



Report on Nuclear Physics Research and Facilities in ASIA

ANPhA

Weiping Liu, CIAE

For Yanlin Ye, PKU

IUPAP WG.9 meeting, June 1, 2013, Rome

General and organization

Asian Nuclear Physics Association ANPhA established on 18 July, 2009



ANPhA Members from 8 countries/region

1. Australia 50
2. China 1,000
3. India 300
4. Japan 1,000
5. Korea 200
6. Mongolia 30
7. Taiwan 50
8. Vietnam 50

total 2,700

Member countries and regions
alphabetical order



Australia



China



India



Japan



Korea



Mongolia



Taiwan



Vietnam



Covers large part of Asia and Oceania

ANPhA web site : <http://ribf.riken.jp/ANPhA/>

Bylaws for Asian Nuclear Physics Association (ANPhA)

Objectives:

1. The objective of ANPhA is to strengthen "**Collaboration**" among Asian nuclear research scientists through the promotion of nuclear physics and its transdisciplinary use and applications.
2. The objective of ANPhA is also to promote "**Education**" in Asian nuclear science through mutual exchange and coordination.
3. It also aims at "**Coordination**" among Asian nuclear scientists by actively utilizing existing research facilities.
4. Furthermore, at a later stage, it will help to discuss **future planning** of nuclear science facilities and instrumentation in Asia.

Board:

8. The ANPhA Board is installed with an appropriate numbers of Board members. Initial Board members are Japan (4), China (4) and Korea (3). This number can be added later by the approval of the Board meeting.
9. The Board may select chair, vice chair(s) and secretary. The term of the chair, vice chair(s) and secretary is two years.
10. The Board meetings shall be held on a regular basis, at least annually, at

AnPhA board

- **Chairs and Secretary:**
- Chair: Yanlin Ye (China)
- **Vice Chair:**
 - Dong-Pil Min (Korea)
 - Anthony Thomas (Australia)
- Secretary:; Tohru Motobayashi (Japan)
- **Members:**
- **Australia:**
 - Anthony Thomas (The University of Adelaide)
- **China:**
 - Yanlin Ye (Peking University)
 - Weiping Liu (China Institute of Atomic Energy)
 - Guoqing Xiao (Institute of Modern Physics)
 - Yugang Ma (Shanghai Institute of Applied Physics)
- **India:**
 - Vivek Datar (Bhabha Atomic Research Centre)
 - Dinesh Kumar Srivastava (Variable Energy Cyclotron Centre)
 - and KEK, Japan)
- **Japan:**
 - Kazuhiro Tanaka (KEK)
 - Tohru Motobayashi (RIKEN)
 - Takaharu Otsuka (The University of Tokyo)
 - Hirokazu Tamura (Tohoku University)
- **Korea:**
 - Dong-Pil Min (Seoul National University)
 - Woo-Young Kim (Kyungpook National University)
 - Byung-Geel Yu (Korea Aerospace University)
- **Taiwan:**
 - Jiunn-Wei Chen (National Taiwan University)
- **Vietnam:**
 - Dao Tien Khoa (INST Hanoi)
- **Monglia:**
 - To be announced
- **Observer:**
 - Angela Bracco (NuPECC Chair, University of Milan, Italy)
 - Hideyuki Sakai (Past Chair, RIKEN, Japan)
 - Shoji Nagamiya (RIKEN)

Coming and finished meetings

- **7th meeting**
 - Apr. 26-27, 2013 @National Taiwan University, Taipei, Taiwan
 - in conjunction with the 5th ANPhA Symposium
- **6th meeting**
 - Aug. 4, 2012 @University of Adelaide, Australia
 - in conjunction with the 4th ANPhA Symposium
- **5th meeting**
 - Nov. 27, 2011 @Institute for Nuclear Science and Technique (INST), Hanoi, Vietnam
 - in conjunction with the International Symposium on Physics of Unstable Nuclei 2011 (ISPUN11)
- **4th meeting**
 - Apr. 30, 2011 @Institute of Modern Physics - Chinese Academy of Sciences (Lanzhou)
 - in conjunction with the 3rd ANPhA Symposium
- **3rd meeting**
 - Oct. 2, 2010 @SungKyunKwan university (Seoul)
 - in conjunction with the 2nd ANPhA Symposium
- **2nd meeting**
 - Jan. 17, 2010 @J-PARC (Tokai)
 - in conjunction with the 1st ANPhA Symposium
- **1st meeting**
 - Jul. 18, 2009 @Peking University,
 - a part of the 3rd preparatory meeting
- **Preparatory meetings**
 - 3rd meeting, 18th Jul. 2009 Beijing
 - 2nd meeting, 21st Jan. 2009, Seoul
 - 1st meeting, 4th Oct. 2008, Tokyo

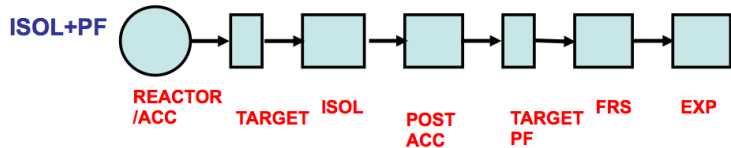
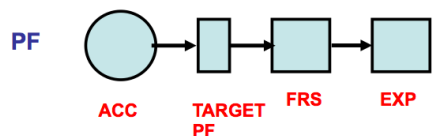
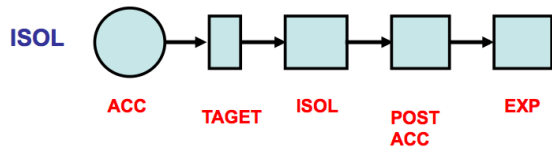
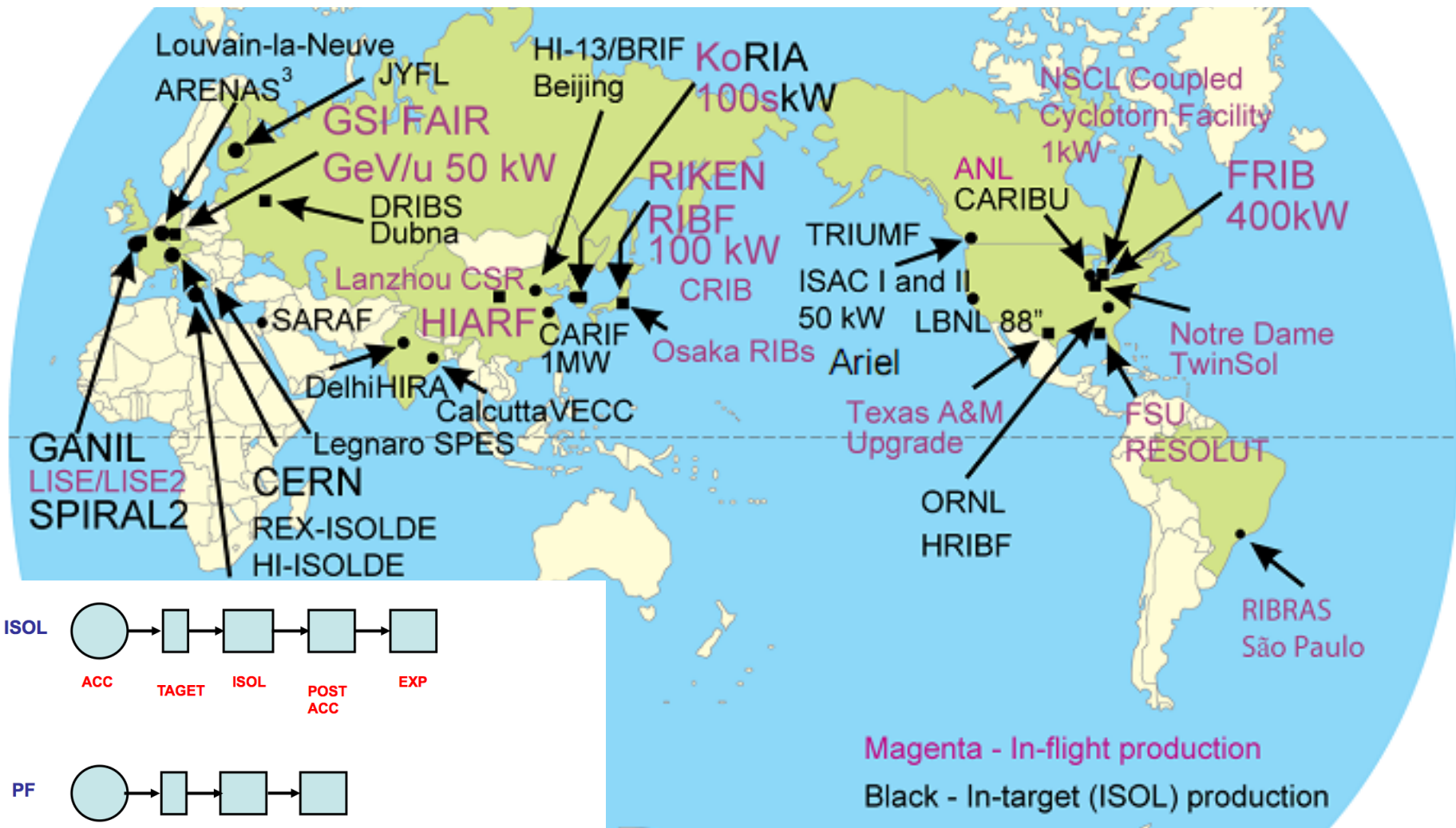
Events with ANPhA Support

- **SNP School 2013**
 - Feb. 14-20, 2013
 - Tokai and Tohoku, Japan
- **International School for Strangeness Nuclear Physics**
- **IWND12**
 - Dec. 16-19, 2012
 - Shenzhen, China
- **The International Workshop on Nuclear Dynamics in Heavy-Ion Reactions**
 - CNSSS12
 - Aug. 29 - Sep. 4, 2012
 - Wako & Hongo, Japan
- **The 11th CNS International Summer School**
 - ISPUN11
 - Nov. 23-28, 2011
 - Hanoi, Vietnam
- **The International Symposium on Physics of Unstable Nuclei 2011**
 - Sep. 26 - Oct. 1, 2011
 - Wako, Saitama, Japan
- **The 10th CNS International Summer School**
- **APFB2011**
 - August 22-26, 2011
 - Seoul, Republic of Korea
- **The Fifth Asia-Pacific Conference on Few-Body Problems in Physics 2011 (APFB2011)**
 - PacSPIN2011
 - June 20-24, 2011
 - Cairns, Australia
- **8th Circum-Pan-Pacific Symposium on High Energy Spin Physics**
 - ISNPA
 - Oct. 13-15, 2010
- **Convention Center of Beihang University, Beijing, China**
- **The International Symposium on Nuclear Physics in Asia**
 - CNS-EFES10
 - Aug. 18-24, 2010
 - Wako, Saitama, Japan
- **The 9th CNS-EFES International Summer School**

Asia facilities and progress

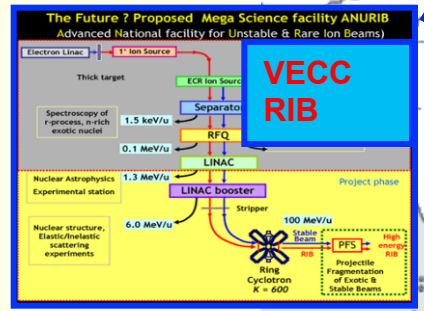
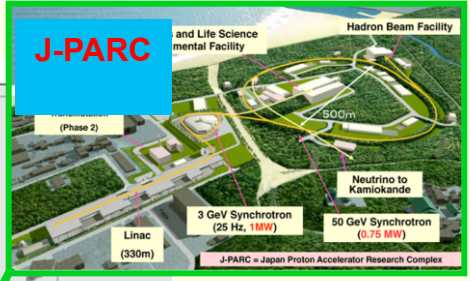
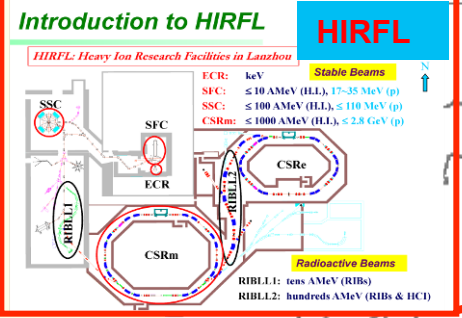
- Australia
- China
- India
- Japan
- Korea
- Mongolia
- Taiwan
- Vietnam

