The GSI Facility and the layout for FAIR

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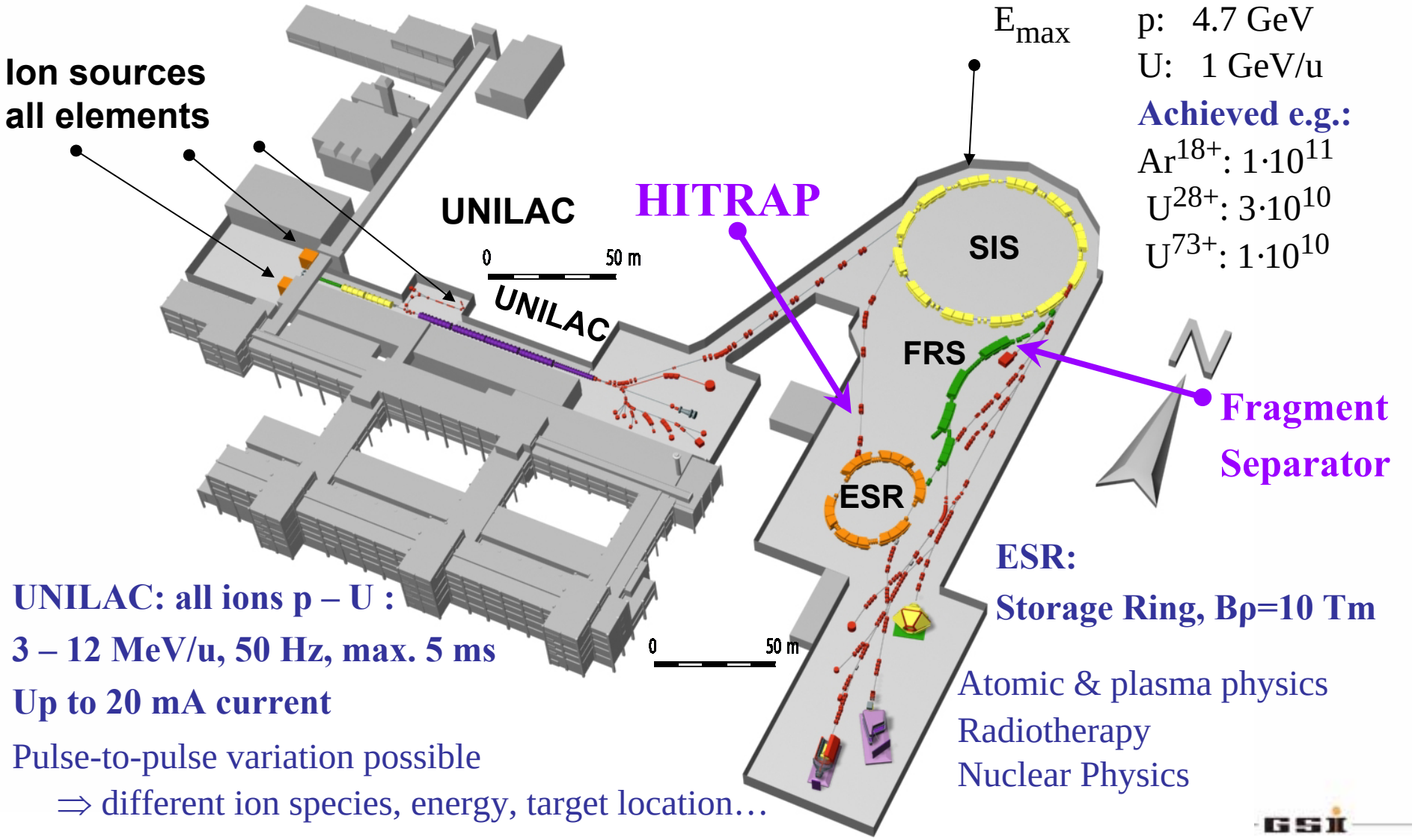
GSI: **National center for heavy ion research**

FAIR: **International Facility for Antiproton and Ion Research**

The Accelerator Facility at GSI



Synchrotron, Bρ=18 Tm

E_{max} p: 4.7 GeV
U: 1 GeV/u

Achieved e.g.:

Ar^{18+}: $1 \cdot 10^{11}$
U^{28+}: $3 \cdot 10^{10}$
U^{73+}: $1 \cdot 10^{10}$

