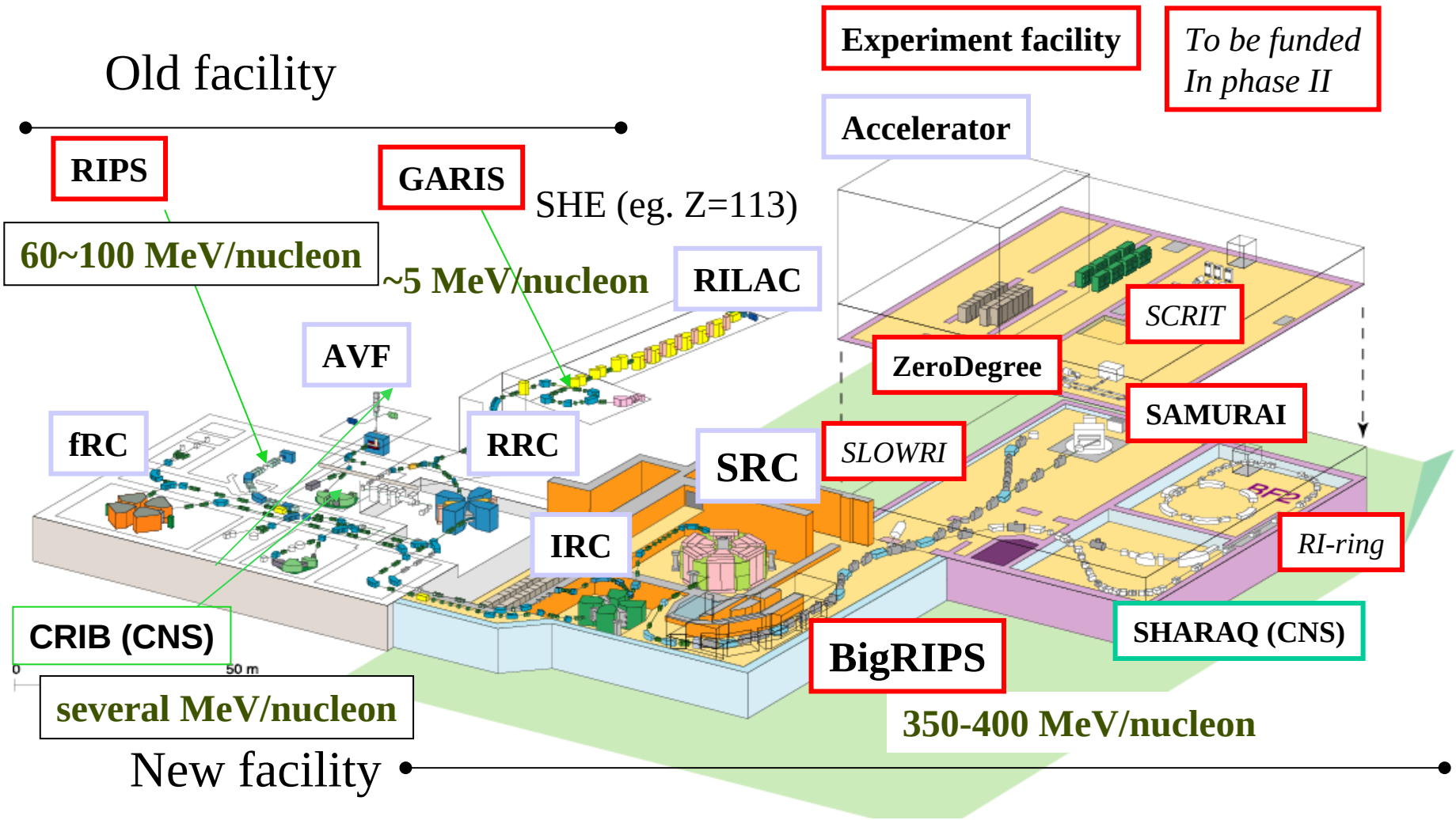
Overview of RIKEN RIBF Facility

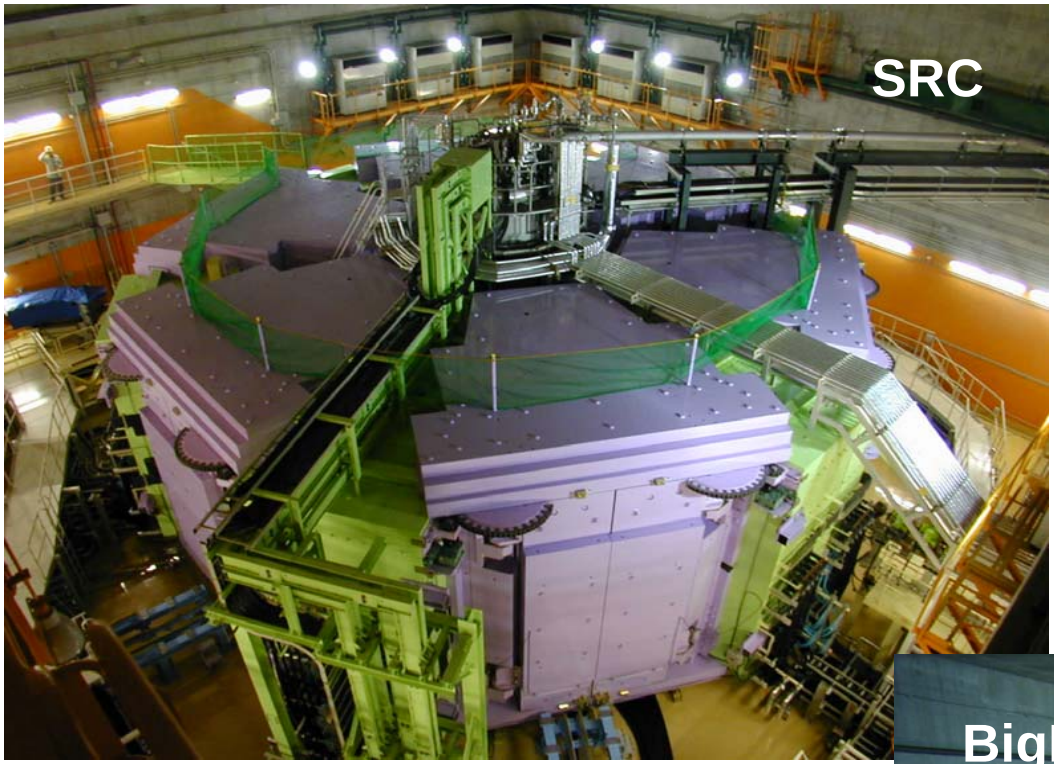
H. Sakurai / T. Motobayashi

RIKEN Nishina Center

RIKEN RI Beam Factory (RIBF)



Intense (80 kW max.) H.I. beams (up to U) of 345*A*MeV at SRC
Fast RI beams by projectile fragmentation and U-fission at BigRIPS
Operation since 2007



