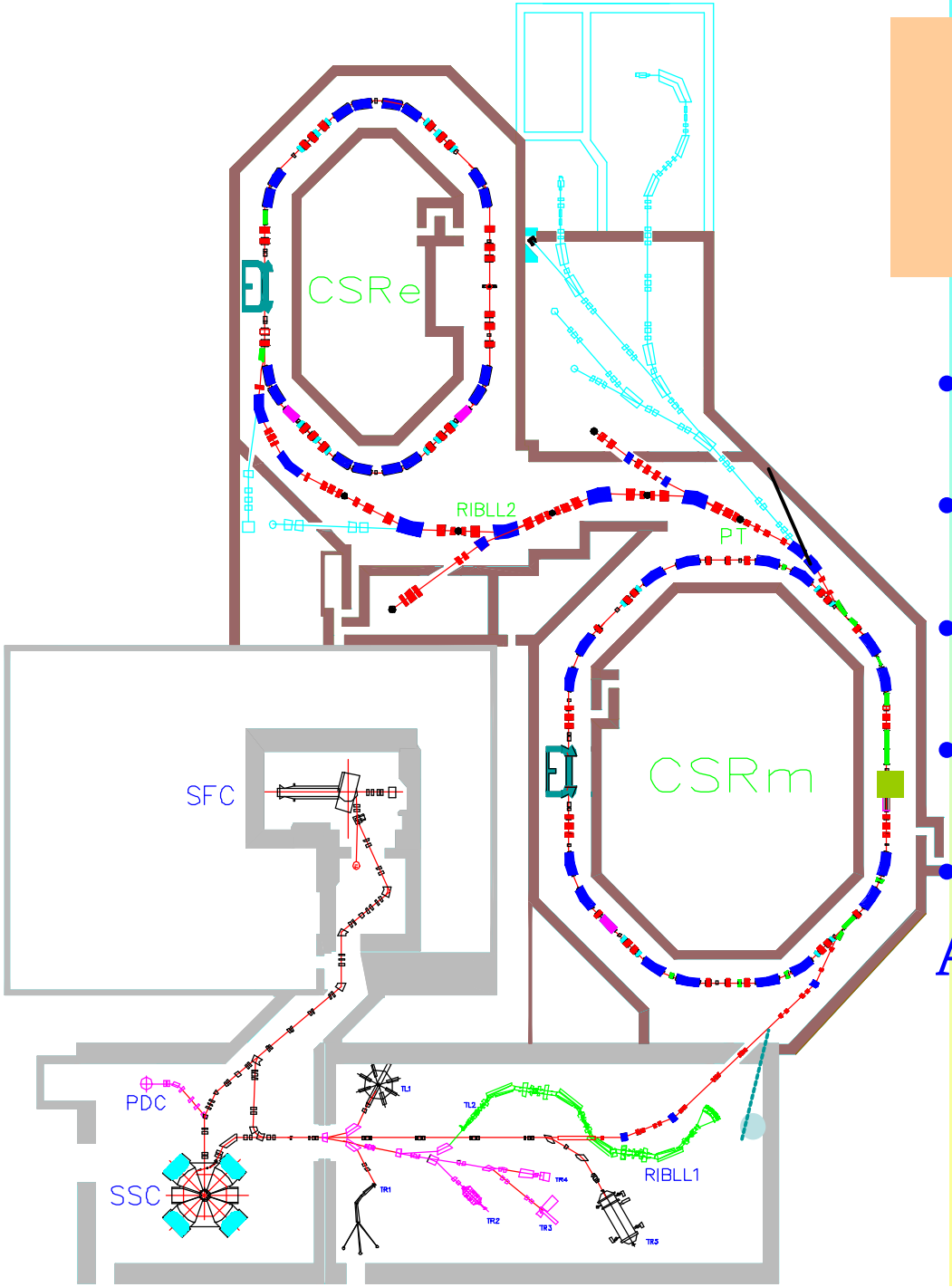
Heavy Element Research at IMP

(Institute of Modern Physics, CAS, Wenlong Zhan)

- Introduction
- Synthesis of ^{259}Db, ^{265}Bh
- Ongoing Upgrade Programs
- Future Development

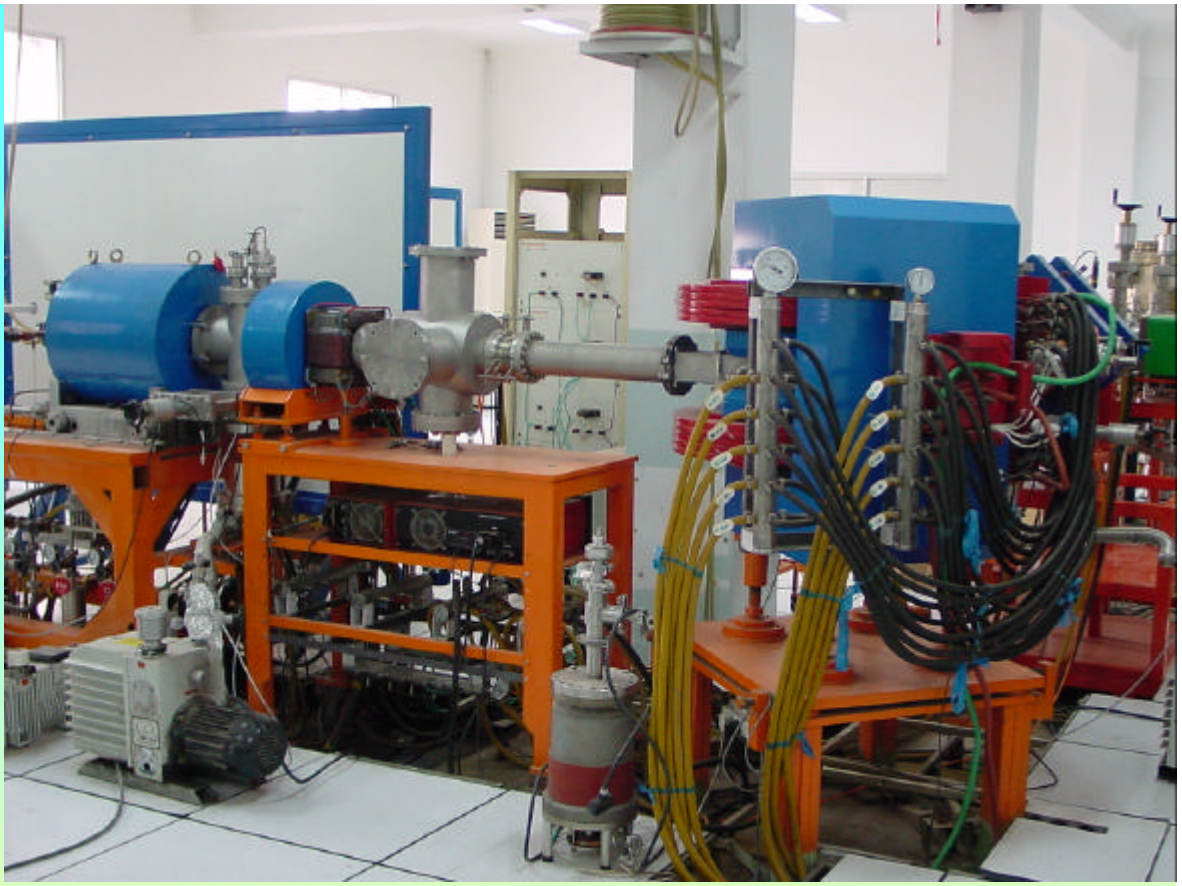
HIRFL Layout



- ECR Ion Source
- SFC K=69(72)
- SSC K=450
- CSRm Quasi-synchrotron
- CSRe High Sensitive & Accuracy Spectrometer

LECR3

RF : 14.5 GHz, 800-1000 W
Extract: f 8mm, 20-25kV
Slit: 10-15 mm
Faraday-cup: -150 V