World wide RIB facilities

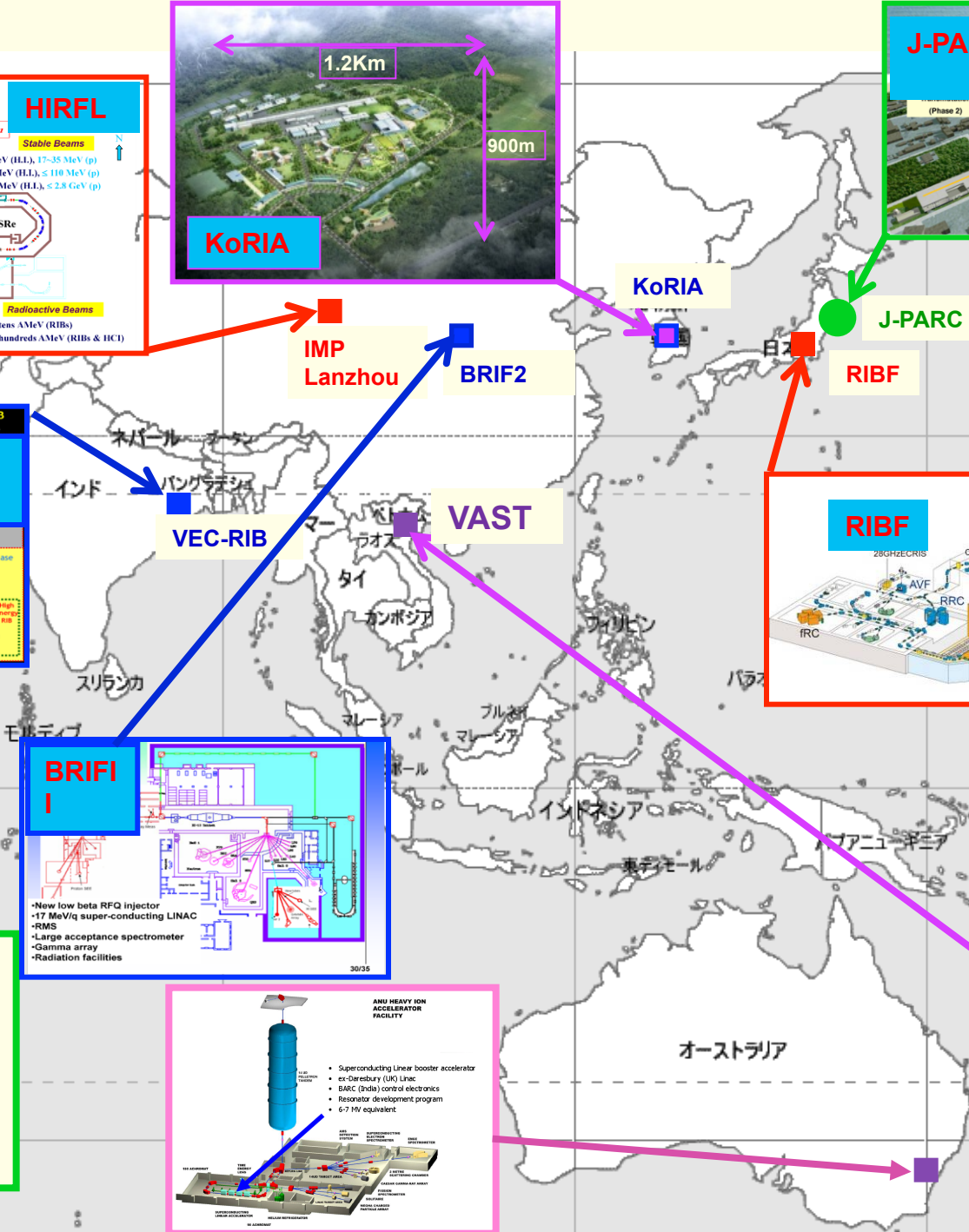
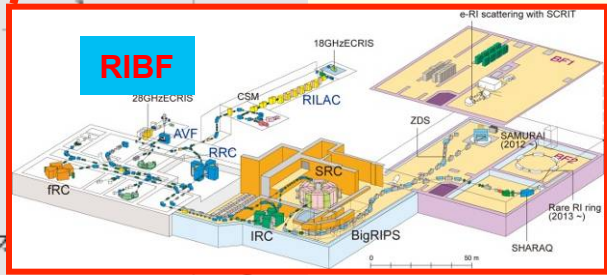
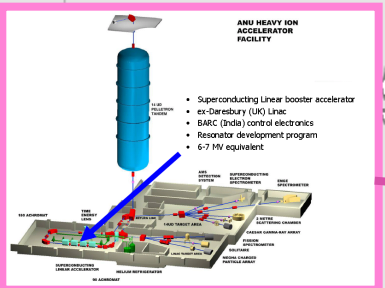
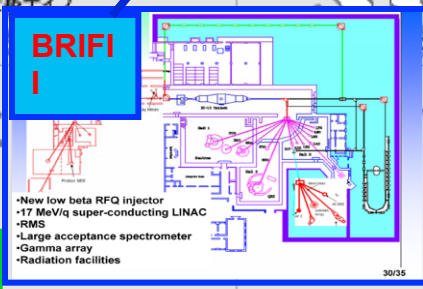


Magenta - In-flight production

Black - In-target (ISOL) production



- Hadron
- In-flight RIB
- ISOL RIB



Some Recent Activities in Japan

J-PARC

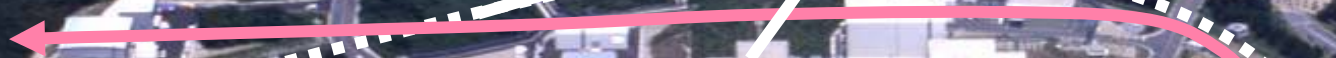
Japan Proton Accelerator Research Complex

400MeV
LINAC

3GeV 333mA (1 MW)

RCS

n to SK 230kW



~500m

MLF

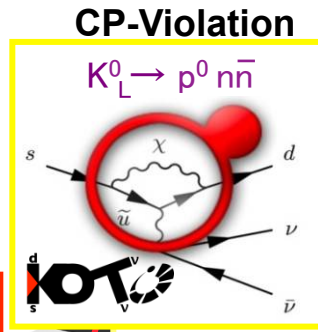
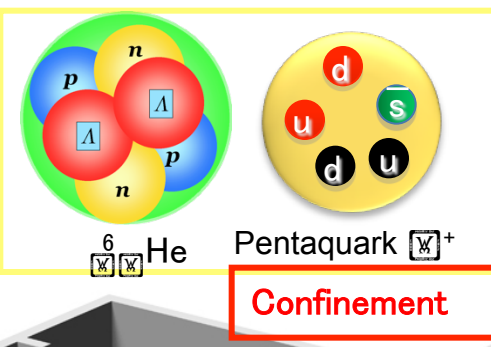
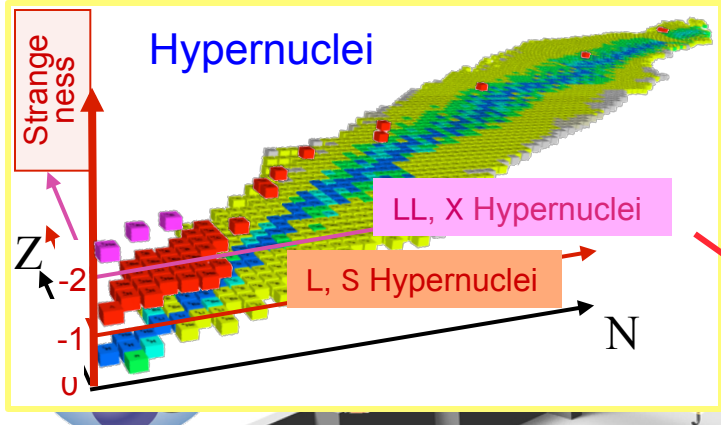
50GeV-PS 20kW
750kW



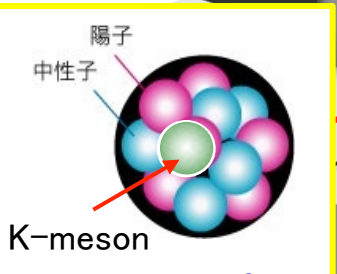
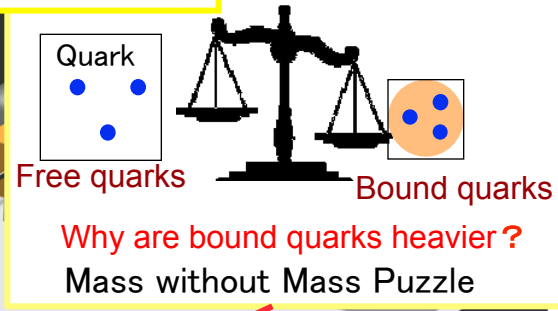
Hadron Hall for Counter Experiments

Nuclear, Hadron, & Particle Physics at Hadron Hall

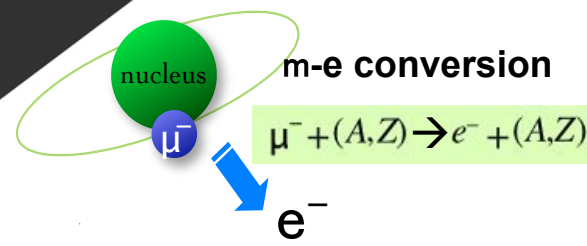
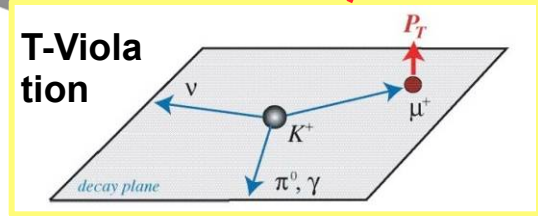
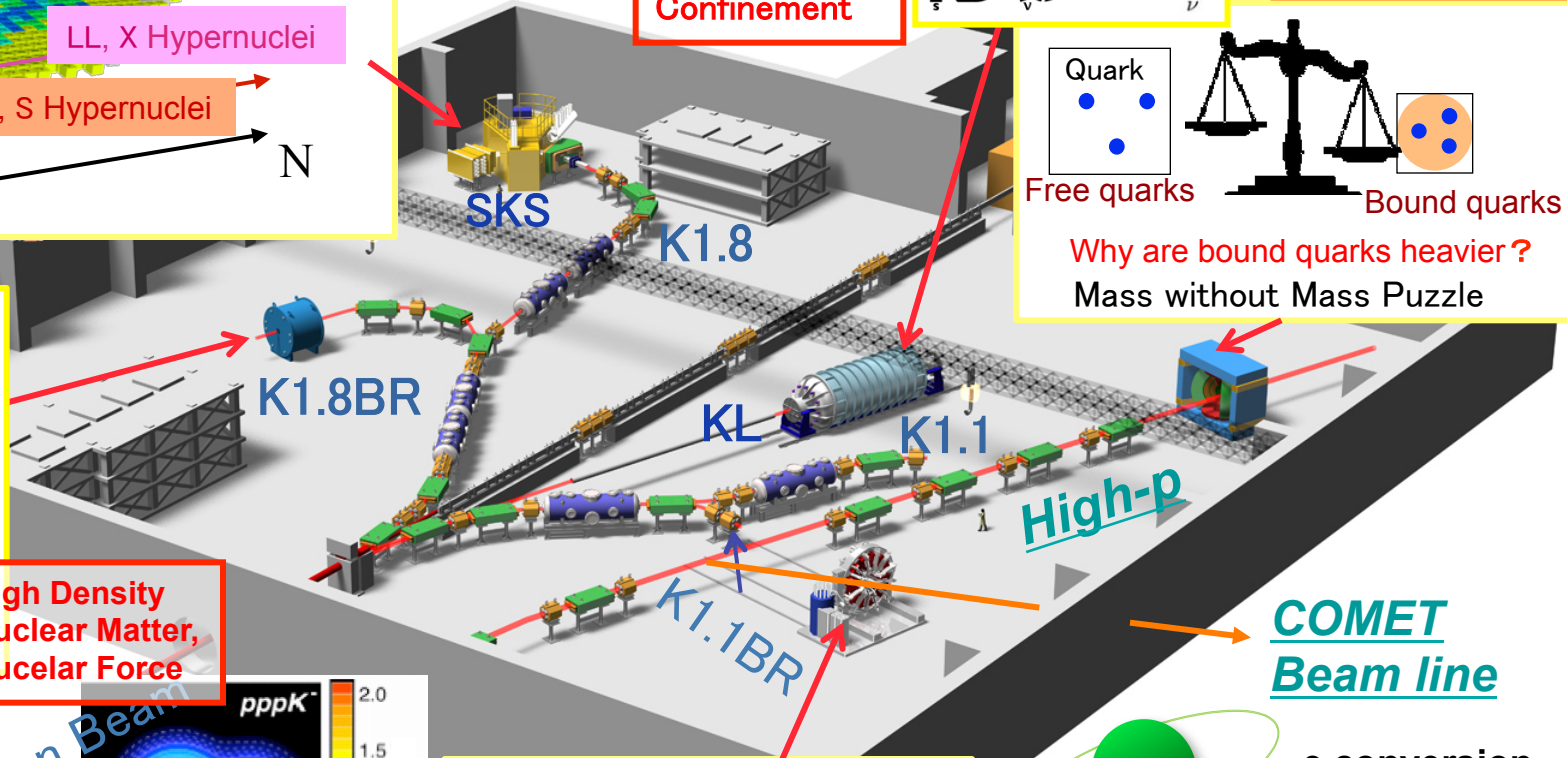
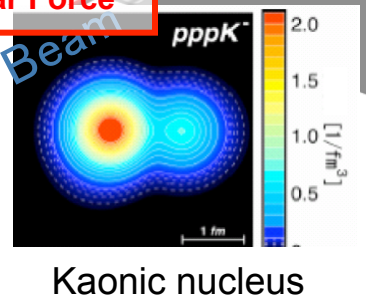
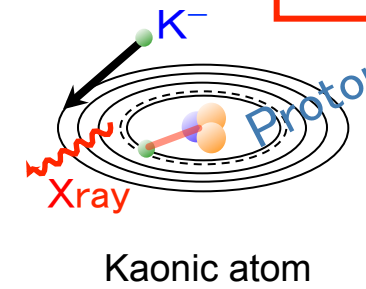
High Density Nuclear Matter, Nuclear Force



Origin of Mass



High Density Nuclear Matter, Nuclear Force



Next Step: Hadron Hall Extension

Both Nuclear Physics community and High Energy Physics community gave high priority to this project.

