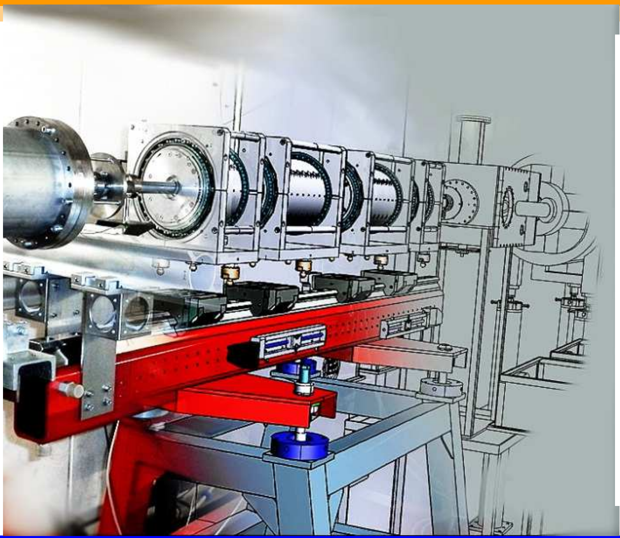
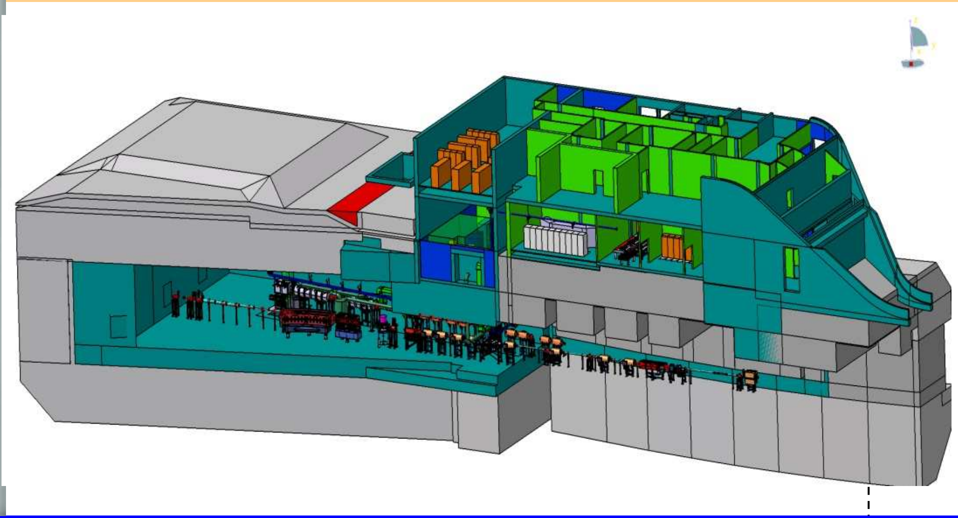




Plasma Physics at FAIR

HELMHOLTZ
GEMEINSCHAFT

Illustrations on the cover page:

- top-left: the PRIOR setup (picture: Philipp-Michael Lang)
- top-right: the plasma physics beam line at the APPA cave
- bottom: aerial view of the FAIR construction site

Forewords

Dear colleagues,

The construction of the FAIR accelerator facility is picking up speed. The preparatory work has now commenced for linking the existing accelerator system of the GSI Helmholtzzentrum für Schwerionenforschung to the FAIR facility, and the official ground-breaking for the FAIR infra-structure will take place on July 4th .
We are excited to host the 2017 meeting of the Plasma Physics Community and very much look forward to a bright future for the whole field!

Sincerely Yours,

Paolo Giubellino

FAIR’s Scientific Managing Director Paolo Giubellino (Photo: Gaby Otto)

FAIR

Facility for Antiproton and Ion research

FAIR is a new international accelerator facility for the research with antiprotons and ions. It will be built within the coming years near Darmstadt in Hesse, Germany. The FAIR accelerator complex has unique capabilities that will allow for a vast research program to investigate key issues such as the evolution of the universe and the origin of matter found in planets and in our environment. FAIR will provide precisely tailored, extremely intense high energy beams of ions, from protons to uranium, as well as extremely intense high quality secondary beams of antiprotons or stable and radioactive ions covering almost the complete nuclear chart. The energy of primary and secondary beams can be varied over a broad range. The operation of the accelerator complex will allow the simultaneous execution of several experiments from different research programs. Research at FAIR comprises 4 programs:

APPA
Atomic, Plasma Physics and Applications

- **Atomic physics:** questions on fundamental constants with highly-charged ions at relativistic energies stored in several rings at high energies down to almost rest.
- **Plasma physics:** determination of EOS, phase transitions, thermodynamical properties in warm dense matter by isochoric heating and homogeneous energy deposition of heavy ions in mesoscopic targets.
- **Biophysics and Material sciences**: radiotherapy or the simulation of the effective radiation dose in deep space.

NUSTAR
NUclear STructure, Astrophysics and Reactions

- formation of elements in astrophysical processes.
- changes of the shell structure with varying proton-to-neutron ratios, limits of existence of nuclei.
- production and separation of radioactive ion beams up to 1 GeV/u of mono-isotopic ions by using the fragment separator Super-FRS
- FAIR will be the only facility that provides several storage-cooler rings (CRYRING, ESR, CR and HESR) for nuclear structure and nuclear astrophysics studies of exotic nuclei allowing unprecedented studies of their properties.

CBM
Compressed Baryonic Matter

- explore phase transitions in nuclear matter between the hadronic phase and the quark-gluon plasma
- explore the quantum chromodynamics (QCD) phase diagram in the region of high baryon densities using high-energy nucleus-nucleus collisions
- study of the equation-of-state of nuclear matter at high densities, and the search for the deconfinement and chiral phase transitions.

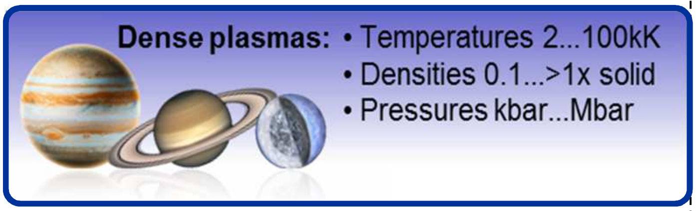
PANDA

- investigation of the strong interaction of quarks and gluons in annihilation reactions, when antiprotons collide with protons.
- experimental proof of the existence of a particle called glue ball.
- find asymmetries in matter and antimatter
- first experiment capable to measure both charged and neutral particles in the energy regions of light and heavy quarks with higher precision than presently achieved in any similar experiment in the world.
- examine detailed properties of the found particles.

FAIR is owned by ten member states and will cost €1,357 million (2005 prices), with Germany providing the bulk of the funding. Several international research collaborations with a total of about 3,000 researchers from 50 countries are working for the realization of FAIR and will profit from its discovery potential, and the unique career opportunities for a new generation of young scientists and engineers all over the world.

High Energy Density Physics at FAIR

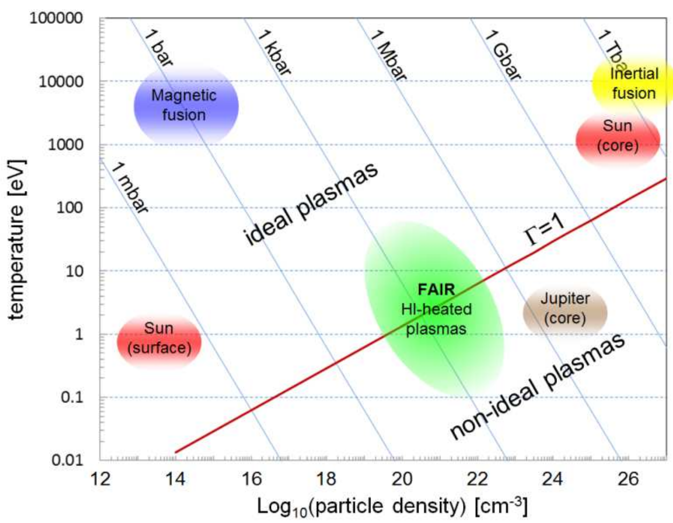
• What is High Energy Density physics?



