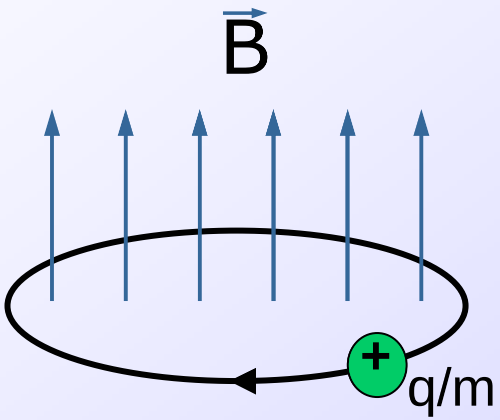
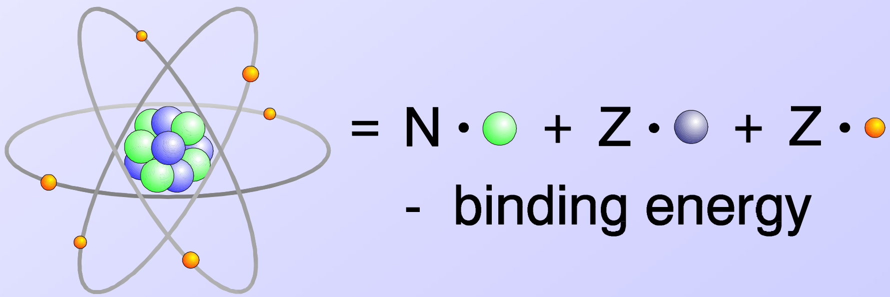
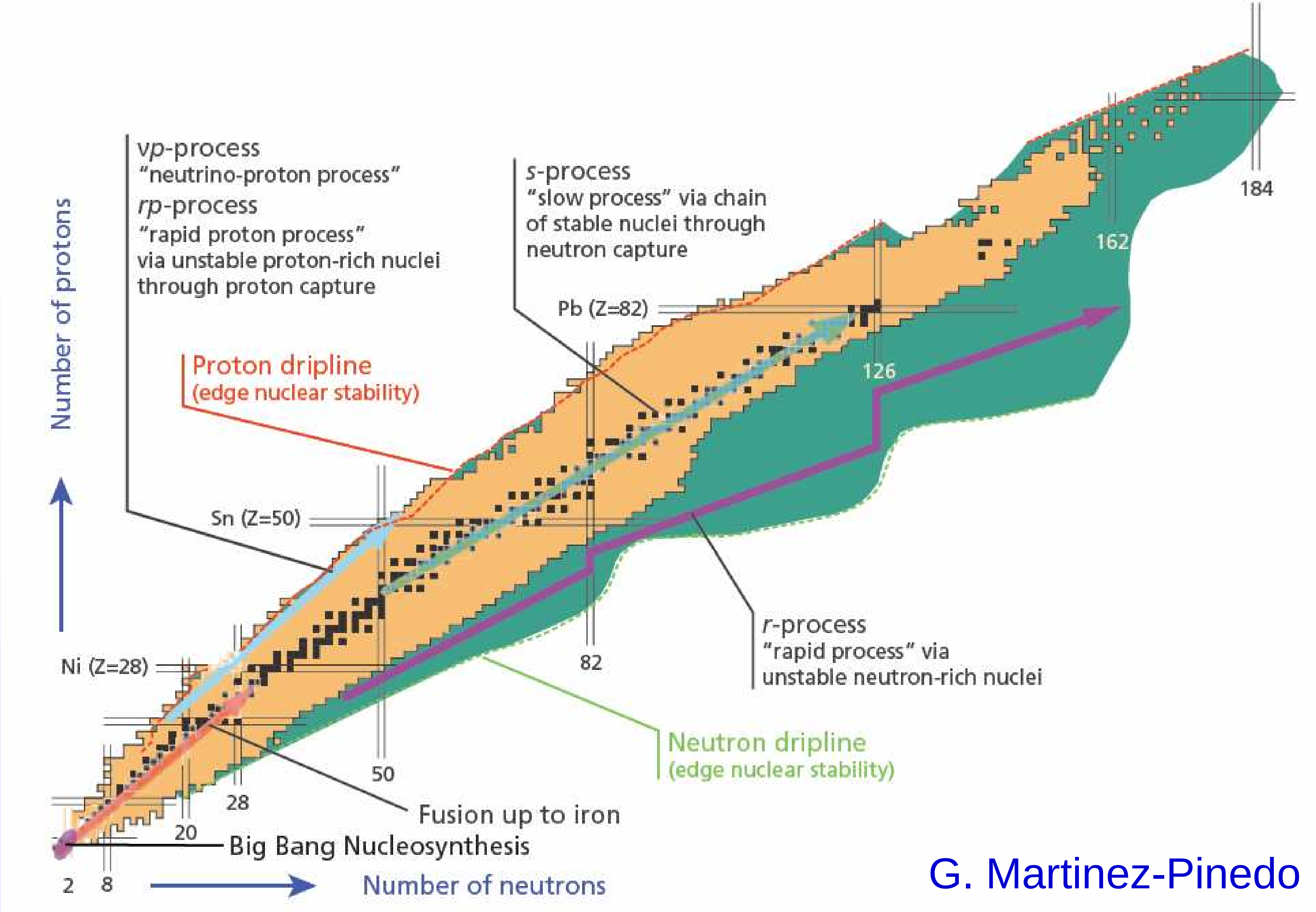
Exploring the r-process path with mass measurements on neutron-rich nuclei at MLLTRAP

