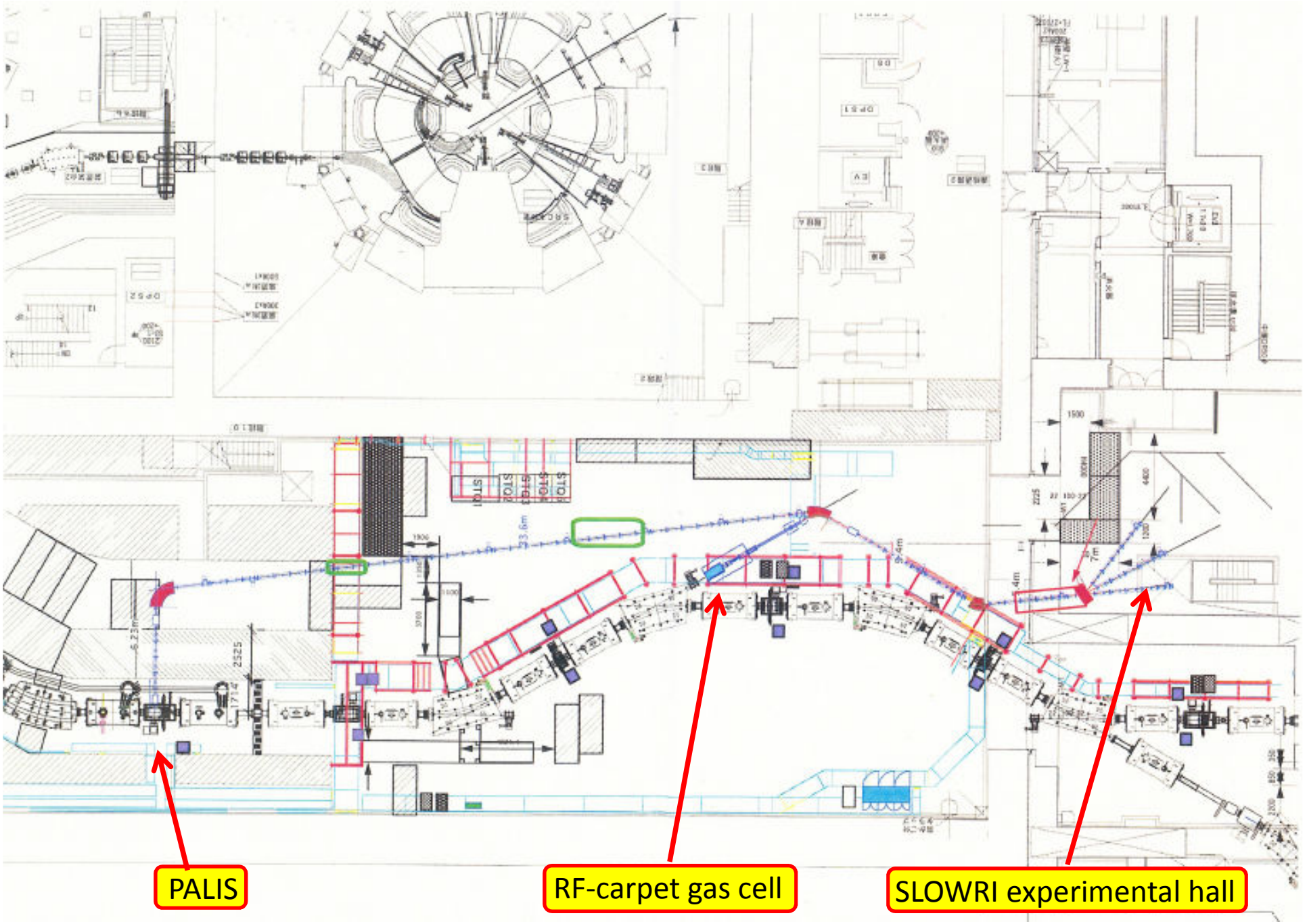
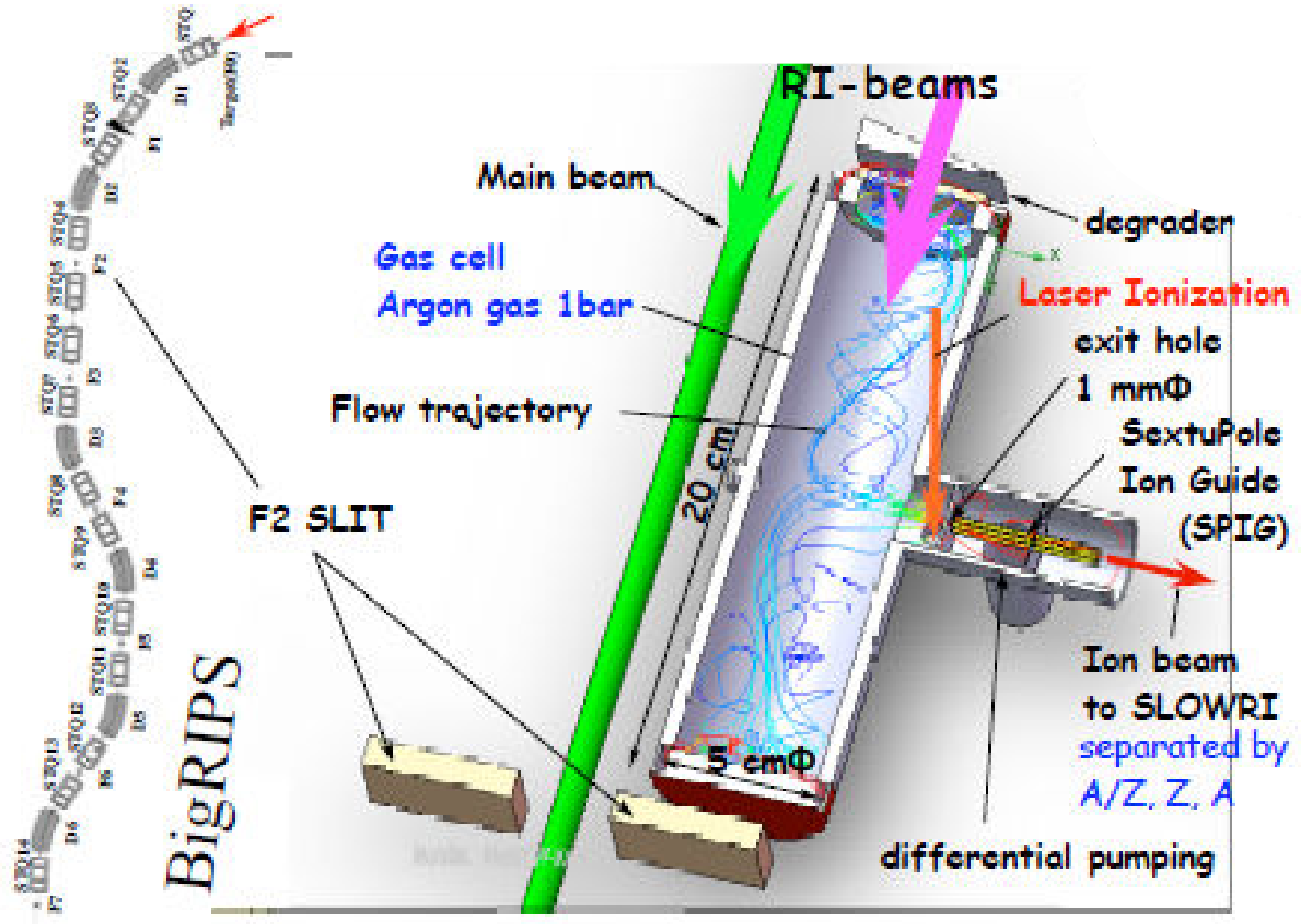
Proposal of laser spectroscopy at SLOWRI

Hideki Iimura

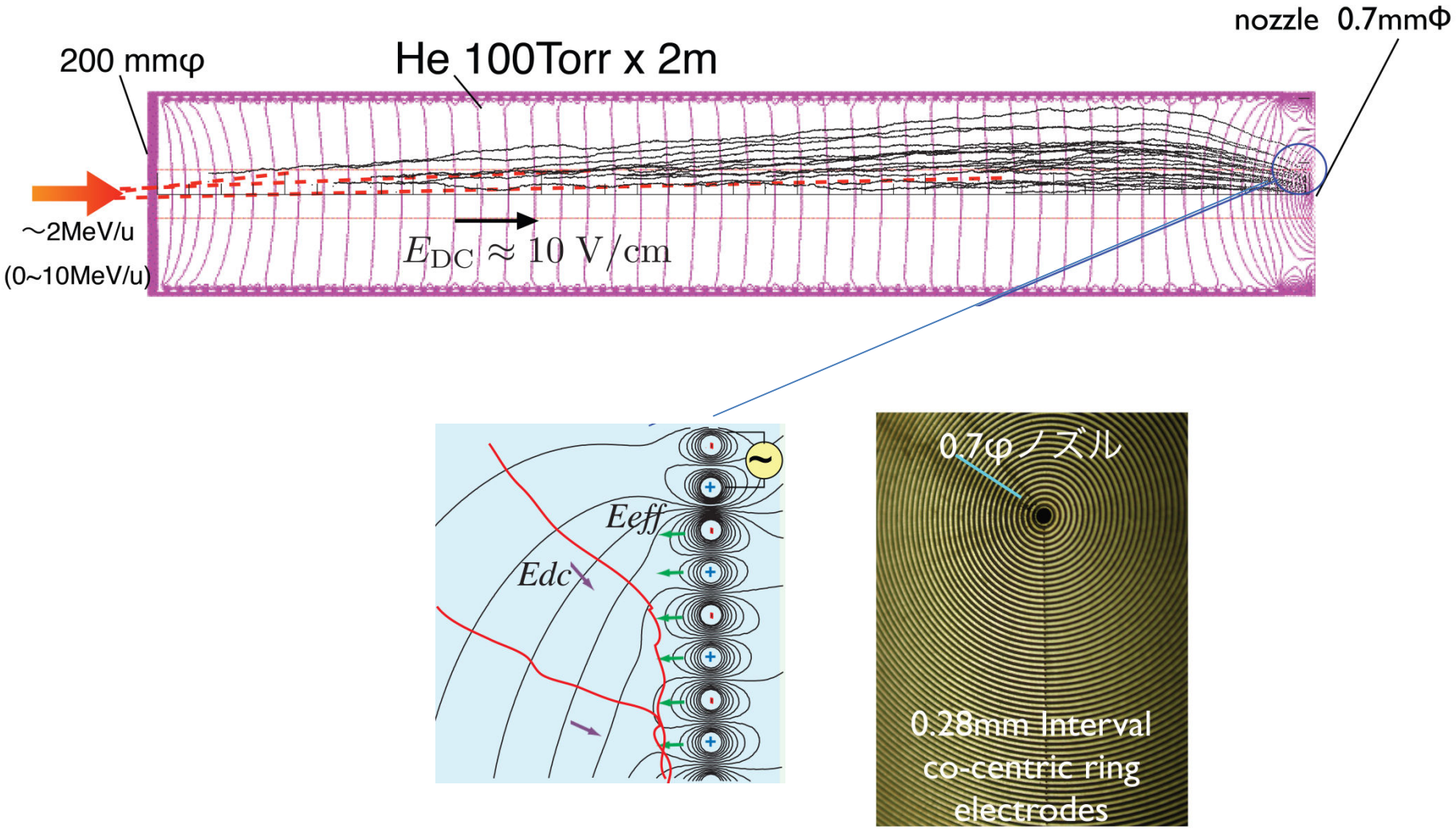
Japan Atomic Energy Agency


PALIS
RF-carpet gas cell
SLOWRI experimental hall

Parasitic Laser Ion-Source (PALIS)



