

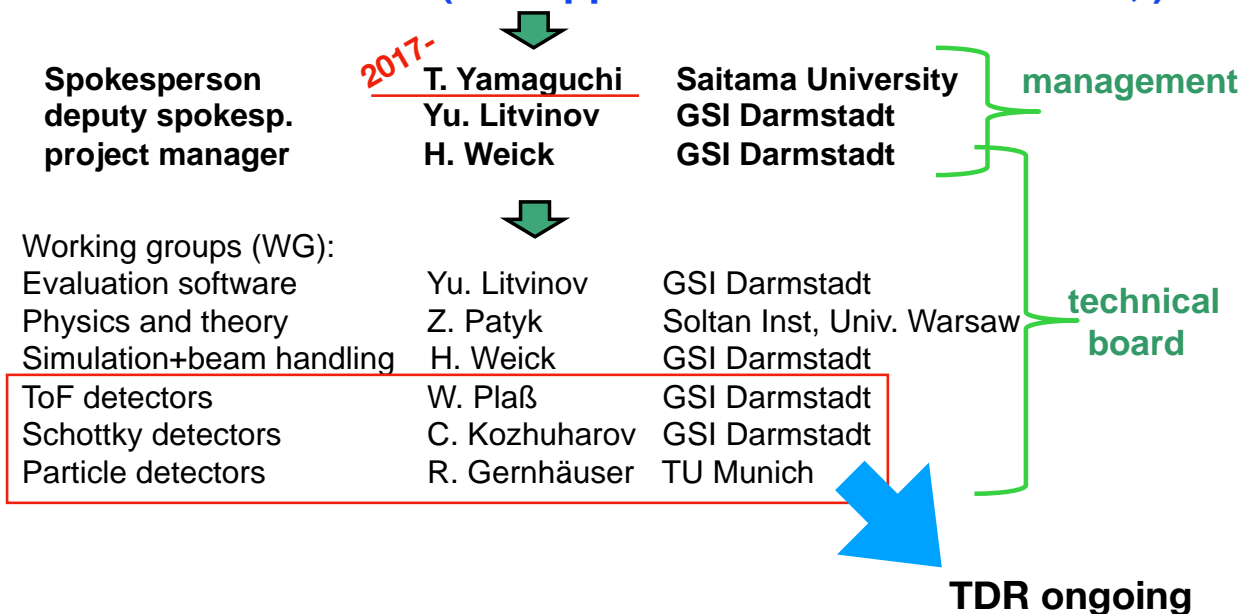
# ILIMA status report

Isomeric beams, Lifetimes and Masses

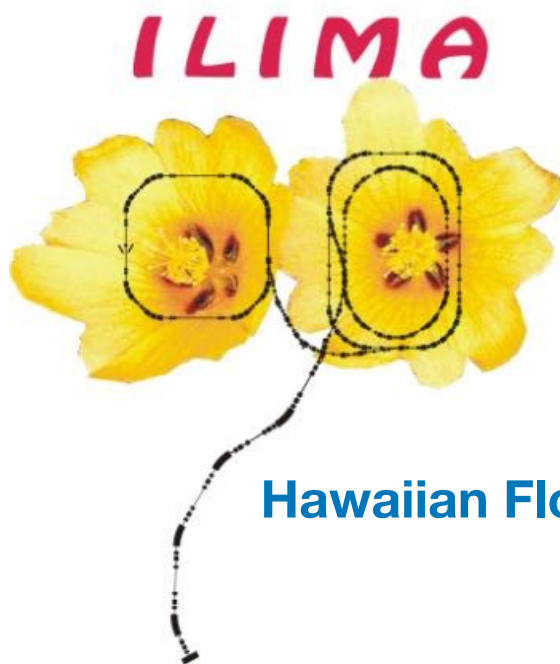
Taka Yamaguchi (Saitama Univ. Japan)  
for ILIMA collaboration

## ILIMA structure

Collaboration board (one appointed from each institute, )



# Isomeric beams, Lifetimes and MAasses

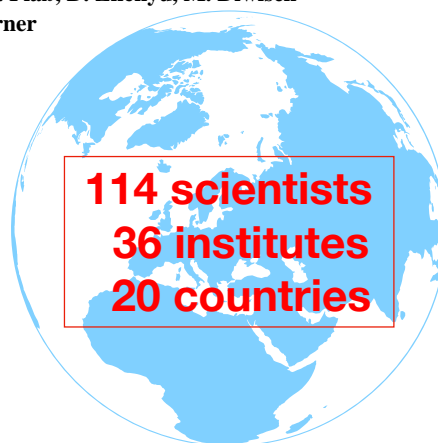


## Hawaiian Flower Lei

for love, honor, friendship



**GSI, Germany:** E. Badura, C. Brandau, C. Dimopoulou, A. Dolinski, P. Egelhof, A. Evdokimov, B. Franczak, B. Franzke, H. Geissel, F. Herfurth, A. Herlert, J. Hoffmann, H.-J. Kluge, R.K. Knöbel, C. Kozhuharov, N. Kurz, S.A. Litvinov, **Yu.A. Litvinov**, M. Marta, G. Münzenberg, F. Montes, F. Nickel, F. Nolden, C. Nociforo, W. Quint, S. Sanjari, C. Scheidenberger, D. Shubina, H. Simon, A. Sobiczewski, M. Steck, Th. Stöhlker, S. Typel, G.K. Vorobjev, **H. Weick**, N. Winckler, M. Winkler **TU Darmstadt, Germany:** A. Arcones, A. Schwenk  
**Gießen, Germany:** D. Boutin, T. Dickel, B. Fabian, A. Fettouhi, M. Petrick, W.R. Plaß, D. Zhenyu, M. Diwisch  
**München, Germany:** T. Faestermann, P. Ring, R. Gernhäuser, A. Najafi, S. Koerner  
**Frankfurt, Germany:** Th. Bürvenich, R. Reifarh  
**Heidelberg, Germany:** K. Blaum, A. Palffy  
**Mainz, Germany:** K.-L. Kratz, B. Pfeiffer  
**St. Petersburg, Russia:** I. Burzov, Yu.N. Novikov, D.M. Seliverstov, Yu. Gusev  
**Orsay, France:** G. Audi, D. Lunney  
**Bruxelles, Belgium:** S. Goriely, P.-H. Heenen, K. Takahashi  
**Thessaloniki, Greece:** G.A. Lalazissis  
**Warsaw, Poland:** Z. Janas, M. Pfützner, Z. Patyk  
**Stockholm, Sweden:** S. Tashenov  
**Surrey, UK:** Z. Podolyak, P.M. Walker, G. Lotay  
**Edinburgh, UK:** P.J. Woods, Z. Liu  
**Manchester, UK:** D.M. Cullen  
**Catania, Italy:** A. Musumarra **Istanbul, Turkey:** B. Cakirli  
**Madrid, Spain:** R. Rodriguez-Guzman **Zagreb, Croatia:** D. Vretenar  
**Belgrade, Serbia:** D. Toprek **JSI, Slovenia:** M. Lipoglavsek  
**UTK, USA:** M. Matoš; **TAMU, USA:** L. Chen  
**MSU, USA:** M. Hausmann, H. Schatz **Notre Dame, USA:** Z. Meisel  
**Los Alamos, USA:** D. Madland, P. Moeller, D. Vieira  
**TRIUMF, Canada:** I. Dillmann  
**Lanzhou, China:** X. Ma, R. Mao, Z. Sun, X. Tu, M. Wang, G. Xiao, H. Xu, X. Yan, Y. Zhang, X. Zhou, Y. Yuan  
**Niigata, Japan:** T. Ohtsubo **Beihang, Beijing, China:** B. Sun  
**Saitama, Japan:** T. Suzuki, **T. Yamaguchi**  
**Tsukuba, Japan:** A. Ozawa **RIKEN, Japan:** T. Uesaka  
**ANU Canberra, Australia:** M.W. Reed **Jammu, India:** R. Devi