Fragment Separator

ESR:
Storage Ring, Bρ=10 Tm

Atomic & plasma physics
Radiotherapy
Nuclear Physics

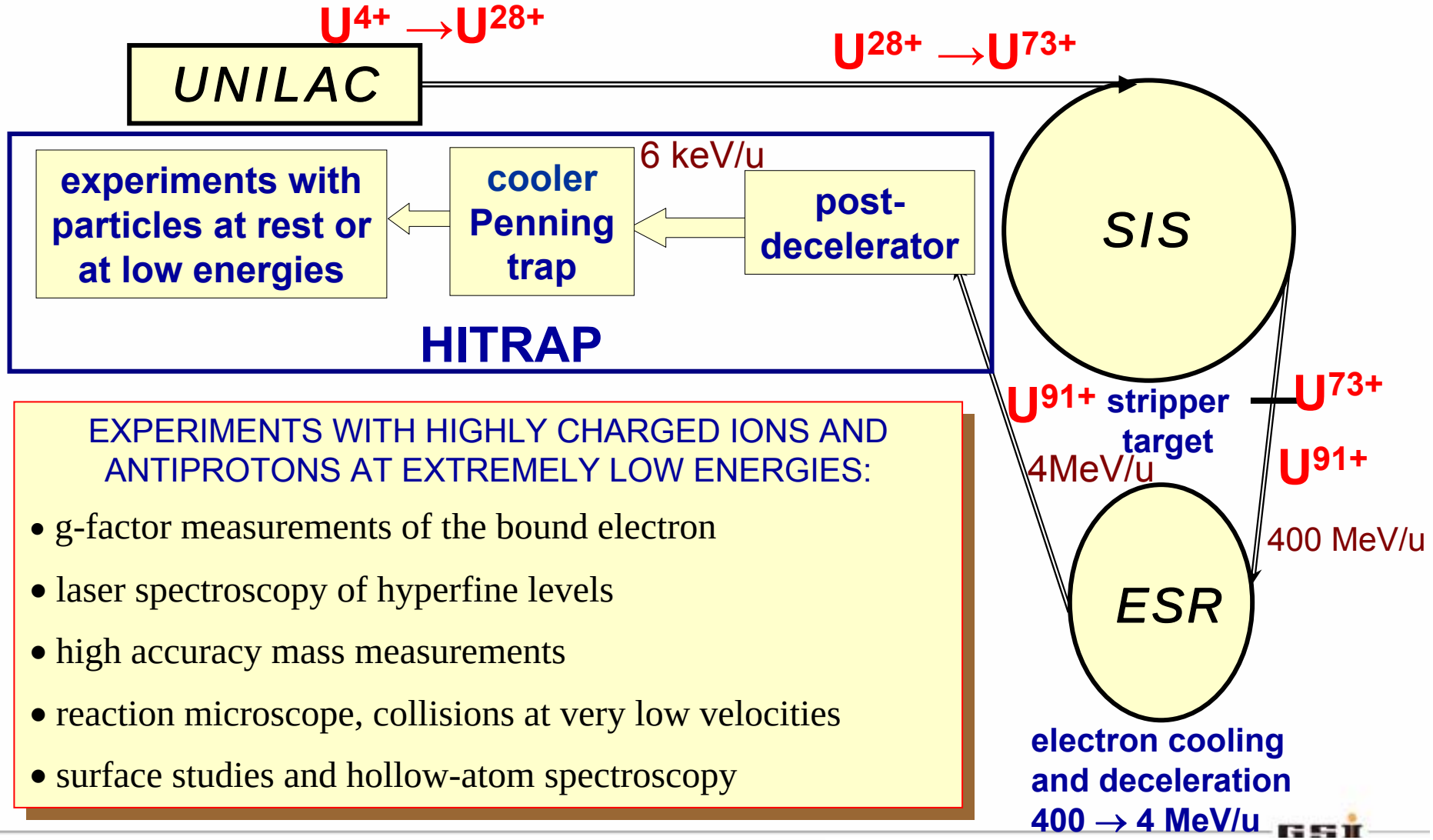
UNILAC: all ions p – U :
3 – 12 MeV/u, 50 Hz, max. 5 ms
Up to 20 mA current

Pulse-to-pulse variation possible
⇒ different ion species, energy, target location…