RF-Carpet Gas Cell



	RF-carpet Gas Cell	PALIS	ISOL
elements	all	~70%	<50%
extraction time	~10 ms	0.1-1 s	~1 s
efficiency	~10%	~1%	
availability	<2 weeks/year	every day	

Wada(RIKEN)

- First step

  in-source laser spectroscopy at PALIS

  high sensitivity

  relatively low resolution

  ↓

  μ

- Second step

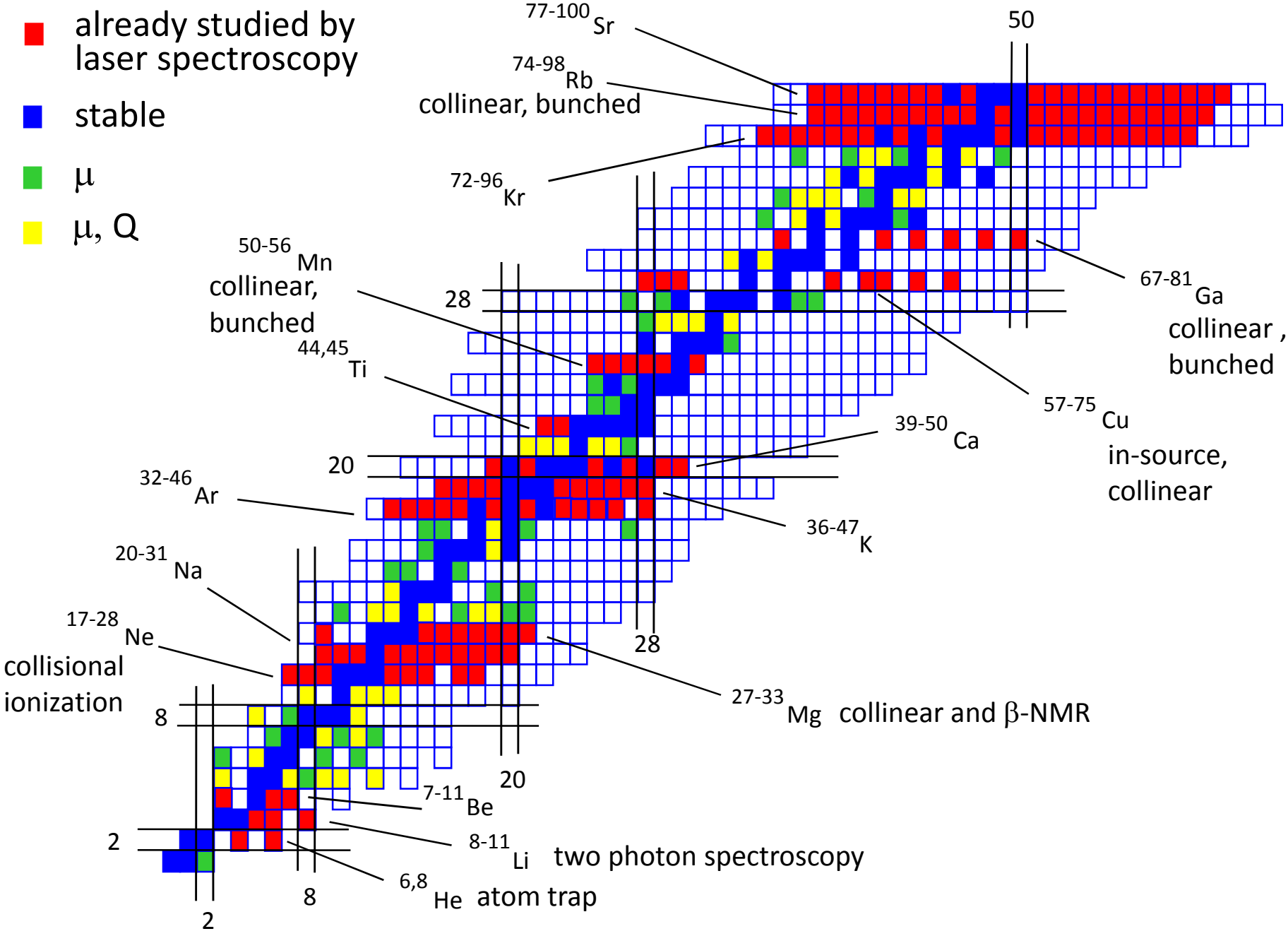
  collinear laser spectroscopy

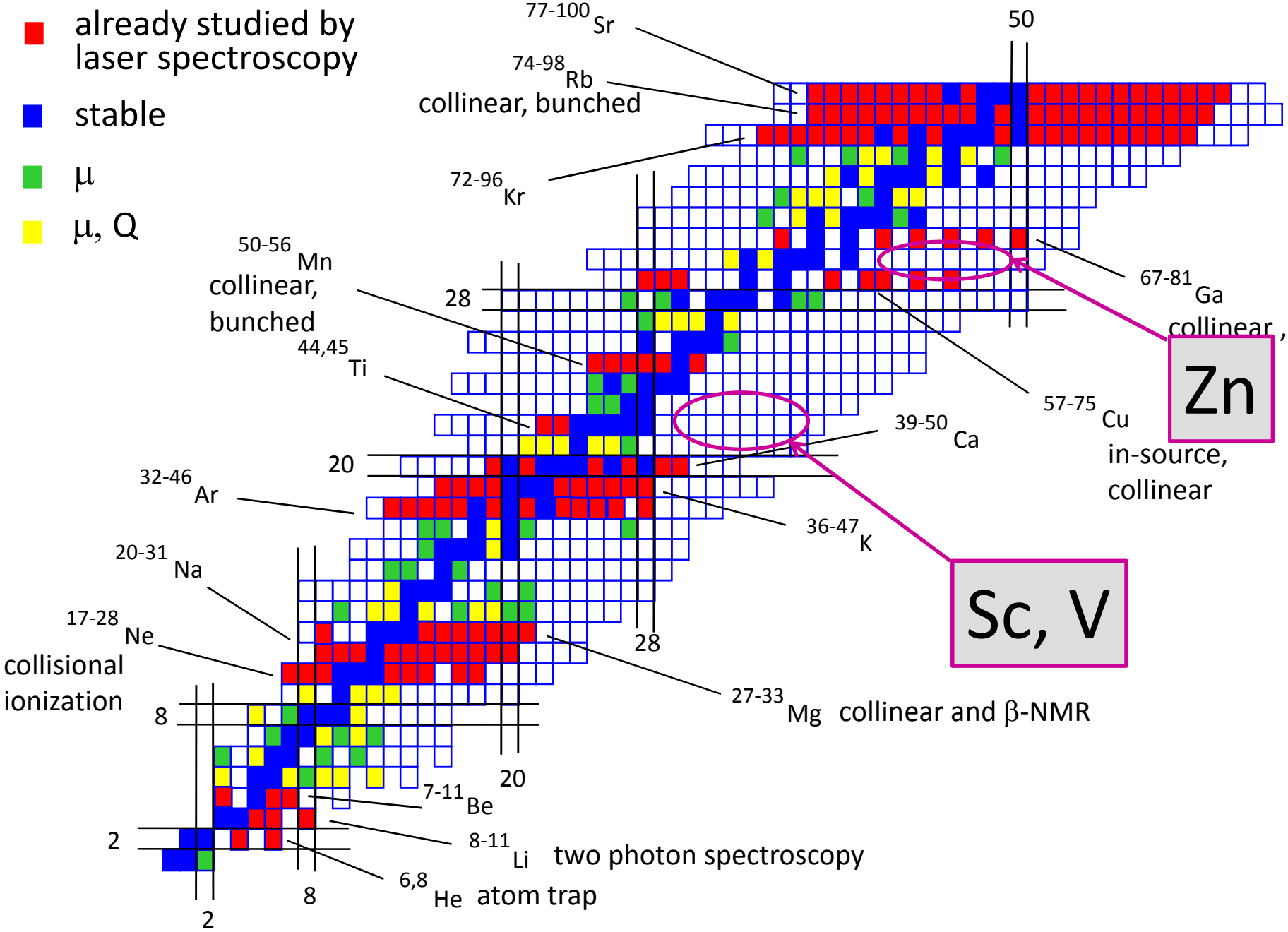
  relatively low sensitivity

  high resolution

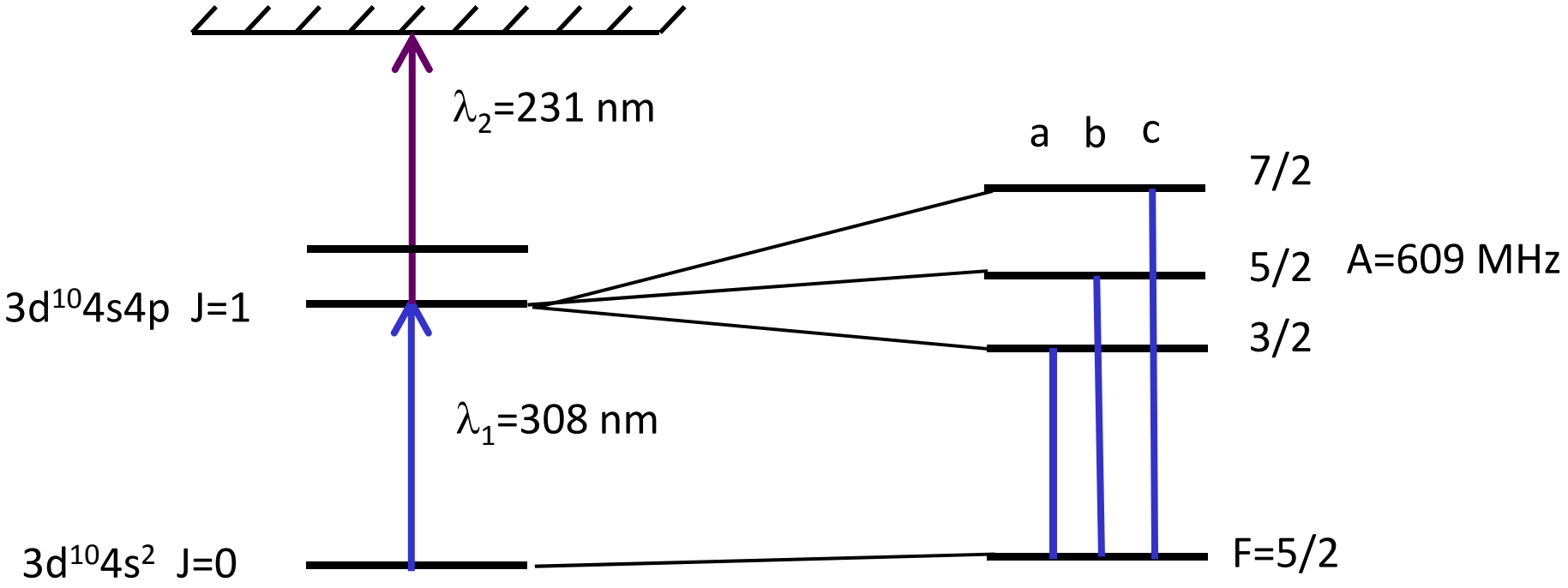
  ↓

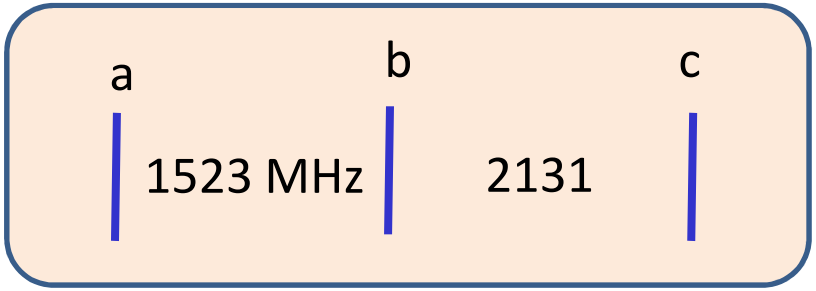
  μ, Q, $\delta\langle r^2 \rangle$

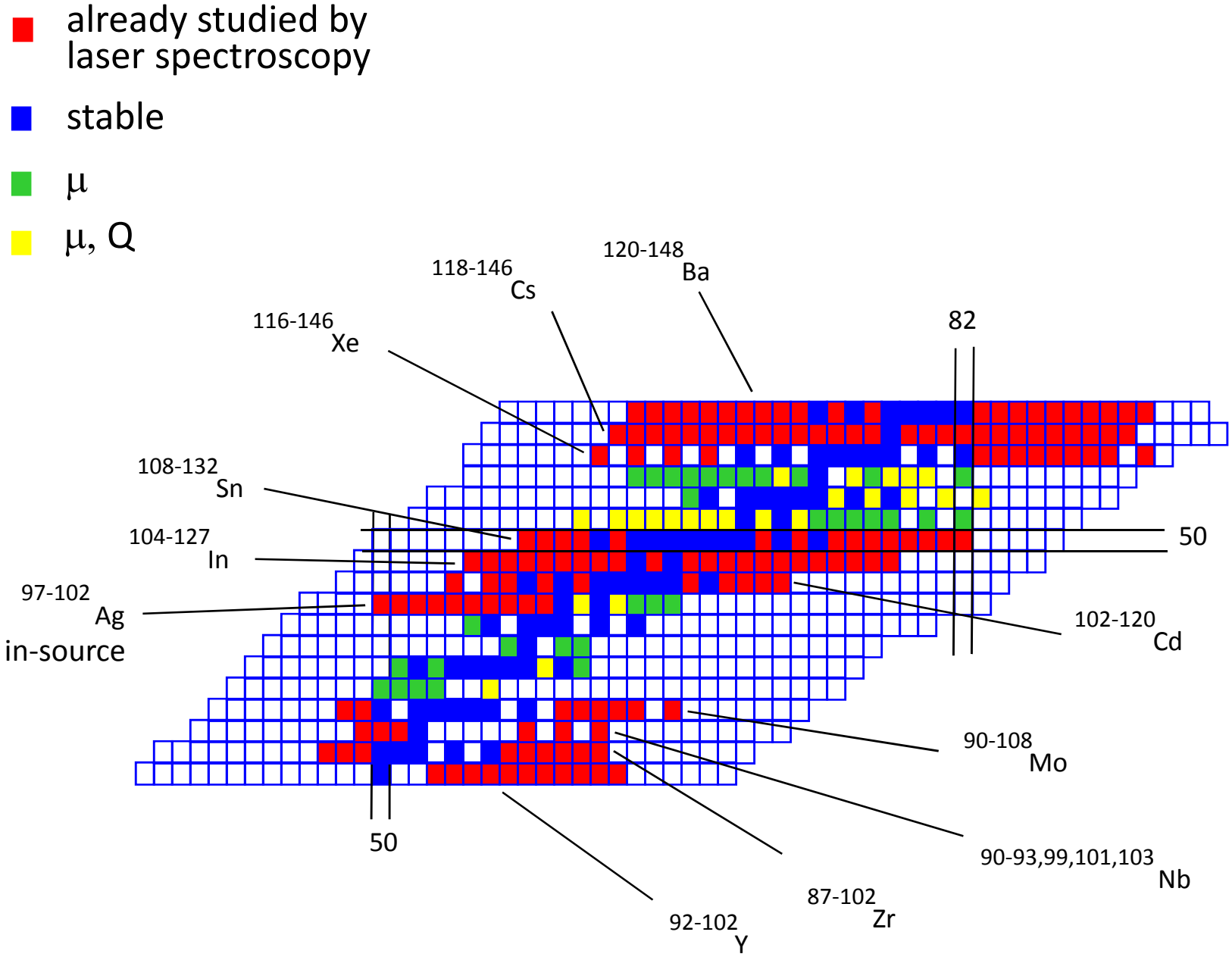

already studied by laser spectroscopy
stable
μ
μ, Q
77-100 Sr
74-98 Rb
collinear, bunched
