FAIR - AN INTERNATIONAL ACCELERATOR FACILITY FOR RESEARCH WITH IONS AND ANTIPROTONS

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Abstract

An overview is given on the international Facility for Antiproton and Ion Research (FAIR) at GSI, its science motivation and gaols, the facility lay-out and characteristics, the schedule for construction, and the international interest/participation in the project.

INTRODUCTION

Over the past few years GSI, with strong participation from the European science community, has developed plans for the international Facility for Antiproton and Ion Research (FAIR) [1]. The proposal was evaluated in 2001/2002 by the Wissenschaftsrat, the science advisory committee to the German federal government, which recommended its realization [2]. Based on this recommendation, the German government gave approval for construction of the facility in 2003, contingent upon two conditions: that a technical plan be developed for staged construction, and that funding for 25% of the total cost come from international partners [3].

SCIENCE GOALS

The science goals underlying the planned FAIR facility span a broad range and are described in a cartoon-like style in Figures 1 and 2. They address essentially all aspects of the structure of matter, from the quark-gluon structure of hadrons to macroscopic objects in the universe and, related to the various hierarchical levels of matter, a number of key aspects of the evolution of the universe. Specific research goals include:

- investigations with beams of short-lived radioactive nuclei, addressing important questions about nuclei far from stability; areas of astrophysics and nucleosynthesis in supernovae and other stellar processes, and tests of fundamental symmetries;
- the study of hadronic matter at the sub-nuclear level with beams of antiprotons, including two key aspects: confinement of quarks and the generation of the hadron masses. They are intimately related to the existence (and spontaneous breaking) of chiral symmetry, a fundamental property of the strong interaction;
- the study of compressed, dense hadronic matter in nucleus-nucleus collisions at high energies;
- the study of bulk matter in the high-density plasma state, a state of matter of interest for inertial confinement fusion and astrophysical settings;
- studies of Quantum Electrodynamics (QED), of extremely strong (electro-magnetic) fields, and of ion-matter interactions.

The science case is worked out in detail in the Conceptual Design Report (CDR) for the facility [1].