Hypernucleus Microscope

HIHR: Very Precise spectroscopy with high-resolution and high-intensity secondary beams

HIHR

KL

Hypernucleus Factory (S=-1, -2)

K1.1, 1.8: Ultimate research of S=-1 and -2 hypernuclei with high-intensity Kaon beams

K1.1

K1.8

CP Violation: from Discovery to Measurement

KL: Measurement of 100 CP violating events to tackle a quest on the matter-dominated universe

K10

Multi-Strangeness / Charmed Nucleus

K10: Nuclear matter with an extreme condition with high-momentum separated secondary beams (Kaons and Antiprotons)

Change of Hadron Mass

High-p

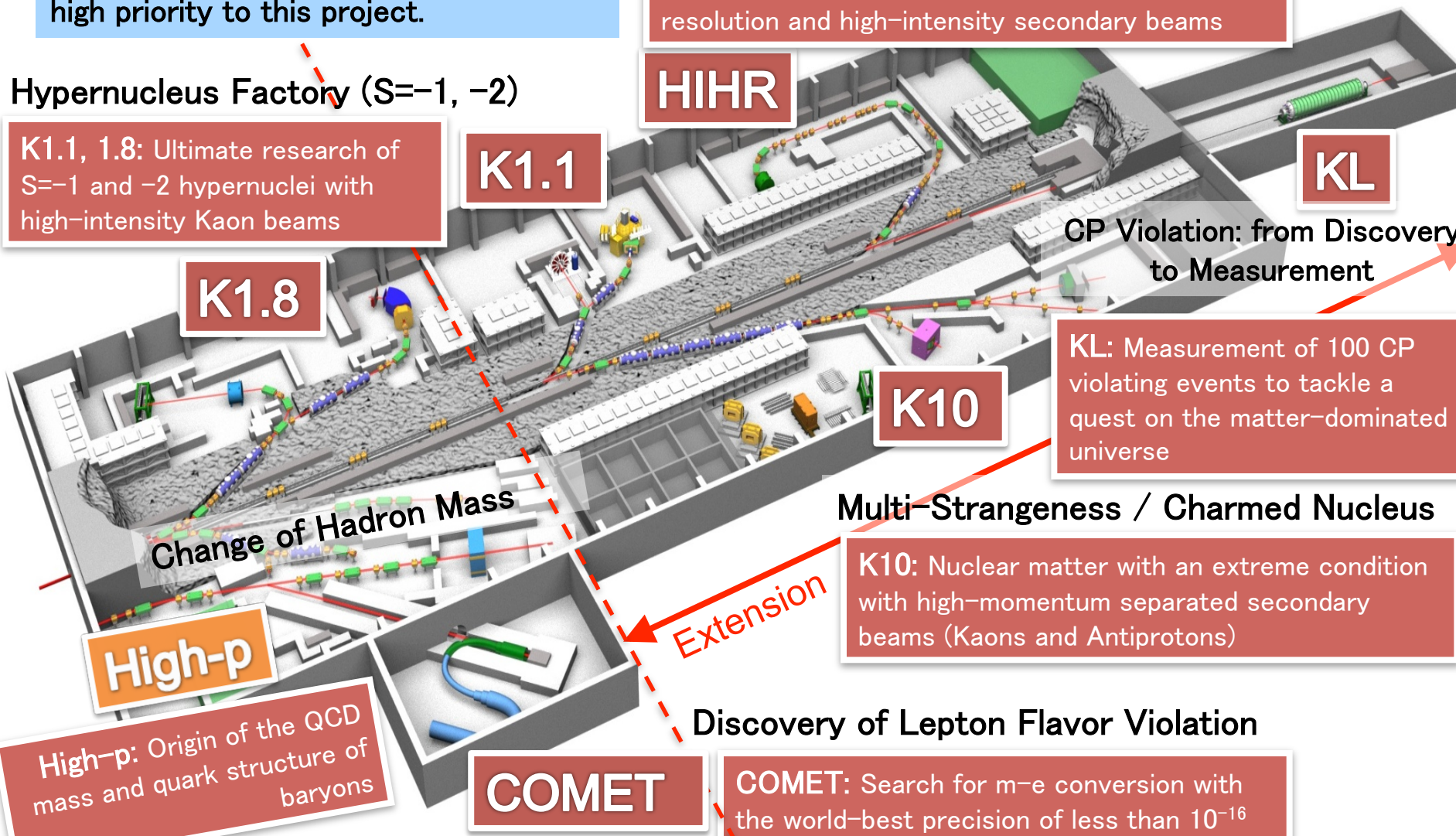
High-p: Origin of the QCD mass and quark structure of baryons

Extension

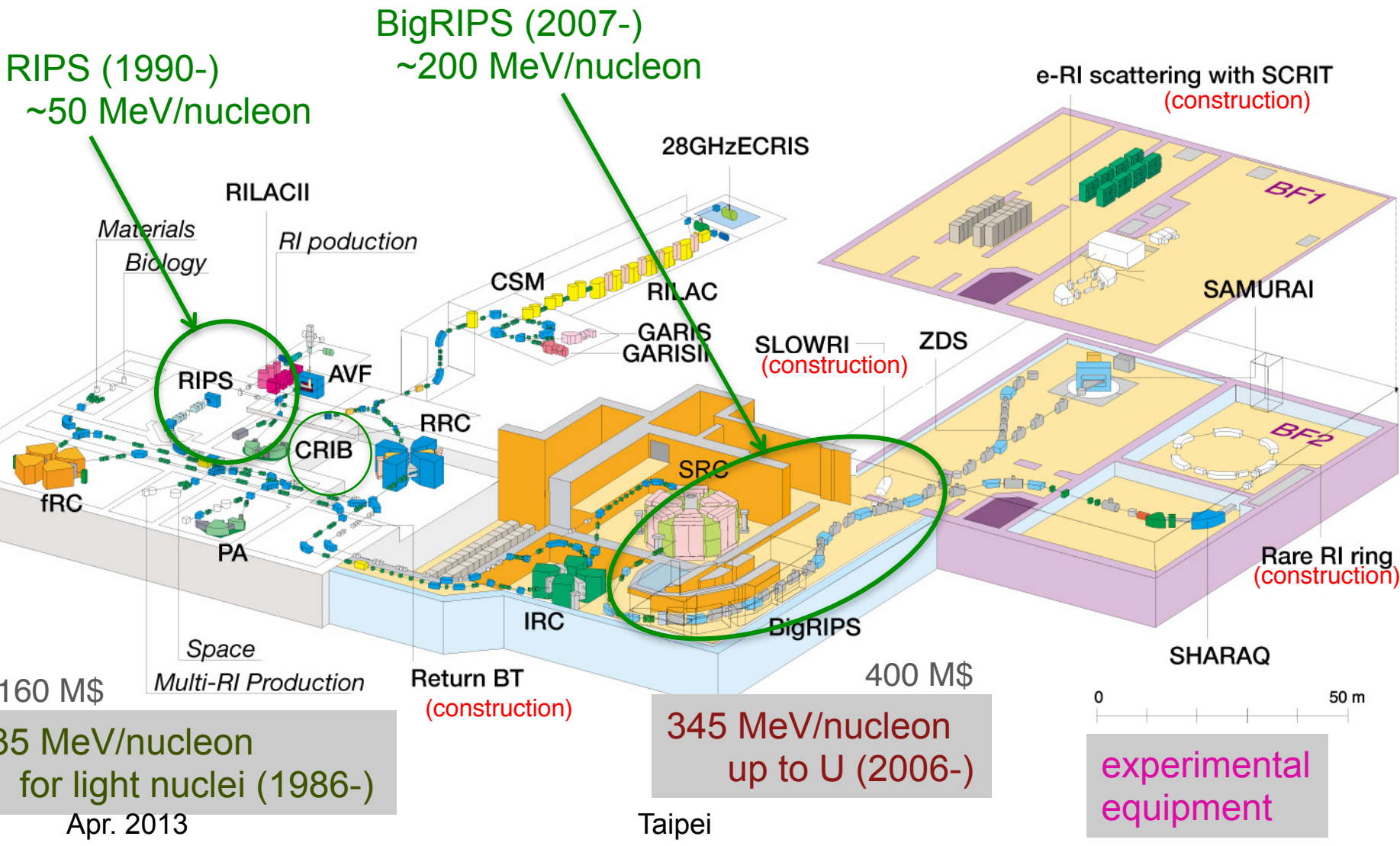
Discovery of Lepton Flavor Violation

COMET

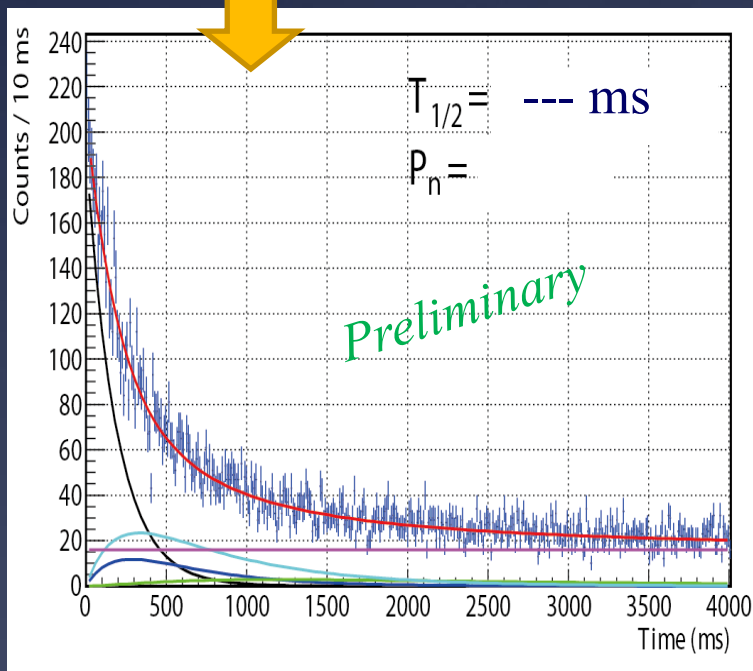
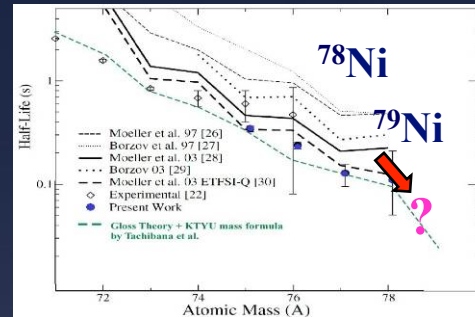
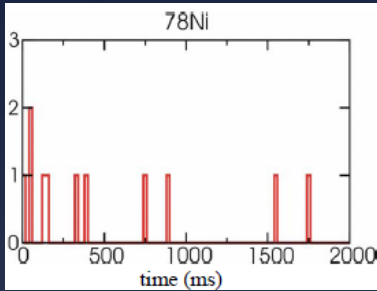
COMET: Search for $m \rightarrow e$ conversion with the world-best precision of less than 10^{-16}



RIBF – a new generation RIB facility in operation
with world highest capability of providing RI beams in coming years!



Hosmer (MSU)
PRL (2006)



New equipment under construction
SCRIT, Rare RI-ring, SLOWRI, Return-BT

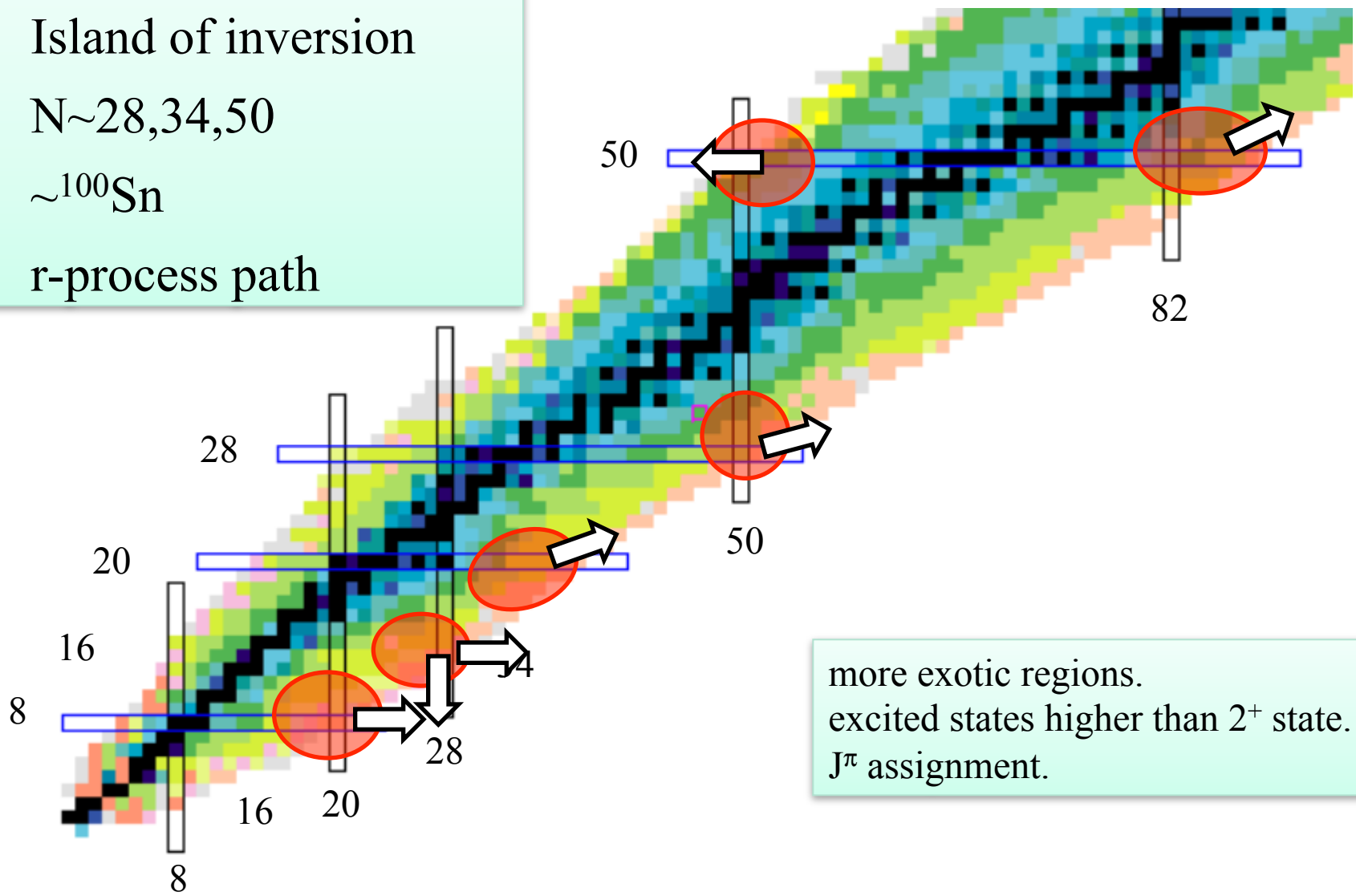
Accelerator development
approaching to the goal intensities
stability: much improved

Toward r-process nuclei

Inbeam γ , SAMURAI, HARAQ, : on-going
CRIB (CNS) *c.f.* Otsuka
KISS (KEK)

Three orders of magnitude higher statistics: ~ 10 events $\rightarrow 10^4$ events

- Playground:
Island of inversion
 $N \sim 28, 34, 50$
 $\sim 100\text{Sn}$
r-process path



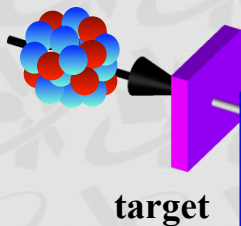
more exotic regions.
excited states higher than 2^+ state.
 J^π assignment.

