

Precision experiments of exotic nuclei at the storage rings

Taka Yamaguchi (Saitama Univ/TCHoU)

for Rare-RI Ring RIBF collaboration

for ILIMA GSI/FAIR collaboration

for IMP collaboration

Overview of storage-ring mass spectrometry

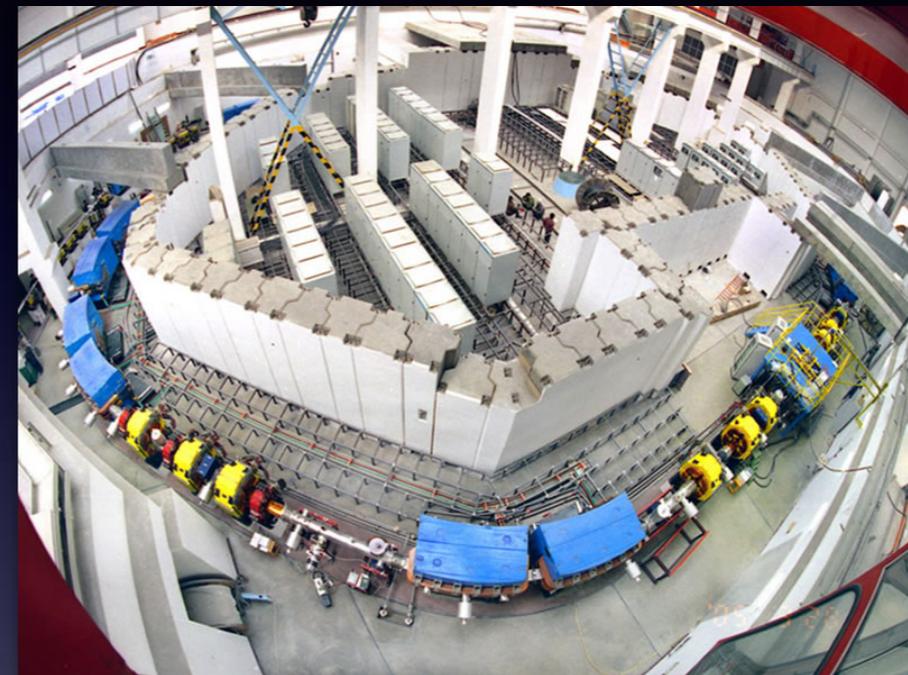
Tsukuba Global Science Week
11 Sep. 2021, Online