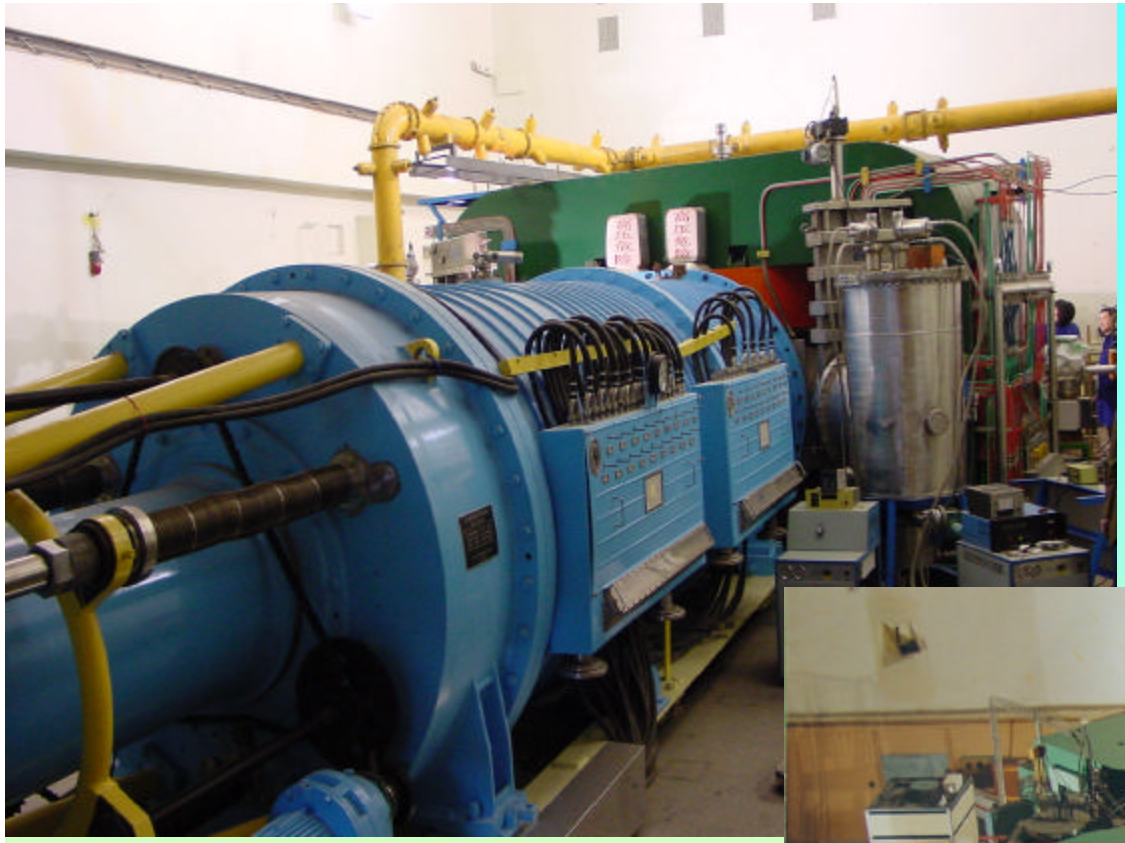
Ar^{11+} 240 eμ A , Ar^{14+} 30 eμ A

Ar^{11+} 325 eμ A at 18GHz

$^{129}Xe^{20+}$ 160 eμ A , Xe^{26+} 95 eμ A, Xe^{30+} 7 eμ A

Ni^{12+} **75 eμ A , Ni^{13+} 57 eμ A, Ni^{15+} 31 eμ A**

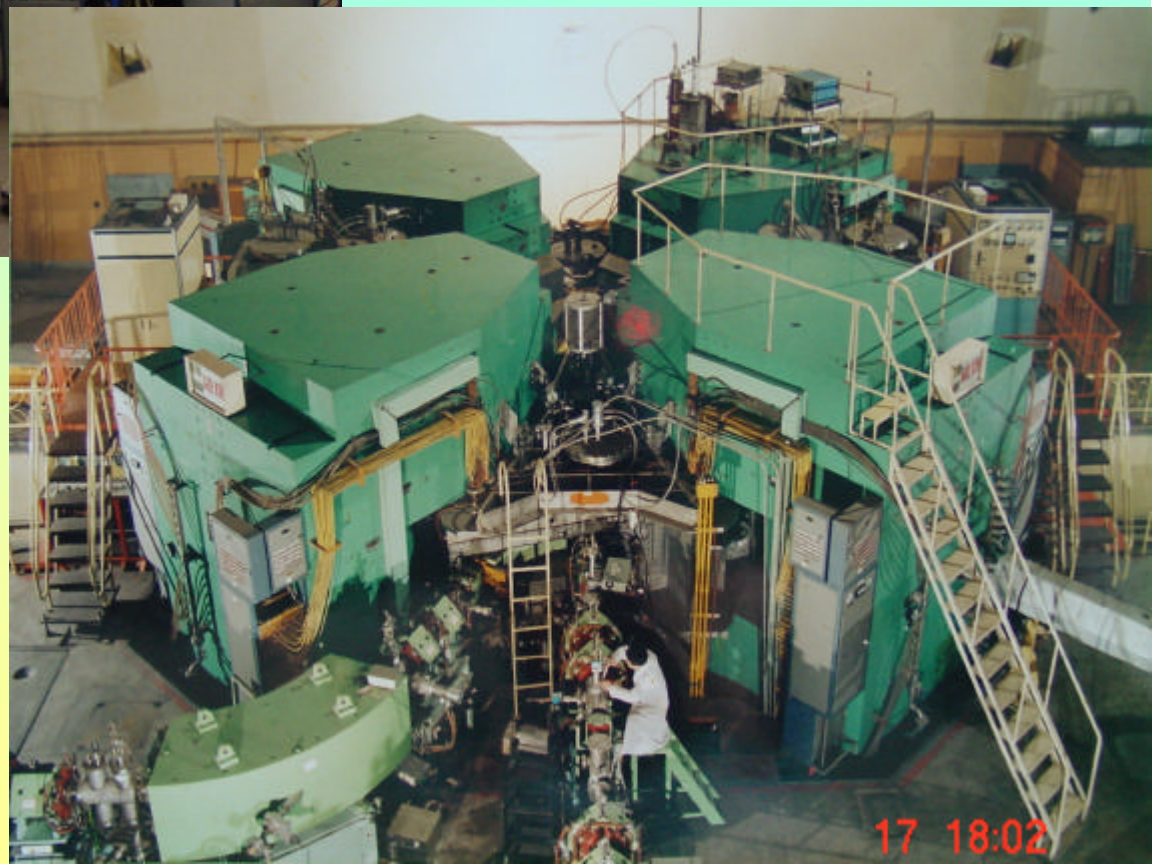
Fe^{11+} 210 **eμ A , Fe^{12+} 175 eμ A, Fe^{13+} 141 eμ A, Fe^{16+} 25 eμ A**



SFC & SSC

$K_{SSC} = 450$

$K_{SFC} = 72$



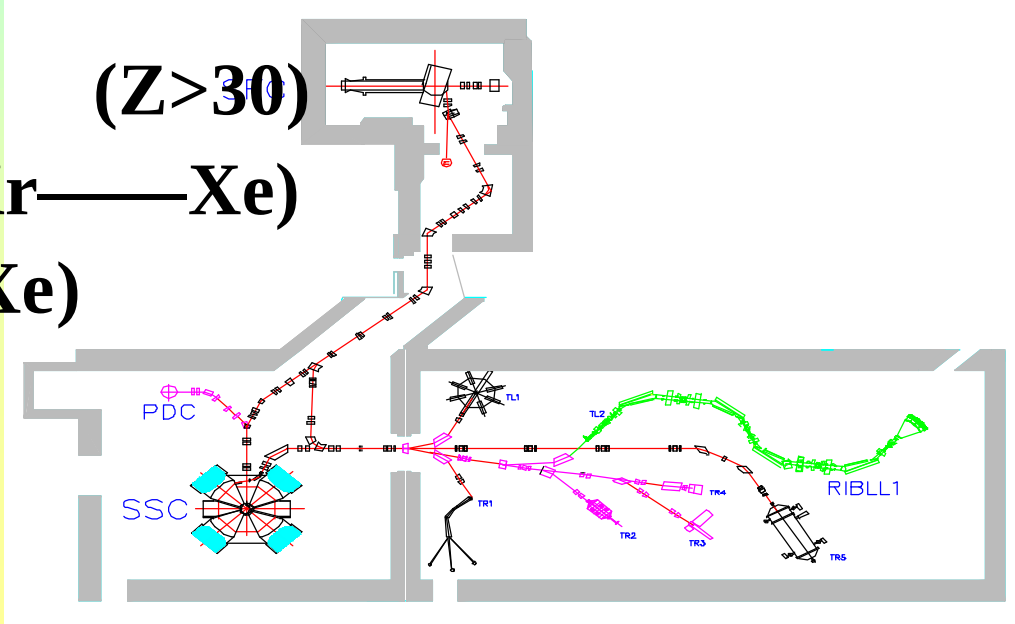
CSR Installation

Beam Intensity at HIRFL (E>5MeV/u)

- **SFC:** **(Z<30)**
  - **Intensity： ~3 ´10^{13}pps (C——Ne)**
  - **>5´10^{12}pps(Mg——Ar)**
  - **>1´10^{12}pps(Ca——*Zn)**

- **SFC+SSC:** **(Z>30)**
  - **Intensity： ~10^{11}pps(Kr——Xe)**
  - **~10^{10}pps(>Xe)**

  ***SECR**



23 New Isotopes

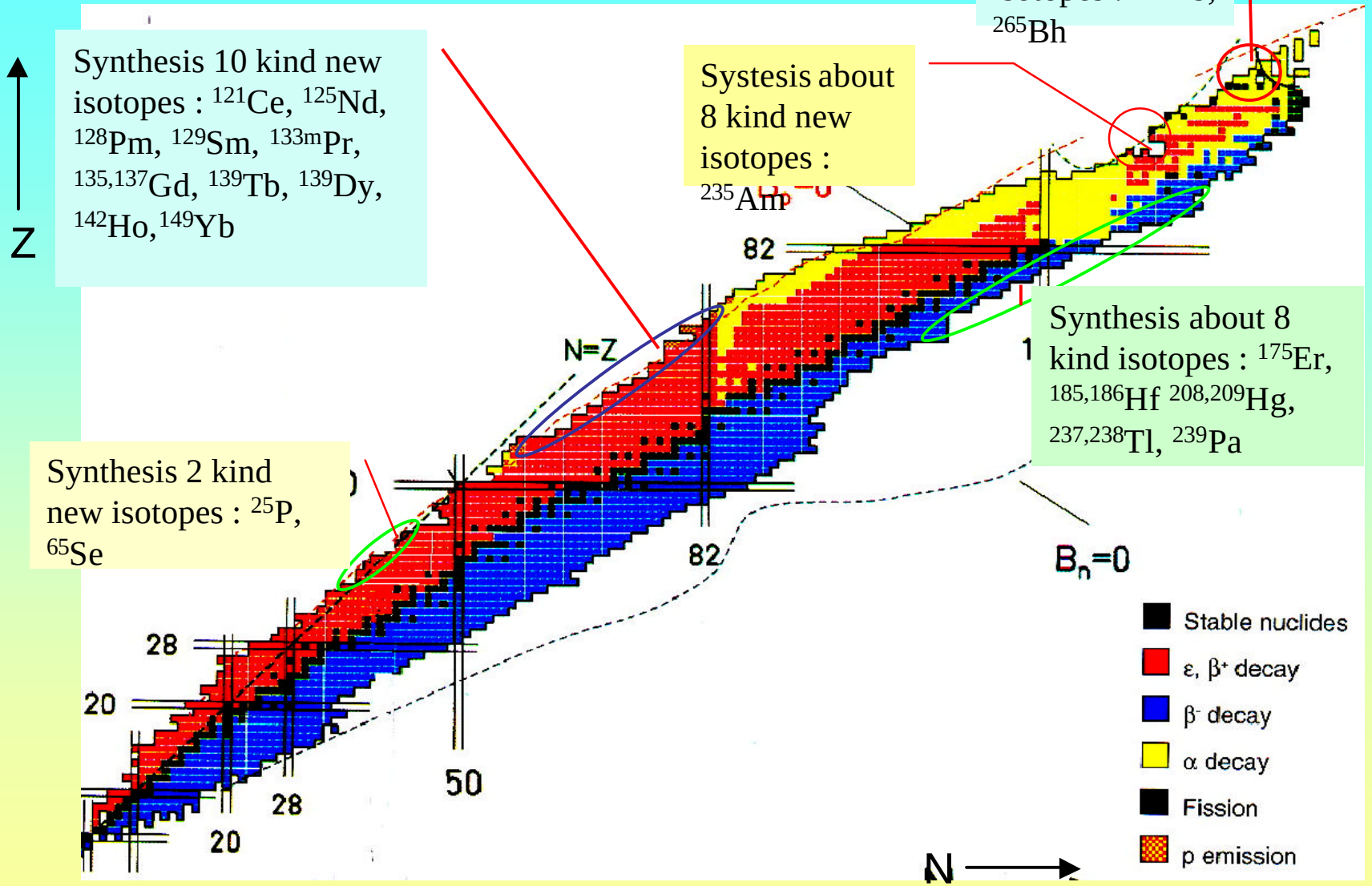
Synthesis 10 kind new isotopes : ^{121}Ce, ^{125}Nd, ^{128}Pm, ^{129}Sm, ^{133m}Pr, ^{135,137}Gd, ^{139}Tb, ^{139}Dy, ^{142}Ho,^{149}Yb