GSI

Generation of slow, highly charged Ions at GSI

HITRAP=Heavy Ion Trap: slow, cooled, highly charged heavy ions

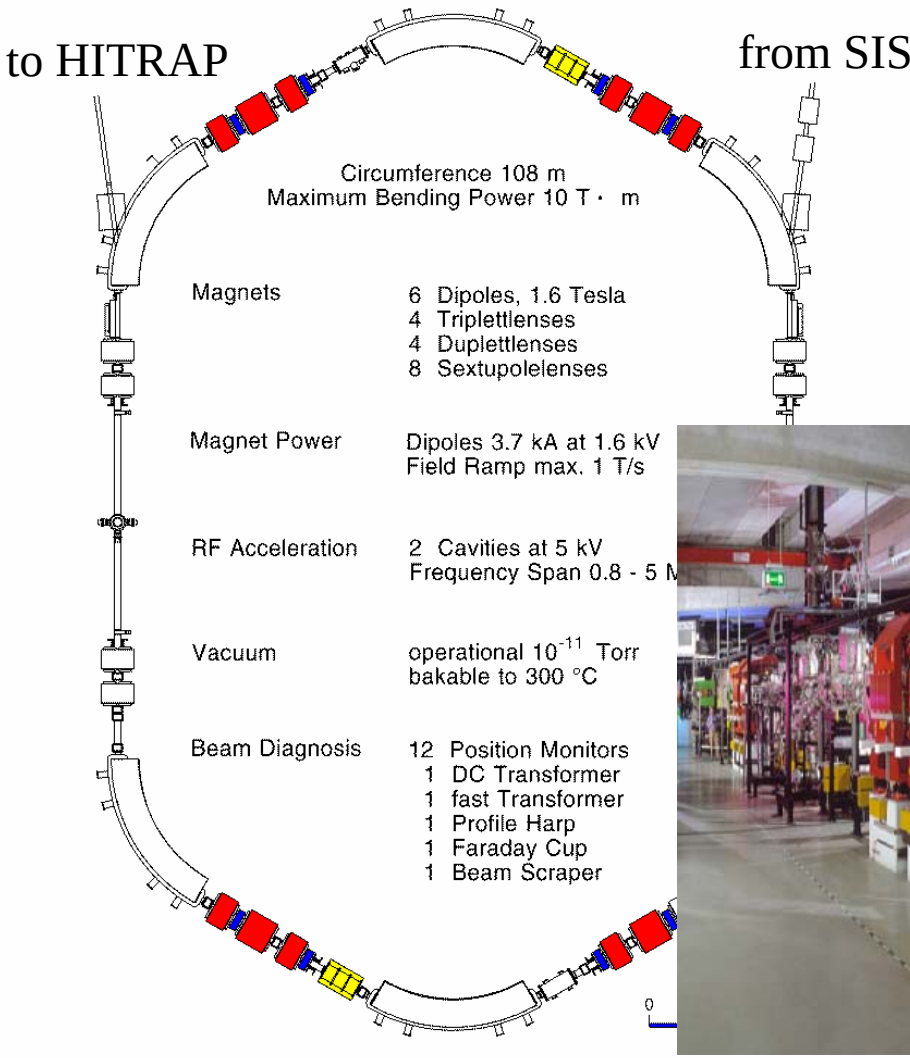


EXPERIMENTS WITH HIGHLY CHARGED IONS AND ANTIPROTONS AT EXTREMELY LOW ENERGIES:

- g-factor measurements of the bound electron
- laser spectroscopy of hyperfine levels
- high accuracy mass measurements
- reaction microscope, collisions at very low velocities
- surface studies and hollow-atom spectroscopy

Plots for HITRAP from W. Quint, F. Herfurth

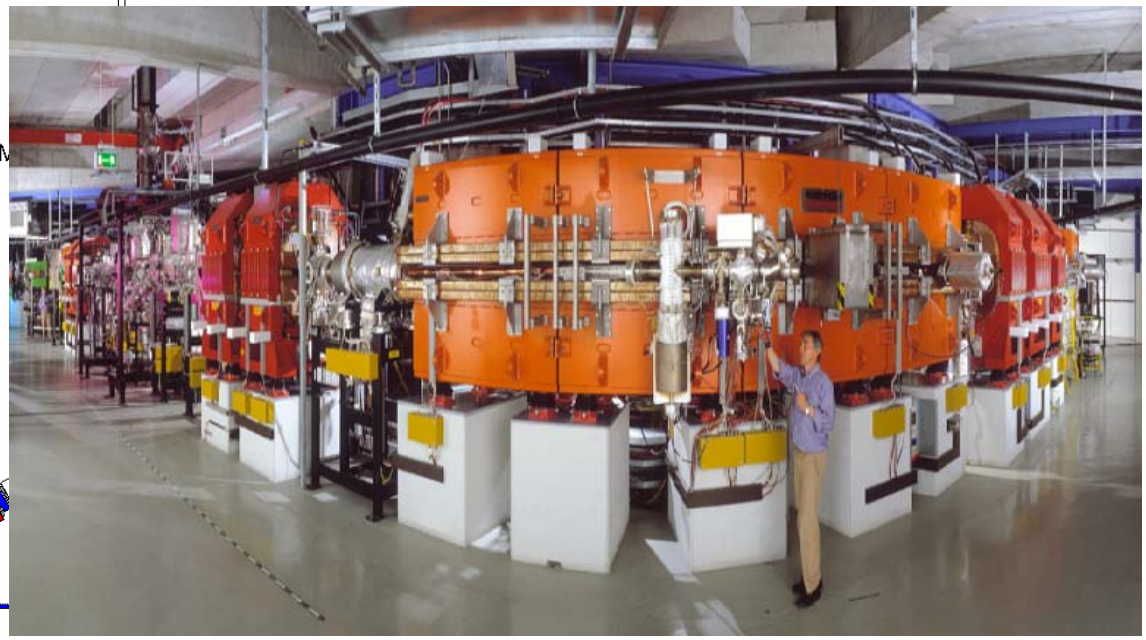
Experimental Storage Ring ESR at GSI



Parameters ESR:

- Circumference 108 m
- Energy ≈400 MeV/u →≈4 MeV/u
- rf frequency 0.8 → 5 MHz
- Cooling electron&stochastic (for emittance reduction)
- Experiments atomic&nuclear physics

