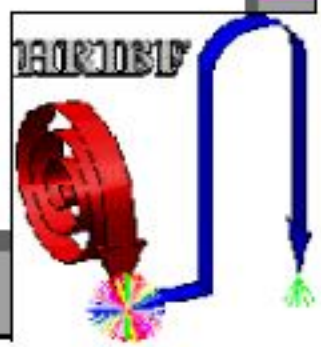
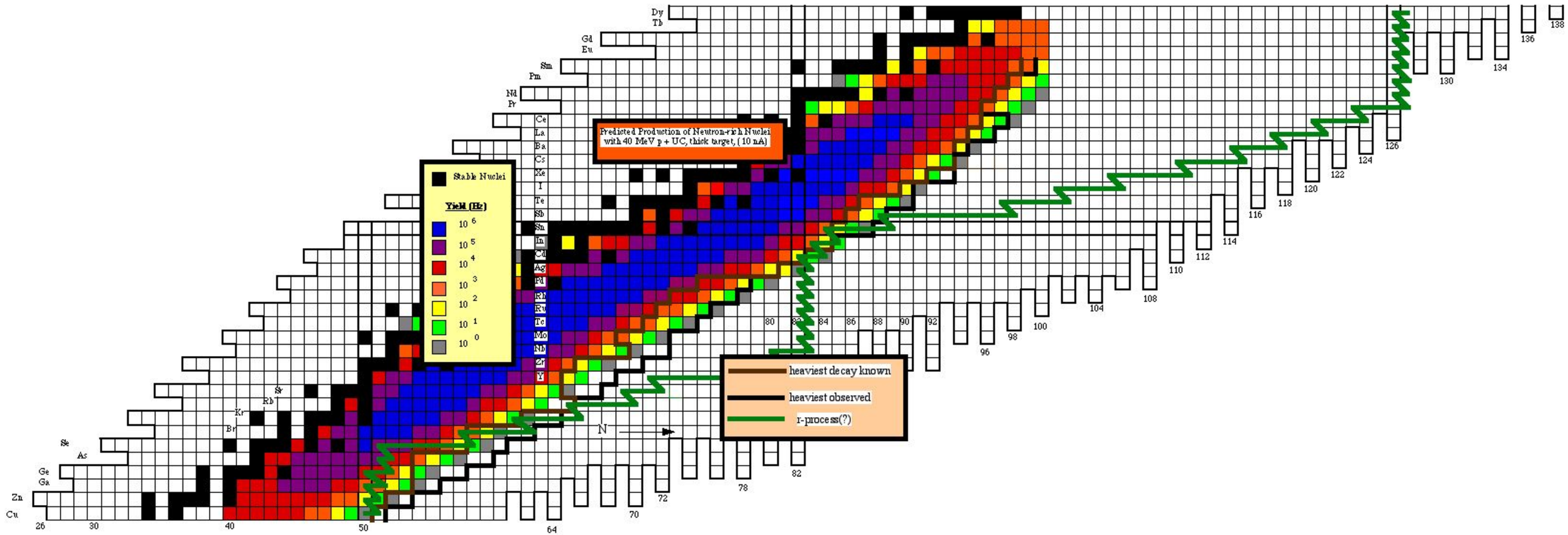
# Decay Studies of Non-accelerated Fission Fragments

