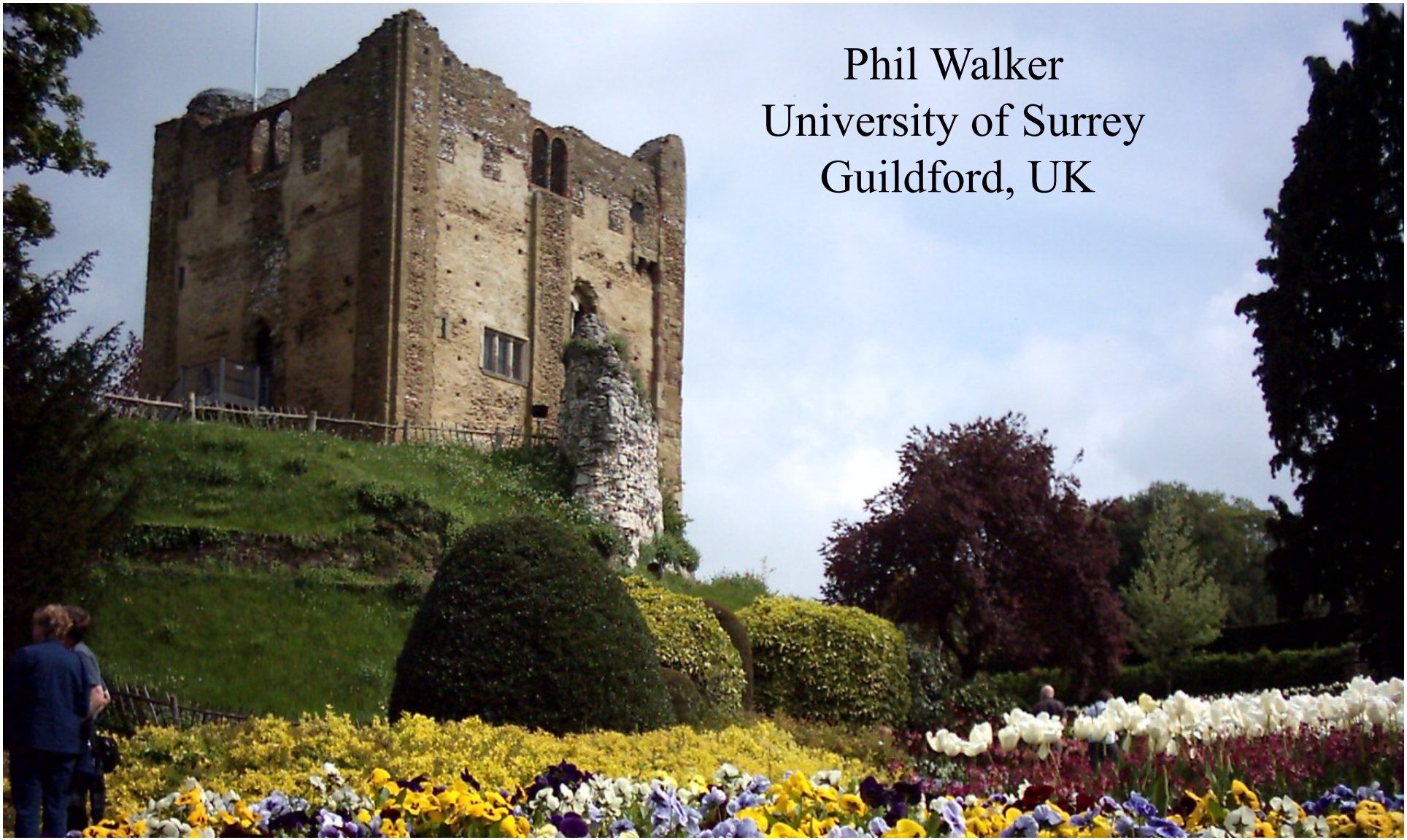
Storage ring measurements of ground-state and isomer properties



Phil Walker
University of Surrey
Guildford, UK

Storage ring measurements of ground-state and isomer properties

- Recent data from the GSI Experimental Storage Ring (ESR)