World's First and Strongest
K2600MeV
Superconducting Ring Cyclotron

400 MeV/u Light-ion beam
345 MeV/u Uranium beam

World's Largest Acceptance
9 Tm
Superconducting RI beam Separator

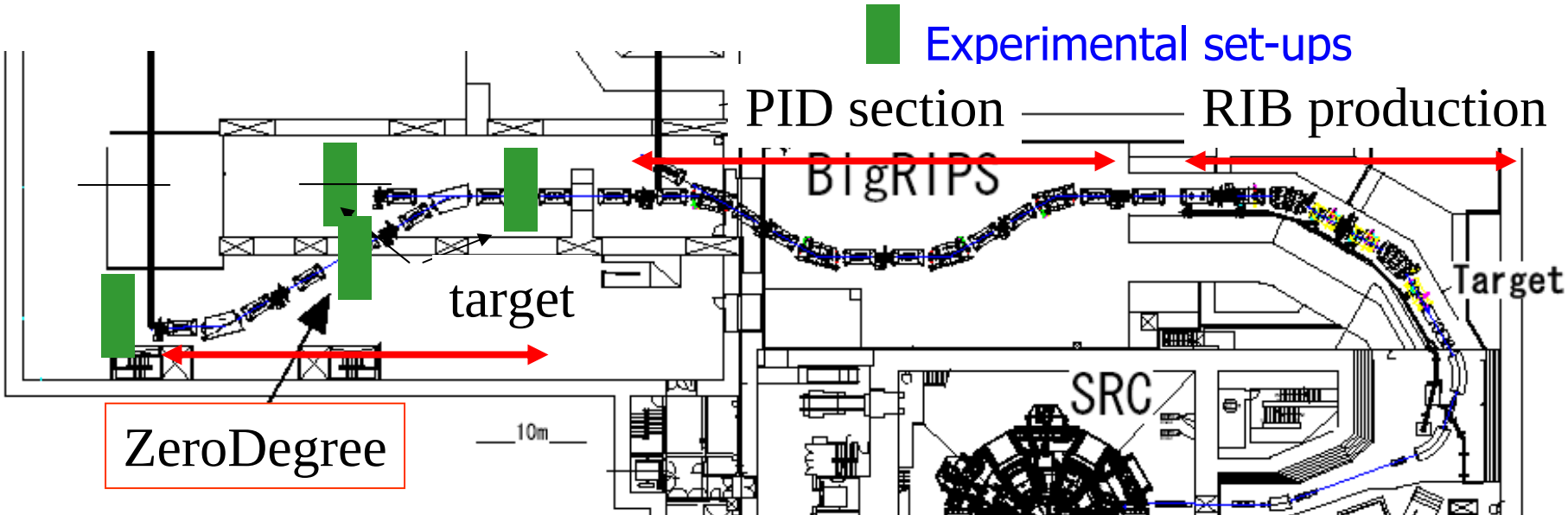
~250-300 MeV/nucleon RIB

BigRIPS /ZeroDegree

Exploration into “Isospin Frontier” toward the drip-lines
Reaction study fit for high energy domain 200-300A MeV

Coordinated by Kubo for BigRIPS
by Aoi for ZeroDegree

BigRIPS	Fragment Separator high acceptance for fission fragments pid for RI beams at the second section
ZeroDegree	Multi-function BT line pid for ejectiles in inclusive- and semi-exclusive measurement medium resolution (p/dp ~ 2000 – 4000)



Programs at BigRIPS/ZeroDegree 2007~

Rare-Isotope Physics Programs

Fast RI beam production to search for new isotopes

Global survey to search for anomalous regions

Aoi
Scheit
Nishimura
Otsu

Specific programs with deuteron beams

BigRIPS in-flight production of fast rare-isotope beams

Ground state properties and low lying excited states via decay spectroscopy / transmission method: particle stability, $T_{1/2}$, Q_β, σ_R, Ex.(2^+)...

Deeply bound pionic states via (d, ^{3}He) at 500 MeV

Three-body force via pol. d+p elastic scattering at 700 MeV

ZeroDegree multi-function beam line for inclusive/semi-inclusive measurements
production of 3rd RI beams

Collectivity and matter distribution via in-beam gamma / missing mass spectroscopy

One step energy regime 200~300 A MeV

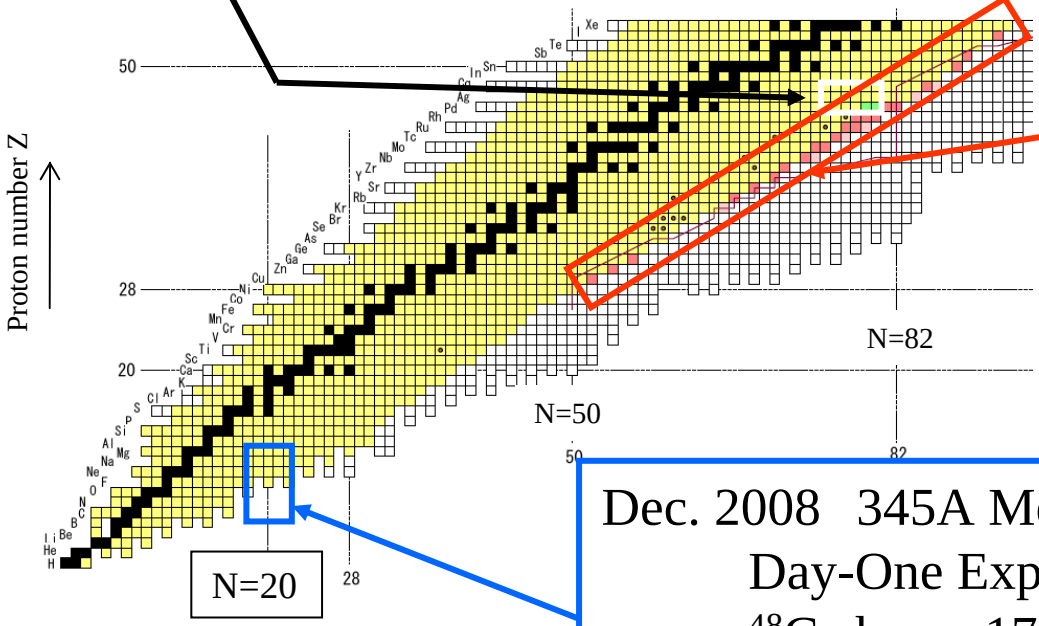
B(E2), B(M1), (p,p), (p,p'), Ex....

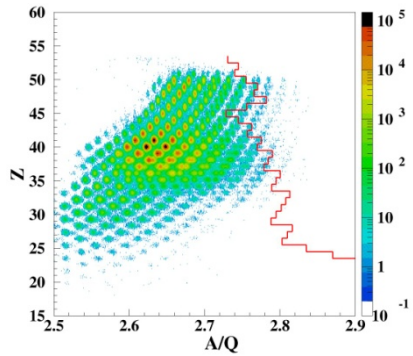
Iso-diffusion

Programs at BigRIPS/ZD in 2007-2008

May 2007 345A MeV ^{238}U beam 0.02 pnA (max)
Two new isotopes, ^{125,126}Pd (Z=46), Onishi et al. JPSJ 77 (08) 083201

Nov. 2008 345A MeV ^{238}U beam 0.4 pnA(max)
More than 20 new isotopes in Zn(Z=30) to I(Z=53)





Dec. 2008 345A MeV ^{48}Ca beam
Day-One Experiments for Island-of-Inversion
^{48}Ca beam 170pnA(max)
^{31}Ne 10 /sec/100pnA, ^{32}Ne 5 /sec/100pnA

Constructions for pol. d beam Experiments in FY2008

IRC bypass beam transport line

- DMH6 (dipole magnet)
  : switch from LINAC-RRC-(fRC)-IRC-SRC mode to AVF-RRC-SRC mode

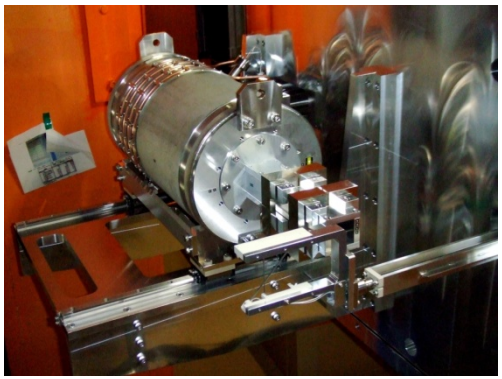
Dpol

- beam line polarimeter
- measurement of beam polarizations prior to acceleration by SRC
- reaction : *d-p* elastic scattering

IRC

SRC

Big-D-Polarimeter



BigDpol

- detection system (plastic scintillators)

Faraday cup

- W(φ3cm×30cm) +Pb(φ25cm×70cm)

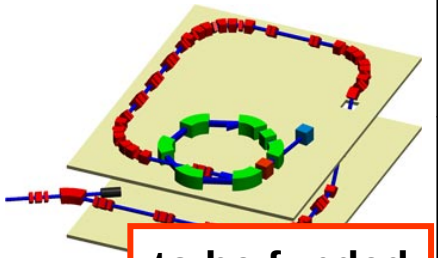
New Devices of RIBF

To maximize the potentials of intense RI beams available at RIBF

for several 100 – 1000 species

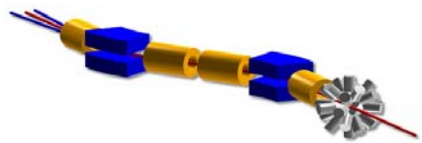
mass
half-life
excited states
deformation
charge radii
matter radii
charge distribution
matter distribution
EM moments
single particle states
astrophysical reactions
giant resonances
exotic modes
HI collisions (EOS)