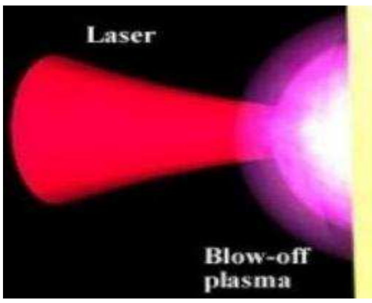
Matter at High Energy Density (HED) is usually referred to as matter at pressures exceeding 1 Mbar. Such extreme conditions are prevalent in the interior of compact physical objects, such as stars, brown dwarfs, giant planets, or the center of the earth. High temperatures (eV to keV) lead to an ionized state of matter, a plasma. Dense plasmas of solid density and above pose a great challenge for theoretical modelling, as the ions are strongly correlated and the electron component is partially degenerate, and in partially ionized plasmas the atomic shell structure is severely perturbed. This results in a rich and complex phenomenology, including phase transitions, coexistence regimes and critical points, insulator-metal transition, and transport properties.

• HED physics at FAIR: a complementary approach

Plasmas at HED conditions can be produced by high-power drivers, such as large-scale laser facilities, high-current discharges, and the latest generation of x-ray lasers. A very active research community exploits these opportunities to experimentally study material at astrophysical conditions in the laboratory. In addition, this research is also driven by important applications such as testing material strength at extreme conditions or developments towards inertial confinement fusion. With the upcoming FAIR facility a new, worldwide unique possibility to conduct complementary research on dense plasmas will become available. With a more than 100-fold increase in particle number, intense heavy ion pulses delivered by FAIR can deposit energy densities exceeding 100 kJ/g in large, dense samples, resulting in volumetric heating up to ~10 eV. This capability will be complemented by advanced diagnostic capabilities, including a high-power laser system to drive secondary radiation sources. In addition, a proton microscopy facility driven by FAIR will allow unprecedented spatial and temporal resolution for accurate imaging of dynamically events driven by external drivers.

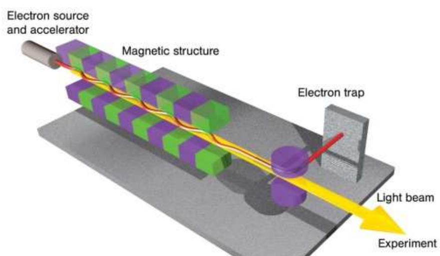


High-power laser beams



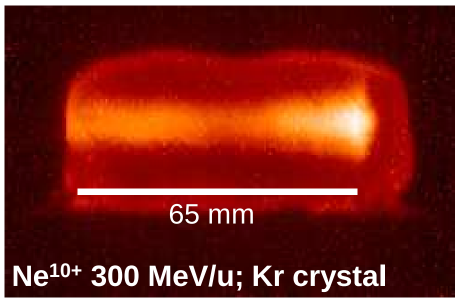
- large gradients
- strong conductive & radiative heating
- rapid hydrodynamic evolution

Ultra-bright x-ray laser pulses



- small sample volume (100 μm^3)
- ultra-short time scales (100 fs)
- highly transient, non-equilibrium
- low-Z target material

Intense heavy ion beams



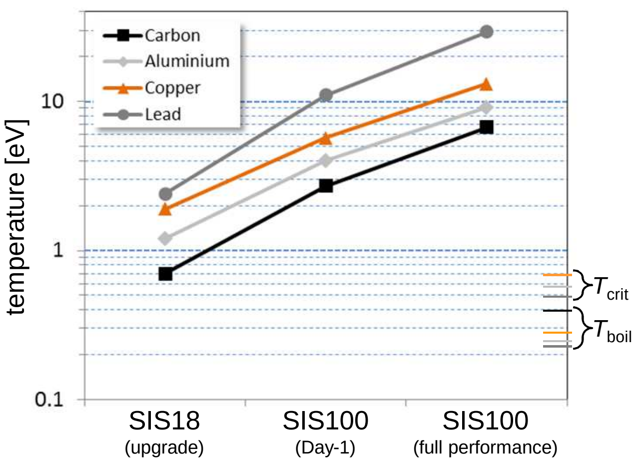
- large sample volume (mm^3)
- long time scales (50 ns)
- local thermal equilibrium
- uniform physical conditions
- any target material

Plasma physics program at FAIR - fundamental properties of matter under extreme conditions

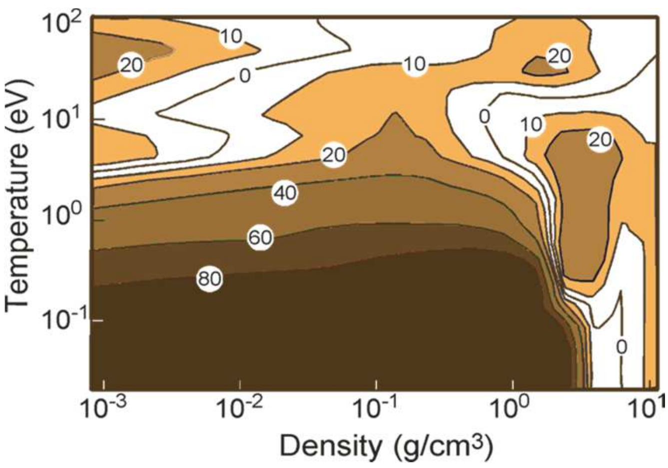
- **Equation-of-state of HED matter, basic thermodynamic properties of matter in unexplored regions of the phase diagram (two-phase regions, critical points, non-ideal plasmas)**
- **Exotic states of matter, metal-to-insulator or plasma phase transitions, non-congruent phase transitions, hydrogen metallization, etc.**
- **Transport and optical properties of HED matter: electrical and thermal conductivity, opacity, etc.**

FAIR offers a unique path towards generating dense plasmas in the laboratory. Quasi-isochoric volumetric heating by the intense heavy ion pulses will yield macroscopic, homogenous HED samples at LTE conditions. Already ion pulses from the upgraded SIS18 synchrotron will reach temperatures well above the predicted critical temperatures of most elements. First beams from the new SIS100 at the APPA cave will boost energy deposition in targets by 5x, and an additional increase by 3-4x is expected when the full projected performance will be reached.

predicted reachable temperatures at FAIR

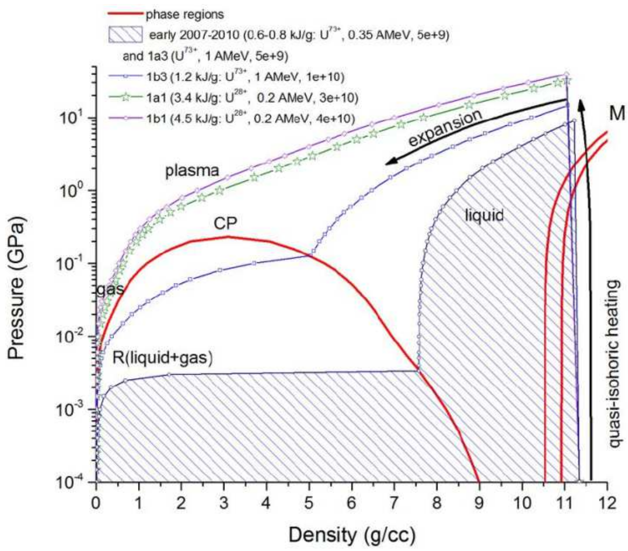


Example: Aluminium Equation-of-State



Contours of pressure difference (in %) between two advanced wide-range semi-empiric equation-of-state models (courtesy R. Lee, LLNL). Theories are in good agreement in regions where experimental data exists. In the warm-dense matter regime (temperatures ~eV, densities of order g/cc) accurate measuremens are challenging and experimental data is scarce.