**Jon Batchelder**

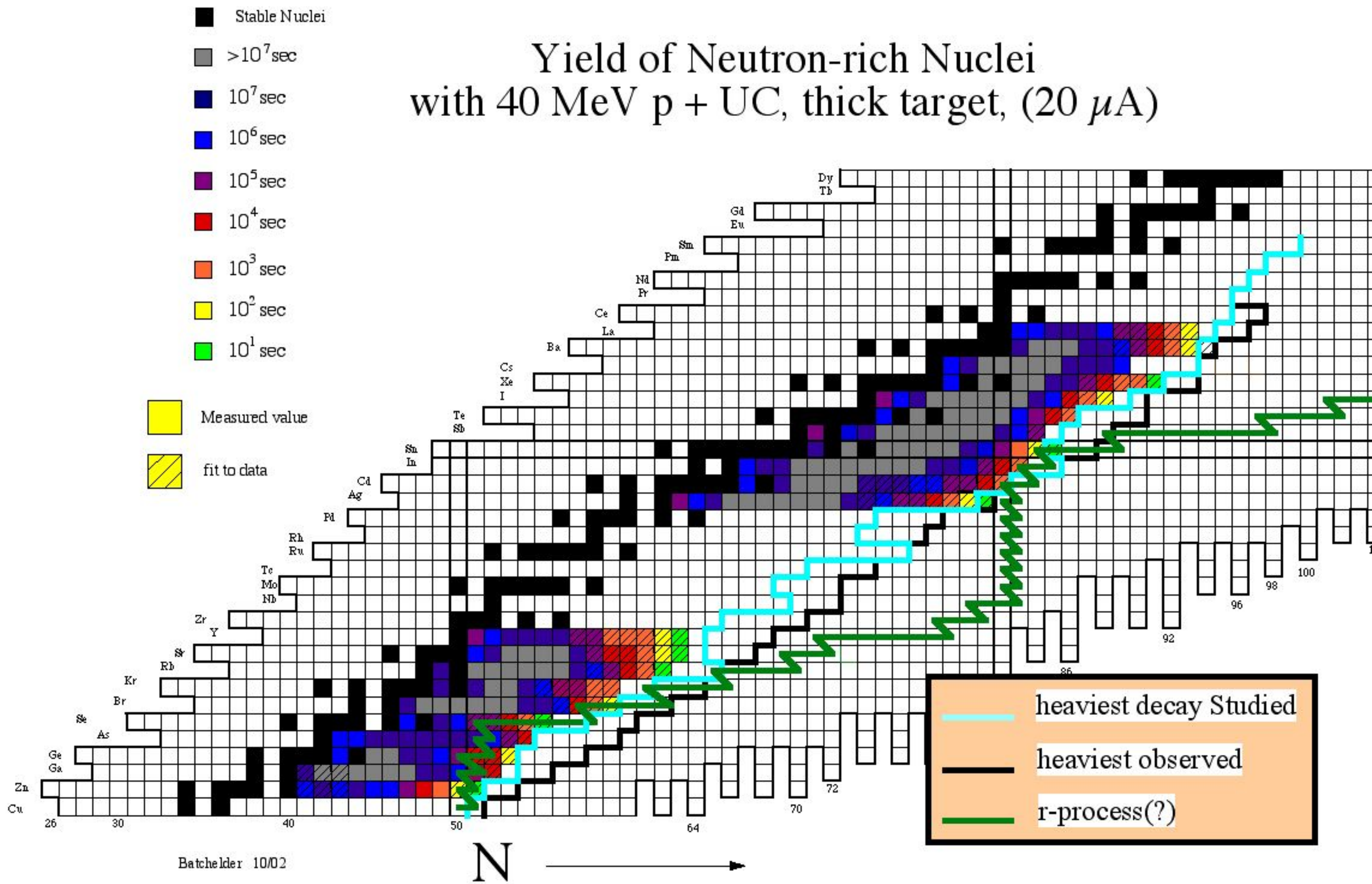
**UNIRIB/ORAU**

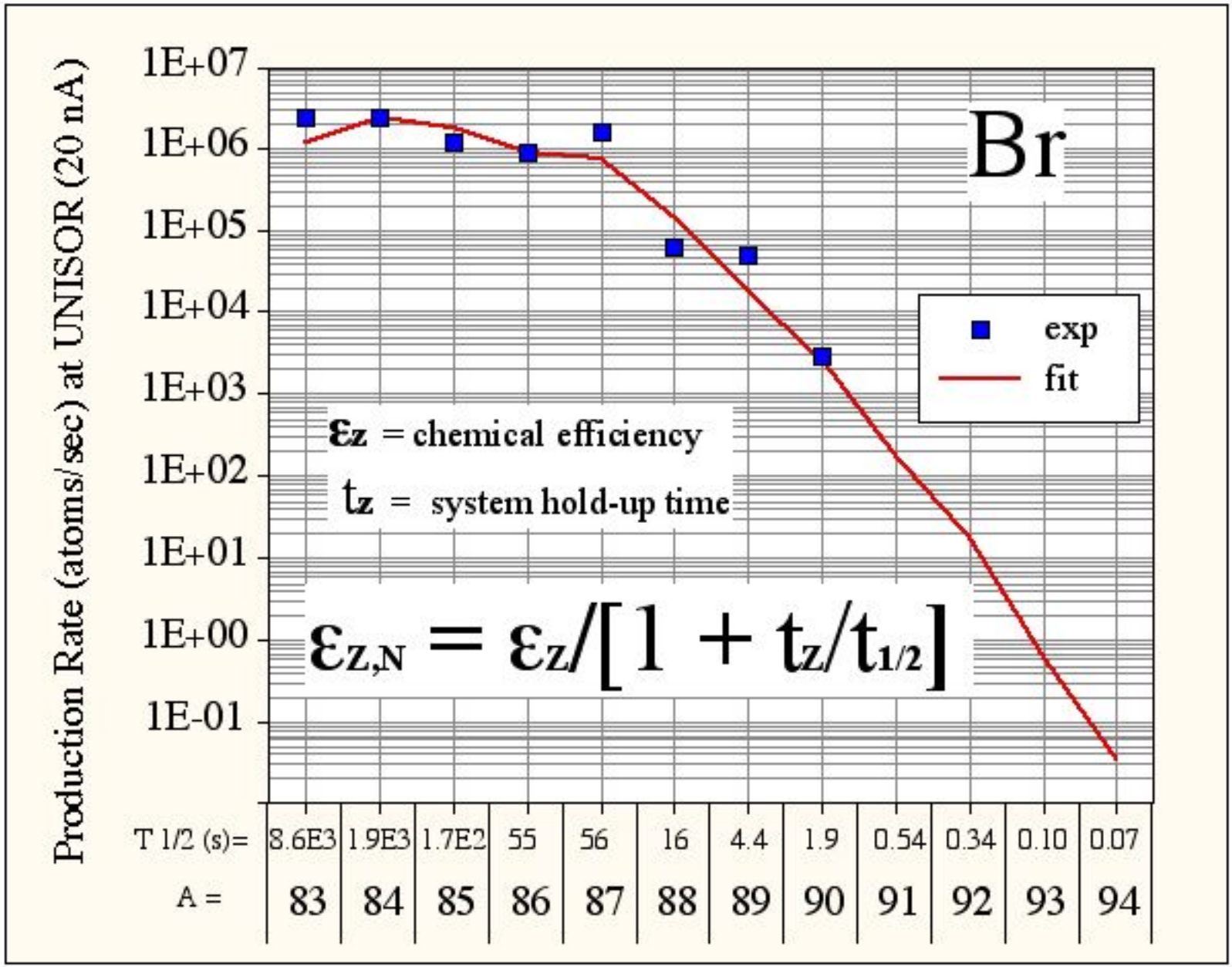


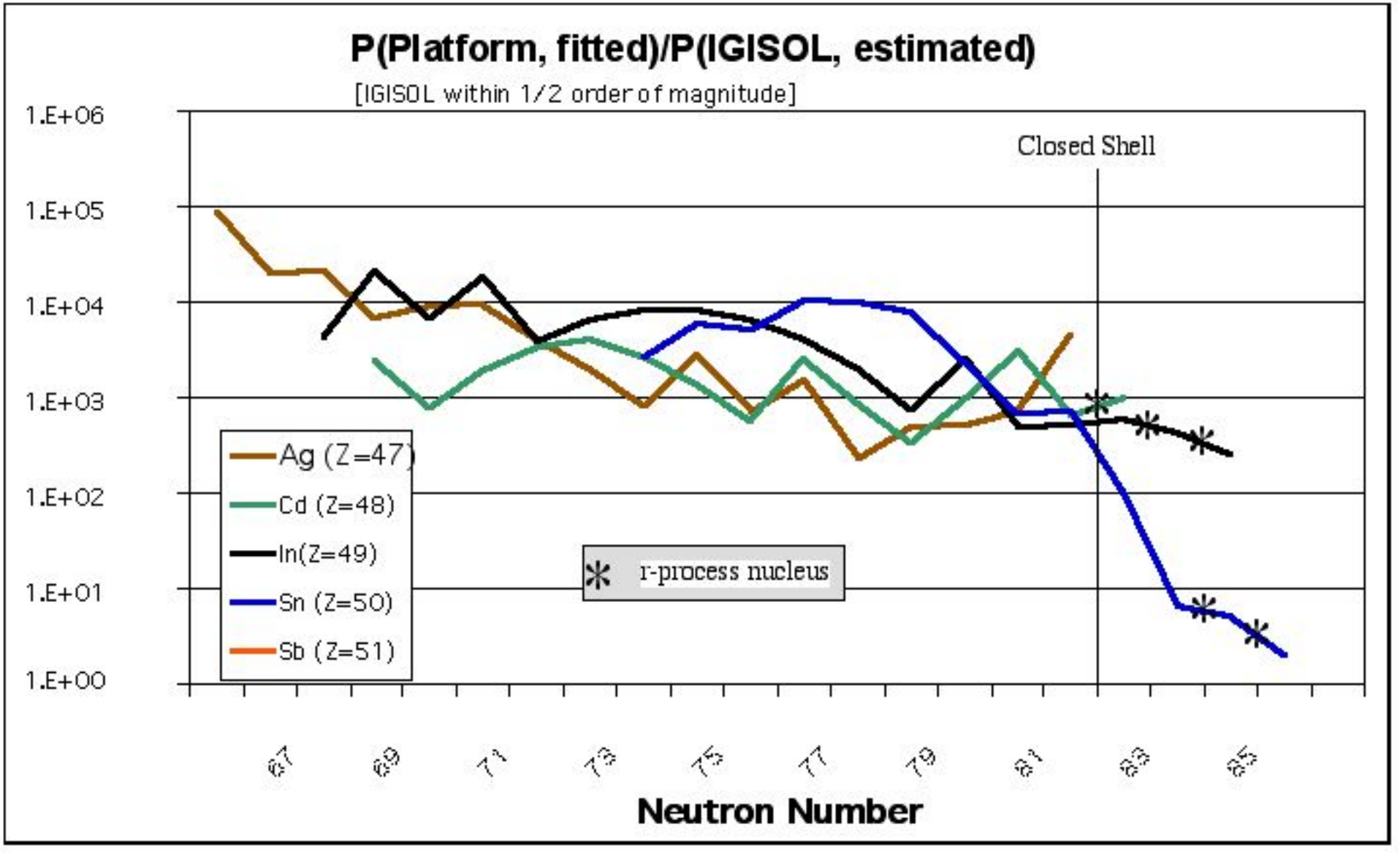


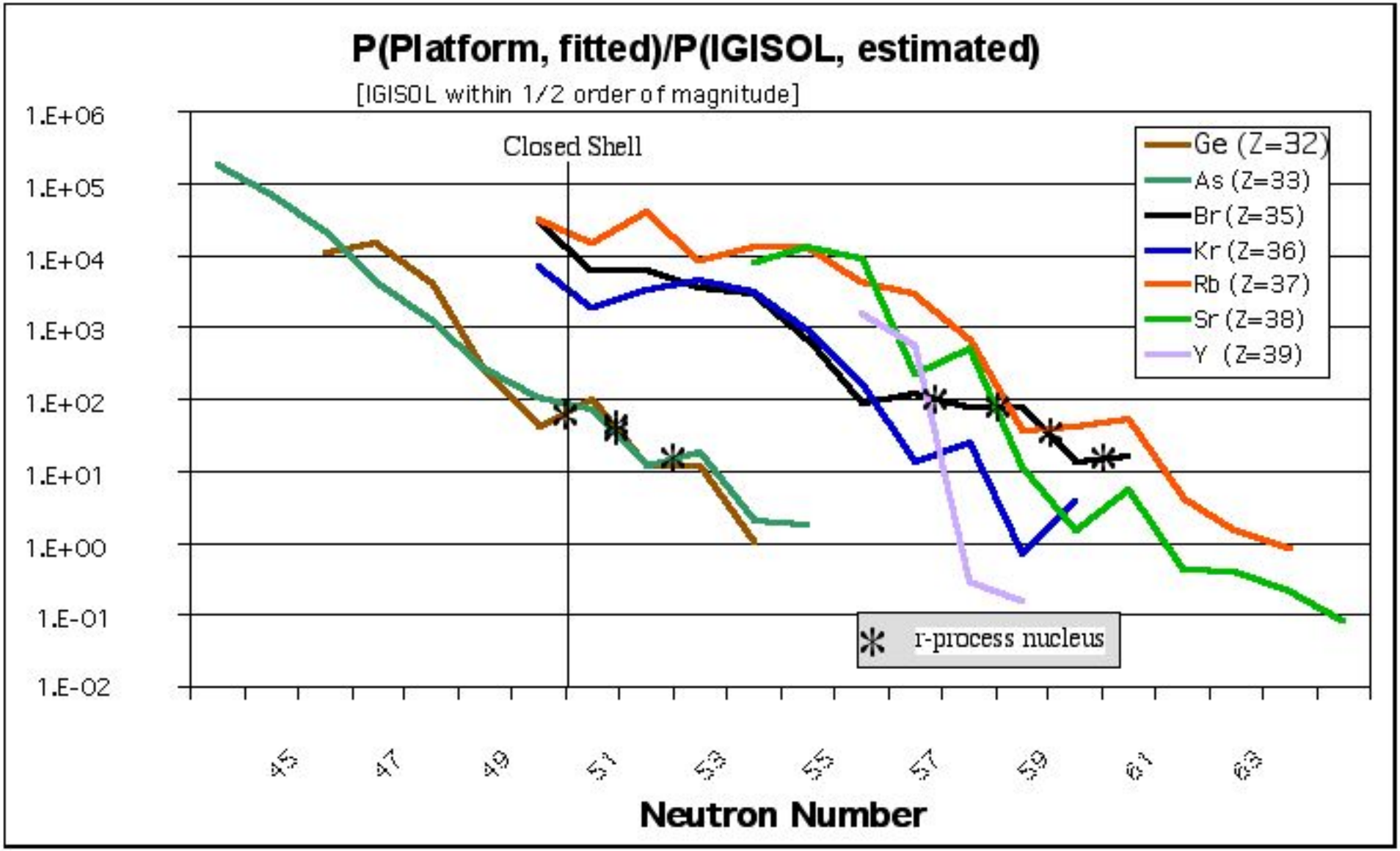

Batchelder 11/30/98

# Yield of Neutron-rich Nuclei with 40 MeV p + UC, thick target, (20 $\mu$A)

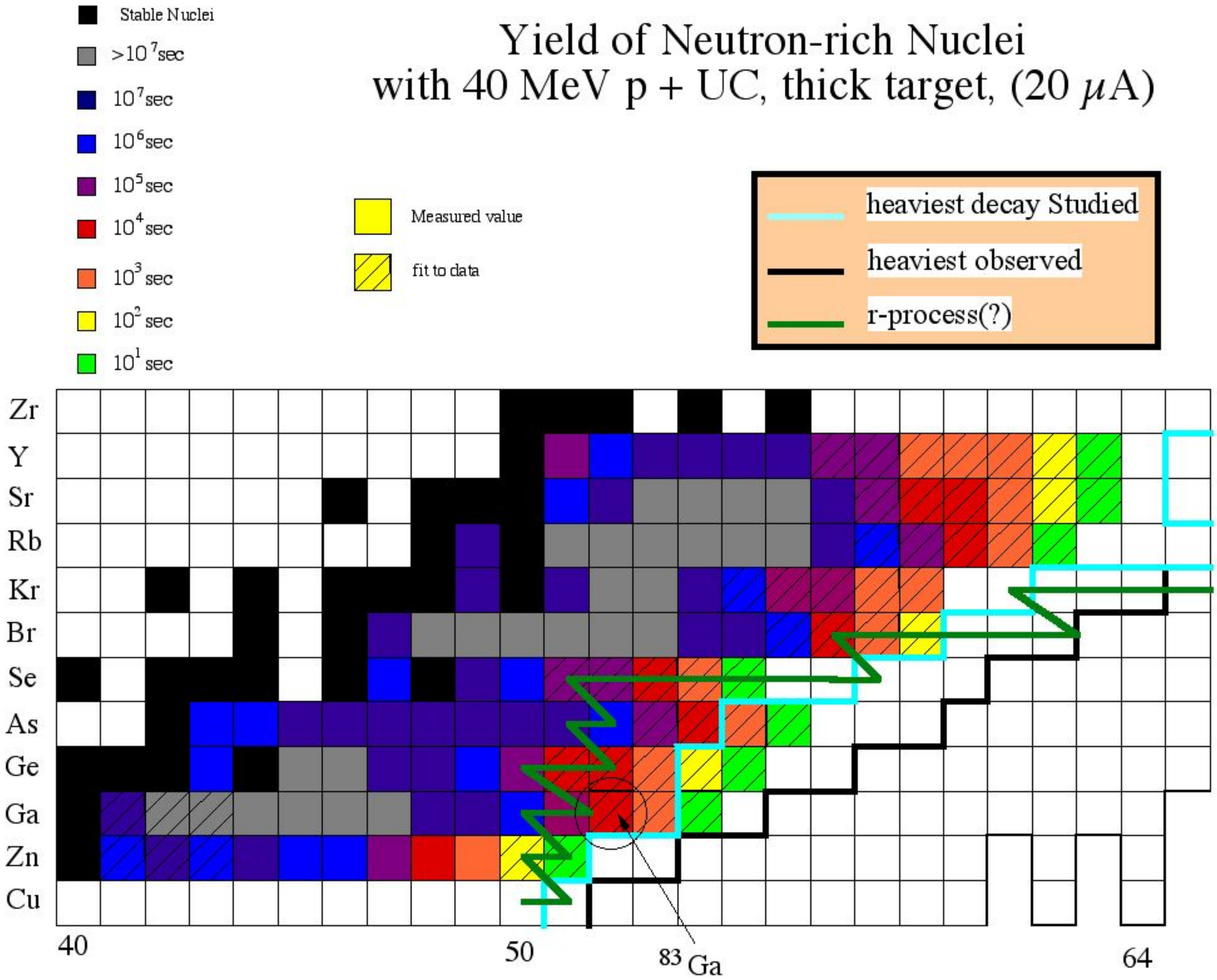



Br
exp
fit
$\varepsilon_Z$ = chemical efficiency
$t_Z$ = system hold-up time
$\varepsilon_{Z,N} = \varepsilon_Z/[1 + t_Z/t_{1/2}]$
