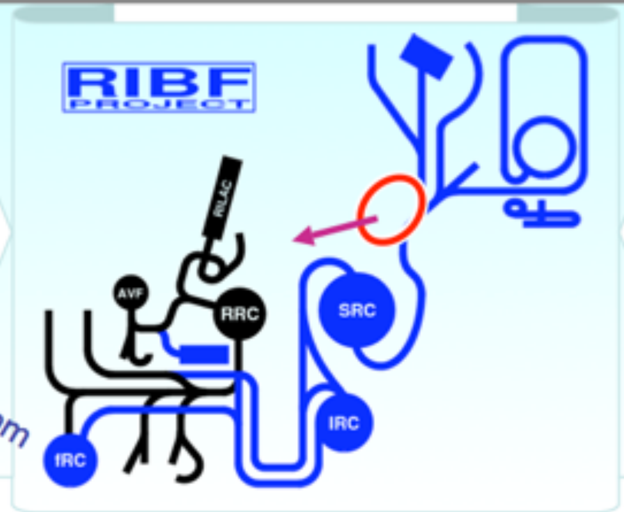
SLOWRI: a universal low-energy RI-beam facility at RIKEN RIBF

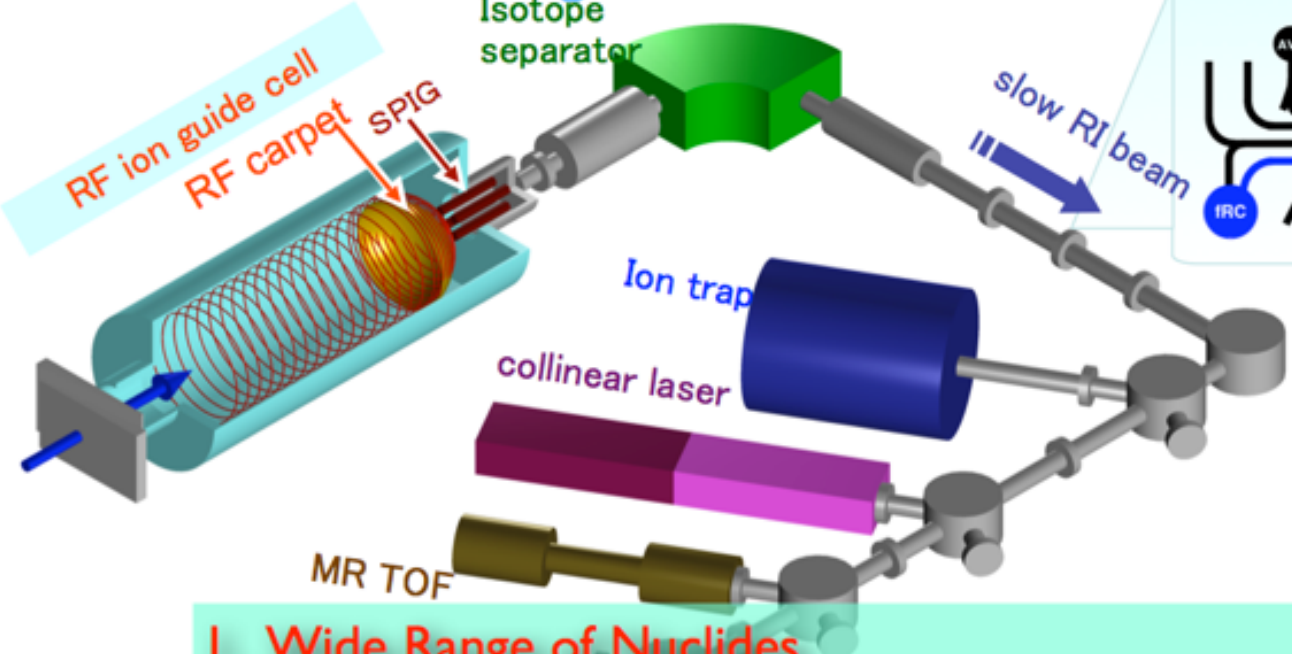
1997	*Basic idea IGISOL6, Dubna (Hyp Int 115(1998)165)*
1998	*Offline studies at INS, UT*
2000	*Online studies with POP at RIKEN RIPS (8Li extracted)*
2002	*RF-carpet with large gas cell (NIM B204, 570 (2003)*
2003	*MRTOF offline studies (NIM B219, 468 (2004)*
2003	*"SLOWRI" named (16th May, 2003)*
2005	*space charge effect (RSI 76 (2005) 103503*
2006	*Laser spectroscopy of radioactive Be (PRA 74(2006)052503*
2007	*HFS of 7Be+ (PRL 101, 212502 (2008))*
2008	*Garbage Collection idea (present "PALIS")*
2009	*Government Regime change*
2010	*HFS of 11Be+ (PRL 112, 162502 (2014))*
2011	*Earthquake*
2012	*PALIS POP offline studies (NIM B295, 1 (2013)*
2012	*MRTOF online studies (PRC 88, 011306(R) (2013)*
2013	*SLOWRI granted (Abenomics)*
2014	*SLOWRI (hardware) installed*

SLOWRI *Phase 1.5*

M.Wada et al



Universal Slow RI beam production based on the rf ion guide method

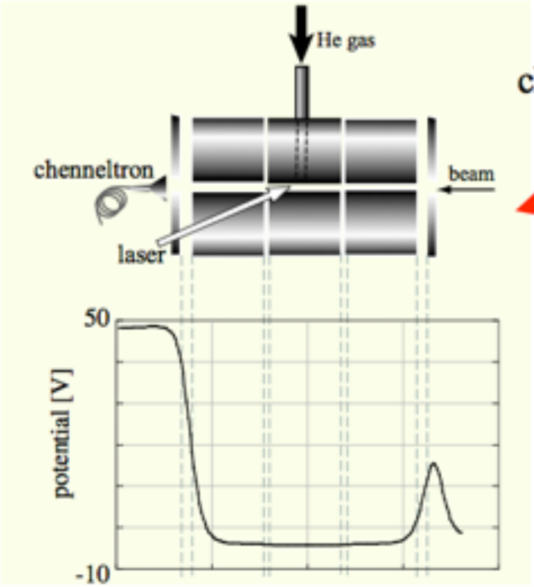


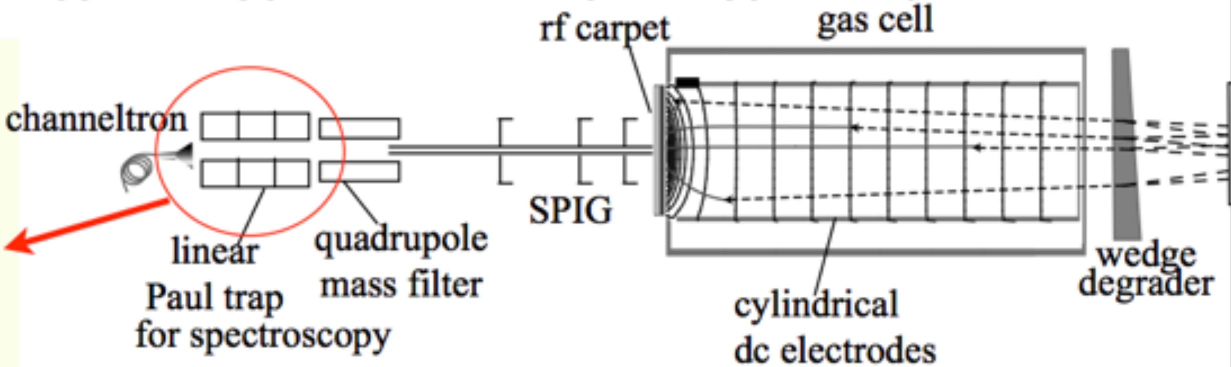
1. Wide Range of Nuclides
   No Chemical Processes in Production & Separation
2. High Purity
   No Isobar No Isotone Contamination
3. Small Emittance
4. Variable Beam Energy
   1-50 keV Slow Beam, <1eV Trapped RI, 1MeV/u (future option)
5. Human Accesibility during On-line Exp.

"Super ISOLDE"

~~Minor ISOLDE~~

Laser Spectroscopy of Trapped Be ions @prototype setup



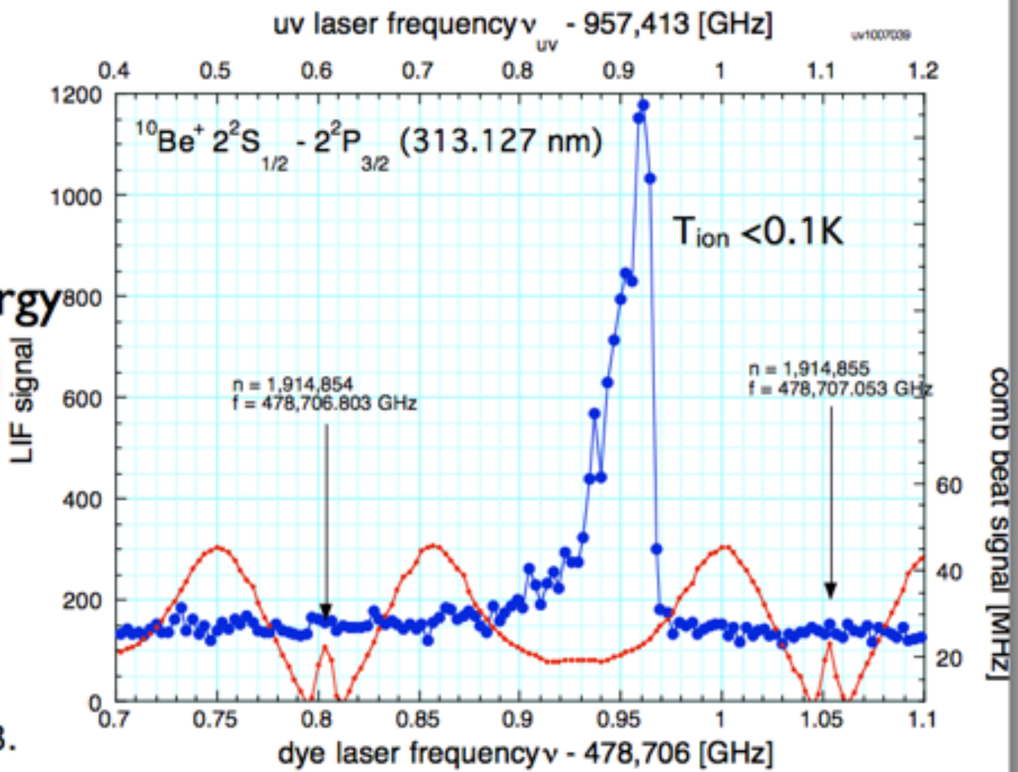


cooling

10^9 eV to 10^{-4} eV in kinetic energy

10^{-13} fold reduction!

