Laser resonant ionization method for purifying radioactive beams

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DESIR meeting November 2007

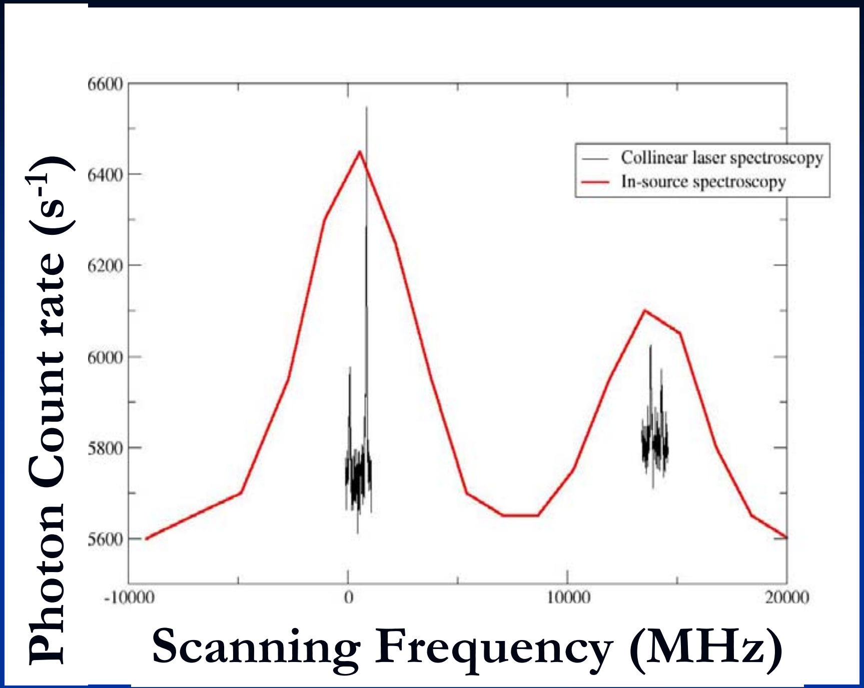
Removing isobaric contamination

1. Neutron Converter
2. Molecular beams (CF_4 gas)
   - Highly selective, access to refractory elements such as Hf
   - Not a universal technique (element dependent) not suitable for all experiments
3. Laser ion source
   - High selectivity but doesn't suppress surface ions
4. Low work function cavities
   - Can suppress surface ions but also may slow down the release time.
5. LIST
   - High suppression of surface ions.

An example of a difficult case: ^{75}Cu

- ^{75}Cu yield ~1E5 ions/μC
- ^{75}Ga isobar yield ~3E7 ions/μC
- Low work function cavities will suppress the yield of Ga but may also slow the release of Cu and reduce the yield.
- Quartz line may suffer from the same problems
- ^{77,78}Cu where yields are <1E3 ions/μC and $t_{1/2}$<1s a slower release is not an option.

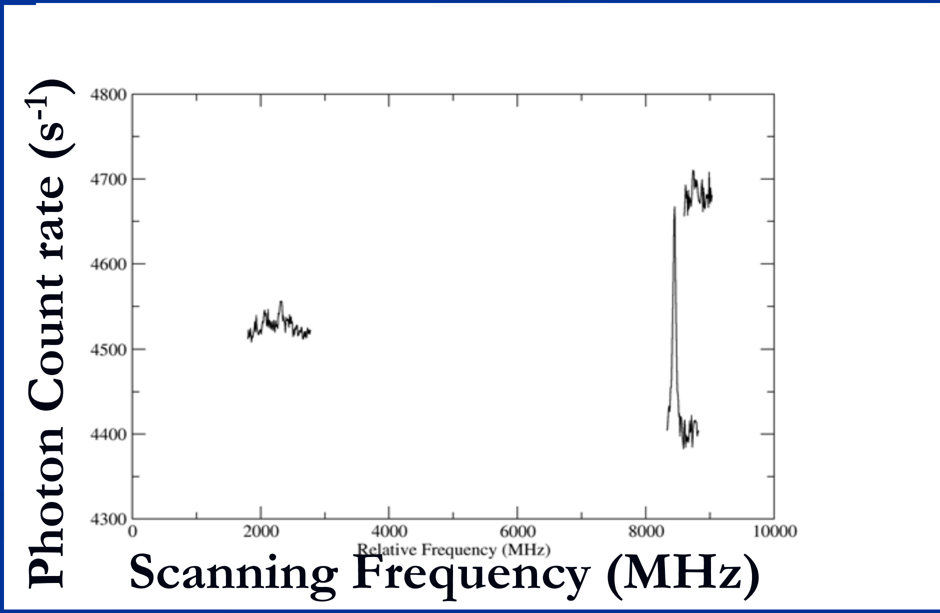
Comparison of collinear laser spectroscopy (fluorescence detection) with in-source RIS on ^{68}Cu.