**Spokesperson: T. Yamaguchi**  
**Deputy Spokesperson: Yu.A. Litvinov**  
**Project Manager: H. Weick**

**Welcome to join us!**

# Isomeric beams, Lifetimes and MAsses

## Technical Proposal for the ILIMA Project

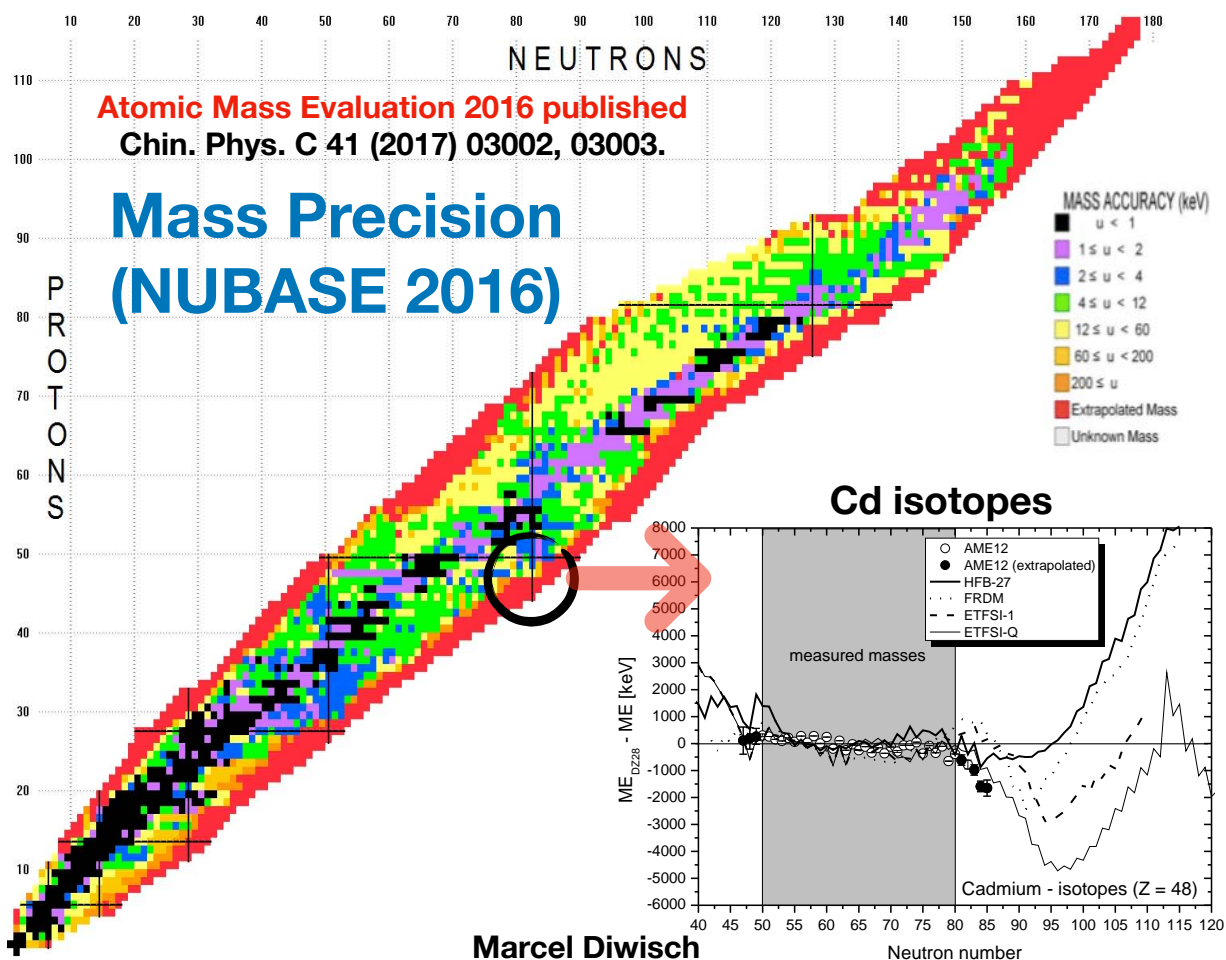
ILIMA  
Isomeric Beams, Lifetimes and Masses  
Collaboration  
2<sup>nd</sup> Feb 2005

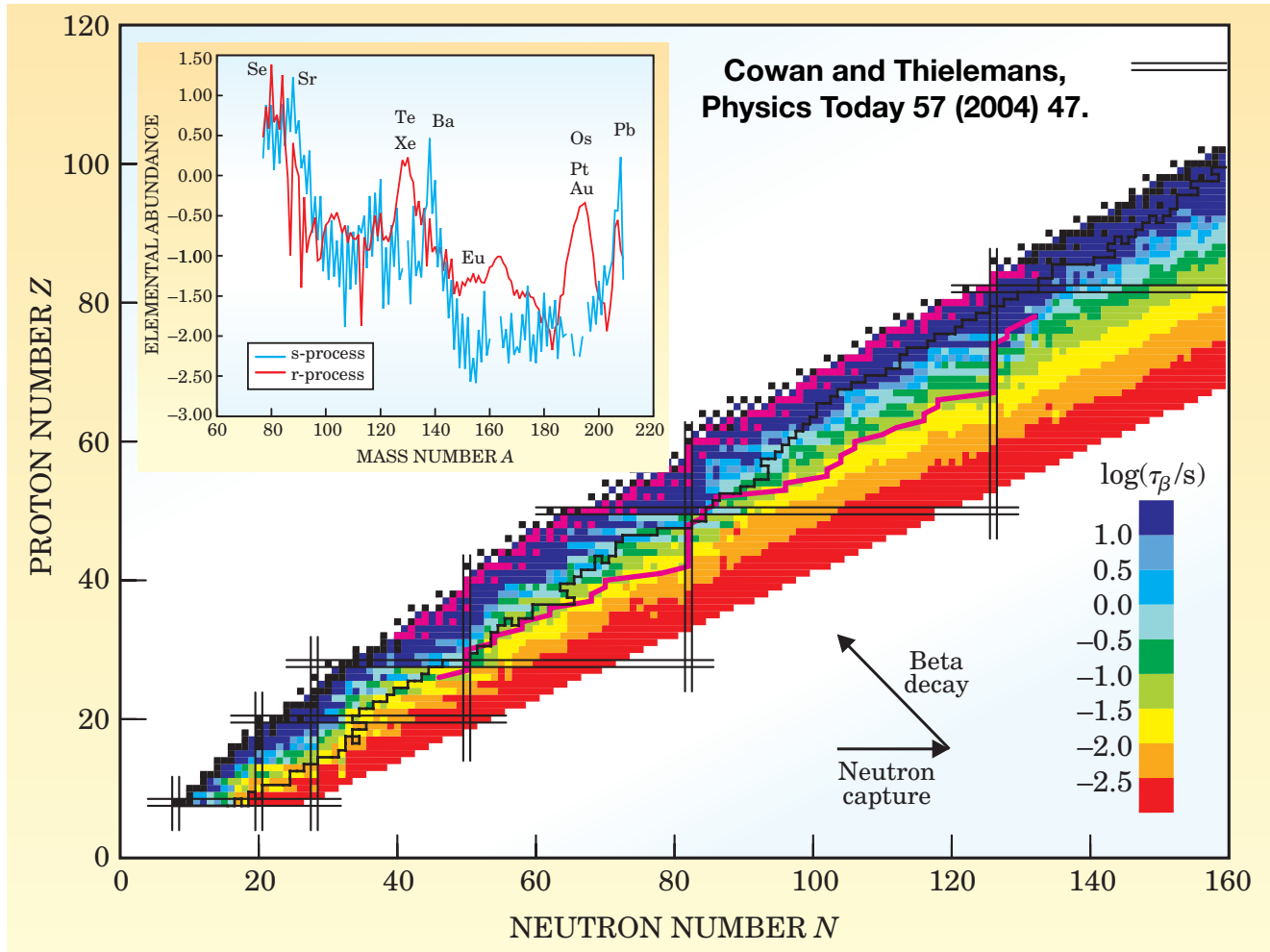
### Abstract:

Precision measurements of nuclear masses and lifetimes of stored exotic nuclei at relativistic energies and studies with isomeric beams are proposed. The planned experiments are a continuation of the successful experimental program at the present FRS-ESR facilities. The new Super-FRS-CR-RESR-NESR facility will yield access to interesting nuclei near and at the drip-lines which can not be accessed with the present facilities.

### Today's talk:

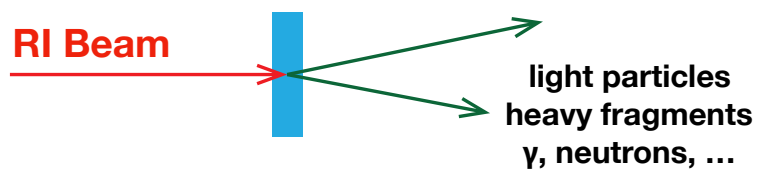
- Overview of the ILIMA project  
Mass measurements with SMS and IMS
- Highlights at the FRS-ESR  
New masses, bound-state beta decay, ...
- R&D status
- Phase-0 proposals



