How the Fair Russia Research Centre came all about:

Moscow, October 5, 2005

Visit of the new president of the Helmholtz Association, Prof.Mlynek to Russia. Here, he recognizes **the BIG number** of fresh PhD students leaving Science. He decides to do something against and asked for suggestions. This led to the FRRC of today.

Dr. Heinze, Prof. Sharkov, Prof.Mlynek, Prof. Heuer

Not to forget :

Dr. Oleg Patarakin

Proposal for a

Joint Helmholtz-ROSATOM
"FAIR-Russia Research Centre"

Prof. Mlynek, president of the German Helmholtz association has accepted the proposal and given a grant of close to 1.3 million Euro for the next 2.5 years

Submitted by

Gesellschaft für Schwerionenforschung, Darmstadt (GSI)
Institute of Theoretical and Experimental Physics, Moscow (ITEP)

Prof. Dr. Horst Stöcker

For GSI:
Prof. Walter F. Henning
Director
Gesellschaft für Schwerionenforschung

Planckstr. 1
64291 Darmstadt
Germany

Tel.: +49-6159-71-2648
Fax: +49-6159-71-2991
Email: henning@gsi.de

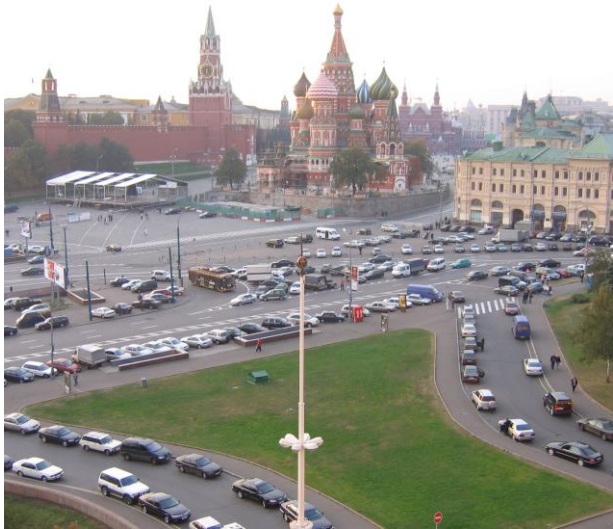
For ITEP:
Prof. Boris Y. Sharkov
Director
Inst. of Theoretical and Experimental Physics
Bolshaya Cheremushkinskaya, 25
117218 Moscow
Russia

Tel.: +7-495-123-02-88
Fax: +7-495-123-30-28
Email: boris.sharkov@itep.ru

For FAIR:
Prof. Hans Gutbrod
FAIR Joint Core Team Leader

Planckstr. 1
64291 Darmstadt
Germany

Tel.: +49-6159-71-2458
Fax: +49-6159-71-3916
Email: H.Gutbrod@gsi.de



Prof. Mlynek, Dr. Uwe Meyer, German Embassy

Dr. Nikolay Spasskiy (Deputy Head of ROSATOM), Prof. Boris Sharkov

Inauguration of FRRC in its new Building 40 at ITEP on August 30th, 2008

Prof. Victor Varentsov, Russian delegate to FAIR JCT and Bruno Becker de Mos, head experiment integration send greetings
August 29th, 2008

Status of FAIR or

Samuel Beckett's 'En attendant Godot *(Waiting for Godot)*'*

ESTRAGON: Let's go.

VLADIMIR: We can't.

ESTRAGON: Why not?

VLADIMIR: We're waiting for Godot.

Germany and other FAIR countries await eagerly the O.K. from Russian government to sign the FAIR convention with the pledged amount of 15%

* from play at Lower 9th Ward in New Orleans

Prof. Boris Sharkov, elected
Scientific FAIR Director

Prof. Sergej Kozub, elected
Head of pre-consortium of SIS 300

Signing ceremony of KACST-GSI Letter of Intent May 3^{d}, 2009

Cosmic Matter in the Lab

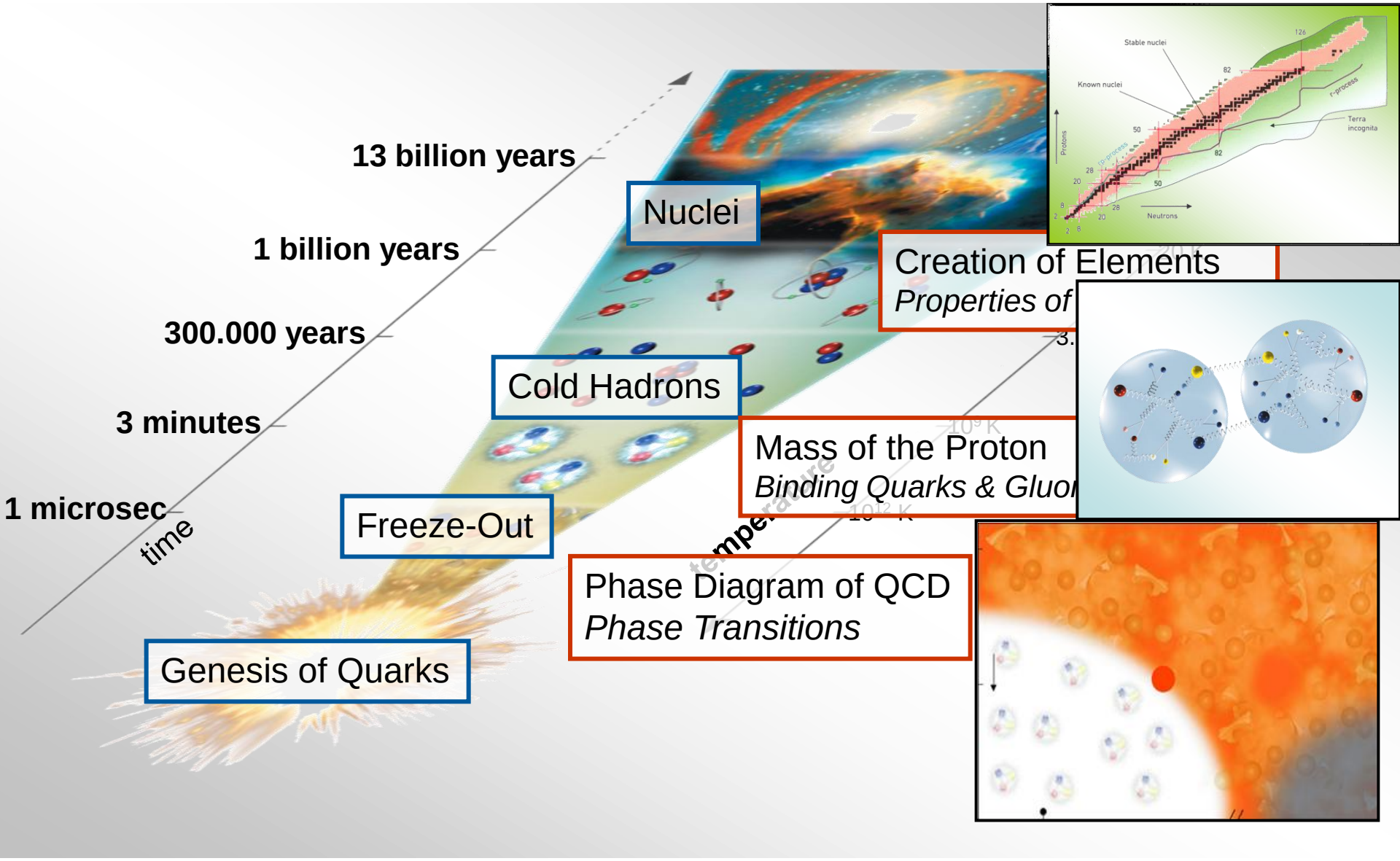
Hans H. Gutbrod

GSI Helmholtzzentrum für Schwerionenforschung

Goethe Universität Frankfurt am Main

Austria China Finnland France Germany Greece India Italy Poland Slovakia Slovenia Spain Sweden Romania Russia UK

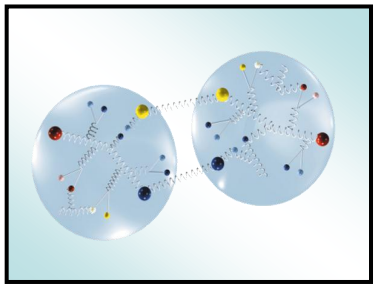
QCD & Big Bang


13 billion years
1 billion years
300.000 years
3 minutes
1 microsec
time
Nuclei
Cold Hadrons
Freeze-Out
Genesis of Quarks
Creation of Elements
Properties of
Mass of the Proton
Binding Quarks & Gluo
Phase Diagram of QCD
Phase Transitions
Stable nuclei
Known nuclei
Protons
Neutrons
Terra incognita

Fundamental Questions – The FAIR Science Case

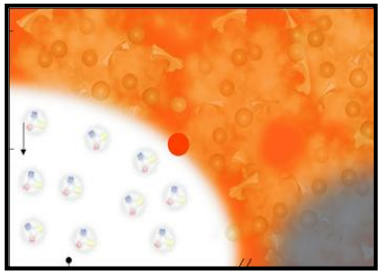
- Proton mass puzzle
  - only 2% of the mass of the proton is governed by quarks
  - 98% of the mass result from the complexity of the strong interaction which is only qualitatively understood
- QCD Phase diagram – free quarks and gluons
  - existence and properties of the quark-gluon plasma
  - chiral restoration
  - critical phenomena and the process of hadronization
- Hadrons – bound systems of quarks and gluons
  - properties of the binding among quarks – extreme hadrons
  - gluonic degrees of freedom and investigation of the structure of hadrons
- Nuclei – bound systems of hadrons
  - study of large proton and neutron excess
  - origin and abundances of the chemical elements

FAIR's science and experimental collaborations



Hadron Structure and Dynamics:
COSY, SIS, FAIR
+ Theory

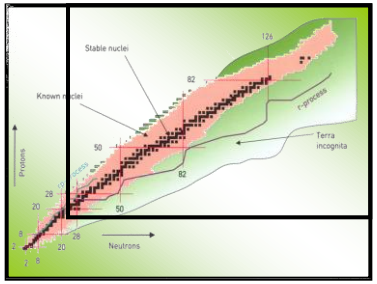
PANDA



Nuclear and Quark Matter:
SIS, CERN, FAIR
+ Theory

CBM

FAIR



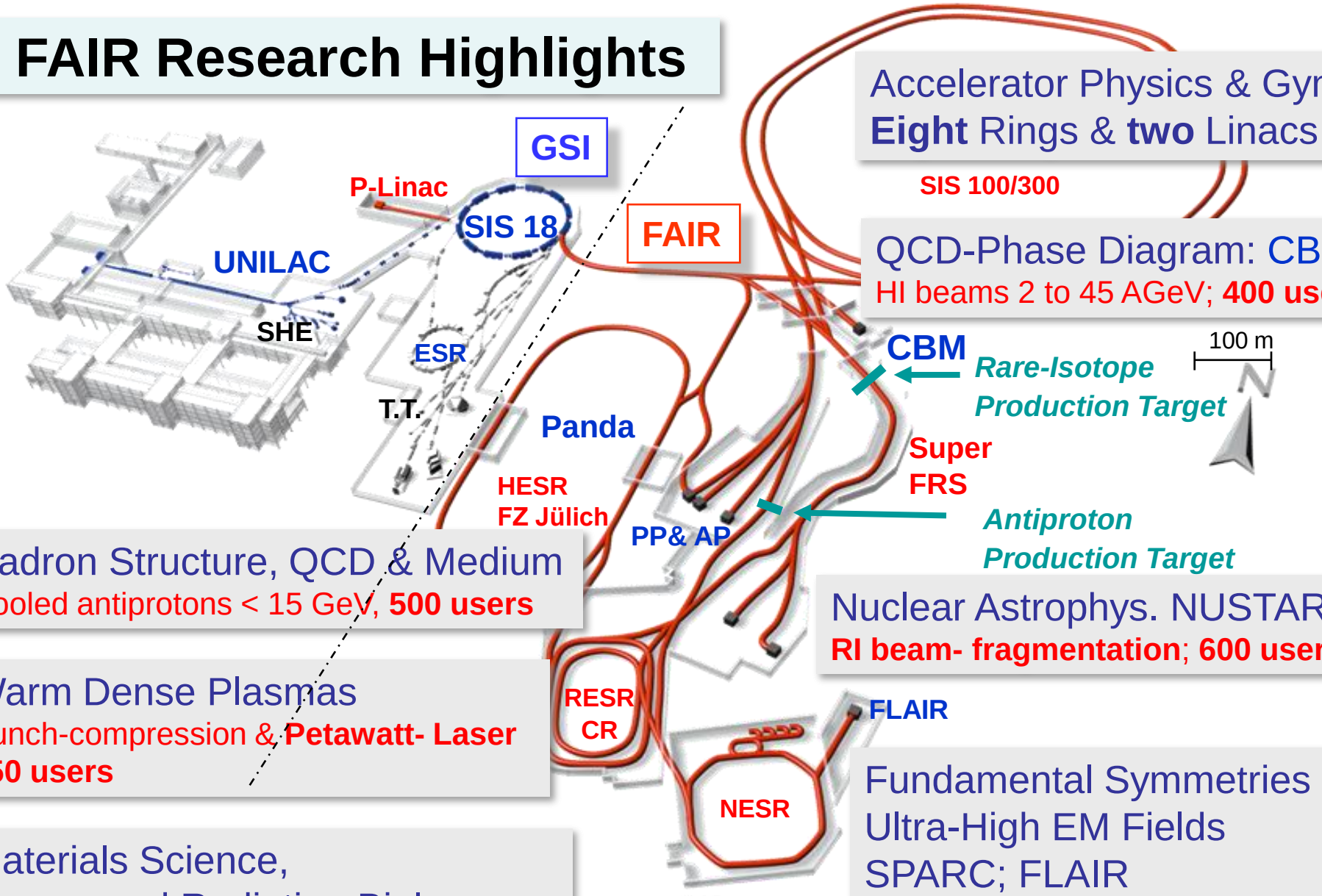
Exotic Nuclei and
Nuclear Astrophysics:
UNILAC, SIS, FAIR
+ Theory