72Cu

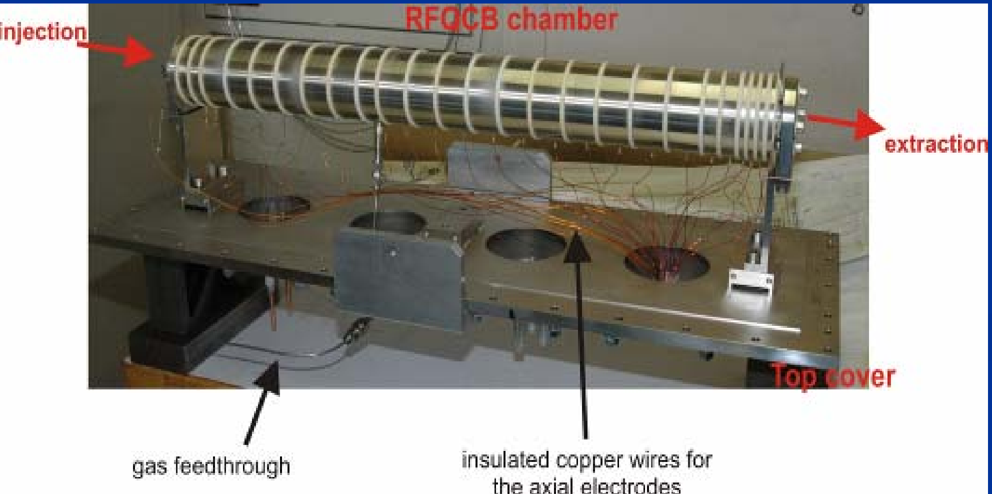
- I=2 >99.73% confidence
- A(S1/2) =-2661(1)MHz
- B(P3/2) = +28(3) MHz

