

# Status of the FAIR Project

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*FAIR Scientific Director (des.)*

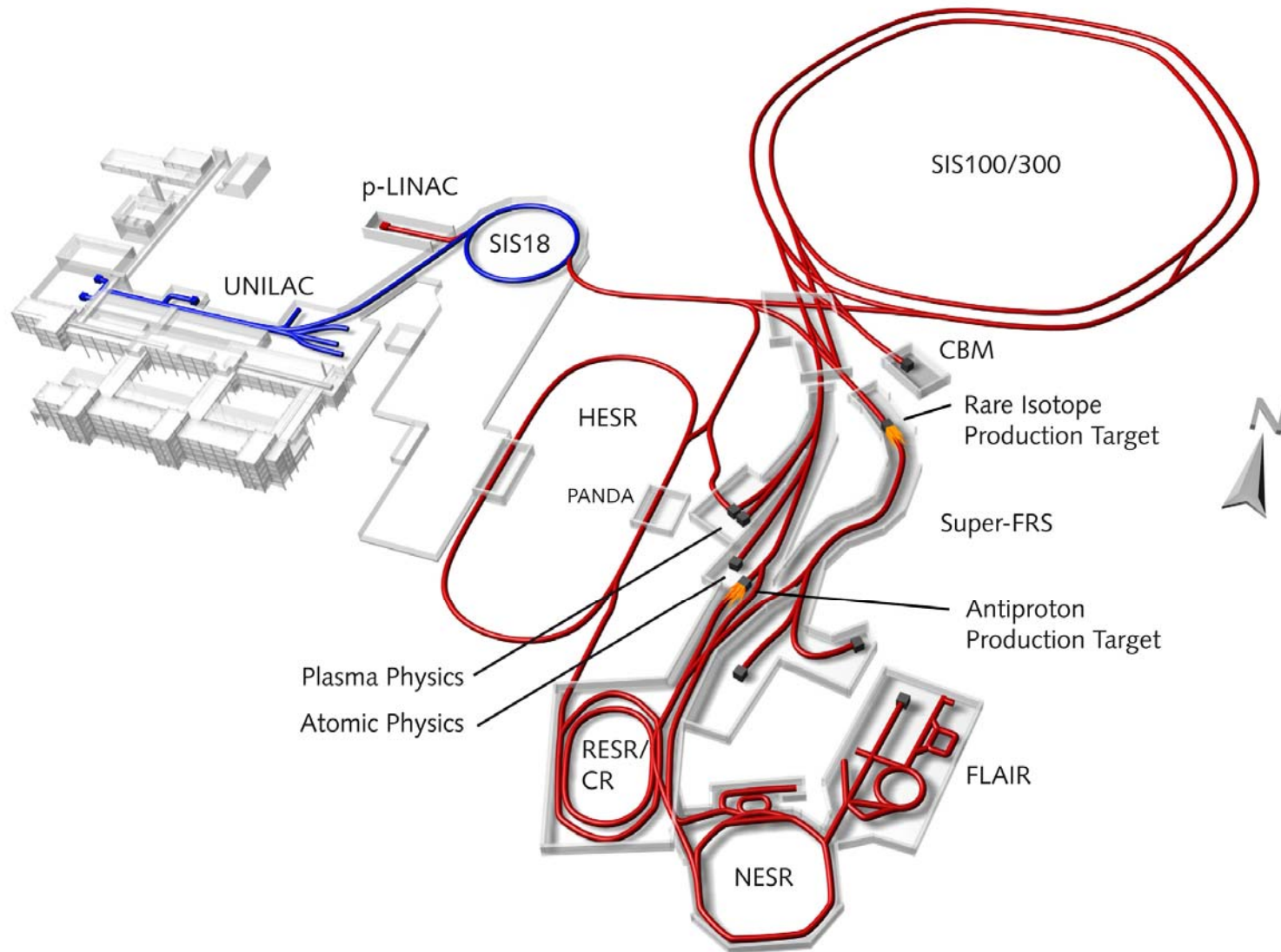
@ KHUK 10.12.2009



Austria China Finland France Germany Greece India Italy Poland Romania Russia Slovakia Slovenia Spain Sweden U K Saudi Arabia



# FAIR facility BTR 2005



# Development of Project Staging

2003	Recommendation by WissenschaftsRat – FAIR Realisation in three stages						
2005	Entire Facility Baseline Technical Report						
2007	Phase A						Phase B SIS300
2009	<b>Module 0</b> SIS100	<b>Module 1</b> expt areas CBM/HADES and APPA	<b>Module 2</b> Super-FRS fixed target area NuSTAR	<b>Module 3</b> pbar facility, incl. CR for PANDA, options for NuSTAR	<b>Module 4</b> LEB for NuSTAR, NESR for NuSTAR and APPA, FLAIR for APPA	<b>Module 5</b> RESR nominal intensity for PANDA & parallel operation with NuSTAR and APPA	Phase B SIS300

Modularized Start Version

- Cost estimate for CC presented by architects
  - a new cost estimate in 2009 for the **accelerator** complex
  - firm commitments of FAIR Member States
  - Detailed list of **site related construction costs** was worked out
  - Germany and State of Hesse announced to cover "site-dependent" construction costs outside FAIR project budget
- + 110 M€ !**



