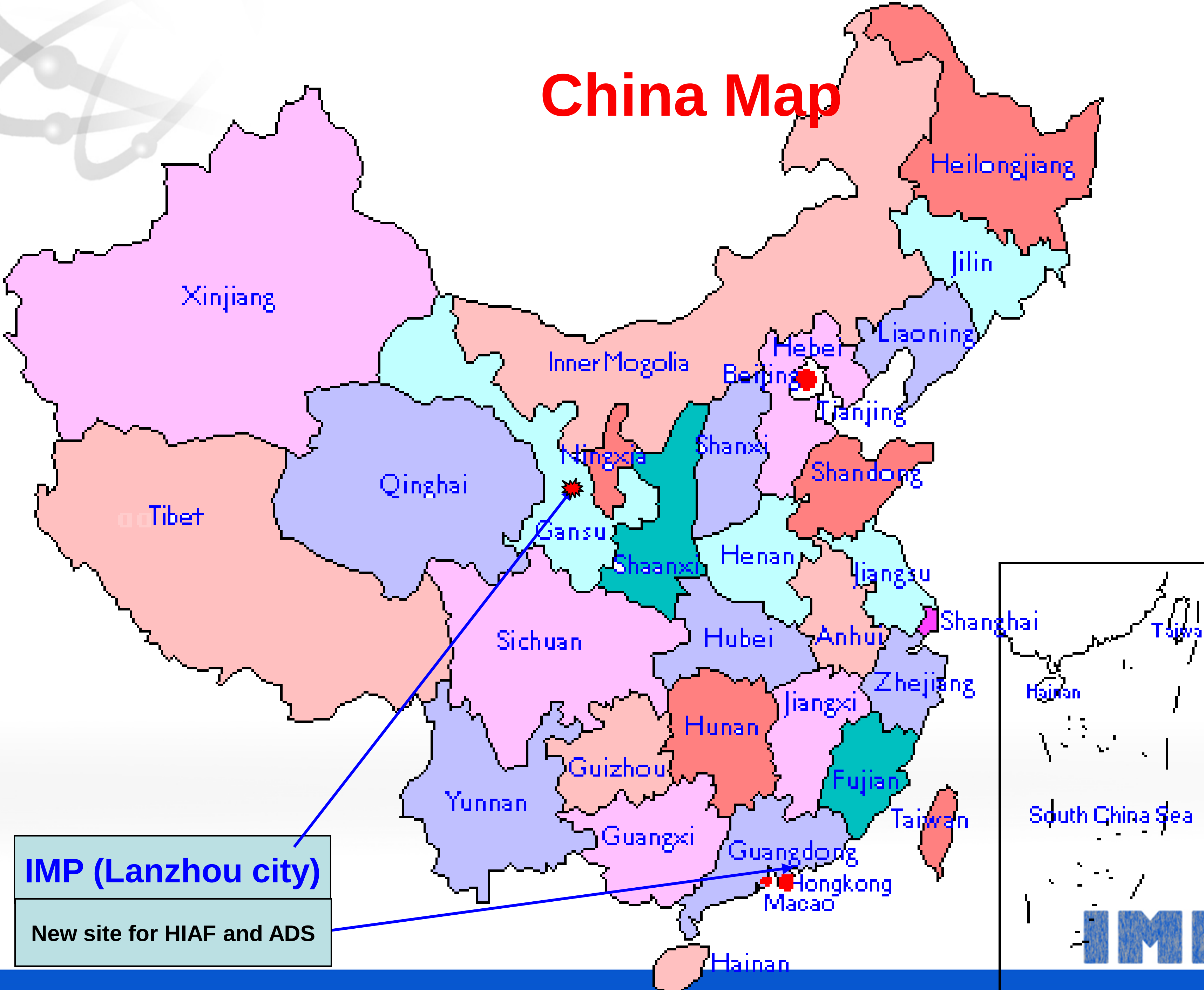
Brief Introduction of IMP

Institute of Modern Physics (IMP), CAS

YUAN Ping, 24/11/2014, IRFU-SCALAY

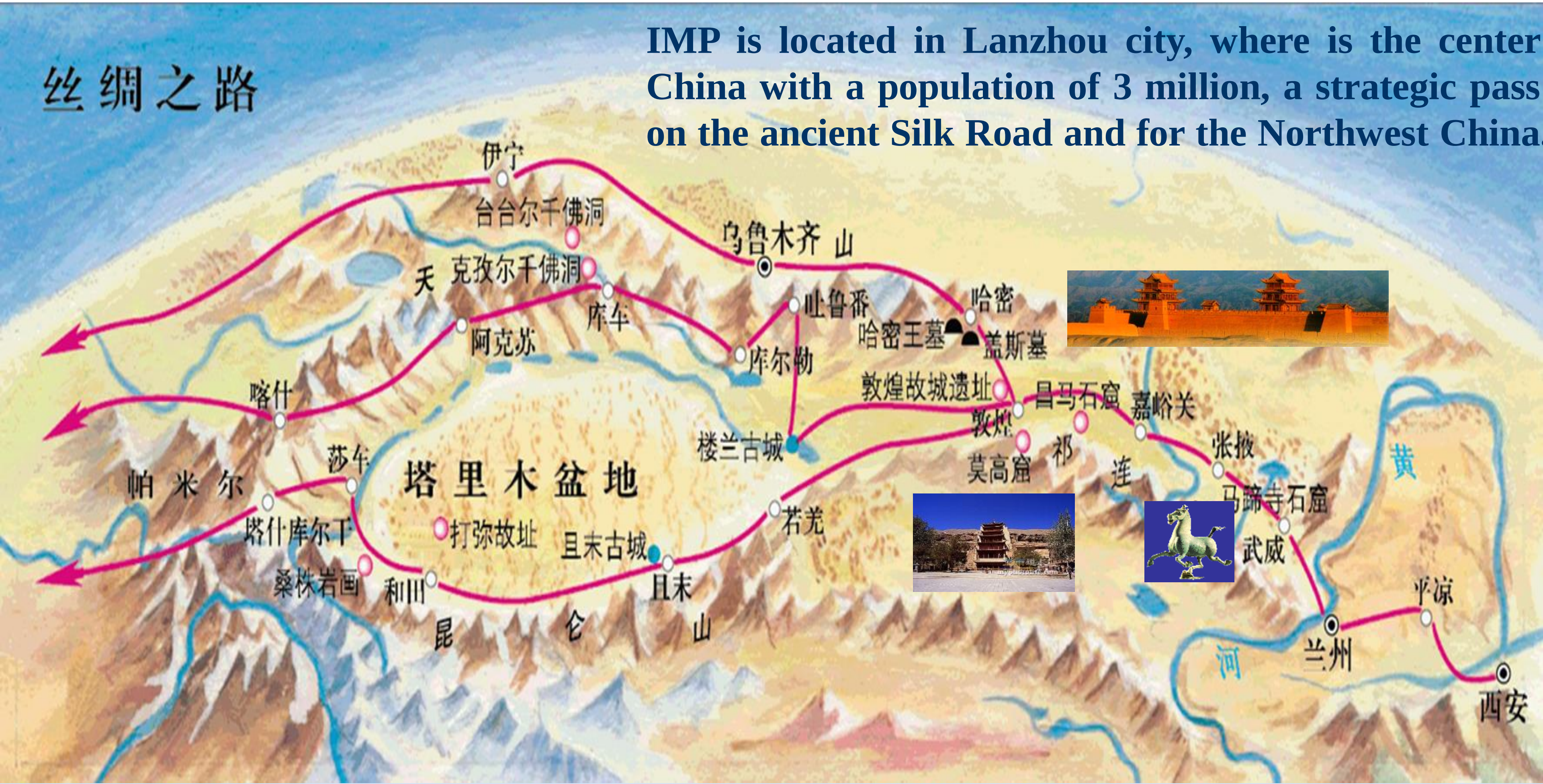
China Map



IMP (Lanzhou city)

New site for HIAF and ADS

IMP is located in Lanzhou city, where is the center China with a population of 3 million, a strategic pass on the ancient Silk Road and for the Northwest China.



A bird view of IMP

Mission of IMP

To probe the scientific issues commonly interested in heavy-ion physics and heavy-ion related interdisciplinary and to boost society developments by innovating nuclear technologies.

Scientific Activities

- **Fundamental researches on nuclear & atomic physics**
  - Reactions with exotic nuclei: elastic scattering, total cross-section, …
  - Nuclear spectroscopy: **mass measurement,** γ-spectroscopy, β-delayed neutron(proton) emission, …
  - Nuclear matter: properties of asymmetric nuclear matter
  - Chemistry of super-heavy elements, and synthesis of new isotopes
  - Key reactions in stellar evolution
  - Spallation & nuclear data for ADS project
  - High energy density physics
  - Hadron physics
  - HCI interaction with laser, electron, molecule, and surface
- **Applications with heavy ions and micro-beams**
  - Material: nano-tech., nuclear energy structural material, …
  - Radio-biology: **tumor therapy**, **mutation breeding**, …
- **Detector and electronics development**
  - Si detectors: Si(Au), Si(Li), Si-strip
  - Scintillator detectors: CsI, LaBr3, plastic sci., liquid sci. …
  - Gaseous detectors: IC, TPC, PPAC, MWPC, MWDC, MicroMeGAS, GEM, …
- **Key technique development related to Accelerator and ADS**

Highest Priorities

- Mass measurement
- key technique R&D related to ADS and HIAF
- Tumor therapy & mutation breeding

History

Prof. C.Z.Yang

Prof. B.W.Wei

Prof. Y.X.Luo

Prof. W.L.Zhan

Prof. G.Q.Xiao

1957–1984
IMP Foundation
SFC Construction
Low-energy nuclear physics
Heavy-ion Physics proposal

1984–1995
SSC Construction
CSR proposal
Heavy-ion physics

1995–1999
New Isotopes
RIBLL Construction
CSR approved
Heavy-ion Physics
Heavy-ion Applications

1999–2008
CSR Construction
Heavy-ion Physics
Heavy-ion cancer therapy

2008–Now
CSR experiments
Heavy-ion Application
ADS Program
Proposal of HIAF

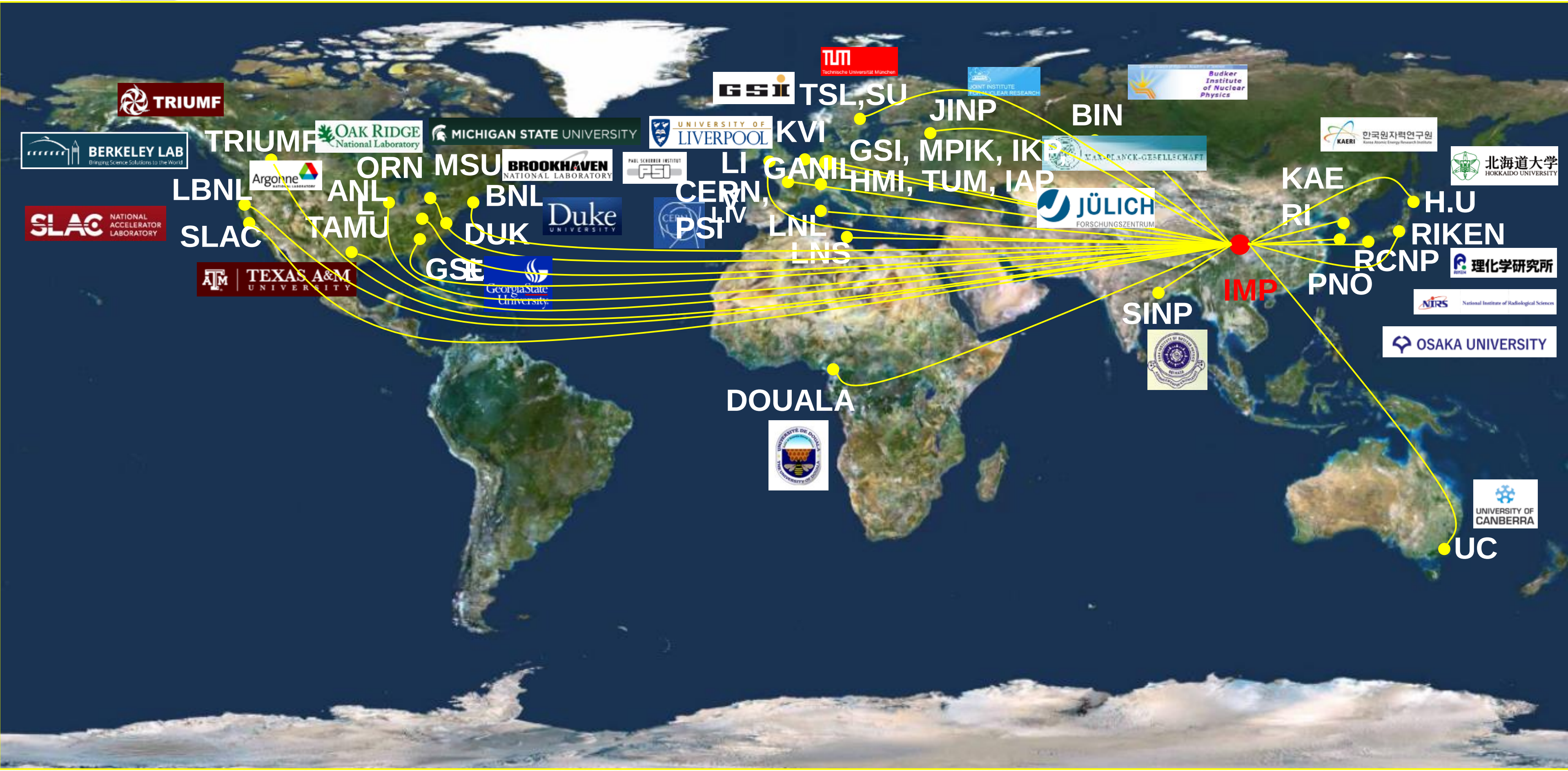
1.5m cyclotron K=69
Collaboration with former Soviet Union

SSC , K=450
Collaboration with GANIL and RIKEN

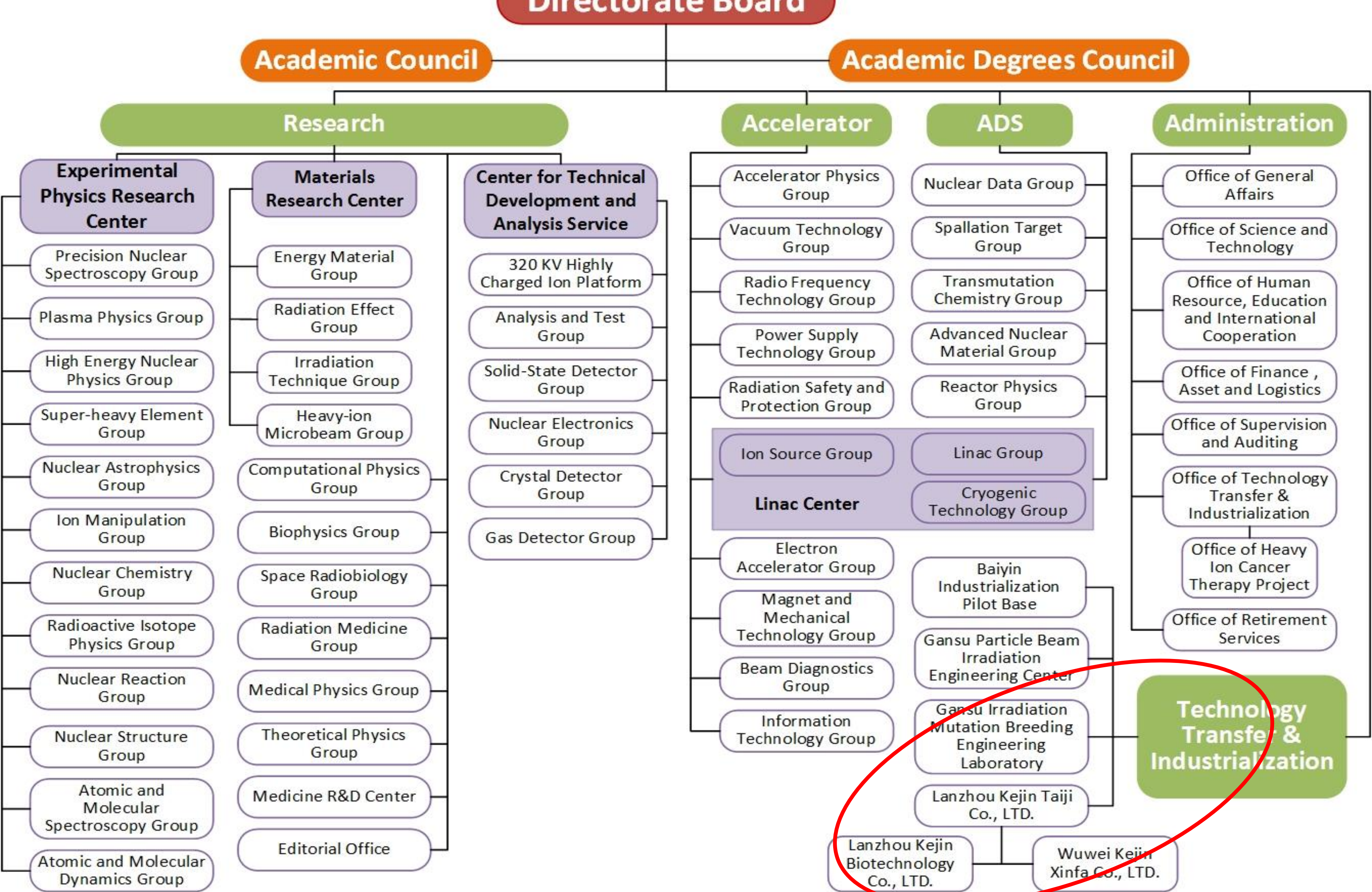
CSR (Cooling Storage Ring)
Collaboration with GSI,GANIL,RIKEN

International Collaboration

International Collaborative Relationships of IMP



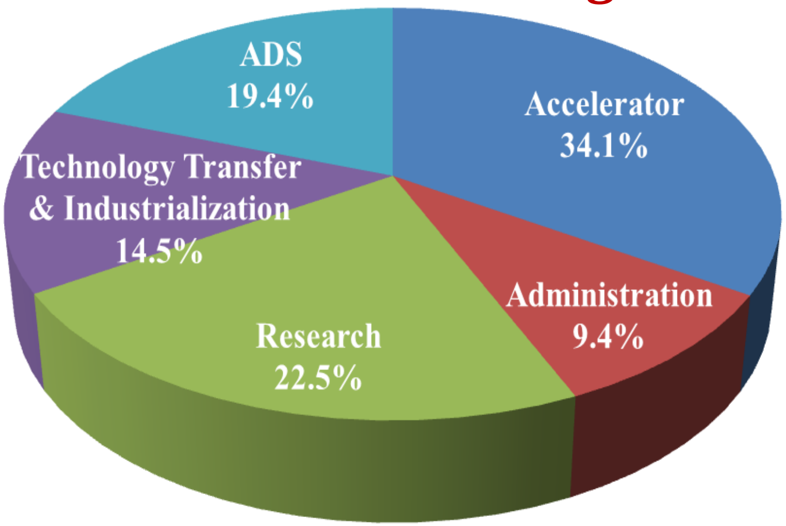
IMP has established collaborations with more than 30 research institutions, universities and national laboratories. Hitherto, 40 memoranda and agreements have been signed to promote the international cooperation.

