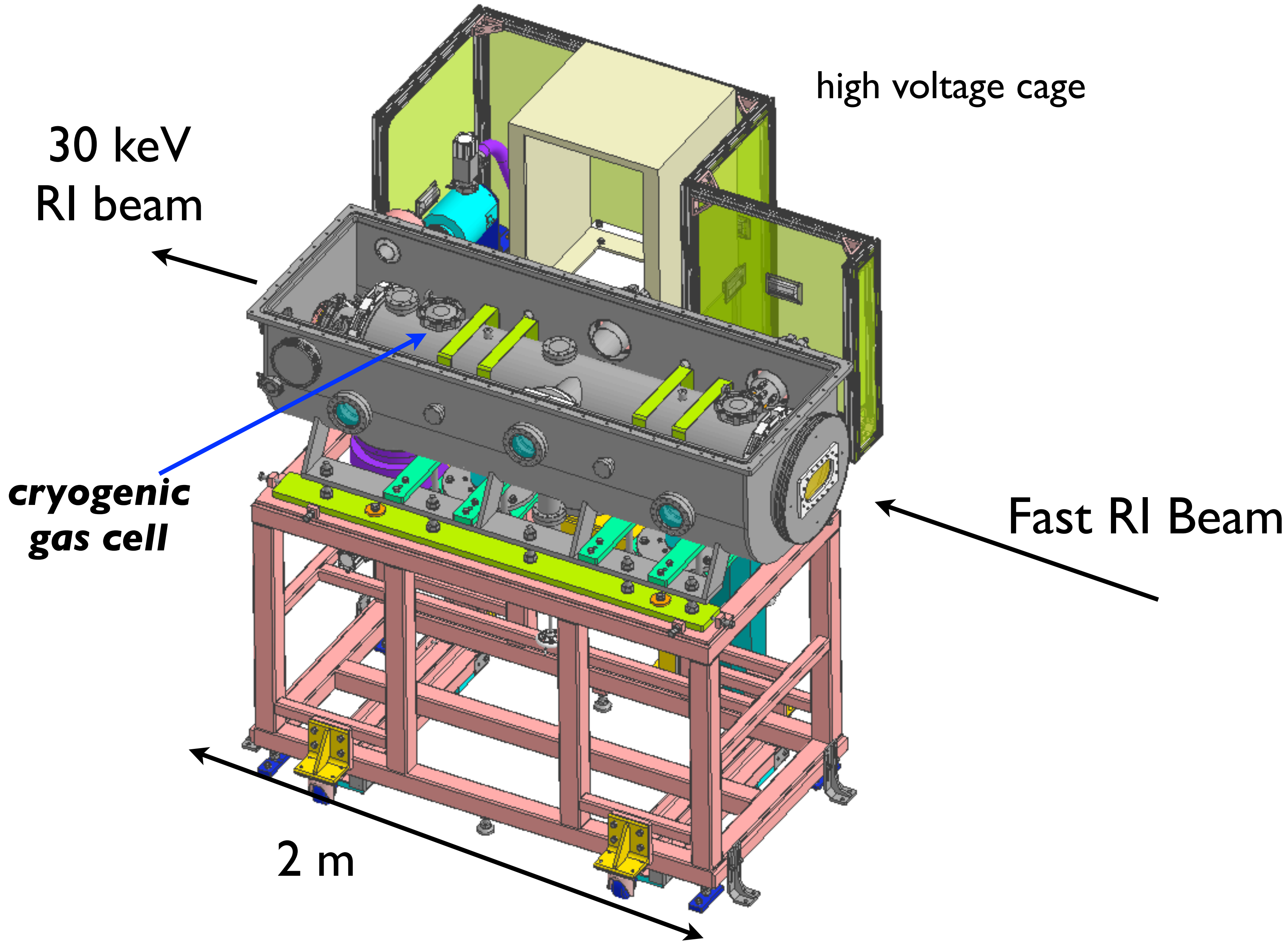
Opportunities with ultra-pure low-energy beams: half-lives, masses and spectroscopy

Peter Schury
RIKEN/SLOWRI

Low-energy beams at RIKEN

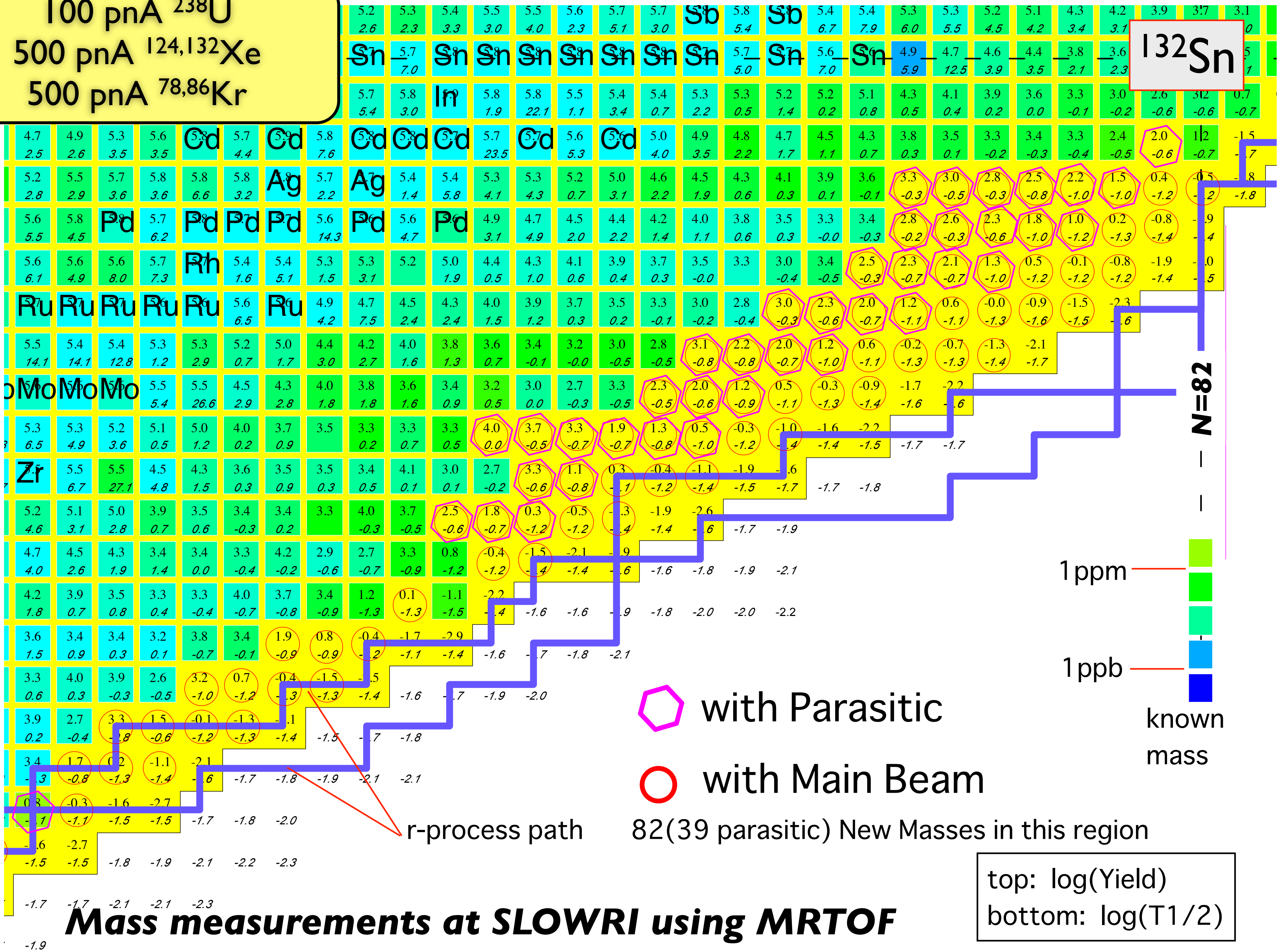
- SLOWRI, RF Carpet Gas Cell
  - Large He gas cell
  - Chemical universality
- SLOWRI, Parasitic Gas Cell (PALIS)
  - Small Ar gas cell
  - Limited to laser ionizable elements
- SlowSHE
  - Small He gas cell
  - designed for SHE