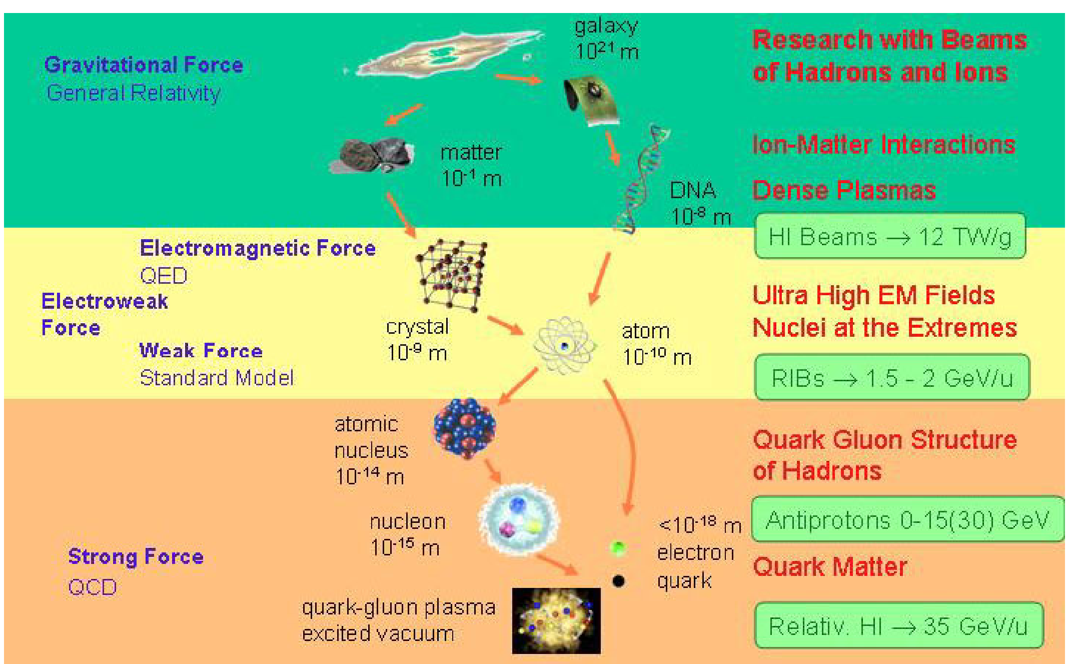

Figure 1: Schematic drawing of the hierarchical structure of matter and the areas of research that will be addressed at the proposed FAIR facility.

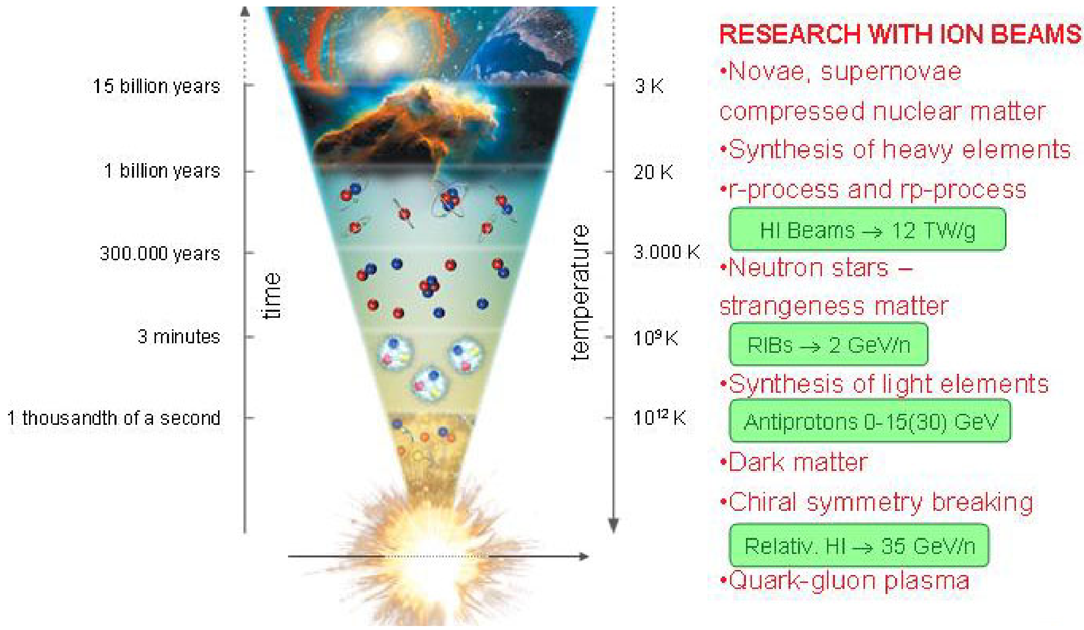

Figure 2. Schematic illustration of the potential interconnections between the evolutionary phases of the universe and the research areas to be pursued at the FAIR facility with beams of ions and antiprotons.

FACILITY LAYOUT AND CHARACTERISTICS

The concept and layout of the new facility (Figure 3) has evolved from the science requirements as follows: substantially higher intensities are achieved, compared to the present system, through faster cycling and, for heavy ions, lower charge state which enters quadratically into the space charge limit. The reduced charge state, and still a desired energy of up to 1.5 AGeV for radioactive beam production, requires a larger magnetic bending power. These aspects are fulfilled by the SIS100 synchrotron.

It also generates intense beams of energetic protons, up to 30 GeV, and from these antiprotons. Heavy ion beams of high energy up to 35 AGeV for the heaviest beams are generated using ions in a high charge state plus the additional, somewhat slower but still rapidly cycling SIS300 synchrotron ring. The intensity required for these beams allows for long spills. Similarly, the SIS300 can be used as a stretcher for radioactive beams.