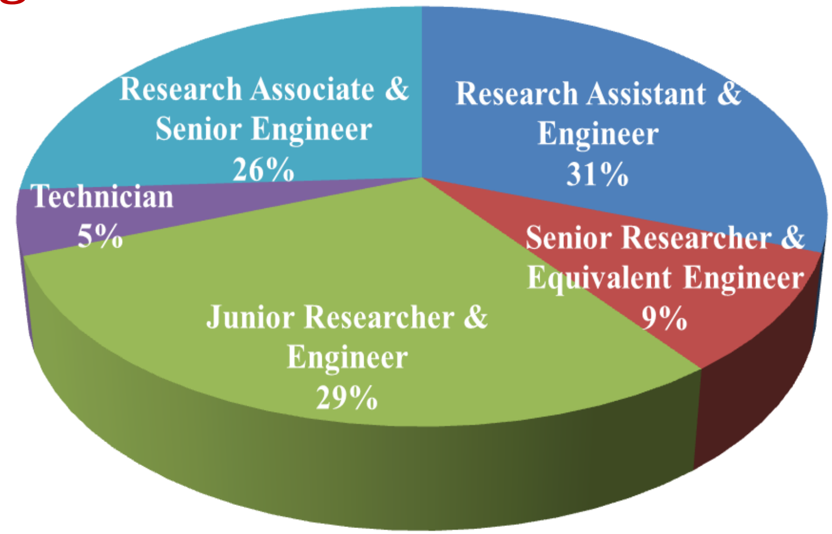


中国科学院近代物理研究所
Institute of Modern Physics , Chinese Academy of Sciences

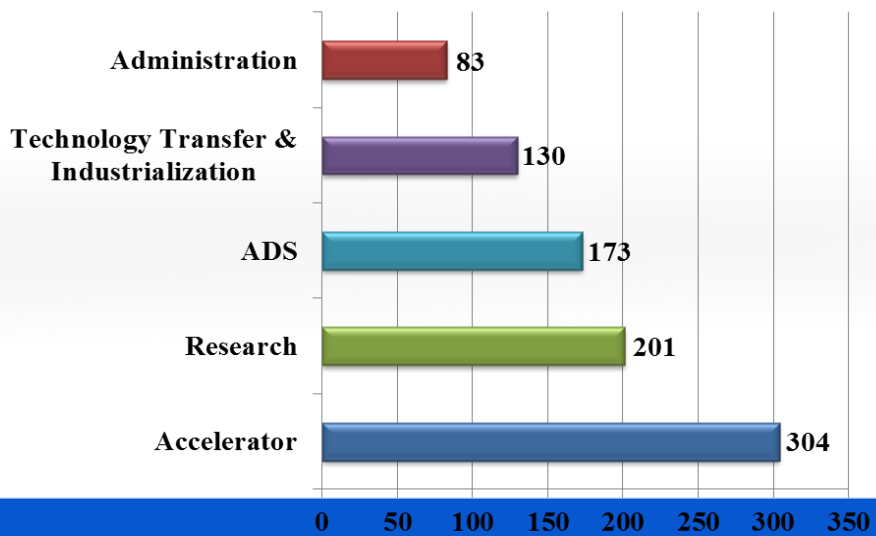
Human Resources

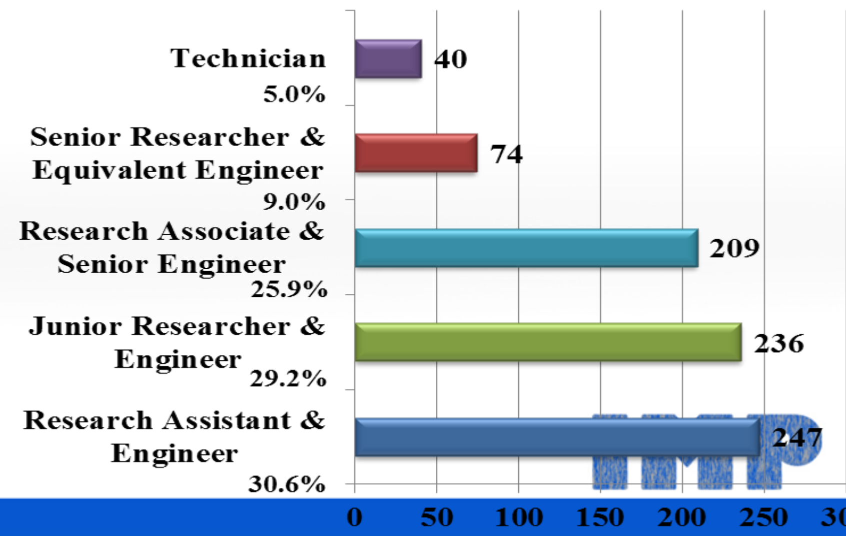
891 employees: 416 are under 35-years old, and 31% have doctoral degree and 44% have master degree. 296 postgraduate students



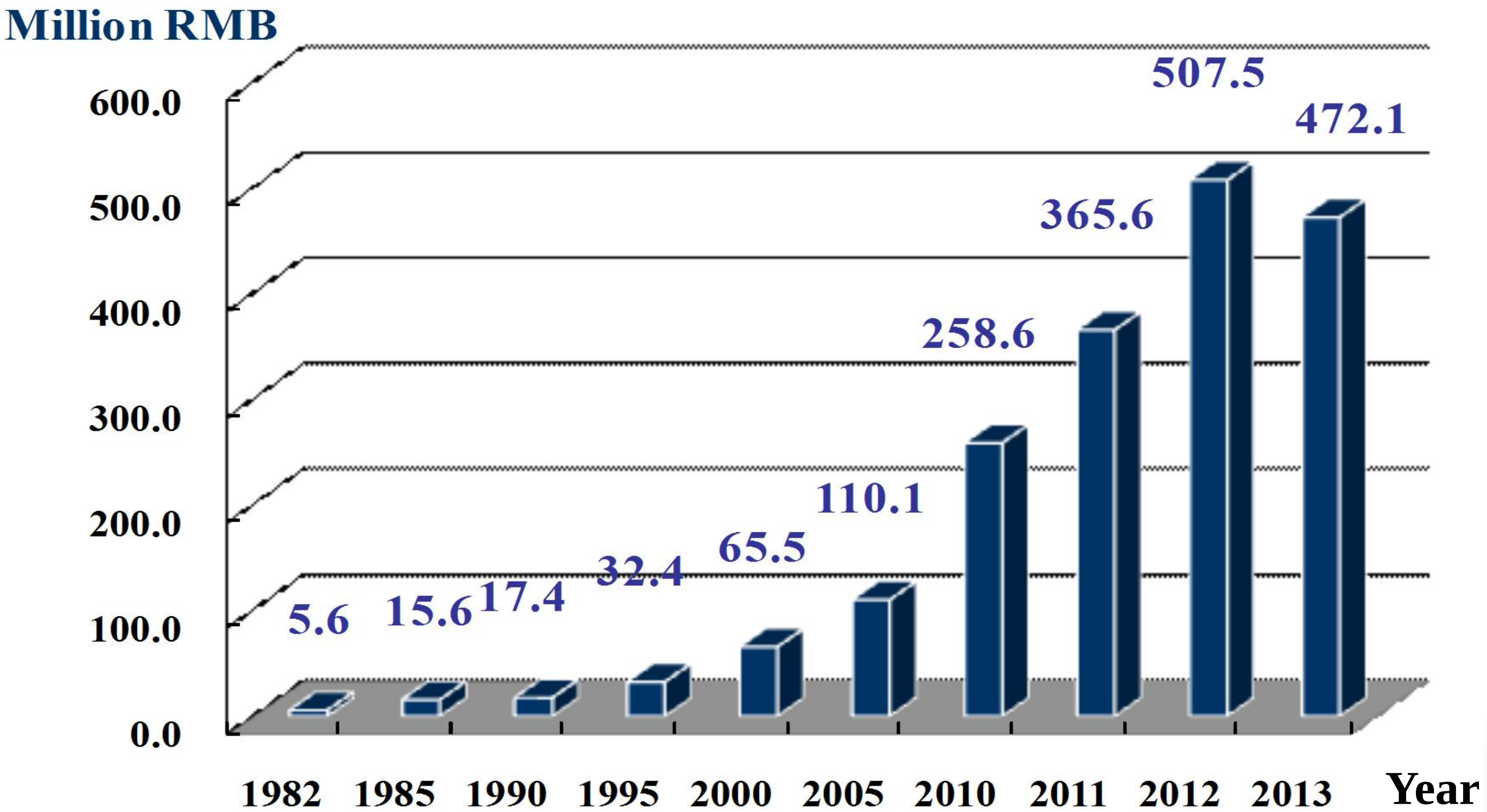


Staff distributions in the departments (left) and in academic titles (right)



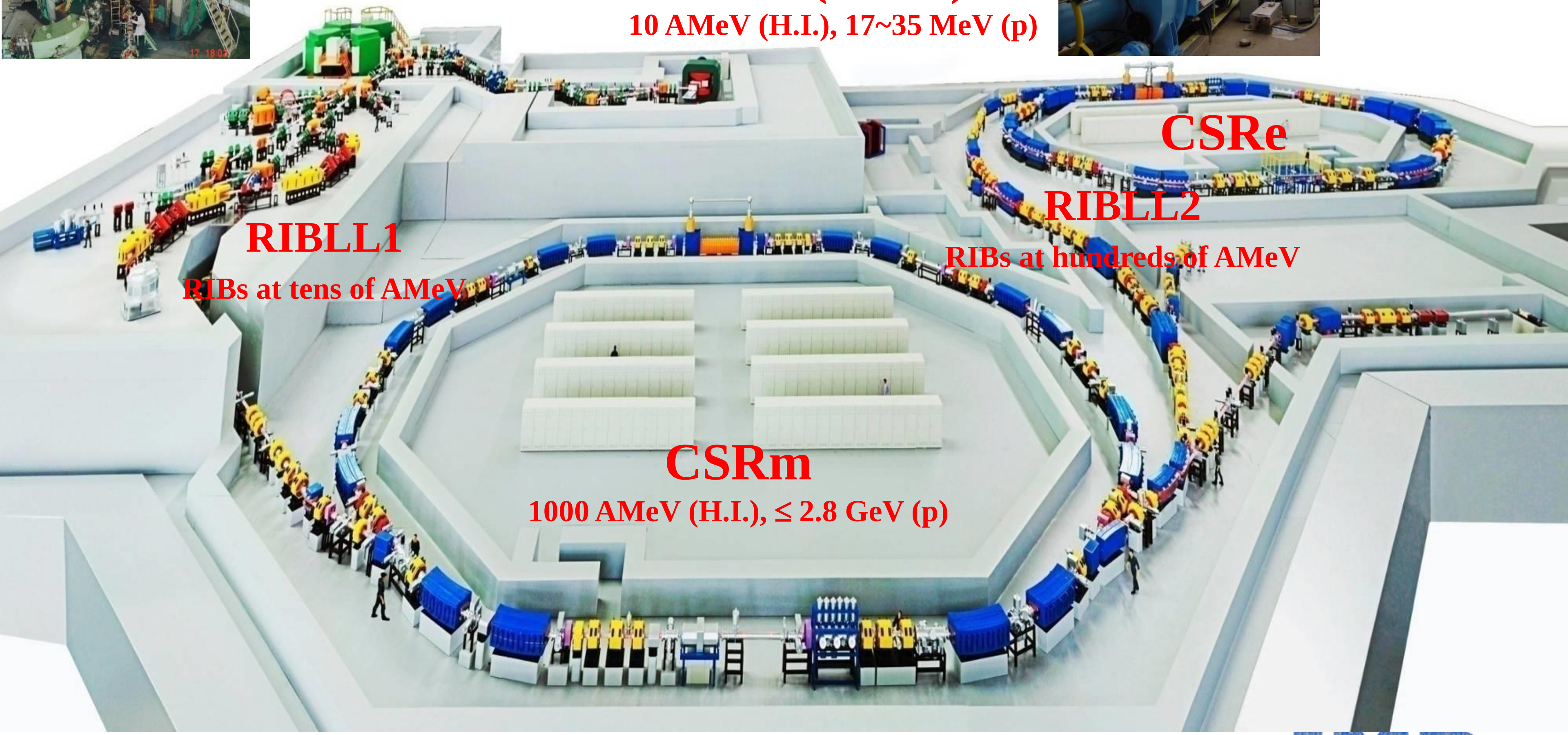


Total budget increased about 90 times since 1982



Existing Facility: HIRFL

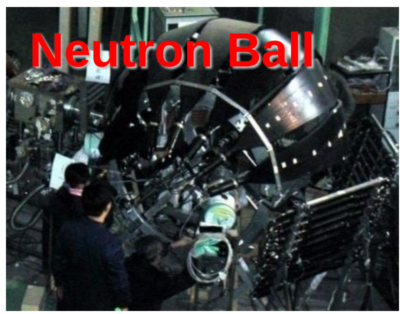
National Laboratory of Heavy Ion Accelerator in Lanzhou

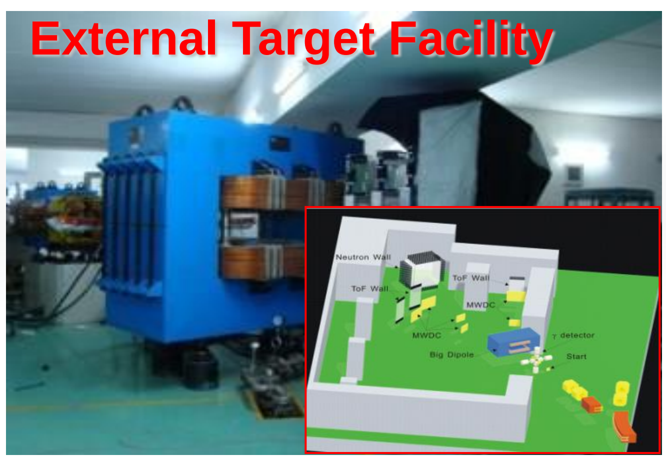


Heavy Ion Research Facility in Lanzhou (HIRFL)

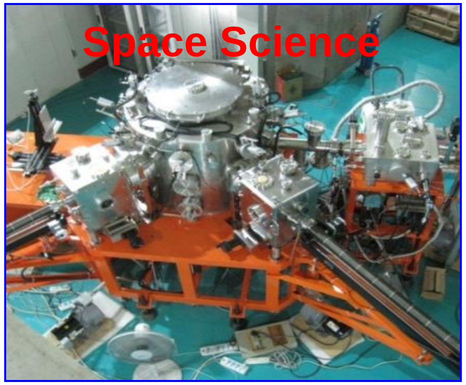
Main Setups for fundamental study

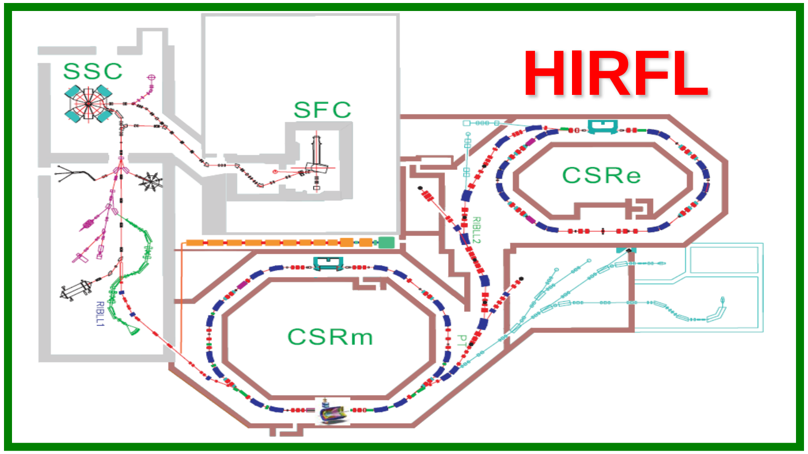
Nuclear structure, Reaction mechanism, and Nuclear Astro-physics