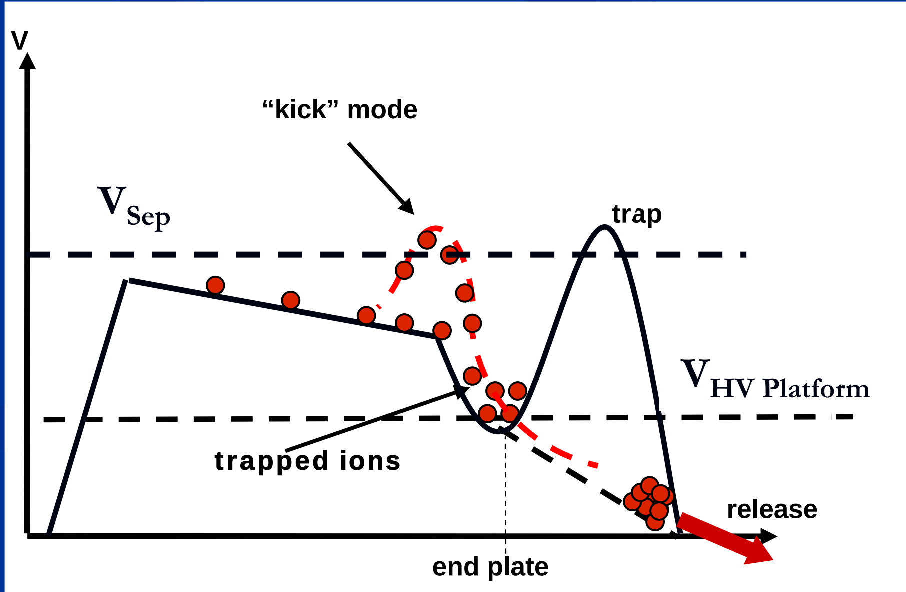
→ μ= -1.345(1)n.m.
Q=+0.21(4)b



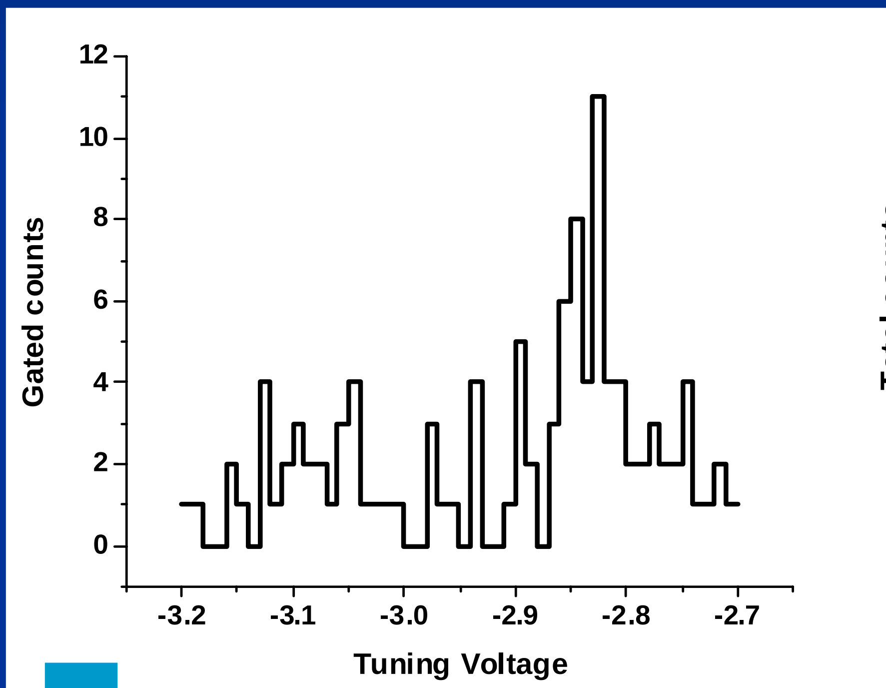
Trap assisted spectroscopy

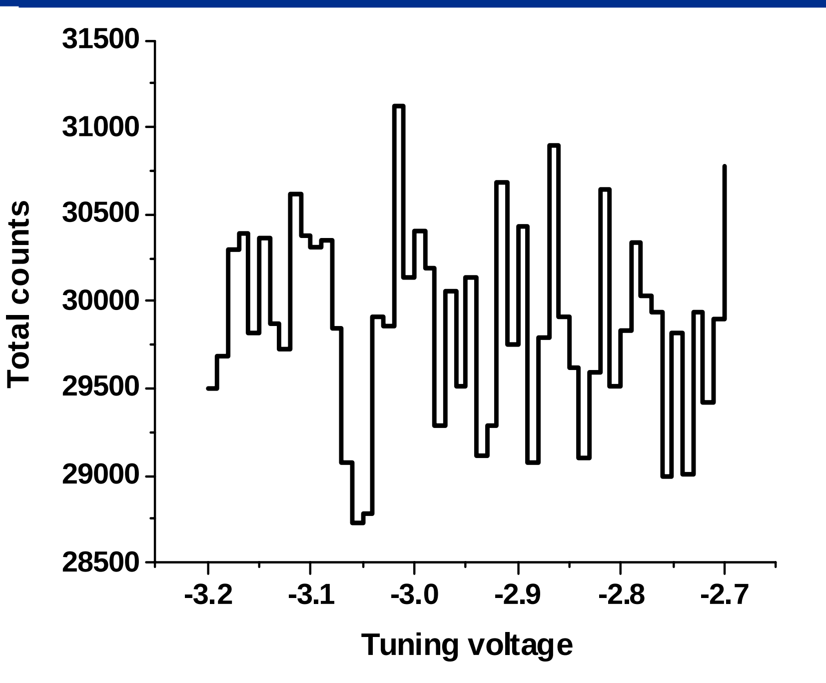
- New RFQ ion beam cooler and Paul trap (ISCOOL) has been tested November 2007.
- Provides a method of collecting ions over hundreds of ms and releasing them in ~6μs.
- A new "kicking mode" may reduce this to ~1μs