72-96 Kr
50
50-56 Mn
collinear, bunched
28
44,45 Ti
67-81 Ga
collinear , bunched
57-75 Cu
in-source, collinear
39-50 Ca
20
32-46 Ar
36-47 K
20-31 Na
17-28 Ne
collisional ionization
28
27-33 Mg collinear and β-NMR
8
20
7-11 Be
2
8-11 Li two photon spectroscopy
6,8 He atom trap
8
2

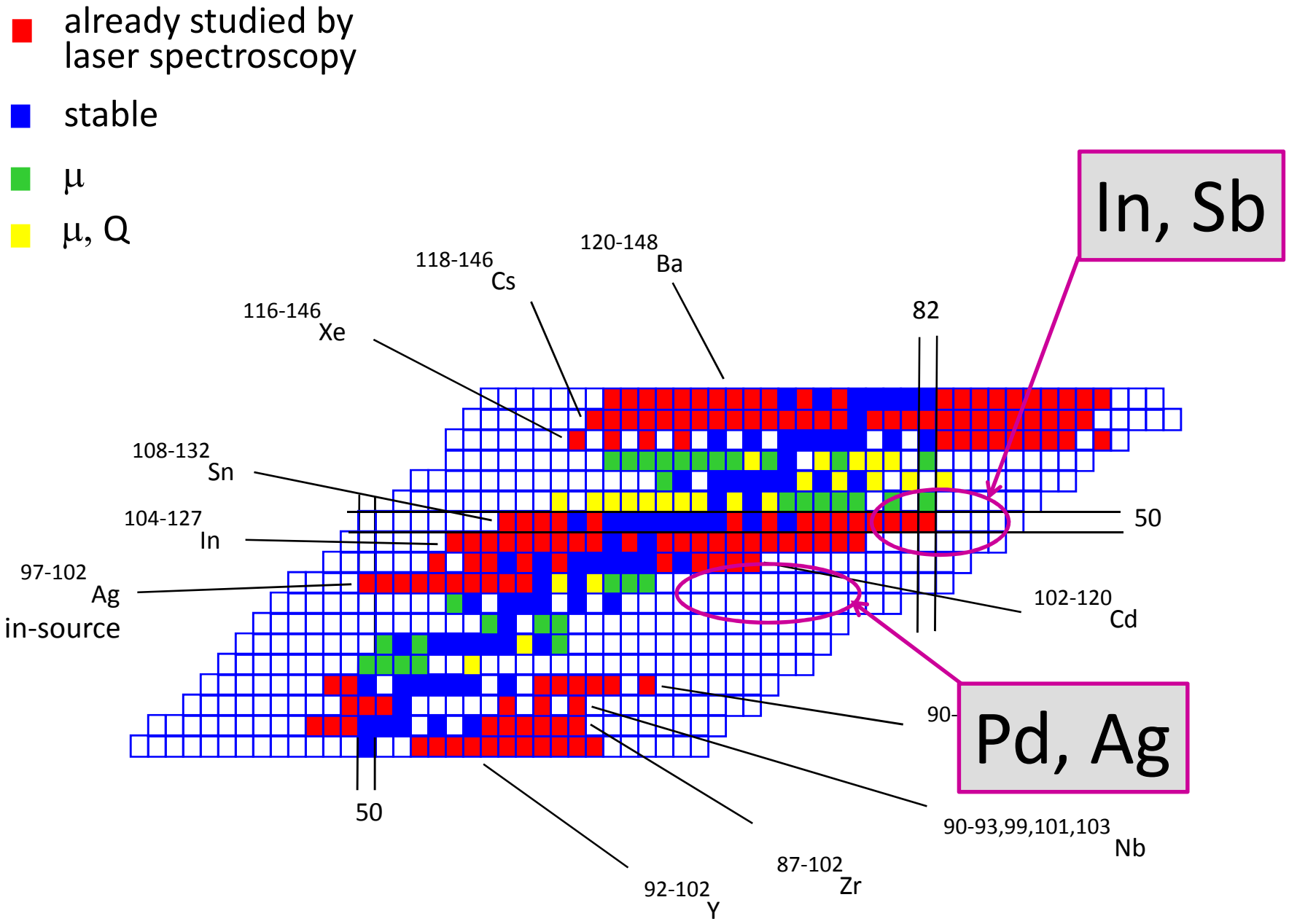

already studied by laser spectroscopy
stable
μ
μ, Q
77-100 Sr
74-98 Rb
collinear, bunched
72-96 Kr
50
50-56 Mn
collinear, bunched
28
44,45 Ti
67-81 Ga
collinear ,
Zn
57-75 Cu
39-50 Ca
in-source, collinear
20
32-46 Ar
36-47 K
20-31 Na
Sc, V
17-28 Ne
collisional ionization
28
27-33 Mg collinear and β-NMR
8
20
7-11 Be
2
8-11 Li two photon spectroscopy
6,8 He atom trap
8
2

Zn (Z=30, N=37, I=5/2)