SLOWRI RF Carpet Gas Cell



r-process nucleosynthesis

100 pnA ^{238}U
500 pnA ^{124,132}Xe
500 pnA ^{78,86}Kr



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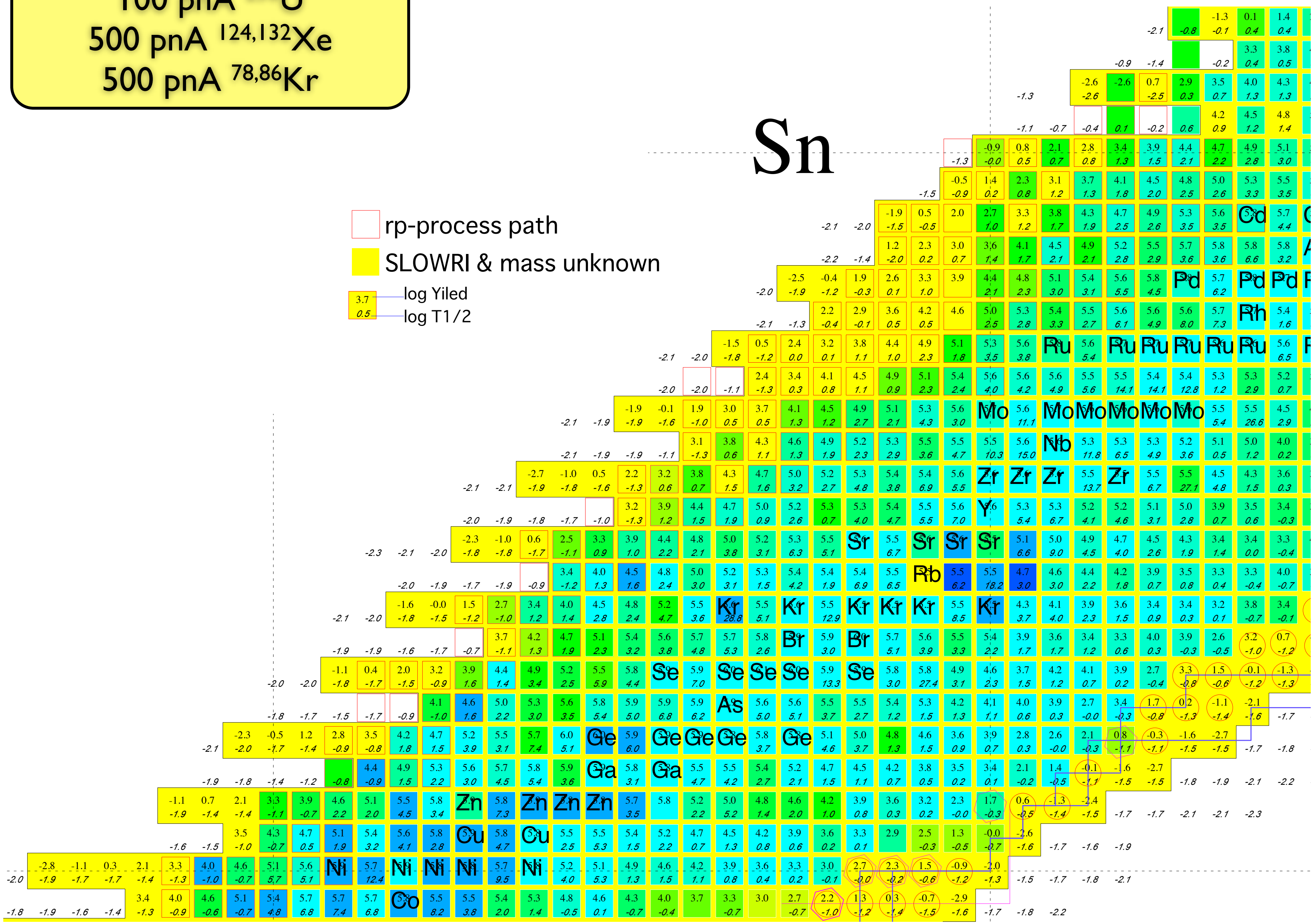

Halo nuclei and Island of Inversion

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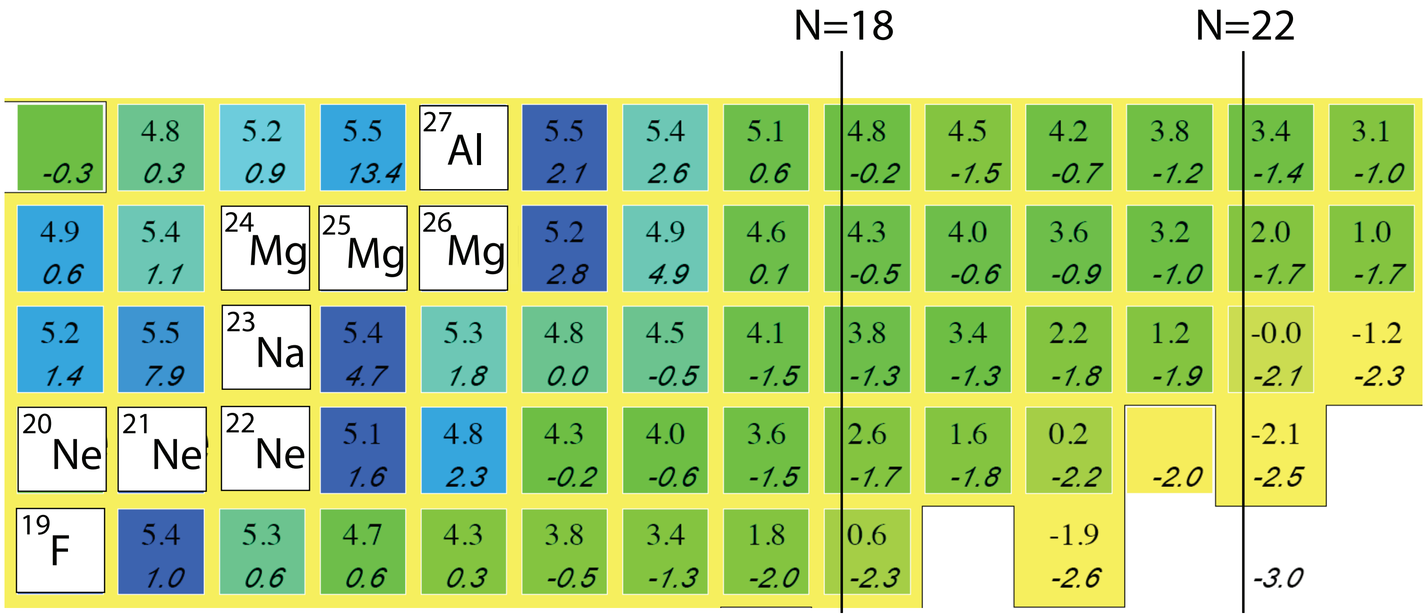
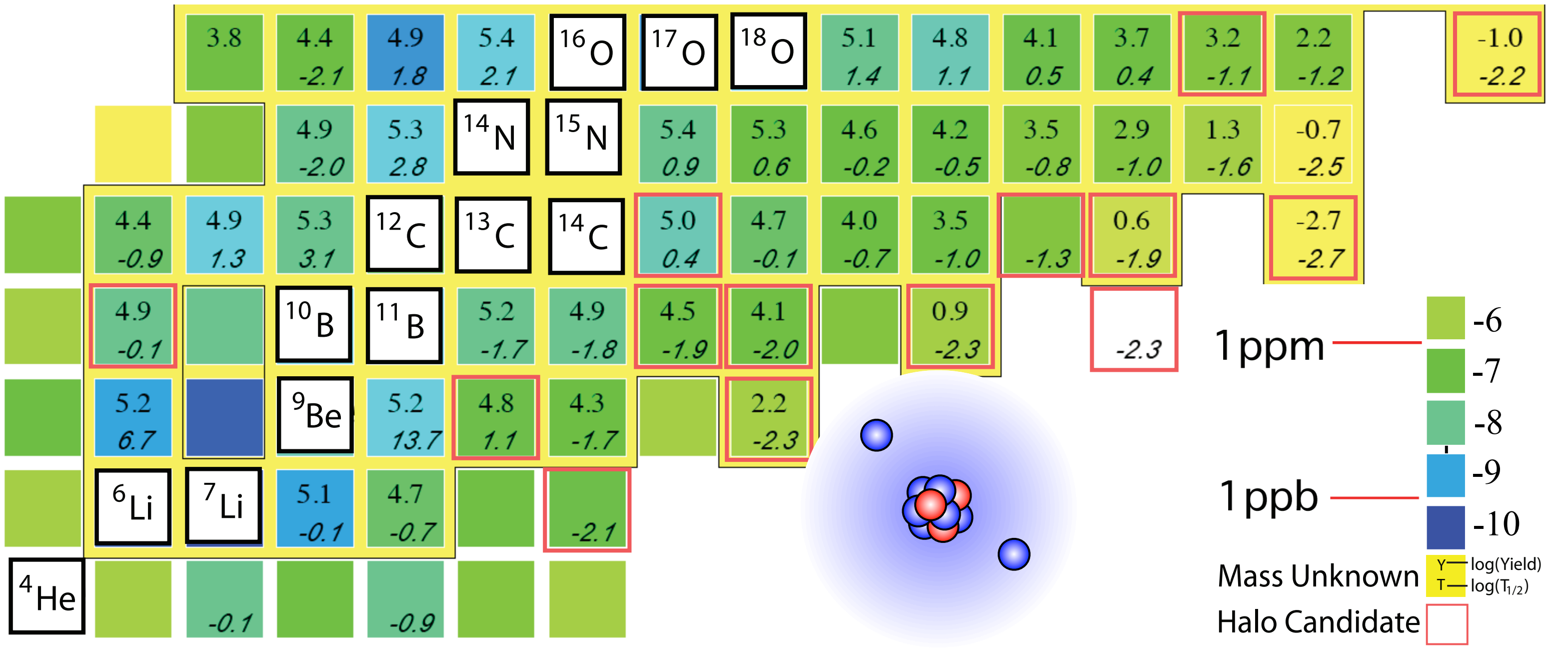
500 pnA $^{78,86}Kr$

