Collaboration between FAIR (GSI, Germany) and NDCX-II

The following is from Boris Sharkov's letter proposing collaboration:

Here we would like to express our strong interest in collaborating on research using the NDCX-II facility at LBNL. NDCX-II offers complementary capabilities to our own existing and planned facilities. A particular motivation is that our existing machine will be shut down temporarily 2015 - 2018 due to the construction of FAIR.

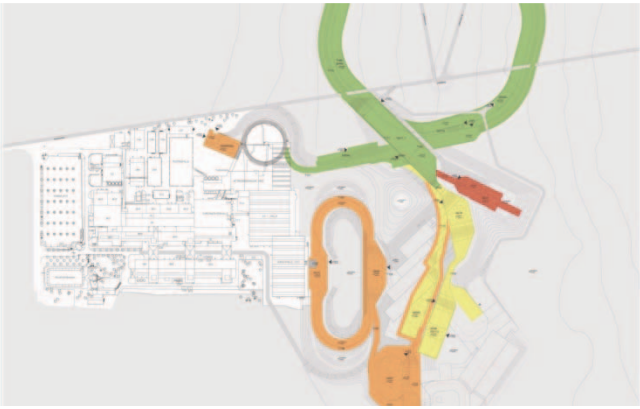
Thus, we would very much like to be able to bring our experiments to NDCX-II on that time frame, including research staff, diagnostics, and targets. This would be through a formal collaboration with the three laboratories constituting the HIFS-VNL. We hope that this will be possible.

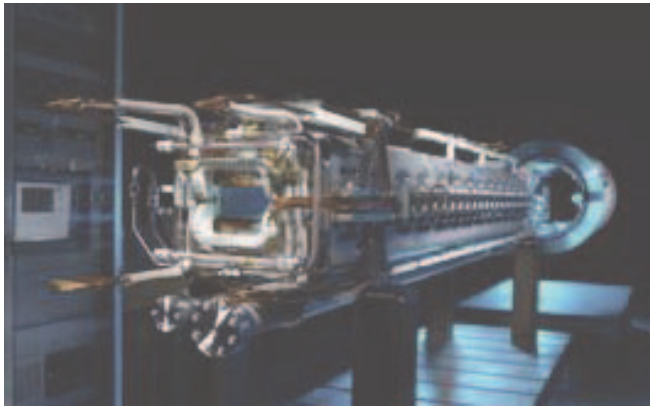
Looking further into the future, FAIR will provide a platform for multi-kiloJoule Heavy Ion Fusion-relevant HEDP studies when it becomes operational in the 2018 time frame. Thus, it is our hope that collaborative research between FAIR and the HIFS-VNL will expand to include target physics experiments on our new facility, including studies related to the high-gain X-target concept for Heavy Ion IFE and other novel ideas.

Collaboration between HIAF (IMP, China) and NDCX-II

The following is from Yongtao Zhao's letter proposing collaboration in:

- HEDP research with Intense Heavy Ion Beam from HIRFL or NDCXII;
- Experiments on heavy ion beam and plasma interaction;
- Simulations and theoretical investigation and designing of HEDP experiments;
- Exchange of students and experts





Experiments towards HIF at FAIR

Boris Sharkov

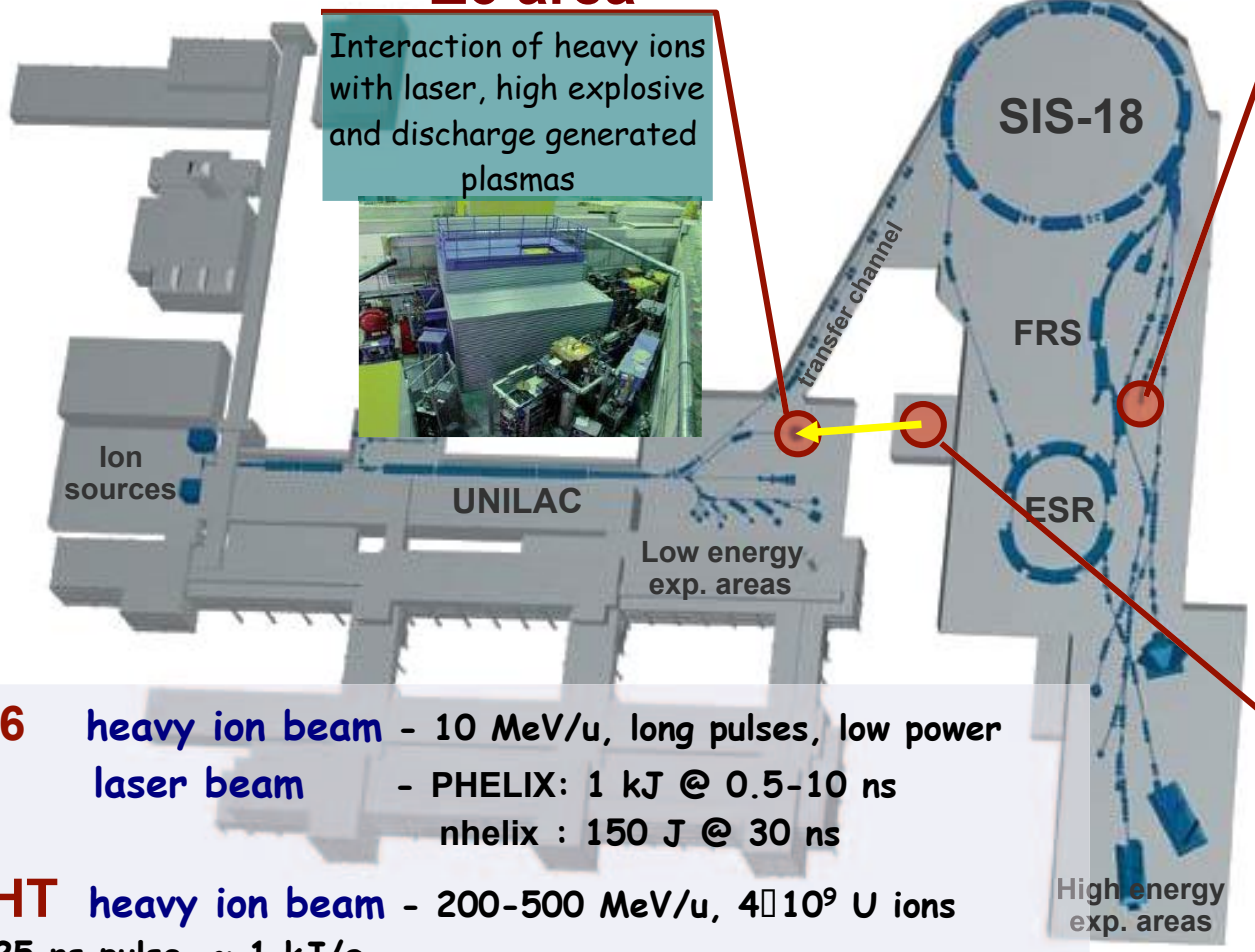
FAIR Scientific Director,
Chairman of the management board