## Presse- mitteilung

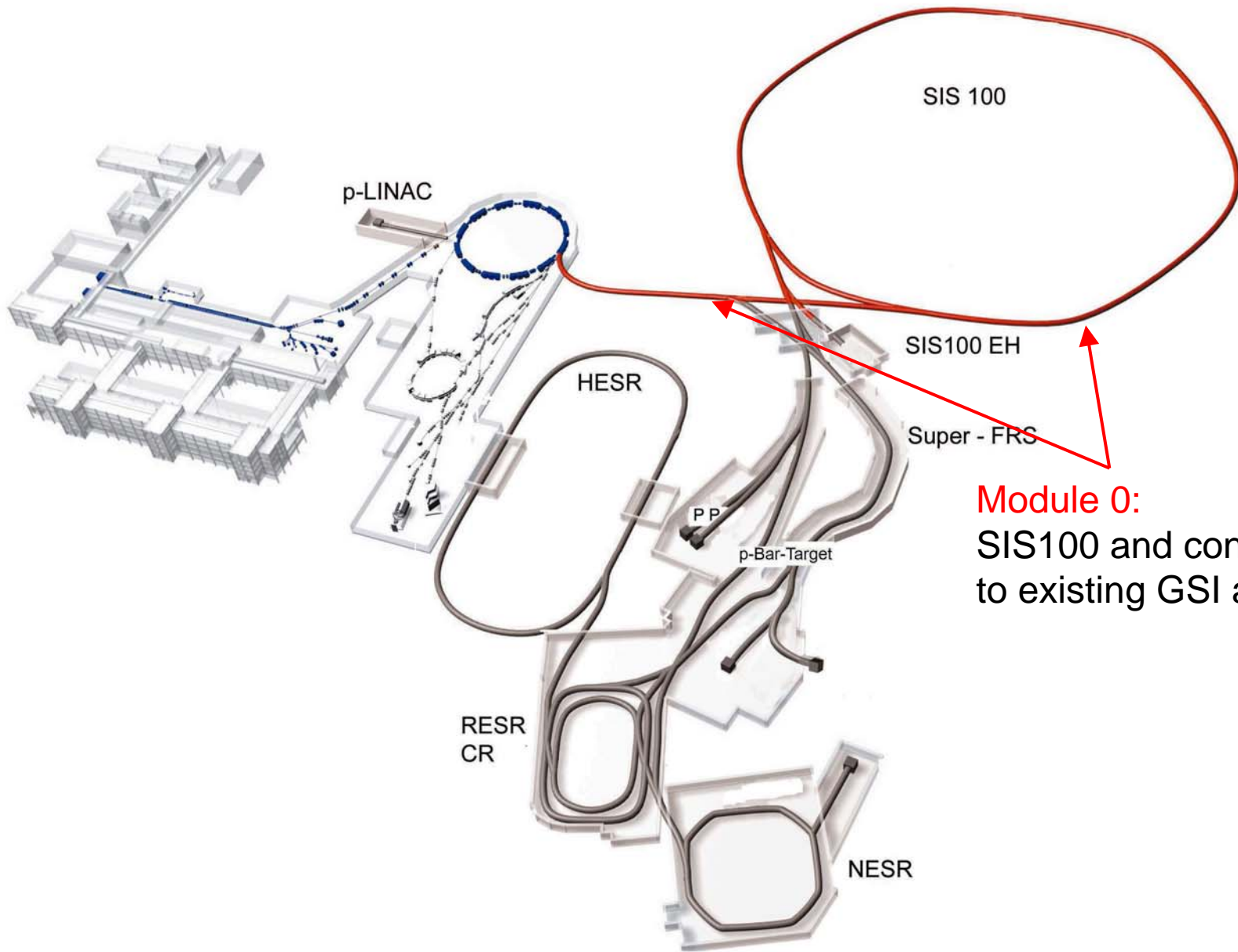
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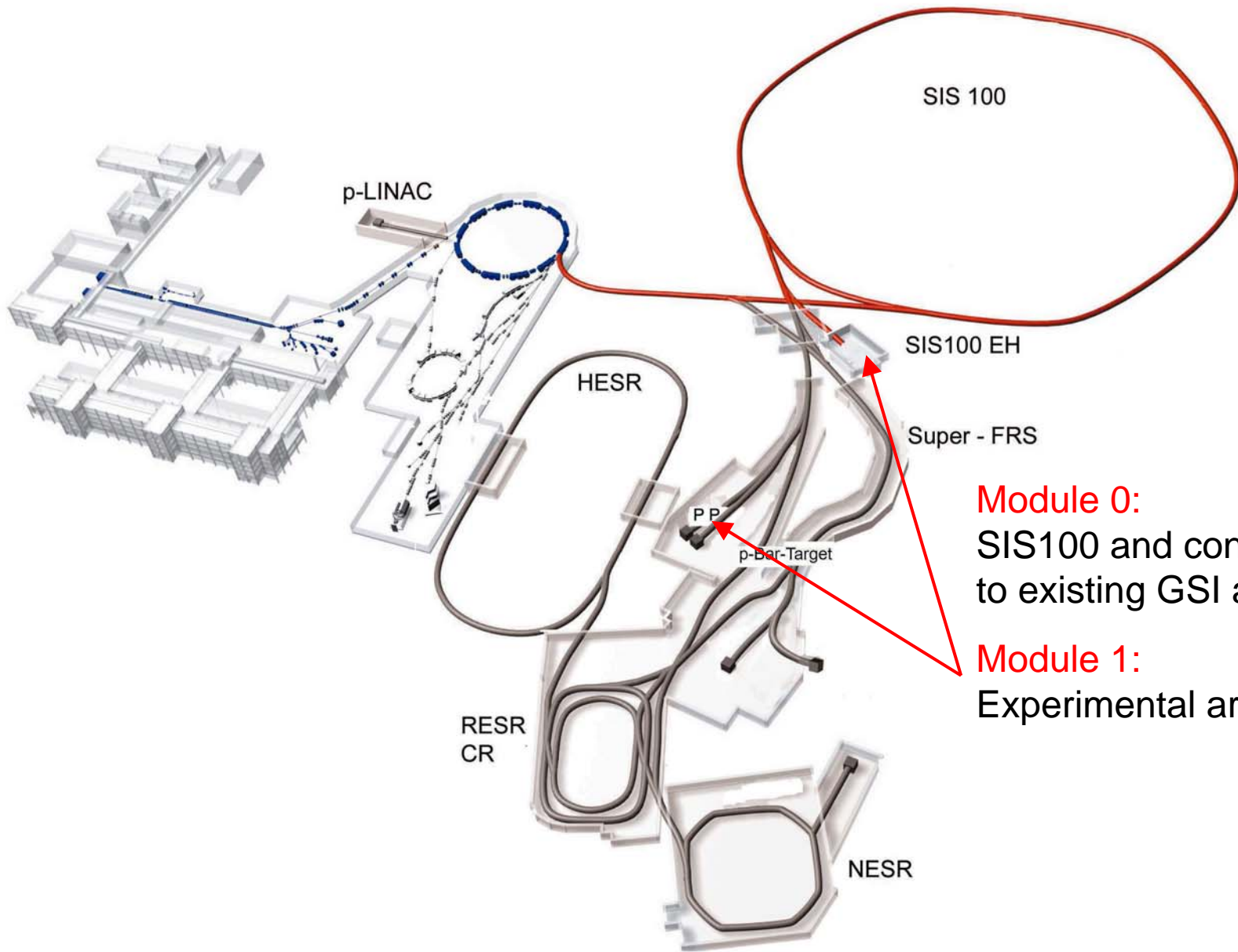
03. September 2009  
216/2009

**Konjunkturpaket II unterstützt Spitzenforschung in Darmstadt**  
Staatssekretär Storm und hessische Ministerin Kühne-Hörmann feiern  
Richtfest für Testinghalle für das internationale Zukunftsprojekt FAIR

Das GSI Helmholtzzentrum ist gut gerüstet für das internationale Zukunftsprojekt FAIR