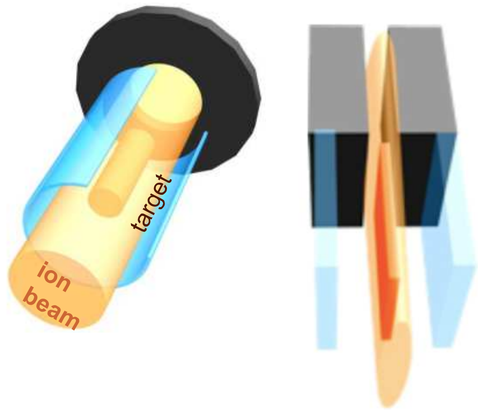
Example: exotic matter states in lead



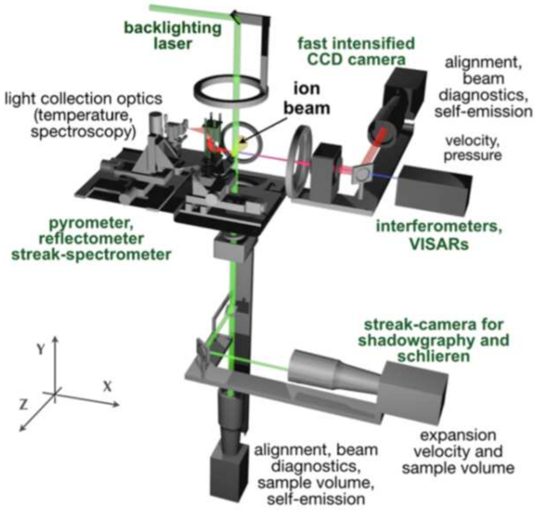
Comprehensive numerical modeling (FPIC3D, IPCP, Chernogolovka) of an experiment planned with FAIR ion beams. Matter states reached in a lead target by heavy ion heating and subsequent expansion cover the 2-phase regime, including the critical point, as well as the strongly-coupled plasma regime. [V. Mintsev et al. Contrib. Plasma Phys. 56, No. 3-4, 281 – 285 (2016)]

Isochoric heating and expansion

The study of the fundamental properties of HED matter has many applications in basic as well as applied science. Constructing an equation-of-state that covers solid, liquid and plasma states is very challenging and depends on experimental data.
At FAIR, we will use a focused intense heavy ion beam to heat a sample uniformly and quasi-isochorically. After the heating is over, the sample expands isentropically. Depending on the deposited energy, the sample will reach different interesting states, such as the critical point region or the warm dense matter region. This experiment will allow us to study the equation-of-state of a wide range of materials in a parameter range that is difficult or even impossible to reach with other methods.



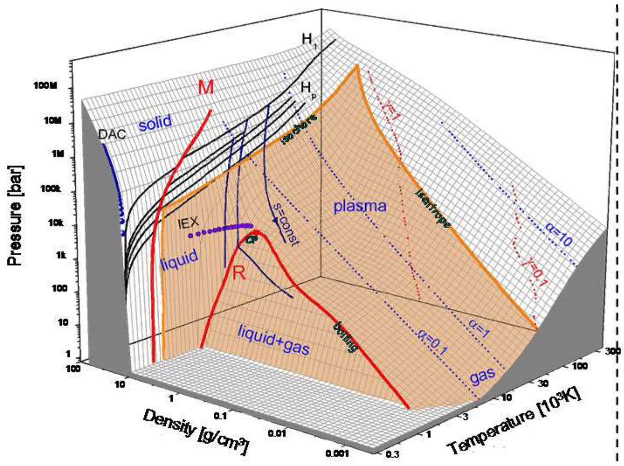
Cylindrical and planar target setup



Diagnostic setup

Two target geometries will be used: a cylindrical (wire) target and a planar (thin foil) target. In both cases, the diameter of the ion beam and the length of the target are much larger than its thickness, so that the dynamics are essentially one dimensional. A surrounding container can be used to limit the expansion of the target. Key physical parameters, such as density, pressure, temperature, expansion velocity and electrical conductivity, will be measured during the heating and during the expansion.
First isochoric heating experiments have already been carried out at GSI using the SIS-18 accelerator. For these experiments, many of the key diagnostics have been developed. FAIR will enable measurements with much higher energy deposition.

The traditional methods to create HED samples use shock compression of matter. These studies are limited to phase regions near the Hugoniot curve of the sample. The use of porous samples has extended the accessible phase region, however low-density regions are not accessible with this method. The wide range of parameters that can be accessed at FAIR (shaded area) is illustrated in the figure on the right. It can be seen that the experiment covers nearly the entire phase diagram, including high-entropy states. Experiments at FAIR will thus enhance our understanding of many phenomena, such as phase transitions, significantly.

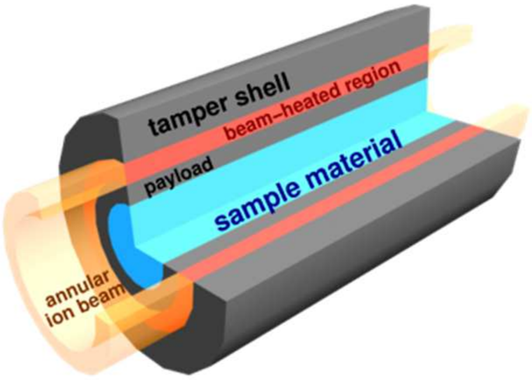


Phase diagram for lead
[N. Tahir et al., PRL 95, 035001 (2005)]

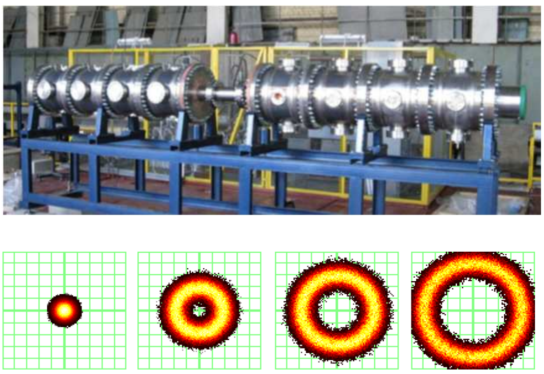
Isentropic compression

Although hydrogen is the simplest element, it still shows a very complex behavior. The properties of hydrogen under extreme pressure are essential for understanding the structure and formation of gas giants like Saturn and Jupiter. A topic of special interest in this regard is the metallization of hydrogen.

FAIR will offer the opportunity to study the properties hydrogen and other light elements under extreme pressures. By using heavy ion beams as a driver, it will be possible to compress hydrogen and other samples to several times their initial densities and megabar pressures, while keeping the sample at sub-eV temperatures.



