection energy (740 MeV/u)
- Experiments at 2 GeV/u

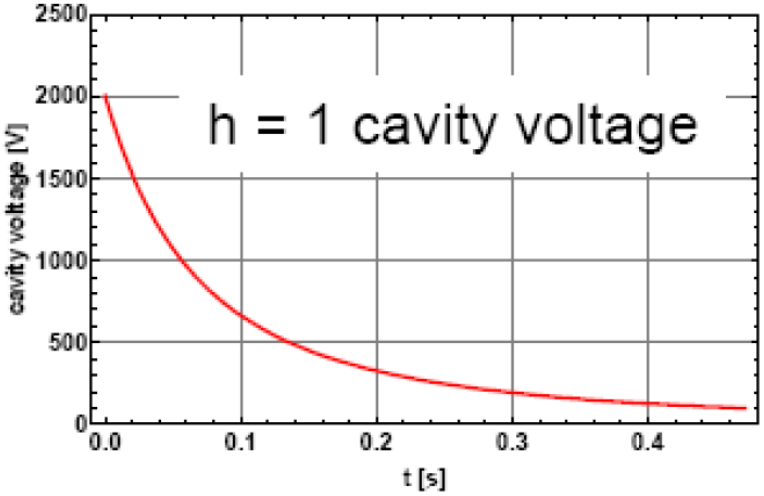
Injection of ions into HESR

- 10^8 ions from CR at 740 MeV/u (13 Tm)
- Injection into standing bucket with U_0=2 kV
  (covers the momentum spread of CR-beam with $\Delta p/p=3.3*10^{-4}$)
- Adiabatic debunching to $\Delta p/p=1*10^{-4}$
- Stochastic momentum cooling to $\Delta p/p=5*10^{-5}$

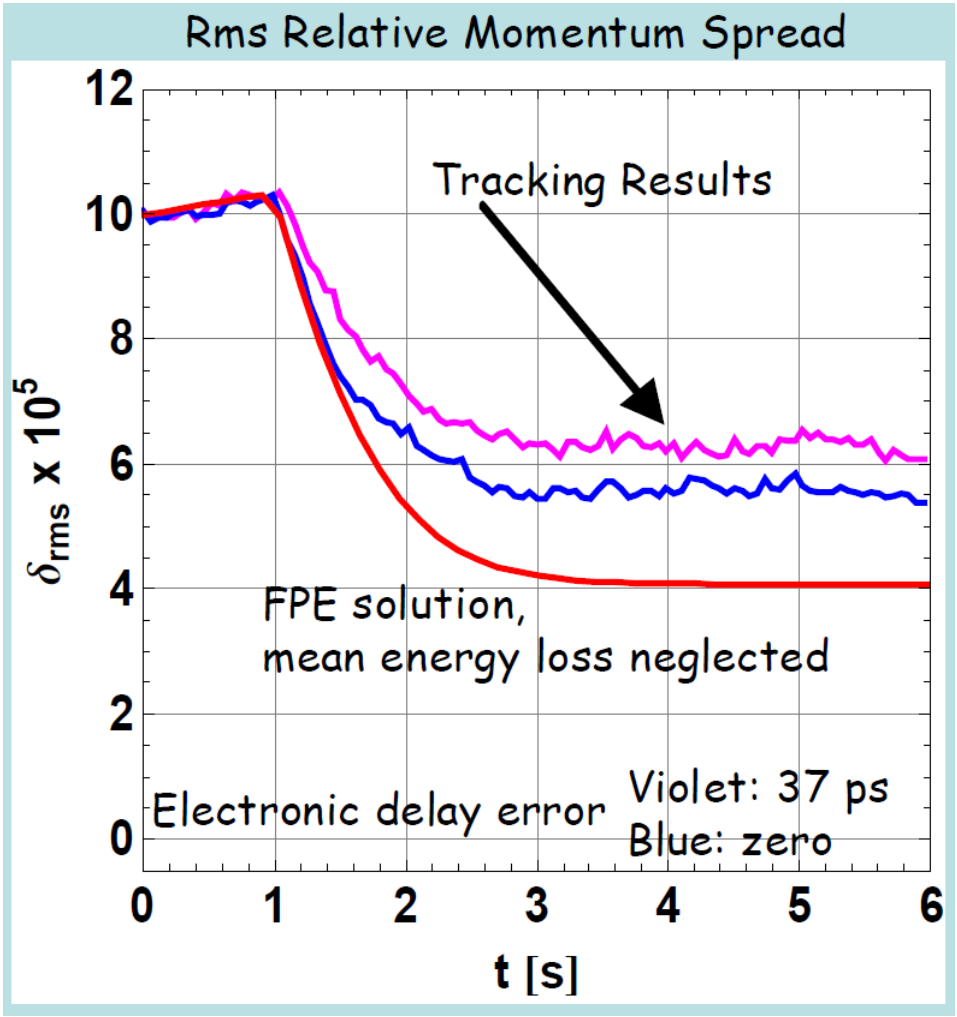
Results of simulations (made by Hans Stockhorst)