Alexander Herlert, CERN



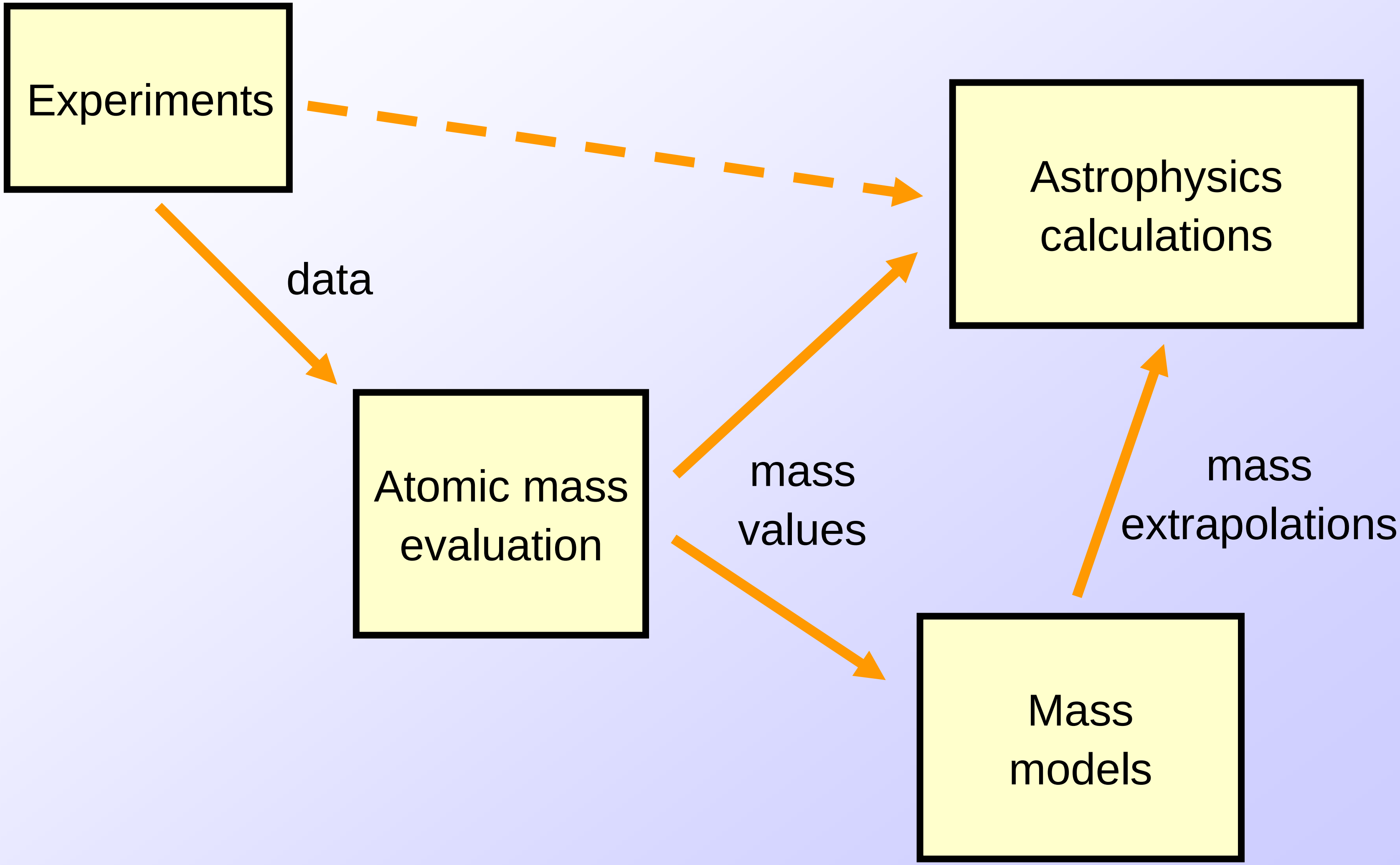


Nucleosynthesis

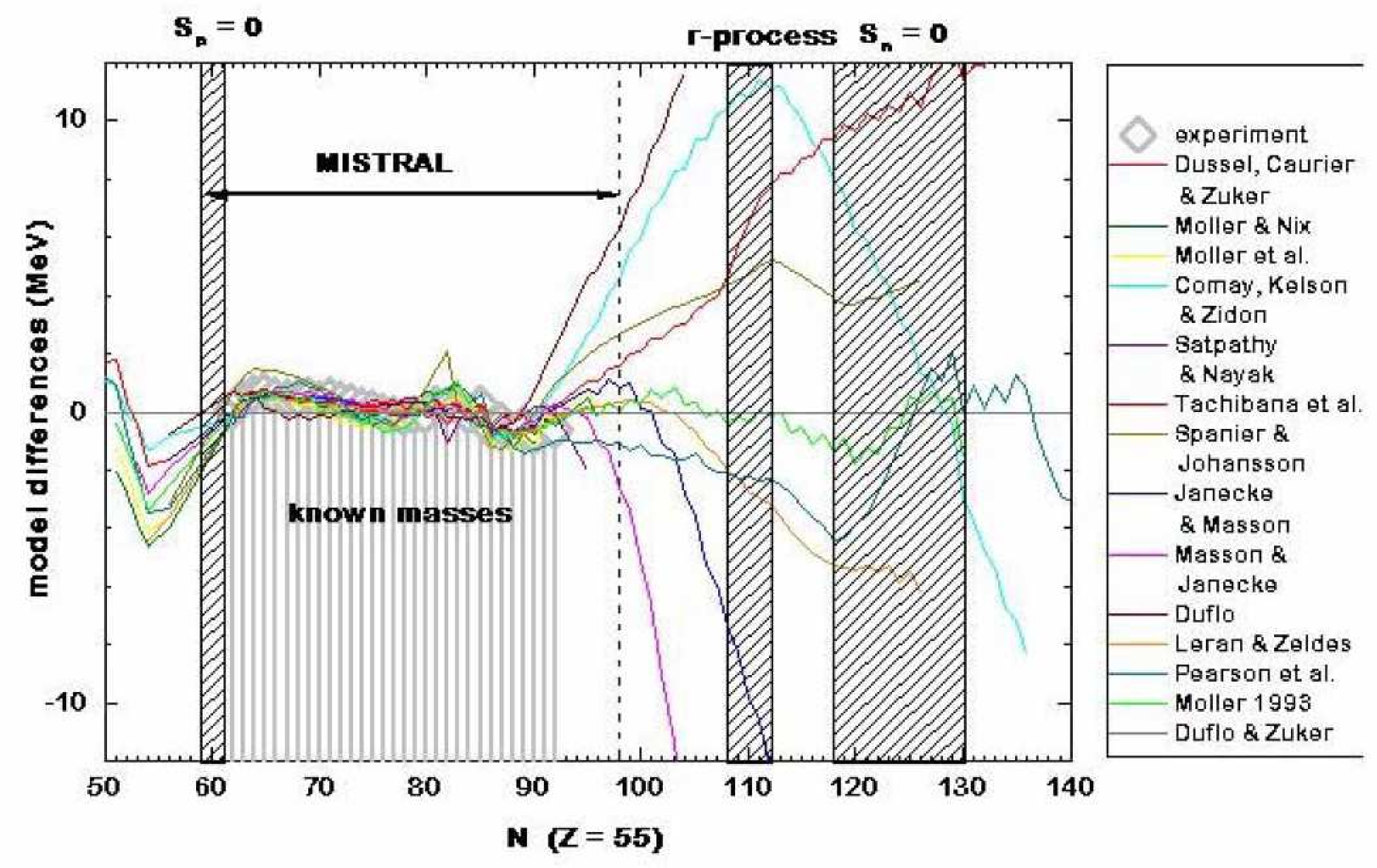


G. Martinez-Pinedo

Mass values for astrophysics calculations

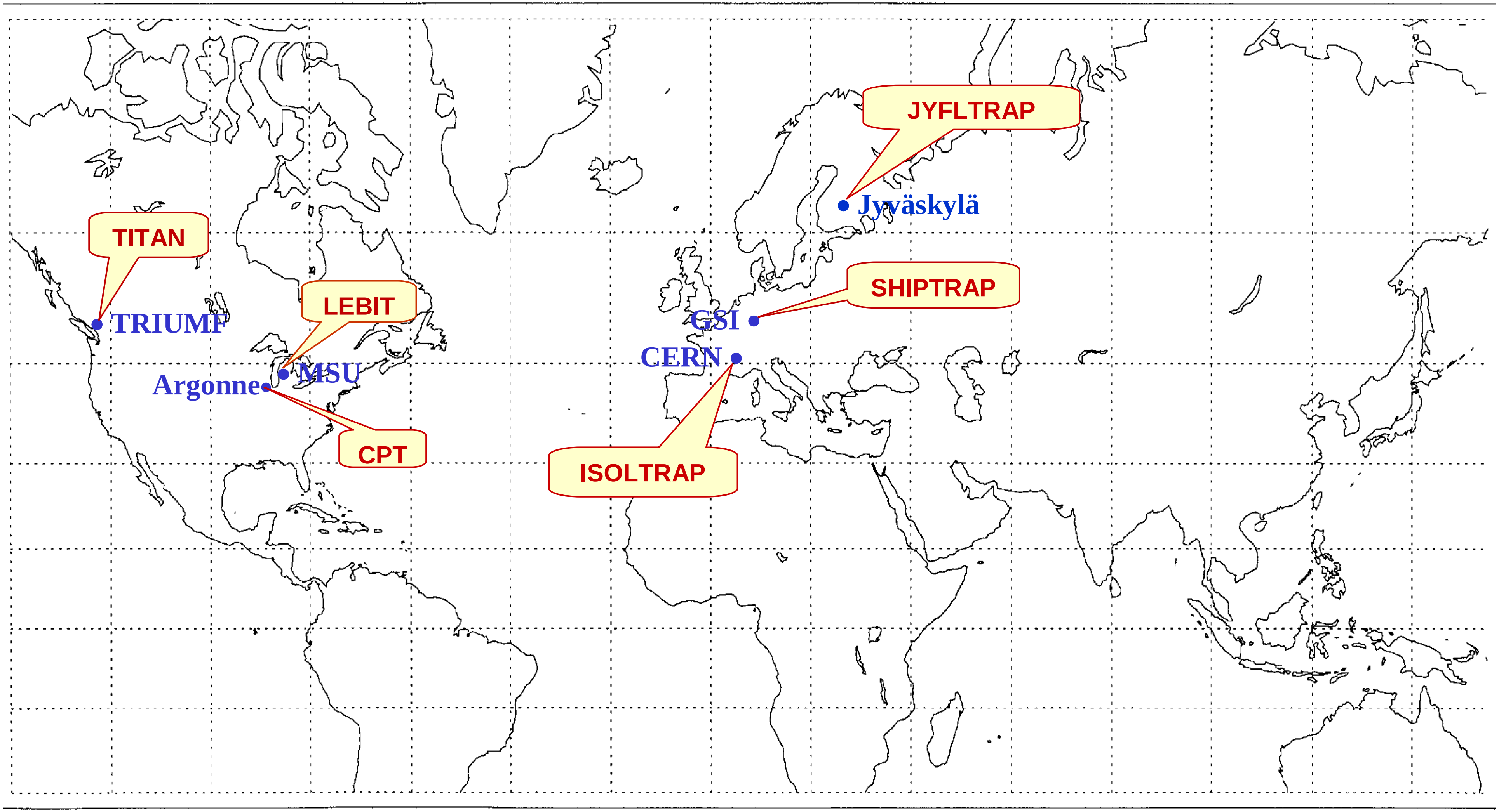


Extrapolation – limitation of mass models?

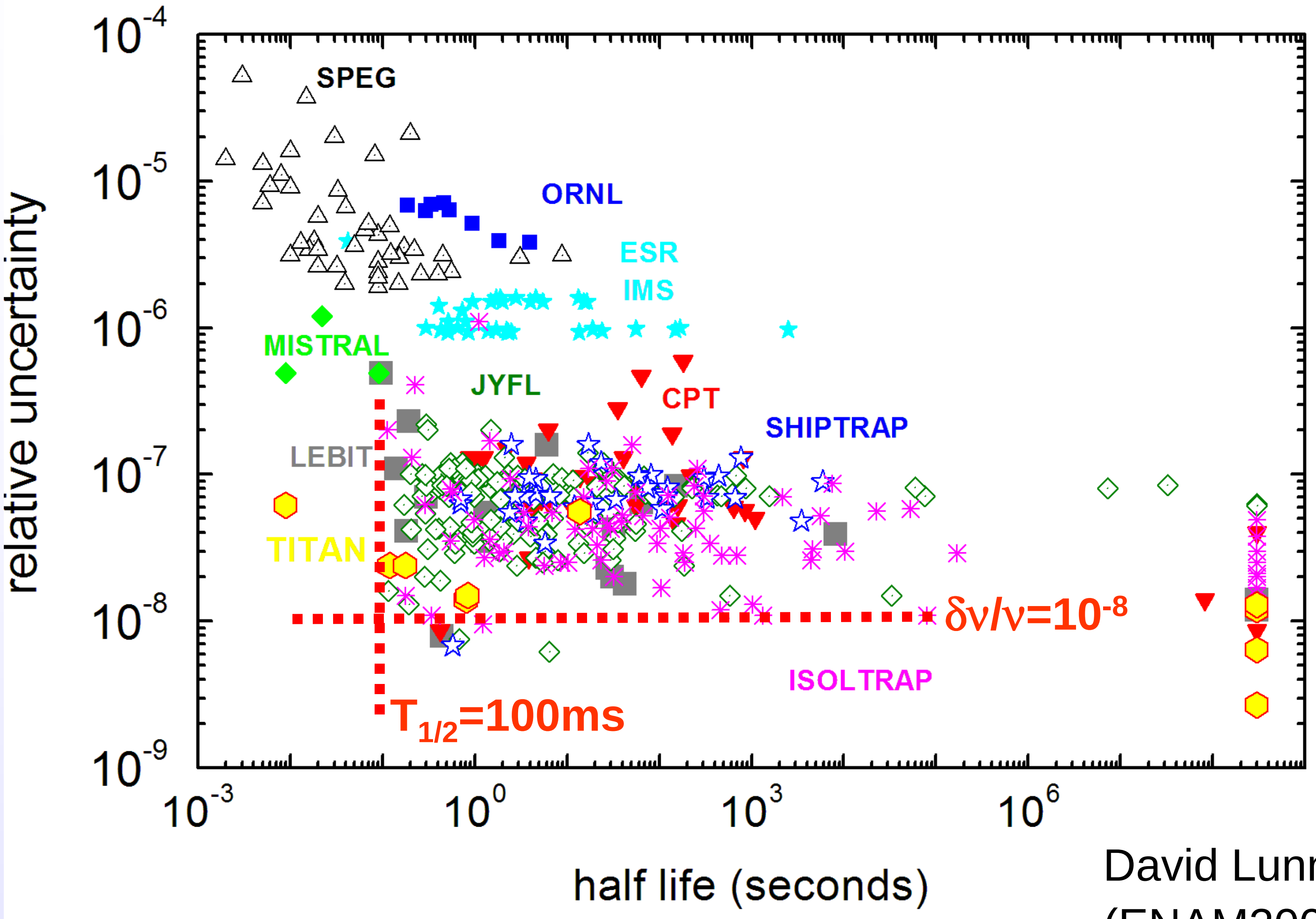


David Lunney (ENAM 1995)

Penning traps for mass measurements on short-lived nuclides

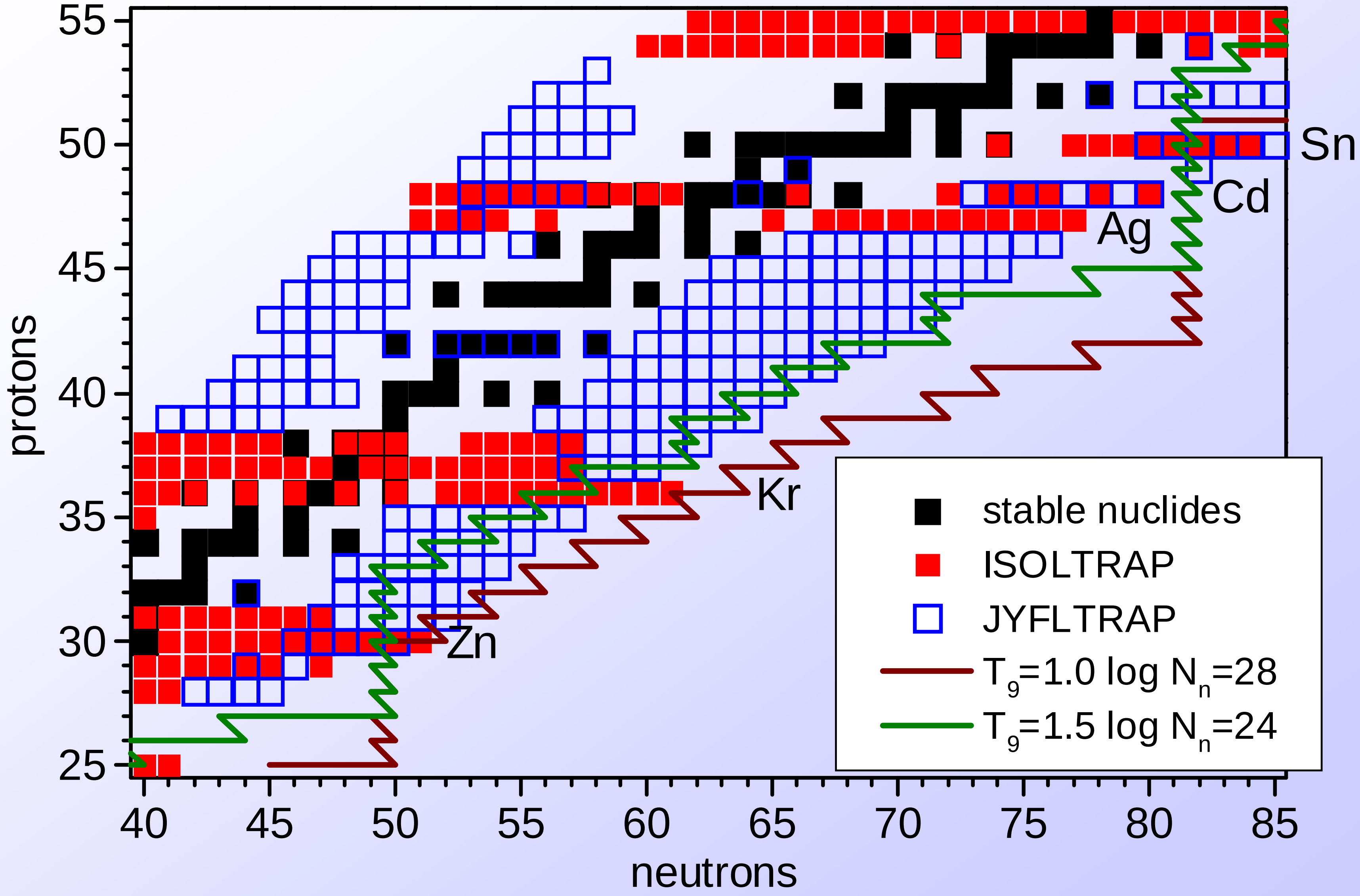


Relative mass uncertainty vs. half life

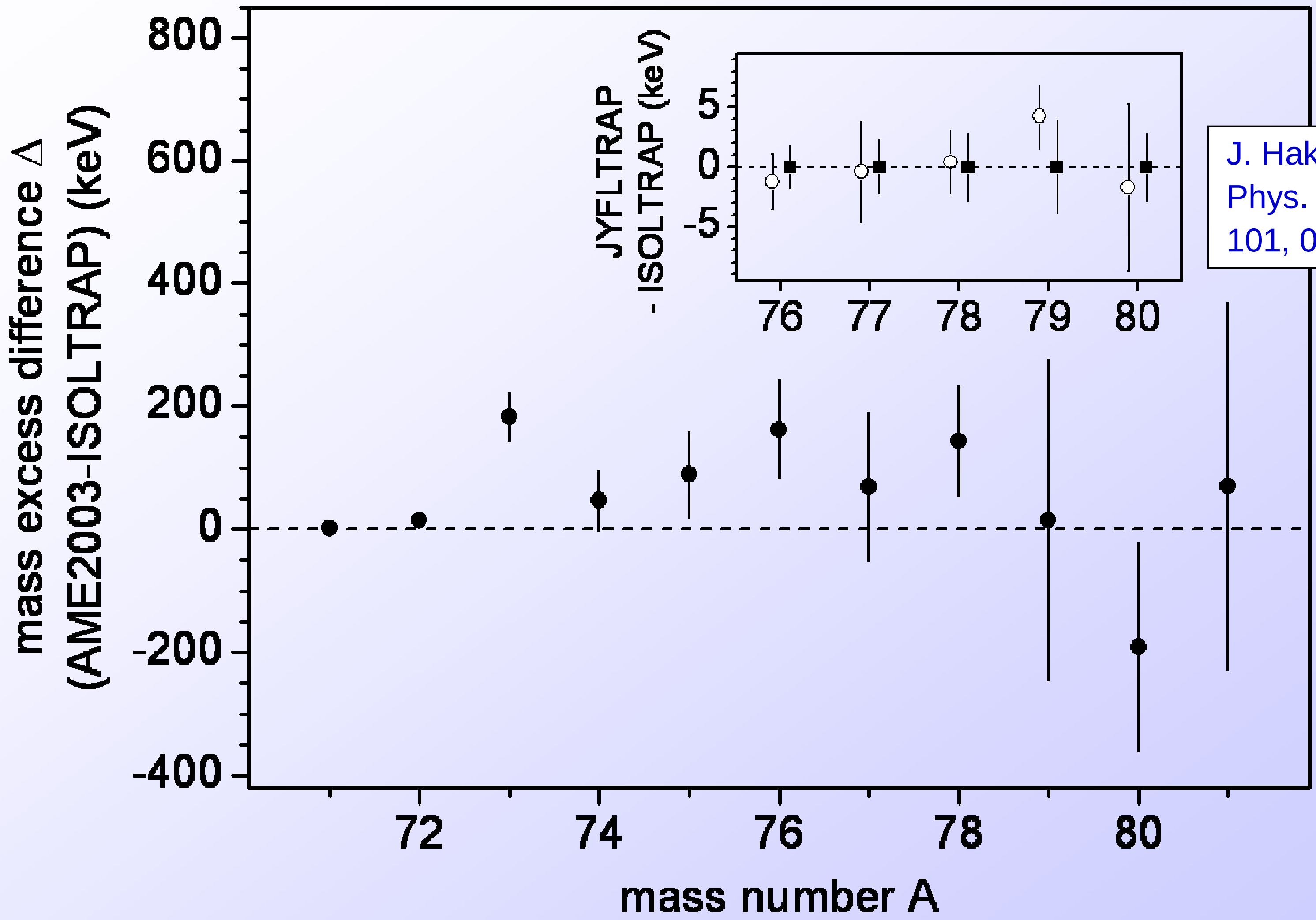


David Lunney
(ENAM2008)