Both, primary and secondary beams can be injected, cooled and stored in a system of rings with internal targets and in-ring experimentation. Rings may be shared for uses with different beams. Based on the developments and excellent experiences with cooled beams at the present GSI facility, the future program will broadly take advantage of this aspect of beam handling. Further details about the beam characteristics, including the possibility of highly parallel operation of up to four experimental programs at a time, can be found in the CDR [1].

SCHEDULE FOR REALIZING FAIR

GSI, together with the interested science communities, has developed a technical plan for a staged construction of the new facility (Figure 4), which was looked at and approved by the German Wissenschaftsrat. Following that plan, the construction of the new facility, i.e. general planning, civil construction and technical installation of the accelerators and experiments, is divided into five phases. The structuring into different, partly overlapping stages will facilitate a phased execution of the project over a period of eight years (assuming a start of the first stage in 2005).

The completion of the phases 1, 3, and 5 is associated with considerably improved capabilities/specifications concerning beam parameters and experimental opportunities. These can and shall be exploited, either for the medium-term research program (after completion of stage 1) at the existing facility, or for the phased approach to the research programs (after completion of stage 3 and 5) at the new facility.

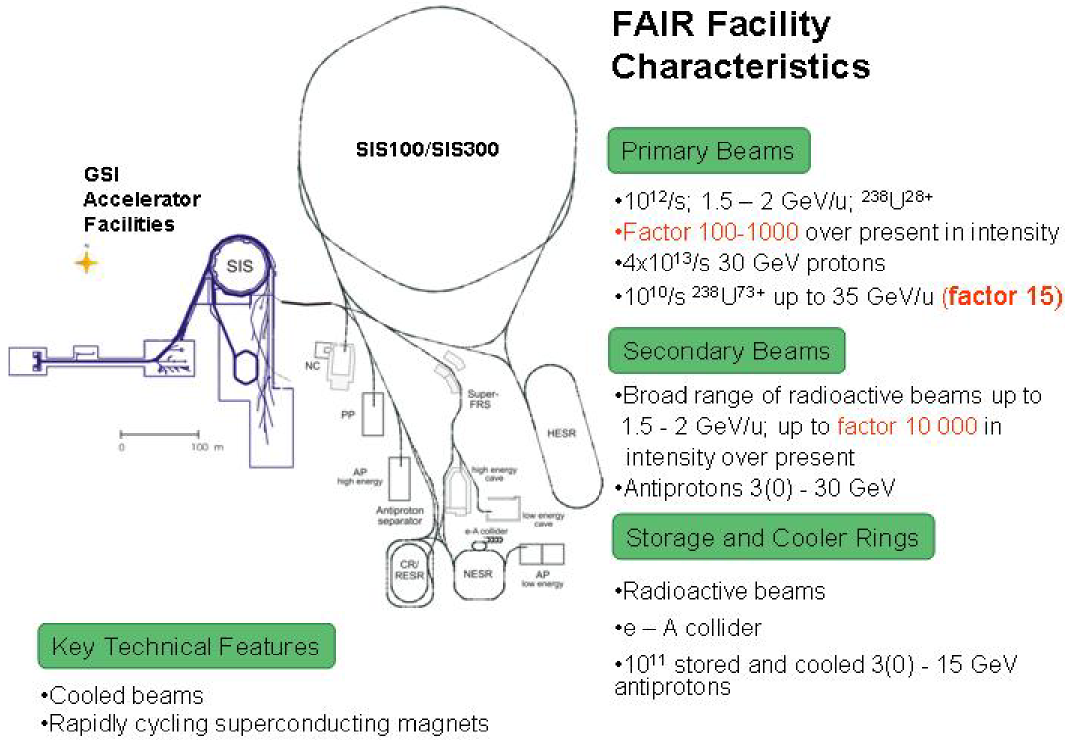

Figure 3: Schematic layout and summary of performance parameters for the proposed future facility FAIR at GSI.