Main Setups for application study





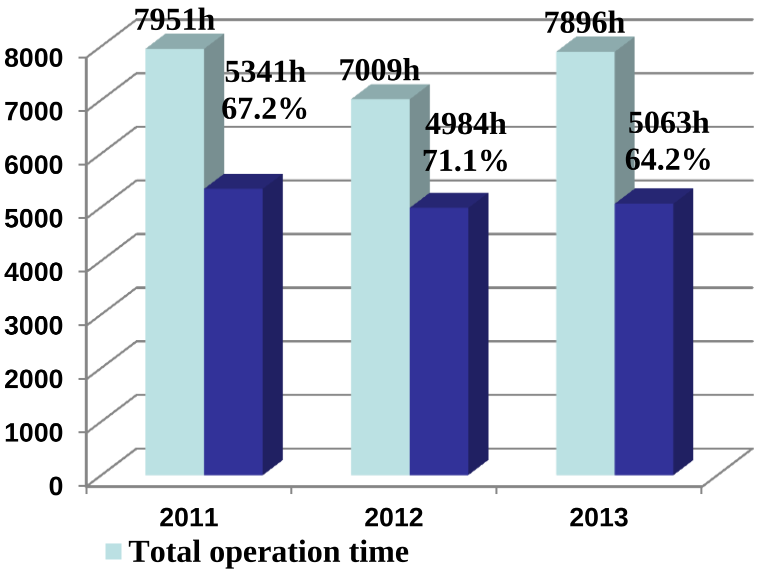
HIRFL Typical Beams

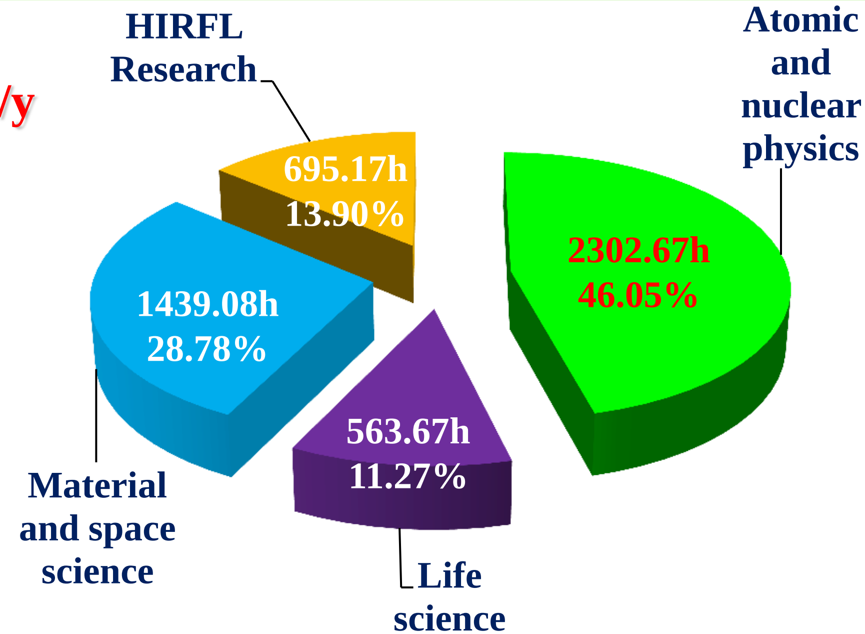
Ions	SFC		SSC		CSR	
	Energy AMeV	Intensity eμA	Energy AMeV	Intensity eμA	Energy AMeV	Intensity ppp
H_2^{1+}	10	7			400	1.40E+08
$^{9}Be^{3+}$	6.89	0.55				
$^{12}C^{5+/6+}$	8.47	2.7	100	0.4		
$^{12}C^{3+}$	4.2	8			122	1.70E+09
$^{12}C^{4+/6+}$	7	10			1000	1.00E+09
$^{14}N^{5+/7+}$	6.957	6	80	0.4		
$^{18}O^{6+/8+}$	6.17	5.9	70	0.45		
$^{18}O^{6+/8+}$	7	4			305.4	1.10E+09
$^{19}F^{7+}$	6.6	3				
$^{22}Ne^{7+/10+}$	6.17	9			70	2.70E+09
$^{26}Mg^{8+/12+}$	6.17	3.5	70	0.35		
$^{28}Si^{9+/14+}$	6.645	2.2	76	0.15		
$^{36}Ar^{8+}$	2.0725	16	22	3.3	368	3.90E+08
$^{35}Cl^{12+}$	6	1				
$^{32}S^{11+/16+}$	7.112	4.8	82	0.2		
$^{22}Ne^{7+/10+}$	6.17	9			70	2.70E+09
$^{40}Ca^{12+}$	5.625	3.5				
$^{58}Ni^{19+}$	6.3	2.4			463.36	8.30E+07
$^{58}Ni^{15+/24+}$	4.53	2.8	50	0.1		
$^{78}Kr^{19+/28+}$	4	4.2			487.9	9.50E+07
$^{86}Kr^{17+/26+}$	2.345	5	25	0.42		
$^{129}Xe^{27+}$	3	4.5			235	7.20E+07
$^{129}Xe^{27+}$	1.844	1.7	19.5	0.4		
$^{112}Sn^{26+/35+}$	3.7	2			392	1.70E+07
$^{208}Pb^{27+}$	1.1	1				
$^{209}Bi^{31+}$	0.911	0.7	9.5	0.06		
$^{209}Bi^{36+}$	2	2			170	1.20E+07
$^{238}U^{32+}$	1.22	1			100	4.40E+07

~23 different beam species (~10 new) provided yearly by HIRFL

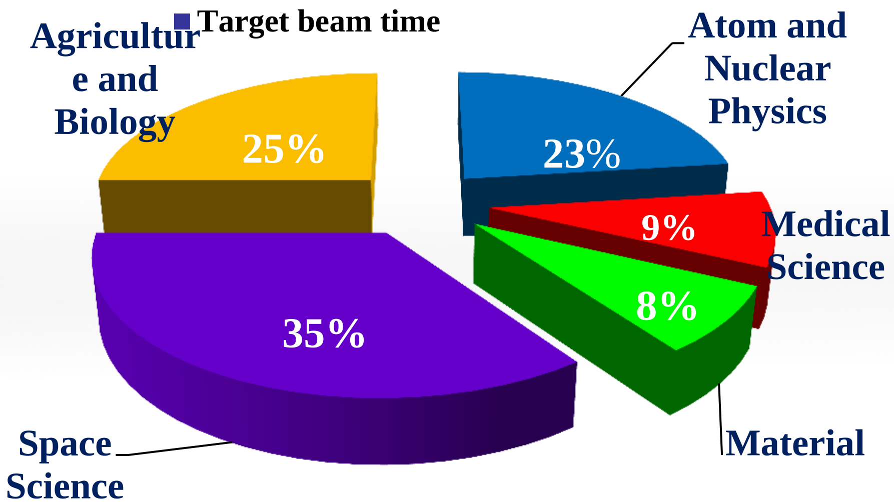
HIRFL Status

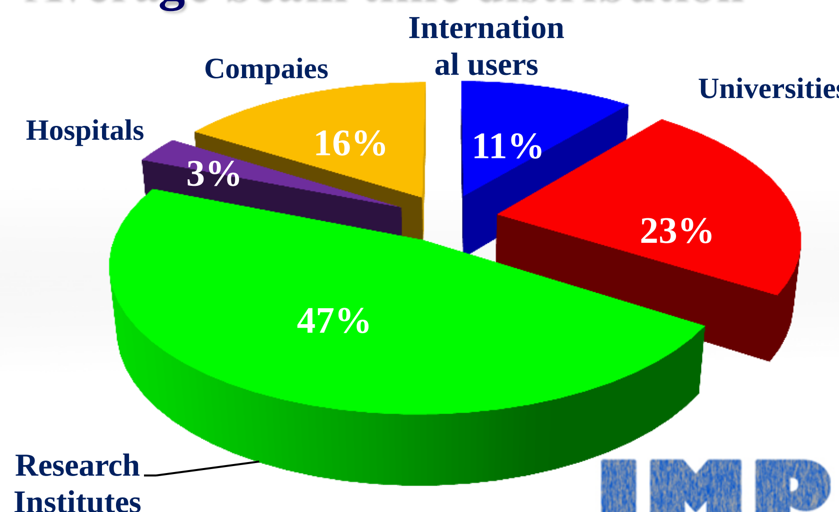
Operation time >7000hrs/year, target time ~5000hrs/y, applied for beam time >14000hrs/y





Average beam time distribution



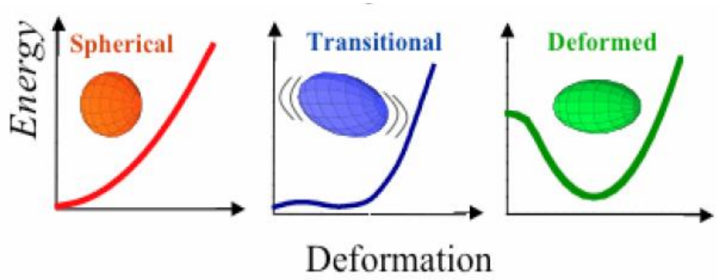


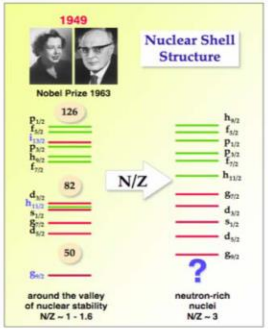
Distribution in Research Fields

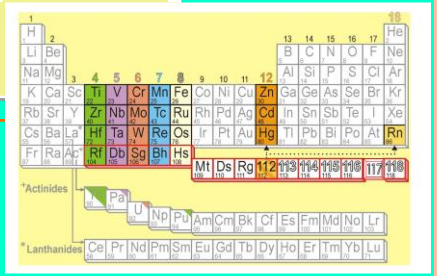
Distribution of ~200 Users Units

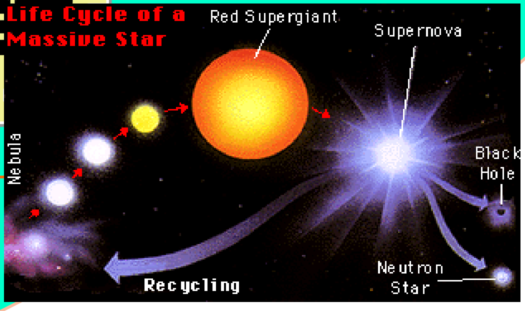
Nuclear Physics

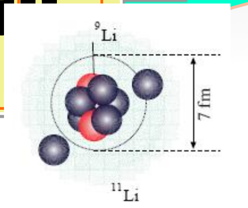
Exploring the limits of nuclear stability
Nuclear structure and nuclear astro-physics









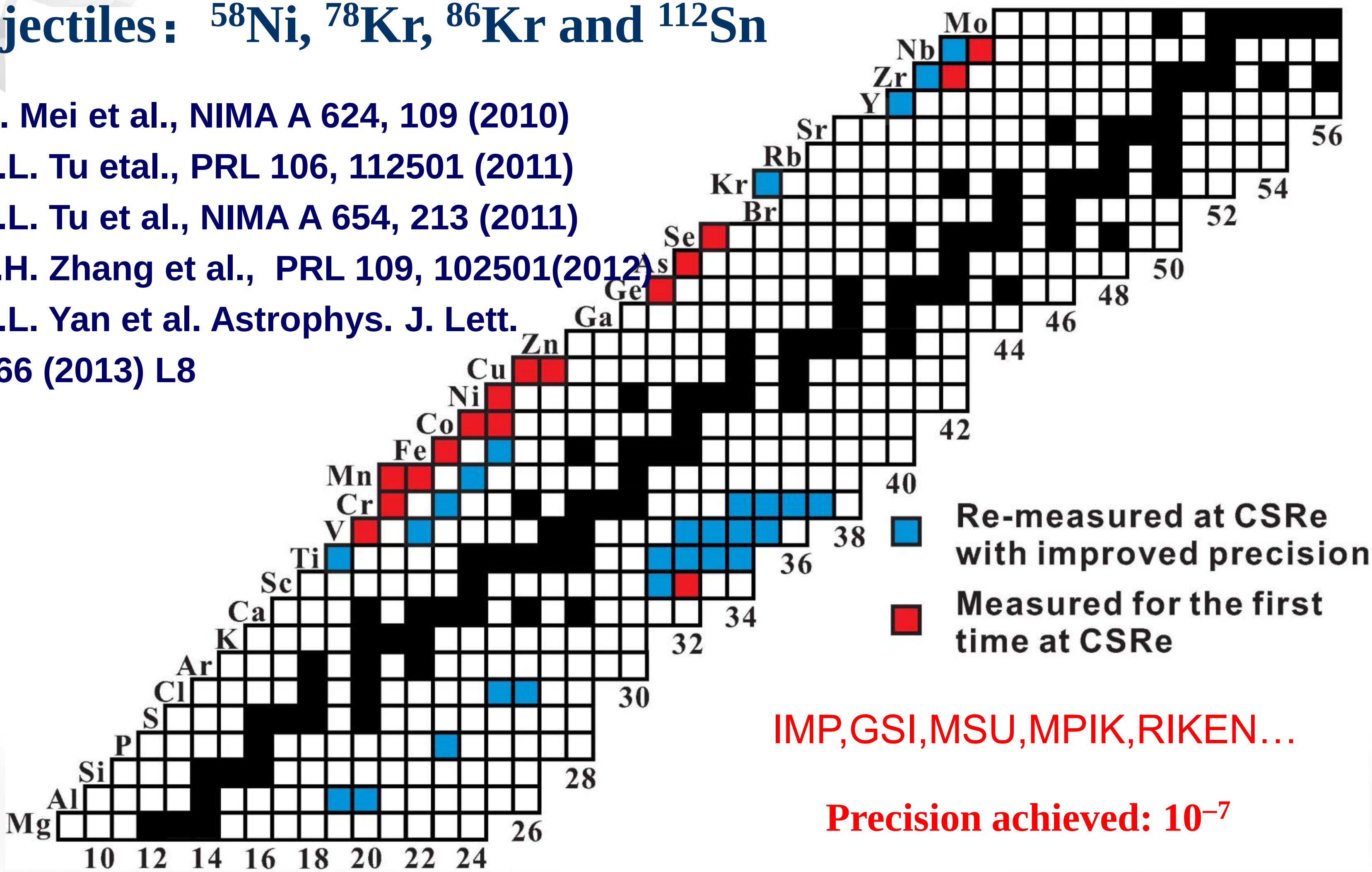


- Precise mass measurements for short-lived nuclei
- Synthesis of new isotopes near the proton-drip line
- Structure and reaction mechanism with exotic beams
- Properties of asym. nuclear matter at high density
- Decay and chemical properties of super-heavy nuclei
- Evolution of collective motion in complex nuclei
- Explosive nuclear astro-physical phenomena

Mass measurement results at CSRe

Projectiles: ^{58}Ni, ^{78}Kr, ^{86}Kr and ^{112}Sn

1. B. Mei et al., NIMA A 624, 109 (2010)
2. X.L. Tu etal., PRL 106, 112501 (2011)
3. X.L. Tu et al., NIMA A 654, 213 (2011)
4. Y.H. Zhang et al., PRL 109, 102501(2012)
5. X.L. Yan et al. Astrophys. J. Lett. 766 (2013) L8



IMP,GSI,MSU,MPIK,RIKEN…

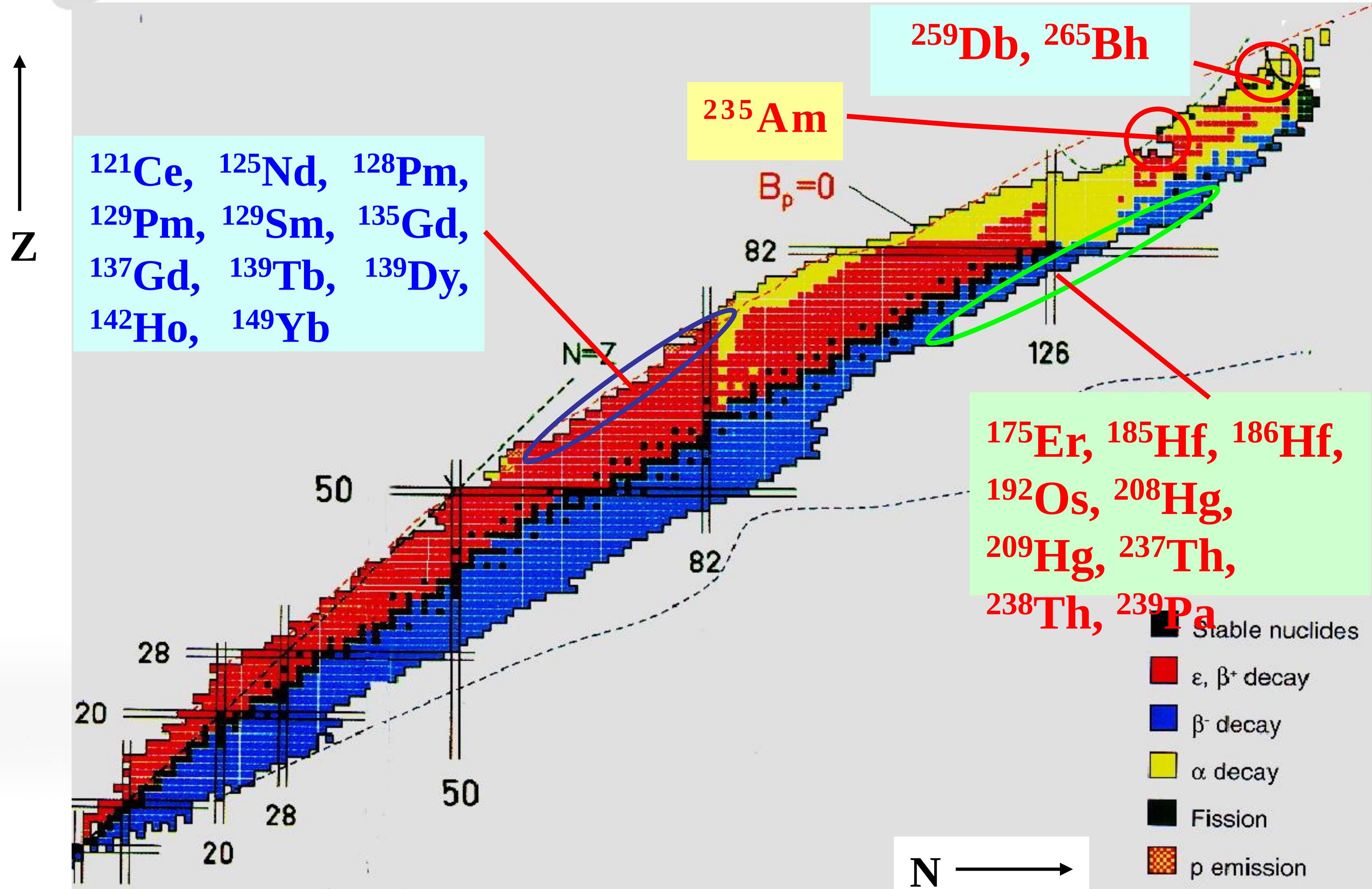
Precision achieved: 10^{-7}

1) 1st time measured for 16 nuclei, and results of ^{49}Fe, ^{53}Ni, ^{63}Ge, ^{65}As, ^{67}Se published