RI Beam Storage Rings Worldwide in Operation



ESR@GSI, Germany

+CRYRING@ESR

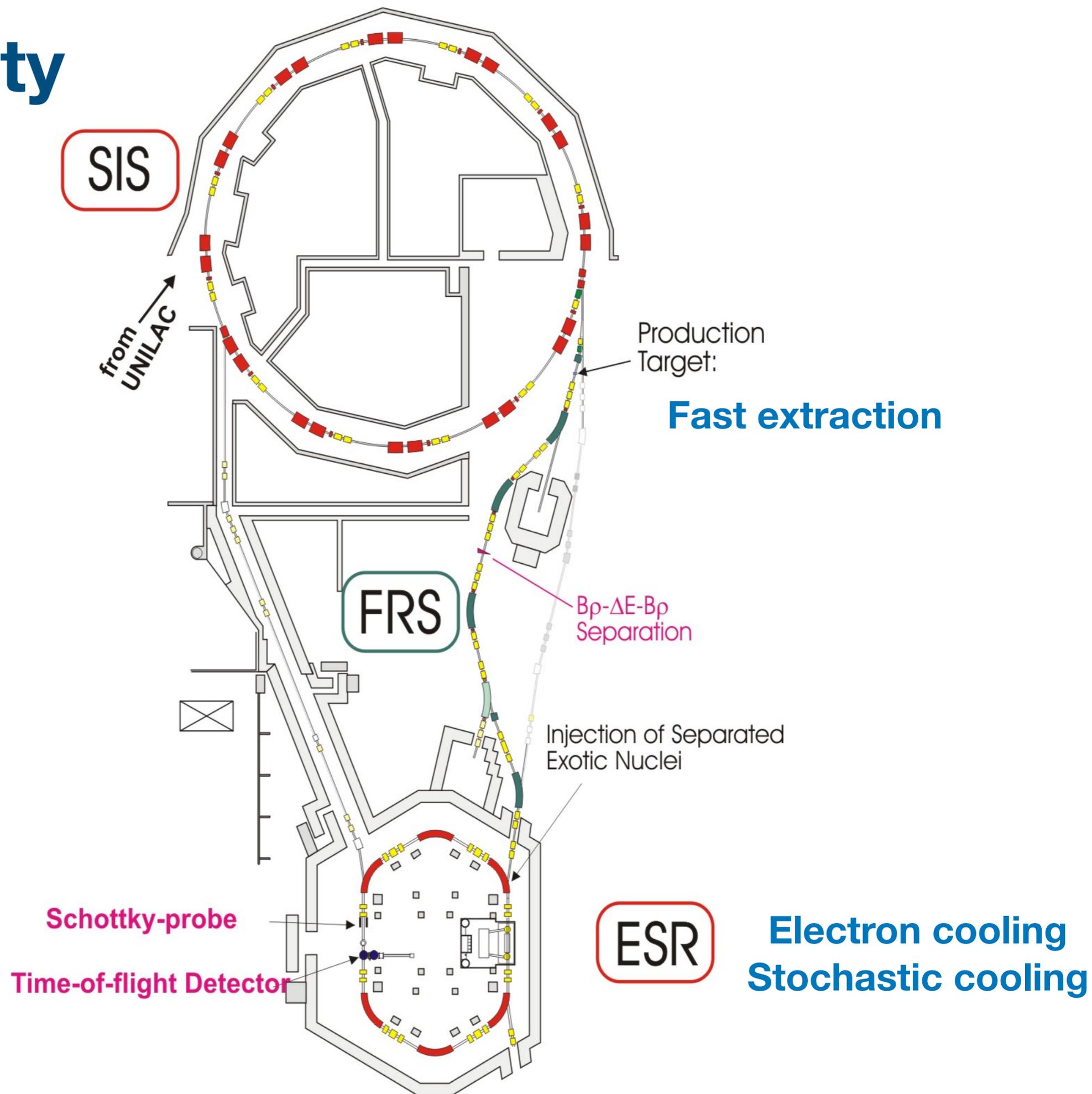


CSRe@IMP, China