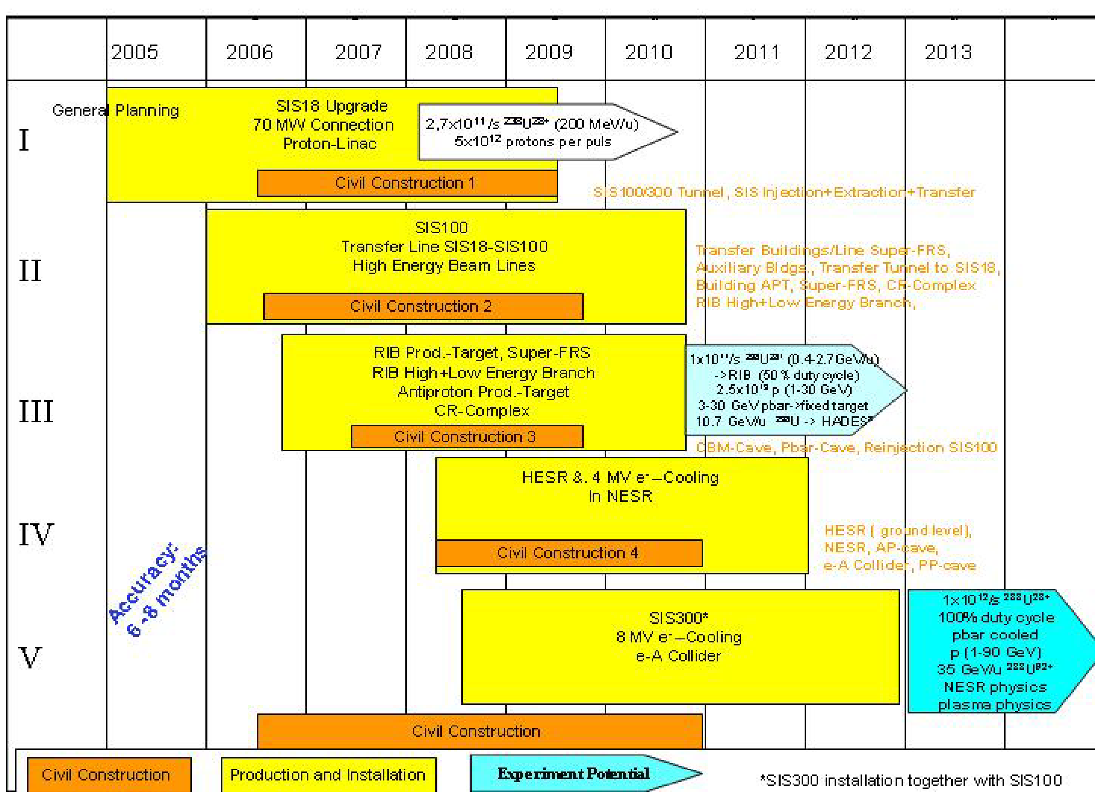

Figure 4: Time schedule for the construction of FAIR.

INTERNATIONAL PARTICIPATION

Major attempts have been made and progress has been achieved in promoting international participation in the FAIR project. Based on an initiative of the Federal Ministry for Education and Research, an international steering committee structure has been established for preparing/accompanying FAIR in all scientific-technical and administrative-financial aspects (Figure 5).

