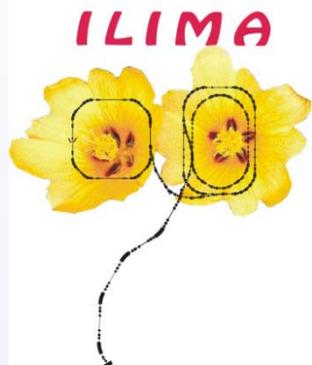


Isomer and ground-state properties of stored exotic nuclei

Phil Walker

University of Surrey, and CERN
Spokesperson for the ILIMA Collaboration at FAIR





Isomer and ground-state properties of stored exotic nuclei

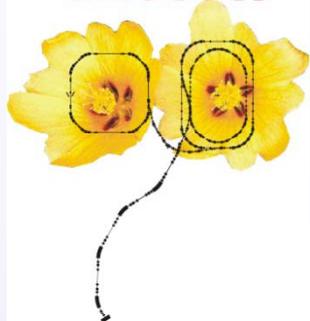
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Data at ~ 400 MeV/u from projectile fragmentation: ESR at GSI

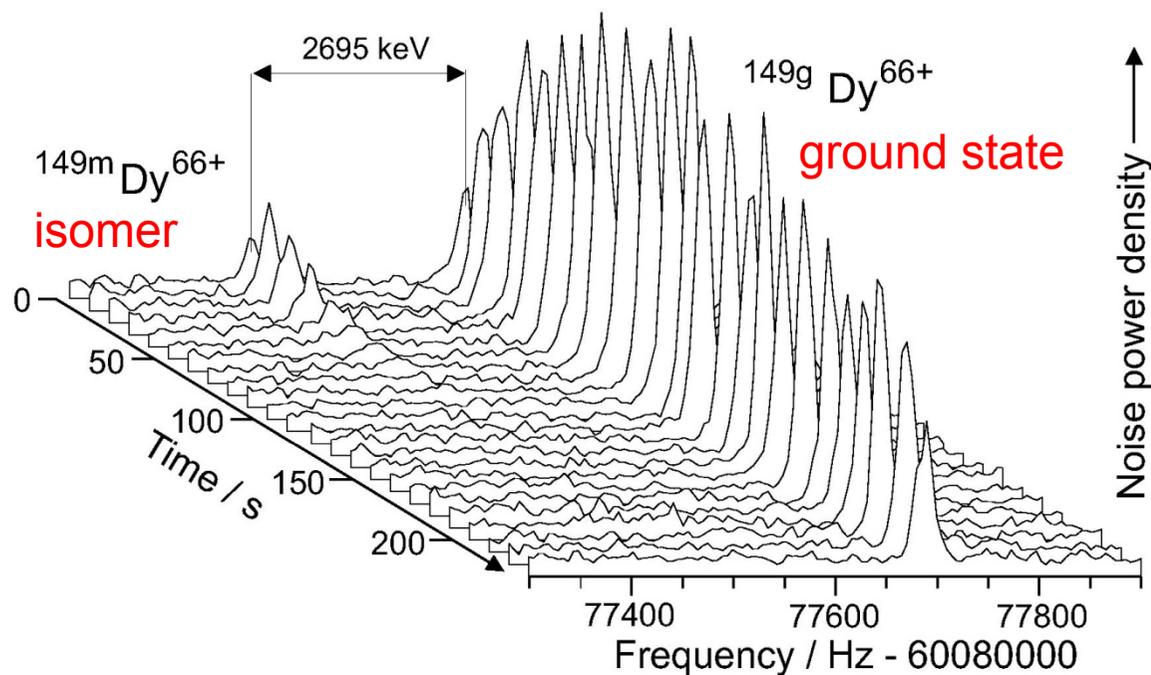


ILIMA



Isomer and ground-state properties of stored exotic nuclei

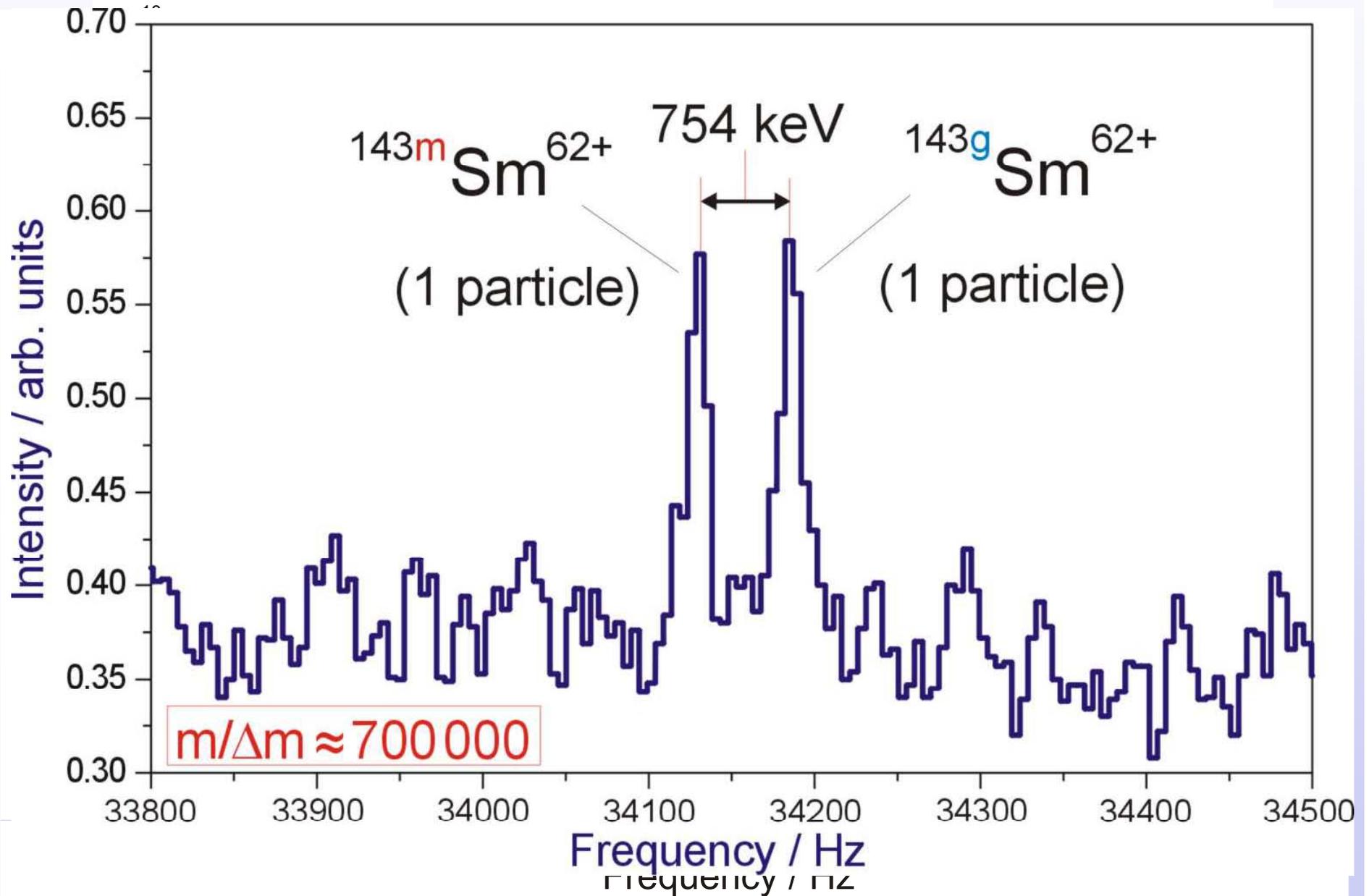
ILIMA: Isomers, Lifetimes and MAsses