SAMURAI large acceptance spectrometer at RIBF secondary beam experiments (2012-)

Superconducting Analyzer for Multi-
particle from Radio Isotope Beam with
7Tm of bending power

Kinematically complete
measurements by detecting
multiple particles in coincidence

RI beam
from BigRIPS



pole(2m dia.)

superconducting
coil

vacuum chamber

Neutron

rotate

- Superconducting Magnet
3T with 2m dia. pole
(designed resolution 1/700)
80cm gap (vertical)
- Heavy Ion Detectors
- Proton Detectors
- Neutron Detectors
- Large Vacuum Chamber
- Rotational Stage

Proton

Heavy Ion

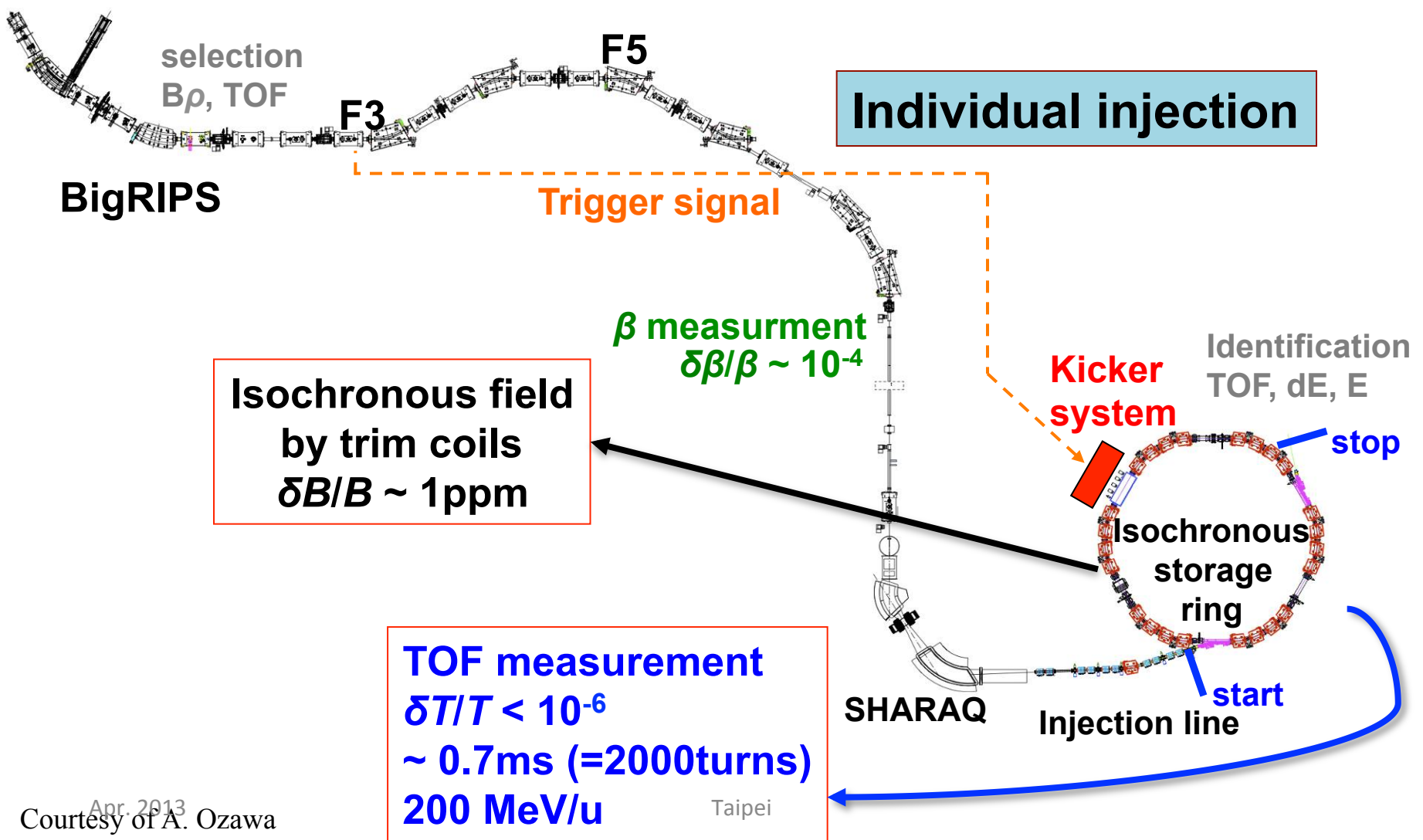
Invariant Mass Measurement

Missing Mass Measurement

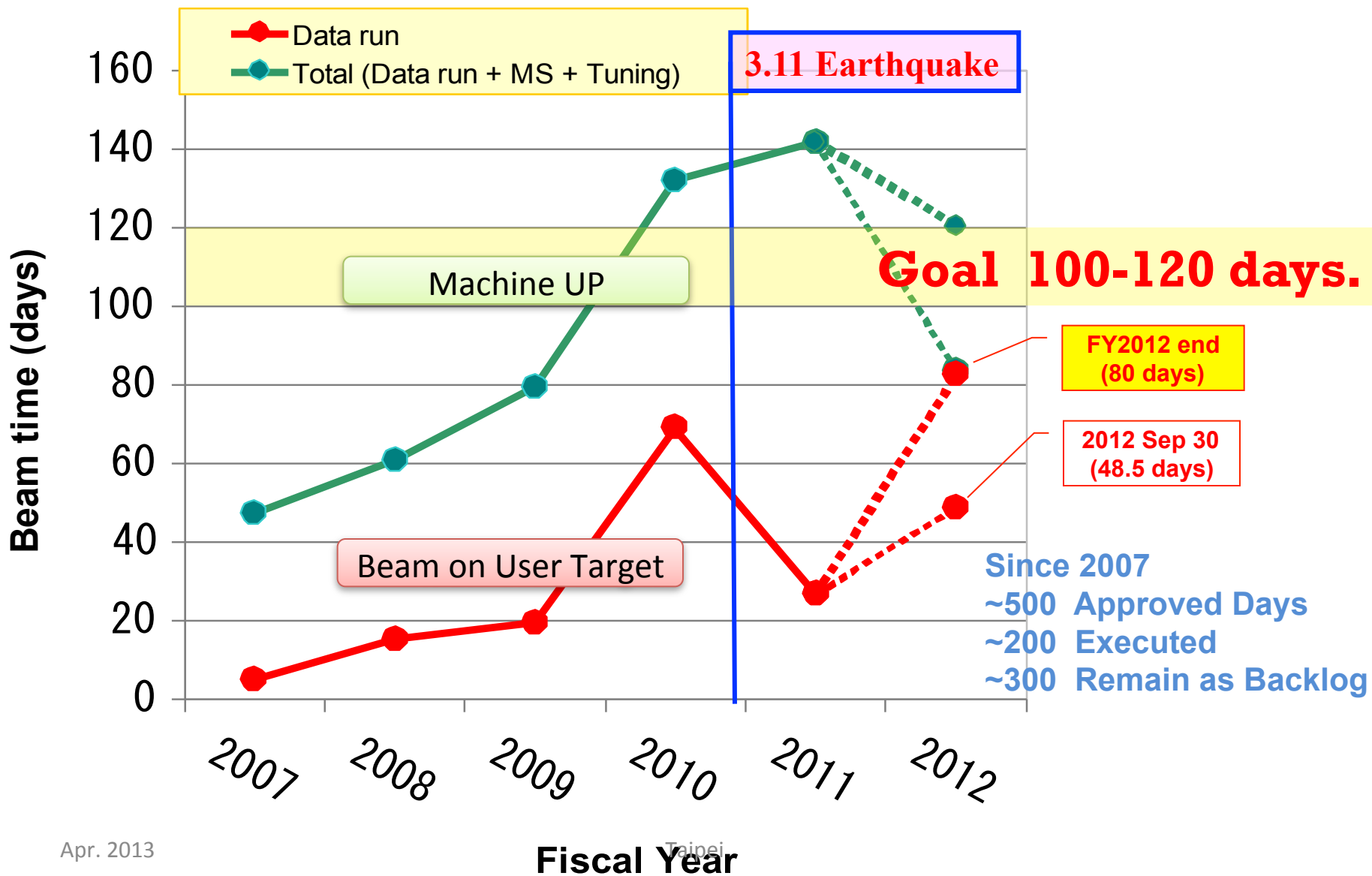
Apr. 2013

Isochronous storage ring method -- under construction

1 event/day, 1ms, 1ppm



Beam time for BigRIPS experiments



Some Recent Activities in China



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

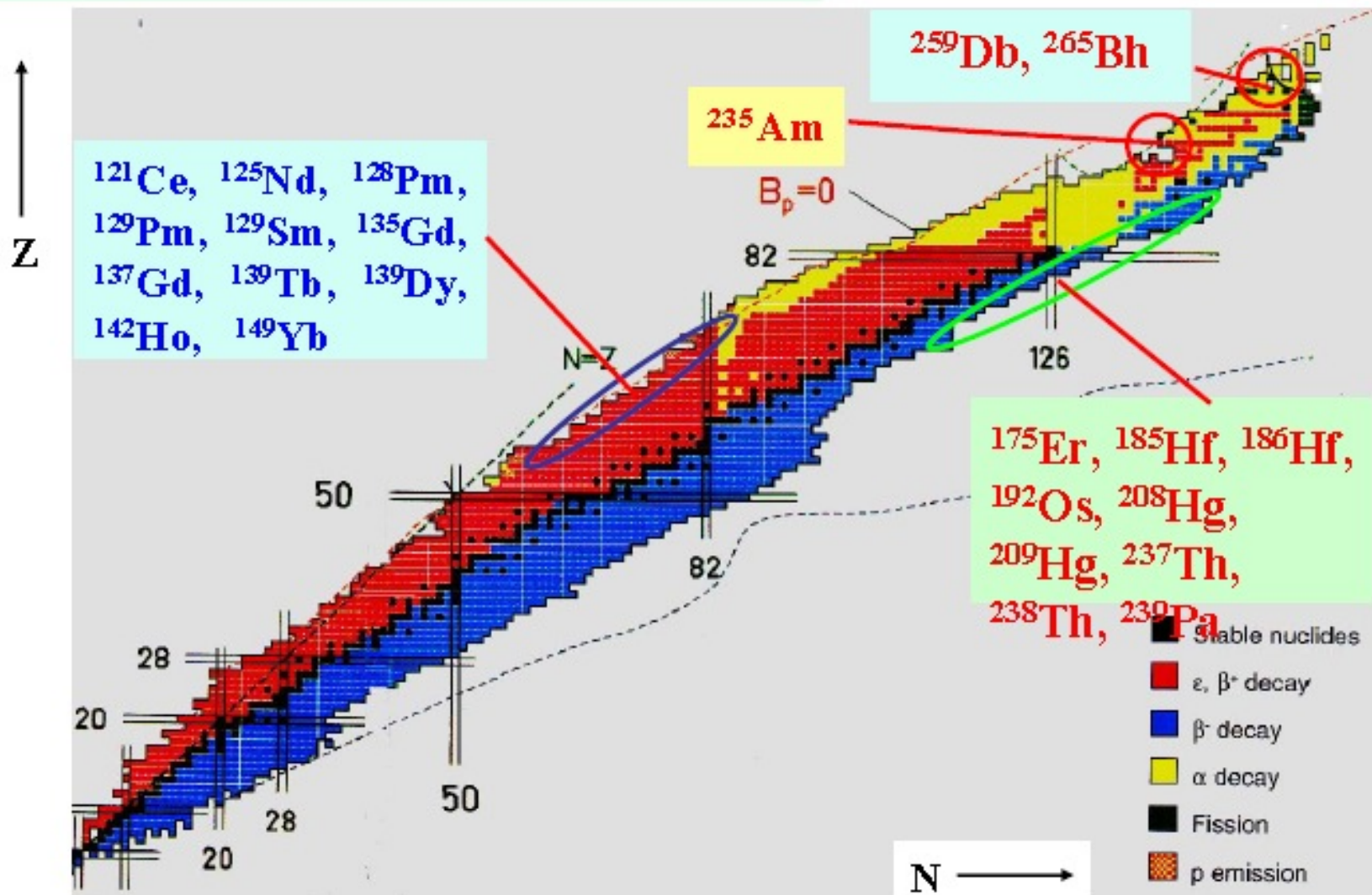
SFC (K=69)
10 AMeV (H.I.), 17~35 MeV (p)



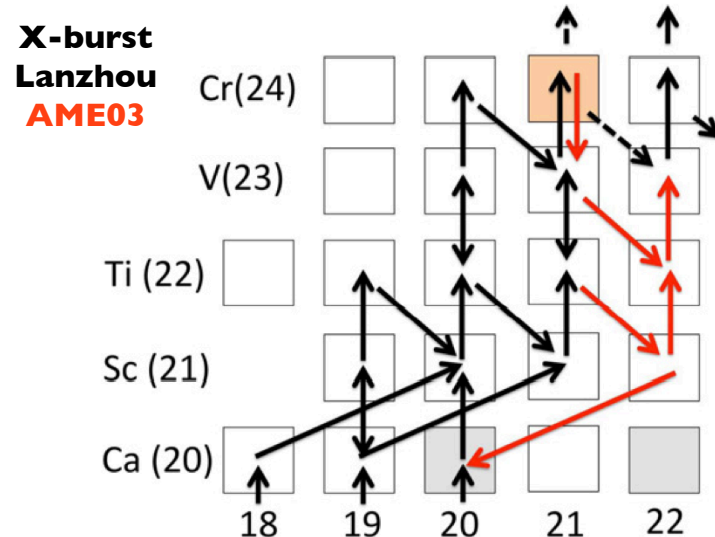
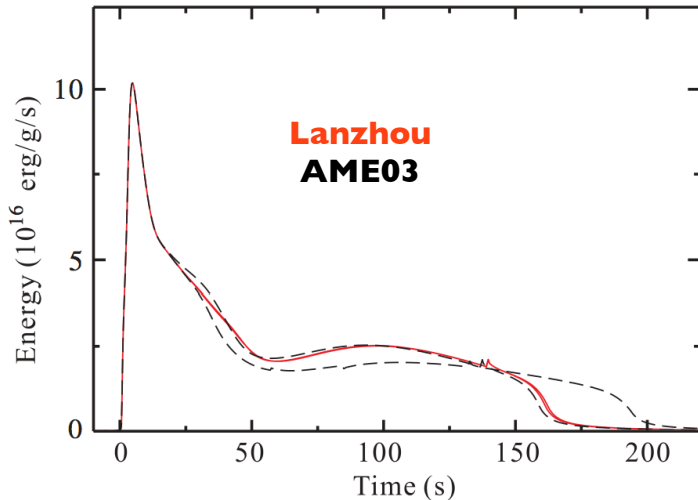
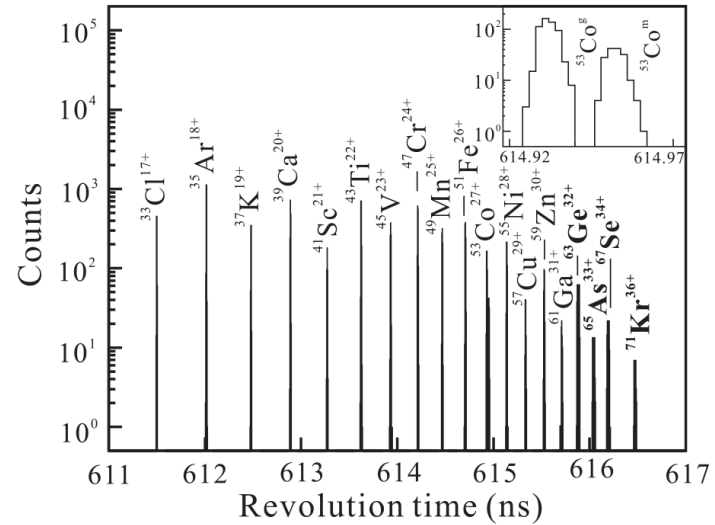
Stable nuclei and secondary beams are available at HIRFL