Rare RI ring



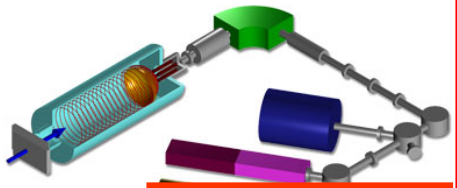
to be funded

ZeroDegree



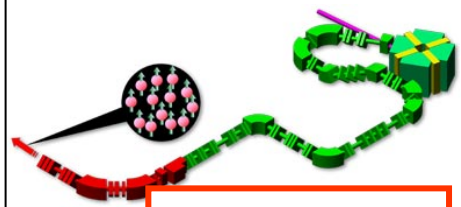
2008-

SLOWRI Wada



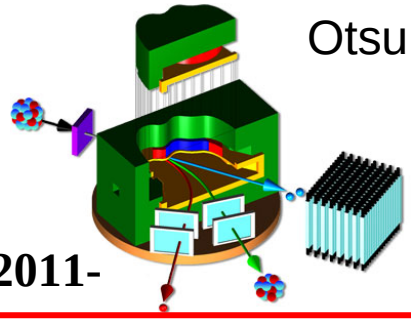
to be funded

IRC-to-RIPS BT



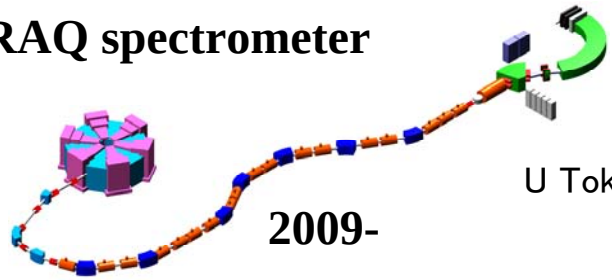
to be funded

SAMURAI Otsu



2011-

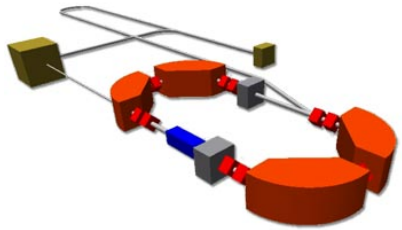
SHARAQ spectrometer



U Tokyo

2009-

SCRIT Wakasugi

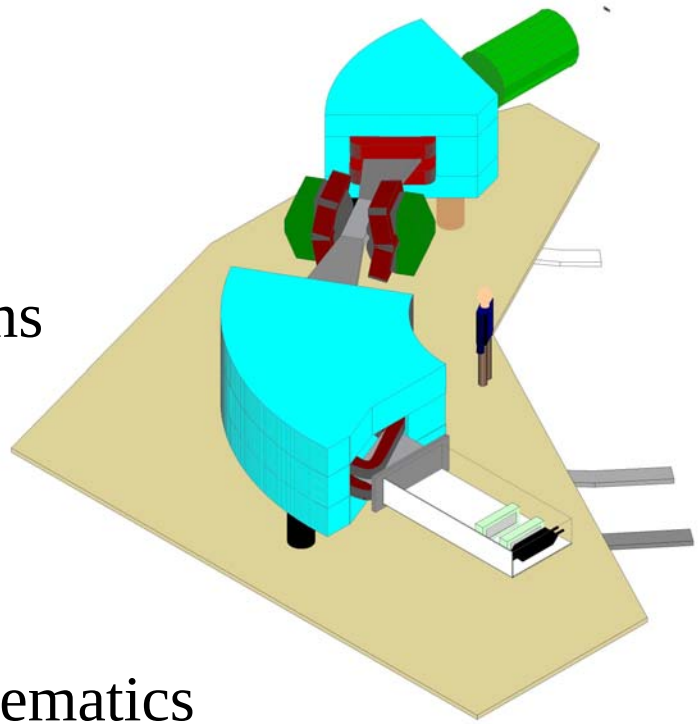


2010-

SHARAQ Spectrometer Sakai et al 2009-

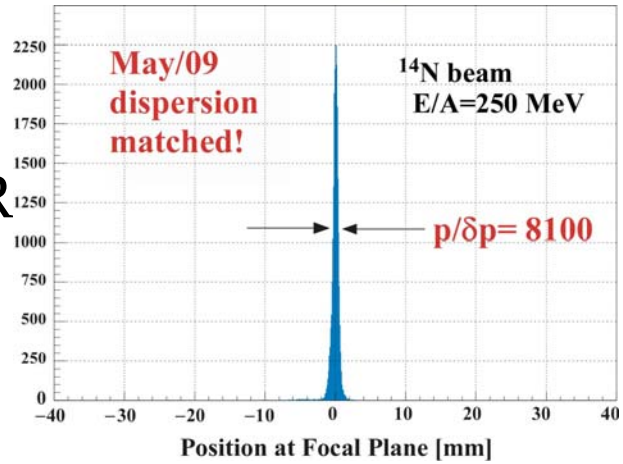
External investment by CNS, Univ. of Tokyo
Focal plane detector made in GANIL, France

High resolution spectrometer for fast RI beams
p/Δp ~ 15,000, Δθ<1mrad, Bρ=6.8Tm
Dispersion matching technique



RI beam as new probe to control Δq, ΔS, ΔT
Missing mass spectroscopy with standard kinematics
Spin-isospin response probed by fast RI beams :
transparent at 300*A* MeV
Double charge exchange : double GTR, IVSMR
Multi-neutron system, etc.

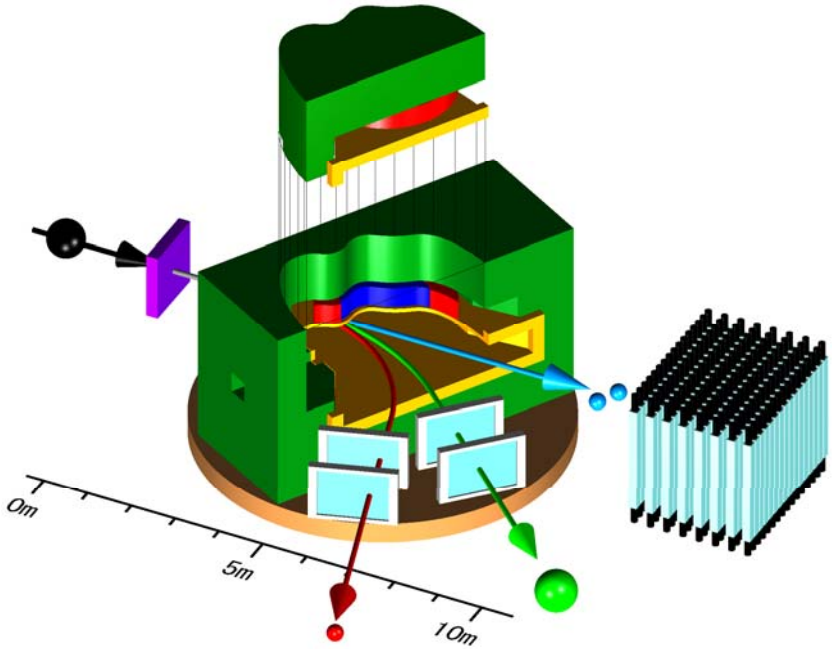
Commissioning in March, May 2009
First experiment in October 2009



SAMURAI Spectrometer Kobayashi et al 2011-

versatile spectrometer with a large superconducting magnet

80cm gap, BL~ 7Tm, Bmax=3T
PID limited to A~100



Invariant/missing mass spectroscopy
giant resonances
single particle states via (p,2p) etc
EOS in asymmetric nuclear matter :
SAMURAI-TPC
Particle correlations in a few-body system 3NF
Coulomb breakup for
radiative capture c.s. (p,γ), (n,γ)
Fission study

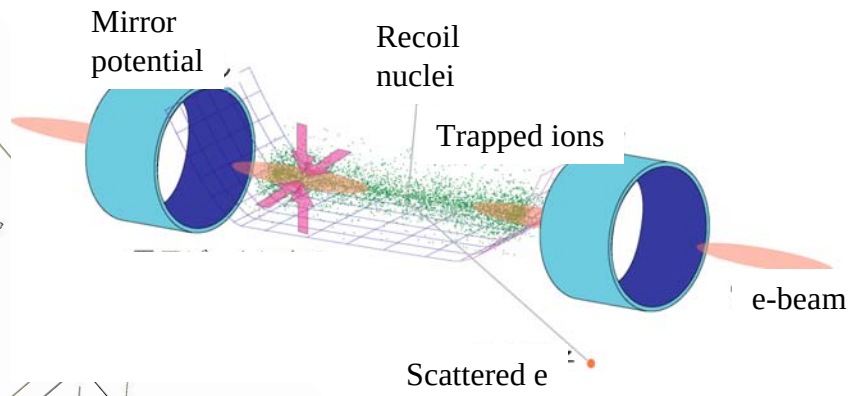
Operation in 2011

15M$ covers
SC-Magnet 9M$
Detectors
neutron counter
electronics, software
STQ for BT

SCRIT-system for e+RI scattering

Wakasugi et al.