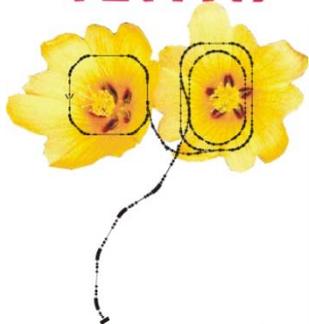
^{149}Dy in the Experimental Storage Ring (ESR) at GSI

[Litvinov et al., Phys. Lett. B573 (2003) 80]

Broad-band Schottky frequency spectra



ILIMA



GSI – FAIR

GSI today

Future facility

SIS 100/300

SIS 18

ESR

ESR

ILIMA

Super-FRS

Intense beams of RIBs and very exotic nuclides

RESR

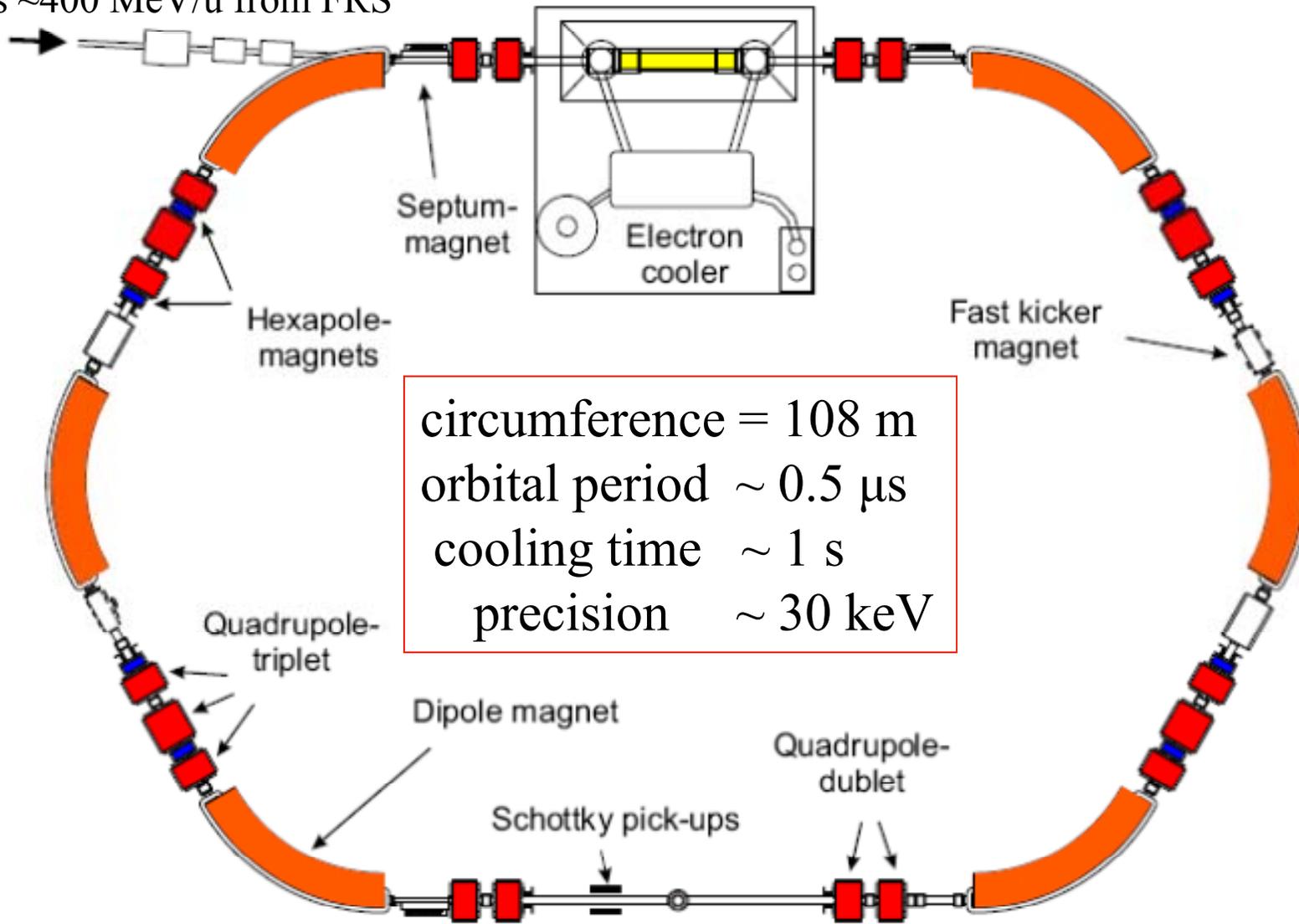
CR

NESR

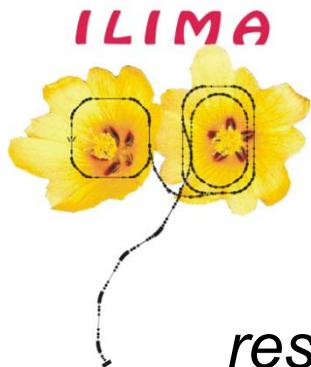


Experimental Storage Ring

ions ~ 400 MeV/u from FRS



circumference = 108 m
orbital period $\sim 0.5 \mu\text{s}$
cooling time ~ 1 s
precision ~ 30 keV