New Isotopes synthesized at IMP



Mass in Lanzhou and rp-process



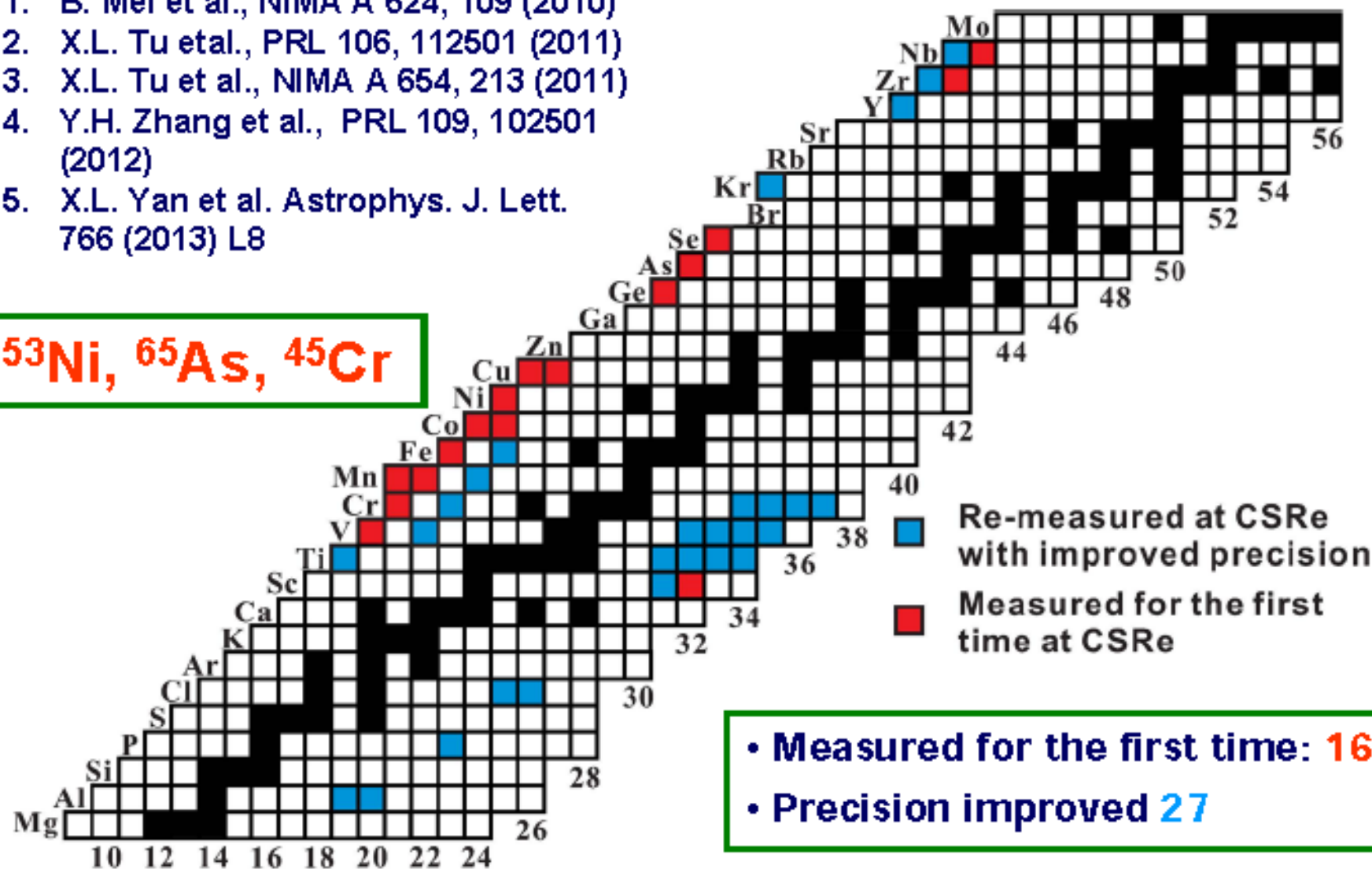
L. Tu, H. S. Xu et al., APJL 106(2011)102501

X. L. Yan, H. S. Xu et al., APJL 766(2013)L8

Mass measurement results at CSRe-Lanzhou

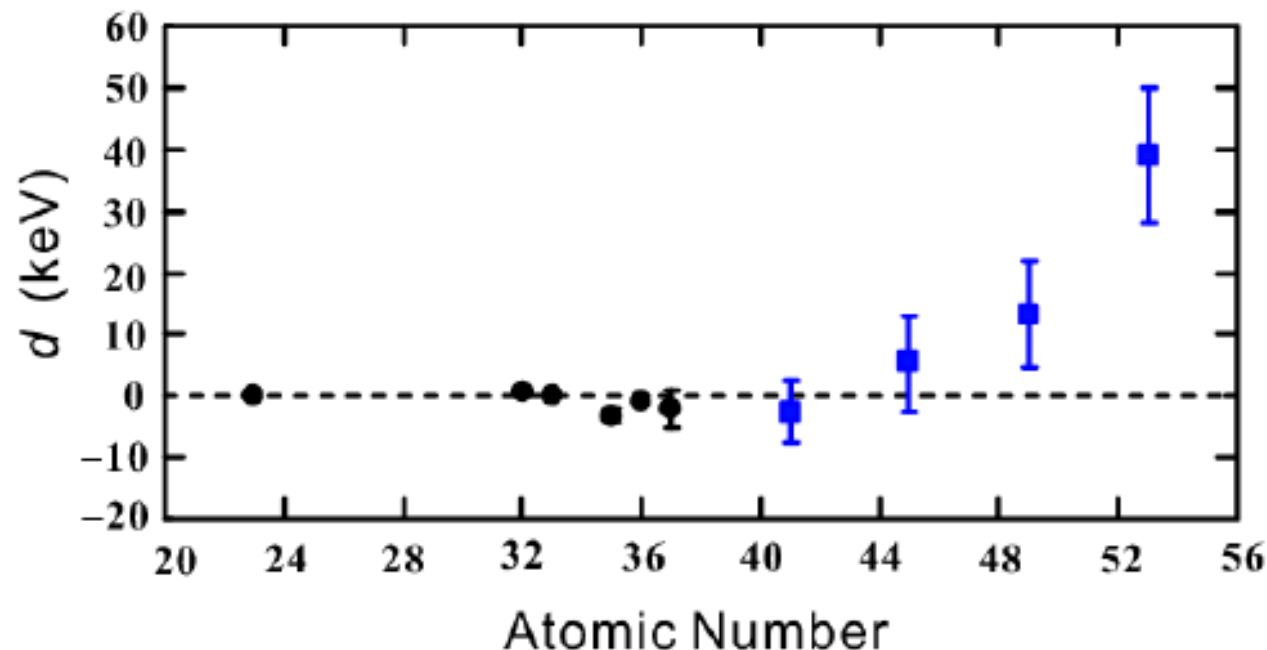
1. B. Mei et al., NIMA A 624, 109 (2010)
2. X.L. Tu et al., PRL 106, 112501 (2011)
3. X.L. Tu et al., NIMA A 654, 213 (2011)
4. Y.H. Zhang et al., PRL 109, 102501 (2012)
5. X.L. Yan et al. Astrophys. J. Lett. 766 (2013) L8

^{53}Ni , ^{65}As , ^{45}Cr



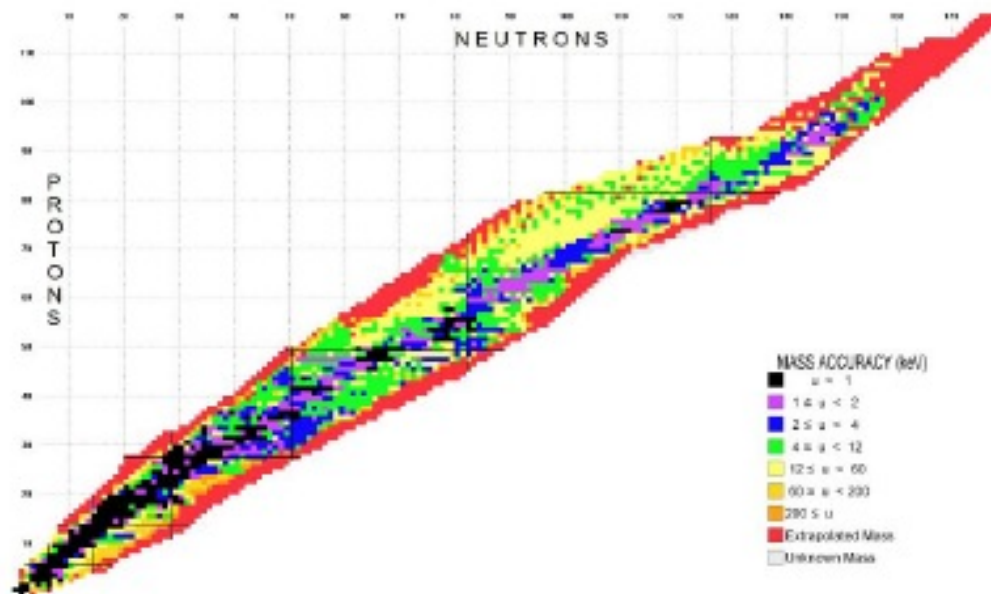
Test the IMME in fp shell nuclei

$$M(T, A, T_3) = a(T, A) + b(T, A)T_3 + c(T, A)T_3^2 + d(T, A)T_3^3$$



Y.H. Zhang et al., PRL 109, 102501 (2012)

d coefficients increase gradually up to $A=53$ for which d is 3.5σ deviated from zero.



AME2012+NUBASE2012 published
in the December issue of
Chinese Physics C.

3827 masses, including
2438 experimental masses for ground state

ISSN 1674-1137

中国物理 C

Chinese Physics C

HIGH ENERGY PHYSICS AND NUCLEAR PHYSICS

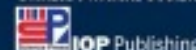
Volume 36 Number 12 December 2012

A Series Journal of the Chinese Physical Society

Online: <http://cpc-hepnp.ihep.ac.cn>

<http://www.iop.org/journals/cpc>

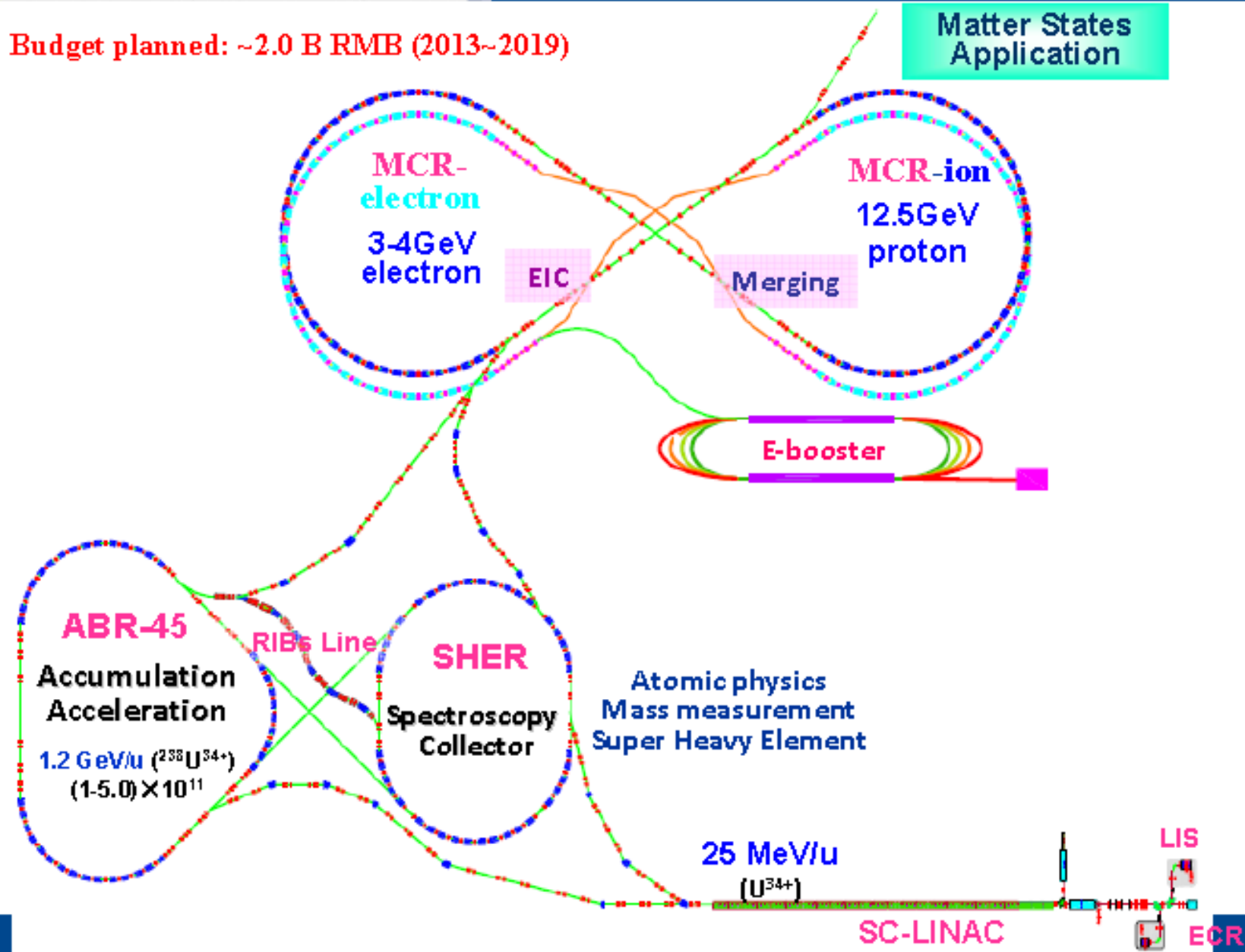
CHINESE PHYSICAL SOCIETY





Budget planned: ~2.0 B RMB (2013~2019)