NUSTAR

APPA

Atoms, Plasma…

FAIR Research Highlights



Accelerator Physics & Gym:
Eight Rings & **two** Linacs

QCD-Phase Diagram: CBM
HI beams 2 to 45 AGeV; **400 users**

Hadron Structure, QCD & Medium
Cooled antiprotons < 15 GeV, **500 users**

Nuclear Astrophys. NUSTAR
RI beam- fragmentation; **600 users**

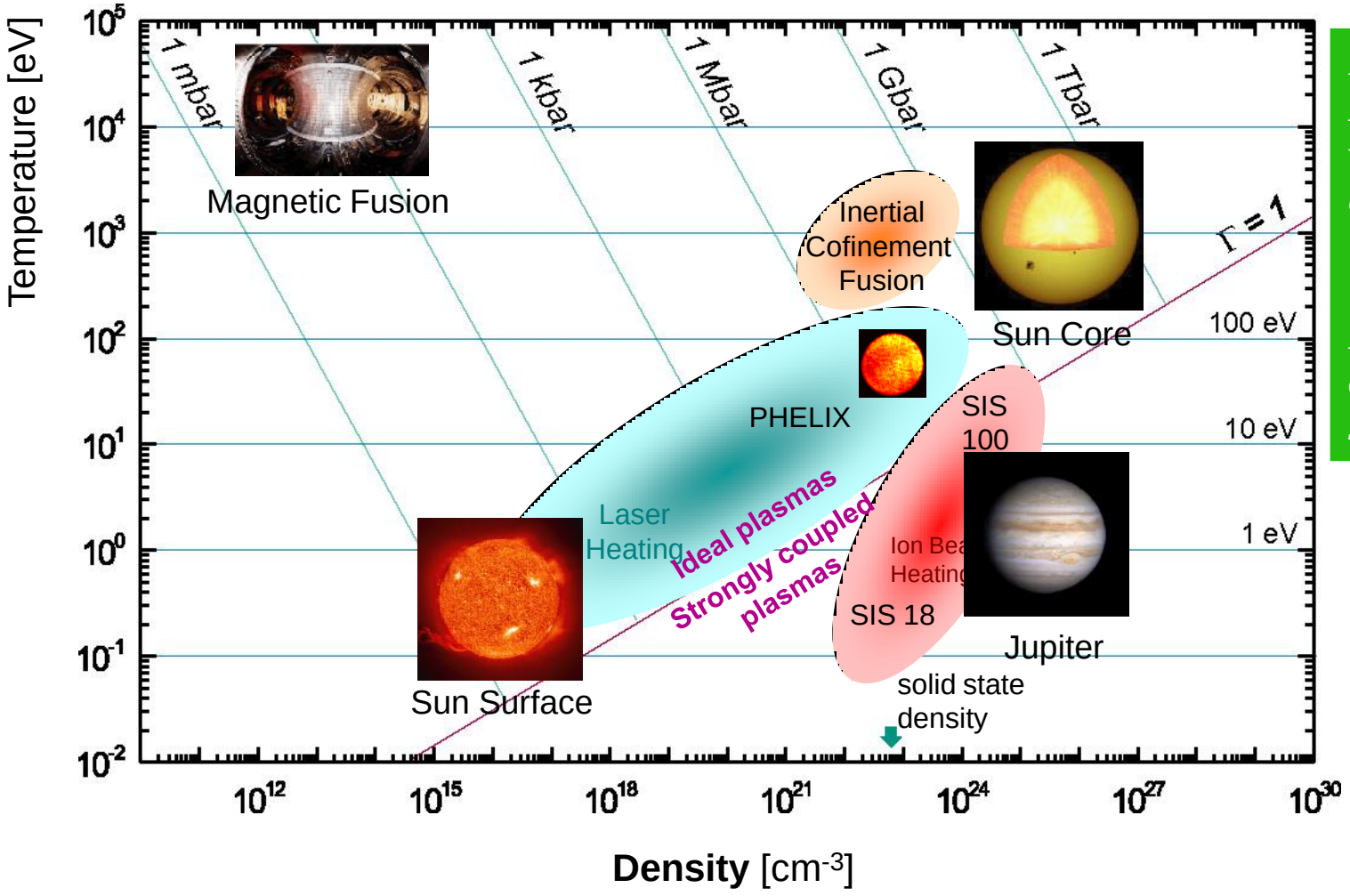
Warm Dense Plasmas
Bunch-compression & **Petawatt- Laser**
250 users

Fundamental Symmetries
Ultra-High EM Fields
SPARC; FLAIR
Antiprotons, Hi-Z ions; **250 users**

Materials Science,
Space- and Radiation Biology
(Ion- & antiproton- beams; **350 users**

Hot EM-Plasmas: high intensity ion bunches hitting petawatt Laser pulses PHELIX

Matter at high energy densities



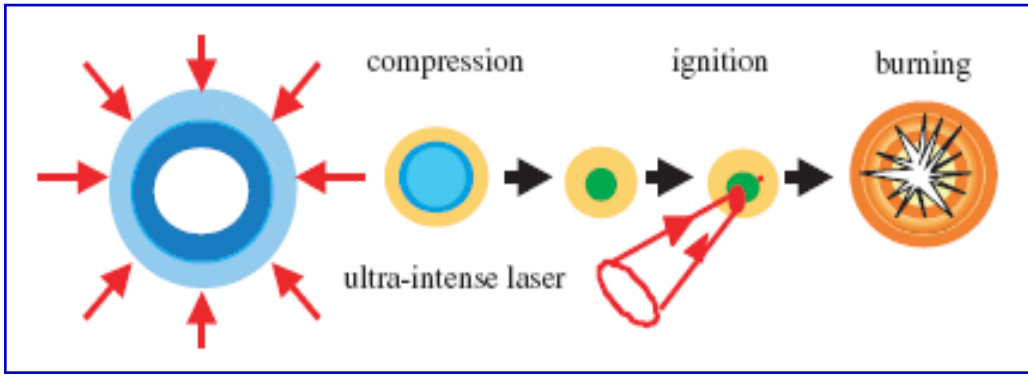
Physics of Fast Ignition (another way to clean energy production)

Equation of state of planetary and stellar matter

SIS-100 will provide 3,000 times the beam power and 600 times higher energy density in the target

Uranium beam	SIS-18	SIS-100	
E_o	400 MeV/u	0.4 – 2.7 GeV/u	
N	$4 \cdot 10^9$	$2 \cdot 10^{12}$	×500
E_{beam}	0.06 kJ	76 kJ	
τ	130 ns	50 ns	
P_{beam}	0.5 GW	1.5 TW	×3000
S_f	~1 mm	~1 mm	
	Lead target		
E_s	1 kJ/g	600 kJ/g	×600
P_s	5 GW/g	12 TW/g	×2400

Towards IC Fusion! FAIR an excellent test bed!

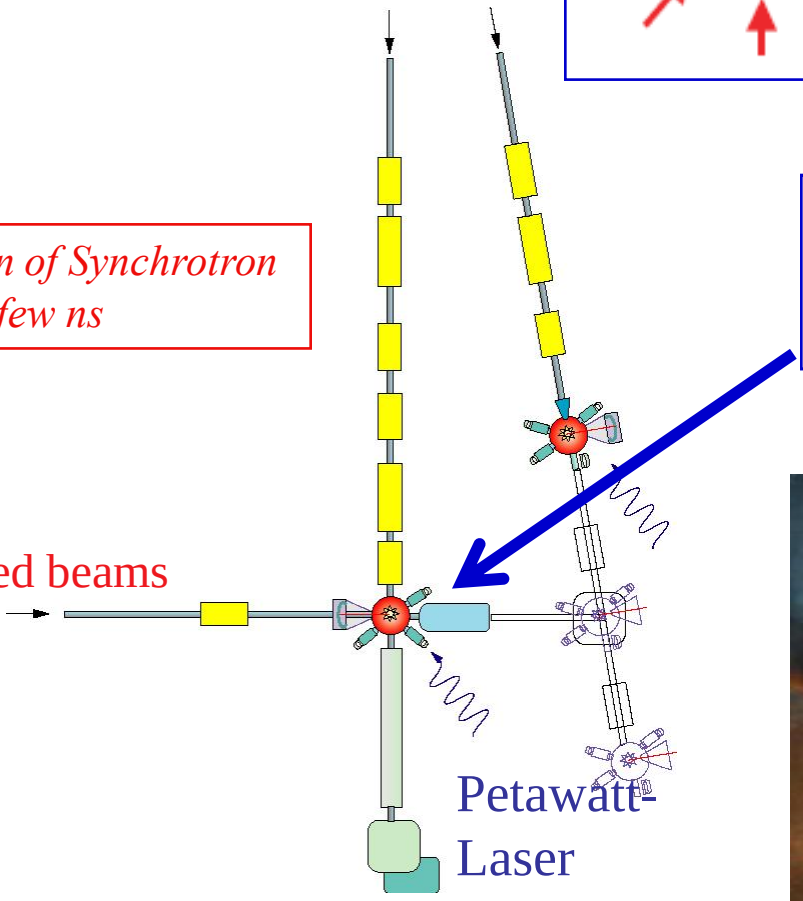


highly bunched beams
from **SIS 100**

Synchronization of Synchrotron and Laser to a few ns

1) Compression SIS100
2) Ignition PHELIX II ?
3) Diagnostics SIS 18

highly bunched beams
from **SIS 18**



Petawatt-
Laser
PHELIX 2

The Physics of Highly Charged Ions

test of bound state QED in the critical field limit

correlated many-body effects on the atomic structure and dynamics

determination of nuclear properties

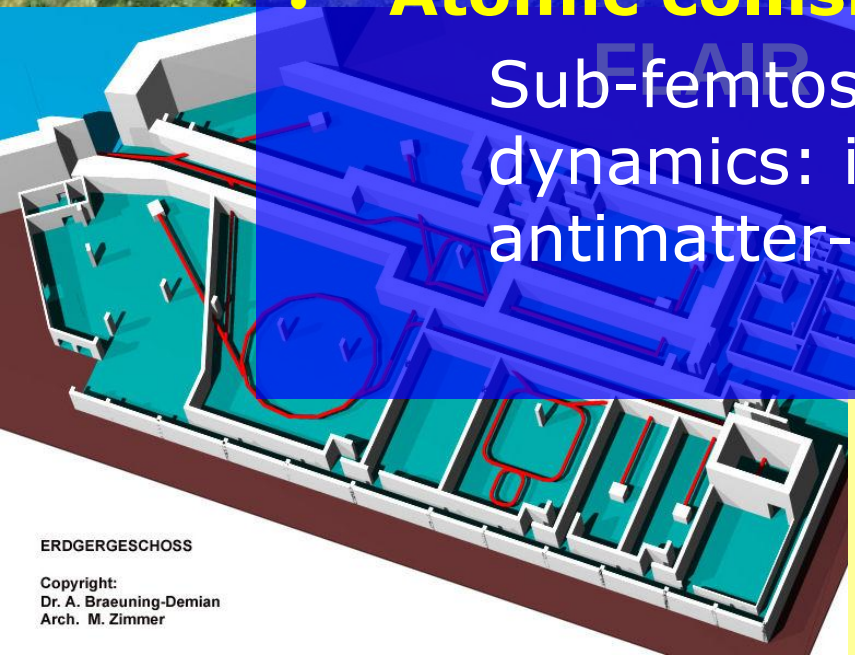
precision determination of fundamental constants

- **Spectroscopy for tests of CPT and QED**

  Antiprotonic atoms: pbar-He! pbar-p, antihydrogen
- **Gravitation of antimatter**

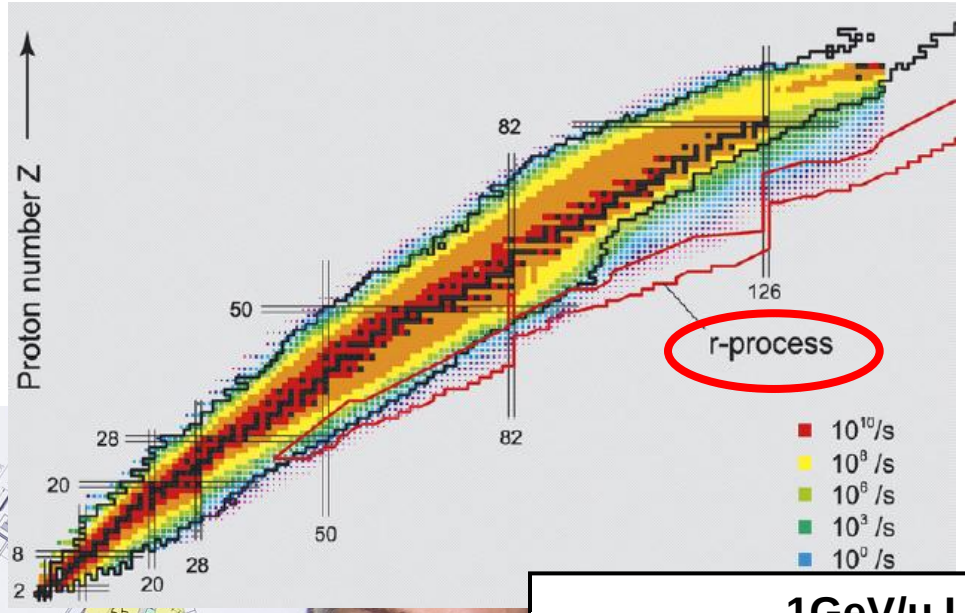
  Trapped and laser-cooled antihydrogen
- **Atomic collisions**

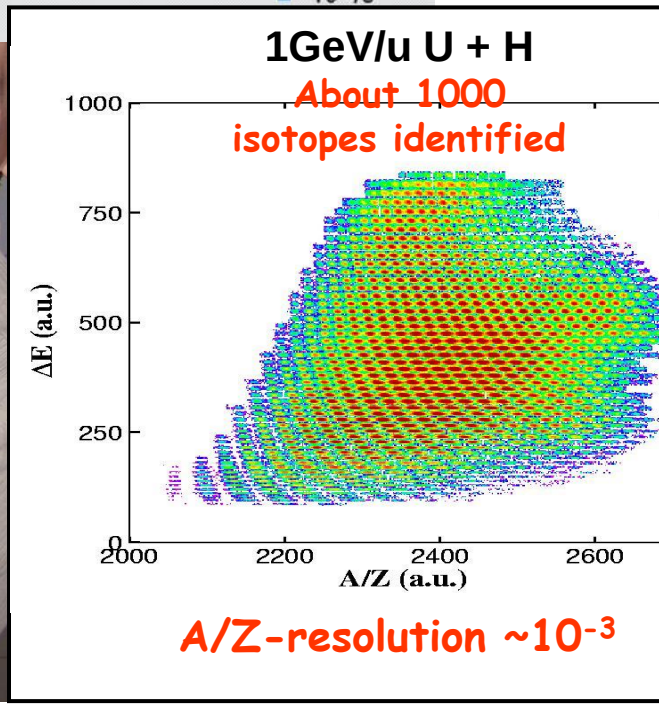
  Sub-femtosecond correlated dynamics: ionization, energy loss, antimatter-matter collisions



Most Intense Source of Antiprotons Worldwide

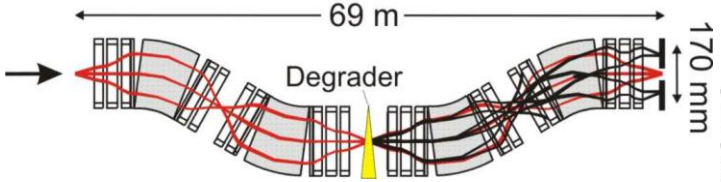
NUSTAR & SuperFRS: exotic astrophysical isotopes