2) Precision improved for 26 nuclei, and results of ^{41}Ti, ^{45}V, ^{45}Cr, ^{47}Cr, etc. published

Synthesis of New Isotopes

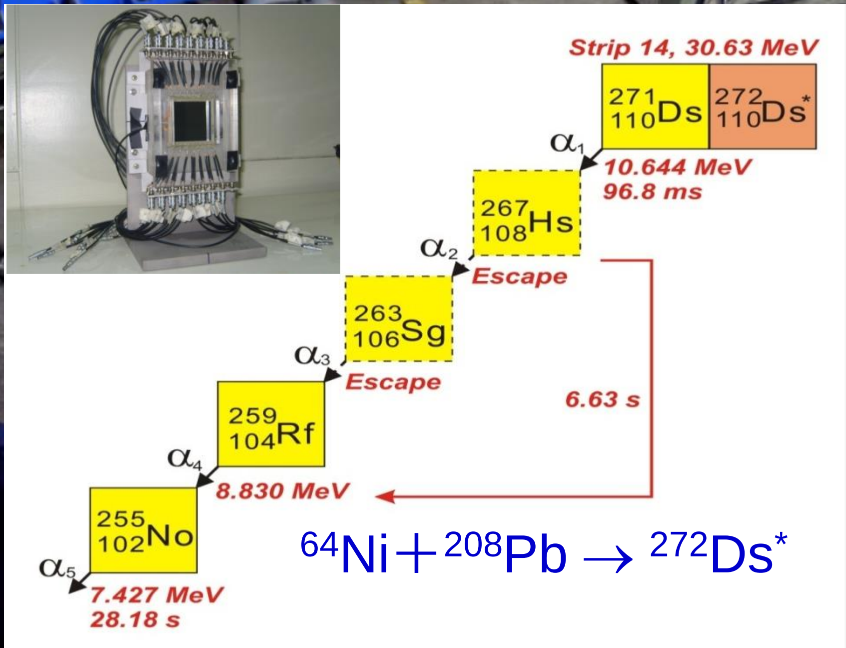
More than 20 New Isotopes synthesized at IMP



SHN (Super Heavy Nuclei) Study

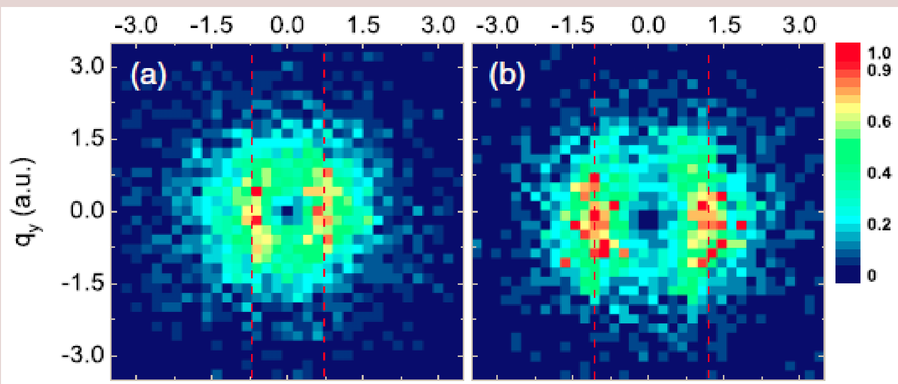
Gas Filled Recoil Separator and Synthesis of Isotope ^{271}Ds

- Tested by α source
- Tested by target recoils
- Tested with typical reactions

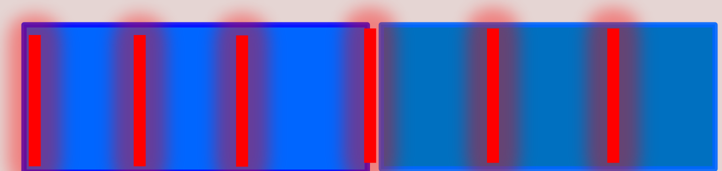


Two-center interference observed in a collision between H_2^+ projectile used as a double slit and helium target atoms using kinematically complete technique

IMP and MPIK collaboration, see Xinwen Ma's talk



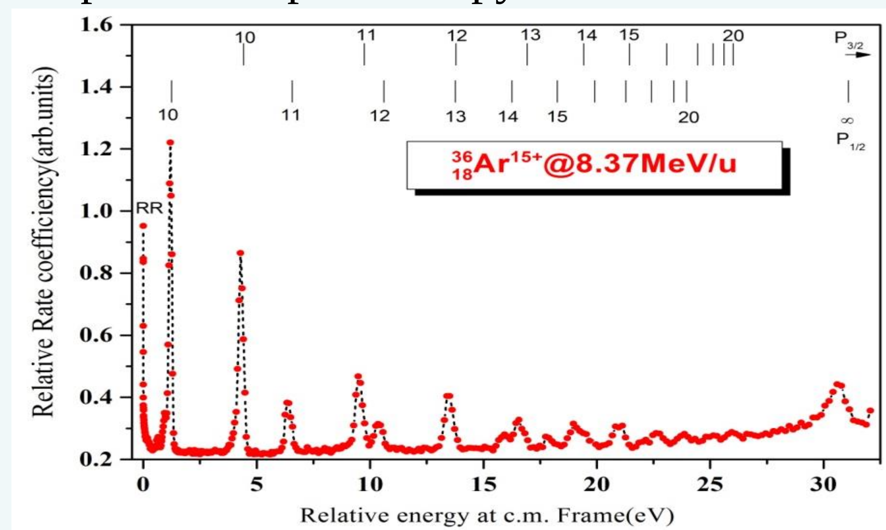
Momentum transfer pattern @ inter-nuclear distances



Theoretical optical interference patt

Dielectronic recombination spectroscopy at cooler storage ring

The resolution of dielectronic recombination spectroscopy is of 100meV. Paved the way to precision spectroscopy at CSR.

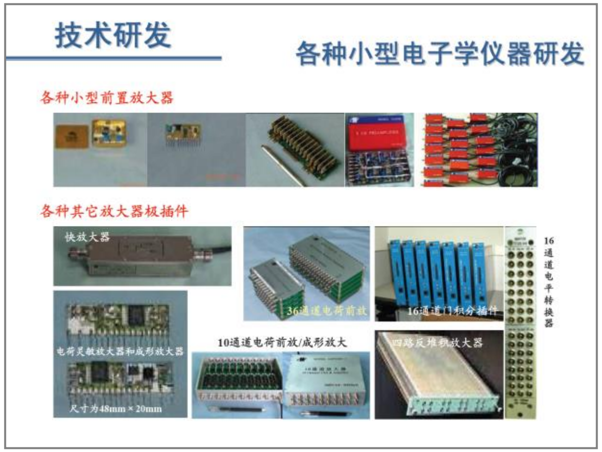


- Phys. Rev. Lett. 112, 023201 (2014)
- Phys. Rev. A 90, 022706 (2014)
- Nucl. Instr. Meth. A736, 75 (2014)
- Phys. Rev. A 87, 062510 (2013)
- Phys. Rev. A 86, 012709 (2012)
- Phys. Rev. A 84, 042710 (2011)

Electronics and Detectors

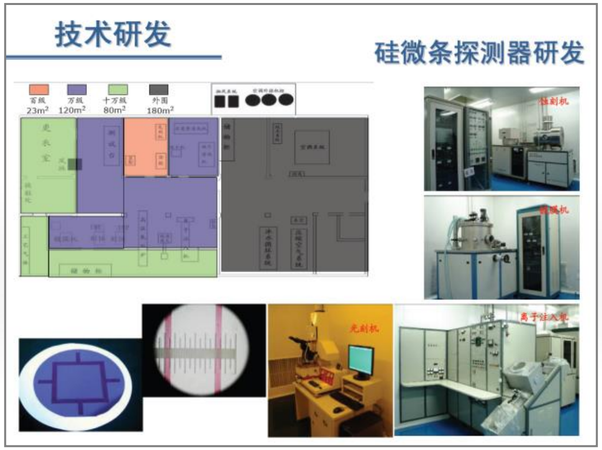
ASIC Based electronics

Conventional electronics



Dedicated electronics

Si strip detectors



Scintillator

Gaseous detectors

IMP

Cancer Therapy

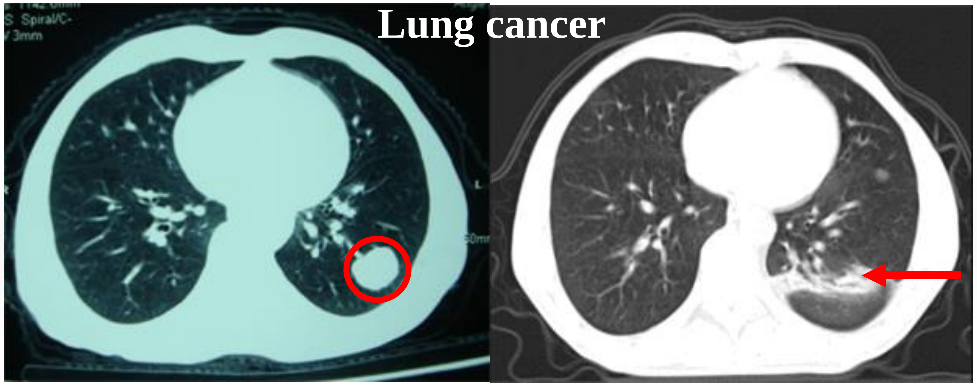
In collaboration with local hospitals, >210 patients of ~ 10 kinds of tumors treated

Clinical device for superficial tumors

Clinical device for deeply seated tumors

Before treatment

18 months after irradiation with carbon ion beams



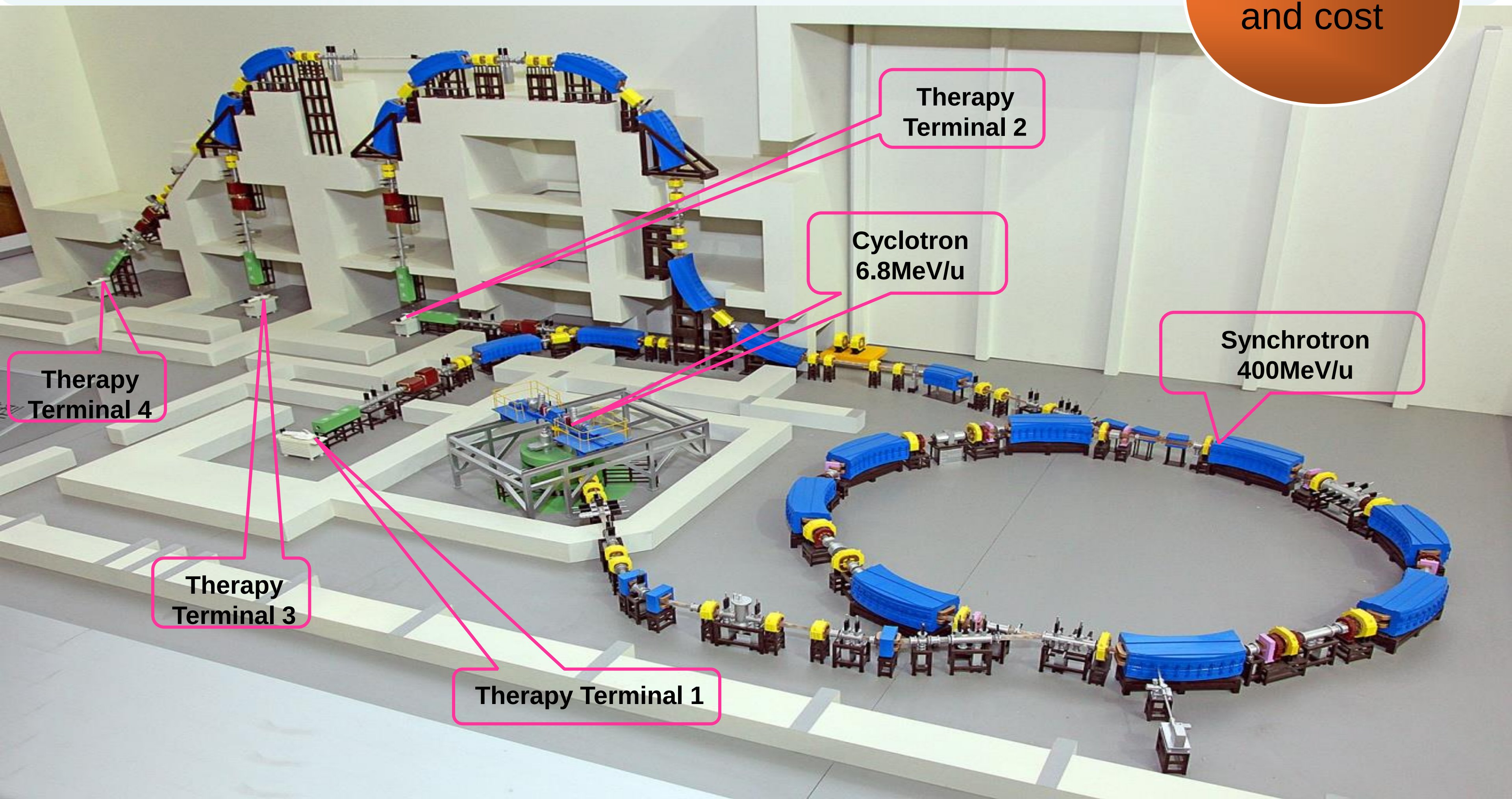
Before treatment

5 months after irradiation with carbon ion beams

Design of Demo Heavy-Ion Cancer Therapy Facility

- Combination of cyclotron injector & synchrotron
- Compact synchrotron with circumference of 56.6m
- 4 treatment terminals
- Proprietary intellectual property rights

Reduce size and cost



Demo Facilities

Two heavy-ion treatment facilities are under construction at Lanzhou city and Wuwei city in Gansu province, and more are under business discussion now

IMP

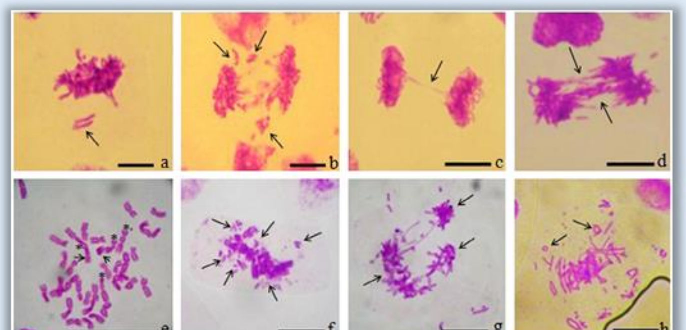
Heavy-ion Mutation Breeding

Mutation Research

Heavy-ion mutation technique

- High mutation frequency
- Broad spectrum of phenotype
- Complex chromosome rearrangement

Wheat

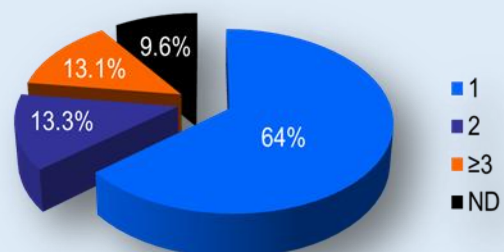


Mitotic chromosome aberration

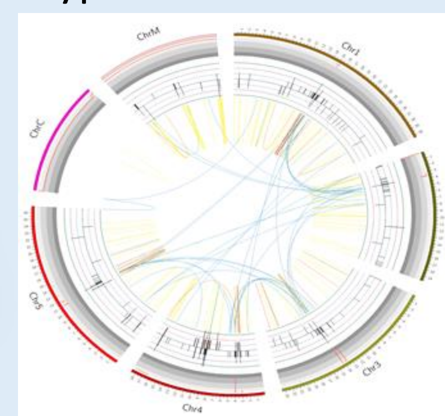
Arabidopsis thaliana

Category of mutation Phenotype	No. of mutants	Mutation rate(%)
Leaf mutants	667	2.33
Stem mutants	77	0.27
Flower mutants	38	0.13
Pre-maturing	442	1.55
Longevity	7	0.02
ND[a]	132	0.46
Total	1363	4.77

Classification of phenotypic variations



Pleiotropic phenotypes



SNP/InDel genome analysis

New Crops and Microbes

A lot new varieties of Crop and Microbes were obtained.