Penning trap mass measurements close to r-process path



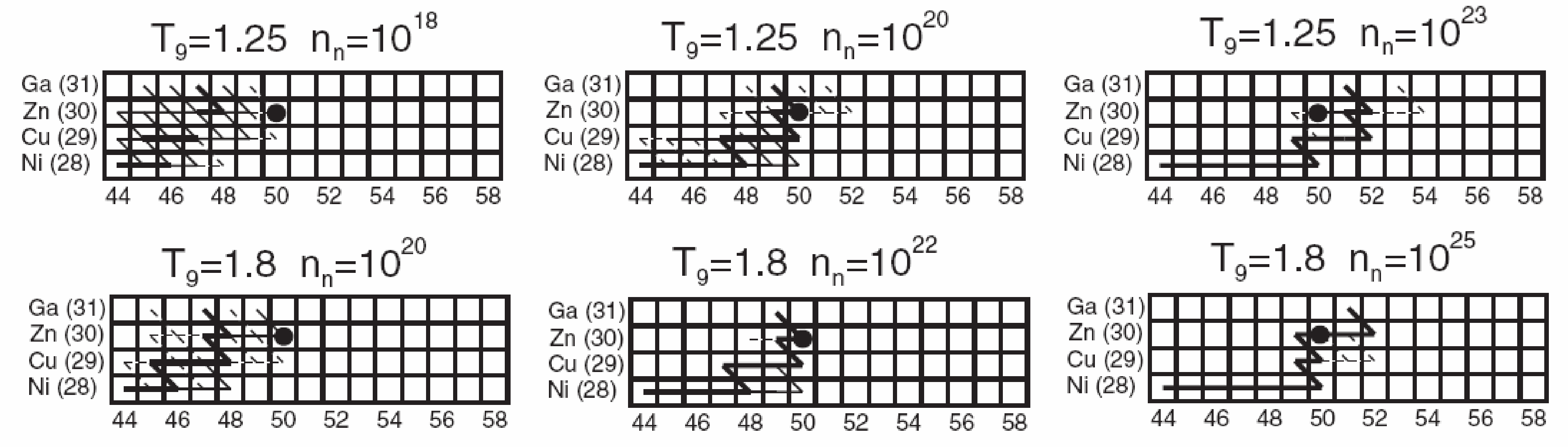
Comparison: ISOLTRAP vs. JYFLTRAP



J. Hakala et al., Phys. Rev. Lett. 101, 052502 (2008)

Baruah et al., PRL 101, 262501 (2008)

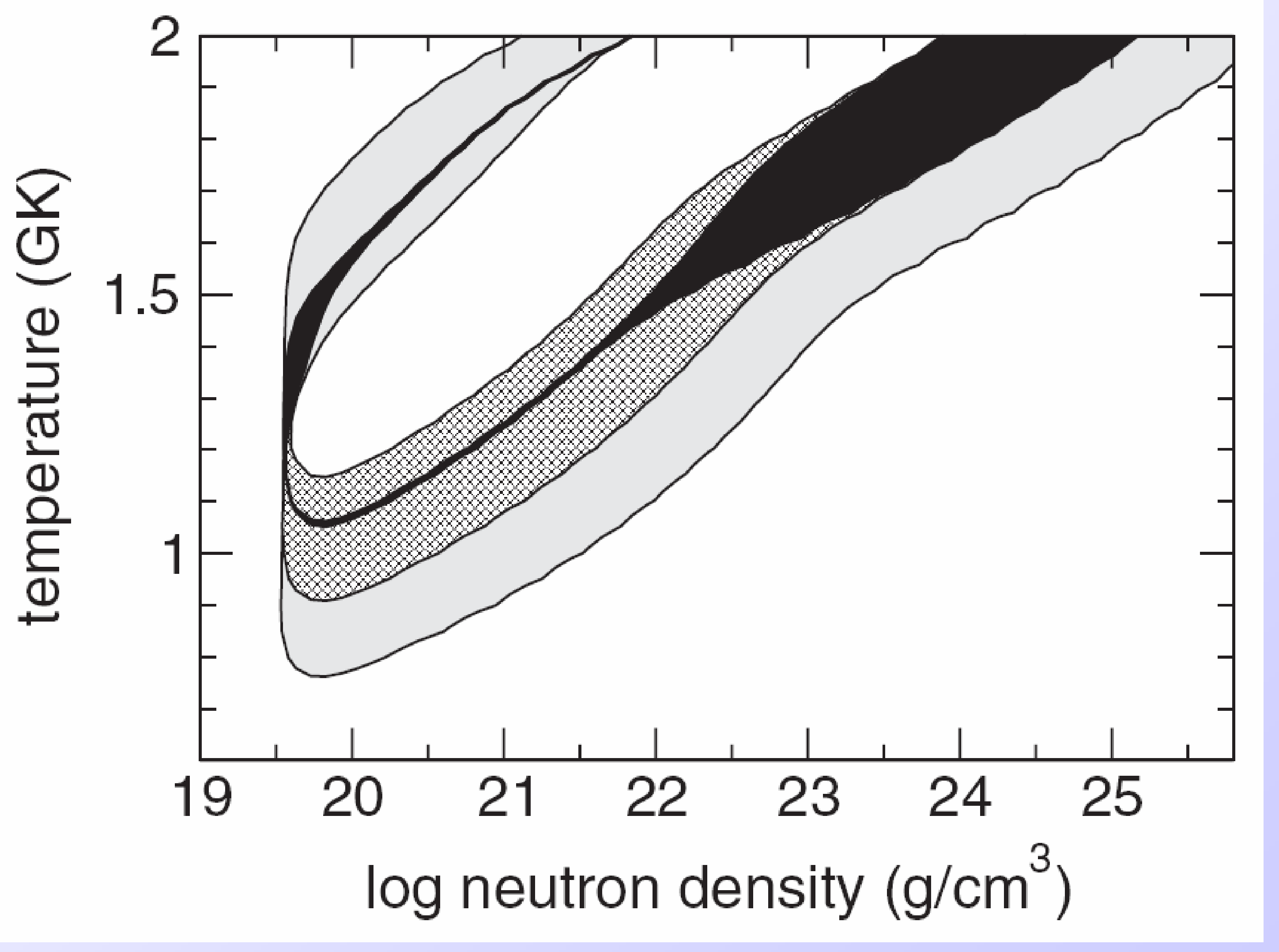
Major waiting point ^{80}Zn (I)



Network calculations by Hendrik Schatz

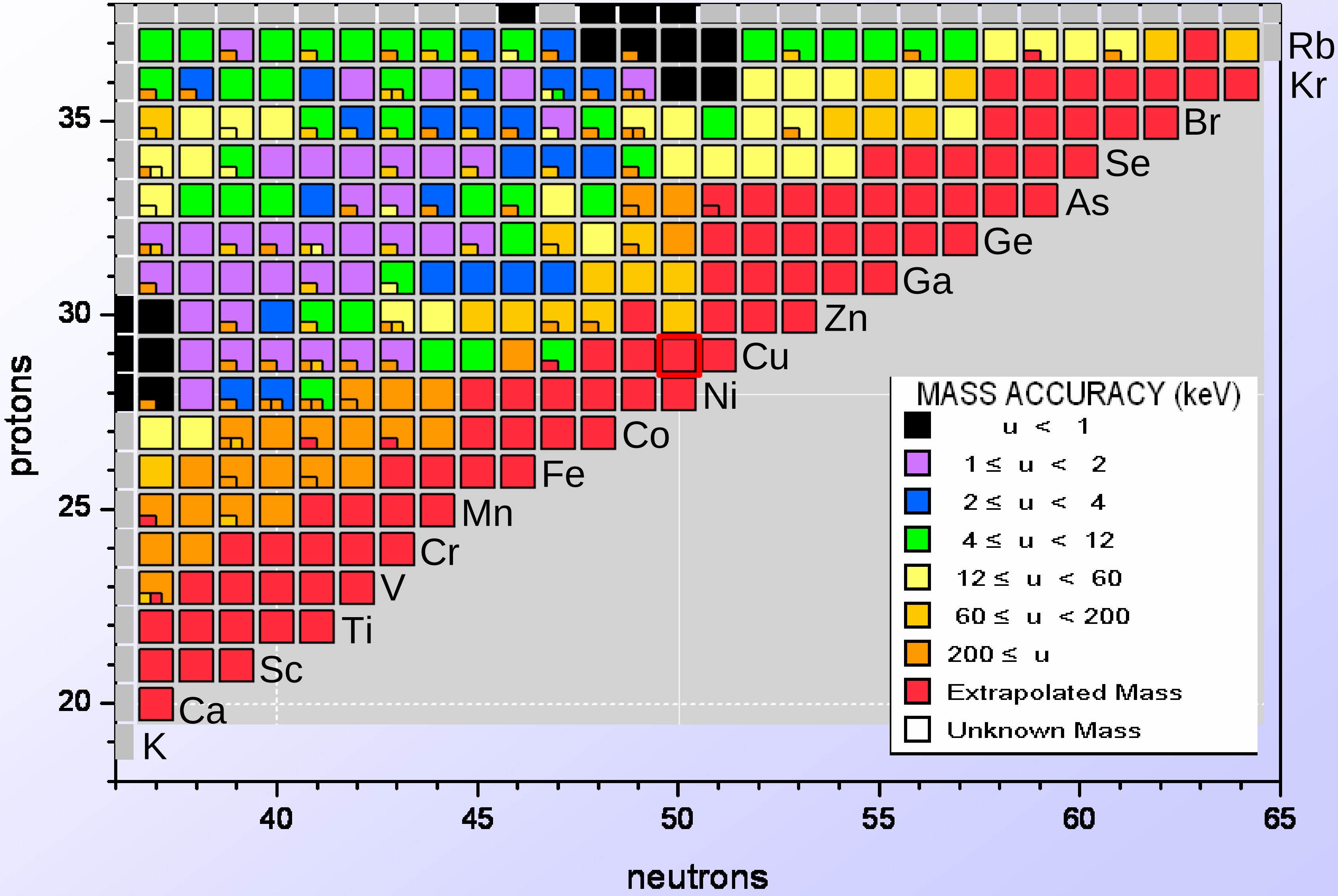
Baruah et al., PRL 101, 262501 (2008)

Major waiting point ^{80}Zn (II)