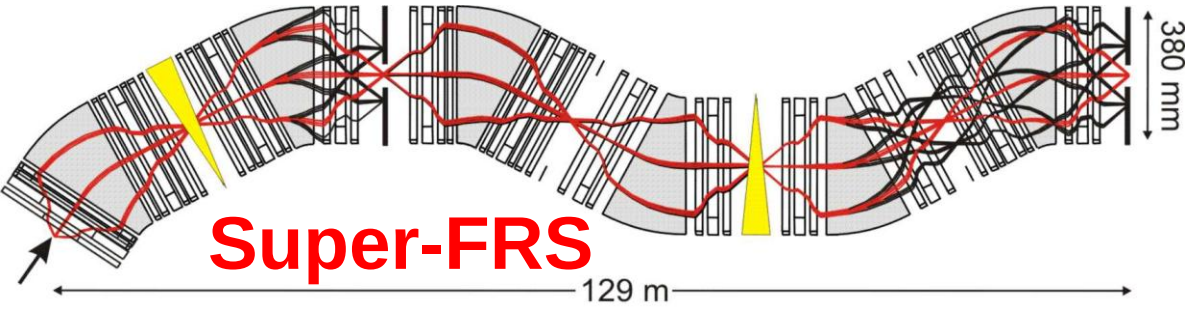


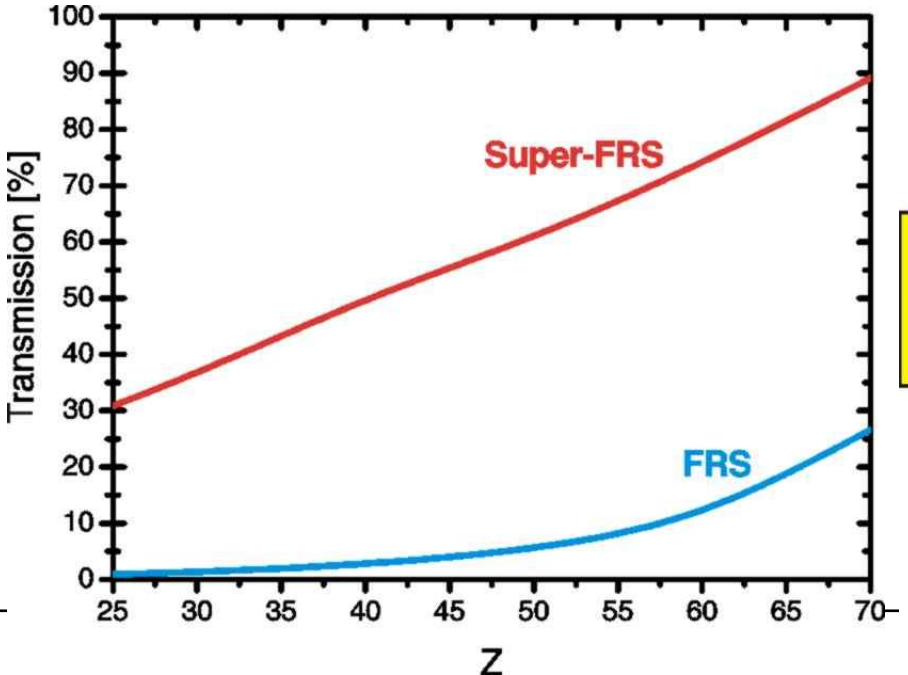
Comparison of FRS with Super-FRS, intensity gain

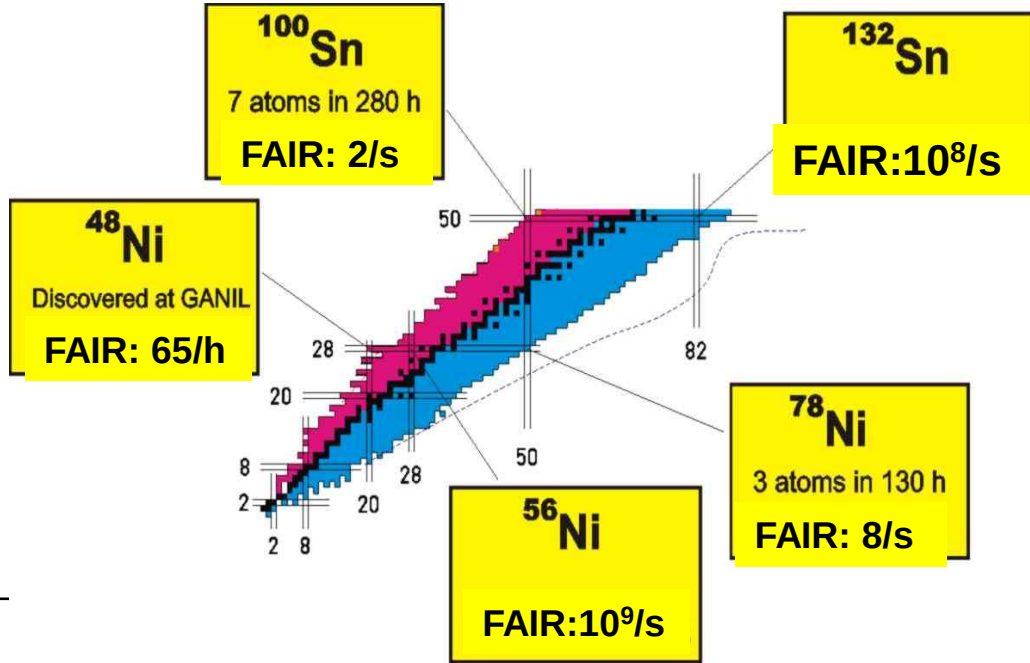
Present FRS



	$B\rho_{max}$	$\Delta p/p$	$\Delta\Phi_x$, $\Delta\Phi_y$	resolving power	gain factor ^{19}C	gain factor ^{132}Sn
FRS	18 Tm	1.0 %	±13, ±13 mrad	1500	1	1
Super-FRS	20 Tm	2.5 %	±40, ±20 mrad	1500	5	10
				including primary rate	250	20 000



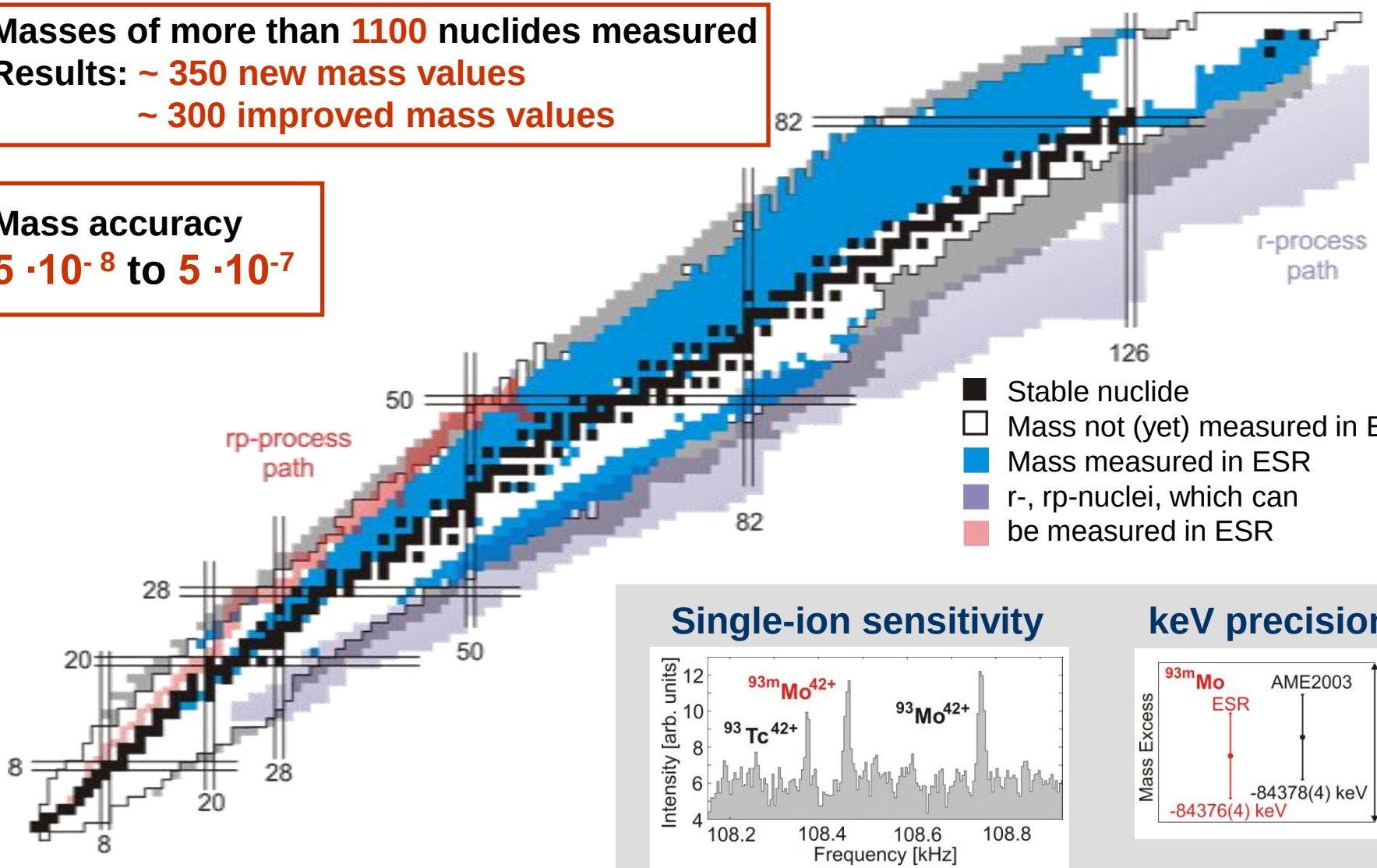




(N)ESR unique! relativistic exotic ions in storage rings

Masses of more than 1100 nuclides measured
Results: ~ 350 new mass values
~ 300 improved mass values

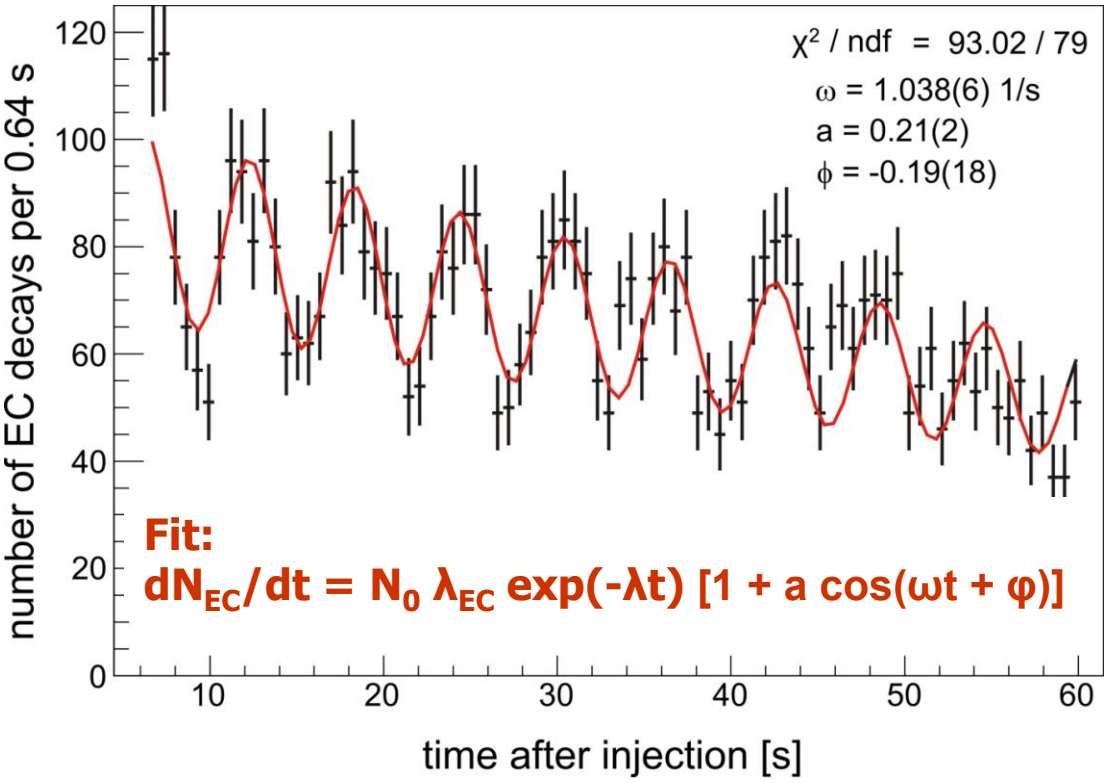
Mass accuracy
$5 \cdot 10^{-8}$ to $5 \cdot 10^{-7}$



Single-ion sensitivity

keV precision

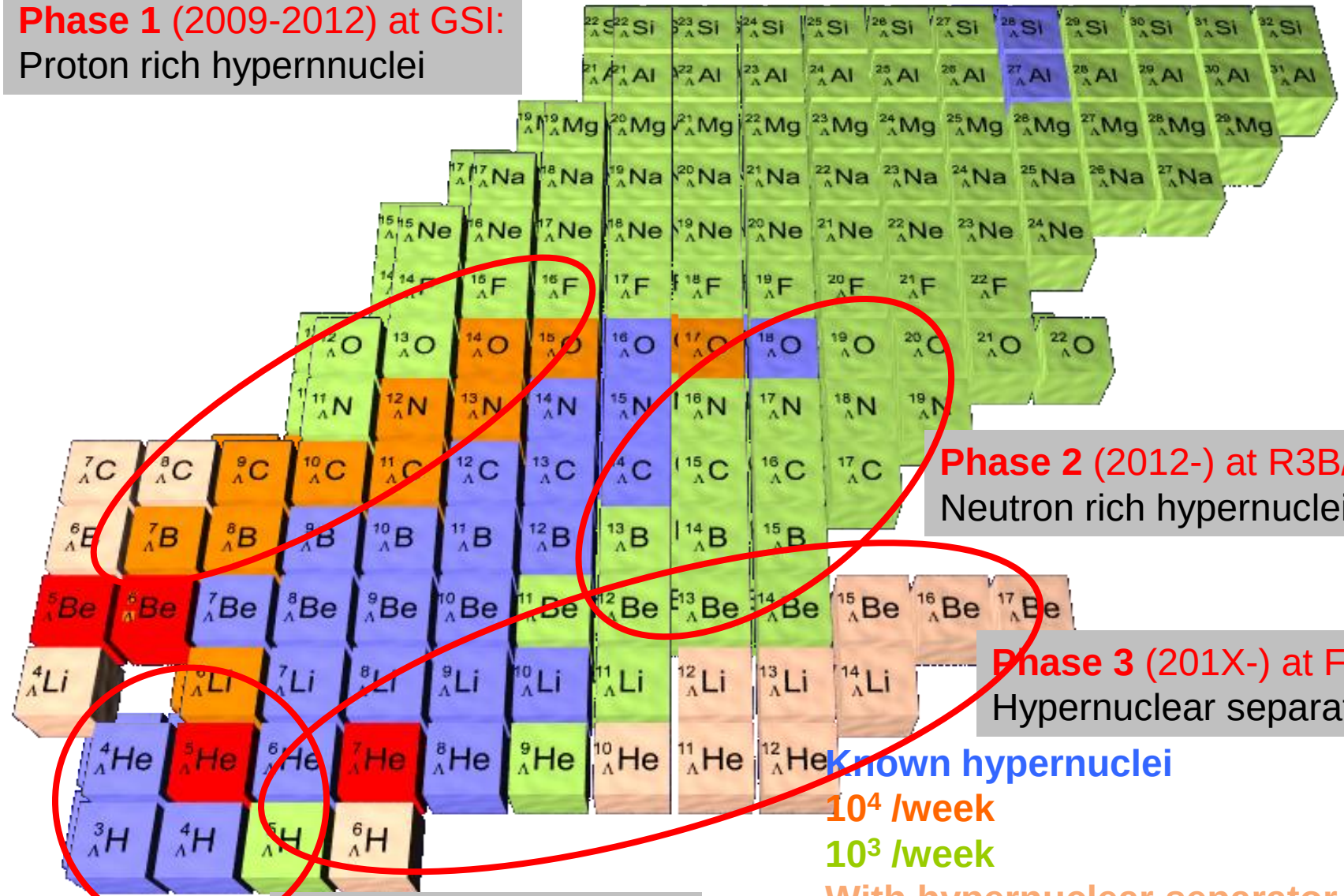
Newly observed decay-properties in H-like iodine