Microtron
- 150MeV, ~1kW
- Two functions
  - Injector for e-storage ring
  - driver for RI production



Wakasugi et al., PRL 100 (2008) 164801
Suda, et al., PRL 102 (2009) 102501

RI Ion Source＋ ISOL
- Photo-induced fission（UC_2）

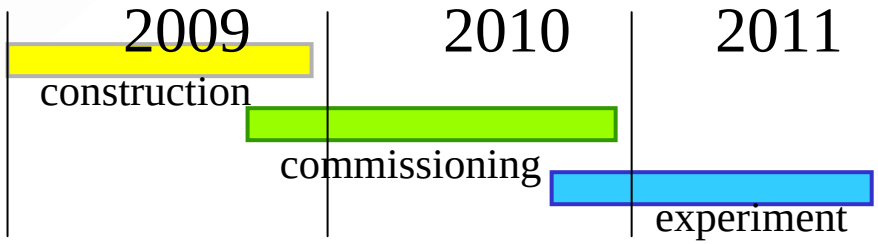
Ion transport line

SCRIT

e-storage ring
- 300MeV (up to 700MeV),300mA

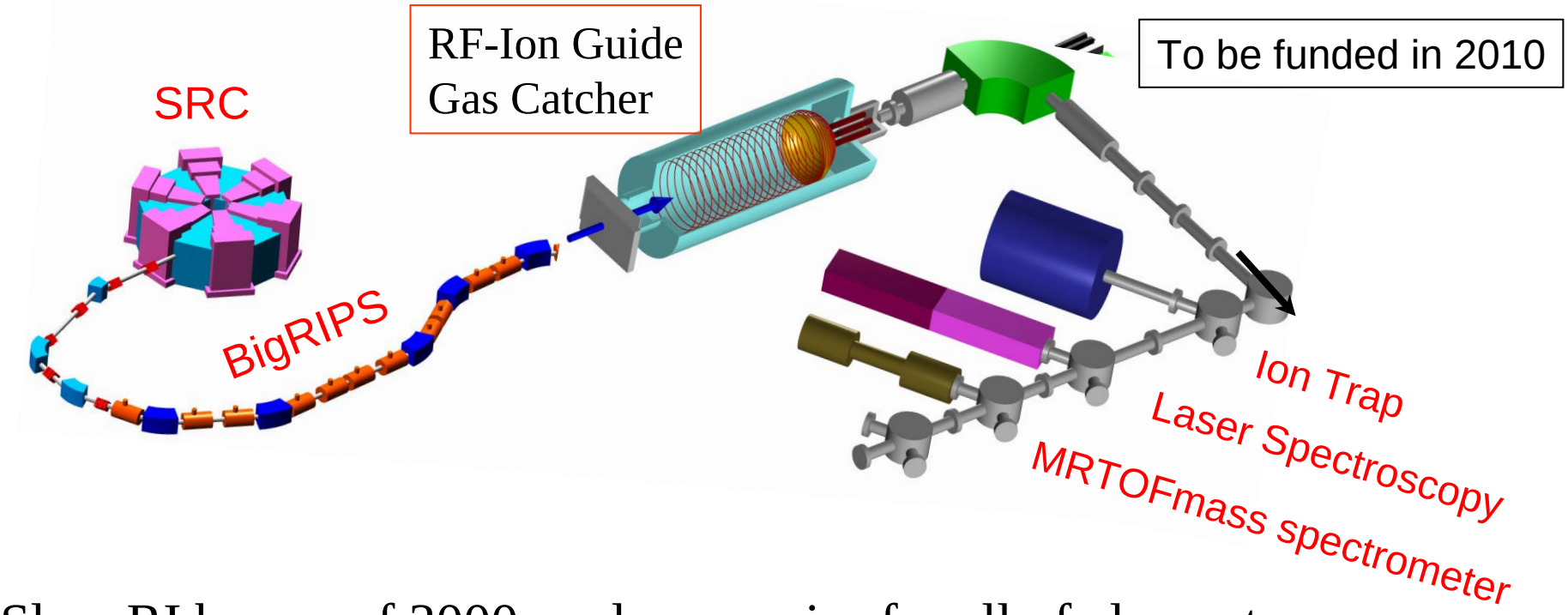
Scattered-e detectors
- DC + Calorimeter

Schedule



SLOWRI

M. Wada et al.



Slow RI beams of 3000 nuclear species for all of elements

Mass spectroscopy ; Penning Trap, MR-TOF for 1000 species
Laser spectroscopy : spin, moment, radii for 600 species
pilot experiments at RIPS for the Be isotopes
Decay spectroscopy : beta-delayed charged-particle emission

Rare-RI Ring

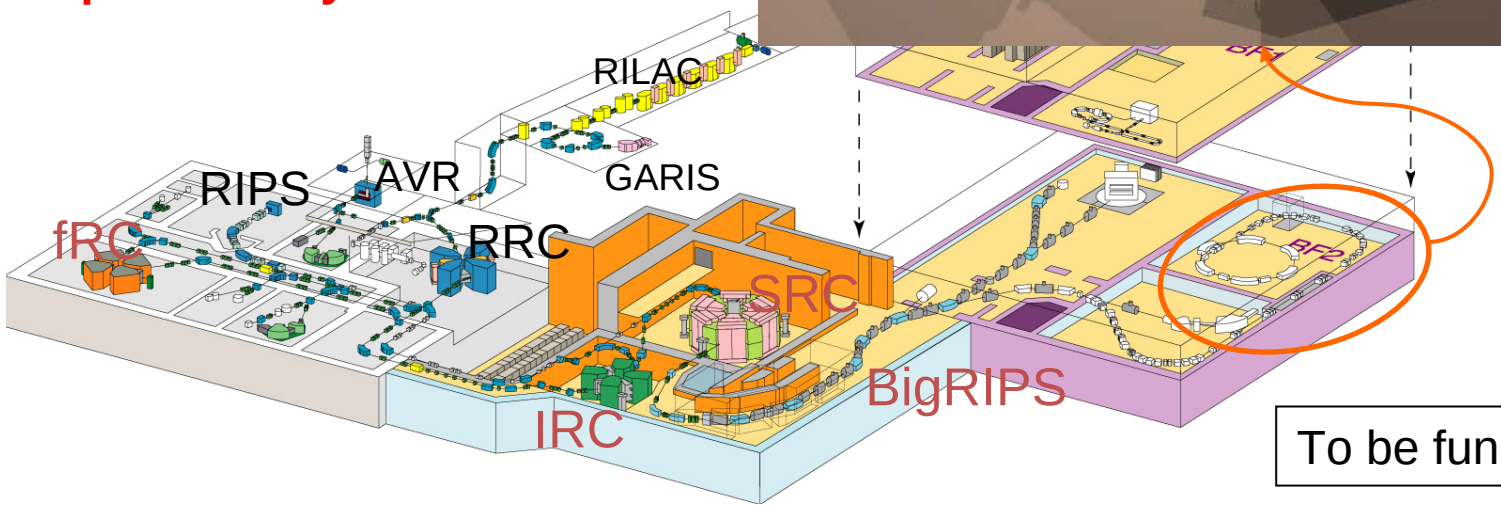
A. Ozawa et al.

