Overview of IMP and HIAF

Institute of Modern Physics, CAS
Guoqing XIAO

July 2, 2018 , Dubna

Brief Introduction to IMP

HIAF project

Conclusions

IMP and Lanzhou city

IMP was founded in 1957 in Lanzhou city, which is on the Silk Road Economic Belt along the yellow river with a population of ~3M. IMP has the largest heavy-ion accelerator system in China.

SILK ROAD

One Belt One Road
One River One accelerator

HISTORY

Prof. C.Z.YANG

Prof. B.W.WEI

Prof. Y.X.LUO

Prof. W.L.ZHAN

Prof. G.Q.XIAO

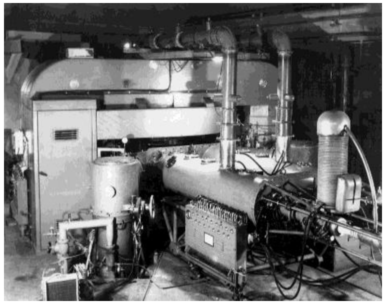
1957-1984
IMP Foundation
SFC Construction
Low-energy nuclear physics
Heavy-ion Physics proposal

1984-1994
SSC Construction
CSR proposal
Heavy-ion physics

1994-1999
New Isotopes
RIBLL Construction
CSR approved
Heavy-ion Physics
Heavy-ion Applications

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

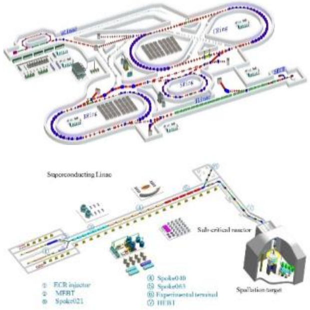
2008-Now
CSR experiments
Heavy-ion Application
ADS Program
Proposal of HIAF



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



1990.4

MoU BETWEEN IMP & DUBNA

1991.11

JINR DELEGATION TO IMP

IMP & Dubna / JINR

МЕЖДУНАРОДНАЯ МЕЖПРАВИТЕЛЬСТВЕННАЯ ОРГАНИЗАЦИЯ
INTERNATIONAL INTERGOVERNMENTAL ORGANIZATION

ОБЪЕДИНЕННЫЙ ИНСТИТУТ ЯДЕРНЫХ ИССЛЕДОВАНИЙ
JOINT INSTITUTE FOR NUCLEAR RES

Россия 141980 Дубна Московской области 141980 Dubna Moscow Region Russia
Telefax: (7-095) 975-23-81 Telex: 911621 DUBNA RU AT: 205493 WOLNA RU
E-mail: post@jinr.ru Tel.: (7-09621) 65-059

19.04.2006 № 010-24/76

на № ______ от ______

Dear Professor ZHAN Wenlong,

Herewith I send you the Protocol on Scientific Collaboration bet of Modern Physics, CAS and Joint Institute for Nuclear Resear vice-director of JINR M.G. Itkis. Please, be so kind after signing tl yourself do send one sample back to JINR.

With best regards,
Professor Igor Meshkov

visiting the other party will be covered according to common agreement.

Article V

Each Contracting Party shall make efforts to provide and facilitate the use of accelerators and related equipments for the collaboration and be obligated to assist in import and export of necessary facilities and materials as well as official procedure of the visiting scholars.

Article VI

Any modification or amendments to this protocol and what not involved in the protocol shall be in necessary cases discussed additionally and decided by the two Contracting Parties.

Article VII

This protocol shall take effect from the date of signature and shall be valid for a period of five years, renewable automatically for successive period of one year unless either party requests its termination by serving a written notice to the other party six months prior to date of expiration.

Done in duplicate on March XX, 2006, in English language, both texts are equally authentic.

ZHAN Wenlong	Mikhail G Itkis
(signed by)	(signed by)
For the Institute of Modern Physics of Chinese Academy of Sciences	For the Joint Institute for Nuclear Research

2006.03

PROTOCOL ON SCIENTIFIC COLLABORATION – IMP&JINR

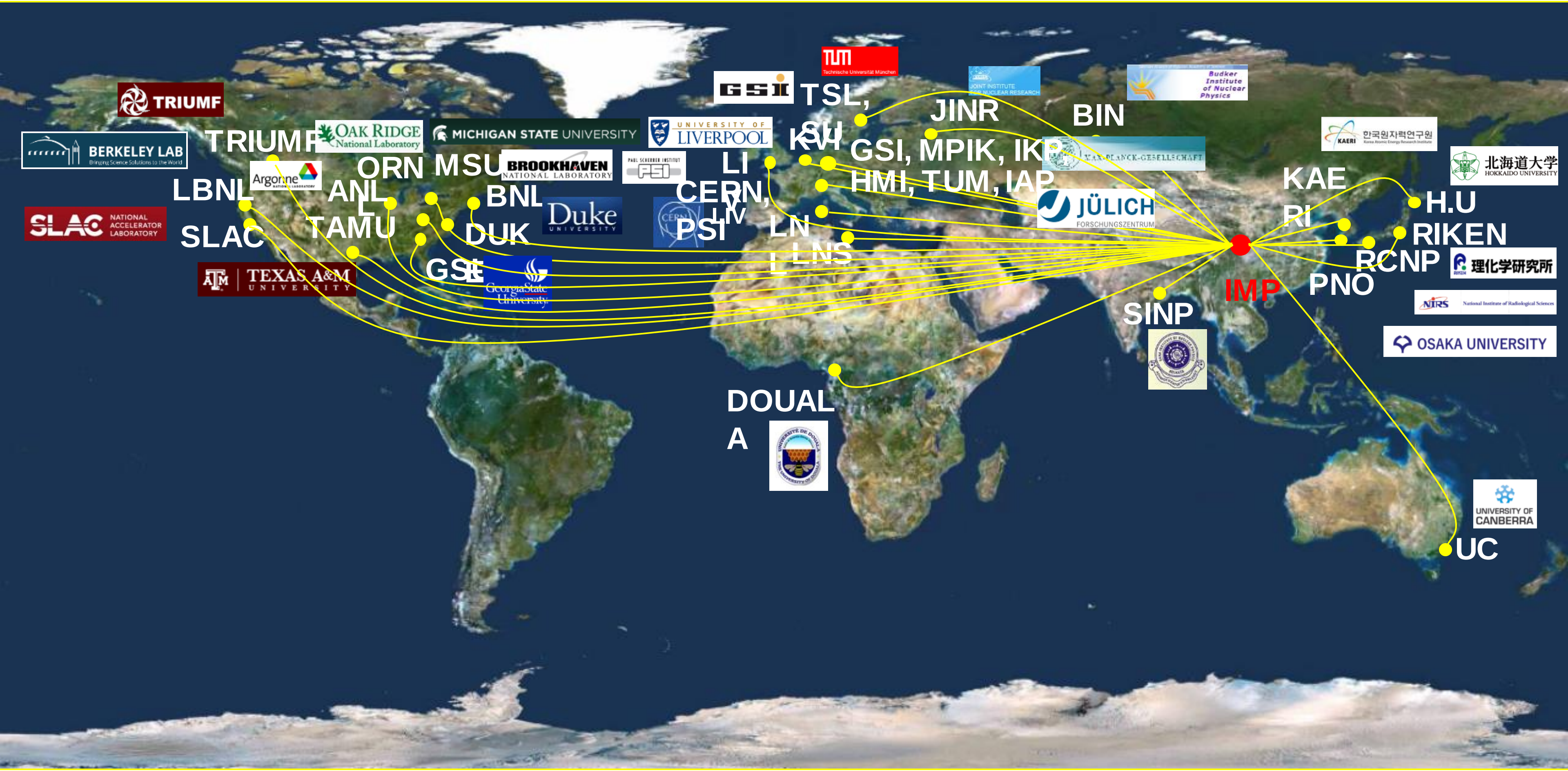
IMP & Dubna / JINR

2016.09

IMP Delegation to Dubna

International Collaboration

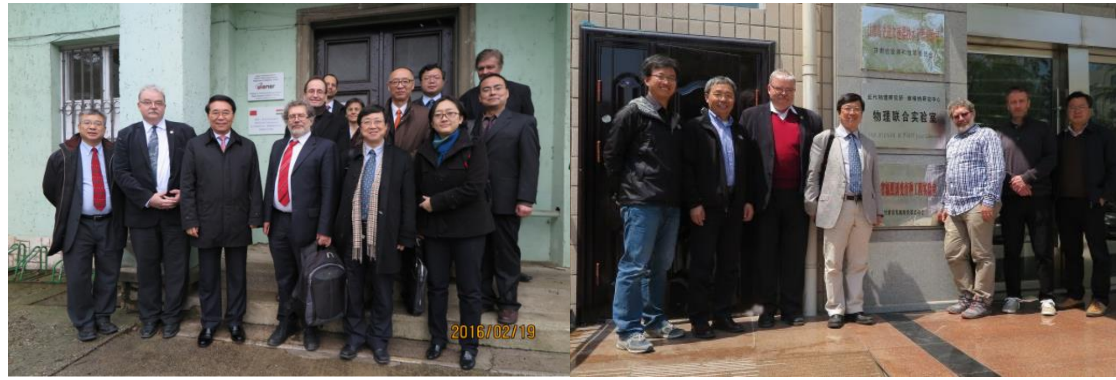
International Collaborative Relationships of IMP



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 collaborations.

International Collaboration

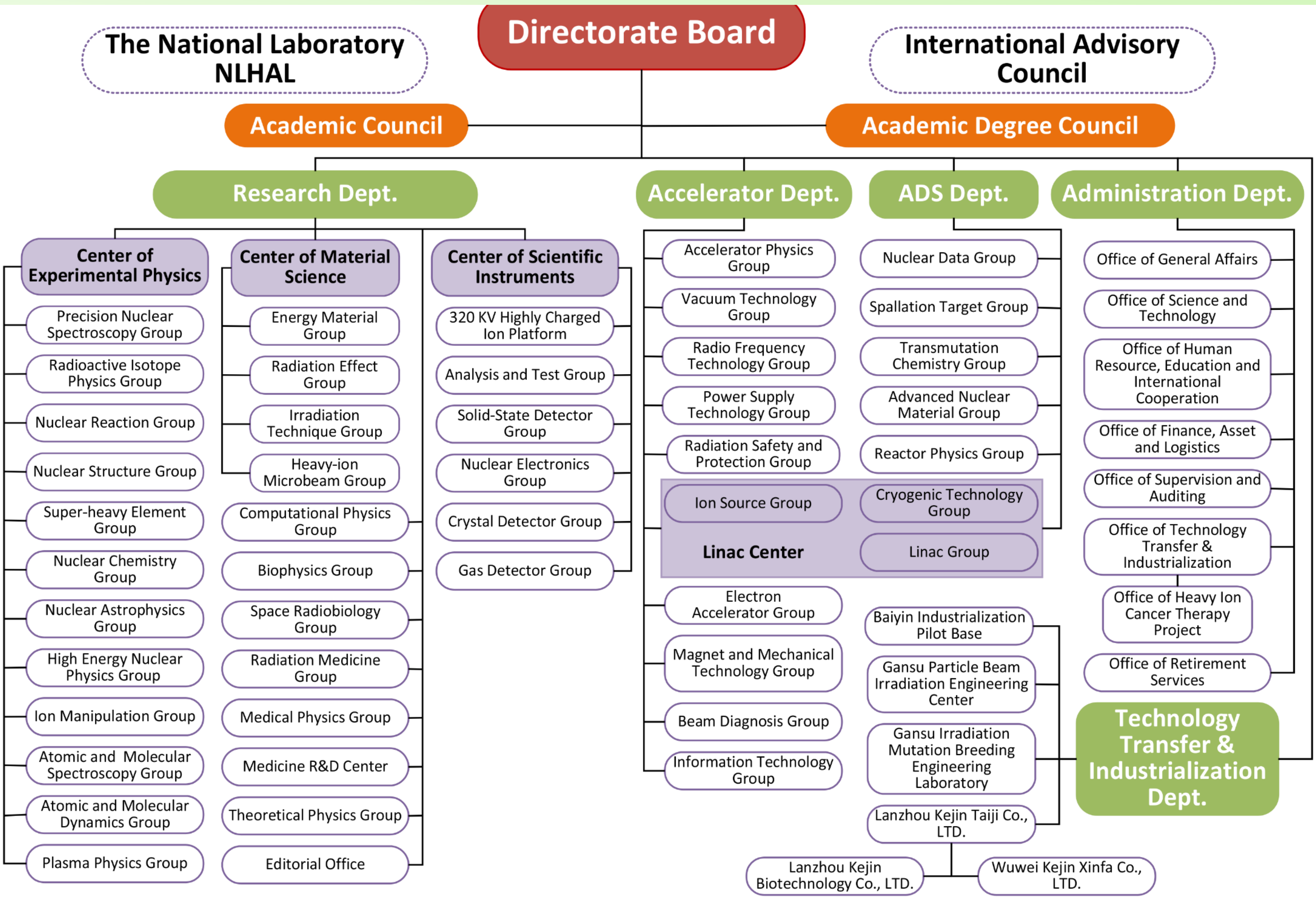
Wigner center established in April 11, 2015 between IMP and Wigner RCP in Hungary



Forein employee and students

12 → 19
(2015) (2016)

Organization of IMP



IMP and Related Centers

Existing Main Facility at IMP

Heavy Ion Research Facility in Lanzhou (HIRFL)

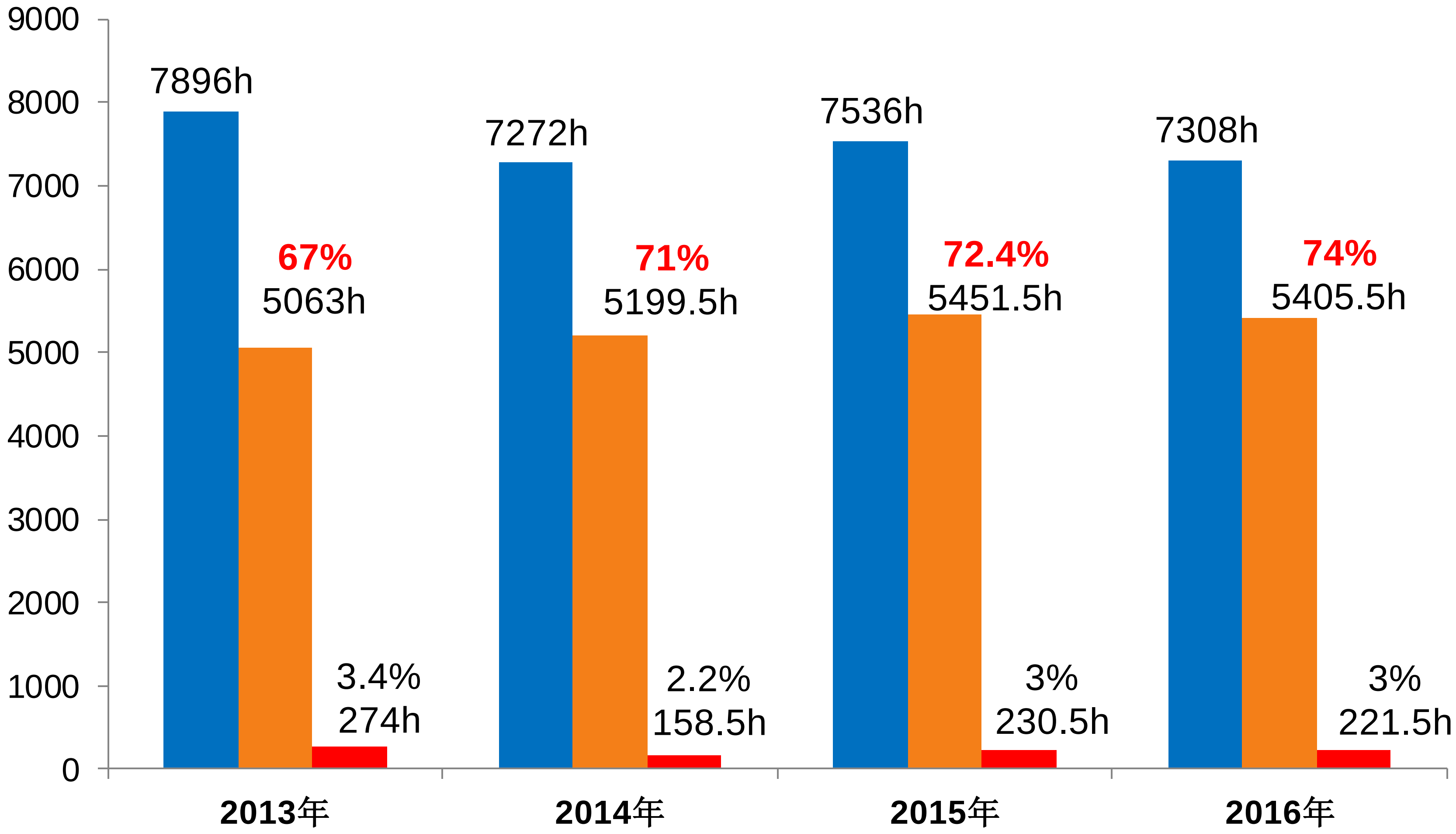
National Laboratory of Heavy Ion Accelerator in Lanzhou(in 1991)

SSC (K=450)
100 AMeV (H.I.), 110 MeV (p)

SFC (K=69)
10 AMeV (H.I.), 17~35 MeV (p)

HIRFL Status

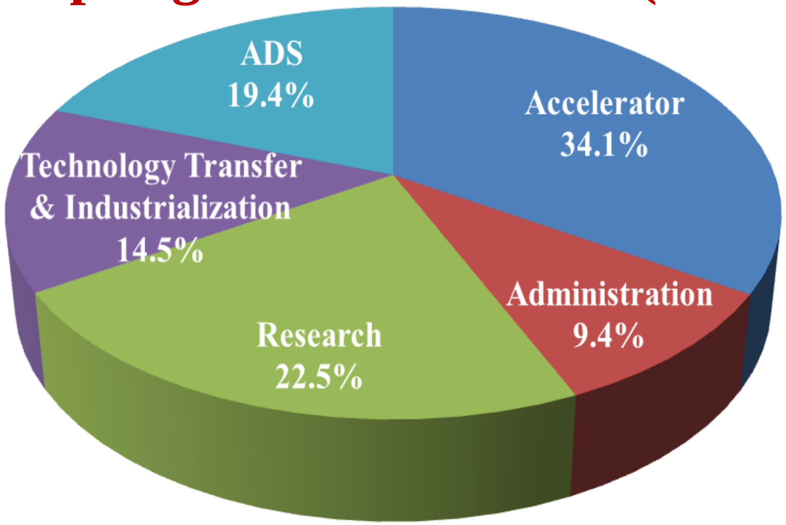
Operation time >7000hrs/year
Experimental target time ~5000hrs/y
User applied beam time >15000hrs/y

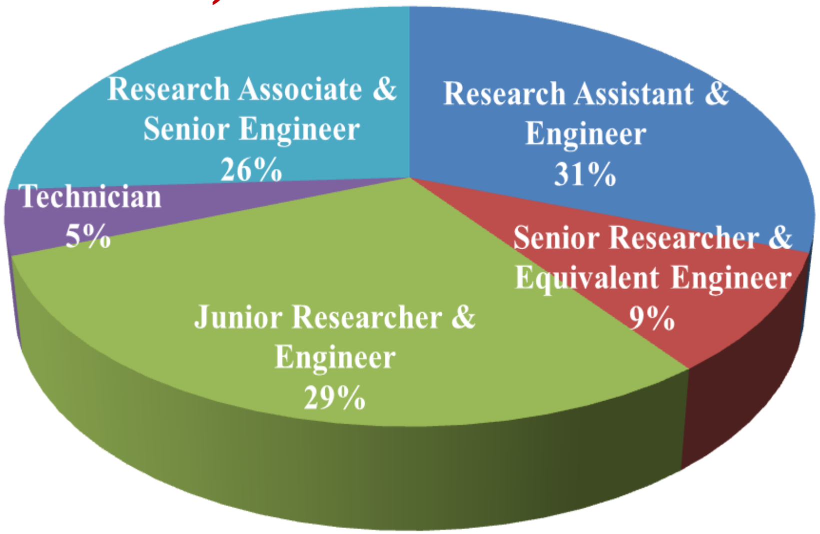


Human Resources

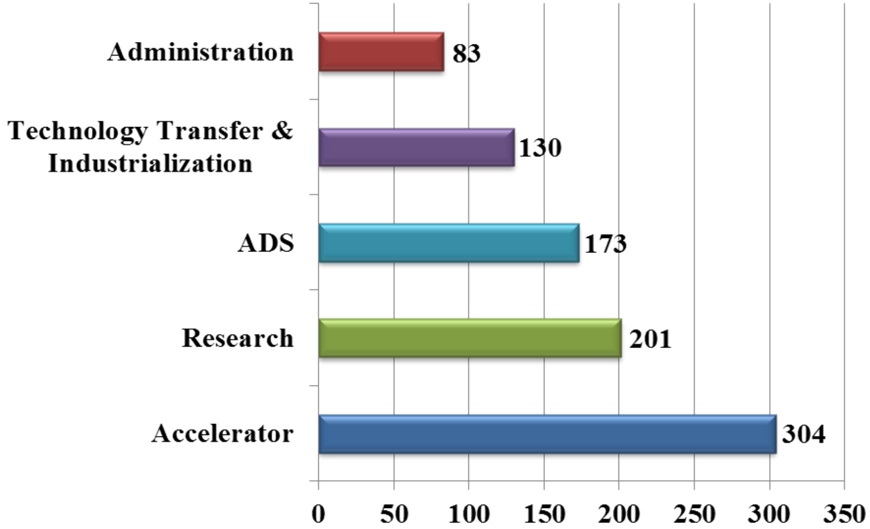
900 employees: half are under 35-years old