Target for the isentropic compression of cryogenic samples



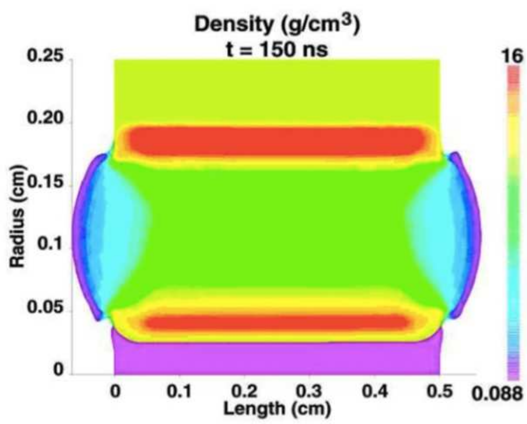
Wobbler prototype and annular beam profiles

The target used in the experiments consists of a cryogenic sample surrounded by a thick shell of heavy material (e.g. gold or lead). The beam is shaped into an annular profile, so that only a small section of the shell is heated by the ion beam, while the sample itself is excluded from heating. The section of the shell between the heated region and the sample acts as a payload. Due to the expansion of the heated region, the payload compresses the sample. A tamper shell prevents the heated region from freely expanding outward, thus maximizing the compression. One possibility to create an annular beam profile would be to use a beam blocker. However, that would result in a loss of achievable heating power due to the beam losses.

To achieve the annular profile without a loss of beam intensity, an RF rotator (wobbler) has been developed at the ITEP in Moscow. With this setup, it will be possible to achieve a heating profile with an asymmetry of less than 1%.

Shown in the figure on the right is the result of a simulation using $5*10^{11}$ 1 AGeV uranium ions to compress hydrogen (initial density 0.09 g/cc). Clearly visible is how the region heated by the ion beam expands and compresses the payload as well as the sample in the center. In this setup, the simulation predicts a maximum density of 1 g/cc, a pressure of 5 Mbar and a temperature of 3000 K.

It is thus possible to study matter at conditions relevant for planetary science with our experiment.

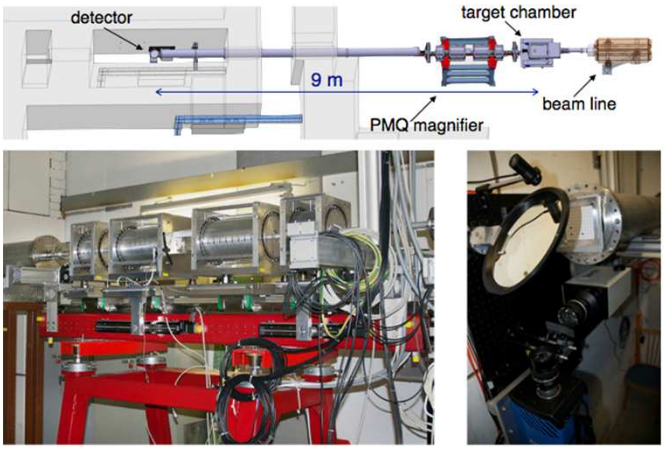


Simulation of ion driven compression

Proton Microscopy

- **What is proton microscopy?**

Proton radiography or microscopy is a powerful technique for probing the interior of dense objects in dynamic experiments by mono-energetic beams of GeV-energy protons, using a special system of magnetic lenses for imaging and aberrations correction. With this technique, one can measure the areal density of a thick sample with sub-percent accuracy, micrometer-level spatial resolution and nanosecond temporal scale.



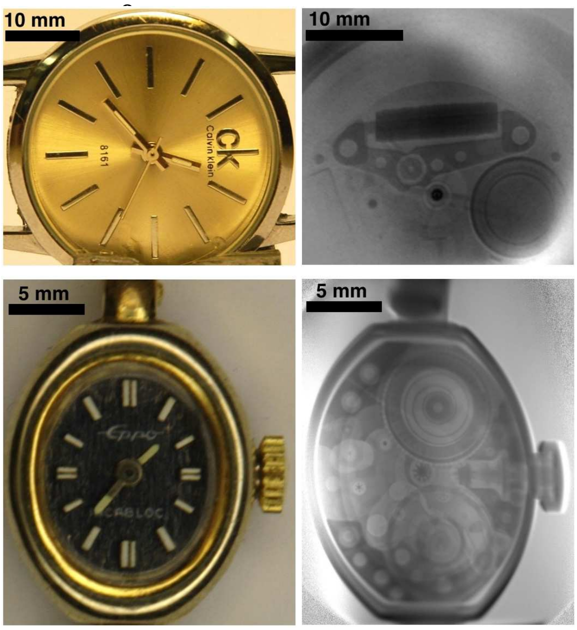
PRIOR-I setup at GSI

- **Proton microscopy at FAIR**

Proton radiography with magnetic lenses was invented in the 1990's at Los Alamos National Laboratory (LANL) as a diagnostic to study dynamic material properties under extreme pressures, densities and strain rates. The capability of radiographic imaging of dynamic systems with unprecedented spatial, temporal and density resolution is of considerable interest for plasma physics and materials research. Therefore high energy proton microscopy (HEPM) is seen as a key diagnostic for high energy density physics experiments at FAIR.

The worldwide unique facility called PRIOR (*Proton Microscope for FAIR*) will employ high-energy (2-5 GeV), high-intensity (up to $2.5{\cdot}10^{13}$ protons per pulse) SIS-100 proton beams for multidisciplinary research such as experiments on fundamental properties of materials in extreme dynamic environments generated by different drivers prominent for warm dense matter research and high energy density physics as well as the PaNTERA (Proton Therapy and Radiography) experiment for biophysics and medicine. Recently a prototype of the PRIOR facility called PRIOR-I has been designed, constructed and successfully commissioned at GSI. The PRIOR-I setup is using NdFeB permanent magnet quadrupoles provide high field gradients (120 T/m). As a result of the experiments with 3.5-4.5 GeV proton beams delivered by SIS-18, 30 µm spatial and 10 ns temporal resolutions have been demonstrated.

The final design of the PRIOR facility (PRIOR-II) employs radiation-resistant electromagnets and assumes that the setup will be first fielded at GSI to use 4 GeV protons from SIS-18 for static or dynamic experiments, and later it will be transferred to the APPA cave at FAIR. The PRIOR-II facility will provide a magnification of about x3 at GSI and up to x8 at FAIR with about 10 µm spatial resolution at the object.

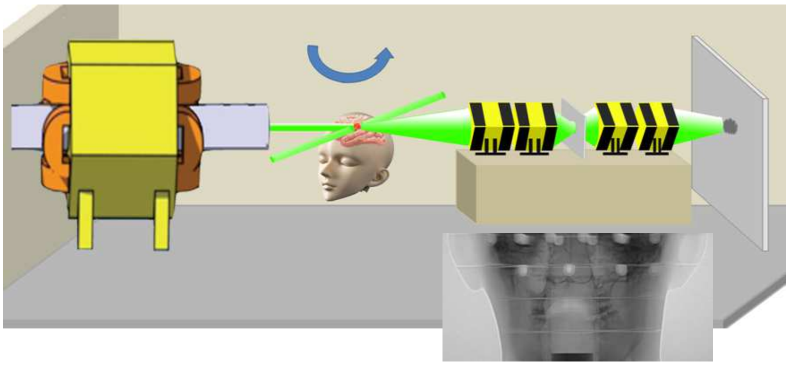


PRIOR-I 3.6 GeV proton radiographs of complex targets. Top: a quartz watch and a radiograph of its central part. One can clearly see the battery and movement. Having a sufficient contrast, one can also see the hour, minute and even second hands of the watch. Bottom: a tiny mechanical watch. Despite a thick stainless steel case back, the fine details of the interior of the watch are well resolved: the crown and the mainspring, pivots and wheels, jewels, etc.