Island of Inversion

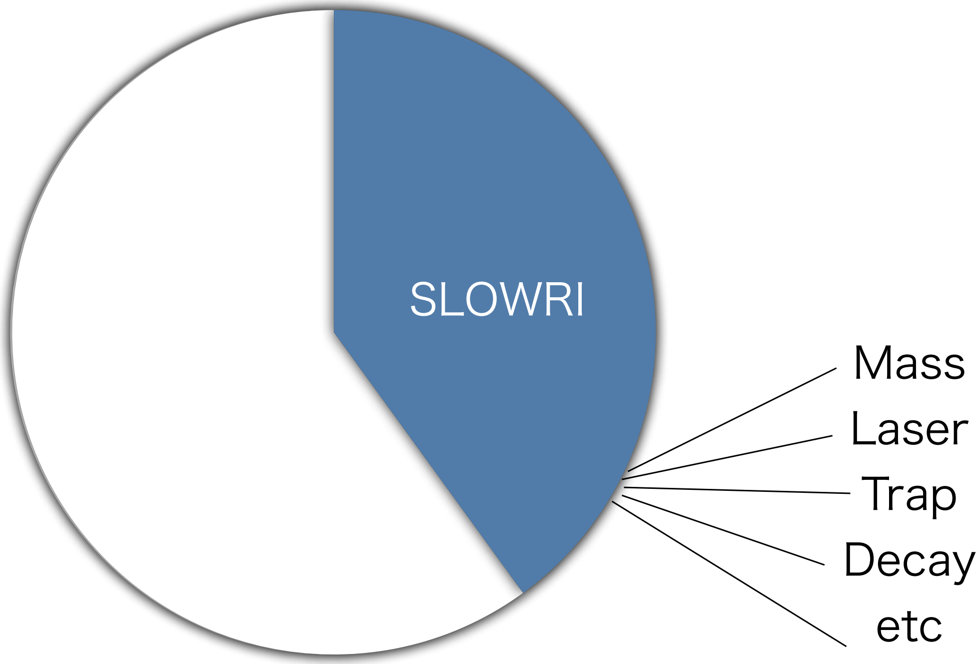


Halo structure



Available Beam Time

RIBF



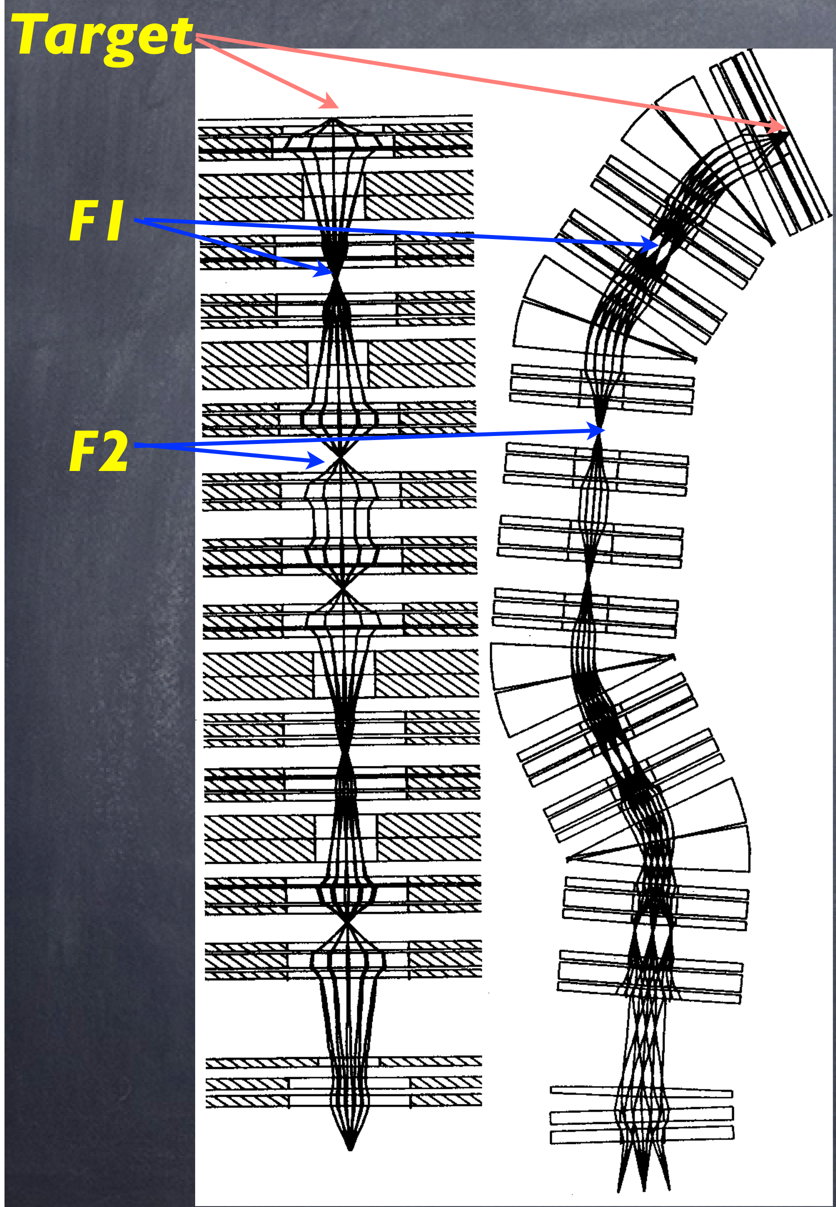
5 months/y

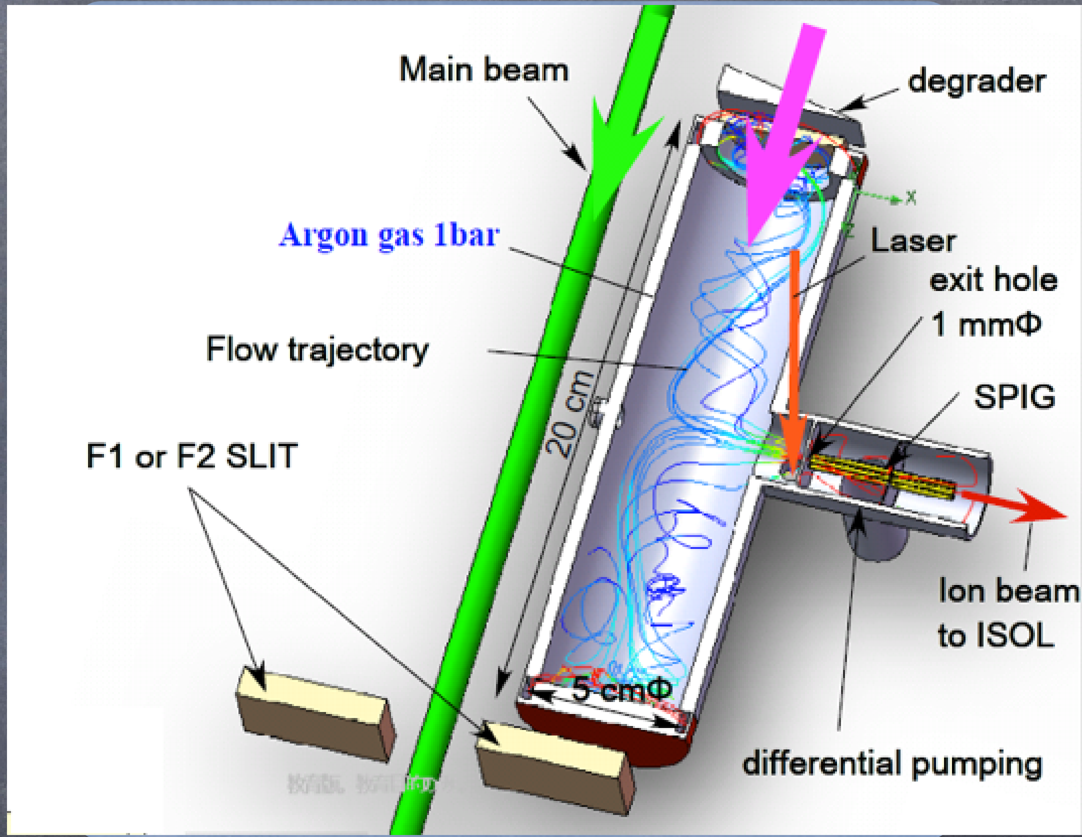
2 weeks/y for SLOWRI ??

5 mon./y for SLOWRI !!

PALIS

PArasitic slow RI-beam with gas catcher Laser Ion Source



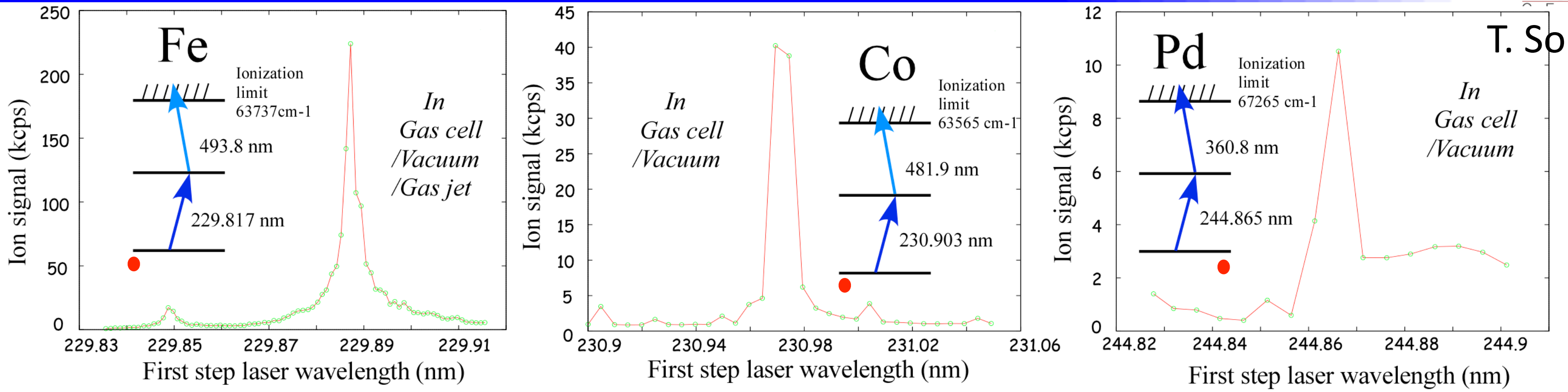


1) Stop & Neutralize in Ar (1 bar)
2) Extract by Gas Flow
3) Re-Ionize at Exit and SPIG

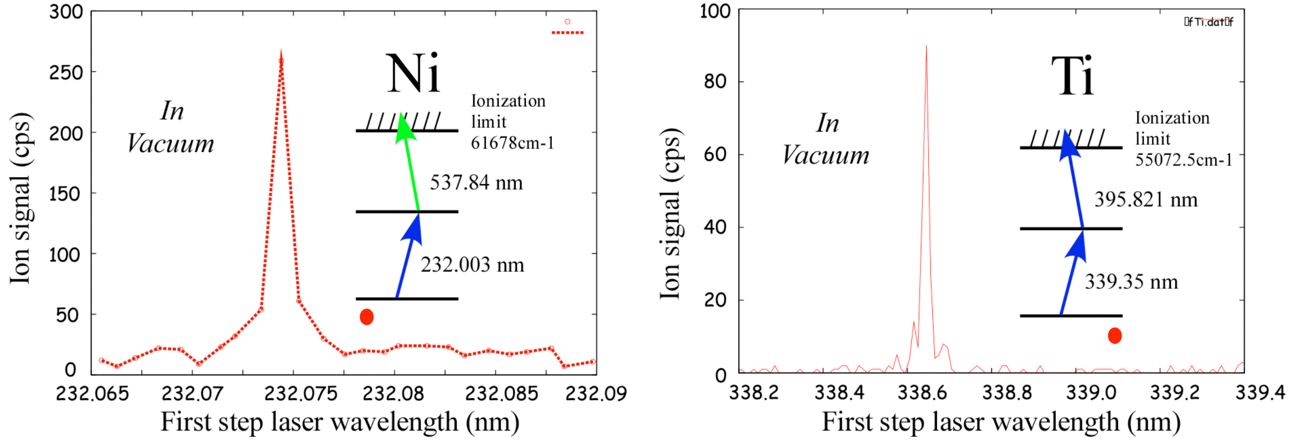
not universal, not very fast but
A/Z, Z, A separation