Systesis about 8 kind new isotopes : ^{235}Am

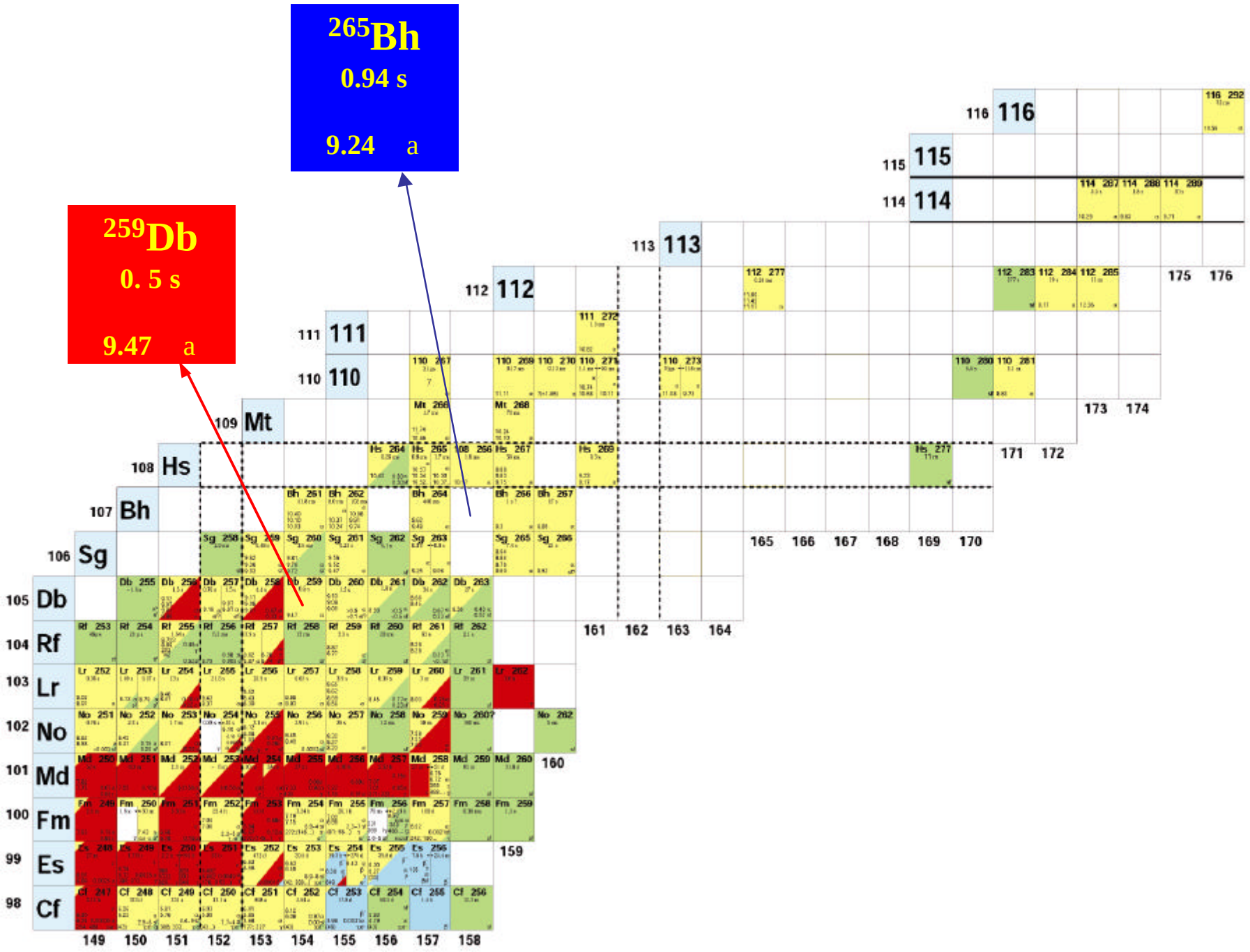
Synthesis 2 kind of heavy isotopes : ^{259}Db, ^{265}Bh

Synthesis about 8 kind isotopes : ^{175}Er, ^{185,186}Hf ^{208,209}Hg, ^{237,238}Tl, ^{239}Pa

Synthesis 2 kind new isotopes : ^{25}P, ^{65}Se

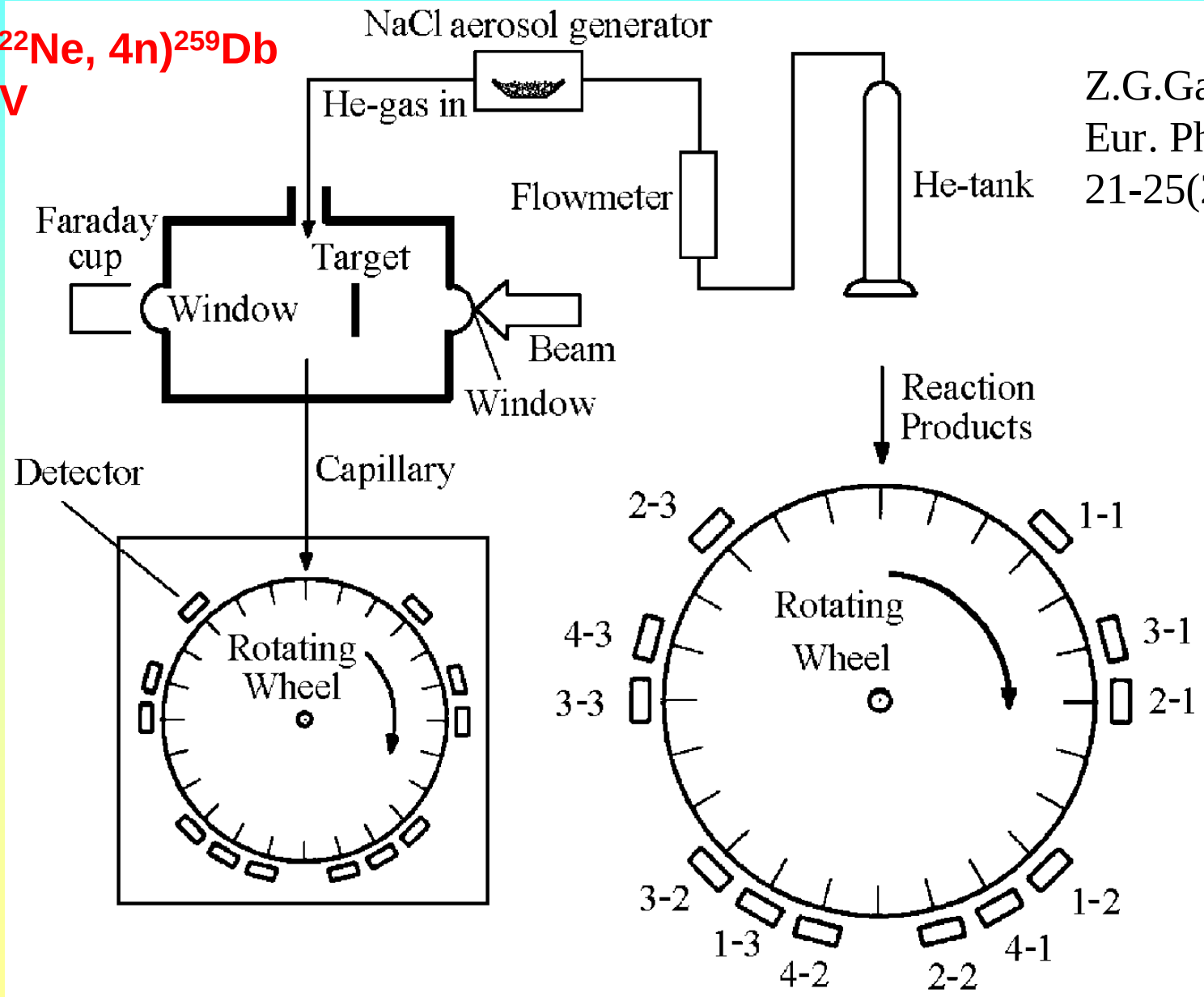


IMP, CAS synthesis about 23 new isotopes from 1993.


^{265}Bh
0.94 s
9.24 a
^{259}Db
0. 5 s
9.47 a
116 116
115 115
114 114
113 113
112 112
111 111
110 110
109 Mt
108 Hs
107 Bh
106 Sg
105 Db
104 Rf
103 Lr
102 No
101 Md
100 Fm
99 Es
98 Cf
149 150 151 152 153 154 155 156 157 158
159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176

