FAIR

International Facility for Antiproton and Ion Research
One of the largest scientific projects in the world with a broad spectrum of research programs:

- Nuclear physics
- Hadron physics
- Atomic physics
- Plasma physics
- Material science
- Biophysics

2007 – 2015 GSI Darmstadt - Germany
~ 1.2 billion euros
Brief History

- 2001 proposal
- 2003 approval by German Government with 75% German contribution and 25% international
- 2004 MoU intend to participate in the construction and science use of FAIR
  Germany, United Kingdom, Sweden, Finland, Spain, Greece, Russia, Italy, France, Poland, India, China, Romania (April 2006)
2004-2006 Preparatory period

- International Steering Committee
- Working group for Scientific and Technical Issues (STI)
  - Scientific Program
  - Technical Design
  - Costs and schedule for the construction and operation
- Working group for Administrative and Funding Issues (AFI)
  - legal aspects
  - legal contracts for contributions to be made by the partner countries
Next steps

- 2006 Convention to participate at the construction (2007-2015) and operation (-2025)
- 2007? ratification by the parliaments
- 2007 start of the construction
- 2011 first stage
- 2015 final stage
Performance Requirements

- Beams of all ion species plus antiprotons
- Highest beam intensities
  - for primary beams – several hundred
  - radioactive beams – 1000 to 10000
- Increase in beam energy: up to 35AGeV for U92+
- High-quality beams: momentum spreads and emittances reduced by several order of magnitudes
# Primary beam parameters from SIS100/300 facility for the different research fields

<table>
<thead>
<tr>
<th>Research Field</th>
<th>Energy</th>
<th>Peak Intensity</th>
<th>Average Intensity</th>
<th>Pulse Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radioactive Ion Beams</td>
<td>0.4 to 1.5 GeV/u for all elements up to uranium</td>
<td>~5·10^{11} per pulse for storage ring experiments</td>
<td>~3·10^{11} per second high duty cycle for fixed target experiments</td>
<td>~60 ns for injection into the storage ring</td>
</tr>
<tr>
<td>Antiprotons</td>
<td>29 GeV protons</td>
<td>4·10^{12} per cycle</td>
<td>--</td>
<td>~25 ns</td>
</tr>
<tr>
<td>Dense Nuclear Matter</td>
<td>up to 34 GeV/u U</td>
<td>--</td>
<td>2·10^9 per second high duty cycle</td>
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</tr>
<tr>
<td>Plasma Physics</td>
<td>0.4 to 1 GeV/u ions</td>
<td>~10^{12} per pulse</td>
<td>--</td>
<td>50 - 100 ns (fixed target)</td>
</tr>
<tr>
<td>Atomic Physics</td>
<td>0.1 to 10 GeV/u ions</td>
<td>--</td>
<td>10^9 per second high duty cycle</td>
<td>--</td>
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</tbody>
</table>
Technological Challenges

- Control of the dynamic vacuum pressure
- Operation with high brightness, high current beams
- High rf voltage gradients
- Fast cycling superconducting magnets
- Cooled secondary beams
Experimental Programs

- Nuclear Structure, Astrophysics and Reactions with Rare-Isotope-Beams NUSTAR
- Hadron Physics with Antiproton Beams – PANDA
- The Compressed Baryonic Matter– CBM
- High Energy Density Bulk Matter Generated with Intense Heavy Ion and Laser Beams – HEDgeHOB, WDM
- Atomic and Fundamental Physics with Highly Charged Ions and Antiprotons – SPARC, FLAIR
- High-Energy Irradiation Facility for Biophysics and Material Research - BIOMAT
Rare Isotope Beams (RIB)
Very high intensities with energies up to 1GeV/A
A superconducting in-flight separator (Super-FRS)
Storage cooler ring
The Rare-Isotope-Beam Facility at FAIR
Experiments at the Rare-Isotope-Beam Facility