RIKEN NiSHiNA CENTER

- Dedicated to IMS
- Measurement time < 1ms
  - For short-lived RI
- High resolution
  $\Delta m/m \sim 10^{-6}$
- High efficiency
  - Individual Injection
  - Large momentum acceptance (~1%)
- High sensitivity
  - Particle identification
  - 1particle/day

Three main parts

- Long injection beam line
- Fast kicker system
- Cyclotron-like storage ring

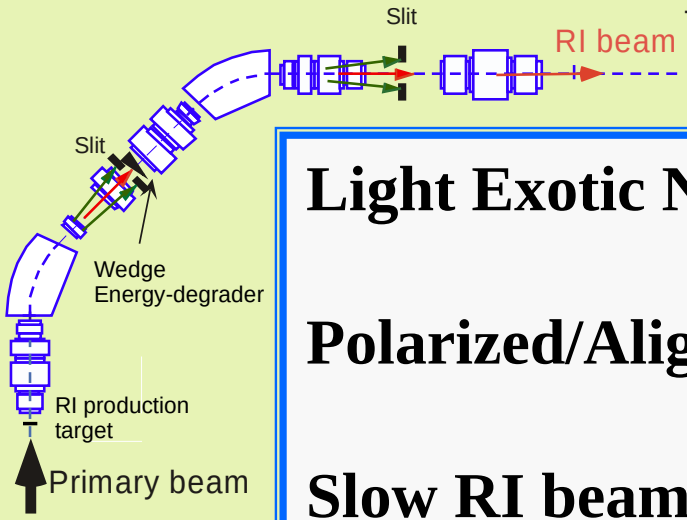


To be funded in 2011

RIPS (RIKEN Projectile-fragment Separator)

Intense RI beams for light mass region
Programs fit for intermediate energy domain ~100A MeV

RIPS (RIKEN Projectile-fragment Separator)



Scientifically coordinated by Ueno

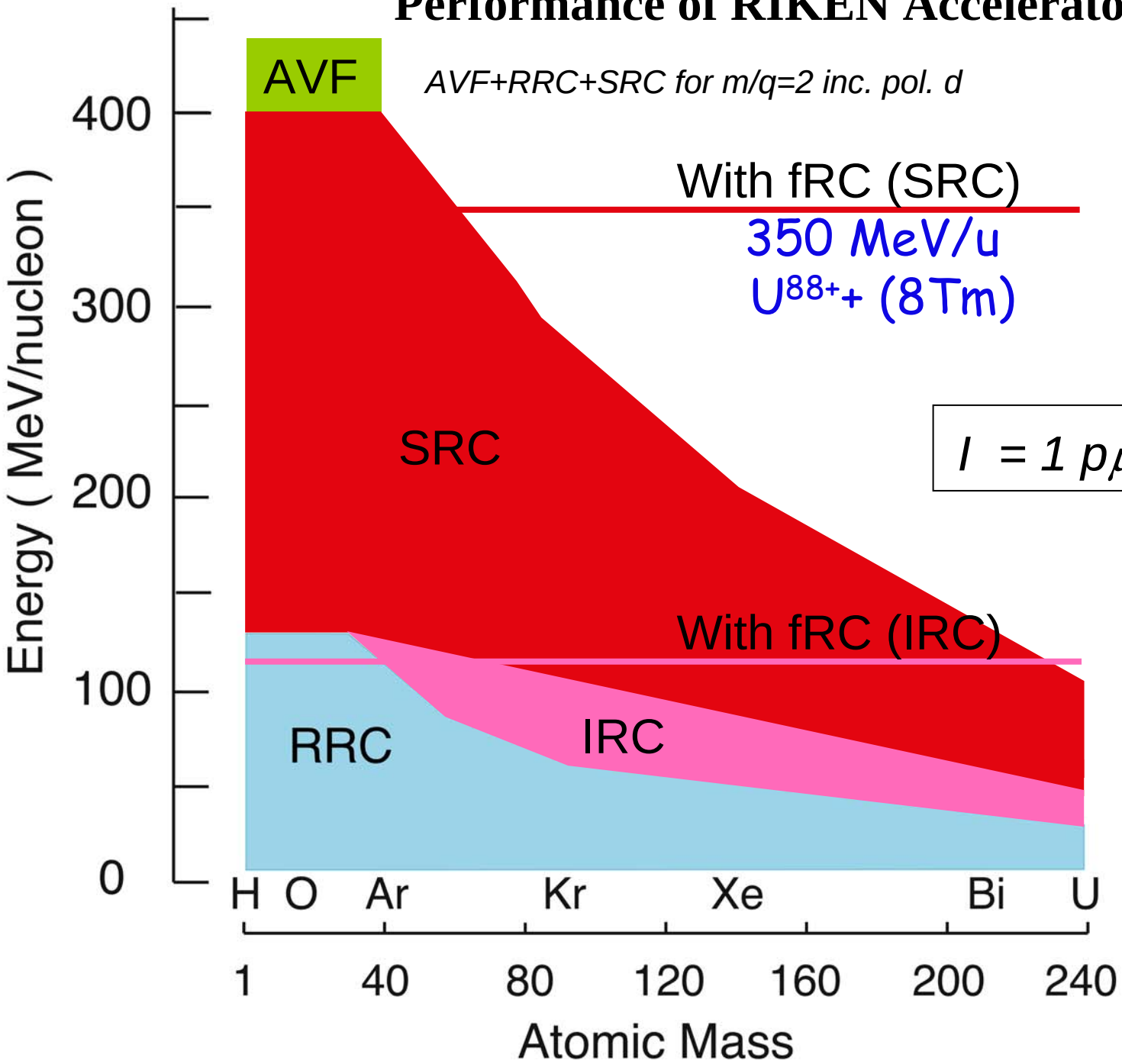
Light Exotic Nuclei such as ^{8}He, ^{11}Li :

Polarized/Aligned RI beams :

Slow RI beams : prototype setup of SLOWRI

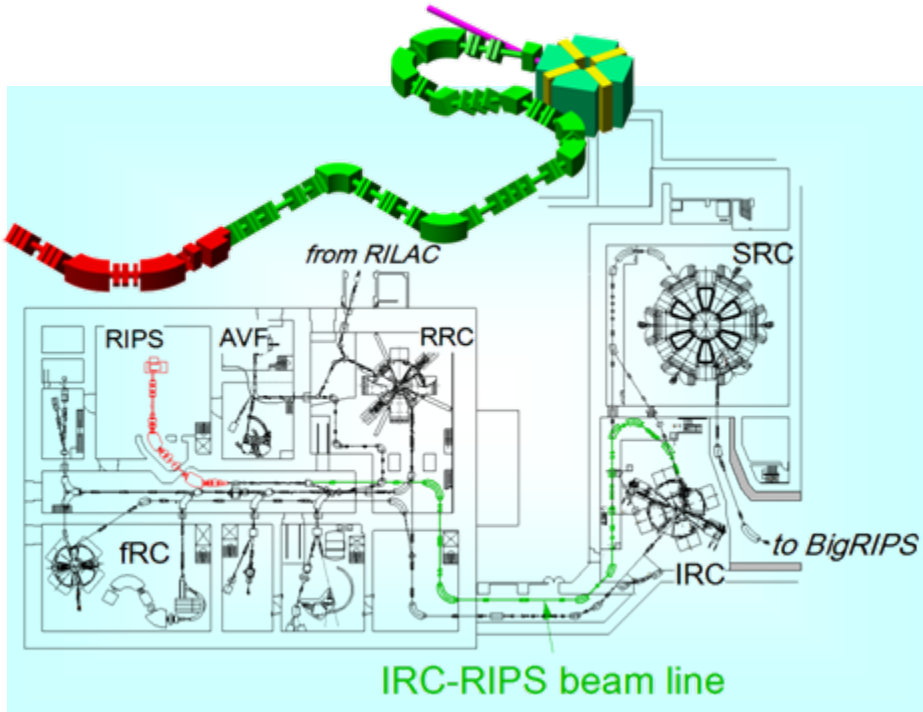
Nuclear Reactions at Low/Intermediate Energy

Performance of RIKEN Accelerator Complex



IRC-to-RIPS BT Line

Ueno et al.