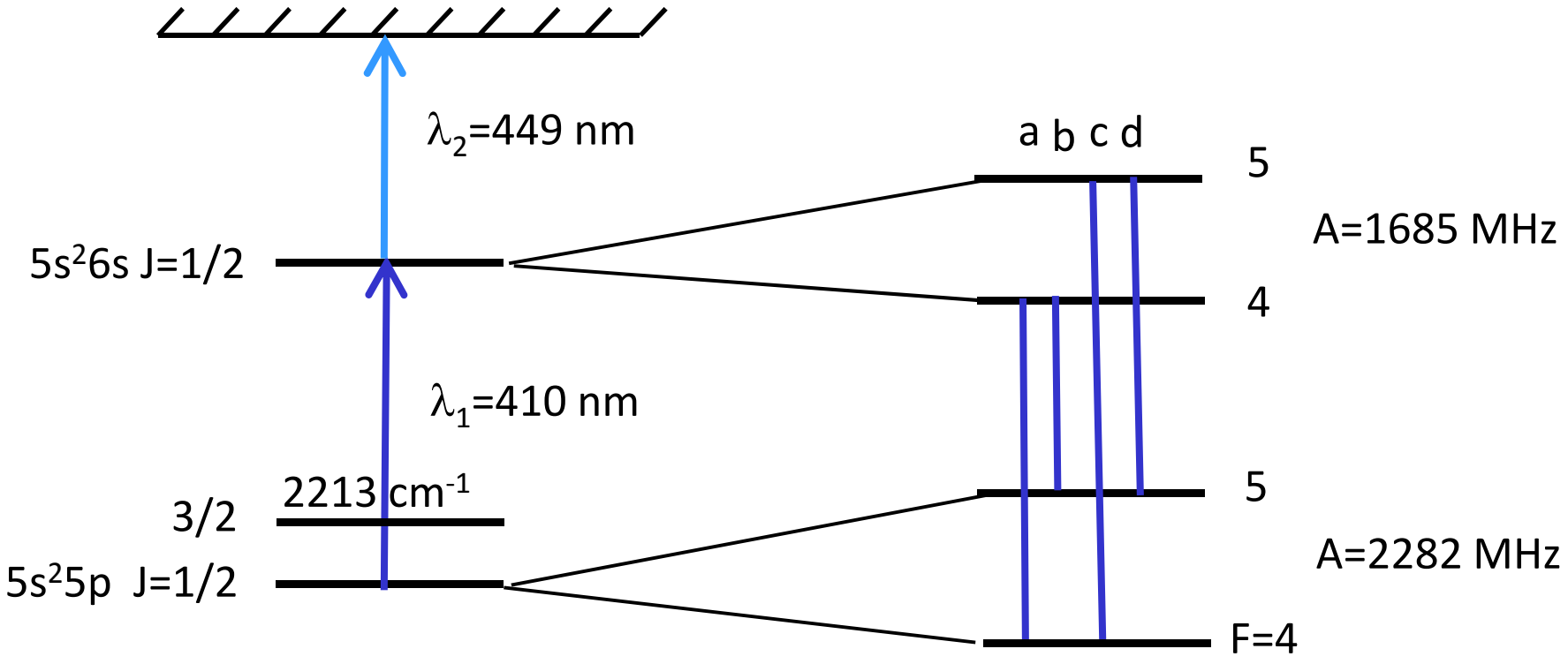


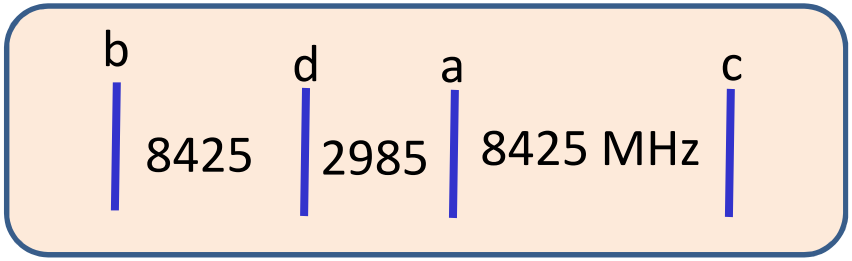


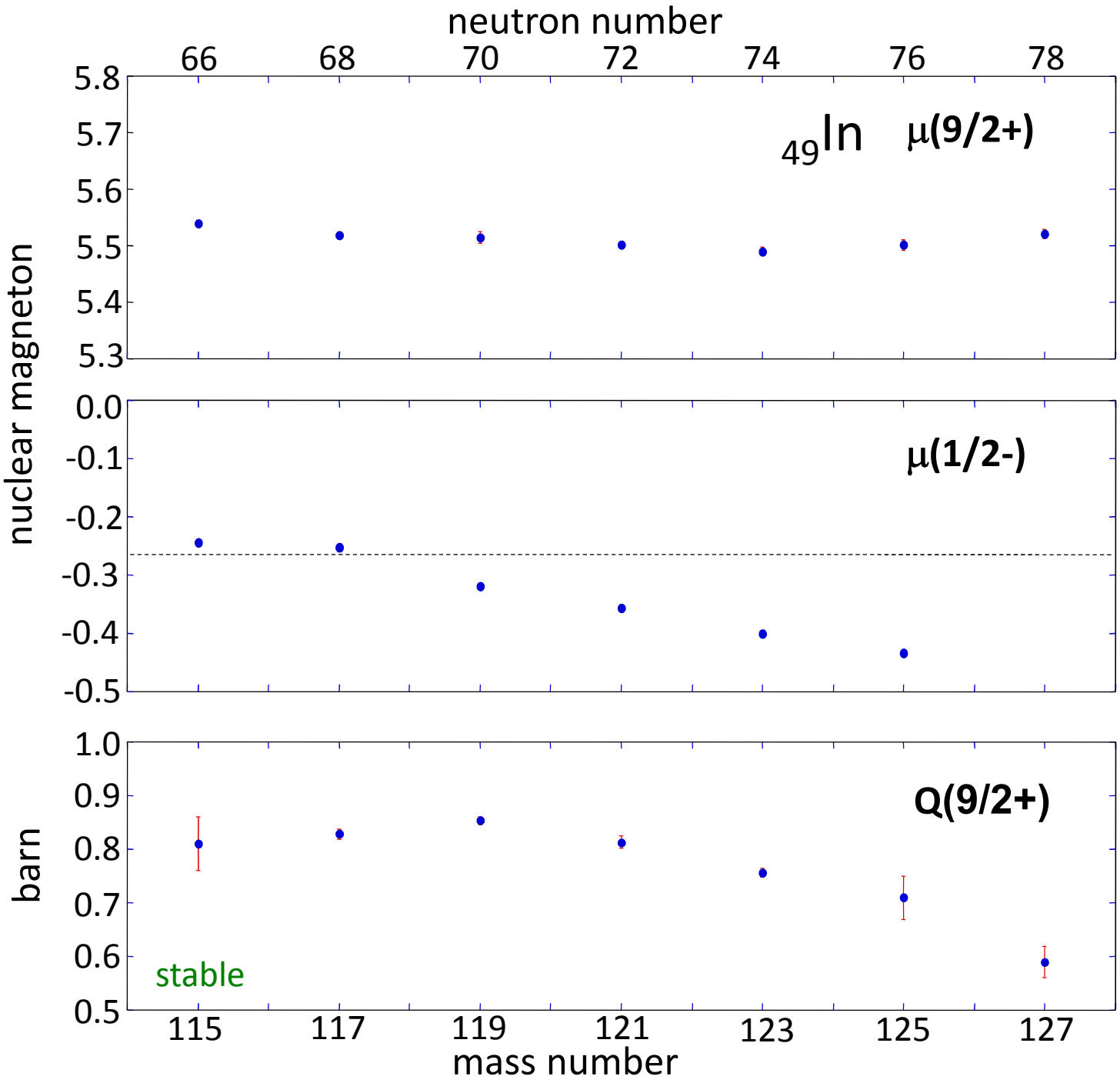

already studied by laser spectroscopy
stable
μ
μ, Q
120-148 Ba
118-146 Cs
116-146 Xe
82
108-132 Sn
104-127 In
50
97-102 Ag in-source
102-120 Cd
90-108 Mo
50
90-93,99,101,103 Nb
87-102 Zr
92-102 Y


already studied by laser spectroscopy
stable
μ
μ, Q
In, Sb
Pd, Ag
120-148 Ba
118-146 Cs
116-146 Xe
82
108-132 Sn
104-127 In
50
97-102 Ag in-source
102-120 Cd
90-
50
90-93,99,101,103 Nb
87-102 Zr
92-102 Y

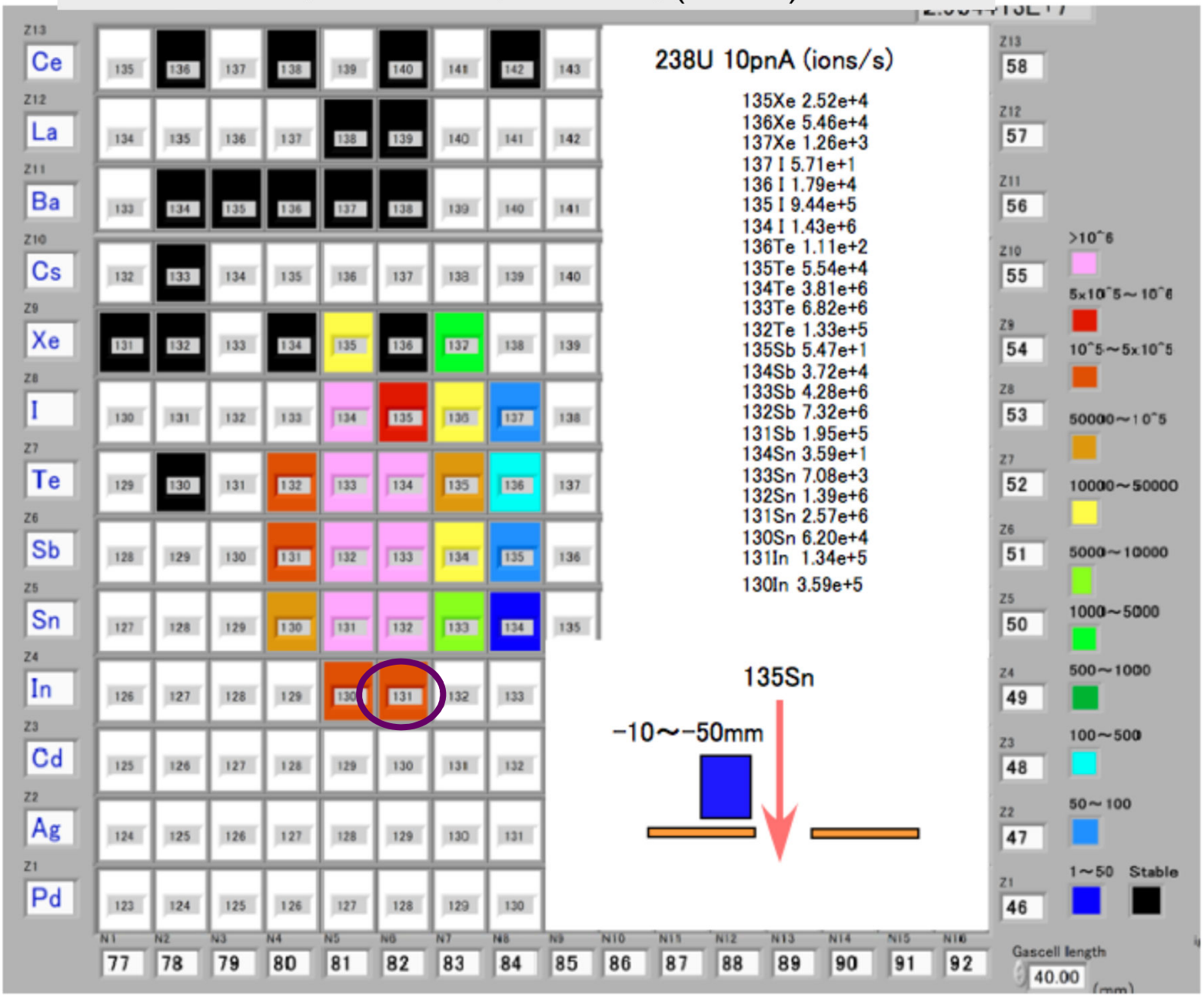
In (Z=49, N=66, I=9/2)