- Orbital electron capture of highly-charged exotic ions
  - exhibits modulated exponential behaviour
  - explanation presently under discussion

Hypernuclear landscape with HypHI

Phase 1 (2009-2012) at GSI:
Proton rich hypernnuclei



Phase 2 (2012-) at R3B/FAIR:
Neutron rich hypernuclei

Phase 3 (201X-) at FAIR:
Hypernuclear separator

Known hypernuclei
10^4 /week
10^3 /week
With hypernuclear separator
Magnetic moments

Phase 0 (2009) at GSI:
Light hypernuclei

PANDA Physics Program

Search for Exotics

- Glue-balls
- Hybrids
- Multi-quark systems

→ QCD Predictions

Charm Hadrons

- High precision spectroscopy of charmonium and D-mesons
- New narrow X,Y, Z states
- CP-violation (with higher luminosity)
- Charm in matter

→ Quark Confinement

→ Heavy-light Systems

Strange and Charm Baryons

- Baryon excitation spectrum
- (Double) Hyper-nuclei

→ Y-N & Y-Y Interaction

Electromagnetic Processes

- Time-like form factors
- Transverse structure functions (Drell Yan)
- Generalized Distribution Amplitudes (GDA)

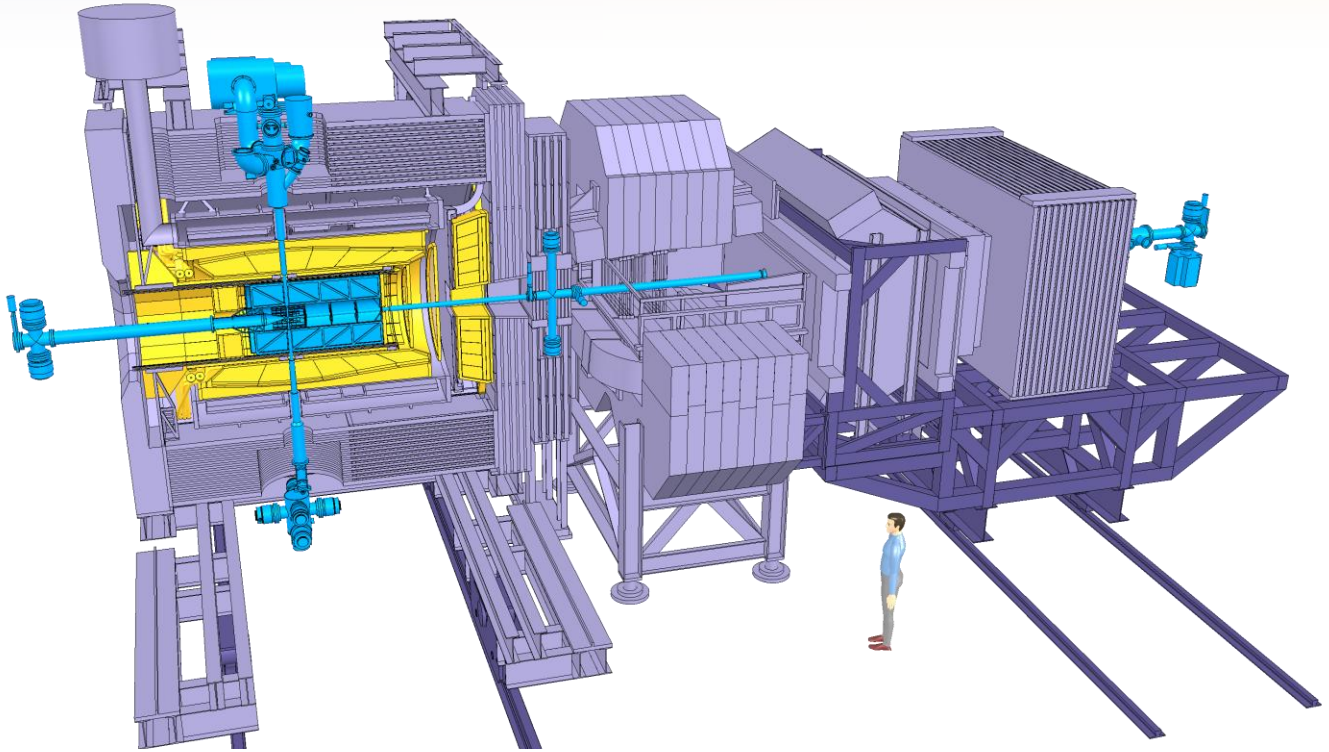
→ From Partons to Hadrons

R&D and Construction of panda

Pellet Target
Micro Vertex Detector
Central Tracker
Luminosity Monitor

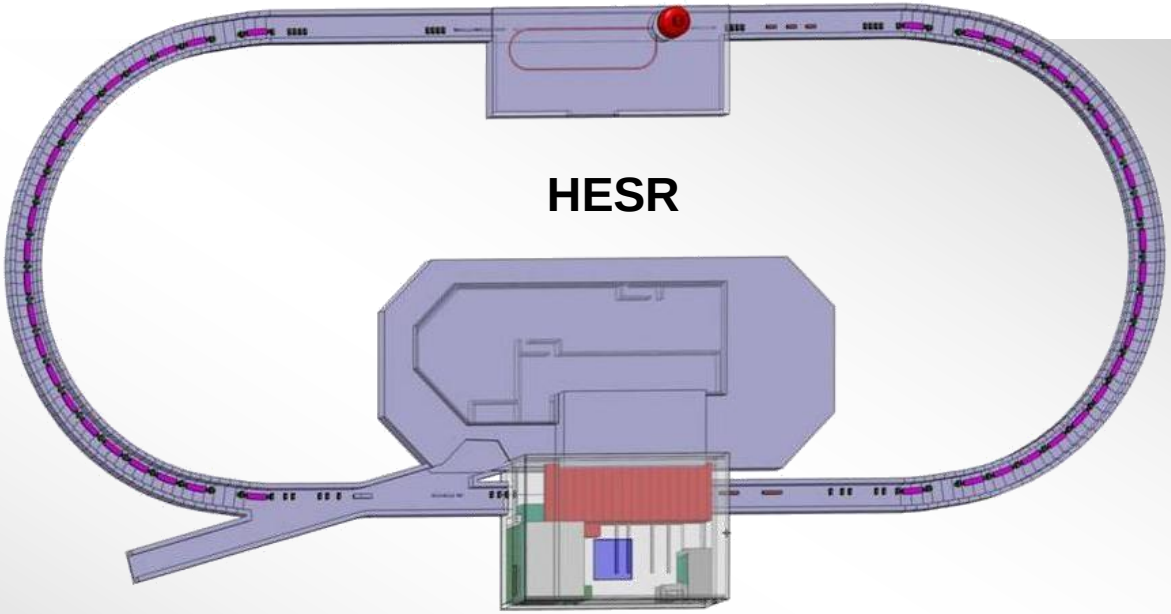
Electronics
Simulation
Physics
Infrastructure
Computing

DIRC Detector
EM Calorimeter
Planar GEMs

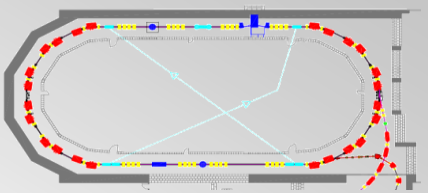


Physics Book, Technical Design Reports: EMC, Magnets, (Targets, Tracking)

HESR with PANDA and Electron Cooler



COSY

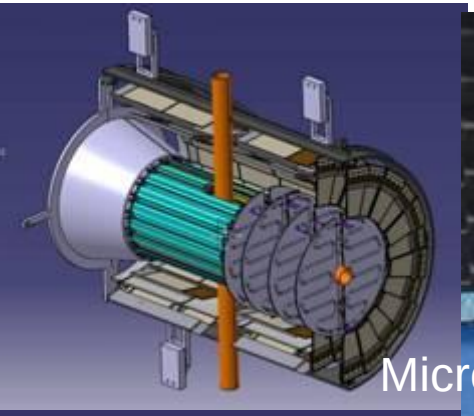


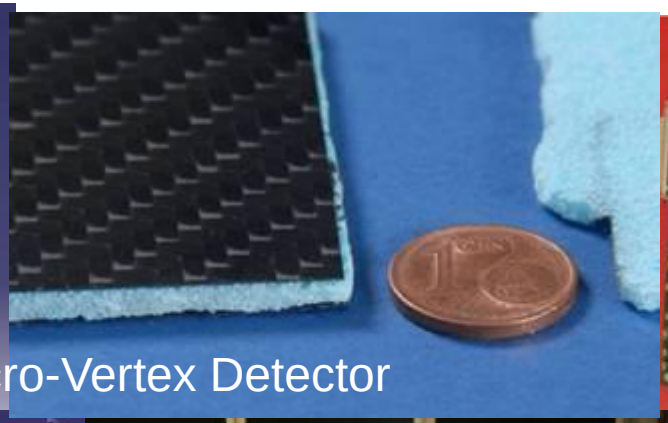
Experience: building, operating and developing COSY

HESR		COSY
574 m	Circumference	184 m
1.5–15 GeV	Momentum	.3-3.7 GeV
< 9 GeV/c	Electron Cooling	<0.5 GeV
Full range	Stochastic Cooli.	1.5-3.7GeV

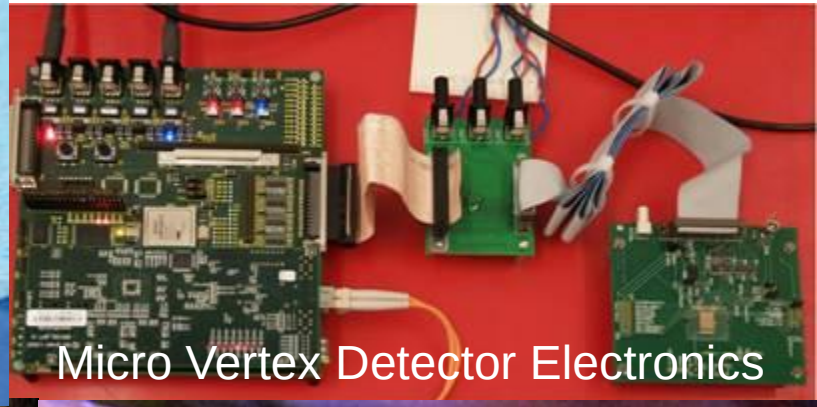
HESR Consortium: Germany (Jülich, GSI), Sweden, Georgia, Poland and Romania