- ^{85}Rb using the 780nm line ($S_{1/2}$-$P_{3/2}$) with a natural line width of 6MHz

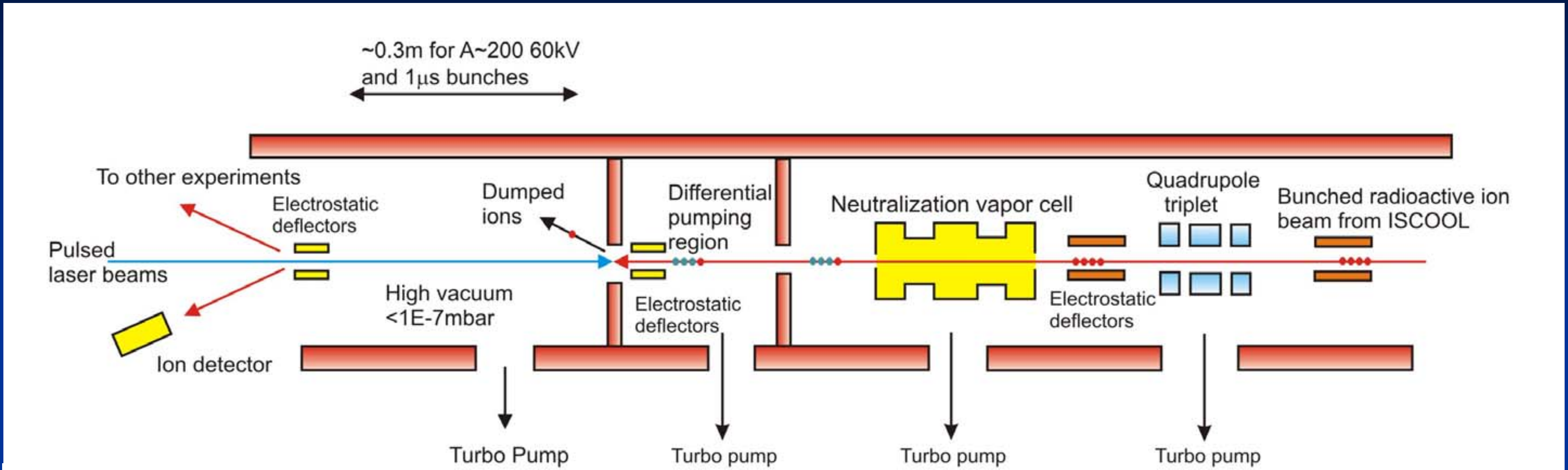


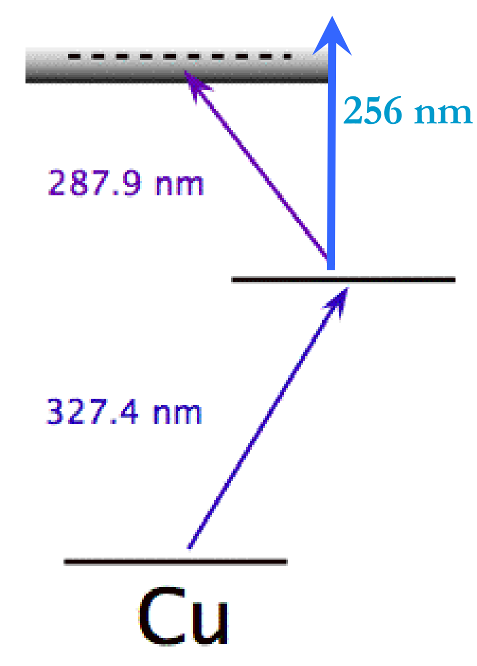


30 000 ions /s
FWHM = 2.5V (14MHz)
Laser power 0.8mW

18 minutes!