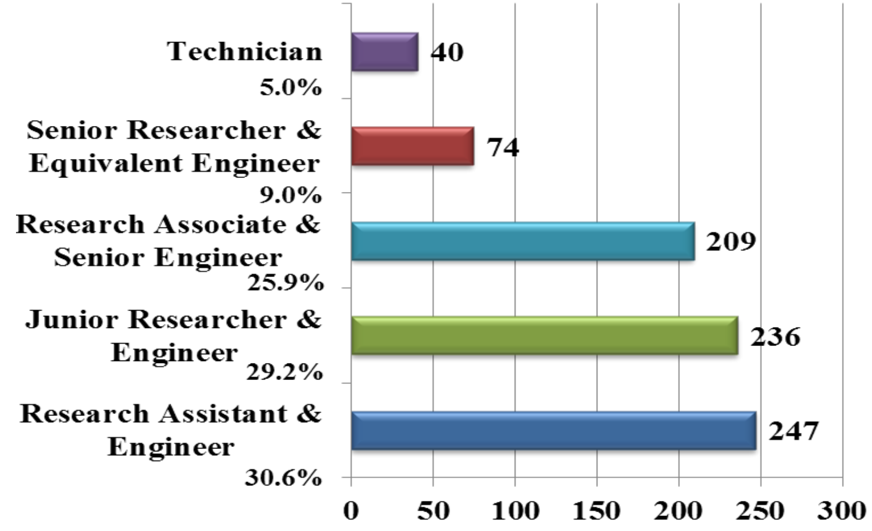
350 postgraduate students (PhD.200,Master150)





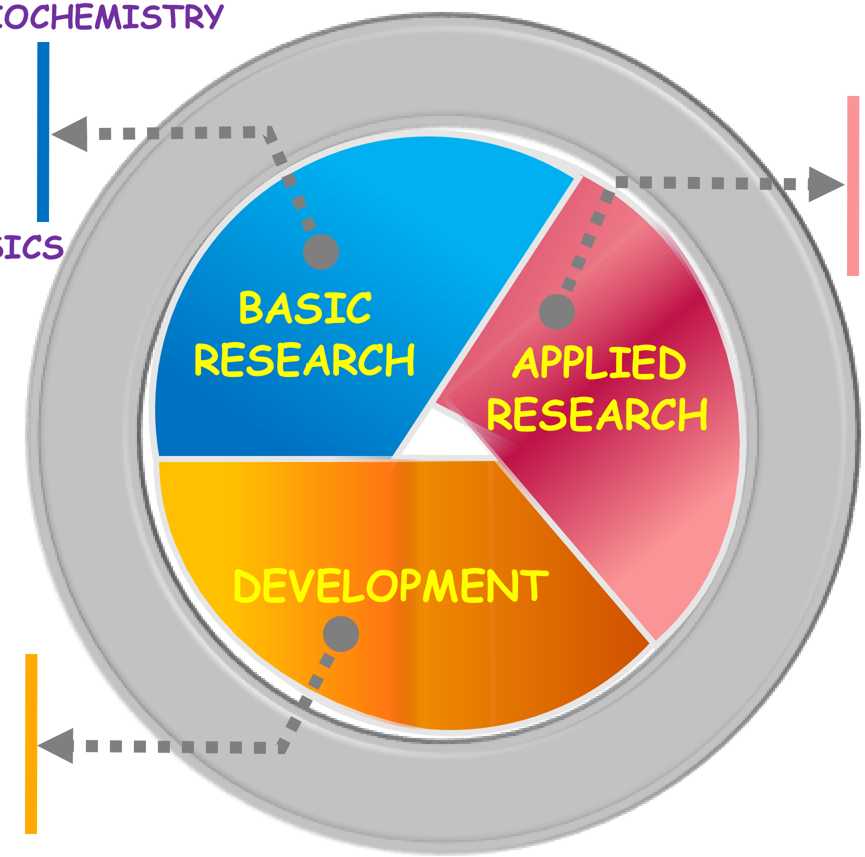
Staff distributions in the departments (left) and in academic titles (right)





RESEARCH FIELDS

- NUCLEAR PHYSICS
- NUCLEAR CHEMISTRY & RADIOCHEMISTRY
- ATOMIC PHYSICS
- MATERIAL SCIENCE
- HIGH ENERGY DENSITY PHYSICS
- HADRON PHYSICS
- ACCELERATOR PHYSICS



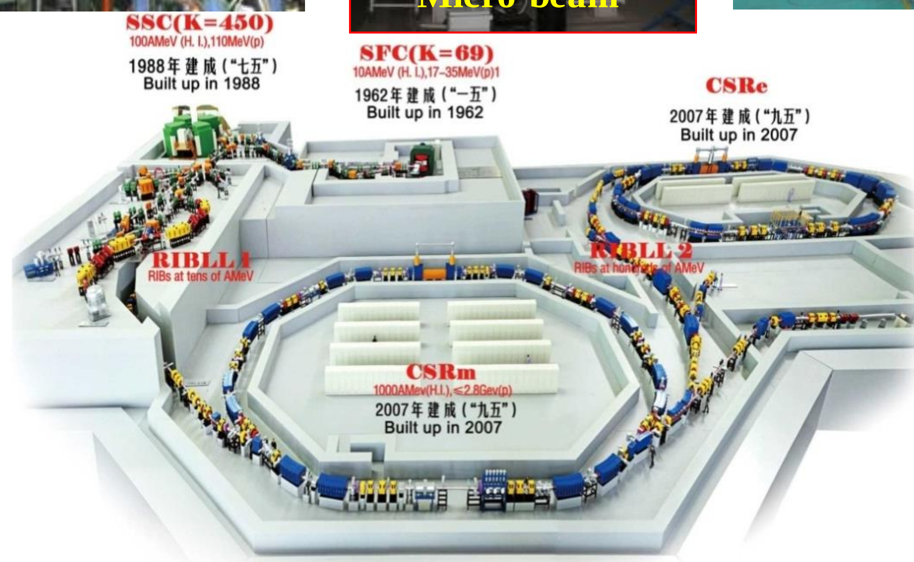
- RADIATION BIOLOGY
- RADIATION MEDICINE
- STRUCTURE MATERIALS
- ADVANCED NUCLEAR ENERGY
- NUCLEAR DETECTION

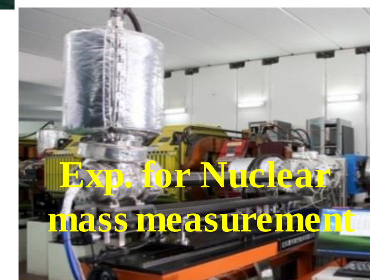
- ION ACCELERATORS
- COMPACT DEVICES
- LARGE-SCALE EXPERIMENTAL SETUPS

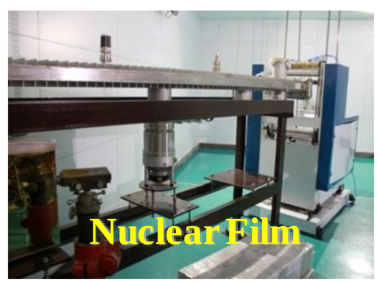
Scientific Activities

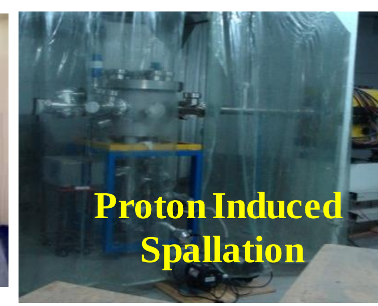
- **Fundamental researches on nuclear & atomic physics**
  - Reactions and structures of nuclei
  - Nuclear spectroscopy
  - Properties of asymmetric nuclear matter
  - Chemistry of super-heavy elements, and synthesis of new isotopes
  - Key reactions in stellar evolution
  - Spallation & nuclear data for ADS
  - High energy density physics
  - Hadron physics
  - HCI interaction with laser, electron, molecule, and surface
- **Applications with protons, heavy ions and micro-beams**
  - ADS, heavy-ion ICF, nanowire and membrane-tech., radiation-resistant material, …
  - Radiation medicine and biology: tumor therapy, mutation breeding, …
  - Detectors development and devices evaluation for satlite and space industry…
- **Detector and electronics development**
  - Si detectors: Si(Au), Si(Li), Si-strip,Si-pixel
  - Scintillator detectors: CsI, LaBr3, plastic sci., liquid sci. …
  - Gaseous detectors: IC, TPC, PPAC, MWPC, MWDC, MicroMeGAS, GEM, …
- **Key technique development related to high intensity accelerators**
  - ECR, Linac, superconducting cavities and magnets,…

Main Setups









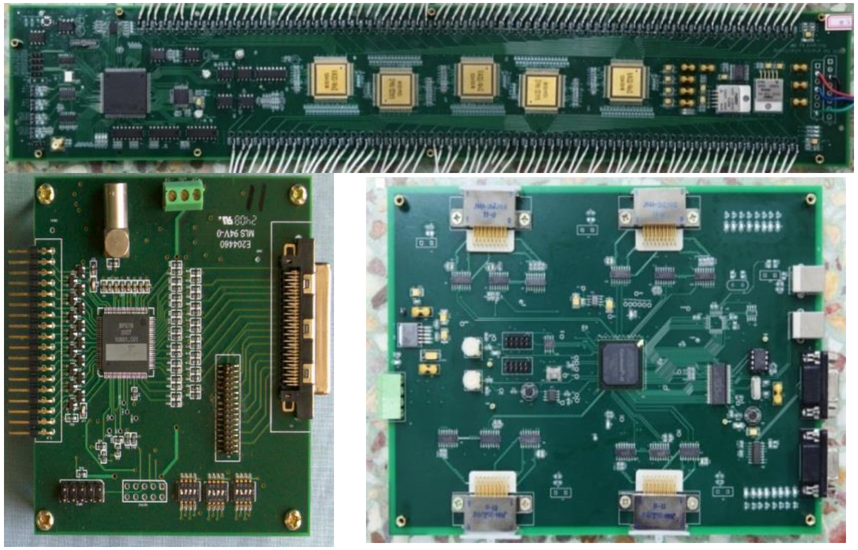
About 20 apparatuses for heavy-ion physics and applications

Technical Support System

Detectors and Electronics

Gaseous Detectors: TPC, MWPC, IC, PPAC

Crystal Detectors: CsI, $LaBr_3$, LYSO



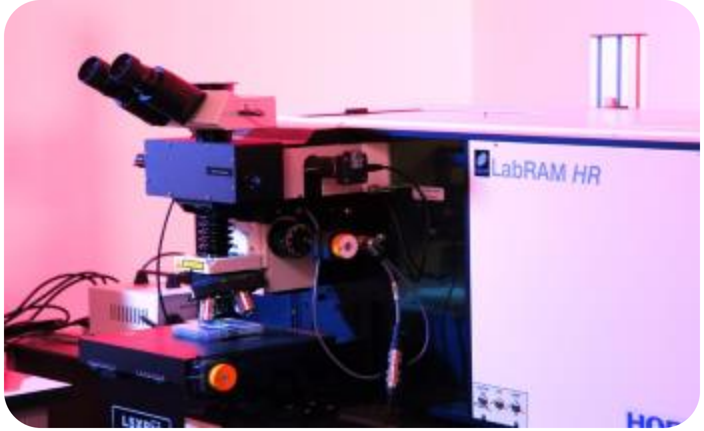
Analog and Digital Electronics

Si Strip Detectors

Instruments and Equipment

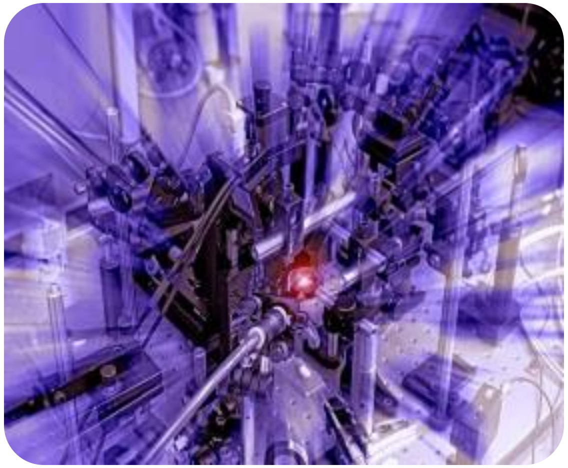
Laser confocal microscope

X-ray irradiation system



Raman spectrometer

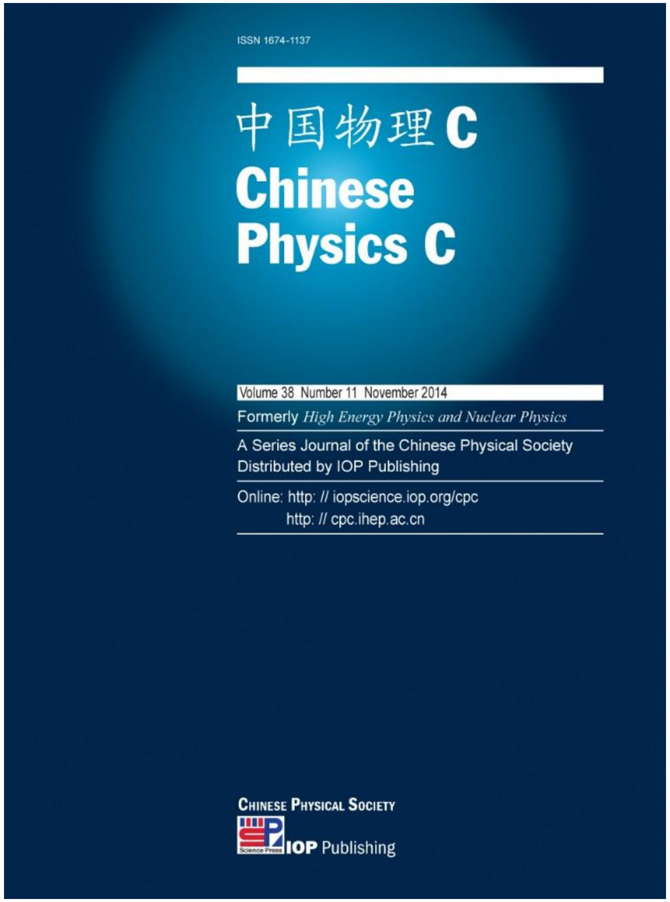
Field emission transmission electron microscopy (TEM)