Energy crops

-- *Sweet sorghum*

JIN TIAN No. 1

Horticulture plants

-- *Tradescatia fluminensis*

Leaf flower

Chinese herbal plants

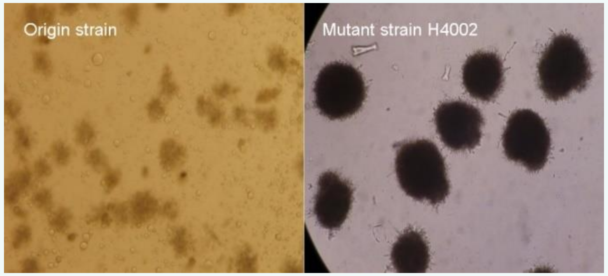
-- *Astragalus and Codonopsis* bre

LONG QI No. 3; Wei Dang No.3

Industrial Microbes

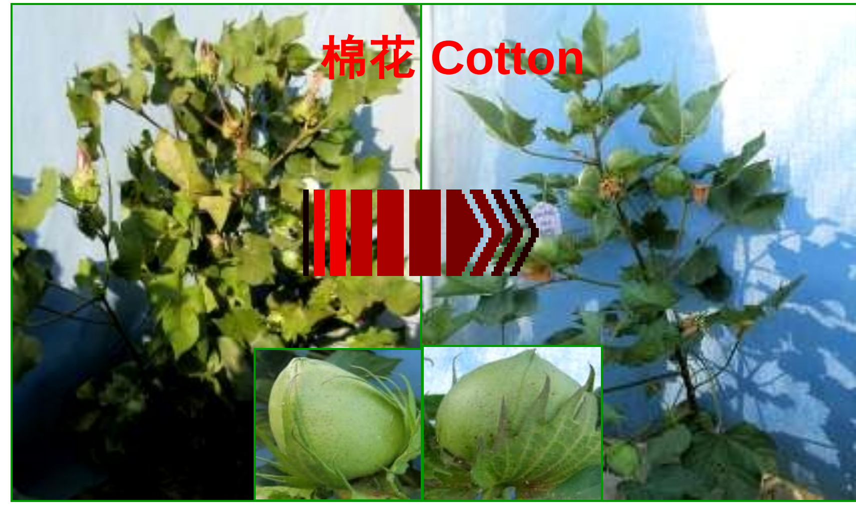
-- *Aspergillus niger*

Mutant H4002



Certificates of new crops issued by Gansu Crop Variety Approval Committee (GCVAC)

Heavy Ion Breeding



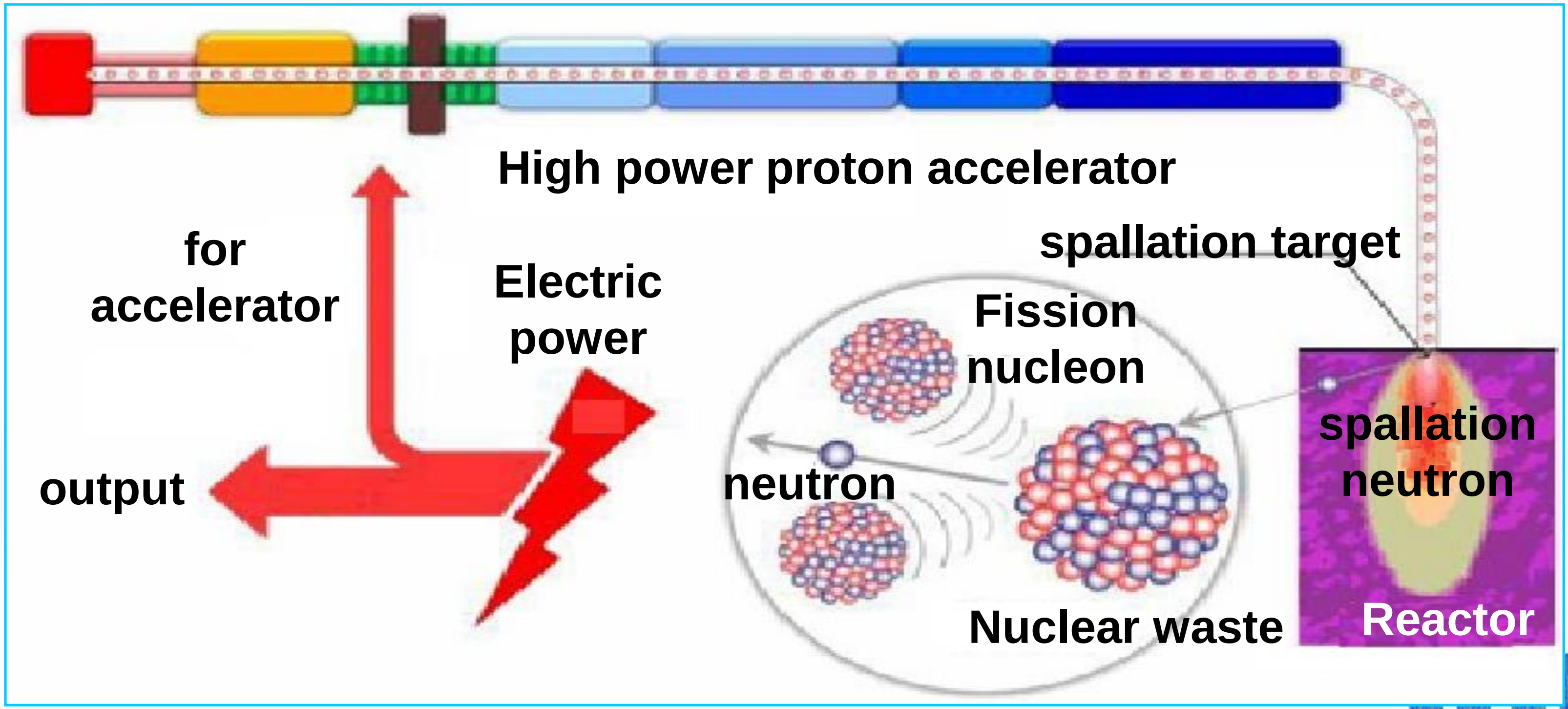
The future developing plan

ADS and HIAF projects

IMP

China-Accelerator Driven Sub-critical System (C-ADS) Project

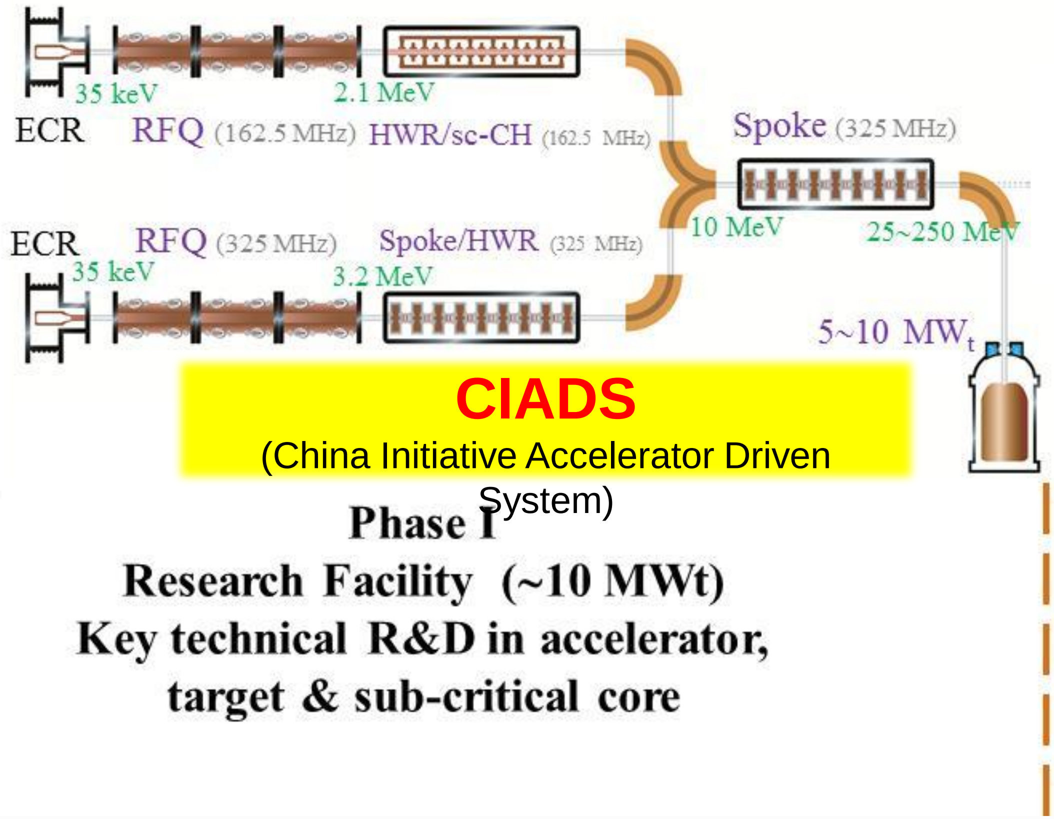
- **Accelerator Driven System was proposed for:**
  - **Nuclear Waste Transmutation**
  - **Accelerator Driven Thorium Reactor (ADTR)**
  - **Isotopes Production … (ex. ISOL RIA)**
- **ADS** consists of **High Power Proton Accelerator**, **Spallation Target/Blanket**, **Material & Fuel** mainly.



Nuclear Power Development in China

- **To June 2014 (www.world-nuclear.org/info/...)**
  - **Operating 20 set reactors, 17.055GW$_{e}$; (6th in world)**
  - ***Produced electricity 104.8GWh/2.1% in 2013; (5th in world)***
  - **Constructing 29 set reactors, 33.035GW$_{e}$; (1st in world)**
  - **Planned 57 set reactors, 61.235 GW$_{e}$; (1st in world)**
- **According to some information: (slower after 2011.3)**
  - **2020: ~58 GW$_{e}$ NPP in operation and 30GW$_{e}$ NPP under construction; >5% of NP to total electricity capacity**
  - **2030: ~10% of NP to total electricity capacity**
  - **2050: >400 GW$_{e}$ NPP → almost same scale of the total capacity in the world todays!**

Roadmap of China ADS Development



CIADS

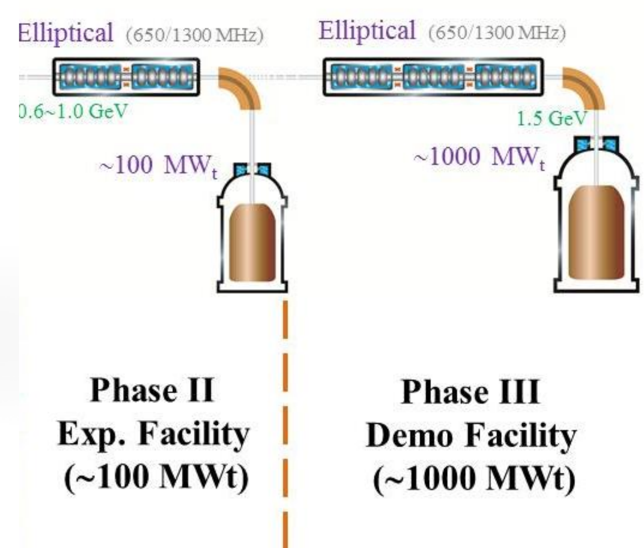
(China Initiative Accelerator Driven System)

Research Facility

~10MWt ~ 2023

2016: Key technical R&Ds (¥1.78 Billion)

2023: CIADS (12th Five Year Plan, ¥1. 8 Billion)



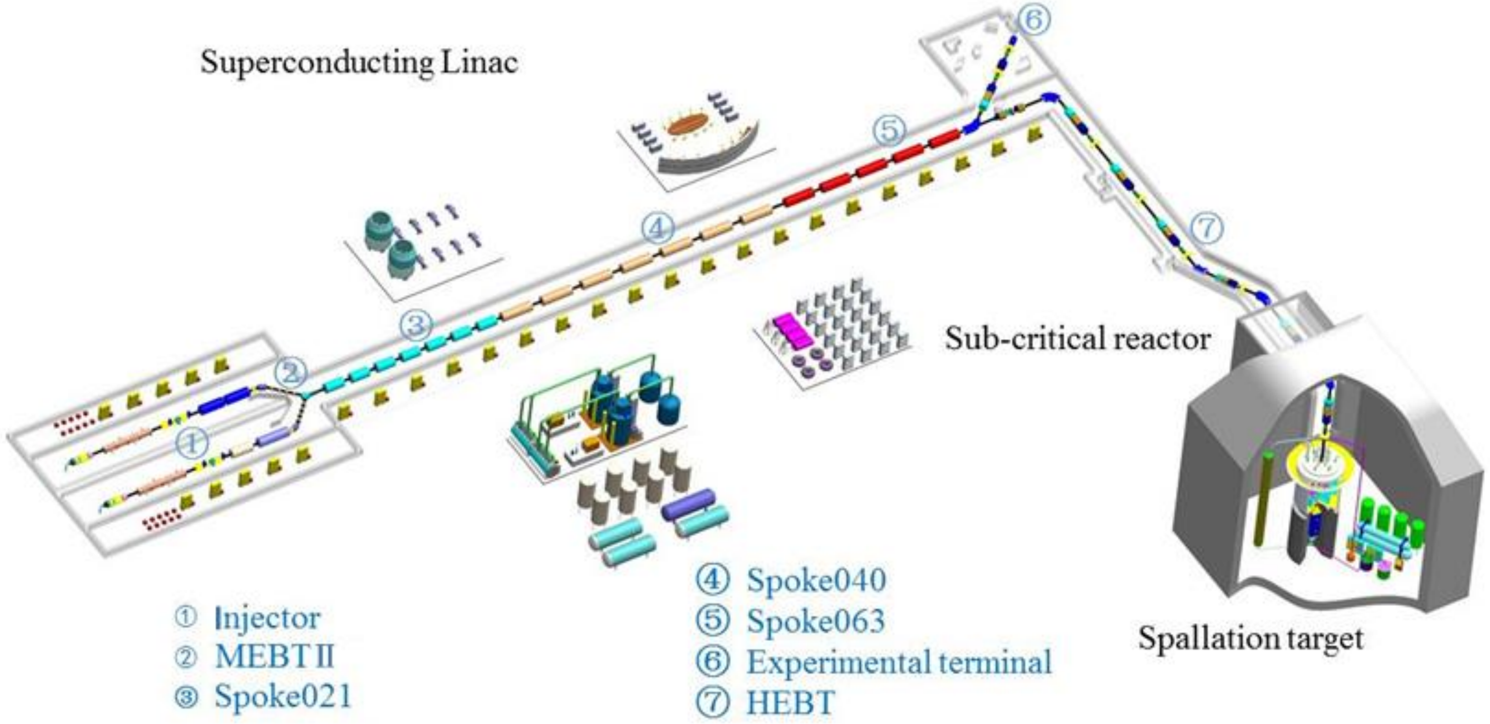
Roadmap for developing ADS facilities in China proposed by CAS

The Conceptual Design of CIADS

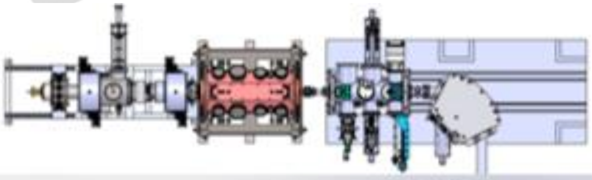
China Initiative Accelerator Driven System

The overall conceptual design of CIADS facility has been worked out

- LINAC: 250 MeV@10 mA with CW mode
- Spallation Target: granular flow spallation target, 2.5 MW
- Sub-critical core: 10 MWt, LBE cooled



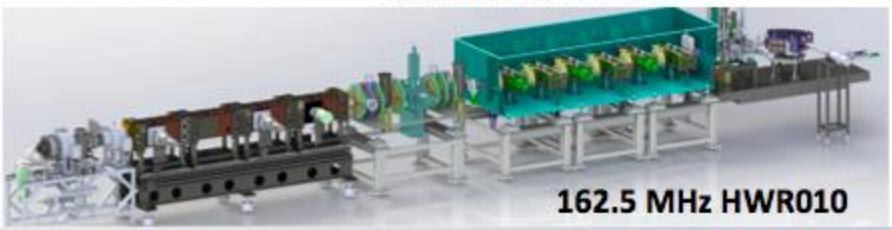
LINAC: Milestones for 25 MeV Commissioning

1


- ECRIS + LEBT + 560keV RFQ prototype
- Validate LIS+LEBT+RFQ design. Learn experiences.
- Completed, 2013

2

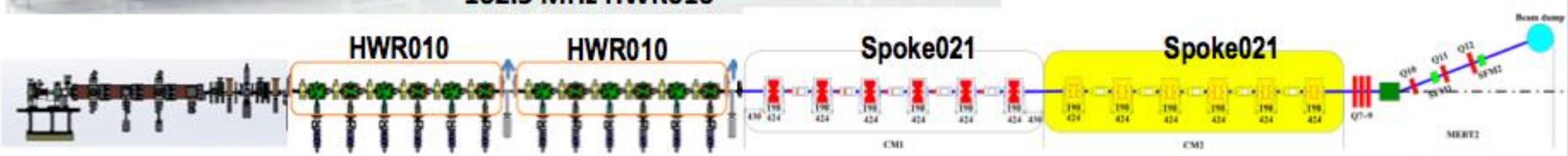

- ECRIS + LEBT + RFQ + MEBT + TCM1, 2.5 MeV
- RFQ commissioning, validate CM design.
- Ongoing, beam commissioning in Sept. 2014

3


- ECRIS+LEBT+RFQ+MEBT+CM6, 5 MeV
- Beam commissioning in March 2015

4


- ECRIS + LEBT + RFQ + MEBT + 2xCM6 +HEBT, 10 MeV
- Dec. 2015—Feb. 2016

5


- ~25 MeV, Dec. Sept. 2016 - 2017

Commissioning of ECR+RFQ+MEBT+TCM

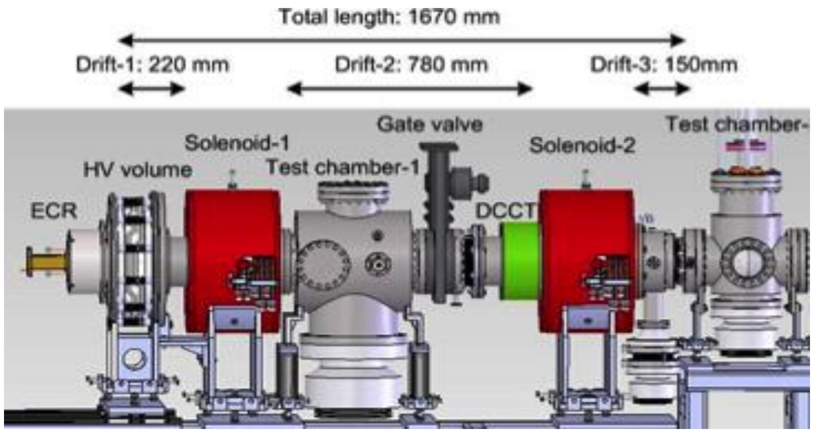
- Installed in August, 2014, and beam commission started in early September
- On October 3, beam with **2.6 MeV & 2.3 mA, 10% duty factor** was realized