⇒ versatile ring for many experiments

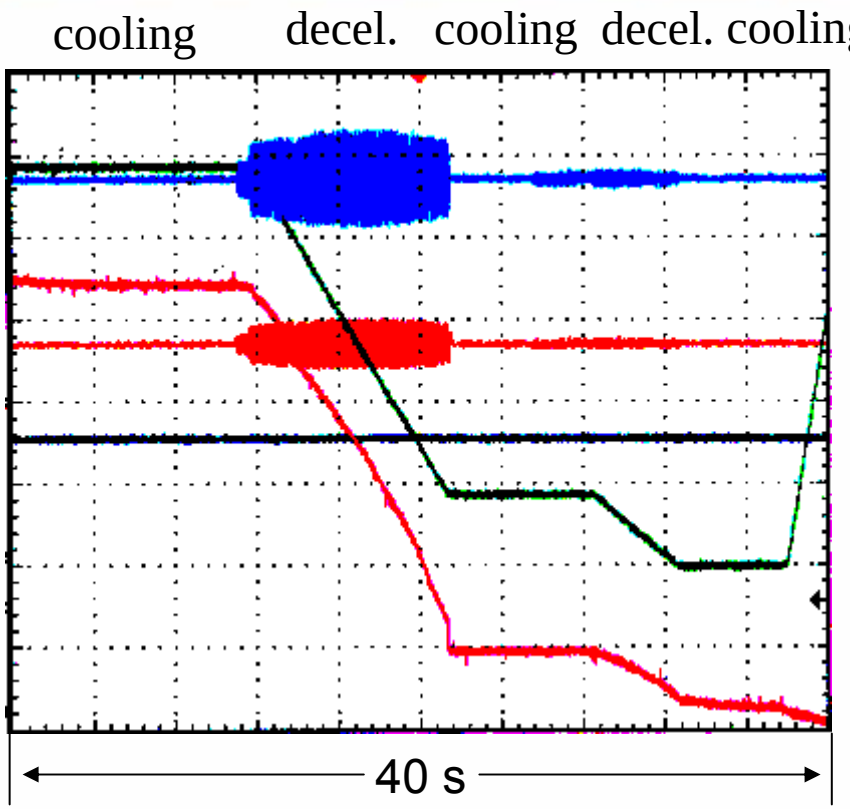


Deceleration Cycle at ESR

time (s)

ESR cycle during recent experiment

5..20	injection, stoch. cooling
3..10	deceleration 400 – 30 MeV/u
2..6	e^- cooling, rebunching
2..5	deceleration 30 – 4 MeV/u
2..5	e^- cooling, ejection
3	reset magnets



Signals:

rf amplitude

BPM

magn.dipole

dc-current

- stochastic cooling at 400 MeV/u injection energy
- rebunching and electron cooling at 30 MeV/u (compensating adiabatic emittance enlargement)
- final cooling at 4 MeV/u

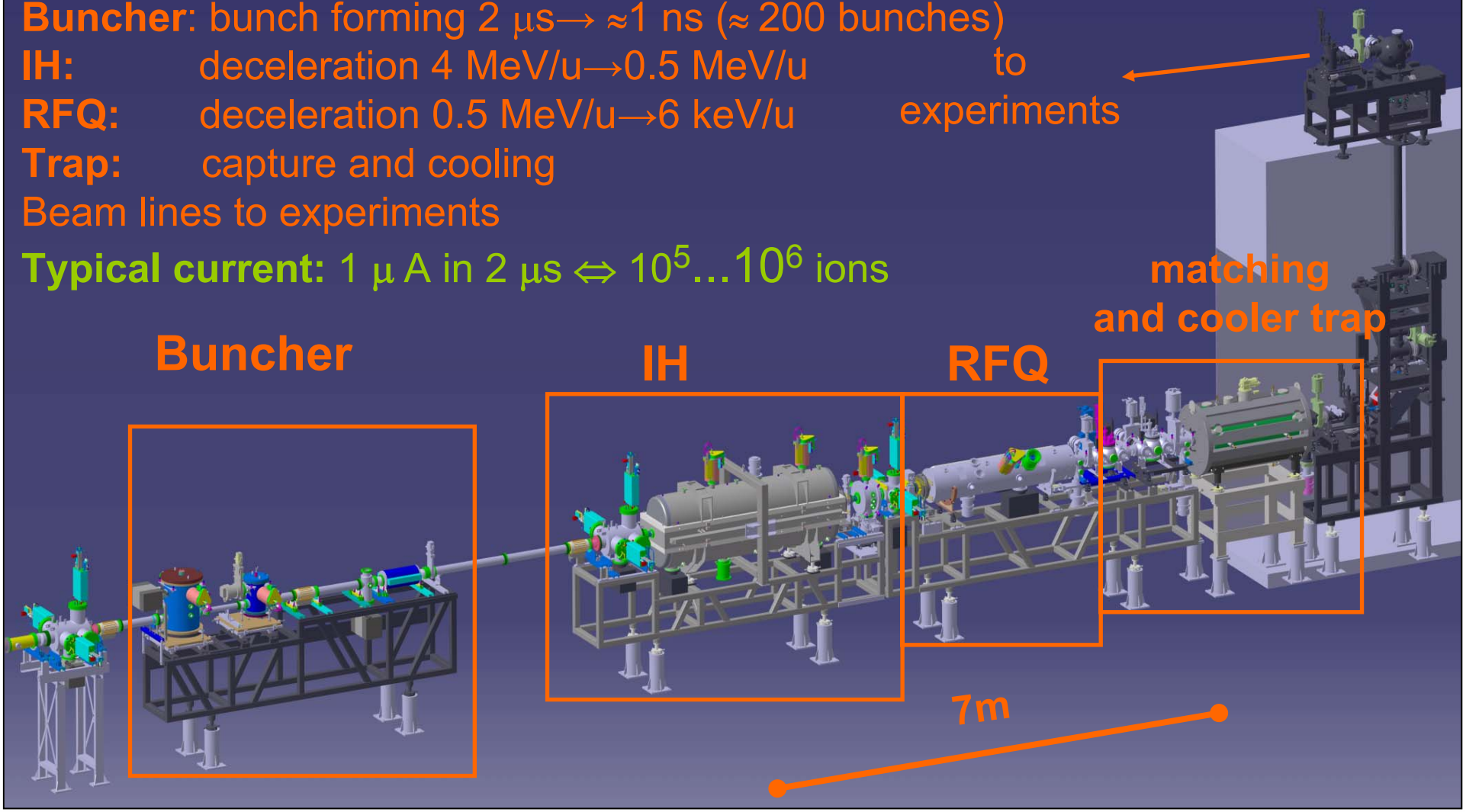
  ⇒ Low emittance beam achieved well suited for HITRAP, but cycle time ≈ **1 min.**