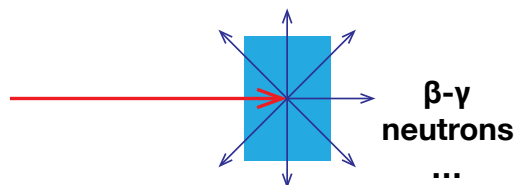


## RI Beam Nuclear Physics Experiments

**Reaction**  
inverse kinematics



**Spectroscopy**  
stopped beam



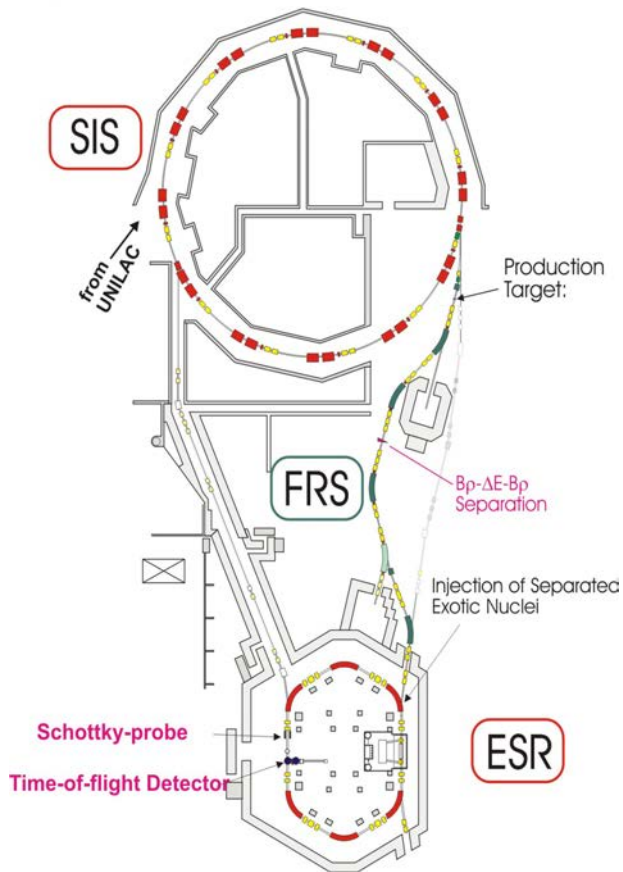
**Storage**  
storage rings, traps



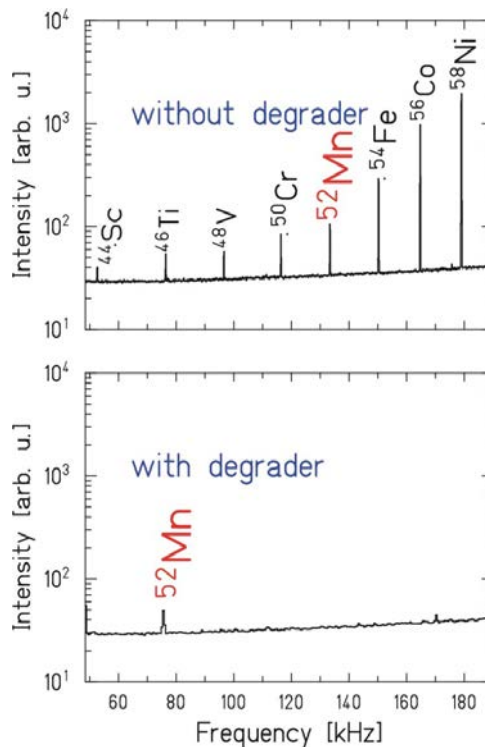
**ILIMA collaboration**



# Existing Facility: SIS-FRS-ESR

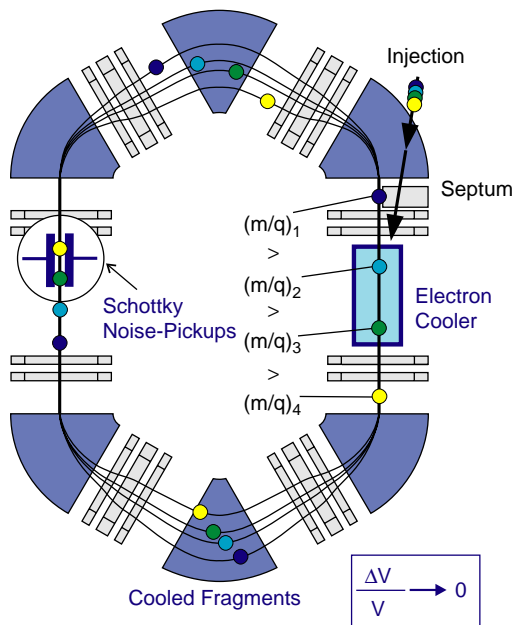


## Monoisotopic Fragment Beams Stored in the ESR



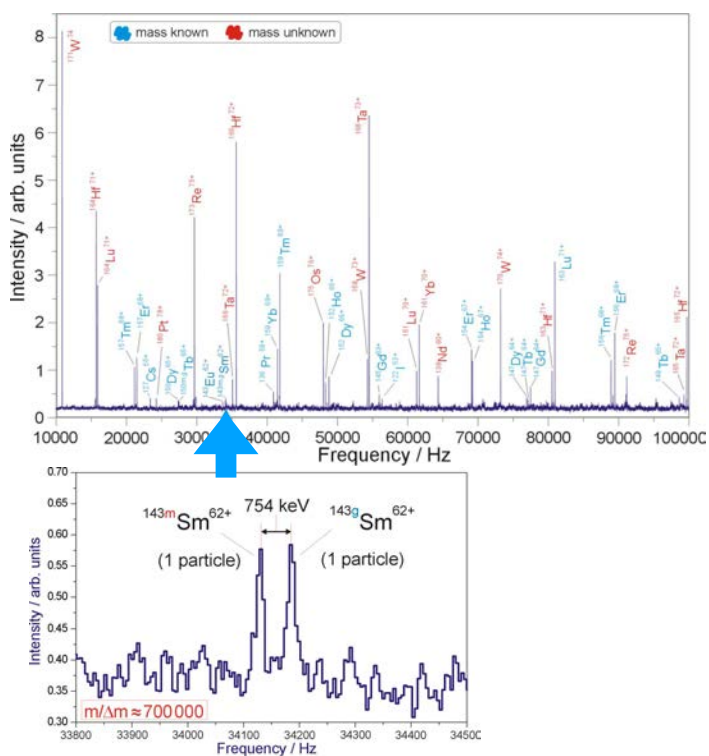
# SMS

## SCHOTTKY MASS SPECTROMETRY

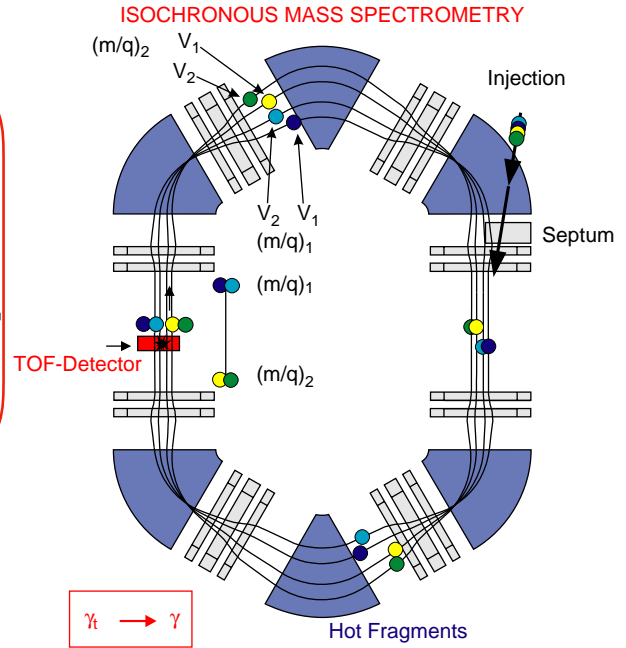
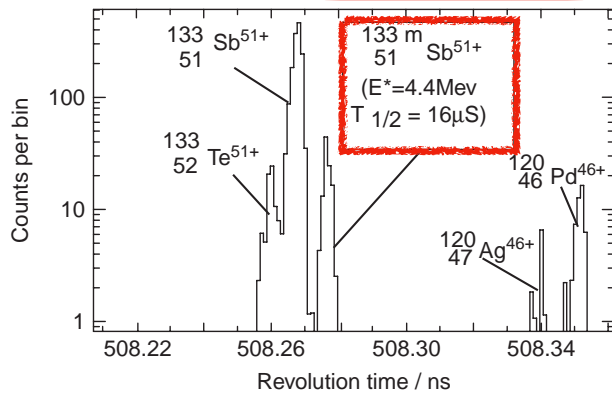
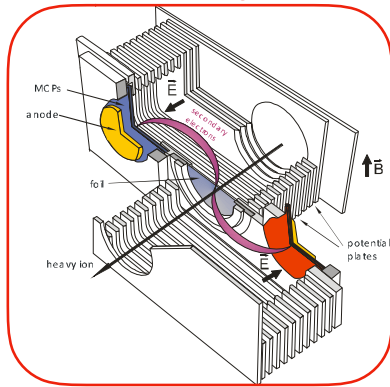


**High resolving power  
Single-ion sensitivity**

$$\frac{\Delta f}{f} = \frac{1}{\gamma_t} \frac{\Delta(m/q)}{m/q} + \frac{\Delta v}{v} \left(1 - \frac{\gamma^2}{\gamma_t^2}\right)$$