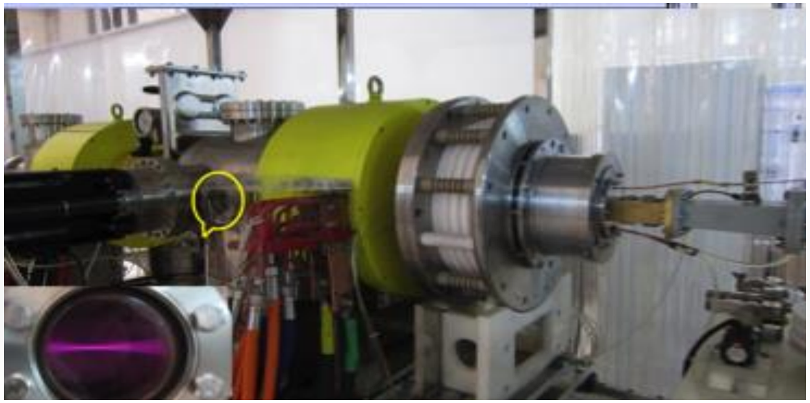
Still on-going

LINAC: Proton Source ECRIS and LEBT

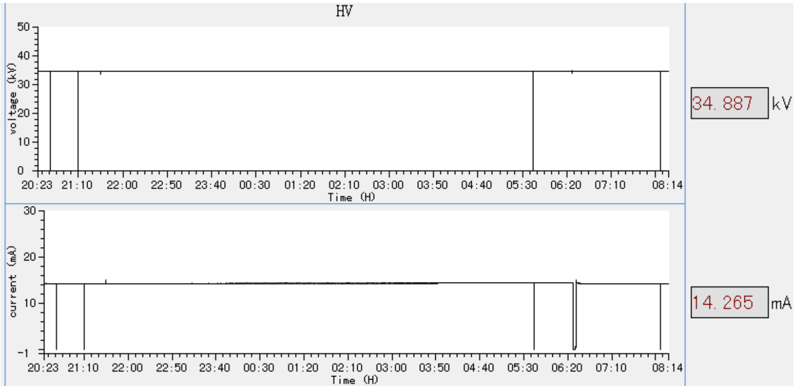
2.45 GHz, 35 keV@20mA

(designed by IMP, manufactured by IMP' KJTJ company)

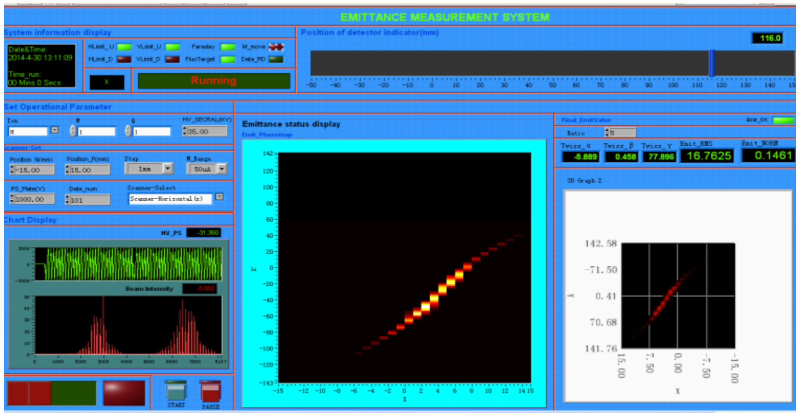




Layout of ECRIS and picture of LEBT



Beam testing at 14mA (12 hrs)

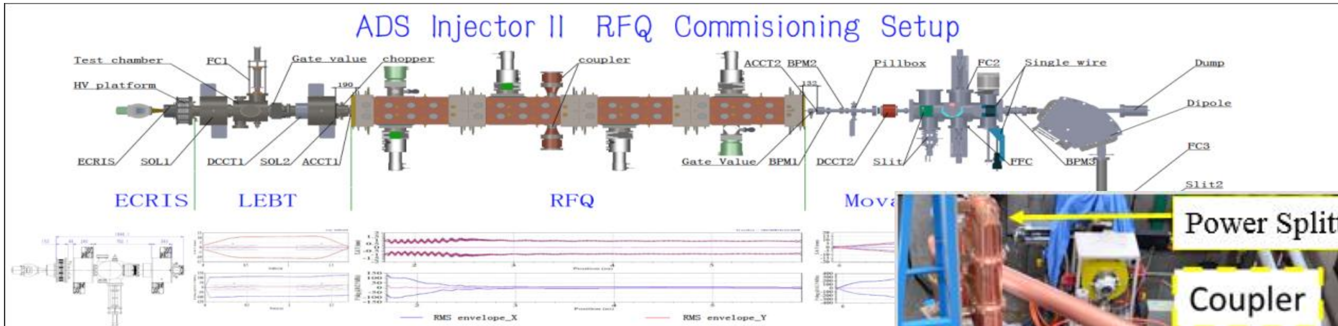


Emittance measurement at 35 keV@11 mA

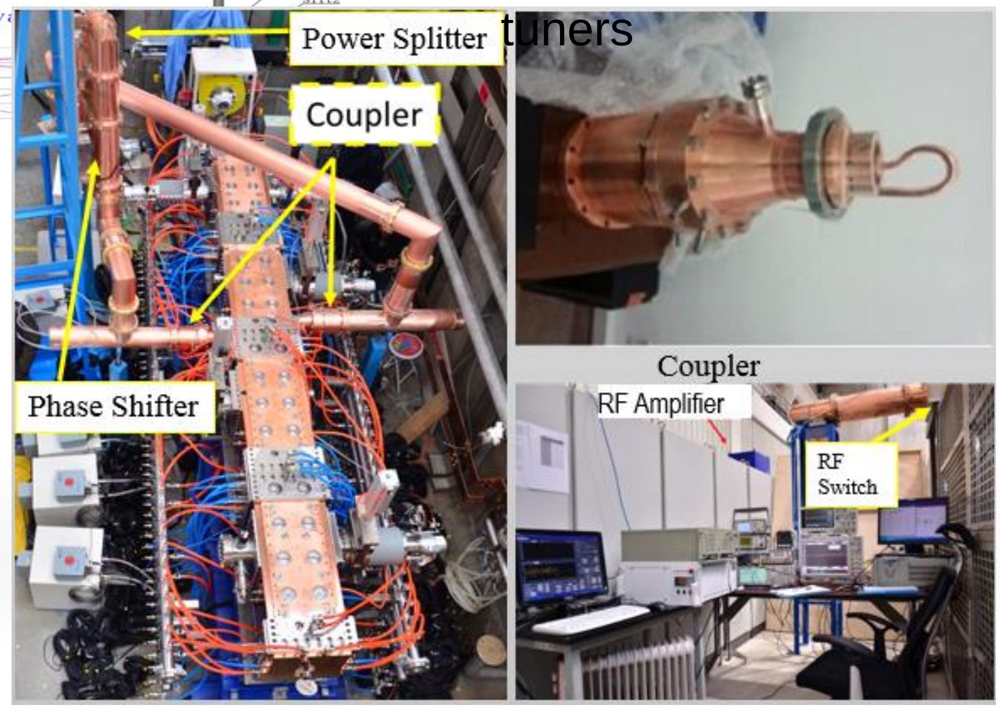
LINAC: RFQ and MEBT

162.5 MHz@10 mA, CW mode

(designed by LBL&IMP, manufactured by IMP's KJTJ company)



4.2 m long, 4 modules, 16 pairs of pi-mode rods, 80 tuners



RF components of the RFQ accelerator system

- Frequency to temperature sensitivity: -16 kHz/^{0}C in vane and 13.2 kHz/^{0}C in wall
- Field flatness: ± 3.9% before tuning, and ±1% after tuning
- **Cold test shows:** the cavity frequency and Q value of 162.46 MHz and 13000 agree well with the design

LINAC: HWR

Cylinder HWR for 162.5 MHz injector of the ADS

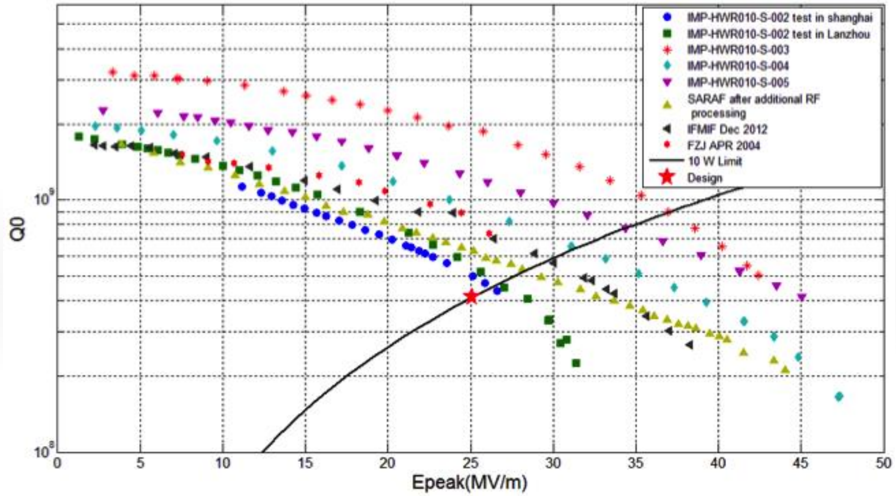
(by IMP, collaborated with HIT, SINAP, JLab, PKU, IHEP, MSU, etc.)

Superconducting HWR fabricated at IMP

- The inner/outer conductor, and the top/bottom covers were fabricated with niobium sheets by deep drawing or electron-beam welding
- The beam pipes, coupler pipes and process port pipes were fabricated with niobium rods by machining

13 HWRs been fabricated, 4 tested

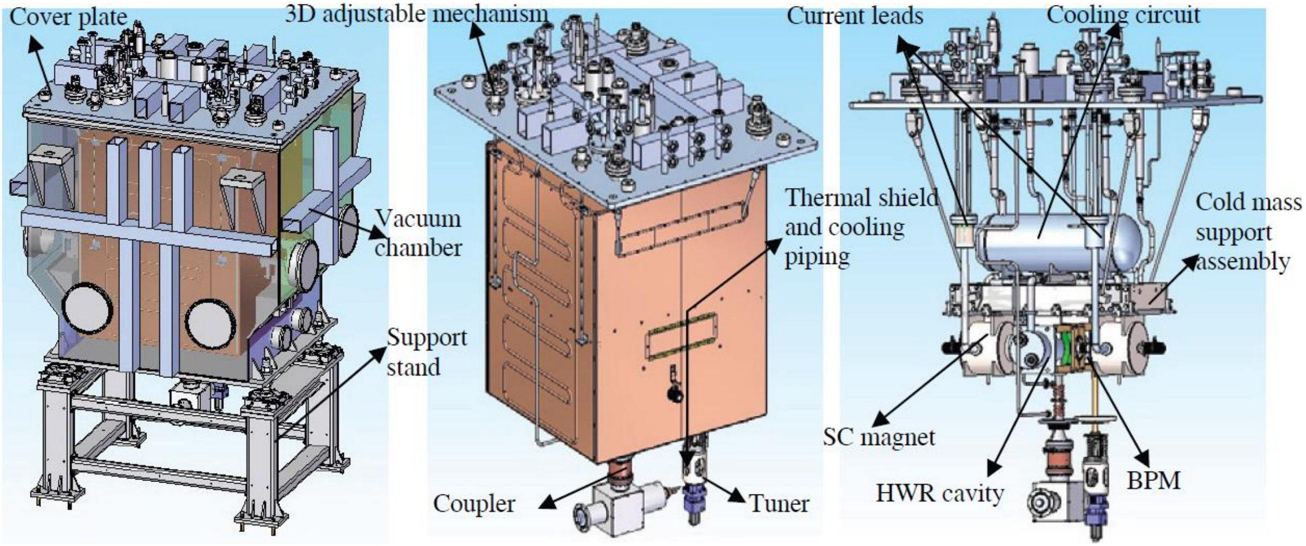
- Vertical test results: all reached the design goals ($Q \sim 4\times10^8$ @4.2 K & Epeak=25 MV/m)
- Best one: Q factor of **2×10^9** at 4.2 K and electric field of 25 MV/m

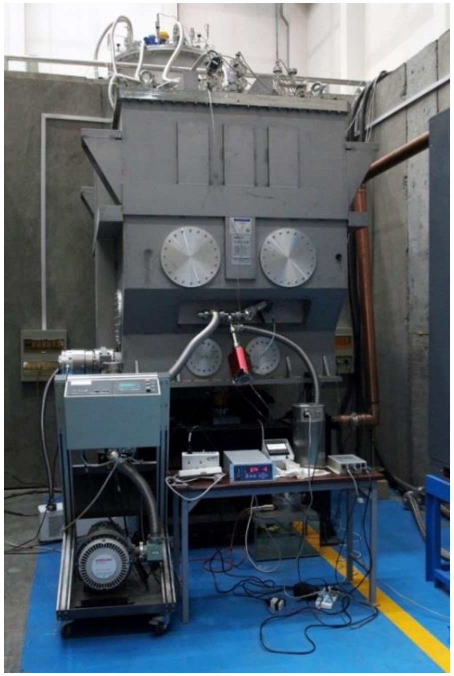


Vertical test results of the HWR cavities

LINAC: Test Cryomodule (TCM)

Cold mass structure of the TCM





Requirements of the cavity and solenoid

Requirements of cavity	
Operating temp.	4.4K
Operating pressure	1.05 bar
Pressure fluctuation	±1.5 mbar
Static heat load	0.1W
Dynamic heat load	10W
Cooling scheme	Bath cooling
Volume of LHe container	10L
Weight of solenoids	45 kg

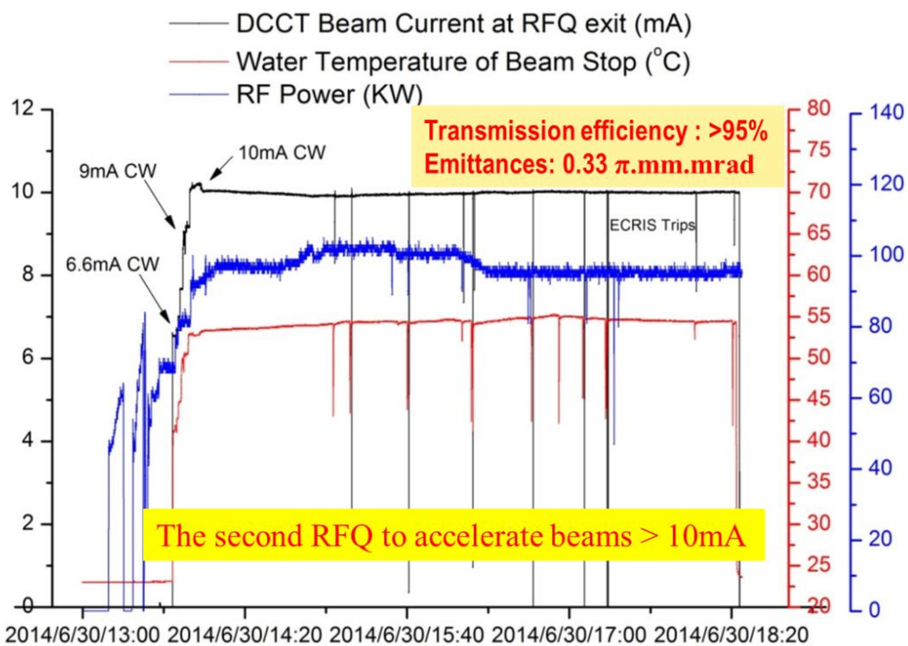
Requirements of solenoid	
Design current	100A,50A,50A
Storage energy	5kJ
quench time	10s
Operating temp.	4.4K
Operating pressure	1.05bar
Cooling scheme	Bath cooling
Volume of Lhe container	4.2 L
Weight of solenoids	30 kg

On 29 September, 2.3 mA proton beam was accelerated by the TCM. The electric field of 25 MV/m was achieved, and the beam was accelerated to the maximum energy of 0.7 MeV.

IMP

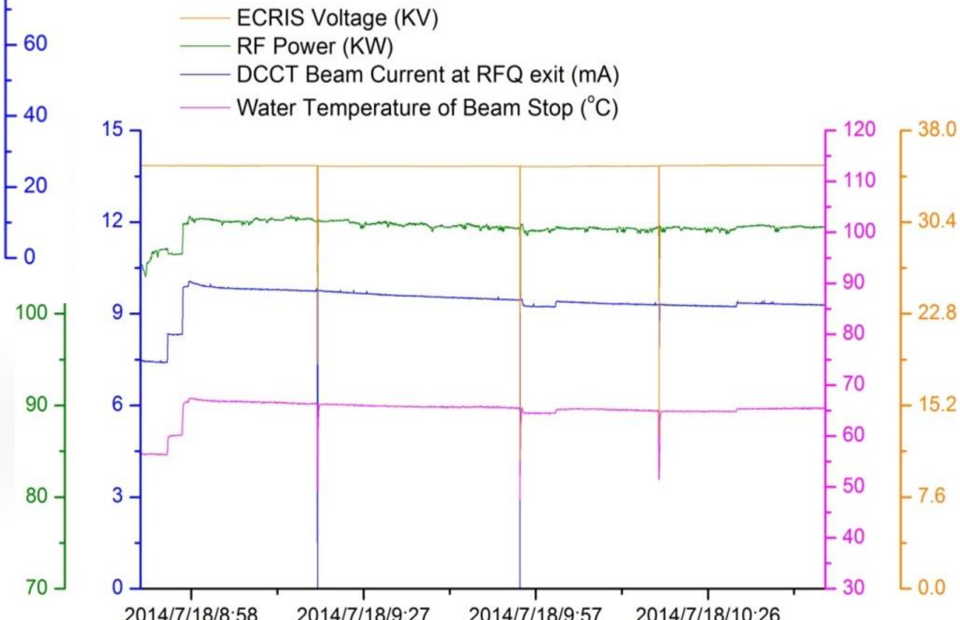
Commissioning of CW Beam @2.1 MeV & 10mA

On June 30, the acceleration of CW beam @ 10 mA succeed

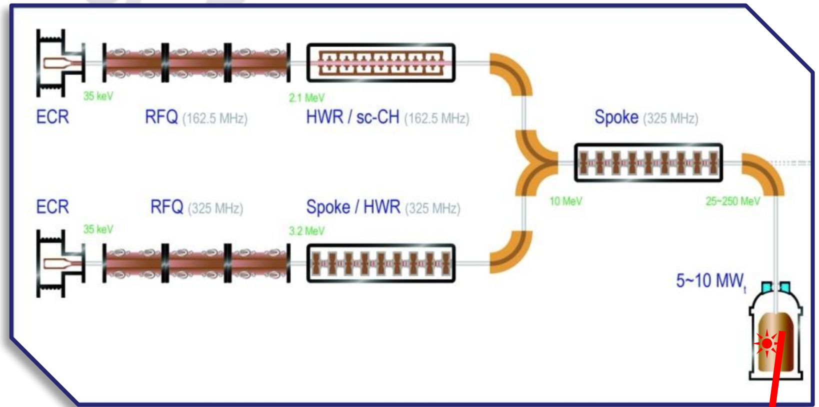


June 30, CW beam@ 10 mA lasted for 4.5 hours

July 18, CW beam @ 10 mA lasted for 2 hours.