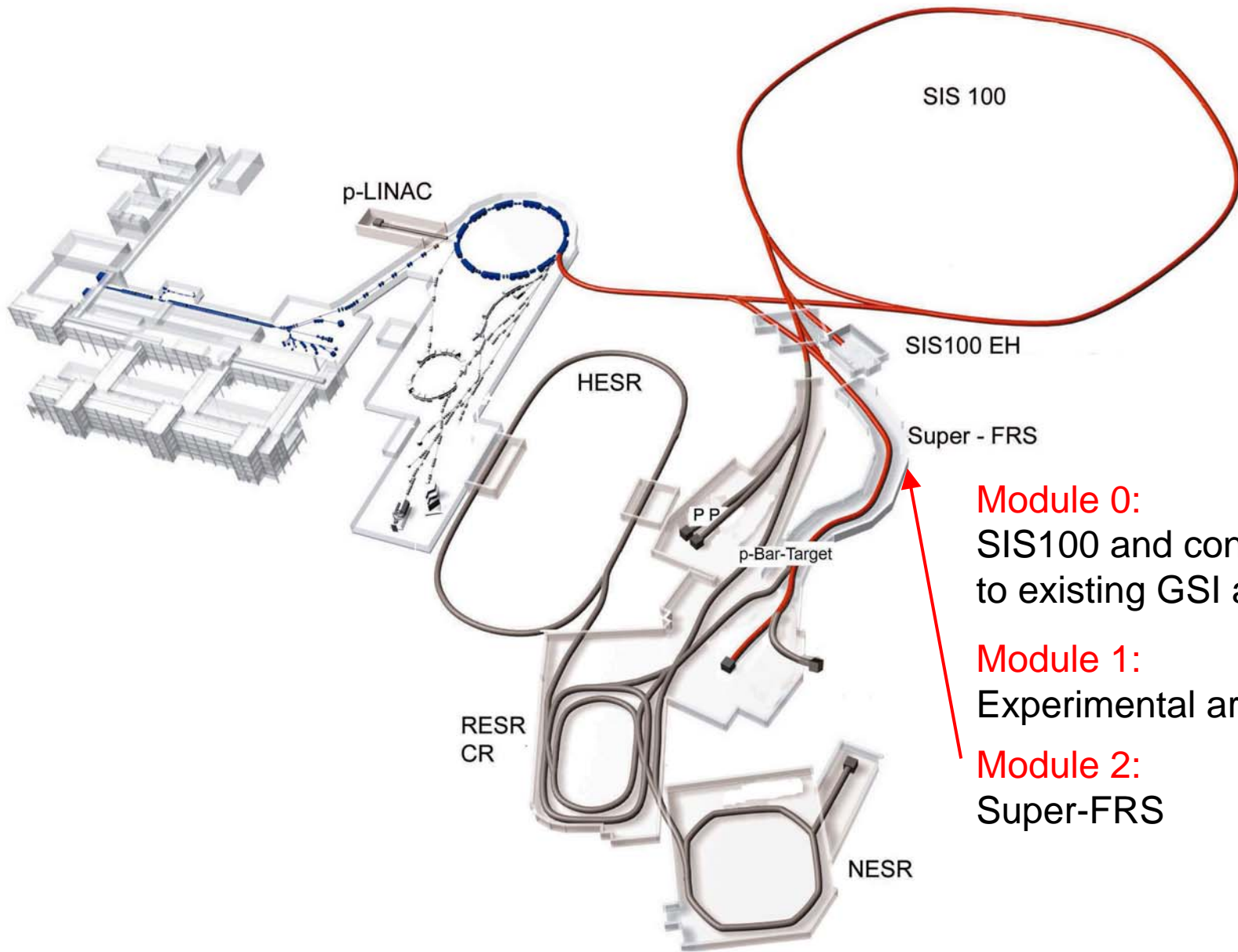


**Module 0:**  
 SIS100 and connection  
 to existing GSI accel.



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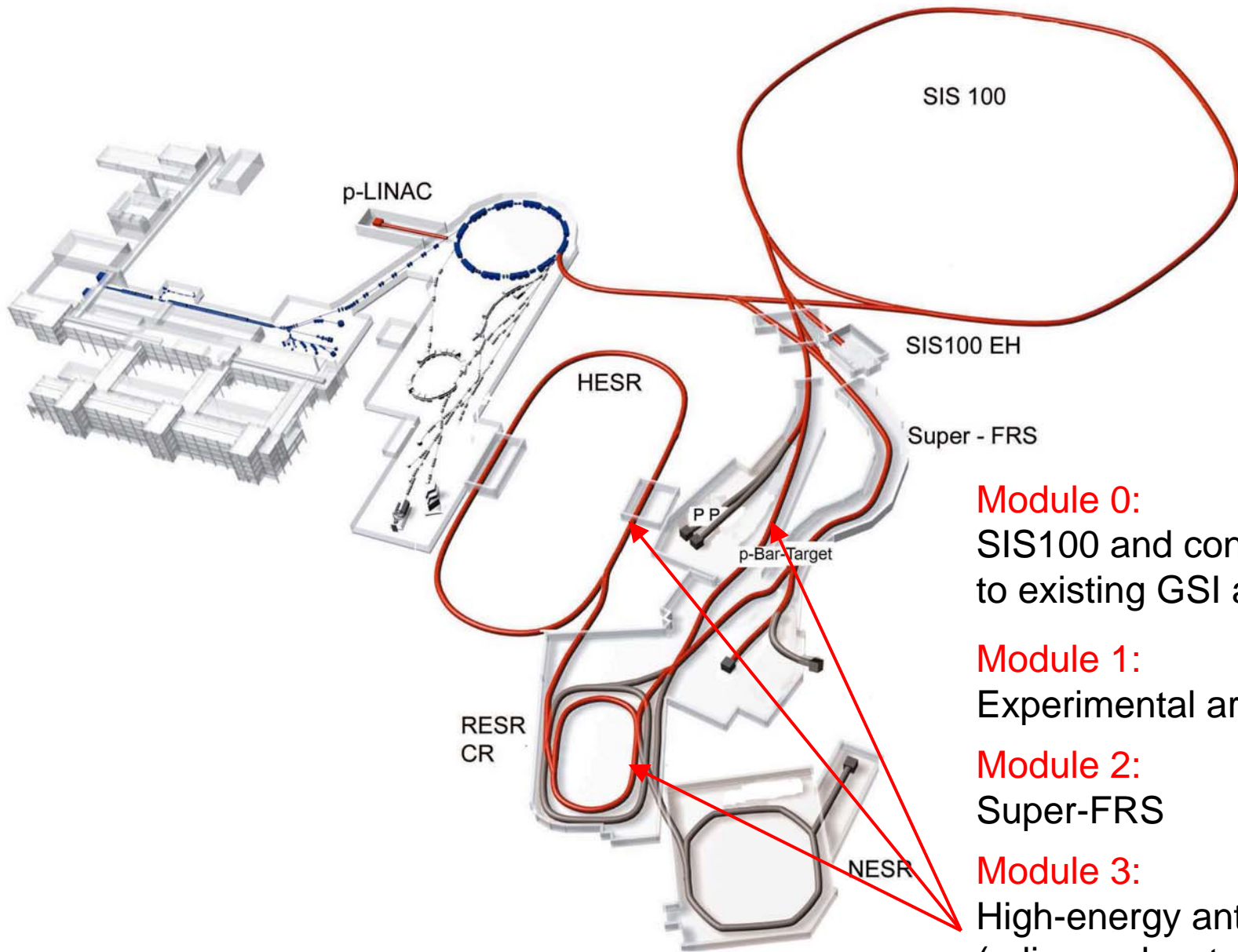
**Module 1:**  
Experimental areas