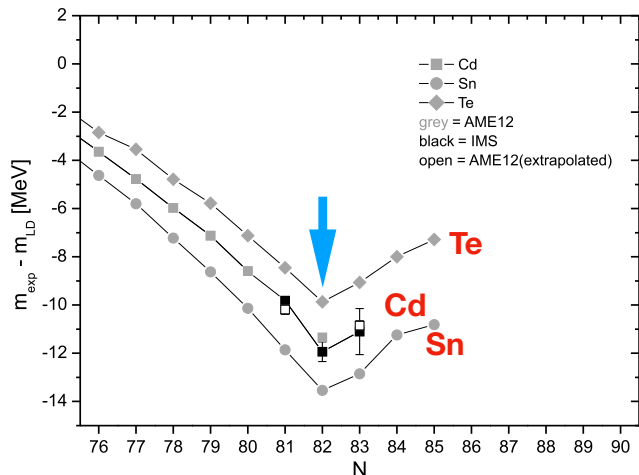
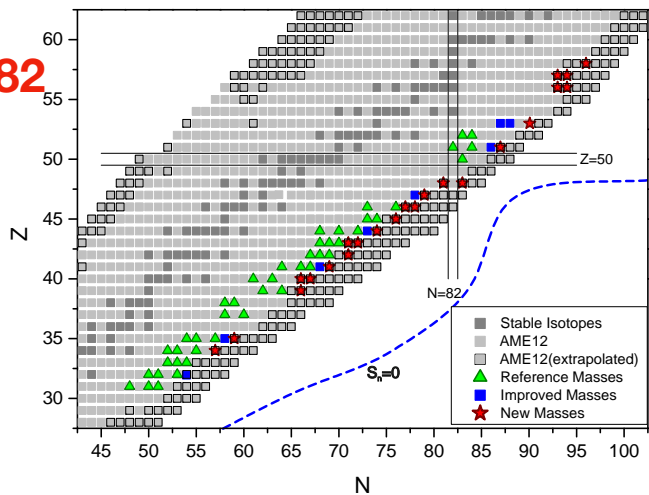
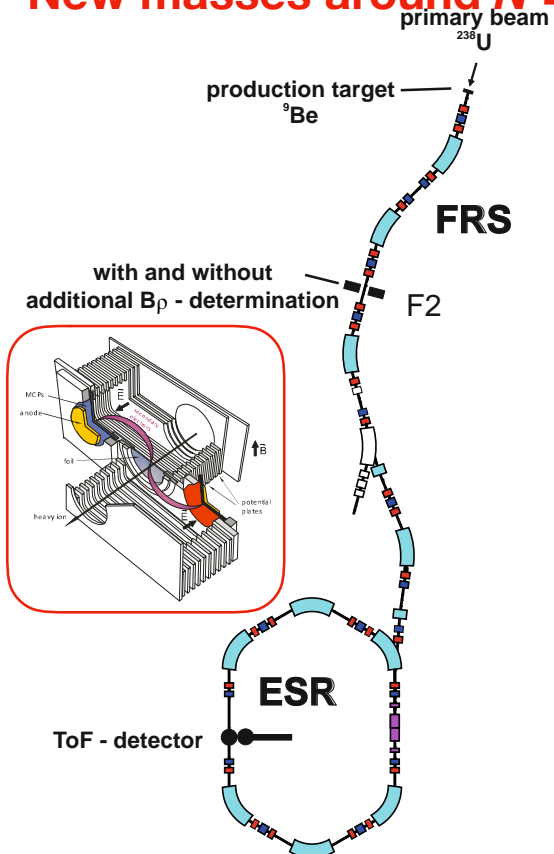
$$\frac{\Delta f}{f} = \frac{1}{\gamma_t} \frac{\Delta(m/q)}{m/q} + \frac{\Delta v}{v} \left( 1 - \frac{\gamma^2}{\gamma_t^2} \right)$$



High resolving power  
Single-ion sensitivity

— Highlight —

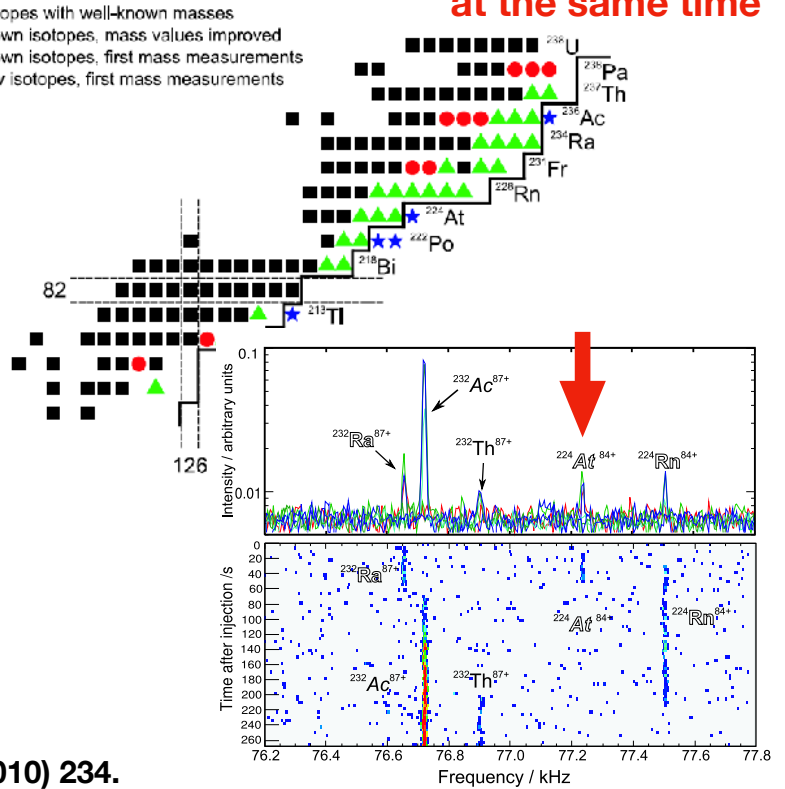
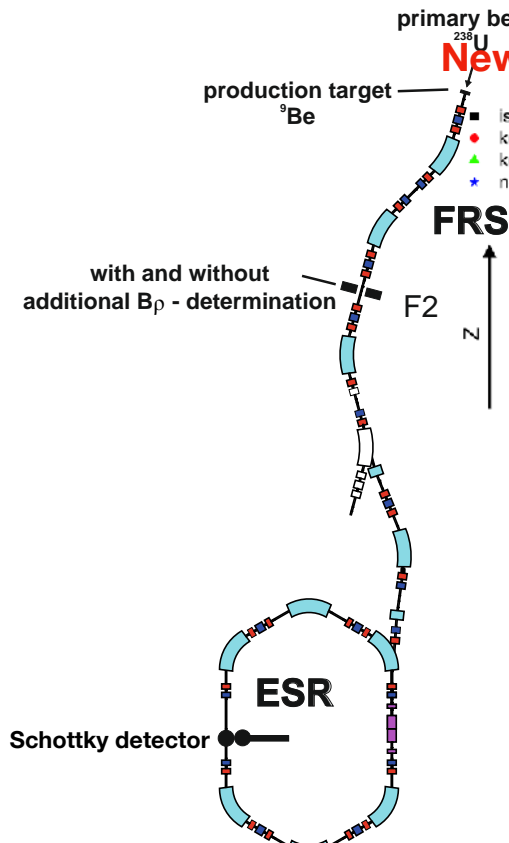
New masses around N = 82



— Highlight —

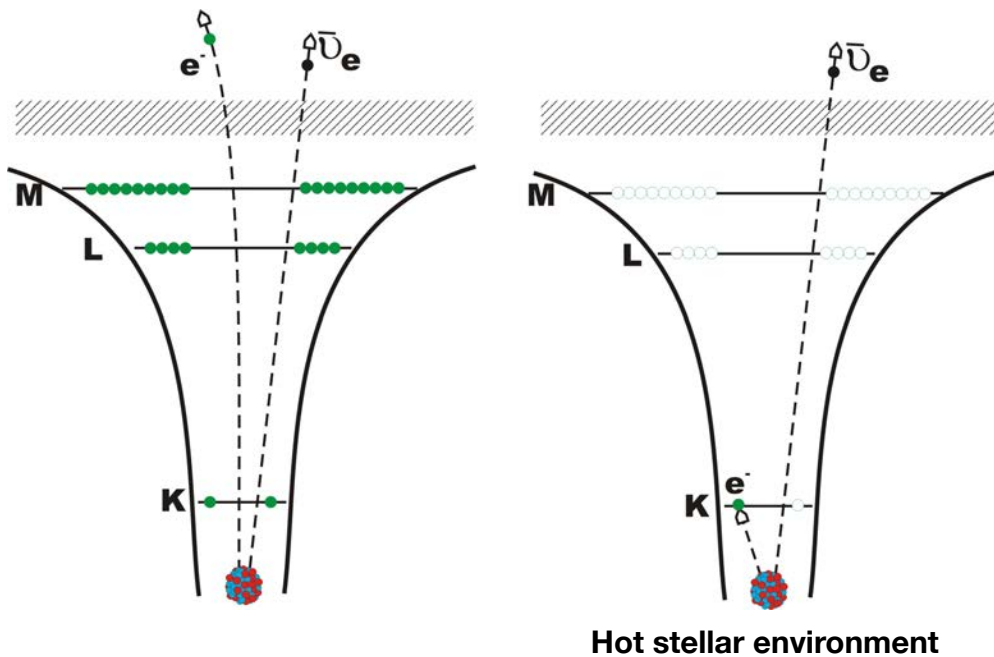
# New isotopes (SMS)

New isotope search and mass measurements  
at the same time

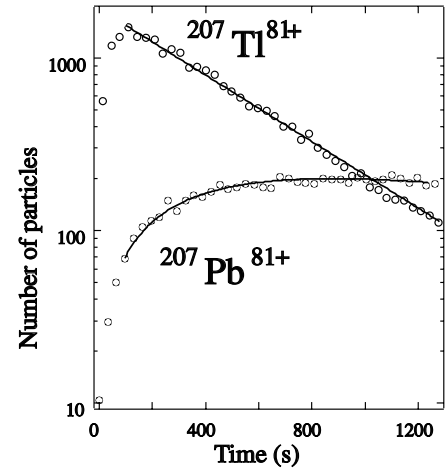
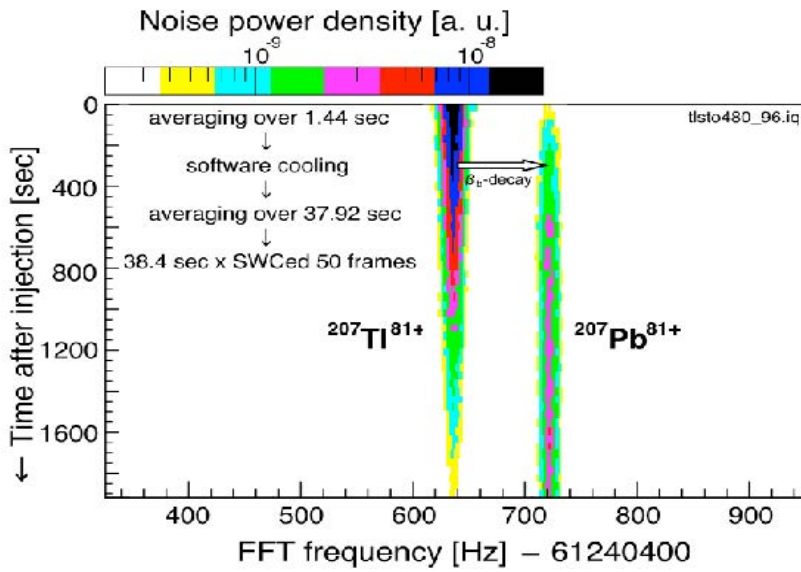


Chen et al., Phys. Lett. B 691 (2010) 234.