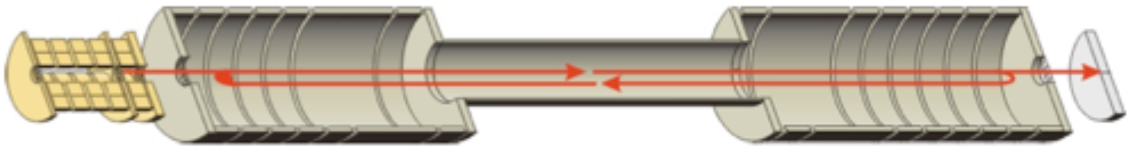
Isotope Shifts → charge radii,
HFS spectroscopy
(BW -effect) → valence n radiii
are in progress.

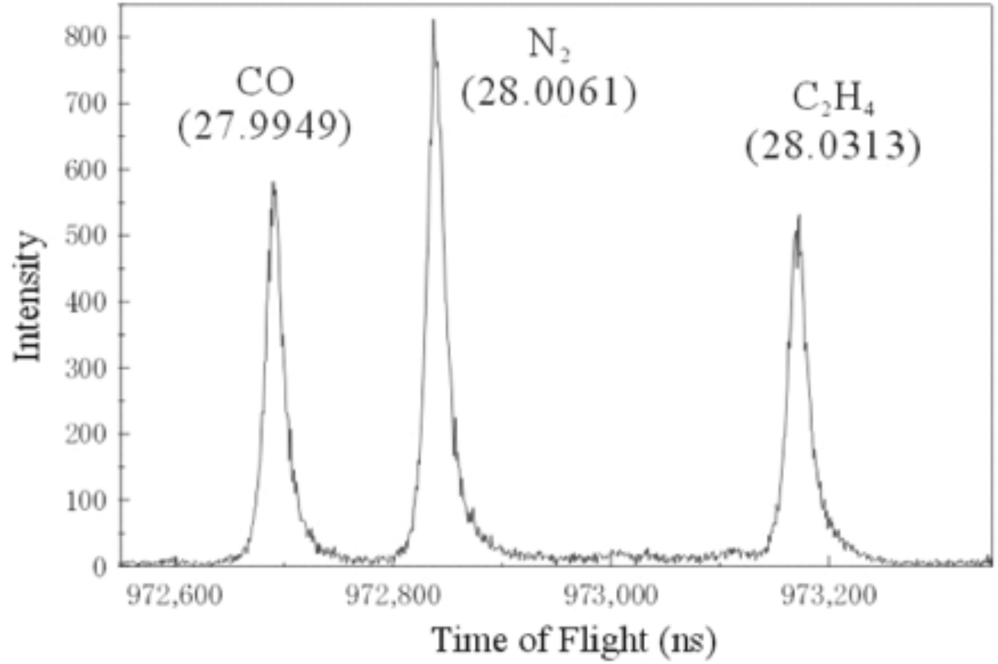


T. Nakamura et al, PRA 74(2006)052503.

Multi-Reflection TOF Mass Spectrometer

Y. Ishida, H. Wollnik et al





1) Short Meas. Time (~2ms)
2) Simple Operation
   Independent from
   Accelerators, RIPS..
3) Simultaneous Isobar meas.
   easy Mass reference
4) High efficiency
   Measurements/ beamtime

Mass Resolving Power
60,000 (TOF~2ms)

$\delta M/M = 6 \times 10$^-7

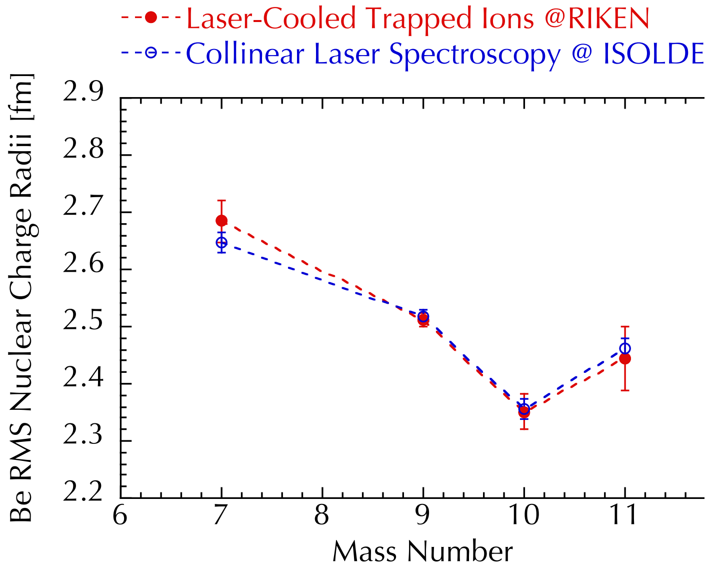
Accuracy Check (Triplet)
δ=5.1(17.8) keV/c²

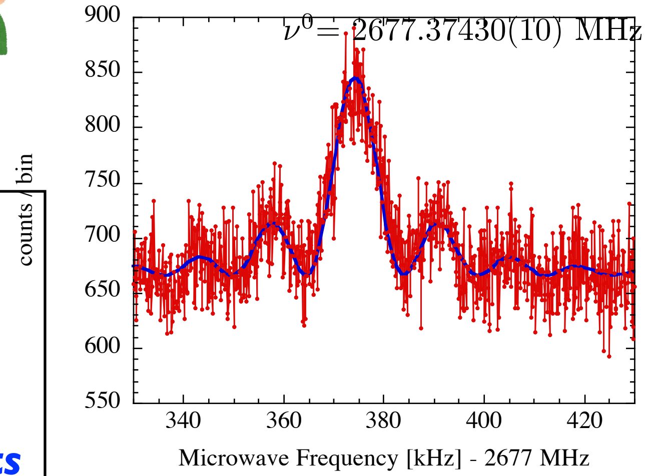
200,000 has been achieved with 7ms meas.

Competitions

Past

	ISOLDE	SLOWRI(prototype)
Laser Spectroscopy of Be isotopes		
Charge radii	PRL 102,062503(2009)	EPJ 10883(2009) sub. to PRC
Hyperfine const.		PRL 101,212502(2008) PRL 112,162502(2014)
First MRTOF online exp		
	Nature 498,346(2013)	PRC 88,011306(R)(2013)