PANDA hardware developments

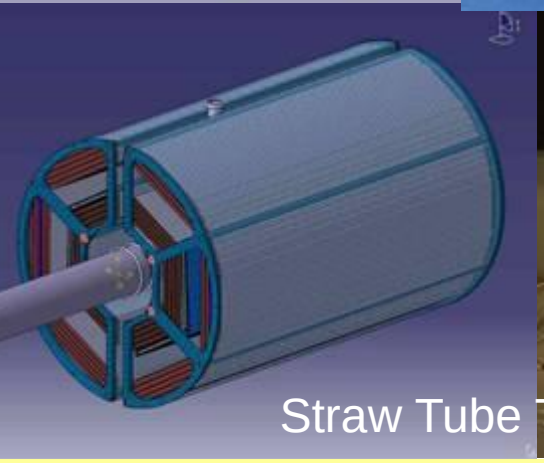




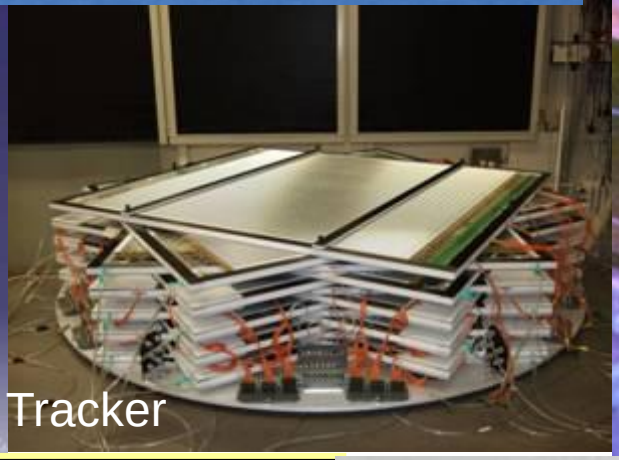
Micro-Vertex Detector

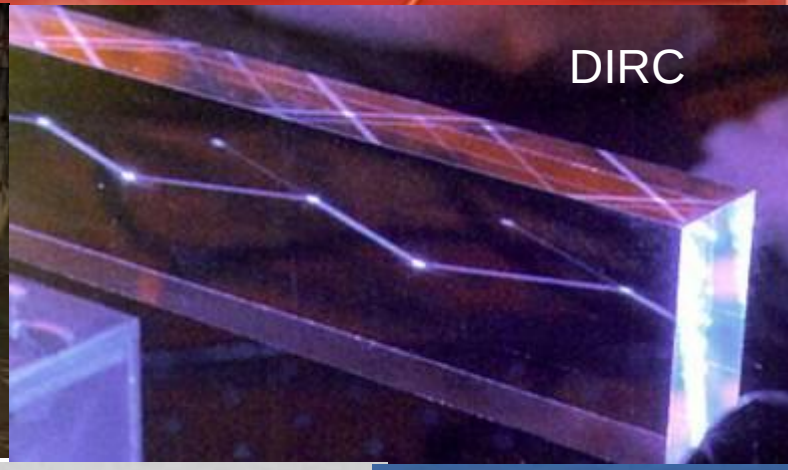


Micro Vertex Detector Electronics



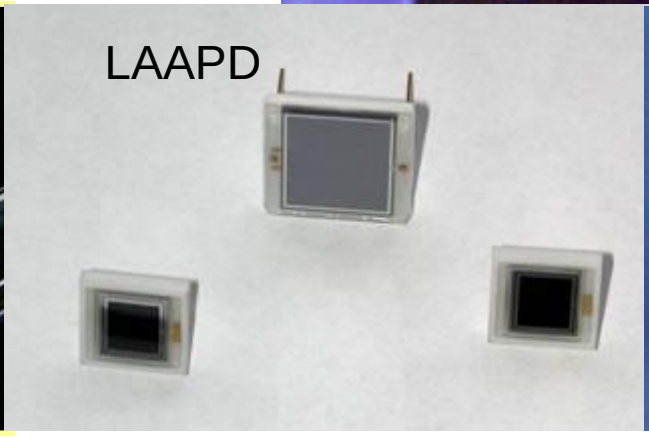
Straw Tube Tracker





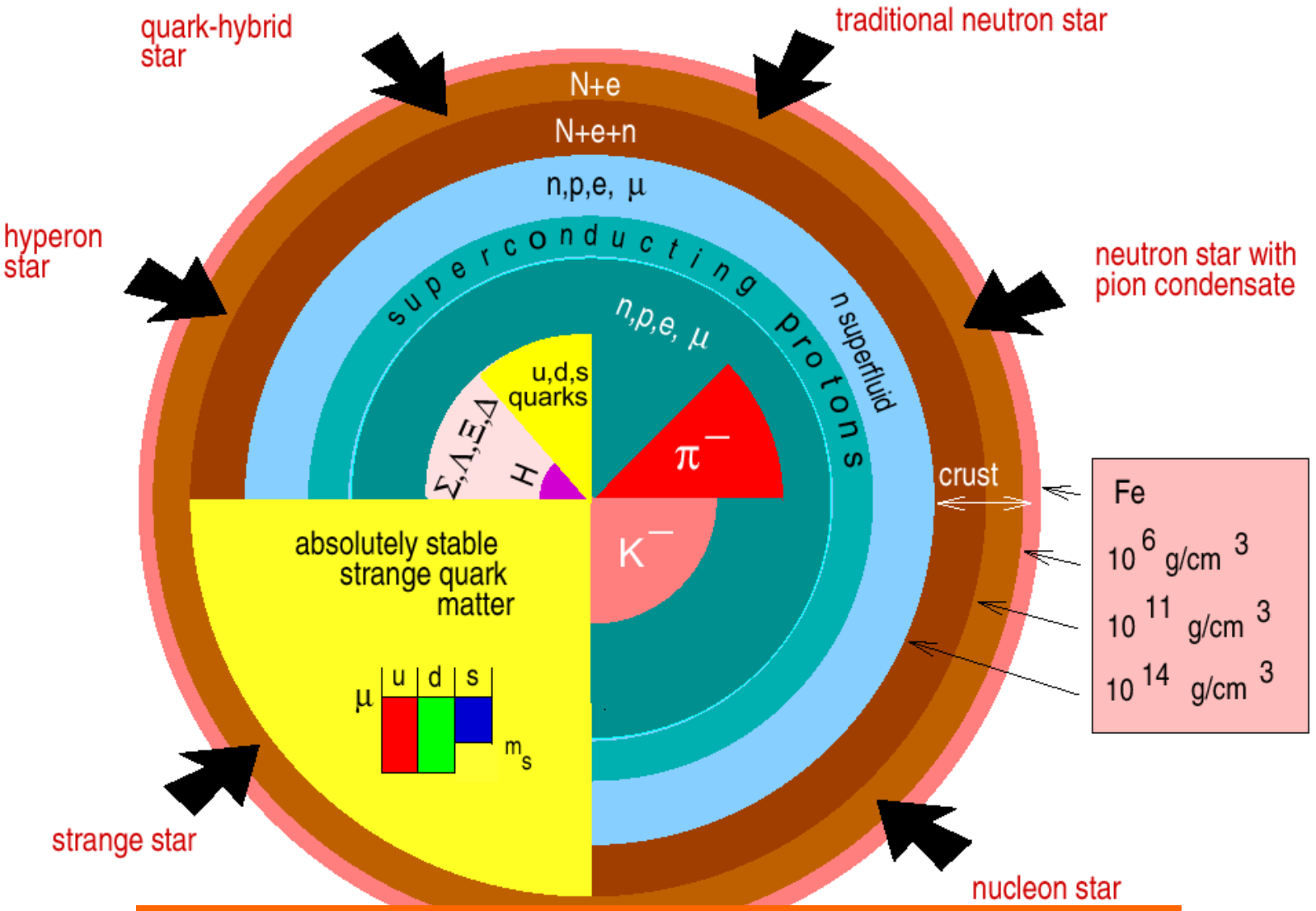
DIRC

EMC PWO crystals



LAAPD

FEE

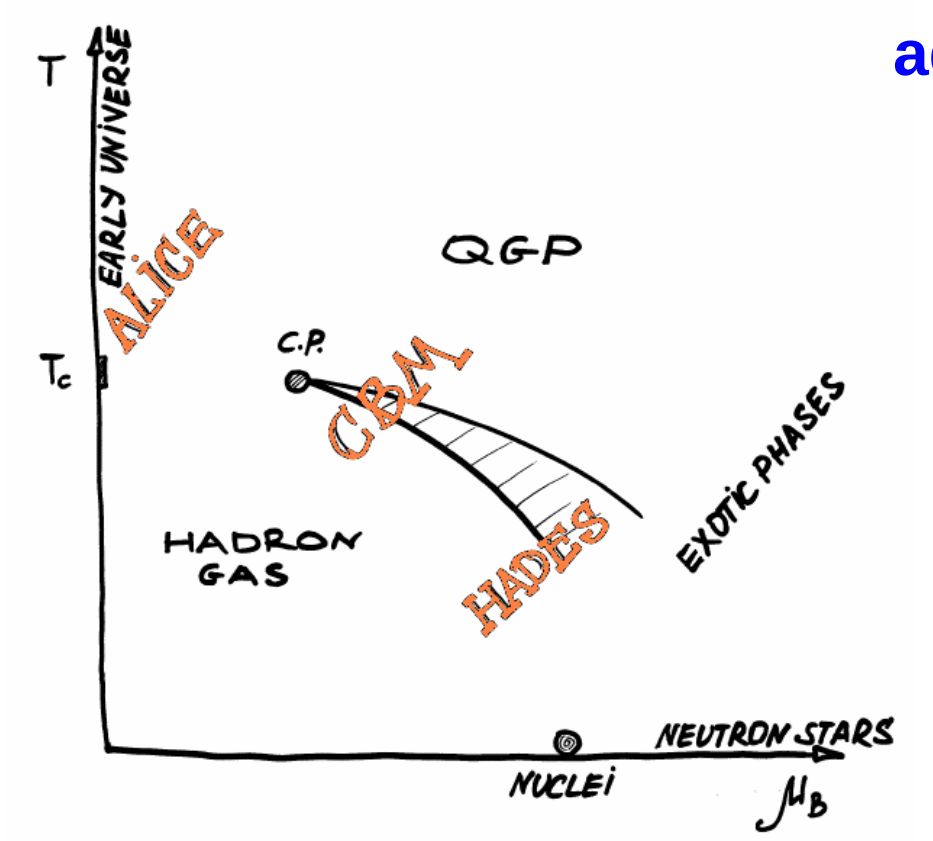


"Strangeness" of dense matter ?
In-medium properties of hadrons ?
Compressibility of nuclear matter?
Deconfinement at high baryon densities ?

as brigh

CBM: Compressed Nuclear and Quark-Gluon Matter

- ***Goal:*** *Create and investigate in the laboratory extreme states of strongly interacting matter.*



Fundamental questions addressed:

→ **What are the properties of deconfined matter?**

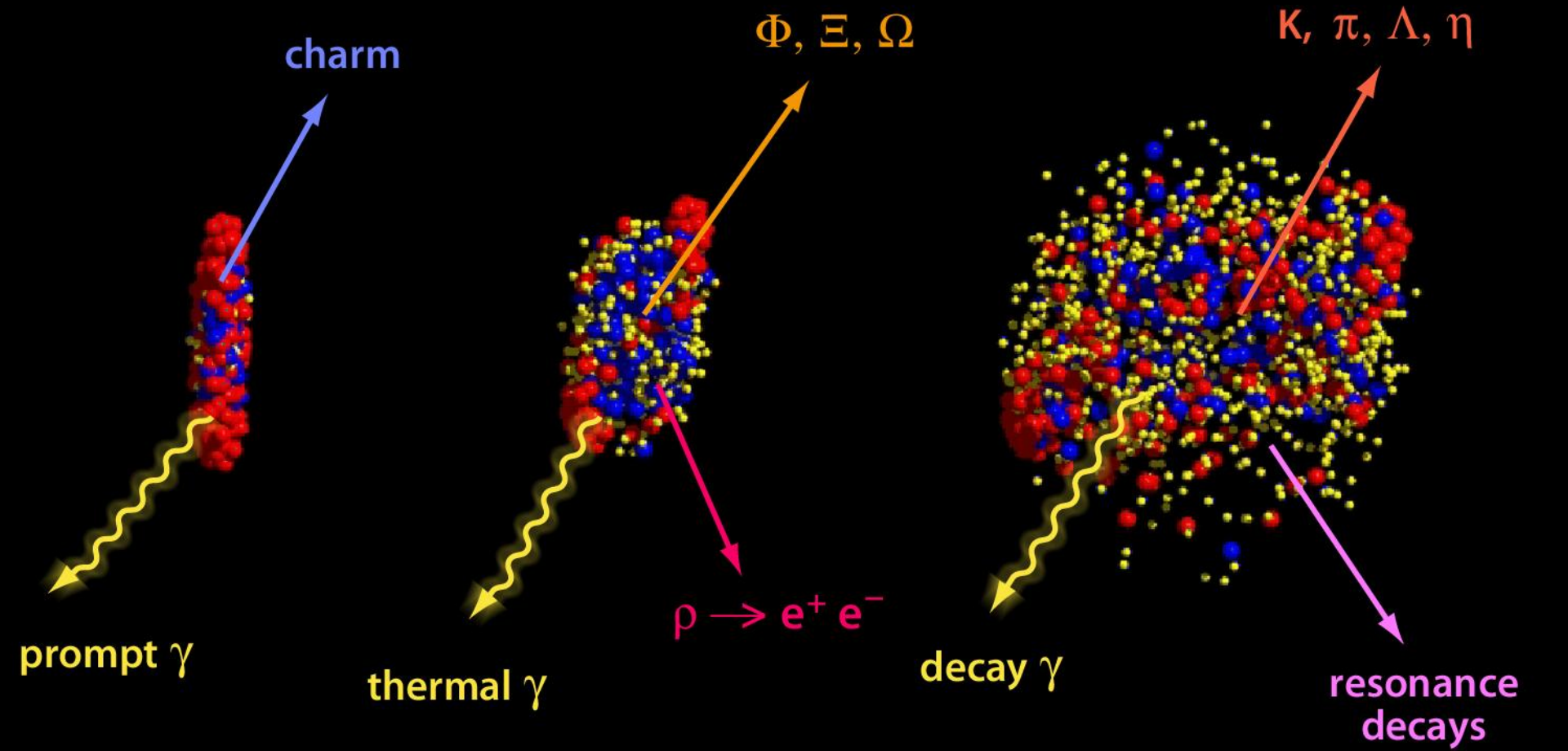
→ **Where are the phase boundaries located?**

→ **Is there a critical point?**

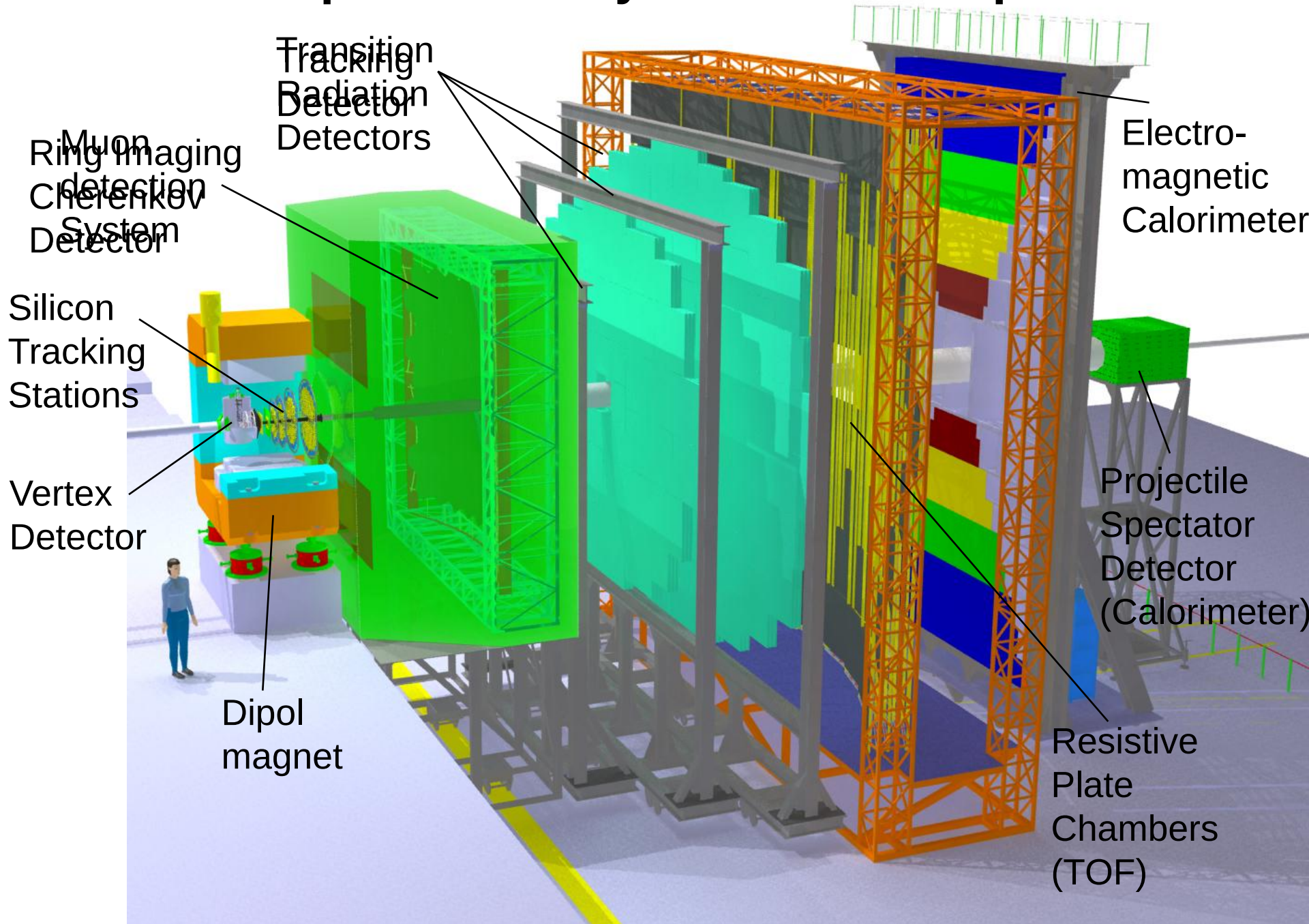
→ **Where are the limits of hadronic existence?**