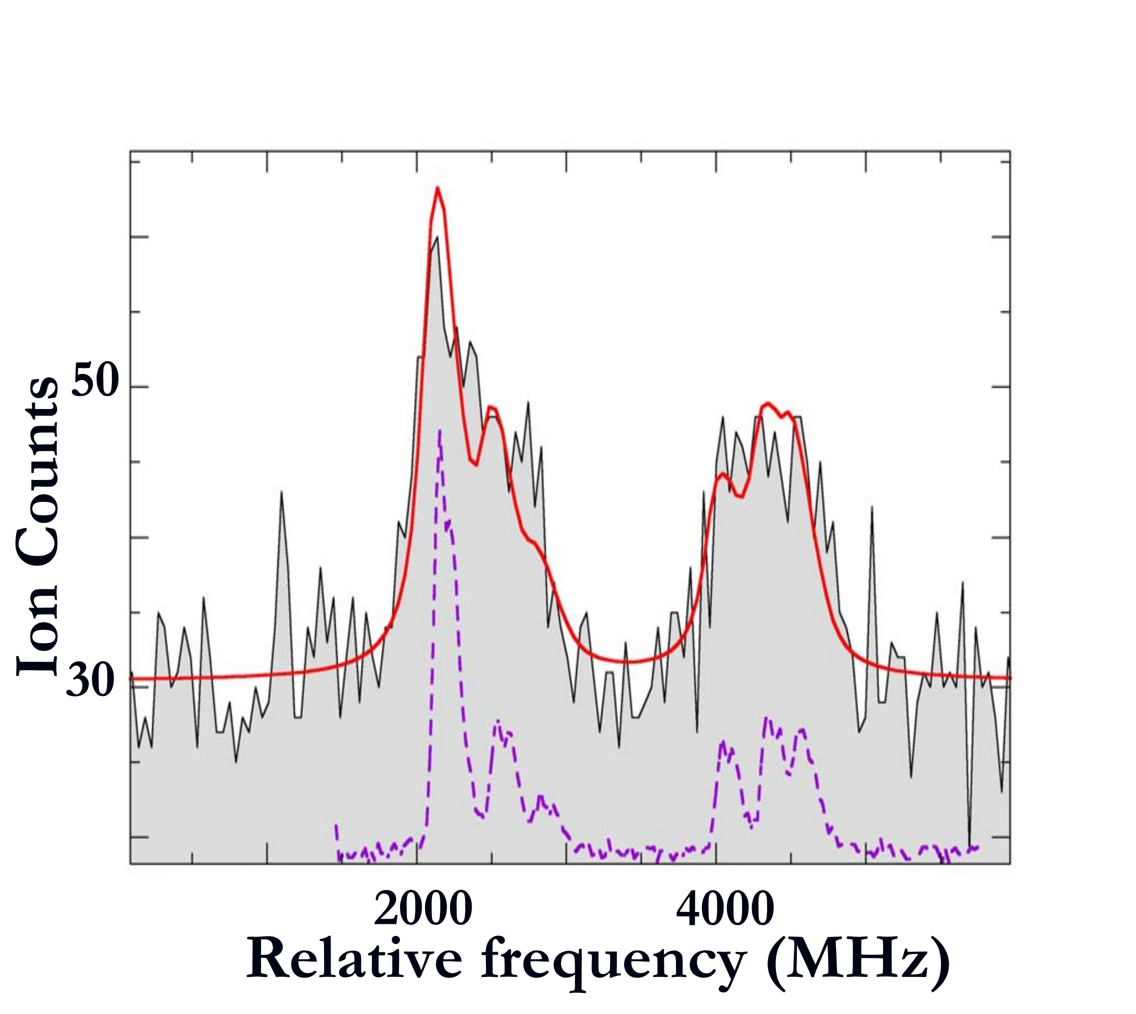
A combination of RIS and collinear





- Method has a demonstrated 1:30 detection efficiency (Al)
- High resolution (Fourier limited with dyes lasers)
- Background depends on pressure
- Transparent to isobaric contamination

First test of technique with Al



200 ions per bunch
6 scans
1:30 efficiency
Factor of 1000 increase in detection efficiency.

Background due to non-resonant collisional ionization in poor vacuum (10^{-5} mbar)
~5 ions per bunch

Requirements for high purification

- Collisional ion rate α pressure

  Therefore ultra high vacuum, for example 10^{-10} mbar would reduce the isobaric contamination by a factor of 10^5

- Second tunable step to Rydberg level which reduced the interaction region from 2m to 1cm

  This will further reduce the impurity level by a factor of 200.