**Module 0:**  
SIS100 and connection  
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**Module 1:**  
Experimental areas

**Module 2:**  
Super-FRS

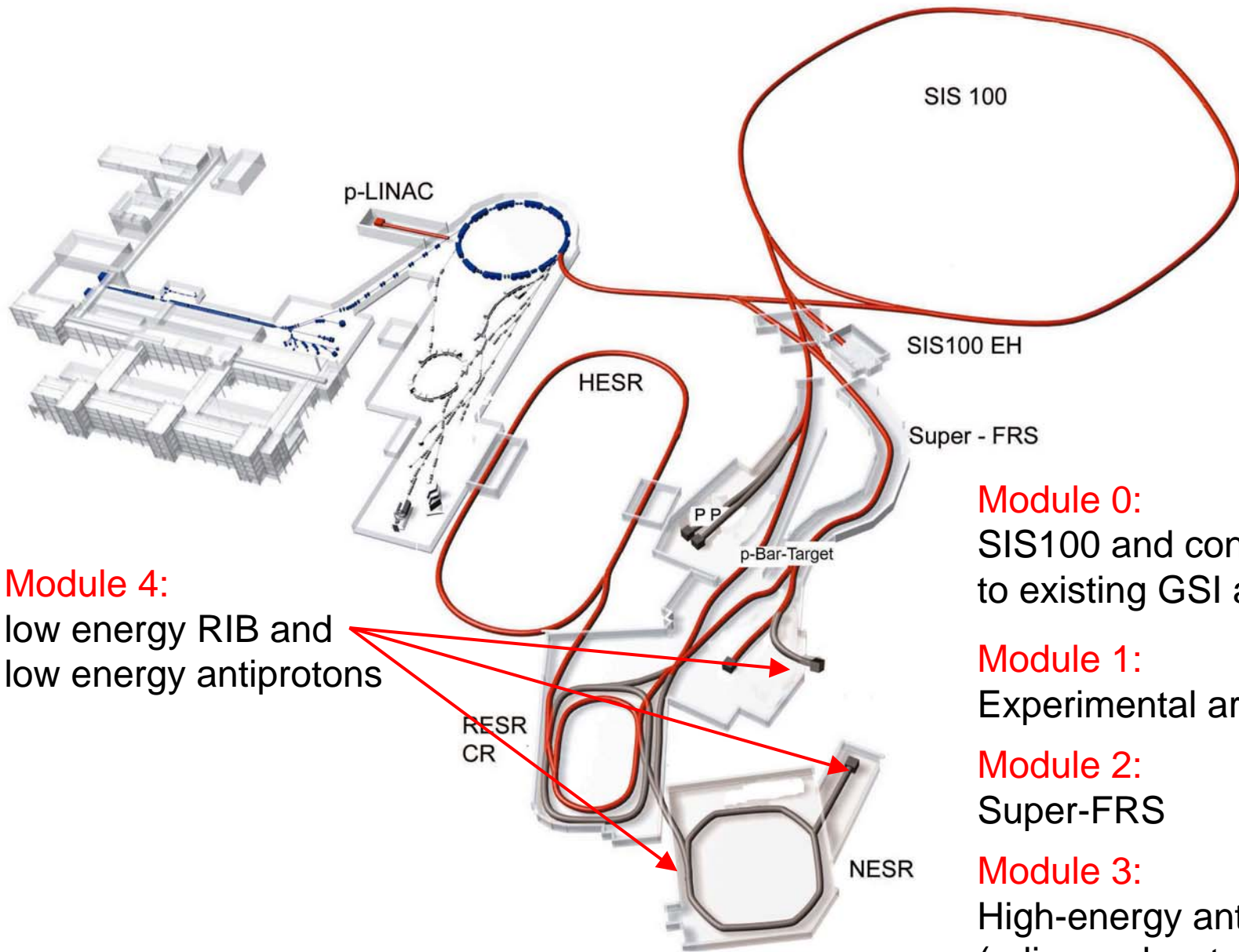


**Module 0:**  
SIS100 and connection  
to existing GSI accel.

**Module 1:**  
Experimental areas

**Module 2:**  
Super-FRS

**Module 3:**  
High-energy antiprotons  
(p-linac, pbar-target, CR,  
HESR)



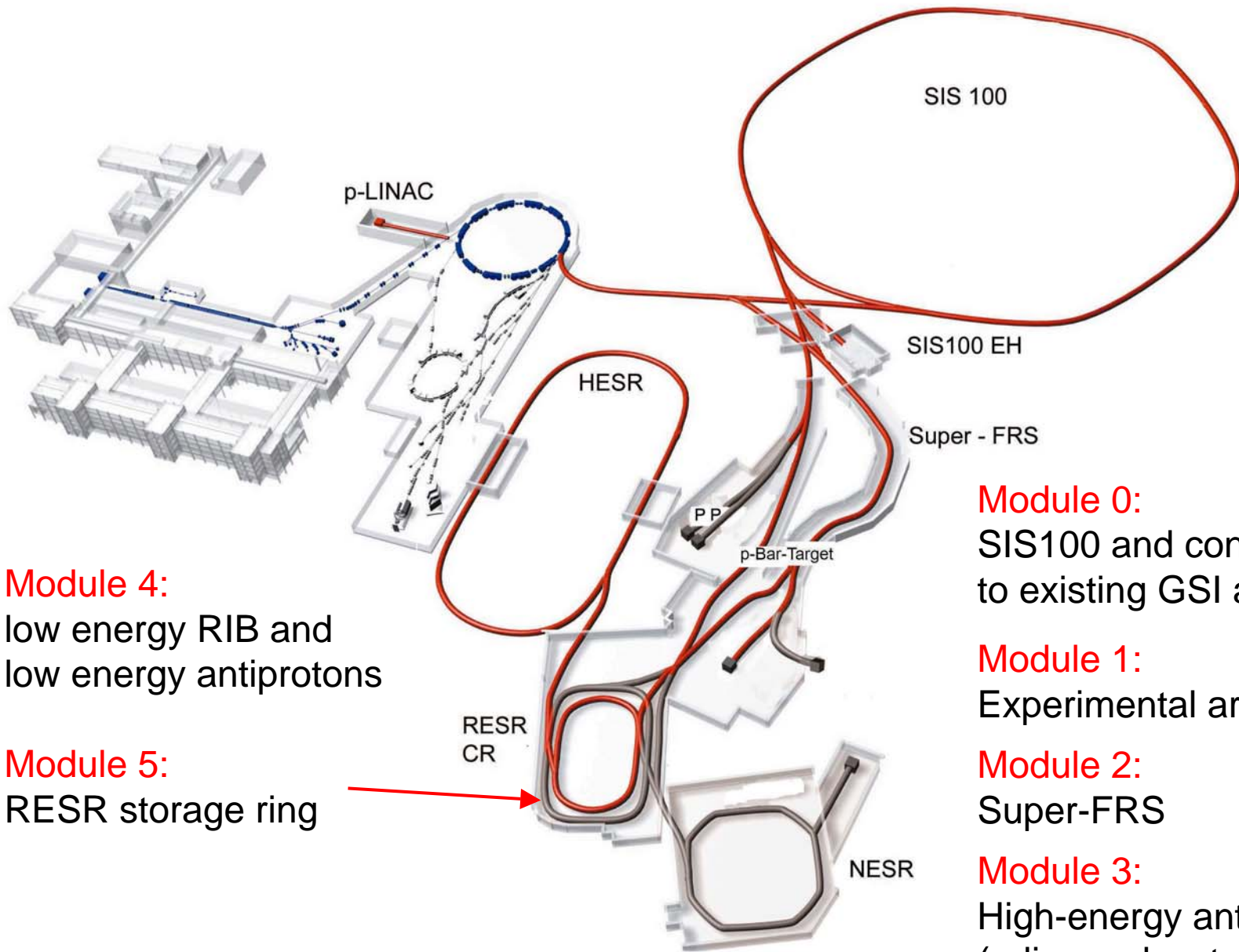
**Module 4:**  
low energy RIB and  
low energy antiprotons