@ HIF 2012 Berkeley

Present Plasma Physics experimental areas at GSI- Darmstad, Germany

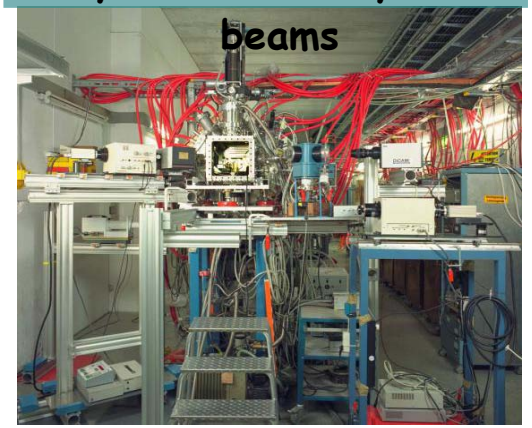
Z6 area

Interaction of heavy ions with laser, high explosive and discharge generated plasmas



HHT area

HED matter generated by intense heavy-ion beams



PHELIX

Petawatt High-Energy Laser for Ion-Beam Experiments

Z6 heavy ion beam - 10 MeV/u, long pulses, low power

laser beam - PHELIX: 1 kJ @ 0.5-10 ns

nhelix : 150 J @ 30 ns

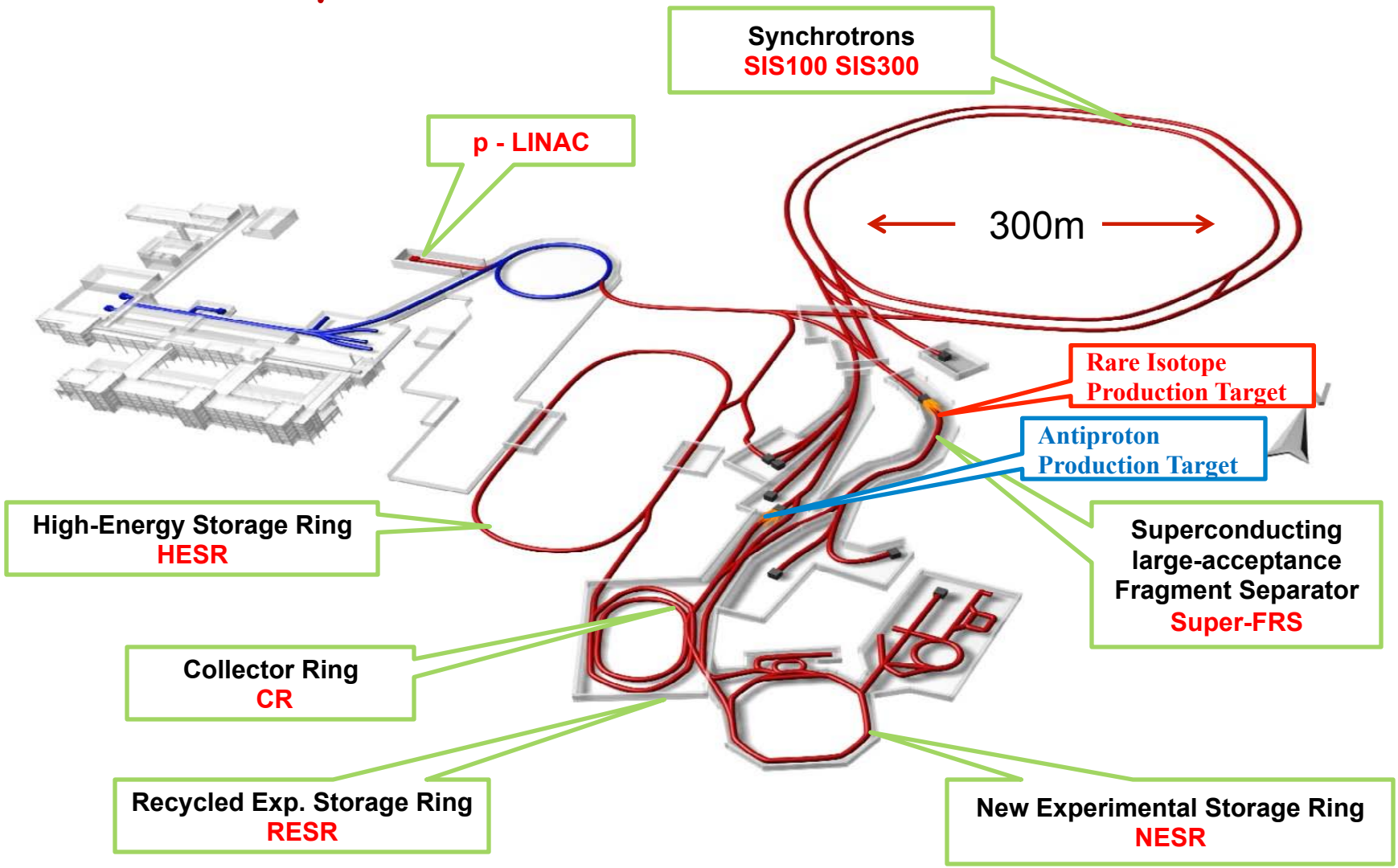
HHT heavy ion beam - 200-500 MeV/u, $4 \cdot 10^9$ U ions in 125 ns pulse, ~ 1 kJ/g