Rare-RI Ring@RIBF

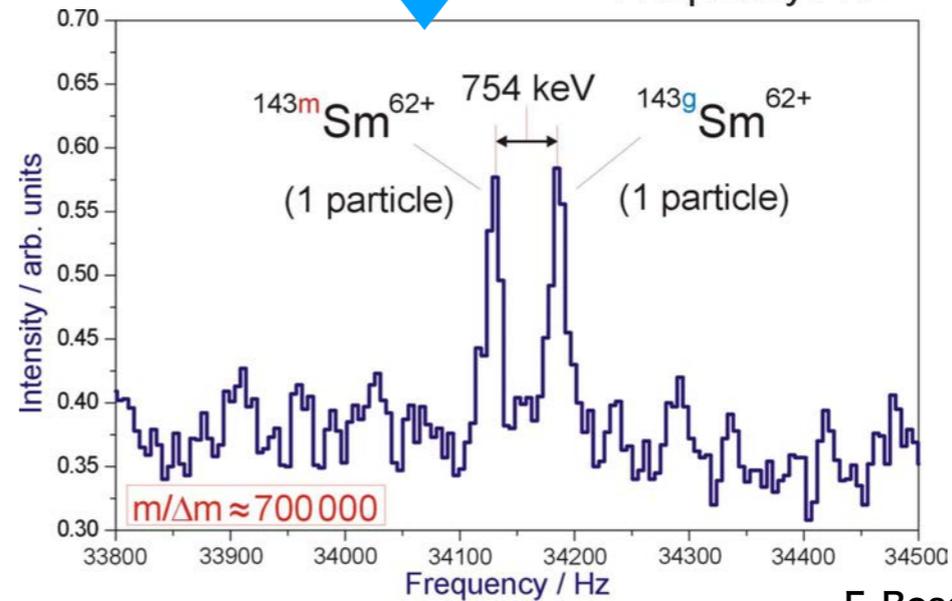
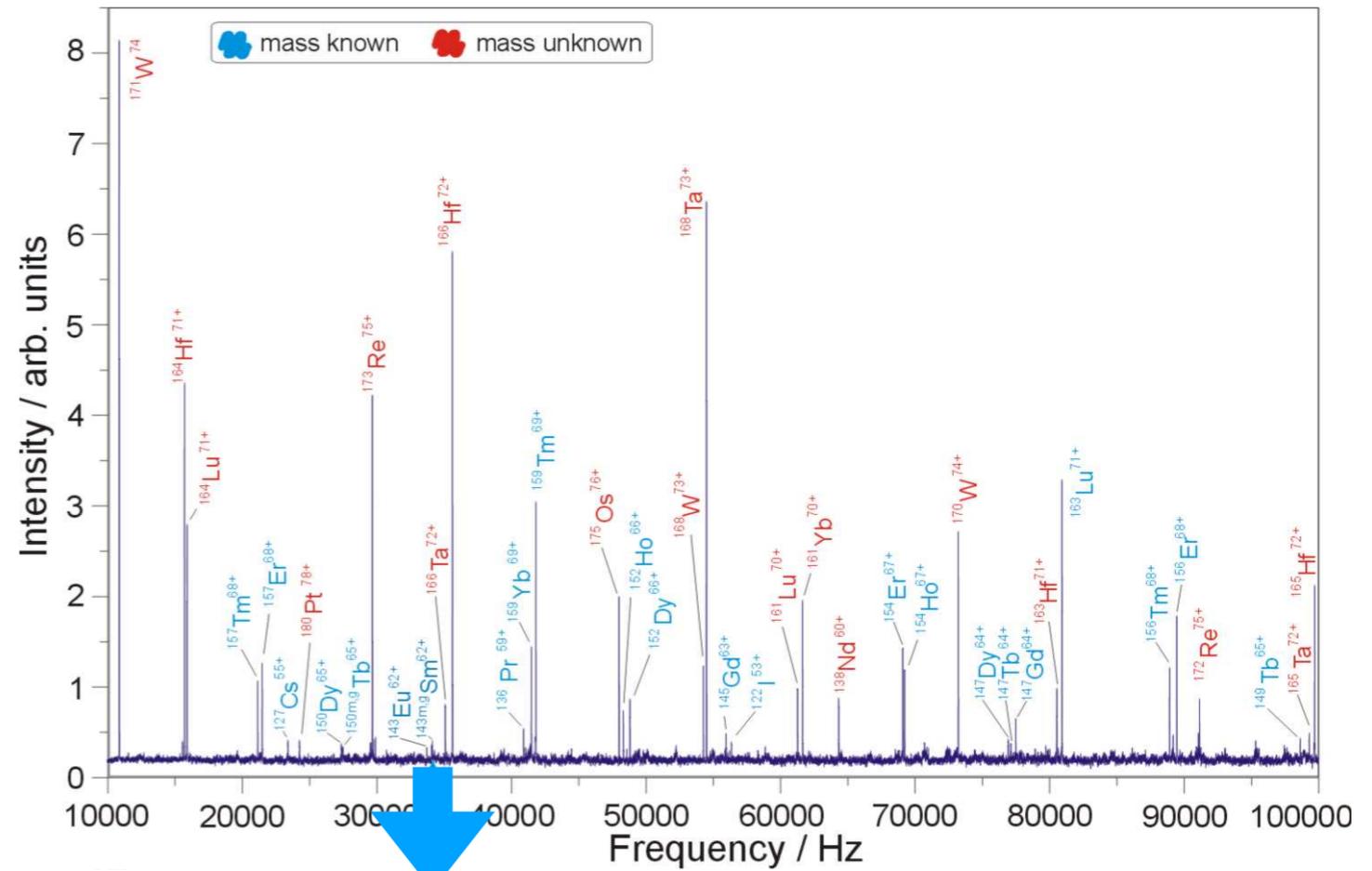
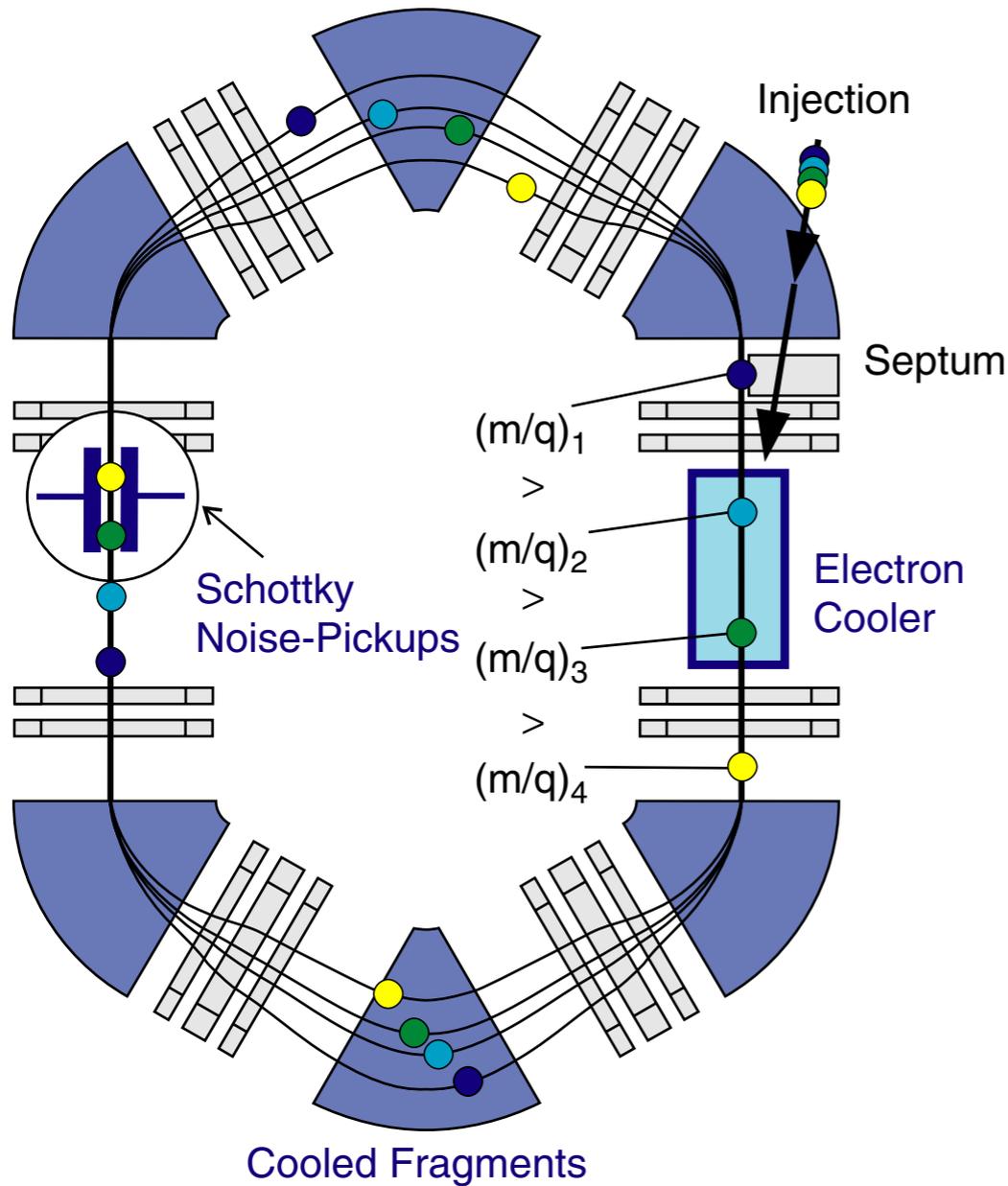
GSI facility