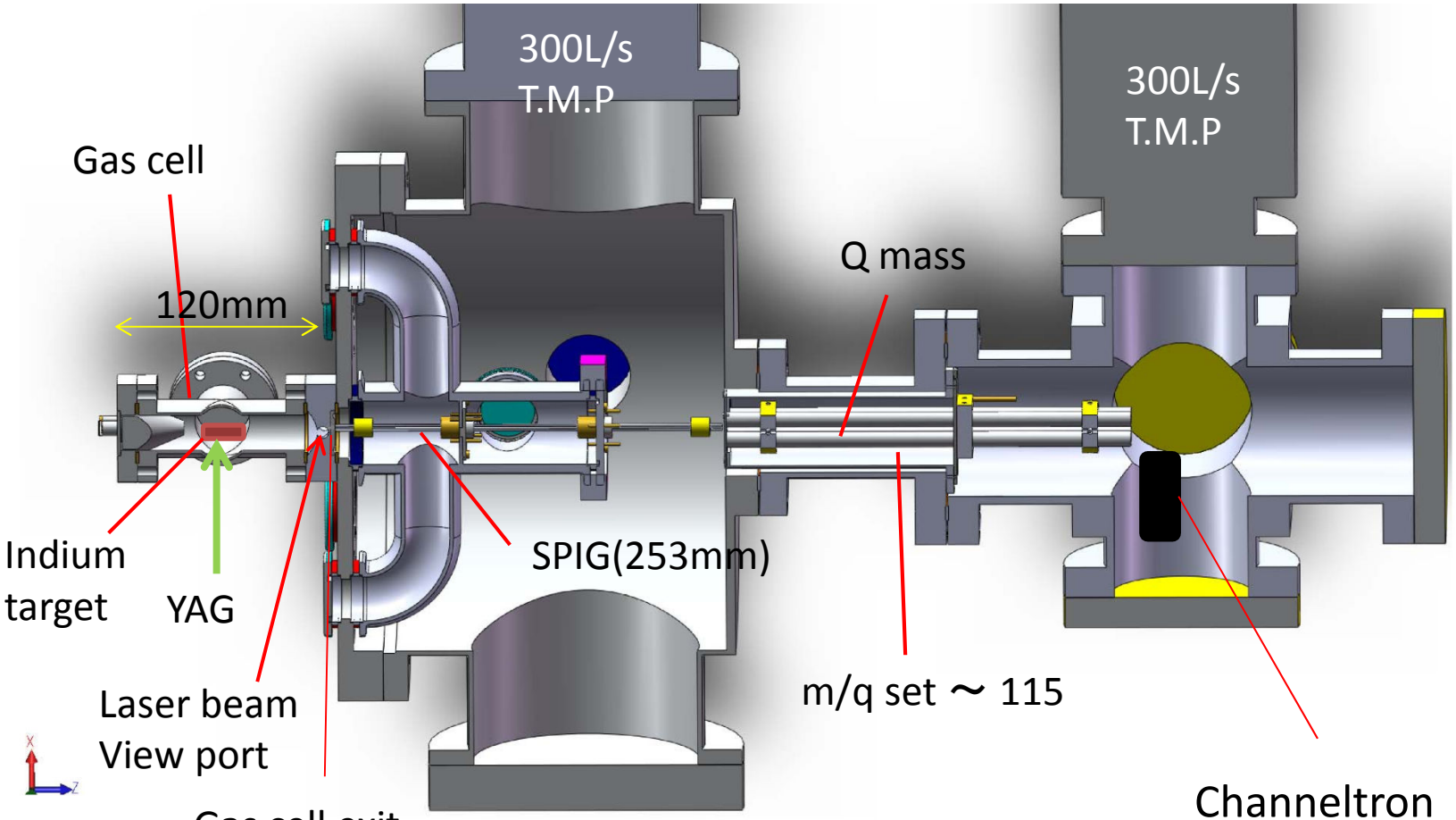



neutron number
66
68
70
72
74
76
78
5.8
5.7
5.6
5.5
5.4
5.3
$_{49}$In μ(9/2+)
nuclear magneton
0.0
-0.1
-0.2
-0.3
-0.4
-0.5
μ(1/2-)
1.0
0.9
0.8
0.7
0.6
0.5
barn
Q(9/2+)
stable
115
117
119
121
123
125
127
mass number

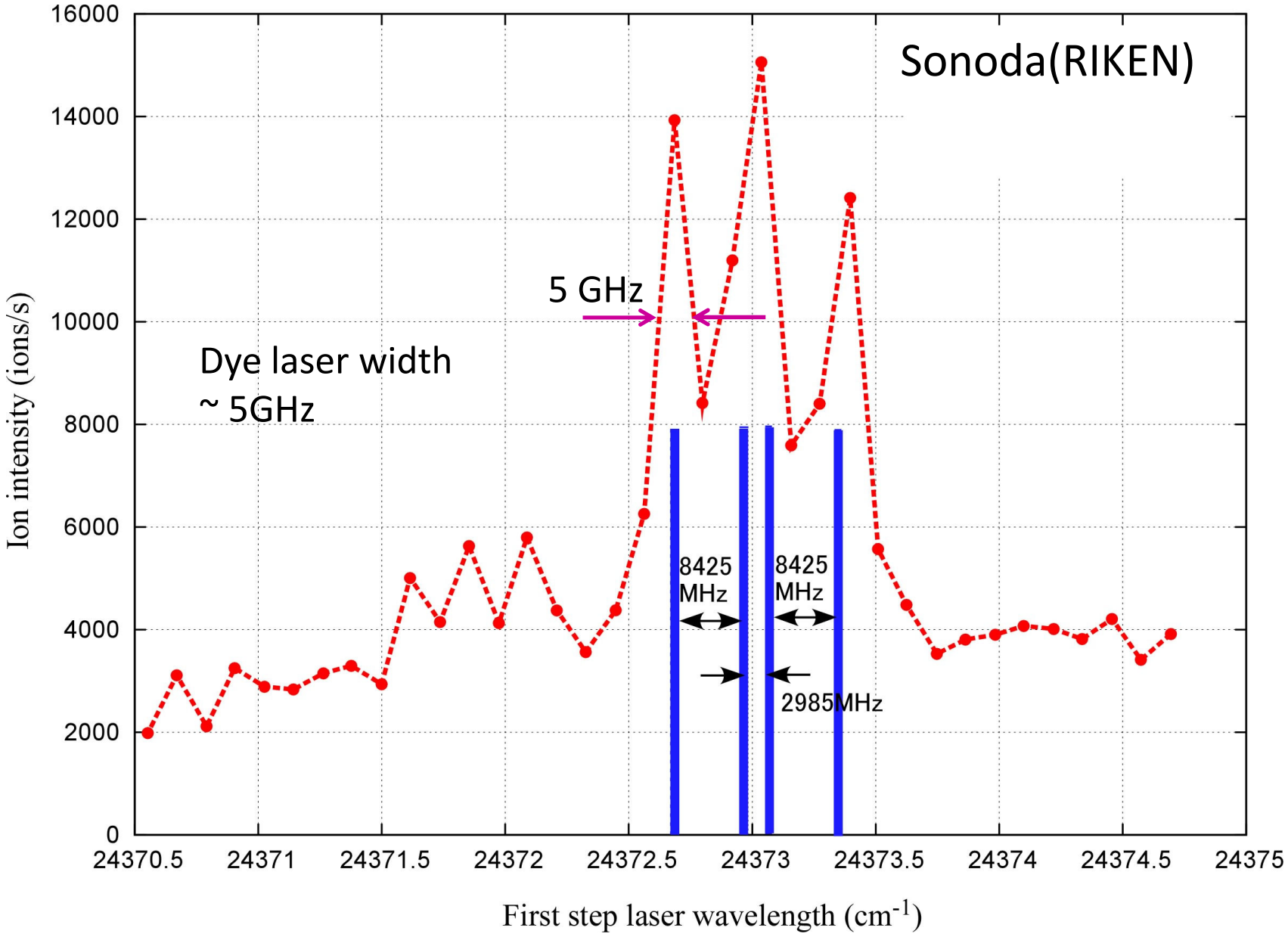
4-8, Dec. 2011, Aoi et al, (Sn135)



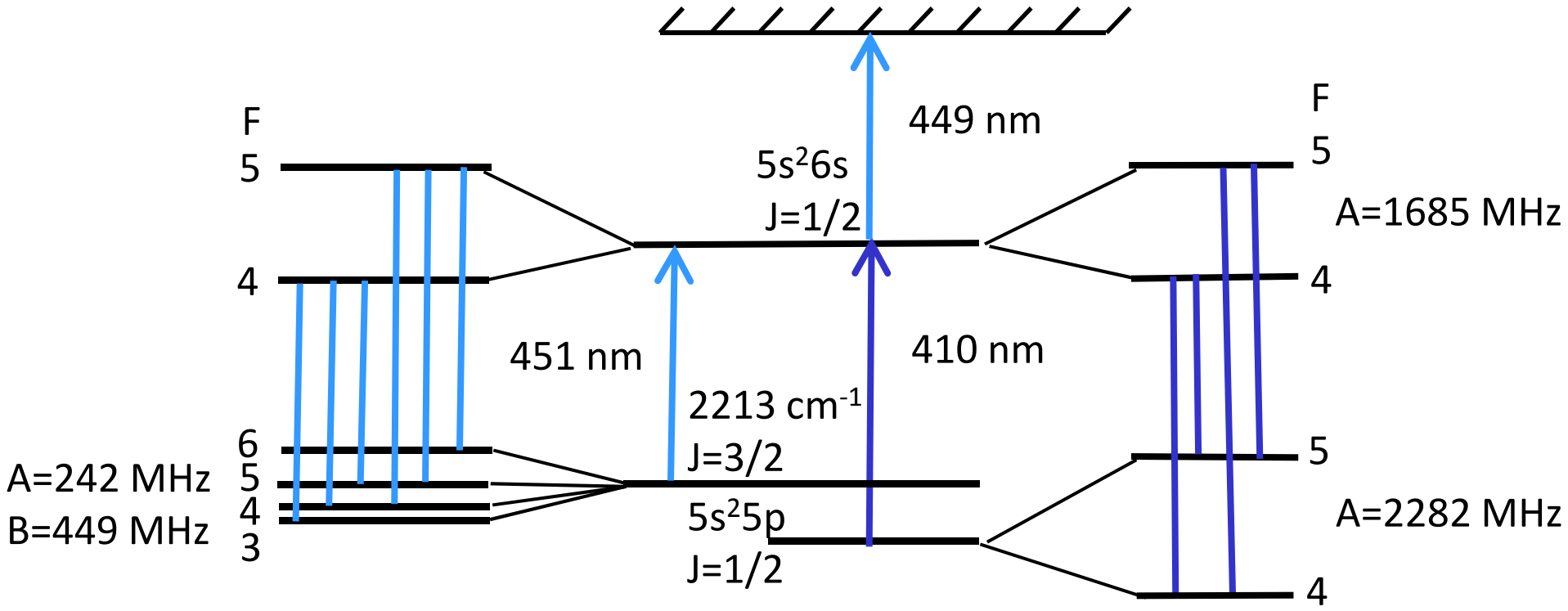
Indium resonant laser ionization 2012 July



^{113,115}In ionization spectrum (July, 2012)



In (Z=49, N=66, I=9/2)



μ, Q ← μ

Isotope Shift = (Normal Mass Shift) +(Specific Mass Shift)+ (Field Shift)

$\delta\langle r^2 \rangle$

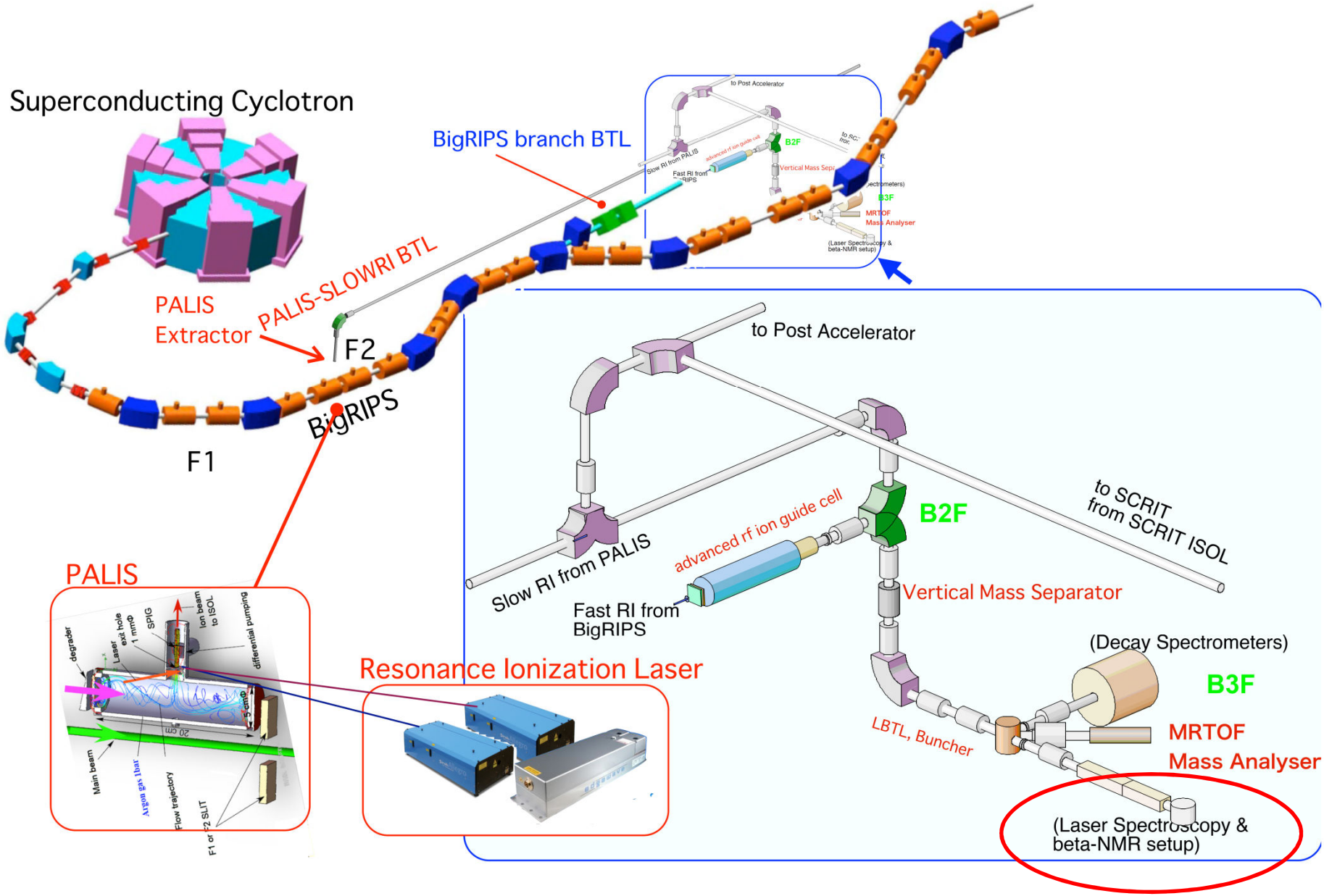
Z	Element	Mass number	Transition	IS (MHz)	NMS (MHz)	FS+SMS (MHz)
19	K	39-41	4s-4p	236	265	-29
29	Cu	63-65	4s-4p	600	244	356
30	Zn	64-66	$4s^2$-4s4p	480	362	118
31	Ga	69-71	4p-5s	-33	165	-198
36	Kr	82-84	5s-5p	60	54	6
37	Rb	85-87	5s-5p	78	56	22
38	Sr	86-88	$5s^2$-5s5p	126	94	32
40	Zr	90-92	$4d^3$5s-$4d^3$5p	-360	84	-444
47	Ag	107-109	$4d^{10}$5s-$4d^{10}$5p	-450	83	-533
48	Cd	112-114	$5s^2$-5s5p	-450	78	-528
49	In	113-115	5p-6s	258	61	197
54	Xe	134-136	6s-6p	-90	22	-112