1st step: Injection from the CR into standing bucket $\Delta p/p=3.3*10^{-4}$
2nd step: adiabatic debunching $\Delta p/p=1.0*10^{-4}$





Momentum cooling of ions at 740 MeV/u



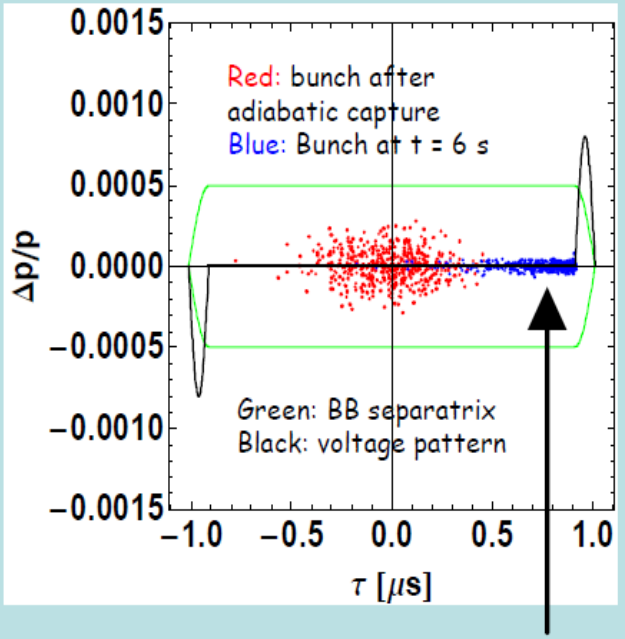
- 10^8 ions
- Target:
  H with 10^{15} cm^{-2}

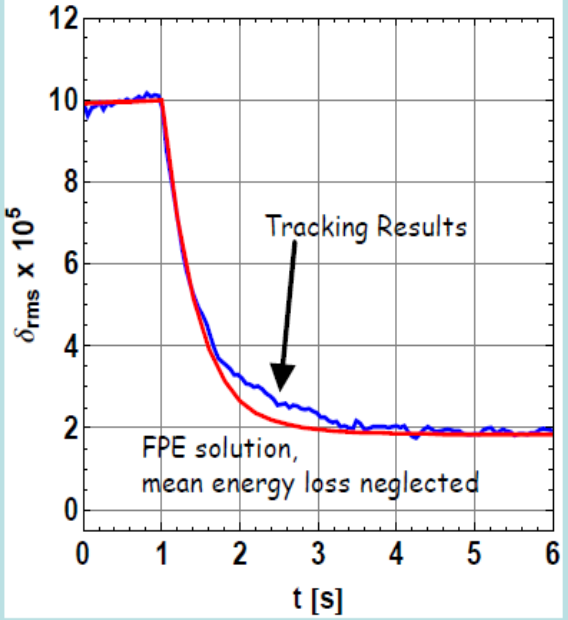
Result:
$\Delta p/p = 5*10^{-5}$ after 5 s

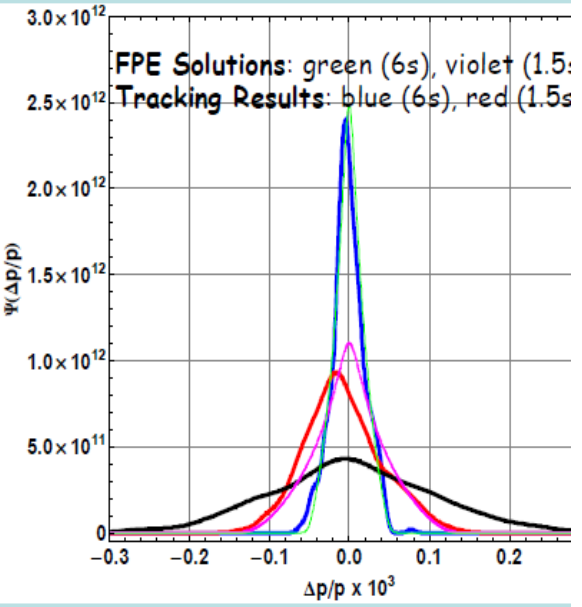
Experiments at 2 GeV/u

- Injection at 740 MeV/c into standing bucket
- Acceleration to experiment energy
- Adiabatic debunching reduces the momentum spread to $\Delta p/p=1*10^{-4}$
- Switch on barrier bucket to compensate the mean energy loss
- Stochastic momentum cooling reaches an equilibrium momentum spread of $2*10^{-5}$

Momentum cooling at 2 GeV/u







Strong bunching: bunch length ≈ 400 ns
Beam no longer quasi DC as at 740 MeV/u with TOF cooling

Implications for HESR

- Magnets of CR, HESR and transfer line have to reverse polarity
- The basic vacuum of 10^{-9} mbar seems reasonable also for heavy ions
- The “standard optics” works, improvements are under discussion
- Electron- and stochastic cooling are necessary for the HI-experiments
- Our requirement: The experimental installations have to be easily removed