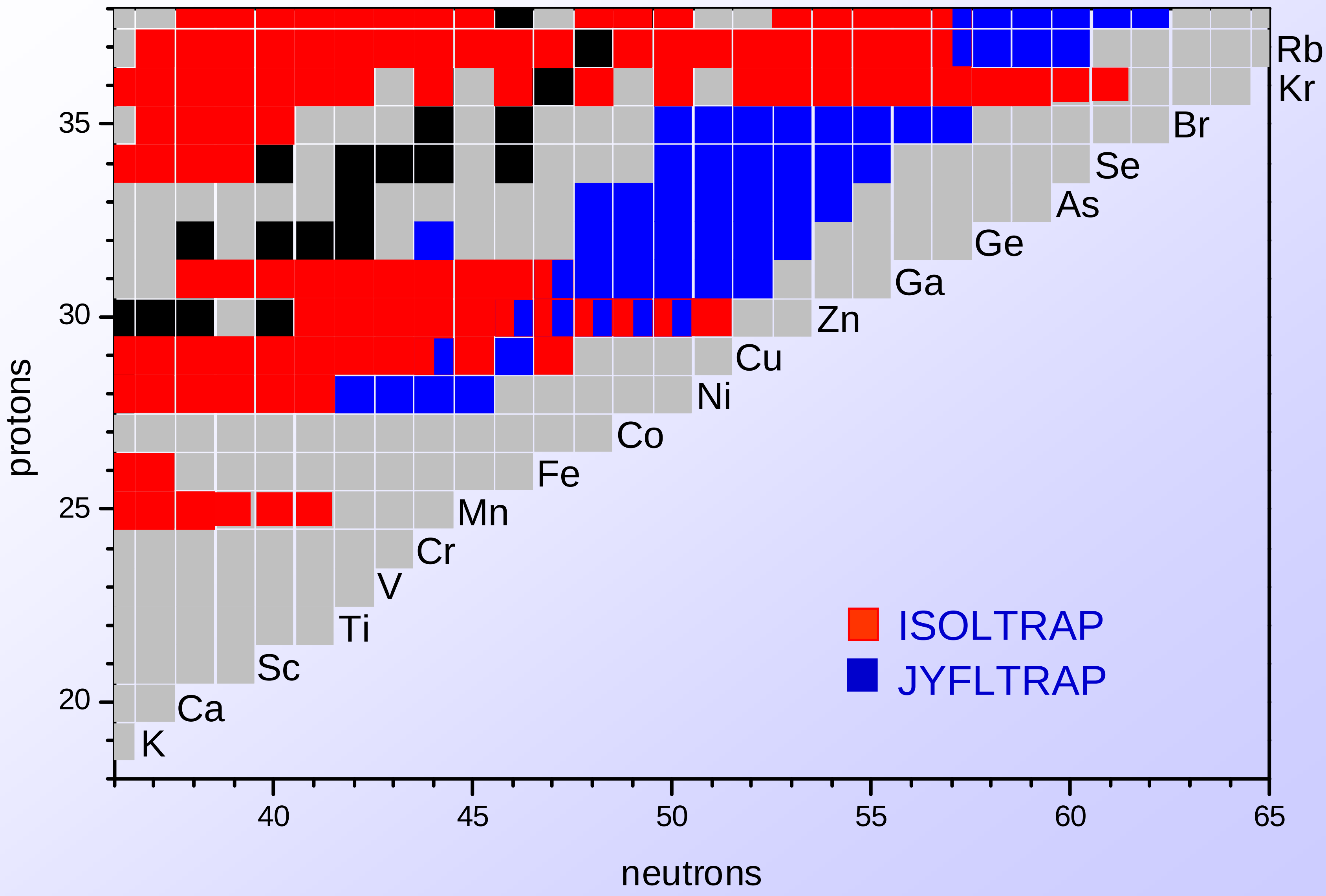


Baruah et al., PRL 101, 262501 (2008)

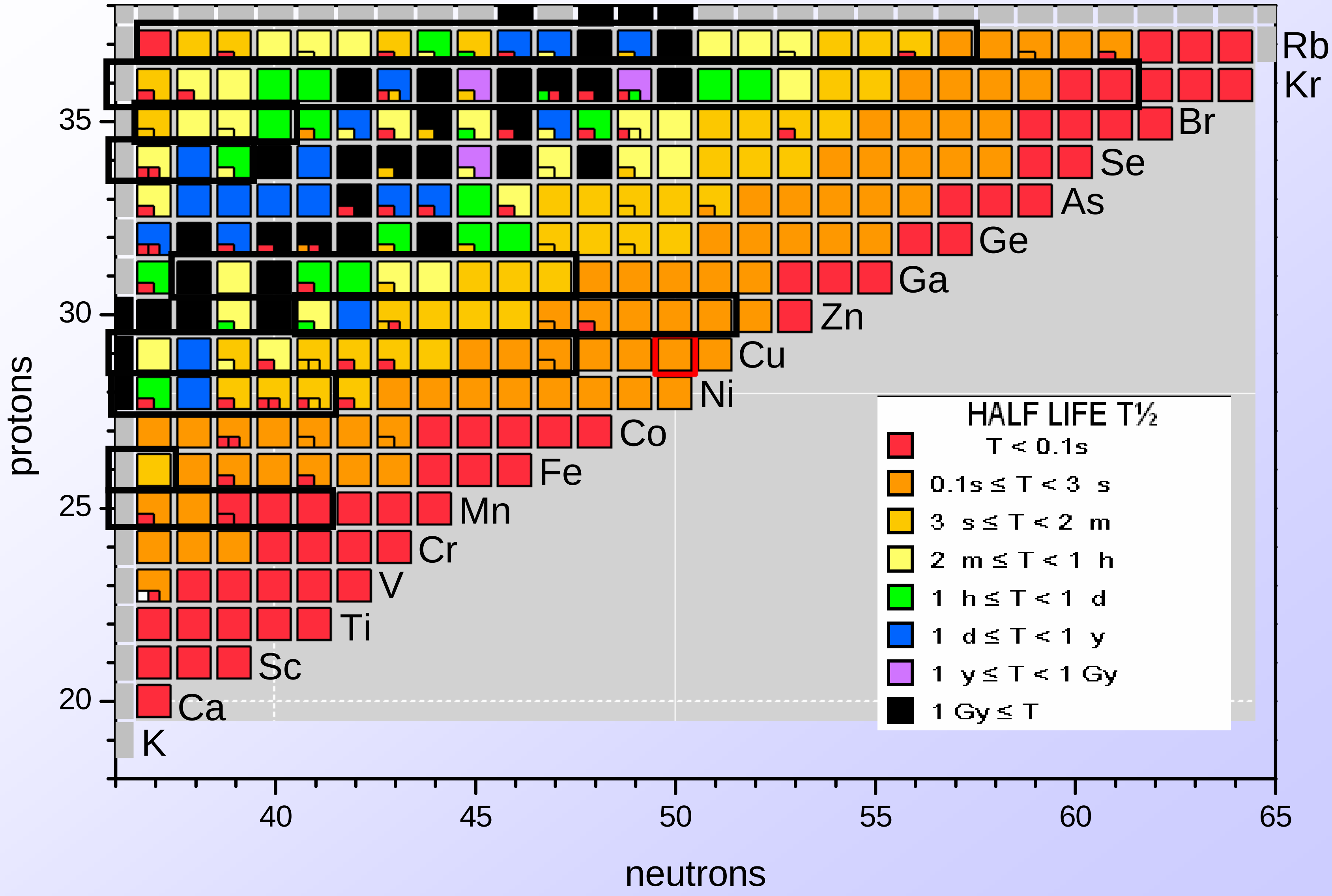
Mass accuracy – AME2003 ...



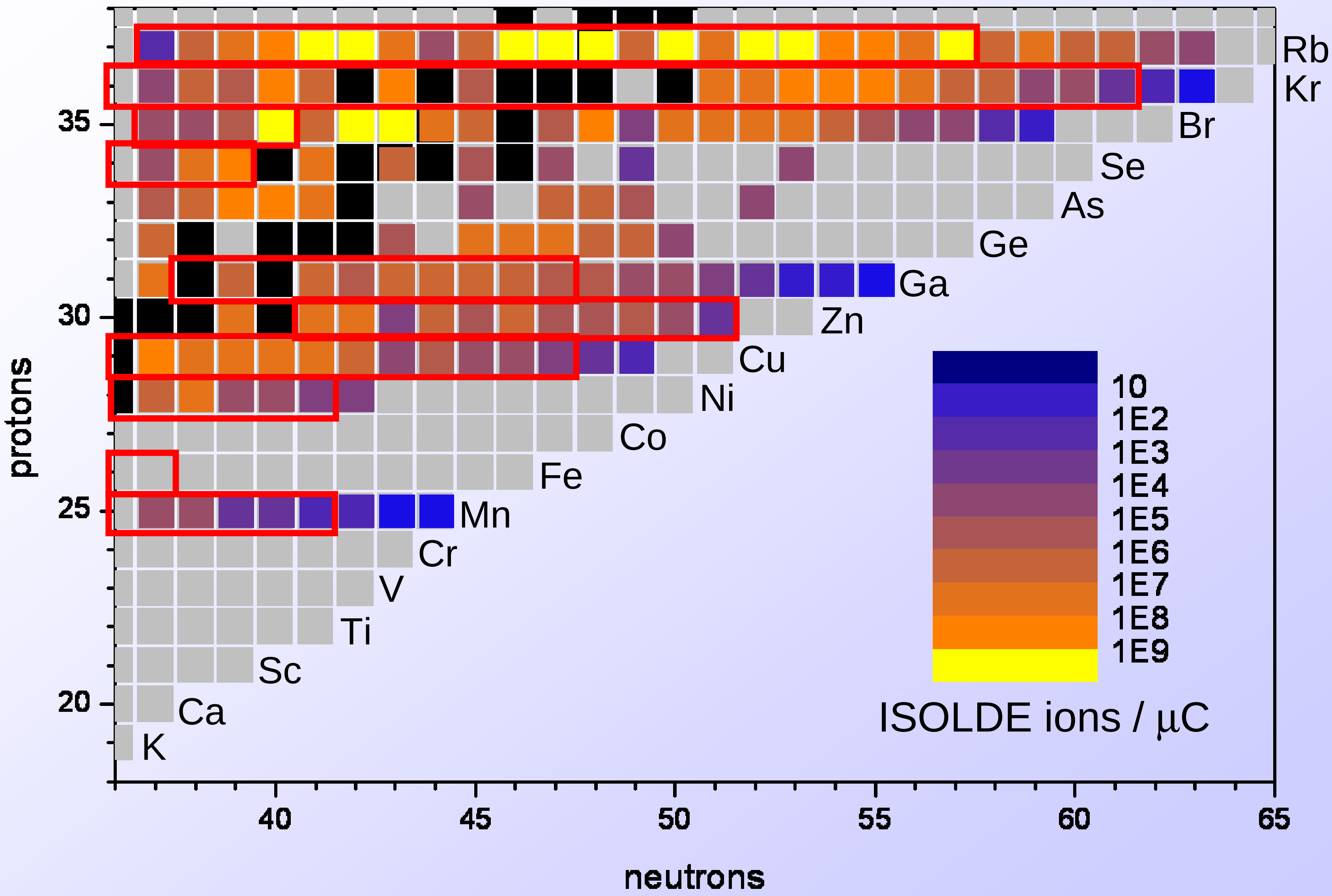
... and mass measurements



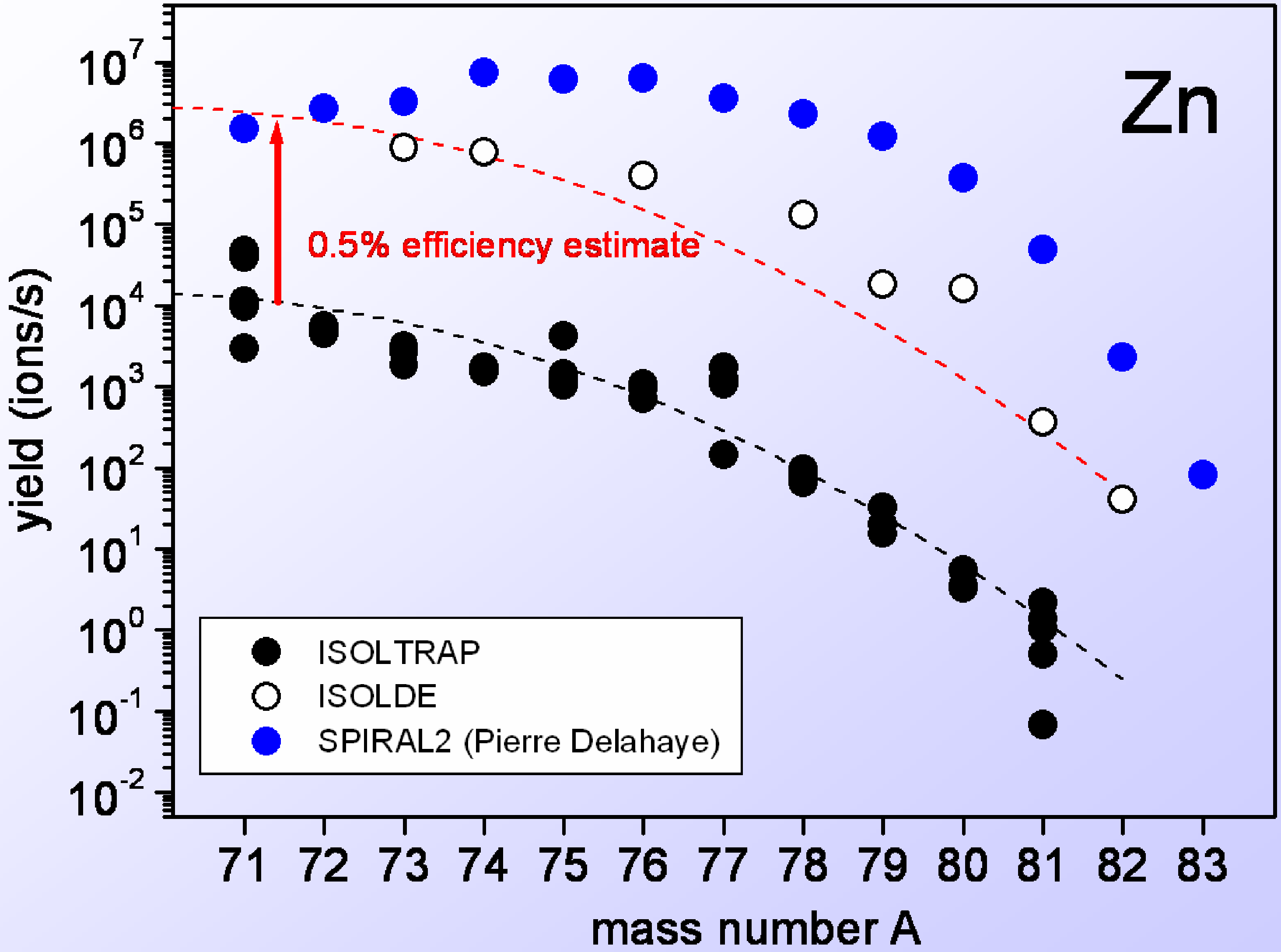
Limitation: Half-life of short-lived nuclides