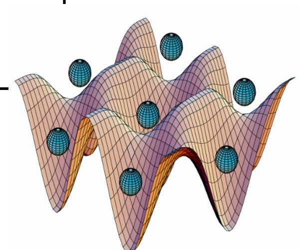
Future

Laser Spectroscopy of DIFFICULT Elements

MRTOF Mass Measurements of DIFFICULT & Short-Lived Elements

Ultra-High Precision Spectroscopy with Optical Lattice Clock

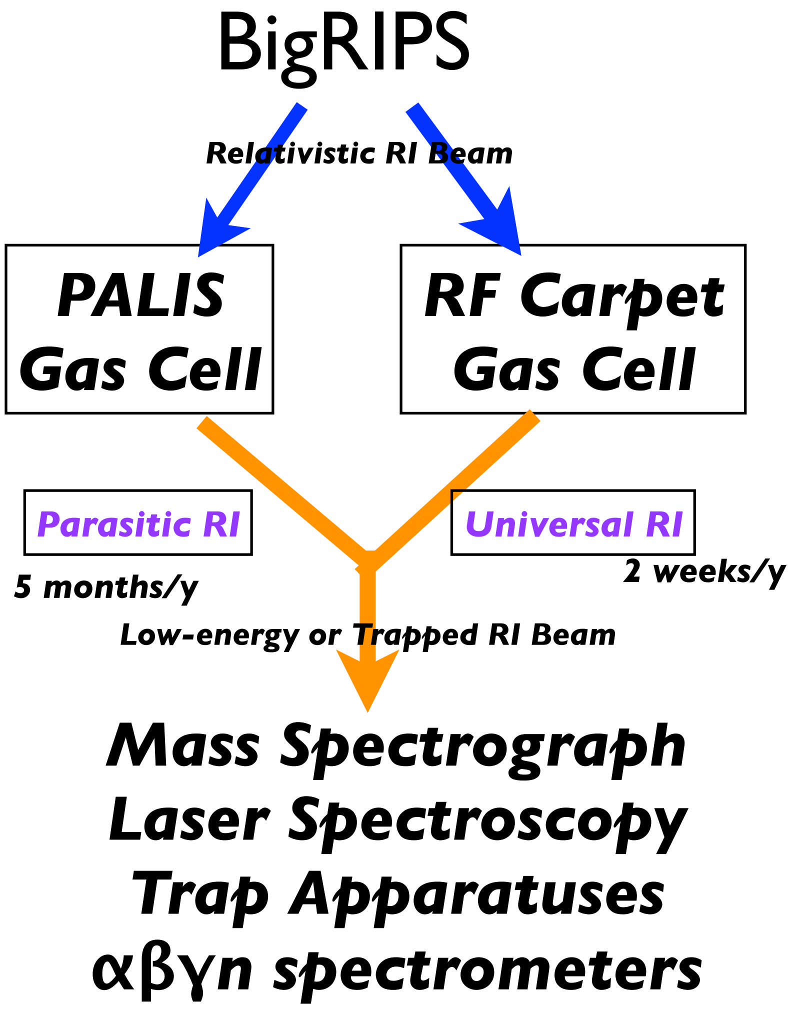
18-digits

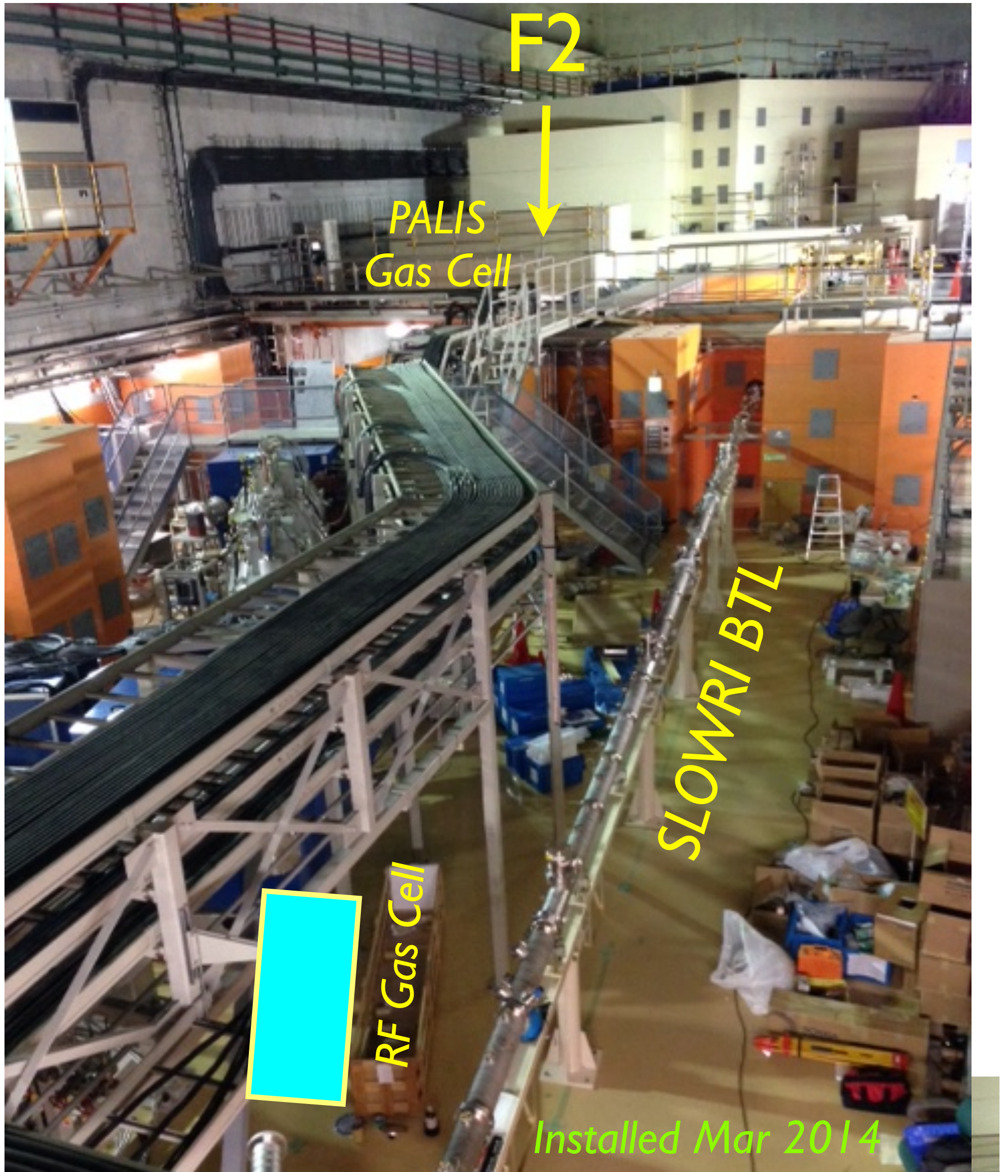


H. Katori
Système Riken

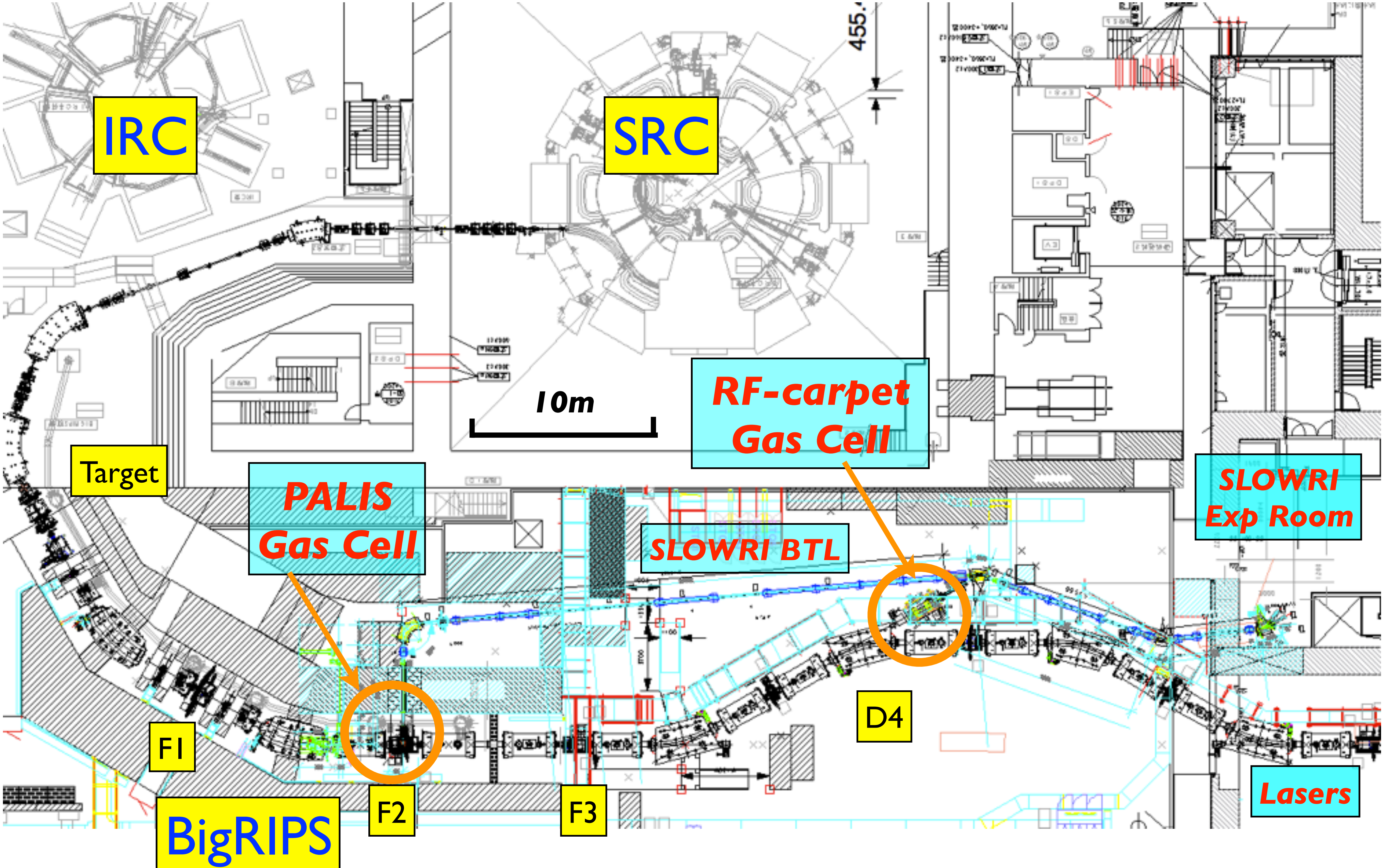
SLOWRI

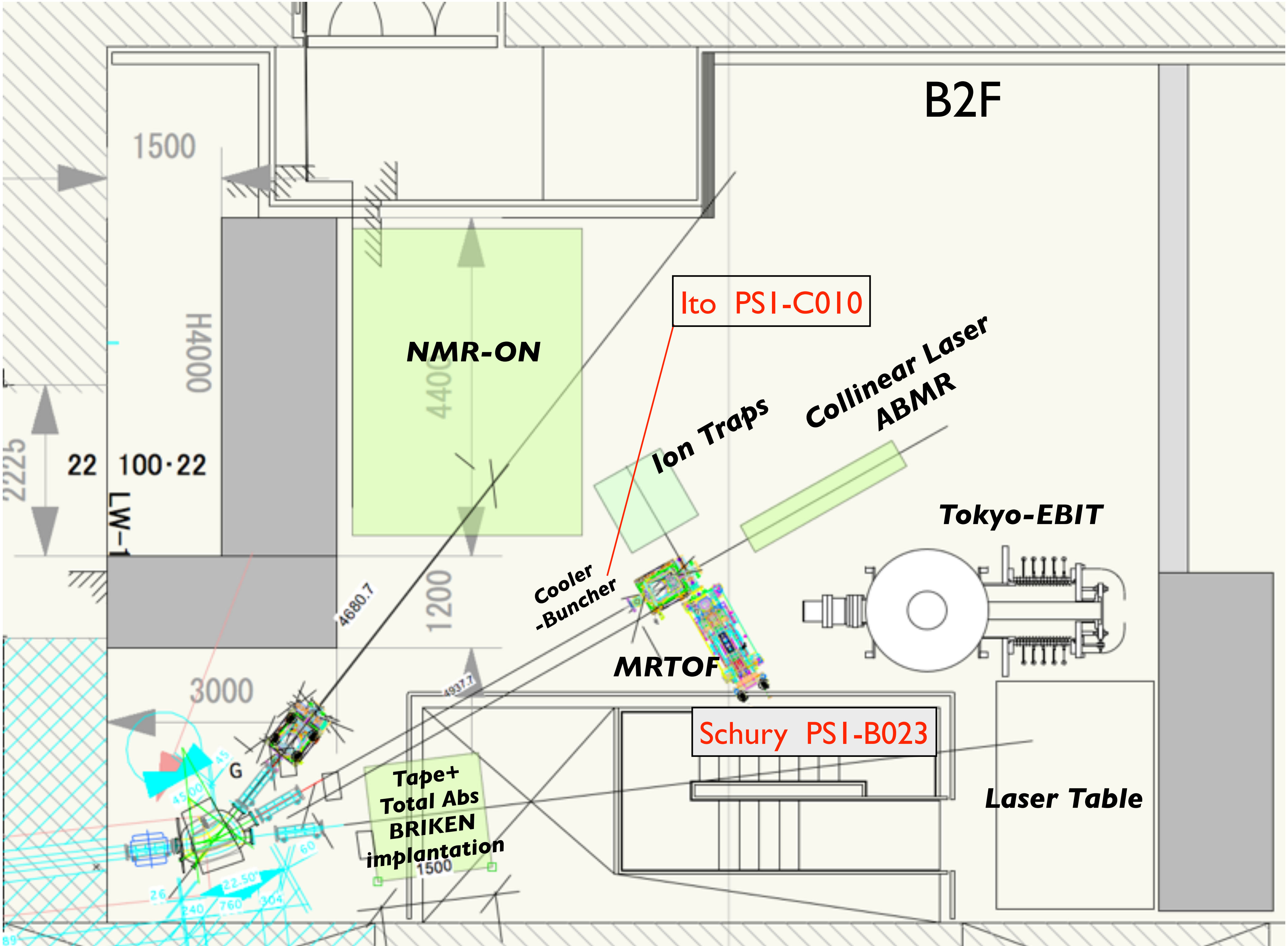
Stopped and low energy RI-beams of all elements for comprehensive precision spectroscopy