## Bound-State Beta Decay of Highly Charged Ions



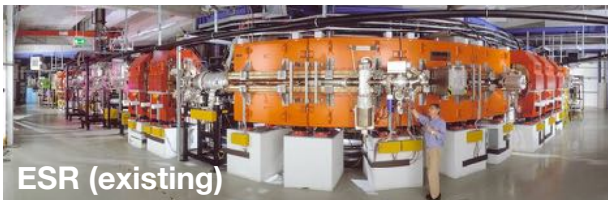
# Bound-State Beta Decay of Highly Charged Ions



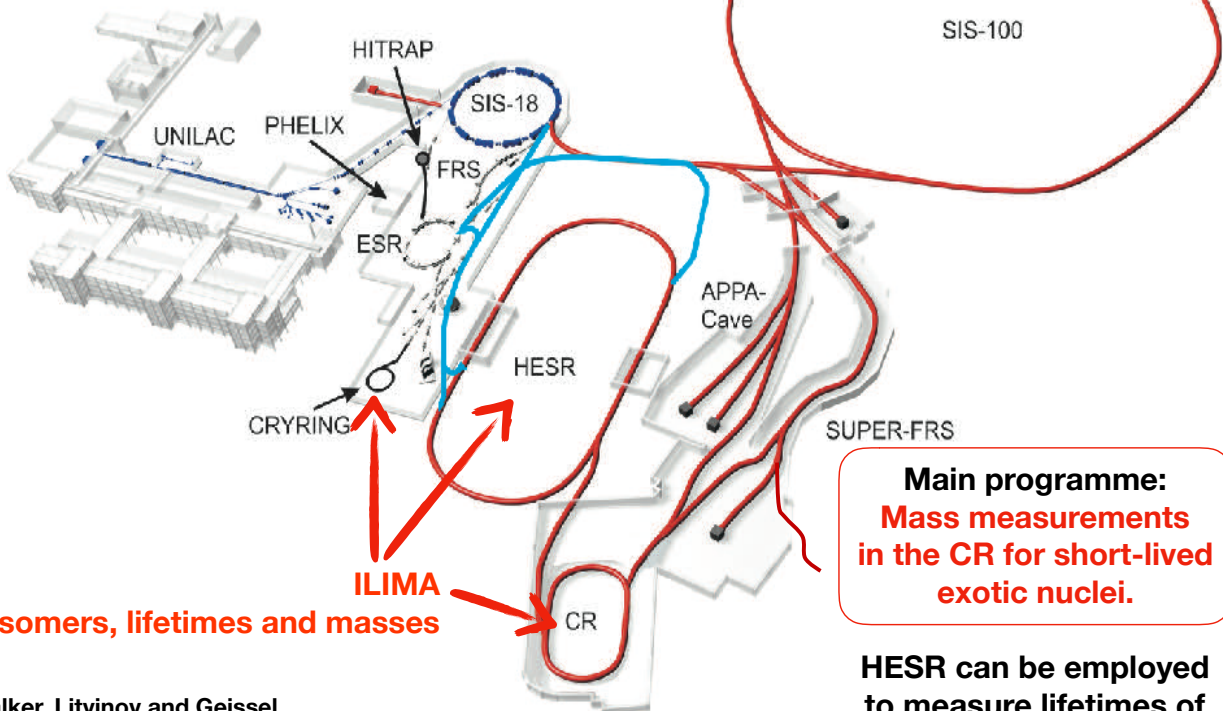
$$\frac{\lambda_{\beta b}}{\lambda_{\beta c}} = 0.188 \pm 0.018$$

$$= 0.171(\text{theo})$$

T. Ohtsubo et al., PRL 95 (2005) 052501.



ESR (existing)



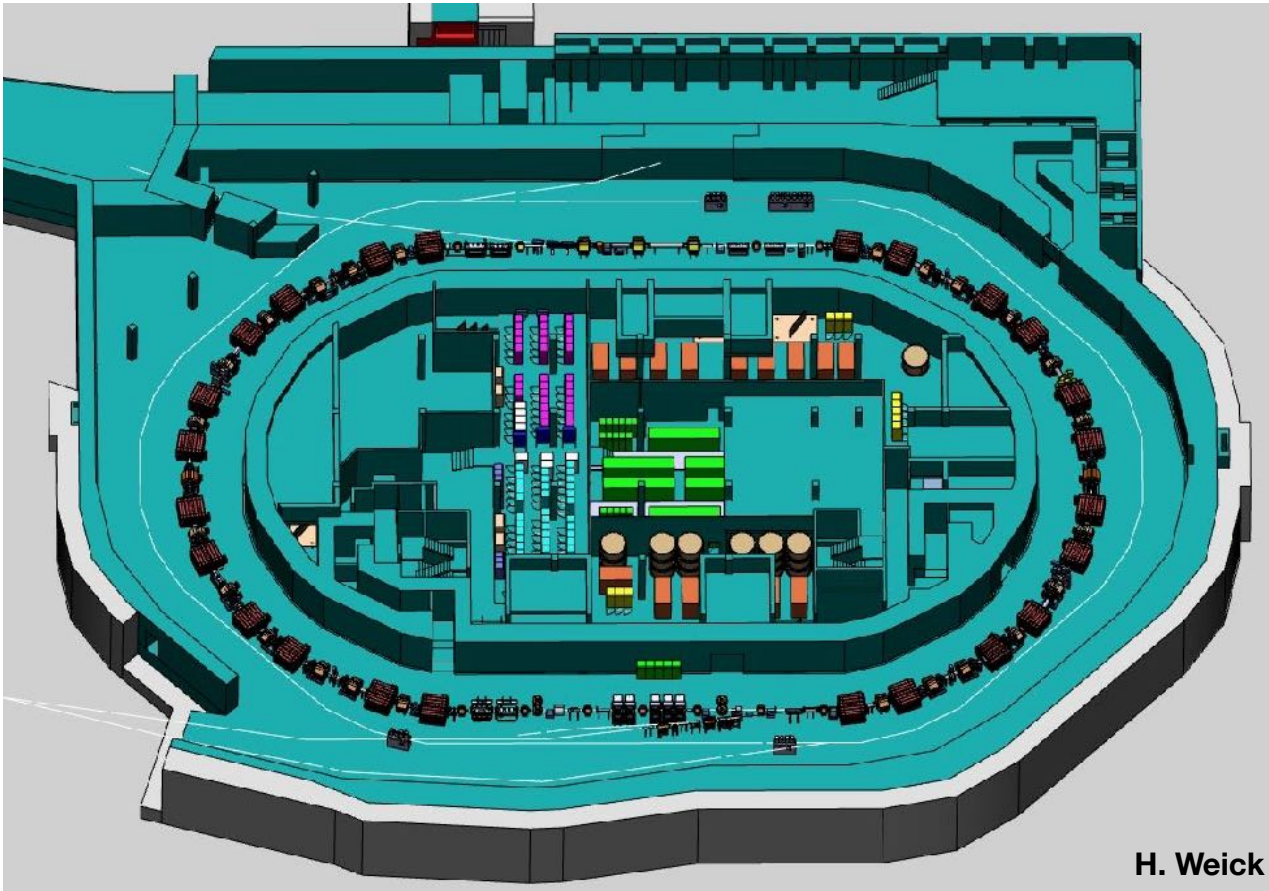
**ILIMA**  
isomers, lifetimes and masses