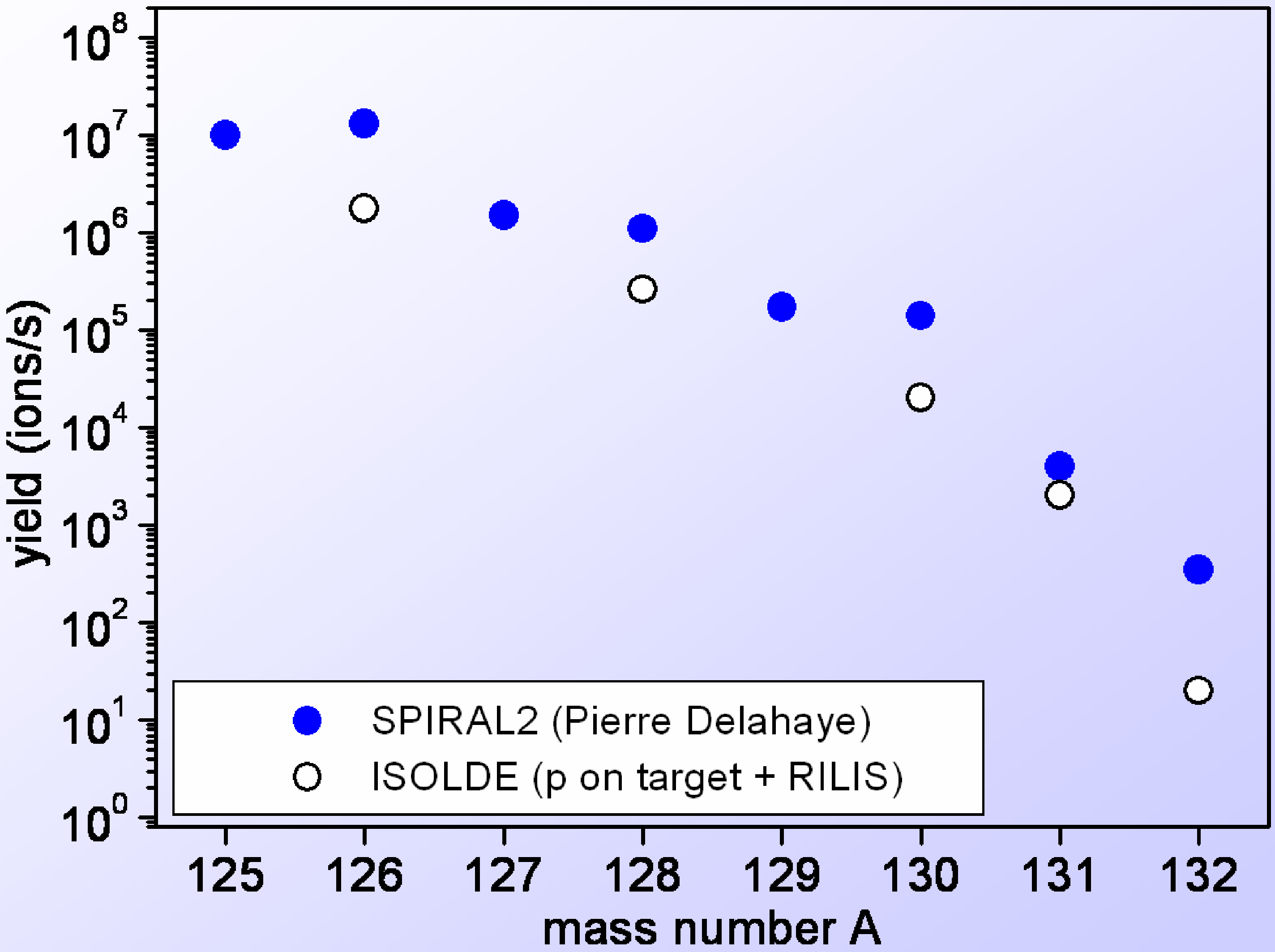
Limitation: Ion yields



Zn yield using neutron converter ISOLTRAP vs. ISOLDE vs. SPIRAL2

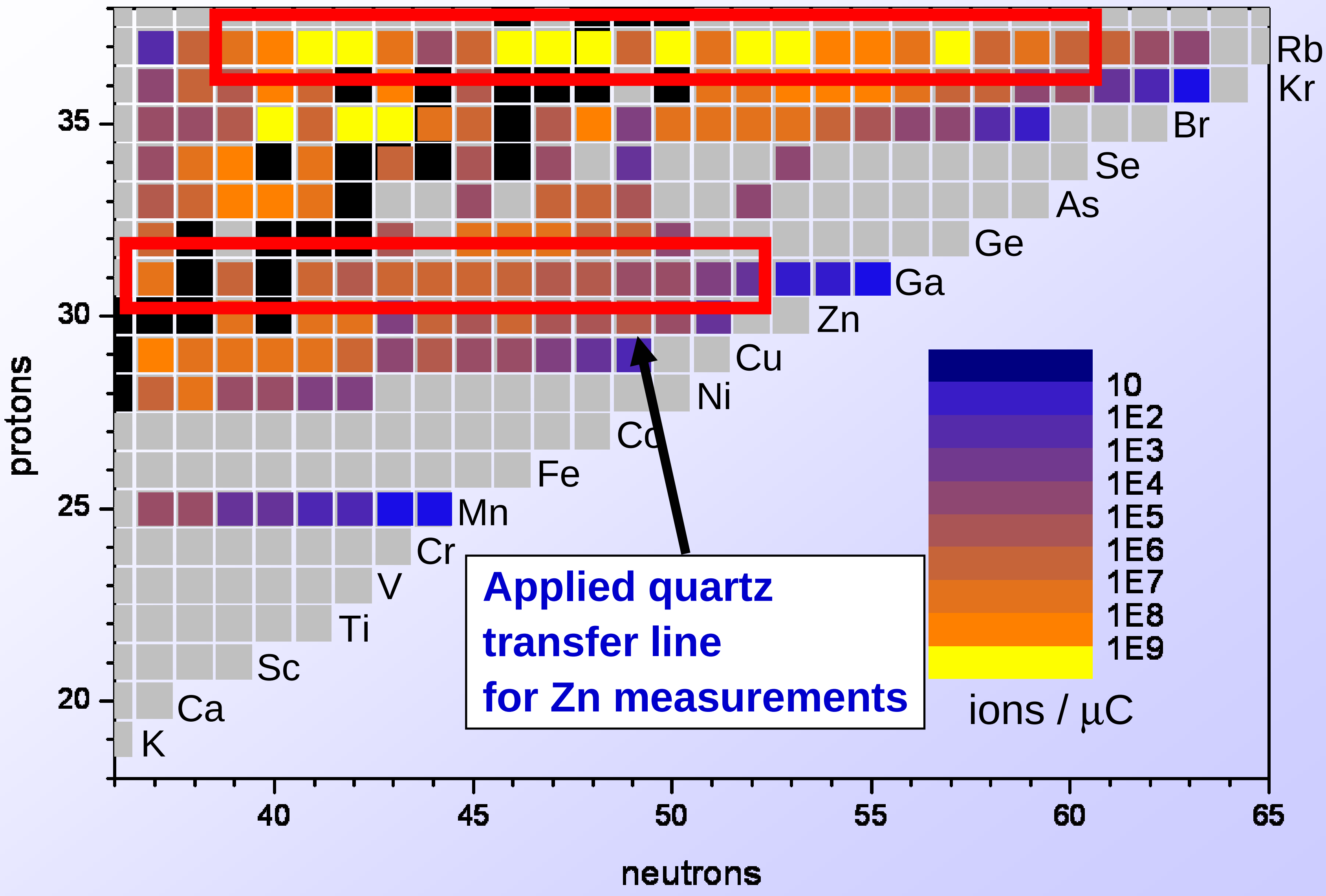


Cd yield

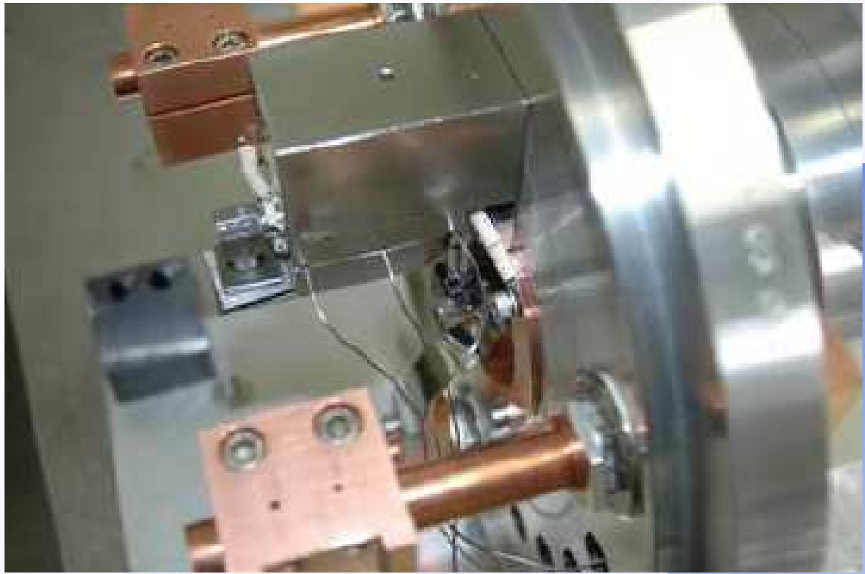


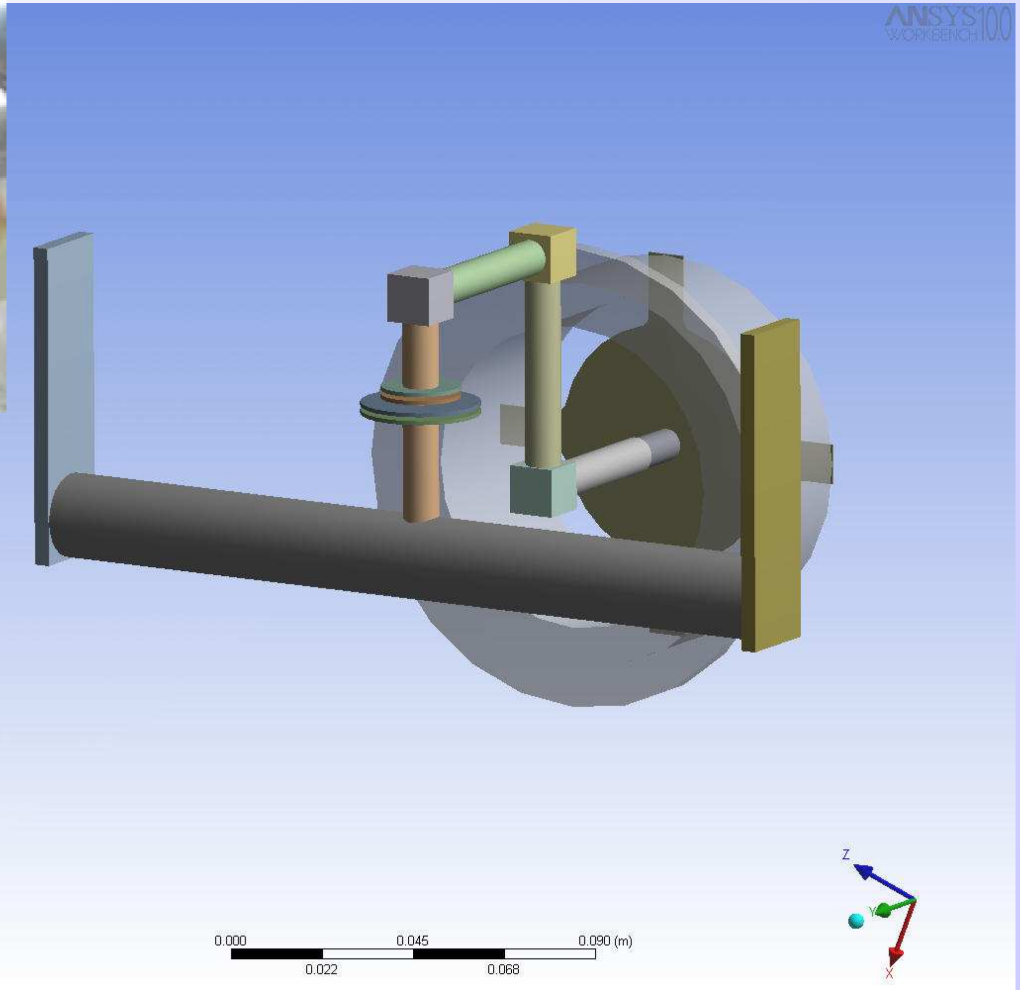
yield (ions/s)
10^8
10^7
10^6
10^5
10^4
10^3
10^2
10^1
10^0
125
126
127
128
129
130
131
132
mass number A
SPIRAL2 (Pierre Delahaye)
ISOLDE (p on target + RILIS)