The HITRAP Decelerator at GSI

Buncher: bunch forming 2 μs→ ≈1 ns (≈ 200 bunches)
IH: deceleration 4 MeV/u→0.5 MeV/u
RFQ: deceleration 0.5 MeV/u→6 keV/u
Trap: capture and cooling
Beam lines to experiments

to experiments

Typical current: 1 μ A in 2 μs ⇔ 10^5…10^6 ions

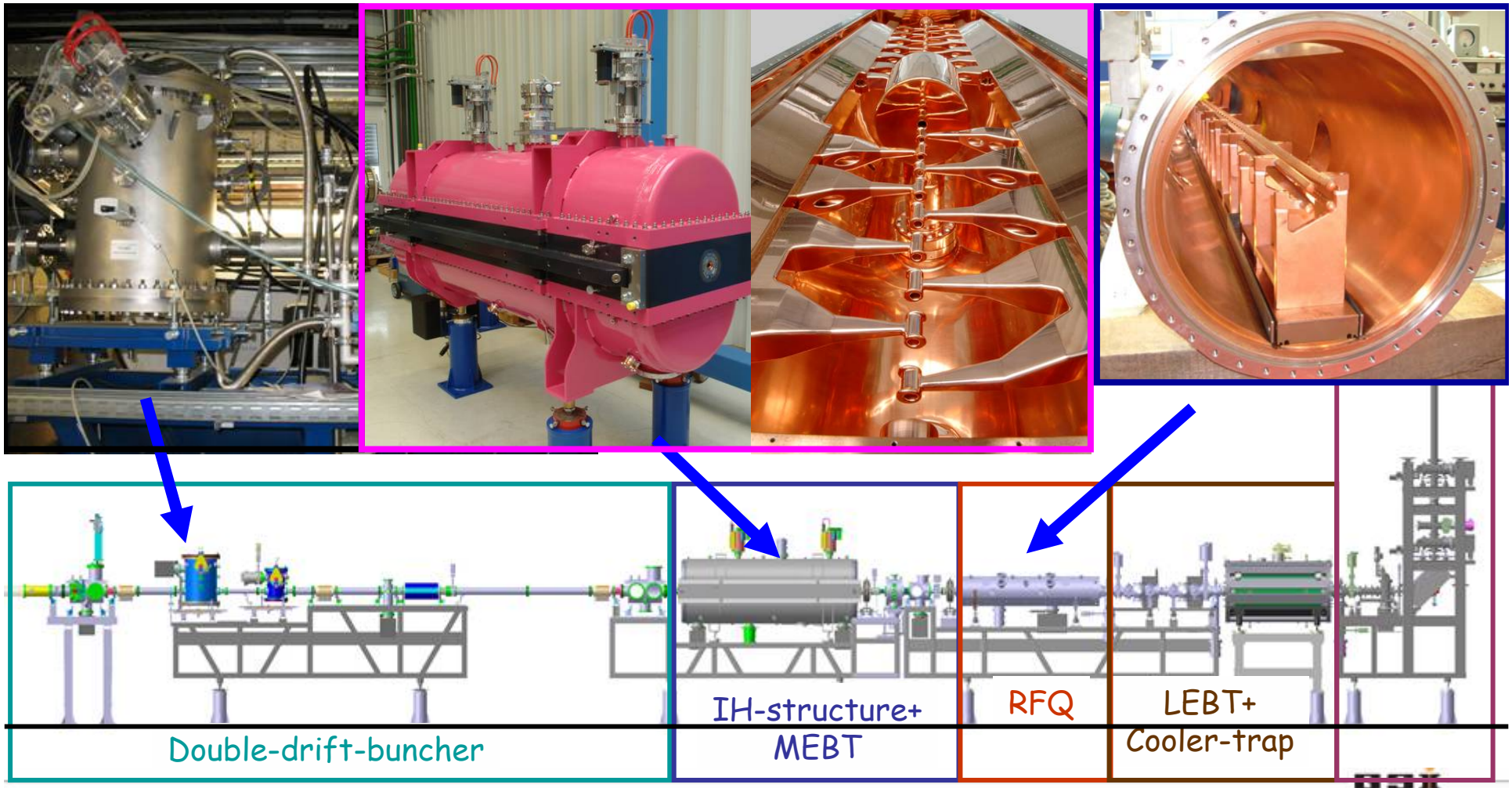


The HITRAP Decelerator at GSI

Buncher
108 & 216 MHz

IH-structure

RFQ



Commissioning Results of HITRAP Decelerator

Stepwise commissioning with different ion beams from May 2007 on:

May 2007: Commissioning of Bunchers starts in May 2007