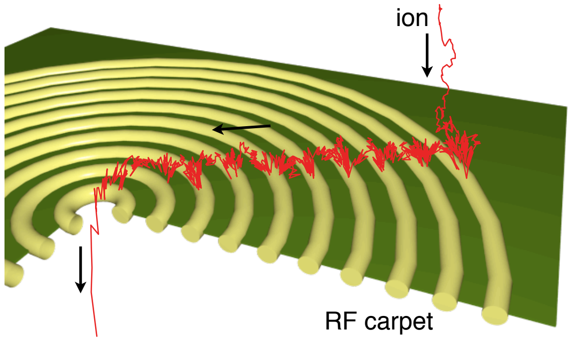
SLOWRI at RIBF





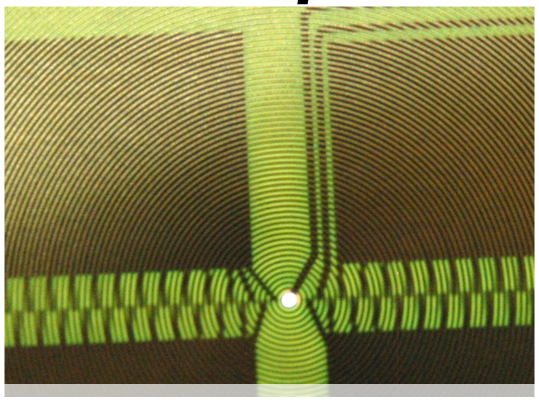
B2F
1500
H4000
NMR-ON
4400
Ito PS1-C010
Ion Traps
Collinear Laser
ABMR
Tokyo-EBIT
Cooler
-Buncher
MRTOF
2225
22
100・22
LW-1
4680.7
1200
3000
4937.7
Schury PS1-B023
Tape+
Total Abs
BRIKEN
implantation
1500
Laser Table
G

RF Carpet Gas Cell -bird's eye view-



Arai PS1-C008

RF Carpet



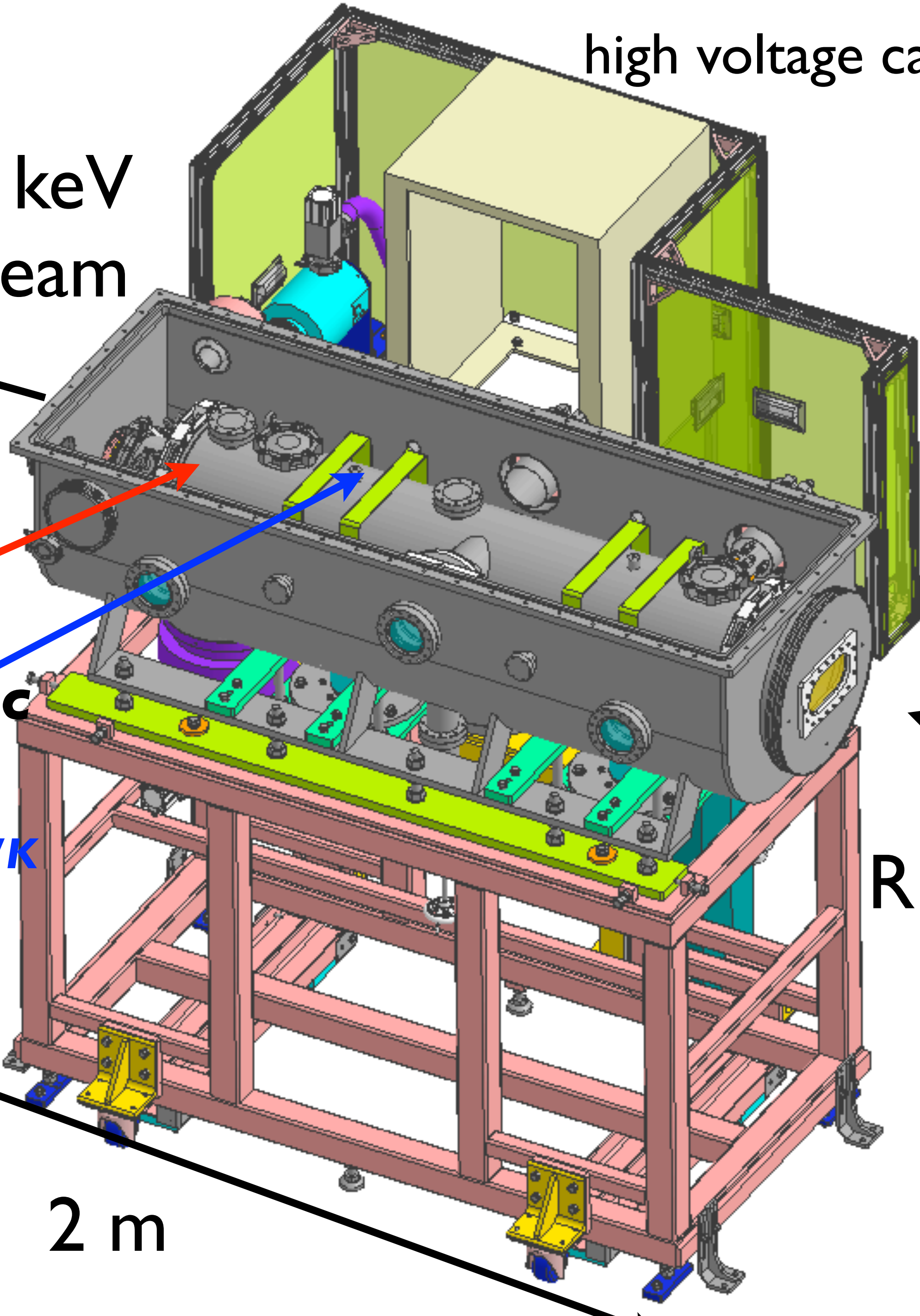
pitch: 160 um (80+80)
exit orifice: 320 umΦ
diameter: 120 mmΦ