Experimental Setup for ^{259}Db

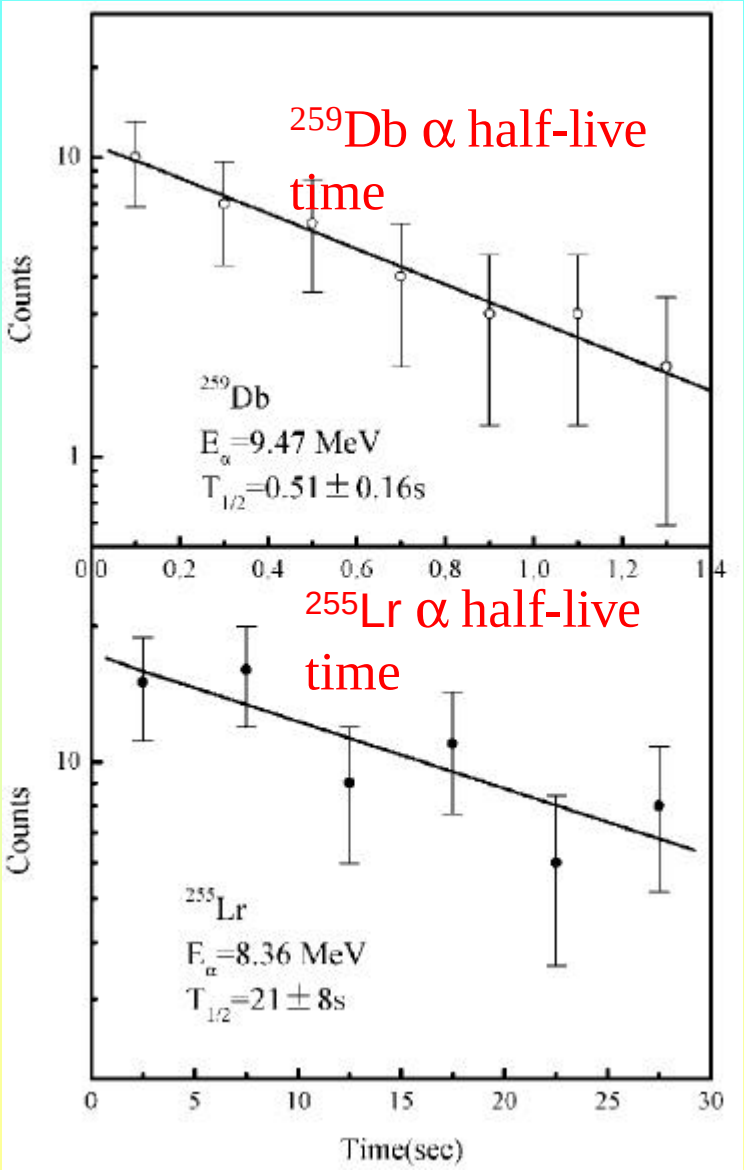
^{241}Am(^{22}Ne, 4n)^{259}Db
118MeV

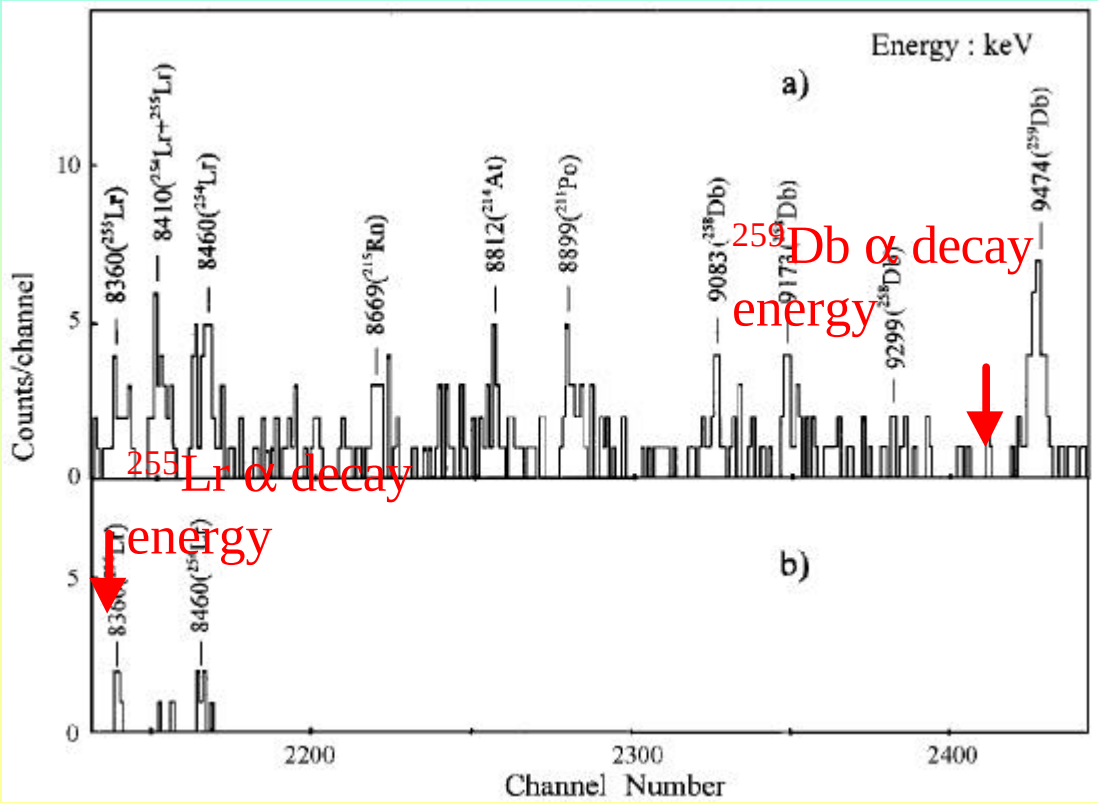


Z.G.Gan, et. at, Eur. Phys. J. 10, 21-25(2001)

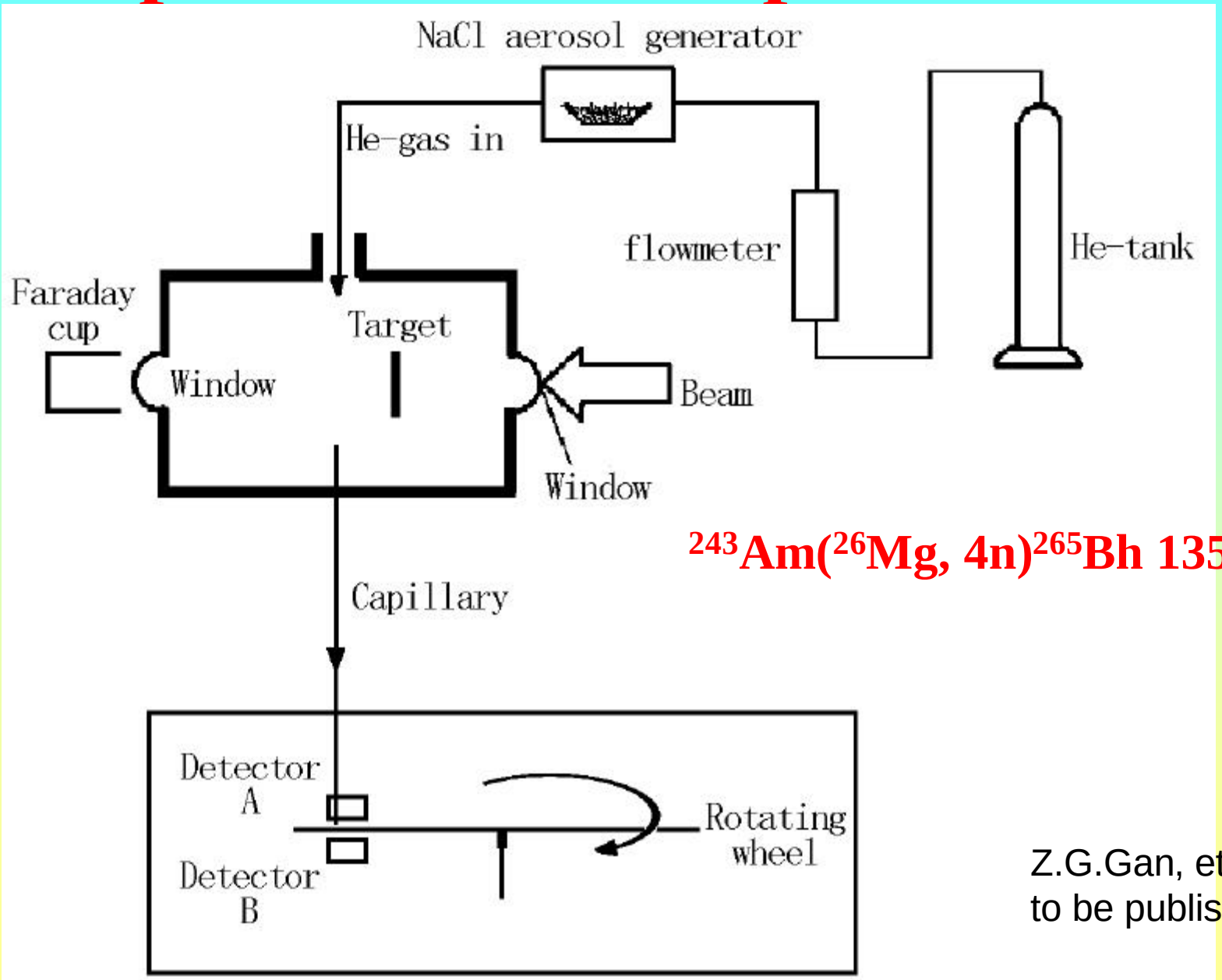
a Decay Chain

^{259}Db ¾ a (9.47 MeV) ® ^{255}Lr ® a (8.36MeV)



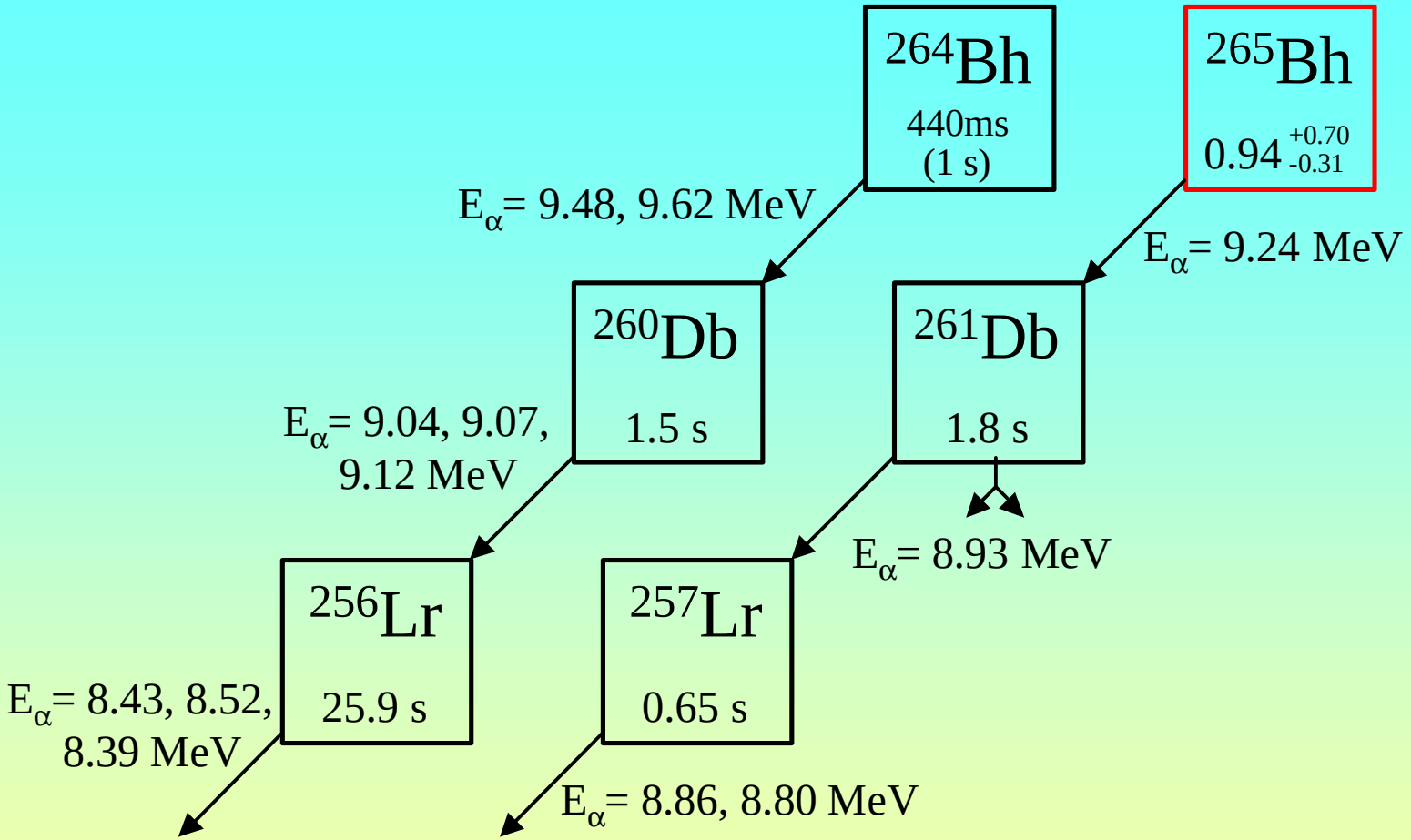


Experimental Setup for ^{265}Bh



^{243}Am(^{26}Mg, 4n)^{265}Bh 135MeV

Z.G.Gan, et. at,
to be published)