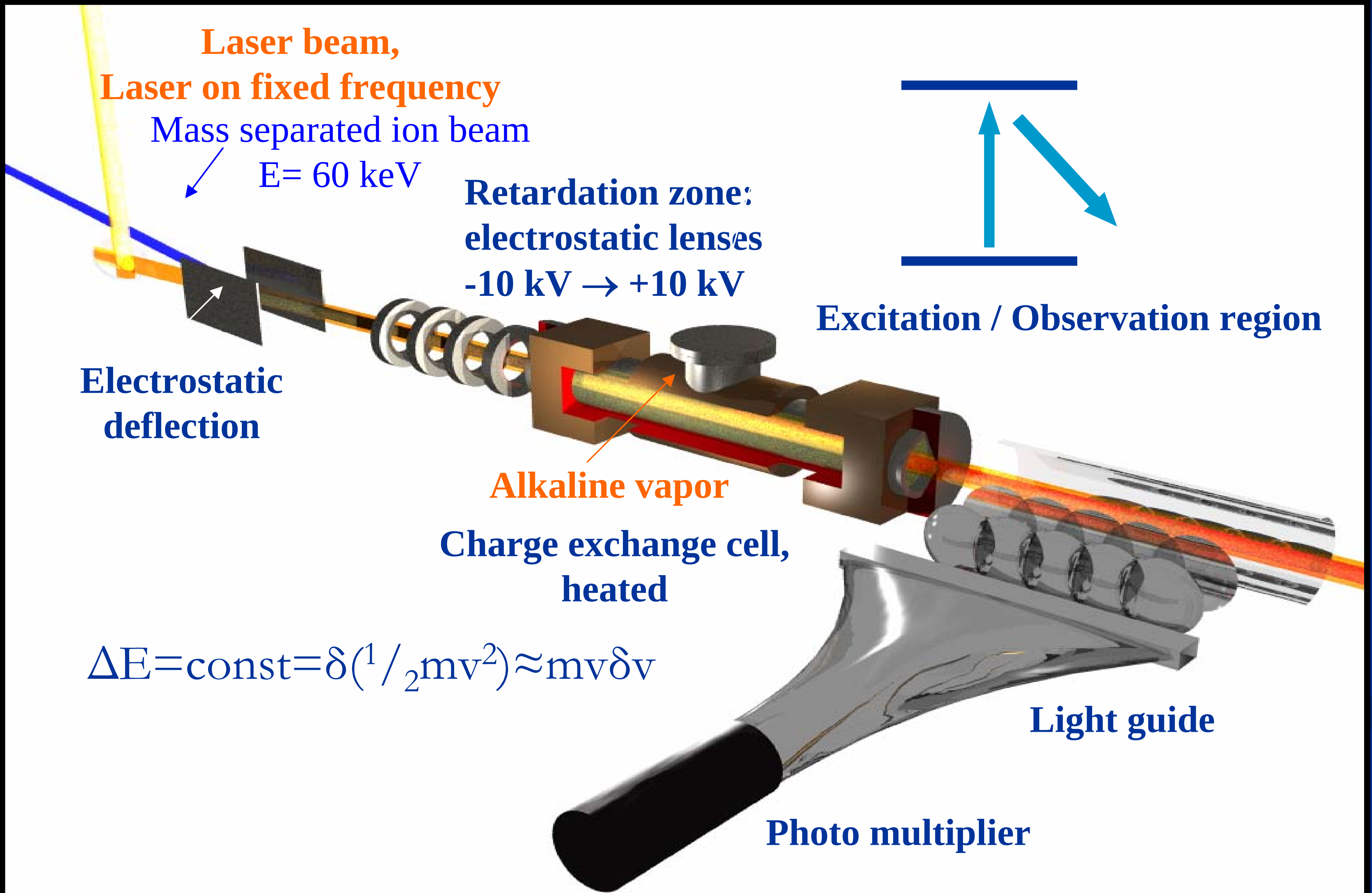
Beam purification factor~ 2×10^7

Applications

- Under these condition it is possible to consider exotic cases such as $^{201,199}Fr$ and the surrounding nuclei which are produced with yields below 1 ions/μC
- Production of ultra pure beams from A>40 onwards
- This technique can also be applied to produce pure polarized beams for future experiments.