Limitation: Isobaric contamination



Need new techniques: Quartz transfer line

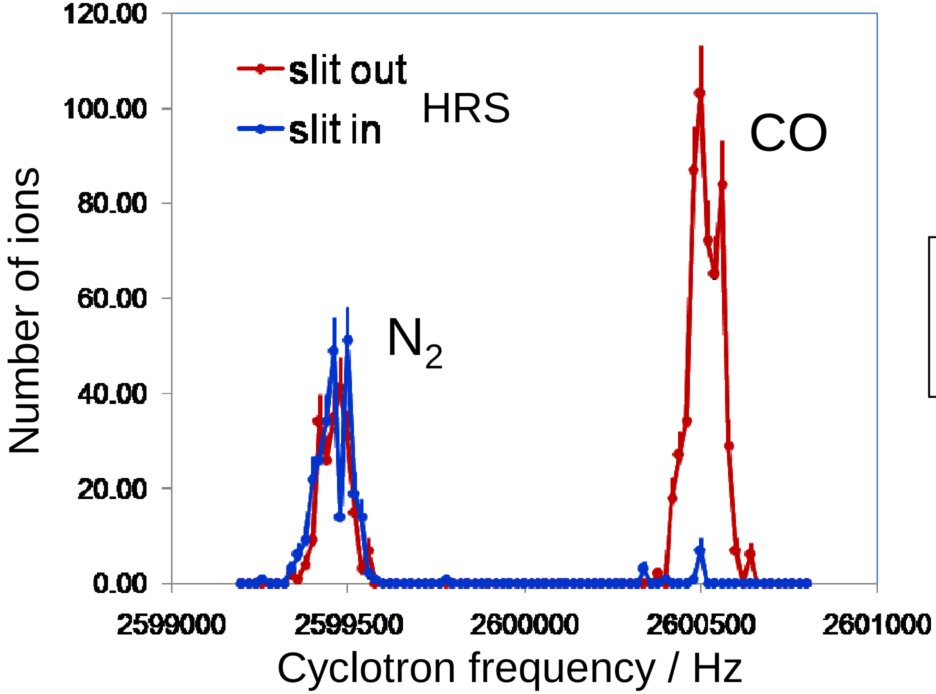




- cooled transfer line
- temperature controlled
- suppression of alkali ions

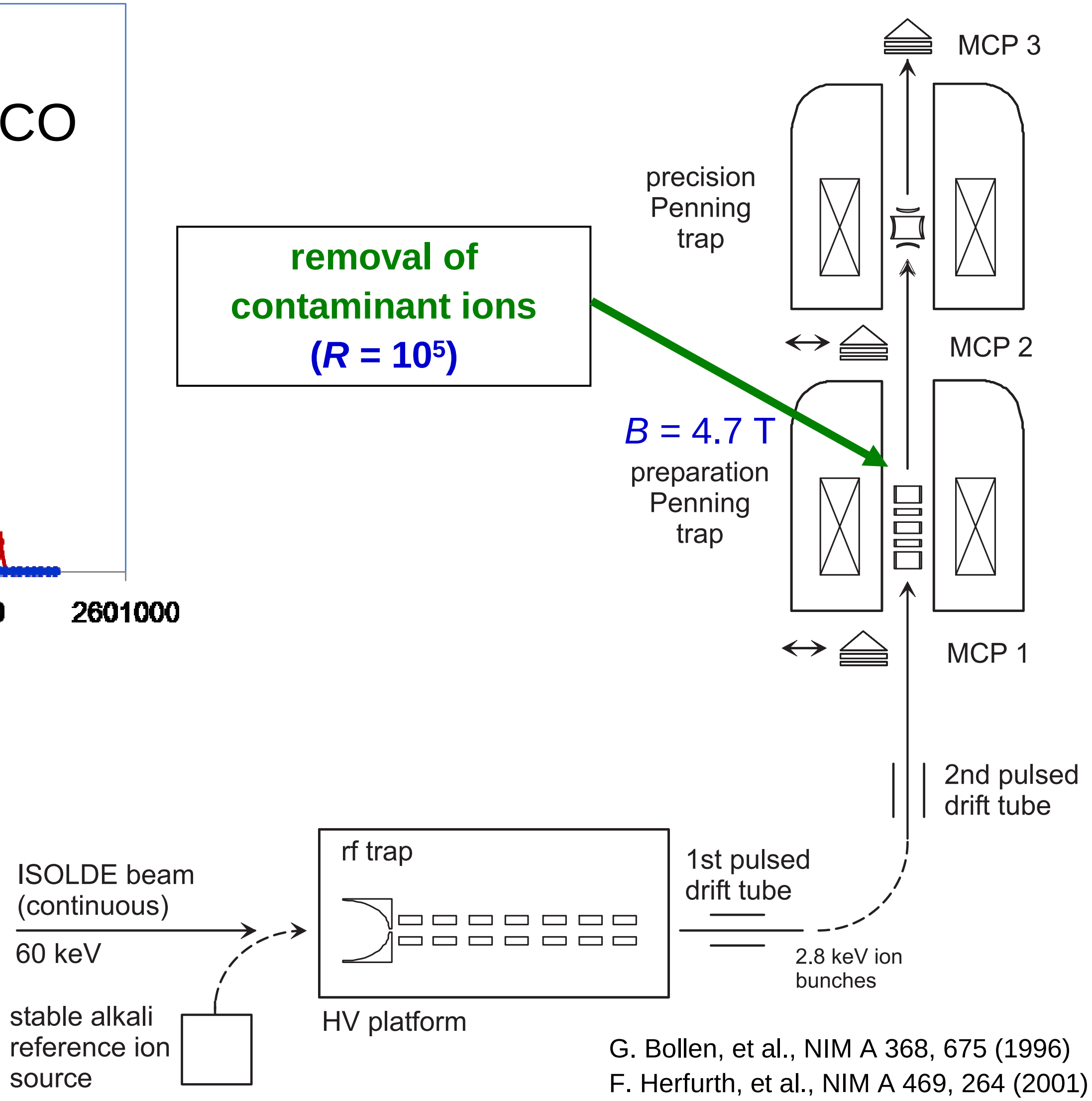
E. Bouquerel et al.

Mass separation in Penning trap



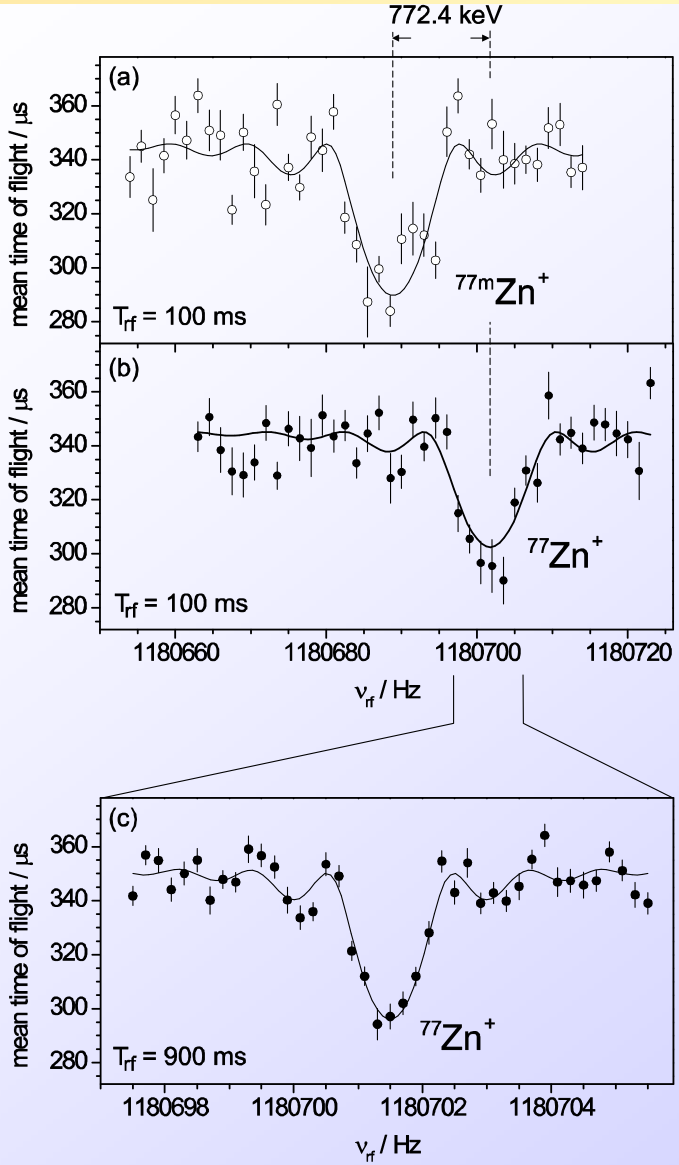
Buffer gas cooling with QP excitation:
Savard et al., Phys. Lett. A 158, 247 (1991)

removal of contaminant ions
($R = 10^5$)