Resonant Ionization test in 2011 at RIKEN

T. Sonoda

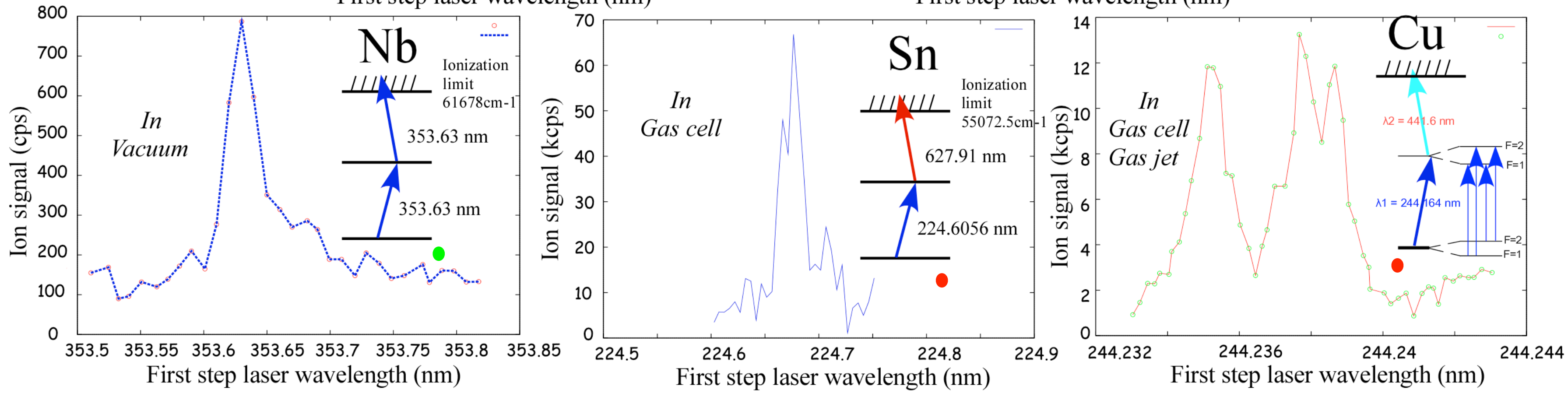


+Indium (2012)

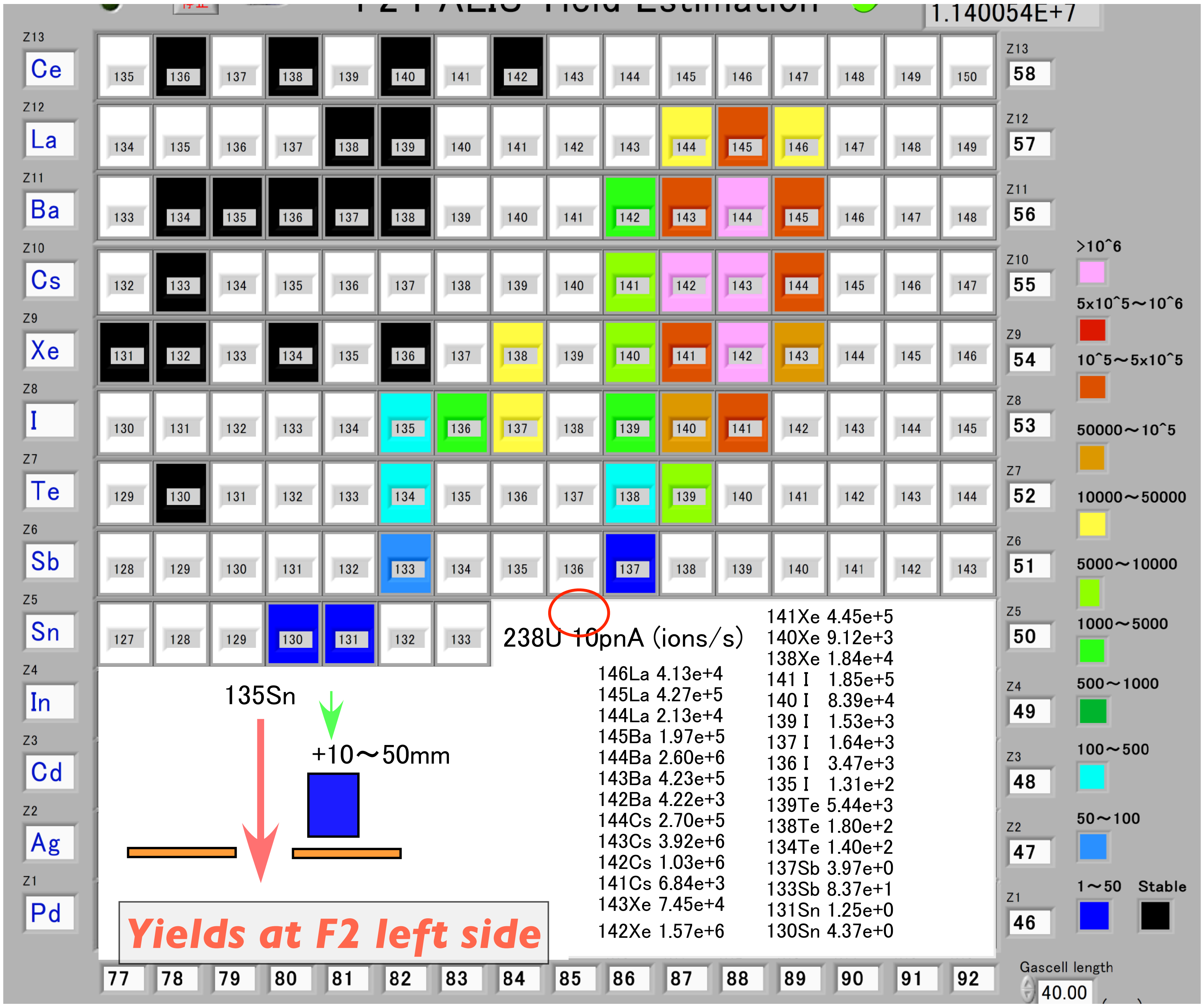


Scheme referencing from Yuri Kudryavtsev

Scheme referencing from Nagoya Univ.



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



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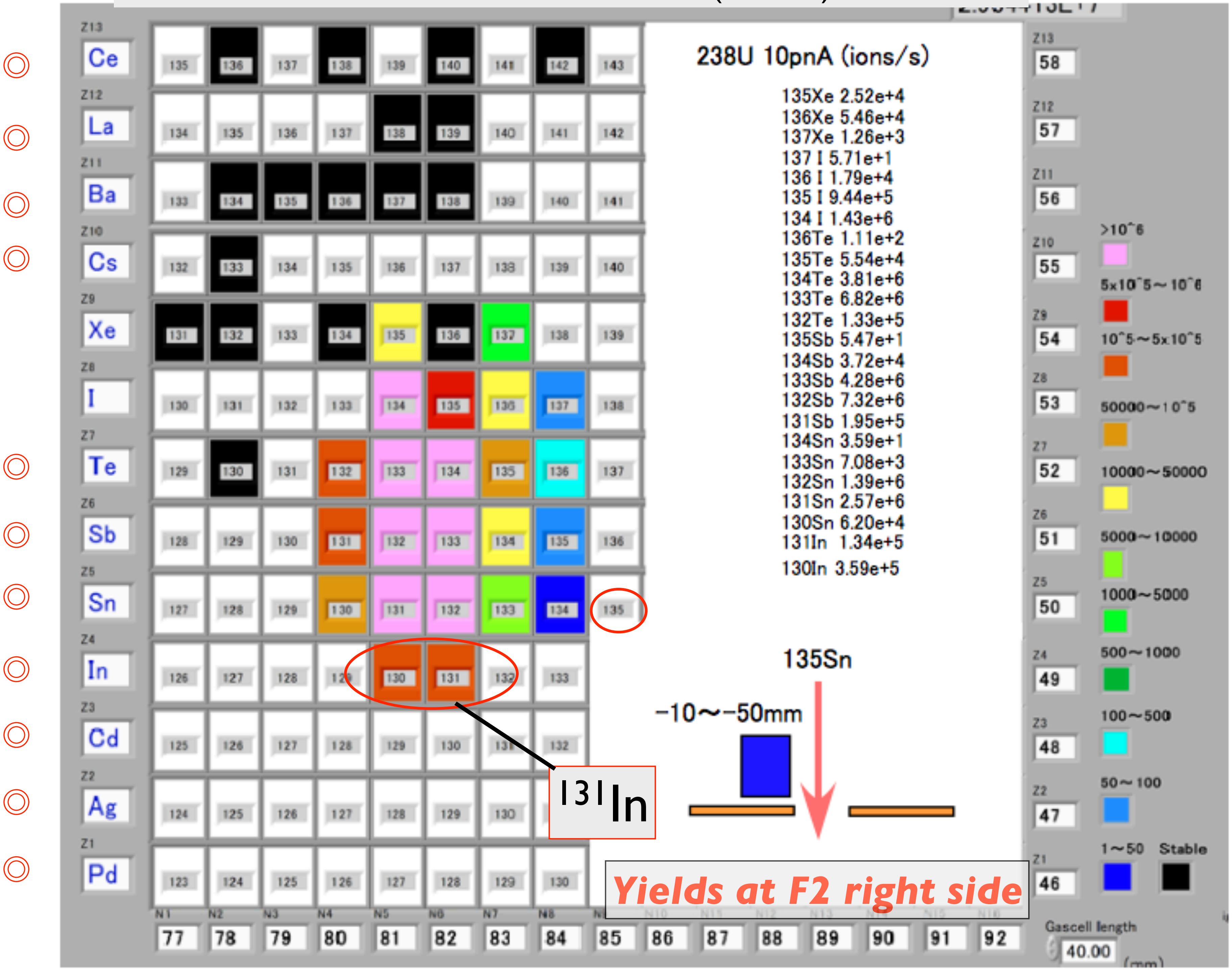
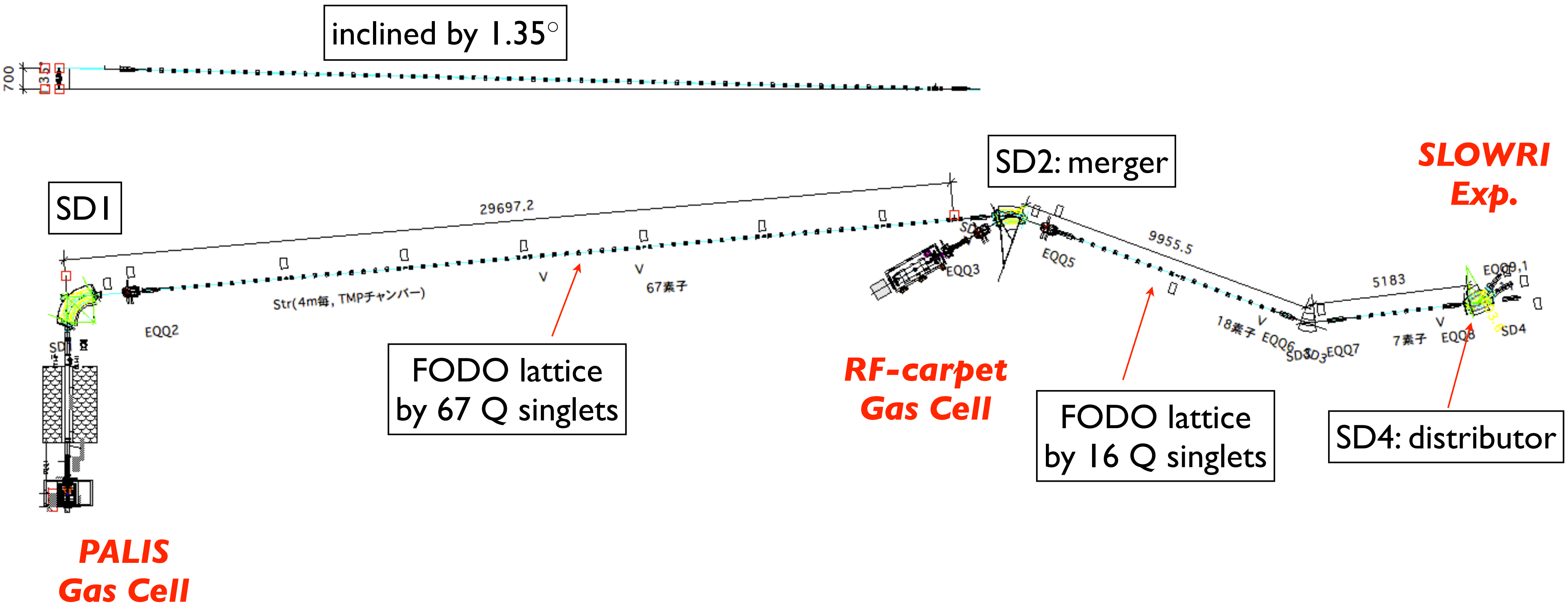