Production Rate (atoms/sec) at UNISOR (20 nA)
1E+07
1E+06
1E+05
1E+04
1E+03
1E+02
1E+01
1E+00
1E-01
T 1/2 (s)= 8.6E3 1.9E3 1.7E2 55 56 16 4.4 1.9 0.54 0.34 0.10 0.07
A = 83 84 85 86 87 88 89 90 91 92 93 94

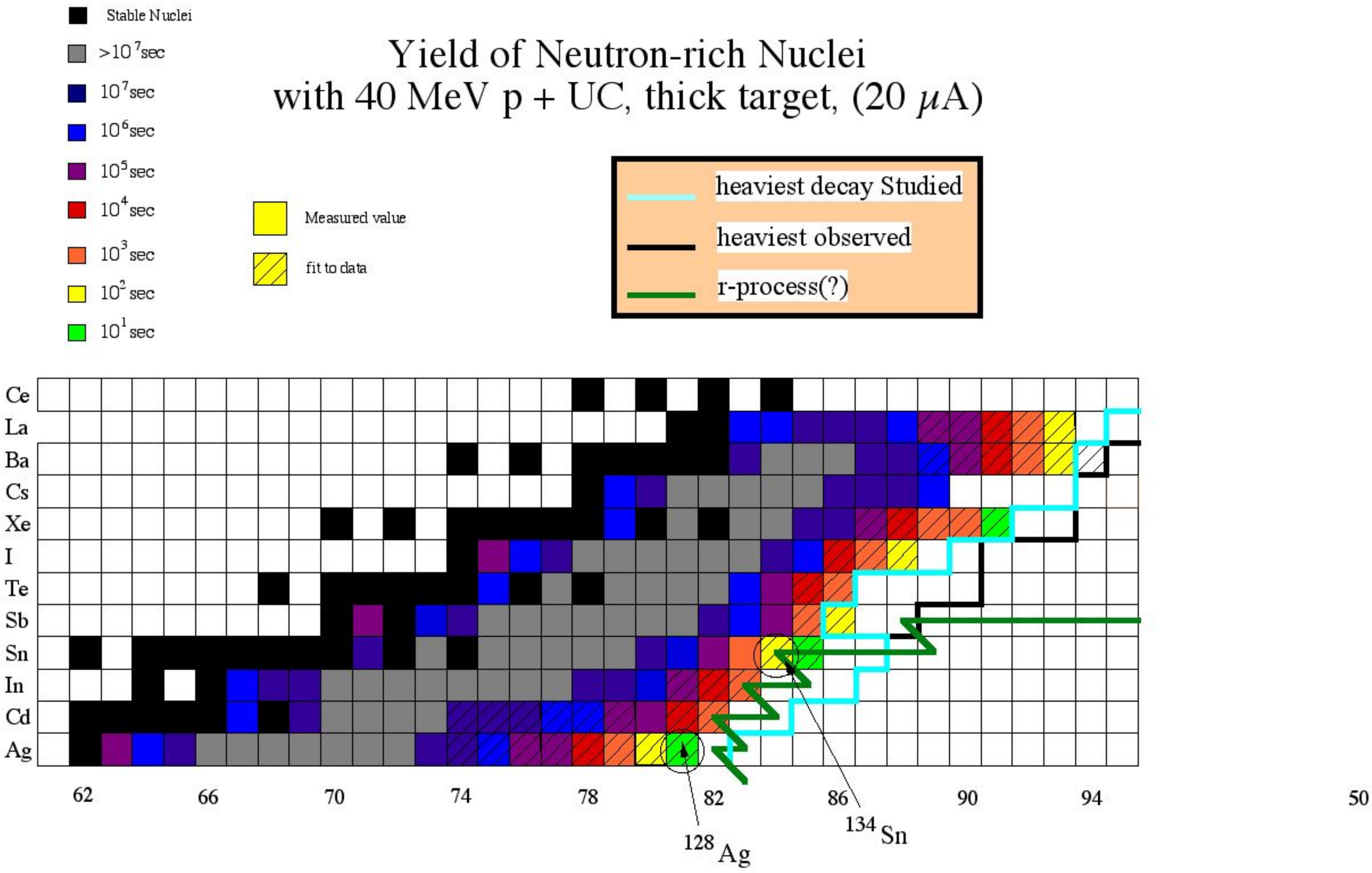

P(Platform, fitted)/P(IGISOL, estimated)
[IGISOL within 1/2 order of magnitude]
1.E+06
1.E+05
1.E+04
1.E+03
1.E+02
1.E+01
1.E+00
Closed Shell
Ag (Z=47)
Cd (Z=48)
In(Z=49)
Sn (Z=50)
Sb (Z=51)
r-process nucleus
67
69
71
73
75
77
79
81
83
85
Neutron Number