SMS and IMS mass measurements

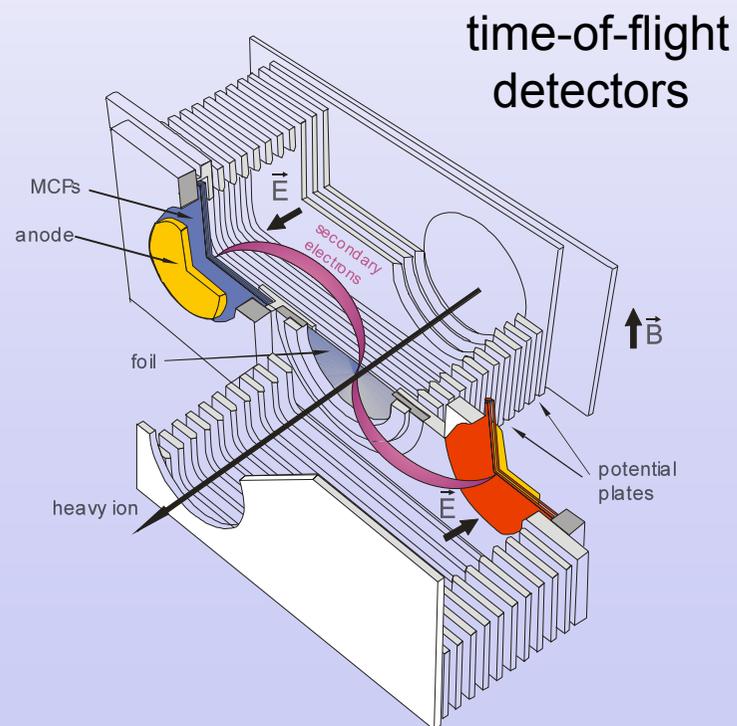
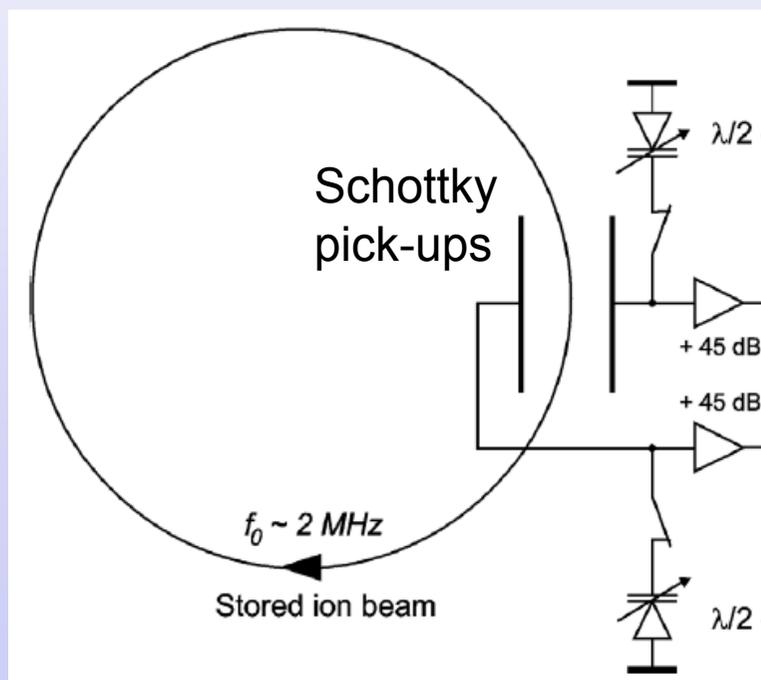
both methods have single-ion sensitivity

resolving power $\sim 10^6$

accuracy $\sim 30 \mu u$, i.e. $\sim 30 keV$

Schottky Mass Spectrometry
(with cooling): $T_{1/2} > 1 s$

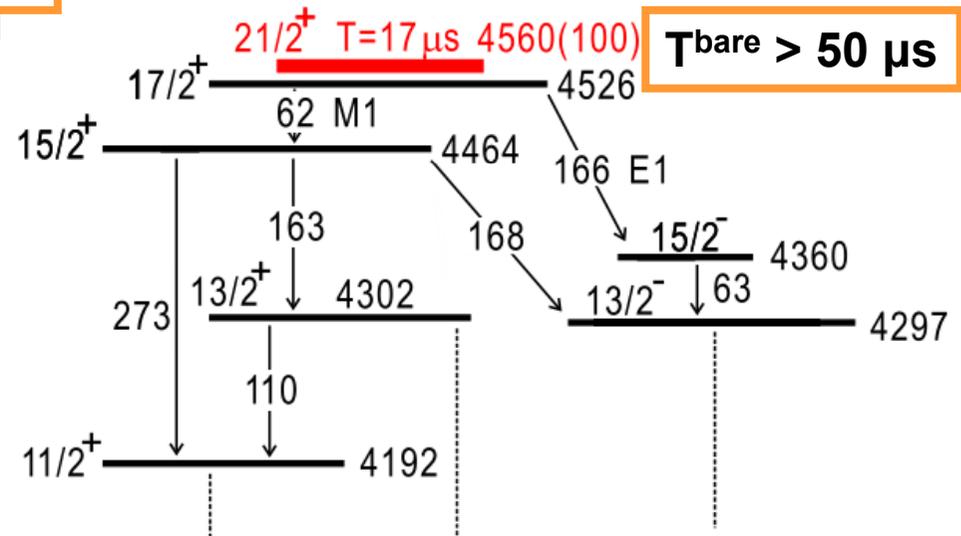
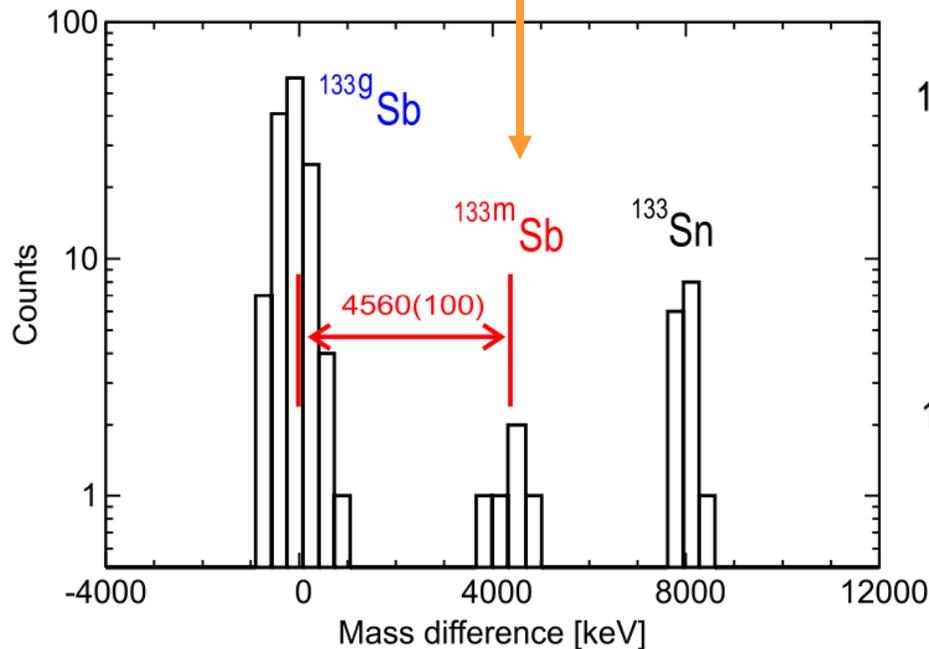
Isochronous Mass Spectrometry:
 $T_{1/2} > 10 \mu s$



Shell-model isomer in n-rich ^{133}Sb

- first direct observation of this isomer
- shortest-lived stored ion

^{238}U fission
isochronous mass spectrometry



$T^{\text{bare}} > 50 \mu\text{s}$

each count
represents
a single ion

consistent with shell-model
calculations: *Urban et al.,
Phys. Rev. C62 (2000) 027301*