Matter States Application





Radioactive nuclear beams, high power pulsed heavy ion beams, polarized proton and electron beams, high intensity low-energy heavy ion beams
Fixed target, e-A collision, A-A merging experiments

Main scientific motivations of HIAF

- To understand the effective strong interaction binding atomic nuclide
 - Limits of nuclear existence, drip-line and super-heavy nuclei, etc
 - New forms of nuclear matter, neutron halo and cluster, etc
 - Quantum levels far from stability, shell closure and evolution, etc
 - New modes of collective motion, exotic shapes, GDR and GMR, etc
 - Dynamical symmetries in nuclei, spin and Isospin symmetries, etc
- To simulate the creation of the trans-iron elements in universe
- To produce HED matter and study the properties of HED matter
- To pin down intrinsic structure of nucleon by electron-ion collision
- To promote heavy ions applications in space and material sciences



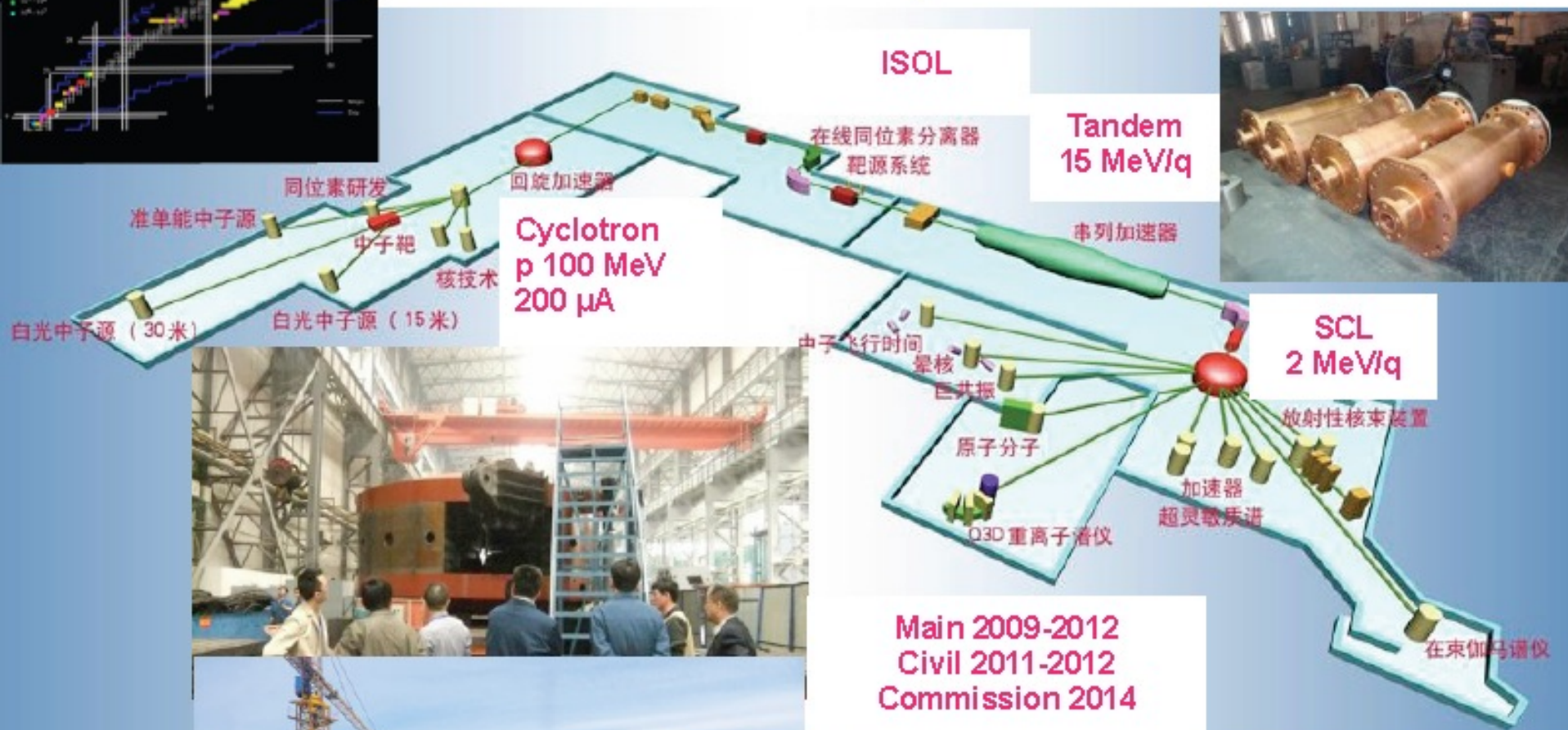
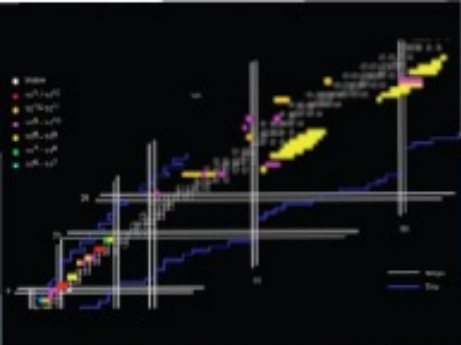
丝绸之路

IMP is located in Lanzhou. Lanzhou city is the capital of Gansu province in the northwest of China with a population of 3 million on the ancient Silk Road.

INPC2016 by IMP proposed

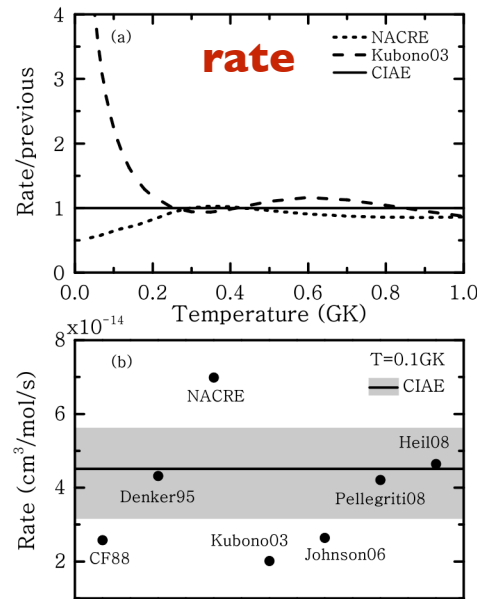
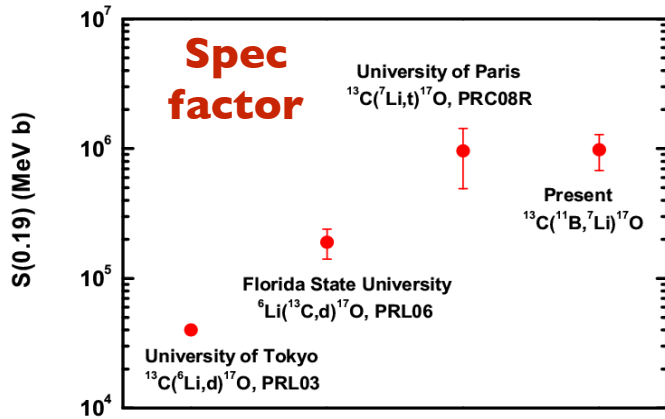


BRIF progress

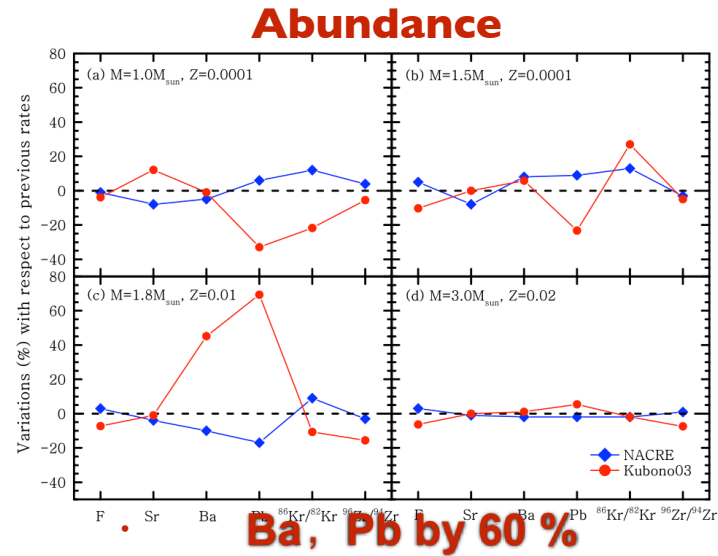
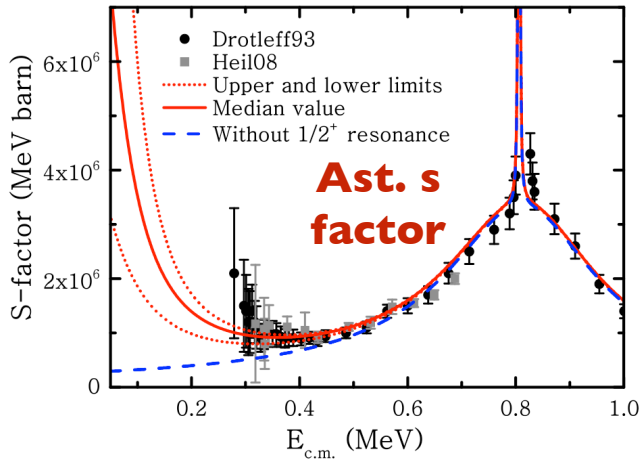


Main 2009-2012
Civil 2011-2012
Commission 2014

B. Guo, ..., W. P. Liu, APJ756 (2012)193.



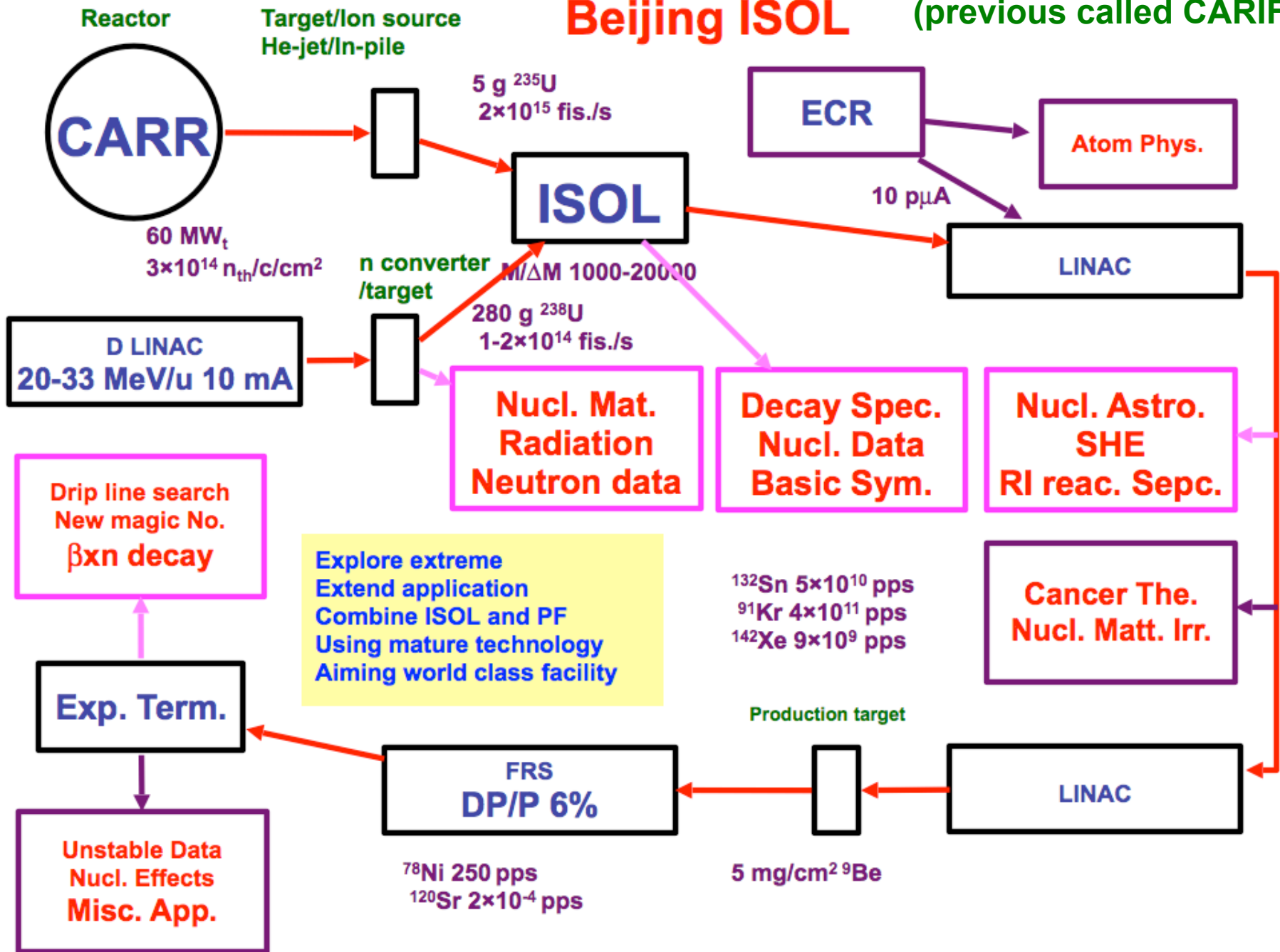
$^{13}\text{C}(\alpha,n)^{16}\text{O}$



• new $^{13}\text{C}(\alpha,n)^{16}\text{O}$ rate of for AGB abundance

Beijing ISOL

(previous called CARIF)