P(Platform, fitted)/P(IGISOL, estimated)
[IGISOL within 1/2 order of magnitude]
Closed Shell
Ge (Z=32)
As (Z=33)
Br (Z=35)
Kr (Z=36)
Rb (Z=37)
Sr (Z=38)
Y (Z=39)
r-process nucleus
1.E+06
1.E+05
1.E+04
1.E+03
1.E+02
1.E+01
1.E+00
1.E-01
1.E-02
45
47
49
51
53
55
57
59
61
63
Neutron Number

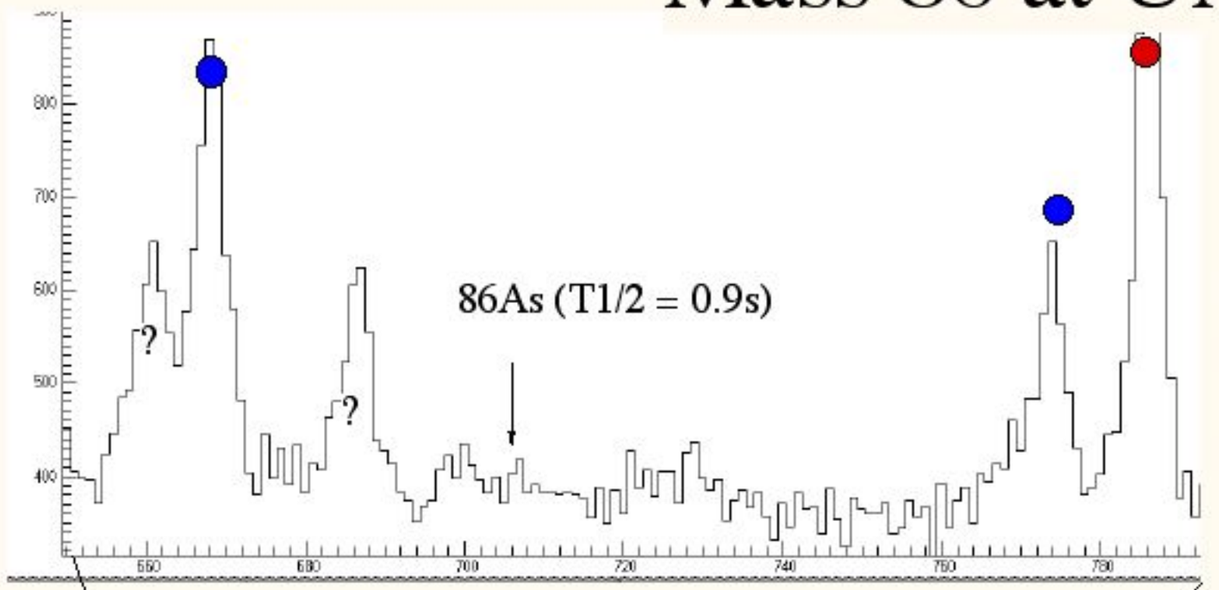
# Yield of Neutron-rich Nuclei with 40 MeV p + UC, thick target, (20 $\mu$A)



# Yield of Neutron-rich Nuclei with 40 MeV p + UC, thick target, (20 $\mu$A)

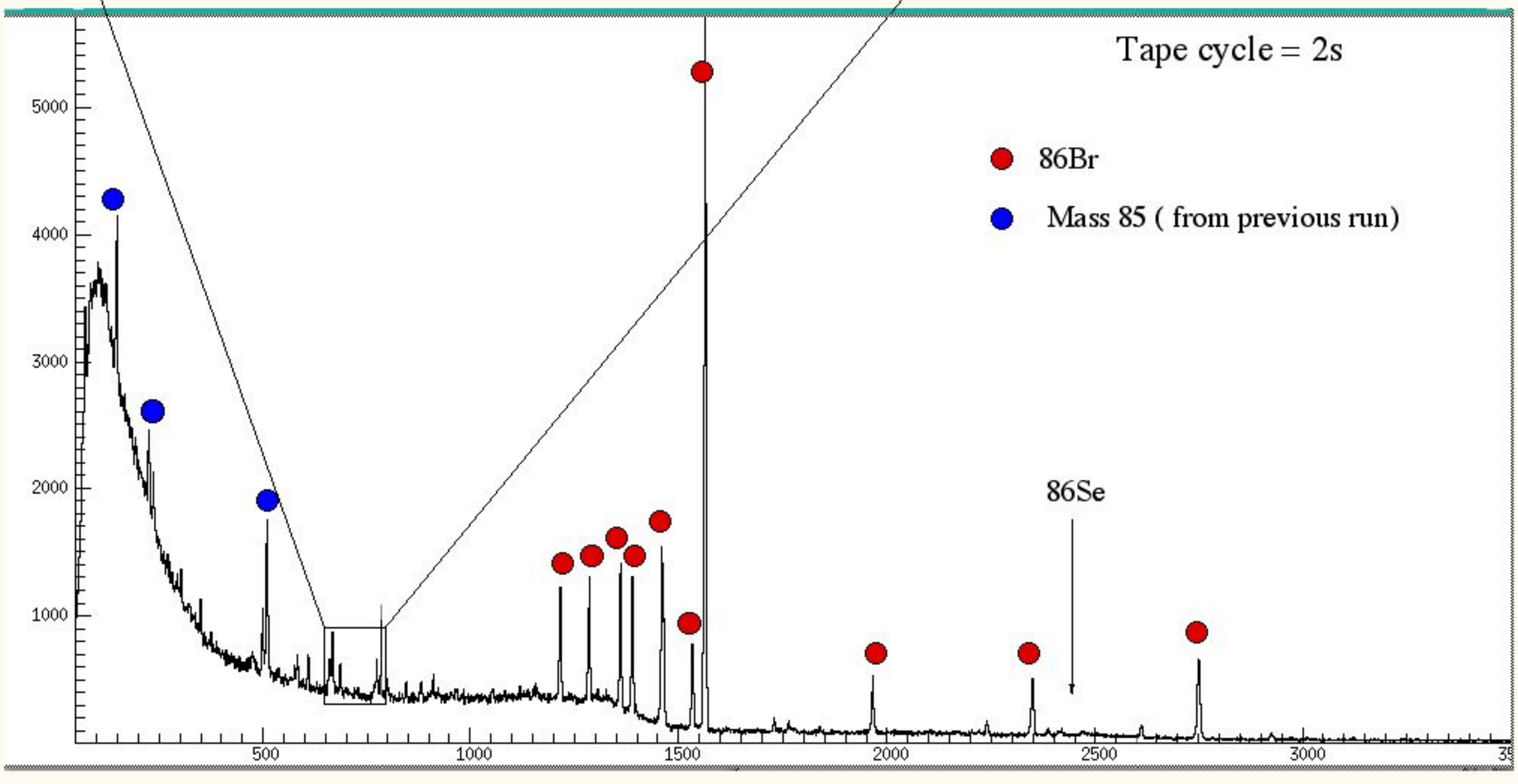


# Mass 86 at UNISOR




**After mass separation**

| | Rate | w/MTC | w/MTOF |
|---|---|---|---|
| As | 4e4 | 0.13% | 94.3% |
| Se | 2e6 | 0.7% | 5.7% |
| Br | 1e9 | 99.25% | 0.02% |



# Ways to accomplish Isobaric separation

- Chemistry

Some elements can be extracted as molecules
SnS, InCl, ...

Different types of ion sources:
kinetic ejection type ion source can cleanly separate out the halides
...