SMS

Schottky Mass Spectrometry

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

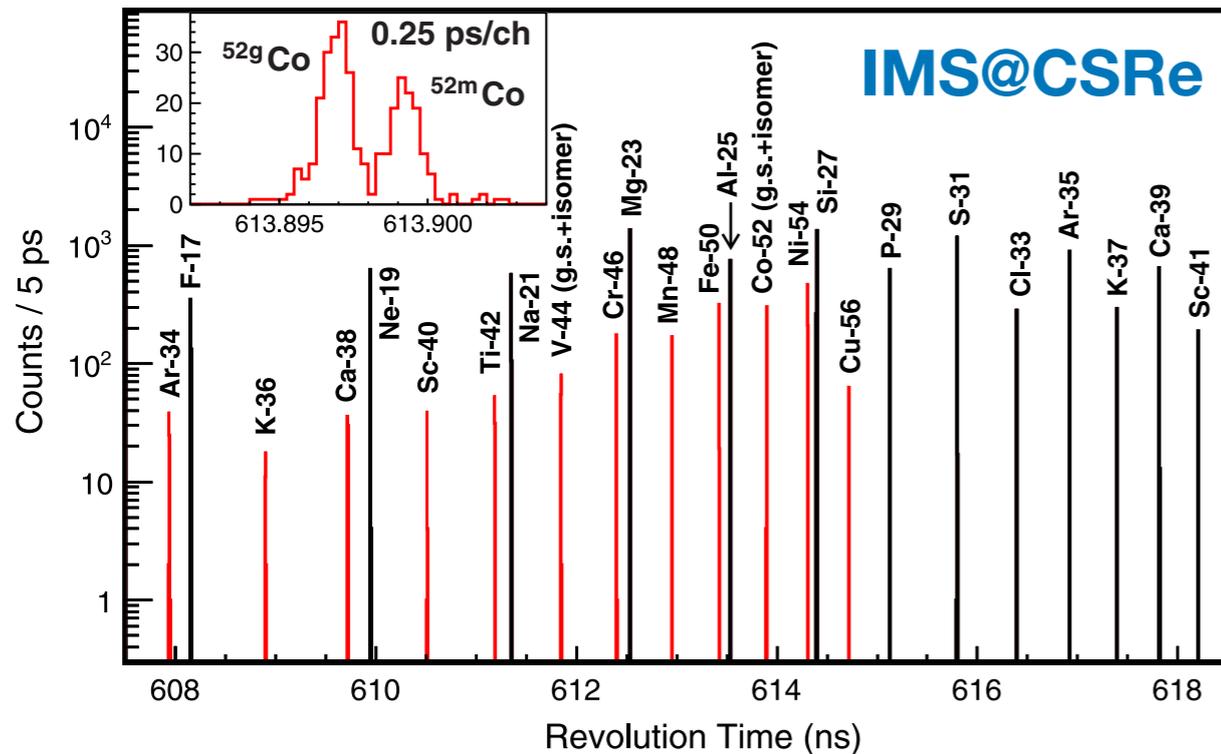