September 2008: Installation of IH decelerator

Spring 2009: Installation of RFQ and Cooler trap

Main results:

ESR:
- ►stable decelerating from 400 to 4 MeV/u, cycle time ~40 s
- ► stochastic cooling after injection implemented
- ► about 10^5…10^7 ions per pulse of 1-2 μs

Buncher:
- ► stable operation with transmission as expected (close to 100%)
- ► bunching demonstrate

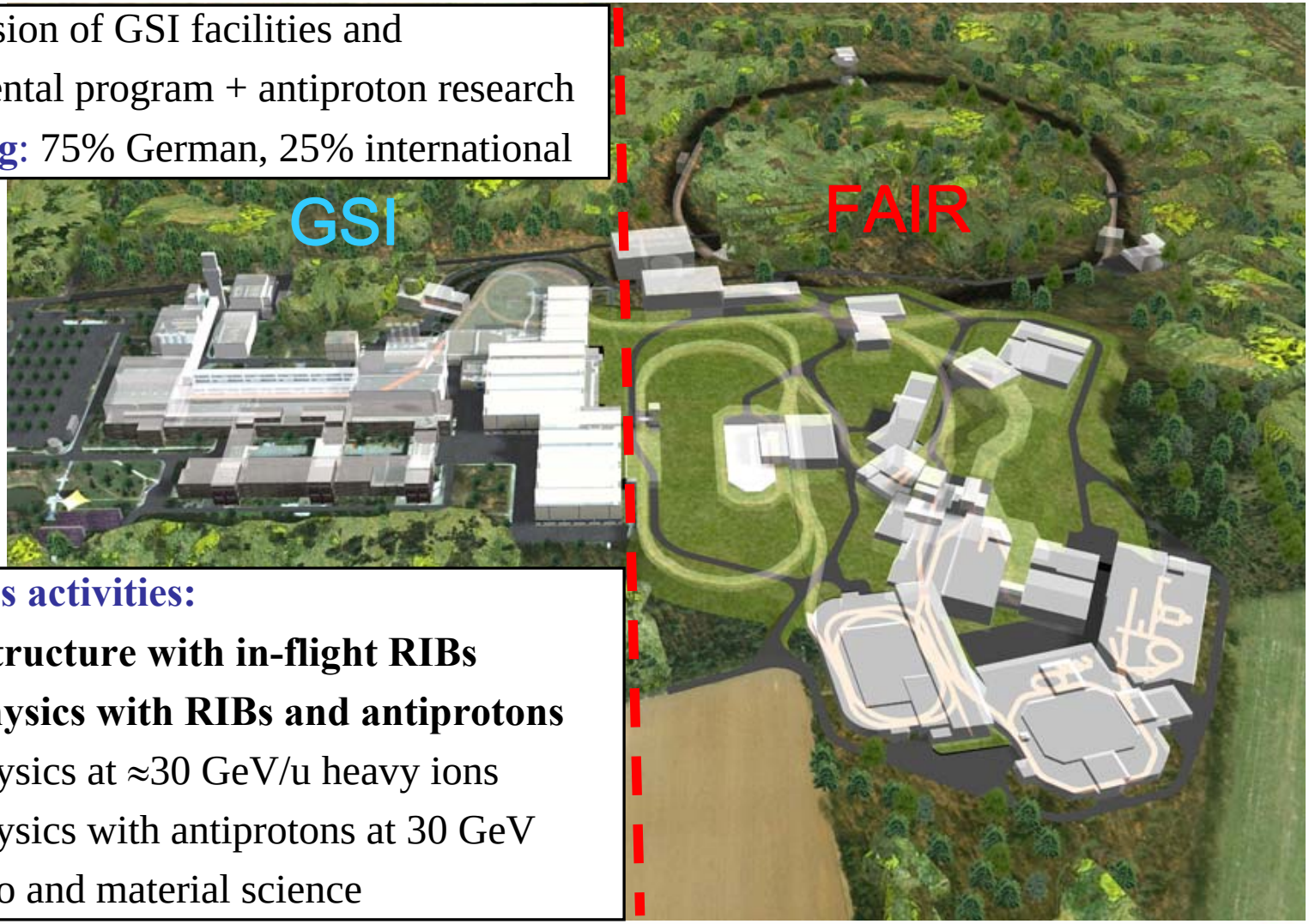
IH:
- ► decelerated ions seen
- ► deceleration efficiency ~10% only (un-expected, only partly understood)
- ► properties of decelerated beam measured