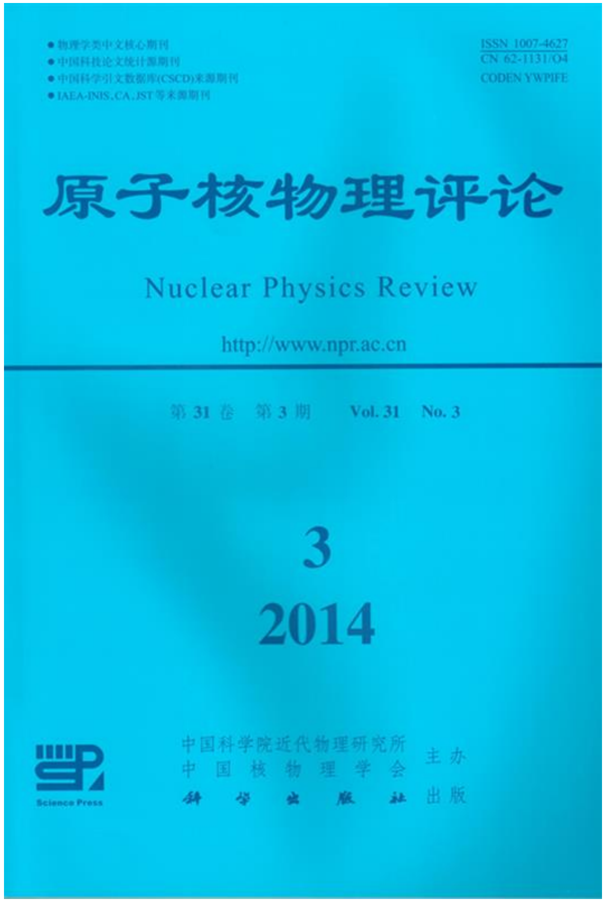
Laser spectrum analyzer

The inverse Compton spectrometer

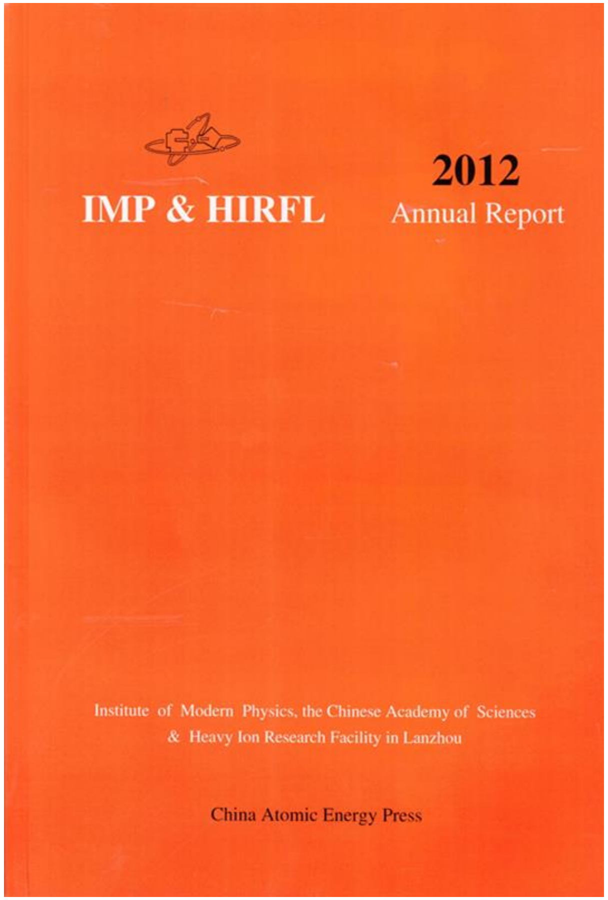
Hosted Journals



CPC, Co-hosted by IHEP and IMP

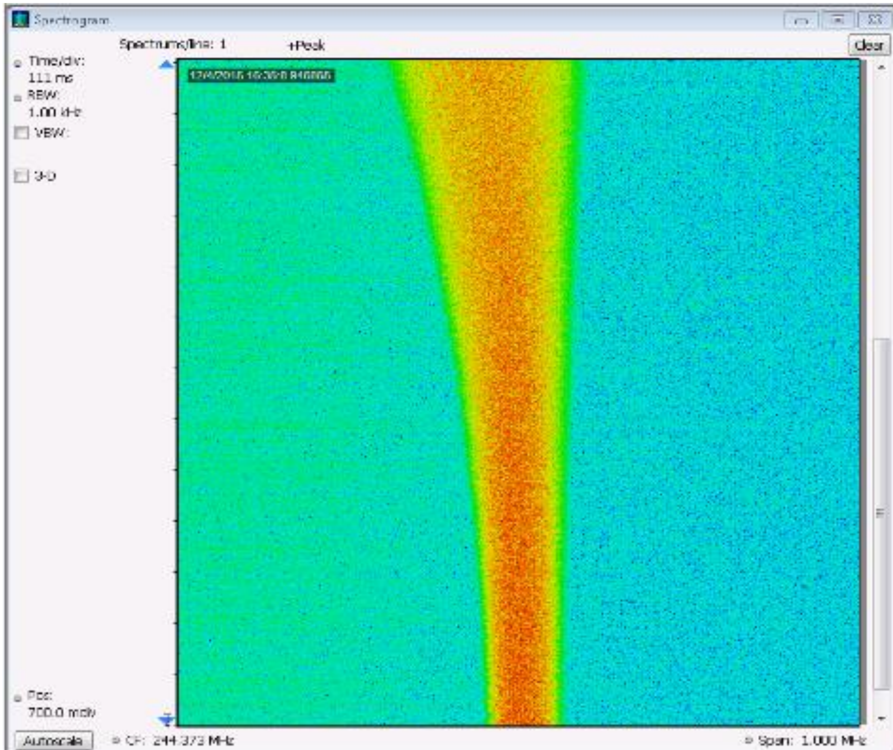


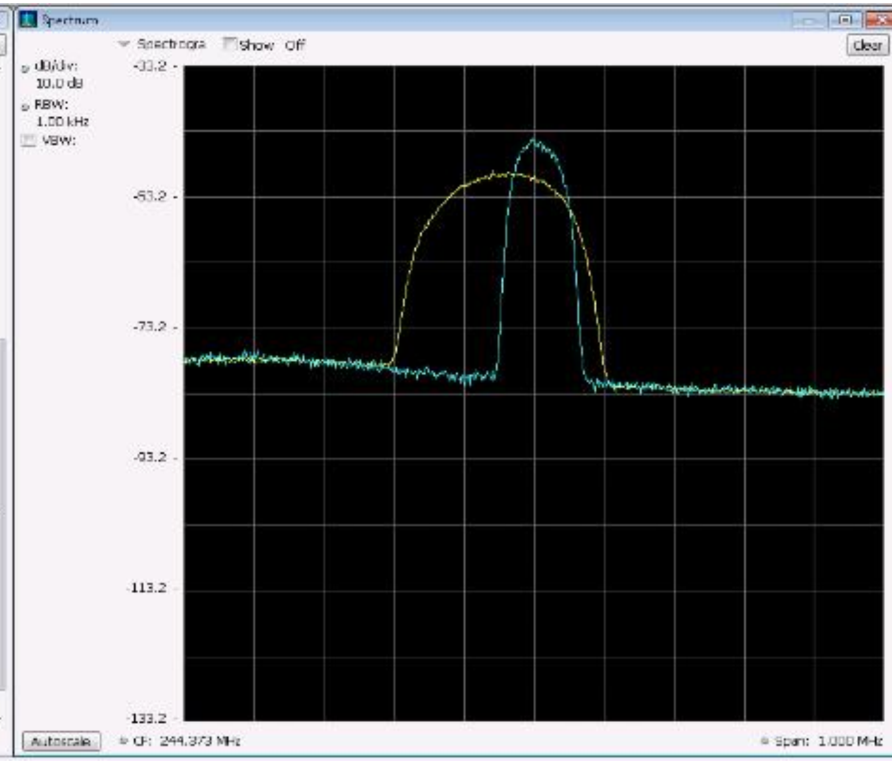
NPR, hosted by IMP

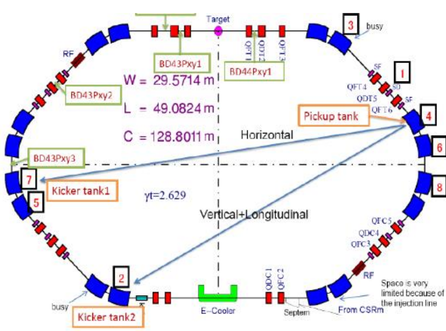


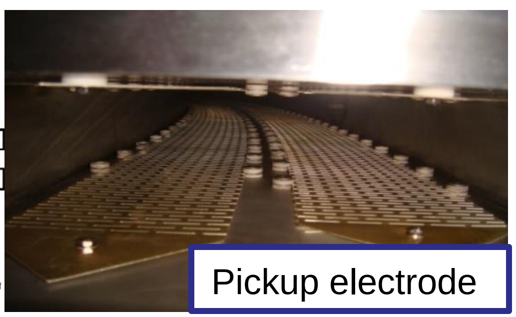
IMP Annual Report

Realization of stochastic cooling for $^{12}C^{6+}$(380MeV/u) beam at CSRm

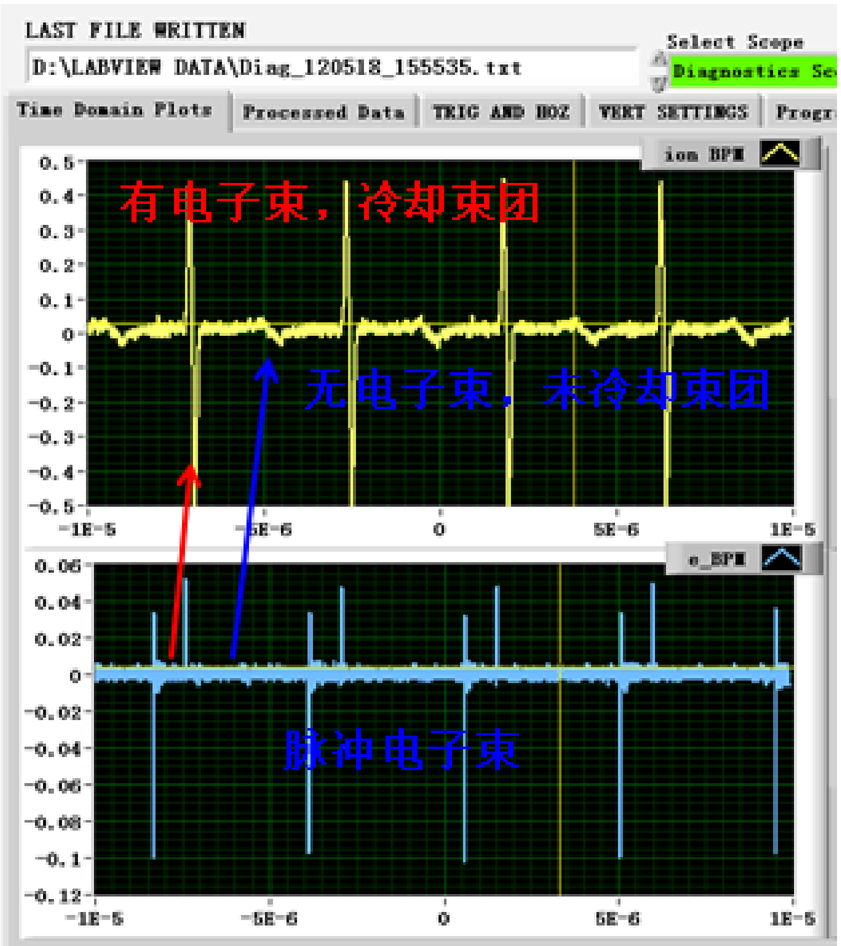


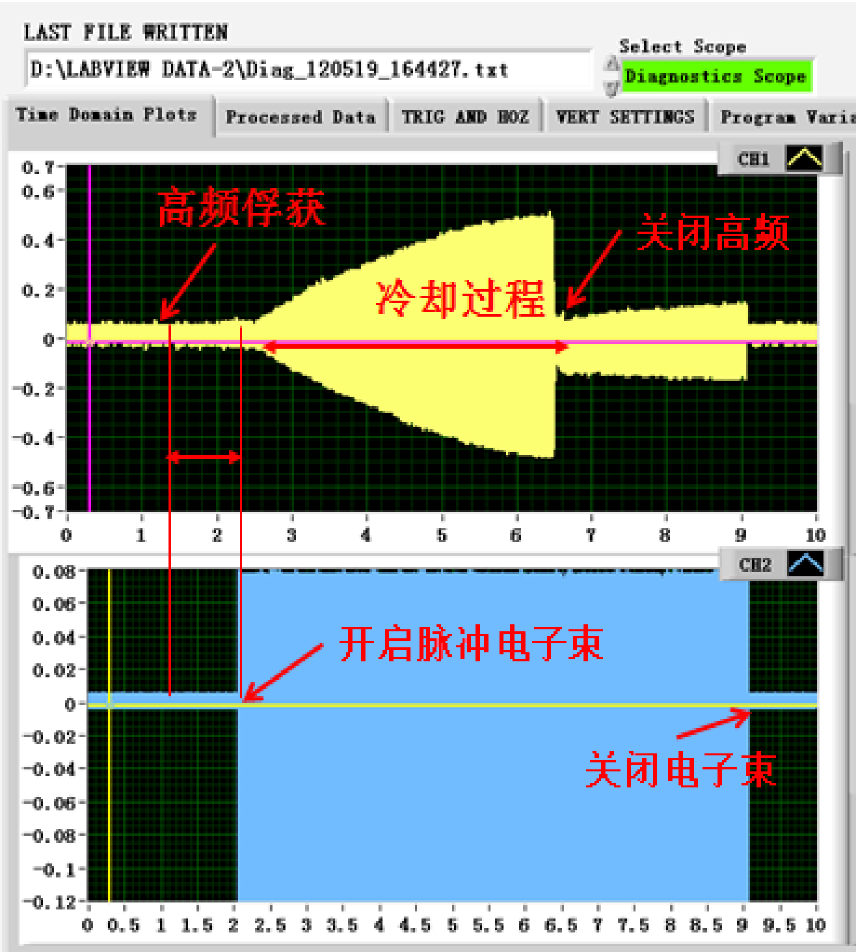






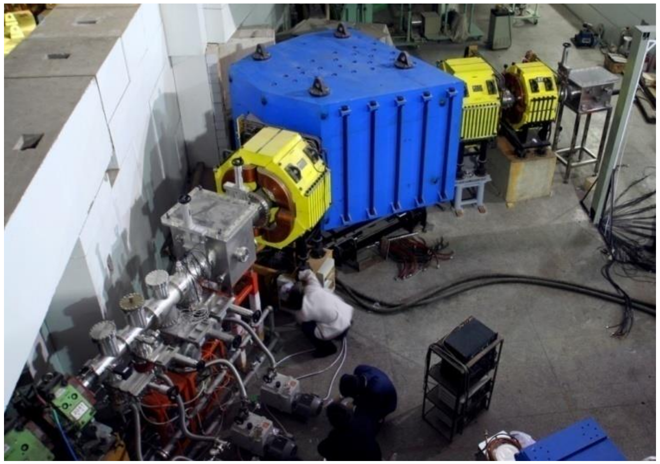
Realization of beam compression and cooling with pulsed electron beam from the electron cooler at CSRm

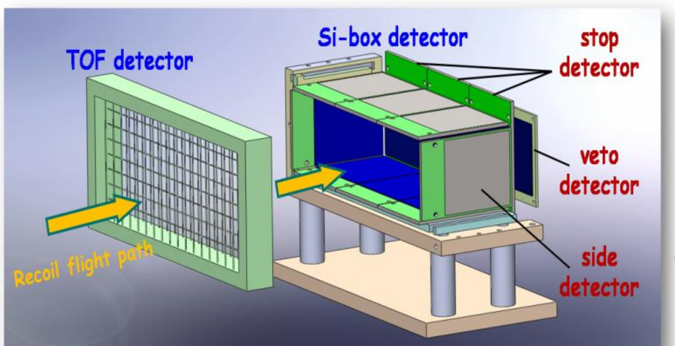




Synthesis of New Isotopes

>30 new isotopes synthesized





Proton rich region
^{205}Ac (2014) , ^{215,216}U (2015), $^{219,\ 223,224}$Np (2016)

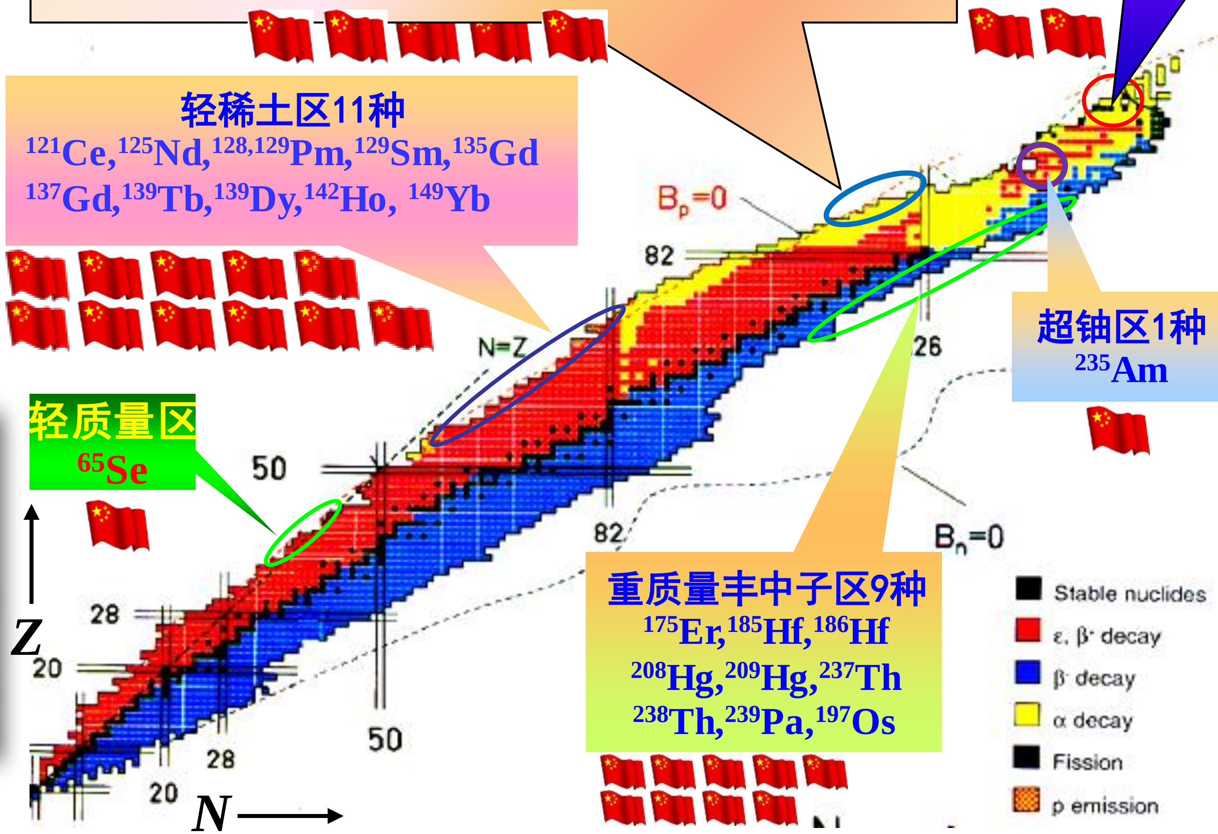
超重区2种
^{259}Db, ^{265}Bh

轻稀土区11种
^{121}Ce, ^{125}Nd, ^{128,129}Pm, ^{129}Sm, ^{135}Gd
^{137}Gd, ^{139}Tb, ^{139}Dy, ^{142}Ho, ^{149}Yb

超铀区1种
^{235}Am

轻质量区
^{65}Se

重质量丰中子区9种
^{175}Er, ^{185}Hf, ^{186}Hf
^{208}Hg, ^{209}Hg, ^{237}Th
^{238}Th, ^{239}Pa, ^{197}Os



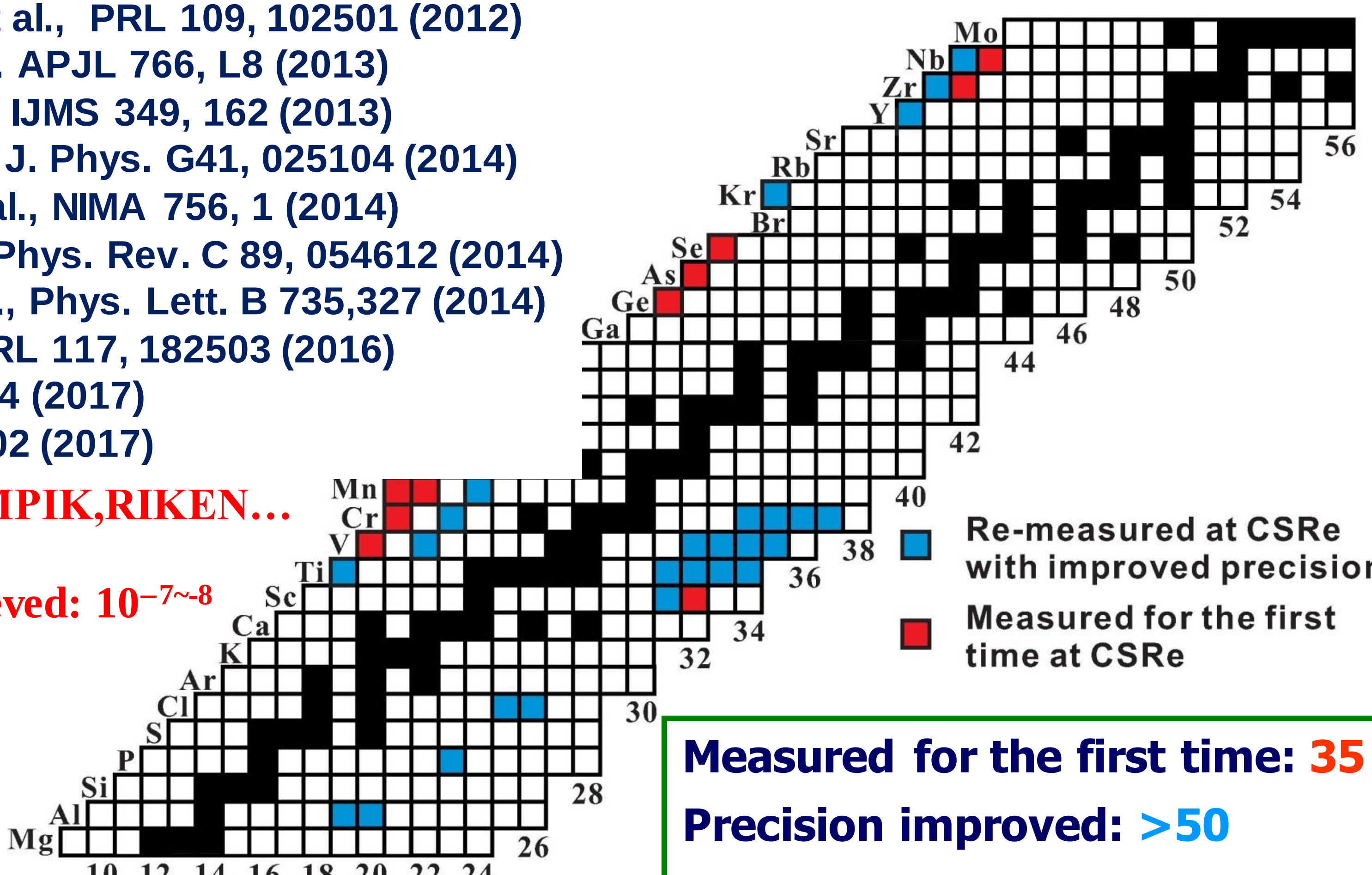
Research Progresses and Achievements

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. APJL 766, L8 (2013)
6. H.S. Xu et al., IJMS 349, 162 (2013)
7. X.L. Tu et al., J. Phys. G41, 025104 (2014)
8. W. Zhang et al., NIMA 756, 1 (2014)
9. B. Mei et al., Phys. Rev. C 89, 054612 (2014)
10. P. Shuai et al., Phys. Lett. B 735,327 (2014)
11. X.Xu et al., PRL 117, 182503 (2016)
12. PLB 767:20-24 (2017)
13. PRC 96 034302 (2017)

Beams: ^{56}Ni, ^{78}Kr, ^{86}Kr, ^{112}Sn

IMP,GSI,MSU,MPIK,RIKEN…

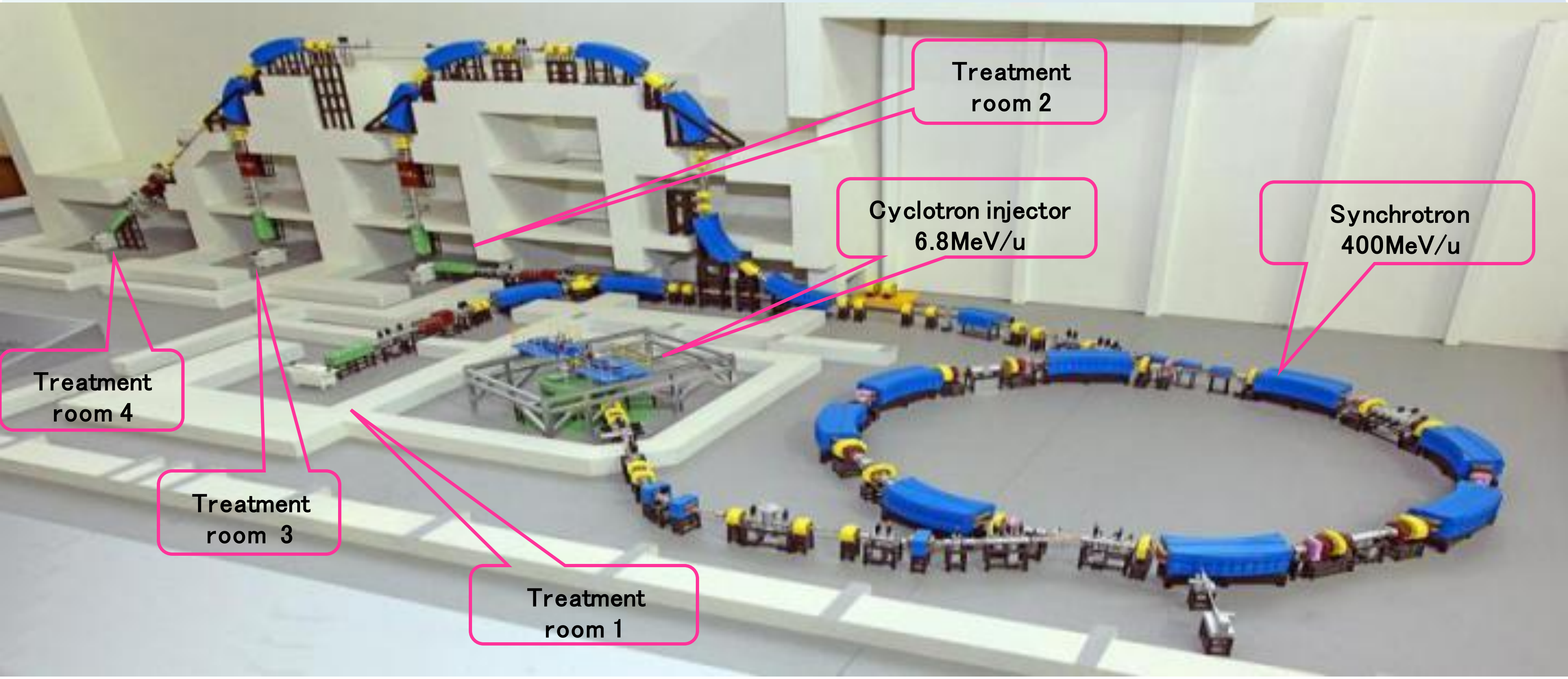
Precision achieved: $10^{-7\sim-8}$



Measured for the first time: 35

Precision improved: >50

Carbon cancer therapy facility



- Cyclotron injector+Synchrotron
- Four treatment rooms (horizontal, vertical, horizontal+vertical, 45 degree)
- Circumference 56.17m, most compact

Main specifications of HIMM

Ion	$^{12}C^{6+}$
Maximum Energy	400.0 MeV/u
Maximum Range	27.0 cm
Step Length of Range	2.0 mm
Dose Rate	0.001 Gy/s ~ 1.0 Gy/s
Radiation Field	200×200 mm^2
Beam Diameter	≤ 12.0 mm
Beam Intensity	$2.0 \times 10^6 \sim 4.0 \times 10^8$ pps
Cut-off Time	< 1.0 ms
Treatment Mode	Active Scanning and Passive Scanning
Treatment Terminal	One horizontal-direction terminal, one vertical-direction terminal, one terminal combined both horizontal and vertical direction, and one 45°-direction terminal.