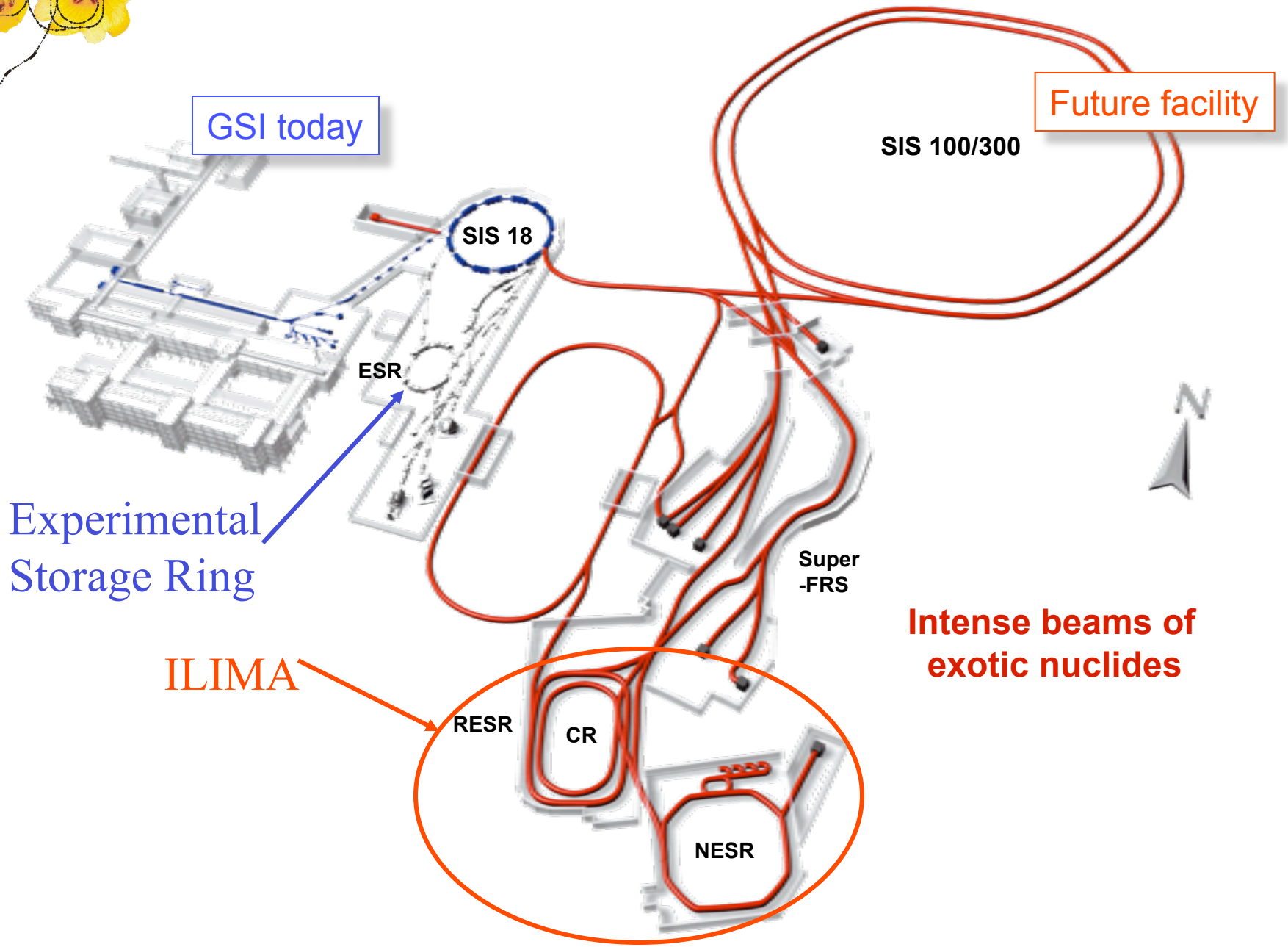
- The *ILIMA* project at FAIR

Isomers, Lifetimes and Masses

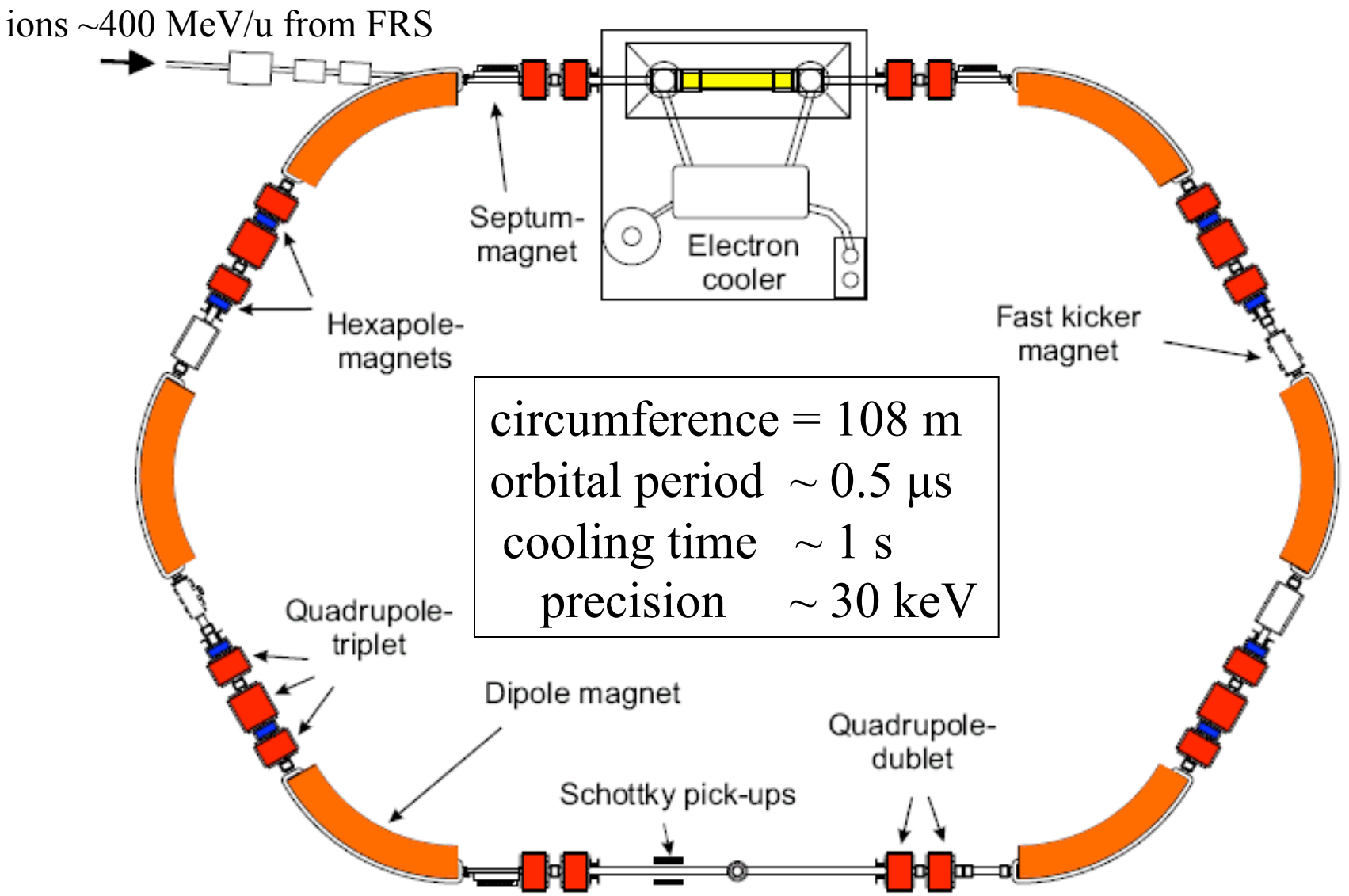
83 scientists, 21 institutions, 11 countries


ILIMA

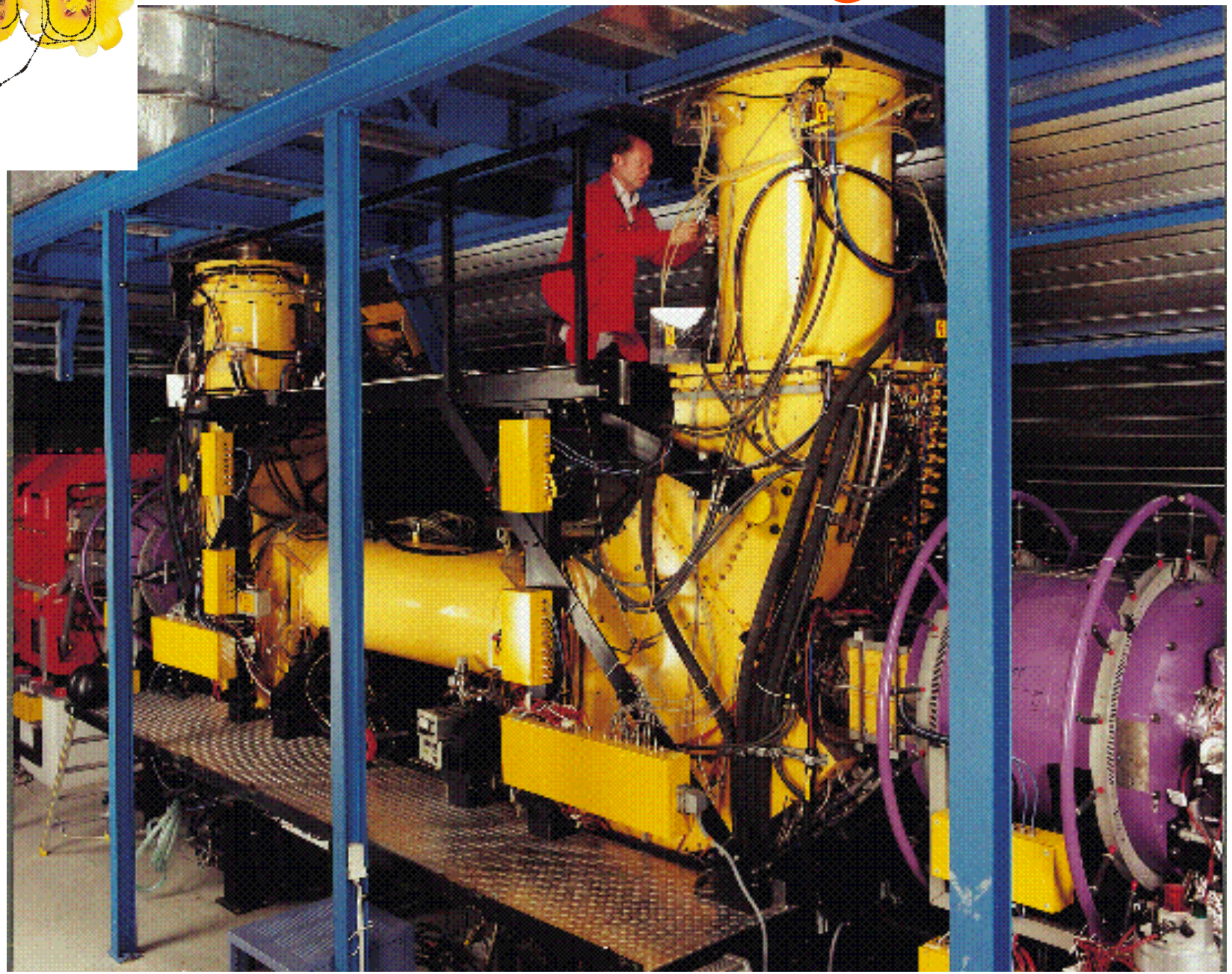
GSI - FAIR


GSI today
Future facility
SIS 100/300
SIS 18
ESR
Experimental
Storage Ring
Super
-FRS
N
Intense beams of
exotic nuclides
ILIMA
RESR
CR
NESR