RFQ:
- ► No test with beam yet

GSI and FAIR in Future

FAIR: Extension of GSI facilities and its experimental program + antiproton research

FAIR funding: 75% German, 25% international



Main physics activities:

- **Nuclear Structure with in-flight RIBs**
- **Atomic Physics with RIBs and antiprotons**
- Hadron Physics at ≈30 GeV/u heavy ions
- Hadron Physics with antiprotons at 30 GeV
- Plasma, Bio and material science

The Facility for Antiproton and Ion Research

UNILAC & SIS18 as injector for ions after upgrade

p-LINAC: high current 70 mA, 70 MeV

SIS100: 100Tm, s-c magnets 2T, 1-29 GeV/u
fast ramping 4 T/s, length 1084 m
design: **p 3*10^{13}, U^{28+} 5*10^{11}**
→high current for RIB-production

S-FRS: 2-step separator,
100-fold higher acceptance

CR: stochastic cooling of RIB and pbar

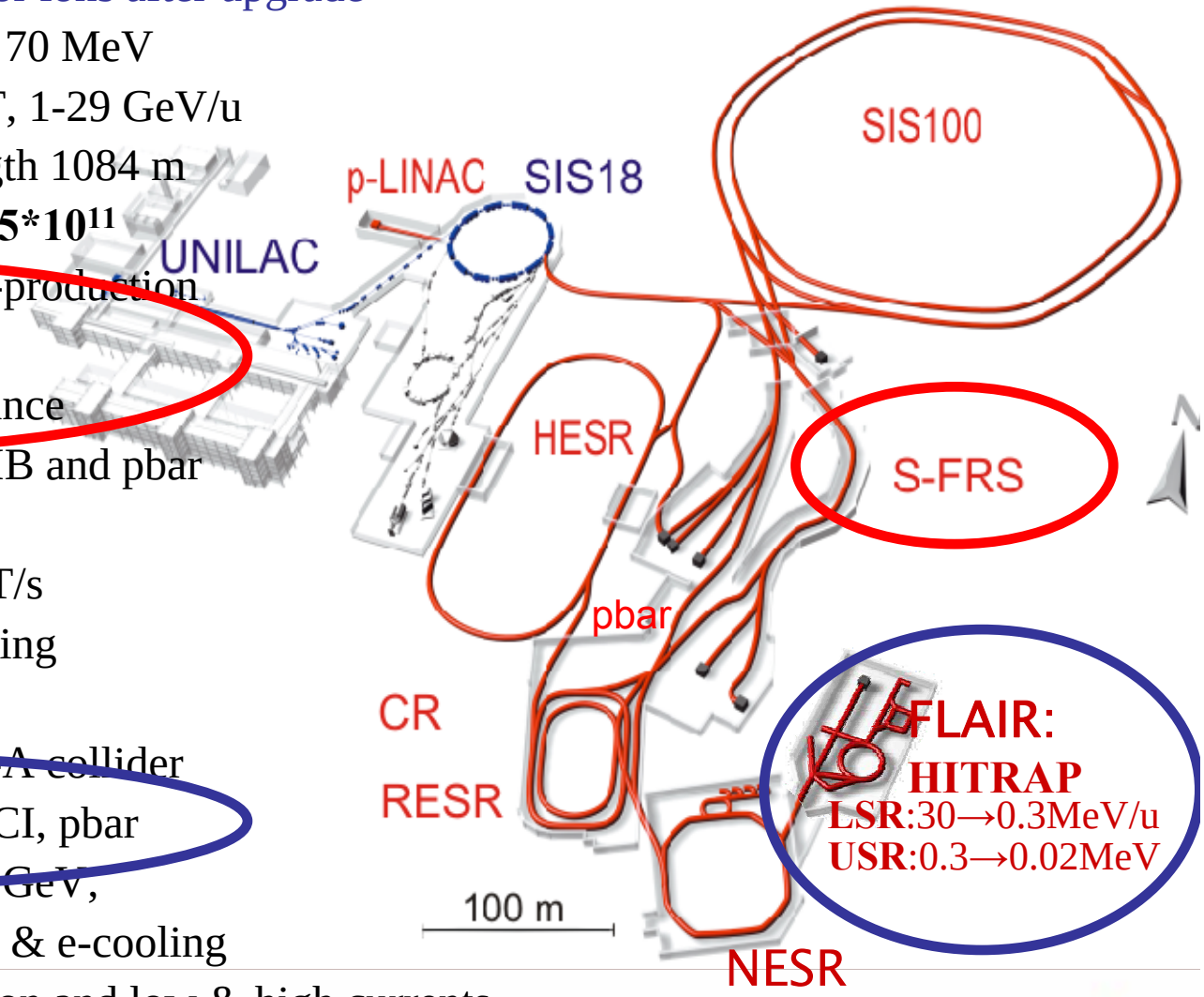
RESR: accumulation of pbar,
deceleration of RIB, 1 T/s

NESR: versatile experimental ring
for stable, RIB, pbar
e-cooling, gas-target, e-A collider

FLAIR: decelerators of RIB, HCI, pbar

HESR: acc. of pbar to max. 14 GeV,
pellet target, stochastic & e-cooling

HEBT: for fast & slow extraction and low & high currents.