Heavy ion therapy center in *Wuwei*

- Covering an area of 2 million square meters
- Total investment: 1.6 billion RMB, including 0.55 billion RMB for heavy ion facility
- Wuwei Tumor Hospital: ① Diagnosis and Treatment of Tumor
  ② Recovery and Recuperate

Wuwei Demo Facility

Cyclotron injector

Synchrotron

CT

Treatment Room

Treatment Control Room

TPS Room

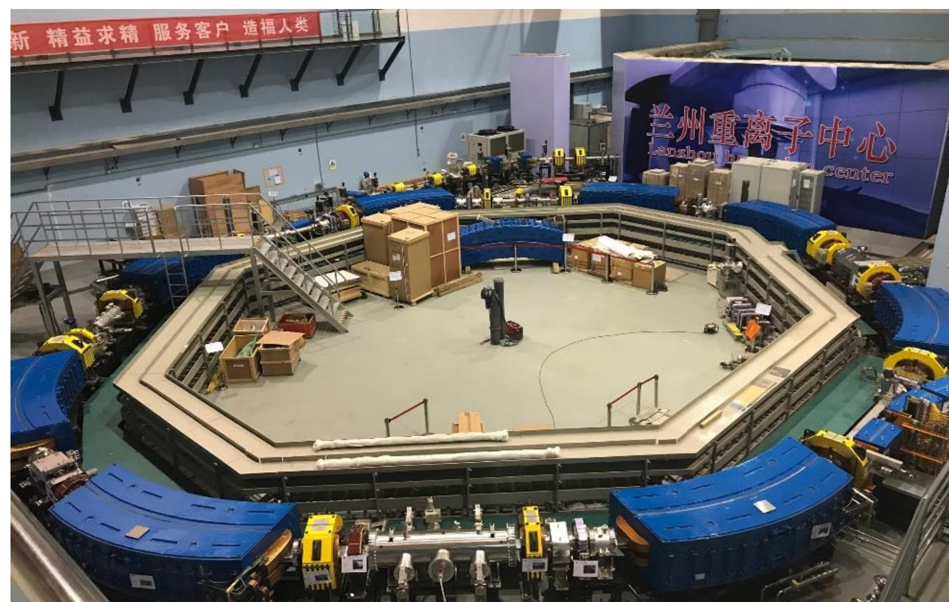
Central Control Room

Milestones of Wuwei Project

- First beam : Dec. 23, 2015
- Registration detections of national and international standards GB9706, GB4793, GB4943, YY0505, IEC60602-2-64 and so on have been completed.
- The clinical trial of 47 patients for CFDA will be followed soon to prove the safety performance and the short term validity of the facility.
- HIMM-Wuwei is expected to get the CFDA permission in 2018.

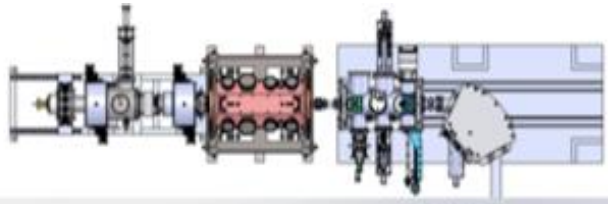
Lanzhou Heavy-Ion Tumor Therapy Center

- Covering 25 acres, a total investment of more than 400 M$
- Relying on Gansu Provincial Tumor Hospital
- Program started in 2009
- Instalation for accelerator is completed
- The beam to the treatmental rooms before the end of 2018



Commissioning Plan of Demo Facility(LINAC)

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

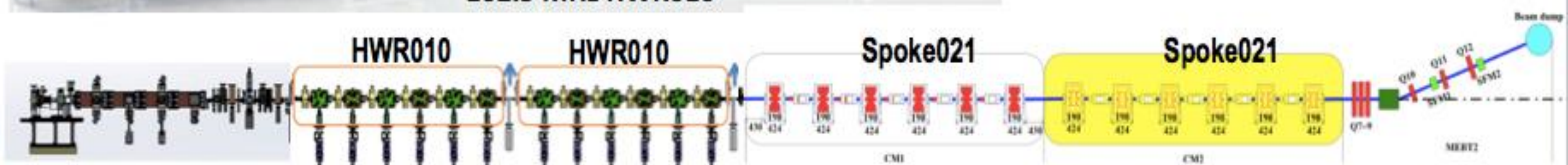
3

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

4

- ECRIS + LEBT + RFQ + MEBT + 2xCM6 +HEBT, 10 MeV
- 1 mA/CW, 10mA/pused, 2016

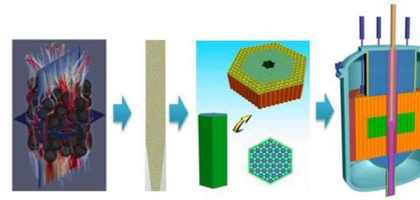
5



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

Dense granular flow target by gravity established

Mass parallel simulation method (GPU) for granular target



- Radiation transport computation in stochastic granular and neutronic analysis, etc.
- Granular flow and fluid flow simulations and thermal-hydraulic analysis.

Coupled computations

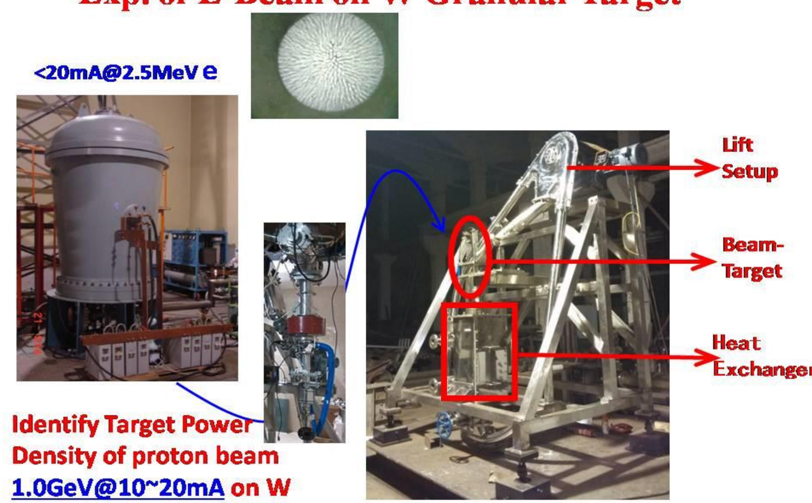
GPU hardware

250 S1070 GPUs ~300 Tflops(S)

128 K20 GPUs ~150 Tflops(D)

2010/11: rank 1 in TOP500; Now rank 8

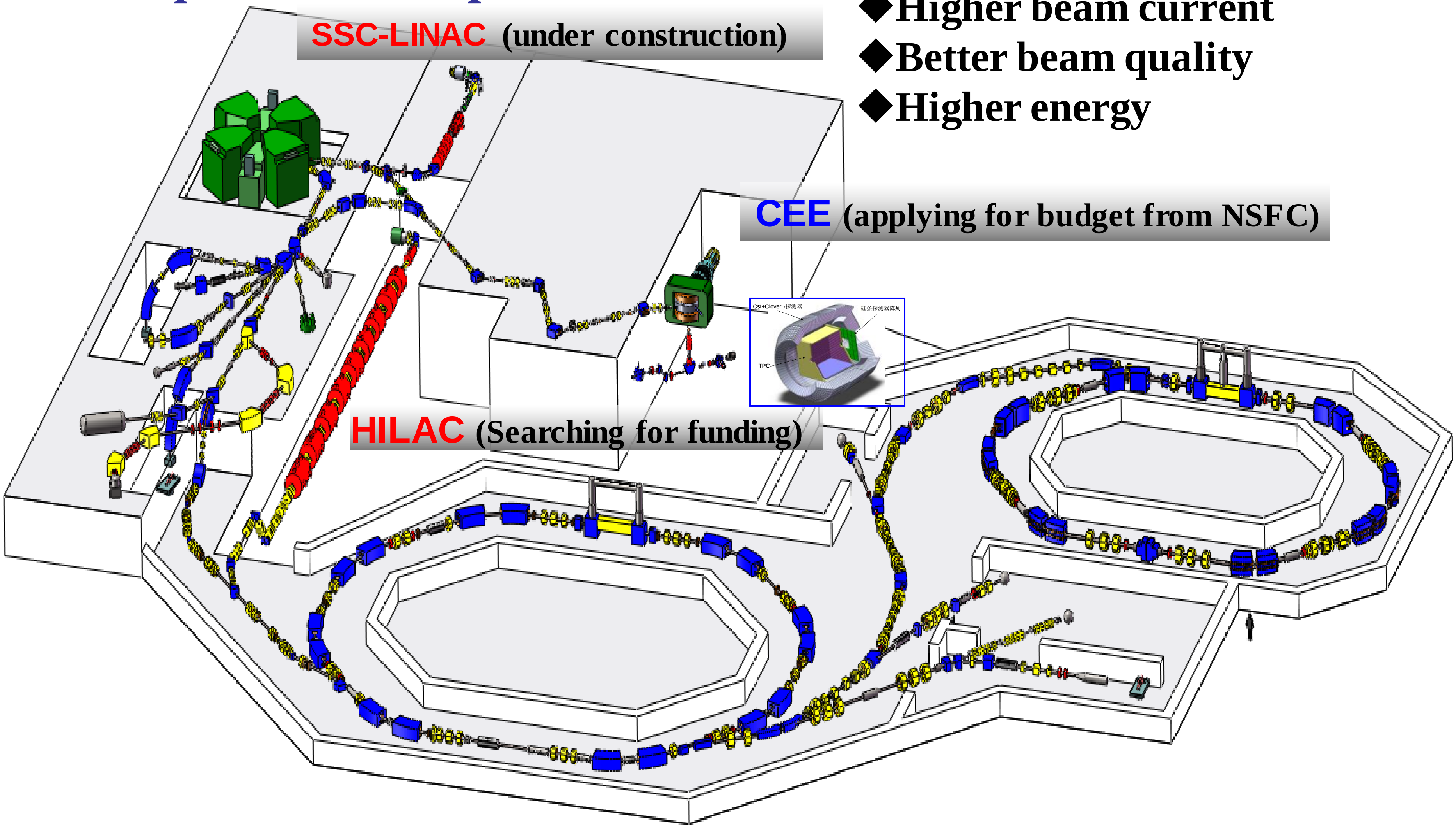
Exp. of E-Beam on W Granular Target

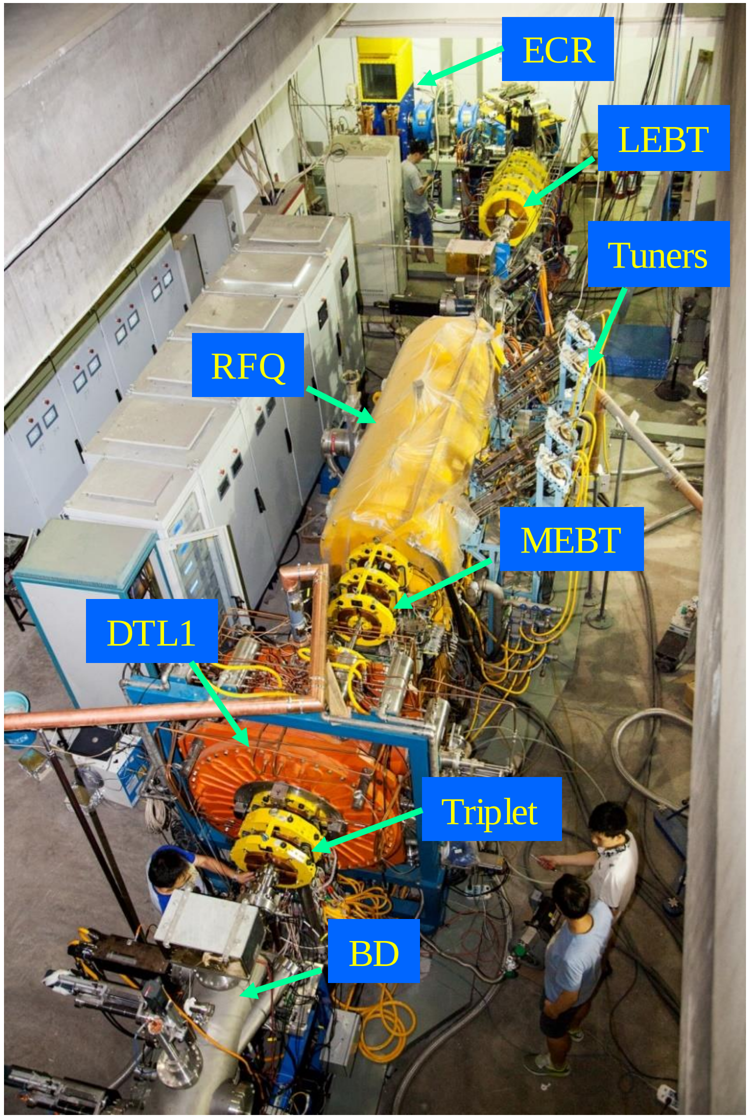


HIRFL Upgrade

- Multi-injectors
- New experiment setups

- Much more operation beamtime
- Higher beam current
- Better beam quality
- Higher energy



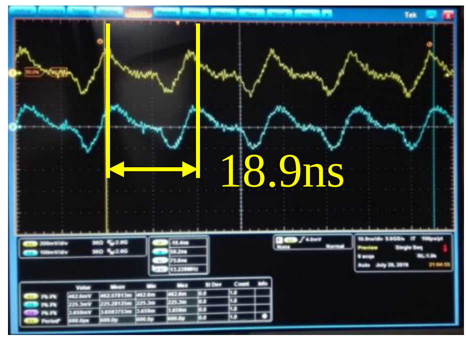


SSC-Linac

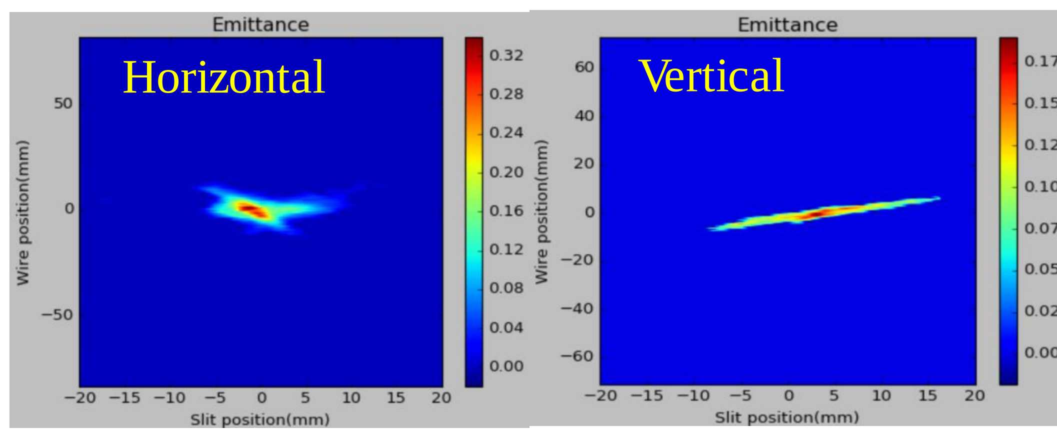
O^{5+} beam extracted

Energy 293.1keV/u

ε_{xnrms}=0.62mm·mrad ε_{ynrms}=0.14mm·mrad

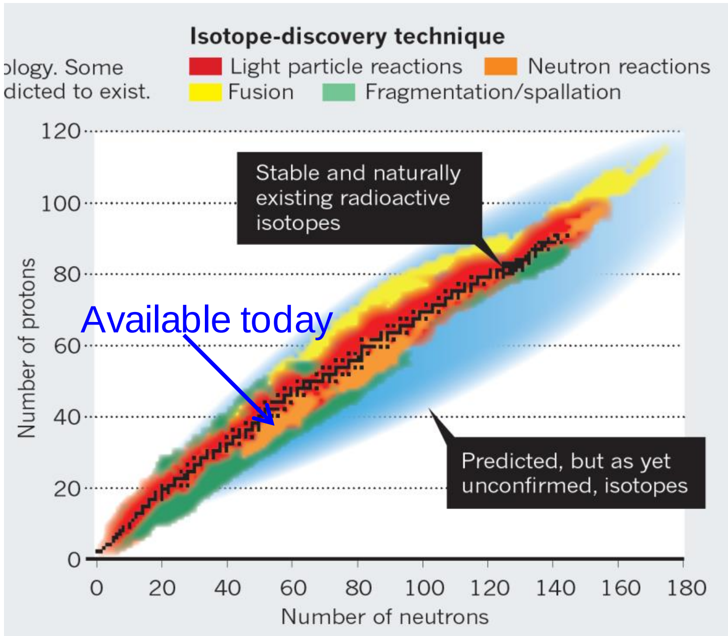


Ion	I(eμA)	
	ECR	**DTL**
$^{16}O^{5+}$	100	70



HIAF: background and motivation

Next-generation high intensity facilities are required for advances in nuclear physics and related research fields:



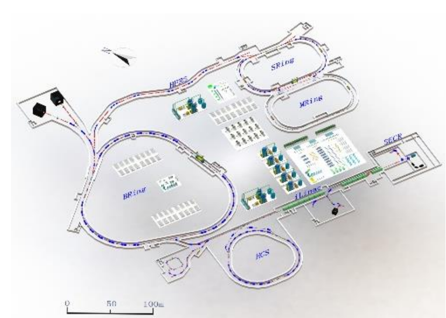
Fascinating and crucial questions

- To explore the limit of nuclear existence
- To study exotic nuclear structure
- Understand the origin of the elements
- To study the properties of High Energy and Density Matter

……

Next-generation facilities being constructed or proposed worldwide:

- SPIRAL2 at GANIL in Caen, France
- FAIR at GSI in Darmstadt, Germany
- FRIB at MSU in the U.S.
- NICA at JINR, Dubna, Russia
- EURISOL in Europe



High Intensity Heavy-ion Accelerator Facility

HIAF in China

HIAF: background and motivation

HIAF: One of 16 large-scale research facilities proposed in China in order to boost basic science, next-generation high intensity facility for advances in nuclear physics and related research fields.

Science motivations:

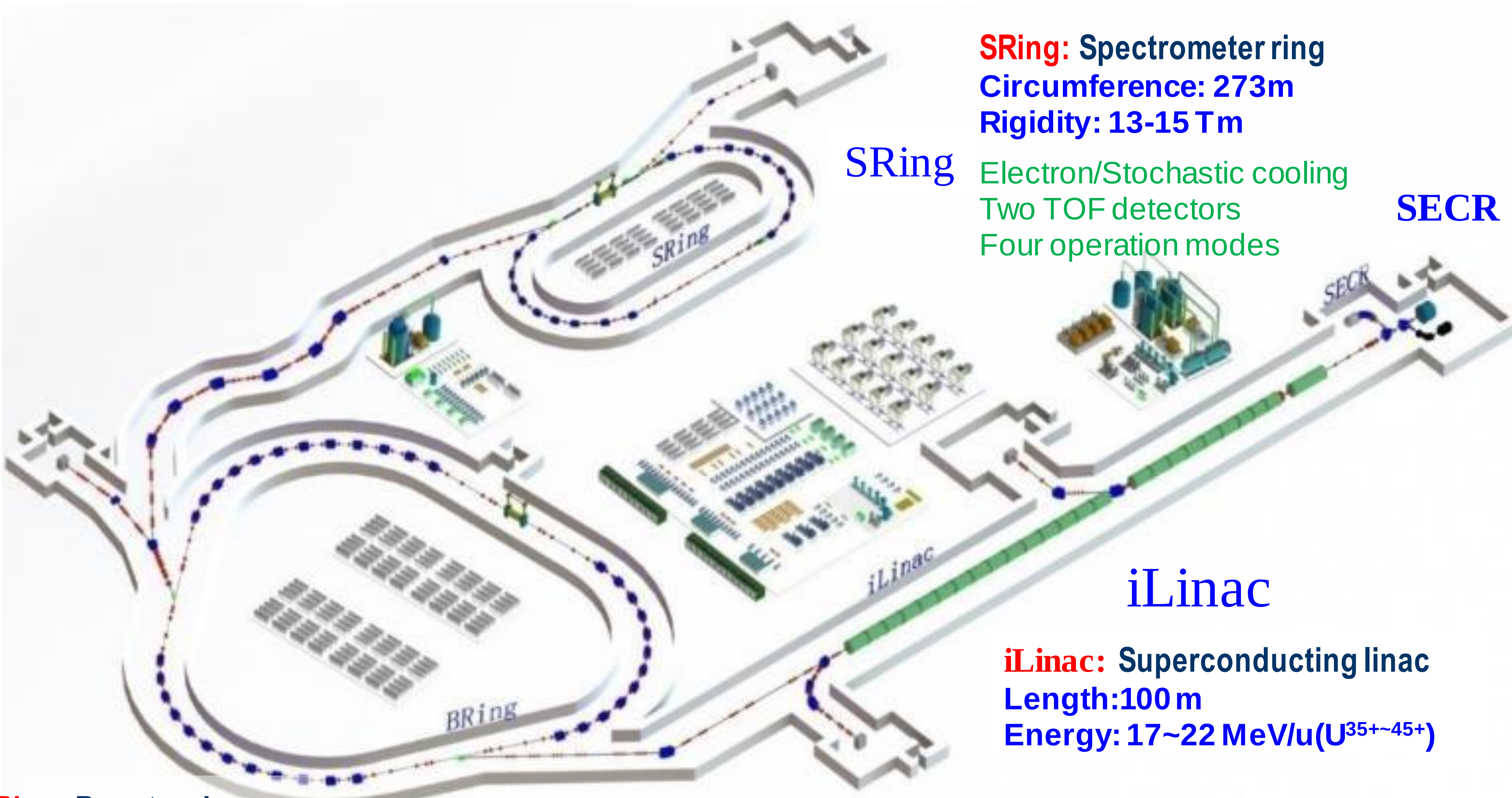
※ High intensity radioactive beams to investigate the structure of exotic nuclei, nuclear reactions of astrophysics and to measure the mass of nuclei with high precision.

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

※ Quasi-continuous beam with wide energy range for applied science.