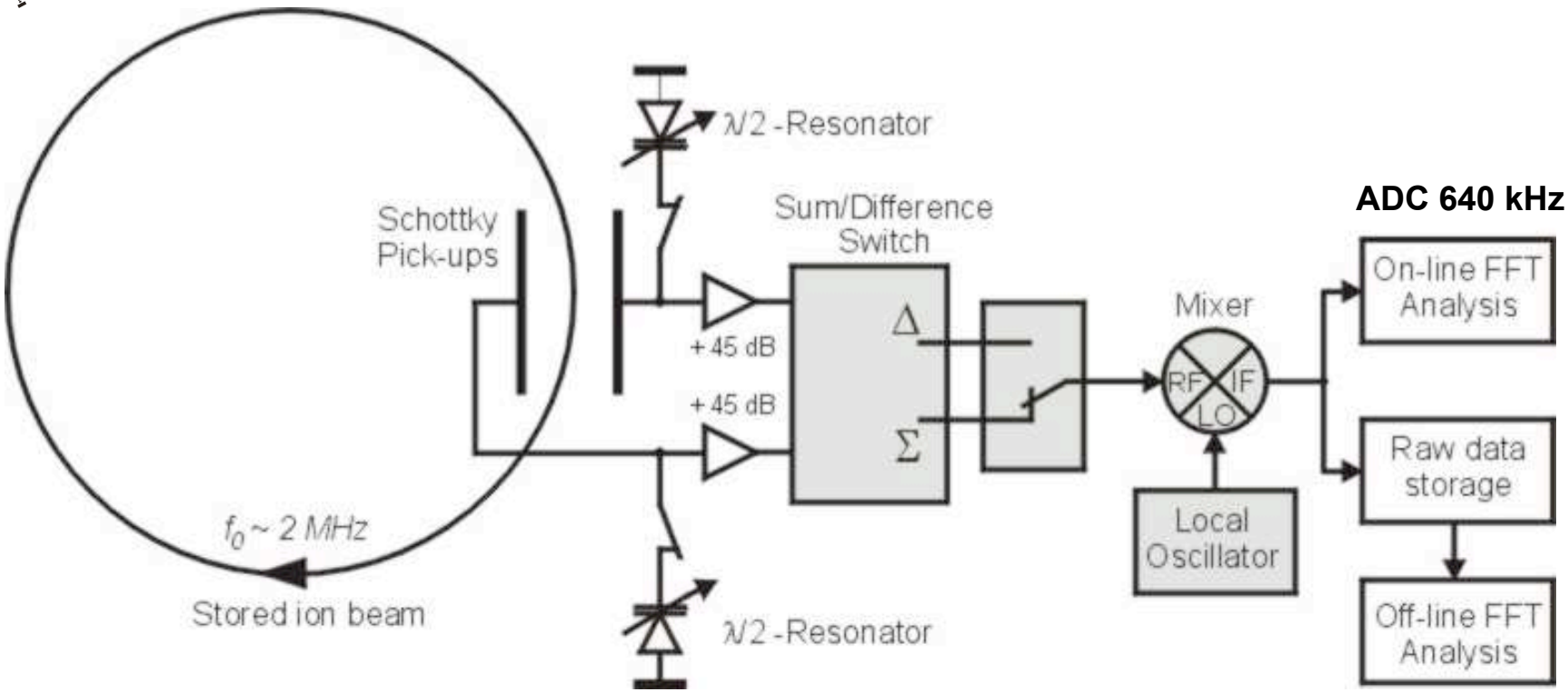
Experimental Storage Ring



electron cooling

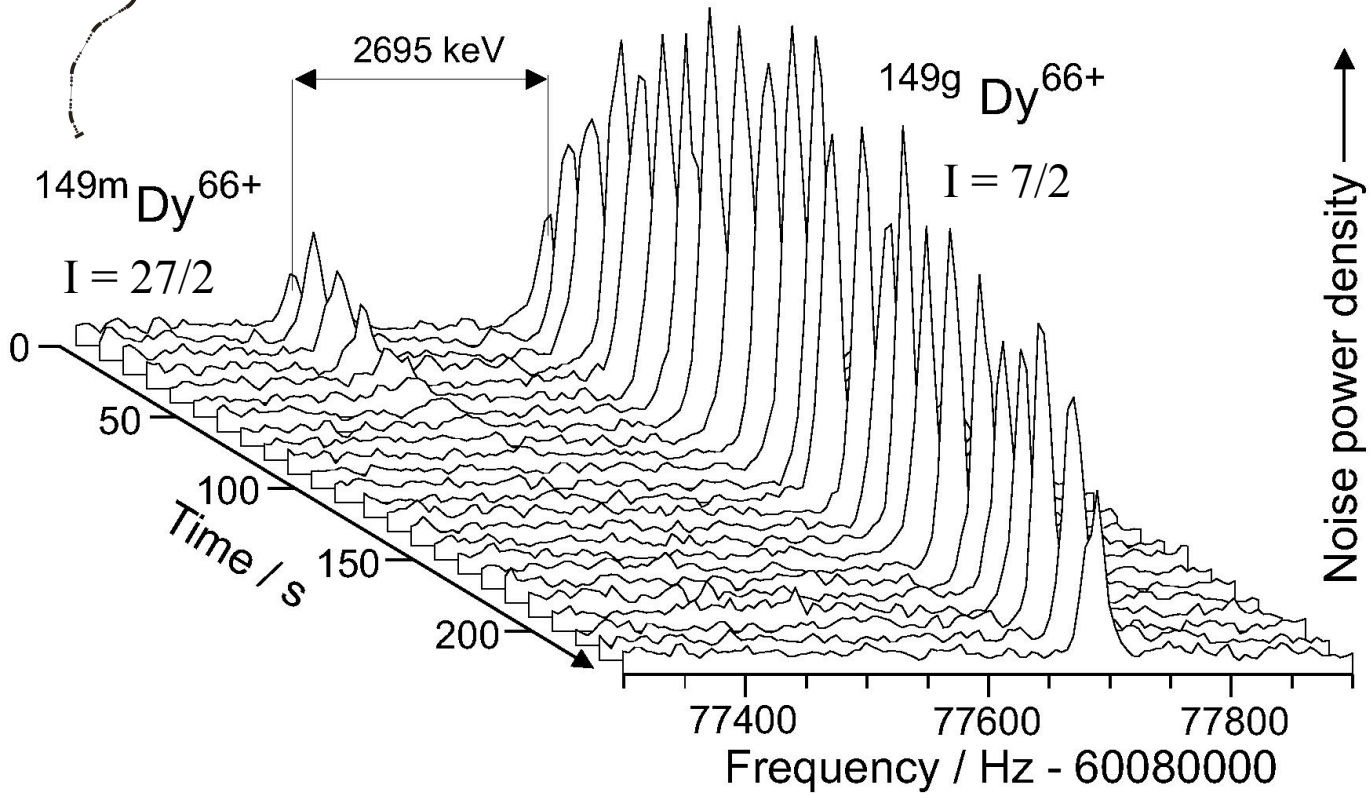


Schottky method



^{149}Dy in the Experimental Storage Ring

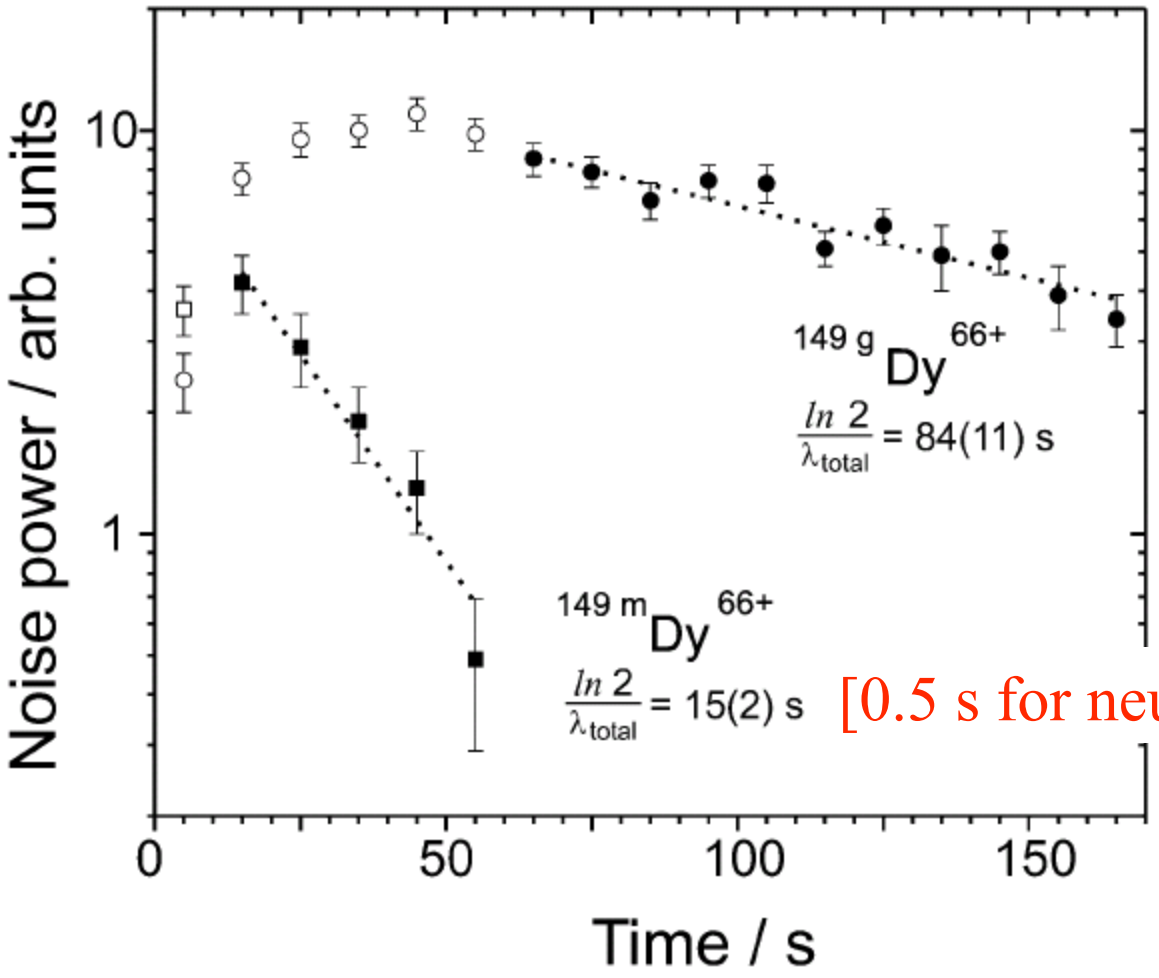
[Litvinov et al., Phys. Lett. B573 (2003) 80]



Isomers, Lifetimes and Masses

[isomers up to I = 43/2 seen in fragmentation
Podolyak et al., Phys. Lett. B632 (2006) 203]