SLOWRI Transport Lines



EQQ1~11: Electrostatic Quadrupole Quartet for matching

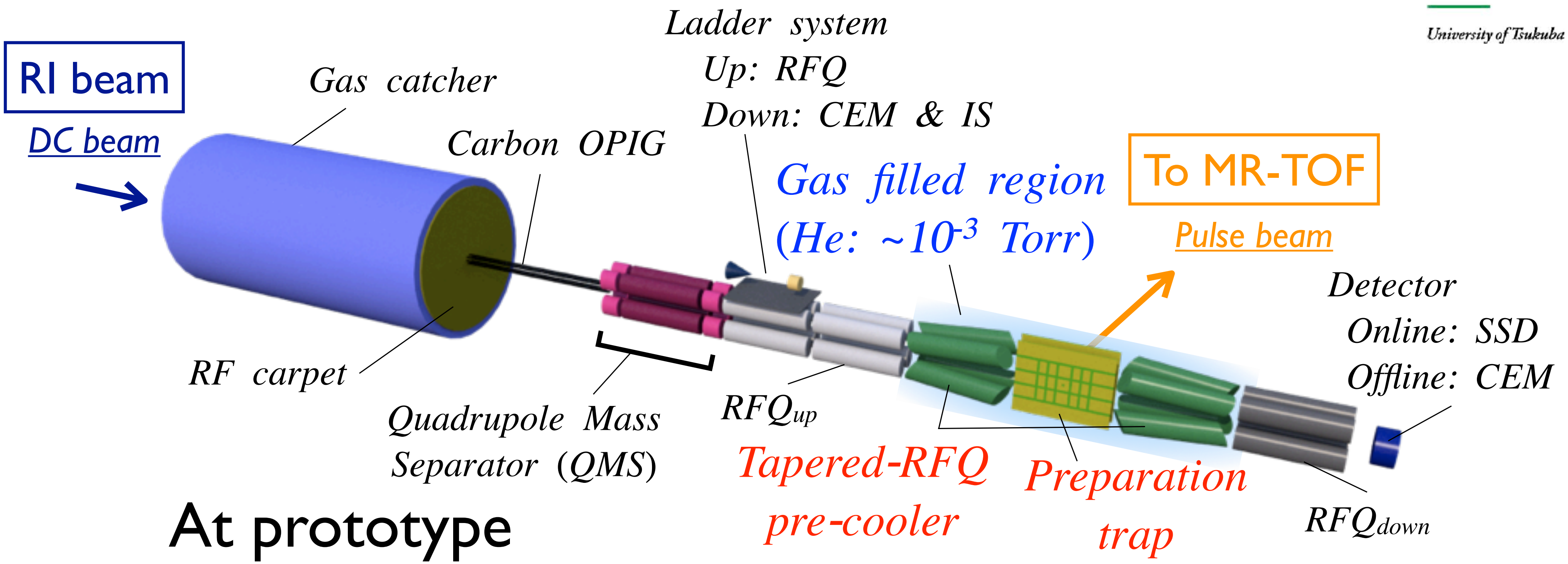
Experimental Possibilities

- Mass Measurements by MRTOF-MS
  - Can also be used as isobar separator
  - R_m~150,000 in <5 ms
  - Isomerically pure beams?
  - Simultaneous mass and $T_{1/2}$ if rate is low
- Decay spectroscopy with ultra-pure samples
  - Half lives
  - Level schemes
  - Delayed neutron multiplicity by radiochemical method

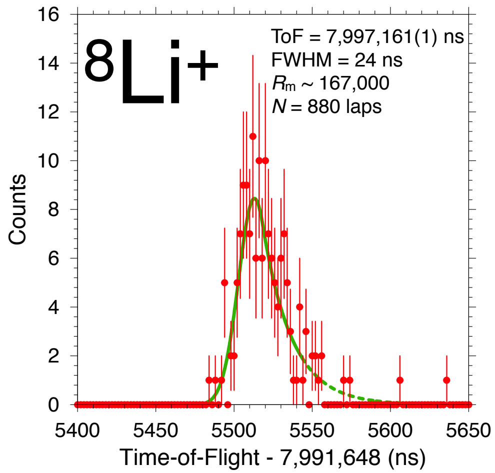
RIKEN NiSHiNA CENTER

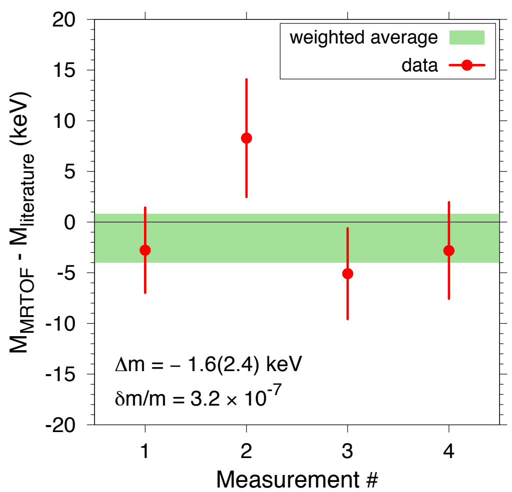
Ion preparation prior to MRTOF

筑波大学 University of Tsukuba



At prototype SLOWRI in E6

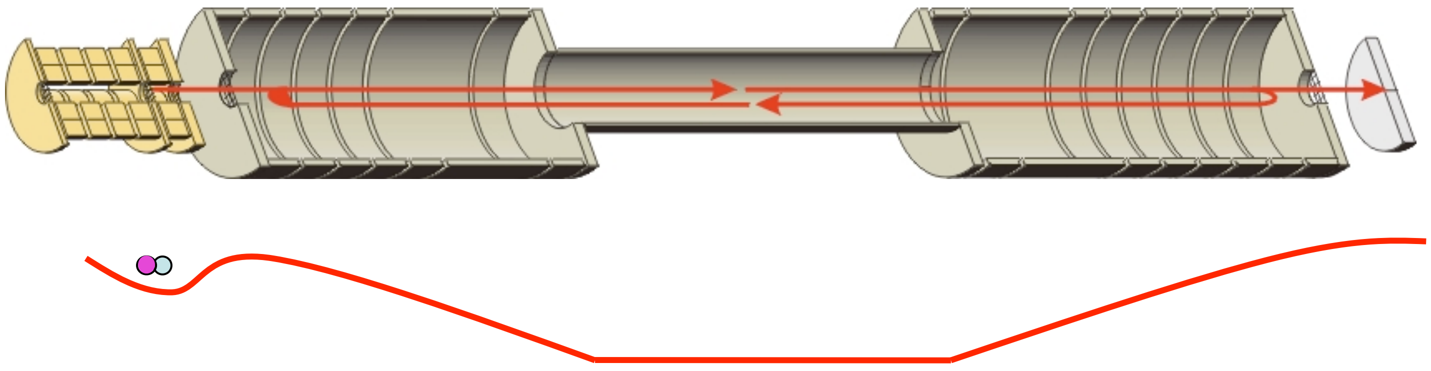


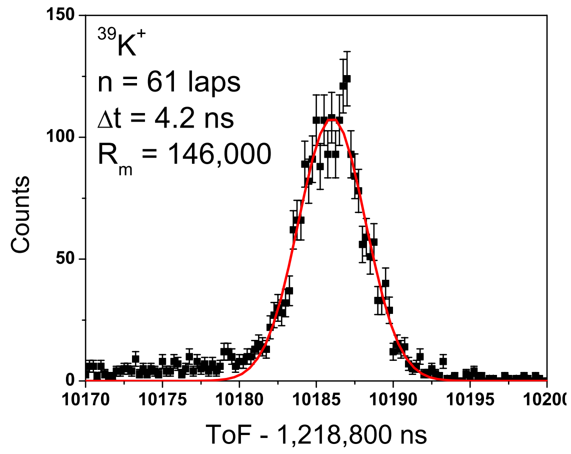


Transport to trap within >1 ms
Cooling time ≈2 ms

Efficiency, extraction to detection:
$\varepsilon(^{7}Li^{+})$ = 2.4%
$\varepsilon(^{8}Li^{+})$ = 2.9%
$\varepsilon(^{23}Na^{+})$ = 12.1%