Compressed Baryonic Matter: **CBM Physics Topics**

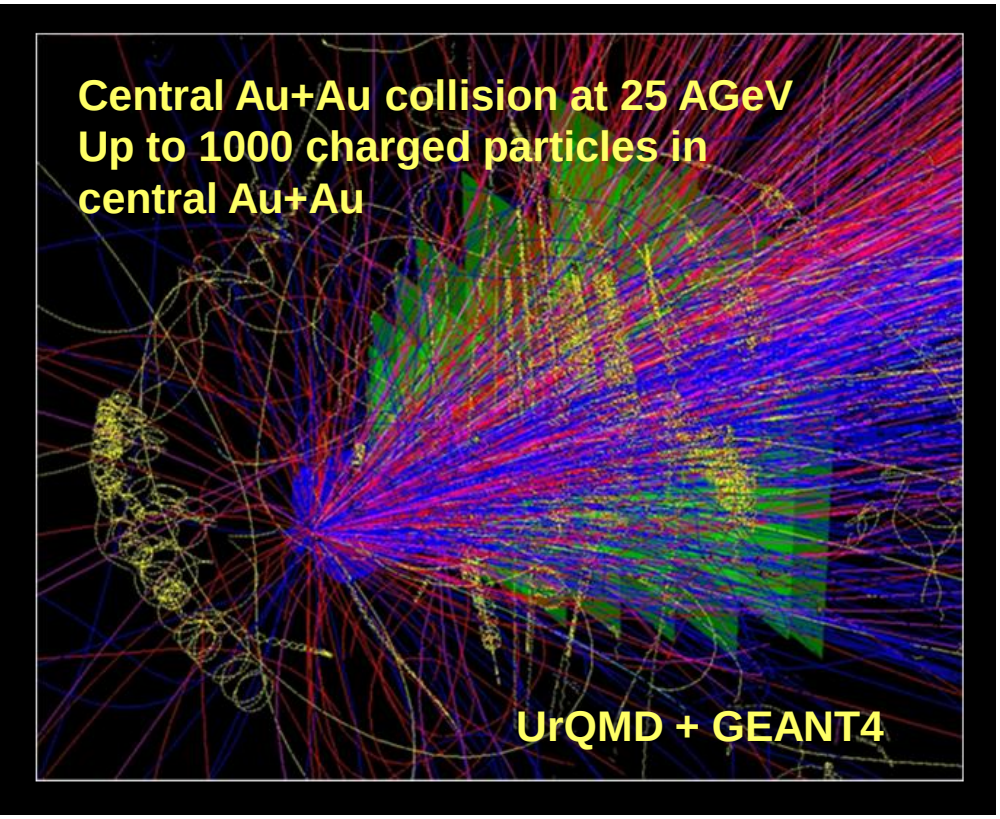
Probing the high density EoS: collapse of coll. flow of protons?
Q-H phase boundary@high ρ_B: multi-strange + charm production
QCD critical point: E-by-E fluctuations: Energy dep. Hadron Yields
Chiral symmetry rest. at high ρ_B: open charm, dilepton prod.



The Compressed Baryonic Matter Experiment



CBM Experimental Challenges



- Measurements with rates up to
- **10^7 Au+Au reactions/sec**

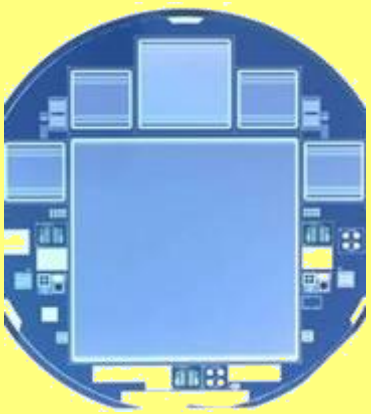
require:

- extremely fast and radiation hard detectors
- free-streaming readout electronics
- high-speed online event selection
- CPU&GPU – PetaFlops / M€
- FAIR Tier-Zero @ GSI

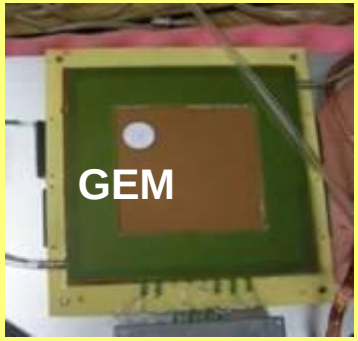
Fast track reconstruction algorithms running on graphic processing units:

- speed 46 ns / track
- track reconstruction efficiency > 96%
- momentum resolution $\Delta p/p < 1.5\%$ speed

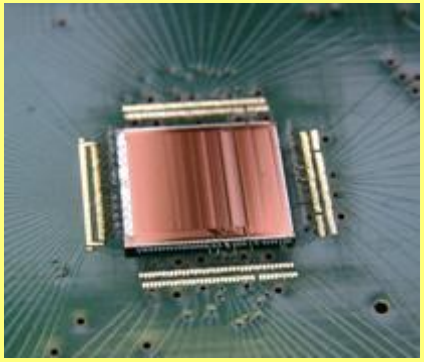
CBM hardware developments



radiation-hard
double-sided silicon
microstrip detectors

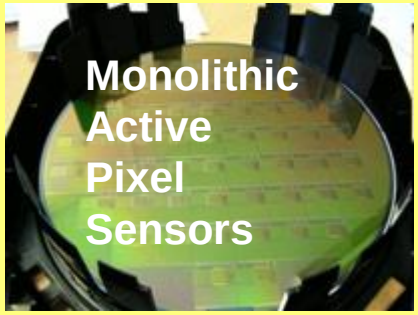


high-rate large-area

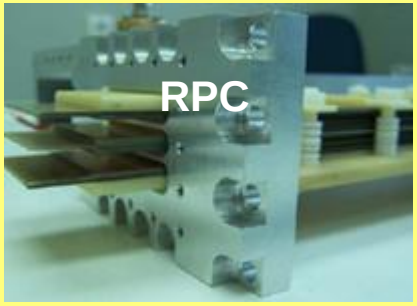


self-triggering
read-out chip
128 ch, 32 MHz

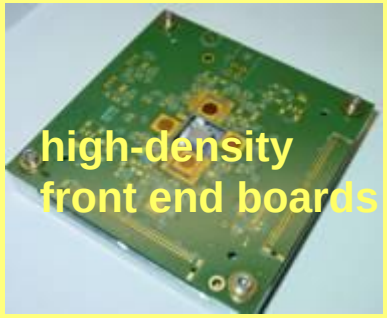
high-rate large-area

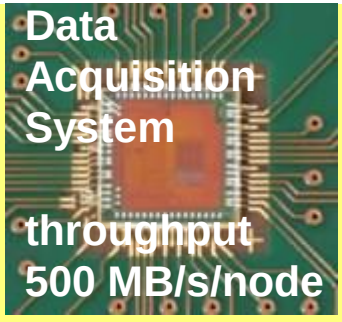


fast on-line event
selection using many-
core architectures
(CELL, LRB, GPUs)

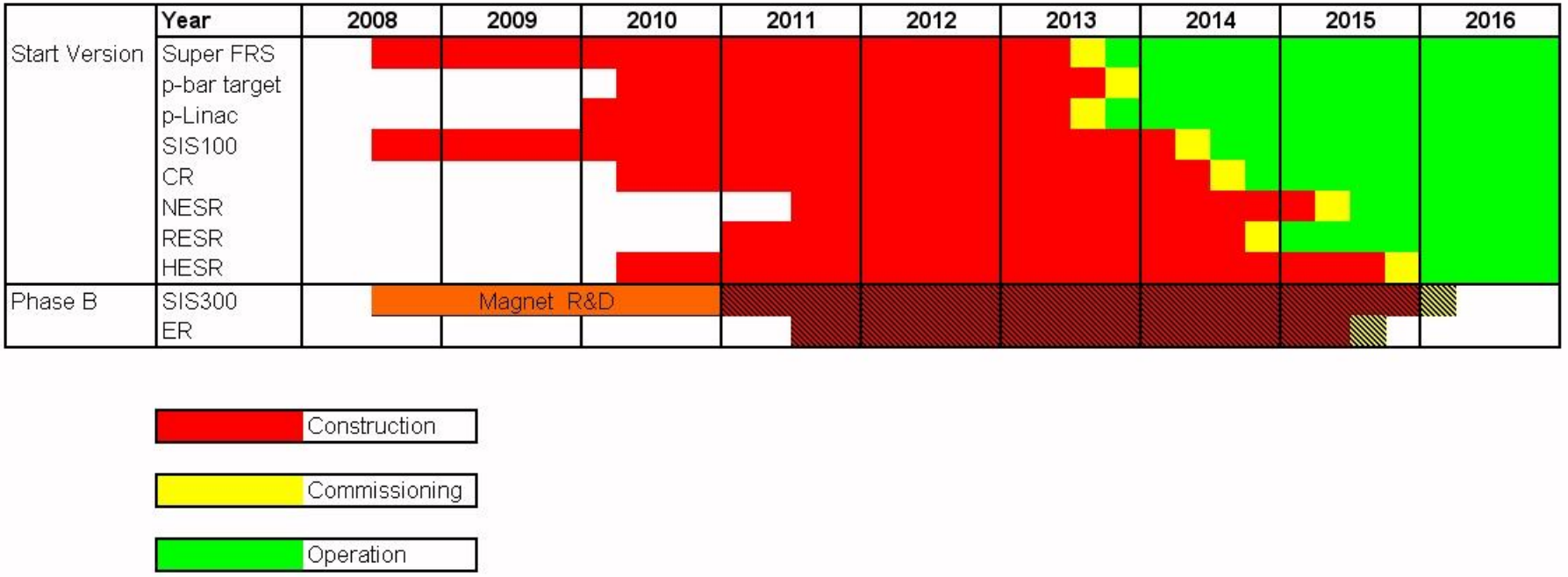


high-rate large-area
semiconductive glass





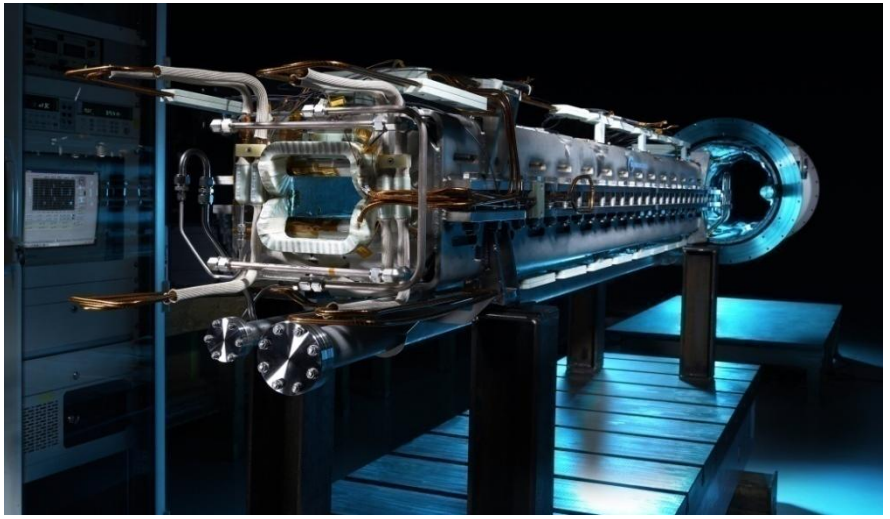
FAIR- accelerator-systems (schedule)



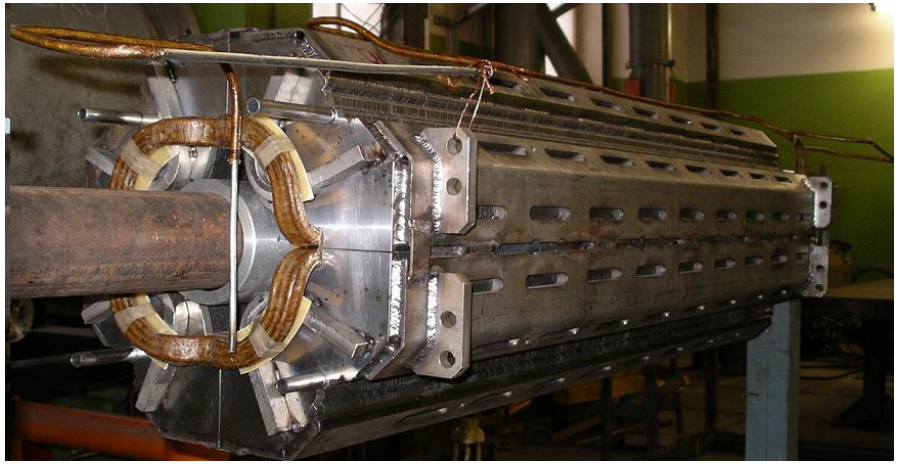
Overall schedule (FAIR accelerator sections)

FAIR- accelerator-systems (R&D-activities, technique)

- Design and construction of superconducting prototype magnets in collaboration with external partners and industry.
- Design studies on Electron Cooling and Stochastic Beam Cooling
- Studies and construction of RF systems, vacuum components etc…