<30 keV
RI beam

cryogenic gas cell

2x175W@77K

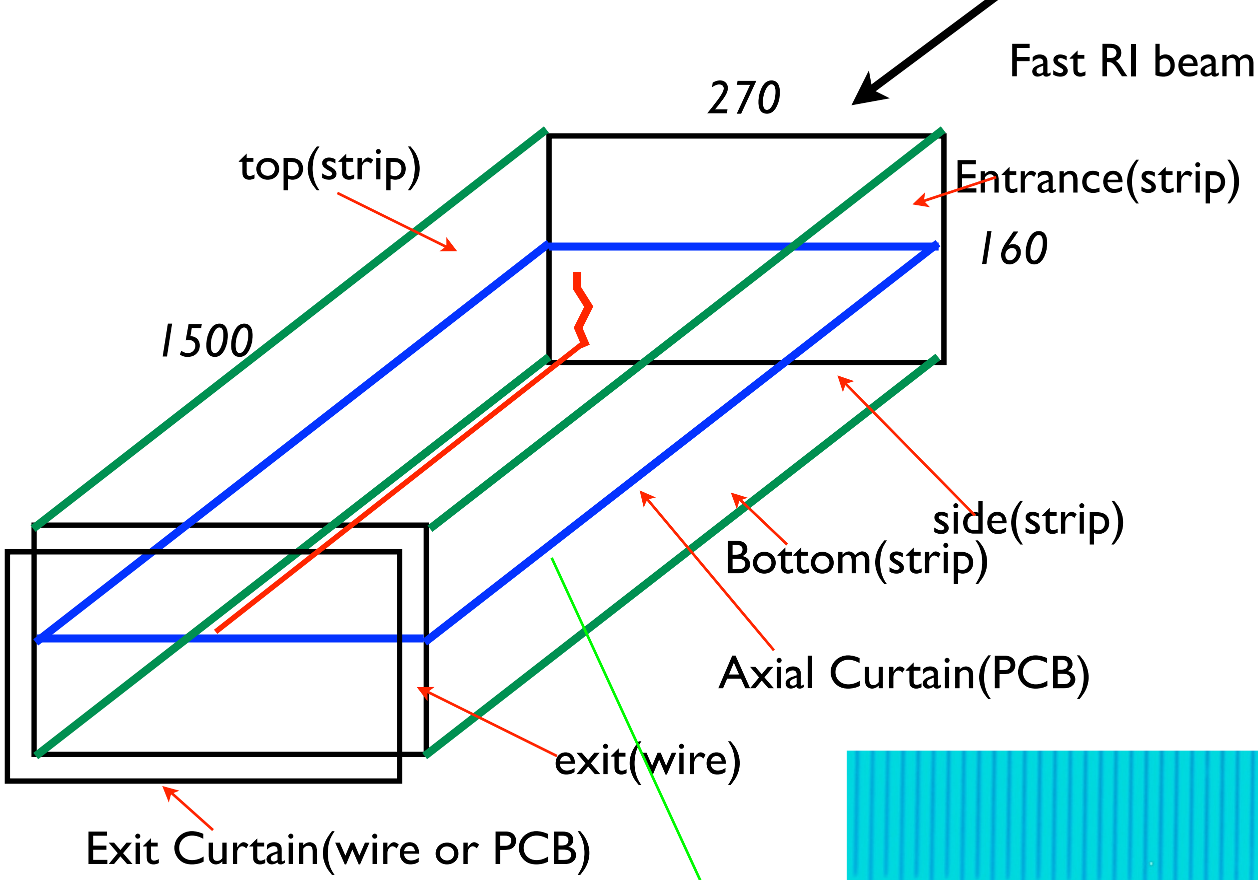
high voltage cage

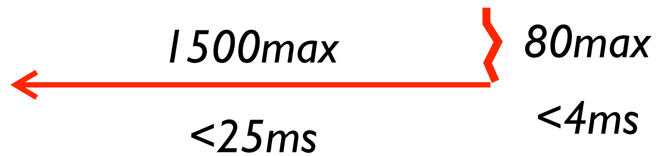


Fast
RI Beam

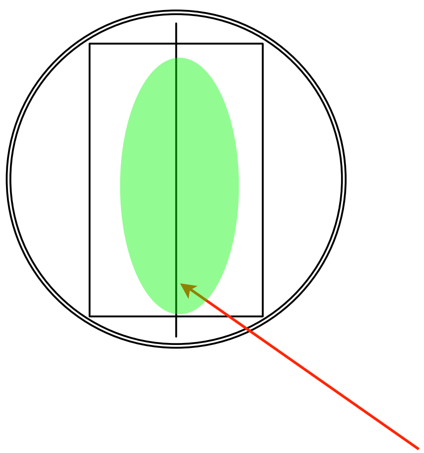
2 m

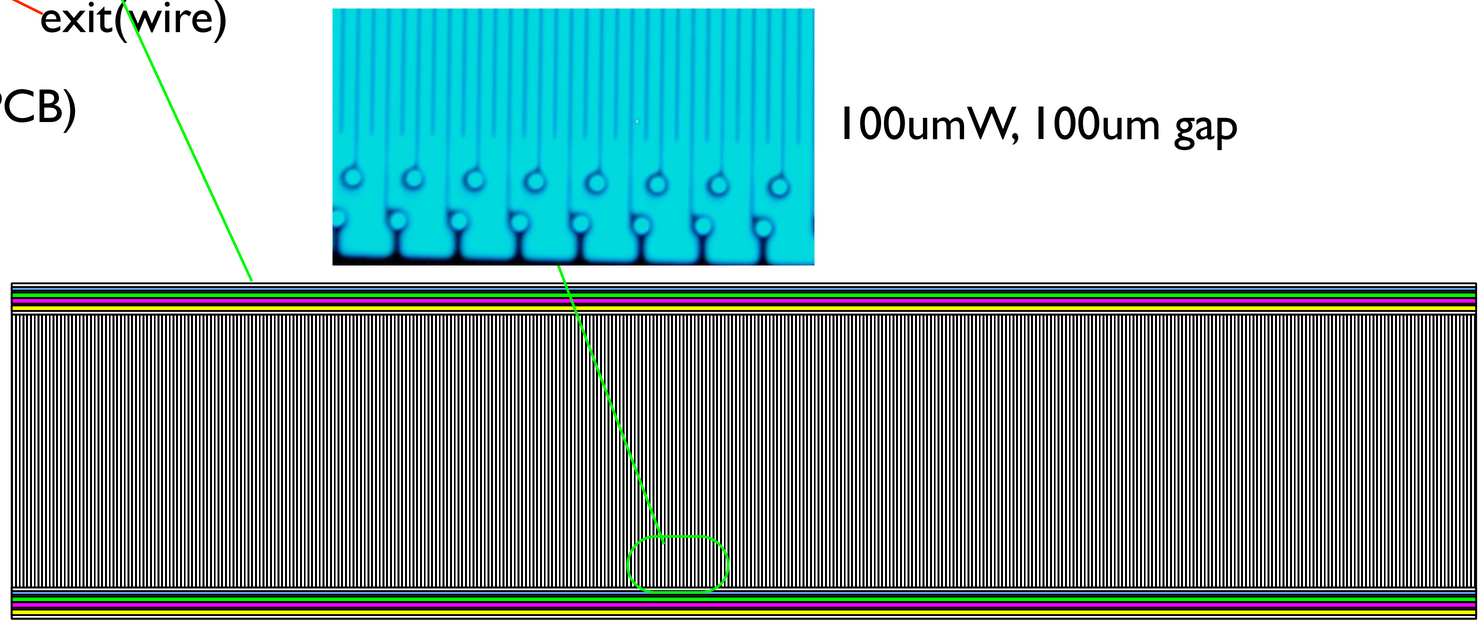
RF transport structure in the cell





total: 30 ms max
10 ms nominal





100umW, 100um gap

Axial Curtain

ion surfing mode transport on a rf curtain

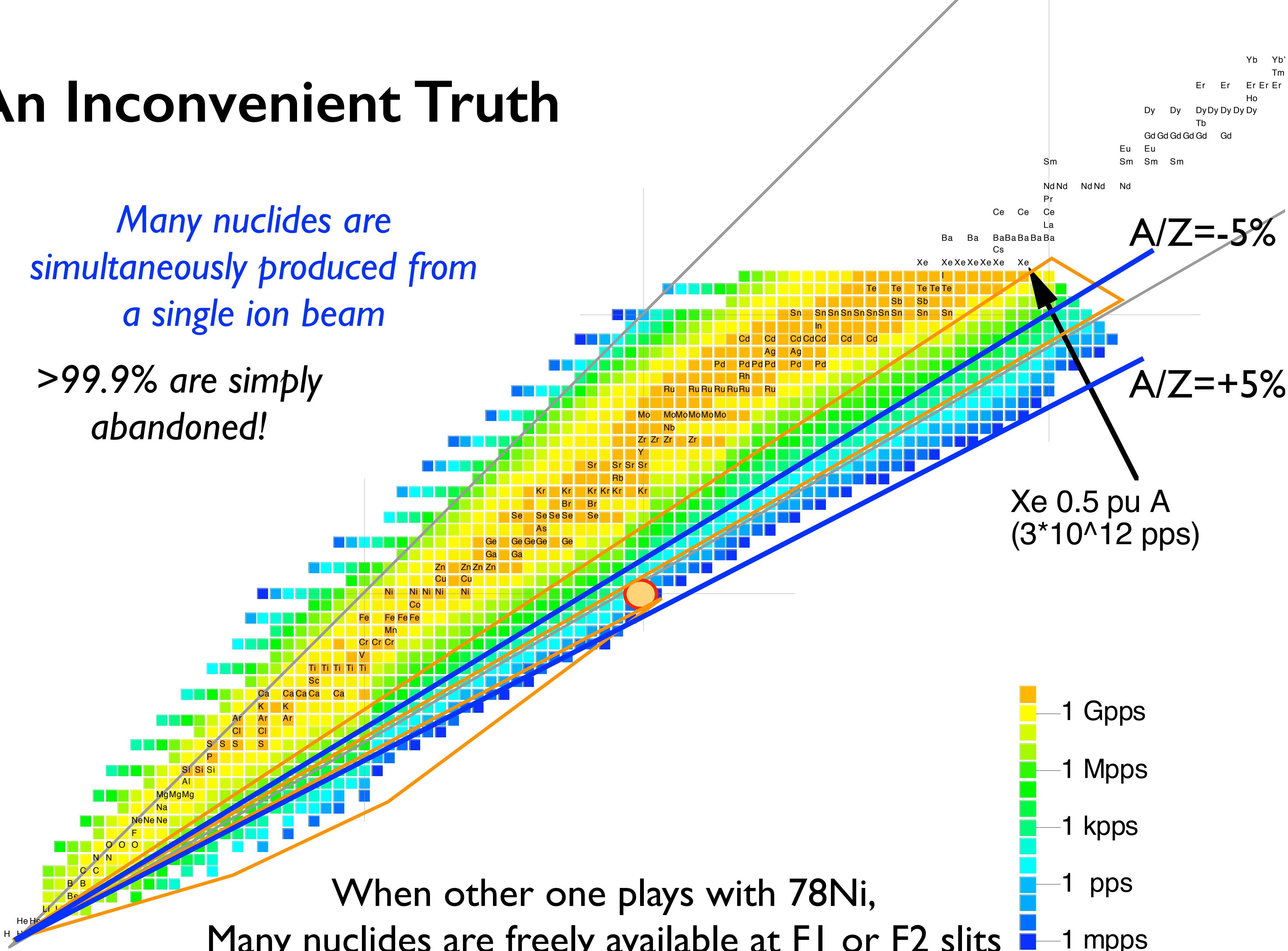
S. Masuda 1972, G. Bollen 2011

IJMS 299(2011)131

An Inconvenient Truth

Many nuclides are simultaneously produced from a single ion beam

>99.9% are simply abandoned!

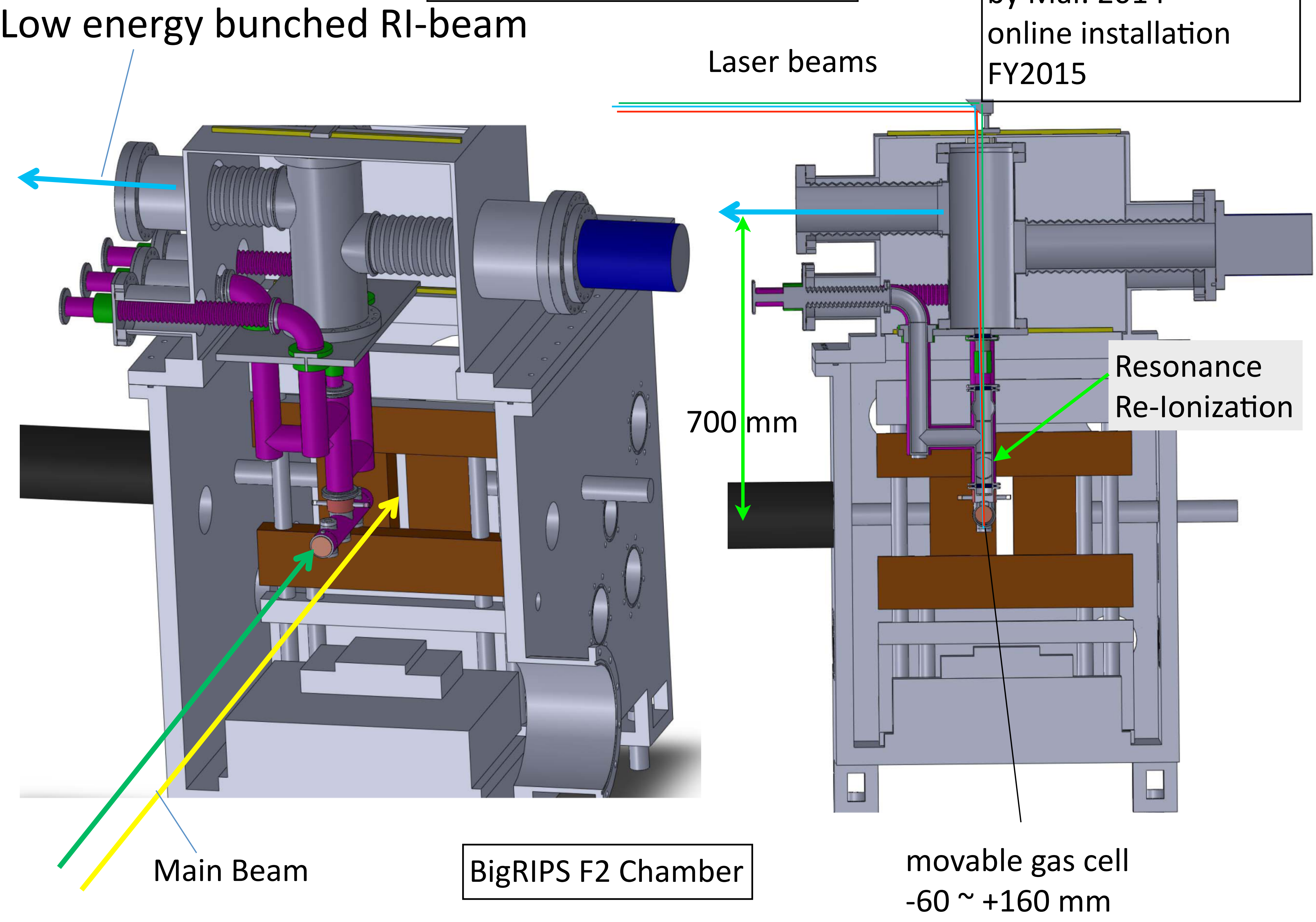


When other one plays with 78Ni,
Many nuclides are freely available at F1 or F2 slits