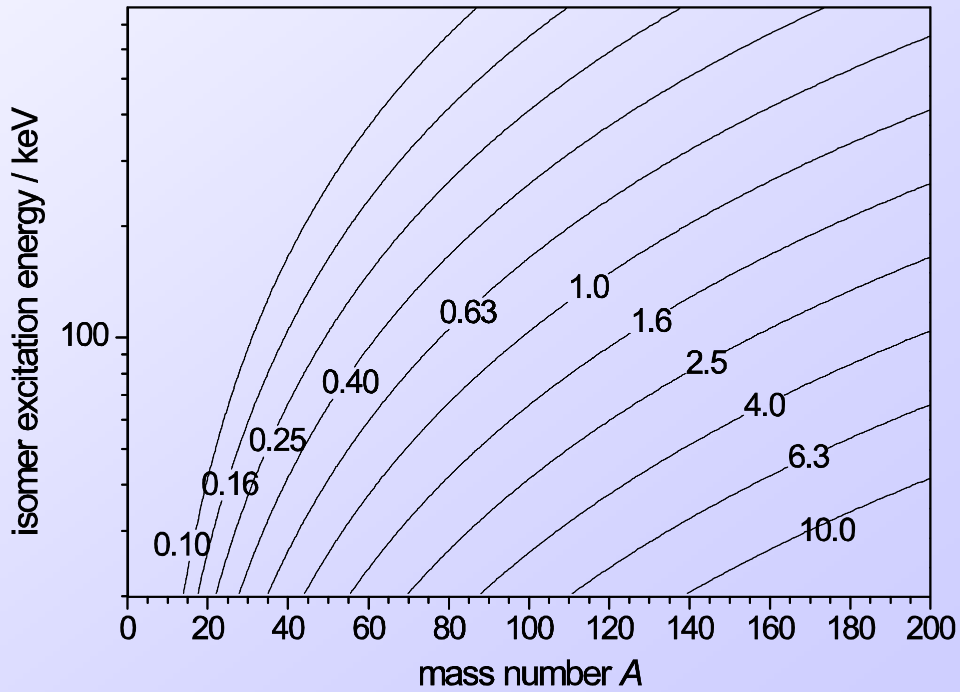


G. Bollen, et al., NIM A 368, 675 (1996)
F. Herfurth, et al., NIM A 469, 264 (2001)

Limitation: Isomer selection/cleaning

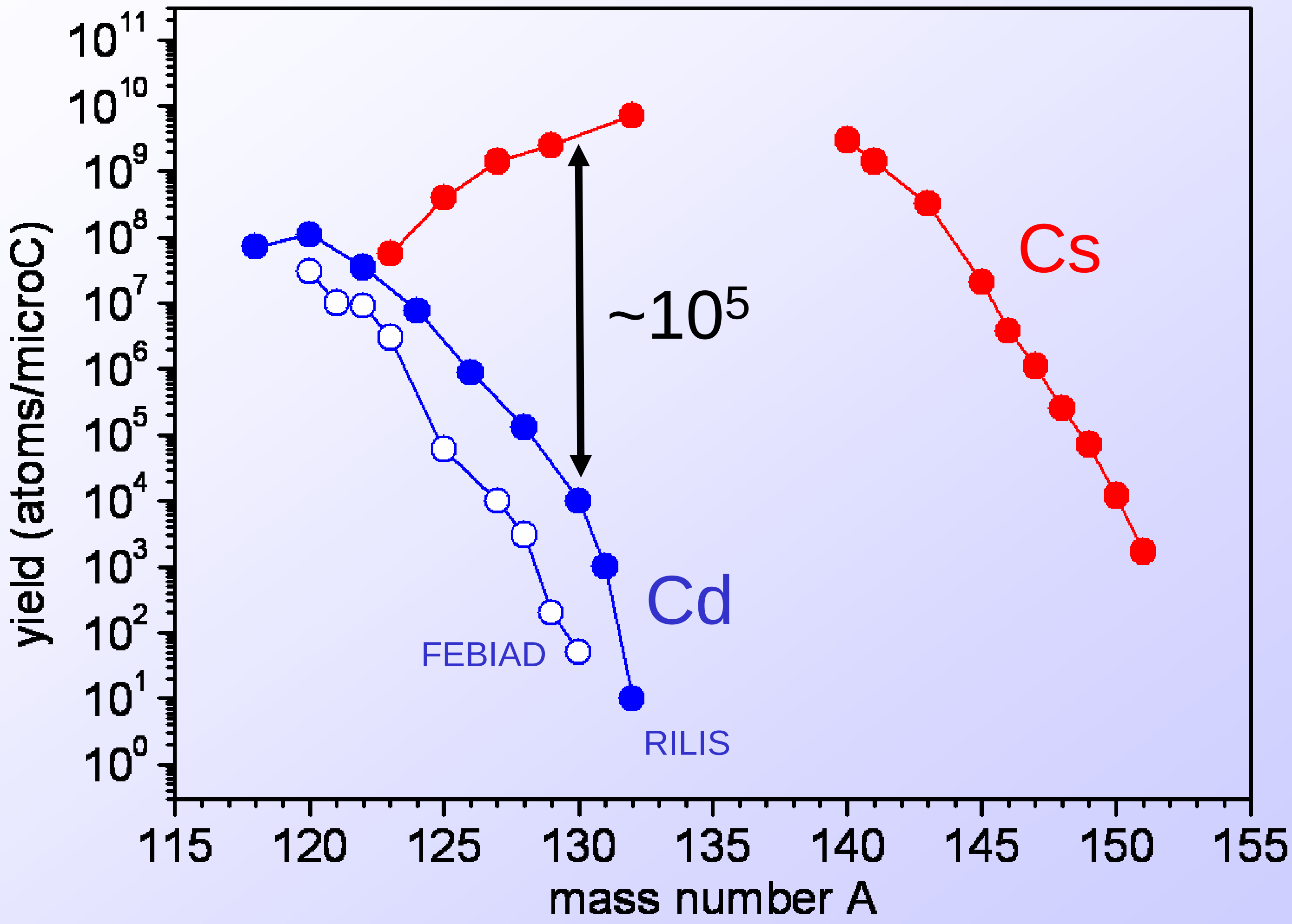


Excitation duration required / s

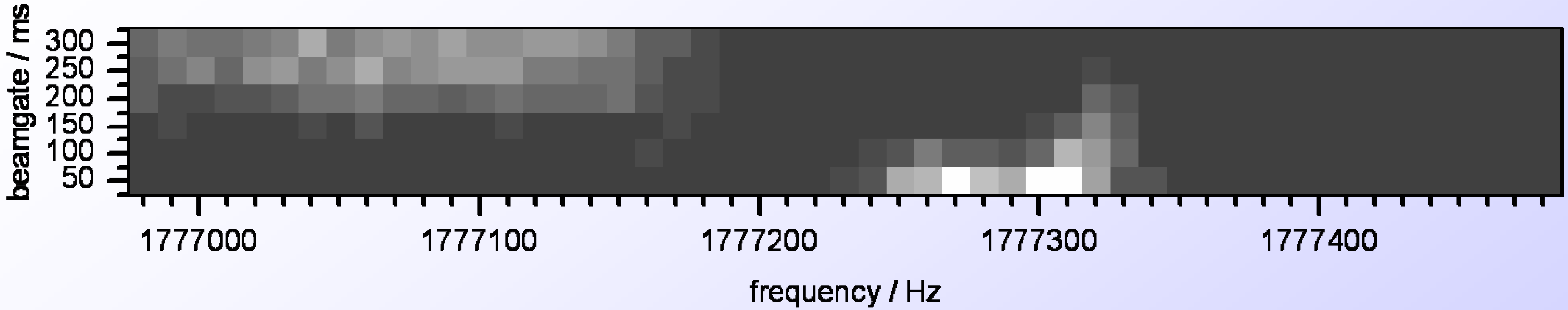


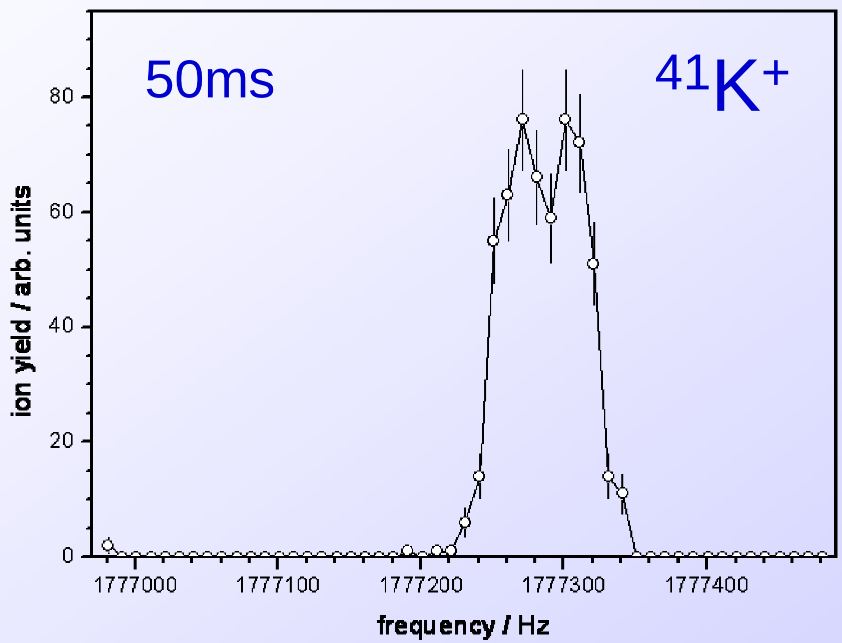
A. Herlert et al., Czech. J. Phys. 56, F277 (2006)

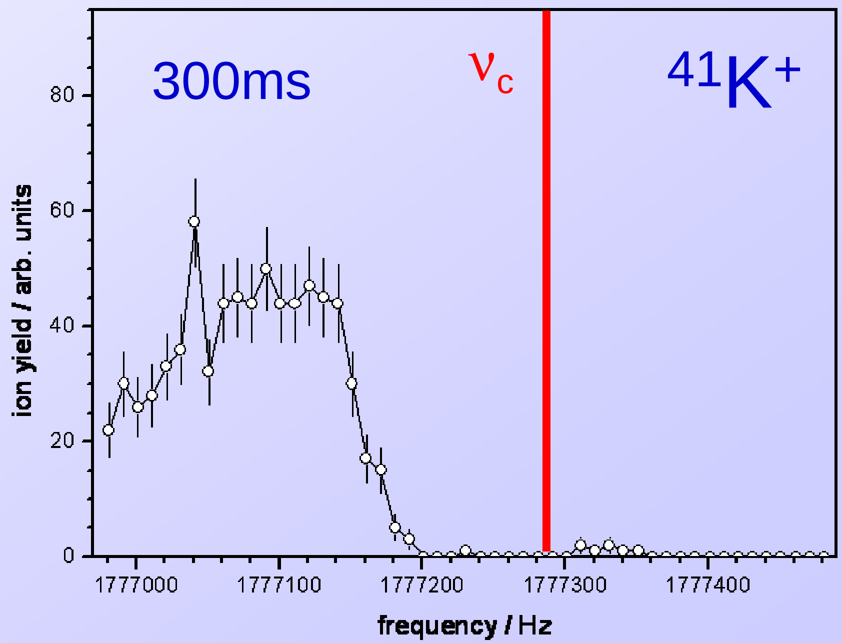
ISOLDE production yields Cd vs. Cs (p on target)



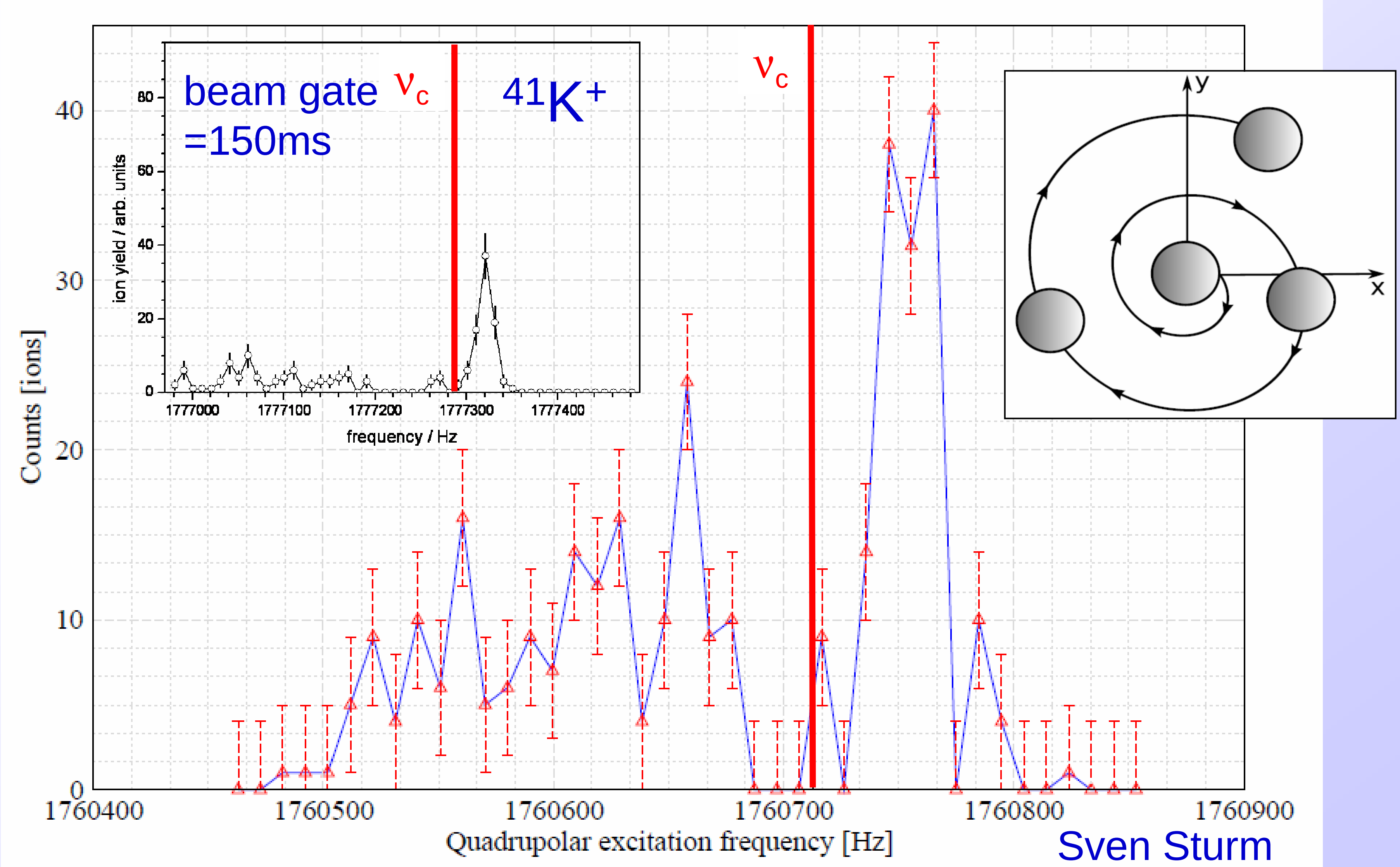
Space-charge effects:
Simultaneous storage of $^{39,41}K^+$