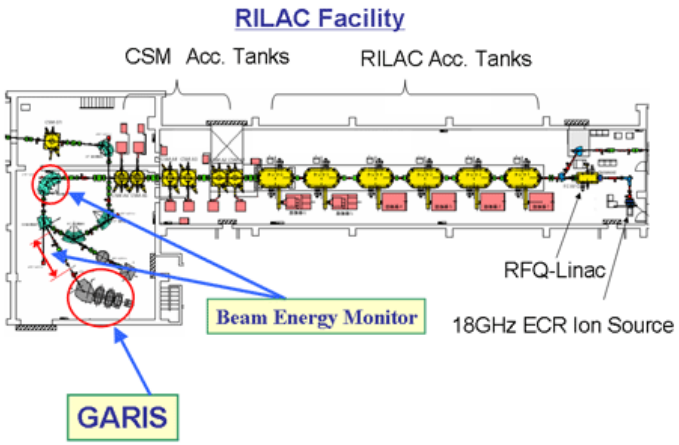
MultiUse of IRC beams

Beam sharing between
RIPS user and
BigRIPS user

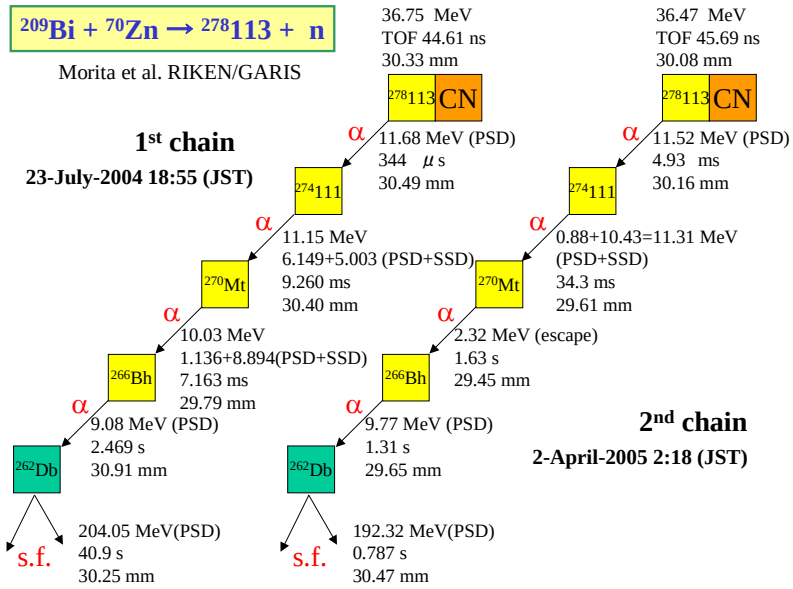
To be funded in 2010

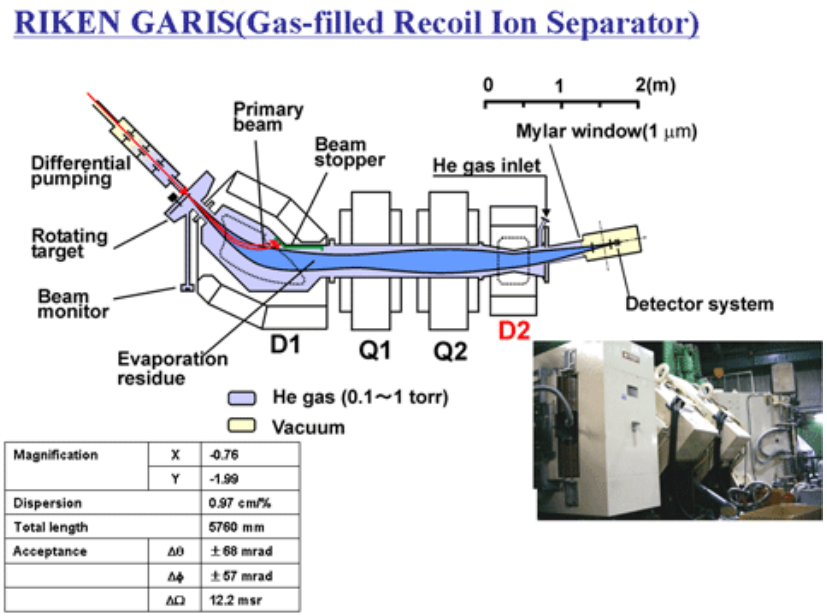
GARIS (gas-filled recoil ion separator)

Morita



113th elements





Magnification	X	-0.76
	Y	-1.99
Dispersion		0.97 cm/%
Total length		5760 mm
Acceptance	Δθ	± 68 mrad
	Δφ	± 57 mrad
	ΔΩ	12.2 msr

Grant-in-Aid

Cm-248 target (7mg 1M$)