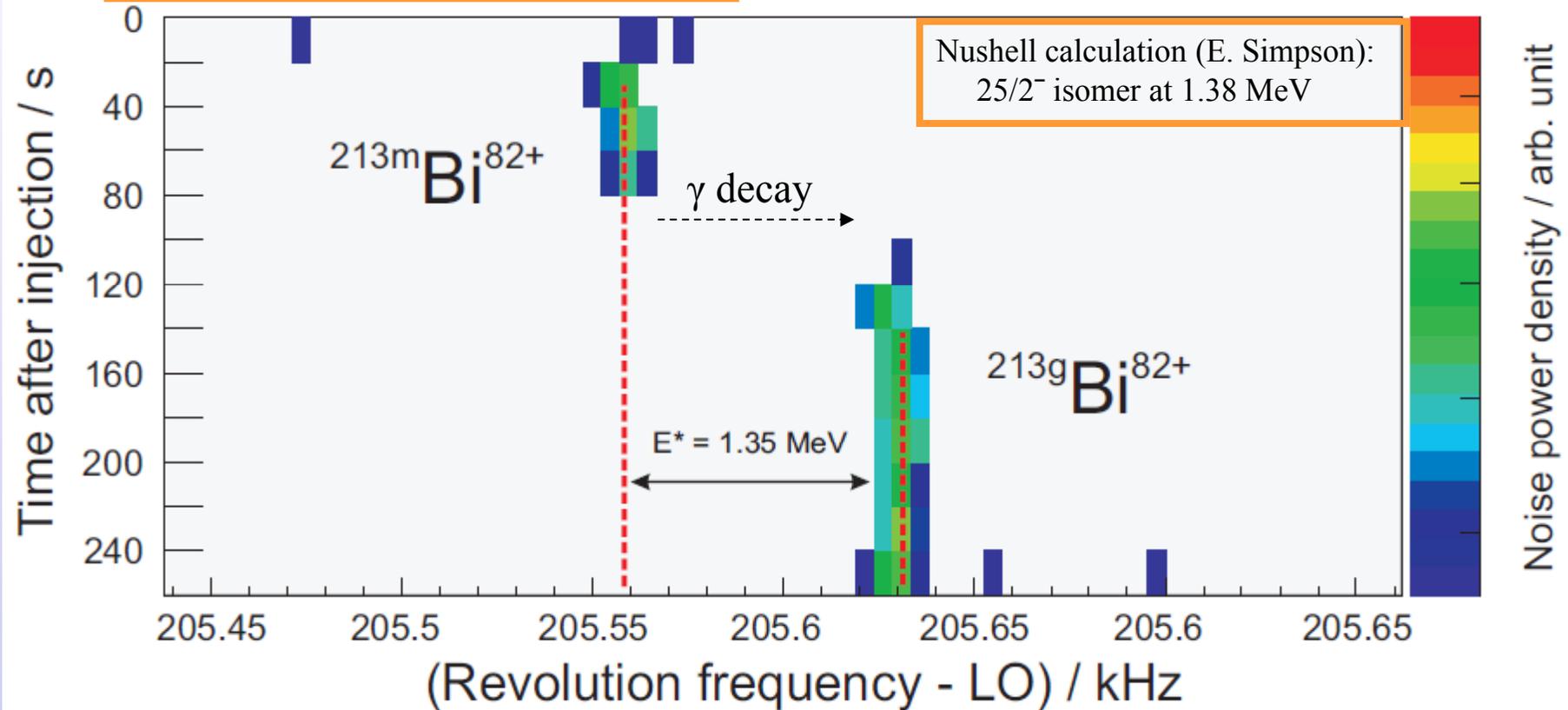
Sun et al., Phys. Lett. B688 (2010) 294

Shell-model isomer in n-rich ^{213}Bi

^{238}U fragmentation

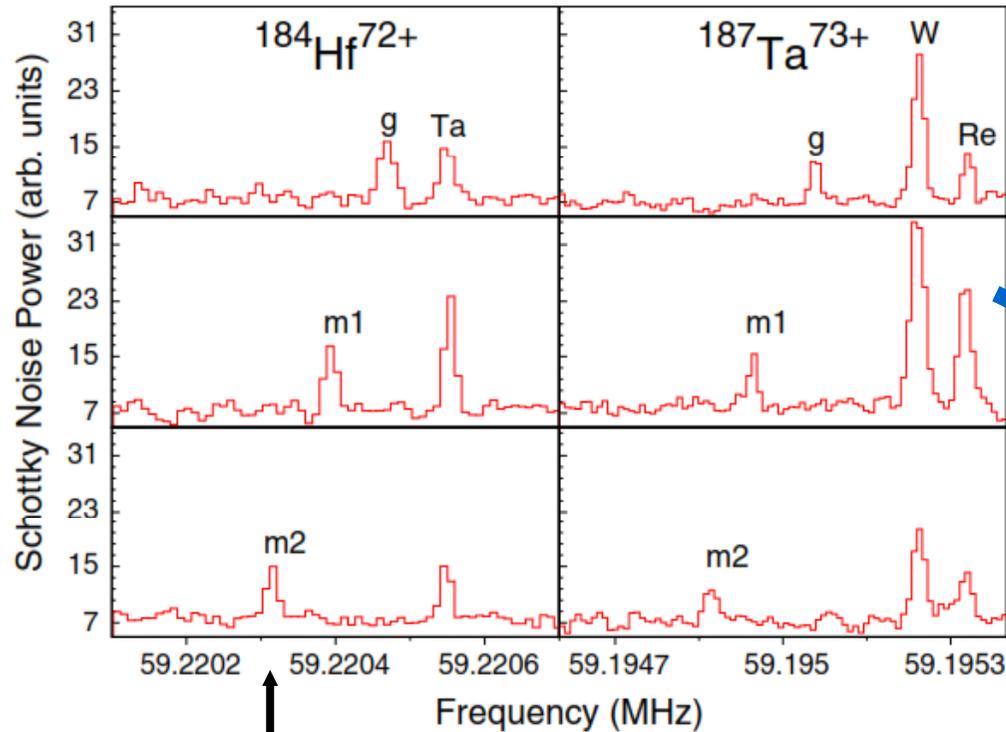
Schottky mass spectrometry

- first observation of this isomer
- single ion with γ decay



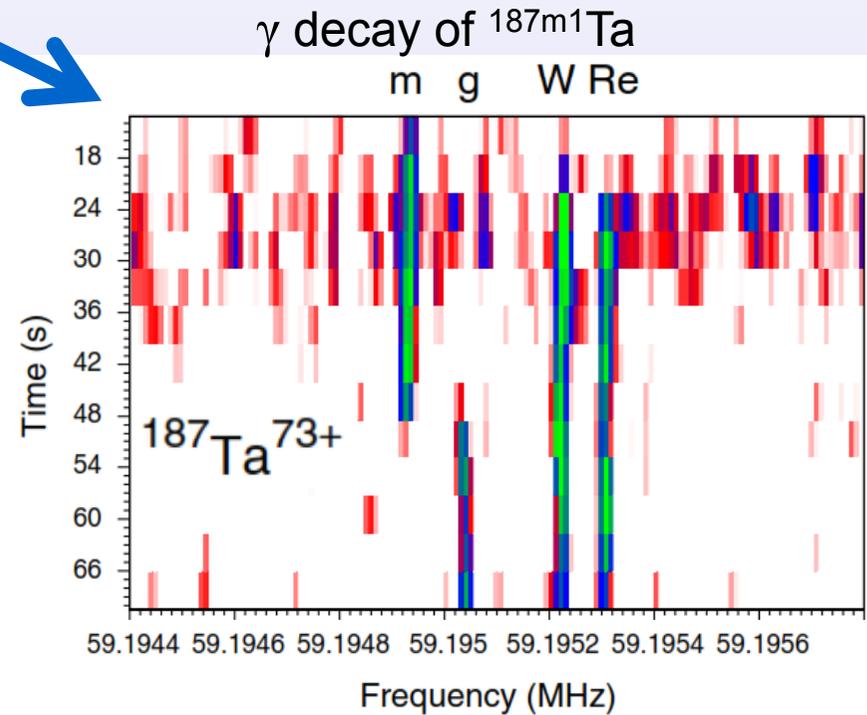