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

※ Spontaneous electron–positron pair production



SRing: Spectrometer ring
Circumference: 273m
Rigidity: 13-15 Tm

Electron/Stochastic cooling
Two TOF detectors
Four operation modes

iLinac: Superconducting linac
Length:100 m
Energy: 17~22 MeV/u($U^{35+\sim45+}$)

BRing: Booster ring
Circumference: 590 m
Rigidity: 34 Tm

Beam accumulation
Beam cooling
Beam acceleration

Approved by Centre government with a budget of ¥1.5 billion in 2015

Main accelerator components of HIAF and Upgade

BRing-S: Booster ring
Circumference: 650 m
Rigidity: 86 Tm

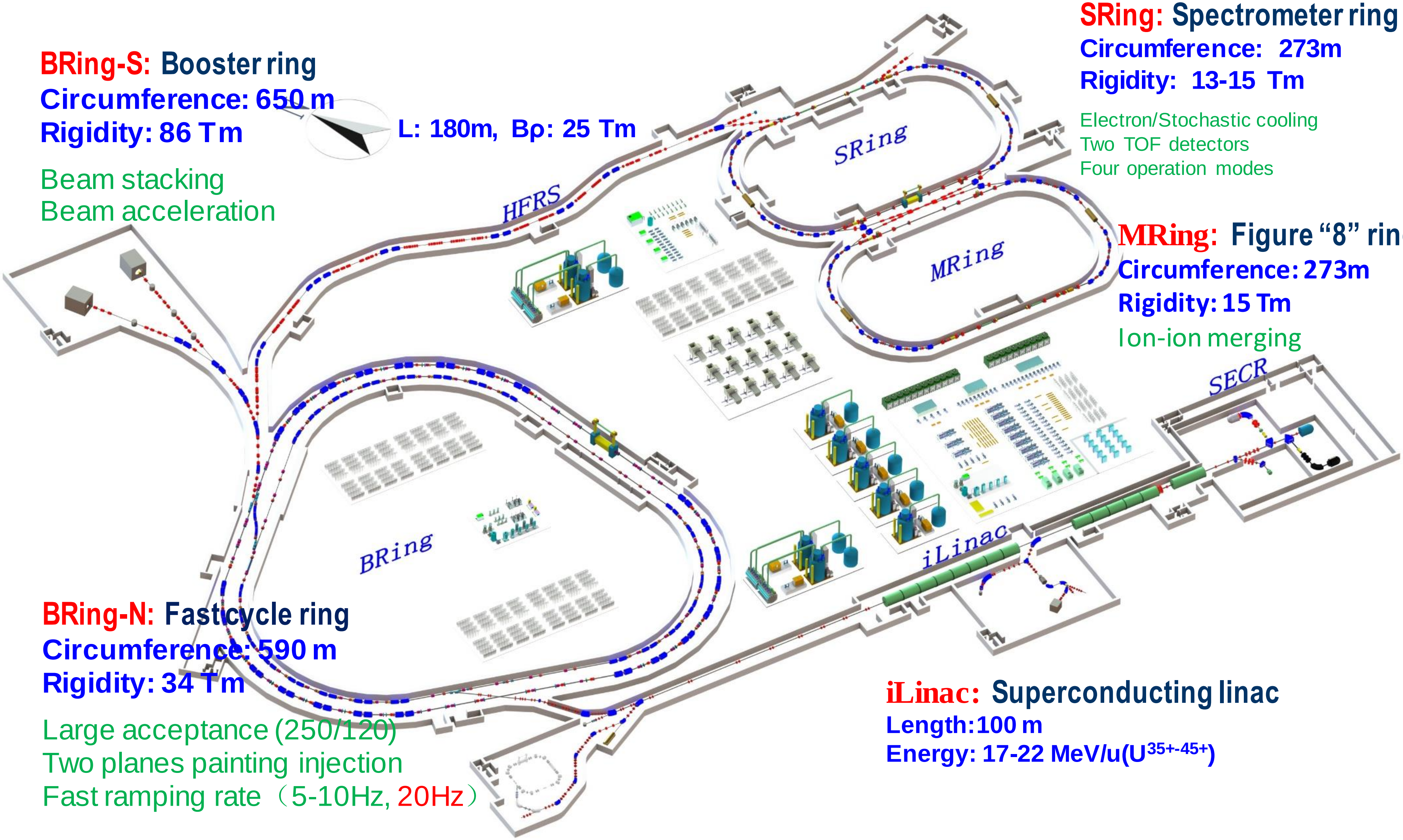
Beam stacking
Beam acceleration

SRing: Spectrometer ring
Circumference: 273m
Rigidity: 13-15 Tm

Electron/Stochastic cooling
Two TOF detectors
Four operation modes

MRing: Figure "8" ring
Circumference: 273m
Rigidity: 15 Tm

Ion-ion merging



BRing-N: Fast cycle ring
Circumference: 590 m
Rigidity: 34 Tm

Large acceptance (250/120)
Two planes painting injection
Fast ramping rate（5-10Hz, 20Hz）

iLinac: Superconducting linac
Length: 100 m
Energy: 17-22 MeV/u($U^{35+-45+}$)

These tunnels will be built in a cut and cover method and will be filled with 5 m overlay of soil. This conforms to the requirements of radiation safety.

Facility for world class experiments

Unprecedented parameters and unique features:

Highest beam Intensity （Comparison with HIRFL）**:**

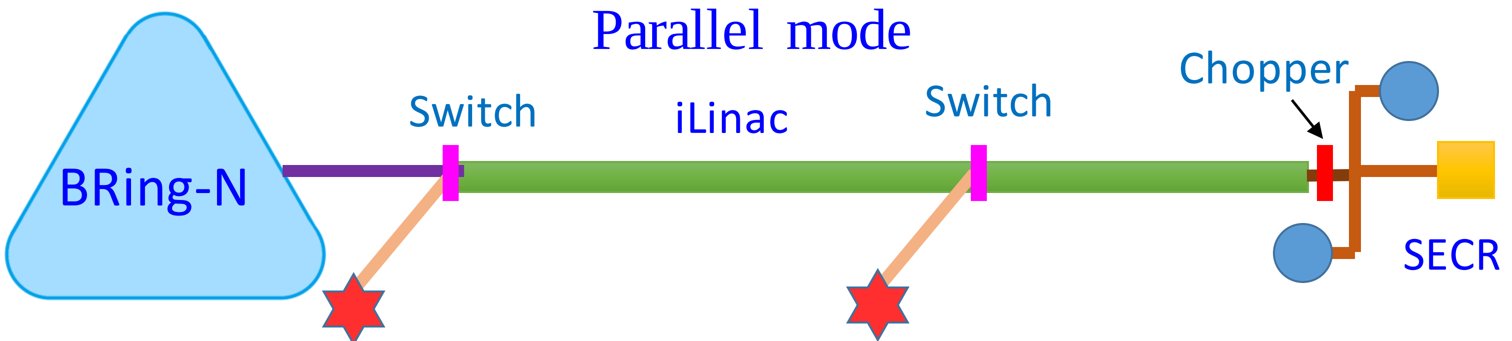
- **Primary beam intensity increases by x 1000 - x 10000**
- **Secondary beam intensity increases by up to x 10000**
- **Highest heavy ion beam intensity in the world**

Precisely-tailored beams - Precision frontiers

- **Beam cooling (**Electron, Stochastic, laser; high quality, very small spot **)**
- **Beam compression (**Ultra-short bunch length: 50-100ns**)**
- **Super long period slow extraction (**Super long, high energy, quasi-continuous beam **)**

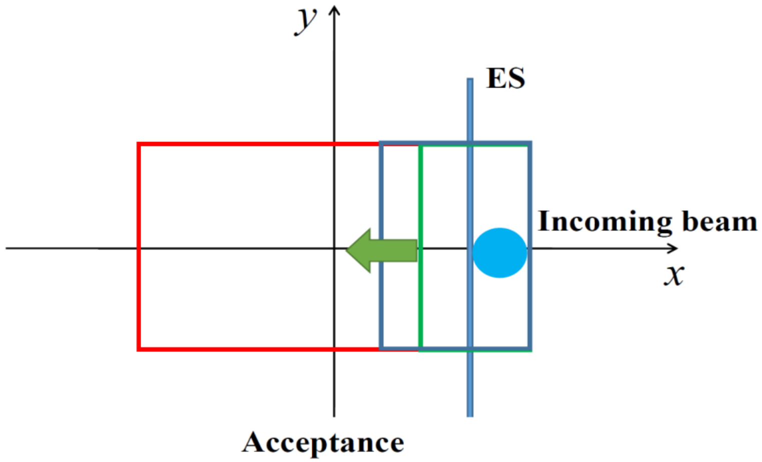
Versatile operation modes:

- **Parallel operation, beam splitting (** increase of target time, high integrated luminosity)

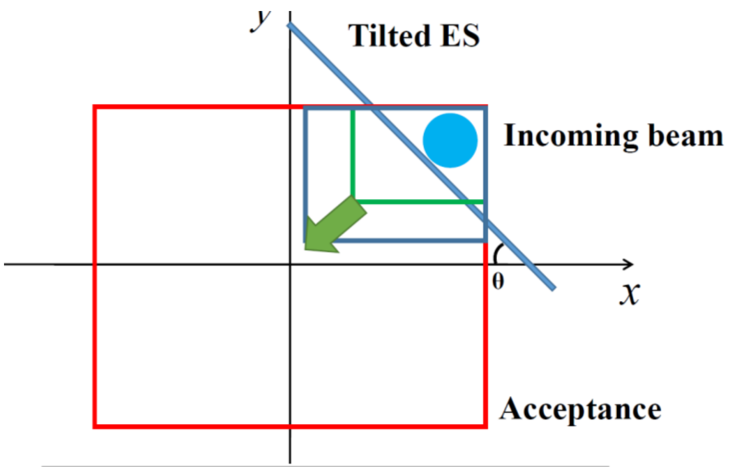


Unprecedented heavy ion beam intensity

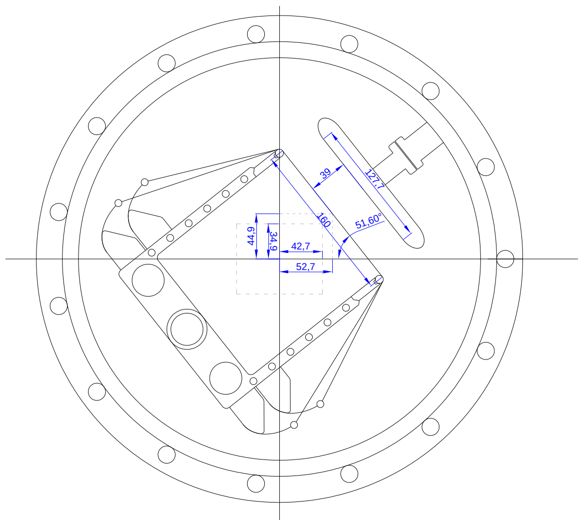
Two planes painting injection

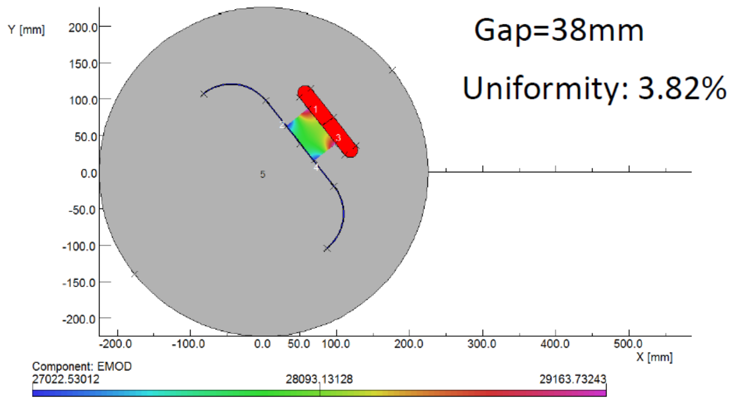


Conventional multi-turn injection



Two-plane painting multiturninjection

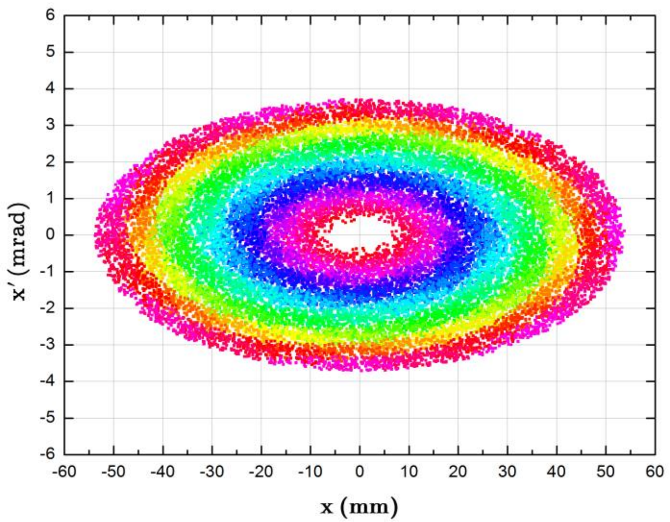


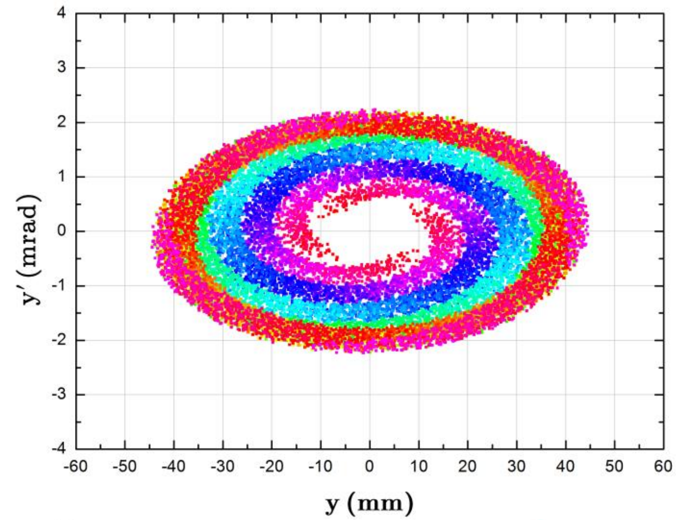


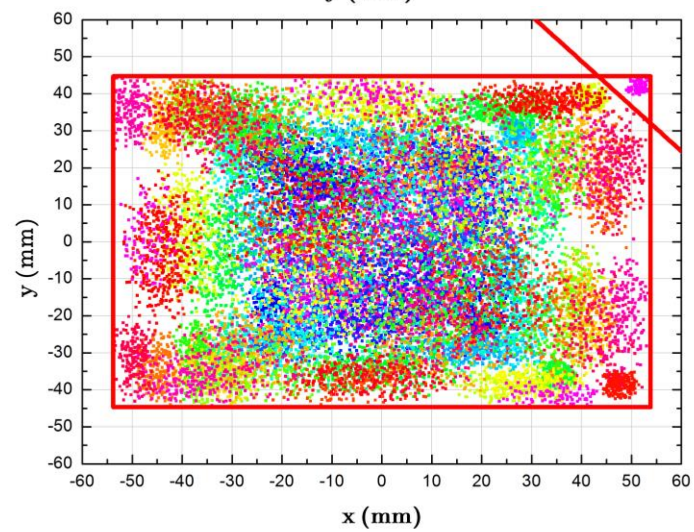
Simultaneous injection in H and V planes using **tilted septum**

Unprecedented heavy ion beam intensity

Simulation results







Ions	Plane	Injection turns	Single injection
$^{238}U^{35+}$	H	33	3.3×10^{10}
	V	16	1.6×10^{10}
	H+V	**150**	**2.0×10^{11}**

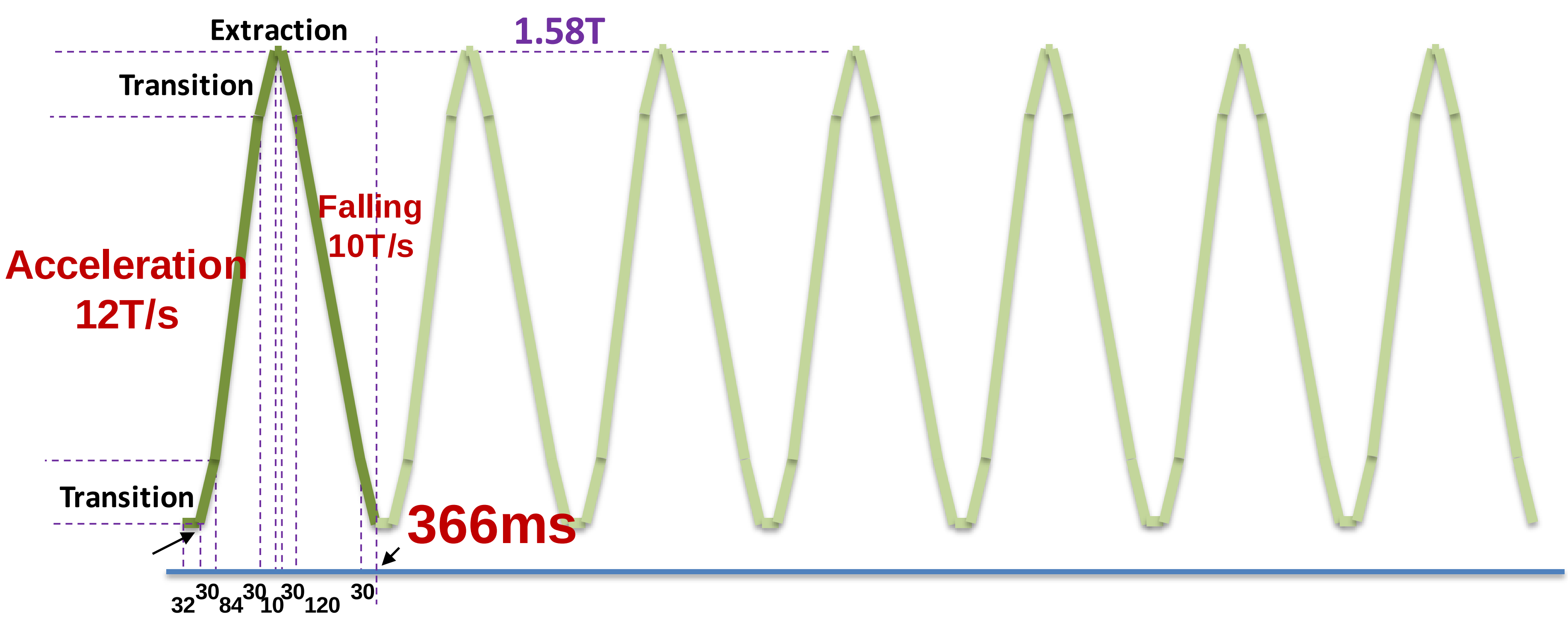
Conclusions:

- The beam intensity could reach 2.0×10^{11} with two planes painting, nearly 10 times over the conventional single-plane injection.

Fast ramping rate mode of BRing-N

Why?

Due to **space charge** and **dynamic vacuum** effect, beam should be launched to the high energy as soon as possible.