For the Q and $\delta\langle r^2\rangle$ measurements,
the resolution of < 100 MHz is needed.

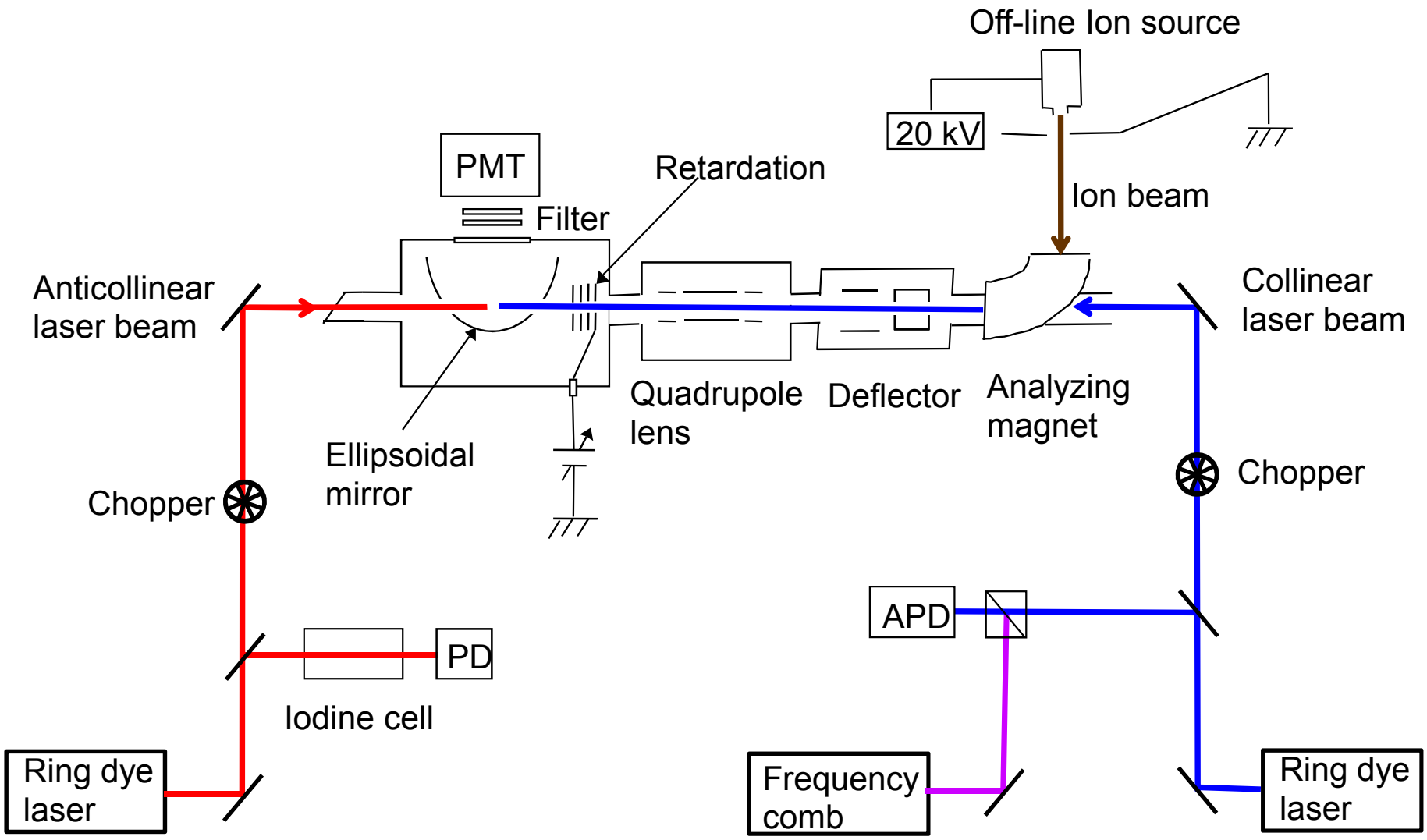
- Improvement of the resolution at PALIS
  narrow band laser
  in gas-jet

- Collinear spectroscopy

SLOWRI 2011 original plan

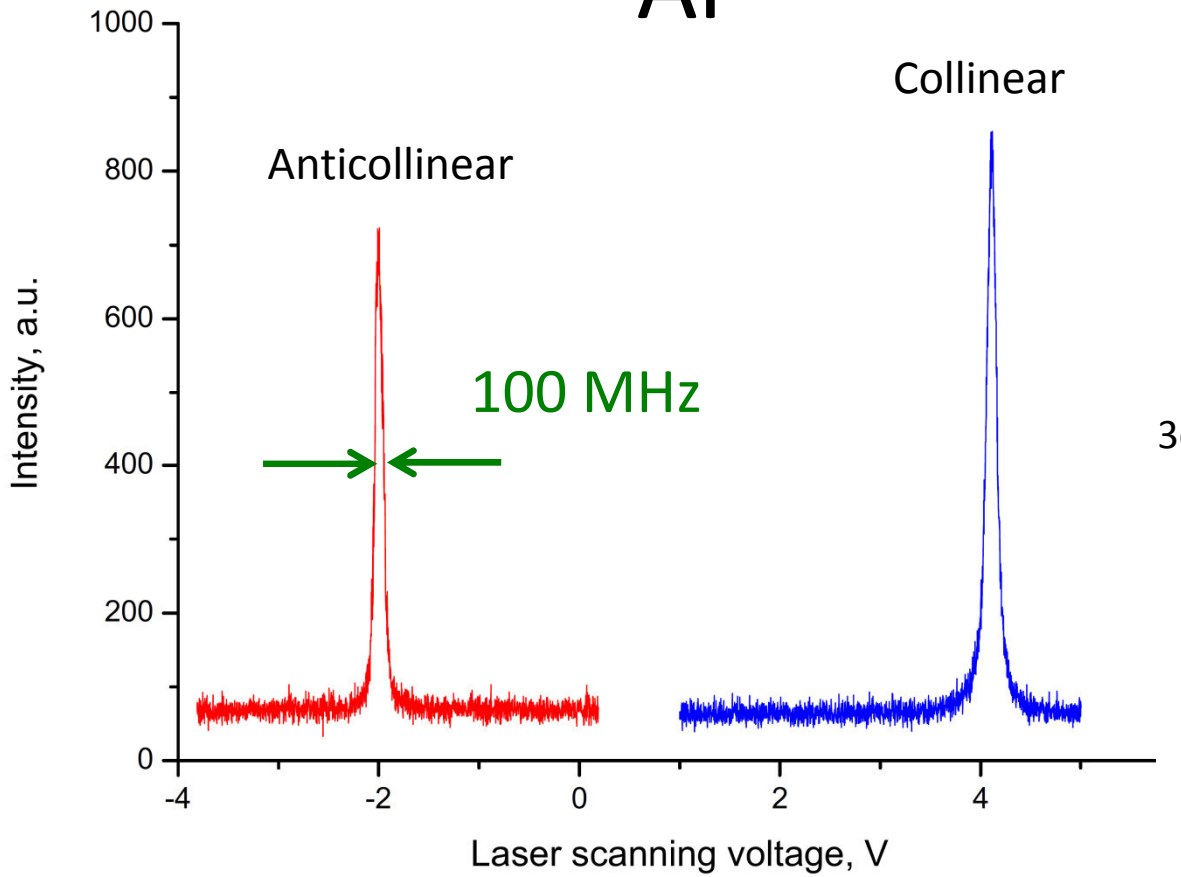


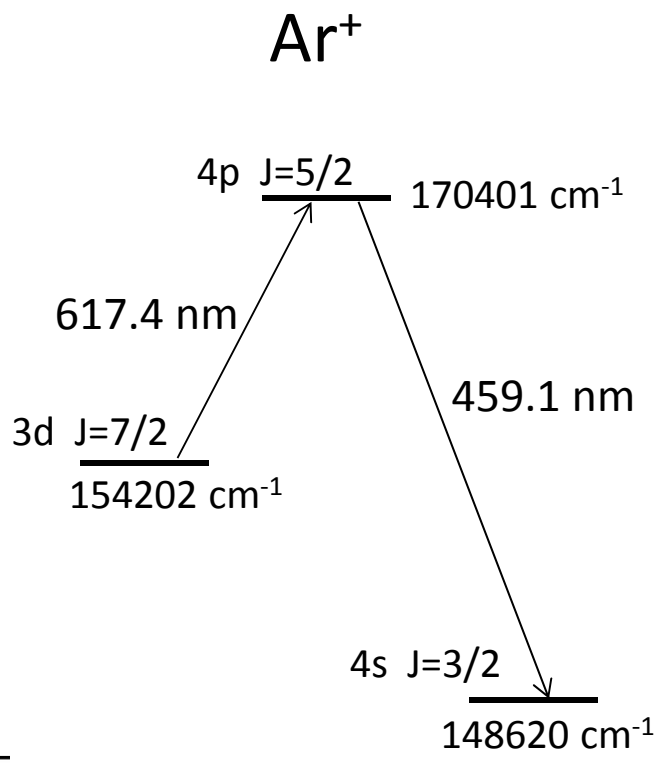
Collinear laser spectroscopy



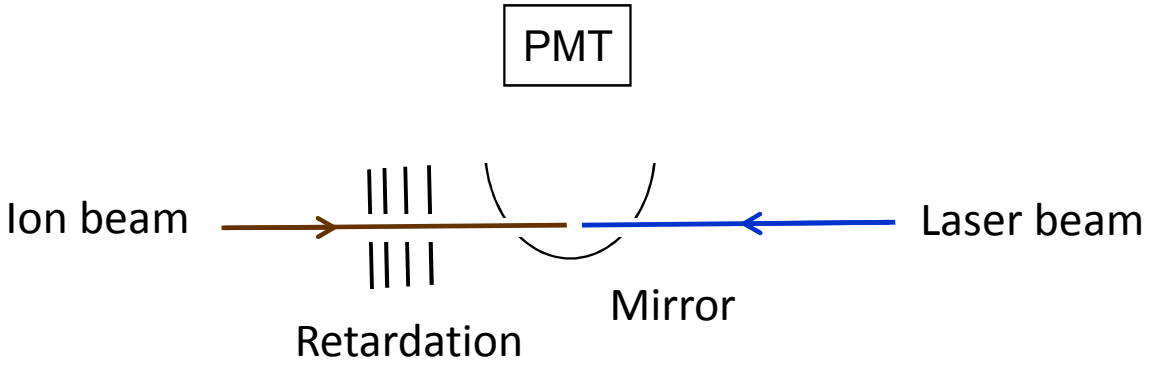
Lioubimov(Texas A&M, RIKEN)