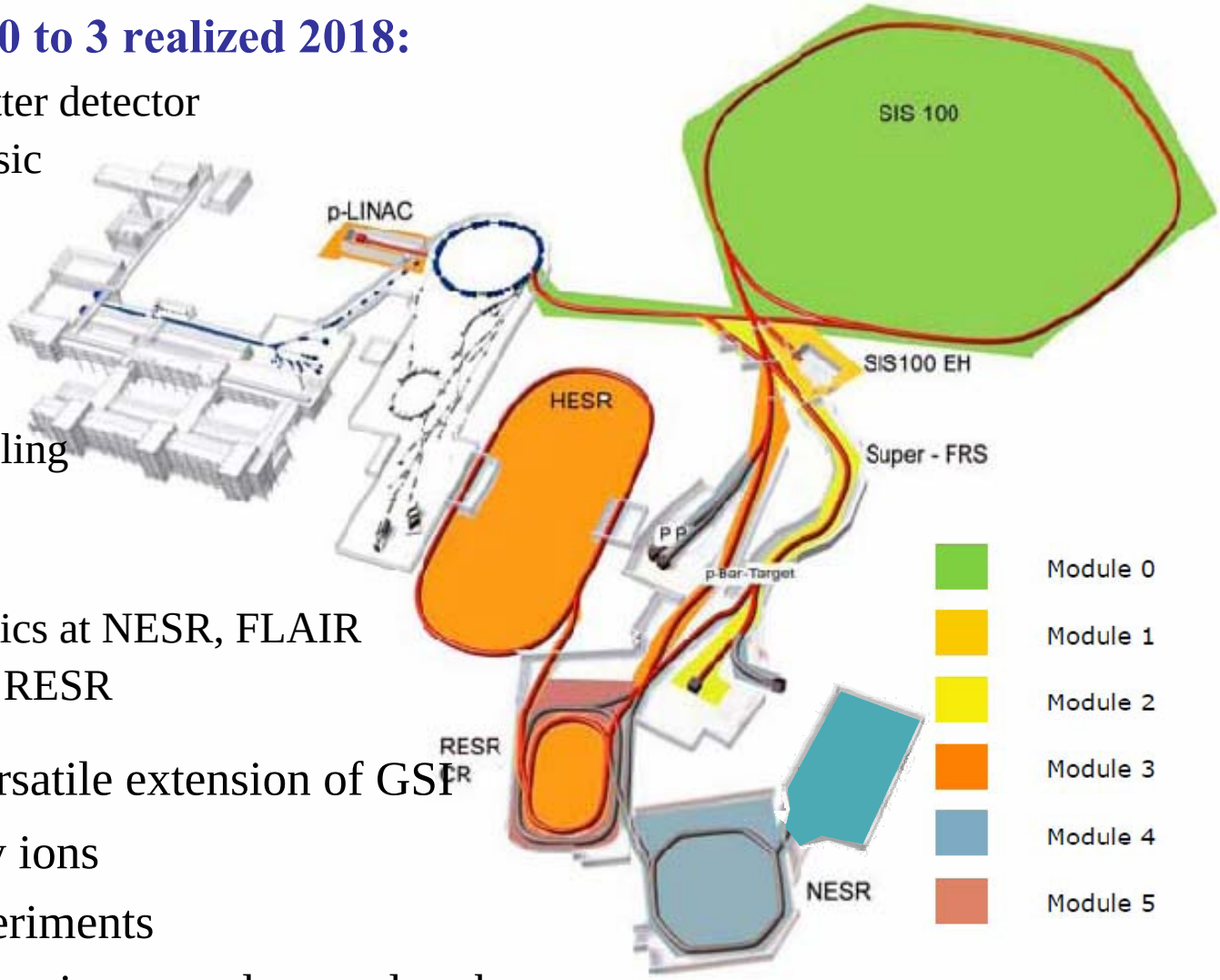
Foreseen Realization of FAIR

Start version: Module 0 to 3 realized 2018:

- Compress Baryonic Matter detector
- Plasma and Atomic physic at fixed targets
- RIBs physics with dedicated detectors
- RIBs in storage ring CR
- pbar production and cooling
- pbar collisions at HESR

Module 4 and 5 later

- Nuclear and atomic physics at NESR, FLAIR
- Accumulation of pbar in RESR



Conclusion: FAIR is versatile extension of GSI

- High currents of heavy ions
- RIBs for versatile experiments
- Cooled, high brilliance primary and secondary beams