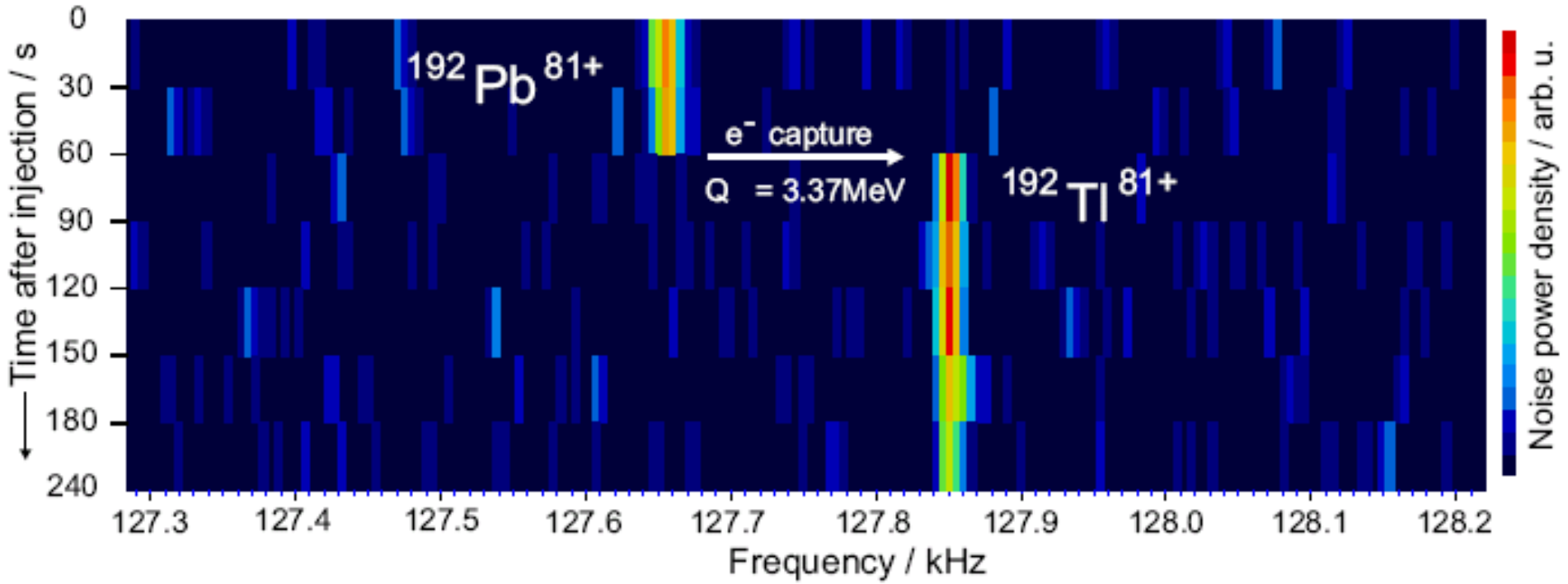
^{149}Dy isomer decay



[0.5 s for neutral atom]

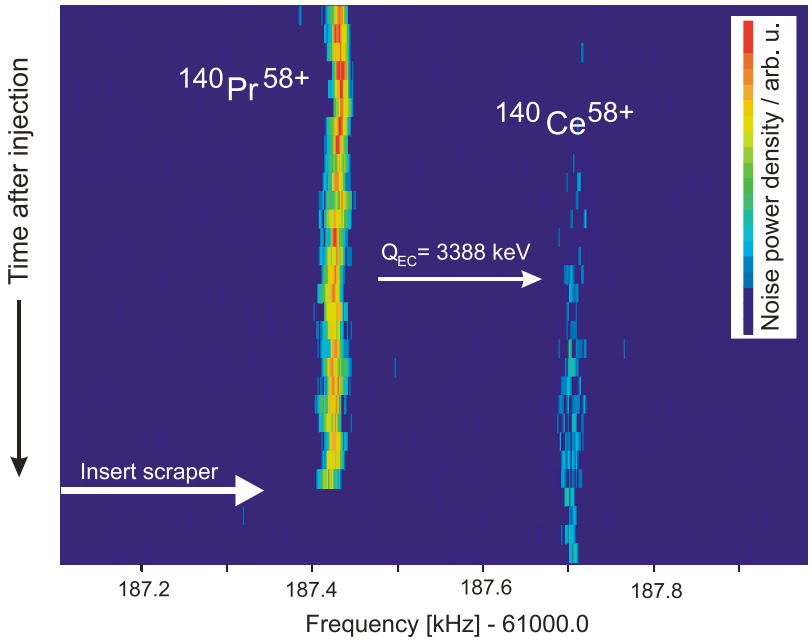
[Litvinov et al., Phys. Lett. B573 (2003) 80]

single-ion in-ring decay

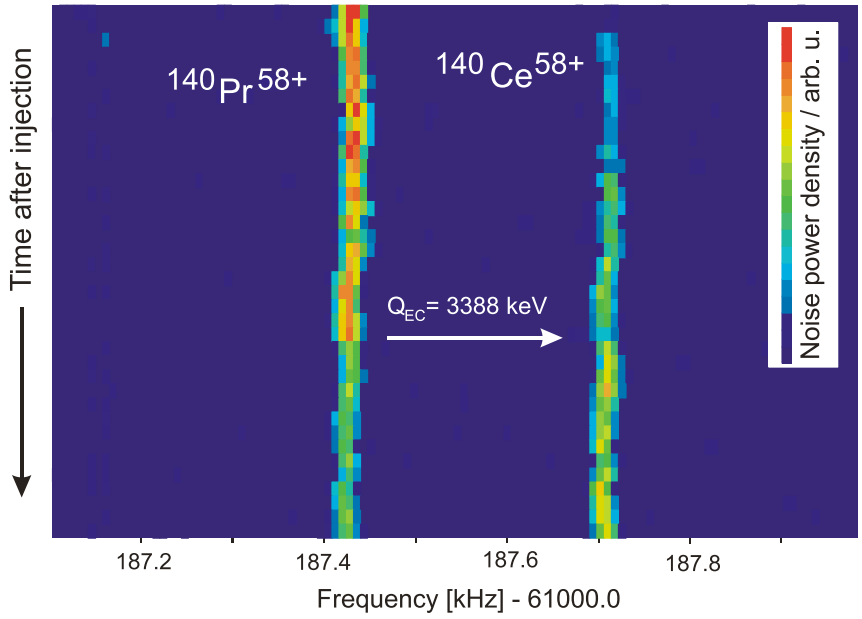


[Litvinov et al., Nucl. Phys. A756 (2005) 3]