Thank You

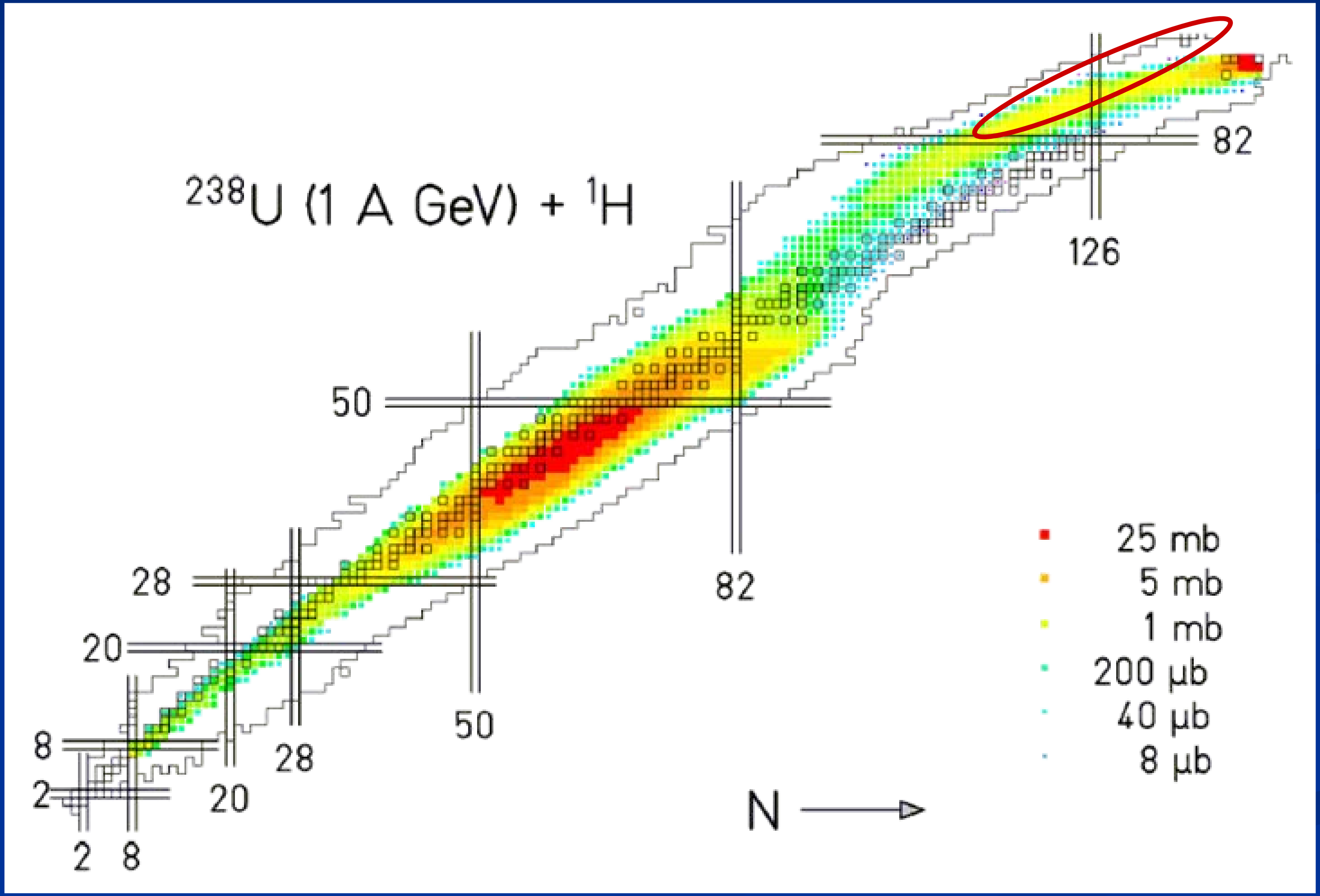
Collinear Laser Spectroscopy

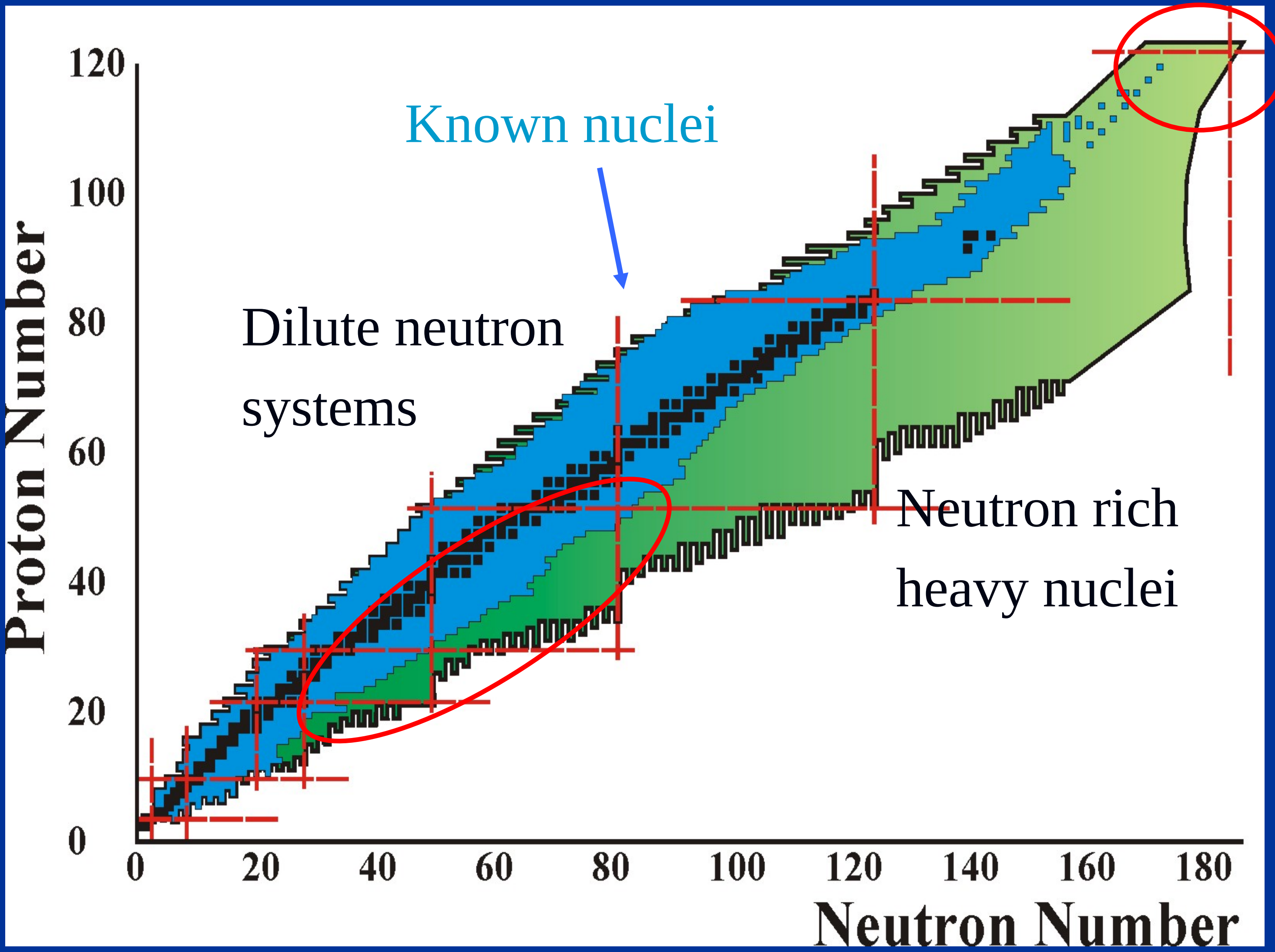


$$\Delta E = const = \delta(^1/_2 mv^2) \approx mv\delta v$$

Beyond 2008

- Can we probe further at ISOLDE .




Known nuclei
Dilute neutron
systems
Neutron rich
heavy nuclei
Proton Number
Neutron Number
0
20
40
60
80
100
120
140
160
180

Route to finding the answers

Production