new spectrometer GARIS-II

under construction

More MT in 2010 and later

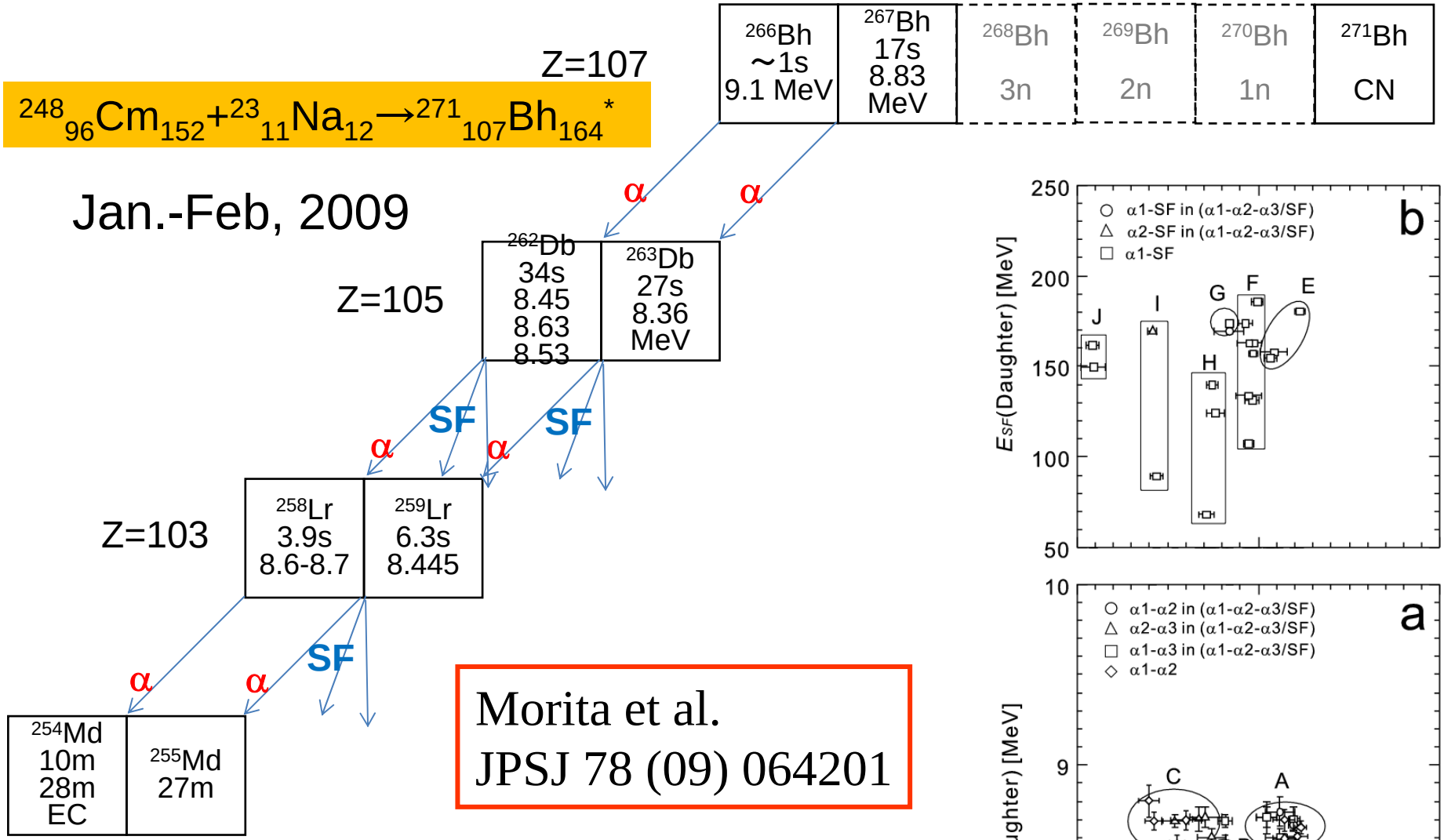
new RILAC-II dedicated for RIBF

300 days at GARIS

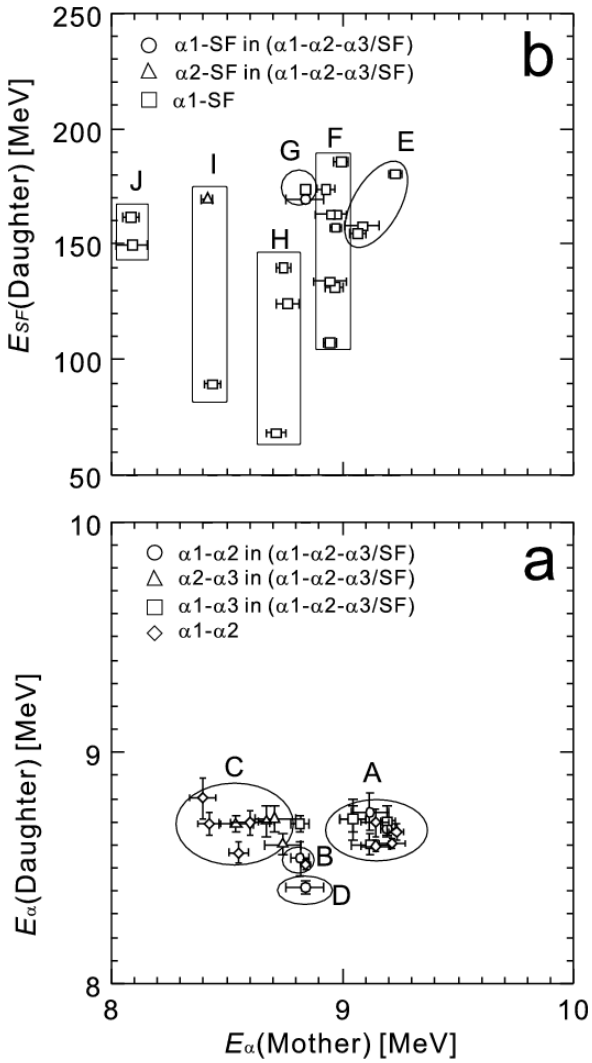
Decay Properties of 266Bh and 262Db Produced in the 248Cm + 23Na Reaction