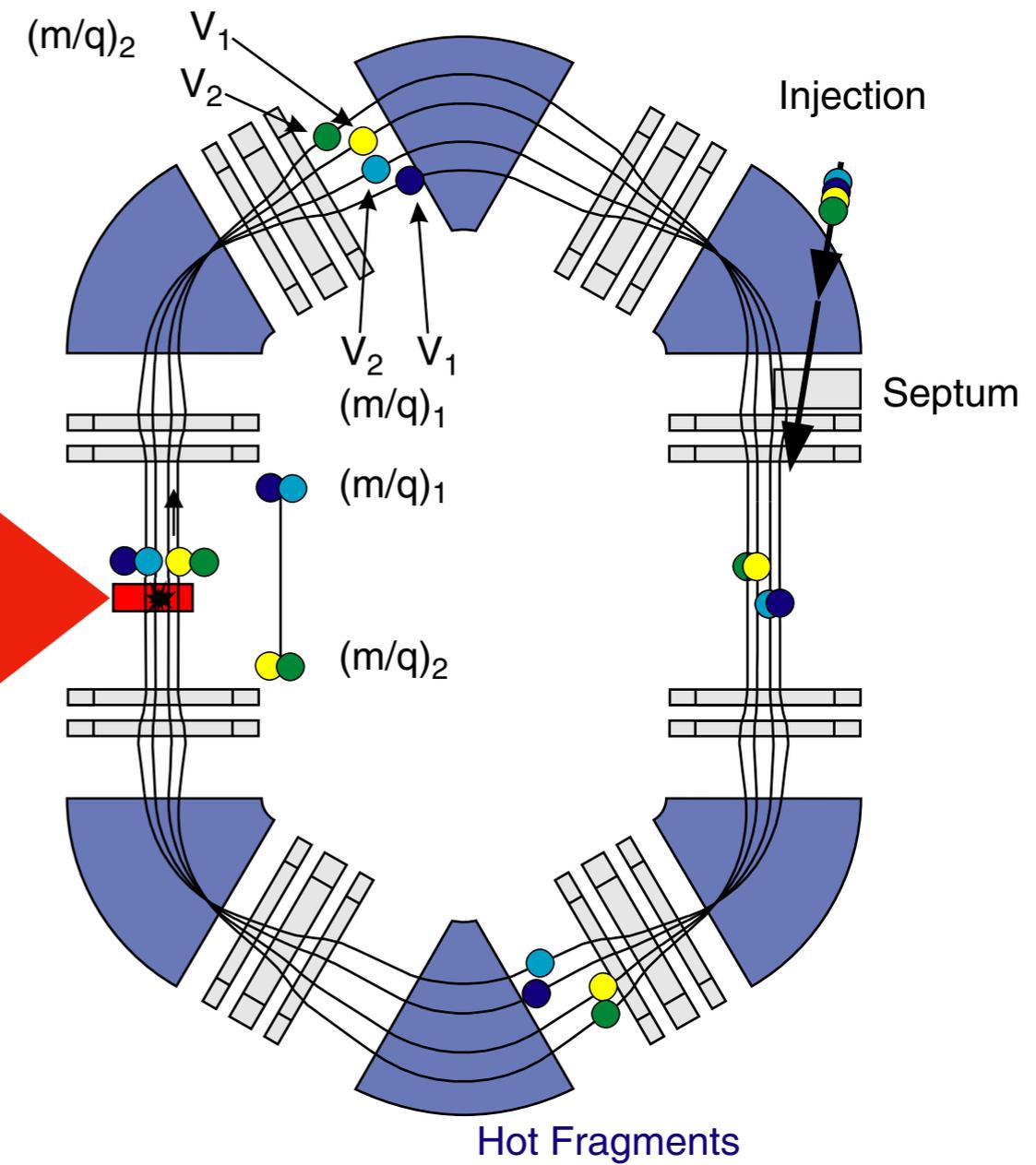
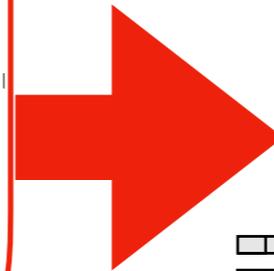
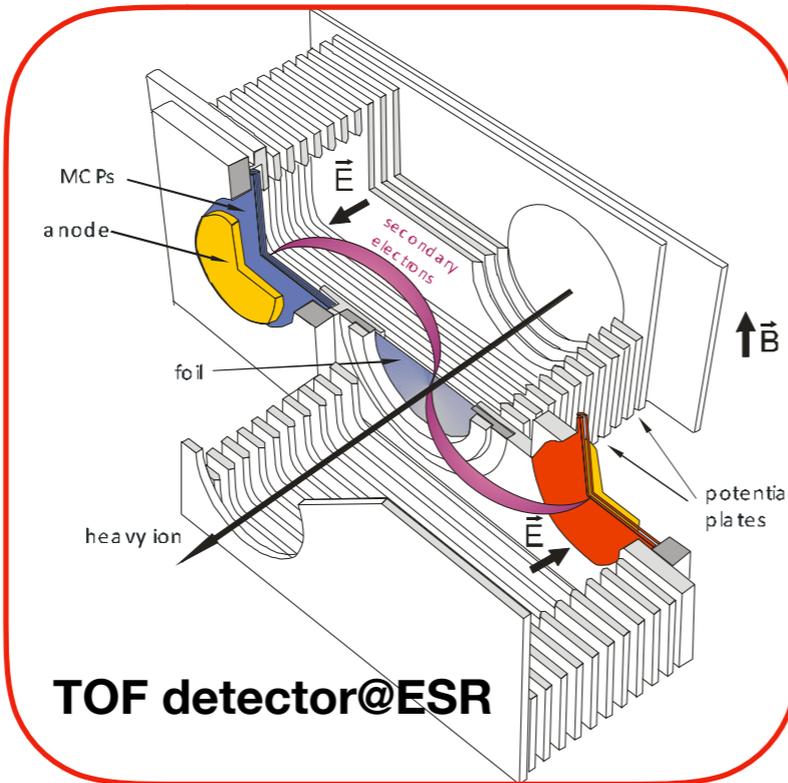