potential for isomer beam purification

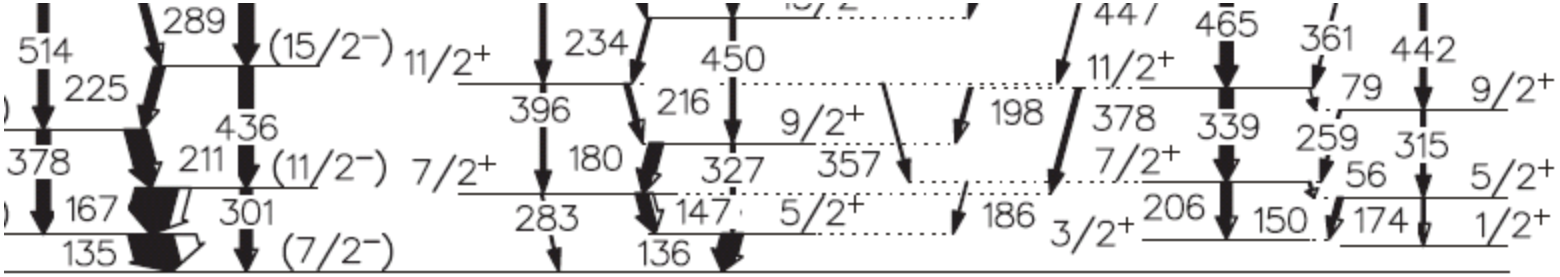


Injection length 170 s



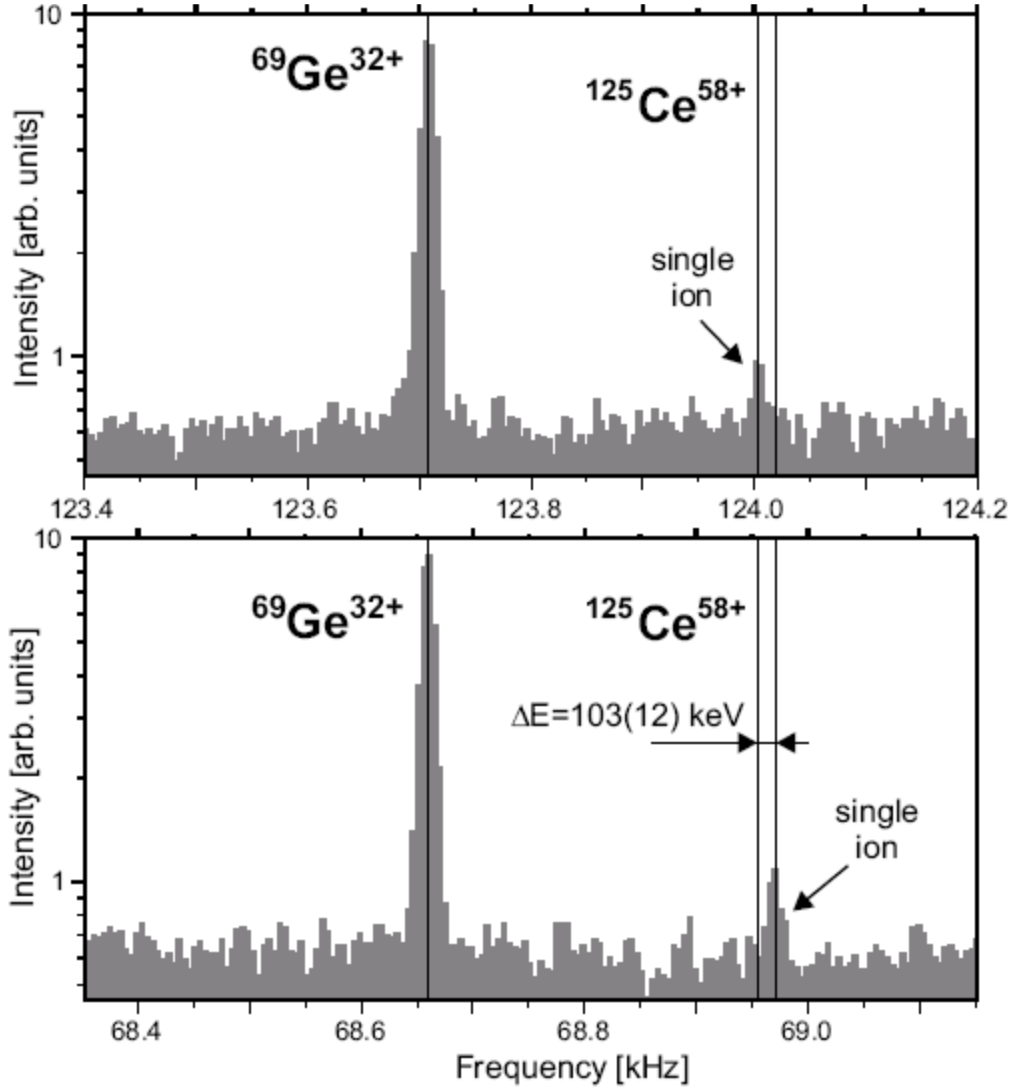
Injection length 520 s

[Bosch et al., Int. J. Mass Spec. 251 (2006) 212]



92 keV

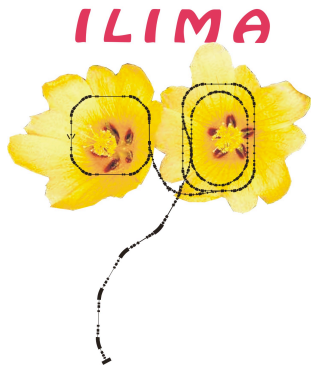
[Petrache et al., Eur. Phys. J. A14 (2002) 439]



$^{125m}Ce^{58+}$ ($t_{1/2}$~150s)

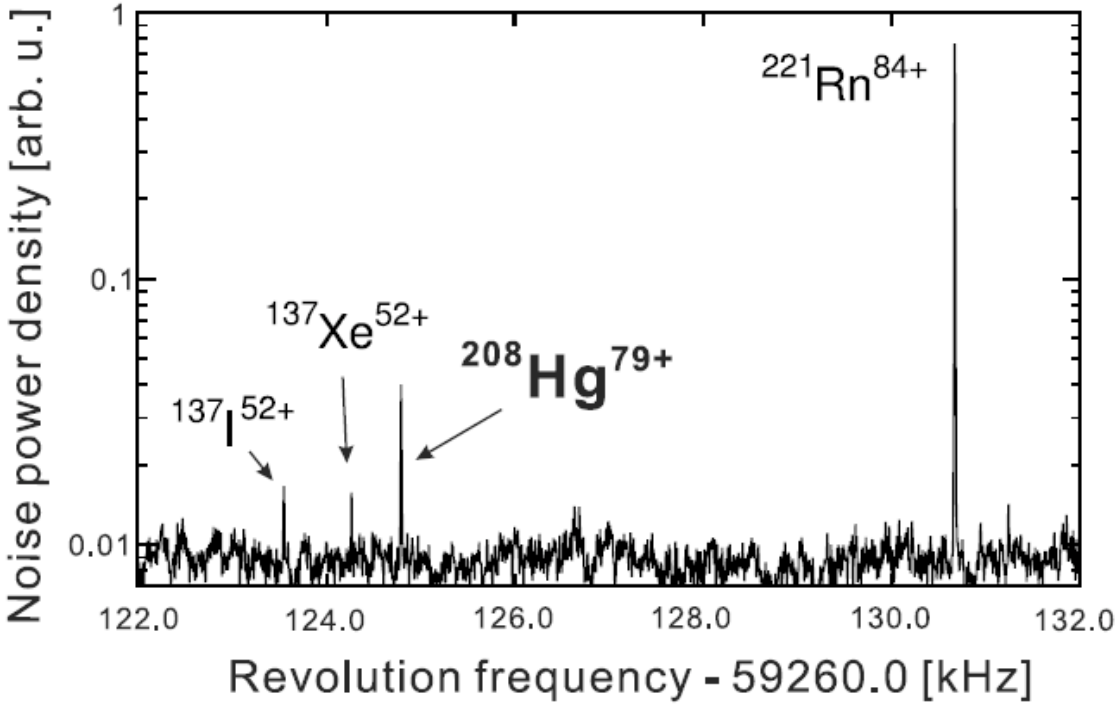
first "new" isomer in ESR

Sun et al., Eur. Phys. J. A31 (2007) 393



proton-neutron interactions: new data

[Chen et al., submitted]



proton-neutron interactions: new data

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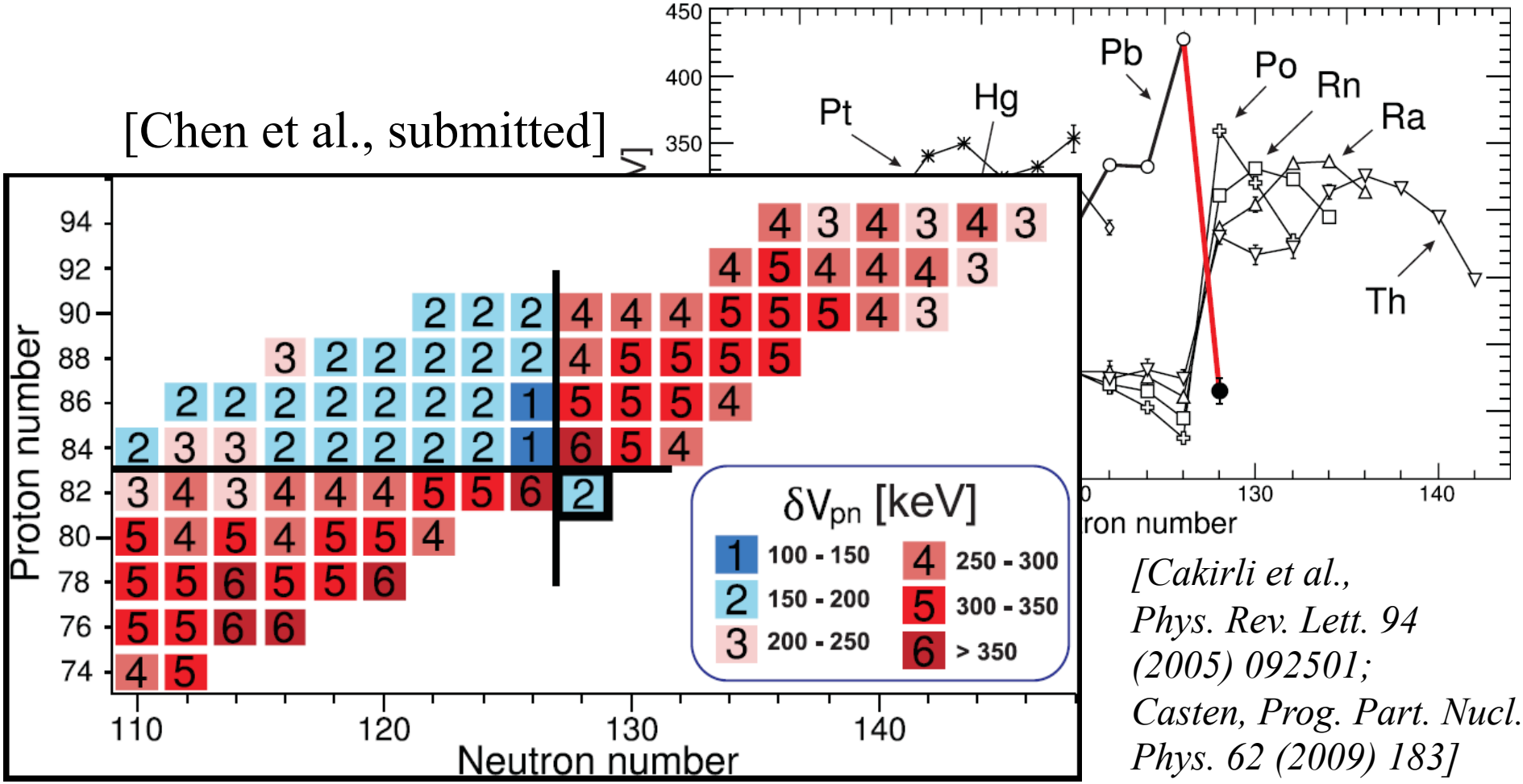
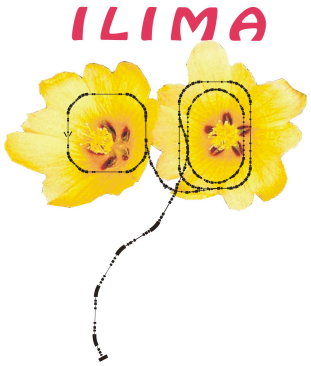