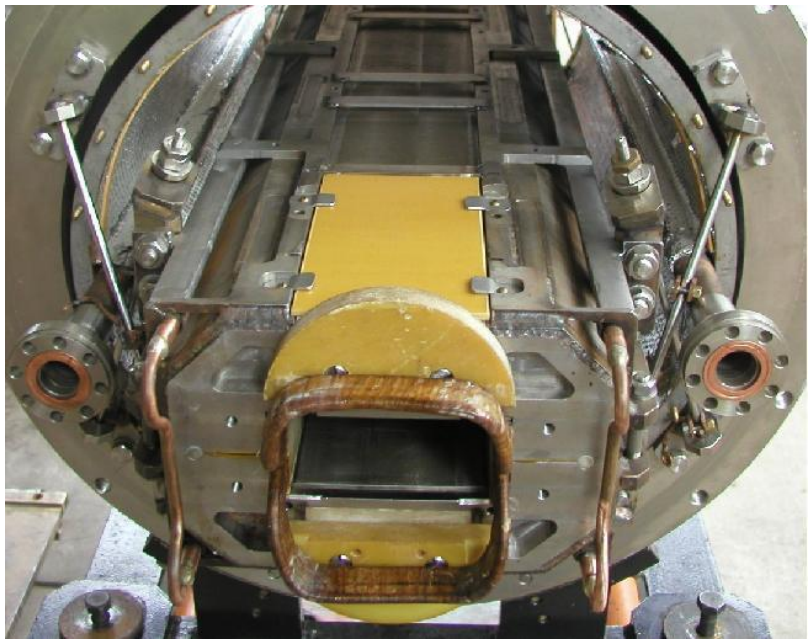
SIS100 superferric dipole prototype

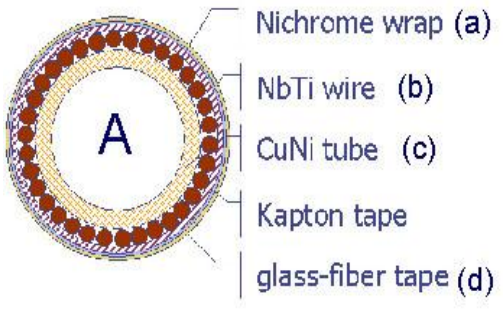


SIS100 superferric quadrupole prototype

Superconducting Magnet R&D (SIS100)

BABCOCK NOELL



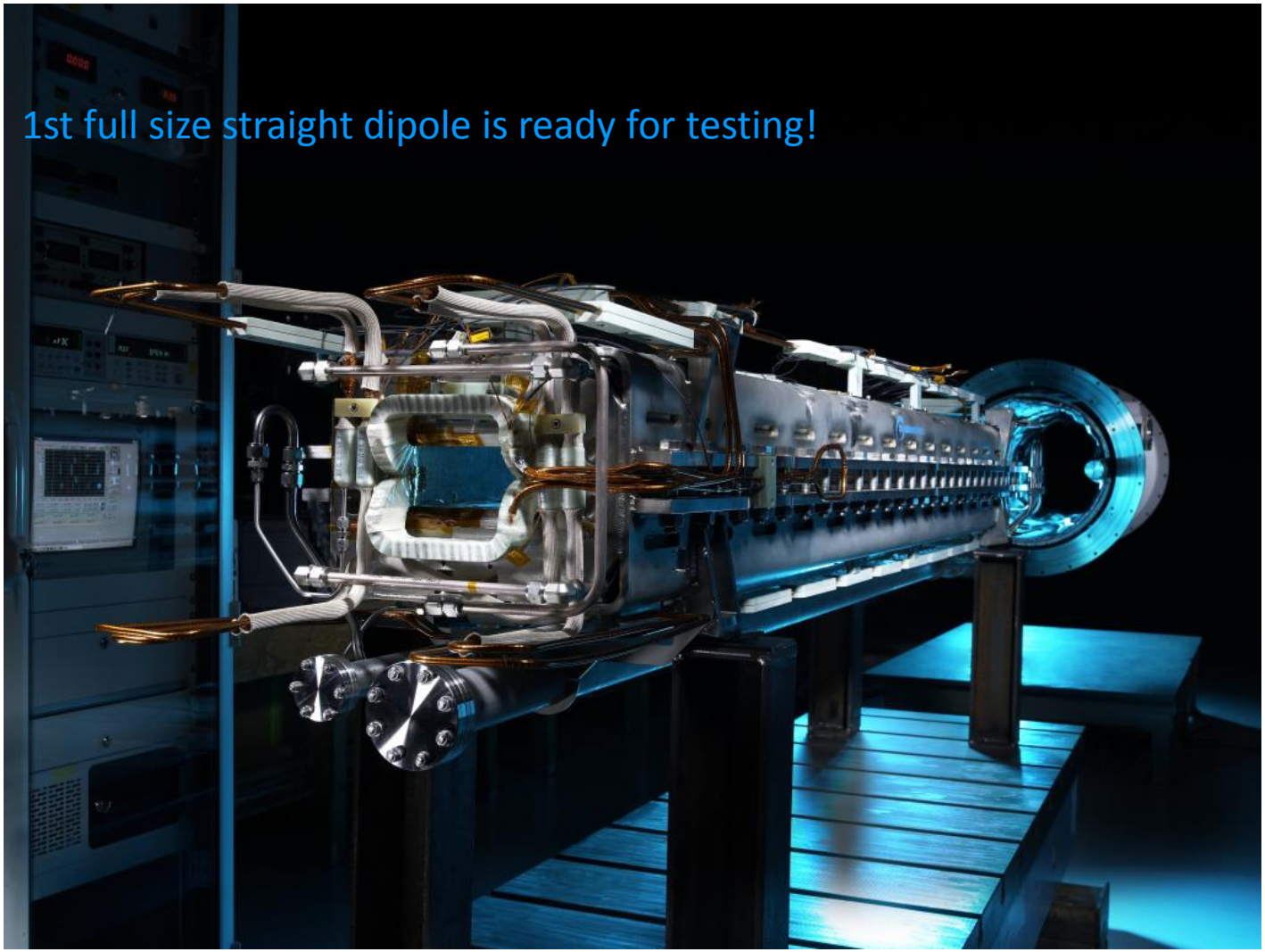


NUCLOTRON Cable

Low loss sc magnet. Losses dominated by eddy currents < 30 W/m. Two-phase LHe cooling (4K).

Prototype production at JINR Dubna, BINP Novosibirsk, and BNG Würzburg

SIS 100 Dipole Magnets
Full Size Model from Babcock Noell GmbH

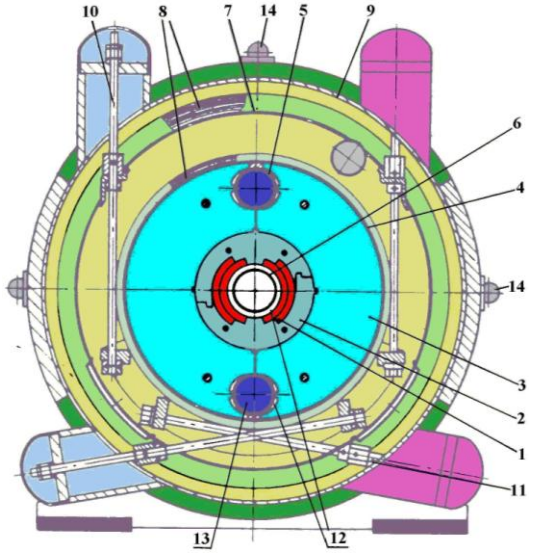


SIS 300 High Energy- and Stretcher Stage

Highly charges ions e.g. U^{92+}-ions up to 34 GeV/u
Intermediate charge state ions U^{28+}- ions at 1.5 to 2.7 GeV/u with 100% duty cycle

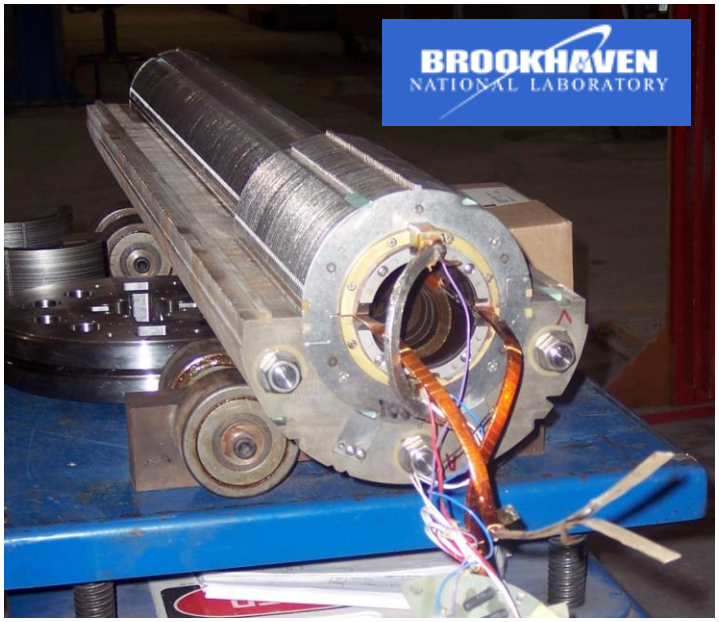
- superconducting high-field magnets and
- stretcher function

$B\rho$= 300 Tm B_{max}= 4.5 T dB/dt= 1 T/s (curved)



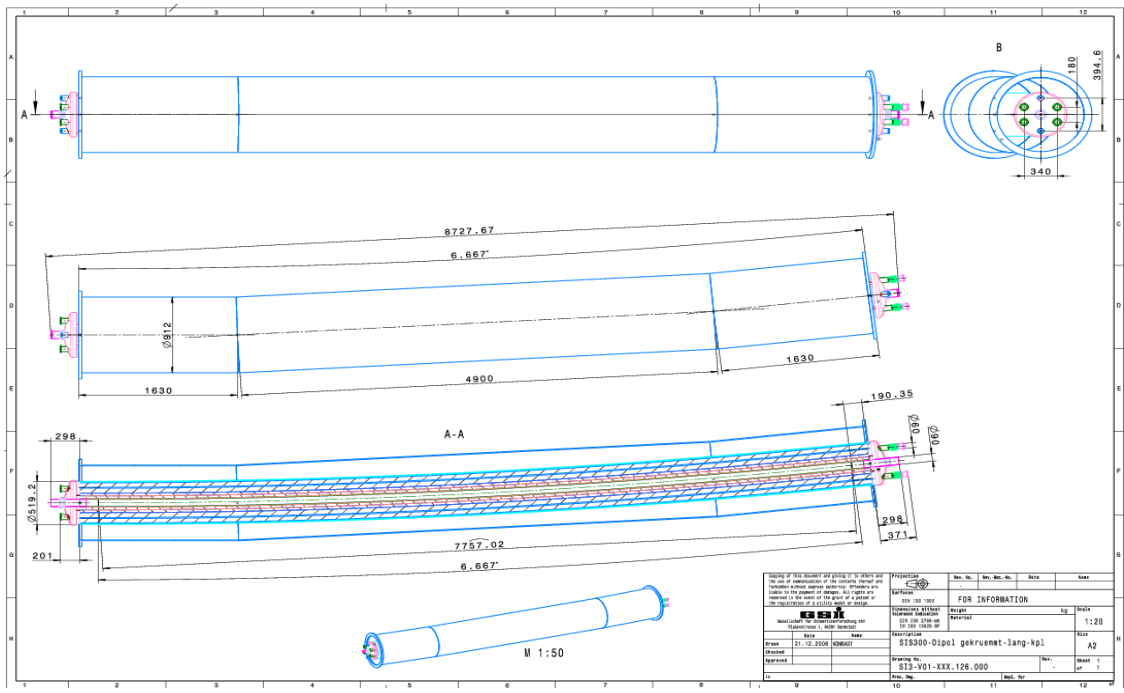
Based on Russian UNK magnets

Superconducting Magnet R&D (SIS300)



First cycling sc cosΘ magnet:
GSI001 by BNL (2003)

SIS300 curved dipole (INFN)



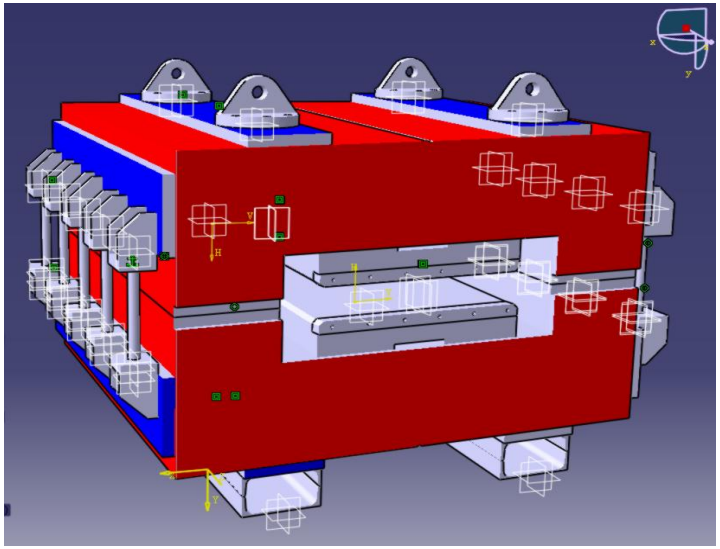
Model under construction

Large Aperture Super Ferric Magnets

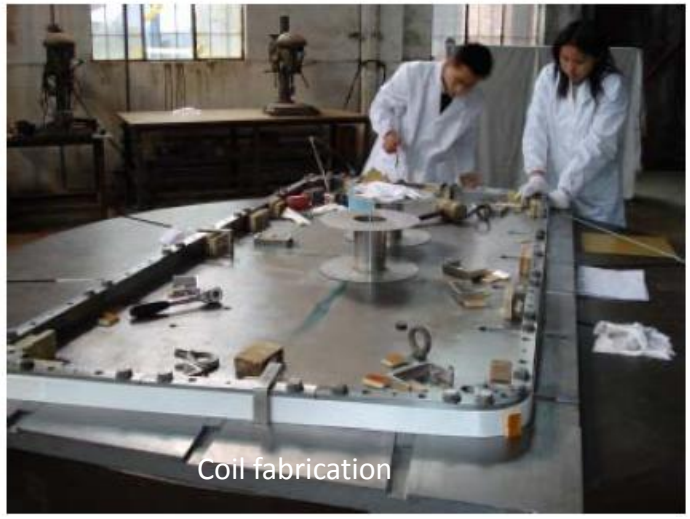
Development of large aperture (up to 380 mm) bending magnets (warm iron, sc coil) in China

Chinese Academy of Science

IMP Lanzhou
IPP Hefei
IEE Beijing



The assembly of die



Coil fabrication

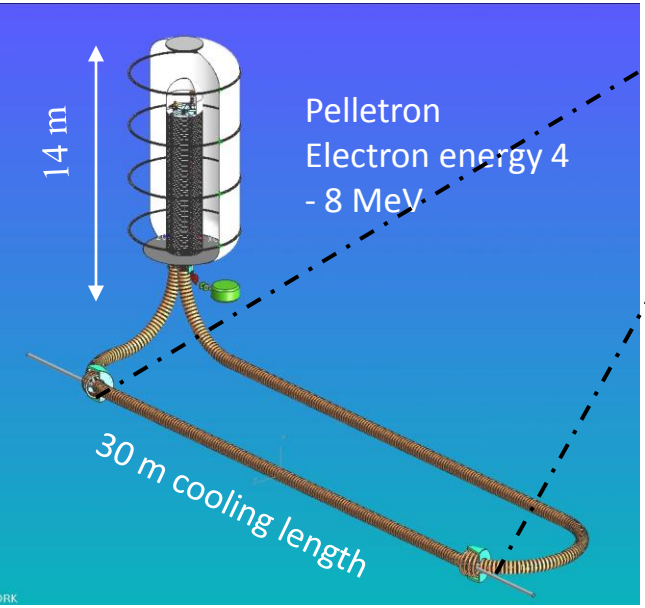
Beam Cooling for Precision Beams

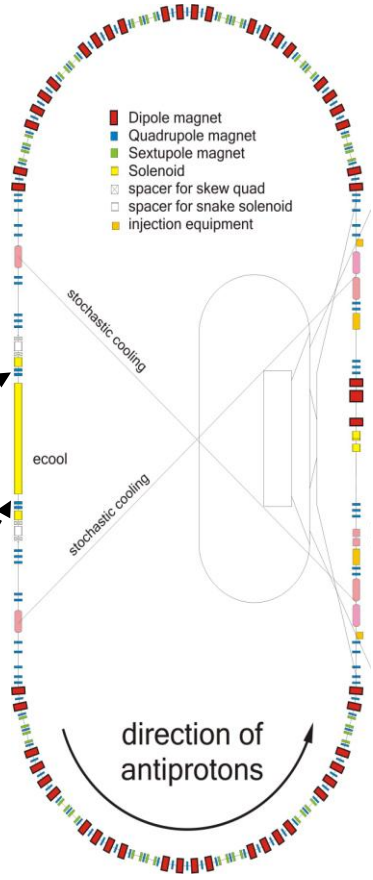
electron cooling at high energies (HESR)