**Module 0:**  
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**Module 4:**  
low energy RIB and  
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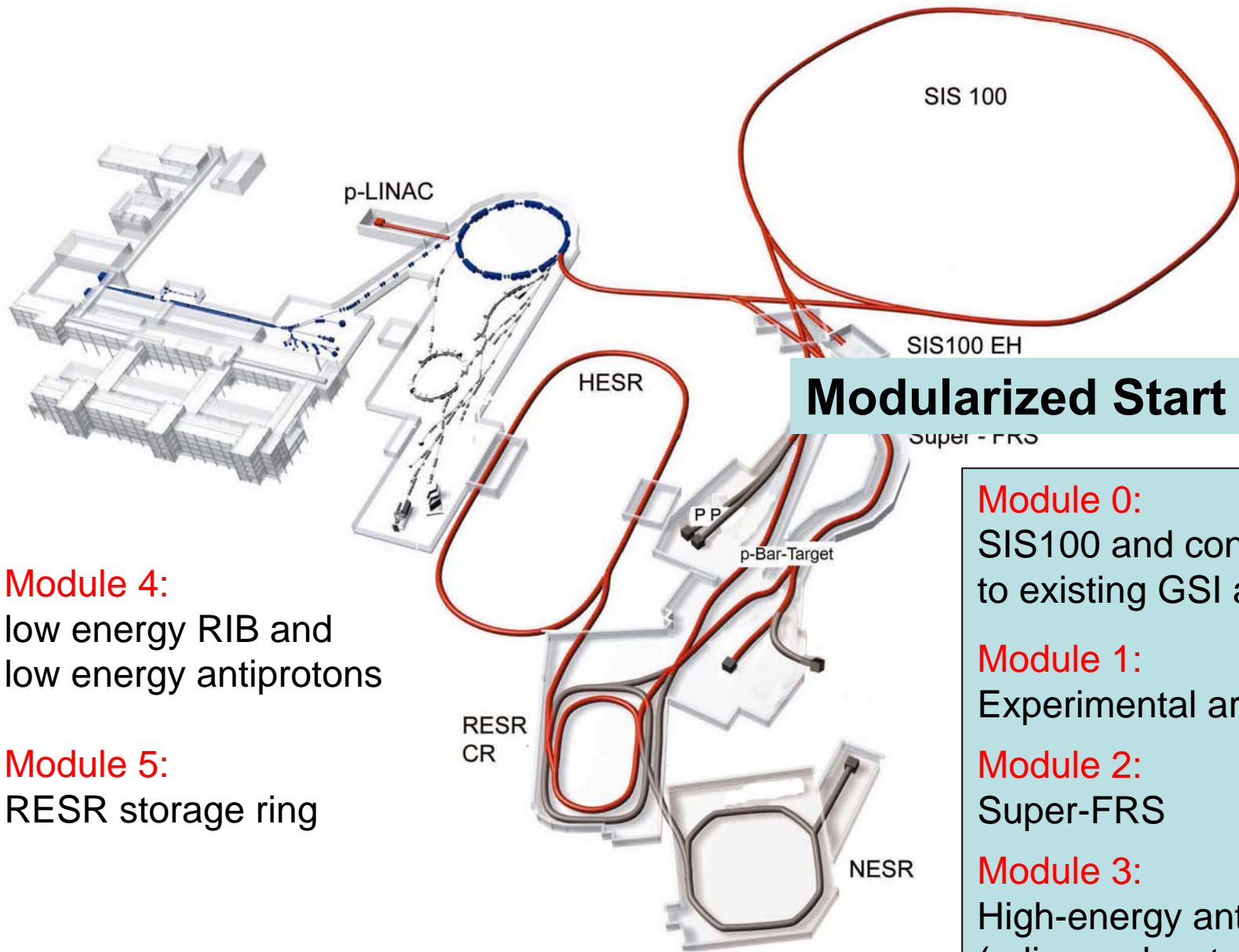
**Module 5:**  
RESR storage ring

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Experimental areas

**Module 2:**  
Super-FRS

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High-energy antiprotons  
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## Modularized Start Version