[Cakirli et al., Phys. Rev. Lett. 94 (2005) 092501; Casten, Prog. Part. Nucl. Phys. 62 (2009) 183]

$$\delta V_{pn}(Z,N) = \frac{1}{4}[B(Z,N) + B(Z-2,N-2) - B(Z,N-2) - B(Z-2,N)],$$



SMS and IMS

mass measurements

both methods have single-ion sensitivity

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

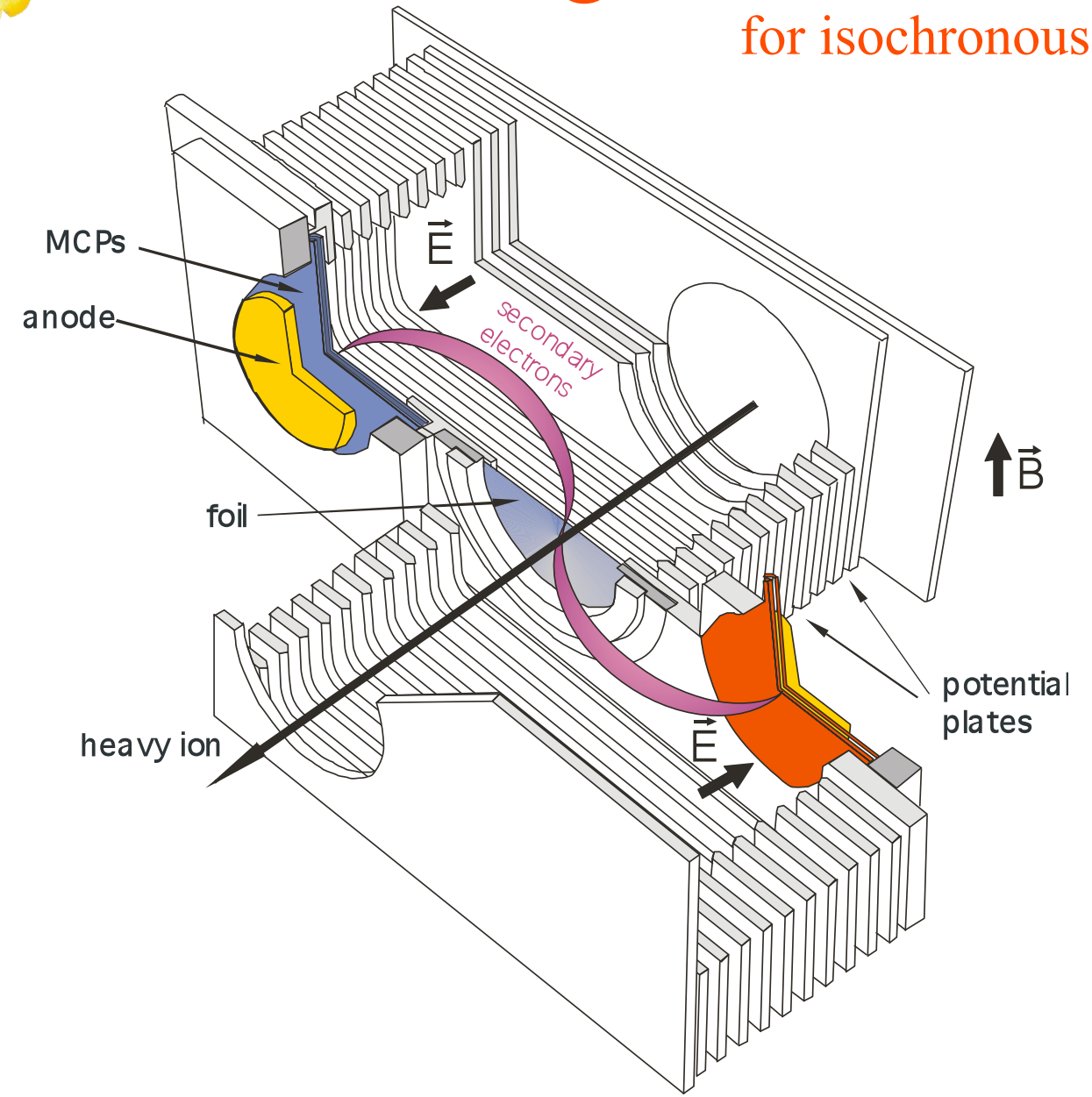
Isochronous Mass Spectrometry: $T_{1/2} > 10$ μs

resolving power ~ 10^6
accuracy ~ 30 μu, i.e. ~ 30 keV (~100 keV for IMS)