IMS

Isochronous Mass Spectrometry

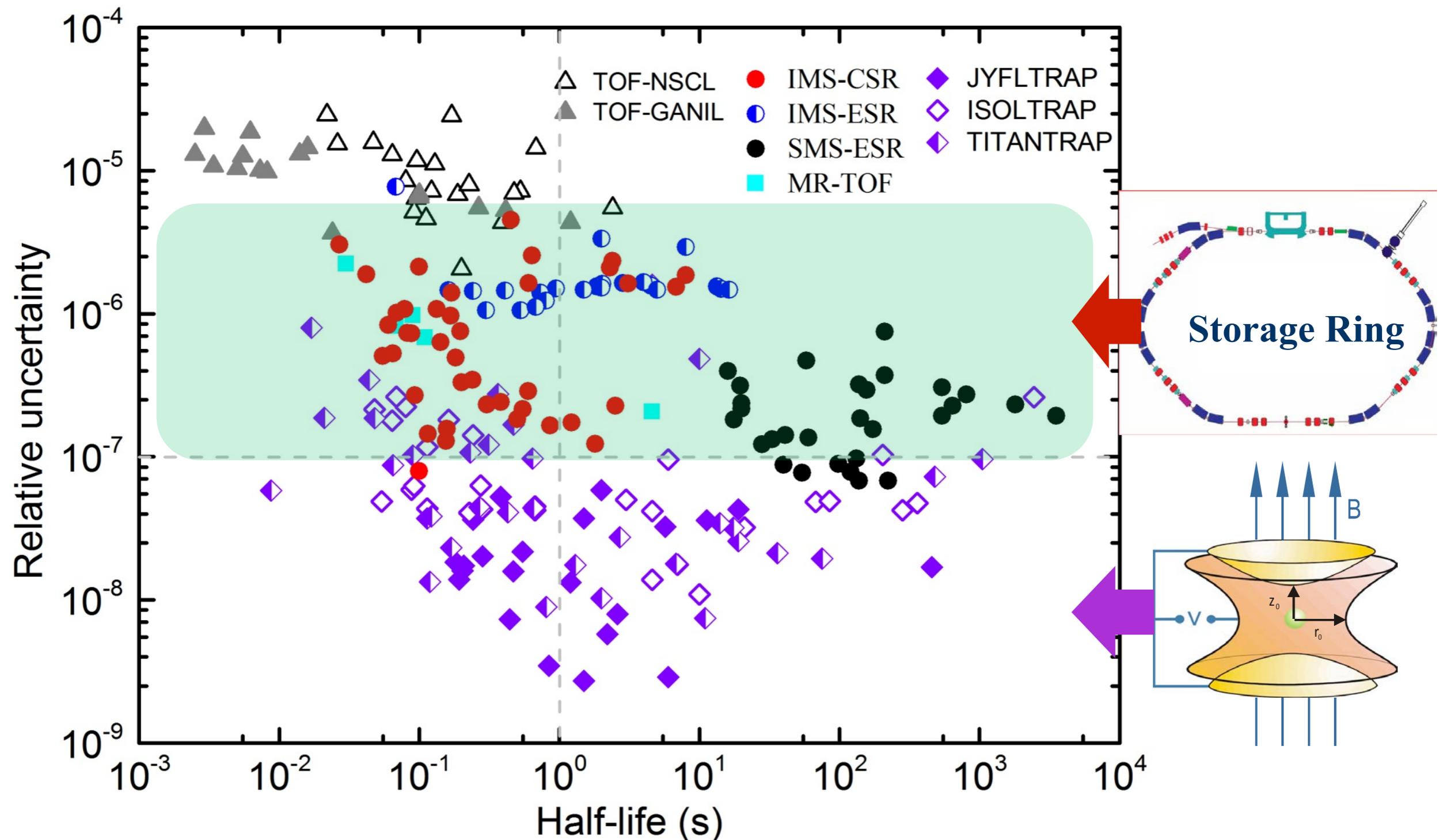
$$\frac{\Delta f}{f} = \frac{1}{\gamma_t} \frac{\Delta(m/q)}{m/q} + \frac{\Delta v}{v} \left(1 - \frac{\gamma^2}{\gamma_t^2} \right)$$