Facility roadmap

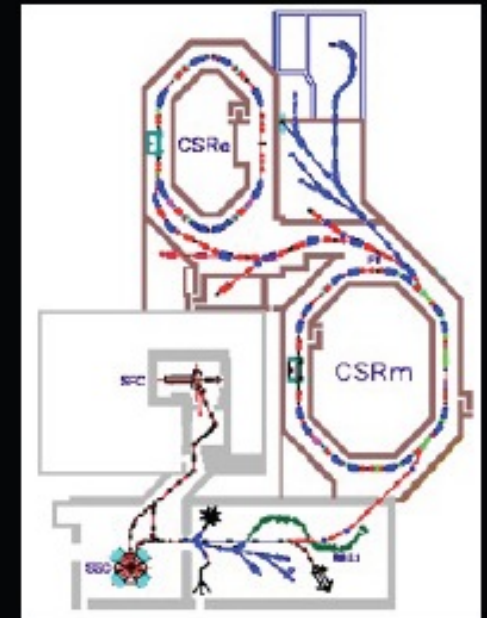
1986
Beijing Tandem, HI-13



1988
Lanzhou Cyclotron, SSC



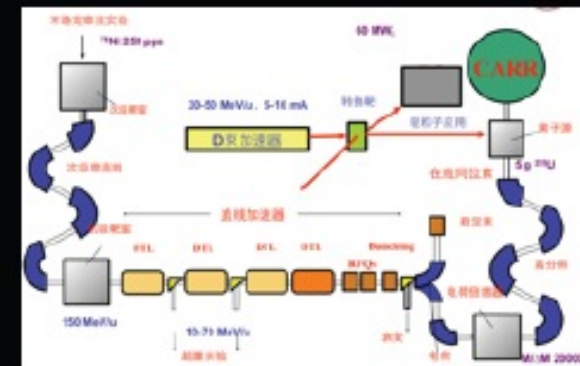
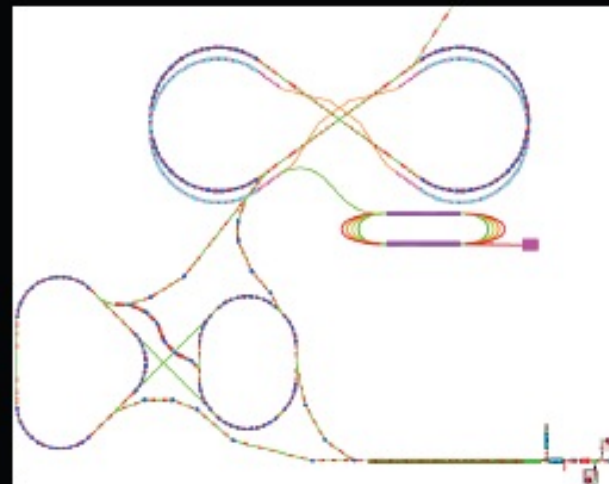
2008
Lanzhou Ring, CSR



2014
Beijing Upgrading, BRIF

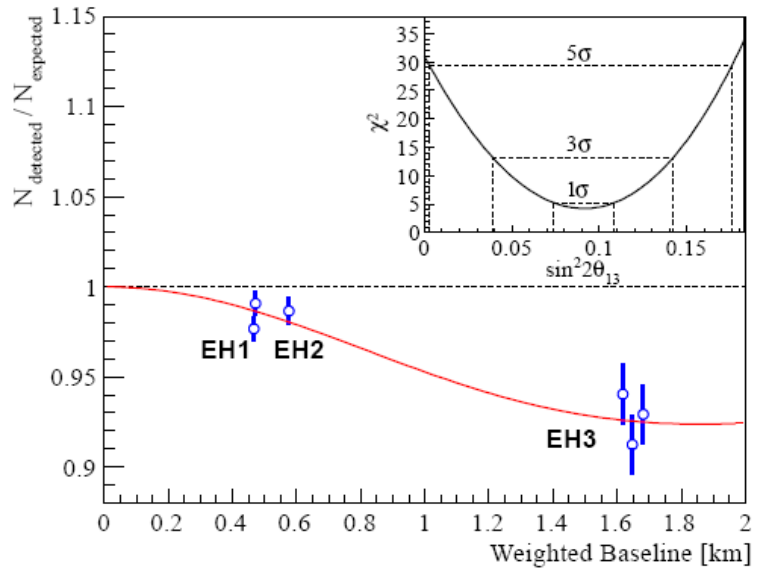
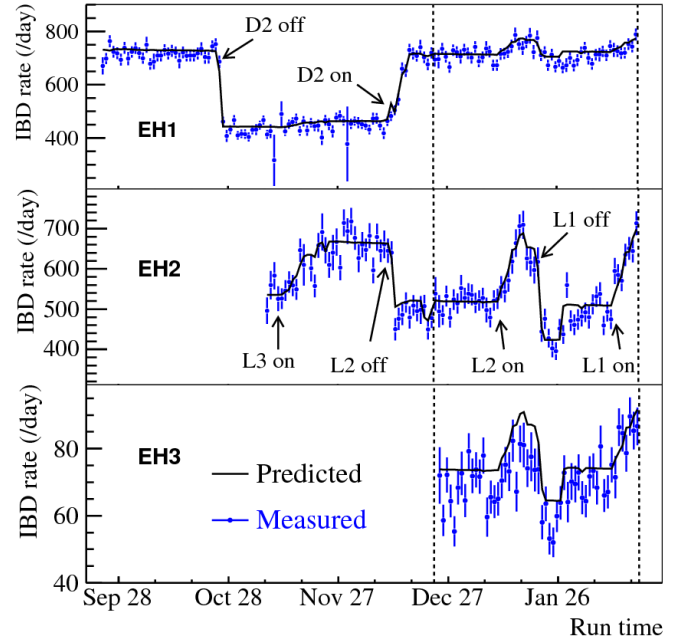
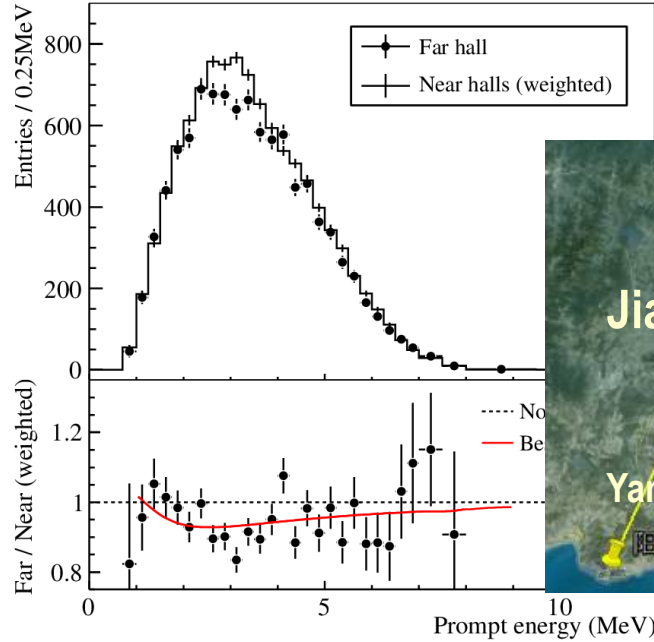
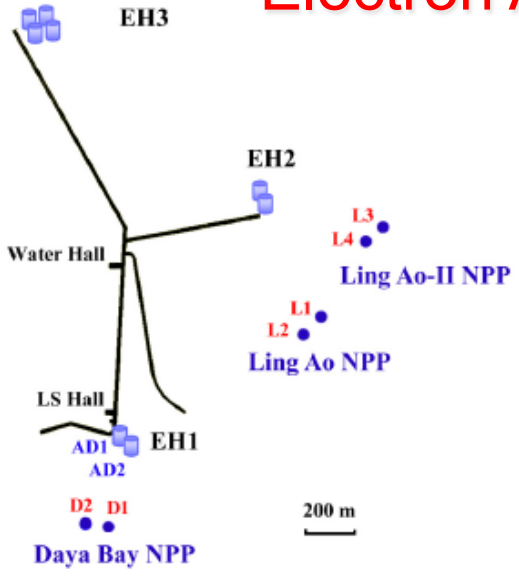
2020?
Heavy-ion Facility, HIAF

2025?
Beijing ISOL



Electron Anti-neutrino Disappearance at Daya Bay

DYB-II



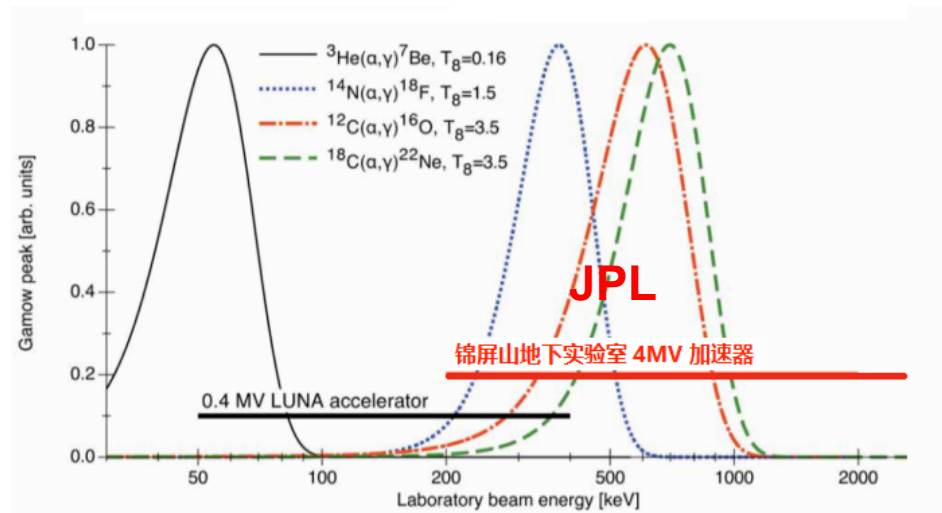
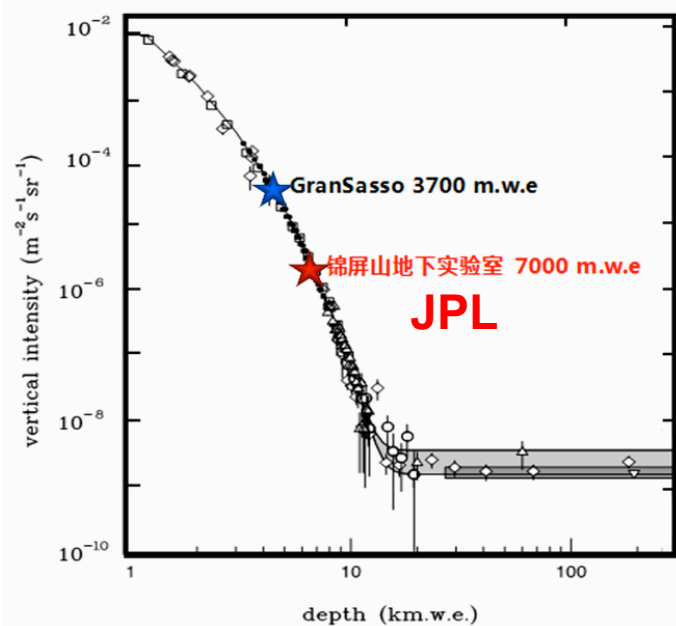
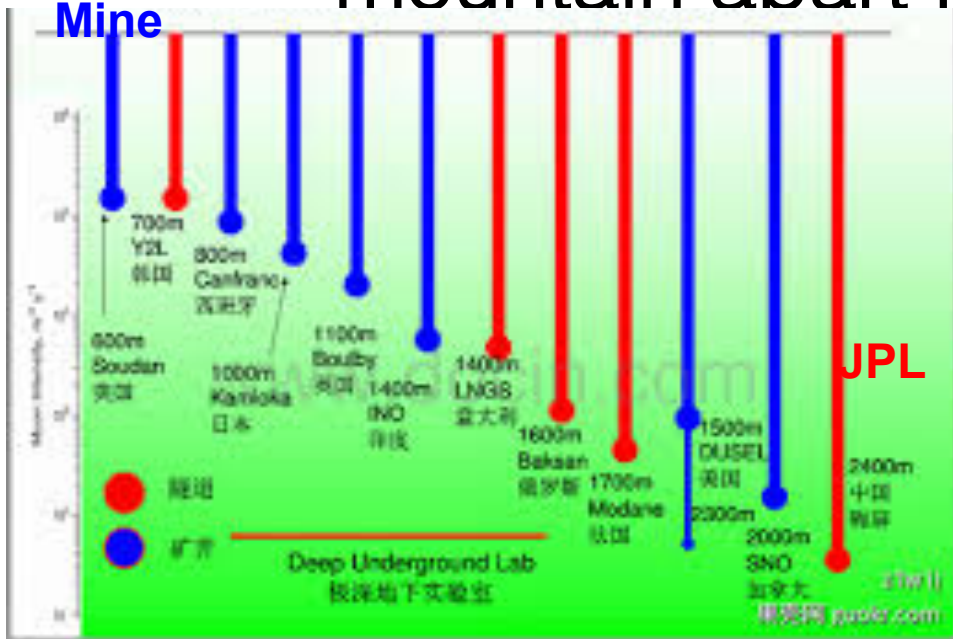
$\text{Sin}^2 2\theta_{13} = 0.092 \pm 0.016 \text{ (stat)} \pm 0.005 \text{ (syst)}$

Phys. Rev. Lett. 108, 171803 (2012)