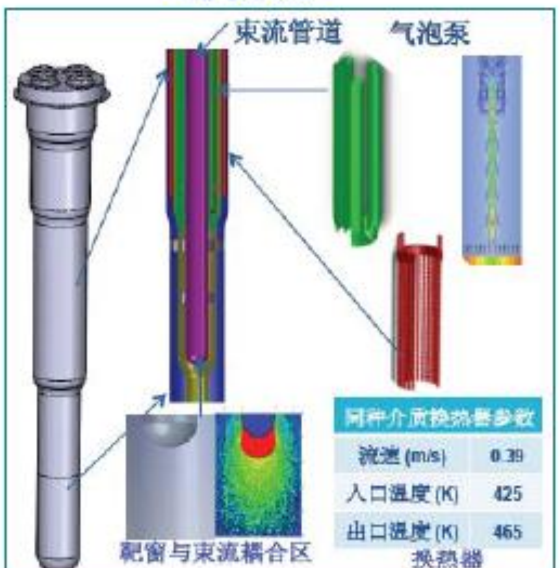
• Spallation Targets



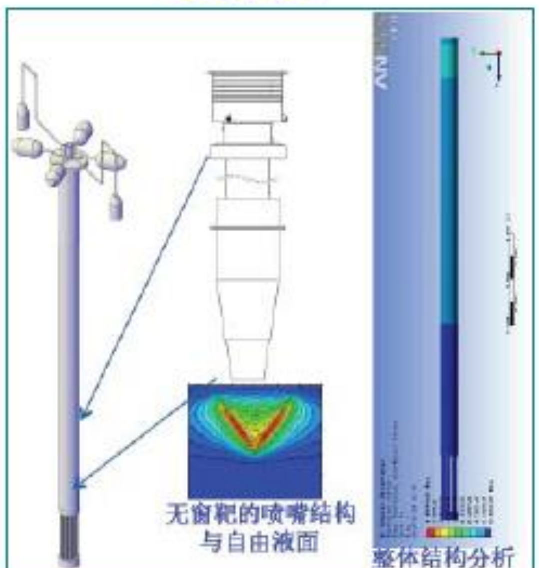
Spallation Target ——

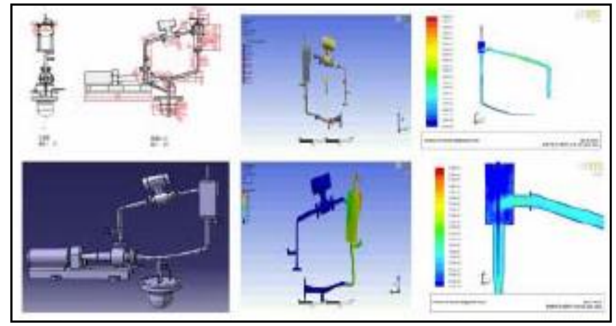
- ➢ LBE target
- ➢ **W Granular target**

LBE target with window



Windowless LBE target





Forced flow liquid LBE loop
Design and simulation (up) and test set-ups (down)

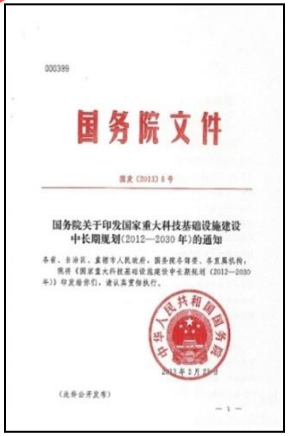
***H**igh **I**ntensity **A**ccelerator **F**acility (HIAF)*

HIAF: background and motivation

HIAF: One of 16 large-scale research facilities proposed in China in order to boost basic science, now under design optimization and technical R&D

The HIAF project:

- Proposed by IMP in 2009.
- Approved in principle by the central government in the end of the 2012.
- Design Report(v1.0) was published in July 2014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国务院文件

国务院关于印发国家重大科技基础设施建设中长期规划(2012—2030年)的通知

各省、自治区、直辖市人民政府，国务院各部委、各直属机构：

现将《国家重大科技基础设施建设中长期规划（2012—2030年）》印发给你们，请认真贯彻执行。

中华人民共和国国务院

（此件公开发布）

— 1 —

（一）海底科学观测网
（二）高能同步辐射光源验证装置
（三）加速器驱动嬗变研究装置
（四）综合极端条件实验装置
（五）强流重离子加速器
（六）高效低碳燃气轮机试验装置
（七）高海拔宇宙线观测站
（八）未来网络试验设施
（九）空间环境地面模拟装置
（十）转化医学研究设施
……

Science motivations:

※ High intensity radioactive beams to investigate the structure of exotic nuclei, nuclear reactions of astrophysics and to measure the mass of nuclei with high precision.

※ High energy and intensity ultra-short bunch heavy ion beams for high energy and high density matter research.

※ High charge state ions for a series of atomic physics programs.

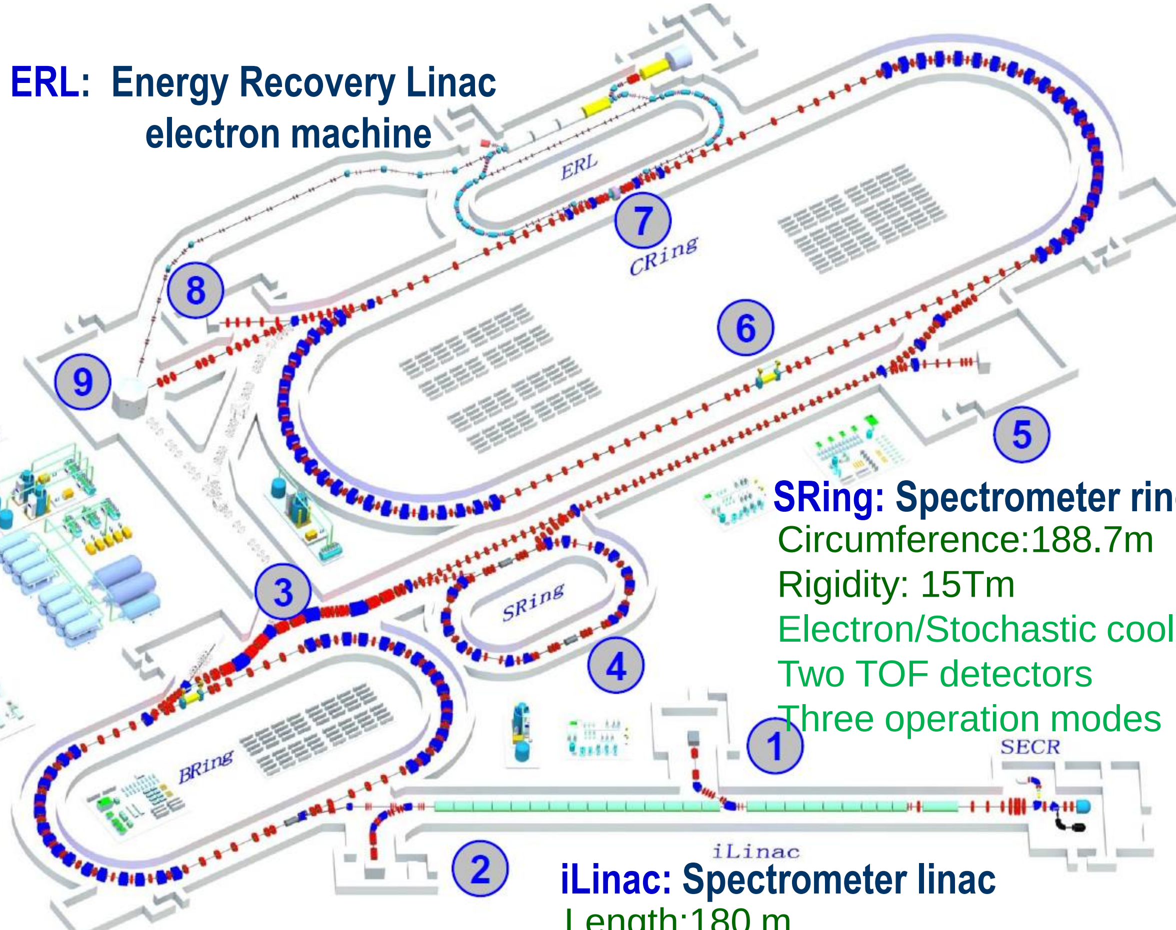
※ Quasi-continuous ion beam (slow extraction) with wide energy range for applied science.

HIAF: Multi-purpose facility

with unprecedented parameters

CRing: Compression ring
Circumference: 804 m
Rigidity: 43 Tm
- Barrier bucket stacking
- Beam compression
- Beam acceleration
- In-beam experiment

ERL: Energy Recovery Linac electron machine



SRing: Spectrometer ring
Circumference:188.7m
Rigidity: 15Tm
- Electron/Stochastic cooling
- Two TOF detectors
- Three operation modes

BRing: Booster ring
Circumference: 402 m
Rigidity: 34 Tm
- Beam accumulation
- Beam cooling
- Beam acceleration

iLinac: Spectrometer linac
Length:180 m
Energy: 25MeV/u(U^{34+})

1. Nuclear structure spectrometer
2. Low energy irradiation target
3. RIBs beam line
4. High precision spectrometer ring
5. External target station
6. Electron-ion recombination spectroscopy
7. Electron-Nucleus Collision (ENC)
8. High Energy Density Physics target
9. High energy irradiation target

IMP

Technical challenges and R&D

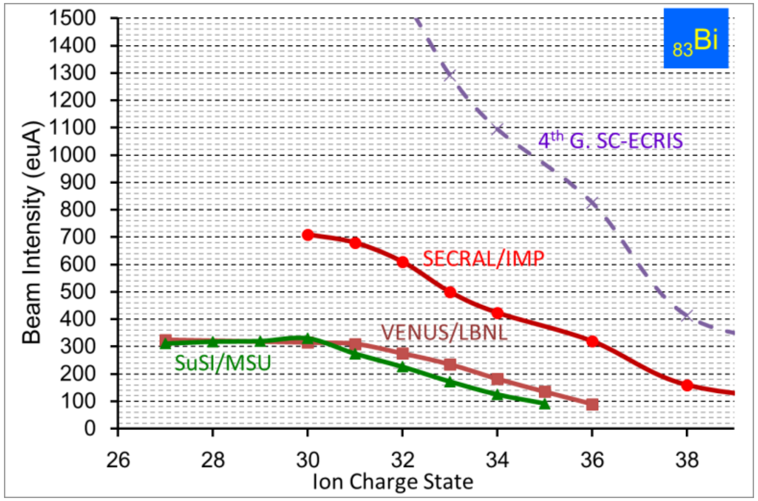
- ※ Superconducting ECR
- ※ Superconducting Linac
- ※ Dynamic vacuum collimator
- ※ Superconducting magnet
- ※ Electron cooling
- ※ Stochastic cooling

Superconducting ECR

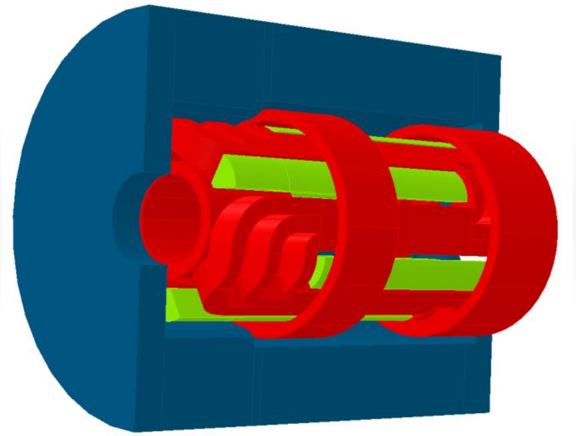
None of existing highly charged ion sources can meet HIAF requirements for the moment

But the 4th Generation ECRIS seems to provide a feasible solution

Ion	Bi^{30+}	U^{34+}
HIAF Beam Intensity (euA)	1500	1700
World Record Intensity (euA)	422	400
3rd Generation Sources	SECRAL/24 GHz	
Gain for HIAF	3.6	4.2



Intense heavy ion beam production



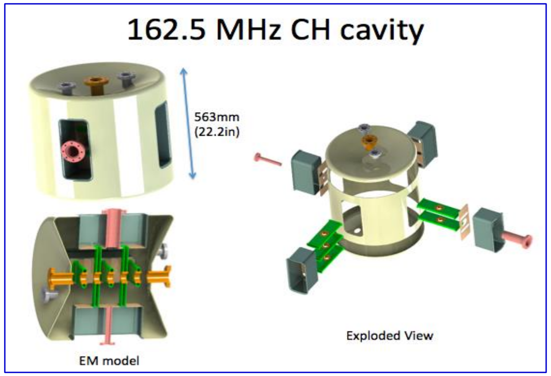
➢ New magnet configuration based on the traditional Ioffe-bar layout can minimize the highest field inside the magnet coils, and maximize the efficient field inside the plasma chamber.

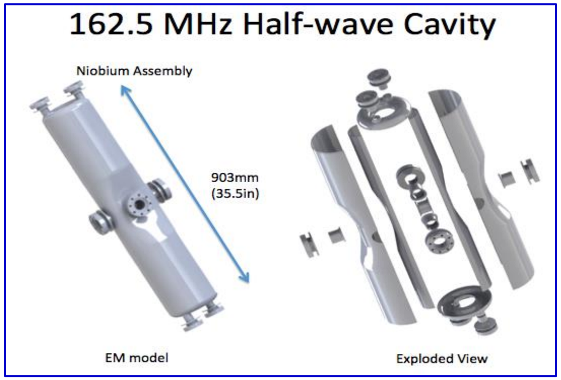
➢ Possible utilizing the matured NbTi technique instead of the cutting edge Nb_3Sn technique will be more cost efficient and technical feasible.

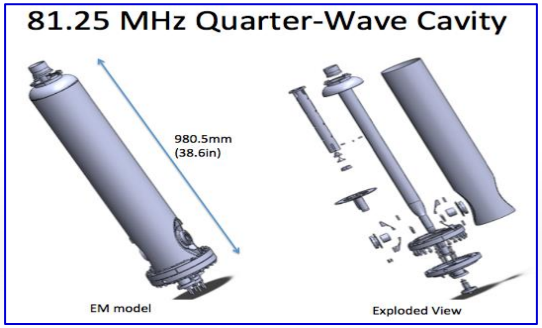
IMP

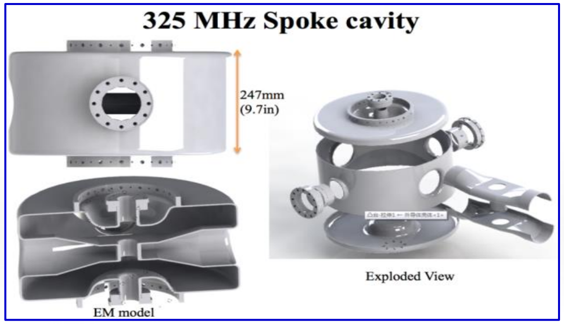
Challenges of iLinac

- **Highest peak current pulse for superconducting ion linac in the world, the peak current is four times higher than at FRIB (CW mode)**
- **Low-Beta SRF cryomodules design and prototype development. There are four types of superconducting cavities developed at IMP**