Chen et al., Nucl. Phys. A882 (2012) 71

High-K isomers in n-rich Hf and Ta



$T_{1/2} \sim 12$ minutes, $E^* = 2.5$ MeV

¹⁹⁷Au fragmentation
Schottky mass spectrometry



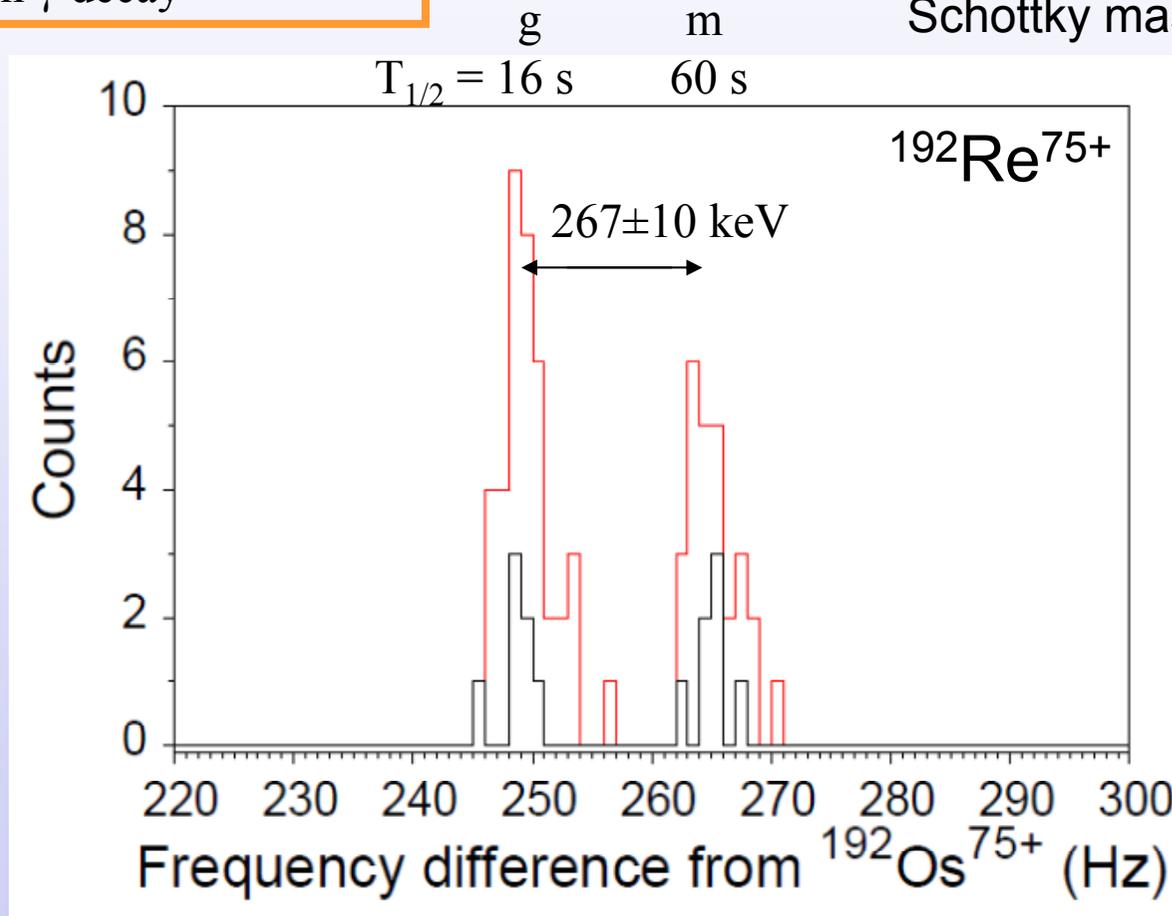
Reed et al., *Phys. Rev. Lett.* 105 (2010) 172501 [Editors' selection]