^{265}Bh,^{264}Bh decay chain? Measurement : ^{265}Bh

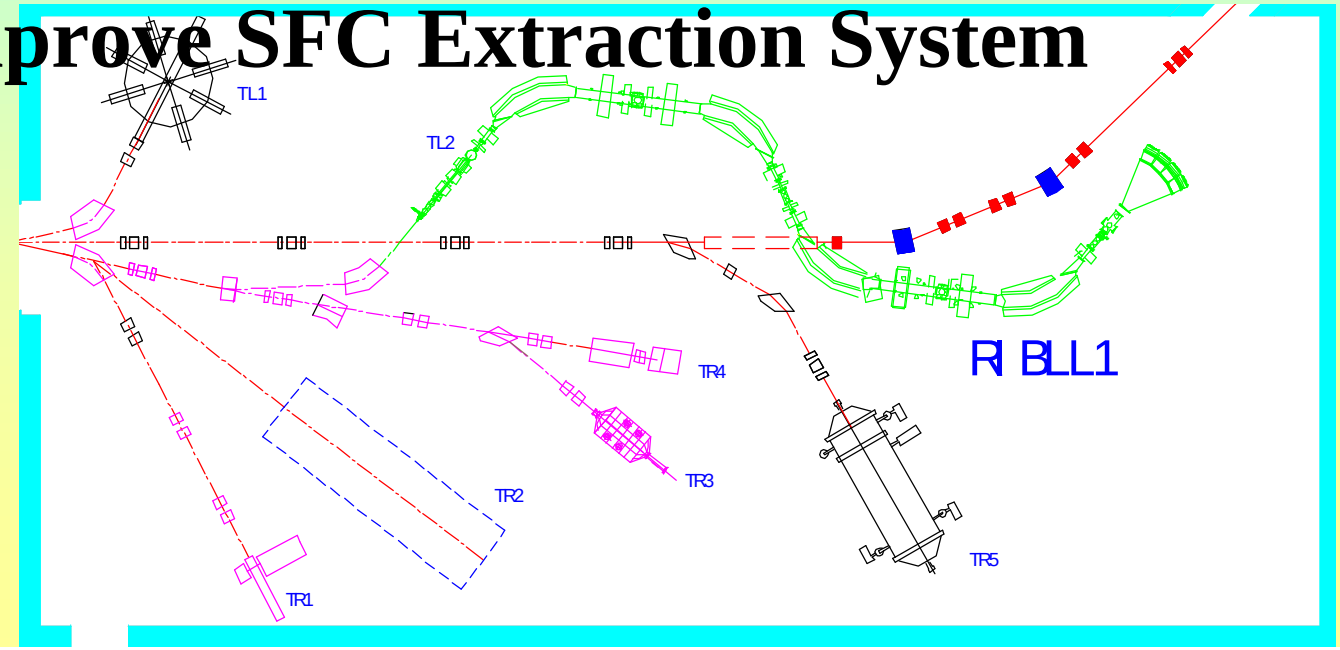
$T_{1/2}$= 0.94 sec., a decay energy E_a= 9.24 MeV.

a Decay Energy & Life Time in Reaction of $^{26}Mg + {}^{243}Am \rightarrow {}^{265}Bh + 4n$

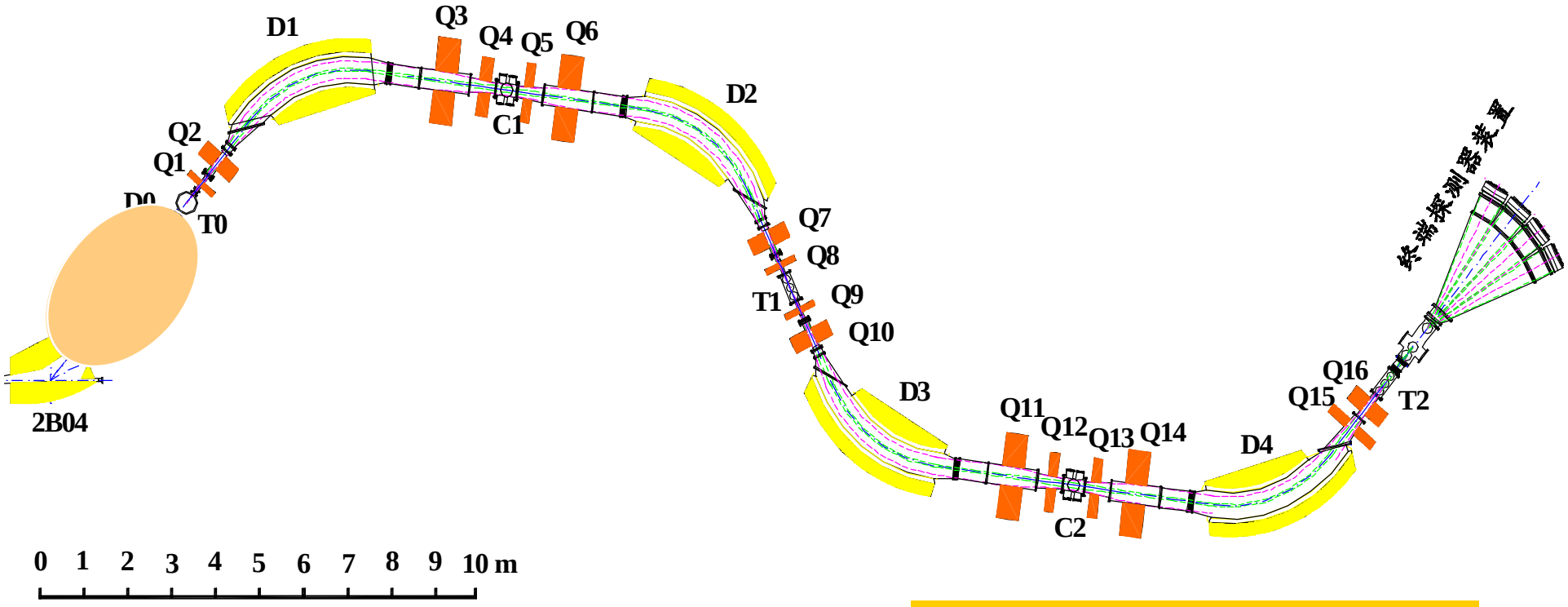
Parent	a_1 / KeV	t_1 / ms	Isotope	a_2 / KeV	t_2 / ms	Isotope	a_3 / KeV	t_3 / ms
^{265}Bh	9268	1736	^{261}Db	9006	4860			
^{265}Bh	9300	1015	^{261}Db	8924	224	^{257}Lr	8905	4639
^{265}Bh	9219	574	^{261}Db	8921	1898	^{257}Lr	8887	1405
^{265}Bh	9274	193	^{261}Db	8918	5834			
^{265}Bh	9222	1140	^{261}Db	8942	436			
^{265}Bh	9179	1933	^{261}Db	8902	1523			
^{265}Bh	9245	2547	^{261}Db	8869	1608			
^{265}Bh	9199	1334	^{261}Db	8927	3480			
^{264}Bh	9440	555	^{260}Db	8988	2686			
^{264}Bh	9501	2770	^{260}Db	9085	1378			
^{264}Bh	9524	1203	^{260}Db	9003	259			
^{264}Bh	9481	2321	^{260}Db	9098	975			

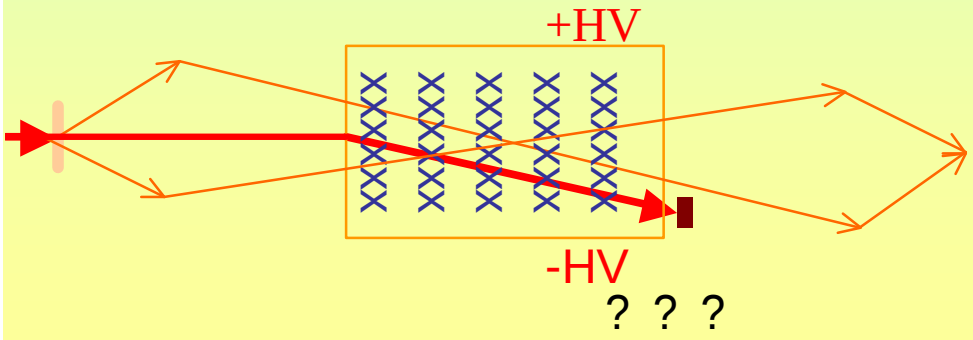
Ongoing Upgrade Programs

- **RIBLL Upgrade for SHE (5.2004)**
- **Superconductor ECR Ion Source (12/2004)**
- **Pulsed Ti:Sa Laser System (12/2004)**
- **New SHE Spectrometer (with Laser RIS) (12/2005)**
- **Improve SFC Extraction System**