Laser beam - PHELIX: 0.5 kJ @ 0.5 ps (PW)

1-5 kJ @ 10 ns

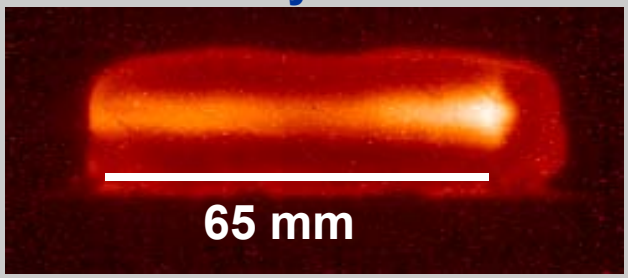
Facility for Antiproton and Ions Research

New accelerator systems to be constructed



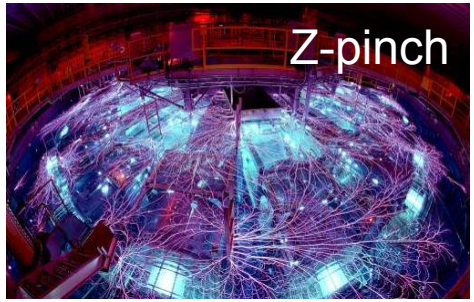
The uniqueness of heavy ion beams compared to other techniques (Laser, Z-pinch)

intense, energetic beams of heavy ions



Ne^{10+} 300 MeV/u; Kr crystal

- large volume of sample (mm^3)
- fairly uniform physical conditions
- thermodynamic equilibrium
- any material



Already within module 1: Compared to GSI, FAIR will provide an ***intensity and energy density increase by a factor of 100.***

WDM-parameters: **T:** up to 10 eV **ρ:** ~ solid **P:** up **to 1** Mbar

Perspectives of HED-experiments at FAIR

Up to **200 times** the beam power and **100 times** higher energy density in the target will be available at FAIR

Ion beam U^{28+}	SIS-18	SIS-100	
Energy/ion	400MeV/u	0.4-27 GeV/u	
Number of ions	4.10^9 ions	5.10^{11} ions	X100
Full energy	0.06 kJ	6 kJ	
Beam duration	130 ns	50 ns	
Beam power	0.5 GW	0.1TW	X200
Lead Target			
Specific energy	1 kJ/g	100 kJ/g	X100
Specific power	5 GW/g	1 TW/g	X200
WDM temperature	~ 1 eV	~10 eV	

only available at FAIR

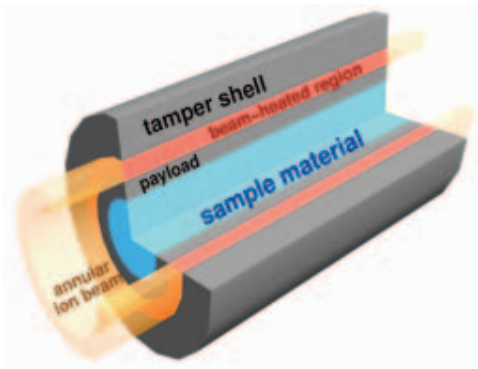
High Energy Density experiments of HEDgeHOB collaboration

HIHEX
Heavy Ion Heating and Expansion

- uniform quasi-isochoric heating of a large-volume dense target, isentropic expansion in 1D plane or cylindrical geometry

Numerous high-entropy HED states:
EOS and transport properties of e.g., non-ideal plasmas, WDM and critical point regions for various materials