Operational Concept

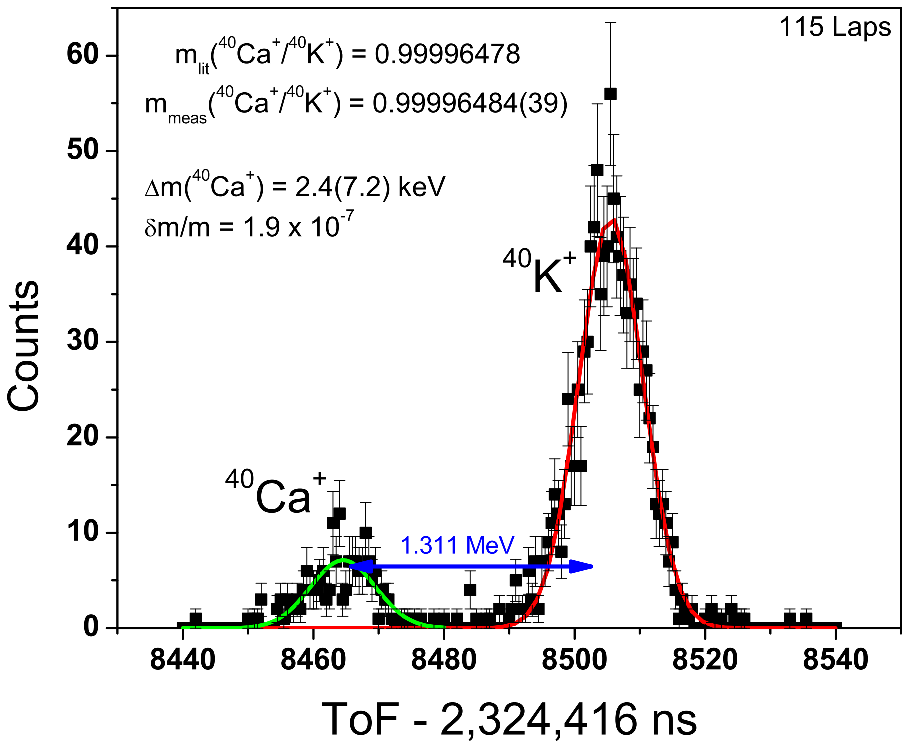


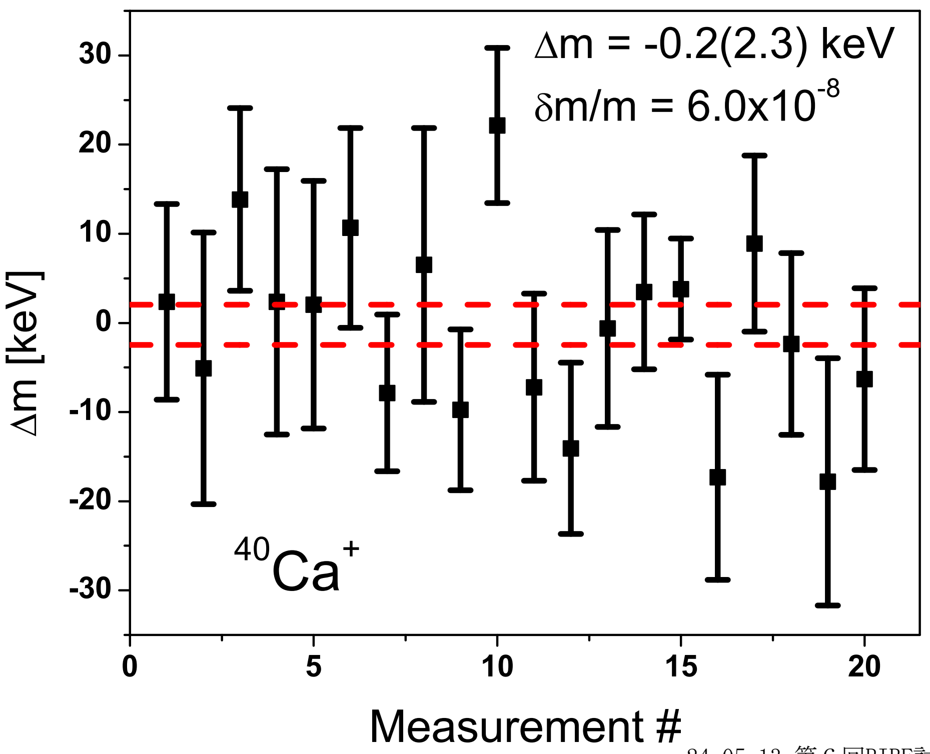


1. Cool ions in buffer gas filled trap
2. Open front end of MRTOF and eject from trap
3. Close front end
   - Ions will reflect between isochronous mirrors
   - Next batch of ions can accumulate and cool
4. Open back end
5. Measure TOF

High-precision offline test

- What is the ultimate precision limit?
- Tested with $^{40}Ca^{+}/^{40}K^{+}$
- Precision limit is $\delta m/m \ll 10^{-7}$





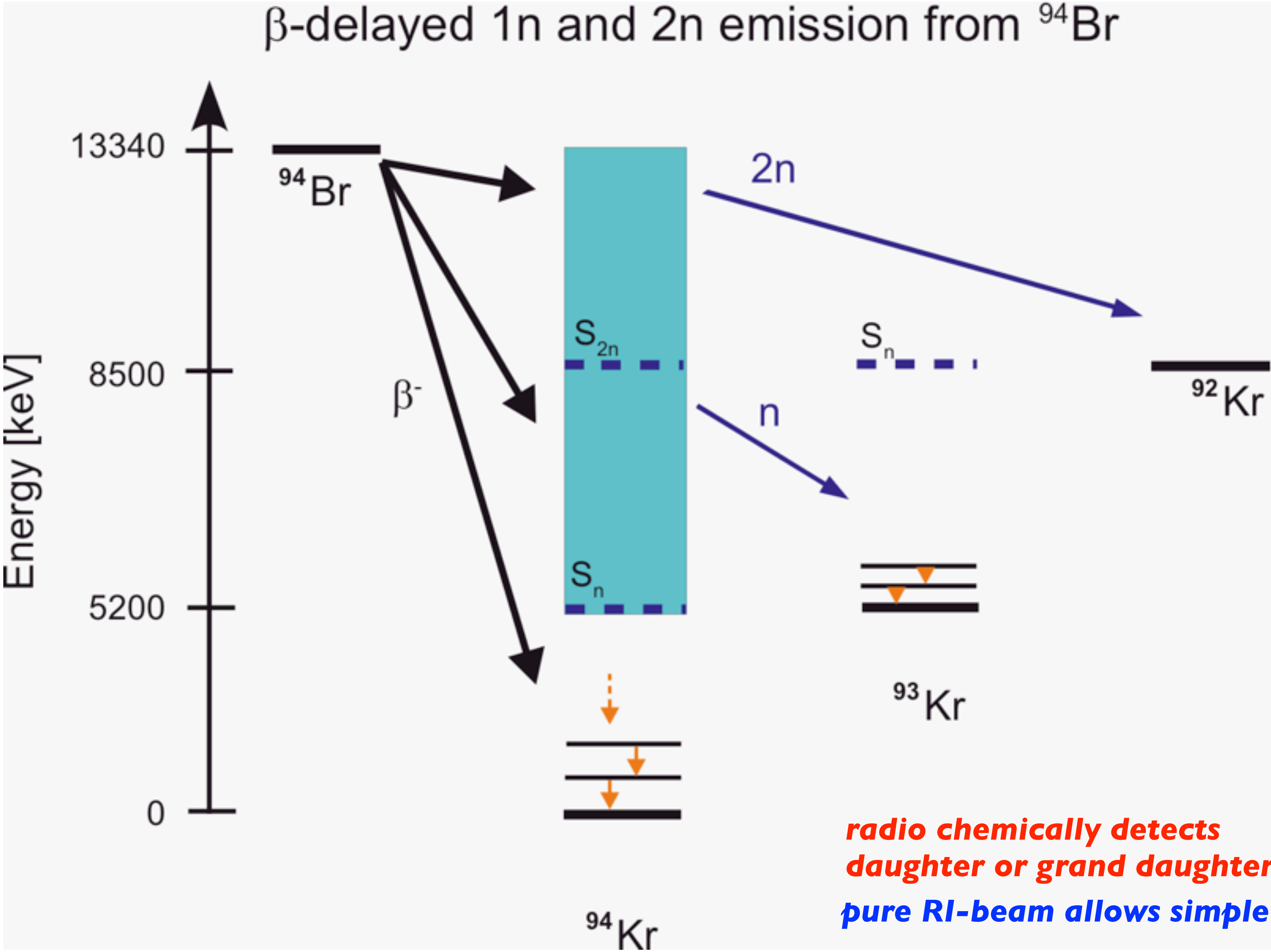
Decay Spectroscopy

EURICA+Tape Transport ← ***Pure Low-Energy RI-beams***

- Level Schemes
  coincidence
- Perturbed Angular Correlations
  Magnet+ Isomeric states
- Delayed Neutron
  radiochemical method