RIBLL Upgrade for SHE

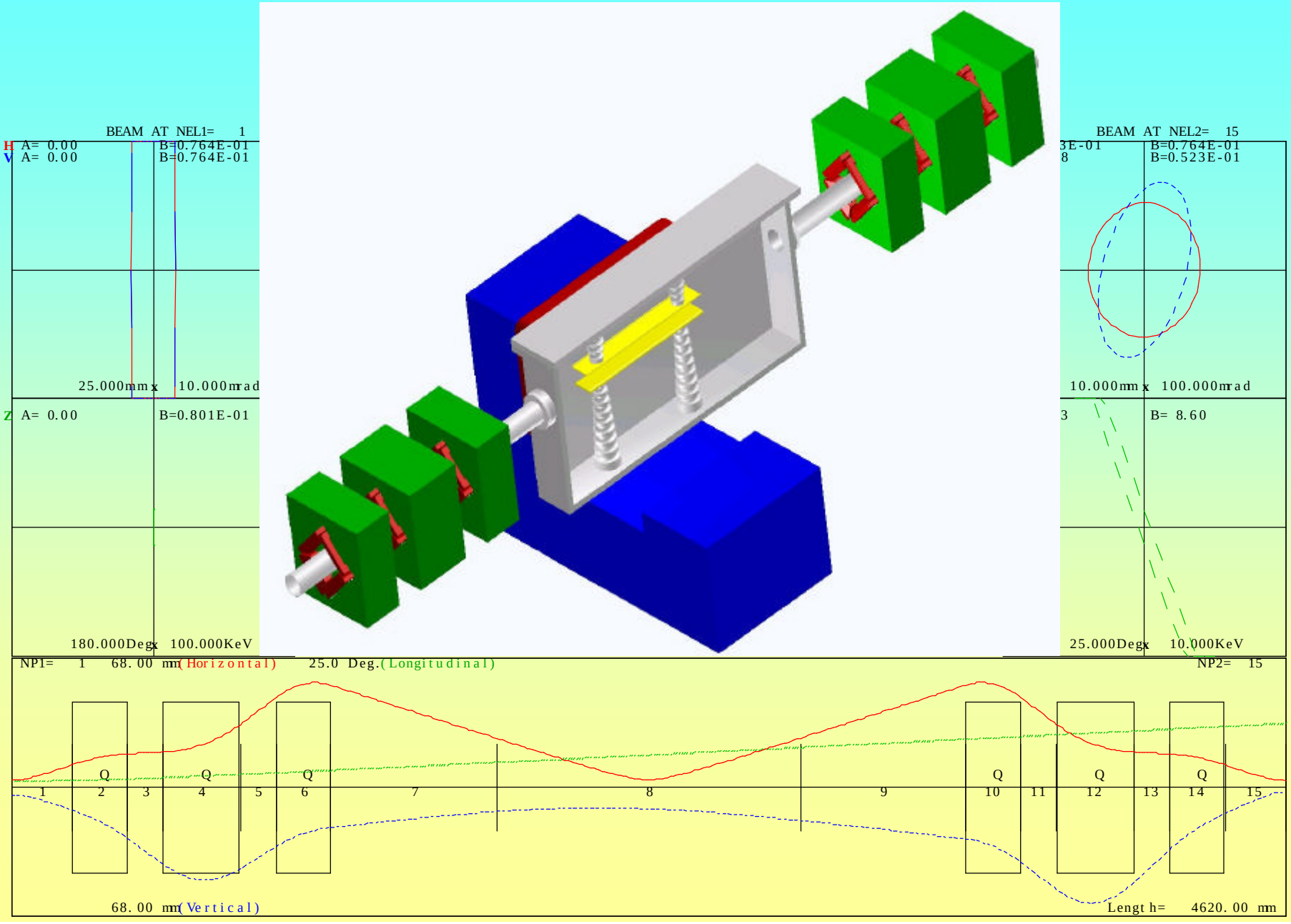




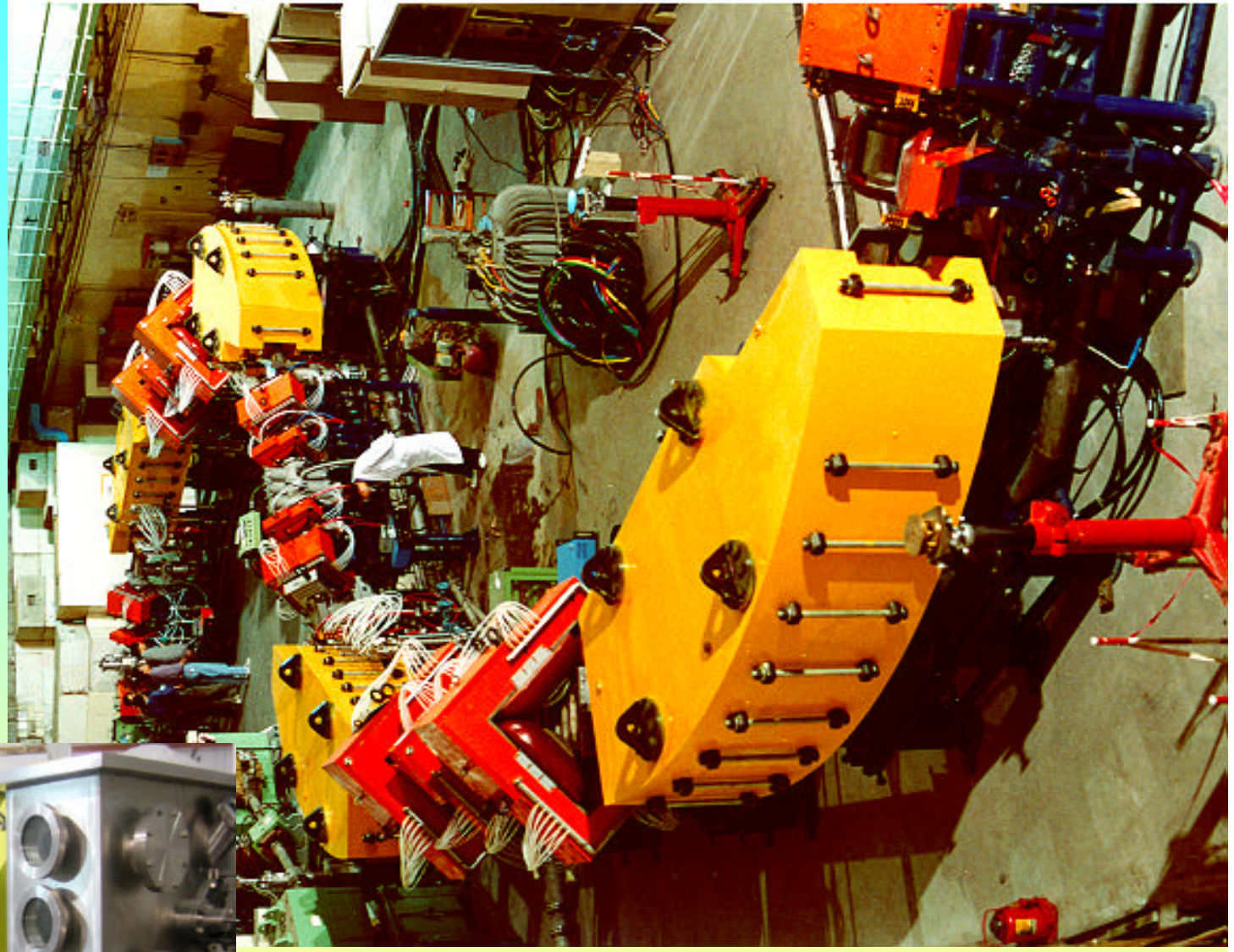
Main Parameters

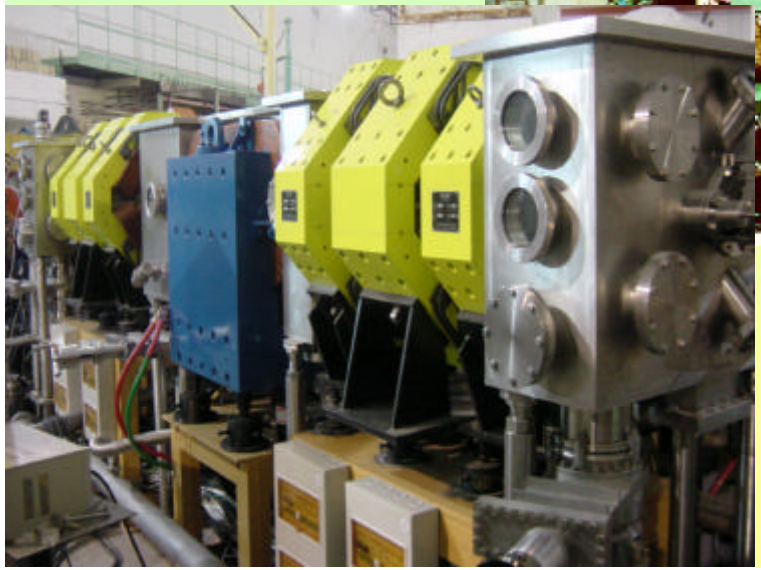
	RIBLL	SHIP
DW	>7msr	~1.7msr
DP/P	~10%	~10%
Brmax	~4.2Tm	~1.2Tm
A/ DA	~300	~300

Wien Filter at RIBLL



RIBLL Upgrade





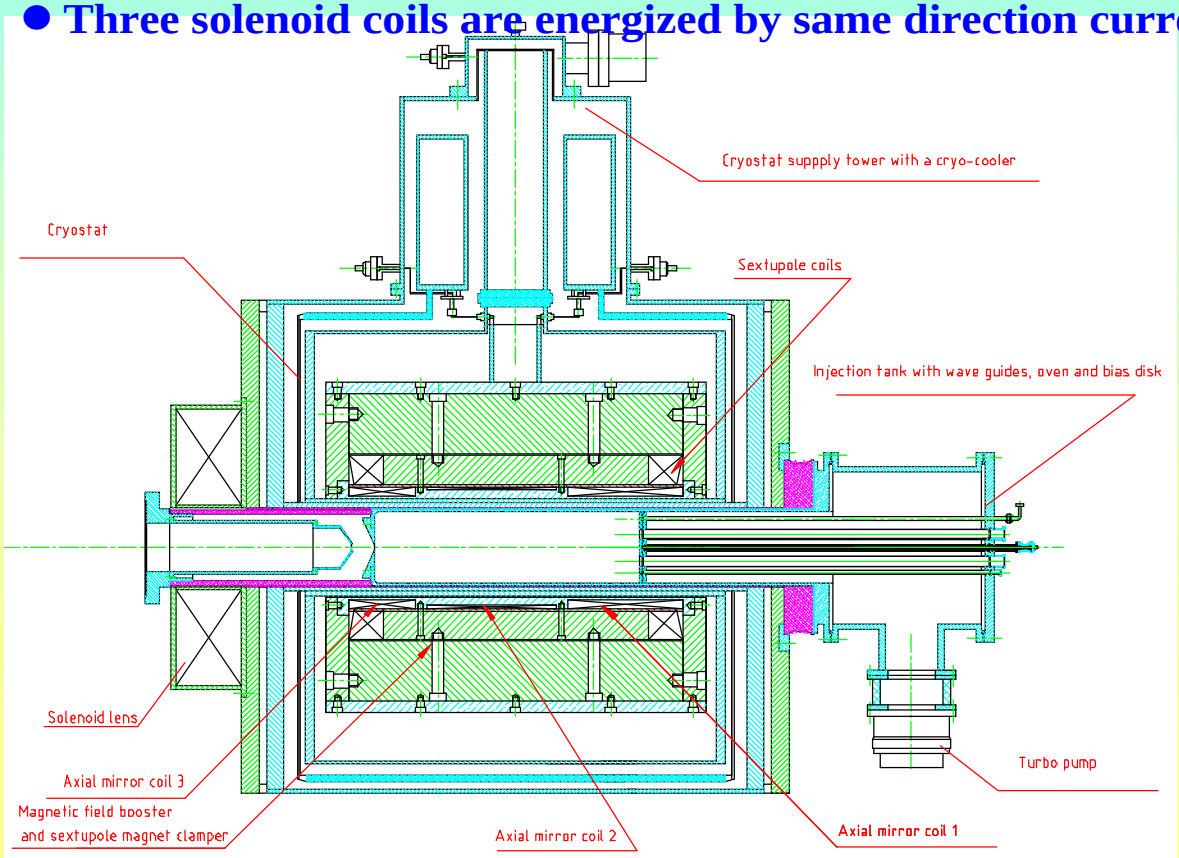
Unique Features of SECRAL

- **Axial solenoid coils are located inside of Sextupole**
  - ⇨ Decrease interaction force
    The Ion source more compact
    Reduce the stored energy
    Reduce stray field
- **Cold iron structure as field booster and clamp**
- **Sextupole with curved saddle-shaped coils**
  - ⇨ More convenient for clamp of the coils
- **Three solenoid coils are energized by same direction current**