ILIMA

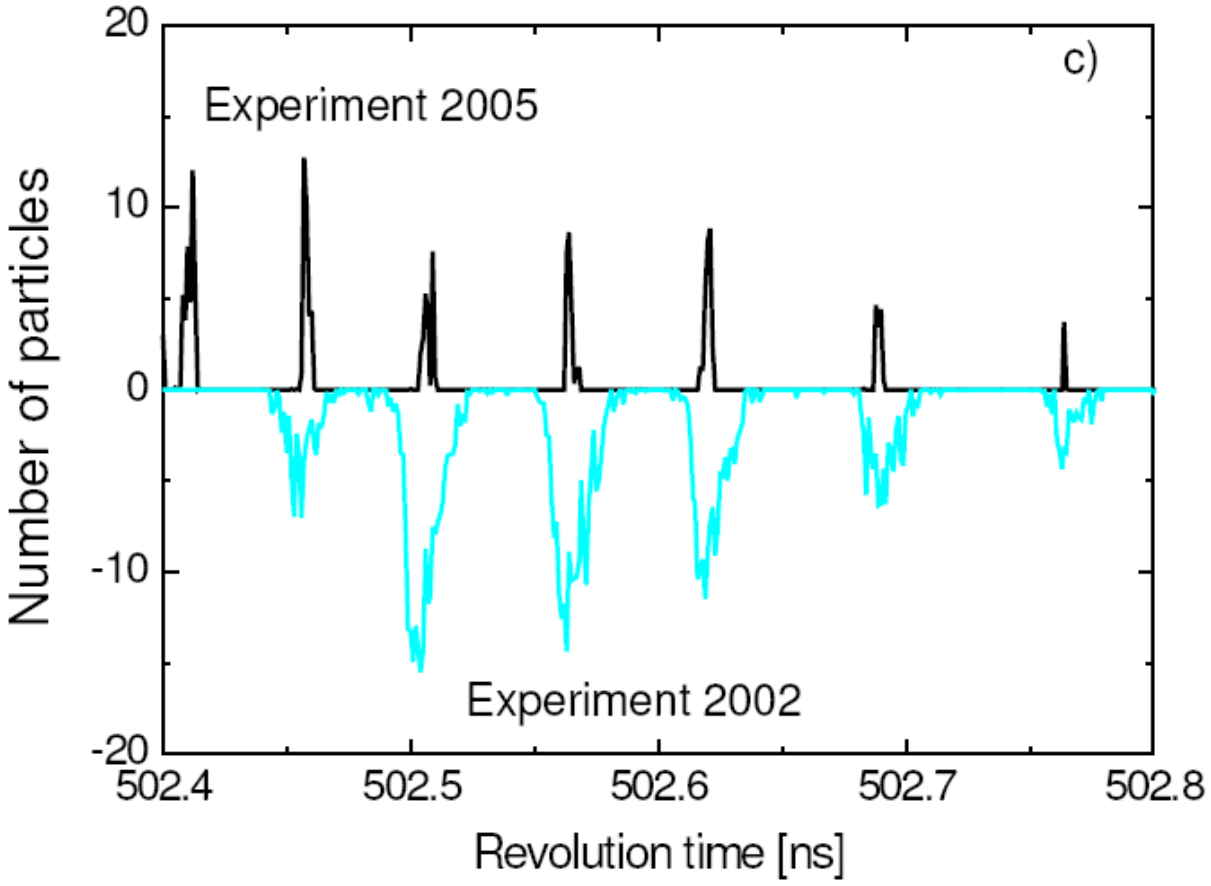
time-of-flight detectors

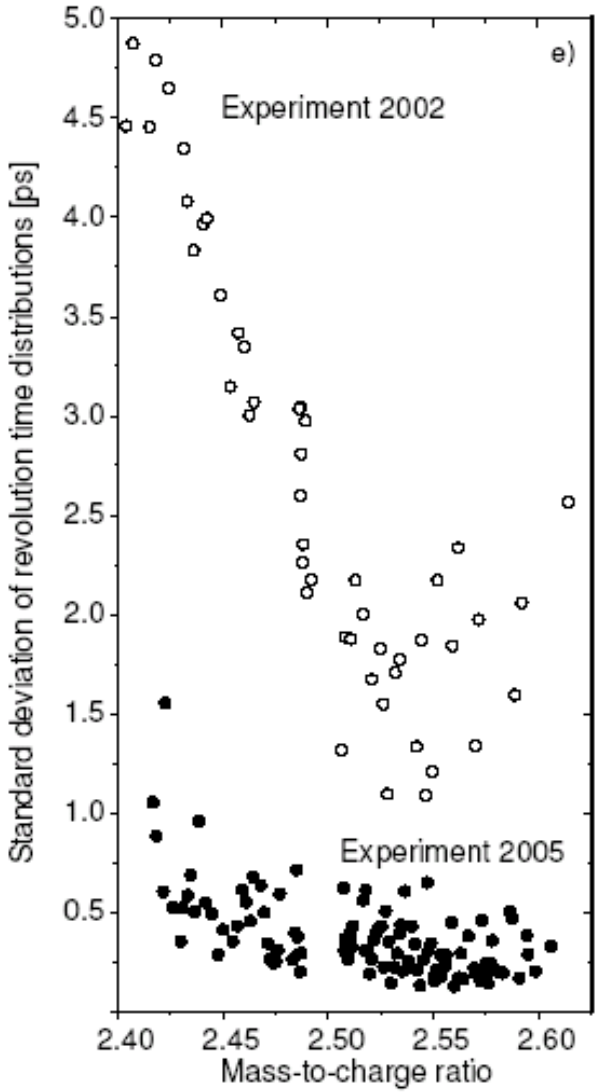
for isochronous method



isochronous method

[Sun et al., Nucl. Phys. A812 (2008) 1;
Knöbel et al., AIP Conf. Proc. 891 (2007) 199]

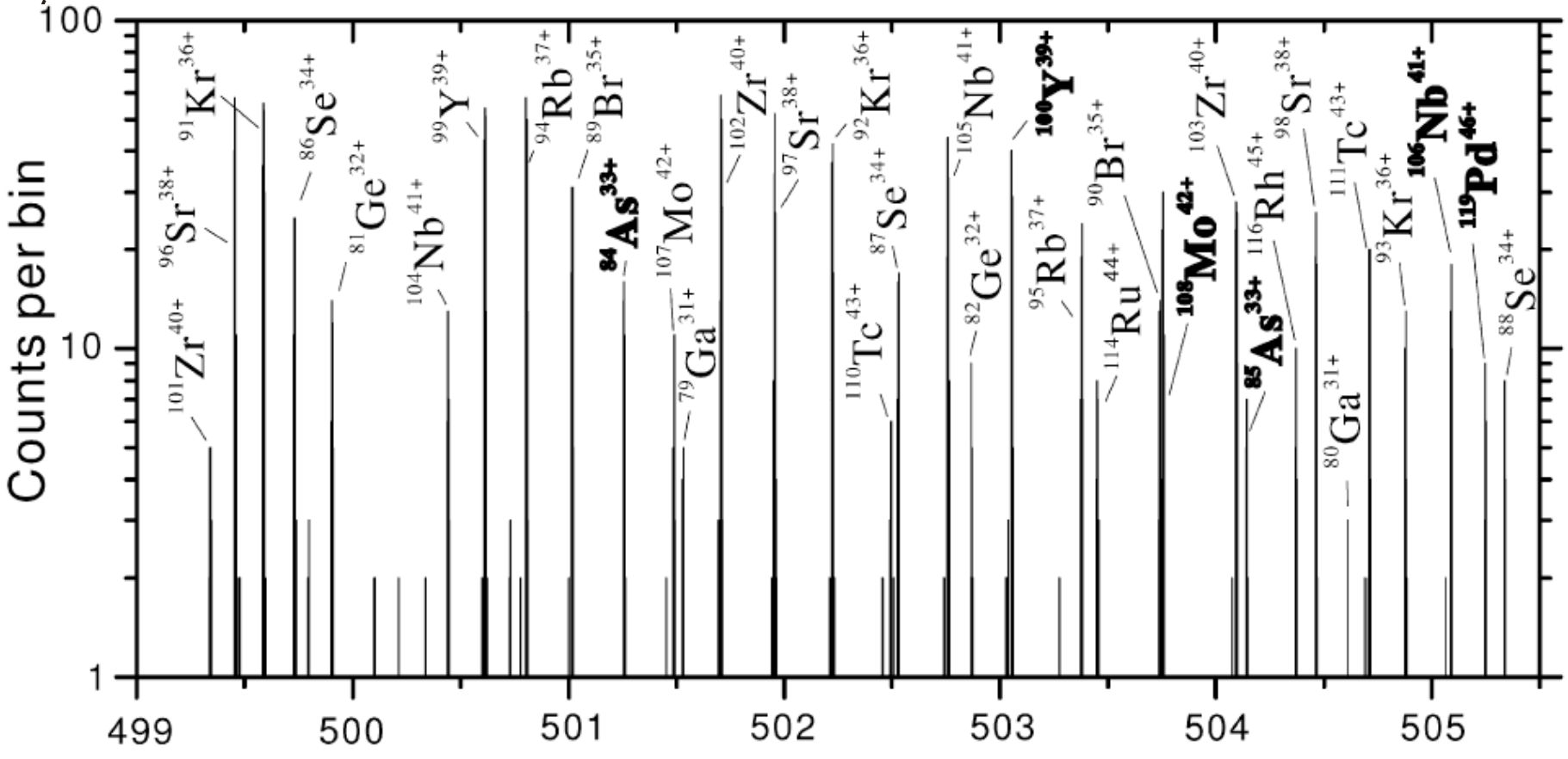




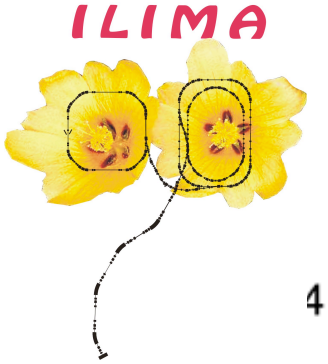
^{238}U primary beam at 411 MeV/u

new IMS results

[Sun et al., Nucl. Phys. A812 (2008) 1]