ε: 10~28%,
high granularity

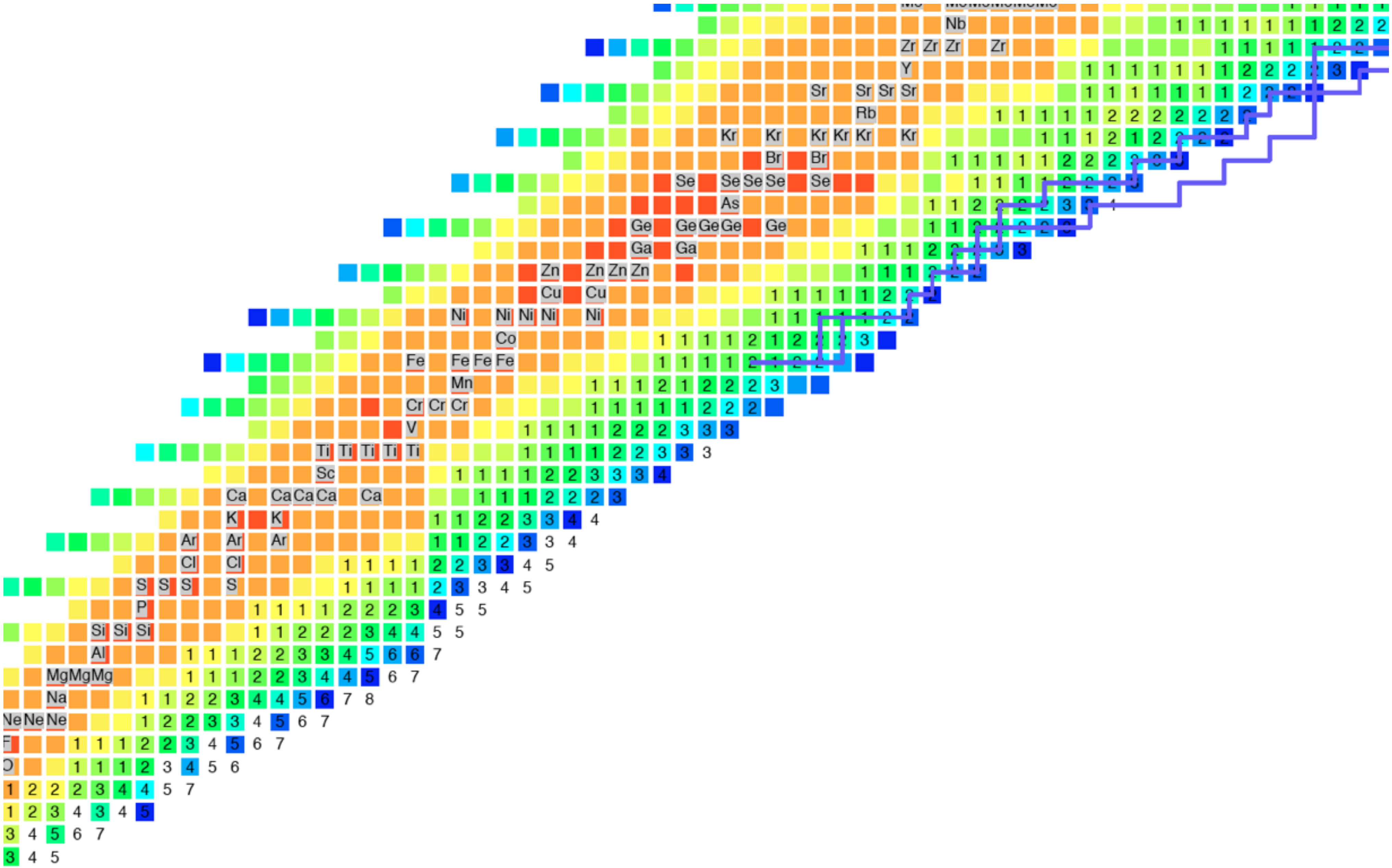
Neutron Multiplicity



radio chemically detects daughter or grand daughters

pure RI-beam allows simple exp.

Maximum Neutron Multiplicity

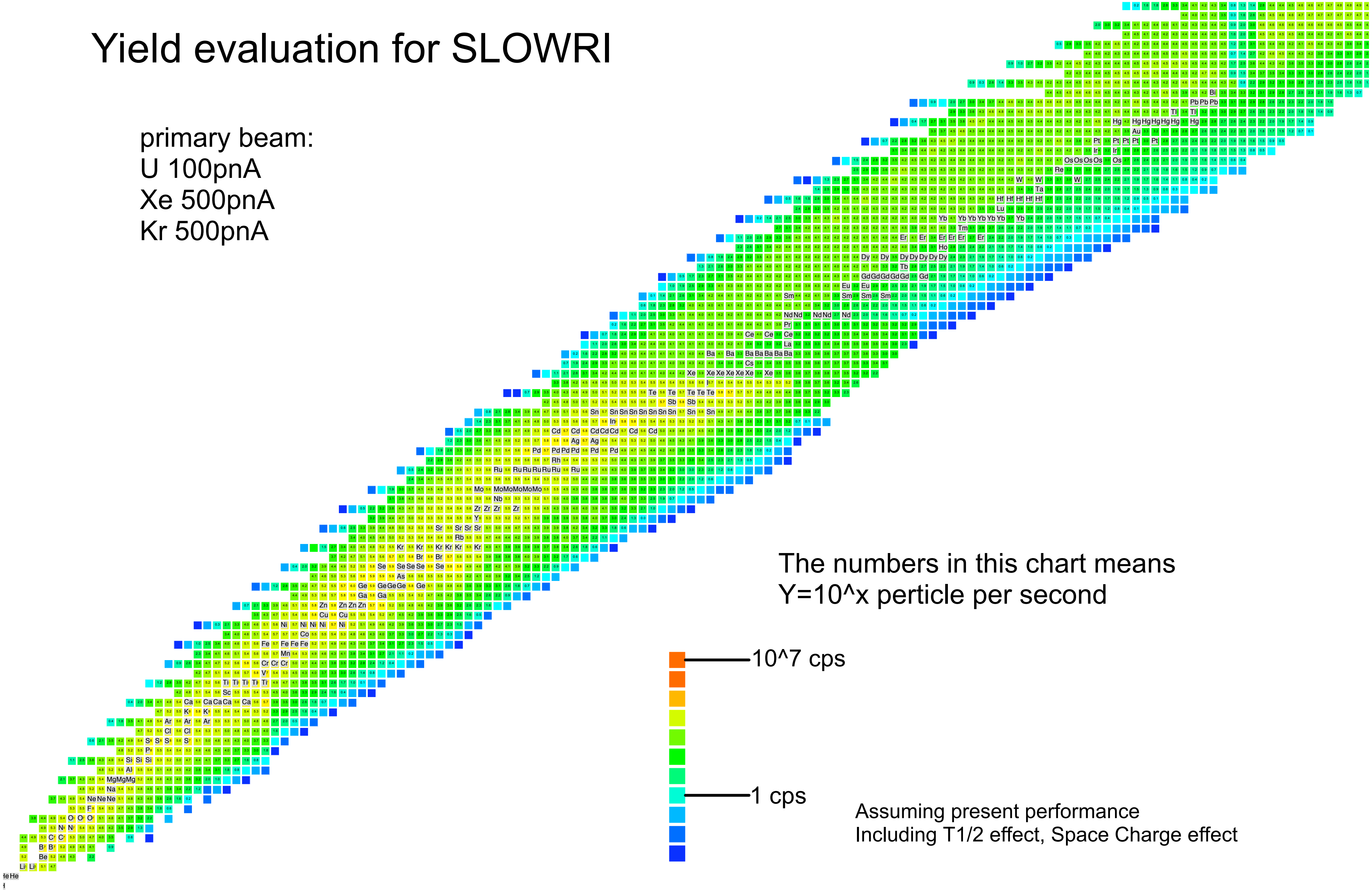


Summary

- SLOWRI will consist of two gas cells
- Parasitic gas cell will allow large amounts of machine time
- SLOWRI will be able to provide ultra-pure beams
- Good opportunities for $T_{1/2}$, mass, β-n, ...