**Main programme:**  
Mass measurements  
in the CR for short-lived  
exotic nuclei.

**HESR can be employed**  
to measure lifetimes of  
long-lived nuclides.

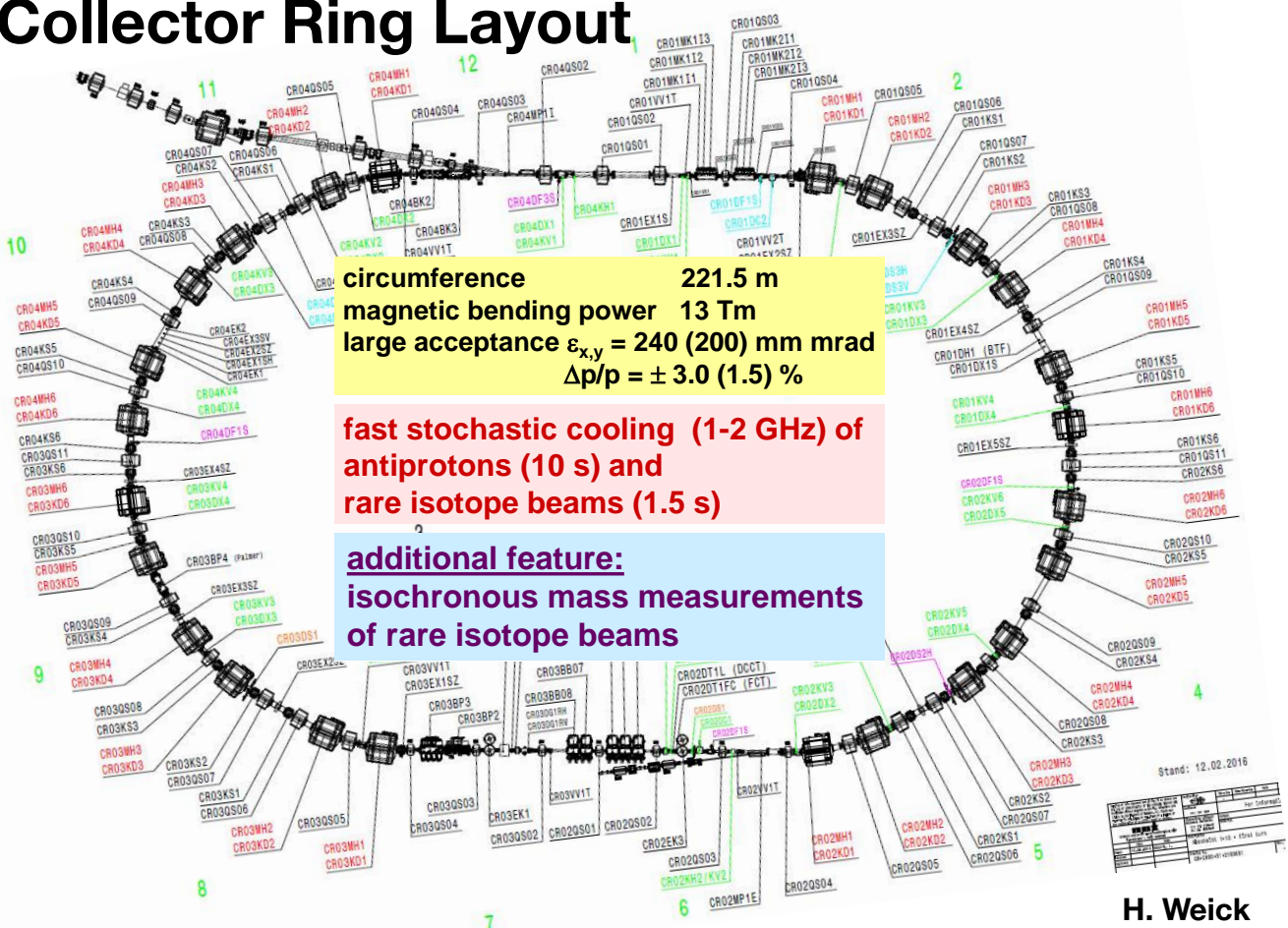


# Collector Ring Layout



H. Weick

# Collector Ring Layout



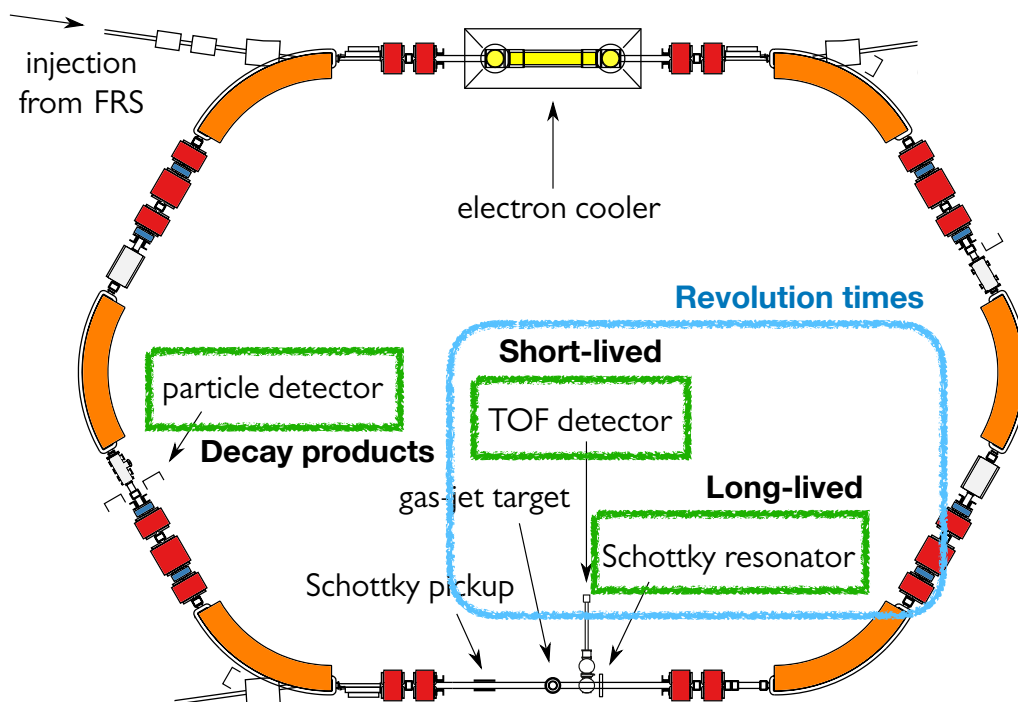
H. Weick

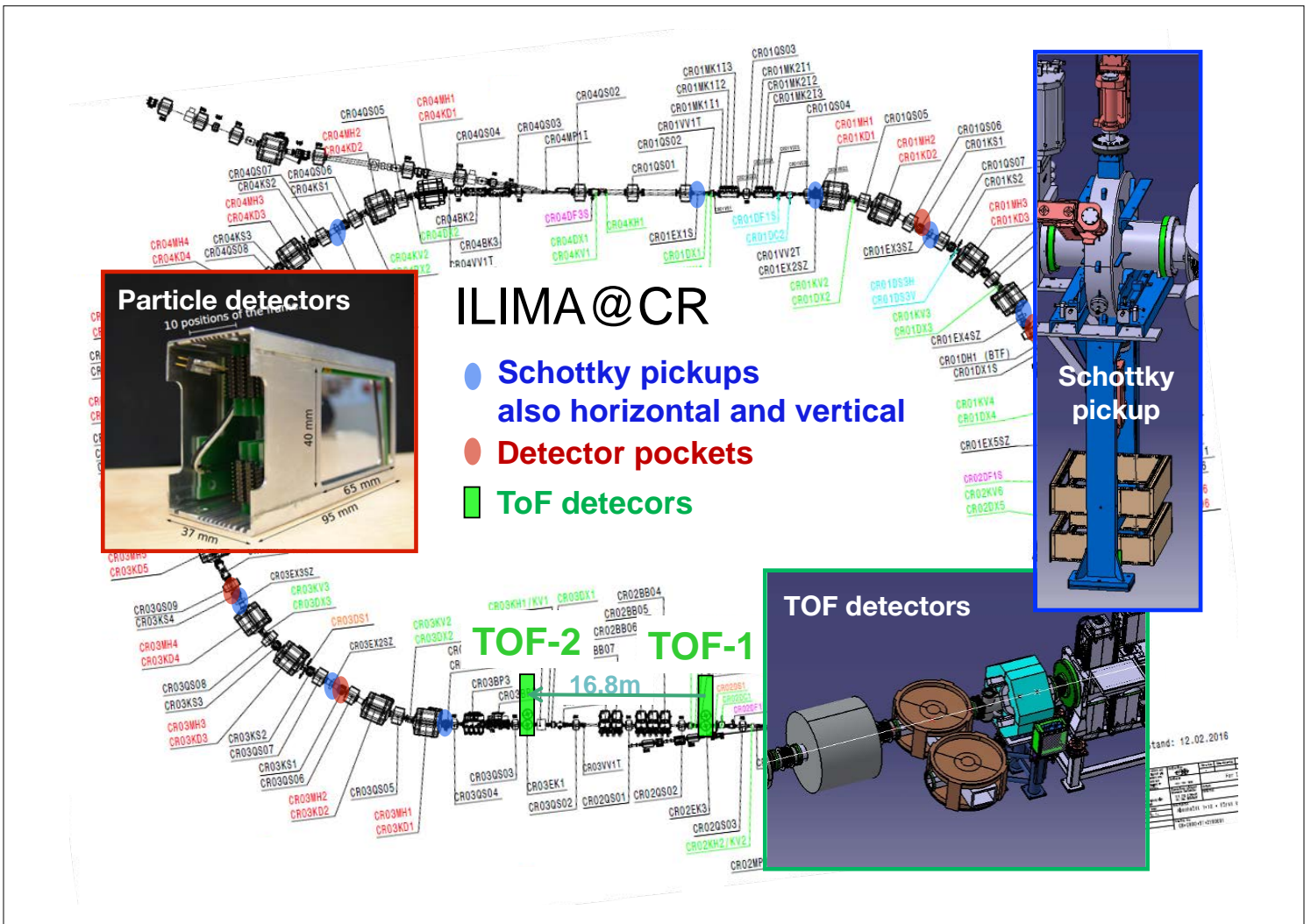


# Working Group Status

TOF detector  
Schottky detector  
Particle detector

## Storage Ring Main Detector Setup





# ILIMA@CR

- Schottky pickups also horizontal and vertical
- Detector pockets
- ToF detectors

## Working Group Status

- **TOF detector**
  - N. Kuzminchuk-Feuerstein et al. NIM A 821 (2016) 160
  - TDR 1st draft soon
- **Schottky detector**
  - New Schottky prototype will arrive soon, Beam test with electron beam at TUD, Installation to ESR next year.
  - TDR ongoing
- **Particle detector**
  - M.A. Najafi et al., NIM A 836 (2016) 1, **CsSiPHOS** (Si stack + CsI)
  - TDR 1st draft completed, under check in the Board