UPPSALA UNIVERSITET

Forschungszentrum Jülich
in der Helmholtz-Gemeinschaft

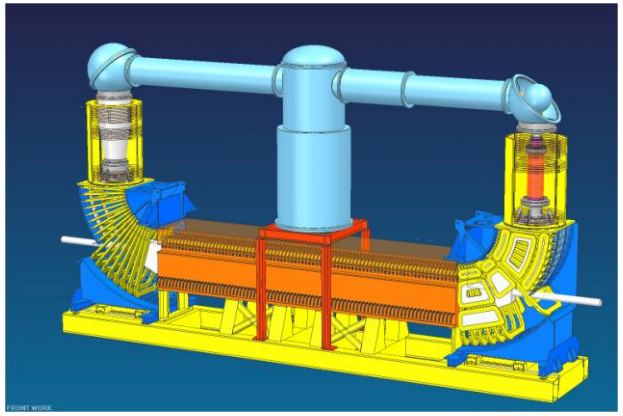
TSL





Cooler Parameters (NESR)	
energy	2 - 450 keV
max. current	2 A
beam radius	2.5-14 mm
magnetic field	
gun	up to 0.4 T
cool. sect.	up to 0.2 T
straightness	2×10^{-5}
vacuum	$\leq 10^{-11}$ mbar

BINP



"No Taxation without Representation !"

Austria China Finland France Germany Greece India Italy Poland Spain Sweden Russia Great Britain Romania

Slowenia

GSI | **IN2P3+CEA** | **FZ-Jülich** | **INDIA** | **Italy** | **Russia** | **Sweden** | **UK** | **...**

Council EEIG
(Representatives of Institutions)

Project Management

GSI | **UK**

Future Project

France | **Russia**

Italy | **INDIA**

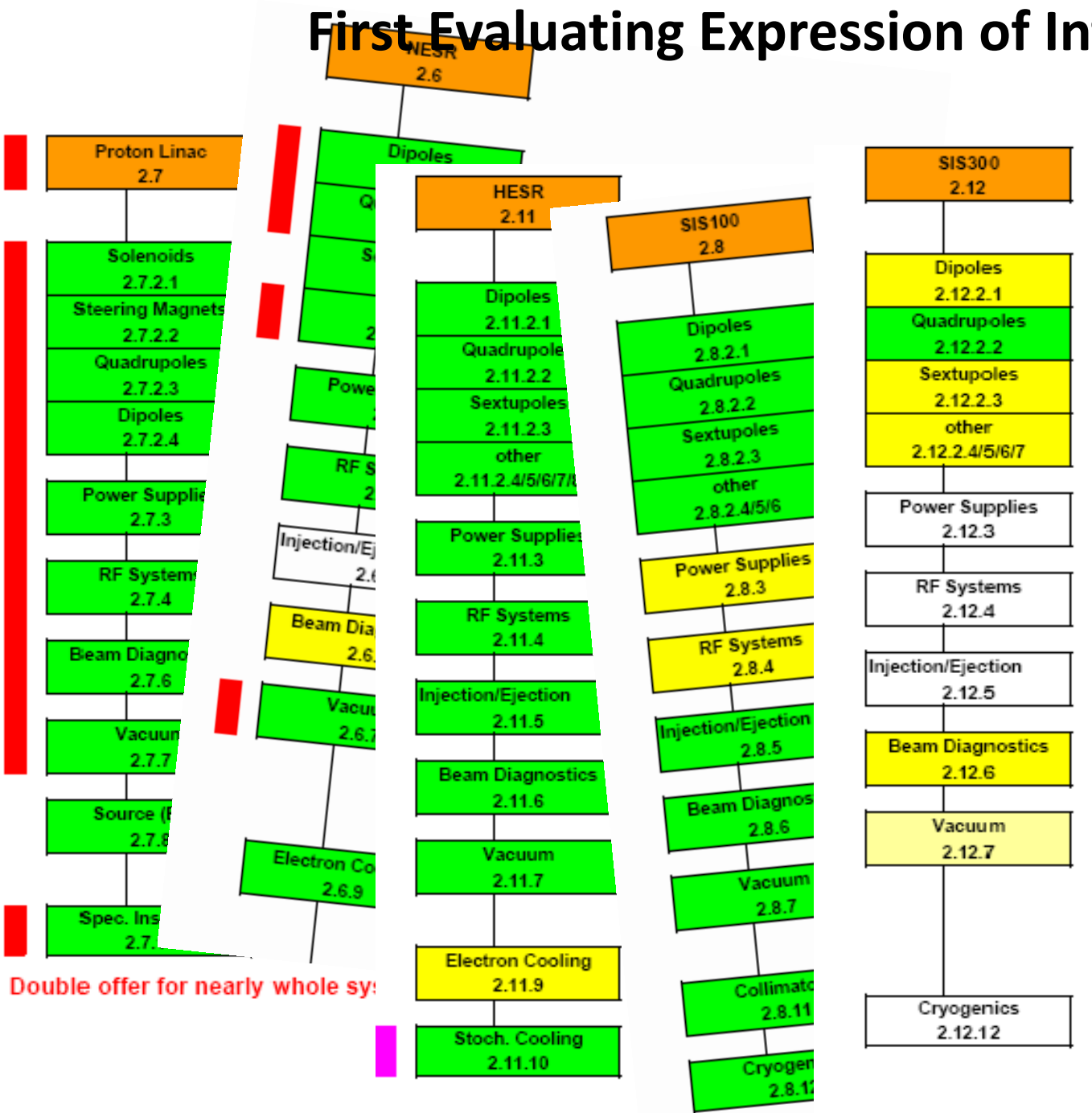
Sweden | **FZ-Jülich** | **...**

Demands of the Project towards GSI and external partners

Resources, Finances, Manpower and Hardware Contributions

Transparency from 2004

First Evaluating Expression of Interest



SIS 100 Pre-Consortium (Peter Spiller SIS100 Machine Coordinator)

WP	EoI No.	Lab	Country	Tech. Coordinator
Magnets	9	JINR	Russia	A. Kovalenko
	12	VNIINM		V. Panzyrnyi / L. Potanina
	13	GSI	Germany	E. Fischer
Power Converters	13	GSI	Germany	H. Ramakers
	4	FINPRO	Finland	A. Heikkila
RF	13	GSI	Germany	H. Klingbeil
Inj/Extr.	9	JINR	Russia	A. Kovalenko
Diagnostics	8	ITEP	Russia	B. Vasiliev / B. Sharkov
	13	GSI	Germany	M. Schwickert
Vacuum	9	JINR	Russia	A. Kovalenko
	18	ICSI	Romania	M. Curuia
	7	CUT	Poland	B. Skoczen
Collimators	9	JINR	Russia	A. Kovalenko
Cryogenics	15	WUT	Poland	M. Chorowski
		BINP	Russia	Y. Shatunov
		IHEP	Russia	S. Kozub

SIS 300 Pre-Consortium (spokesperson Sergey Kozub)

Formed in March 2009

- Preconsortium Board consists of responsible SIS300 systems: Pasquale Fabbricatore - dipoles, Sergey Kozub - quadrupoles, multipoles, cryogenic system, Dmitry Lyakin – beam diagnostic, Peter Spiller – other systems.
- positions of Spokesperson Deputy and Resourse Coordinator have been left opened.

Super FRS Pre-Consortium (Martin Winkler, SUPER-FRS Machine Coordinator)

WP	EoI No.	Lab	Country	Tech. Coordinator
Magnets	11	CIEMAT	Spain	I. Rodriguez
		CEA Saclay	France	N. Alamanos
	14	IMP Lanzhou	China	P. YUAN
	5	BINP	Russia	Y. Shatunov
	1	VECC	India	R. Bhandari
	13	GSI	Germany	H. Leibrock
Power Converters	13	GSI	Germany	H. Ramakers
	(4)	Prizztech	Finland	P. Suominen
Diagnostics	informal	Uni Jyväskylä	Finland	A. Jokinen, I. Moore
	13	GSI	Germany	M. Schwickert
Vacuum	5	BINP	Russia	Y. Shatunov
Special Insertions	1	VECC	India	A. Chakrabarti, S. Chattopadhyay
	2	Profex	Romania	C. Gornic
	13	GSI	Germany	
Cryogenics	15	WUT	Poland	M. Chorowski
		IHEP	Russia	S. Kozub



Collector-Ring Pre-Consortium (Markus Steck, CR Machine Coordinator)

WP	Lab	Country	Tech. Coordinator
Magnets	BINP	Russia	Y. Shatunov
	GSI	Germany	H. Leibrock
Power Converters	GSI	Germany	H. Ramakers
RF	GSI	Germany	H. Klingbeil
Injection/Extraction	IMP Lanzhou	China	P. YUAN, D. GAO
	GSI	Germany	U. Blell
Diagnostics	GSI	Germany	M. Schwickert
Vacuum	BINP	Russia	Y. Shatunov
	GSI	Germany	A. Krämer
Stochastic Cooling	ITEP	Russia	B. Vasiliev / B. Sharkov
	GSI	Germany	F. Nolden

Construction of new test and assembly hall (ca. 3000 m^2) and new detector laboratory in preparation of FAIR

The Big Challenge ...

Gain Factors

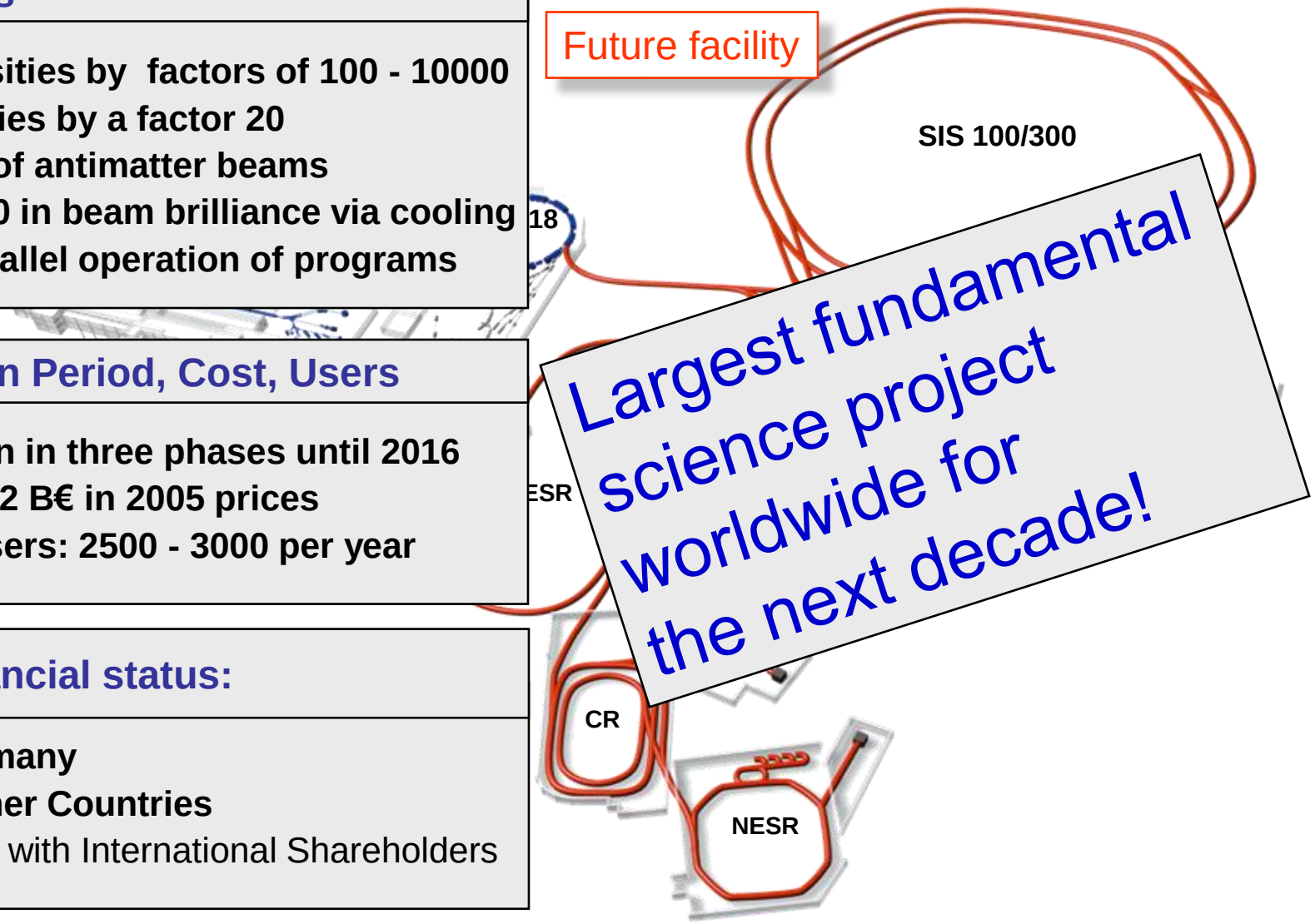
- **Beam intensities by factors of 100 - 10000**
- **Beam energies by a factor 20**
- **Production of antimatter beams**
- **Factor 10000 in beam brilliance via cooling**
- **Efficient parallel operation of programs**

Construction Period, Cost, Users

- **Construction in three phases until 2016**
- **Total cost 1.2 B€ in 2005 prices**
- **Scientific users: 2500 - 3000 per year**

Present financial status:

- 705 M€ **Germany**
- 400 M€ **Partner Countries**
- → FAIR GmbH with International Shareholders




FAIR
You are most kindly requested to help building
your
Russian international laboratory at Darmstadt
Observers
Austria
China
Finnland
France
Germany
Greece
India
Italy
Poland
Slovakia
Slovenia
Spain
Sweden
Romania
Russia
UK