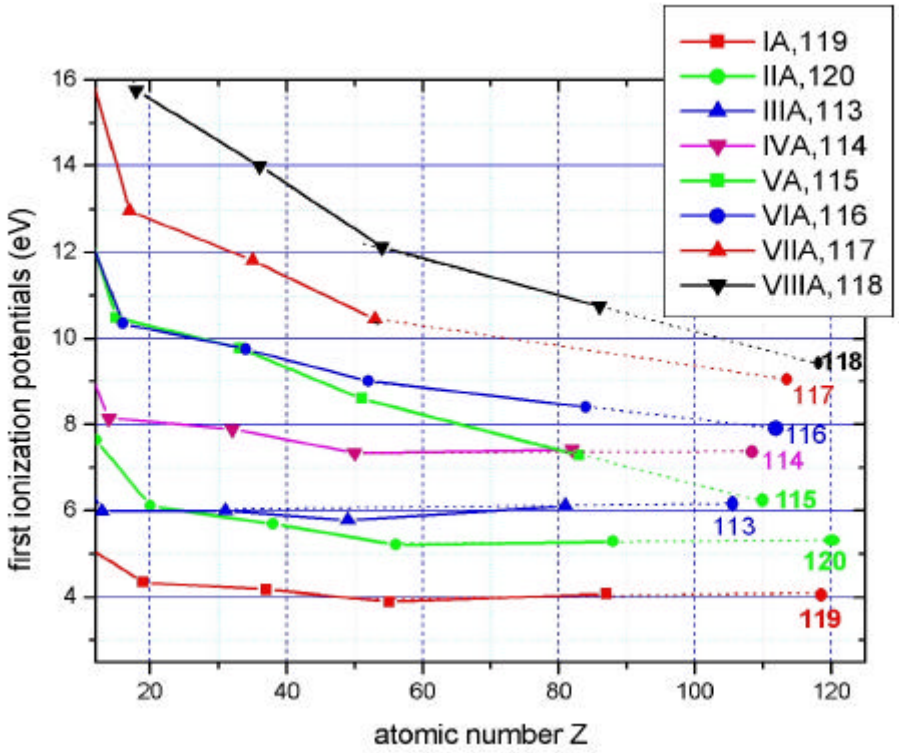
$^{64}Ni^{17+}$ 50mA

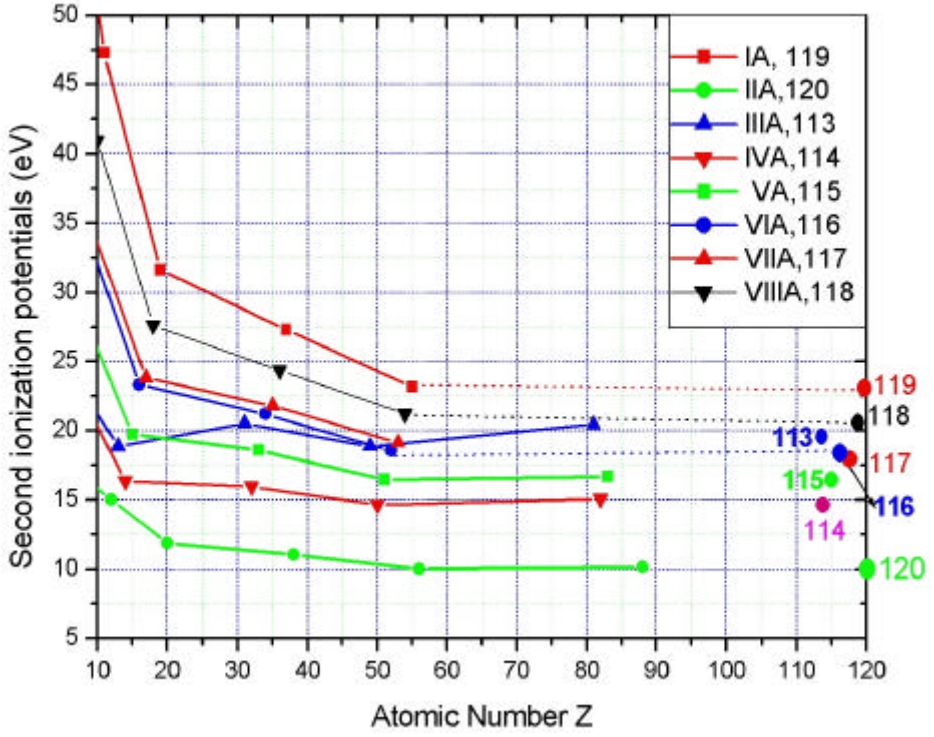
$^{86}Kr^{25+}$ 50mA

$^{132}Xe^{30+}$ 50mA



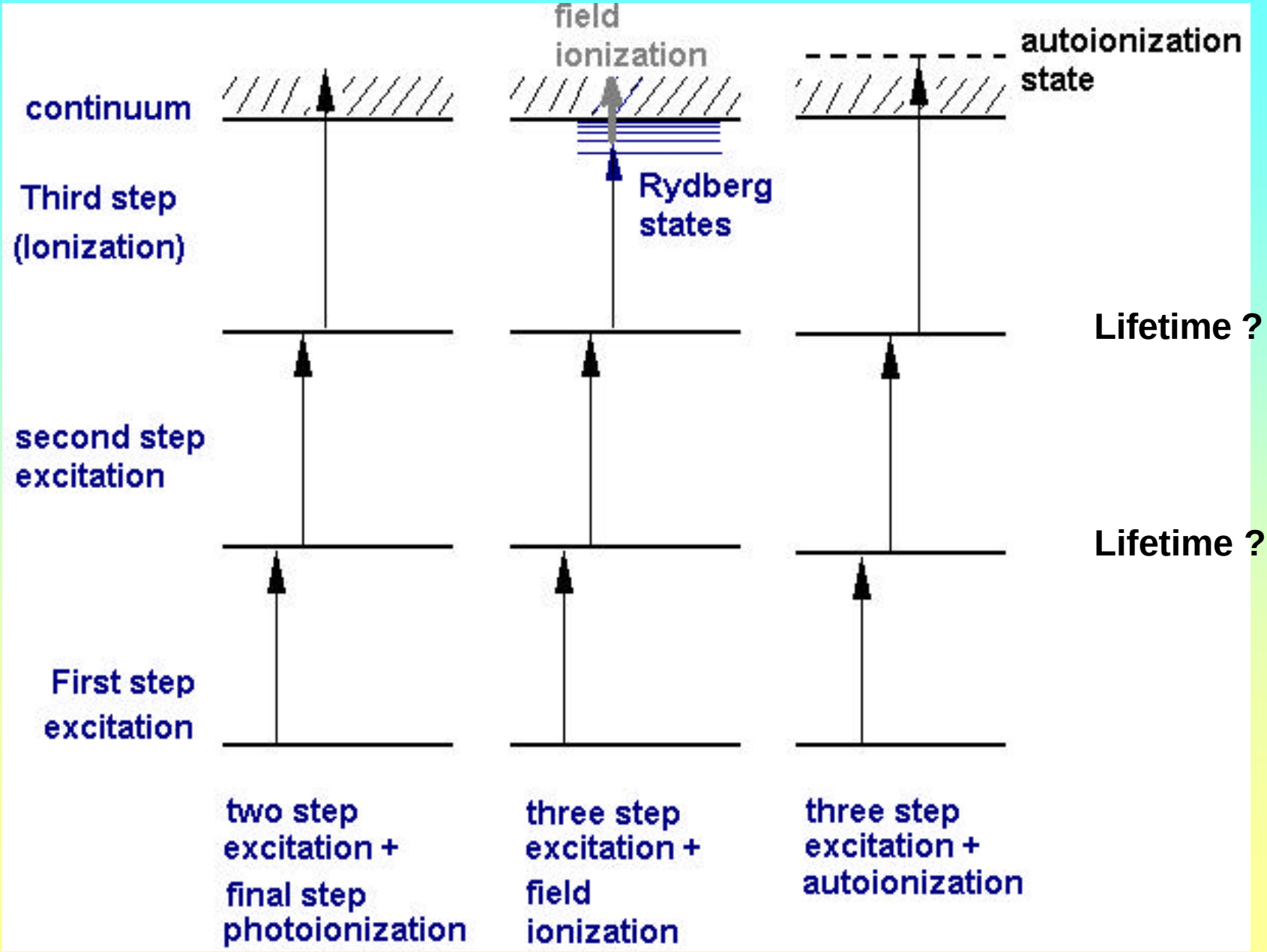
Identification Z by RIS ?