LAPLAS
Laboratory Planetary Sciences



- hollow (ring-shaped) beam heats a heavy tamper shell cylindrical implosion and low-entropy compression

Mbar pressures @ moderate temperatures:
high-density HED states, e.g. hydrogen metallization problem, interior of Jupiter and Saturn

Road Map FAIR Site & Buildings

1. Handing in of preplanning documents to hbm
2. Clarification of user requirements Modularized Start Version (MSV)
3. Start revised preplanning for MSV
4. Expected approval of revised planning for MSV
5. Preparation of documents for building permit
6. Expected approval for (partial) building permit
7. Start site preparation (construction roads, clearing trees)
8. Award contracts on civil construction work lot 1 … 4
9. Completion of civil construction work lot 1 … 4
10. Start installation of accelerators and detectors

HEDP and HIF research at IMP-Lanzhou

Yongtao Zhao, Lei Yang, Jiancheng Yang, Hongwei Zhao, Hushan Xu, Guoqing Xiao, Wenlong Zhan, & PPlers at IMP,CAS

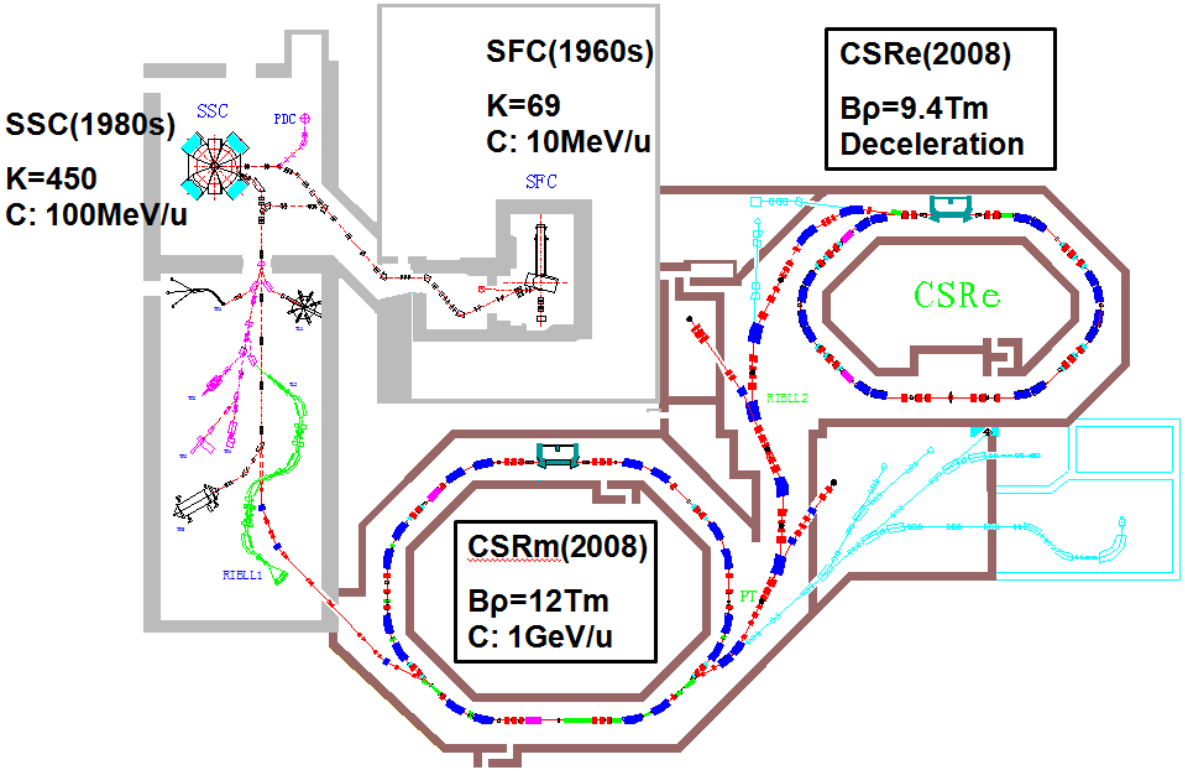
Cooperated with

Dieter Hoffmann, Alexander Golubev, Younian Wang, Xiaoan Zhang, Zhonfeng Xu from TUD, ITEP,DLUT,XYNU,XJTU

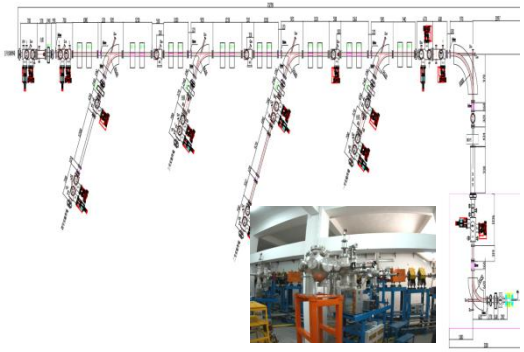
Main Facilities

➢Institute of Modern Physics (IMP,CAS), was founded in 1957. As one of the four national laboratory, the National Laboratory for the Heavy Ion Research Facility in Lanzhou (NL-HIRFL) was established at the IMP in 1991.