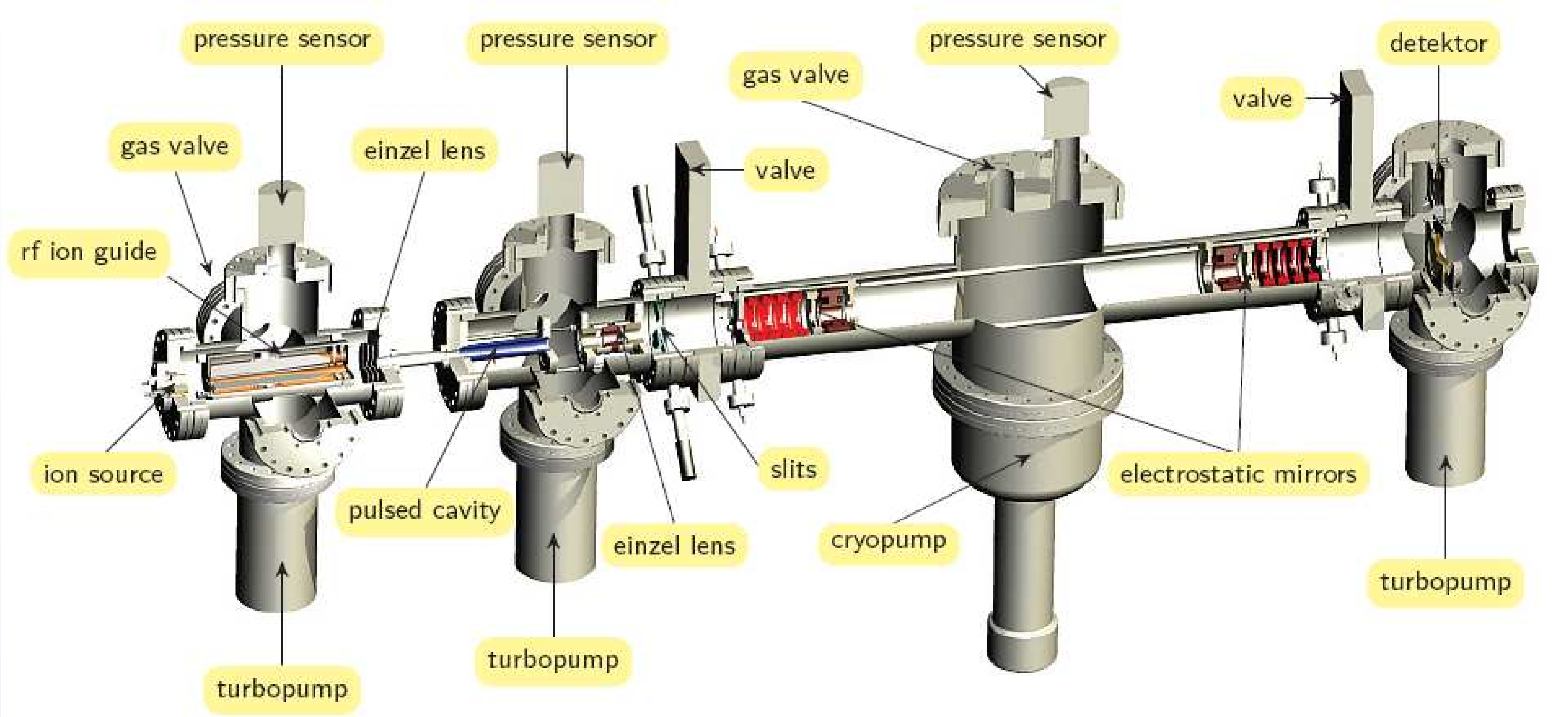


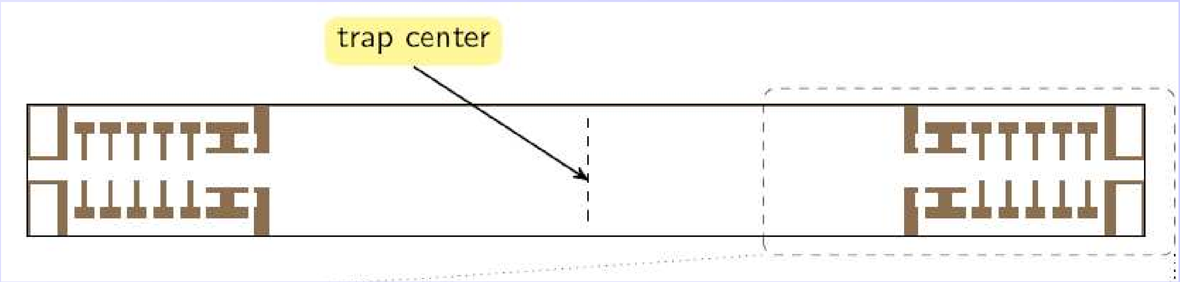


Simulation of space-charge effect



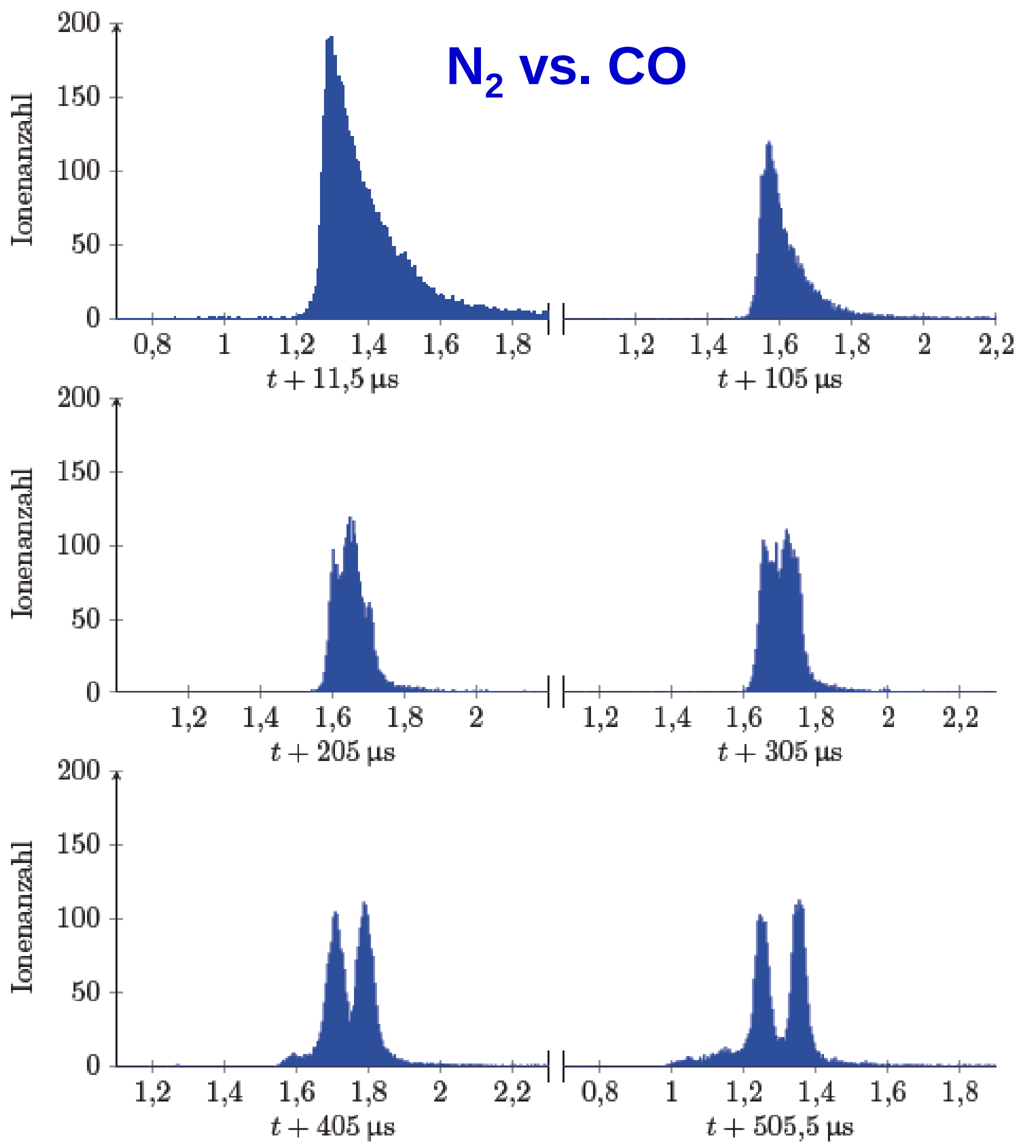
Possible solution: Electrostatic ion trap (MR-TOF)



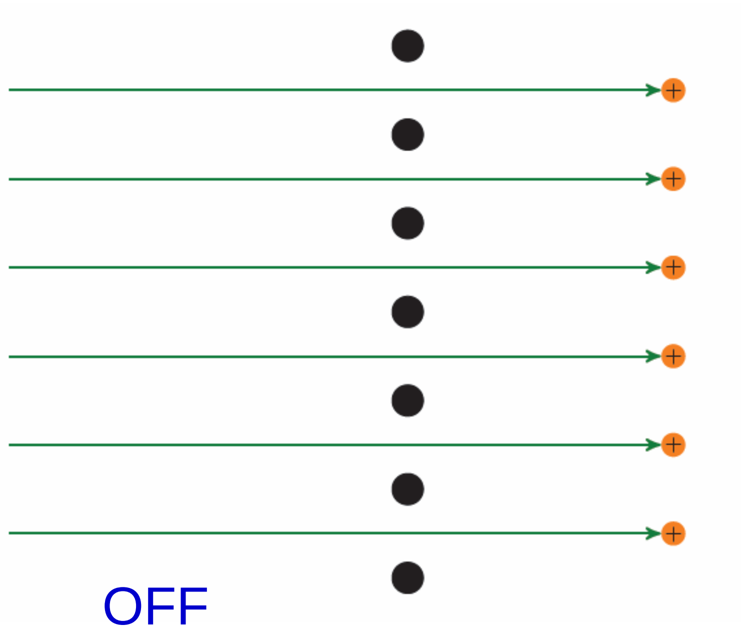


Robert Wolf

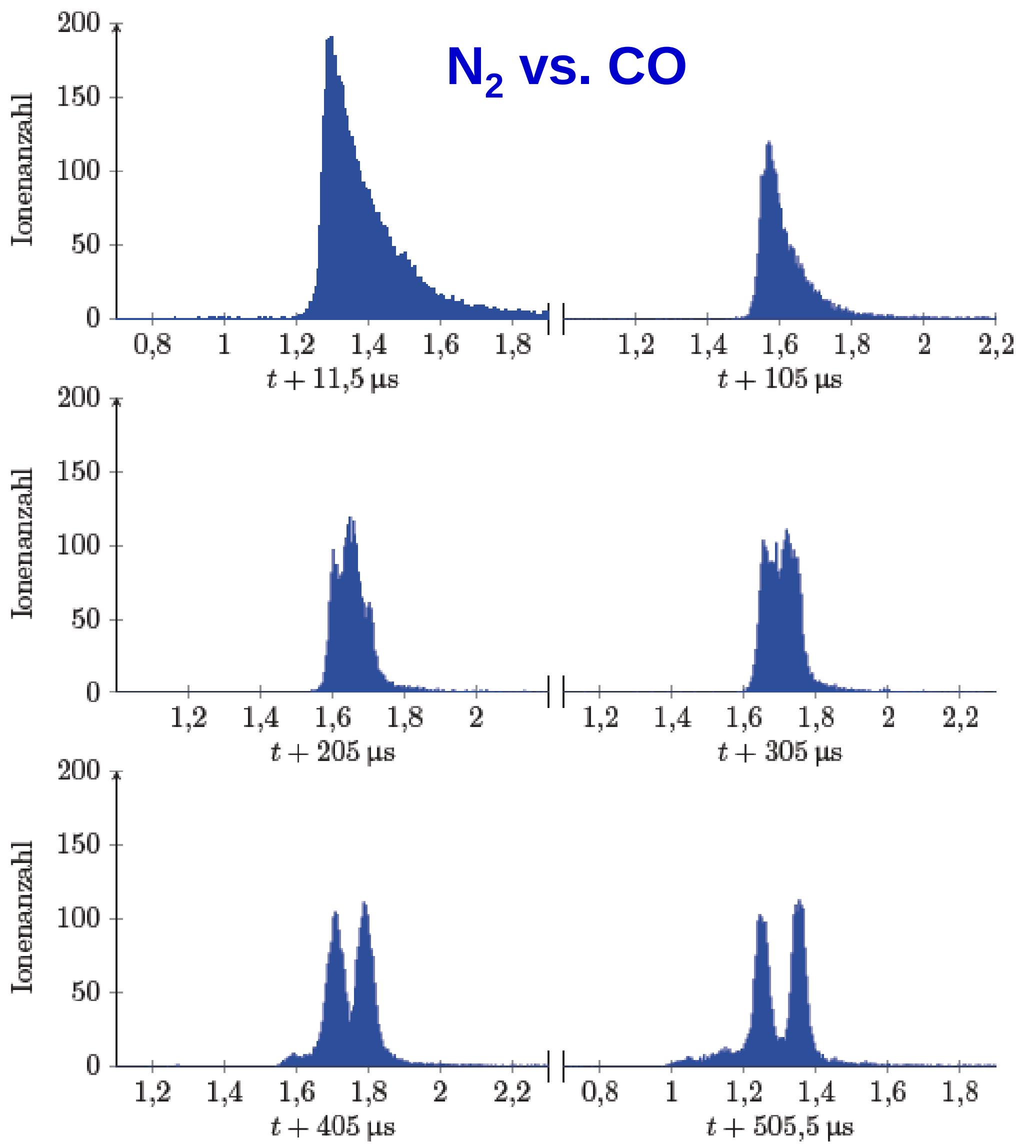
Time-of-flight gating and ion removal



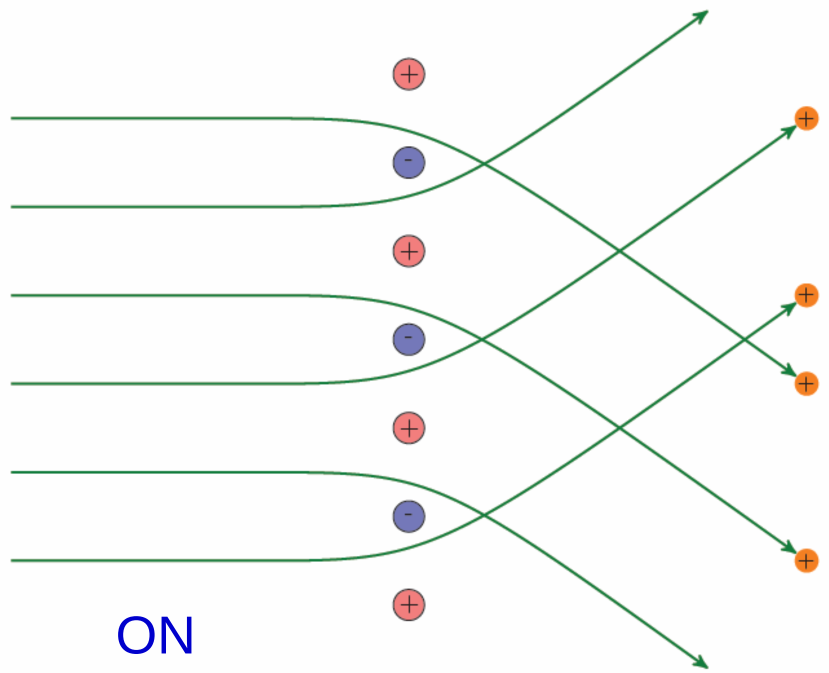
Bradbury-Nielsen-Beamgate



Time-of-flight gating and ion removal



Bradbury-Nielsen-Beamgate



Summary

- Penning traps allows one to obtain accurate and precise mass values of short-lived isotopes
- Limitation due to purity, yield, and half-life
  - need good HRS – reduce isobaric contamination and space charge
  - application of MR-TOF – fast reduction/removal of contamination
  - efficient RFQ cooler and buncher – reduce ion loss
- Possible mass measurements with MLLTRAP at DESIR:
  - ^{82}Zn (+ ^{83}Zn?)
  - ^{129,130,131,132}Cd
  - and many other neutron-rich isotopes ...