Interdisciplinary aspects

- **Biophysics**

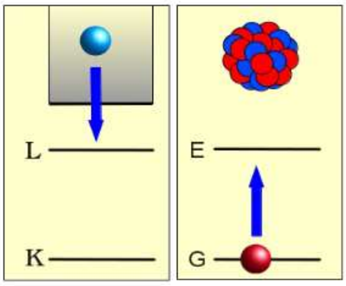
Building up on the success of hadron therapy, proton microscopy can be employed to drive applications in biology and medicine like the Proton Therapy and Radiography (PaNTERA) project. Here, relativistic protons (4.5 GeV) will be used to image biological tissues for image-guided, high-resolution, real time, stereotactic radiosurgery (proton theranostics). This technique will greatly extend the possibility of hadron therapy and open new treatment possibilities for complicated cases when the tumor is located close to sensitive organs. It will also greatly improve the existing treatments by offering a much better control over the dose and monitoring of the tumors.



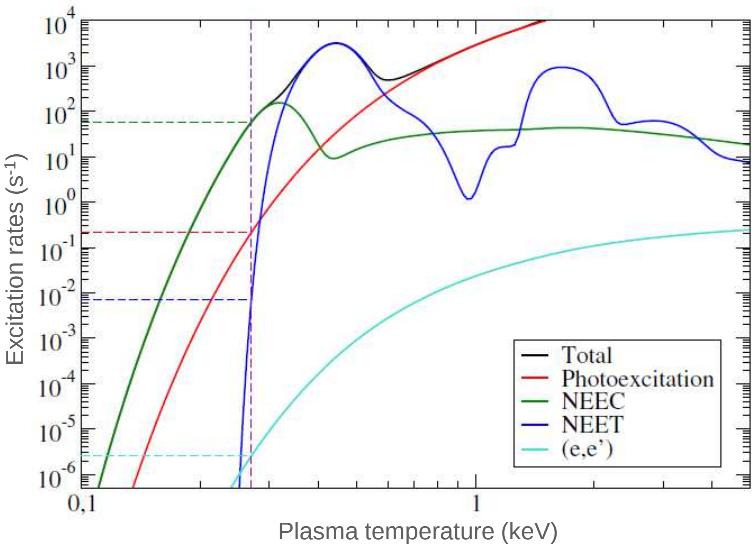
principle of the tumor imaging via proton microscopy
[M. Prall et al., Scientific Reports (2016)]

- **Nuclear physics in Plasma**

There are many nuclear processes that are predicted to happen in astronomical objects like supernovae and that could be re-created in the laboratory. Among those, nuclear excitation via electron capture (NEEC) or electron transition (NEET) are long standing issues that remains mostly unexplored because of the scarce experimental data available. Transition energies in the keV range are in general necessary to create such coupling between the electrons and nucleus, conditions that one can easily find in plasma. In addition, the choice of resonances is limited and the preparation of the right isotope with the right isomeric state is an additional complication. FAIR will offer a worldwide unique opportunity for the generation of rare relevant isotopes and also for bringing them simultaneously or sequentially in various plasma conditions to study these phenomena. Such experiments will find excellent conditions at the APPA target stations either in the APPA cave or in storage rings.



Example of a NEET transition in ^{84}Rb. This effect is predicted to become dominant already at plasma temperatures around 300 eV for the 3.5 keV nuclear M1 transition

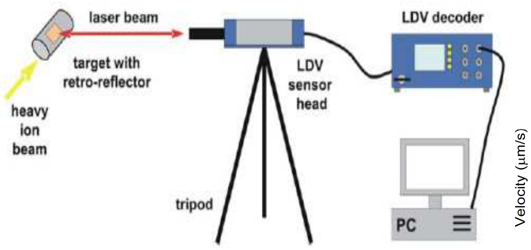


Excitation rates for the transition $6^- \to 5^-$ in ^{84}Rb as a function of the plasma temperature. (source: PhD thesis Denis-Petit)

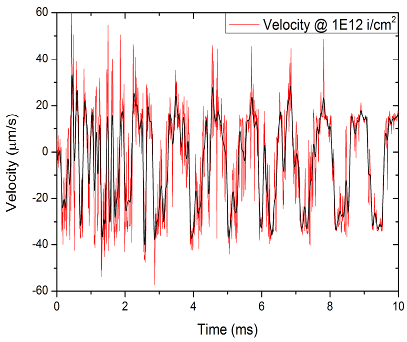
• Material research under extreme conditions

The exposition of materials to short high-energy and high-intensity ion beam pulses will for instance lead to a better understanding of the thermomechanical response of materials to the instantaneous deposition of highest energy densities. By time-resolved laser-based diagnostics shock wave effects can be analyzed allowing important tests of damage processes in functional materials.

Combining SIS 100 ion beams and laser-driven particle beams will provide complex radiation fields suitable to study radiation effects on materials and electronics relevant for space applications..

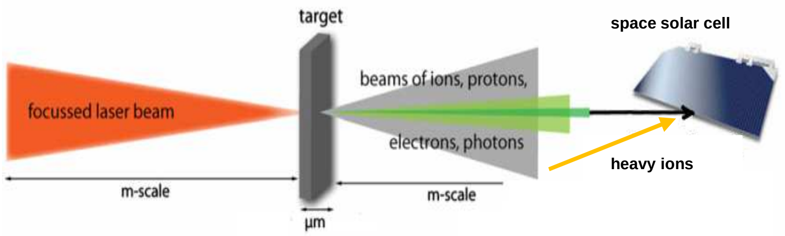


Exp. S334 at SIS18, A.Kelic, R.Wilfinger et. al.



Beam-induced stress waves in high power targets.

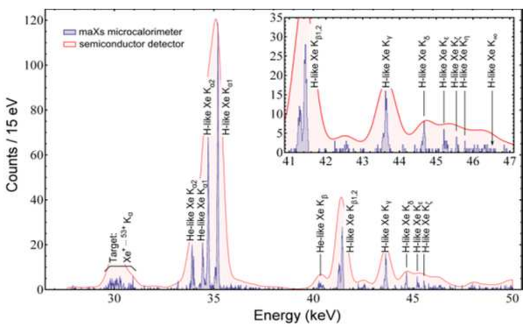
Space components tests in complex radiation fields



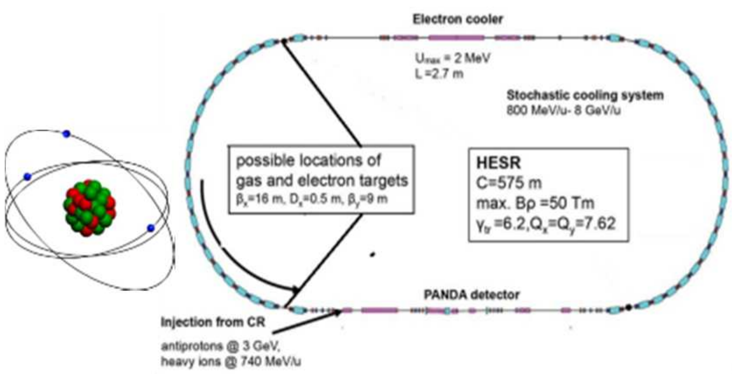
• Atomic physics

There are fundamental atomic processes happening in heavily coupled plasmas that remain to be studied like the excitations and the change of binding energies of atoms and ions. Here the opportunity to create such heavily coupled plasmas with FAIR and to diagnose them with high-intensity lasers will enable fascinating studies. And additionally, the possibility to store highly charged ions at relativistic velocities in combination with high-power and soft x-ray laser sources create the conditions for precision experiments on QED contributions, parity violation and pair production.