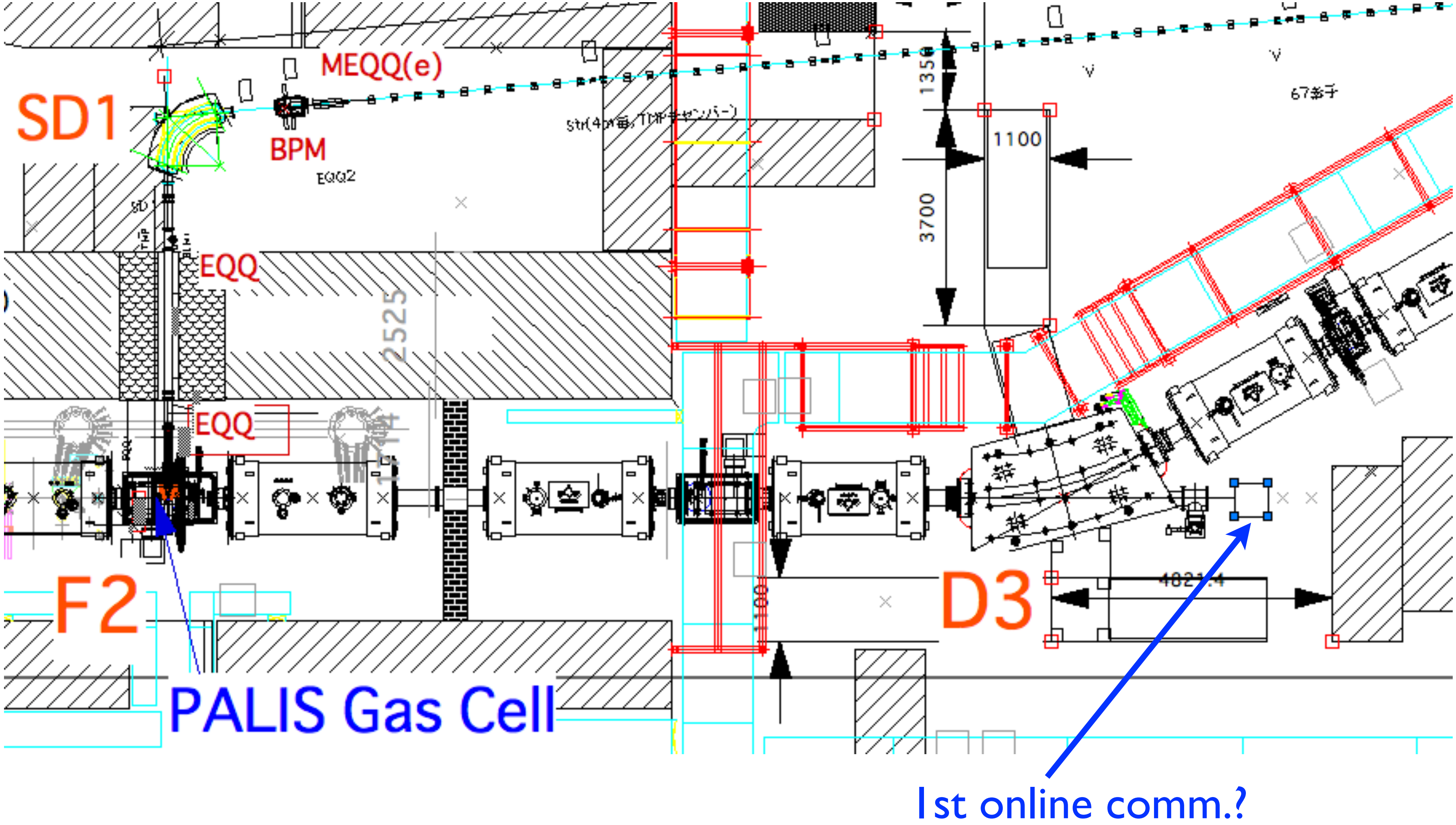
Sonoda PS2-C001

PALIS Gas Cell

offline installation
by Mar. 2014
online installation
FY2015

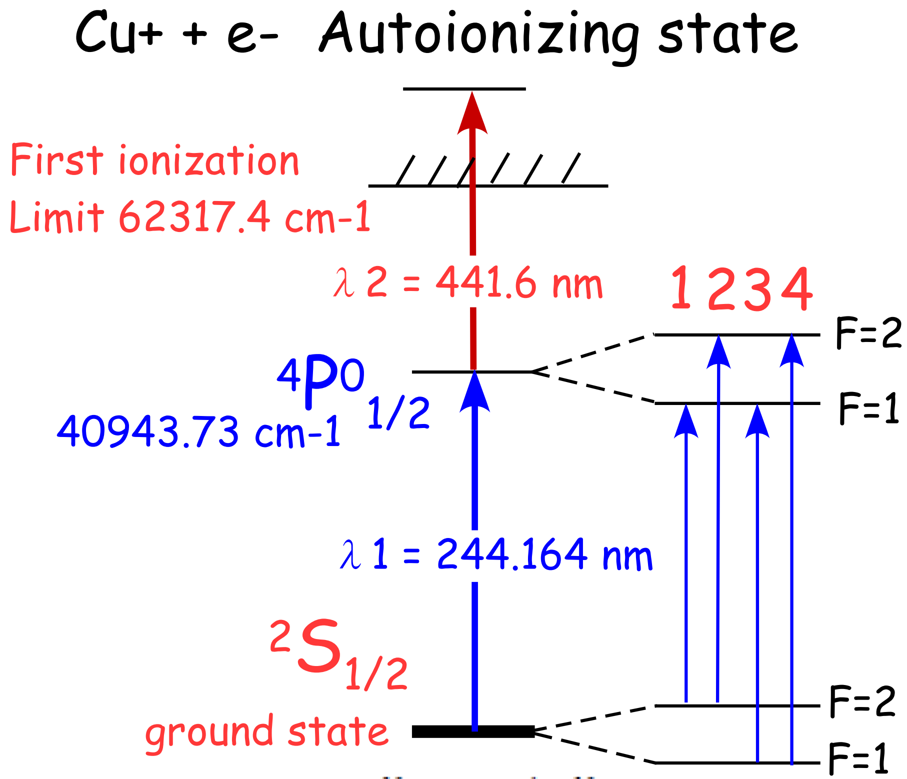


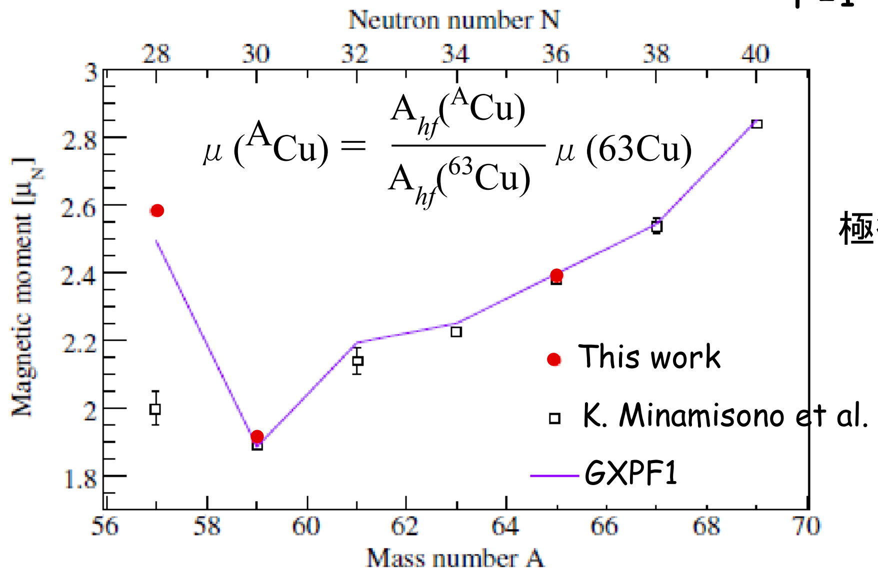
DayZero exp. of PALIS



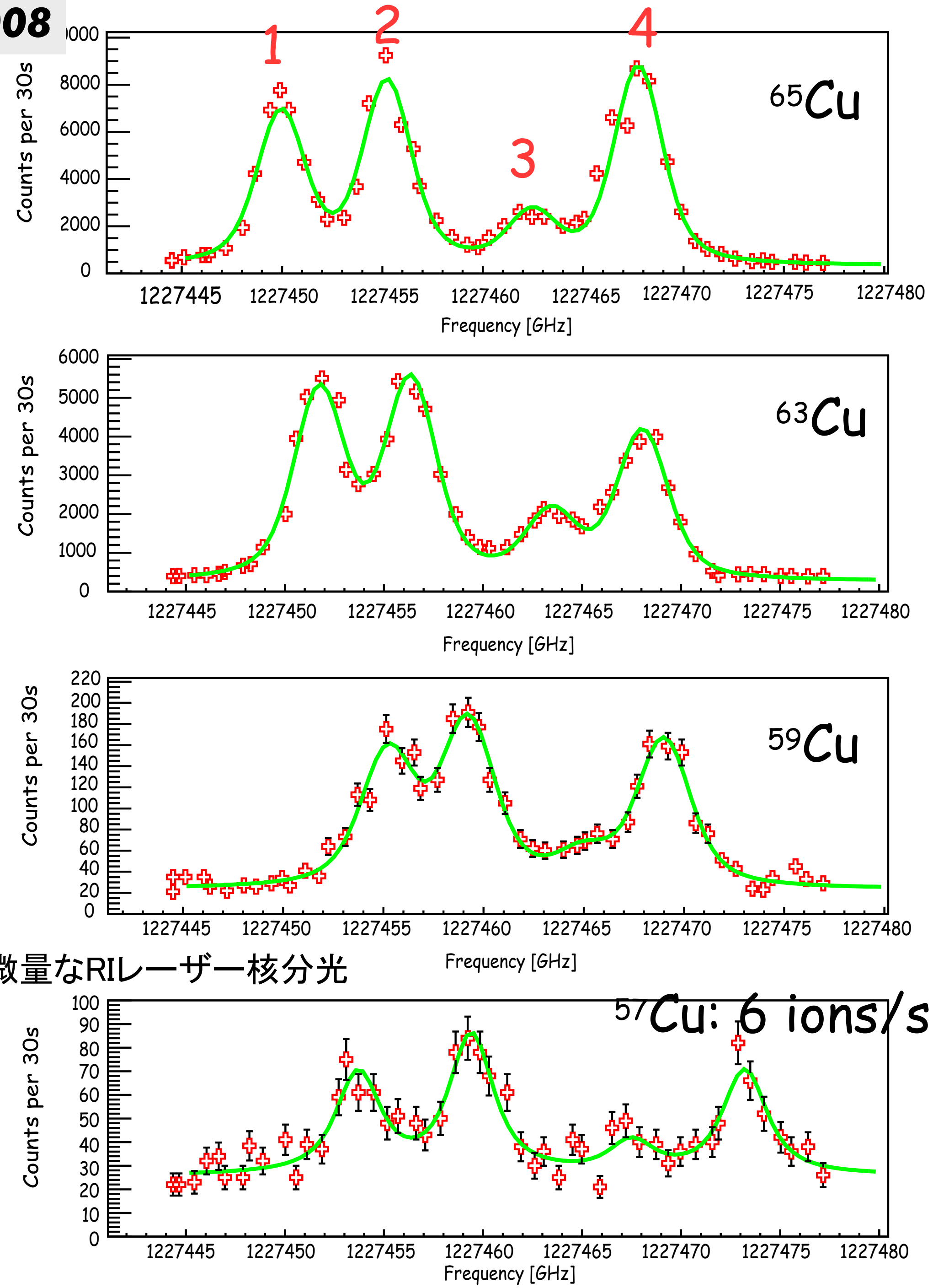
RIS spectroscopy for Cu, In isotopes @D3_out