**Module 4:**  
low energy RIB and  
low energy antiprotons

**Module 5:**  
RESR storage ring

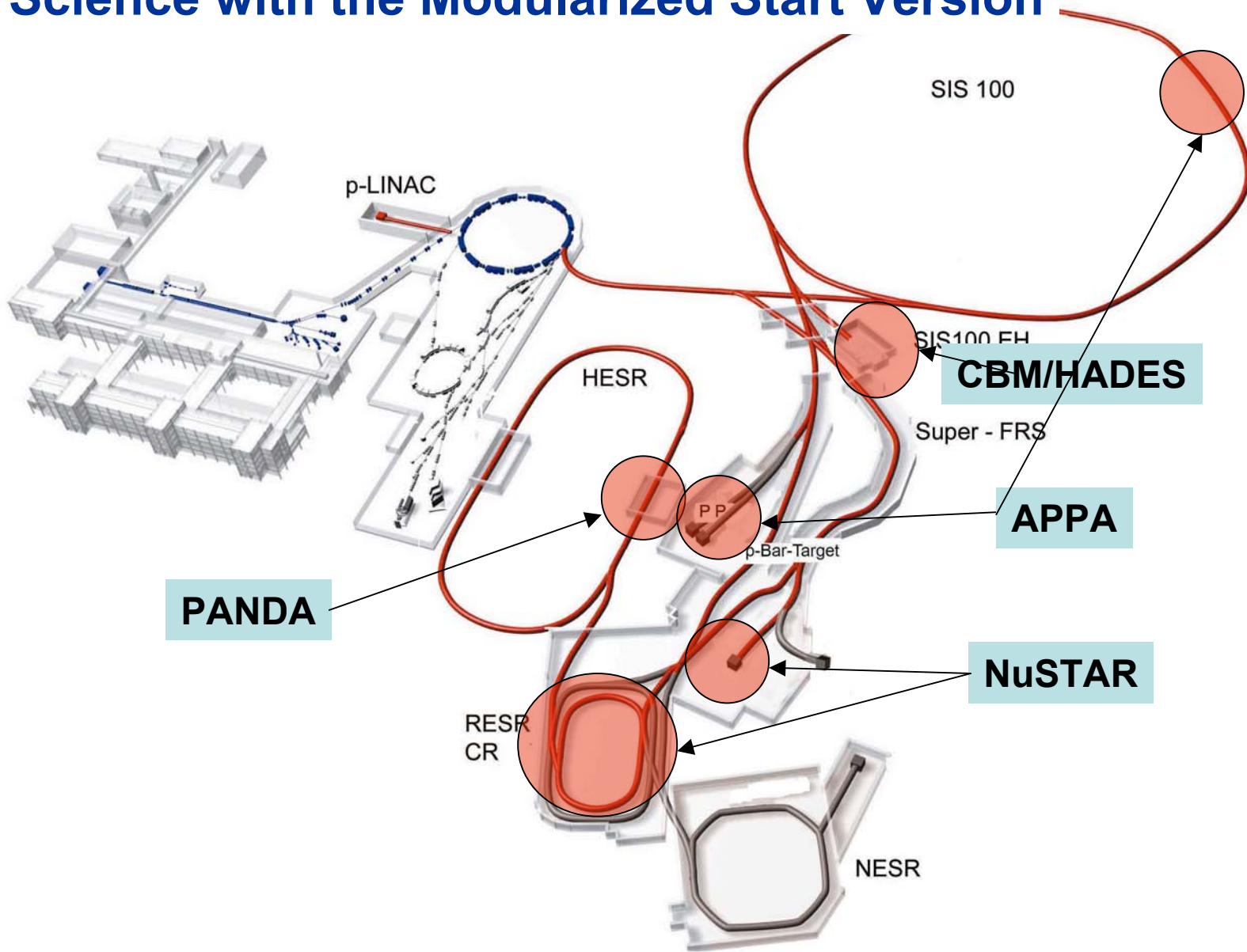
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# Science with the Modularized Start Version



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**Outstanding research opportunities are offered to all four scientific pillars of FAIR by the Modularized Start Version**



## Plasma- physics

- **246 scientists**
- **55 institutions**
- **16 countries**

## BIOMAT

- **110 scientists**
- **28 institutions**
- **12 countries**

## SPARC

- **284 scientists**
- **83 institutions**
- **26 countries**

## FLAIR

- **144 scientists**
- **49 institutions**
- **15 countries**

# Summary: APPA Collaborations

**Module 1: Unique research opportunities for atomic-, bio-, and plasma-physics as well as applied sciences (BIOMAT, HEDgeHOB, SPARC)**

**Highest Charge States**

*Extreme static fields*

**Relativistic Energies**

*Extreme dynamical fields and ultrashort pulses*

**Highest Intensities**

*Very high energy densities and pressures*

## **Modules 4 and 5: Additional Research Opportunities**

**SPARC** *Precision studies using cooled, stored and trapped ions*

**FLAIR** *Most intense source of low-energy antiprotons will be accessible*

**HEDgeHOB/WDM** *Diagnostic tools of high power laser and of proton radiography are optional*

# The CBM Collaboration: 55 institutions, 450 members

## Croatia:

RBI, Zagreb  
Split Univ.

## China:

CCNU Wuhan  
Tsinghua Univ.  
USTC Hefei

## Czech Republic:

CAS, Rez  
Techn. Univ. Prague

## France:

IPHC Strasbourg

## Hungaria:

KFKI Budapest  
Budapest Univ.

## Norway:

Univ. Bergen

## India:

Aligarh Muslim Univ.  
Panjab Univ.  
Rajasthan Univ.  
Univ. of Jammu  
Univ. of Kashmir  
Univ. of Calcutta  
B.H. Univ. Varanasi  
VECC Kolkata  
SAHA Kolkata  
IOP Bhubaneswar  
IIT Kharagpur  
Gauhati Univ.

## Korea:

Korea Univ. Seoul  
Pusan Nat. Univ.

## Germany:

Univ. Heidelberg, P.I.  
Univ. Heidelberg, KIP  
Univ. Heidelberg, ZITI  
Univ. Frankfurt IKF  
Univ. Frankfurt, FIAS  
Univ. Münster  
FZ Dresden  
GSI Darmstadt  
Univ. Wuppertal

## Poland:

Jag. Univ. Krakow  
Warsaw Univ.  
Silesia Univ. Katowice  
AGH Krakow

## Portugal:

LIP Coimbra

## Romania:

NIPNE Bucharest  
Univ. Bucharest

## Russia:

IHEP Protvino  
INR Troitzk  
ITEP Moscow  
KRI, St. Petersburg  
Kurchatov Inst., Moscow  
LHEP, JINR Dubna  
LIT, JINR Dubna  
MEPHI Moscow  
Obninsk State Univ.  
PNPI Gatchina  
SINP MSU, Moscow  
St. Petersburg P. Univ.