1st and 2nd Ionization Potential

Possible Excitation & Ionization RIS

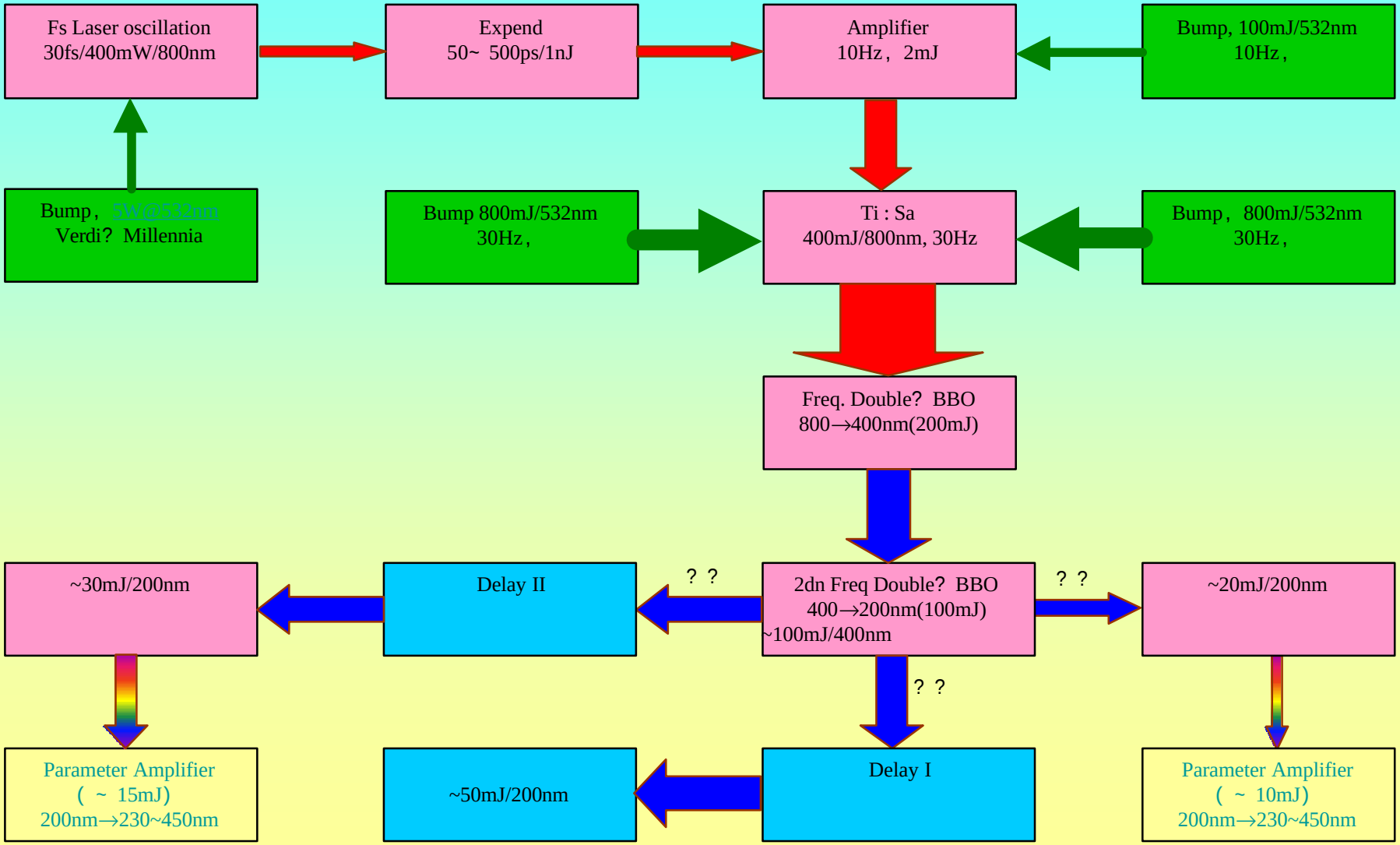


Key Point of Identify Z by RIS

- Strong Laser with $10^{15\text{-}17}$/p for excitation cross section about $10^{-15\text{--}17}/cm^2$
- Maintain SHE in a small location → RFQ
- Precise excitation level → QED Calc.
- Half-lives of excitation state
- 1sr or/both 2nd ionization
- Laser photo energy > 6eV ?

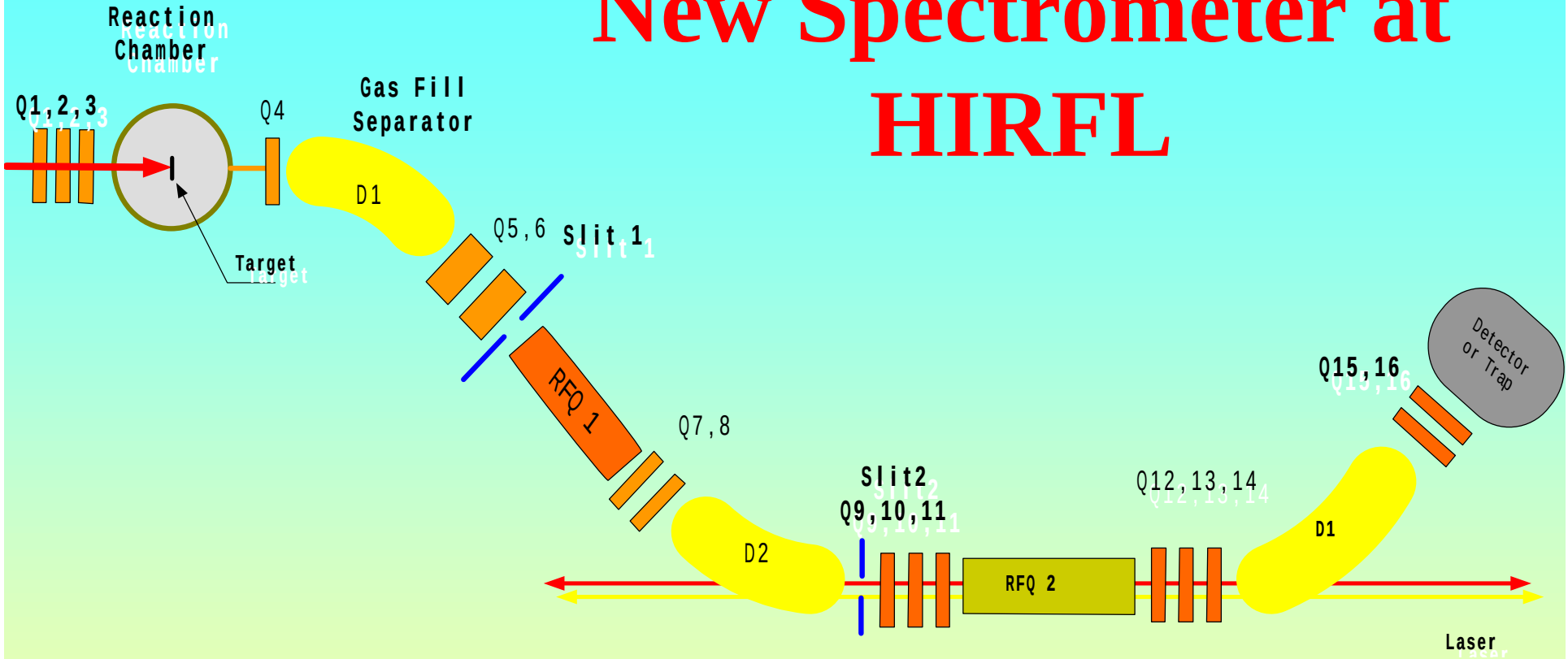
Pulsed Ti:Sa Laser System

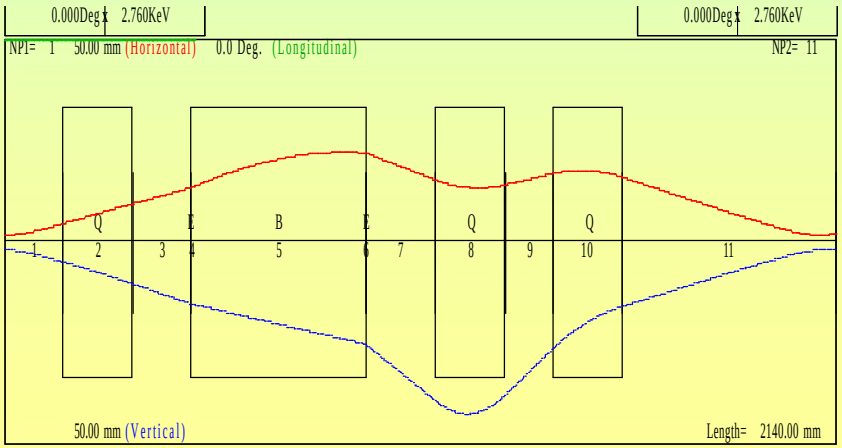
(Tunnable pulse width >50ps & >10ps between each pulse)



Pulsed Laser Assemble

New Spectrometer at HIRFL

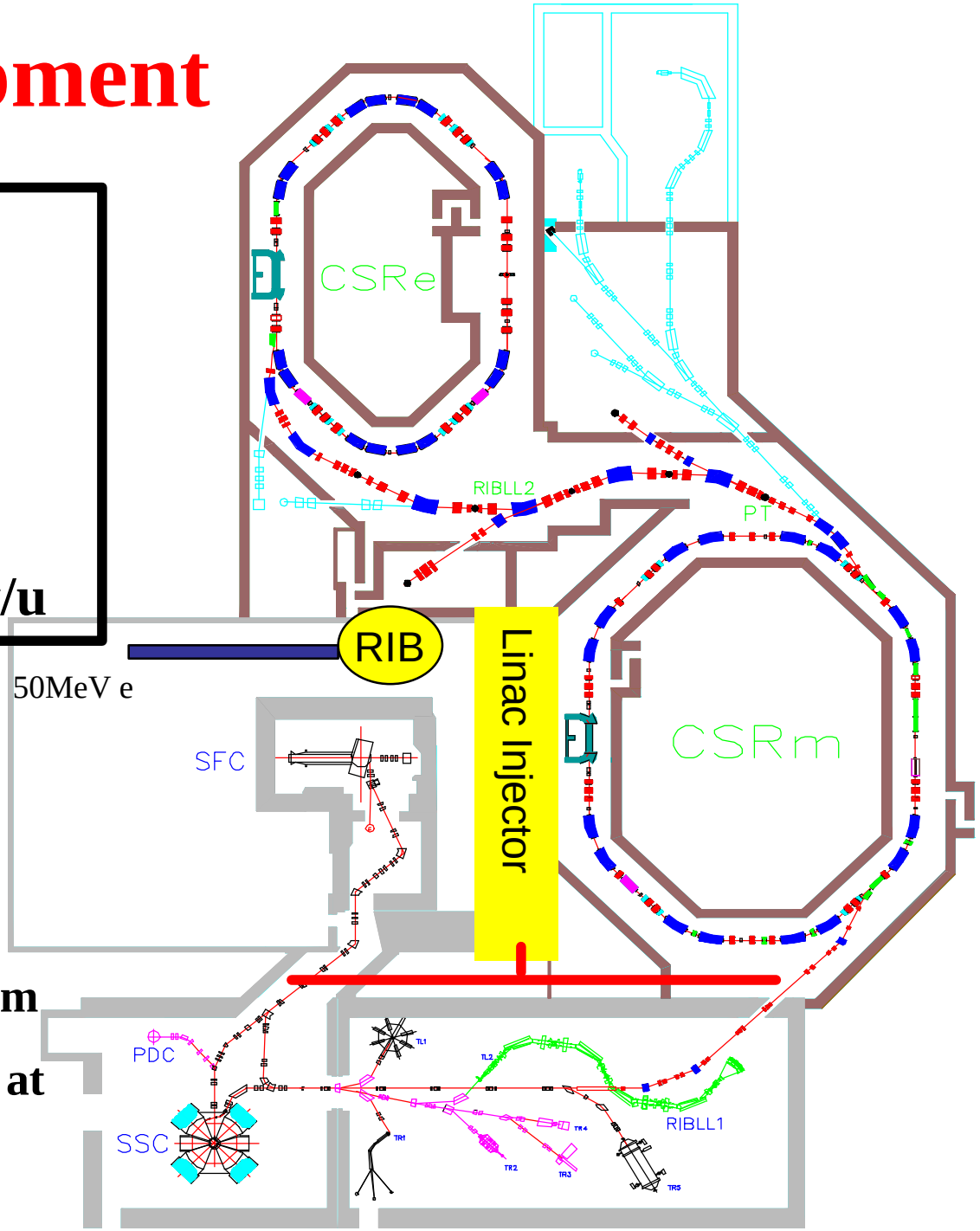




DW	**30~50 msr**
Brmax	**2.5Tm**
A/ DA	**>400**

Future Development

- **ISOL Type RIB**
  - **50MeV e+C--- g+^{238}U or**
  - **50MeV e+^{238}UC**
  - **(>10^{13} fission/s)**
- **Linac Energy: 6—10 Mev/u**



Feature:

- **High intensity beam for SHE**
- **Fission tape RIB beam**
- **Integral ability of HIRFL System**
- **High accuracy RIB experiment at CSR**

Thank you !

Measurement Method