Repetition rate：3-5 Hz, 5-10Hz

Unprecedented heavy ion beam intensity

Basic beam parameters

	Ions	Energy	Intensity
SECR	$^{238}U^{35+}$	14 keV/u	0.05-0.1 pmA
iLinac	$^{238}U^{35+}$	17 MeV/u	0.028-0.05 pmA
BRing-N	$^{238}U^{35+}$	0.8 GeV/u	~2.0×10^{11} ppp
BRing-S	$^{238}U^{35+}$	2.3 GeV/u	~1.0×10^{12} ppp
	$^{238}U^{76+}$	5.8 GeV/u	~5.0×10^{11} ppp
	$^{238}U^{92+}$	7.3 GeV/u	~5.0×10^{11} ppp
SRing	RIBs: neutron-rich, proton-rich	0.84 GeV/u(A/q=3)	~10^{9-10} ppp
	Fully stripped heavy ions H-like, He-like heavy ions	0.8 GeV/u($^{238}U^{92+}$)	~10^{11-12} ppp

Unprecedented heavy ion beam intensity

The highest pulse heavy ion beam intensity in the world

Institute	Machine	Planned Intensity	Achieved Intensity	Ion species	Repetition rate
BNL	AGS Booster		5×10^{9}	Au^{32+}	
CERN	LEIR		9×10^{8}	Pb^{54+}	
JINR	NICA Booster	4×10^{9}		Au^{32+}	
GSI	SIS18	1.0×10^{11}	3×10^{10}	U^{28+}	2.7Hz
FAIR	SIS100	4.0×10^{11}		U^{28+}	
IMP	HIAF-BRing-N	2.0×10^{11}		U^{35+}	5-10Hz, 10-20Hz
IMP	HIAF-BRing-S	1.0×10^{12} 2.0×10^{12}		U^{35+}	

Multi-function storage ring

Key devices

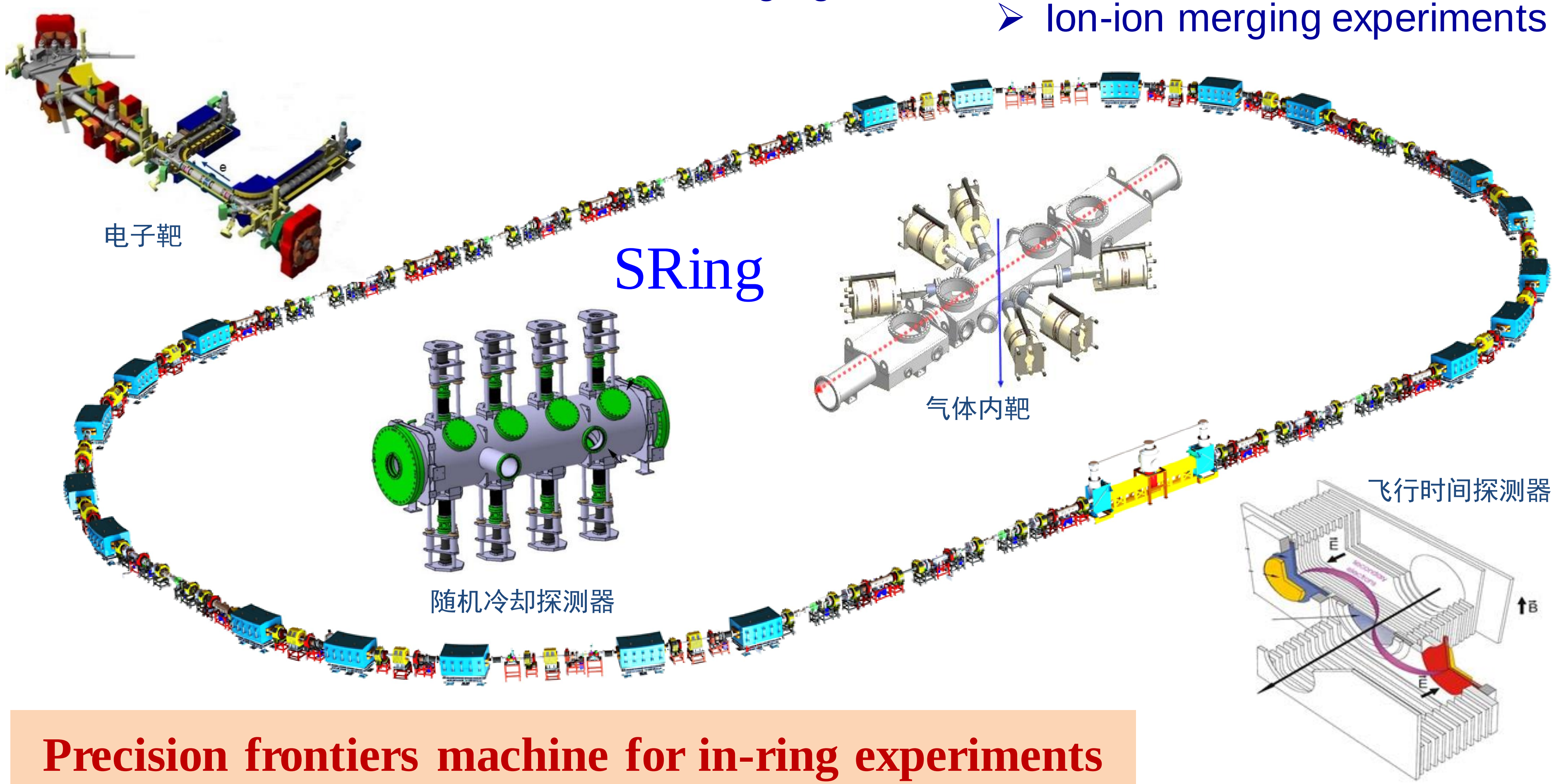
- Electron cooling
- Stochastic cooling
- Two TOF detectors
- Electron target

Operation modes

- Isochronous mode
- Normal Mode
- Internal-target Mode
- Ion-ion merging Mode

Experiment programs

- Gas-jet target experiments
- DR experiments
- IMS & SMS
- Laser cooling
- Ion-ion merging experiments

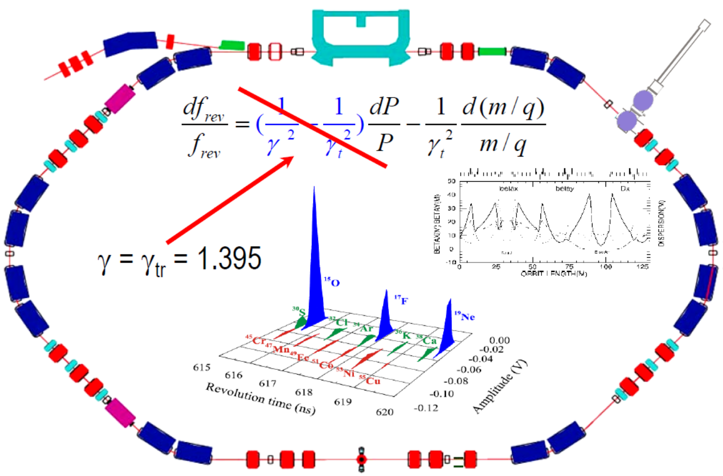


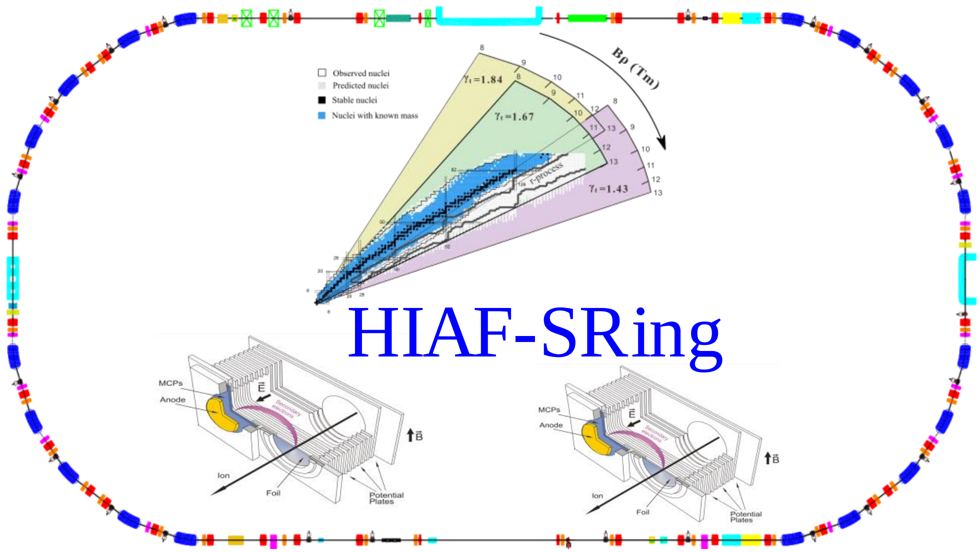
Precision frontiers machine for in-ring experiments

Multi-function storage ring

Isochronous mode with two TOF

HIRFL-CSRe



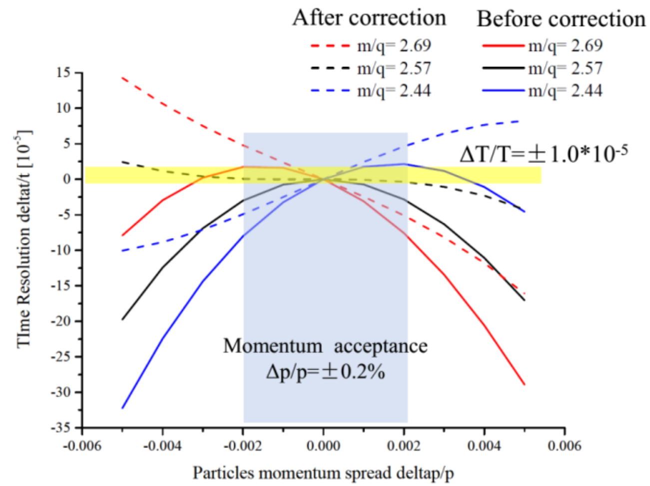


Beams： ^{58}Ni, ^{78}Kr, ^{86}Kr and ^{112}Sn

>80 masses are measured
Measured for the first time: 35
Precision improved: >50

Precision achieved: $\Delta M/M\sim10^{-7}$

Demonstrated the TOF mode first time in the world

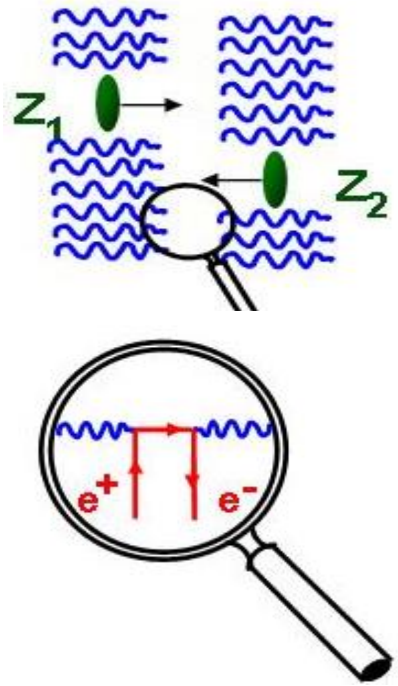


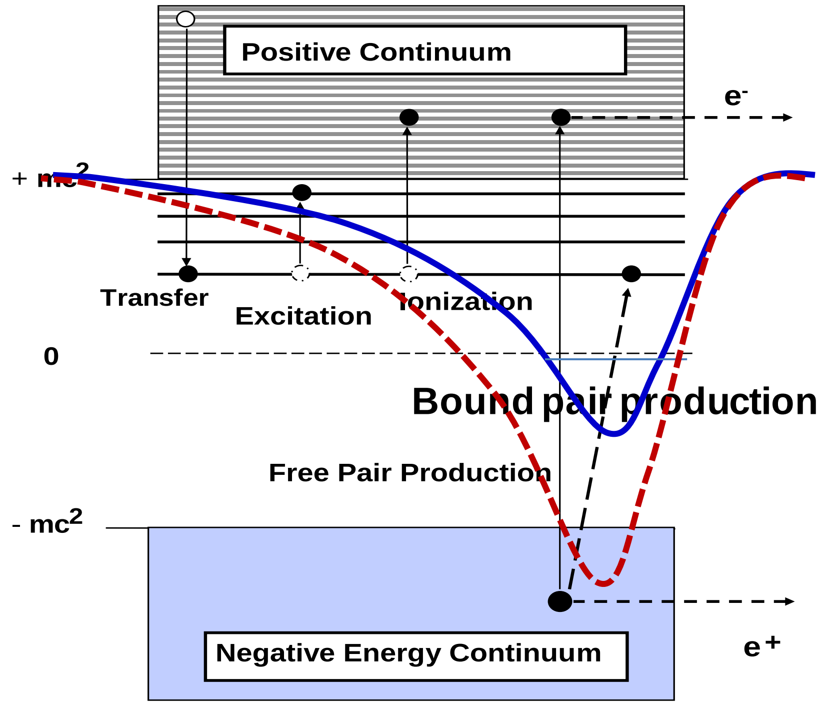
$\Delta M/M\sim10^{-7}$-10^{-8}

Figure-8 shape ring for ion-merging

Spontaneous electron–positron pair production

Q
E
D





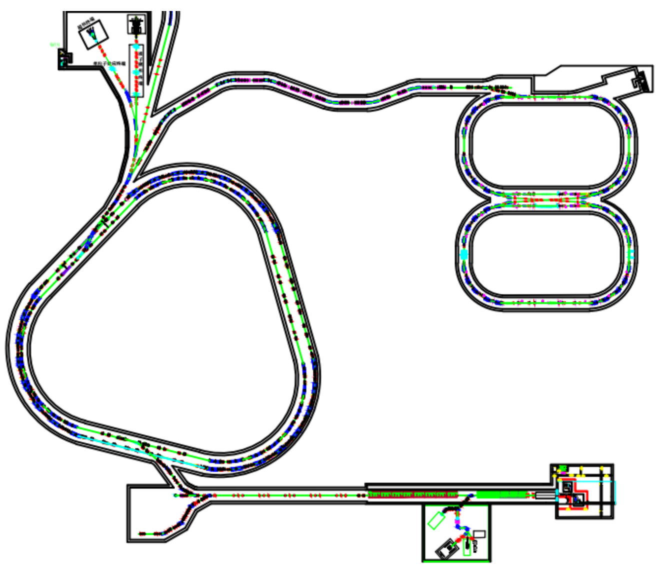
- A fundamental question of QED-spontaneous electron-positron pair creation in supercritical Coulomb fields
- Theory prediction: occur in the collisions of two very heavy ions with the total atomic number $Z1 + Z2 \geq 173$.
- Failed to observe in fixed target experiments due to the interference of extranuclear electrons.

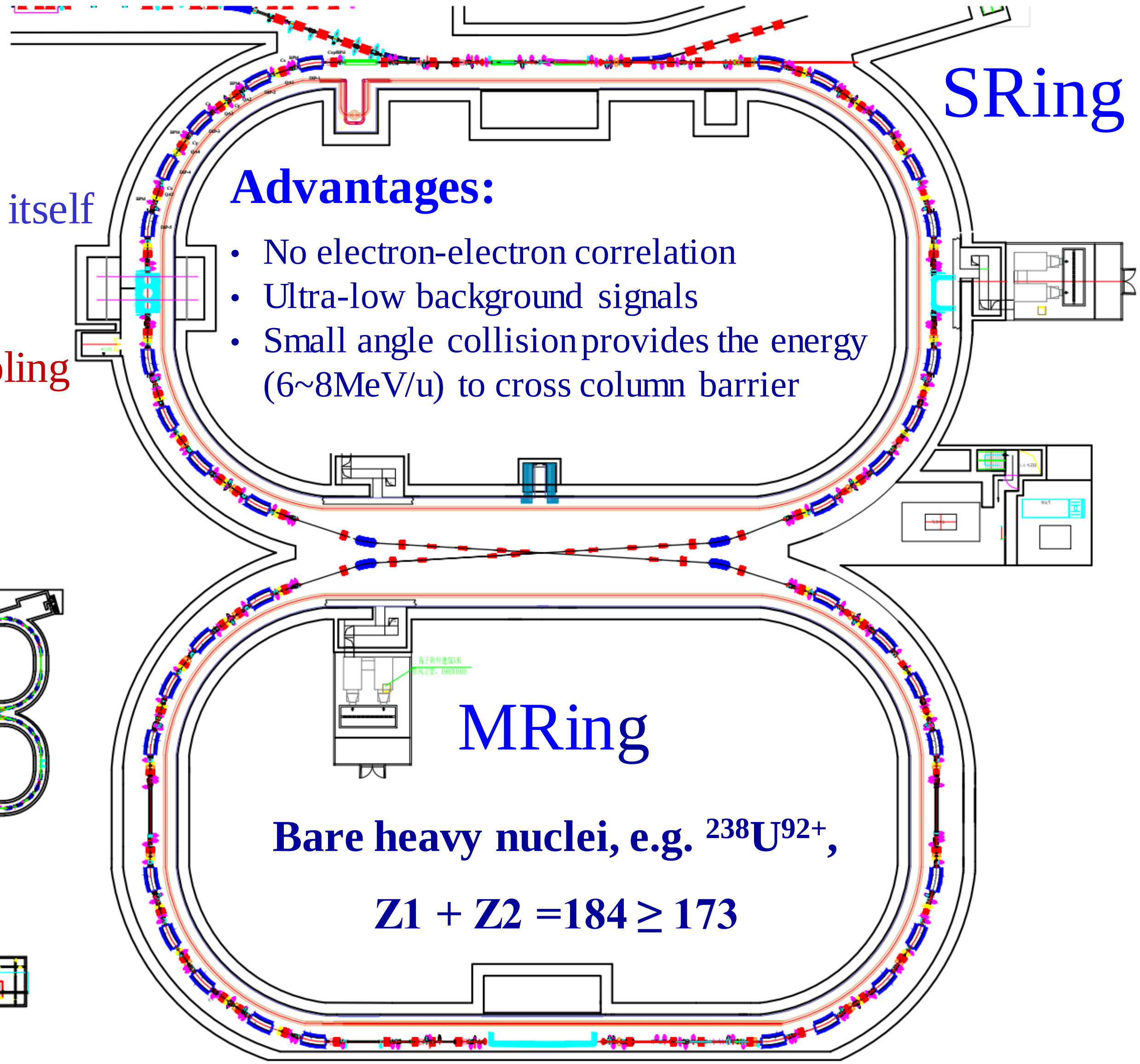
Figure-8 shape ring for ion-merging

First ion-ion merging facility in the world

Unique features:

- "8" shape ring
- Coasting beam merging with itself scheme
- Based on SRing
- Sharing the injection and cooling system
- No powerful RF system





Advantages:

- No electron-electron correlation
- Ultra-low background signals
- Small angle collision provides the energy (6~8MeV/u) to cross column barrier

Bare heavy nuclei, e.g. $^{238}U^{92+}$,

$Z1 + Z2 = 184 \geq 173$

Figure-8 shape ring for ion-merging

HIAF

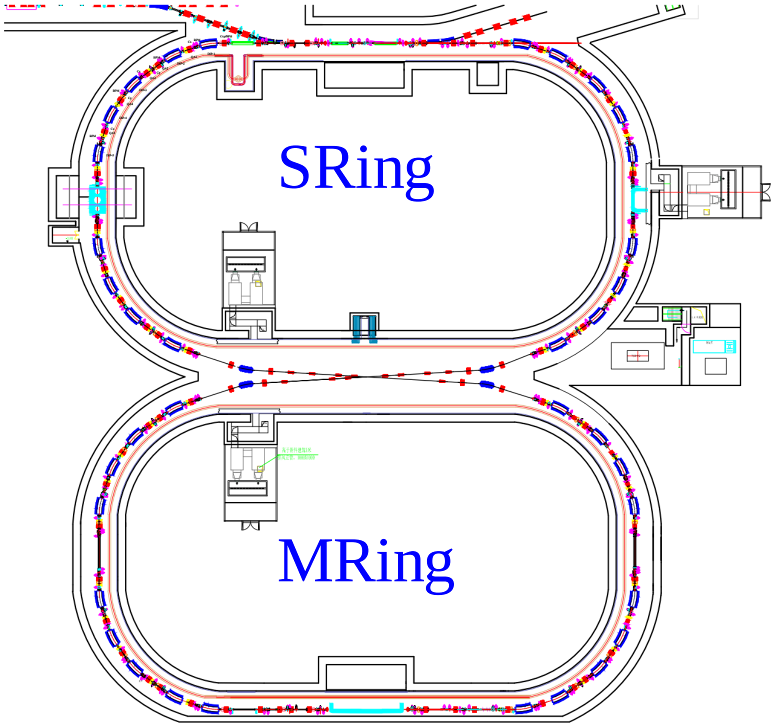
Merging beam parameters - First phase

Parameter	Value
Ion	$^{238}U^{92+}$
Energy(MeV/u)	637(800)
Circumference(m)	483.8
Frequency(MHz)	0.50(0.52)
Crossing angle(◦)	6.8
CM energy(MeV/u)	6(8)
Particle number	**$7(8)\times10^{10}$**
$\varepsilon_{x,rms}/\varepsilon_{y,rms}$ (π mm mrad)	1/1
β^*_x/β^*_y(m)	1/0.03
$\sigma_{x,rms}/\sigma_{y,rms}$ (mm)	1/0.173
Laslett tune shift	-0.1(-0.077)
Hourglass factor	0.9
Luminosity($cm^{-2}s^{-1}$)	**$4.4(5.4)\times10^{23}$**

Figure-8 shape ring for ion-merging

Merging beam parameters – **Update- 1000 times**

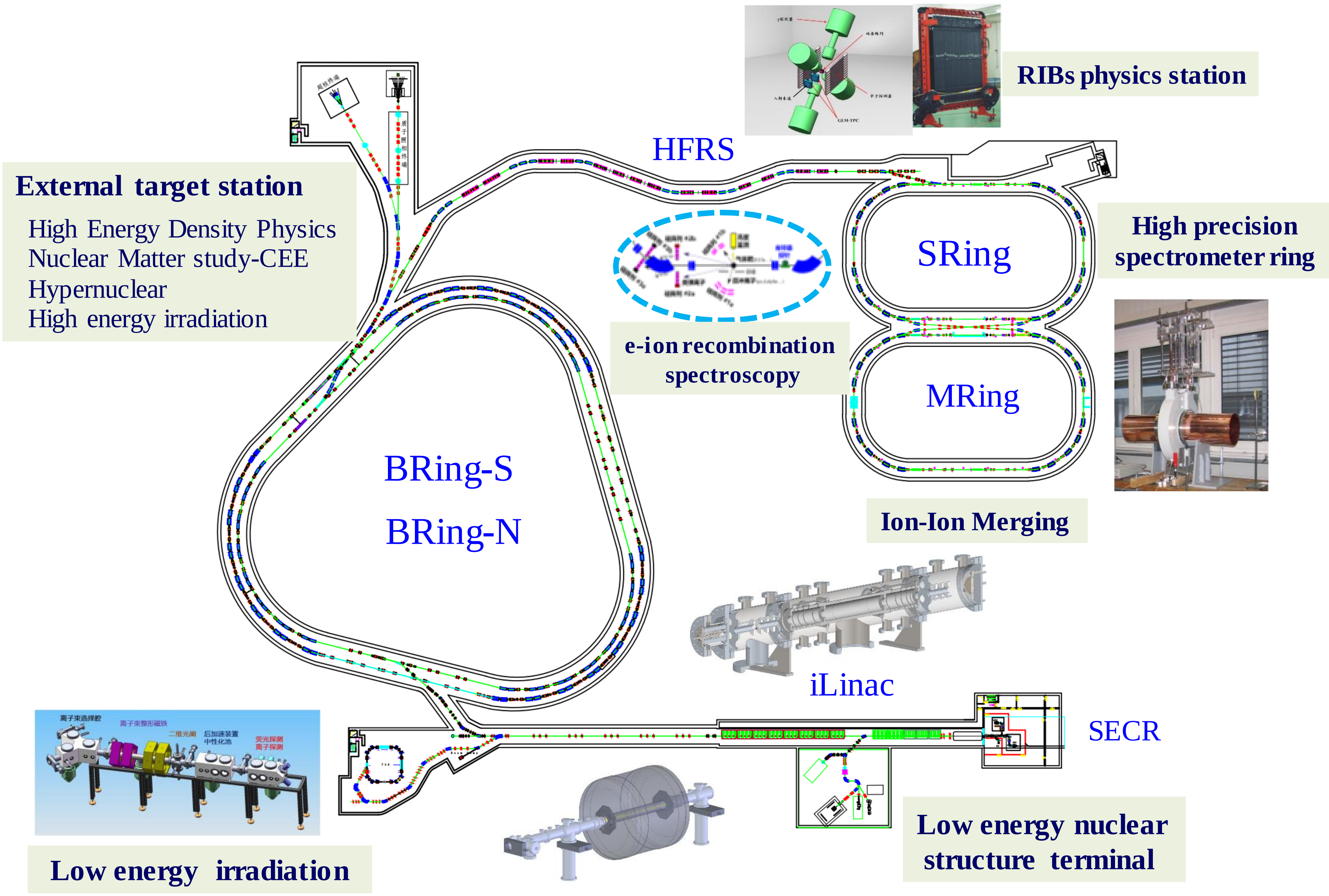
Parameter	Value
Ion	$^{238}U^{92+}$
Energy(MeV/u)	4300
Circumference(m)	472.7
Frequency(MHz)	0.624
Crossing angle(◦)	1.93
CM energy(MeV/u)	8
Particle number	**3×10^{12}**
$\varepsilon_{x,rms}/\varepsilon_{y,rms}$ (π mm mrad)	1/1
β^*_x/β^*_y(m)	0.1/0.02
$\sigma_{x,rms}/\sigma_{y,rms}$ (mm)	0.316/0.141
Laslett tune shift	-0.08
Hourglass factor	0.9
Luminosity($cm^{-2}s^{-1}$)	**4.1×10^{26}**