## Ukraine:

T. Shevchenko Univ. Kiev  
Kiev Inst. Nucl. Research



14<sup>th</sup> CBM Collaboration meeting  
5-9 Oct. 2009, Split, Croatia

# Summary: CBM/HADES at FAIR

Physics program with large discovery potential at Module 0,1:

- Exploring the equation-of-state of nuclear matter at neutron star densities with multistrange hyperons.
- First measurements of lepton pairs at SIS100 energies to study the modification of hadron properties in dense nuclear matter, and the electromagnetic structure of dense nuclear matter.
- Searching for strange matter.
- First measurement of charm production and propagation at threshold energies.

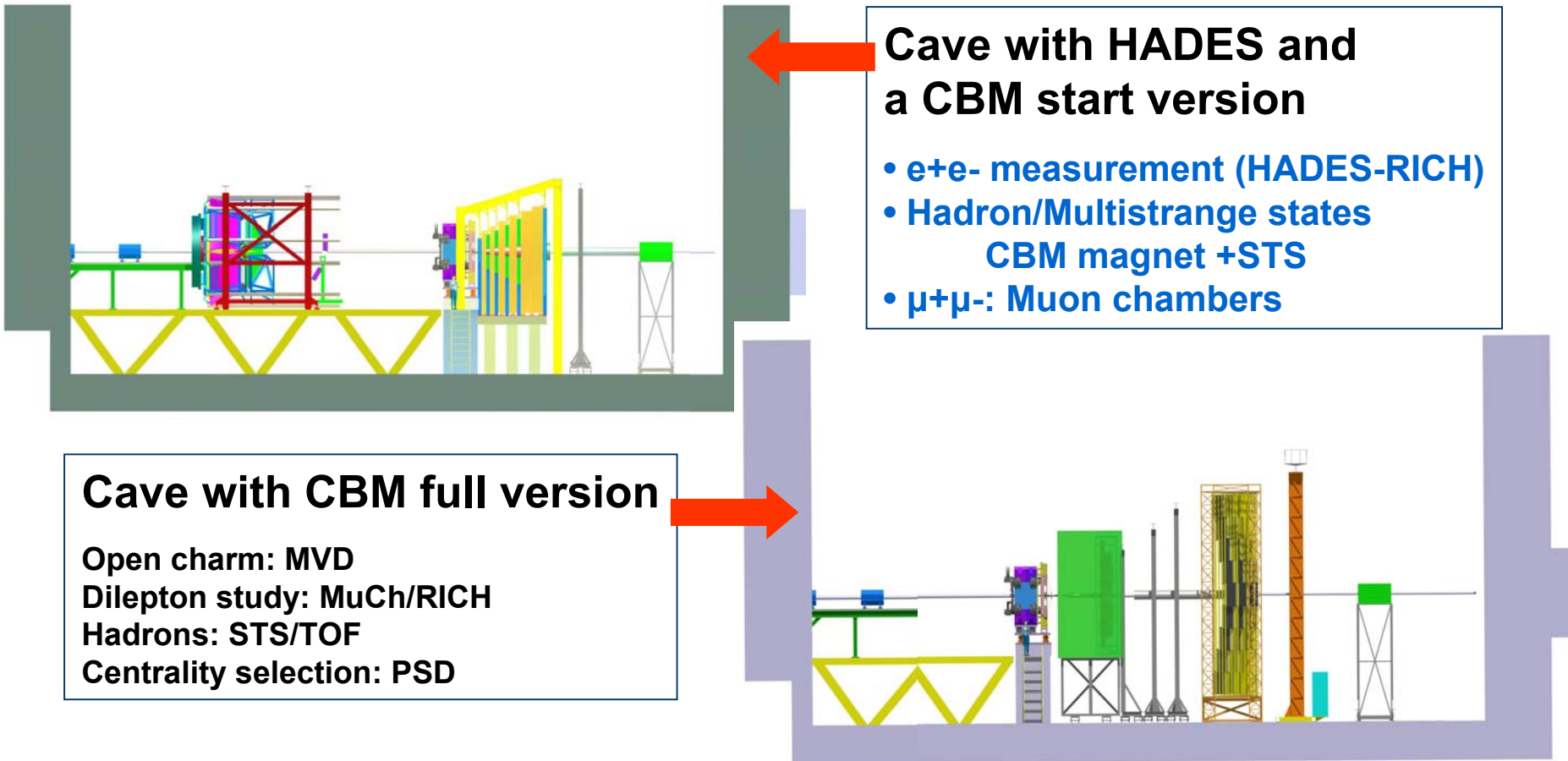
Full version of FAIR:

Mapping the QCD phase diagram, and searching for

- the deconfinement and chiral phase transitions,
- the QCD critical endpoint,
- new states of matter at the highest baryon densities.

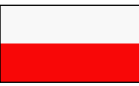
# Experimental equipment (FAIR Modules 0,1)

- HADES: existing setup at SIS18
- CBM: New instrument with ultra radiation-hard and high-rate detectors, free-streaming electronics, online event selection



# Nuclear Structure, Astrophysics and Reactions

> 800 members from 37 countries and 146 institutions



# Summary: NuSTAR Collaboration

## Module 0-3: Unique research opportunities to study Nuclear Structure and Dynamics and Nuclear Astrophysics

<b>R3B</b>	full program, reactions at relativistic energies, complete kinematics
<b>ILIMA</b>	unique measurements of masses and half-lives in the CR
<b>HISPEC, DESPEC</b>	in-beam (50-100 AMeV) & decay spectroscopy
<b>MATS, LASPEC</b>	precision ground state properties

## Modules 4 and 5: Additional Research Opportunities

<b>ILIMA</b>	cooled beams, unique decay modes, isomeric beams in NESR
<b>EXL</b>	elastic and inelastic scattering on internal H, He target in NESR
<b>HISPEC</b>	energy buncher: access to heavier nuclei, low-energy beams
<b>MATS, LASPEC</b>	energy buncher: faster extraction, cleaner beams

# NuSTAR Experiments in Modularized Start Version

## Accommodate LEB experiments at available Super-FRS branch

- **HISPEC:** In-Flight Spectroscopy
- **DESPEC:** Decay Spectroscopy
- **MATS:** Penning trap system (Masses, Trap Assisted Spectroscopy)
- **LASPEC:** LASER Spectroscopy (Spins, Moments, isotope shifts)