Ex. RIS Spectroscopy in Gas Cell @Leuven 2008



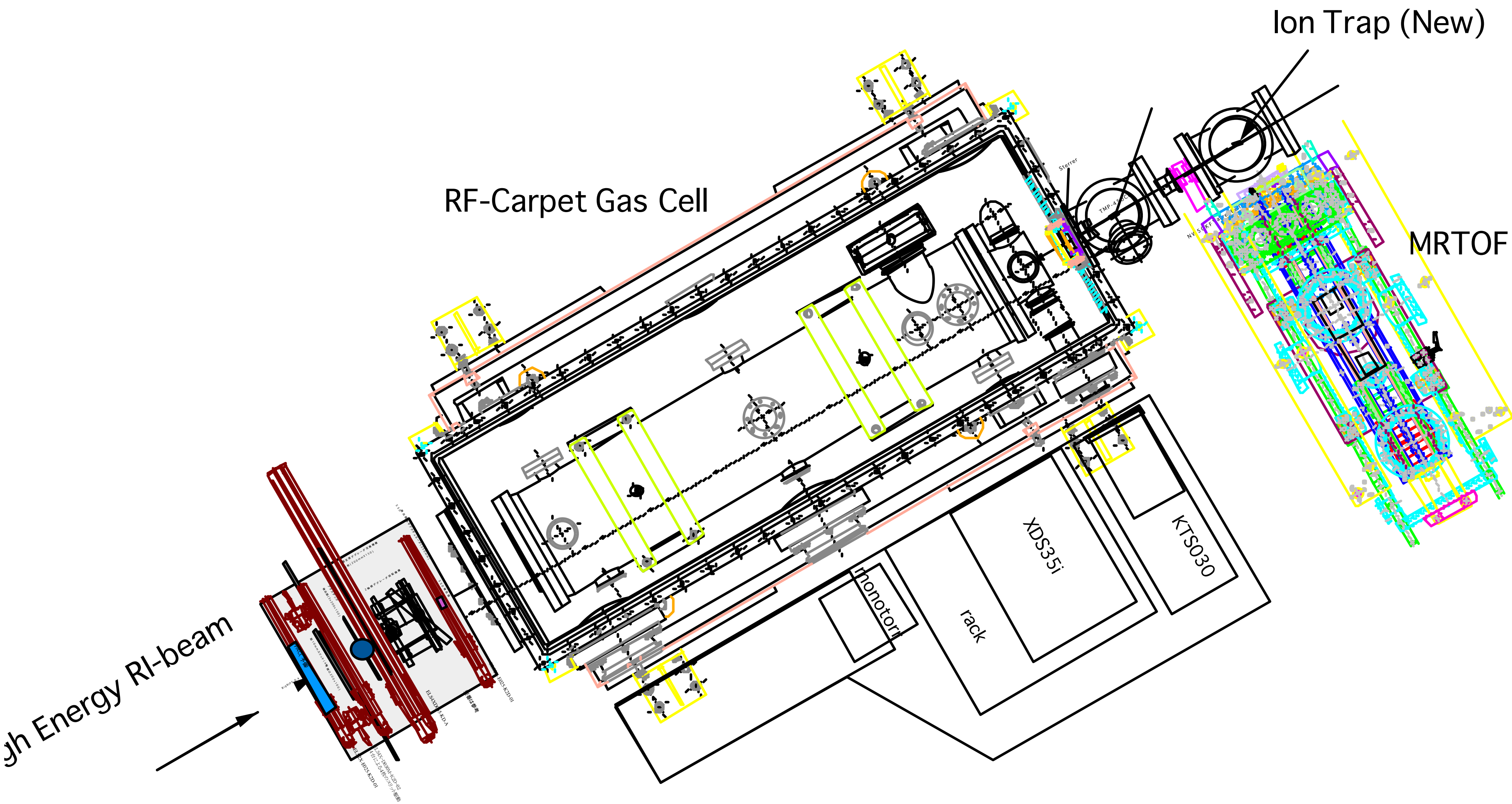


極微量なRIレーザー核分光



T.E. Cocolios, A.N. Andreyev, B. Bastin, N. Bree, J. Buscher, J. Elseviers, J. Gentens, M. Huyse, Yu. Kudryavtsev, D. Pauwels, T. Sonoda, P. Van den Bergh and P. Van Duppen Phys. Rev. Lett. 103, 102501-3 (2009).