Shape(?) isomer in n-rich ^{192}Re

- first observation of this isomer
- 7 ions with γ decay

^{197}Au fragmentation

Schottky mass spectrometry

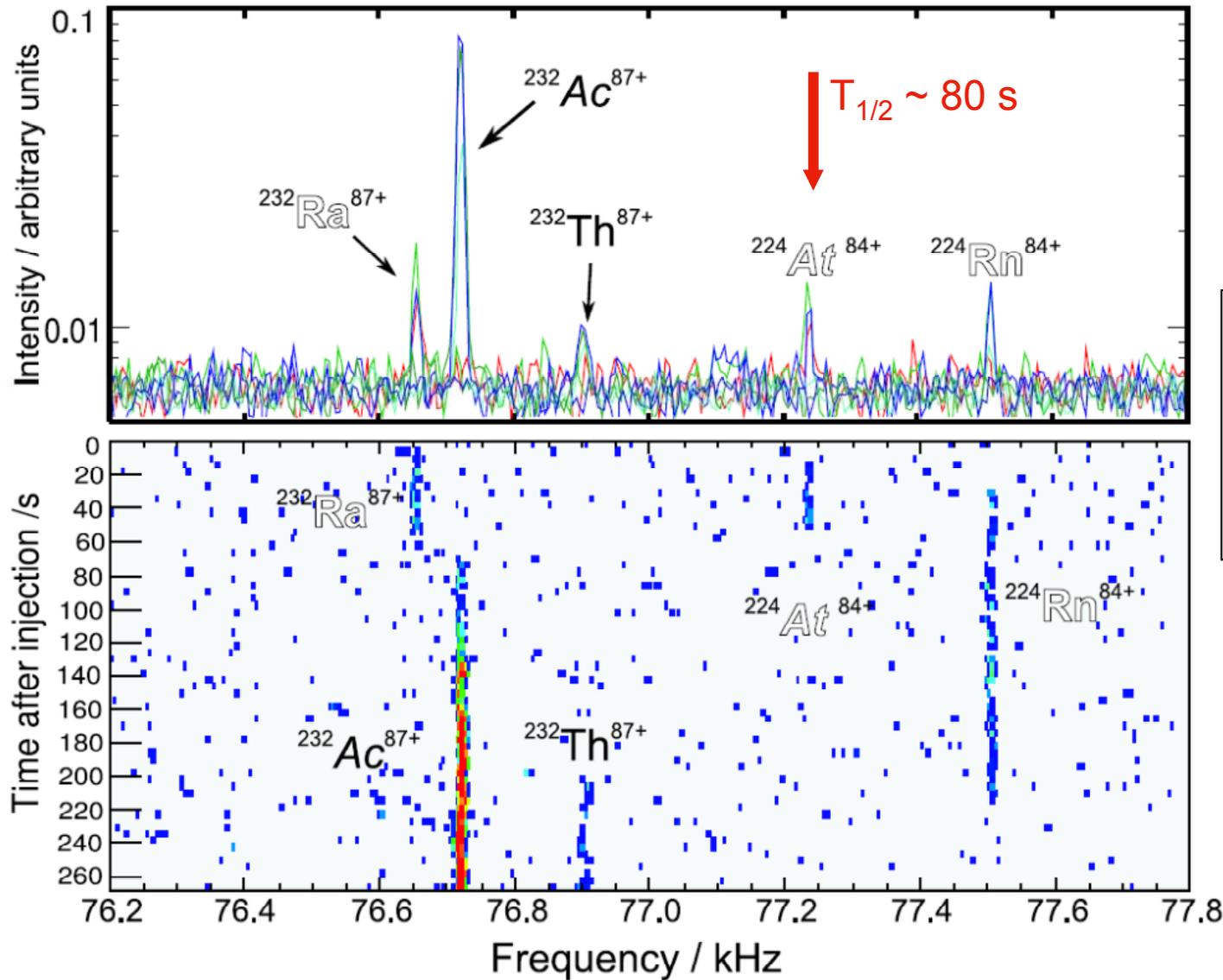


each count
represents
a single ion

— all ions
— ions before
and after
 γ decay

M.W. Reed, PhD Thesis 2012, and to be published

New isotopes and masses of heavy elements



- existence
 - half-life
 - mass
- all in one measurement*

NEW ISOTOPES

^{236}Ac

^{224}At

$^{221,222}\text{Po}$

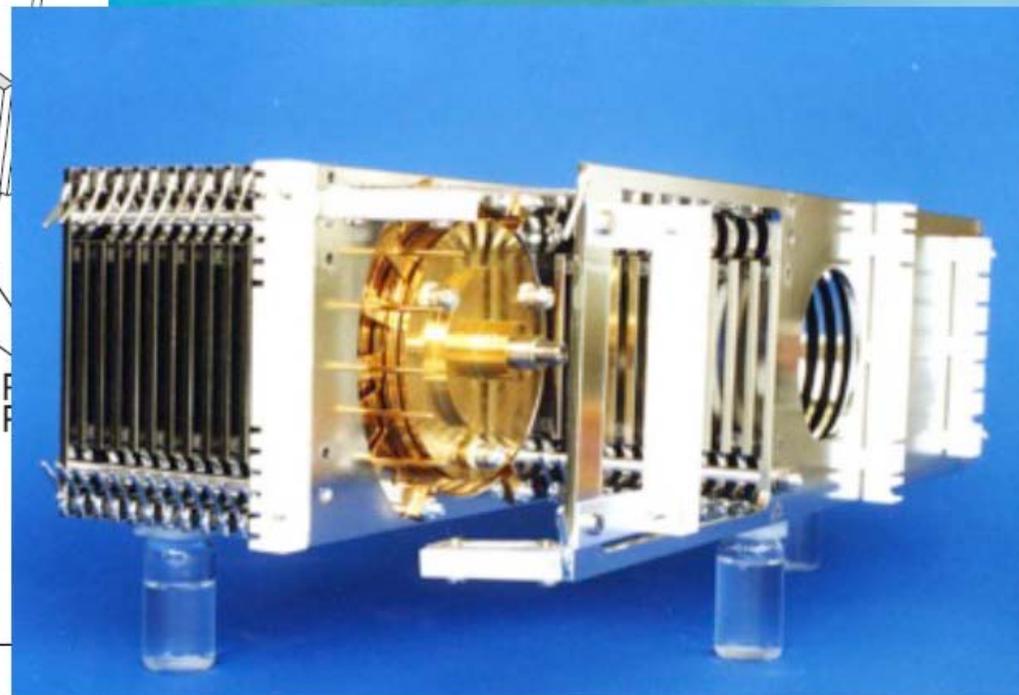
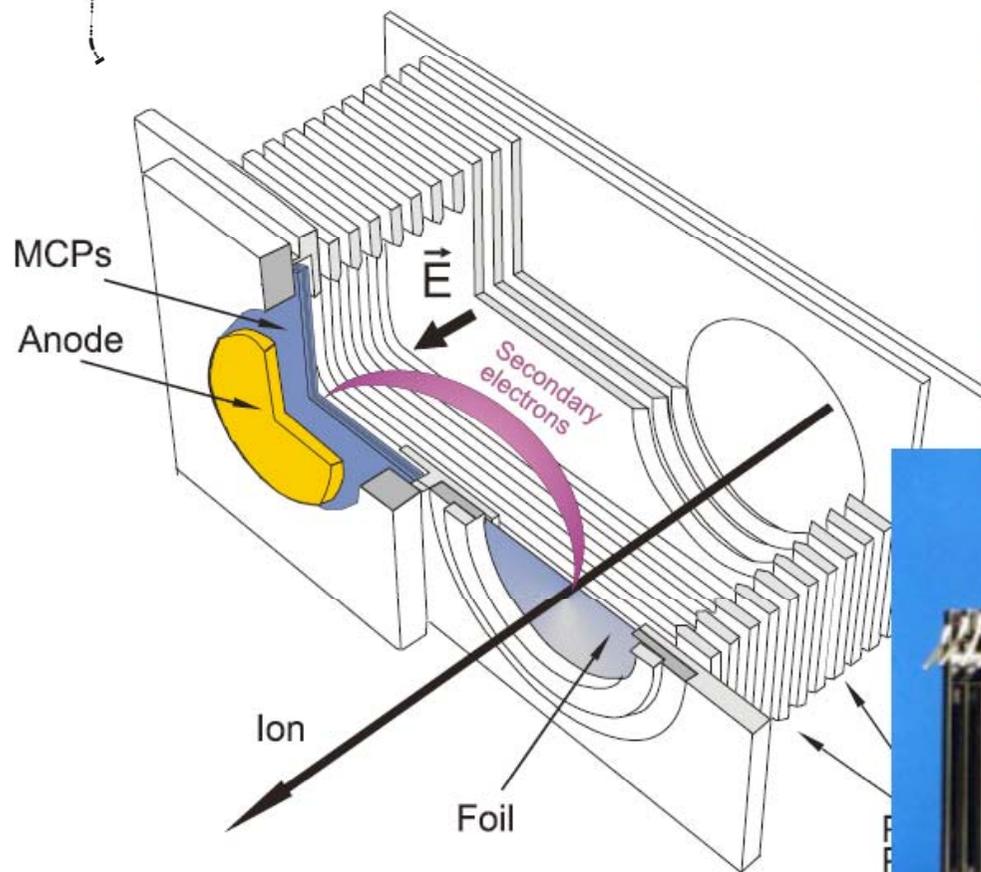
^{213}Tl