- Basic research in heavy ion physics
- Related interdisciplinary science
- Accelerator physics and technology
- Applications of nuclear technology

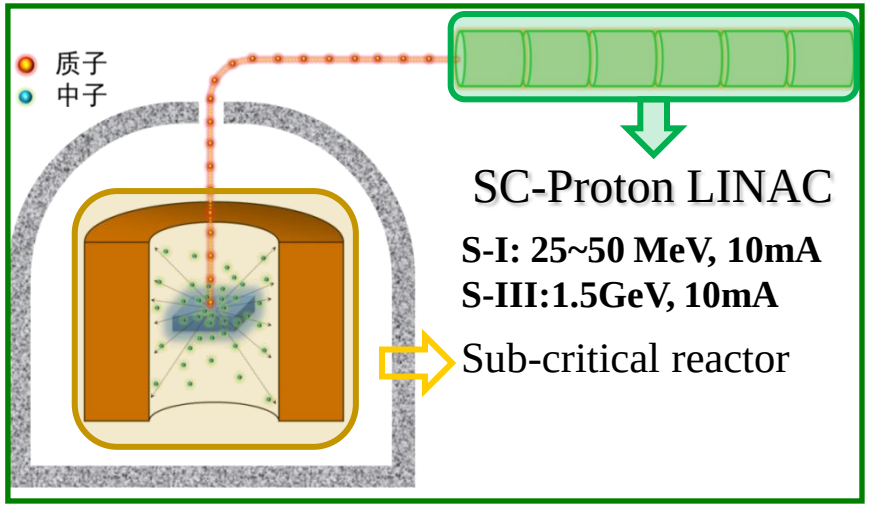


Layout of the main facilities at HIRFL

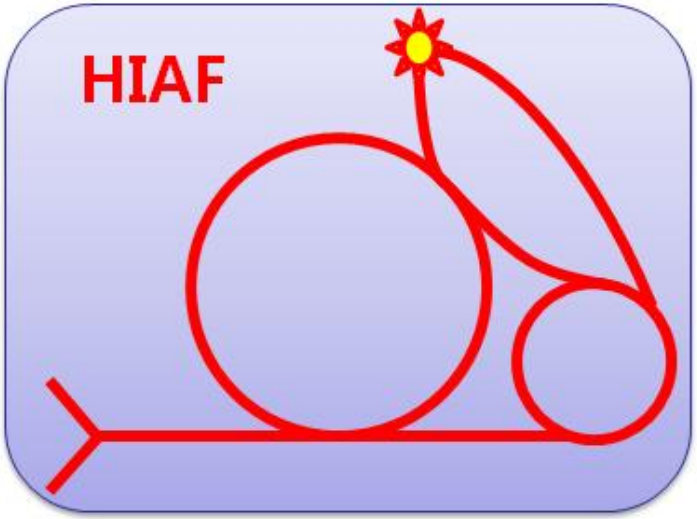


SC-ECR and 320kV ECR Platform

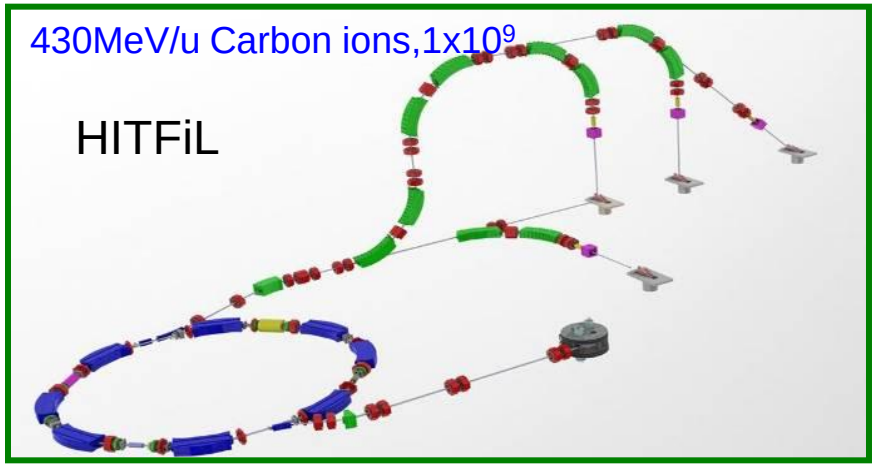
Future Facilities



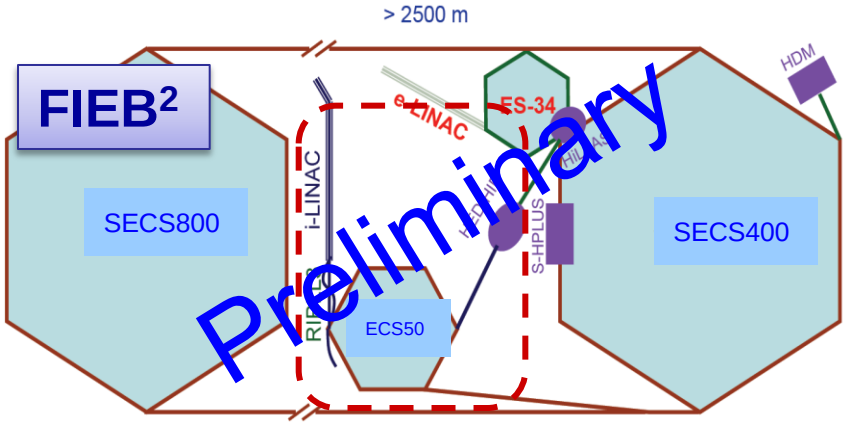
ADS Project 2011-2032
Budget approved: 1.78B RMB, 2011-2015