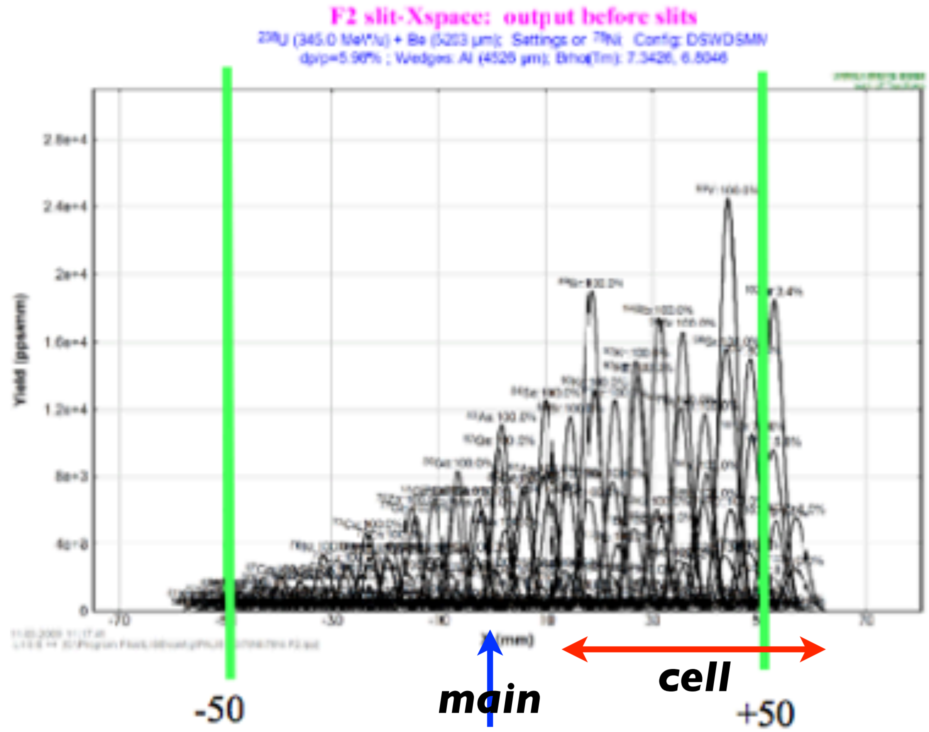
Yield evaluation for SLOWRI

primary beam:
U 100pnA
Xe 500pnA
Kr 500pnA



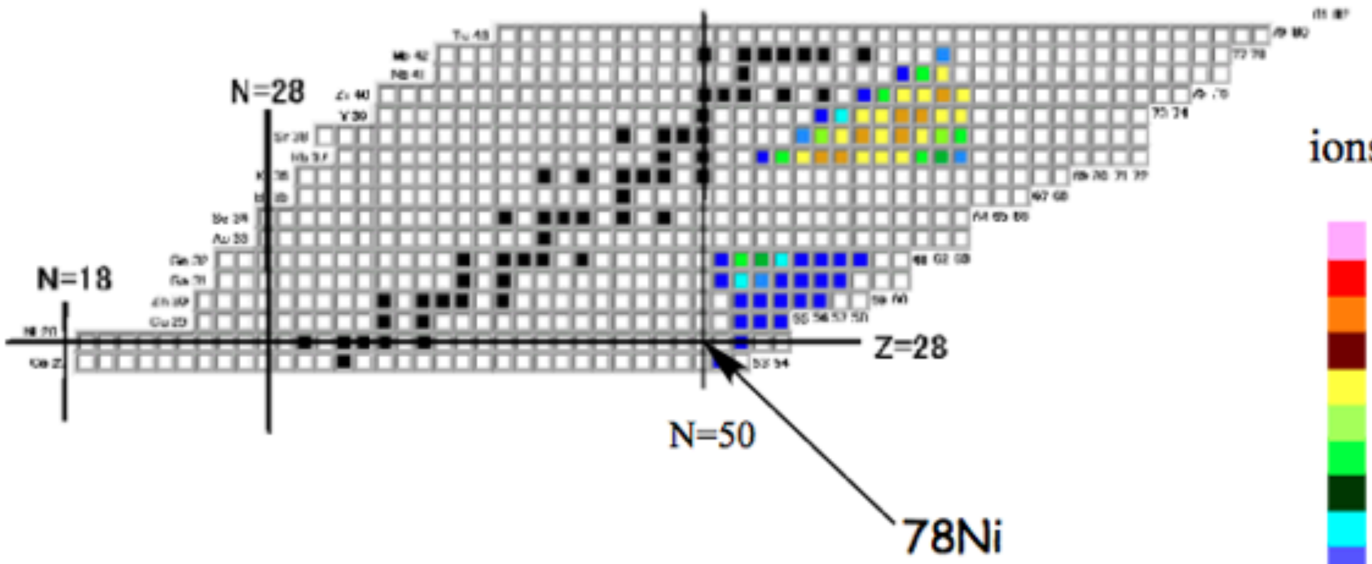
The numbers in this chart means
Y=10^x perticle per second

Assuming present performance
Including T1/2 effect, Space Charge effect

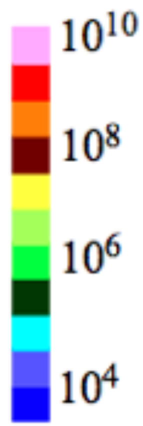


238U 345MeV/u + Be (5512um)
Wedges: Al(4526um)
Setting on 78Ni

Total number of ions entering into the degrader
9.1x10^8 ions/sec for 1puA primary beam

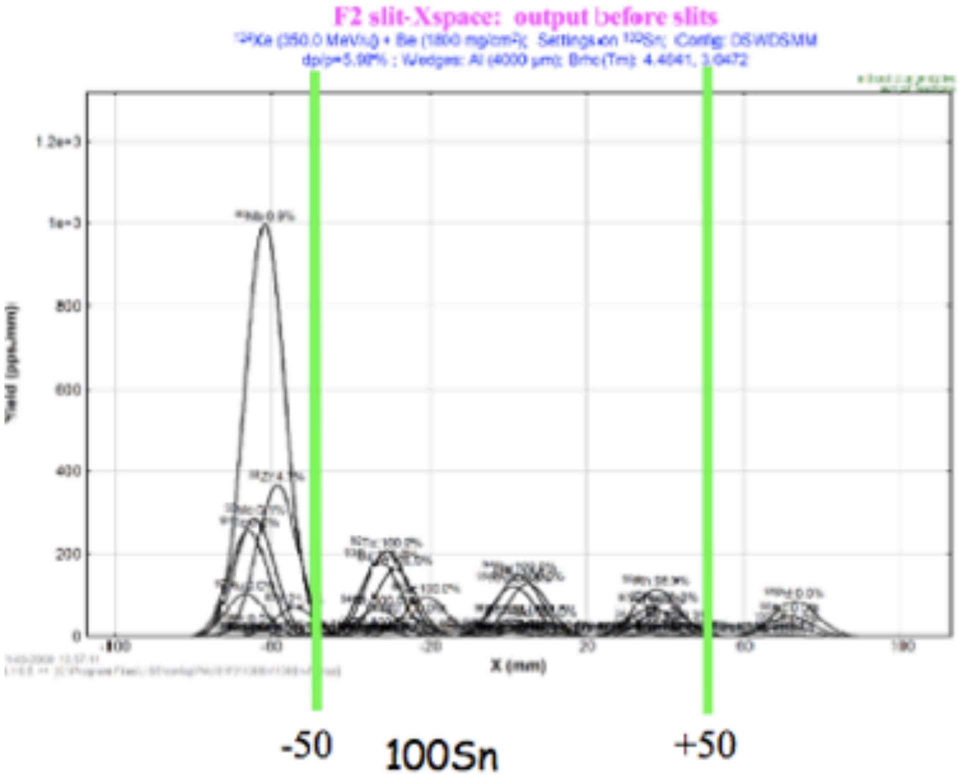


ions/sec (for primary beam 1puA)



Gas cell@F2

X=10 ~ 60 mm



124Xe 360MeV/u + Be (1800mg/cm

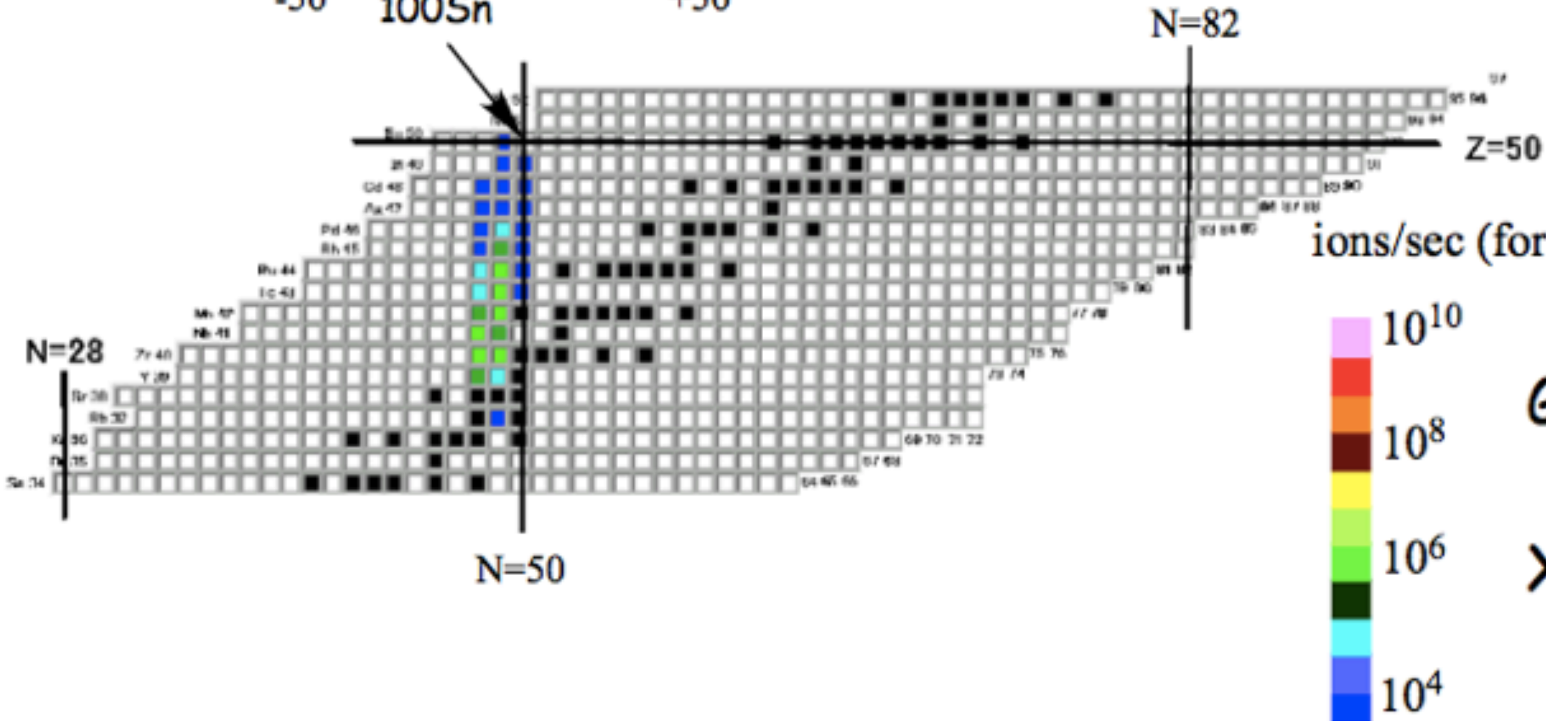
Wedges: Al(4000um)

Setting on 100Sn

Total number of ions entering into the degra

2.1x10^{7} ions/sec for 1puA primary beam

ions/sec (for primary beam 1puA)



Gas cell@F2

X=-60 ~ -10 mm