There are many common tools and diagnostics between the APPA collaborations within the APPA cave but also concerning the adjacent high energy storage ring HESR.. In particular, a common development on high peak power lasers and x-ray diagnostics will create a strong synergetic momentum.

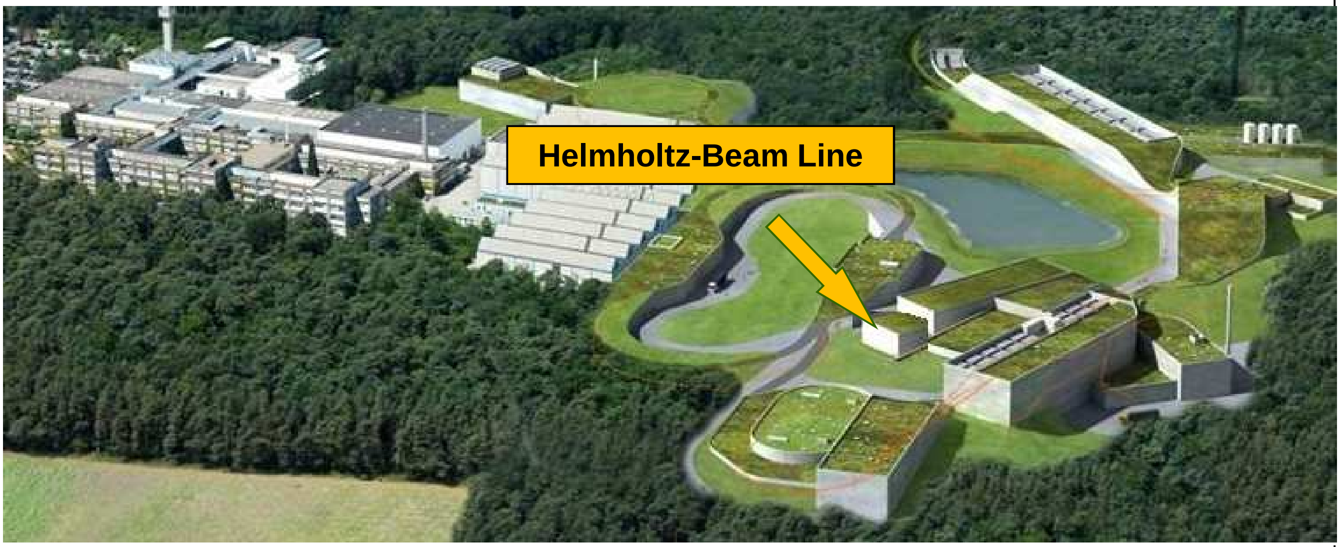


High resoution x-ray spectra
[D Hengstler et al., Physica Scripta (2015)]



Relativistic ions in the HESR

Laser capabilities for Plasma physics



An artistic view of FAIR with the Helmholtz beamline building

- **A high-energy kilojoule laser**

The heating of macroscopic and mesoscopic targets is a unique feature of the FAIR machine. The laser-based diagnostics must therefore produce fluxes of particles that are high enough to beat background noise and propagate through sensible amount of opaque materials. If one considers that the laser is not necessarily used as a direct diagnostic but rather a driver for secondary sources, a laser with a high energy in the kilojoule range is mandatory requirement. For various reasons like back-reflection management and plasma absorption, frequency conversion of the beam to 2 or 3 ω is a desired feature that is commonly used in various laboratories with success.

- **A flexible facility**

A laser with a dual nanosecond and femtosecond front end and shot rate in the minute range is a versatile machine that can support the many diagnostic setups for FAIR and additionally be used as a compression driver. The architecture can also evolve toward higher peak powers either using parametric amplifiers (OPCPA) or the more prospective “C^3” scheme [Mourou et al. Opt. Comm. (2012)].

- **Roadmap**

There are many bottlenecks that need to be addressed in order to realize a high shot rate kilo-joule class laser. A prototype amplifier is being university Darmstadt to demonstrate operation of large-aperture glass slab amplifiers at shot rates compatible with the experimental shot rates at FAIR in the minute range. To validate this concept a prototype 100 J sub-nanosecond laser is being built and will be installed in the APPA cave for the Day-one experiments and the cave commissioning phase.

Laser expertise within Helmholtz

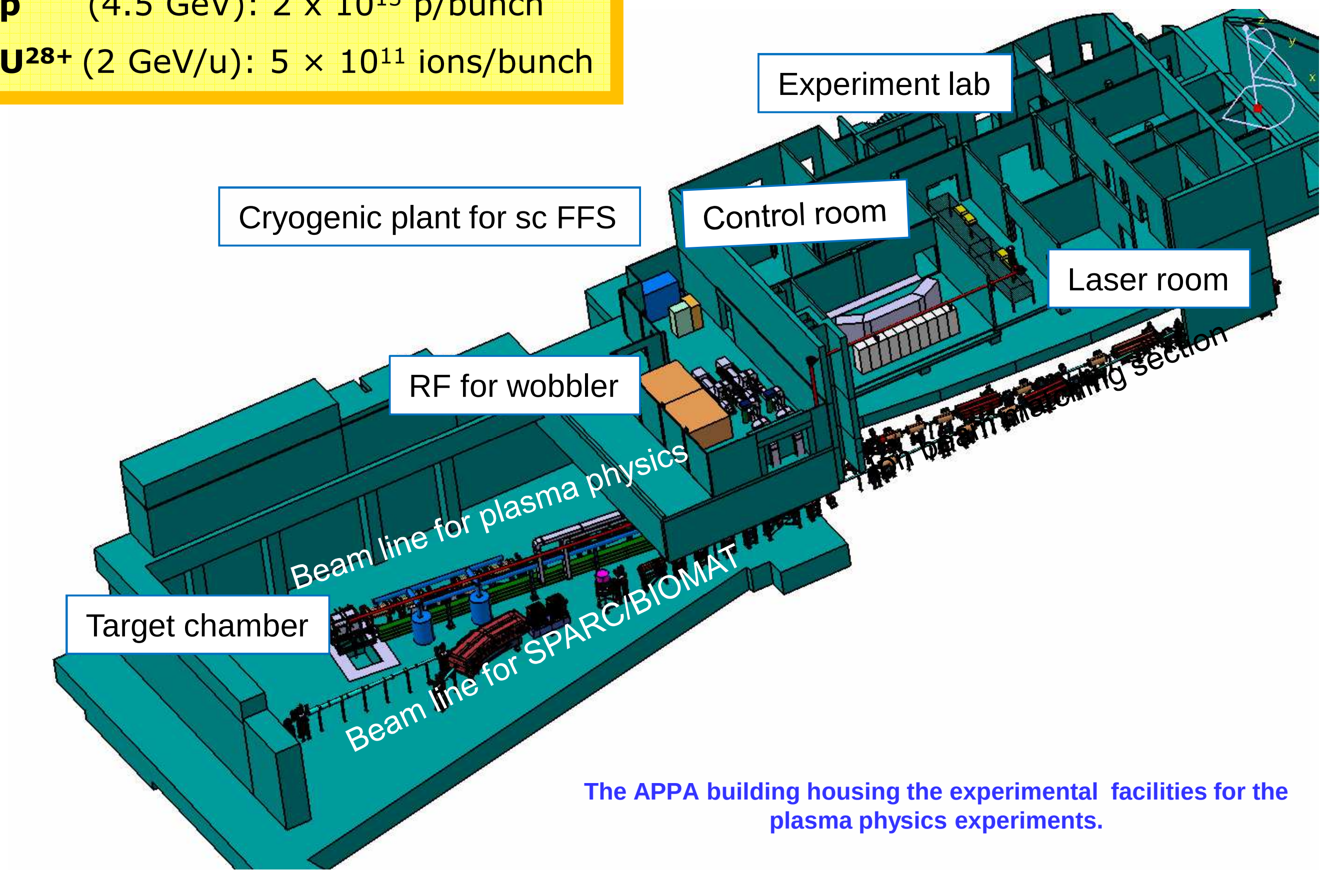
The Helmholtz association is strongly involved in the development (POLARIS at the HI Jena) and operation of some of the largest civilian lasers in the world like the petawatt laser PHELIX at GSI and the multi 100 terawatt laser DRACO at HZDR. This represents a large group of experts dedicated to the conception, development and operation of laser sources. For this reason, the new machine will build on the well-established existing expertise of the Helmholtz centers involved in the project.