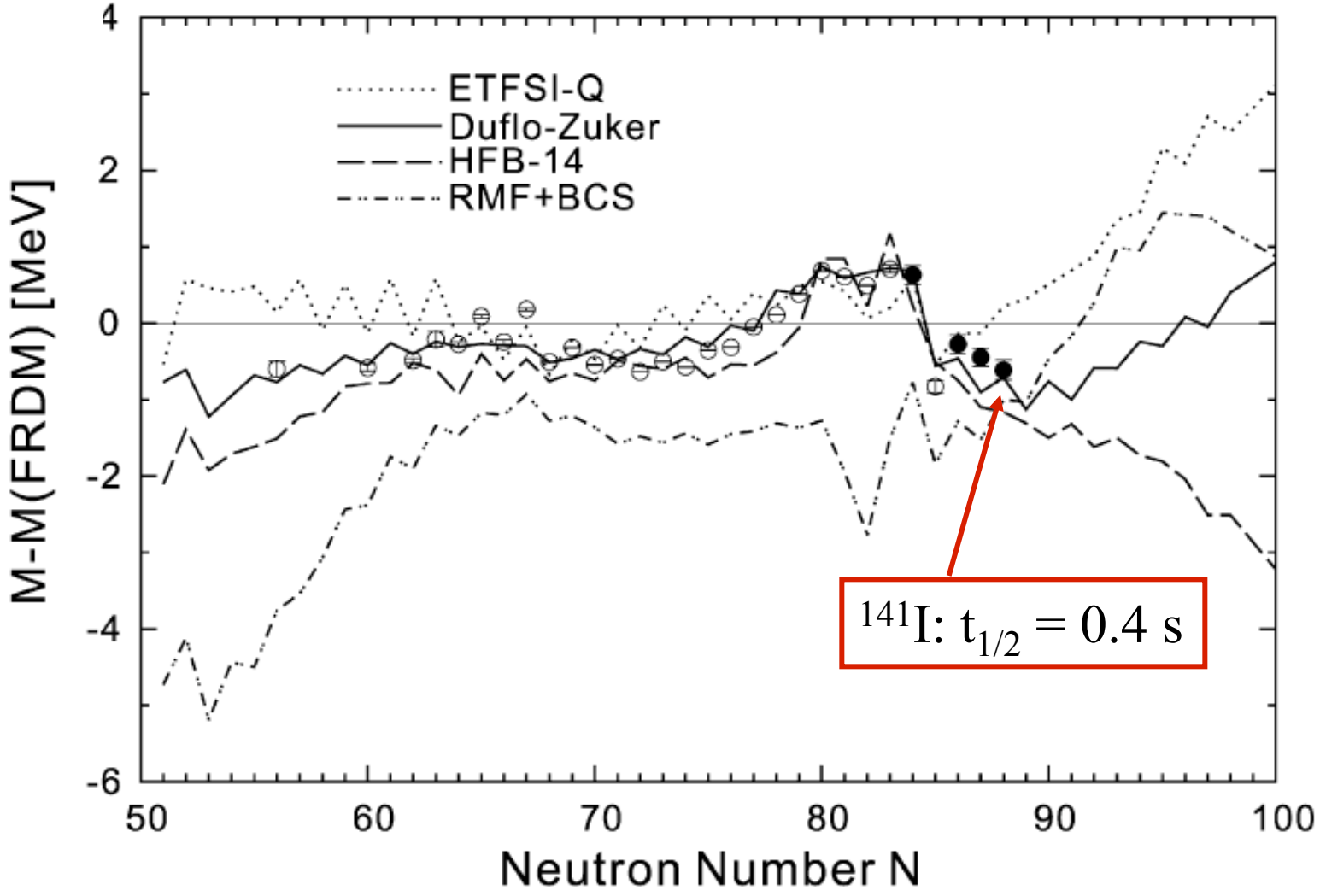


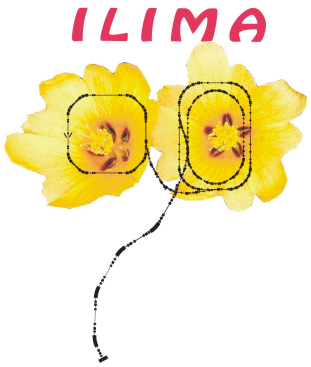
^{238}U primary beam at 411 MeV/u

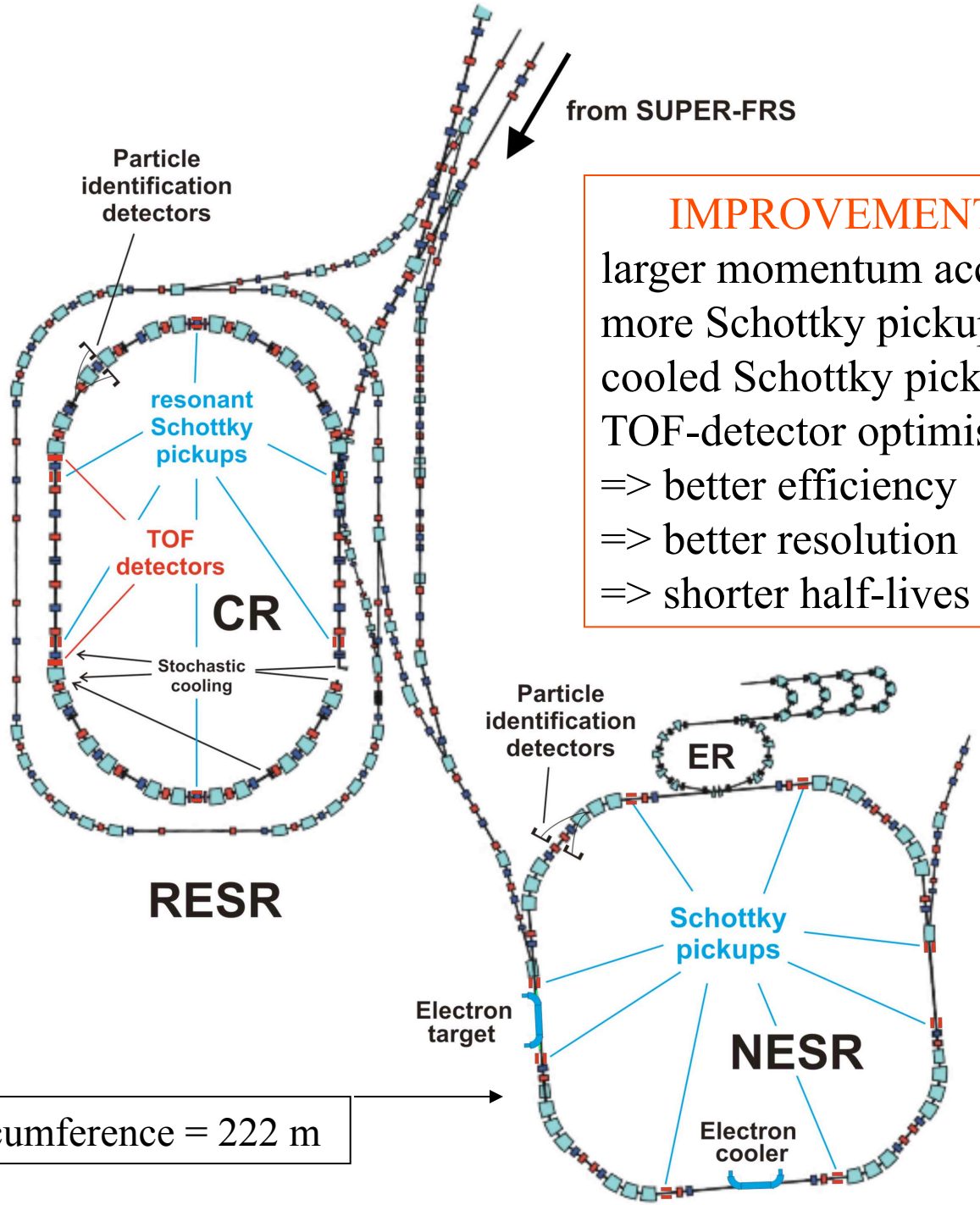


iodine isotope masses

[Sun et al., Nucl. Phys. A812 (2008) 1]



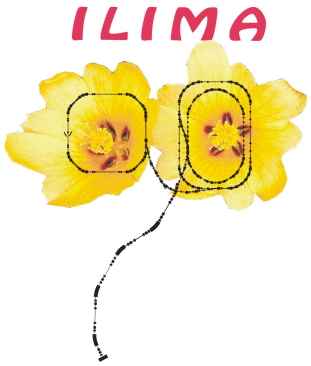




IMPROVEMENTS

larger momentum acceptance
more Schottky pickups
cooled Schottky pickups
TOF-detector optimisation
=> better efficiency
=> better resolution
=> shorter half-lives

NESR circumference = 222 m



more beam (x1000)
more efficiency (x10)
more sensitivity

potential for new masses with ILIMA

ILIMA collaboration

GSI, Germany: E. Badura, K. Beckert, F. Bosch, C. Brandau, C. Dimopoulou, A. Dolinski, P.Egelhof, B. Franczak, B. Franzke, H. Geissel, F. Herfurth, J. Hoffmann, H.-J. Kluge, R.K. Knöbel, C. Kozhuharov, N. Kurz, S.A. Litvinov, Yu.A. Litvinov, G. Münzenberg, F. Montes, I. Nesmiyan, F. Nickel, F. Nolden, C. Nociforo, W. Ott, W. Quint, C. Scheidenberger, H. Simon, M. Steck, Th. Stöhlker, B. Sun, S. Typel, G.K. Vorobjev, H. Weick, N. Winckler, M. Winkler

Gießen, Germany: D. Boutin, L. Chen, T. Dickel, B. Fabian, M. Petrick, W.R. Plaß

München, Germany: T. Faestermann, P. Kienle, L. Maier, P. Ring, D. Vretenar

Frankfurt,Germany: Th. Bürvenich

Heidelberg, Germany: A. Palffy

Mainz, Germany: K. Blaum, K.-L. Kratz, B. Pfeiffer

St.Petersburg, Russia: Yu.N. Novikov, D.M. Seliverstov, Yu. Gusev

Orsay, France: G. Audi, D. Lunney

Bruxelles, Belgium: K. Takahashi, S. Goriely, P-H. Heenen

Thessaloniki, Greece: G.A. Lalazissis

Warsaw, Poland: Z. Janas, M. Pfützner, Z. Patyk

Stockholm, Sweden: S. Tashenov

Surrey,UK: Z. Podolyak, P.M. Walker, I.J. Cullen

Edinburgh, UK: P.J. Woods, Z. Liu

Manchester, UK: D.M. Cullen

MSU, USA: M. Hausmann, M. Matoš, H. Schatz

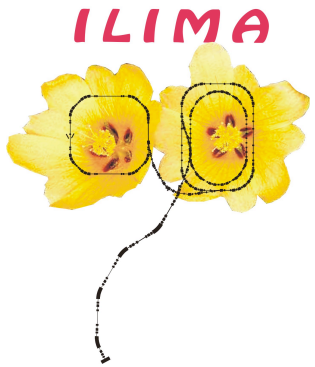
Los Alamos, USA: D. Madland, P. Moeller, D. Vieira

Lanzhou, China: Ruishi Mao, Zhiyu Sun, Guoqing Xiao

Niigata, Japan: T. Ohtsubo

Saitama, Japan: T. Suzuki, T. Yamaguchi

Tsukuba, Japan: A. Ozawa



83 scientists
21 institutions
11 countries

summary: masses and isomers

- Schottky method: ~30 keV accuracy, >1 s
- isochronous method: ~100 keV accuracy, >10 μs
- exceptional (single-ion) sensitivity
- **surprising directions:**