Possibilities of nuclear astrophysics in Jinping

**Tunnel
Mine**

mountain apart from dark physics



Some Recent Activities in Korea

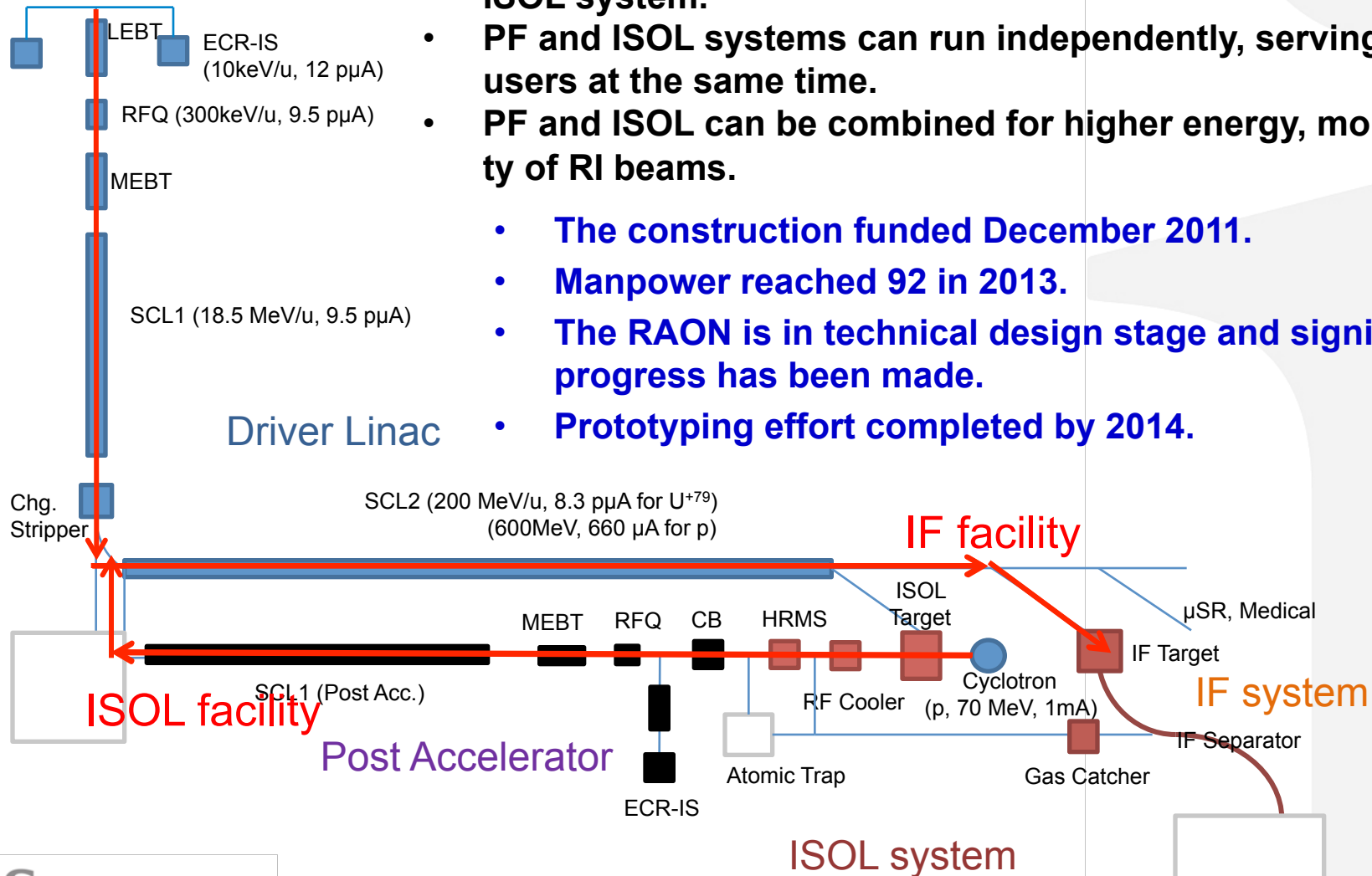
The RAON Heavy Ion Accelerator of Korea



From Dong-O Jeon
Institute for Basic Science

RAON's Uniqueness

- RAON is a unique facility in the world that has both PF and ISOL system.
- PF and ISOL systems can run independently, serving more users at the same time.
- PF and ISOL can be combined for higher energy, more variety of RI beams.
 - The construction funded December 2011.
 - Manpower reached 92 in 2013.
 - The RAON is in technical design stage and significant progress has been made.
 - Prototyping effort completed by 2014.



Some Recent Activities in India

ACCELERATORS FOR NUCLEAR PHYSICS

Inter University Accelerator Centre, New Delhi

(15 MV Pelletron & SC Nb QWR based Linac for energy augmentation, High Current Injector)

Tata Institute of Fundamental Research, Mumbai

(14 MV Pelletron, SC Pb plated Cu QWR based Linac Booster for energy gain)

Variable Energy Cyclotron Centre, Kolkata

(224 cm Variable Energy Cyclotron, K-500 SC Cyclotron Accelerator, RIB facility)

Saha Institute of Nuclear Physics, Kolkata

(3 MV tandetron, to be installed)

224cm Variable Energy Cyclotron; Operating since 1977



Training ground of nuclear physicists in the country!

K=130 Room Temperature Cyclotron (Now giving alphas, protons, & deuterons)

- **Modernization has led to:**
 - **Greatly improved stability of beam on target.**
 - **Much larger beam currents.**
 - **Smooth and uninterrupted operation for days at a stretch.**
- **Plans Ahead:**
 - **Up-gradation of RF Cavity Components**
 - **Up-gradation of Extraction System**
 - **It will lead to extraction of higher energy beam and leak-free operation of the RF system.**
 - **Introduction of beam chopper, for neutron studies.**

VECC SUPERCONDUCTING CYCLOTRON

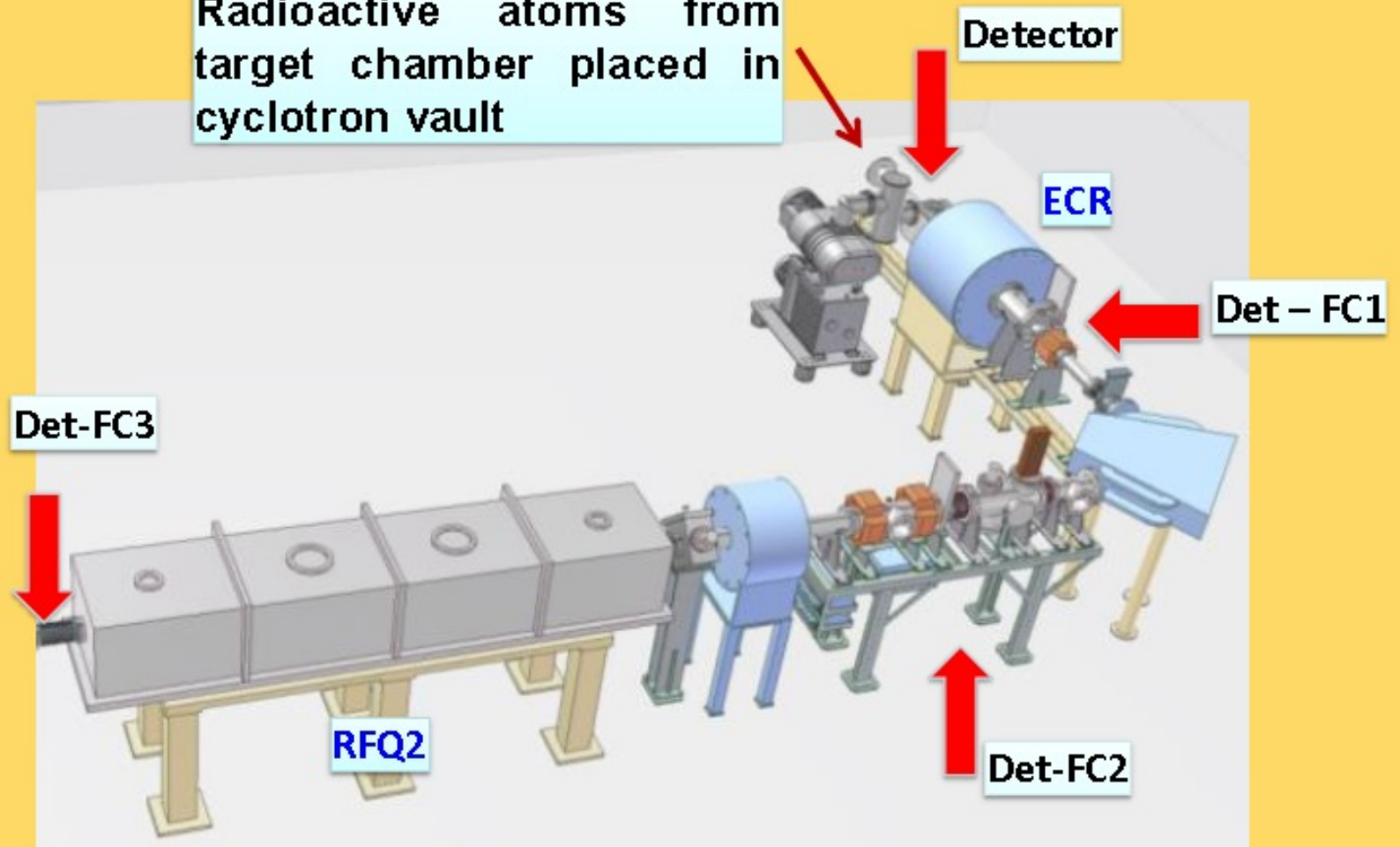
- ▶ $K_{\text{bend}}=520$
- ▶ Accelerate heavy ion beams
- ▶ Energy
 - ▶ 80 MeV/nucleon for light ions
 - ▶ 8 MeV/nucleon for heavy ions
- ▶ Radio-frequency system
 - ▶ 9-27 MHz
 - ▶ 80 kV maximum Dee voltage
- ▶ Superconducting magnet
 - ▶ Average magnetic field = 5 Tesla
 - ▶ 100 Tonnes magnet iron
 - ▶ 12.5 Tonnes cryostat



Advanced Radioactive Ion Beam Facility Project : VECC,
Kolkata

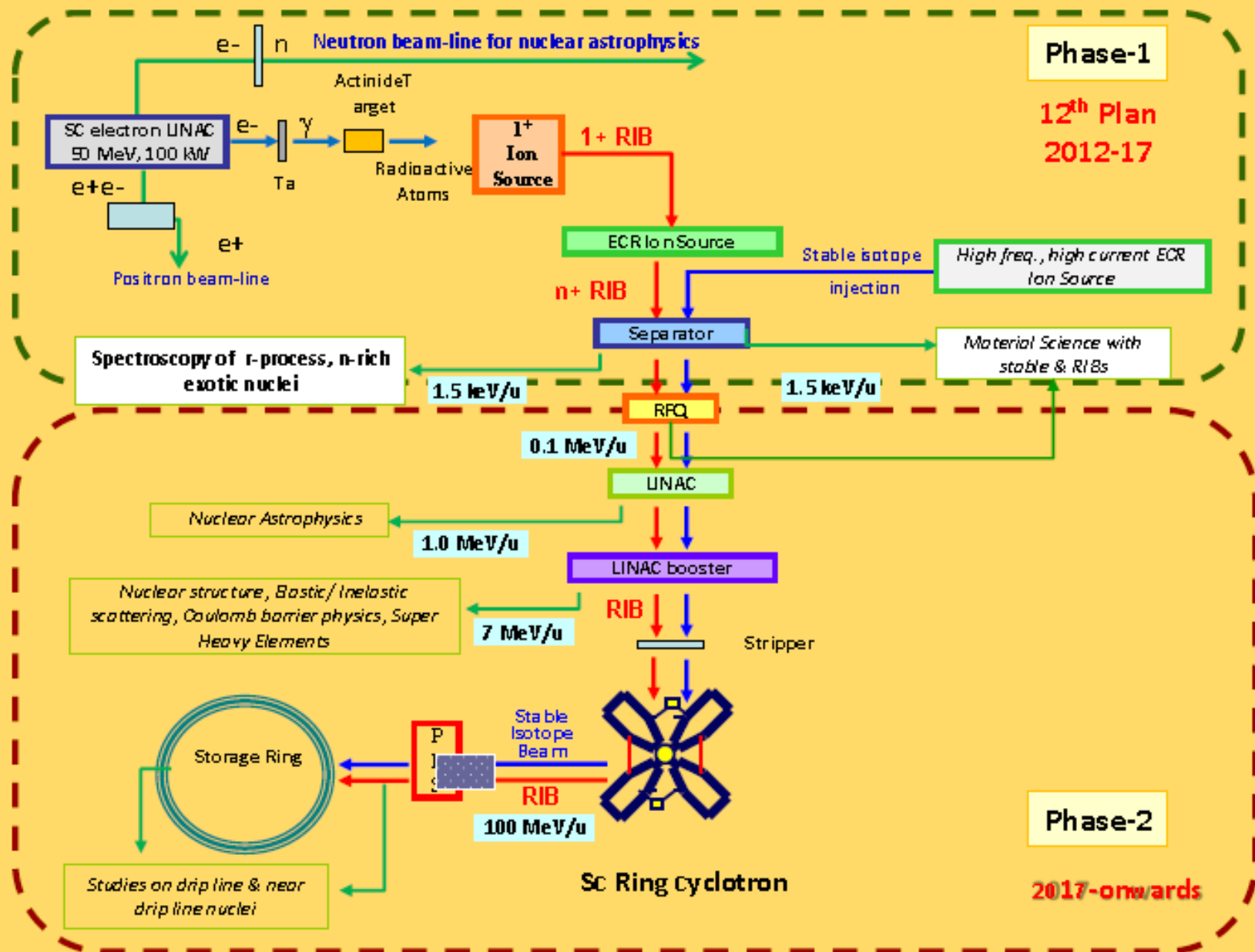
Production & Acceleration of RIBs for the first time using a novel technique

Radioactive atoms from
target chamber placed in
cyclotron vault



Schematic layout of ANURIB facility

Advanced National Facility for Unstable and Rare Isotope Beams



Conclusions

- **Nuclear communities are well organized and supported by existing facilities and funds in many Asia countries**
- **World level research work would be achieved if the new and proposed facilities take full potential and commissioned, in Japan, China, Korea, India etc**
- **ANPhA is a good platform to exchange ideas on physics driven facilities ideas, so they can complement and enhance each other, with collaboration to WG9/C12, NuPECC, and NSAC etc**