Advantages - clean, high efficiency, low cost
Disadvantages - few cases, separate research project for each

- **Laser ion sources**

Advantages - very clean, relatively high efficiency, established technology, flexible
Disadvantages - separate research project for each element, high cost

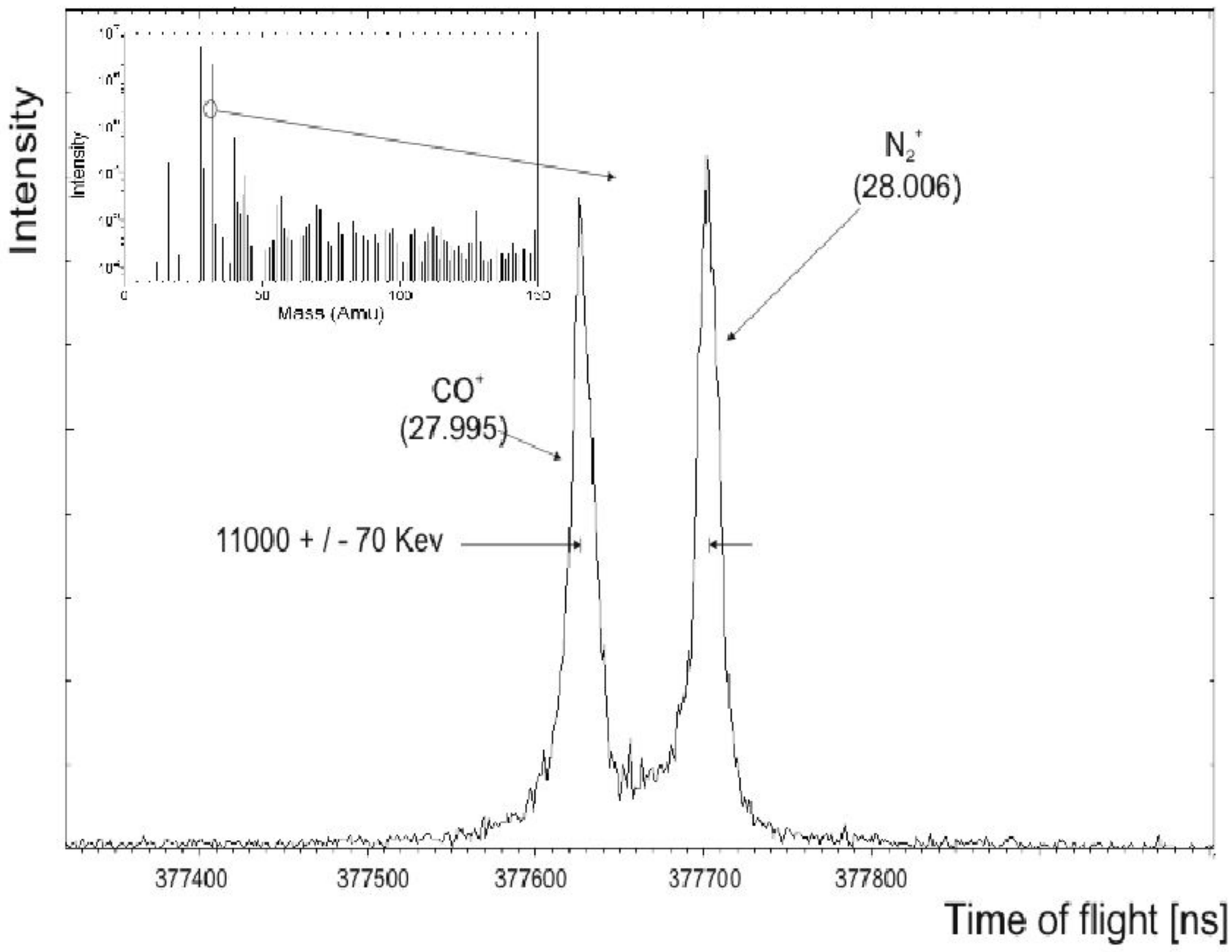
- **Time of flight device**

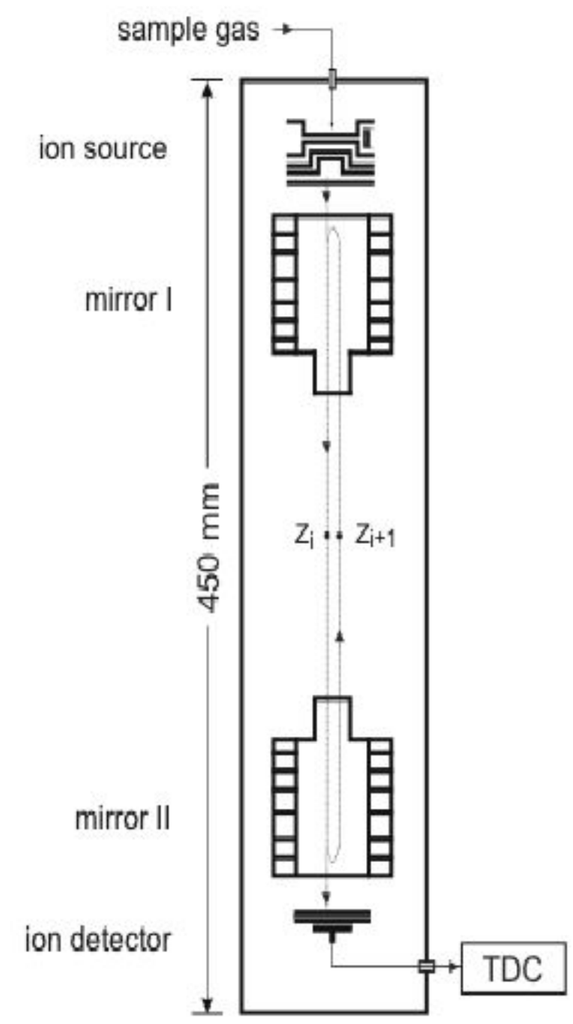
Advantages - clean, universal (no chemical dependence)
Disadvantages - lower efficiency, development needed.