- The high-energy branch (up to 1GeV/A)
  - large variety of scattering exp. for nuclear structure
    (Reactions with RIBs at Relativistic energies-R³B)
- The low-energy branch (1-100 MeV/u)
  - nuclear spectroscopy for nuclear structure
    High Resolution in-beam spectroscopy HISPEC
    Decay Spectroscopy with stopped implanted ions DESPEC
  - laser spectroscopy for elm moments LASPEC
  - mass measurements and decay studies MATS
  - production of radionuclids for (off-site) n-capture NCAP
- The ring branch:
  - Mass and lifetime measurements ILIMA
  - Light-ion induced direct reactions EXL
  - Electron-RIB scattering ELISe
  - Antiproton-RIB collider to measure radii for protons and neutrons AIC
Research program: Gluonic excitations and the physics of strange and charm quarks

Unique, unparalleled worldwide facility:
- Antiproton beams 1-15 GeV high intensity and quality,
- The PANDA detector
Setup of the PANDA detector
Compressed Baryonic Matter CBM

- The Phase Diagram of Strongly Interacting Matter
CBM detector
High Energy Density Generated with Intense Heavy Beams HEDgeHOB

- High Energy Density Bulk Matter Generated with Intense Heavy Ion and Laser Beams 12TW/g

- 3 experiments:
  - Heavy Ion Heating and Expansion HIHEX
  - Laboratory Planetary Sciences LAPLAS
  - Warm Dense Matter WDM
Atomic and Fundamental Physics with Highly Charged Ions and Antiprotons

- Stored Particle Atomic Physics Research SPARC
  - Highly relativistic heavy ions
  - High-energy beams
  - Fundamental atomic physics studies
  - Low-energy beams

- Facility for Low-energy Antiproton Ion Research FLAIR
  - Precision spectroscopy of antiprotonic atoms and antihydrogen
  - Interaction of antimatter with matter: exploring subfemtosecond correlated dynamics
  - Nuclear and particle physics with antiprotons
Atomic Physics Experiments

The New Experimental Storage Ring NESR

Fixed target / cove ap
Ion bunch
Laser

HITRAP

Electron cooler

Injection

Electron collider

Laser pulse
X-ray pulse

Ions at rest
High-Energy Irradiation Facility for Biophysics and Material Research - BIOMAT

- Research program: Space radiation effects
  - heavy ion induced modifications of solids under extremely high pressure
  - analysis of material modifications induced by relativistic heavy ions
  - Radiation hardness of materials

- Equipments:
  - Magnetic scanner system
  - Flexible irradiation set-ups
  - Instrumentation for in-situ diagnostics of irradiated samples
Romanian participation

- SPARC – C. Ciortea
- NUSTAR HISPEC/DESPEC - N.V. Zamfir
- $R^3B$ – D. Hasegan
- PANDA – D. Pantea
- CBM – M. Petrovici
Parallel Operation
Offline Computing for FAIR

- is expected to be in the same order of magnitude as LHC computing
- Estimation up to the first year of operation including a new building: 20 mil. euros
Civil Engineering

- The ring tunnel below ground (17m) in a cut and cover method. Concrete walls with a thickness of 1.5 m
- 14 ha of forest – revegetated or compensated for in another area
- 2003-2006 Development plan approved by the City of Darmstadt Council
Legal Structure of FAIR

Is still to be negotiated between the partner countries

- FAIR will be organized as a Limited Liability Company GmbH
- The FAIR convention shall be valid for an initial time of ten years of operation after completion of the construction phase
- Organs:
  - Council - the shareholders’ assembly
  - Managing Directors
- The final act shall put the Convention into force provisionally before ratification by the parliaments
- Minimum total contribution per country: 0.4-4%
General Costing Scheme

- Construction costs: 1.2 billions euros
  - Accelerators 592
  - sFRS 81
  - Civil Construction 289
  - Baseline exp. Facilities 180

- Operation costs for the FAIR Accelerator facility – 135 Meuro/year

- Operation costs for the 18 experiments – difficult to estimate ~ 7 Meuro/year
Workshop Ro@FAIR
Potențialul participării comunității științifice și industrii din România la Proiectul internațional FAIR de la GSI-Darmstadt, Germania

Co-președinții Comitetului de organizare:
Dr. Nicolae Vasile
Dr. Nicolae-Victor Zamfir

Fizica oferă industrii extraordinare oportunități de afaceri în cadrul celui mai important proiect european de cercetare.

Locul destășurării:
Camera de Comert și Industrie a României și a Municipiului București,
Str. Octavian Goga, nr. 2, Sector 3

6 iunie 2006 • București • ROMANIA