High Intensity heavy-ion Acc. Facility
Budget Proposed: 1.98B RMB, (2013-2017)



Heavy Ion Therapy Facility in Lanzhou
Budget approved: 0.5B RMB, 2011-2013

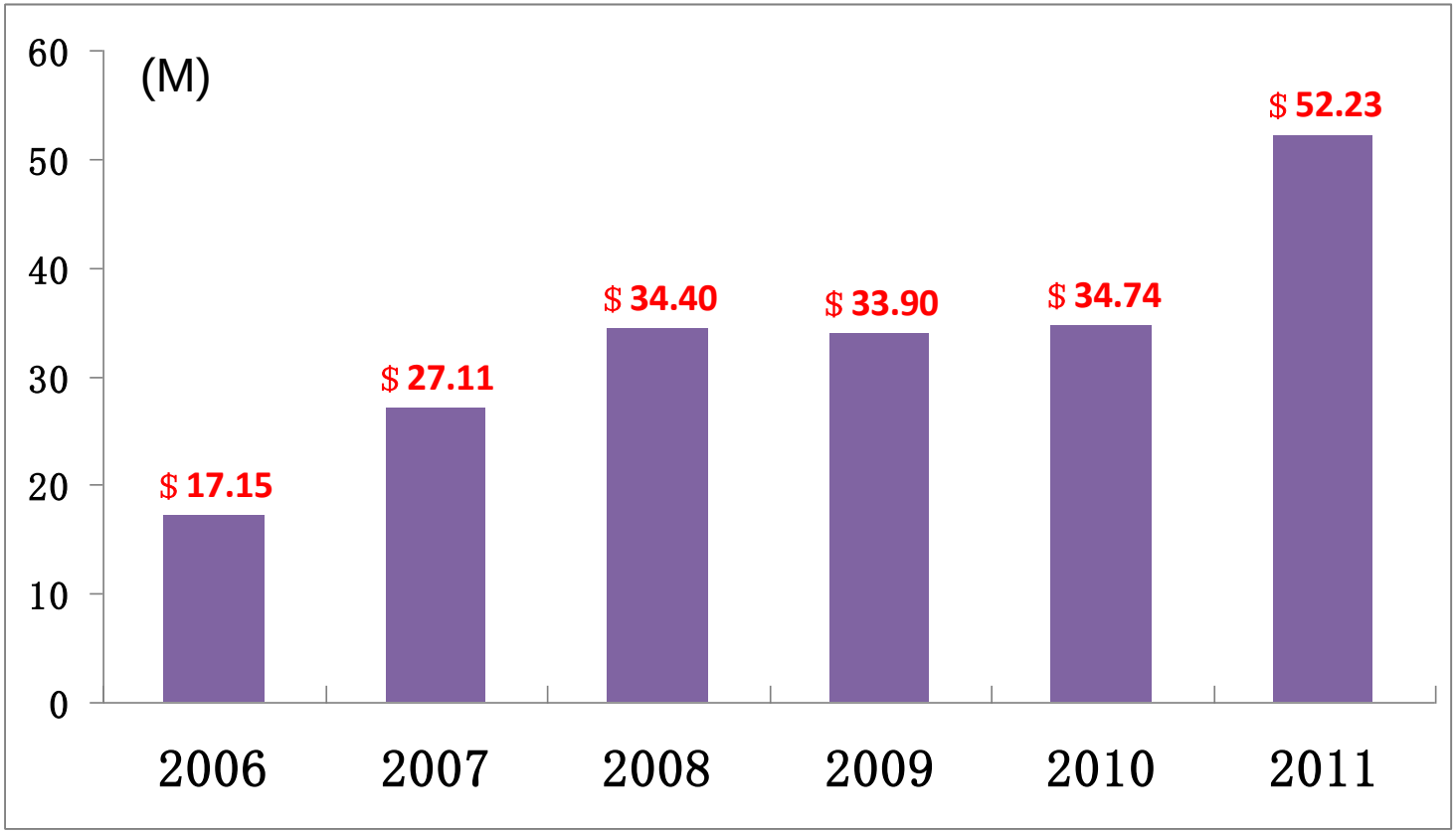


Facility of Ion, Electron, and Beta Beams
Budget poposed:14.7B RMB,2020-2035

Manpower & Budget

Total manpower now: 733 (+211) permanent staffs
+ 20 Post-docs
+ 150 temporary
+ 240 graduate students