^{40}Ar



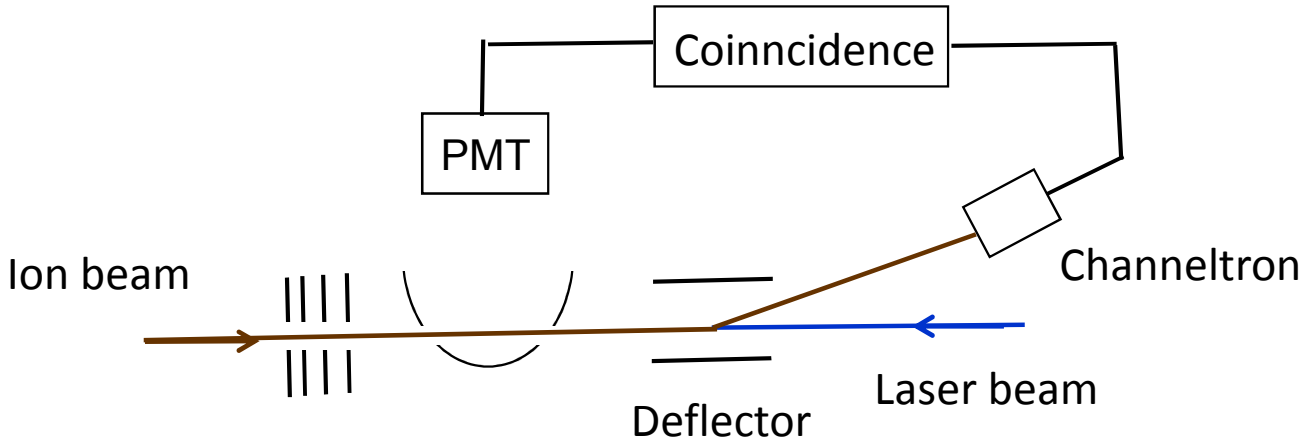


$$\nu_0 = (\nu_{anticoll} \times \nu_{coll})^{1/2} \rightarrow \nu_0 = 485573619.7\ (3)\ \text{MHz}$$



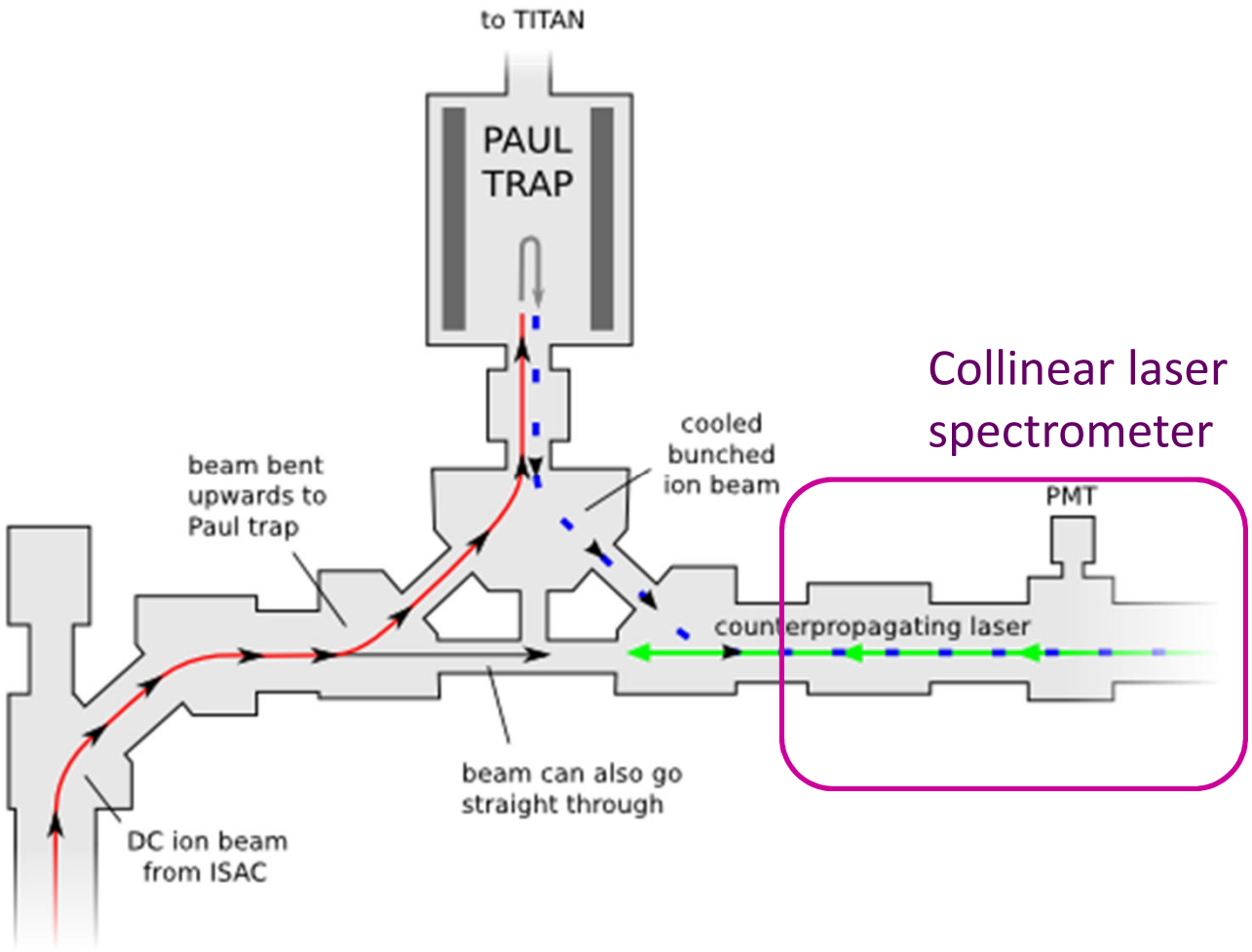
Minimum yield
~ 10^4 ions/sec

Noise:
- Dark current of PMT
- Scatter of laser
- Photons from ion beam



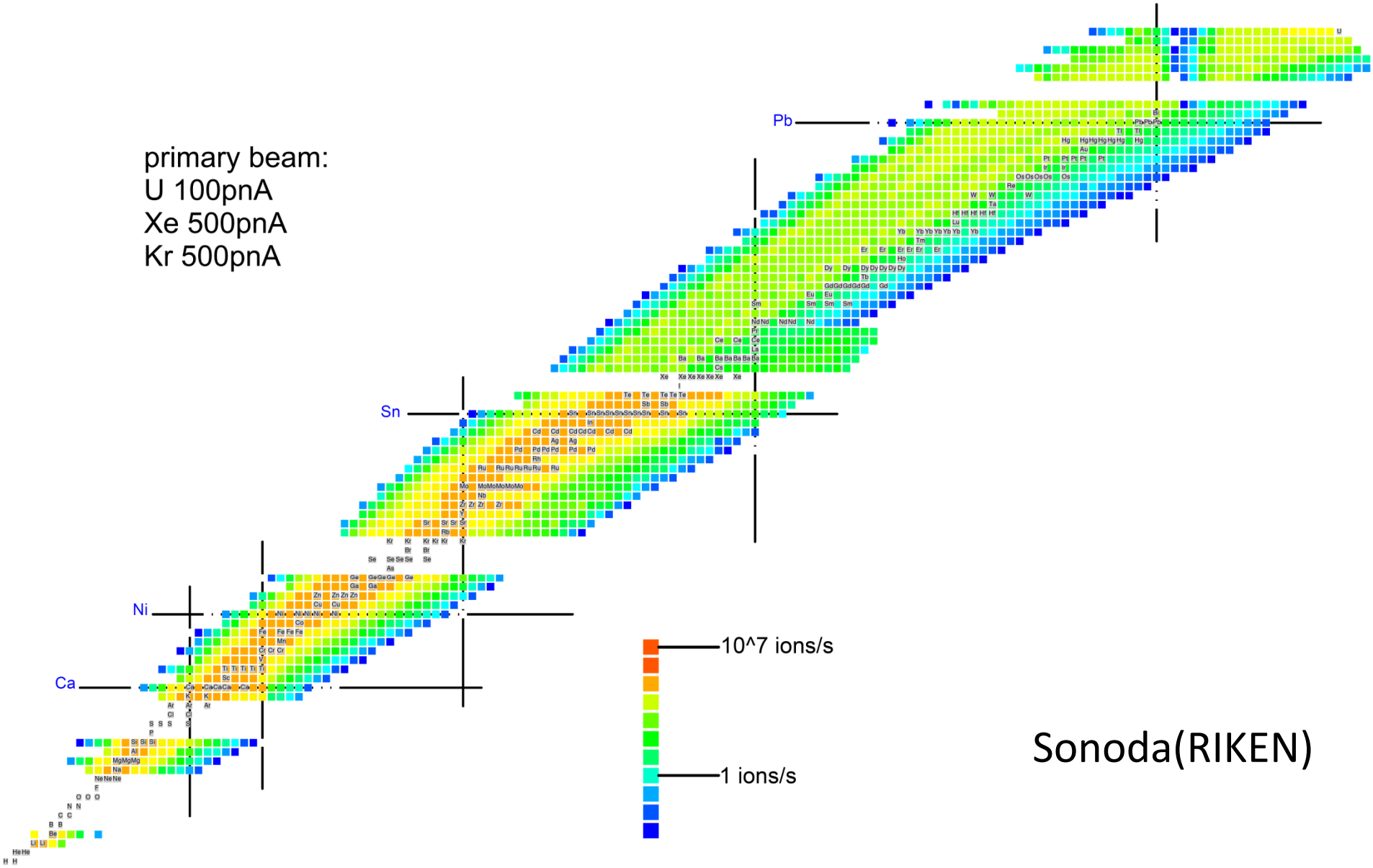
Minimum yield
~ 10^2 ions/sec

Reverse Ion Extraction from Buncher (TRIUMF)