The APPA Cave for Plasma physics

- **A 900 m^2 fully shielded experimental area for APPA**

The experiments of the plasma physics community will be performed in the APPA building, a dedicated building for the collaborations of atomic, plasma, material and biophysics research. The experimental area (cave) will house two beam lines, one of them being dedicated to plasma physics. The beam line is designed to deliver the ion beam for all experimental schemas with a minimum of modifications: heavy ion beams for isochoric heating, ring-shaped focus for the compression experiments, as well as the appropriate proton beam for the PRIOR experiments in both configurations.

p (4.5 GeV): 2 x 10^{13} p/bunch
U^{28+} (2 GeV/u): 5 × 10^{11} ions/bunch

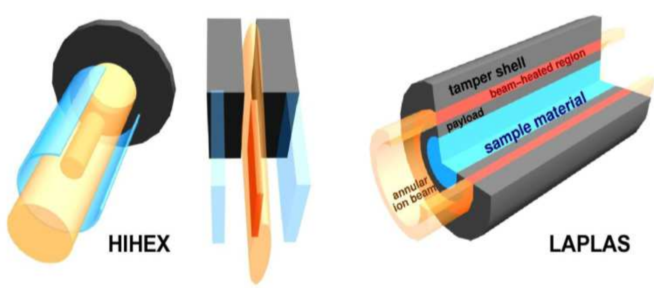


The APPA building housing the experimental facilities for the plasma physics experiments.

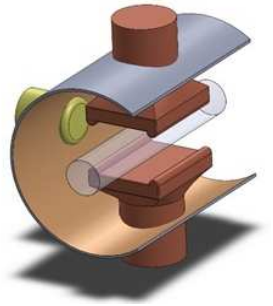
- **Dedicated experimental equipment:**

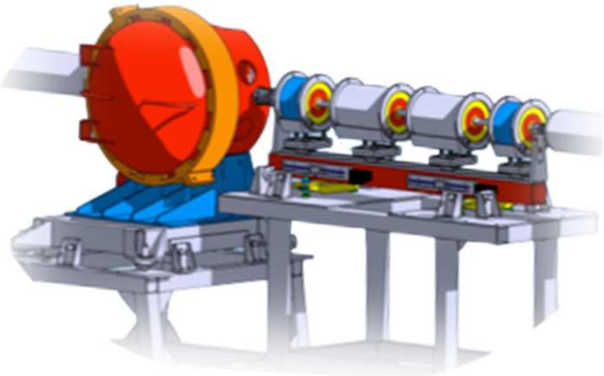
The technical equipment that has to be provided by the collaboration consists of the following elements:

The Matching section consists of 8 normal conducting quadrupoles, magnetic steerers, beam diagnostics for heavy ions as well as for protons and vacuum devices. Its task is to pre-shape the ion beam for the different demands of the experiment, e.g. provide the wobbler with a parallel heavy ion beam, the PRIOR system with a parallel proton beam or the final focusing system (FFS) for generating a small, large or elliptical spot.



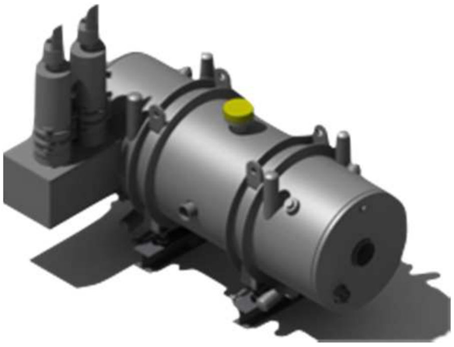
The Wobbler, consisting of two RF deflectors in perpendicular directions and running at a frequency of 324 MHz, will revolve the ion beam in order to create a ring shaped focus in the target plane for compression experiments. With a revolution time as short as 3 ns, the ion beam is then focused down by the FFS to a spot with a radius around 1 mm and a ring radius of 1.5 to 2.5 mm. The RF infrastructure is situated above the cave.

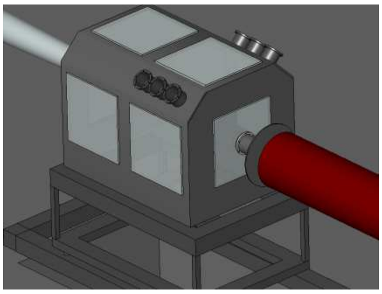




For PRIOR experiments, the wobbler will be moved out and replaced by an additional target chamber adapted to the external driver (pulsed power, laser, gas gun, etc.) and for the proton microscope by the 4-nc electrical quadrupoles for the imaging. The imaging detector will be placed in the target chamber at the end of the beam line.

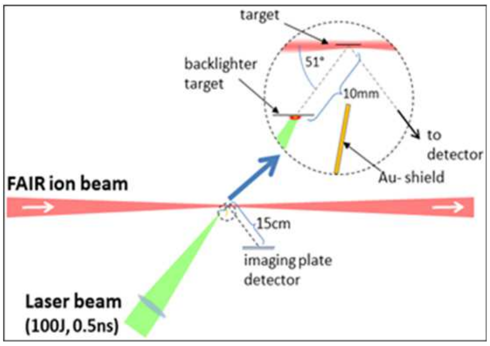
The Final Focusing System (FFS) includes four superconducting 33-T/m quadrupoles and the involving cryogenic plant for the cooling. Its task is to generate the desired focal spot, from smallest spot size (compression experiments, isochoric heating of wires), over large spot sizes (isochoric heating of macroscopic samples, foils) to elliptical shapes (heating of plates from side). Additionally, it acts for the large scale proton microscopy as imaging system providing the necessary field of view with its aperture of 200 mm.