**In-ring
TOF detector
(C foil + MCP)**



Brief results from CSRe mass measurements

Precisions of new masses since 2010



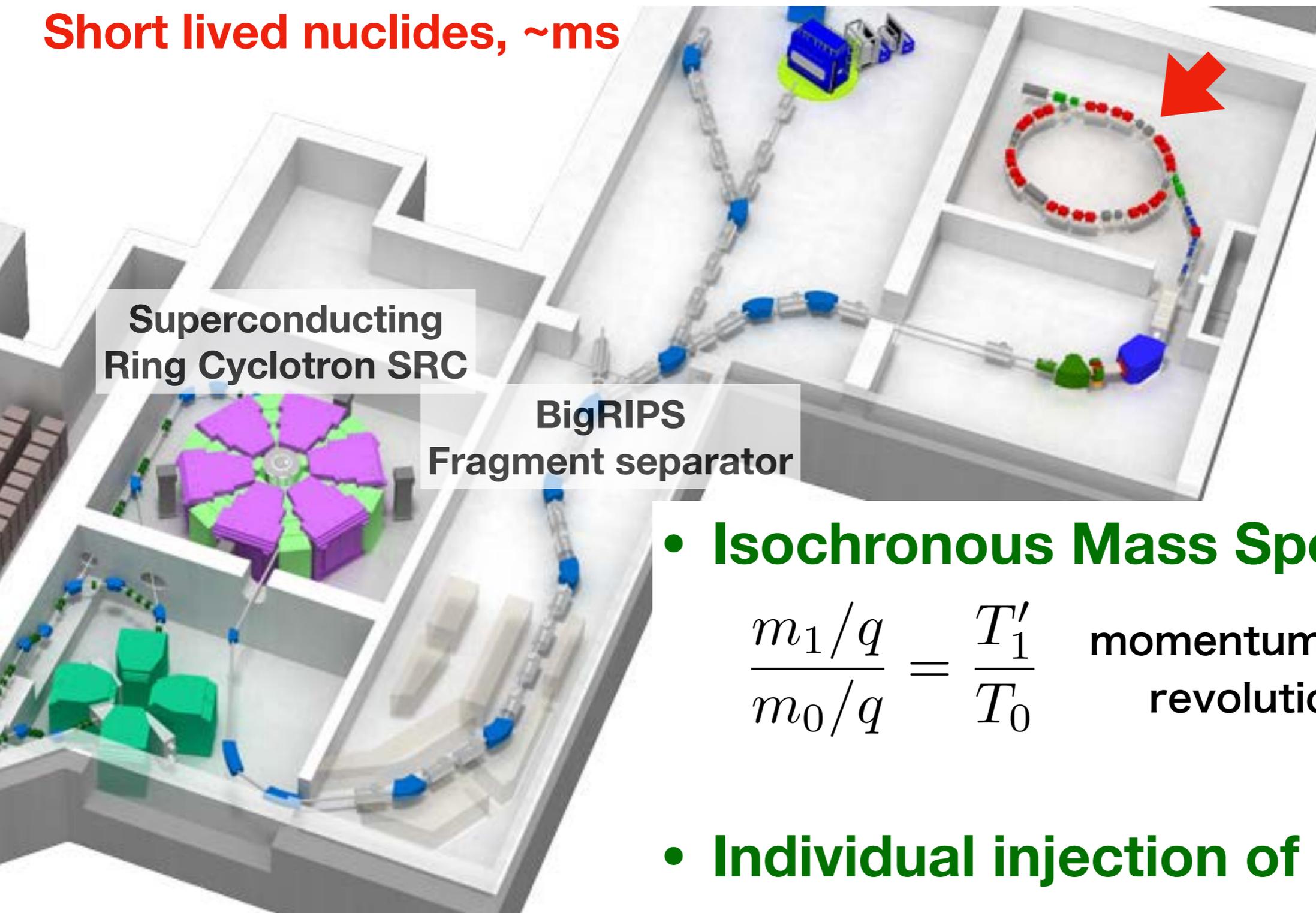
Rare-RI Ring: R3

A dedicated device for precision mass measurements

Rare RI:

Very low production rates, ~1/day

Short lived nuclides, ~ms



Superconducting
Ring Cyclotron SRC

BigRIPS
Fragment separator

- **Isochronous Mass Spectrometry**

$$\frac{m_1/q}{m_0/q} = \frac{T'_1}{T_0} \quad \begin{array}{l} \text{momentum corrected} \\ \text{revolution times} \end{array}$$