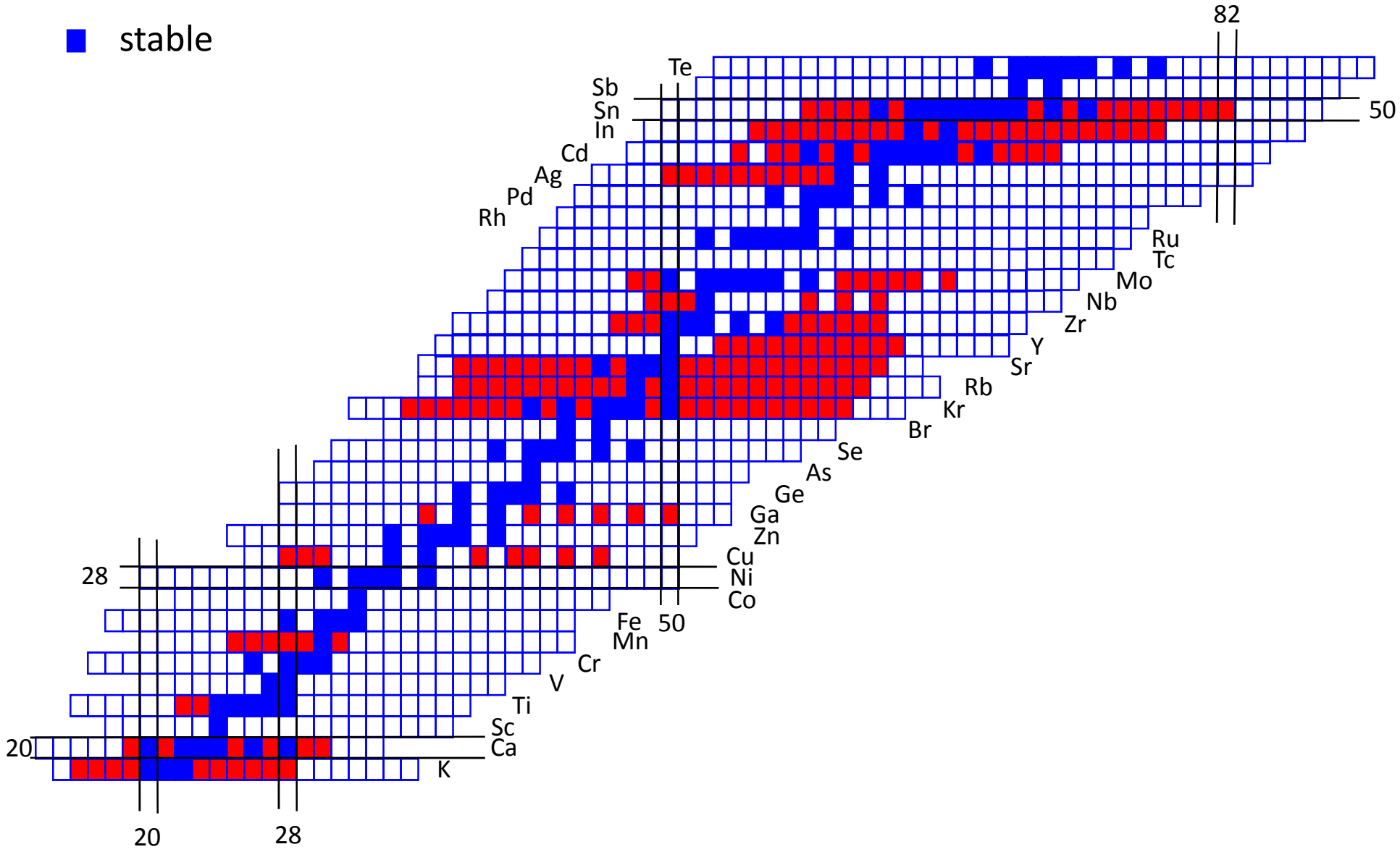


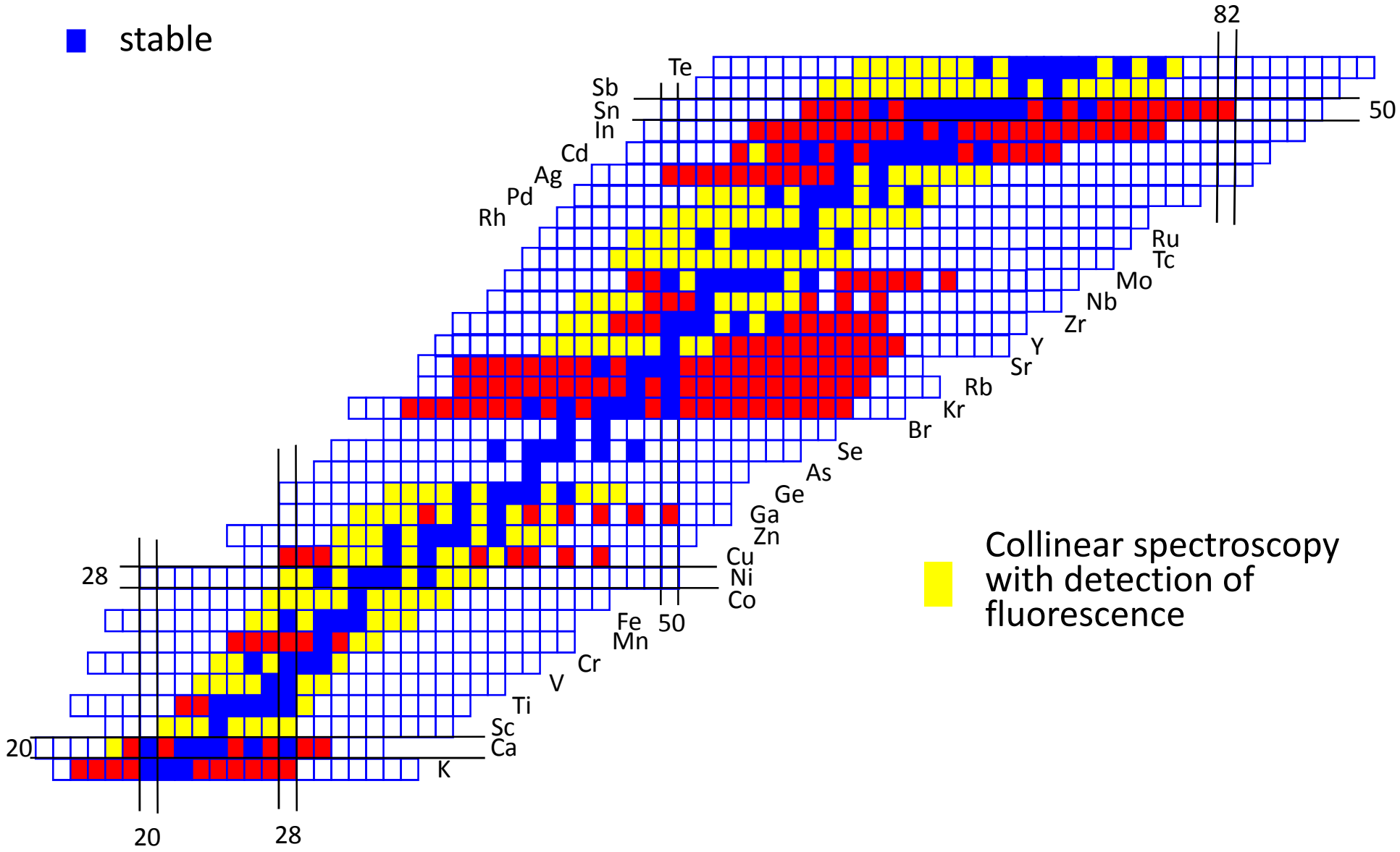
$$\text{Noise Reduction} = \frac{\text{Bunched Noise}}{\text{DC Noise}} = \frac{\text{Pulse duration}}{\text{Time between pulses}} \cong \frac{5\ \mu s}{50\ ms} = 10^{-4}$$

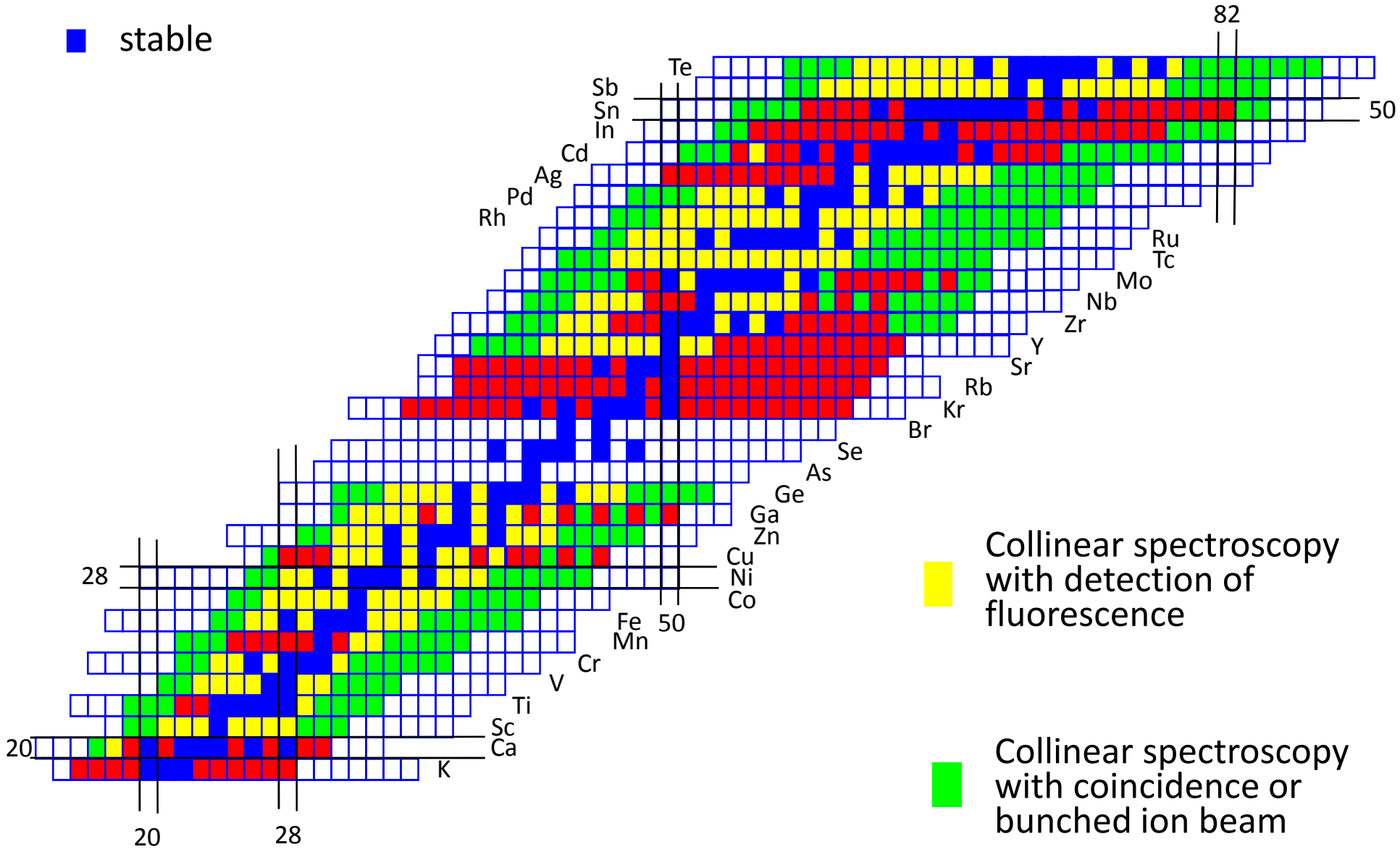
Expected yield by PALIS on-line experiments



Sonoda(RIKEN)


already studied by laser spectroscopy
stable
82
50
50
28
20
20
28
Te
Sb
Sn
In
Cd
Ag
Pd
Rh
Ru
Tc
Mo
Nb
Zr
Y
Sr
Rb
Kr
Br
Se
As
Ge
Ga
Zn
Cu
Ni
Co
Fe
Mn
Cr
V
Ti
Sc
Ca
K


already studied by laser spectroscopy
stable
Collinear spectroscopy with detection of fluorescence
82
50
50
28
20
20
28
Te
Sb
Sn
In
Cd
Ag
Pd
Rh
Ru
Tc
Mo
Nb
Zr
Y
Sr
Rb
Kr
Br
Se
As
Ge
Ga
Zn
Cu
Ni
Co
Fe
Mn
Cr
V
Ti
Sc
Ca
K


already studied by laser spectroscopy
stable
Collinear spectroscopy with detection of fluorescence
Collinear spectroscopy with coincidence or bunched ion beam
82
50
28
20
Te
Sb
Sn
In
Cd
Ag
Pd
Rh
Ru
Tc
Mo
Nb
Zr
Y
Sr
Rb
Kr
Br
Se
As
Ge
Ga
Zn
Cu
Ni
Co
Fe
Mn
Cr
V
Ti
Sc
Ca
K