FAIR/NUSTAR/ILIMA/TDR/DETECTOR

The ILIMA ring detector for particle identification, life time measurement and beam diagnostics

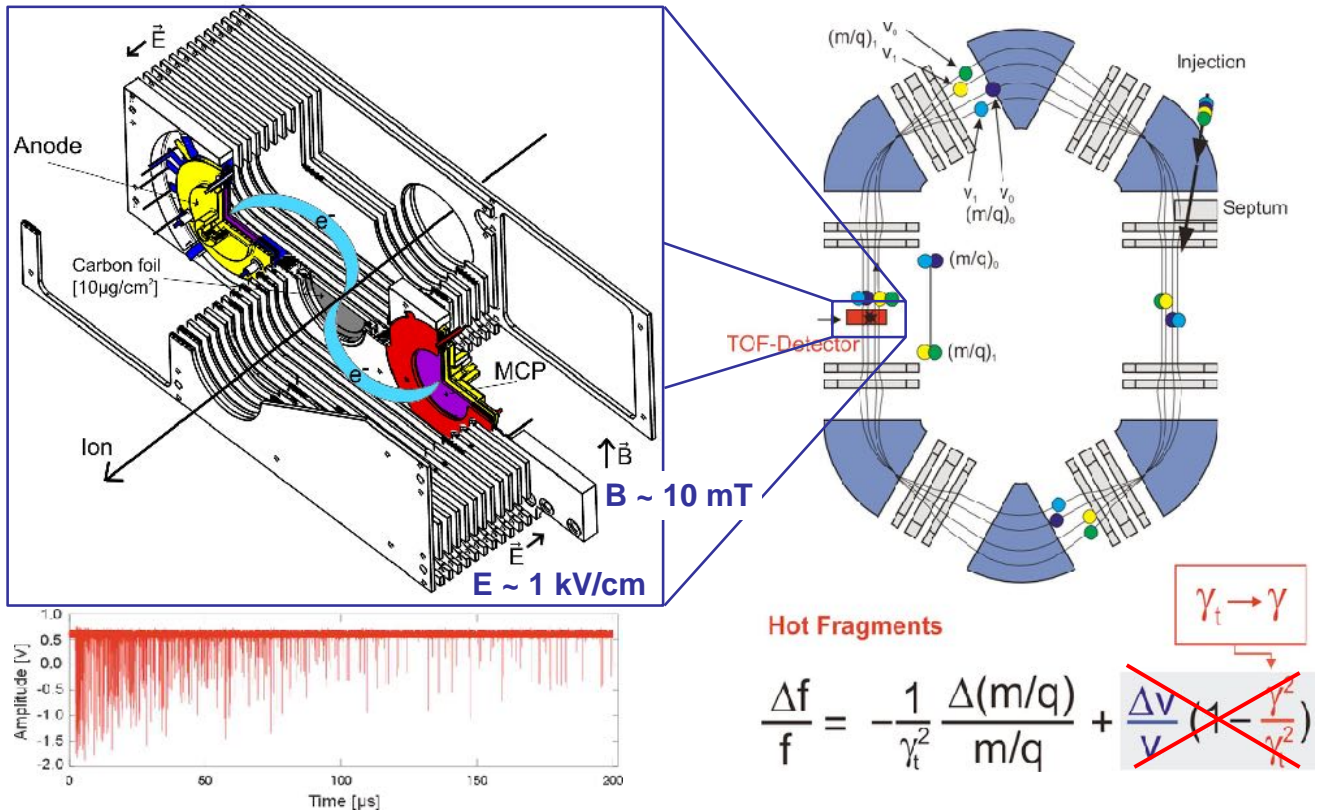
Technical Report for the Design, Construction and Commissioning of The Heavy Ion Detector

September 21, 2017

R/ID	Name	E-Mail
Project Leader/Spokesperson	Takayuki Yamaguchi	yamaguti@mail.saitama-u.ac.jp
Deputy	Yuri Litvinov	Y.Litvinov@gsi.de
Technical Coordinator	Yuri Litvinov	Y.Litvinov@gsi.de
Deputy	X	
Project Coordinator	Habib Weick	H.Weick@gsi.de
Contact Person at the FAIR site	Habib Weick	H.Weick@gsi.de
Detector Convener	Roman Gerthäuser	Roman.Gerthaeuser@tum.de
Deputy	Thomas Faustermann	Thomas.Faustermann@ph.tum.de

# Isochronous Mass Spectrometry (IMS) at FRS-ESR

## Time-of-Flight detector

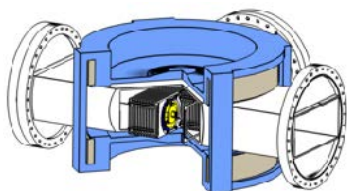


## TOF Detectors for the ESR and for the CR

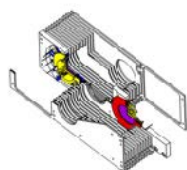
### ESR

L = 108 m  
 Bp = 6,4 Tm  
 $\gamma_t = 1,4$   
 $\Delta p/p = 0,2 \%$   
 $\epsilon_x = 7 \text{ mm mrad}$

TOF detector (1x)



B-field homogeneity radius 100 mm

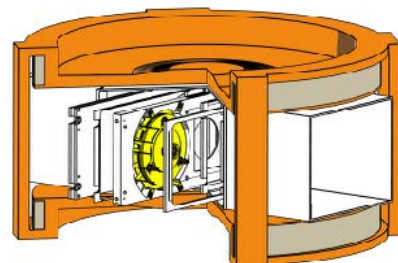


Foil diameter 40 mm  
 Efficiency  $\approx 78\%$   
 Timing accuracy  $\approx 45 \text{ ps}$

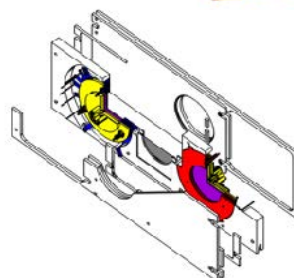
### CR

L = 221,45 m  
 Bp = 13 Tm  
 $\gamma_t = 1,67$   
 $\Delta p/p = 0,5 \%$   
 $\epsilon_x = 100 \text{ mm mrad}$

TOF detector (2x)



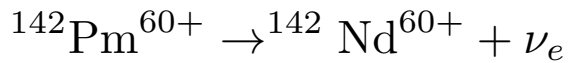
B-field homogeneity radius 200 mm



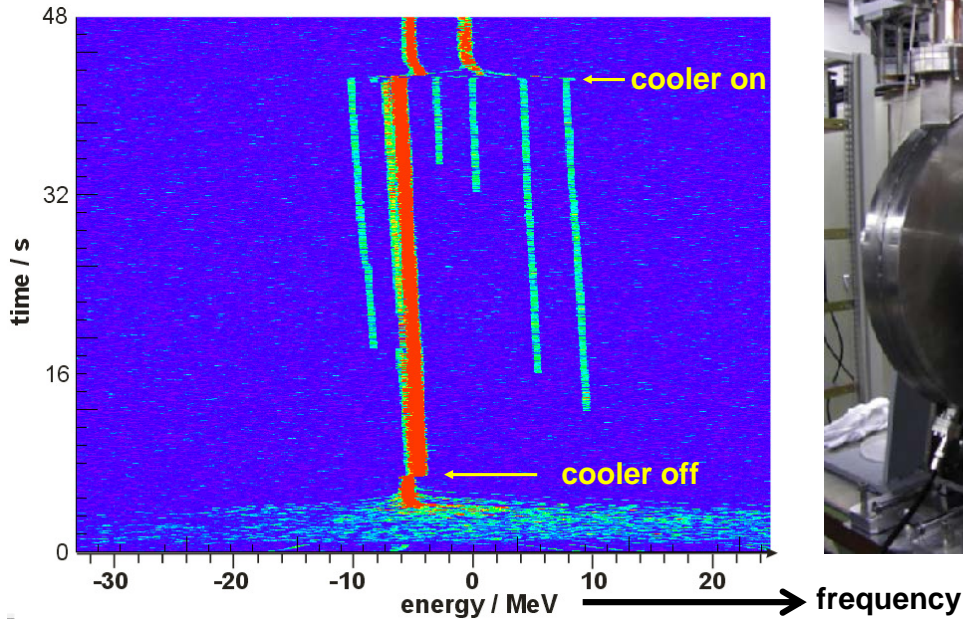
Foil diameter 80 mm  
 Efficiency  $\approx 98\%$   
 Timing accuracy  $\approx 35 \text{ ps}$



# Schottky Mass Spectrometry: Resonant Pickup



EC decay of  $^{142}\text{Pm}$ , cooling switched off



Nolden et al., NIM A 659 (2011) 69.  
Bosch et al., PPNP 73 (2013) 84.

## 2017 Update: Electromagnetic non destructive detectors for ILIMA

Prototype of the CR longitudinal resonator. Production still not finished...