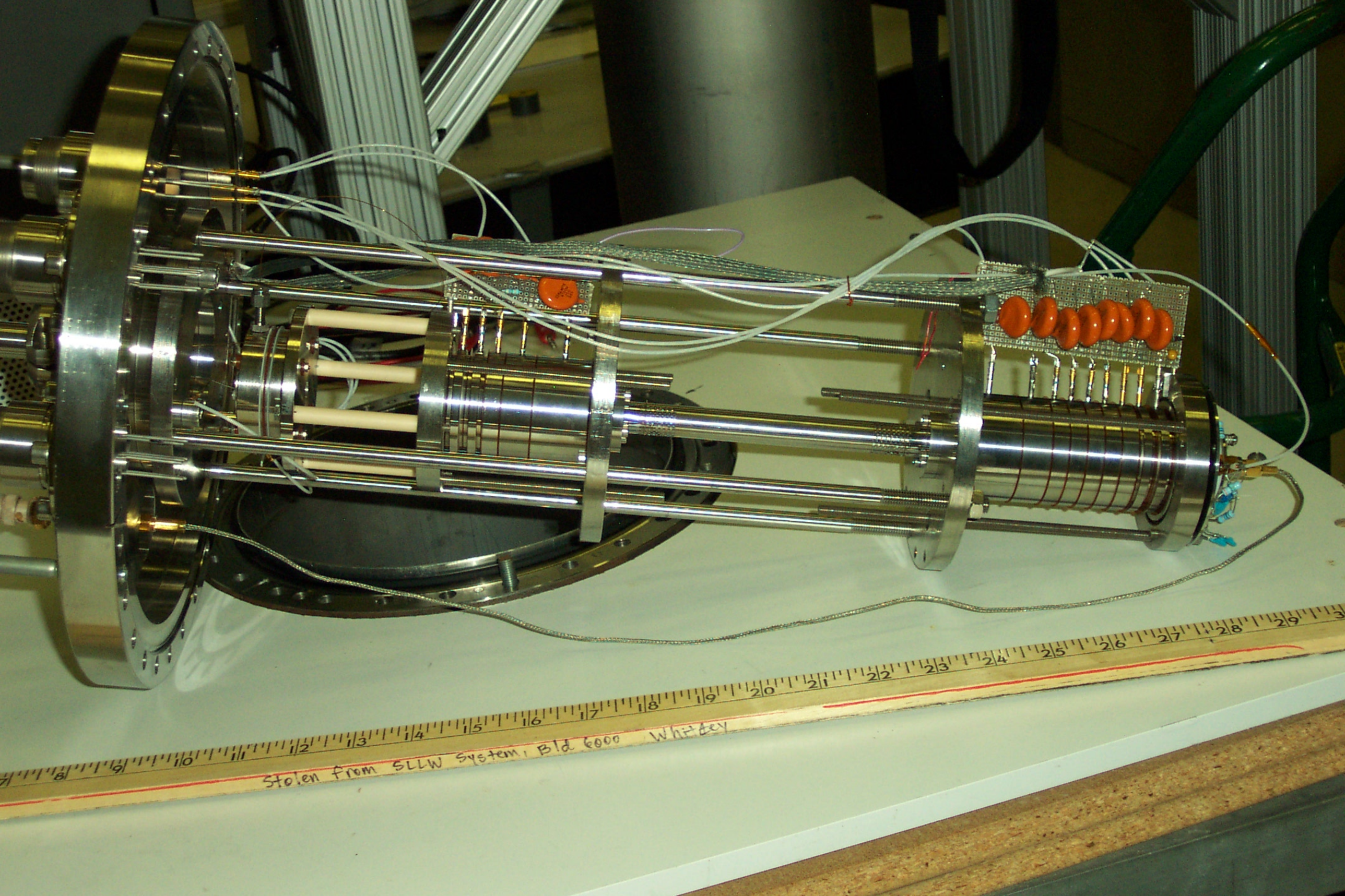
# Pure Iodine beams off the platfom

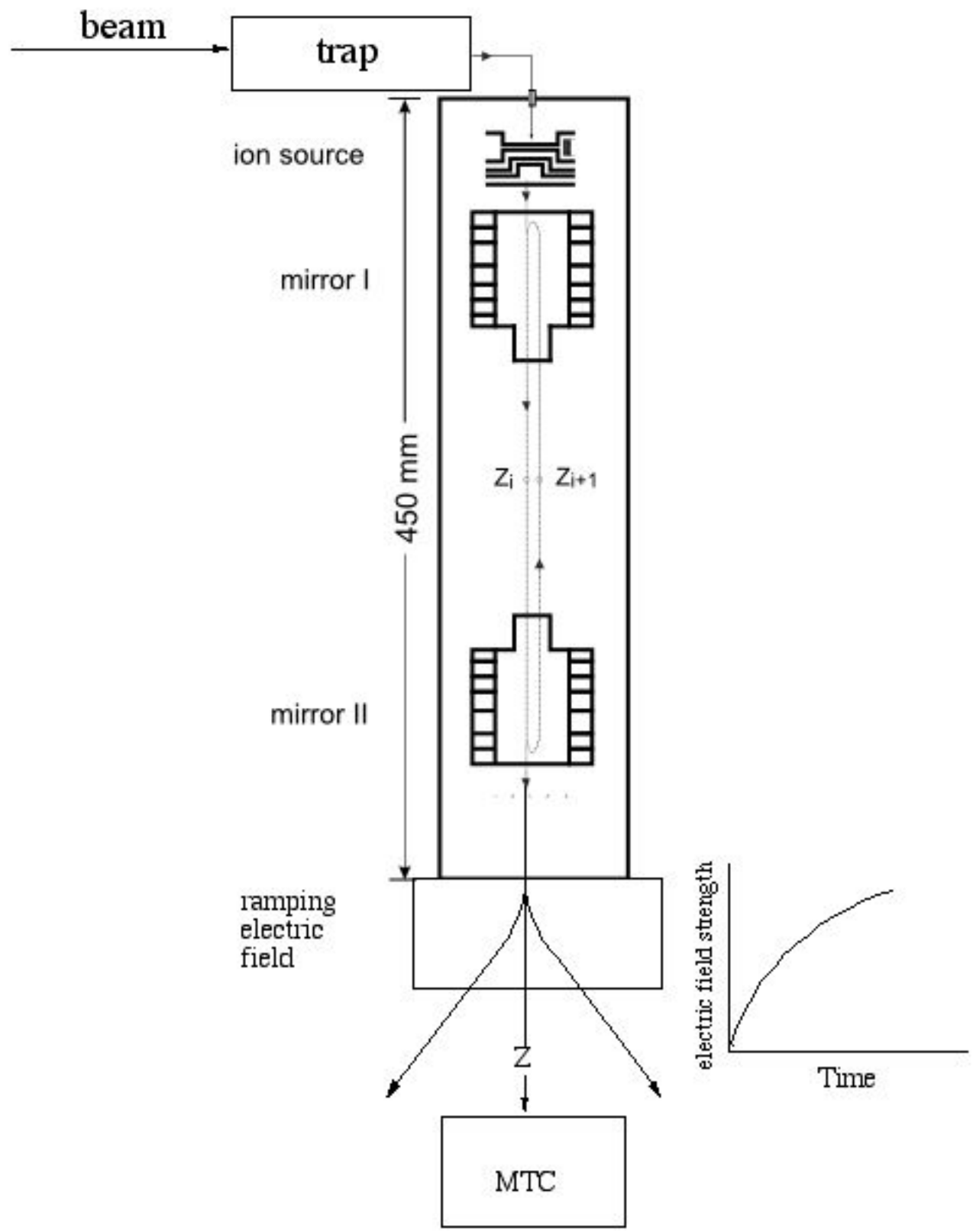
| A | "dirty" | clean |
|---|---|---|
| 136 | 1.8E8 | 9.2E6 |
| 137 | 5.3E7 | 2.7E6 |
| 138 | 5.5E6 | 2.8E5 |
| 139 | 4.9E5 | 2.4E4 |
| 140 | 3.0E4 | 1.5E3 |
| 141 | 1.9E3 | 9.3E1 |
| 142 | 7.5E1 | **3.7** |
| 143 | 4.6 | 0.2 |

A. Casares
D. Radford
H. Wollnik

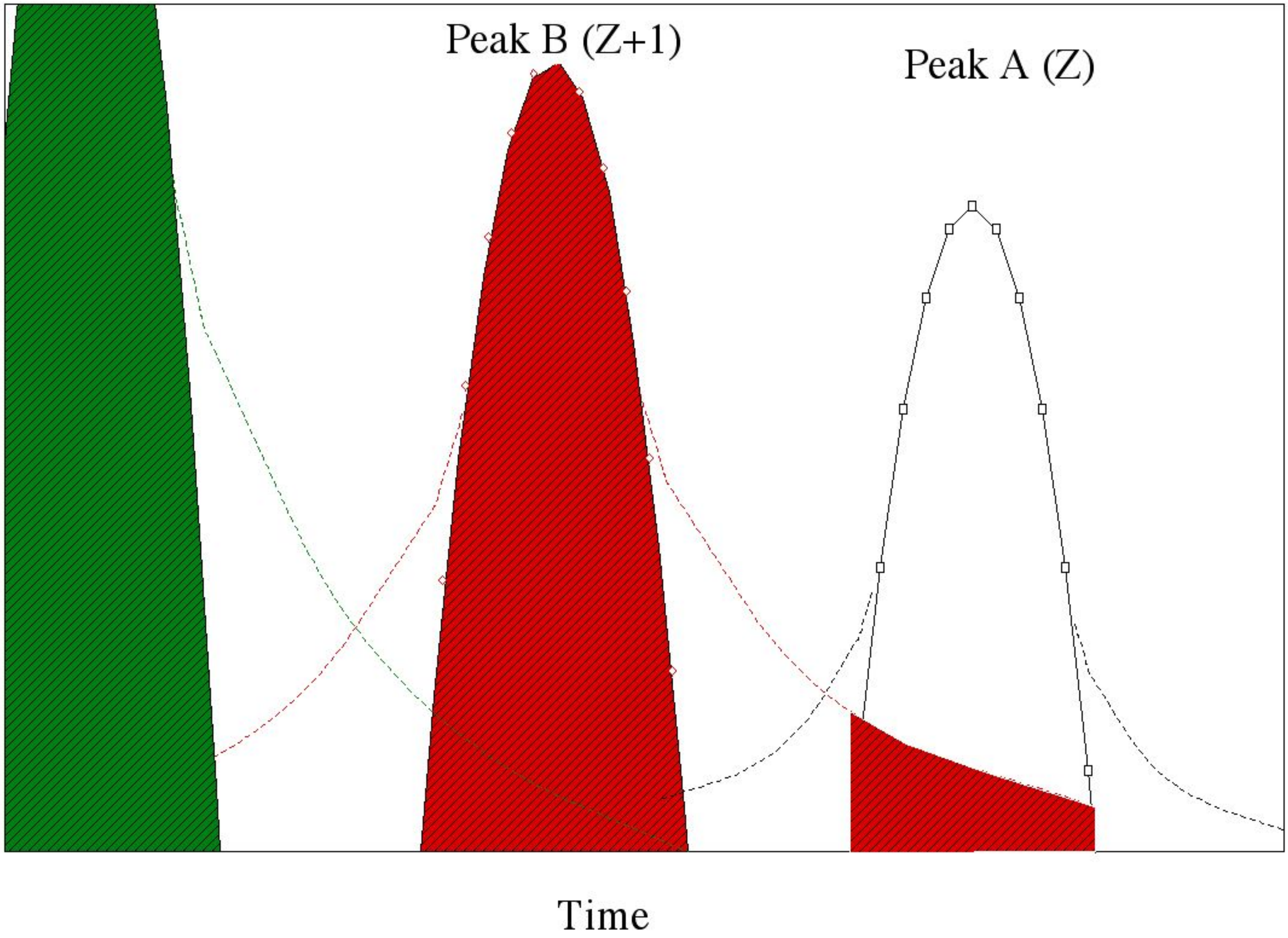



Stolen from SLLW System, Bld 6000 Whitley


beam
trap
ion source
mirror I
450 mm
$Z_i$
$Z_{i+1}$
mirror II
ramping
electric
field
Z
MTC
electric field strength
Time