- **The average uncontrolled beam loss should be limited to below 1 W/m level**

R&D of Dynamic vacuum

Collimator prototype development

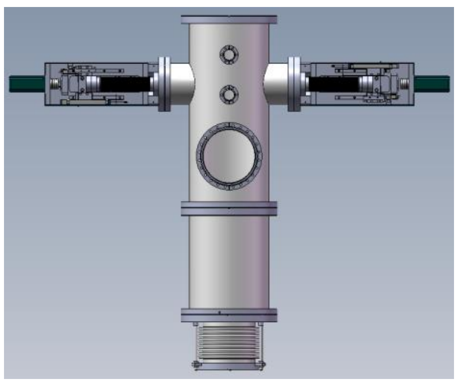
First step - Test platform

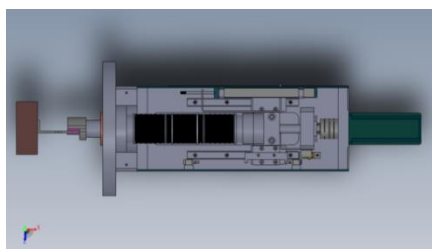
Desorption measurement

Control system and vacuum system test

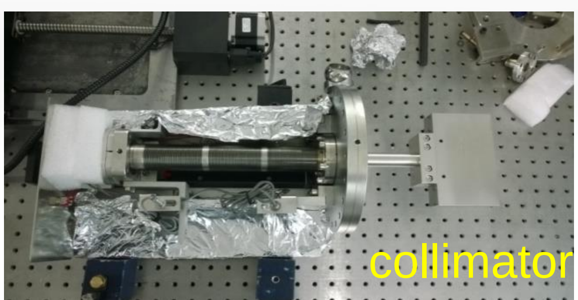
Install at PISA or E-point

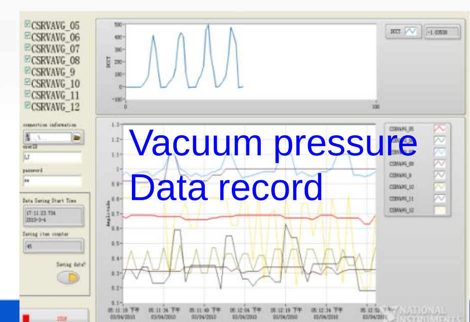
The mechanical design has been finished





Fabrication of hardware components

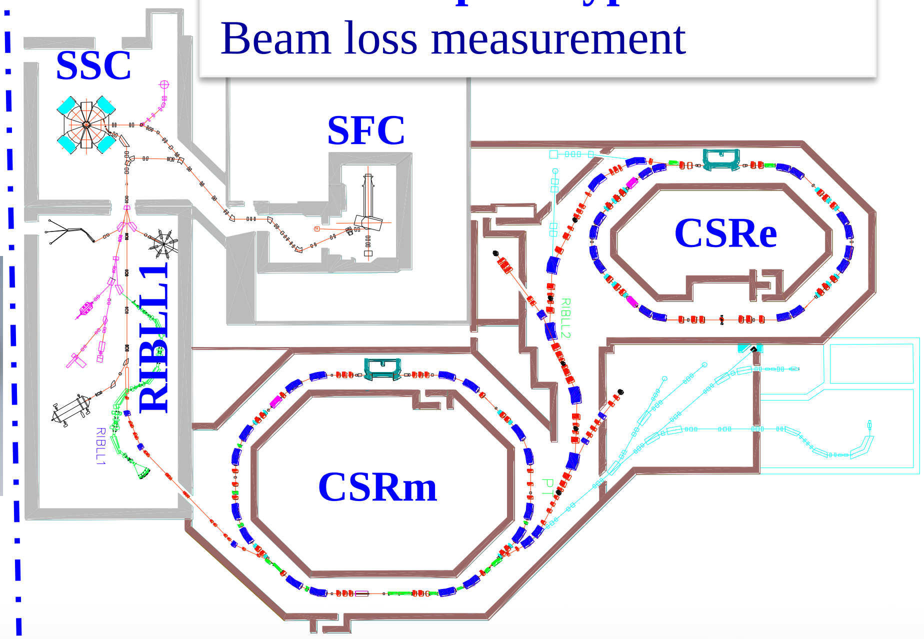




Second step –

Collimator prototype of CSRm

Beam loss measurement

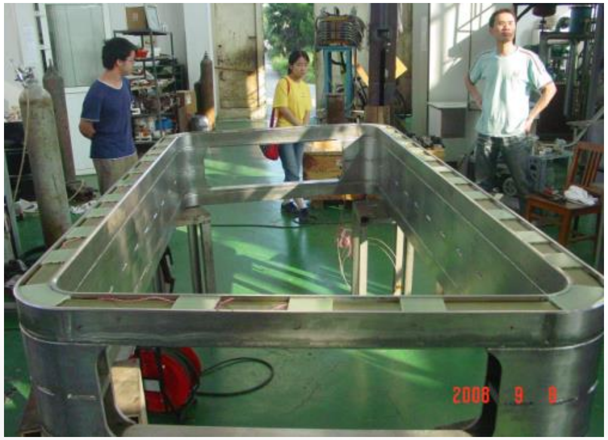


Fast cycling magnetic field super-ferric dipole

BRing, CRing and SRing

Features and design proposal:

- Big gap — Superconducting coil
- Big good field region — Warm iron
- Fast-cycling magnet（small inductance）— large operation current， liquid helium inner cooling superconducting cable
- Type of cooling — Forced flow cooling with super-critical helium/two-phase helium



- Superconducting solenoids: 3T, 5T, 7T for Penning trap
- The superconducting dipole prototype for the super-FRS has been fabricated and tested at IMP, and it has been already transferred to GSI

R&D of SC magnet for HIAF

Fabrication

Fabrication of superconducting cable

Fabrication of coil case

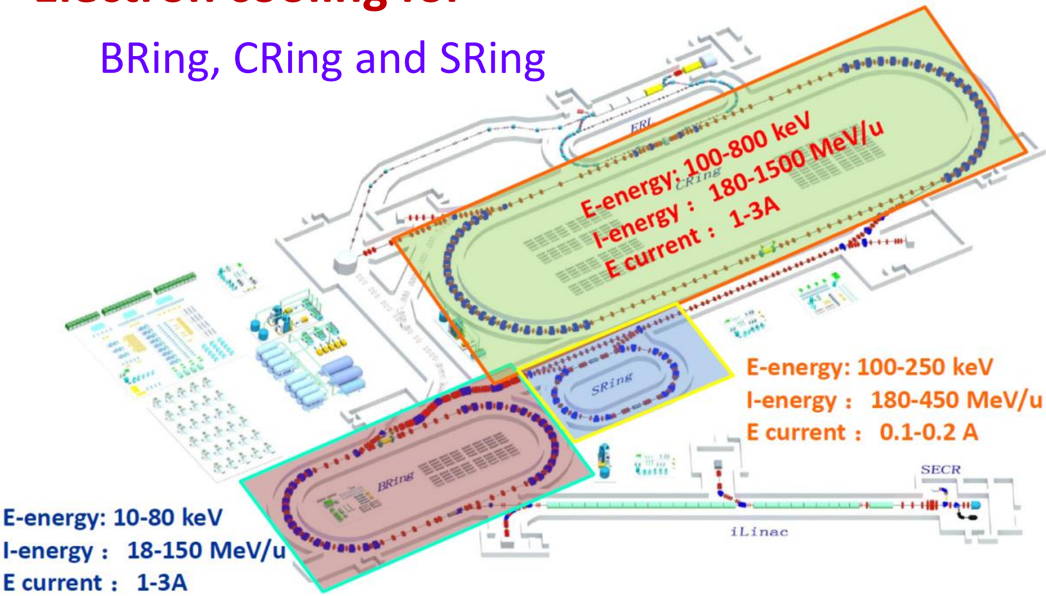
Fabrication of cryostat

- A new type of superconducting cable is designed and fabricated
- The coil case fabrication has been finished
- The current leads and cooling system are still under design
- The quench protection system will be established in the next step

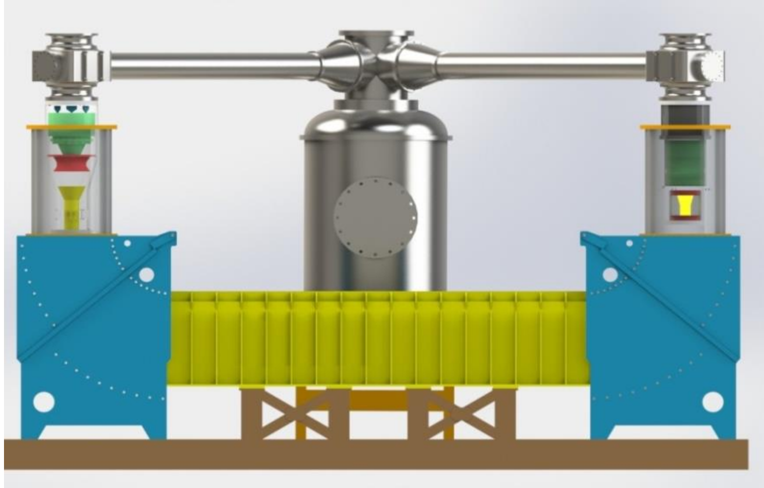
Electron cooling

Electron cooling for

BRing, CRing and SRing



Sketch of the magnetized Electron cooling system for HIAF



Well-established electron cooling of existing facility-HIRFL

CSRm e-cooler

E-energy: 4-35keV
I-energy :7-50MeV/u
E current :1-3A

CSRe e-cooler

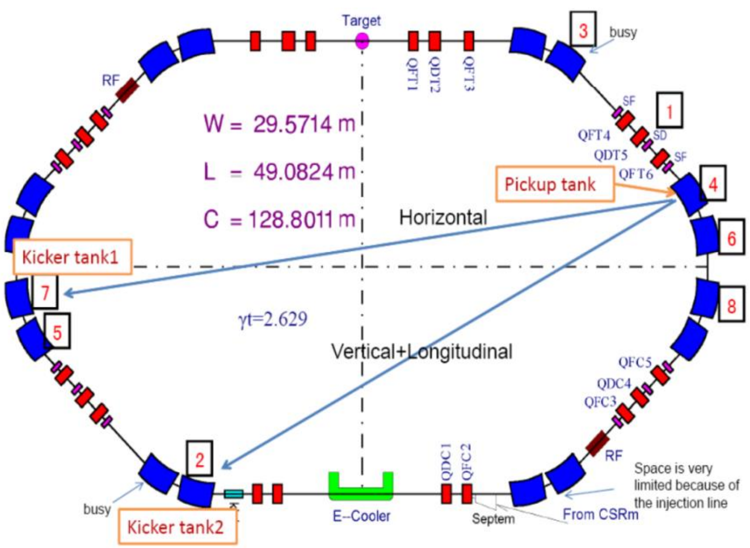
E-energy:10-300keV
I-energy:25-500MeV/u
E-current:1-3A

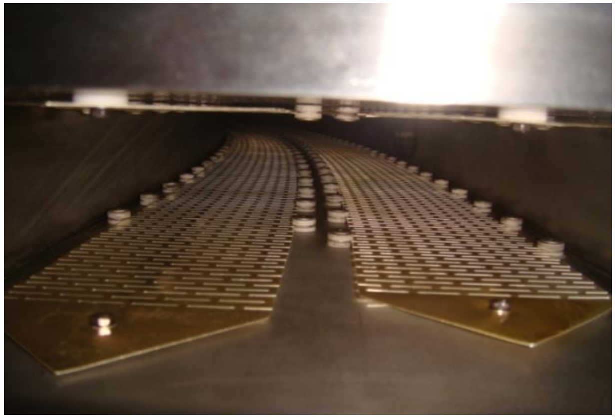
The hollow e-beam can be obtained in both of two e-coolers to partially solve the problem due to the space charge effect and reduce the effect of recombination between the ions and the e-beam. The intensity gain factor of C beam is more than 300.

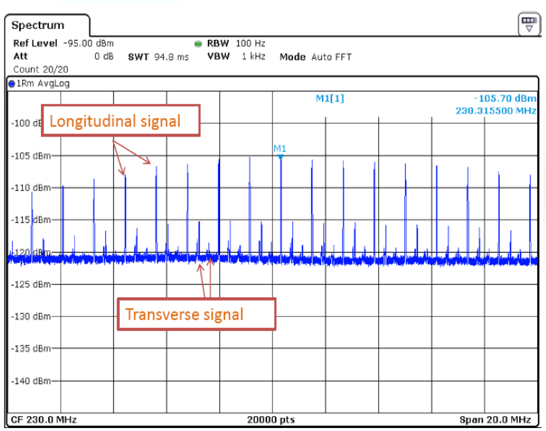
IMP

Stochastic cooling of CSRe

A novel type of 2.76 m long slotted pick-up was developed (in cooperation with CERN and GSI) for CSRe stochastic cooling. The key components have been fabricated and installed in CSRe, the tuning of machine for stochastic cooling will start next year.





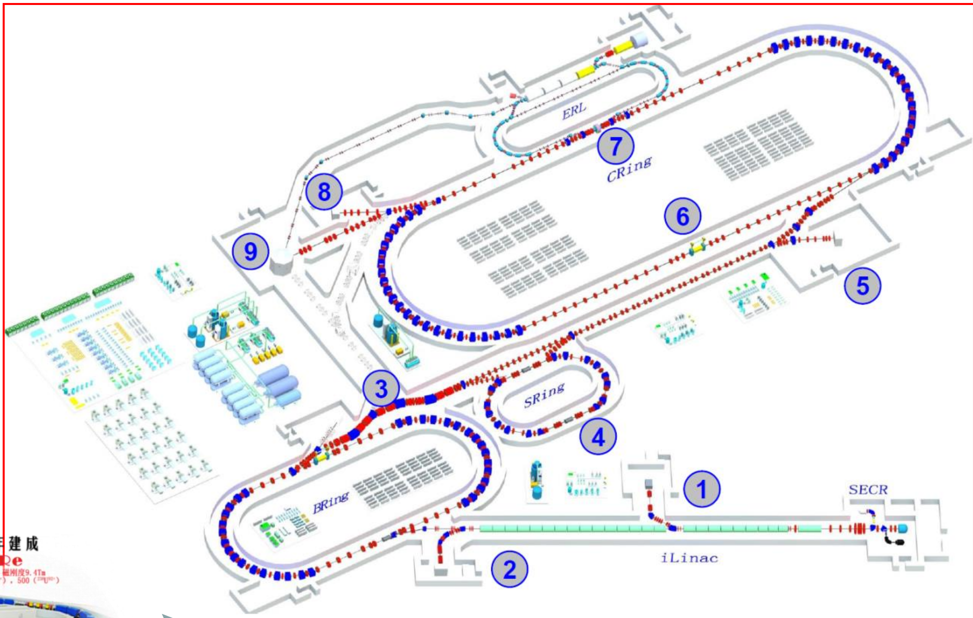


The beam test ($^{117}Sn^{50+}$, 253 MeV/u) results show it is a well-suited structure for CSRe stochastic cooling.

Perspectives

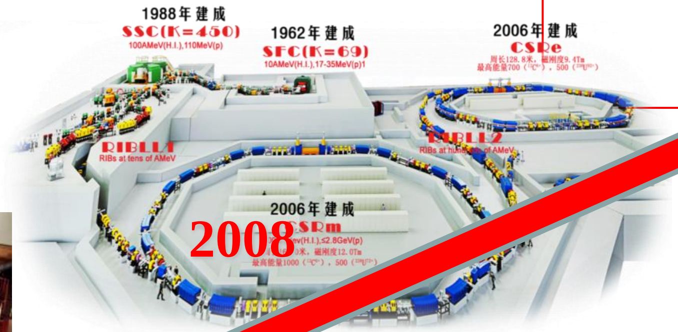
It is challenging!

But no insurmountable difficulties



HIAF

CSR



2008

SSC

1988

SFC

1962

HIRFL

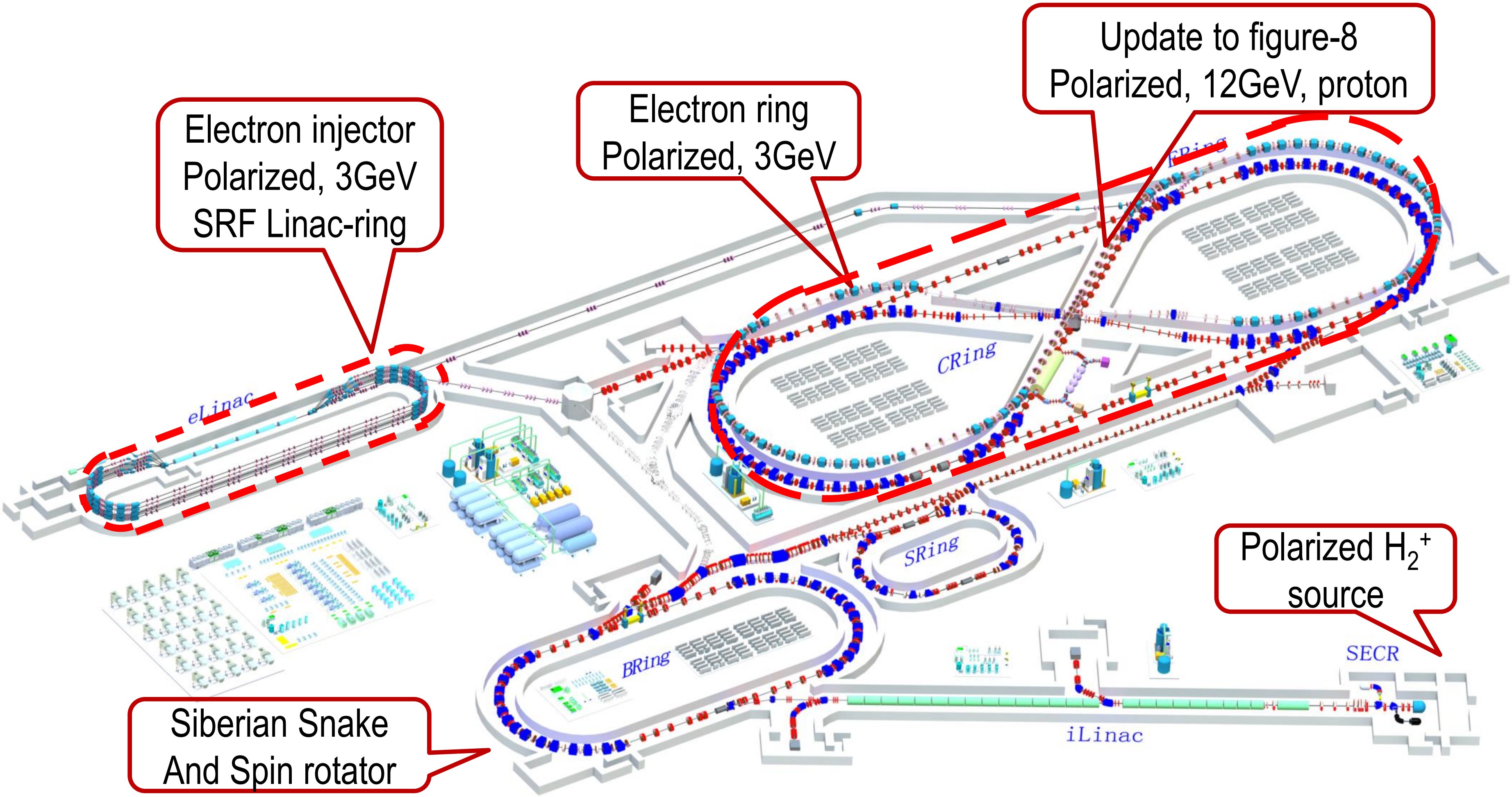
Budget of HIAF (1st phase)

Items	1st phase (MRMB)
iLinac	550
BRing	320
CRing	370
eLinac	50
ERing	
High energy electron cooling	
Beam transfer line	50
Experiment setups	330
Cryogenics	205
Civil engineering	245
Tunnel construction	180
Contingency cost	70
Total of facility	2370 (central government)
Land & infrastructure	1400 (local government)
Total	**3770**

Second phase for HIAF-EIC

A High Luminosity for Electron-Ion Collider
A New Experimental Quest to Study the Sea quark and Gluon

HIAF design maintains a well defined path for EIC



Site of HIAF and CIADS projects-new campus

Thank you for your attention!

Wish more collaborations!