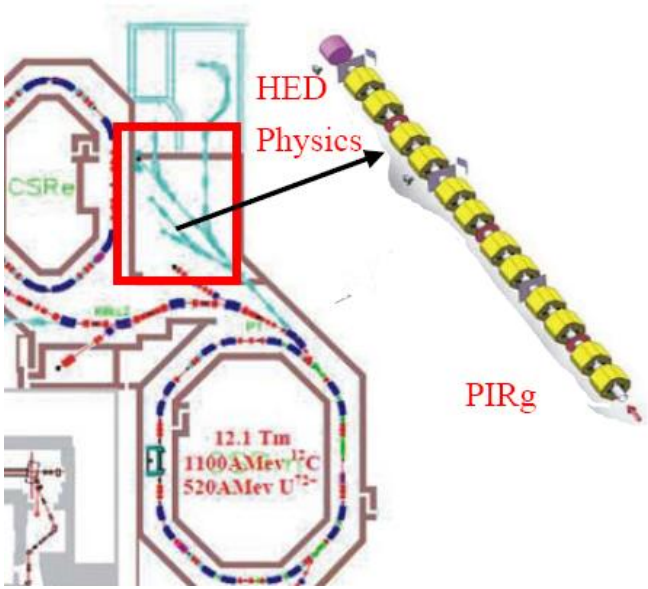
Budget in 2012: ~70M$ (expected)

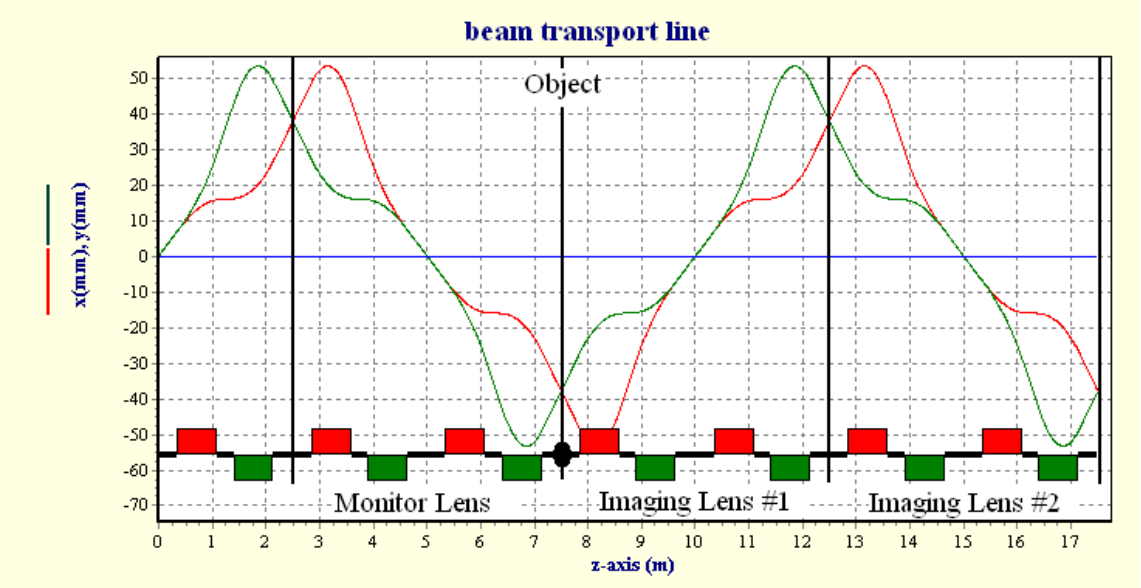


Current activities in plasma physics

- **Highly charged ion Physics(Atomic Pr. in Plasma)**
  - **Intense energy deposition**: Nano-etching effects, etc.
  - **Inner shell processes during collisions**: X ray emission
- **Beam plasma interaction**
  - **Energy loss and the charge effects**
  - **Transportation**: plasma lens and plasma stripper
- **High Energy Density(HED) matter generated by intense heavy ion beam**
  - **Heavy ion/proton radiography and other diagnostics**
  - Beam compressing, focusing and precisely controlling
  - Theories and simulations…

Proton/Ion Radiography @CSR





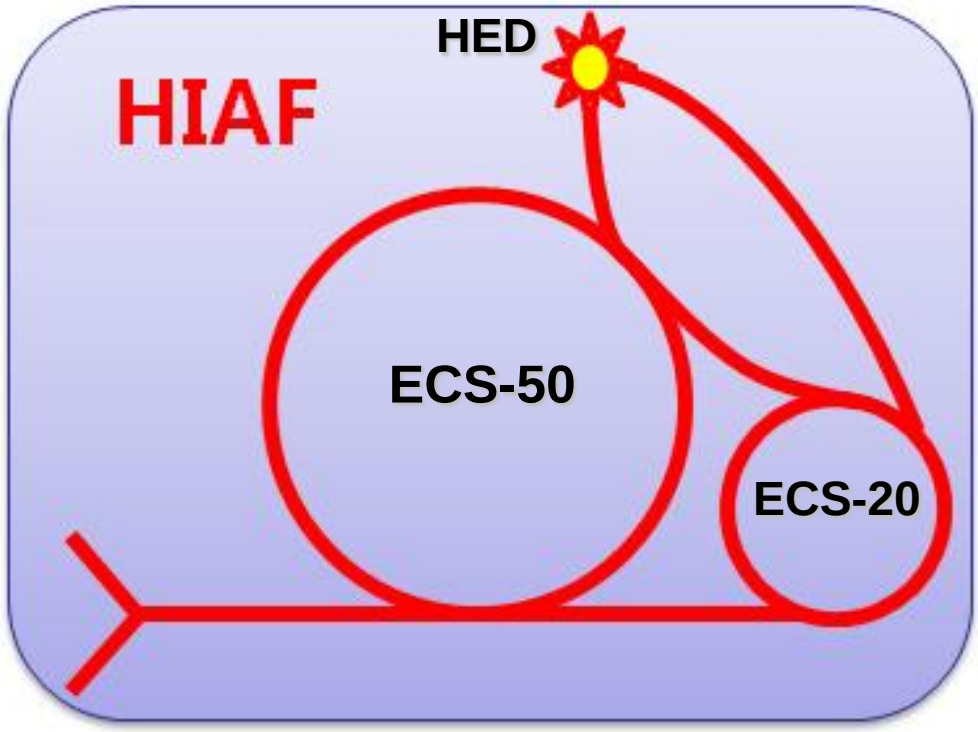
PIRg beam line (Proton/Ion Radiography) under construction