*Chen et al.,
Phys. Lett.
B691 (2010) 234;
Nucl. Phys.
A882 (2012) 71*

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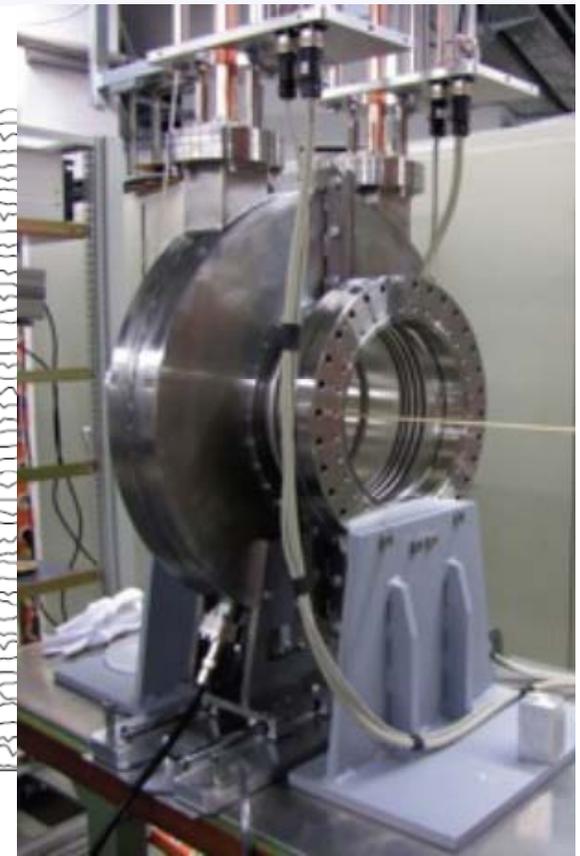
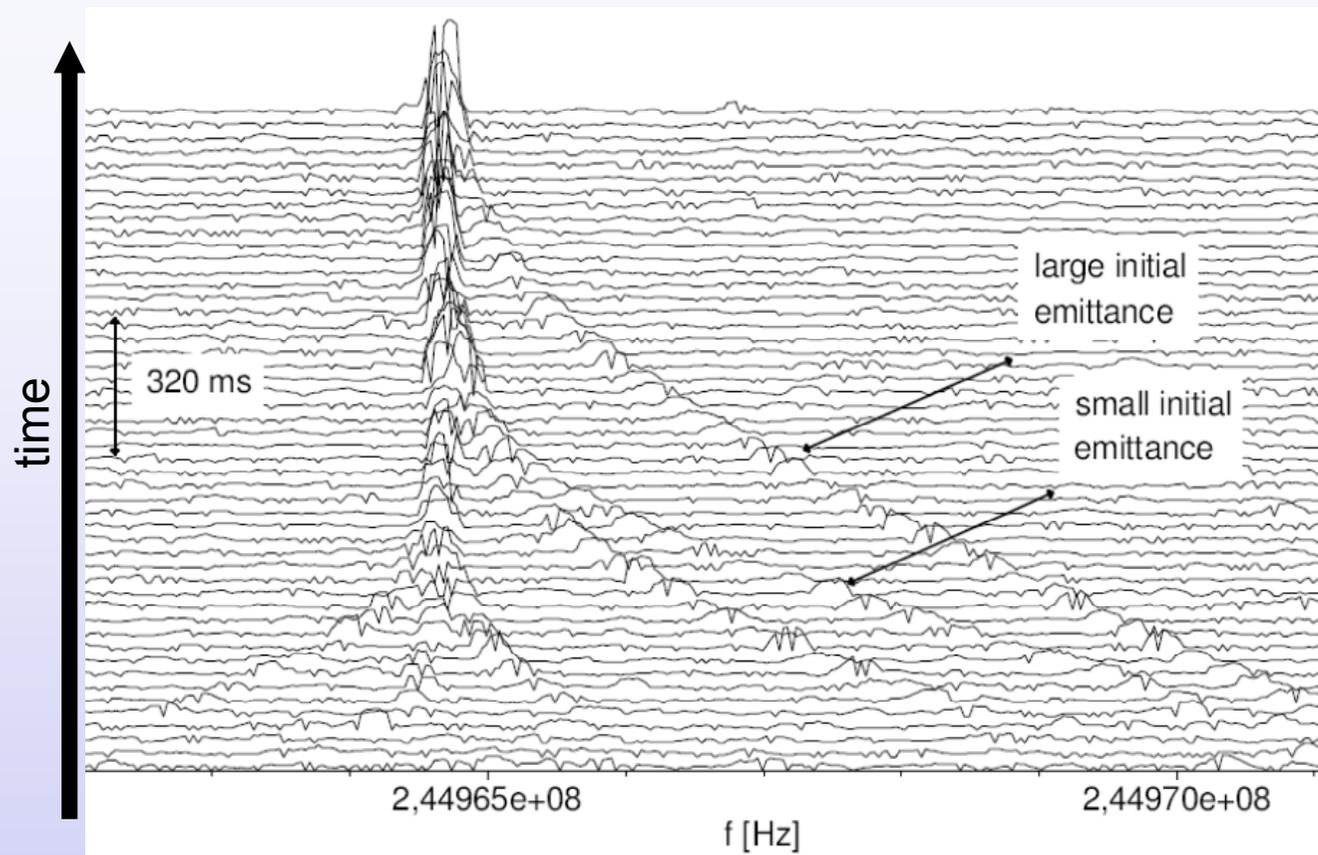