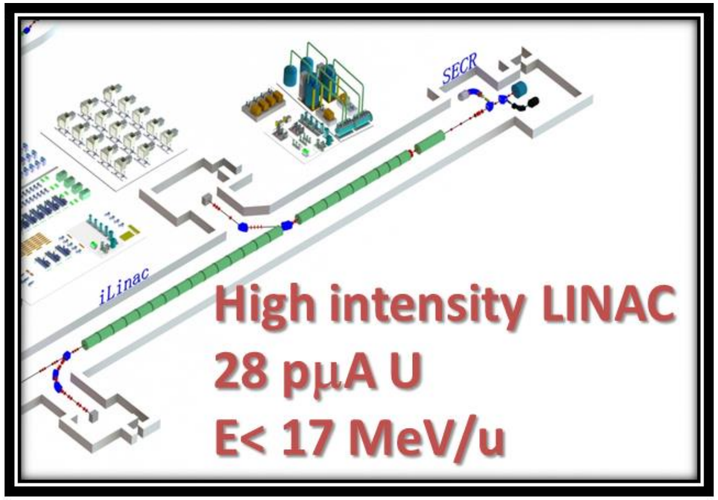


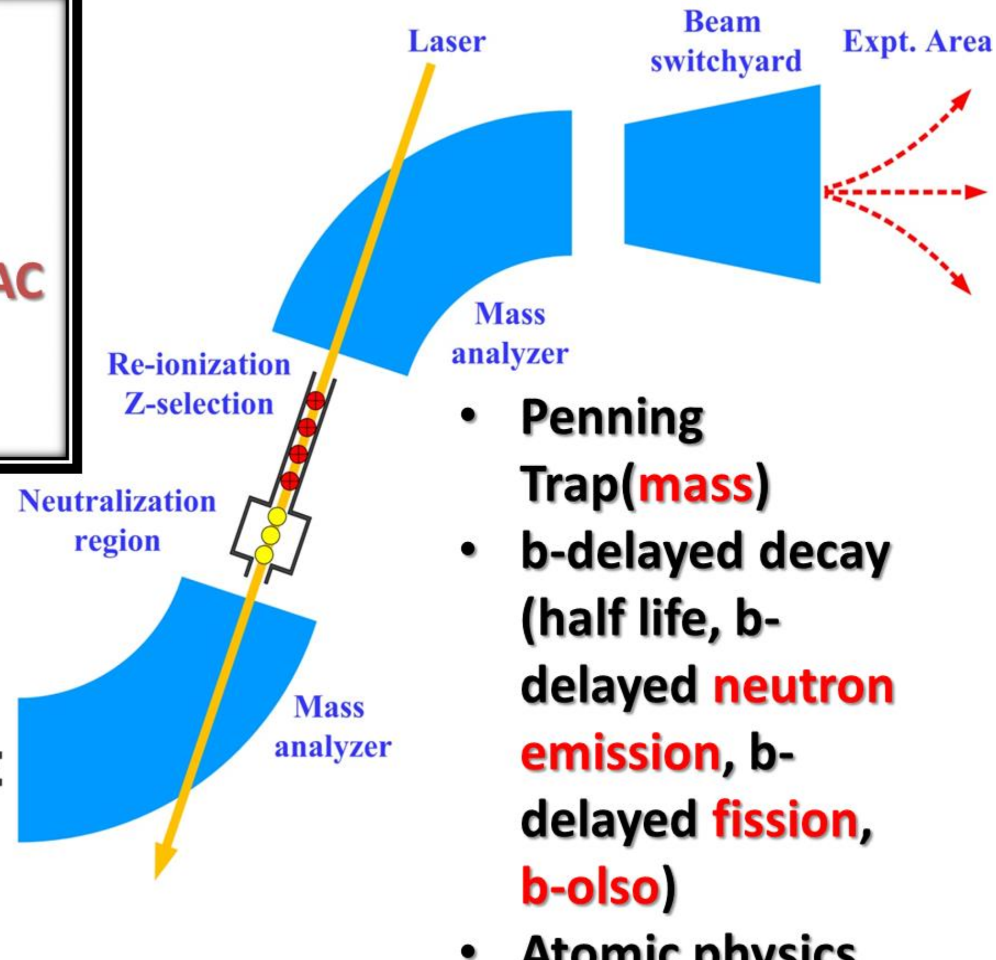
Update-1： SC magnet to 4T

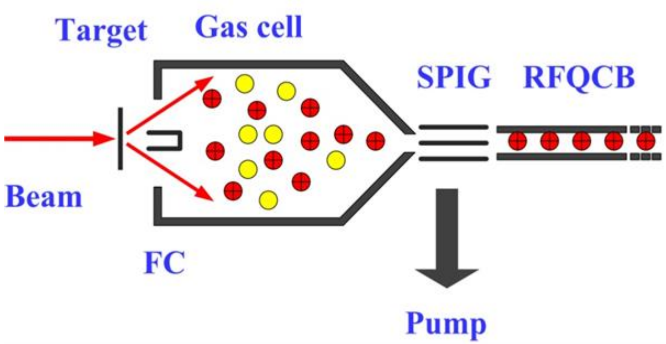
Update-2： New interaction section with small cross angle

Experiment terminals

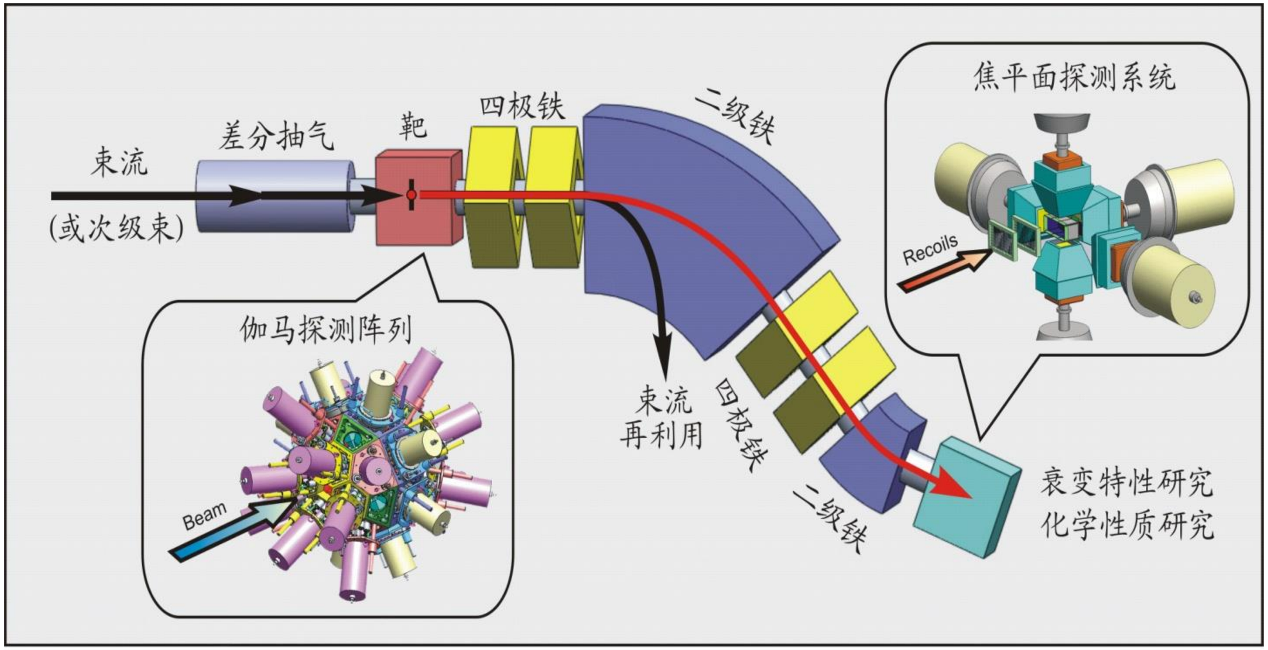








- Penning Trap(mass)
- b-delayed decay (half life, b-delayed neutron emission, b-delayed fission, b-olso)
- Atomic physics



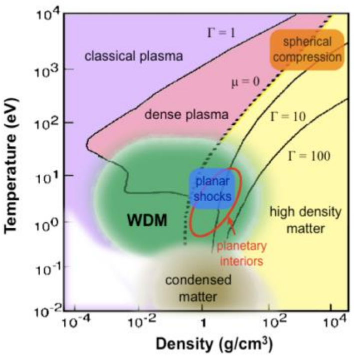
Total efficiency>50%

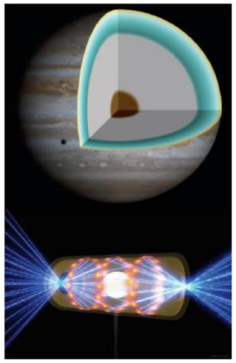
Detecting efficiency:
~10% for 1.0MeV gamma ray
~80% for α particle with 10.0MeV

It is possible to observe the isotopes near the proton drip line and the superheavy isotopes

Measuring nuclei decays

observing the new isotopes





WDM
Important in Planetary Physics and ICF

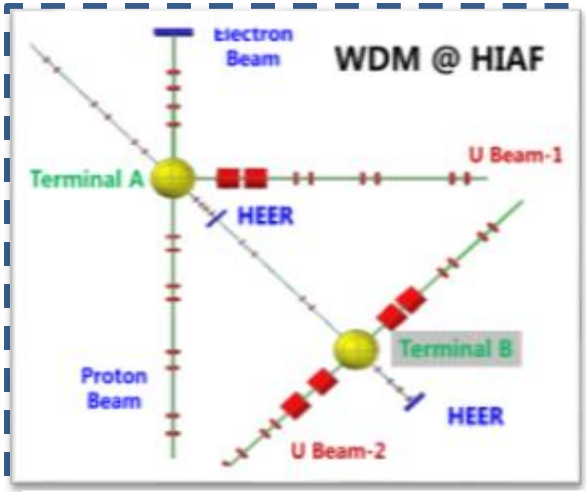
Ion beam parameters @HIAF

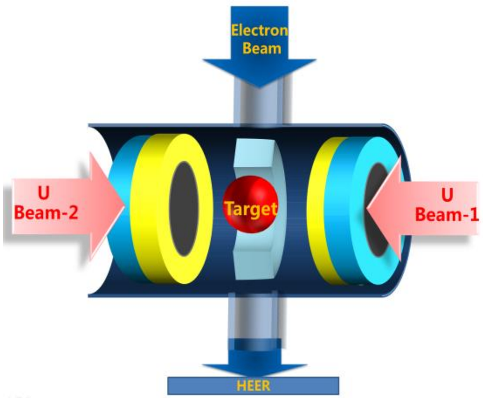
U^{34+} ions

Energy: 0.8 GeV/u; Spot size: ~1.0 mm

Bunch length:~100ns;

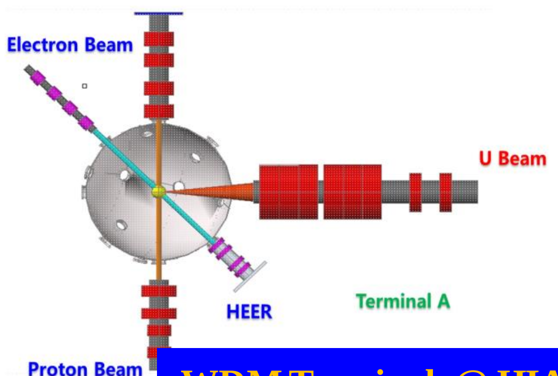
Intensity:~ 1.0×10^{11} ppp

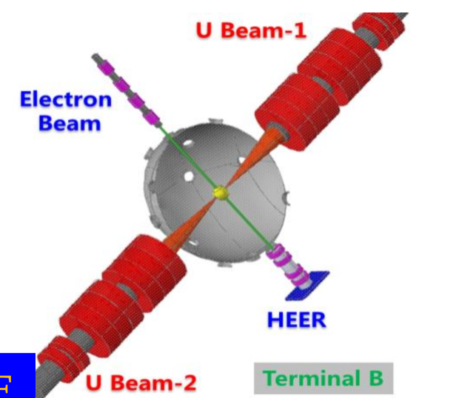




Accessible state of WDM(simulation)

	50 ns	100 ns	150 ns
E (kJ/g)	15.30	14.80	14.00
P (GPa)	91.0	75.0	58.0
T (K)	60000	58000	55000
ρ (g/cm^3)	11.00	10.2	9.3



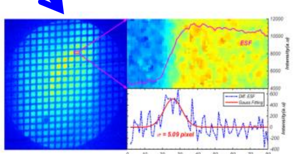


WDM Terminal @ HIAF

HEER- High energy electron radiography

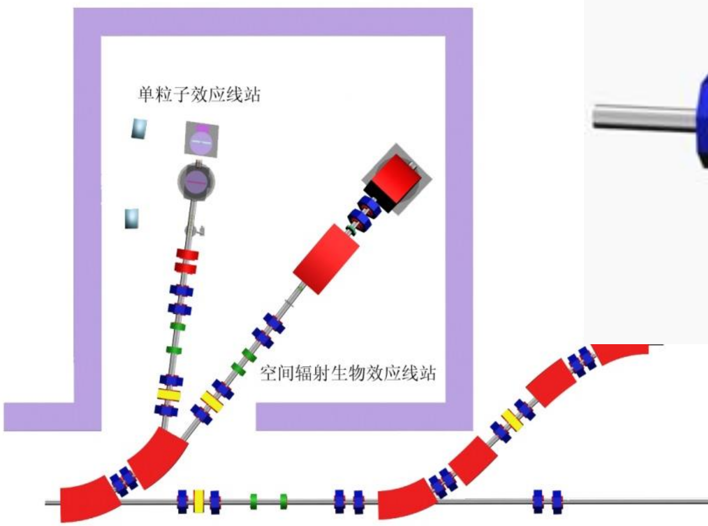
TEM Grid

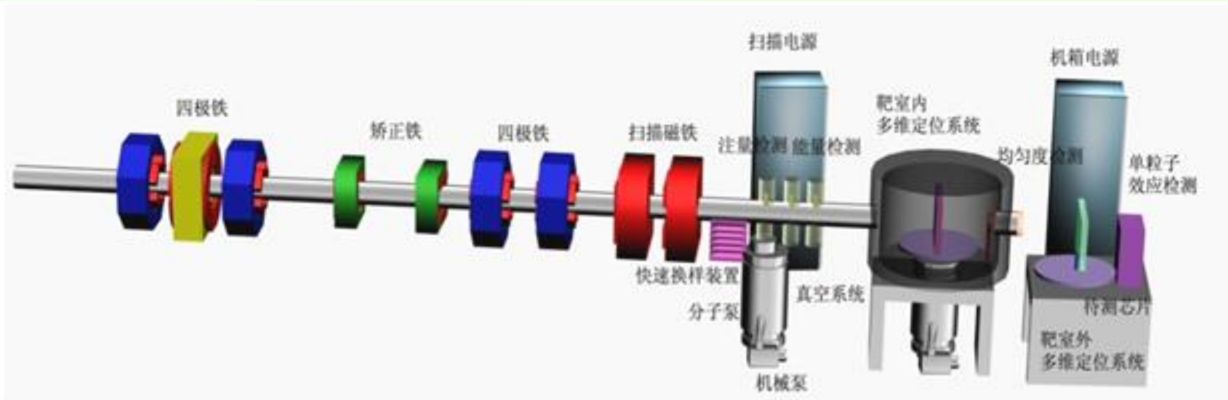
Temporal resolution: ~ps



Spatial resolution: ~μm

High sensitivity on density

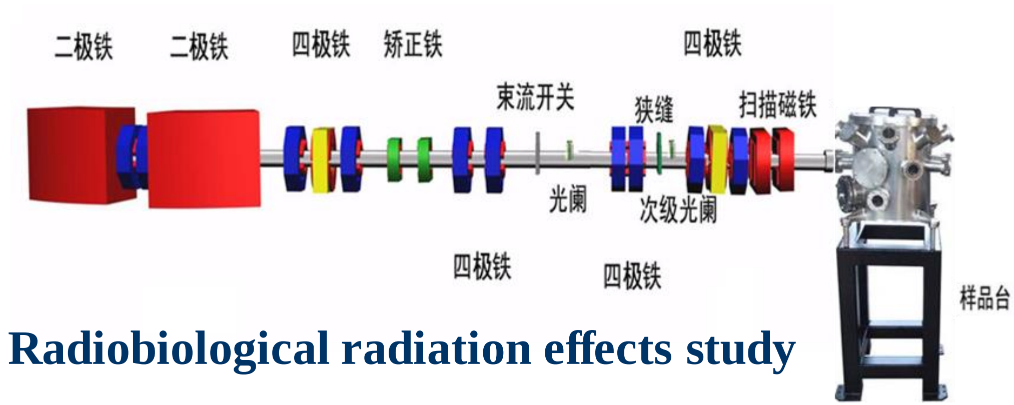




Space radiation effects study

Universal high energy radiation beam lines

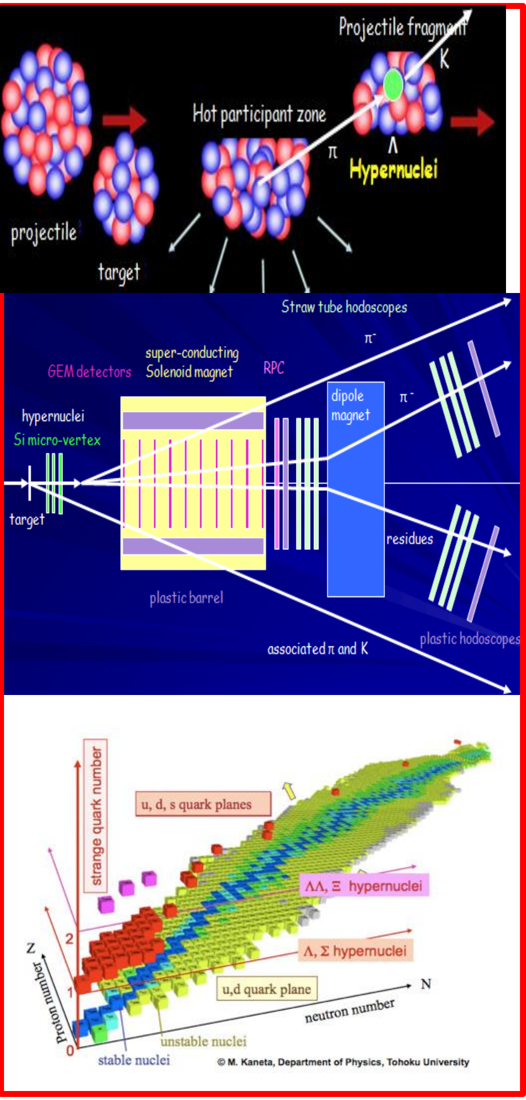
- **Ion range: μm ~ cm**
- **Positioning accuracy: μm ~ mm**
- **Scan area: 20cm × 20cm**
- **Ion homogeneity: >90%**

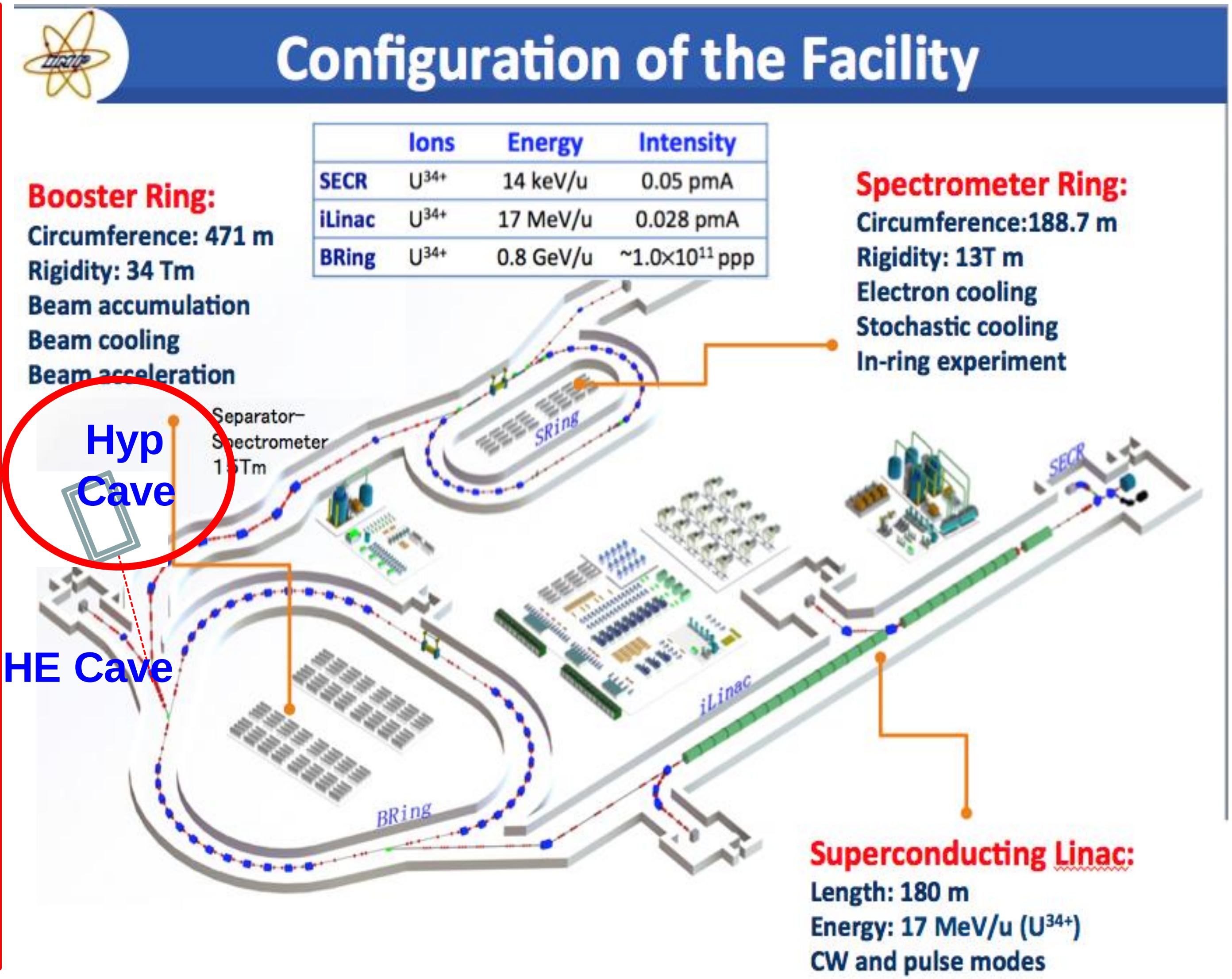


Radiobiological radiation effects study

Providing technical support for evaluation and prediction of single event effects rate of electronic devices in space, as well as valuable data to ensure the health and safety of astronauts.