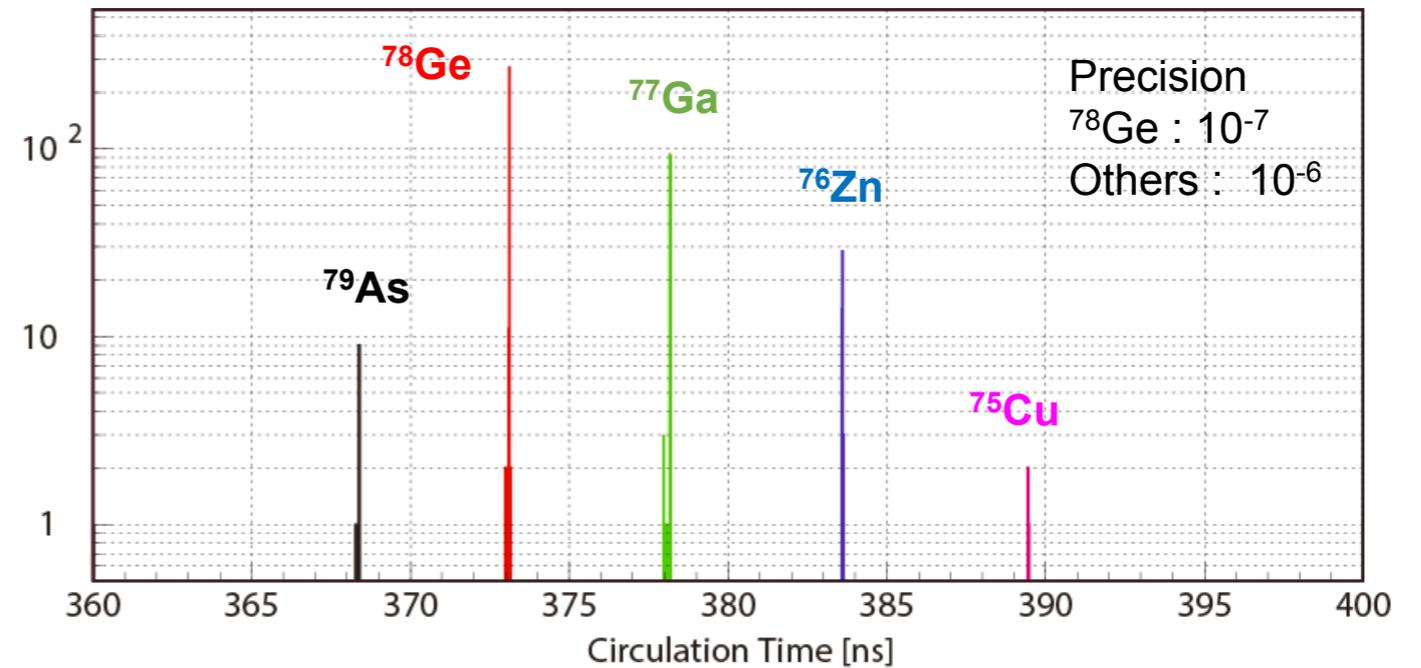
- **Individual injection of RI beam**

First Mass Measurement

With known masses

^{238}U 345 MeV/u \rightarrow ^{78}Ge 168 MeV/u fission fragments

Se-78 23.77	Se-79 2.95E5y *3.92m	Se-80 49.61	Se-81 *57.28m 18.45m	Se-82 8.73 8.3E19y
As-77 1.62d	As-78 1.51h	As-79 9.01m	As-80 15.2s	As-81 33.3s
Ge-76 7.73	Ge-77 11.211h *53.7%	Ge-78 1.47h	Ge-79 *39.0s 18.98s	Ge-80 29.5s
Ga-75 2.10m	Ga-76 32.6s	Ga-77 13.2s	Ga-78 5.09s	Ga-79 2.847s
Zn-74 1.59m	Zn-75 10.2s	Zn-76 5.7s	Zn-77 2.09s *1.05s	Zn-78 1.47s
Cu-73 4.2s	Cu-74 1.63s	Cu-75 1.224s	Cu-76 641ms	Cu-77 457.9ms
Ni-72 1.57s	Ni-73 640ms	Ni-74 680ms	Ni-75 344ms	Ni-76 238ms



In summary



ESR

1992
First storage
of RI beam



See talk by Y. Litvinov at 19:50(JST)

FAIR
~2025



CSRe

2011
First
masses



HIAF
~2025



Rare-RI Ring

RIBF
2006



2017

Day-1:
 $^{74}\text{Ni} \sim 1.2 \times 10^{-5}$

Day-2:
 $^{74}\text{Ni} \sim 3 \times 10^{-6}$



Isochronous cond.: $\sim 10^{-6}$
Total transmission: $\sim 10^{-2}$
Mass accuracy: $10^{-6} - 10^{-7}$

We are ready to delve into unexplored territories of masses

Thank you