### Primary Beams

- $10^{12}/s$ ; 1.5-2 GeV/u;  $^{238}\text{U}^{28+}$
- Factor 100-1000

## Super-FRS

### Secondary Beams

- up to factor **10 000**

High-Energy Branch

Ring Branch

- **R<sup>3</sup>B:** (full capability)  
Reactions with Relativistic  
Radioactive Beams in complete  
kinematics

- **ILIMA in CR:**  
Masses and Half-lives for short-lived ions

**SIS 100**

At present 410 physicists from 53 institutions in 16 countries



Basel, Beijing, Bochum, IIT Bombay, Bonn, Brescia, IFIN Bucharest, Catania, IIT Chicago, Cracow, IFJ PAN Cracow, Cracow UT, Edinburgh, Erlangen, Ferrara, Frankfurt, Genova, Giessen, Glasgow, GSI, FZ Jülich, JINR Dubna, Katowice, KVI Groningen, Lanzhou, LNF, Lund, Mainz, Minsk, ITEP Moscow, MPEI Moscow, TU München, Münster, Northwestern, BINP Novosibirsk, IPN Orsay, Pavia, IHEP Protvino, PNPI St.Petersburg, KTH Stockholm, Stockholm, Dep. A. Avogadro Torino, Dep. Fis. Sperimentale Torino, Torino Politecnico, Trieste, TSL Uppsala, Tübingen, Uppsala, Valencia, SINS Warsaw, TU Warsaw, AAS Wien

# Summary: PANDA Collaboration

## Module 0-3: $\bar{p}$ -induced reactions studied with FAIR have an enormous impact in particle physics

All  $\bar{q}q$  states can be formed directly (not only  $1^{--}$ )  
 $\bar{p}p$  cross section is high  
High probability for production of exotic states  
Low final state multiplicities  
Nucleon structure can be studied

- discovery potential
- precision studies 1st time
- 2 states  $1^{--}$  are predicted
- allows complete PWA
- via electromagnetic processes

## Module 5: Additional Research Opportunities

Higher luminosity

Maximizes the yield, and then rare phenomena can be studied

# Cost Estimate Modules 0-3 (Price Basis 2005)

<b>Total accelerator and personnel Modules 0 - 3</b>	<b>502</b>
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<b>Total civil construction Modules 0 - 3</b>	<b>400</b>
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<b>Experiment funding</b>	<b>78</b>
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<b>FAIR GmbH personnel and running costs</b>	<b>47</b>
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<b>Grand Total Modules 0 - 3</b>	<b>1027</b>
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all values in M€

# Firm Commitments

FAIR Countries	Total declared Contribution (k€)
Austria	5.000
China	12.000
Finland	5.000
France	27.000
Germany	705.000
Great Britain	8.000
Greece	4.000
India	36.000
Italy	42.000
Poland	23.740
Romania	11.870
Russia	178.050
Slovenia	12.000
Slovakia	6.000
Spain	19.000
Sweden	10.000
<b>Total</b>	<b>1.104.660</b>
<b>Firm Commitments</b>	<b>1.038.660</b>

not firm for the first batch

Kingdom of Saudi-Arabia signed the Declaration to contribute at least 1 %

# Finance Summary

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Cost of Modularized Start Version = 1027 M€

Firm funding commitments of FAIR Partners = 1039 M€

Modularized Start Version secures a swift start within the current funding commitments

# Roadmap

- Driven by civil construction
- Aim for earliest commissioning of accelerators and respective experiments
- Start of construction 2010/11

<b>Module</b>	<b>Construction time (months)</b>	<b>Operational</b>
0	72	2015 / 16
1	28	2015 / 16
2	60	2016
3	60	2016

# Optimization Progress

## Sub-committee of the Machine Advisory Committee

- evaluate radioprotection and safety concept
  - evaluation of parameters entering the radiation calculations
  - access strategies to accelerators and experiments
- optimize cost/value ratio for civil construction

Membership: experts from other centers as well as some MAC members

# Conclusions

- Based on recent cost estimates and firm commitments of FAIR Member States the Modularized Start Version is elaborated
- Modules 0-3 ensure a physics programme that is unique, competitive with great discovery potential
- All FAIR science communities can perform excellent physics from early on
- The facility can be smoothly upgraded towards the full version of FAIR
- Setup of the international FAIR company proceeds in parallel

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**FAIR will open a new era in hadronic, nuclear and atomic research as well as in applied science.**

**The White Paper outlines **the path** to achieve this goal.**

**The Modularized Start Version provides an outstanding and world-leading research program for all scientific FAIR communities.**

1. The Modularized Start Version is the right way to proceed.
2. The project is more focussed and is in even better shape.
3. We should now start as soon as possible!

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***Thank you for attention !***

# FAIR Costing Issues

## ■ Accelerator

- costs defined by Costbook (CB) V 5.0 as of price basis 2005
- in-kind contributions account for CB values
- actual costs have to be covered by contributing FAIR Member States

## ■ Experiment

- baseline experiment funding: 78 M€
- additional experiment contributions outside FAIR project financing

## ■ Civil Construction

- cash contributions to civil construction  
75 % Germany, 25 % other FAIR Member States

## ■ Personnel

- accelerator coordination personnel accounted for in Costbook
- 400 FTE for FAIR GmbH over 8 years period

# Detailed Cost Estimate Modules 0 – 3 (Price Basis 2005)

		Cost estimate [M€] 2005 price basis
<b>Module 0</b>	SIS 100 with connection to GSI accelerators	
	Sum civil construction	223
	Sum accelerator and personnel	259
	<b>Total Module 0</b>	<b>482</b>
<b>Module 1</b>	SIS100 experiments areas	
	Sum civil construction	19
	Sum accelerator and personnel	4
	<b>Total Module 1</b>	<b>23</b>
<b>Module 2</b>	Super-FRS w/o CR	
	Sum civil construction*	70
	Sum accelerator and personnel	111
	<b>Total Module 2</b>	<b>181</b>
<b>Module 3</b>	High-energ antiprotons (p-linac, antiproton target, CR, HESR)	
	Sum civil construction*	88
	Sum accelerator and personnel	128
	<b>Total Module 3</b>	<b>217</b>

# Detailed Cost Estimate Modules 4 and 5 (Price Basis 2005)

		Cost estimate [M€] 2005 price basis
<b>Module 4</b>	Low energy RIBs and antiprotons	
	Sum civil construction	77
	Sum accelerator and personnel	27
	<b>Total Module 4</b>	<b>104</b>
<b>Module 5</b>	RESR storage ring	
	Sum civil construction	0
	Sum accelerator and personnel	19
	<b>Total Module 5</b>	<b>19</b>