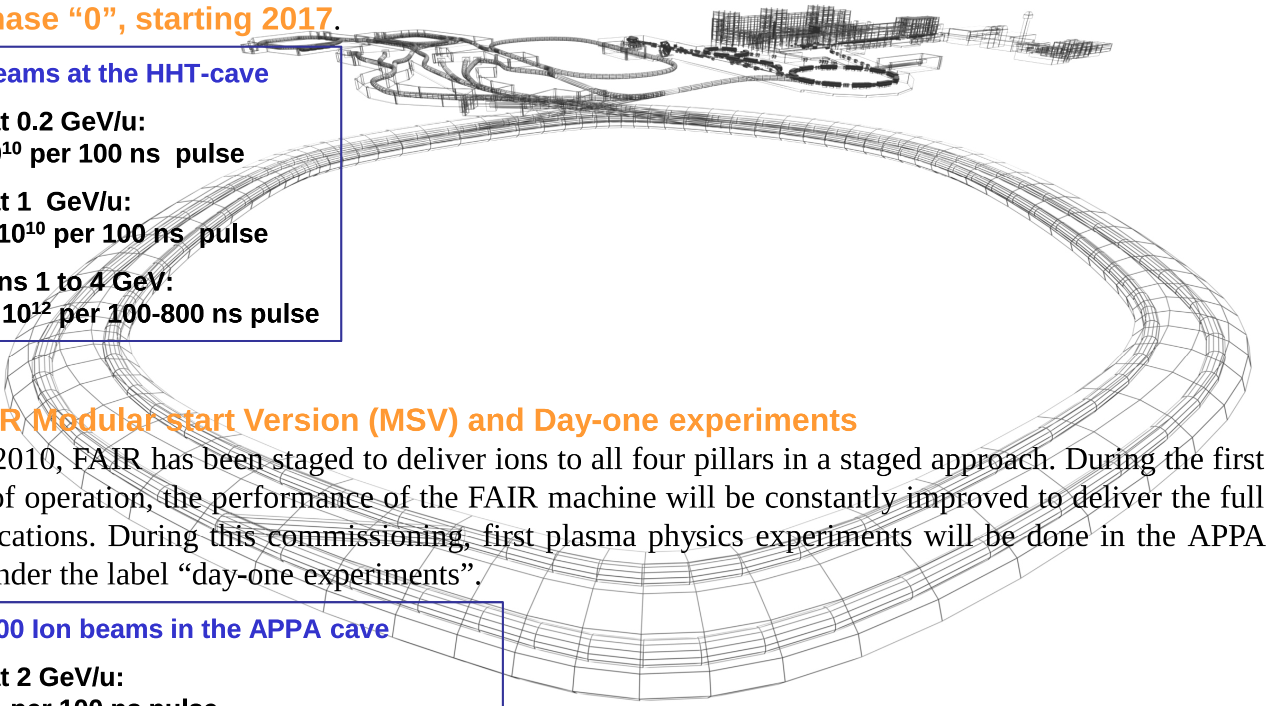
The Target Chamber will house a target exchange system with a reservoir for up to 50 targets, the target alignment system, versatile detectors depending on the experiment and the appropriate vacuum system. It is designed modularly, so it can be configured to accept the 100J/2ω laser beam at first and the Helmholtz Beamline laser later on.

The Diagnostic Laser (100 J, 2 ω, 0.1 - 10 ns) is located above the cave in an air-conditioned clean room. There will be two laser beam lines, one down to the target chamber in the cave, the other into the neighboring Experiment Preparation Lab, where a copy of the target chamber will be placed, so that the experimental set up can be pre-aligned, calibrated or tested offline.



The Control Room finally will contain some control panels with sufficient screens and several racks, where all devises in the cave will be remote controlled and all experiment signals for the data acquisition from the cave will be collected.

Steps on the way to FAIR



- **Phase "0", starting 2017.**

Ion beams at the HHT-cave

U^{28+} at 0.2 GeV/u:
3.5 10^{10} per 100 ns pulse

U^{73+} at 1 GeV/u:
0.5-1 10^{10} per 100 ns pulse

protons 1 to 4 GeV:
0.4–5 10^{12} per 100-800 ns pulse

- **FAIR Modular start Version (MSV) and Day-one experiments**

Since 2010, FAIR has been staged to deliver ions to all four pillars in a staged approach. During the first years of operation, the performance of the FAIR machine will be constantly improved to deliver the full specifications. During this commissioning, first plasma physics experiments will be done in the APPA cave under the label "day-one experiments".

SIS-100 Ion beams in the APPA cave

U^{28+} at 2 GeV/u:
2*10^{11} per 100 ns pulse

U^{92+} at 8.4 GeV/u:
2.3 *10^{10} per pulse in 100 ns

protons 2 to 5 GeV:
2.5 10^{13} per pulse in 50-3400 0 ns

- **Full FAIR performance**

The full realization of FAIR will include not only outstanding ion beam parameters in a fully shielded environment but also state of the art diagnostics centered around a laser facility that will deliver two additional kilojoule laser beams to the FAIR APPA cave. This worldwide unique combination will be the ideal experimental place to study plasma physics on a mesoscale.

SIS 100 Ion beams (full performance)

U^{28+} at 2 GeV/u:
5 10^{11} per 70 ns pulse

protons 2 to 5 GeV:
2.5 10^{13} per 50-3400 ns pulse

Target material	Beam	E (kJ/g)	T (K)	P (Gpa)
Pb	a	3.4	20 360	32.8
	b	0.64	4 430	8.9
	c	4.5	25 790	39.3
	d	1.2	8 220	14.6
Ni	a	3.5	4 652	3.11
	b	0.8	1 720	1.7
	c	4.5	5 490	4.7
	d	1.4	2 330	2.6
Cu	a	3.7	7 260	8.8
	b	0.7	1 517	3.7
	c	4.9	9 460	12.1
	d	1.4	2 946	5.0

Predicted thermodynamic states (temperature and pressure) in the target materials for different uranium beam parameters: (a) U28+, 0.2 AGeV, $3\cdot10^{10}$ ions/bunch; (b) U73+, 1 AGeV, $5\cdot10^{9}$ ions/bunch; (c) U28+, 0.2 AGeV, $4\cdot10^{10}$ ions/bunch; (d) U73+, 1 AGeV, $1\cdot10^{10}$ ions/bunch. [V. Mintsev et al. Contrib. Plasma Phys. 56, No. 3-4, 281 – 285 (2016)]

The International Collaboration for Plasma Physics at FAIR

In July 2017 civil construction for the FAIR facility will start. This marks the beginning of a new phase of the project, also for the collaborations. In this view the Collaboration for Plasma Physics at FAIR has been restructured. As of now, the collaboration is organized around its new management board which met for the first time in February 2017.

After a necessary shut down, the GSI accelerators will restart operation within 2018. Beam times will be available at GSI's facilities including the high-energy cave HHT for preparing experiments and diagnostics for FAIR starting in 2018 and every year after that, as much as the construction of FAIR allows. In parallel, the plasma physics department at GSI acts as a host laboratory and actively prepares the infrastructure in the APPA cave with the help and the advice of the Collaboration for Plasma Physics at FAIR. For that, the work is divided in work packages according to the original proposal for FAIR:: The collaboration is open for new members and invites to actively participate in the preparation of FAIR.

Technical work packages for the preparation of Plasma Physics at FAIR

Work Package	Coordinator/ GSI contact
T1: Beam line	D. Varentsov
T1.1: FFS superconducting quadrupoles	S. Kozub/ D. Schumacher
T1.2: Beam line infrastructure	K. Weyrich
T1.3: Wobbler	A. Golubev/ O. Rosmej
T1.4: PRIOR	F. Merrill/ D. Varentsov
T2: Civil construction	A. Blazevic
T3: Target station	N. Shilkin/ A. Tauschwitz
T4: HE laser at FAIR	M. Roth/ V. Bagnoud
T5: LAPLAS cryogenic target system	E. Koresheva/ O. Rosmej
T6: DAQ	A. Kantsyrev/ D. Varentsov

Annual community report:

Important contributions are collected and published in a yearly GSI Report "News and Reports from High Energy Density generated by Heavy Ion and Laser Beams". This is available in a printed version and under: https://indico.gsi.de/getFile.py/access?resId=0&materialId=5&confId=5681

Annual community meeting:

An annual meeting for all scientist interested in high energy density physics is held at the Darmstädter Haus in Hirschegg, Austria during the 1st week in February. This international workshop has now a tradition of 35 years!

Plasma physics web page of GSI:
https://www.gsi.de/pp
Information on FAIR and the FAIR collaborations:
http://www.fair-center.de

Contributors to this brochure:

V. Bagnoud (Editor), M. Bernards, A. Blazevic, D. Hoffmann, T. Kühl, S. Neff, P. Neumayer, O. Rosmej, B. Sharkov,, D. Varentsov, and K. Weyrich