Assume area of Peak B reduced by 10-3

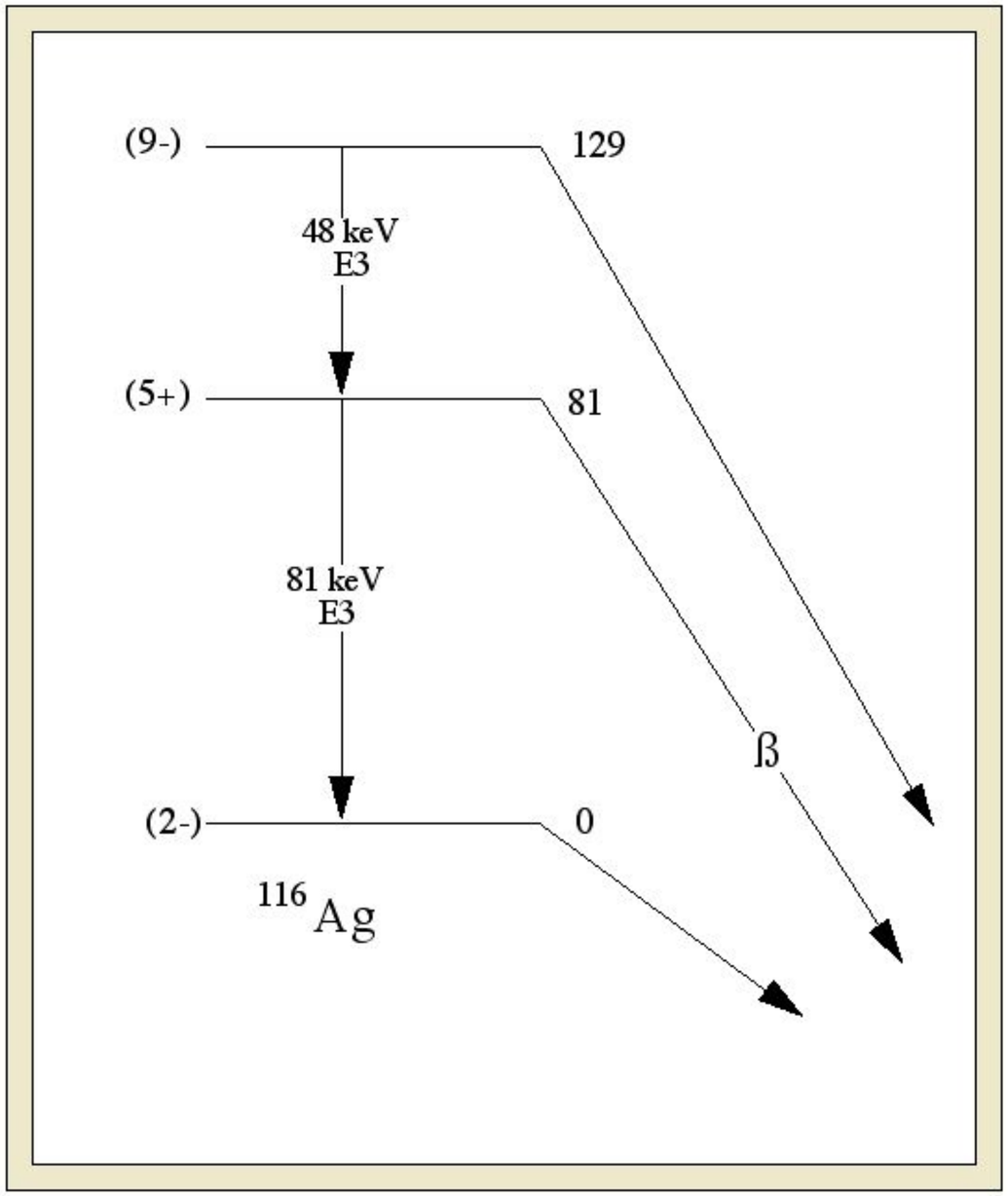


# 20$\mu$A p + UC

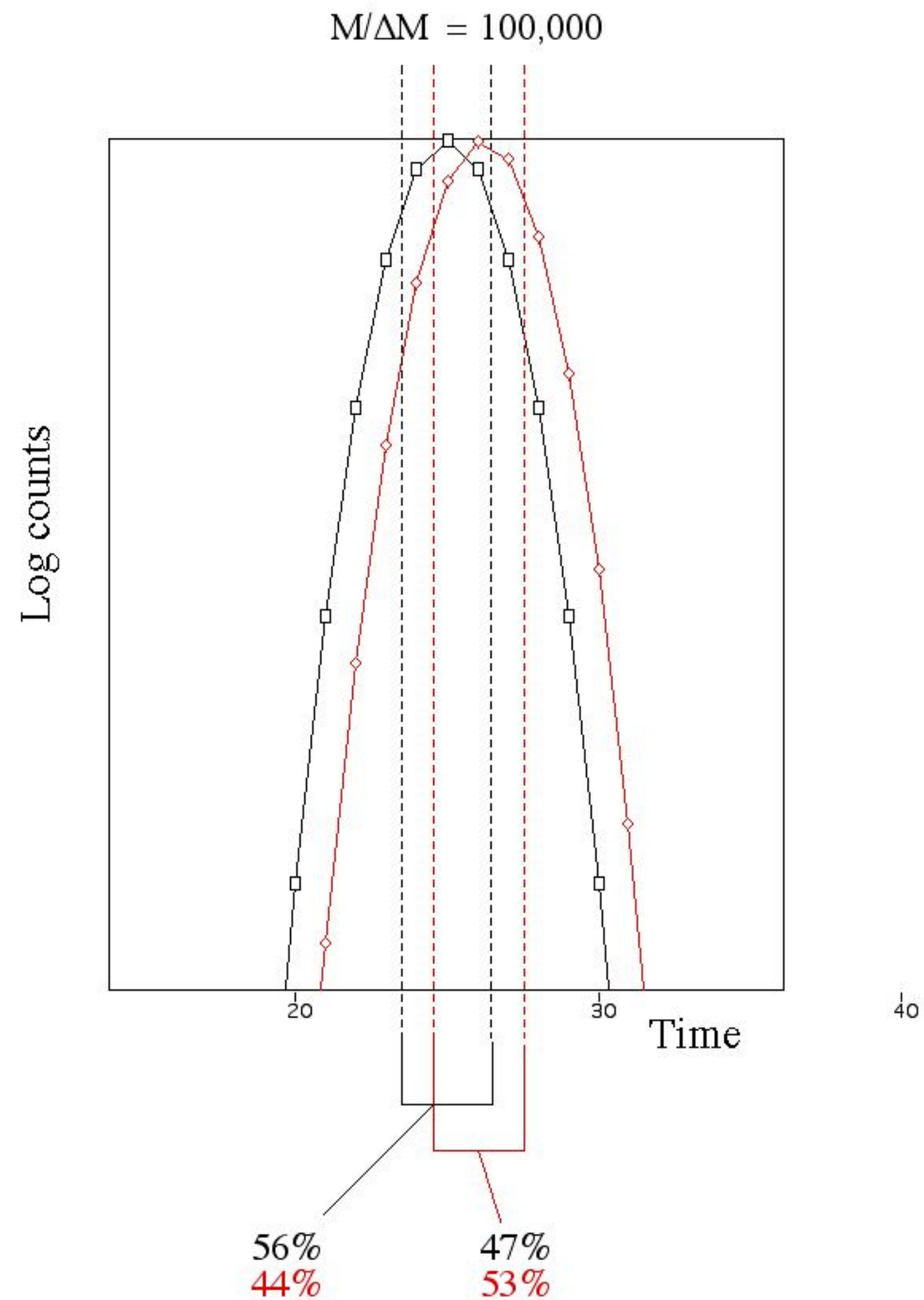
| species | $T_{1/2}$(s) | After mass separator Overall Rate (Hz) | calculated Rate (Hz) w/ MTC | calculated Rate (Hz) w/MTOF |
|---|---|---|---|---|
| $^{82}$Ga | 0.6 | 1.2e3 | 815 | 16.3 |
| $^{82}$Ge | 4.6 | 3.5e3 | 559 | 1.4 |
| $^{82}$As | 19.1 | 6.1e4 | 2182 | 0.03 |
| Tape cycle | 1s | | | |
| % $^{82}$Ga | | **1.81%** | **22.9%** | **92%** |
| $^{83}$Ga | 0.3 | 86 | 78 | 1.6 |
| $^{83}$Ge | 1.9 | 561 | 188 | 0.3 |
| $^{83}$As | 13.4 | 7.4e4 | 3.7e3 | 0.01 |
| $^{83}$Se | 1340 | 3.1e5 | 163 | |
| $^{83}$Br | 8640 | 1.2e6 | 97 | |
| Tape cycle | 1s | | | |
| % $^{83}$Ga | | **0.01%** | **1.8%** | **81.7%** |

# 20$\mu$A p + UC

| | | After mass separator | | |
|---|---|---|---|---|
| | | Overall | calculated Rate (Hz) | |
| **species** | **$T_{1/2}$(s)** | **Rate (Hz)** | **w/ MTC** | **w/MTOF** |
| $^{126}$Ag | 0.11 | 1.6e5 | 1.6e5 | 3200 |
| $^{126}$Cd | 0.5 | 1.1e8 | 8.3e7 | 3830 |
| $^{126}$In | 1.6 | 6.4e9 | 2.2e9 | 496 |
| Tape cycle | 1s | | | |
| % $^{126}$Ag | | **0%** | **0.01%** | **42.5%** |
| $^{128}$Ag | 0.06 | 1.4e3 | 1.4e3 | 3 |
| $^{128}$Cd | 0.34 | 9.7e6 | 8.4e6 | 192 |
| $^{128}$In | 0.84 | 8.3e8 | 4.7e8 | 10 |
| Tape cycle | 1s | | | |
| % $^{128}$Ag | | **0.0002%** | **0.0003%** | **12.2%** |