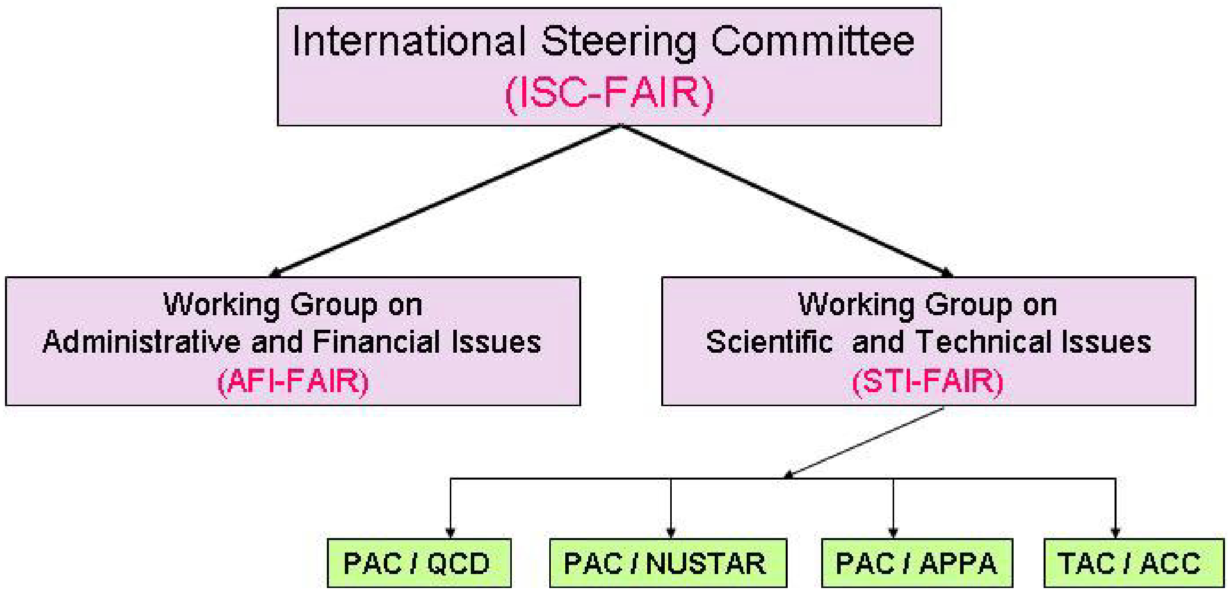

Figure 5: International Steering Structure during the preparation phase for the FAIR Project.

The newly established bodies include:

- the International Steering Committee (ISC-FAIR) with representatives from ministries/funding agencies of potential partner countries (so far ten countries plus observers from two further countries)
- two working groups, established by the ISC-FAIR: (i) the AFI-FAIR working group on administrative and funding issues: its mandate is to prepare a Memorandum of Understanding (MoU) as formal basis for cooperation until (legal) contracts between the FAIR partners can be made in 2006. Moreover the AFI will investigate (and propose to the ISC-FAIR) possible legal structures for the construction and operation of FAIR; (ii) the STI-FAIR working group on scientific and technical issues. The STI-FAIR has formed three Program Advisory Committees (PACs) for the scientific areas: QCD & hadronic matter physics; nuclear structure and astrophysics; atomic physics, plasma physics and other research and a Technical Advisory Committee (TAC) for all accelerator issues.

In a first step the PACs have recently evaluated altogether 25 Letters of Intent (LOIs) for experiments at the FAIR facility that were submitted by a broad science community comprising over 1800 scientists [4]. At the same time, the TAC reviewed the progress made with respect to R&D for the planned new accelerator facility [5].

The next steps will be, in the course of 2005, the submission and evaluation of technical proposals for the experiments proposed at FAIR and of technical reports for the accelerator components. The evaluation results including also cost reviews will be the basis to select/define, within ISC-FAIR, the experiments/working packages that finally will become integral parts of the international FAIR project.

REFERENCES

[1] http://www-aix.gsi.de/GSI-Future/cdr/
[2] Press release 24/2002, www.wissenschaftsrat.de/
[3] Press release, 5.2.03, www.bmbf.de/presse01/799
[4] http://www.gsi.de/zukunftsprojekt/loi.html
[5] See the contributions on FAIR accelerator issues submitted to this Conference