Day zero exp @ rf gas cell



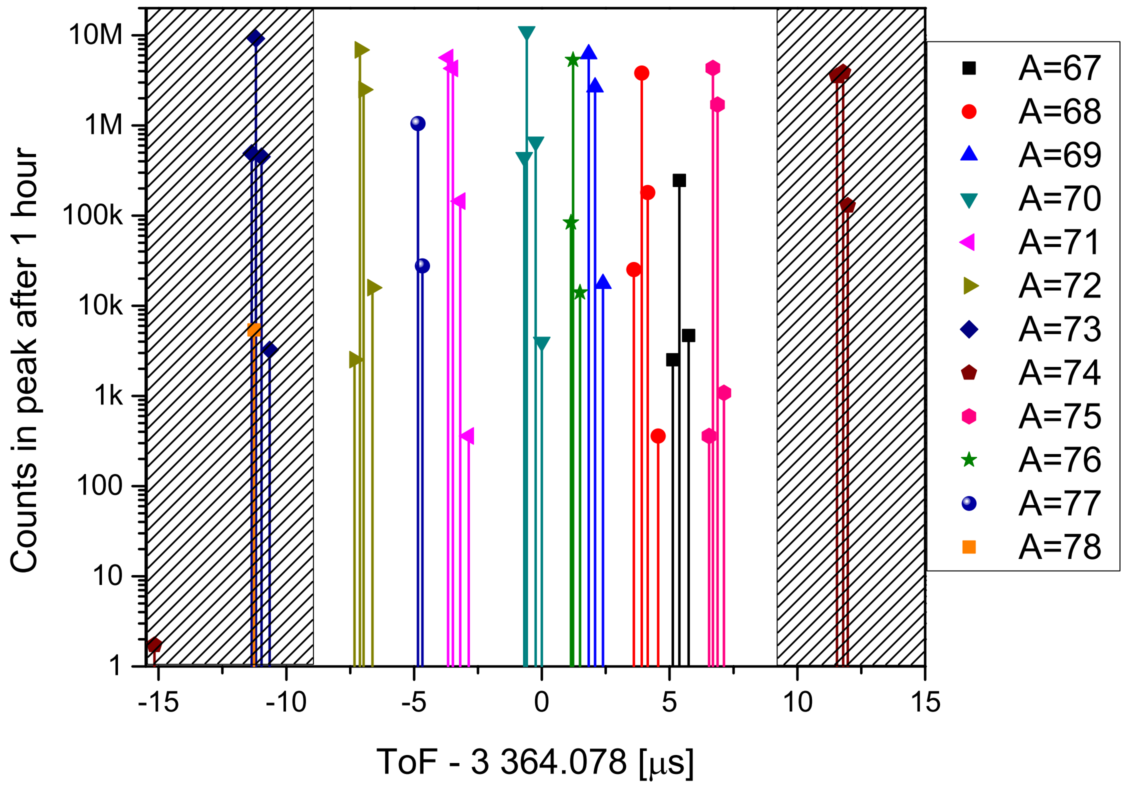
direct coupling of MRTOF to Gas Cell

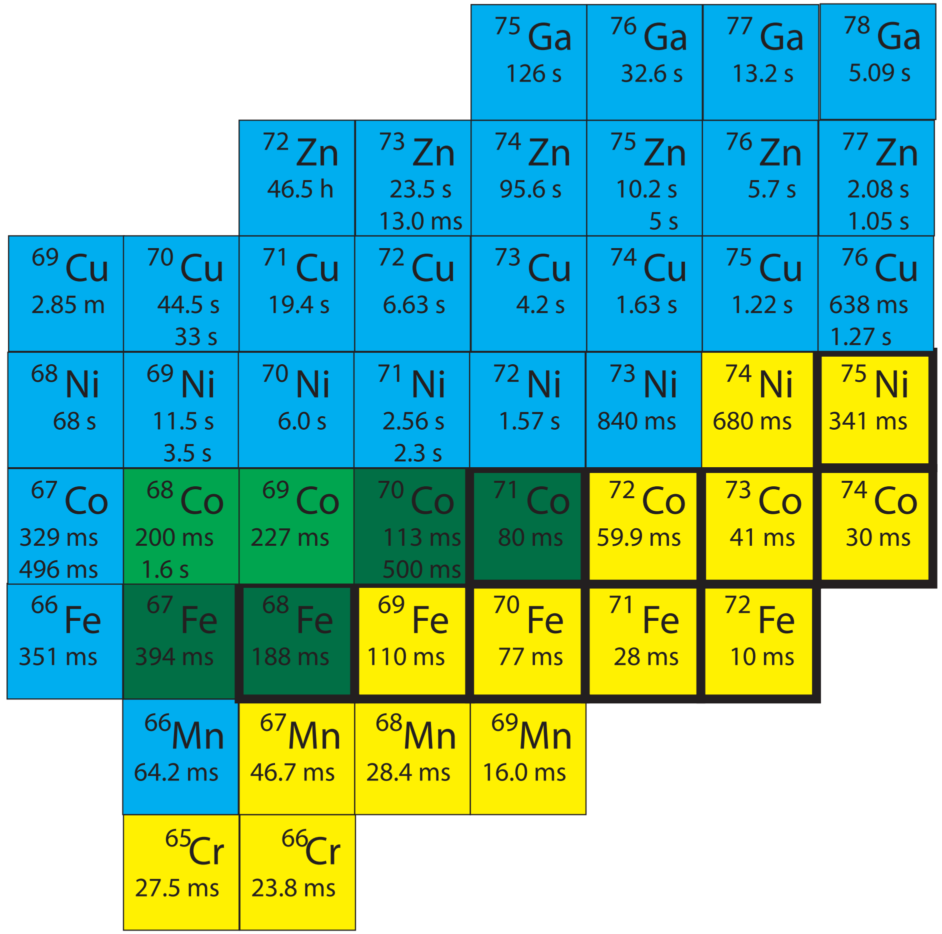
Wide band mass spectrograph

Schury PS1-B023

simultaneously measure multiple A nuclides

P. Schury et al, IJMS, 359(2014)19





Different A ions have different # of laps,
Identification of # laps is possible by a simple algorithm.

- Lets see the results in ARIS 2017 in North America

Two type gas cell for SLOWRI

pros & cons

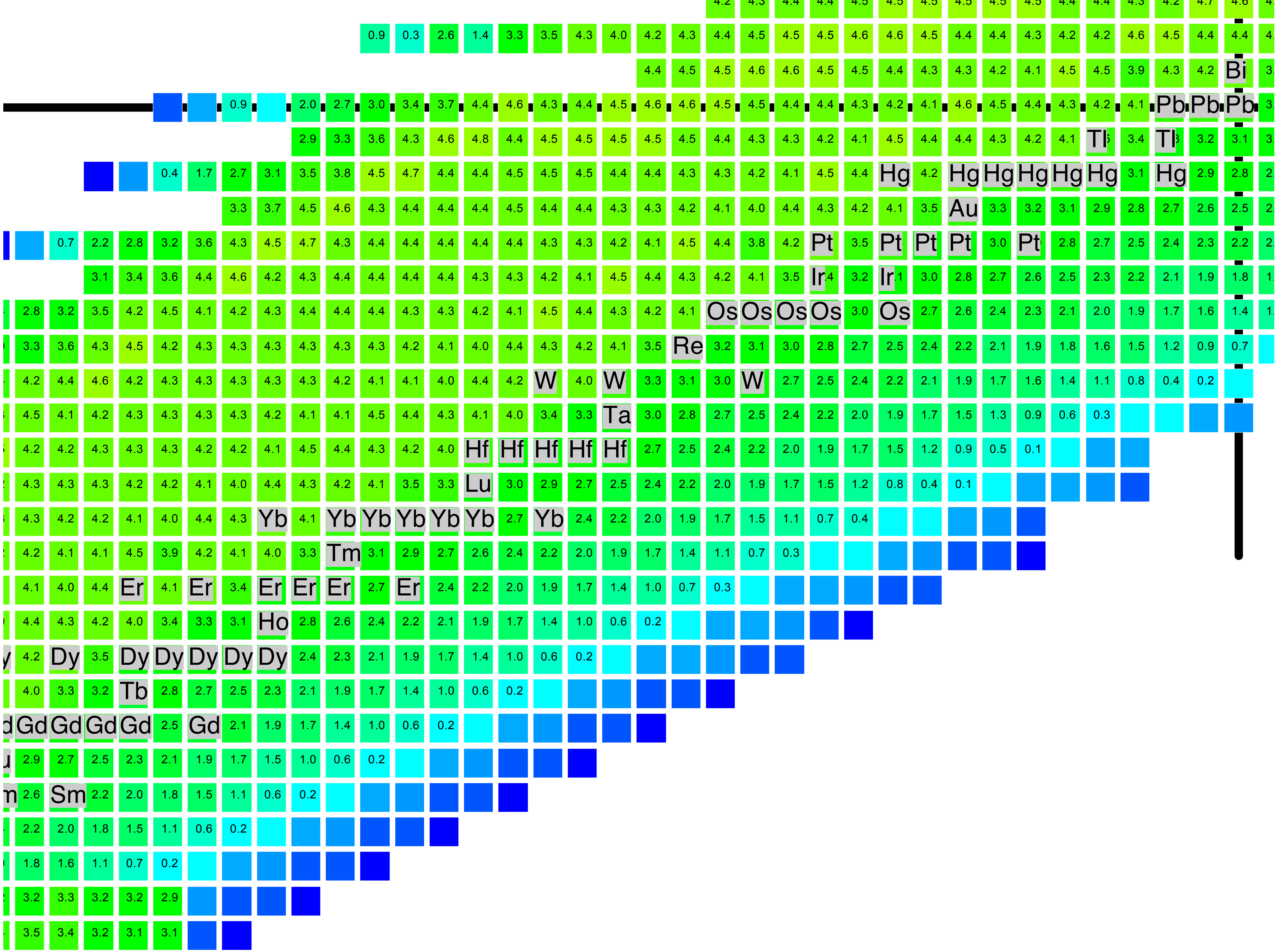
	RF-carpet Gas Cell	PALIS Gas Cell Laser IS	PALIS IGISOL	ISOL
elements	≈all	≈70% elements	≈all	<50%
nominal extraction	≈10 ms	≈0.1 s	≈0.1 s	≈1s
total efficiency	≈10 %	≈1 %	≈1 %	
availability	< 2 weeks/year	≈everyday	≈everyday	
purity	○	◎	△	X

under reevaluation by Sonoda

very complementary

daily exp. using PALIS,

particular nuclei using RF gas cell with main beam


Bi
Pb
Tl
Hg
Au
Pt
Ir
Os
Re
W
Ta
Hf
Lu
Yb
Tm
Er
Ho
Dy
Tb
Gd
Sm

Trapped Charged Particles and Fundamental Physics 2014

December 1 – 5, 2014

Takamatsu, Shikoku Island, Japan

1st circular

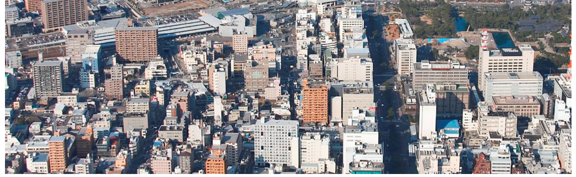
The sixth international conference on Trapped Charged Particles and Fundamental Physics (TCP2014) will be held in Takamatsu, on the Japanese island of Shikoku, during December 1 – 5, 2014. This conference belongs to the series of conferences started in Lysekil (Sweden) in 1994, followed by a conference at Asilomar (USA) in 1998, Wildbad Kreuth (Germany) in 2002, Parksville on Vancouver Island (Canada) 2006 and Saariselkä, northern Finland in 2010. The conference in Takamatsu will focus on recent developments and highlights in the field of trapped charged particles. In particular, it will address the following scientific fields:

- Fundamental Interactions and Symmetries
- Quantum and QED Effects
- Precision Spectroscopy and Frequency Standards
- Anti-Hydrogen
- Plasma Effects and Collective Behavior
- Ion Traps for Radioactive Nuclei and Highly Charged Ions
- Storage Ring Physics
- Applications of Particle Trapping: Chemistry, Trace Analysis, …

The conference will consist of both invited and contributed lectures, as well as a poster session. The conference venue will simultaneously host the 11th International Workshop on Non-Neutral Plasmas (NNP2014) and a joint session will be held.

The TCP conference will be preceded by a school on Trapped Charged Particles at RIKEN in Wako, Japan, during November 28-29. This will provide a perfect opportunity for graduate students to directly interact with and gain knowledge from leading figures in the field of trapped-ion physics prior to the conference.

Up-to-date conference information will be available at the conference website http://tcp2014.riken.jp or by emailing "tcp2014 at riken.jp"



Local Organizers (tentative):

H. Higaki, Hiroshima University
A. Ozawa, Tsukuba University
P. Schury, RIKEN (Scientific Secretary)
T. Uesaka, RIKEN
N. Nakamura, University of Electro-Communications
Y. Sakemi, CYRIC, Tohoku University
H. Ueno, RIKEN
M. Wada, RIKEN (Chair)

International Advisory Committee (tentative):

J. Äystö, University of Helsinki
K. Blaum, MPI for Nuclear Physics, Heidelberg
A. Czarnecki, U. Alberta
M. Doser, CERN
A. Jokinen, University of Jyväskylä
Y.-K. Kim, IBS, Daejeon
X. Ma, Institute of Modern Physics, Lanzhou
G. Savard, ANL/U. Chicago
R. Schuch, Stockholm University
M. Wada, RIKEN
D. Wineland, NIST Boulder
G. Bollen, NSCL/MSU
J. Bollinger, NIST Boulder
J. Dilling, TRIUMF
G. Gabrielse, Harvard University
K. Jungmann, KVI Groningen
H.-J. Kluge, GSI Darmstadt
O. Naviliat-Cuncic, NSCL/MSU
C. Scheidenberger, GSI Darmstadt
N. Severijns, U. Leuven
E. Widmann, S. Meyer Institute Vienna

48 invited speaker candidates

Call for Abstract, soon

School lecturers are not fixed yet