Status of the Project

- The In-Kind contract between FAIR and Jülich was signed in 2012
- Main magnets, i.e. dipoles and quadrupoles are ordered by FAIR.
- Quadrupole power supplies have been ordered
- RF-components for stoch. cooling and acceleration cavity have been ordered
- Injection kicker is ordered
- All other components are specified and will be ordered according to our time schedule and spending profile

In-Kind contributions to HESR

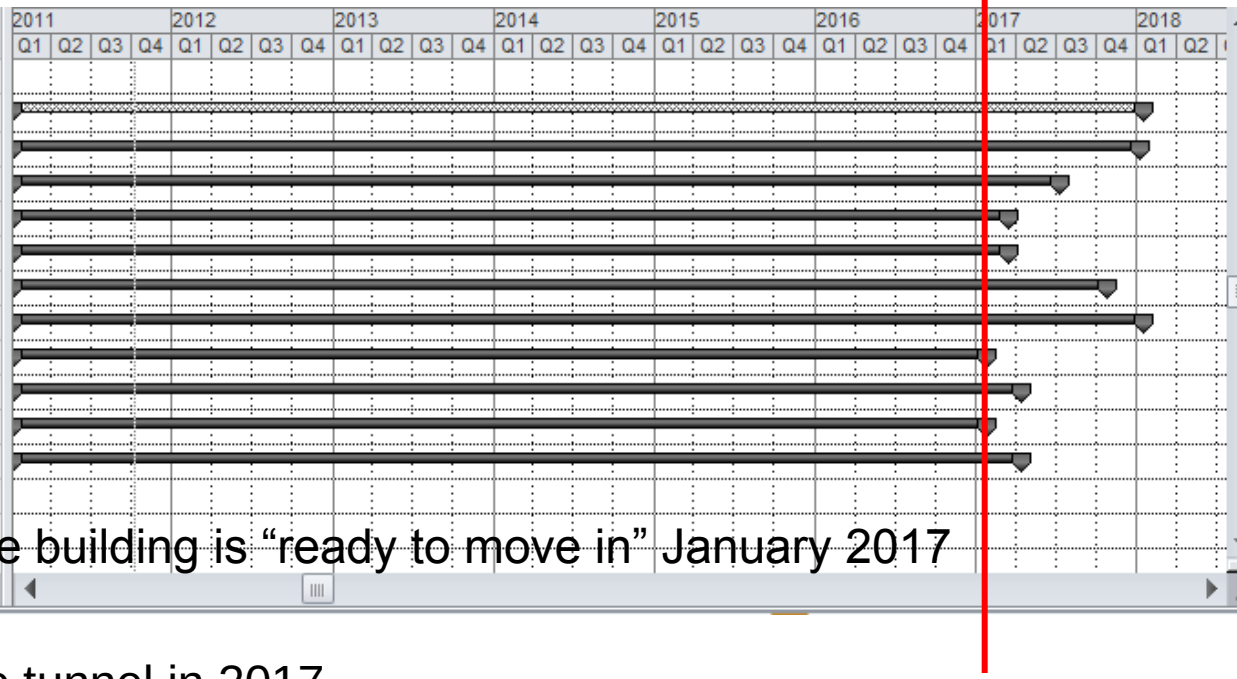
- The In-Kind contract between FAIR and Slovenia for the beam diagnostics is under preparation.

- The In-Kind contract with Romania for the sextupoles, closed orbit steerers and the corresponding power supplies is prepared for signature.

HESR overall time schedule

All detailed specs are ready and part of the In-Kind contract

	Vorgangsname	Dauer	Fertig stellen
13			
14	HESR	91.85 M	Di 16/01/18
15	Magnets	91.55 M	Mo 08/01/18
58	Power Converters	85.05 M	Mo 10/07/17
101	RF-Systems	80.85 M	Di 14/03/17
144	Injection/Extraction	80.85 M	Di 14/03/17
187	Beam Diagnostics	89 M	Fr 27/10/17
230	Vacuum	91.85 M	Di 16/01/18
273	Electron Cooling	79.2 M	Do 26/01/17
316	Stochastic Cooling	81.9 M	Mi 12/04/17
359	Experimental Devices	79.2 M	Do 26/01/17
402	PANDA integration	82 M	Fr 14/04/17



We still assume the building is “ready to move in” January 2017

Then installation in the tunnel in 2017,
commissioning without beam 2018,
commissioning with beam in 2018
start experiment 2019

→ what ever it will be,
where ever it will come from

Conclusions for Ions in the HESR

- Operation of HESR with ions is possible without Hardware modifications

  (Except dipoles and 1 quadrupole for a Laser channel)

- The radiation protection shows that the actual shielding is sufficient for a loss rate of
  - 10^7 anti-protons per sec
  - 10^9 ions per sec

Thank you for your attention