$^{248}_{96}Cm_{152} + ^{23}_{11}Na_{12} \rightarrow ^{271}_{107}Bh_{164}^{*}$

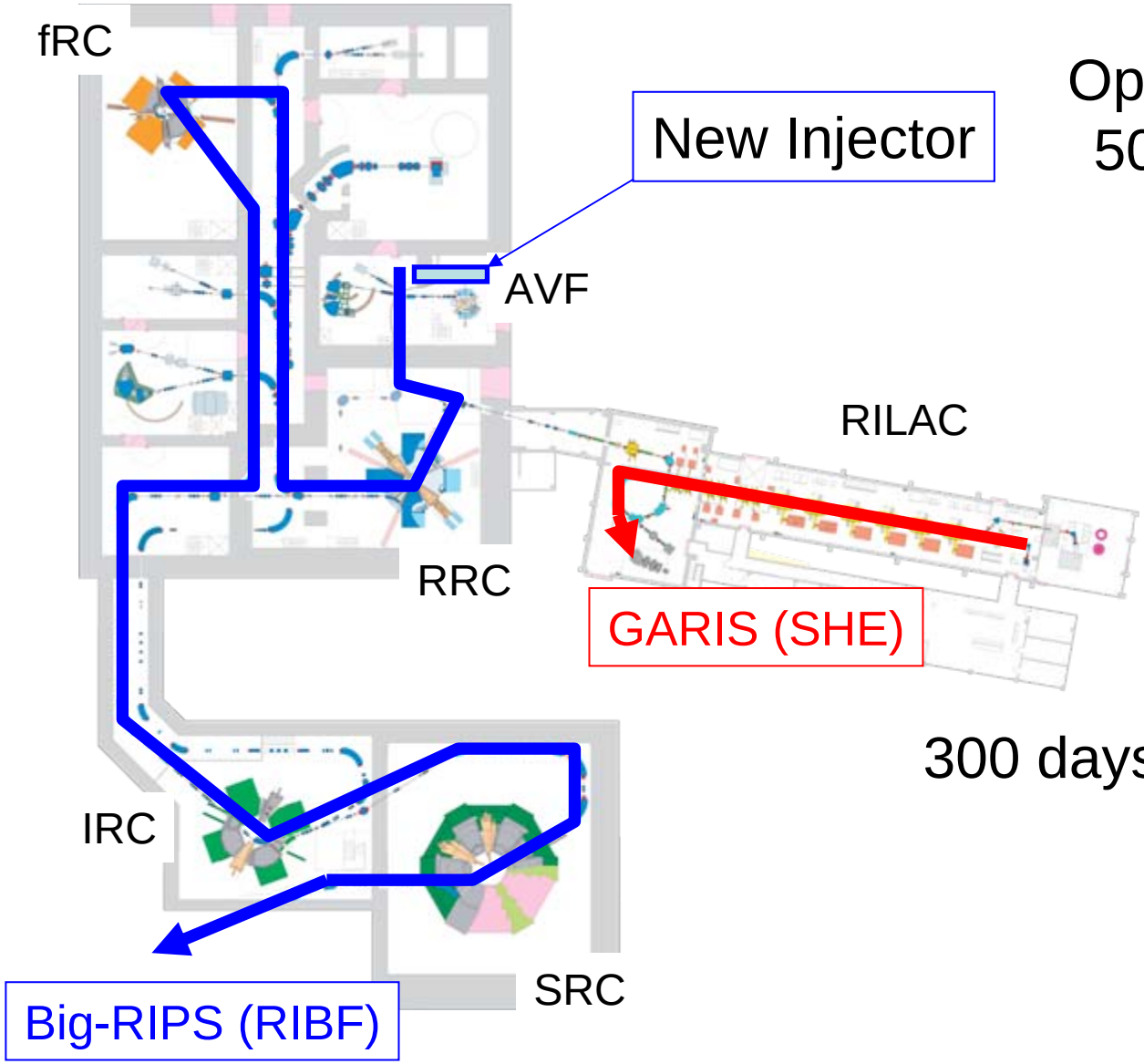
Jan.-Feb, 2009



Morita et al.
JPSJ 78 (09) 064201



Independent operation of RIBF and SHE research



Operational in 2010
50 - 100 pnA of U
for RIBF

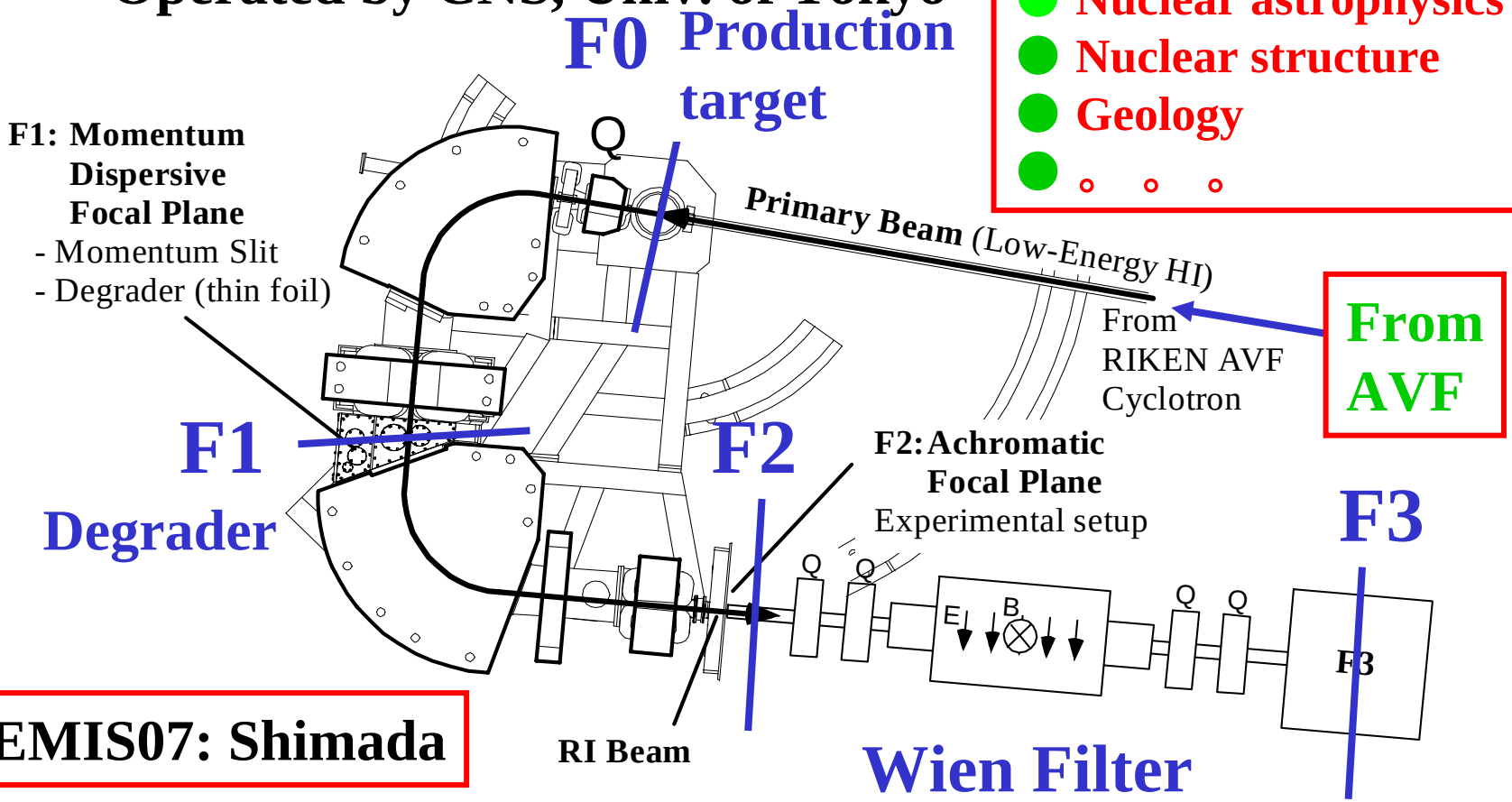
300 days per year for SHE

Low-energy in-flight RI beam separator CRIB

http://www.cns.s.u-tokyo.ac.jp/crib/crib-intro.html

Operated by CNS, Univ. of Tokyo

- Nuclear astrophysics
- Nuclear structure
- Geology
- ...



EMIS07: Shimada

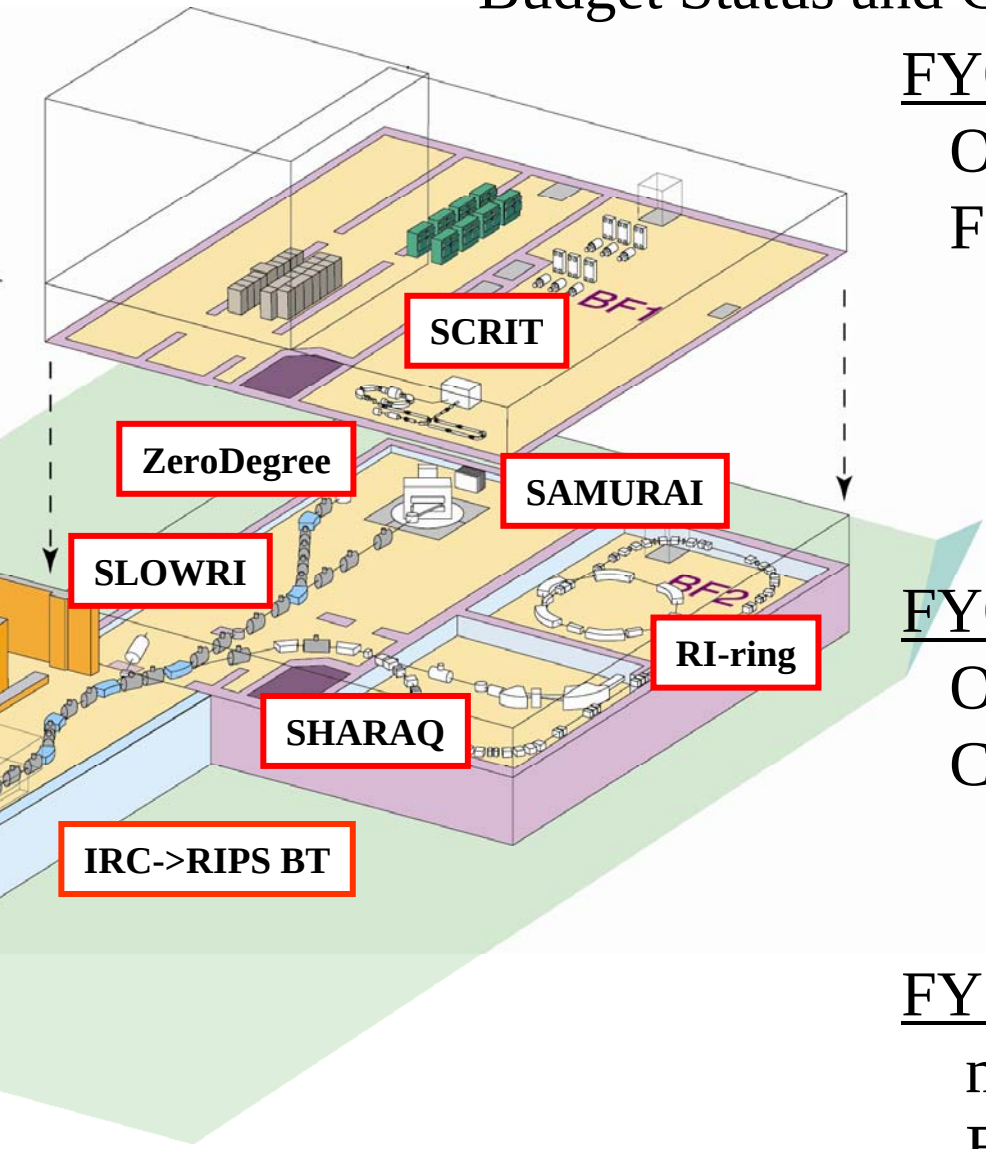
Low-E pol. RIBs

0 — 5 m

Yanagisawa, Kubono, et al: NIM A 539 74 (2005)

Collaborators;
Italy, Canada,Korea, Brazil, China, Vietnam, Hungary

Budget Status and Construction Plan



FY08

Operation for 5months

Facility Construction

SAMURAI (15M$ for FY08-11)

magnet, detectors

SHARAQ (high resolution)

BT line (2M$ for FY08)

FY09

Operation budget for 5.1 months

Construction budget for

SCRIT (e-RI)

a new injector linac (2010-)

FY10

more than 6 months operation

Budget for SLOWRI, IRC-RIPS BT

FY11

Budget for RI-ring

Beam intensities of 345 MeV/nucleon beams at RIBF

pnA

	^{48}Ca	Kr	Xe	^{238}U
Achieved FY2008	170 (Av. 100)	30 *1	-	0.4 (Av. 0.3)
Expected FY2009	200	30 *2	10	5 *3

*1: 1min *2: Limited by e04 CS *3: SC-ECR

MT plan in 2009 and 2010

2009 Oct. Xe commissioning up to SRC
Nov. U-238, Dec. Ca-48

2010 April O-18 (p2p), (ppn) experiment
May-June Ca-48 MUST2 campaign, etc.

Oct. Not decided yet.
Nov.-Dec. Xe/U with a new injector+
28GHz SC-ECR

2011 Jan-March Not decided yet.