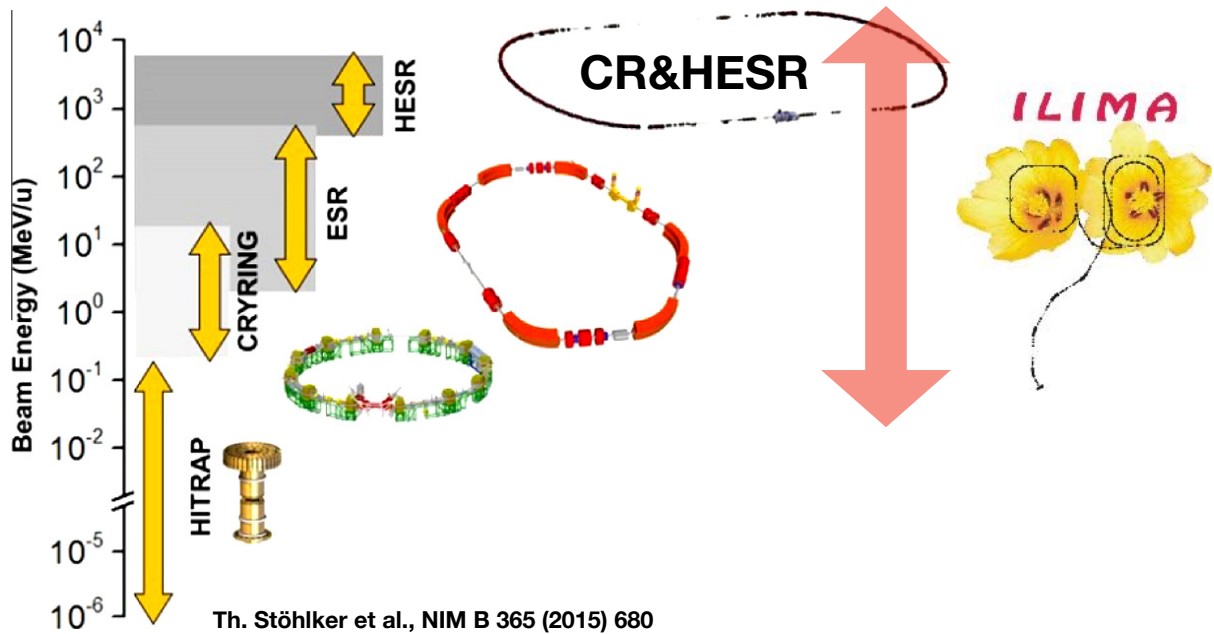
### ESR/HESR/CR variable Q resonator

Newly dedicated lab renovated / prepared for the measurement of non-destructive detectors. Just finished!

# Stored Ions in Wide Energy Range

Highly charged exotic nuclei in storage rings

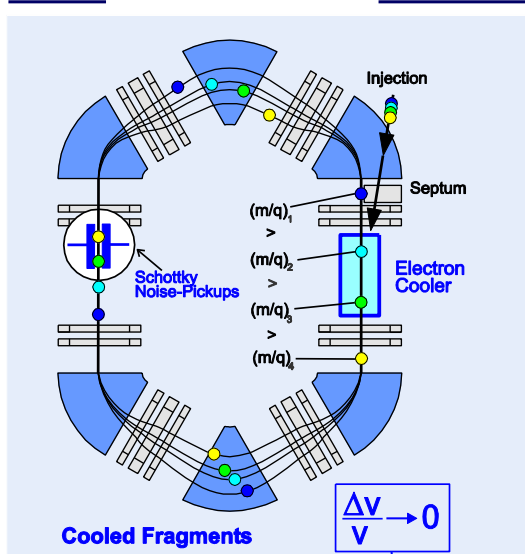
accuracy ~30 keV  
half-life limit ~20  $\mu$ s  
single-ion sensitivity/week



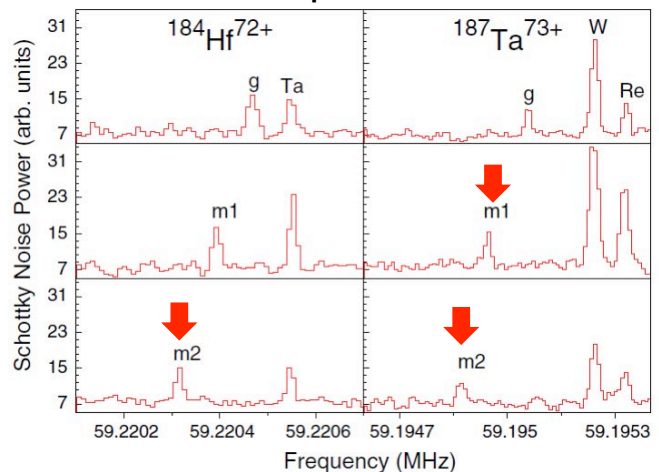
## FAIR Phase-0 Beam Time in 2018/2019

Long-lived isomers in the Experimental Storage Ring: study of  $^{186-188}\text{Hf}$  (search for new K-isomer) Spokesperson: P. Walker

### SCHOTTKY MASS SPECTROMETRY



Successful results of previous E048: new isomers



M.W. Reed et al., PRL105 (2010) 172501  
M.W. Reed et al., PRC86 (2012) 054321

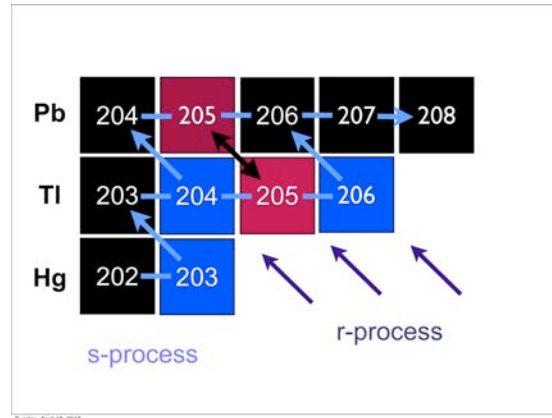
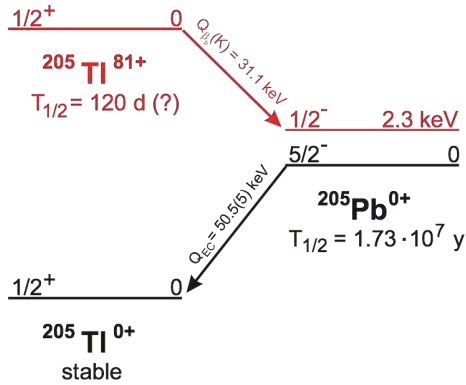
$$\frac{\Delta f}{f} = -\frac{1}{\gamma^2} \frac{\Delta(m/q)}{m/q} + \frac{\Delta v}{v} \left(1 - \frac{\gamma^2}{\gamma'^2}\right)$$



# FAIR Phase-0 Beam Time in 2018/2019

Measurement of the bound-state beta decay of bare  $^{205}\text{Tl}$  ions

Spokesperson: Y. Litvinov



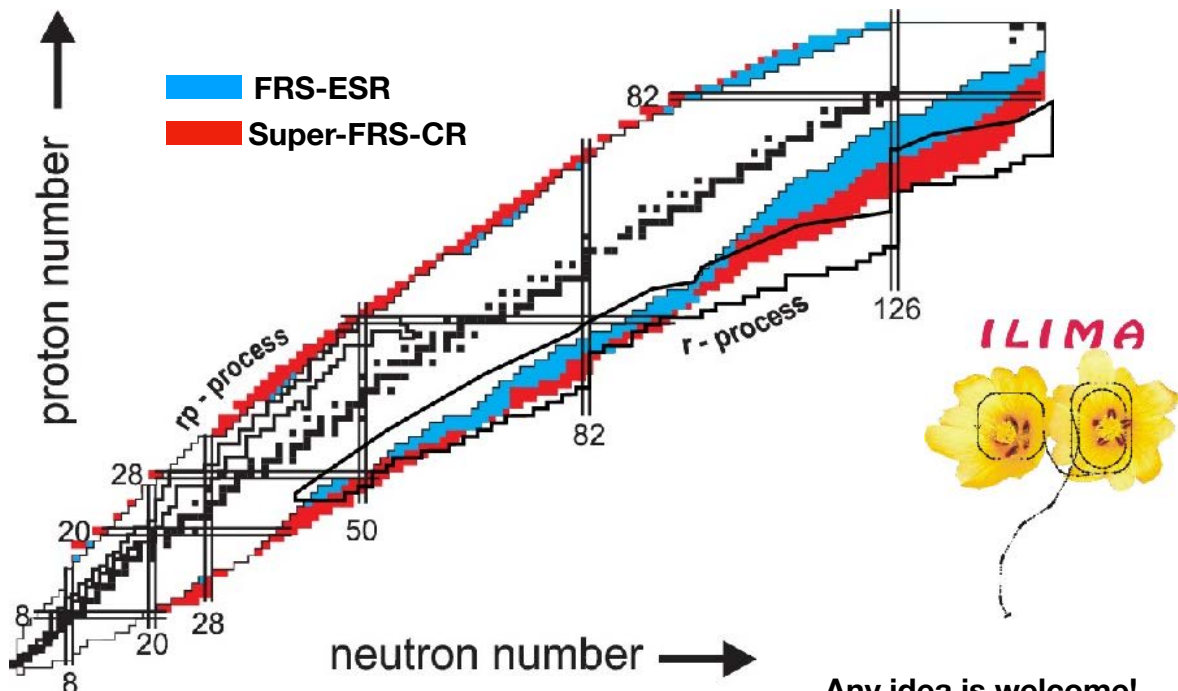
1.  $^{205}\text{Pb}/^{205}\text{Tl}$  pair as s-process cosmochronometer
2. The flux of solar pp neutrinos (LOREX project)



ILIMA, SPARC, LOREX collaborations

In summary,

## Potential for new masses with ILIMA



Any idea is welcome!  
Theoreticians also welcome!

FAIR Phase-0 Beam Time starts in 2018/2019