Main parameters

particle/energy（GeV/u）	p(0.8~2.2)，C(0.4~0.83)
Max. irrad. diameter（mm）	100
Intensity（proton）	1×10^{10}~1×10^{11}
Particle/pixel	10^4
pixel/frame	$10^{6\sim7}$
Q surface field（T）	1.2
Q bore radius（mm）	60

A test experiment with 2GeV proton is planned to be carried out in Sep. 2012.

HEDP at HIAF: Beam parameters



High Intensity heavy-ion Acc. Facility
(Heavy Ion Advanced Facility)

HIAF: the 12th 5-year-plan of China

Budget: 1.98b RMB (1.2b)

LINAC: 150MeV/u (50MeV/u)

Main ring: ECS50 (ECS45)

Add a booster ring(ECS20)

Add a cross-beam line( )

Typical Beam Parameters for HED

Preliminary

E: 500-3000MeV/u

N: $1*10^{12}$(ECS20);2-5*10^{12}(ECS50)

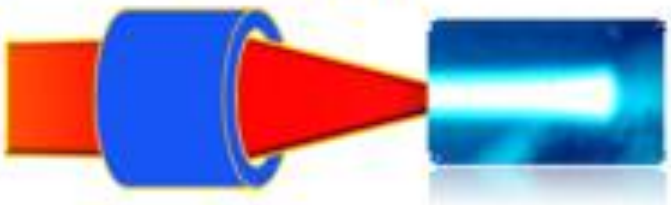
FWHM : <1mm

τ : <100ns (50ns after upgrading)

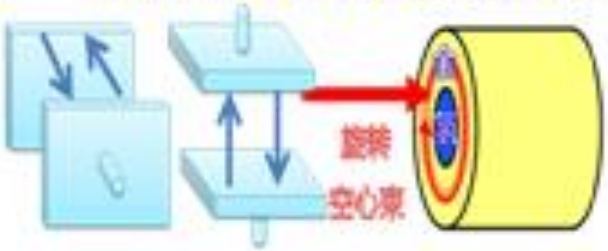
The TP for HIAF will be finalized and handed up to NDRC in Oct.2012.
After approved, constructions may be started from 2013.
NDCR: National Development and Reform Commission P.R.C.

HEDP at HIAF: Tech. Proposals

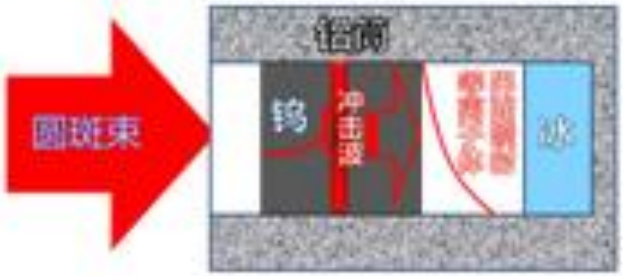
1. Direct heating



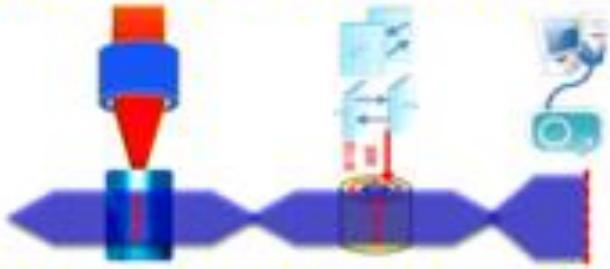
2. Ring-shaped compressing



3. Ramp Compression

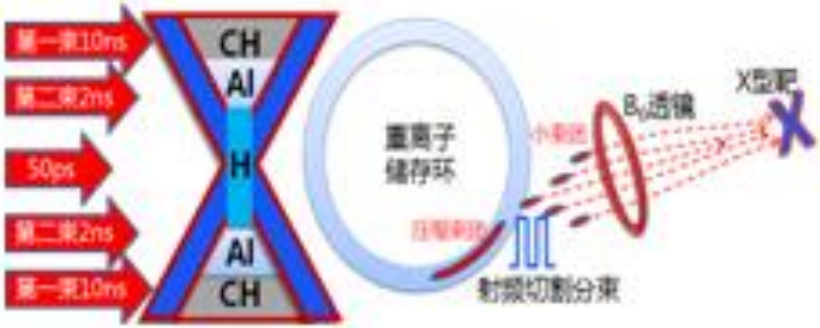


4. Double beams 1 (Radiography)



5. Double beam2 (Comp. + Heating)

6. X-Target



Your proposals are very much welcomed!