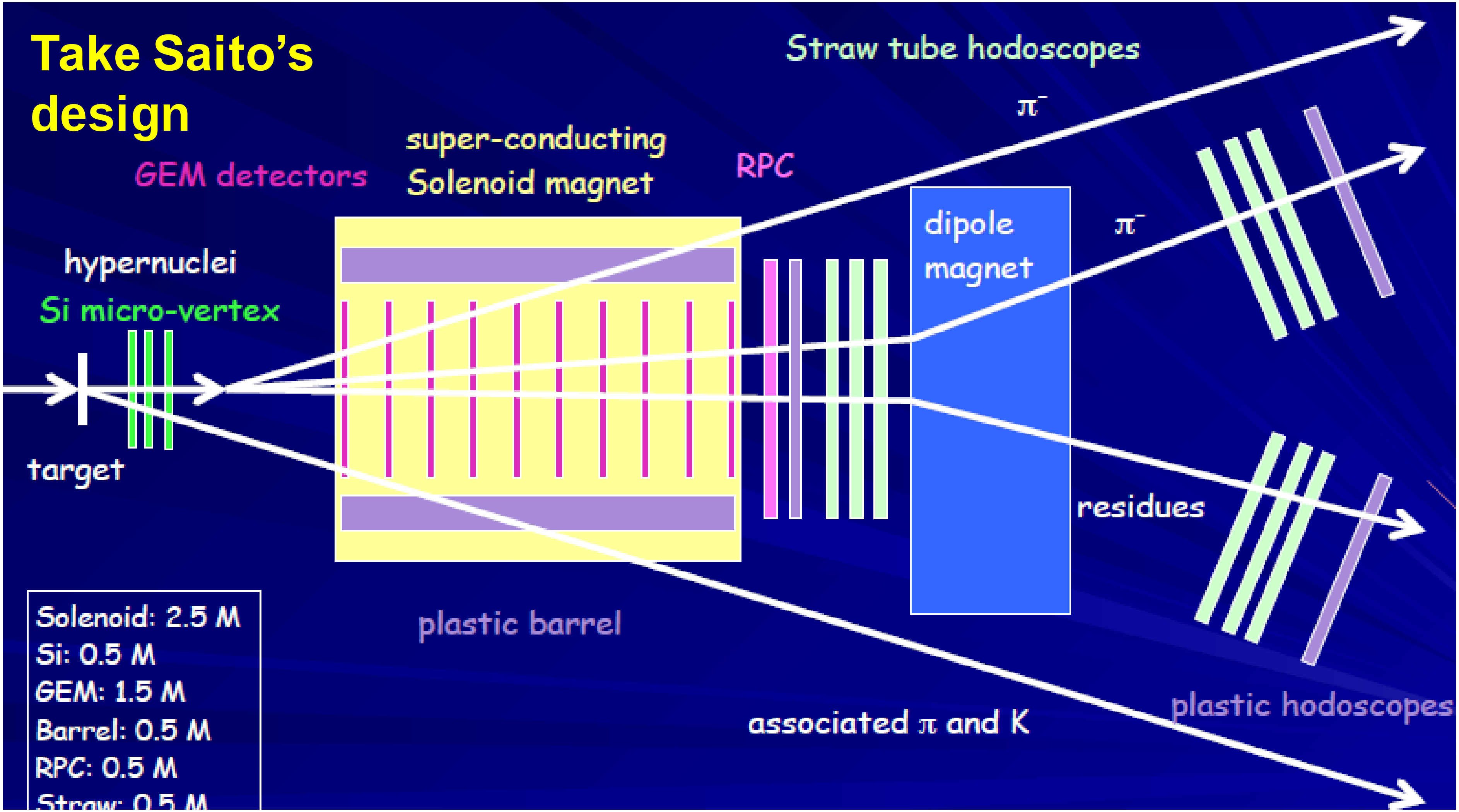
Hypernuclear physics at HIAF



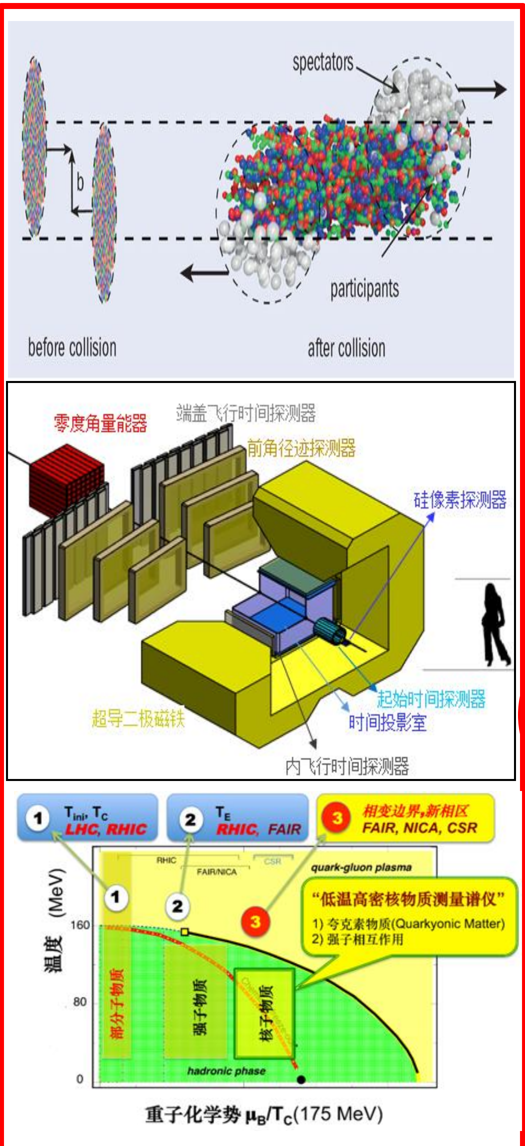


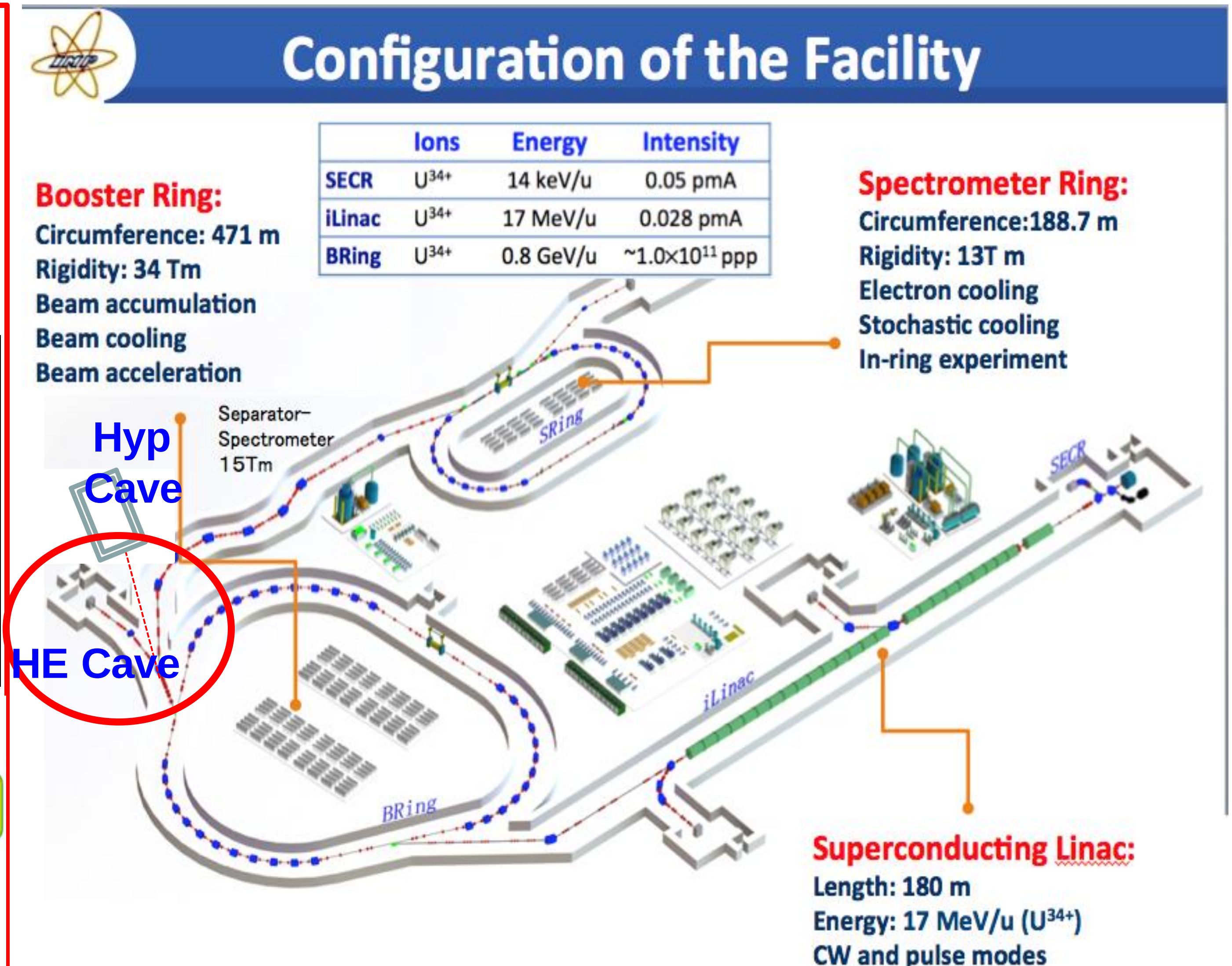
	Ions	Energy	Intensity
SECR	U^{34+}	14 keV/u	0.05 pmA
iLinac	U^{34+}	17 MeV/u	0.028 pmA
BRing	U^{34+}	0.8 GeV/u	~1.0×10^{11} ppp

Hypernuclear spectrometer



Heavy-ion physics at HIAF



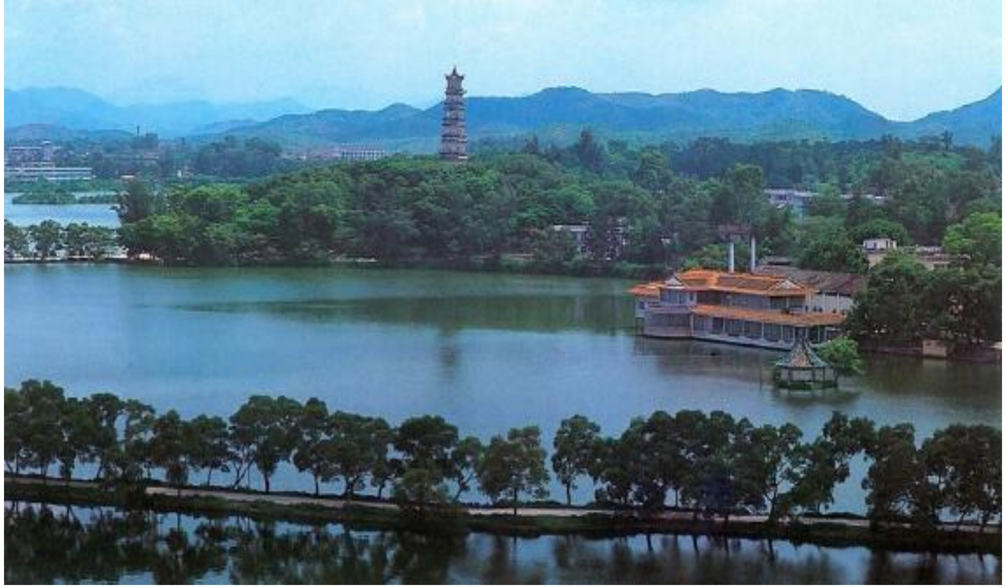


Site of HIAF and CIADS at Huizhou City

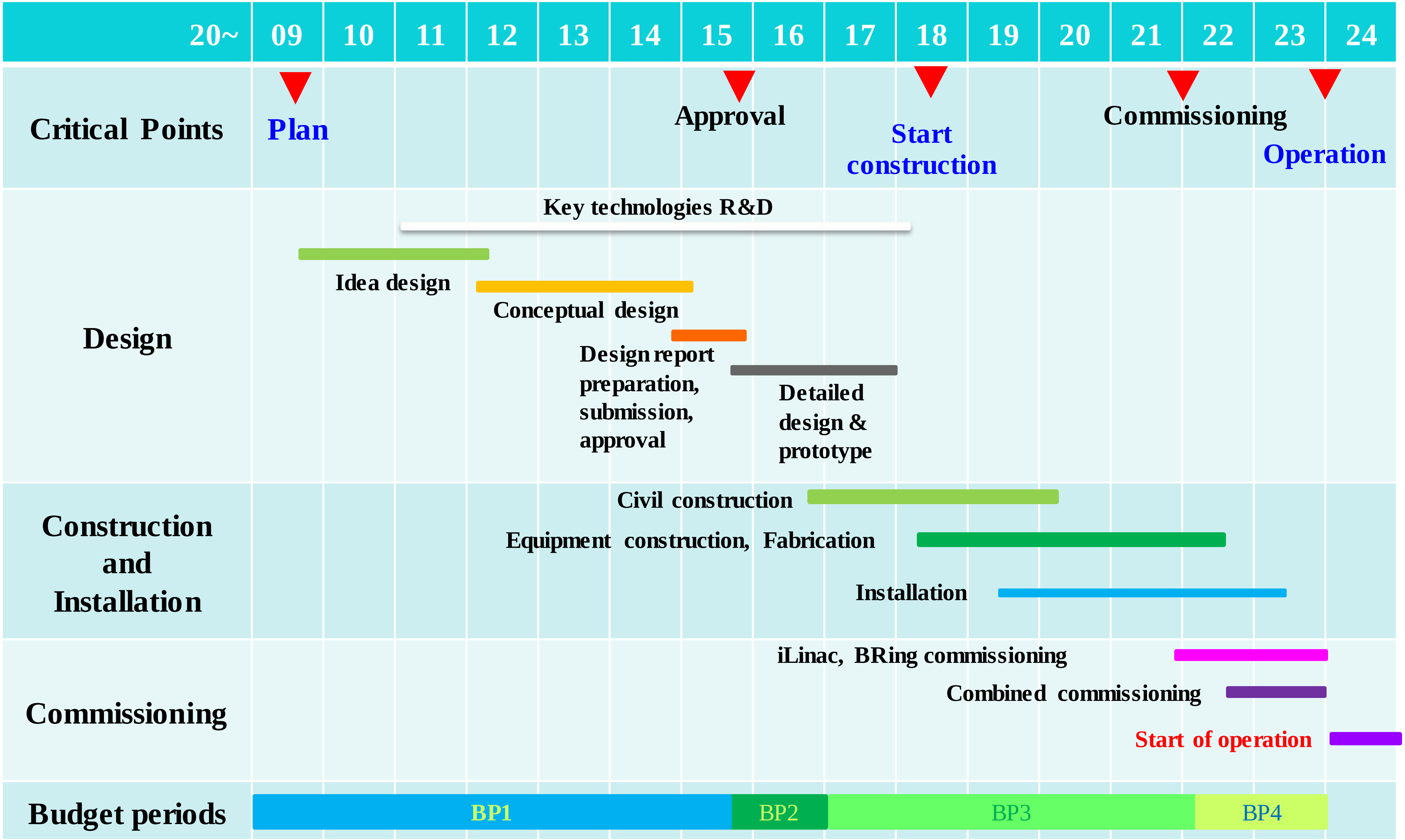
180 km to HongKong and 90 km to Shenzhen

Both HIAF and CIADS projects at same site

Project site near the coast



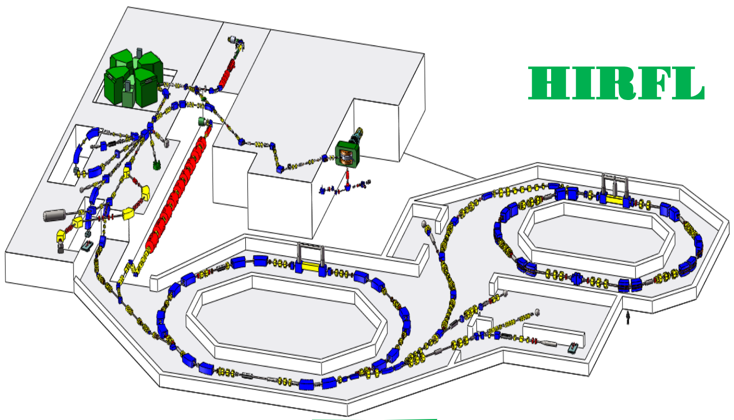
New campus for IMP locates at Huizhou city


20~
09
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
Critical Points
Plan
Approval
Start construction
Commissioning
Operation
Design
Key technologies R&D
Idea design
Conceptual design
Design report preparation, submission, approval
Detailed design & prototype
Construction and Installation
Civil construction
Equipment construction, Fabrication
Installation
Commissioning
iLinac, BRing commissioning
Combined commissioning
Start of operation
Budget periods
BP1
BP2
BP3
BP4

Conclusion

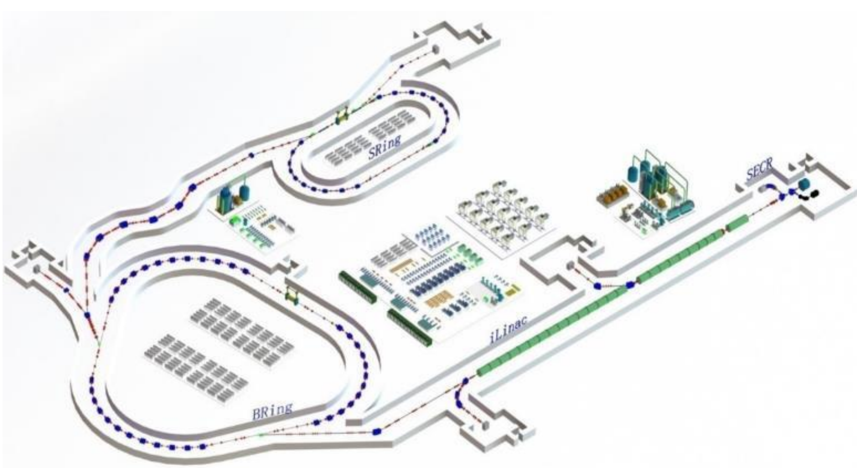
Based on HIRFL,HIAF and CIADS, the largest center of nuclear science and technology in China will be built in the ten years, all collaborations are welcomed.

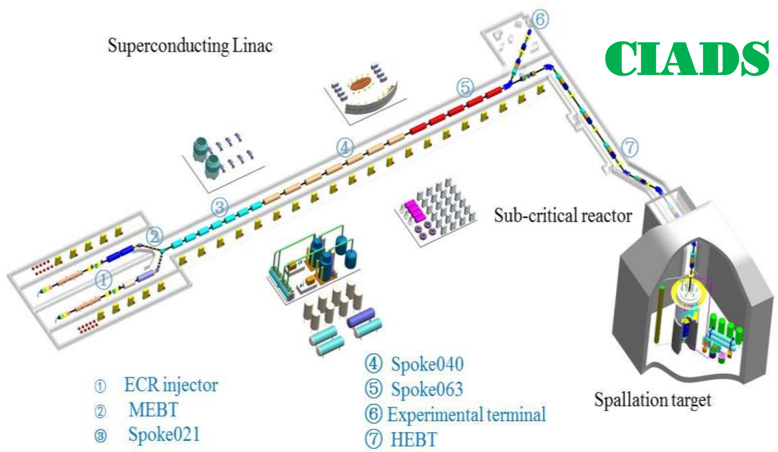
- Nuclear physics
- Atomic physics
- Nuclear chemistry
- Hadron physics
- High Energy Density physics
- Neutron Physics
- Accelerator physics



- Advanced nuclear energy
- Radiation biology
- Radiation medical
- Radiation material
- Nuclear detecting technology
- Accelerator manufacture

HIAF






Thank you for
your attention!
Welcome
Collaboration!