Time-of-Flight detector for the IMS



isochronous mass spectrometry

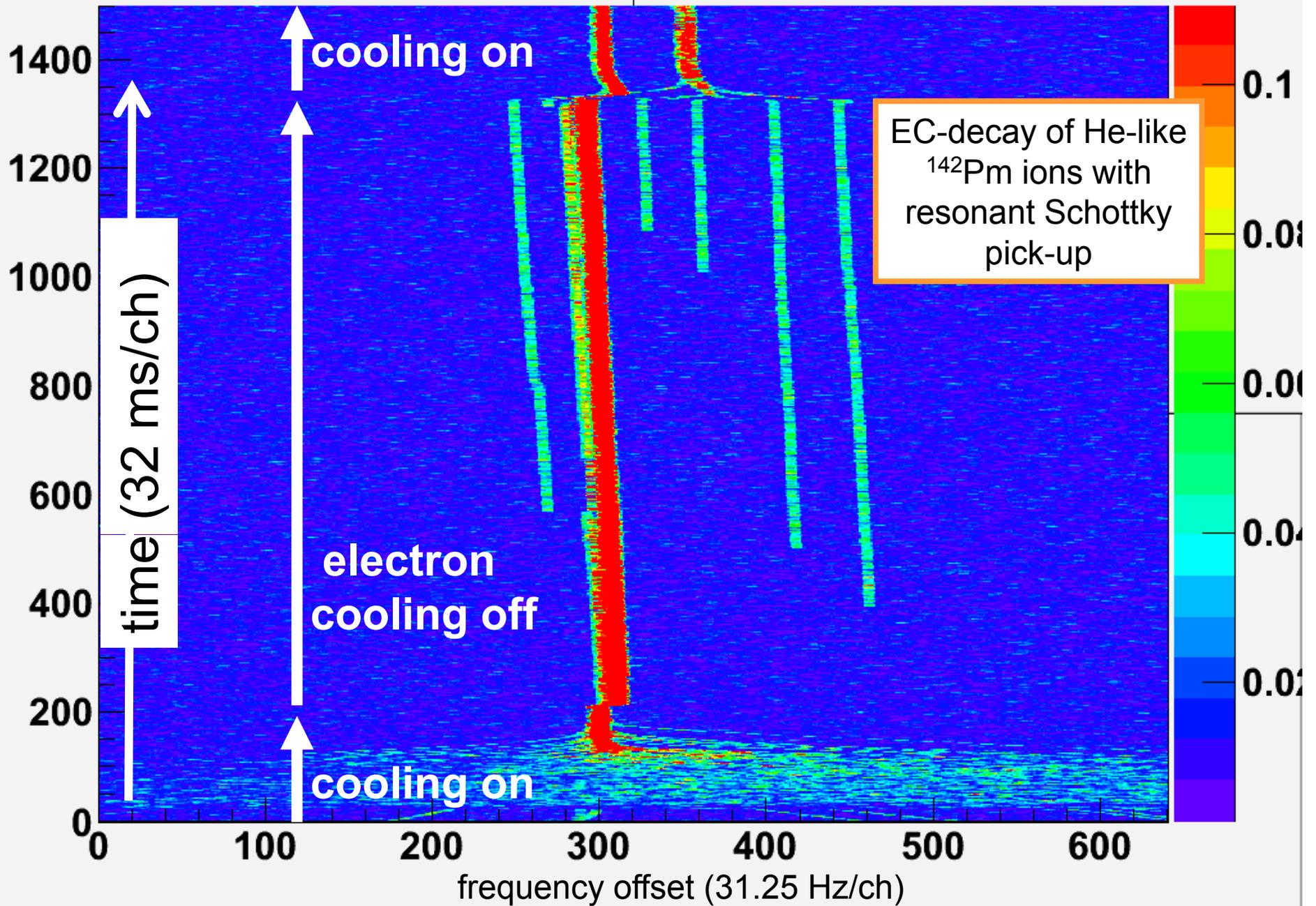
resonant Schottky pick-up



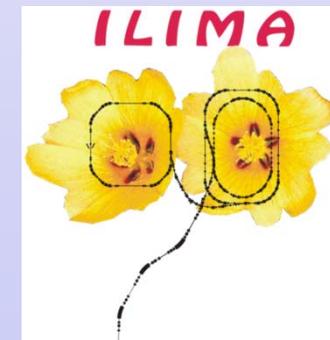
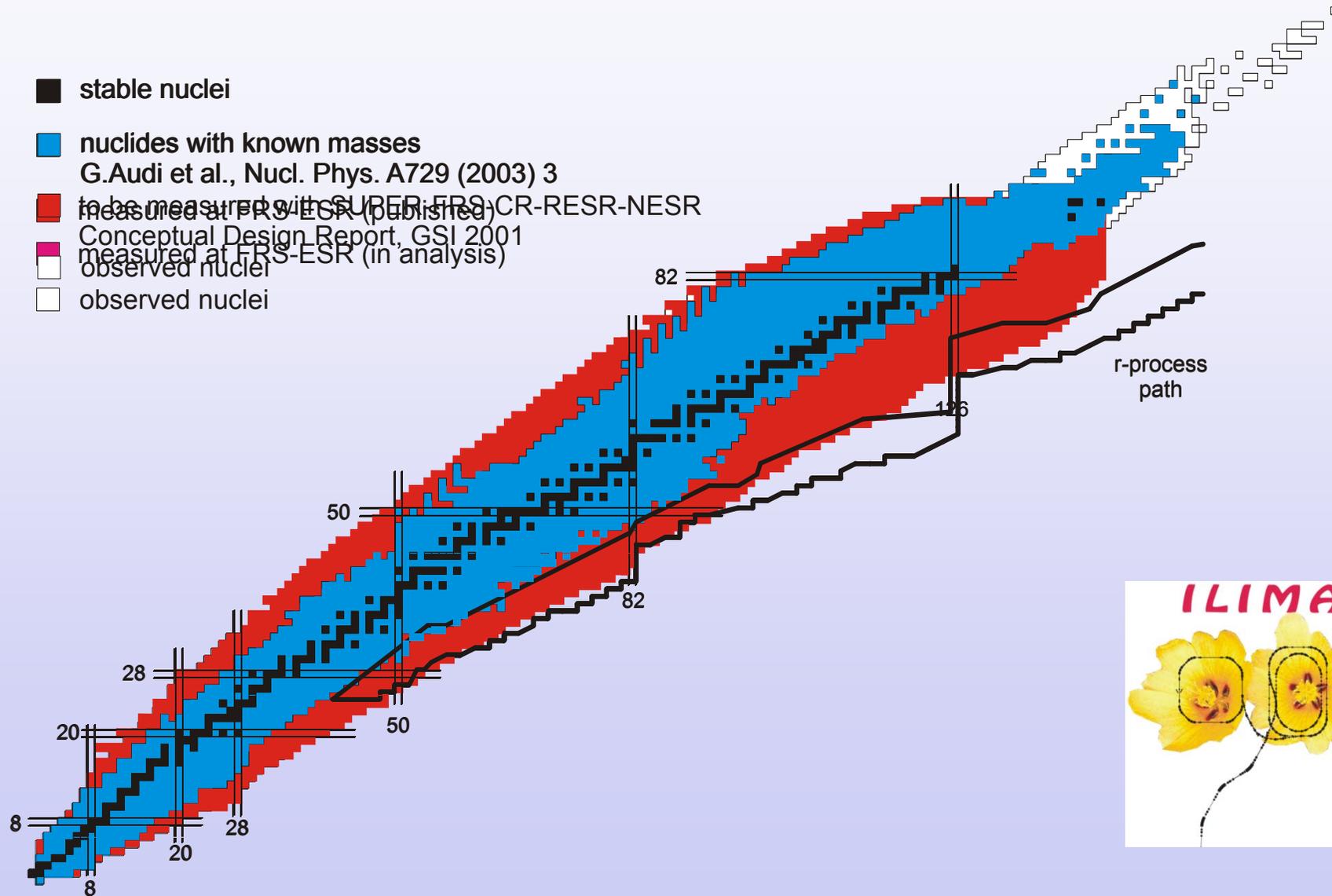
Electron cooling of six $^{142}\text{Pm}^{59+}$ (He-like) ions

Nolden et al., Nucl. Inst. Meth. A659 (2011) 69

Nolden et al., NIM A659 (2011) 69, and Yu. Litvinov, private communication



ILIMA: Main Physics Goals



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25 institutes
14 countries