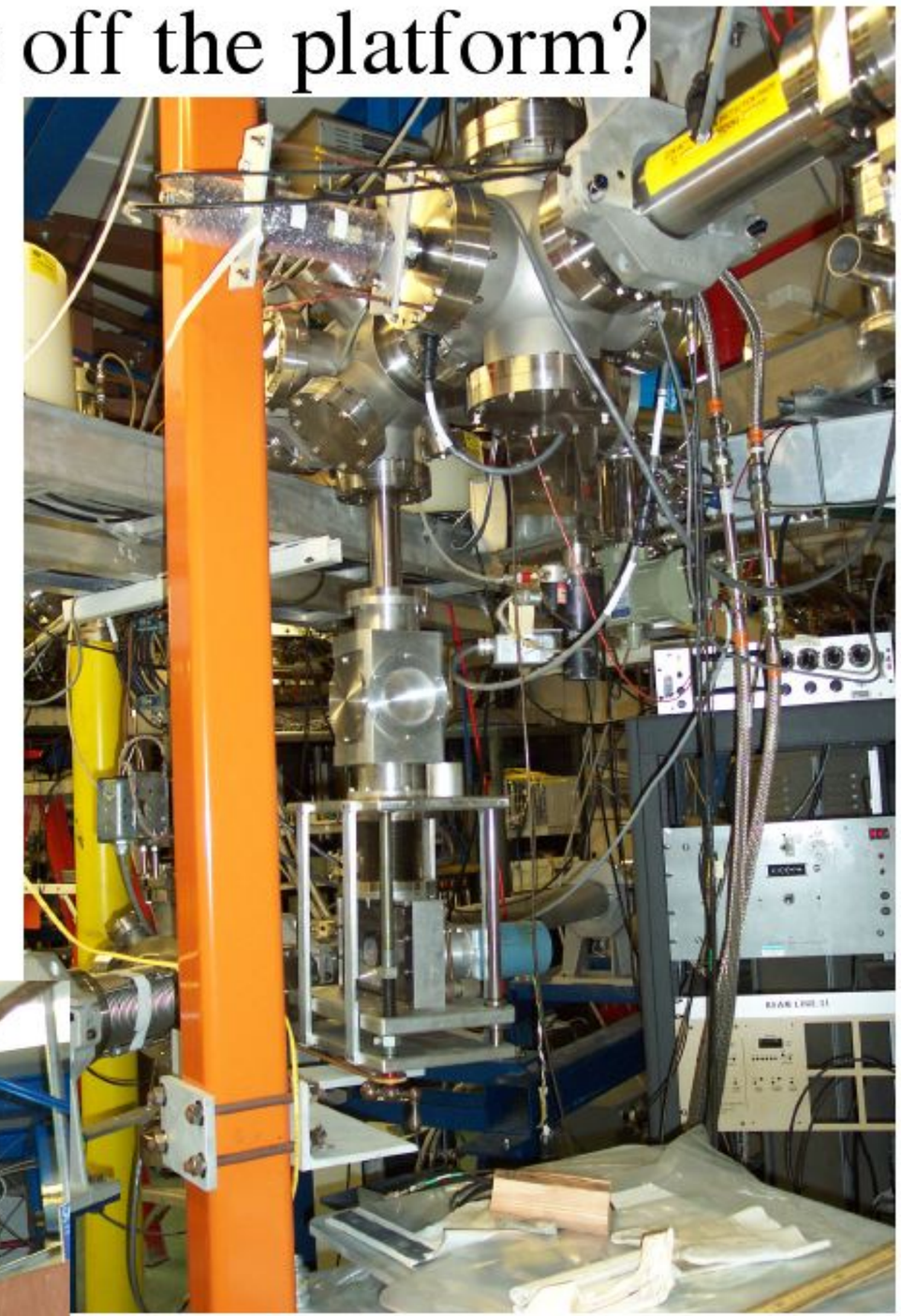

2 isomers ~50 keV apart

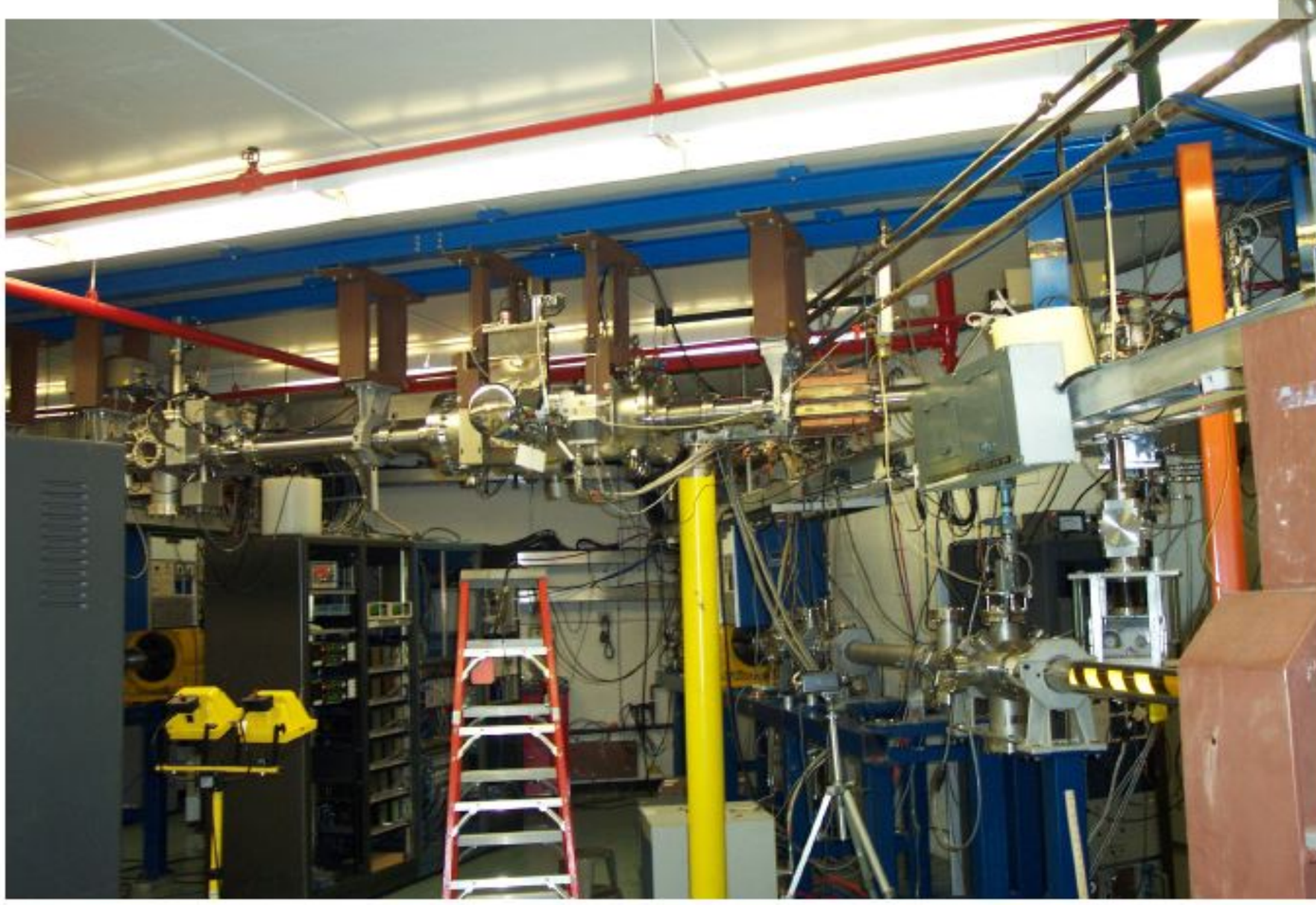


# Where can we do measurements off the platform?

Mini-Cards?

MTOF + CARDS?





# Conclusions

**TOF**

- Working MTOF system will allow us to performed detailed spectroscopy on nuclei produced in induced fission of UC in the presence of very high backgrounds.

  For example:
  - Properties of r-process nuclei
  - Shell structure and isomerism near the closed(?) neutron shells 50 and 82.

- A prototype system is operational now. Much work is needed to develop the injection system.

- Future developements may include mass measurements and separation of HI reaction products (i.e. after RMS).

**Detection System**

- CARDS/MTC system fully commissioned.
  - Flexible setup: different combinations of detectors possible.
  - Low energy e- detector BESCA

- Digital electronic system
  - Can handle higher rates without problem of pileup.
  - Continuous time stamping for all events
  - Flexible, most gates done in software